

Space for Water

*Pierre-Philippe Mathieu – Vienna 24 April 2012
Directorate of Earth Observation Programs, ESA*



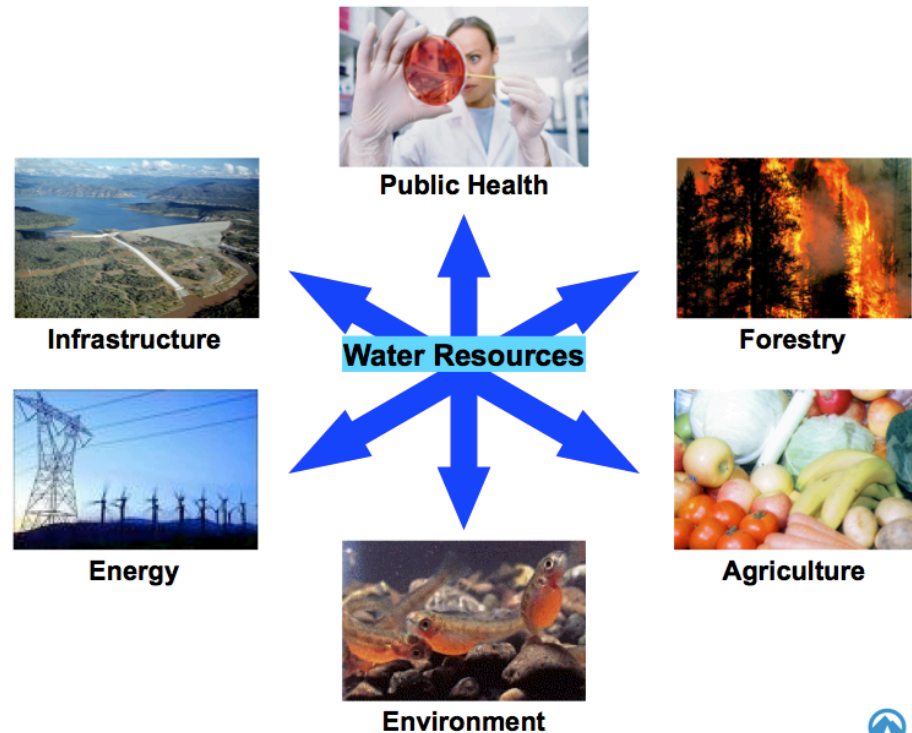
We came all this way to discover the moon,
and the most important thing is that we discovered the Earth
Bill Anders, 1968

- **Importance of Water**
- **Challenge of Sustainability**
- **Data**
- **Satellite Observation**
- **Applications**
- **Concluding Remarks**

The Challenge of Water Management

The Importance : Socio-Economic

- Essential for Life
- Economic Driver
- Environmental Risk
(e.g. flood, drought)
- Security Issue (e.g. food)



Water is key to some of the core economic, social, and political problems of our time such as poverty, environmental sustainability, human and ecosystem health, conflict, and economic prosperity.

The Importance : Science

AUGUST 2007

TRENBERTH ET AL.

759

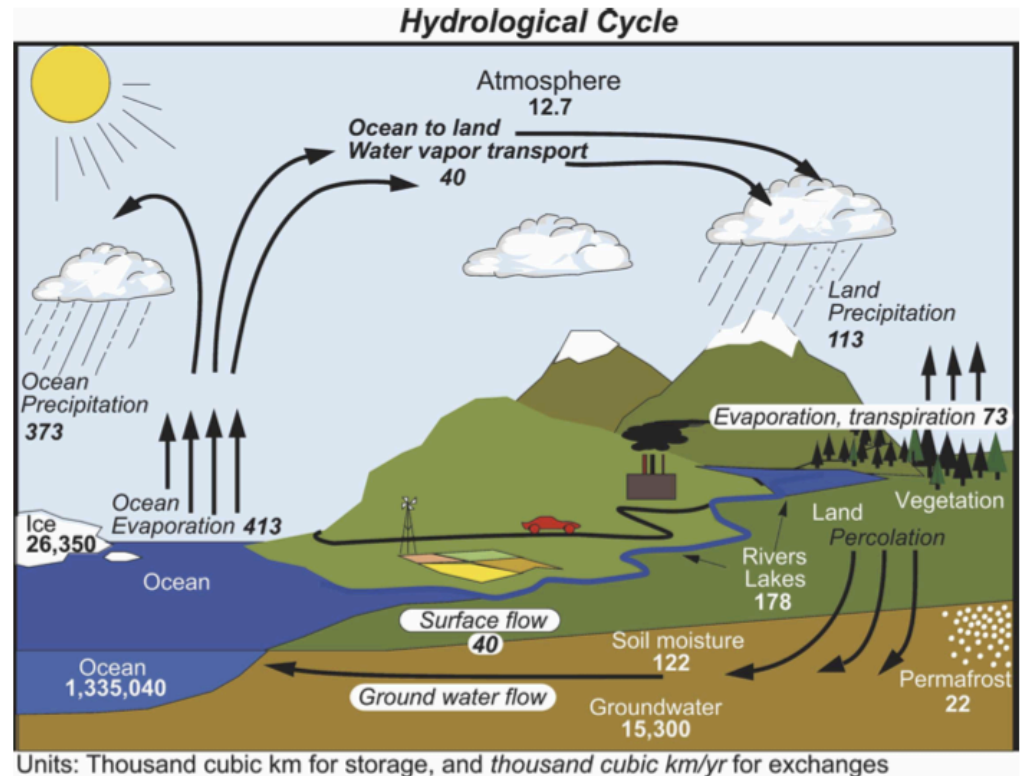


FIG. 1. The hydrological cycle. Estimates of the main water reservoirs, given in plain font in 10^3 km^3 , and the flow of moisture through the system, given in slant font ($10^3 \text{ km}^3 \text{ yr}^{-1}$), equivalent to Eg (10^{18} g) yr^{-1} .

Precip, Evaporation, Run-off

- $\frac{3}{4}$ Planet is ocean

- Climate Regulator

- Heart of Water Balance

- Most Important GHG

- Uncertainty (e.g. cloud, glacier balance)

- Tipping Point (e.g. Greenland, Antarctica Conveyor Belt)

The Issue – Water Stress & Connectivity

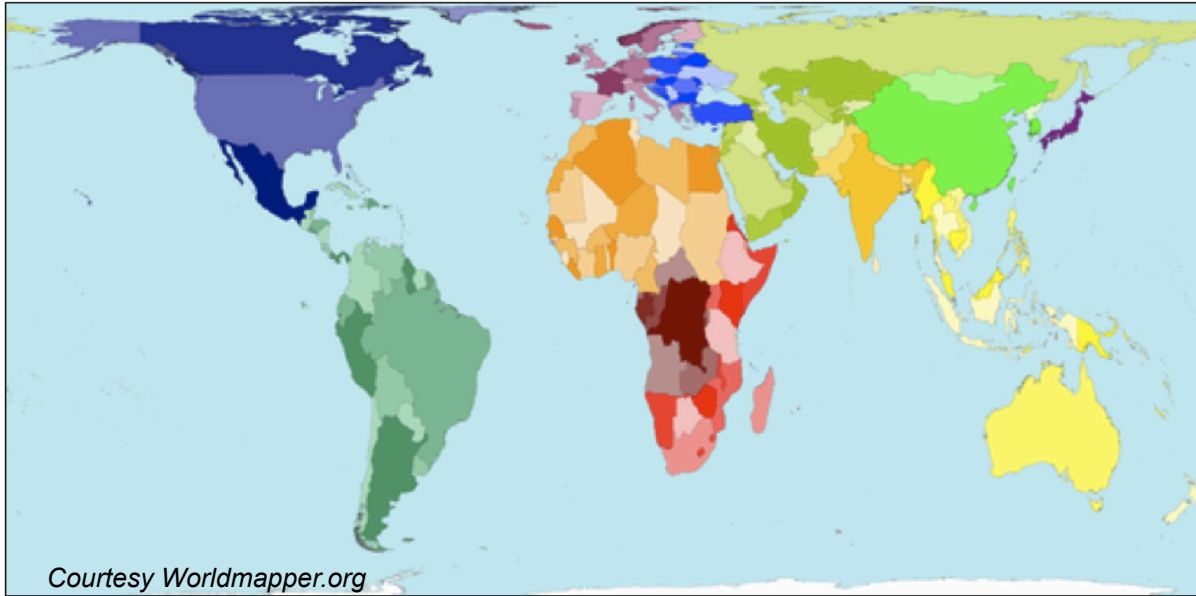
[< Previous Map](#)

Land Area

Map No. 1

[Open PDF poster](#)

[Next Map >](#)



Courtesy Worldmapper.org

The land area of each territory is shown here.

The total land area of these 200 territories is 13,056 million hectares. Divided up equally that would be 2.1 hectares for each person. A hectare is 100 metres by 100 metres.

However, population is not evenly spread: Australia's land area is 21 times bigger than Japan's, but Japan's population is more than six times bigger than Australia's.

"Secure access to land remains essential for diverse land-based livelihoods and is a precondition for sustainable agriculture, economic growth and poverty reduction." Oxfam, 2006

Each territory's size on the map is drawn according to its land area.

The Issue – Water under Pressure

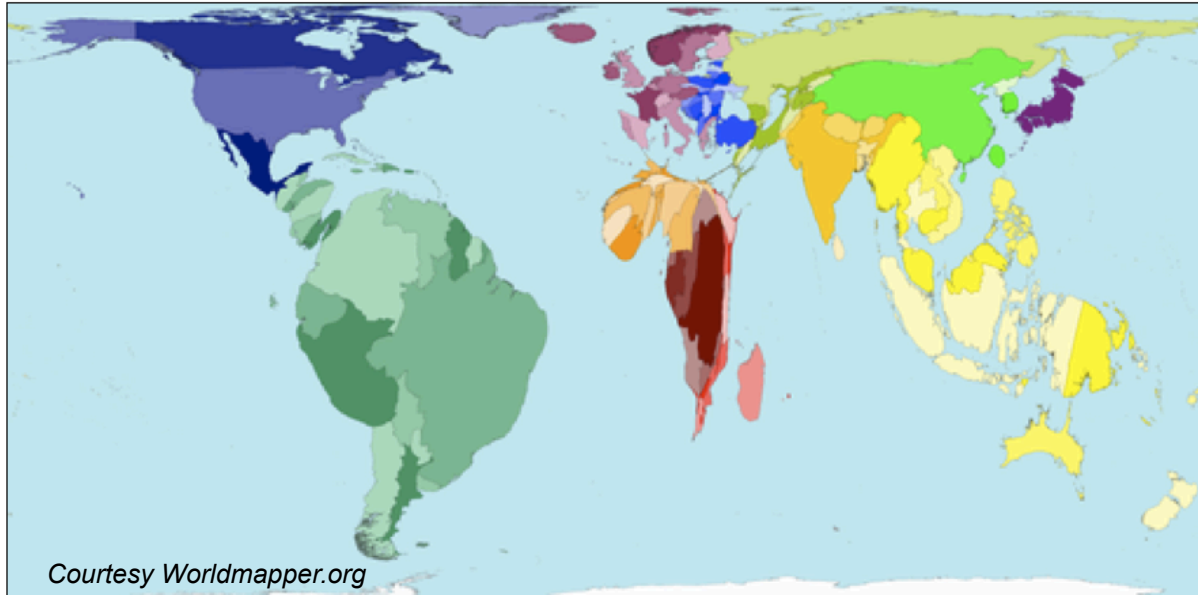
< Previous Map

Water Resources

Map No. 102

[Open PDF poster](#)

[Next Map >](#)



Water resources here include only freshwater, because saline (sea) water requires treatment before most uses. Only 43 600 cubic kilometres of freshwater is available as a resource each year, despite more than twice this amount falling as precipitation (rain and snow). Much is lost through evaporation. Those countries with higher rainfall often have larger water resources. Of all the water available, the regions of South America and Asia Pacific have the most.

People living in Kuwait use sea water that is processed at a desalination plant. As such Kuwait has no area on this map because there are no freshwater resources there.

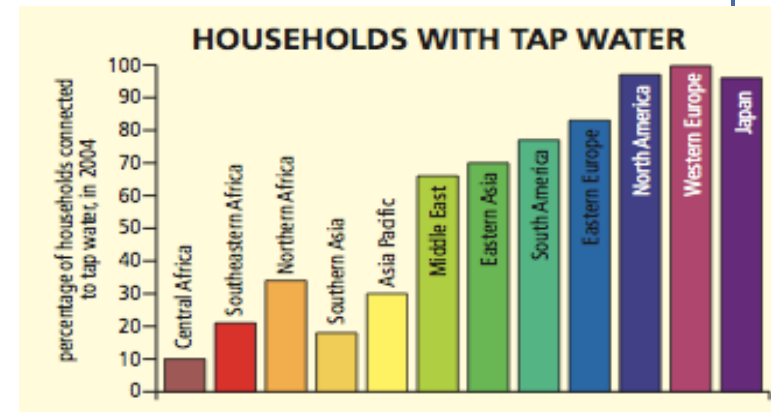
"The Amazonian basin, where ten of the twenty largest rivers in the world are to be found ... represents one fifth of the entire fresh water reserves of the planet." Brazilian Government's Ministry of External Affairs, 2002

Territory size shows the proportion of all worldwide freshwater resources found there.

TOP 7 GLOBAL WATER CONSUMERS



Water Connected?



The Issue – Population Growth

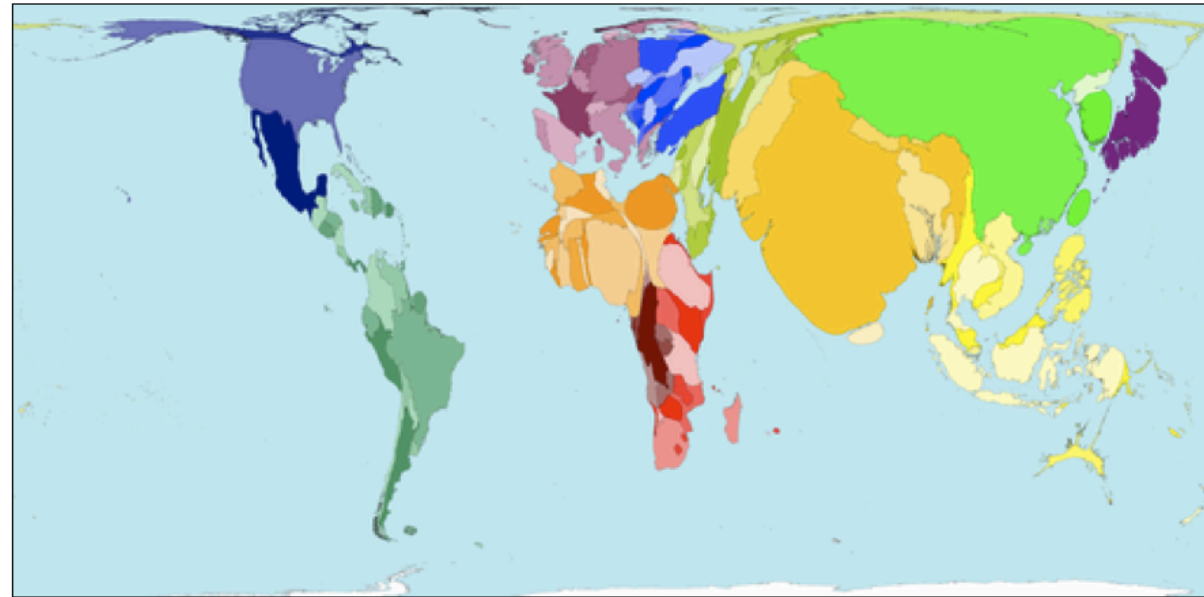
[< Previous Map](#)

Total Population

Map No. 2

[Open PDF poster](#)

[Next Map >](#)



In Spring 2000 world population estimates reached 6 billion; that is 6 thousand million. The distribution of the earth's population is shown in this map.

India, China and Japan appear large on the map because they have large populations. Panama, Namibia and Guinea-Bissau have small populations so are barely visible on the map.

Population is very weakly related to land area. However, Sudan which is geographically the largest country in Africa, has a smaller population than Nigeria, Egypt, Ethiopia, Democratic Republic of Congo, South Africa and Tanzania.

Note: Many of the maps' subjects relate to people, so this map serves as a good reference map for comparison with many other maps.

The size of each territory shows the relative proportion of the world's population living there.

"Out of every 100 persons added to the population in the coming decade, 97 will live in developing countries." Hania Zlotnik, 2005

The Issue – Population Growth

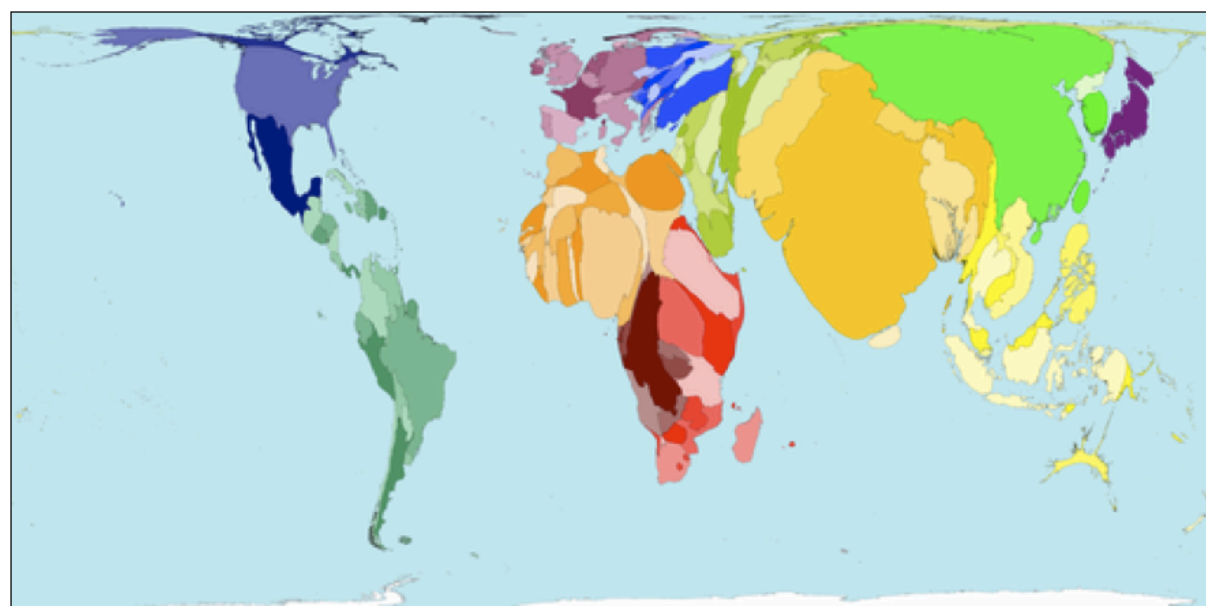
[< Previous Map](#)

Population 2050

Map No. 11

[Open PDF poster](#)

[Next Map >](#)



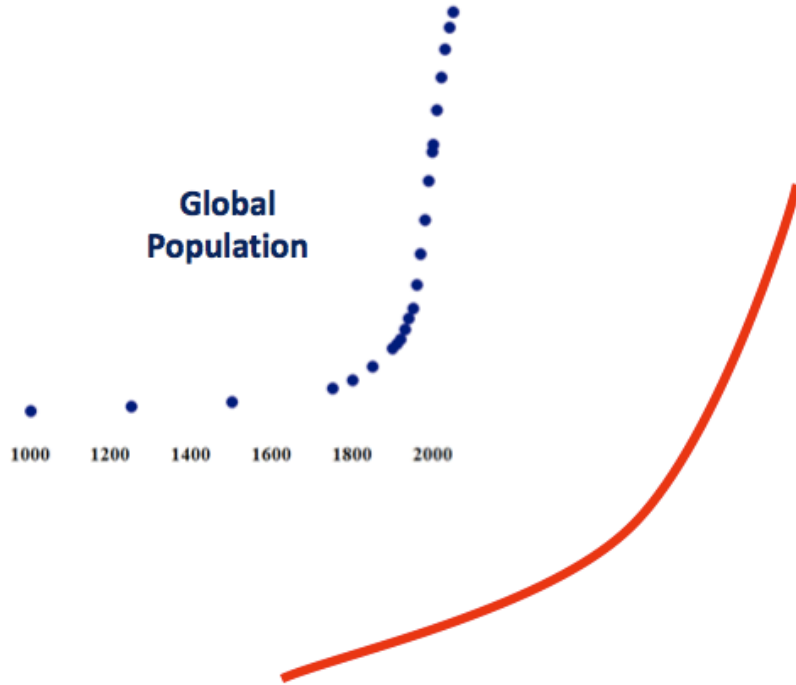
By 2050 it is estimated that the earth's human population will be 9.07 billion. 62% of the people will live in Africa, Southern Asia and Eastern Asia - numerically this is the same as if all the world's current population lived just in these regions. In addition another 3000 000 000 will be spread across the rest of the world.

All numbers shown here are estimates - estimates are never perfect.

"The choices that today's generation of young people aged 15-24 years make about the size and spacing of their families will determine whether Planet Earth will have 8, 9 or 11 billion people in the year 2050." United Nations Population Fund. 2005

This map shows the predicted distribution for the estimated world population in 2050.

The Issue - A New Geophysical Force

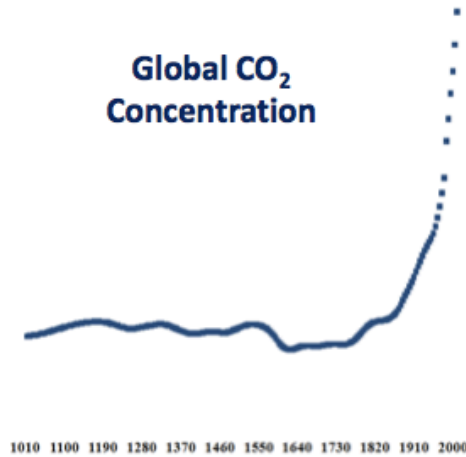


ANTHROPOCÈNE

ANTHROPOCÈNE [ãtrɔposɛn] n. m. – 2002 (PAUL CRUTZEN); DU GREC ANTHROPOS « HUMAIN » ET KAINOS « RÉCENT »

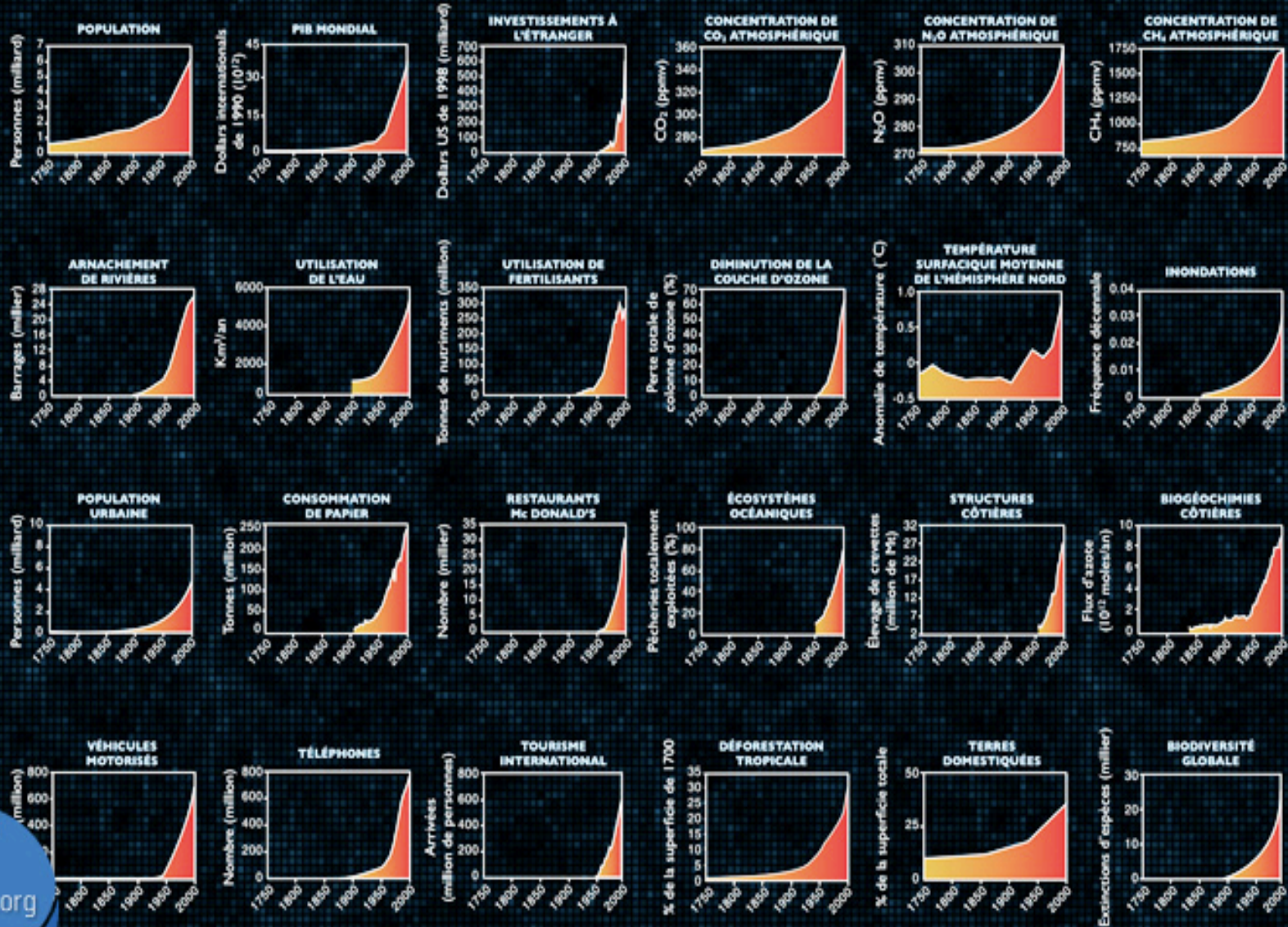
■ **1 GÉOL.** Période la plus récente du Quaternaire, succédant à l'Holocène. ■ **2** Changement du régime de l'activité des sociétés industrialisées amorcé au tournant du 19^{ème} siècle et causant depuis des bouleversements d'une ampleur sans précédent au sein de la biosphère terrestre — changement climatique, érosion de la biodiversité, pollution des mers, des terres et des airs — lesquels commandent un remaniement global de la conscience.

■ **SYN.** déprédation, crise environnementale, seuil critique, changement de régime, changement de paradigme, nouvelle ère.



The Issue - A New Geophysical Force

L'Anthropocène | Symptômes d'une nouvelle époque



The **Challenge** – (Sustainable) Water Management

***“If you cannot measure it,
You cannot manage it”
Lord Kelvin***

We do NOT know accurately...

How much water the world *has* ..? Stock ?

How much water *flows* ? Exchanges hydrological cycle ... ?

How much water is *used* ? Human / Ecosystem ?

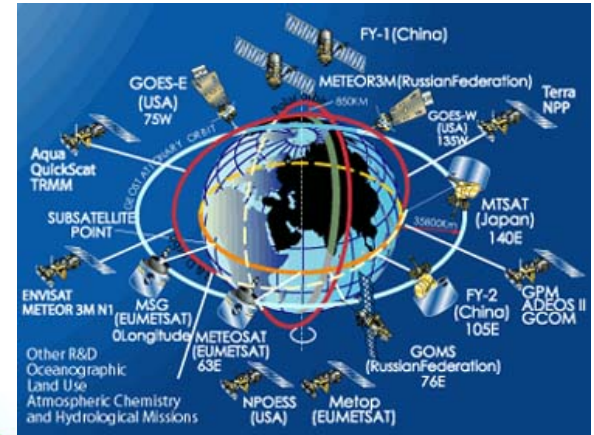
How much water is *needed* ? Sustain Ecosystem ? ...

We NEED better & accurate data

Quantify water mass & fluxes ...

Constrain, initialize water model prediction ...

The Challenge – Data Gathering



Citizen
Science

Better DATA, Better UNDERSTANDING,
Better MODEL, Better FORECAST, Better DECISION?

The Challenge – Data Usage

Data heterogeneous, incomplete (data gaps), of different nature, scales... Issue of Gap Filling, Interoperability, Traceability, Exploitation (Baseline, Ground Truth, time series.).



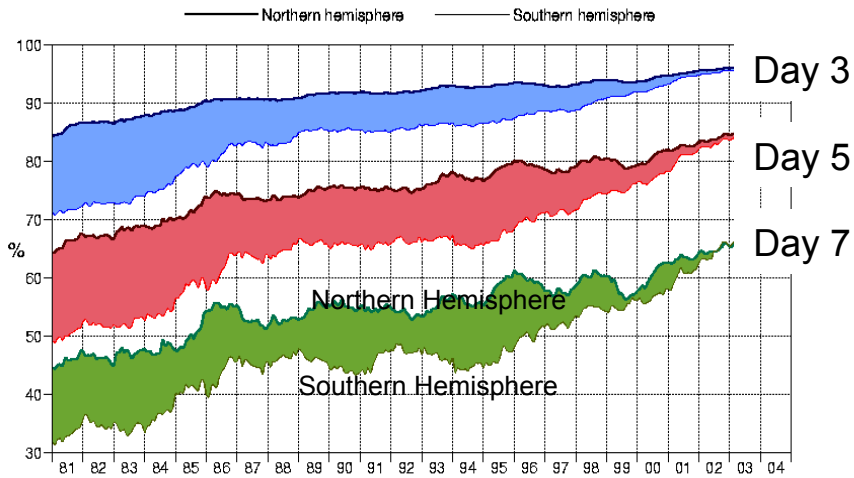
Paradox – so many data (Big Data), ... so little use?
Moving from *Availability* to *Usability*



Earth Observation (EO) from Space: Value & Capability

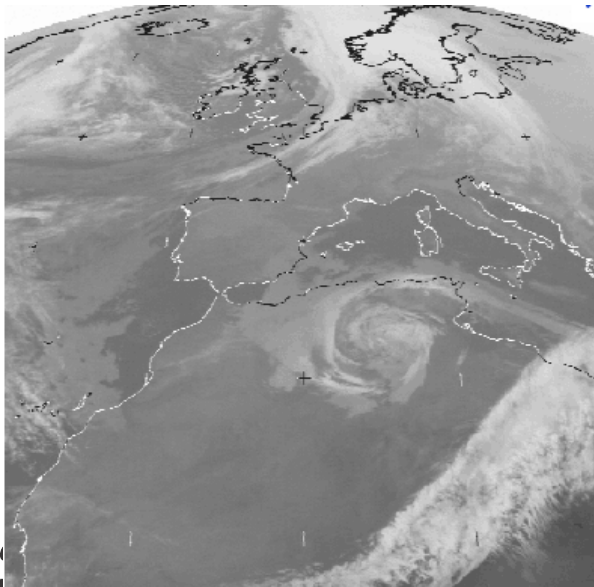
Weather Forecasting

Weather Forecast Skill



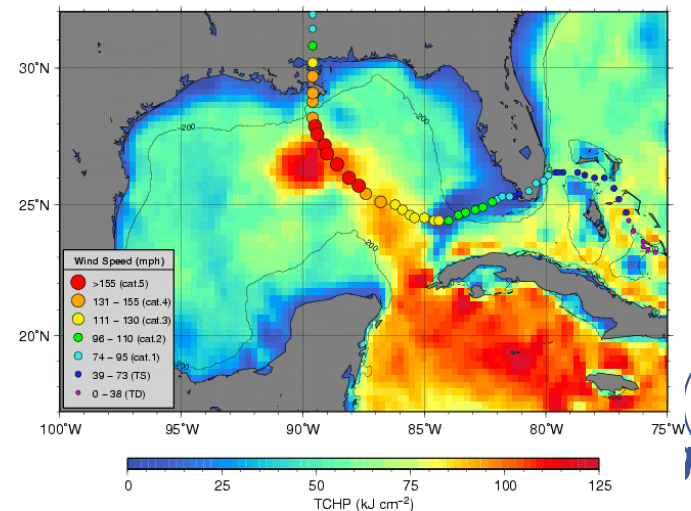
“EO is now the single most important component of the global observing system for Numerical Weather Prediction”

*Jean-Noel Thepaut, ECMWF
(European Center for Medium-Range Forecast)*

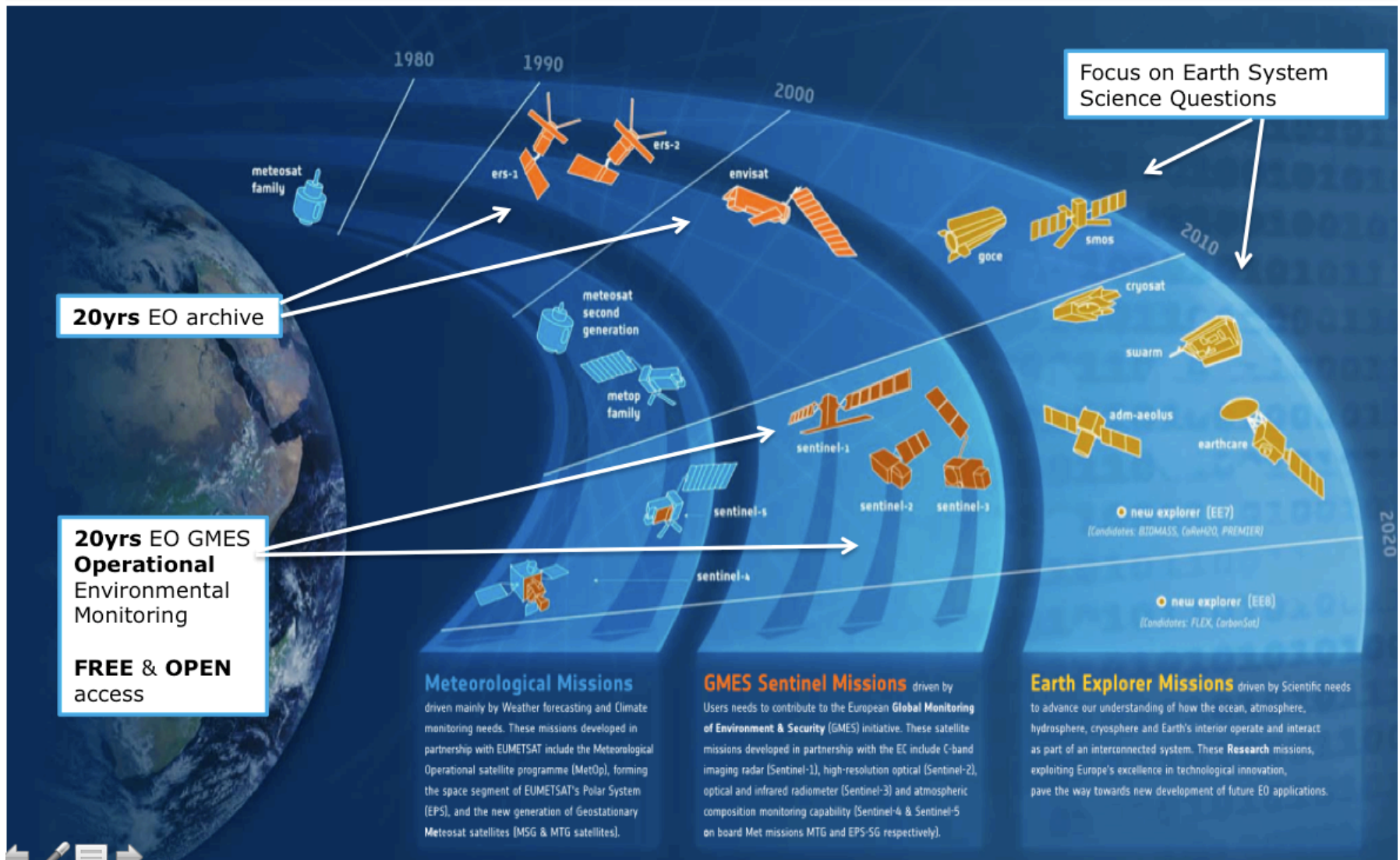


Hurricane Katrina

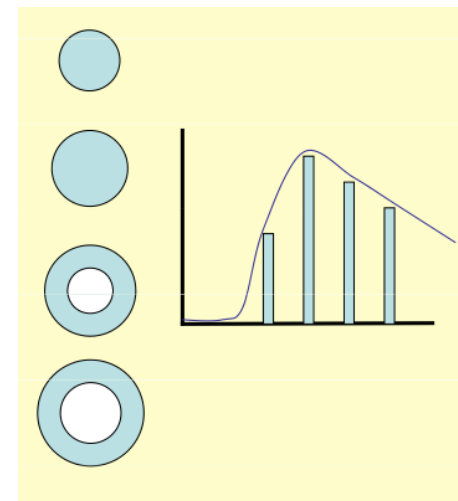
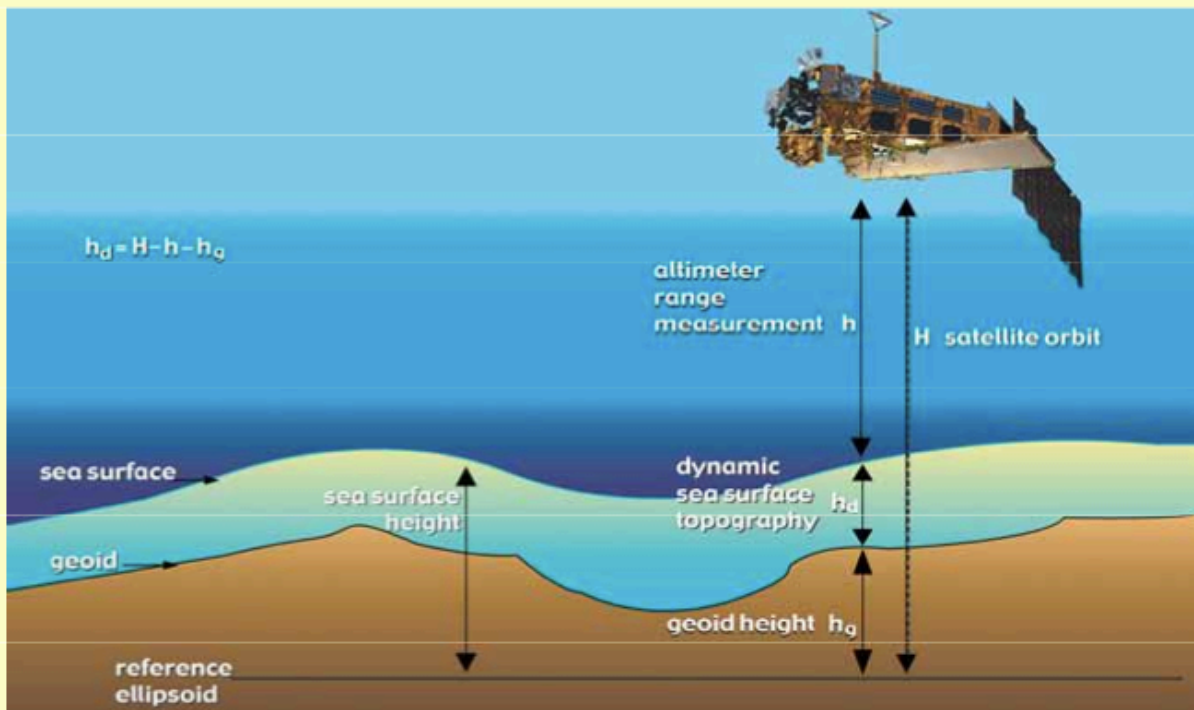
Sub-surface (Heat Content)



Expanding European Observing Capability

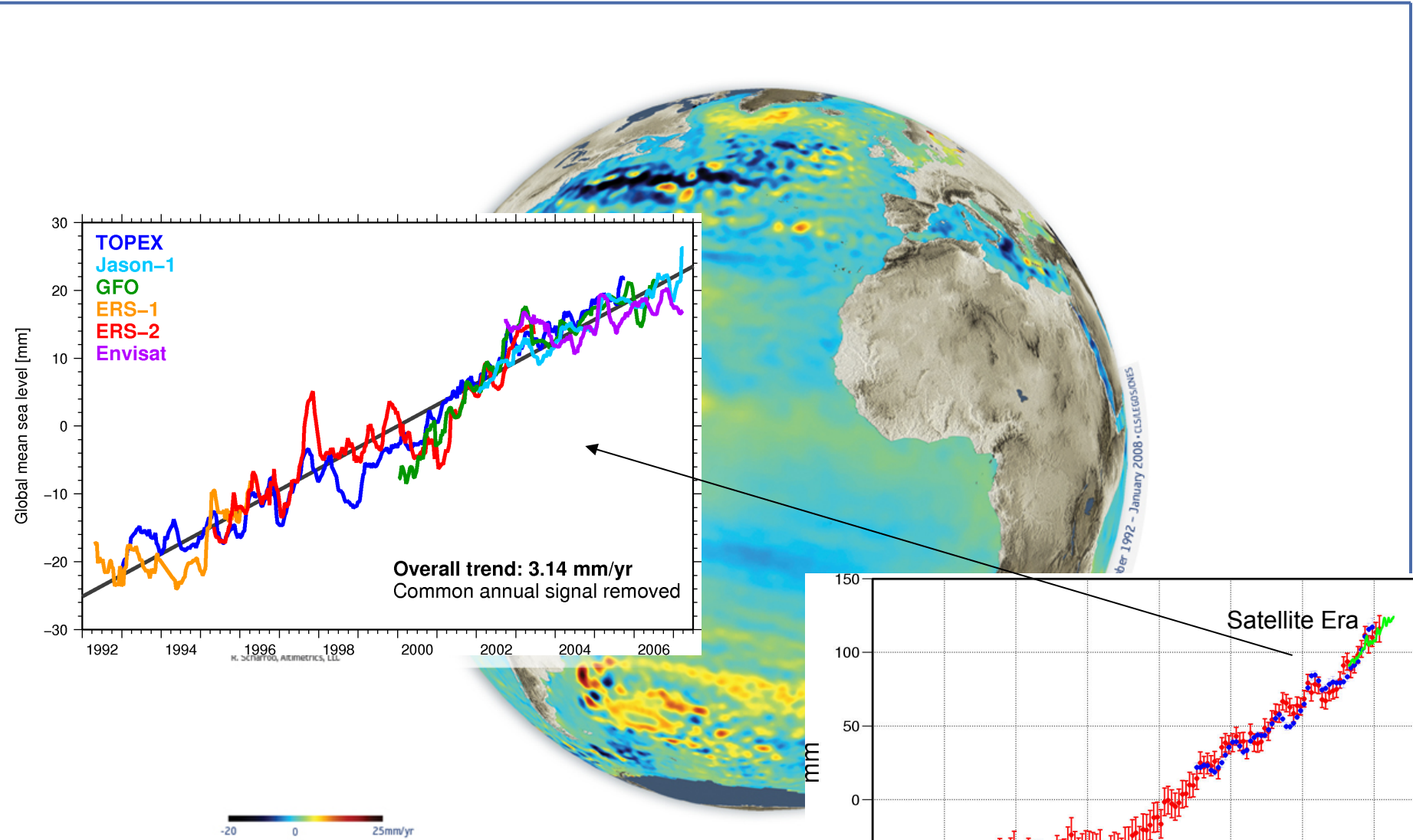


Satellite Active Microwave RS (Radar Altimeter)

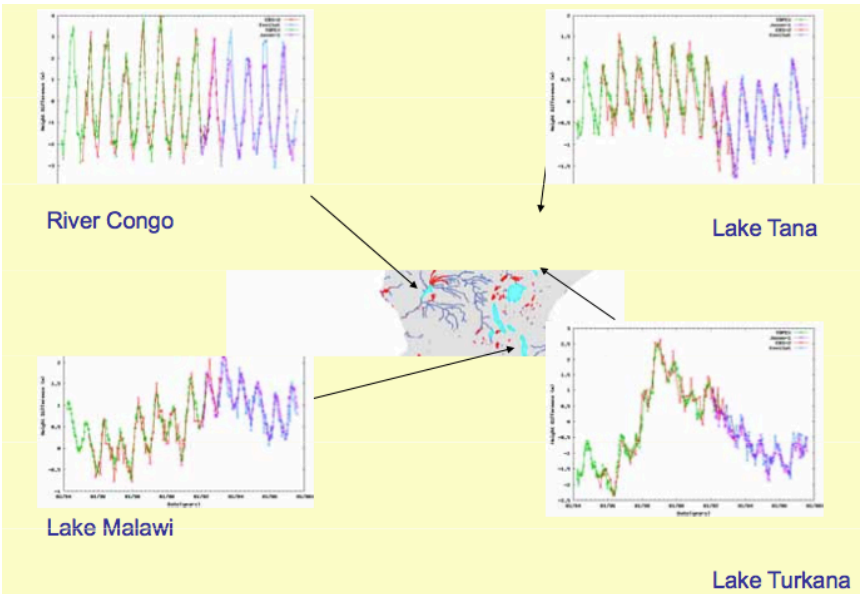


Speed Radar

Altimetry : Global Sea Level Rise



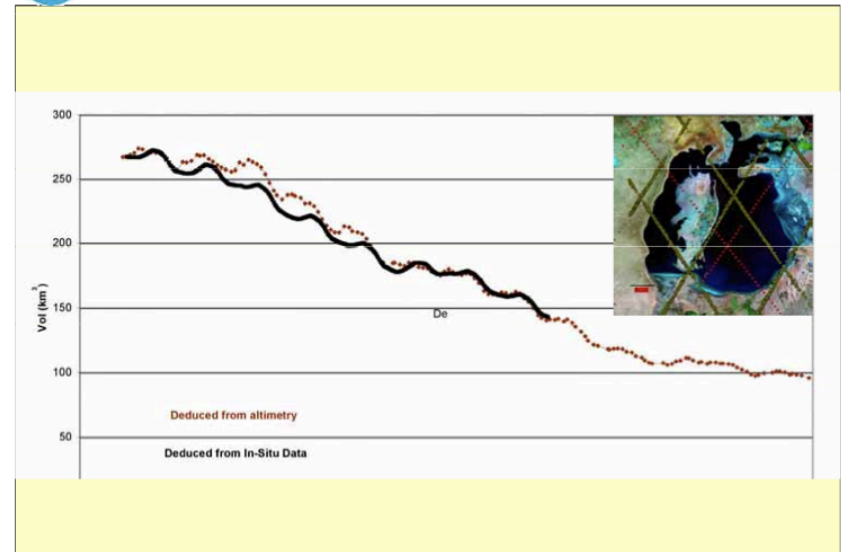
Altimetry : Hydrology



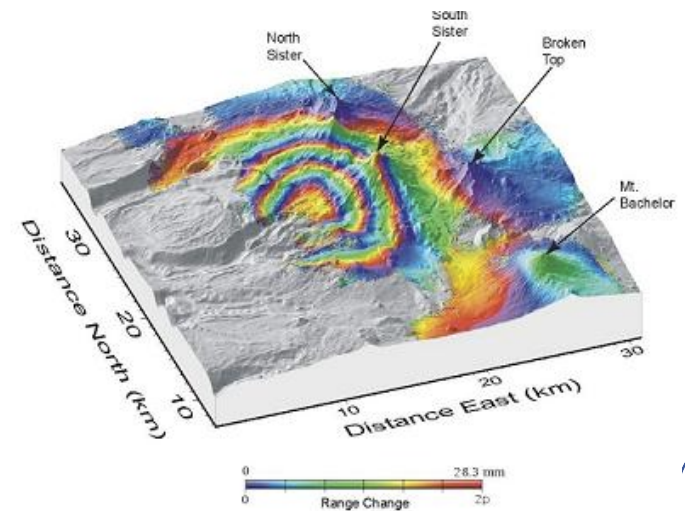
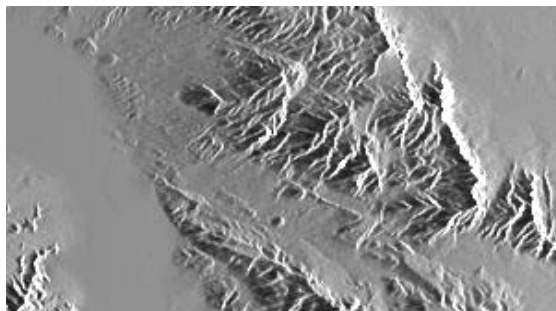
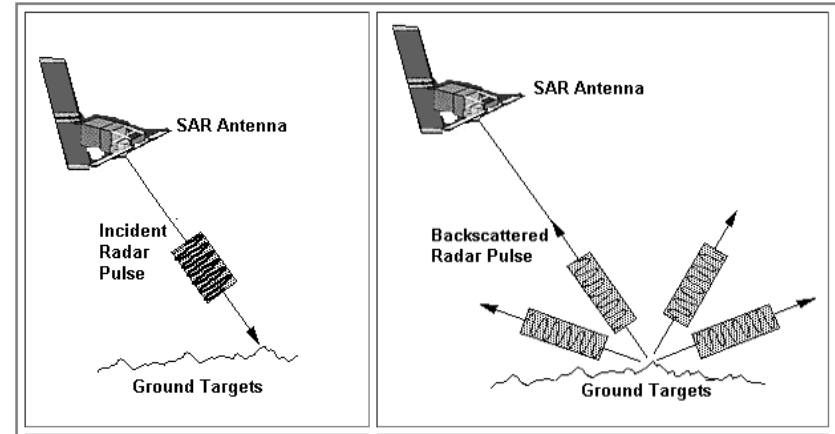
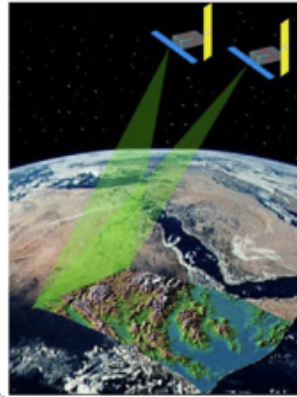
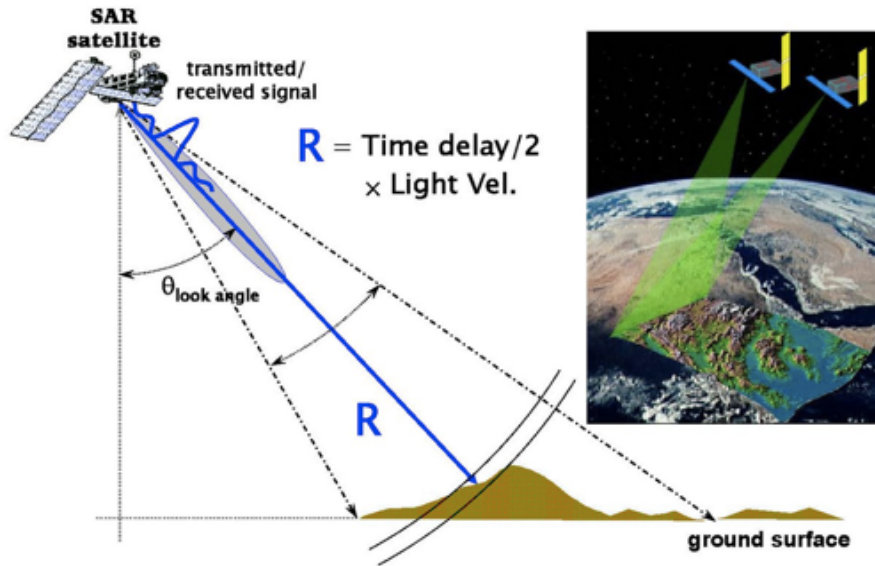
River & Lake products



South Aral Sea - Cazenave & Crétaux 



Satellite Active Microwave RS (SAR imaging radar)

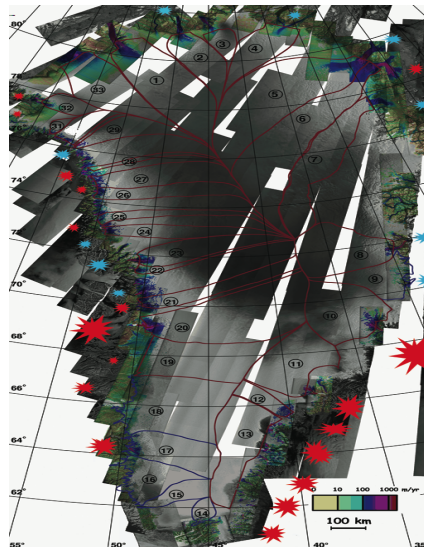


SAR : Ice Melting

Collapse of Larsen B ice shelf, Antarctica

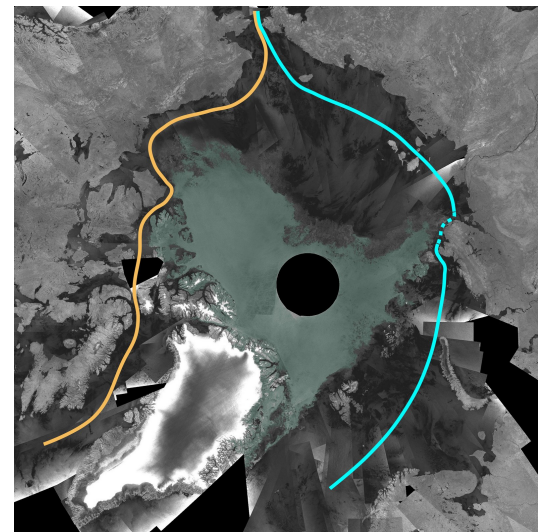
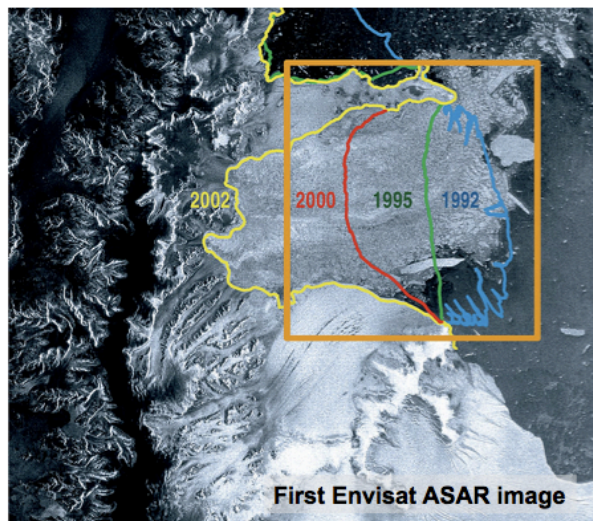
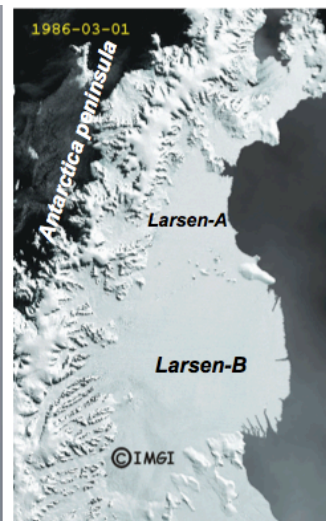


Melting of Greenland ice sheet

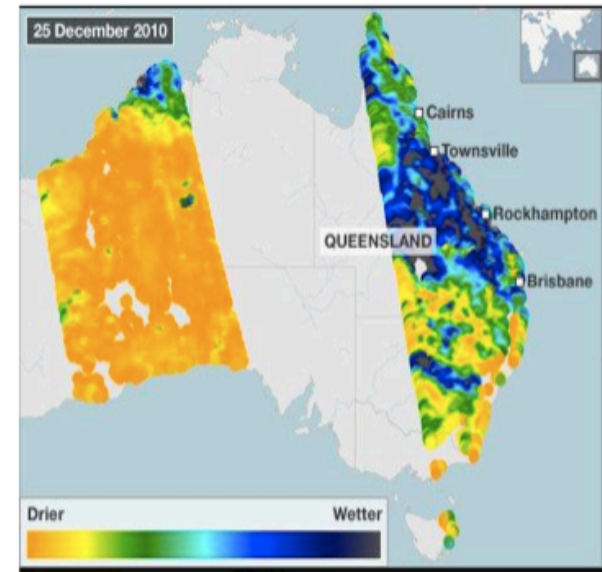


Courtesy
Eric Rignot

Melting / Thinning of sea-ice



Satellite Passive Microwave RS



Soil Moisture derived from SMOS 25.12.2010



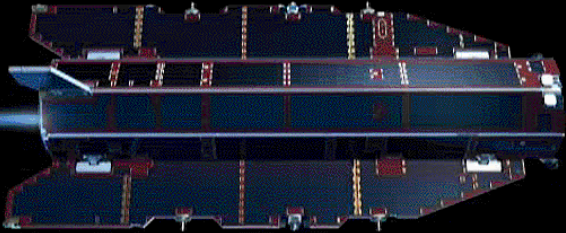
Airborne Calibration/Validation Experiments for SMOS (AACES) test site in the Murrumbidgee Catchment (outlined in red)

Taking *in situ* soil moisture measurements during the five-week campaign in southeast Australia to validate data f

European Space Agency

Satellite Gravimetry

GOCE (Gravity Field & steady-state Ocean Circulation)

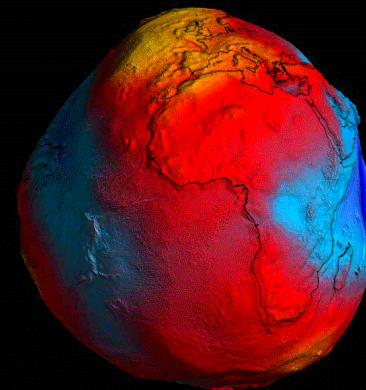
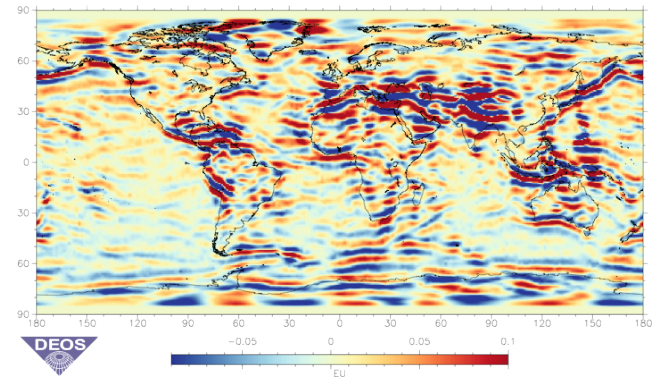


GOCE Main Objectives

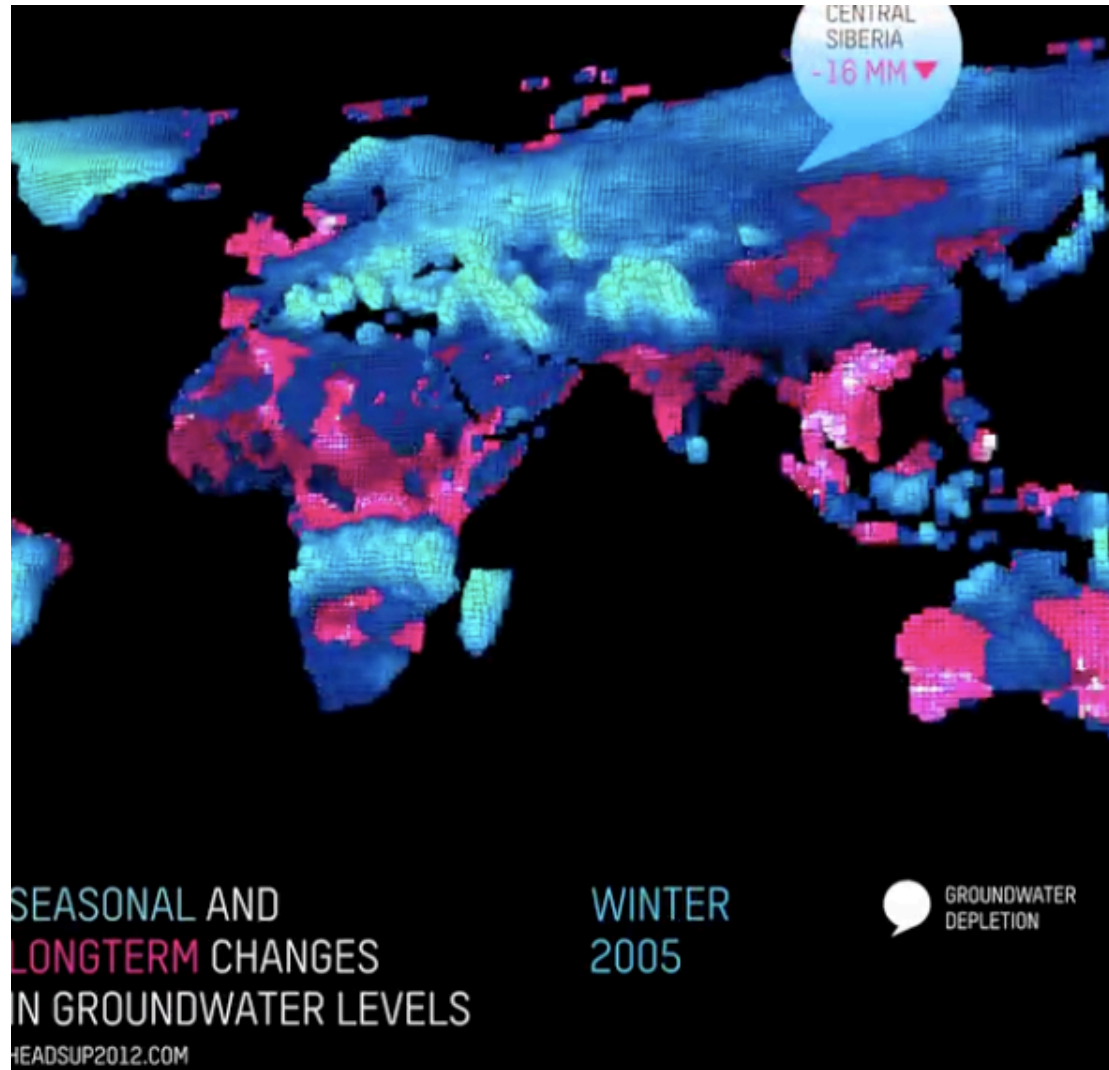
- global ocean circulation and transfer of heat
- + physics of the Earth's interior
- + sea level records, ice sheets and sea level change

New Geoid from GOCE recently unveiled
at the Fourth International GOCE User Workshop
hosted at the Technische Universität München in Munich, March 2011,

Observed gravity gradients (e.g. U_{xx})
from 260+km altitude since 2009
1-2cm geoid 100km resolution



Ground Water measured by GRACE

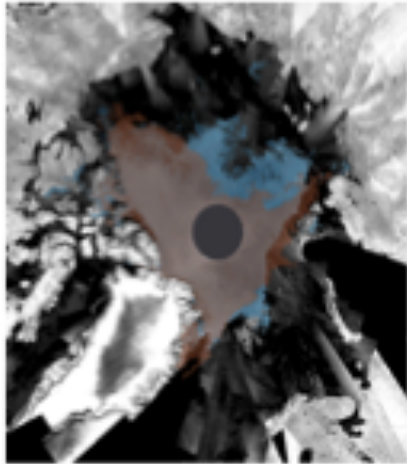


Scientific & Societal Applications

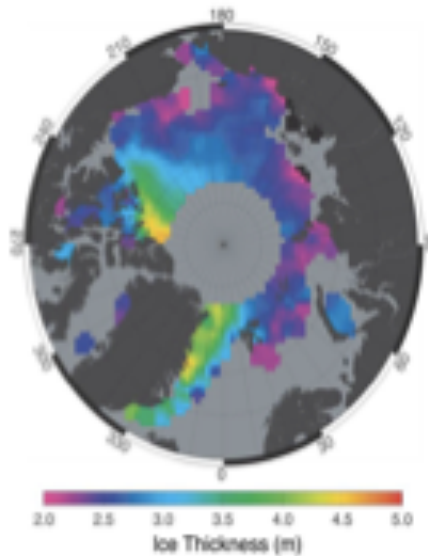
Climate : Understanding

Sea Ice Contribution to Freshwater flux and impact on thermohaline circulation:

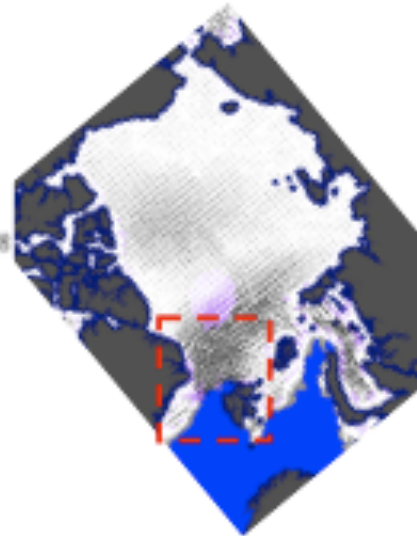
Sea ice extent & distribution + Sea ice thickness + Sea ice drift = Freshwater flux as ice



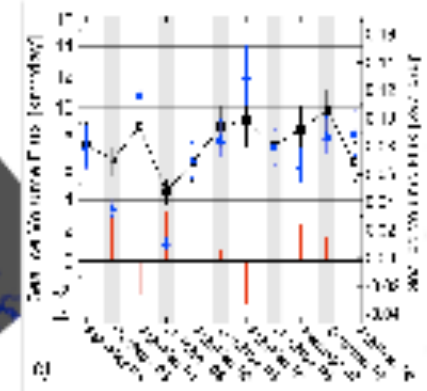
SAR
(Envisat (ASAR),
Sentinel-1)



+ Altimetry
(ERS, Envisat,
CryoSat, Sentinel-3)



+ SAR & Scatterometer
(Envisat, Sentinel-1
MetOp)

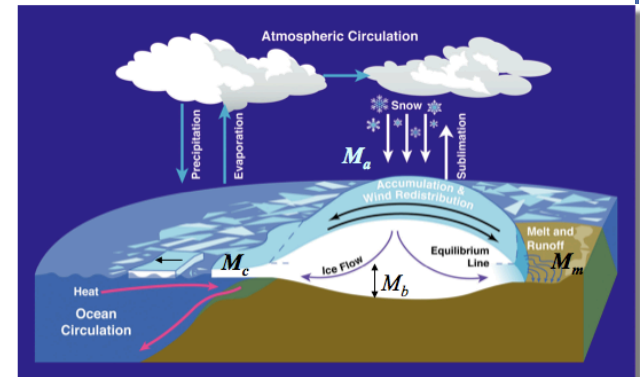
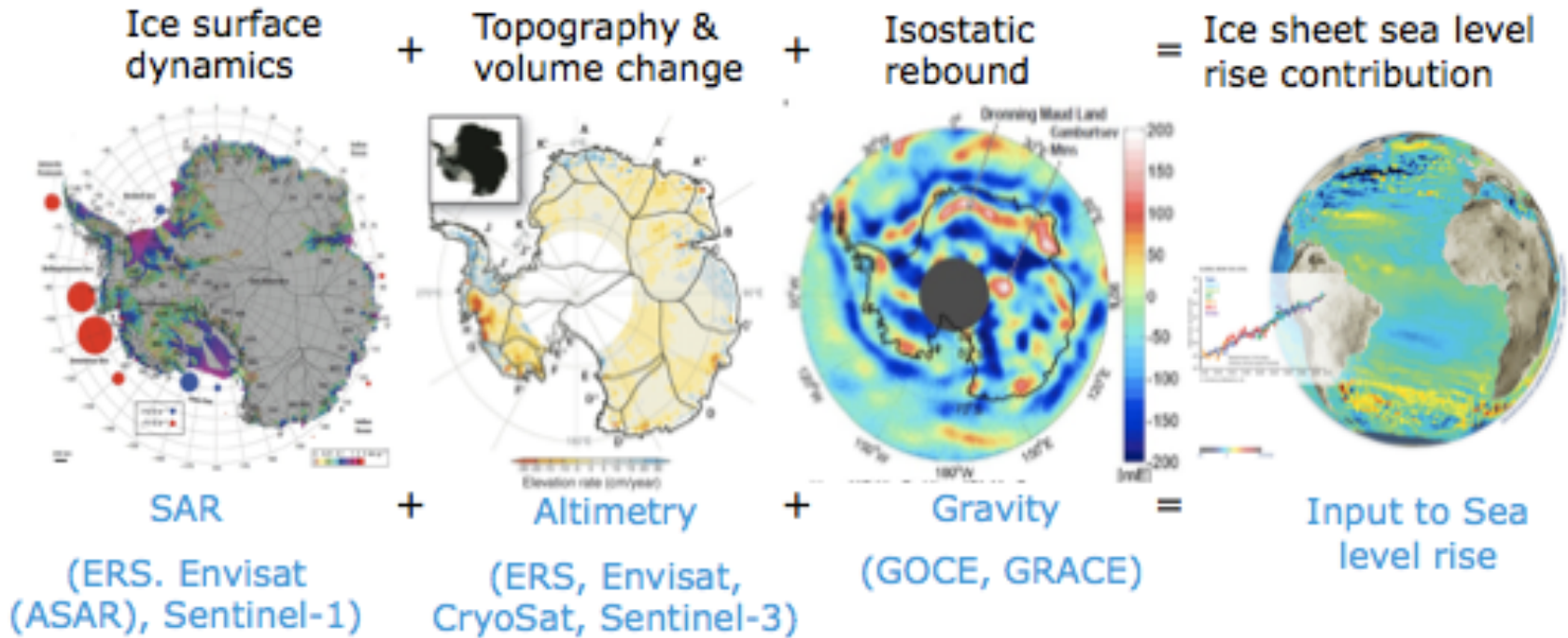


Freshwater flux
contribution

European Space Agency

Climate : Attribution

Ice Sheet contribution to Sea Level Rise:

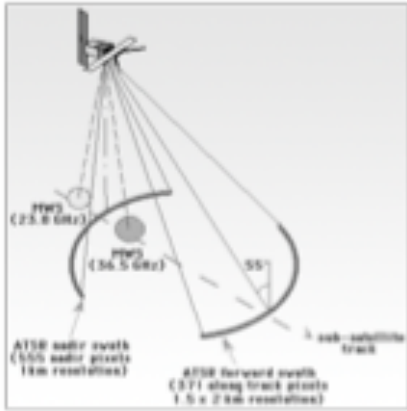


$$\frac{\delta V}{\delta a} = M_a - M_m - M_c$$

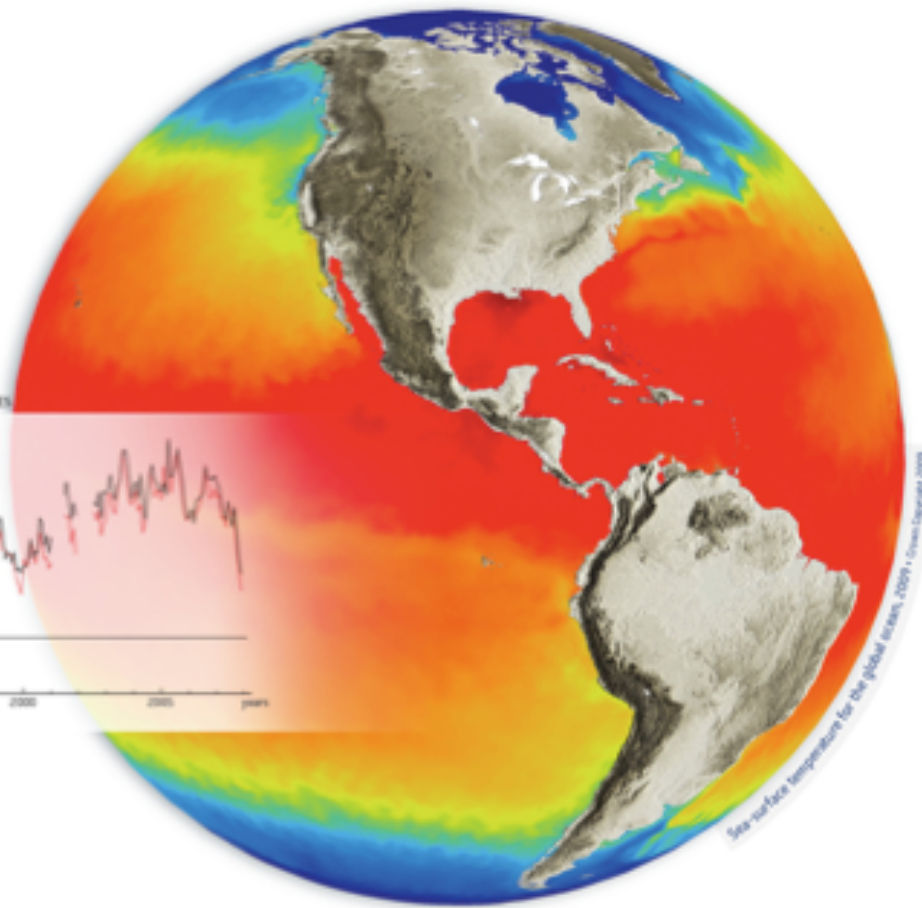
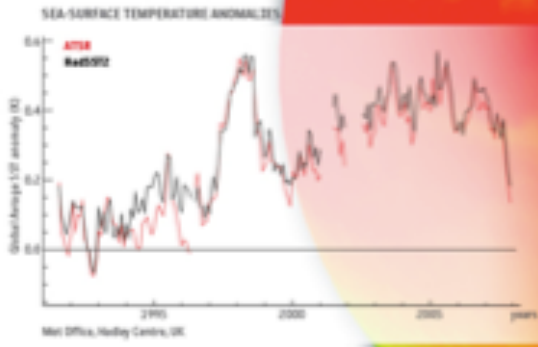
Volume change per year Accumulation Surface Melt Calving

Courtesy Mark Drinkwater Roger Haagmans

Climate: Monitoring



AATSR
 High Accuracy
 0.3K
 Needed to
 Capture
 Climate Signal



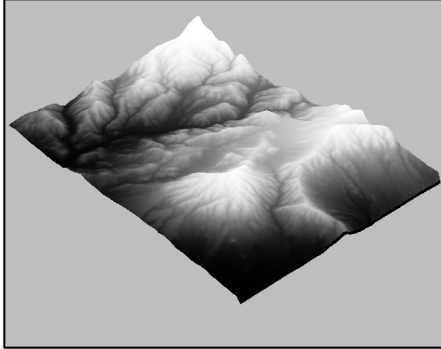
European Space Agency

European Space Agency
 Agence spatiale européenne

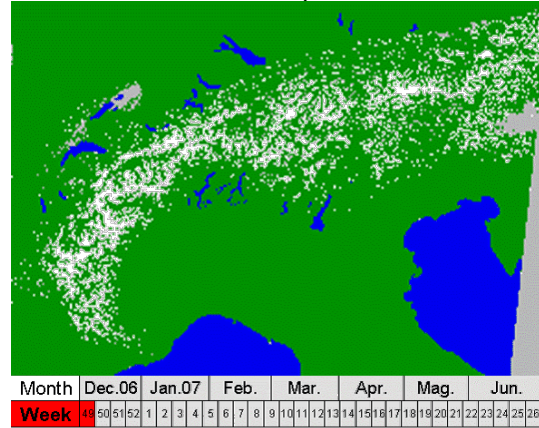


Energy : Supporting Hydropower

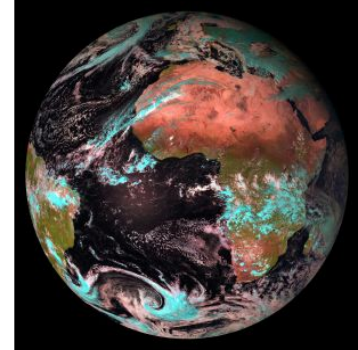
Digital Elevation Model
Land Cover (ENISAT/SAR)



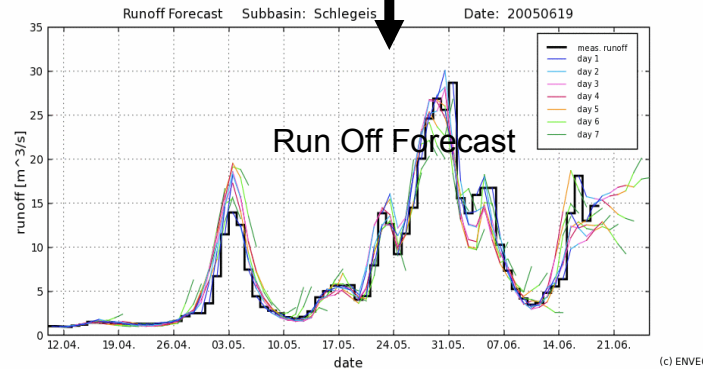
Snow Cover Extent (ENVISAT/MERIS)



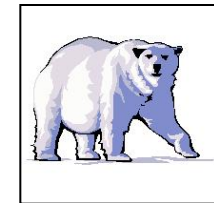
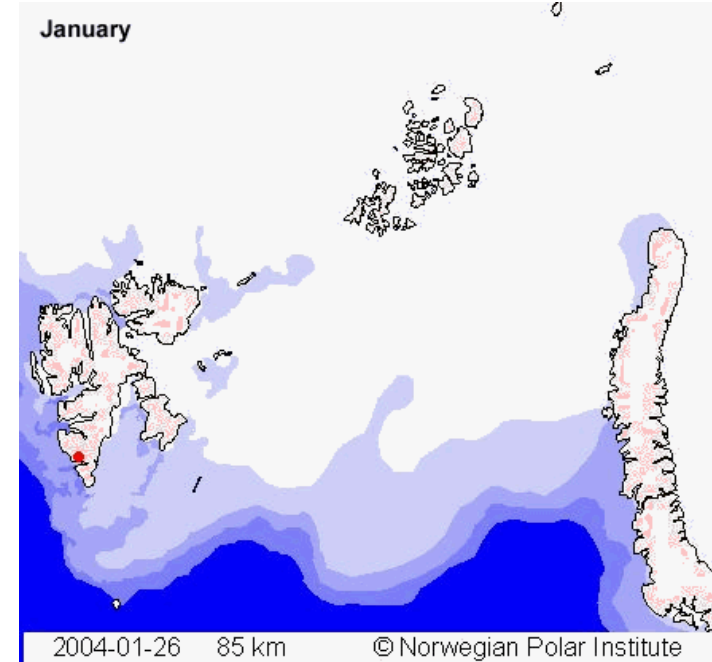
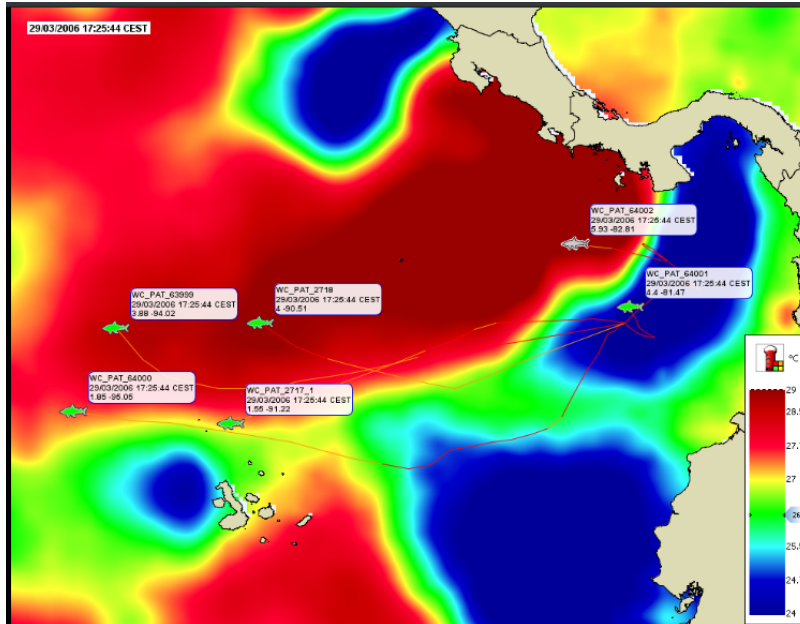
Weather Condition (MSG)



Hydrological Model

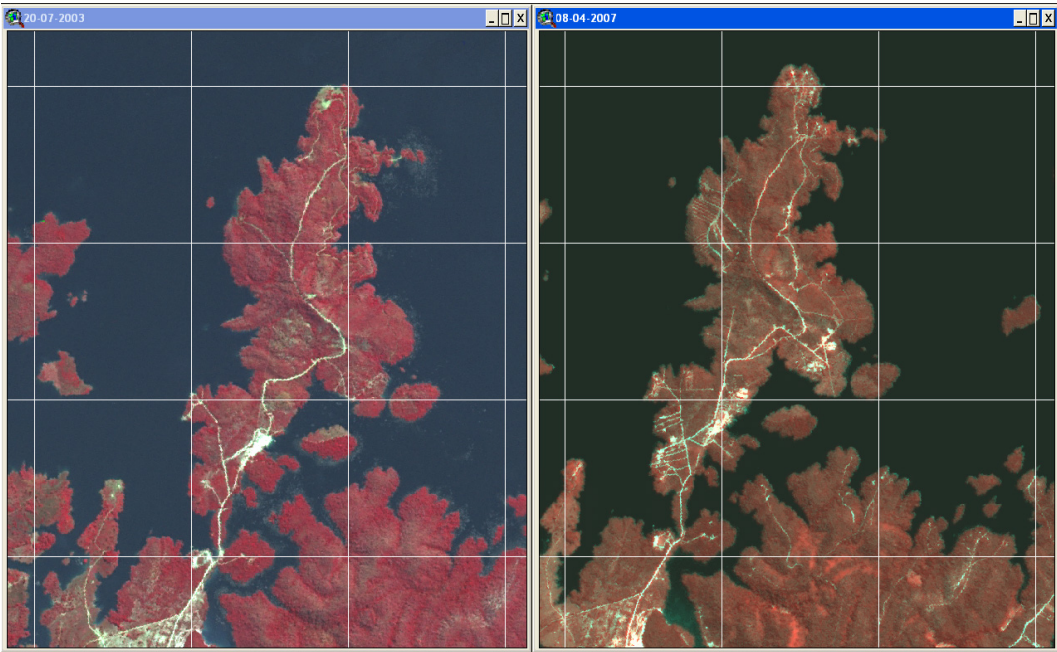


Biodiversity : Wildlife Habitat Monitoring



UNCBD COP9
Bonn, May 2008
ESA side event

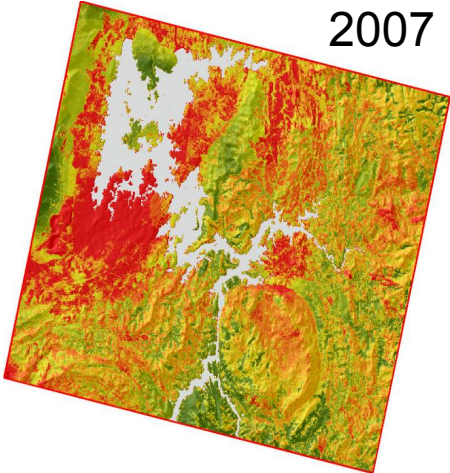
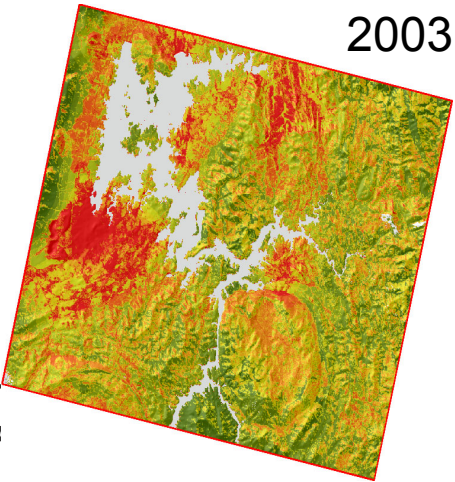
Energy & Biodiversity : Hydropower Dams, Brazil



Definition of indices for Sustainability reporting
In line with GRI guidelines to quantify forest fragmentation

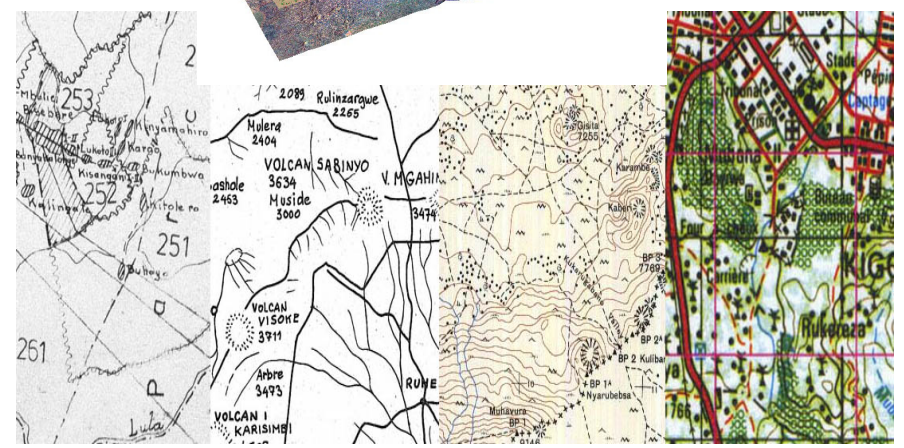
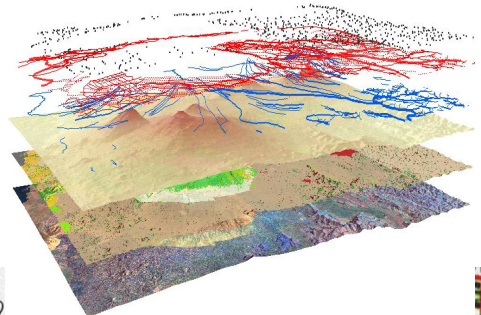
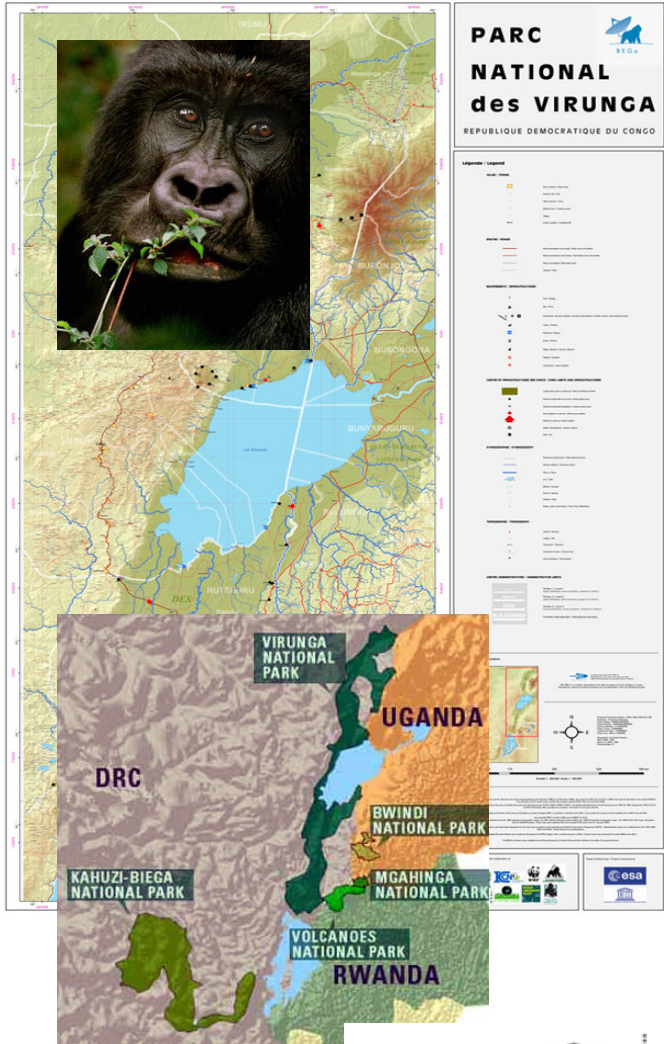


Tractele Engineering



Also useful to Support ECOSYSTEM SERVICES

Biodiversity : UNESCO World Heritage, Congo



"These maps make our efforts more effective, we can also clarify the exact location of our national park boundaries, improve our biological inventories of the parks, and plan out gorilla eco-tourism."

Eulalie Bashige, Director General of the Institut Congolais pour la Conservation de la Nature (ICCN) of the Democratic Republic of Congo (DRC)

Water Security : Drought Early Warning System

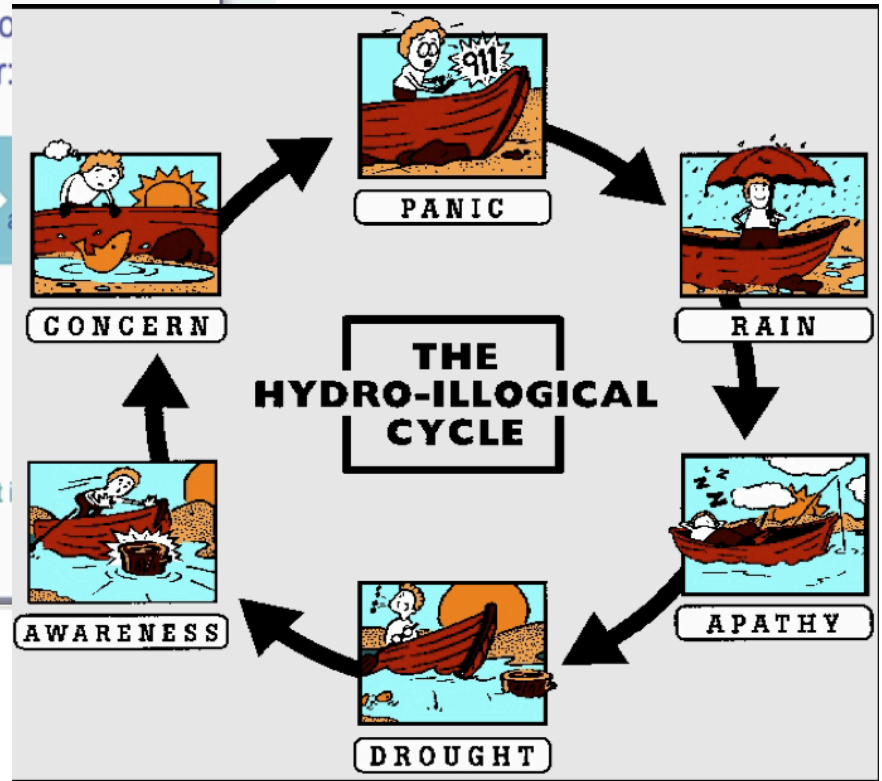
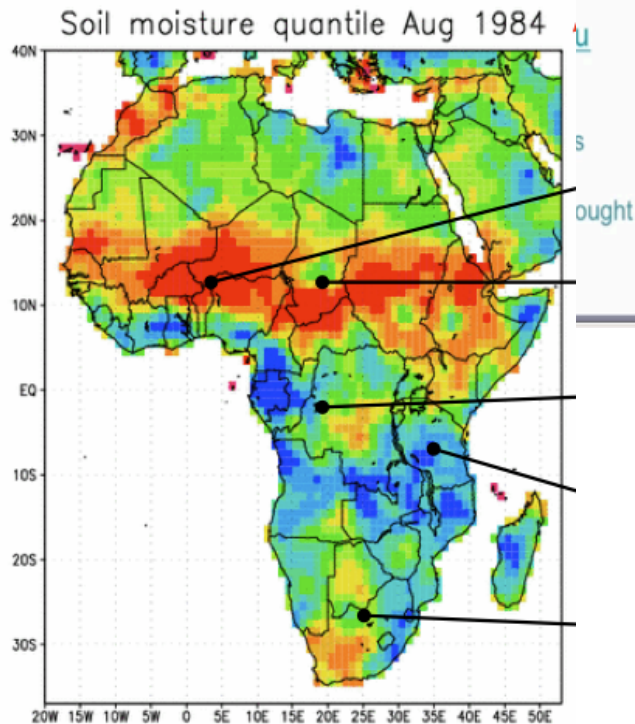
- ▼ AIP-3 Introduction
 - Instructions
 - Sections Overview
- ▼ SBA Scenarios
 - Energy
 - Disaster Management
 - Biodiversity: E-Habitat
 - Biodiversity: Arctic SDI
 - Air Quality
 - Drought: Global
 - Drought: European**
- ▼ Technical Arrangements
 - Data Sharing
 - Data Harmonization
 - Semantics & Ontology


 GROUP ON EARTH OBSERVATIONS

European Drought Observatory (EDO)

Joint Research Centre (JRC) develops
 prototype of EDO by 2012 for





Courtesy Don Wilhite, Eric Wood, Voigt

Food Security : Agriculture

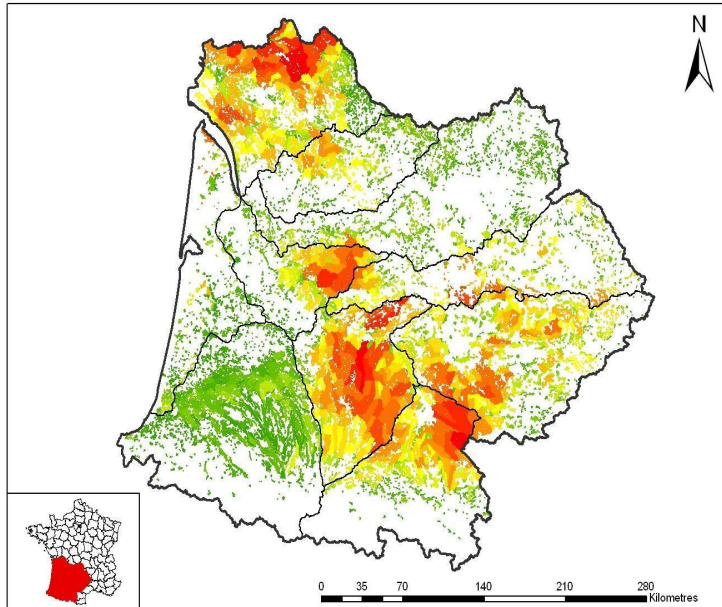


Winter-spring Crops map 2005
per hydrological unit
- Adour Garonne catchment -

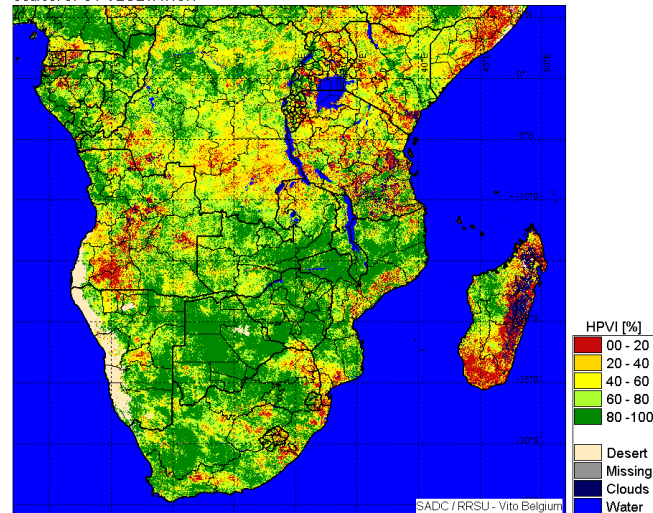
GSE Land



Agence de l'Eau
Adour Garonne



Region: SADC
Period: February, 2008, Dekad 2/3
Theme: Normalized Difference Vegetation Index (NDVI)
Historical Probability VI (HPVI = VPI)
Source: SPOT-VEGETATION



HR Land cover map 2005
(Moselle / Sarre catchment)

Aquaculture, Chile



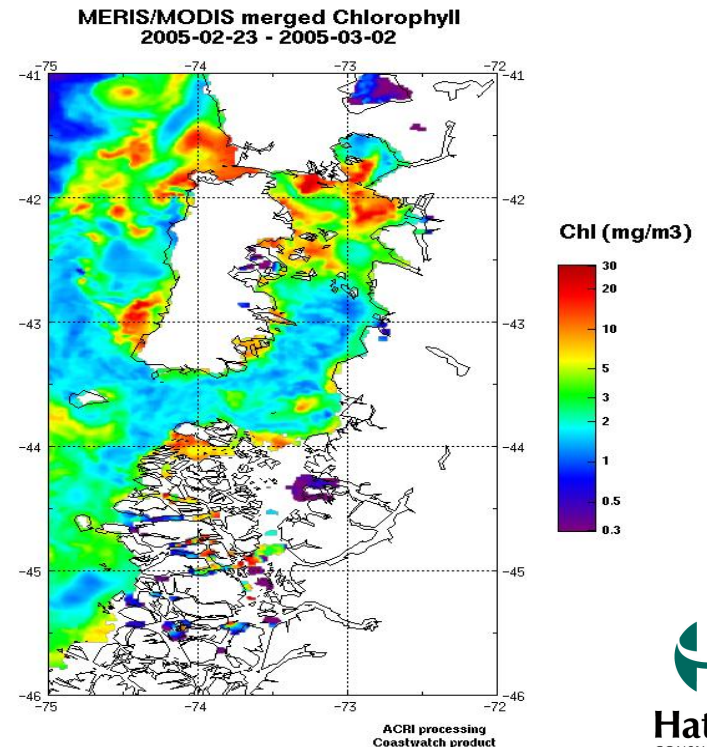
Chile is becoming key producer of salmon in the world
(\$1 billion/yr)

Industry report in Chile estimated the losses to the industry
from Harmful Algae Bloom (HABs)
are \$50 Million USD/year (2004).

NRT EO data have been integrated in a hydrodynamic model
to provide via internet a **HAB Early Warning Service**.

*"To obtain the amount of information covered with
the EO data, alternative methods will be of
considerable higher cost. With in situ measurements
you cannot produce a gradient map as obtained with
EO images. The value of this information is the area
and resolution obtained in a single didactic image."*

Francisco Puga , Manager, Mainstream Group
Development



Flood Risk : Glacial Lake Outburst, Nepal

1985 Dig Tsho outburst

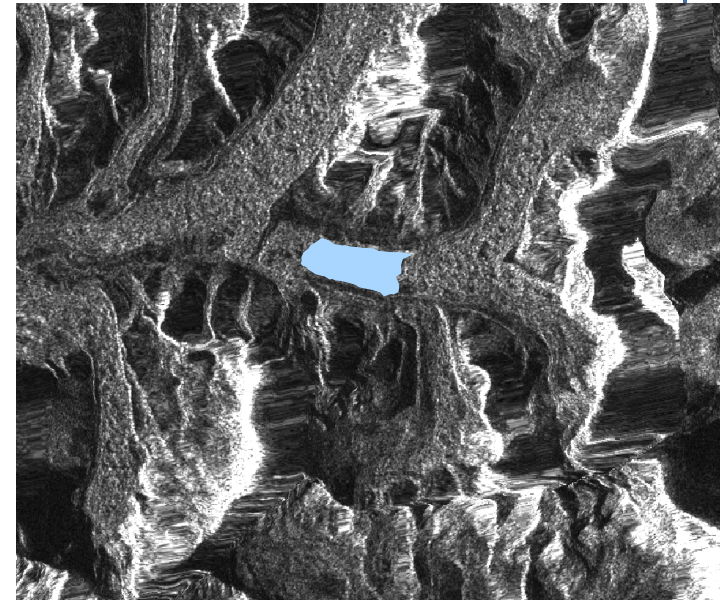


GMES service delivered to International Centre for Integrated Mountain Development“.



On average, air temperatures in the Himalayas are 1°C higher now than in the 1970s.

2000+ glacial lakes in Nepal out of which a few are estimated to be potentially dangerous.



ENVISAT ASAR 09 Mar 2007
Lake Imia, Nepal



International Space Charter



The poster features a blue background with a grid pattern. At the top left is the International Space Charter logo, which includes a globe and the text 'INTERNATIONAL CHARTER FOR SPACE & MAJOR DISASTERS' and 'L'Accordo Internazionale sullo Spazio e le Catastrofi'. Below the logo, the title 'International Charter Space and Major Disasters' is written in white and yellow. A central text block reads: 'Space Agencies together support humanitarian relief efforts around the world.' The bottom left shows a satellite in orbit over Earth. The right side of the poster is a vertical strip of six images: a volcanic eruption, a flooded area with people, a lava flow, a bird on a branch, a storm, and a polluted river. Logos for ESA and CNES are at the bottom right. The text 'European Space Agency' and 'Agence spatiale européenne' is at the bottom left.

International Charter
Space and Major Disasters

Space Agencies together support humanitarian relief efforts around the world.

European Space Agency
Agence spatiale européenne

esa
CNES

- Aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through authorized users
- Authorized users are a **civil protection, rescue, defense or security body** from the country of a Charter member
- Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property
- Members are: ESA, CNES, CSA, NOAA, ISRO,... ect.

Concluding Remarks

*Mankind has become a
geophysical parameter*

***Water has become
a strategic security
issue***

***Data needed to make
informed decision
EO from Space, the
global view***

***EO from Space
the global view***



Relying on special type of experts
..... without accurate data

Many thanks for your attention ...



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