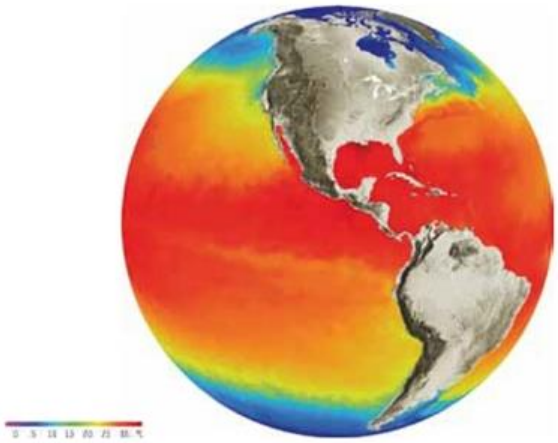
Sea Surface Temperature and Instrument Development at ESA



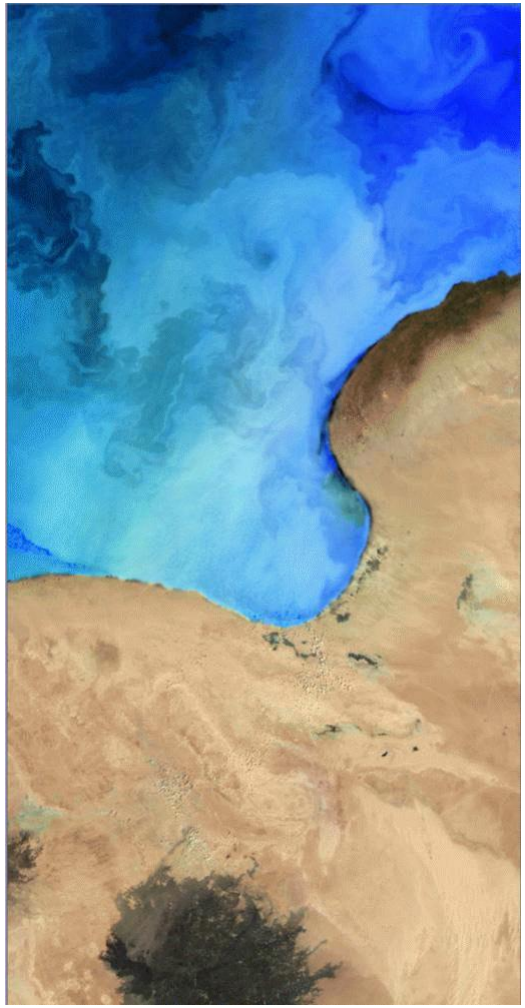
Craig Donlon

European Space Agency, ESTEC, The Netherlands

GHRSST XVI Science Team Meeting, ESA ESTEC, The Netherlands, 20-24th July, 2015

Overview

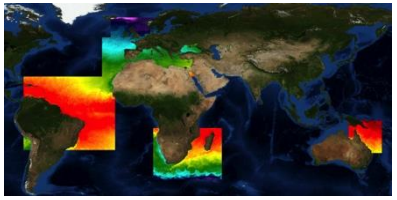
- Rapid tour of SST related activities @ESA (not exhaustive!)
- C-band Passive Microwave developments
- High-resolution thermal infrared (S2 Companion)
- Sentinel-3 Sea and Land Surface Temperature Radiometer
- Summary
- Susanne Mecklenburg

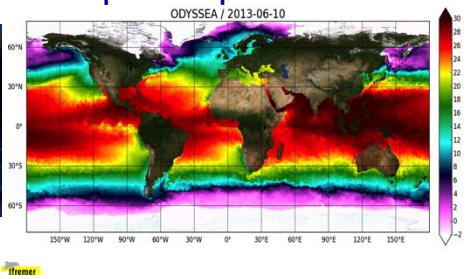


Medspiration Evolution (J-F Piolle)

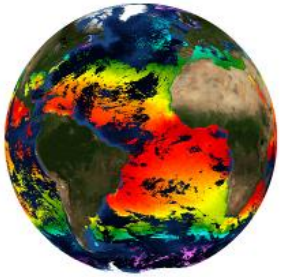
Build on Medspiration assets and reach further user community

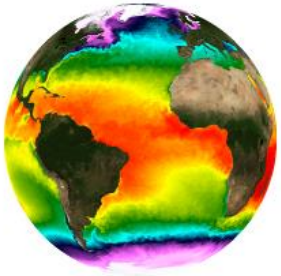
Sustain and develop new products

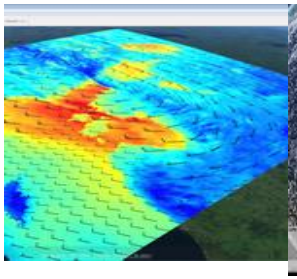


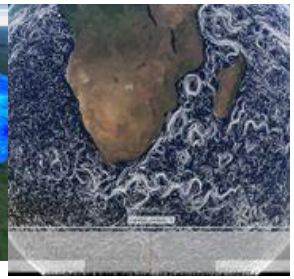


Outreach

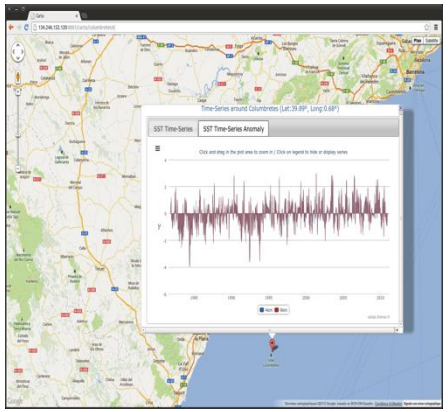




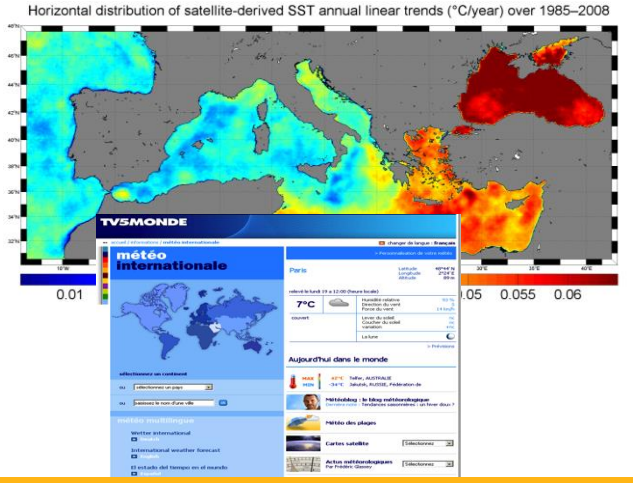




Analytics



User applications



Access

Data are accessible through FTP, OpenDAP, WMS

Static and dynamic visualisation available

Details at : **http://www.medspiration.org**

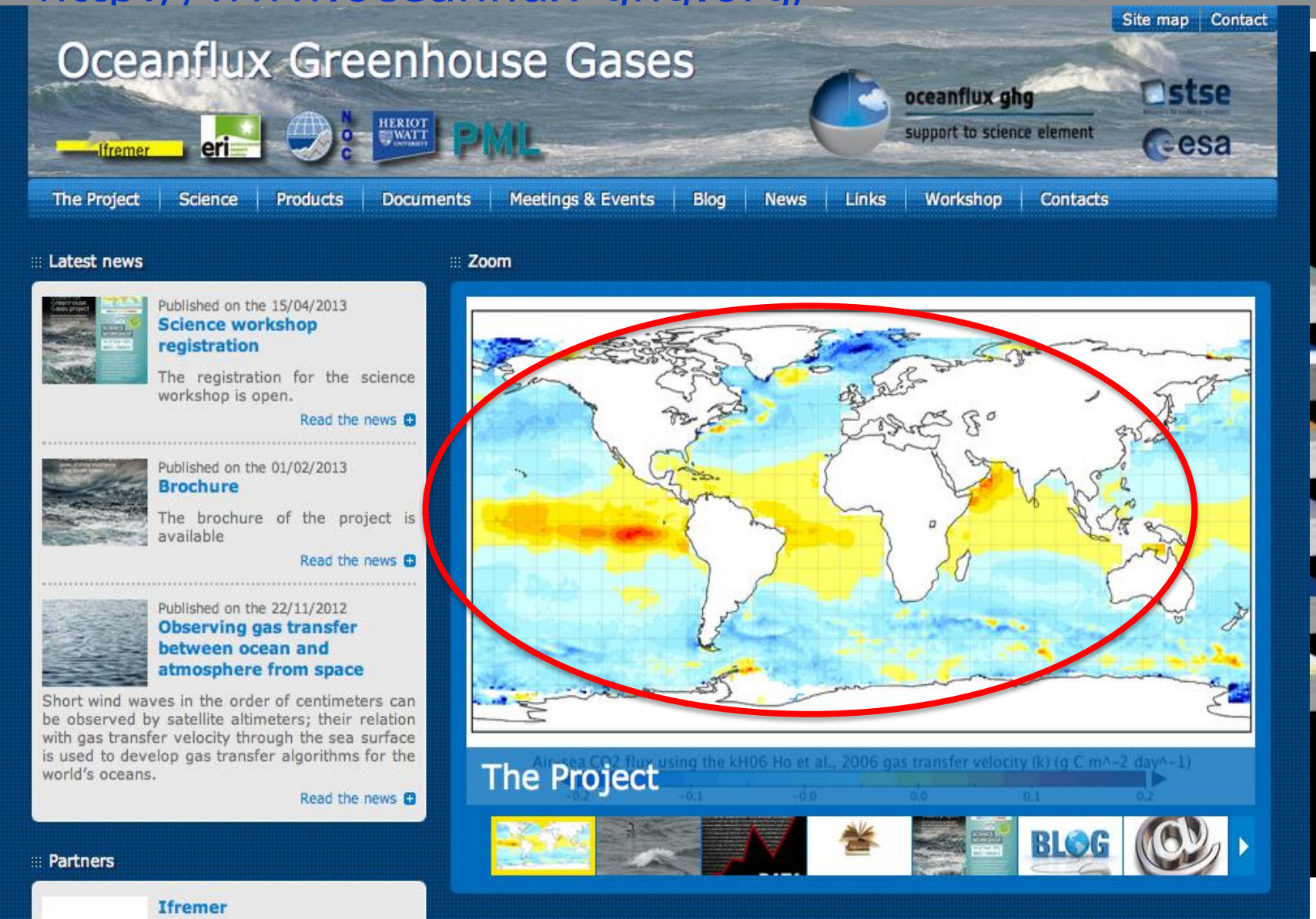
Ifremer

esa

medspiration
EUROPEAN NODE
FOR SEA SURFACE TEMPERATURE

ESA STSE OceanFlux GHG: New Climatology of CO_2 Gas flux

http://www.oceanflux-ghg.org/



Oceanflux Greenhouse Gases Evolution

oceanflux evolution
support to science element

stse
esa

Cook your own climatology!

OceanFlux project offers to interested partners the ability to run their own climatology processing, selecting the parameterization and input data of their choices. This processing configuration can be defined online through a web interface. Users can then connect to the Nephelae processing platform of Ifremer/CERSAT and execute their climatology computation remotely.

This guidelines describes how you can cook your own climatology.

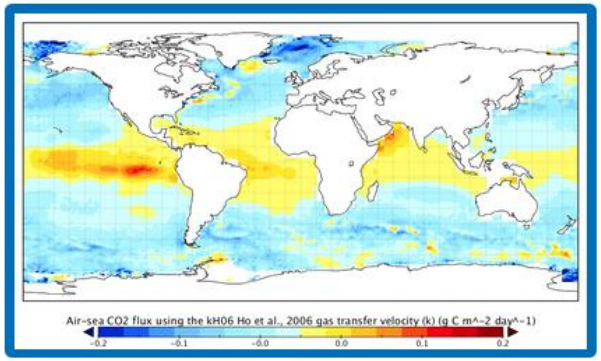
The Project

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

esa

solas

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



Registration

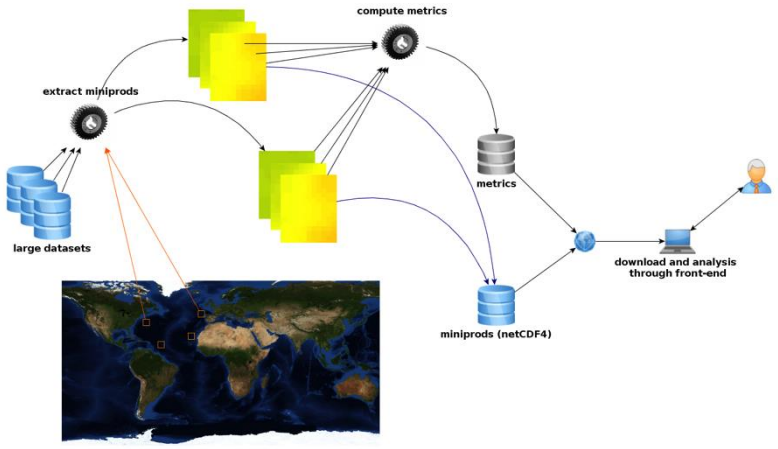
To register for access to the Nephalae Cloud, enabling you to access all of the open-access datasets and processing tools, you are requested to fill in the project registration form :

- http://www.oceanflux-ghg.org/Products/Tools

By registering for access to the OceanFlux GHG and Nephalae Cloud system you are agreeing to the Ifremer data access and systems terms and conditions.

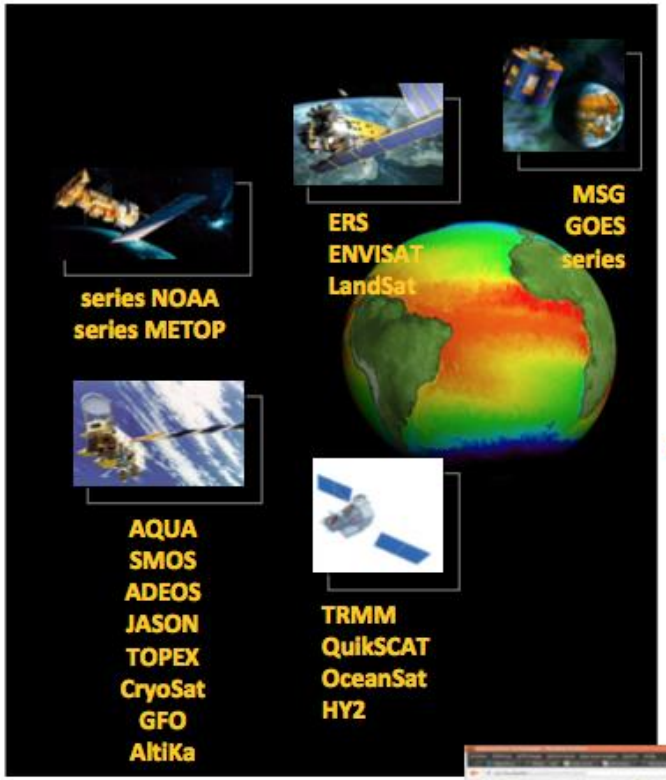
ESA Felyx: *New High resolution diagnostic data system to access and study long-term archives of satellite earth observations*

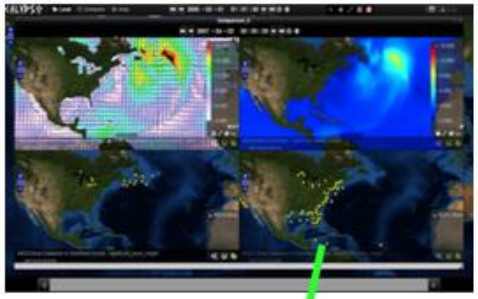
- Building on the HRDDS concept
- A new system that allows **federation of distributed DDS**
- Processing and analysis tools
- Sub-setting, Metrics, analysis
- Everything we dreamt of with the DDS…
- Available Now!!!



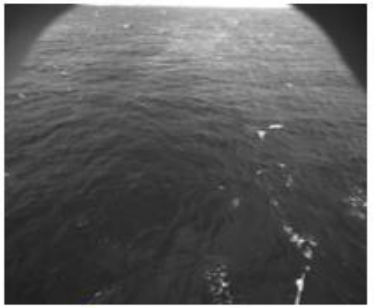
http://hrdds.ifremer.fr

Nephelae big data platform





Analysis, comparison and synergy tools



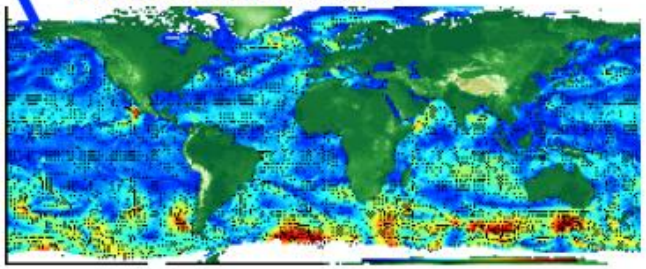
Stereo video camera

Nephelae

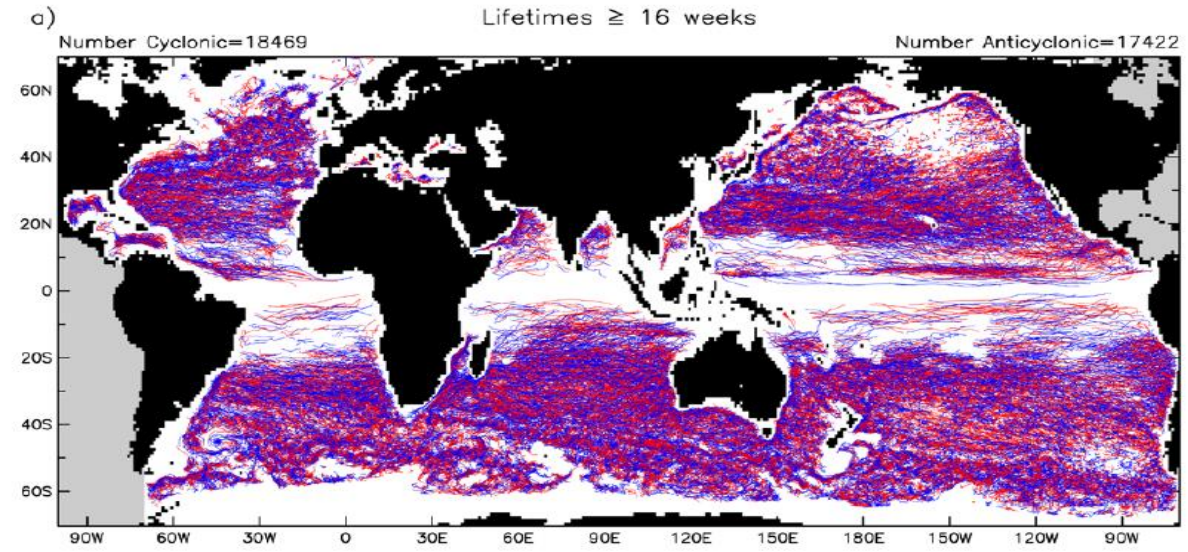
Buoys, floats

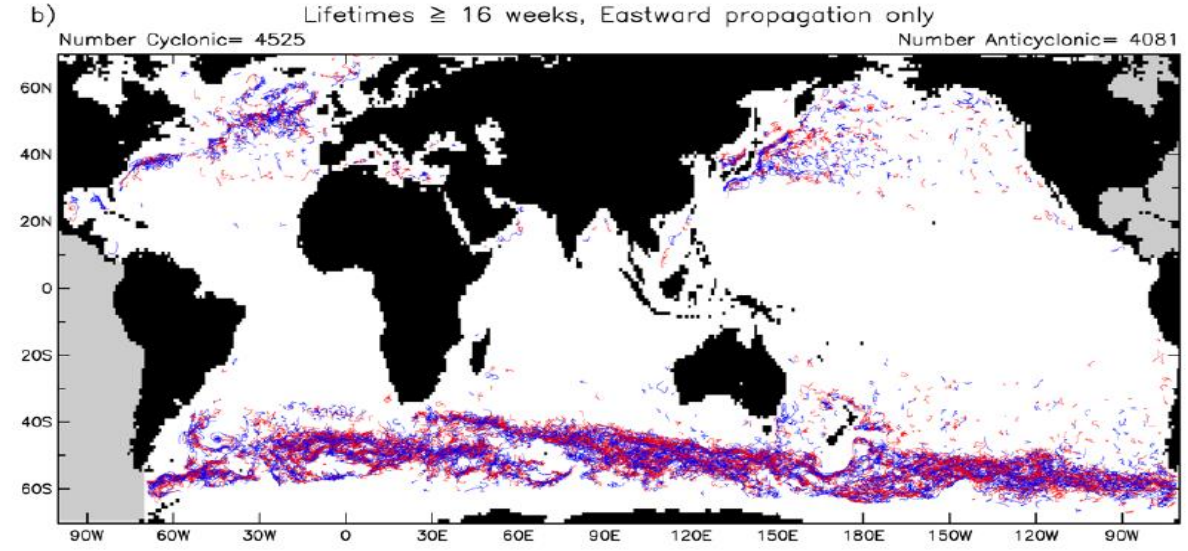
Processing tools

Weather, ocean, wave models



1.5 PB
600 processing cores
2.5 TB memory



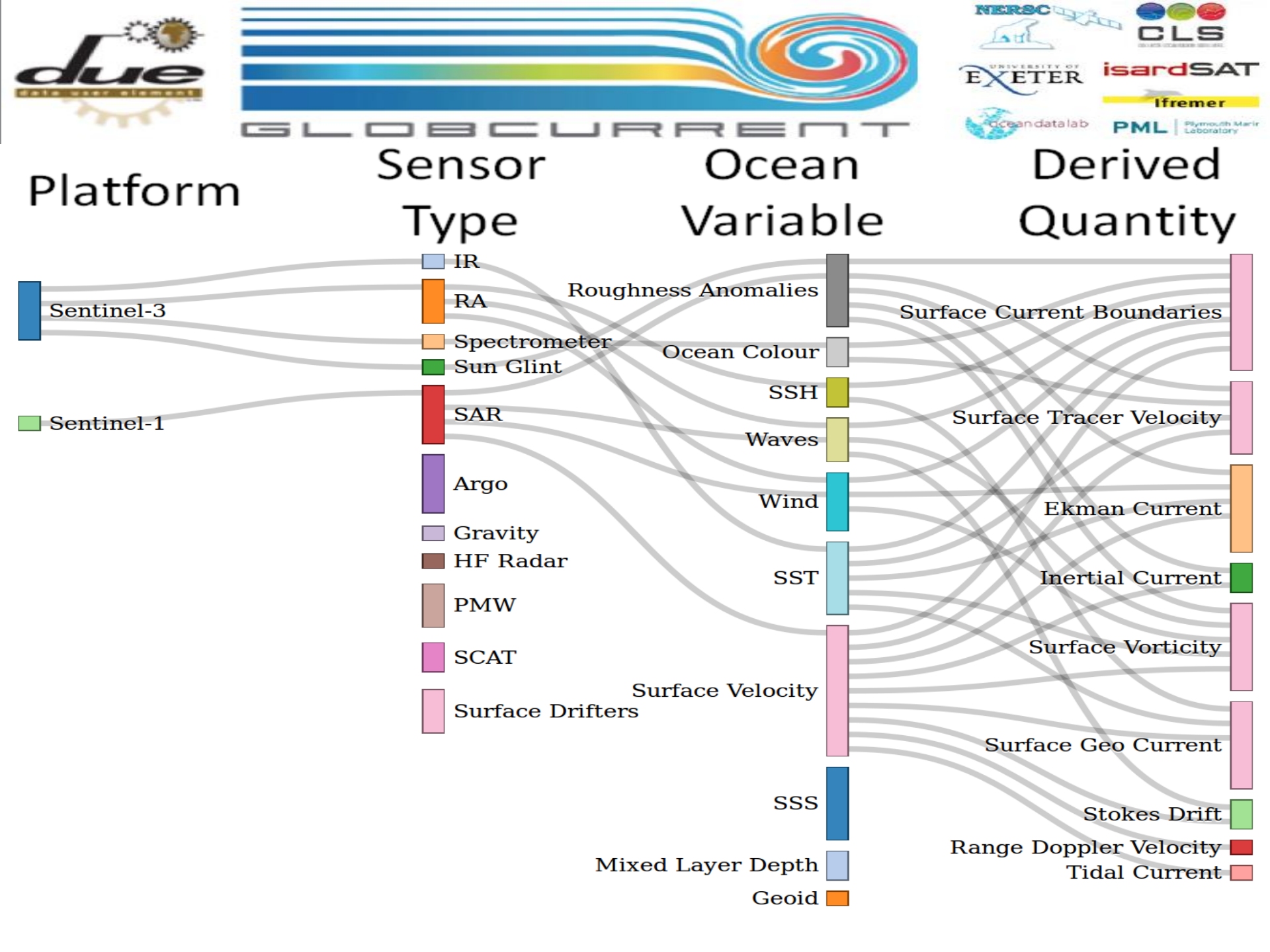


The trajectories of cyclonic (blue lines) and anti-cyclonic (red lines) eddies over a 16-year period derived from altimetry

Upper) lifetimes ≥16 weeks

Lower) lifetimes ≥16 weeks for eddies with net eastward displacement.

(From Chelton et al, 2011)

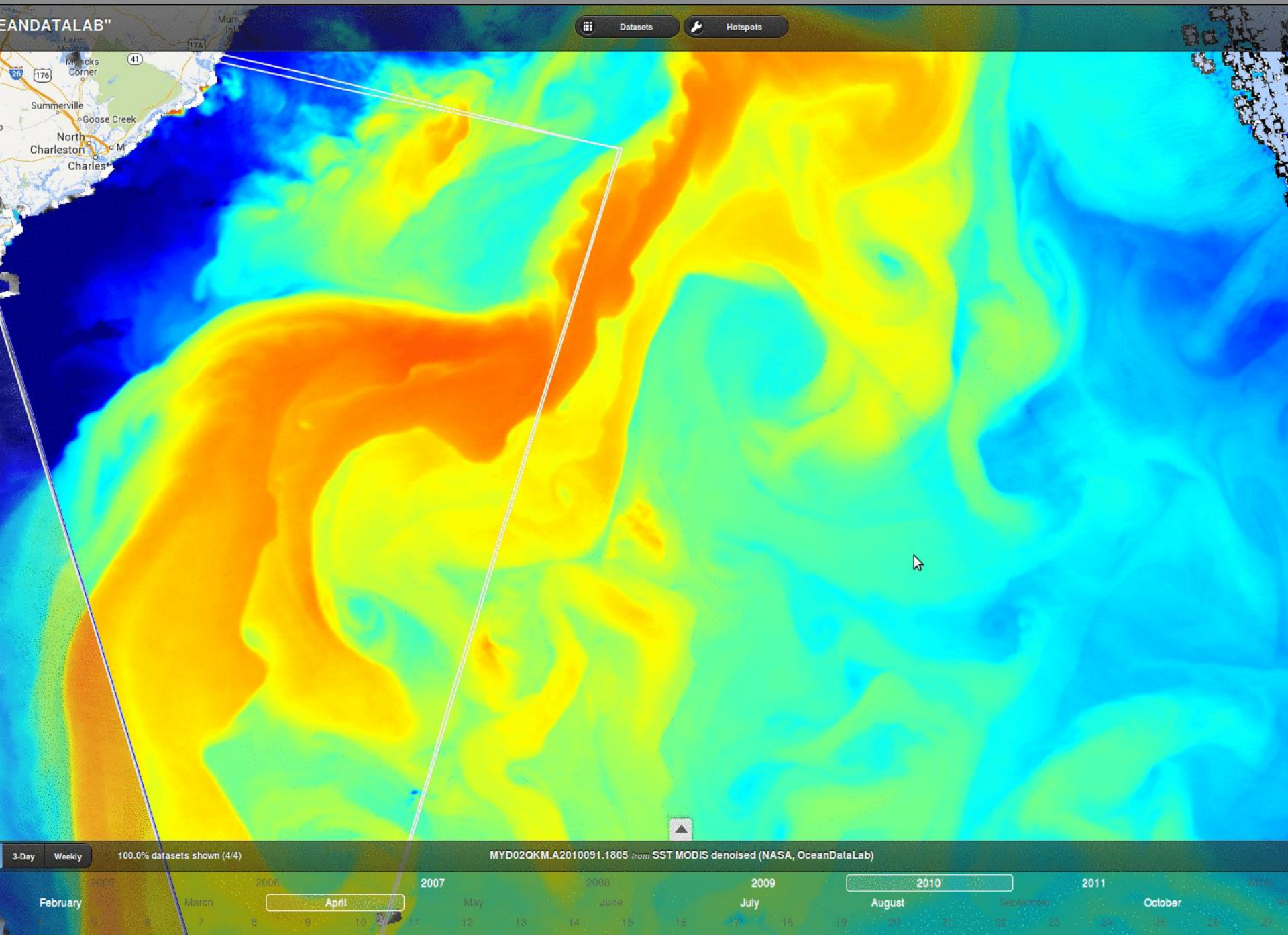

GLOBCURRENT
Platform
Sensor Type
Ocean Variable
Derived Quantity
Sentinel-3
Sentinel-1
IR
RA
Spectrometer
Sun Glint
SAR
Argo
Gravity
HF Radar
PMW
SCAT
Surface Drifters
Roughness Anomalies
Ocean Colour
SSH
Waves
Wind
SST
Surface Velocity
SSS
Mixed Layer Depth
Geoid
Surface Current Boundaries
Surface Tracer Velocity
Ekman Current
Inertial Current
Surface Vorticity
Surface Geo Current
Stokes Drift
Range Doppler Velocity
Tidal Current

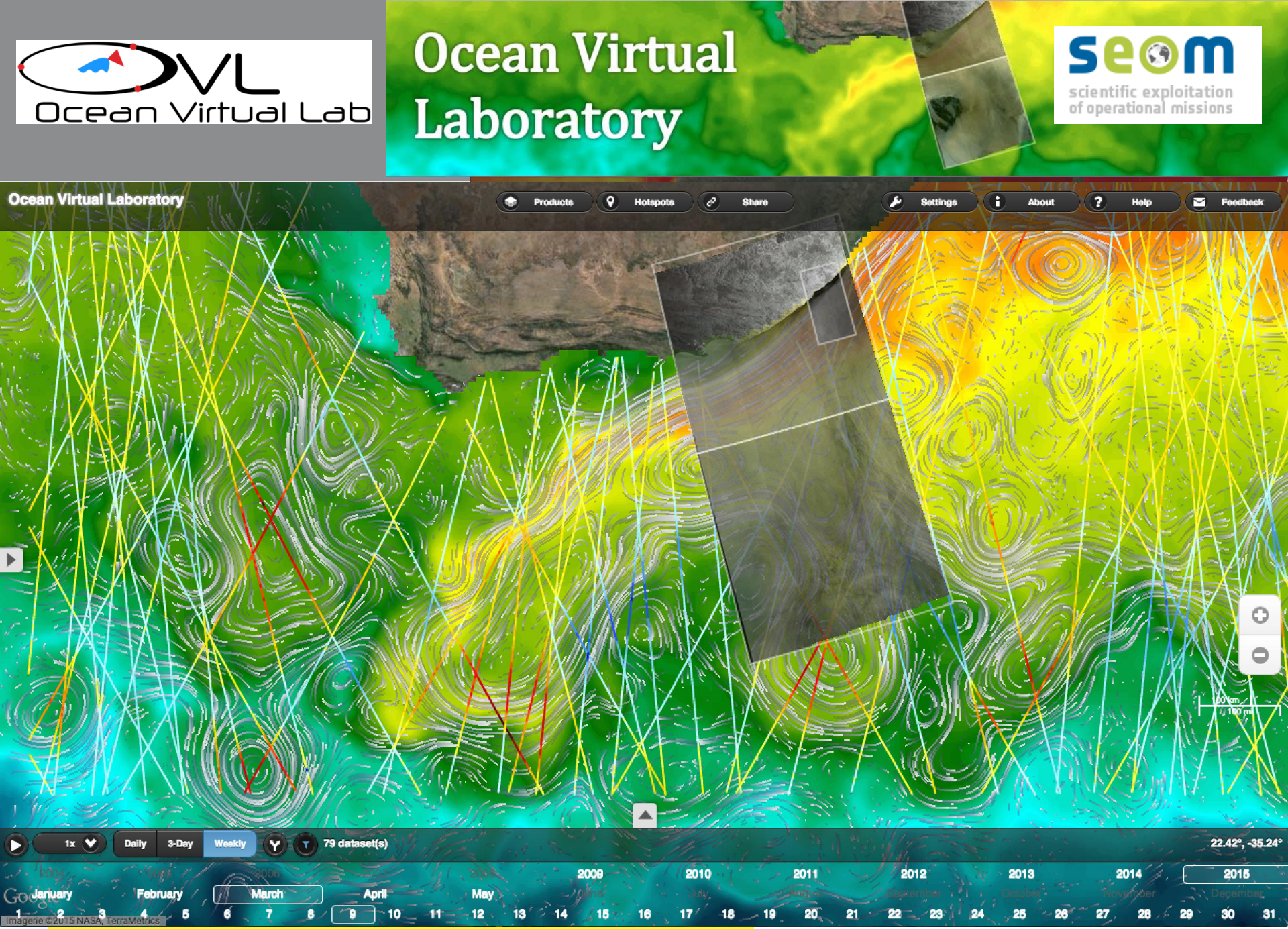
MERIS Glitter analysis

Meso- and submeso-scale details

What about "normalized structural" (gradient) assimilation of these products?

(B. Chapron et al)

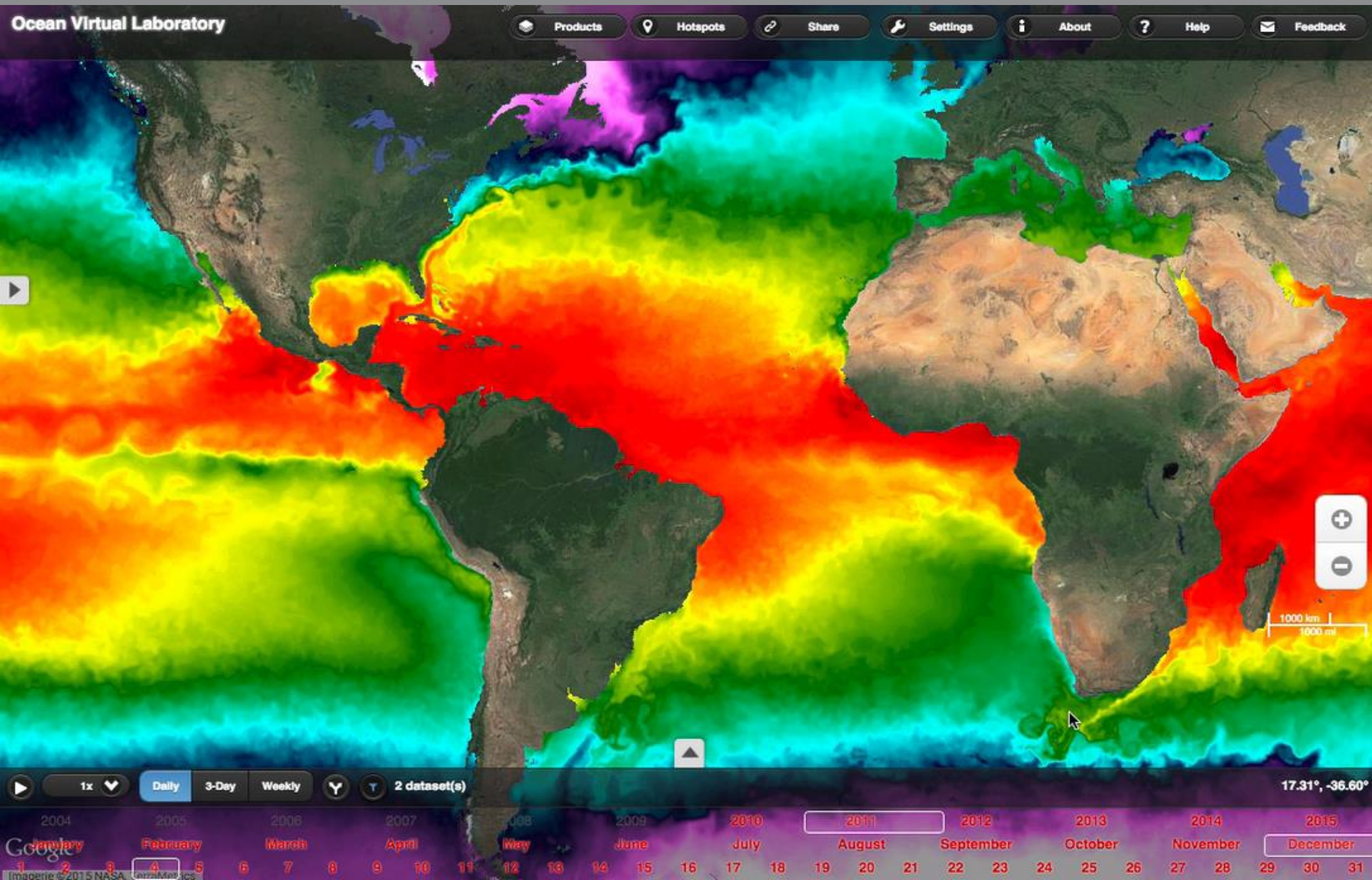

EANDATALAB"
Datasets
Hotspots
Summerville
Goose Creek
North Charleston
3-Day
Weekly
100.0% datasets shown (4/4)
MYD02QKM.A2010091.1805 from SST MODIS denoised (NASA, OceanDataLab)
2005
2006
2007
2008
2009
2010
2011
February
March
April
May
June
July
August
September
October


OVL
Ocean Virtual Lab
Ocean Virtual Laboratory
seom
scientific exploitation of operational missions
Ocean Virtual Laboratory
Products
Hotspots
Share
Settings
About
Help
Feedback
1x
Daily
3-Day
Weekly
79 dataset(s)
22.42°, -35.24°
2009
2010
2011
2012
2013
2014
2015
January
February
March
April
May
Imagerie ©2015 NASA, TerraMetrics

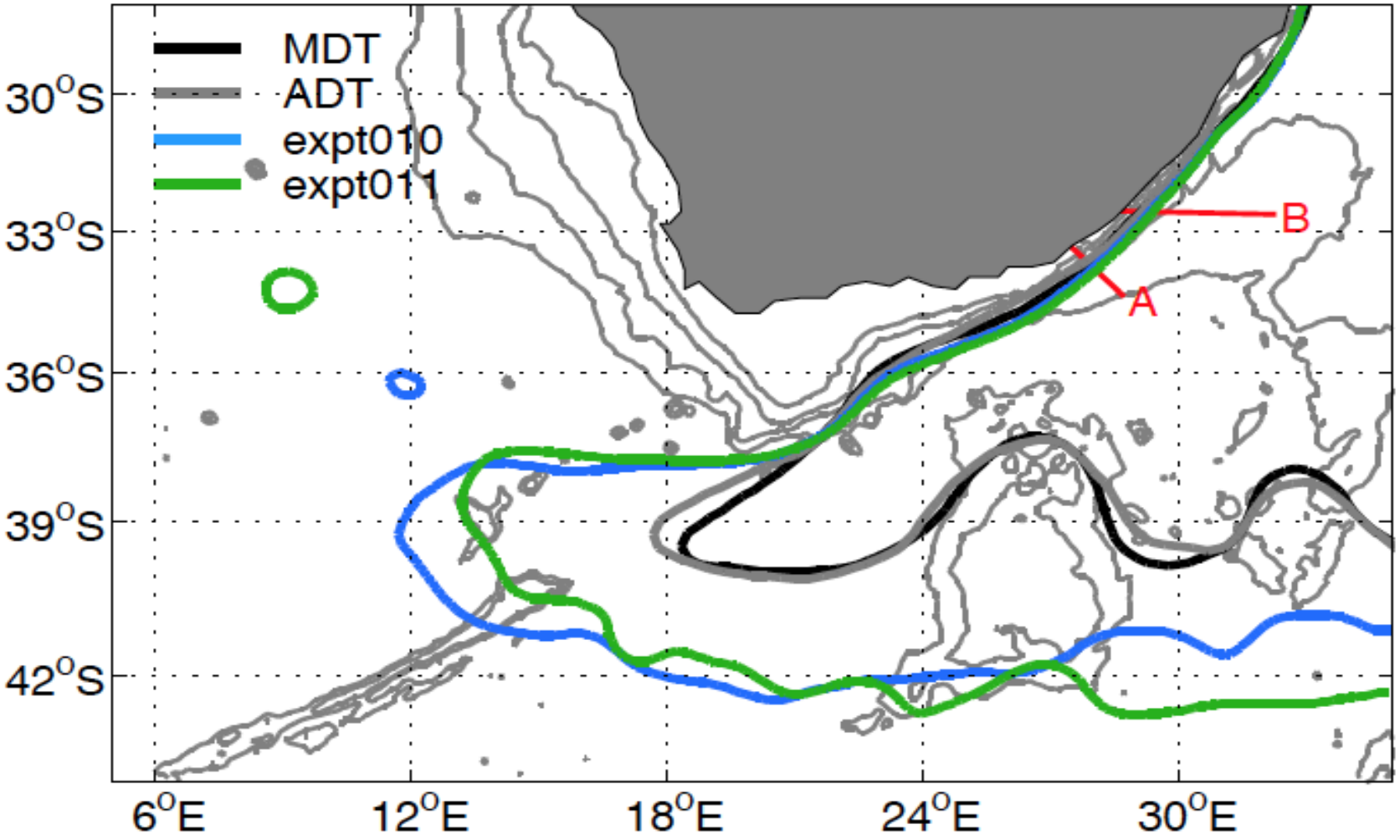
seom
scientific exploitation of operational missions

OVL
Ocean Virtual Lab

esa



Validation: Frontal locations observed & modelled



→ OCEAN SURFACE CURRENTS: TOWARDS FUTURE MISSION CONCEPTS

The Second International Meeting to explore novel technologies and future mission concepts to measure ocean Surface Currents from Space

2–3 November 2015 | IFREMER Brest | France

- Science Requirements
- New Techniques
- New Technology
- New Mission Concepts
- Future Directions and Challenges

Progress using:

- Optical Imagery
- Synthetic Aperture Radar
- Altimetry
- Gravimetry
- Scatterometry
- Geomagnetics
- Interferometry
- Sensor synergy
- Constellations/Convoy

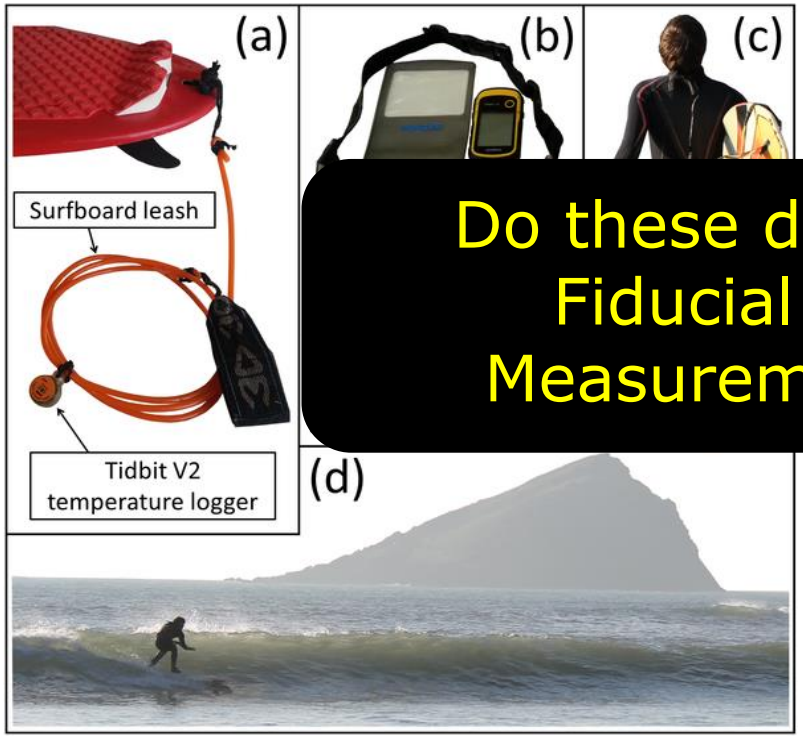
For more information please go to **www.congrexprojects.com/2015-events/15c13/introduction**

Contacts: **craig.donlon@esa.int** | **christopher.buck@esa.int**

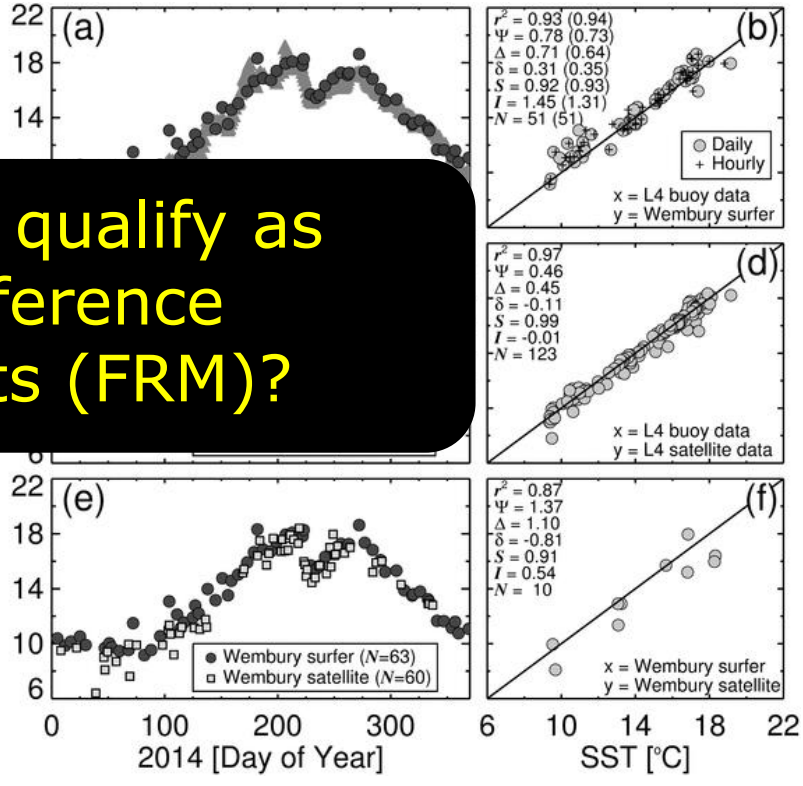
On the Potential of Surfers to Monitor Environmental Indicators in the Coastal Zone

Robert J. W. Brewin , Lee de Mora, Thomas Jackson, Thomas G. Brewin, Jamie Shutler

Published: July 8, 2015 • DOI: 10.1371/journal.pone.0127706



Do these data qualify as Fiducial Reference Measurements (FRM)?



C-band Passive Microwave Instruments

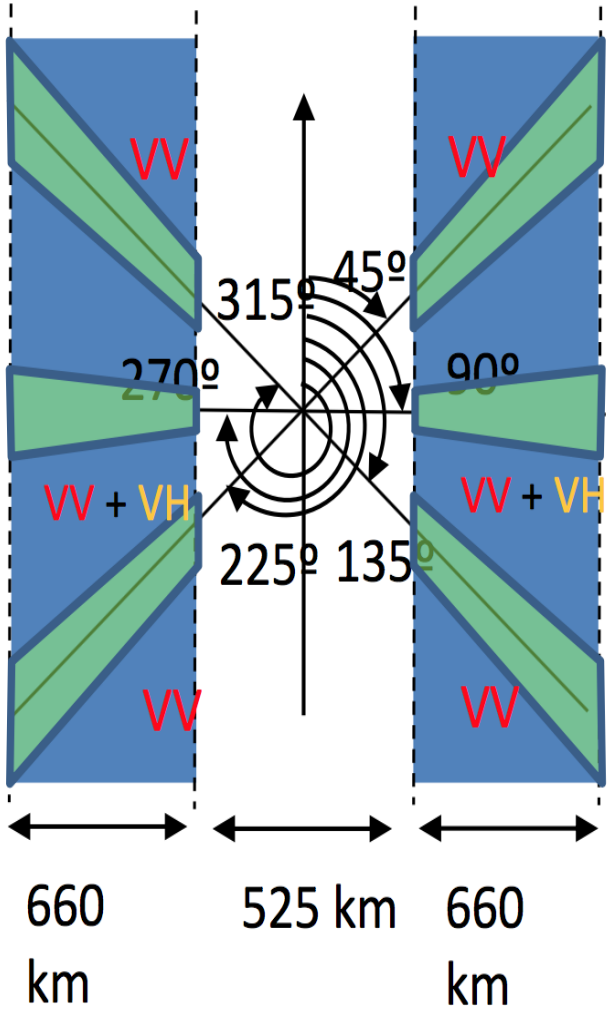
- Since 2010, ESA has been working on pre-phase A development activities in support of a new generation of C-band Passive Microwave Radiometers
- Main drivers: Real-aperture imager capable of measurement within 5-15 km of the shoreline
- Global coverage (all surfaces) with a daily revisit.
- Channel specifications:

Channel Frequency (GHz)	Pol.	NEΔT (K) (T/B/O)	Bias (K)	Primary purpose (secondary in brackets)	Spatial resolution (km) (T/B/O)
6.9	H & V	0.35/0.3/0.25	0.25	SST (soil moisture, land surface temperature)	76/20/5
10.65	H & V	0.5/0.44/0.4	0.35	Ocean surface wind, (surface roughness correction for SST), soil moisture, heavy precipitation over ocean	50/20/5
	Full	0.25/0.22/0.2	0.25		
18.7	H & V	0.6/0.5/0.44	0.5	Ocean surface wind, (surface roughness correction for SST), sea ice, precipitation over ocean	25/10/5
	Full	0.3/0.25/0.22	0.25		
23.8	H & V	0.6/0.45/0.3	0.5	Total column water vapour over ocean	25/10/5
31.4	H & V	0.6/0.5/0.42	0.5	Ocean surface wind, sea ice, snow, precipitation over ocean	15/10/5
	Full	0.3/0.25/0.21	0.25		
89.0	H & V	1.0/0.8/0.5	1.0	Sea ice and snow, precipitation and snowfall	10/5/1

Expecting a Mission Proposal for the ESA Earth Explorer-9 Call due in 2015/16

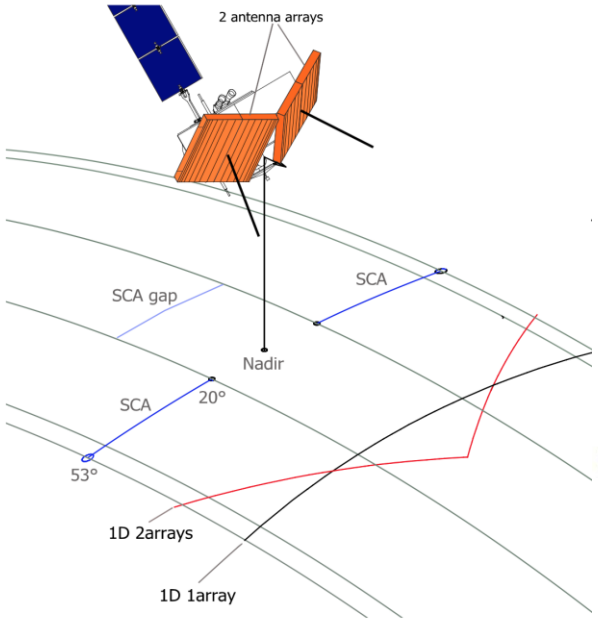
Microwat: Convoy with EPS-SG

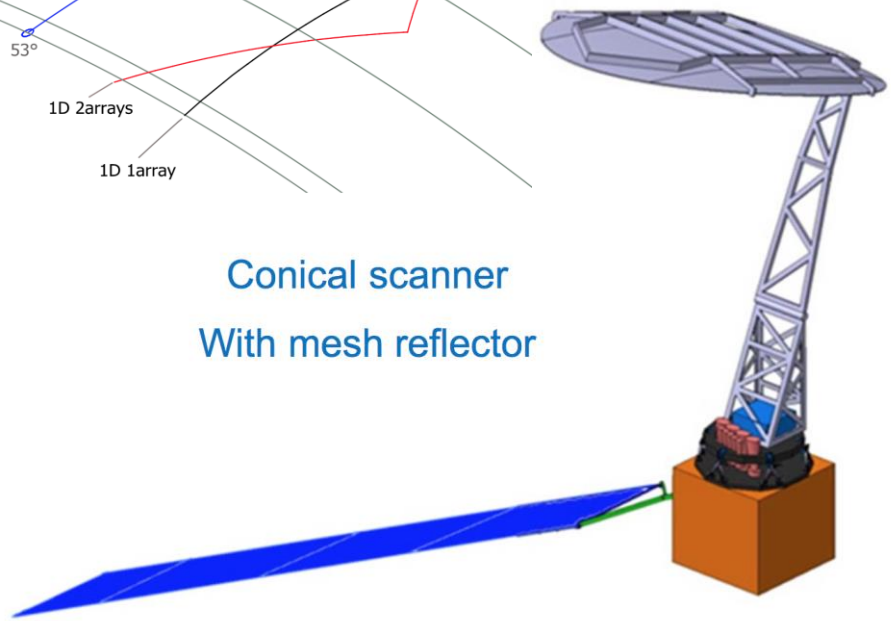
Parameter	ASCAT	SCA
Frequency	5.3 GHz	
Polarisation	VV for all beams	VV for all beams + VH for Mid-beams
Azimuth views	45°, 90° and 135° w.r.t. satellite track	
Min. incidence	25°	20° [G]
Horizontal resolution	Nom: (50 km)² High res.: (25 - 35 km)²	Nom: (25 km)² [G] High res.: (17 - 22 km)²
Horizontal sampling	Nom: (25 km)² High res.: (12.5 km)²	Nom: (12.5 km)² [G] High res.: (6.25 km)²
Radiometric resolution	≤ 3 % for $\theta_i \leq 25°$ at 4 m/s cross-wind (VV) ≤ (0.175×θ_i – 1.375) % for $\theta_i > 25°$ at 4 m/s cross-wind (VV)	
Coverage	97 % in 48 hrs.	99 % in 48 hrs. [G]



Microwat (Airbus)

- Preliminary design of 1D inclined interferometer and a conical scanner
- Trade off between the two designs to be compatible with VEGA.
- Preliminary trade-off discounted the interferometer concept (number of antenna elements too high) adding channels complex
- Baseline work on the refinement of previous Microwat concept
- Mesh antenna, better AMC (SMAP & native approach), better calibration

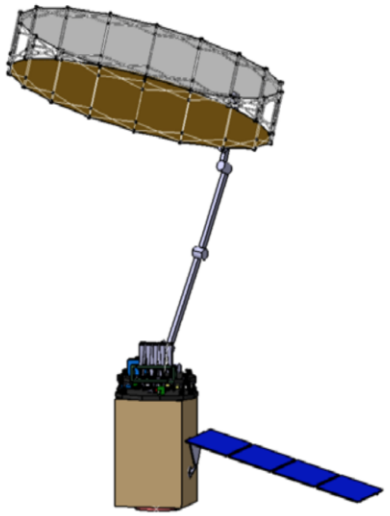




"Study on Advanced Radiometer for SST Observations
Conclusion

- novel mission for microwave radiometry in LEO at 6.9GHz and 18.7GHz
  - full Stoke Parameters are acquired at 18.7 GHz
  - RFI suppression is base-lined
- respectively 20Km and 10Km ground resolution.

These performances are ranked "Breakthrough" in the requirement

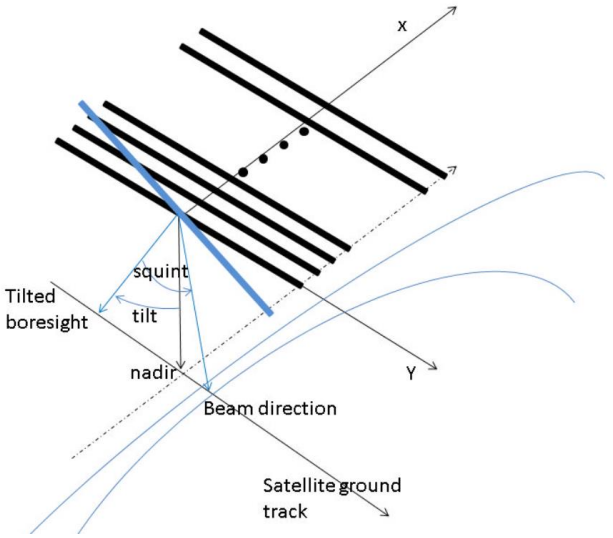


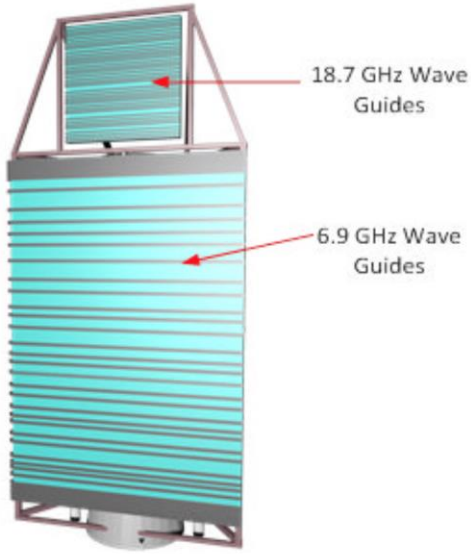
- .5m mesh antenna payload together with a Vega launch
- The overall missions is in 1KW, 1.2T range.

Launch possible in 2020/2021 with European technology

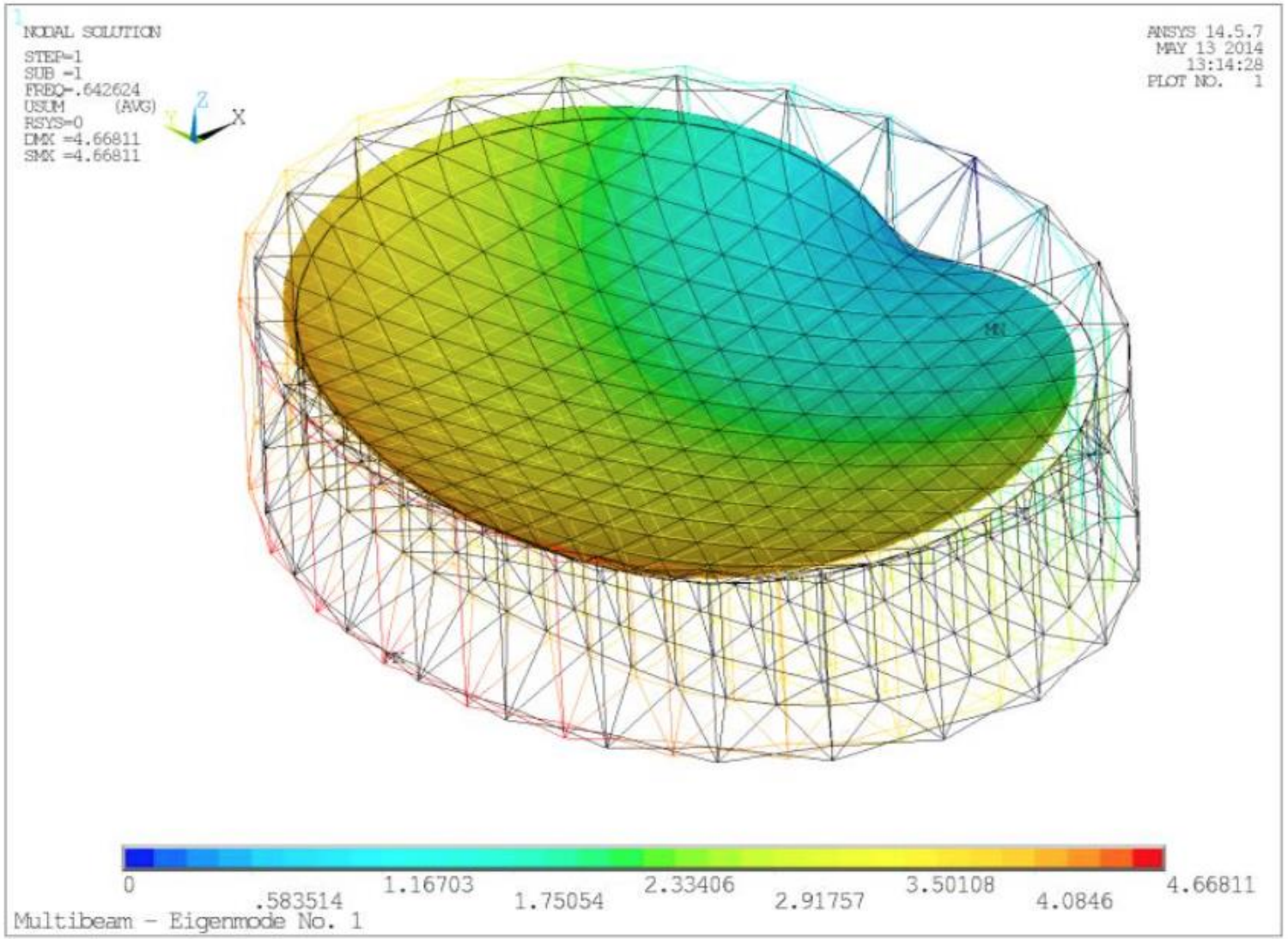
Microwat

- Parallel contract to Airbus to consider the same requirements Conical scanner and interferometer).
- Good study of a 1D tilted interferometer case
- Use of waveguide antenna technologies – requires further work (zero baseline issue) but is very attractive
- Thinned array concept for 18.7 and 6.9 GHz
- NEdT 0.2K or better
- Resolution < 10km met for majority of ~500 km swath
- But…final trade-off selected the the conical scanner



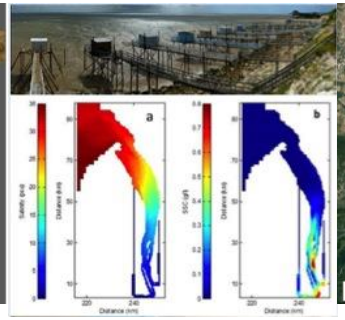


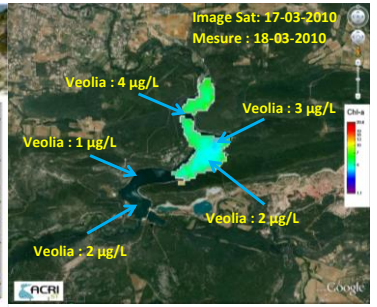
Microwat (TICRA)



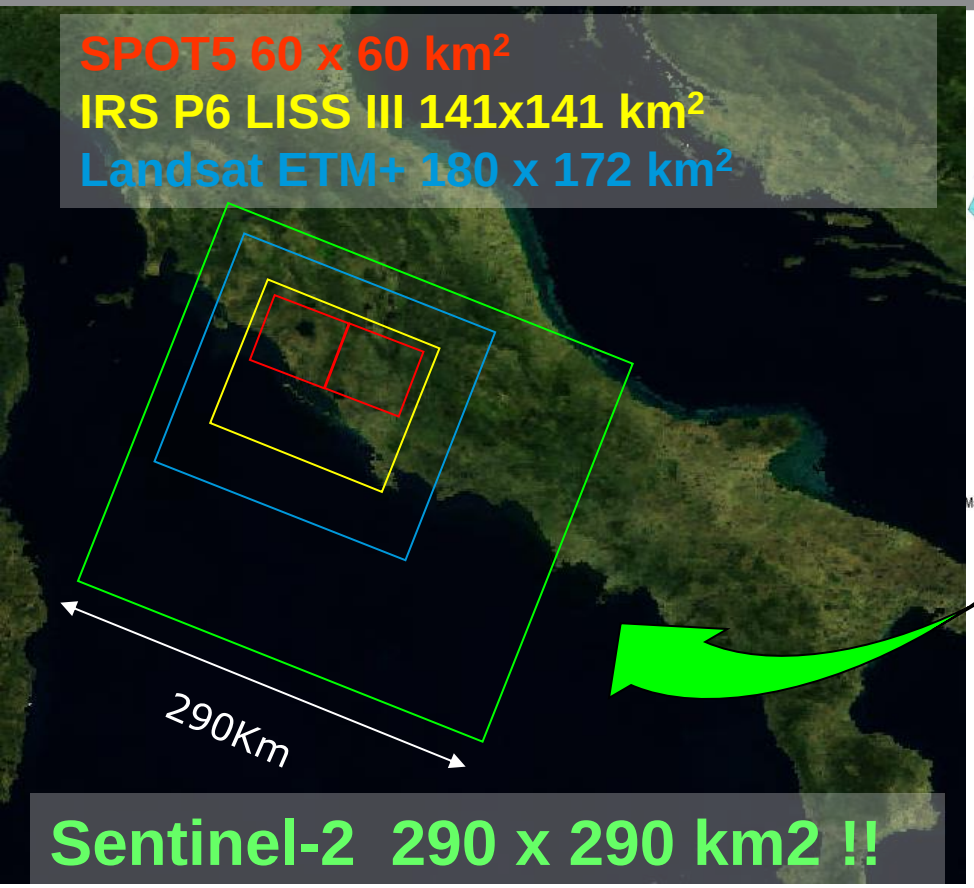
Sentinel-2 TIR Companion

- Sentinel-2 2014 workshop
- Clear need for high resolution (20-100m) thermal infrared channels to complement the Sentinel-2 spectral bands was expressed.
- GHRSST 2014 endorsed the need for coastal environments

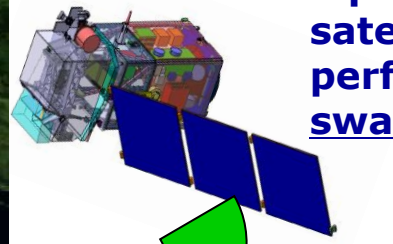


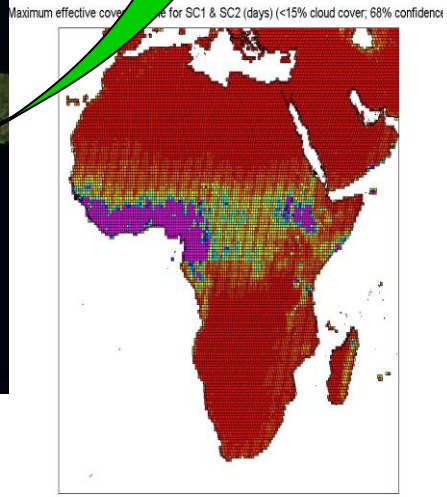


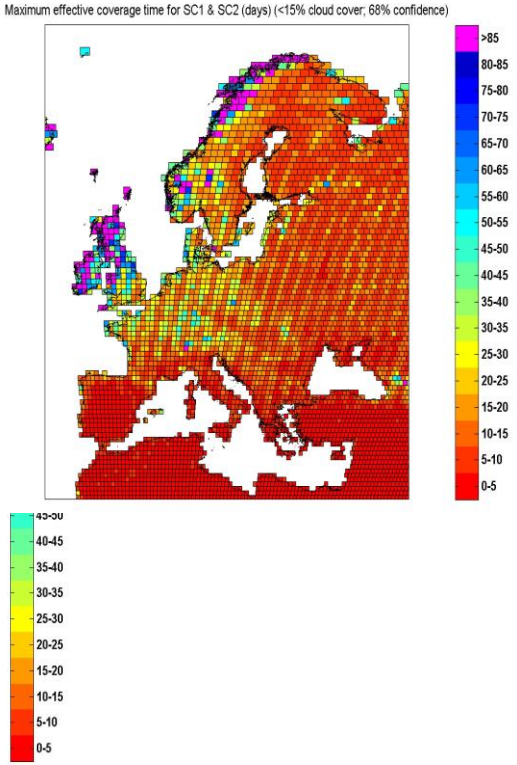
Sentinel-2 swath & coverage



High revisit time (5 days at equator) → assured by twin satellite observations performed over a very large swath



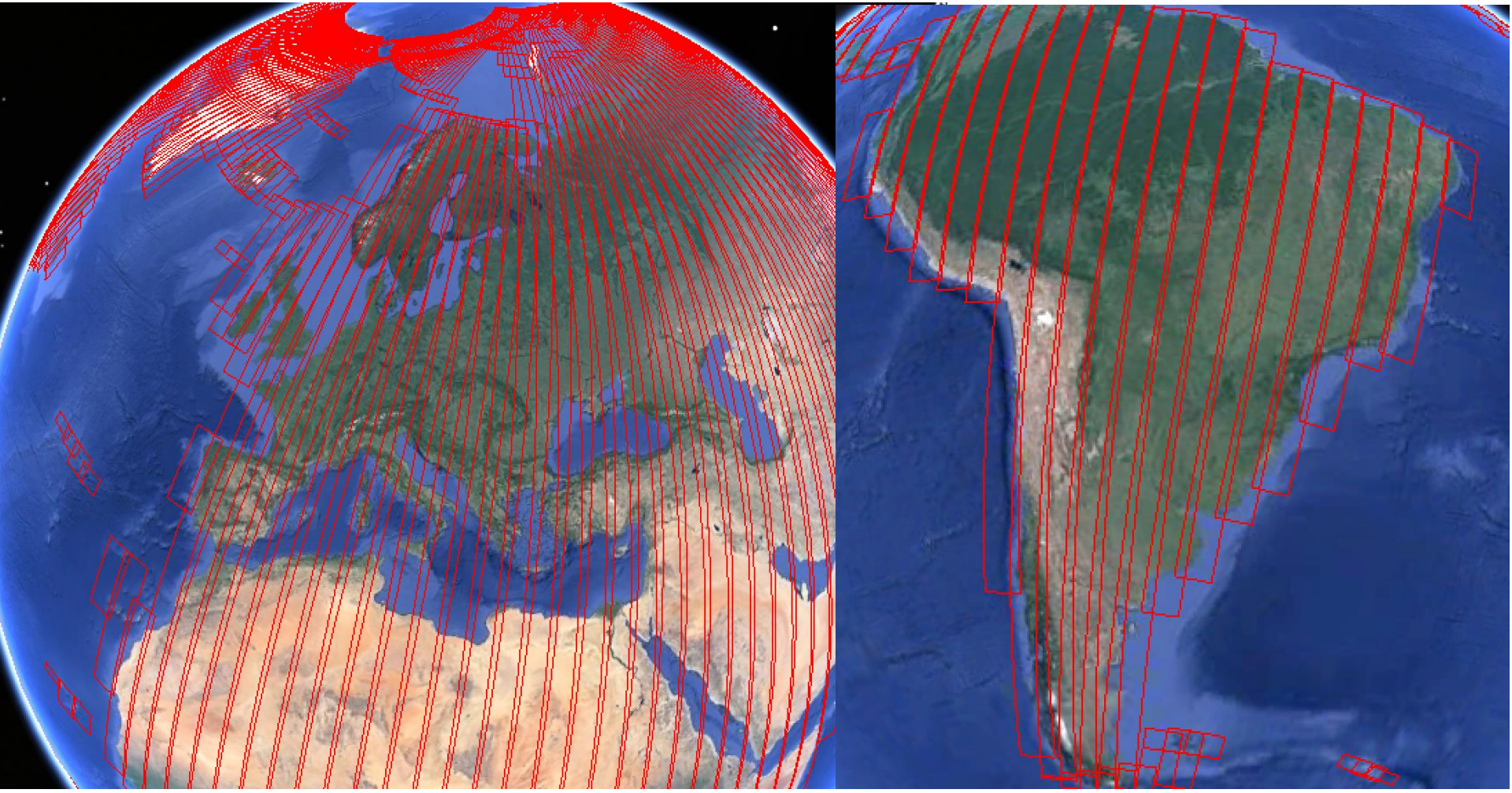




Geographical Coverage:

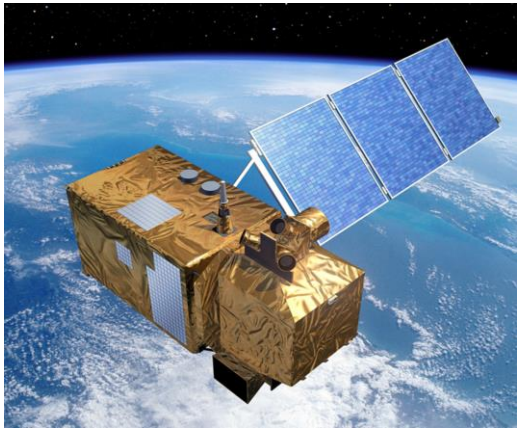
- All land masses 56° S bis 83° N incl. major islands All EU Islands < 20 km off the coast
- All Mediterranean
- Inland waters and all closed seas

S2 assumption on coastal acquisitions
20 km offshore 280 km swath – lots of data.



High Resolution TIR for coastal applications

Thermal Infrared (TIR) Imaging missions in convoy with Sentinel-2



Parameter	Range / Description
Spatial resolution	< 50 to 120 m
Revisit	1 to 3 days
Spectral bands	10 - 12 micron baseline, 8.6 and 9.1 micron useful
Absolute calibration	< 1K
NEDT	< 0.3 K @ 290 K
Additional measurements	Vis, NIR needed for NDVI, LAI and albedo estimations
Temporal separation	< 60 seconds (between TIR meas. and Vis/NIR/SWIR)

Overview of concepts under study at ESA
- within context of ESA EO Convoy Studies

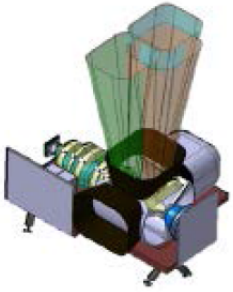
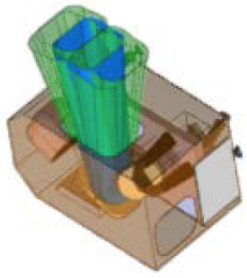
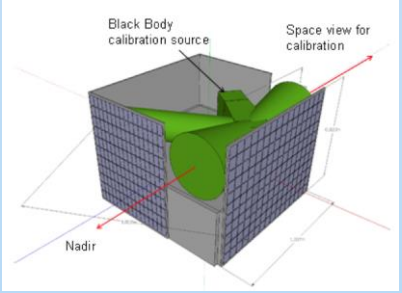
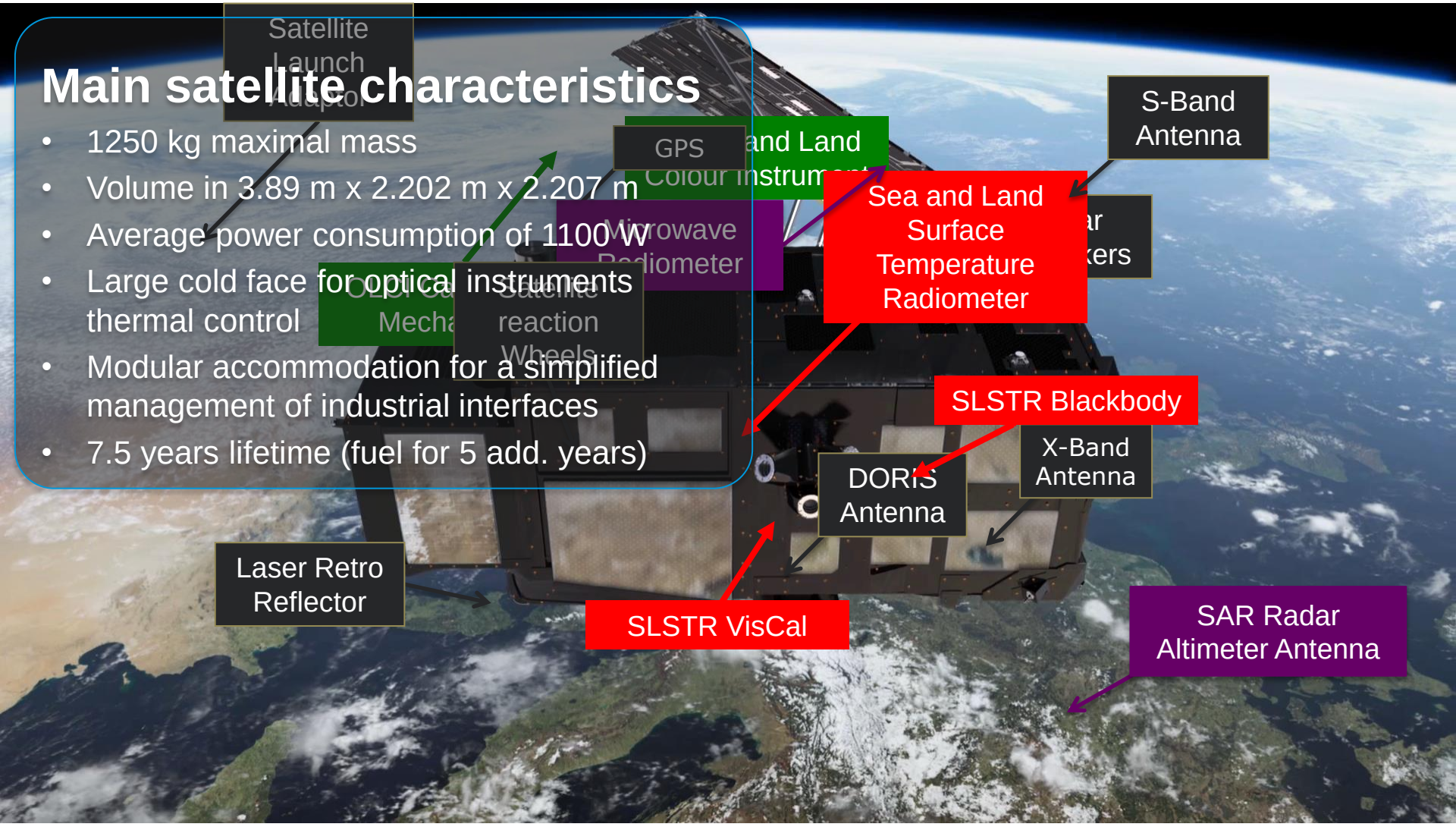
	Concept A	Concept B	Concept C
GSD/Swath	100m / 300 km	100m / 300km	100 m / 290 km
Spectral band number	2 minimum	2 minimum	2
NEDT on each band	0.2 K	0.2 K	< 0.2 K
MTF (ACT/ALT)	0.28/0.12	0.28/0.28	
TIR Detector	COTS microbolometer 1024x768 pixels with 17 µm pitch	COTS microbolometer 1024x768 pixels with 17 µm pitch	COTS microbolometers 1024 x 768 pixels 17µ pitch
Concept	Pushbroom	Step-and-stare	Push broom
Calibration	On board	On board	On-board
Mass	91 kg	75 kg	40 – 70 kg
Volume	89x69x55 cm3	87x66x57 cm3	1.1 m x 0.3 m x 0.4 m
Power	62 W	60 W	> 30 W
Picture of the assembly			

Image credit: AirBus DS Image credit: AirBus DS Image credit: SSTL

Sentinel-3

Sentinel-3: A bigger Picture for Copernicus

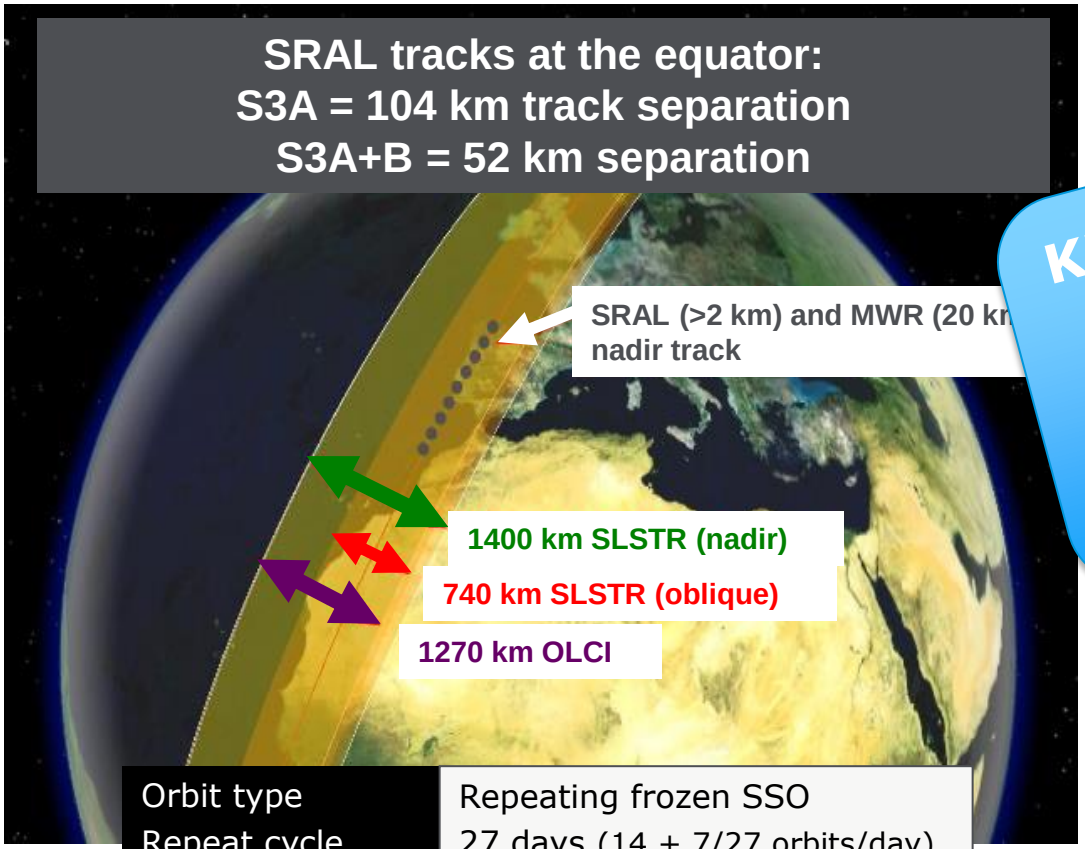


Main satellite characteristics

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

Sentinel-3: Satellite Orbit details

Instrument Swath



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

Ground Track Patterns

KML of ground tracks for S3A and S3B are available at

sentinel.esa.int

SRAL orbit drivers:

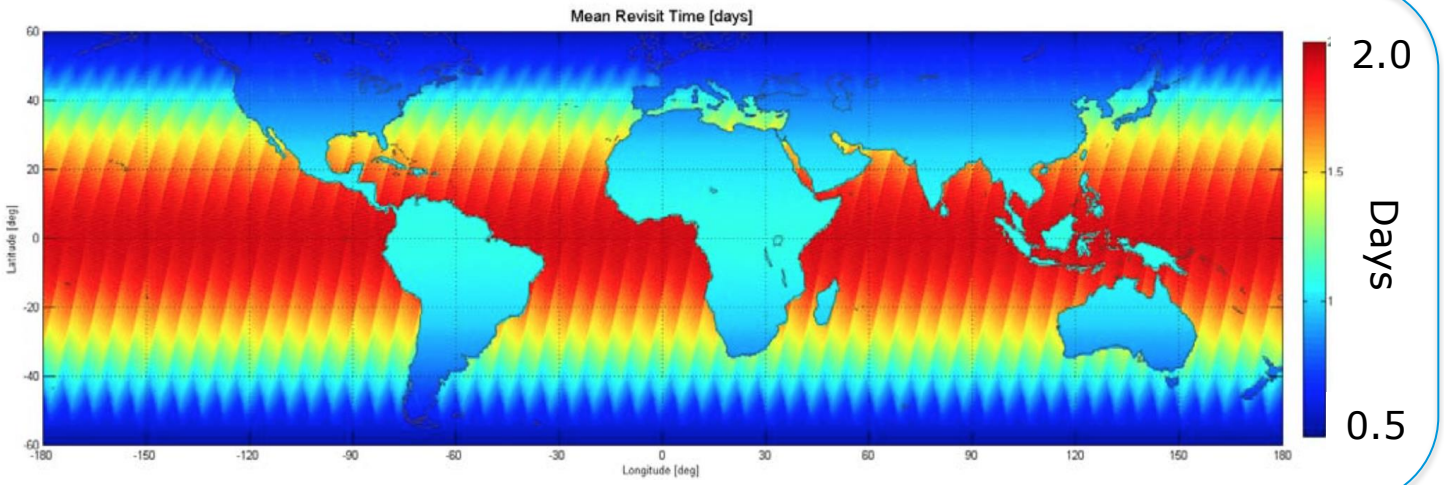
- **Ground track repeatability,**
- **Dense spatial sampling**

Orbit control requirement:

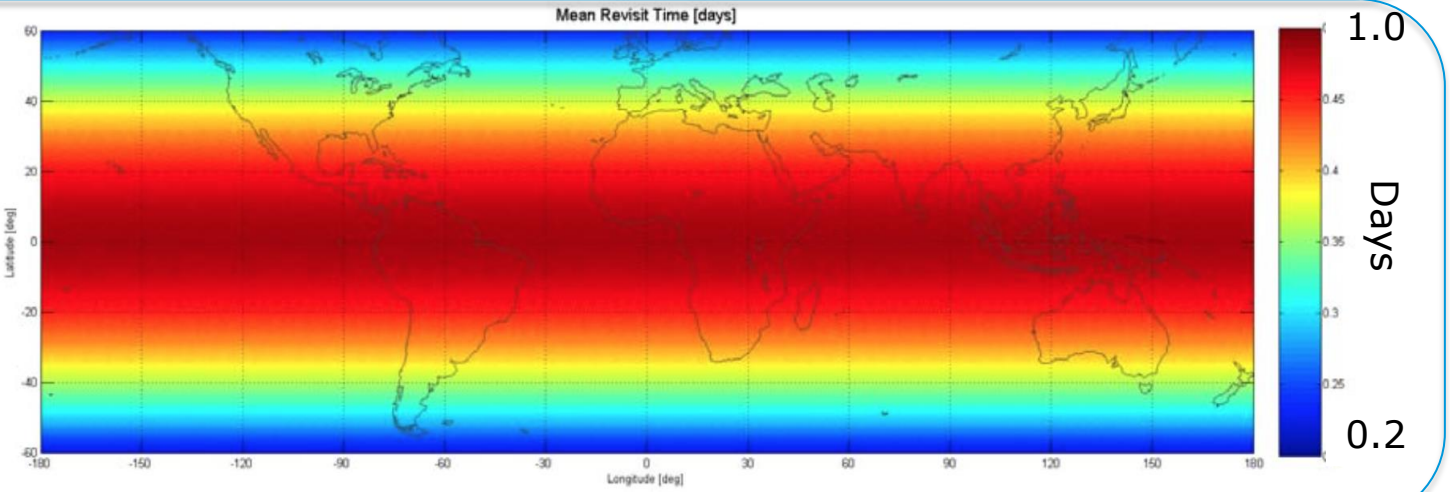
- **Ground track dead-band ±1km**

Sentinel-3 Optical Coverage

OLCI mean revisit time with 2 satellites



SLSTR nadir-view mean revisit time with 2 satellites

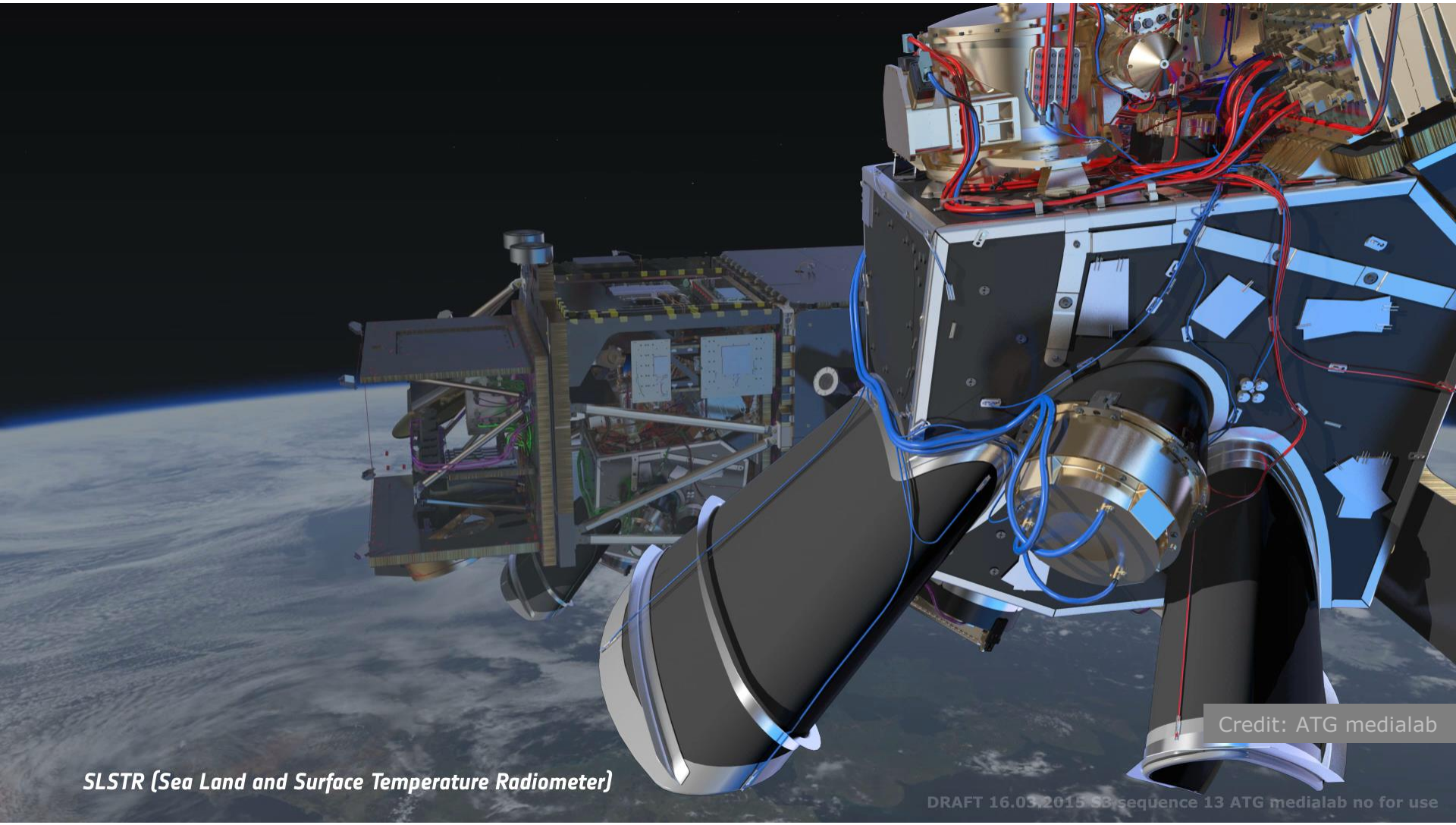



ThalesAlenia
Space
A Thales / Finmeccanica Company
REMOVE BEFORE FLIGHT
REMOVE BEFORE FLIGHT
REMOVE BEFORE FLIGHT
STR1 SN19

Spectral Channels: (A)ATSR & SLSTR

		ATSR-1	ATSR-2	AATSR	SLSTR
		ERS-1	ERS-2	ENVISAT	Sentinel3
Swath [km]	Nadir	500	500	500	1400
	oblique	500	500	500	740
SSI [km] VIS/SWIR	Resolution at sub sat point	1	1	1	0.5
SSI [km] IR		1	1	1	1
Band 1[12]	Chlorophyll	-	0.555	0.555	0.555
Band 2	Veg. Index	-	0.659	0.659	0.659
Band 3	Veg. Index	-	0.865	0.865	0.865
Band 4	Cloud clearing	-	-	-	1.375
Band 5	Cloud clearing	1.610	1.610	1.610	1.610
Band 6	Cloud clearing	-	-	-	2.250
Band 7	SST	3.740	3.740	3.740	3.740
Band 7 F	Fire	-	-	-	3.740
Band 8	SST	10.850	10.850	10.850	10.850
Band 8 F	Fire	-	-	-	10.850
Band 9	SST	12.000	12.000	12.000	12.000
Life time [years]	As designed	3	3	5	7.5
	As flown	1991-2000	1995-2008	2002-2012	

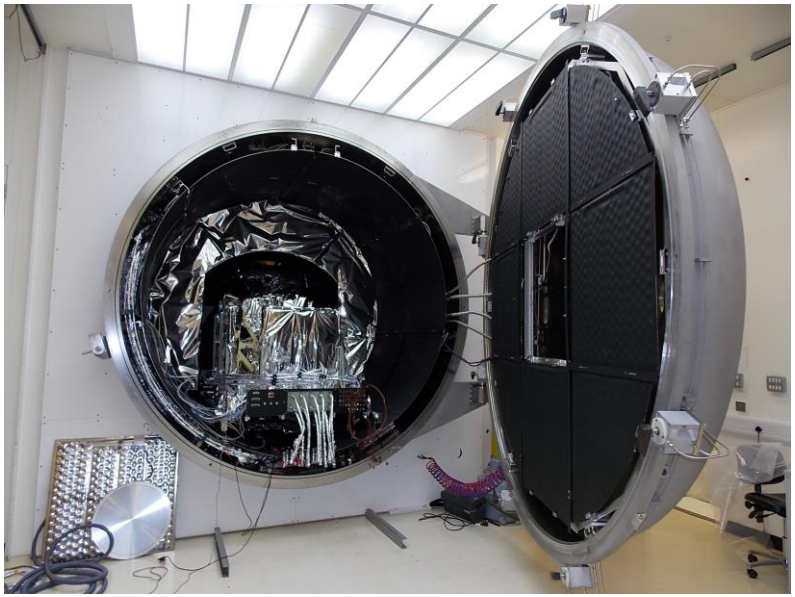
Sentinel-3 SLSTR



The Sea and Land Surface Temperature Radiometer (SLSTR)

Key Improvements compared to AATSR:

- **number of spectral bands from 7 to 9 (new 1.3 and 2.2um) for better Ci Cloud detection**
- **increased resolution for VIS and SWIR channels (0.5 km @ nadir, TIR 1 km @nadir)**
- **maintain along track scanning with increased swath of oblique view to 740 km**
- **increased nadir swath coverage to 1400 km**
- **100% overlap with OLCI**
- **improved coverage Ocean < 4 days (practically ~ 2 days)**
- **dedicated Active Fire channels**
- **Timeliness: 3 hours NRT Level 2 product**



SLSTR FM2 emerging from Thermal Vacuum Chamber after characterization and calibration tests at RAL, UK May 2015

SLSTR – FM2: Spectral calibration

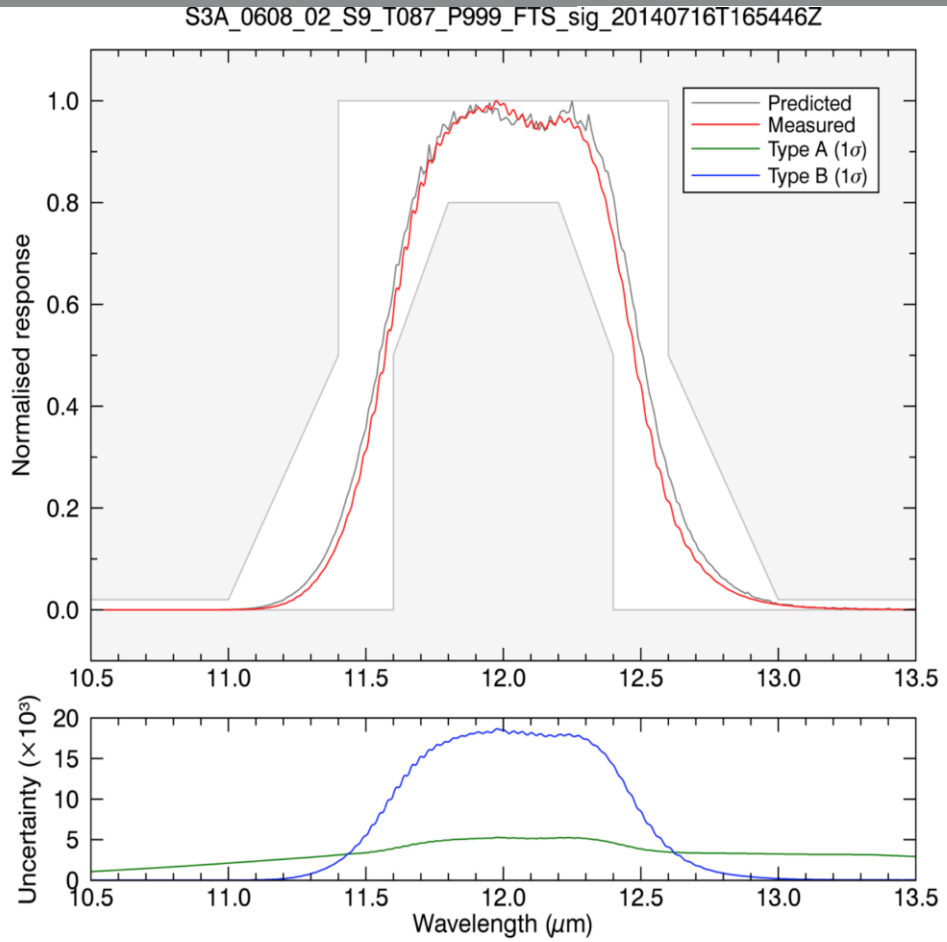


Figure 8.27 The normalised unpolarised spectral response of S9 detector 1 (analogue signal) at 87K.

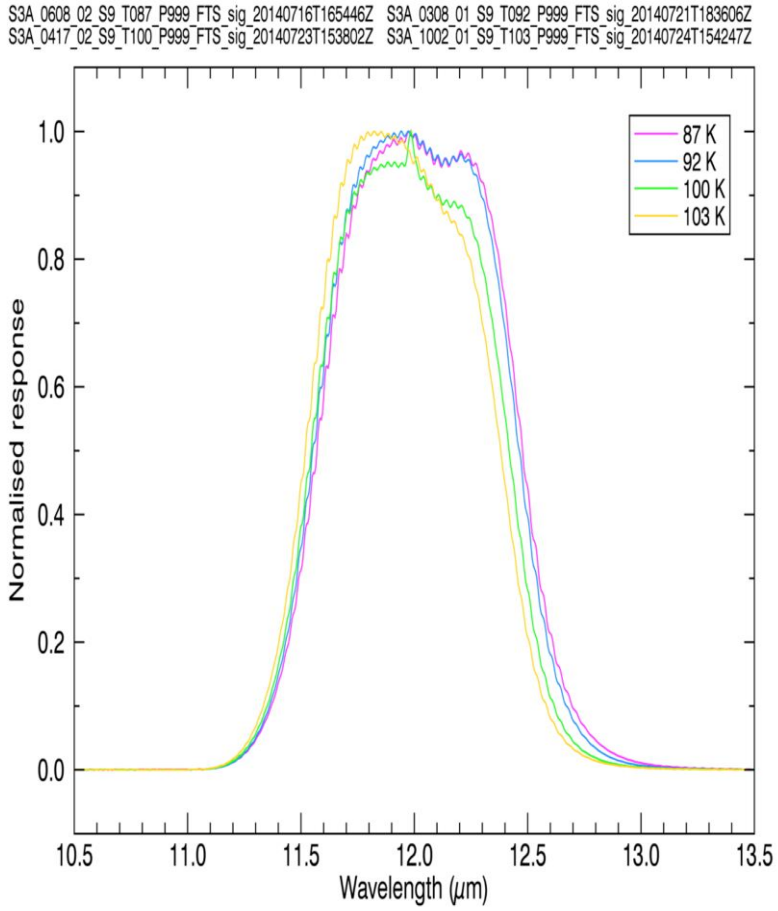


Figure 8.37 Temperature dependence of the unpolarised normalised response of S9 detector 1 (analogue signal).

available on sentinel.esa.int

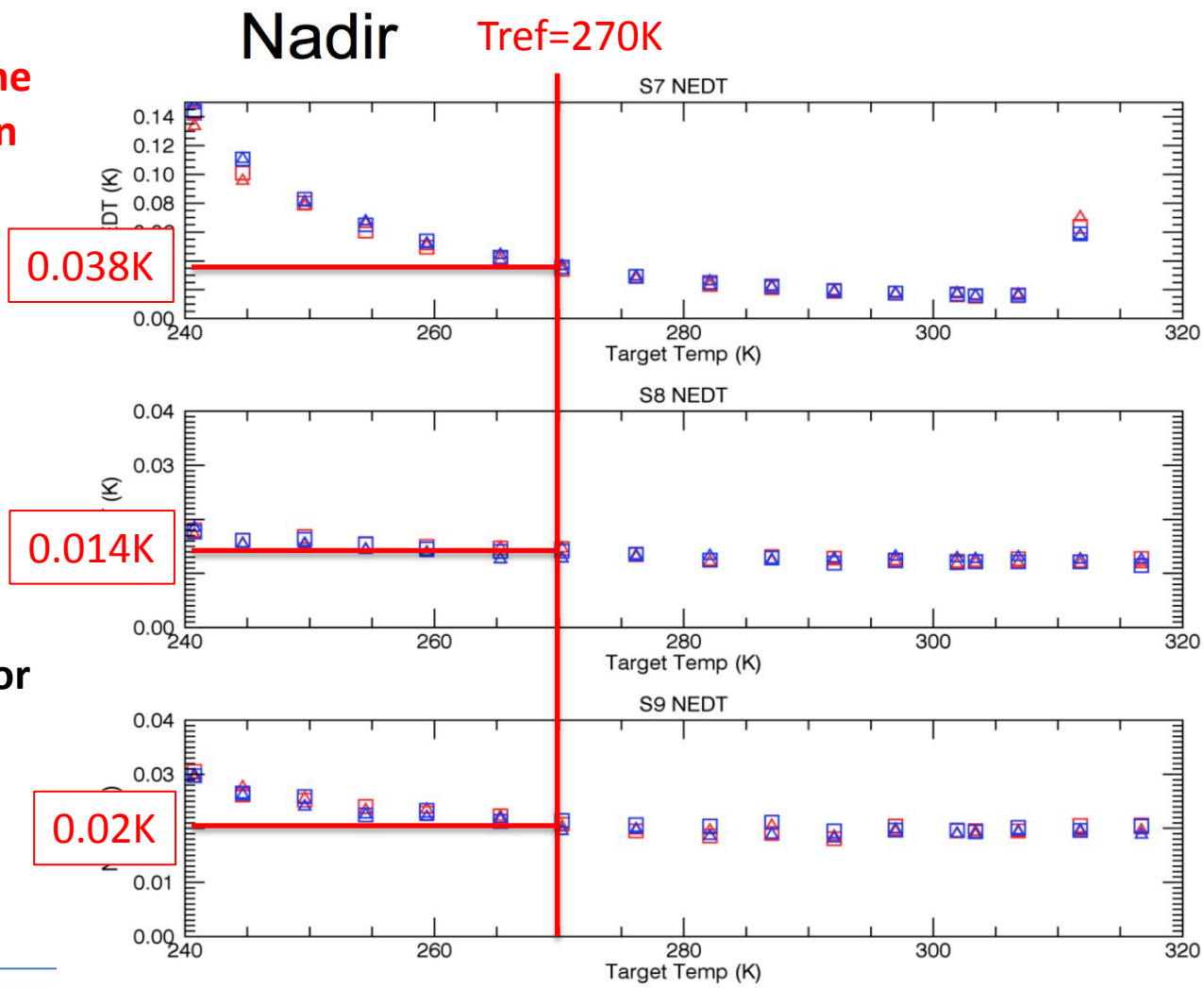
S3A SLSTR: performance

Preliminary Results from the recent calibration campaign in TVAC@RAL

Excellent Thermal NEdT

Saturation on S7@308K
Adjustment of integration time (76 → 50µs) resolves issue.

Data now being analyzed for final results



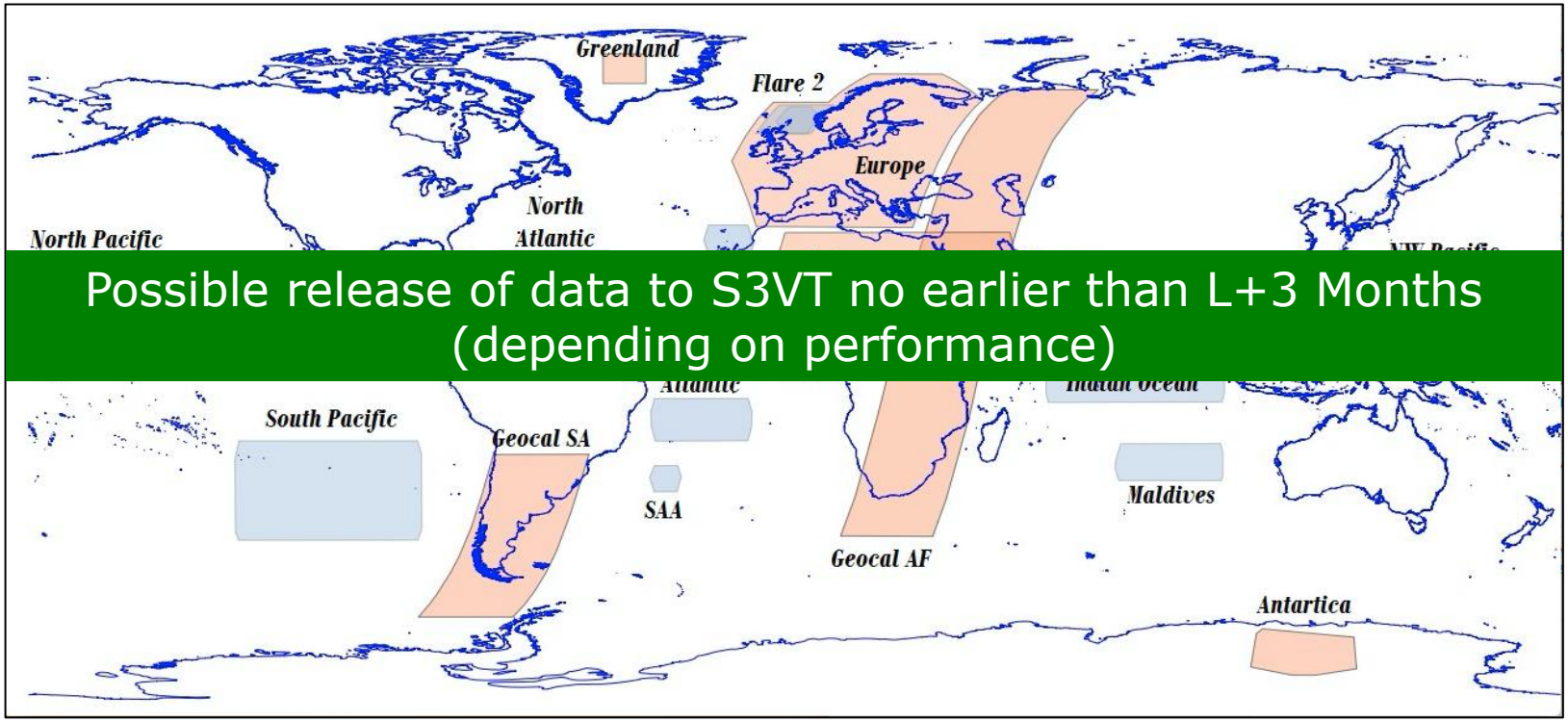
AATSR Heritage
SLSTR New Bands

Launch Campaign

- **S3A has a planned launch from Plesetsk cosmodrome on 31st October 2015**
- Mechanical compatibility tests with the Rockot are complete
- Licenses to launch have been granted
- Satellite transportation to Plesetsk has been booked
- Detailed planning of the Launch campaign is progressing well

Defined Optical Regions of Interest

A Generic request for the early part of the E1 mission cal/val activities
L1B: OLCI: L+5 weeks SLSTR L+8 weeks, SYNERGY (L1C): L+10 weeks
Specific L2: L+ 10w



Sentinel-3A Status

- **Platform readiness:**
  - Sentinel-3A AIT progressing: Full satellite integrated since early July 2014
  - Mechanical Test Campaign successfully completed by end 2014
  - Alert on one component in SLSTR and MWR instruments with preventive repair now complete.
- **Payload readiness:**
  - **SRAL** PFM instrument integrated on Satellite and tests complete.
  - **MWR** PFM integrated on Sentinel-3A satellite. Repaired unit (see alert above) to be swapped in June.
  - **SLSTR-FM2** electrical, mechanical, functional as well as VIS radiometric calibration tests completed; Analysis of characterization results ongoing, instrument being integrated into satellite
  - **OLCI** defective camera detected in Oct 2014 and replaced in Nov; root cause found; replacement of all OLCI-A cameras with those produced for OLCI-B in progress
- **S3A launch window end Oct. 2015 (shipping to launch 20th Sept. 2015)**
  - Export licenses for S3A launch from Russia granted
- **Sentinel-3B** Assembly, Integration and Test on-going

Conclusions

- Readiness of Sentinel-3A Satellite and testing **on track for a launch by end October 2015**
- All ground segment facilities supporting the Sentinel-3 commissioning (predicted duration 5 months after launch) and operations are in place, both at ESA and EUMETSAT
- Sentinel-3B Satellite integration well advanced. On track for a launch approx. 18 months after Sentinel-3A (i.e. Q2-2017)
- Procurement of Sentinel-3C and -3D Satellites started
  - ITT process on-going, with the objective to have the EC agreement to the contract proposal in October 2015
  - KO of industrial activities planned before end of 2015, for a delivery of the C and D models by end 2021, well in advance compared to the predicted lifetime of the A and B models (7 years min from start of operations)
- With the inclusion of the C and D models to the fleet of Sentinel-3 satellite, mission continuity is ensured for at least 25 years from the launch of the first Satellite

S3A Launch : 31st October 2015
(Assuming no show-stoppers!)

Thank You –
any Questions

Contact: Craig.Donlon@esa.int

European Commission

esa EUMETSAT ECMWF European Environment Agency Mercator Ocean Ocean Forecasters