Physical Observations used for Assimilation

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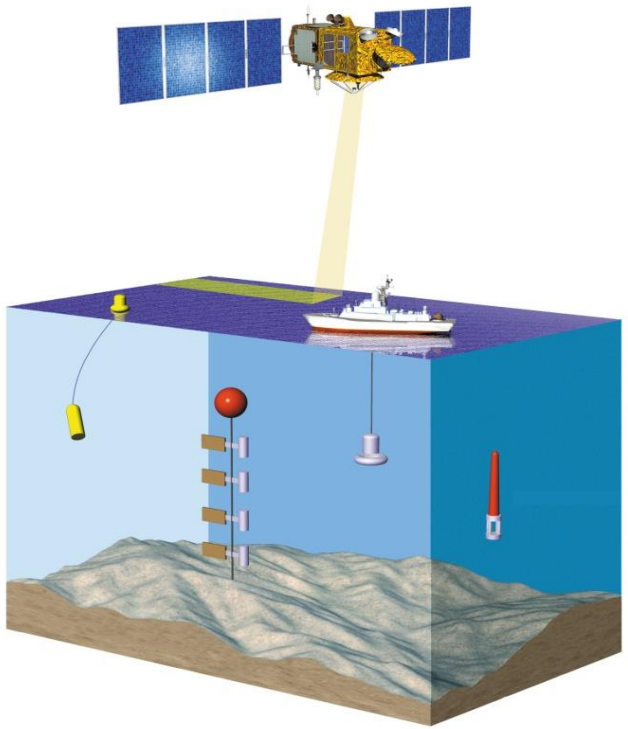
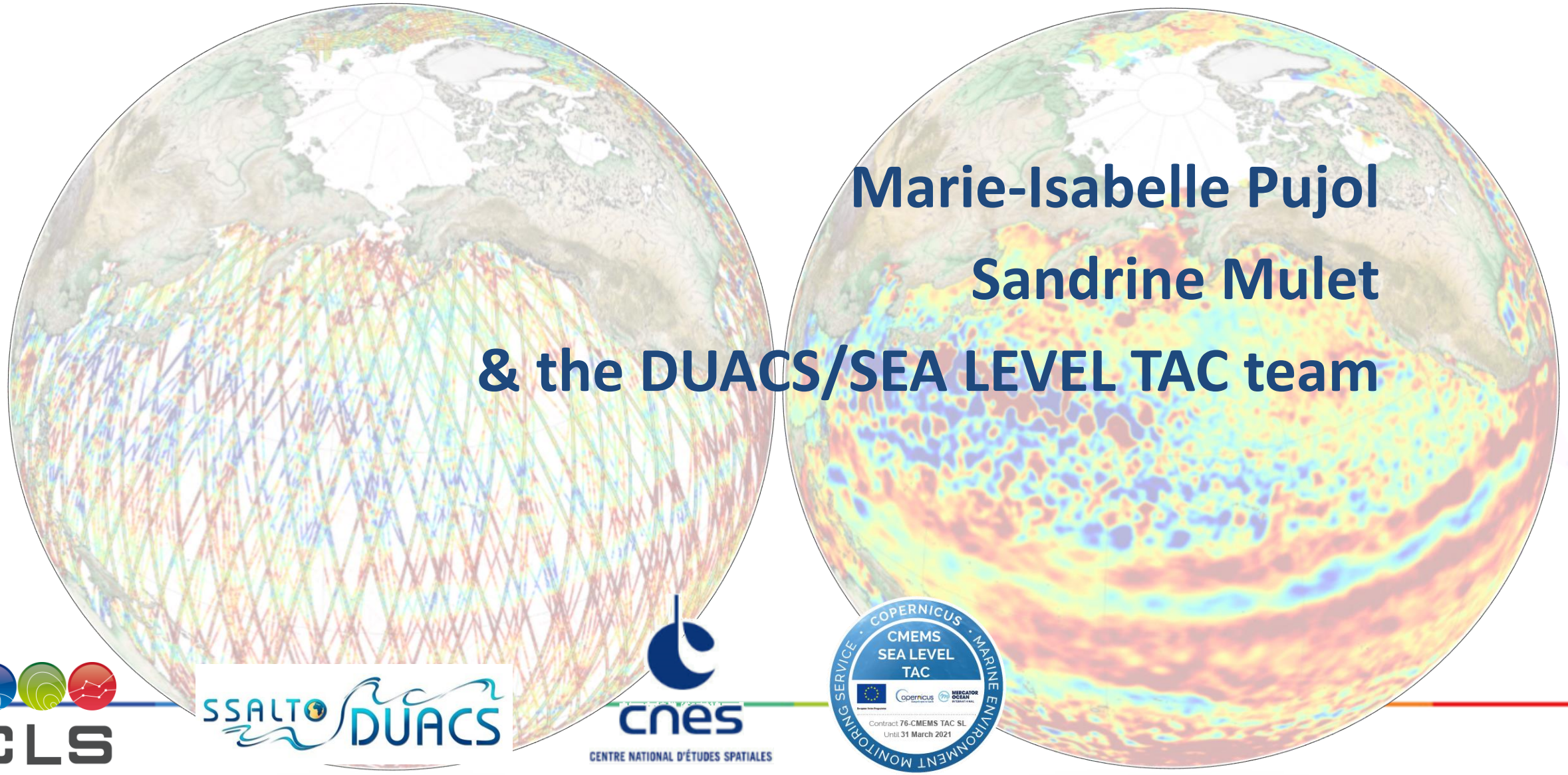
Physical Observations used for Assimilation



- Sea level anomalies from satellite altimeter + MDT
- In-situ T/S profiles
- SST from satellites

Altimeter products



Marie-Isabelle Pujol

Sandrine Mulet

& the DUACS/SEA LEVEL TAC team

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SSALTO DUACS

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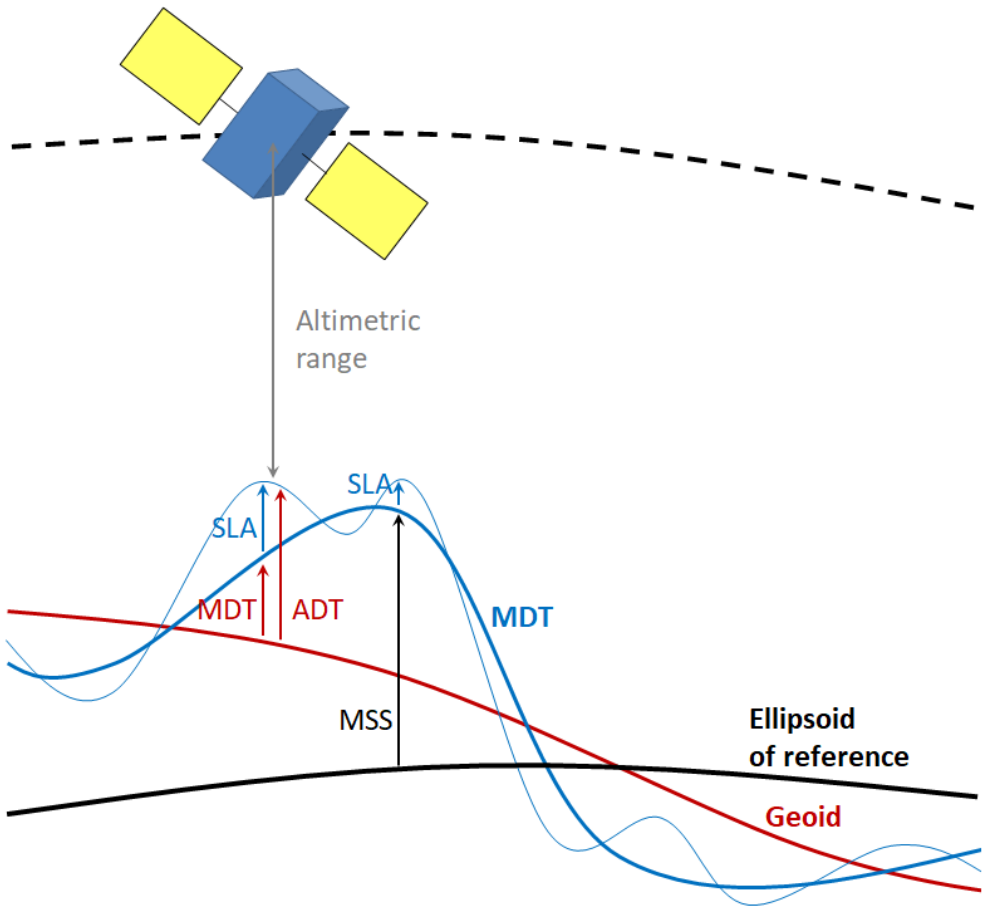
COPERNICUS · MARINE ENVIRONMENT MONITORING SERVICE
CMEMS SEA LEVEL TAC
Contract 76-CMEMS TAC SL
Until 31 March 2021

Altimeter processing overview



Objective: extract the **SL** information from the altimeter measurement

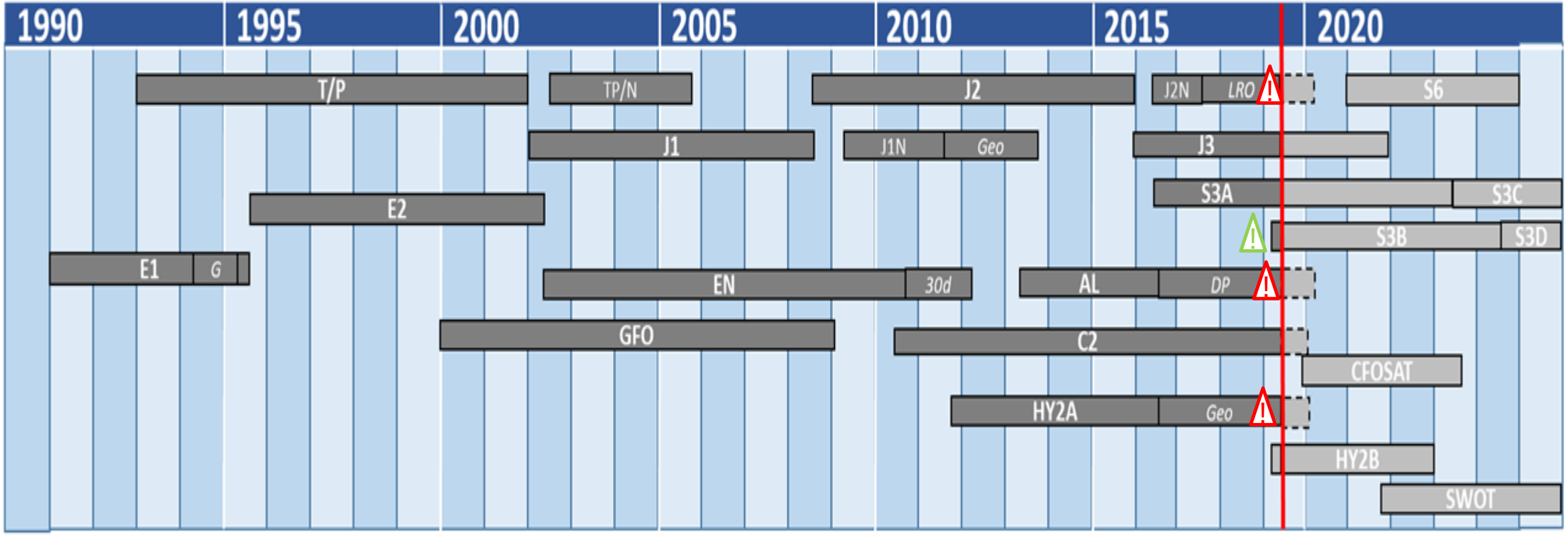
➔ **SLA** referenced to a MSS

➔ Need of a **MDT** to take into account the dynamic of the ocean

ADT = SLA + MDT

equivalent to model **SSH**

Altimeter constellation



- J2: safehold mode, expected back end of May
- AL: misspointing issue, desactivated from the NRT
- HY2A: only use in REP
- S3B: in the NRT system since April 2nd

CMEMS SL-TAC products available

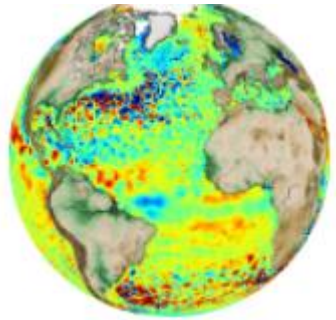
The processing includes :

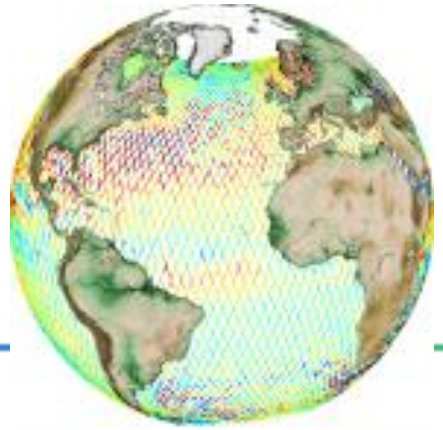
- valid measurement selection
- cross-calibration between the different altimeters (reduction of global and regional biases)
- noise reduction (low pass filtering)

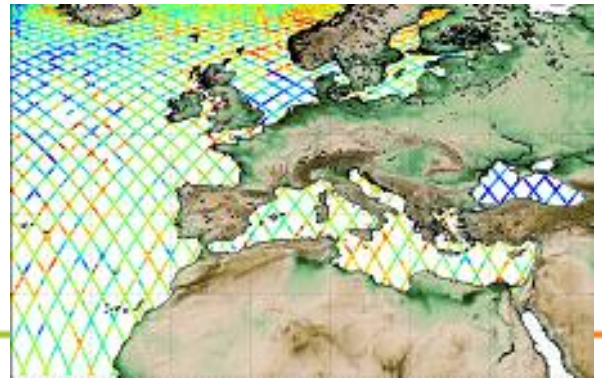
Along-track (L3) products available from April 16th 2019 :

	Global Ocean	Europe Area
NRT	SEALEVEL_GLO_PHY_L3_NRT_OBSERVATIONS_008_044 (*)	SEALEVEL_EUR_PHY_L3_NRT_OBSERVATIONS_008_059
REP	SEALEVEL_GLO_PHY_L3_REP_OBSERVATIONS_008_062	SEALEVEL_EUR_PHY_L3_REP_OBSERVATIONS_008_061

+ L4

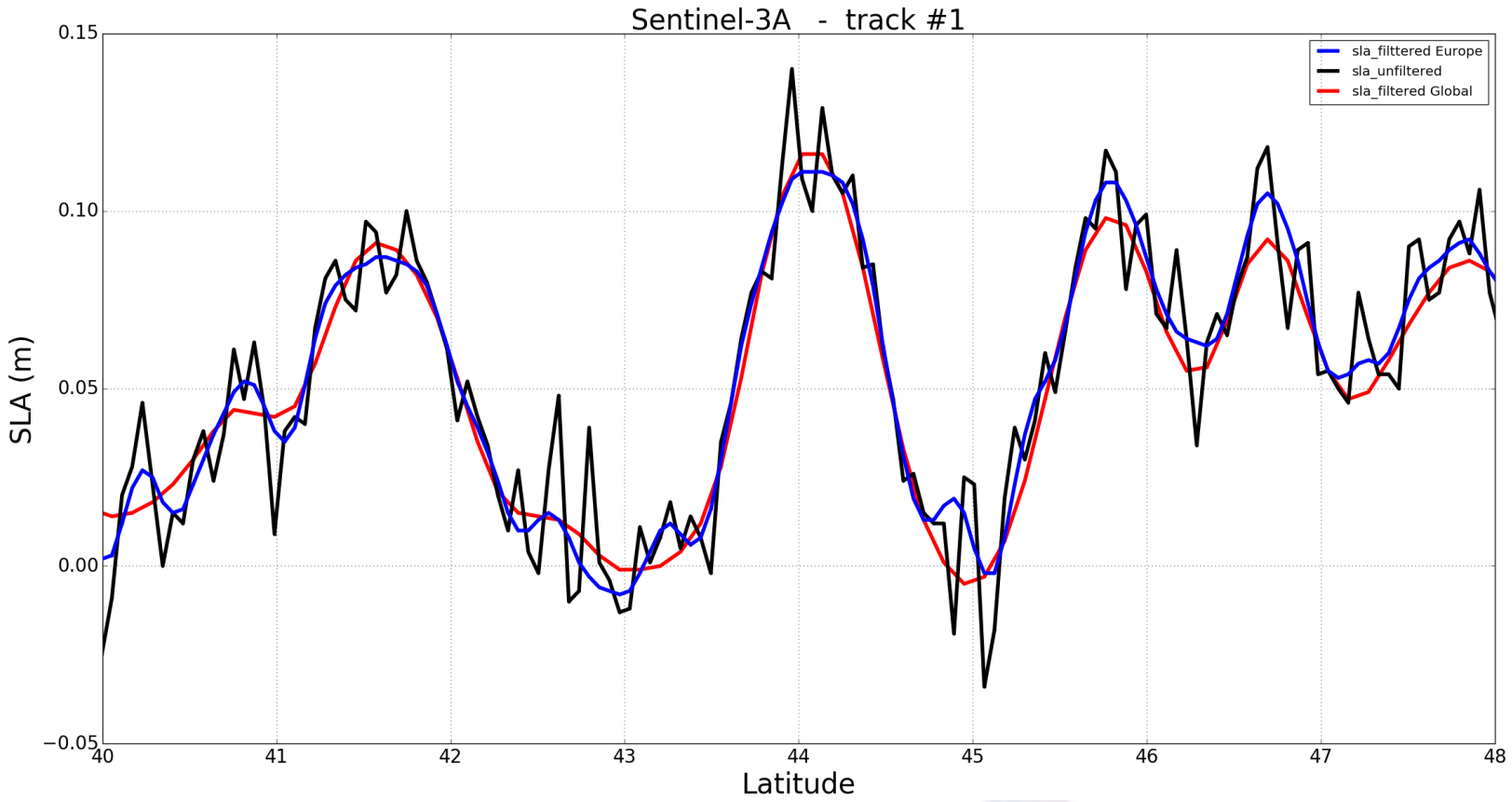






CMEMS SL-TAC products available

sla_filtered	Sea Level Anomaly, with noise reduction by filtering
sla_unfiltered	Sea Level Anomaly
lwe	Long Wavelength Error
dac	Dynamic atmospheric correction
ocean_tide	Ocean tide height
mdt	Mean dynamic topography



Filtering

GLO: < ~65 km

EUR: < ~40 km

Subsampling

GLO: 1pt/~14 km

EUR: 1pt/~7km

CMEMS SL-TAC products available

sla_filtered	Sea Level Anomaly, with noise reduction by filtering
sla_unfiltered	Sea Level Anomaly
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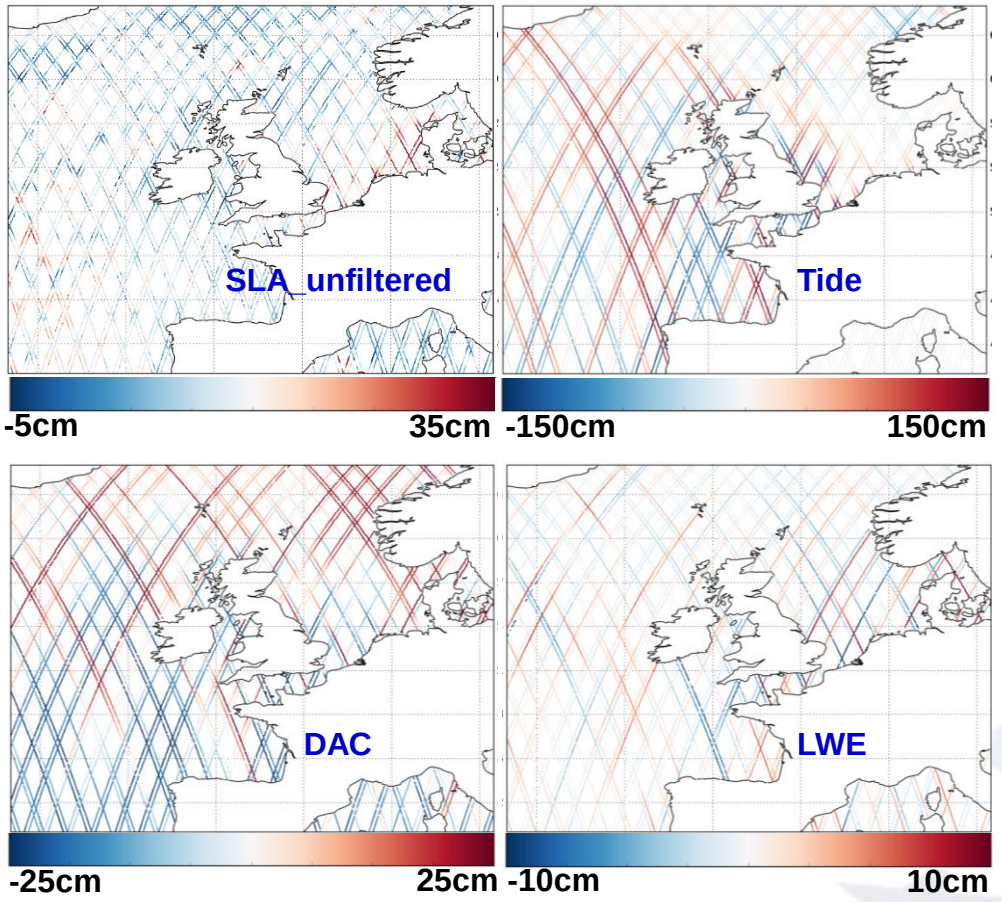


Courtesy of Robert King

TAPAS workshop, April 2019

Met Office

How to use SL-TAC products

SLA delivered is already corrected from different signals, i.e. these signal are removed from the altimeter measurement

$$\mathbf{SLA_{alti;\ available\ on\ product}} = \text{Orbit} - \text{Range} - \mathbf{OceanTide_{alti}} - \mathbf{DAC_{alti}} + \mathbf{LWE} - \text{OtherCorrections} - \text{MSS}$$

Ocean Tide : FES2014 model

DAC: Includes inverse barometer for the low frequencies (> 20 days) and dynamic wind & pressure forcing effects from MOG2D model for the high frequencies (< 20 days)

LWE: Empirical correction that remove residual Orbit Error signals, but also part of DAC and tide residual signals

How to use SL-TAC products

You want to **keep the HF signal & the tide signal** in the SLA content (e.g. to compare with model forced by wind & pressure & tides)

- First solution : change the model output physical content → need to compute DAC, Tides & LWE correction from model outputs:

$$SLA_{alti\_equiv} = SLA_{model} - DAC_{model} - OceanTide_{model} [+ LWE_{model}]$$

- Second solution : change the altimeter physical content:

$$SLA_{model\_equiv} = SLA_{alti} + OceanTide_{alti} + DAC_{alti} - LWE$$

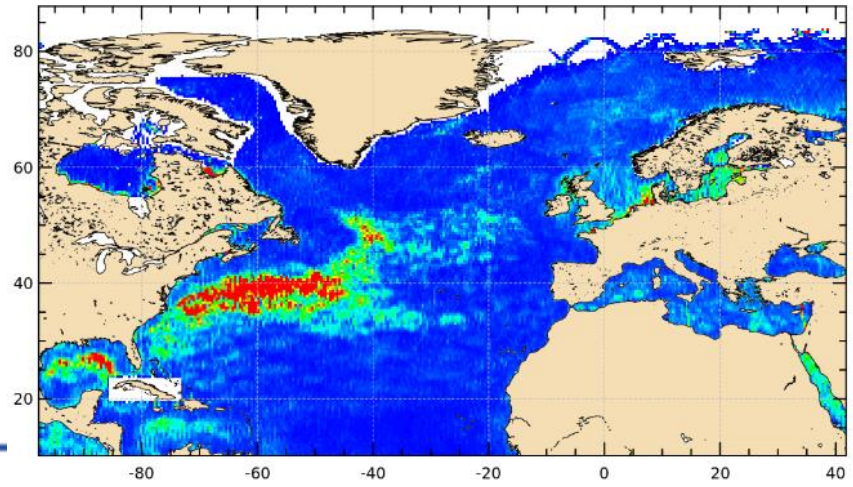
LWE: Some residual Orbit Error signals might remain in the alti data in this case
→ Interest to use a home-made LWE error correction as proposed by M. Benkiran

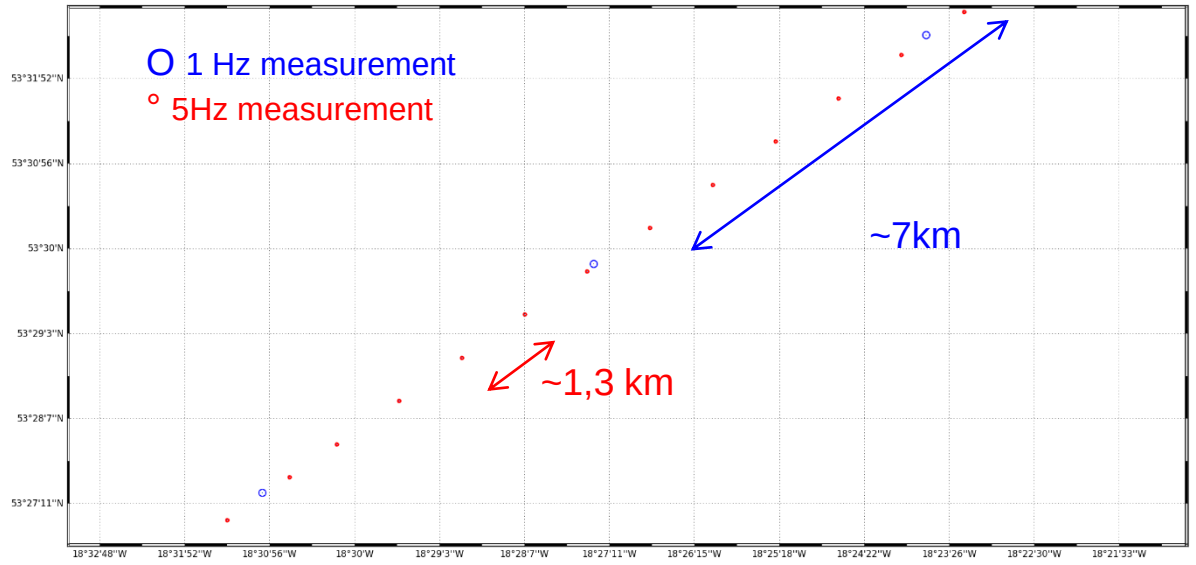
Experimental 5Hz products (~1.3 km)

Work in progress
Samples available on AVISO+

- Delayed Time L3 along-track product
- 5 Hz sampling : one measurement / ~1.3km
- Content:
  - sla_unfiltered not available
  - **ib_lf** : low frequency component (> 20 days) of the IB
  - **internal wave** component from Ray&al. (2016)
  - **across-track velocities**

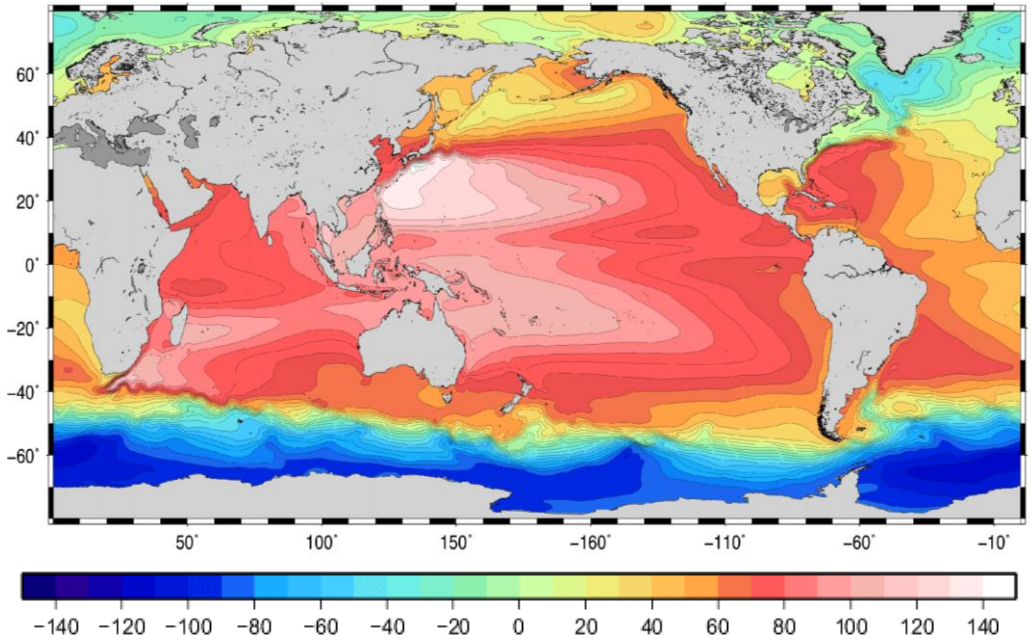
Mission		Start date L3	End date L3
Jason-2	J2	2015-01-01	2016-02-29
Cryosat 2	C2	2015-01-01	2015-12-31
Altika	AL	2015-01-01	2017-02-03
Jason-3	J3	2016-03-28	2017-03-29
Sentinel-3A	S3A	2016-04-06	2017-04-17



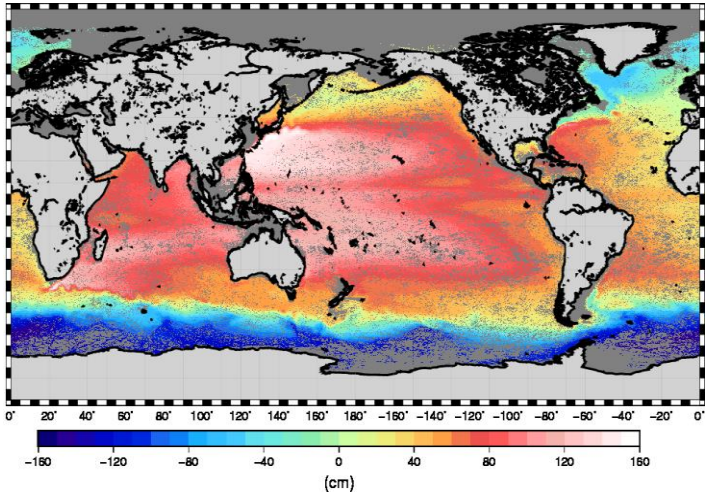


METHOD to compute the CNES-CLS MDT

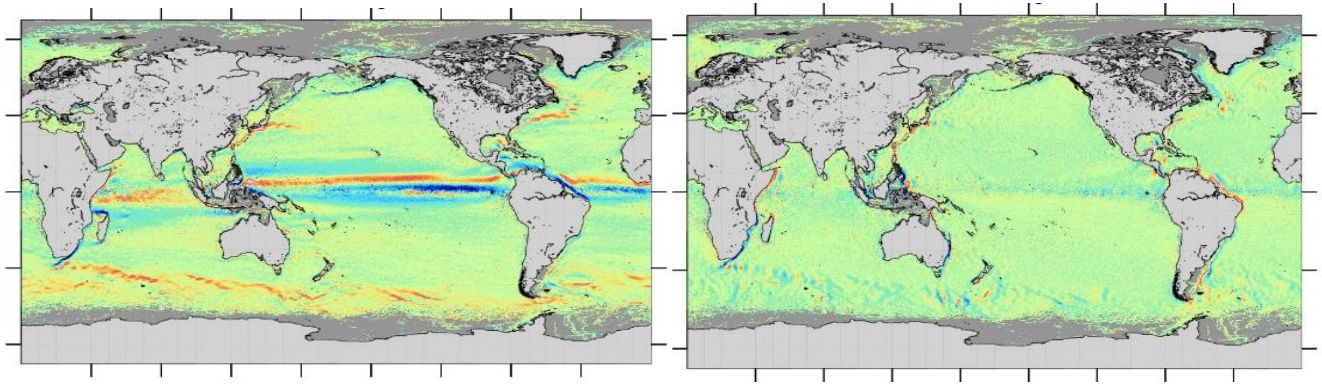
First guess
GRACE/GOCE + CNES-CLS15 MSS



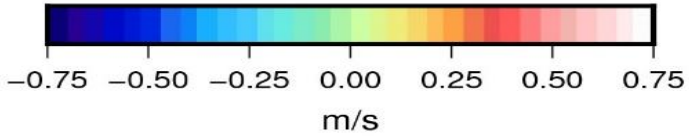
In situ observations of synthetic heights Argo profiles



In situ observations of synthetic velocities Surface drifters



Multivariate Optimal Interpolation



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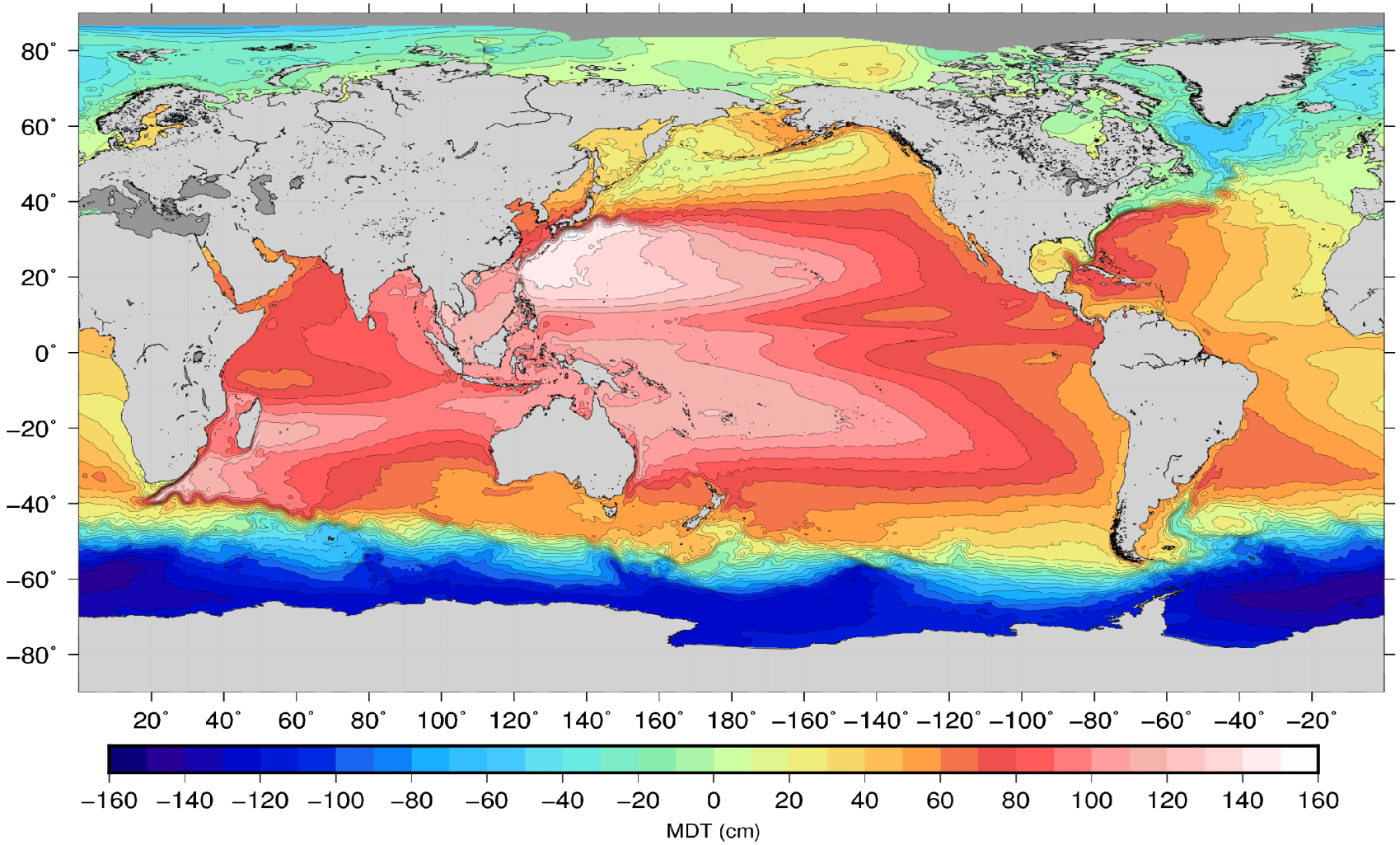
Rio and Hernandez, 2004; Rio et al, 2005, 2011, 2014, 2019 (in prep)

	MDT CNES-CLS13	MDT CNES-CLS18
MSS	CNES-CLS11 (Schaeffer et al, 2012)	**CNES-CLS15** (Pujol et al, 2018)
Geoid	EGM-DIR-R4 (Bruinsma et al, 2012) 2 years of reprocessed GOCE data +7 years of GRACE data	**GOCO05S** (Mayer-Gürr,et al. 2015) Complete GOCE mission (Nov 2009-October 2013) + 10.5 years of GRACE data
First guess of the first guess	Compute in the spatial domain and filtered at 200km of resolution with Gaussian filter	Compute in the **spectral domain** DO250 and then filtered at 200 km of resolution in the spatial domain with a Gaussian filter
First Guess filtering	Optimal filter (Rio et al, 2011)	Optimal filter (Rio et al, 2011) **with updated parameters**
Altimeter data	Delayed-Time DUACS-2010 (Dibarboure et al, 2011)	Delayed-Time **DUACS-2018** (Taburet et al, under review)
Hydrological data	CTD (Cora3.4), ARGO Pref variable 200/400/900/1200/1900 Period 1993-2012	CTD and ARGO Pref variable 200/400/900/1200/1900 from CORA4.2 (1993-2013), CORA5.0 (2014-2015) and CORA5.1 (2016) Period **1993-2016**
Ekman model	Parameters fitted over the period 1993-2012, by longitude, latitude and month (Rio et al, 2014) Two levels: 0m and 15m	Parameters fitted over the period **1993-2016** **by latitude and Mixed Layer Depth** (from ARMOR3D) Two levels: 0m and 15m
Wind Slippage correction	Rio et al, 2012	**Update** of Rio et al, 2012 in order not to discard the trajectories beginning/end
Drifter filtering	3 days	**Max (24 hours, Inertial Period)**
Resolution	Global ¼°	Global **1/8°**
Reference Time period	1993-2012	1993-2012

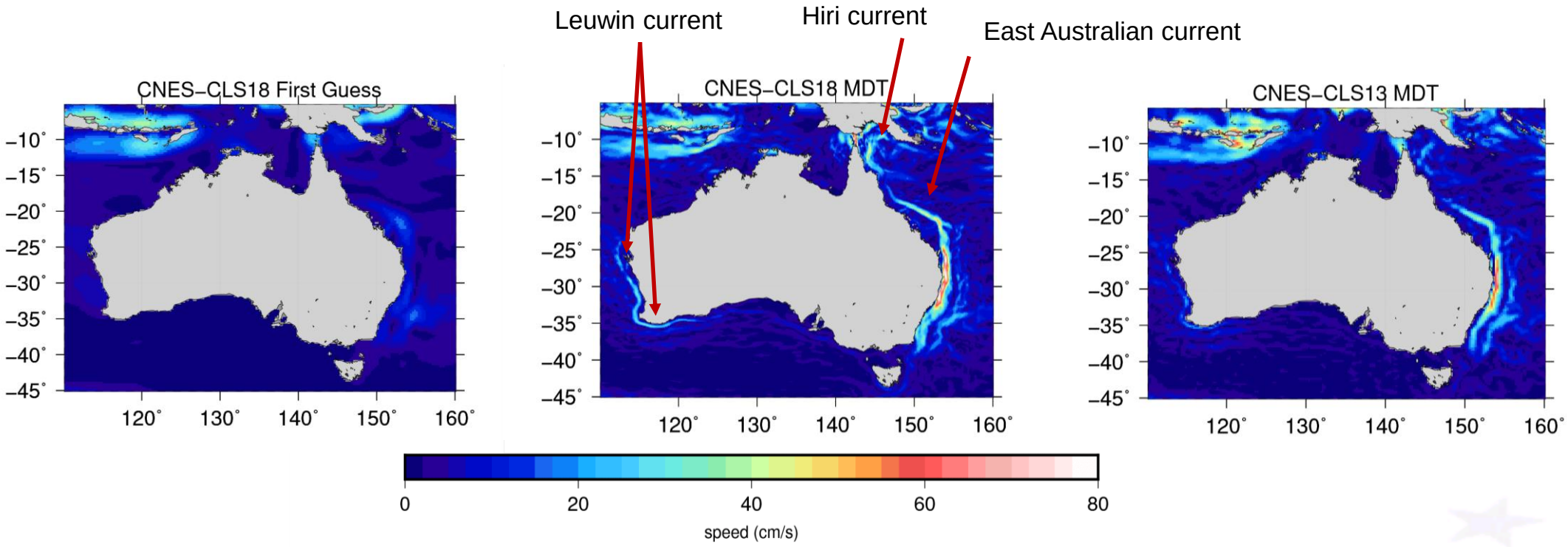
CNES-CLS18 Mean Dynamic Topography

AVISO+ in June 2019



- Horizontal resolution: **1/8°**
- Reference time period: **1993-2012**

Associated mean geostrophic velocities



➔ **The use of an observation-based MDT has proved to improve both the analysis and the forecasts of OGCM assimilating SLA**

- Haines K., J. A. Johannessen, P. Knudsen, D. Lea, M.-H. Rio, L. Bertino, F. Davidson et F. Hernandez (2011). An ocean modelling and assimilation guide to using GOCE geoid products. Ocean Science, 7(1):151–164.
- Hamon M., E. Greiner, P.-Y. Le Traon and E. Remy (2019). Impact of multiple altimeter data and mean dynamic topography in a global analysis and forecasting system, accepted, JAOT.

In situ products (T/S profiles)

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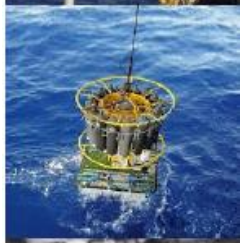
CMEMS IN SITU OCEAN TAC
Contract 82-CMEMS TAC INSITU
Until 31 March 2021

CLS

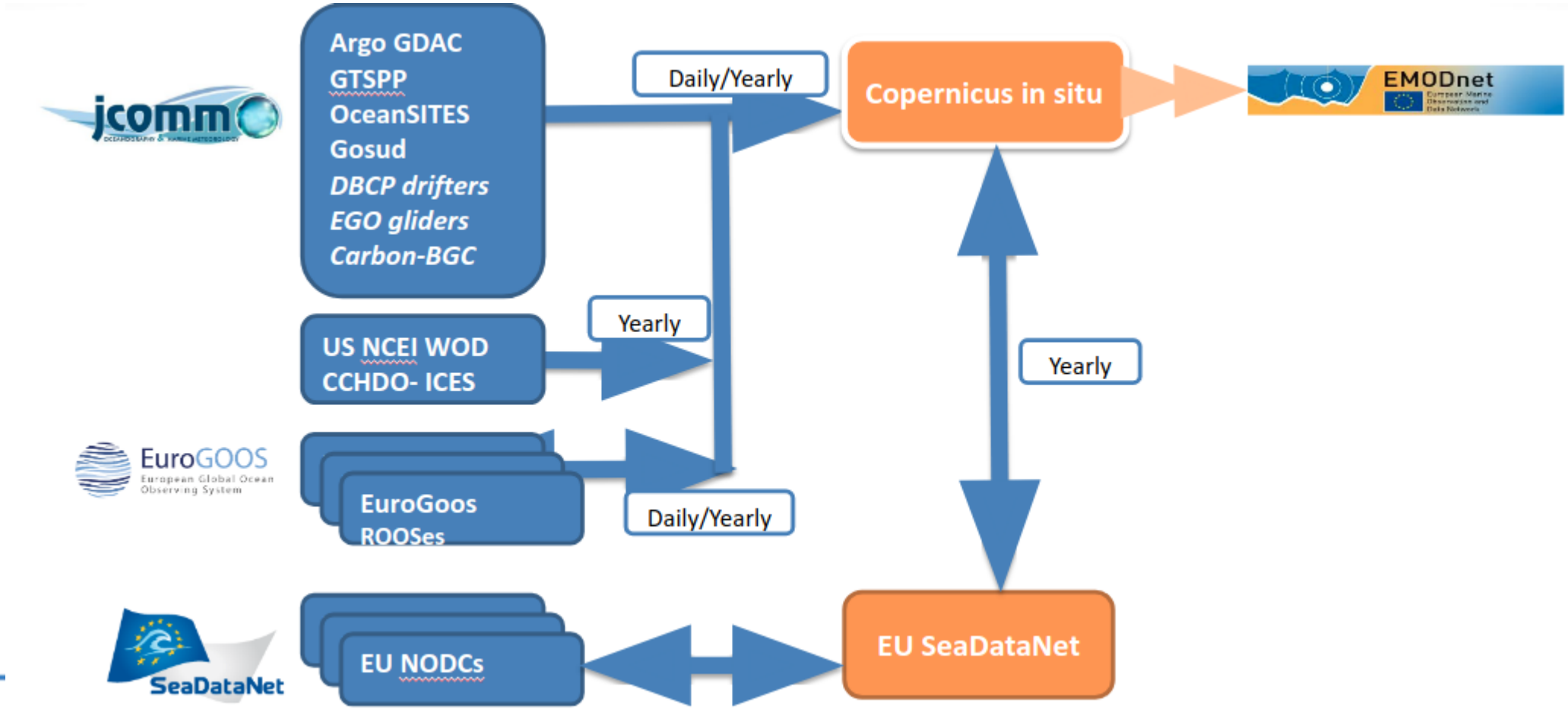
Coriolis

CMEMS In situ TAC integrated in the EU and International in situ data management landscape

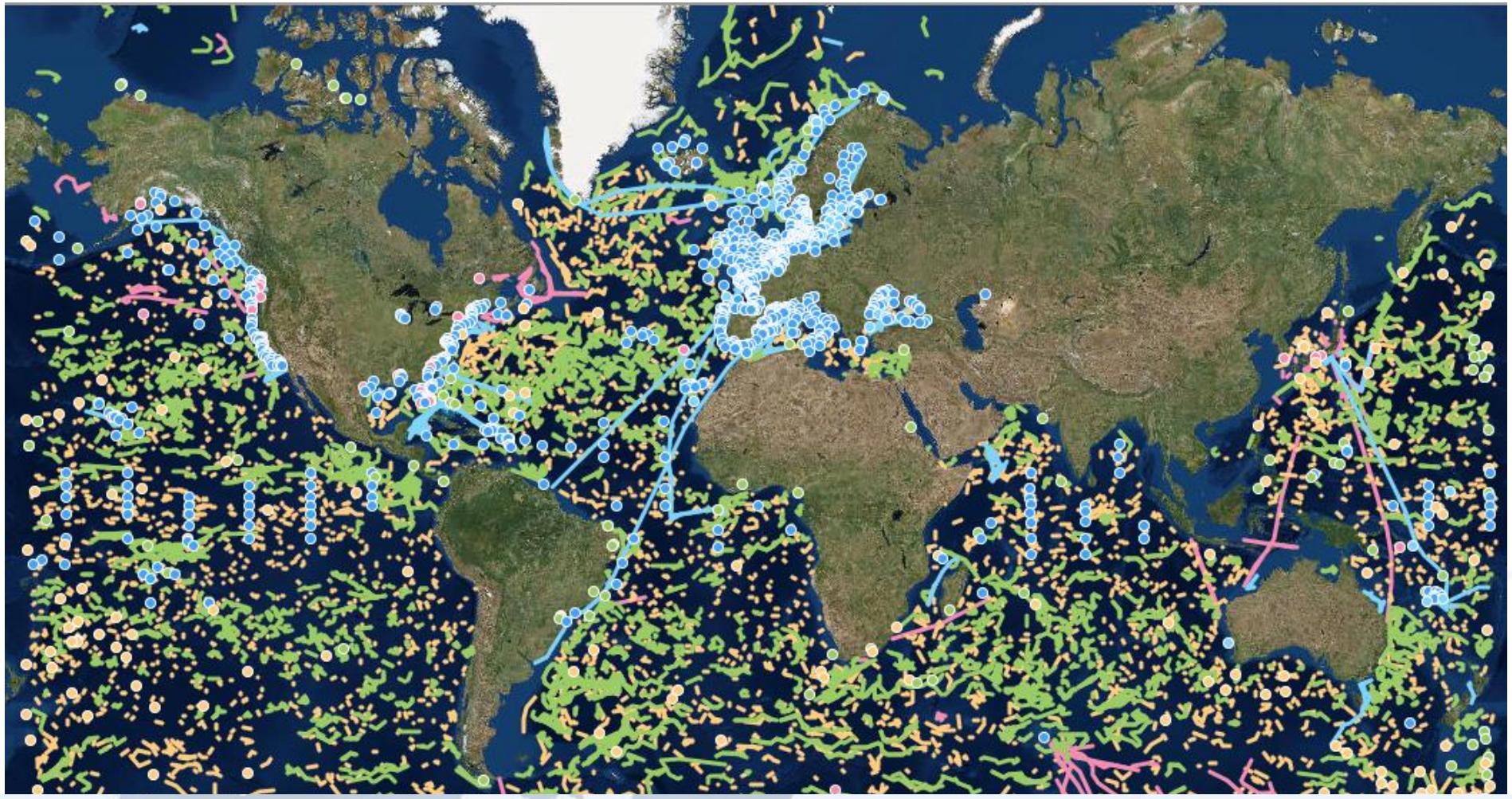





➔ **First challenge :** to gathered all the individual observations



http://www.marineinsitu.eu



Total number of platforms
37696
Since ever

Volume of data
2534 MB
From last 30 days

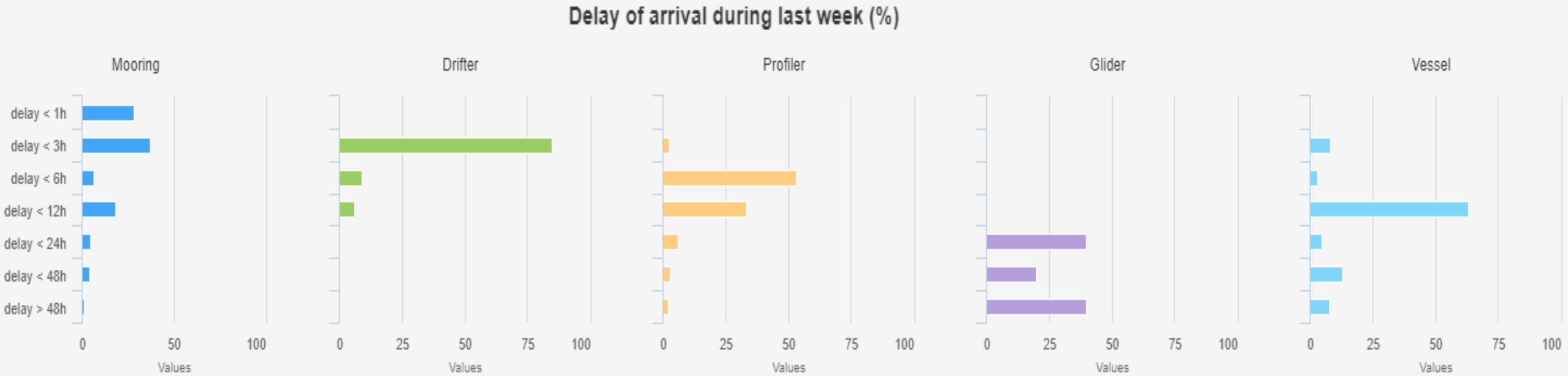
Data providers
313
From last 30 days

Number active platforms
7047
From last 30 days

Services availability
~ 99.9 %
From last 30 days

Delay of arrival

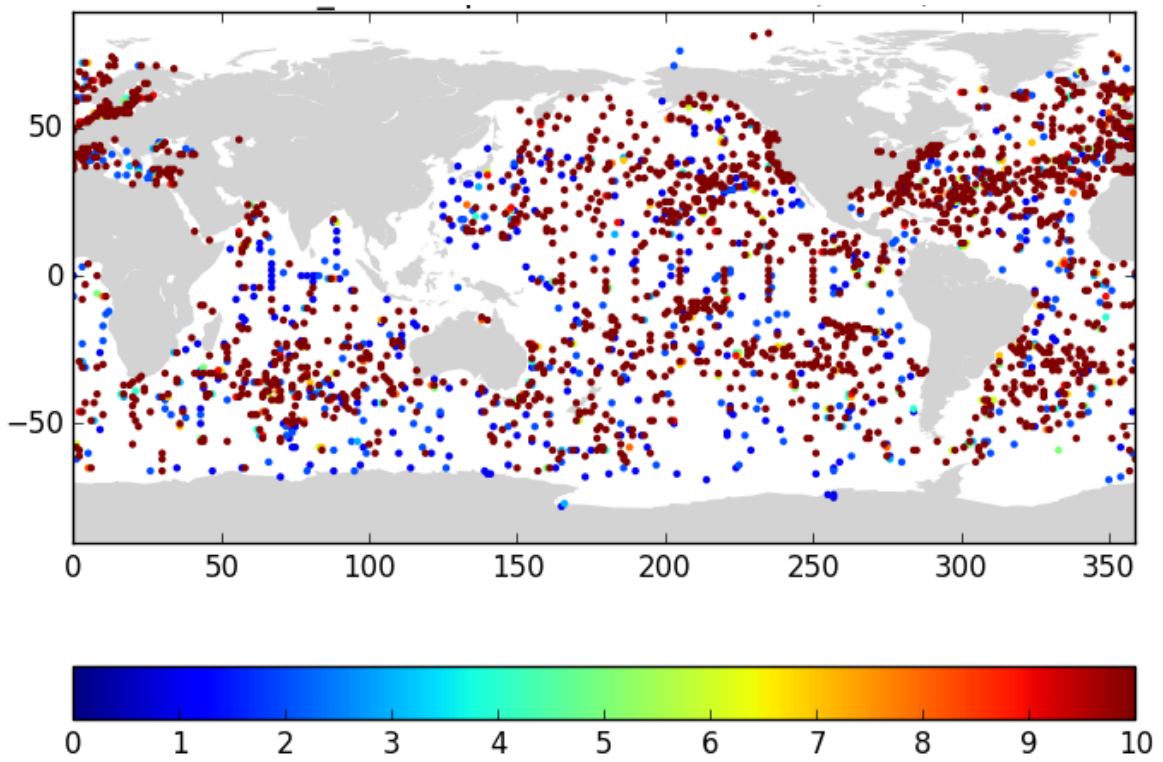
➔ **Second challenge :** process the data quickly



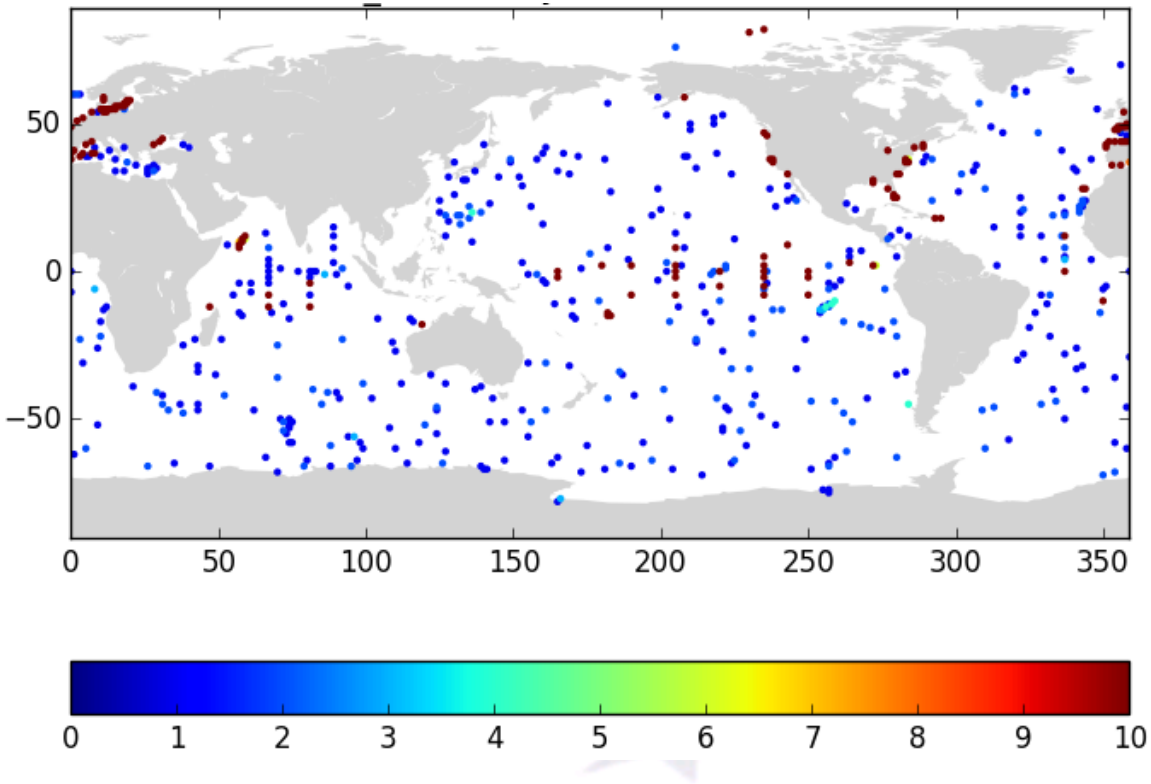
T/S profiles - Inventory: latest, 1 day, all profiles

INSITU_GLO_NRT_OBSERVATIONS_013_030
(INSITU_GLO_TS_REP_OBSERVATIONS_013_001_b: 1950->mid-2018)

73 763 **Temperature** profiles (20190422)

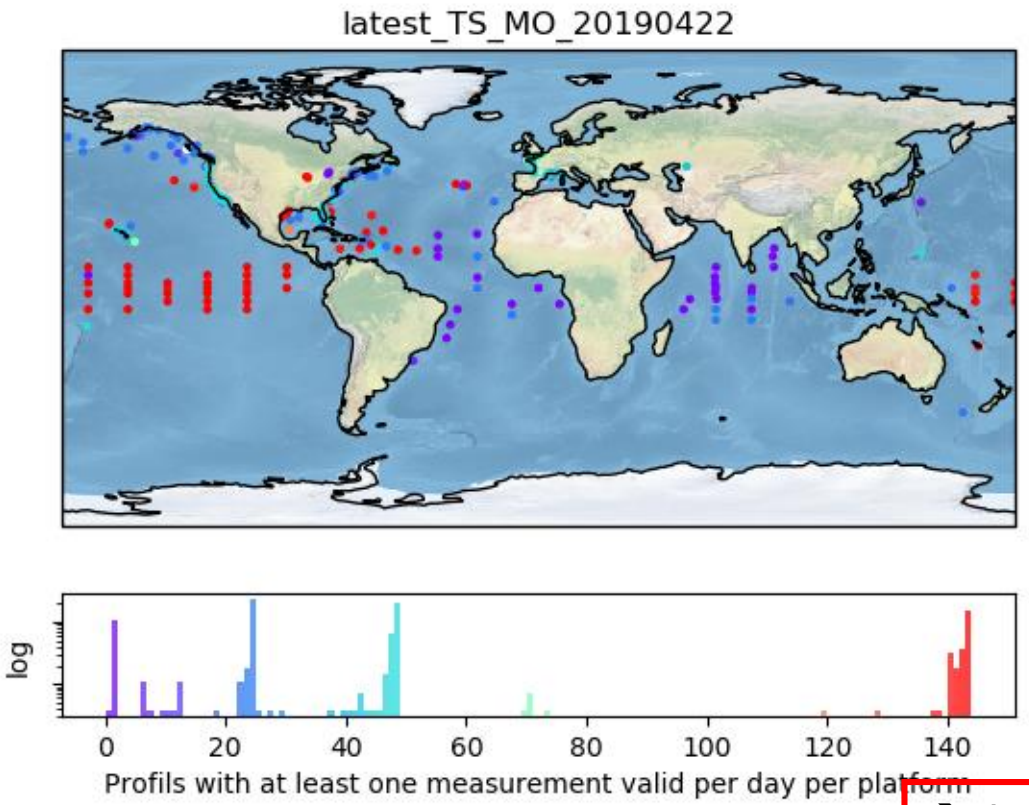


15 398 **Salinity** profiles (20190422)

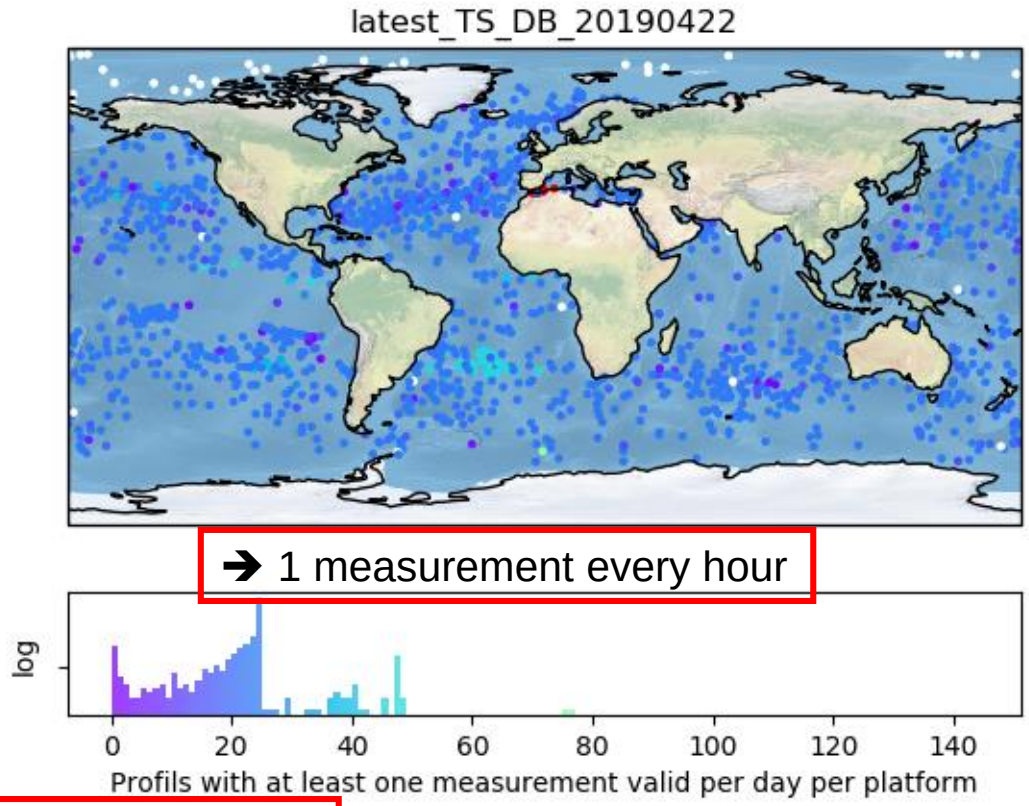


T/S profiles - Inventory: latest, 1 day, all profiles

Moorings



Surface drifters

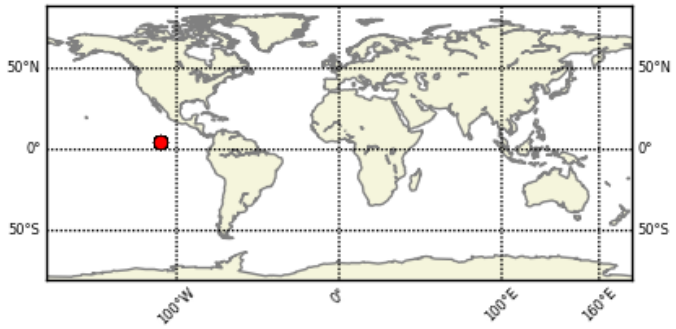


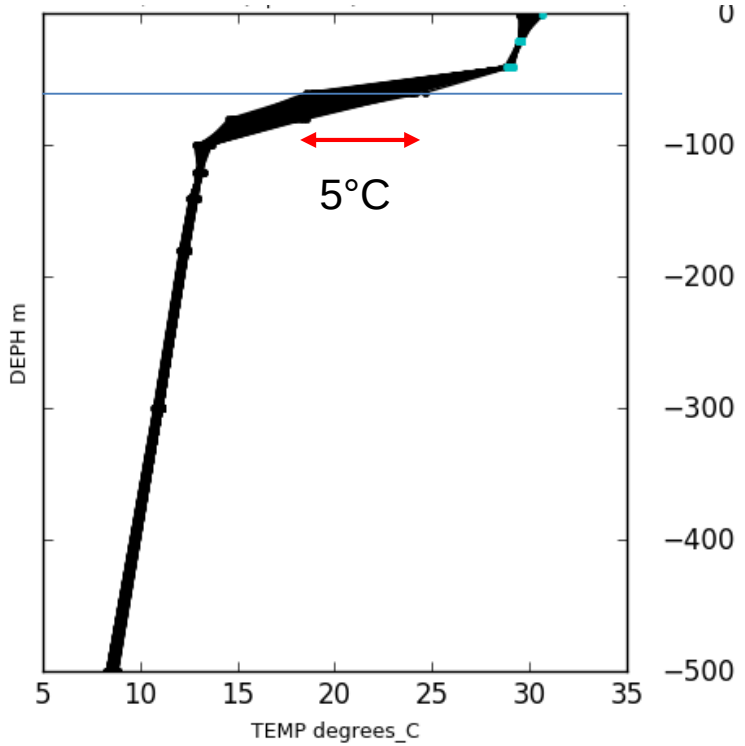
➔ 1 measurement every hour

➔ 1 profile every 10 minutes

T/S profiles - Inventory: latest, 1 day, all profiles

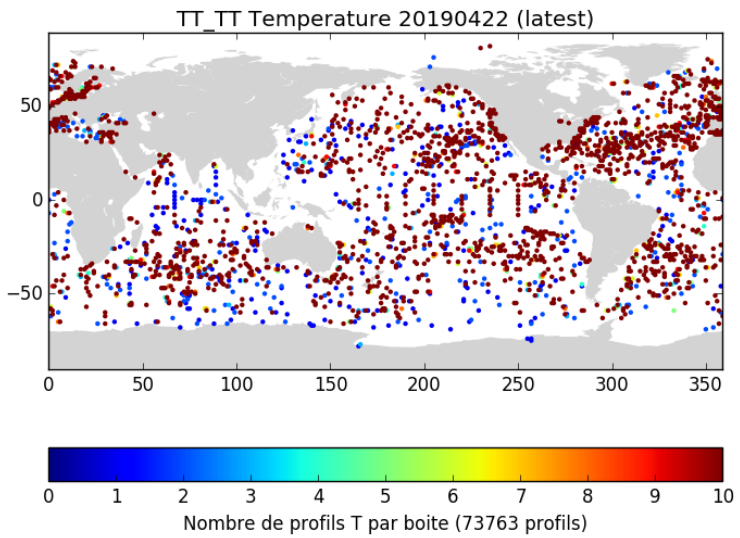
Mooring: 5°N, 110°W, **144 profiles**, 20190422





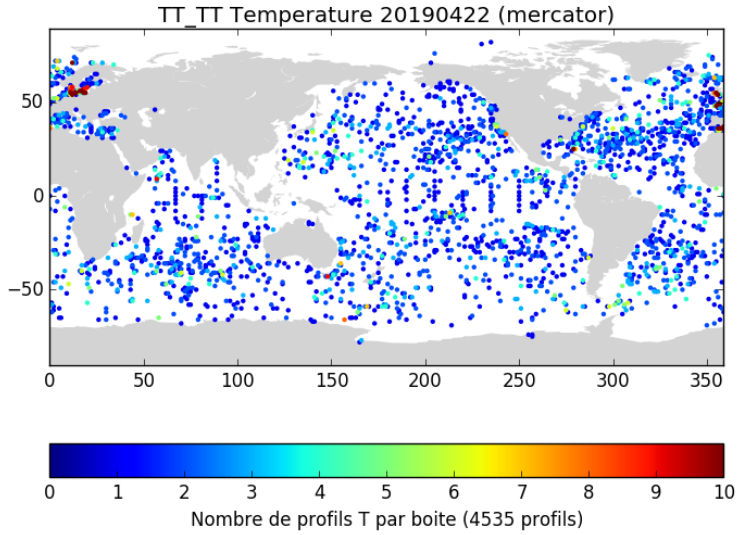
➔ 1 profile every 10 minutes

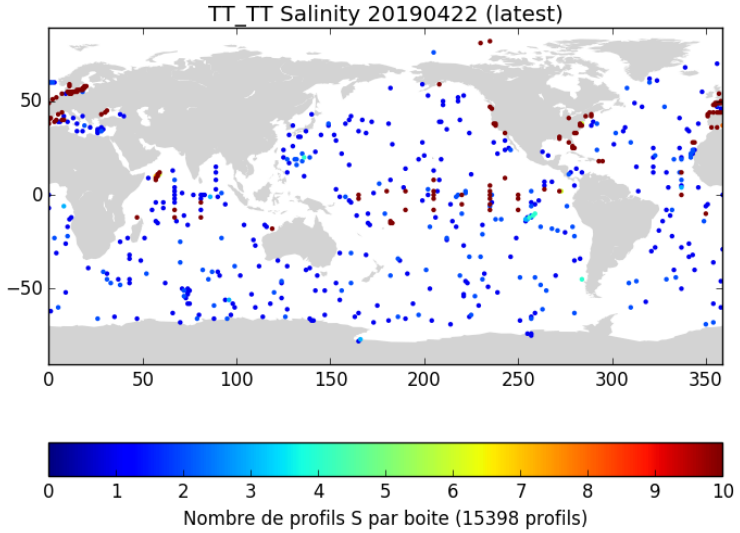
T/S profiles - Selection: 1 day, 1 profile/day/platform



Temperature

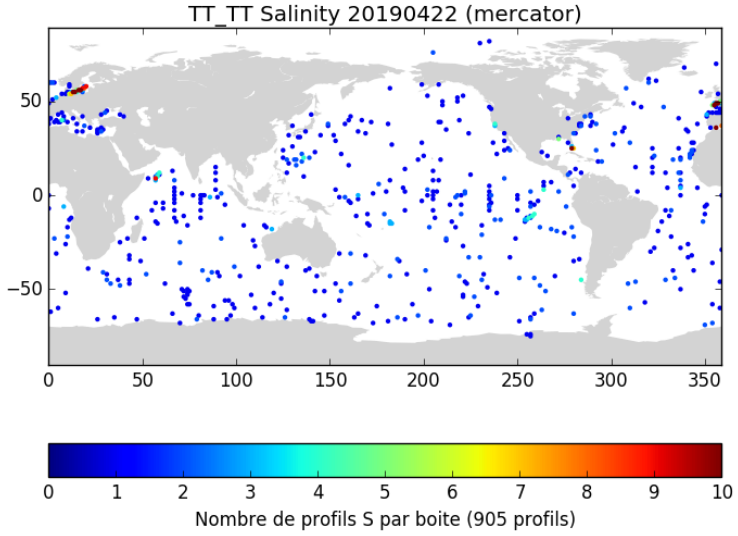
73 763 ➔ 4 535





Salinity

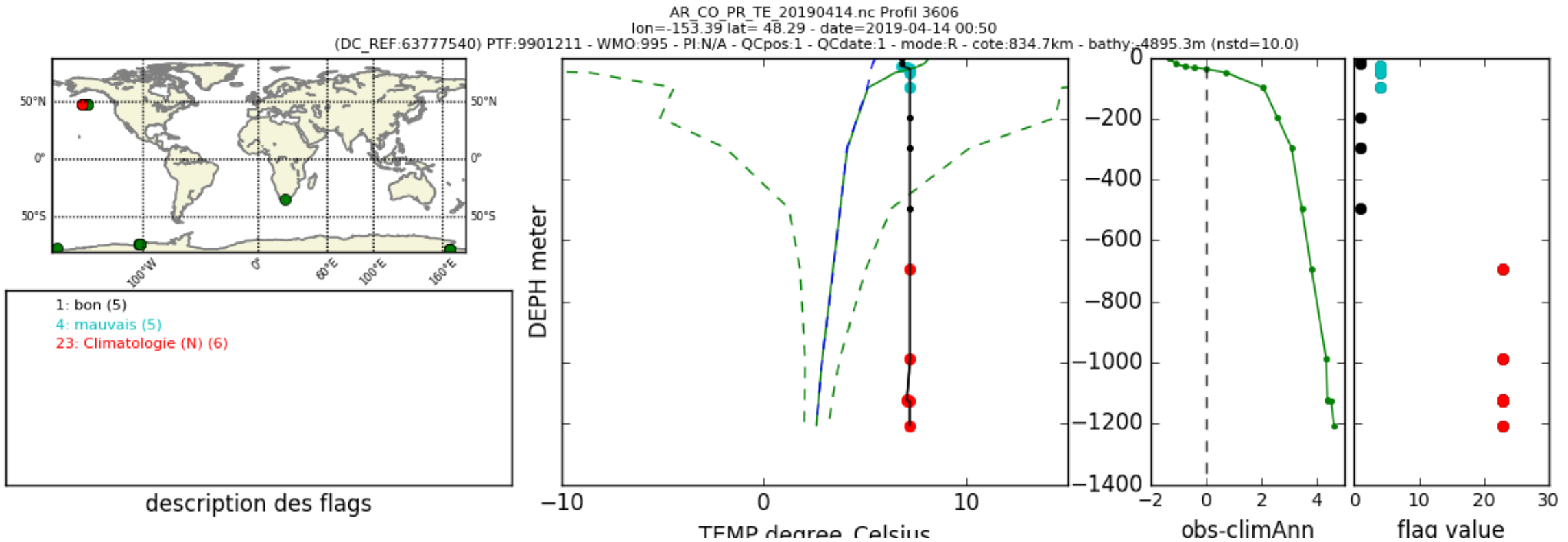
15 398 ➔ 905



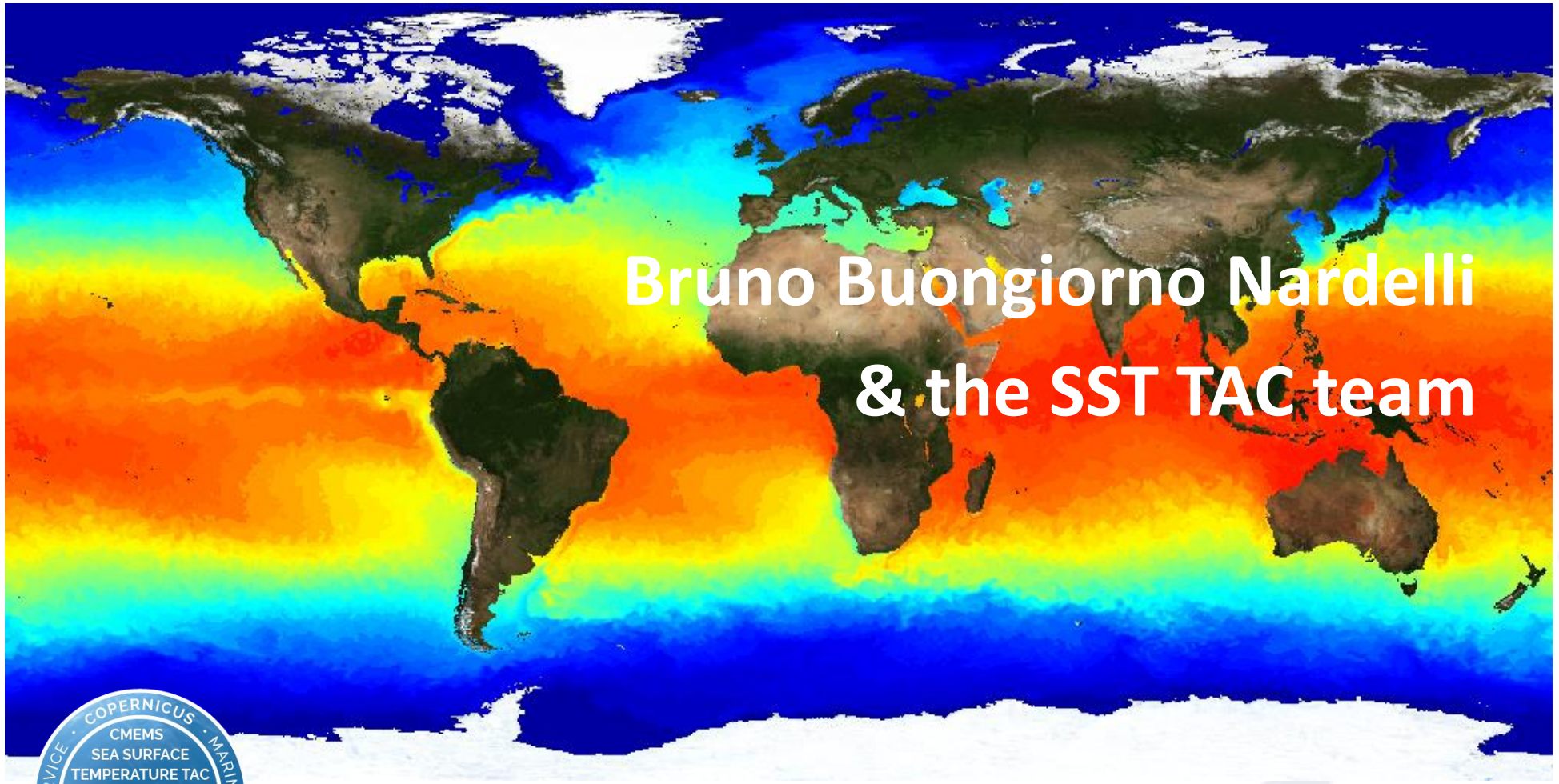
T/S profiles - Qualification ➔ flag

➔ **Third challenge** : qualify the data

!!! Each field (TEMP, PSAL, JULD, POSITION) comes with a **flag**



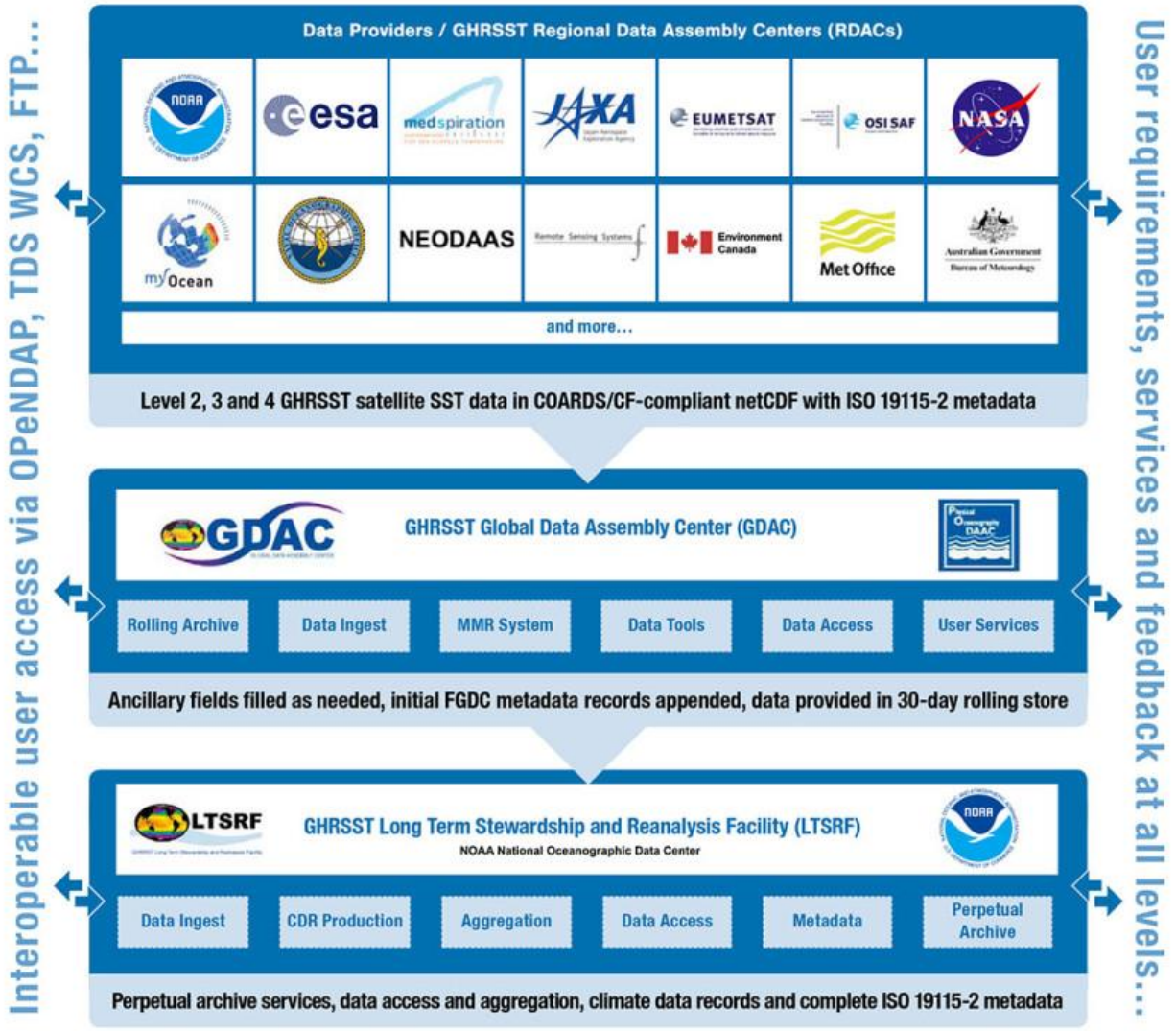
SST products



SST: the international framework

GHRSST
GROUP FOR HIGH RESOLUTION SEA SURFACE TEMPERATURE

https://www.ghrsst.org/



NRT: products within few hours
REP: consistent re-processed time series

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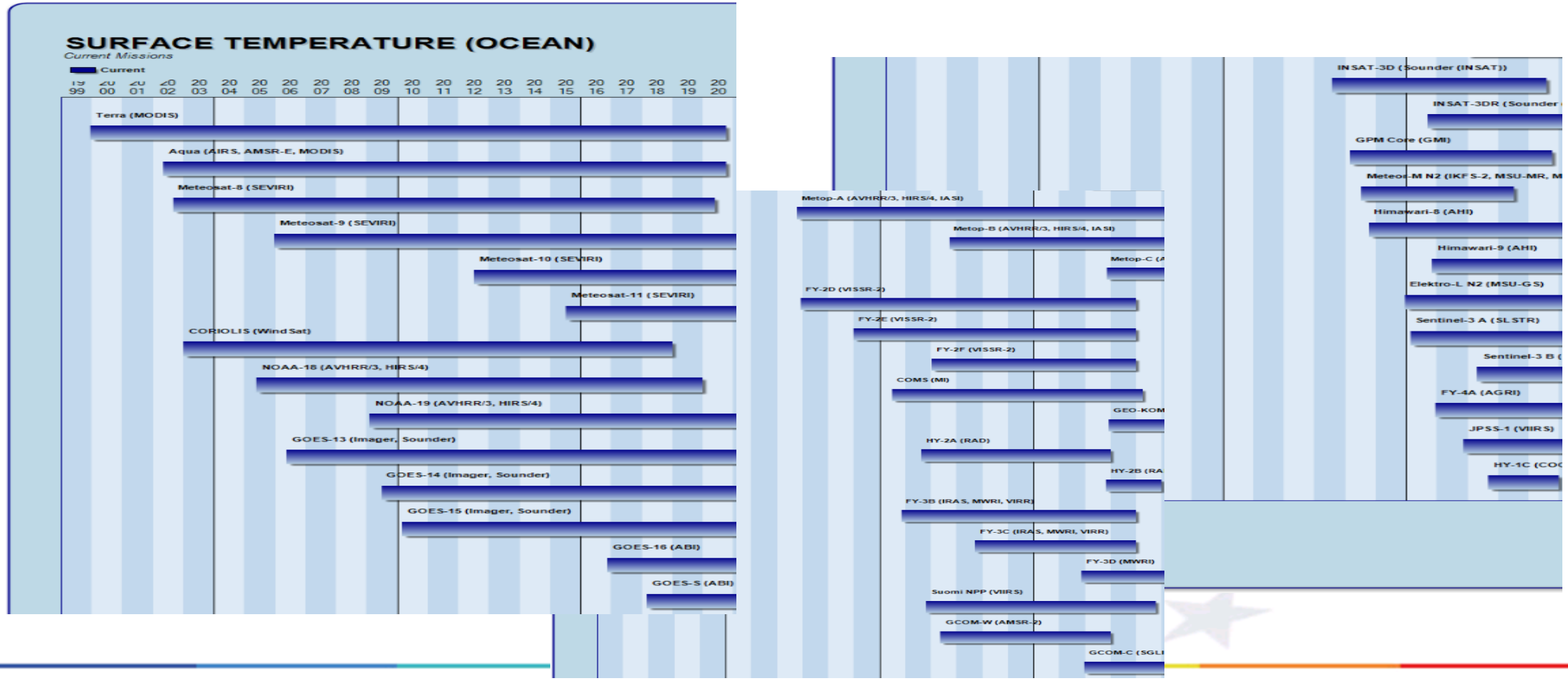
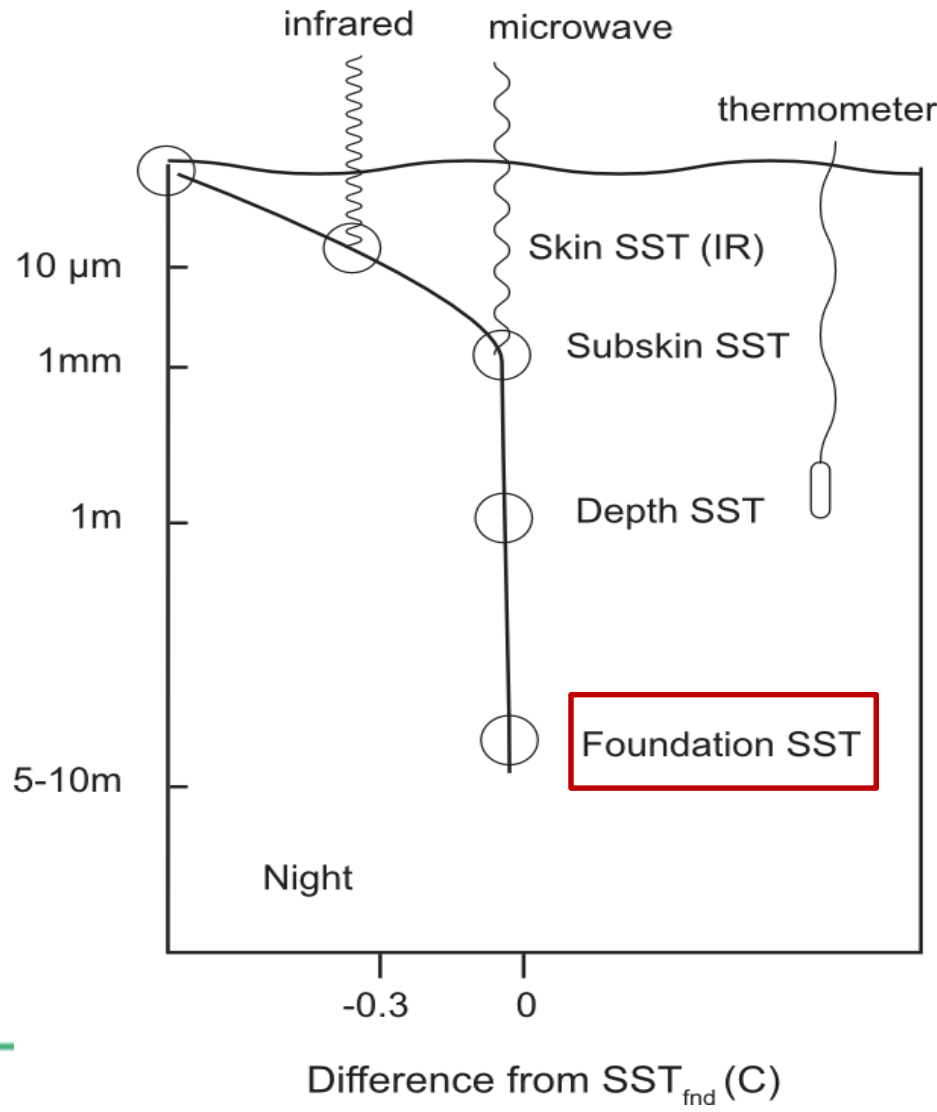
SST constellation



28

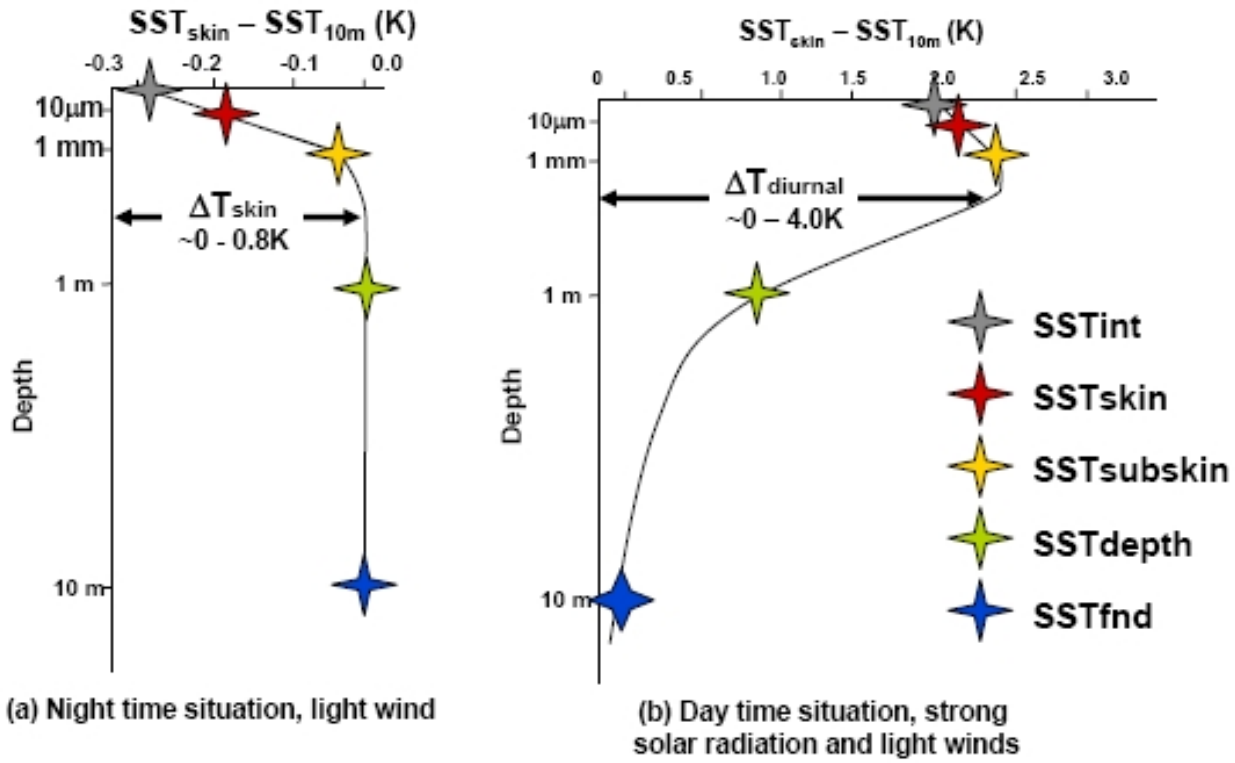
GHRSST: common SST definitions

- SST definitions are related to the instruments and to the retrieval algorithm used
- Satellite products may provide different SSTs



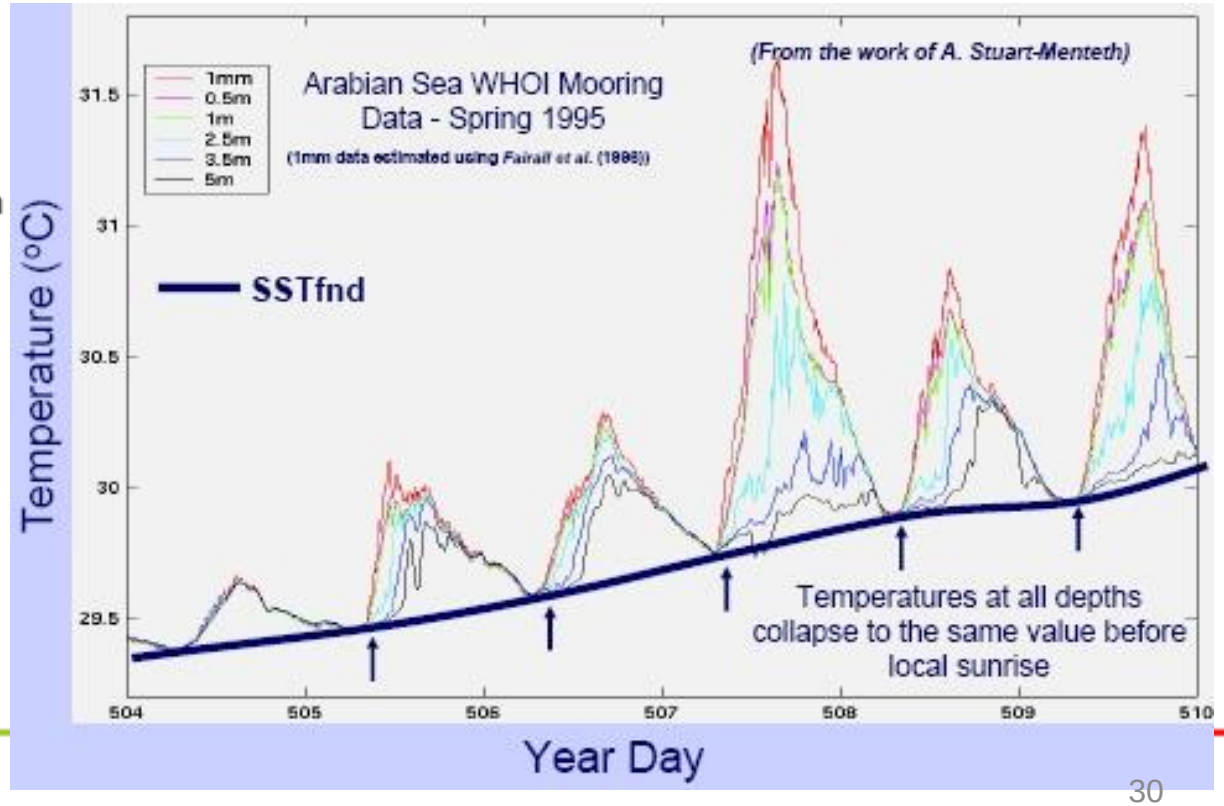
* free of diurnal temperature variability

SST: diurnal cycle



(a) Night time situation, light wind

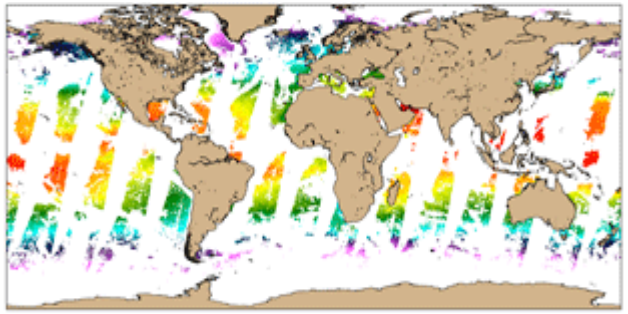
(b) Day time situation, strong solar radiation and light winds



SST Satellite product definitions, pros/cons

L2P (Pre-processed):

- the lowest level SST observations
- provide the highest number of true observations in time (at the original spatial resolution “pixel”)
- have limited coverage: single passages, no data under clouds (IR), rain (MW)
- do not include any adjustment of biases among different sensors/overpasses
- provided with Sensor Specific Error Statistics: provide an estimate of systematic and random errors at pixel level + quality level flags



Advanced users

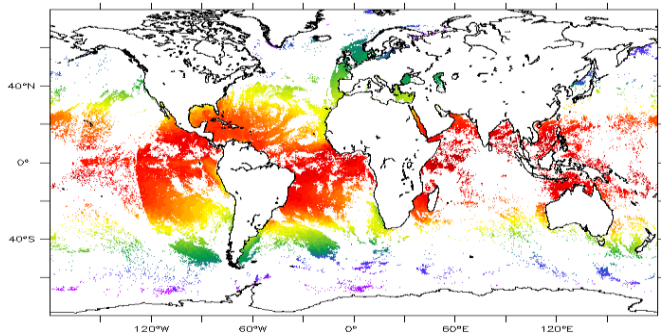
Skin & subskin SST

Producers: NASA, NOAA, EUMETSAT, OSI-SAF, ESA…

SST Satellite product definitions, pros/cons

L3S (Super-collated):

- combine observations from multiple sensors/passes
- providing higher coverage and including an adjustment of biases
- provide a composite/average
- are still affected by data voids due to cloud/rain.



Subskin SST, night-time data only (=Foundation SST)

Odyssea, Ifremer, CMEMS

SST_GLO_SST_L3S_NRT_OBSERVATIONS_010_010

- Global: 0.1° horizontal resolution, daily (each grid point is dated)

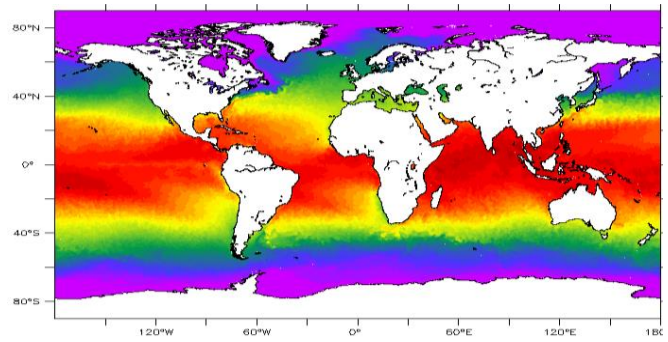
SST_EUR_SST_L3S_NRT_OBSERVATIONS_010_009_A

- European North Western Shelves: 0.02° horizontal resolution, daily

SST Satellite product definitions, pros/cons

L4 (gridded):

- generated by combining satellite and in situ observations within Optimal Interpolation/Variational methods
- gap-free maps ➔ original data smoothed (degree of smoothing, homogeneity of spectral content in space depend on the algorithm/configuration)



Foundation SST

Ostia, Met Office, CMEMS

SST_GLO_SST_L4_NRT_OBSERVATIONS_010_001

Global: 0.05° horizontal resolution, daily

Skin SST

Ostia, Met Office, CMEMS

SST_GLO_SST_L4_NRT_OBSERVATIONS_010_014

Global: 0.25° horizontal resolution, **hourly**

Many more products...

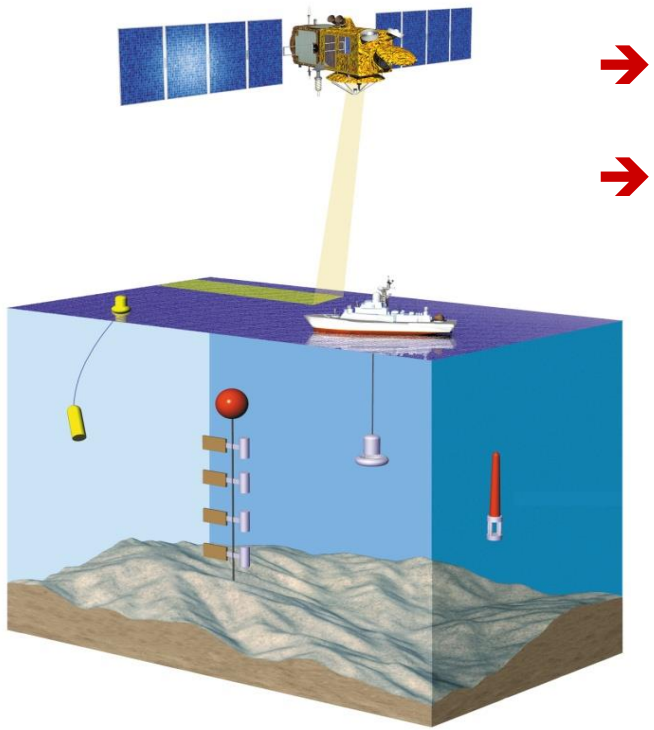
GHRSST MULTI-PRODUCT ENSEMBLE (GMPE)

Each day the GHRSST Multi-product Ensemble (GMPE) experiment, coordinated by the GHRSST Inter-Calibration TAG (IC-TAG), produces a median SST map and associated standard deviation map using SST analysis data collected over the last 24 hour period (i.e. yesterday). Thus, the nominal analysis time for the GMPE median ensemble SST is 12:00Z for the previous day (i.e., T-1). The image data sets are updated each day ~13:30Z.

The GMPE median ensemble SST map (click here) is computed as a median average using a variety of GHRSST L4 analysis products after their differing analysis grids have been homogenised by area averaging onto a standard 0.5° lat/lon grid. Although several analyses provide greater coverage (such as large lakes) the median-ensemble SST coverage is restricted by the use of the OSTIA analysis land mask. The GMPE median ensemble SST is currently derived using the following inputs:

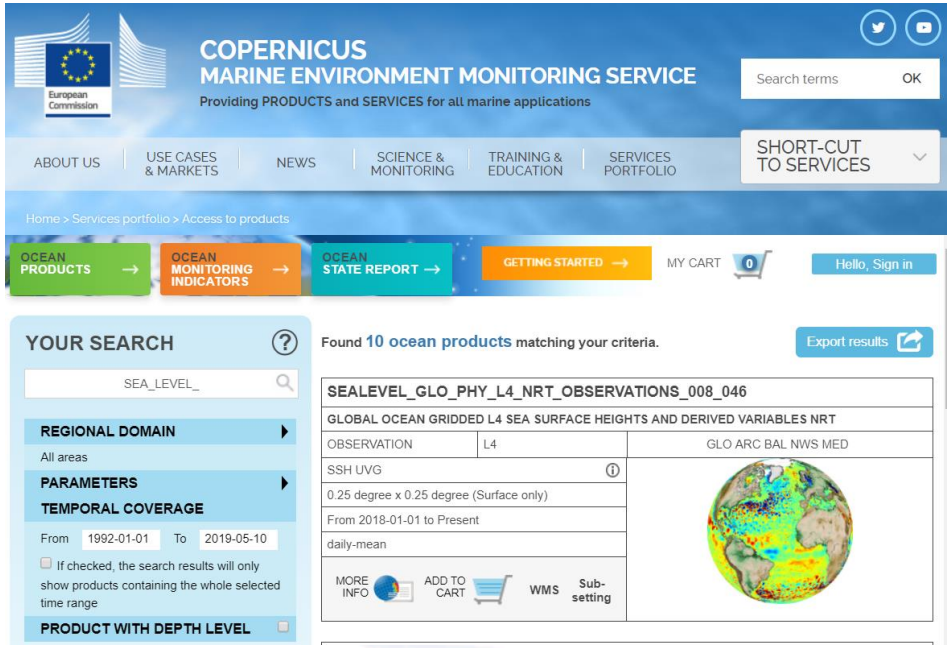
- Met Office OSTIA SST analysis
- NCEP RTG_SST_HR SST analysis
- NAVOCEANO NAVO K10 SST observations
- JMA MGDSST SST analysis
- RSS RSS MW Fusion SST analysis
- RSS RSS MW+IR Fusion SST analysis
- FNMOC GHRSST-PP SST and sea Ice analysis
- Ifremer ODYSSEA SST analysis
- NOAA AVHRR OI (Reynolds).
- Meterological Service of Canada (CMC) 1/3 degree SST analysis.
- BMRC GAMSSA SST analysis

Physical Observations used for Assimilation



- ➔ Sea level anomalies from satellite altimeter
- ➔ In-situ T/S profiles
- ➔ SST from satellites

- ➢ Product User Manual
- ➢ Quality Information Document



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