

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



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

Intellectual Motivations for Long-Term Observation Programs

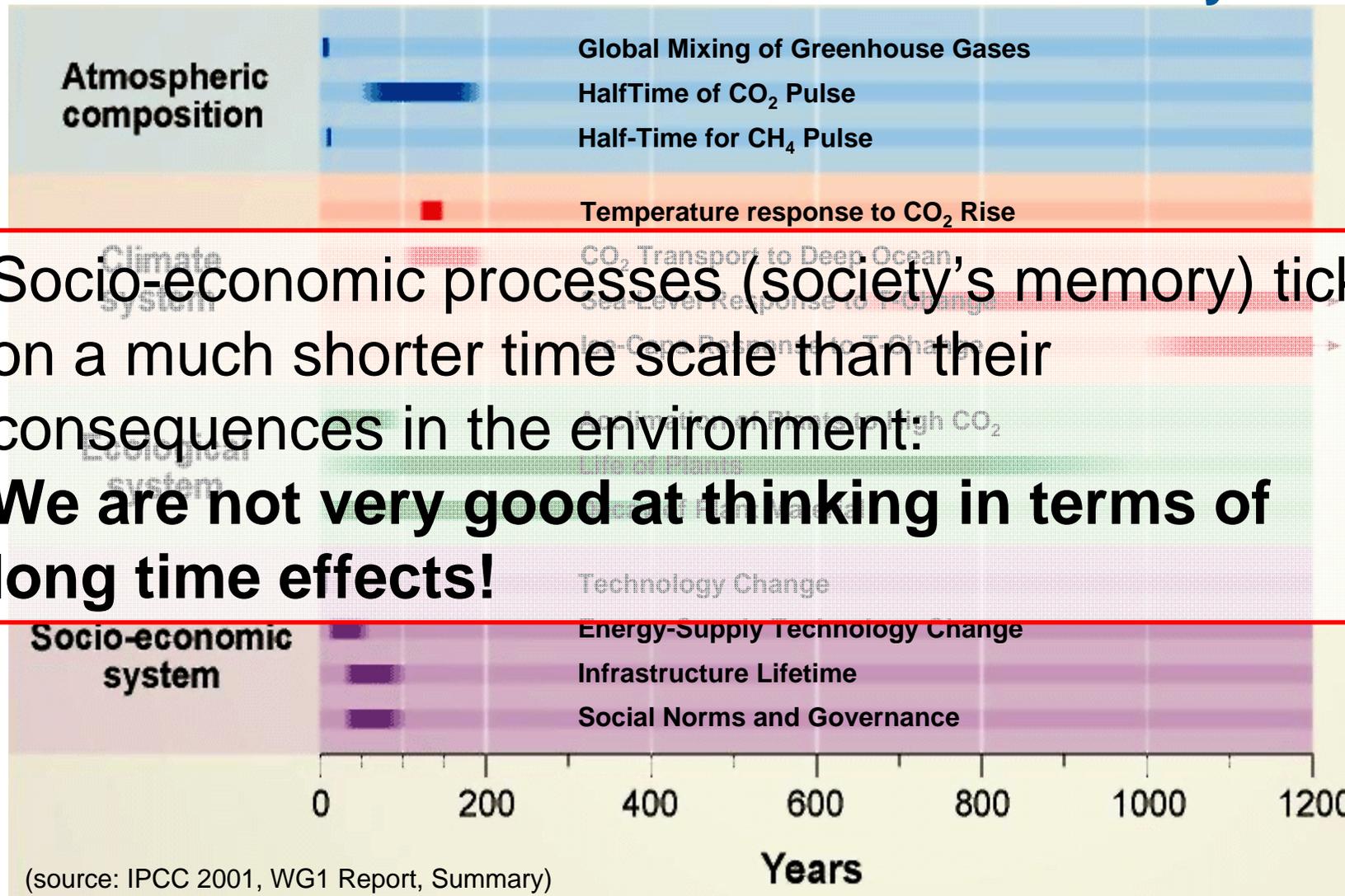
- **Systems Dynamics:** Temporal scales of ecosystem – atmosphere interactions
- **Diagnostic Science:** Detection of trends and analysis of global change impacts
- **Environmental Science Methodology:** Non-manipulative field experimentation

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



Time Scales of Processes in the Environmental System

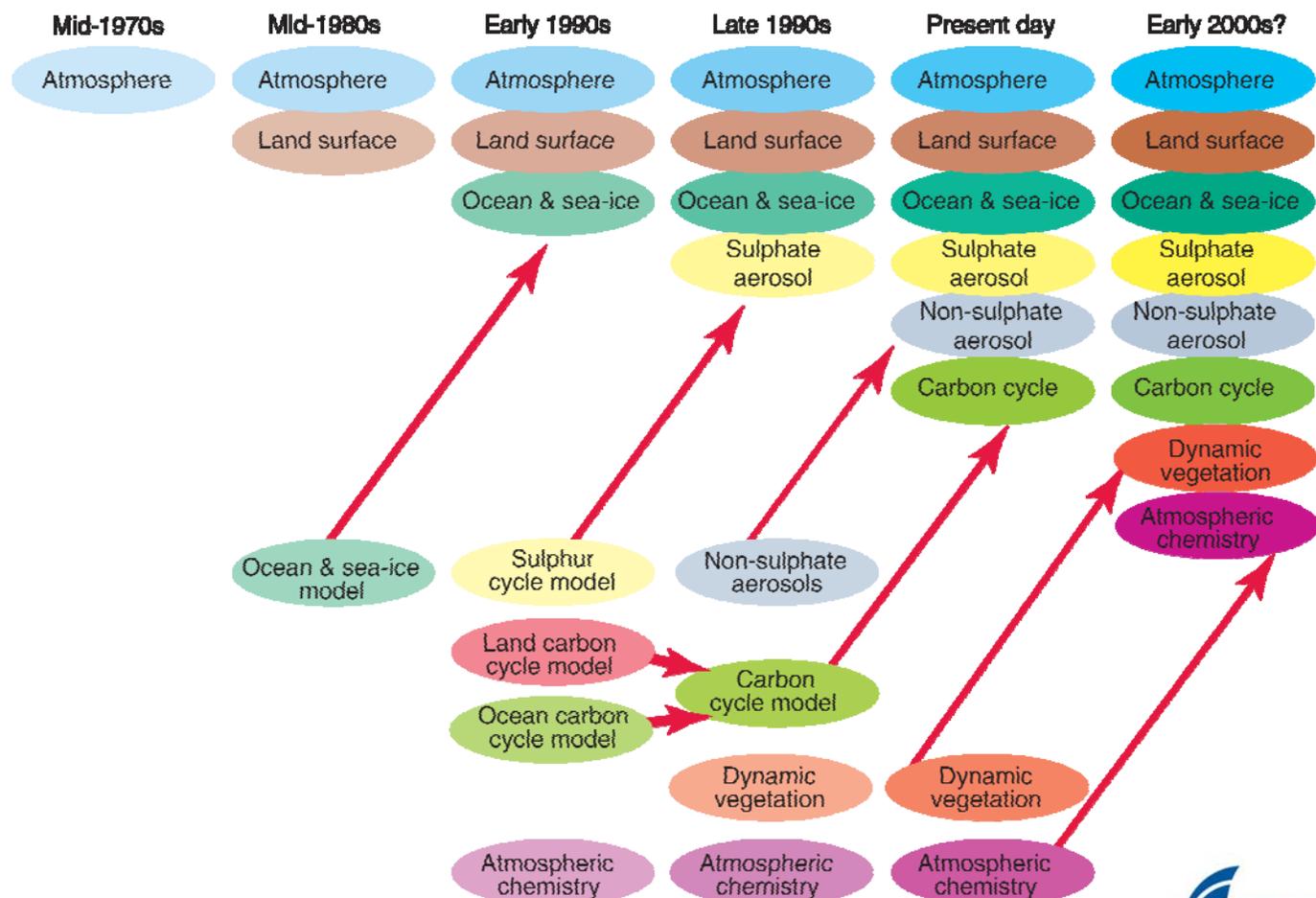


Socio-economic processes (society's memory) tick on a much shorter time scale than their consequences in the environment:
We are not very good at thinking in terms of long time effects!



Process Knowledge of Land-Surface-Atmosphere Interaction is Recent

The Development of Climate models, Past, Present and Future



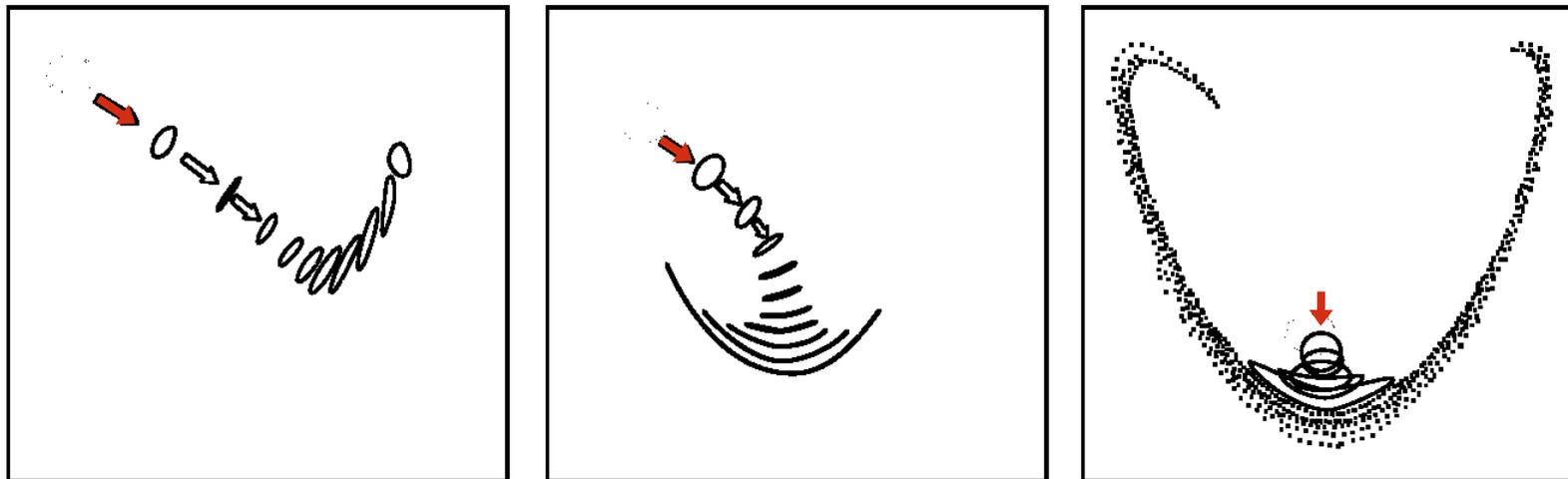
(source: IPCC 2001, WG1 Report, Summary)



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



Example: Forest-Atmosphere Exchange of CO₂ (FLUXNET)

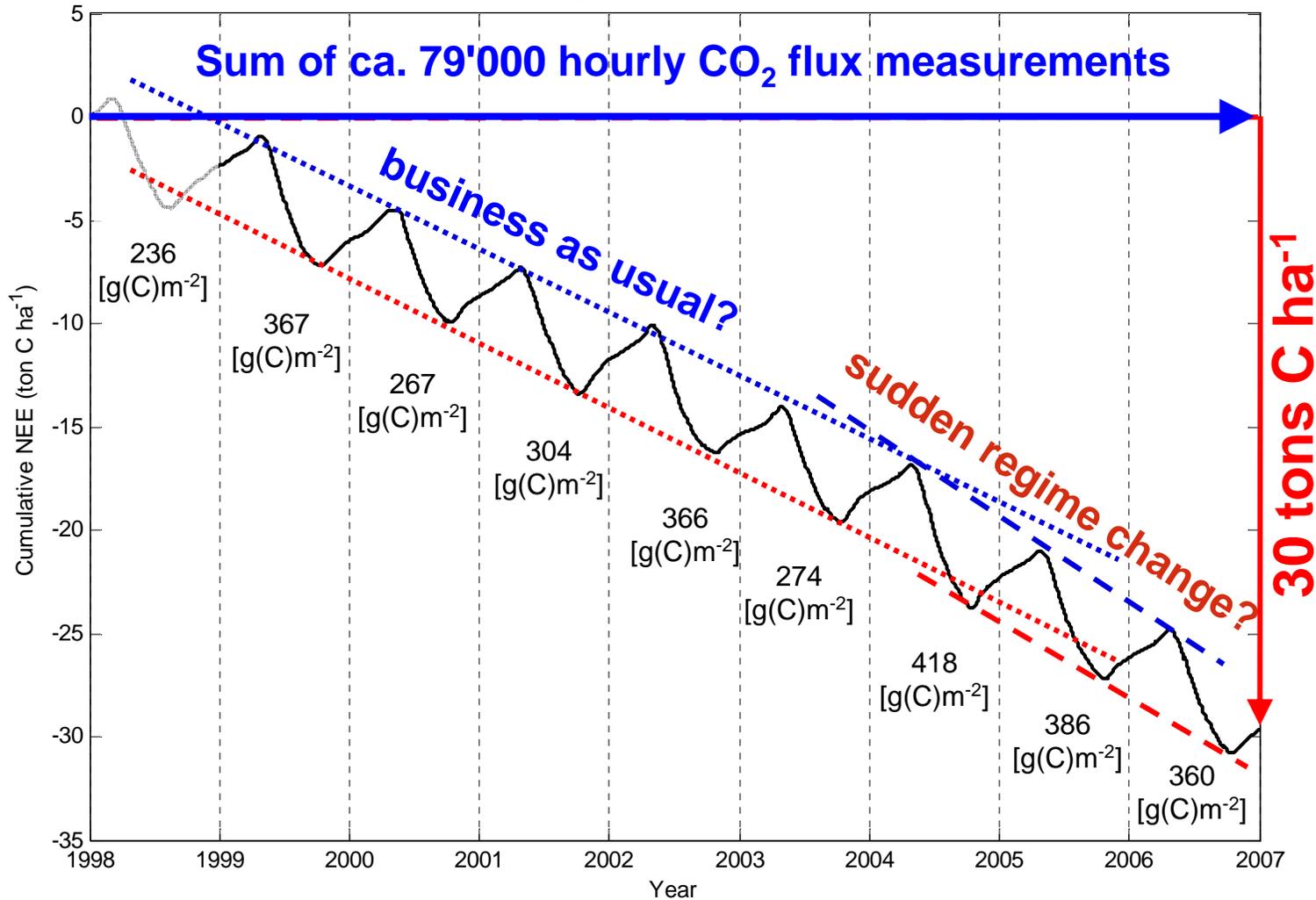
MMSF Site, Indiana (USA), 1998 – (continuing)





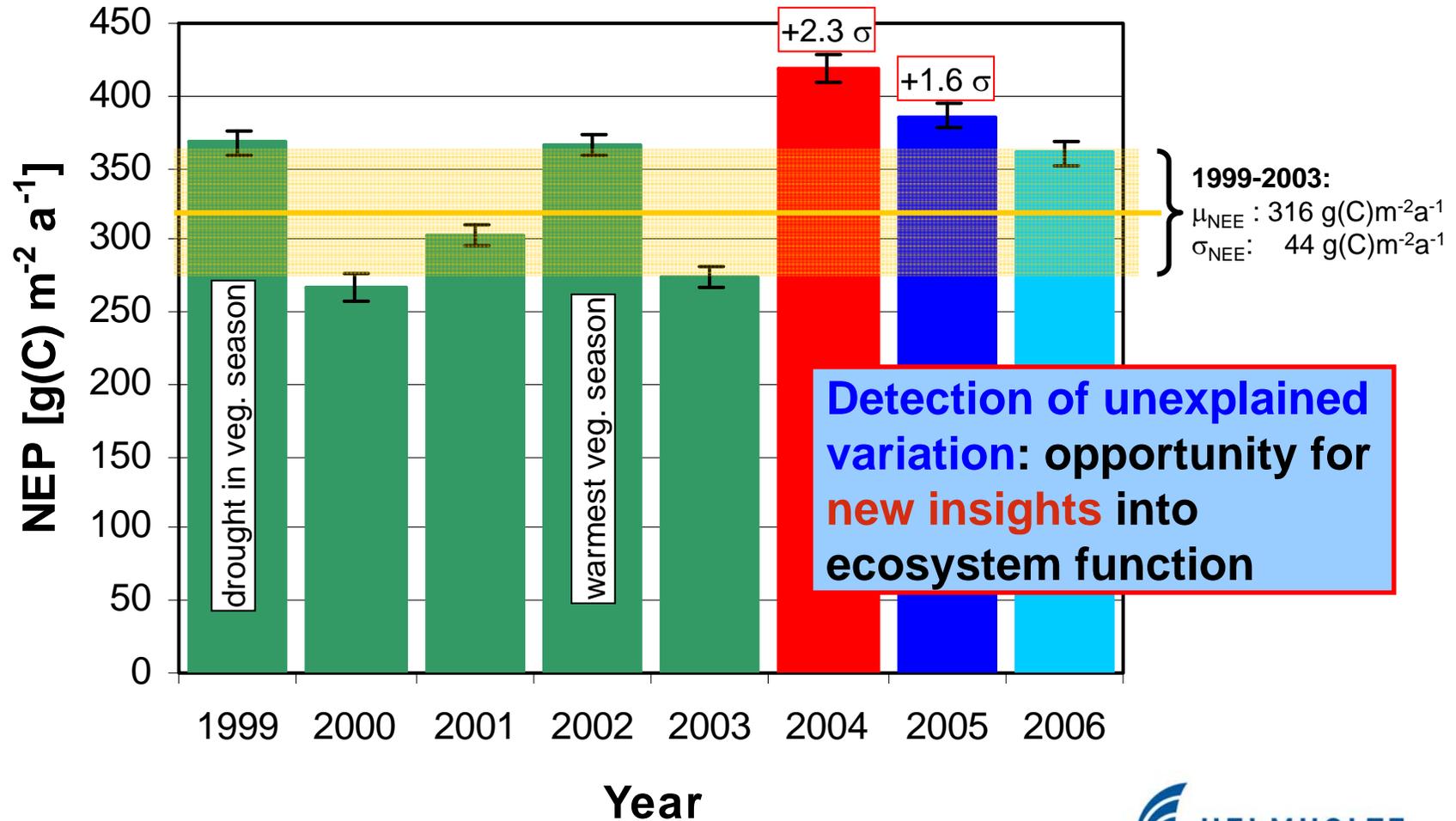
Cumulative Exchange of CO₂ over 9 Years (MMSF)

NEE: *Net Ecosystem Exchange* = Respiration - Assimilation





Annual Net Ecosystem Production (NEP)





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



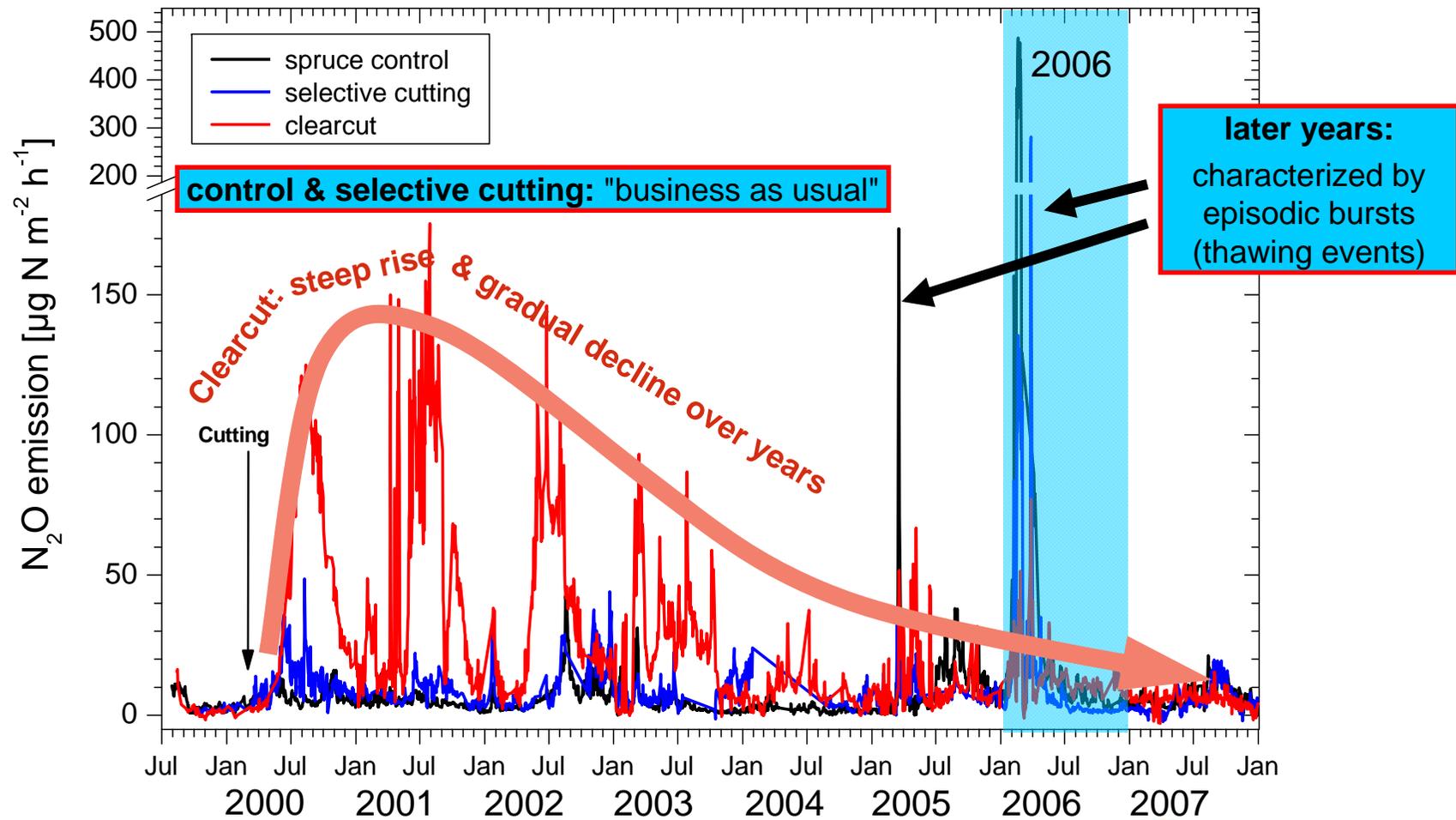
Example: Forest-Atmosphere Exchange of N₂O (NitroEurope)

Höglwald Site, Upper Bavaria, 1994 – (continuing)





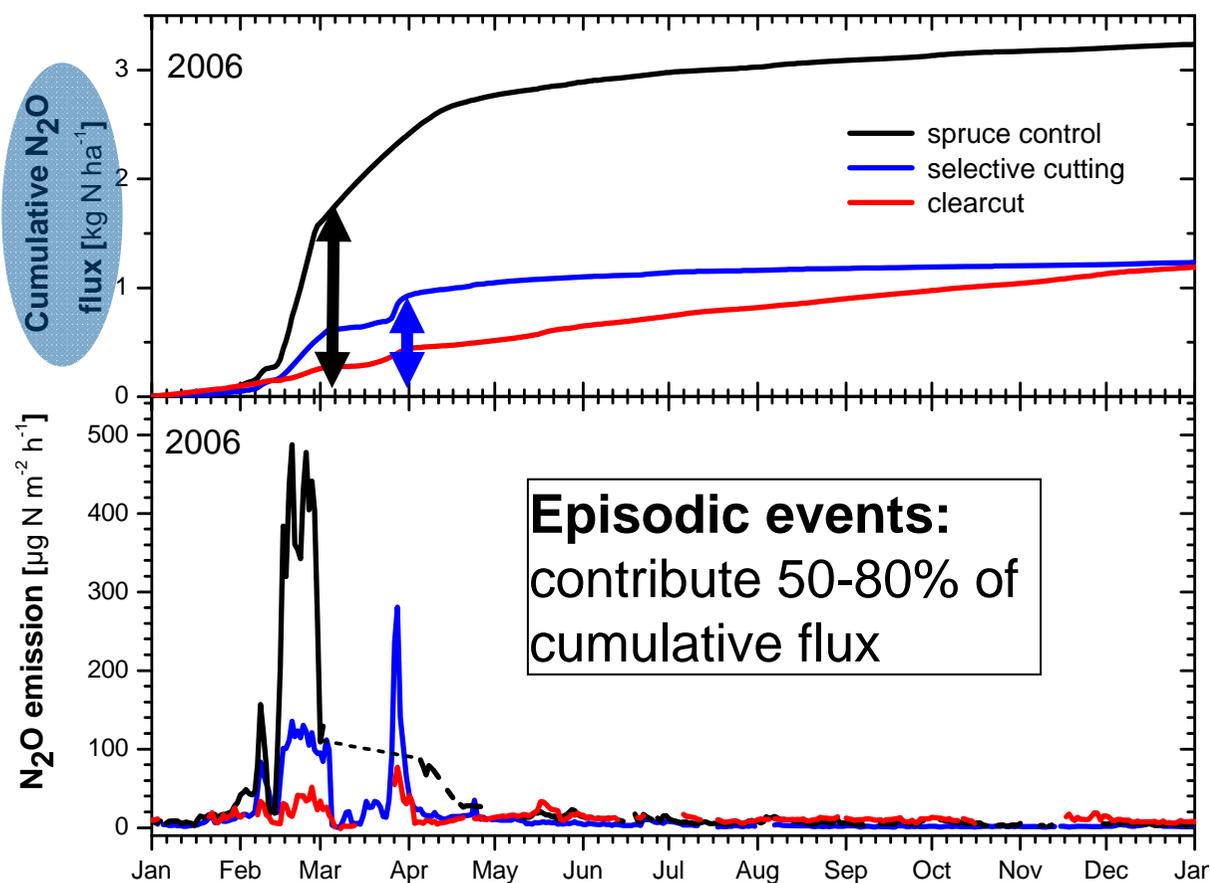
N₂O Emissions at Höglwald Forest Long-Term Site





N₂O Emissions at Höglwald Forest Long-Term Site

2006 short-term thaw events



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

leads to **detailed process studies, lab experiments and model development**



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



Thank you for your attention!