ClimChAlp – Regional Climate Data

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Outline

- Introduction
- GCM data
- Available regional data
- Climate of the 20th Century
- Future climate
- Outlook
- Conclusions

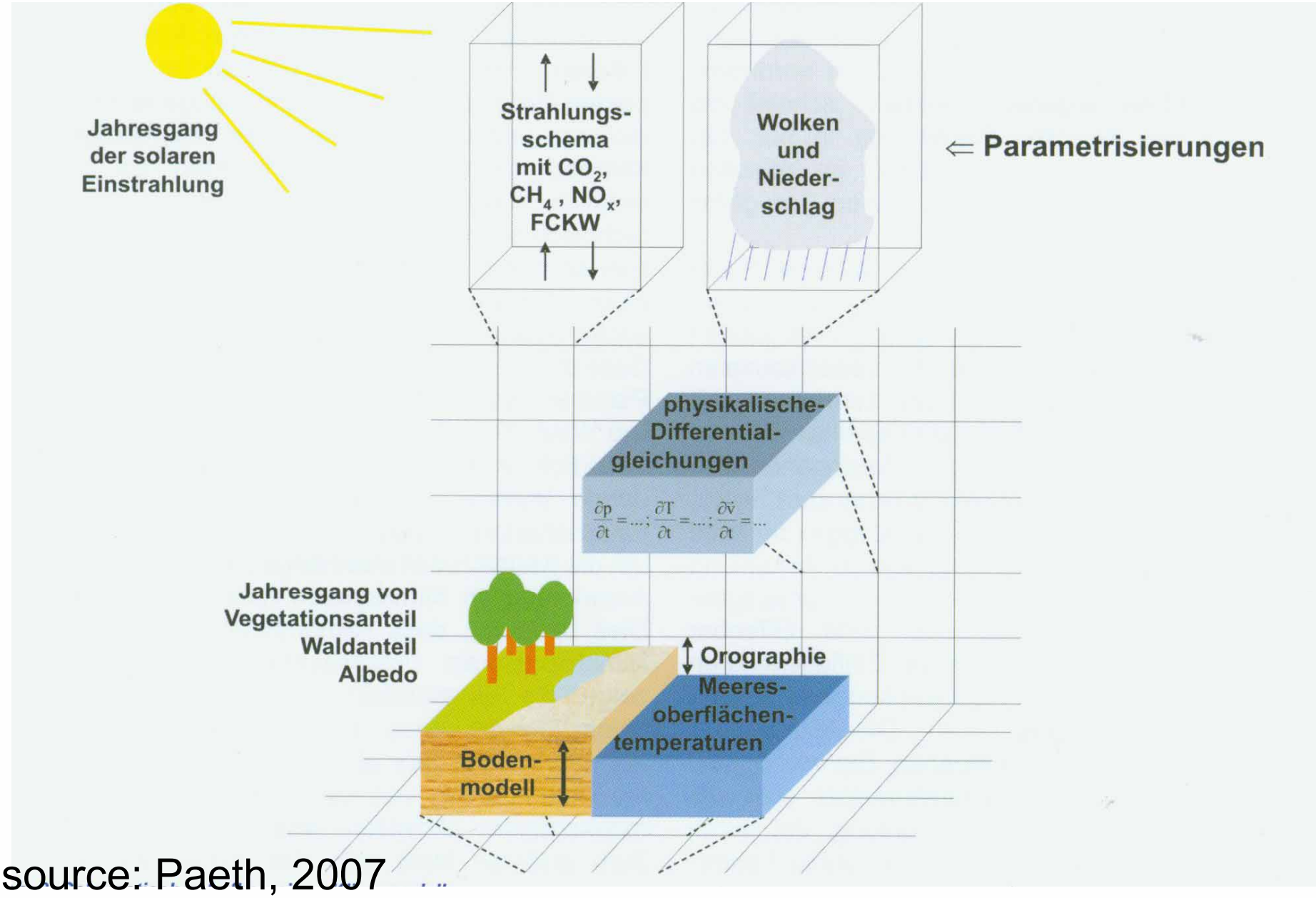
Aims of ClimChAlp

The ClimChAlp Interreg III B Alpine Space project aims at supporting the political decisions regarding protection and natural disasters prevention due to climate change in the Alps

Aims of the present project:

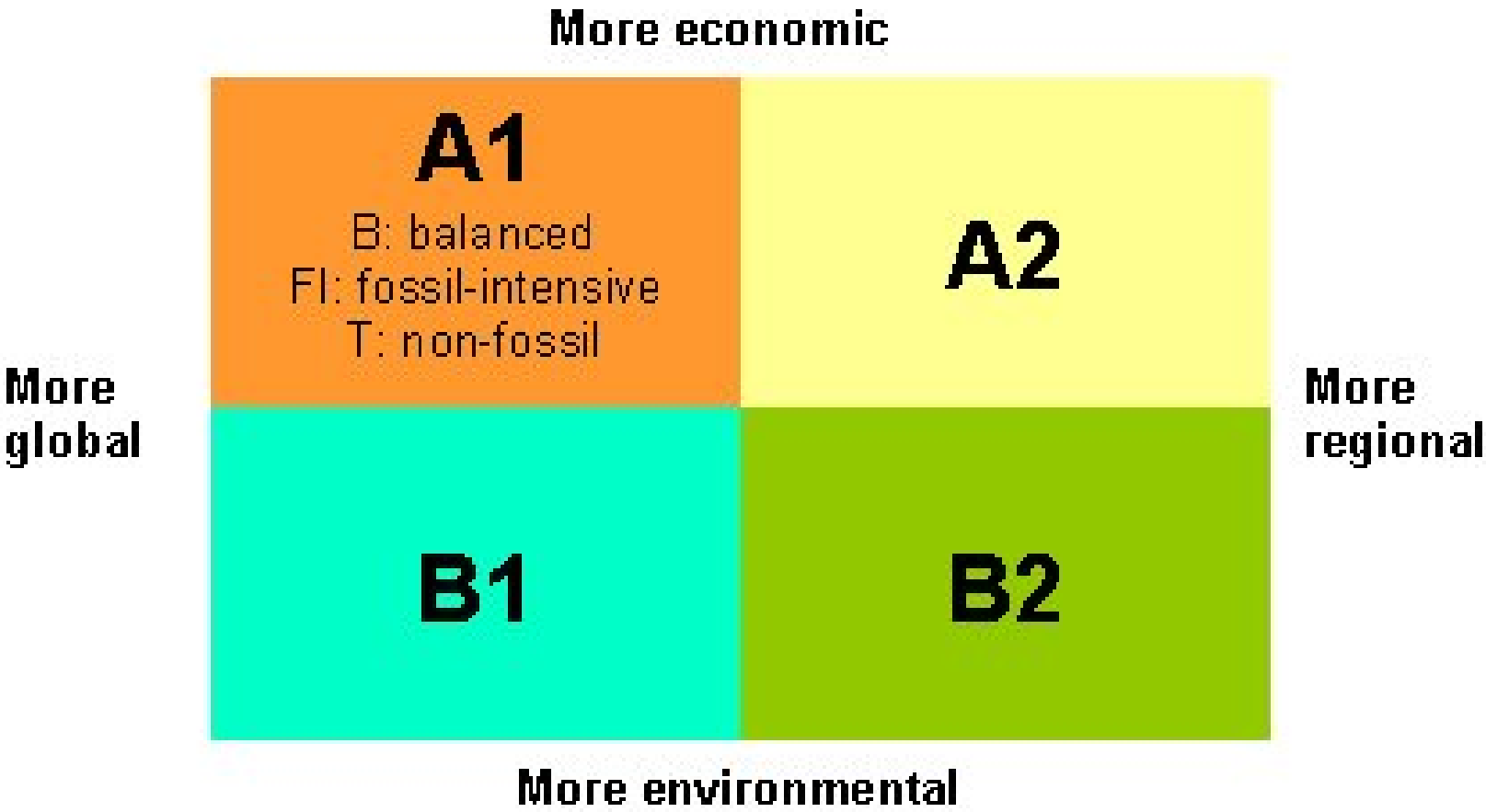
- Provision of information on available high resolution climate change, climatology data data for the Alps
- Comparison of available high resolution climate change data
- Recommendation for application in smaller alpine catchments in hydrological applications

General Circulation Model (GCM)

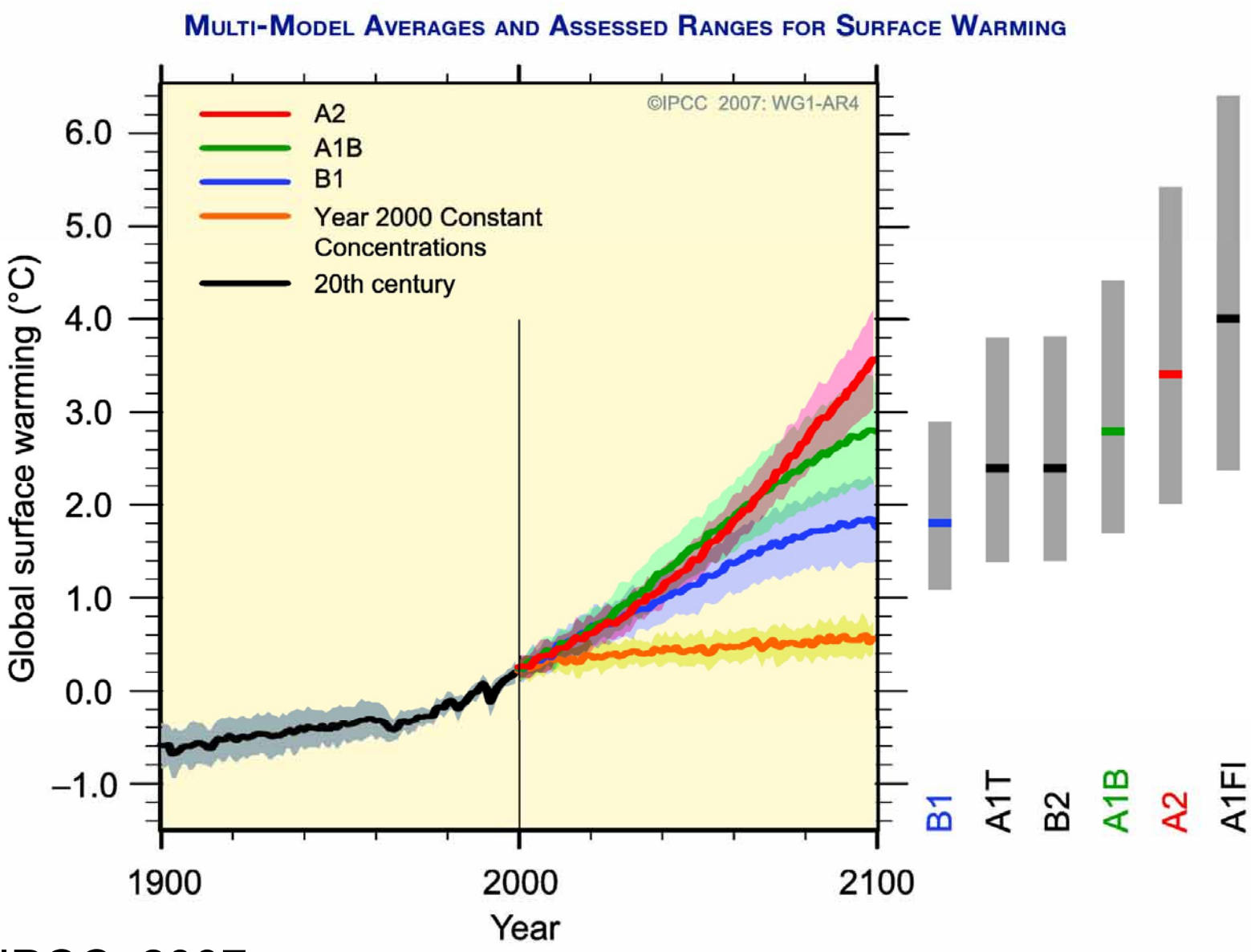


source: Paeth, 2007

SRES Scenarios



Global temperature change

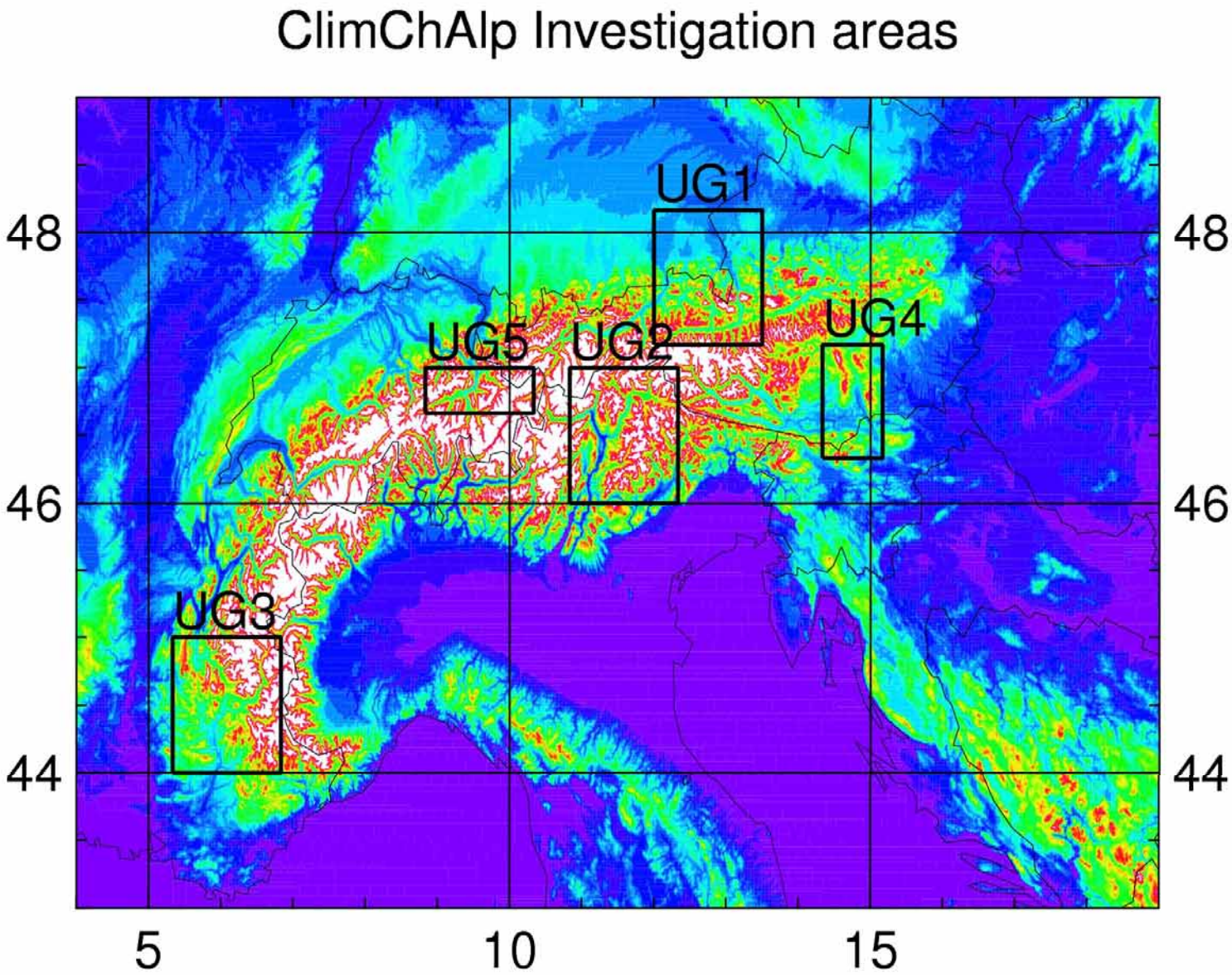


Source: IPCC, 2007

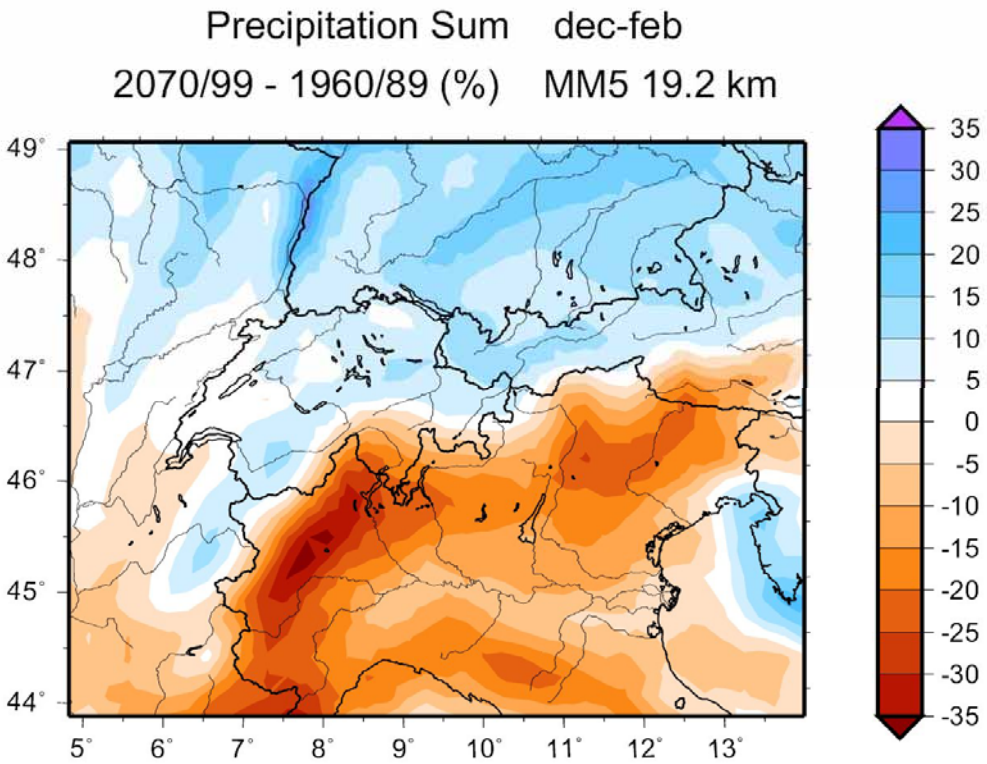
Selected GCM Climate Change Scenario runs

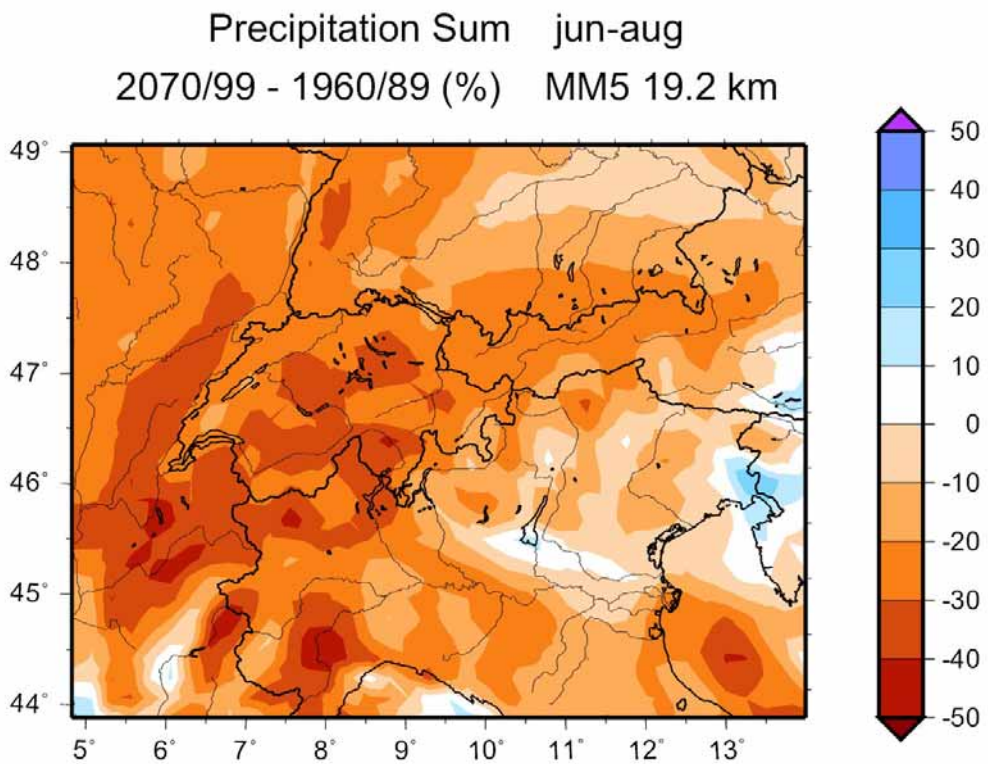
Lqvwlwxwlrq	Frxqwu	ISFF Report	Prgho	WUXQF	JUIG	O	Vfhqduhr
METO	United	TAR	HadCM3	-	2.5° x3.75°	19	A1FI,A2(3),B1,b2(2)
	Kingdom	AR4	HadCM3	-	2.5° x3.75°	19	A2,A1B,B1
		AR4	HasGEM1	-	1.25°x1.875	38	A2,A1B,B1
MPI		TAR	ECHAM/OPYC3	T42	2.8°x2.8°	19	A2,B2
		AR4/ENS	ECHAM5/MPI-OI	T63	1.5°x 1.5°	31	A2(3),A1B(3),B1(3)
NCAR	USA	TAR AR4	PCM	T42	2.8°x2.8°	18	A1B,A2,B2
CCCma	Canada	TAR AR4	CGCM2	T32	3.8°x 3.8°	10	A2,B2
CSIRO	Australia	TAR AR4	CSIRO Mk2 CSIRO Mk3	R21	3.2° x 5.6°	9	A1,A2,B1,B2
JIGO	USA	TAR AR4	JIGOU63 FP 513 CM2.1	R30	2.2° x 3.8°	14	A2,B2

Investigation areas

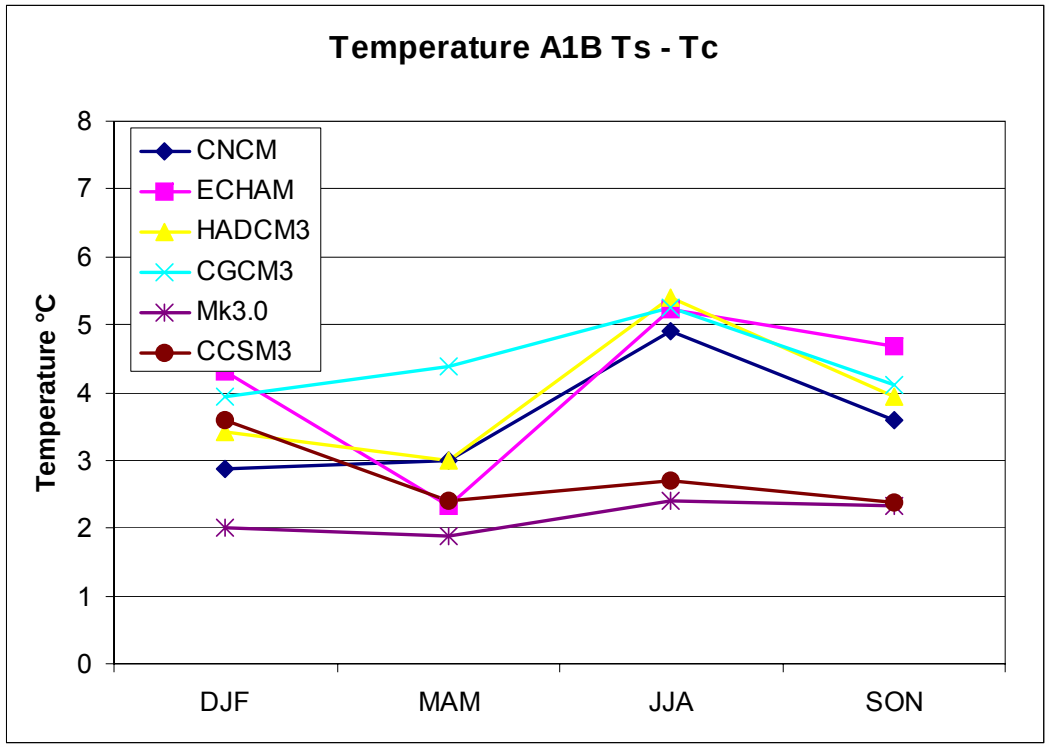


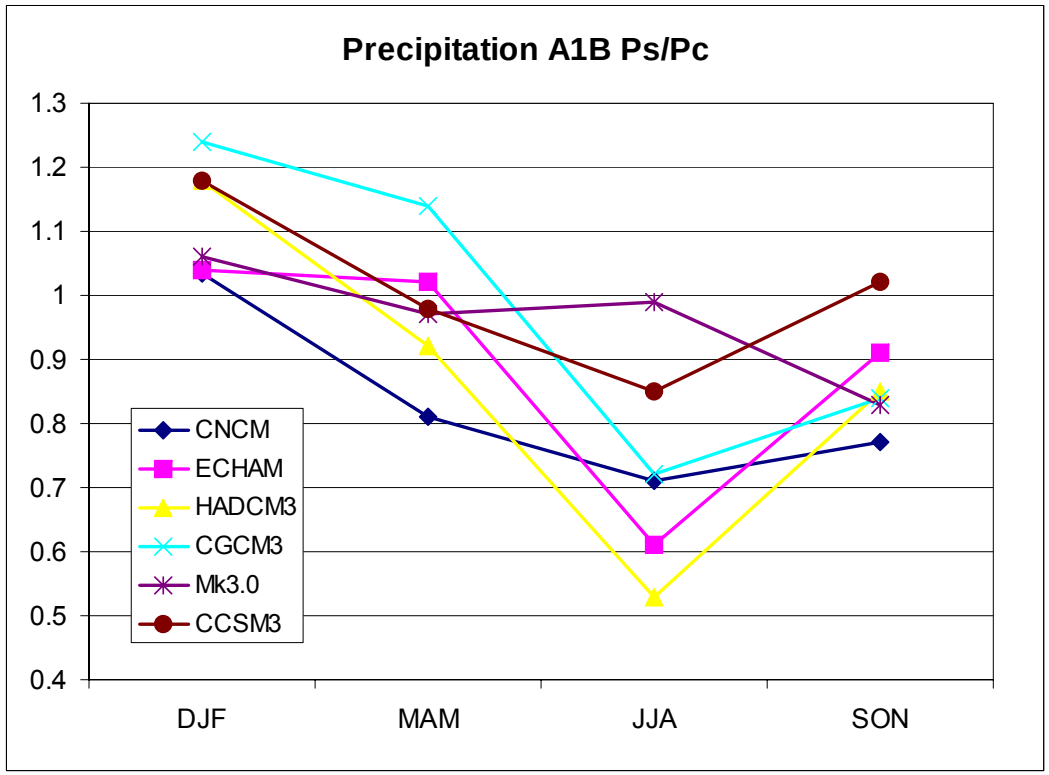
ECHAM4 – MM5 RCM





GCM – Greater Alpine Area (GAR)





c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Principle of Downscaling of Climate Change Data

Regionalization techniques

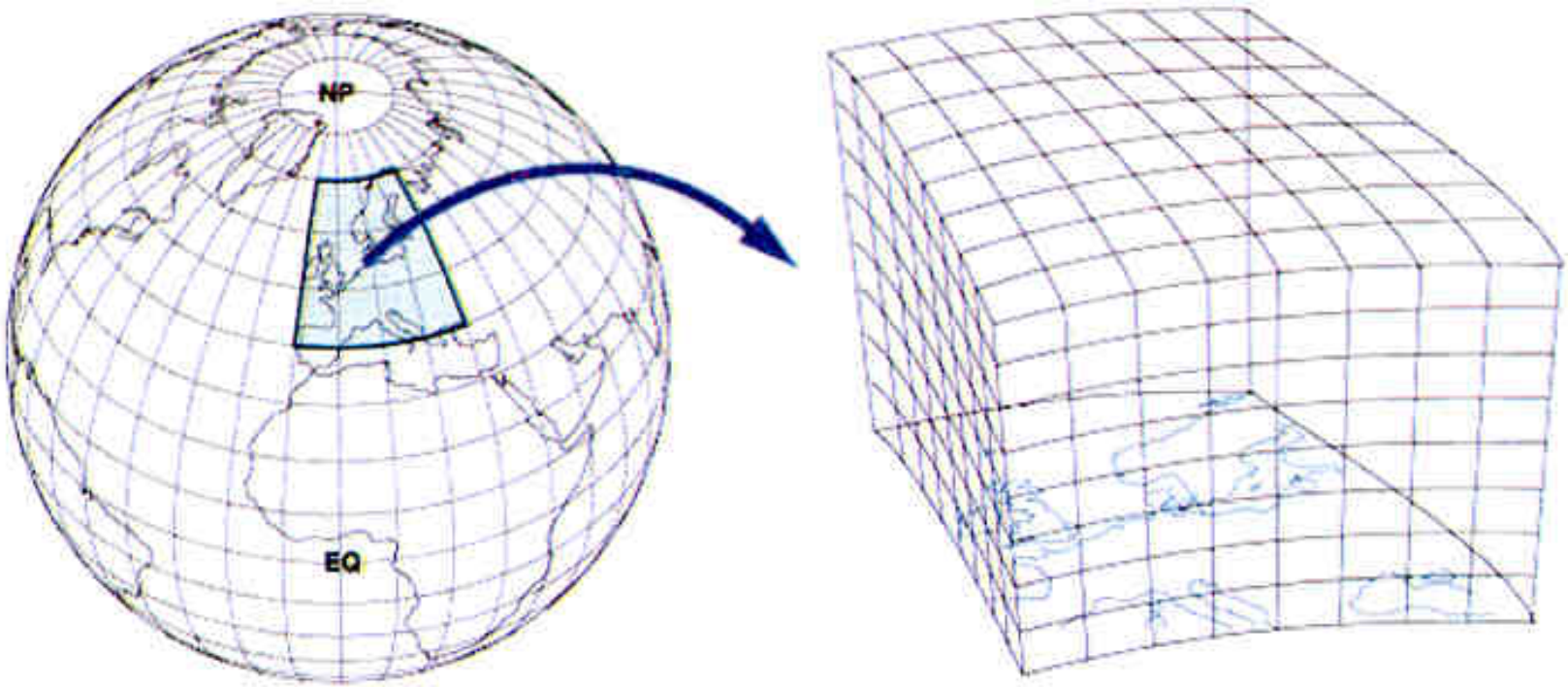
Statistical downscaling
- statistical relations between large scale forcing & station observed variables
- e.g. via multiple regression, canonical correlation analysis, circulation pattern analysis
- computationally efficient
- climate change information derived only at station locations
- gridded fields obtained by spatial interpolation between station locations
- persistence of statistical relations under changing climate conditions assumed

Dynamical downscaling
- 3-dim regional atmospheric models (RCM) based on conservation laws, physical relations, parameterizations for subgridscale processes
- nested approach: global model provides lateral boundaries of regional model
- computationally expensive
- usually coupled atmosphere-land surface modeling systems

+ Combined statistical-dynamical methods

Principle of Downscaling of Climate Change Data

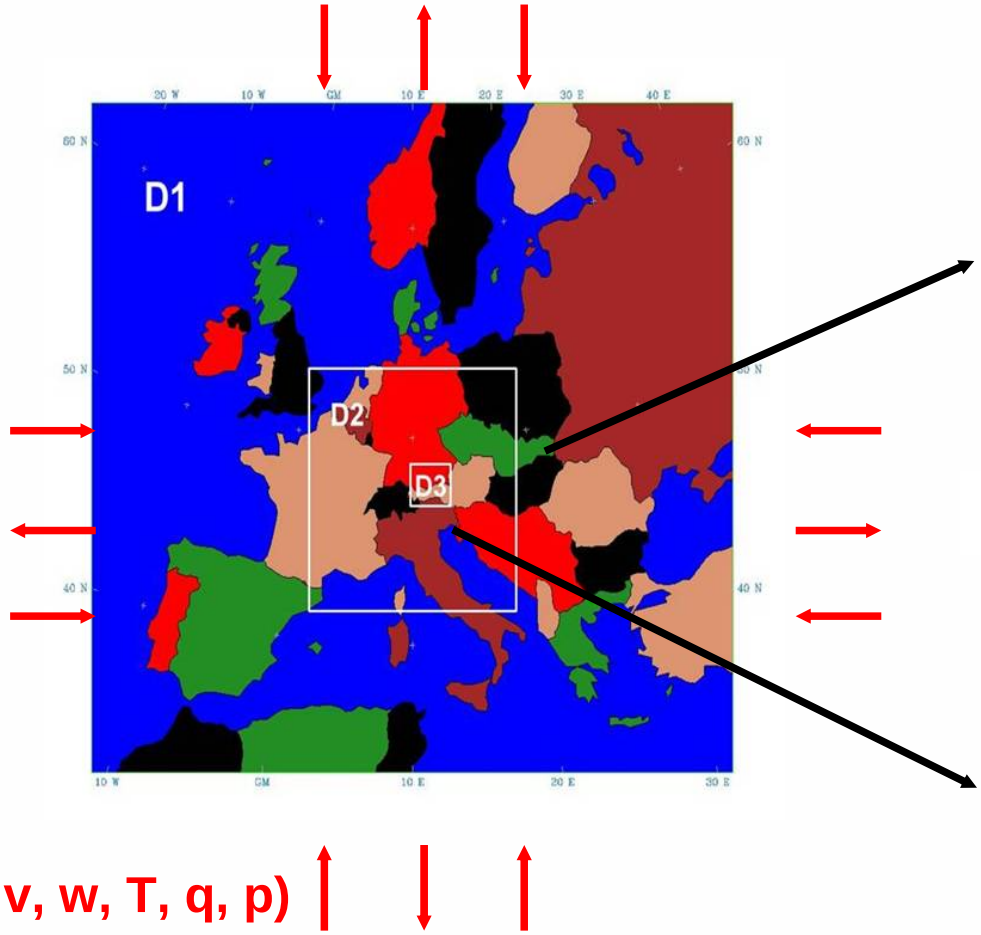
Dynamical Downscaling: Regional Climate Models (RCMs)

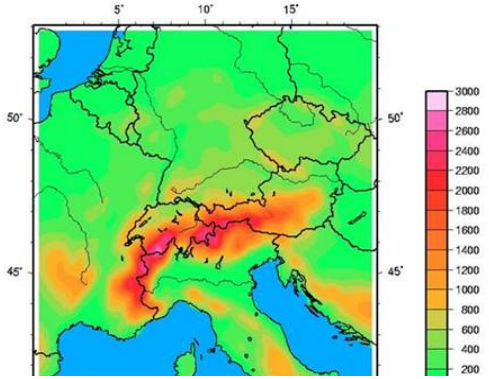


Principle of Downscaling of Climate Change Data

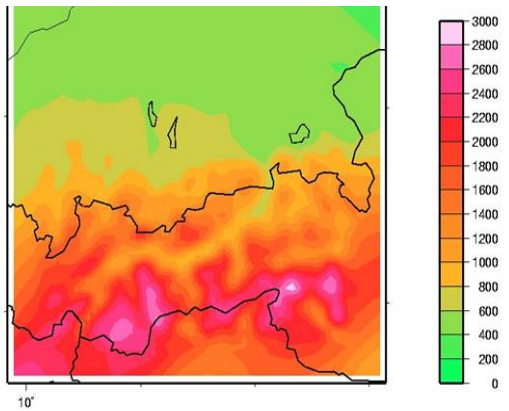
RCM: forced by global model (boundary- & initial value problem)

High spatial resolution ⇒ detailed consideration of orography





Orography in 20x20 km^2 resolution



Orography in 4x4 km^2 resolution

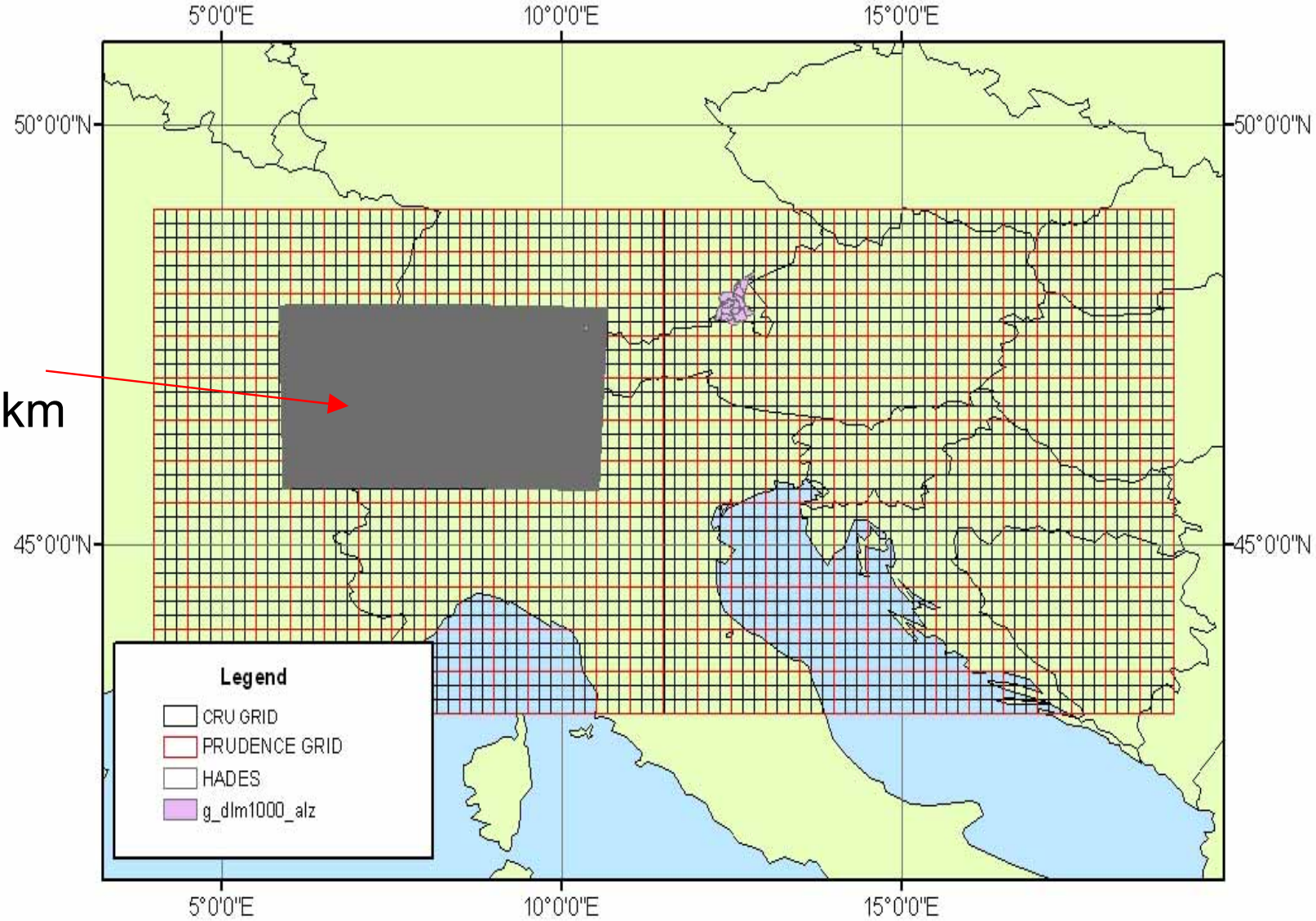
Performance Analysis: Applied Statistics

- Temperature
  - Monthly mean (All Areas)
  - Mean (DJF MAM JJA SON) (All areas)

- Precipitation
  - Monthly mean
  - Mean (DJF MAM JJA SON) [mm/day] (All Areas)
  - Wet-day frequency (Precip. >= 1 mm)[fraction] (UG1)
  - Wet-day frequency (Precip. >= 15 mm)[fraction] (UG1)

Alpine data extent

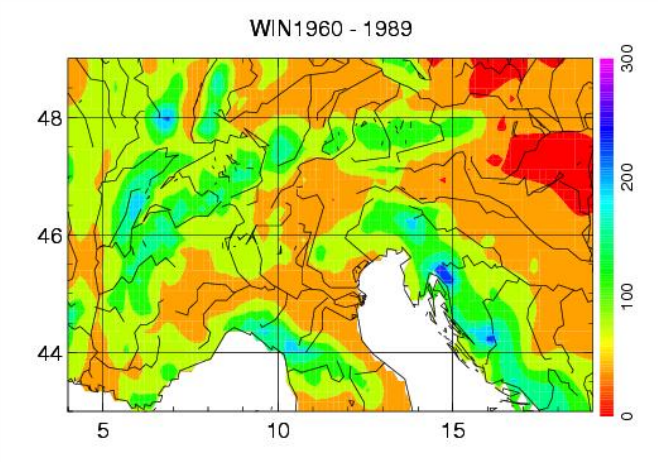
HADES
2km x 2km



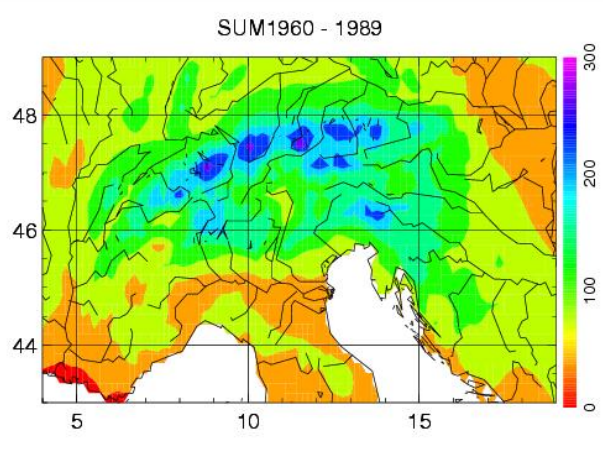
Resolutions : 0.5° x 05° and 10' x 10'

Observational data

- CRU ALP-IMP 10’ gridded monthly
- CRU TS1.2 10’ gridded monthly
- Measurements on monitoring stations, daily (UG1 only)
- CRU 0.5° gridded monthly
- Delaware University , 0.5° gridded monthly

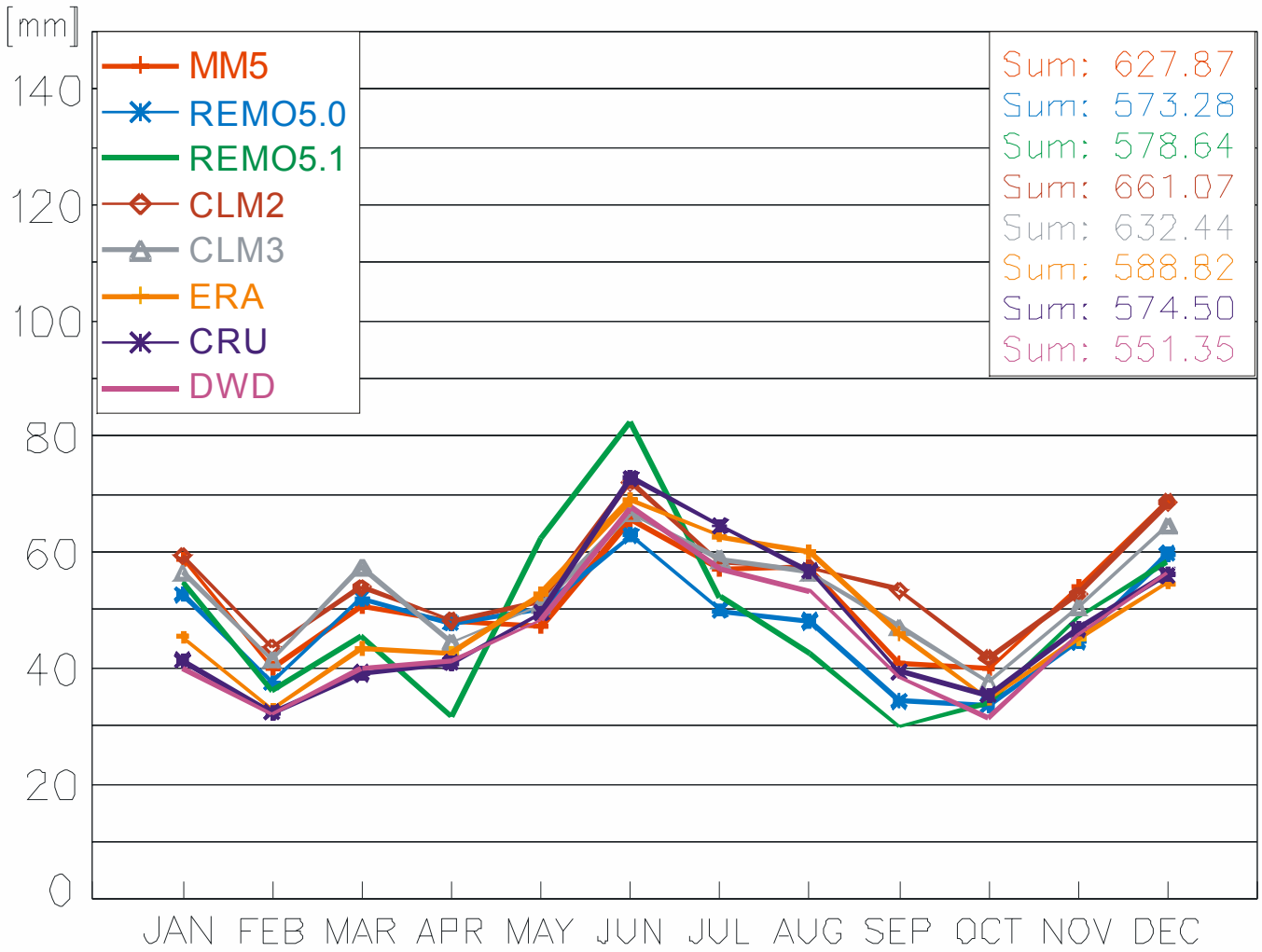


CRU-Alpine Climate Data

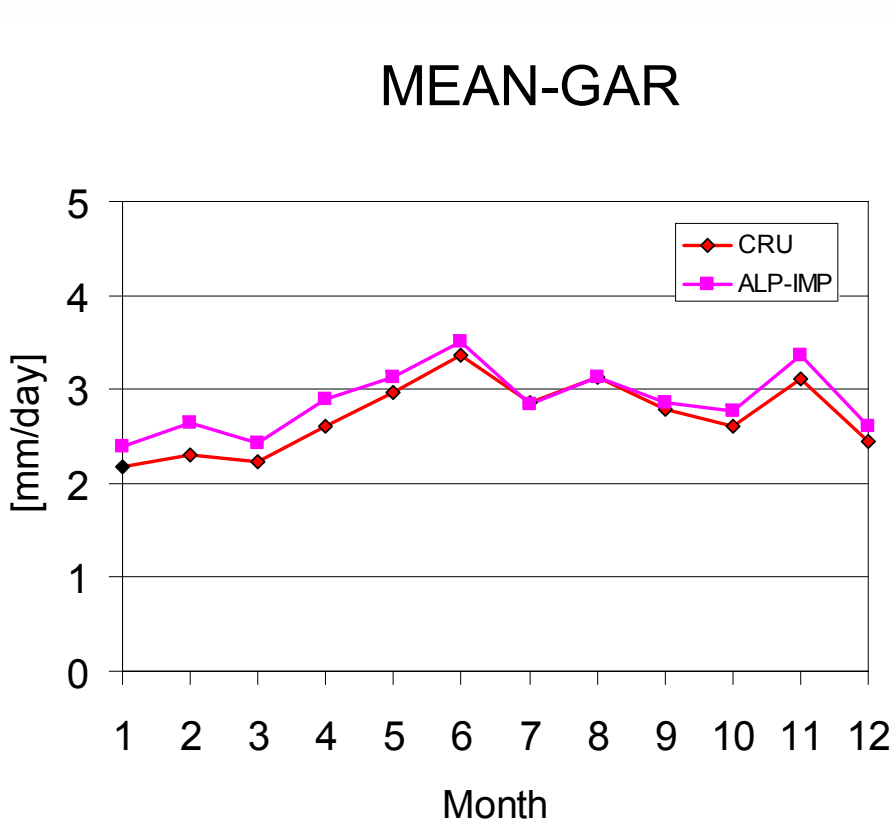


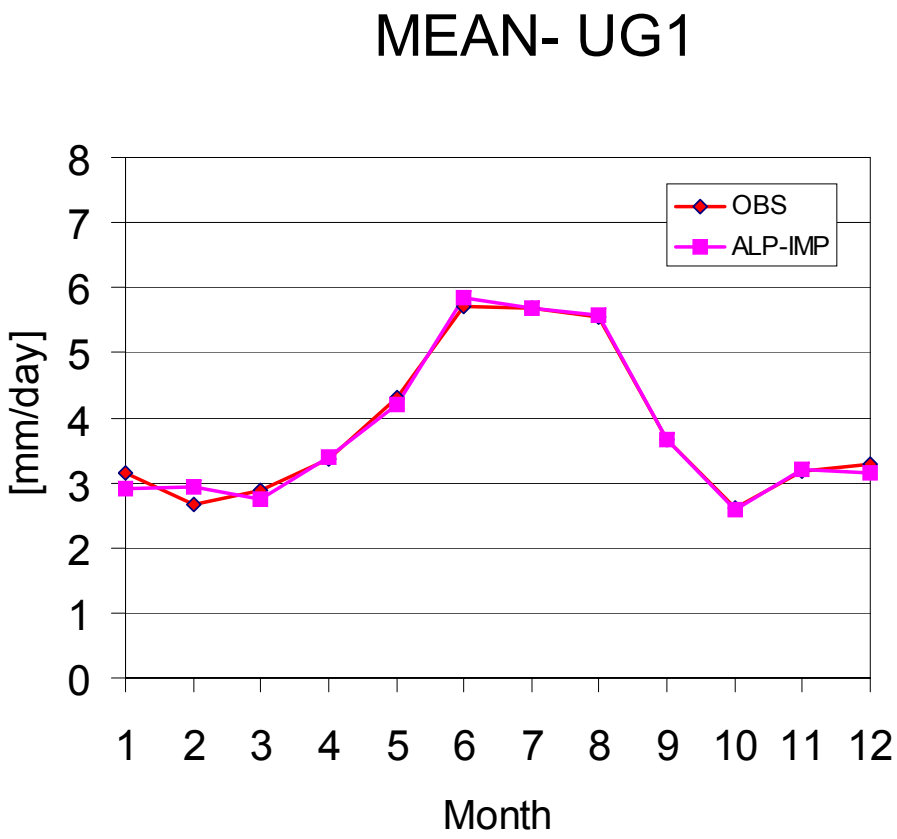
Regionale Climate Modeling: DEKLIM-QUIRCS

Annual cycle of precipitation in Germany



Relation ALP-IMP, CRU, OBS



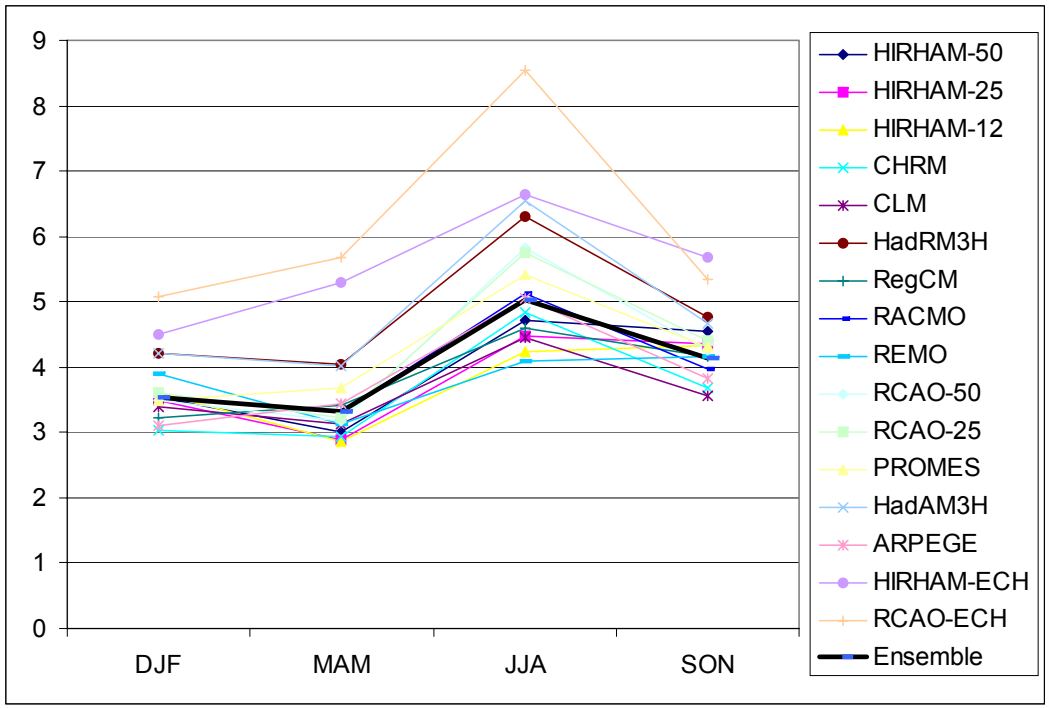


CRU 1.2 (10'), (CRU) ALP-IMP (10'), OBS – station mean in 10' grid

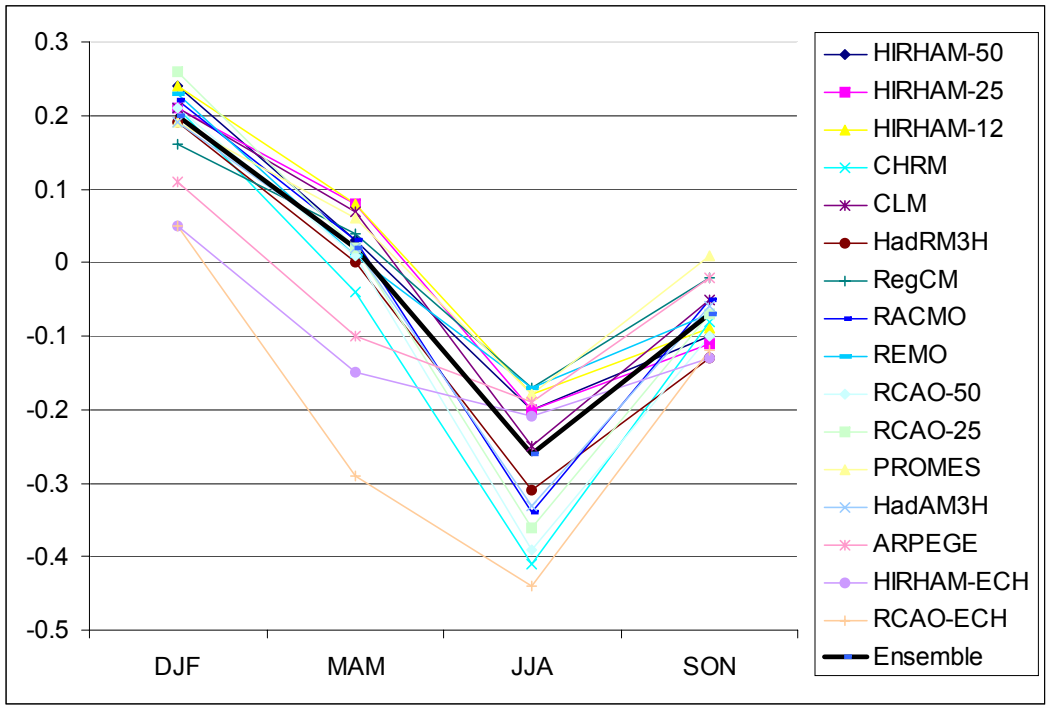
PRUDENCE Project

0.5° x 0.5° grid ≅ GAR area

Temperature Ts-Tc [°C]



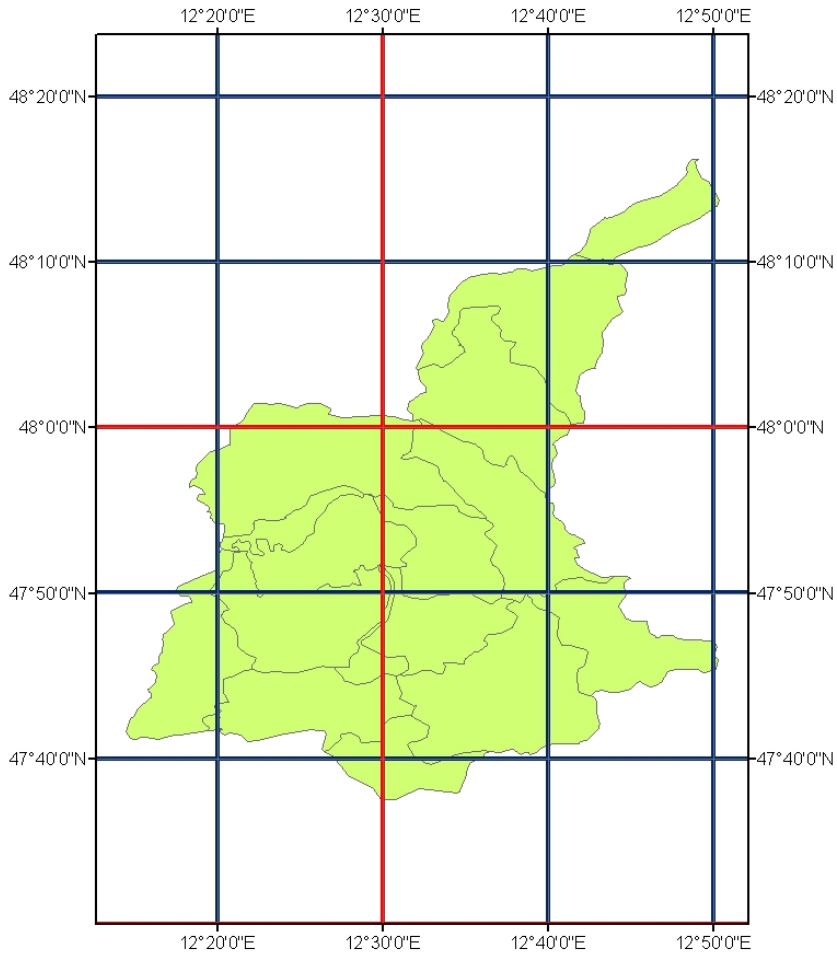
Precipitation Ps-Pc



c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Spatial resolution (Example Alz – Area)

ALP-IMP 1/6 ° x 1/6 ° (blue) and 0.5°x0.5° (red) grids



In any investigation at least 2dx !

Available high resolution data

SRES	GCM	RCM	SDM	Ensembles
SRES B1	ECHAM5	CLM		2?
	ECHAM5	REMO		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES B2	Had3	RegCM		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A1B	ECHAM5	CLM		2?
	ECHAM5	REMO		1
SRES A1FI	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A1	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1
SRES A2	Had3	HIRHAM		1
	Had3	ReGCM		1
	EGHAM5	REMO		1
	PCM		TYN	1
	Had3		TYN	1
	CSIRO2		TYN	1
	CGCM		TYN	1

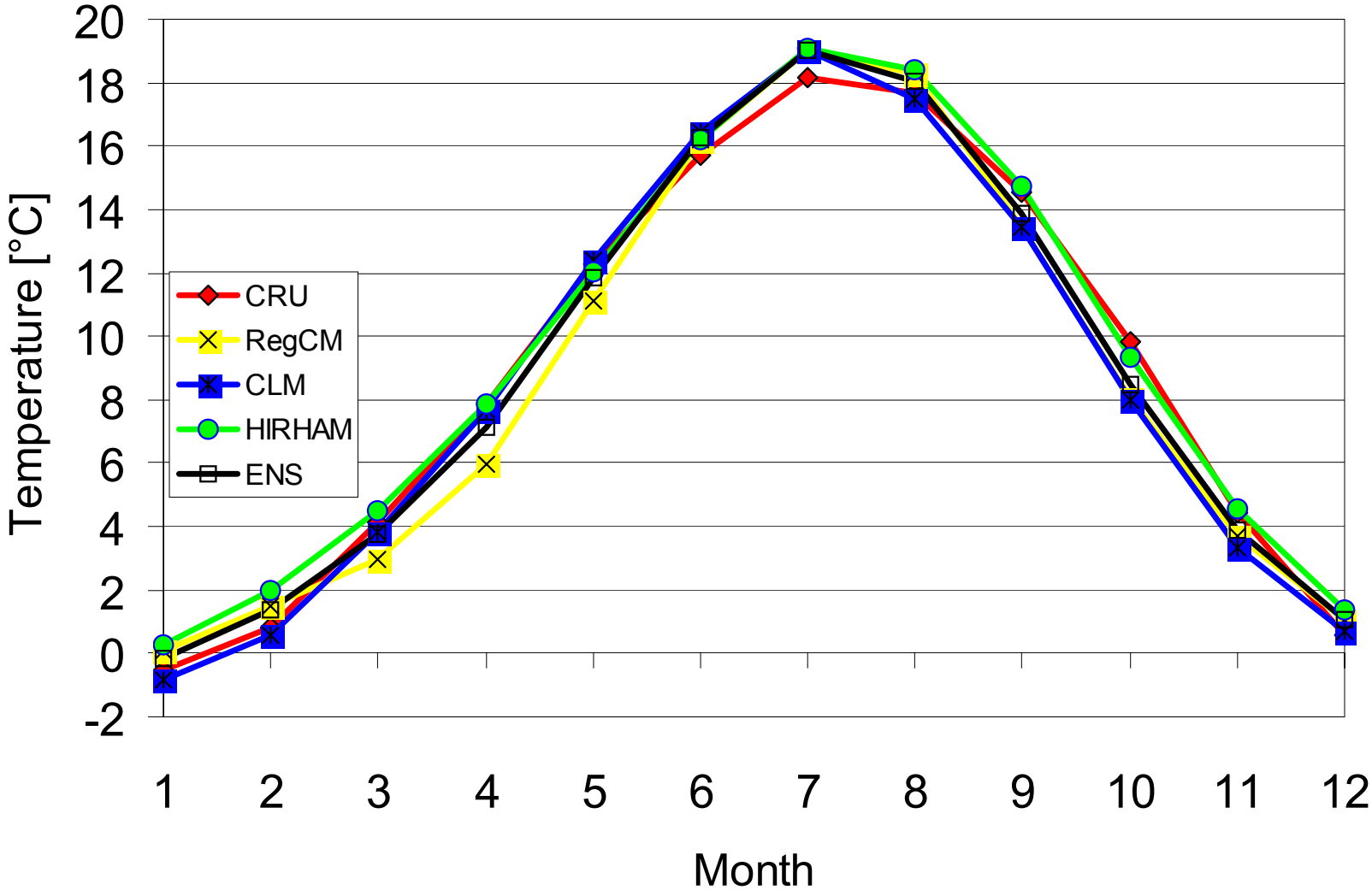
CLM – hourly data will be available from CERA Database. Scenario A1B only until 2055! Workshop in December will decide when the data will be made available to all users

RegCM – daily -> all parameters, hourly ->data not available

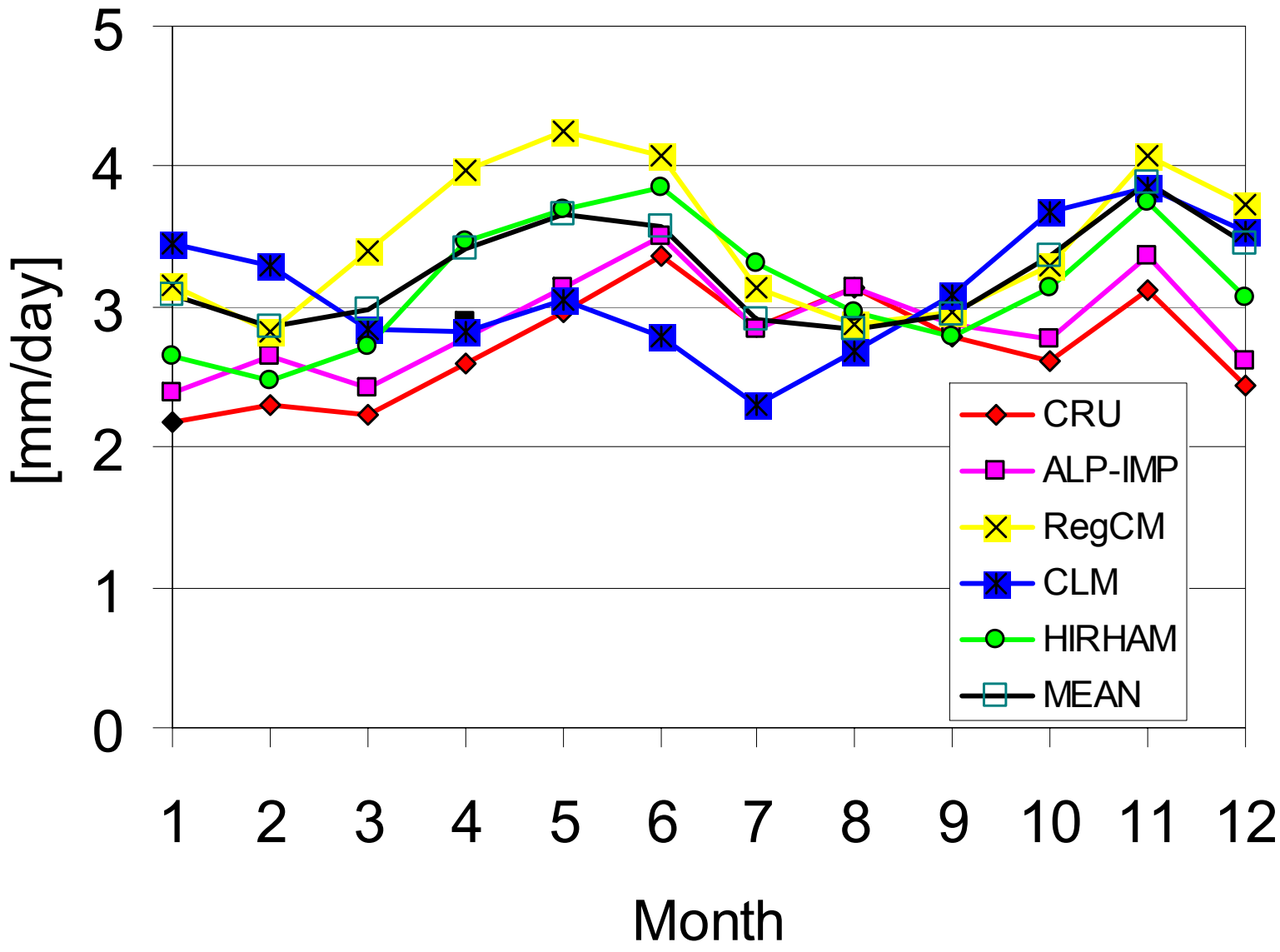
REMO – hourly data available from CERA Database

HIRHAM – daily data in the Internet, hourly ?

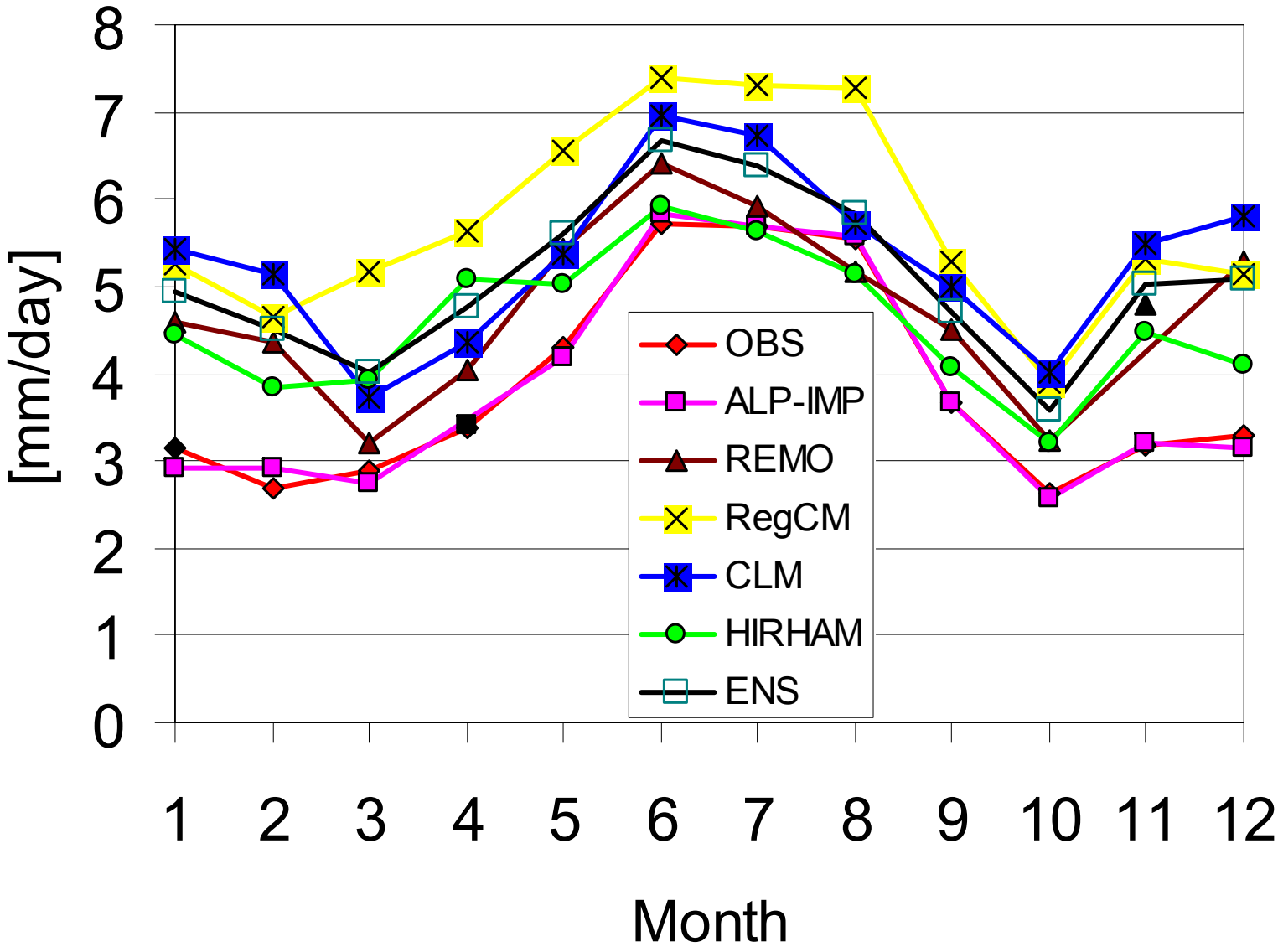
Mean Temperature 1961-1990: GAR - CRU



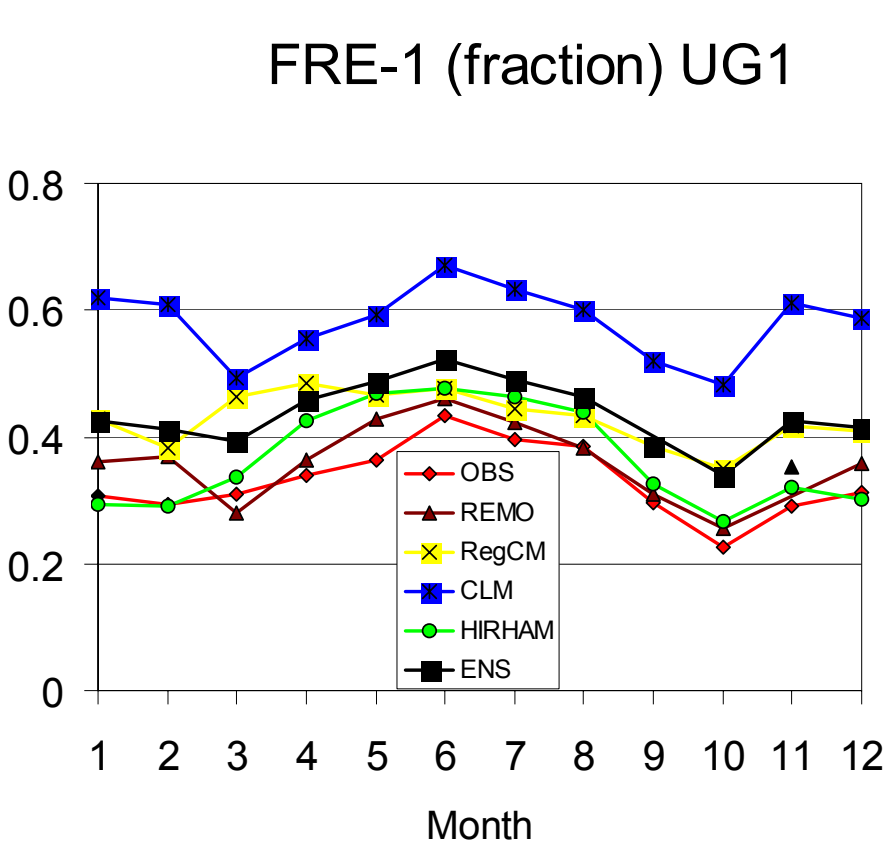
Precipitation 1961-1990: GAR - CRU and ALP-IMP

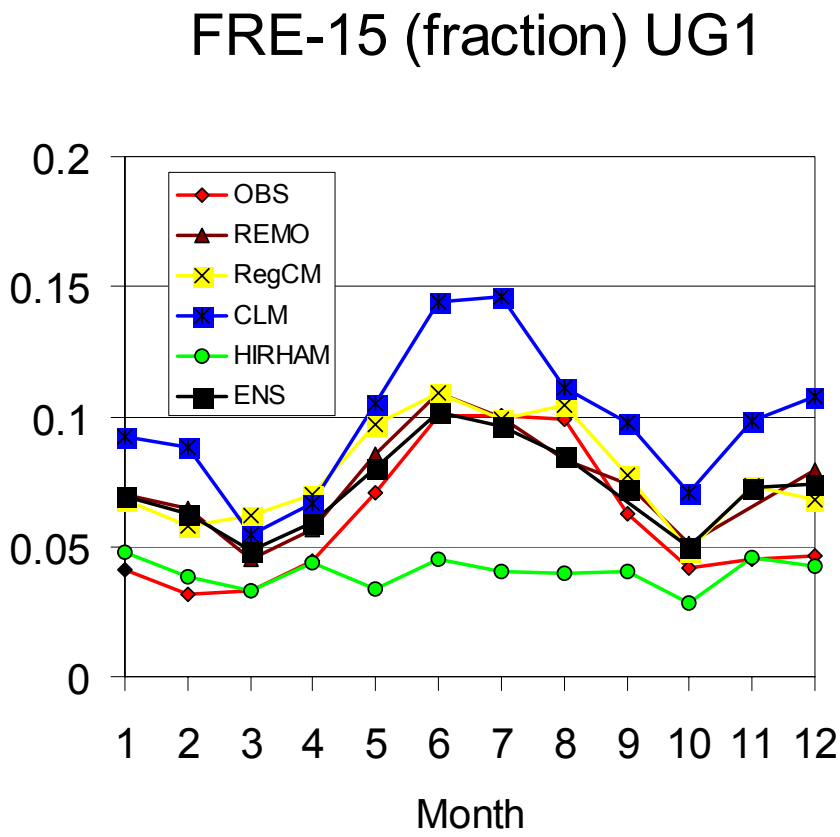


Precipitation 1961-1990: UG1 - OBS and ALP-IMP



Precipitation statistics UG1





Performance for Present Climate (Precipitation)

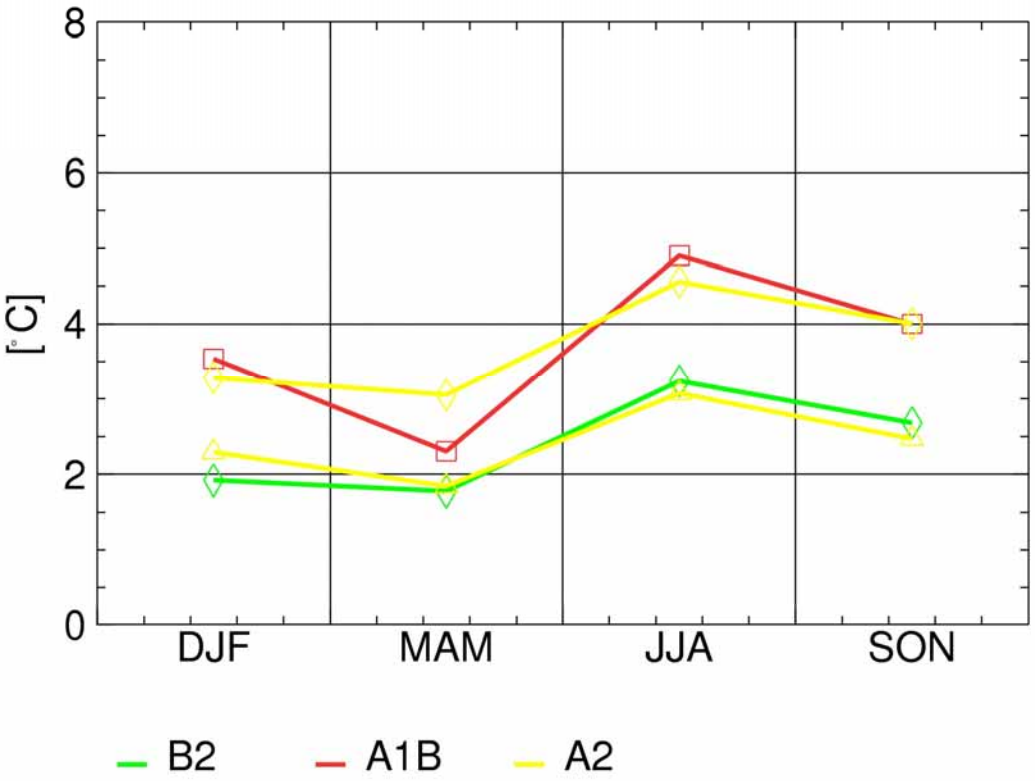
Bias of RCM in domain mean (diagnostics in % of observed values)

Model	DJF							
	GAR	UG1			UG2	UG3	UG4	UG5
	Mean	Mean	FRE-1	FRE-15	Mean	Mean	Mean	Mean
CLM	34	80	99	142	58	58	15	35
HIRHAM	7	36	-3	8	38	3	8	31
RegCM	27	65	34	63	36	48	-1	108
REMO	-	56	19	80	-	-	-	-
ENS	23	60	37	74	44	36	7	58
OBS	-	3.03	0.3	0.04	-	-	-	-
ALP-IMP	2.55				1.75	2.9	1.7	2.9
	JJA							
CLM	-18	15	57	34	-8	-8	-38	-9
HIRHAM	7	-2	14	-59	17	28	-9	1
RegCM	6	30	12	4	42	10	-14	35
REMO	-	3	4	-3	-	-	-	-
ENS	-2	12	22	-6	17	10	-20	9
OBS	-	5.7	0.4	0.1	-	-	-	-
ALP-IMP	3.16				4	2.3	4.6	4.6

[model resolutions < 20 km]

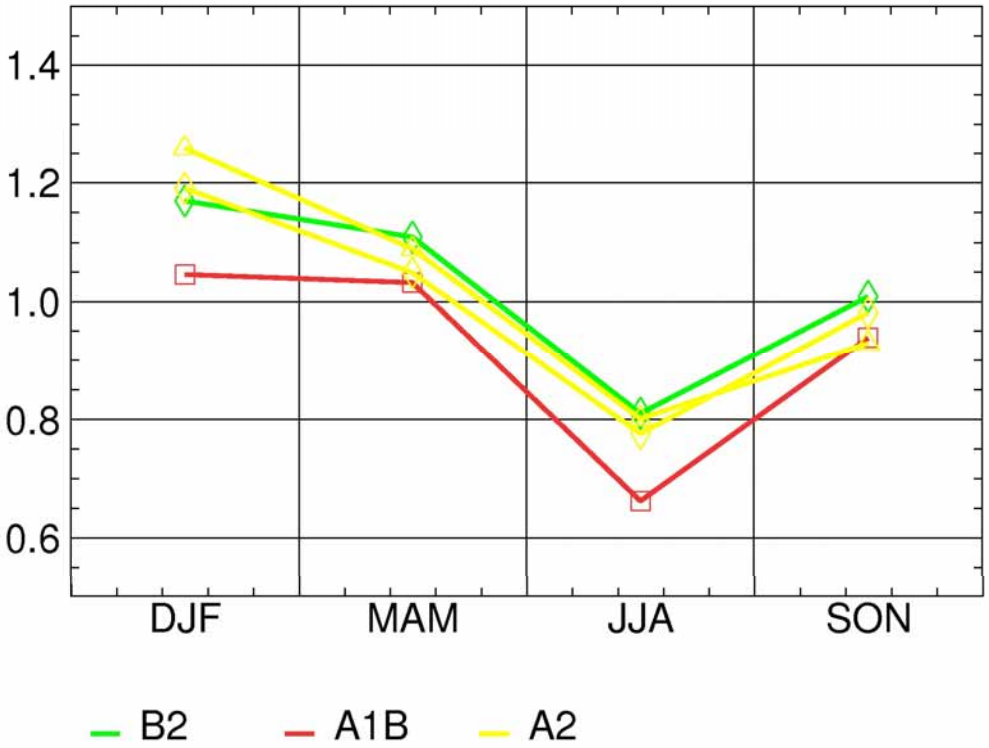
Future climate (CLM, HIRHAM and RegCM)

Temperature GAR Ts-Tc



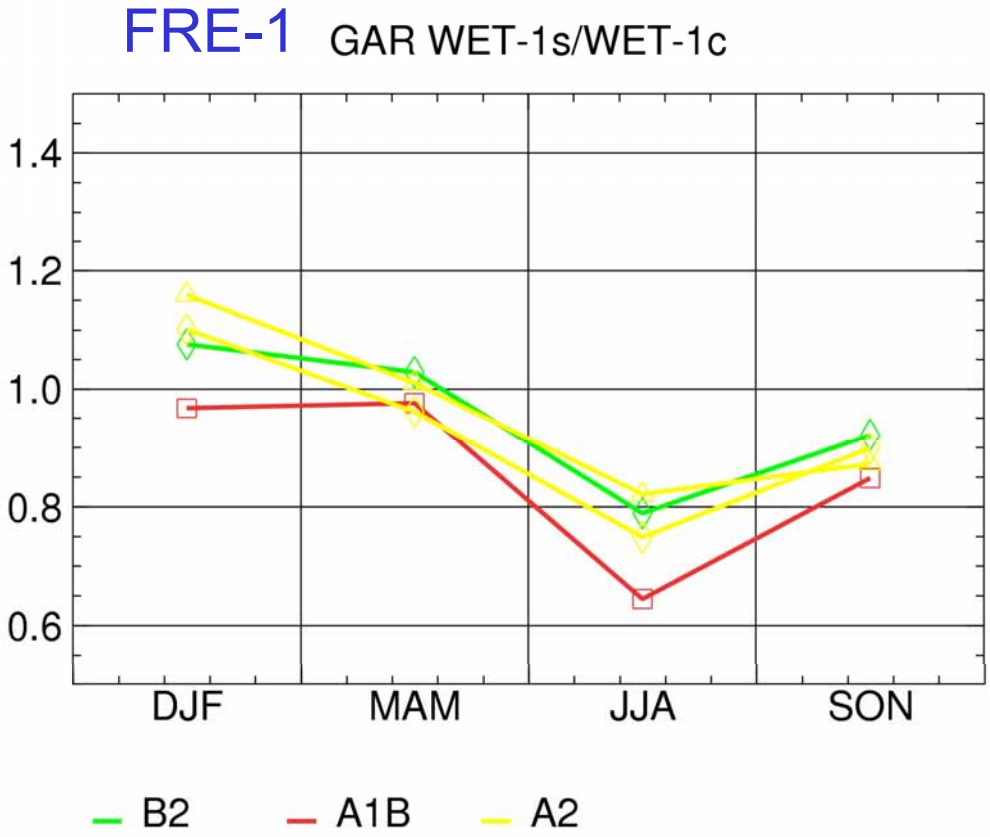
Δ: HIRHAM (HadCM3)
□: CLM (ECHAM5)
◊: RegCM (HadCM3)

Precipitation GAR Ps/Pc

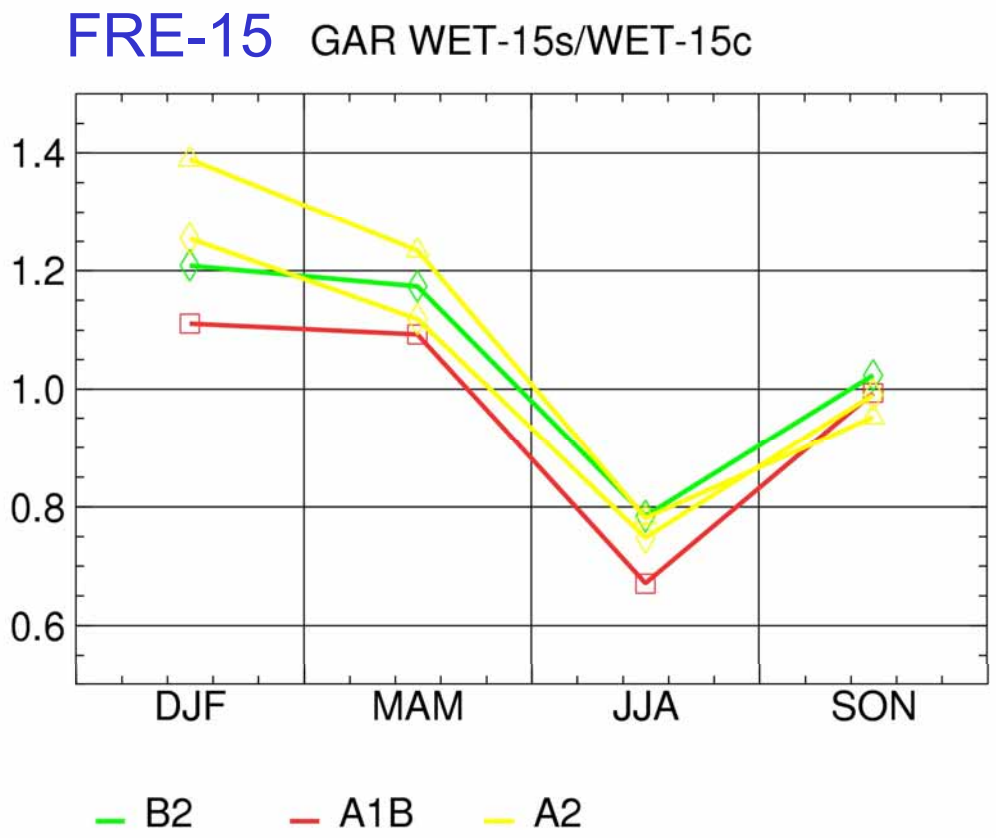


c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Future climate (CLM, HIRHAM and RegCM)

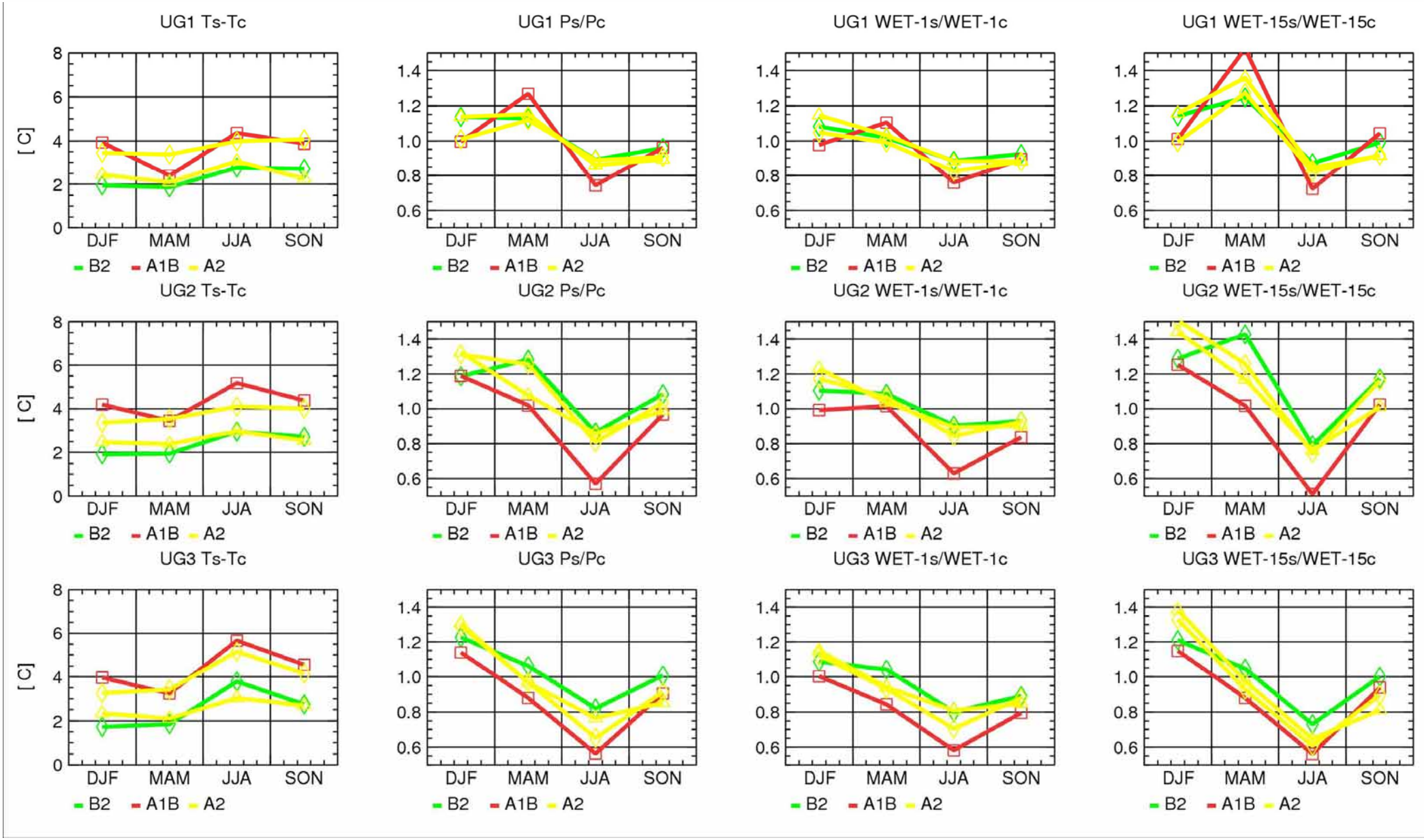


Δ: HIRHAM (HadCM3)
□: CLM (ECHAM5)
◊: RegCM (HadCM3)

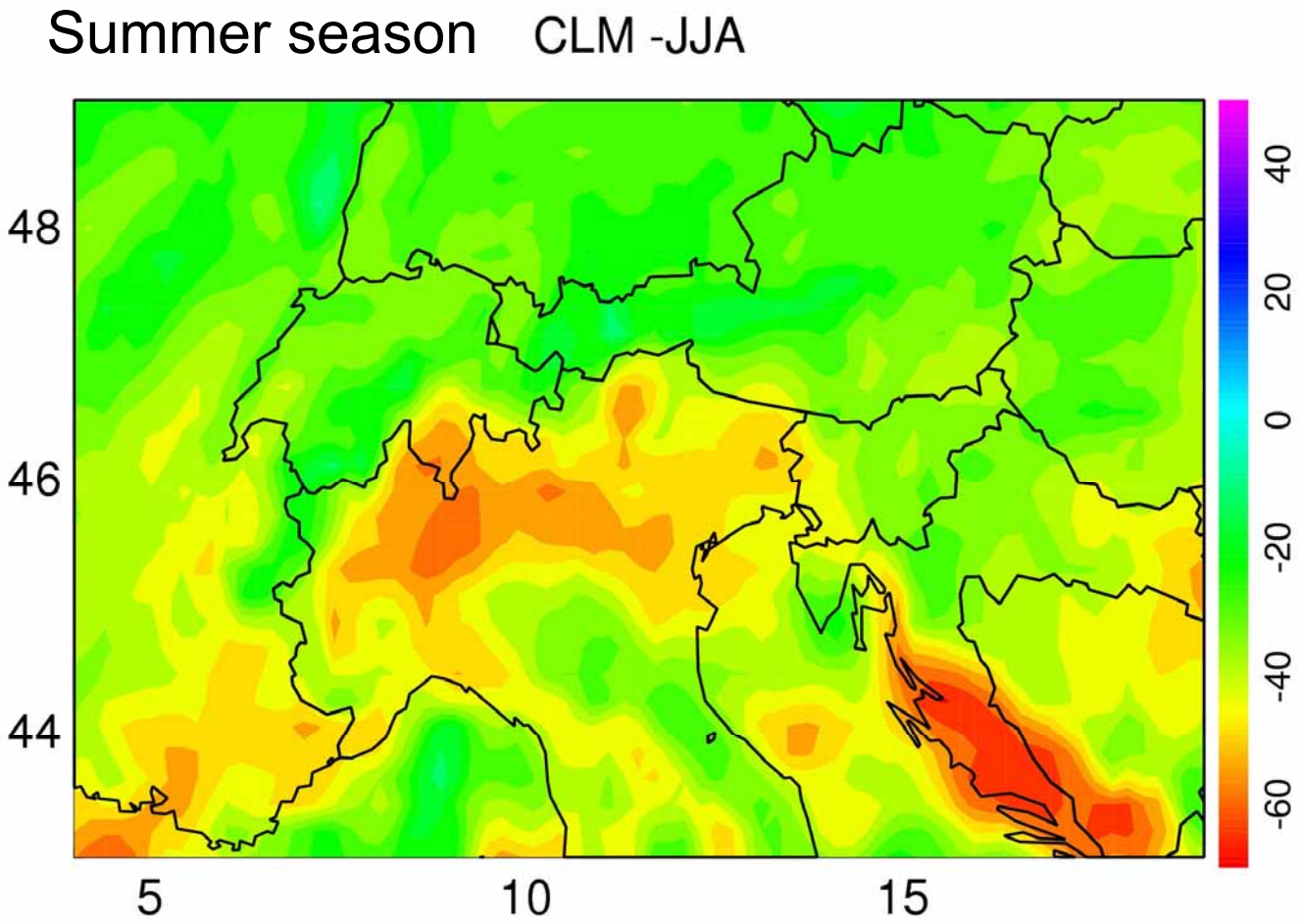


c - control run (1961 – 1990)
s - scenario run (2071 – 2100)

Future Climate UG1 – UG3

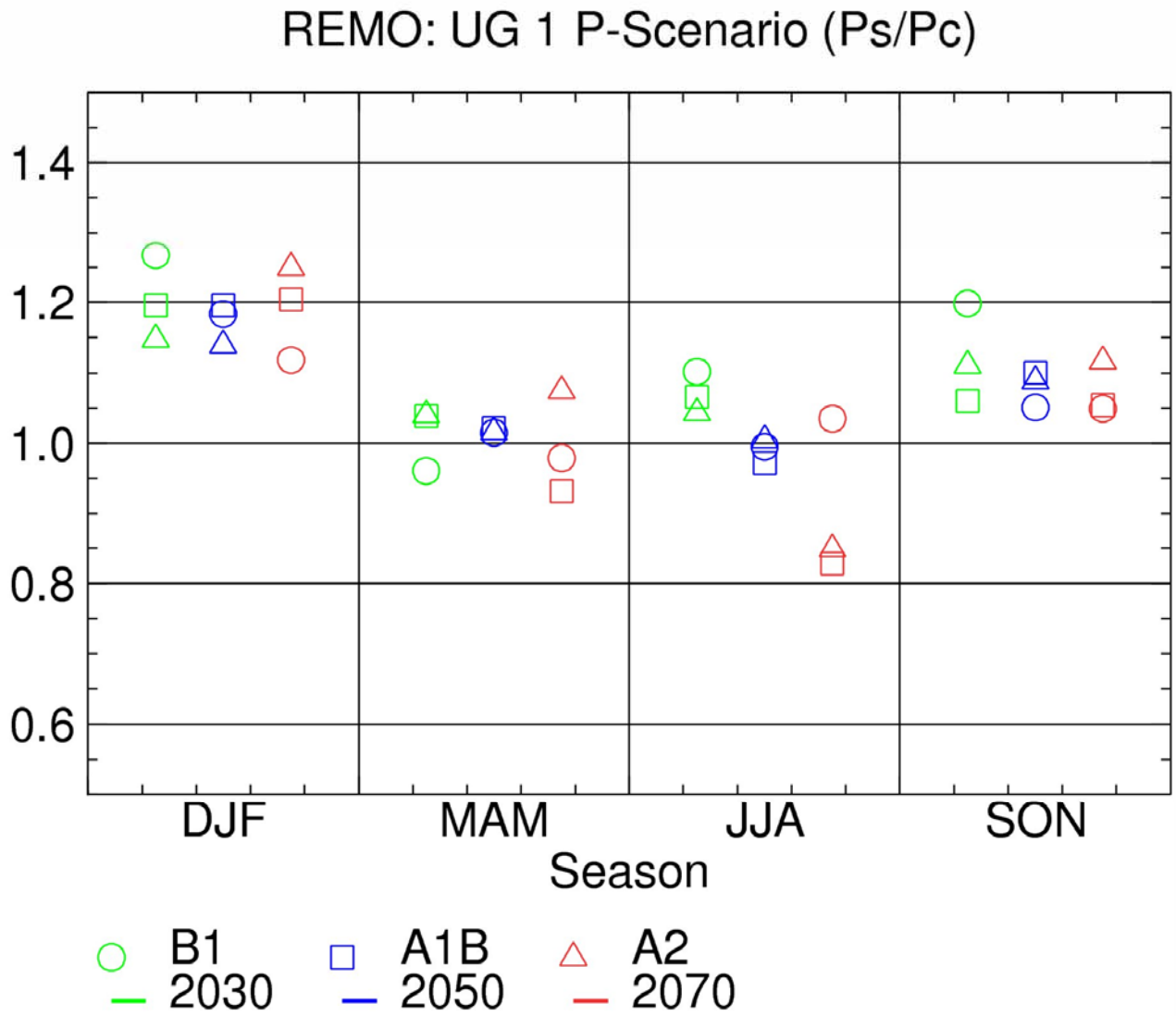


Future Climate – precipitation change [%] (CLM)

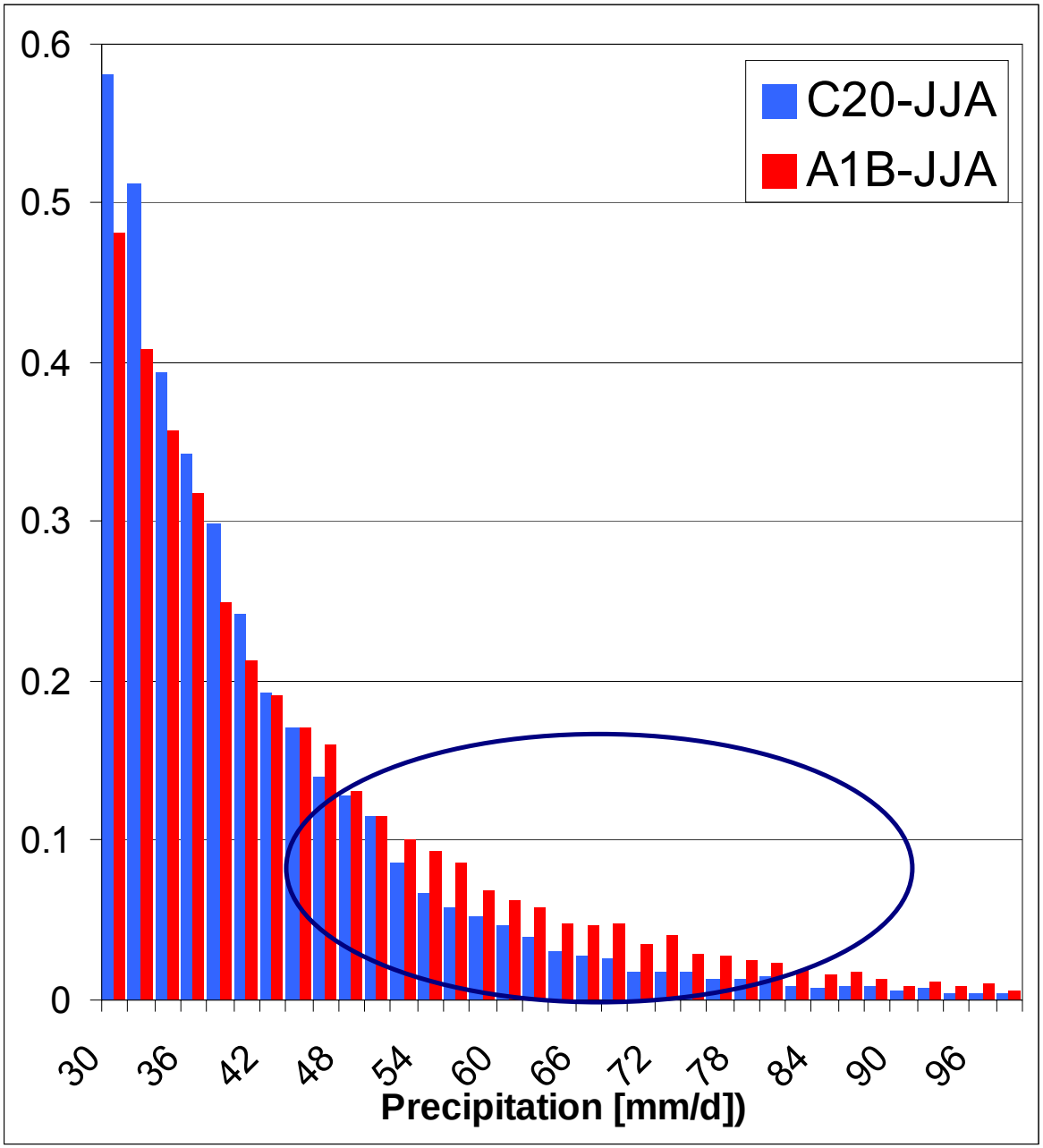


Future Climate – Precipitation change

Advantage of transient runs!



Future Climate – UG1 – REMO model



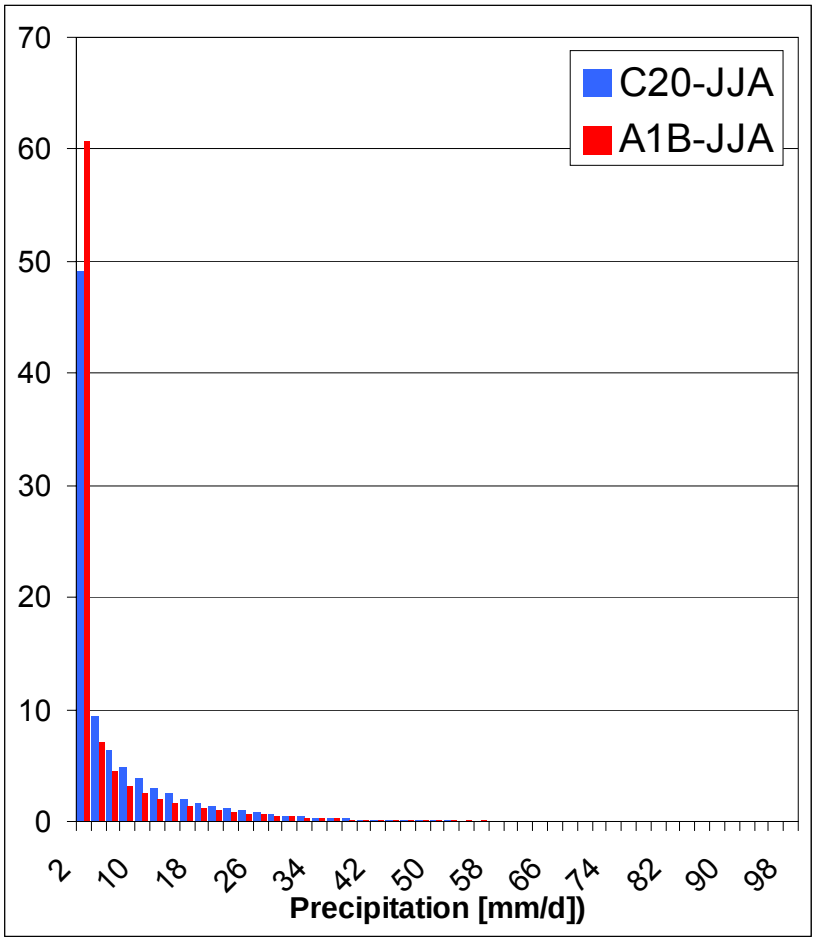
Conclusions

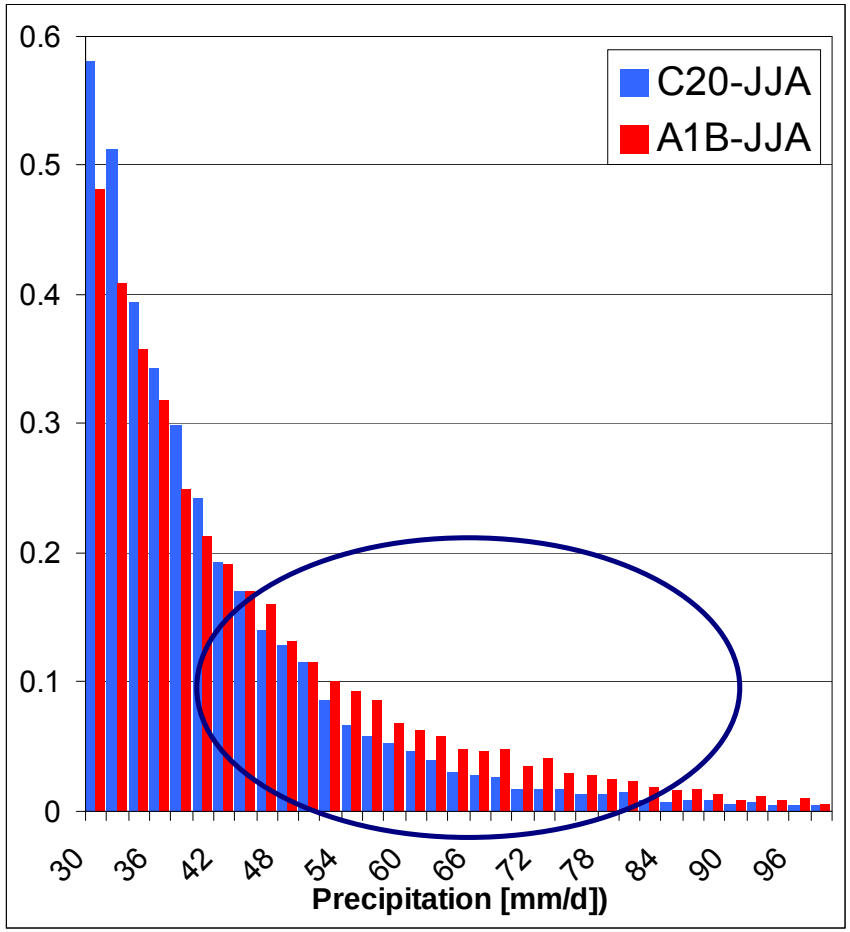
- No single model can be identified as best:
  performance depends on selected variable and area
- Direction of projected change has higher reliability than absolute numbers
- RCM uncertainties overlap scenario based ranges!

- Recommendation for hydrological impact analysis:
  1) should be based on ensemble data set
  2) biases in precipitation actually require correction techniques
  3) there is further a clear need for high resolution driving data
- More detailed climatology needed (daily station-statistics)


Vielen Dank für die Aufmerksamkeit

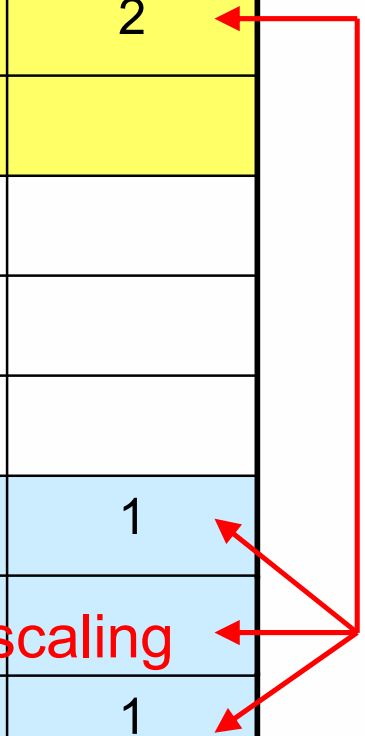
Future Climate – UG1 - REMO





Selected GCM Climate Change Scenario runs

Institution	GCM	AFI	A2	A1B	B1	B2
UKMO	HadCM3	1	3	1	1	2
MPI-MET	ECHAM5		3	3	3	
IPSL	CM4					
CNRM	CM3					
NERSC						
NCAR	PCM		1			1
CCCma	CGC2M2					
CSIRO	CSIRO-Mk2	1	1		1	1

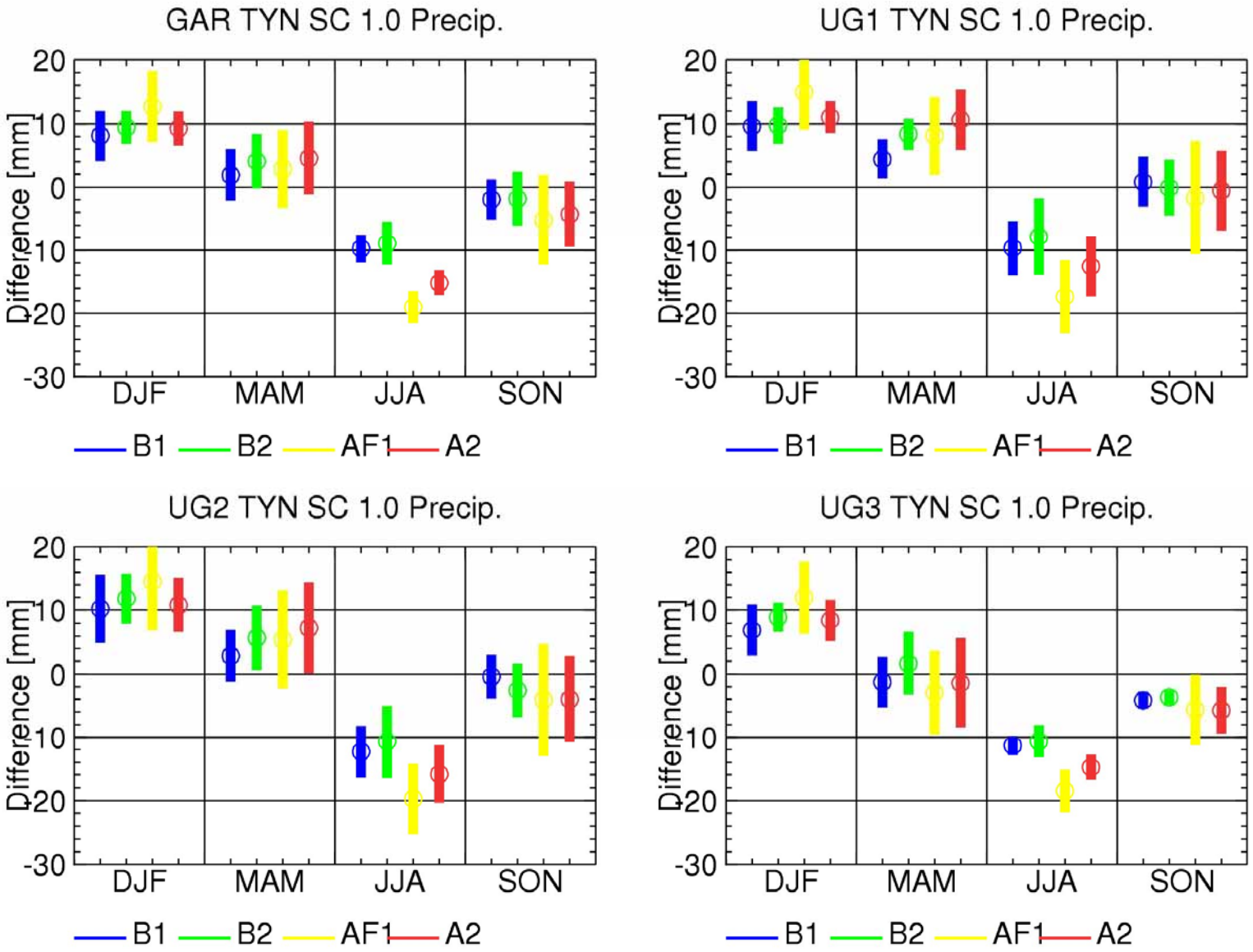


Bias of RCM from Frei(2006)

Model	Nothern Alps				Southern Alps			
		DJF		JJA		DJF		JJA
	MEAN	FRE-1	MEAN	FRE-1	MEAN	FRE-1	MEAN	FRE-1
CHRM	1	9	-26	-17	-23	-10	-25	-18
CLM	46	33	-5	3	0	8	-10	-13
HADRM3H	36	10	1	-1	26	12	-25	-15
HADRM3P	32	8	-10	-10	10	1	-30	-14
HIRHAM	19	28	3	46	-18	24	-10	55
REMO	16	25	20	23	-17	12	15	24
SMHI	3	30	-29	-18	-1	39	-31	-26

[model resolutions 0.5°]

Statistical downscaling



ENSEMBLES IP6 PROJECT (2004 – 2009)

Develop an ensemble prediction system for climate change:

- based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe,
- validated against quality controlled, high resolution gridded datasets for Europe,
- to produce an objective probabilistic estimate of uncertainty in future climate at the seasonal to decadal and longer timescales

Now GCM data available: IPSL(_CM4), CNRM(-CM3), MPI- ECHAM5), BCCR(-BCM2), UKMO(-HADCM3), UKMO(-HADGEM1), FUB(-EGMAM), DMI(-ECHAM5).

In work:

Regional model runs with 25km resolution

Statistical downscaling tool with WEB interface