ESA Climate Change initiative
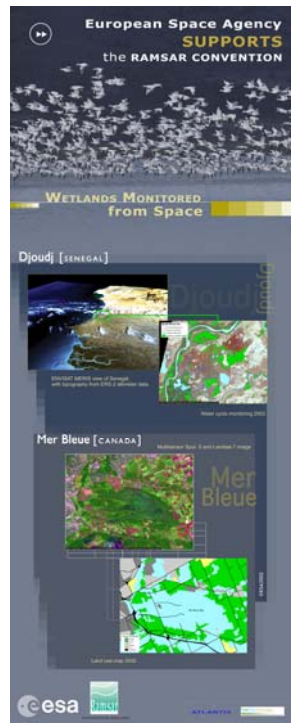
Global Monitoring of Essential Climate Variables Precursors

03 December 2008

Olivier Arino

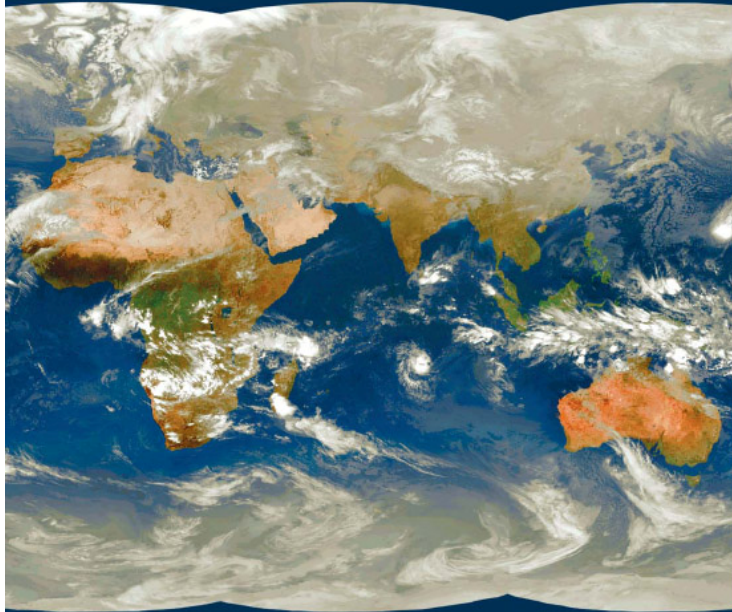Science Applications and New Technologies department,

Earth Observation directorate

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- **UNFCCC**, UN Framework Convention on Climate Change
- **UNCCD**, UN Convention to Combat Desertification
- **UNCBD**, UN Convention on Biodiversity
- **RAMSAR**, Intergovernmental Convention on Wetlands
- **WHC**, World Heritage Convention

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GLOBAL
CLIMATE
OBSERVING

GEO 1000R
February 2005

**Global Earth Observation
System of Systems
GEOSS**

10-Year Implementation Plan Reference Document

Group on Earth Observations

UNITED NATIONS
ENVIRONMENT PROGRAMME

THE CEOS IMPLEMENTATION PLAN
FOR
SPACE-BASED OBSERVATIONS FOR GEOSS

Version 0.1.10
7th May 2007

CEOS

Committee on Earth Observation Satellites

To realize the full potential of the long-term global Earth Observation archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by United Nations Framework Convention on Climate Change (UNFCCC).

- Implement all steps necessary for the systematic generation and regular updating of the relevant ECVs,

- A coherent and continuous suite of actions fully coordinated with on-going international efforts in the climate change community (eg. WCRP, IGBP)

- Ensure full capital is derived from on-going & planned ESA missions for climate purposes,

- **Focus on 21 ECVs (ESA missions :18 primary, 3 secondary)**

The International Partners:

- **UNFCCC** which coordinates the interests and decisions of its Parties on Climate Policy,

- **GCOS** which represents the scientific and technical requirements of the Global Climate Observing System on behalf of UNFCCC,

- **CEOS** which serves as a focal point for Earth Observation related activities of Space Agencies

- **Individual Partner Space Agencies** with whom ESA cooperates bilaterally (e.g. NOAA, NASA, JAXA, CNES, Eumetsat)

- **International Climate Research Programmes**, which represent the collective interests and priorities of the worldwide climate research (e.g WCRP, IGBP)

- **EC and National Research Programmes** which establish research priorities and provide resources for climate research community within Europe (eg EC Framework Programme)

EO mission per ECVs

Mission column groups: ERS-1 (1991) · ERS-2 (1995) · Envisat (2002) · Earth Explorer · Sentinels · Eumetsat · (others)

ECV	Measurement	Radar Altimeter (ERS-1)	ATSR-1	SAR Wave Mode (ERS-1)	SAR Image Mode (ERS-1)	Scatterometer (ERS-1)	Radar Altimeter (ERS-2)	ATSR-2	SAR Wave Mode (ERS-2)	SAR Image Mode (ERS-2)	Scatterometer (ERS-2)	GOME	Radar Altimeter (Envisat)	AATSR	MERIS	ASAR Wave Mode	ASAR Image Mode	Schiamachy	MIPAS	GOMOS	GOCE (2008)	SMOS (2009)	Cryosat (2009)	ADM/AEOLEUS (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	Count
O.2	Sea level and variability of its global mean	●					●						●										●					●							●								●							7
O.3	Sea surface temperature		●					●						●														●			●								●											6
O.4	Ocean colour and oceanic chlorophyll-a concentration														●													●													●	●								4
O.5	Wave height & other measures of sea state	●		●			●		●				●			●							●			●		●							●								●							11
O.6	Measurement of changes in sea-surface salinity																					●																								●				2
O.1	Sea-ice concentration				●					●								●								●															●						●	●		7
T.1	Lakes	●	●		●		●	●		●			●	●	●		●									●	●	●							●		●	●	●		●	●					●	●		21
T.2	Glaciers and Ice Caps	●			●		●			●			●										●			●		●																			●	●		11
T.5	Maps of land cover type, for detection of land cover change		●					●							●		●										●	●								●	●	●	●		●	●								12
T.6	Maps of fAPAR		●					●							●		●											●								●			●		●	●								9
T.7	Maps of Leaf Area Index		●					●							●		●											●								●			●		●	●								9
T.8	Global, above ground forest biomass & forest biomass change			●						●								●								●																					●	●		6
T.9	Burnt area, active fire maps and fire radiated power		●					●							●		●											●								●			●		●	●								9
T.10	Research towards global near-surface soil moisture map					●					●						●					●												●															●	6
T.3	Snow areal extent		●		●	●		●		●	●			●	●		●									●	●												●											12
T.4	Directional hemispherical (black sky) albedo		●					●							●		●											●				●				●			●		●								●	10
A.4	Cloud properties		●					●				●		●	●			●	●						●						●	●	●	●																12
A.7	Profiles and total columns of ozone											●						●	●	●												●												●	●				●	8
A.8	Aerosol Optical depth and other aerosol properties		●					●				●		●	●			●	●	●											●	●	●	●										●						13
A.9	Distribution of greenhouse gases, such as CO2 and CH4																	●	●										●	●			●																●	6
A.10	Upper-air Wind																							●																										1
	Count	4	#	1	5	2	4	#	1	4	3	3	4	#	#	1	6	4	4	2	0	2	3	1	1	6	2	#	3	3	4	3	1	1	3	5	2	2	8	1	7	6	2	1	1	1	4	4	4	

Category groupings (left band): OCEAN — O.1–O.6; LAND — T.1–T.10; ATMOSPHERE — A.4–A.10

Five Programme Elements

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. Developing improved models and algorithms for production of the required variables from emerging data sources, consistent with the long term record

4. 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

5. Assessing the trends and consistency of the ECV records in the context of climate models and assimilation schemes

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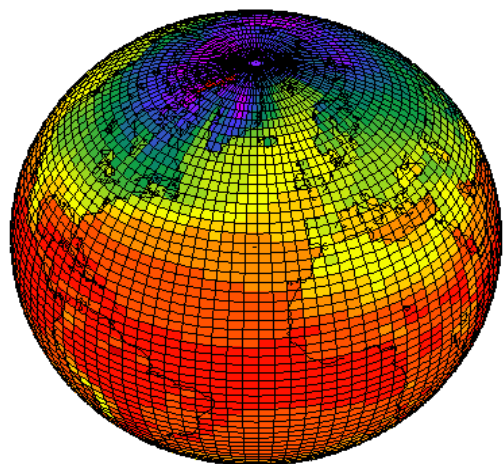
Ocean related ECVs

Essential Climate Variable	ESA global observation commitments
Sea Ice	*GlobIce*
Sea Level	*ERS-1 & ERS-2 & ENVISAT altimeters*
Sea Surface Temperature	*Medspiration*
Ocean Colour	*GlobColour*
Sea State	*GlobWave**
Ocean Salinity	*SMOS***

* in preparation (start 2008 and 2009)
** future dedicated satellite mission (launch 2009)

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ECV pre-cursors

Land related ECVs

Essential Climate Variable	ESA global observation commitments
Snow Cover	*GlobSnow**
Soil Moisture	*SMOS***
Glaciers	*GlobGlacier*
Lake Levels	*(regional activities)*
Albedo	*GlobAlbedo**
fAPAR	*GlobCarbon*
Leaf Area Index	*GlobCarbon*
Fire disturbance	*GlobCarbon/ATSR World Fire Atlas*
Land Cover	*GlobCover*
Biomass	*(regional activities, e.g. Siberia)*

* in preparation (start 2008 and 2009)
** future dedicated satellite mission (launch 2008)

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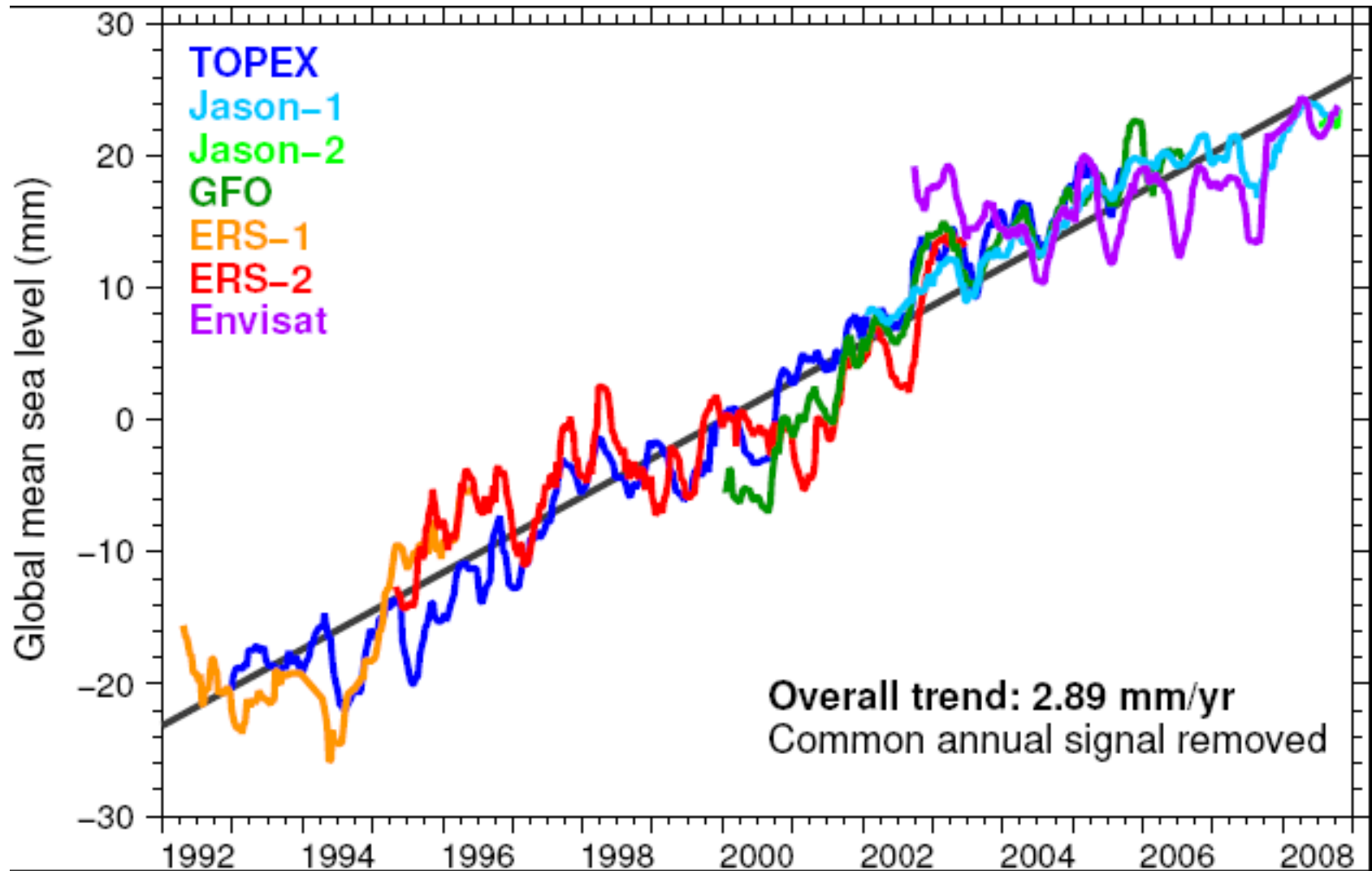
Global Sea Level Trend

Multi−Mission Sea Level Trends (period : Oct−1992 to Jan−2008)

Trends (mm/year, I.B. : applied / wet tropo. : RADIOMETER−derived, seasonal signal removed)

© CLS/LEGOS/CNES

Sea Surface Temperature Change

ERS-1/2 ATSR data
trend: 0.13°K / decade

AVHRR data
trend: 0.09°K / decade

SST anomaly (°C)

0.4
0.2
0.0
-0.2
-0.4

1986   1988   1990   1992   1994   1996   1998   2000

Time (years)
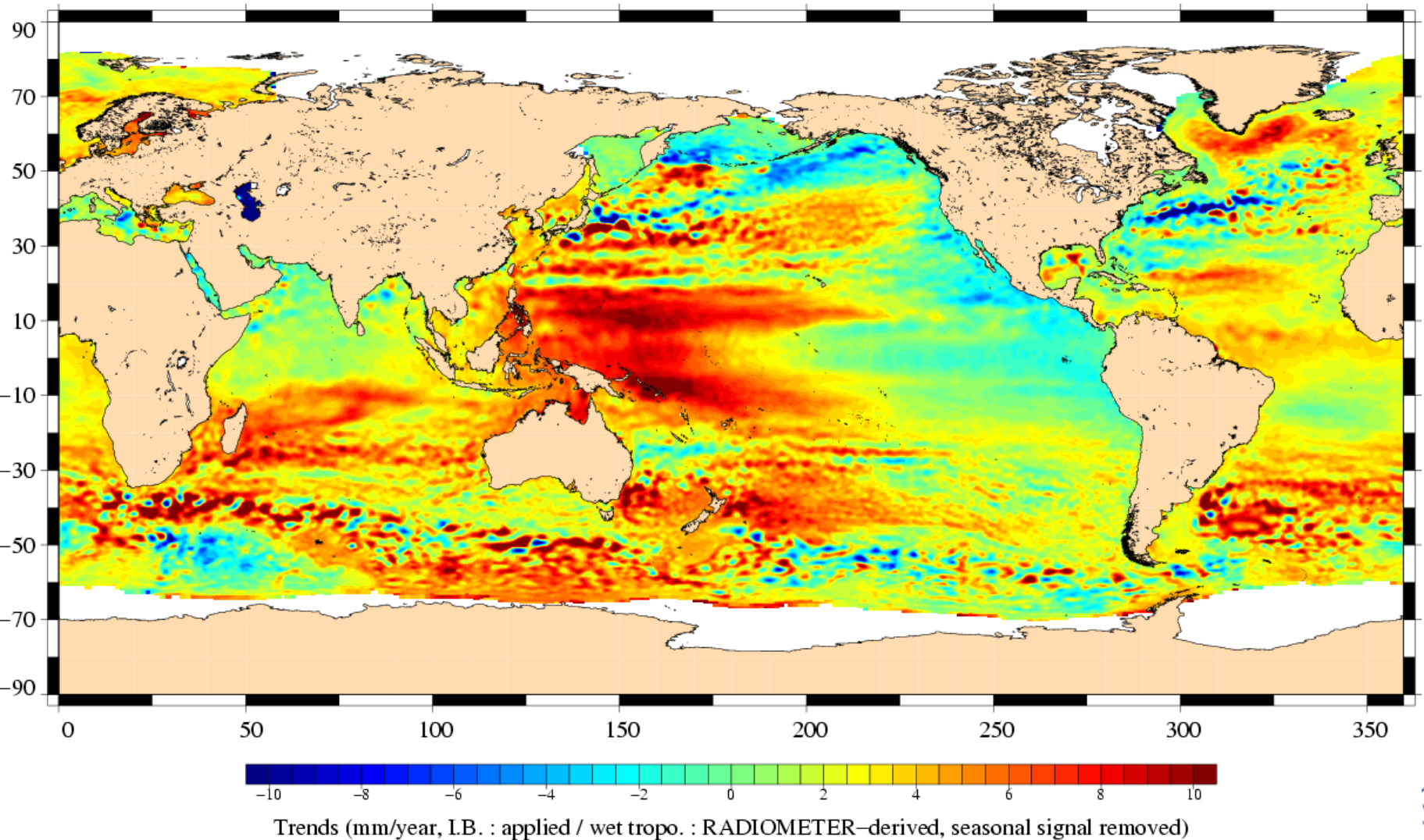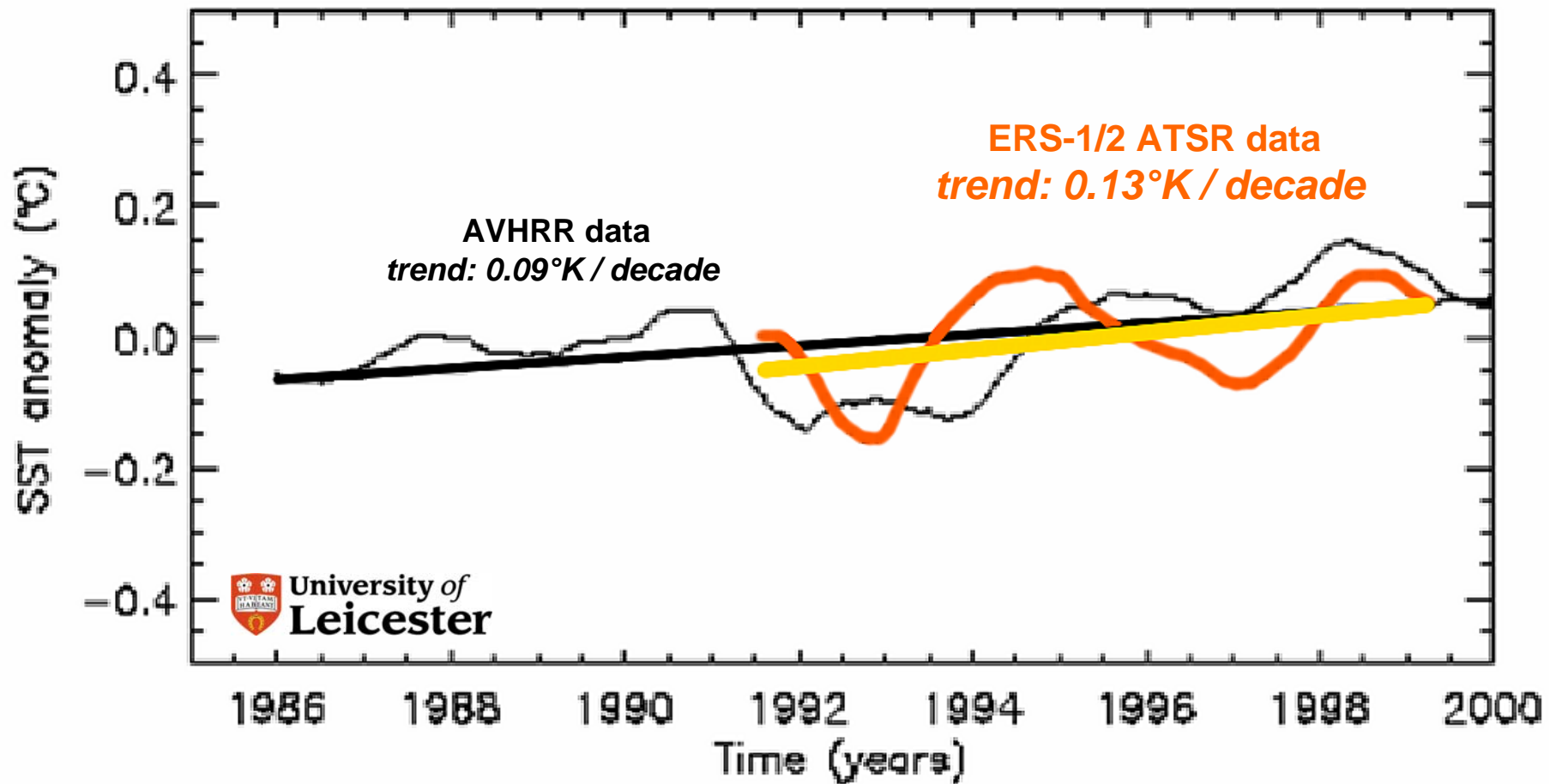
University of Leicester

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Sea Surface Temperature Change
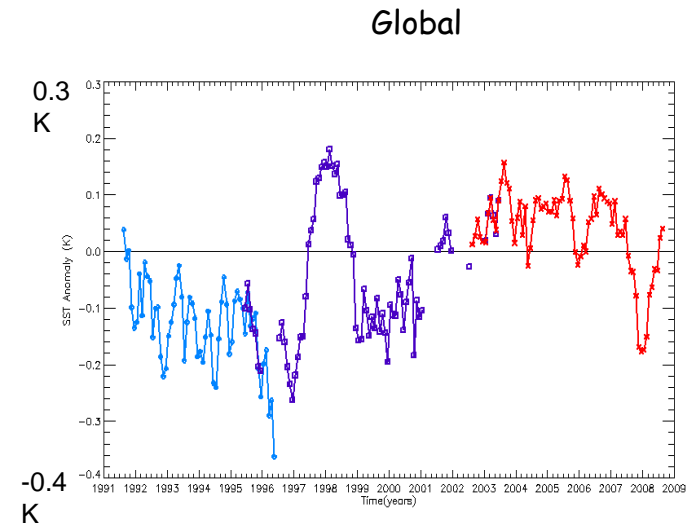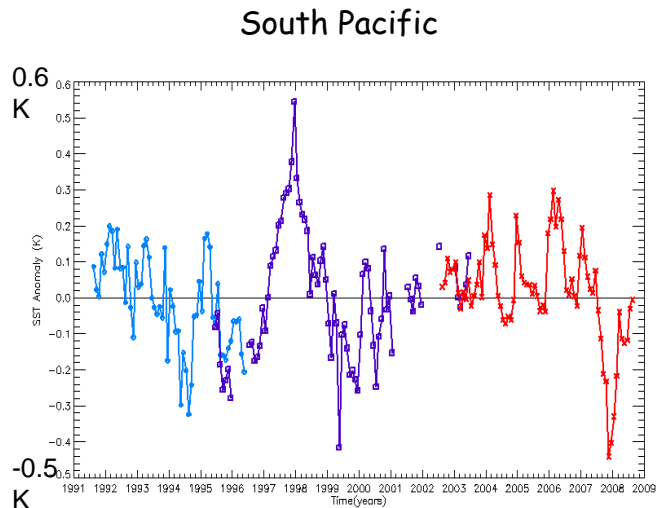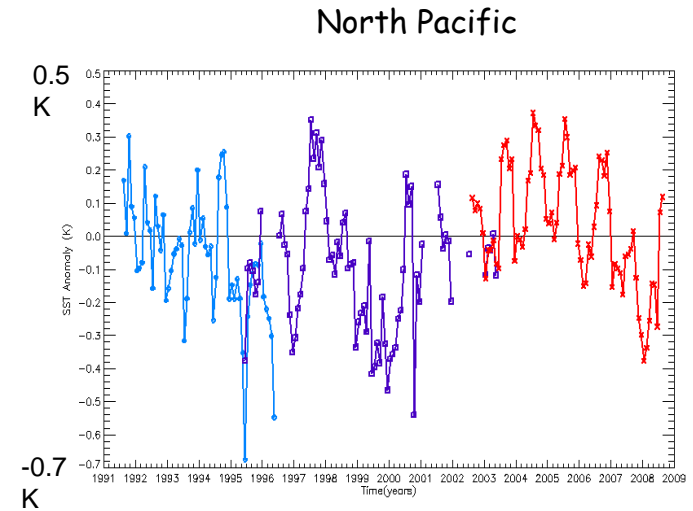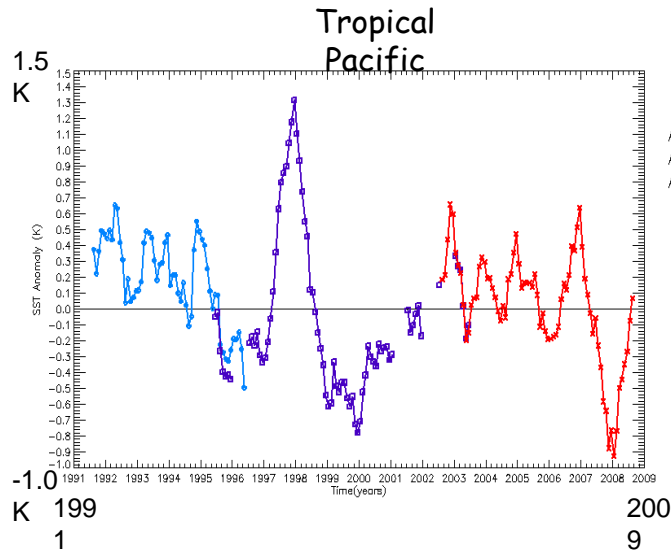
(Veal et al., 2008)

GlobCOLOUR

Developing a European Service for Ocean Colour

Satellite based ocean colour information
supporting the requirements
of global ocean carbon cycle research.

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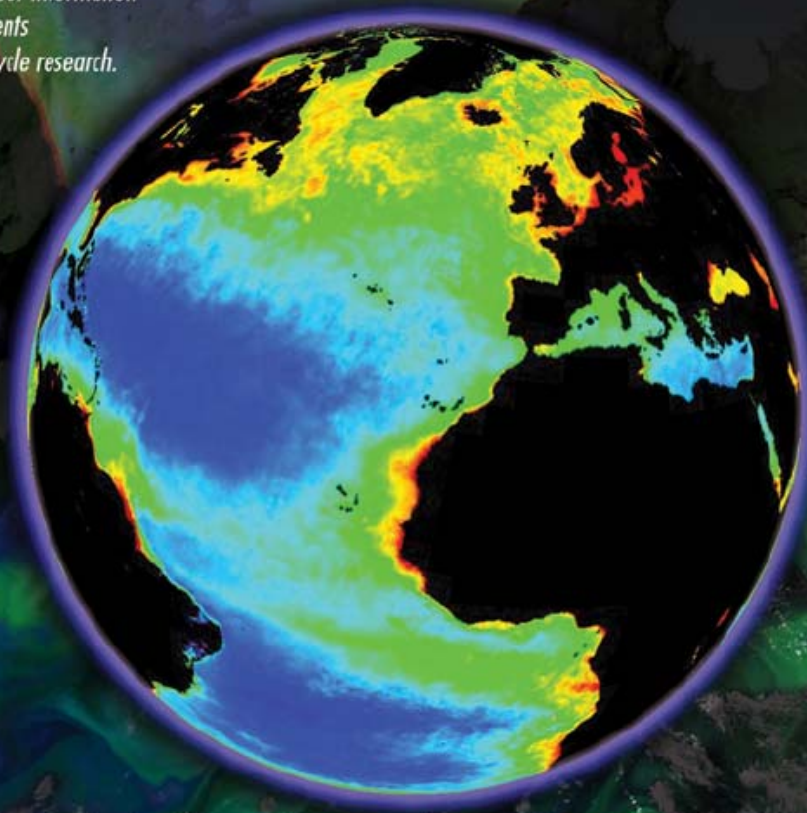
Global Ocean Colour

Why GlobCOLOUR?

- Ocean colour is an "essential climate variable" needed to support the carbon cycle monitoring requirements of the UNFCCC

- User Consultations with IOCCG (ocean colour scientists), and IOCCP (marine carbon cycle modellers) led to identification of a strong User Requirement to make combined use of all available global ocean colour observations to provide the best possible ocean colour climate data record to support global change research

What is GlobColour?

- GlobColour provides a suite of consistent ocean colour products from 1997-present, derived from the three major global satellite missions: SeaWiFS, MODIS and MERIS
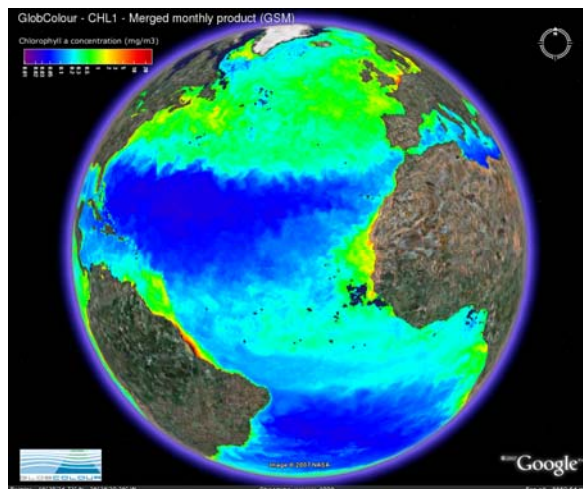
Improved spatial and temporal coverage (removal of clouds):

- *Merged products provide same coverage as best single sensor product, but in half the time.*
- *Error statistics and credibility are improved by merging*
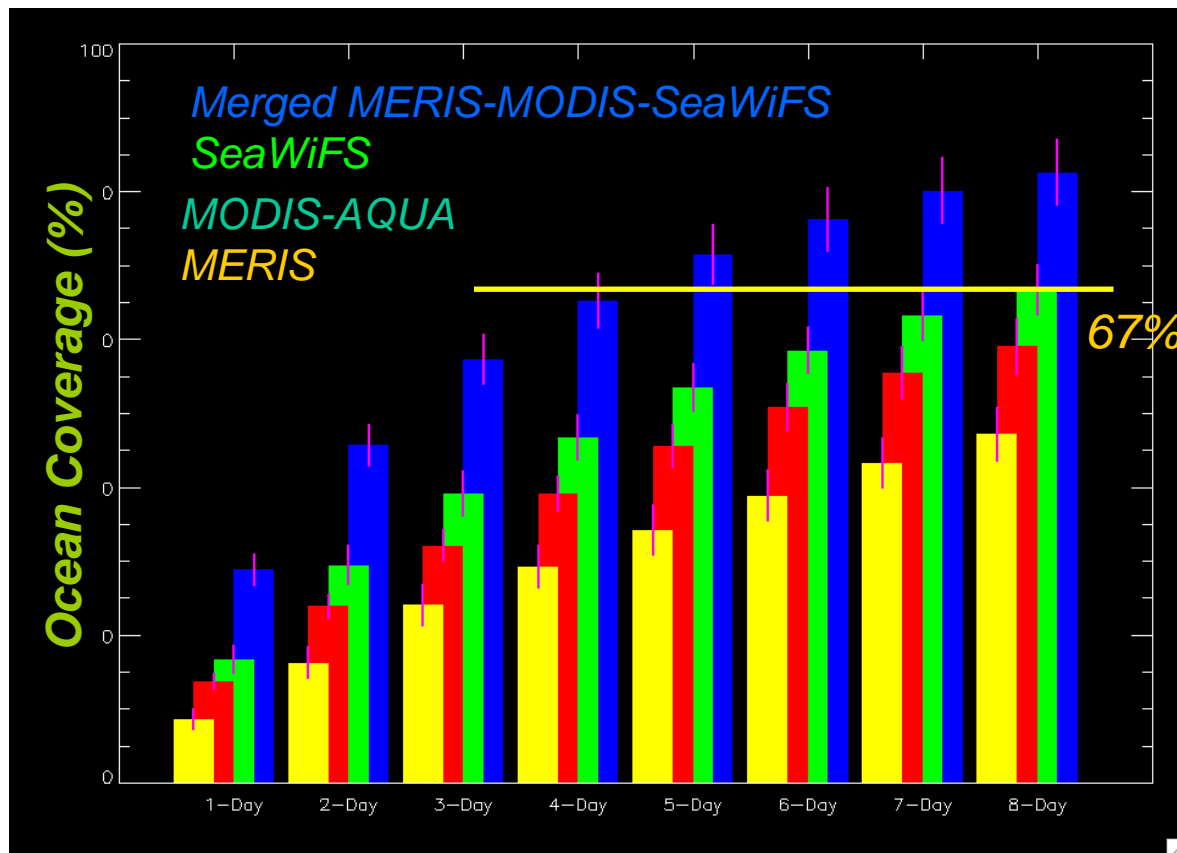
Source : S. Maritorena (ICESS, UCSB)

PacS35 – Time-series
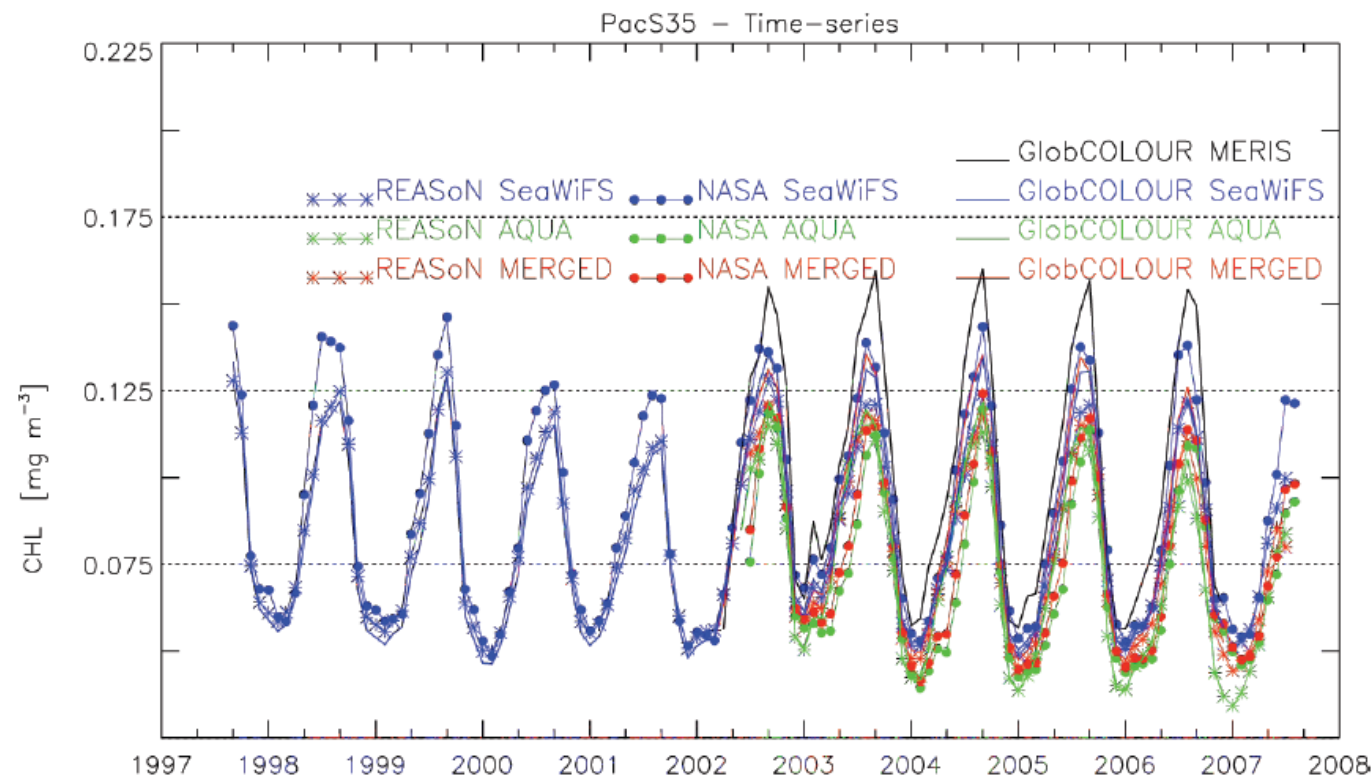
Research is currently underway to investigate whether the observed trends are significant,
and if so, whether they reflect the impact of climate change or can be explained by natural variability
(A. Morel, A. Mangin, S. Maritorena)

GlobCover Version 2 - 300m

December 2004/June 2006 [ENVISAT MERIS]

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GlobCover Land Cover

Partnership: ESA - JRC

Programs: GOFC - IGBP

Users: FAO, UNEP, EEA

Objectives: **A service for a Global Land Cover Map 2005/2006**
                        by using MERIS data at 300m

Outputs: Version 2 (December 2004 / June 2006)
                                10 bimonthly composites
                                annual composite (year2005)
                                demo composite (Dec2004/June2006)
                                land cover map
                    A hardware & software system

Schedule: KO GlobCover April 2005
                    GlobCover V1 13 February 2008
                    GlobCover V2 18 August 2008
                    1st User consultation JRC, June 2007
                    2nd User Consultation, FAO, March 2008
                    3rd User Consultation, EEA, September 2008

Implementation: ESA, UK PAC, MEDIAS, Brockmann Consult, UCL, ACRI

O. Arino, D. Gross, F. Ranera , M. Leroy, P. Bicheron, C. Brockmann, P. Defourny, C. Vancutsem, L. Shouten, F. Achard, L. Bourg, J. Latham, A. Di Gregorio, R. Witt, M. Herold, J. Sambale, S. Plummer, JL. Weber, L. Shouten
GlobCover: ESA service for Global Land Cover from MERIS, IGARSS 2007 proceedings,

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GlobCover Land Cover

➢ESA Globcover Data Access tool (GCAT)

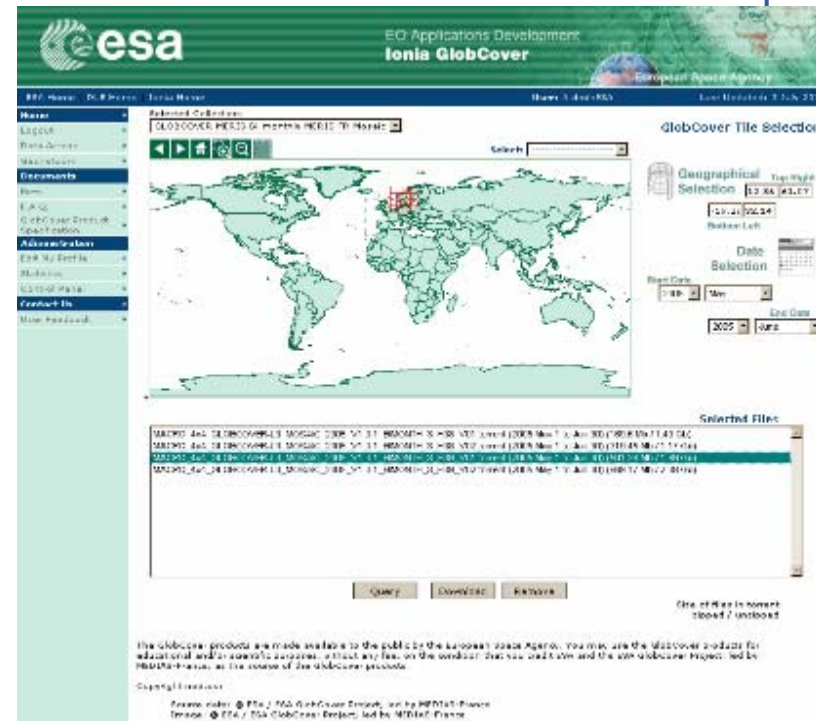**http://www.esa.int/due/ionia/globcover**

➢Bit torrent / HTTP

➢Available 10 bi-monthly Reflectance
　　　　1 annual Reflectance (2005)

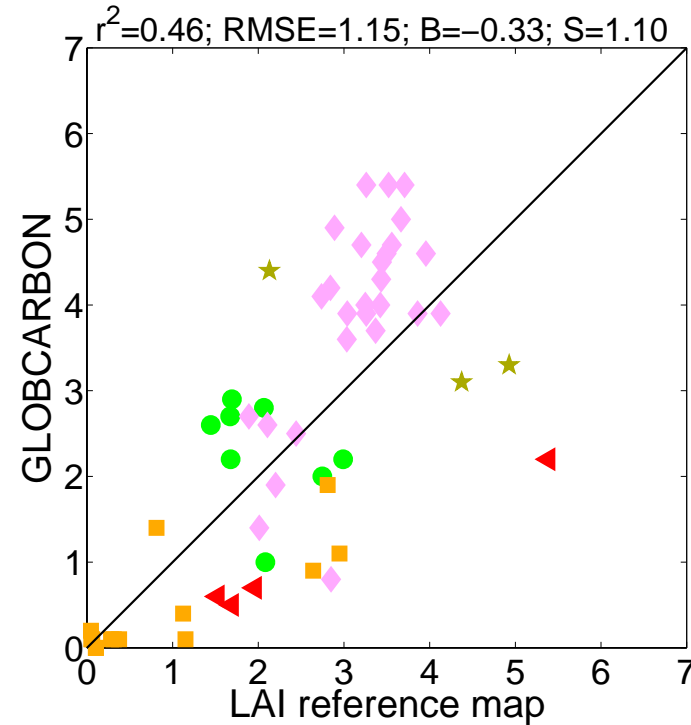**Land Cover + PDM (September 2008)**
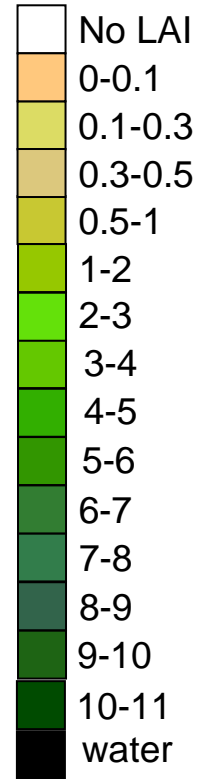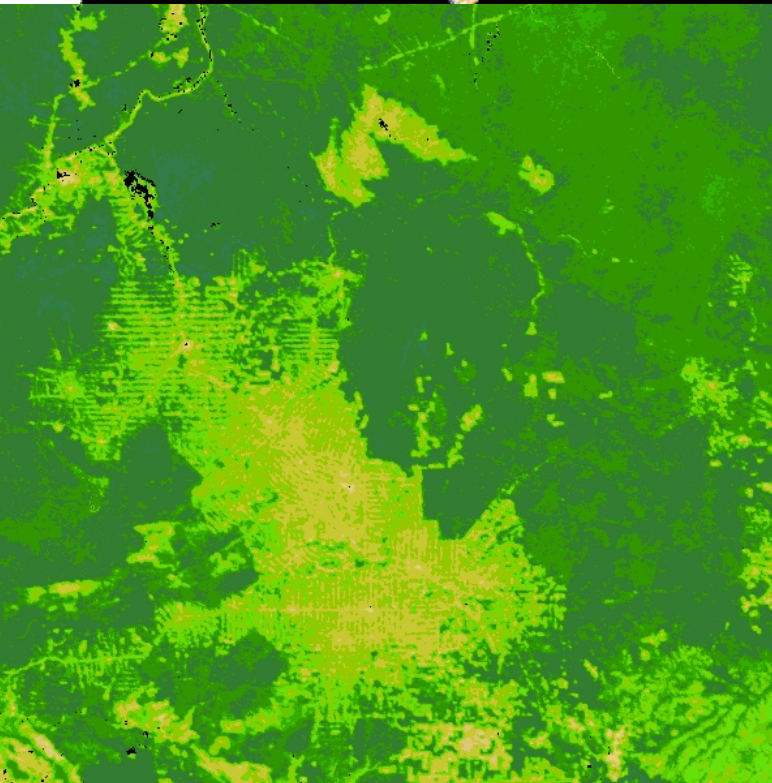
+

Validation Report (December 2008)

➢Postel/Medias-France
GlobCover Data access tool

http://postel.mediasfrance.org

➢HTTP

- GLOBCOVER versus homogeneous validation points for 6 main LC types from LCCS dichotomeous phase: **78%**

- GLOBCOVER versus homogeneous validation points for 22 GLOBCOVER classes weighted by area: **73%**

- **Two points: same accuracy as previous and automated processing**

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GlobCarbon LAI

r^2=0.46; RMSE=1.15; B=−0.33; S=1.10

Legend:
- ● ENF
- ★ EBF
- ◀ Crop
- ■ Grass
- ◆ Mixed Forest (DBF+ENF)

Color scale:
- No LAI
- 0-0.1
- 0.1-0.3
- 0.3-0.5
- 0.5-1
- 1-2
- 2-3
- 3-4
- 4-5
- 5-6
- 6-7
- 7-8
- 8-9
- 9-10
- 10-11
- water

Axes: GLOBCARBON (y), LAI reference map (x)

ATSR World Fire Atlas

http://dup.esrin.esa.int/ionia/wfa/

ATSR World Fire Atlas
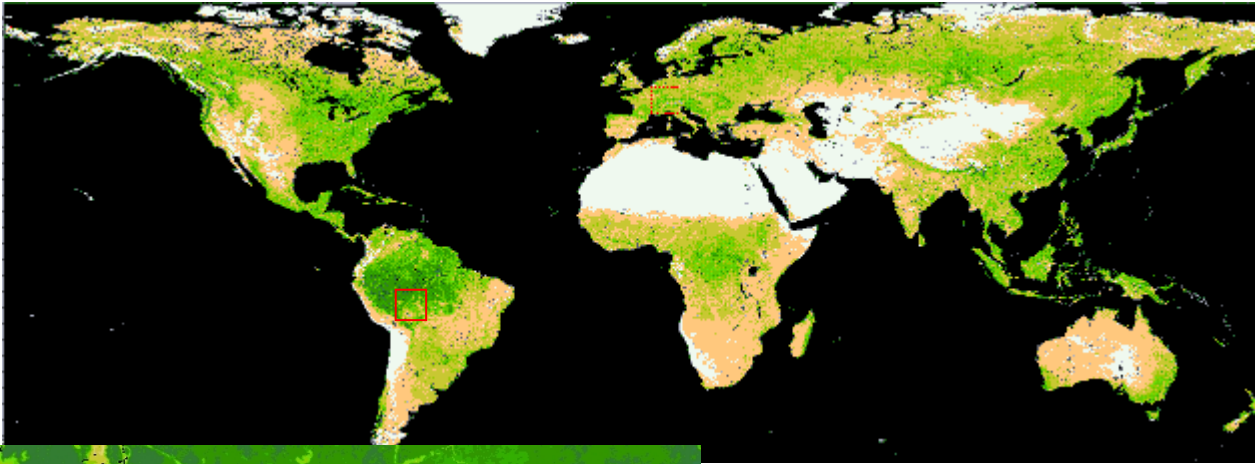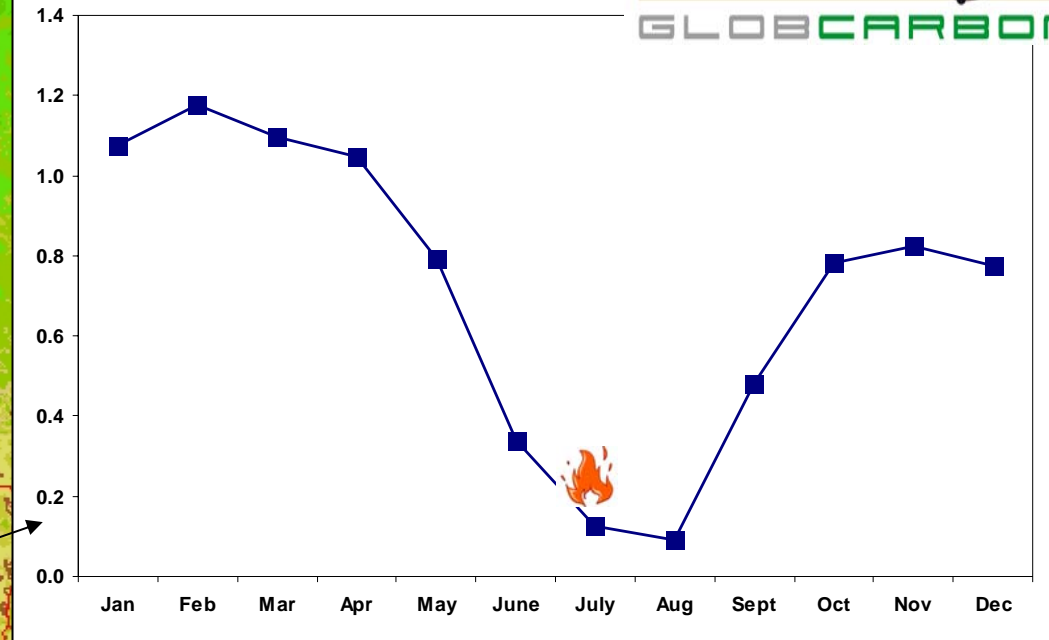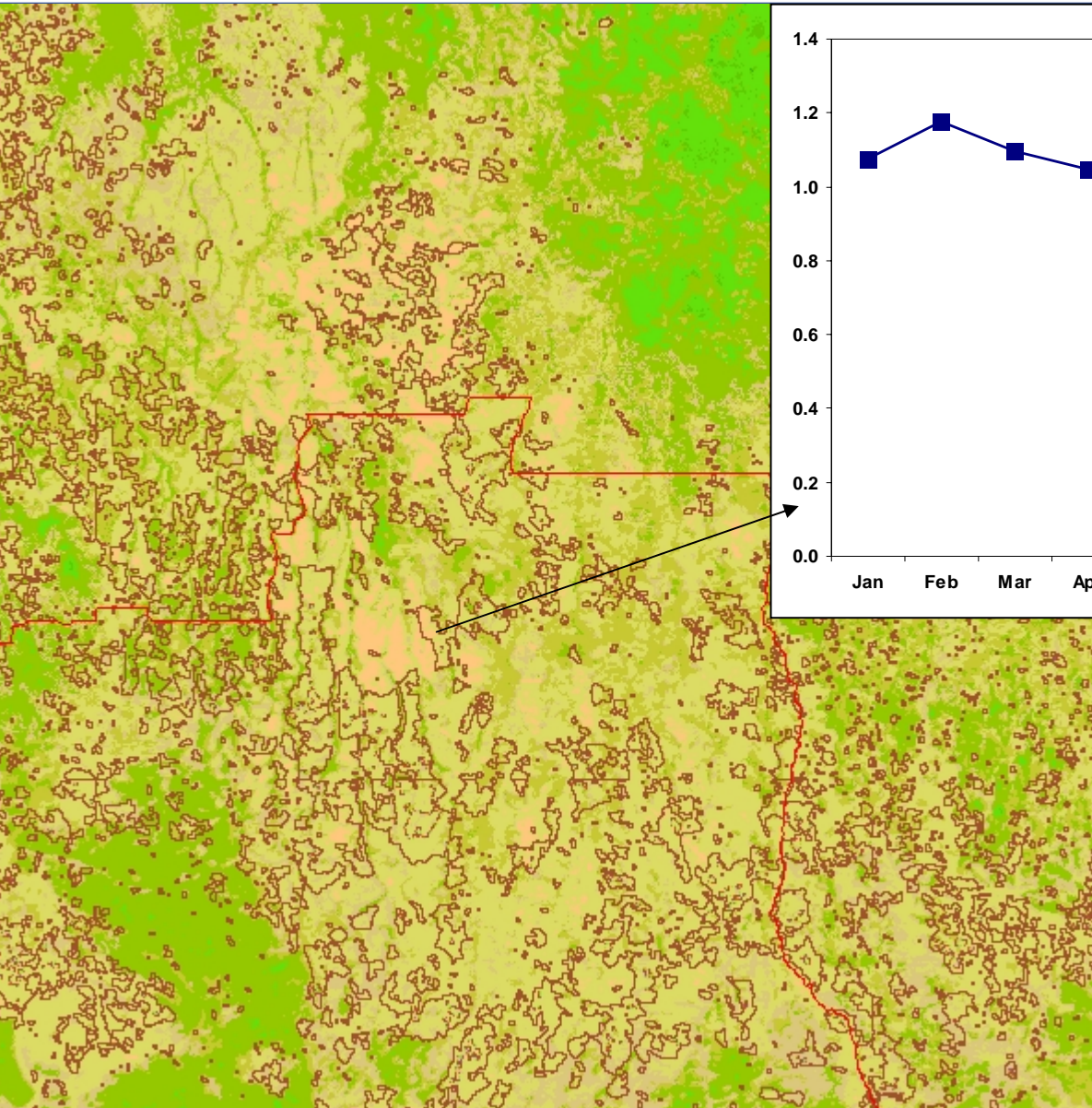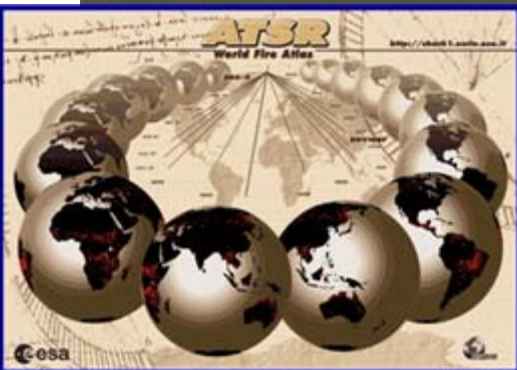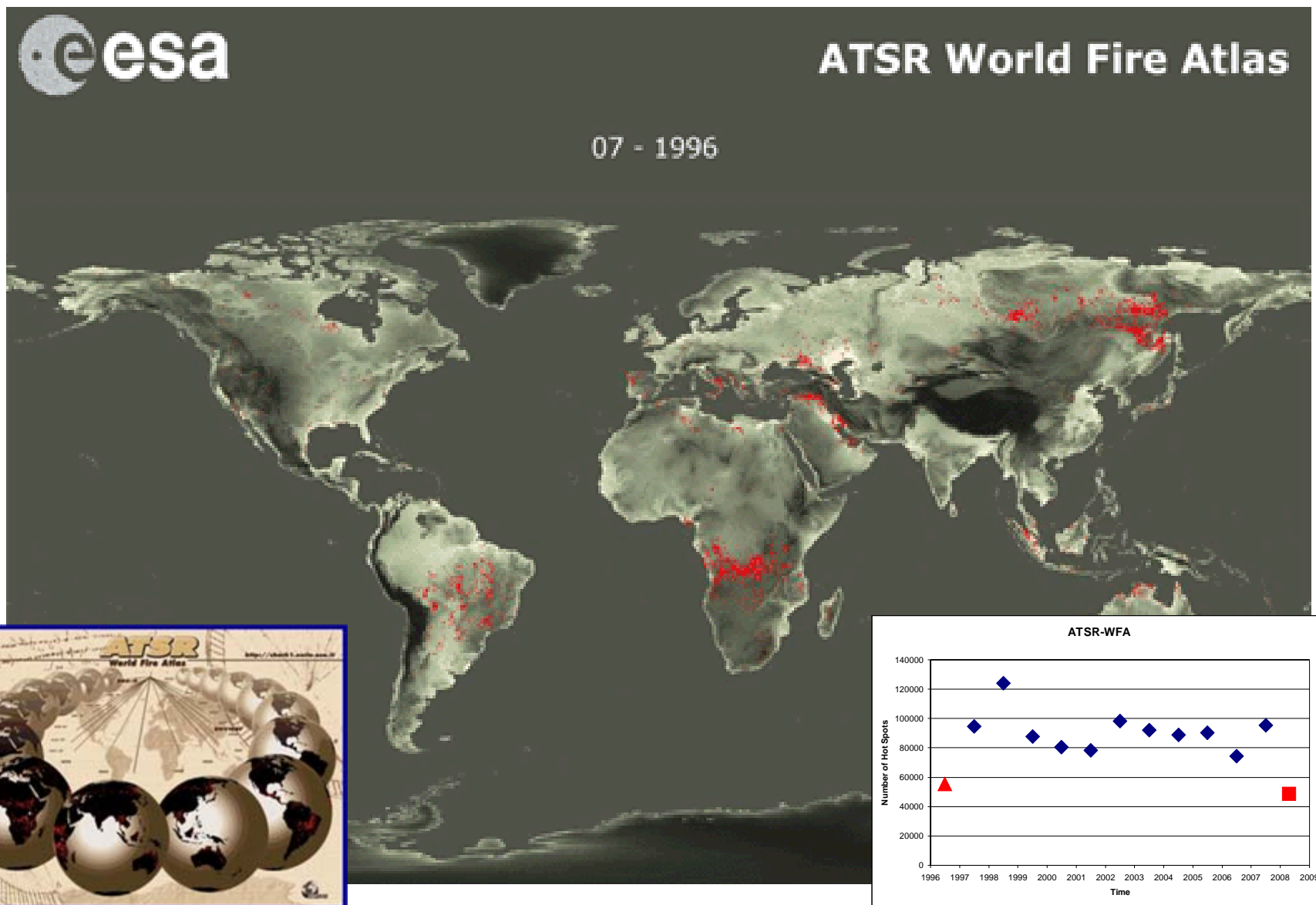
New York Time, Liberation, 30 August 2007
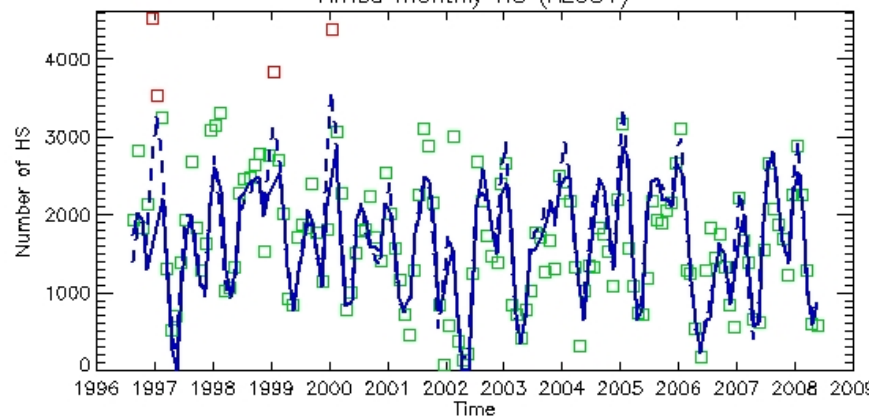
Continental Statistics
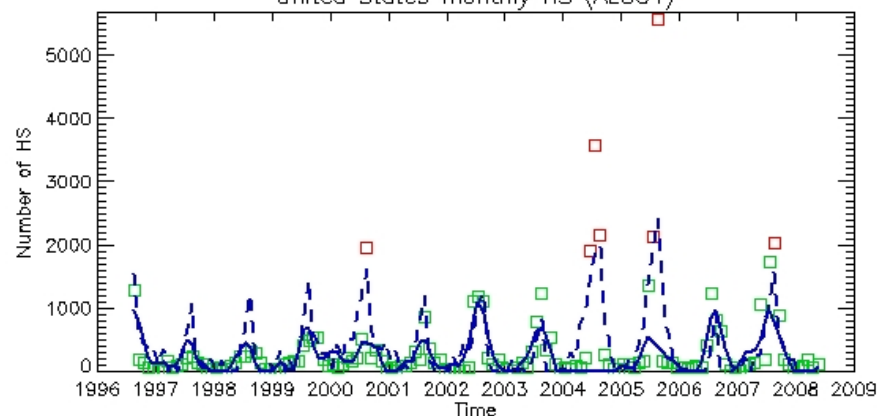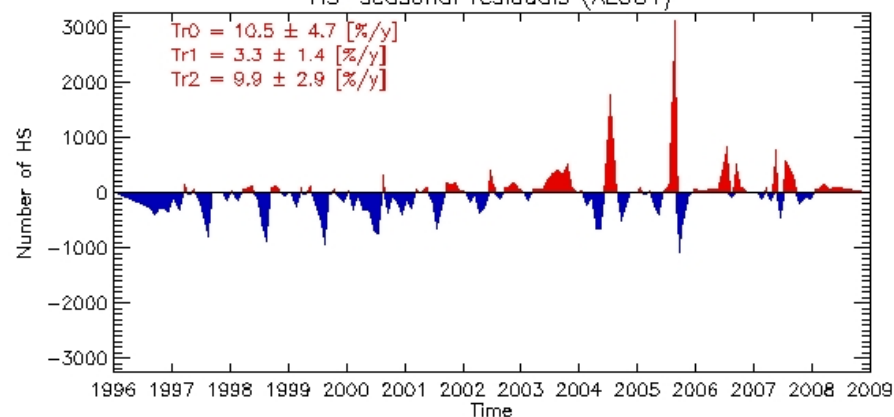
Africa: trend 2 - 4 % year

USA: trend 3 - 10 % year

Continental Trends

ATSR—WFA ALGO1 Hot Spot trends (199607 — 200806)

Percentage trend (%/y) within 2x2 deg cell
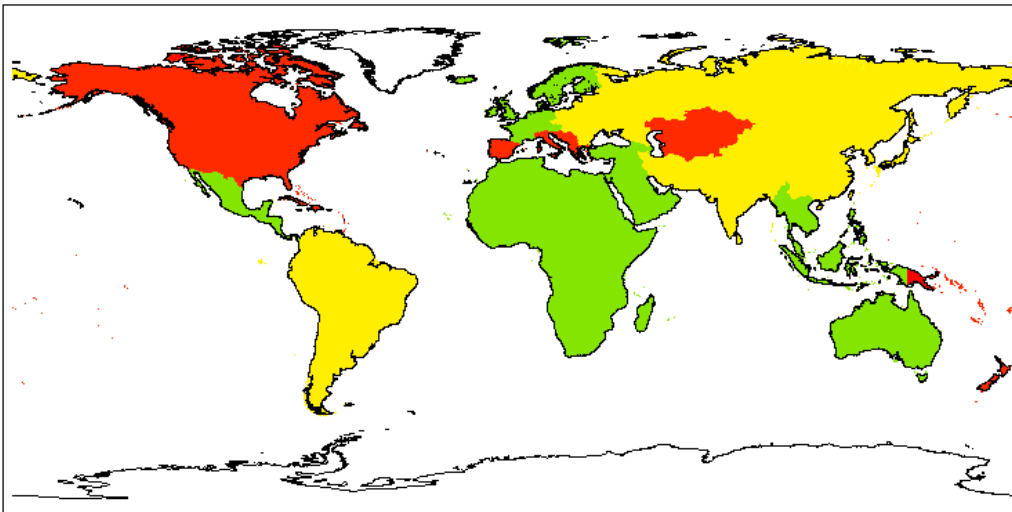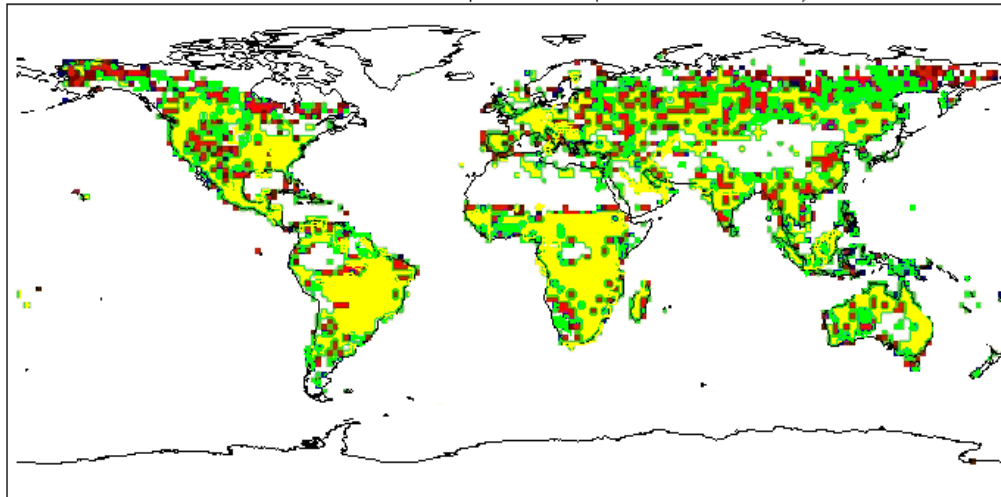
Red: significant increase
Green: significant decrease
Yellow: cannot say

EO mission per ECVs

Column groups: **ERS-1 (1991)** (Radar Altimeter, ATSR-1, SAR Wave Mode, SAR Image Mode, Scatterometer); **ERS-2 (1995)** (Radar Altimeter, ATSR-2, SAR Wave Mode, SAR Image Mode, Scatte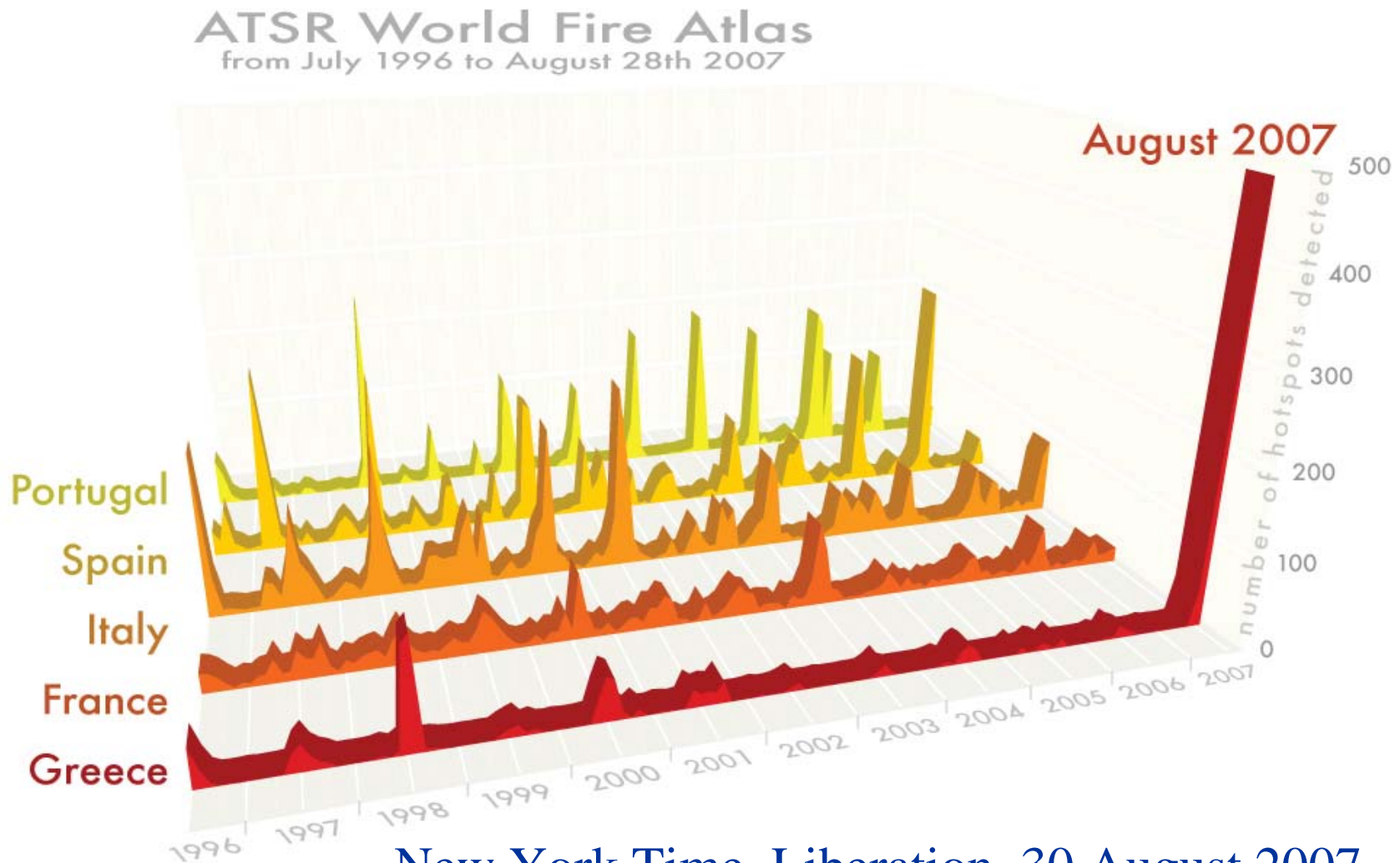rometer, GOME); **Envisat (2002)** (Radar Altimeter, AATSR, MERIS, ASAR Wave Mode, ASAR Image Mode, Schiamachy, MIPAS, GOMOS); **Earth Explorer** (GOCE (2008), SMOS (2009), Cryosat (2009), ADM/AEOLEUS (2009), EarthCARE (2012)); **Sentinels** (Sentinel 1 (2012), Sentinel 2 (2012), Sentinel 3 (2012), Sentinel 4, Sentinel 5); **Eumetsat** (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; Count.

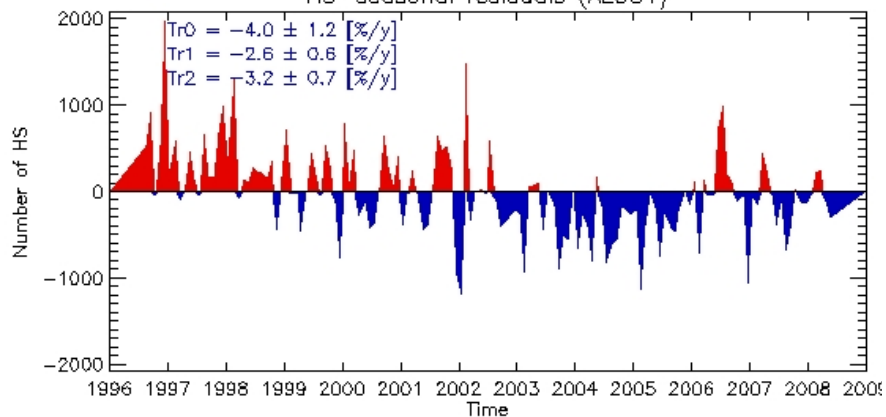| Group	ECV	Measurement	Count
OCEAN	O.2	Sea level and variability of its global mean	7
OCEAN	O.3	Sea surface temperature	6
OCEAN	O.4	Ocean colour and oceanic chlorophyll-a concentration	4
OCEAN	O.5	Wave height & other measures of sea state	11
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LAND	T.1	Lakes	21
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LAND	T.7	Maps of Leaf Area Index	9
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LAND	T.10	Research towards global near-surface soil moisture map	6
LAND	T.3	Snow areal extent	12
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ATMOSPHERE	A.4	Cloud properties	12
ATMOSPHERE	A.7	Profiles and total columns of ozone	8
ATMOSPHERE	A.8	Aerosol Optical depth and other aerosol properties	13
ATMOSPHERE	A.9	Distribution of greenhouse gases, such as CO2 and CH4	6
ATMOSPHERE	A.10	Upper-air Wind	1

Column totals (bottom row): 4, #, 1, 5, 2, 4, #, 1, 4, 3, 3, 4, #, #, 1, 6, 4, 4, 2, 0, 2, 3, 1, 1, 6, 2, #, 3, 3, 4, 3, 1, 1, 3, 5, 2, 2, 8, 1, 7, 6, 2, 1, 1, 1, 4, 4, 4