ESA's contribtion to GEWEX

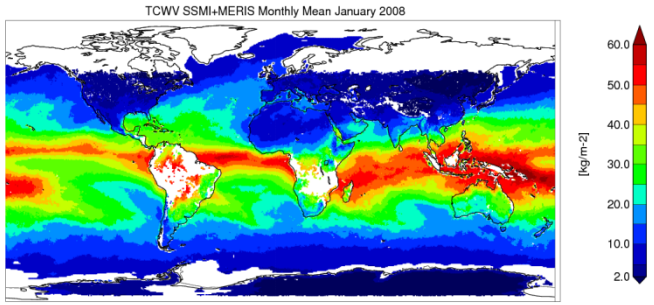
GEWEX SSG 8

ETH Zürich, CH, 25 – 28. 1. 2016

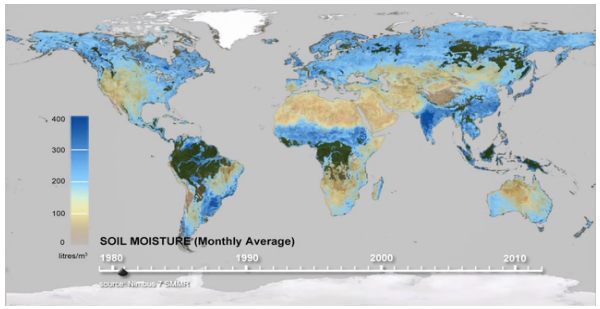
Michael Rast, European Space Agency

Head, Science Strategy, Coordination and Planning Office
Directorate of Earth Observation Programmes
ESA-ESRIN

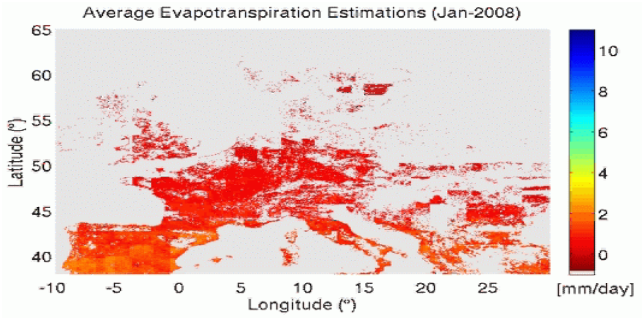
EO and the Water Cycle



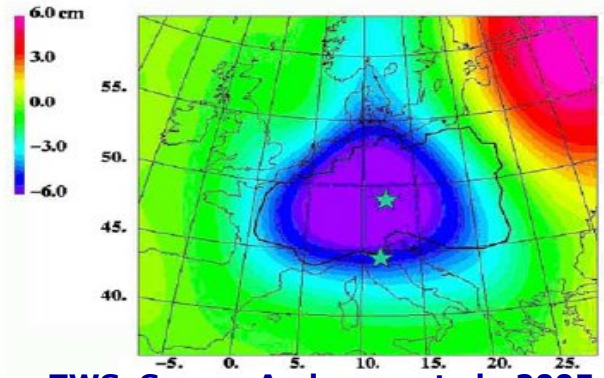
Water Vapour. Source: ESA GlobVapour



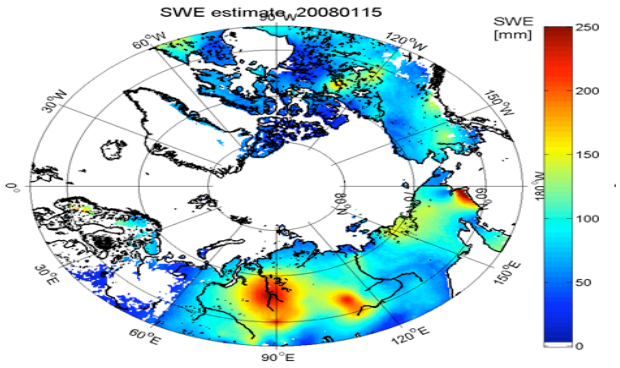
Soil Moisture. Source ESA WACMOS



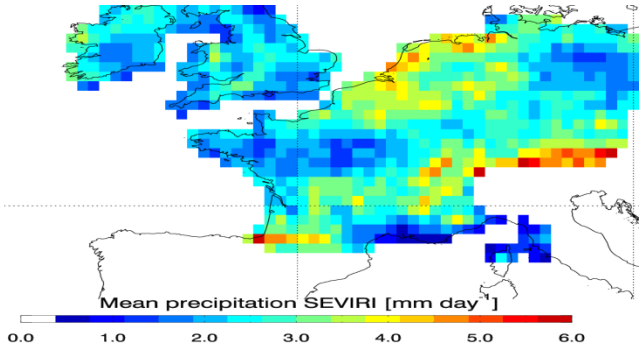
Latent Heat Flux. Source: ESA WACMOS



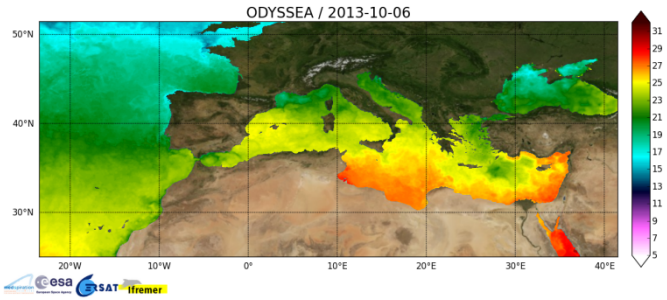
TWS. Source Andersen et al., 2005



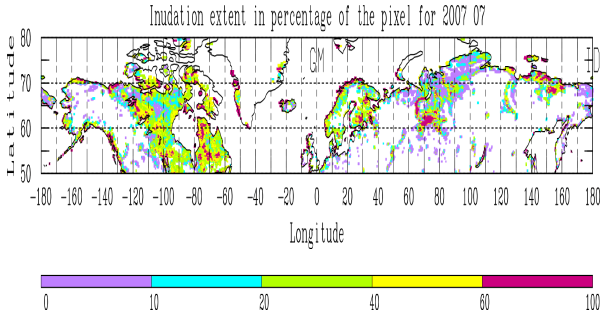
SWE. Source: ESA GlobSnow



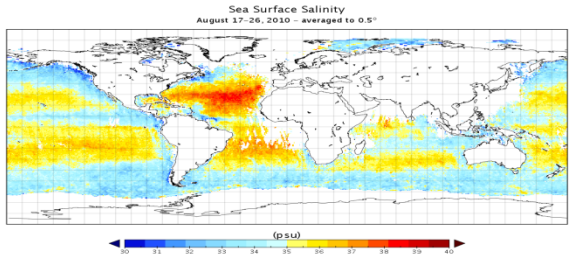
Precipitation. Source: ESA WACMOS



SST. Source: ESA Medspiration



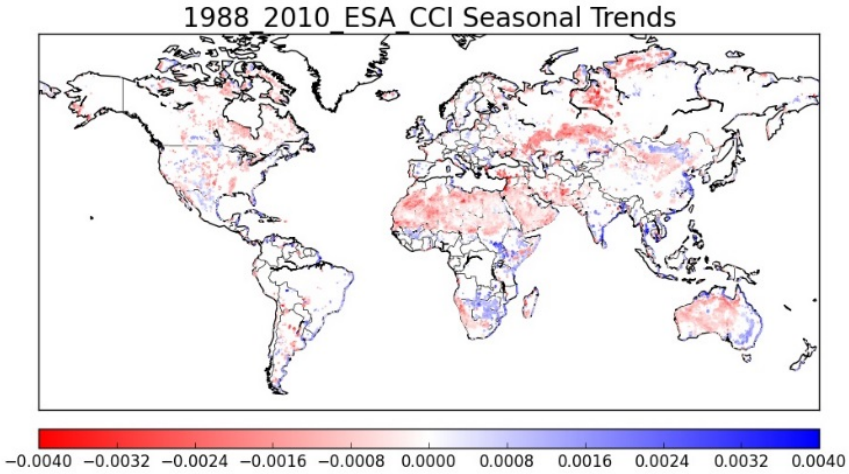
Global Inundation. Source: LEGOS

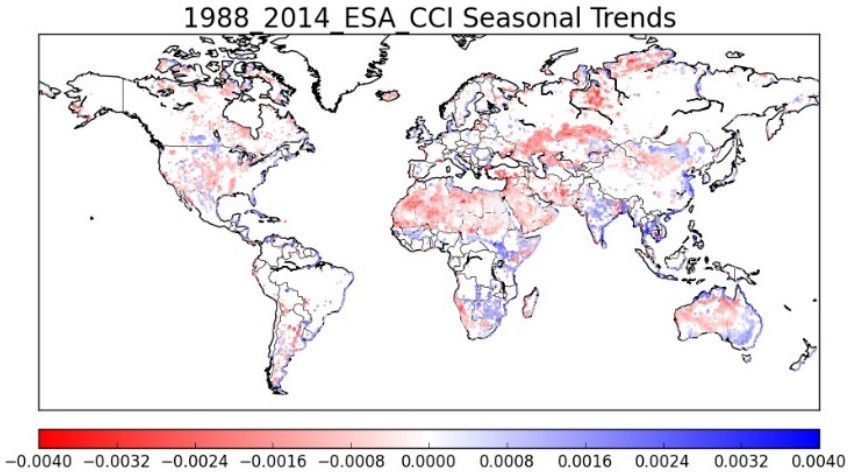


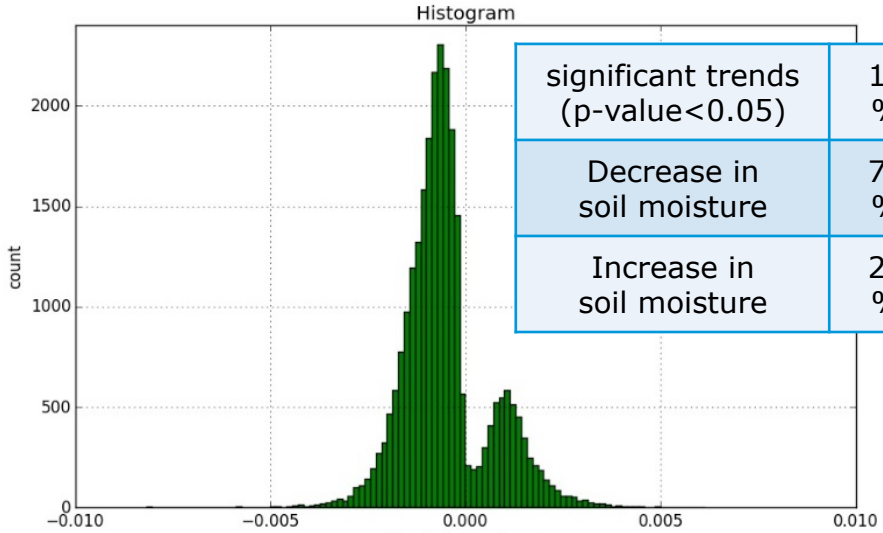
SSS. Source: BEC

The Water Issue

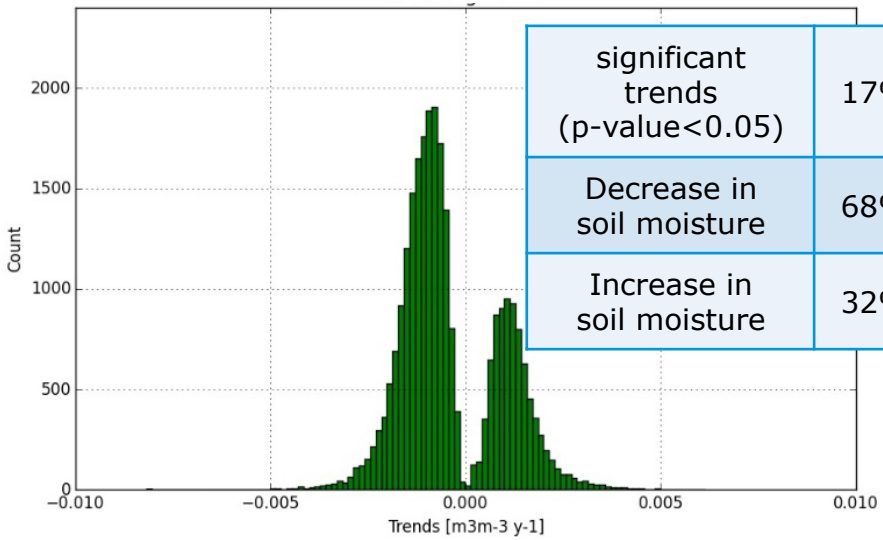
Trends* in seasonal means: 1988-2010 (top) 1988-2014 (bottom)







significant trends (p-value<0.05)	17 %
Decrease in soil moisture	79 %
Increase in soil moisture	21 %



significant trends (p-value<0.05)	17%
Decrease in soil moisture	68%
Increase in soil moisture	32%

Agency

*** Based on v02.2; only significant trends (p<0.05); at least 1 value every year**

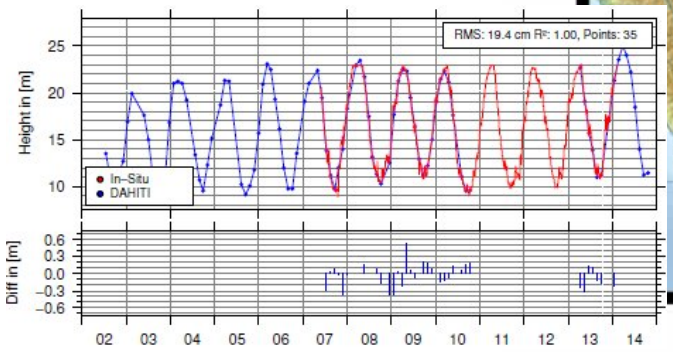
Surface water levels from satellite;

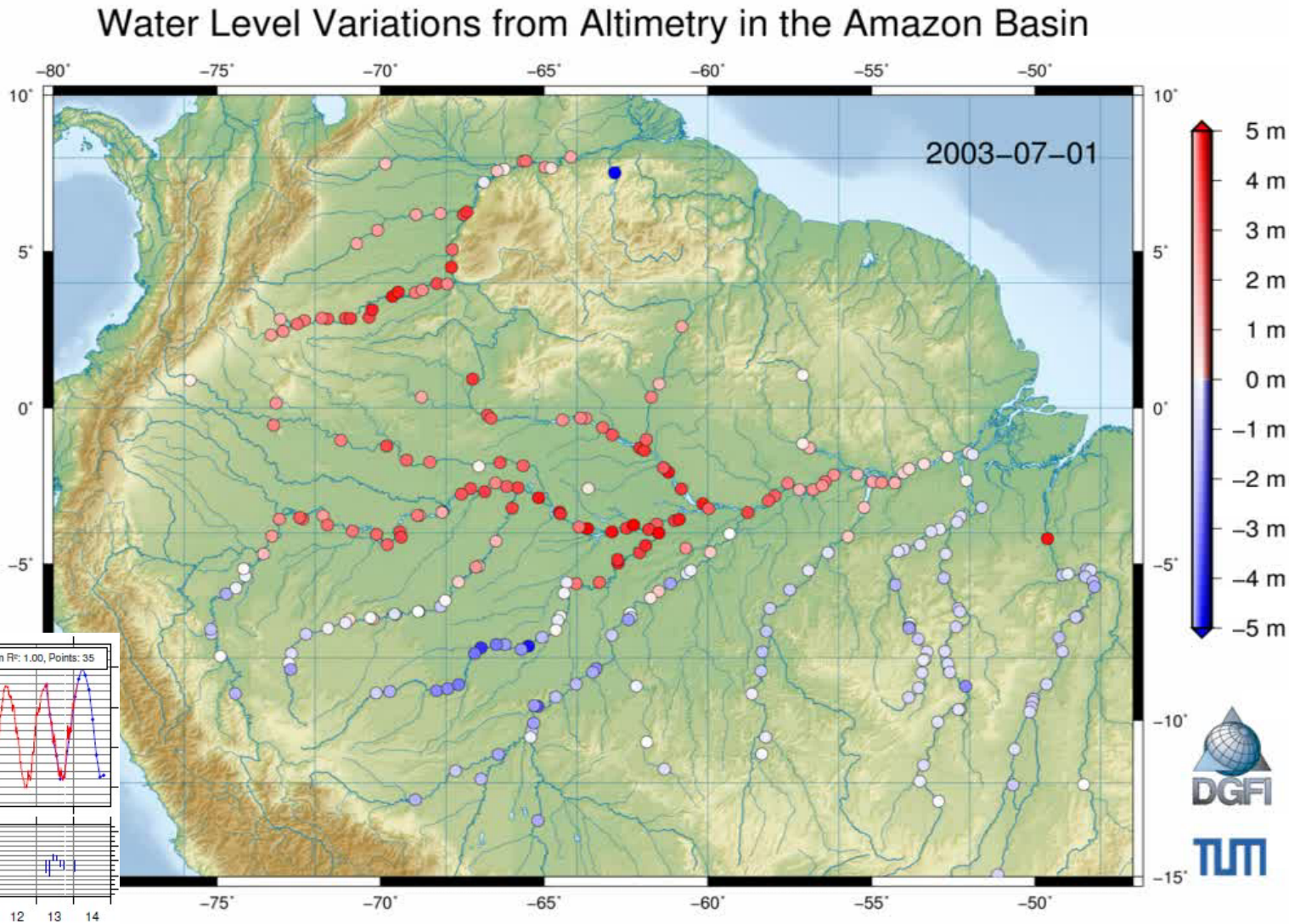
Satellite altimeters provides long-term record or water level obervations completeing in-situ networks

Data from: TOPEX/ Poseidon, Jason-1, Jason-2, ERS-2, Envisat, SARAL/AltiKa

(Schwatke et al., 2015)

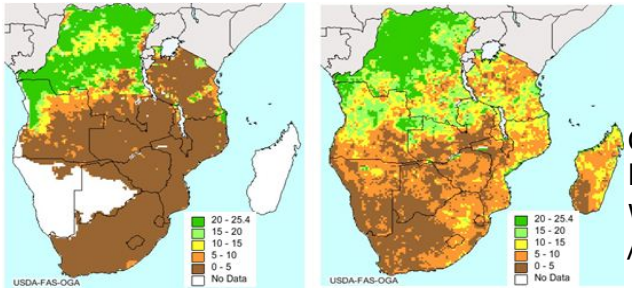
Time series over Madeira river compared with in-situ data





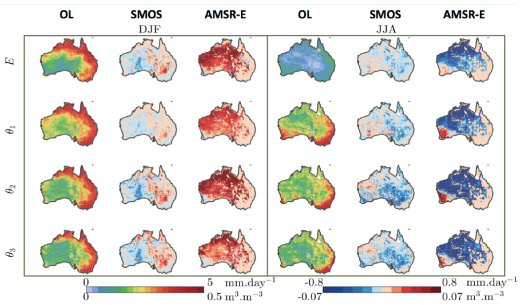
SMOS operational applications leading to societal benefits

SMOS surface and derived root-zone soil moisture provides an essential input for NWP, hydrology, water cycle research and several applications



Credit: USDA Crop Explorer, website: http://www.pecad.fas.usda.gov/cropexplorer/

DROUGHTS SMOS soil moisture data used to detect drought and improve crop yield prediction.

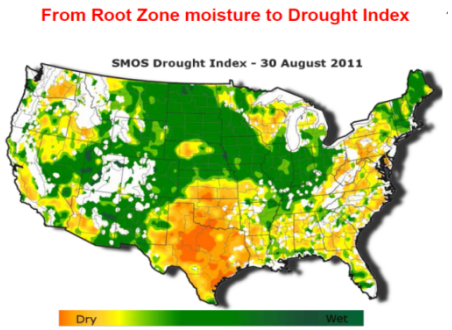


GLEAM SMOS ET over Australia

Credit: University of Ghent.

Using SMOS to retrieve other **WATER CYCLE VARIABLES**.

- Evaporation
- Rainfall
- Vegetation water content
- Frozen soil

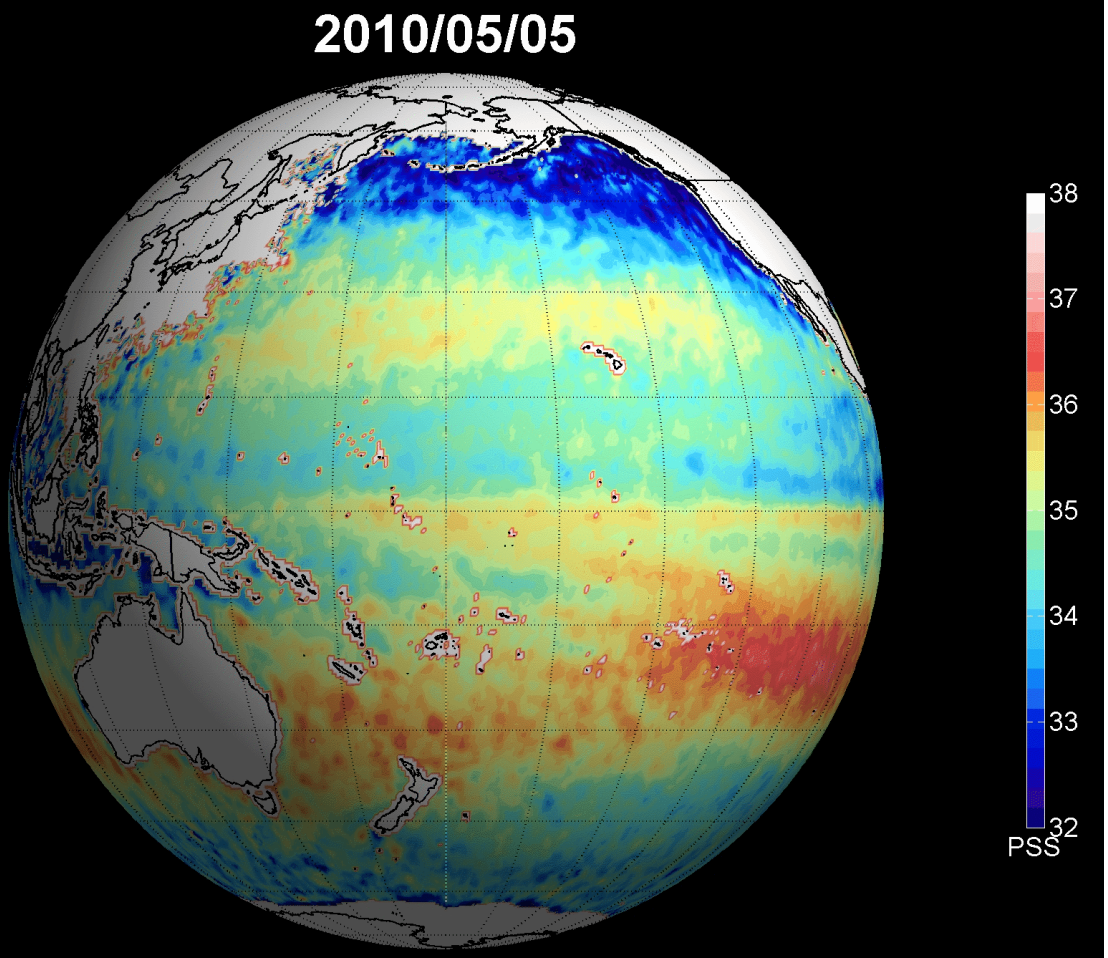


Credit: CESBIO.

SMOS surface and derived root-zone soil moisture provides input for the drought index, an important **AGRICULTURAL MONITORING AND PREDICTION TOOL** for plant available water.

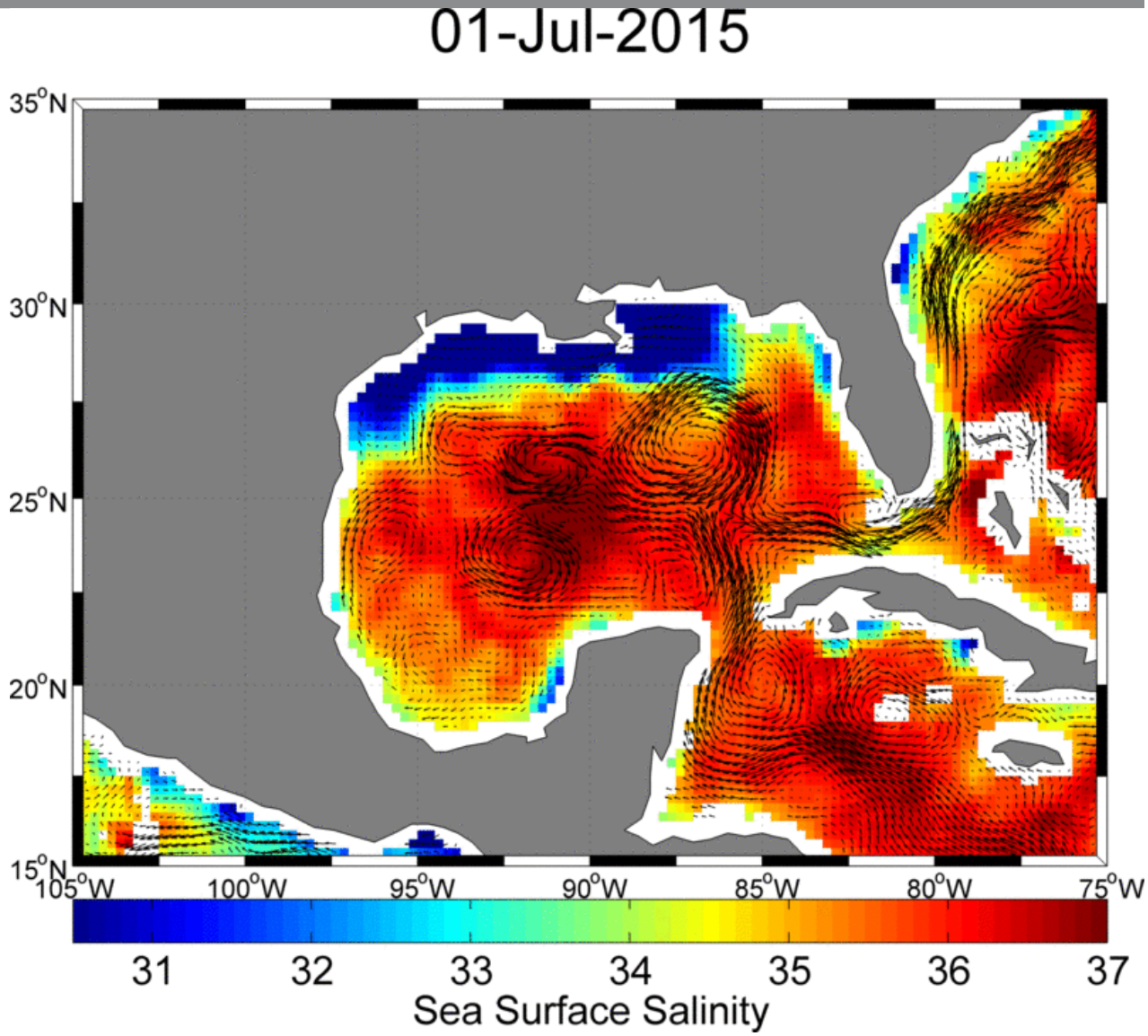
SMOS

- Water cycle components over the ocean largely dominate in the contribution to the global freshwater cycle budget.
- Most rain comes from the sea (especially extreme rains).
- Latent heat fluxes dominate the transfer of energy and water from ocean to atmosphere.
- Salinity is a direct indicator of net water and energy exchange with other parts of the climate system.
- It responds to the state of the atmosphere through Ekman advection and wind driven mixing, so may be a hypersensitive indicator of change.



SMOS: Monitoring freshwater flow from rivers

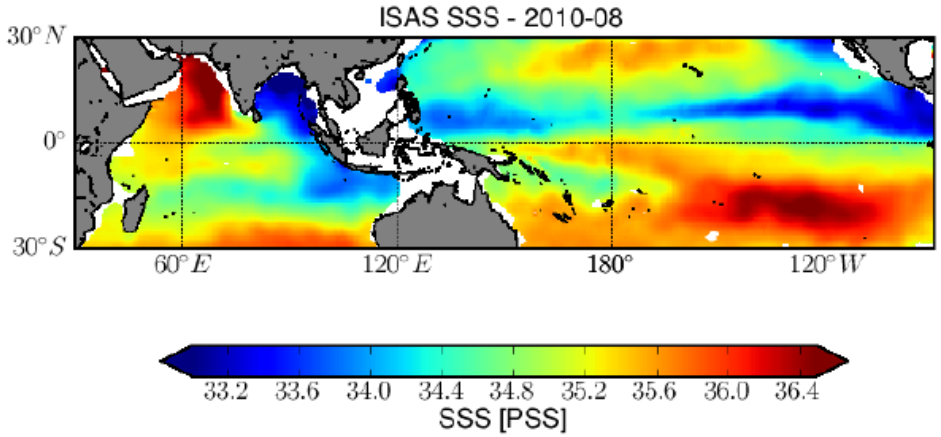
SMOS data now allow the regular monitoring of the seasonal & interannual variability in the discharge & advection of freshwater river plumes into the ocean.

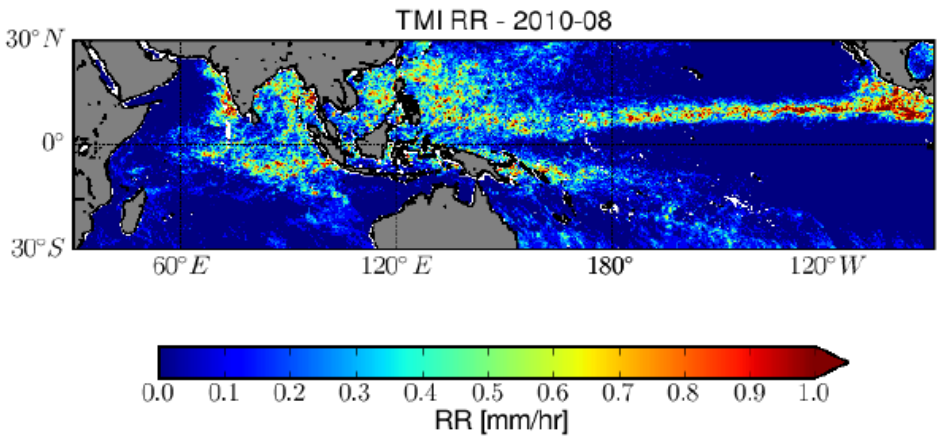


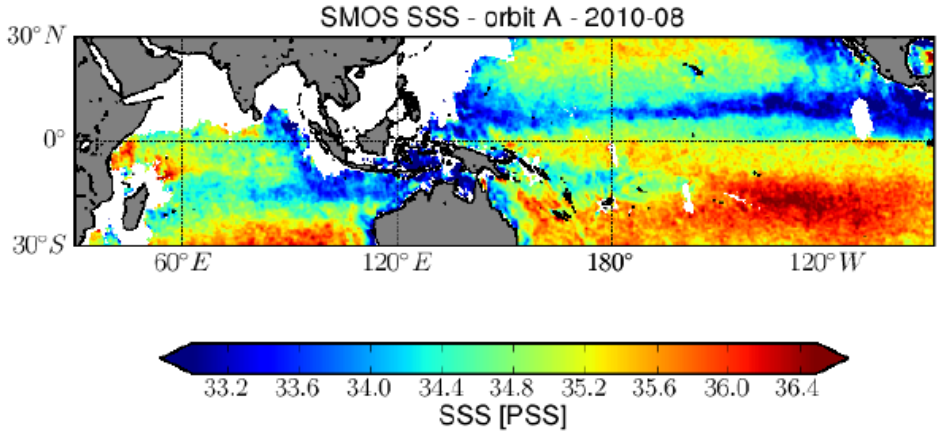
Merged SMOS and SMAP SSS to form 3 days running means over Mississippi plume area

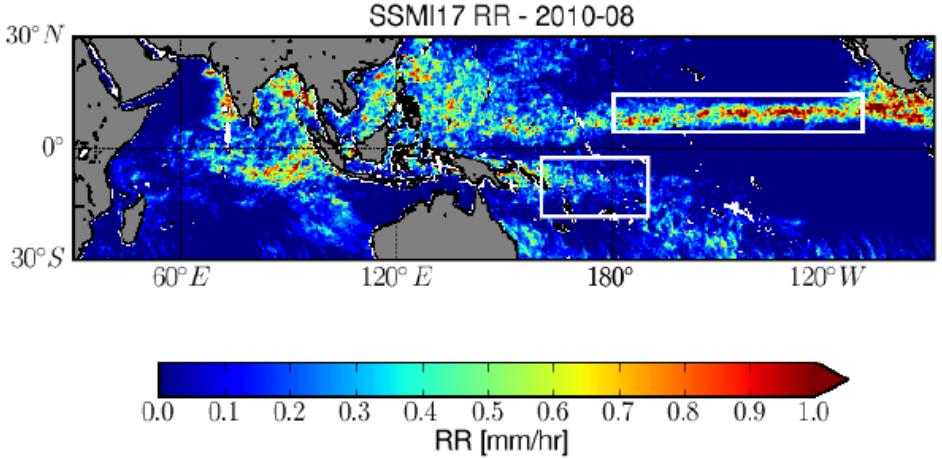
Source: IFREMER, FR

SMOS: Monitoring freshwater flow from rainfall



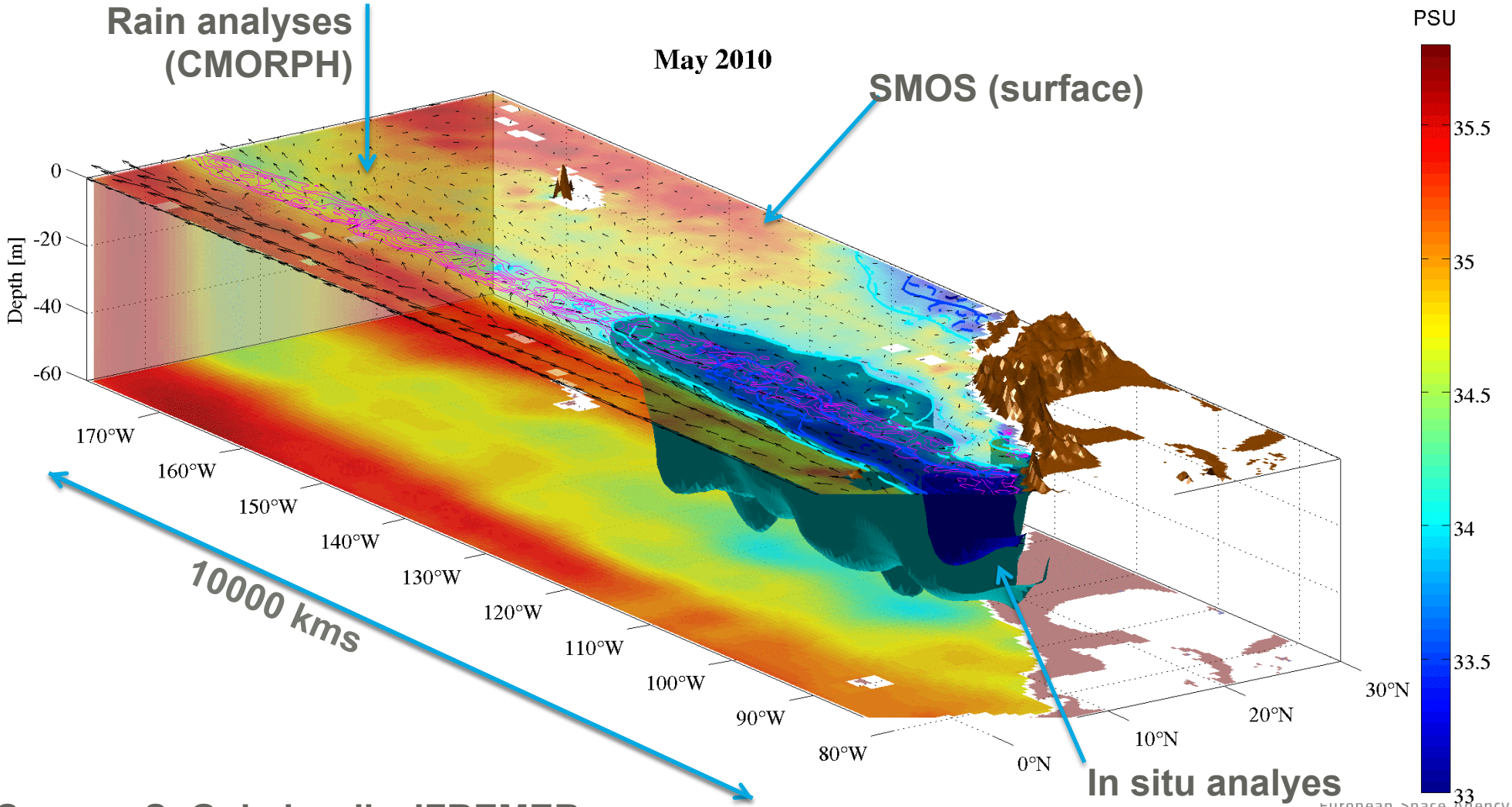






Through its links with Precipitations, SMOS salinity data provide a new tool to better characterize the increase in the marine tropical hydrological cycle strength

SMOS: Monitoring freshwater flow from rainfall
Eastern Pacific Freshpool in 3D



Source: S. Guimbard's, IFREMER

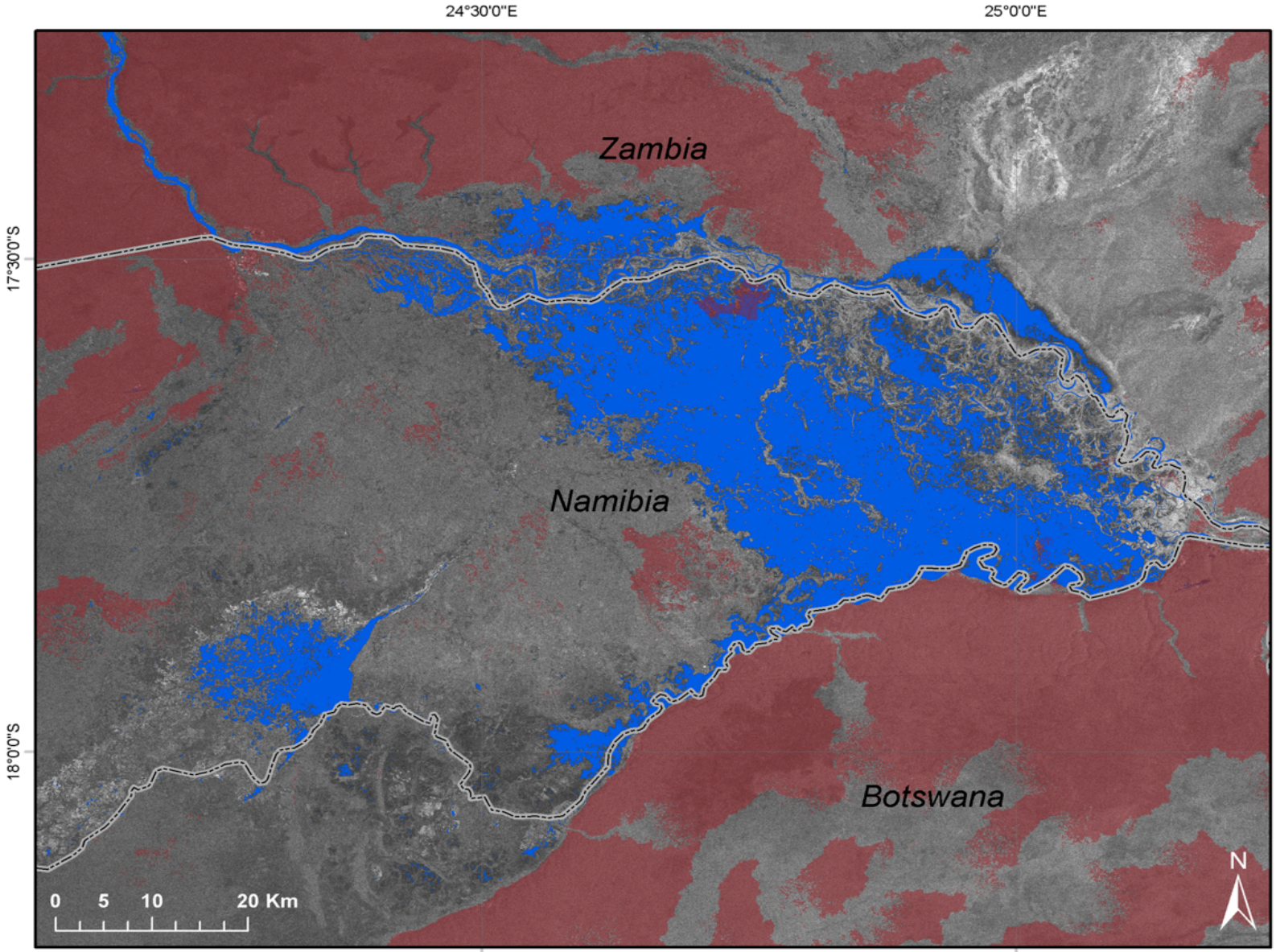
EarthCARE – ESA-JAXA's clouds and aerosol mission

- **EarthCARE a new contribution to the water cycle:**

- To provide a better understanding of the **interactions between cloud, radiative and aerosol processes** that play a role in water cycle and climate regulation
- High-performance lidar and radar technology (JAXA) that has never been flown in space before.
- Will provide global observations of the vertical structure of clouds and aerosols at the same time as taking measurements of radiation

- **Planned launch 2018**

Sentinel-1 Flood Monitoring of Caprivi Flood Plain, Namibia



Legend

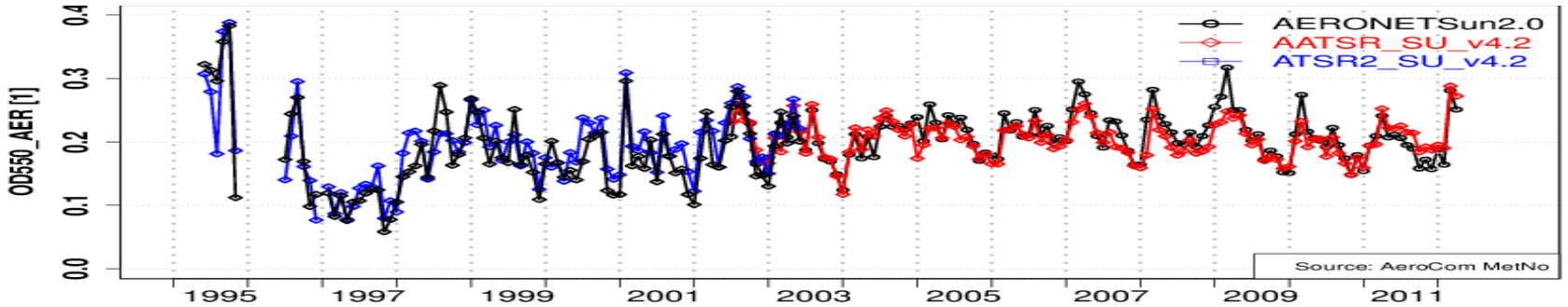
- Country border
- Derived HAND Index > 10 m
- Flooded areas

Description:
This map shows the flooding situation in the Caprivi flood plain of Zambezi River on 13th of April, 2014. The flood was delineated with the Water Observation and Information System (WOIS) based on SENTINEL-1A satellite data.

Source data:
SENTINEL-1A IW mode, 20 m resolution, acquired on 13th of April, 2014 at 03:50 GMT.
SENTINEL-1 image was provided by the European Space Agency.

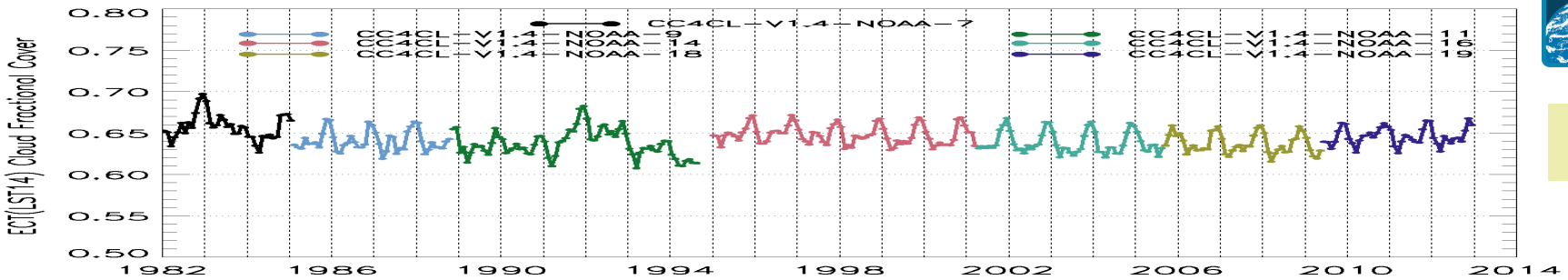
Cartographic Reference
Projection: EPSG:4326
Datum: WGS 84

ESA CCI Long-term Climate data records



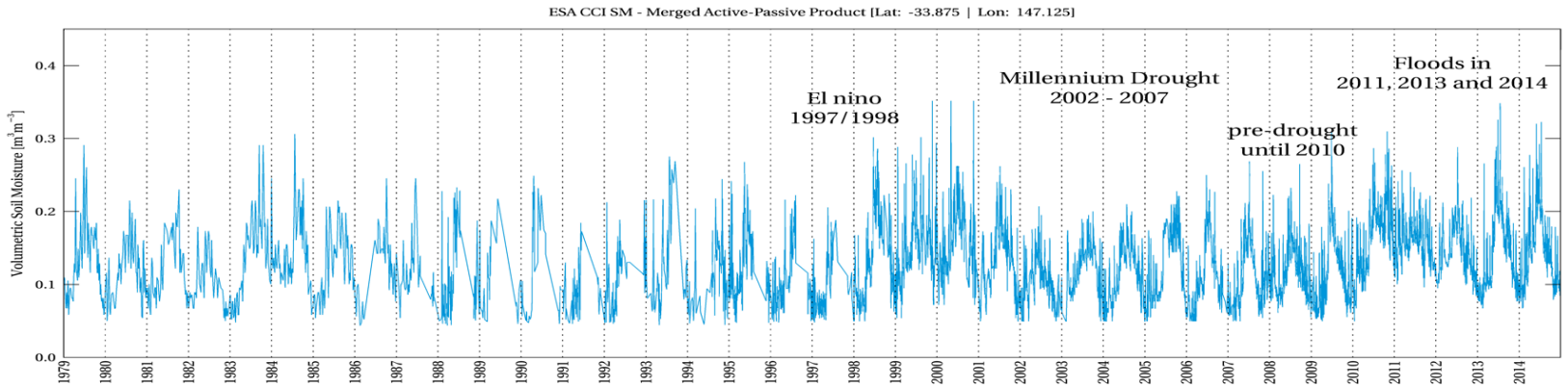
aerosol cci

CCI/AATSR time series compared with AERONET



cloud cci

30yrs of Cloud Cover from AVHRR



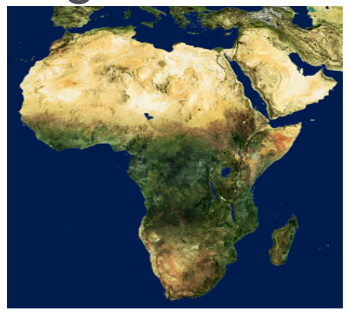
soil moisture cci

Soil moisture active-passive merged product for Eastern Australia

European Space Agency

The TIGER Initiative: Looking After Water in Africa

- TIGER is based on a **user driven approach under African leadership**
  - Endorsed by the African Ministers' Council On Water (AMCOW)
  - Launched in 2002 responding to World Summit on Sustainable Development



- Assist African scientists, technical centres and water authorities to **develop the tools, the knowledge and the capacity** to exploit EO technology for the monitoring and management of water resources;
- **African Community:**
  TIGER involves more than **150 African institutions in 42 countries** who participate in **development projects & capacity building** actions;

Water Observation Information System
For African Water Authorities

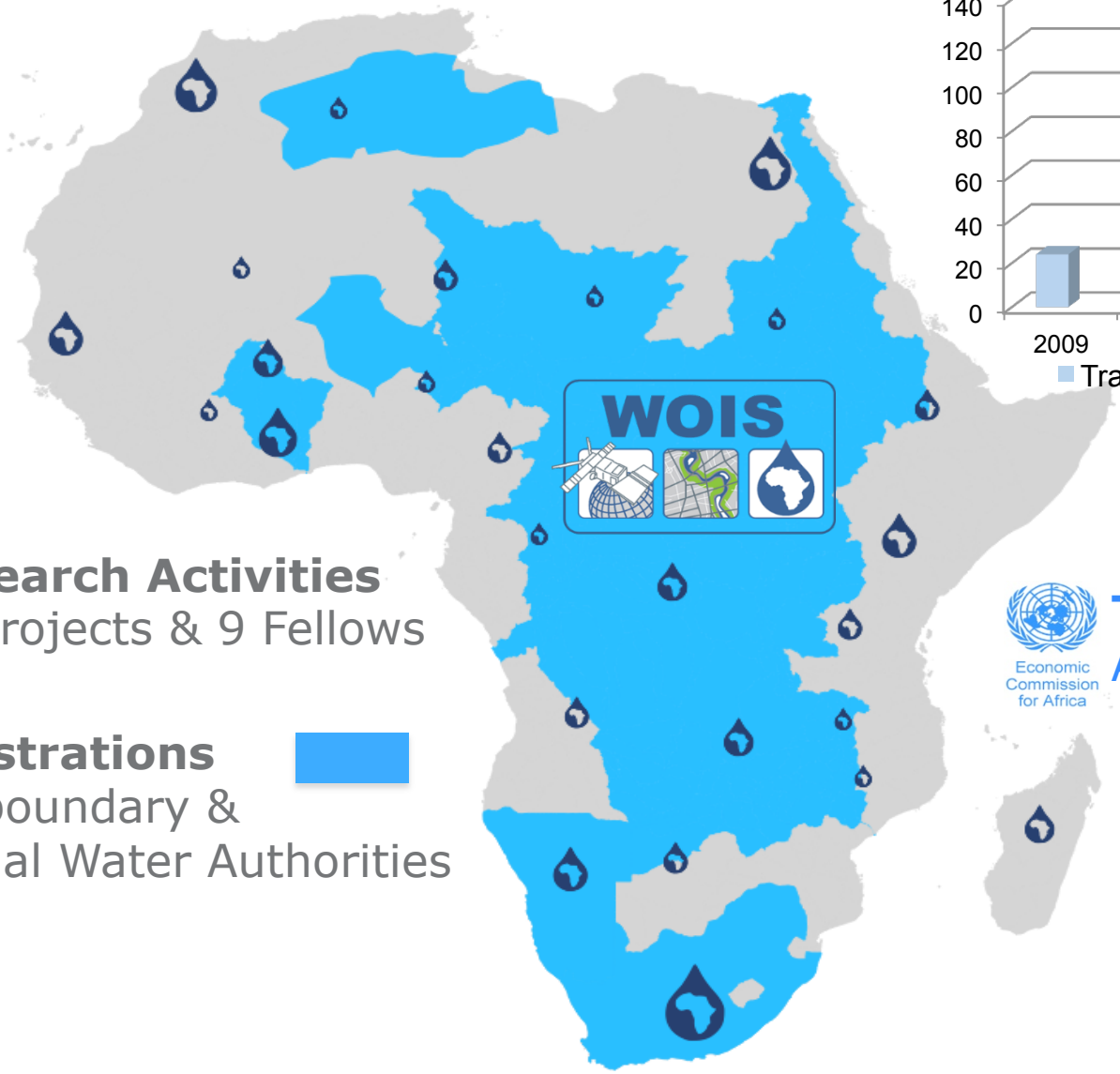
Objective: Enable African water authorities to improve IWRM by exploiting Earth Observation (EO) technology

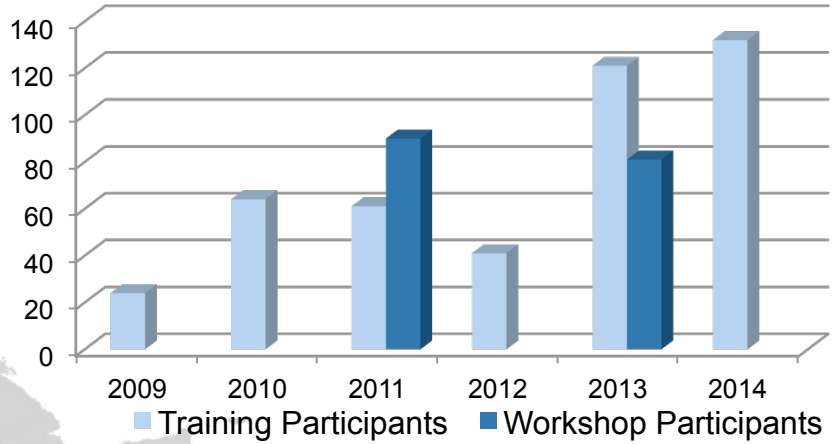
- Implement an operational Water Observation Information System (WOIS) for monitoring water resources
- Developed in collaboration with African water authorities

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

Enabling the Use of Earth Observation Data for Integrated Water Resource Management in Africa with the Water Observation and Information System
Radoslaw Guzinski et al., *Remote Sens.* **2014**, *6*(8), 7819-7839; doi:10.3390/rs6087819

TIGER's Footprint in Africa
Building an African EO community





Research Activities
80 projects & 9 Fellows

Demonstrations
4 Transboundary &
4 National Water Authorities

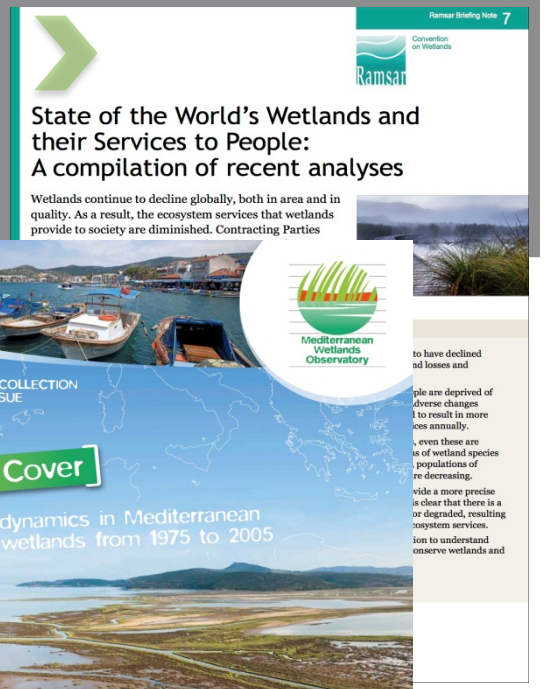
TIGER Workshop
Addis Ababa, Feb. 2016

Economic Commission for Africa

Water Cycle Science 2015: preparing ESA activities 2017-2021

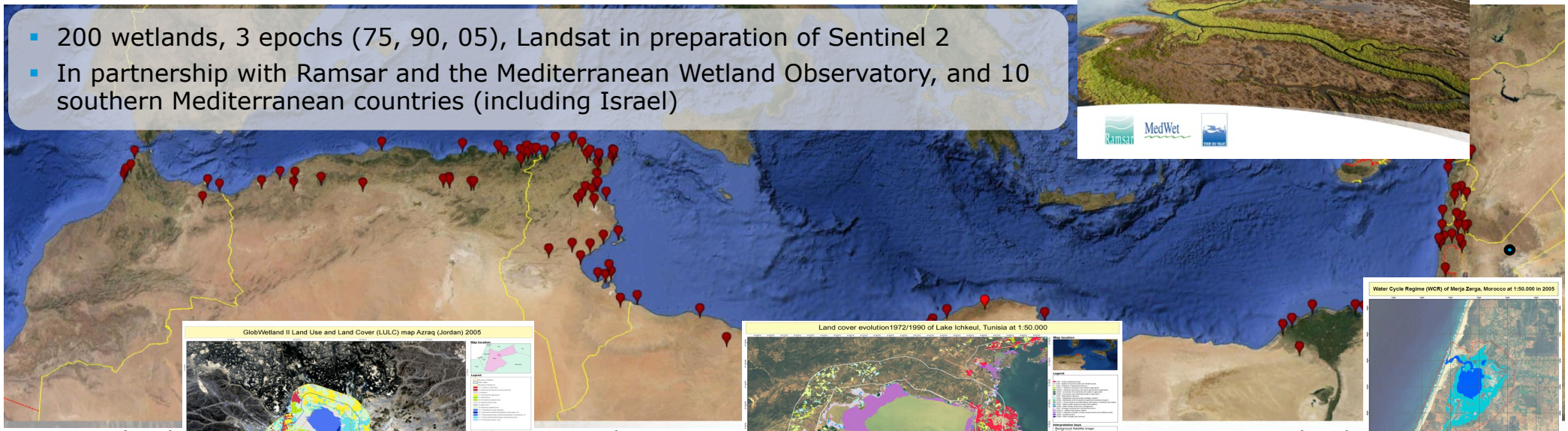
- *October 2015: Workshop recommendations*
- *October 2015-January 2016: Further elaboration and Workshop Report preparation (community effort)*
- *2015-2016: ESA EO science and innovation programme (EOEP-5) preparation;*
- *December 2016 - ESA Ministerial Council (programme review/funding by Member States)*
- *2017-2021: Implementation*
- *From January 2017: Address recommendations and needs through dedicated Invitations To Tender and other actions.*

GlobWetland II, a Mediterranean regional pilot project of the Ramsar Convention

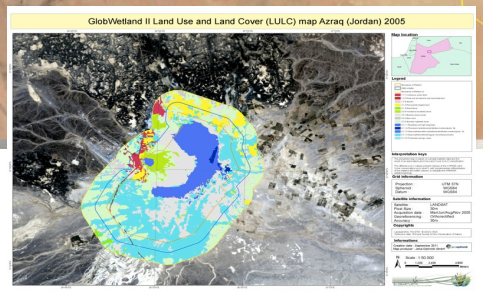


- Development and qualification of EO approaches and tools for **wetland inventory, assessment and monitoring**.
- **Regional Demonstrator** for Nat./Reg. wetland observatories.
- GlobWetland II maps and tools used by **MedWet** (Ramsar Mediterranean Wetlands Initiative, 26 countries) to assess **trends in Mediterranean coastal wetlands** over the last 30y.
- GlobWetland II approaches selected amongst Ramsar **Best Case Practices** to estimate the State of the World Wetlands.

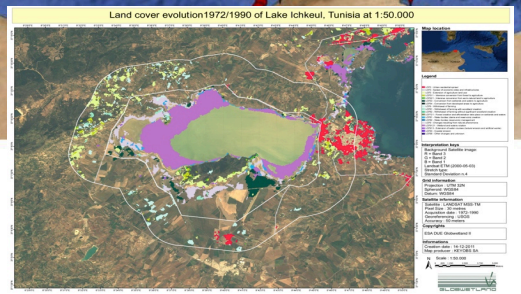
- 200 wetlands, 3 epochs (75, 90, 05), Landsat in preparation of Sentinel 2
- In partnership with Ramsar and the Mediterranean Wetland Observatory, and 10 southern Mediterranean countries (including Israel)



Wetland Habitat Mapping



Changes in wetland areas



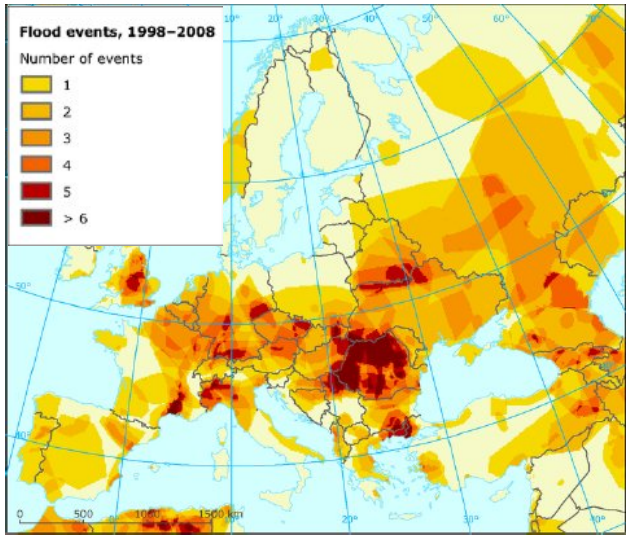
Wetland Inundation Regimes

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:

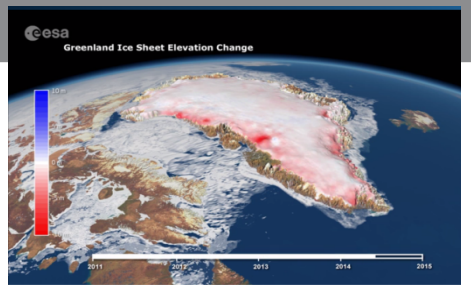
- Assess the quality of current EO-based products to characterise the water cycle over the Med area;
- Develop a new consistent datasets of the ocean , land and atmosphere products that closes the water budget over the Mediterranean area;
- Perform a water cycle budget closure experiment assessing the variability and trends of the Mediterranean water cycle based on EO;
- The project will also:

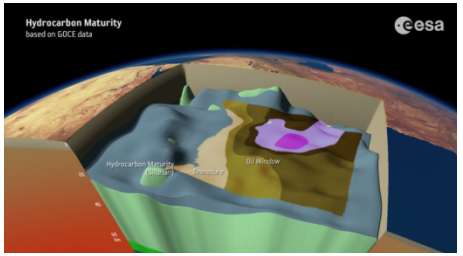
- Study the impact of climate variability on the Mediterranean water cycle;
- Enhance current estimates of river discharge;
- Study the links of the water cycle and Oceanic circulation;
- Enhance Flash-floods prediction;

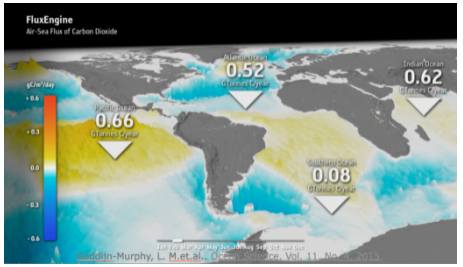


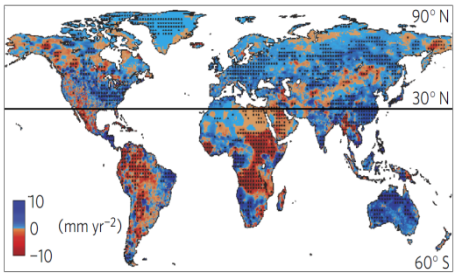
EE Science Highlights (1 of 2)

- Reconciled Ice Sheet Mass Balance variations and Sea Level Impact (STSE)
- First demonstration of lithosphere modelling and sub-surface geophysics from GOCE (STSE)
- First Ocean CO_2 flux climatology from space (STSE)
- Global evapotranspiration anomaly trend due to El Niño-La Niña (STSE)



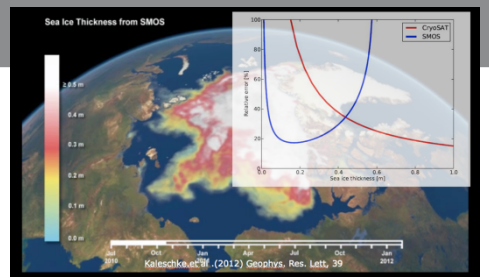


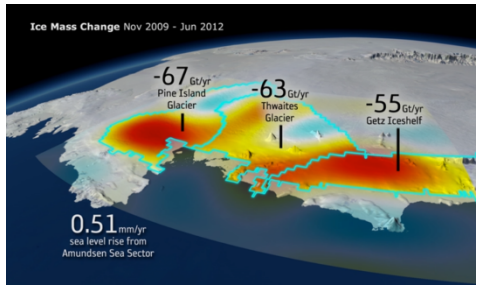


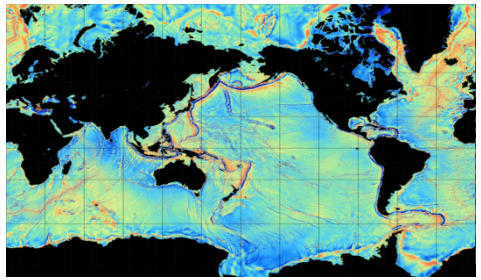


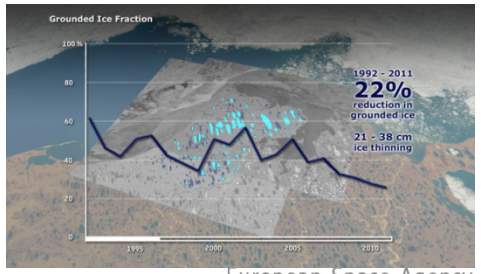
EE Science Highlights (2 of 2)

- First dataset of seasonal sea ice thickness from SMOS (STSE, L2)
- First demonstration of Antarctic GOCE-GRACE combination for ice-mass change estimates (STSE)
- Sea-floor tectonic structure revealed by new CryoSat-2+Jason-2 global marine gravity model (MOM)
- 20 years climate record of decay of Alaskan Arctic lake ice (STSE)





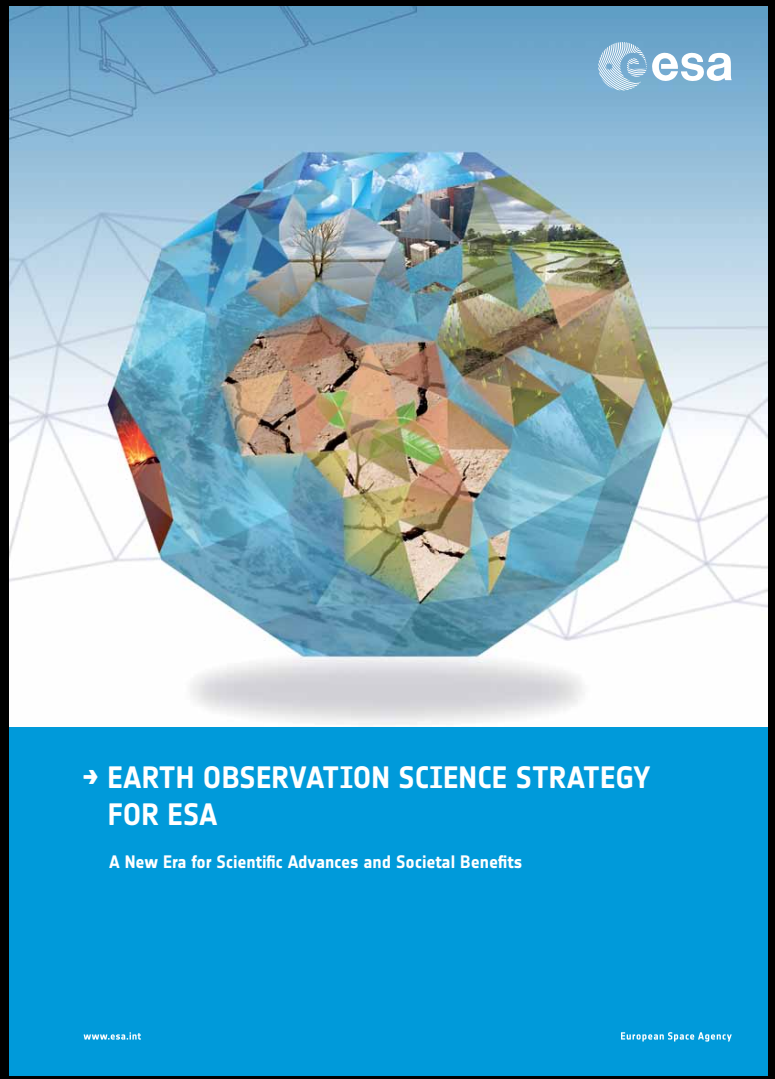




New EO Science Strategy for ESA

Key elements:

- ground-breaking exploratory missions
- sustained observations
- international cooperation
- translational science
- wider communication
  - COP-21
    30 Nov -11 Dec 2015, Paris
  - LPS
    9-13 May 2016, Prague




Thank you for your attention!
European Space Agency