Designing new ultra high resolution Sea Surface Temperature products in coastal areas for the future TRISHNA mission

Laura Orgambide [(1)], Emmanuelle Autret [(1)], Elea Paul [(1)],

Jean-François Piollé [(1)], Stéphane Saux-Picart [(2)], P. Gamet [(3)]

(1) Ifremer, Univ. Brest, CNRS, IRD, Laboratoire d'Oceanographie Physique et Spatiale (LOPS), IUEM, Brest, France, (2) CNRM UMR3589, Météo-France – CNRS, Centre d'Etudes en Météorologie Satellitaire, France, (3) CNES, Toulouse, France

Sea Surface Temperature interests and existing products

Essential Climate Variable (ECV)

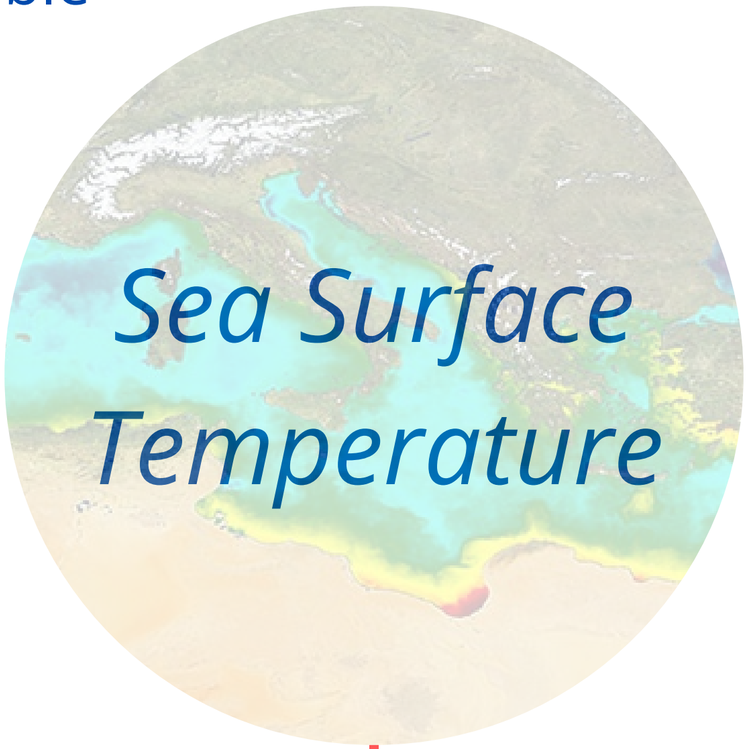
marine biodiversity

weather and oceanographic forecasting systems

fishery

offshore activities monitoring

water quality monitoring



Suffers notoriously quality in coastal area

1-km resolution products

VIIRS (Suomi-NPP) *AVHRR (METOP)*

SLSTR (Sentinel-3)

GHRSST *

study mesoscale and sub-mesocale features

*GHRRST: Group for High-Resolution Sea Surface Temperature

CALISTA product for the future TRISHNA mission

High spatial resolution thermal data

ECOSTRESS

Landsat 8/9

TRISHNA

LSTM

SBG

New coastal applications

water quality monitoring

aquaculture

offshore activities

CALISTA* product

A high spatial resolution SST product

split-window algorithm

calibrate and validate the estimated SST product with GHRSST SST products and/or *in-situ measurements*

*CALISTA : Coastal 100m resolution Sea Surface Temperature from satellite infrared sensors

Input data and area of interest

High spatial resolution thermal data

ECOSTRESS

- downloading 35 To
- over Iberia Biscay Irish (IBI) Zone
- from 2019 to present
- 3 thermal infrared bands in the 8-12.5 µm
- 70 m spatial resolution

LANDSAT 9 - TIRS

- downloading in progress …
- over Iberia Biscay Irish (IBI) Zone
- from 2021 to present
- 2 thermal infrared bands in the 10.6-12.5 µm
- 60 m spatial resolution

GHRSST SST products for calibration and validation

SLSTR (Sentinel-3) VIIRS (Suomi-NPP) AVHRR (METOP)

- ~ 1 km resolution

Iberia Biscay Irish (IBI) zone

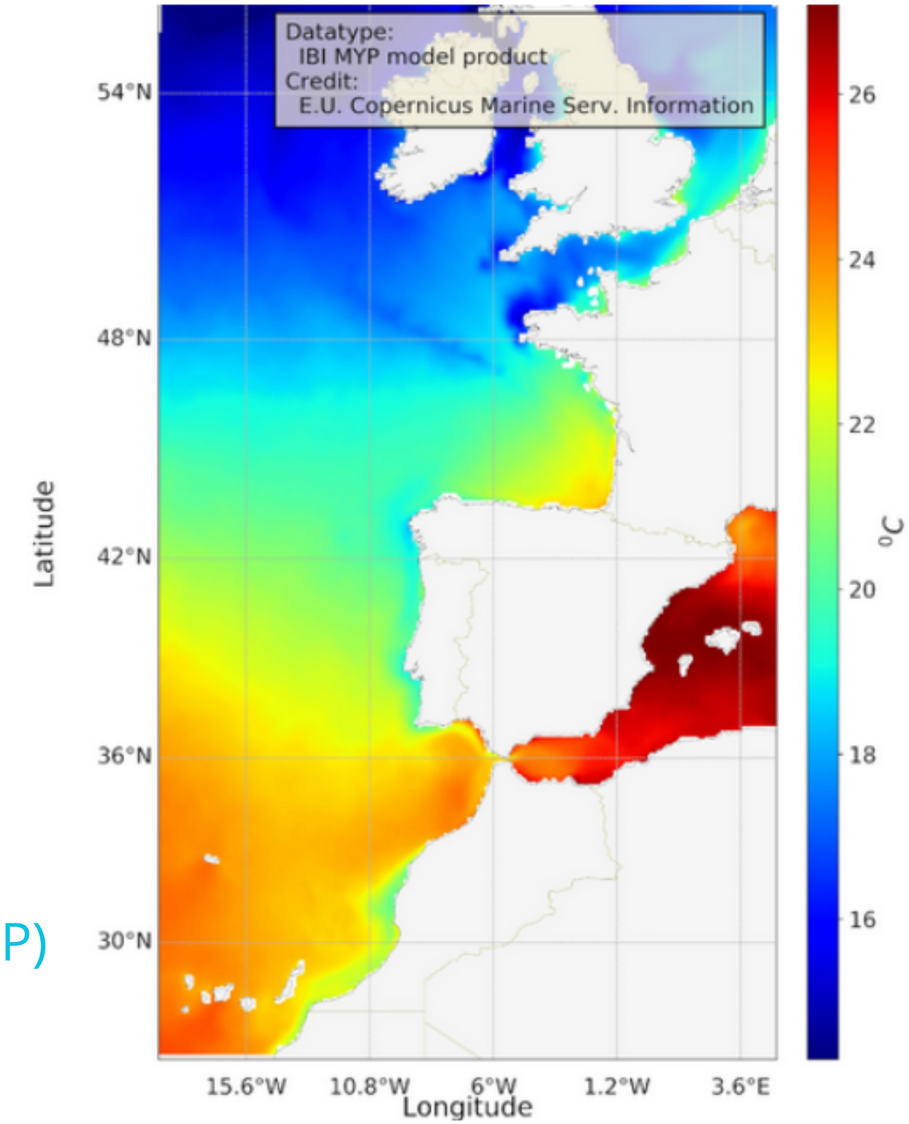
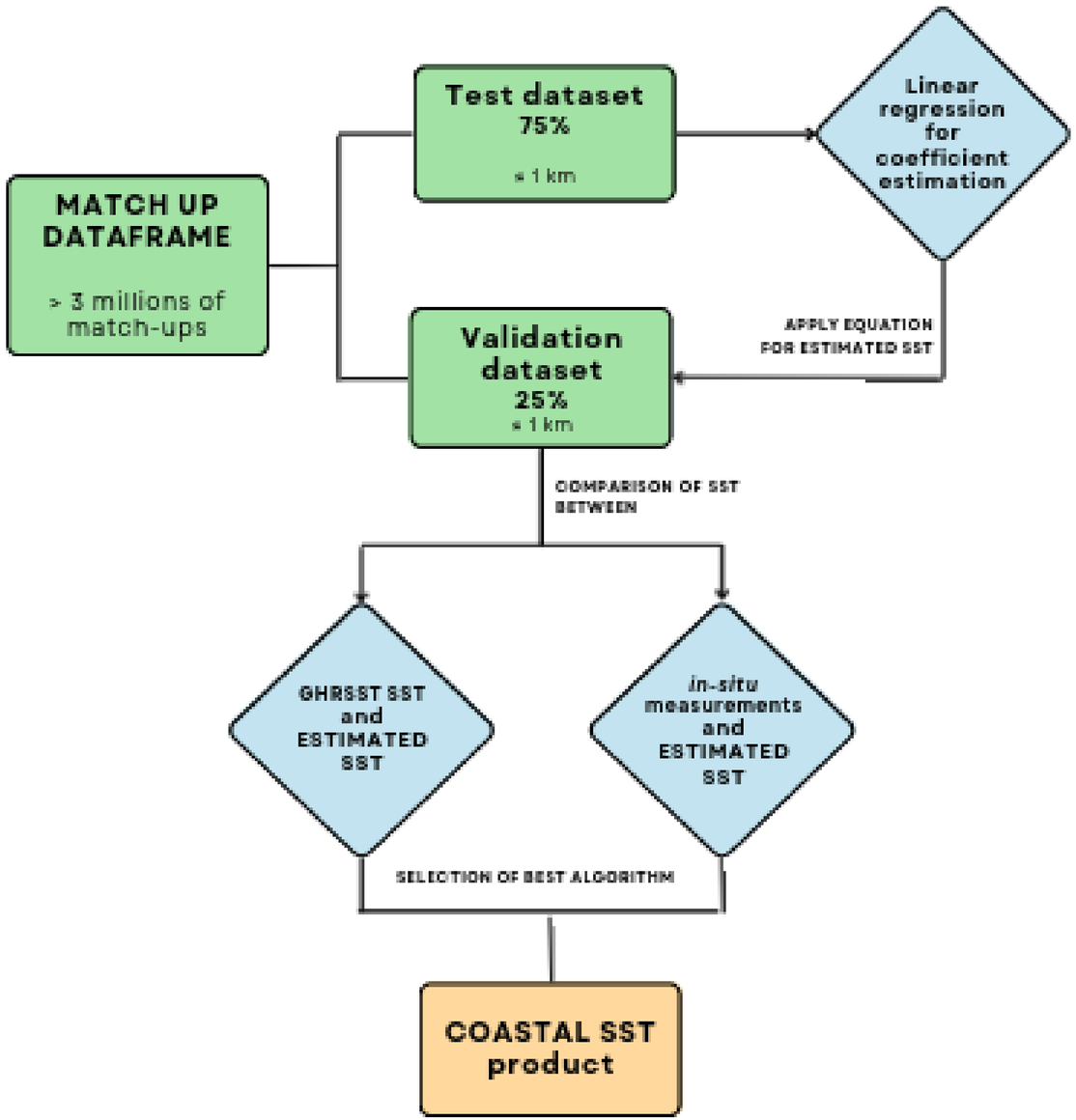


Figure 1 - Sea Surface Temperature MYP model over Iberia Biscay Irish (IBI) zone. Source: E.U. Copernicus Marine Service Information.

SST estimation method with 4 split-window equations

SST ESTIMATION WITH SPLIT-WINDOW ALGORITHM



4 split-window algorithm tested:

→ NLSST

$$estimated\_SST = (a \times BT8 + b \times (sec-1) + c \times dBT + d + e \times (sec-1)$$

→ NLSST2

$$estimated\_SST = (a + b \times (sec-1)) \times BT8 + (c + d \times (sec-1)) \times dBT + e + f \times (sec-1)$$

→ NLCSST

$$estimated\_SST = (a + b \times (sec-1)) \times BT10 + (c + d \times (sec-1)) \times dBT + e + f \times (sec-1)$$

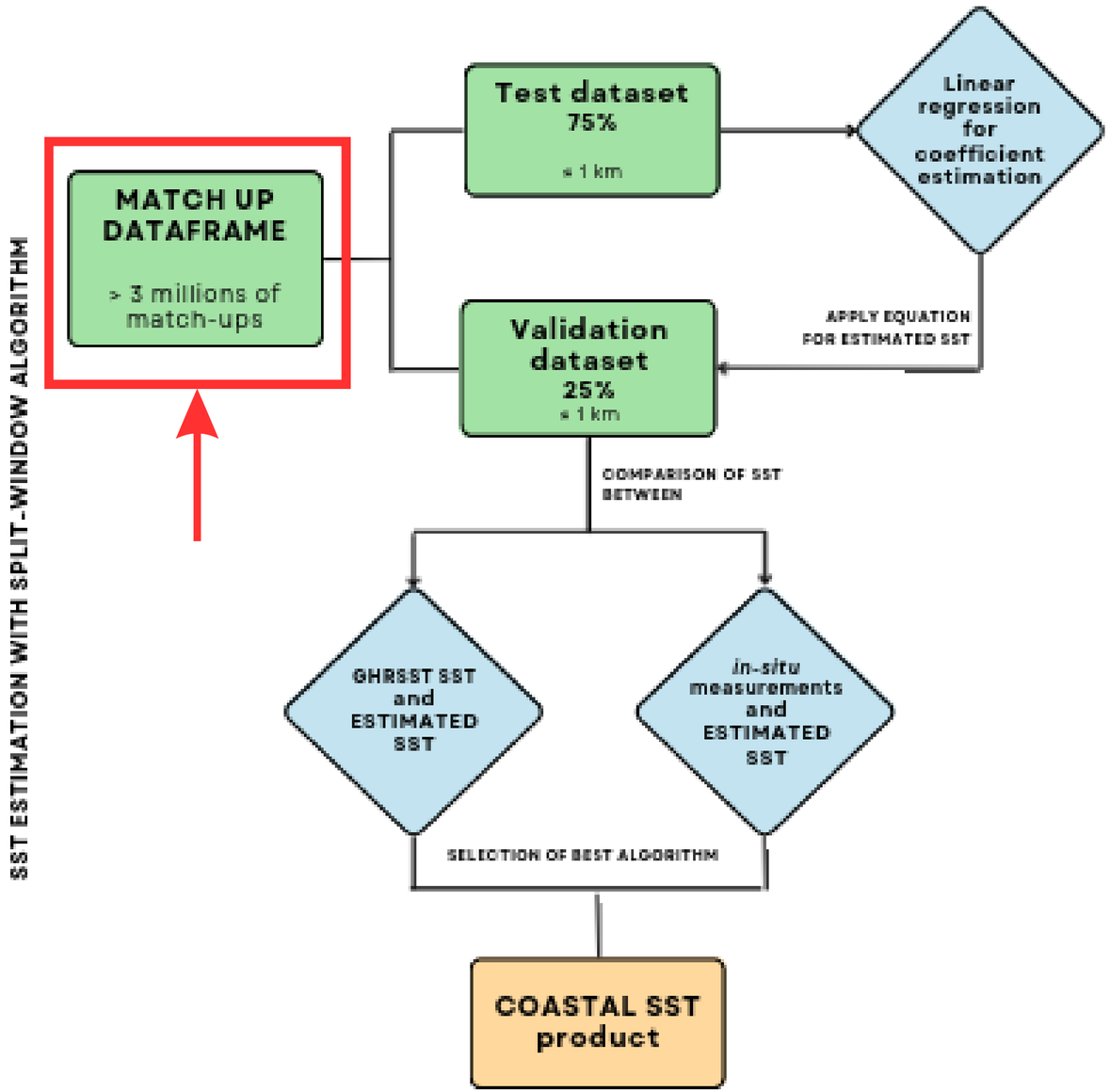
→ NL3CSST

$$estimated\_SST = (a + b \times (sec-1)) \times BT10 + (c + d \times (sec-1)) \times dBT8 + e + f \times (sec-1)$$

where dBT = BT10 - BT12 ; dBT8 = BT8 - BT12 and where sec is the secante of zenithal satellite view.

→ **4 equations x (3 reference sensors (VIIRS, SLSTR, AVHRR) + RTTOV) = 16 combinations to assess**

SST estimation method with 4 split-window equations



4 split-window algorithm tested:

→ NLSST

$$estimated\_SST = (a \times BT8 + b \times (sec-1) + c \times dBT + d + e \times (sec-1)$$

→ NLSST2

$$estimated\_SST = (a + b \times (sec-1)) \times BT8 + (c + d \times (sec-1)) \times dBT + e + f \times (sec-1)$$

→ NLCSST

$$estimated\_SST = (a + b \times (sec-1)) \times BT10 + (c + d \times (sec-1)) \times dBT + e + f \times (sec-1)$$

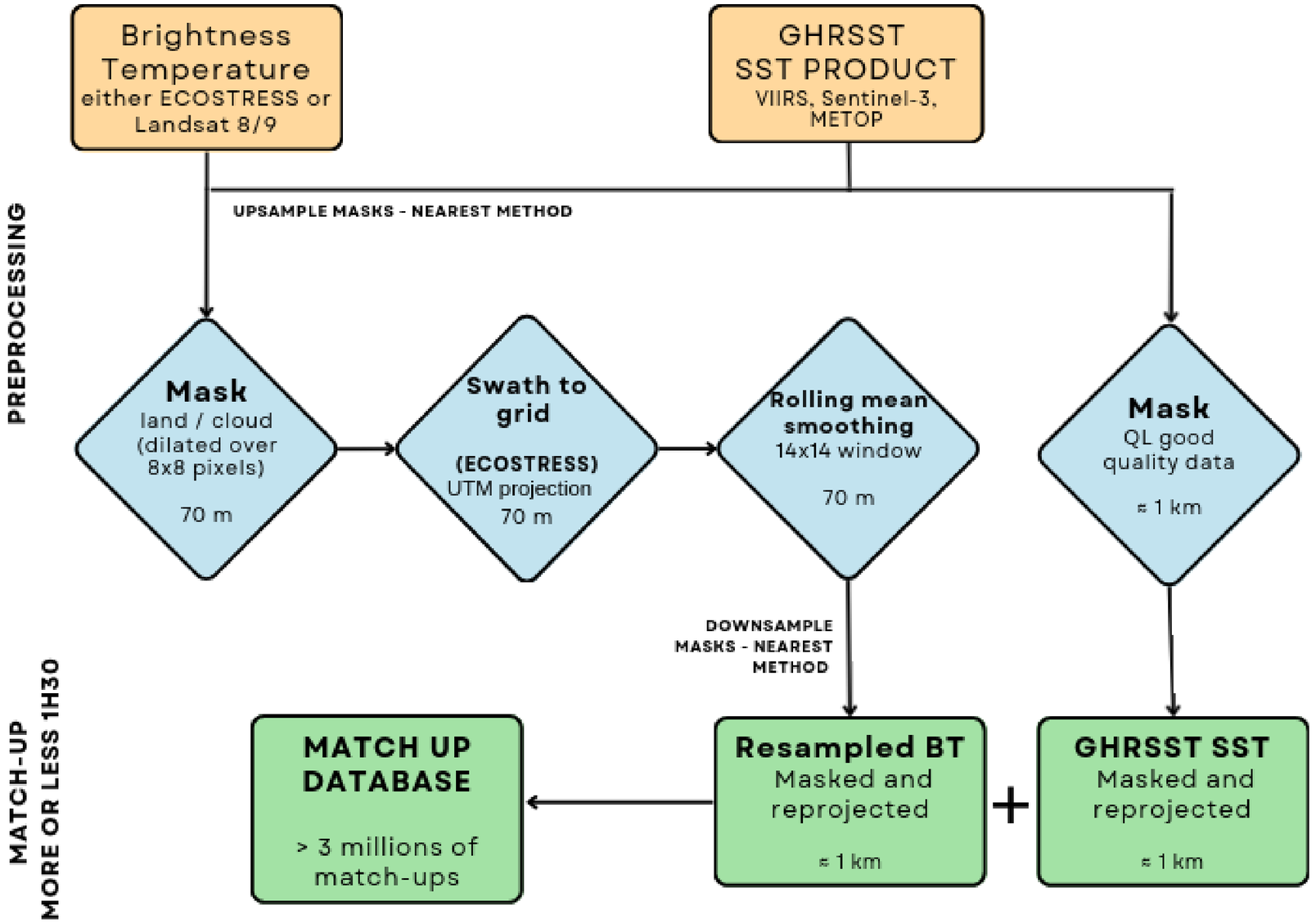
→ NL3CSST

$$estimated\_SST = (a + b \times (sec-1)) \times BT10 + (c + d \times (sec-1)) \times dBT8 + e + f \times (sec-1)$$

where dBT = BT10 - BT12 ; dBT8 = BT8 - BT12 and where sec is the secante of zenithal satellite view.

→ **4 equations x (3 reference sensors (VIIRS, SLSTR, AVHRR) + RTTOV) = 16 combinations to assess**

Match-up database for algorithm definition



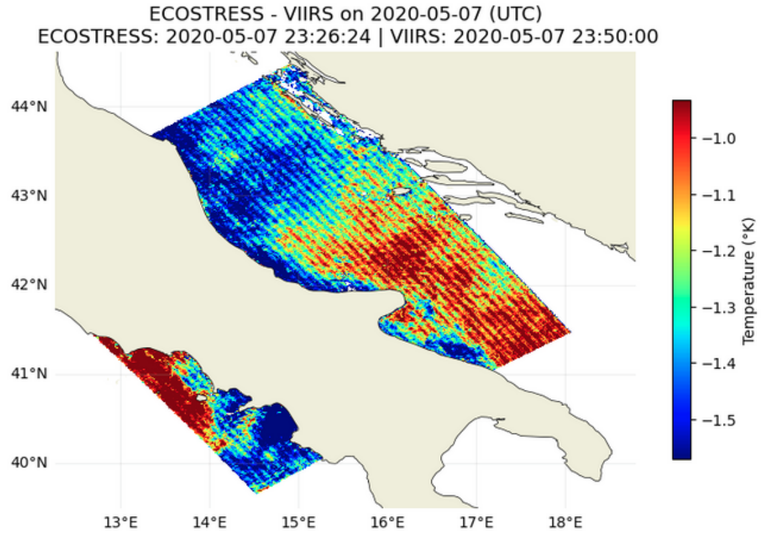


Figure 2 - Example of match-up between ECOSTRESS and VIIRS. Source: Laura Orgambide, CALISTA project.

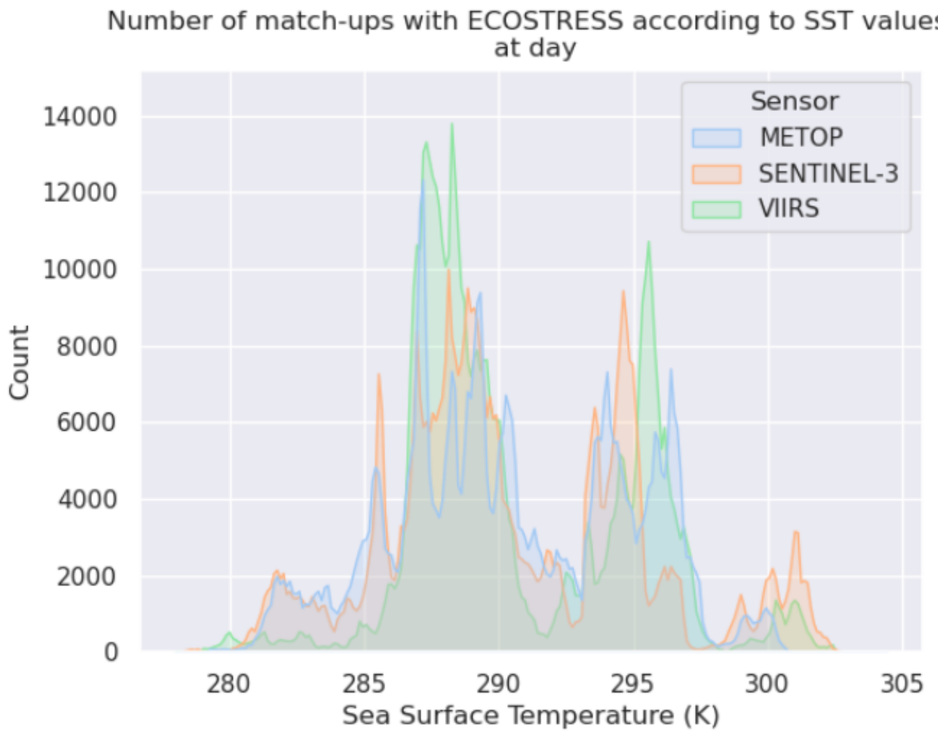
→ masking process reveals quality defect in products (see discussion)

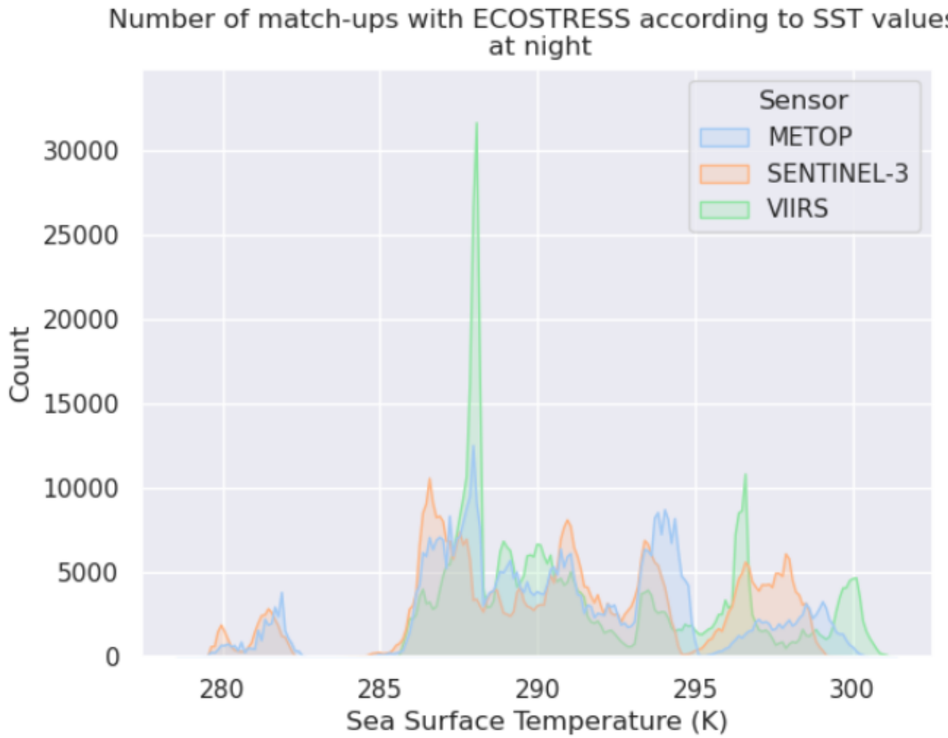
→ match-up database requires to select data carefully (see 3. Data)

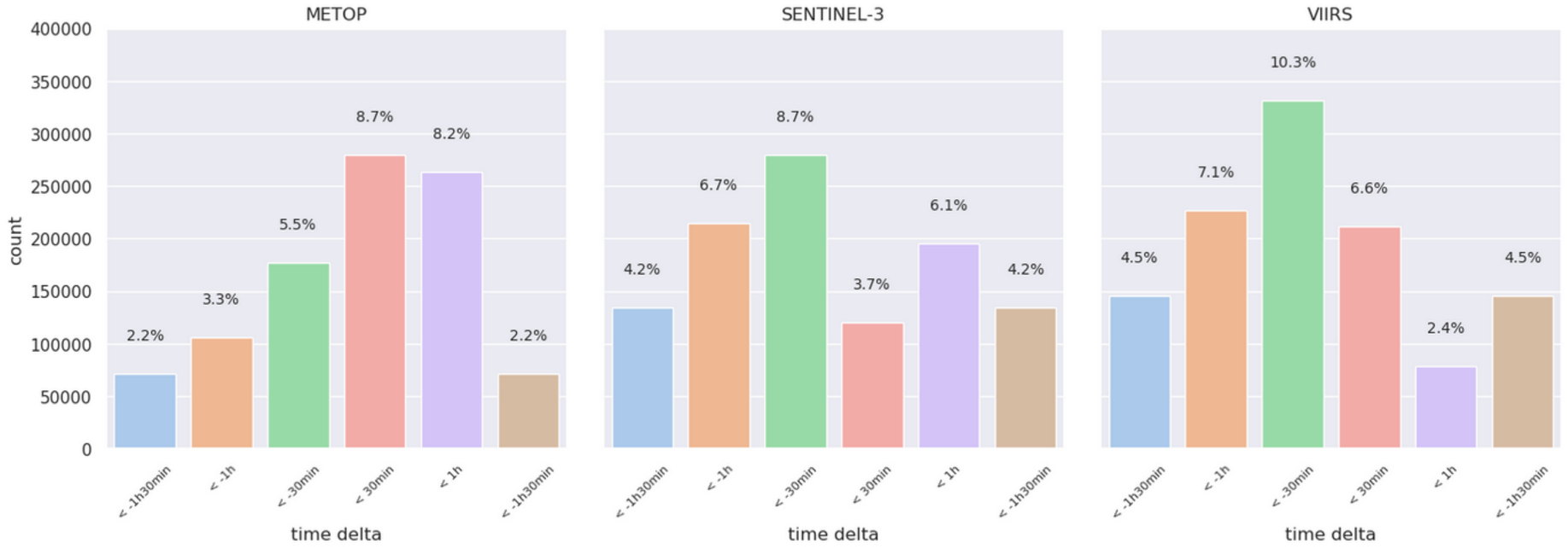
3. Method

Selecting representative oceanographic database

- 168 scenes selected with visual quality assessment
- around 3 millions of match-ups
- evenly distributed between 280 K to 300 K and day/night flag
- most of match-ups have a time delta inferior to more or less 30 minutes

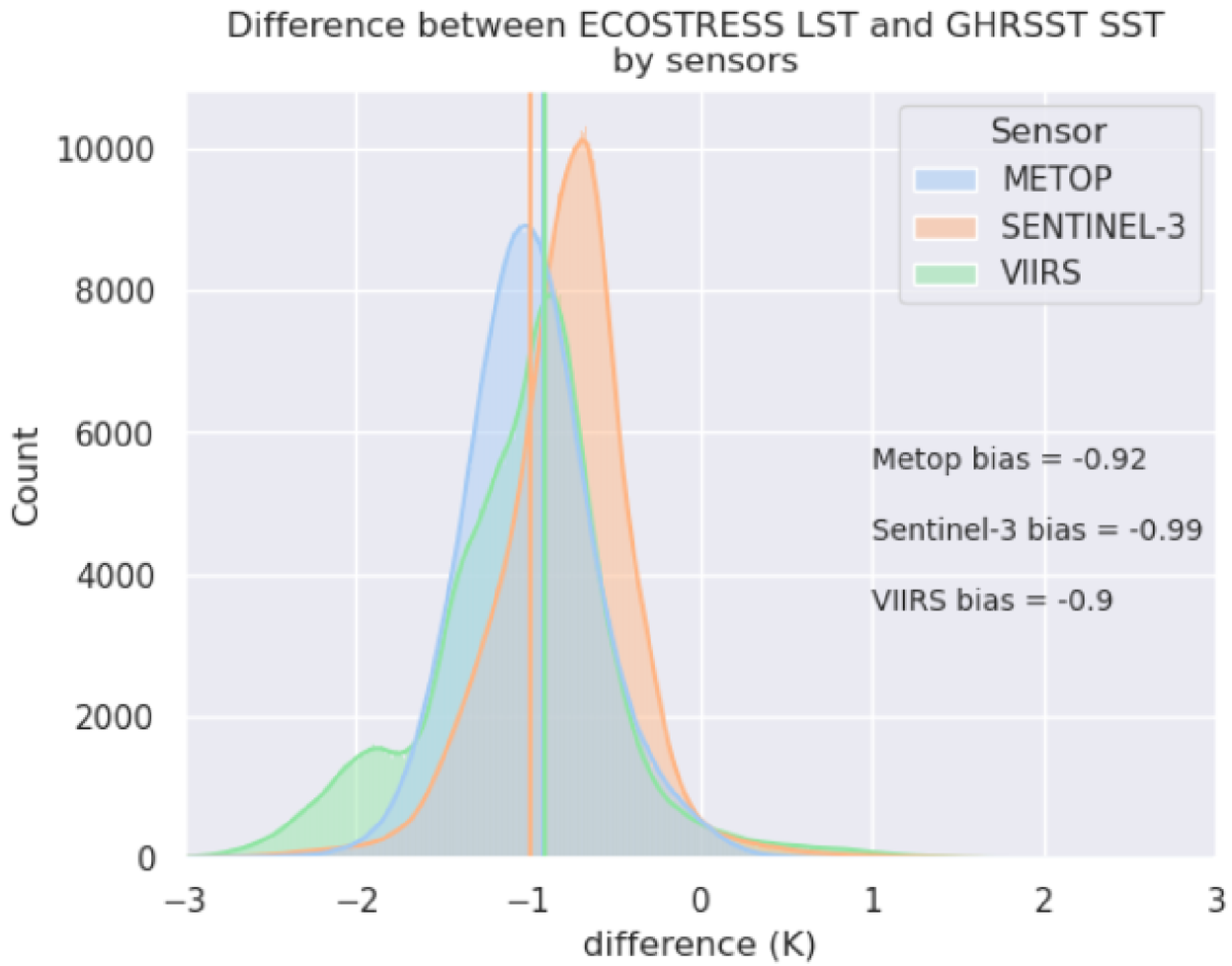


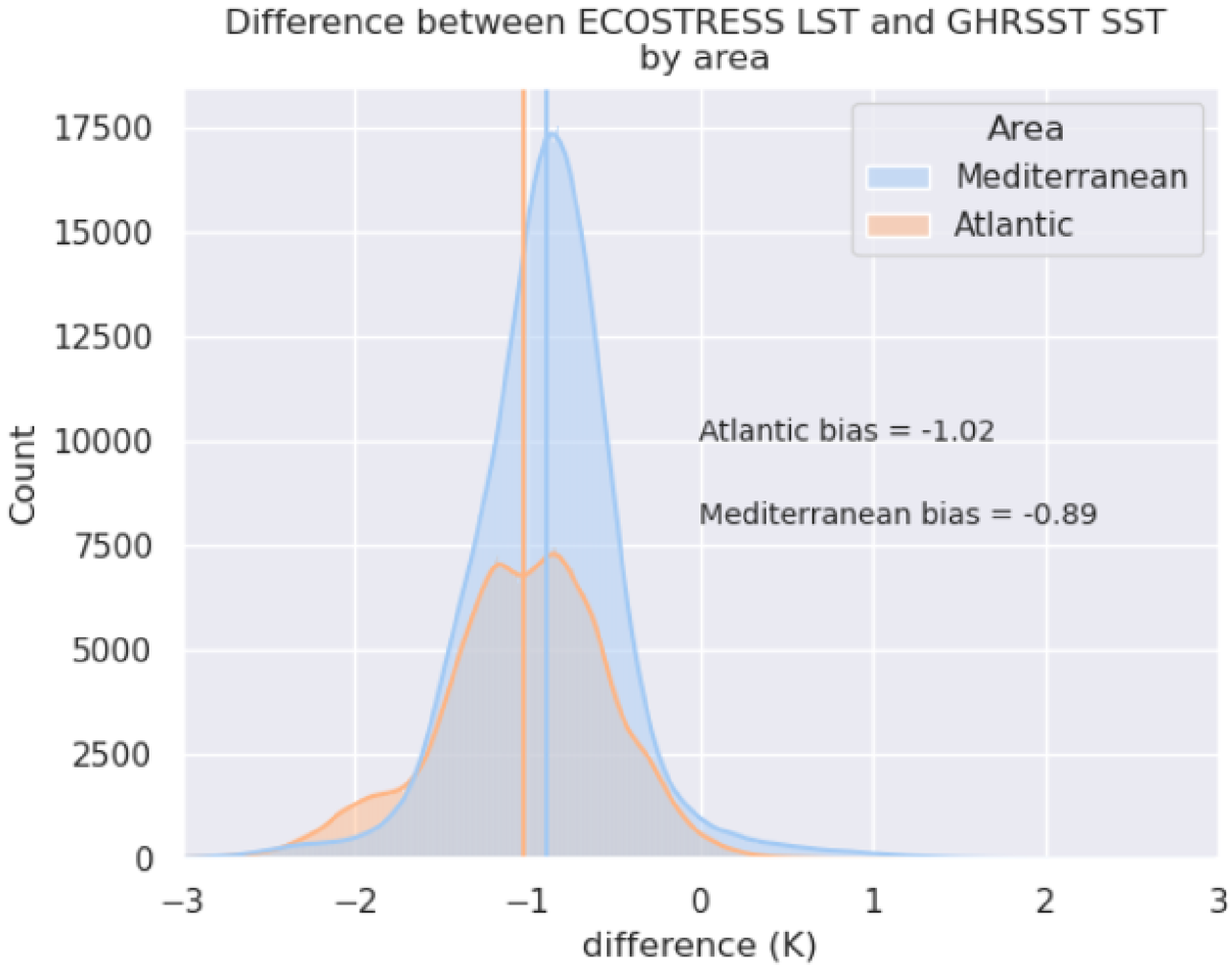




Comparison GHRSST SST with ECOSTRESS Land Surface Temperature (LST)

Land Surface Temperature product from NASA





→ With Land Surface Temperature (LST) match-ups, a systematic bias of 1 K is observed (See D. Wethey's presentation)

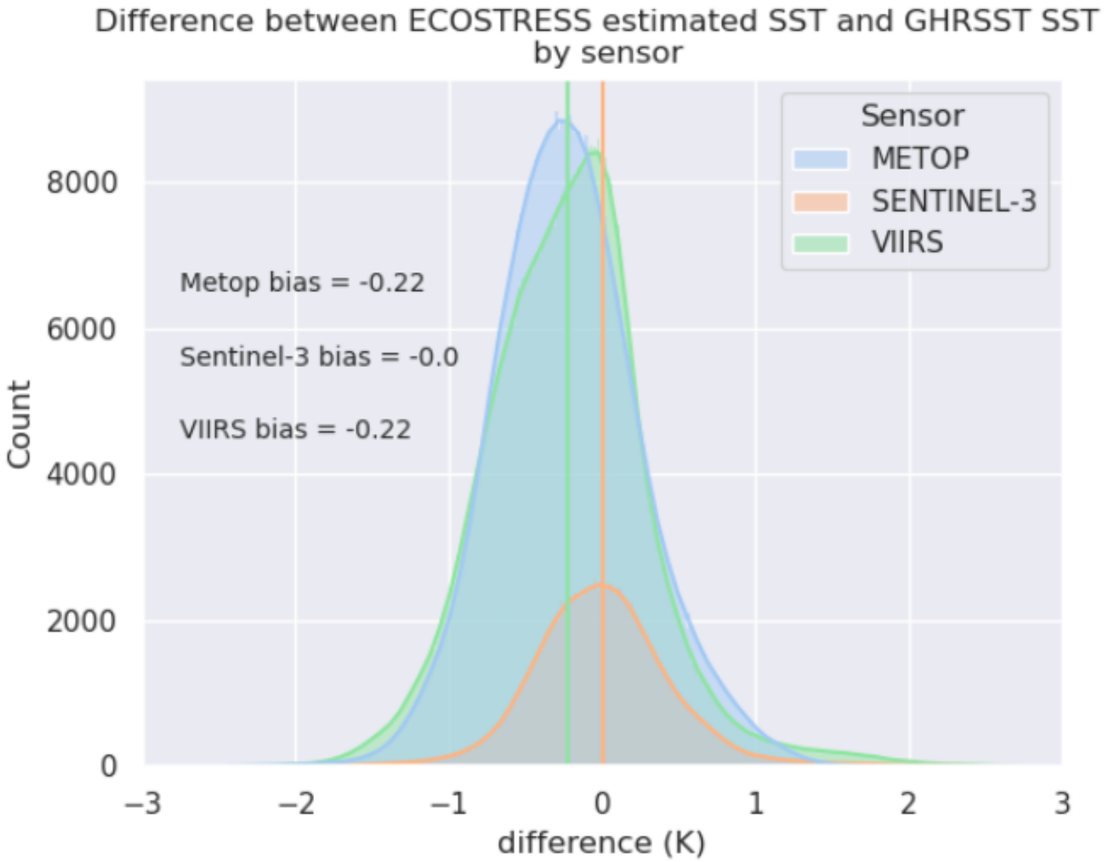
→ Cold bias over coastal regions in the Atlantic and the Mediterranean Sea

4. First results

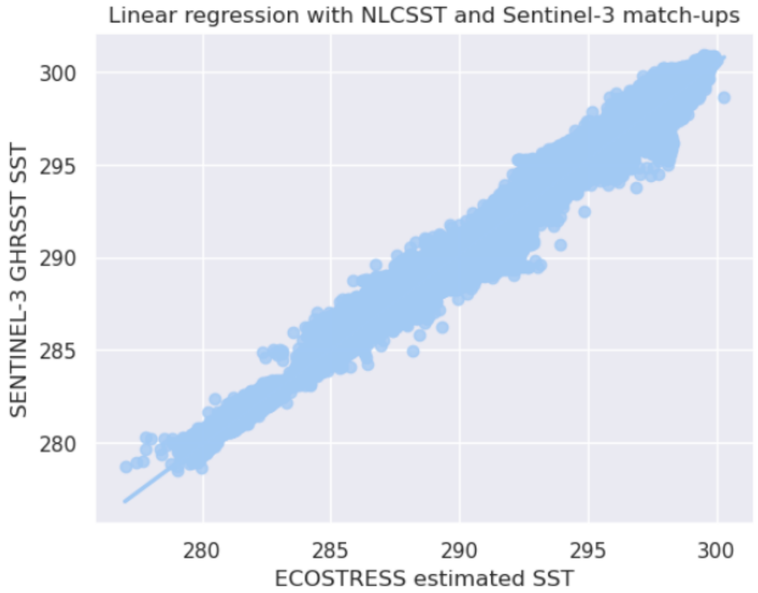
Validation of ECOSTRESS estimated Sea Surface Temperature (SST)

- NLCSST equation ajusted with Sentinel-3 data was selected.
- SST bias ~ 0 K when compared to the Sentinel-3 validation dataset
- SST bias ~ -0.2 K when compared to the METOP or to the VIIRS validation dataset

Sea Surface Temperature retrievals from Ifremer CALISTA product



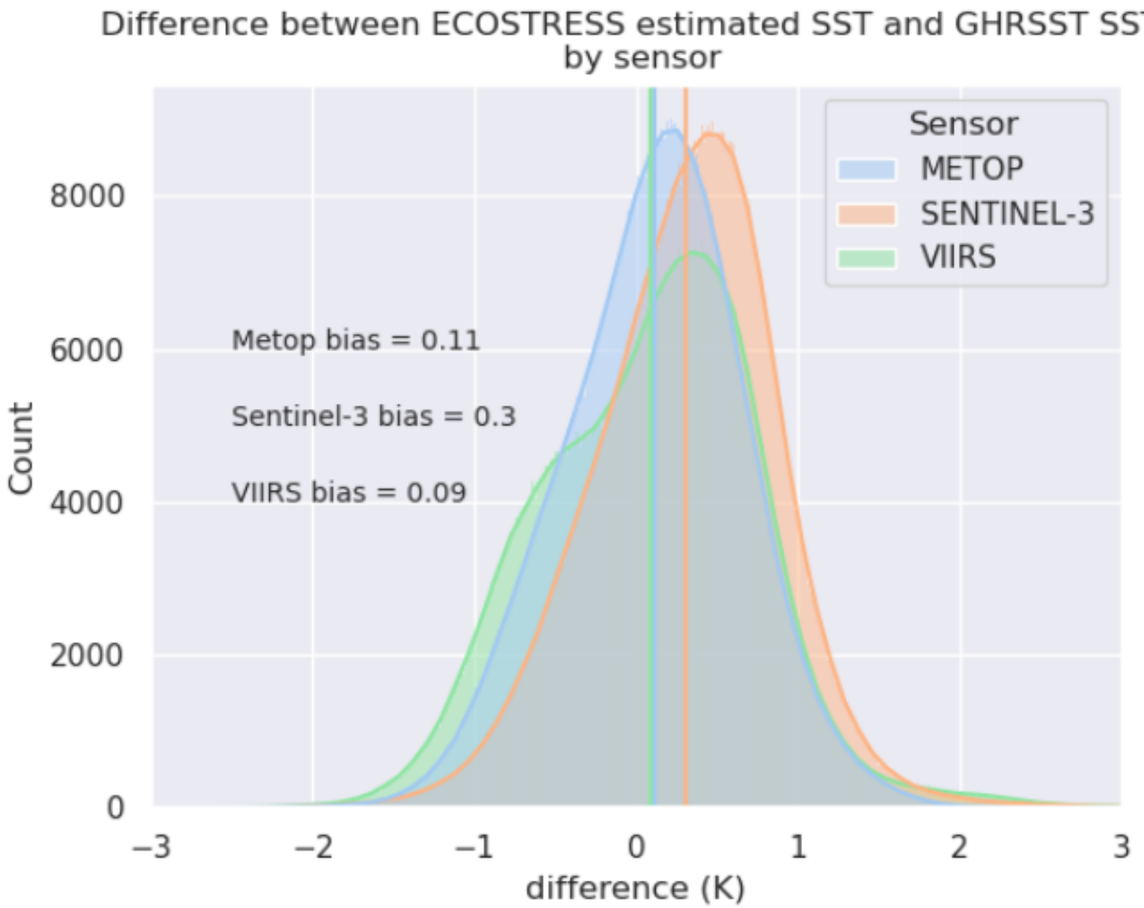
The estimation SST with ECOSTRESS images is computed with NLCSST split-window algorithm and adjusted with Sentinel-3 SST product.



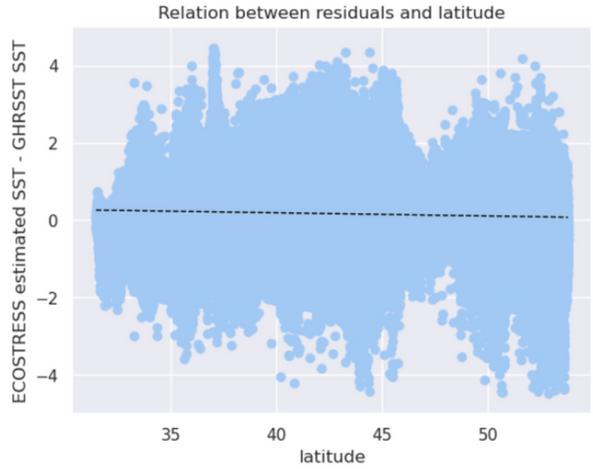
See Discussion

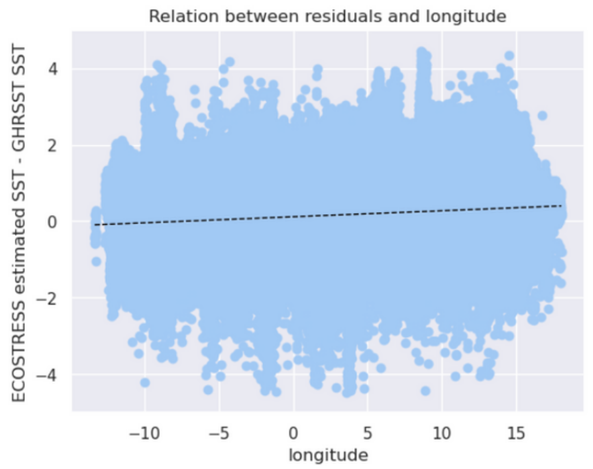
- presence of outliers
- masking problems and image noise
- validation off the coast, not for pixels close to the coast (*in-situ* validation required)

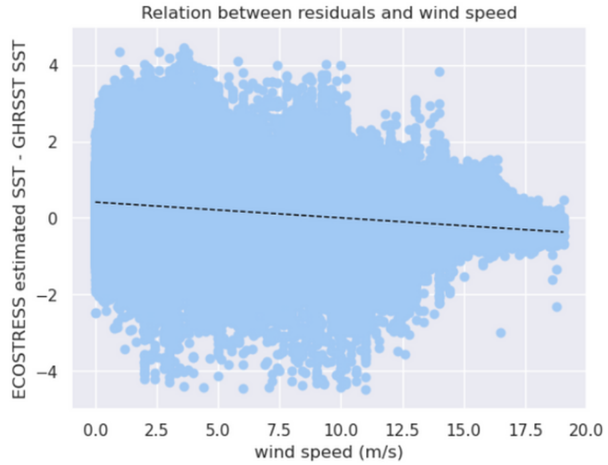
SST estimation from RTTOV method

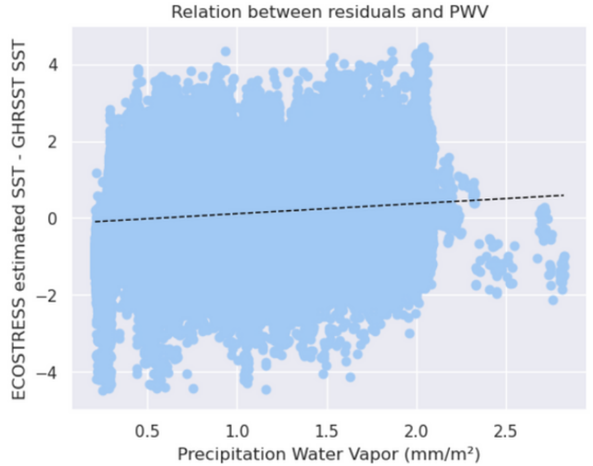


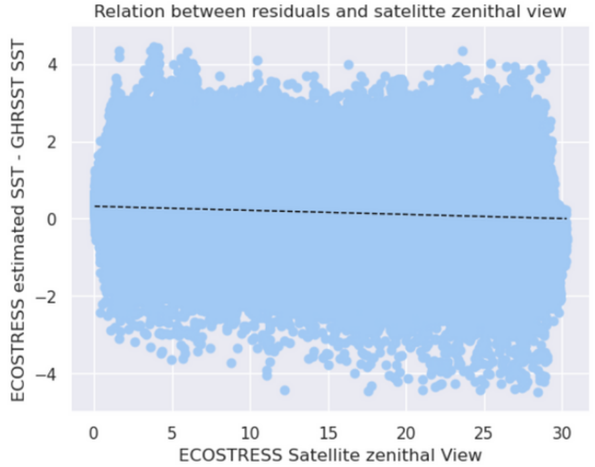
- RTTOV NLCSST coefficients are tested over the match-up database.
- mean bias: 0.16
- standard deviation: 0.61









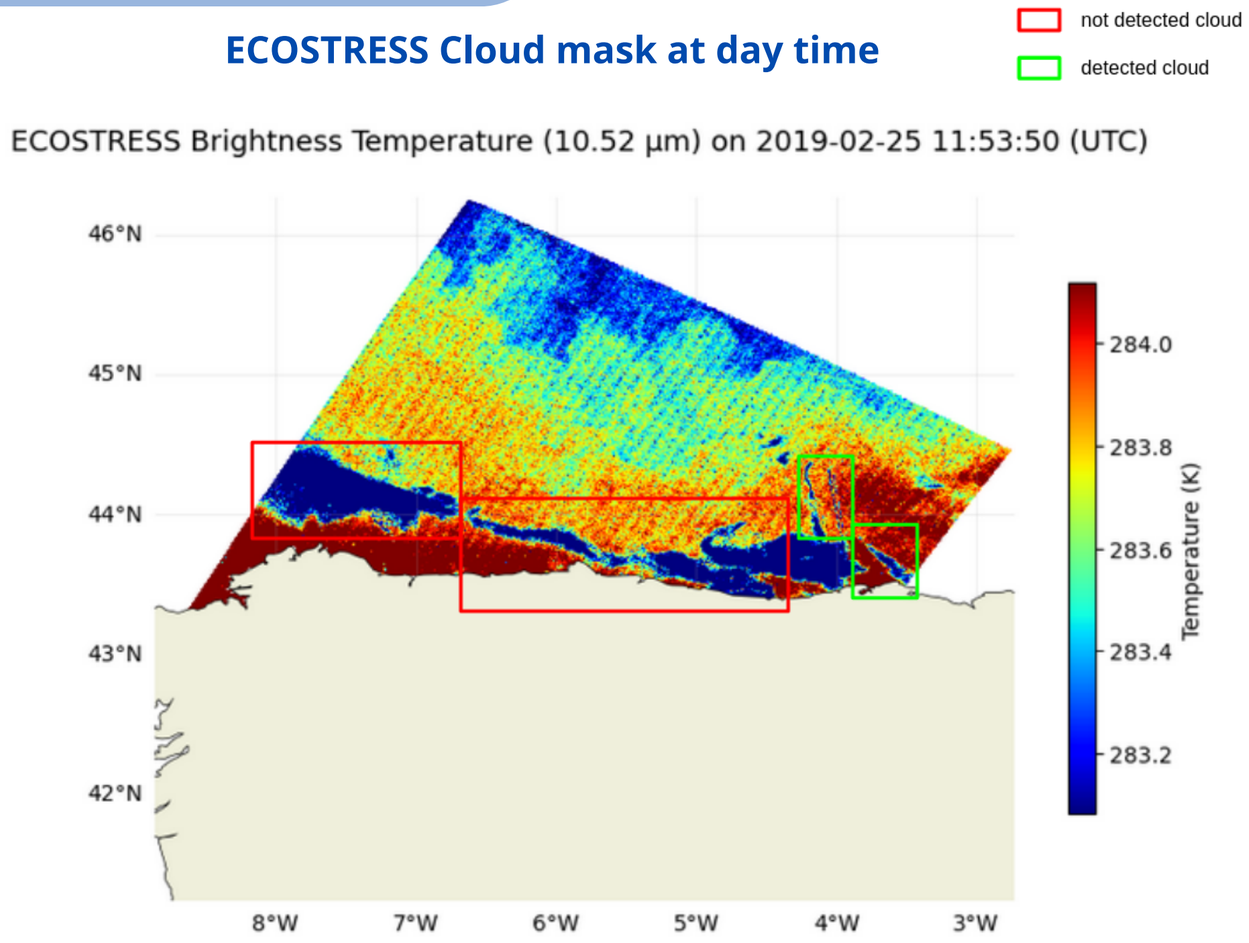


See Discussion

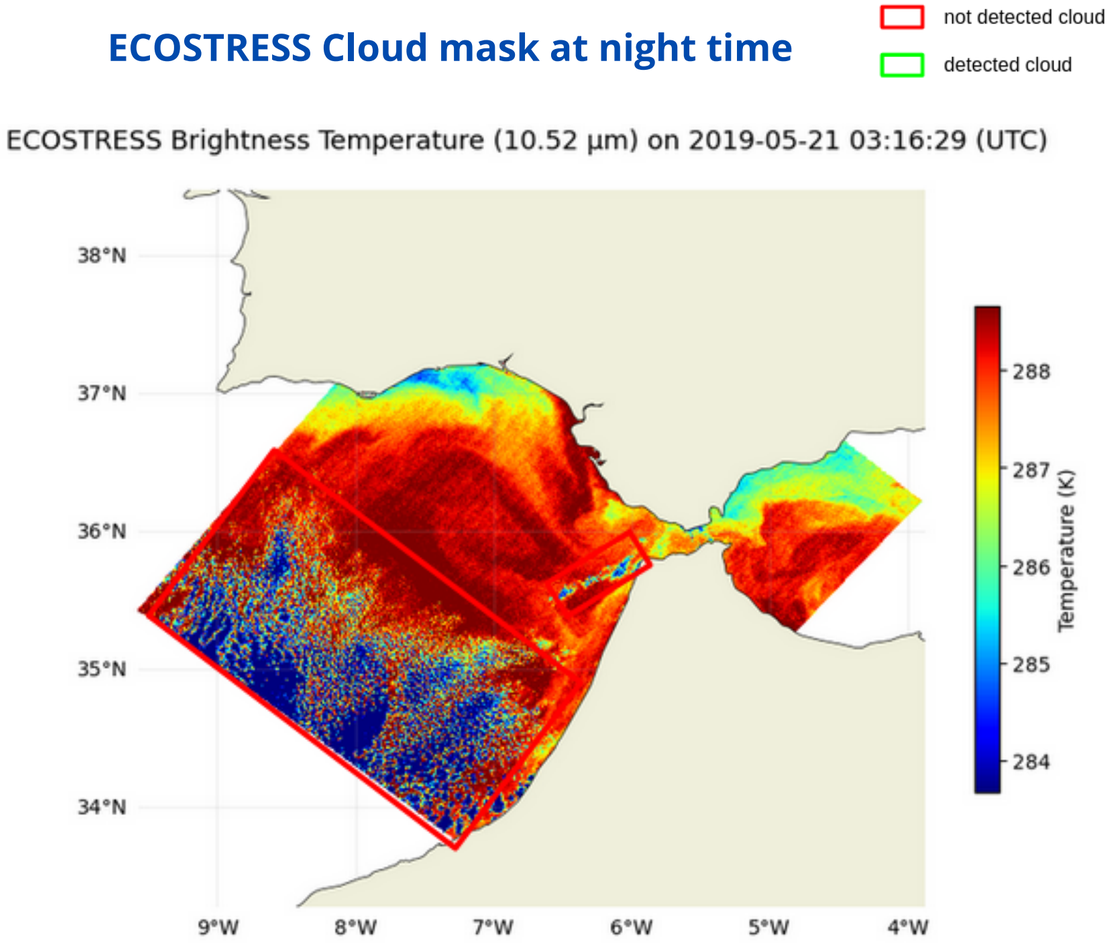
- analysis of outliers
- sensibility test with the Jacobians

Quality assessment of ECOSTRESS cloud mask

ECOSTRESS Cloud mask at day time



ECOSTRESS Cloud mask at night time



Observations:

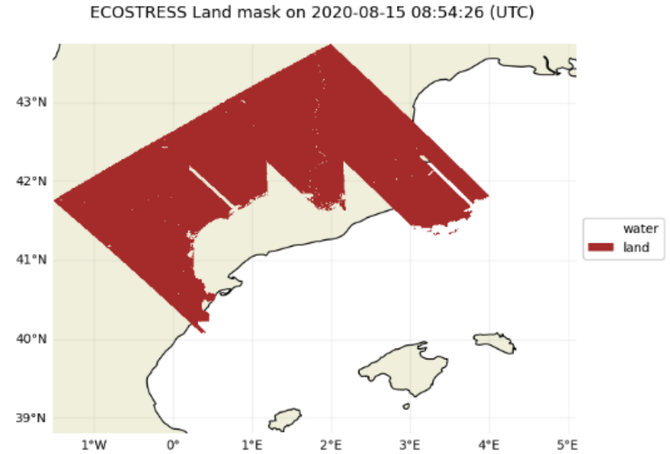
- underestimation of cloudy pixels at day and night time
- cold fronts sometimes detected as cloudy pixels

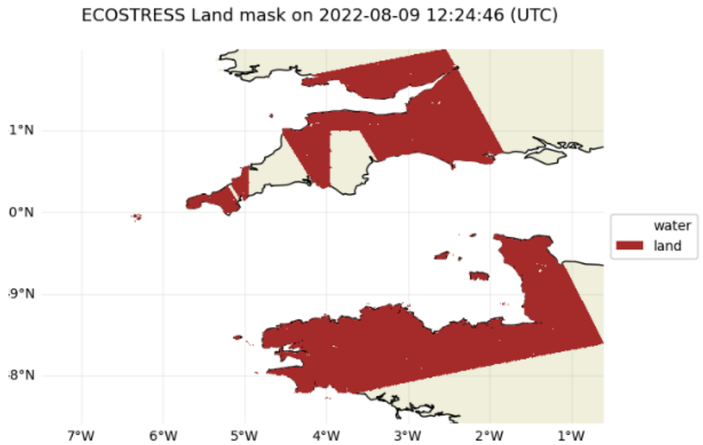
Challenges and solutions:

- selection of ECOSTRESS dataset by visual inspection to avoid clouds in the match-up database
- using external data such as SEVIRI cloud mask and work on cloud masking method

Quality assessment of ECOSTRESS land mask

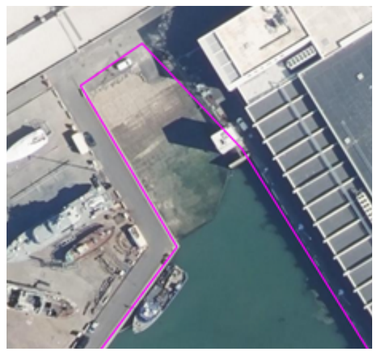
LAND MASK ERRORS →





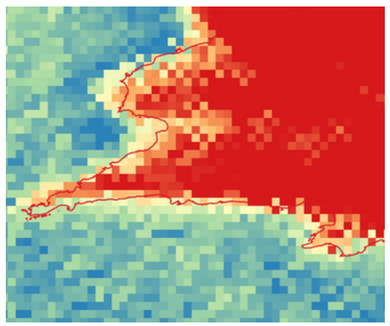
APPLY SHORELINE SHAPEFILE →

> for French coast: Land-Sea Limit produced by the SHOM
> for European coasts: Europe Coastline shapefile produced by the European Environment Agency



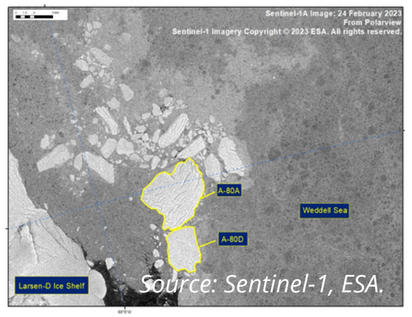
Source: SHOM Land-Sea limit available on Géoportail.

REMAINING CHALLENGES →



Geolocation

Mapping tidal flats



Sea-ice mapping

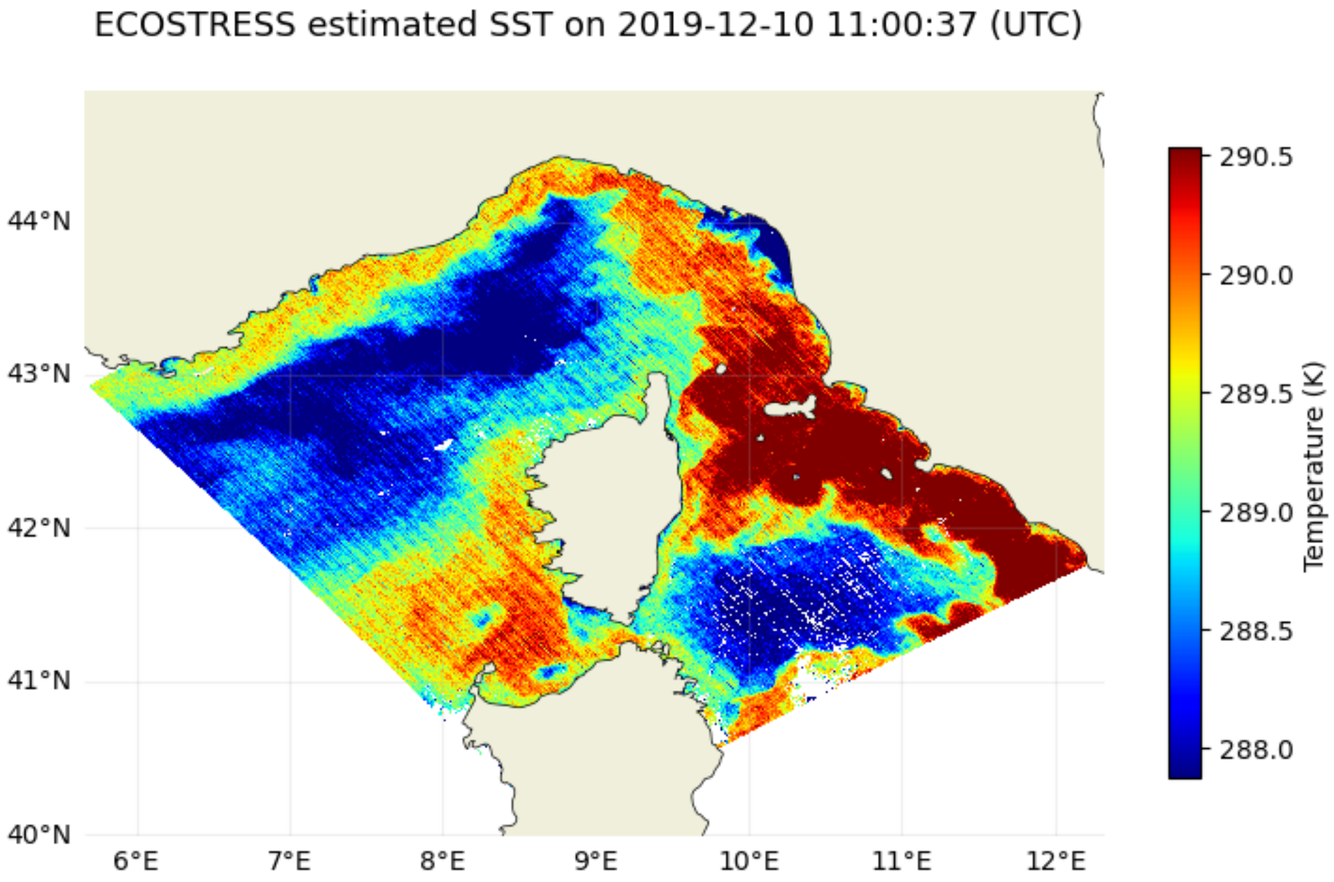
→ **DYNAMIC LAND AND SEA-ICE MASK IS NEEDED**

*SHOM : French Navy Hydrographic and Oceanographic Service

5. Conclusion

Perspectives and future work

improve the representativeness
and the independence of the dataset



sensitivity study to aerosols,
turbidity, etc.

denoising

improve cloud
masking and land-
sea-ice discrimination

validation with *in-situ*
measurements

error identification

Contact:
laura.orgambide@ifremer.fr