Meteorological Services and Satellites as the Pillar for Understanding the Earth System

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Our Survival Parameters?

Solar radiation + Water from the skies
that allow
Biomass production by plants

The most important climate parameters?

Solar radiation flux density + clouds + precipitation +
atmospheric composition (dominated by life)

Conclusions

Weather and climate dominate habitability
and
rapid climate change must threaten life

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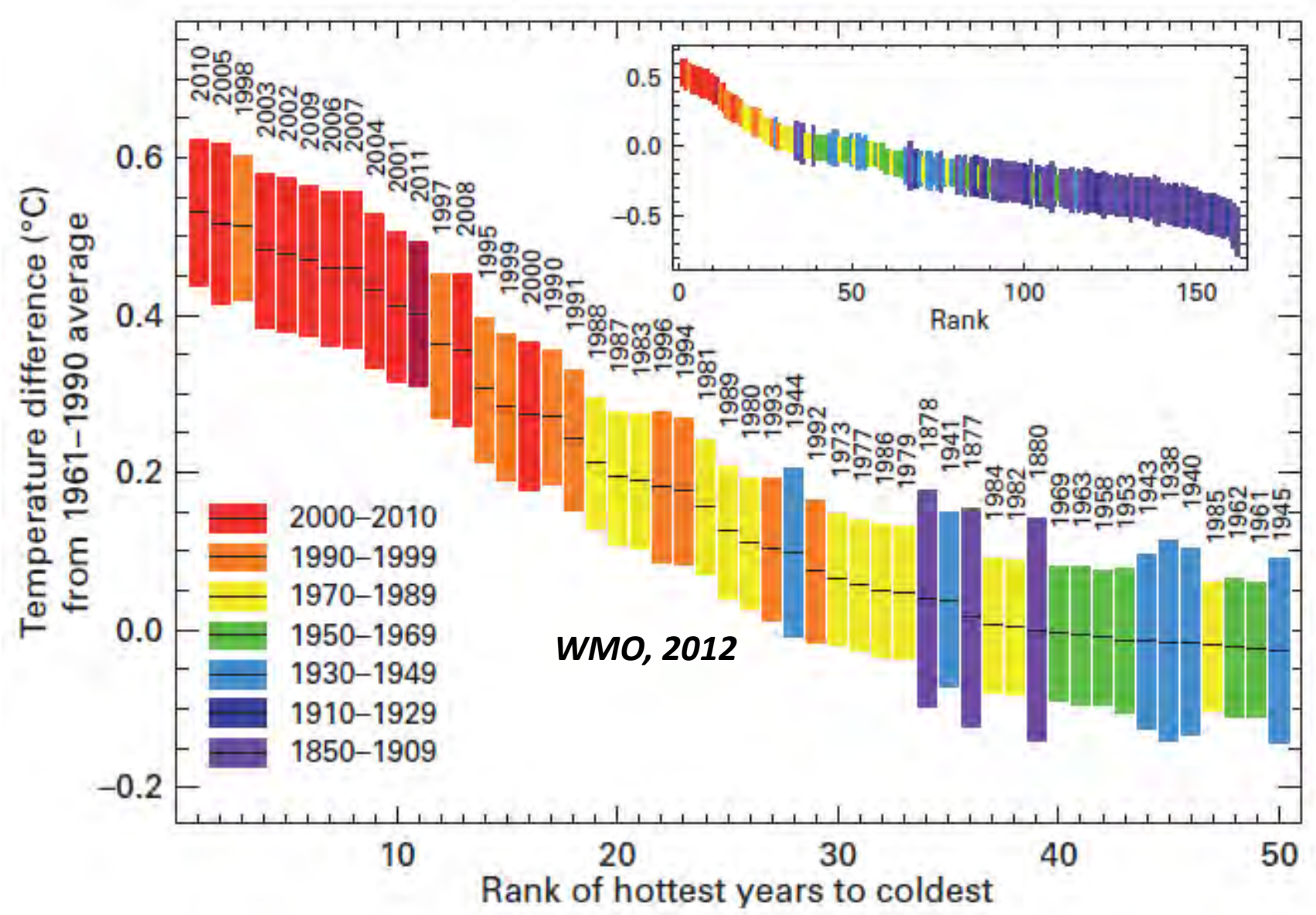
The Present Situation

Thanks to all Met Services since 1850

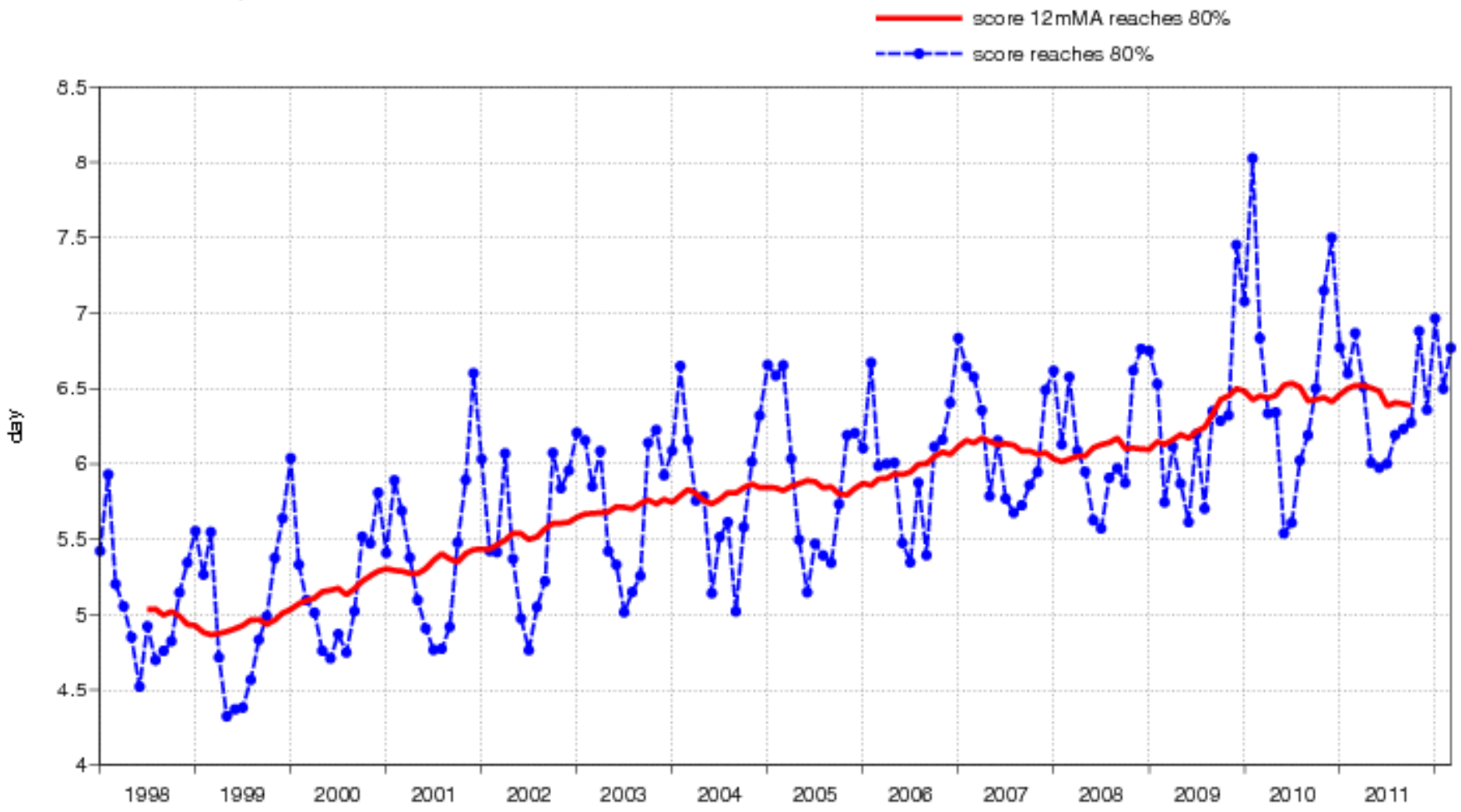


ECMWF deterministic 00,12UTC forecast skill

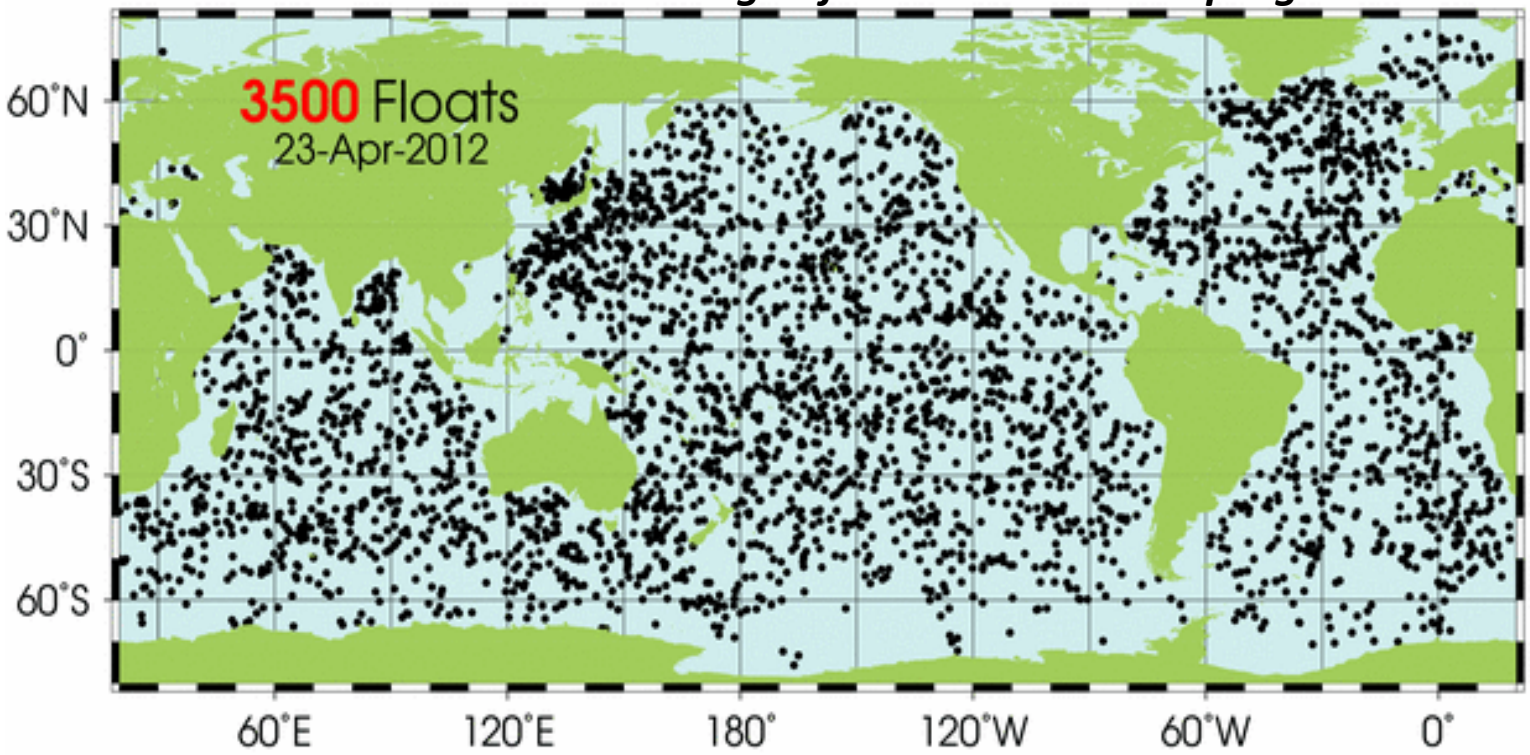
500hPa geopotential

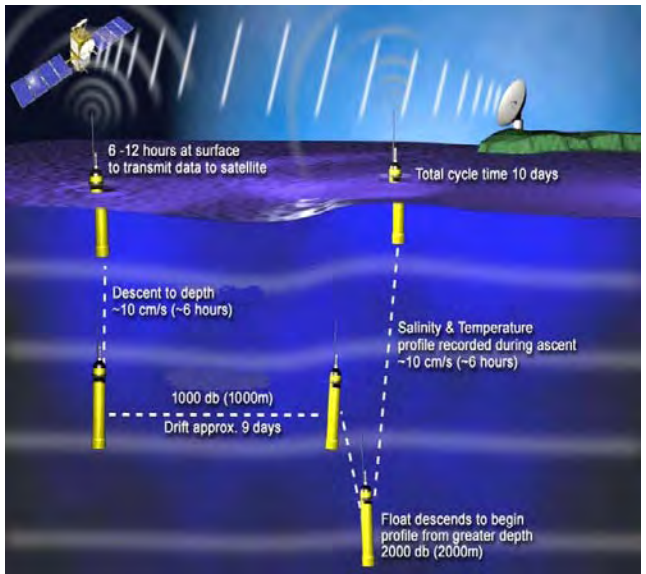
Lead time of Anomaly correlation reaching 80%

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)



Part of the ocean observing system used for seasonal prediction
Teil der Ozeanbeobachtungen für die Jahreszeitenprognose





ECMWF Seasonal Forecast

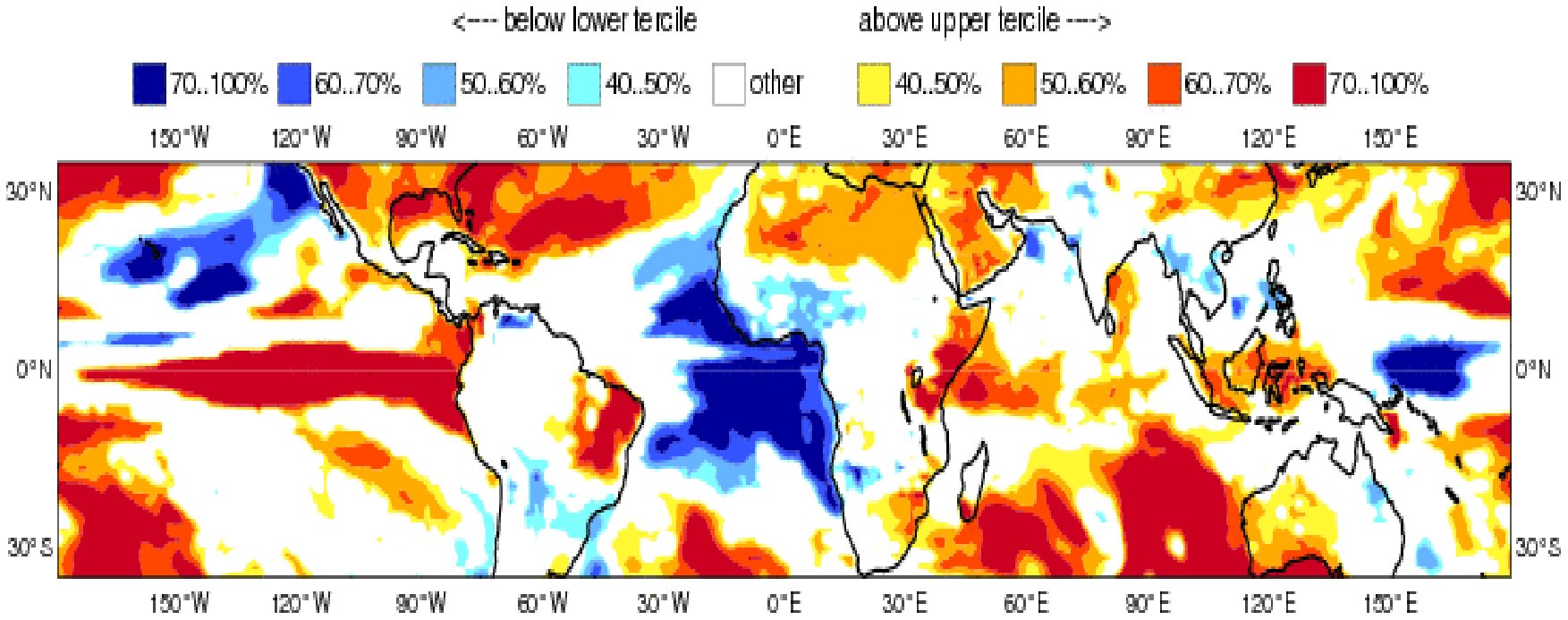
Prob(most likely category of 2m temperature)

Forecast start reference is 01/04/12

Ensemble size = 51, climate size = 450

System 4

MJJ 2012



ECMWF Seasonal Forecast

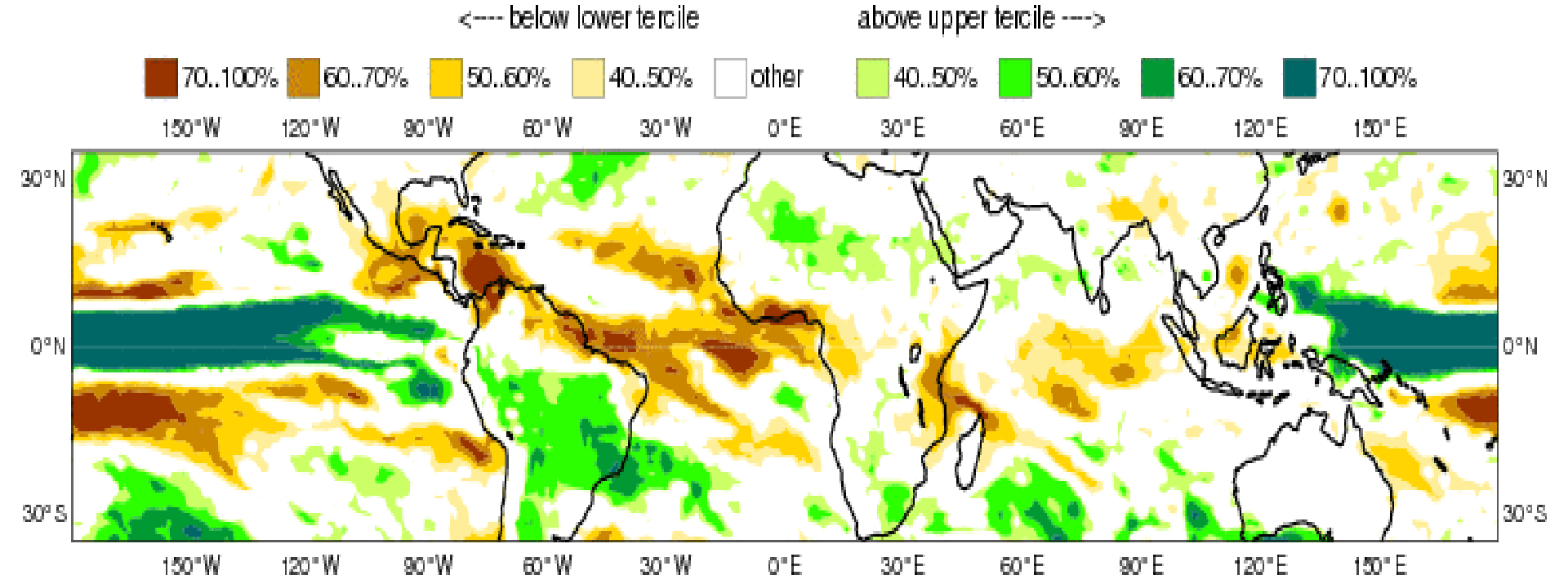
Prob(most likely category of precipitation)

Forecast start reference is 01/04/12

Ensemble size = 51, climate size = 450

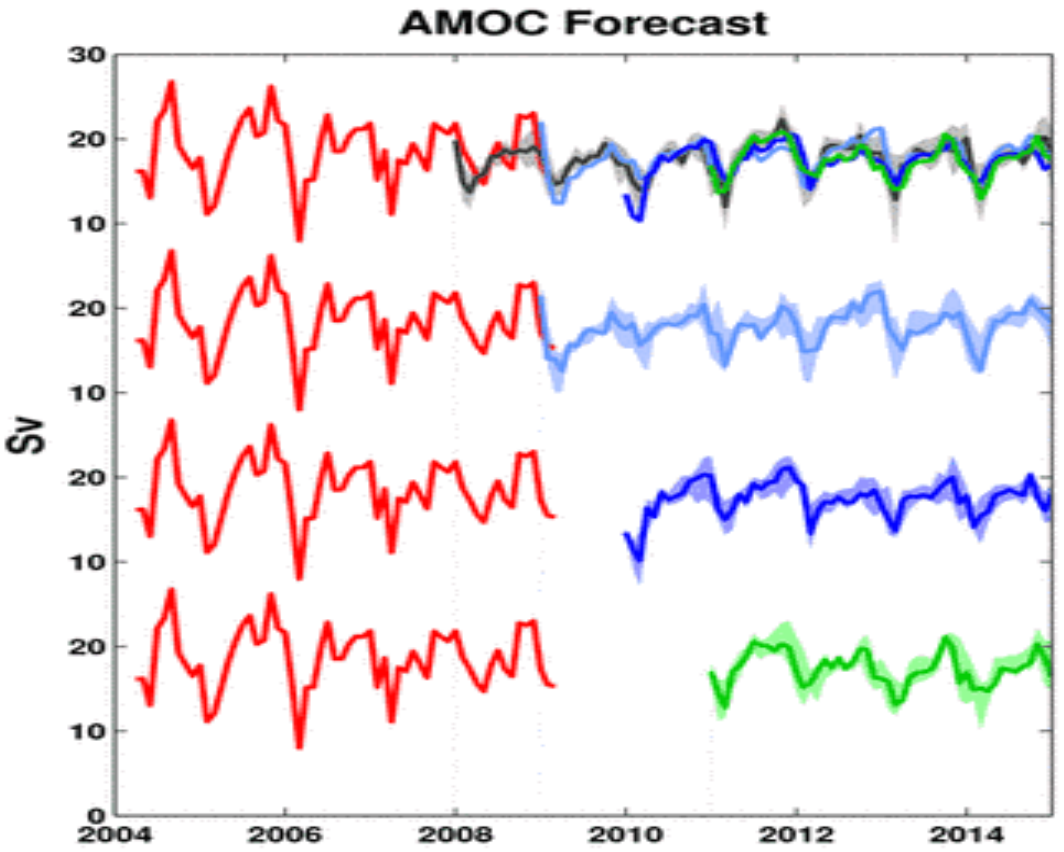
System 4

JAS 2012




26.5° North

Multiyear prediction of the Atlantic Meridional Overturning Circulation (AMOC)



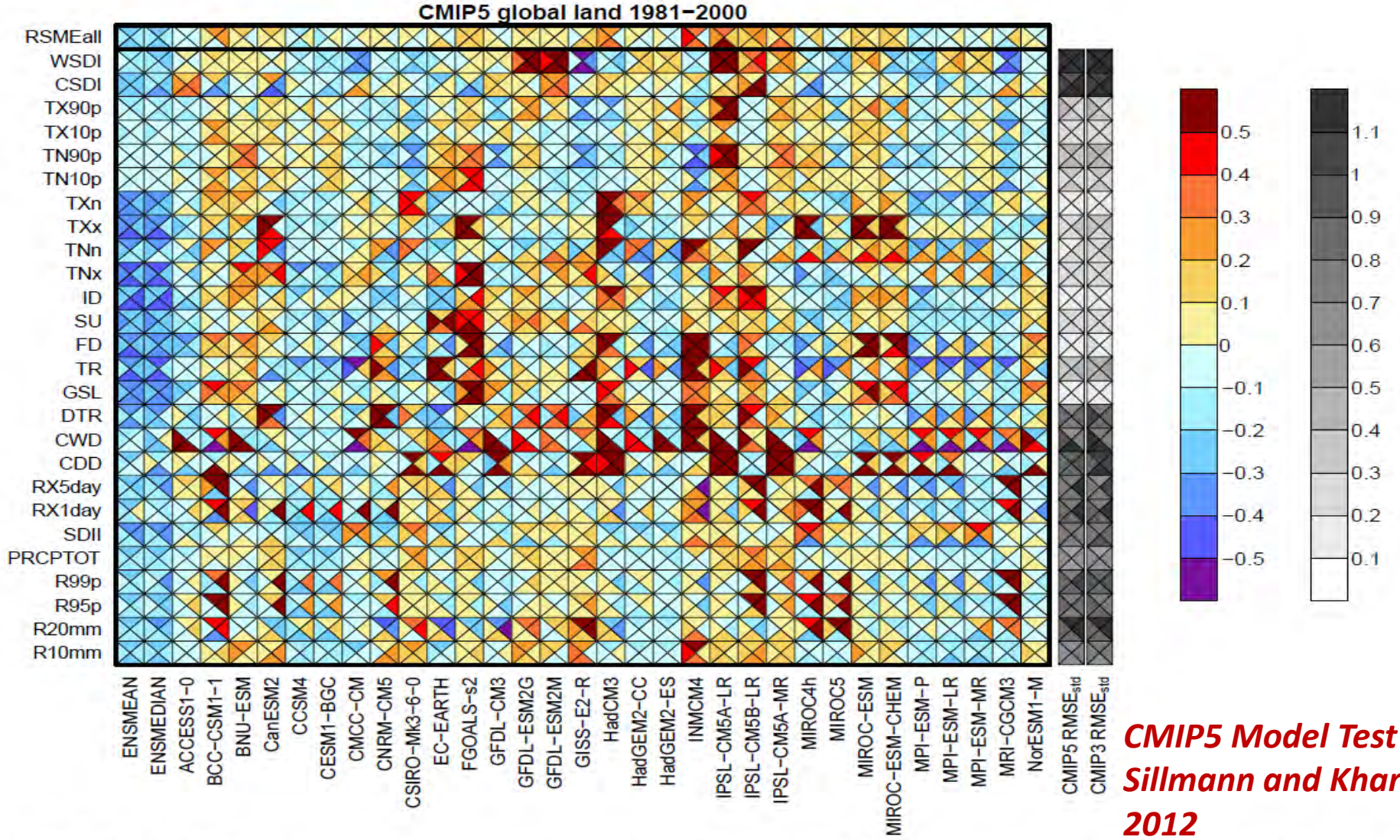
Observations in red, ensemble mean predictions in grey, light blue, dark blue, green for prediction start in January 2008,2009,2010, 2011

Matei et al.
Science 2012

Jungclaus 2012:

First attempts in decadal climate prediction, based on ocean initialization, show promising results and achieve significant multi-year predictive skill for crucial climate quantities (e.g., North Atlantic near surface air temperature, Atlantic MOC, deep water formation)

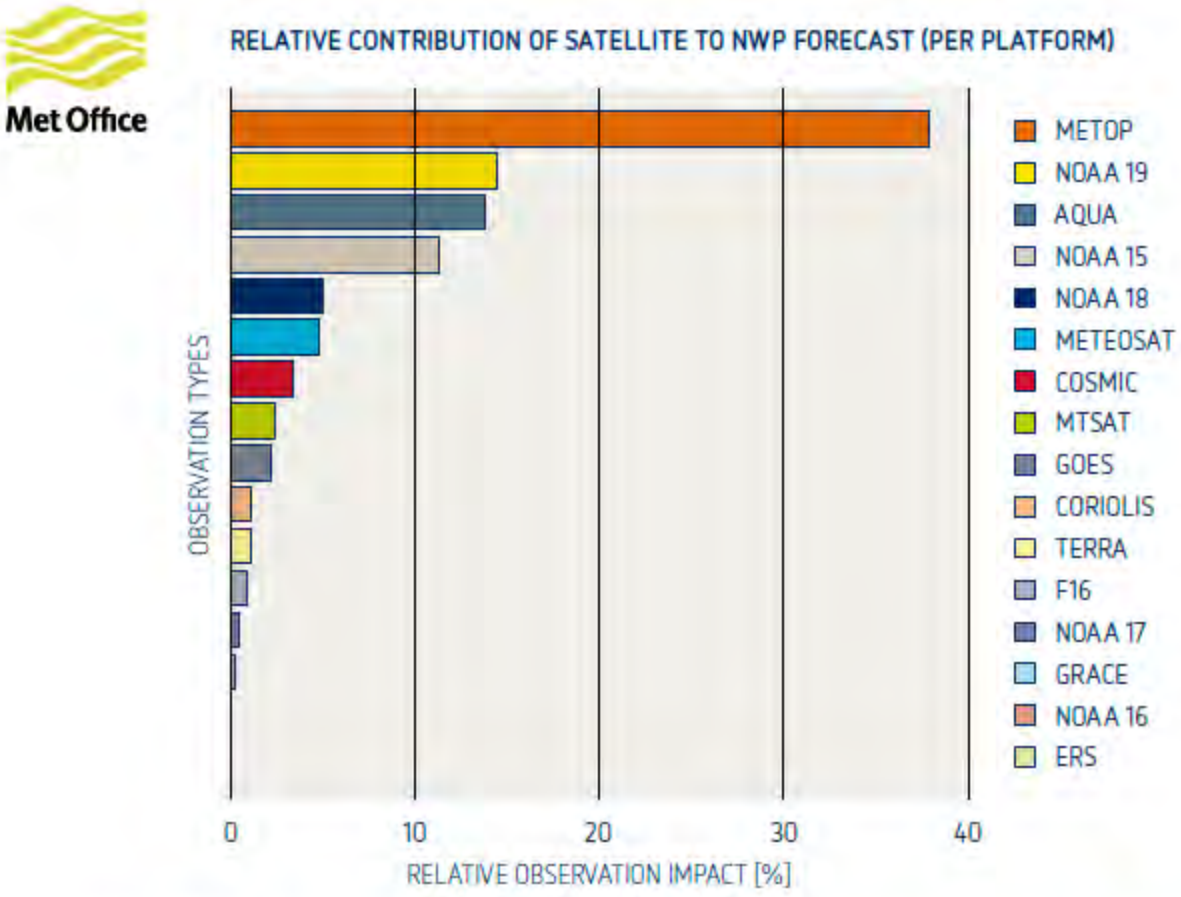
Can Climate Models Correctly Calculate Recent Climate ?



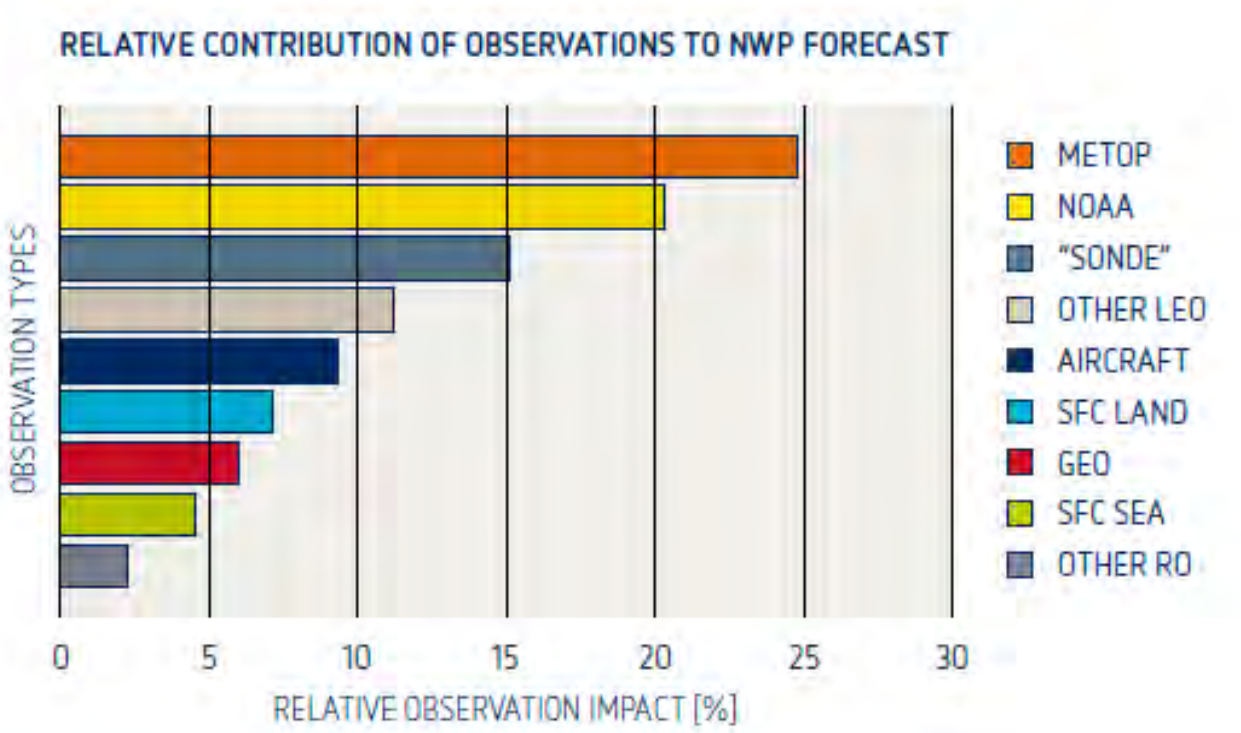
CMIP5 Model Test Sillmann and Kharin 2012

Figure 10. The "portrait" diagram of relative spatially averaged RMS errors in the 1981–2000 climatologies of temperature and precipitation indices simulated by the CMIP5 models with respect to the four reanalyes, ERA40 (left triangle), ERAinterim (upper triangle), NCEP1 (right triangle) and NCEP2 (lower triangle). The RMS errors are spatially averaged over gobal land grid points. The top row indicates the mean relative RMSE across all indices for a particular model and the gray-shaded columns on the right side indicates the standardized median RMSE$_{median,std}$ for CMIP3 and CMIP5 (see text for details).

BENEFITS OF OPERATIONAL METEOROLOGICAL SATELLITES

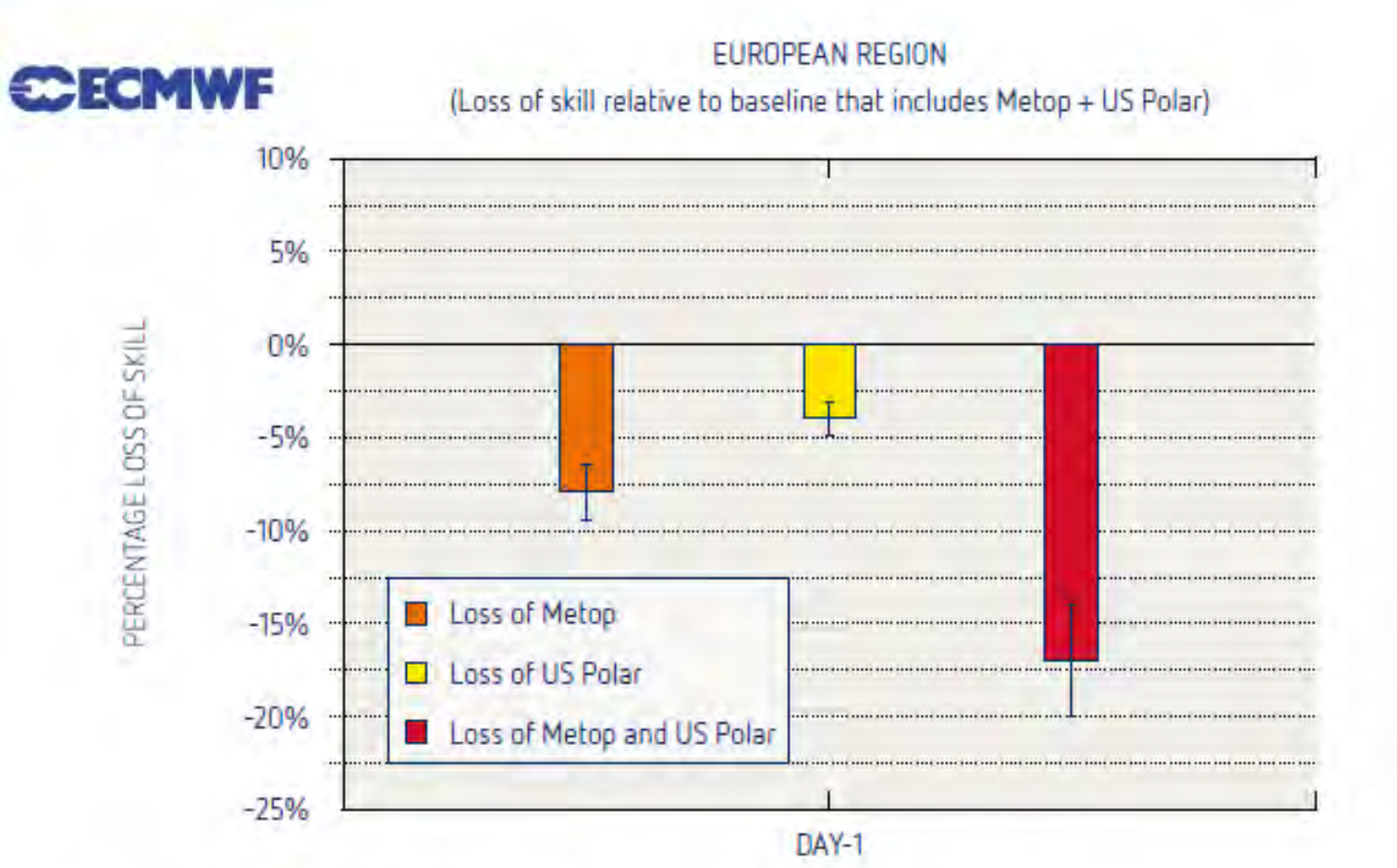


Many operational and experimental satellite data are already assimilated into the starting fields for numerical weather prediction



METOP
NOAA
Radiosonden
Andere polare
Flugzeuge
Landoberfläche
Geostationäre
Meeresoberfläche
Andere

The most significant impact by METOP



Loss of 24 hour forecast skill due to failure of operational polar orbiting satellites

BENEFIT AREA	MINIMUM	LIKELY
Protection of Property and Infra-structure	€1.32 billion/year	€5.4 billion/year
Added Value to the European Economy	€10.23 billion/year	€41.0 billion/year
Private Use by European Citizens	€4.0 billion/year	€15.0 billion/year
TOTAL	**€15.55 billion/year**	**€61.4 billion/year**

Benefit through EPS-SG for EU27, solely by improved weather prediction
(Met Office)

The overall benefit of planned EPS-SG

When these highly conservative annual benefit estimates are cumulated over 20 years with an annual discount rate of 4% and contrasted with the estimated €3 billion cost of the EPS-SG Programme, the minimum benefit to cost ratio is over 5 and the likely ratio exceeds 20, with the understanding that these ratios would increase by a factor of 3, if a 25% apportionment was assumed instead of the worst case 8%.

It would not at all be wise not to go for it

RECENT ACHIEVEMENTS
OF
REMOTE SENSING WITH SATELLITES

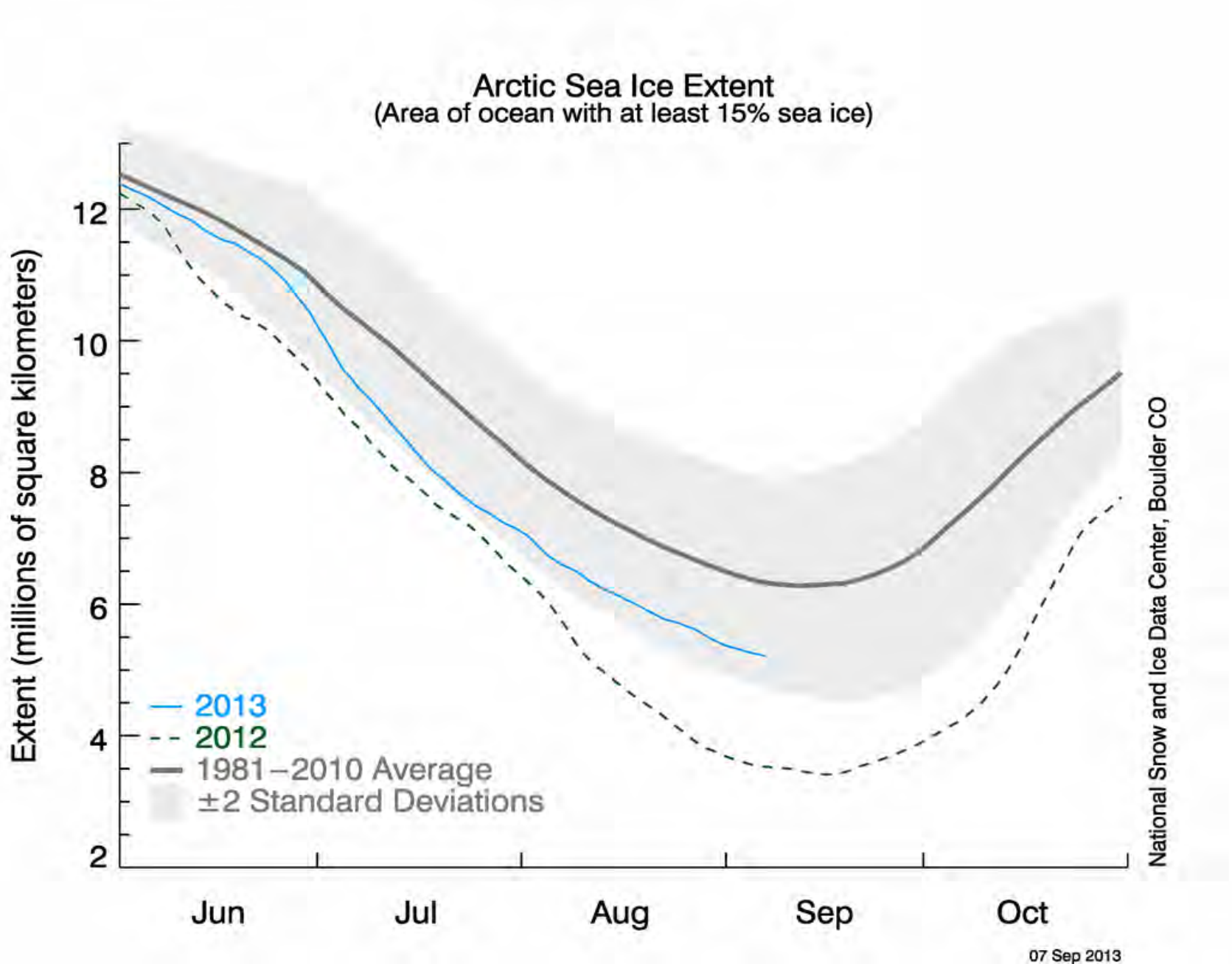
Because the atmosphere is semi-transparent, it can in principle be observed with high vertical and horizontal resolution at high frequency: At present technological state of the art it is mainly a question of money spent for remote sensing preferably for satellites

Also the surface can at the same time be observed with high accuracy at high frequency

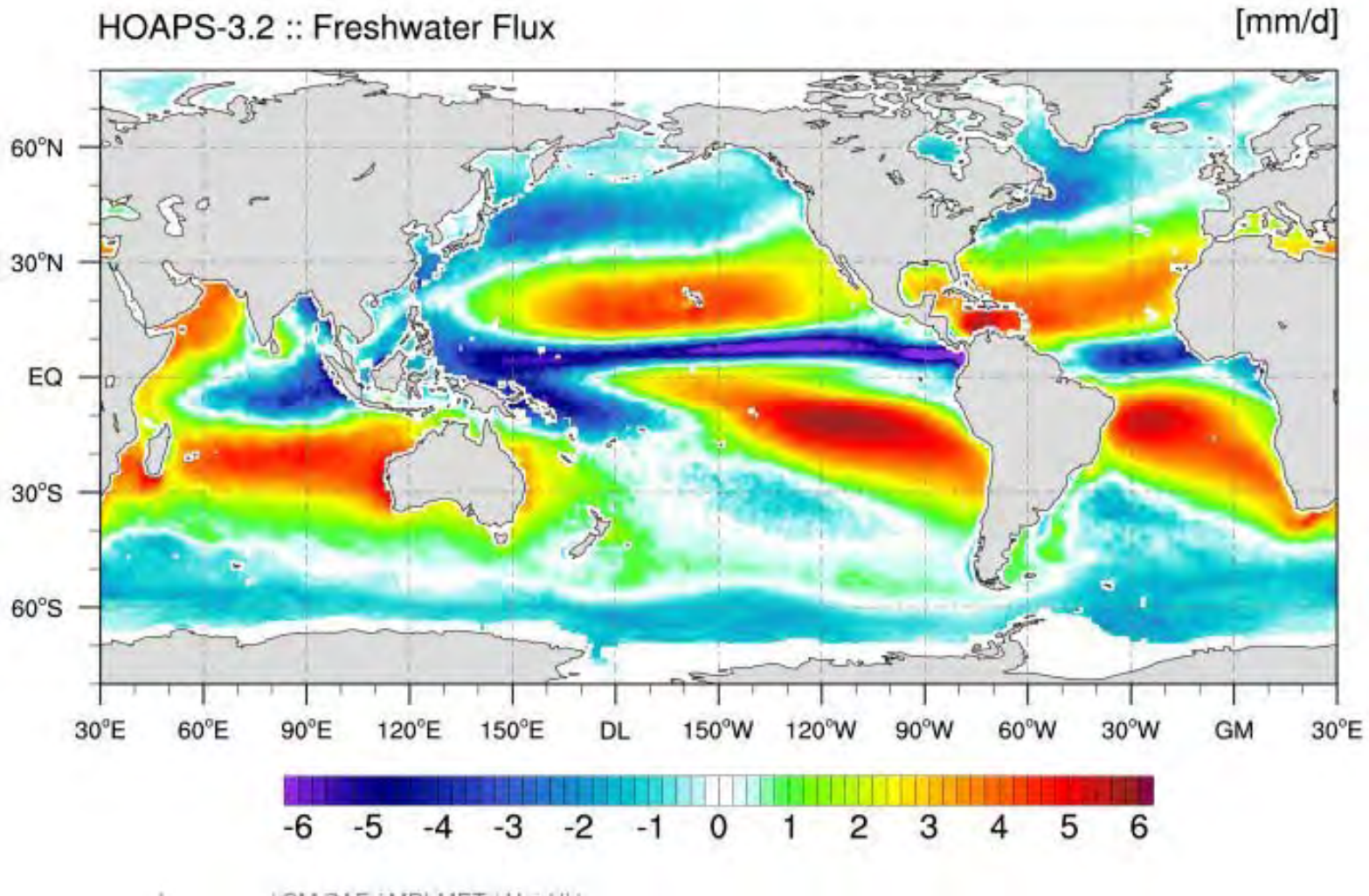
Therefore at least Meteorology, Climatology, Hydrology and Oceanography have to join forces and finances

OPERATIONAL SATELLITES

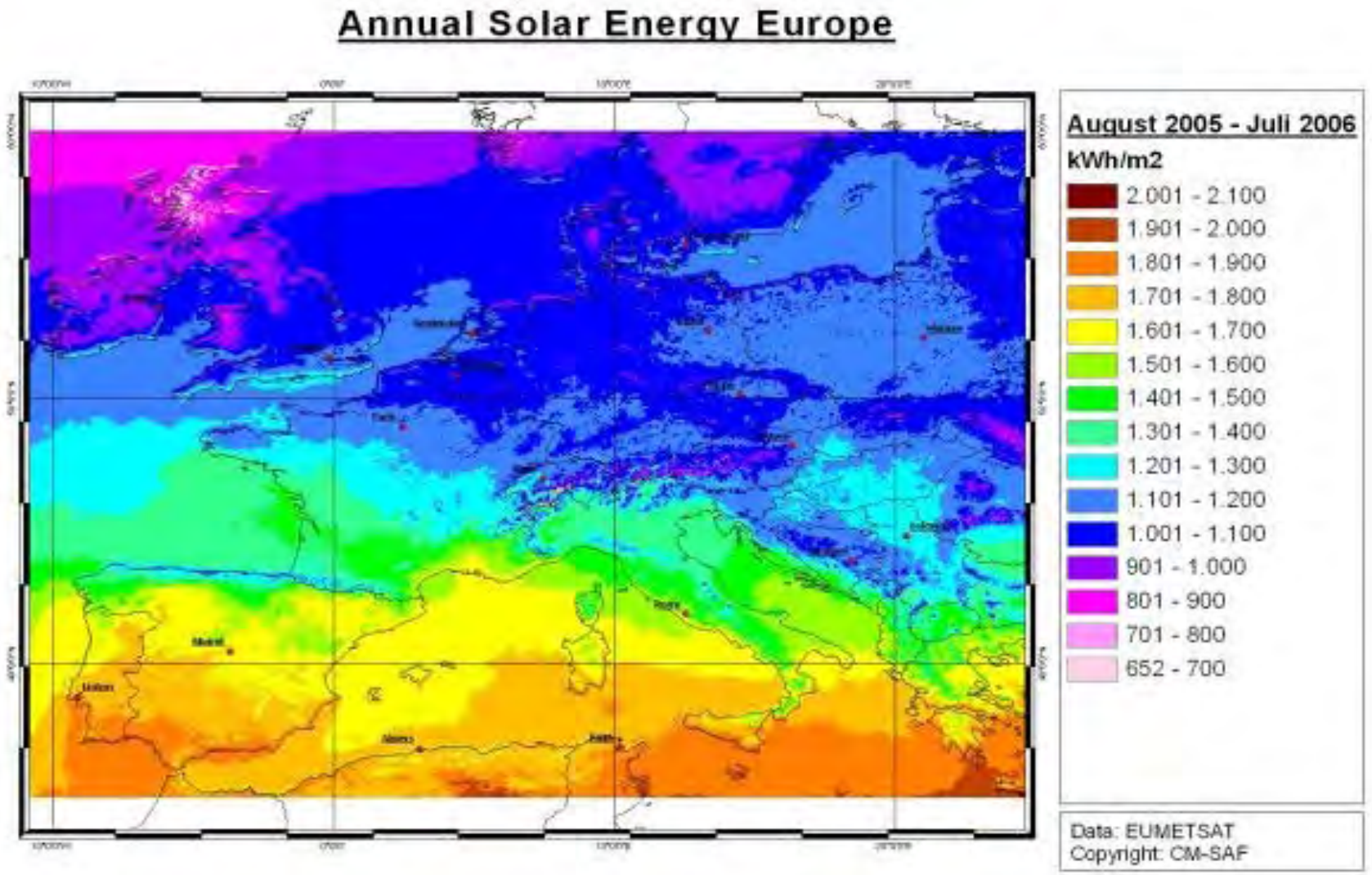
The Shrinking Arctic Marine Cryosphere



HOAPS
Net Freshwater Flux over the Ocean



Das Angebot für Fotovoltaik in Europa



An operational Meteorological Satellite as the air chemistry sensor

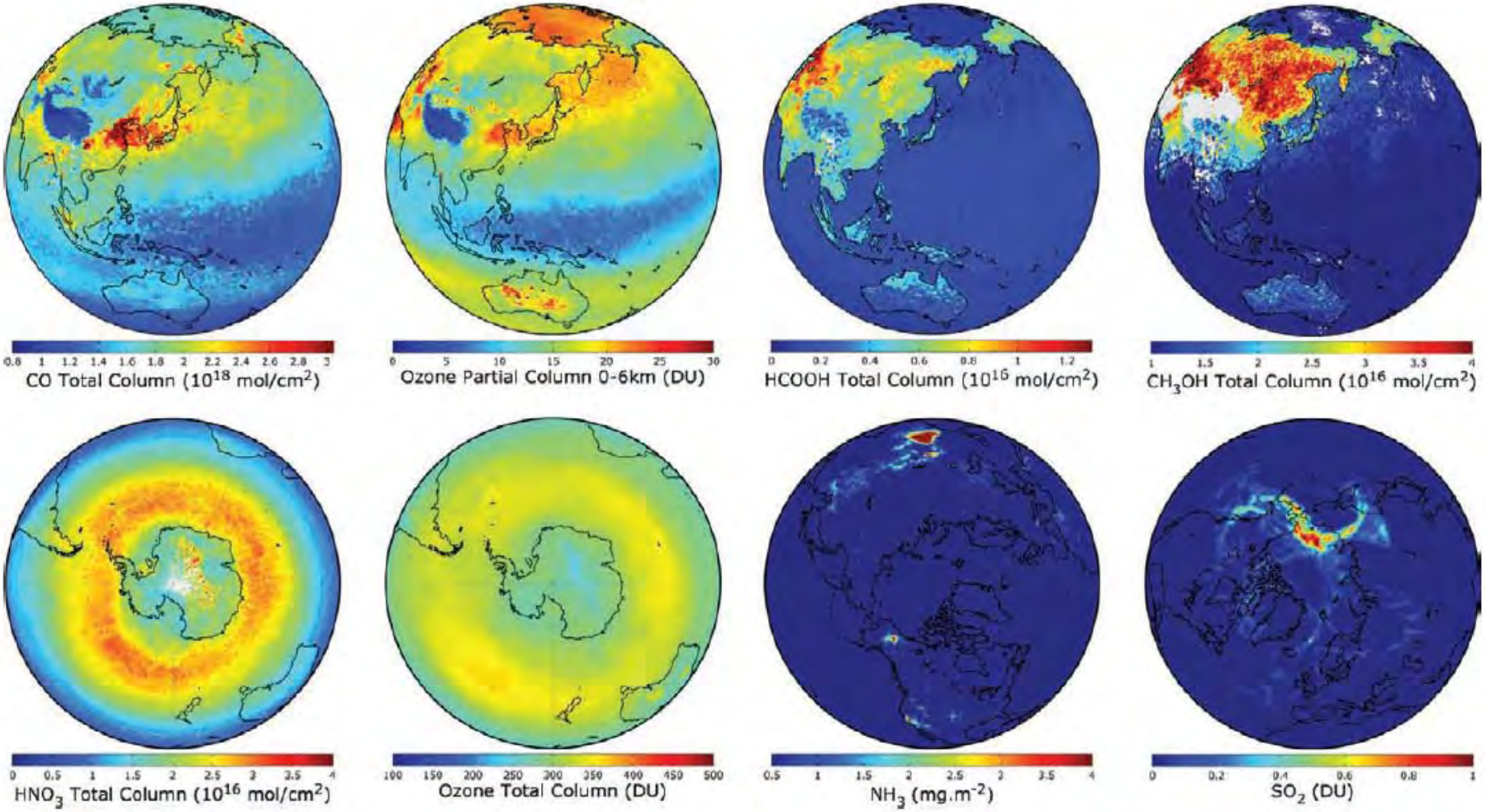
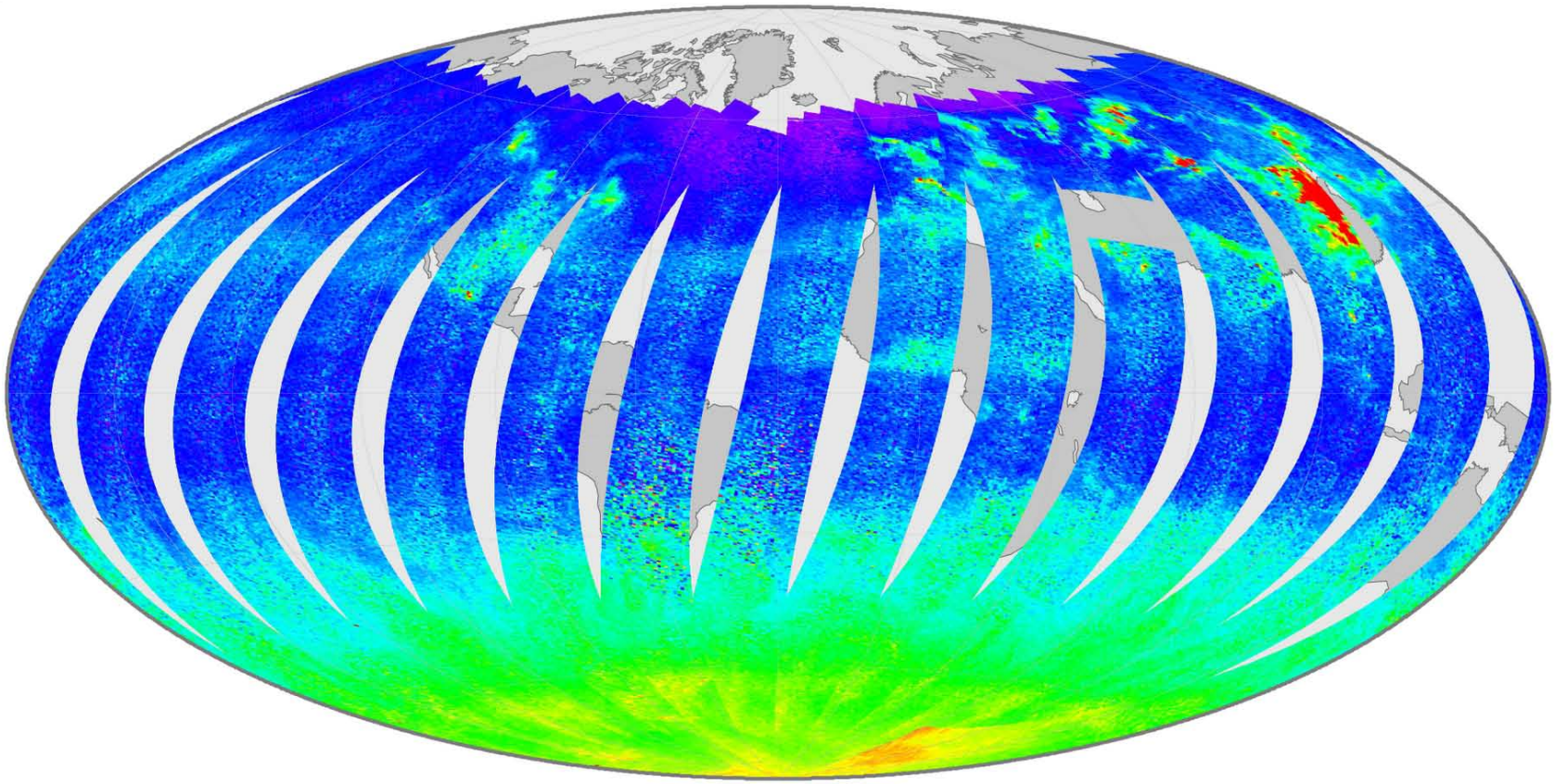


FIG. 9. Trace gas distributions retrieved from IASI spectra, averaged over 1 month of observations in Jul 2008. (top) Total columns for the chemistry gases carbon monoxide, ozone (tropospheric column), formic acid, and methanol. (bottom left) Polar projection over the Antarctic of ozone and nitric acid total columns, prior to the development of the ozone hole. (bottom right) Arctic projection showing hotspots of ammonia over continental areas and the SO_2 plume following Okmok eruption.

NO_2

Nitrogen Dioxide total column

Acquisition Time	Sensor	Plot Range	Algorithm
18-DEC-2012 00:02:54	GOME-2	0.0 : 21.3	GDP 4.6
18-DEC-2012 23:45:59	MetOp-B	2.8 ± 1.4	UPAS 1.3.7



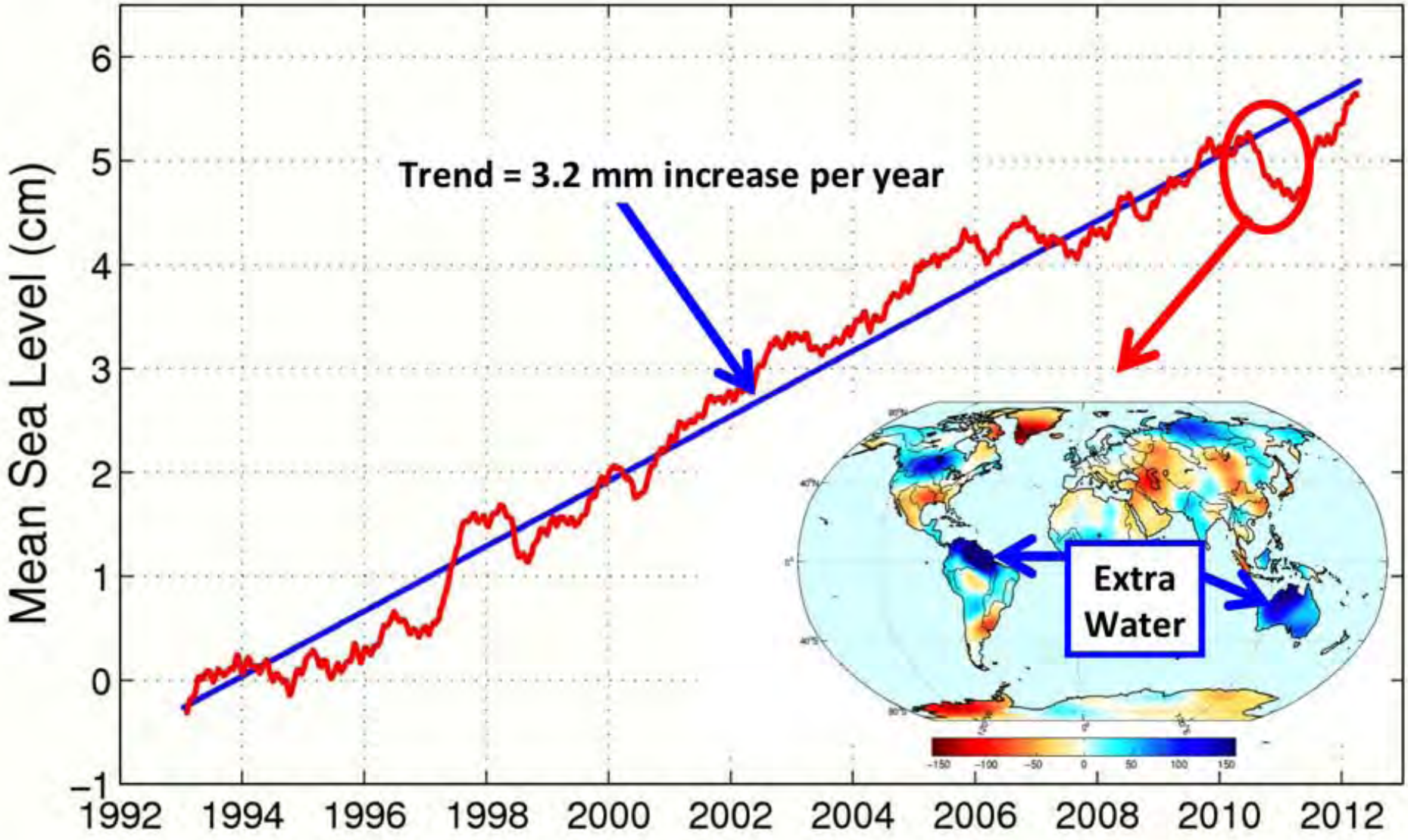
[1e15 mol/cm^2]

O3M SAF EUMETSAT DLR

http://atmos.eoc.dlr.de/gome2b

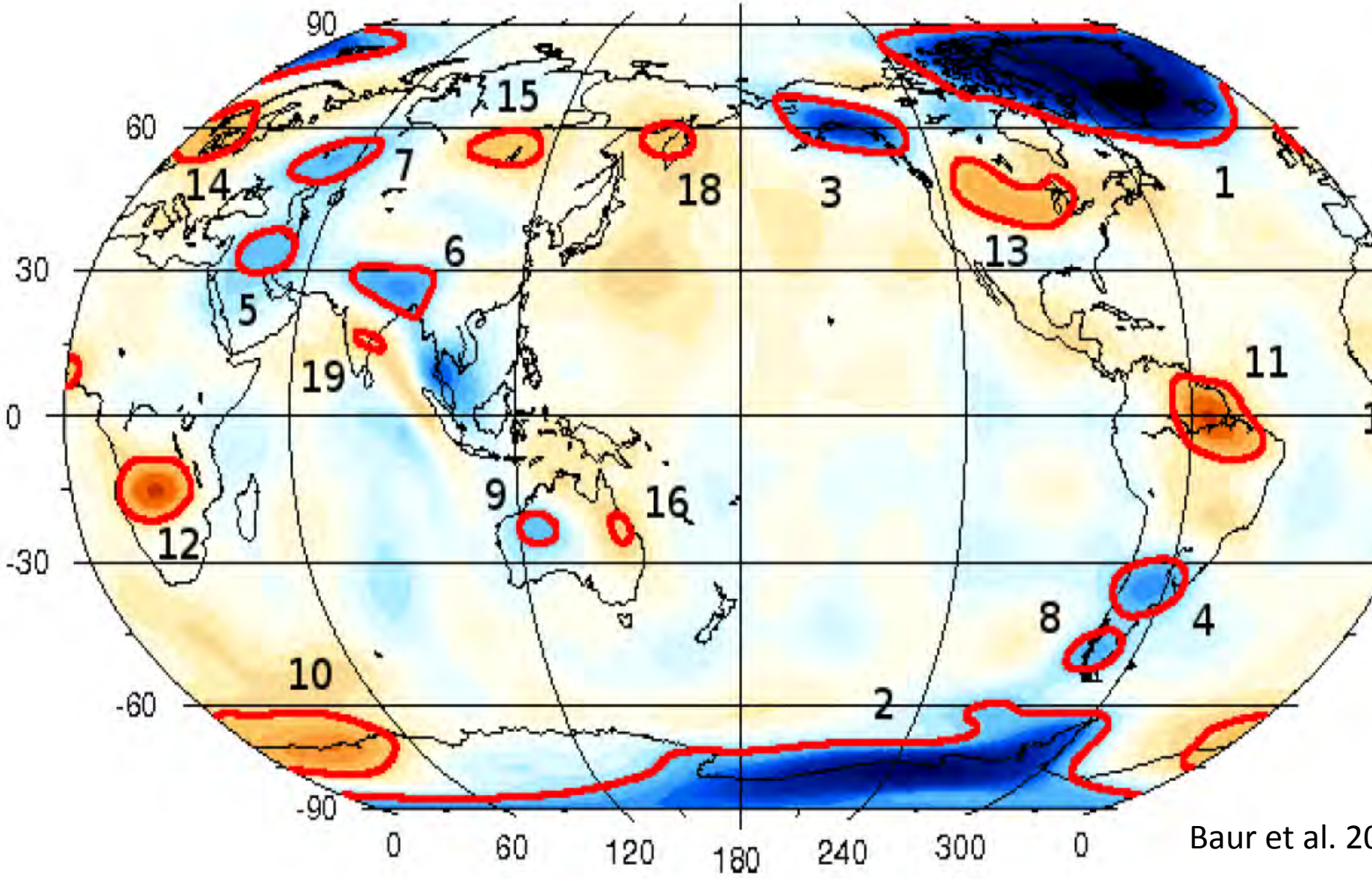
MIX OF OPERATIONAL AND EXPERIMENTAL SATELLITES

Meeresspiegeländerung, seit diese von Satelliten aus genauer beobachtet werden können



Regions of interest

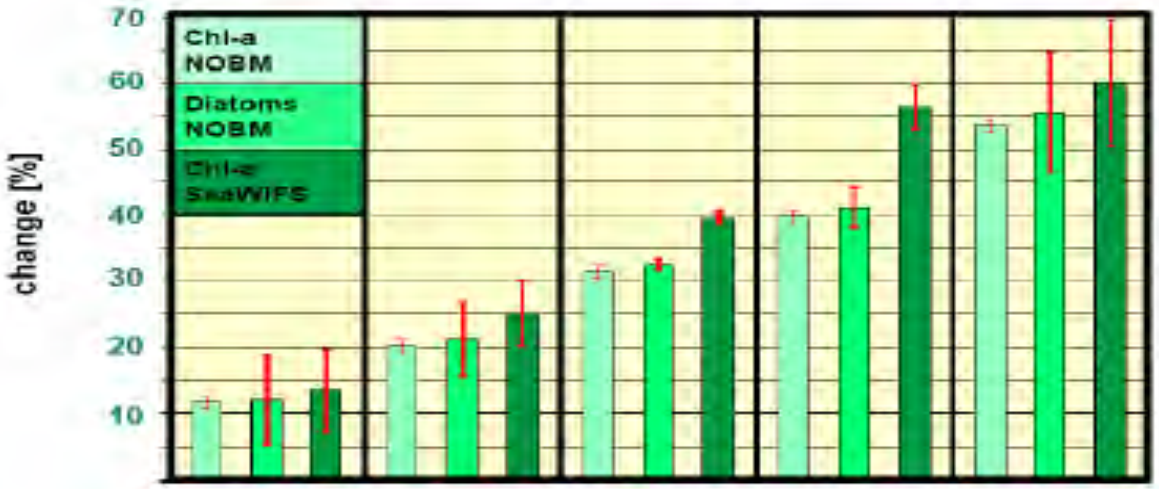
Redistribution of Water GRACE 2002 - 2011



Baur et al. 20

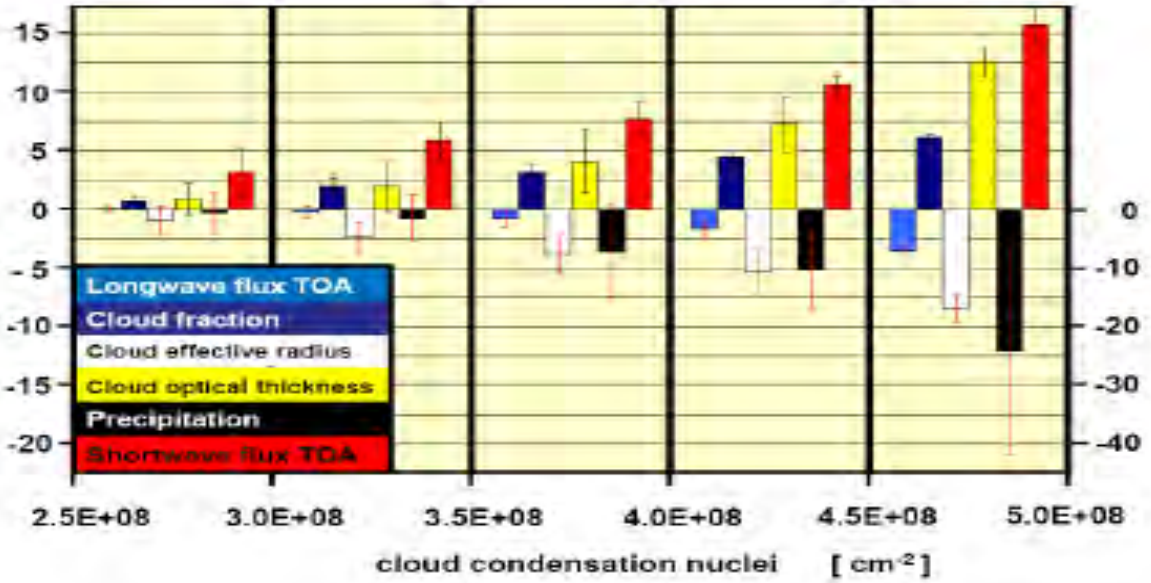
Biological control of climate parameters in the Southern Ocean

a

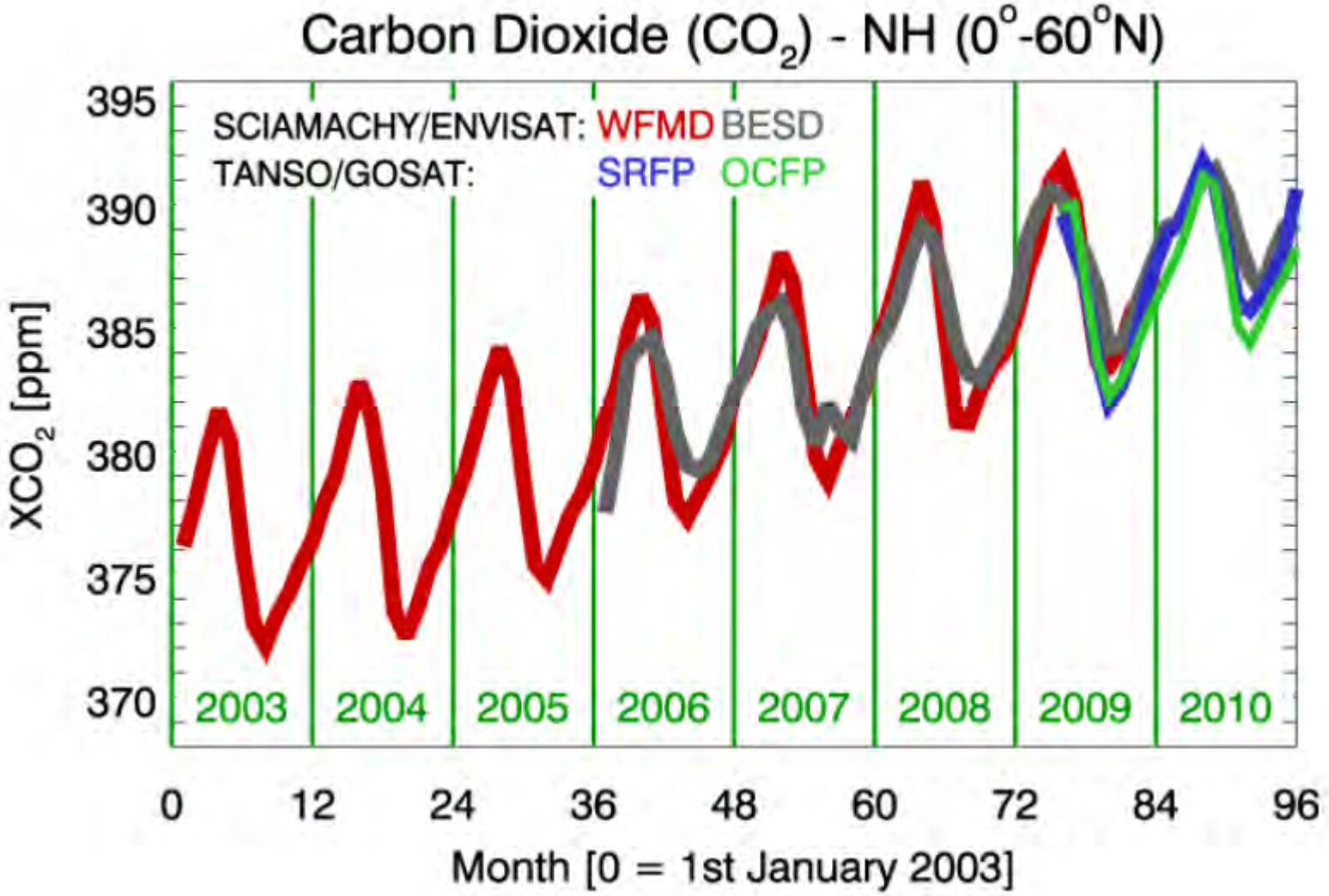


b

Krüger and Grassl (2011)

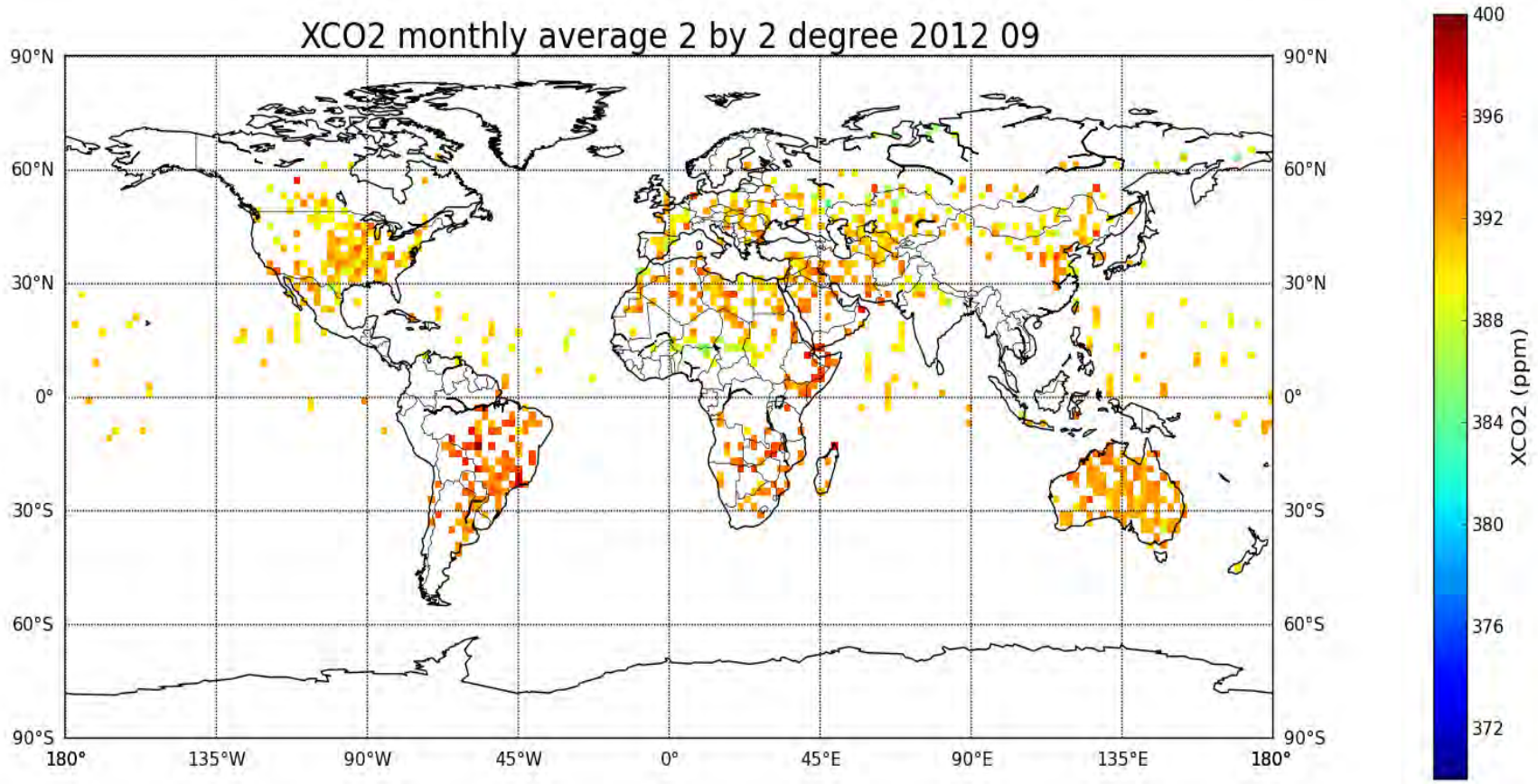


Experimentelle Satelliten



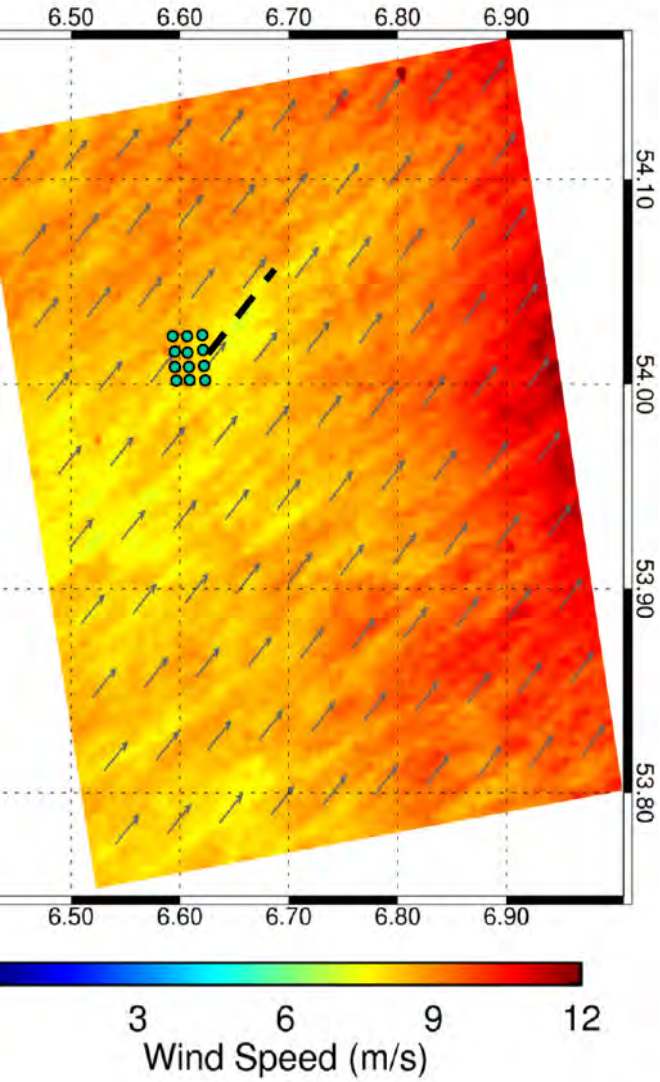
Buchwitz et al. 2012

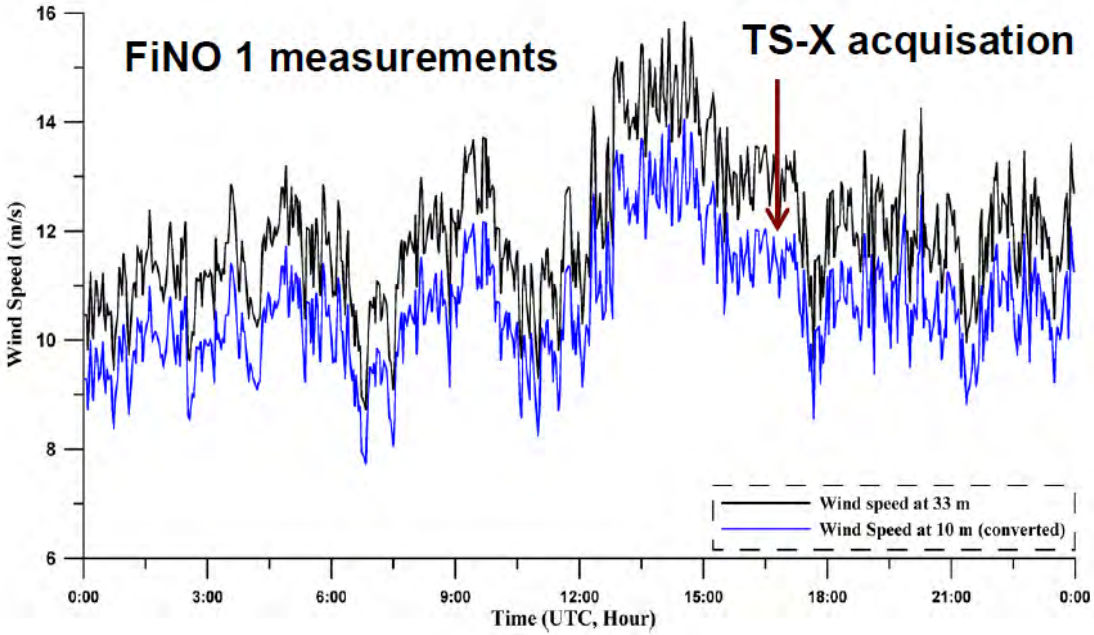
Carbon Dioxide Column Contents
September 2012
GOSAT



Influence of Off-shore Wind Parks on Waves

(TerraSAR-X)



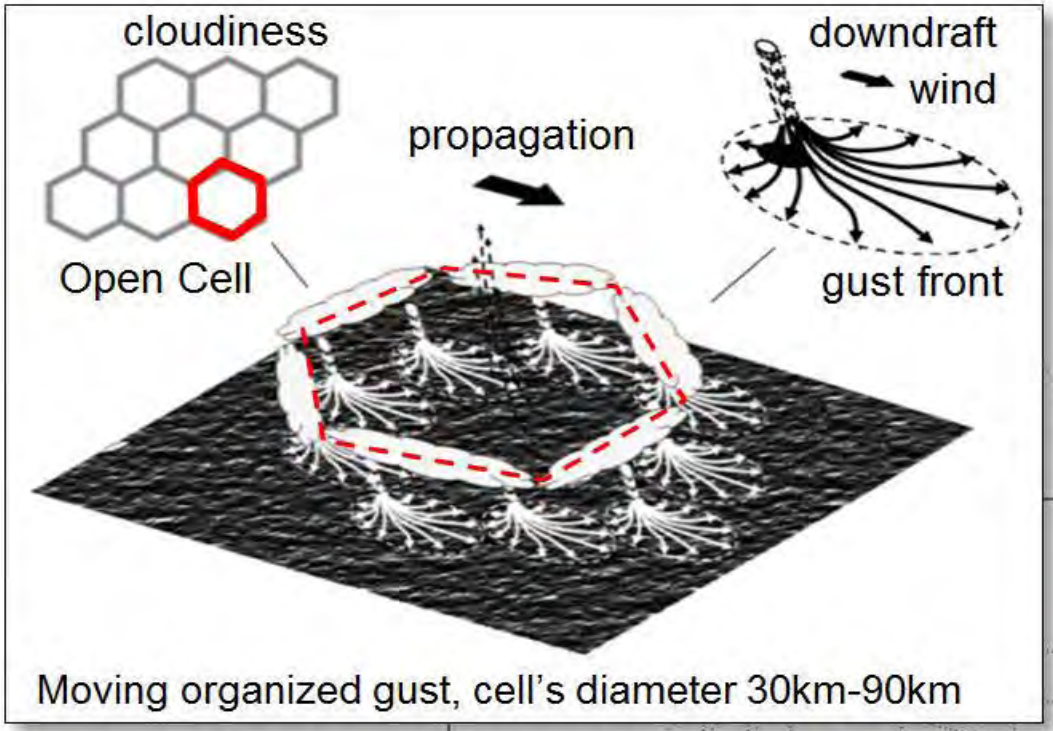


- ✓ **TSX – windspd: 10.3 m/s**
  In situ – windspd: 10.5 m/s
- ✓ **Extension of wind turbine wake: ca. 15 km**

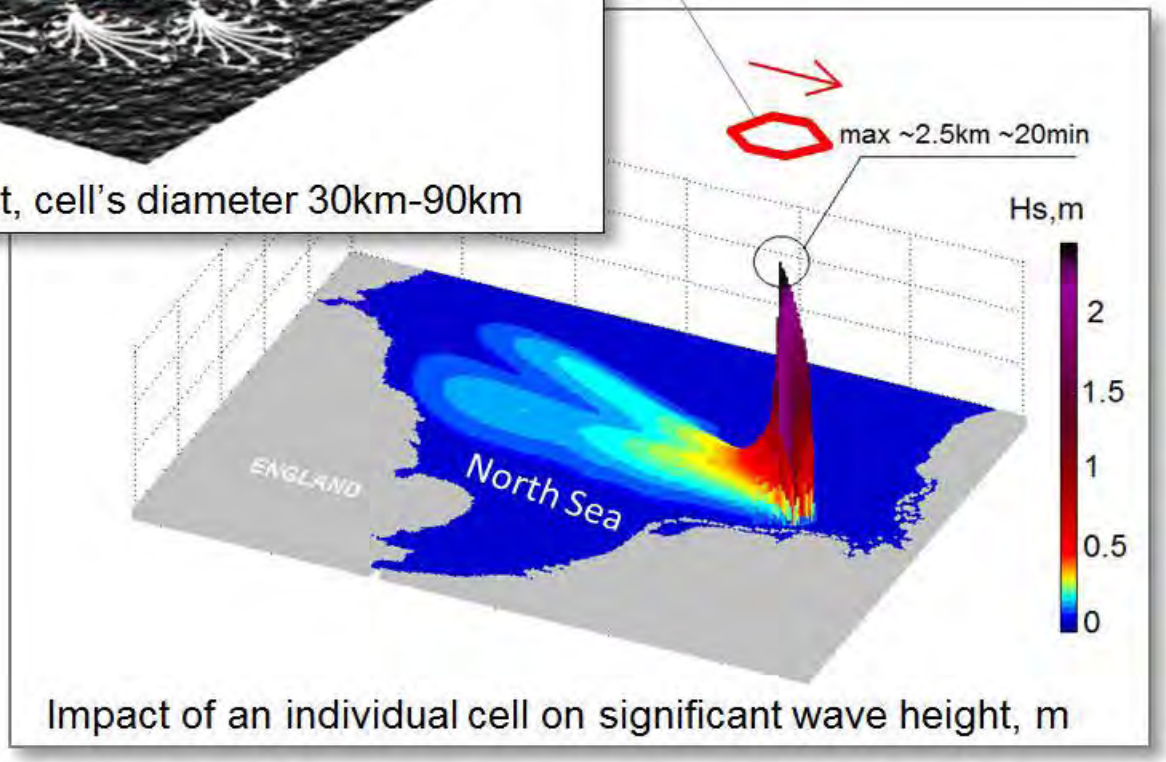
Li et al. 2012

TerraSar-X

Li et al. 2012



Moving organized gust, cell's diameter 30km-90km



Impact of an individual cell on significant wave height, m

GRAND CHALLENGES

The High Level Policy Advisory Committee (HISPAC) to ESA's DG has proposed four grand science themes:

- ***Terrestrial and Cosmic Climate***
- ***Understanding Gravity***
- ***Life in the Universe***
- ***Cosmic Radiation and Magnetism***

All four are related with planet Earth

My Wishlist (for remote sensing from space)

1) For Earth Observation from space (atmosphere and surface) a system's approach is needed spanning all spatial scales down to 1m horizontal resolution, with hyperspectral resolution from the extreme UV to the microwaves at up to an hourly rate, including a multispectral interferometric SAR

2) Observation of vertical motion in the atmosphere from geo-stationary orbit resolving cloud scales (several hundred meters) in order to understand convection, a weak point in present atmospheric circulation models

Because scientific progress is mainly restricted to a subset of the OECD countries so far, the forecasting or prediction windows will be filled by these, but they will help all countries. In Europe we need ESA, Eumetsat, ECMWF, the EU and all the European Services (becoming more integrated) to improve the understanding of the Earth system, a prerequisite for the approach to sustainable development.

My Political Wish

Because there is no sustainable development without improved predictions on a range of time scales for weather, climate, volcanism and seismic hazards in a world with nine billion heads we need a long-term strategy of GEOSS supported by an UN organisation for Geosciences as a whole and integrated services .

Europe has to take the lead in this integration