Earth Observation & Climate Change

Stephen Briggs

Head, Earth Observation Science,
Applications and Future Technologies

Summer School
Alpbach, 27 July 2010

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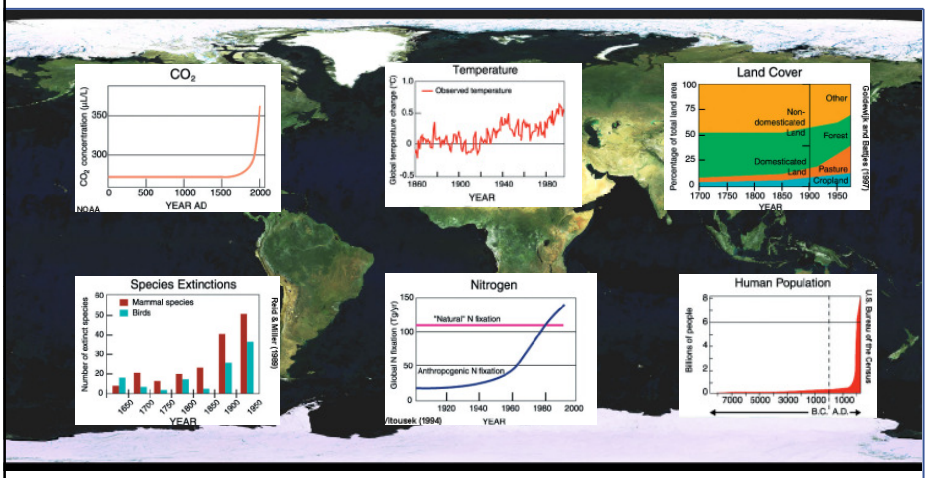
ESA Initiative on Climate Change



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

(Image: MERIS mosaic)

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- *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*

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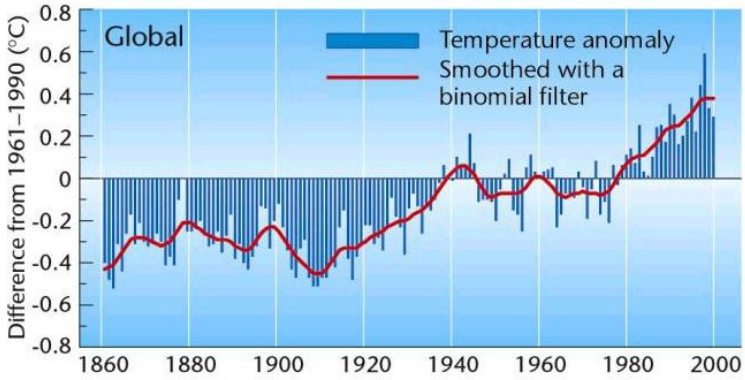
Global mean surface temperature has increased more than .5°C since the beginning of the 20th century, with this warming likely being the largest during any century over the past 1,000 years for the Northern hemisphere.



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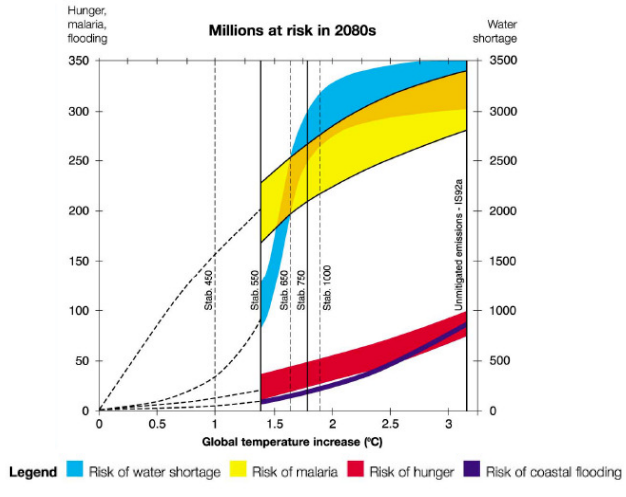
Vulnerability Assessment : Impacts as a function of Climate Change

(Parry et al. 2001 http://www.greenpeace.org/raw/content/usa/press/reports/millions-at-risk.pdf)



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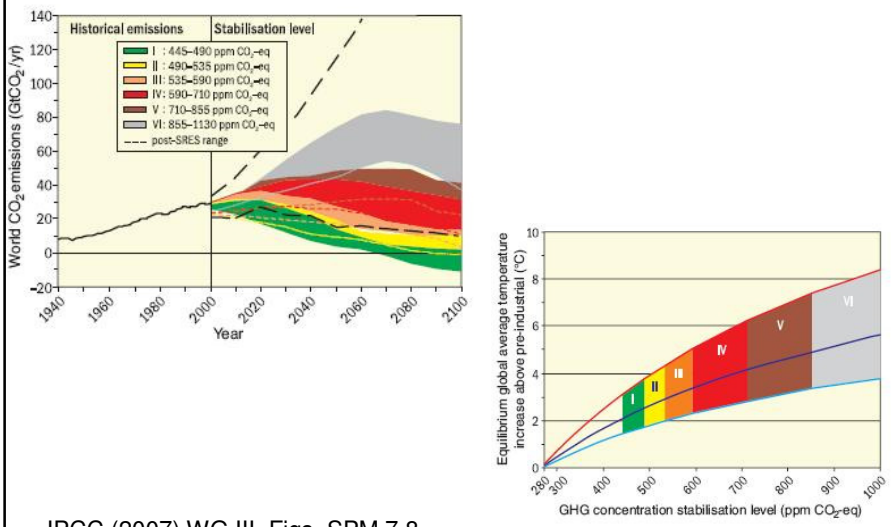
Emission scenarios / stabilisation levels



IPCC (2007) WG III, Figs. SPM.7,8

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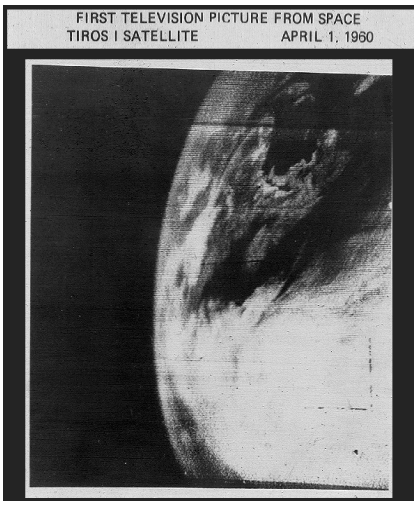
First image of the Earth from space



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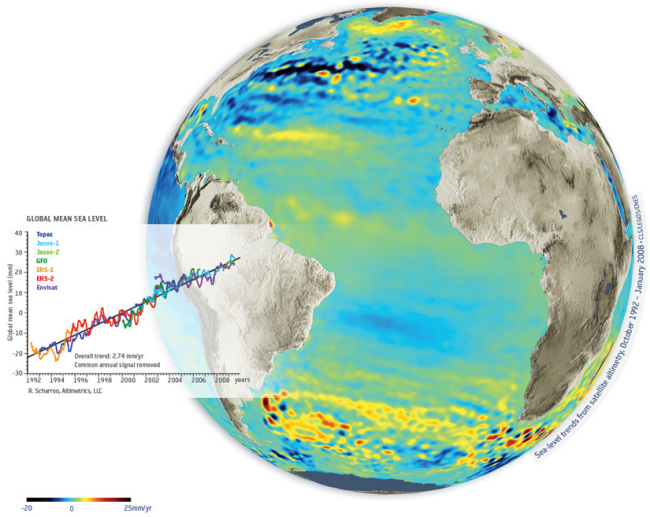
Global sea level increasing



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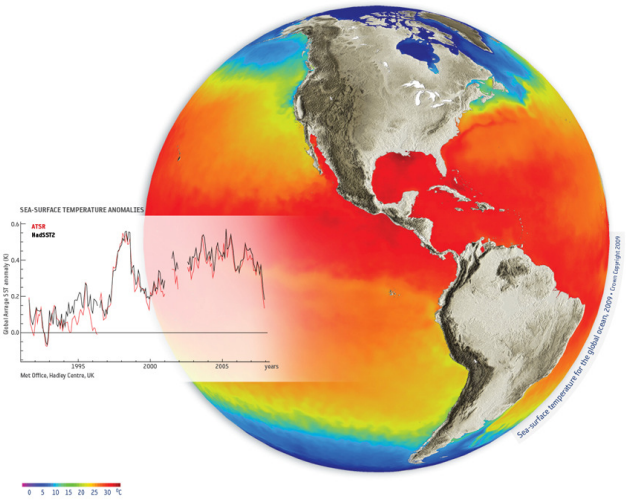
Sea Surface Temperature increasing



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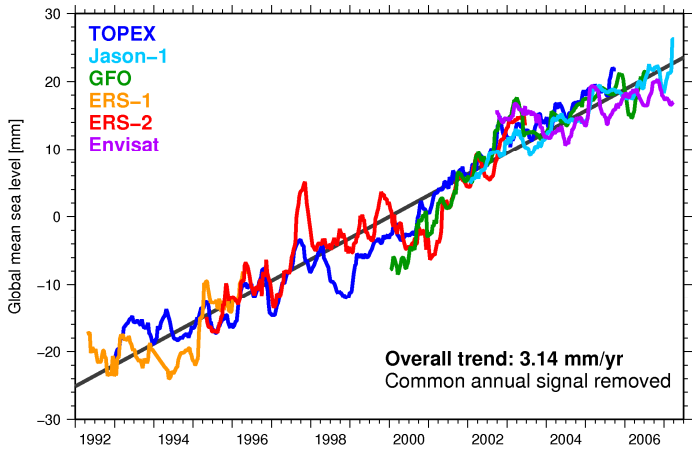
Sea level rise



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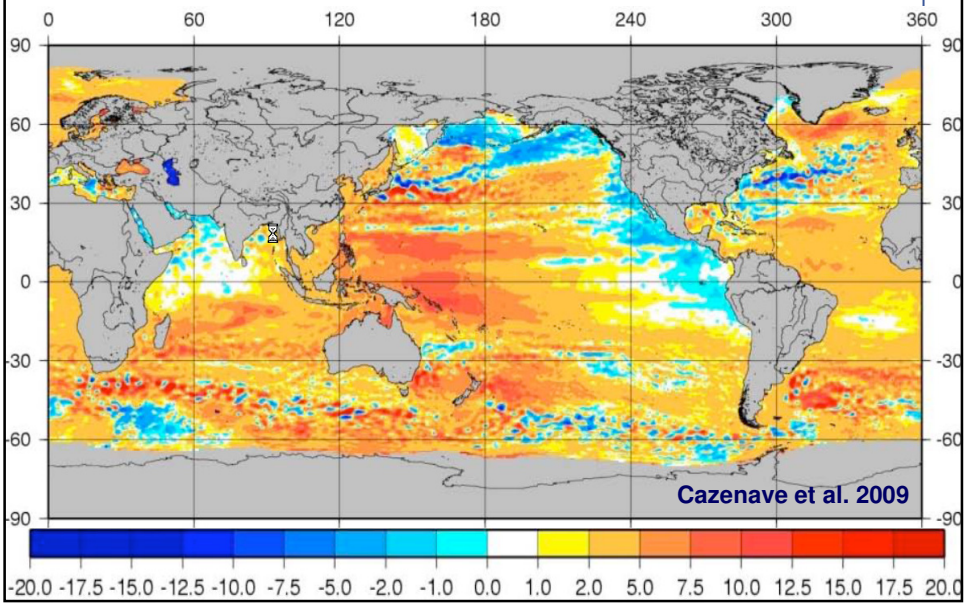
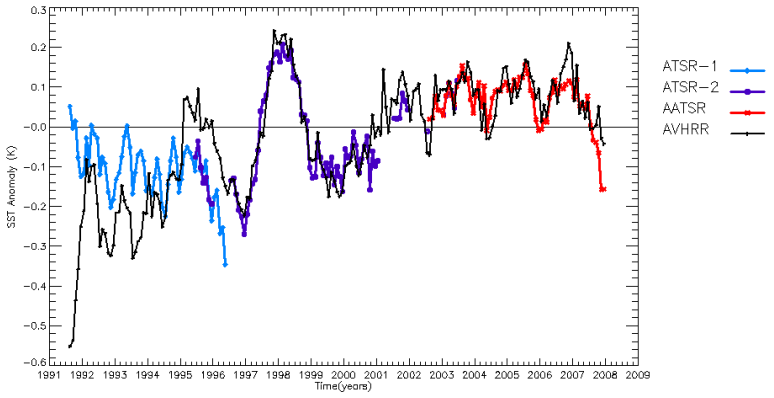
regional sea-level trends (mm p.a.)





Leicester University: Veal et al., MERIS/AATSR Workshop, ESRIN, 22-26 Sept 2008

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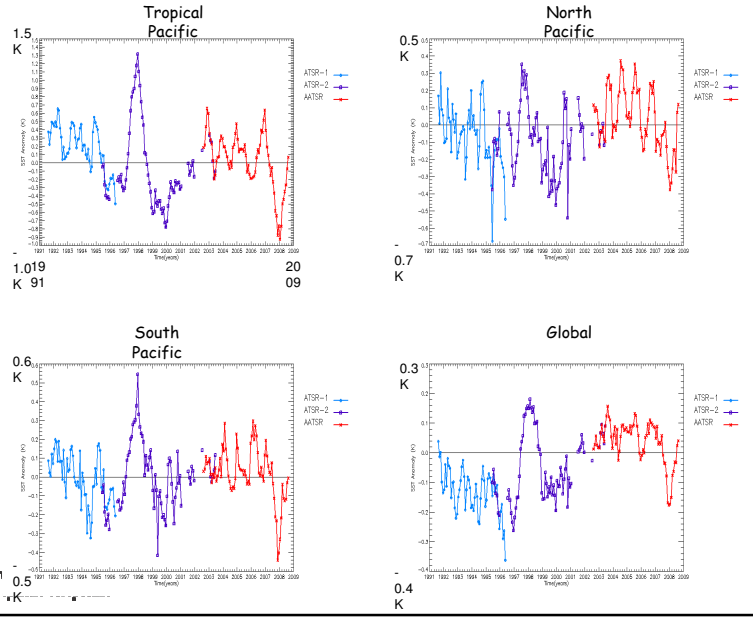
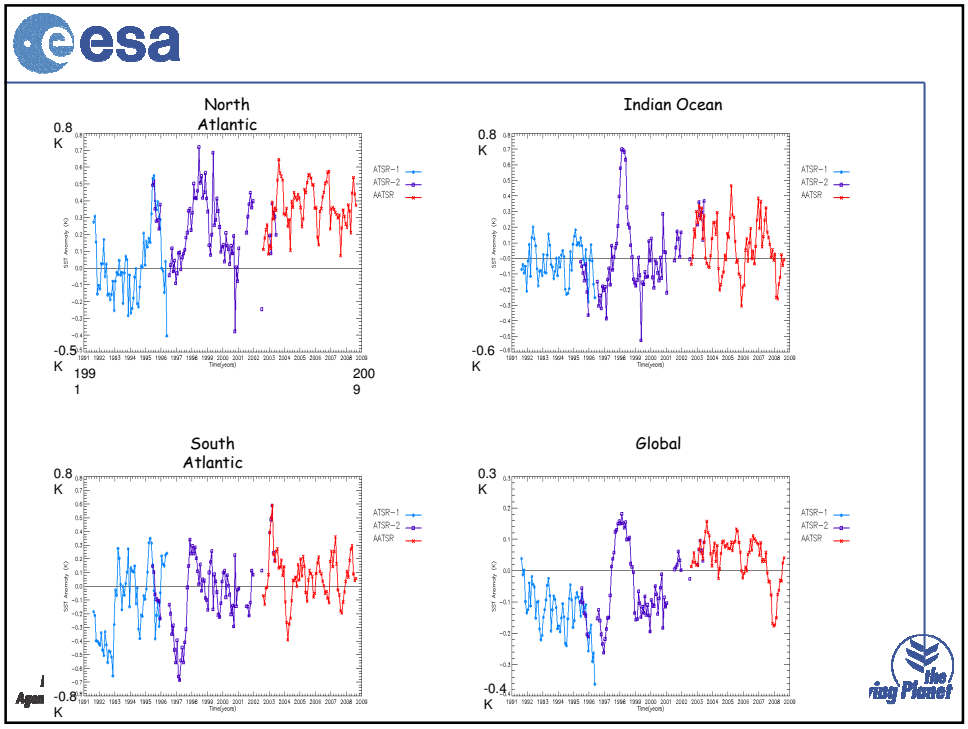
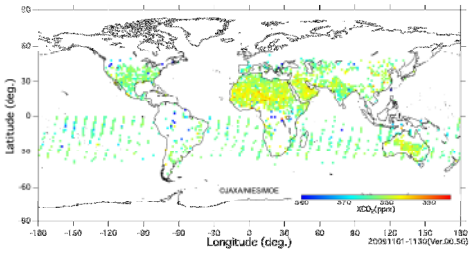


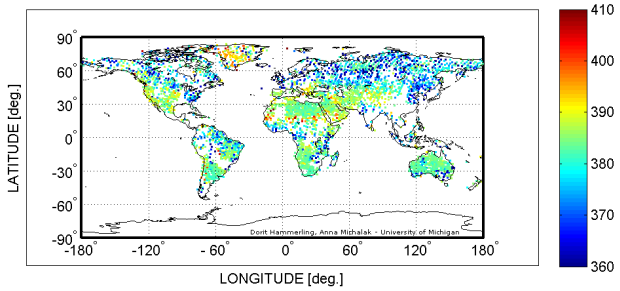


CO_2 Column Density

Upper panel: Data on November 2009, processed by JAXA/NIES/MOE
Lower panel: Data on July 2009, processed by ACOS Team



2009/07/24 - 2009/07/26



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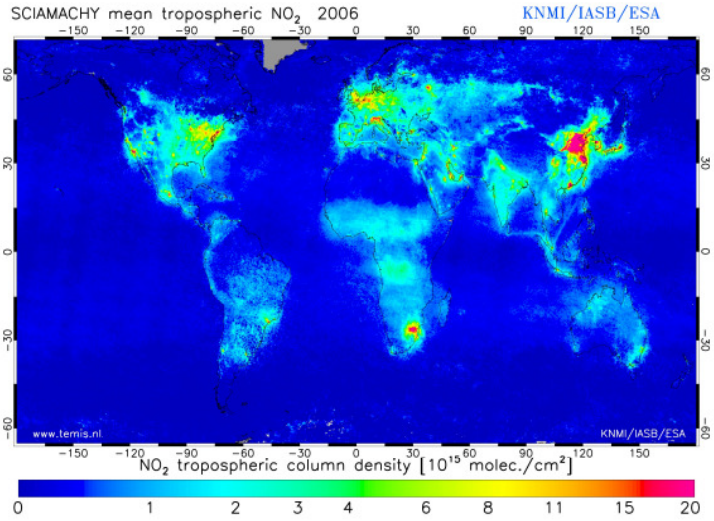
NO_2 concentration



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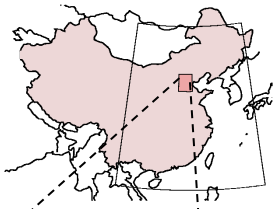
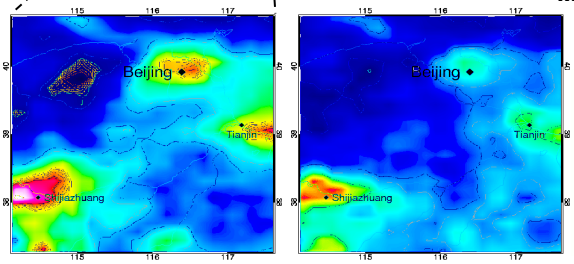
NO_2 reductions detected from space during the 2008 Beijing Olympic Games

Mijling et al., Geophys. Res. Lett. (2009)



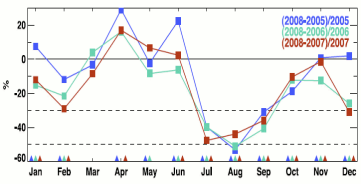
OMI, 2007

OMI, 2008



Monthly OMI NO2 over Beijing

Witte et al. (2009)



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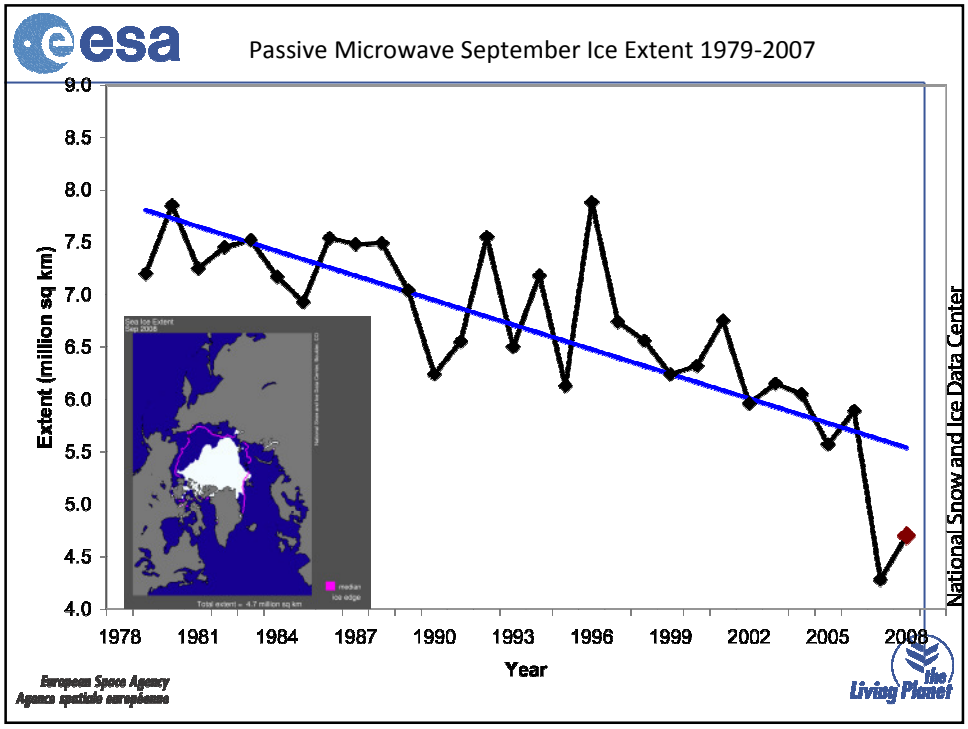
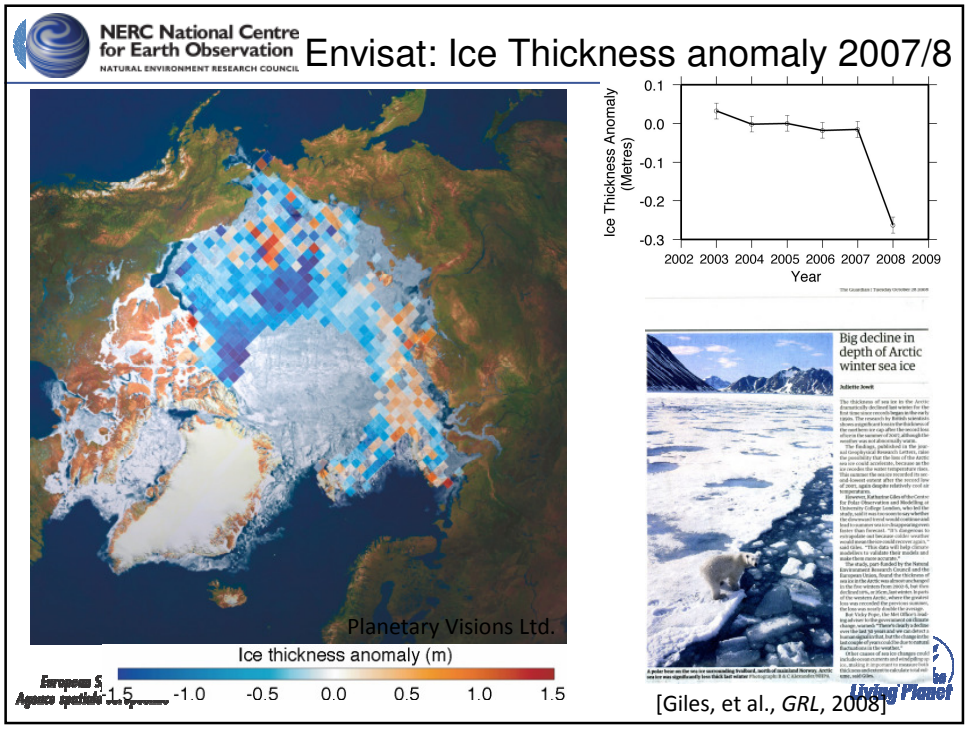
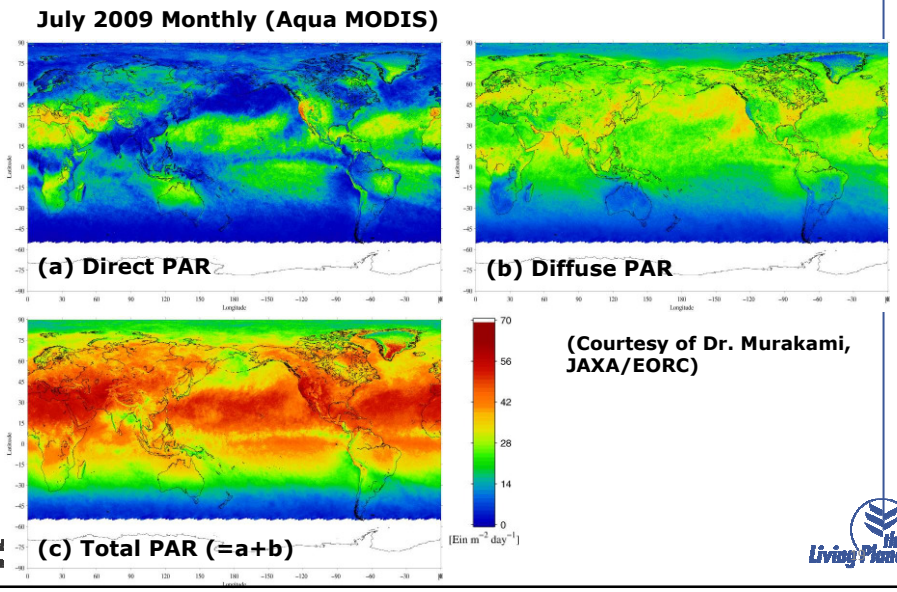




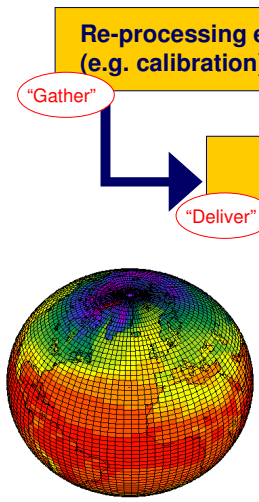
[Giles, et al., *GRL*, 2008]

Estimation of Total, Direct and Diffuse Components of PAR



(Courtesy of Dr. Murakami, JAXA/EORC)

Climate Change Initiative



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

"Gather"

ECV generation (e.g. validation & bias)

"Deliver"

ECV assimilation & assessment

"Exploit"

FEEDBACK LOOP:

OUTPUT TO

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

Education & Awareness

"Show"

The Essential Climate Variables addressed in CCI:

	ECV
Ocean	Sea Ice
	Sea Level
	Sea Surface Temperature
	Ocean Colour
Terrestrial	Glaciers and Ice Caps
	Land Cover
	Fire Disturbance
Atmosphere	Cloud properties
	Ozone
	Aerosol properties
	Greenhouse Gases

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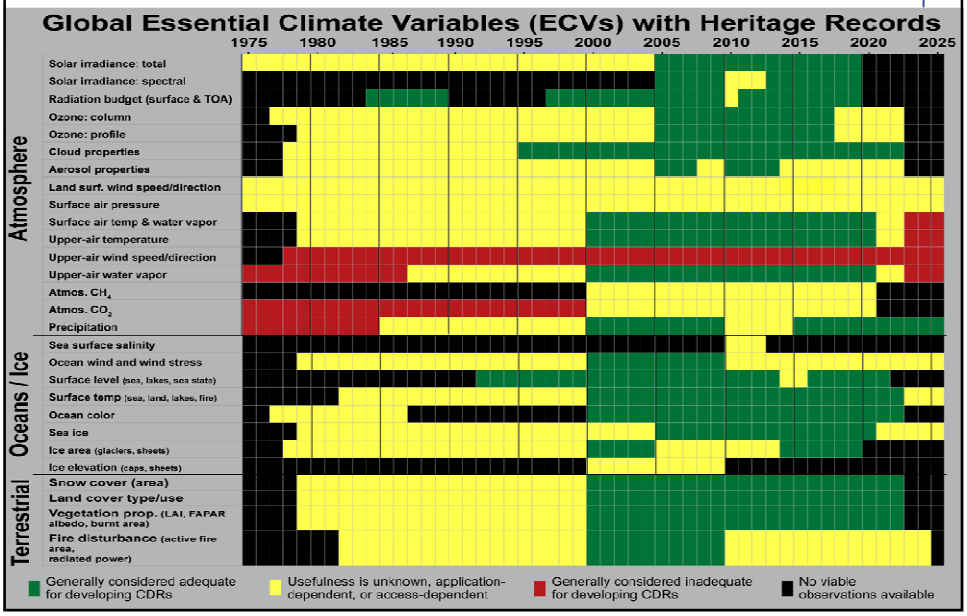
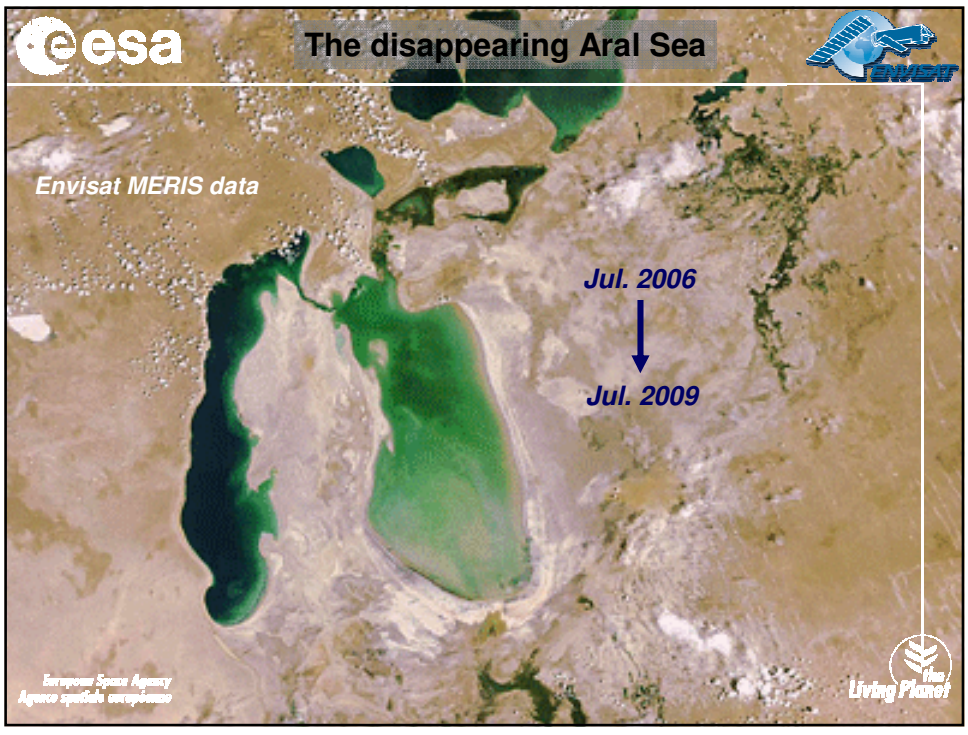
Combining Research and Operational Satellite Data Can Unlock Further Climate Information



Climate Change Mitigation



UNFCCC COP-15 Copenhagen

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ESA at COP-15 Copenhagen

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Why Forests - Why Carbon?

- A large proportion (up to 20%) of global emissions are thought to arise from tropical deforestation
- Reduced deforestation and increased reforestation is a rapid response to reducing emissions
- For countries, there are potentially very significant environmental, social and economic benefits and implications that parallel the climate benefit (e.g. biodiversity…)
- Design of effective national forest monitoring systems that can serve UNFCCC - Climate Change negotiations, is a key decision at COP-15 (Copenhagen 2009)
- Therefore efforts on designing of operational forest monitoring systems must focus on these economic and policy drivers, not on technology

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What is REDD?

The basic idea behind Reducing Emissions from Deforestation and Degradation (REDD) is simple:

Countries that are willing and able to reduce emissions from deforestation should be financially compensated for doing so.

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Decision text for Copenhagen:

[Draft decision [-/CP.15]

Decision on methodological guidance for activities relating to reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

(c) To establish, according to national circumstances and capabilities, robust and transparent [national forest[1]] monitoring systems and, if appropriate, subnational systems as part of national monitoring systems that] [forest monitoring systems that]:

(i) Use a combination of remote sensing and ground-based forest carbon inventory approaches for estimating, as appropriate, anthropogenic forest-related greenhouse gas emissions by sources and removals by sinks, forest carbon stocks and forest area changes;

(ii) Provide estimates that are transparent, consistent, as far as possible accurate, and that reduce uncertainties, taking into account national capabilities and capacities;

(iii) [Ensure that these monitoring systems and their results are open to independent review as agreed by the Conference of the Parties;]

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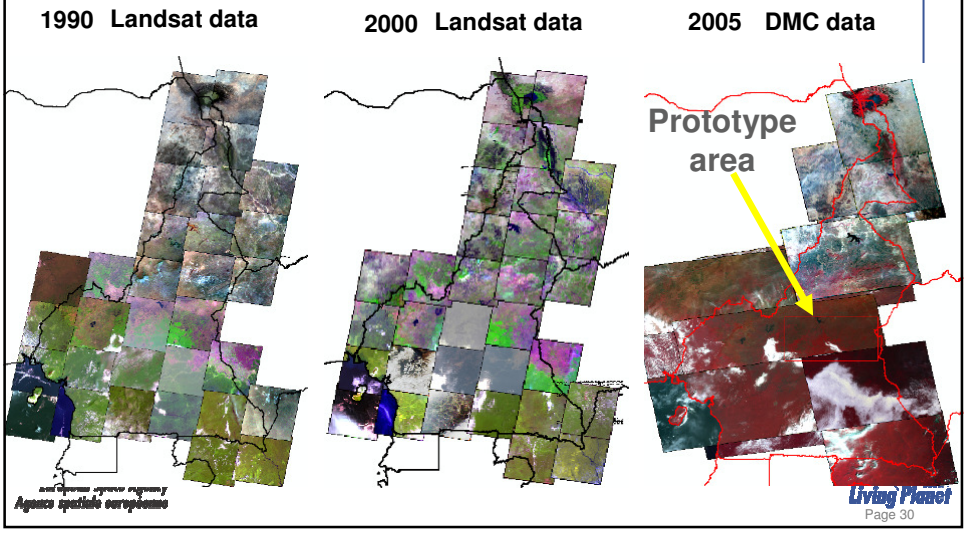
EO Data Coverage - Cameroon



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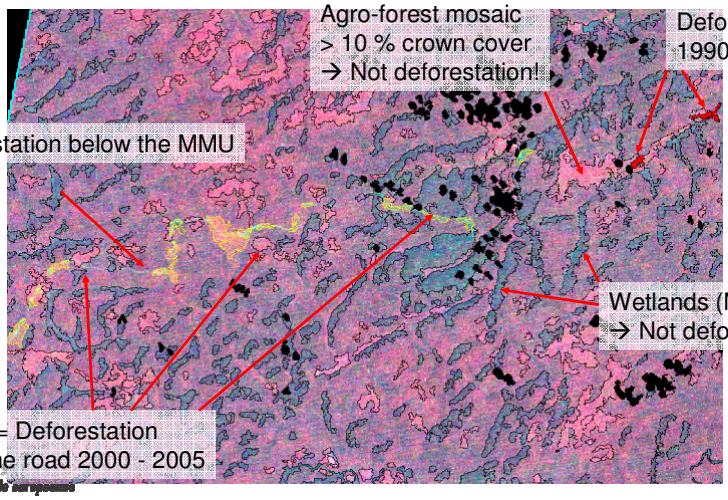
Deforestation Mapping: Cameroon

Forest area in province EST
2005 RGB = NIR/Red/Green with segmentation



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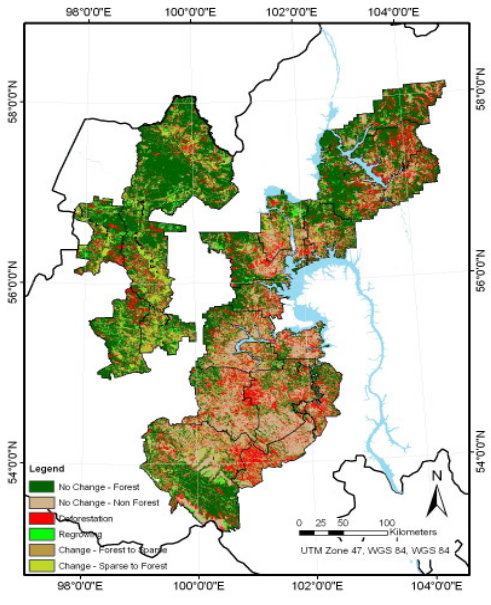
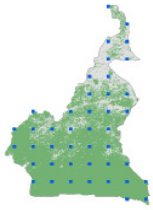
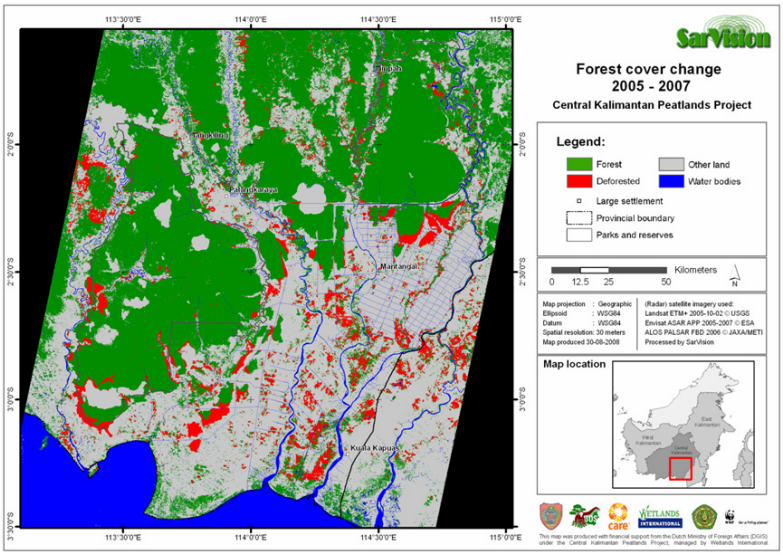
Forestry : REDD





- **Integrate the application of EO technologies with the policy formulation,**
- **Use of Landsat (1990, 2000), DMC (2005), ALOS/PALSAR,**
- **Pilot regions in Cameroon,**
- **Establish baseline projections of emissions caused by deforestation and degradation**
- **Facilitate the regional and international exchange on learning experiences**

Forest Cover Change



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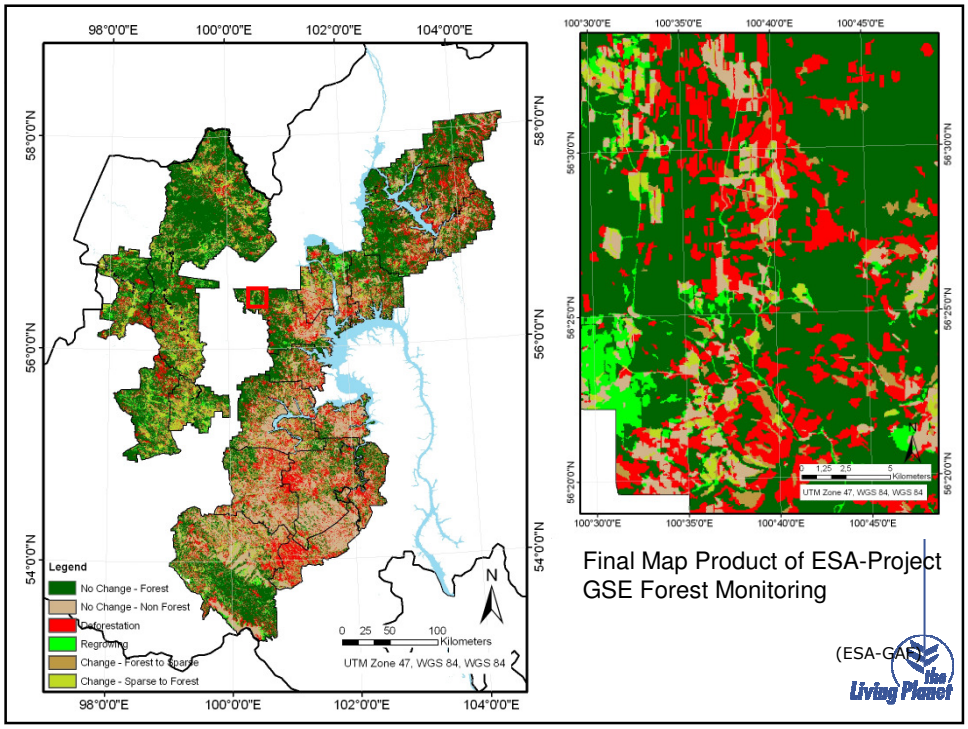

Final Map Product of ESA-Project GSE Forest Monitoring

(ESA-GAF)

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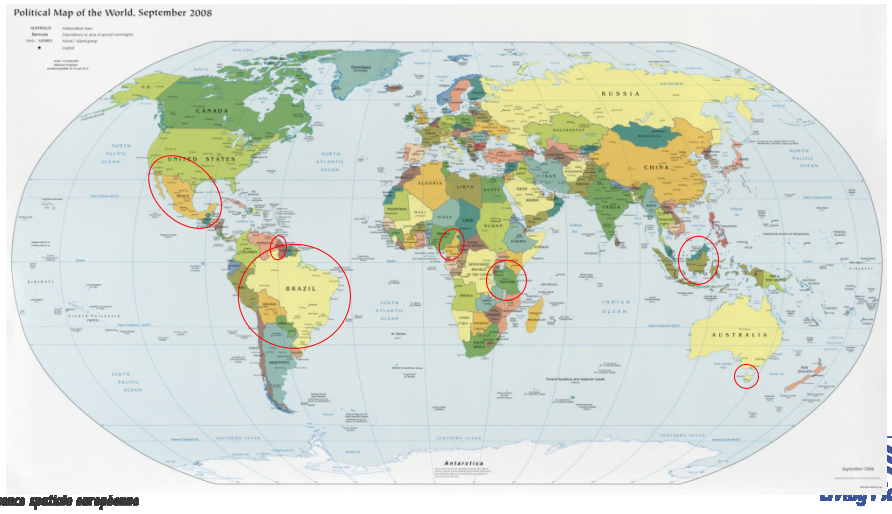
The GEO FCT initiative

- GEO Forest Carbon Task (FCT) supports countries establishing national systems for forest carbon tracking by:
  - access to long-term satellite, airborne and in situ data, and the associated analysis and prediction tools
  - creating the framework and technical standards for a global network of national systems
  - following the guidelines for the United Nations Framework Convention on Climate Change (UNFCCC)

The GEO FCT Partnership

- Supported by governments committed to forest carbon monitoring: Australia, Canada, Japan and Norway
- CEOS and its member space agencies: notable contributions from ASI, DLR, ESA, INPE, JAXA, ISRO, USGS, coordinated by ESA.
- UN-FAO, GOFC-GOLD, EC-JRC & other research groups
- Google, Prince's Rainforest Project (UK),…
- Seven governments wish to cooperate as 'National Demonstrators' for the project in 2009-2010
  - Australia, Brazil, Cameroon, Guyana, Indonesia, Mexico and Tanzania.

National Demonstrators



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GEO FCT Partnership: Demonstrators

- Growing list of candidates for 2010 participation

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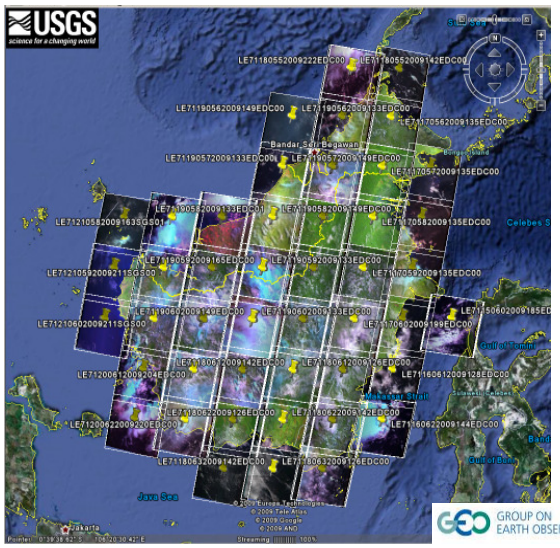
Landsat Acquisitions over Borneo

173 2009 ETM+ Scenes in USGS Archive (May – August)

No Landsat 5 TM data available from the USGS archive.

Request for Landsat 5 support to Thailand, GISTDA



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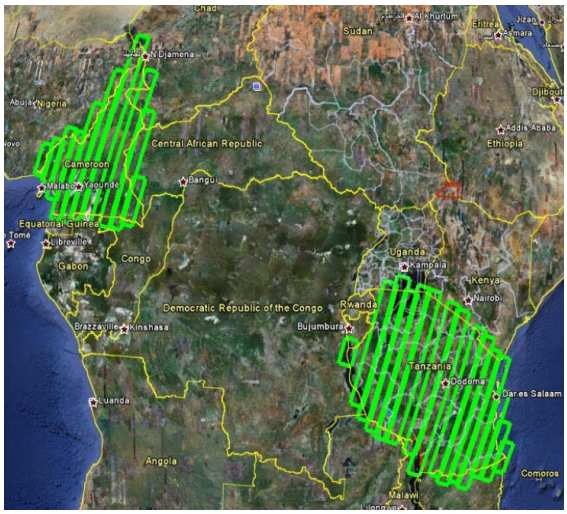
Envisat ASAR Acquisition over Africa



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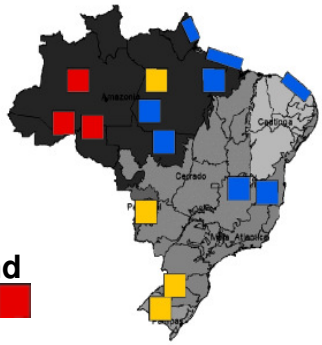
CSA-ESA Coordination over Brazil

- **RADARSAT-2**
- **ENVISAT ASAR**

Conflict with ENVISAT C-band sensor calibration sites in Amazonia



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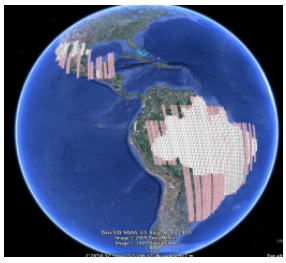
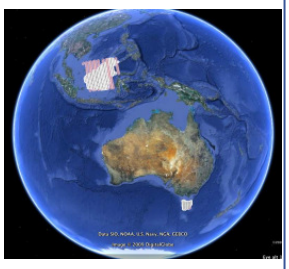
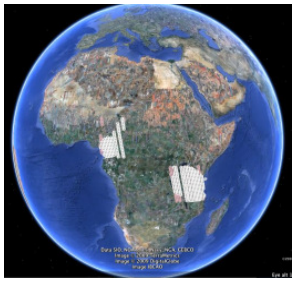
PALSAR acquisition status (June 12 - Aug 31, 2009)



Cameroon - 2 coverages
June/July; Sep/Oct

Tanzania - 2 coverages
June/July; Sep/Oct





Brazil & Guyana - 2 coverages
June/July; Aug/Sep

Mexico - 2 coverages
Aug/Sep; Sep/Oct

Borneo - 2 coverages
June/July; Aug/Sep

Tasmania - 2 coverages
June/July; Aug/Sep

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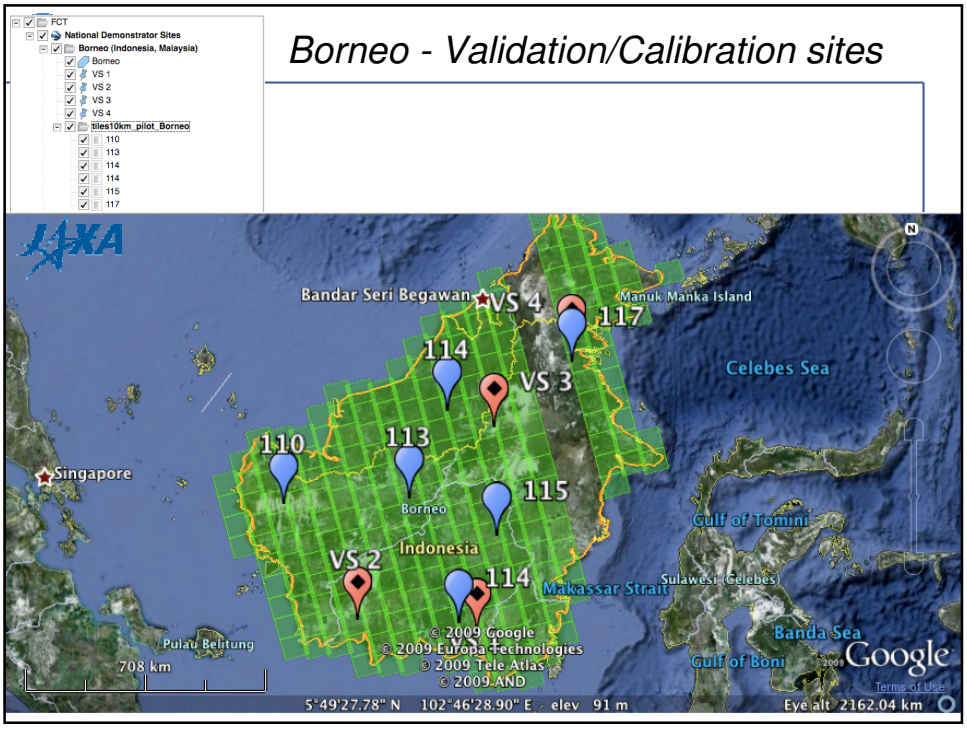
Borneo - Validation/Calibration sites



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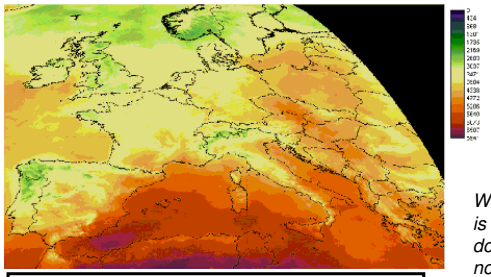
Renewable Energy : Solar

Ground irradiance



EO services for site identification, plant management, grid management, and consulting (architects, urban planning)

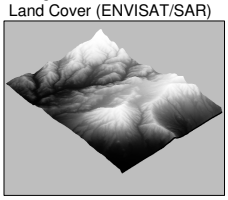
Exploiting MSG every 15 min, Envisat for atmospheric correction

When a new market is opened, a site evaluation is not available, as usually other PV-operators do not publish their production values. We are now expanding into countries like Germany, Italy and Spain where we have no operation experiences. Investment costs of about 5 to 12 million Euros are planned. To assure the flow back of these investments we must be sure that we build the PV systems at locations with enough solar radiation. Therefore we will need satellite derived irradiance data.

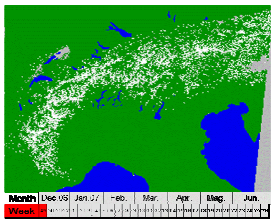
Robert Kröni, Edisun Power AG director

Renewable Energy : Hydropower

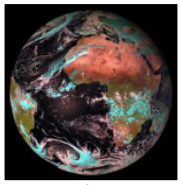
Digital Elevation Model
Land Cover (ENVISAT/SAR)



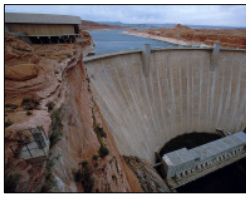
Snow Cover Extent (ENVISAT/MERIS)

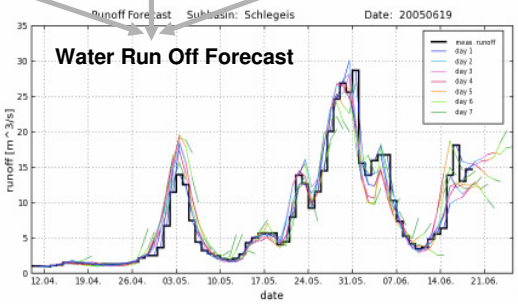


Weather Conditions (MSG)



via Hydrological Model



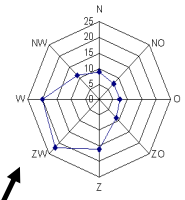


Verbund Austrian Alps

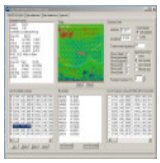
Statkraft Scandinavia

Renewable Energy : Wind

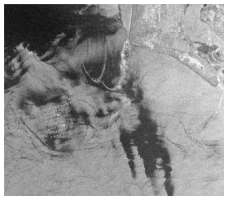
Wind rose



Industry software for
resources estimation



High-res
Regional
Radar

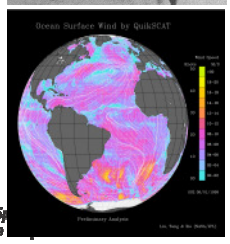


Risø DTU
National Laboratory for Sustainable Energy

Vestas

>15 years archived history is crucial

Low-res
Global
Scatt



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Powerful Simplicity

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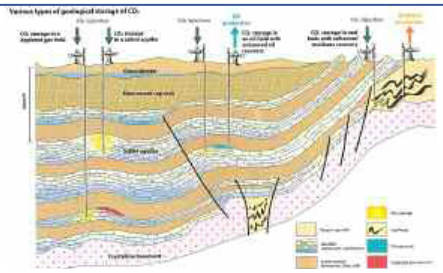
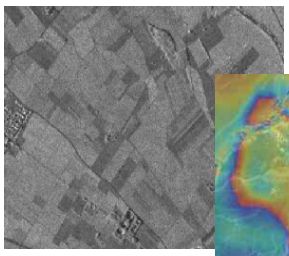
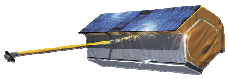
Courtesy RISOE

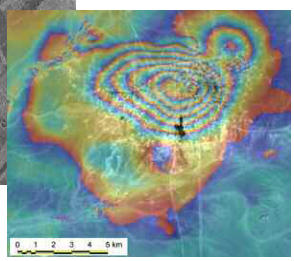
Carbon Capture & Storage

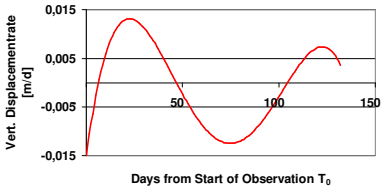


- **Demonstrate potential of high-res SAR Interferometry for storage site motion monitoring in compliance with EU directive for CCS operation,**
- **Service trial in progress for gas storage site in Central Europe with a major O&G company and industry standards organisation.**









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Climate Change Adaptation

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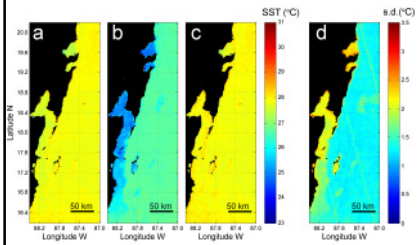
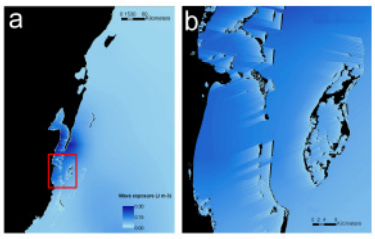
Coral Reef Health & Stress, Caribbean

- **Health indicators :** reef extent, reef rugosity, coral and macro-algal cover, coral population structure, coral mortality, coral bleaching, coral diseases, herbivory,
- **Stress indicators :** Sedimentation, pollution, coastal development, over-fishing, ocean acidification, thermal stress



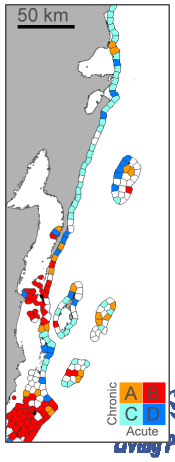
SST patterns (ATSR)

a. Average
b. Min monthly mean
c. Max monthly mean
d. Std Dev

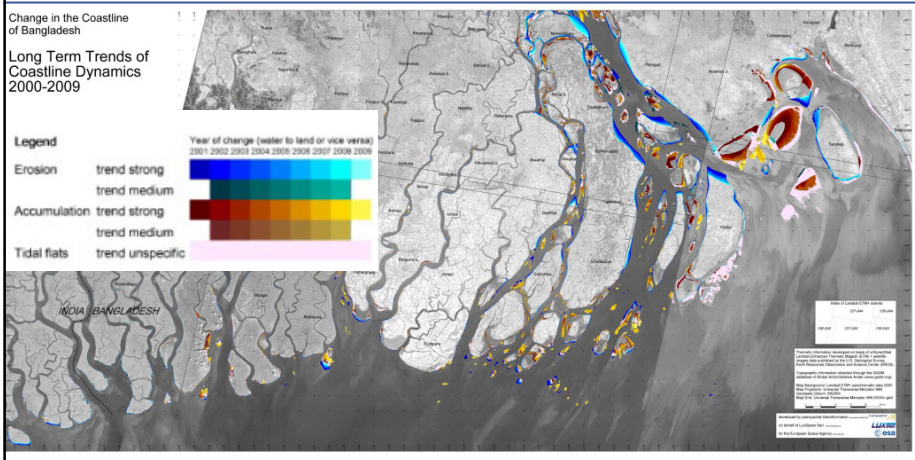


Characterisation of Thermal stress regime

Wave exposure map (from shape of basin, wind-speed & direction (ERS Scatt)



Coastline Change, Bangladesh



- **Technically challenging (large tidal effects to de-couple)**
- **Project completing, preliminary results (under evaluation),**
- **High dynamic land loss & gain; trend towards erosion in East**
- **2 separate studies, use of Landsat, SPOT, QuickBird, IKONOS**

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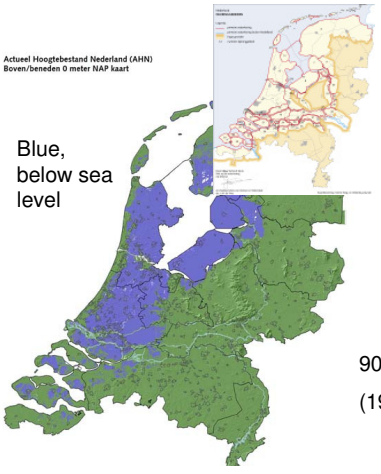
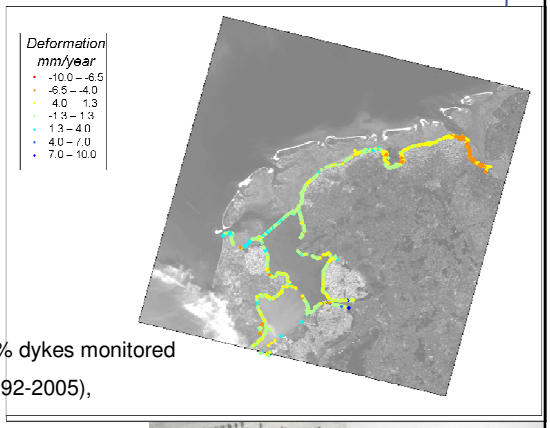
Land Motion: Dyke Stability





90% dykes monitored (1992-2005),

17000 km of water barriers: 3565 km primary water barriers (big rivers, sea, Ijsselmeer, Markermeer), 14000 km regional water barriers

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Courtesy R. Hansen Delft Institute of Earth Observation and Space Systems

Summary

Satellite data support 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

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