

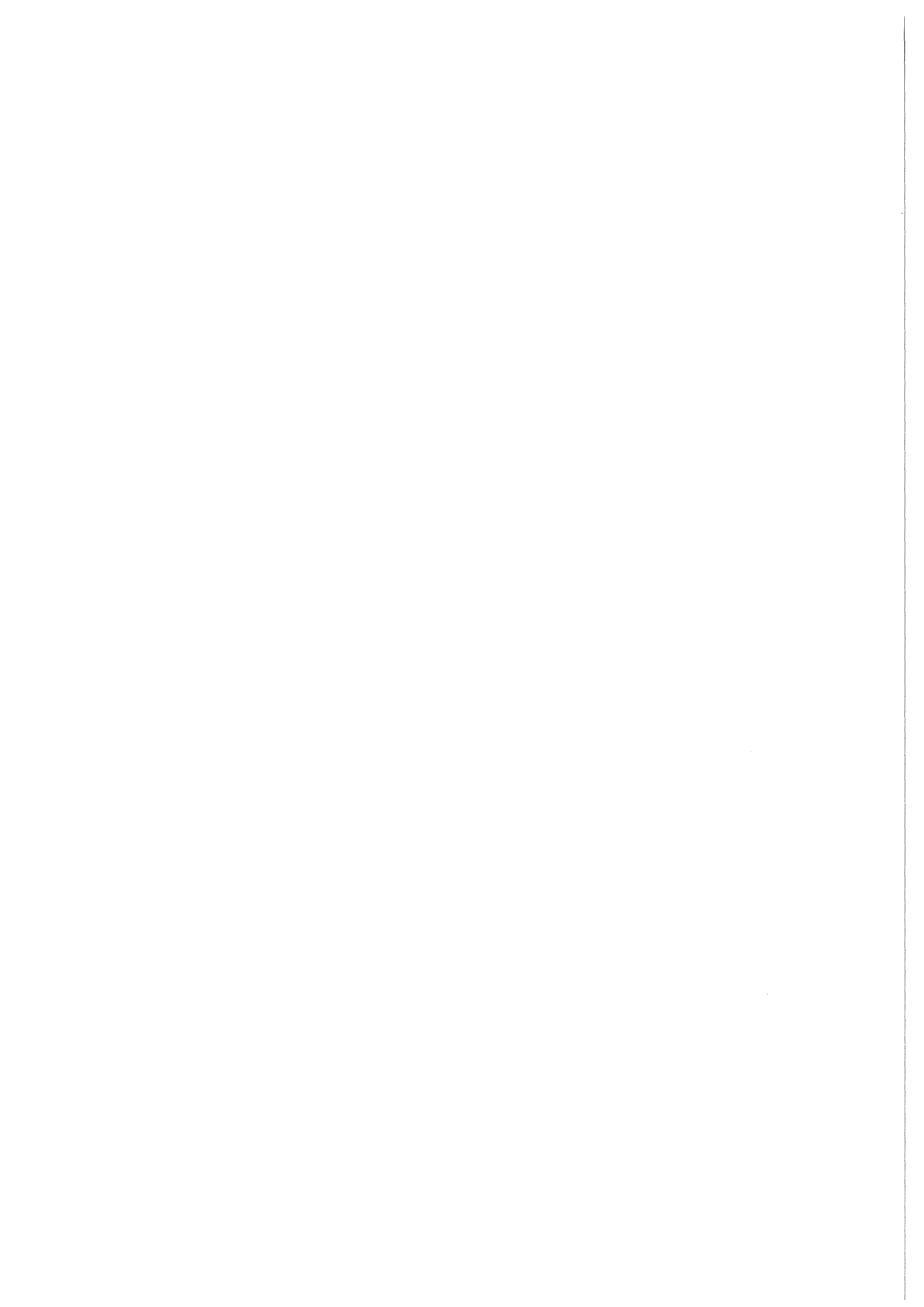


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UFOING
A Program for Assessing the
Off-site Consequences from
Ingestion of Accidentally
Released Radionuclides

C. Steinhauer
Institut für Neutronenphysik und Reaktortechnik
Projektgruppe LWR-Sicherheit

Kernforschungszentrum Karlsruhe



Kernforschungszentrum Karlsruhe
Institut für Neutronenphysik und Reaktortechnik
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from ingestion of accidentally released radionuclides

C. Steinhauer

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UFOING:

Ein Programm zur Abschätzung der Unfallfolgen durch Ingestion von Radionukliden nach unfallbedingter Freisetzung

Kurzfassung

Mit dem Programm UFOING können die Konsequenzen, die über den Ingestionspfad nach unfallbedingten Freisetzungen von Radionukliden in die Atmosphäre auftreten, abgeschätzt werden. Es wurde als eine eigenständige Ergänzung zum Programmsystem UFOMOD entwickelt, um schnellere und detailliertere Untersuchungen der ingestionsbezogenen Konsequenzen zu erlauben, als sie mit der in UFOMOD realisierten Version von UFOING möglich sind.

Für angenommene Freisetzungen zu verschiedenen Zeiten des Jahres werden altersabhängige Individualdosen, Kollektivdosen, zeitabhängige Individualrisiken für letale stochastische somatische Effekte, deren Gesamtzahlen, sowie die von Nahrungsmittelverboten betroffenen Flächen und die abgeschätzten Zeitdauern der Verbote berechnet. Zusätzlich können prozentuale Beiträge von Radionukliden und Nahrungsmitteln zu den Dosen und Risiken ermittelt werden.

Der erste Teil dieses Berichts gibt eine Übersicht über das Programm. Die anderen Teile enthalten eine Benutzer- und Programmanleitung sowie Beschreibungen der verwendeten Daten und der Version von UFOING, die in UFOMOD implementiert ist.

Abstract

The program UFOING estimates foodchain - related consequences following accidental releases of radionuclides to the atmosphere. It was developed as a stand-alone supplement to the accident consequence assessment program system UFOMOD to allow faster and more detailed investigations of the consequences arising from the foodchain pathways than possible with the version of UFOING which is implemented in UFOMOD.

For assumed releases at different times of the year, age dependent individual doses, collective doses, individual risks for fatal stochastic somatic health effects as a function of time, the total numbers of the effects, and the areas affected by foodbans together with the estimated duration of the bans are calculated. In addition, percentage contributions of radionuclides and foodstuffs to the doses and risks can be evaluated.

In the first part of this report, an overview over the program is given. The other parts contain a user's guide, a program guide, and descriptions of the data employed and of the version of UFOING which is implemented in UFOMOD.

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List of abbreviations

ACA	accident consequence assessment
ADC	(normalized) activity-dose-coefficient
ARC	(normalized) activity-risk-coefficient
CCFD	complementary cumulative frequency distribution
DRS-B	Deutsche Risikostudie Phase B (German Risk Study - Phase B)
FG	following generations (generations born after the accident)
GI	gastro-intestinal tract
GSF	Gesellschaft für Strahlen- und Umweltforschung mbH, Neuherberg
ICRP	International Commission on Radiological Protection
IL	intervention level
I/O	input/output
KfK	Kernforschungszentrum (nuclear research centre) Karlsruhe, FRG
LG	living generations (generations alive at the time of the accident)
LLI	lower large intestine
SI	small intestine
ULI	upper large intestine

Introduction

The program UFOING estimates foodchain - related consequences following accidental releases of radionuclides to the atmosphere. It was developed as a stand-alone supplement to the accident consequence assessment program system UFOMOD [1] to allow faster and more detailed investigations of the consequences arising from the foodchain pathways than possible with the version of UFOING which is implemented in UFOMOD.

For assumed releases at different times of the year, age dependent individual doses, collective doses, individual risks for fatal stochastic somatic health effects as a function of time, the total numbers of the effects, and the areas affected by foodbans together with the estimated duration of the bans are calculated. In addition, percentage contributions of radionuclides and foodstuffs to the doses and risks can be evaluated.

As input data, UFOING requires initial activity concentrations of the radionuclides deposited on the ground, specific activities in the foodstuffs as a function of time, and data about the radiation exposure and risk as a function of age and time.

The initial ground concentrations in each grid element are calculated by the subroutine CONCEN of the UFOMOD subsystems /NL or /FL for the assessment of late consequences in the near and far range, respectively. These data have to be produced in an UFOMOD run and modified by one of the preprocessor programs of UFOING.

The other data come from models not incorporated in UFOMOD or UFOING. The original data from the models have to be processed by preprocessor programs to generate the input files UFOING works with. Currently, files are used which are based on data provided by the Gesellschaft für Strahlen- und Umweltforschung (GSF) mbH, Neuherberg. However, the files generated by the preprocessors are designed in such a way, that the implementation of other data is possible without changes in the UFOING source code, even if they have different characteristics (e.g. types or numbers of foodstuffs, organs, age groups etc.).

UFOING contains several independent modules, each of which performs a different task. The replacement of existing modules or the addition of new ones is very easy and can be done without changing more than a few statements, if any, in the source code.

The program is written in Standard FORTRAN-77 with the exception of INCLUDE- and NAMELIST statements, which are elements of extended versions of the standard language.

This description of UFOING refers to the program version /JU88. It consists of five parts, each of which can be read independently. However, in Parts II - V it is assumed that the reader is familiar with the contents of Part I. Some parts also require a limited knowledge of the UFOMOD program system. For this, the reader is referred to references [1] and [2].

Part I describes the structure of the program, the program modules and the default data sets. The readers only interested to get an overview over the program may stop here.

The user's guide, Part II, is intended for those who are involved in running the program. It explains the runtime options, the units and files required in a run, an example run, and the preprocessor for the UFOMOD ground concentrations.

The program guide, Part III, is of interest to those who want to modify or add program modules, to implement new data sets, or to install the program on their own computers. Details are given about the source code and the data files, the UFOMOD environment of UFOING, and about the transfer of the source code and the default data sets to other institutions.

Part IV describes the generation of the default ingestion data for the specific activities in the foodstuffs, consumption rates, and dose factors.

Part V outlines the version of UFOING which is implemented in the program system UFOMOD.

The work has been performed in the frame of the GERMAN RISK STUDY - Phase B (DRS-B); it has been supported by the Commission of the European Communities within the project MARIA (Methods for Assessing the Radiological Impact of Accidents) of the Radiation Protection Programme (Contract No. BI6-F-128-D).

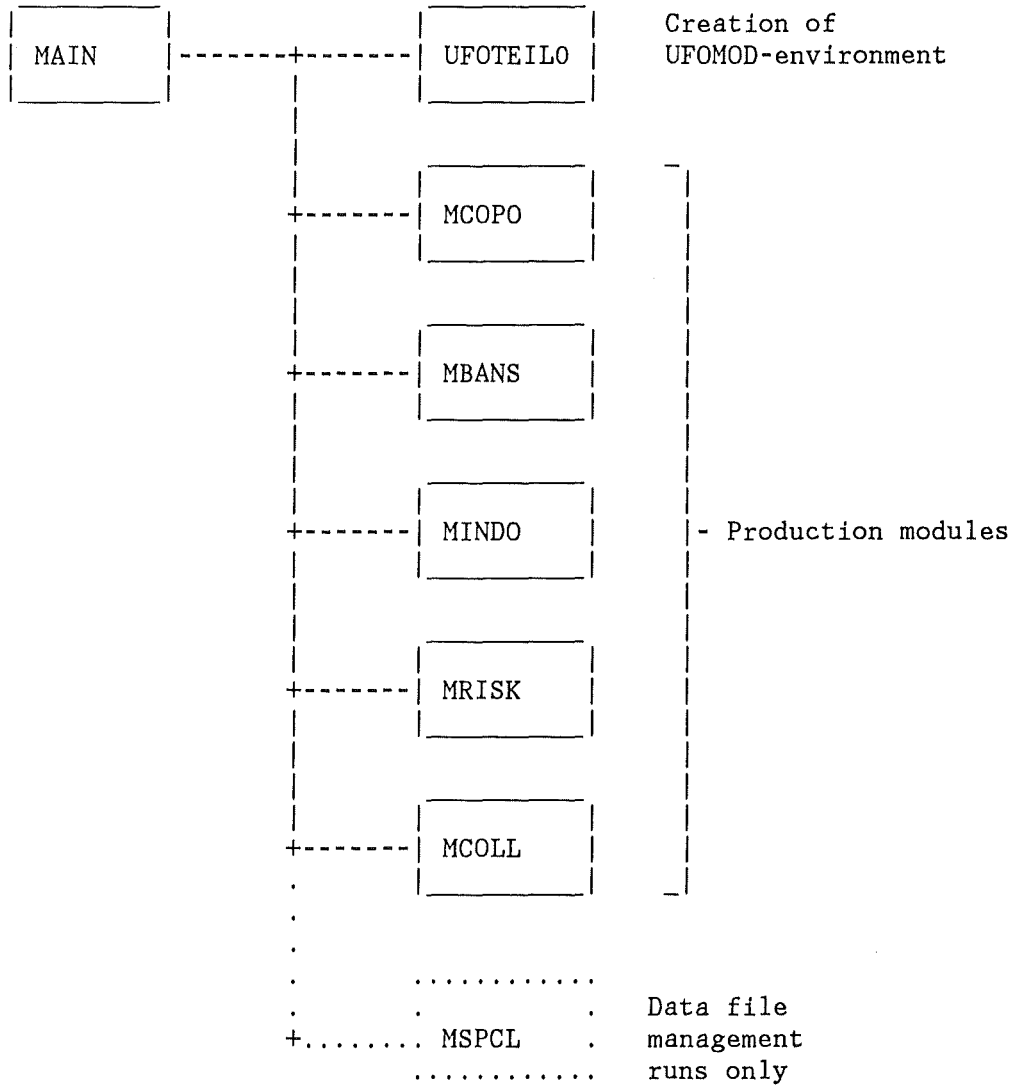
Part I

Basic features of UFOING

A. Overview

UFOING consists of eight modules, each of which performs a different task. The basic structure of the program is illustrated below:

Fig. I.1 Program modules of UFOING/JU88



Module MAIN provides data needed by all production modules and prints general information about the run. It contains, among others, the main program which calls all other modules.

Module UFOTEILO creates the UFOMOD-environment needed for UFOING by assigning values to variables and arrays in common blocks and by setting up temporary data files.

The module(s) collectively referred to as MSPCL are required for data file management runs. A dummy module is provided for production runs.

The production modules are for the calculation and output of the results. Details about the modules are given in Chapter B; their functions are summarized in Tab. I.1. Each of the modules can be run stand-alone or in combination with others.

Tab. I.1: Tasks performed by the production modules

module MCOPO

Calculation of contributions of radionuclides and foodstuffs to potential individual organ doses as a function of the year of ingestion for one selected distance.

module MBANS

Calculation of CCFDs¹⁾ and their statistical quantities of the areas affected by foodbans and of the maximum distances up to which foodbans are estimated as a function of time after the accident. - Estimation of the durations of the foodbans, which are required as input by the other modules when foodbans are to be taken into account.

module MINDO 2)

Calculation of CCFDs and their statistical quantities of individual lifetime doses as a function of the age of the individual at the time of the accident. - Calculation of percentage contributions of nuclides and foodstuffs to the doses for one selected distance.

module MRISK 2)

Calculation of CCFDs and their statistical quantities of the individual cumulative risk for fatal cancers as a function of time after the accident optionally for the generations alive at the time of the accident (LG) or the following generations (FG) or their sum. - Calculation of the percentage contributions of LG and FG to the sum. - Calculation of percentage contributions of nuclides and foodstuffs to the risks for one selected distance.

module MCOLL 2)

Calculation of expectation values of the numbers of radiation induced fatal cancers and of the numbers of fatal effects avoided by foodbans, or, alternatively, of the collective doses / doses saved and the percentage contributions of radionuclides and foodstuffs to the doses. All results are calculated for the living generations.

Notes:

- 1) CCFD = Complementary Cumulative Frequency Distribution
 - 2) Results can be calculated with and without foodbans
-

The modules MBANS, MINDO and MRISK calculate CCFDs for selected distance bands. The CCFDs are written (unformatted) on output files, which may be used later in graphics programs. Statistical quantities of the CCFDs are always printed out, e.g. mean values and percentiles. The CCFDs for the individual doses and risks and their statistical quantities refer to an individual situated anywhere on the given distance band: the 95th percentile, for instance, means, that in 95% of all accident situations considered, the corresponding dose- or risk value is not exceeded, independent of the angular position of the individual.

Unlike UFOMOD, which calculates both fatal and non-fatal effects, UFOING considers only fatal effects; in all estimations of risk-related results, a linear dose-response-relationship is assumed.

In the current version of UFOING, all dose- and risk calculations are based on the individual intake approach under the assumption of local production and consumption of the foodstuffs.

The decisions about foodbands in the foodbands module are made only on the ground of dose intervention levels, and agricultural production data are not taken into account.

In the future, alternative modules for the calculation of the collective doses/risks and the foodbands will be provided which make use of other assumptions (see Chapter D).

All modules need data to operate with. Two categories of data can be distinguished: "runtime options" and "constants". The runtime options define the properties of the actual run to the program (e.g. which of the production modules are to be called), and must be specified by the user for every run of UFOING in the form of card image and NAMELIST input. The constants are required for the calculations (e.g. initial activity concentrations on the ground, dose factors etc.) and are kept on unformatted data sets.

The initial ground concentrations are available for the source term, the meteorological zone, the sites, the weather sequences, distances and grids defined in the UFOMOD run in which the data were calculated.

Tab. I.2 lists the radionuclides, and Tab. I.3 the foodstuffs, foodband and risk integration times, organs and ages, for which specific activities in the foodstuffs, consumption rates and dose- and risk-data are currently available at KfK (the "default data sets"); a brief description of these data is given in Chapter C.

If data other than the default ones are employed, they can have a different parameterization than the one shown in Tab. I.2 and I.3, but they must comply with some conventions (Part III, Chapter C). It should be noted, that many of the runtime options (e.g. the selection of the organs to be considered), refer to the parameterization of the data and depend therefore on the data sets actually used in a run.

Tab. I.2: The default ingestion nuclides

name of nuclide	<u>Identification number of nuclide</u> ¹⁾²⁾		
	UFOING (MUKING)	UFOMOD (MUKUFC)	UFOMOD (MUKUFD)
SR- 89	1	24	24
SR- 90	2	25	25
Y - 90	3	30	30
Y - 91	4	32	32
ZR- 95	5	36	36
NB- 95	6	40	40
MO- 99	7	43	43
RU-103	8	48	48
RU-106	9	50	50
TE-127M	10	68	68
TE-129M	11	70	70
TE-132	12	74	74
I -129	13	78	78
I -131	14	80	80
I -133	15	82	82
I -135	16	84	84
CS-134	17	92	92
CS-136	18	94	94
CS-137	19	95	95
BA-140	20	98	98
CE-144	21	104	104
PU-238	22	126	126
PU-239	23	127	127
PU-240	24	128	128
PU-241	25	129	129
PU-242	26	130	130
AM-241	27	131	131
AM-241D	28	129	131
AM-242M	29	132	132
AM-243	30	134	134
CM-244	31	137	137
-	0	0	0
-	0	0	0
-	0	0	0
-	0	0	0

Notes

(1) Not all of the possible positions are currently used.

(2) MUKUFC and MUKUFD are the identification numbers of each nuclide in the basic UFOMOD nuclide array. MUKUFC is used for addressing the initial ground concentrations, MUKUFD for addressing the dose- or risk-factors. Both numbers are identical for all nuclides with the exception of "Am-241D":

Am-241 originating from the decay Pu-241 -> Am-241 after deposition is treated as a nuclide "Am-241D". When calculating doses or risks from "Am-241D", the initial activity concentration from the mother (Pu-241) and the dose- or risk- factor from the daughter must be used; therefore, MUKUFC and MUKUFD are different here. The assignment of the dose - or risk factor to its correct position in the data bases is done by the preprocessors; UFOING running in production mode does not need the array MUKUFD.

Tab. I.3: Parameterization of the default ingestion data

Foodstuffs:¹⁾

Nr. 1 - 5:	MILK	BEEF	PORK	GRAIN	POTATOES
Nr. 6 - 8:	L. VEG.	NL. VEG.	R. VEG.		

End of foodbans = begin of ingestion (the "banarray"):

Nr. 1 - 5:	0 a	1 a	2 a	5 a	10 a
Nr. 6 - 10:	20 a	30 a	40 a	50 a	70 a

Organs for dose- and foodban calculations:

Nr. 1 - 5:	BREAST	B. SURF.	LUNG	B.MARROW	THYROID
Nr. 6 - 10:	REMAINDR	STOMACH	LLI WALL	LIVER	PANCREAS
Nr. 11 - 15:	EFF.DOSE	GONADS	ADRENALS	BLADWALL	BRAIN
Nr. 16 - 20:	SI+CONT.	ULI WALL	KIDNEYS	SKIN	SPLEEN
Nr. 21 - 22:	THYMUS	UTERUS			

Organs for the calculation of risks/numbers of effects:²⁾

Nr. 1 - 5:	BREAST	B. SURF.	LUNG	B.MARROW	THYROID
Nr. 6 - 10:	REMAINDR	STOMACH	LLI WALL	LIVER	PANCREAS
Nr. 11 - 12:	-	GONADS			

Integration times for risk calculations:

Nr. 1 - 5:	5 a	10 a	20 a	30 a	40 a
Nr. 6- 10:	50 a	70 a	90 a	150 a	200 a

age groups:

Nr. 1 - 5:	0 a	1-4 a	5-9 a	10-14 a	15-19 a
Nr. 6:	>= 20 a				

Notes:

1) L., NL., R. VEG. = leafy, non-leafy, root vegetables

2) Position 11 is empty in the default ARC data sets

B. The production modules

B.1 Contributions of radionuclides and foodstuffs to potential individual doses (MCOPO)

The potential individual doses are calculated in the following way:

$$D(n,o,f;a;t_{ig}) = AG(n) * C(f,a) * AF(n,f,t_{ig}) * G(n,o,a)$$

where

n,o,f indices indicating the radionuclide (n), the organ or tissue (o) and the foodstuff (f)
a index indicating the age group the individual belongs to
t_{ig} year of ingestion

D dose [Sv] which an individual of the age group a receives over the rest of the life when consuming the foodstuff in a given year. The life span is taken to be 70 years.

AG initial ground concentration [Bq/m²]

C food consumption rate [kg/a]

AF yearly time integral of the specific activity in the foodstuff normalized to unit initial ground deposit [Bq*a/kg)/(Bq/m²)]

G dose conversion factor [Sv/Bq_{ingested}]:

$$G = \int_0^{Tmax} dt g(n,o,a,te)$$

where

g differential dose conversion factor [Sv/(Bq*a)]

te time of radiation exposure after ingestion

Tmax 70a - age; the age is taken to be the lower edge of the corresponding age interval

The normalized specific activities in the foodstuffs depend on the assumed time of the release.

The contributions of the radionuclides and foodstuffs to the doses are evaluated for one distance and for an individual belonging to one age group.

The age group, the distance, the organs and the years of ingestion for which the contribution are to be evaluated have to be selected. The consumption rates for each foodstuff and the selected age must be specified.

B.2 Foodbans and their duration (MBANS)

In the current version, the decisions about foodbans are based on doses: Bans are assumed to be introduced, when the lifetime doses resulting from ingestion of a single foodstuff or from the sum of certain foodstuffs ("foodgroups" with one or more members) in the first year after the accident exceed predefined intervention levels (IL). The bans are assumed to be withdrawn, when the yearly doses from ingestion in some later year are below other predefined intervention levels. The doses are calculated in the same way as in module MCOPO; the selection of the organs to be considered for banning is up to the user.

The starting times of the year, in which the doses are to be compared with the corresponding ILs, are defined by the "banarray", e.g. the starting time 0 means testing of the first year's doses. If the doses exceed the corresponding ILs up to a time T_a , but not for a time T_b , it is assumed that the duration of foodbans is greater than T_a years and that the ingestion begins at T_b . Some examples for possible combinations with the default banarray shown in Tab. I.3 are given below:

$D(T=0), D(T=1) \geq IL, D(T=2) < IL: \text{dur.} > 1 \text{ a, ing.beg. after yr. 2}$
 $D(T=0) \dots D(T=5) \geq IL, D(T=10) < IL: \text{dur.} > 5 \text{ a, ing.beg. after yr.10}$
 $D(T=0) \dots D(T=50) \geq IL, D(T=70) < IL: \text{dur.} > 50 \text{ a, ing.beg. after yr.70}$
 $D(T=0) \dots D(T=70) \geq IL \qquad \text{dur.} > 70 \text{ a, ing.beg. - none -}$

Output of the module are statistical quantities of the CCFDs of the areas affected by foodbans and of the maximum distances up to which foodbans are calculated for each foodgroup, both as a function of time after the accident. - At present, no account is taken of agricultural production data, i.e. the results give the areas which would be affected by restrictions of the food distribution if the foodstuff(s) to be banned would be produced there.

The durations of the bans for each foodstuff, which are required as input by other modules when foodbans are to be taken into account, are written to a data file for later use.

The formation of foodgroups for banning from the available foodstuffs is directed by the user. For each foodstuff, an age of the consumer and a corresponding consumption rate can be specified. This allows to consider foodbans under different assumptions about the consumer groups in each run without the necessity to change the source code of the module.

For each foodgroup, intervention levels for the introduction and withdrawal of the bans can be specified for each available organ or tissue.

B.3 Individual doses (MINDO)

The individual dose is calculated in the following way:

$$D(n,o,f,a;t_{si}) = AG(n) * ADC(n,o,f,a;t_{si})$$

where

- n,o,f indices indicating the radionuclide (n), the organ or tissue (o) and the foodstuff (f)
- a index indicating the age group the individual belongs to at the time of the accident
- t_{si} starting time of ingestion - see text -
- D dose [Sv] which an individual of a given age group at the time of the accident receives over the rest of the life when consuming the foodstuff over some time period (see text). The life span is taken to be 75 years.
- AG initial ground concentration [Bq/m^2]
- ADC activity-dose-coefficient normalized to unit initial ground deposit [$Sv/(Bq/m^2)$]:

$$ADC = \int_{t_{si}}^{T_{max}} dt_i AF(n,f,t_i) * C(f,a+t_i) \int_0^{T_{max}-t_i} dt_e g(n,o,a+t_i,t_e)$$

where

- g differential dose conversion factor [$Sv/(Bq*a)$]
- t_i, t_e times of ingestion and subsequent radiation exposure, respectively
- T_{max} 75a - age at accident; the age is taken to be the lower edge of the corresponding age interval
- AF specific activity in the foodstuff normalized to unit initial ground deposit [$Bq/kg)/(Bq/m^2)$]
- C food consumption rate [kg/a]

The first integral of the activity-dose-coefficients (ADCs) describes the intake of the activity with the foodstuffs by the individual, the second integral the radiation exposure resulting from this intake.

The ADCs contain the normalized specific activities in the foodstuffs and depend therefore on the assumed time of the release.

If foodbans are taken into account, the ingestion is assumed to be continuous from the end of the foodbans to the end of life of the individual. If foodbans are not considered, the user may specify a year in which the ingestion is to start. This gives a limited opportunity to study the time dependence of the potential doses by repeating the calculations with different starting times of ingestion.

The statistical quantities of the CCFds of the doses can be evaluated for all distances available from UFOMOD or a subset, the percentage contributions of nuclides and foodstuffs to the doses for one distance only.

The distances, the organs, whether foodbans shall be taken into account, and, if not, the time when the ingestion shall start, have to be specified.

B.4 Cumulative individual risks (MRISK)

The cumulative individual risk to die from a radiation induced cancer is calculated by:

$$R(n,o,f;t_{is};t_{ob}) = AG(n) * ARC(n,o,f,t_{is},t_{ob})$$

where

- n,o,f indices indicating the radionuclide (n), the fatal health effect (o) and the foodstuff (f)
- t_{is} starting time of ingestion - see text -
- t_{ob} observation time after the accident
- R cumulative risk - see text -
- AG initial ground concentration [Bq/m²]
- ARC activity-risk-coefficient normalized to unit initial ground deposit [1/(Bq/m²)] - see text -

The concept of normalized activity-risk-coefficients (ARCs) has been introduced in UFOMOD to estimate the number of fatal cancers as a function of time after the accident [3, 4]. For the ingestion pathways, the ARCs quantify the risk to develop a fatal cancer after the ingestion of a contaminated foodstuff for an individual, which is representative either for the living generations or, summarily, for all following generations.

The method of the ARCs was developed to provide an efficient means for calculating the numbers of health effects. The risk calculated in this way is a measure of the average risk present in the entire population, it is not a measure of the risk of an individual member of the population.

As for the activity-dose-coefficients, the ARCs depend on the assumed time of the release.

If foodbans are taken into account, the ingestion is assumed to be continuous from the end of the foodbans to the end of life of the individual, which is treated probabilistically in the ARCs. If foodbans are not considered, the user may specify a year in which the ingestion is to start. This gives a limited opportunity to study the dependence of the potential risks of the starting time of ingestion by repeating the calculations with different starting times.

The statistical quantities of the CCFDs of the risks can be evaluated for all distances available from UFOMOD or a subset, the percentage contributions of nuclides and foodstuffs to the risks for one distance only. Both sets of results can be generated for the living or the following generations or their sum.

The user must select the health effects and distances to be considered, whether foodbans shall be taken into account, and, if not, the time when the ingestion shall start, and whether the calculations are to be performed for the living or the following generations, or the sum of both.

B.5 Numbers of fatal cancers and collective doses (MCOLL)

Module MCOLL calculates either collective doses or the numbers of fatal cancers. The latter are calculated using two different methods: the first one is based on collective doses, the second one on the formalism of the ARCs; both methods currently rely on the assumption of local production and consumption of the foodstuffs.

The collective dose is obtained by summing up the collective dose contributions from each grid element. Each contribution is calculated by multiplication of the individual dose with the number of individuals in the grid element. The individual dose is calculated in the same way as in module MINDO, therefore, the collective dose applies only to the population alive at the time of the accident (LG). The number of fatal health effects is obtained by multiplication of the collective dose with a time-integrated risk factor.

Two different approaches in calculating the collective doses / number of health effects from the collective doses are made: in first one, the contributions from the different age groups are calculated and added together; in the second approach, all individuals are treated as adults.

With the activity-risk-coefficients, the number of fatal effects in the living generations is obtained by multiplication of the individual risk, which is calculated as in module MRISK, with the number of individuals in each grid element and summation over all grid elements. Here, only the ARCs for the LG are employed and only one observation time is used (the maximum time or another time specified by the user).

If foodbans are to be taken into account, the ingestion is assumed to be continuous from the end of the foodbans to the end of life of the individual (a fixed life span is assumed in the approaches A1 and A2; in the ARCs, the life span is treated probabilistically).

If foodbans are not considered, in dose runs the user may specify a year in which the ingestion is to start. This gives a limited opportunity to study the dependence of the collective dose of the starting time of ingestion by repeating the calculations with different starting times. In health effects runs, the ingestion is always assumed to start at the time of the accident.

Output of the module are, for each site, the expectation values of the numbers of fatal cancer cases and the number of cases averted by foodbans or, alternatively, of the collective doses / doses saved. Optionally, percentage contributions of radionuclides and foodstuffs to the collective doses calculated with approach 1 can be issued in dose runs.

The user must first decide, whether the health effects or the collective doses are to be calculated. The organs to be considered and whether foodbans shall be taken into account must be specified. A further option allows the limitation of the calculations up to some maximum distance.

In dose runs, it must be indicated if the contributions are to be evaluated. If foodbans are not considered, the time when the ingestion is to start can be selected from the banarray. - In health effects runs, the observation time for the ARCs can be selected.

Default values are provided for the fractions of the population belonging to each age group and the average risk coefficients, but the values can be changed with corresponding runtime options.

C. The default ingestion data

C.1 Specific activities in the foodstuffs and treatment of seasonality

The normalized specific activities for the foodstuffs listed in Tab. I.3 are based on data provided by the GSF for the DRS-B, which were calculated with the dynamic terrestrial foodchain transport model ECOSYS [5].

ECOSYS considers the contamination of the soil, of plant products by foliar and root uptake and by resuspension, of milk, beef and pork, and the effects of storage and decontamination of the foodstuffs.

The data used in UFOING were calculated with 'best estimate' parameter values, which represent approximately the centre of the range of their natural variation. Additionally, two sets of data were made available with an 'upper' and 'lower' parameter set, which reflect the uncertainty in establishing the centre values. These data are of interest for uncertainty analyses of the foodchain related accident consequences.

The interface between ECOSYS and the accident consequence model is the single deposition of a radionuclide on agricultural surfaces. For radionuclides originating from a radioactive decay chain after being deposited, e.g. Am-241 from the decay Pu-241 \rightarrow Am-241, the single deposition of the mother nuclide is the normalization value.

In principle, ECOSYS can calculate specific activities in the foodstuffs for a release on any day of the year. Such an amount of data cannot reasonably be handled in an ACA code. Therefore, to approximate seasonal effects, two data sets are used in UFOING, one for a release on 1st of January and one for a release on 1st of July. These two times can be regarded as representative for the time outside the vegetation period and for an upper estimate during the vegetation period.

In UFOING, results are calculated for either the 1st of July or the 1st of January. All weather sequences are attributed to the assumed date, regardless of their real date.

The original data provided by the GSF are in the form of yearly integrals of the specific activities up to 200 years. The time zero is always the time of the release. This way to integrate the data leads to problems with the current foodban module of UFOING, because, for instance, the second years integrals may exceed the first year ones. Therefore, the original data had to be modified in order to be usable by UFOING. In effect, the original rigid time scale of integration in the first year is replaced by a scale which is approximately oriented on the effects of direct deposition on the contamination of the foodstuffs and its first production after the accident. All following years are counted from this artificial "year" onwards. The total activity integrated over all times was kept the same.

The problems encountered in connection with the foodban module and the modifications of the original data are explained in Part IV, Chapter A.

C.2 Consumption rates

Average age dependent consumption rates for the FRG were derived for use in the DRS-B for the foodstuffs listed in Tab. I.3.

Consumption rates for foodstuffs consumed in a processed form (e.g. butter, bread) were added to the consumption rates of the unprepared foodstuff, i.e. the assumption is made, that the specific activities in the foodstuffs are not changed by manufacturing. The data for males and females, when available, were averaged. Seasonal differences were not taken into account. More details about the derivation of the data are given in Part IV, Chapter B.

The resulting consumption rates are summarized below:

Tab. I.4: Average consumption rates for the FRG

foodstuff	consumption rate [kg/a] for age group [a]					
	0	1-4	5- 9	10-14	15-19	>= 20
Milk (including milk products)	210	80	90	100	110	115
Beef (including veal, sausages etc.)	5	10	10	15	15	20
Pork (including ham etc.)	0	25	35	40	45	50
Cereals	10	35	55	65	80	95
Potatoes	5	15	20	30	40	70
Leafy vegetables	10	10	15	15	20	20
Non-leafy vegetables	10	20	25	25	25	25
Root vegetables	10	10	10	10	15	15

C.3 Dose conversion factors and activity-dose-coefficients

For the calculation of doses, UFOING requires time integrated dose conversion factors and activity-dose-coefficients. The data currently in use are based on data which were provided by the GSF for the DRS-B [6]. These data give the cumulative dose resulting from a single intake of activity by ingestion for an individual with a given age at the time of ingestion as a function of time after the intake.

The GSF data base contains time-integrated dose conversion factors for a large number of radionuclides, organs; integration times and two values of the resorption factor. From these data, the following data were derived:

- data reduced to one value of the resorption factor
- average values for the age group 0a from the data for age 0a and 1a

- data for other integration times
- average data for gonads
- dose conversion factors for the effective dose and a remainder according to ICRP 26 [7]
- data differentiated with respect to age and time for the evaluation of the activity-dose- and -risk coefficients.

The processing of the original data is described in Part IV, Chapter C.

By historical reasons, there are some inconsistencies in the derived data:

(1) The life spans were taken to be 70 a for the dose-conversion factors, but 75 a for the ADCs. The influence of the difference of five years on the results is negligible.

(2) All age-dependent results calculated with UFOING are intended to represent averages over each age group. Accordingly, all other data related to the age (e.g. consumption rates, risk factors) are average values with respect to the age groups. The original GSF dose conversion factors, however, apply to an individual with a given age (the lower edge of the age intervals listed in Tab. I.3), and were not averaged later (exception: age group 0 a, by some other reason). This inconsistency leads to either a slight over- or underestimation, dependent on the age group, the organ/tissue or health effect, the radionuclide and the type of result considered.

(3) The data for the breast and the uterus apply to females only, but the collective doses are calculated with the total numbers of individuals in UFOING. Therefore, in calculations of the collective doses resulting from irradiation of breast or uterus, the results must be divided by two (can be achieved with one of the runtime options).

C.4 Activity-risk-coefficients and average risk factors

Mathematically, the activity risk-coefficients are expressed by a multiple time integral over the age and life expectancy of the population, the age and time dependence of the intake of the activity by ingestion, the subsequent radiation exposure and the risk resulting from the exposure.

Therefore, the calculation of the ARCs requires the age and life expectancy distribution in the population, the specific activities in the foodstuffs, the consumption rates, differential dose conversion factors and time integrated risk factors. The demographic data were derived for the FRG under the assumption of a stationary population [3], for all other data with the exception of the risk factors, the data described in the preceding chapters were used.

Risk factors were made available for the DRS-B by the GSF [8, 9]. They quantify the cumulative numbers of radiation induced fatal stochastic somatic health effects per unit dose equivalent as a function of time after a single radiation exposure of a subgroup of a population and are parameterized with respect to the sex of the individual and the age group it belongs to at the time of exposure.

This data base has been developed by the GSF in the frame of a study carried out on the data currently available from Hiroshima and Nagasaki and other epidemiological studies. The factors for leukemia and bone cancer are based on the assumption of an absolute risk model, for all other factors, relative risk models have been used. As an example, average values derived with a linear dose-response-relationship for a population of one million individuals exposed with 0.01 Sv each are shown in Tab. I.5.

Tab. I.5: Average risk factors for fatal cancers

organ/tissue	effect	model ¹⁾	risk ²⁾
breast	cancers	R	80 ³⁾
bone surface	cancers	A	1
lung	cancers	R	90
red bone marrow	leukemia	A	52
thyroid	cancers	R	17
remainder	cancers	R	38
stomach	cancers	R	224 ⁴⁾
colon	cancers	R	
liver	cancers	R	
pancreas	cancers	R	

notes:

- 1) A: absolute risk model; R: relative risk model
- 2) Linear dose-response-relationship assumed. The values apply to a collective of 1 million individuals exposed to 0.01 Sv each.
- 3) average value for the population
- 4) summarily for the GI-tract

It should be noted, that for the breast, the value shown in Tab. I.5 is an average value for the population, whereas the values of the ARCs apply to females only.

D. Future improvements

Both UFOING and the version implemented in UFOMOD will be improved with respect to the following aspects:

Foodban module

An alternative foodban module will be developed in which the decisions about the bans are based on intervention levels for the specific activities in the in the foodstuffs instead on doses.

This module will be in agreement with the current regulations for foodbans within the CEC.

Agricultural production data for foodbans:

The use of agricultural production data in the foodbans module will enable to quantify the amounts of foodstuffs interdicted for distribution instead of the areas potentially affected by the bans.

Collective module

An alternative module will be developed to calculate the collective doses and the number of late fatal health effects using agricultural production data.

As in the current module MINDO for the approaches A1 and A2, this approximation relies on the fact that the assumption (within UFOING) of a linear dose-response-relationship for stochastic health effects means that the total incidence of these injuries is related only to the collective intake. However, in the new model, the collective intake will be calculated from the predicted specific activities in the foodstuffs and agricultural production data without reference to the individual intake and dose.

This method will give a more accurate estimate of the collective risk than the method currently used. It has the disadvantage, that no information is obtained on the ranges of individual doses and risk which make up the collective doses and risks. Also, since the formalism of the ARCs is not applicable in this case, the time dependence of the risks and the numbers of the health effects cannot be quantified directly.

Radionuclides

Data for the transport of tritium (in the form of HT and HTO) through the foodchains will be included.

This, together with a model for UFOMOD of the atmospheric transport of HT and HTO which is under development at KfK, will enable an assessment of the foodchain-related consequences of tritium releases from fusion reactors.

Wet deposition

Currently, the interface between the foodchain transport model (represented by the precalculated data for the specific activities in the foodstuffs) and the accident consequence model is the total activity

initially deposited on the ground. No consideration is given to the deposition process (wet or dry). However, the deposition process may have a considerable influence on the level of the direct contamination of foodstuffs. It is planned to include this aspect in the future.

Part II
User's guide

A. UFOING input

A.1 Runtime options for the module MAIN and the production modules

The variables, with which an UFOING-run is steered, are listed in Tab.II.1. In there, also the data types and dimensions of the variables are given. Most of the dimensions are coded in PARAMETER statements, their current default values are shown below:

Tab. II.2: Default dimensions in UFOING/JU88

MAXAGE = 6	MAXBAN = 10	MAXFOO = 8	MAXIML = 35	MAXING = 30
MAXORG = 12	MAXORK = 22	MAXPER = 10	MAXDIS = 35	MAXTIS=MAXDIS+1

The radionuclides, organs, foodstuffs, bantimes (= starting times of ingestion, the "banarray") and ages have to be selected among those known by UFOING; a list of the number and meaning of possible items is contained in each of the UFOING-data sets the program uses at runtime. This implies, that items adressable with the runtime options may depend on the data files which are used in the actual run. - In the application examples given later in this chapter, the selections refer to the parameterization of the default data sets, which are listed in Tab. I.2 and I.3 in Part I.

The distances which can be adressed with some of the runtime options depend on UFOMOD, and the selectable distances are those for which the ground concentrations data file created by UFOMOD was produced. The default distances implemented in the UFOMOD subsystems /NL and /FL, respectively, are given in Tab. II.3; the application examples refer to the default parameterization of UFOMOD/FL.

Tab. II.3: Default distances in UFOMOD

1 - 5:	10 km	20 km	30 km	40 km	50 km	<u>UFOMOD/FL</u>
6 - 10:	60 km	70 km	80 km	90 km	100 km	
11 - 15:	125 km	150 km	175 km	200 km	300 km	
16 - 20:	400 km	500 km	600 km	700 km	800 km	
21 - 25:	900 km	1000 km	1100 km	1200 km	1300 km	
26 - 30:	1400 km	1500 km	1600 km	1700 km	1800 km	
31 - 35:	1900 km	2000 km	2100 km	2200 km	2300 km	
1 - 5:	0.250 km	0.400 km	0.635 km	0.875 km	1.150 km	<u>UFOMOD/NL</u>
6 - 10:	1.550 km	2.100 km	2.700 km	3.700 km	4.900 km	
11 - 15:	6.550 km	8.750 km	11.50 km	15.50 km	21.00 km	
16 - 20:	27.00 km	37.00 km	49.00 km	65.50 km	87.50 km	
21 - 35:			- not used -			

Tab. II.1: Data type, dimensions and targets of variables

<u>variable</u>	<u>type</u>	<u>dimension</u>	<u>target</u>
ACCFDL	REAL*4	2	lower boundaries for CCFD sums
ACCFDU	REAL*4	2	upper boundaries for CCFD sums
DCCFDL	REAL*4	2	lower boundaries for CCFD sums
DCCFDU	REAL*4	2	upper boundaries for CCFD sums
FBILIB	REAL*4	(MAXORG,MAXFOO)	ILs for introduction (/IB) and
FBILWB	REAL*4	(MAXORG,MAXFOO)	withdrawal (/WB) of foodbans
FCR	REAL*4	MAXFOO	food consumption rates
GRPNAM	CHARACTER*8	MAXFOO	names of foodgroups for banning
IACCFL	INTEGER*4		lower boundaries of CCFDs
IACCFU	INTEGER*4		upper boundaries of CCFDs
IDCCFL	INTEGER*4		lower boundaries of CCFDs
IDCCFU	INTEGER*4		upper boundaries of CCFDs
IGN	INTEGER*4		number of selected nuclides
IGNUKS	INTEGER*4	MAXIML	identification of selected nucl.
MYBANS	INTEGER*4		activation of module MBANS
MYBTIM	INTEGER*4	MAXBAN	selection of bantimes
MYCOLL	INTEGER*4		activation of module MCOLL
MYCONT	INTEGER*4		evaluate contributions (MCOLL)
MYCOPO	INTEGER*4		activation of module MCOPO
MYDIST	INTEGER*4	1 (in MCOPO and MCOLL) MAXDIS+1 (else)	selection of UFOMOD-distances taking account of foodbans
MYFBNY	INTEGER*4		
MYFCAG	INTEGER*4	1 (MCOPO) MAXFOO (MBANS)	selection of age group(s) the consumer(s) belong to
MYFGRP	INTEGER*4	MAXFOO	grouping of foodstuffs for bans
MYGENE	INTEGER*4		selection of generations
MYINDO	INTEGER*4		activation of module MINDO
MYIGST	INTEGER*4		begin of ing. when no foodbans
MYORGS	INTEGER*4	MAXORK	selection of organs
MYOPTS	INTEGER*4		calculation of health effects or collective doses in MCOLL
MYPRNT	INTEGER*4		printout of input data files
MYRISK	INTEGER*4		activation of module MRISK
MYROBS	INTEGER*4		obervation times of ARC in MCOLL
NPERZ	INTEGER*4		number of percentiles for CCFDs
PERZ	REAL*4	MAXPER	percentiles for CCFDs
POPAGE	REAL*4	MAXAGE	fractions of population in age groups
POPRSK	REAL*4	(MAXORK,MAXAGE)	risk factors for MCOLL
RUNTXT	CHARACTER*8	10	header text for the run

In the following, the runtime options are described for each module and application examples are given. Besides for the module MAIN, all user input is via NAMELIST lists and must obey the NAMELIST conventions. For most of the options, no default values are provided.

Input for module MAIN - NAMELIST groups JMAIN1 and JMAIN2

In production runs, the user specifies runtime options to the main program with two NAMELIST blocks, JMAIN1 and JMAIN2; block JMAIN1 is always required.

JMAIN2 is only required, if the user wants to influence the selection of the radionuclides considered in the run (example 2). When JMAIN2 is omitted, UFOING will take the intersection of all nuclides it knows from the ingestion nuclides definition file with all those contained in the ground concentrations data file.

The first card of the user input in production runs is always the title card +INGSTRT. Then follows the NAMELIST group JMAIN1. If the user also wants to specify runtime options via JMAIN2, this block must be preceded by the title card +INGISOT. The input to the main program ends with the title card +INGSTOP.

The user input in a special run (e.g. for data file management) consists only of the title card +INGSPCL. An example for running UFOING this way is given in the Appendix.

Variables and their coding (NAMELIST group JMAIN1):

MYCOPO		
MYBANS		
MYINDO		- Selection of the production modules to be called
MYRISK		(0 = not to be called (<u>default</u>); NE.0 = to be called)
MYCOLL		

RUNTXT A character string which can be used to enter a text which characterizes the run.

 This text will be the first record of the foodban flags data file, if one is created in the run.

Variables and their coding (NAMELIST group JMAIN2):

IGN	Total number of ingestion nuclides requested specifically by the user (up to MAXING nuclides can be selected)
IGNUKS	UFOING - identification numbers of the requested nuclides

Example 1:

The module MAIN shall run with the following options:

- Call to all modules
- All possible nuclides are to be considered (default)

The title card and NAMELIST-input is:

```
+INGSTRT
&JMAIN1
  MYCOPO=1,MYBANS=1,MYINDO=1,MYRISK=1,MYCOLL=1,
  RUNTXT='EXAMPLE ', 'RUN ** U', 'FOINGFL ', '** SOME ', 'RELEASE ',
        'CATEGORY', ' ** ECOS', 'YS DATA ', 'FROM JUL', 'Y ** ',
&END
+INGSTOP
```

Example 2:

The module MAIN shall run with the following options:

- Call only the foodbans module
- Only the nuclides Sr-90, I-131, Cs-134 and Cs-137 shall be considered

The title card and NAMELIST-input is:

```
+INGSTRT
&JMAIN1
  MYCOPO=0,MYBANS=1,MYINDO=0,MYRISK=0,MYCOLL=0,
  RUNTXT='ANOTHER ', 'EXAMPLE ', 'TO DEMON', 'STRATE T', 'HE SELEC',
        'TION OF ', 'NUCLIDES', 'BY THE U', 'SER ',
&END
+INGISOT
&JMAIN2
  IGN=4,
  IGNUKS=2,14,17,19,31*0
&END
+INGSTOP
```

Input for module MCOPO - NAMELIST group JGCOPO

Variables and their coding:

MYPRNT control-printout of the contents of input-data set(s)

- MYPRNT = 0 no printout (default)
- MYPRNT = 1 printout of specific activities in foodstuffs
- MYPRNT = 2 printout of dose-conversion-factors
- MYPRNT = 3 both

- MYFCAG Selection of the age group the consumer belongs to
(for identification of the the corresponding dose factor).
- MYFCAG is the number of the element in the age-array of the
input data, which contains the desired age group.
- FCR Consumption rates for each foodstuff (kg/a) for a consumer
belonging to above age group.
- MYDIST The distance for which the contributions shall be evaluated.
- MYDIST is the number of the element in the distance - array
of the input data, which contains the desired distance.
- MYBTIM Selection of the times the ingestion shall start.
- For each of the times in the banarray, fill in a zero for skip
or any number for not to be skipped when calculating the
contributions.
- MYORGS Selection of organs or tissues.
- For each of the organs available, fill in a zero for skip or
a number which identifies the position of this organ in the
consecutive array of selected organs. Up to MAXORG organs can
be selected.

Example:

The module MCOPO shall run with the following options:

- Adult individual
- Some reasonable consumption rates for adults (see NAMELIST-input)
- Distance 500 km (UFOMOD/FL)
- start times of ingestion: 0, 1, 2, 5, 10, 50, 70 a (from banarray)
- Calculations of the effective dose, thyroid, bone marrow, lung,
remainder (in this order)

The NAMELIST-input is:

```
&JGCOPO
MYFCAG= 6,
FCR = 115., 20., 50., 95., 70., 20., 25., 15.,
MYDIST= 17,
MYBTIM= 1, 1, 1, 1, 1, 0, 0, 0, 1, 1,
MYORGS= 0, 0, 4, 3, 2, 5, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
&END
```

Input for module MBANS - NAMELIST group JGBANS

(I N T E R V E N T I O N L E V E L S B A S E D O N D O S E S)

Variables and their coding:

- MYPRNT control-printout of the contents of input-data set(s)
- MYPRNT = 0 no printout (default)
 MYPRNT = 1 printout of specific activities in foodstuffs
 MYPRNT = 2 printout of dose-conversion-factors
 MYPRNT = 3 both
- MYFCAG For each foodstuff:
 Selection of the age group the consumer belongs to
 (for identification of the the corresponding dose factor).
- MYFCAG are the numbers of the elements in the age-array of the
 input data, which contain the desired age group.
- FCR Consumption rates for each foodstuff (kg/a) for a consumer
 belonging to above age groups.
- MYFGRP Grouping of foodstuffs:
- The doses coming from either one foodstuff or from the sum of
 several foodstuffs can be compared with intervention levels. A
 foodgroup consists of one or more foodstuffs, but no foodstuff
 can belong to more than one foodgroup. Also, for foodstuffs of
 one foodgroup, the same ages must be specified - this is not
 checked by the program!
- The coding is as follows: Decide first for each foodstuff to
 which foodgroup it shall belong. Assign an integer number be-
 tween 1 and the total number of foodgroups to each group - the
 order is arbitrary, but the numbers must be unique for each
 group. Now the array MYFGRP can be set up: For each foodstuff
 from the list of available foodstuffs, specify the number of
 the group it belongs to - positive if the foodstuff is the
 only group member or if it is the first foodstuff encountered
 which belongs to a multiple foodgroup - negative for the
 remaining foodstuffs belonging to this group.
- If a foodstuff shall not be considered for banning, fill in a
 zero in the corresponding position (see example 2).
- GRPNAM Invent names (8 characters) to identify the foodgroups and -
 for each foodstuff, fill the name of the group the foodstuff
 belongs to into the array GRPNAM.

MYORGS Selection of the organs or tissues, for which intervention levels will be specified.

For each of the organs available, fill in a zero for skip or a number which identifies the position of this organ in the consecutive array of selected organs. Up to MAXORG organs can be selected.

FBILIB Intervention levels for the introduction (-IB) and the withdrawal (-WB) of foodbans (i.e. for the first year and the following years).

These are two - dimensional arrays with the dimensions (MAXORG,MAXFOO). The order of organs is the one selected with MYORGS, the order of foodstuffs is the one given by the input-data. Unused positions in FBIL/IB/WB must be filled, but any numbers will do.

Fill FBIL/IB/WB with the intervention levels for each organ and foodstuff. For the foodstuffs, only the ILs for the first (or only) member of each foodgroup must be specified correctly - for the remaining members of the group this IL is taken automatically, and the IL refers to the sum of the doses from all foodstuffs in the group.

Intervention levels must be specified for all selected organs and foodstuffs in the way above. However, it may be wanted not to consider a certain combination of an organ / foodgroup for banning (see example 2). Then this IL can be set to a very high value, which will never be exceeded.

If an intervention level shall apply only to the first year, it has to be de-activated by setting the corresponding IL in FBILWB to some value high enough never to be exceeded (example 1 and 2). *** Do not try to activate in FBILWB an IL which was de-activated in FBILIB - the program will simply ignore it ***

IACCFL, IACCFU, ACCFDL, ACCFDU (areas) Selection of the ranges
IDCCFL, IDCCFU, DCCFDL, DCCFDU (distances) of the CCFDs

I/A/D/CCFL, I/A/D/CCFU:

Logarithms of the lower and upper boundaries between which the the CCFDs will be constructed

A/D/CCFDL, A/D/CCFDU (2 values each):

Lower and upper boundaries for two intervals, in which the probabilities will be summed up for the printout of the statistical quantities

NPERZ, PERZ Selection of the percentiles of the CCFDs for the printout of the statistical quantities (applies to both areas and distances)

NPERZ: Number of percentiles to be considered.

PERZ: The percentiles
(e.g. 99. for the 99% fractile of the CCFD)

Example 1:

The module MBANS shall run with the following options:

- Ban groups and consumption rates:

WRKB.ER. = total intake from all foodstuffs by an average adult
i.e. all foodstuffs belong to the same foodgroup and
are eaten by an adult consumer; for the consumption
rates see the NAMELIST - input.

- For the foodbans, the effective dose and the thyroid dose (in this order) shall be compared with following intervention levels:

Intervention levels for introduction of bans:

WRK.ER.: $5 \cdot 10^{-3}$ Sv (eff. dose) and $5 \cdot 10^{-2}$ Sv (thyroid)

Intervention levels for withdrawal of bans:

WRK.ER.: $5 \cdot 10^{-4}$ Sv (eff. dose)

To eliminate the thyroid from the procedure,
its intervention level is set to a very high value.

- CCFDs to be constructed in the range 10^{-1} - 10^{+6} ; the probabilities shall be summed up for the ranges 10^{-1} - 10^{+2} and 10^{+2} - 10^{+6}
- CCFDs to be constructed in the range 10^{-1} - 10^{+4} ; the probabilities shall be summed up for the ranges 10^{-1} - $5 \cdot 10^{-2}$ and $5 \cdot 10^{-2}$ - 10^{+4}
- the values shall be printed for 10 fractiles (10%, 20%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%) (both areas and distances)

The NAMELIST-input is:

```
&JGBANS
FCR = 115., 20., 50., 95., 70., 20., 25., 15.,
MYFCAG= 6, 6, 6, 6, 6, 6, 6, 6,
MYFGRP= 1, -1, -1, -1, -1, -1, -1, -1,
GRPNAM='WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.',
        'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.',
MYORGS= 0, 0, 0, 0, 2, 0, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
FBILIB=5.OE-3, 5.OE-2, 10* -1.0,
        12* -1.0,
        12* -1.0,
        12* -1.0,
        12* -1.0,
        12* -1.0,
```

```

12* -1.0,
12* -1.0,
FBILWB=5.0E-4, 9.9E+9, 10* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
IACCFU=+6,
IACCFDL= -1, IACCFDU= 1.000E+02,
ACCFDU= 1.000E+02, 1.000E+06,
IDCCFU=+4,
IDCCFDL= -1, IDCCFDU= 5.000E+02,
DCCFDU= 1.000E-01, 1.000E+04,
DCCFDL= 5.000E+02,
NPERZ= 10, PERZ = 10., 20., 40., 50., 60., 70., 80., 90., 95., 99.
&END
```

Example 2 (foodban related input only):

- Ban groups

(for demonstration only, some of the groups are not meaningful)

- Ban group 1: milk consumed by children in the age group 0 a
- Ban group 2: beef + pork consumed by adults
- Ban group 3: grain products + all vegetables consumed by individuals of the age group 10-14 a

-> potatoes shall not be considered for banning, i.e. they will always be consumed!

- For the foodbans, the effective dose and the thyroid dose (in this order) shall be compared with following intervention levels:

Intervention levels for introduction of bans:

- Ban group 1: 10^{-4} Sv (eff. dose) and 10^{-3} Sv (thyroid)
- Ban group 2: 10^{-3} Sv (eff. dose)
- Ban group 3: 10^{-3} Sv (thyroid)

To eliminate the thyroid for group 2 and the eff. dose for group 3 from the procedure, the intervention levels are set to very high values.

Intervention levels for withdrawal of bans:

- Ban group 1: 10^{-4} SV (thyroid)

I.e. all other ILs must be de-activated or kept inactive.

The NAMELIST-input is given below. The text enclosed in stars are comments and not part of the input.


```
&JGBANS
FCR = 210., 20., 50., 65., 0., 15., 25., 10.,
MYFCAG= 1, 6, 6, 4, 0, 4, 4, 4,
MYFGRP= 1, 2, -2, 3, 0, -3, -3, -3,
GRPNAM='MILK CH.', 'MEAT AD.', 'MEAT AD.', 'MIX10-14', 'NOT USED',
        'MIX10-14', 'MIX10-14', 'MIX10-14',
FBILIB=1.0E-4, 1.0E-3, 10* -1.0, * milk children *
        1.0E-3, 9.9E+9, 10* -1.0, * meat adults, eff. dose only *
        12* -1.0, * any numbers ... *
        9.9E+9, 1.0E-3, 10* -1.0, * Mixed prod., thyroid only *
        12* -1.0, * no potatoes; what stands *
        12* -1.0, * here, *
        12* -1.0, * does not *
        12* -1.0, * matter! *
FBILWB=9.9E+9, 1.0E-4, 10* -1.0, * milk ch.; reactivate EDE *
        9.9E+9, 9.9E+9, 10* -1.0, * reactivate meat consumption *
        12* -1.0, * any numbers ... *
        9.9E+9, 9.9E+9, 10* -1.0, * reactivate mixed consumption*
        12* -1.0, * What stands here, *
        12* -1.0, * does *
        12* -1.0, * not *
        12* -1.0, * matter! *
* rest of the input as in example 1 *
&END
```

Input for module MINDO - NAMELIST groups JGINDO

Variables and their coding:

MYPRNT control-printout of the contents of input-data set(s)

MYPRNT = 0 no printout (default)
MYPRNT = 1 printout

MYFBNY Calculations without (0) or with foodbans (1)

MYIGST - Only for MYFBNY=0: The time when the ingestion shall start. This time can be selected from the banarray by specifying the number of the array element which contains the desired time (default T=0).

MYDIST The distances for which the CCFDs shall be evaluated *and* the one distance for which the contributions of radionuclides and foodstuffs shall be evaluated.

For each of the MAXDIS distance bands available from UFOMOD, fill in a zero for skip or any number for not to be skipped when calculating the CCFDs. In position MAXDIS+1, fill in the the number of the array element which contains the distance band chosen for the contributions of nuclides/foodstuffs, or a zero, if the contributions are not wanted. If they are, this

distance band must also be among the distances selected for the CCFDs.

MYORGS Selection of organs or tissues.

For each of the organs available, fill in a zero for skip or a number which identifies the position of this organ in the consecutive array of selected organs. Up to MAXORG organs can be selected.

IDCCFL, IDCCFU, DCCFDL, DCCFDU, NPERZ, PERZ
Specifications for the ranges and percentiles of the CCFDs
(coding explained in the MBANS section)

Example:

The module MINDO shall run with the following options:

- With foodbans
- CCFDs for the distances 100 km and 500 km and the contributions of radionuclides and foodstuffs for the distance 500 km (UFOMOD/FL)
- Calculations for the thyroid, bone marrow, lung and remainder (in this order)
- Suitable boundaries and percentiles for the CCFDs (see example)

The NAMELIST-input is:

```
&JGINDO
MYFBNY= 1,
MYDIST= 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
        0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
        0, 0, 0, 0, 0, 17,
MYORGS= 0, 0, 4, 3, 2, 0, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
IDCCFL= -4, IDCCFU= +6,
DCCFDL= 1.000E-04, 1.500E-02,
DCCFDU= 1.500E-02, 1.000E+06,
NPERZ= 10, PERZ = 10., 20., 40., 50., 60., 70., 80., 90., 95., 99.
&END
```

Input for module MRISK - NAMELIST groups JGRISK

Variables and their coding:

MYPRNT control-printout of the contents of input-data set(s)

MYPRNT = 0 no printout (default)
MYPRNT = 1 printout

MYGENE Calculations to be performed for the living (1), the following generations (2) or their sum (3)

MYFBNY Calculations without (0) or with foodbans (1)

MYIGST - Only for MYFBNY=0: The time when the ingestion shall start. This time can be selected from the banarray by specifying the number of the array element which contains the desired time (default T=0).

MYDIST The distances for which the CCFDs shall be evaluated *and* the one distance for which the contributions of radionuclides and foodstuffs shall be evaluated.

For each of the MAXDIS distance bands available from UFOMOD, fill in a zero for skip or any number for not to be skipped when calculating the CCFDs. In position MAXDIS+1, fill in the the number of the array element which contains the distance band chosen for the contributions of nuclides/foodstuffs, or a zero, if the contributions are not wanted. If they are, this distance band must also be among the distances selected for the CCFDs.

MYORGS Selection of organs or tissues.

For each of the organs available, fill in a zero for skip or a number which identifies the position of this organ in the consecutive array of selected organs. Up to MAXORG organs can be selected.

IDCCFL, IDCCFU, DCCFDL, DCCFDU, NPERZ, PERZ
Specifications for the ranges and percentiles of the CCFDs
(coding explained in the MBANS section)

Example:

The module MRISK shall run with the following options:

- Calculations for the sum of the living and following generations
- With foodbans
- CCFDs for the distances 100 km and 500 km and the contributions of radionuclides and foodstuffs for the distance 500 km (UFOMOD/FL)
- Calculations for the thyroid, bone marrow, lung and remainder (in this order)
- Suitable boundaries for the CCFDs (see example)

The NAMELIST-input is:

```
&JGRISK
MYFBNY= 1,MYGENE= 3,
MYDIST= 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
        0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 17,
MYORGS= 0, 0, 3, 2, 1, 4, 0, 0, 0, 0,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
IDCCFL= -13,IDCCFU= -2,
DCCFDL= 1.000E-06, 1.000E-04,
DCCFDU= 1.000E-04, 1.000E-02,
NPERZ= 10,PERZ = 10.,20.,40.,50.,60.,70.,80.,90.,95.,99.
&END
```

Input for module MCOLL - NAMELIST groups JGCOLL

(CALCULATIONS BASED ON INDIVIDUAL INTAKE)

Variables and their coding:

MYOPT3 Selection of the types of results to be calculated:

MYOPTS = 1 number of fatal cancers (default)

MYOPTS = 2 collective doses

MYFBNY Calculations without (0) or with foodbans (1)

MYDIST The distance up to which the collective quantities shall be evaluated:

MYDIST is the number of the array element which contains the desired distance - the maximum number is default.

MYORGS Selection of organs or tissues.

For each of the organs available, fill in a zero for skip or a number which identifies the position number of this organ in the consecutive array of selected organs. - Up to MAXORG organs can be selected.

Notes:

MYORGS(IOR)=negative Position number signals, that the results for this organ shall be divided by a factor of 2.This is helpful, if the activity-dose- and risk-coefficients both apply to to females and not to the population as a whole (see Part I, Chapters C.3 and C.4).

Caution: Actually, the input constants and not the results are divided. Both the activity-dose- and -risk- coefficients are divided, but not the risk coefficients used in the

approaches A1 and A2 in the calculations of the numbers of the health effects (see Part I, Chapter B.5).

For calculations of the number of health effects, the organs must be selected from those available for risk calculations. For calculations of collective doses, they must be selected from those available for dose calculations (see examples).

POPAGE Fractions of the population belonging to each age group. For POPAGE, default values are provided which were derived for the FRG under the assumption of a stationary population; the default values are:

age group 0 a:	0.01	-	age group 1- 4 a:	0.04
age group 5- 9 a:	0.06	-	age group 10-14 a:	0.08
age group 15-19 a:	0.08	-	age group >= 20 a:	0.73

for MYOPTS = 1 only:

POPRSK Time-integrated risk factors for the living generations for the calculation of the numbers of health effects with the collective dose approaches A1 and A2.

For POPRSK, default values are implemented in the code for several (but not all) health effects.

If values for POPRSK are given, they must be specified for the health effects available for risk calculations.

MYROBS The integration time of the activity-risk-coefficients to calculate the number of health effects with approach A3 by address of the array element which contains the time. -> The default value for MYROBS is the maximum time.

MYFBNY=0 implies here that the ingestion starts at T=0.

for MYOPTS = 2 only:

MYCONT Calculation of contributions of nuclides/foodstuffs. (This increases the CPU-time, see Chapter B.2)

MYCONT = 0 No (default)

MYCONT = 1 Yes; contributions to collective doses

MYCONT = 2 Yes; contributions to collective doses saved

MYFBNY=0: MYIGST selects from the banarray the time the ingestion shall start by specifying the number of the array element which contains the desired time (default T=0).

Example 1:

The module MCOLL shall run with the following options:

- With foodbans
- Calculation of the numbers of health effects (default)
- Observation time 70 a for the ARCs used in approach A3
- Calculations for the lung, leukemia, and the thyroid (in this order)
- Default values for the age distribution in the population
- Default values for the time-integrated risk factors
(both for the collective dose approaches A1 and A2)

The NAMELIST-input is:

```
&JGCOLL
MYFBNY= 1,MYROBS= 7,
MYORGS= 0, 0, 1, 2, 3, 0, 0, 0, 0, 0,
        0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
&END
```

Example 2:

The module MCOLL shall run with the following options:

- With foodbans
- Calculation of the collective doses
- No contributions of radionuclides and foodstuffs (default)
- Calculations for the effective dose and the thyroid (in this order)
- Default values for the age distribution in the population

The NAMELIST-input is:

```
&JGCOLL
MYFBNY= 1,MYOPTS= 2,
MYORGS= 0, 0, 0, 0, 2, 0, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0,
        0, 0,
&END
```

A.2 UFOING input related to UFOMOD

The data required by UFOING in connection with UFOMOD are:

- initial activity concentrations on the ground
- nuclide and population data
- information about the release, the meteorological zone, the sites, the weather sequences, the distances and the grids.

The activity concentrations on the ground have to be produced in an UFOMOD run; however, in order to be usable by UFOING, they must be processed by one of the UFOING preprocessor routines. - The nuclide- and population data are read by UFOTEILO from data files at runtime and are made available for later use in COMMON blocks (nuclides) and a data file (population data). - All other data enter the program via UFOMOD user input, which is read by UFOTEILO.

For the UFOTEILO user input, the input groups UNFTYP, METEOZON and ERGEB are required in an UFOING run. The first two groups must contain exactly the same specifications as in the run which produced the ground concentrations file. - To avoid activities of UFOTEILO not related to UFOING (in fact, some of them would lead to an abnormal end of the run), all options in the NAMELIST list &OPTION of the input group ERGEB should be set to zero. - An example for the user input for UFOTEILO is given in Chapter B.1.

Although it is possible in UFOMOD to change at runtime the distances to be considered, this is not recommended in connection with UFOING runs, since, by technical reasons, UFOING knows the distances from a BLOCK DATA program unit of UFOING and not from UFOMOD. - If the user by some reason wants to change the distances in UFOMOD (e.g. to set up new default values for the UFOMOD program system), the corresponding BLOCK DATA in UFOING must be changed (program units BLCKNL and BLCKFL for UFOMOD/NL and UFOMOD/FL, respectively).

More details about the UFOMOD environment of UFOING are given in Part III, Chapter E.

A.3 Input/output units and data files

Tab. II.4 and II.5 show the input units and files required by UFOTEILO in an UFOING-run and by the rest of UFOING, respectively. The units are referred to in the code by INTEGER*4 constants which are initialized in the BLOCK DATA program units SCOMMON (UFOTEILO) and BLCKNF (UFOING). The values given in the tables are the current default values.

Details about the structures of the files and cross references between files and program units can be found in reference [2] (UFOTEILO) and in Part III of the UFOING-description.

Tab. II.4: Units and files required by UFOTEILO

<u>variable</u>	<u>default</u>	<u>file content</u>
NEIN	5	user - input for UFOTEILO
NUNITS(8)	8	release data
NUNITS(13)	13	starting times and probabilities of weather sequences
NUNITS(20)	20	population data (output from UFOTEILO; used by UFOING; unit INUFOP in BLOCK DATA BLCKNF of UFOING must be set to this number)
NUNITS(31)	31	population data (input to UFOTEILO)
NUNITS(40)	40	nuclide data from UFOMOD
NAUS	61	printout from UFOTEILO (NAUS=6 in UFOTEILO, this is changed to 61 by UFOING)

Tab. II.5: Units and files required by UFOING (without UFOTEILO)

<u>variable</u>	<u>default</u>	<u>file content</u>
SYSPRINT	6	default for printout from system programs on IBMs
LGR	50	runtime options for UFOING
LPT	60	printout from the UFOING program
INUFOP	20	population data (output from UFOTEILO; see Tab. II.4)
INUFOC	70	ground concentrations from UFOMOD (processed)
INUKIG	71	UFOING ingestion nuclides master file
INFCT	72	specific activities in the foodstuffs
INCOPO *	74	constants for module MCOPO (dose factors)
INBANS *	75	constants for module MBANS (dose factors)
ININDO *	76	constants for module MINDO (activity-dose-coeff.)
INRISK *	77	constants for module MRISK (activity-risk-coeff.)
INCOLL *	78	constants for module MCOLL (activity-dose- and risk-coefficients)
IOBANS +	80	foodban flags from module MBANS for other modules
IOTMP1/2	81/82	used to pass information from the subroutines which calculate the results to the subroutines which evaluate the CCFDs
IOCC21 *	91	module MBANS: CCFDs (areas)
IOCC22 *	92	module MBANS: CCFDs (distances)
IOCC03 *	93	module MINDO: CCFDs (doses)
IOCC04 *	94	module MRISK: CCFDs (risks)

Notes:

*) Only required if the corresponding module is called in the run

+) Only required in runs with foodbans

The data sets for the specific activities in the foodstuffs and the activity-dose- and risk- coefficients depend on the assumed time of the release (see Part I, Chapters C.1, B.3, B.4). They all must refer to the same release date; the consistency of files with respect to the assumed release date is not checked by the program.

All UFOING constants data files contain a description of the number and meaning of the parameters for which data are present in the file (e.g. for how many and which organs and age groups in the case of dose factors), i.e. they are self-defining. Therefore, different data files can be used in different runs without changes in the source code, provided that the numbers of parameters do not exceed the maximum number defined in the code, that the formats comply with the UFOING conventions (see Part III, Chapter C), and finally, that all files used are compatible with each other. The last constraint means, that data which depend on the same parameters (e.g. on the possible durations of foodbans, the "banarray", which is contained either explicitly or implicitly in almost all data), must refer to parameters identical in number and meaning. The compatibility of the input data files with each other is only partly checked by the program. It also should be remembered, that many of the runtime options (e.g. which organs to be considered), also depend on the input files actually used.

The foodban flags file, which originates from module MBANS, is used by the modules MINDO, MRISK and MCOLL when the consideration of foodbans is requested (i.e. MYFBNY=1). In this case, the file can either be created in the run - then module MBANS must be active (i.e. MYBANS=1) and the file can be temporary. Or it may already have been created in a previous run and is to be reused - then module MBANS must not be active (i.e. MYBANS=0) and the file is permanent.

The first record of the foodban flags file contains the text RUNTXT (Chapter A.1), which identifies the run in which it is created. This record is always printed out by each module when using the file. This is helpful to avoid confusion when foodban flags files created in a previous run are reused.

The CCFD files can be temporary or may be made permanent for later use in graphics programs.

A.4 Consistency checks of the input data

UFOING performs some checks on the runtime options and the input data. For instance, error messages will be issued if one of the following conditions are met:

runtime options:

- (a) number of selected organs greater than the maximum number of organs allowed for selection or greater than the numbers of organs in the data file used

input data:

- (b) number of radionuclides contained in an input data set is not identical to the one contained in the file connected to unit INNUKS
- (c) number of foodstuffs or bantimes contained in an input data set is not identical to the ones contained in the file connected to unit INFCT.

- (d) number of parameters contained in a data file exceeds the maximum number of parameters defined in the source code
- (e) number of selected radionuclides exceed the maximum defined in the source code

The error conditions (a) and others connected with the runtime options which are not mentioned in the list above, can easily be remedied by specifying the runtime options in agreement with the rules explained in Chapter A.1 and with the contents of the data files used.

The error conditions (b) and (c) show, that the input data are inconsistent with respect to the numbers of radionuclides, foodstuffs, bantimes. Cure: Use data sets which are compatible with each other. - The meaning of the data corresponding to the parameters (i.e. the names of the radionuclides, foodstuffs bantimes), and the numbers of organs and ages are not crosschecked.

The error condition (d) is an indication, that the program was not implemented properly on the computer, because at installation it should be made sure that the dimensions for all parameters are set up in such a way that the program can cope with all available input data sets (Part III, Chapter C.3).

The error condition (e) can occur, because in the source code the maximum number of ingestion nuclides which can be selected in a run (MAXING in Tab. II.2) is set smaller than the maximum number of selectable nuclides (MAXIML in Tab. II.2) This is done so, because with all source terms used so far, much fewer radionuclides for ingestion were observed than those defined by MAXIML. If this error message does actually appear and all other reasons for the error can be excluded, the dimension MAXING must be increased then; however, in this case, Chapter C.3 (item (3)) in Part III should be studied.

For more details about the connection between the input data and the corresponding data arrays and the dimensions involved the reader is referred to Part III, Chapter C.

All error messages consist of two identification numbers, which indicate the internal numbers of the message in the central error subroutine, ERRBOX, and are of interest to the programmer rather than to the user, a text explaining in which subroutine and, possibly, related to data from which NAMELIST group or input unit, the error occurred, and a text briefly describing the nature of the error. The run will be aborted after printout of the message.

B. Example run

The example run presented in this chapter is only intended to demonstrate the performance of UFOING and not for a discussion of the results. The calculations were done on the IBM 3090-200/Siemens 7890-M computers at KfK, the job control language (JCL, Chapter B.1) and the CPU-times (Chapter B.2) refer to this system.

The following assumptions were made:

- ground concentrations produced with the submodule UFOMOD/FL
 - example LWR source term (1 release phase)
 - 144 weather sequences (cyclic sampling, uniform probabilities)
 - 1 site; uniform population distribution
 - a release in summer (represented by the 1st of July)
-

B.1 Job control and user input

The job control for the example run is shown on the following pages; the user input is included as a part of the JCL here.

About 4000 k bytes virtual storage are required for the run. The size of the "bare" load module is smaller (about 3000 k bytes), the difference is used for file buffers for the input files connected to the load module at runtime.

There exist three subsystems of UFOMOD for assessing the short term (/NE) and the long term accident consequences in the near range (/NL) and the far range (/FL). UFOING can run in connection with both the long term subsystems /NL and /FL, but for each subsystem, a different load module is required.

There are several ways to produce an UFOING load module from the FORTRAN source code. Here it was chosen to have all UFOING-code which is independent of the UFOMOD-version in the data set UFOINGNF.FORT, and all code which depends on the UFOMOD-version (here: UFOMOD/FL) in the data set UFOINGFL.FORT; the data set UFOBZZ.FORT contains the UFOMOD/FL code with UFOTEILO as the member TEILO. All data sets consist of program units as well as INCLUDE members. The resulting object module and the load module are for the UFOMOD-subsystem /FL. In a similar way, a load module for the subsystem /NL can be created.

In the example JCL, the UFOING source code of UFOINGNF.FORT is distributed over members which correspond to the module MAIN and the production modules described in Part I, Chapter A (the additional members, DSPCL and MROOT, contain a dummy for module MSPCL and the subroutines which are called by more than one module, respectively (Part III, Chapter A)).

This break up of the code has the advantage, that it is very easy to replace a module for a given task by another one, provided that the alternative module complies with the conventions for the UFOING code. For instance, if two versions would exist for module MCOLL, one which uses the individual intake approach and one which uses production data, they could be contained in two different members of UFOINGNF.FORT. The

selection of the desired module can then be done by specifying the corresponding member in the JCL. However, if the alternative module requires different NAMELIST input and/or input data files, this has to be taken care of, too.

The program unit BLCKFL, which initializes the UFOMOD/FL-distances for UFOING, has to be addressed explicitly, because it is not (and cannot be) contained in UFOTEILO.

The user input for UFOTEILO contains all the information and modifications required for an UFOING run, which were explained in Chapter A.2. - The user input for UFOING is entirely made up from examples given in Chapter A.1, and, here, the same default data sets with the corresponding parameterizations are assumed.

In the example run, foodbans shall be taken into account in all modules (except MCOPO). The foodban flags file is created in this run (i.e. MBANS is called), and the file is temporary.

The data files for the specific activities in the foodstuffs, the activity-dose- and risk- coefficients depend on the assumed time of the release (here: July). For release times other than July, corresponding data sets must be used.

Job - cards for the example - run (user input included instream)

```
//INRxxxxx JOB (xxxx,xxx,xxxxx),xxxxxxxxxx,REGION=4096K,TIME=3
//*MAIN LINES=10
//* ----- */
//*          Creation and execution of the load module          */
//* ----- */
//FVCLG EXEC FVCLG,                * compile - link - go
//          PARM.C=NOSOURCE        * no printed output from
//C.SYSPRINT DD DUMMY              * the compiler
//C.SYSLIB  DD DSN=INR065.UFOINGNF.FORT,DISP=SHR          * INCLUDE
//          DD DSN=INR065.UFOINGFL.FORT,DISP=SHR          * data
//          DD DSN=INR188.UFOBZZ.FORT,DISP=SHR,LABEL=(1,,IN) *sets
//C.SYSIN   DD DSN=INR065.UFOINGNF.FORT(MAIN),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MCOPO),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MBANS),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MINDO),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MRISK),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MCOLL),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(MROOT),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(DSPCL),DISP=SHR
//          DD DSN=INR065.UFOINGFL.FORT(BLCKFL),DISP=SHR
//          DD DSN=INR188.UFOBZZ.FORT(TEILO),DISP=SHR,LABEL=(1,,IN)
//* ----- */
//* LPT LPT LPT LPT LPT LPT LPT LPT LPT LPT LPT LPT LPT LPT */
//* ----- */
//* Unit 6 : Printout from the system                          */
//* Unit 60 : Printout from UFOING                            */
//* ----- */
//G.FT06F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=133,RECFM=FA,BUFNO=1)
//G.FT60F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=133,RECFM=FA,BUFNO=1)
```

```
/** ----- */
/**          Data sets required by UFOTEILO          */
/** ----- */
/** SYSIN   : User input for UFOTEILO (NEIN=SYSIN here, see Ch. A.3) */
/** unit   8: Release data                                          */
/** unit  13: Starting times and probabilities of weather sequences */
/**          -> Not required here because of cyclic sampling method */
/** unit  20: Population data (out)                                  */
/** unit  31: Population data (in)                                  */
/**          -> Not required here because of uniform population     */
/** unit  40: Nuclide data from UFOMOD                             */
/** unit  61: Printout from UFOTEILO (suppressed in the example)   */
/** ----- */
//G.SYSIN   DD *
@ GROUND CONCENTRATIONS FOR UFOING
@ UFOMOD SUBSYSTEM FL
@ SOME EXAMPLE LWR-RELEASE
@ CYCLIC SAMPLING + UNIFORM PROB. FOR WEATHER & UNIF. POP. DISTRIB.
RASTER
&NETZ IBVOUT=1,&END
UNFTYP
LWR-XMPL          1          0          1
                1          60  0.000E0  4.000E1  4.000E1
METEOZON
3KARLSRHE        144          1          0          0          3          10          117
                1600         1200          800          560          320          200
OOEXAMPLE        0  1.00E+ 0          0
                2.50E+02
ERGER
&OPTION
IDSART=0, IEXPO=5*0, IDFOUT=0, IAROUT=0, ILFOUT=3*0,
NOMET=0, NOCONC=0, NOPOTD=0, NOPOTR=0, NOLATD=0, NOLATR=0, NOPOPS=0, NOPROT=0,
ICOAUS=0, IDSAUS=0, IRSAUS=0, IPSAUS=0, IPFAUS=0, NOPERF=0,
NOOTKZ=0, NOODOS=0, NOOIND=0, NOOPOP=0
&END
ENDE
//G.FT08F001 DD DISP=SHR, DSN=INR188.UNFDATA.FK25ZZ, LABEL=(, , , IN)
//G.FT20F001 DD UNIT=SYSDA, DCB=(RECFM=VBS, BLKSIZE=32760, LRECL=X)
//G.FT40F001 DD DISP=SHR, DSN=INR482.HEADER.DATA, LABEL=(, , , IN)
//G.FT61F001 DD DUMMY
/** ----- */
/**          User input for UFOING          */
/** ----- */
//G.FT50F001 DD *
+INGSTR
&JMAIN1
MYCOPO=1, MYBANS=1, MYINDO=1, MYRISK=1, MYCOLL=1,
RUNTXT='EXAMPLE ', 'RUN ** U', 'FOINGFL ', '** SOME ', 'RELEASE ',
       'CATEGORY', ' ** ECOS', 'YS DATA ', 'FROM JUL', 'Y ** ',
&END
+INGSTOP
&JGCOPO
MYFCAG= 6,
FCR    = 115., 20., 50., 95., 70., 20., 25., 15.,
MYDIST= 17,
MYBTIM= 1, 1, 1, 1, 1, 0, 0, 0, 1, 1,
MYORGS= 0, 0, 4, 3, 2, 5, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
&END
```

&JGBANS

FCR = 115., 20., 50., 95., 70., 20., 25., 15.,
MYFCAG= 6, 6, 6, 6, 6, 6, 6, 6,
MYFGRP= 1, -1, -1, -1, -1, -1, -1, -1,
GRPNAM='WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.',
'WRKB.ER.', 'WRKB.ER.', 'WRKB.ER.',
MYORGS= 0, 0, 0, 0, 2, 0, 0, 0, 0, 0,
1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
FBILIB=5.0E-3, 5.0E-2, 10* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
FBILWB=5.0E-4, 9.9E+9, 10* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
12* -1.0,
IACCFD= -1, IACCFU=+6,
ACCFDL= 1.000E-01, 1.000E+02,
ACCFDU= 1.000E+02, 1.000E+06,
IDCCFL= -1, IDCCFU=+4,
DCCFDL= 1.000E-01, 5.000E+02,
DCCFDU= 5.000E+02, 1.000E+04,
NPERZ= 10, PERZ = 10., 20., 40., 50., 60., 70., 80., 90., 95., 99.

&END

&JGINDO

MYFBNY= 1,
MYDIST= 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 17,
MYORGS= 0, 0, 4, 3, 2, 0, 0, 0, 0, 0,
1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
IDCCFL= -4, IDCCFU= +6,
DCCFDL= 1.000E-04, 1.500E-02,
DCCFDU= 1.500E-02, 1.000E+06,
NPERZ= 10, PERZ = 10., 20., 40., 50., 60., 70., 80., 90., 95., 99.

&END

&JGRISK

MYGENE= 3, MYFBNY= 1,
MYDIST= 0, 0, 0, 0, 0, 0, 0, 0, 0, 1,
0, 0, 0, 0, 0, 0, 1, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 17,
MYORGS= 0, 0, 3, 2, 1, 4, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
IDCCFL= -13, IDCCFU= -2,
DCCFDL= 1.000E-06, 1.000E-04,
DCCFDU= 1.000E-04, 1.000E-02,
NPERZ= 10, PERZ = 10., 20., 40., 50., 60., 70., 80., 90., 95., 99.

&END

```
&JGCOLL
MYFBNY= 1,MYOPTS= 2,
MYORGS= 0, 0, 0, 0, 2, 0, 0, 0, 0, 0,
        1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
```

&END

```
/** ----- */
/**          UFOING input data sets          */
/** ----- */
/** unit 70: Ground concentrations            */
/** unit 71: Ingestion nuclides master file  */
/** unit 72: specific activities in the foodstuffs for a release */
/**          at 1st of July (JUL)            */
/** unit 74: Dose conversion factors for module MCOPO */
/** unit 75: Dose conversion factors for module MBANS */
/** unit 76: Activity-dose-coefficients for module MINDO */
/**          for a release at 1st of July     */
/** unit 77: Activity-risk-coefficients for module MRISK for the */
/**          living (LG) and following(FG) generations for a */
/**          release at 1st of July (JUL)     */
/** unit 78: Activity-dose- and risk- coefficients for module MCOLL */
/**          for a release at 1st of July     */
/** ----- */
//G.FT70F001 DD DSN=INR065.CONCEN.FLFK25KA,DISP=SHR,
//          LABEL=(1,,IN)
//G.FT71F001 DD DSN=INR065.UFOINGNF.DATA(INGNUKS),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT72F001 DD DSN=INR065.UFOINGNF.DATA(ECOJULPR),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT74F001 DD DSN=INR065.UFOINGNF.DATA(GSFDORI1),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT75F001 DD DSN=INR065.UFOINGNF.DATA(GSFDORI1),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT76F001 DD DSN=INR065.UFOINGNF.DATA(GSFDORI2),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT77F001 DD DSN=INR065.UFOINGNF.DATA(HLGJULIG),DISP=SHR,
//          LABEL=(1,,IN)
//          DD DSN=INR065.UFOINGNF.DATA(HFGJULIG),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT78F001 DD DSN=INR065.UFOINGNF.DATA(GSFDORI2),DISP=SHR,
//          LABEL=(1,,IN)
//          DD DSN=INR065.UFOINGNF.DATA(HLGJULIG),DISP=SHR,
//          LABEL=(1,,IN)
/** ----- */
/**          UFOING work data sets          */
/** ----- */
/** unit 80: Foodban flags which give the duration of the bans. */
/** units 81/82: Used to pass information from the subroutines which */
/**          calculate the results to the subroutines which evaluate */
/**          the CCFDs. */
/** ----- */
//G.FT80F001 DD DSN=&&FT80,DISP=(NEW,PASS),UNIT=SYSDA,
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(1,1),RLSE)
//G.FT81F001 DD DSN=&&FT81,DISP=(NEW,PASS),UNIT=SYSDA,
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(5,1),RLSE)
//G.FT82F001 DD DSN=&&FT82,DISP=(NEW,PASS),UNIT=SYSDA,
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(TRK,(10,1),RLSE)
```

```

/** ----- */
/**          UFOING work data sets - CCFDs          */
/** ----- */
//G.FT91F001 DD DSN=&&FT91,DISP=(NEW,PASS),UNIT=SYSDA,   * areas
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(5,1),RLSE)
//G.FT92F001 DD DSN=&&FT92,DISP=(NEW,PASS),UNIT=SYSDA,   * distances
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(5,1),RLSE)
//G.FT93F001 DD DSN=&&FT93,DISP=(NEW,PASS),UNIT=SYSDA,   * doses
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(5,1),RLSE)
//G.FT94F001 DD DSN=&&FT94,DISP=(NEW,PASS),UNIT=SYSDA,   * risks
//          DCB=(RECFM=VBS,BLKSIZE=32760,LRECL=X),
//          SPACE=(CYL,(5,1),RLSE)

```

B.2 CPU times

The computing times required by each production module depend on:

- (1) the number of release phases, weather sequences, azimuthal grid elements
- (2) the number of ingestion nuclides
- (3) the number of organs, foodstuffs, distances etc. considered
- (4) the number of sites

The number of release phases, weather sequences, grid elements, and ingestion nuclides are the same in all modules, whereas the items listed under (3) may vary between the modules, dependent on the runtime options. The number of sites is relevant only for module MCOLL.

The (rounded) CPU-times needed by each module in the example run are shown below:

Tab. II.6 Approximate CPU - times for the example run		
module	CPU times	Comments
MCOPO	5 s	5 organs, 7 times
MBANS	25 s	2 organs / 1 foodgroup for banning
MINDO	15 s	4 organs, 2 distances
MRISK	35 s	4 organs, 2 distances
-----	-----	-----
MCOLL	95 s	health effects run: 3 organs, 1 site
MCOLL	55 s	coll.dose run: 2 organs, 1 site, no contrib.
MCOLL	95 s	coll.dose run: 2 organs, 1 site, contrib.

B.3 Printout

As an example for the printout of UFOING, output from the modules MAIN, MCOPO, MBANS and MCOLL is shown on the following pages. The format was slightly modified and shortened to make it fit into the format of this text. Comments have been included on occasion; they are embedded in stars (*) and are not part of the original output.

The printout appears in turn for each module. From the module MAIN, information about the radionuclides considered in the run, the release type and the number of weather sequences contained in the ground concentrations file from UFOMOD, and the foodchain transport model is given. From the production modules, the output consists of information about the data file(s) for constants used in the run, about the runtime options specified, and, finally, the results. The information about the input files was found to be helpful to avoid confusion when comparing the outputs from runs with identical runtime options, but with different data files (e.g. for assumed releases on 1st of January and July, respectively).

=====
MODULE MAIN MODULE MAIN MODULE MAIN MODULE MAIN MODULE MAIN
=====

* General information about the run is printed here. *

--- DATE 25. 7.88 -- TIME 10:40:18 -- UFOING -- VERSION JULY 1988/1 ---

+ WARNING: NUCLIDE NOT FOUND IN UFOLIST Y - 90 *****
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST ZR- 95 * UFOING tries to *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST RU-103 * select the required*
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST I -129 * nuclides (here: *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST I -135 * all, since JMAIN2 *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST PU-238 * was not given) *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST PU-239 * from those *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST PU-240 * provided by UFOMOD.*
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST PU-241 * A message is *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST PU-242 * issued for each *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST AM-241 * nuclide *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST AM-241D * which cannot *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST AM-242M * be found among *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST AM-243 * the UFOMOD ones. *
+ WARNING: NUCLIDE NOT FOUND IN UFOLIST CM-244 *****

NUCLIDE FILE HEADER:

CRINGNUK FROM 8. 3.88 * 35 INGESTION NUCLIDES * 141 UFOMOD NUCLIDES

* List of the nuclides considered in the run. UFO and ING are the *
* primary identification numbers of the nuclides in UFOMOD and UFOING,*
* respectively, and NR are the numbers the nuclides have in this run. *

NUCLIDES SELECTED FOR INGESTION:

UFO	ING	NR	NAME
24	1	1	SR- 89
25	2	2	SR- 90
32	4	3	Y - 91
40	6	4	NB- 95
43	7	5	MO- 99
50	9	6	RU-106
68	10	7	TE-127M
70	11	8	TE-129M
74	12	9	TE-132
80	14	10	I -131
82	15	11	I -133
92	17	12	CS-134
94	18	13	CS-136
95	19	14	CS-137
98	20	15	BA-140
104	21	16	CE-144

 * Short info describing the run. If a ban-flag file is created, this *
 * is also its header (i.e. runtime option RUNTXT is printed here). *

RUN IDENTIFICATION:

EXAMPLE RUN**UFOINGFL**SOME RELEASE CATEGORY**ECOSYS DATA FROM JULY

 * LMAX is the number of weather sequences considered in the run. *

RELEASE TYPE AND LMAX: LWR-XMPL 144

 * Information about the foodchain transport data file *
 * ----- *
 * First comes the file header, then a list of the relevant parameters.*
 * This information is read from the data file. - The "time steps" are *
 * the "banarray" for the possible durations of the foodbans. *

FCT - DATA FILE HEADER:

CRECSYS2 MODIF. 8. 3.88 GSFMAR87.DATA YEARLY INTEGRLS
 ((BQ*A/KG) / (BQ/M**2))

FCT - MODEL AND TIME OF RELEASE: ECOSYS JULY

FOODSTUFFS IN FCT - MODEL:	MILK	BEEF	PORK	GRAIN
	POTATOES	L. VEG.	NL. VEG	R. VEG
TIME STEPS IN FCT - MODEL:	0 A	1 A	2 A	5 A
TIME STEPS IN FCT - MODEL:	10 A	20 A	30 A	40 A
TIME STEPS IN FCT - MODEL:	50 A	70 A		

=====

MODULE MCOPO MODULE MCOPO MODULE MCOPO MODULE MCOPO MODULE MCOPO

=====

```
*****
* Information about the input data file(s)                                     *
* -----                                                                    *
* First comes the file header, then a list of the relevant parameters.*
* This information is read from the data file(s).                             *
*****
```

```
CRECSYS2 MODIF.   8. 3.88 GSFMAR87.DATA    YEARLY INTEGRLS
                                                    ((BQ*A/KG) / (BQ/M**2))
```

FCT MODEL: ECOSYS JULY

FOODSTUFFS:	MILK L. VEG.	BEEF NL. VEG.	PORK R. VEG.	GRAIN	POTATOES
BANTIMES:	0 A 20 A	1 A 30 A	2 A 40 A	5 A 50 A	10 A 70 A

```
CRFDORI1 FROM    9. 3.88 * DCFS FOR IG * INTEGR. TO 70A - AGE *
```

ORGANS:	BREAST	B. SURF.	LUNG	B.MARROW	THYROID
	REMAINDR	STOMACH	LLI WALL	LIVER	PANCREAS
	EFF.DOSE	GONADS	ADRENALS	BLADWALL	BRAIN
	SI+CONT.	ULI WALL	KIDNEYS	SKIN	SPLEEN
	THYMUS	UTERUS			

AGES:	0 A	1 A	5 A	10 A	15 A
	20 A				

```
*****
* Information about the runtime options                                     *
*****
```

FOODSTUFF:	MILK	BEEF	PORK	GRAIN.
CONS. RATE (KG/A):	1.15E+02	2.00E+01	5.00E+01	9.50E+01

FOODSTUFF:	POTATOES	L. VEG.	NL. VEG.	R. VEG.
CONS. RATE (KG/A):	7.00E+01	2.00E+01	2.50E+01	1.50E+01

CONSUMER AGE: 20 A

```

*****
*
* Percentage contributions of radionuclides and foodstuffs to doses
* -----
*
* Notes:
*
* The "VALUE" is given in arbitrary units (ARB.UNITS); the numeric
* value is the dose sum over all grid elements in the selected
* distance. The numbers allow a relative comparison of the doses
* for the different organs and years of ingestion.
*
* The reference value (REFVAL) is the value for the dose in the
* first year ge.1 which was selected by the runtime options (here:
* year 1) - it can easily be identified by the 100% contributions!
*
* Only those nuclides are printed, which contribute 0.1% or more
* to at least one of the organ doses -> by this and by rounding,
* columns may slightly differ from 100% when summed up from output.
*
*****

```

POTENTIAL INDIVIDUAL DOSE (ARB.UNITS) FROM YEARLY INTAKE OF FOOD

```

RELEASE CATEGORY:          LWR-XMPL
REPRESENTIVE DISTANCE (KM):      500 KM
FOODCHAIN - TRANSPORT - MODEL:  ECOSYS
ASSUMED RELEASE AT FIRST OF:    JULY

```

BEGIN OF INTAKE AT T = 0 A

NUCLIDES	EFF.DOSE	THYROID	B.MARROW	LUNG	REMAINDR
SR- 89	0.2%	0.0%	0.3%	0.0%	0.1%
SR- 90	0.4%	0.0%	2.2%	0.0%	0.0%
RU-106	0.1%	0.0%	0.0%	0.0%	0.1%
TE-127M	0.1%	0.0%	0.3%	0.0%	0.0%
TE-129M	0.1%	0.0%	0.1%	0.0%	0.0%
TE-132	0.2%	2.0%	0.0%	0.0%	0.0%
I -131	5.8%	67.6%	0.1%	0.1%	0.1%
I -133	0.0%	0.4%	0.0%	0.0%	0.0%
CS-134	64.1%	20.5%	66.6%	67.9%	69.0%
CS-136	0.1%	0.0%	0.1%	0.1%	0.1%
CS-137	28.6%	9.5%	30.3%	31.8%	30.4%
VALUE	5.31E+01	1.50E+02	4.92E+01	4.52E+01	5.08E+01
VAL/REFVAL	1.00E+02	1.00E+02	1.00E+02	1.00E+02	1.00E+02
MILK	19.7%	63.2%	16.2%	15.5%	15.5%
BEEF	2.7%	1.1%	2.8%	2.8%	2.9%
PORK	29.8%	9.7%	31.2%	32.1%	32.0%
GRAIN	26.5%	8.5%	28.4%	28.2%	28.1%
POTATOES	16.4%	5.3%	17.1%	17.5%	17.5%
L. VEG.	1.9%	11.1%	1.1%	0.8%	0.9%
NL. VEG.	0.2%	0.1%	0.2%	0.2%	0.2%
R. VEG.	2.8%	1.1%	2.9%	3.0%	3.0%

MILK

SR- 89	0.1%	0.0%	0.2%	0.0%	0.1%
SR- 90	0.2%	0.0%	1.0%	0.0%	0.0%
TE-132	0.1%	0.6%	0.0%	0.0%	0.0%
I -131	5.0%	57.7%	0.1%	0.1%	0.1%
I -133	0.0%	0.3%	0.0%	0.0%	0.0%
CS-134	10.2%	3.3%	10.6%	10.8%	11.0%
CS-136	0.1%	0.0%	0.1%	0.1%	0.1%
CS-137	4.0%	1.3%	4.2%	4.4%	4.2%

BEEF

TE-132	0.0%	0.1%	0.0%	0.0%	0.0%
CS-134	1.8%	0.6%	1.9%	2.0%	2.0%
CS-137	0.8%	0.3%	0.8%	0.9%	0.8%

PORK

CS-134	20.4%	6.5%	21.1%	21.6%	21.9%
CS-137	9.5%	3.1%	10.0%	10.5%	10.0%

GRAIN

SR- 90	0.2%	0.0%	0.9%	0.0%	0.0%
TE-127M	0.0%	0.0%	0.1%	0.0%	0.0%
CS-134	17.9%	5.7%	18.6%	19.0%	19.3%
CS-137	8.2%	2.7%	8.7%	9.2%	8.8%

POTATOES

CS-134	11.2%	3.6%	11.6%	11.9%	12.0%
CS-137	5.1%	1.7%	5.4%	5.7%	5.4%

L. VEG.

SR- 90	0.0%	0.0%	0.2%	0.0%	0.0%
TE-132	0.1%	1.3%	0.0%	0.0%	0.0%
I -131	0.8%	9.5%	0.0%	0.0%	0.0%
CS-134	0.5%	0.2%	0.5%	0.5%	0.6%
CS-137	0.2%	0.1%	0.2%	0.2%	0.2%

NL. VEG.

CS-134	0.1%	0.0%	0.1%	0.1%	0.1%
--------	------	------	------	------	------

R. VEG.

I -131	0.0%	0.2%	0.0%	0.0%	0.0%
CS-134	1.9%	0.6%	2.0%	2.1%	2.1%
CS-137	0.8%	0.3%	0.9%	0.9%	0.9%

```

BEGIN OF INTAKE AT T =          1  A *****
BEGIN OF INTAKE AT T =          2  A *
BEGIN OF INTAKE AT T =          5  A *
BEGIN OF INTAKE AT T =          10 A * more printout which is *
***** * left out here *
*   years 20, 30, 40 were not selected * *
***** *
BEGIN OF INTAKE AT T =          50 A *****
  
```

```

BEGIN OF INTAKE AT T =          70 A
-----
  
```

NUCLIDES	EFF.DOSE	THYROID	B.MARROW	LUNG	REMAINDR
SR- 90	16.3%	0.7%	49.6%	0.7%	0.9%
CS-137	83.7%	99.3%	50.4%	99.3%	99.1%
VALUE	2.86E-03	2.26E-03	4.66E-03	2.28E-03	2.46E-03
VAL/REFVAL	5.39E-03	1.50E-03	9.47E-03	5.04E-03	4.83E-03
MILK	32.4%	38.1%	20.2%	38.1%	38.0%
BEEF	5.8%	6.9%	3.5%	6.9%	6.9%
PORK	17.6%	20.9%	10.7%	20.9%	20.8%
GRAIN	17.7%	13.2%	27.4%	13.2%	13.3%
POTATOES	12.1%	11.5%	13.2%	11.5%	11.5%
L. VEG.	4.2%	2.8%	7.3%	2.8%	2.8%
NL. VEG.	6.3%	4.1%	11.0%	4.1%	4.2%
R. VEG.	3.8%	2.5%	6.6%	2.5%	2.5%

MILK

```

-----
SR- 90      0.3%      0.0%      0.9%      0.0%      0.0%
CS-137     32.1%     38.1%     19.3%     38.1%     38.0%
  
```

BEEF

```

-----
CS-137      5.8%      6.9%      3.5%      6.9%      6.9%
  
```

```

*****
*
*
*
*
* More printout which is left out here for: pork, grain products, *
*                                           potatoes, leafy veg., *
*                                           non-leafy vegetables *
*
*
*
*****
  
```

R. VEG.

```

-----
SR- 90      1.8%      0.1%      5.4%      0.1%      0.1%
CS-137      2.0%      2.4%      1.2%      2.4%      2.4%
  
```

=====
MODULE MBANS MODULE MBANS MODULE MBANS MODULE MBANS MODULE MBANS
=====

* Information about the input data file(s) *
* ----- *
* First comes the file header, then a list of the relevant parameters.*
* This information is read from the data file(s). *
* *
* The printout of information about the data file for the specific *
* activities in the foodstuffs is omitted here. *

CRFDORI1 FROM 9. 3.88 * DCFS FOR IG * INTEGR. TO 70A - AGE *
GSF-DATA DEZ. 86

ORGANS: BREAST B. SURF. LUNG B.MARROW THYROID
REMAINDR STOMACH LLI WALL LIVER PANCREAS
EFF.DOSE GONADS ADRENALS BLADWALL BRAIN
SI+CONT. ULI WALL KIDNEYS SKIN SPLEEN
THYMUS UTERUS

AGES: 0 A 1 A 5 A 10 A 15 A
20 A

* Information about runtime options / bantimes from model *

FOODSTUFF: MILK BEEF PORK GRAIN
BAN GROUP: WRKB.ER. WRKB.ER. WRKB.ER. WRKB.ER.
CONS. RATE (KG/A): 1.15E+02 2.00E+01 5.00E+01 9.50E+01
CONSUMER AGE: 20 A 20 A 20 A 20 A

FOODSTUFF: POTATOES L. VEG. NL. VEG. R. VEG.
BAN GROUP: WRKB.ER. WRKB.ER. WRKB.ER. WRKB.ER.
CONS. RATE (KG/A): 7.00E+01 2.00E+01 2.50E+01 1.50E+01
CONSUMER AGE: 20 A 20 A 20 A 20 A

BANTIMES: 0 A 1 A 2 A 5 A 10 A
20 A 30 A 40 A 50 A 70 A

INTERVENTION LEVELS FOR IMPOSEMENT OF FOODBANS: *****
* *
EFF.DOSE THYROID * The ILS *
WRKB.ER. 5.00E-03 5.00E-02 * are printed out *
* for each *

INTERVENTION LEVELS FOR WITHDRAWAL OF FOODBANS: * foodgroup *
* (here: only one) *
* *
EFF.DOSE THYROID *
WRKB.ER. 5.00E-04 9.90E+09 *****

BANFLAG FILE HEADER:

EXAMPLE RUN**UFOINGFL**SOME RELEASE CATEGORY**ECOSYS DATA FROM JULY **

 * Statistical quantities of the CCFDs *
 * of the areas and distances affected by foodbans *
 * ----- *
 * A -1.00 indicates, that no value corresponding to the percentile *
 * was found in the range (LOW EDGE, HIGH EDGE) of the CCFDs. *

RELEASE CATEGORY: LWR-XMPL FOODGROUP: WRKB.ER.

LOW EDGE / *HIGH EDGE* OF CCFDS: 1.00E-01 1.00E+06

AREAS AFFECTED BY AGRICULTURAL COUNTERMEASURES (KM**2)

DURATION OF FOODBANS IS GT.	0 A	1 A	*****
MINIMUM VALUE	1.10E+04	1.35E+02	* *
EXPECTATION VALUE	2.13E+05	8.27E+03	* *
MAXIMUM VALUE	1.07E+06	5.62E+04	* more *
FREQ. FOR VAL. EQ. 0	0.00E+00	0.00E+00	* *
FREQ. FOR VAL. LT. *LOW*	0.00E+00	0.00E+00	* printout *
FREQ. FOR VAL. FROM 0 TO *HIGH*	1.00E+00	1.00E+00	* *
FROM= 1.00E-01 TO = 1.00E+02	0.00E+00	0.00E+00	* which is *
FROM= 1.00E+02 TO = 1.00E+06	9.93E-01	1.00E+00	* *
10. PERCENTILE	4.01E+04	3.23E+02	* omitted *
20. PERCENTILE	6.80E+04	6.45E+02	* *
40. PERCENTILE	1.32E+05	2.80E+03	* here *
50. PERCENTILE	1.62E+05	4.51E+03	* *
60. PERCENTILE	1.98E+05	6.56E+03	* *
70. PERCENTILE	2.43E+05	8.51E+03	* *
80. PERCENTILE	3.26E+05	1.24E+04	* *
90. PERCENTILE	4.67E+05	1.98E+04	* *
95. PERCENTILE	6.22E+05	2.83E+04	* *
99. PERCENTILE	8.36E+05	5.54E+04	*****

DURATION OF FOODBANS IS GT.	*****	50 A	70 A
MINIMUM VALUE	* *	0.00E+00	0.00E+00
EXPECTATION VALUE	* *	3.74E+02	1.70E+02
MAXIMUM VALUE	* *	9.91E+03	5.36E+03
FREQ. FOR VAL. EQ. 0	* more *	1.25E-01	3.06E-01
FREQ. FOR VAL. LT. *LOW*	* *	1.25E-01	3.06E-01
FREQ. FOR VAL. FROM 0 TO *HIGH*	* printout *	1.00E+00	1.00E+00
FROM= 1.00E-01 TO = 1.00E+02	* *	3.96E-01	3.54E-01
FROM= 1.00E+02 TO = 1.00E+06	* which is *	4.79E-01	3.40E-01
10. PERCENTILE	* *	-1.00E+00	-1.00E+00
20. PERCENTILE	* omitted *	2.22E+01	-1.00E+00
40. PERCENTILE	* *	5.54E+01	2.22E+01
50. PERCENTILE	* here *	9.14E+01	3.32E+01
60. PERCENTILE	* *	1.91E+02	6.39E+01
70. PERCENTILE	* *	2.98E+02	1.42E+01
80. PERCENTILE	* *	5.11E+02	2.88E+02
90. PERCENTILE	* *	7.71E+02	4.19E+02
95. PERCENTILE	* *	1.06E+02	4.84E+02
99. PERCENTILE	*****	3.83E+03	1.94E+03

RELEASE CATEGORY: LWR-XMLP FOODGROUP: WRKB.ER.

LOW EDGE / *HIGH EDGE* OF CCFDS: 1.00E-01 1.00E+04

MAXIMUM DISTANCE OF AGRICULTURAL COUNTERMEASURES (KM)

DURATION OF FOODBANS IS GT.	0 A	1 A	*****
MINIMUM VALUE	3.50E+02	2.50E+01	* *
EXPECTATION VALUE	1.27E+03	3.07E+02	* *
MAXIMUM VALUE	1.95E+03	1.65E+03	* more *
FREQ. FOR VAL. EQ. 0	0.00E+00	0.00E+00	* *
FREQ. FOR VAL. LT. *LOW*	0.00E+00	0.00E+00	* printout *
FREQ. FOR VAL. FROM 0 TO *HIGH*	1.00E+00	1.00E+00	* *
FROM= 1.00E-01 TO = 5.00E+02	5.56E-02	7.85E-01	* which is *
FROM= 5.00E+02 TO = 1.00E+04	9.44E-01	2.15E-02	* *
10. PERCENTILE	6.51E+02	5.52E+01	* omitted *
20. PERCENTILE	9.50E+02	7.55E+01	* *
40. PERCENTILE	1.25E+03	1.38E+02	* here *
50. PERCENTILE	1.35E+03	2.51E+02	* *
60. PERCENTILE	1.46E+03	2.51E+02	* *
70. PERCENTILE	1.55E+03	3.50E+02	* *
80. PERCENTILE	1.66E+03	5.52E+02	* *
90. PERCENTILE	1.76E+03	6.51E+02	* *
95. PERCENTILE	1.76E+03	8.52E+02	* *
99. PERCENTILE	1.86E+03	1.46E+03	*****

DURATION OF FOODBANS IS GT.	*****	50 A	70 A
MINIMUM VALUE	* *	0.00E+00	0.00E+00
EXPECTATION VALUE	* *	4.96E+01	3.14E+01
MAXIMUM VALUE	* more *	3.50E+02	2.50E+02
FREQ. FOR (VAL. EQ. 0)	* *	1.25E-01	3.06E-01
FREQ. FOR (VAL. LT. *LOW*)	* printout *	1.25E-01	3.06E-01
FREQ. FOR (VAL. FROM 0 TO *HIGH*)*	* *	1.00E+00	1.00E+00
FROM= 1.00E-01 TO = 5.00E+02	* which is *	8.75E-01	6.94E-01
FROM= 5.00E+02 TO = 1.00E+04	* *	0.00E+00	0.00E+00
10. PERCENTILE	* omitted *	-1.00E+00	-1.00E+00
20. PERCENTILE	* *	1.51E+01	-1.00E+00
40. PERCENTILE	* here *	1.51E+01	1.51E+01
50. PERCENTILE	* *	2.51E+01	1.51E+01
60. PERCENTILE	* *	4.52E+01	2.51E+01
70. PERCENTILE	* *	6.51E+01	3.50E+01
80. PERCENTILE	* *	7.55E+01	4.52E+01
90. PERCENTILE	* *	1.13E+02	7.55E+01
95. PERCENTILE	* *	1.88E+02	1.38E+02
99. PERCENTILE	*****	2.51E+02	1.88E+02

=====
MODULE MCOLL MODULE MCOLL MODULE MCOLL MODULE MCOLL
=====

* Information about the input data file(s) *
* ----- *
* First comes the file header, then a list of the relevant parameters.*
* This information is read from the data file (s). *

CRFDORI2 FROM 10. 3.88*ACTIVITY DOSE FACTORS IG*JULY*GSF-DATA DEZ.86

FOODSTUFFS: MILK BEEF PORK GRAIN POTATOES
L. VEG. NL. VEG. R. VEG.
BANTIMES: 0 A 1 A 2 A 5 A 10 A
20 A 30 A 40 A 50 A 70 A
ORGANS: BREAST B. SURF. LUNG B.MARROW THYROID
REMAINDR STOMACH LLI WALL LIVER PANCREAS
EFF.DOSE GONADS ADRENALS BLADWALL BRAIN
SI+CONT. ULI WALL KIDNEYS SKIN SPLEEN
THYMUS UTERUS
AGES: 0 A 1 A 5 A 10 A 15 A
20 A

*
* A similar output for the activity-risk-coefficients would appear *
* here in a risk run - in a dose run, no ARCs are required. *
*

* Information about the runtime options *

RESULTS TO BE CALCULATED: COLLECTIVE DOSE
RESULTS HAVE BEEN CALCULATED: WITH FOODBANS
CONTRIBUTION OF NUKS/FOOD: NONE
MAX. DISTANCE FOR CALCULATIONS: 2300 KM
ORGANS / HEALTH EFFECTS: EFF.DOSE THYROID

* Possibly, here a message "result divided by two for ..." will ap- *
* pear. See Chapter A.1 (module MCOLL) for the reason. *

DATA USED FOR APPROACHES 1 AND 2:

AGE GROUP: 0 A 1 A 5 A 10 A 15 A 20 A
FRACTION OF POPULATION: 0.01 0.04 0.06 0.08 0.08 0.73

BANFLAG FILE HEADER:

EXAMPLE RUN**UFOINGFL**SOME RELEASE CATEGORY**ECOSYS DATA FROM JULY**

*
* Expectation values of *
* the numbers of health effects or of collective doses *
* for the living generations *
*
* ----- *
*
* In a run without foodbans, the item "saved" is zero and the results *
* equal the item "sums". In a run with foodbans, the "sum" equals the *
* results without foodbans. *
*

RESULTS ARE CALCULATED VIA INTAKE (LOCAL PRODUCTION AND CONSUMPTION
ASSUMED)

APPROACH A1: COLL. DOSE (AGE DEPENDENT)
APPROACH A2: COLL. DOSE (ADULTS)

EXPECTATION VALUE OF COLLECTIVE DOSES (LG) FOR EFF. DOSE

SITE		EXAMPLE
DOSES/NO. OF EFF.	A1	2.13E+05
AVERTED BY BANS	A1	6.11E+06
SUM	A1	6.32E+06
DOSES/NO. OF EFF.	A2	2.10E+05
AVERTED BY BANS	A2	5.99E+06
SUM	A2	6.20E+06

EXPECTATION VALUE OF COLLECTIVE DOSES (LG) FOR THYROID

SITE		EXAMPLE
DOSES/NO. OF EFF.	A1	9.97E+05
AVERTED BY BANS	A1	3.73E+07
SUM	A1	3.82E+07
DOSES/NO. OF EFF.	A2	6.08E+05
AVERTED BY BANS	A2	2.22E+07
SUM	A2	2.27E+07

Appendix: The UFOING-preprocessor for the UFOMOD data file of activity concentrations

The time-integrated activity concentrations data file produced by the subroutine CONCEN of UFOMOD contains both air- and ground concentrations and the loop over the release phases. The air concentrations are of no relevance at all for UFOING, and the loop over the release phases is not needed.

Although it is not compelling to remove the phase loop, experience has shown that keeping it in UFOING considerably increases the CPU-time. Removing both the phase-loop and the air concentrations has the additional advantage that the resulting data set is much smaller than the original one.

Therefore, the UFOMOD output is processed with the UFOING-preprocessor program CRCONC. Besides for ignoring the air-concentrations on output, this program performs two tasks:

- It calculates the sum of the activity concentrations over the release phases for each grid element.
- It produces a flag array JDUSED which tells for each grid element, whether the activity concentration is zero or not (JDUSED = 0 or 1, respectively).

The job control for this "special run" of UFOING and the source code of CRCONC are shown on the following pages (the reason for separating the compilation of CRCONC from the rest is that compiler printout was wanted only for CRCONC).

The job shown here is the one with which the ground concentrations file used in the example run in Chapter B, CONCEN.FK25FL, was created on the IBM 3090-200/Siemens 7890-M computers at KfK.

The source code of CRCONC is independent of the subsystems /FL and /NL, but the INCLUDE-members CDEUFO and CDEUFR (near top of source listing) are not. In the example, all source code which depends on the UFOMOD subsystem (here: /FL) is contained in the data set UFOINGFL.FORT, the independent code in the data set UFOINGNF.FORT (besides for CRCONC, which is instream).

CRCONC is added to the UFOING system by replacing the subroutine RUNSPC, which is dummy in production runs, by the corresponding source code, but keeping the name "RUNSPC" for the (entrance) program unit. This is done so to enable the inclusion of any preprocessor into the system without having to add or change a CALL-statement in the main program of UFOING.

The load module is created here from the following pieces of UFOING-code:

- The subroutine RUNSPC, which contains the CRCONC code (instream)
- A "skeleton" of the UFOING source code, which contains only the program units MAIN, BLKNF, PRMAIN, ERRBOX, UCOPY, UZERO and YDTIME


```

SUBROUTINE RUNSPC
INCLUDE (PARING)
C-
PARAMETER(MAXUZ1=      MAXGRI*MAXDIS)
PARAMETER(MAXUZ2=MAXUFO*MAXGRI*MAXDIS)
C-
INCLUDE (CDEING)
INCLUDE (CDEUFO)
INCLUDE (CDEUFR)
C-----C
C   LOCAL                                     C
C-----C
      DIMENSION  SURCON(MAXUFO,MAXGRI,MAXDIS)
      DIMENSION  UFOAIR(MAXUFO),UFOGND(MAXUFO)
C-----C
C-                                     CHANGE DEFAULT OF INUFOC IN UFOING
      INUFOC=22
C-----C
C   LOOPINGS FOR UFOMOD                                     C
C-----C
C-BEG-----WEATHER SEQUENCES
      DO 5000 IWEA=1,LMAX
      CALL UZERO(JDUSED,MAXUZ1)
      CALL UZERO(SURCON,MAXUZ2)
C-BEG-----RAD.DISTANCES
      DO 4000 IDIS=1,IMAX
      READ(INUFOC) DUM,((JUSED(I,J),I=1,NPHASE),J=1,JMAX)
C-BEG-----GRIDSGRIDS
      DO 3000 IGRI=1,JMAX
C-BEG-----PHASES
C-                                     CREATION OF TOTAL DEPOSITED ACTIVITY CONCENTRATION
C-                                     AND OF FLAG JDUSED
      DO 2000 IPHA=1,NPHASE
C-
      IF(JUSED(IPHA,IGRI).EQ.0) GO TO 2000
C-
      JDUSED(IGRI, IDIS)=1
      READ(INUFOC) DUM,(UFOGND(INU),UFOAIR(INU),INU=1,NUKRED)
C-
      DO 2010 INU=1,NUKRED
      SURCON(INU,IGRI, IDIS)=SURCON(INU,IGRI, IDIS)+UFOGND(INU)
      2010 CONTINUE
C-END-----PHASES
      2000 CONTINUE
C-END-----GRIDSGRIDS
      3000 CONTINUE
C-END-----RAD.DISTANCES
      4000 CONTINUE
      WRITE(IOTMP1) ((JDUSED(IGRI, IDIS),IGRI=1,JMAX), IDIS=1,IMAX)
      DO 5010 IDIS=1,IMAX
      DO 5010 IGRI=1,JMAX
      IF(JDUSED(IGRI, IDIS).NE.0)
      & WRITE(IOTMP1) (SURCON(INU,IGRI, IDIS), INU=1,NUKRED)
      5010 CONTINUE
C-END-----WEATHER SEQUENCES
      5000 CONTINUE
C-
      RETURN
      END
```

```
/** ----- */
/**          COMPILE - LINK - GO          */
/** ----- */
//STEP3 EXEC FVCLG,
//          PARM.C=NOSOURCE
//C.SYSPRINT DD DUMMY,SYSOUT=
//C.SYSLIB   DD DSN=INR065.UFOINGNF.FORT,DISP=SHR
//          DD DSN=INR065.UFOINGFL.FORT,DISP=SHR
//          DD DSN=INR188.UFOBZZ.FORT,DISP=SHR,LABEL=(1,,IN)
//C.SYSIN    DD DSN=INR065.UFOINGNF.FORT(SKELET),DISP=SHR
//          DD DSN=INR065.UFOINGNF.FORT(DPROD),DISP=SHR
//          DD DSN=INR065.UFOINGFL.FORT(BLCKFL),DISP=SHR
//          DD DSN=INR188.UFOBZZ.FORT(TEILO),DISP=SHR,LABEL=(1,,IN)
/** ----- */
/** LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT  LPT */
/** ----- */
//G.FT06F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=133,RECFM=FA,BUFNO=1)
//G.FT60F001 DD SYSOUT=*,
//          DCB=(LRECL=133,BLKSIZE=133,RECFM=FA,BUFNO=1)
/** ----- */
/**          Data sets required by UFOTEILO          */
/** ----- */
/**          The data set UFOINGNF.NAML(FLFK25KA) contains the user */
/**          input to UFOTEILO of the example shown in Chapter B.1. */
/** ----- */
//G.SYSIN    DD DSN=INR065.UFOINGNF.NAML(FLFK25KA),DISP=SHR,
//          LABEL=(1,,IN)
//G.FT08F001 DD DISP=SHR,DSN=INR188.UNFDATA.FK25ZZ,LABEL=(,,IN)
//G.FT20F001 DD UNIT=SYSDA,DCB=DCB.VBS
//G.FT22F001 DD UNIT=T6250,VOL=SER=DV3526,DSN=CONCEN.FLFK25KA,
//          DCB=(RECFM=VBS,BLKSIZE=30000,DEN=4),DISP=(,PASS),LABEL=1
//G.FT40F001 DD DISP=SHR,DSN=INR482.HEADER.DATA,LABEL=(,,IN)
//G.FT61F001 DD DUMMY
/** ----- */
/**          Title cards and NAMELIST - input for UFOING          */
/** ----- */
//G.FT50F001 DD *
+INGSPCL
/** ----- */
/** UFOING          *RUNSPC*          *RUNSPC*          *RUNSPC*          UFOING */
/** ----- */
//G.FT81F001 DD DSN=INR065.CONCEN.FLFK25KA,DISP=SHR,LABEL=(1,,OUT)
/** ----- */
```

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Part III
Program guide

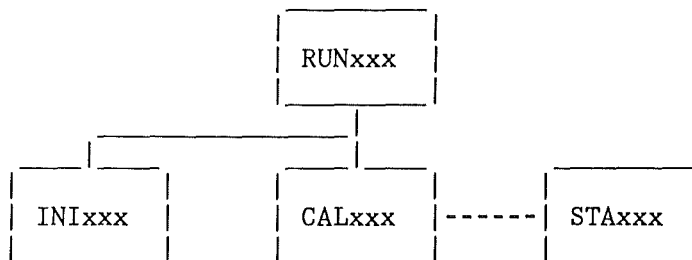
A. Modules and program units

A.1 Program units and their naming and calling conventions

The current tree structure of UFOING is shown in Fig. III.1, a brief description of the tasks of the program units is given in Tab. III.1 on page 66. The subroutines, which are characterized by a module's name or an abbreviation of it, namely ..MAIN, ...COP, ...BAN, ...IND, ...RSK, ...COL, ...SPC, belong uniquely to the corresponding module and must not be called outside the module. All other subroutines perform auxiliary functions such as copying arrays (UCOPY), issuing error messages (ERRBOX), or calculating CCFDs (XCCFDA) etc., and can be called by any program unit of UFOING.

The internal structure of each production module is shown in the figure below; xxx stands symbolically for the reference to the module's name.

Fig. III.2: Internal structure of the production modules



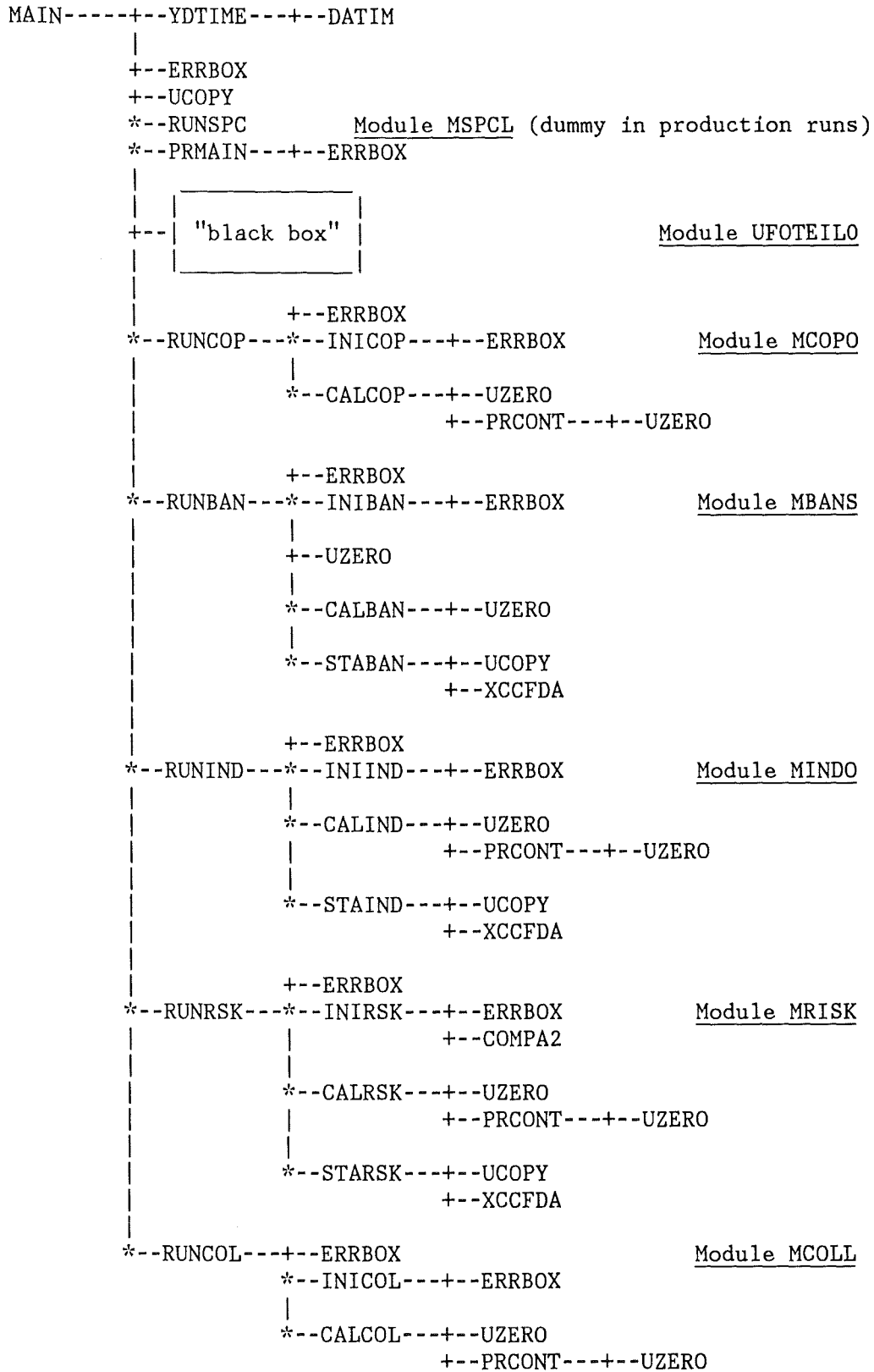
The entry subroutines of each module, RUNXXX, are called by the main program. They read and process the runtime options for the module and call the data initialization and (entry) calculation subroutines, INIxxx and CALxxx, respectively.

The initialization subroutines read the data files for constants and set up arrays containing the foodchain transport model-, dose- or risk data etc..

The calculation of results is performed in the subroutines CALxxx, which may call subsidiary subroutines, such as STAxix, which set up arrays required for the calculation of statistical quantities of the CCFDs with the auxiliary subroutine XCCFDA.

The rule, that no module subroutine is allowed to be called outside the module implies, that there can be identical subroutines with different names in the code (e.g. for INIxxx). This method has the advantage, that modules can be exchanged completely independent of each other; the increase in the size of the load module is negligible in comparison to the total size.

Fig. III.1:
Program units of UFOING/JU88 (FORTRAN77 intrinsic functions omitted)



Tab. III.1: Tasks performed by the program units (without UFOTEILO)

BLCKNF - BLOCK DATA for UFOING (independent of UFOMOD - subsystem)
BLCKNL - BLOCK DATA for UFOING (UFOMOD/NL distances -> Chapter E.1)
BLCKFL - BLOCK DATA for UFOING (UFOMOD/FL distances -> Chapter E.1)

CALBAN - Calculations for MBANS
CALCOL - Calculations for MCOLL
CALCOP - Calculations for MCOPO
CALIND - Calculations for MINDO
CALRSK - Calculations for MRISK
COMPA2 - Compare two character strings but ignore specified character

DATIM - Gives date and time - see YDTIME

ERRBOX - Central error message / error stop subroutine

INIBAN - Initialization of data for module MBANS
INICOL - Initialization of data for module MCOLL
INICOP - Initialization of data for module MCOPO
INIIND - Initialization of data for module MINDO
INIRSK - Initialization of data for module MRISK

MAIN - Main program

RUNBAN - Setup- and entry subroutine for MBANS
RUNCOL - Setup- and entry subroutine for MCOLL
RUNCOP - Setup- and entry subroutine for MCOPO
RUNIND - Setup- and entry subroutine for MINDO
RUNRSK - Setup- and entry subroutine for MRISK
RUNSPC - entry subroutine for MSPCL; dummy in production runs to avoid an unsatisfied external reference (for more information, see Part II, Appendix).

STABAN - Setup for evaluation of CCFDs for MBANS
STACOL - Setup for evaluation of CCFDs for MCOLL
STARSK - Setup for evaluation of CCFDs for MRISK

PRCONT - Print percentage contributions (Here: of nuclides/foodstuffs)
PRMAIN - Print general information about current run for MAIN

UCOPY - Copy an array or parts of it into another array
UZERO - Set an array or parts of it to zero

XCCFDA - Construction of multiple CCFDs; print statistical quantities

YDTIME - Print date and time; calls DATIM (IBM VS-compiler).
A compiler independent dummy version of YDTIME is available.

A.2 Rules for the implementation of a new production module

(1) Make sure that the new module complies with the UFOING naming and coding conventions for the subroutines, the common blocks and the I/O-units (Chapters A.1, B.1, and D.1).

If the new module replaces an existing one:

(2) Make sure that the RUNxxx-subroutine of the new module has the same name as the old one.

If the new module is to be added to the existing ones:

(3a) Make sure that the RUNxxx-subroutine of the new module does not have the same name as any of the existing ones.

(3b) Insert a CALL RUNxxx statement in the main program (just before the STOP statement).

(3c) Insert in the main program a corresponding run option in NAMELIST/JMAIN1/; add a comment in the section describing the run options.

Always:

(4a) Add a comment describing the length of the blank common block in the corresponding comment section of the main program.

(4b) Check the length of the blank common. If it exceeds the current maximum length, set the length of the blank common block in the main program to the new maximum length.

(4c) If the number of logical I/O - units has changed, modify COMMON/IGUNIT/ and the comment section of the main program which describes the I/O-units correspondingly.

If the data set containing the UFOING source code is sequential, an old existing module must be replaced by the new version; a new module must be added to the existing ones.

If the data set containing the source code is partitioned and the members correspond to the production modules, the new module can be included as a member of its own. This has the advantage that different versions of the same production module can be kept in the data set, and the selection of the appropriate one can be steered with the job control at runtime.

B. Common blocks and include members

B.1 Common block categories and naming conventions

UFOING uses several named common blocks to share information between program units, and a blank common block to provide a bulk storage area on which program units may work independently. This bulk area reduces the program size considerably, because all the rather large data arrays, which need to be accessed only within one module, can occupy the same storage space. The reason for choosing a blank common block is, that it may be of different length in each program unit and can therefore be employed without being bothered with length adjustment considerations.

According to it's use in the program, each common block can be attributed to one of the following categories:

A: UFOING global common blocks

The named common blocks of this category are used to provide data required by all modules with the exception of UFOTEILO. The names of such common blocks all start with the prefix "IG" followed by four characters which must not refer to any of the module names.

B: UFOING module common blocks

These named common blocks are used to pass information between module subroutines (e.g. frequently used data, relatively small arrays; large arrays should be kept in the blank common block). The names of the common blocks are characterized by the prefix "IG" followed by the module names.

C: UFOING garbage common blocks

These common blocks provide storage which can be used concurrently by program units. The management of the use of this storage space must be done by the programmer. The maximum size of the area is defined in the main program. (Blank common and common CMUELL for character variables).

D: UFOING special common blocks

These named common blocks provide storage shared between some module subroutines, or between some of the module subroutines and auxiliary subroutines. Their names all begin with the character "A" followed by an abbreviation of the name of the subroutine, for which the information contained in the common block is set up for.

E and F: UFOTEILO common blocks:

The commons of UFOTEILO as a part of the UFOMOD program system are, as a whole, treated as a "black box" with respect to UFOING (E). A subset of these common blocks contains information also needed by UFOING (F). More details about the common blocks of category F

are given in Chapters B.2 and E.1.

B.2 Include members

Some frequently used groups of common blocks and constants are referred to by INCLUDE statements in the source code to facilitate program maintenance.

The common blocks of category A are contained in the include member CDEING. The dimensions of arrays from CDEING and of some other frequently used arrays are defined with parameter constants, which are collected in the include member PARING. Their current default values are shown below:

Tab. III.2: Dimension constants contained in PARING/JU88

PARAMETER (MAXAGE= 6,MAXBAN= 10)	* ages and bantimes	*
PARAMETER (MAXDIS= 35,MAXTIS= MAXDIS+1)	* UFOMOD distances	*
PARAMETER (MAXFOO= 8)	* foodstuffs	*
PARAMETER (MAXGRI= 72)	* UFOMOD grids	*
PARAMETER (MAXIML= 35,MAXING= 30)	* ingestion nuclides	*
PARAMETER (MAXORK= 22,MAXORG= 12)	* organs	*
PARAMETER (MAXOBS= 10)	* observation times for ARCs	*
PARAMETER (MAXSIT= 5)	* UFOMOD sites	*
PARAMETER (MAXUFO= 60)	* UFOMOD nuclides	*

The common blocks of category E and dimension constants for arrays in the common blocks are kept in include members of the UFOMOD program system; they depend on the UFOMOD version.

The common blocks of UFOMOD, which are of relevance for UFOING, i.e. the category F common blocks, are distributed over the include members CDEUFO, CDEUFL, CDEUFN, CDEUFR and CDEUFS of UFOING; they also depend on the UFOMOD version. The individual members contain single common blocks or groups of common blocks frequently used together in the program units of UFOING.

More details about include members with respect to the different versions of UFOMOD are given in Chapter E.1.

For a transfer of the source code to other institutions, the include statements can be replaced by the corresponding code of the include members, if neccessary.

C. Ingestion related data

C.1 Input data and data arrays

UFOING needs information about the activity per unit mass and initial deposit in the consumed foodstuffs as a function of time and about the radiation exposure and risk as a function of age and time. This information is read by the program from data sets.

The basic idea when designing the data sets was, that it should be possible to use data from different foodchain transport-, dose- or risk models without having to modify the source code. Besides for their numeric values, data from different models may differ by one or the other of the following parameters:

Number and meaning of nuclides
Number and meaning of foodstuffs
Number and meaning of bantimes
Number and meaning of organs
Number and meaning of ages

To cope with such differences, each data file was to let explain itself by specifying before the actual data and after a file header the numbers and meanings of the corresponding parameters. This leads to the following general structure of the ingestion - related data sets used by UFOING:

File header
Number of nuclides, foodstuffs, organs etc.
Names of nuclides, foodstuffs, organs etc.
Data

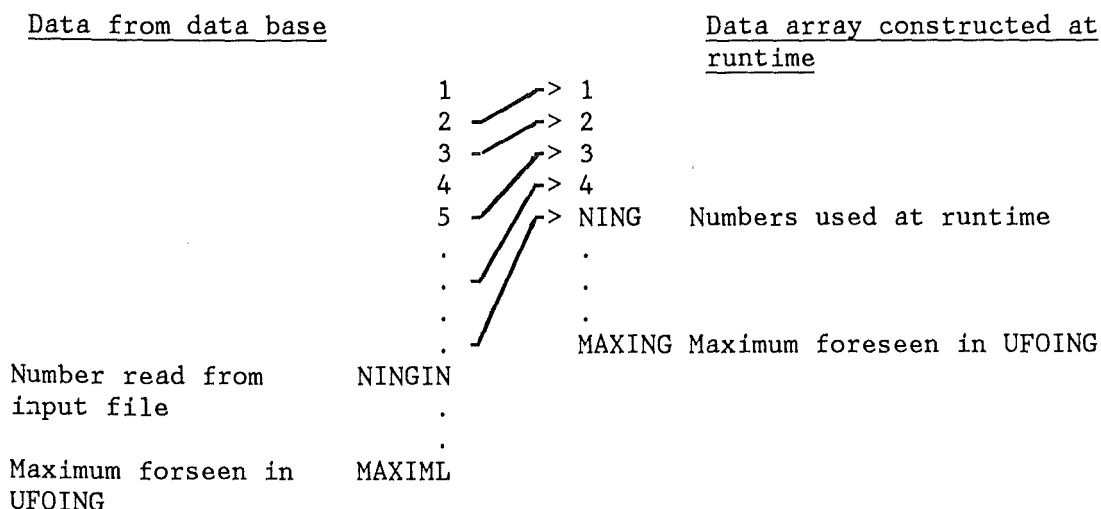
Because in each run of UFOING a different subset of radionuclides and/or organs from the input data may be considered, arrays are constructed at runtime, which contain, in compressed form, only those data actually required. This is illustrated in Fig. III.3 on the next two pages.

For the radionuclides, either the full intersection of all nuclides from the ingestion nuclide definition file with all those for which ground concentration data were calculated with UFOMOD is taken, or a subset of the full intersection defined by the user. The construction of the compressed array is rather complicated and will be explained in detail in Chapter E.2. Figure (a) shows only the front-end sides of the process to illustrate the different dimensions involved. For the ages, foodstuffs, bantimes, and also for the observation times of the activity-risk-coefficients, all data contained in the actual file are taken (b). The selection of organs (c) is entirely steered by the runtime option MYORGS (see Part II, Chapter A.1).

The maximum numbers of radionuclides, organs, foodstuffs etc. mentioned in Fig. III.3 are the numbers used for the dimensions of the primary data arrays and the compressed arrays; for their current default values, see Tab. III.2 in Chapter B.2.

Fig. III.3: Construction of ingestion data arrays at runtime

(a) Arrays which refer to nuclides (NUK)



(b) Arrays which refer to ages (AGE), bans (BAN), foodstuffs (FOO) and observation times (OBS)

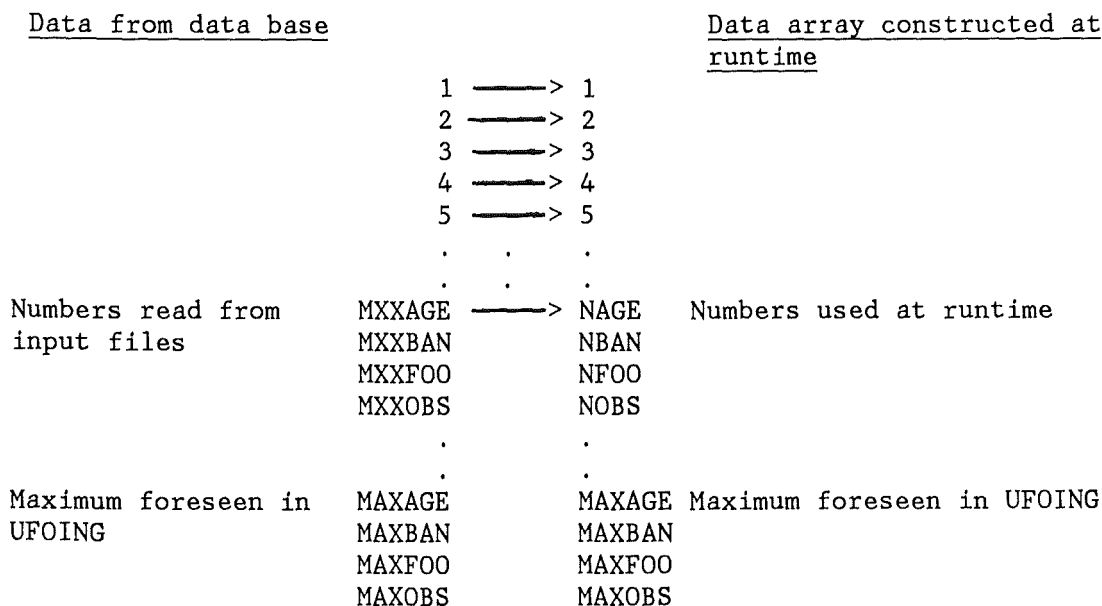
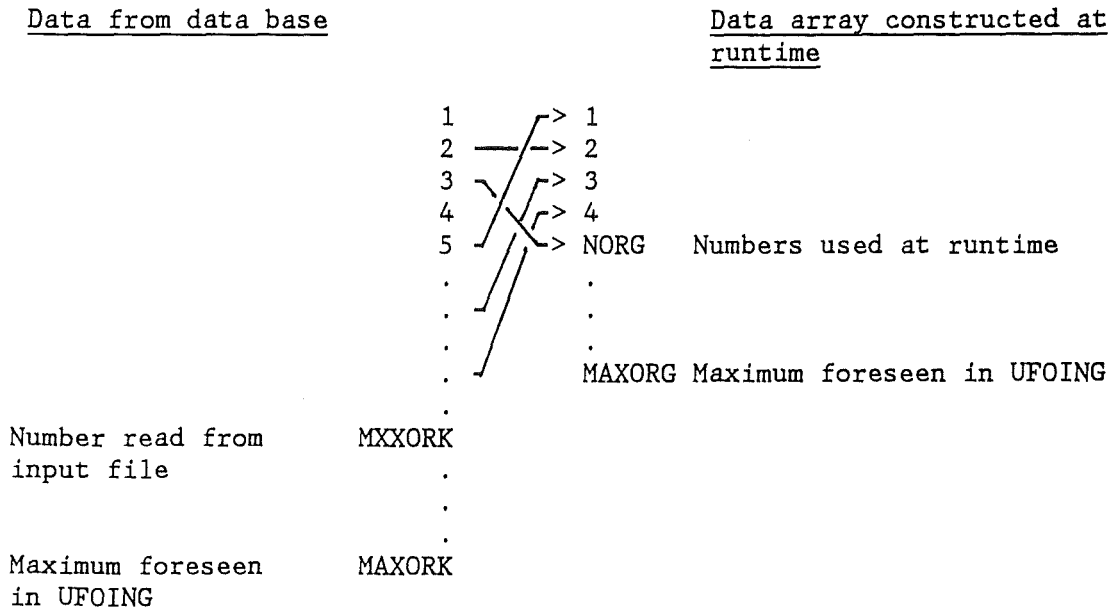


Fig. III.3: Construction of ingestion data arrays at runtime (cont'd)

(c) Arrays which refer to organs (ORG)



C.2 Structures of the ingestion data files

In the following, the structures of the ingestion data files are shown by means of the corresponding read statements.

The number of radionuclides contained in the ingestion nuclide definition file (NINGIN) and the number of foodstuffs (NFOO) and bantimes (NBAN) in the file of the specific activities in the foodstuffs are read by module MAIN. Any data set referring to these parameters must contain the same numbers, otherwise, an error message will be issued and the run aborted. Also, no parameter number is allowed to exceed the corresponding dimension constant.

The ingestion nuclides are connected to the logical unit INUKIG, the specific activities to unit INFCT. The other data sets may be connected to more than one logical unit ("IN...." below).

Ingestion nuclides definition file

```
CHARACTER*8 HEADER,MUKNAM
DIMENSION HEADER(10),MUKNAM(MAXIML)
DIMENSION MUKING(MAXIML),MUKUFC(MAXIML),MUKUFD(MAXIML)

READ (INUKIG) HEADER
```

```
READ (INUKIG) NINGIN
IF(NINGIN.GT.MAXIML) CALL ERRBOX(,,)
READ (INUKIG) (MUKNAM(INU),INU=1,NINGIN),
&             (MUKING(INU),INU=1,NINGIN),
&             (MUKUFC(INU),INU=1,NINGIN),
&             (MUKUFD(INU),INU=1,NINGIN),
```

Notes:

HEADER = File identification
NINGIN = Number of nuclides contained in the file
MUKNAM = Names of the nuclides
MUKING = Adresses of nuclides in basic UFOING array (Chapter E.2)
MUKUFC = Adresses of nuclides in basic UFOMOD array (Chapter E.2)
MUKUFD = Adresses of nuclides in basic UFOMOD array (Chapter E.2)

normalized specific activities in the foodstuffs

```
CHARACTER*8 BANNAM,FOONAM,HEADER,MODNAM,MONNAM
DIMENSION BANNAM(MAXBAN),FOONAM(MAXFOO),HEADER(10)
DIMENSION FCTDAT(MAXIML,MAXFOO,MAXBAN)
```

```
READ (INFCT) HEADER
READ (INFCT) MXXIML,NFOO,NBAN,NBYR1
IF(MXXIML.NE.NINGIN) CALL ERRBOX(,,)
IF(NFOO .GT.MAXFOO) CALL ERRBOX(,,)
IF(NBAN .GT.MAXBAN) CALL ERRBOX(,,)
READ (INFCT) MODNAM,MONNAM,
&         (FOONAM(IFO),IFO=1,NFOO),
&         (BANNAM(IBA),IBA=1,NBAN)
READ (INFCT) (((FCTDAT(INU,IFO,IBA),INU=1,NINGIN),IFO=1,NFOO),
&             IBA=1,NBAN)
```

Notes:

HEADER = File identification
MXXIML = Number of nuclides contained in the file
NBAN = Number of bantimes contained in the file
NBYR1 = Adress of year 1 in the banarray
NFOO = Number of foodstuffs contained in the file
BANNAM = Names of the bantimes
FOONAM = Names of the foodstuffs
MODNAM = Name of model
MONNAM = Name of month
FCTDAT = the data

Time integrated dose conversion factors

```
CHARACTER*8 HEADER,ORKNAM
DIMENSION HEADER(10),ORKNAM(MAXORK)
DIMENSION DCFDAT(MAXIML,MAXORK,MAXAGE)
```

```
READ (IN....) HEADER
READ (IN....) MXXIML,MXXORK,NAGE
IF(MXXIML.NE.NINGIN) CALL ERRBOX(,,)
IF(MXXORK.GT.MAXORK) CALL ERRBOX(,,)
IF(NAGE .GT.MAXAGE) CALL ERRBOX(,,)
```

```
READ (IN....) (ORKNAM(IOR),IOR=1,MXXORK),  
& (AGENAM(IAG),IAG=1,NAGE)  
READ (IN....) ((DCFDAT(INU,IOR,IAG),INU=1,NINGIN),  
& IOR=1,MXXORK),IAG=1,NAGE)
```

Notes:

HEADER = File identification
MXXIML = Number of nuclides contained in the file
MXXORK = Number of organs contained in file
NAGE = Number of age groups contained in the file
AGENAM = Names of the age groups
ORKNAM = Names of the organs
DCFDAT = the data

Activity-dose-coefficients

```
CHARACTER*8 AGENAM,BANNAM,FOONAM,HEADER,ORKNAM  
DIMENSION AGENAM(MAXAGE),BANNAM(MAXBAN),FOONAM(MAXFOO)  
DIMENSION HEADER(10),ORKNAM(MAXORK)  
DIMENSION BUFF(MAXIML)  
  
READ (IN....) HEADER  
READ (IN....) MXXIML,MXXORK,NAGE,MXXBAN,MXXFOO  
IF(NAGE .GT.MAXAGE) CALL ERRBOX(,,)  
IF(MXXIML.NE.NINGIN) CALL ERRBOX(,,)  
IF(MXXBAN.NE.NBAN ) CALL ERRBOX(,,)  
IF(MXXFOO.NE.NFOO ) CALL ERRBOX(,,)  
IF(MXXORK.GT.MAXORK) CALL ERRBOX(,,)  
READ (IN....) (FOONAM(IFO),IFO=1,NFOO),  
& (BANNAM(IBA),IBA=1,NBAN),  
& (AGENAM(IAG),IAG=1,NAGE),  
& (ORKNAM(IAG),IAG=1,MXXORK)  
DO #1 IOR=1,MXXORK  
DO #2 IAG=1,NAGE  
DO #3 IBA=1,NBAN  
DO #4 IFO=1,NFOO  
READ (IN....) (BUFF(INU),INU=1,NINGIN)  
#4 CONTINUE  
#3 CONTINUE  
#2 CONTINUE  
#1 CONTINUE
```

Notes:

HEADER = File identification
MXXBAN = Number of bantimes contained in the file
MXXFOO = Number of foodstuffs contained in the file
MXXIML = Number of nuclides contained in the file
MXXORK = Number of organs contained in the file
NAGE = Number of age groups contained in the file
AGENAM = Names of the age groups
BANNAM = Names of the bantimes
FOONAM = Names of the foodstuffs
ORKNAM = Names of the organs
BUFF = the data

Activity-risk-coefficients

```
CHARACTER*8 BANNAM,FOONAM,HEADER,OBSNAM,ORKNAM
DIMENSION BANNAM(MAXBAN),FOONAM(MAXFOO)
DIMENSION HEADER(10),OBSNAM(MAXOBS),ORKNAM(MAXORK)
DIMENSION BUFF(MAXOBS)
```

```
DO #1 IGEN=1,2 *** IGEN=1: LG / IGEN=2: FG ***
READ (IN....) HEADER
READ (IN....) MXXIML,MXXORK,MXXBAN,MXXFOO,NOBS
IF(MXXIML.NE.NINGIN) CALL ERRBOX(,,)
IF(MXXBAN.NE.NBAN ) CALL ERRBOX(,,)
IF(MXXFOO.NE.NFOO ) CALL ERRBOX(,,)
IF(MXXORK.GT.MAXORK) CALL ERRBOX(,,)
IF(NOBS .GT.MAXOBS) CALL ERRBOX(,,)
READ (IN....) (FOONAM(IFO),IFO=1,NFOO)
READ (IN....) (BANNAM(IBA),IBA=1,NBAN)
READ (IN....) (ORKNAM(IOR),IOR=1,MXXORK)
READ (IN....) (OBSNAM(IOB),IOB=1,NOBS)
DO #2 INU=1,NINGIN
DO #3 IOR=1,MXXORK
DO #4 IFO=1,NFOO
DO #5 IBA=1,NBAN
READ (IN....) (BUFF(IOB),IOB=1,NOBS)
#5 CONTINUE
#4 CONTINUE
#3 CONTINUE
#2 CONTINUE
#1 CONTINUE
```

Notes:

```
HEADER = File identification
MXXBAN = Number of bantimes contained in the file
MXXFOO = Number of foodstuffs contained in the file
MXXIML = Number of nuclides contained in the file
MXXORK = Number of organs contained in the file
NOBS   = Number of observation times contained in the file
BANNAM = Names of the bantimes
FOONAM = Names of the foodstuffs
OBSNAM = Names of the observation times
ORKNAM = Names of the organs
BUFF   = the data
```

C.3 Rules for the implementation of new ingestion data sets

(1) Make sure, that the data set complies with the corresponding file structure explained in the previous chapter.

Compare the maximum number for each parameter with the corresponding dimension constant in the include member PARING. If no number exceeds the dimension, proceed to (2), else to (3). In any case, for data sets containing activity-dose- and -risk-coefficients ("ADCs" or "ARCs", respectively), the rules (4) and (5) must be followed.

(2) Compare for each parameter (e.g. organs) their meanings (e.g. thyroid, lung etc.) with the defaults. If the new data set is a subset of the default one, i.e. some items are missing but the rest are the same,

or it contains the same items in a different order, it is recommended to use the default parameterization by reordering the data, and, eventually, inserting zeroes for the missing values, because it was found to be easier to memorize unused positions in a fixed array than parameter permutations when specifying runtime options for different data sets. - If, by some reason, this recommendation is not followed, or if the meanings of the parameters differ, nothing special has to be cared for if the data set does not contain ADCs or ARCs.

(3) Adjust the corresponding dimension constant to the new value to enable the user to work with any input data set without changes in the source code. After such a modification, the programmer should inspect the lengths of all common blocks (especially of the BLANK COMMON and COMMON/CMUELL/) for possible re-adjustments. Also, some WRITE statements might require modifications.

(4) The current model MCOLL uses both ADCs and ARCs as input. For this module, it is necessary that for any pair of ARC- and ADC-files used together, which contain, for instance, NARC health effects and NADC organs, respectively, the 1..NARC effects must match with the first 1..NARC=<NADC organs with the exception, that some of the positions in the ARCs file can be unused. However, in this case, the vacant positions must be filled with zeroes.

If this rule is not obeyed, the program will probably perform quite normal, but the results produced by module MCOLL when calculating the numbers of fatal cancers, can be correct or wrong, dependent on which of the health effects are selected with the runtime options.

(5) An additional convention holds for ARC files: Two data sets are required, one for the living (LG) and one for the following (FG) generations (Part I, Chapter B.4), which must contain data for the same 1 ... NOBS observation times. In general, however, the maximum observation time is about 90 a for LG, for FG it is greater. In such a case, the missing values for LG must be filled with the maximum value; this makes sense because the values represent cumulative numbers.

D. Input/output units and the corresponding data files
(without UFOTEILO)

D.1 Connection between logical I/O - units and program units

Fig. III.4 illustrates the cross references between the logical I/O-units and the program units of UFOING. The I/O-unit LPT (the line printer) is used in many program units; this unit is not included in the figure.

Some of the initialization subroutines may require the same input data, which could thus be addressed by only one logical unit number. However, it was decided to supply each INIxxx routine with an own unique reference number to facilitate the exchange of modules.

Since at runtime some of the data sets are attached to more than one unit, as it can be seen in Fig. III.4 and in Part II, Chapter B.1, a REWIND statement should be coded routinely for any unit (except LCR and LPT) before it's first reference in a module.

The reference numbers of the I/O units are coded by integer variables in all modules of UFOING with the exception of UFOTEILO. The variables are collected in the global common block COMMON/IGUNIT/, which is initialized in the BLOCK DATA unit BLCKNF. The default values for the reference numbers are shown in Tab. II.5 in Part II.

Fig. III.4: I/O units and program units

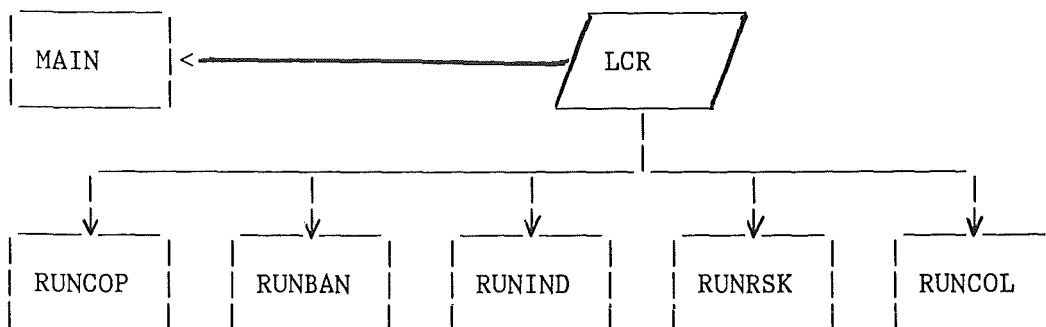


Fig. III.4: I/O units and program units (continuation)

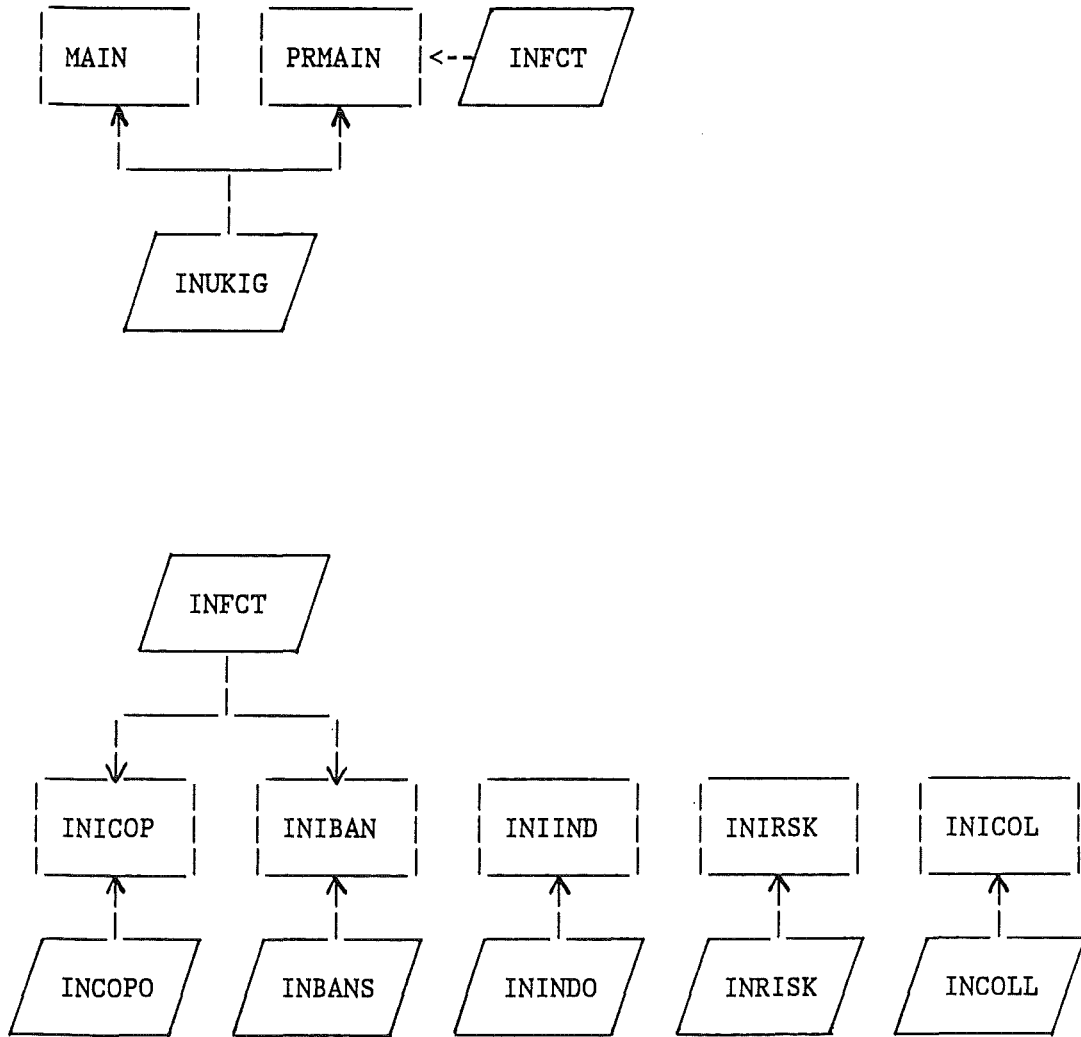
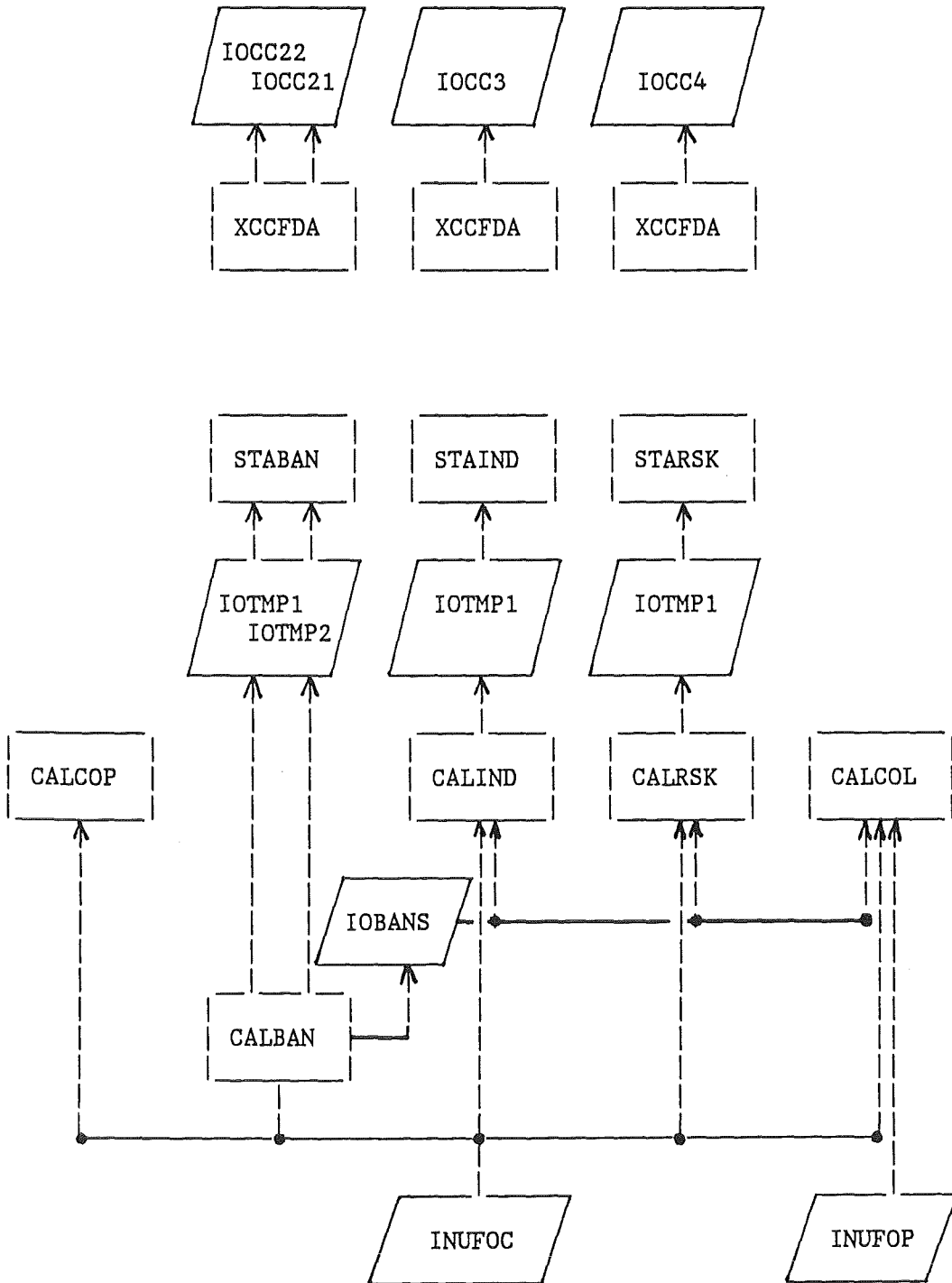


Fig. III.4: I/O units and program units (continuation)



D.2 Connection between logical I/O - units and data files

The contents of the files attached to the logical I/O units and the file structures are summarized below. Besides for LCR and LPT, all files contain unformatted data.

- LCR Runtime options for UFOING; the input format is described in Part II, Chapter A.1.
- LPT All printed output from UFOING (except UFOTEILO); maximum record length is 133.
- INUKIG Definition of the ingestion nuclides of UFOING.
Permanent file; input only.
For the file structure, see Chapter C.2.
- INFCT Data from the foodchain transport model.
Permanent file; input only.
For the file structure, see Chapter C.2.
- INCOPO Dose - conversion - factors for ingestion.
Permanent file; input only.
For the file structure, see Chapter C.2.
- INBANS Dose - conversion - factors for ingestion.
Permanent file; input only.
For the file structure, see Chapter C.2.
- ININDO Activity - dose - coefficients for ingestion.
Permanent file; input only.
For the file structure, see Chapter C.2.
- INCOLL Activity - dose - and - risk - coefficients for ingestion.
Permanent files; input only.
For the structure of the files, see Chapter C.2.
- INRISK Activity - risk - coefficients for ingestion.
Permanent files; input only.
For the file structure, see Chapter C.2.
- INUFOC Initial ground concentrations from UFOING preprocessor CRCONC.
Permanent file; input only.
For the file structure, see Chapter E.3.
- INUFOP Population data; file is created by UFOTEILO.
Temporary file; output in UFOTEILO; input elsewhere
For the file structure, see Chapter E.3.
- IOBANS Flag for duration of foodbans for other modules.
Temporary or permanent (see Part II, Chapter A.3)

File structure:

```
CHARACTER*8 HEADER(10)      * File identification *  
DIMENSION IGUSED(MAXFOO)
```

```
WRITE/READ (IOBANS) HEADER
DO #1 IWEA=1,LMAX *****
DO #2 IDIS=1,IMAX * UFOMOD loop structures; see F.3 *
DO #3 IGRI=1,JMAX *****
WRITE/READ (IOBANS) IGUSED * Duration of foodbans *
#3 CONTINUE
#2 CONTINUE
#1 CONTINUE

IOTMP1 Temporary data file _|_ file structure can be different in
IOTMP2 Temporary data file _|_ each module

IOCC## CCFDs for given distances
Temporary or permanent (e.g. for use in graphics programs).

IOCC21 Areas affected by foodbans
IOCC22 Distances of foodbans
IOCC03 Age dependent individual doses by ingestion
IOCC04 Time dependent individual risk by ingestion

IOCC##<0 suppresses the output of the CCFDs to a data file;
this does not affect the printout of the statistical
quantities of the CCFDs, which will always be given.

File structure:

PARAMETER (MAXCCF= 20,MAXSTP=1800)
DIMENSION CCFD(MAXSTP,MAXCCF),XCENTR(MAXSTP)

DO #1 I=1,NCCFD
READ (IOCC##) XCENTR
READ (IOCC##) (CCFD(J,I),J=1,MAXSTP)
#1 CONTINUE

NCCFD = number of CCFDs (1.LE.NCCFD.LE.MAXCCF), each of which
with identical array XCENTR
XCENTR = centres of the MAXSTP x - intervals
CCFD = y - values
```

E. The UFOMOD environment of UFOING

E.1 The UFOING source code with respect to UFOMOD

There exist three subsystems of UFOMOD for assessing the short term (/NE) and the long term accident consequences in the near range (/NL) and the far range (/FL), respectively. UFOING runs in connection with the two long term subsystems /NL and /FL. This leads to a principal division of the UFOING code into three parts, which is illustrated in Fig. III.5: one part contains the source code of UFOING, which is independent of the UFOMOD subsystems, another part the source code of UFOMOD/FL or /NL, and the third part the pieces of the UFOING code dependent on the UFOMOD subsystems; the compiled program or the load module is always for either /FL or /NL.

The UFOMOD code referred to collectively as UFOTEILO is the code interface between UFOING and the UFOMOD program system; it is required for setting up temporary data files and for the assignment of initial values to variables and arrays, e.g. for the common blocks of category F.

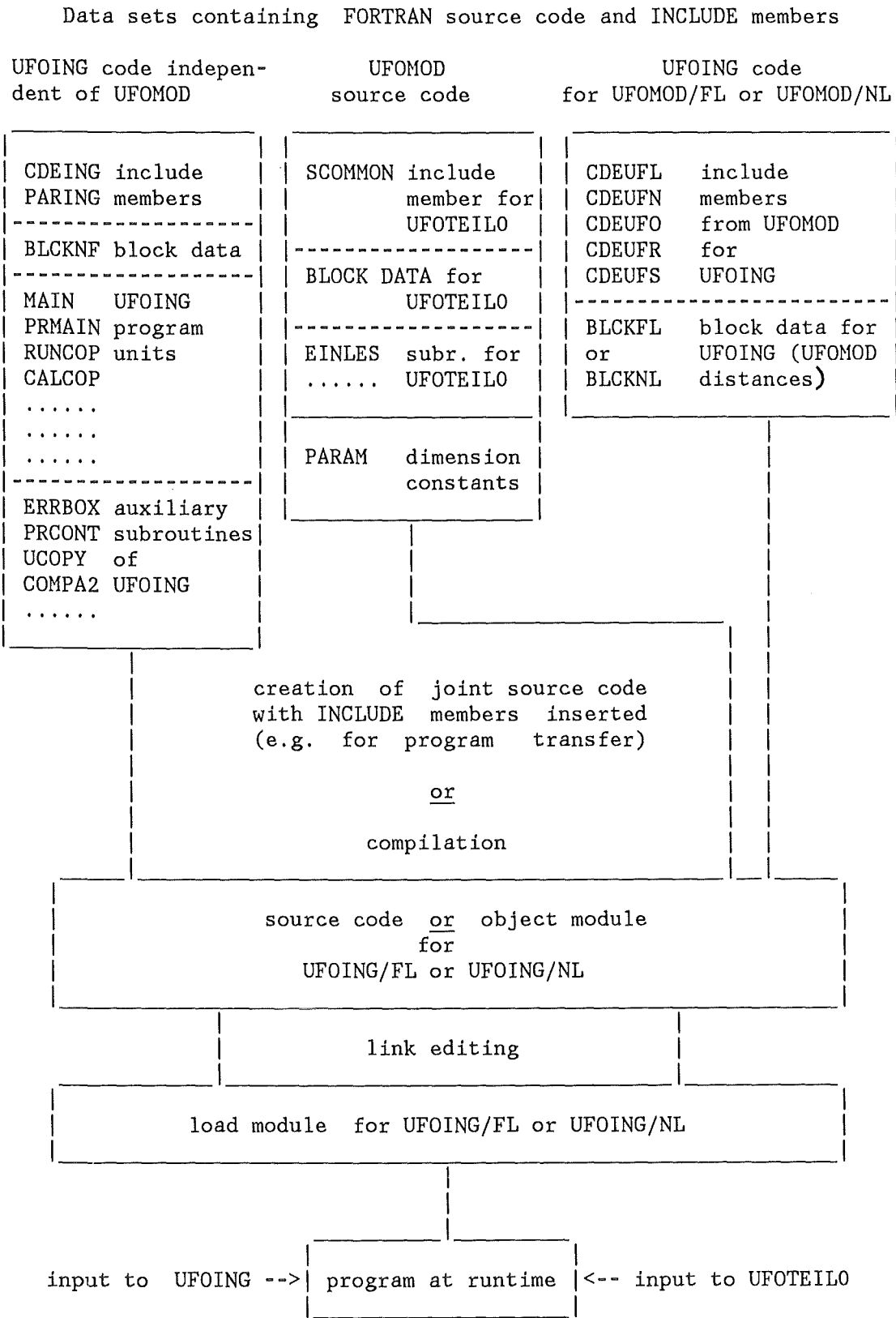
It is in principle possible to write an own interface module for UFOING to provide the required information, and this was actually done so in the past. This had the advantage, that only the data really needed by UFOING could be addressed and the interface was transparent to the UFOING user. However, it soon turned out that it was impossible to keep up with developments of the UFOMOD program system. Therefore, those program units of UFOMOD, which generate the required data, are now referred to directly in UFOING; they make up the "module UFOTEILO". Although these program units also perform other tasks not needed for UFOING and contain some unnecessary overhead, it is now relatively easy to follow up changes in UFOMOD.

UFOTEILO consists of the subroutines of the part currently called TEILO in the UFOMOD program system (i.e. the UFOMOD module EINLES), and the two include members SCOMMON, which contains the common blocks of category E (Chapter B.1), and PARAM, which contains dimension constants for arrays in SCOMMON.

The include members CDEUFL ... CDEUFS of UFOING contain only those common blocks from SCOMMON, which are needed in UFOING (Category F common blocks; see Chapter B.1). The contents of the common blocks are summarized in Tab. III.3 on page 84. All common blocks require the contents of PARAM, but only in member CDEUFO a corresponding INCLUDE statement is already contained; for the others, an INCLUDE statement must be placed in the code.

The default distances in UFOMOD are contained in a common block of UFOMOD. However, this is of different length for the two subsystems, which makes it impossible in UFOING to use dimensions independent of the subsystems. Therefore, not the UFOMOD common block is used but an UFOING special common block, COMMON/AMAIN/, which contains the distances dimensioned to the maximum dimension. The setting of initial values for COMMON/AMAIN/ is done in the BLOCK DATA program units BLCKNL or BLCKFL.

Fig. III.5: Division of the UFOING source code and the load module



Tab. III.3: Contents of the common blocks of Category F

INCLUDE member		Common block name	Contents
CDEUF/x	1)2)		
	R	FREISD	Source term data (for preprocessors)
	O S	ISO	Information about the nuclides and nuclide dependent parameters
L	O	METPAR	Information about meteorological parameters
	N	NAME	Names of source term, met. zones etc.
L	O	PROB	Probabilities
L	O	RASTER	Grid definitions
	S	UNIT	Unit reference numbers of UFOTEILO
L	O	USED	Flags telling if there are non-zero concentrations in the grid

Note:

- 1) x stands symbolically for L, N, O, R, or S; the common blocks can be contained in more than one include member.
 - 2) CDEUFO contains a reference to the UFOMOD-include member PARAM
-

E.2 The UFOING / UFOMOD nuclide interface

For radionuclides, UFOING can consider the intersection of all nuclides it knows from its ingestion nuclides definition file with all those contained in the ground concentrations data file from UFOMOD, or a subset of the intersection, which can be defined by the user. Because UFOMOD may offer different nuclides for different source terms, an individual mapping of the UFOING and UFOMOD nuclides in each run is required.

The mapping and the selection of the nuclides for UFOING is performed in the main program. Compressed arrays, NUKING and NUKUFO, are constructed, which allow the identification of the selected nuclides in the input files for the ground concentrations from UFOMOD and for the ingestion data, respectively.

The code performing the selection in the main program is listed and commented below; Fig. III.6 at the end of the chapter illustrates the procedure.

Statements for the selection of the UFOING ingestion nuclides

Step 1

The UFOING ingestion nuclides definition file is read, which contains, - among other information - the names of the ingestion nuclides (MUKNAM), their identification numbers for UFOING (MUKING) and UFOMOD (MUKUFC). (MUKUFD is not used in the production modules, but in some preprocessors and in the UFOING version implemented in UFOMOD)

```
READ(INUKIG) HEADER
READ(INUKIG) NINGIN
IF(NINGIN.GT.MAXIML) CALL ERRBOX(,,)   *** boundary protection ***
  READ (INUKIG) (MUKNAM(INU), INU=1, NINGIN),
&             (MUKING(INU), INU=1, NINGIN),
&             (MUKUFC(INU), INU=1, NINGIN),
&             (MUKUFD(INU), INU=1, NINGIN)
```

Step 2

The user may want to select only a few nuclides he is interested in. If that is so, IGN is the number of nuclides he wants to consider and IGNUKS contains their UFOING - identification numbers. If IGN is zero, UFOING will take all the ingestion nuclides made available by UFOMOD. Then, IGN is set to NINGIN and all the UFOING identification numbers are copied to IGNUKS.

```
READ(LCR, JMAIN2)           *** JMAIN2: IGN, IGNUKS(1...MAXIML) ***
IF(IGN.EQ.0) THEN
  IGN=NINGIN
  CALL UCOPY(MUKING(1), IGNUKS(1), NINGIN)
END IF
```

Step 3

Loop over all requested nuclides. Check, if selection code makes sense. If not, skip it. MUKING(())=0 signals an empty position in the UFOING nuclide file; skip this also.

```
NING=0
DO #1 INU=1,IGN
  IF(IGNUKS(INU).LE.0) GO TO #1
  IF(MUKING(IGNUKS(INU)).LE.0) GO TO #1
```

Step 4

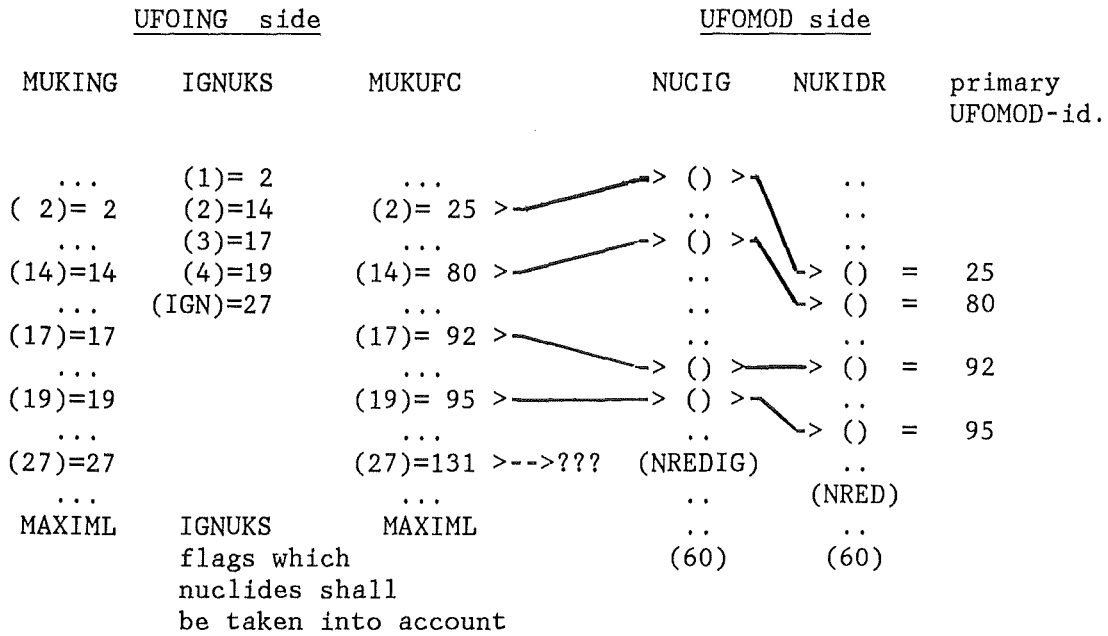
Loop over all ingestion nuclides delivered by UFOMOD. Compare their UFOMOD identification number with the UFOMOD identification number of the requested nuclide. If they match, take it and add it to the arrays containing the identification numbers which are later used for:

NUKING construction of the compressed ingestion data arrays (-> C.1)
 NUKUFO construction of the compressed ground concen. arrays (-> E.3)

```

DO #2 JNU=1,NREDIG
  IF(NUKIDR(NUCIG(JNU)).EQ.MUKUFC(IGNUKS(INU))) THEN
    NING=NING+1
    NUKING(NING)=IGNUKS(INU)
    NUKUFO(NING)=NUCIG(JNU)
    NUKNAM(NING)=MUKNAM(IGNUKS(INU))          * nuclide names *
    GO TO #1
  END IF
#2 CONTINUE
  *** issue a warning message, that a requested nuclide was not ***
  *** found among the nuclides delivered by UFOMOD ***
#1 CONTINUE
    
```

Fig. III.6: Graphic example for the selection of ingestion nuclides



Notes:

MUKING contains the primary identification numbers of the UFOING ingestion nuclides.

MUKUFC contains the corresponding primary UFOMOD identification number for each of the above nuclides.

NUKIDR contains the primary UFOMOD identification number of each of the NRED nuclides considered in UFOMOD.

NUCIG specifies, which of the NUKIDR nuclides are considered for ingestion in UFOMOD.

In the example, a warning message would be issued for the nuclide with the UFOMOD primary identification number 131, because it was requested but could not be found among the NREDIG nuclides.

E.3 Structures of the files containing the activity concentrations on ground and the population data

The activity concentrations on the ground used in UFOING are calculated in an UFOMOD run and modified somewhat in order to be usable by UFOING (see Part II, Appendix). - The file containing the population data is created by UFOTEILO during an UFOING run.

The file structures and the loop structures, in which the ground concentrations and the population data are imbedded, are dictated by UFOMOD; they are shown below for the two files.

Ground concentrations

```
DIMENSION JDUSED(MAXGRI,MAXDIS),SURCON(MAXING),UFOGND(MAXUFO)

DO #1 IWEA=1,LMAX          *** loop over weather sequences ***
READ(INUFOC) ((JDUSED(IGRI, IDIS),IGRI=1,JMAX),IDIS=1,IMAX)
DO #2 IDIS=1,IMAX          *** loop over distances          ***
DO #3 IGRI=1,JMAX          *** loop over grids              ***
IF(JDUSED(IGRI, IDIS).GT.0) THEN
  READ(INUFOC) (UFOGND(INU), INU=1,NUFO)
  DO #4 INU=1,NING
    SURCON(INU)=UFOGND(NUKUFO(INU))
#4  CONTINUE
  END IF
  *** more code to do something with the concentrations ***
#3 CONTINUE
#2 CONTINUE
#1 CONTINUE
```

Notes:

LMAX, IMAX, JMAX come from UFOTEILO via common blocks

JDUSED is a flag telling if there is non-zero ground concentration in the grid. This flag is created by the UFOING pre-processor CRCONC (Part III, Appendix).

INUFOC unit reference number for the ground concentrations

UFOGND are the ground concentrations for the 1...NREDIG UFOMOD-nuclides (NUFO is set to NREDIG in UFOING)

SURCON compressed array of ground concentrations

NING number of ingestion nuclides considered by UFOING in the run

For NUKUFC see Fig. III.6 in the preceding chapter.

Population data

```
DIMENSION IPOPD(MAXSIT,MAXGRI,MAXDIS)

DO #1 ISIT=1,NSTMAX
  READ(INUFOP) IDUM,
  &      ((IPOP(D(ISIT,IGRI,DIS),IGRI=1,JMAX),DIS=1,IMAX),JDUM
#1 CONTINUE
```

Notes:

IMAX, JMAX come from UFOTEILO via common blocks

INUFOP: unit reference number for the population data

F. Program and data transfer

The source code and the input data sets can be send via tapes to interested institutions on request.

The source code is available optionally as the original source code, with it's division into a part independent of the UFOMOD subsystem and the parts which depend on it, together with the various INCLUDE members, or as a self - contained source code for one or the other of the UFOMOD subsystems, in which the INCLUDE - statements are replaced by the pieces of code from the corresponding INCLUDE members.

The unformatted data sets used at KfK as input for UFOING can be converted to formatted data sets with a program TRNSDATA. The formatted data files are larger than the original ones and may also have a different file structure. The re-creation of the unformatted data files can be carried out with a program TRNSDATB. Both programs can be made available.

Part IV

The generation of the default ingestion data

In this part it is described, how the the specific activities in foodstuffs, the consumption rates and the dose conversion data, which form the current default data base for UFOING, are derived from the original data.

The corresponding data sets are produced by preprocessor programs of UFOING. An example for the implementation of any of the preprocessors which requires UFOING/UFOMOD-environment into the UFOING program, the runtime options, and the UFOING/UFOMOD data sets needed can be found in the Appendix of Part II.

A further preprocessor (CRINGNUK) is required for the implementation of the ingestion nuclides definition file, which contains the numbers of the nuclides with respect to UFOING and UFOMOD and their names. This program does not need UFOING environment, and nothing else but the file structure has to be cared for, which is explained in Part III, Chapter C.2.

In the following, all parameters on the UFOING-side refer to the default parameterization shown in Tab. I.2 and I.3 in Part I, Chapter A. - The symbols used in the text to identify data, indices etc. are not necessarily the same as in the preprocessors.

A. Normalized specific activities in foodstuffs

A.1 Overview

The ECOSYS data were provided in the form of yearly integrals of the normalized specific activities for the release times 1st of January and 1st of July.

The assumptions made in the model about the production of food- and feedstuffs are shown below:

Tab. IV.1: Time scales for the production of plant products in ECOSYS

food/feed product	begin of growth	growth period	harvest
grain	15. 3.	150 d	15. 8.
potatoes	15. 4.	150 d	15. 9.
leafy vegetables	1. 4.	50 d	20. 5.-15.10.
nonleafy vegetables	1. 4.	120 d	1. 8.-15.10.
root vegetables	1. 4.	120 d	1. 8.-15.10.
pasture grass	1. 4.	45 d	15. 5.- 1.11.
maize	15. 4.	150 d	15. 9.

Outside the vegetation period of pasture grass, dairy cattle are assumed to stay indoors and to be fed on stored hay produced between 15.5. and 15.7. Beef cattle and pigs are assumed to stay indoors all over the year and to be fed on grain products, grass, hay and maize (beef) or on grain and potatoes (pigs).

According to the modelling concept in the first stage of the DRS-B, it was decided, that the ECOSYS data for the DRS-B should be in the form of yearly time integrals over the specific activities, and that the integration times should always start at the assumed time of the release. This way of integration in combination with the assumptions about the production times of the food/feedstuffs in ECOSYS lead to some peculiarities of the integrals in the first two years, which are explained below and illustrated schematically for the example "Cs-137 in grain products" in Fig. IV.1 (January) and IV.2 (July). In the figures, the contamination of the crops in a year i is indicated by A_i ; between two harvests, the contamination decreases only by radioactive decay, i.e. by a very small amount for Cs-137. - The Figures IV.3 and IV.4 show, among other data explained later, the corresponding values of the integrals (all figures on the following two pages).

Release at 1st of January:

As it can be seen from Tab. IV.1, all food- and feed plants are not yet on the field, and all animals are kept indoors and fed on uncontaminated stored fodder. Thus, no immediate contamination of the foodproducts takes place at all. It is only later in the year, when the plants start to grow and become contaminated by root uptake (and, eventually, by resuspension), that non-zero specific activities in the foodstuffs can occur. As a consequence, for nuclides with a sufficiently long radioactive half-life, the integrals in the first year are generally smaller than in the second year.

In the example for grain, this effect is rather marked due to the large gap between the start of integration and the first harvest, as Fig. IV.3 shows.

Release at 1st of July:

At this time of the year, all food- and feedcrops are standing on the fields; therefore, the contamination of the foodstuffs is dominated by direct deposition onto the plants and, for some nuclides, by subsequent translocation processes. This leads to much higher activity levels in the foodstuffs than the more inefficient processes of root uptake/resuspension. The time scales for integration and production can produce a protraction of the effects of direct deposition to the second years integrals, although the foodstuffs actually produced in the second year are in general not affected by direct deposition any more (exception: meat from cows and pigs, which are partially fed on grain and maize).

The effect of the time delay between the start of the integration and the first harvest/slaughter for some of the foodstuffs is less pronounced than for January because of the smaller time gap.

Fig. IV.1:

Time scales for grain products for a release on 1st of January

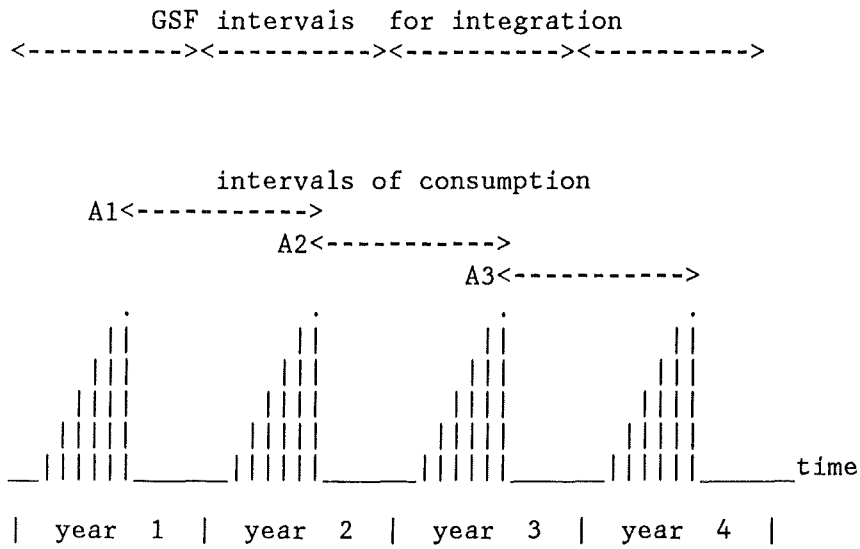


Fig. IV.2: Time scales for grain products for a release on 1st of July

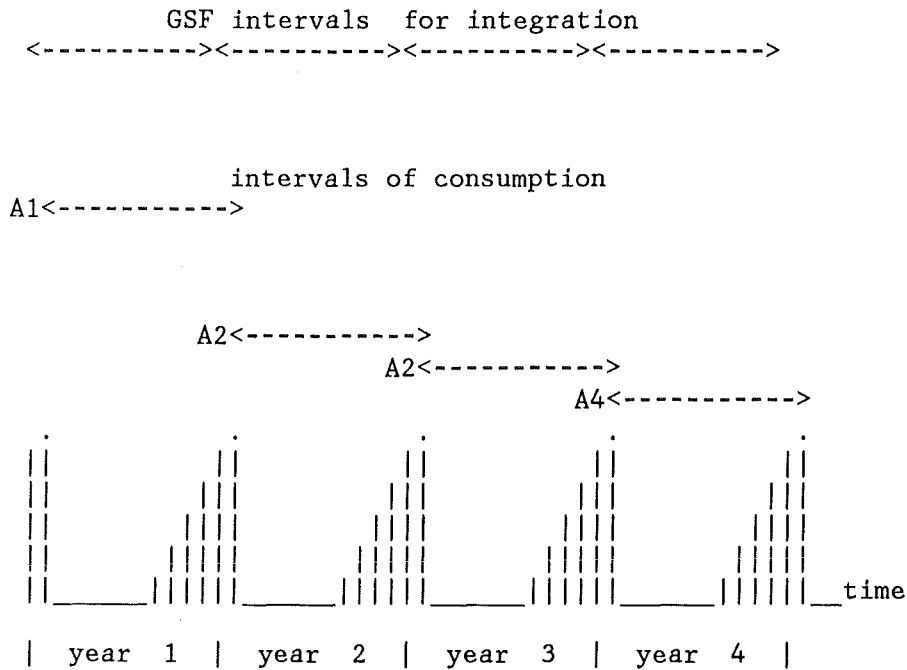


Fig. IV.3: The original and the modified data for Cs-137 in grain products for a release on 1st of January

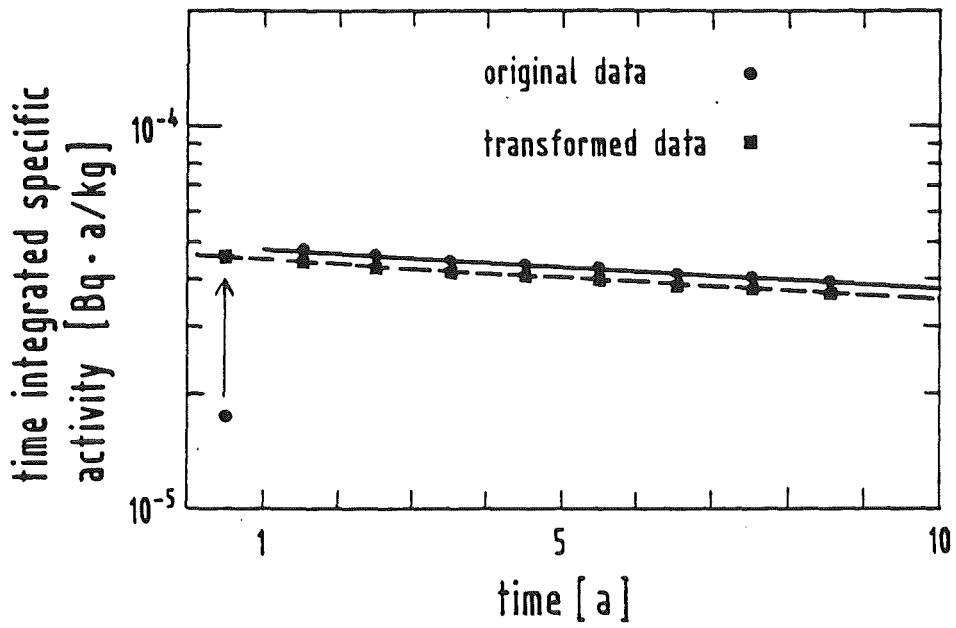
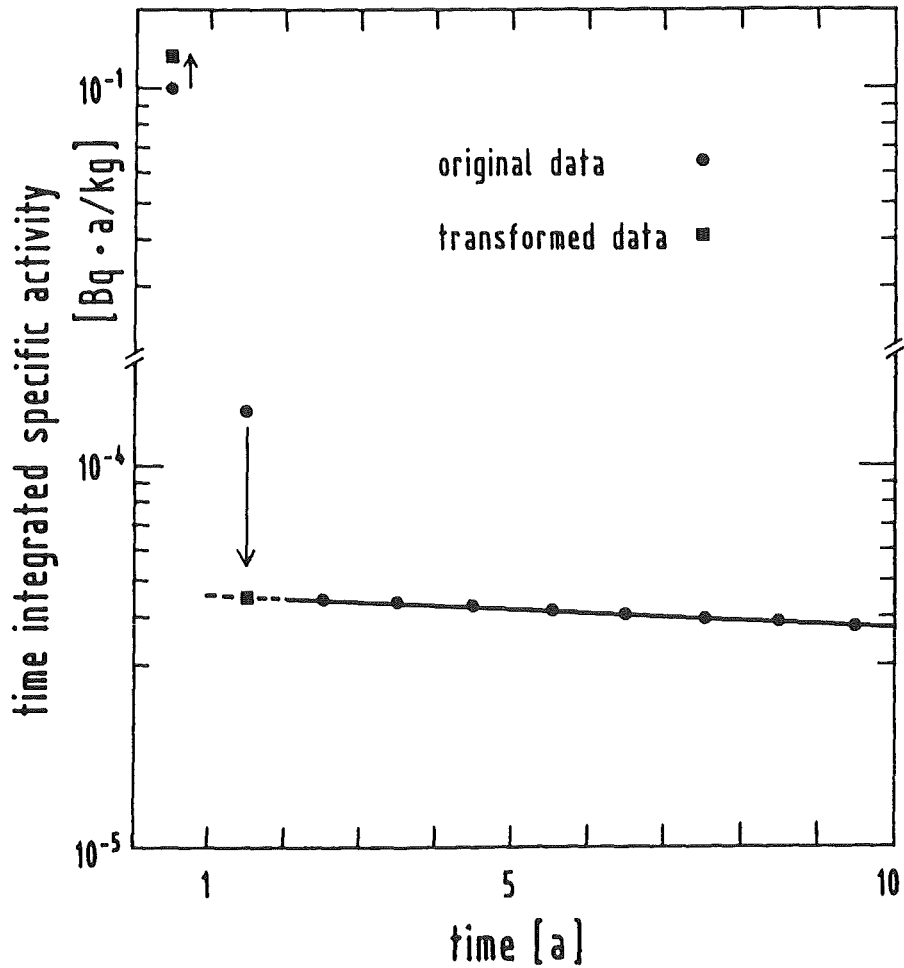


Fig. IV.4: The original and the modified data for Cs-137 in grain products for a release on 1st of July



The effects mentioned above lead to conflicts with the current foodban module of UFOING. In this module, foodbans are assumed to be imposed, if the doses resulting from ingestion in the first year exceed a given intervention level (IL), and, if this is the case, to be withdrawn, if the doses in some later year are below a given IL. Clearly, this procedure cannot work properly with the ECOSYS data for January. However, this is a technical difficulty which could be solved by changing the foodban algorithm. A more fundamental problem is, that in practice, no foodstuff would be banned in the first year, but allowed to be distributed in the second year, if it has still the same contamination level! This unsensical result could come out of the foodban module for instance with the ECOSYS July data of the contamination of cereals with nuclides with a long radioactive half life, if the intervention level in the 1st year is exceeded but not the IL in the 2nd year: 1.5/12 of the first year's crop is assumed to be consumed in the second year (harvest on 15.8.!).

Therefore, the original data were modified for UFOING with the the aim to replace the original rigid time scale of integration in the first year by a scale which is approximately oriented on the effects of direct deposition and the production cycle. The following years are counted from this artificial "year" onwards and the total activity integrated over all times is kept the same. The resulting data are more consistent with the logic of the current foodban model.

The calculations are performed with the preprocessor CRECSYS2 and are described in the next two chapters. Two data sets are produced for each release date, one containing only the yearly integrals for the times contained in the banarray, which is used by UFOING, and one containing yearly values for up to 200 a, which is used by the programs calculating activity-dose- or -risk-coefficients. For the latter, an array NTIFCT is set up, which tells for each nuclide how many non-zero values exist, and only those values will be written to the output file together with NTIFCT in order to reduce the size of the data set.

Radionuclides, which originate from radioactive decay chains after deposition and may turn up in the foodchains after a long time after the accident, pose also a problem in connection with the foodbans which cannot be solved at present. However, the only decay chain currently considered in UFOING is Pu-241 \rightarrow Am-241, and this is not expected to contribute significantly with present release terms.

A.2 Processing of the January-data

It is assumed, that all contamination is caused by root uptake/resuspension and any deviation from this behaviour in the first year is attributed to the time delay between the time of the accident and the first production of the foodstuff.

Fig. IV.3 shows a linear decrease of the data on a logarithmic scale between the years 2 and 9; this behaviour can be observed for all foodstuffs and radionuclides. The modified data are calculated from the original ones in the following way:

$$\text{DEL} = |\ln(A_3) - \ln(A_2)| / (3-2) \quad \text{slope for long-term contamination}$$

$A1'' = \exp(\ln(A2)+DEL)$ extrapolation of long-term contamination
to year 1

$f = \sum A_i / (A1'' + \sum A_j)$ normalization factor; $i=1..MAX; j=2..MAX$

$A1' = f*A1''$ and $A_j' = f*A_j$ shifting of each value to get the sum
right; $j = 2 \dots MAX$

where A_i are the original and A_i' the modified integrals in the year i .

The renormalization is required to keep the original integral over all times the same. - For the short-lived nuclides, only A_1 is not equal zero; in this case, no processing is required. The values for Am-241 coming from Pu-241 are left unchanged. - The modified data for the grain example are shown in Fig. IV.3.

A.3 Processing of the July-data

To separate approximately the crops contaminated by direct deposition from the following crops which are not, it was assumed, that any excess in the original second year's data over the contribution expected from root uptake/resuspension comes from the protraction of the direct contamination due to the way the ECOSYS data were integrated; this excess was then removed from the second year's value and added to the first year's value. The rest of the data was left unchanged and the total integral over all times is not affected.

The modified 1st year's data are still called "values for year 1" in UFOING. However, the time intervals (counted from the release time) implicitly inherent in the data for "year 1" are now oriented on both the effects of direct deposition and the production/consumption of the foodstuffs and therefore of varying length, dependent on the radioactive half life and the foodstuff; they range from some weeks (e.g. I-131) to slightly more than a year (e.g. Cs-137 in grain products). All other data correspond to time intervals of one year counted from the end of "year 1" onwards.

In practice, as for January, a linear behaviour on a logarithmic scale is assumed between year 3 and year 9, and the modified data for all nuclides and foodstuffs are obtained in the following way:

$DEL = |\ln(A4)-\ln(A3)| / (4-3)$ slope for long-term contamination

$A2' = \exp(\ln(A3)+DEL)$ extrapolation of long-term contamination
to year 2

$A1' = A1 + (A2-A2')$ shifting of excess to year 1

where A_i are the original and A_i' the modified integrals in the year i .

For the short-lived nuclides, only A_1 is not equal zero; in this case, no processing is required. The values for Am-241 coming from Pu-241 are left unchanged. - The data modified in this way for the grain example are included in Fig. IV.4.

B. Consumption rates

B.1 Overview

Average age dependent consumption rates for the FRG for the foodstuffs considered in ECOSYS were derived from data published in [10] (Schwarz and Kersting) and in [11] to [13] (Ernährungsberichte (diet reports)):

Schwarz and Kersting

Their analysis is based on dietary data from 114 infants of 1-13 months and 176 children of 1-14 years of age from a nutritional survey conducted by the Forschungsinstitut für Kinderernährung, Dortmund, in the urban and suburban areas of the city of Dortmund between August 1965 to June 1975 [14, 15]. The survey was performed on normally developed healthy individuals living in families of various socioeconomic classes or in family-like full time care centres (Kinderheim). The consumed amounts of food were recorded by weighing or measuring the pre-meal and post-meal quantities. Intake data for infants up to 1 month of age are not included in the study.

The raw data from this study were grouped into food categories and analyzed statistically by the authors. They present mean values, standard deviations and ranges of consumption rates for the age groups 1-2.9, 3-5.9, 6-8.9, 9-13 months and 1-1.9, 2-2.9, 3-3.9, 4-5.9, 6-9.9, 10-14 years.

Ernährungsberichte

These reports base their analysis on two types of statistical information:

(a) Statistical samples of the income and consumption from the Statistisches Bundesamt Wiesbaden (Federal Authority of Statistics). In [11-13], data from 1973, 1977/78 and 1980/81 were used, respectively.

(b) Agricultural statistics issued regularly by the Bundesminister für Ernährung, Landwirtschaft und Forsten (Federal Minister of Nourishment, Agriculture and Forests).

The sex- and age- dependency of the consumption rates is estimated indirectly with a regression method. The contributions from the outdoors consumption of foodstuffs, e.g. in canteens, restaurants etc. are approximately accounted for by the analysis of indirect data.

Average consumption rates for both sexes are given for the age groups 4-6 a, 7-9 a, 10-12 a, 13-14 a, 15-18 a, 19-35 a, 36-50 a, 51-65 a, > 66 a or collectively for adults with the following degree of detail:

- [11]: Tab. 1/22 - data for above age groups and individual foodstuffs
[12]: Tab. 1/18 and 1/19: - data for above age groups and foodgroups
Tab. 1/20 - data for adults and individual foodstuffs
[13]: Tab. 1/4 - data for above age groups and foodgroups
Tab. 1/5 - data for adults and individual foodstuffs

The foodstuffs/foodgroups from all references had to be appointed to the UFOING foodgroups; this will be explained in the following chapters. Data for foodstuffs consumed in a processed form were added to the consumption rates of the unprepared foodstuff, i.e. the assumption was made, that the specific activities in the foodstuffs are not changed by manufacturing.

The data from [10] for the ages 1-13 months were weighted with the fractions of the corresponding time intervals to one year and added together to obtain an average consumption rate for the first year of life:

$$C(0) = (2 * C(1-2.9) + 3 * C(3-5.9) + 3 * C(6-8.9) + 4 * C(9-13)) / 12$$

The values from [11-13] were averaged with respect to sex. The consumption rates for the last four of the age groups were combined to obtain average values for the age group ≥ 20 a:

$$C(\geq 20) = 0.3 * C(19-34) + 0.3 * C(35-50) + 0.22 * C(50-65) + 0.18 * C(\geq 66)$$

where the weights are the fractions of the population belonging to the corresponding age group; they were derived from demographic data for the FRG [16, 17].

The error bars for the consumption rates from [10] shown in the figures in Chapters B.2 - B7 are the standard deviations given in this reference.

B.2 Milk and milk products

Milk in fresh and processed form was combined to the foodgroup "milk incl. milk products", which comprises of:

reference [10]: milk, yogurt, cream etc., butter, cheese.

references [11-13]: drinkable milk of any type, condensed milk, any type of cream, yogurt, milk powder, any type of cheese, butter (items 040 - 060 in [11]; G05-G07 in [12, 13]).

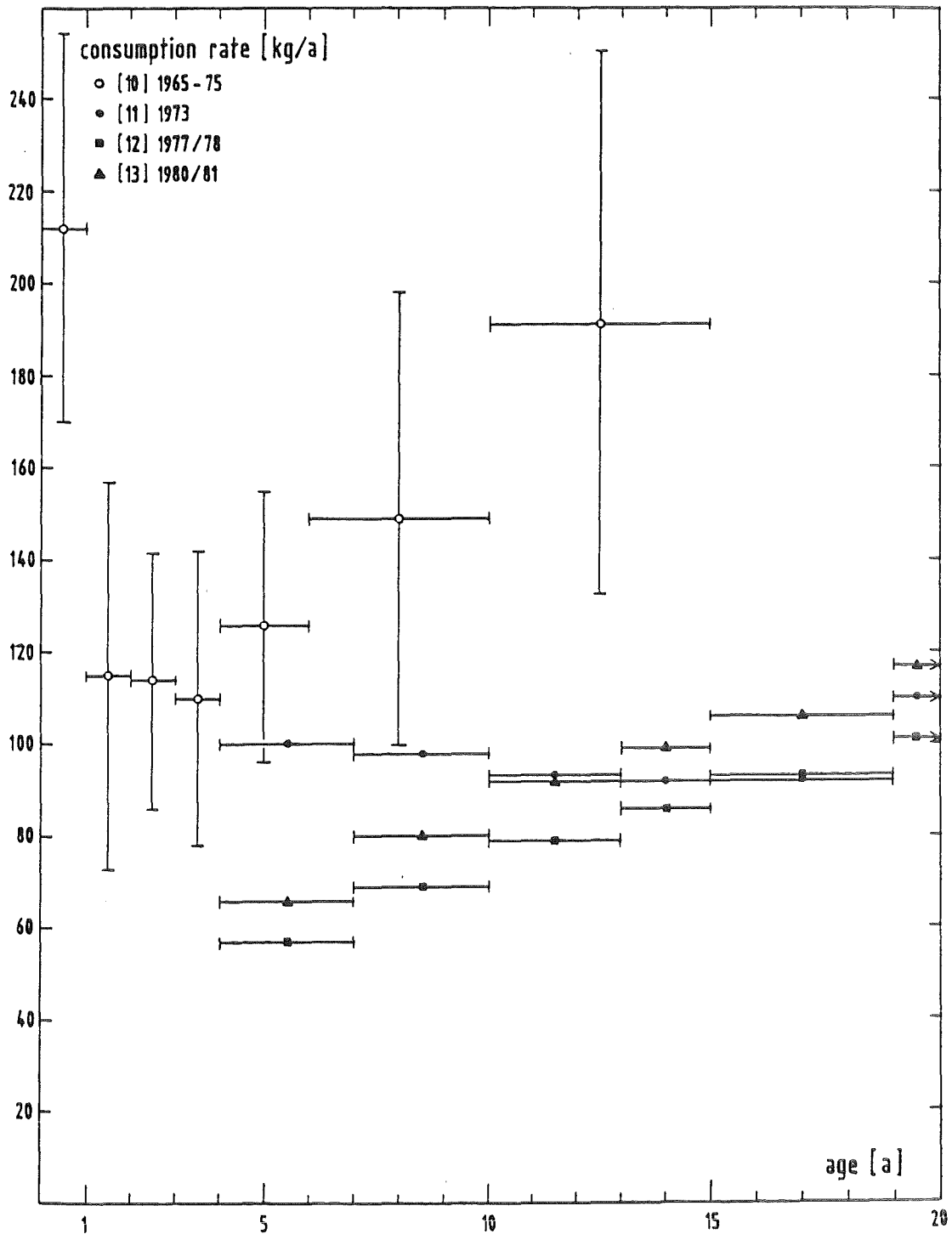
From references [12, 13] it was derived, that, on average, 72% of the milk products are consumed as fresh milk (including buttermilk, yogurt), 10% as condensed milk or cream, 12% as cheese, and 6% as butter (approximate values).

The resulting consumption rates are shown in Fig. IV.4. The well-known decrease in milk consumption over the last decade can be observed; however, the data from [13] suggest a reversal of this trend in 1980. The data from [10] generally exceed those from the other references, this may be a combination of trend and regional effects (Dortmund is a heavy industry area).

The consumption rates chosen for UFOING are listed below. The values for the age groups 1, 5 and 6 follow the data from [10] and [13], respectively. For the age groups 3 and 4, values somewhat greater than those in [13] were taken to be on the safe side. The value for age group 2 was obtained by linear extrapolation from the values for age groups 3-4.

age [a]:	0	1-4	5- 9	10-14	15-19	≥ 20
rate [kg/a]:	210	80	90	100	110	115

Fig. IV.5: Average consumption rates for milk



B.3 Beef and pork

References [10], [12] and [13] (items 01, 02) give age dependent data for the total consumption of meat and meat products. Only reference [11] provides age-dependencies for the consumption of beef, veal, pork, mutton, poultry, game including wildfowl, minced meat, offals and several varieties of processed meat, e.g. sausages, bacon etc. (items 001-019); references [12] [13] give corresponding data for adults only.

To obtain consumption rates for beef (including veal) and pork, percentage contributions of the consumption of beef to the total meat consumption were determined. The total meat consumption was taken to be the sum from all meat and meat products, with the exception of poultry and game. The assumption was made, that sausage etc. consists entirely of pork, and that minced meat and offals are consumed to 50% from beef and pork each (minced meat/offals and sausage etc. were found to contribute to about 13% and 45% to the total meat consumption, respectively, rather independent of age). The percentage contributions for beef are listed below:

Tab. IV.2: Percentage contributions of beef to total meat consumption

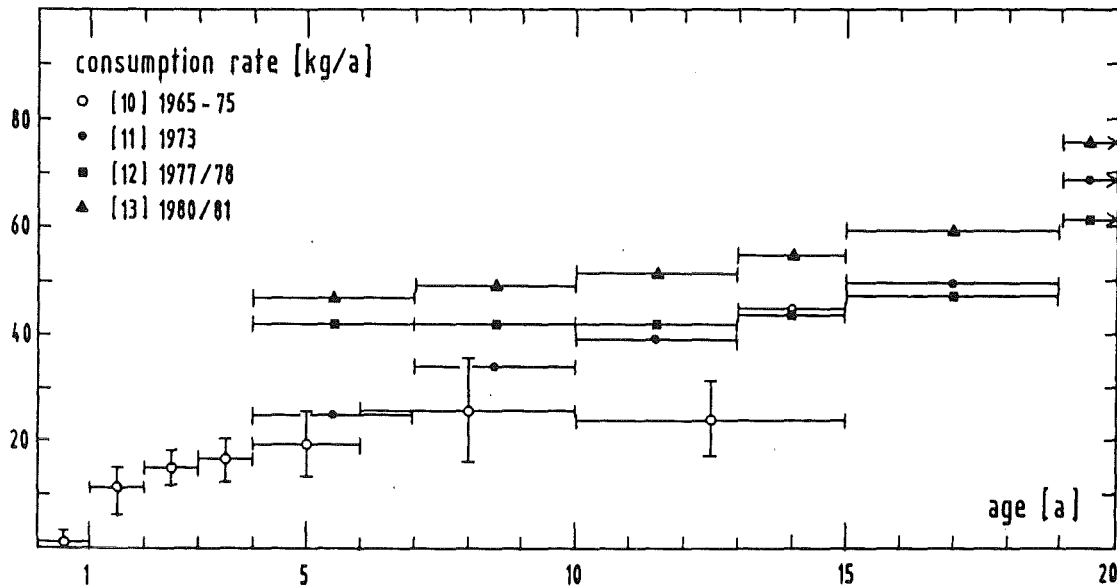
<u>Reference</u>	<u>age [a]</u>					
	4- 6	7- 9	10-12	13-14	15-19	19-65
[11]	20	20	20	21	22	24
[12]						21
[13]						35

Fig. IV.6 shows the total meat consumption rates. The data from [11-13] show an increase in the meat consumption over the years, and the data from [10] fit well into the picture.

From the figure, rates for the total meat consumption were derived to serve as a base for the determination of the beef and pork rates; for the age groups 1 and 3-6 values were chosen, which follow the data from [10] and [13], respectively; the value for age group 2 was obtained by linear extrapolation from the values for the age groups 3-5. - For the beef contributions, for age group 1 it was assumed, that all meat is consumed as beef; for adults, a value of 28% was taken with the same age dependency as derived from [11] (Tab. IV.2); for age group 2, the same value as for age group 3 was taken. - The consumption of pork is complementary to the beef consumption. The following (rounded) consumption rates ([kg/a]) were obtained:

age [a]:	0	1-4	5- 9	10-14	15-19	>= 20
beef:	5	10	10	15	15	20
pork:	0	25	35	40	45	50
meat sum:	5	35	45	55	60	70

Fig. IV.6: Average consumption rates for meat



B.4 Cereals

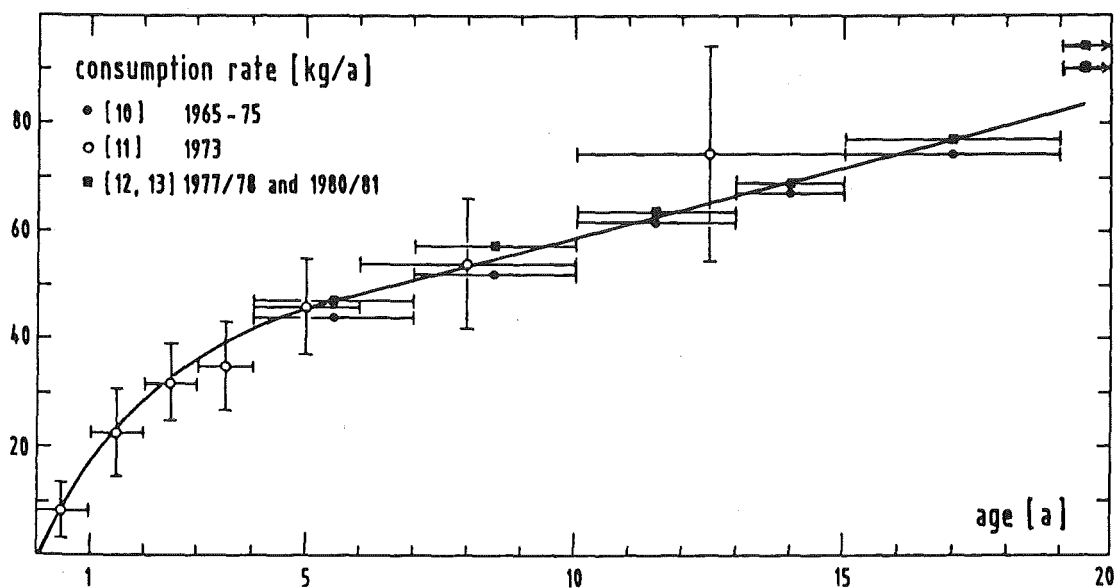
Grain is consumed almost entirely in a processed form, e.g. bread, flour, noodles, biscuits, cake etc.. From reference [11], the corresponding data were added (items 080-091 and 094, 098). Reference [10] gives data for cereals (including rice), and [12, 13] for bread and bakery products (item G-09)¹⁾ and nutritive products (item G-10), which includes flour, noodles, but also rice, legumes and products made from potatoes. From the tables 1/20 in [12] and 1/5 in [13] it was derived, that these products contribute to about 20% to the total of G-10 for adults, and the values for G-10 were reduced by this amount for all age groups.

A remarkably consistent picture emerges from the resulting consumption rates, as it can be seen from Fig. IV.7 (the data from [12] and [13] lie very close together and are represented by one symbol). The data were fitted by hand with the curve indicated in the figure; from this curve, the following (rounded) consumption rates were determined:

age [a]:	0	1-4	5-9	10-14	15-19	>= 20
rate [kg/a]:	10	35	55	65	80	95

1) Item G-09/04 in [12] is called "edible oil", but is actually pastry, as can be seen from the errata list to [12].

Fig. IV.7: Average consumption rates for cereals



B.5 Potatoes

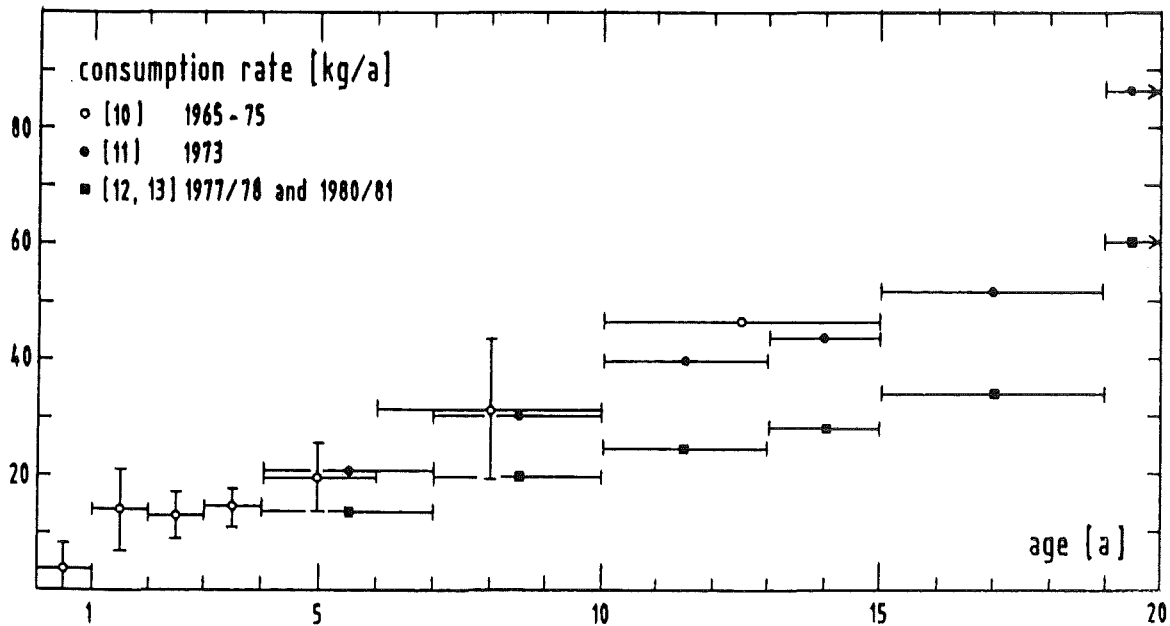
All references provide values for potatoes. Additionally, values for products made from potatoes are specified in [11] (age-dependent, item 097) and [12, 13] (adults, item G-106). The data from [11] show, that the consumption of such products is rather independent of age, and the corresponding values for adults in [12, 13] were added to the potatoe consumption rates (3 kg/a).

The resulting values show a decrease of the potatoe consumption over the years (Fig. IV.8 on the following page; the data from [12] and [13] are virtually indistinguishable and are represented by one symbol).

In deriving rates for UFOING, the trend was not ignored completely but also not followed entirely:

age [a]:	0	1-4	5- 9	10-14	15-19	>= 20
rate [kg/a]:	5	15	20	30	40	70

Fig. IV.8: Average consumption rates for potatoes



B.6 Vegetables

In UFOING, three categories of vegetables are distinguished with respect to the consumed parts of the plants:

Leafy vegetables (LV): lettuce, spinach, cabbage etc.

Non-leafy vegetables (NLV): legumes, tomatoes, cauliflower etc.

Root vegetables (RV): carrots, onions, garlic, asparagus etc..

Reference [10] provides data for each group, reference [11] for individual fresh vegetables (items 110-119) and for ready-to-eat and deep frozen vegetables, and references [12, 13] summarily for fresh vegetables (item G-12) and vegetable products (item G-13).

The consumption rates for the three type of vegetables were derived in a similar way as for beef and pork: from all references, the total consumption rate was determined as the base value, and the rates for the three groups were obtained using percentage contributions derived from the references; the total consumption rates were taken to be the sum of all items.

Percentage contributions were derived from [10, 11] (age dependent, but no data for children in the first year of life) and from [12, 13] (adults). The contributions could be calculated for fresh vegetables only. For processed vegetables, which contribute to about 30-40% to the total vegetable consumption, in absence of data the same percentage contributions were assumed. The results are listed in Tab. IV.3. From the table it can be seen, that non-leafy vegetables contribute to about 45-50% to the total fresh vegetable consumption, and leafy vegetables to

about 25-35%. The contributions of root vegetables is somewhat greater in [10] than in the other references, but this may be a regional or time effect.

Tab. IV.3: Percentage contributions of vegetable groups to the consumption of fresh vegetables

Ref.	V.grp	age [a]						
		0-0.9	1-1.9	2-2.9	3-3.9	4-5.9	6-9.9	10-14
[10]	LV	-	25	21	24	18	26	29
	NLV	-	33	43	46	50	46	39
	RV	-	41	36	30	32	28	32
		4-6	7-9	10-12	13-14	15-18	>=19	
[11]	LV	-	25	26	27	29	35	35
	NLV	-	48	49	48	47	42	42
	RV	-	27	25	25	24	24	24
[12]	LV	-	-	-	-	-	-	33
	NLV	-	-	-	-	-	-	45
	RV	-	-	-	-	-	-	23
[13]	LV	-	-	-	-	-	-	33
	NLV	-	-	-	-	-	-	48
	RV	-	-	-	-	-	-	20

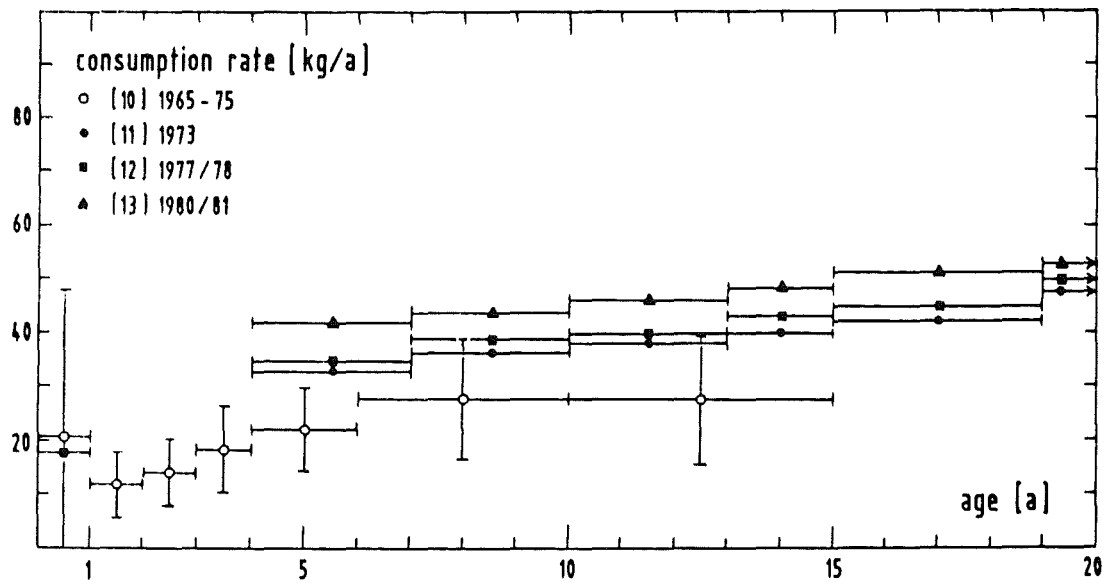
The total consumption rates are shown in Fig. IV.8. The data show an increase in the vegetable consumption over the years, but the age dependency is not so strong as for the other foodstuffs discussed so far.

Total consumption rates for UFOING were derived from the figure; hereby it was assumed, that the trend will probably continue, i.e. values somewhat above those from [12, 13] were chosen. Since the data from [10] are compatible with a linear increase of the consumption up to about 7 a of age, the values for ages smaller than 5 a were obtained by linear extrapolation.

The consumption rates for the three type of vegetables were derived by applying the percentage contributions to the total consumption. For age group 1, in absence of data it was assumed, that each category contributes to 1/3 to the total. The following (rounded) consumption rates ([kg/a]) were obtained:

age [a]:	0	1-4	5- 9	10-14	15-19	>= 20
Leafy veg.:	10	10	15	15	20	20
Non-leafy veg.:	10	20	25	25	25	25
Root veg.:	10	10	10	10	15	15
Sum:	30	40	50	50	60	60

Fig. IV.8: Average consumption rates for vegetables

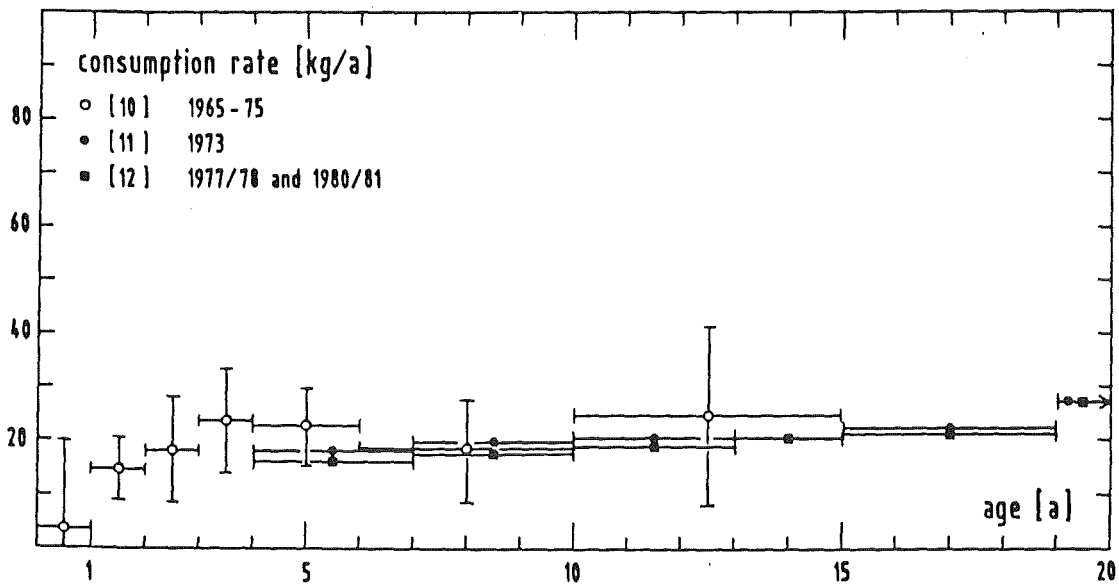


B.7 Fresh domestic fruit

Fruit is at present not considered in UFOING, because no data were available for this foodstuff from ECOSYS. However, the consumption rates are comparable with the rates for leafy vegetables, as Fig. IV.9 shows. The data shown correspond to the items "fresh domestic food" provided in all references, they comprise apples, pears, stone fruits, strawberries and other berries and grape.

Since this food is consumed in a fresh form and may be directly contaminated during the summer period, it seems worthwhile to include it in the future.

Fig. IV.9: Average consumption rates for fresh domestic fruit



B.8 Seasonal and regional variations

In UFOING, average consumption rates are applied for all seasons and regions. Tab. IV.4 shows standard deviations (sd) and ranges of seasonal and regional variations for some foodstuffs related to the UFOING foodgroups to give an impression about the parameter uncertainties related to these aspects. The data were derived from Tab. 1/23 and 1/24 in reference [11]; they quantify in percent the consumption with respect to the season or the region in comparison to the average consumption; the two tables in [11] do not contain identical foodstuffs and it was not possible to show both variations for all foodstuffs:

Tab. IV.4: Seasonal and regional variations of consumption

foodstuff	season		region	
	sd	range	sd	range
Veal	-		38	(47, 159)
Pork	5	(92, 109)	8	(83, 119)
Fresh milk	4	(91, 108)	12	(82, 128)
Buttermilk	46	(70, 176)	-	
Black/mixed bread	3	(93, 104)	8	(90, 116)
White bread	8	(89, 113)	-	
Noodles	-		24	(59, 145)
Potatoes	78	(45, 334)	15	(80, 131)
Tomatoes	74	(25, 225)	-	

Fresh milk is one of the most important contributors to the ingestion doses. It is produced continuously over the year and its consumption shows little variations both with respect to season and region. The absence of large seasonal variations can also be observed for the other foodstuffs in the table, which are produced independent of the season (meat, bread, noodles); however, here, some larger regional differences occur, e.g. the well-known north-south asymmetry in the noodle-consumption in the FRG. The foodstuffs the production of which is bound to the season, e.g. tomatoes, potatoes, or which bear some other relation to the season, e.g. buttermilk, a popular refreshing drink in the FRG, show a marked seasonal dependence.

B.9 The consumption rates data file

The UFOING consumption rates are written to a data file with the preprocessor CRFCRBRD. This file is not used in UFOING, but by some other preprocessors. The first part of the file contains, besides for the usual file overhead, the consumption rates for the age groups, the second part the same data in age steps of one year:

```

CHARACTER*8 HEADER,ORKNAM
DIMENSION HEADER(10),AGENAM(MAXAGE),FOONAM(MAXFOO)
DIMENSION FCR(MAXAGE,MAXFOO),FFCR(MXXAGE,MAXFOO)

READ(unit) HEADER
READ(unit) NFOO,NAGE1,NAGE2
READ(unit) (FOONAM(IFO),IFO=1,NFOO),(AGENAM(IAG),IAG=1,NAGE1)
READ(unit) ((FCR(IAG,IFO),IAG=1,NAGE1),IFO=1,NFOO)
READ(unit) ((FFCR(JAG,IFO),JAG=1,NAGE2),IFO=1,NFOO)

```

Notes:

MXXAGE = 80
MAXAGE, MAXFOO as defined in the UFOING include member PARING
(see Part III, Chapter B.2).

For each age group IAG and foodstuff IFO:

$$\text{FFCR}(\text{JAGL}+1 \dots \text{JAGR}+1, \text{IFO}) = \text{FCR}(\text{IAG}, \text{IFO})$$

where

IAG: index of the age group.

JAGL, JAGR: the corresponding ages shifted by 1 to avoid the index 0

(e.g. IAG=2 corresponds to (JAGL, JAGR) = (1,4)).

The right boundary of interval No. 6 is set to MXXAGE-1.

HEADER = File identification

NFOO = Number of foodstuffs contained in the file

NAGE1 = Number of age groups contained in the file

NAGE2 = Number of age steps contained in the file

FOONAM = Names of the foodstuffs

AGENAM = Names of the age groups

FCR = the data for the age groups

FFCR = the data for the age steps of 1 year

D. Dose conversion factors and activity-dose-coefficients

The dose data currently in use in UFOING are derived from data provided by the GSF [6]. The original data give the cumulative dose resulting from a single intake of activity by ingestion for an individual with a given age at the time of ingestion as a function of time after the intake. The buildup of activity from radioactive decay chains after ingestion is included in the dose factors.

The GSF data base contains time-integrated dose conversion factors for a large number of radionuclides, organs, integration times, two values of the resorption factor (f1,f2), and for the ages 0a, 1a, 5a, 10a, 15a, 20a, which correspond to the left boundaries of the UFOING age intervals. The names of the organs are shown in Tab. IV.5; the other items in this table will be explained later. The values for the breast, the uterus and ovaries apply to females, the values for testes to males; all others represent average values with respect to sex.

Tab. IV.5: Data for the preprocessor CRFDORIO

number in GSF data	organ	UFOING number	used for remainder	Weight in Eff. dose
1	Adrenals	13	*	+
2	Bladder wall	14	*	+
3	Bone surface	2		0.03
4	Brain	15	*	+
5	Breast	1		0.15
6	Stomach wall	7		+
7	SI+contents	16	*	+
8	ULI wall	17	*	+
9	LLI wall	8		+
10	Kidneys	18	*	+
11	Liver	9		+
12	Lungs	3		0.12
13	Ovaries	-----	see text	-----
14	Pancreas	10		+
15	Bone marrow	4		0.12
16	Skin	19		-
17	Spleen	20	*	+
18	Testes	-----	see text	-----
19	Thymus	21	*	+
20	Thyroid	5		0.03
21	Uterus	22	*	+

The processing of the original data is done in 4 steps:

Step 1: Some general modifications, such as a reduction of the radionuclides, integration times and resorption factors to the ones required by UFOING, reordering of organs, and the calculation of values for gonads, the effective dose, and a remainder. The resulting data set is the basis for all following steps.

Step 2: Calculation of dose conversion factors, which are integrated for 70 a - age.

Step 3: Calculation of dose conversion factors differentiated with respect to time for time- and age intervals of one year. - These data are required for the calculation of the activity-dose- and -risk-coefficients.

Step 4: Calculation of the activity-dose-coefficients.

In the following, the different steps are described. Unless explicitly defined otherwise, the "age" means always the lower boundaries of the UFOING age intervals.

Step 1 (preprocessor CRFDORIO):

(1) The original GSF file contains data for 126 radionuclides. From these, only the data for the nuclides contained in the ingestion nuclides definition file are taken.

(2) The integration times of the original data are: 1 d, 7 d, 10 d, 1 a, 5 a, 10 a, 20 a, 30 a, 40 a, 50 a, 70 a. The first three times are skipped.

(3) The original data were reduced to one value of (f1,f2): for all nuclides with the exception of Mo and Pu, the f1 - values were used.

(4) Calculation of a dose factor for gonads (UFOING number 12) by taking the arithmetic mean of the dose factors for ovaries and testes.

(5) Calculation of a dose factor for the remainder (UFOING number 6) by taking the arithmetic mean of the dose factors of the organs marked with a "*" in Tab. IV.5.

(6) Calculation of an approximate dose conversion factor for the effective dose (UFOING number 11) by adding together

- the original values for the organs with the GSF-numbers 3, 5, 12, 15, 20 multiplied with the corresponding weights from Tab. IV.5
- the value for gonads derived in (4) multiplied by 0.25
- the sum of the five most significant dose conversion factors from the organs marked by a "+" in Tab. IV.5 multiplied by 0.06 each.

All weights are taken from ICRP-26, p. 21 [7].

(7) For the first year of life (i.e. age group 0 a), the arithmetic mean of the values for age 0 and age 1 are taken.

(8) The organs are reordered to fit into the UFOING scheme of organs; the corresponding UFOING numbers are shown in Tab. IV.5.

Step 2 (preprocessor CRFDORI1):

CRFDORI1 is for the calculation of dose conversion factors which give approximately the lifetime doses resulting from a single intake: for the age groups number 3 - 6, the dose conversion factors created in Step 1 are interpolated linearly to the times 70a-age; for the age groups 1 - 3, the maximum integration time (70 a) is taken.

Step 3 (preprocessor CRFDORI3):

(1) The data created in Step 1 are differentiated with respect to the integration times in time steps of one year each. The differential data for each of the integration time intervals of the original data were obtained under the assumption of a linear relationship between the boundary values in the following way:

$$DDCF'(1, IAG, ,) = DCF(1, IAG, ,)$$

and for IGT = 1 to 7:

$$DDCF'(JGTL+1..JGTR, IAG, ,) = (DCF(IGT+1, IAG, ,) - DCF(IGT, IAG, ,)) / (JGTR - JGTL)$$

where

IGT: index of the time interval. IGT corresponds to the left boundary of the interval, IGT+1 to the left boundary of the next interval, which is the right boundary for the interval Nr. IGT.

JGTL, JGTR: the corresponding times.
(e.g. IGT=7 corresponds to (JGTL, JGTR) = (50, 70)).

IAG: index of the age group.

DCF: the time-integrated dose conversion factors from step 1.

DDCF': the differentials with respect to the integration time in time steps of one year.

The two commas in the argument list stand for the indices of the organs and radionuclides, which are omitted here.

The upper edge of the integration time, 70 a, was artificially extended to 80 a by taking the 70 a value of the DDCF' for the time interval 70 - 79 a.

For each of the age groups the maximum time, IGTMAX, is determined, for which the DDCF' is greater than zero.

(2) When deriving the data for age intervals of one year each, it was assumed that the original dose conversion factors represent average values for the age groups considered in UFOING, and the value, which corresponds to the lower edge of each age group, was taken for the rest of the age interval:

DDCF(1...IGTMAX(1),1,,) = DDCF'(1...IGTMAX(1),1,,)

and for IAG = 2 to 6:

DDCF(1...IGTMAX(IAG),JAGL+1...JAGR+1,,) = DDCF'(1...IGTMAX(IAG),IAG,,)

where

IGTMAX, DDCF': as above

IAG: index of the age interval.

JAGL, JAGR: the corresponding ages
(e.g. IAG=2 corresponds to (JAGL,JAGR) = (1,4)).
The right boundary of interval Nr. 6 was set to 79 a.

DDCF: the differentials with respect to the integration time
with time and age steps of one year.

From the array IGTMAX, an array JGTMAX is set up, which tells for each age step how many non-zero values of the DDCFs exist, and only those will be written to the output file together with JGTMAX in order to reduce the size of the file.

Step 4 (preprocessor CRFDORI2):

The activity-dose-coefficients normalized to unit initial ground deposit, ADCs, describe mathematically the intake of activity with the foodstuffs, which starts at some time after the accident and is assumed to continue up to the end of life of the individual (taken to be the average life expectancy in the FRG, 75 a), and the radiation exposure resulting from this intake:

ADC(n,o,f;a;tsi) =

$$\int_{tsi}^{Tmax} dti AF(n,f,ti)*C(f,a+ti) \int_0^{Tmax-ti} dte g(n,o,a+ti,te)$$

where

n,o,f: indices indicating the radionuclide (n), the organ or tissue (o) and the foodstuff (f)

a: age of the individual at the time of the accident

Tmax: 75a - age at accident

tsi: starting time of ingestion

ti,te: times of ingestion and subsequent radiation exposure, respectively

AF: specific activity in the foodstuff normalized to unit initial

ground deposit [Bq/kg)/(Bq/m²)]

C: food consumption rate [kg/a]

g: differential dose conversion factor [Sv/(Bq*a)]

The ADCs contain the normalized specific activities in the foodstuffs and depend therefore on the assumed time of the release.

In practice, the ADCs are calculated by replacing the integrals by sums over time steps of length 1:

For KIGMIN > KIGMAX:

$$\text{ADC}(n, o, f; \text{IAG}; \text{IBA}) = 0$$

For KIGMIN <= KIGMAX:

$$\text{ADC}(n, o, f; \text{IAG}; \text{IBA}) =$$

KIG=KIGMAX

$$\sum_{\text{KIG}=\text{KIGMIN}}^{\text{KIG}=\text{KIGMAX}} \text{AFI}(n, f, \text{KIG}) * \text{C}(f, \text{JAG}(\text{IAG}) + \text{KIG} - 1) * \text{D}(n, o, \text{KEXMAX}(\text{KIG}), \text{JAG}(\text{IAG}) + \text{KIG} - 1)$$

with

$$\text{D} = \sum_{\text{KEX}=1}^{\text{KEX}=\text{KEXMAX}(\text{KIG})} \text{DDCF}(n, o, \text{KEX}, \text{JAG}(\text{IAG}) + \text{KIG} - 1)$$

where

n, o, f, C: as above

C: consumption rates [kg/a] for age steps of 1 year (see Ch. B.9)

AFI: yearly integrals of the specific activity in the foodstuff normalized to unit initial ground deposit [Bq/kg)/(Bq/m²)]

DDCF: the differentials from Step 3

and

IAG, JAG: indices representing the age group and the corresponding age:

IAG = 1, 2, 3, 4, 5, 6
JAG = 1, 2, 6, 11, 16, 21
age = 0, 1, 5, 10, 15, 20 a

IBA, JBA: indices for the banarray and the corresponding time:

IBA = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10
JBA = 1, 2, 3, 6, 11, 21, 31, 41, 51, 71
time = 0, 1, 2, 5, 10, 20, 30, 40, 50, 70 a

KIG,KEX: indices representing the intake and the exposure times

KIGMIN: JBA(IBA)

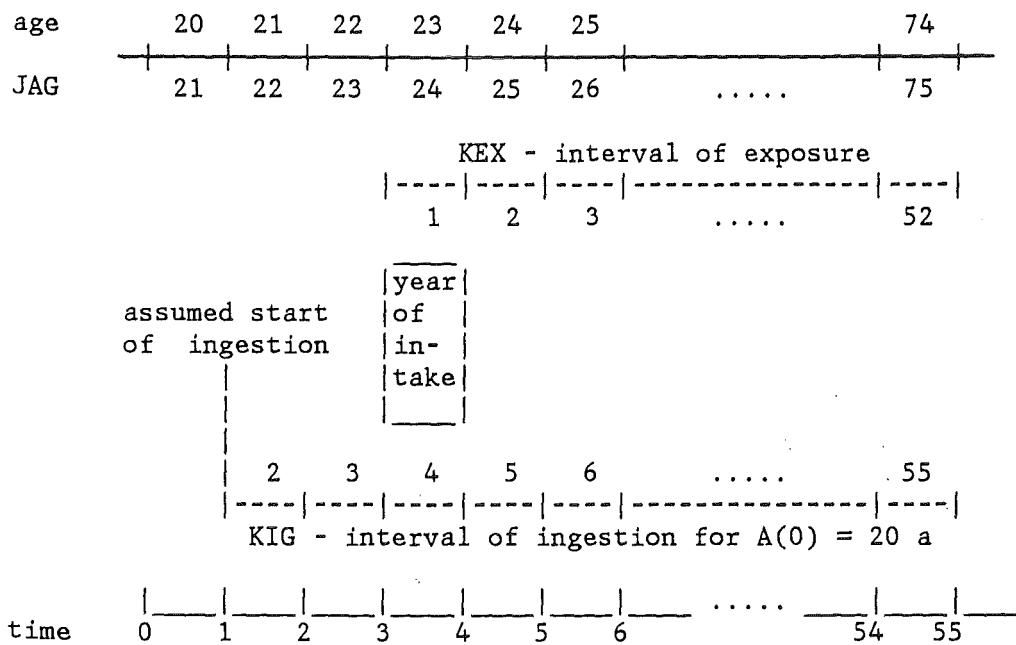
KIGMAX: 75-JAG(IAG)+1

KEXMAX: KIGMAX-KIG+1

The shift of 1 between the ages and times and the contents of the arrays JAG and JBA was introduced to avoid the index 0 when addressing AFI, DDCF etc., which is not valid for all compilers.

The time scales for ingestion, exposure, and age, and the corresponding indices are illustrated below for an individual with age 20 a at the time of the accident:

Fig. IV.11: Graphic example for the calculation of the ADS



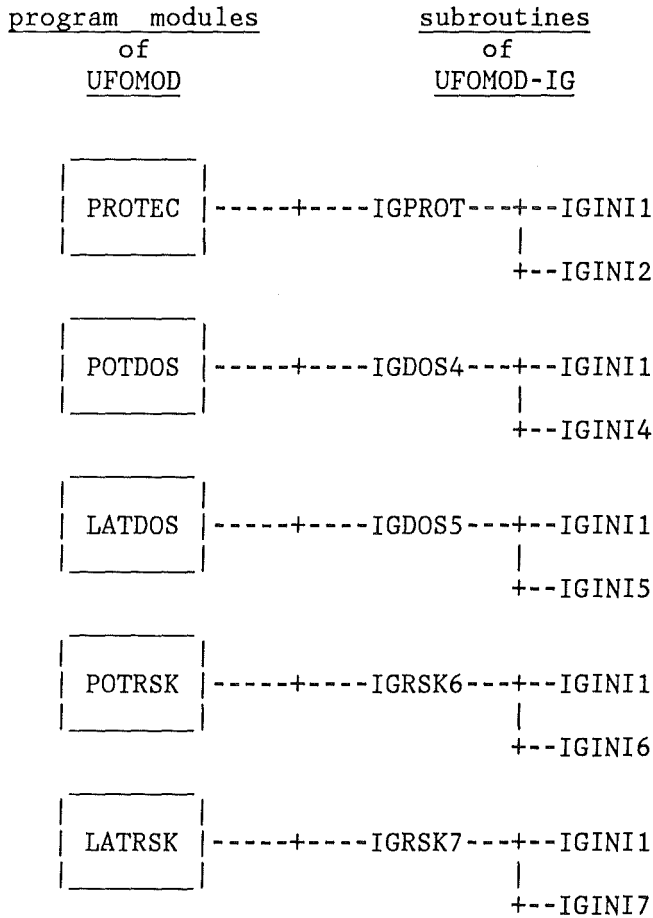
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Part V

The version of UFOING implemented in UFOMOD

Modified versions of some parts of UFOING are implemented in the UFOMOD program system to calculate the ingestion related accident consequences for UFOMOD; they are here collectively referred to as "UFOMOD-IG". The subroutines of UFOMOD-IG are shown in Fig. V.1 together with the program modules of UFOMOD which call the subroutines.

Fig. V.1: Structure of UFOMOD-IG



In IGPROT, the foodbans and their duration are calculated for each foodstuff. IGDOS4/IGDOS5 calculate the individual lifetime doses, IGRSK6/IGRSK7 the individual risk, without and with taking the effects of foodbans into account, respectively. The further evaluation of the results produced by the subroutines to give CCFDs etc. is performed elsewhere in UFOMOD.

IGINI1 is for the initialization of the ingestion nuclides considered in the run: always the intersection of all ingestion nuclides contained in the ingestion nuclides definition file with all those from the UFOMOD activity concentrations on the ground is taken; the selection cannot be influenced by the user as it is possible in UFOING. The other initialization subroutines, IGINI2 - IGINI7, set up all other data needed for the calculations.

IGINI1 corresponds to parts of the main program of UFOING, the subroutines IGPROT, IGDOS4/IGDOS5 and IGRSK6/IGRSK7 together with their individual initialization subroutines correspond to the calculation and initialization subroutines of the UFOING modules MBANS, MINDO and MRISK, respectively.

There are some differences between UFOMOD-IG and UFOING which do not affect the calculations but the flexibility of UFOMOD-IG; for the calculations of the results, with the exception of the treatment of seasonal effects, all algorithms, assumptions and data sets are identical to those described in Part I for the corresponding UFOING module. The aspects, in which UFOMOD-IG differs from the corresponding parts of UFOING, are described below.

Treatment of seasonality

As in UFOING, ingestion data sets are used for assumed releases on the 1st of January and of July, respectively. However, the weather sequences are treated in a different way:

The year is divided into a "summer period", which is taken to last from April to October, and a "winter" period from November to March. Each weather sequence is, depending on its real date, attributed to one of the time periods, and the results are calculated with the ingestion data representative for the corresponding period. The values obtained in this way approximately represent averages over the different seasons.

In order to keep the size of the load module manageable, the ingestion data are not kept in core for both release times. Instead, every time the weather sequence considered indicates a change of the season from "summer" to "winter" or backwards, all ingestion data are re-initialized. For each new initialization, the characteristics of the data file currently in use are printed out for control. As an example, for weather sequences covering a period of two years, this happens five times in a run.

Mapping of UFOING and UFOMOD nuclides

This is performed in the way described in Part III, Chapter E.2 with one exception: UFOMOD-IG uses an additional array NUKUFD to address the nuclide, for which the calculated results shall be stored in the array(s) of results. This is necessary, because UFOMOD does not treat the radionuclides from decay chains as (artificial) nuclides of their own, as UFOING does (see below). The addressing of the ground concentrations and dose- or risk- data is done with the arrays NUKUFC and NUKING as in UFOING (all three arrays are set up in subroutine IGINI1).

A radionuclide originating from a radioactive decay after deposition is treated differently in UFOMOD-IG, dependent on whether a corresponding nuclide is present in the ground concentrations from UFOMOD or not. In the first case, the doses/risks resulting from the deposited nuclide and the nuclide coming from the decay chain are added together, in the second case, the dose- or risk contribution from the daughter is added to the mother, in order not to lose it. This is illustrated in the following examples for the decay Pu-241 -> Am-241:

Example 1:

PU-241 $R(\text{PU-241}) = \text{GC}(\text{PU-241}) * \text{CF}(\text{PU-241})$
Am-241 - ground concentrations $R(\text{AM-241}) = \text{GC}(\text{Am-241}) * \text{CF}(\text{AM-241})$
exist $+ \text{GC}(\text{Pu-241}) * \text{CF}(\text{AM-241D})$
for such a nuclide

Example 2:

PU-241 $R(\text{PU-241}) = \text{GC}(\text{PU-241}) * \text{CF}(\text{PU-241})$
 $+ \text{GC}(\text{PU-241}) * \text{CF}(\text{AM-241D})$
Am-241 - ground concentrations
do not exist
for such a nuclide

where R stands for the result, GC for the ground concentration, and CF for the (normalized) conversion factor.

Organs / health effects considered

The number and order of the organs considered in UFOMOD-IG is different to the ones in UFOING ([2] and Part I, Tab. I.3). Therefore, each of the IGINI2 - IGINI7 subroutines contains an array IORNEW, which brings the organs from the input data files into the order required by UFOMOD. The values for IORNEW are currently set up by DATA statements in the source code and refer to the UFOING default parameterization.

Use of parameters other than organs

The individual doses and risks are parameterized with respect to the organs/health effects and radionuclides in IGDOS4/5 and IGRSK6/7. All doses are calculated for adults only. Two versions exist of UFOMOD-IG which differ with respect to the calculation of the individual risks: in one version, the risk is calculated only for the maximum observation time, in the other one, the full range of observation times is retained.

Capability to work with data sets other than the default ones

UFOMOD-IG is currently only able to run with the default data sets of UFOING. However, only relatively few modifications of the source code are required to make it as flexible as UFOING with respect to operate with different ingestion data files.

Runtime options for UFOMOD-IG

Only a few of the UFOING runtime options are made use of in UFOMOD-IG. A description of the subset is given in reference [2].

Checks on input data

No checks are performed on the runtime options for UFOMOD-IG and the ingestion input data with the exception of the number of ingestion nuclides considered in the run, which must not exceed the maximum number permitted (defined by the PARAMETER constant MAXING in the source code).

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