From L1 to L2 SST : Signal/errors and gaps

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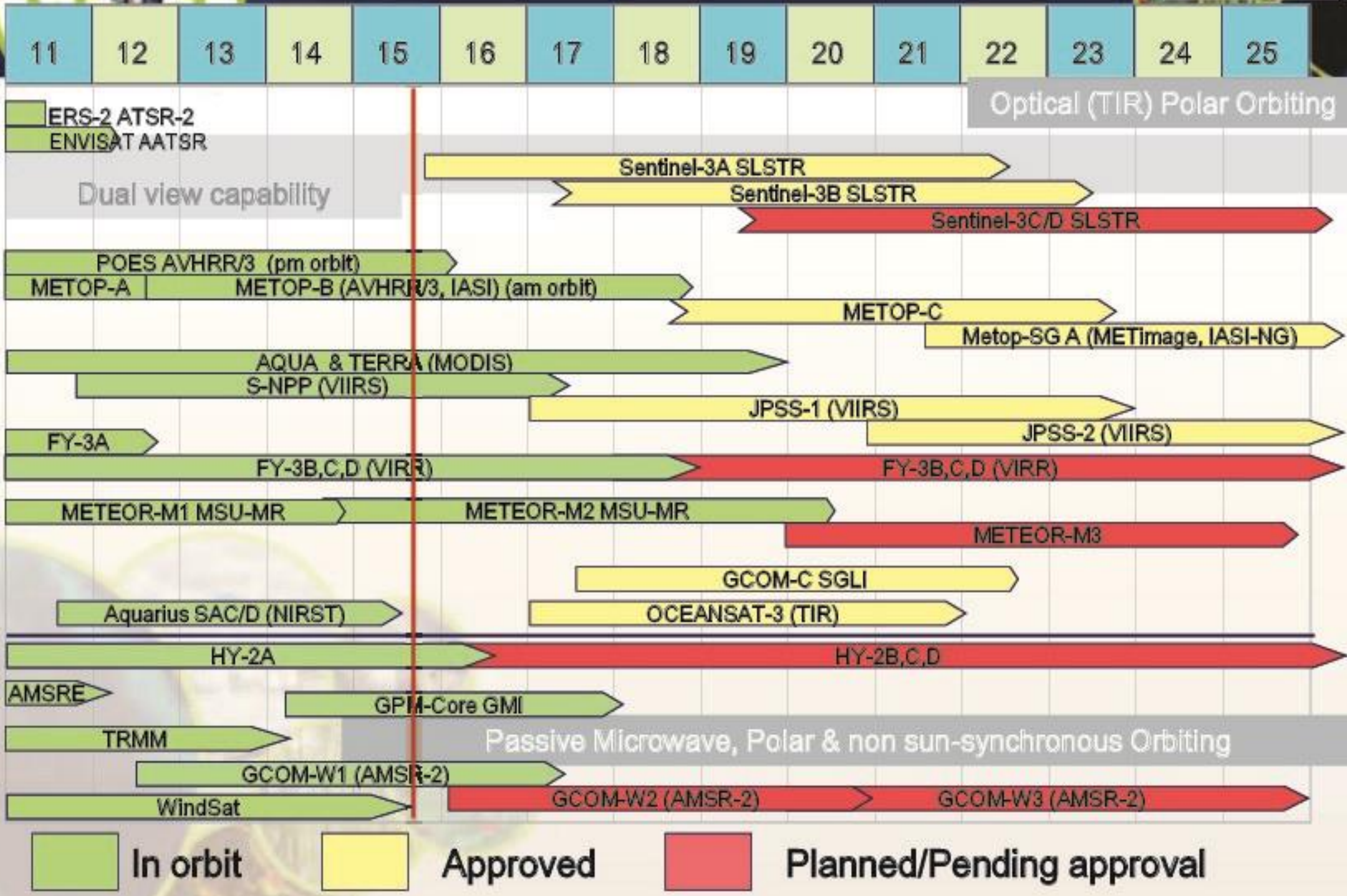
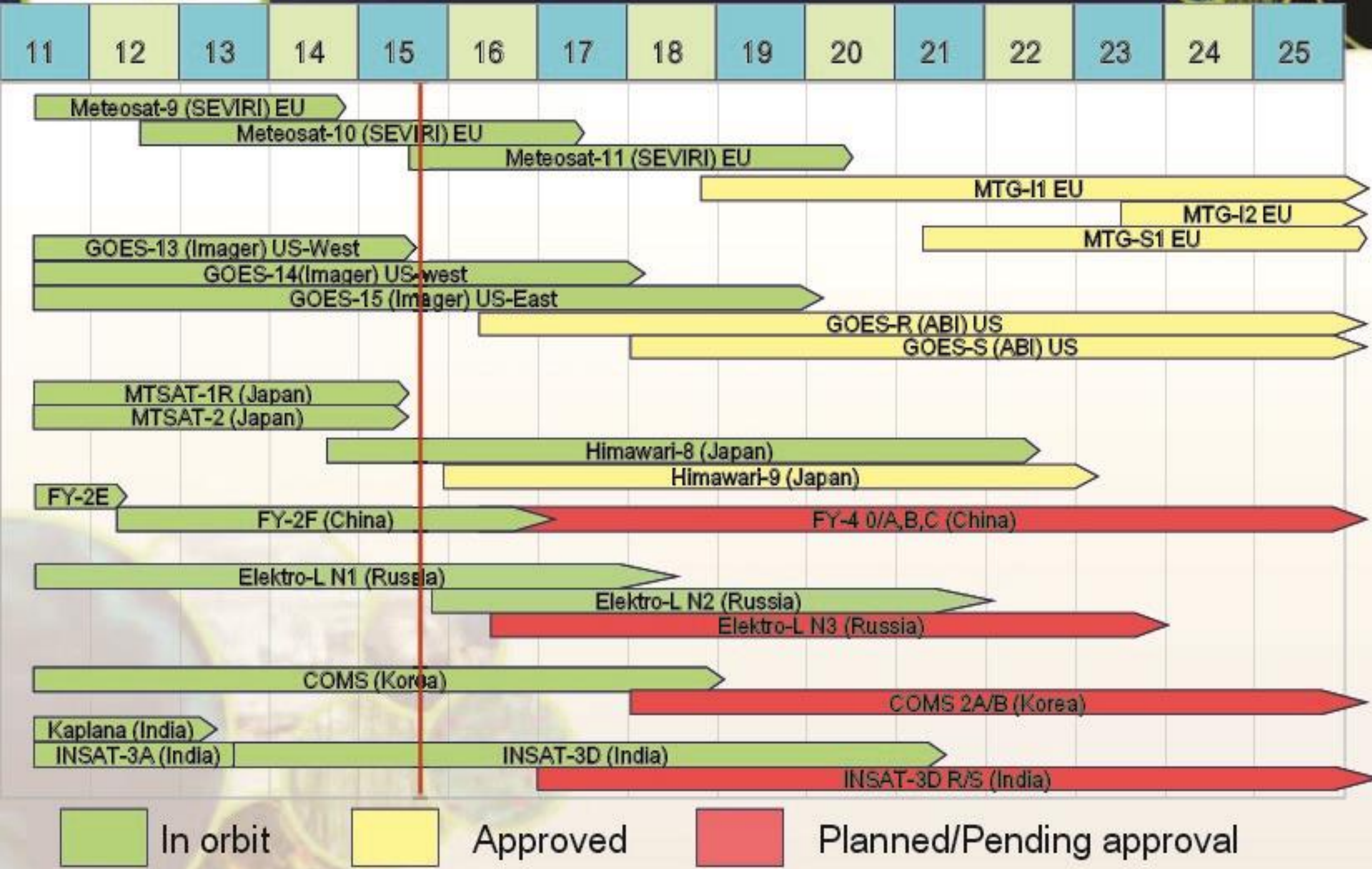
Content

- Which operational satellite/sensors for SST ?
- Main challenge for accurate IR SST processing : clouds
- SST retrieval from IR radiances : methods and error sources
- SSTs from geostationary satellites : new perspectives

Sea Surface Temperature (Polar orbiting)



Sea Surface Temperature (Geostationary)



Satellite/sensor versus retrieved SSTs characteristics

Satellite/ sensor	Hor. Res.	Obs Freq.	Coverage	Main Lim.
LEO IR	1 → 0.5 km	12 h (better at HL)	global	clouds, aerosols, sea ice
LEO MW	25 → ?? km	12 h (better at HL)	global	rain, land cont., sea ice
GEO IR	3 → 2 (1 ?) km	15-30 → 10-15 min	geo disk	clouds, aerosols, sea ice

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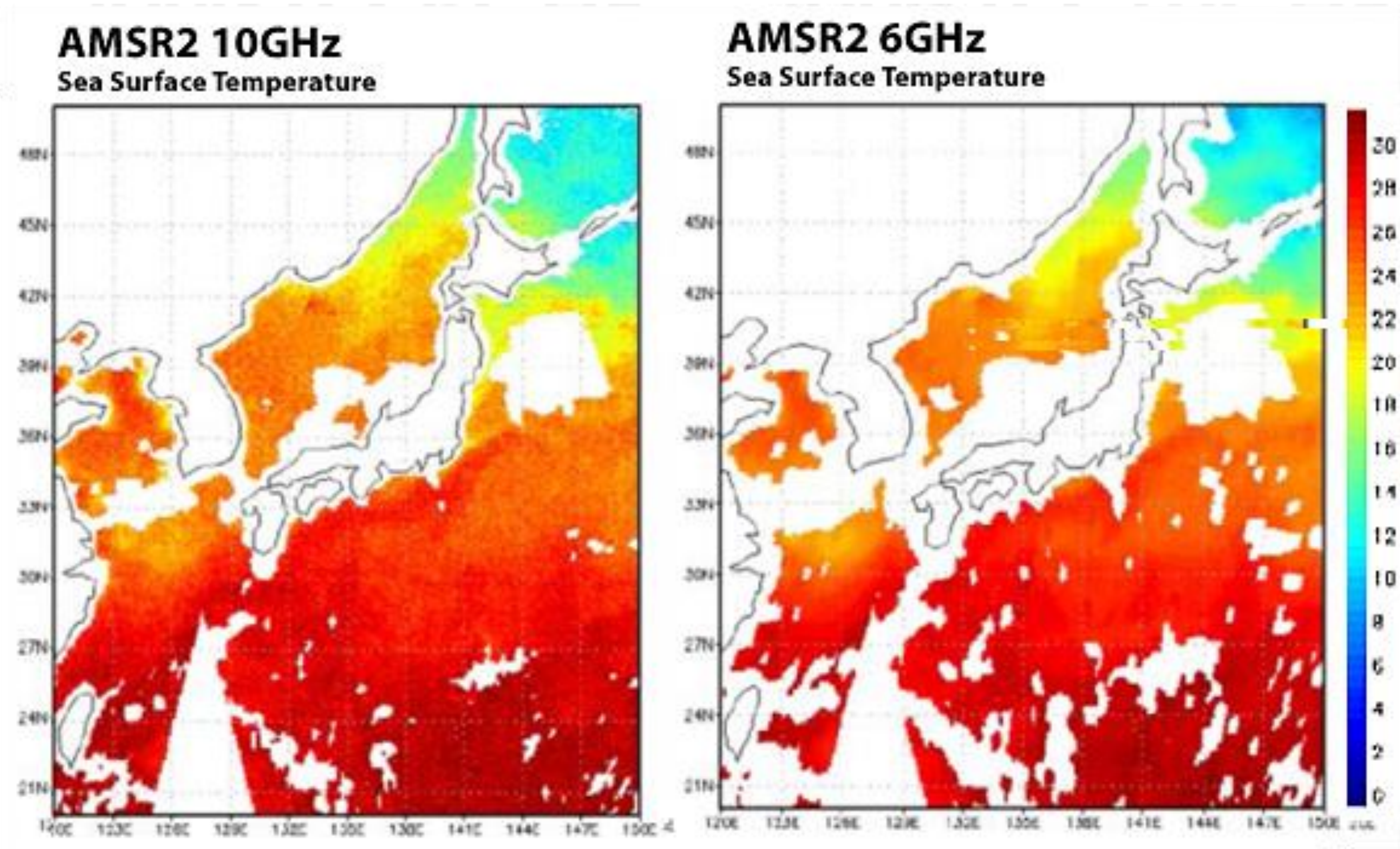
Microwave SSTs : land contamination problem



Ex. of AMSR-2 SSTs around Japan (source : JAXA)

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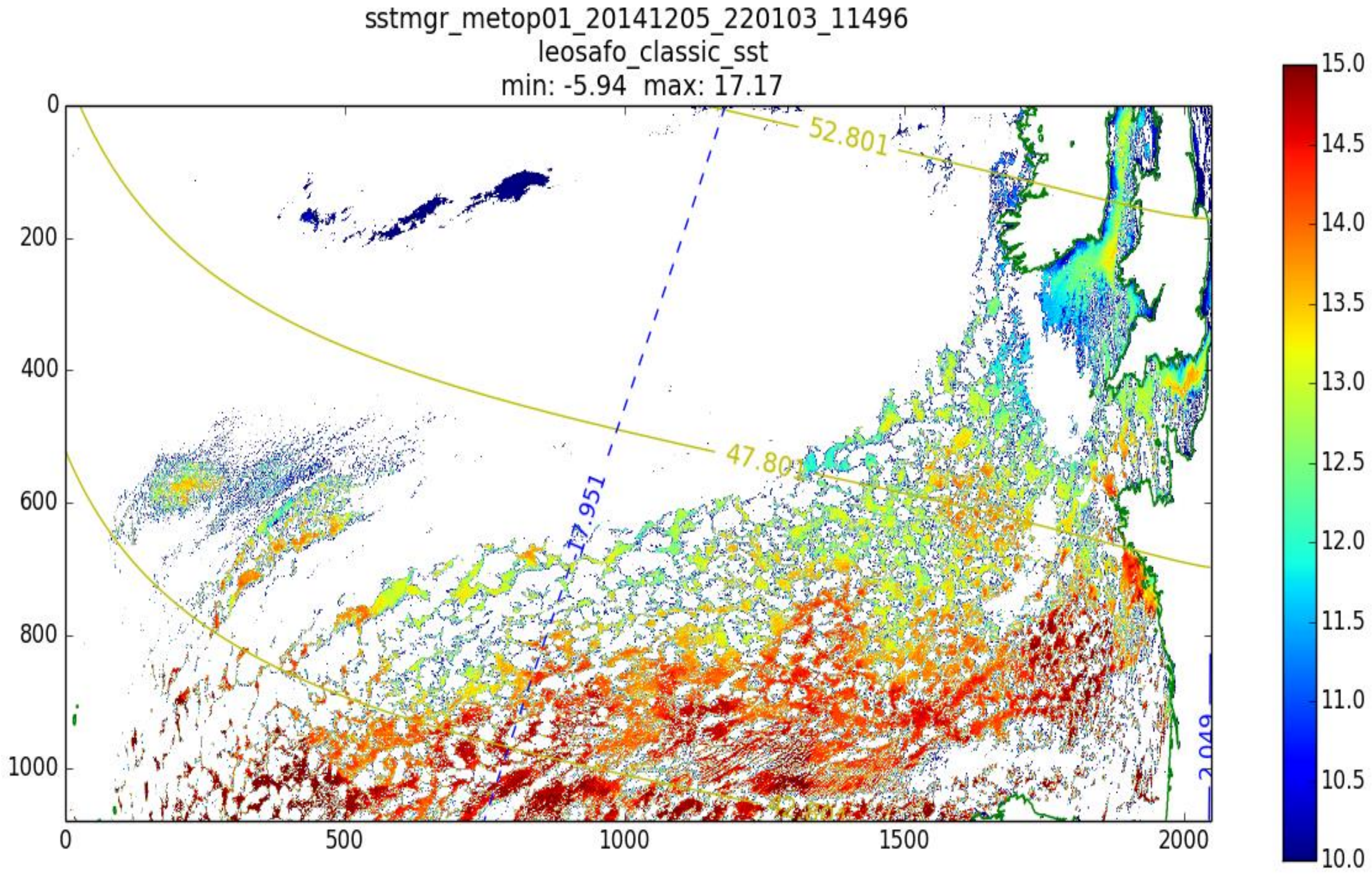
Cloud detection : THE issue for IR SSTs

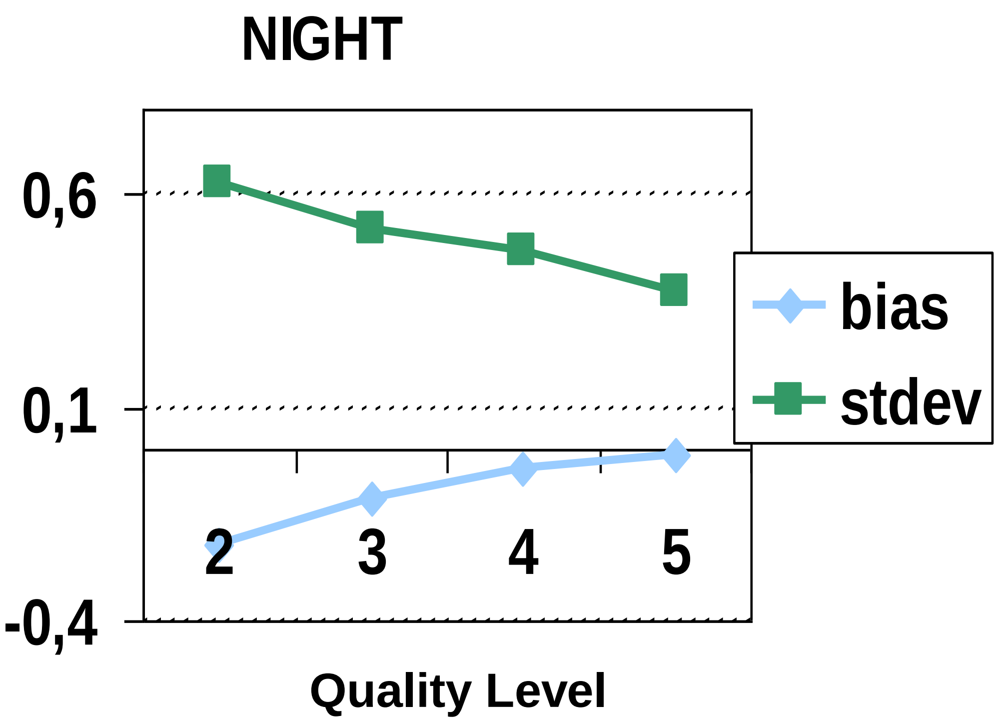
Ex: raw METOP01/AVHRR SSTs retrieved from MAIA cloud free pixels

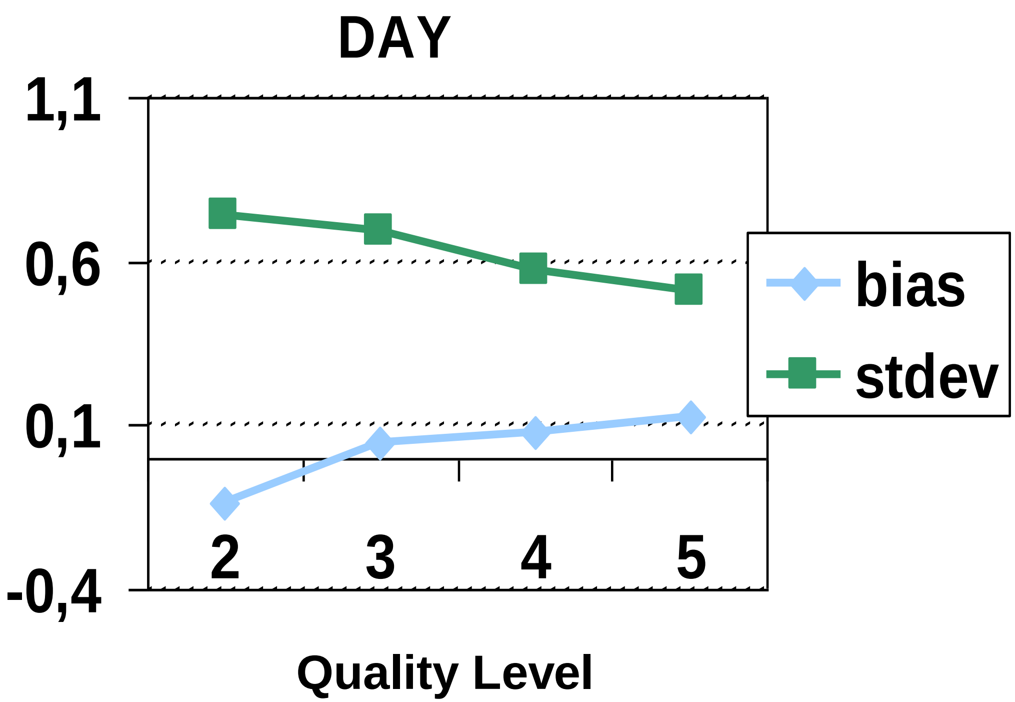


Cloud mask control : an essential step

- Ex : list of tests contributing to SST quality level in OSI SAF SST processing :
  - SST value (against min. SST climatology)
  - SST gradient (against max. SST gradient climatology)
  - SST time variation (geo satellites only)
  - Dust index
  - Distance to cloud
  - Sea ice probability

Impact of cloud mask control on IR SST quality





OSI SAF METOP02/AVHRR global SST validation results using drifting buoy measurements

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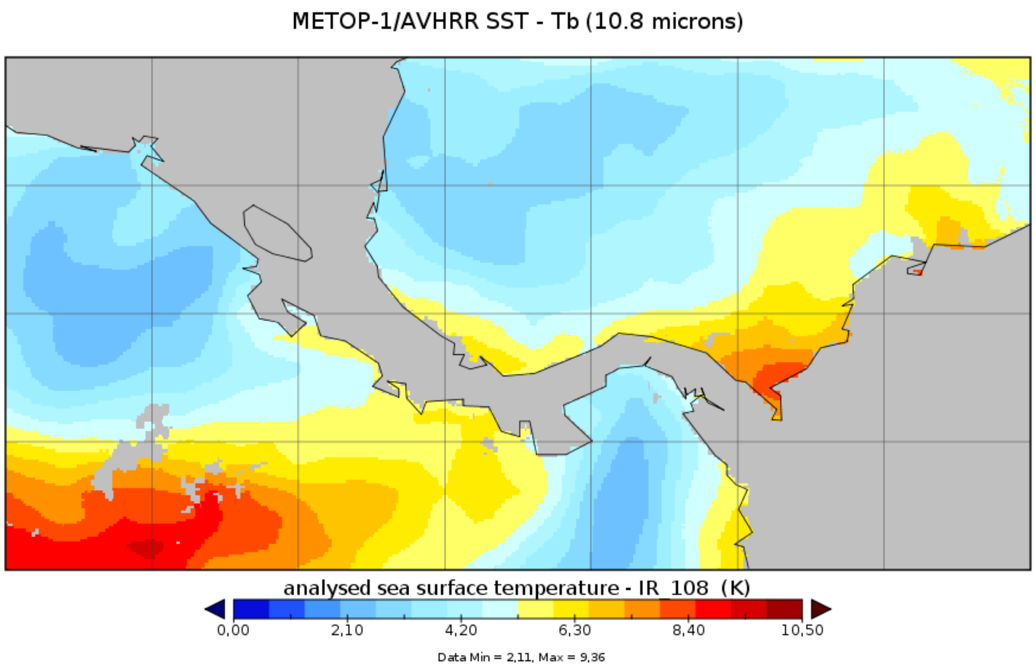
IR SSTs and clouds : ways to improve ?

- Most of current NRT cloud detection schemes are based on thresholding methods, which need a careful tuning, and don't provide quantitative uncertainty estimates

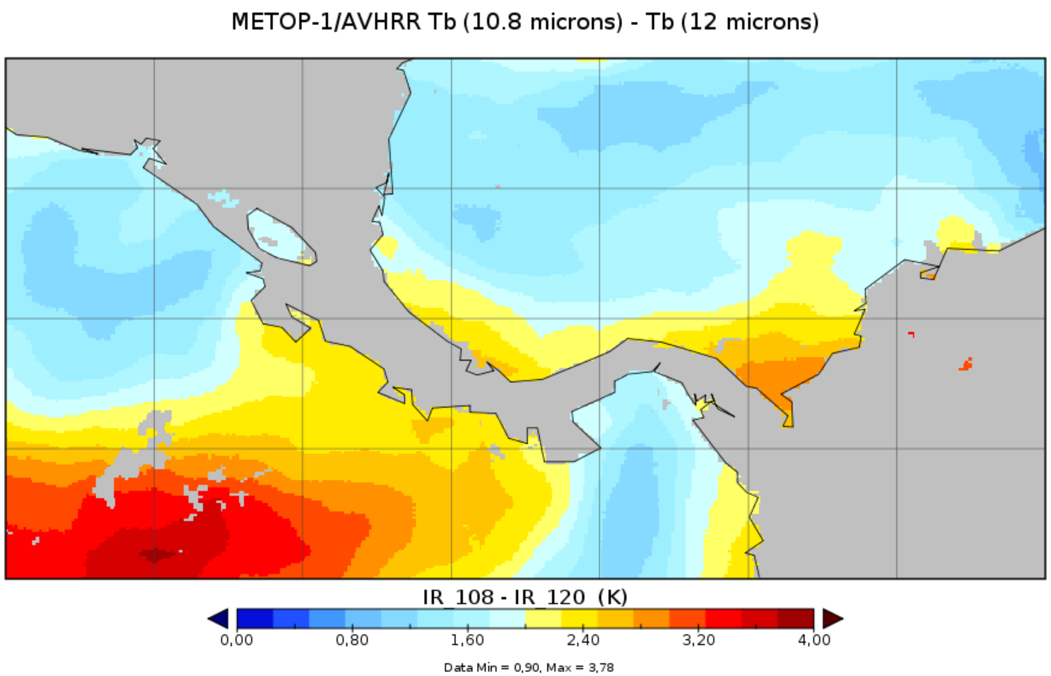
- Current methods for cloud mask control by NRT satellite SST producers are empirical and diverse, which makes resulting quality information difficult to use in an operational context : improve methods and homogeneity ? (GHRSST role ?)

- Bayesian cloud detection schemes are promising : optimal estimation framework, provide probabilities which can be used to derive SST quality information and uncertainty estimates

“Traditional” algorithms for IR SST retrieval : physical basis



SST – BT (11 µ)



BT (11 µ) – BT (12 µ)

⇒ Strong correlation between atmospheric absorption by water vapour at 11 microns and differential absorption at 11 and 12 microns

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Current methodologies for IR SST retrieval

- "Traditional" SST algorithm :

  $SST = a_0 + a^T y_o$, y_o = observed BTs

  a_0 ,a^T derived a-priori from off-line RTM simulations using a set of atmospheric profiles (can be further adjusted using buoy observations)

- "Traditional" SST algorithm plus NWP-based corrections :

  $SST = SST_g + a^T (y_o - y_s)$

  y_s = on-line simulated BTs using RTM, SST_g (SST analysis) and NWP outputs

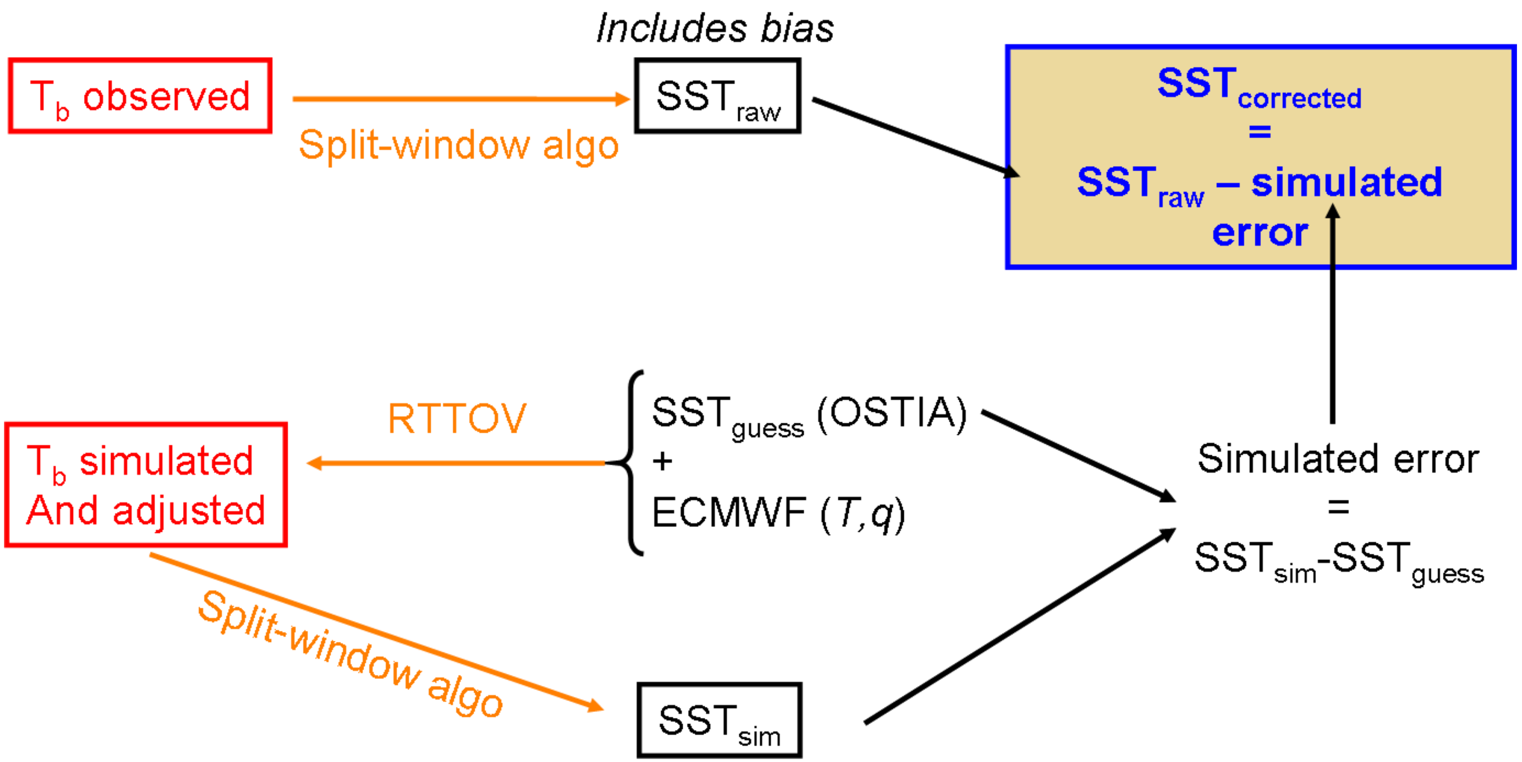
- Optimal Estimation :

  $X = X_g + (K^T S_o^{-1} K + S_g^{-1})^{-1} K^T S_o^{-1} (y_o - y_s)$

  X = (SST, TWVC), K = on-line simulated jacobians using RTM, SST_g and NWP outputs

$\Rightarrow$ Problem : adjustment of simulated brightness temperatures

OSI SAF SST retrieval methodology



Classical NL algorithm

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Algorithm correction (Le Borgne et al. 2011) to remove regional and seasonal biases.

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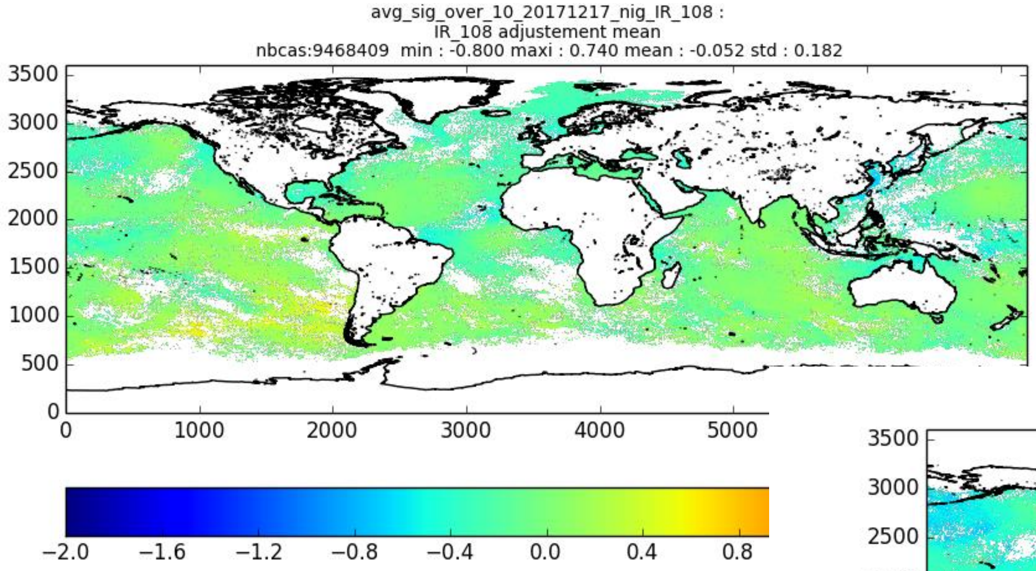
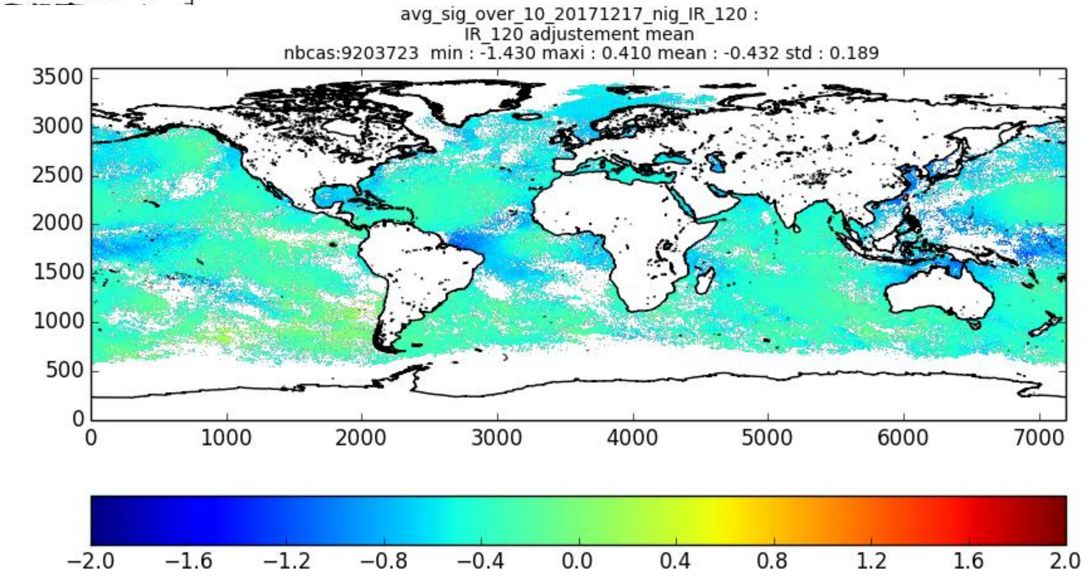
OSI SAF BT adjustment (METOP01/AVHRR)



Mean BT adjustment 11 µ : -0.05 K



METOP01/AVHRR
10-day average
07-17 December 2017

Mean BT adjustment 12 µ : -0.43 K

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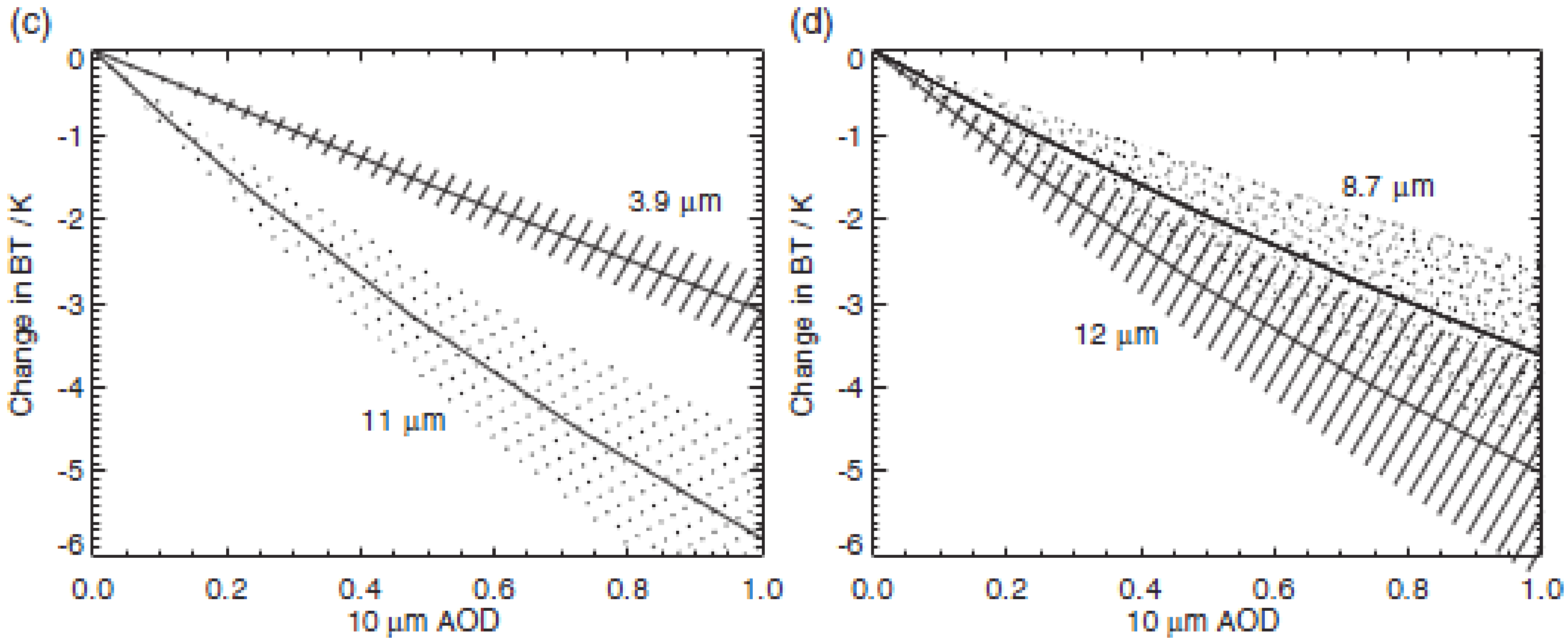
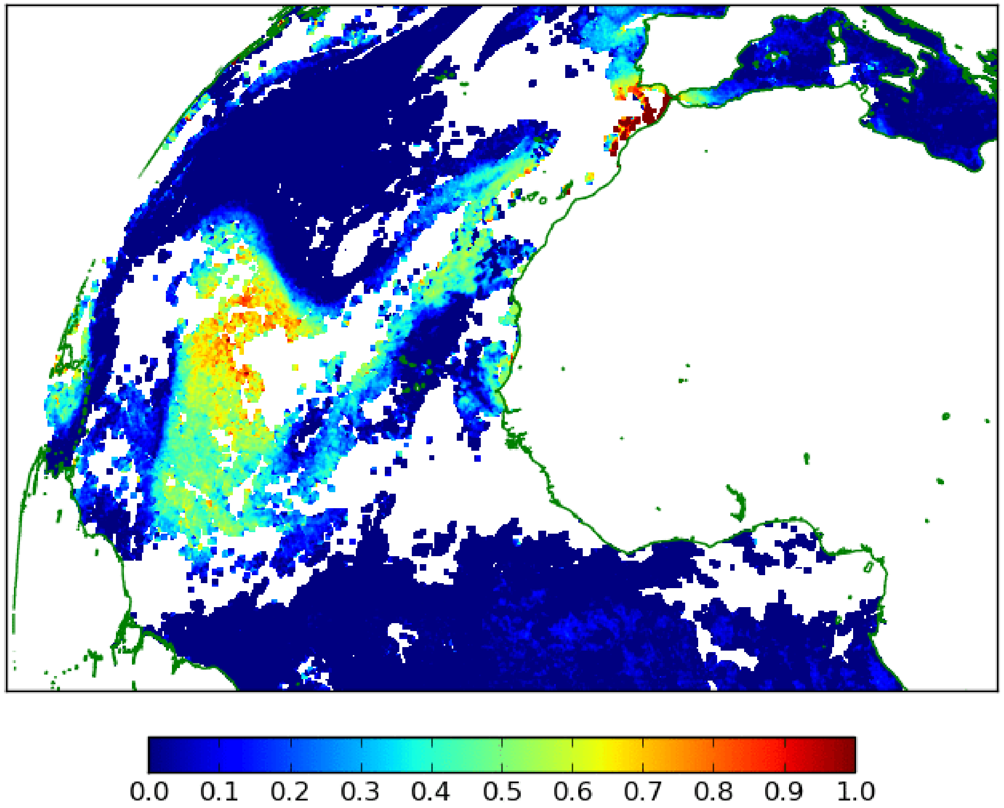
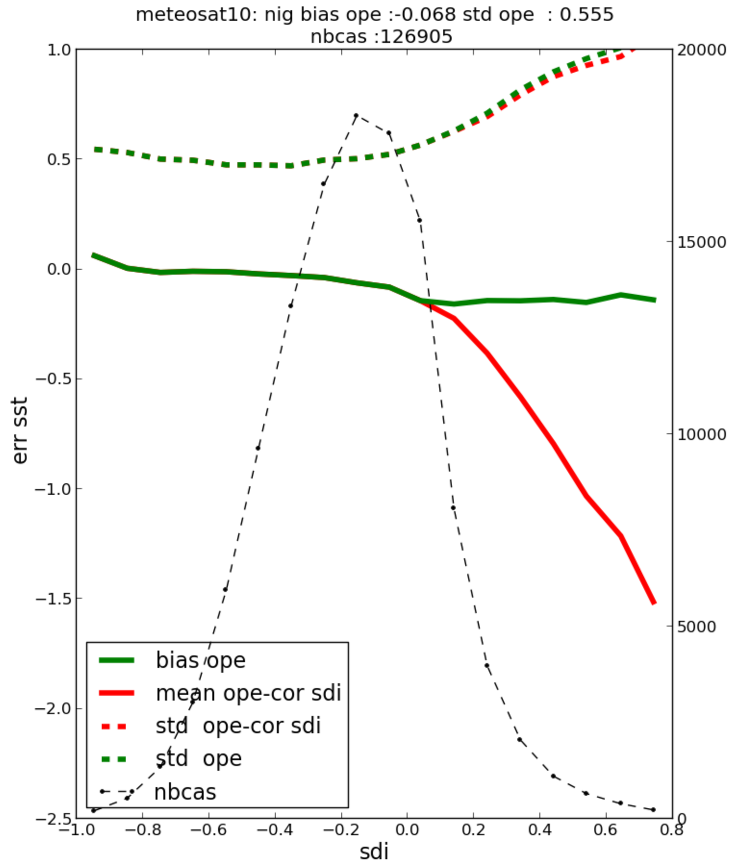
Impact of dust on IR BTs



Merchant et al., 2006 : mean (lines) and 1-σ range (shading) of change in BT versus AOD assuming a layer of aerosol evenly distributed between 2 and 3 km altitude

OSI SAF MSG/SEVIRI Saharan Dust Index (SDI)





SDI = a (BT3.9 - BT8.7) + b (BT10.8 - BT12.0) + c (night-time)

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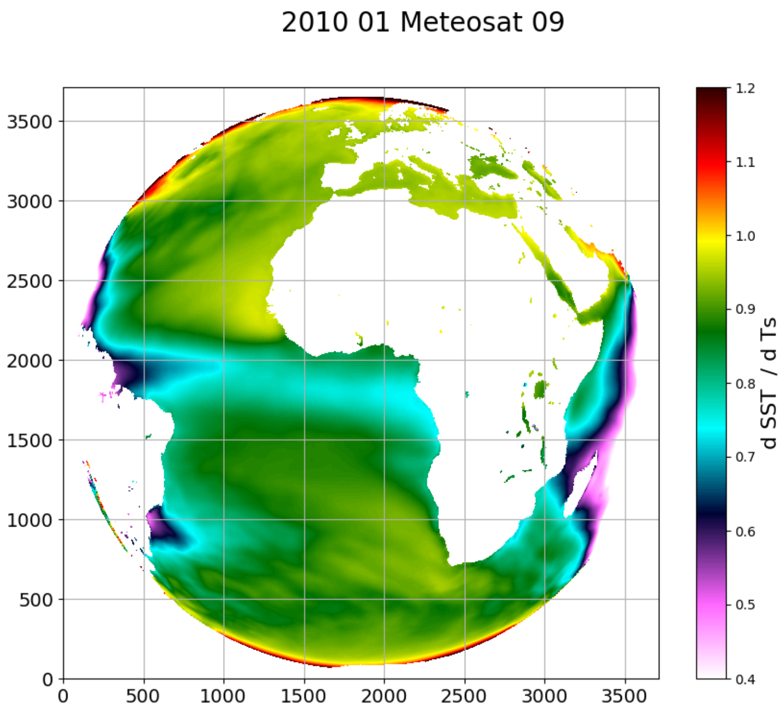
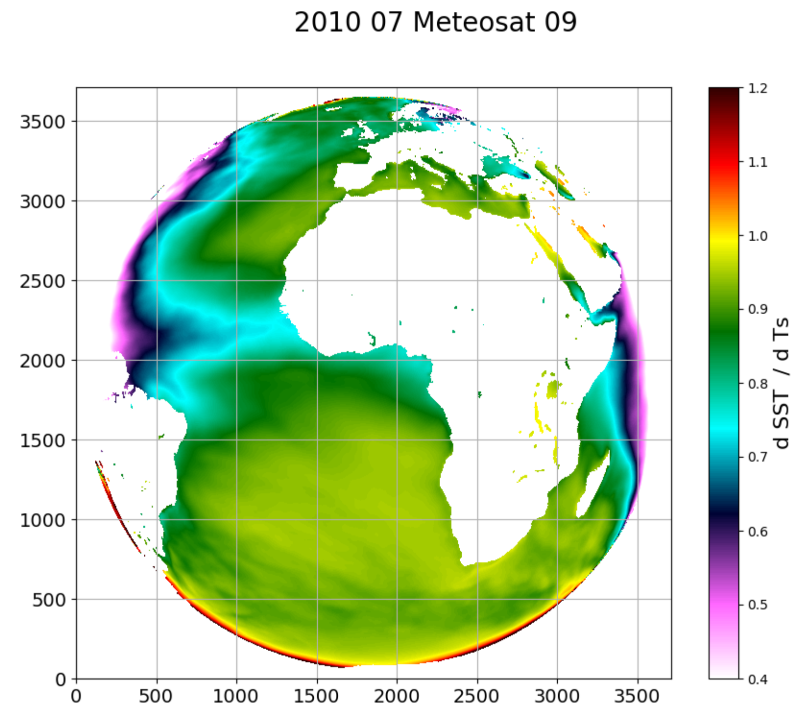
Sensitivity of retrieved IR SSTs to true SSTs

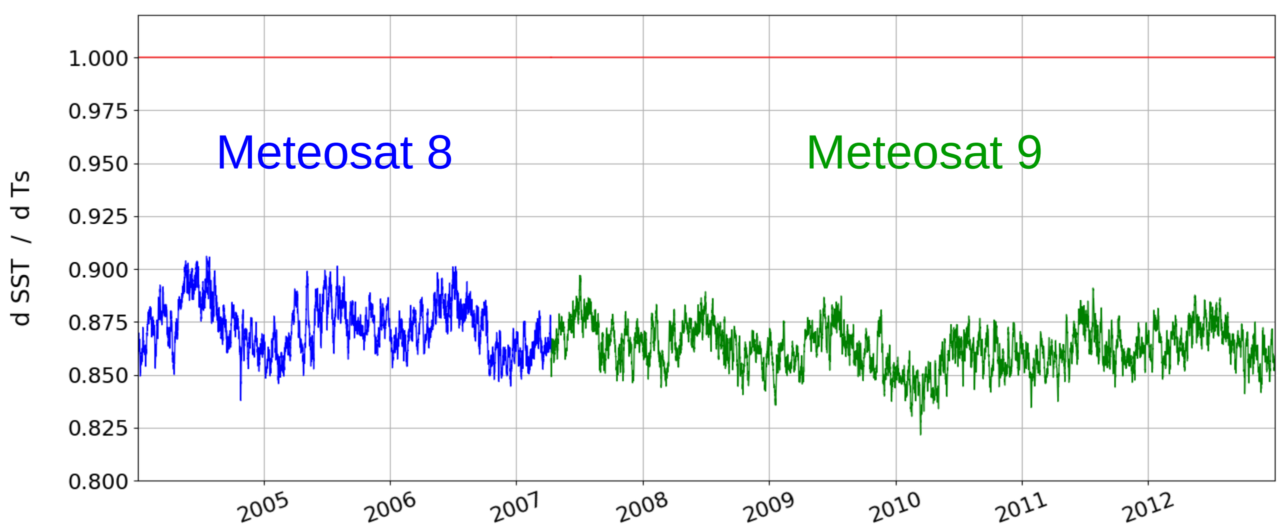


January 2010



June 2010

OSI SAF
MSG/SEVIRI
$\partial\, SST_{ret} / \partial\, SST_{true}$



IR SST retrievals : ways to improve ?

- Errors in IR SST retrievals mainly result from errors in cloud detection, but also from errors in observed and simulated Brightness Temperatures (including RTM errors), SST algorithms, dust detection/correction….
- Optimal estimation methods are very promising, because they provide a theoretical framework which can in principle consistently address BT adjustment issues (bias correction), first guess errors and dust contamination (simultaneous retrieval of SST, water vapour and dust content), benefitting from enhanced information content in new LEO and GEO optical imagers
- Optimal estimation methods also provide better information for SST quality information and uncertainty estimates (ex : χ^2)

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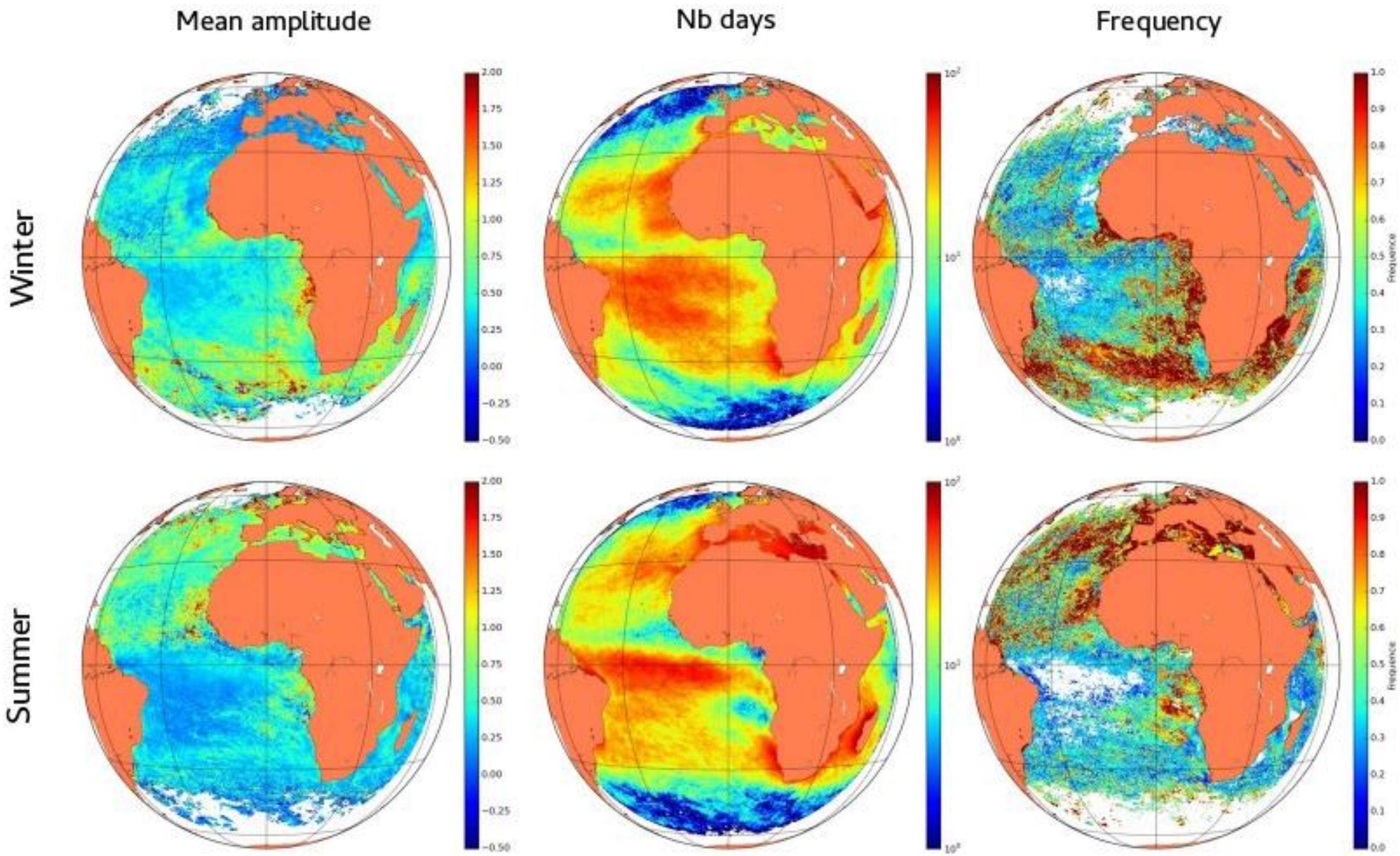
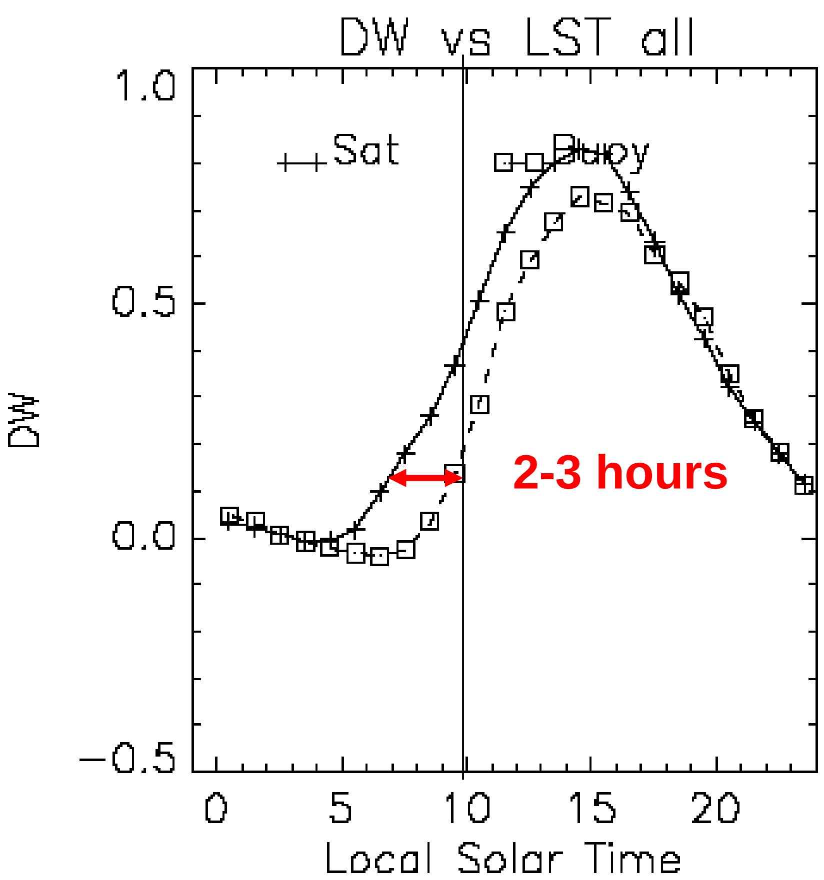
MSG/SEVIRI : occurrence of diurnal warming events

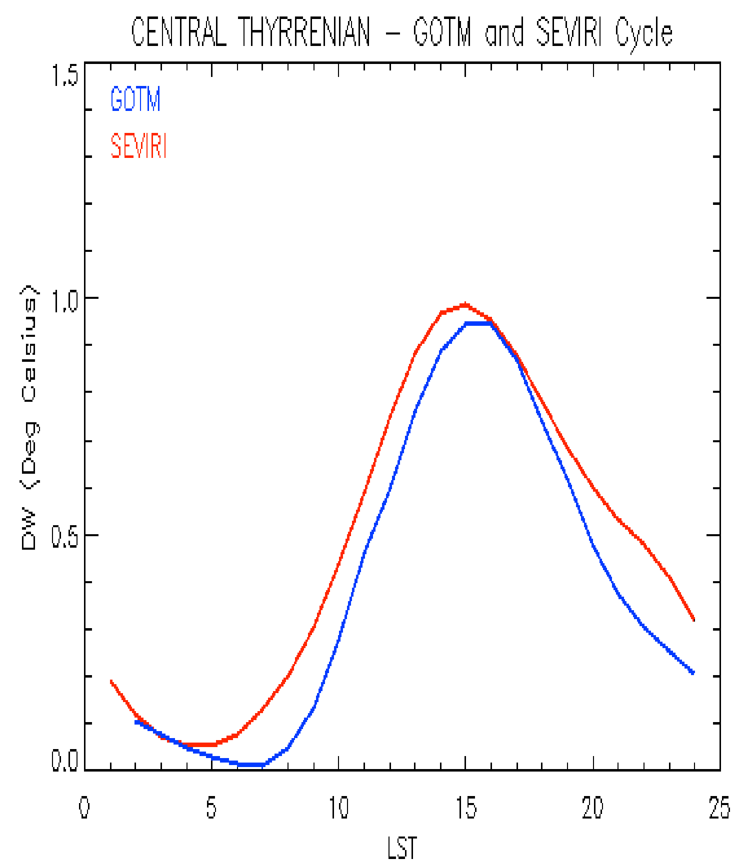


Year 2005

MSG/SEVIRI : observing the (skin) SST diurnal cycle



SEVIRI vs drifters



SEVIRI vs 1D-model

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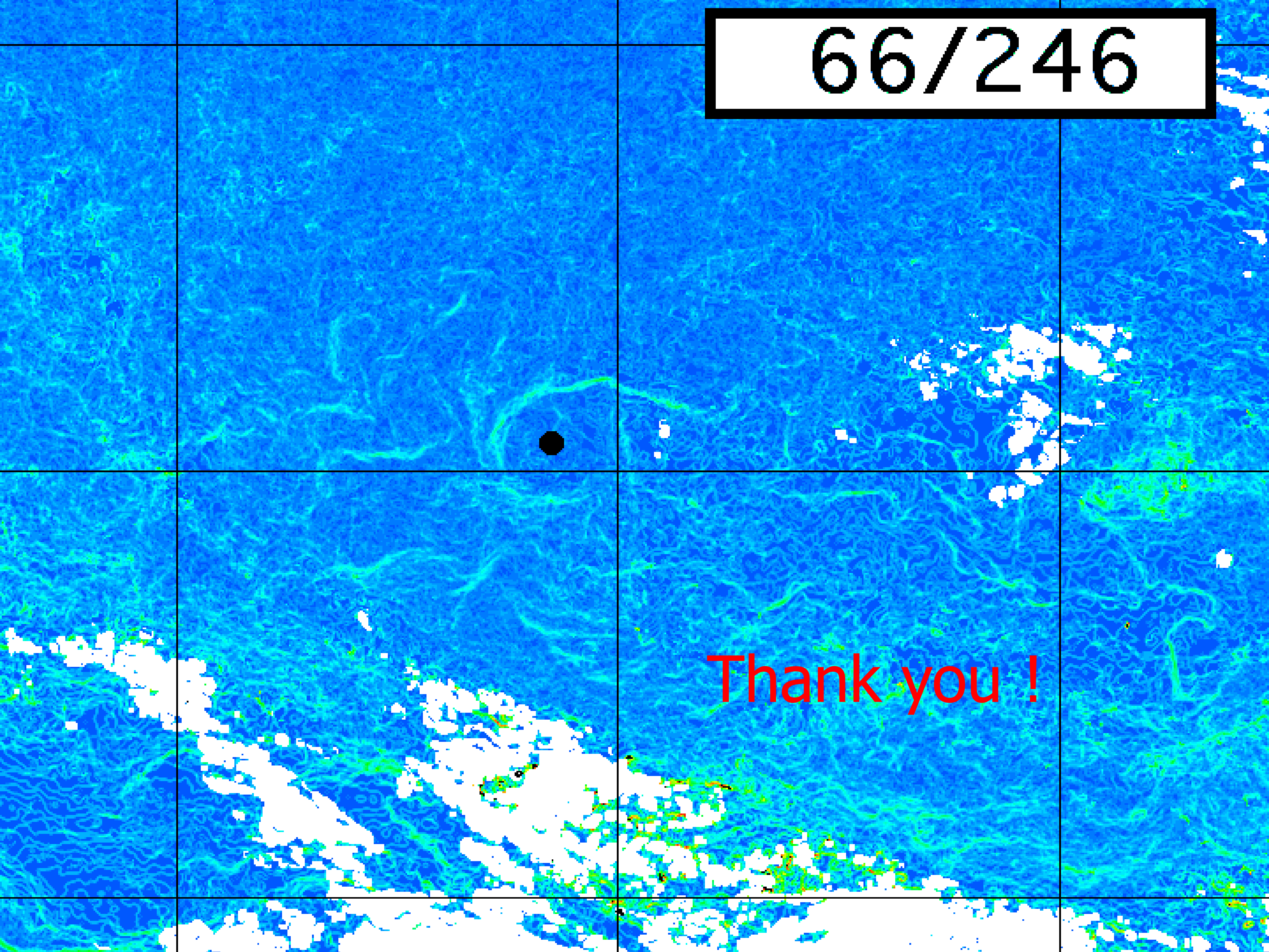
GEO SSTs : a step forward for fine scale ocean observations

- Fine scale variability of skin SST has a significant impact on ocean/atmosphere fluxes
- High repetitiveness measurements help to mitigate cloud coverage issues, and are important to sample high frequency processes (ex : diurnal warming, tidal effects in coastal area…..)
- Accuracy of NRT IR SSTs from current GEO imagers (ex : MSG/SEVIRI) is now similar to the ones from LEO imagers
- New generation GEO imagers (AHI, ABI, FCI…) have enhanced capabilities in terms of horizontal resolution (2 km, potentially 1 km with FCI), time sampling (10 – 15 min) and radiometric accuracy
- Long term availability of NRT IR SSTs is now well secured, except over Indian Ocean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Thank you !

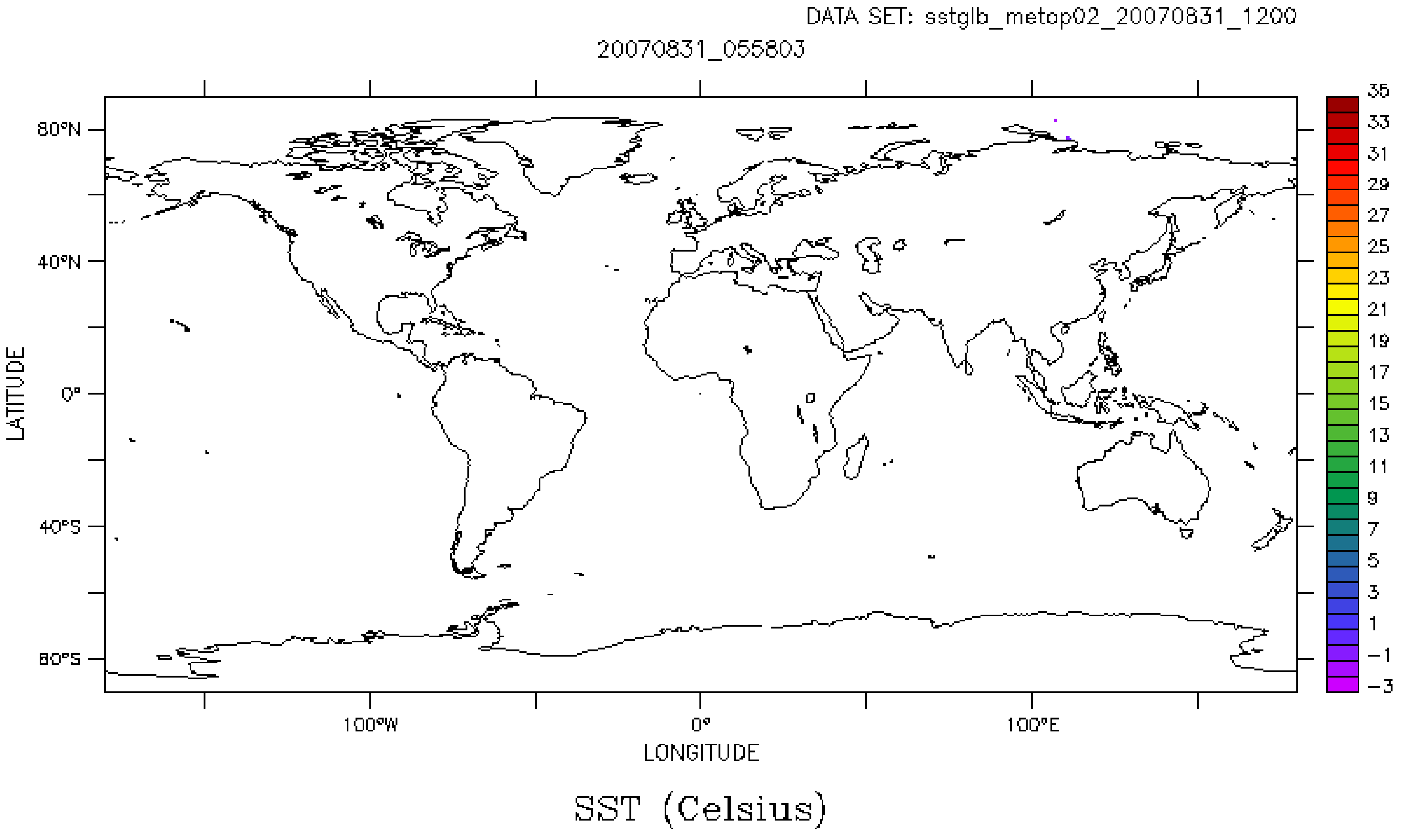
Back-up slides

OSI SAF cloud mask control

Indicator	Description/purpose
SST value indicator	This indicators aims at attributing a lower quality level to SST values too different from climatology. The local value of estimated SST is compared to a climatology of SST, the larger the difference between estimated SST and SST climatology, the higher the indicator.
SST gradient indicator	The main objective of this indicator is to attribute a lower quality level to pixels in areas were the gradients are unrealistically large due to the presence of undetected cloud cover in most cases. The local value of the SST gradient is compared to a climatology of maximum gradient.
Dust indicator	This indicator influences the quality level of pixels contaminated by Saharan dusts. It is directly related to the SDI, or the NAAPS dust Aerosol Optical Depth (AOD) in case of missing SDI.
Distance-to-cloud indicator	Pixels in the immediate vicinity of clouds are likely to be partly covered by cloud or affected by transparent undetected clouds. This indicator is never set to 100 because being in the vicinity of cloud should not be the only reason to degrade the quality level to 2.
Ice indicator	The purpose of this indicator is to degrade the quality of pixels suspected to contain ice. A Bayesian ice detection method is used to determine the probability of presence of ice for each pixel. This probability is converted into the ice indicator (which also includes consideration about visible channel when available, the ice edge product of the OSI SAF, and MAIA ice mask).
Algorithm risk indicator	The indicator takes into account the fact that high satellite zenith angle is likely to lead to higher uncertainty because of higher atmospheric optical depth. This indicator is directly linked to the satellite zenith angle.
SST correction indicator	This indicator is based on the assumption that high SST corrections are associated with high uncertainties. It is directly linked to the value of the SST correction.

OSI SAF NRT global SST (METOP/AVHRR)

Full resolution SST (metagranules, GHRSST L2P format)

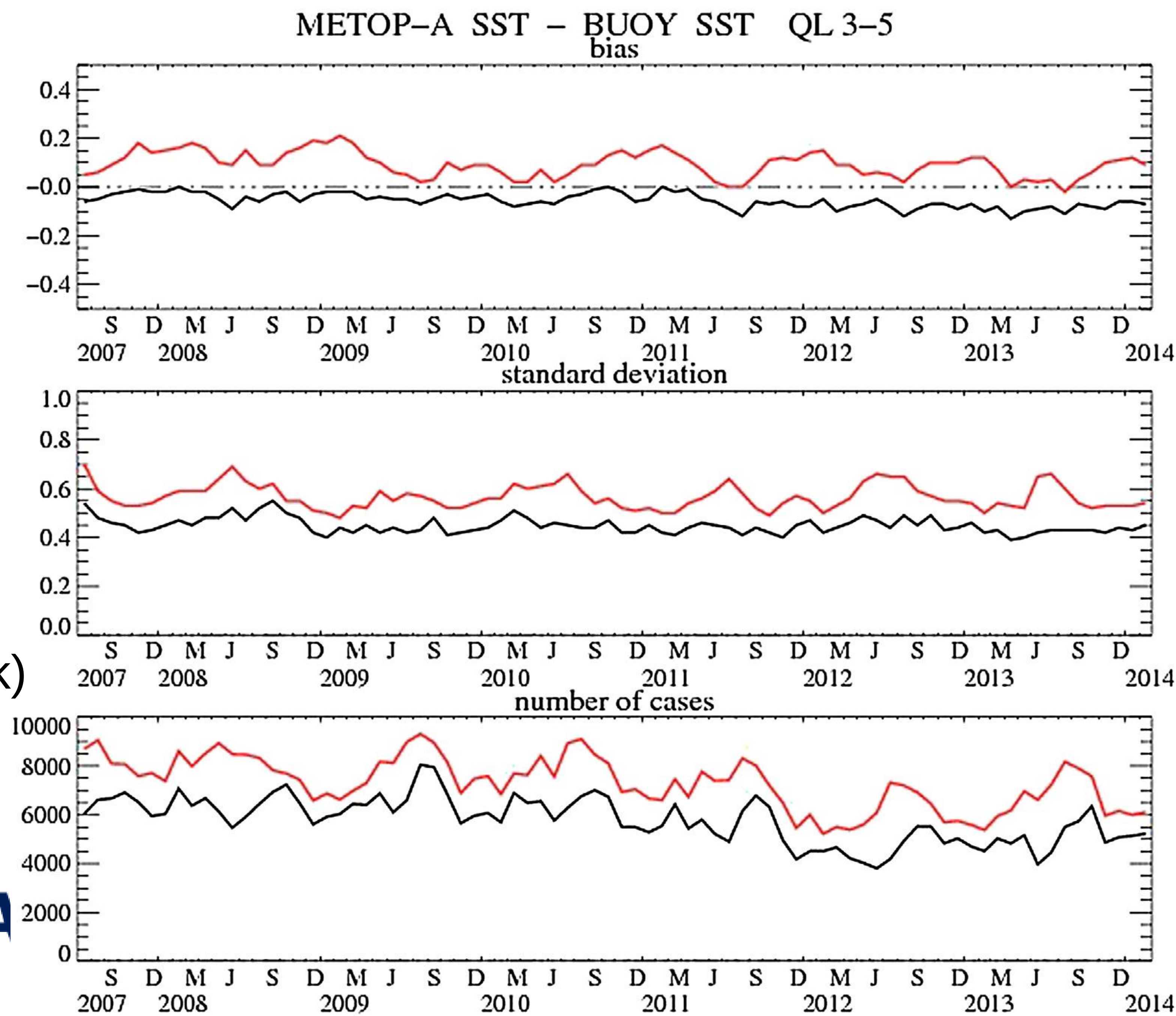


OSI SAF NRT global SST validation (METOP/AVHRR)

Global monthly error statistics against drifting buoys

- daytime (red)

- night time (black)



OSI SAF NRT global SST validation (MSG/SEVIRI)

Comparison against drifting buoys

(night time)