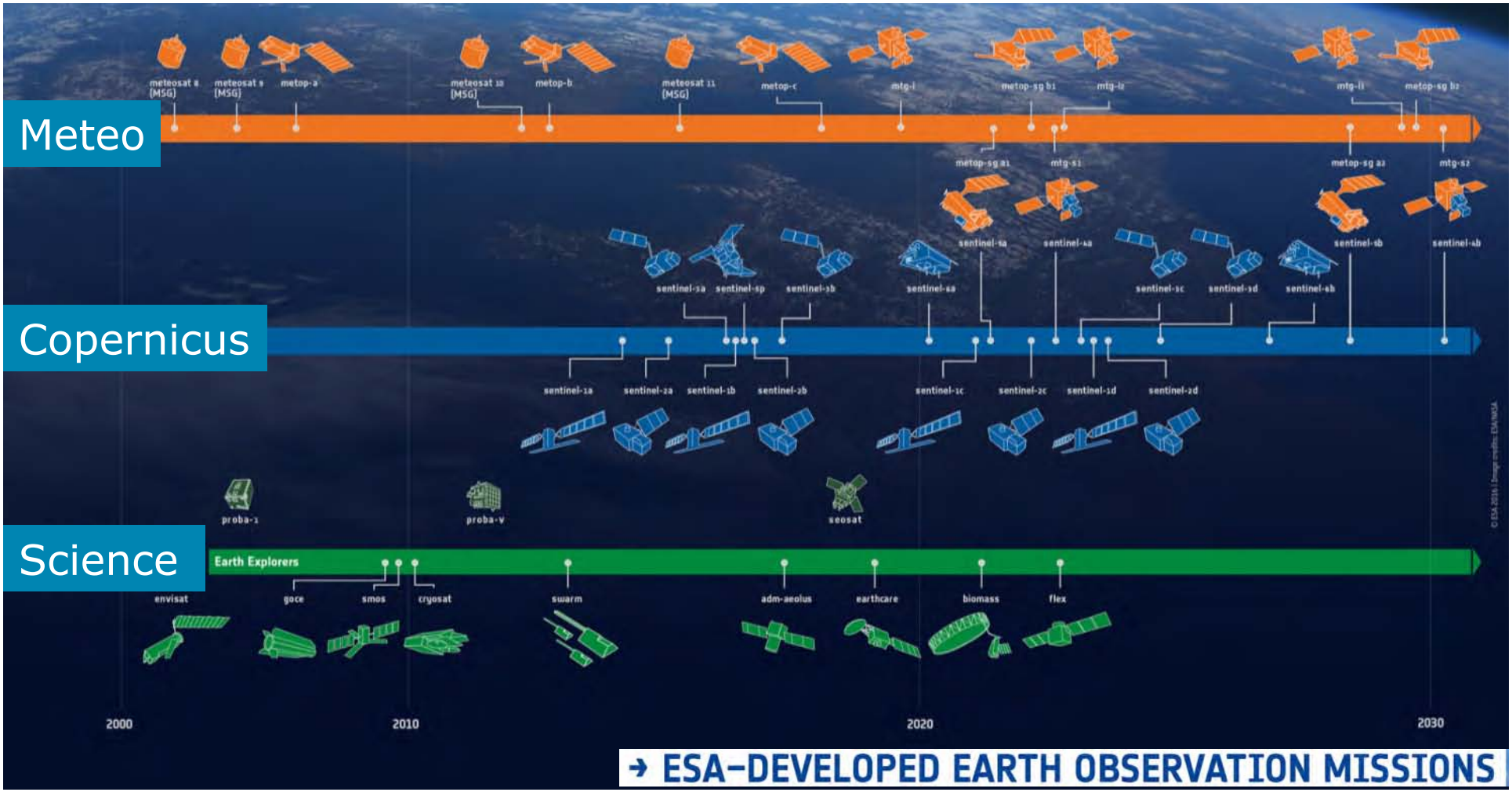
ESA's Earth Observation Programmes - Activities related to GEWEX

GEWEX SSG 6. – 9. March 2017

Sanya, China

Michael Rast
ESA-ESRIN


Meteo
Copernicus
Science
meteosat 8 (MSG)
meteosat 9 (MSG)
metop-a
meteosat 10 (MSG)
metop-b
meteosat 11 (MSG)
metop-c
mtg-i
metop-sg b1
mtg-i2
mtg-i1
metop-sg b2
metop-sg a1
mtg-s1
metop-sg a2
mtg-s2
sentinel-5a
sentinel-4a
sentinel-5b
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sentinel-5p
sentinel-3a
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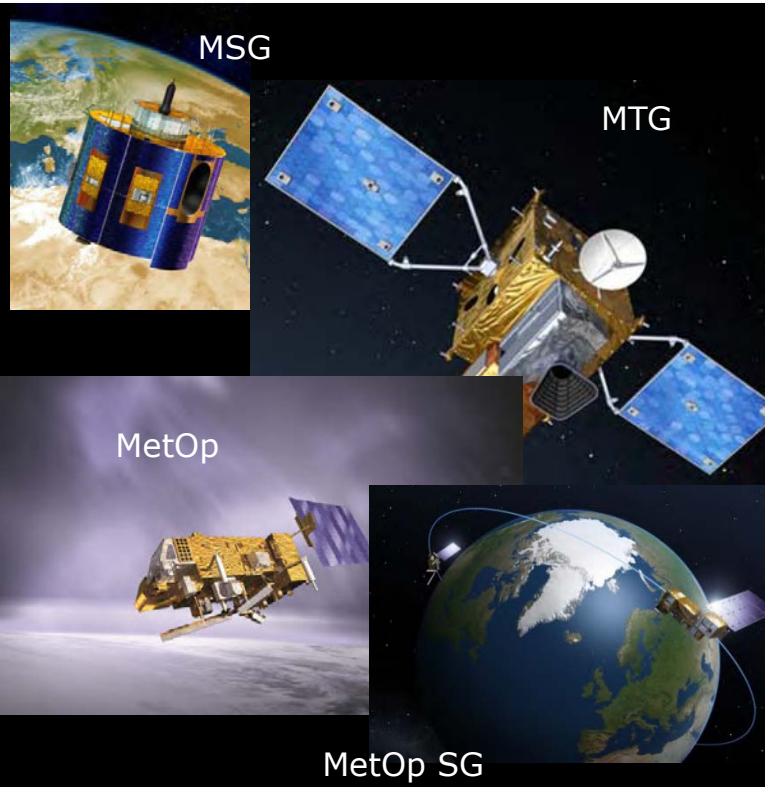
sentinel-2d
proba-1
proba-v
seosat
Earth Explorers
envisat
goce
smos
cryosat
swarm
adm-aeolus
earthcare
biomass
flex
2000
2010
2020
2030
→ ESA-DEVELOPED EARTH OBSERVATION MISSIONS

Meteorological Missions

- ESA develops prototype satellites and, on behalf of EUMETSAT, procures recurrent satellites
- EUMETSAT operates the satellites
- Currently Meteosat Second Generation (MSG) in GEO and MetOp in LEO in orbit
- Meteosat Third Generation (MTG) and MetOp Second Generation under development, launch in next decade



Copernicus: A New Generation of Data Sources

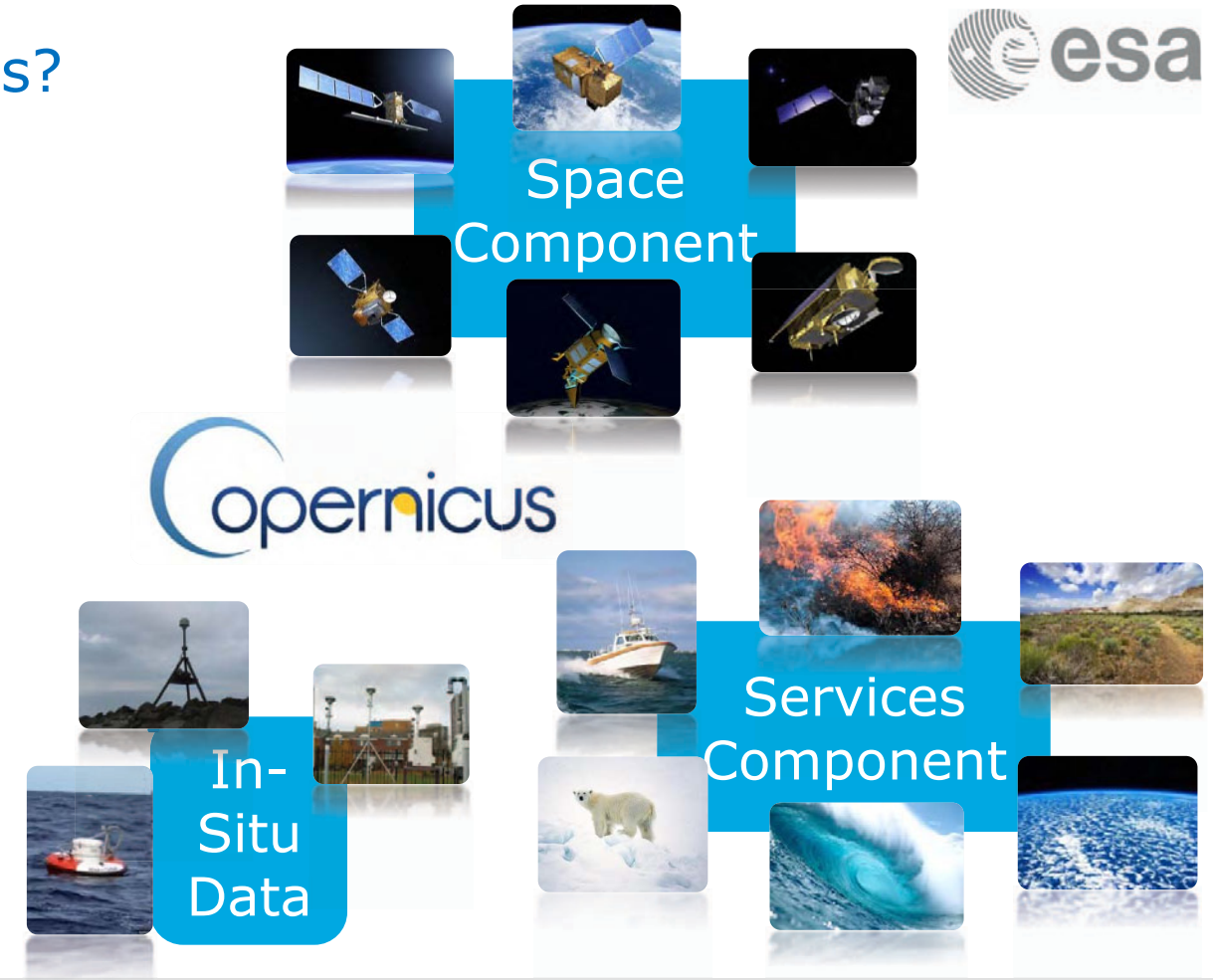
- Copernicus - European space flagship programme, led by the EU
- ESA is responsible for space component, Sentinel development, operation of some Sentinels, data buy from other partners, system evolution
- Sentinels – most comprehensive EO system world-wide for environmental monitoring
- Free and open data policy

European Space Agency

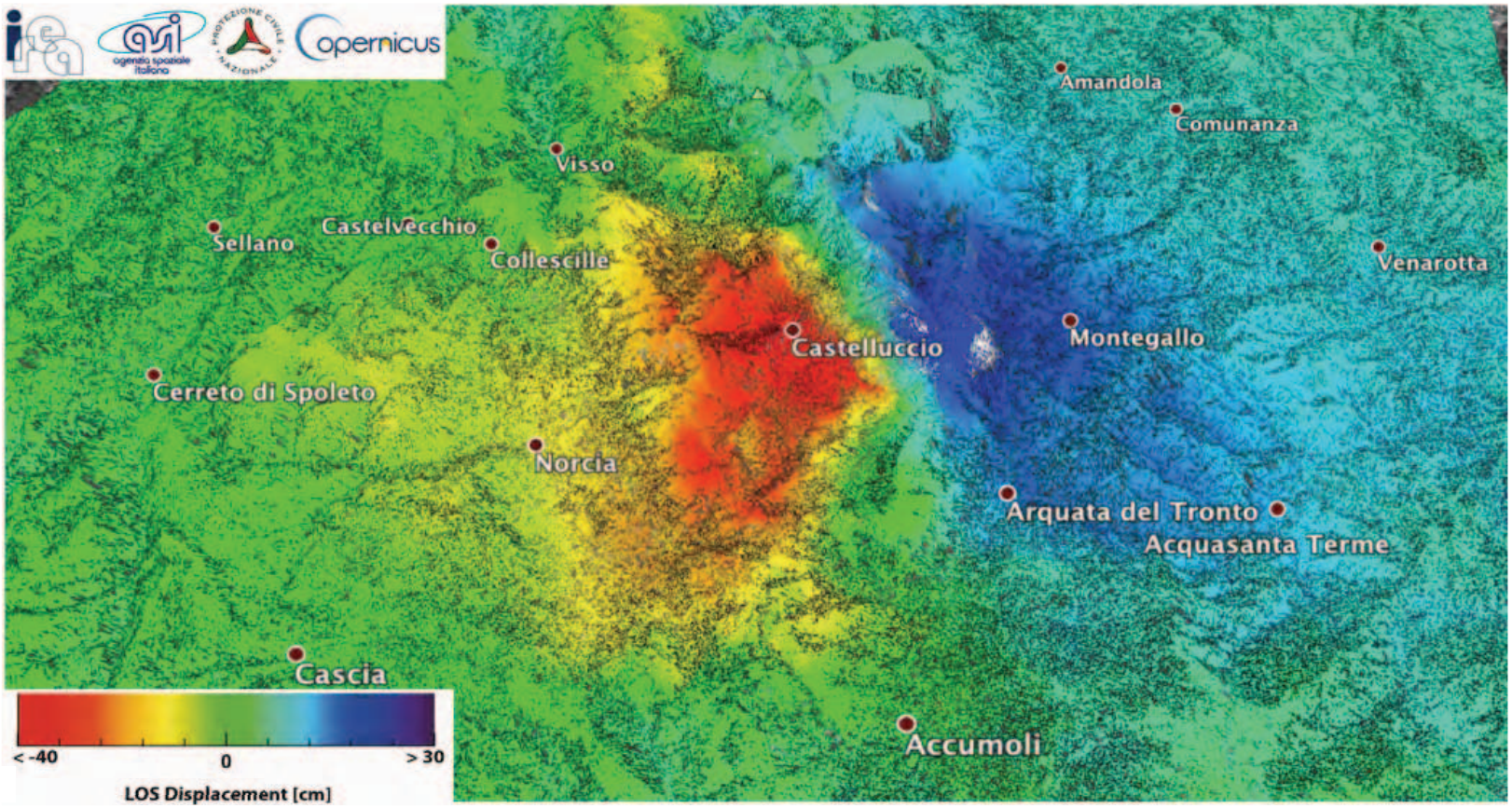
What is Copernicus?

European response to global needs:

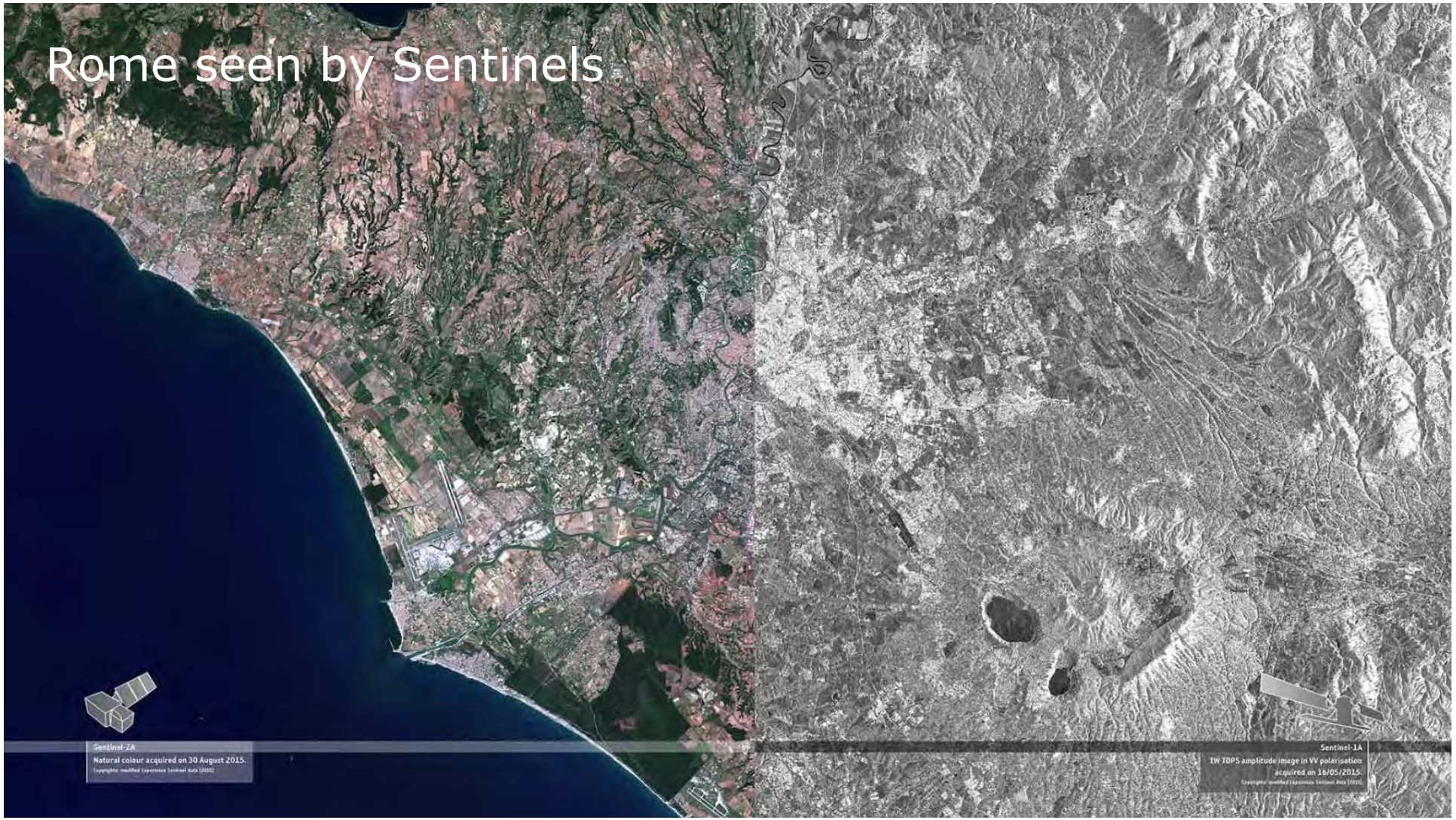
- to manage the environment,
- to mitigate the effects of climate change and
- to ensure civil security



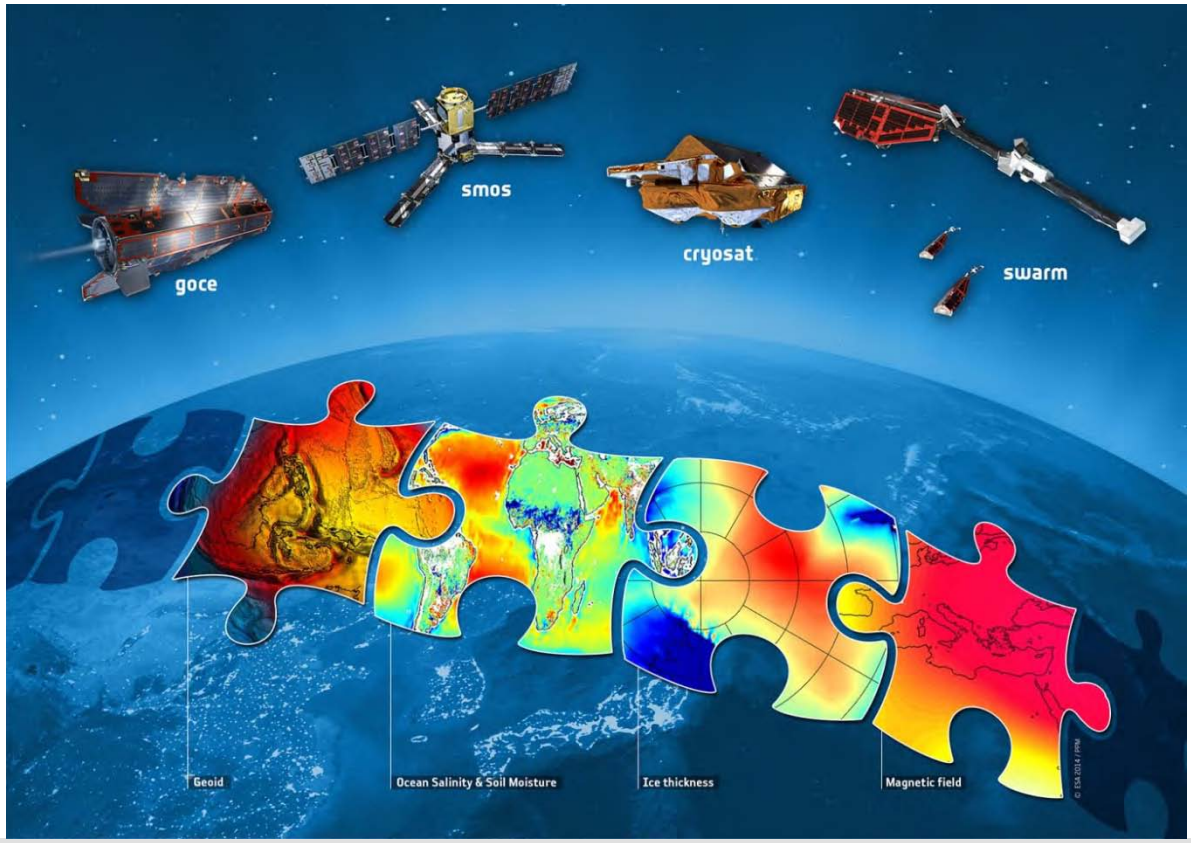
Copernicus: Earthquake Italy 30 Oct 2016



Rome seen by Sentinels



Earth Explorers launched so far

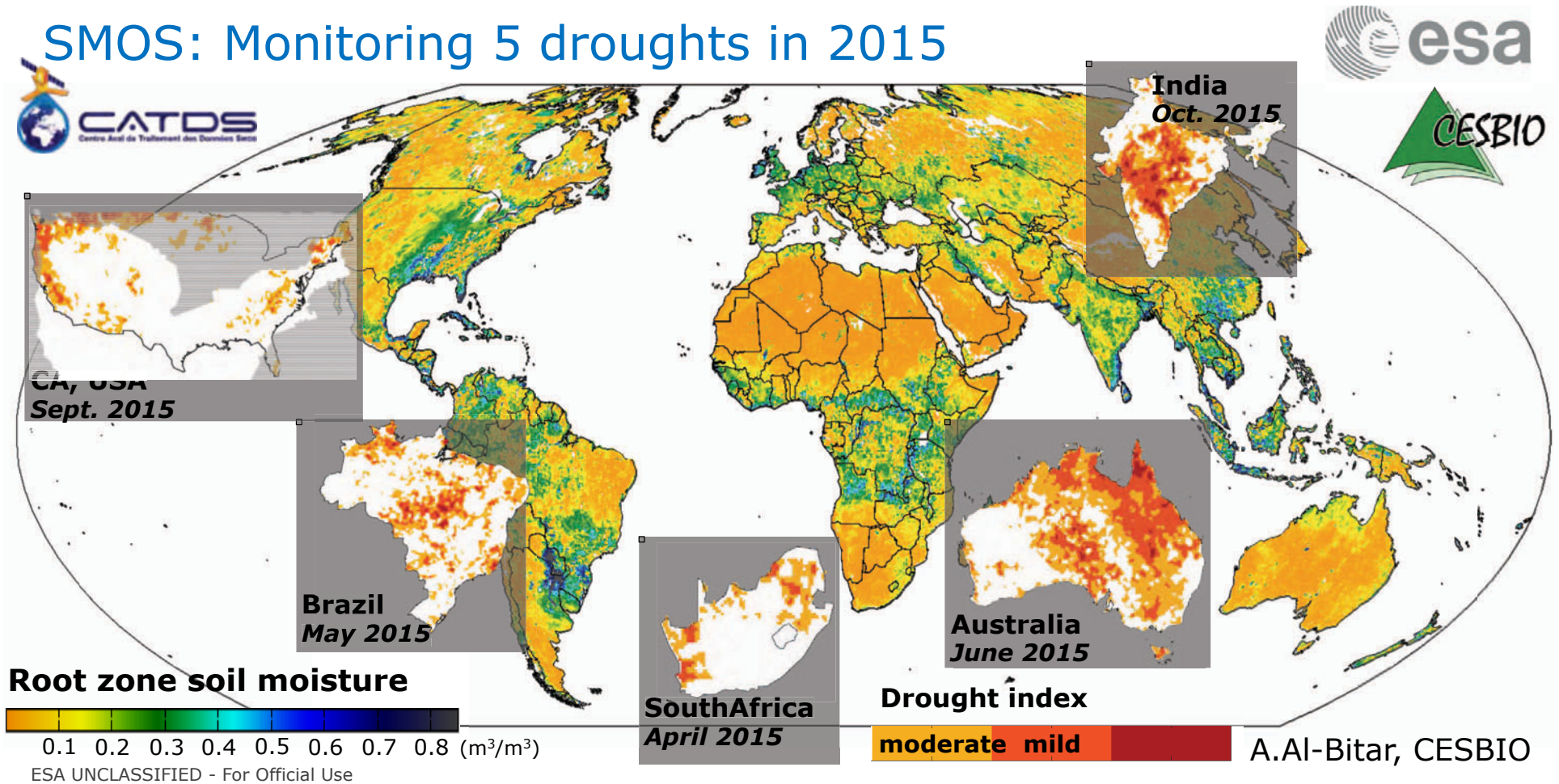


Swarm: Wandering Magnetic North

SMOS – Surface Moisture and Ocean Salinity

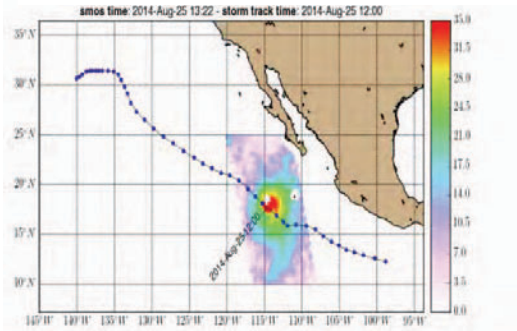
- Data delivery since February 2010
- Complete Earth coverage within three days
- Radio Frequency Interference (RFI) mitigation continues
- Outstanding international cooperation

SMOS: Monitoring 5 droughts in 2015

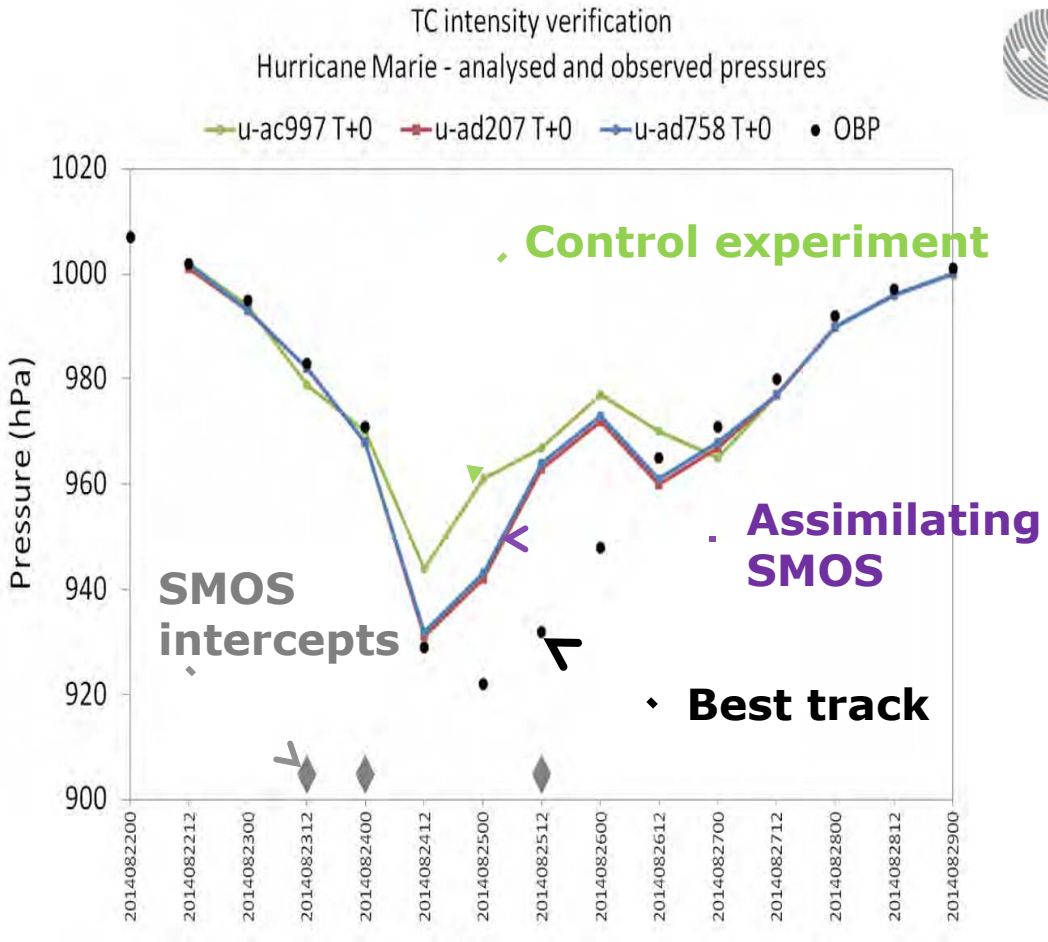


SMOS and Storms

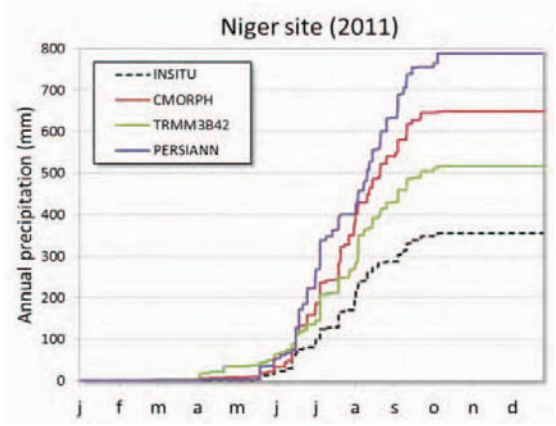
Track and intensity of Hurricane Marie, Aug 2014, according to Saffir-Simpson hurricane wind scale



SMOS intercepting Hurricane Marie



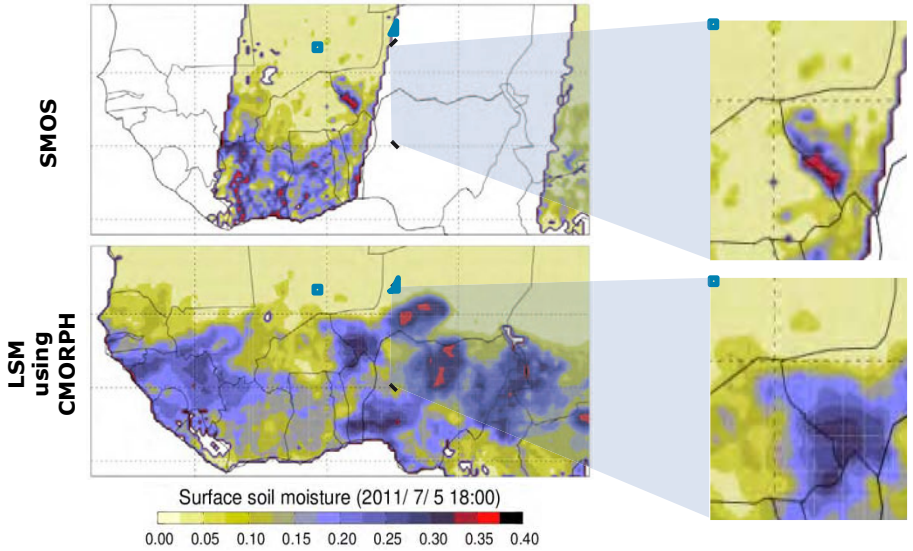
Enhancing Rainfall estimates bottom-up



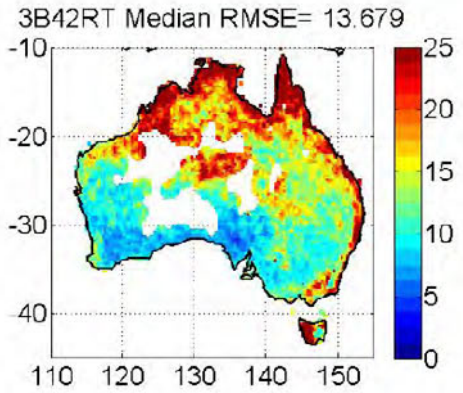
- The project will further advance three existing methods; SEN2RAIN (IRPI, IT), LMAA (LTHE) and SMART (USGS);
- Develop and validate new products at global scale with error and uncertainties characterisation.

On-going research and development continues to address the accuracy and the resolution (temporal and spatial) of rainfall products (Kidd and Levizzani, 2011).

Rainfall signals from soil moisture observations may help to enhance existing rainfall products (example below shows the soil moisture signal of a rainfall event captured by SMOS and not by a LSM based on CMORPH)



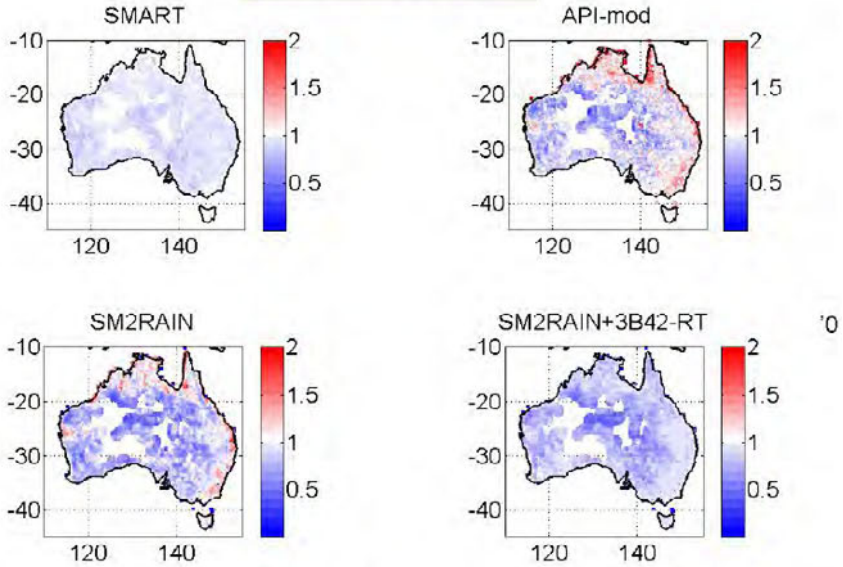
Enhancing Rainfall estimates bottom-up



RMSE maps for 5-day rainfall accumulation

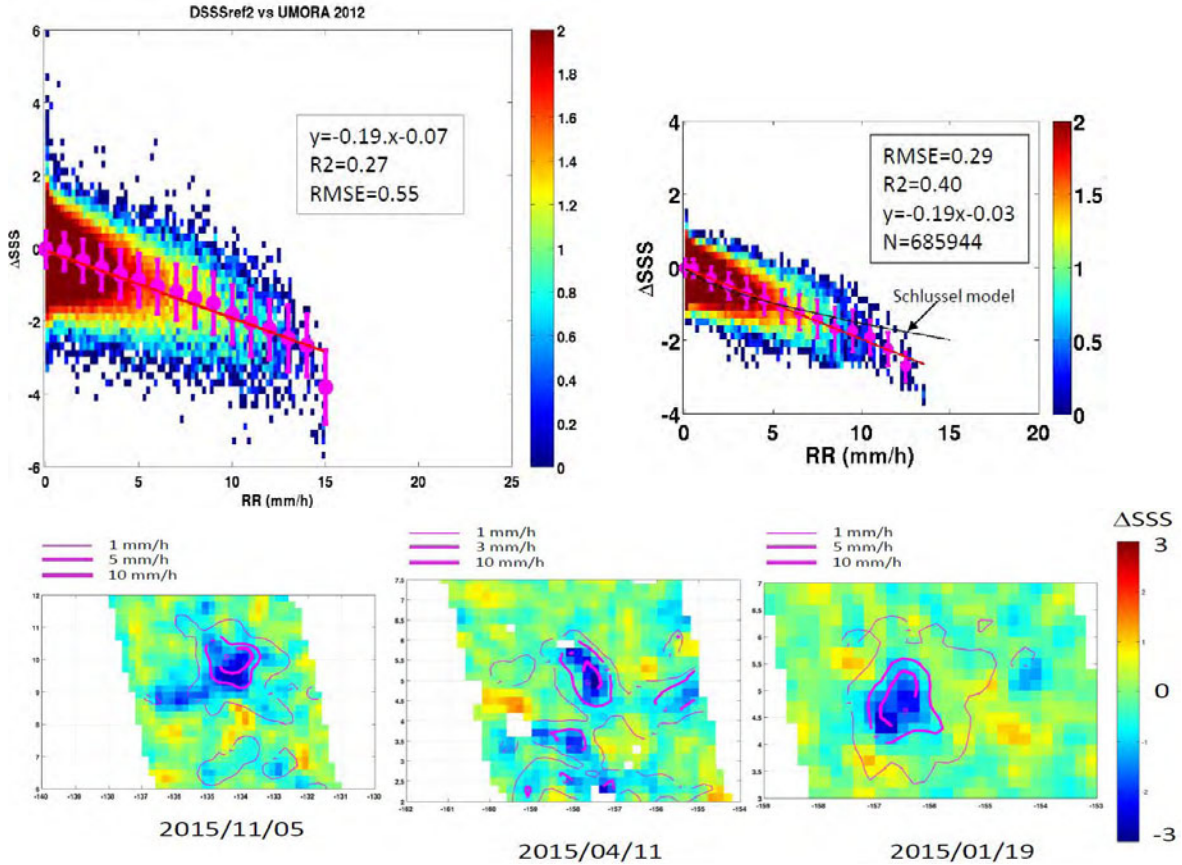
AWAP observed rainfall as benchmark

RED: WORSE ☹
BLUE: BETTER ☺



Ratio between the RMSE maps obtained with the "corrected" products and 3B42RT

Enhancing Rainfall estimates over the Ocean



To which extent can we use SSS as a rain gauge?

- **No direct relationship between monthly RR and monthly SSS freshening (other processes (e.g. advection) play a big role)**
- **Can we characterize a DSSS-RR relationship at short time scale (~30mn)?**

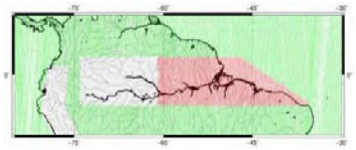
SMOS DSSS & RemSS RR [-15mn; +30mn] Pacific ITCZ 2012 year. Slope ~-0.2pss/ mm/h

Satellite rainfall (SSMIs) and SMOS freshenings (DSSS = SSS-SSSref) are closely correlated (Boutin et al. 2013, 2014) at local scale and short temporal scale (<30mn)

Cryosat – the Ice Mission

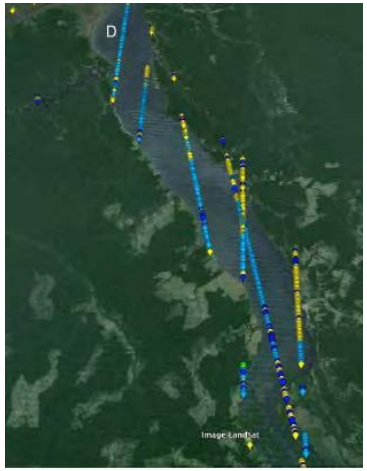
- First interferometric altimeter in space
- Global sea ice thickness measurements
- Data used for ice research, but increasingly also for oceanography

CryoSat SAR for Inland Waters

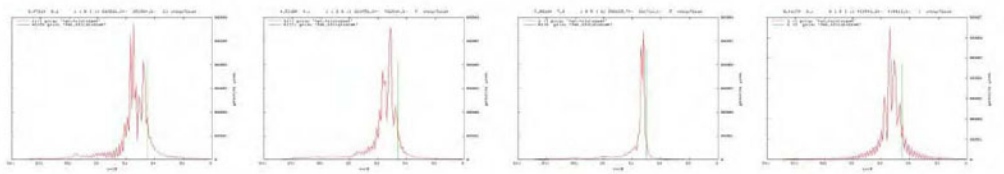


Six months of SAR (red) and LRM (green) tracks over the Amazon Basin

Previous satellite radar altimeters lost significant amounts of information due to onboard echo averaging. The high along-track sampling of Cryosat-2 altimeter in SAR mode offers the opportunity to recover high frequency signals over much of the Earth's land surface.



3.5 month of SAR L1B data categorized using waveform shape with water echoes selected using a river mask. Shape identification gives geographic distribution of water-waveforms and complex echo shapes with water components. Brightest echoes often complex shapes, multi-target responses.

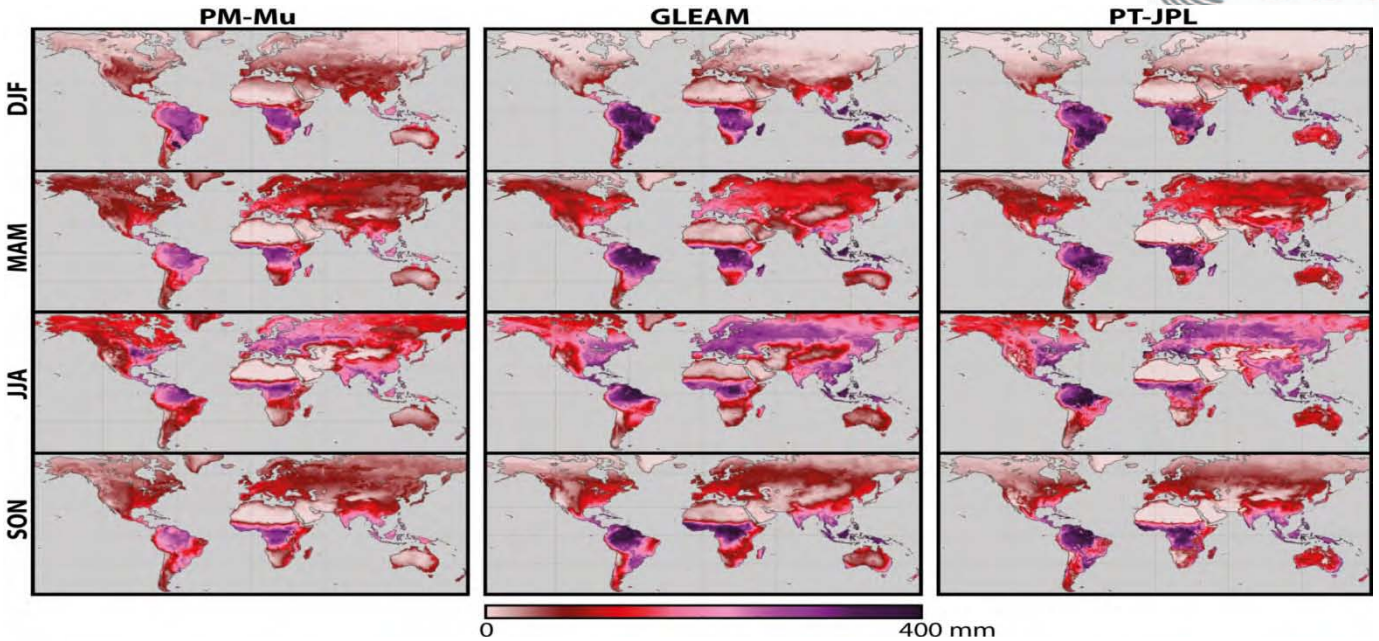


Combination of 'simple' quasi-specular returns and complex multi-target echoes (more numerous than from previous altimeters) allows to enhance waveform parameterisation in order to improve height calculation.

WACMOS-ET: Intercomparison of Global ET

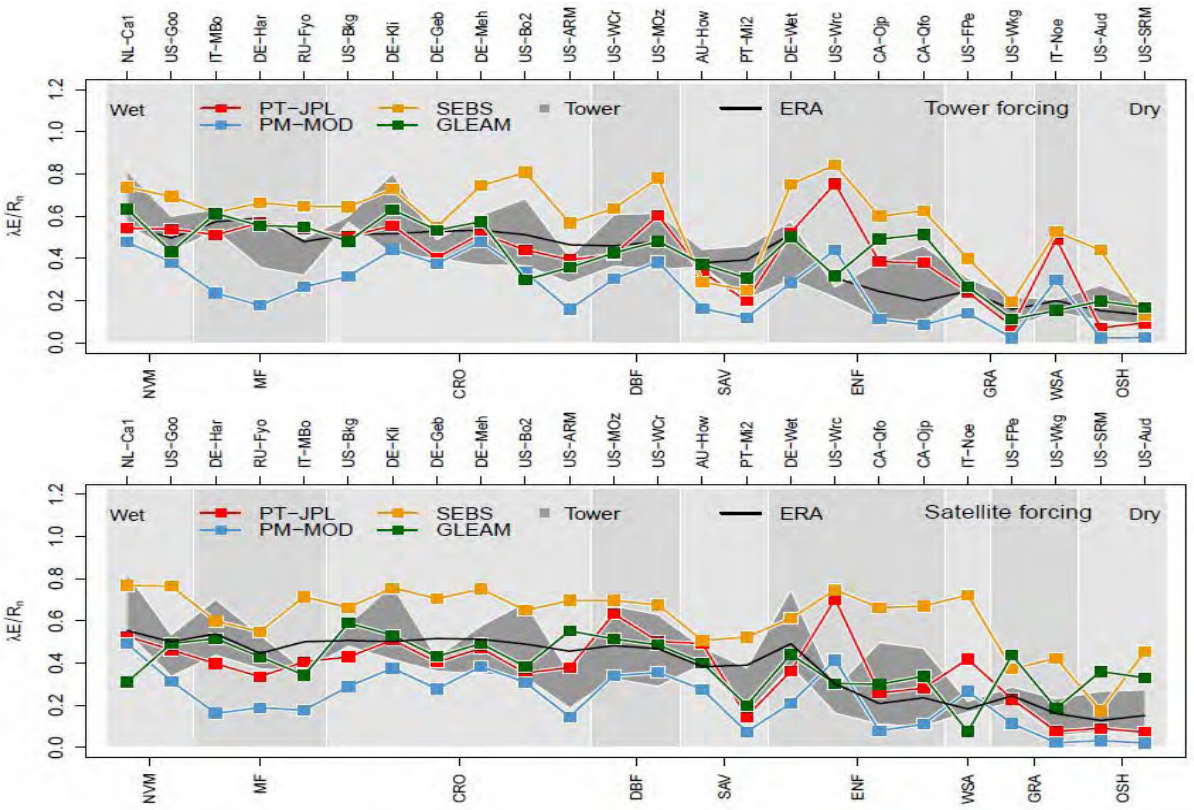
WACMOS-ET was a contribution to GEWEX LandFlux to cross-compare main global ET products: PM-Mu, PT-JPL, GLEAM and SEBS.

Comparison was based on a reprocessing of algorithms based on a reference input dataset.



Mean seasonal differences. Average evaporation for PM-Mu, GLEAM and PT-JPL during boreal summer (June, July and August) and austral summer (December, January and February). The ERA-Interim reanalysis and MTE are considered for comparison. The three years of data (2005-–-2007) are used in the calculation of these seasonal averages

WACMOS-ET: Intercomparison of Global ET



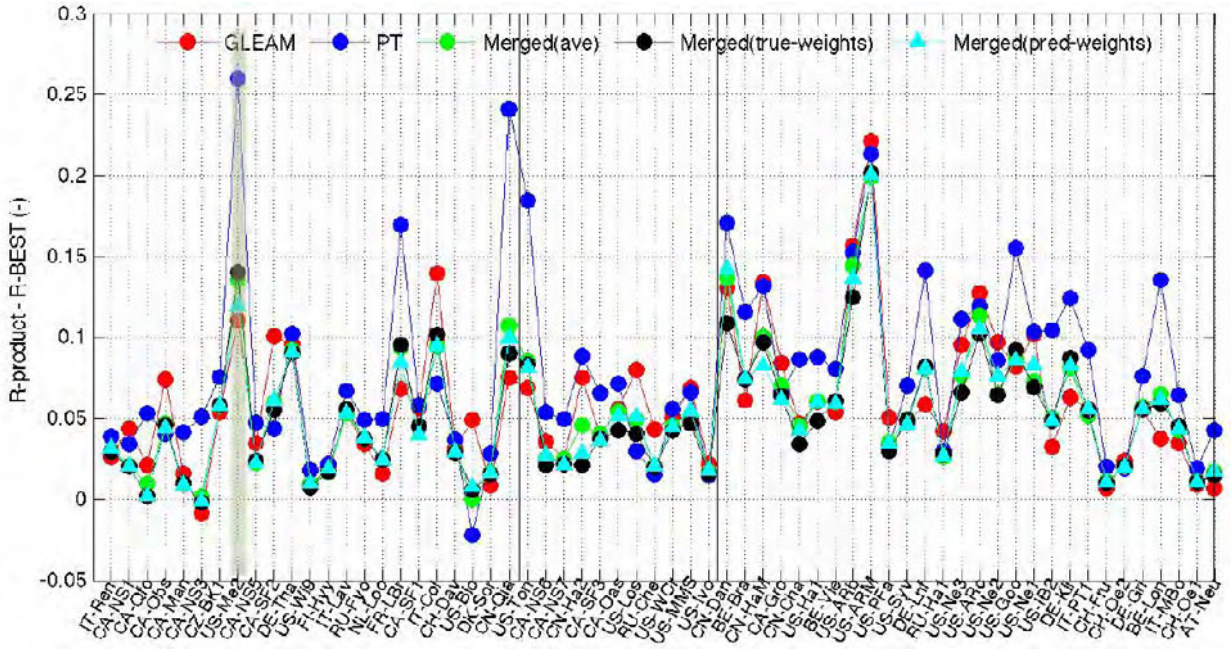
Station means of 3-hourly Evaporative fraction derived from Eddy Covariance-observed and estimated with tower-forced (top panel) and satellite-forced (bottom panel) against tower reference, as function of biomes, sorted from wet to dry (based on the biome average).

The grey area denotes the range of evaporative fraction (grey area) between Eddy Covariance and Energy Residual tower measurements.

The black line denotes EF derived from ERA-Interim ET and Rn.

WACMOS: Intercomparison of Global ET products

Contribution to GEWEX Land-Flux



As a reference a BEST product was created by choosing the closes estimate (GLEAM or PT) to the tower observation.

Figure plots the difference between product correlation and BEST product correlation.

At 41/62 stations weighted R > average R for "true" weights method, 36/62 for predicted weights, but again very small differences.

In overall the merging approach enhance single products except for a number of towers.

An experiment with a larger datset of tower data needed.

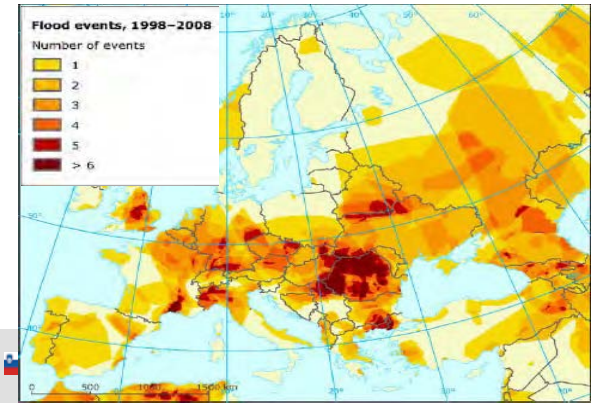
WACMOS-MED: A new collaboration with HYMEX

ESA-HYMEX WACMOS-Med*:* Is a new collaboration with the Mediterranean regional project of GEWEX (HYMEX) aimed at:

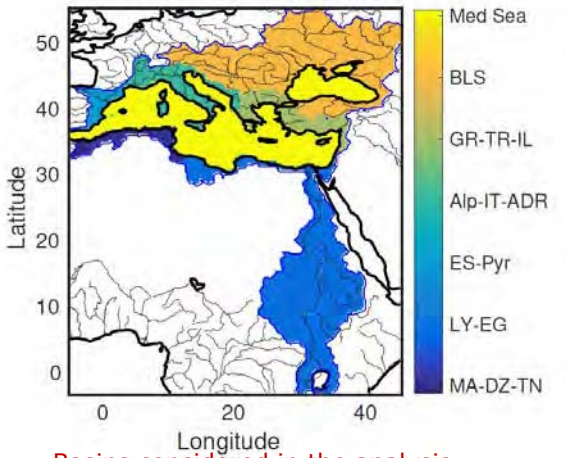
- Assess the quality of current EO-based products to characterise the water cycle over the Med area;
- Develop a new consistent datasets of the ocean , land and atmosphere products that closes the water budget over the Mediterranean area;
- Perform a water cycle budget closure experiment assessing the variability and trends of the Mediterranean water cycle based on EO;
- Implement an integrated approach exploiting the budget closure condition as a constrain to merge the existing different datasets;

The project will also:

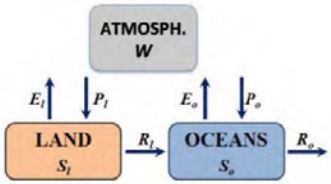
- Study the impact of climate variability on the Mediterranean water cycle;
- Enhance current estimates of river discharge;
- Study the links of the water cycle and Oceanic circulation;
- Explore potential improvements to Flash-floods predictions;



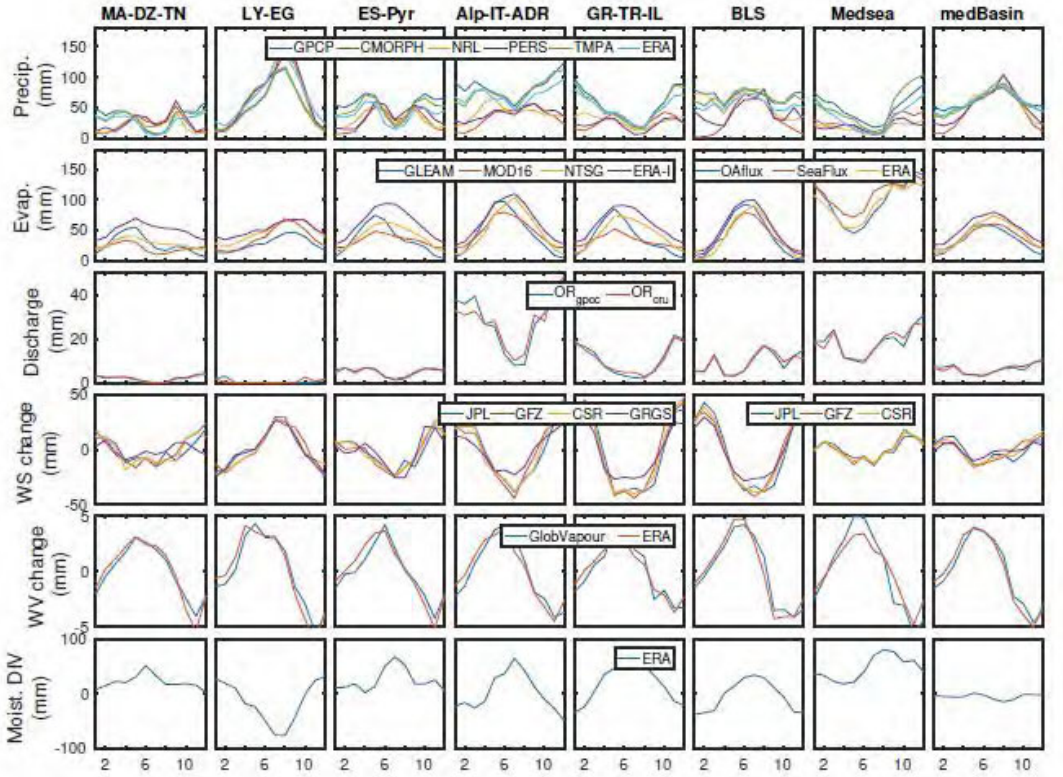
Advancing Science: Water Cycle in the Mediterranean



Basins considered in the analysis

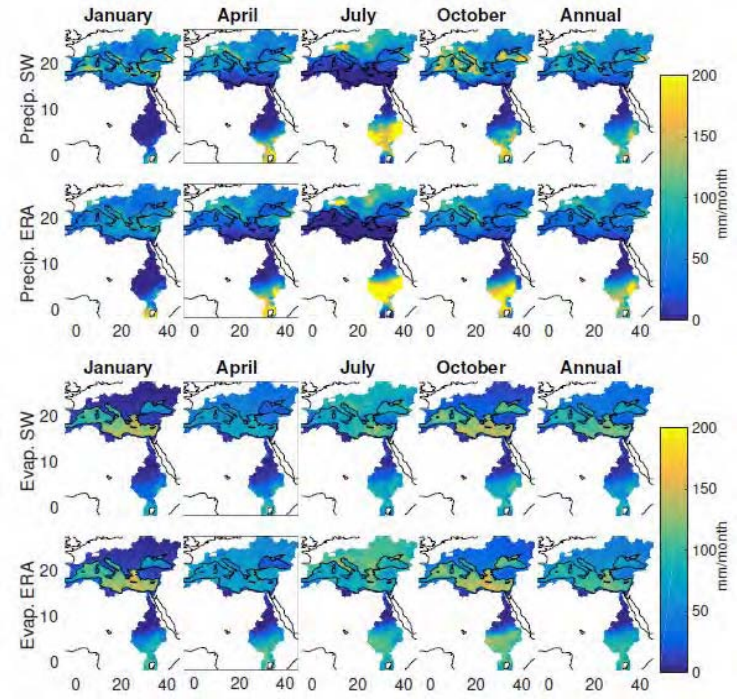


Integration approach will consider ocean, atmosphere and land components

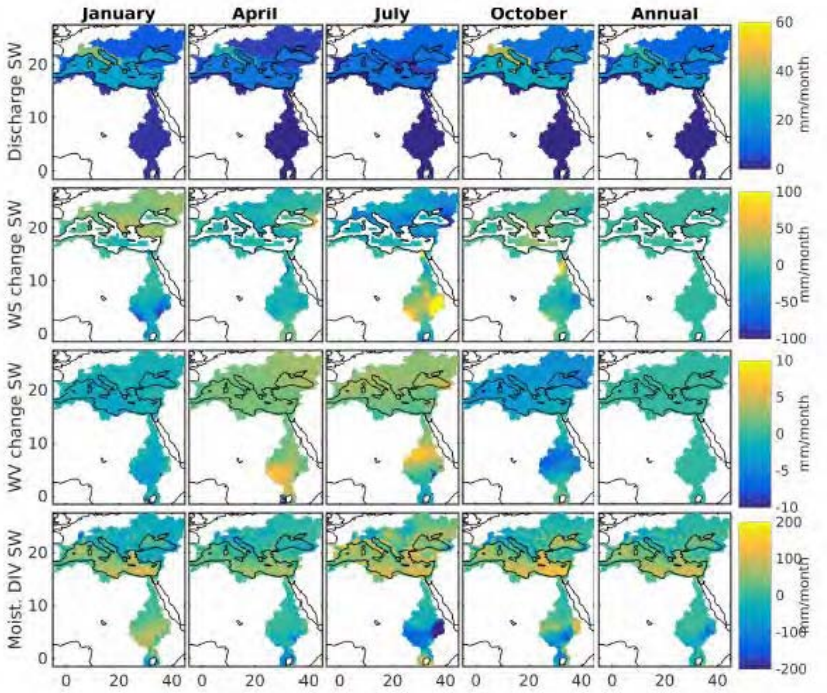


Water cycle seasonality depicted through its various water components (in rows) over the various sub-basins (in columns) in Mediterranean region viewed from Earth Observation and reanalysis

WACMOS-MED: Water Cycle in the Mediterranean

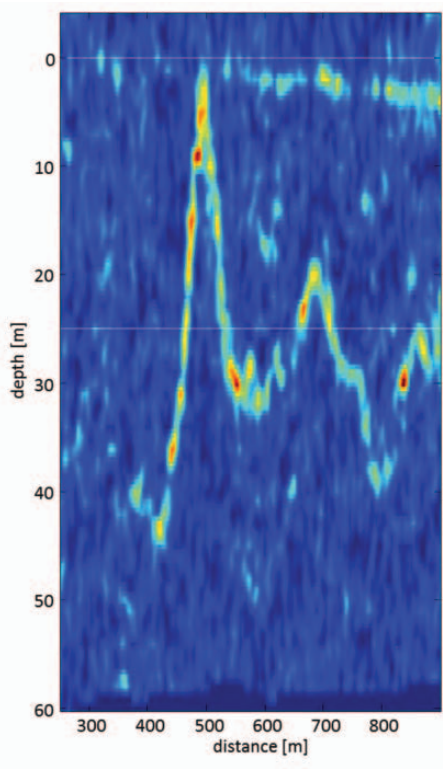


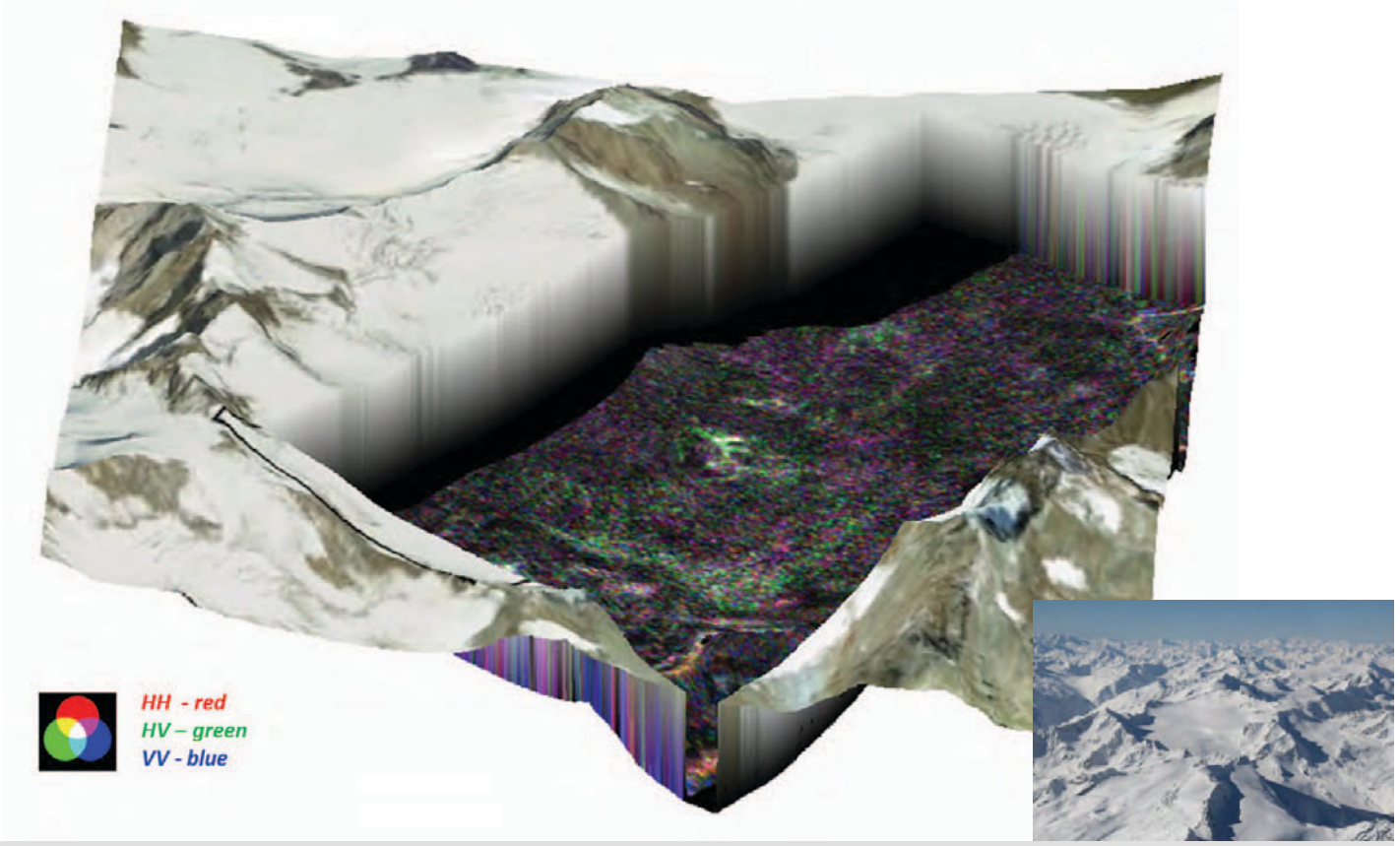
Monthly mean patterns for: precipitation (top panel) and evapo(transpi)ration (bottom panel) using a simple weighting (SW) integration approach (first row of each panel) and ERA-I (second row).



From top to bottom, monthly mean patterns for: discharge, water storage, water vapor and moisture divergence in SW.

Mountains under Mittelbergferner Glacier





TIGER Capacity Building Facility (TCBF):

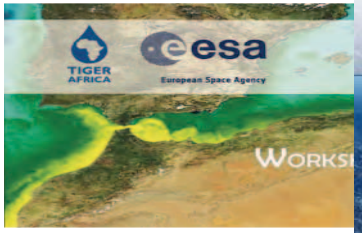
Training Activities:

Dedicated Training courses in Africa & Europe

Empowerment of Regional Centres: AGHRYMET (Niger), RCMRD (Kenya), SANSA (South Africa); OSS (Tunisia)

Partnership with UNDP Cap-Net for Training of Trainers

Water Research Component



TIGE , South Africa

"To us TIGER is the precursor for GMES & Africa, particular if we look water resource management…"
Mahama Ouedraogo, African Uni

African EO Water Community

- **100** registered participants
- 19 African & 10 European countries
- 8 trans-boundary Basin authorities, 10 National water authorities, 9 Intergovernmental Organisations, 31 R&D institutions
- 7th TIGER workshop since start of TIGER in 2002

African – European research collaboration
TIGER Research Projects & Fellowships

International Research Studies

Collaboration between **African and European scientists**

TIGER Research

Collaborative … between institutes – open research calls

TIGER Research Fellowships

1 year scientific visits of young African scientists

Objectives:

Identify water research topics in Africa

Develop innovative EO algorithms

Ongoing: 10 Research projects on Water for Agriculture

TIGER Capacity Building Facility (TCBF):

TIGER Training Kit

New
70h teaching

- Data & Tools (WOIS)
- Water quality monitoring
- Flood mapping
- Vegetation & evapotranspiration
- Crop monitoring
- Land cover mapping

Water Observation Information System For African Water Authorities

Objective: Enable African water authorities to improve IWRM by exploiting Earth Observation (EO) technology

- Implement an operational Water Observation Information System (WOIS) for monitoring water resources
- Developed in collaboration with African water authorities

400 downloads, 65 countries

- Transboundary Observation Capacity
- Transparent tool for Reporting & IWRM
- Sustainability through Open Source & CB

Support for Monitoring & Reporting

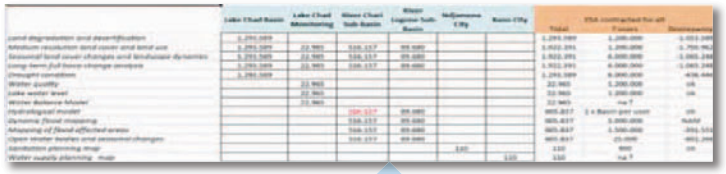
LAKE CHAD BASIN CHARACTERIZATION

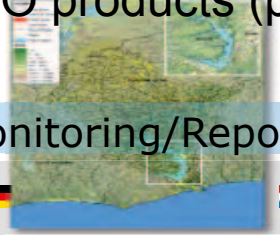
"The WOIS will allow us to assess environmental variables by catchment over the whole basin for the
1st State of the Lake Chad Basin Report"

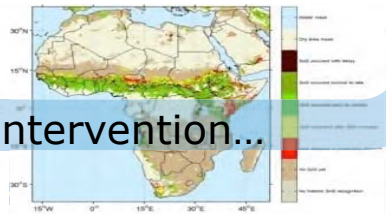
Mohammed Bila,
Head of the Lake Chad Basin Observatory, LCBC

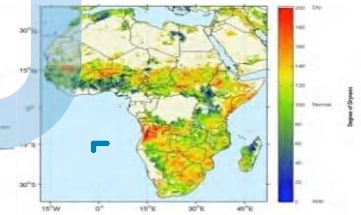
WOIS integrated information:

- hydrological network
- Land cover, seasonal and long-term map of changes
- Drought condition and water stress anomaly
- other operational EO products (precipitation, etc.)





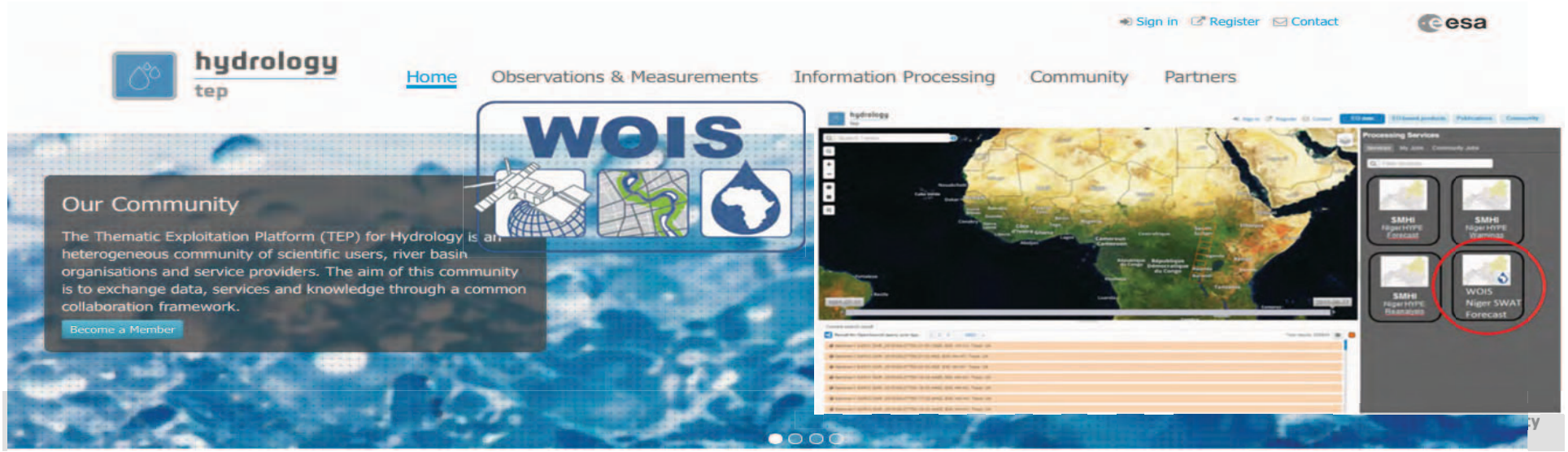




Monitoring/Reporting/Management/Intervention...

Hydro-TEP: WOIS in the cloud
Dealing with large data volume

- Collaborative & open platform for large data volume processing & sharing for IWRM
- Hydrological modeling, flood mapping, small water bodies mapping, water quality & water level
- Supports algorithm development, sharing of data, tools & knowhow



SDG 6.6 & 15.1: Freshwater Ecosystem

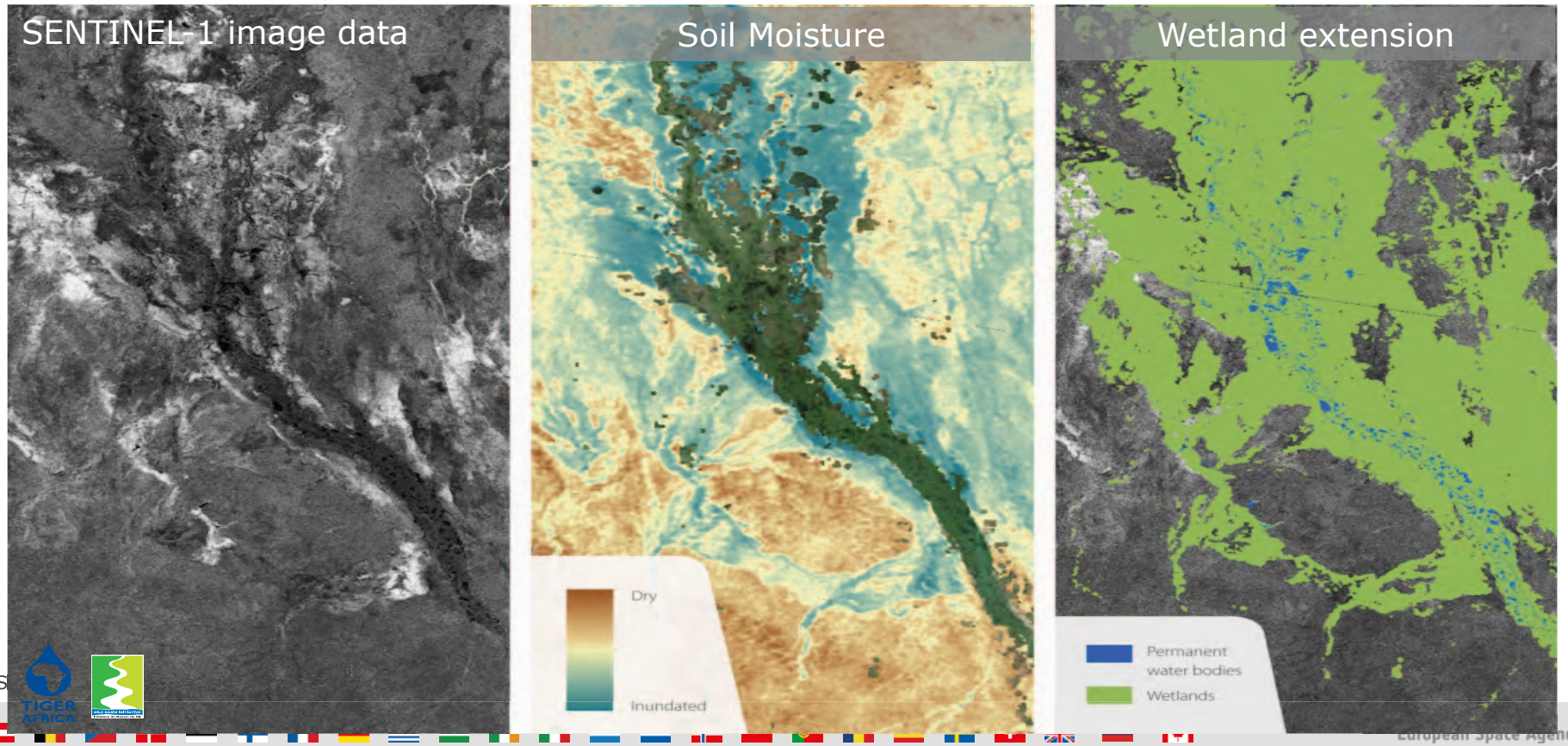
→ GLOBWETLAND AFRICA

Towards satellite-based Wetland Observing Systems in Africa

GLOBWETLAND AFRICA IN A NUTSHELL

- Exploit increasing capabilities of satellite observations for wetlands inventory, assessment and monitoring
- Develop EO methods and tools to better assess conditions of wetlands and monitor trends over time
- Enhance capacity of African stakeholders to develop national and regional wetland observatories
- Access "freely available" satellite data from the Sentinel missions of the European Copernicus initiative

SDG 6.6 Water & Wetland Extent
Sudd wetland, South Sudan



Contains modified Copernicus Sentinel data [2015]

Partnerships for Implementation
Sustainable Development Initiative

- EO informing Development activities & investments
  - planning, design, implementation & monitoring
- Collaboration with International Development Banks

THE WORLD BANK · IFAD · European Investment Bank · ADB · European Bank for Reconstruction and Development

THE WORLD BANK IBRD • IDA — Working for a World Free of Poverty

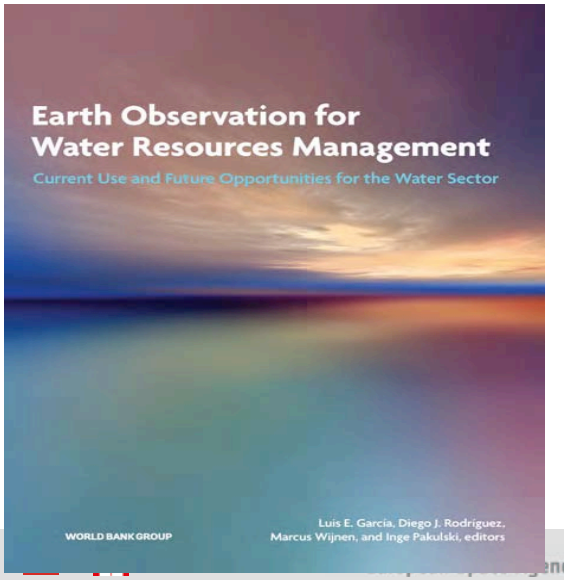
ABOUT | DATA | RESEARCH | LEARNING | NEWS | PROJECTS & OPERATIONS | PUBLICATIONS | COUNTRIES | TOPICS

News

PRESS RELEASE

World Bank and European Space Agency to Use Earth Observation Systems for Sustainable Development

December 3, 2015



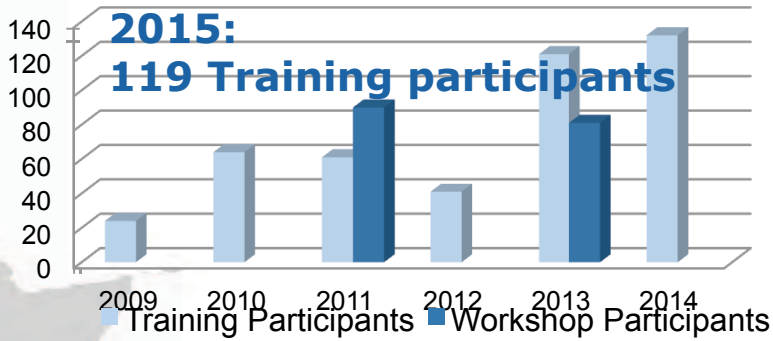
"Earth observation is key to the sustainable development goals,"

Laura Tuck, World Bank Vice President for Sustainable Development

TIGER's Footprint in Africa
A contribution to AfriGEOSS

Research Activities
90 projects & 9 Fellows

WOIS Application
4 Transboundary &
4 National Water Authorities



Capitalizing on 10 years of TIGER research results = 22 papers!

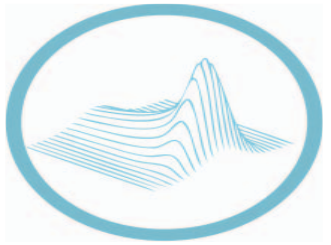
Thematic Exploitation Platform (TEP) for Hydrology

A heterogeneous community of scientific users, river basin organisations and service providers aiming to exchange data, services and knowledge through a common collaboration framework.

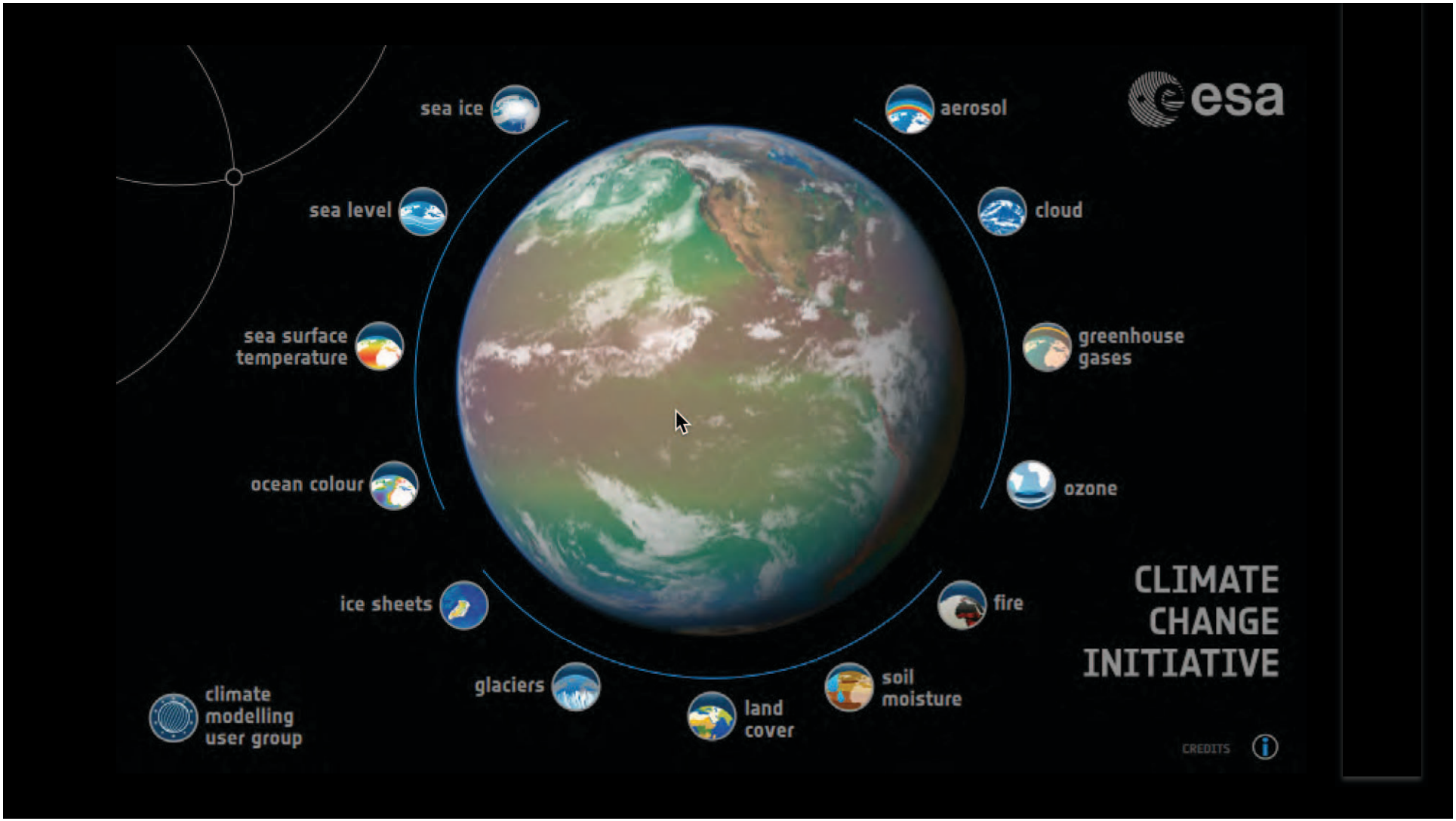
hydrology-tep.eo.esa.int

Community Platform
An open, collaborative and inclusive community where users can **SHARE** information, knowledge, algorithms, methods, tools, results, products, services

Service Platform
A portal providing **LARGE SCALE EO SERVICES & PRODUCTS** customised for hydrology applications. Flood monitoring and small Water bodies mapping, Water quality and level, Hydrological models



Enhancing Platform
A workspace based on the Cloud where users can discover, access, **PROCESS**, **UPLOAD**, visualise, manipulate and compare data


esa
sea ice
aerosol
sea level
cloud
sea surface temperature
greenhouse gases
ocean colour
ozone
ice sheets
fire
glaciers
soil moisture
land cover
climate modelling user group
CLIMATE CHANGE INITIATIVE
CREDITS

Upcoming Earth Explorers

ADM-Aeolus

- Global observations of wind profiles for analysis of global 3D wind field
- Launch planned for end 2017

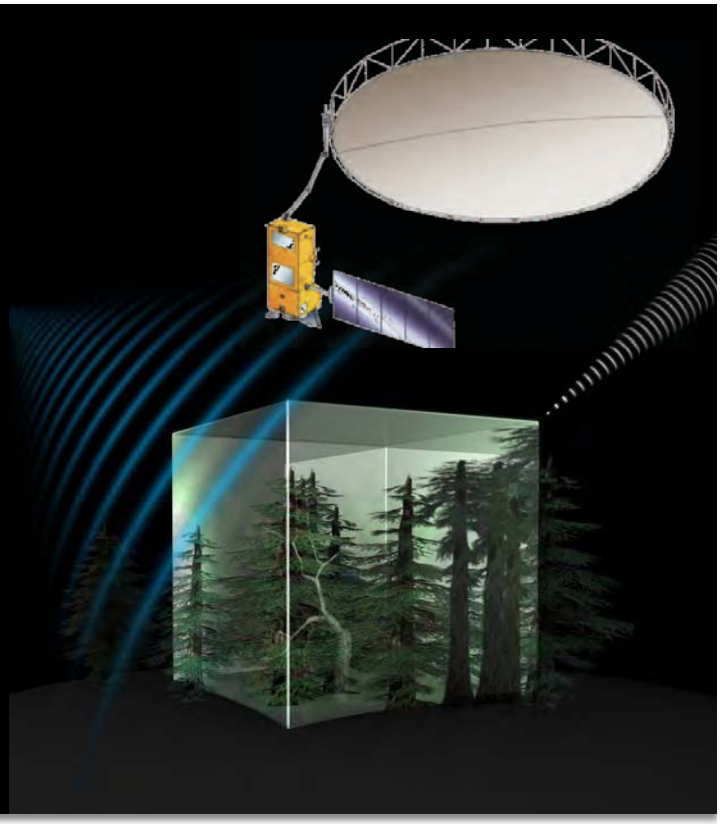
EarthCARE

- Global observations of clouds, aerosols and radiation
- Launch planned for 2019

Further Earth Explorer Missions

- 7th Earth Explorer: Biomass
  - Biomass estimates based on global interferometric and polarimetric P-Band Radar observations

- 8th Earth Explorer: FLEX
  - global maps of vegetation fluorescence, which can be converted into an indicator of photosynthetic activity



Improvement of European involvement in GEWEX

- How can ESA intensify its contribution to GEWEX?
- How can ESA and GEWEX cooperate to implement the 2016 Workshop Scientific Agenda (eo4water)?
- Shall we promote a new initiative on the Water Cycle in the Ocean?
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- + ?