On the use of MCSST and NLSST for the study of spatio-temporal trends in ocean thermal gradients

Marouan Bouali, Paulo Polito, Olga Sato
Instituto Oceanografico da Universidade de São Paulo;
marouan.bouali@usp.br, marouanbouali@gmail.com

1. MOTIVATION

The analysis of thermal dynamics from high resolution satellite images of sea surface temperature (SST) provides valuable information on the state of the ocean and its future long term changes. While extensive research has been conducted for the statistical validation of satellite-based SST via comparison with *in situ* measurements, little effort has been dedicated to the validation of ocean thermal gradients.

There are currently many SST products available to users derived from different satellite sensors and with different SST retrieval formulations. When it comes to the study of spatio-temporal trends in SST gradients, one major question arises:

Do SST products generated with different SST formulations lead to similar synoptic and time-averaged representations of ocean dynamics?

2. METHODOLOGY and DATA

In this work we focus on two operational SST formulations namely, the Non Linear SST (**NLSST**):

$$NLSST = a1 + a2BT11 + a3\ \mathbf{SST_{ref}}\ (BT11-BT12) + a4(BT11-BT12)(sec(\theta)-1)$$

and the Multichannel SST (**MCSST**):

$$MCSST = a1 + a2BT39 + a3(BT39 - BT4) + a4(BT39 - BT4)(sec(\theta)-1)$$

More specifically, we use the 4 μm (MCSST) and 11 μm (NLSST) nighttime Level 2 Aqua **MODIS** SST (http://oceancolor.gsfc.nasa.gov) acquired over the Brazil-Malvinas confluence region for the period from 2005 to 2010.

3. SYNOPTIC DATA (Level 2, 1 km resolution)

The analysis of level 2 SST imagery from MCSST and NLSST shows how the amount of Gaussian noise in level 1 Brightness Temperatures (BTs) affects the observation of thermal gradients. This can be seen in Fig 1 in both the SST fields and the magnitude of SST gradients.

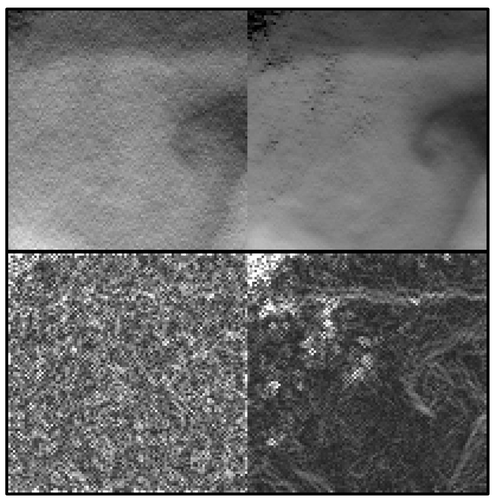

Fig. 1. On top panels Aqua MODIS SST derived with the NLSST formulation (left) and the MCSST (right). Note how the MCSST is spatially more homogeneous. This is even clearer when computing the SST gradient magnitudes (bottom panels)

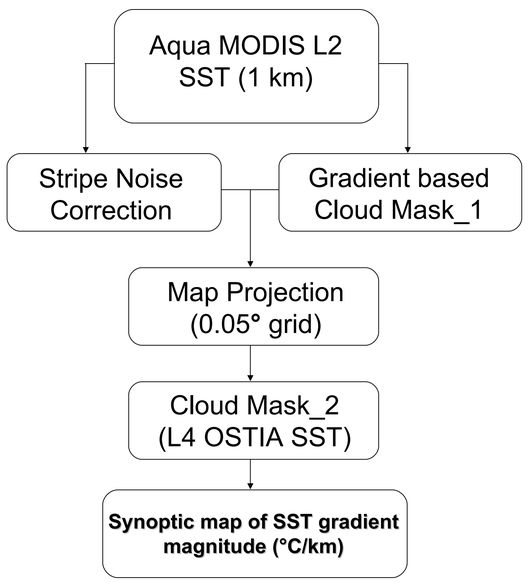

Fig. 2. Processing chain from level 2 SST to level 3 maps of SST gradient magnitudes.

4. COMPOSITE DATA (Level 3, 0.05° grid)

Level 2 SST products were post-processed with a destriping algorithm and a cloud masking scheme that mitigates the misclassification of sharp thermal fronts as clouds. Synoptic Level 3 maps of SST gradient magnitudes were averaged in time to produce monthly, seasonal, annual and 5 years composite maps (see processing chain in Fig 2). Differences when using NLSST and MCSST are illustrated in Fig 3.

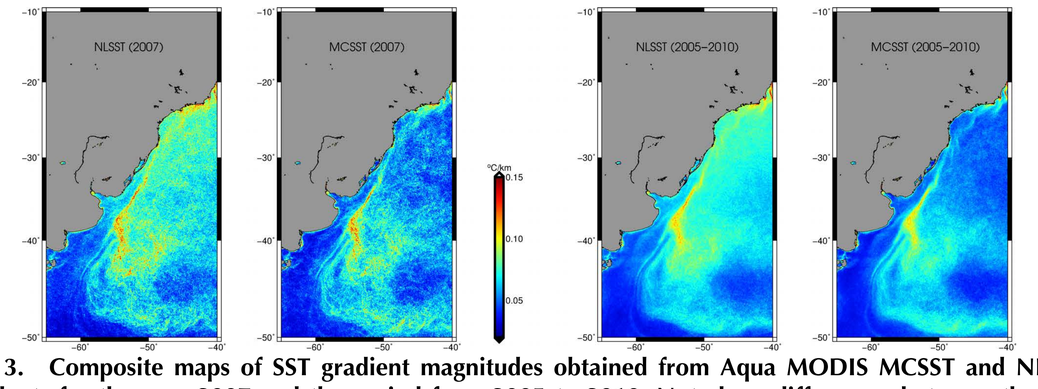

Fig. 3. Composite maps of SST gradient magnitudes obtained from Aqua MODIS MCSST and NLSST products for the year 2007 and the period from 2005 to 2010. Note how differences between the two datasets appear mostly towards lower latitudes i.e., higher SST values

5. SST VALUES vs SST GRADIENTS

The use of a reference SST in the NLSST introduces a systematic correlation between SST gradient magnitudes and SST values that is not observed in the MCSST dataset

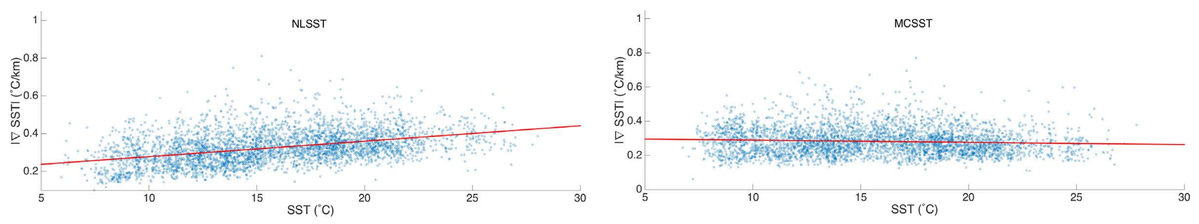

Fig. 4. Scatter plot between the magnitude of SST gradients and the values of SST. Each point represents an annual mean in the 0.05° grid. Note how a clear positive correlation between SST and SST gradient magnitudes exists in the case of the NLSST.

Long term trends

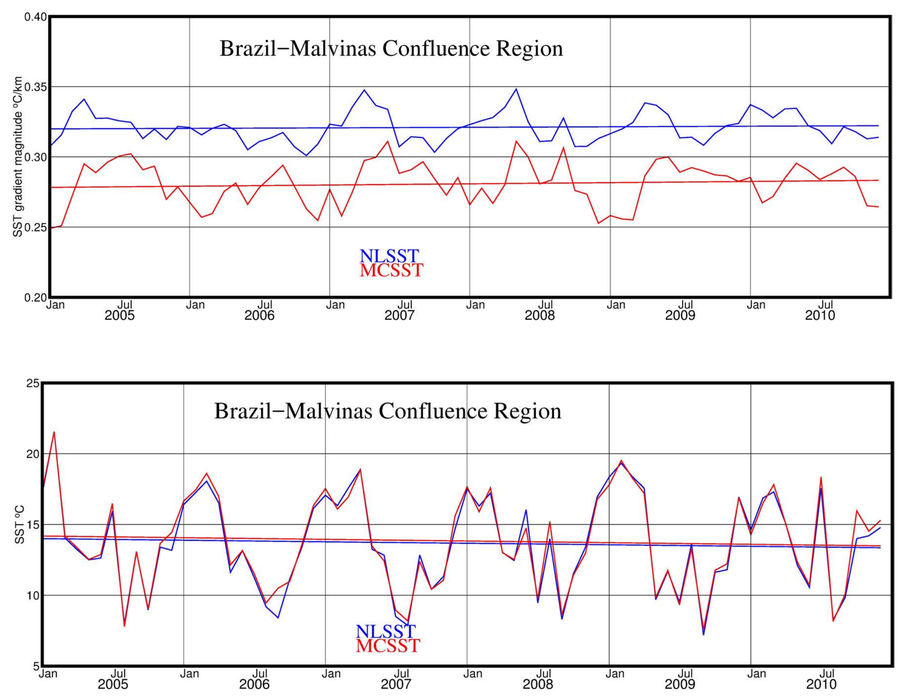

Fig. 5. Time series (2005-2010) of SST gradient magnitudes and SST values in the Brazil-Malvinas confluence region using Aqua MODIS NLSST and MCSST

The time series of SST values derived from MCSST and NLSST are highly consistent (correlation of the order of 0.97). However, major differences are seen when analyzing the magnitude of thermal fronts, i.e :

* The magnitude of thermal fronts in the NLSST is higher than that observed in the MCSST with monthly mean differences of up to 0.06 ˚C/km.

* The trend in SST gradient magnitudes from the NLSST product differs from that observed when using the MCSST.

6. CONCLUDING REMARKS

* SST products derived from MCSST and NLSST are consistent statistically **but not** geometrically.

* Unlike the MCSST, the NLSST uses a **reference SST** as a **multiplier** of the noisy term *(BT11−BT12)*

* This inevitably results in a **spatial** and possibly a **temporal** correlation between SST gradient magnitudes and SST values

* Consequently, any existing trend in the SST could be transfered into the trend of SST gradient magnitudes which may lead to erroneous interpretation of the spatial distribution and long term changes of ocean dynamics.

* The introduction of time/latitude dependent coefficients in the SST retrieval equation (collection 6 of MODIS) may further affect the study of spatio-temporal trends in thermal fronts

Acknowledgment: *FAPESP 2017/04887-0 , FAPESP 2018/00528-9*