Atmosphere – Land Surface Interactions:
Why do we Need Long-Term Observations ?

Hans Peter Schmid
Forschungszentrum Karlsruhe, Garmisch-Partenkirchen

TERENO Kick-Off Meeting
Berlin, Sept. 22, 2008

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

What do we get out of long-term observations?
Intellectual Motivations and Practical Benefits

Intellectual Motivations for Long-Term Observation Programs

- **Systems Dynamics**: Temporal scales of ecosystem – atmosphere interactions
- **Diagnostic Science**: Detection of trends and analysis of global change impacts
- **Environmental Science Methodology**: Non-manipulative field experimentation

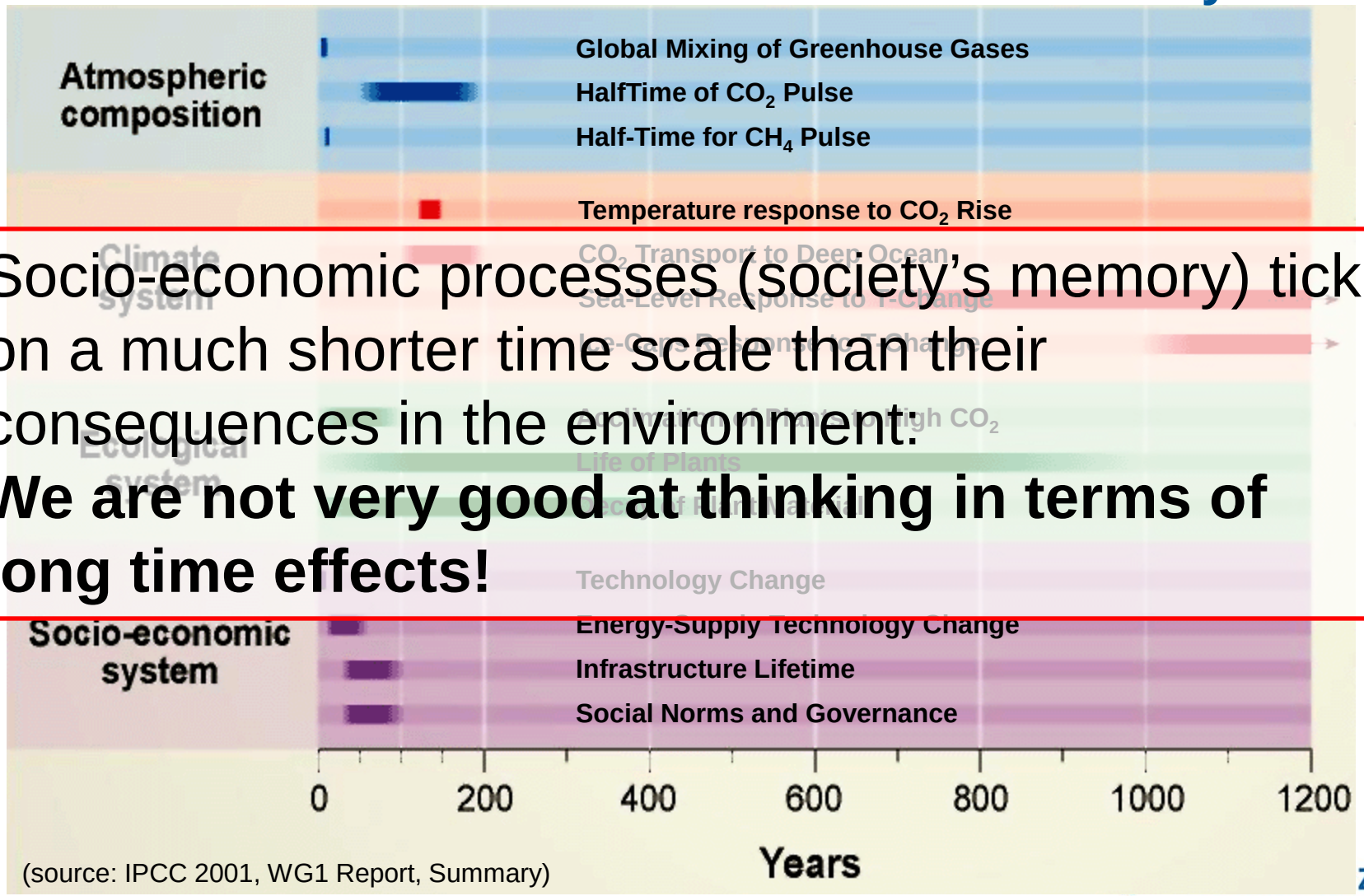
Practical Benefits of Long-Term Observation Programs:

- **Enhance knowledge** of complex exchange and transformation processes
- **Database** for model development and testing
- **Benchmark** for global coverage satellite observations
- **Training ground** for young scientists and environmental engineers

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Time Scales of Processes in the Environmental System



Socio-economic processes (society's memory) tick on a much shorter time scale than their consequences in the environment:

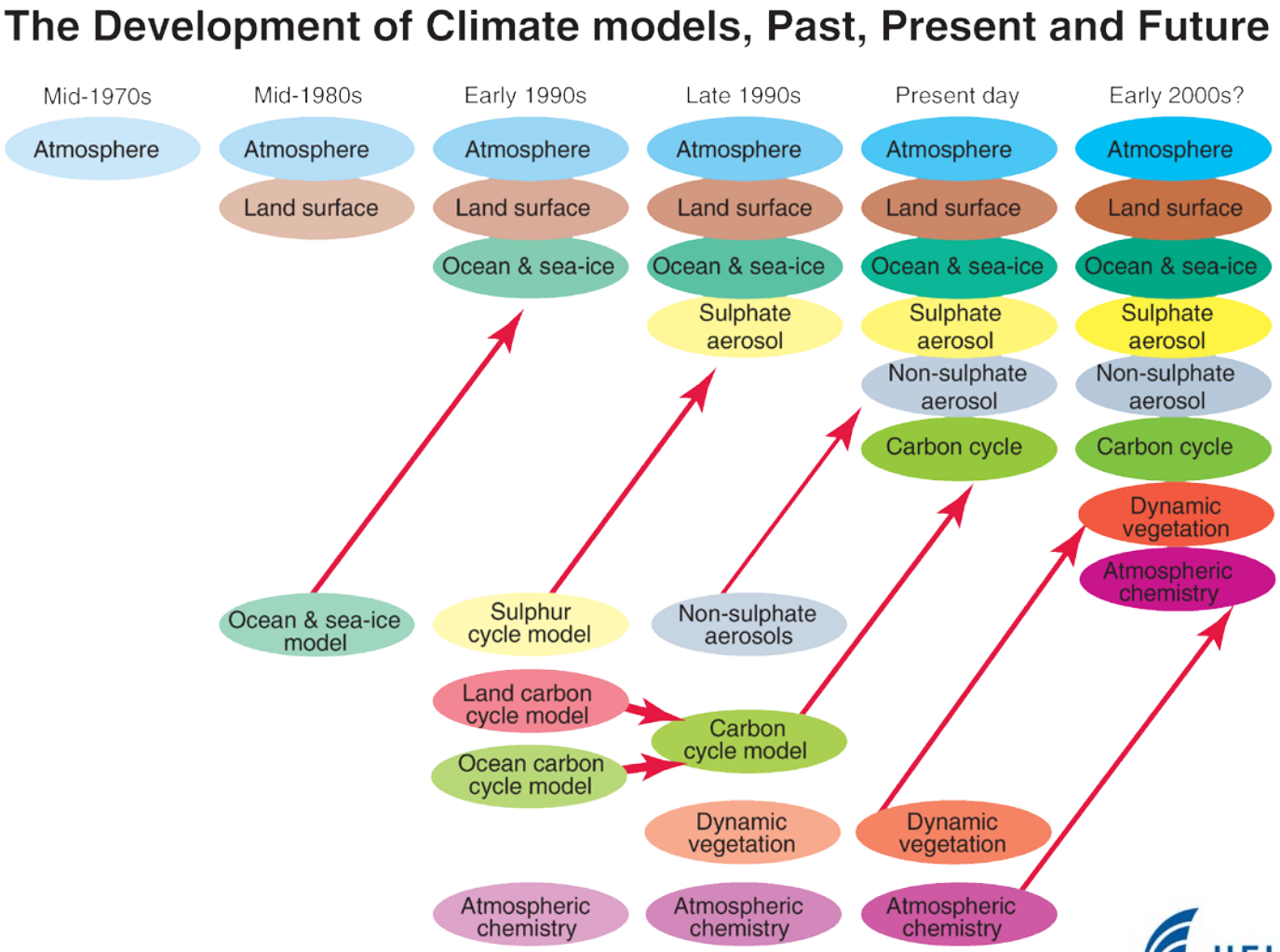
We are not very good at thinking in terms of long time effects!

(source: IPCC 2001, WG1 Report, Summary)

Z
ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Process Knowledge of Land-Surface-Atmosphere Interaction is Recent



(source: IPCC 2001, WG1 Report, Summary)

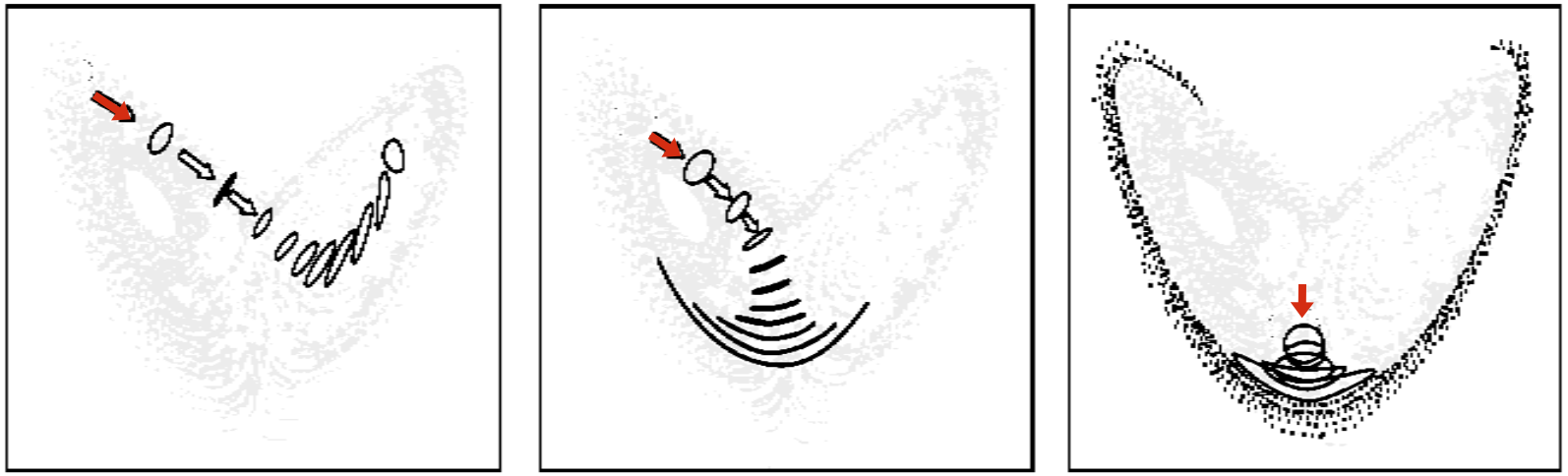
HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Short-Term vs. Long-Term Observations

In search of the "Ensemble": all possible states of a system

- individual short campaigns show development and transformation paths
- may be disjunct; generalities not evident: case studies



(from Wallace and Hobbs, 2006, Fig. 7.26)

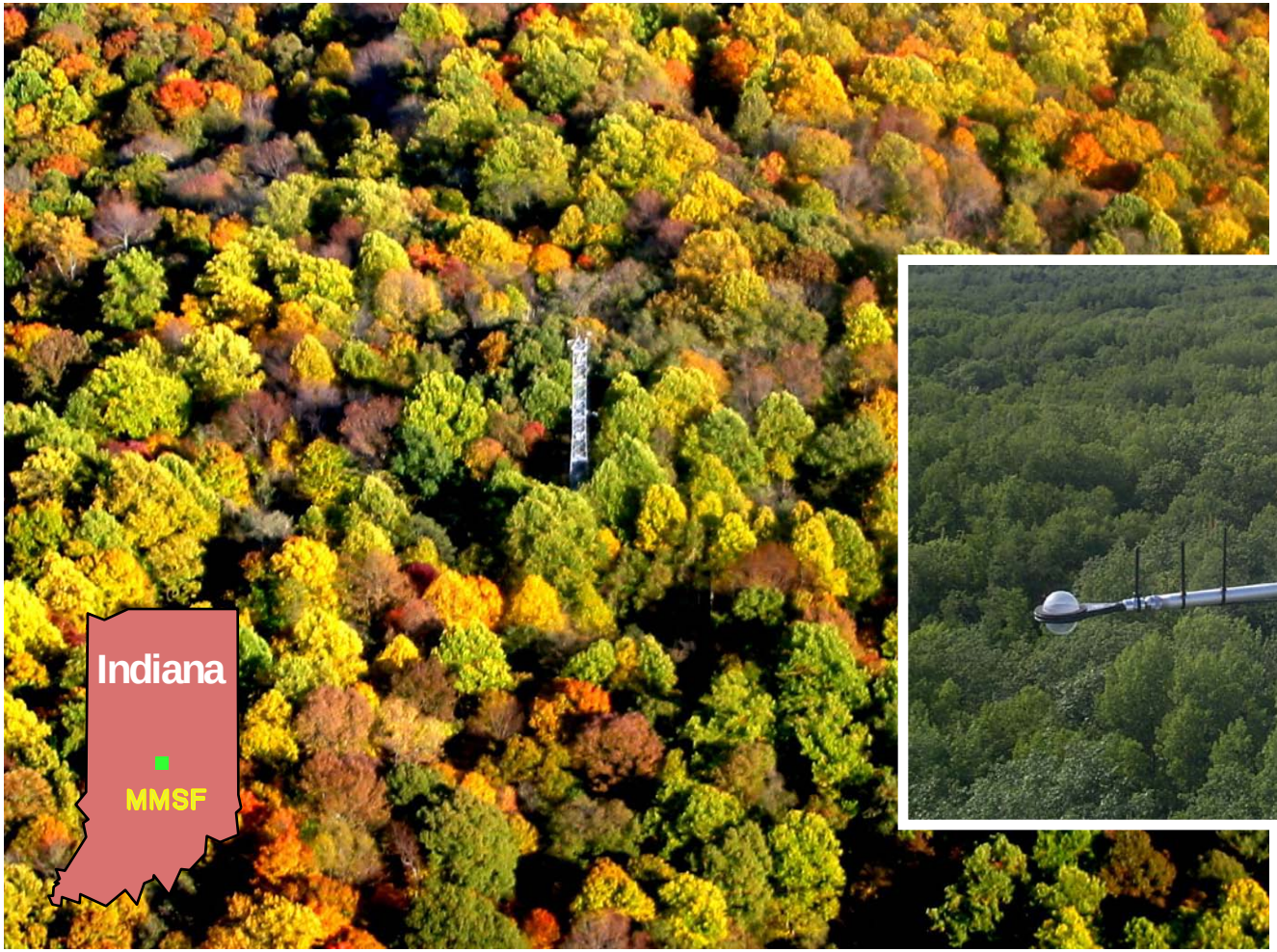
- long-term observations (may) make patterns, generalities evident
- provide a more complete view of the system
- improve model development and testing capabilities

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Example: Forest-Atmosphere Exchange of CO_2 (FLUXNET)

MMSF Site, Indiana (USA), 1998 – (continuing)

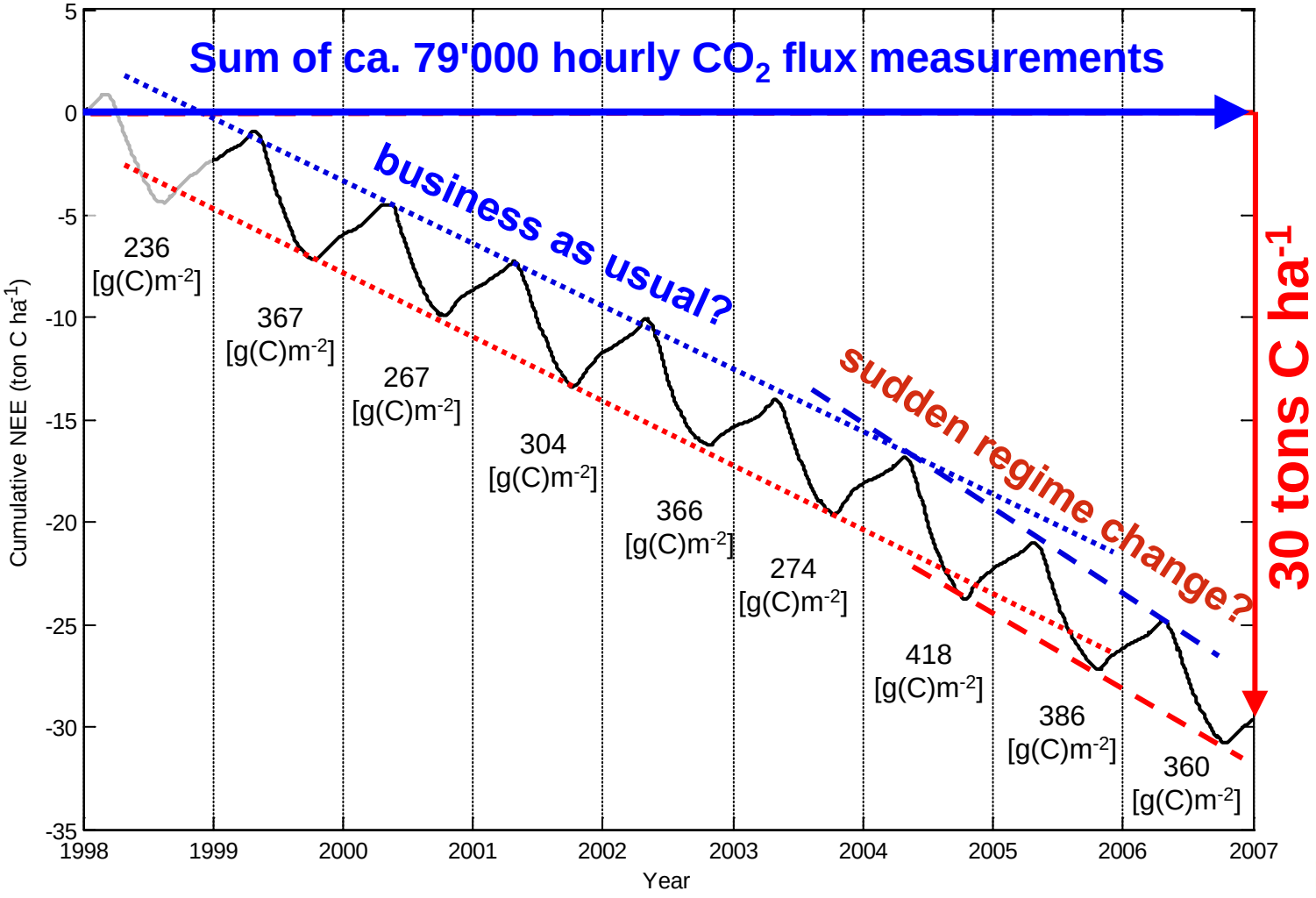


HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Cumulative Exchange of CO_2 over 9 Years (MMSF)

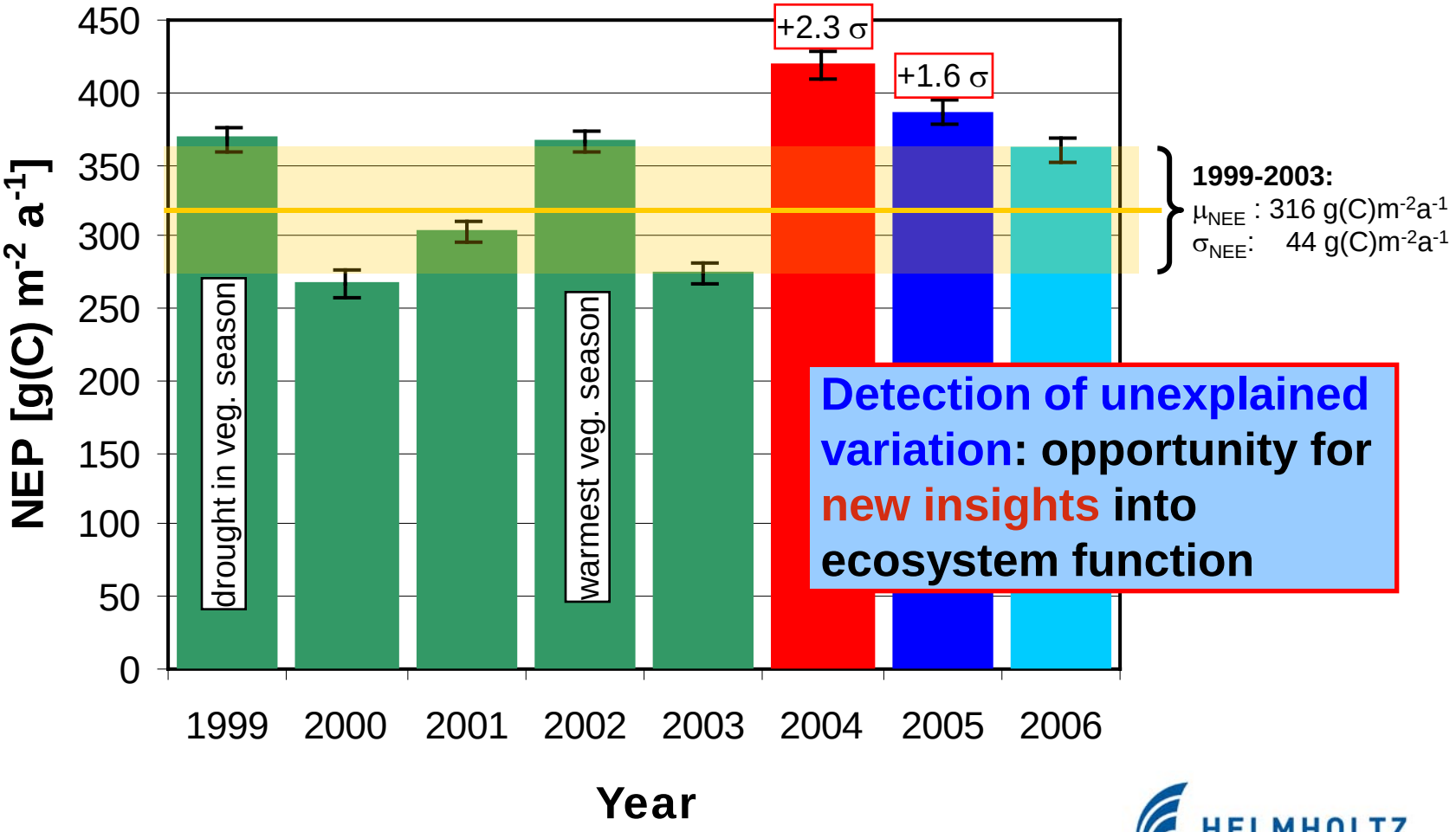
NEE: *Net Ecosystem Exchange* = Respiration - Assimilation



HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Annual Net Ecosystem Production (NEP)



HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

What can cause these Effects ?

... 2004 was the Year of the Brood X Cicada

entirely new and unexpected linkages and mechanisms are being considered (work in progress...)

17 year periodical cicada: next emergence in 2021

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

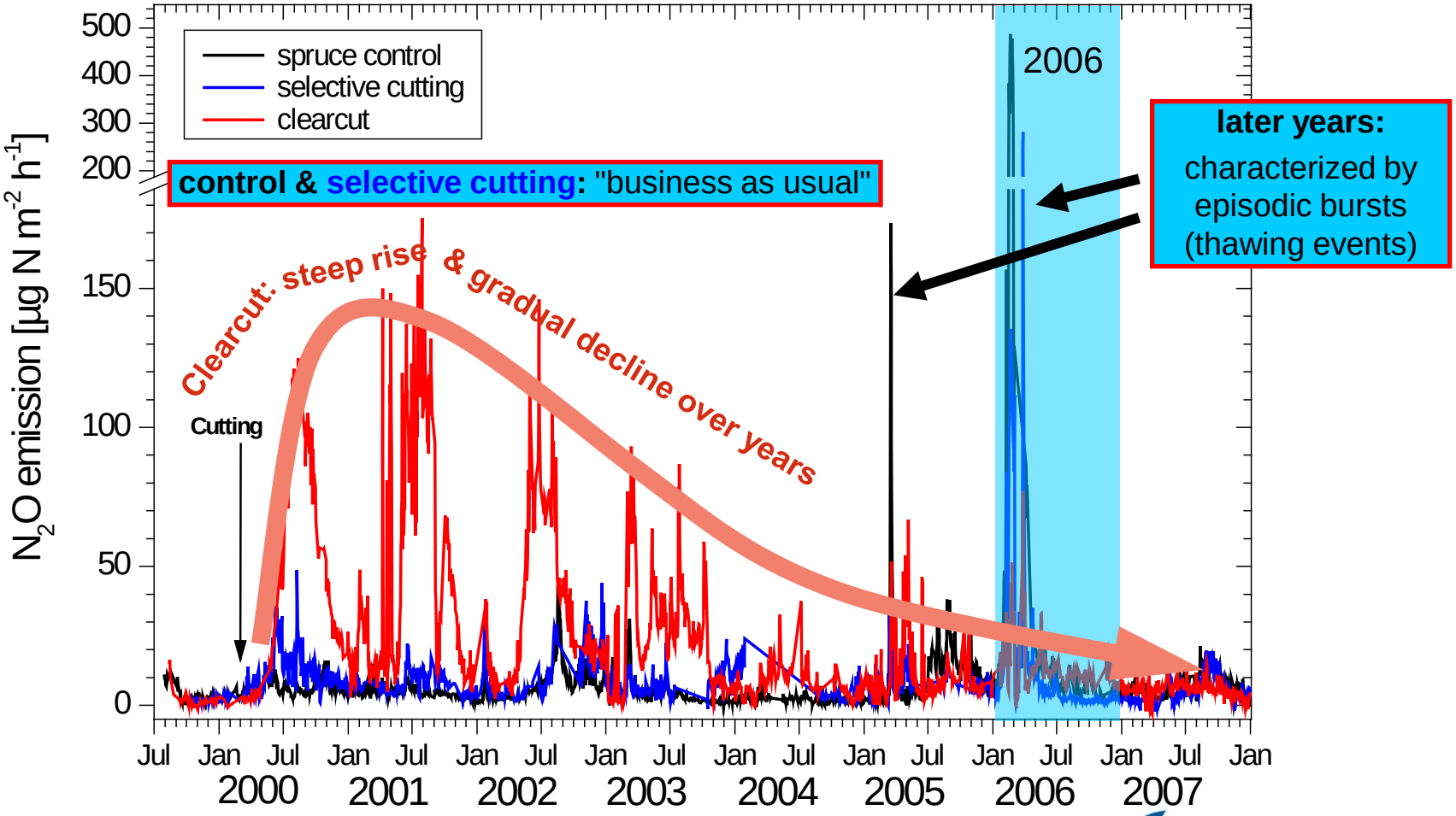
Example: Forest-Atmosphere Exchange of N_2O (NitroEurope)

Höglwald Site, Upper Bavaria, 1994 – (continuing)

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

N_2O Emissions at Höglwald Forest Long-Term Site

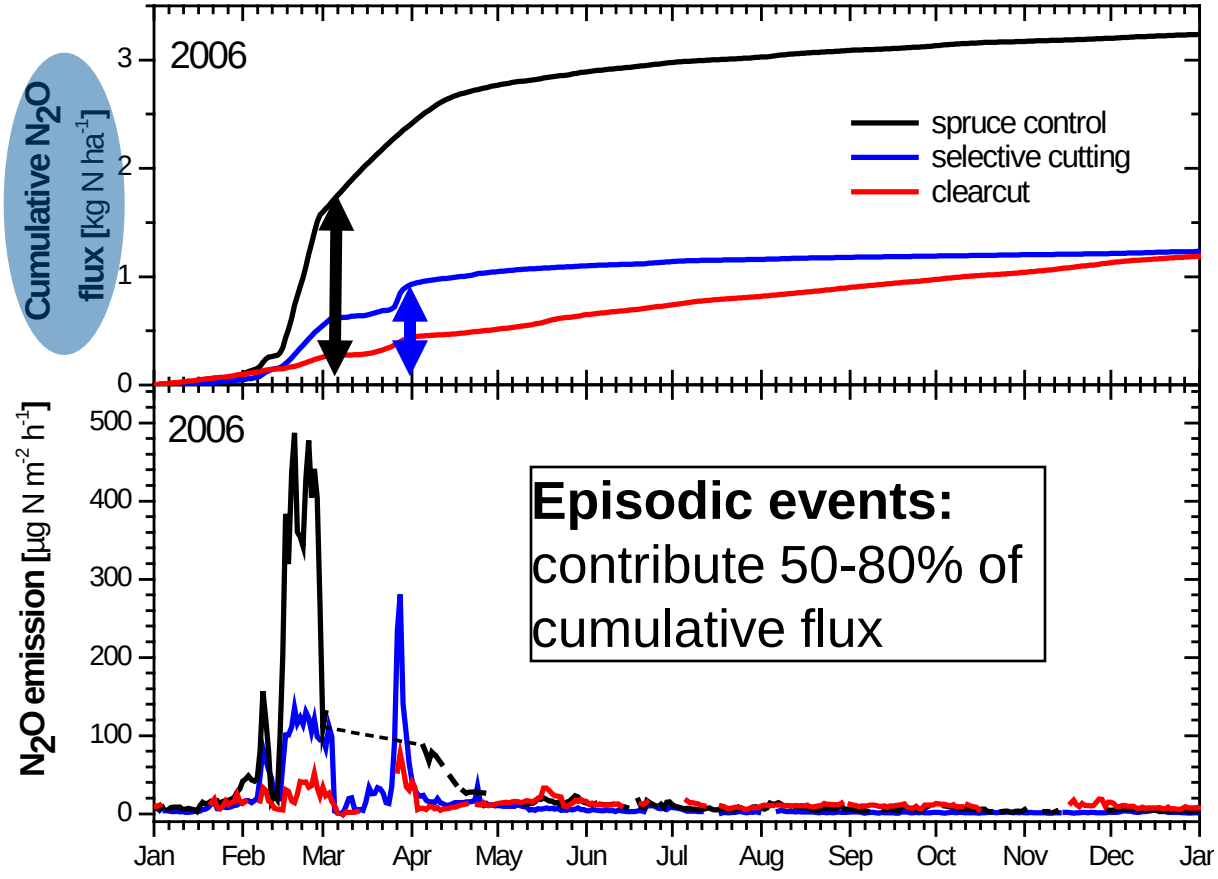


HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

N_2O Emissions at Höglwald Forest Long-Term Site

2006 short-term thaw events



Episodic events:
contribute 50-80% of cumulative flux

Impact of episodic events detected only due to continuous, long-term observation

leads to detailed process studies, lab experiments and model development

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Conducting Science in the Environment ?

We do not have replicates of the atmosphere, of climate….

source: Science, 22 Aug. 2008, cover

- **Long time series** in place of experimental replica
- **Conditional data selection** (out of collected time series) in place of experimental control:
- **Field experiments** in place of laboratory experiments

Long-term observations provide an essential methodology for environmental science

HELMHOLTZ ASSOCIATION

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Thank you for your attention!

HELMHOLTZ ASSOCIATION