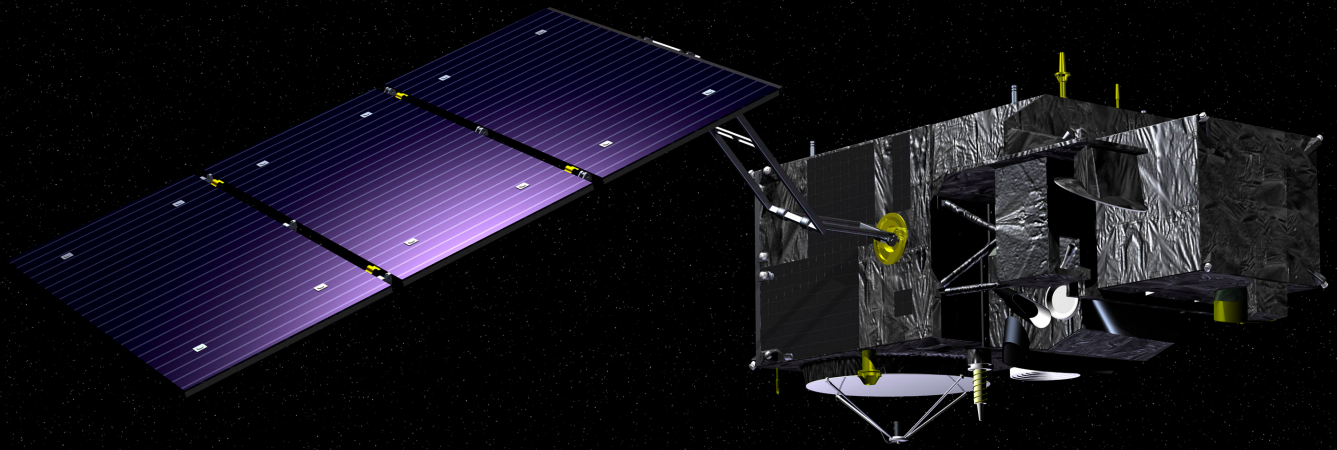
The Sentinel-3 Mission

C. Donlon, B. Berruti, J. Nieke, P. Goryl, P. Femenias, C. Mavrocordatos, H. Rebhan, B. Seitz, and U. Klein

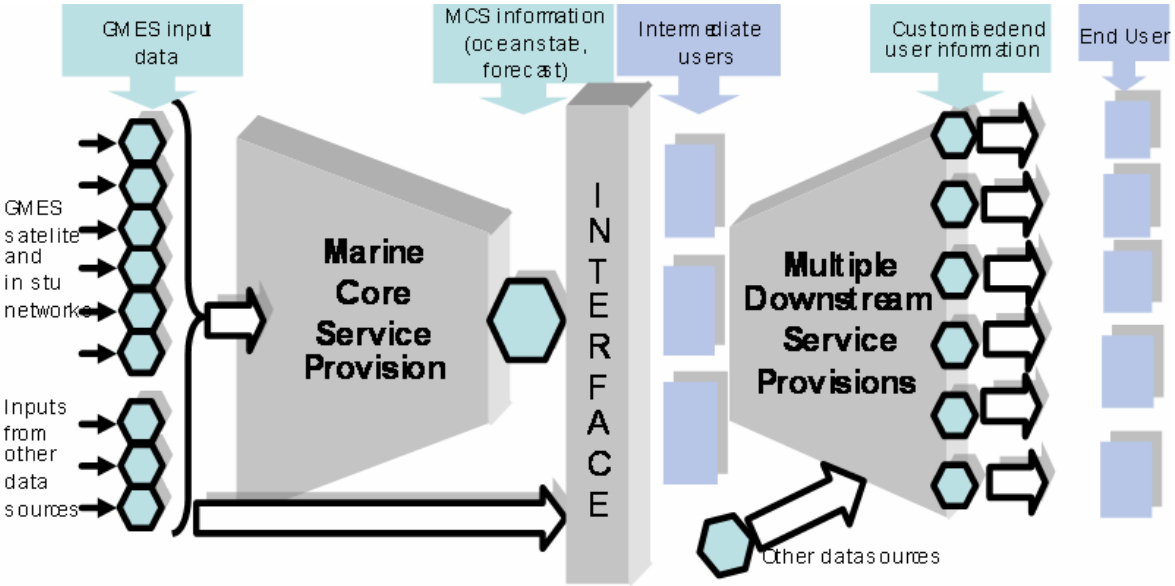


GMES

Global Monitoring for Environment and Security

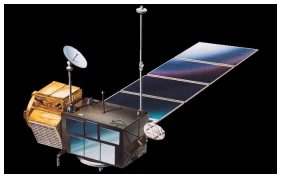
S3 Background: Aim

- **The aim of Sentinel-3 Mission:**
  - ***To provide continuity of ENVISAT type Optical and Topography measurement capabilities with high availability, high accuracy, with timely delivery and, in a sustained operational manner for GMES users.***



From GMES MCS Implementation Group report by P.Ryder & al, Oct 2005

Sentinel-3 Mission Heritage



1992: TOPEX / Poseidon-1

Poseidon-1

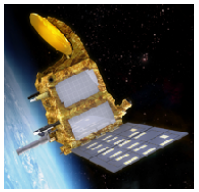
2001: JASON-1

Poseidon-2

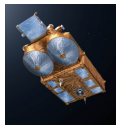
2008: JASON-2

Poseidon-3

2012:AltiKa

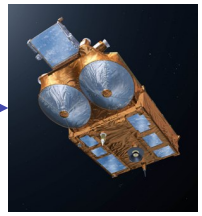


SARAL



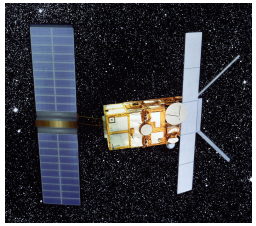
SIRAL

2005: CryoSat-1



SIRAL

2010: CryoSat-2



1992: ERS-1
1995: ERS-2

RA

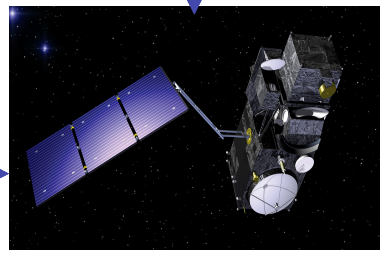
ATSR

2002: ENVISAT

RA-2

AATSR

MERIS



2013: Sentinel-3

SRAL, MWR, POD

SLSTR

OLCI

Vegetation

1998: SPOT-4

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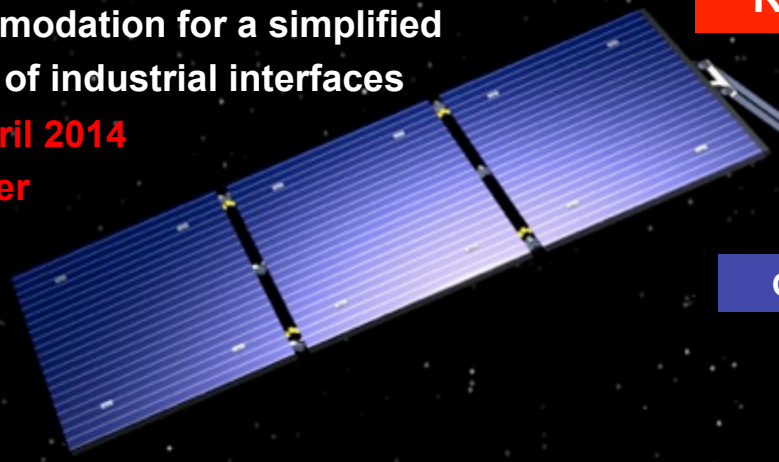
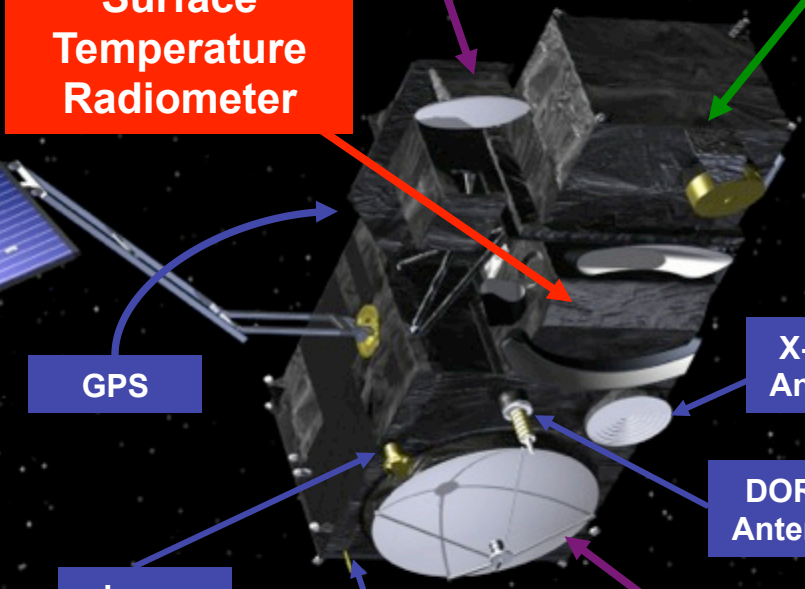
Sentinel-3: Continuity of ENVISAT Ocean Observation

esa

Main satellite characteristics

- 1250 kg maximal mass
- Volume in 3.89 m x 2.202 m x 2.207 m
- Average power consumption of 1100 W
- 7.5 years lifetime (fuel for 5 add. years)
- Large cold face for optical instruments thermal control
- Modular accommodation for a simplified management of industrial interfaces
- Launch S3A April 2014
- Launch S3B later





Observation Data Management:

- 21.25 Gb (170 Gbit) of observation data per orbit
- Space to ground data rate 2 x 280 Mbps X-Band
- 1 ground contact per orbit
- 3h delivery timeliness (from satellite sensing)

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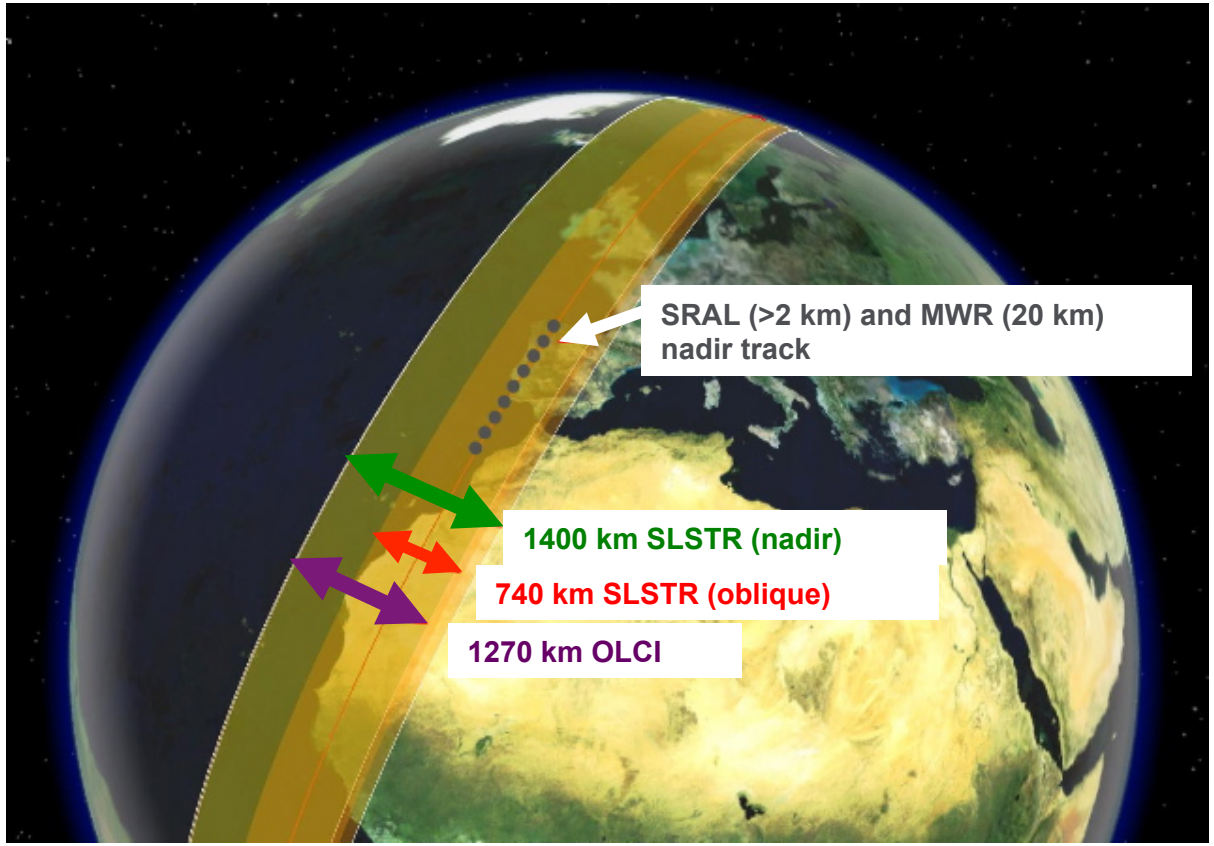
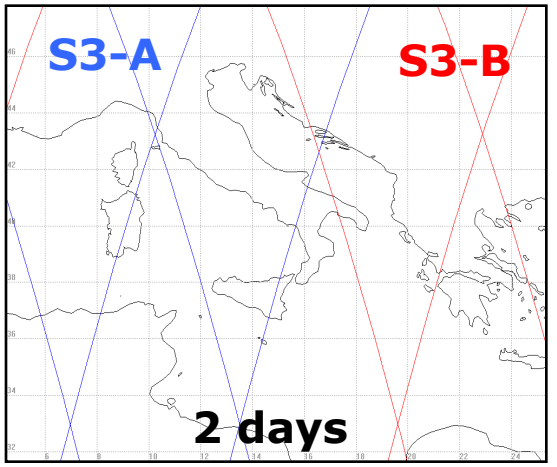
Sentinel-3: Instrument Swath and Satellite Orbit

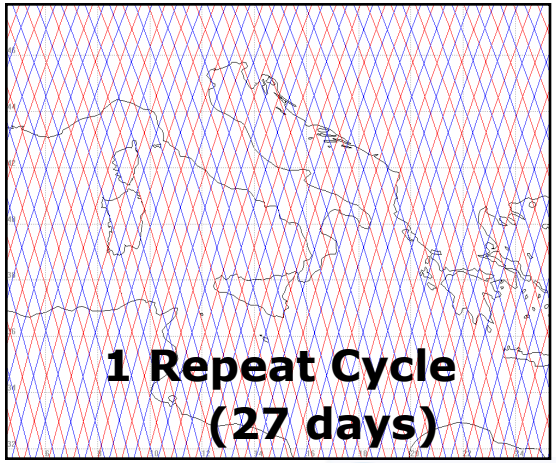
Instrument Swath Patterns



Orbit type	Repeating frozen SSO
Repeat cycle	27 days (14 + 7/27 orbits/day)
LTDN	10:00
Average altitude	815 km
Inclination	98.65 deg

Ground Track Patterns





S3: Topography Mission

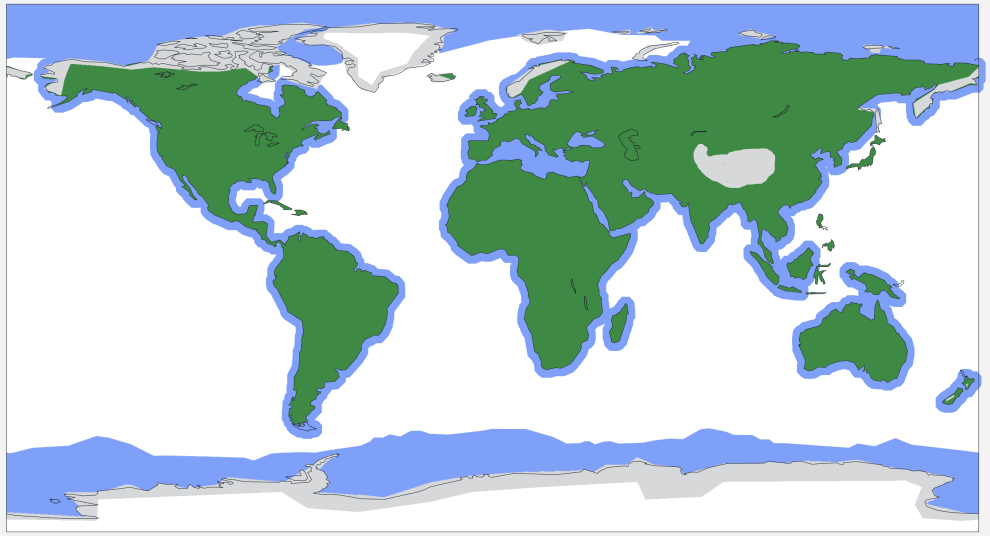
Topography package:

1. **Dual frequency Synthetic Aperture Radar Altimeter (SRAL)**
2. **Microwave Radiometer (MWR)**
3. **Precise Orbit Determination (POD)**

Key Improvements:

SAR & LRM mode
Better POD
Better open & closed Loop tracking
Polar Ocean

S3 Topography mission Mode mask



Ocean SAR mode map now in discussion

Observed surfaces

- **Open ocean, coastal ocean**
- **Ice sheets (interiors and margins)**
- **Sea ice**
- **In-land water (rivers & lakes)**

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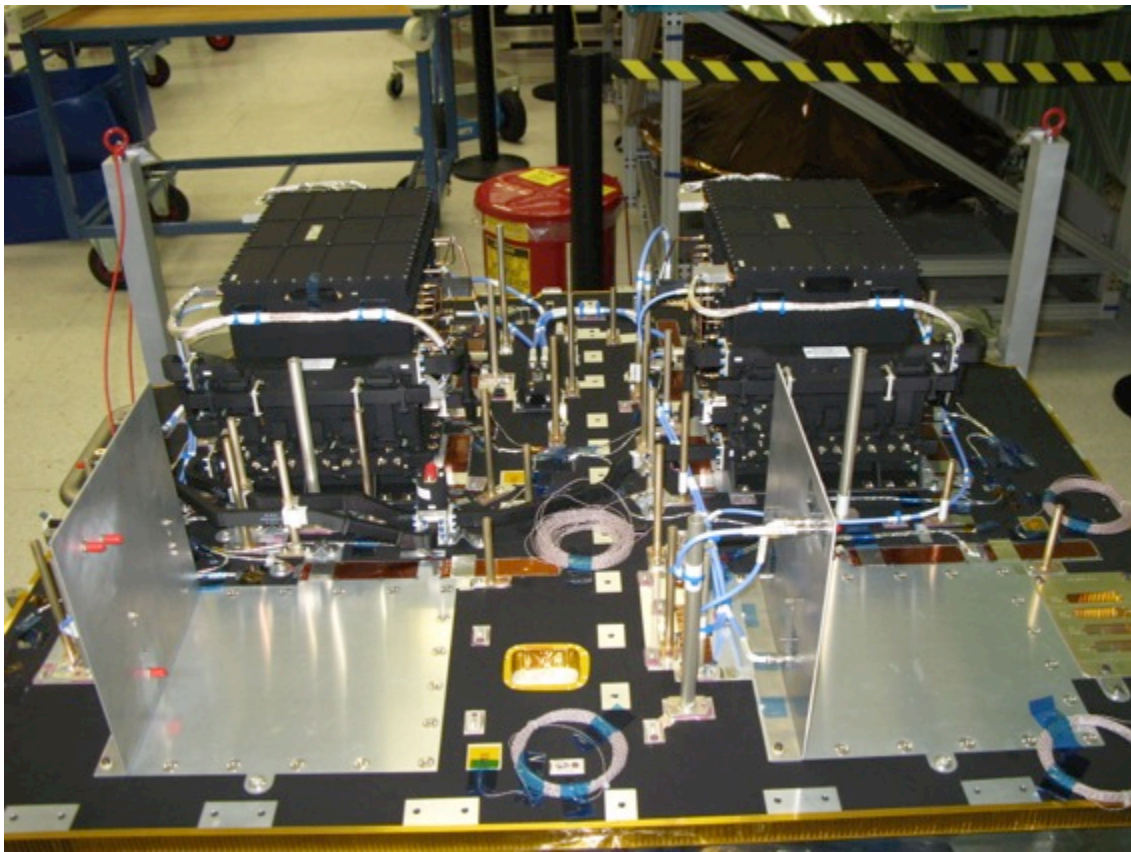
S3 SAR RADAR Altimeter

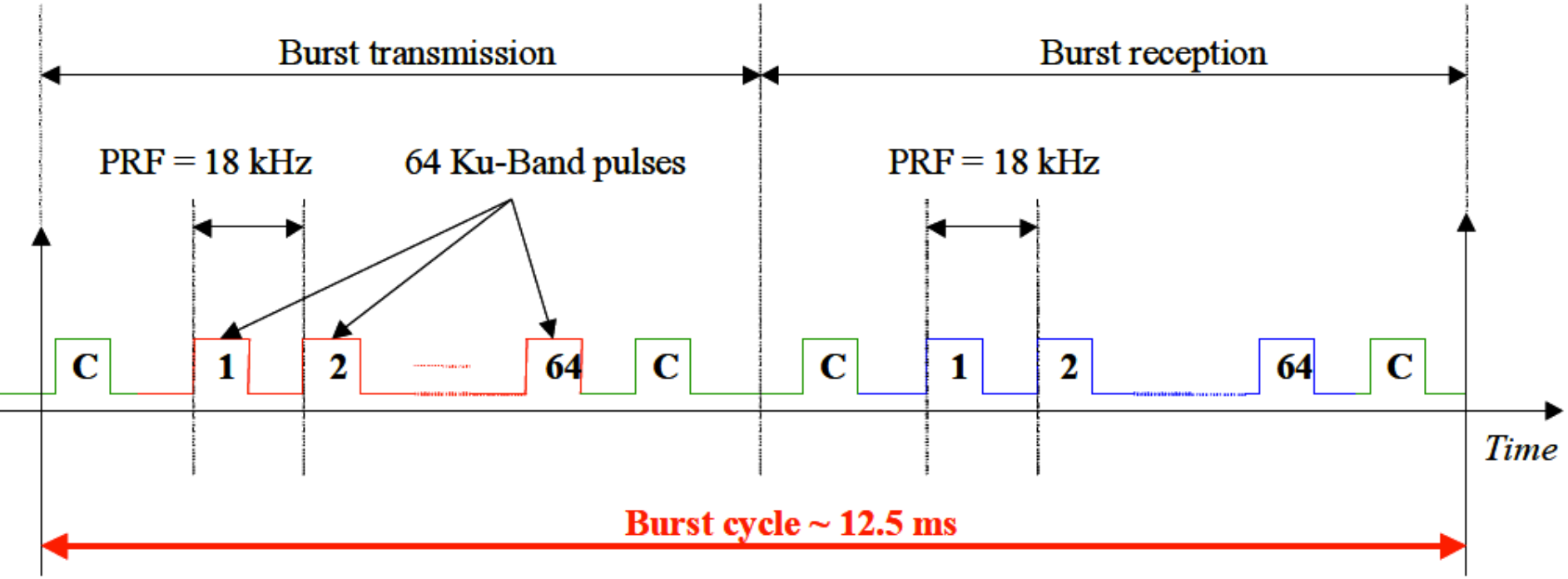
- **Dual frequency Ku/C band Radar Altimeter**
  - CryoSat and Jason heritage
  - High horizontal resolution (~300m in SAR mode)
- **SRAL Radar features:**
  - Ku-Band (13.575 GHz) : main frequency
  - C-Band (5.41 GHz) : ionosphere corrections
  - Fully redundant electronics
- **Measurement modes:**
- **2 radar modes:**
  - Low Resolution Mode (LRM) and
  - High Resolution SAR mode
- **2 tracking modes:**
  - Closed-loop (traditional) and
  - Open-loop tracking modes over rough surfaces
- **Any radar mode can be combined to any tracking mode**

Objective: To retrieve orbit altitude information with an end-to-end accuracy of 3 cm (Ocean)

Supported by MWR, GPS, LRR and DORIS



SRAL Chronograms

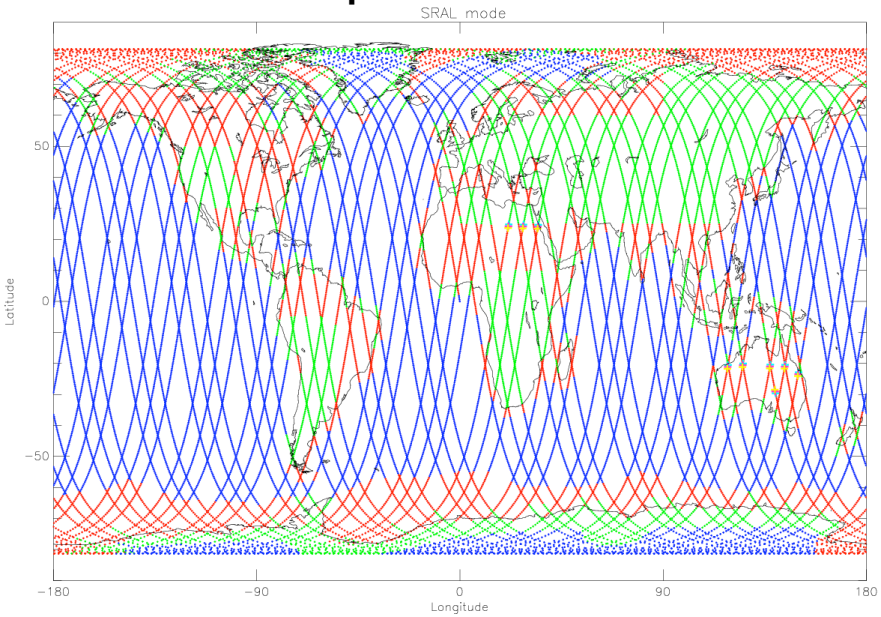


SAR burst pattern

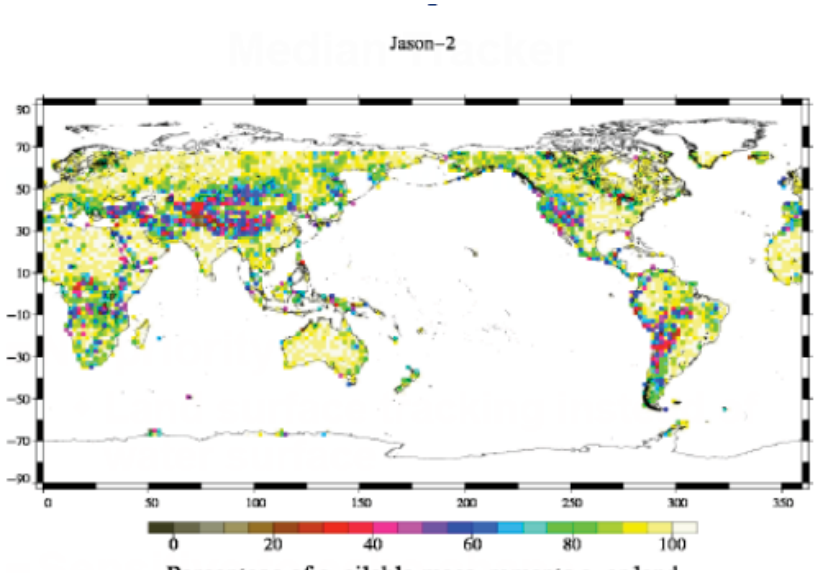
SRAL Mode Mask

Baseline Mission:

- SAR mode in coastal zones and EU Seas only
- LRM over open ocean
- Maximizes the use of SAR capability over the Land surface (unproven)
- This is the Operational Baseline



SAR Closed Loop tracking
SAR Open Loop tracking (uses on-board DEM)
LRM Closed Loop tracking
LRM Open Loop tracking



JASON-2 altimeter tracking is less efficient in sloping terrain – potentially worse for S3 SAR mode as we have less echoes

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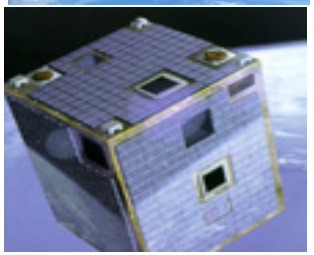
S3 PDGS Data volume (uncompressed)

	Level 0 GB/Orbit	Level 1 GB/ Orbit	Level 2 Marine GB/Orbit	Level 2 Land GB/ Orbit
OLCI	9.5	29.6	35.5	7.8
SLSTR	4.8	45.6	5.8	2.8
SYN (OLCI +SLTSR)		55.8		31.2
SRAL + MWR	5.8	0.12	0.09	0.07
Total (GB/ orbit)	20.1	131.12	41.39	41.87

	Level 0			Level 1			Level 2 Marine			Level 2 Land		
	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year
OLCI	9.47	134.98	48.11	29.60	422.07	150.45	35.50	506.20	180.43	7.82	111.51	39.75
SLSTR	4.80	68.40	24.38	45.60	650.22	231.77	5.80	82.65	29.46	2.81	40.11	14.30
SYN (OLCI+SLSTR)	0	0	0	55.80	795.67	283.61	0	0	0	31.21	452.70	161.64
SRAL	5.82	82.98	29.58	0.12	1.65	0.59	0.09	1.31	0.47	0.07	1.00	0.36
MWR	0.003	0.039	0.014	0.003	0.039	0.014	0	0	0	0	0	0
GNSS/DORIS	0.03	0.39	0.14	0	0	0	0	0	0	0	0	0
NavAtt	0.001	0.010	0.004	0	0	0	0	0	0	0	0	0
HKTM	0.044	0.631	0.225	0	0	0	0	0	0	0	0	0
TOTAL	20.16	287.43	102.45	131.12	1,869.65	666.43	41.39	590.16	210.36	41.91	605.32	216.04
	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year	GB/Orbit	GB/Day	TB/Year

ESA's Earth Observation data
Respective data policies



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Sentinel Data Policy

Full and open access to Sentinel data to all users

In practical terms

- Anybody has the right to access acquired Sentinel data
- Licenses for the Sentinel data are free of charge
- However the funding for the actual access in routine phase is under discussion with EU

Contributing missions (to GMES) and Third Party Missions

Data Policy of individual data providers

Summary

- Two Sentinel-3 satellites are being built now to provide **operational data streams required by EC GMES Services.**
- S3A will launch in April 2014 (earliest) and S3B ~18 months later.
- SRAL provides both SAR and LRM capability
- The baseline SRAL operational mode mask has been defined based on user requirements
  - LRM over the open ocean
  - SAR mode in the 300km coastal zone and inland seas
- The mask definition was derived to fulfill requirements and minimize the number of operational SRAL Mode switches.

Thank you - any questions?

For more information http://www.esa.int

See Donlon et al (2012) The GMES Sentinel-3 Mission, *Remote Sensing of Environment,* **http://dx.doi.org/10.1016/j.rse.2011.07.024**

and the Mission Requirements Traceability Document (MRTD) at http://download.esa.int/docs/EarthObservation/GMES_Sentinel-3_MRTD_Iss-1_Rev-0-issued-signed.pdf

Contact: craig.donlon@esa.int

EUMETSAT

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http://www.sen3symposium.org/

esa

esa

3rd meris/(a)atsr & olci/slstr preparatory workshop

15 - 19 october 2012

European Space Agency

ESA | Congrex - ESA's Professional Conference Organiser | List of events

- Background
- Objectives
- Themes
- Abstract Submission
- Organisation
- Deadlines
- Organizing Committee
- Scientific Committee
- Flyer
- Contact

Background

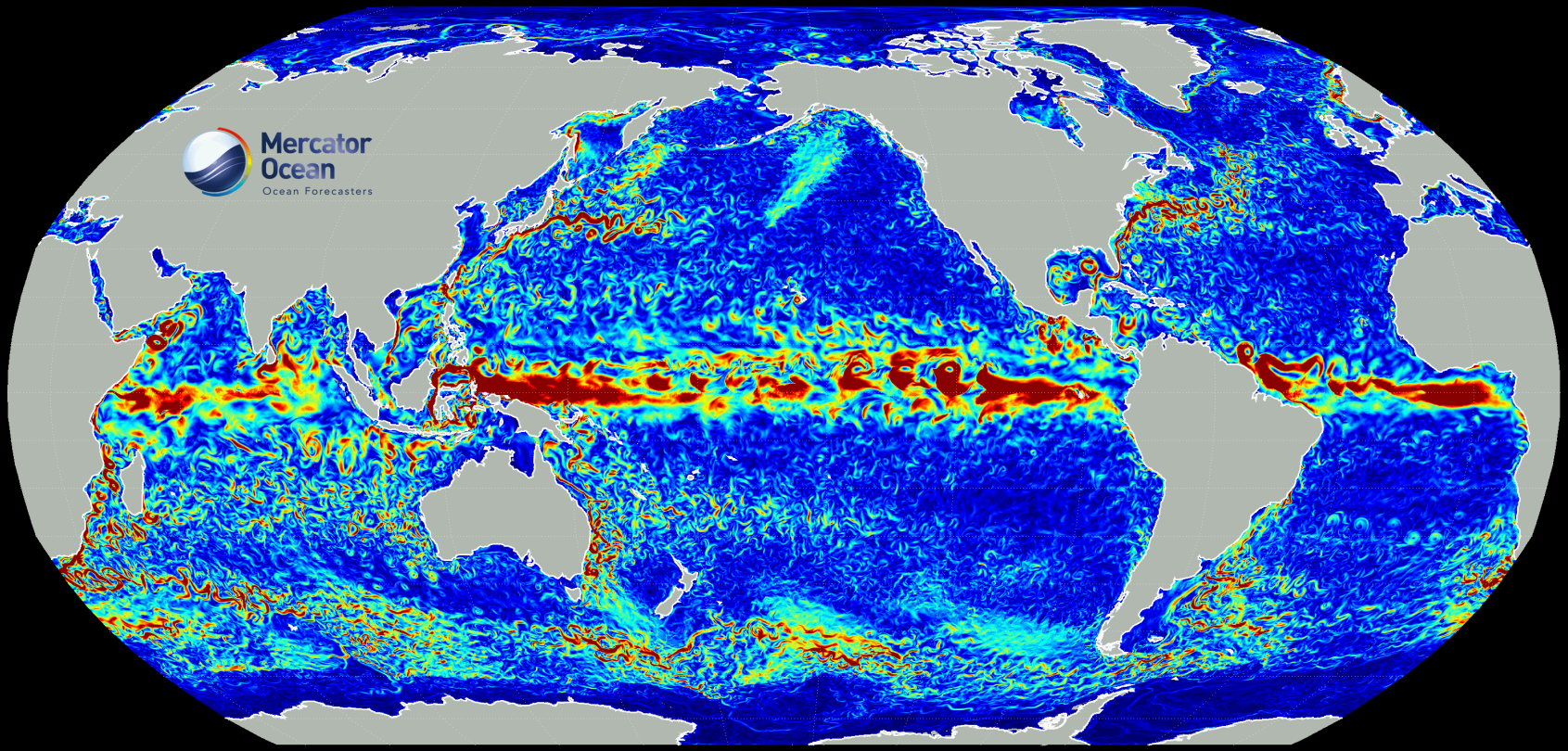
The European Space Agency, together with Eumetsat, is organising the 3rd MERIS/(A)ATSR and OCLI-SLSTR (Sentinel-3) Preparatory Workshop, which will be hosted in ESA-ESRIN, Frascati, Italy, from 15 to 19 October 2012.

Participation

The workshop is open to ESA Principle Investigators and co-investigators, scientists and students using MERIS/(A)ATSR data, future follow-on Sentinel-3 OLCI/SLSTR data users, representatives from GMES services, national, European and international space agencies and value adding industries.

Sentinel-3 Applications

- Mercator Global 1/12 Nov 2011 (6 day forecast) Surface Velocity m/s



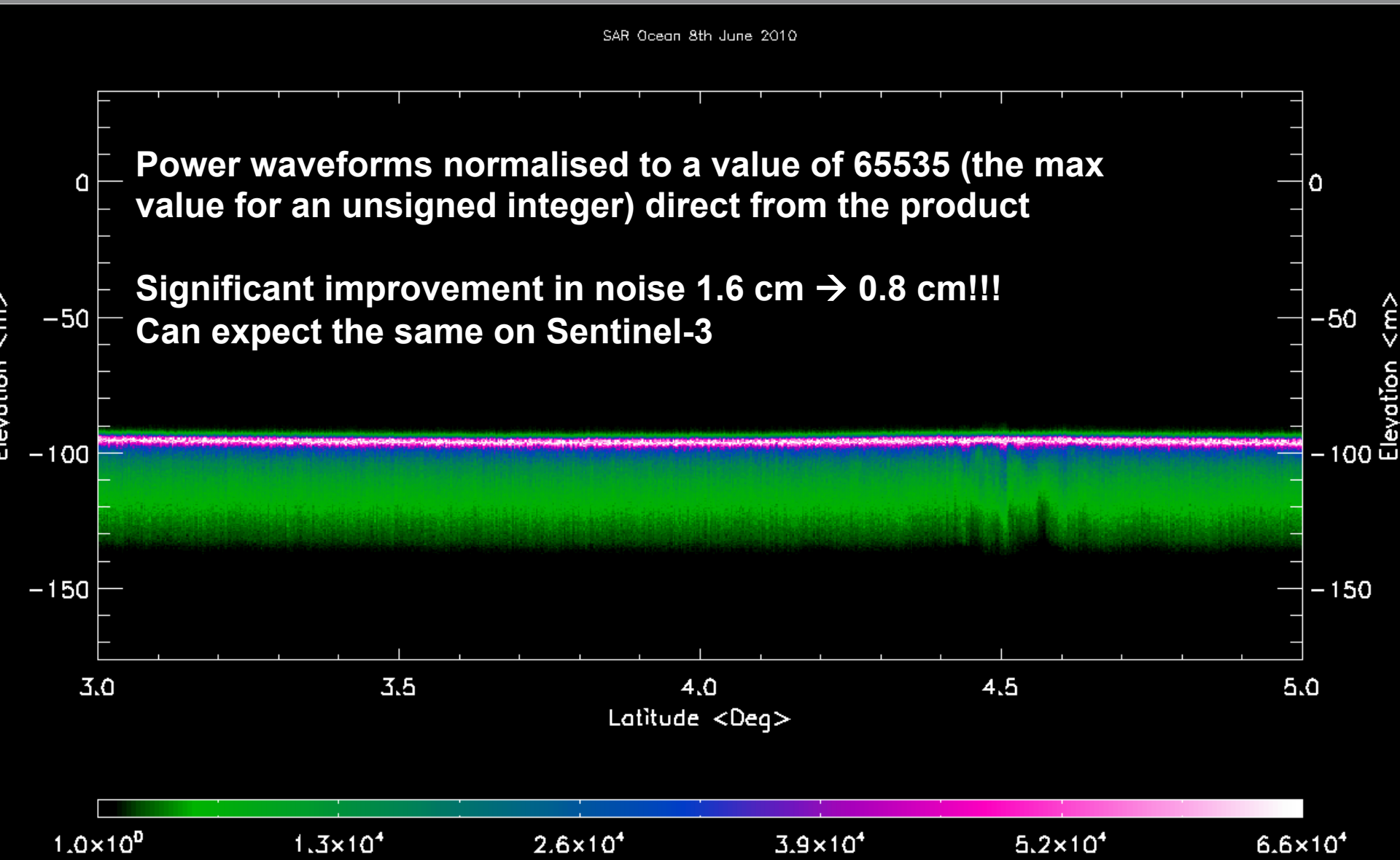
Sentinel-3 Optical Revisit time and coverage

Optical missions:
Short Revisit times for optical payload, even with 1 single satellite

		Revisit at Equator	Revisit for latitude > 30°	Requ.
Ocean Colour (Sun-glint free, day only)	1 Satellite	< 3.8 days	< 2.8 days	< 2 days
	2 Satellites	< 1.9 days	< 1.4 days	
Land reflectance (day only)	1 Satellite	< 2.2 days	< 1.8 days	< 2 days
	2 Satellites	< 1.1 day	< 0.9 day	
SLSTR dual view (day and night)	1 Satellite	< 1.9 days	< 1.5 days	< 4 days
	2 Satellites	< 0.9 day	< 0.8 day	

- Data delivery timeliness:
- Near-Real Time (< 3 hr) availability of the L2 products
- Slow Time Critical (STC) (1 to 2 days) delivery of higher quality products for assimilation in models (e.g. SSH, SST)

Altimeter SAR Mode
(help form CryoSat in Equatorial Indian Ocean)



S3: Precise Orbit Determination (POD)

8 channel GPS receiver (~3m NRT, 2-3cm on ground)

- Satellite Navigation – AOCS (on-board – permanent function)
- Datation of scientific telemetry (on-board – permanent function)
- Control of SRAL open-loop tracking (on-board – commanded function)
- POD (on ground)
- USO frequency monitoring (on-ground)

DORIS Navigation receiver (~1 cm)

- Provide USO frequency to SRAL (on-board – permanent function)
- Control of SRAL open-loop tracking (on-board – commanded function)
- POD (on ground)
- USO frequency monitoring (on-ground)

Laser Retro-Reflector (<2 cm)

- Contribution to POD, validation of POD solution

POD radial accuracy requirements (rms)

- **Near Real Time (NRT < 3h): 10 cm (8 cm goal)**
- **Short Time Critical (STC < 48h): 4 cm (3 cm goal)**
- **Non Time Critical (NTC < 1 month): 3 cm (2 cm goal)**

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Sentinel – 3 Core GS
User Products list

Level 1
ESA/EUMETSAT

LEVEL 1
- OLCI L1B
- SLSTR L1B

Marine products
EUMETSAT

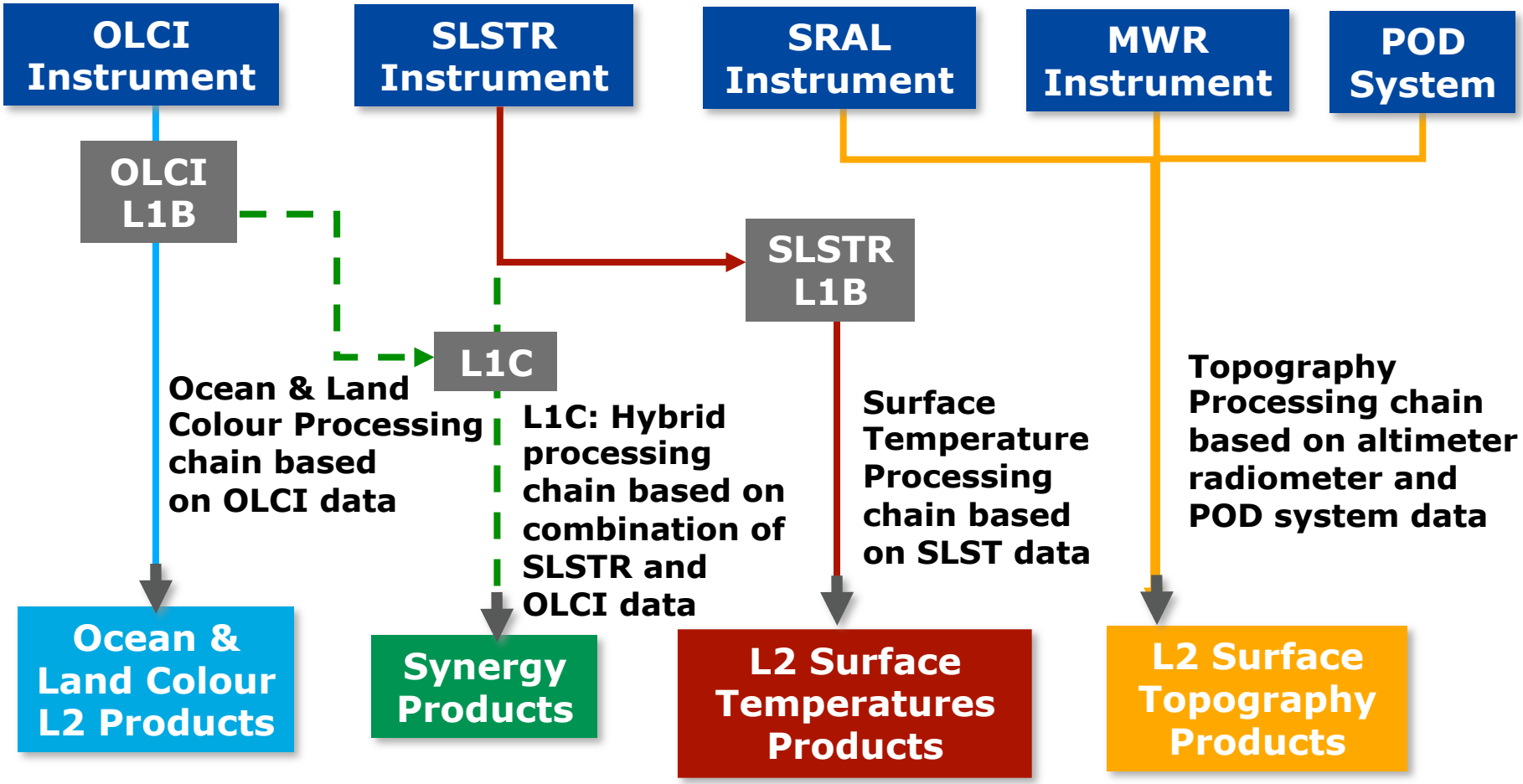
LEVEL 2
- OLCI ocean color
- SLSTR sea
- SRAL L2

Land products
ESA

LEVEL 2
- OLCI Land
- SLSTR Land
- SYNERGY / VGT
- SRAL L2

NB: Validated Level 2 products are swiftly available through commissioning and GIO Phase

S3: Data processing chains



Product delivery timeliness:

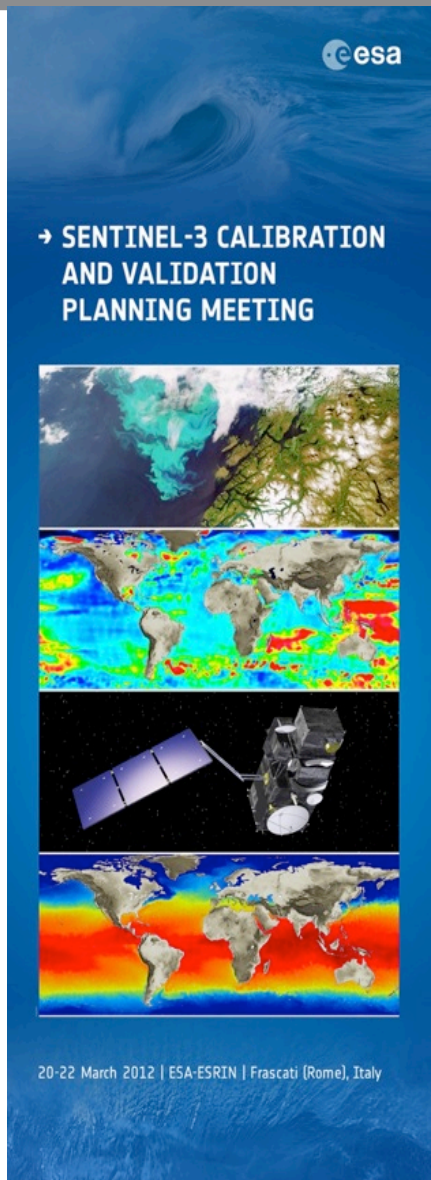
- **Near-Real Time (< 3 hr) availability of L2 products (and L1b)**
- **1 to 2 days delivery of higher quality topography products for assimilation in models**

Sentinel-3 Core PDGS
Optical geophysical parameters list

Geophysical Product	Application Domain	Spatial Resolution	Continuity	Measurement Source
Normalised Water Surface Reflectances		300 m , 1.2 km	Envisat	OLCI
Chlorophyll Concentration for open ocean waters		300 m , 1.2 km	Envisat	OLCI
Chlorophyll Concentration for Coastal waters		300 m , 1.2 km	Envisat	OLCI
Total suspended Matter		300 m , 1.2 km	Envisat	OLCI
Diffuse attenuation coefficient		300 m , 1.2 km	GCM* (e.g. Modis)	OLCI
Coloured Detrital and Dissolved Material		300 m , 1.2 km	Envisat	OLCI
Photosynthetically active radiation		300 m , 1.2 km	Envisat	OLCI
Aerosol Optical Depth over water	 	300 m , 1.2 km	Envisat	OLCI
Aerosol Angstrom exponent over water	 	300 m , 1.2 km	Envisat	OLCI
Integrated Water Vapour Column		300 m , 1.2 km	Envisat	OLCI
Sea Surface Temperature		1 km	Envisat	SLSTR
Land Surface Temperature		1 km	Envisat	SLSTR
Fraction of Absorbed PAR		300 m , 1.2 km	Envisat	OLCI
Terrestrial Chlorophyll Index		300 m , 1.2 km	Envisat	OLCI
Surface Reflectances over Land		300 m	Envisat	OLCI+SLSTR
Aerosol Optical Depth over Land	 	300 m	Envisat	OLCI+SLSTR
Aerosol Angstrom exponent over Land	 	300 m	Envisat	OLCI+SLSTR
Vegetation-like Surface Reflectances 1 day Synthesis		1 km	Vegetation	OLCI+SLSTR
Vegetation-like Surface Reflectances 10 days Synthesis		1 km	Vegetation	OLCI+SLSTR
Vegetation Normalised Difference of Vegetation Index		1 km	Vegetation	OLCI+SLSTR

S3 Validation Team

- A Sentinel-3 Validation team will be convened (S3-VT) in the next few months building on the outcomes of the S3 Cal/Val Planning workshop in March 2012
- The S3-VT will have several thematic sub-groups
- An S3-VT call will be initiated in the next few months
- Collaborative G/S Collaboration agreements will be used to formalise the operational relationship with the Agencies
- Privileged access to operational data over target sites will be an initial focus (ramped up with PDGS and MPC capability)
- Expect a first S3-VT meeting in the last quarter 2012



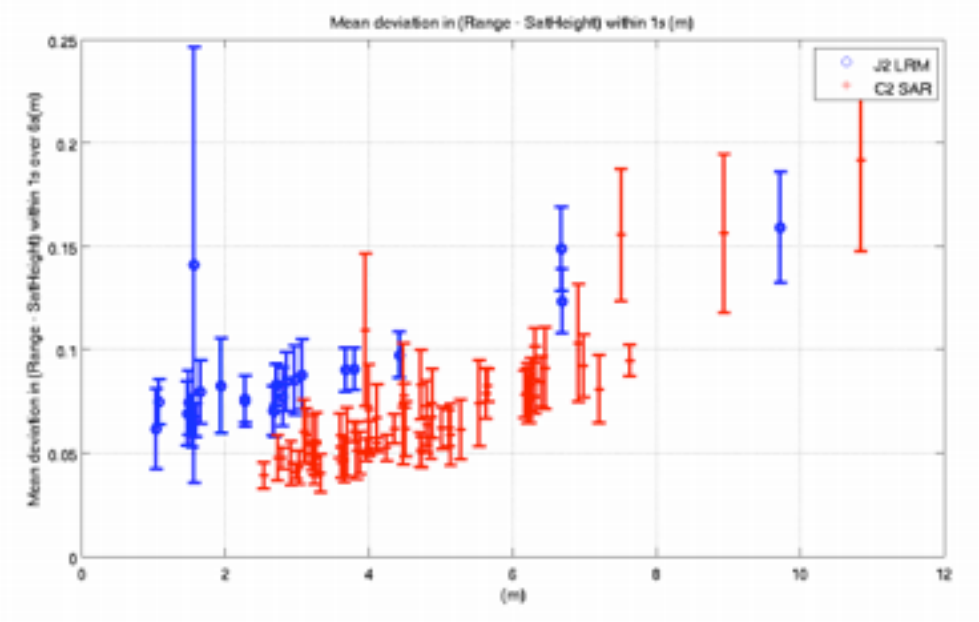
Sentinel-3: Status summary

- Sentinel-3 A & B units are under development
- S3 satellite CDR close-out in Nov-2011
- OLCI EM testing partly on-going, FM production started
- Cal/Val and in-orbit verification plans for commissioning phase defined
- ESA coordinating with EUMETSAT the development of the ground segment

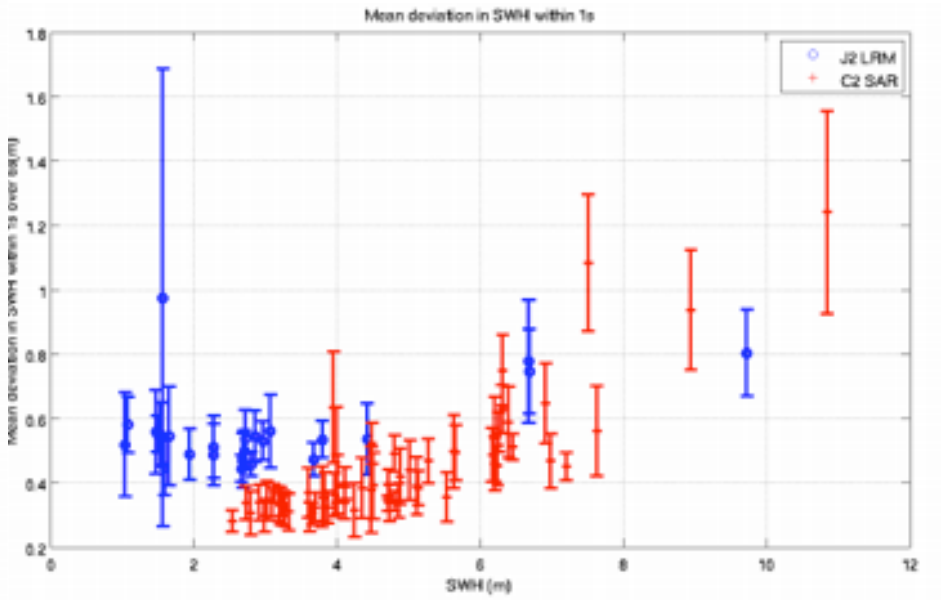
- **Current approved funding includes:**
  - Development of the Sentinel-3A & 3B satellites until their Final Acceptance Review
  - Development of the associated Ground Segment facilities and tools
  - Launch and Commissioning Phase (approx. 5 months) of Sentinel-3A
  - ESA coordinating with EUMETSAT the development of the ground segment
  - S3 Validation team call expected in late 2012 – International call
- **Launch of the Sentinel-3A currently foreseen for Apr 2014**
- **Launch of the Sentinel-3B expected ~18 months later**
  - EUMETSAT in charge of the operation of the marine Mission
  - ESA will be the operator of the land Mission

SAR vs LRM…

- ESA SAMOSA http://www.satoc.eu/projects/samosa/



Retrieval accuracy at 20Hz



Absolute range anomaly vs Hs

Jason-2 LRM (blue) and Cryosat-2 SAR (red)

Data in a small region of the Norwegian Sea between July 2010 and March 2011. The Cryosat-2 SAR data were re-tracked with the SAMOSA1 Extended model.

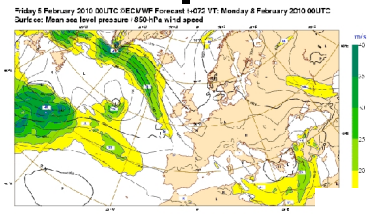
Sentinel-3 STM: Products Timeliness

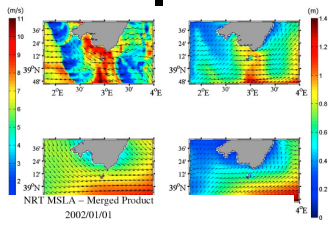
T0 Sensing time

3 h | **2-3 d** | **~30 d** | **~1/2 y** | time

NRT products

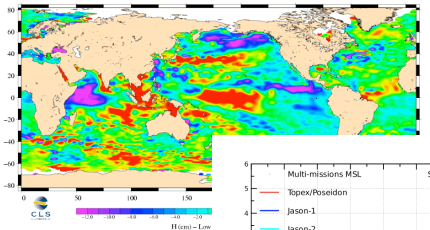
Ocean forecasting,
Meteorology, Oceanography





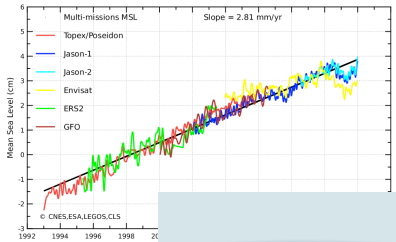
STC products

Operational Ocean,
Ocean forecasting,
Oceanography



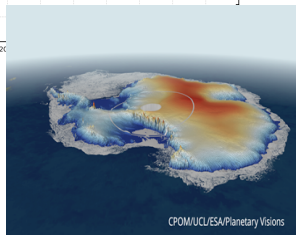
NTC products

Climatology,
Oceanography,
Data exploitation



Reprocessing Campaign

NTC products



NRT: Near Real time
STC: Slow Time Critical
NTC: Non time Critical