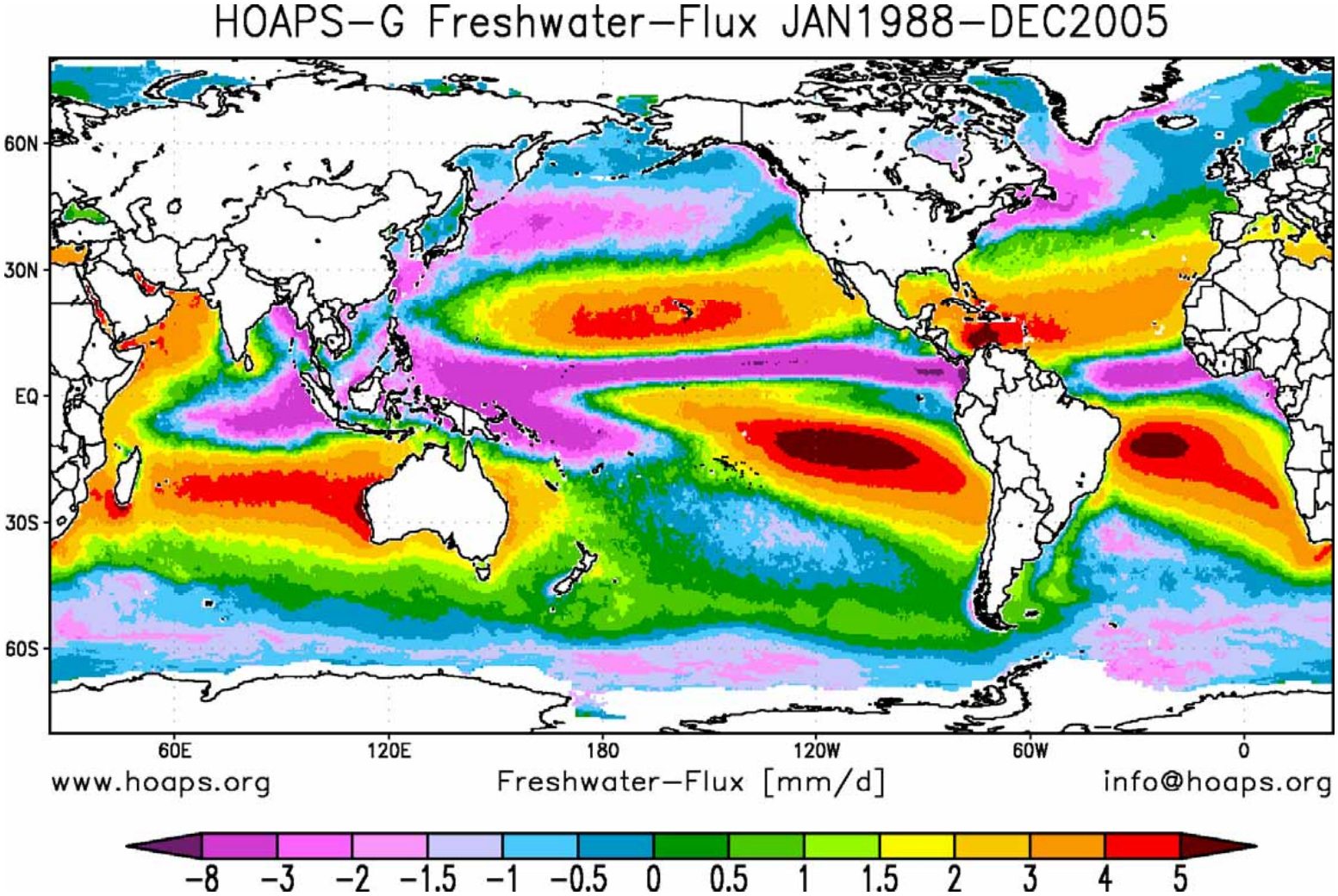
Climate Change Monitoring from Space

Hartmut Grassl

Max Planck Institute for Meteorology, Hamburg

Contribution to
Space Tools and Solutions for Monitoring
the Atmosphere and Land Cover
UN / Austria / ESA Symposium
Graz, Austria, 9 to 12 September 2008


HOAPS–G Freshwater–Flux JAN1988–DEC2005
60N
30N
EQ
30S
60S
60E
120E
180
120W
60W
0
www.hoaps.org
Freshwater–Flux [mm/d]
info@hoaps.org
−8
−3
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
3
4
5

Earth Observation from Space Contributes to

- Detection and Exploitation of Windows of Predictability
- Warning of Geohazards and Mitigation of their Impacts
- Control of Compliance with International Law

Earth Observation from Space is the Backbone of Services

- established for weather forecasting
- in build-up phase for
  - oceanography
  - disaster prevention and mitigation
  - chemical weather forecast

Climate data from satellites (GCOS)

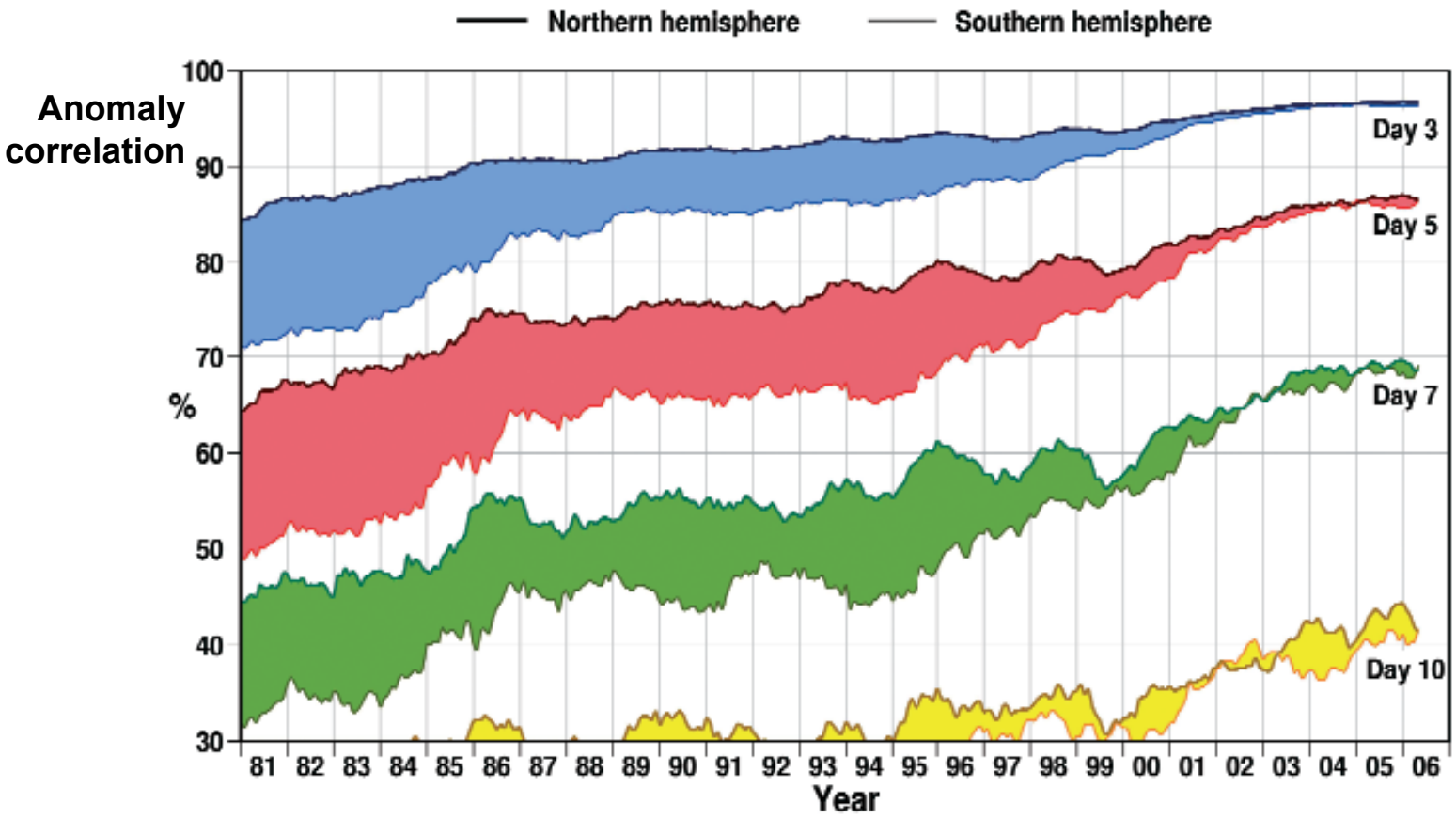
Table 1. Essential Climate Variables that are both currently feasible for global implementation and have a high impact on UNFCCC requirements.

Domain	Essential Climate Variables	
Atmospheric (over land, sea and ice)	**Surface:**	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.
	Upper-air:	Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.
	Composition:	Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties.
Oceanic	**Surface:**	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.
	Sub-surface:	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance.	

- variable depends on satellite observations

From GCOS IP 2004

Impact of satellite data on forecast skill



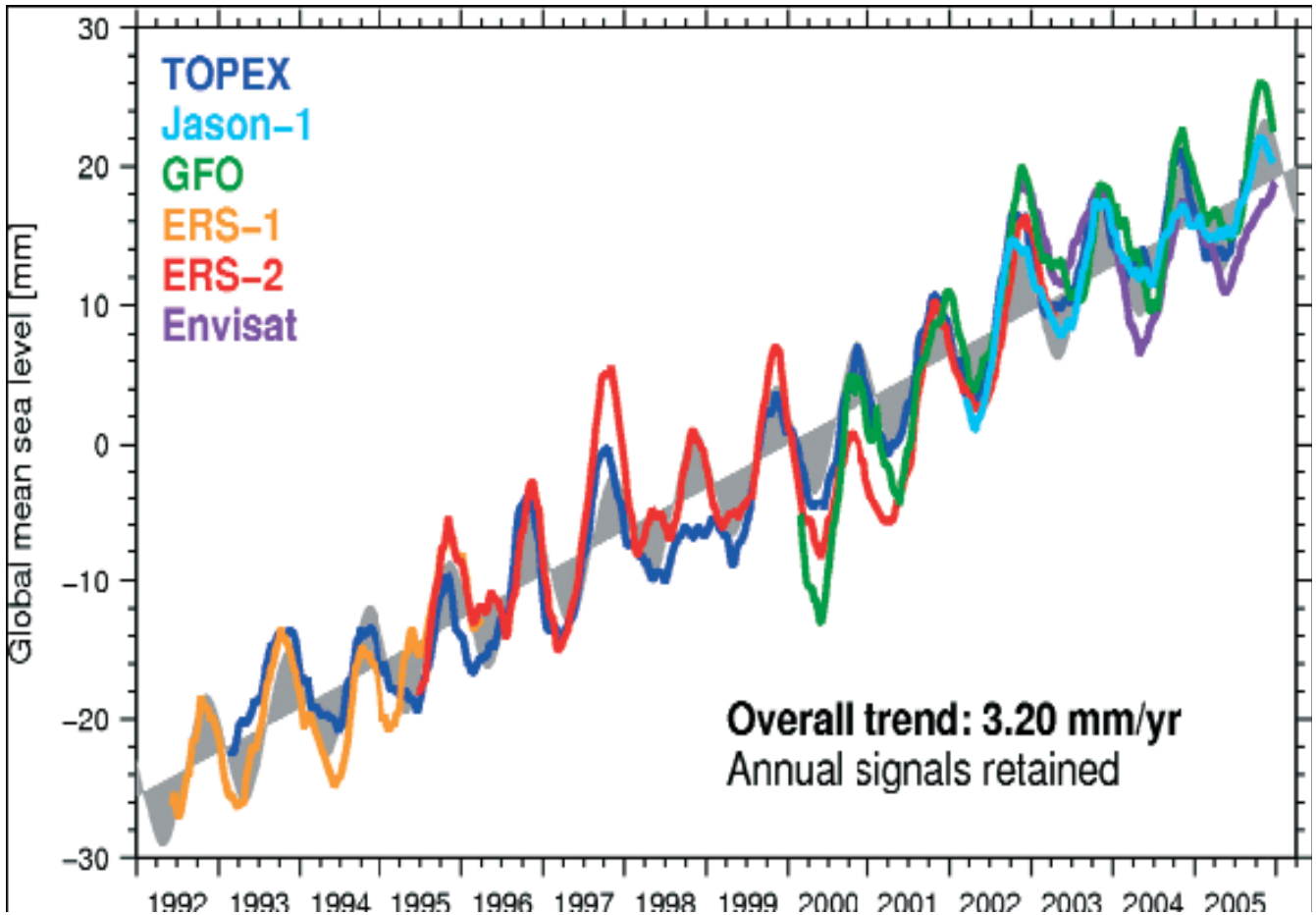
Increase in anomaly correlation of 500hPa height forecasts during recent decades is to a large extent due to the assimilation of satellite data

Source: The Changing Earth (SP-1304, ESA, 2006)

Trend Analyses with Satellites

Variable	Start of Analysis	Observed Trend
Sea Level	1992	+ 3.2 ± 0.5 mm/a
SST	1991	+ 0.13 ± 0.03 °C/10a
ozone column	1978	intensification of ozone hole until 2006
nitrogen dioxide	1995	+ 50% over China
cloud albedo	1981	-2% over Europe due to pollution abatement policies and collapse of Soviet Union
solar output	1979	no trend

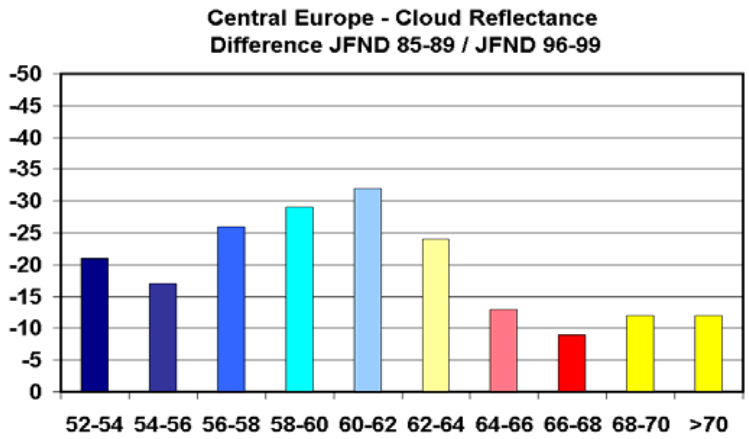
Observed global sea level rise

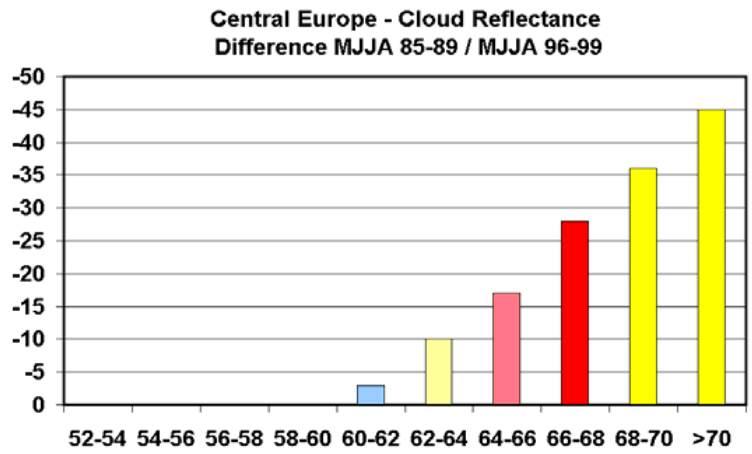


Sea level rise derived from several satellite altimeters

Source: The Changing Earth (SP-1304, ESA, 2006)

Cloud reflectance over Europe around 1990

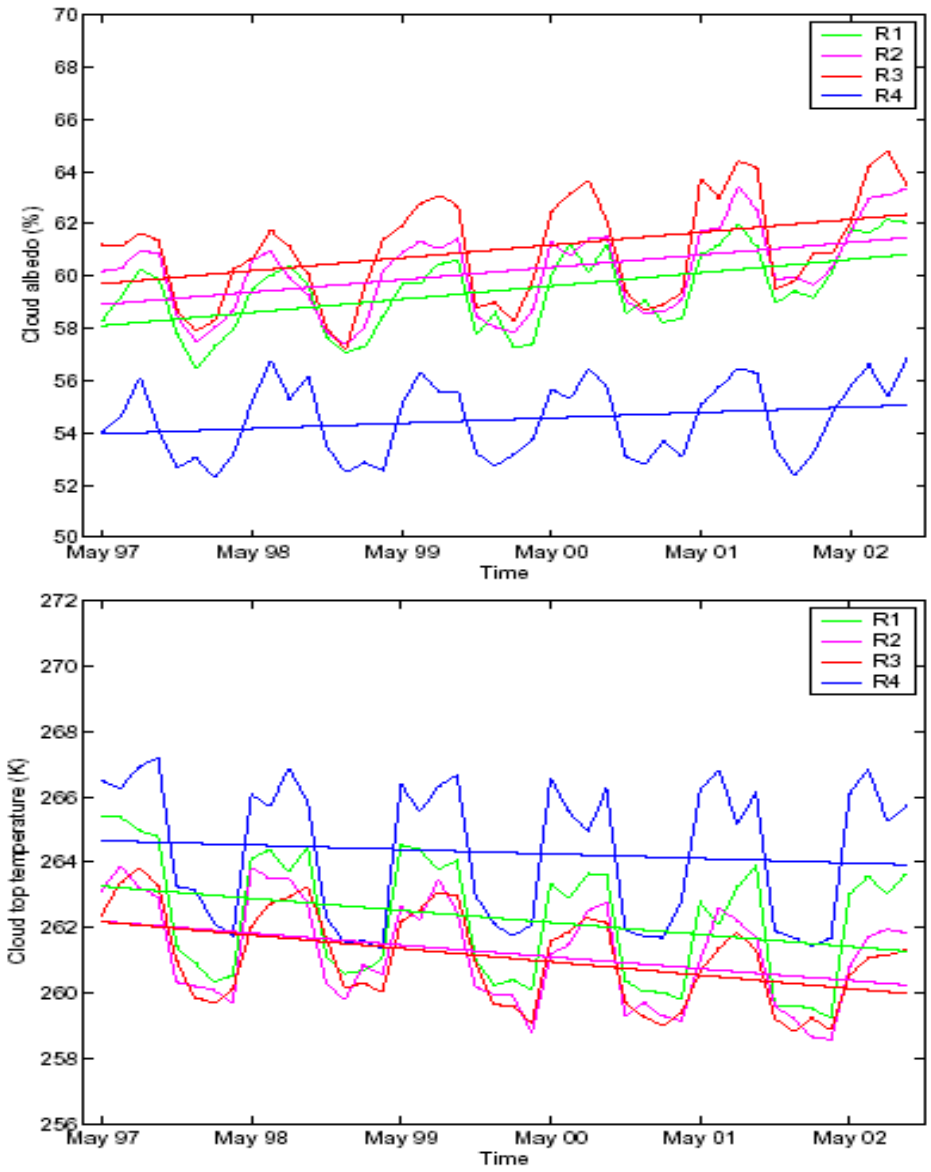




Decrease of cloud reflectance (unit: %) in thousandth from 1985-89 to 1996-99 for different mean reflectance classes as derived from AVHRR channel 2 satellite measurements over parts of Central Europe for winter(left) and summer (right) months. This is interpreted as a net reaction to less aerosol and soot emission after the breakdown of the eastern European industry production around 1990.

O. Krüger / H. Graßl (2002)

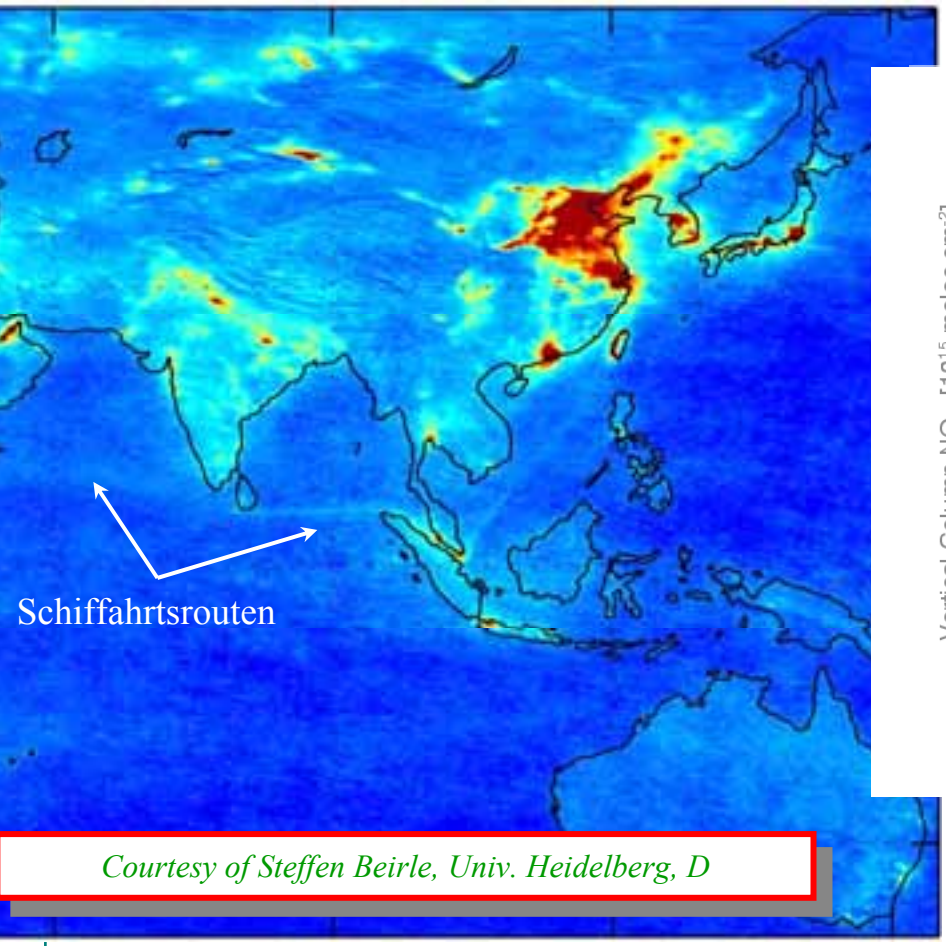
Cloud reflectance and ship emissions



Trend observed in monthly averaged cloud albedo (upper panel) and CTTs (lower panel) between May 97 and Aug. 02 for 3 harbour areas (R1, R3), the English Channel (R2) and a relatively remote ocean region (R4) clearly confirms the influence of increasing ship emissions. In additon to an albedo increase the reduction of clout top temperature hints at more intense convective activity in aerosol loaden clouds.

Courtesy of: A. Devasthale (2006)

Understanding the Earth System



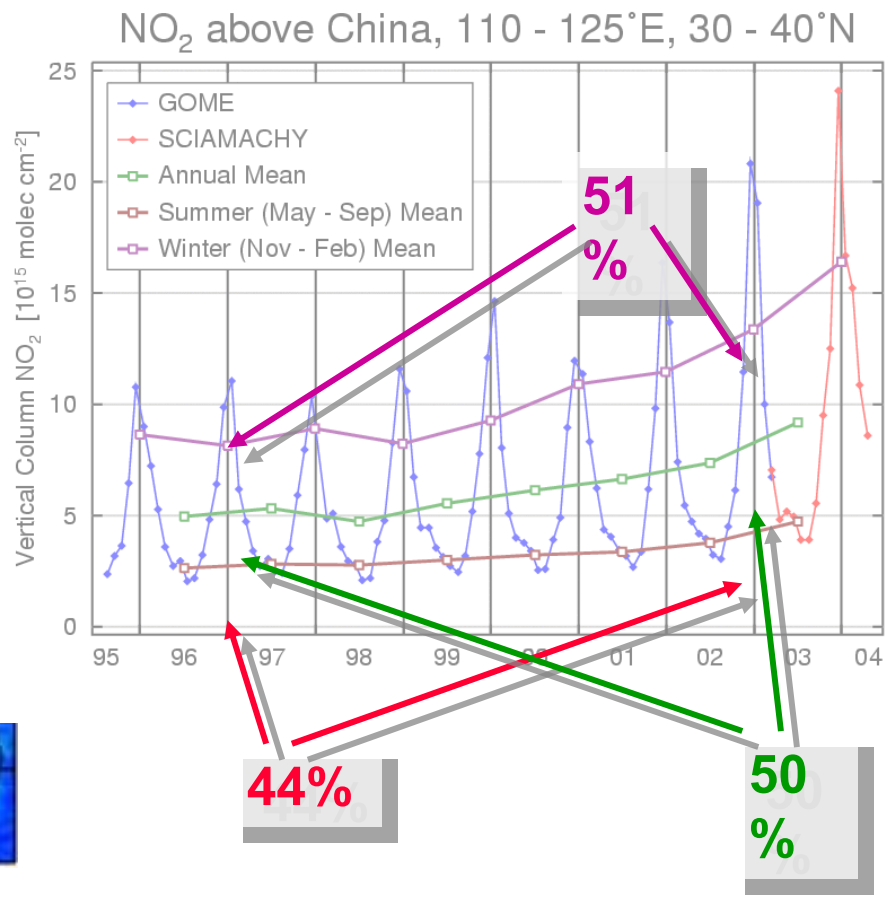
Courtesy of Steffen Beirle, Univ. Heidelberg, D

NO_2- column content observed by SCIAMACHY

-1 0 1 2 3 4 5 6

10^{15} molecules/cm²

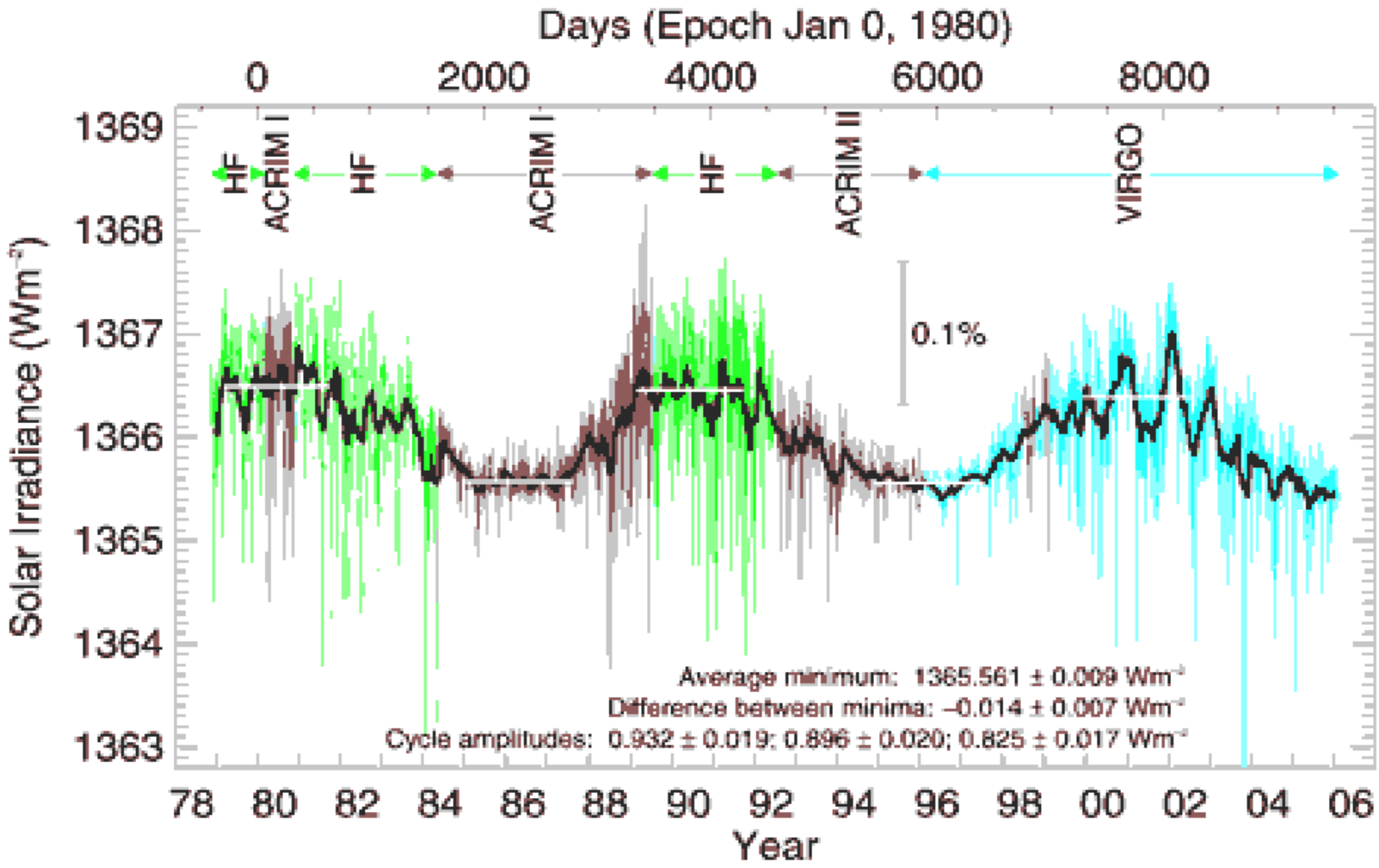
Ein Institut der Max-Planck-Gesellschaft
An Institute of the Max Planck Society



Increase in NO_2-concentration by 50%

Courtesy of John Burrows, Univ. Bremen, D

Stability of the solar constant



Source: PMOD/WRC in Davos

Challenges to be answered soon

- Source and sink distribution of CO, CH_4 and CO_2 by inverse modelling using data from ENVISAT, METOP
- Trends of cloudiness by better intercalibration of satellite series
- Phytoplankton time series through combination of CZCS, SeaWiFS, MODIS and MERIS

Did Earth Observation Influence International Law?

- yes, for the Montreal Protocol

- yes in parts, for EU climate policy if EU council decisions of March 2007 are implemented

- hopefully, for the follow-up to the Kyoto Protocol

Do we have a balanced European system of Earth Observation?

Component	Institution	Purpose
Earth Explorer Core and Opportunity Missions	ESA-EOEP	New observations with new technologies for understanding the Earth System
Operational Meteorological Satellites (built by ESA)	EUMETSAT	Improved weather forecasts, Fundamental data for GMES services
Sentinel de la Terre (GMES operational satellite series)	European Commission + ESA	New operational services within GMES, as part of GEOSS

Answer: Yes, soon

Thank You