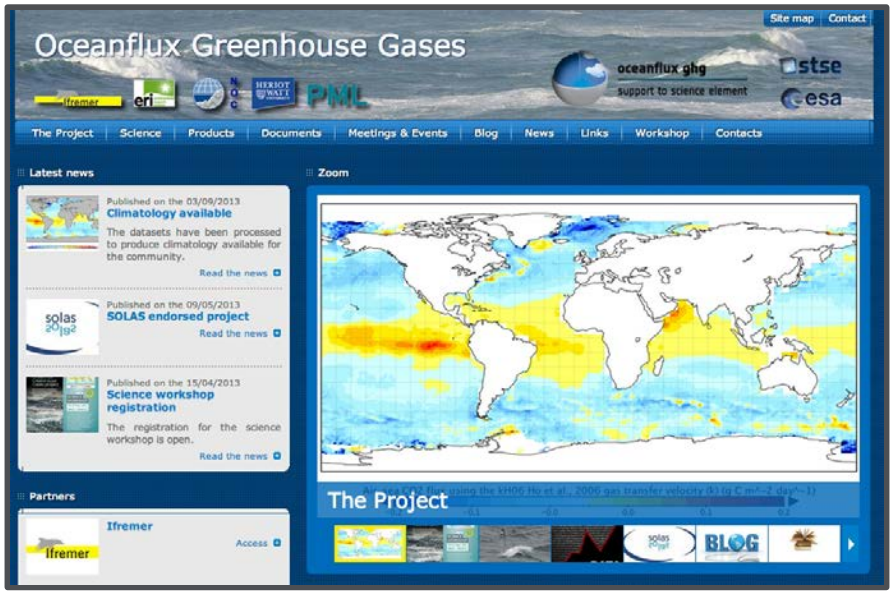
OceanFlux Greenhouse Gas: Science Workshop

IFREMER, Brest France, 24-27th September 2013

Craig Donlon and Diego Fernandez
European Space Agency



Overview

- European Space Agency
- Support to Science Element (STSE)
- SOLAS and ESA
- STSE OceanFlux GHG Project
- Workshop expectations
- Summary

Purpose of ESA

"To provide for and promote, for exclusively peaceful purposes, cooperation among European states in **space research** and **technology** and their **space applications.**"

Article 2 of ESA Convention

ESA: 20 Member States, growing Eastwards

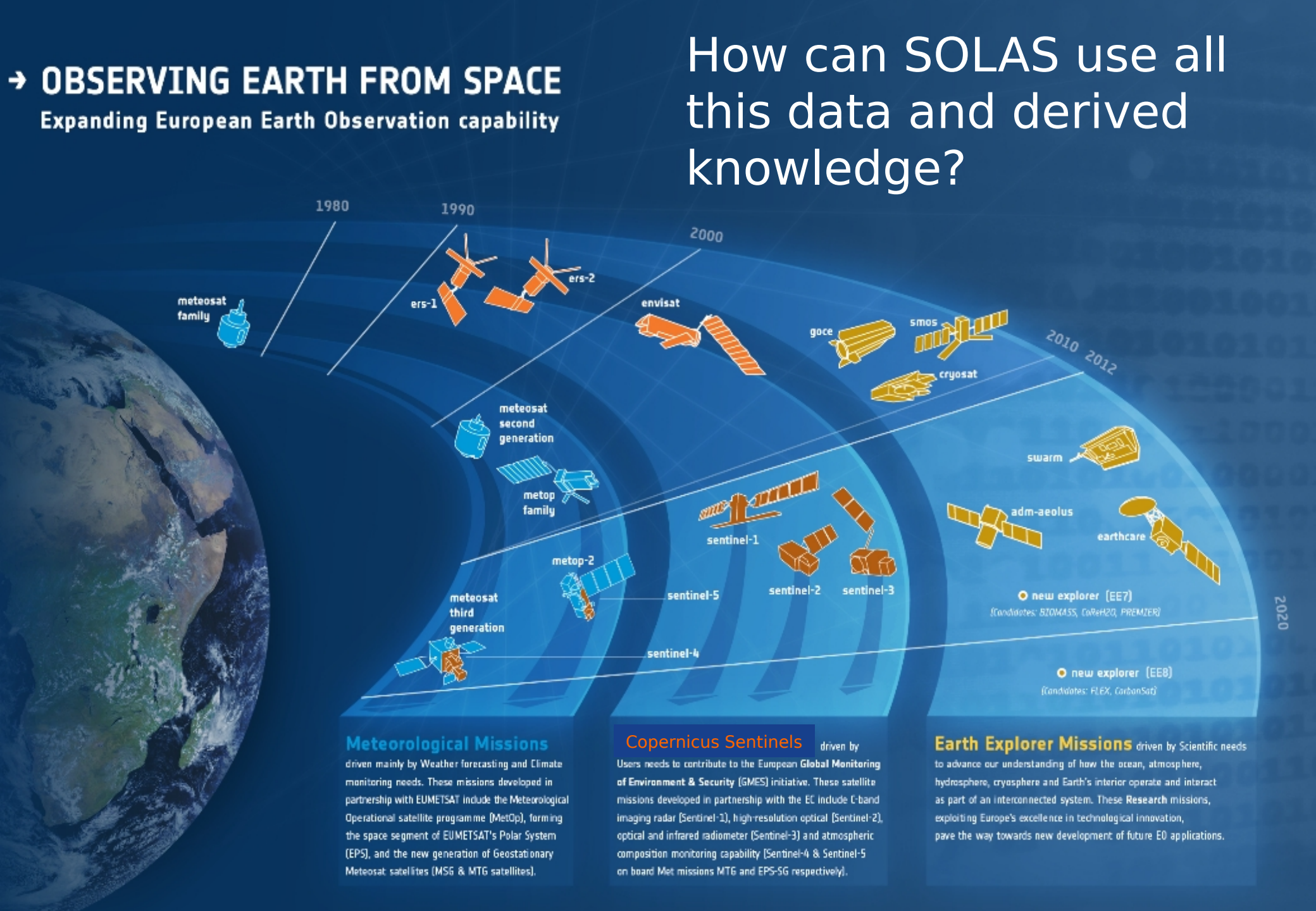
ESA has 20 Member States: 18 states of the EU (AT, BE, CZ, DE, DK, ES, FI, FR, IT, GR, IE, LU, NL, PT, RO, SE, UK, PO) plus Norway and Switzerland.

Seven other EU states have Cooperation Agreements with ESA: Estonia, Slovenia, Hungary, Cyprus, Latvia, Lithuania and the Slovak Republic.

Bulgaria and Malta are negotiating Cooperation Agreements.

Canada takes part in some programmes under a Cooperation Agreement.

How can SOLAS use all this data and derived knowledge?



CryoSat2: ESA's Ice Mission

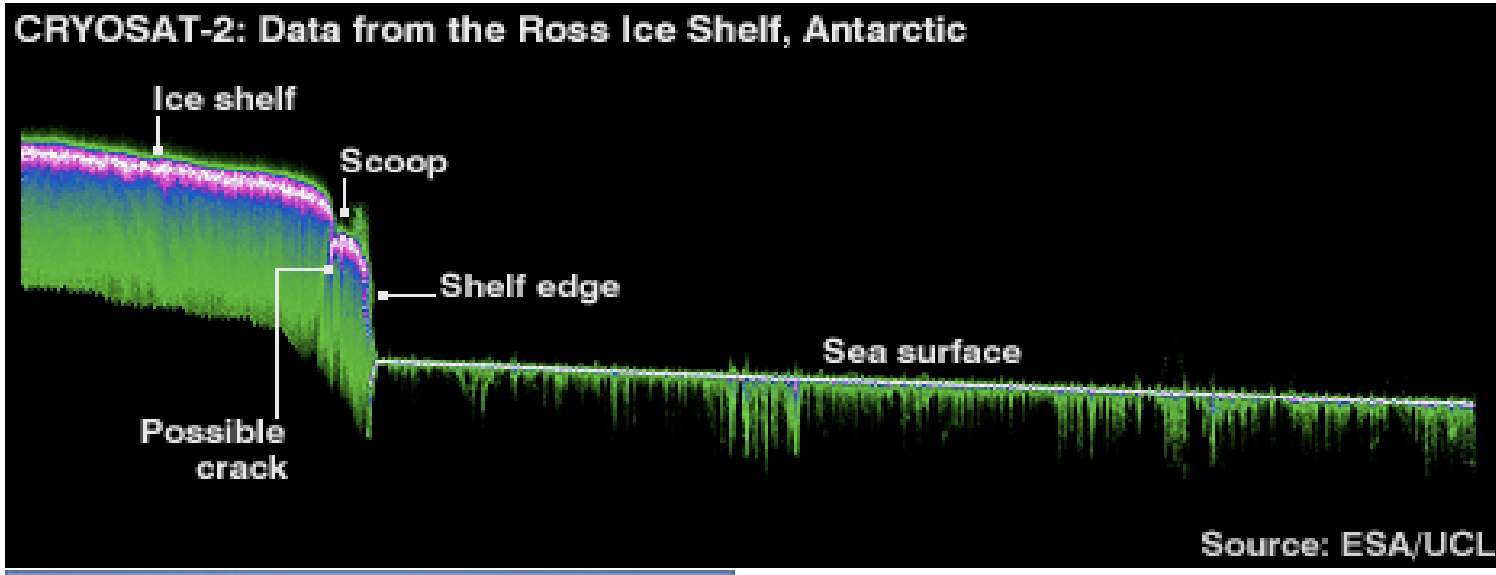
Launched 8th April 2010

Its objectives are to improve our understanding of:

- thickness and mass fluctuations of polar land and marine ice
- to quantify rates of thinning/thickening due to climate variations
- Instrument: Ku band SIRAL (SAR Interferometric Radar Altimeter).

www.esa.int/livingplanet/cryosat

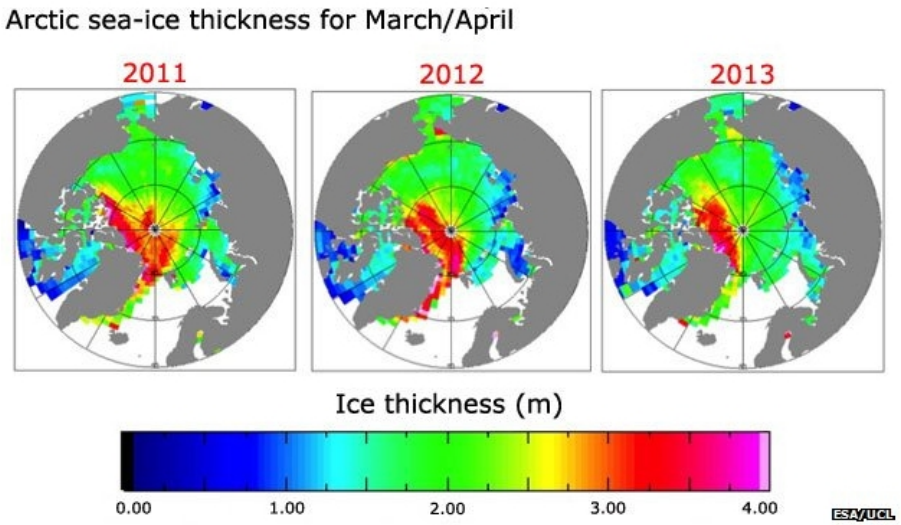
Cryosat over Ocean and the Ross Ice Shelf

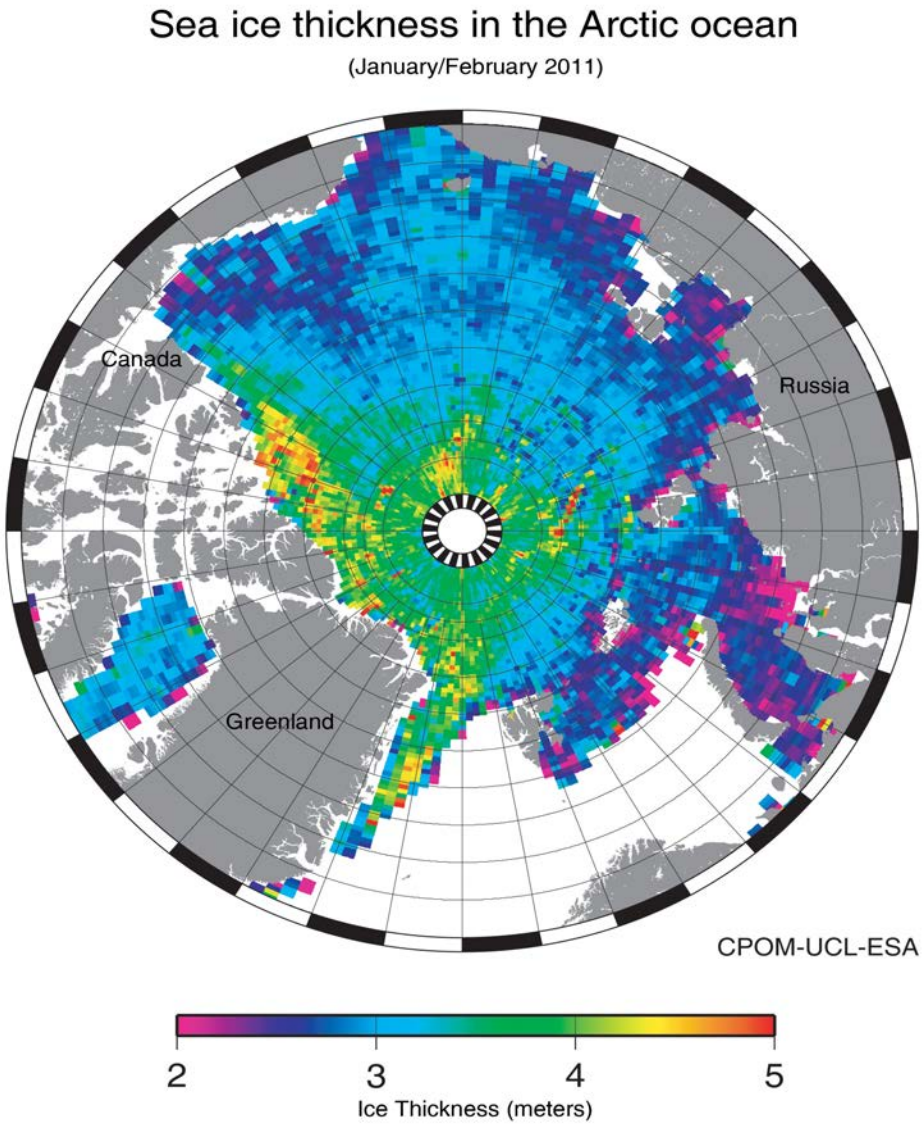


Cryosat is able to measure through the transition between the sea surface and across the shelf edge

Arctic Ocean sea ice thickness from Cryosat (University College London)

- The first map of sea-ice thickness from ESA's CryoSat mission
- Data from January and February 2011have been used to show the thickness of the ice as it approaches its annual maximum.
- Thanks to CryoSat's orbit, ice thickness close to the North Pole can be seen for the first time.

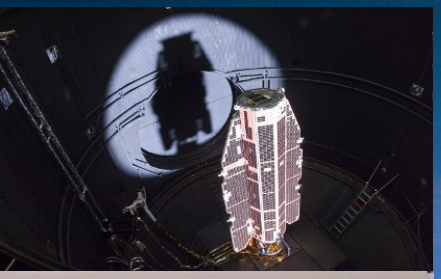




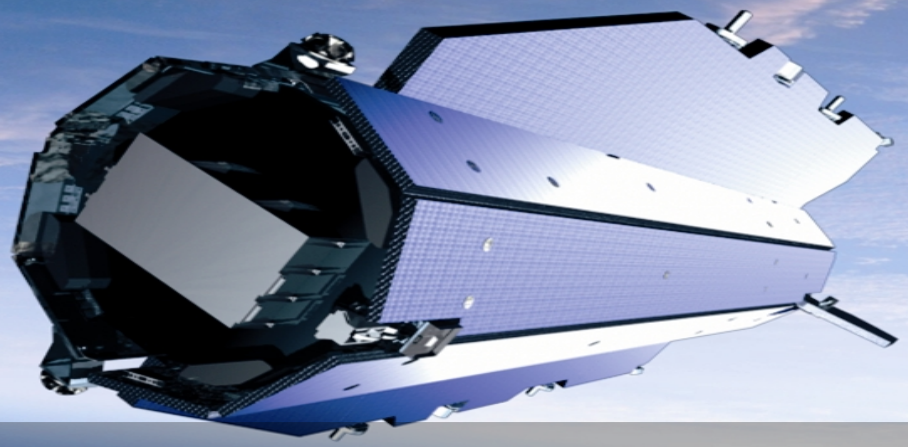
GOCE: ESA's Gravity Mission

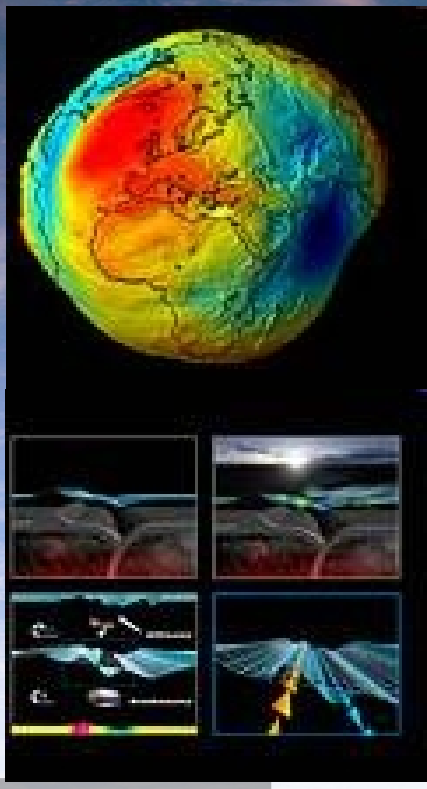
www.esa.int/livingplanet/goce

The Gravity field and steady-state Ocean Circulation Explorer (GOCE)



Launched 2nd March 2009!!



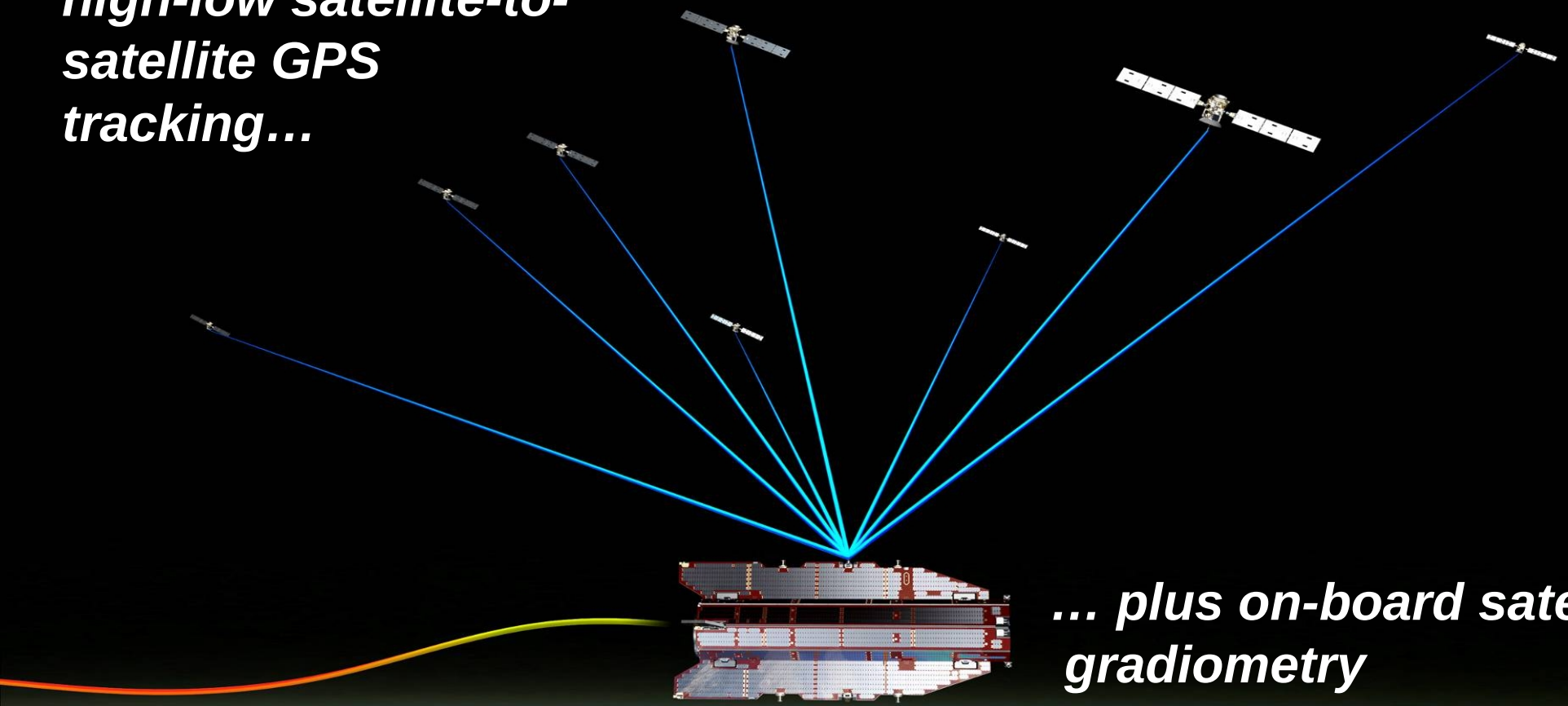


Its objectives are to improve understanding of:

- global ocean circulation and transfer of heat
- physics of the Earth's interior (lithosphere & mantle)
- sea level records, topographic processes, evolution of ice sheets and sea level change

GOCE: Measurement Approach:
Measures accelerations of proof masses due to gravity field variations

high-low satellite-to-satellite GPS tracking…



… plus on-board satellite gradiometry

Low earth orbit of ~250 km requires drag-Free Attitude Control to combat the effects of air drag – uses an ion propulsion engine

SMOS: Soil Moisture and Ocean Salinity Mission

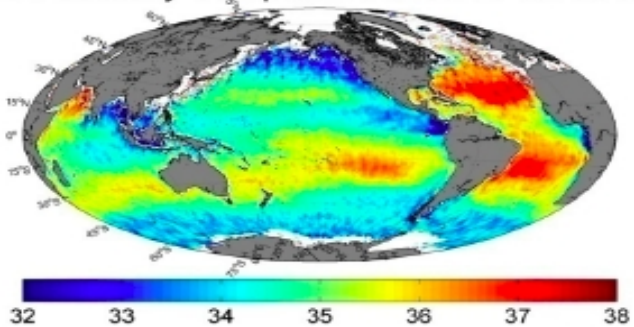
www.esa.int/smos

Launched 2nd Nov 2009!!

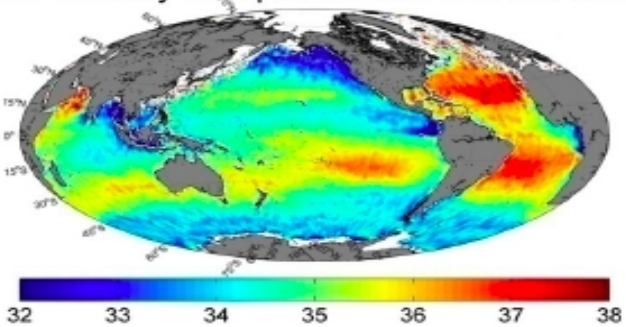
Its objectives are:

- to provide global maps of soil moisture and ocean salinity for hydrological studies (**Accuracy of 0.1 psu for a 10-30 day average for an open ocean area of 200 x 200 km)**
- to advance our understanding of the freshwater cycle
- to improve climate, weather and extreme-event forecasting
- Instrument: Microwave Imaging Radiometer with Aperture Synthesis (MIRAS)

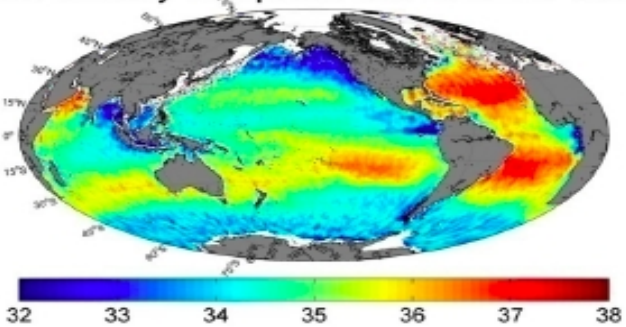
SSS Monthly Composite Jan 2010-0.5°x0.5°



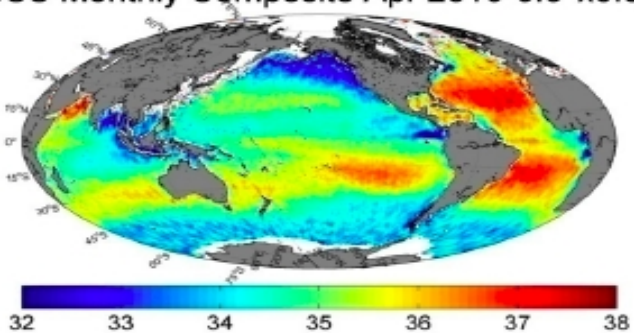
SSS Monthly Composite Feb 2010-0.5°x0.5°



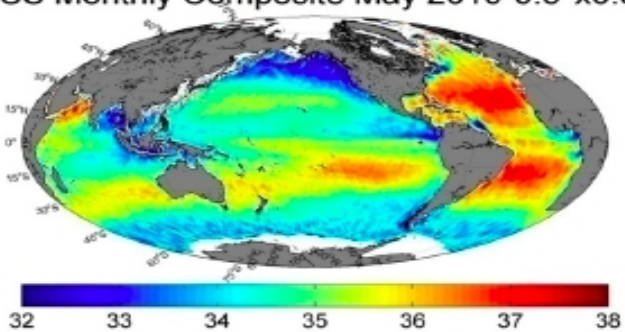
SSS Monthly Composite Mar 2010-0.5°x0.5°



SSS Monthly Composite Apr 2010-0.5°x0.5°



SSS Monthly Composite May 2010-0.5°x0.5°



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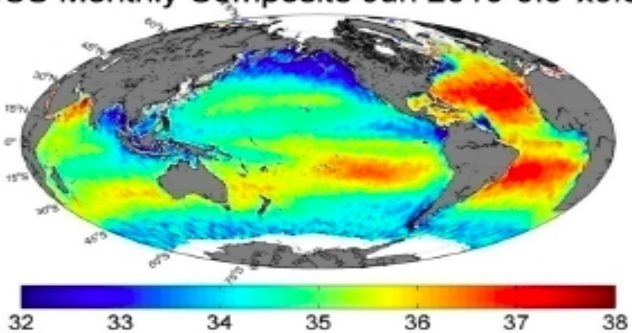
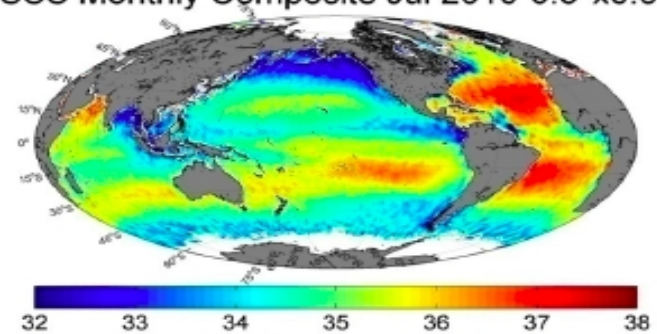
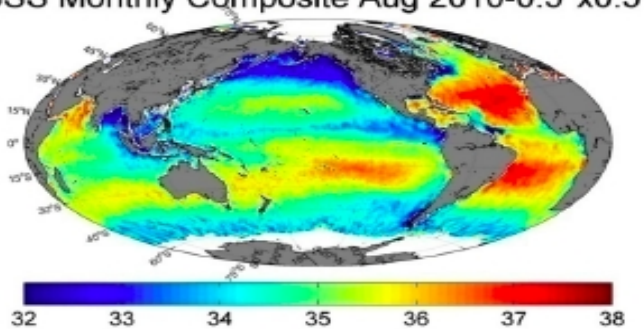


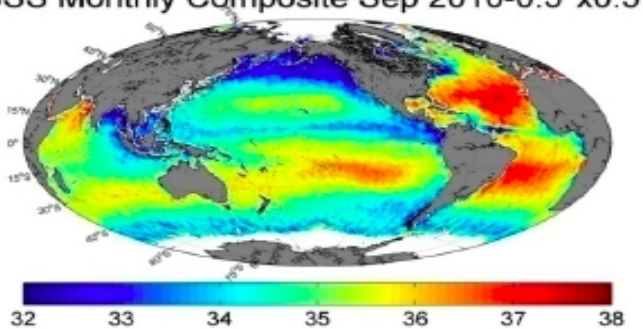
SSS Monthly Composite Jul 2010-0.5°x0.5°



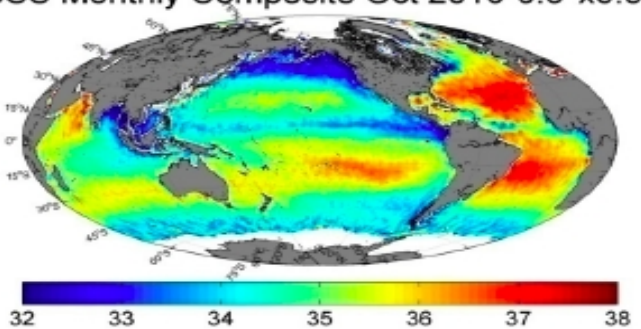
SSS Monthly Composite Aug 2010-0.5°x0.5°



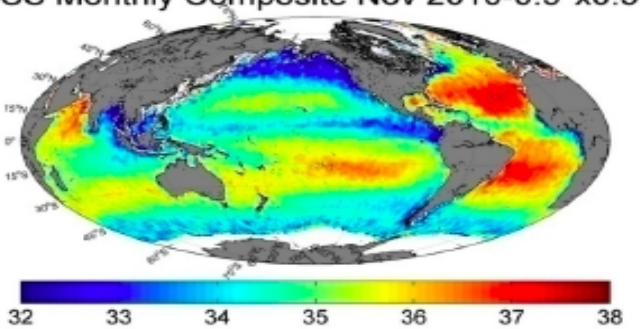
SSS Monthly Composite Sep 2010-0.5°x0.5°



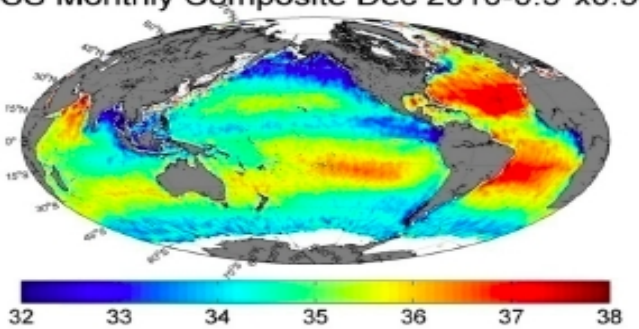
SSS Monthly Composite Oct 2010-0.5°x0.5°



SSS Monthly Composite Nov 2010-0.5°x0.5°

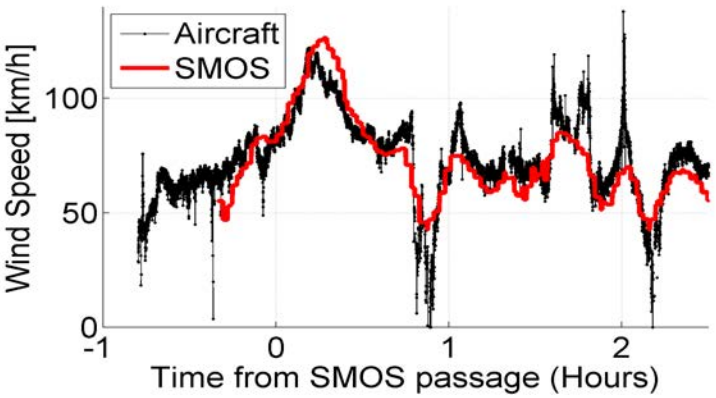


SSS Monthly Composite Dec 2010-0.5°x0.5°



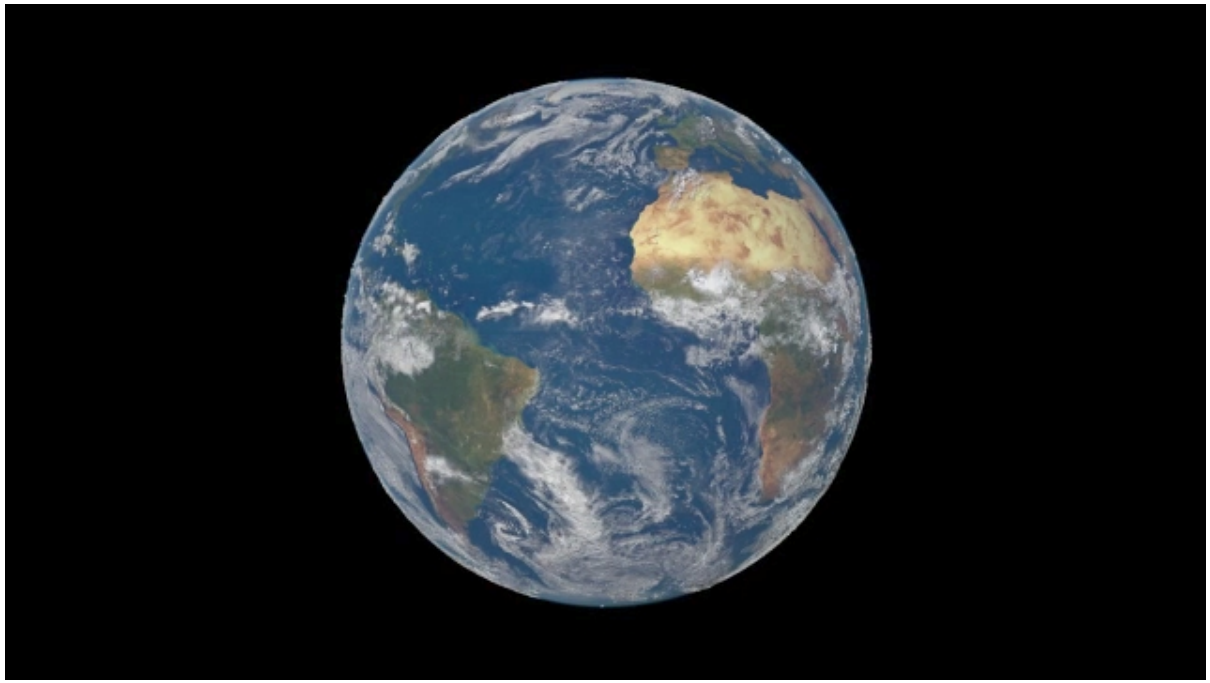
SMOS for traking hurricanes: SMOS+ STORM

Result 1: **L-band is less sensitive to roughness and foam changes than at the higher C-band microwave frequencies. At the same time wind induced excess TB increases quasi-linearly with surface wind speed at a rate of 0.3 K/m s−1 and 0.7 K/m s−1 below and above the hurricane-force wind speed threshold (~32 m s−1).**



Surface wind speed during Hurricane Sandy taken from a NOAA aircraft and from SMOS

(Credits: IFREMER/NOAA/HRD)



Sea Surface Wind Speed fields in meter per second retrieved from SMOS data over the Saffir-Simpson category 5 hurricane IGOR that developed in the North Atlantic ocean from 11 to 19 September 2010. (N.Reul (Ifremer) and J. Tenerelli (CLS)).

Swarm: ESA's Magnetic Field Mission

Its objectives are:

- **To provide the best-ever survey of the Earth's geomagnetic field and its variation in time**
- **to gain new insight into the Earth's interior and climate.**

Using magnetometers, accelerometers, GPS and electric field meters

SWARM: Scientific objectives

Objectives: the Earth

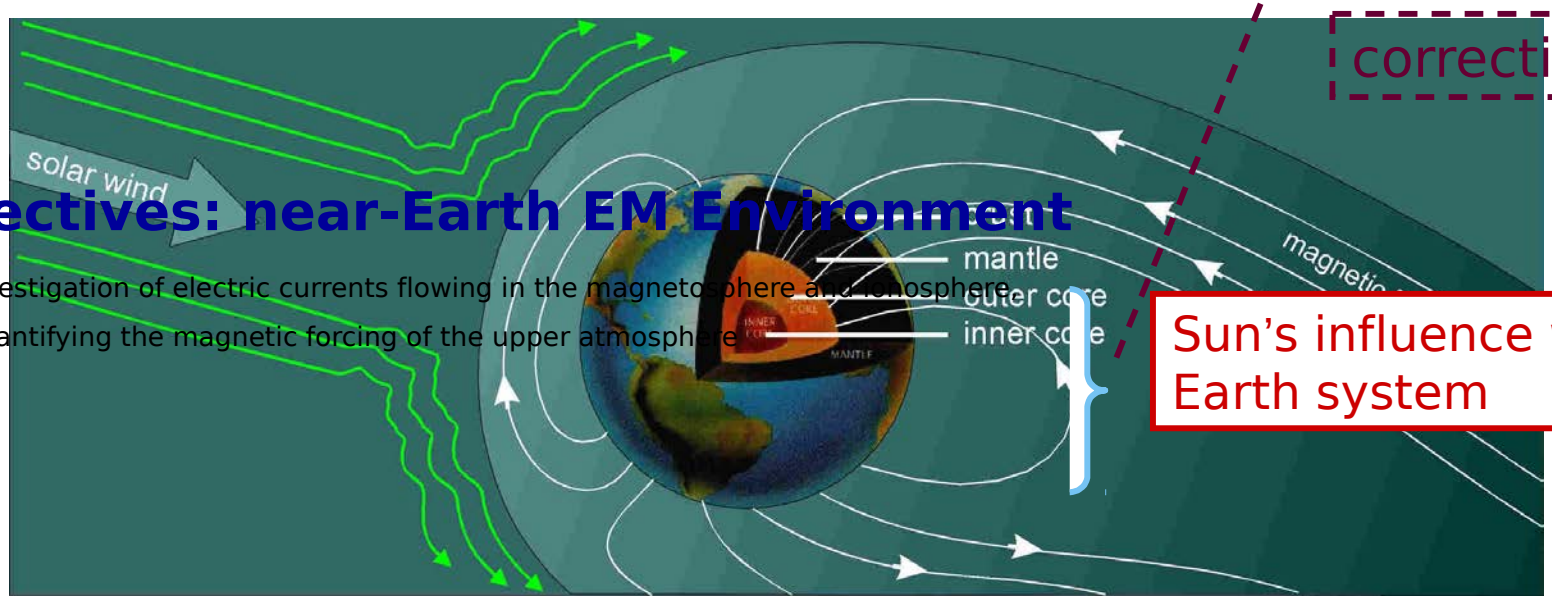
- ✓ Studies of core dynamics, geodynamo processes, and core-mantle interaction,
- ✓ Mapping of the lithospheric magnetisation and its interpretation,
- ✓ Determination of the 3-D electrical conductivity of
- ✓ Identifying the ocean circulation by its magnetic signature

Unique view “inside” the Earth from space for core, mantle & crust

correction

Objectives: near-Earth EM Environment

- ✓ Investigation of electric currents flowing in the magnetosphere and ionosphere
- ✓ Quantifying the magnetic forcing of the upper atmosphere



Sun’s influence within Earth system

ADM-Aeolus – ESA‘s wind mission

Mission objectives:

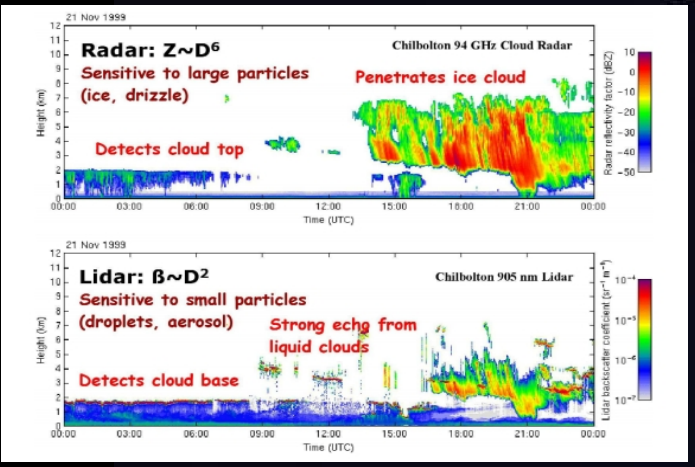
- to provide global observations of **3-D wind fields** giving a more accurate picture of the Earth's global energy budget
- to improve the quality of **weather forecasting**
- to enhance our understanding of **atmospheric dynamics and climate processes**

Status:

Manufacturing of the ALADIN instrument ongoing

Satellite acceptance review planned by mid 2013

EarthCARE – ESA‘s aerosol mission



A joint ESA-JAXA mission (LIDAR, RADAR, VIS/TIR radiometers):

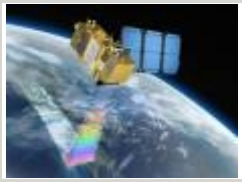
- **To quantify and thus improve understanding of cloud-aerosol-radiation interactions**
- **To include such parameters correctly and reliably in climate and weather prediction models**

Status: *Preparation of Phase C/D, Launch in 2015-16*

GMES Space Component: dedicated missions

Sentinel-1 (A/B) – SAR imaging
All weather, day/night applications, interferometry

2013 /2015



Sentinel-2 (A/B) – Multi-spectral imaging
Land applications: urban, forest, agriculture,…
Continuity of Landsat, SPOT

2014 /2016

Sentinel-3 (A/B) – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry

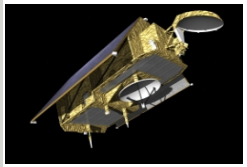
2014/2017

Sentinel-4 (A/B) – Geostationary atmospheric
Atmospheric composition monitoring, trans-boundary pollution

2019/2027

Sentinel-5 precursor/ Sentinel-5 (A/B) – Low-orbit atmospheric
Atmospheric composition monitoring

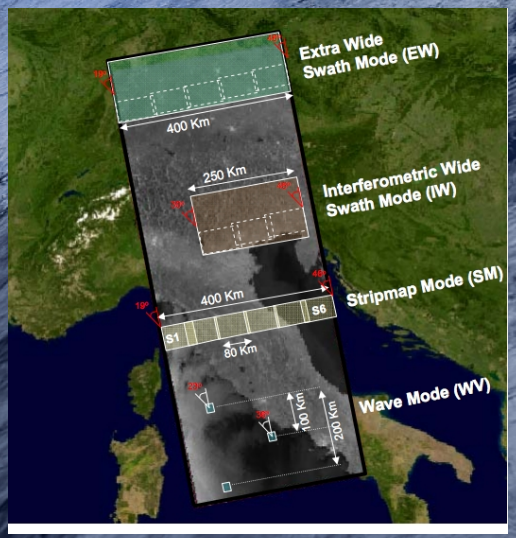
2015/2020/2027



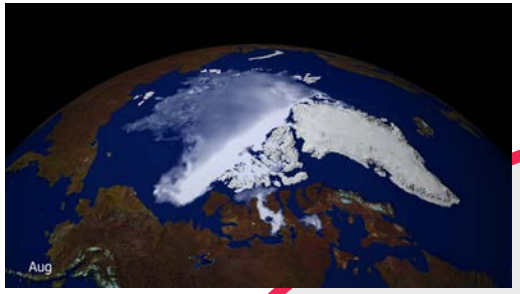
Jason-CS (A/B) – Low inclination Altimetry
Sea-level, wave height and marine wind speed

2018/2023

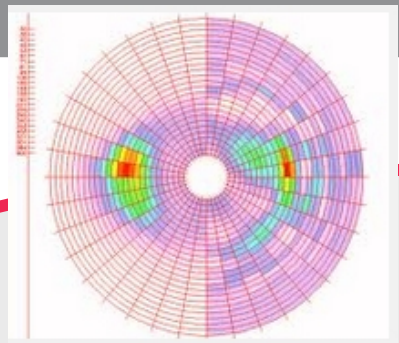
Sentinel-1 for Science



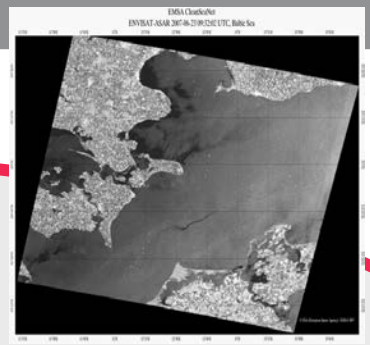
Few examples of Sentinel-1 applications



Arctic ice extent
August 2009
(Credit: MyOcean)

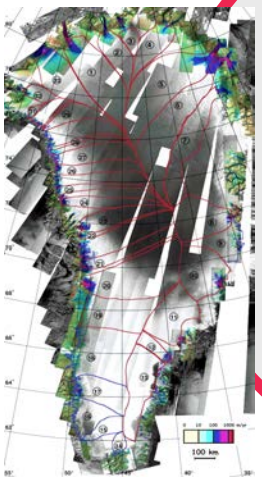


Wave spectral information
(Credit: ESA)



Oil spill detection
and Surveillance
(Credit: EMSA)

Ship detection
(Credit: ESA)



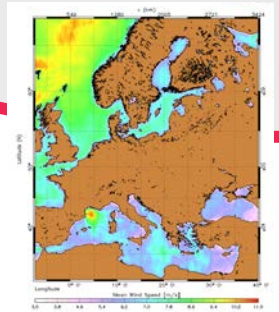
Acceleration of Greenland
glaciers flow
(Credit: Rignot et Al)

C-band SAR observations support a wide range of applications

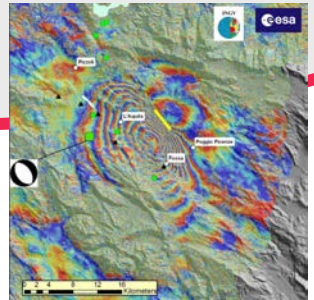
Land use
(Credit: ESA)

Emergency management:
flooding
(Credit: SAFER, DLR)

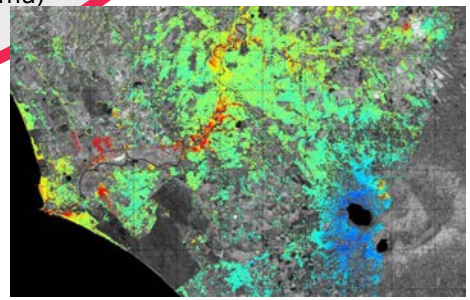
Mean wind speed
from 2005 to 2009
(Credit: CLS)



Earthquake
analysis
(Credit: INGV)



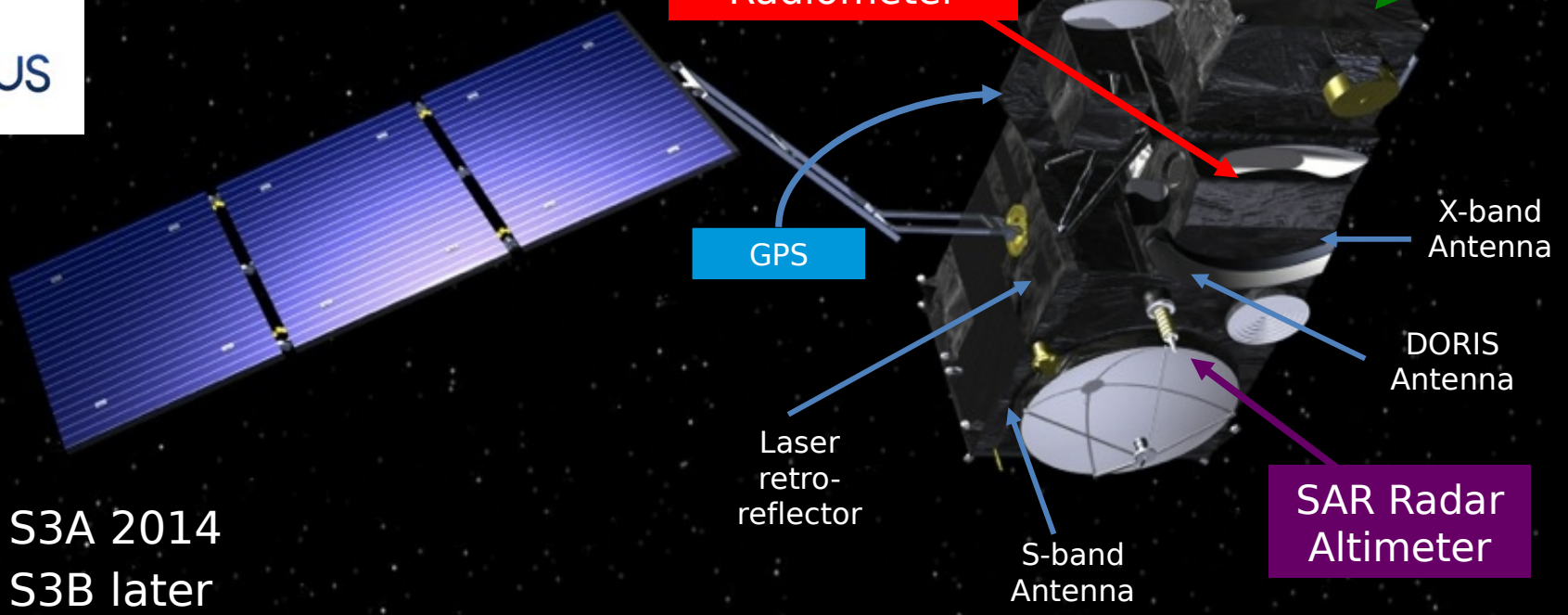
Subsidence map
1992-2006
(Credit: Terrafirma)



Sentinel-3

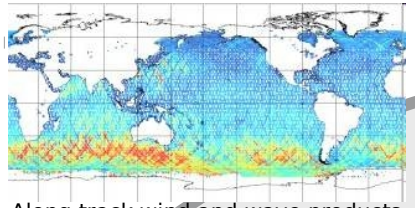
Main satellite characteristics

- 1250 kg maximal mass
- Volume in 3.89 m x 2.202 m x 2.207 m
- 7.5 years lifetime (fuel for 5 add. years)

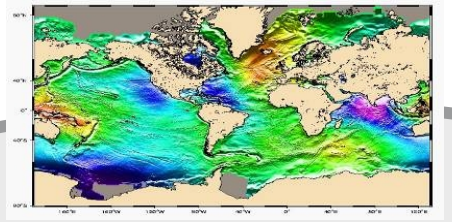


- Launch S3A 2014
- Launch S3B later
- 3h delivery timeliness (from satellite sensing)

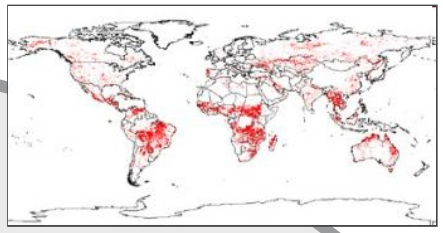
Sentinel-3 Product Examples



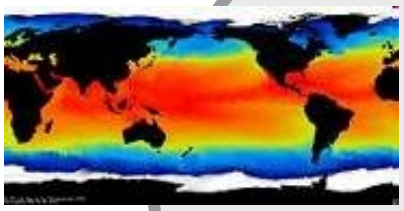
Along track wind and wave products
(Credit: AVISO)



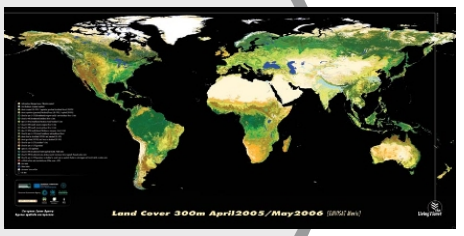
Sea Surface Height products
(Credit: CLS)



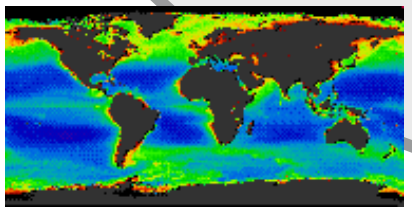
Fire products
(Credit: ESA World Fire atlas)



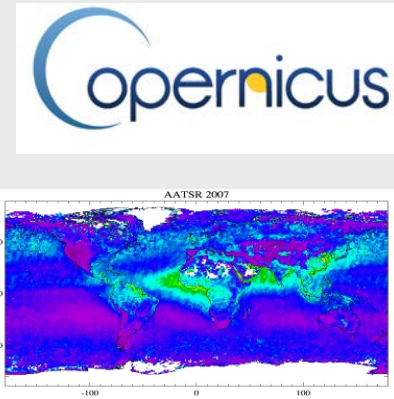
Sea Surface Temperature products
(Credit: Met Office)



Land cover products
(Credit: ESA)



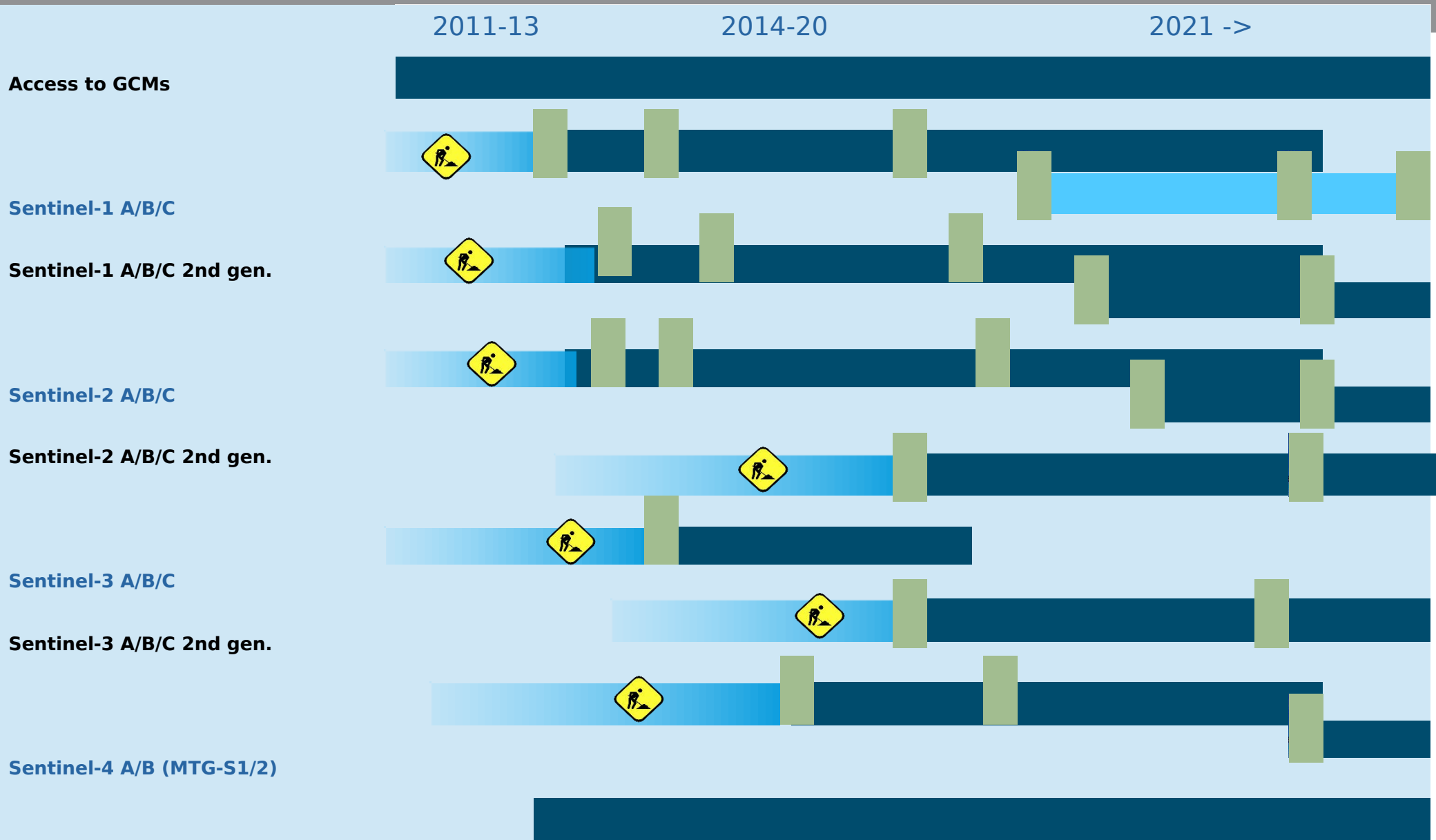
Ocean colour products
(Credit: MyOcean)



Atmospheric aerosol products
(Credit: GlobAerosol)

User parameters derived from L1b products (Credit: GEO)

Users need long term perspectives



ESA missions catalogue and ordering tool
The EO-Help Desk

EOLI-SA: on-line multi-mission catalogue

http://earth.esa.int/EOLi/EOLi.html

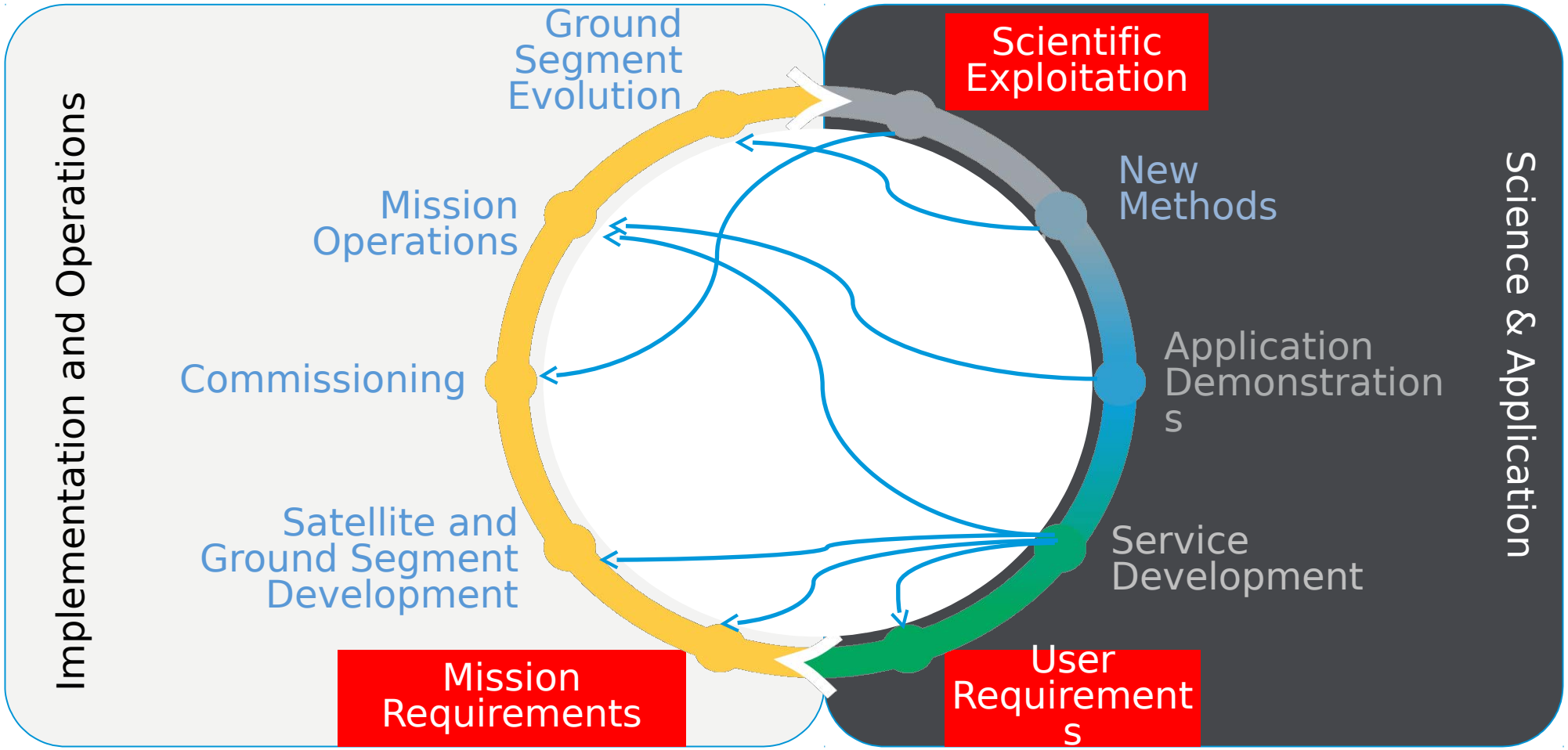
User interface is eohelp@eo.esa.int

Help Desk: handles users' requests for information and users' complaints

Order Desk: handles users' orders

Documentation Desk: distributes documentation

nce and New Satellite Missions



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Brochure: STSE Support to Science Element

STSE Report 2008 - 2012

The **Support To Science Element (STSE)** is a programmatic component of the Earth Observation Envelope Programme (EOEP), an optional programme of the European Space Agency, currently subscribed by 14 ESA Member States.

STSE aims at providing scientific support for both future and on-going missions, by taking a proactive role in the formulation of new mission concepts and of the related scientific agenda, by offering a multi-mission support to the scientific use of ESA Earth Observation missions data and to the promotion of the achieved results.

Search projects by thematic areas

News

Key events

ESA organises the **1st Intern. EO Convoy & Constellation Concepts Workshop, 9-11 Oct 2013** at ESA/ESTEC, Noordwijk, NL.

New opportunities

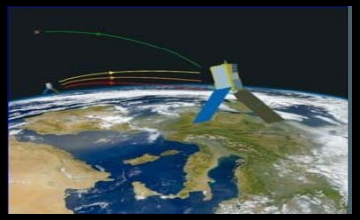
The Support To Science Element (STSE) is preparing a number of new opportunities to be **launched within 2013**.

Related links

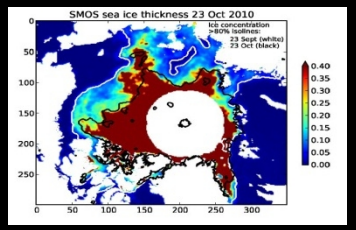
- Living Planet Programme
- Earth Explorers
- EO Principal Investigator Portal
- Data User Element
- Multi-mission EO Portal

ESA Support To Science Element (STSE)

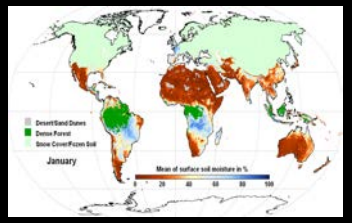
STSE provides a coherent and flexible platform for innovation across ESA EO science activities following an end-to-end approach to science addressing four major Action Lines:



Science Support to Novel Mission Concepts

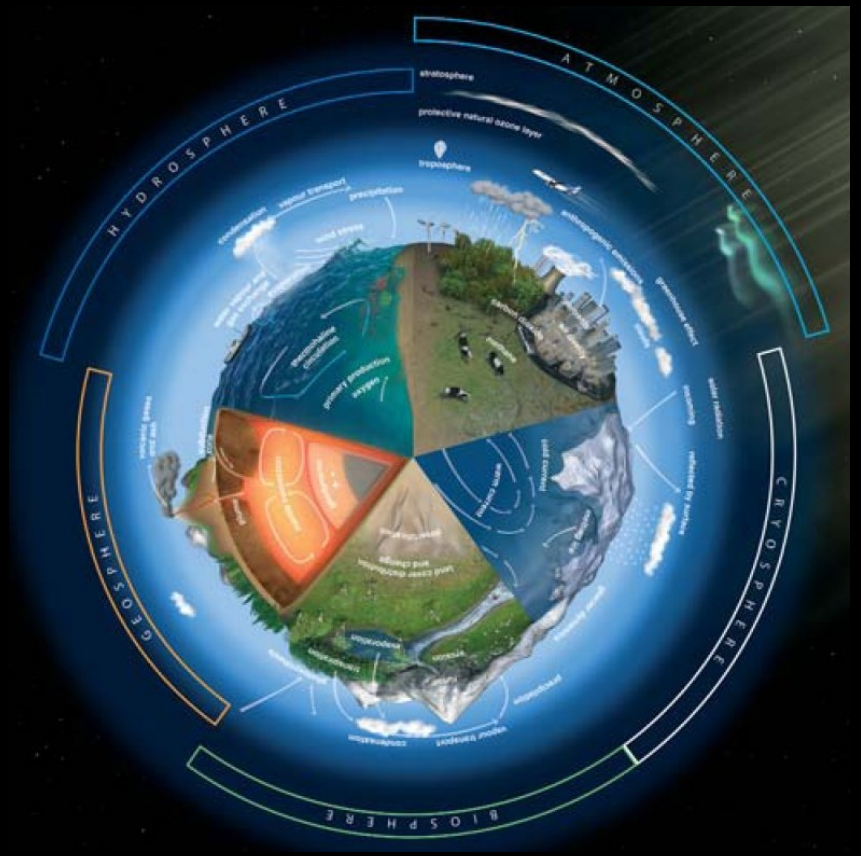


Novel Algorithms & Products



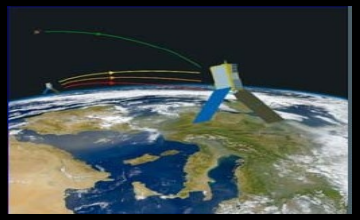
Support to Earth System Science

Support the Next Generation of Scientists

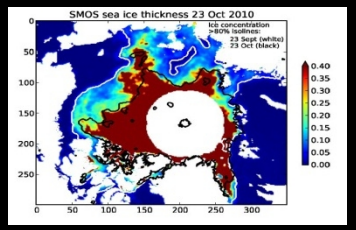


Support To Science Element

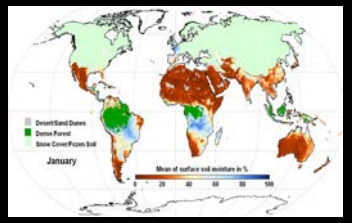
STSE represents a pathfinder for science and innovation providing a flexible mechanism to address the scientific needs and requirements of the Earth System Science Community in terms of novel missions, new algorithms and products and innovative Earth science results



Science Support to Novel Mission Concepts



Novel Algorithms & Products

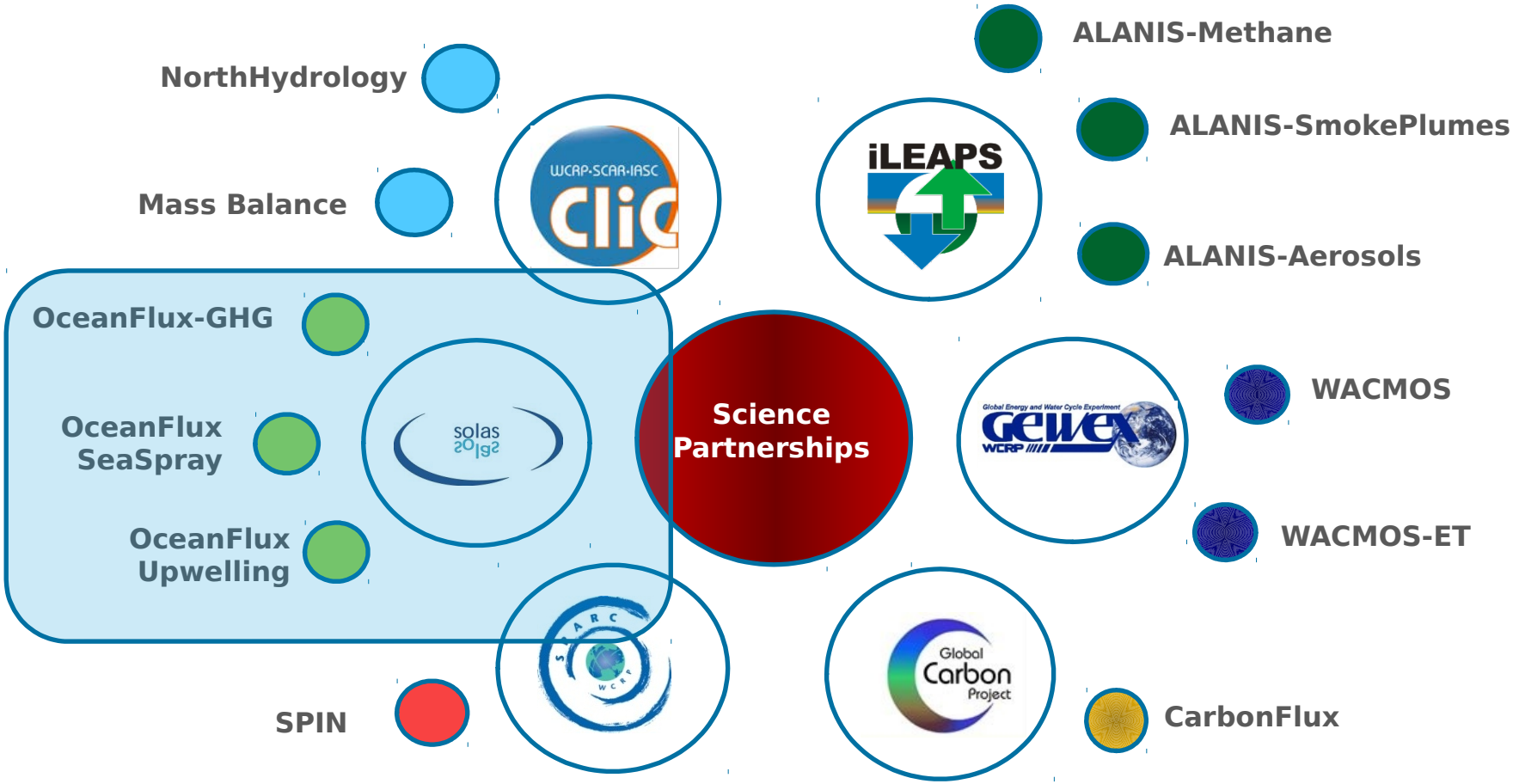


Support to Earth System Science

Support the Next Generation of Scientists

- **Addressing today's major open questions in Earth Science with ESA data**
- **Contributing to major international science efforts**
- **Promoting ESA data within a wide scientific community**
- **Maximising the use of ESA archives**

New Earth Science Results:
ESA contribution to International Science Programmes



surface ocean solas lower atmosphere study

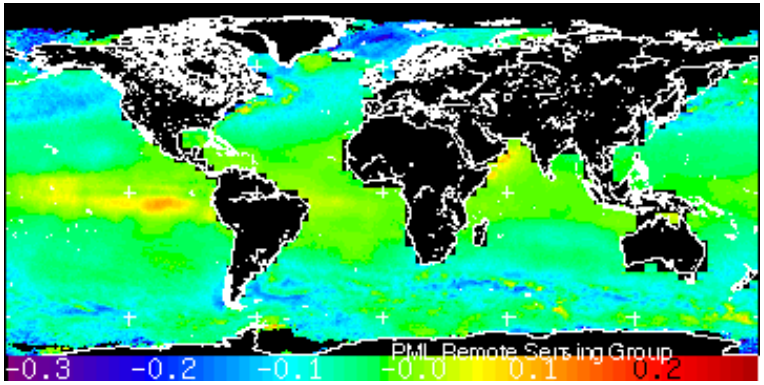
Home | About | Activities | Resources | Community

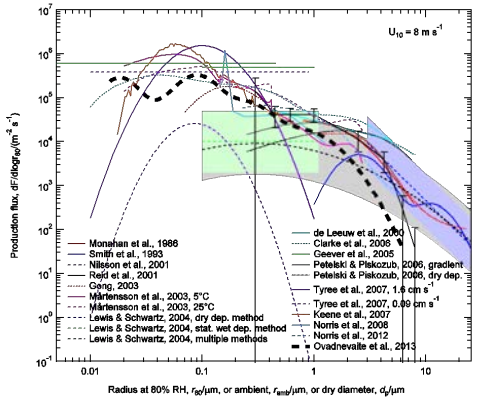
SURFACE OCEAN - LOWER ATMOSPHERE STUDY

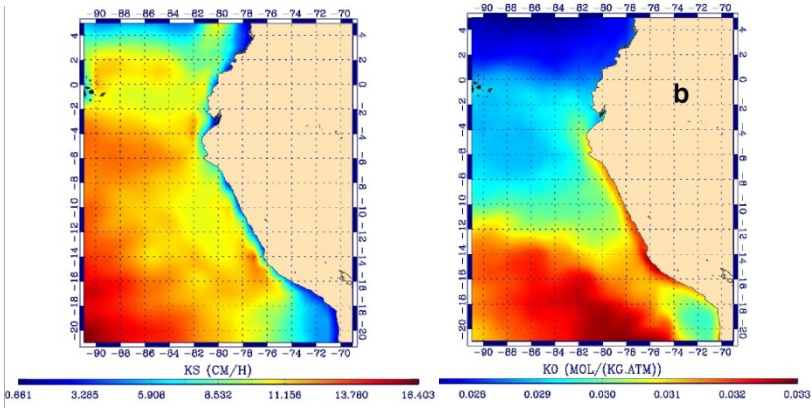
Ocean-Atmosphere Interactions

ESA-SOLAS collaboration:

- **Started in 2009, at the last SOLAS Open Science Conference (discussion session);**
- **A workshop was organised in 2010 to collect preliminary scientific requirements;**
- **As a result 3 projects “OceanFlux” have been launched in 2011;**
- **ESA-SOLAS-EGU EO for Ocean-Atmosphere Interactions Science, Frascati, 2011;**
- **An special issue on Biogeoscience and Ocean Science was organised as a result of the conference;**







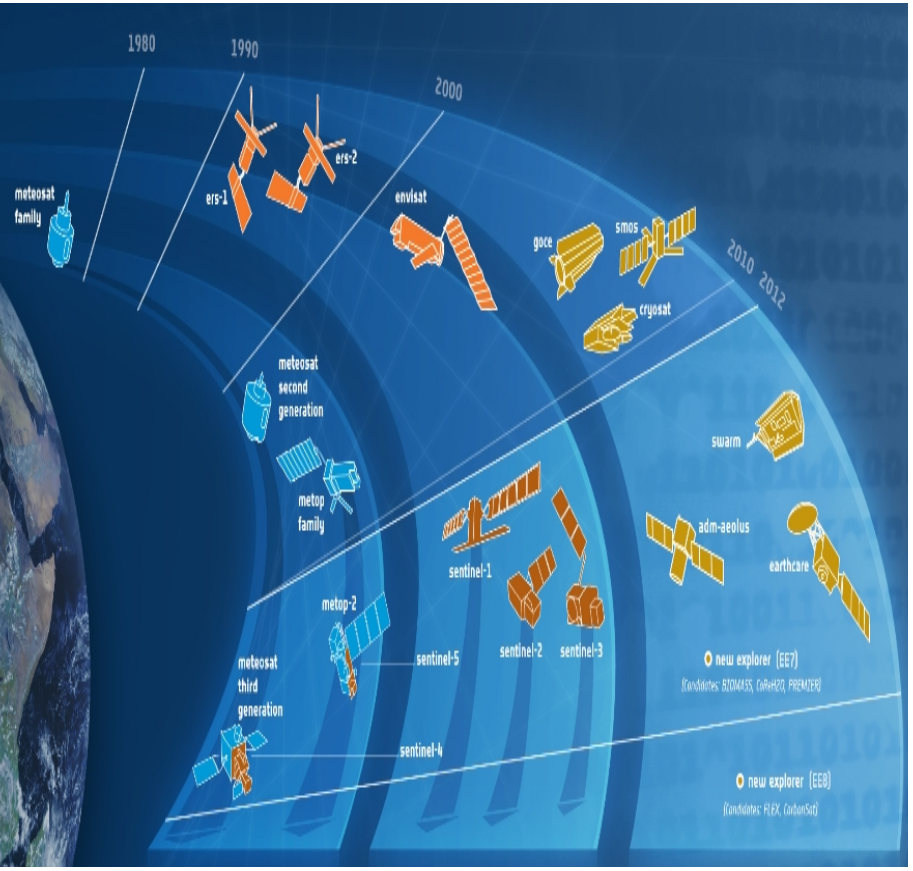
oceanflux ghg
support to science element

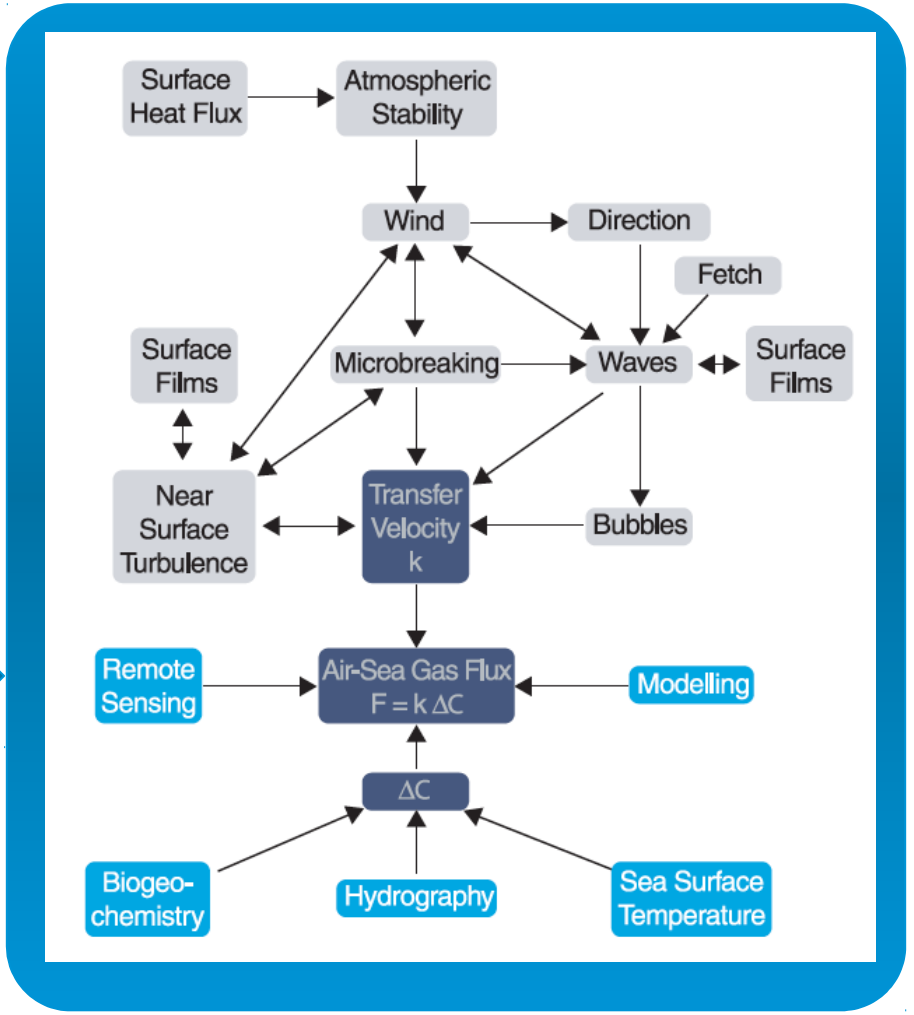
oceanflux sea-spray
support to science element

oceanflux upwelling
support to science element

Agency

Air-sea gas exchange: Scientific application of EO data





The aim of the *OceanFlux* GHG Project

To improve quantitative air-sea flux estimates of CO2 and other greenhouse gases using EO data in synergy in the Atlantic Ocean and European Shelf Seas.

Objectives:

1. **Develop novel or existing methodologies/algorithms using Earth Observation data and create new products for use by the SOLAS and other communities.**
2. Estimate and **reduce uncertainty** in conventional gas transfer computations relative to EO driven computations,
3. **Compute air sea gas transfer flux calculations** using satellite data including a validated estimate of uncertainty,
4. **Exploit modeling frameworks** to develop more dynamic and accurate estimates of air sea gas transfer on a sub-weekly timescale

ESA STSE OceanFlux GHG Project design

ESA Support to Science Element

OceanFlux GHG – Reference Baseline

ESA Contract No. 4000104762/11/I-AM

Deliverable: D-2.7

FINAL

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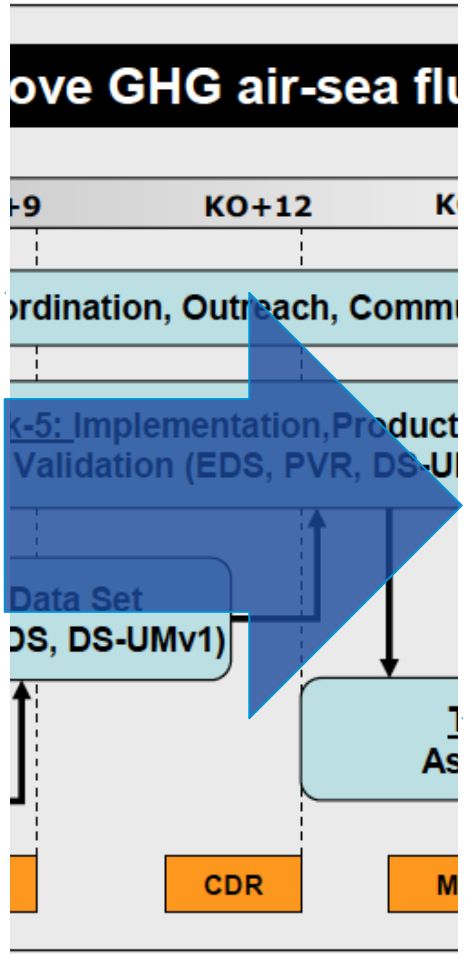

e OceanFlux GHG proje
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OceanFlux GHG

Scientific Impact Assessment Report

ESA Contract No. 4000104762/11/I-AM

Deliverable: D-2.17

DRAFT

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Heriot Watt University

ESA STSE OceanFlux GHG Example 2010

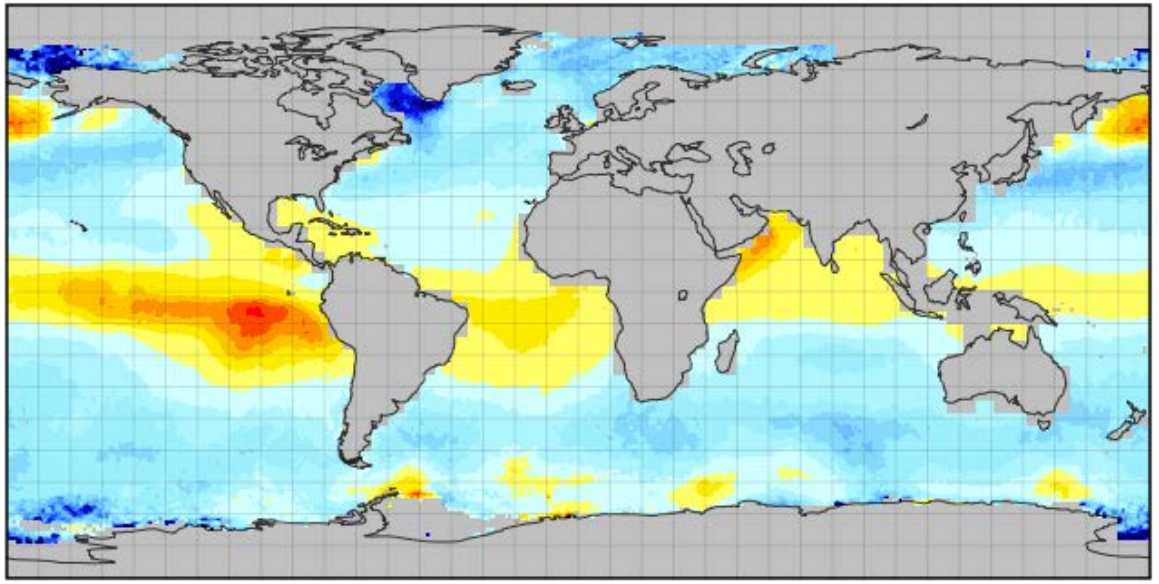
Global regular grid 1o x 1o NetCDF 3.0, CF 1.6

Uncertainty information included

Attribute and quality indicator layers (including surface biology from OC CCI, diurnal warming etc).

Data at different depths (e.g. interfacial and mass boundary layer CO2 concentrations)

Quantities: SSTskin, SSTfnd, salinity, whitecap coverage, solubility, fugacity, ktotal, krain +..)



Example daily mean flux 2010

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PML Plymouth Marine Laboratory

oceanflux ghg
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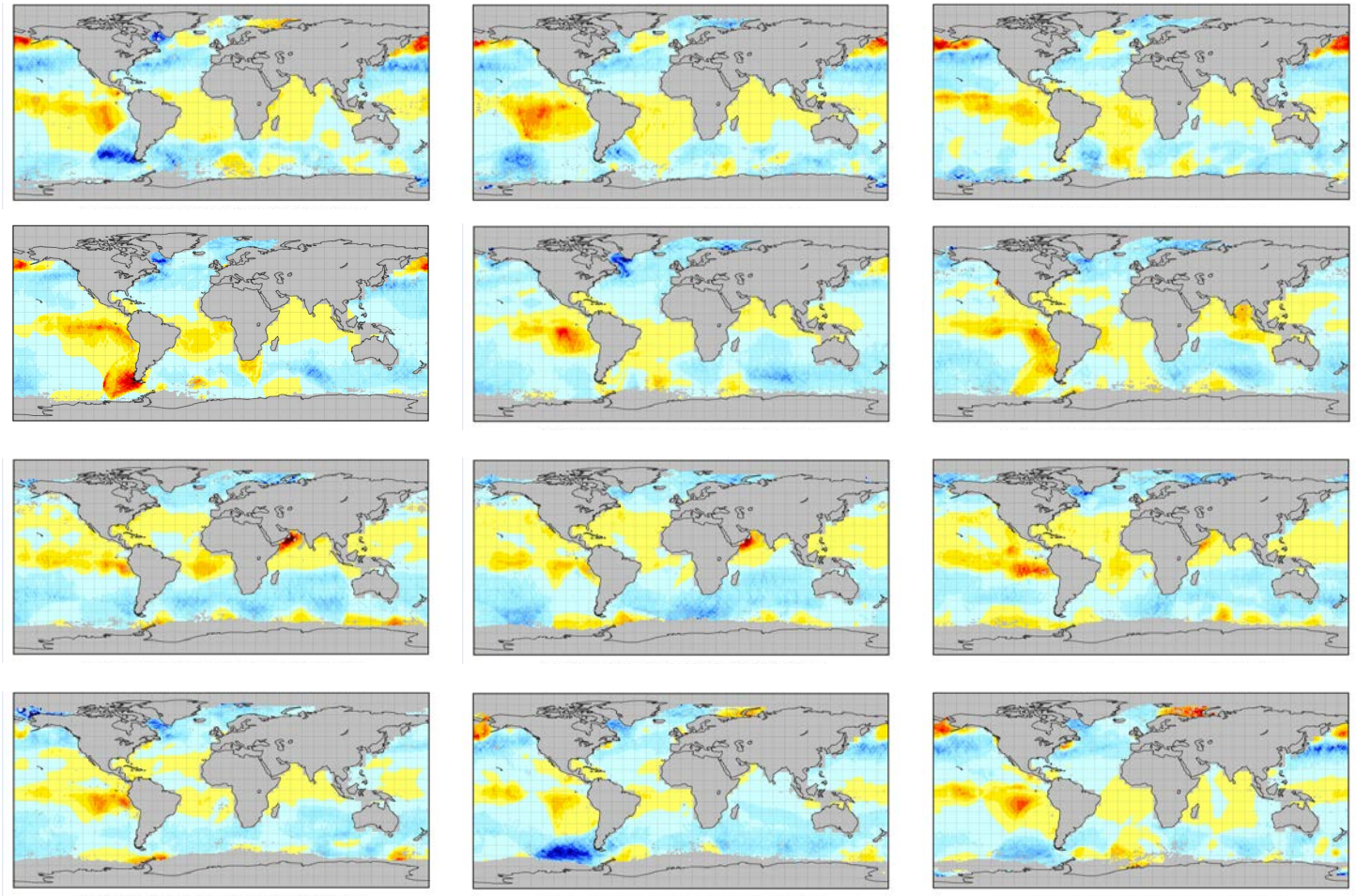
ESA STSE OceanFlux GHG: Example Global Monthly 2010



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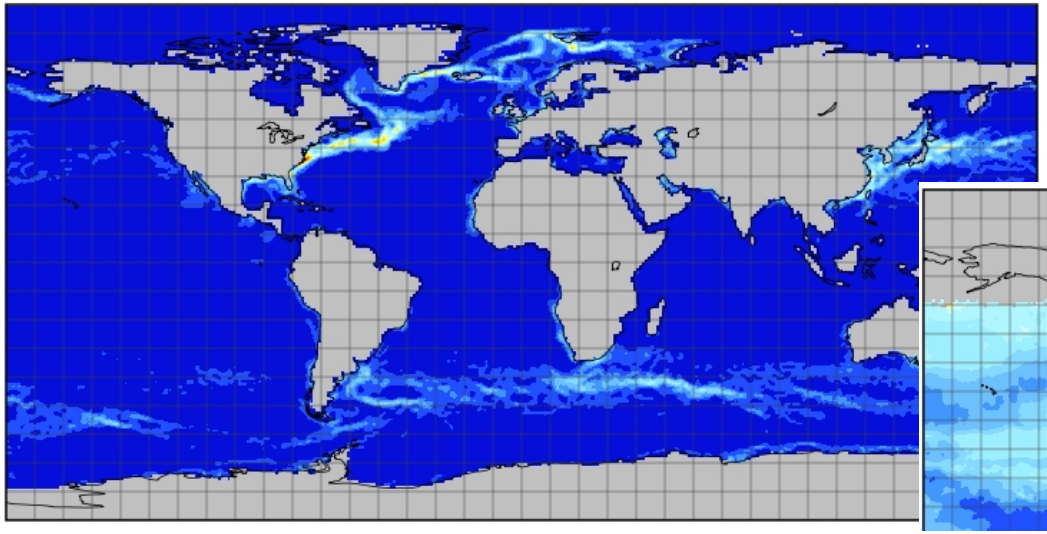
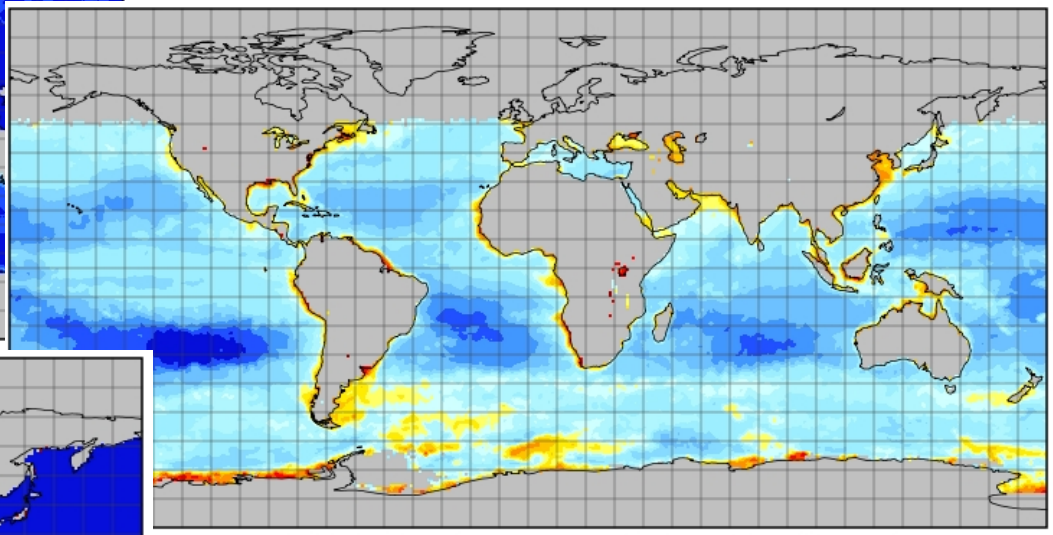
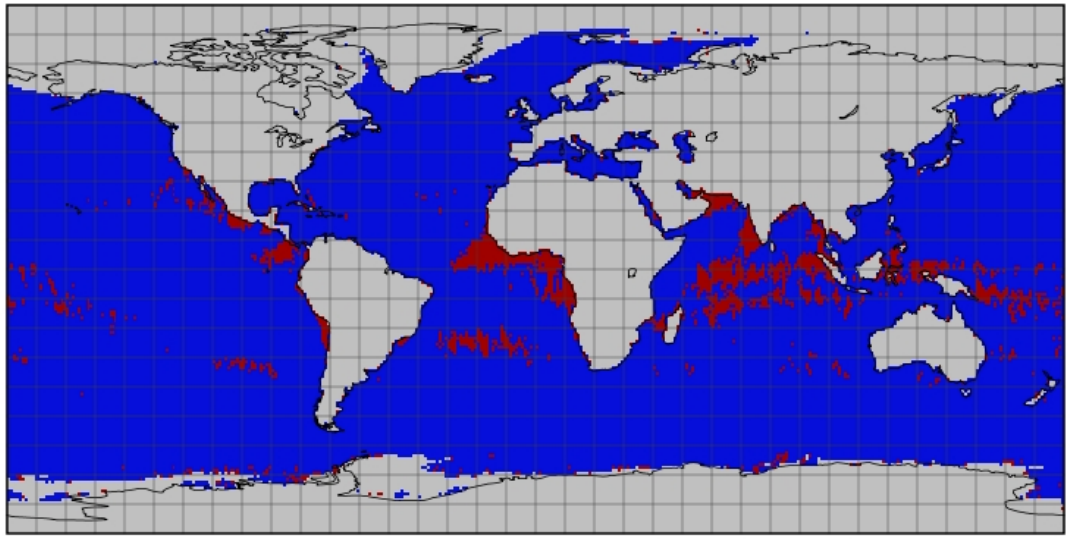
OceanFlux GHG – process indicator layers



Persistent SST fronts (GHRSST)

Surface chl-a (ESA CCI)





Regions of low wind

PML Plymouth Marine Laboratory

oceanflux ghg
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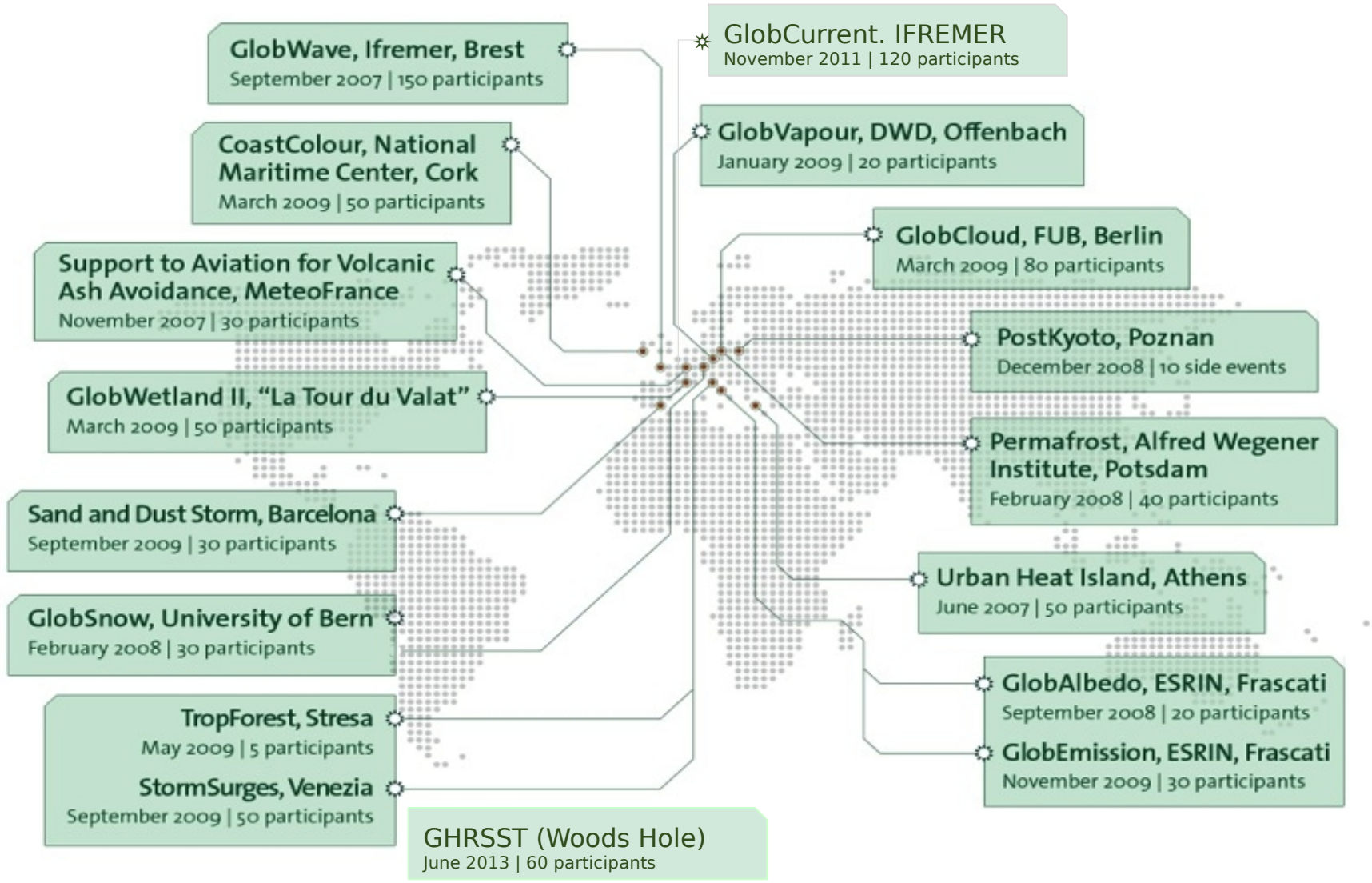
Main Aims of this workshop

- **Eat, breathe, talk Science!**
- **Exchange information** on the results of the project with other researchers
- **Raise awareness** of the utility of EO for GHG fluxes research
- **Obtain feedback** that can help to define the Scientific Roadmap and the Final Report.
- Help ESA define **what comes next…**

ESA Data User Element (DUE) consultation meetings, listening to user communities



Possible Future options under EOEP-5

- **GlobFlux?**
- Data User Element (DUE)
- What can be done to pull-develop demonstration services to the OceanFlux Community?
- How might this look?
- Options to fund up to 1.5MEuro
- Need to start user Consultations in the next 12 months

- **Are there enough users for a viable demonstration user service?**

Summary

Where are we now?

- **OceanFlux GHG Workshop, IFREMER, Brest, 24-27 September 2013;**
- **OceanFlux Sea Spray Workshop, Galway University, 30th September – 2nd October 2013;**

This workshop represents an opportunity to:

- **Present and review the OceanFlux projects results;**
- **Review existing key activities and latest scientific results from the community;**
- **Identify next scientific challenges and opportunities;**
- **Collect feedback and recommendations for potential follow-on actions;**

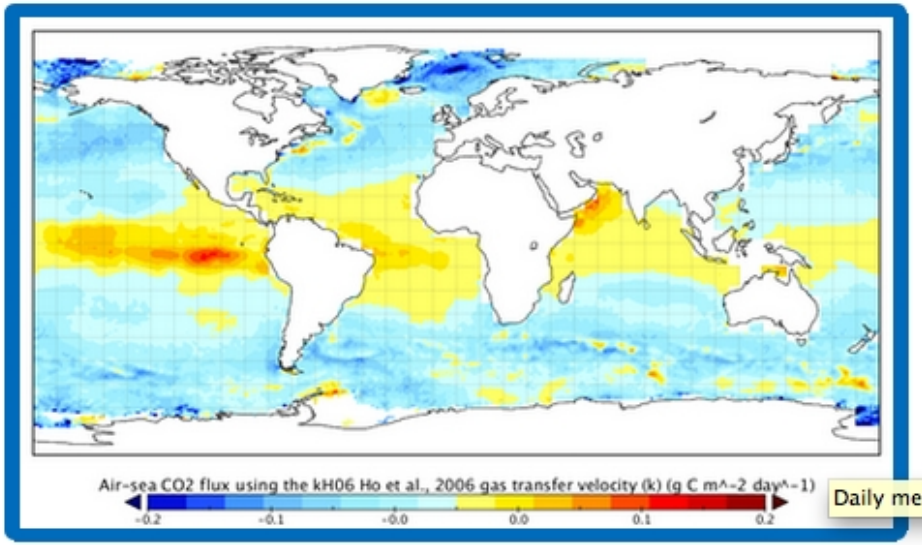
Some additional proposals to discuss:

- **New ESA-SOLAS-EGU Conference in 2014 (*3 years after the first one*)?**
- **Novel Missions Concepts Workshop for ocean-fluxes in 2014?**
  - ***What are the observational gaps and key scientific challenges to be addressed;***
  - ***What are the potential mission concepts that may respond to those needs;***
  - ***What are the technological challenges to be faced;***
  - ***What are the next generation of EO missions to address SOLAS scientific needs;***

Keywords : project

The Project

The Oceanflux Greenhouse Gases project is a two year project funded by the European Space Agency, endorsed by the International SOLAS project.



The objective is to improve the quantification of air-sea exchanges of greenhouse gases.

The air-sea exchanges of greenhouse gases are of prime importance in the climate system. There are large [illegible]ies in the estimates of fluxes, even for CO2 which is the most studied, much of these uncertainties arises