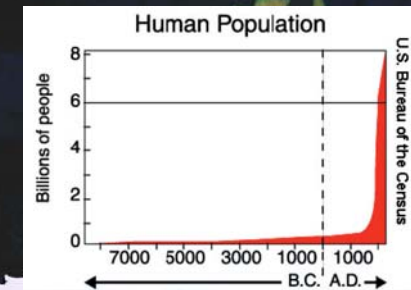
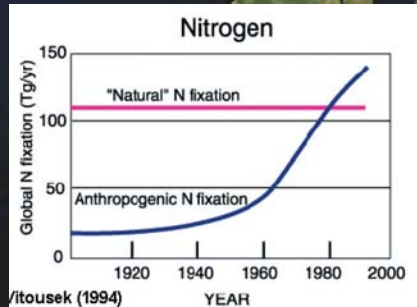
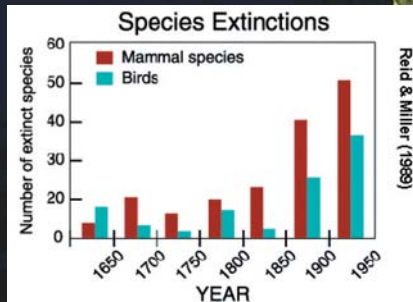
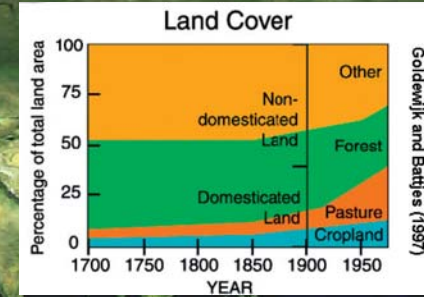
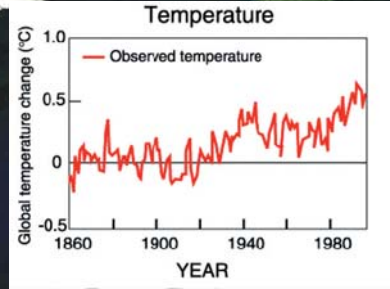
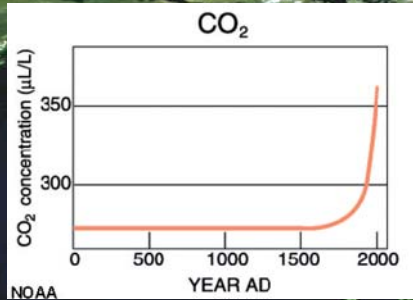


ESA Earth Observation & Climate Change

Friends of ICES Meeting
Geneva, 7 January 2011

Michael Rast, ESA - ESRIN

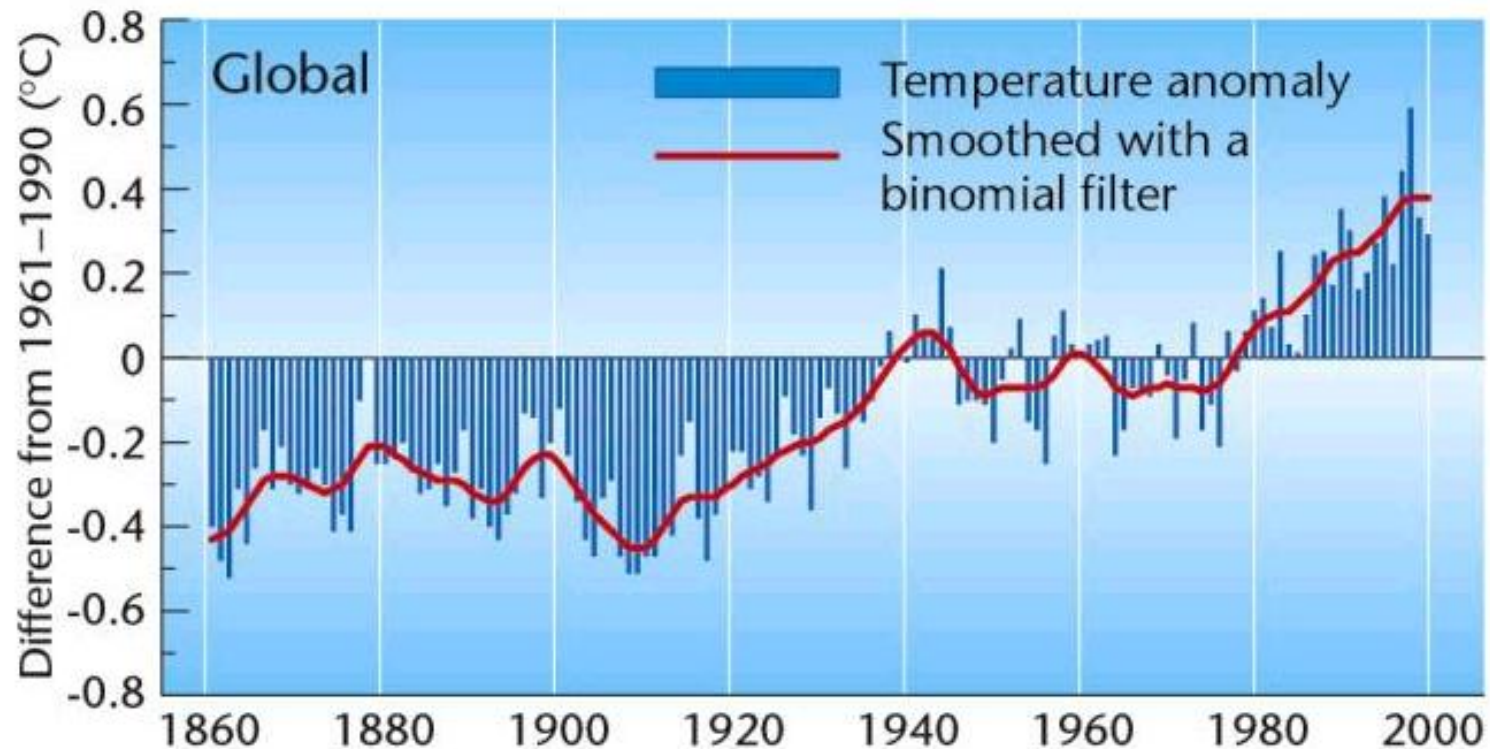


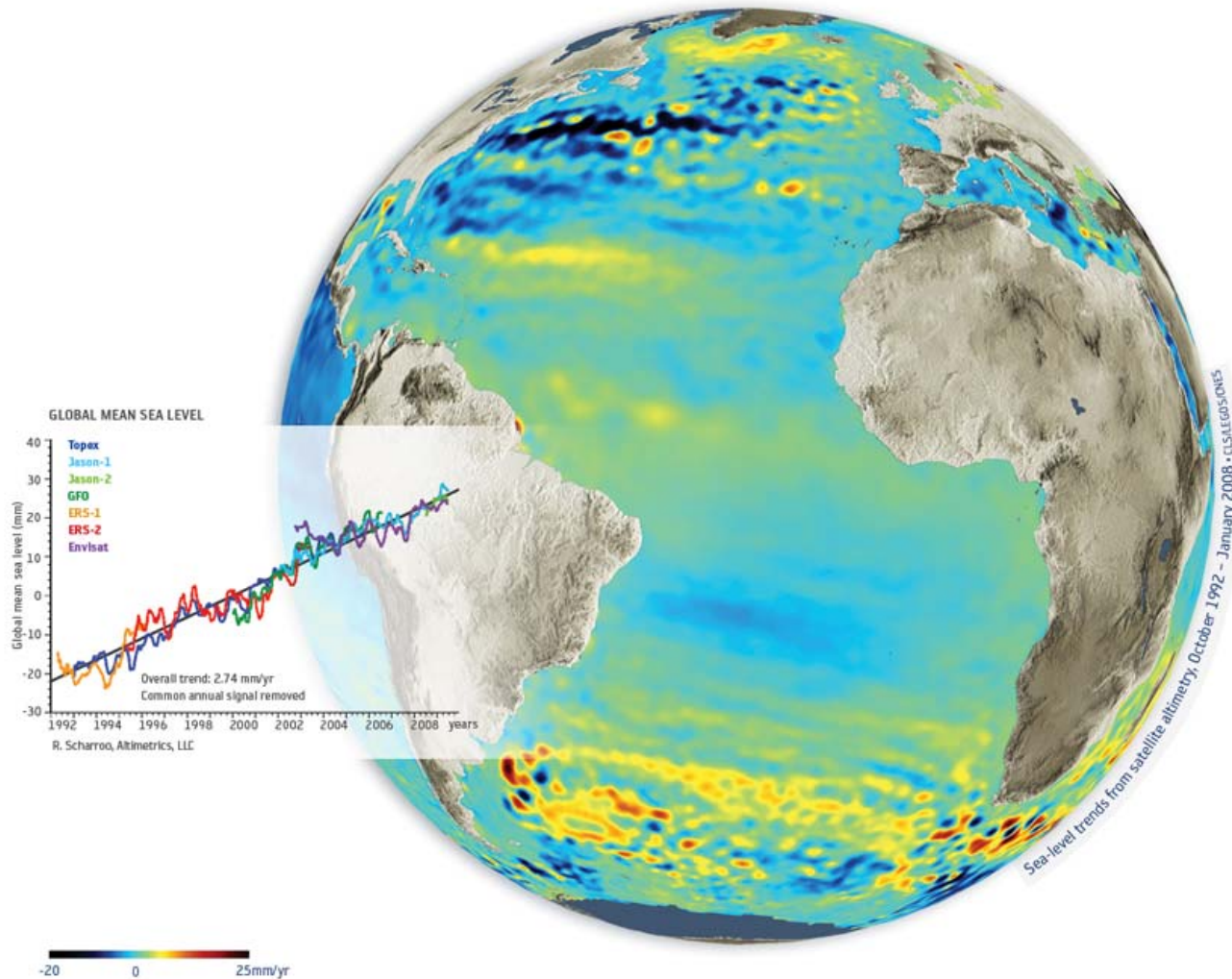
Based on information compiled by the International Geosphere-Biosphere Programme (IGBP).

(Image: MERIS mosaic)

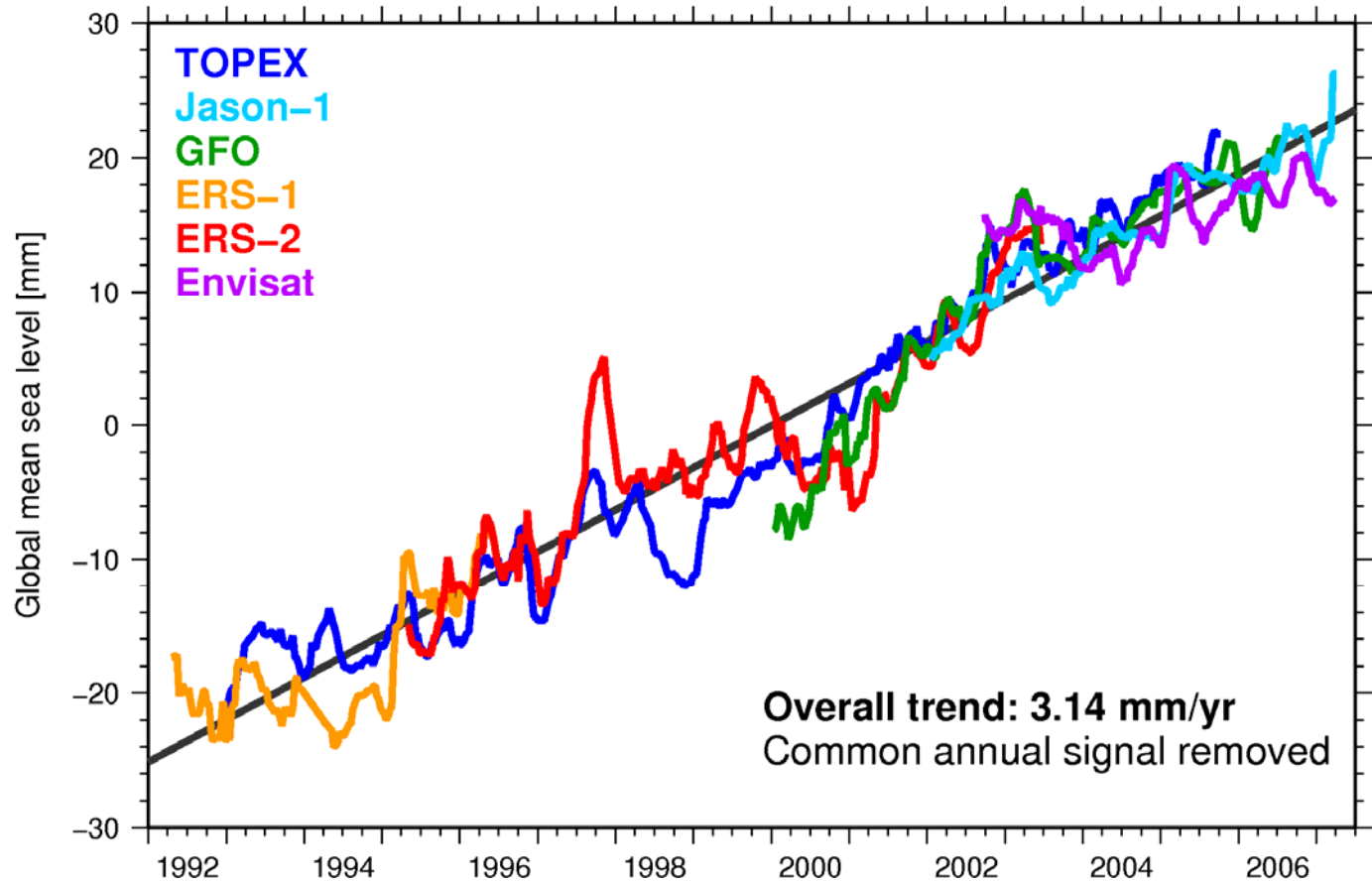
- Data Sources:
- Carbon Dioxide: NOAA.
- Land Cover: Goldewijk & Battjes, National Institute for Public Health and the Environment (RIVM), Netherlands, 1997.
- Temperature: Source unspecified.
- Species Extinction: Reid & Miller, World Resources Institute, Washington DC, 1989.
- Nitrogen: Vitousek, 1994,
- Human Population: US Bureau of the Census

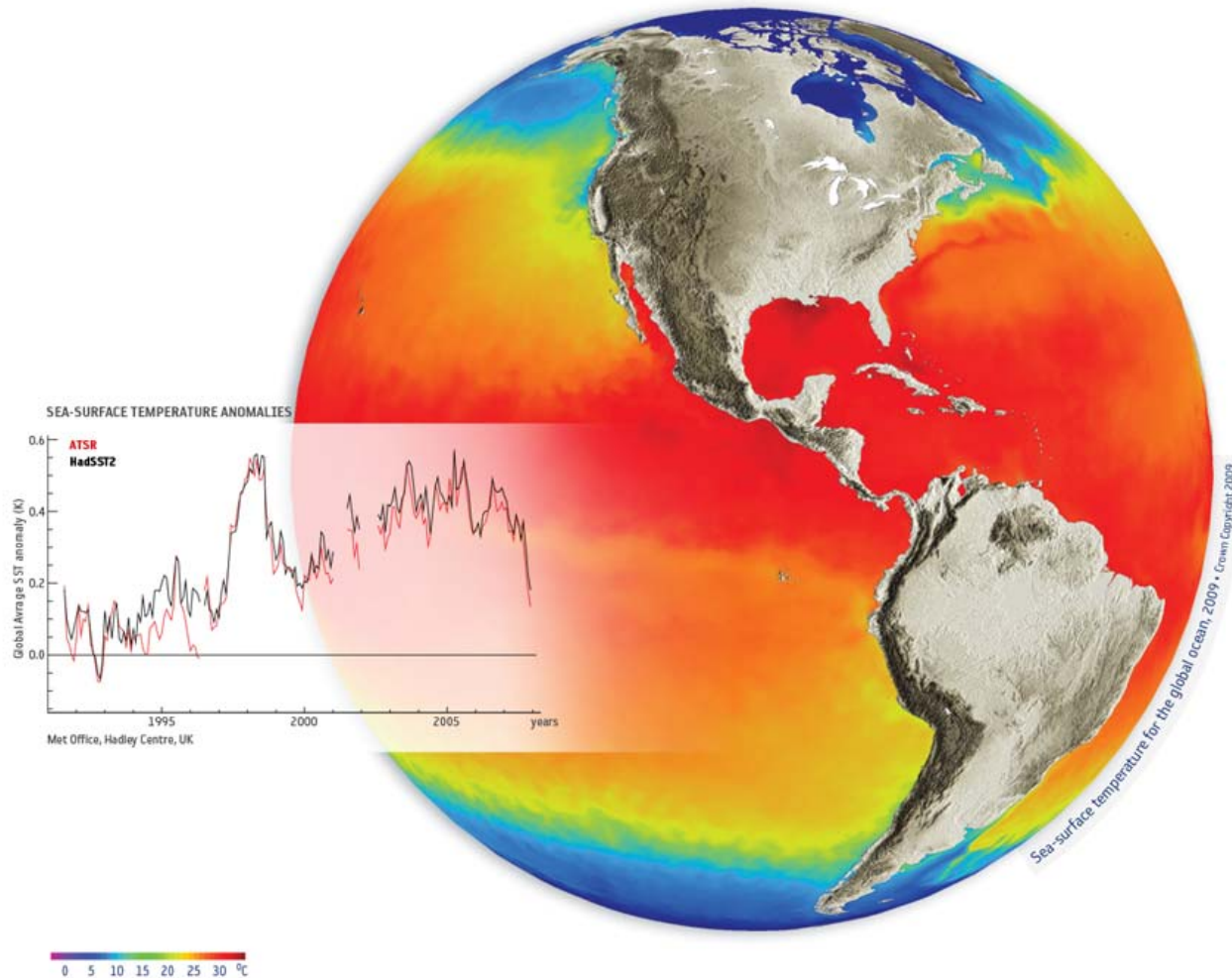
Global mean surface temperature has increased more than $.5^{\circ}\text{C}$ since the beginning of the 20th century, with this warming likely being the largest during any century over the past 1,000 years for the Northern hemisphere.



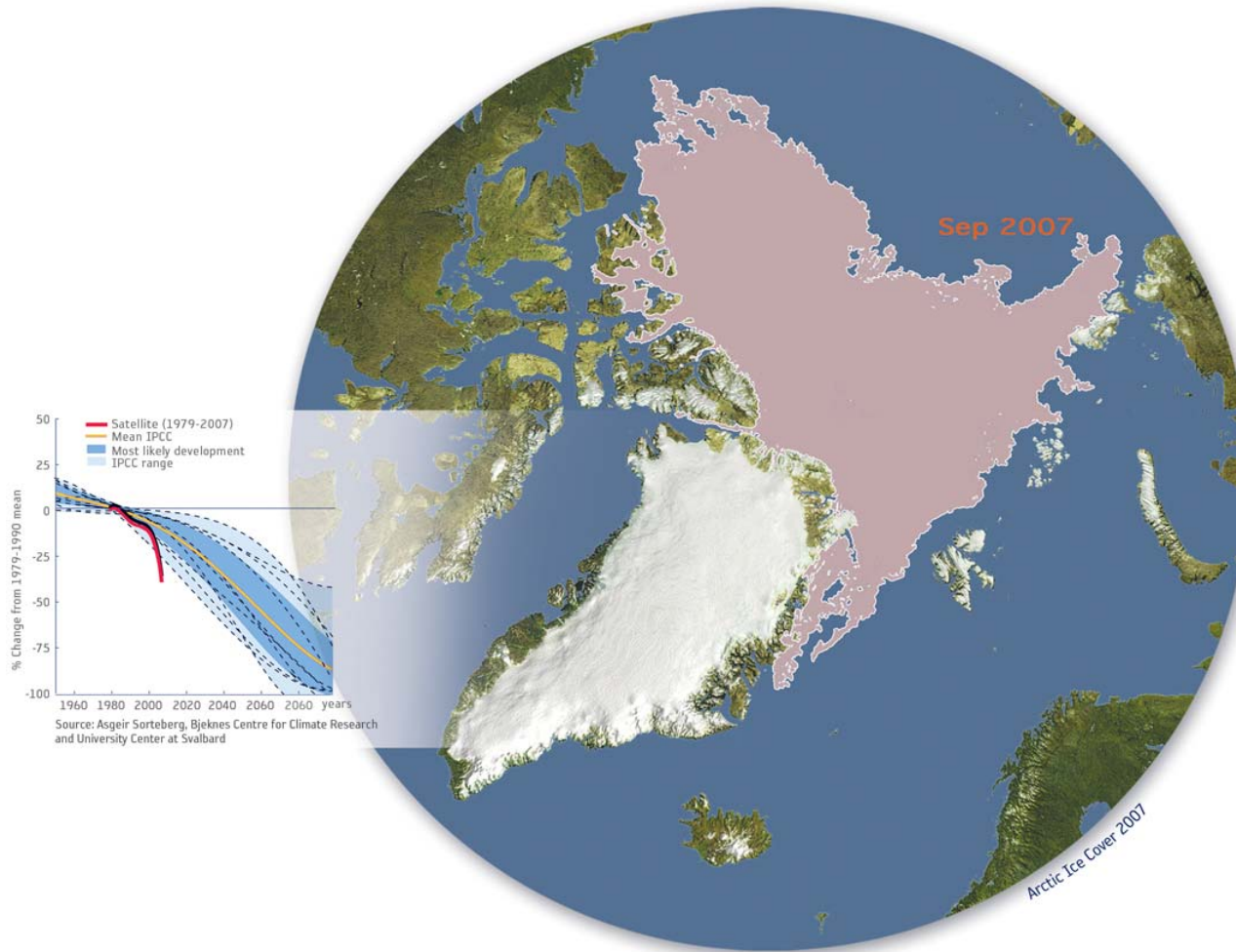


Sea level rise

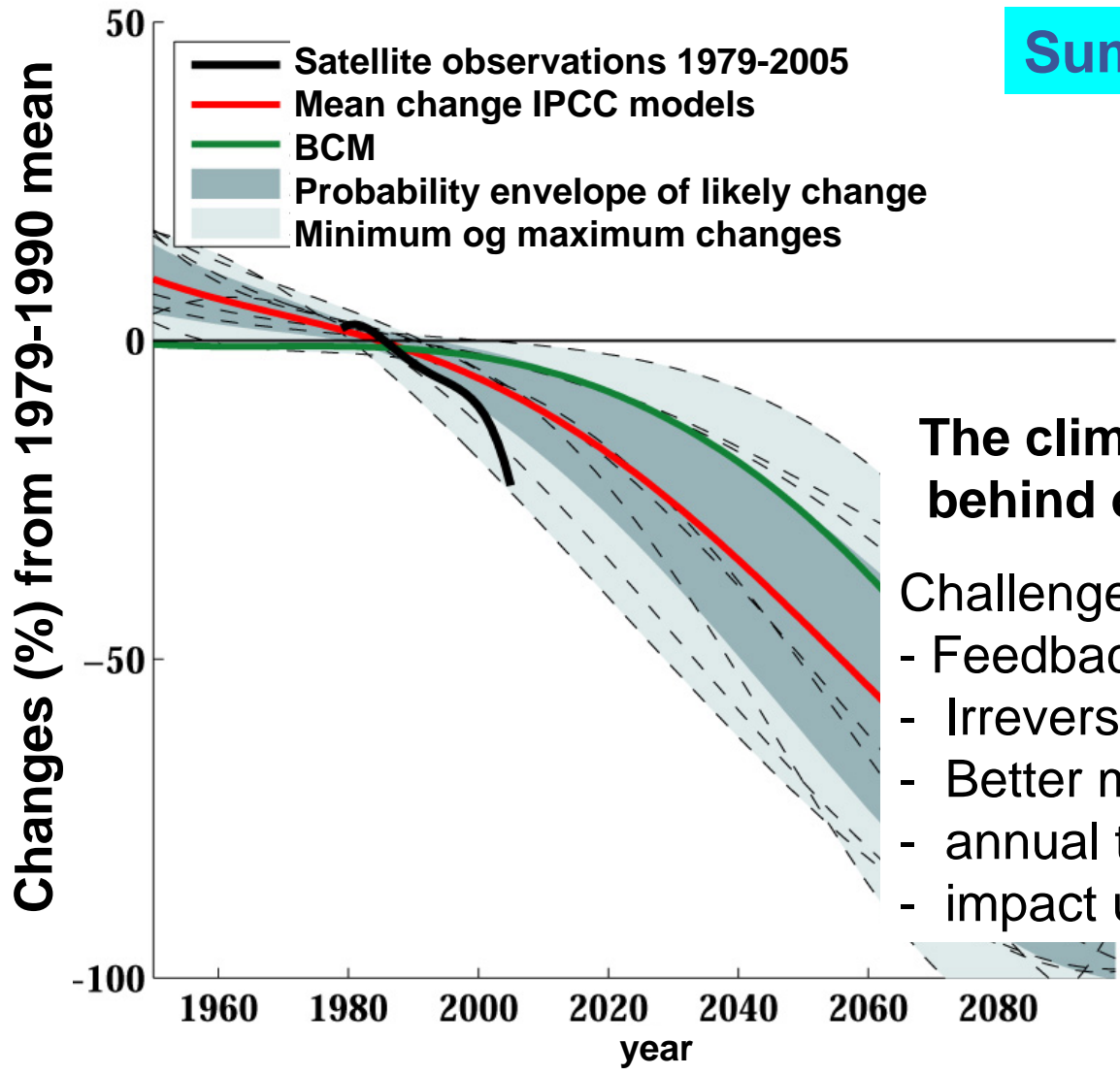




Arctic sea ice decreasing in time

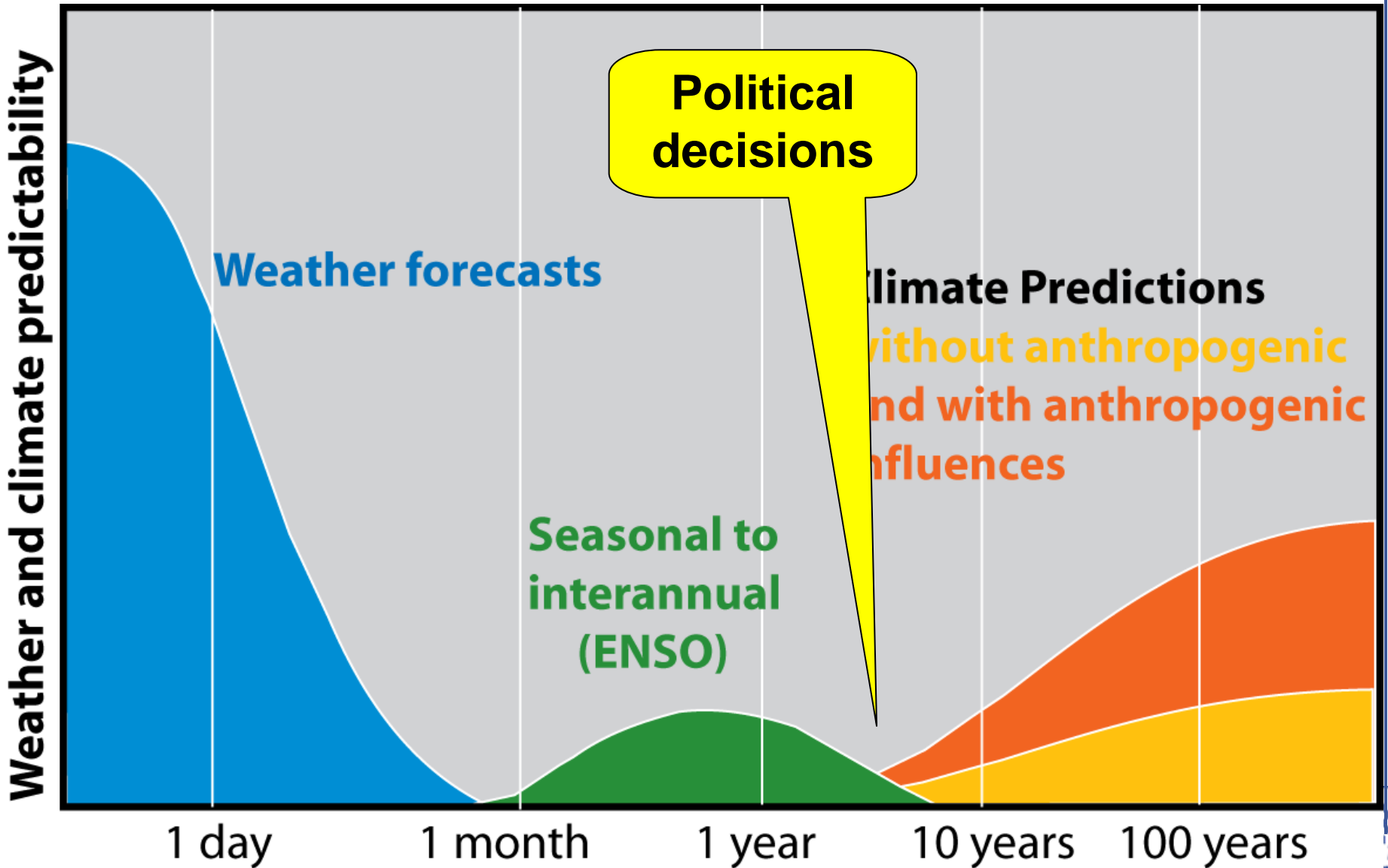


Summer Ice conditions

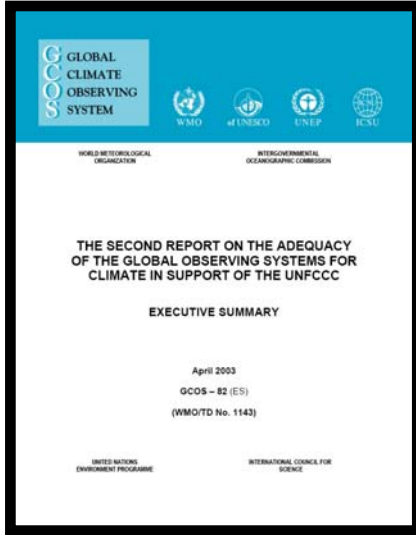


The climate models are 30 years behind observed sea ice retreat

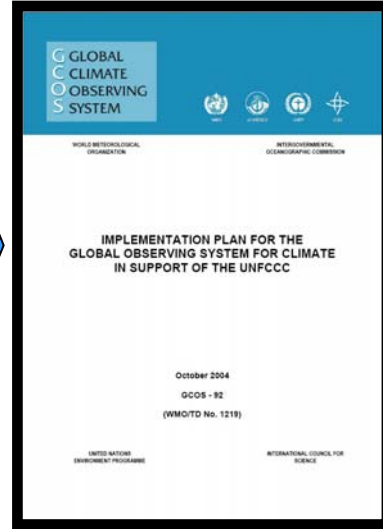
- Challenges:
- Feedbacks
 - Irreversible changes
 - Better models
 - annual to decadal forecasting
 - impact understanding/simulation



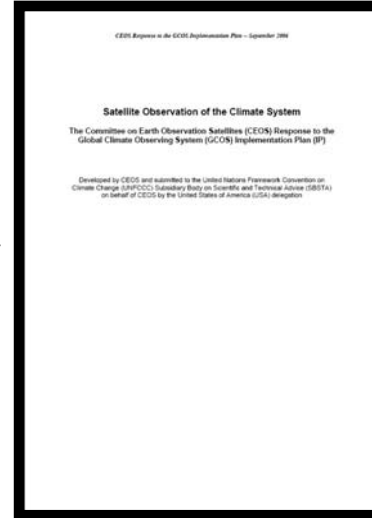
GCOS-82 in 2003



GCOS-92 in 2004



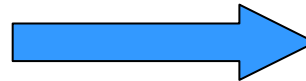
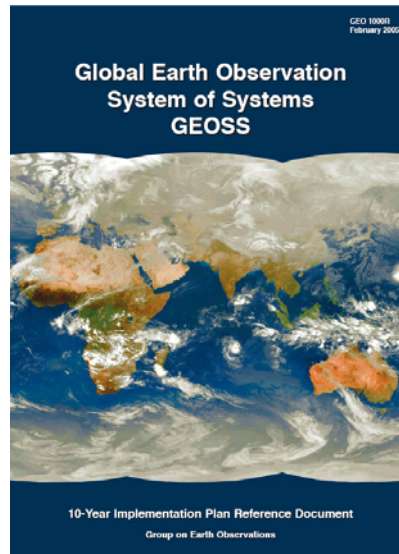
GCOS-107 in 2006



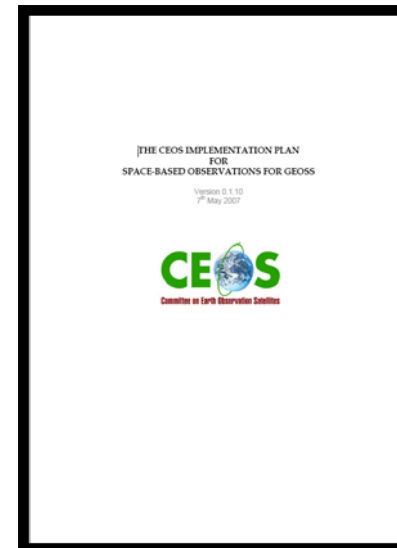
CEOS response 2006



GEOSS 10-year plan in 2005



CEOS IP for GEOSS in 2007



The ESA Climate Change Initiative (CCI) Programme Content

INPUT FROM

Long Term Archiving Programmes
Multi-mission infrastructure

Re-processing ex archive
(e.g. calibration)

“Gather”

ECV generation
(e.g. validation & bias)

“Deliver”

ECV assimilation
& assessment

“Exploit”

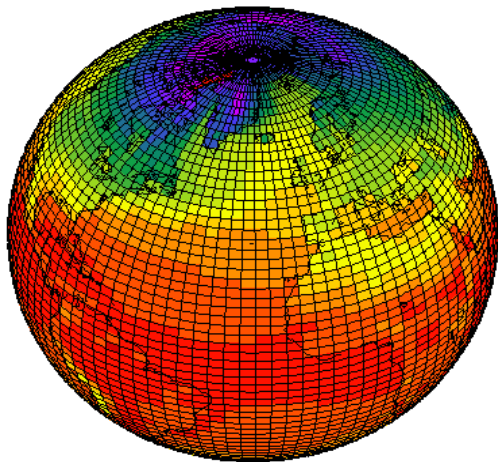
FEEDBACK LOOP:
6 year programme
for 3 cycles

OUTPUT TO

International Climate Programmes
EC & MS R&D Programmes
IPCC Process, UNFCCC

Education & Awareness

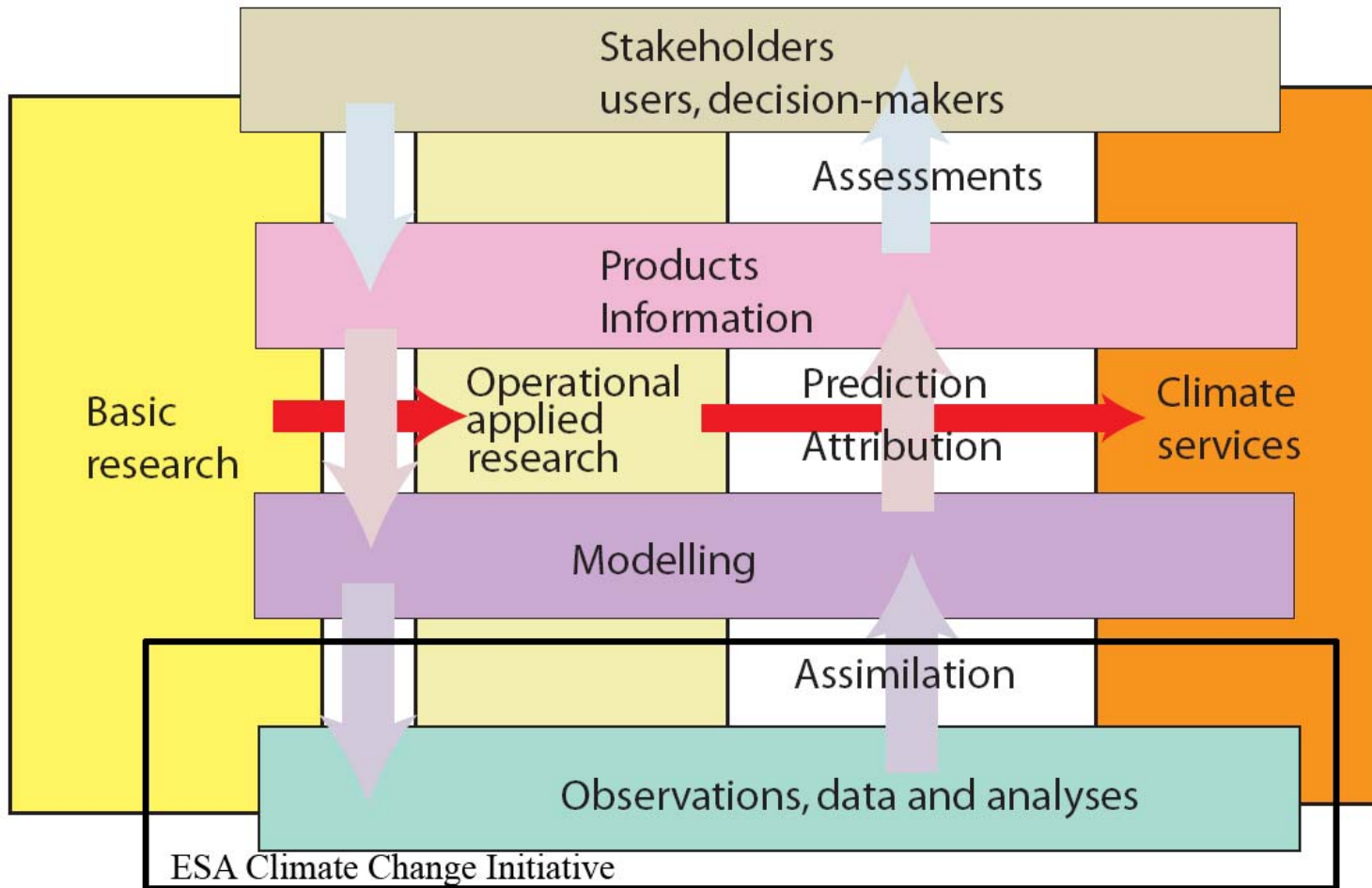
“Show”



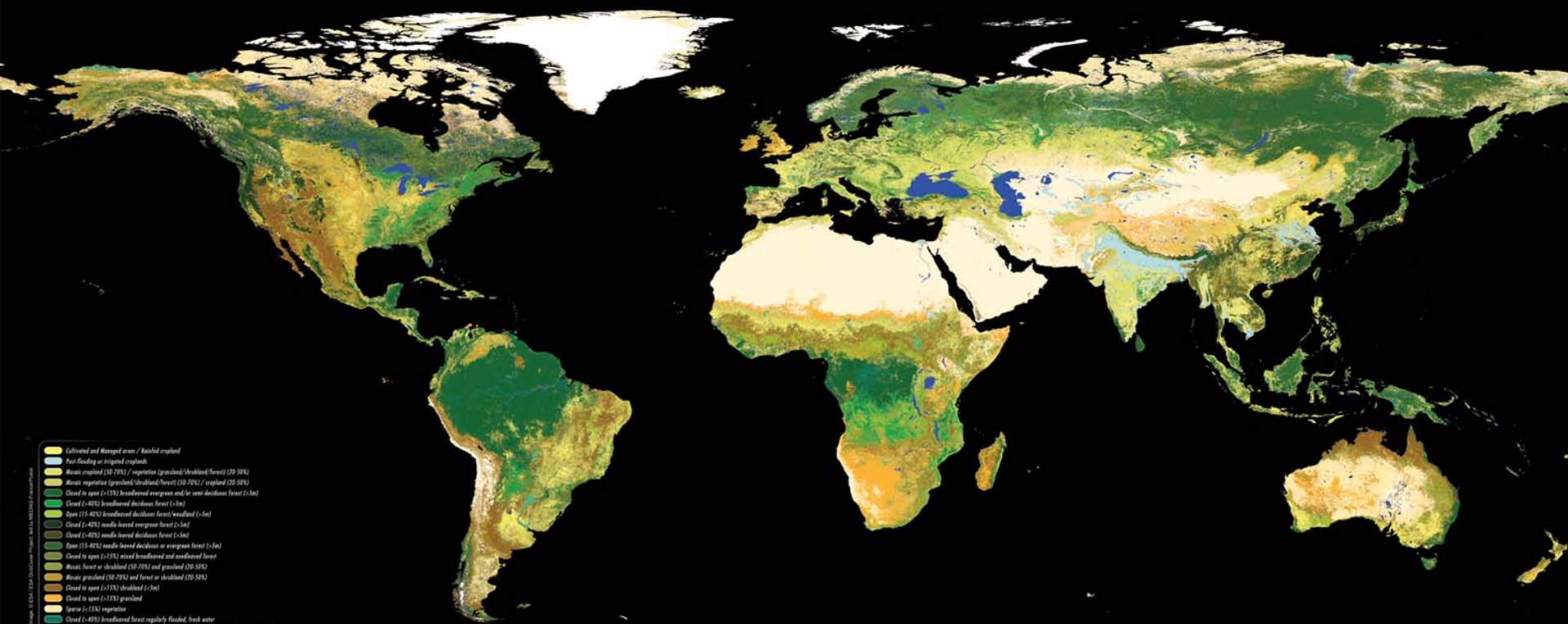
1. Gathering, **collating and preserving** the long-term time series in ESA' s distributed archives.
2. **(Re-)Processing** periodically the basic EO-data sets from each individual mission and applying the most up-to-date algorithms and cal/val corrections
3. **Integrating** the calibrated data sets derived from individual contributing EO mission and sensors to constitute the most comprehensive and well-characterized **global long term records** possible for each ECV
4. Assessing the trends and **consistency of the ECV records** in the context of climate models and assimilation schemes
5. Developing improved **models and algorithms for production of the required variables** from emerging data sources, consistent with the long term record

Atmosphere	Surface (0, 0, 6)	<i>Air Temperature; Precipitation ; Air pressure; Water vapour; Surface radiation budget; Wind Speed & direction;</i>
	Upper air (1, 1, 3)	Cloud properties, Wind speed & direction <i>Earth radiation budget; Upper-air temperature; Water vapour;</i>
	Composition (3, 0, 0)	Carbon dioxide Methane & other GHGs; Ozone; Aerosol properties
Ocean	Surface (4, 2, 1)	Sea-surface Temp; Sea-level; Sea-ice; Ocean colour; Sea state; Sea-surface salinity <i>Carbon dioxide partial pressure</i>
	Sub-surface (0, 0, 7)	<i>Temperature; Salinity; Current; Nutrients; Carbon; Ocean tracers; Phytoplankton</i>
Terrestrial (3, 7, 4)	Glaciers & ice caps; Land Cover; Fire disturbance Fraction of absorbed photo-synthetically active radiation; LAI , Albedo Biomass, Lake levels, Snow cover, Soil moisture <i>Water use, Ground water, River discharge</i> <i>Permafrost and seasonally-frozen ground</i>	

ECV	Measurement	ERS-1 (1991)		ERS-2 (1995)		Envisat (2002)				Earth Explorer			Sentinels		Eumetsat			Other Missions										Count																						
		Radar Altimeter	ATSR-1	SAR Wave Mode	SAR Image Mode	Scatterometer	Radar Altimeter	ATSR-2	SAR Wave Mode	SAR Image Mode	Scatterometer	GOME	Radar Altimeter	AATSR	MERIS	ASAR Wave Mode	ASAR Image Mode	Schiamachy	MIPAS	GOMOS	GOCE (2008)	SAMOS (2009)	Cryosat (2009)	ADMAEOLEUS (2009)	EarthCARE (2012)	Sentinel 1 (2012)	Sentinel 2 (2012)		Sentinel 3 (2012)	Sentinel 4	Sentinel 5	MSG (2002)	GOME-2 (2006)	IASI (2006)	ASCATT (2006)	Topex/JASON (1991)	SPOT - VGT (1998)	SPOT - HRV (1986)	Landsat (1972)	AVHRR (1981)	DMSP - SSMI (1987)	MODIS (1999)	SeaWiFS (1997)	Geosat Follow-on (1998)	OMI (2004)	TOMS (1978)	Aquarius (2010)	Radarsat (1995)	JERS/ALOS (1991/2006)	Other Missions
OCEAN	O.2 Sea level and variability of its global mean	●				●																																						8						
	O.3 Sea surface temperature		●				●																				●								●								7							
	O.4 Ocean colour and oceanic chlorophyll-a concentration																																									4								
	O.5 Wave height & other measures of sea state	●		●			●		●																																	12								
	O.6 Measurement of changes in sea-surface salinity																																					●				3								
	O.1 Sea-ice concentration																																									7								
LAND	T.1 Lakes	●	●	●			●	●	●	●	●																															21								
	T.2 Glaciers and Ice Caps	●		●			●																																			12								
	T.5 Maps of land cover type, for detection of land cover change							●																			●	●							●	●						11								
	T.6 Maps of fAPAR																											●								●	●					8								
	T.7 Maps of Leaf Area Index																											●								●	●					8								
	T.8 Global, above ground forest biomass & forest biomass change																																				●	●				6								
	T.9 Burnt area, active fire maps and fire radiated power		●					●																													●	●				10								
	T.10 Research towards global near-surface soil moisture map																																					●			6									
	T.3 Snow areal extent		●	●	●		●	●	●					●																							●	●				16								
	T.4 Directional hemispherical (black sky) albedo																																					●	●				9							
ATMOSPHERE	A.4 Cloud properties	●					●																																				13							
	A.7 Profiles and total columns of ozone																																				●	●					8							
	A.8 Aerosol Optical depth and other aerosol properties																																				●						17							
	A.9 Distribution of greenhouse gases, such as CO2 and CH4																																						●				7							
	A.10 Upper-air WInd																																										1							
		4	5	1	5	2	4	10	1	4	3	3	4	10	10	1	6	4	4	4	2	4	2	3	3	2	6	2	13	3	3	4	3	1	1	3	6	2	2	8	2	10	7	2	1	2	1	4	4	7



(from K. Trenberth: *Observational needs for climate prediction and adaptation*, WMO Bulletin 57(1), January 2008)



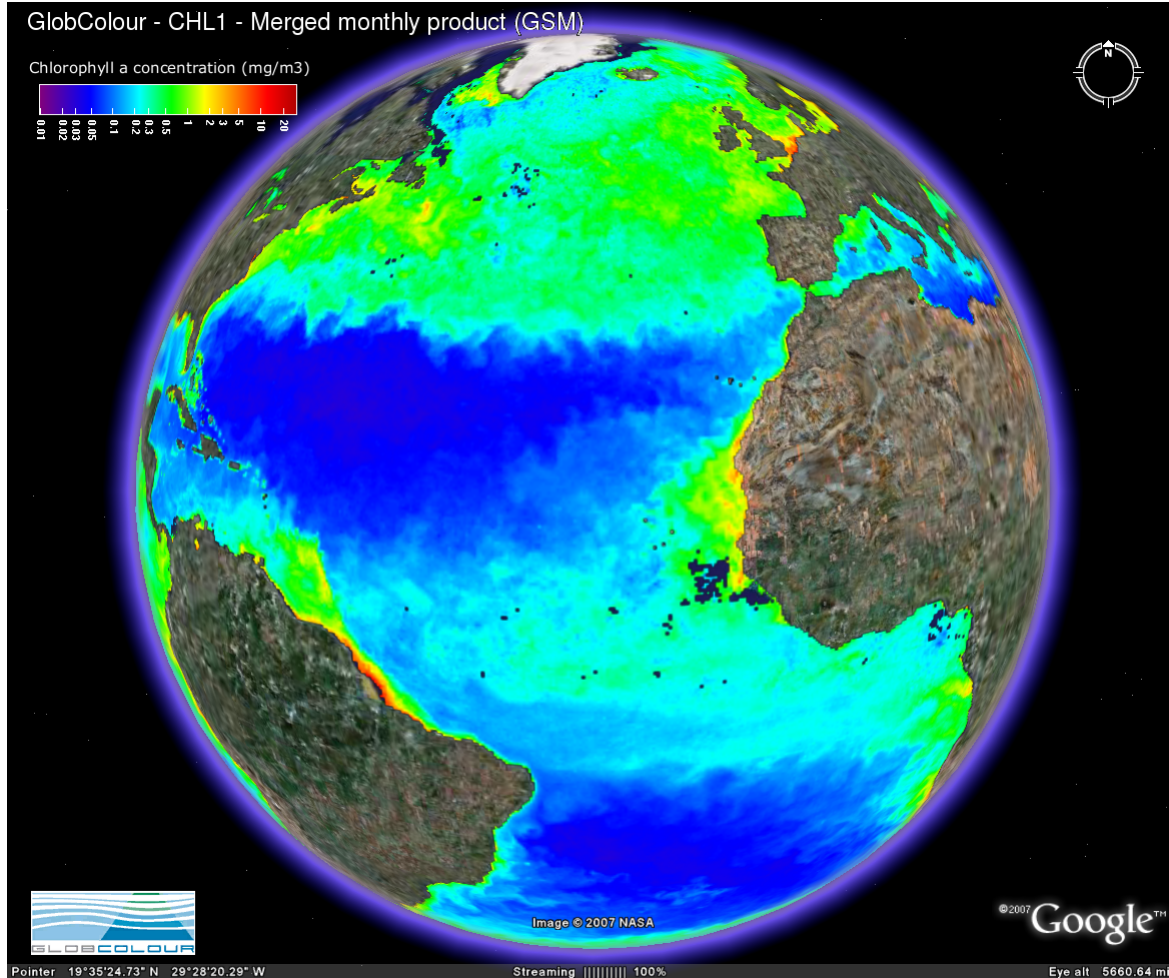
- Cultivated and Managed areas / Rainfed cropland
- Past Grazing or original cropland
- Mixed cropland (10-20%) / vegetation (grassland/shrubland/forest) (20-50%)
- Mixed vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)
- Closed to open (<15%) broadleaved evergreen and/or semi-deciduous forest (<5m)
- Closed (>40%) broadleaved deciduous forest (<5m)
- Open (15-40%) broadleaved deciduous forest (semi)wood (<5m)
- Closed (>40%) needle-leaved evergreen forest (<5m)
- Closed (>40%) needle-leaved deciduous forest (<5m)
- Open (15-40%) needle-leaved deciduous or evergreen forest (<5m)
- Closed to open (<15%) mixed broadleaved and needle-leaved forest
- Mixed forest or shrubland (10-30%) and grassland (20-30%)
- Mixed grassland (50-70%) and forest or shrubland (10-30%)
- Closed to open (<15%) shrubland (<5m)
- Closed to open (<15%) grassland
- Sparse (<15%) vegetation
- Closed (>40%) broadleaved forest regularly flooded, fresh water
- Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded, saline water
- Closed to open (<15%) grassland or shrubland or woody veg. regularly flooded or waterlogged soil, fresh, brackish or saline water
- Artificial surfaces and associated areas (urban areas <50%)
- Bare areas
- Water bodies
- Permanent snow and ice
- No data

GlobCover Version 2 - 300m

December 2004/June 2006 [ENVISAT MERIS]

European Space Agency
Agence spatiale européenne

To access GlobCover data: <http://www.esa.int/Enr/main/globcover>



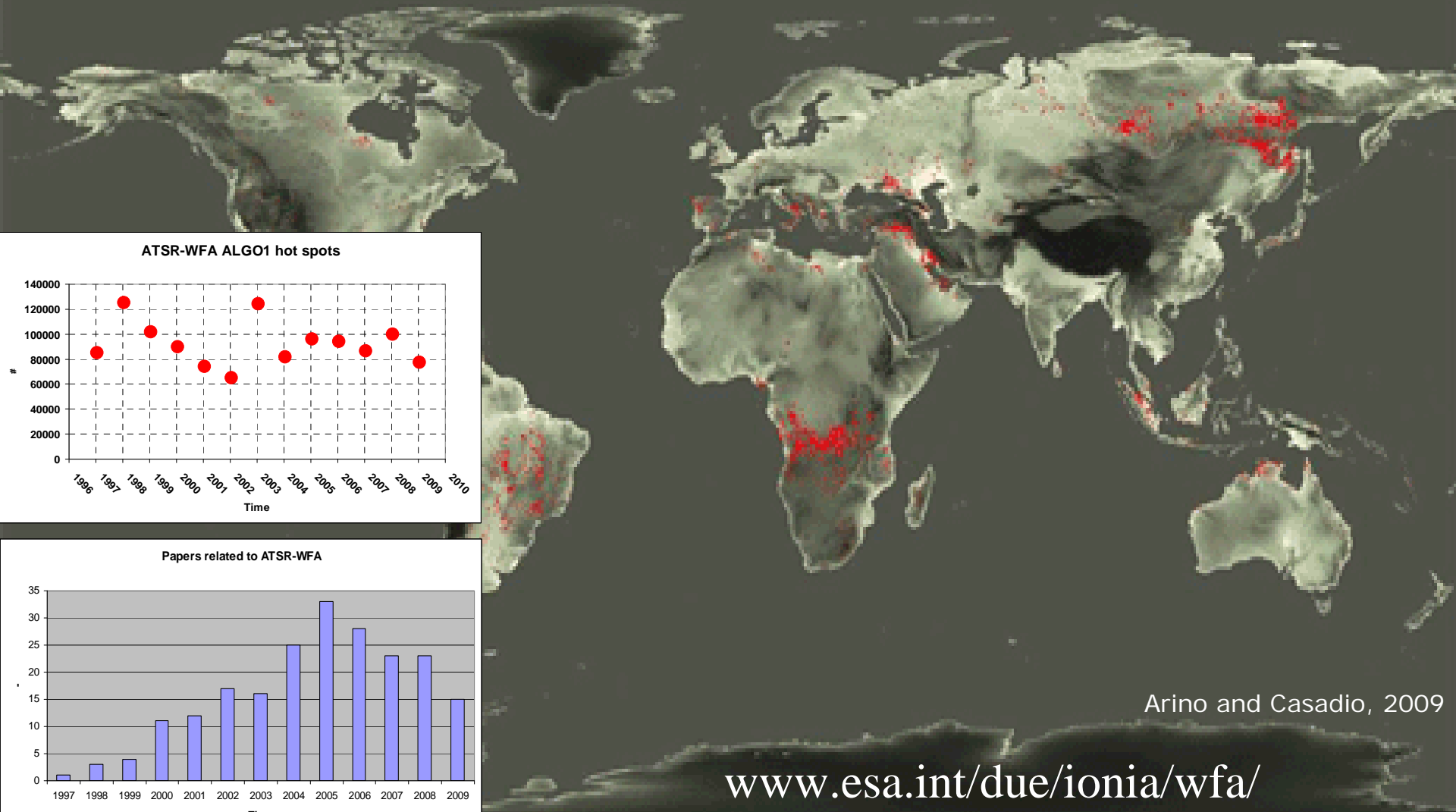
ESA GlobColour Project

Global merged MERIS-MODIS-SeaWiFS ocean colour product (Chl_a) April 2003.

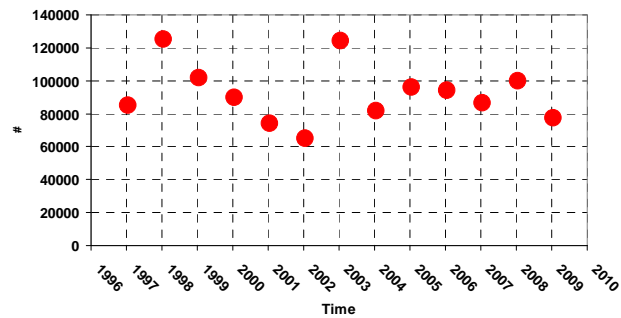
Credit: ACRI, LOV, Univ. Plymouth, ICESS, NIVA, Brockmann Consult, DLR, ESA, NASA, GeoEye



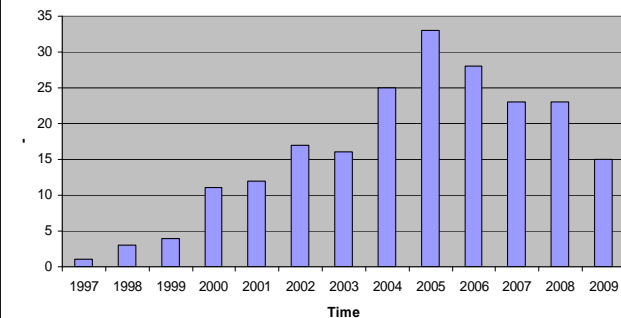
07 - 1996



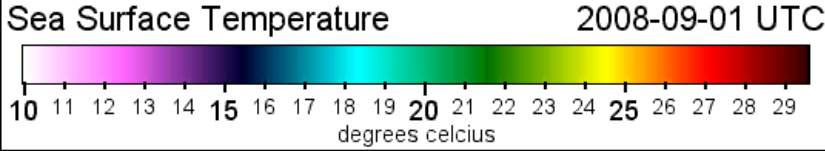
ATSR-WFA ALGO1 hot spots



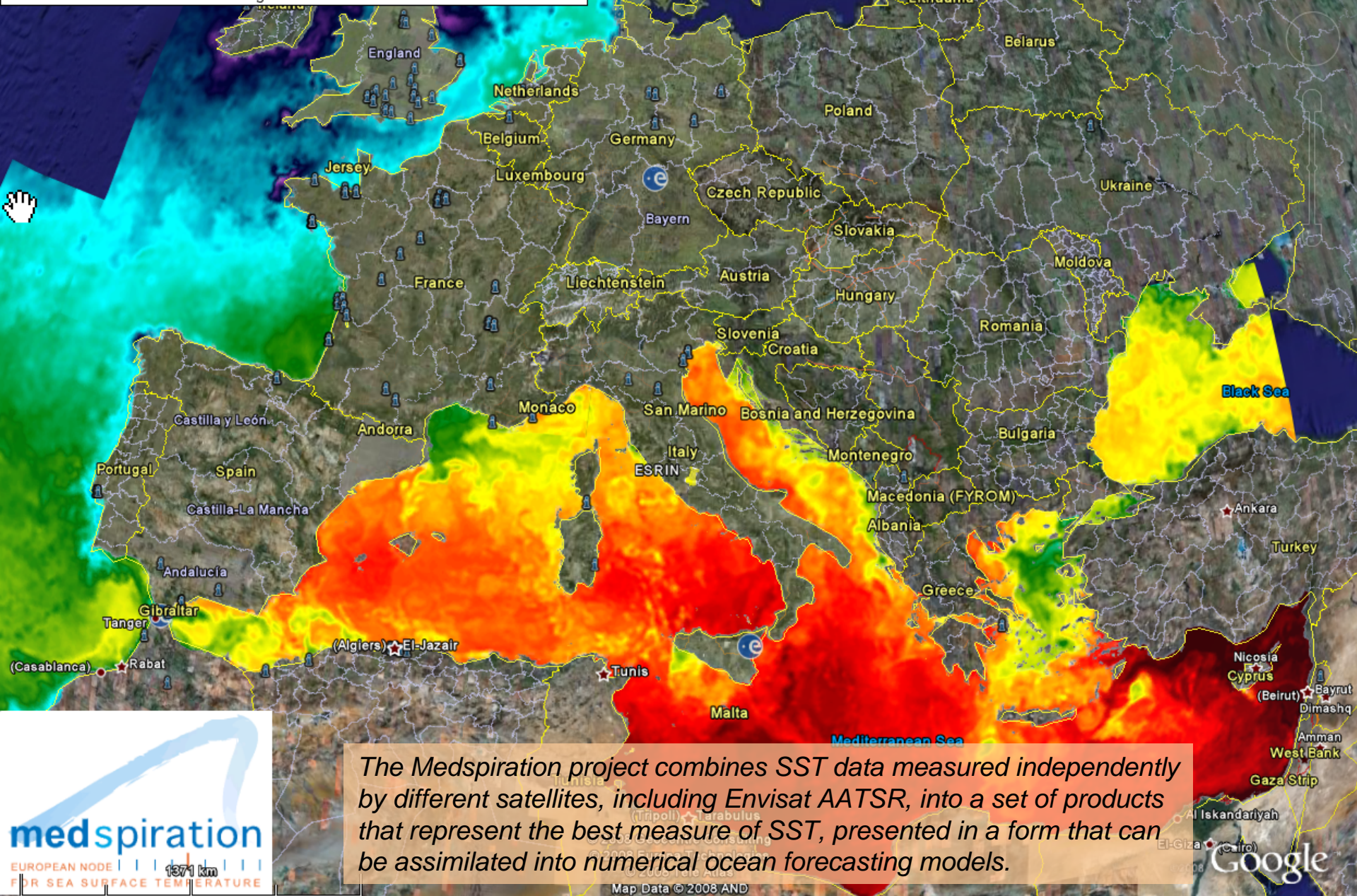
Papers related to ATSR-WFA



Arino and Casadio, 2009



<http://www.medspiration.org>



medspiration
EUROPEAN NODE | 1371 km |
FOR SEA SURFACE TEMPERATURE

The Medspiration project combines SST data measured independently by different satellites, including Envisat AATSR, into a set of products that represent the best measure of SST, presented in a form that can be assimilated into numerical ocean forecasting models.

lat 45.535835° lon -17.215575°

Map Data © 2008 AND

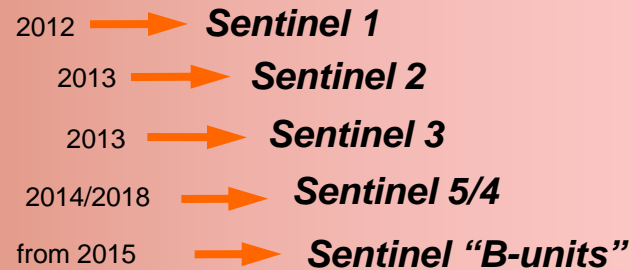
Eye alt 3431.40 km

Earth Explorer Missions



Science

Earth Watch Missions (GMES)



Applications & Services

GMES in cooperation with the European Commission

METEOSAT



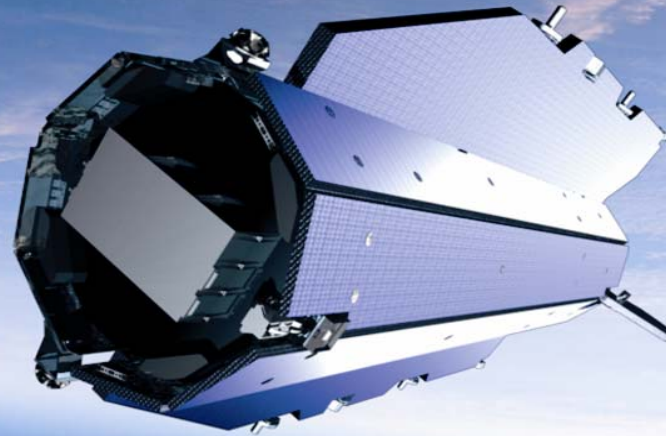
Meteorology

Meteosat-1 to Meteosat-7



Meteorological Missions in cooperation with EUMETSAT

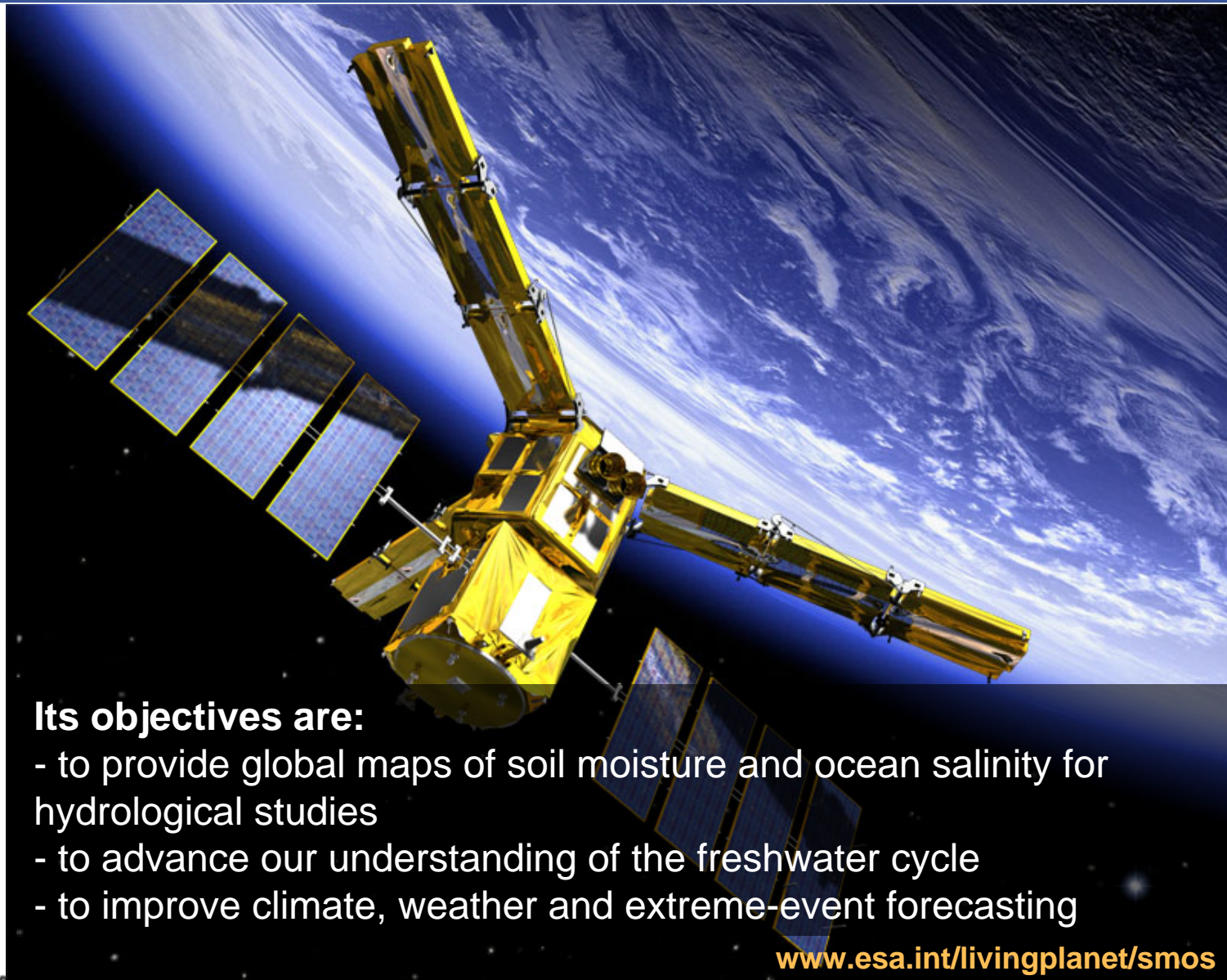
The Gravity field and steady-state Ocean Circulation Explorer (GOCE)



Its objectives are to improve understanding of:

- global ocean circulation and transfer of heat
- physics of the Earth's interior (lithosphere & mantle)
- sea level records, topographic processes, evolution of ice sheets and sea level change

www.esa.int/livingplanet/goce



Its objectives are:

- to provide global maps of soil moisture and ocean salinity for hydrological studies
- to advance our understanding of the freshwater cycle
- to improve climate, weather and extreme-event forecasting

www.esa.int/livingplanet/smos



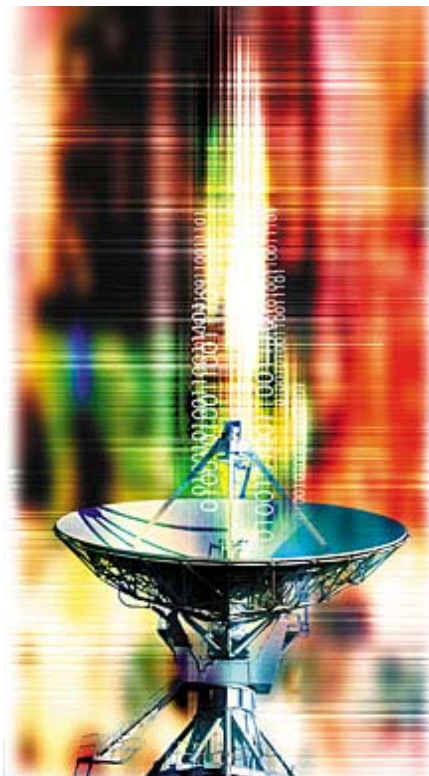
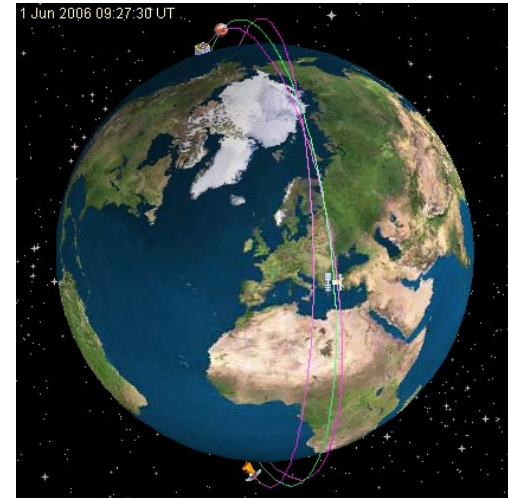
Its objectives are to improve our understanding of:

- thickness and mass fluctuations of polar land and marine ice
- to quantify rates of thinning/thickening due to climate variations

www.esa.int/livingplanet/cryosat

© ESA / 2009 / Illustration P. CASBIS

Global Monitoring for Environment and Security

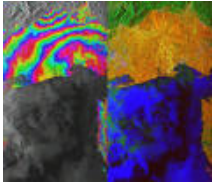


ne

European **independence** in data sources for environment and security monitoring *and*

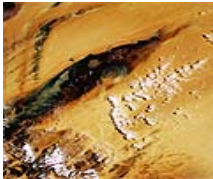
The European **contribution** to the Global Earth Observation System of Systems (GEOSS)

The GMES Sentinels



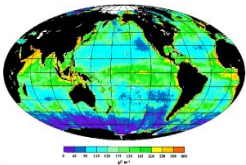
Sentinel 1 – SAR imaging

All weather, day/night applications, interferometry



Sentinel 2 – Superspectral imaging

Continuity of Landsat, SPOT & Vegetation-type data



Sentinel 3 – Ocean monitoring

Wide-swath ocean color and surface temperature sensors, altimeter



Sentinel 4 – Geostationary atmospheric

Atmospheric composition monitoring, trans-boundary pollution

Sentinel 5 – Low-orbit atmospheric

Atmospheric composition monitoring

ESA supports climate...

...**modeling and prediction** - through provision of ECV data to climate modellers (ECMWF, Meteo-France, UKMO, MPI...)

...**mitigation** - through e.g. forest monitoring (REDD)

...**adaptation** - by management of climate impacts

...**attribution** - through (eventually) identification of sources and sinks