Applications of Data Assimilation in Earth System Science

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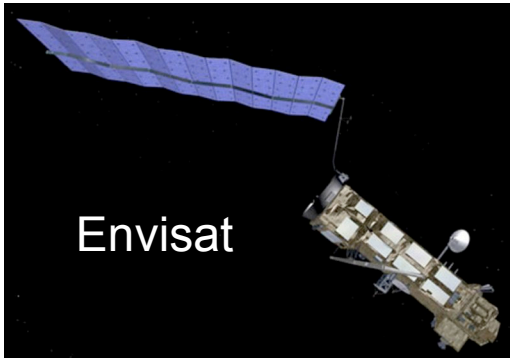
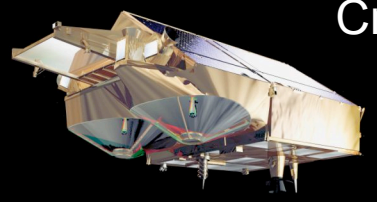
NATURAL ENVIRONMENT RESEARCH COUNCIL

£2Bn in new observing capabilities to be exploited in the next 5 years

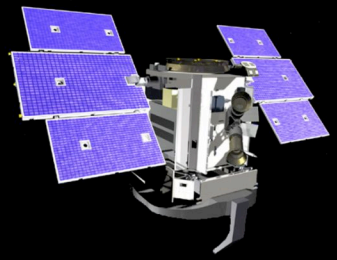


Envisat

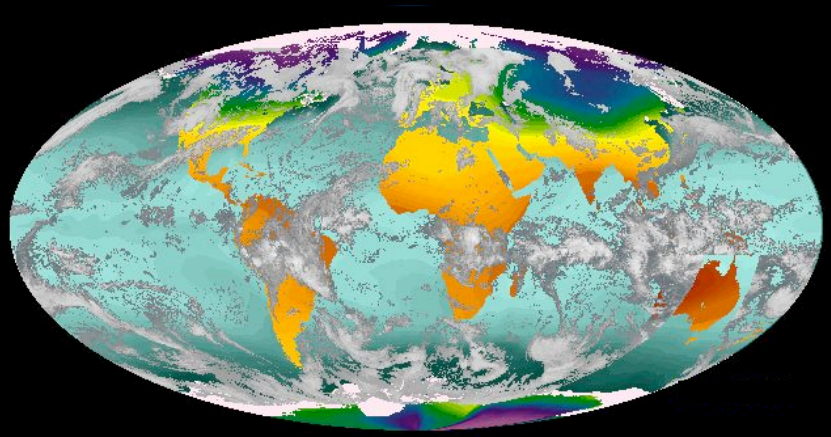


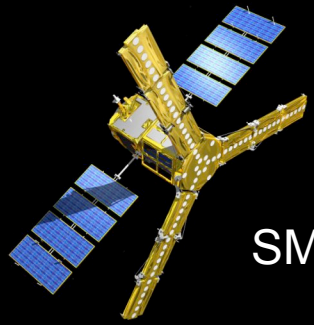
Cryosat II

Jason 2



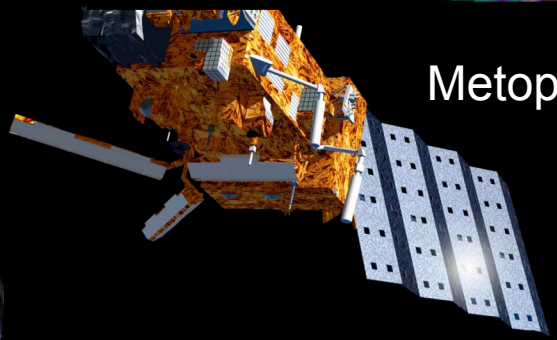
Icesat



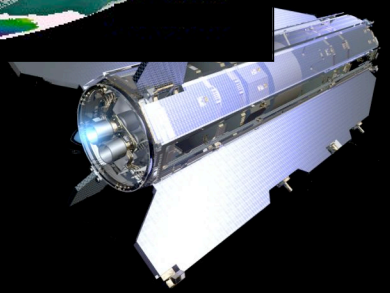


SMOS

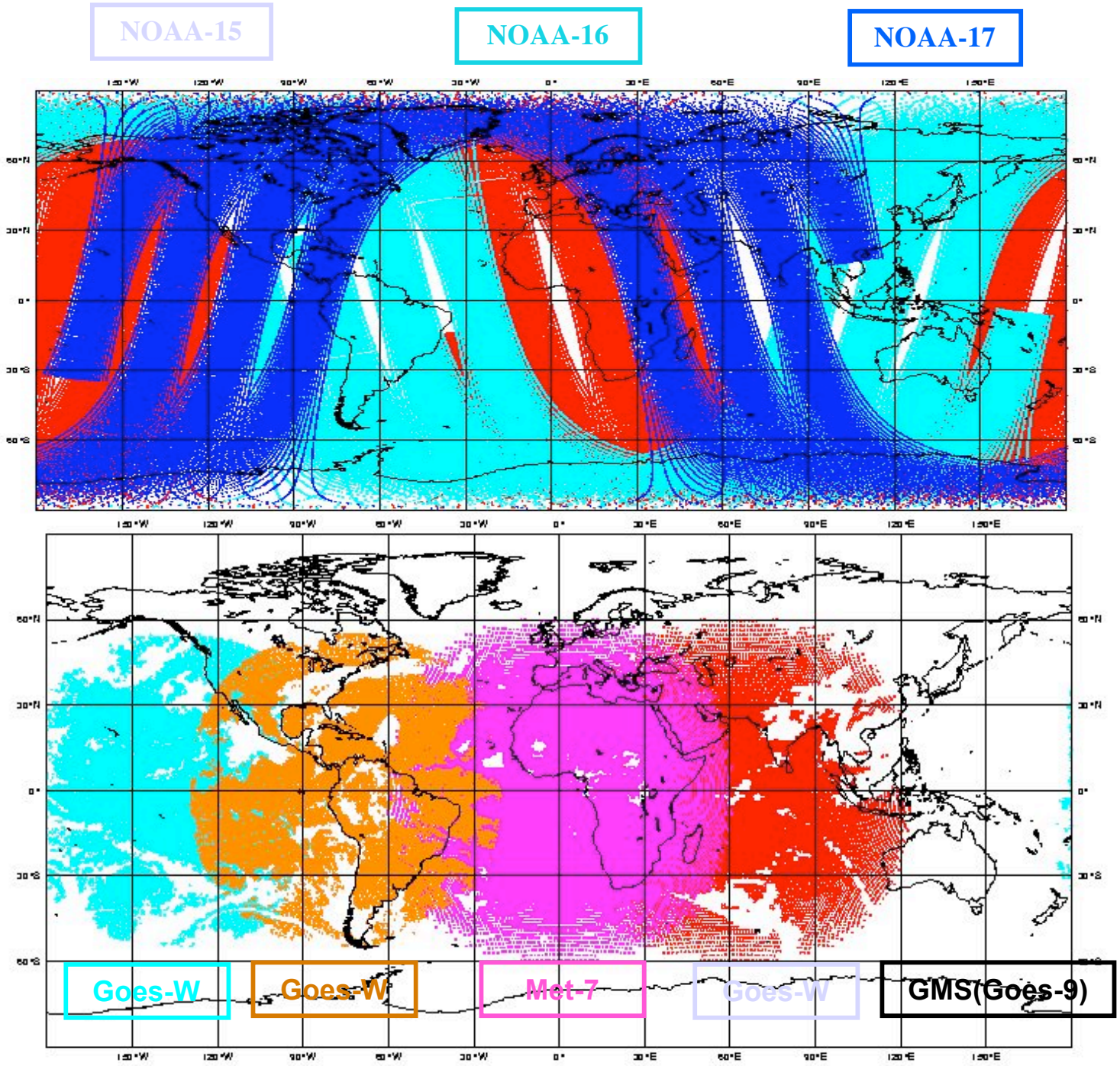
Cloudsat



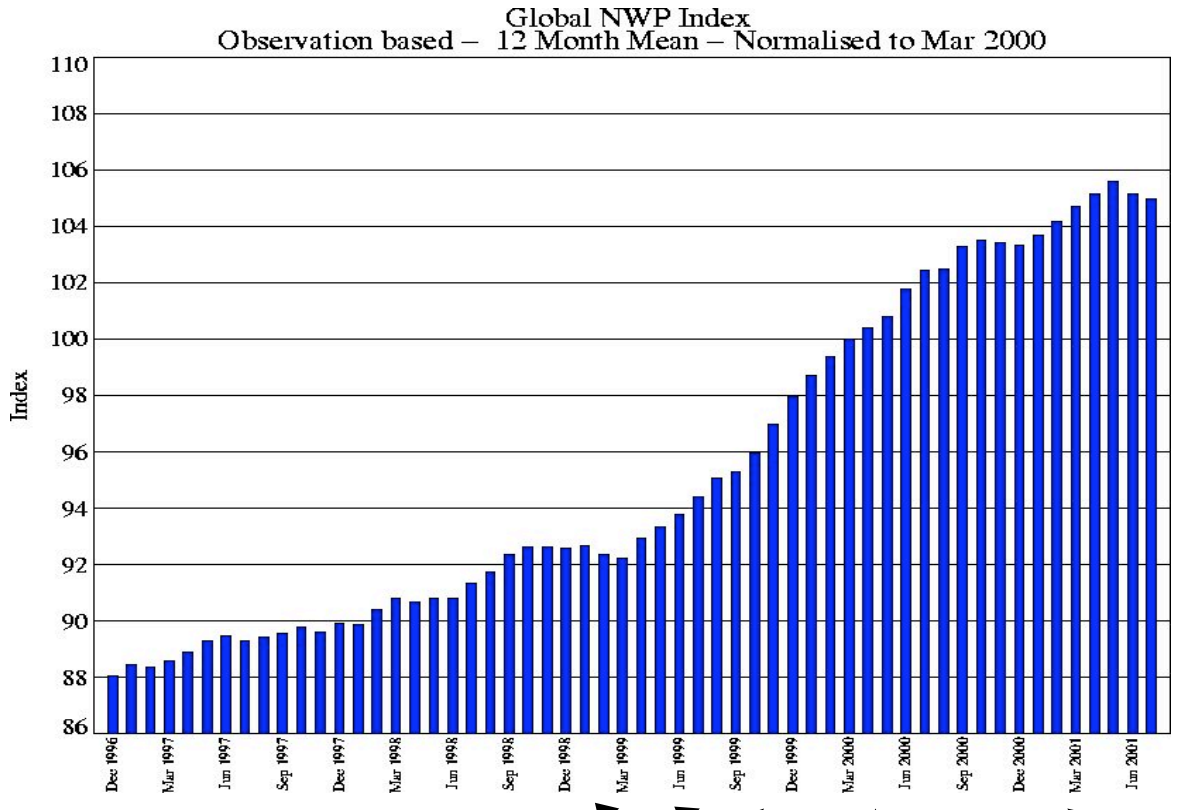
Metop



Weather Forecasting


NOAA-15
NOAA-16
NOAA-17
Goes-W
Goes-W
Met-7
Goes-W
GMS(Goes-9)

Impact on NWP at the Met Office



Mar 99. 3D-Var and ATOVS

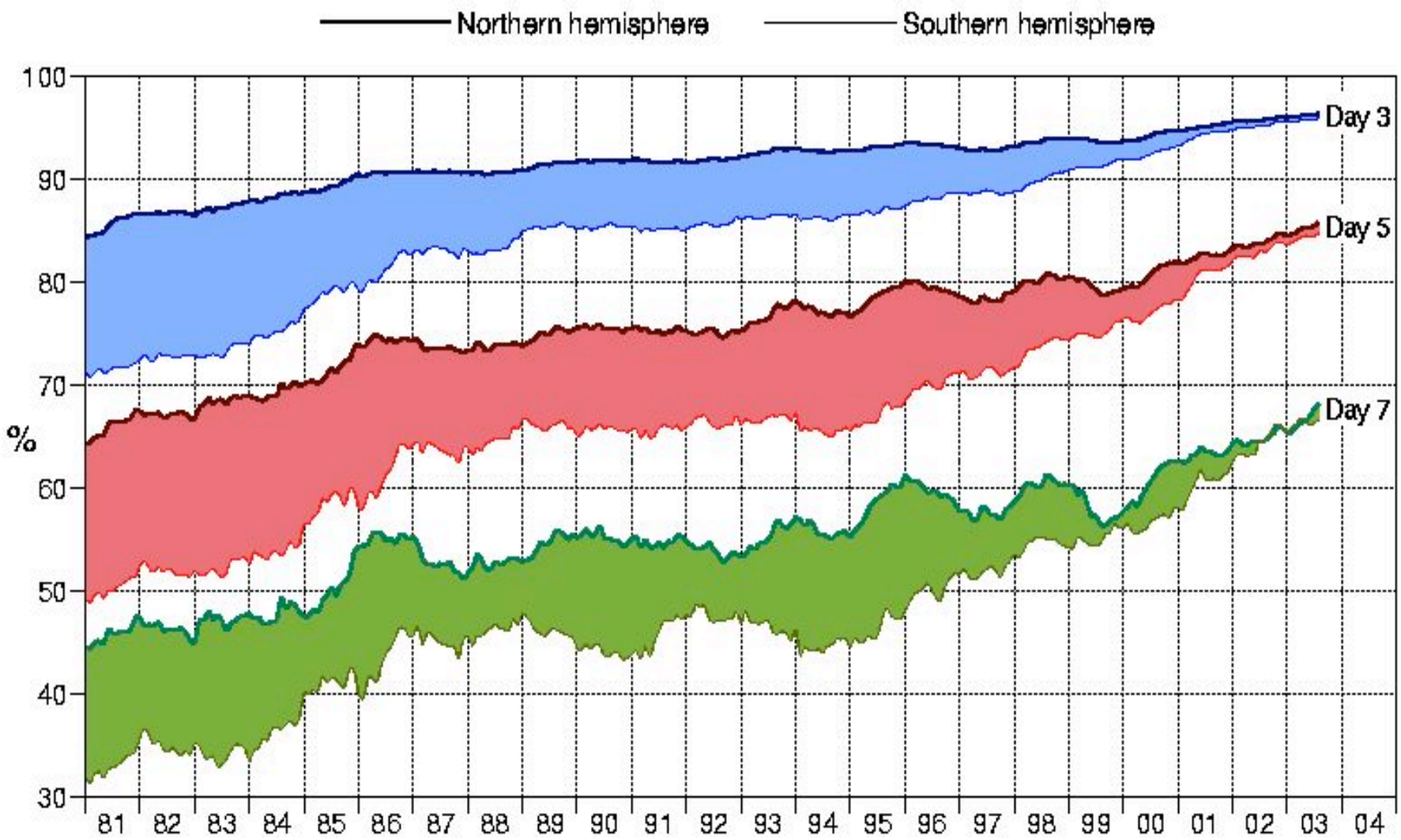
Jul 99. ATOVS over Siberia, sea-ice from SSM/I

Oct 99. ATOVS as radiances, SSM/I winds

May 00. Retune 3D-Var

Feb/Apr 01. 2nd satellites, ATOVS + SSM/I

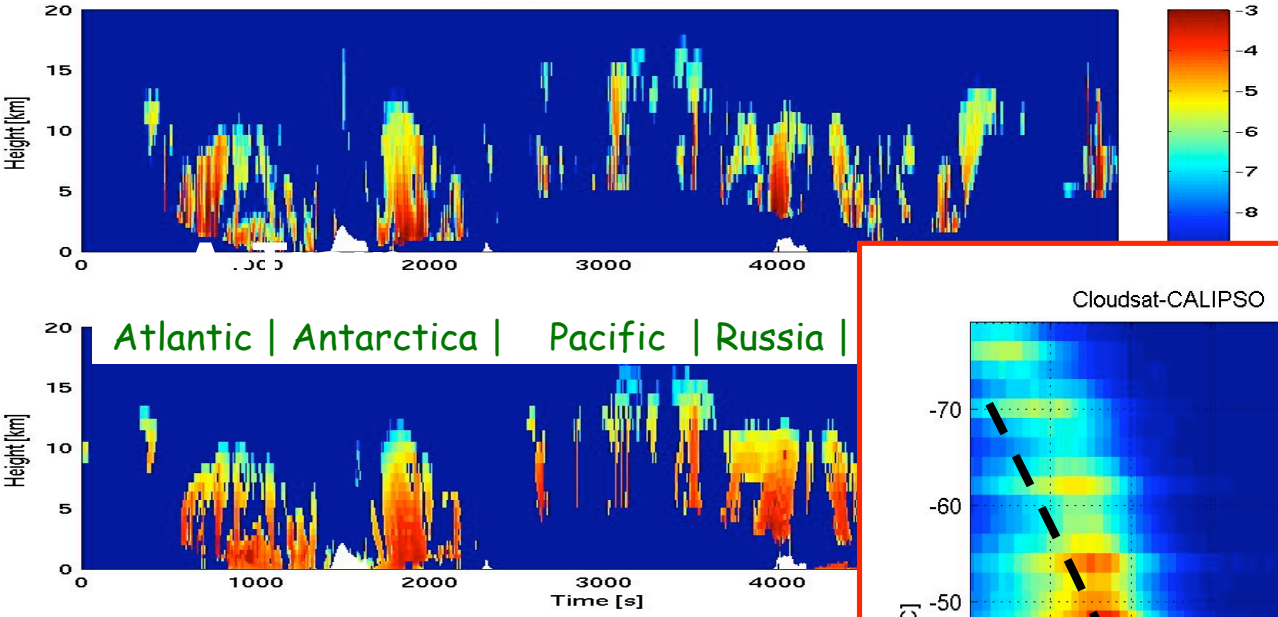
Anomaly correlation of 500hPa height forecasts



Atmospheric Processes: clouds and microphysics

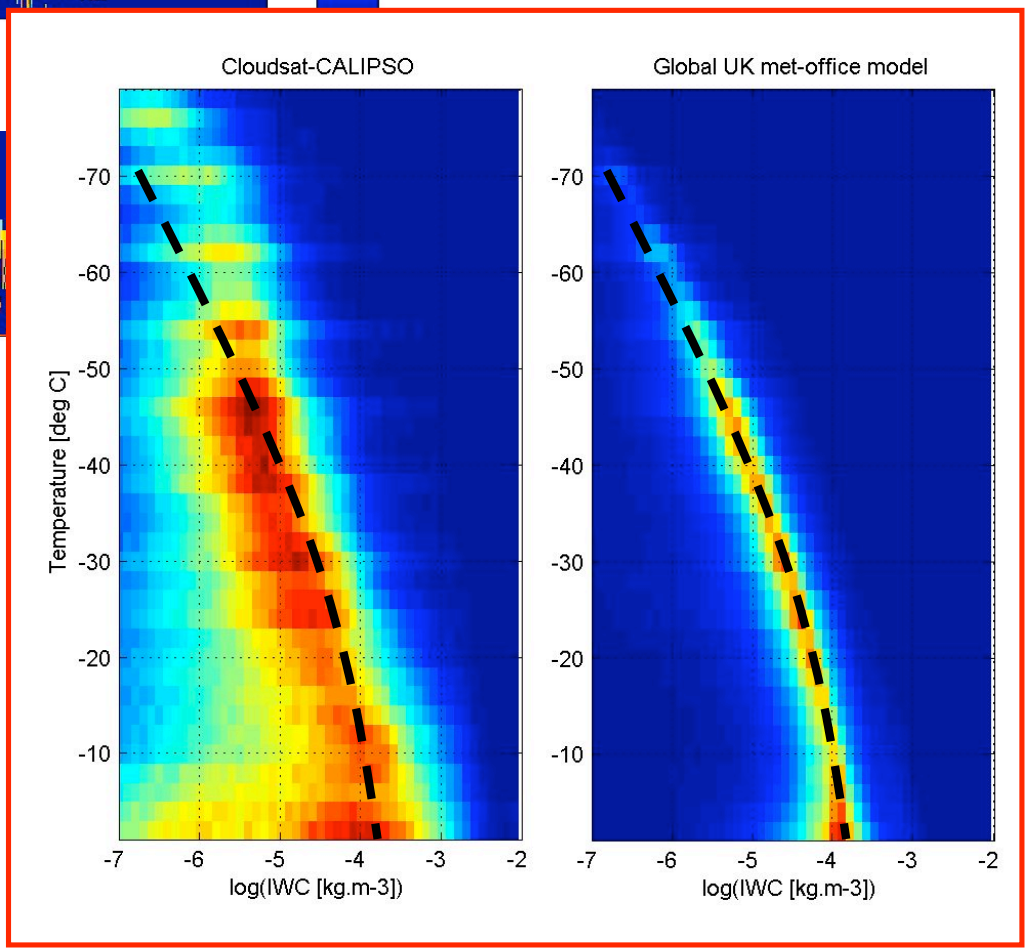
Variational ice cloud retrievals

Robin Hogan and Julien Delanoe



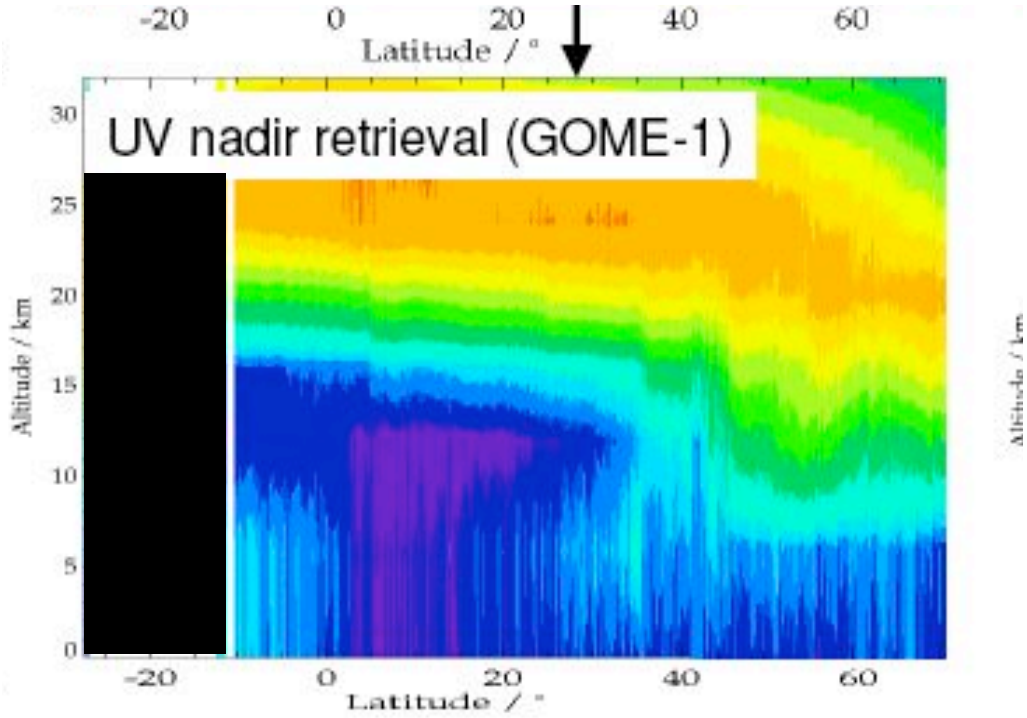
One orbit of ice water content from 1D-VAR retrieval

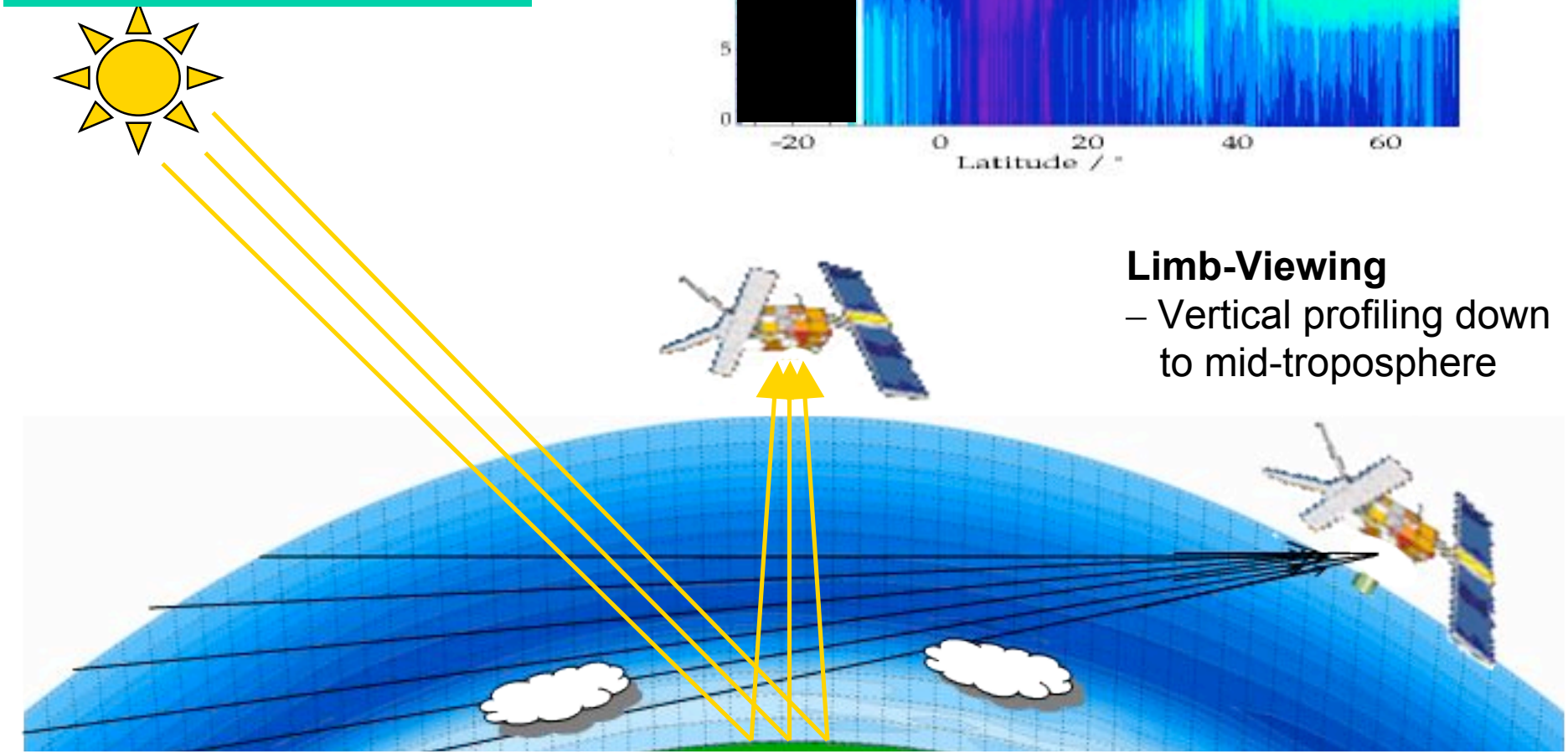
One month comparison



Air Pollution Forecasting

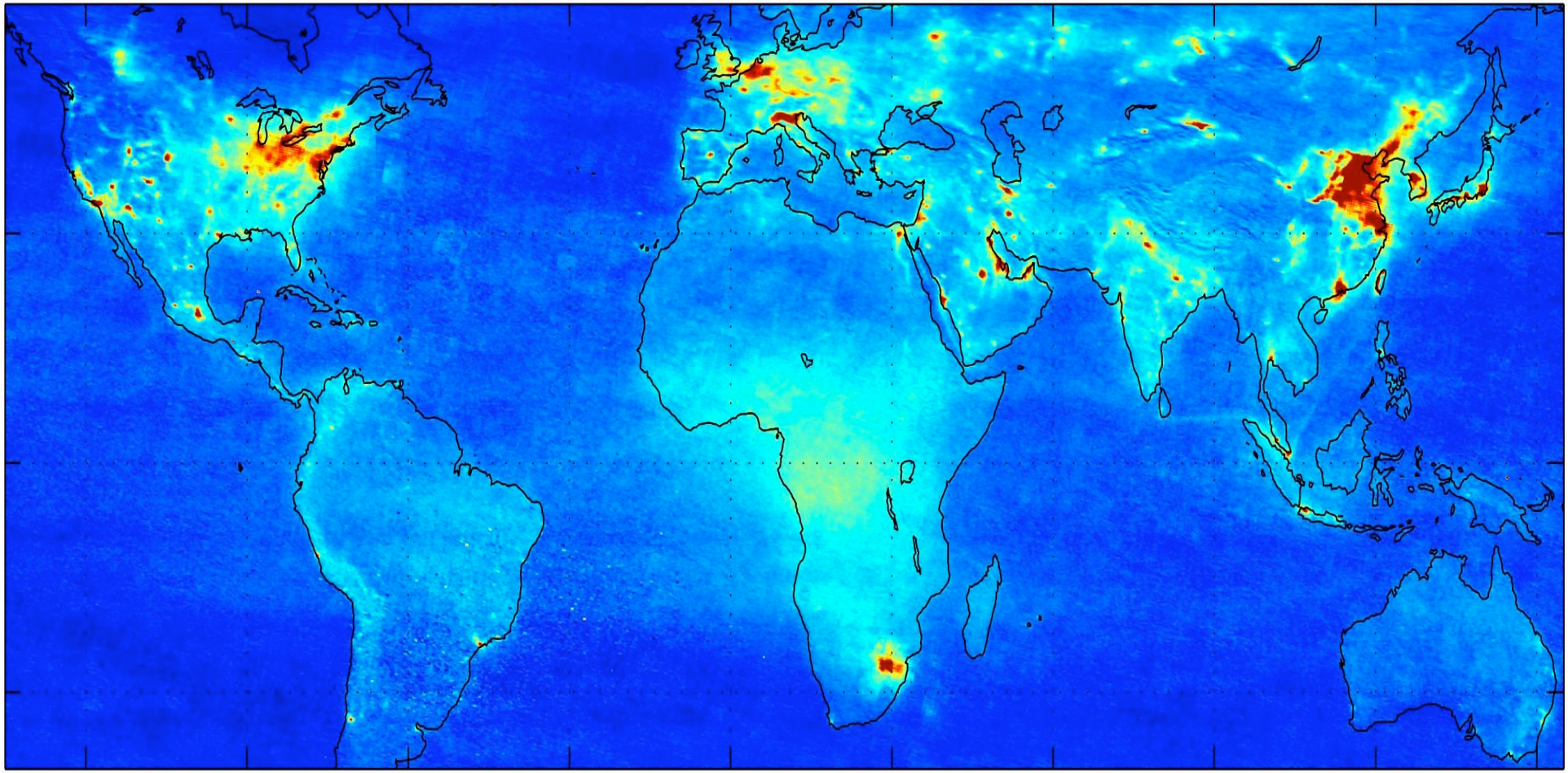
Nadir-Viewing
– Near-surface layer seen between clouds *but*
– Little or no vertical resolution





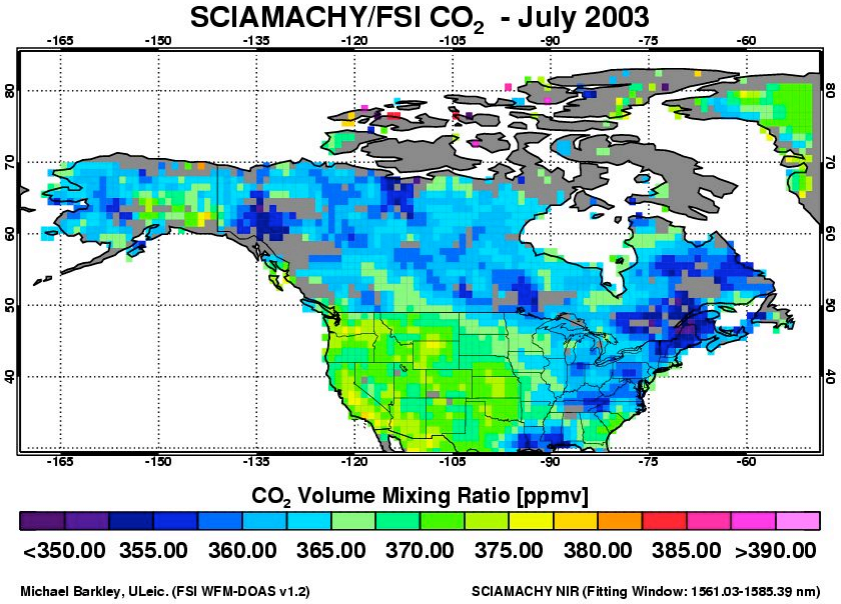
Limb-Viewing
– Vertical profiling down to mid-troposphere

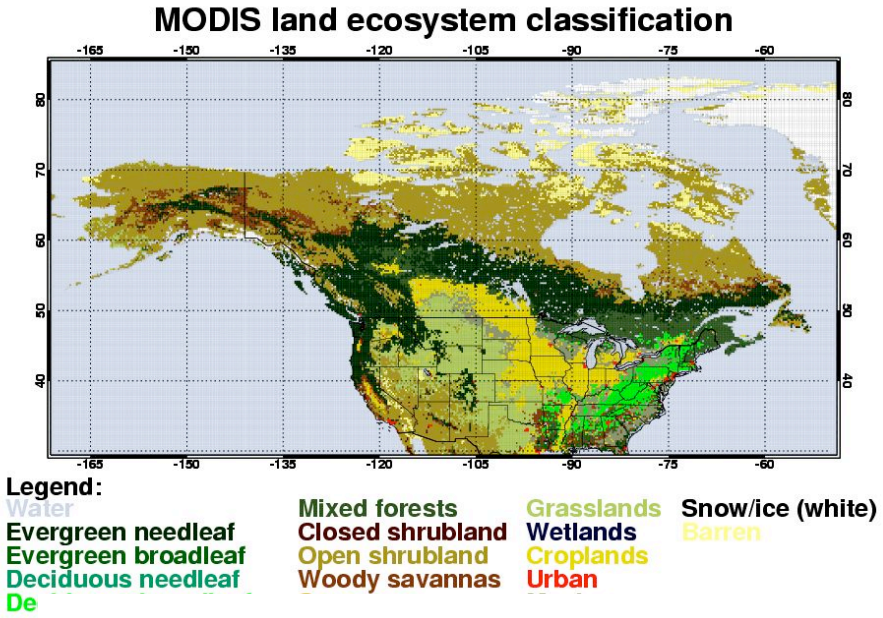
Understanding and predicting the spread of pollutants:NO_2 from SCIAMACHY



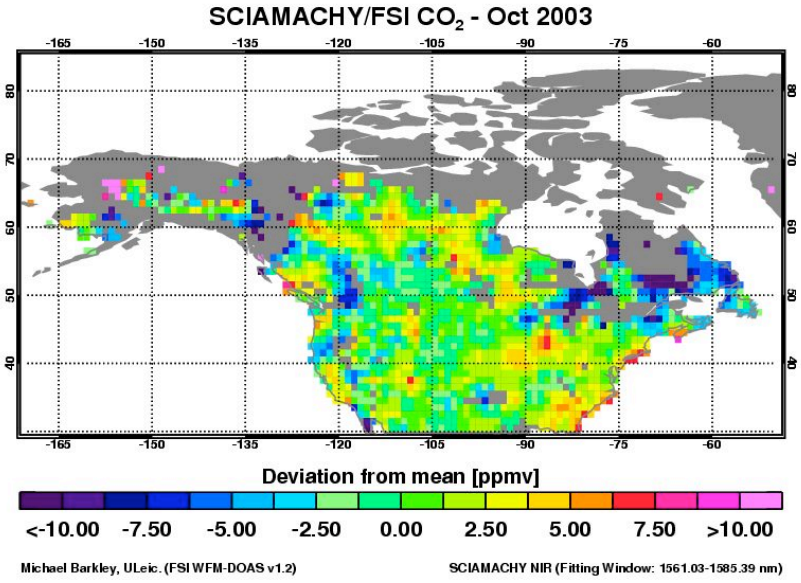
Estimating Surface Fluxes of Greenhouse Gases

Atmospheric CO_2 and land cover



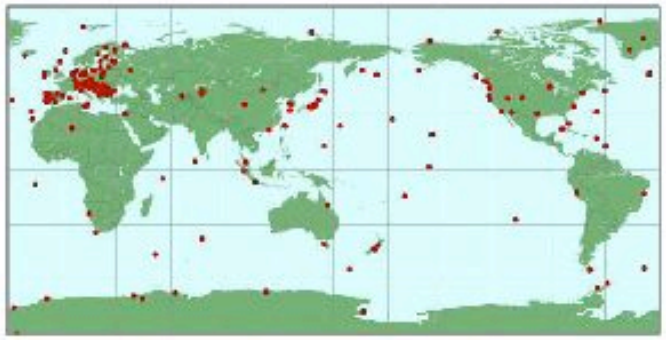


- Greater CO_2 uptake by forests compared to crops & grass plains?
- Seasonal variability?
- Identification of sub-continental CO_2 sources/sinks ?



GHG Observing Points

Ground Stations (current)

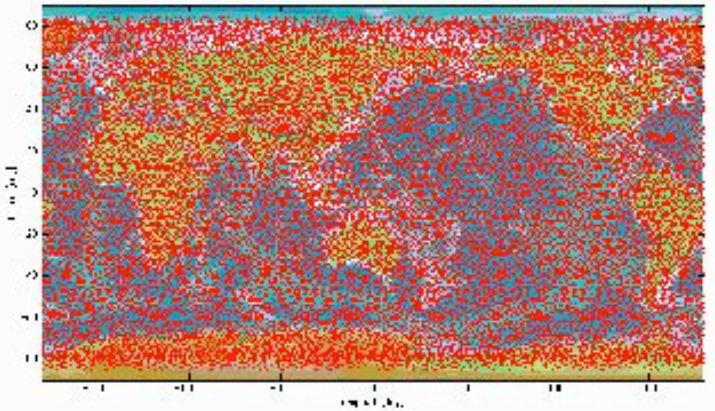


(By WMO WDCGG)

- 274 ground stations in the world.
- The observing data from these stations is distributed from WDCGG of WMO
- The number of stations is limited, and they exists unevenly in the world.

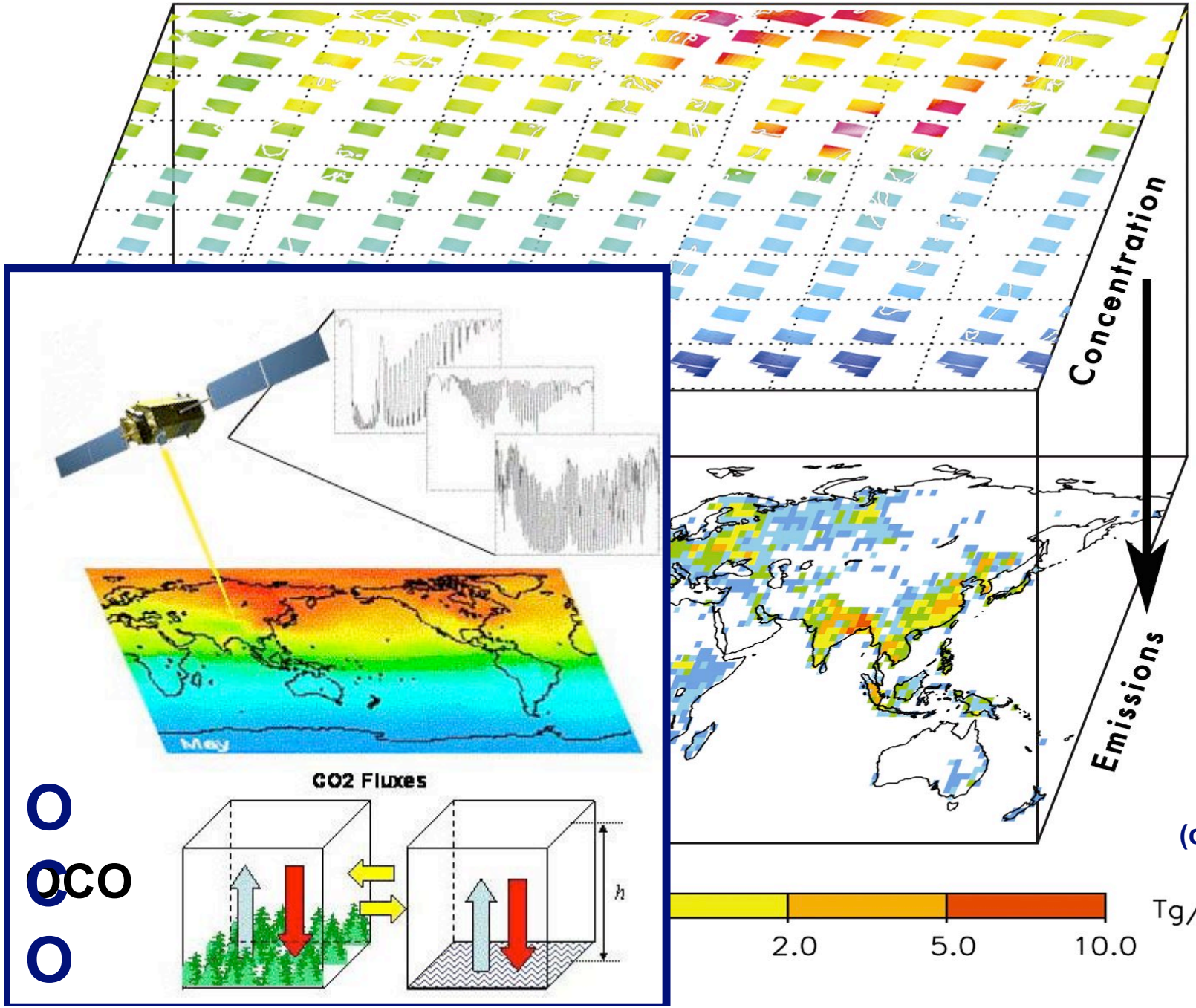
WDCGG: World Data Center for Greenhouse Gases
WMO :World Meteorological Organization

From Space (GOSAT)



- Over 100,000 points per 3days
- Global and frequent observation with an single instrument

Satellite observations of column CO2 by GOSAT and OCO will revolutionise our knowledge of the C cycle. Effective use of these data with models is a key challenge of the next 5 years and beyond.



- Synthetic SCIAMACHY measurements of CH_4 total column

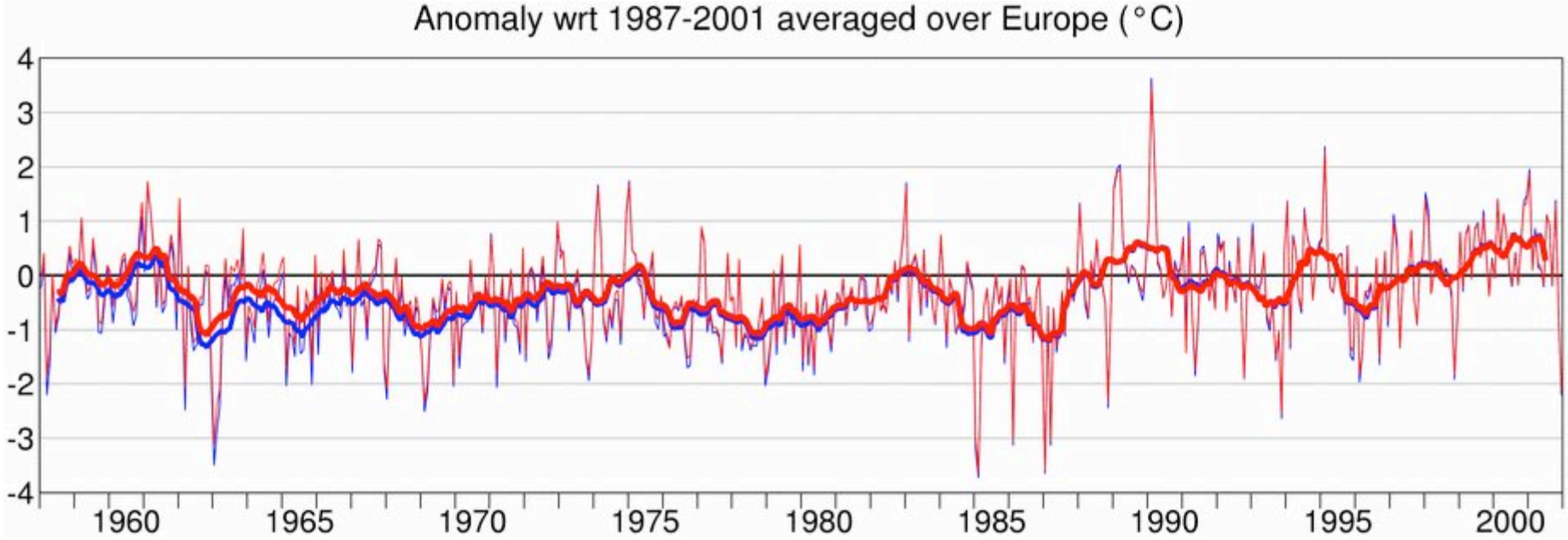
- Assimilation into a Chemical Transport model

- Methane Emissions (critical for Kyoto inventories)

Courtesy KNMI

Atmospheric Re-Analysis

Trend and variability in two-metre temperature



CRUTEM2v (Jones and Moberg, 2003)

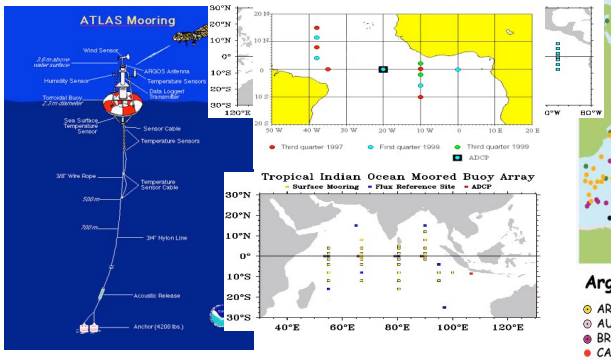
ERA-40

Linear trend (1979-2001):	**CRUTEM2v**	**0.46°C/decade**
	ERA-40	**0.42°C/decade**

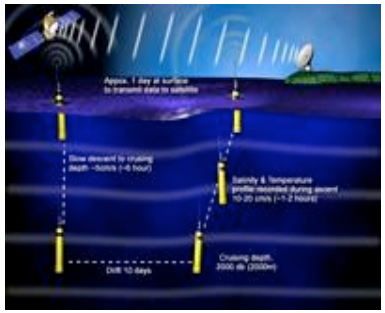
Coupled Atmosphere-Ocean Forecasting

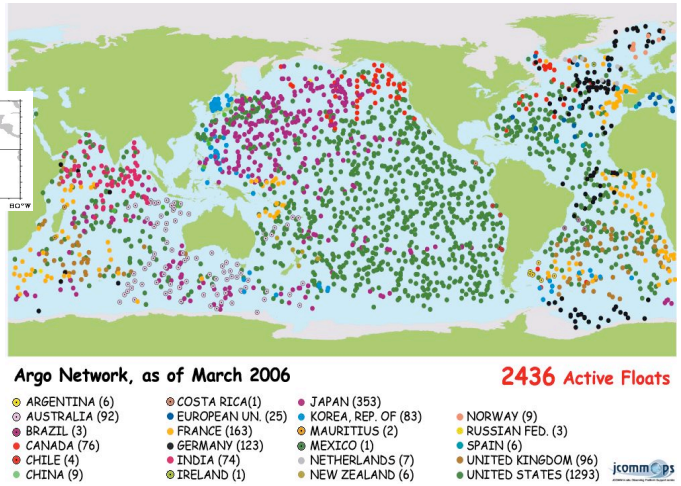
Real Time Ocean Observations

Moorings



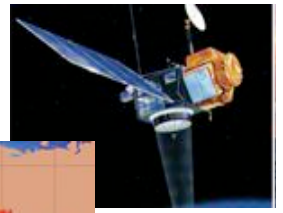
ARGO floats

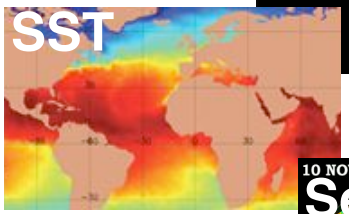


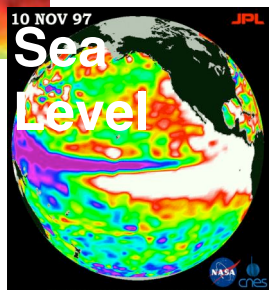


XBT (eXpendable BathiThermograph)

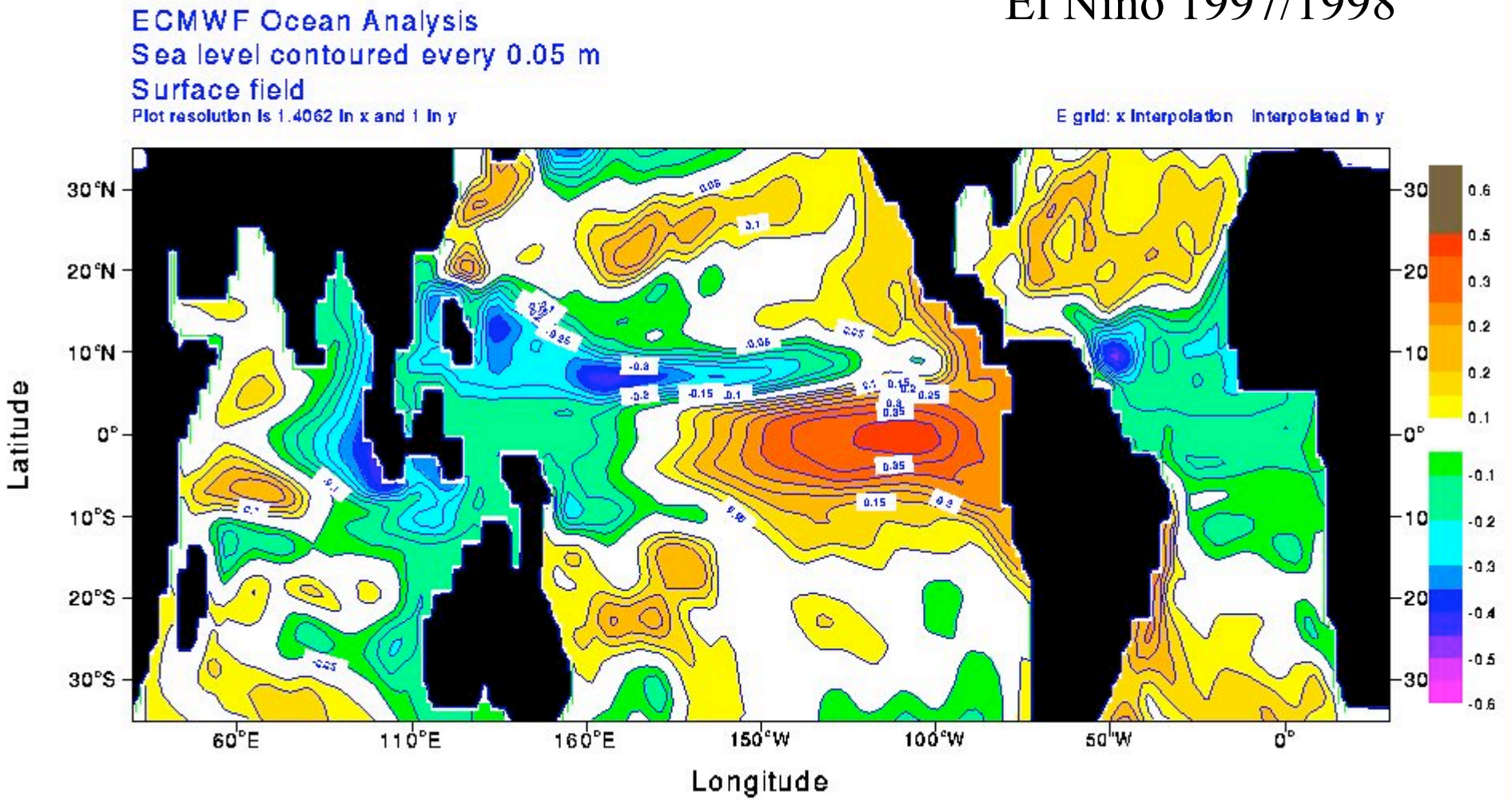
Satellite



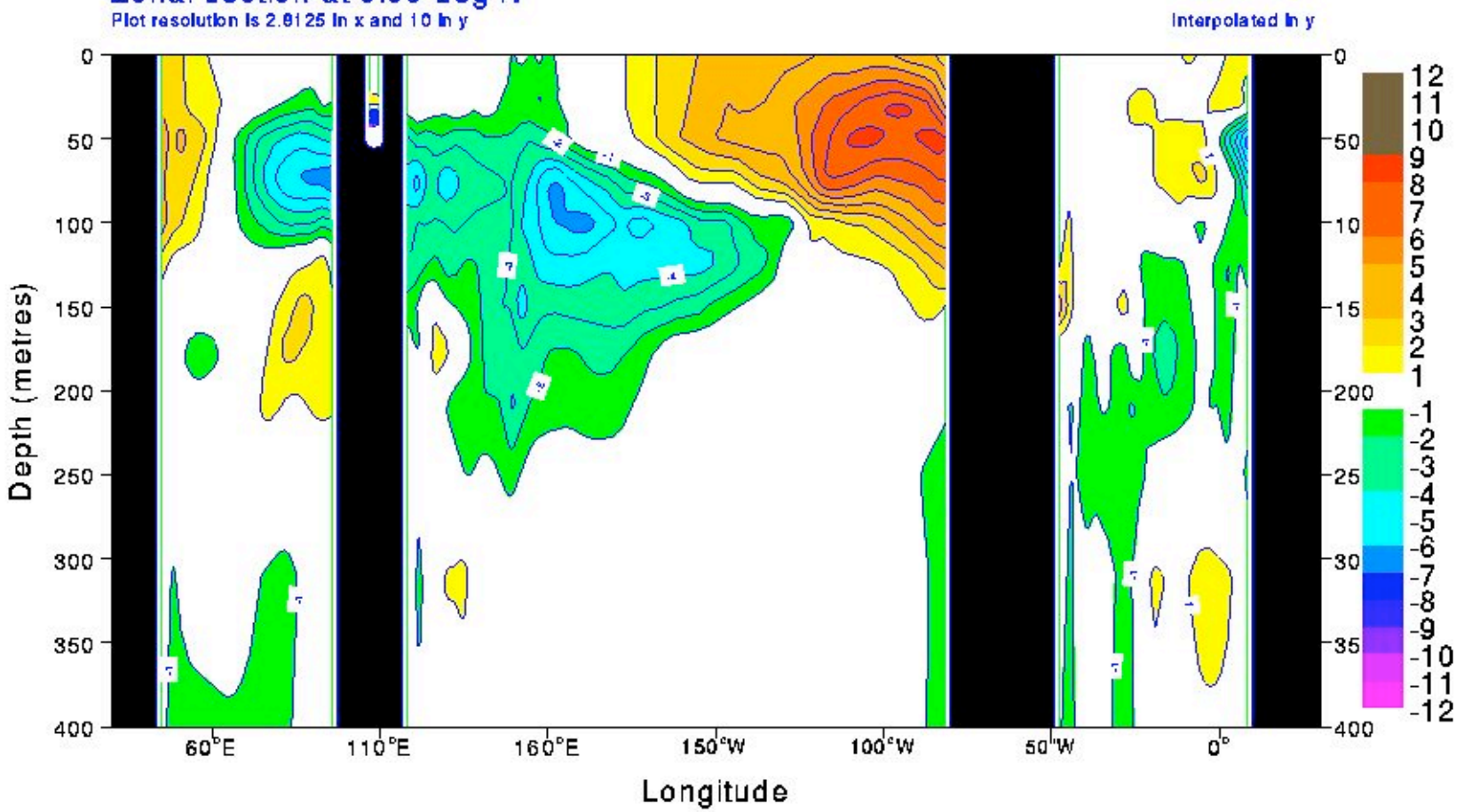




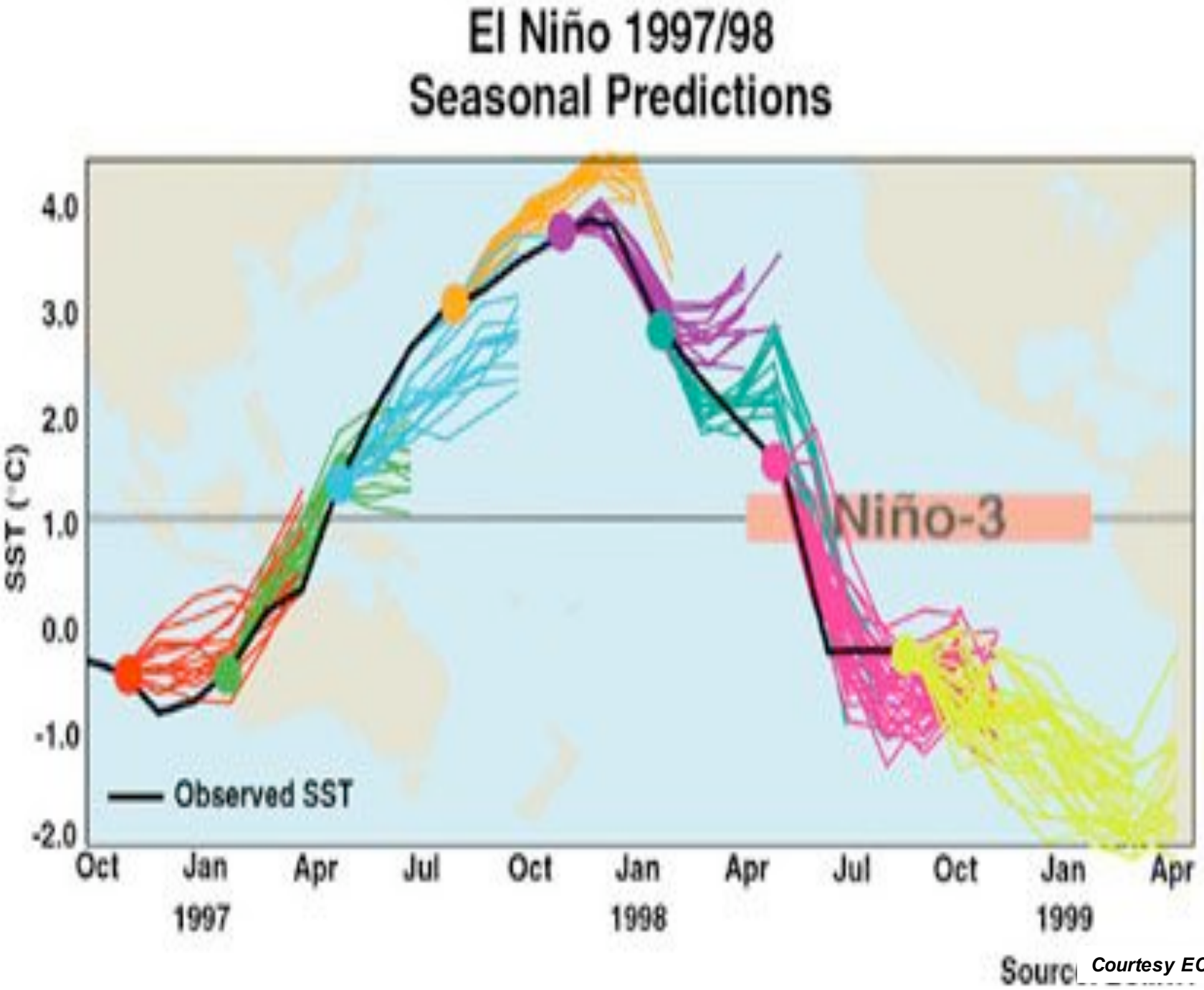
El Nino 1997/1998



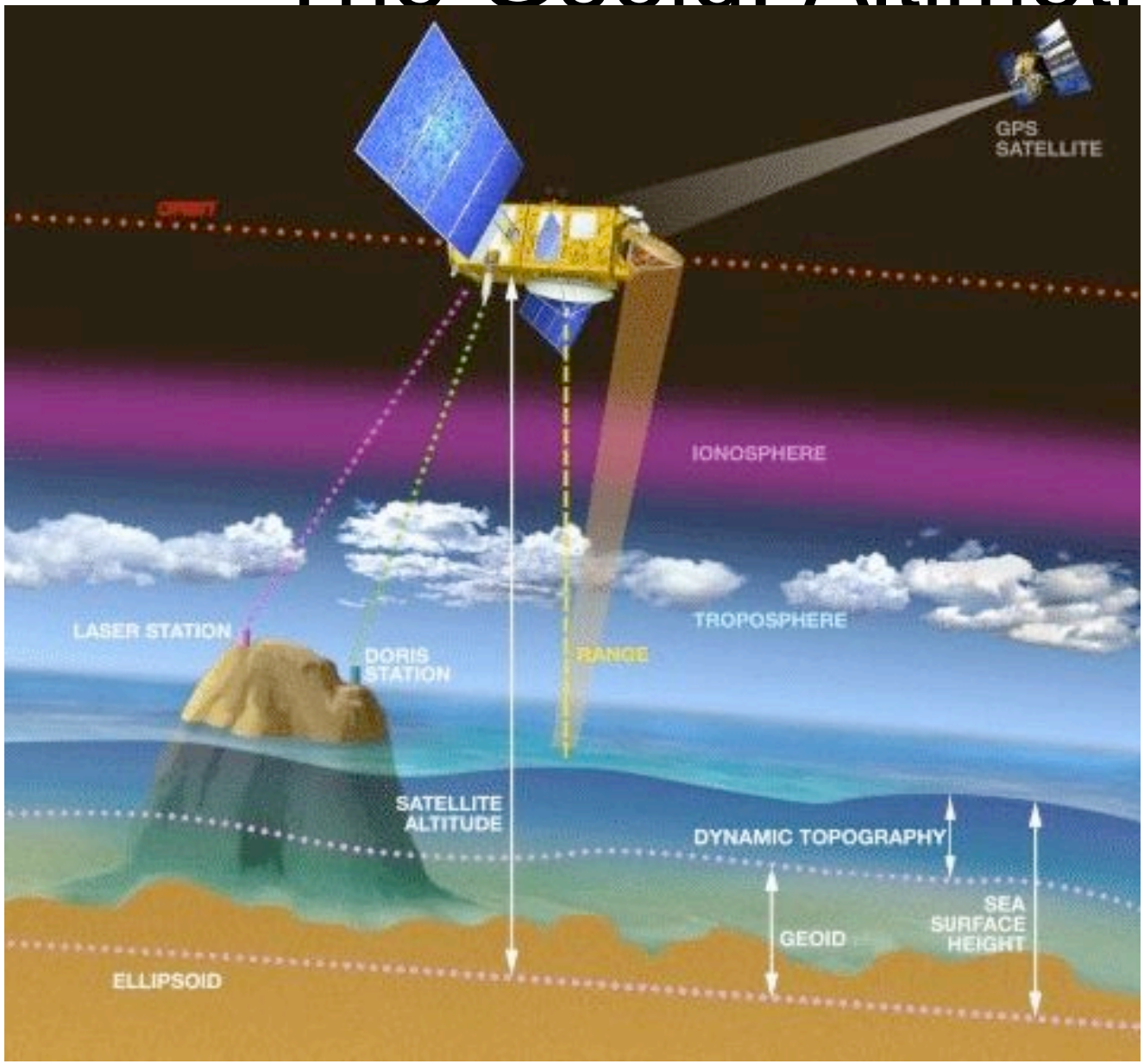
El Nino 1997/1998



MAGICS 5.3 hades - emos Wed Feb 18 18:28:45 1998


El Niño 1997/98
Seasonal Predictions
SST (°C)
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
Niño-3
Observed SST
Oct
Jan
Apr
Jul
Oct
Jan
Apr
Jul
Oct
Jan
Apr
1997
1998
1999
Courtesy ECMWF

The Geoid, Altimetry and imilation



. Assimilation assumes <u>full DT</u>

DT= MDT + SSH_anomaly
where
MDT = Time mean DT

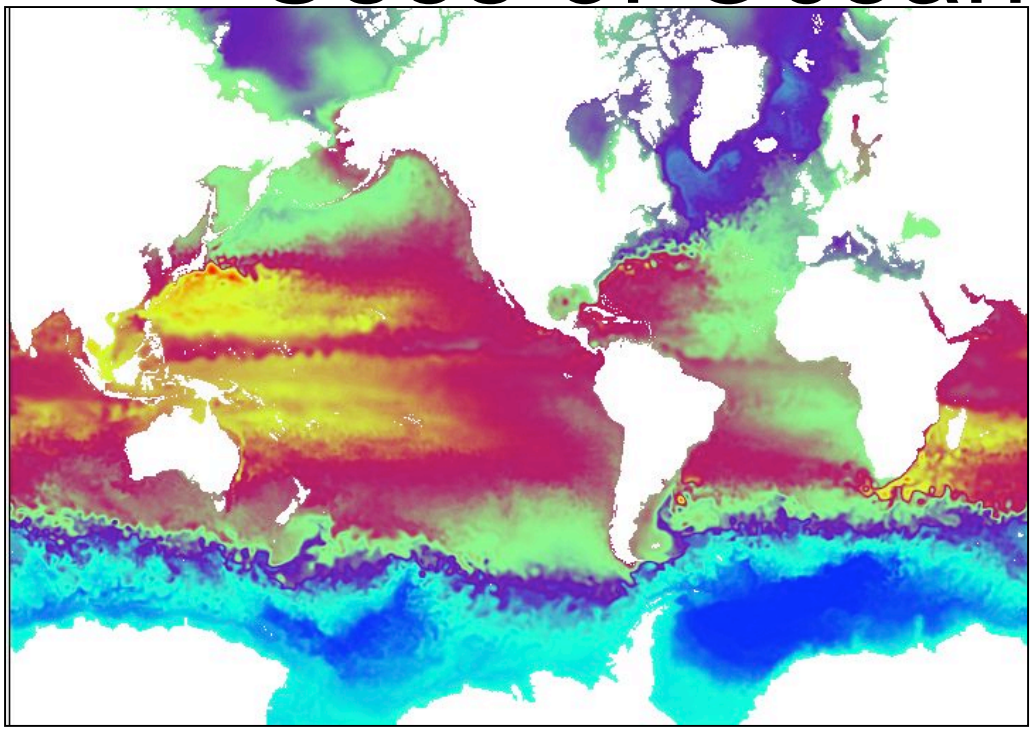
Like to use
MDT = Mean_SSH – Geoid

In practice
MDT model product

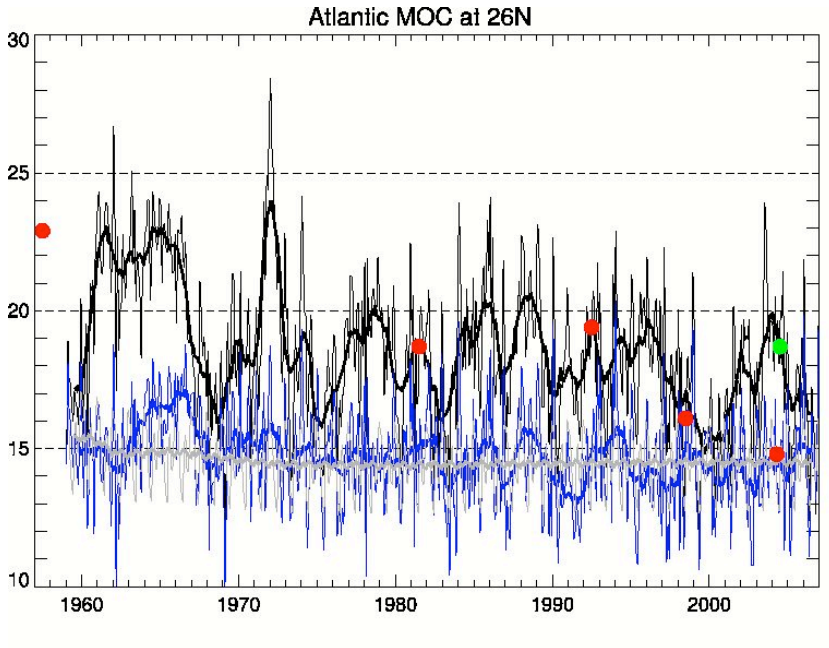
Error characteristics of SSH_anomaly and MDT Completely different

DT= MDT + SSH_anomaly
MDT error represents constant observation bias

Uses of Ocean Reanalysis



Analysed sea level 26-31 Dec 2004
Global ¼ NEMO 18 yr Synthesis with assimilation
Eg. Better Gulf Stream separation here aids Altimeter and GOCE assimilation for NCEO)

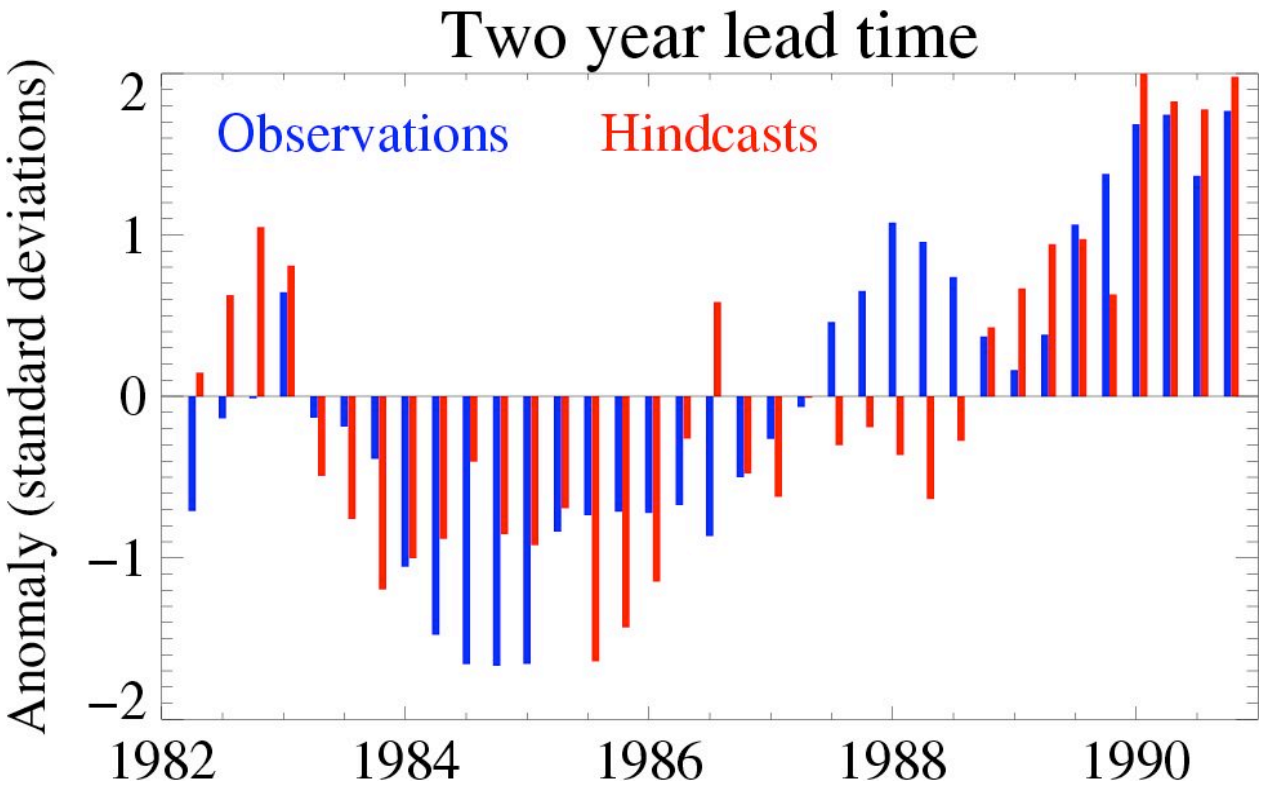


Thermohaline MOC transports in ECMWF reanalysis compared to Bryden section based annual means (Black line is assimilation)
Balmaseda et al 2007

Seasonal-Decadal Prediction

- Intitialize Ocean, Ice + Land
- Ensemble prediction ~10yrs

Ensemble forecasts of global mean temperature

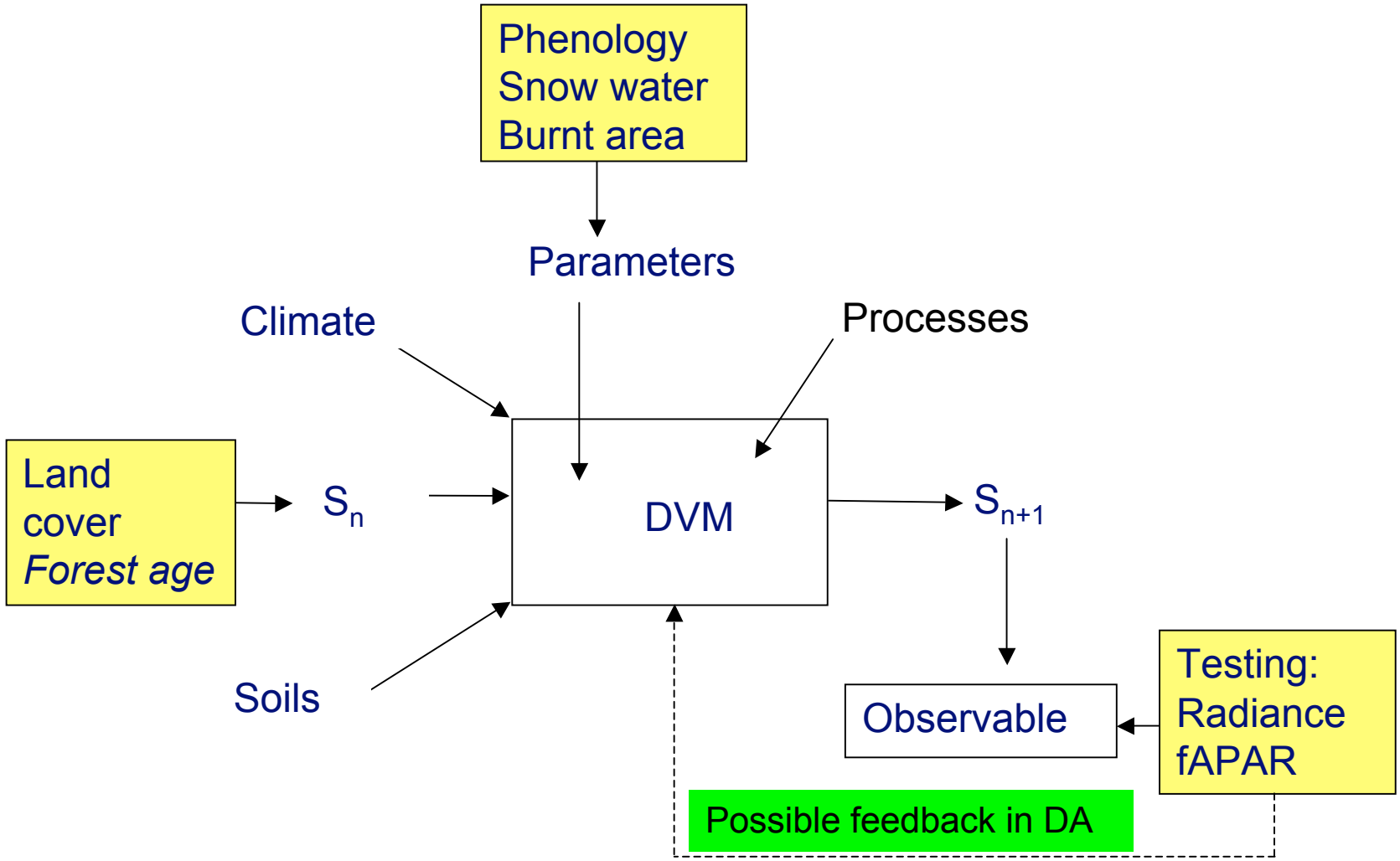


<u>Other useful predictions</u>

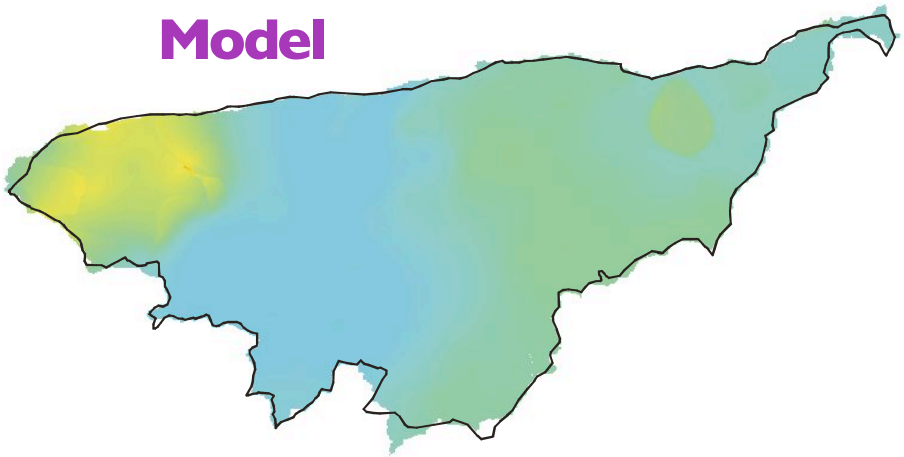
- Thermohaline strength
- Poleward Ht. transport
- Sea Ice extent
- Nino3, NAO…
- Precipitation
- Snow Cover
- Storm Statistics.

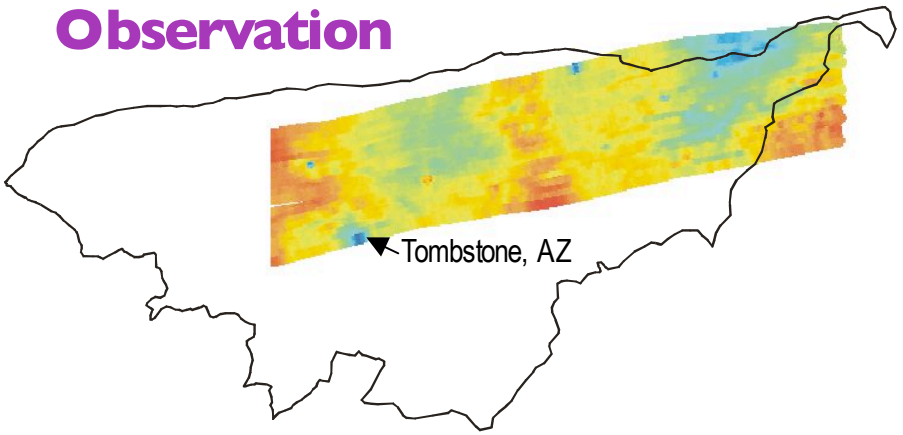
Land Surface Assimilation

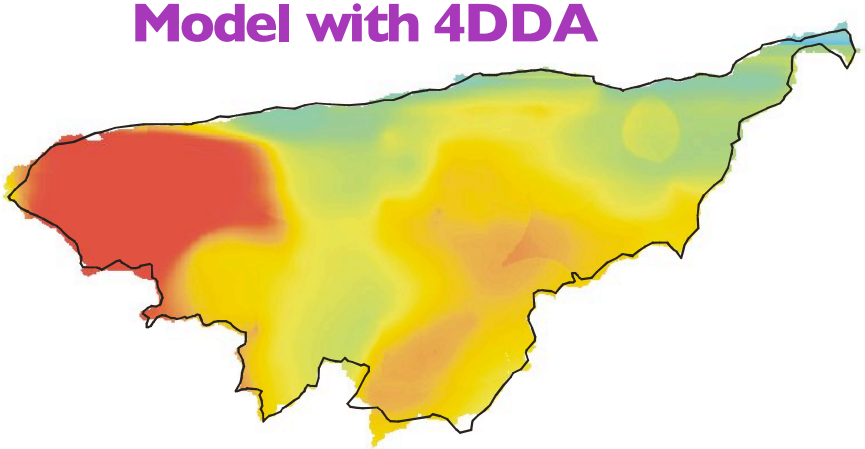
EO interactions with a Dynamic Vegetation Model

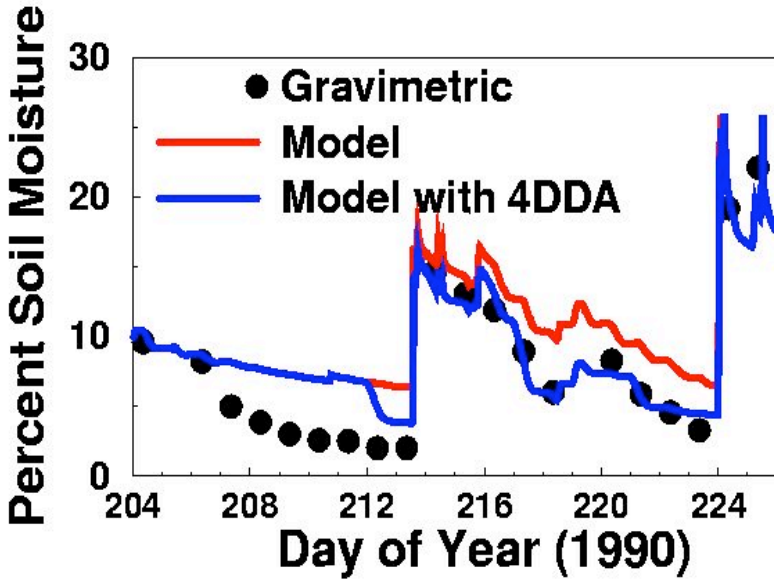


Regional Scale: *Walnut Gulch (Monsoon 90)*





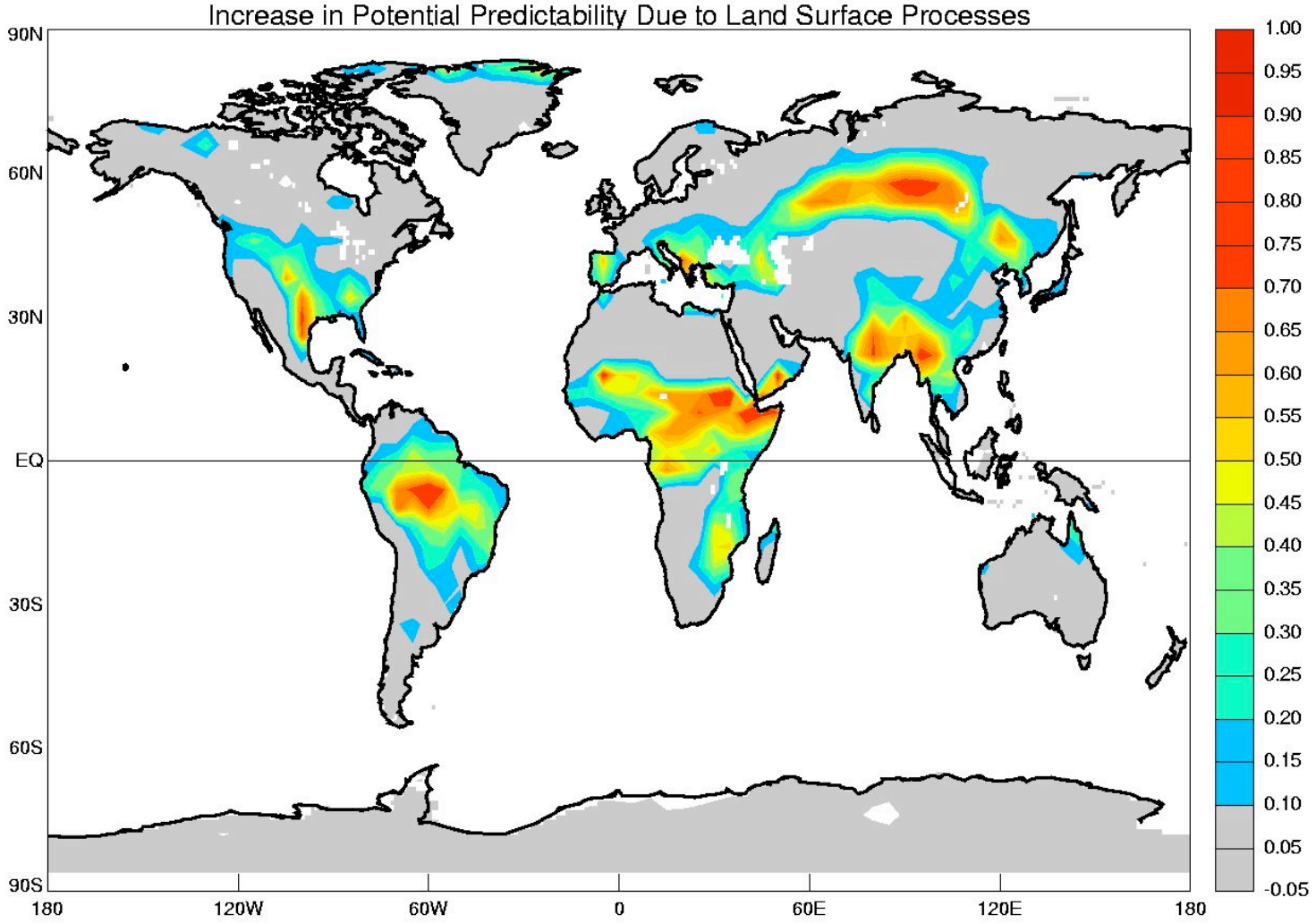




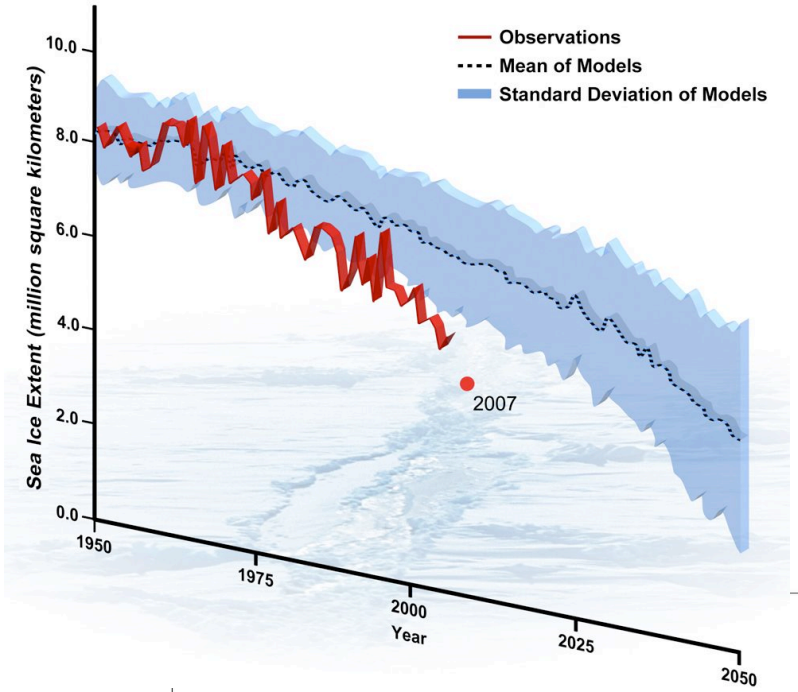
Houser et al., 1998

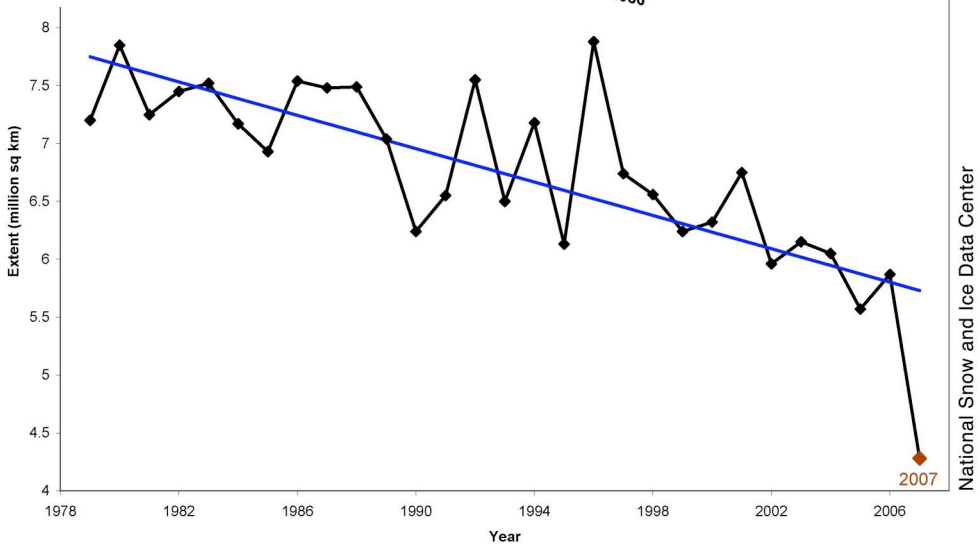
Land Initialization: Motivation

- Knowledge of soil moisture has a greater impact on the predictability of summertime precipitation over land at mid-latitudes than Sea Surface Temperature (SST).

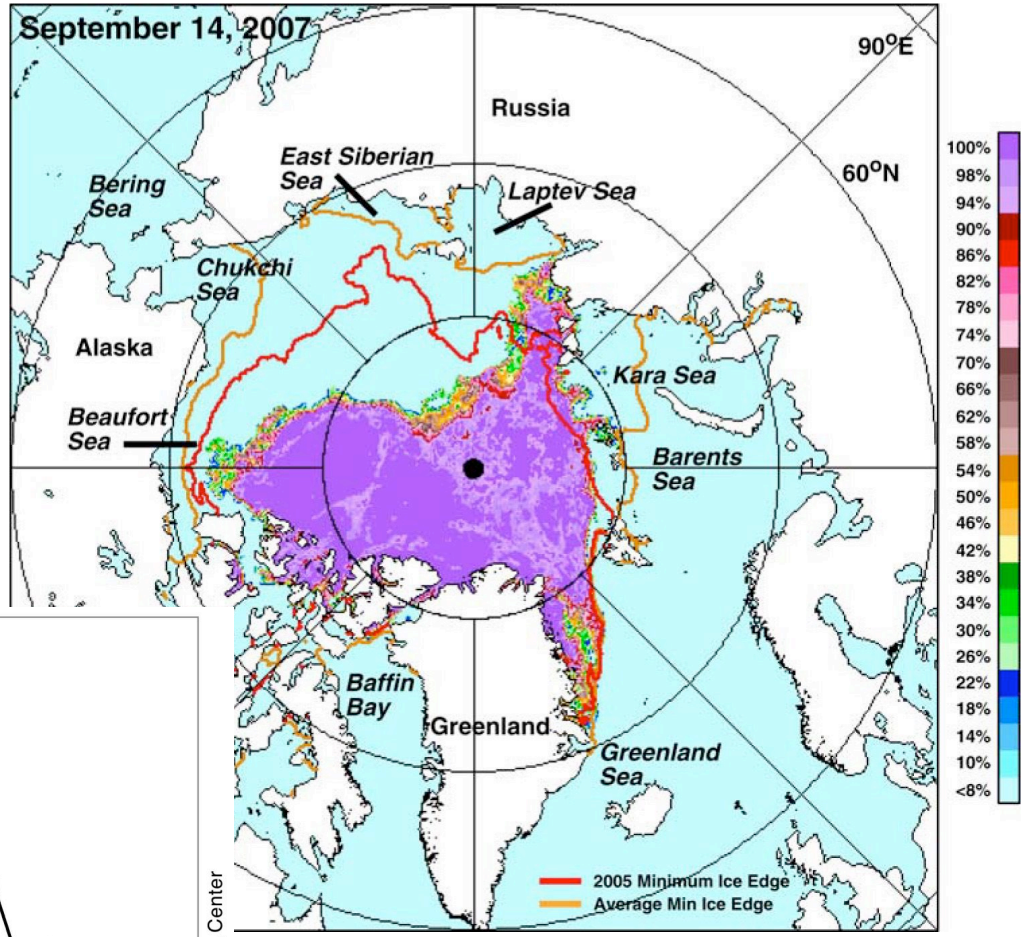


Arctic Sea Ice Extent: Summer 2007



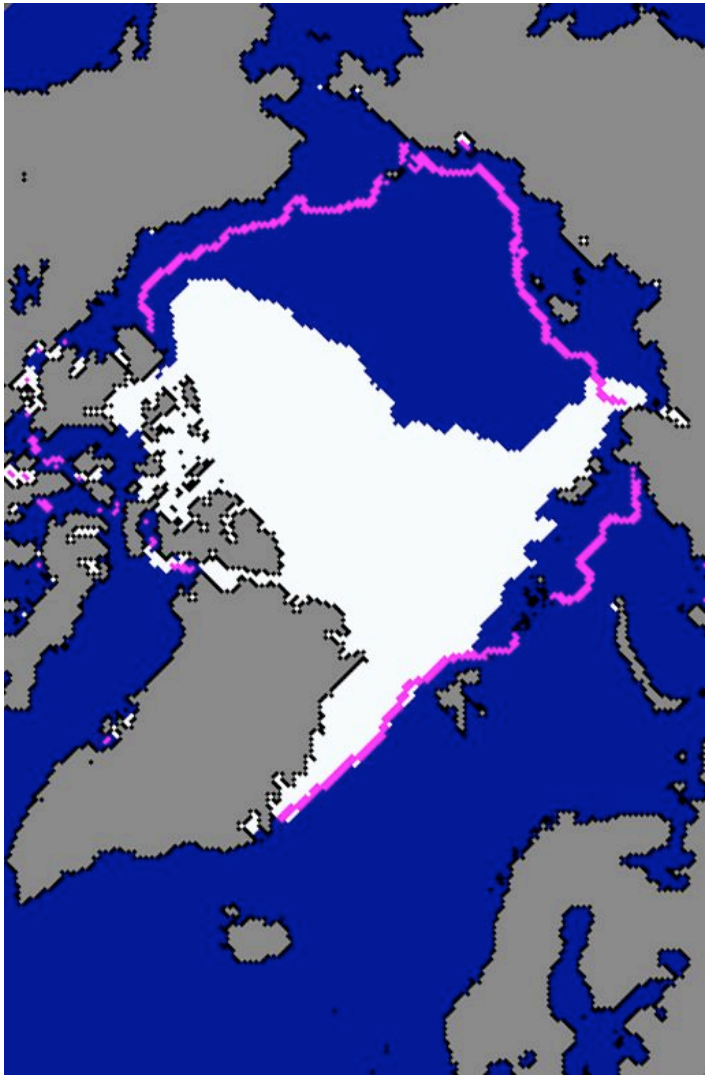


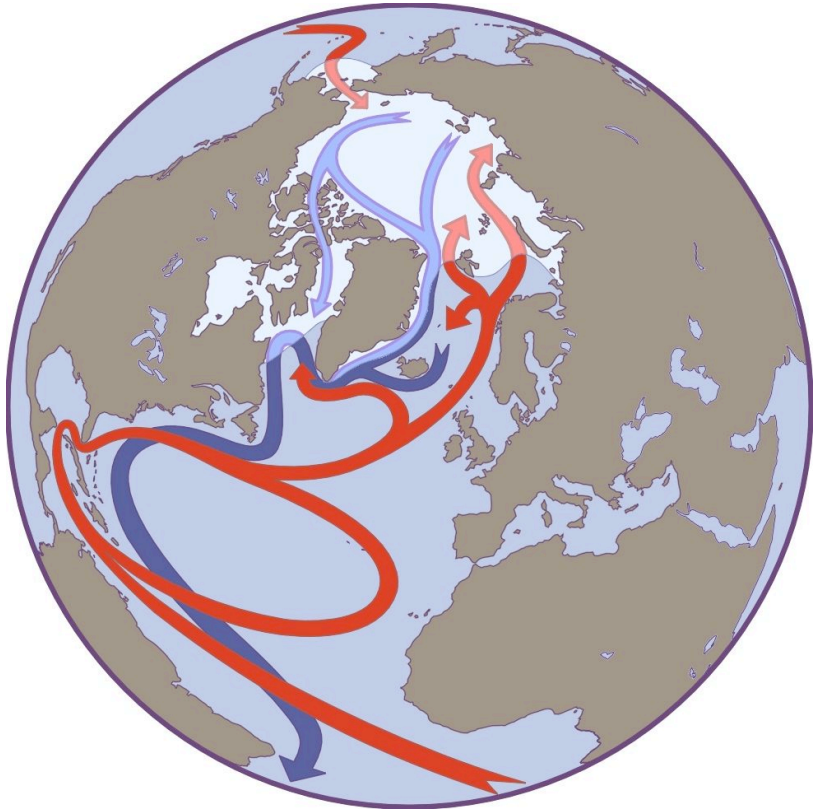
National Snow and Ice Data Center



[Comiso, 2008]

Quantifying polar change and its global consequences

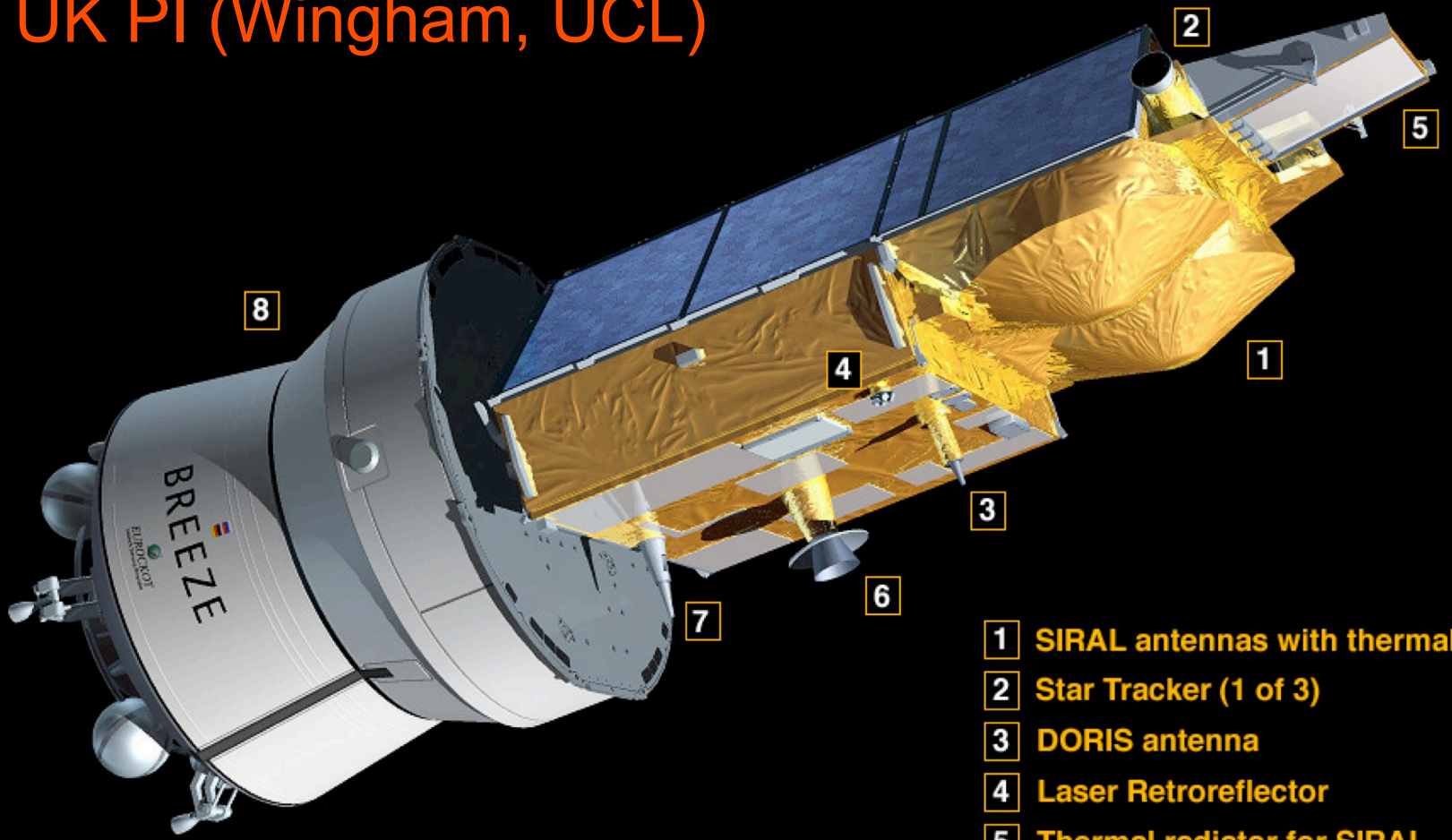




2007 Arctic sea ice summer minimum (compared with climatological average)
Impact on global ocean circulation?

CryoSat
the satellite attached to the launcher upper stage

UK PI (Wingham, UCL)



1. SIRAL antennas with thermal covers
2. Star Tracker (1 of 3)
3. DORIS antenna
4. Laser Retroreflector
5. Thermal radiator for SIRAL
6. X-band telemetry antenna
7. S-band TTC antenna
8. Breeze KM upper stage

END