NASA/CNES/EUMETSAT/NOAA/ESA

Program status

Contents

- CEOS Ocean Surface Topography Virtual Constellation
- CNES (Juliette Lambin)
- EUMETSAT (François Parisot)
- NOAA (Laury Miller)
- NASA (Eric Lindstrom)
- ESA (Jérôme Benveniste)

28th Plenary session
Tromsø, Norway
28-30 October 2014

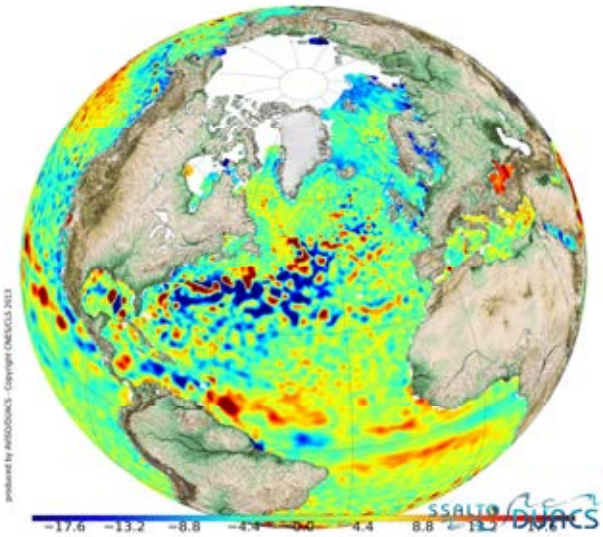
OST-VC – fulfilling user requirements

Inter-agency cooperation at work in altimetry

Altimetry is a 1-D measurement aiming a measuring the 2D sea surface topography and its time variations:

- require constellation of at least 4 satellites with careful intercalibration
- require level 3-4 products transfoming 4-satellite profiles into maps

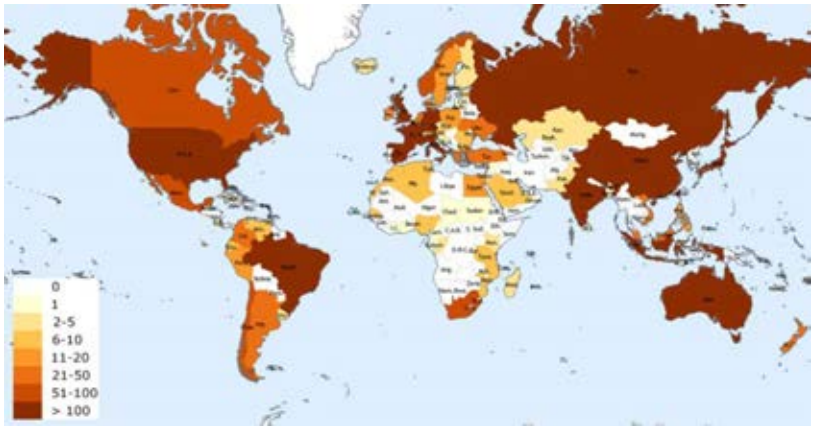
=> requirements expressed in CEOS OST-VC Document "The Next 15 Years of Satellite Altimetry"
http://www.ceos.org/images/OST/SatelliteAltimetryReport_2009-10.pdf



As of today, 4 altimetry missions are operating:

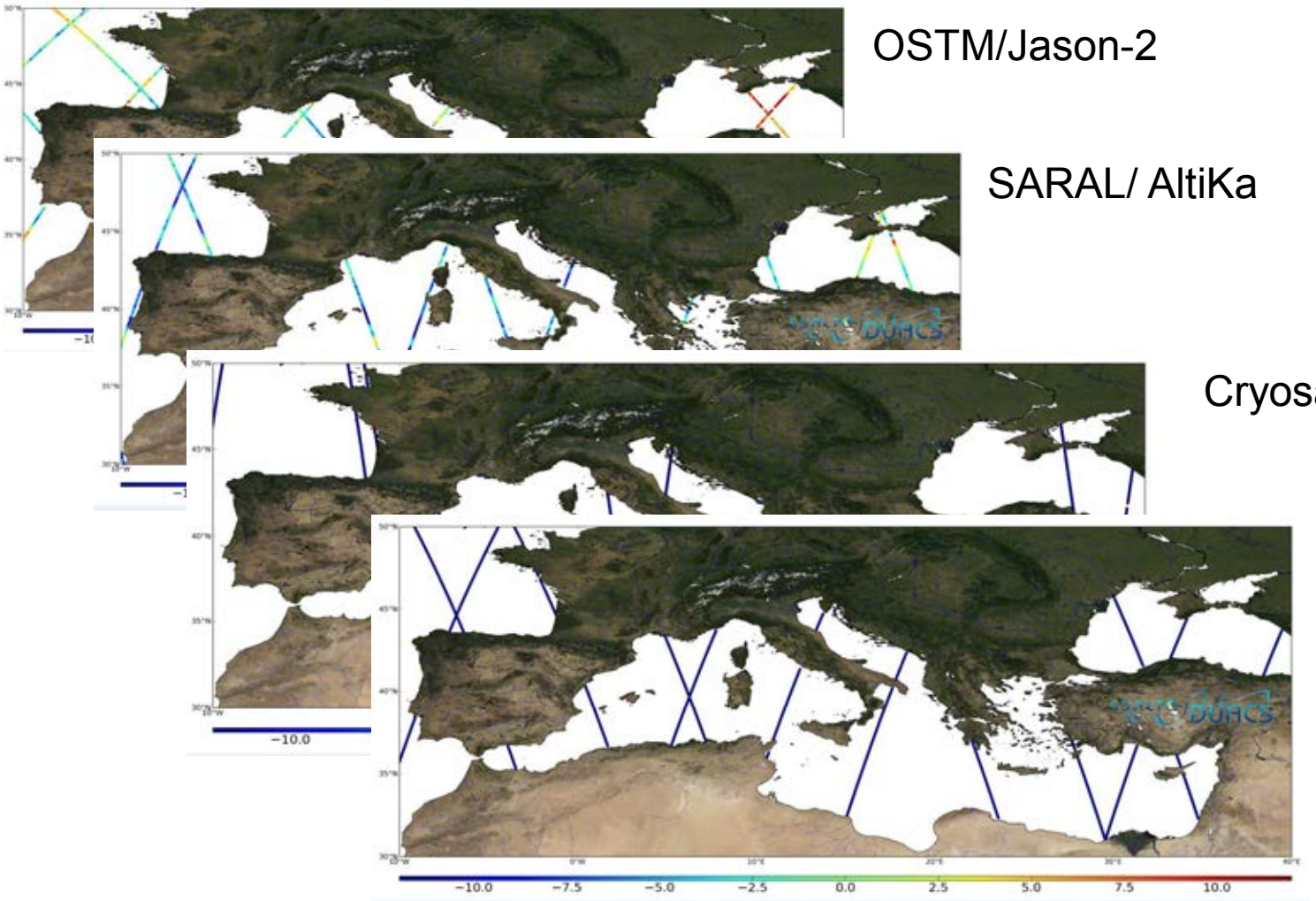
- OSTM/Jason-2 (reference mission), NASA/CNES/EUMETSAT/NOAA
- Cryosat-2 (ice mission with ocean capability), ESA
- Hy-2A, CNSA/NSOAS
- SARAL /AltiKa, CNES/ISRO

Heterogeneous programmatic set-up, but multi-mission products freely available in NRT through AVISO/DUACS



http://www.aviso.altimetry.fr: > 5000 registered users

Uncalibrated individual missions



OSTM/Jason-2

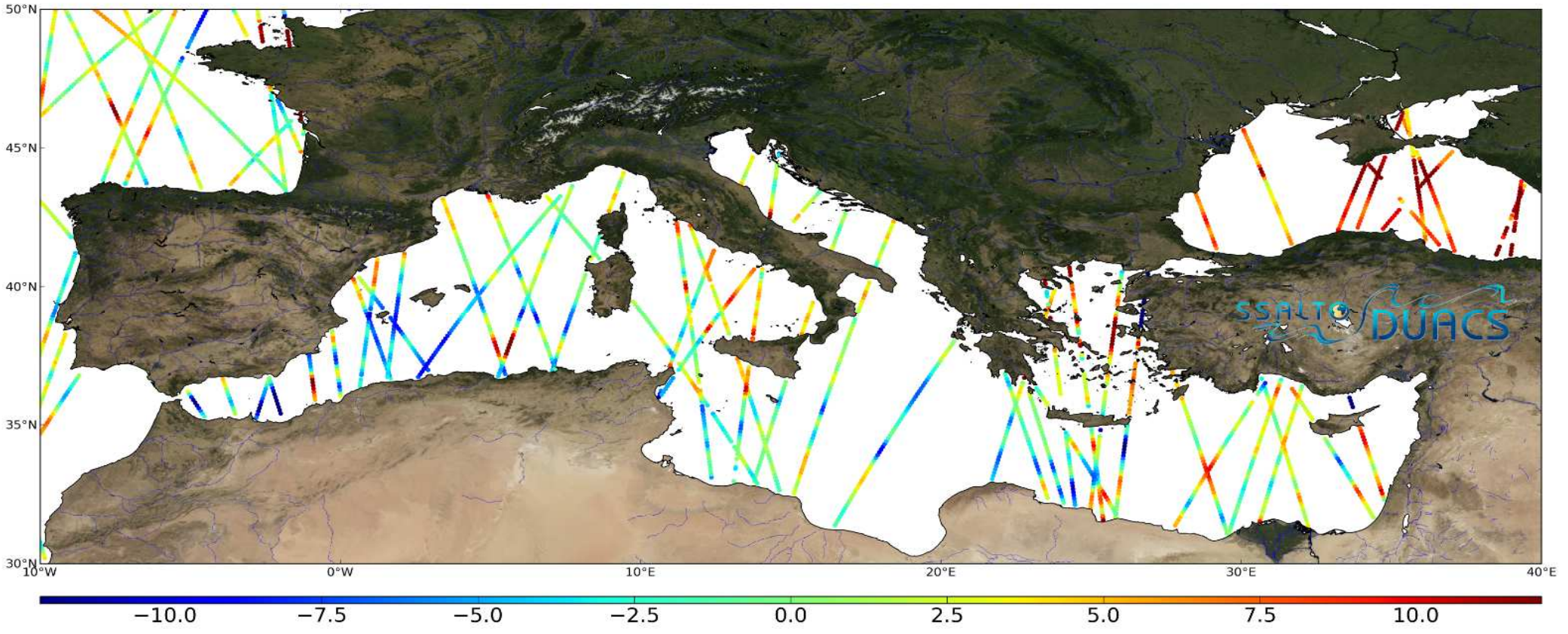
SARAL/ AltiKa

Cryosat-2

Hy-2A

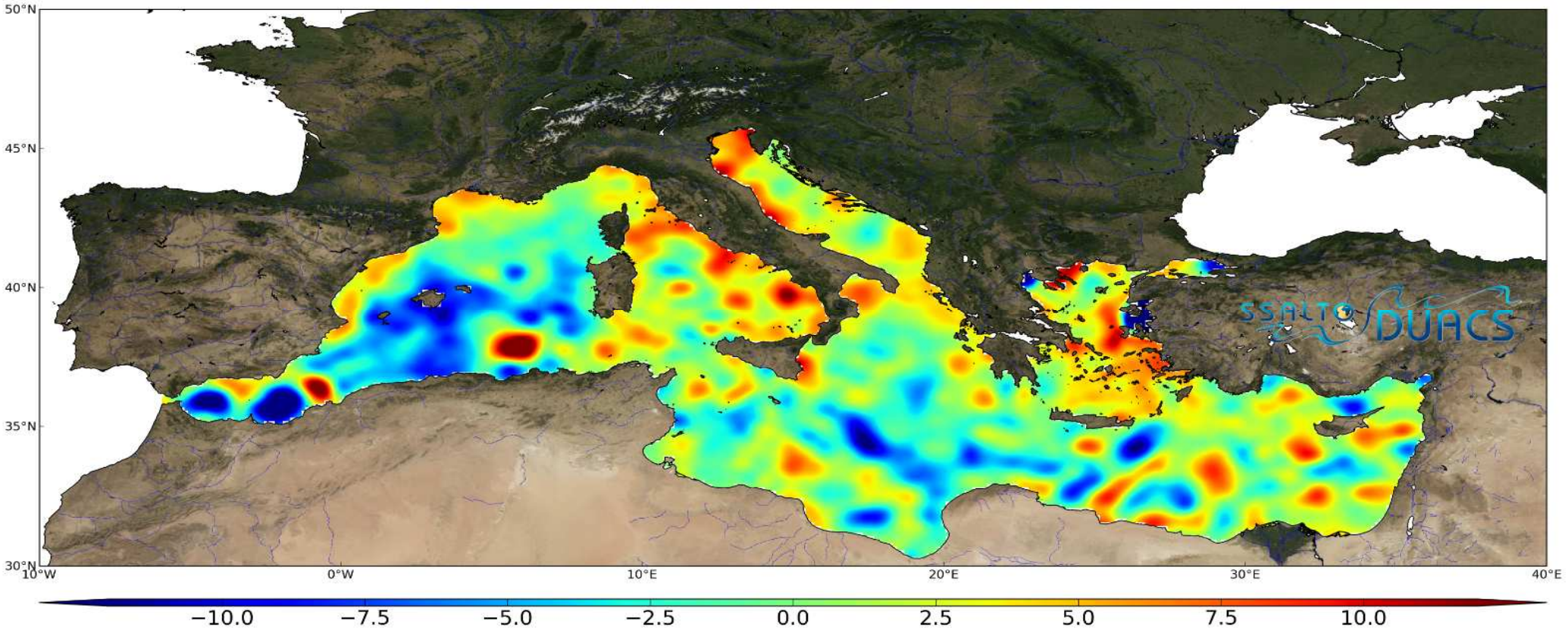
After intercalibration

Level 3 – Sea Level Anomaly (cm)

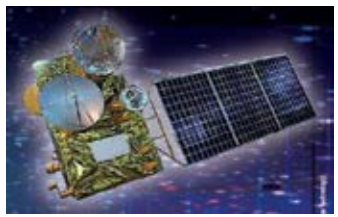


1D-2D mapping

Level 4 – Sea Level Anomaly (cm)



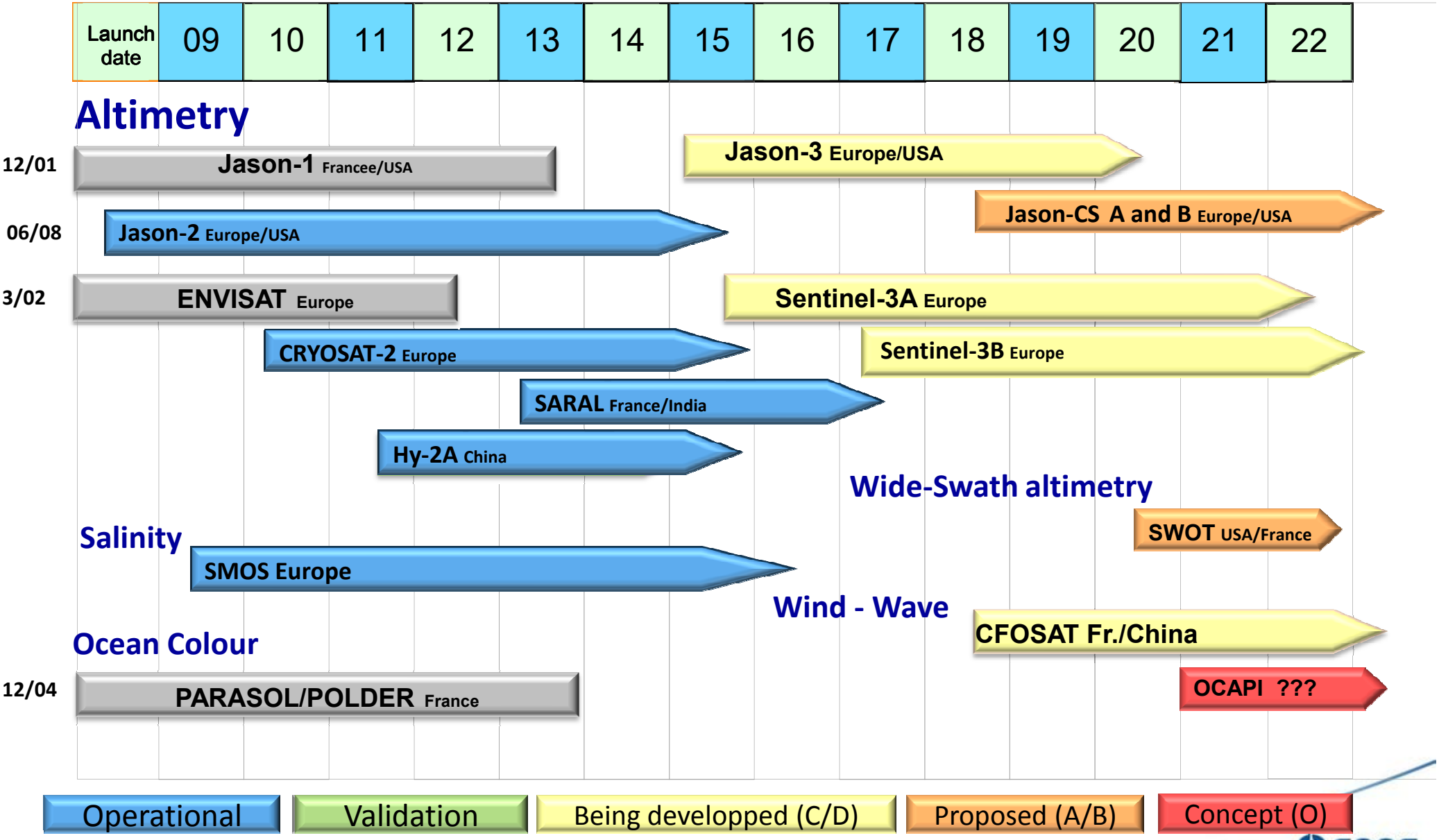
CNES OCEAN PROGRAM STATUS



Juliette Lambin

Juliette.lambin@cnes.fr

Ocean missions @ CNES (various levels of contributions)



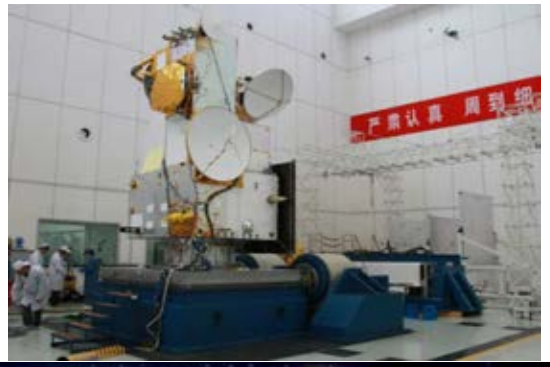
One slide on… HY-2A

HY for Hai Yáng (ocean)
SSO orbit, ~970 km
14-day cycle

Physical oceanography satellite from "China National Space Administration" (CNSA),

- Altimetry payload: Ku-C altimeter, Ku/K/Ka radiometer, LRA, GPS, DORIS
- Ku-band Wind scatterometer
- 5-frequency radiometer (SST°)

- CNES participation:
  - POD processing
  - Inclusion of altimetry data into AVISO multimission product (after validation)



Launched August 15, 2011

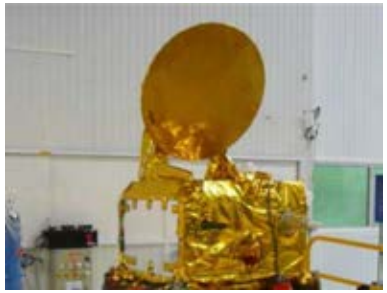
CNES activities status :

- Routine S-IGDR delivery from NSOAS to CNES OK
- Routine processing of S-IGDR at CNES OK
- Integration into DUACS system OK

You benfit from Hy-2 data in AVISO maps…

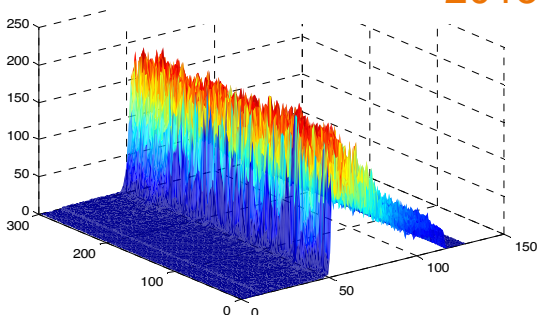
SARAL: 2013-2014 very fruitful beginnings!

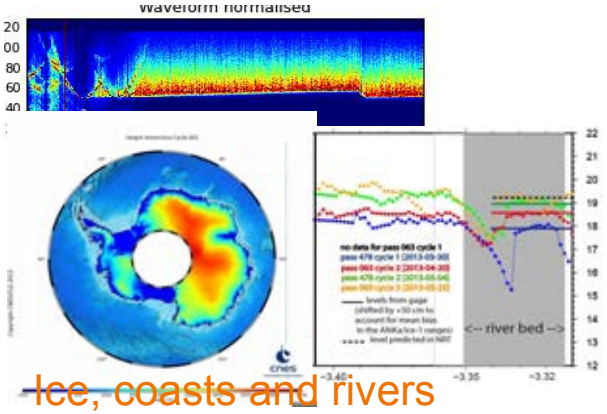
AltiKa et Argos-3, July2011



PSLV 25 Feb 2013

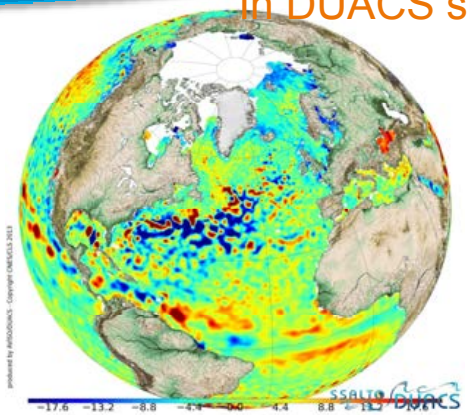
« beautiful » waveforms on 26 feb 2013



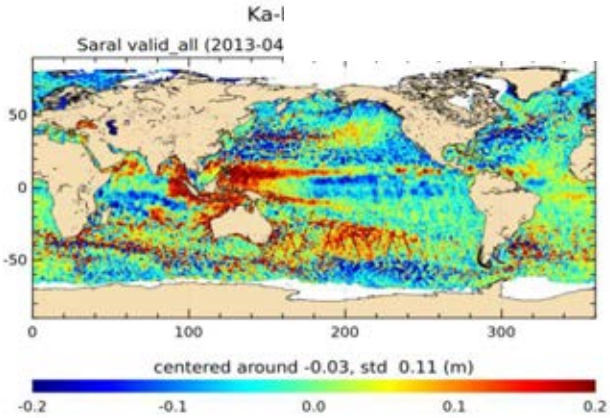


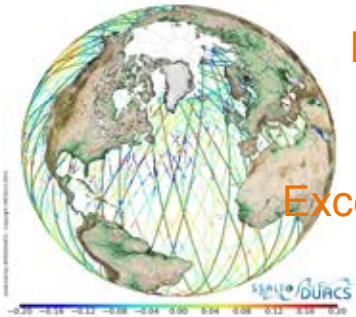
Ice, coasts and rivers as well

In DUACS since July 2013



Good quality from day 1





Exact orbit since summer 2013

Excellent availability

CFOSAT
China-France Oceanography SATellite

China-France Cooperation

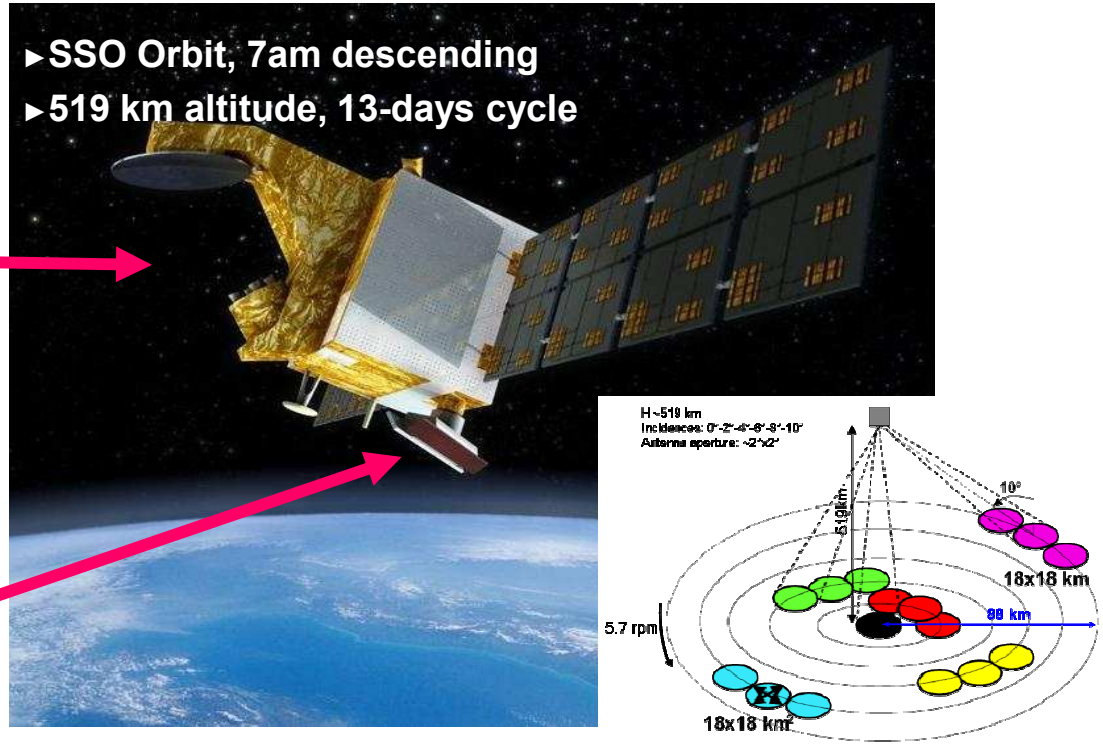
- Currently in phase C/D
- **Launch expected in 2018**

SWIM, new spaceborne instrument

- technology innovations (antenna, on-board digital processing)
- Nadir chanel ~altimeter

SCAT, new concept of wind scatterometer

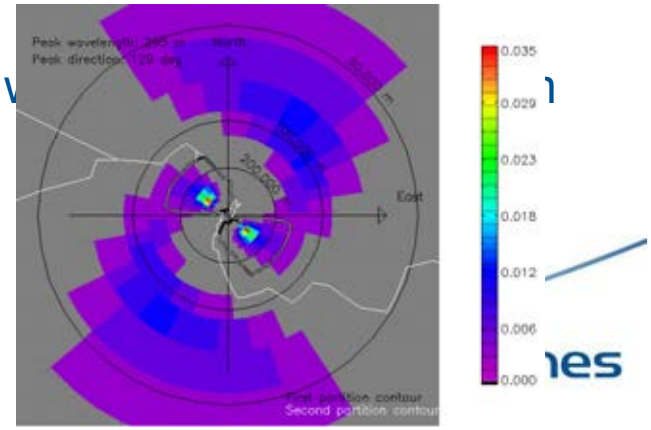
- Ku-band, rotating fan-beam



Global access to 2D v… with high angular resolution

Joint measurements of winds and waves

PI: Danièle Hauser (CNRS/LATMOS)



Future plans

In March 2014 CNES held a « science prospective seminar », to request from the scientific community recommendations for future missions.

- Ocean #1 priority: OCAPI: ocean color from the geostationary orbit over Europe and Atlantic Ocean (with interest from land surfaces community)

- Other or longer term recommendations:
  - THIRSTY: High resolution surface temperature (land/coastal: 100m)
  - AltiKa-2: follow-on from the SARAL mission (Ocean/Cryosphere/Inland waters)
  - SWORD: Radar mission dedicated to surface currents / wind/ wave monitoring
  - SMOS-Next: SMOS (salinity & soil moisture) new generation, with much higher resolution

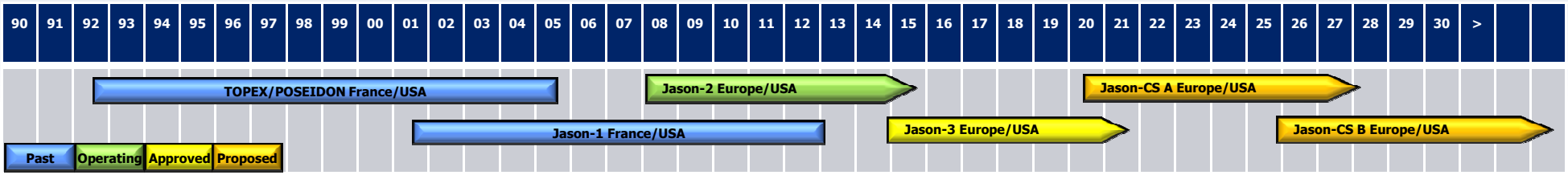
Implementation of those recommendation will probably depend on international cooperation opportunities.

Jason-3

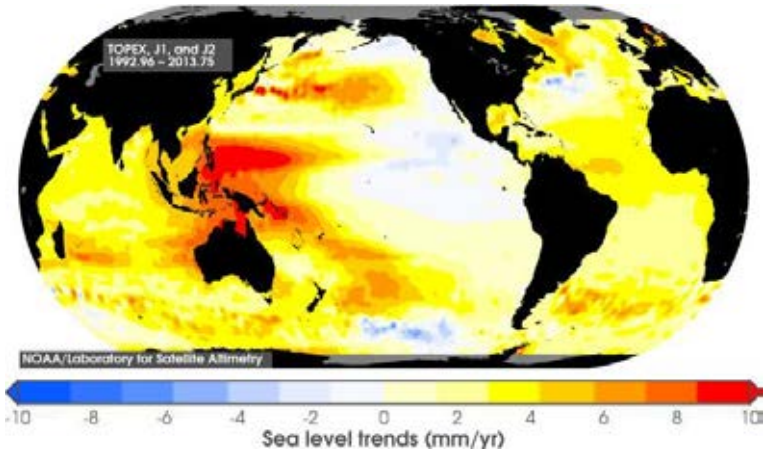
- Nominal progress of satellite and ground system preparation activities (see detailed presentation)
  for the launch on March 31st, 2015.
- Programmatic status at EUMETSAT
  - Eumetsat will fund launch campaign preparation and launch campaign activities
  - All build up for operations and operations cost (European part) for the full life time of the mission will be funded by the European Commission
- Decision for go ahead needs to be taken shortly and is conditional to:
  - In Europe, signature of the EUMETSAT-EU Delegation Agreement. Document has been approved by EUMETSAT Council, waiting for EU approval
  - Confirmation by NOAA of March 31st launch date

Jason-CS: Continuity of Service for Topography

- **Prime mission objective: Continue high-precision global sea level time series**
  with an error on sea level trend < 1 mm/year
- Continuity with past altimeters in the reference series (all operated in LRM)



Global Sea Level Trends
Over Past 21+ Years
(1992 to 2013)



- **Promise of an unprecedented 40 years long systematic measurement**
- **Great boon for climate, sea level rise monitoring**

Partnership and responsibility sharing

EUMETSAT: System responsible,development of ground segment, operations, Jason-CS B (part)

ESA: development of Jason-CS A, procurement of Jason-CS B, LEOP, IOV, L1b Ground Processor Prototypes

NOAA: provision of US payload, launcher, ground station and part of ground segment, operations

EU: funding of operations and Jason-CS B (part)

CNES: expert support, operational services

NASA: development of US payload instruments

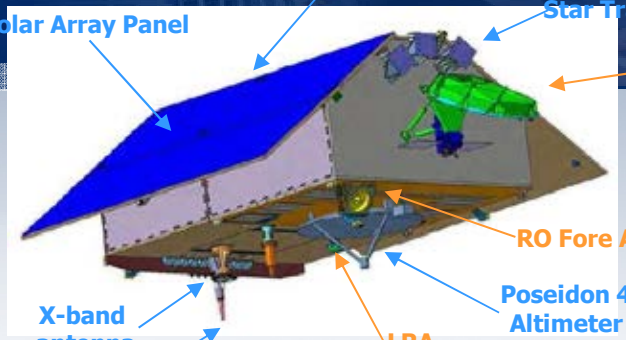
- Current working assumptions; Preparation of formal agreements ongoing

Sentinel 6/ Jason-CS

- Which name !
  - Request received from the European Commission to rename Jason-CS to Sentinel 6
  - After consultation with partners, the proposal is, for EUMETSAT:
    - Sentinel 6 Mission implemented through two Jason-CS satellites (equivalent to OSTM/Jason-2)
    - But the name of the EUMETSAT programme remains Jason-CS
    - So, in our documentation, we use Jason-CS when we speak of our programme or of the satellite and we use Sentinel 6 for the overall mission, its services, products, system activities etc....
- Programmatic status
  - Third Potential Participant Meeting at EUMETSAT on October 23rd
    - Presentation of Programme Proposal and updated End User Requirement Document
    - Objective is to open the programme for subscription at next Council (end of November) and get a Programme entry into force by mid 2015
    - Challenging schedule and objective !

Sentinel 6 System Elements

Launch Vehicle TBD type

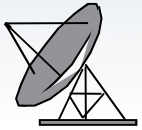


USA Elements (NOAA, NASA/JPL, UCAR)
European Elements (EUMETSAT, ESA, EC, CNES)

USA X/S-band Ground Station Fairbanks (Wallops as S-band backup)

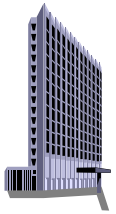
ESA ESTEC (sat. devlpt)

ESA ESOC (LEOP)



European X/S-band Ground Station TBD Site

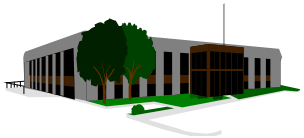
EUMETSAT
System, G/S devlpt and S/C Operations



UCAR RO processing

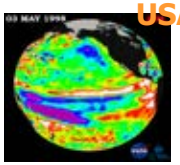
NOAA

CNES

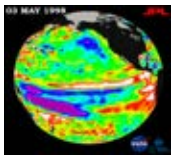


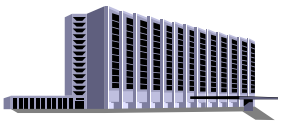
Altimetry Mission Performance Support and POD Service

Operational Product Processing & Distribution: USA Users



Operational and Science Product Processing & Distribution: European Users, Copernicus (EC)





NASA/JPL
NASA Instrument Ops

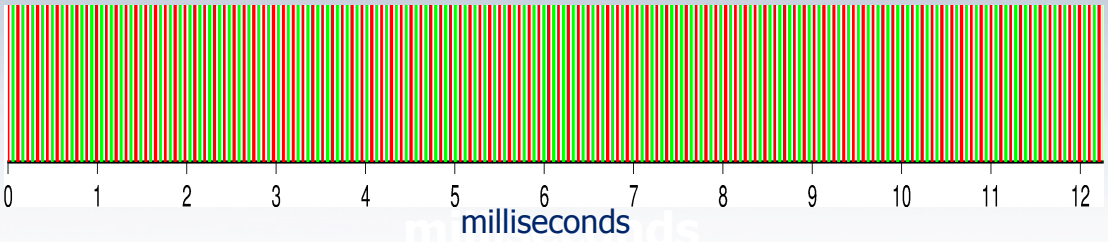
EUMETSAT

Programme status at EUMETSAT

- Technical aspects:
  - System Phase B activities ongoing.
  - System Requirement Review (SRR) Part 1 took place in February 2014, SRR Part 2 planned for Q1 2015.
  - System Preliminary Design Review in Q3 2016.
  - Ground Segment activities just started.

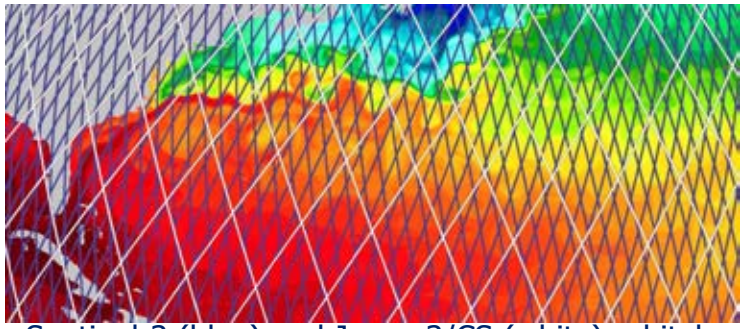
Jason-CS: Continuity of Service for Topography

- Jason-CS altimeter "Interleaved" mode:
  - SAR and LRM simultaneously
  - no "burst", continuous Tx/Rx
  - PRF ~9 kHz



  - Interleaved mode ready for higher resolution (SAR mode) future but systematically linking with the past (LRM simultaneously)
  - Expected to be a breakthrough: access to sub-mesoscale variability of currents

- Combination with Sentinel-3:
  - Jason as the reference for cross-calibration and enhancement of all altimeter missions
  - Jason and Sentinel-3 orbits complement each other for optimum sampling of variability of ocean circulation



Sentinel-3 (blue) and Jason-3/CS (white) orbital paths in the west tropical Atlantic (source: MyOcean)

EUMETSAT

Jason-CS at OSTST'14

- Product Baseline: a Jason-CS product analysis has been ran, taking into account the need for measurement continuity between the Jason missions and seeking harmonisation with contemporary mission (Sentinel-3) within the **boundaries of the programma**tic constraints. The result of this analysis **is** a product baseline, described in poster #15.

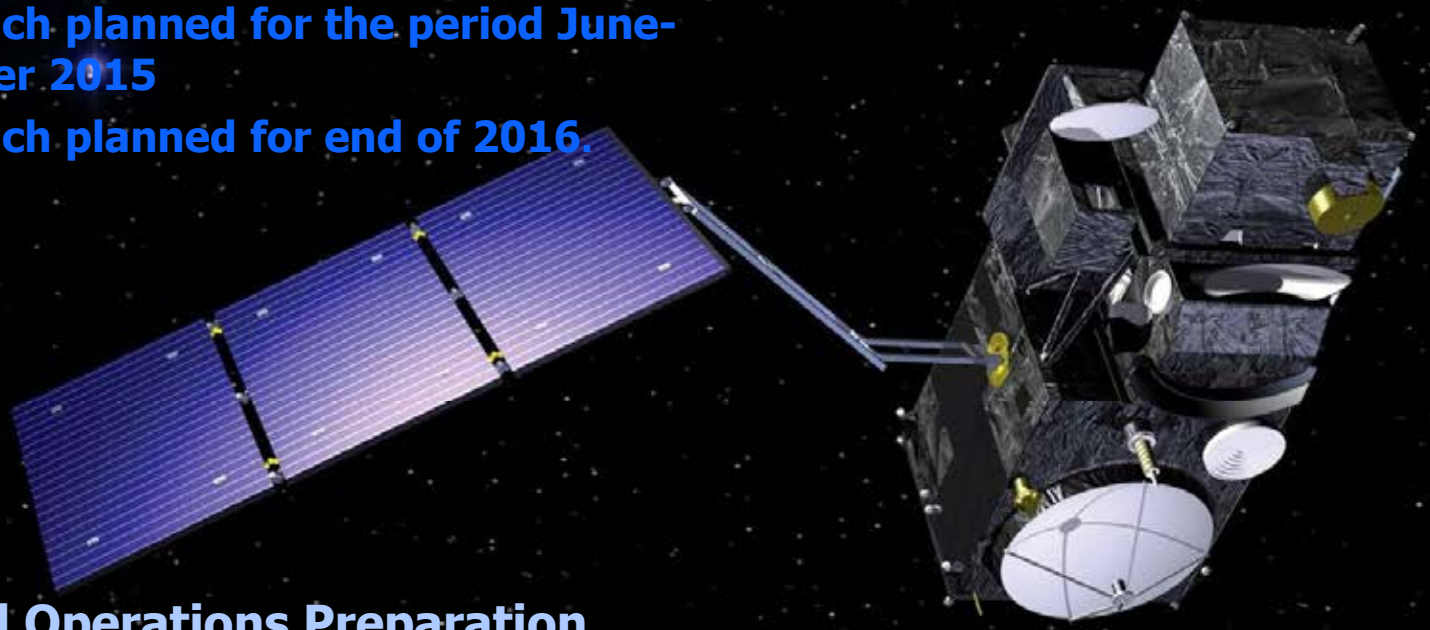
- Several other presentations and posters about Jason-CS: **Interleave mode, L1 prototype processor, processing methods, test data, calibration, and more.**

- Jason-CS **presentation** at EuroGOOS in Lisbon this week by Hans Bonekamp.

Sentinel 3 Status

Space Segment

- **S3A Launch planned for the period June-September 2015**
- **S3B Launch planned for end of 2016.**



System and Operations Preparation

- Ground Segment Verification Testing Support
- Operations Procedure Preparation & System Familiarisation ongoing

FOS for Routine Operations

- Acceptance Review in preparation with kick off on 4/11/14.

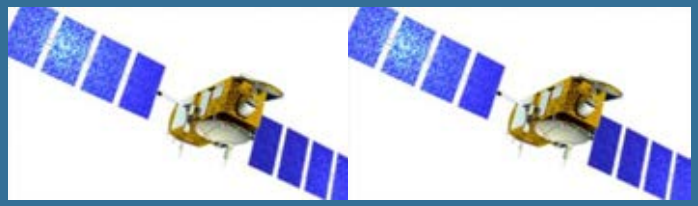
PDGS Marine Centre

Factory testing of launch version (V2L) starting on 3/11/14 covering Core Ground Station in Svalbard and Marine Centre in EUMETSAT, Marine Centre Site acceptance is due end 2014 and overall acceptance in February 2015

J.Huart

NOAA Jason-3 Program Status

- NOAA internal ground segment acceptance testing completed
- 4-Partner ground segment operational qualification testing progressing well.
- Space-X Falcon 9 v1.1 now completed 8 successful launches. NASA certification on-going.
- NOAA will control and down-link telemetry for both Jason-2/OSTM and Jason-3 at Fairbanks, Barrow, Wallops, Usingen-1 & Usingen-2 ground stations.
- First time that one agency will be responsible for managing both satellites flying 1 minute apart during Tandem Mission.



- Scheduled March 31st launch unchanged.

NOAA Jason-CS Program Status

- 5-partner ground operations planning meeting hosted at NOAA/NSOF, July 2014. Follow-on planned for January 2015.
- Level 1 requirements document in final stages of review.
- NOAA participating in Phase B and System Requirement Reviews
- JPL, on behalf on NOAA, continuing development of AMR-C radiometer, including external calibrator.
- Advanced planning for GPS Radio Occultation (RO) secondary mission underway.
- Radio Occultation will provide ~1000 vertical atmospheric profiles of temperature & humidity per day for use in operational numerical weather prediction models.
- NOAA FY16 Jason-CS budget initiative in preparation.

NASA Program Summary

Dr. Eric Lindstrom

NASA HQ

Physical Oceanography Program

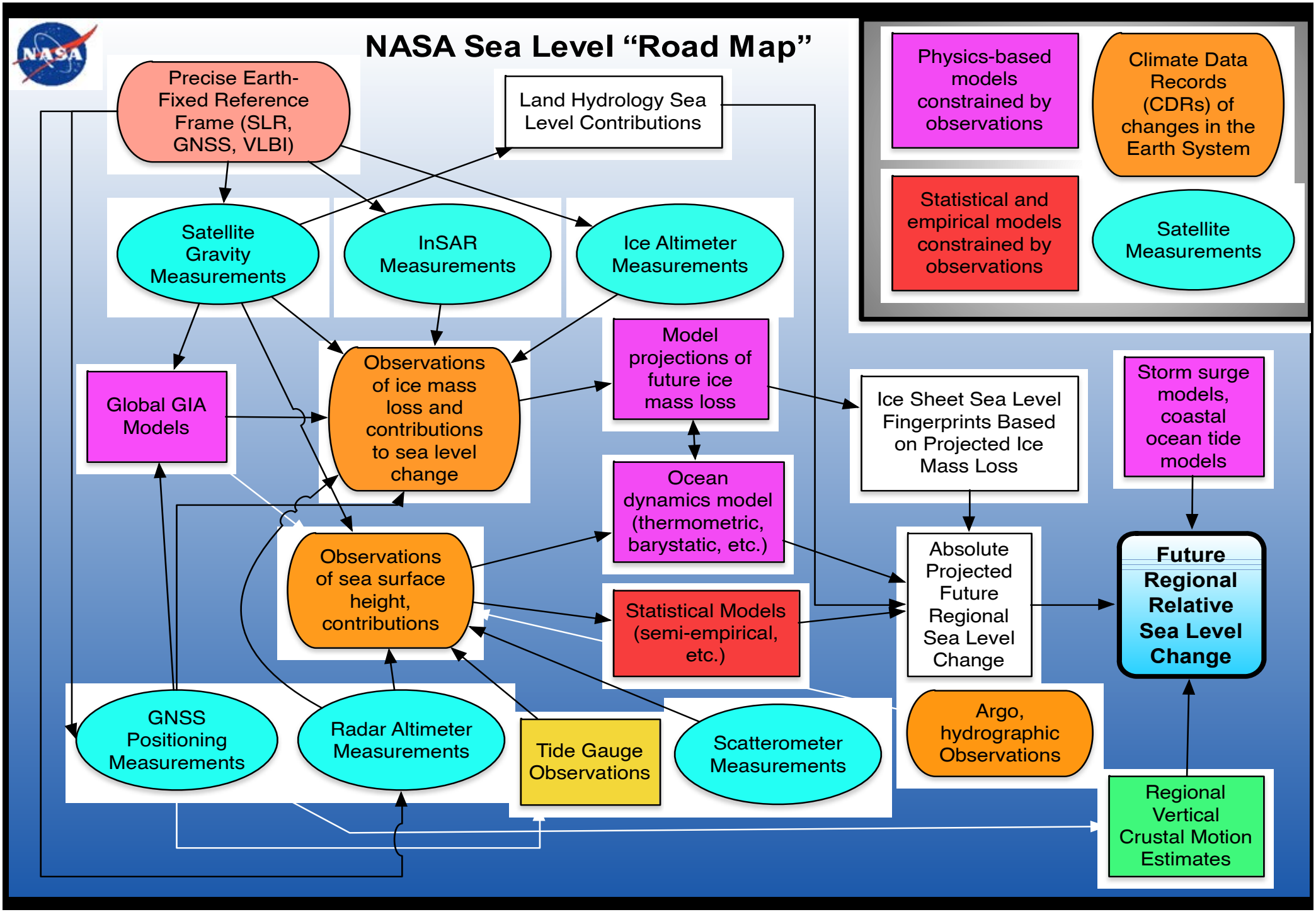
Washington, DC

NASA Sea Level Change Team (N-SLCT) PI Meeting

Oct 14-16, 2014 Scripps Institution of Oceanography

NASA Sea Level Change Team

- Tackle major problems and scientific questions limiting the accurate projection of future regional sea level change.
- Address the interdisciplinary nature of these problems (e.g. ocean-ice sheet interaction, interannual land hydrology-sea level fluctuations)
- Use a web portal to enable communication and research activity across the team.


NASA Sea Level "Road Map"
Precise Earth-Fixed Reference Frame (SLR, GNSS, VLBI)
Land Hydrology Sea Level Contributions
Satellite Gravity Measurements
InSAR Measurements
Ice Altimeter Measurements
Global GIA Models
Observations of ice mass loss and contributions to sea level change
Model projections of future ice mass loss
Ice Sheet Sea Level Fingerprints Based on Projected Ice Mass Loss
Storm surge models, coastal ocean tide models
Ocean dynamics model (thermometric, barystatic, etc.)
Observations of sea surface height, contributions
Statistical Models (semi-empirical, etc.)
Absolute Projected Future Regional Sea Level Change
Future Regional Relative Sea Level Change
GNSS Positioning Measurements
Radar Altimeter Measurements
Tide Gauge Observations
Scatterometer Measurements
Argo, hydrographic Observations
Regional Vertical Crustal Motion Estimates
Physics-based models constrained by observations
Climate Data Records (CDRs) of changes in the Earth System
Statistical and empirical models constrained by observations
Satellite Measurements

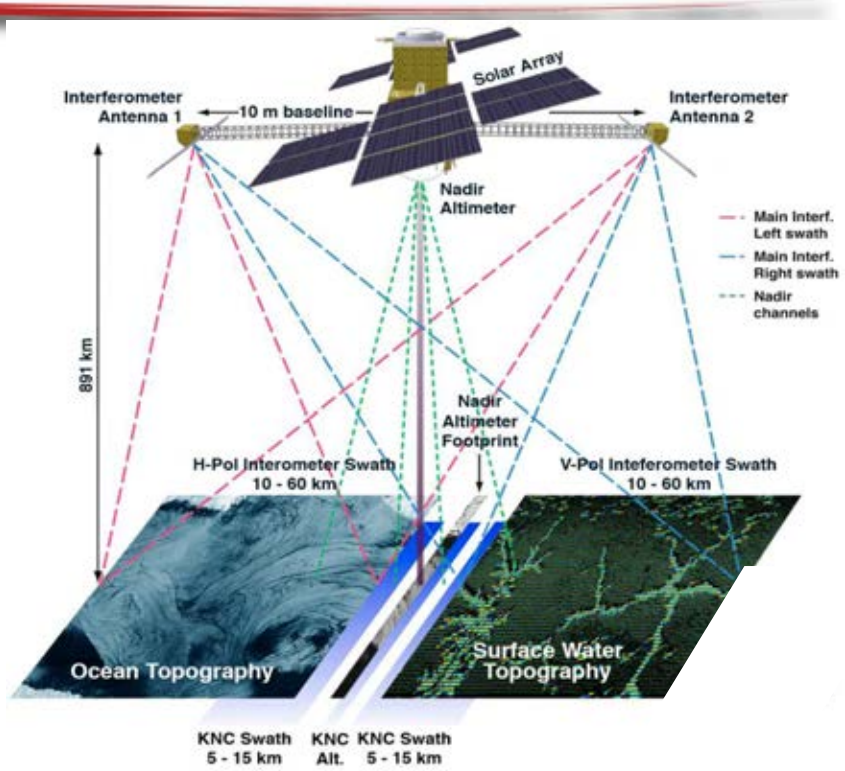
SWOT Mission Overview

Mission Science

Oceanography: Characterize the ocean mesoscale and sub-mesoscale circulation at spatial resolutions of 15 km and greater.

Hydrology: To provide a global inventory of all terrestrial water bodies whose surface area exceeds $(250m)^2$ (lakes, reservoirs, wetlands) and rivers whose width exceeds 100 m (rivers).

- To measure the global storage change in fresh water bodies at sub-monthly, seasonal, and annual time scales.
- To estimate the global change in river discharge at sub-monthly, seasonal, and annual time scales.



Mission Architecture

- Ka-band SAR interferometric (KaRIn) system with 2 swaths, 50 km each
- Produces heights and co-registered all-weather imagery
- Conventional altimeter for nadir coverage, radiometer for wet-tropospheric delay, and GPSP/DORIS/LRA for Precision Orbit Determination.
- On-Board interferometric SAR processing over the ocean (1 km^2 resolution) for data vol. reduction.

- Partnered mission with CNES (+CSA & UKSA)
- Science mission duration of 3 years
- Cal orbit: 857 km, 77.6º Incl., 1 day repeat
- Science orbit: 891 km, 77.6º Incl., 21 day repeat
- Flight System: ~2000kg, ~1900W
- Launch Vehicle: NASA medium/intermediate class
- Category 2 Project, Risk Class: C
- Target Launch Readiness: Oct 2020

SWOT Science Team 2016-2019

- Present SWOT Science Definition Team finishes end of 2015
- AirSWOT continues instrument check-out flights in 2014 and plans validation in both ocean and hydrological experiments in 2015.
- Next SWOT SDT Meeting 13-15 January 2015 in San Diego. (See Lee Fu for details)
- NASA ROSES and CNES TOSCA in 2015 will invite proposals for SWOT Science Team
- Likely that proposals due late Spring 2015; selected projects start 1/1/16; four year duration.

Jason-2/3 & Jason-CS/Sent.6

- NASA continues its support of OSTM/Jason-2 operations and building of Jason-3
- NASA continues its support of OSTST (next call for proposals in ROSES 2016) but balanced against growing support for SWOT
- NASA continues scientific and technical support of the Jason series.

ESA Programmes Status

- ERS-1/2 Reprocessing: REAPER Project
- Envisat Reprocessing
- CryoSat Mission Status
- Sentinel-3 Mission Status
- GOCE Mission Status
- SMOS Mission Status

Jérôme Benveniste, OSTST 2014, Lake Constance

ERS Reprocessing: REAPER

!!! ERS-1 & ERS-2 REAPER DATA NOW AVAILABLE !!!

- **REAPER** is a reprocessing activity intended to produce a homogeneous ERS-1 & ERS-2 Altimetry dataset, improved with a uniform set of algorithms and models, and cross-calibrated with ENVISAT (V2.1).
  - **17 years of reprocessed data in total, for both altimeter and microwave radiometer.**
- Many improvements have been made to the L1, L2 and Calibration processing of the ERS data. These improvements have largely derived from the processing developed for ENVISAT.
  - **Improvements to the Orbit and update of auxiliary models**
  - **Improvements to L1 / Calibration Processing and to Level 2 Processing**
  - The REAPER L2 ERS-2 products have been **cross-calibrated with ENVISAT**.
  - The REAPER L2 ERS-1 products have been then **cross-calibrated with ERS-2**.
- **Data Access**
  - The ERS-1/2 REAPER products have been released in September 2014 in NetCDF v3 format. The dataset is composed of the following three product types and is now freely accessible online upon **Fast Registration**:
    - GDR - (ERS_ALT_2_)
    - SGDR - (ERS_ALT_2S)
    - METEO - (ERS_ALT_2M)

For more information on REAPER data access contact ESA eohelp@esa.int

For more information on REAPER project see http://reaper.mssl.ucl.ac.uk/ or contact reaper@mssl.ucl.ac.uk

SEE POSTER !

ENVISAT Reprocessing

- In 2012, ENVISAT mission was interrupted, after 10 years of altimetric measurements. Two years later, the mission's database is still maintained, studied and used. Used as a reference for the expected behavior of the very young or future missions such as AltiKa or Sentinel 3, historical database still evolves.
- **Next reprocessing** is getting prepared with tens of algorithm improvements planned for the future products. The major evolutions are listed below with an overview on the expected effects on errors reduction at different scales.
  - **Large and short scales error reduction: MSL improvement and SSH variance at crossovers decrease**
    - New orbit standard
    - New wet tropospheric corrections
    - PTR Internal Path Delay drift
    - Look Up Tables for small waves correction
    - New ionospheric correction filtering method
  - **New fields available !!**
    - ERA-Interim meteo Fields (dry/wet tropospheric corrections)
    - 2 new wet tropospheric corrections
    - ACE
    - LEGOS Echo and Geo correction over ice shelves
    - EGM 2008
    - MSS DTU-10…

Current Homogeneous dataset available on:
ftp://diss-nas fp.eo.esa.int
Envisat Corrected SSH products now available on ODES portal:
http://odes.altimetry.cnes.fr

GDR will be available in NetCDF format S3 compliant

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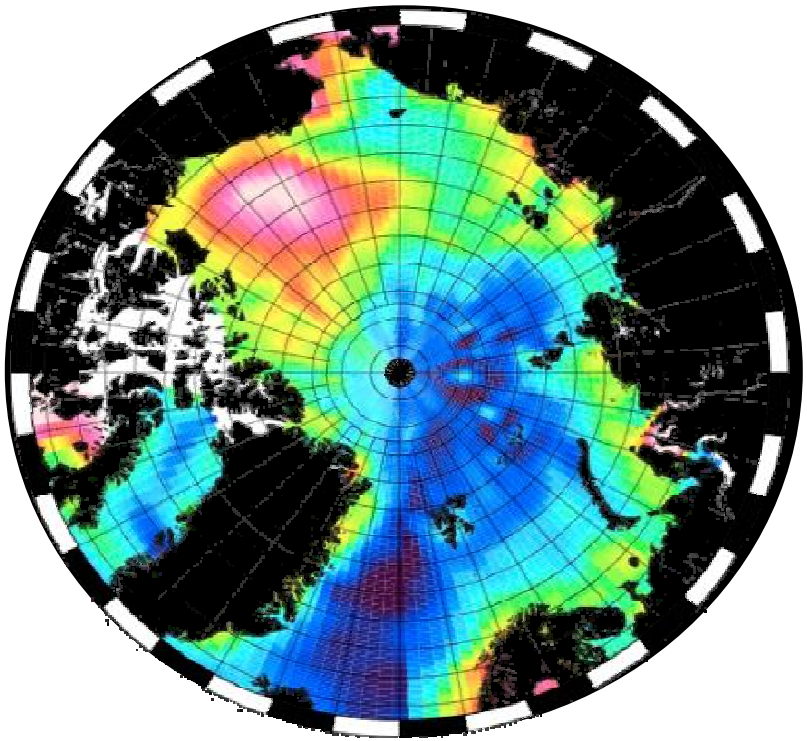
CryoSat Mission Status

- Mission extend until **February 2017**
- Excellent status of platform and payload after four years of operations. SIRAL exceeding technical performance (still using side A). First estimation of mission requirements were achieved successfully
- Operations can continue until **2020** without major impact on mission performance
- Ground segment continuously evolving to accommodate new products and demand from worldwide community. Ocean chain (IOP, GOP) released in 2014 with more than 15% of open sea covered in SAR.
- CryoSat seen as the precursor mission of Sentinel-3 and Sentinel-6 and fundamental for their development and for user ramp-up to SAR
- Release of Baseline C (Cryo-chain) by January 2015, followed by reprocessing campaign



UCL, 2013

SENTINEL-3 STATUS MAIN MESSAGES

- Readiness of Sentinel-3A platform and instrument integration and testing on track with some technical issues to solve
- Launch window foreseen for June to September 2015
- All ground segment facilities supporting the S-3 operations are in place
- Mission Performance Centre for S-3 has been kick-off in mid-October
- EC issued some change requests to mission baseline (SRAL SAR operations, additional products: AOD, FRP, SYN within 24 h), which are presently under investigation and implementation
- Data access will follow same route as for Sentinel-1
- Please note 2nd Sentinel-3 validation workshop on 3-4 December at EUMETSAT

  http://www.eumetsat.int/website/home/News/ConferencesandEvents/DAT_2326254.html

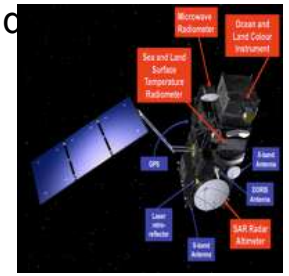
Sentinel-3A Status

- Current launch window June-Sept 2015, depending on export license clearance from US State Department for launch from Russia
- **Platform readiness**
  - Intermediate Satellite Qualification Review successfully completed => Environmental test campaign released
  - Sentinel-3A AIT progressing: Full satellite (including OLCI) integrated since early July
- **Payload readiness**
  - **SRAL** PFM instrument integrated on Satellite and tests on-going.
  - **MWR** PFM integrated on Sentinel-3A satellite. No open issues
  - **SLSTR** PFM functional testing performed without major issues, further tests on-going; SLSTR FM2 tests on-going, calibration in Q1 2015, integration (swap of instruments) at satellite level in April 2015
  - **OLCI** PFM instrument integrated on Sentinel-3A; investigation on-going concerning thermal issues affecting 1 camera on PFM detected during thermal vacuum tests and decision taken to remove the camera and swap it (now) by camera FM6 originally allocated to OLCI-FM2 and currently ready
- **Sentinel-3B** Assembly, Integration and Test on-going

Sentinel-3A in TAS test facilities in July 2015

SENTINEL-3

- **Extension of the SAR mode** from the coastal zone to the full ocean to provide high-resolution (~300m along-track), low-noise altimeter data in an operational context for the first time (Plan to be confirmed).
- **Two tracking modes**: autonomous closed-loop tracking of range and gain and open loop with DEM.
- The **selected orbit** is the result of a trade-off between the constraints imposed by all sensors and operational constraints based on requirements for:
  - a short revisit time for the optical instruments, which imposed an orbit subcycle of 4 days;
  - a long orbit cycle, implying short spacing between ground tracks, suitable for mesoscale (100–300 km) ocean topography
- The resulting orbit is polar, Sun-synchronous (98.6° inclination), with a mean altitude of 815 km and a repeat cycle of 27 days (14 + 7/27 revolutions per day). The local time of the equator crossing (LTDN) is 10:00 a.m.
- Sentinel-3B will be placed in the same orbit with an offset of 180°, with ground track in the middle of the ground tracks of the first satellite (inter-track separation of 52 km at the equator), thus optimising payload coverage while maintaining a balance between topography and optical mission coverage.
- In a two-satellite configuration, after one complete cycle, the inter-track separation will be reduced to 52 km at the equator.
- The launch of the first satellite, Sentinel-3A, is planned for 3rd q the launch of Sentinel-3B some 12–18 months later.



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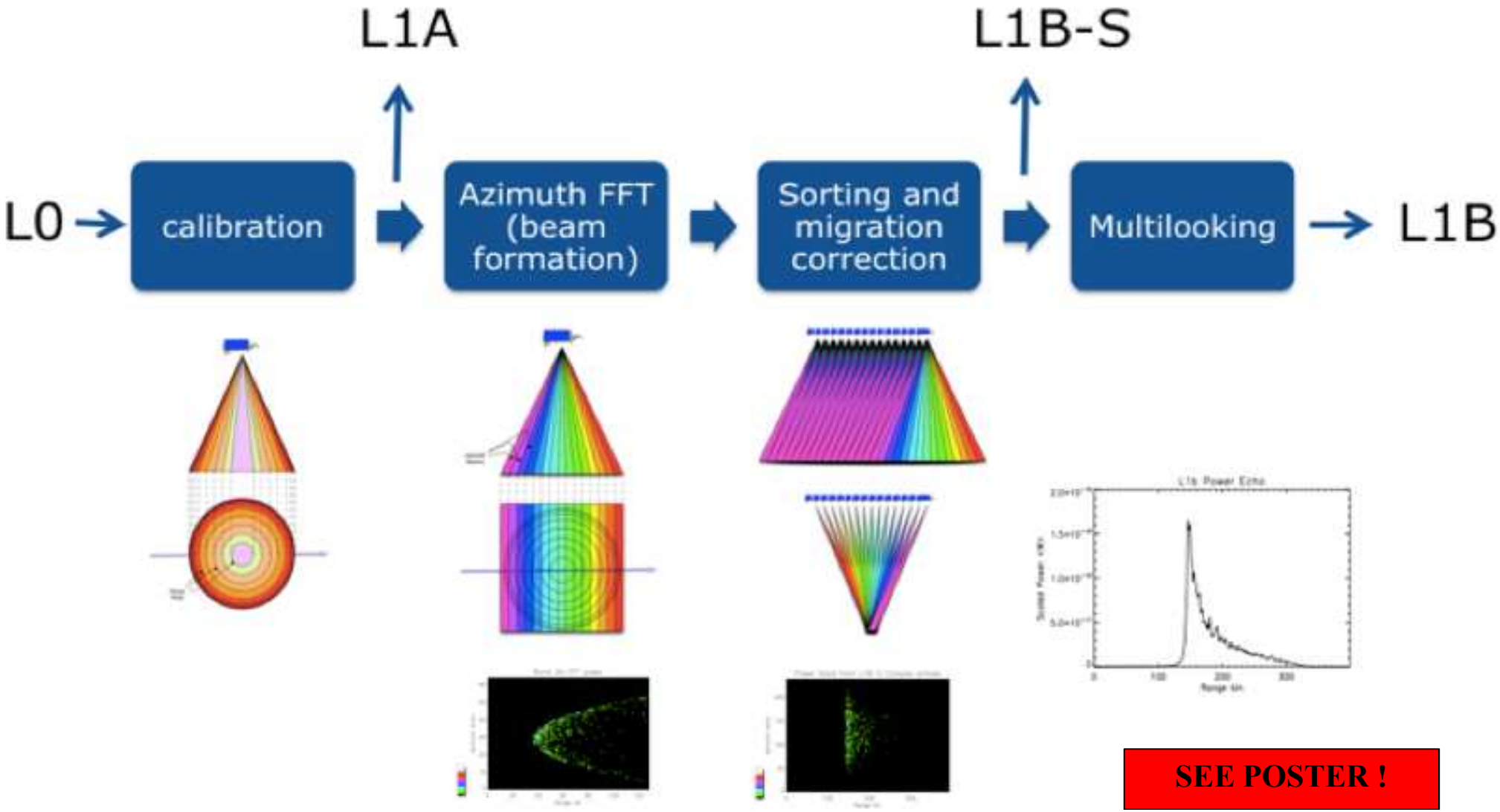
SENTINEL-3: Provision of additional L1 data



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SENTINEL-3 for Science Workshop

Abstract deadline 31 January 2015 – seom.esa.int/S3forScience2015

GOCE: mission accomplished but exploitation continues

Key ssues

- Release 5 gravity field products (models and grids) are available, with full error information
- Complete error covariance matrix available
- Extremely low orbit operations proved extremely successful, approximately doubling the information content and quality of the GOCE products

www.goce2014.org

Report on exactly 1700 days of flight

DOCUMENT

GOCE *End-of-Mission Operations Report*

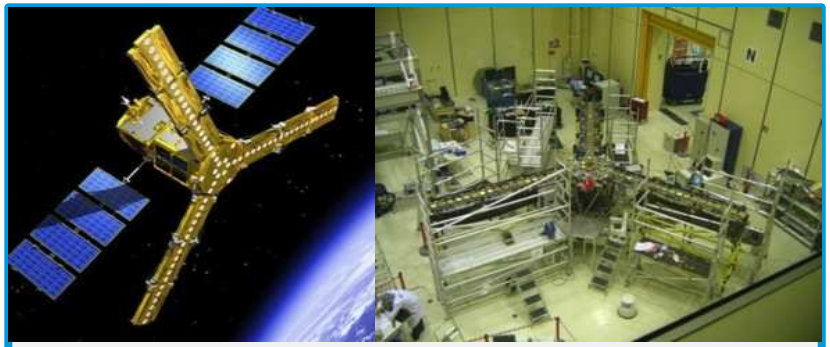
Prepared by	GOCE Flight Control Team (HSO-OEG)
Reference	GO-RP-ESC-FS-6268
Issue	1
Revision	0
Date of Issue	07/02/2014
Status	Authorised
Document Type	RP
Distribution	

available on
earth.esa.int/goce

SMOS: SATELLITE AND PAYLOAD *STATUS*

- SMOS mission operations have recently been extended to 2017 by ESA (Feb) and CNES (end of year).
- ESAC stated that "…Based on the evidence for technical and scientific excellence given above, ESAC recommends that the extension of the SMOS mission be confirmed until the end of EOEP-4."

  + detailed recommendations (ESA/PB-EO/DOSTAG(2014)45)
- High data availability (98.6%; of which 1.68% Cal.)
- Platform fully operational, all sub-systems in good health and no sign of degradation (remaining propellant sufficient for another 120 years in orbit!)
- Payload status & performance excellent after ~5 years of operations with some well-identified anomalies with recovery procedures in place
- Very reliable ground segment operations (99% within 1-3 days from sensing, 90% for NRT within 3 hours)
- 2nd reprocessing campaign in 2014 with reprocessed data up to level 2 available beginning 2015
- New data products (soil moisture in NRT, sea ice thickness) to be included into portfolio.



THE MISSION

Launch - 2 November 2009

Orbit - ~ altitude of 758 km; inclination of 98.44°; low-Earth orbit, polar, sun-synchronous, quasi-circular, dusk-dawn (6am/6pm), 23-day repeat cycle, 3-day sub-cycle

Operations shared between ESA (overall mission management and ground segment operations) and CNES (responsible for platform operations)

THE PAYLOAD

MIRAS, the Microwave Imaging Radiometer using Aperture Synthesis instrument, is a passive microwave 2-D interferometric radiometer measuring in L-Band (1.4GHz, 21cm); 69 antennas are equally distributed over the 3 arms and the central structure.