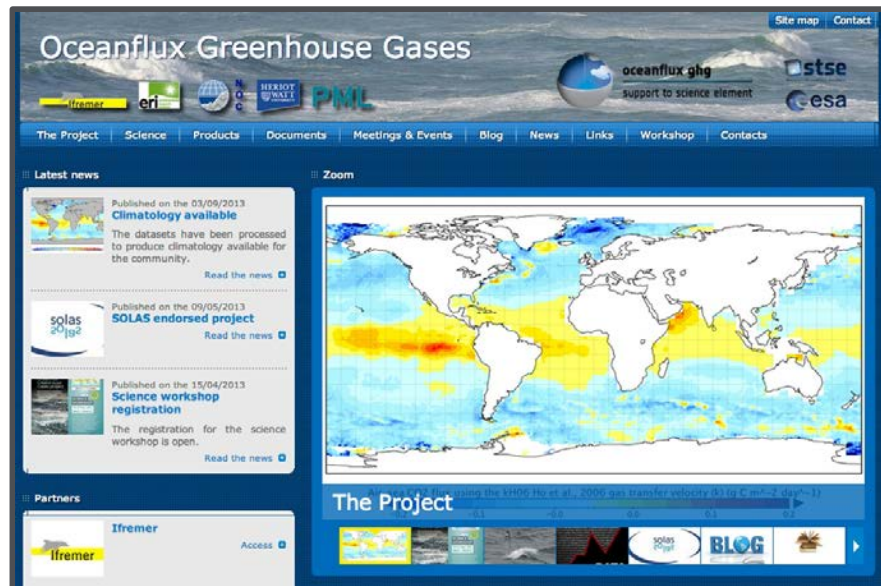


OceanFlux Greenhouse Gas: Science Workshop

IFREMER, Brest France, 24-27th September 2013



Craig Donlon and Diego Fernandez
European Space Agency



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



The OceanFlux Greenhouse Gases project

Aims to improve the quantification of air-sea exchanges of greenhouse gases, of prime importance in the climate system.

Mean daily global air-sea CO₂ flux output

solas 2013

SCIENCE WORKSHOP

24-27 Sept. 2013

BREST | FRANCE

Scientists, engineers, and Reference User Group members are invited to attend the Science Workshop which will take place towards the end of the project, to allow the partners to present the results, gain user feedback and to plan future aims and collaborations.

esa stse

ifremer

“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.

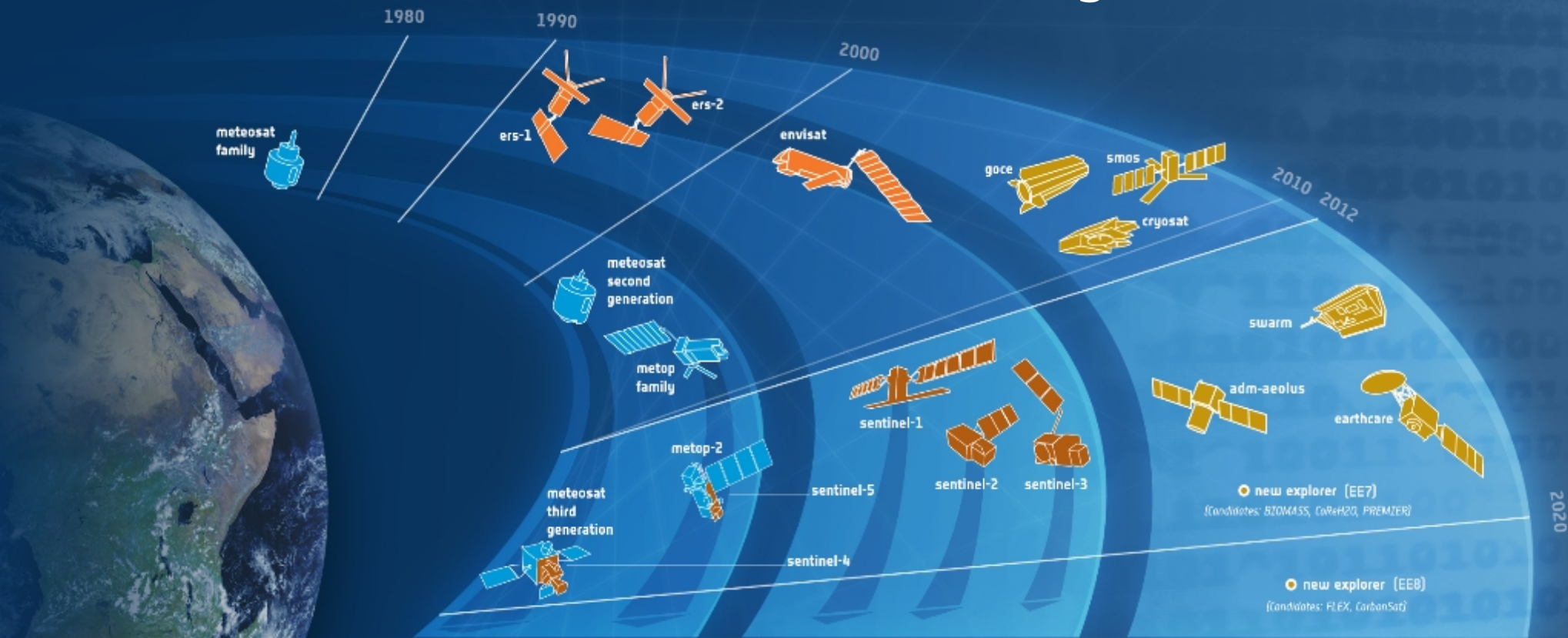
Canada takes part in some programmes under a Cooperation Agreement.



→ OBSERVING EARTH FROM SPACE

Expanding European Earth Observation capability

How can SOLAS use all this data and derived knowledge?



Meteorological Missions

driven mainly by Weather forecasting and Climate monitoring needs. These missions developed in partnership with EUMETSAT include the Meteorological Operational satellite programme (MetOp), forming the space segment of EUMETSAT's Polar System (EPS), and the new generation of Geostationary Meteosat satellites (MSG & MTG satellites).

Copernicus Sentinels

driven by Users needs to contribute to the European Global Monitoring of Environment & Security (GMES) initiative. These satellite missions developed in partnership with the EC include C-band imaging radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring capability (Sentinel-4 & Sentinel-5 on board Met missions MTG and EPS-SG respectively).

Earth Explorer Missions

driven by Scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth's interior operate and interact as part of an interconnected system. These Research missions, exploiting Europe's excellence in technological innovation, pave the way towards new development of future EO applications.

CryoSat2: ESA's Ice Mission



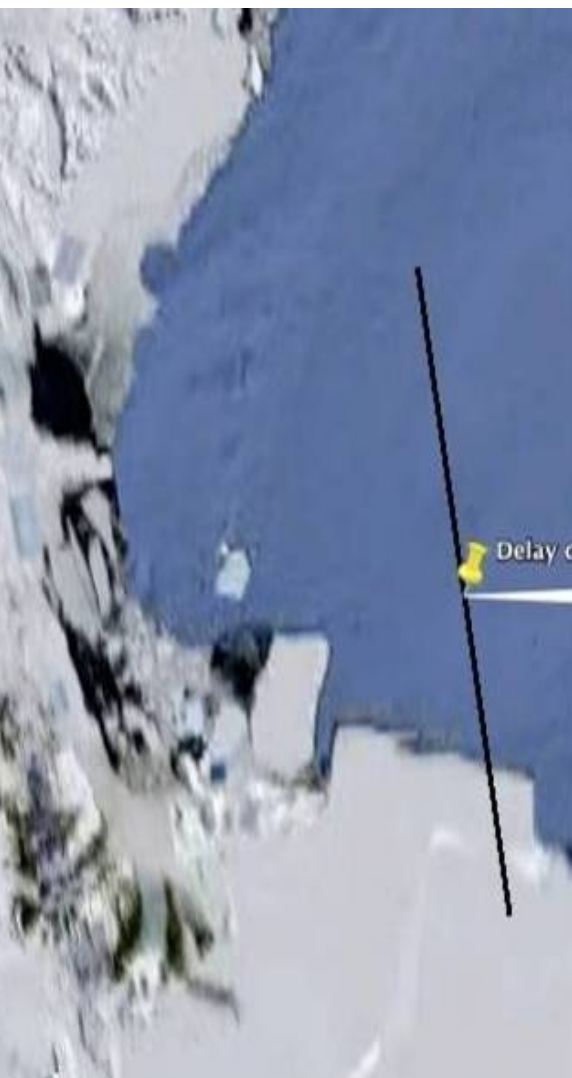
Launched 8th
April 2010



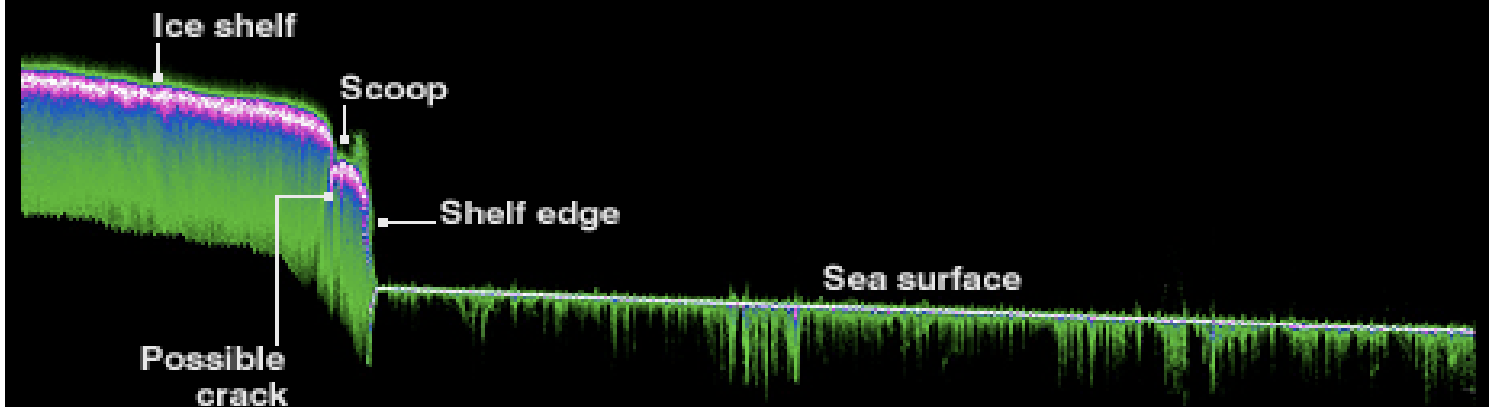
Its objectives are to improve our understanding of:

- 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).

Cryosat over Ocean and the Ross Ice Shelf



CRYOSAT-2: Data from the Ross Ice Shelf, Antarctic



Source: ESA/UCL

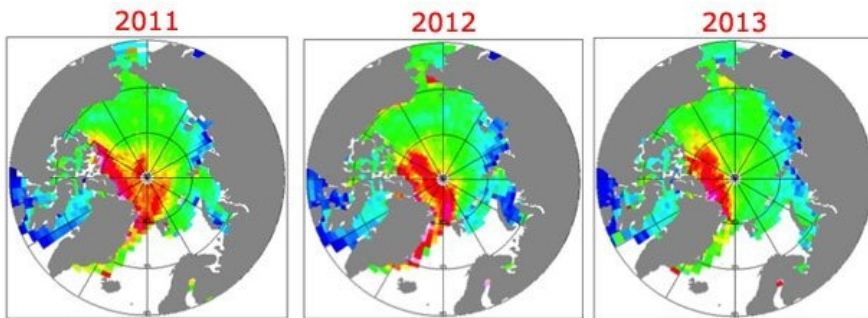


Cryosat is able to measure through the transition between the sea surface and across the shelf edge

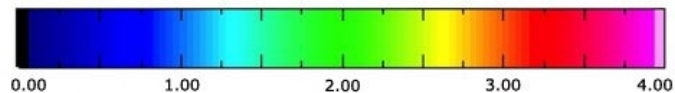
Arctic Ocean sea ice thickness from Cryosat (University College London)

- The first map of sea-ice thickness from ESA's CryoSat mission
- Data from January and February 2011 have 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.

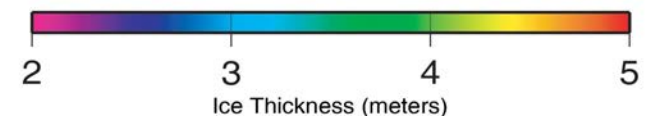
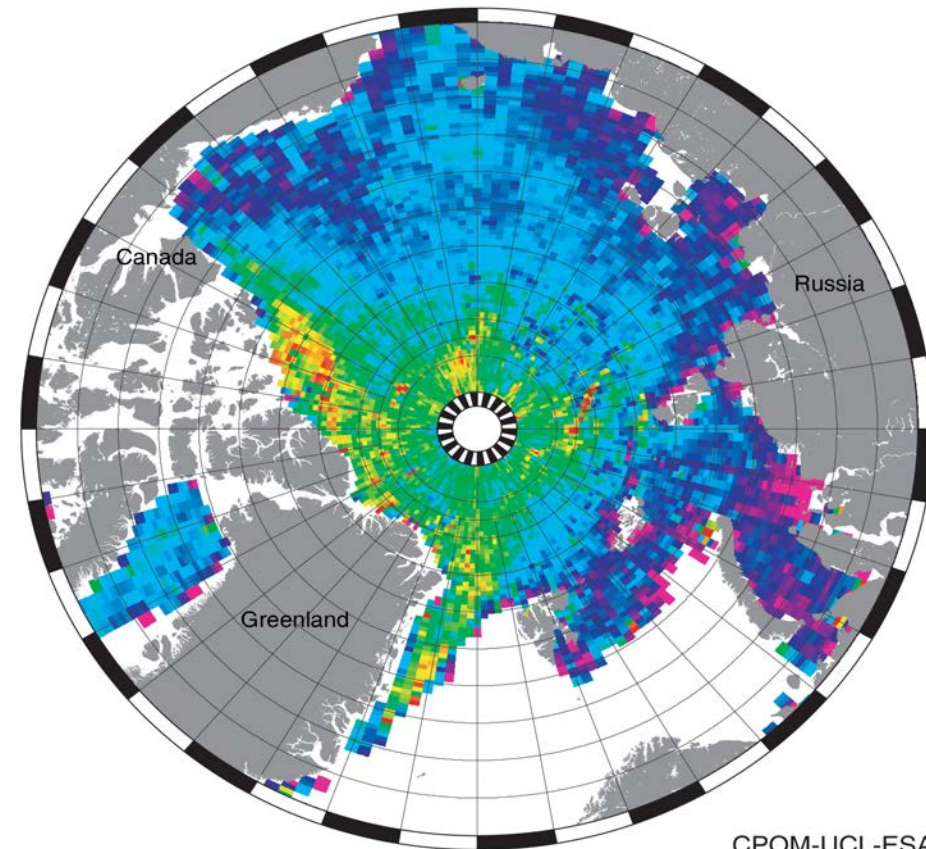
Arctic sea-ice thickness for March/April



Ice thickness (m)



Sea ice thickness in the Arctic ocean
(January/February 2011)

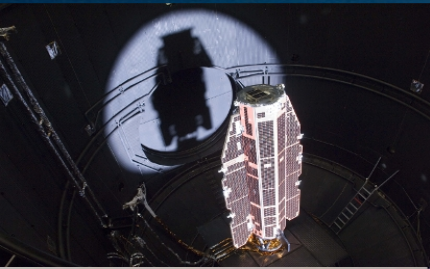


GOCE: ESA's Gravity Mission

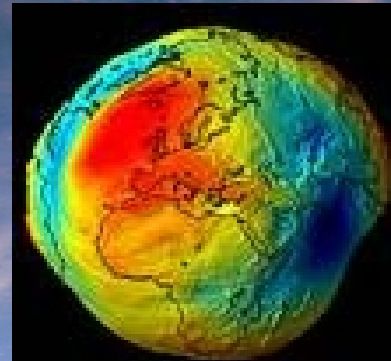
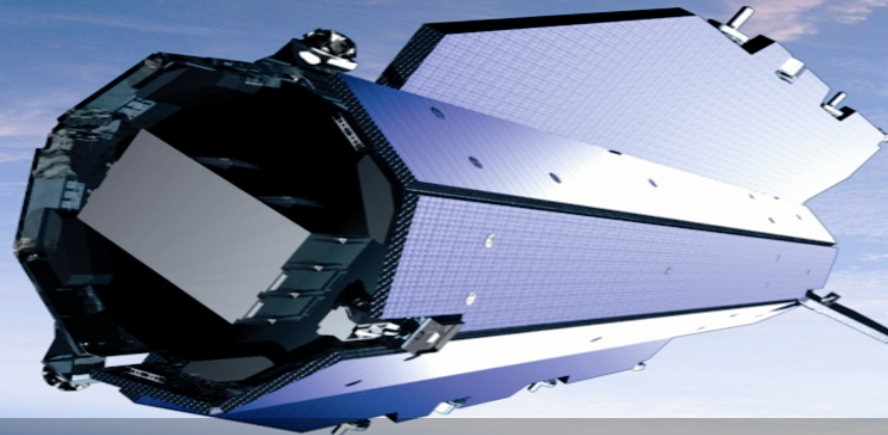
www.esa.int/livingplanet/goce



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



Launched 2nd March 2009!!



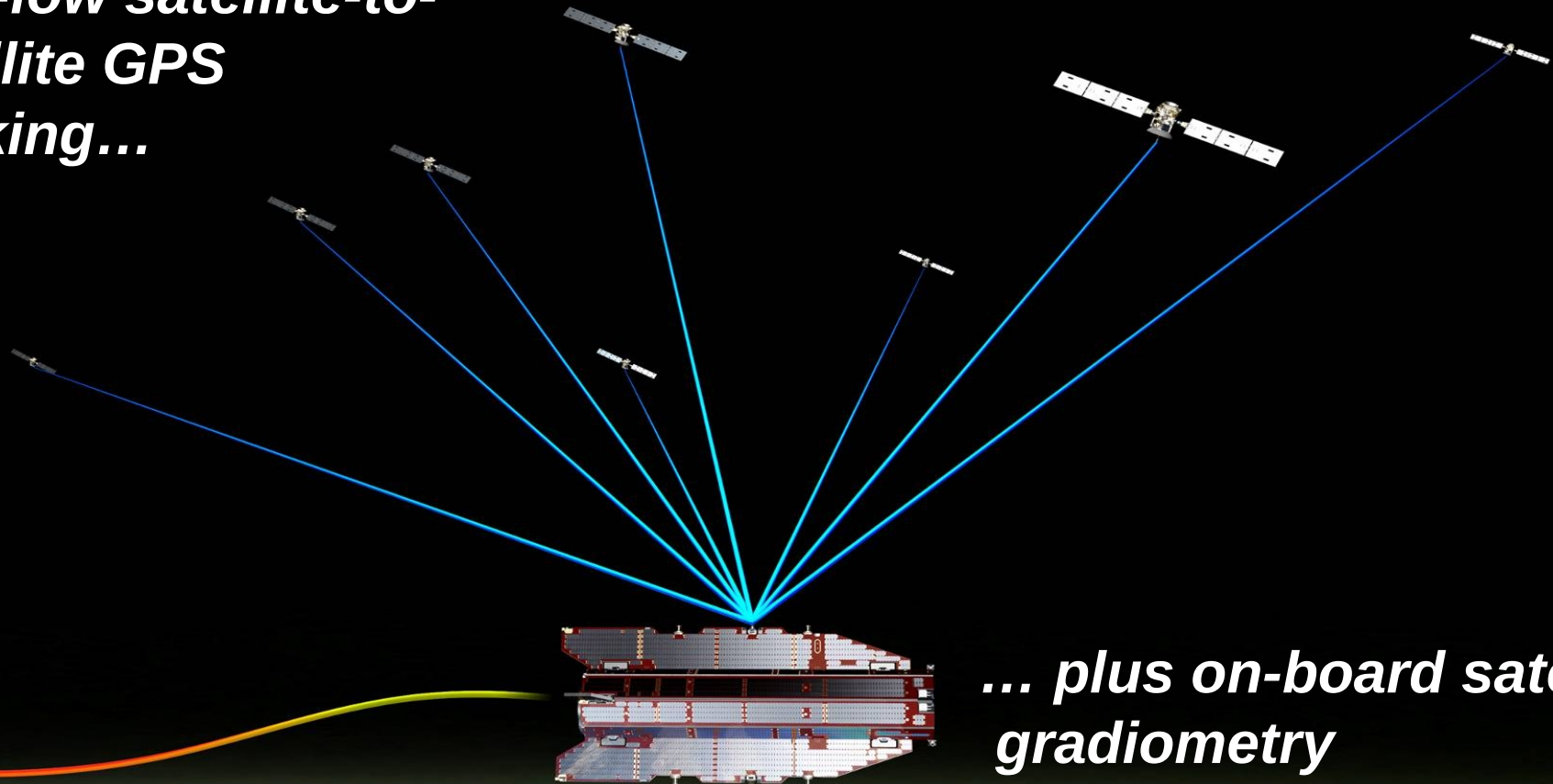
Its objectives are to improve understanding of:

- 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



esa

SMOS: Soil Moisture and Ocean Salinity Mission

www.esa.int/smos



Launched 2nd Nov 2009!!



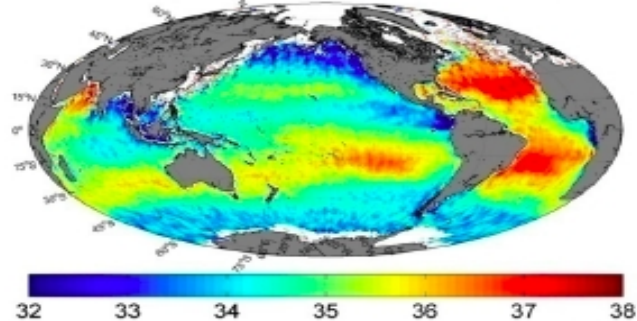
Its objectives are:

- 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)

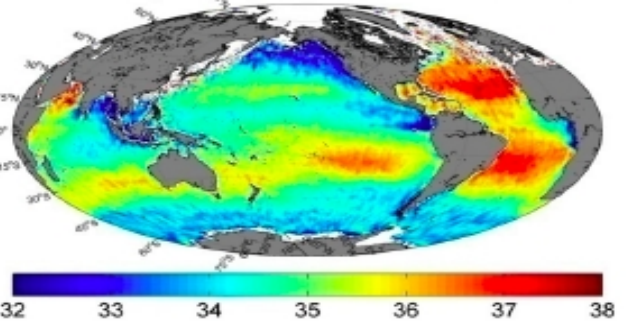
www.esa.int

European Space Agency

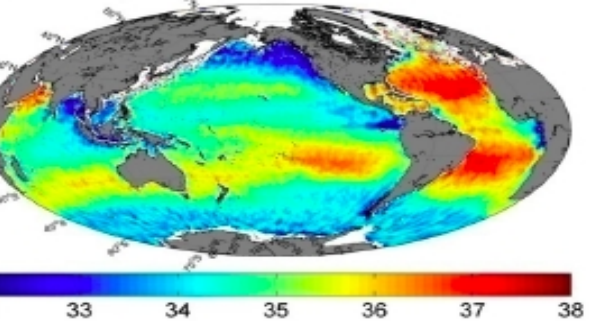
SSS Monthly Composite Jan 2010-0.5°x0.5°



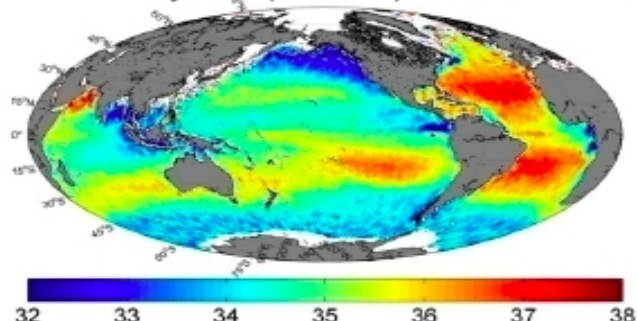
SSS Monthly Composite Feb 2010-0.5°x0.5°



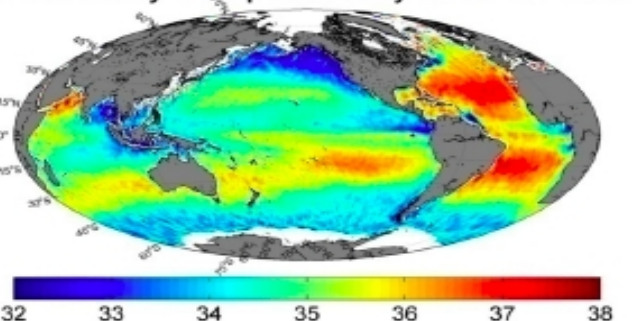
SSS Monthly Composite Mar 2010-0.5°x0.5°



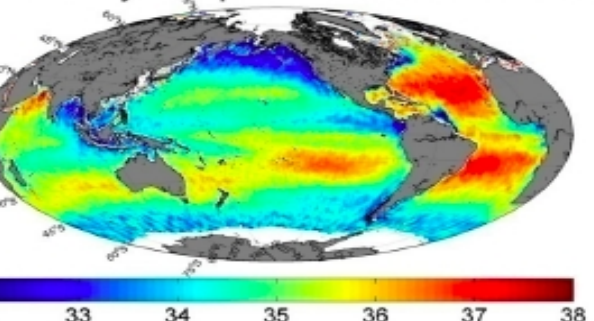
SSS Monthly Composite Apr 2010-0.5°x0.5°



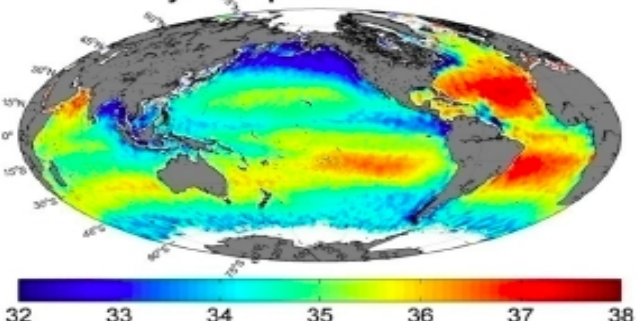
SSS Monthly Composite May 2010-0.5°x0.5°



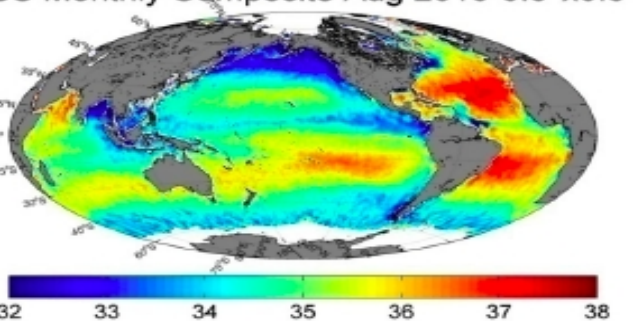
SSS Monthly Composite Jun 2010-0.5°x0.5°



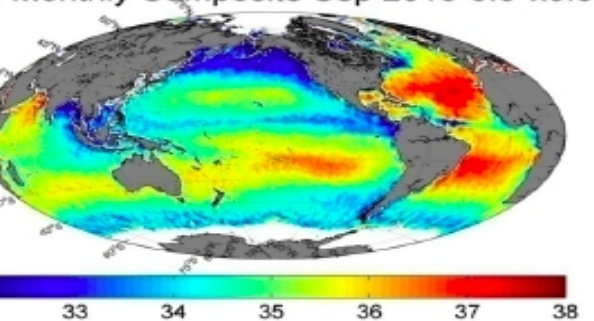
SSS Monthly Composite Jul 2010-0.5°x0.5°



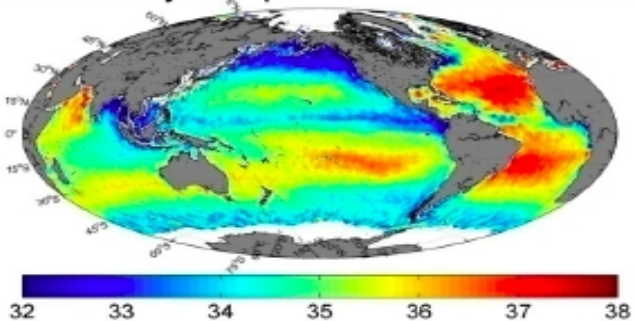
SSS Monthly Composite Aug 2010-0.5°x0.5°



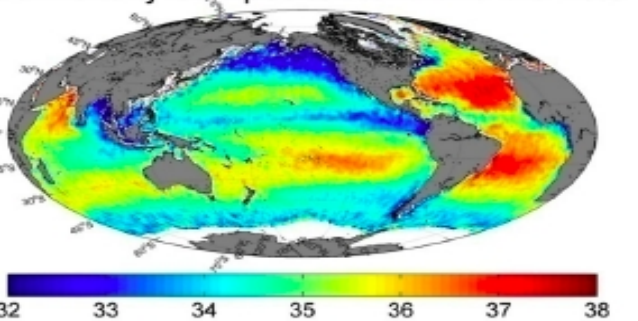
SSS Monthly Composite Sep 2010-0.5°x0.5°



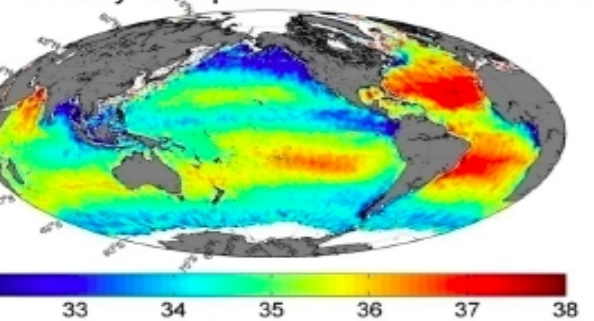
SSS Monthly Composite Oct 2010-0.5°x0.5°



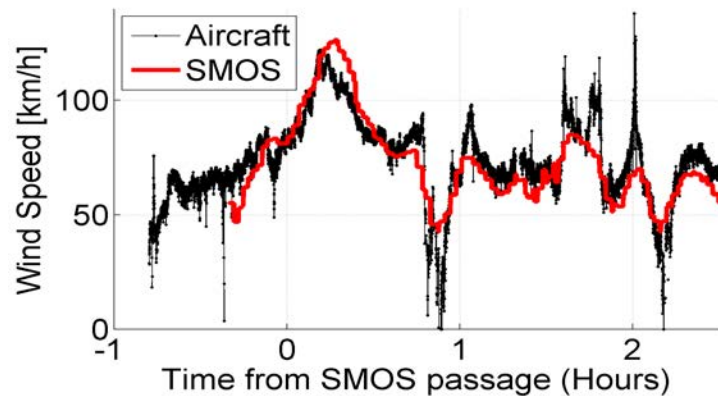
SSS Monthly Composite Nov 2010-0.5°x0.5°



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



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 ($\sim 32 \text{ m s}^{-1}$).



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



Launch October 14th (TBC)

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

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 the mantle,
- ✓ Identifying the ocean circulation by its magnetic signature

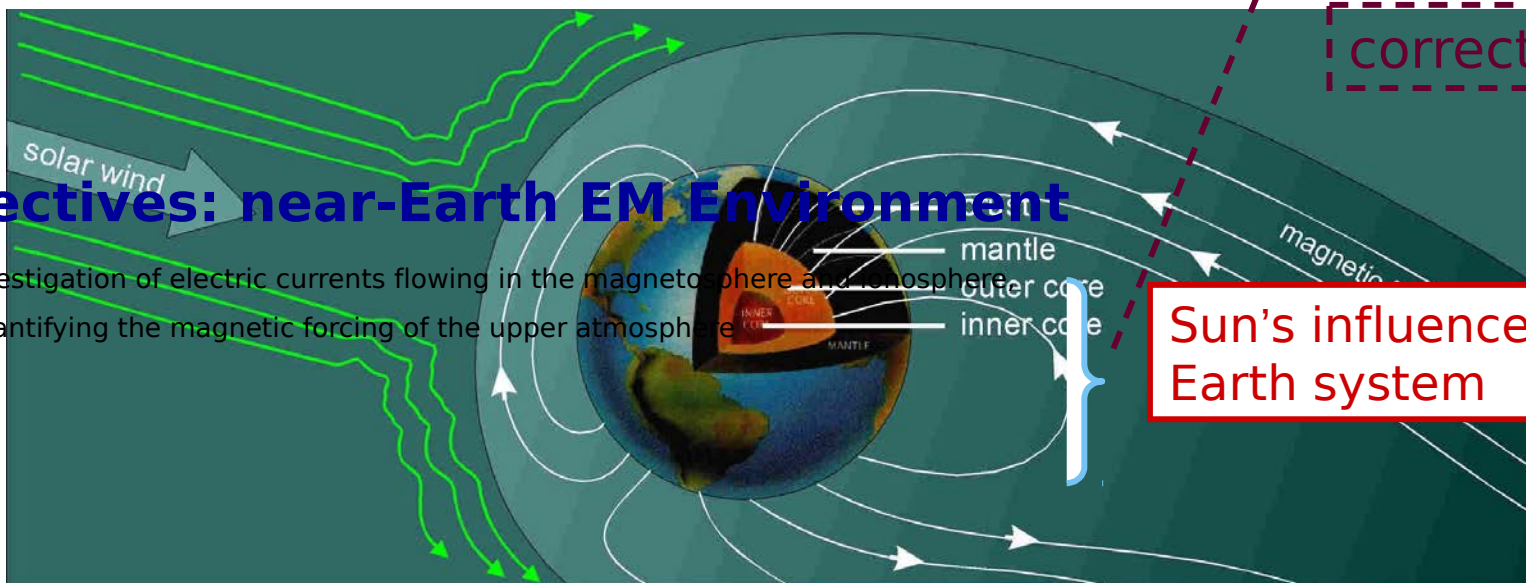
Unique view “inside” the Earth from space for core, mantle & crust

Objectives: near-Earth EM Environment

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

correction

Sun's influence within Earth system



ADM-Aeolus - ESA's wind mission



Mission objectives:

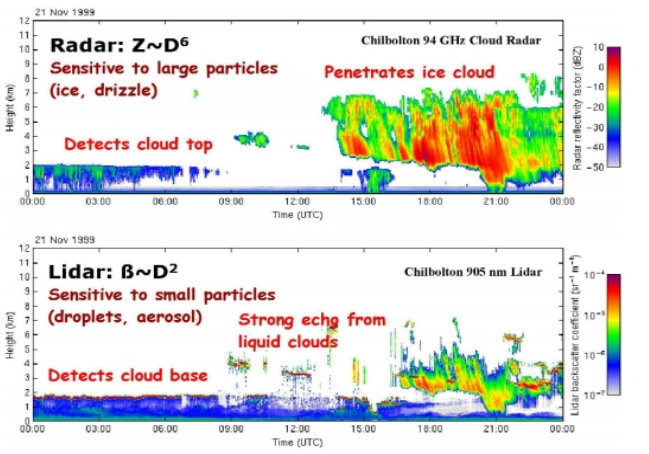
- to provide global observations of **3-D wind fields** giving a more accurate picture of the Earth's global energy budget
- to improve the quality of **weather forecasting**
- to enhance our understanding of **atmospheric dynamics and climate processes**

Status:

Manufacturing of the ALADIN instrument ongoing

Satellite acceptance review planned by mid 2013





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

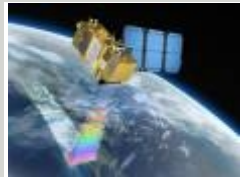
Status: *Preparation of Phase C/D, Launch in 2015-16*

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



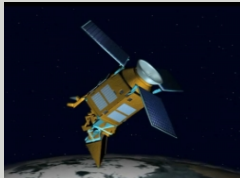
Sentinel-3 (A/B) – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land
surface temperature, altimetry

2014/2017



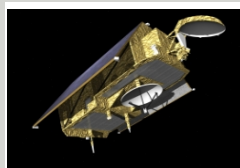
Sentinel-4 (A/B) – Geostationary atmospheric
Atmospheric composition monitoring, trans-
boundary pollution

2019/2027



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

2015/2020/2027

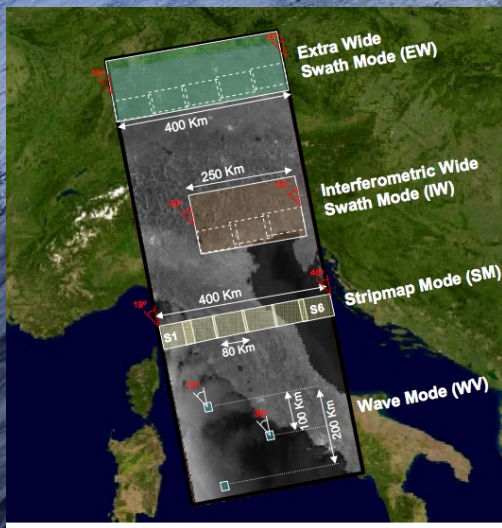
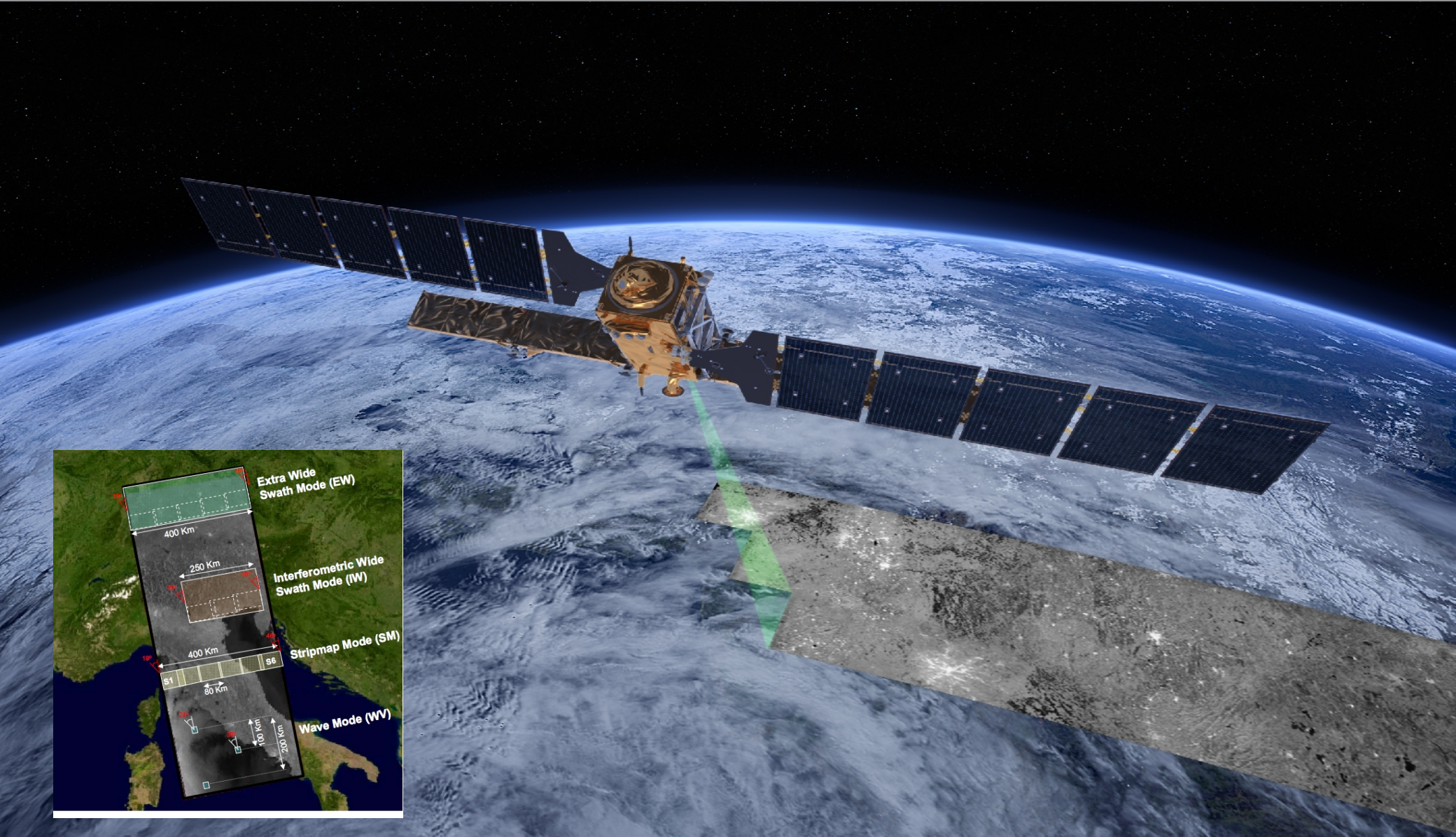


Jason-CS (A/B) – Low inclination Altimetry
Sea-level, wave height and marine wind speed

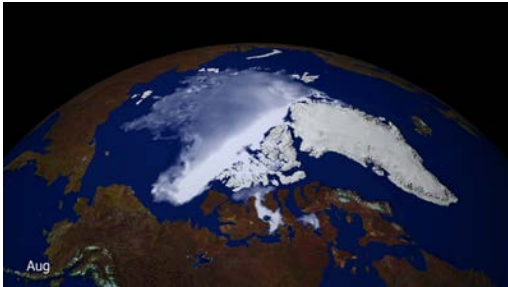
2018/2023



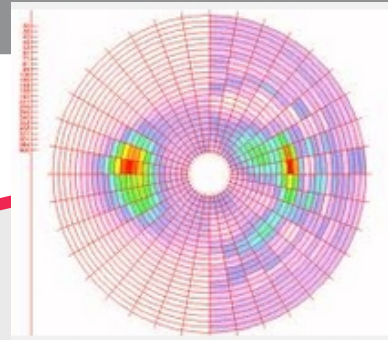
Sentinel-1 for Science



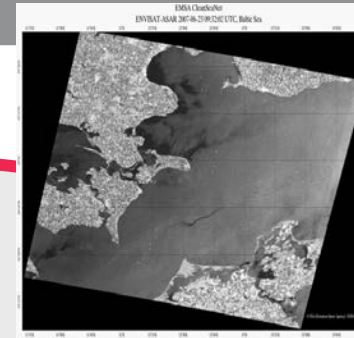
Few examples of Sentinel-1 applications



Arctic ice extent
August 2009
(Credit: MyOcean)



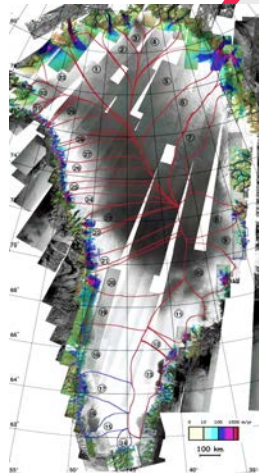
Wave spectral information
(Credit: ESA)



Oil spill detection
and Surveillance
(Credit: EMSA)



Ship detection
(Credit: ESA)



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

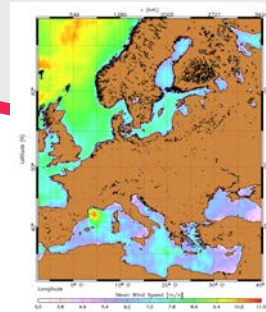
**C-band SAR observations support
a wide range of applications**



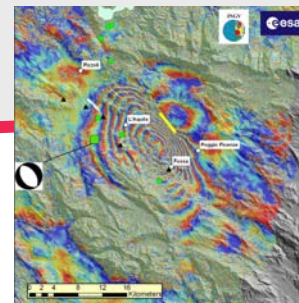
Emergency management:
flooding
(Credit: SAFER, DLR)



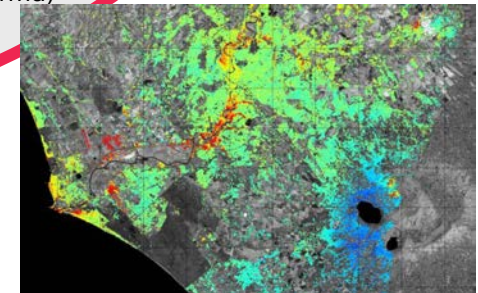
Mean wind speed
from 2005 to 2009
(Credit: CLS)



Earthquake
analysis
(Credit: INGV)



Subsidence map
1992-2006
(Credit: TerraFirma)



Land use
(Credit: ESA)



Sentinel-3

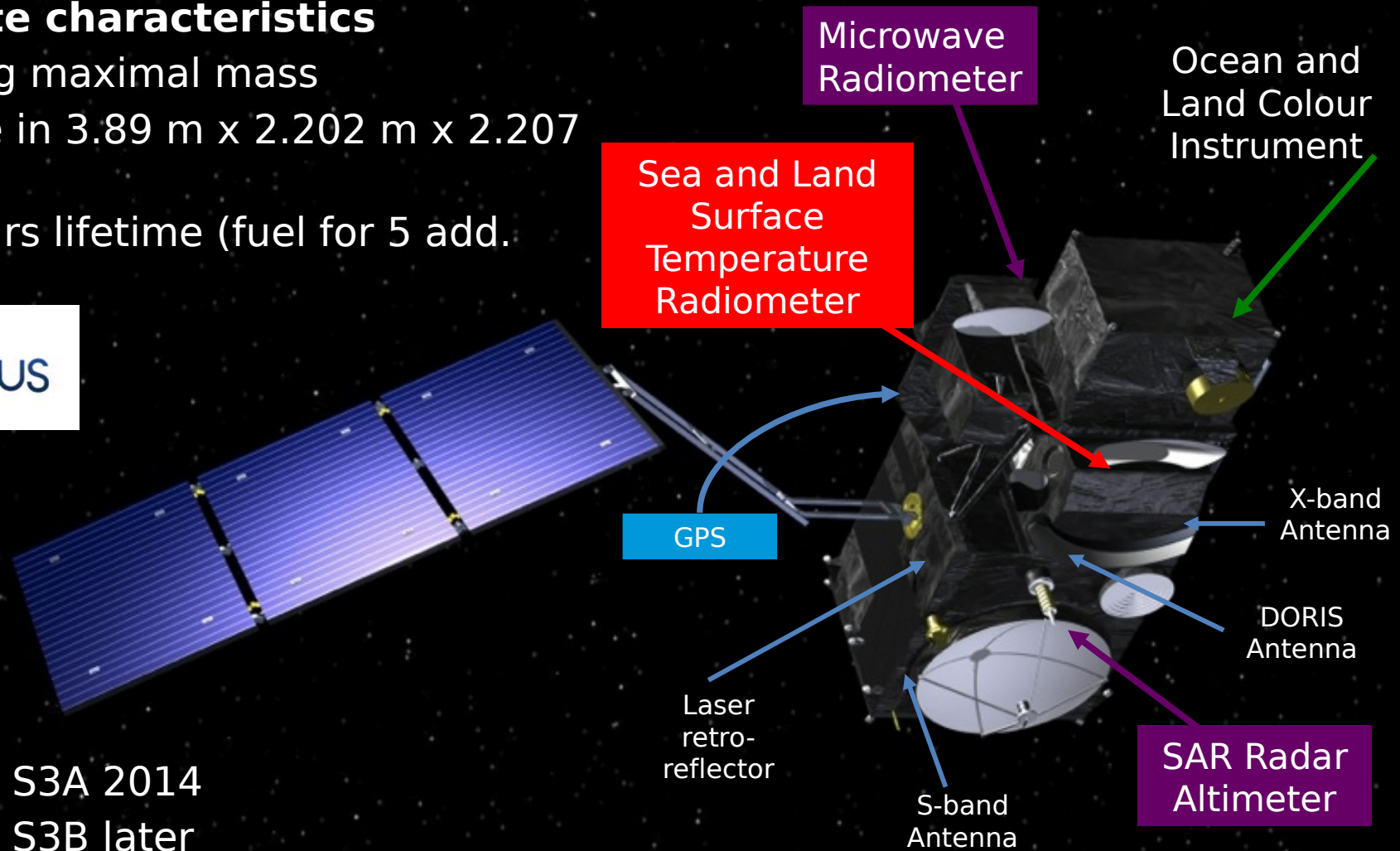


Main satellite characteristics

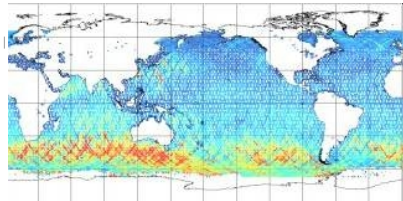
- 1250 kg maximal mass
- Volume in 3.89 m x 2.202 m x 2.207 m
- 7.5 years lifetime (fuel for 5 add. years)



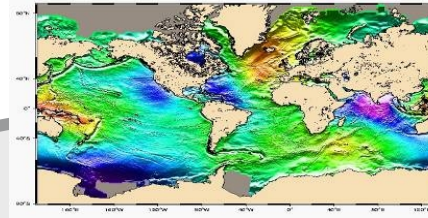
- Launch S3A 2014
- Launch S3B later
- 3h delivery timeliness (from satellite sensing)



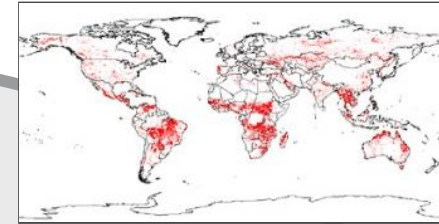
Sentinel-3 Product Examples



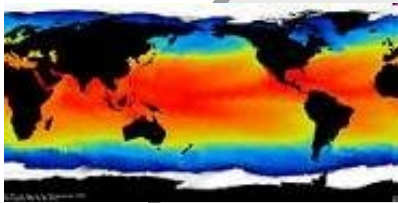
Along track wind and wave products
(Credit: AVISO)



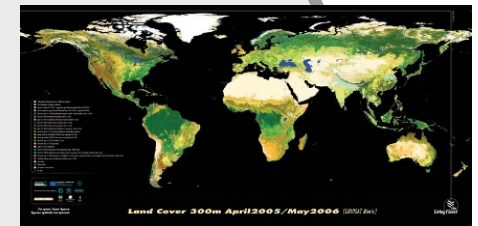
Sea Surface Height products
(Credit: CLS)



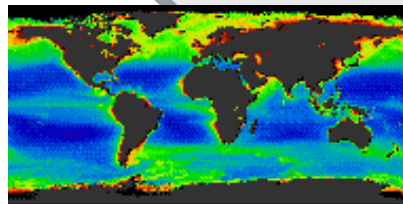
Fire products
(Credit: ESA World Fire atlas)



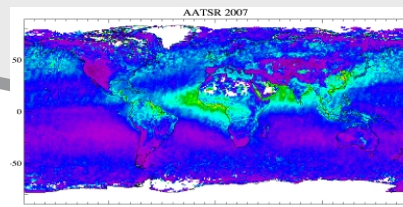
Sea Surface Temperature products
(Credit: Met Office)



Land cover products
(Credit: ESA)



Ocean colour products
(Credit: MyOcean)

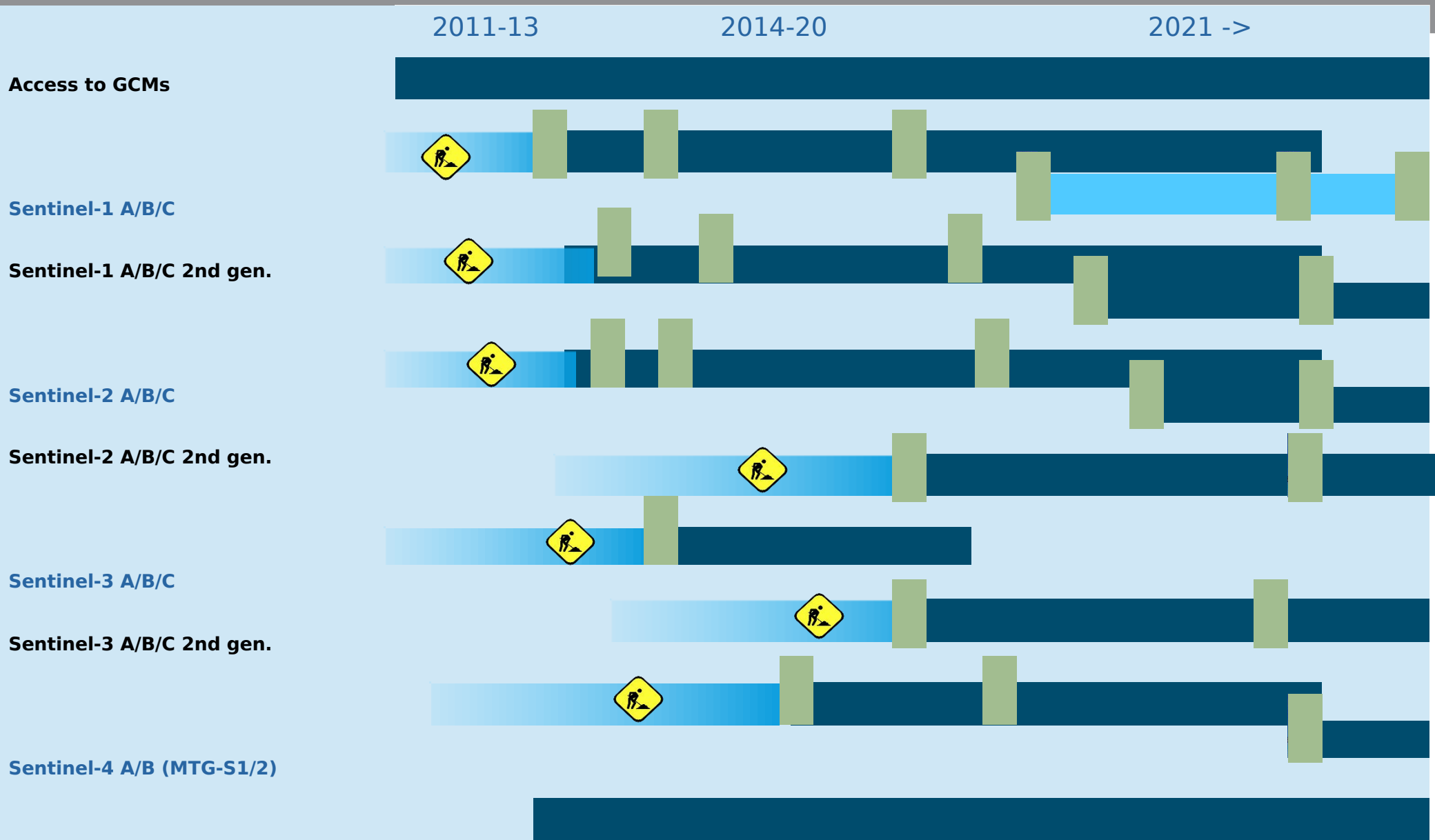


Atmospheric aerosol products
(Credit: GlobAerosol)



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>

A screenshot of the EOLI website interface. The page has a dark blue header with the ESA logo and the text 'EOLI Screenshots'. Below the header, the main title 'EOLI "ESA's Link to Earth Observation"' is displayed. The page is divided into several sections: 'EOLI (Earth Observation Link) is the European Space Agency's client for Earth Observation Catalogue and Ordering Services.', 'Using EOLI, you can browse the metadata and preview images of Earth Observation data acquired by the satellites ENVISAT, ERS, Landsat, IKONOS, DMC, ALOS, SPOT, Kompsat, Proba, IRS, SCISAT.', 'Scientific Users with a registered account can order or download products of various processing levels.', 'Contacts' section with a link to 'EO Helpdesk' and contact information for 'olivier.barois@esa.int'. 'Resources' section with links to 'Video Tutorial', 'User Manual', 'Quick Guide', and 'EOLI-SA procedure for data ordering'. 'Download & Install' section with a table of download links for Windows, MacOS X, Linux, and Generic Unix.

EOLI Screenshots

EOLI "ESA's Link to Earth Observation"

EOLI (Earth Observation Link) is the European Space Agency's client for Earth Observation Catalogue and Ordering Services.

Using EOLI, you can browse the metadata and preview images of Earth Observation data acquired by the satellites ENVISAT, ERS, Landsat, IKONOS, DMC, ALOS, SPOT, Kompsat, Proba, IRS, SCISAT.

Scientific Users with a registered account can order or download products of various processing levels.

Contacts

For any question on using EOLI, on the catalogue and ordering service, on registration, or any other EO related information, please contact our Help Desk:

[EO Helpdesk](#)

For comments and suggestions on the EOLI Client: olivier.barois@esa.int

Resources

- [Video Tutorial](#) (Requires Quicktime)
- [User Manual](#) [HTML] [PDF]
- [Quick Guide](#) [PDF]
- [EOLI-SA procedure for data ordering](#) [PDF]
- [See how EOLI is linked to various Earth Observation resources.](#) [PDF]

Download & Install

EOLI is a java application which is supported on all major platforms: Windows (95/98/ME/2000/NT/XP), Linux, MacOS X and other Unix systems. Java SE Runtime Environment 1.5 or later is required.

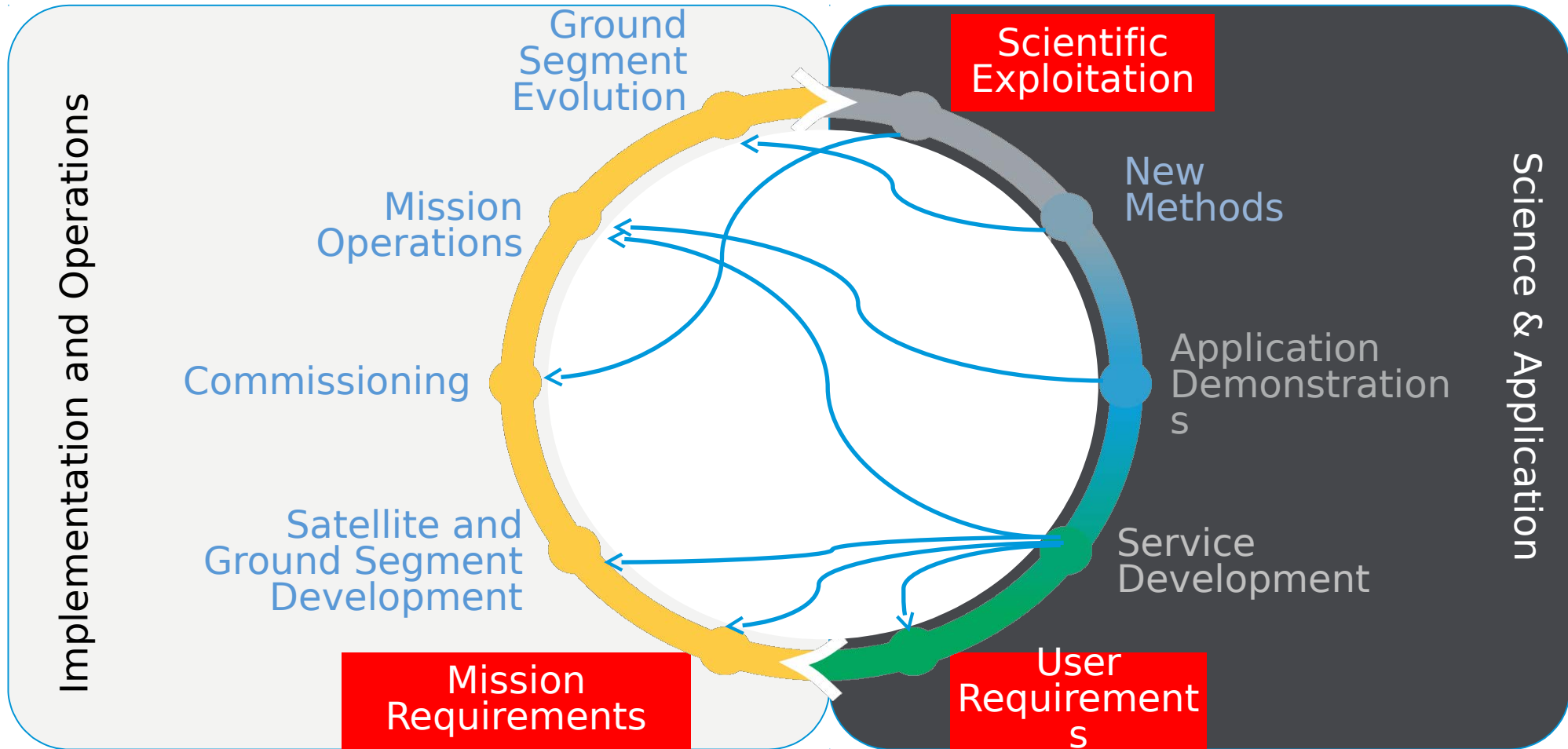
	Windows	eoli-9.2.0-windows.msi
	MacOS X	eoli-9.2.0-macosx.dmg
	Linux	eoli-9.2.0-linux.deb eoli-9.2.0-linux.rpm
	Generic Unix	eoli-9.2.0-unix-generic.tar

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



Programme Area

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STSE Video

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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



→ The Changing Earth Science Network

Supporting the next generation of European Earth Scientists

- [▶ What is it?](#)
- [▶ Projects](#)
- [▶ The Challenges](#)
- [▶ Open Calls](#)

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



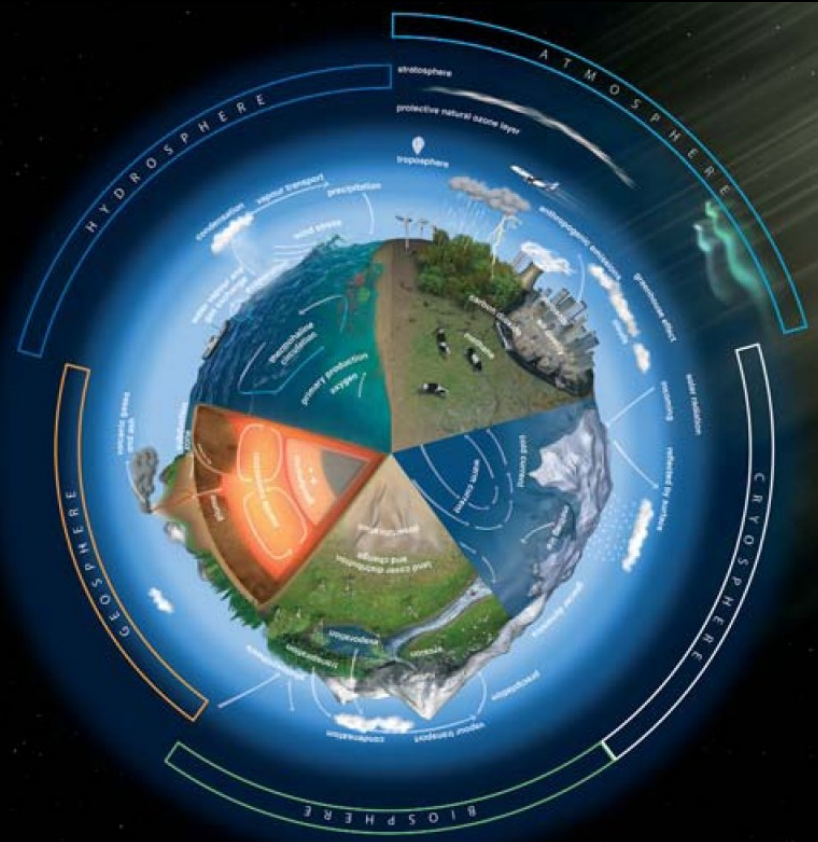
Novel Algorithms & Products



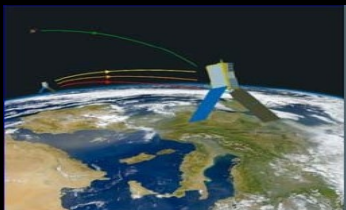
Support to Earth System Science



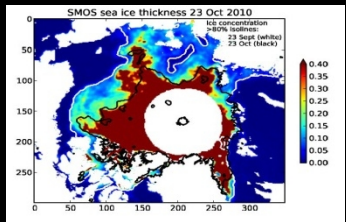
Support the Next Generation of Scientists



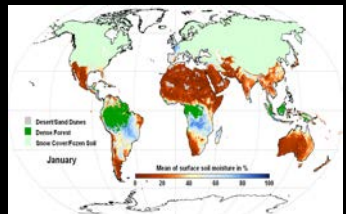
STSE represents a pathfinder for science and innovation providing a flexible mechanism to address the scientific needs and requirements of the Earth System Science Community in terms of novel missions, new algorithms and products and innovative Earth science results



Science Support to Novel Mission Concepts



Novel Algorithms & Products



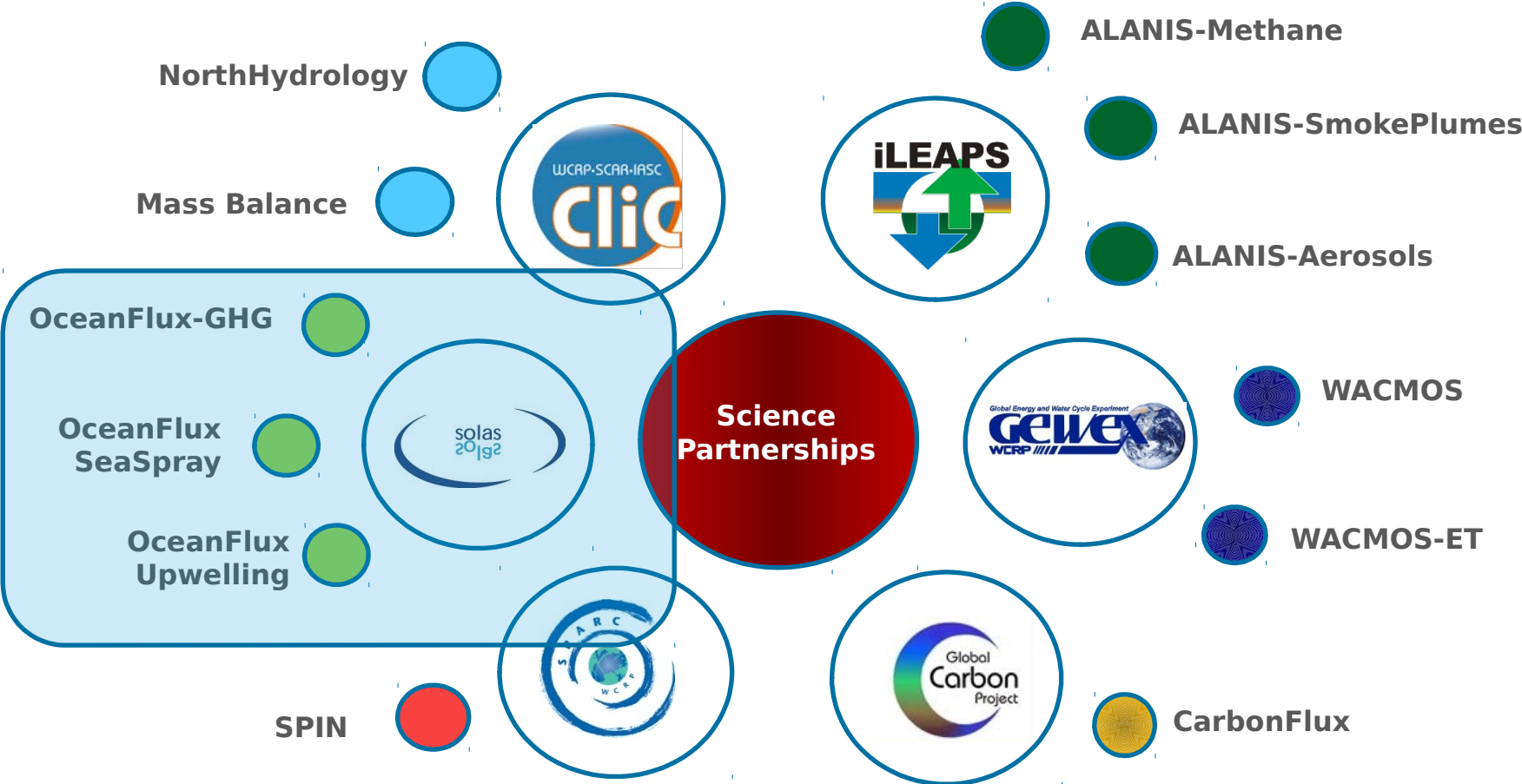
Support to Earth System Science



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



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Surface Ocean

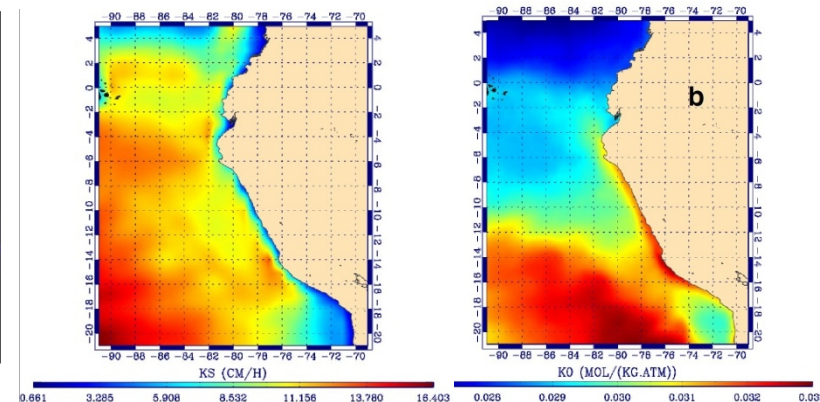
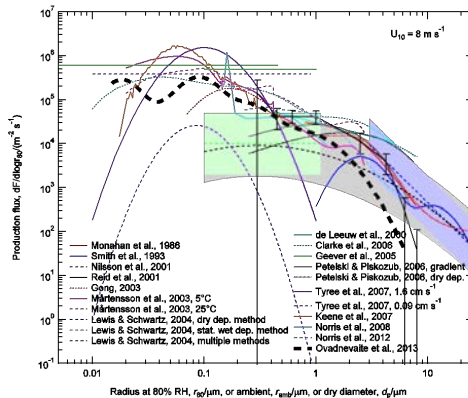
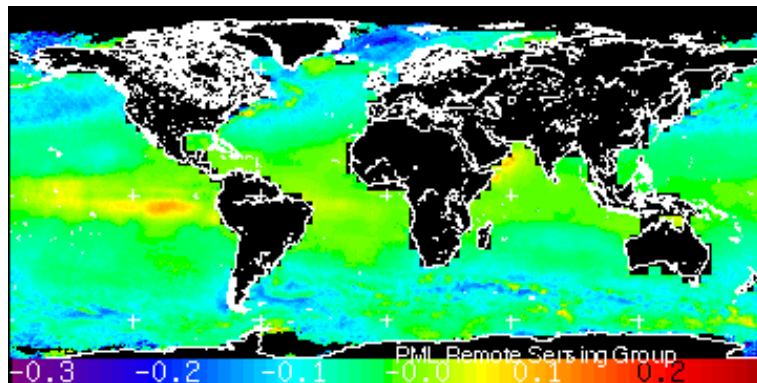
solas
2019

Lower Atmosphere Study

SURFACE OCEAN - LOWER ATMOSPHERE STUDY

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

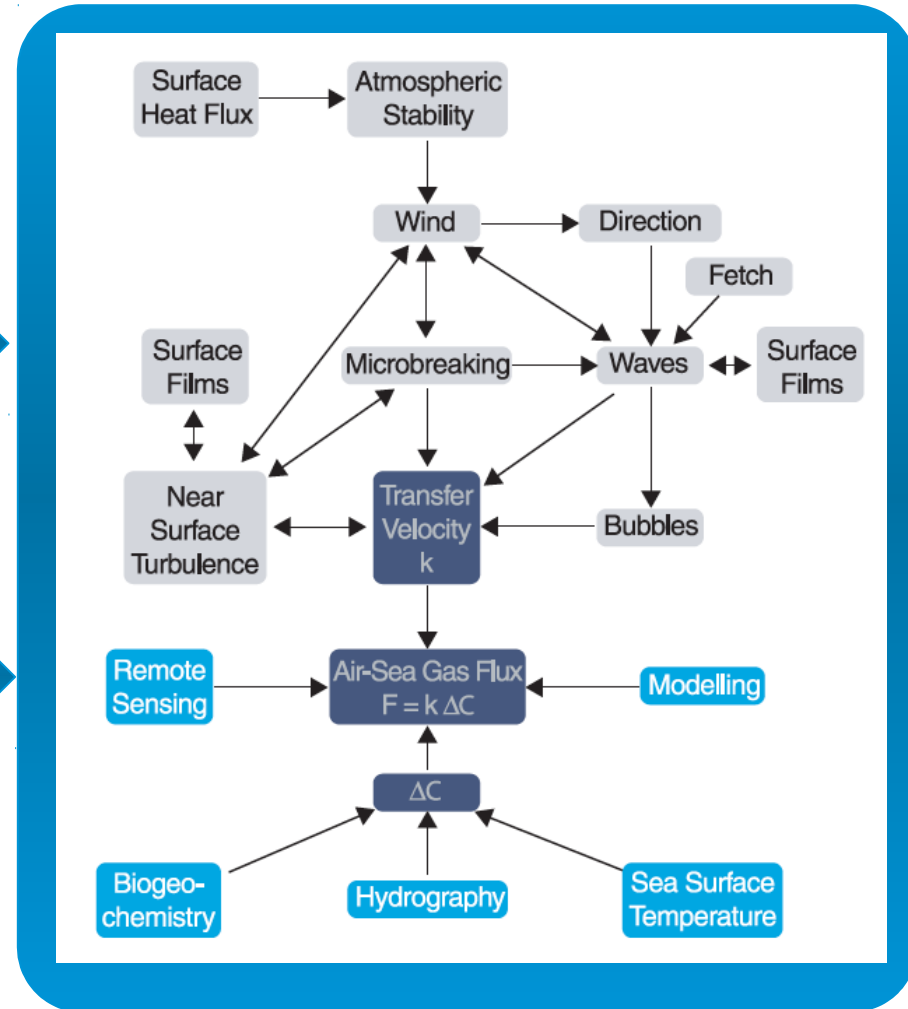
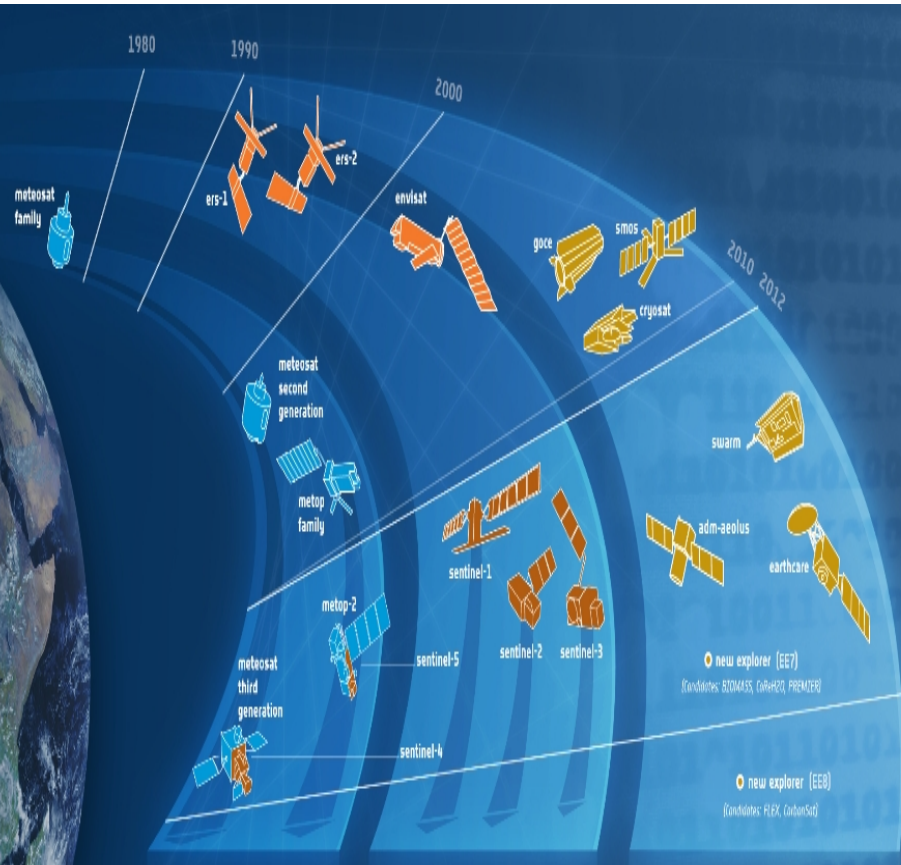
support to science element



oceanflux upwelling

support to science element

Air-sea gas exchange: Scientific application of EO data



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

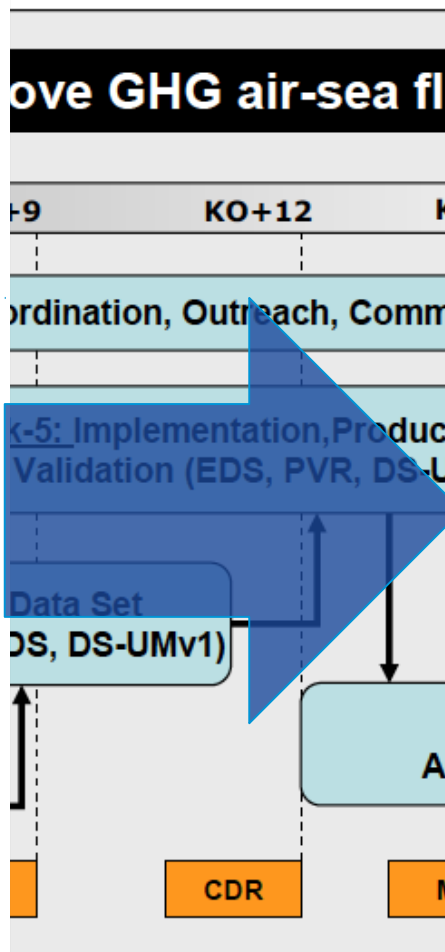
Deliverable: D-2.7

FINAL

David Woolf

David.Woolf@thurso.uhi.ac.uk

North Highland College



the OceanFlux GHG project boxes.



ESA Support to Science Element

OceanFlux GHG

Scientific Impact Assessment Report

ESA Contract No. 4000104762/11/I-AM

Deliverable: D-2.17

DRAFT

David Woolf

d.k.woolf@hw.ac.uk

Heriot Watt University



ESA STSE OceanFlux GHG Example 2010



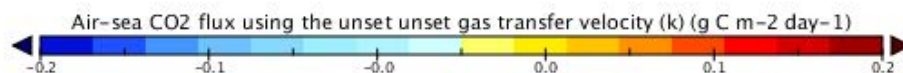
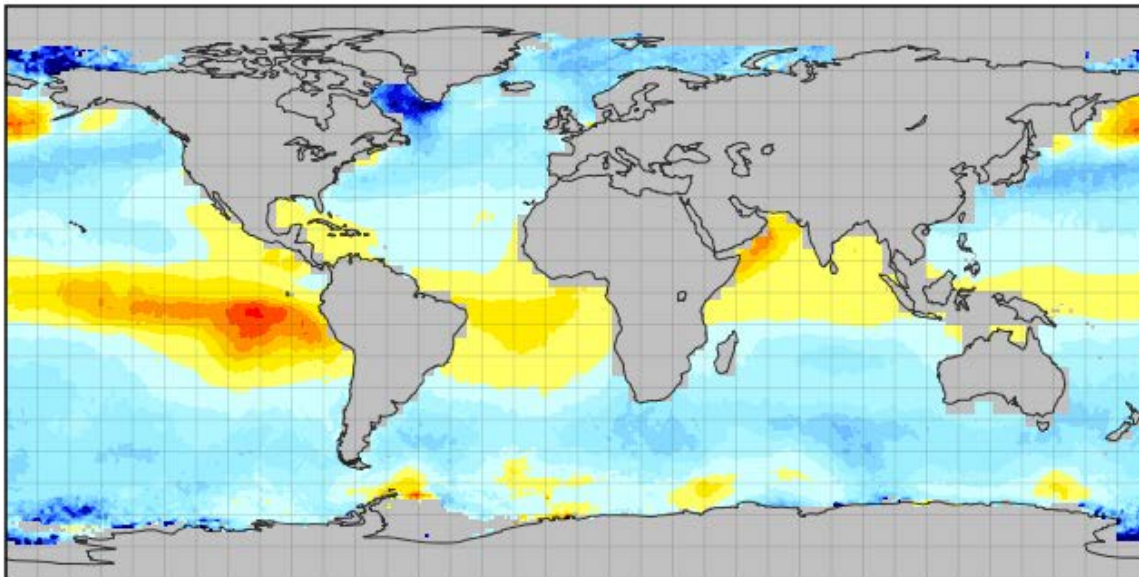
Global regular grid 1o x 1o NetCDF 3.0, CF 1.6

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)

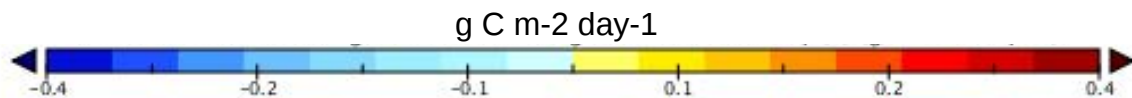
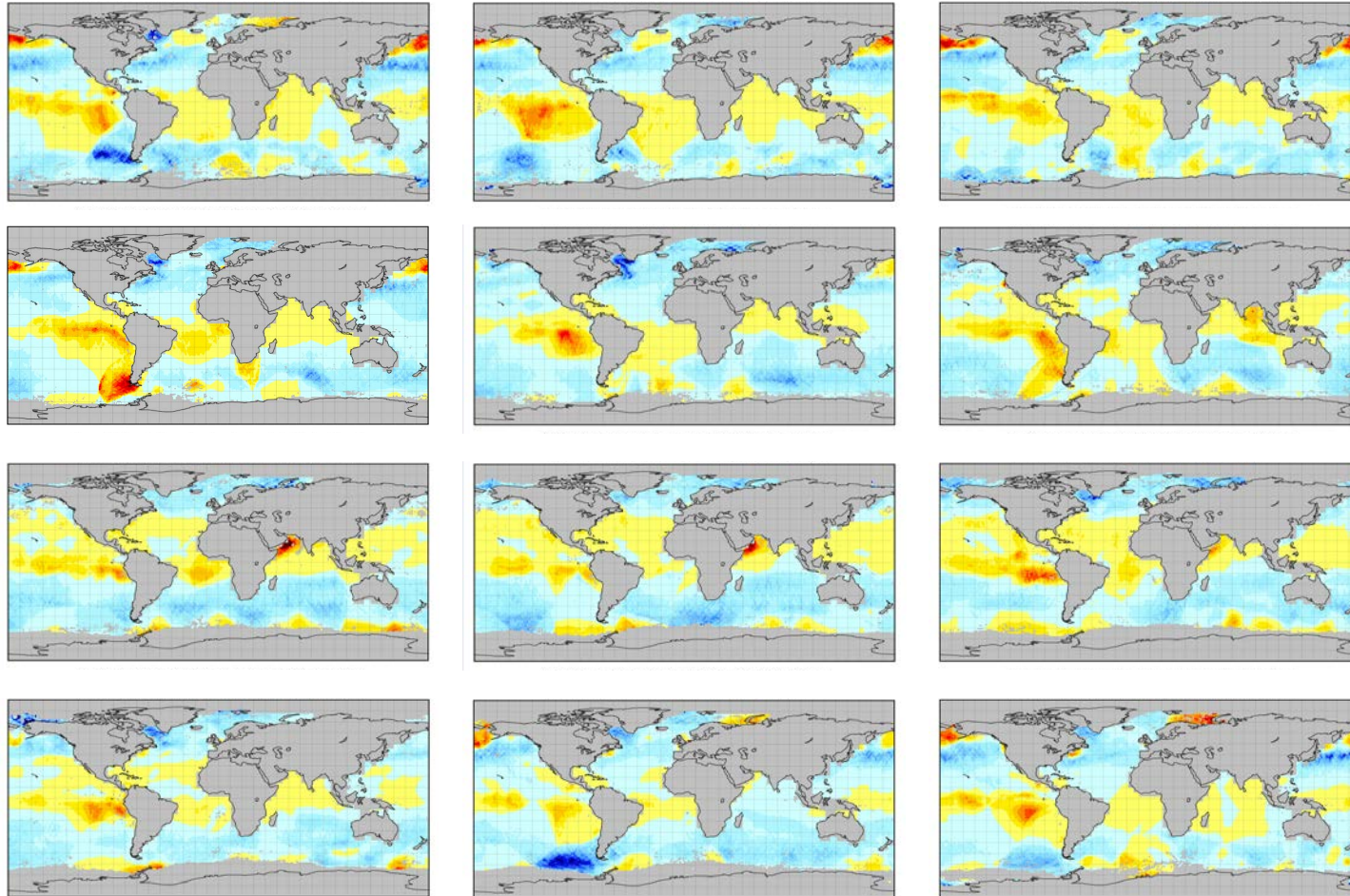
Quantities: SSTskin, SSTfnd, salinity, whitecap coverage, solubility, fugacity, ktotat, krain +..)



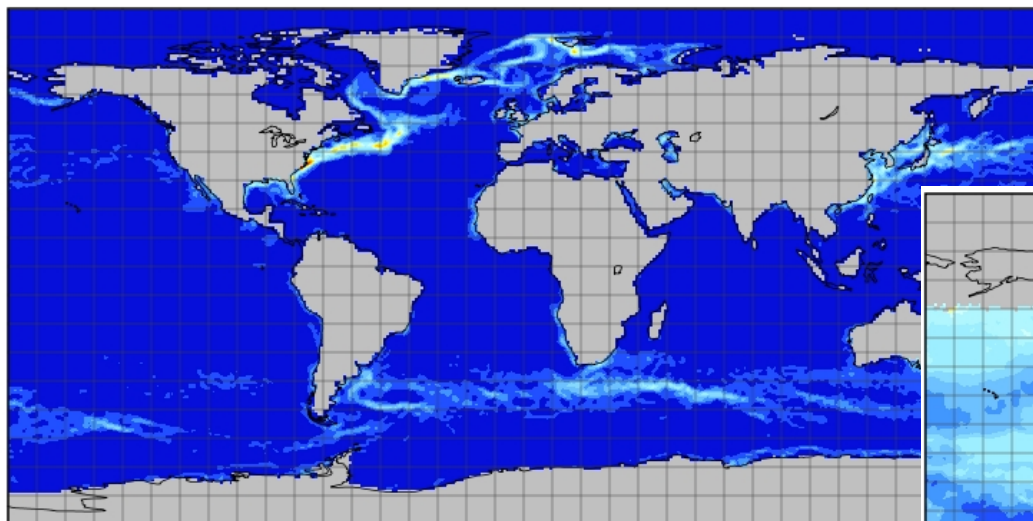
Example daily mean flux 2010



ESA STSE OceanFlux GHG: Example Global Monthly 2010

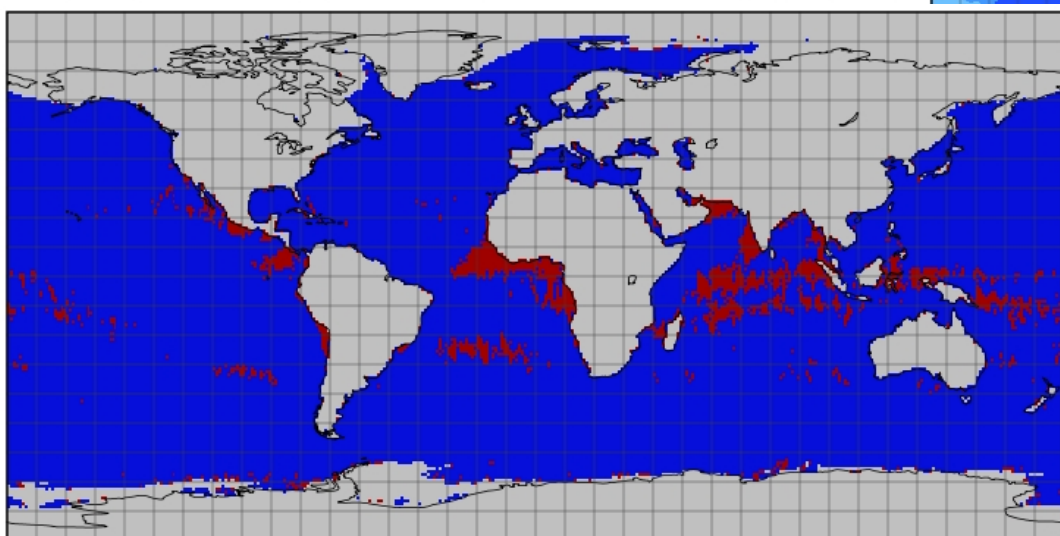
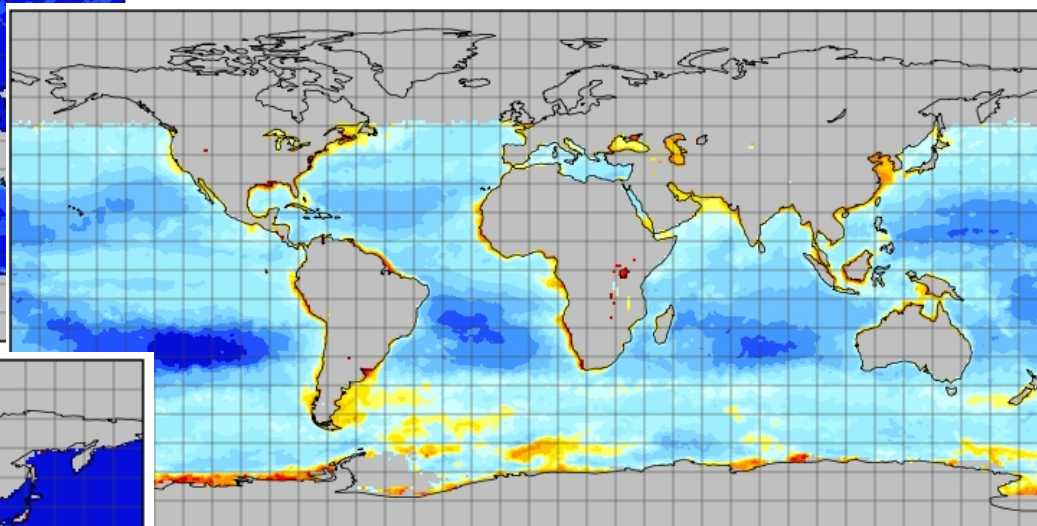


OceanFlux GHG – process indicator layers



Persistent SST fronts (GHRSSST)

Surface chl-a (ESA CCI)



Regions of low wind



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...**

The poster is divided into two main vertical sections. The left section has a dark background with a photograph of ocean waves and a white spiral graphic. The right section has a light blue background with a world map showing CO2 fluxes and various logos.

The OceanFlux Greenhouse Gases project

Aims to improve the quantification of air-sea exchanges of greenhouse gases, of prime importance in the climate system.

Mean daily global air-sea CO₂ flux net output

solas 2013

SCIENCE WORKSHOP

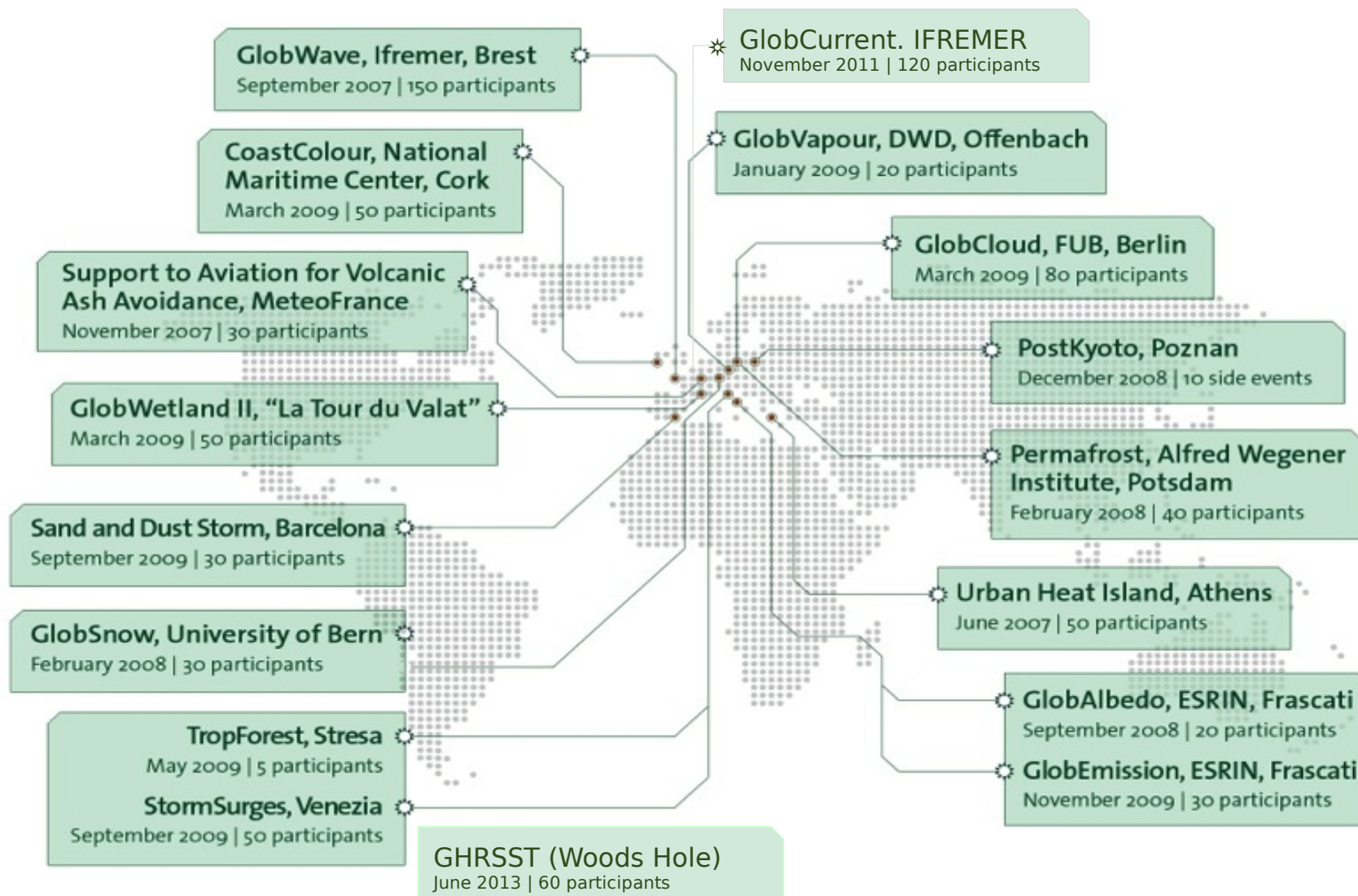
24-27 Sept. 2013

BREST | FRANCE

Scientists, engineers, and Reference User Group members are invited to attend the Science Workshop which will take place towards the end of the project, to allow the partners to present the results, gain user feedback and to plan future aims and collaborations.

Logos at the bottom include: esa, stse, ifremer, and a small ESA logo on the right edge.

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



- **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?**



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;*

Oceanflux Greenhouse Gases



- The Project
- Science
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- Blog
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- Approach
- Data processing
- Team
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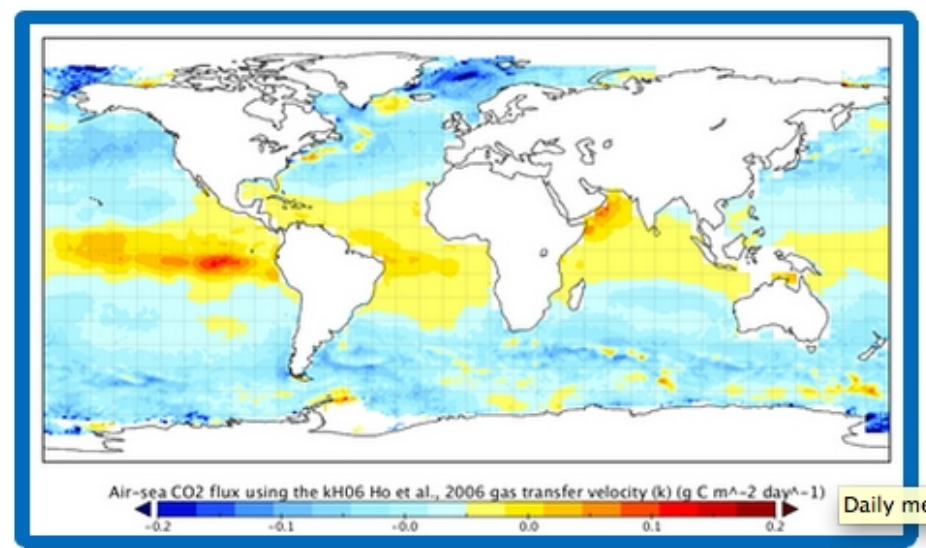
The Project



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 differences in the estimates of fluxes, even for CO₂ which is the most studied, much of these uncertainties arises