Comparison of VIIRS SST fields obtained from differing SST equations applied to a region covering the northern Gulf of Mexico and western North Atlantic

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INTRODUCTION

Sea Surface Temperature (SST) retrievals derived from data acquired by the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor on-board the S-NPP satellite are produced using a number of SST equations. This study examines the effect on the produced SST fields of daytime SST equations that are or were used by the Naval Oceanographic Office (NAVOCEANO), NOAA/STAR, Météo France, the Integrated Data Processing Segment (IDPS) and the University of Miami. For the Météo France equation, coefficient values from NAVOCEANO, NOAA and Météo France are tested. To match a scene provided by the University of Miami, the region in this study covers the Northern Gulf of Mexico and part of the Western North Atlantic for a daytime scene which was captured on May 14, 2013. We attempt to validate the SST fields by comparing the satellite derived values with those of drifting or moored buoys. We also examine the end of scan region as it is the area where results of the SST equations differ most. Analyzing the difference in temperature at the overlap between swaths provides insight on how well the various equations and coefficients combinations perform at higher satellite zenith angles.

SST EQUATIONS
(as of November 2013)

- IDPS (standard NLSST equation)

$$a_0 + a_1 T_{11} + a_2 T_f \left(T_{11} - T_{12}\right) + a_3 \left(T_{11} - T_{12}\right)\left(\frac{1}{\cos(\theta)} - 1\right)$$

with first guess T_f in Celsius.

A.NL53deg – NAVOCEANO (expanded NLSST equation/operational)

$$a_0 + a_1 T_{11} + \left(a_3 + a_4 T_f + a_5\left(\frac{1}{\cos(\theta)} - 1\right)\right)\left(T_{11} - T_{12}\right)$$

- NL+2 -NAVOCEANO (NLSST equation with extra angle terms)

$$a_0 + a_1 T_{11} + \left(a_3 + a_4 T_f + \left(a_5 + a_7 T_f\right)\left(\frac{1}{\cos(\theta)} - 1\right)\right)\left(T_{11} - T_{12}\right) + a_6\left(\frac{1}{\cos(\theta)} - 1\right)$$

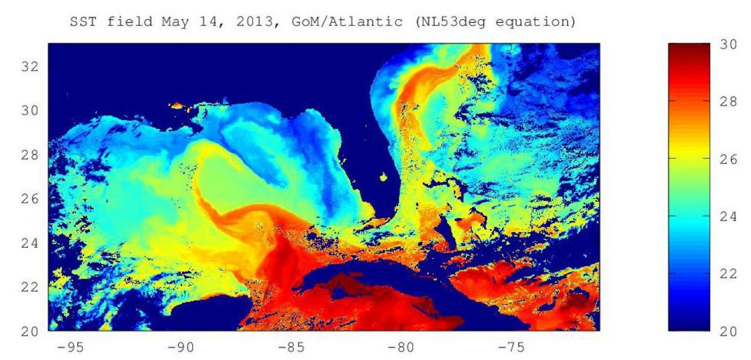
- NLC - OSI-SAF/Météo France (NLSST equation with extra angle terms)

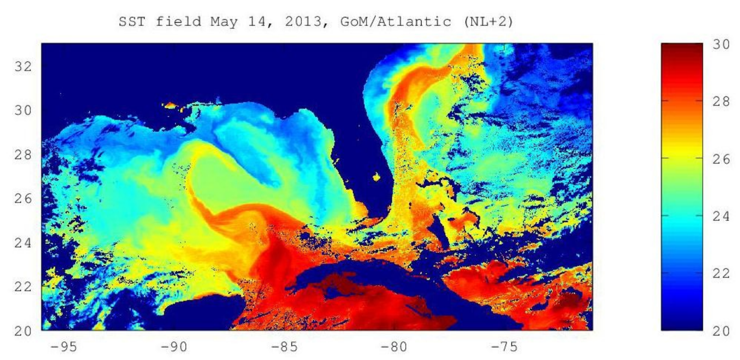
$$a_0 + \left(a_1 + a_2\left(\frac{1}{\cos(\theta)} - 1\right)\right)T_{11} + \left(a_3 + a_4 T_f + a_5\left(\frac{1}{\cos(\theta)} - 1\right)\right)\left(T_{11} - T_{12}\right) + a_6\left(\frac{1}{\cos(\theta)} - 1\right)$$

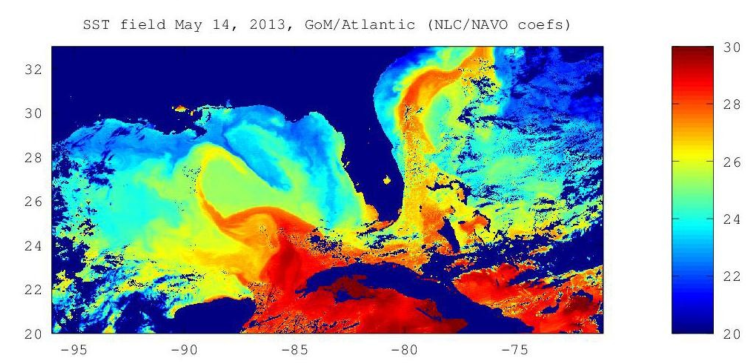
- Miami: University of Miami uses the NLD equation with a domain divided by latitude bands

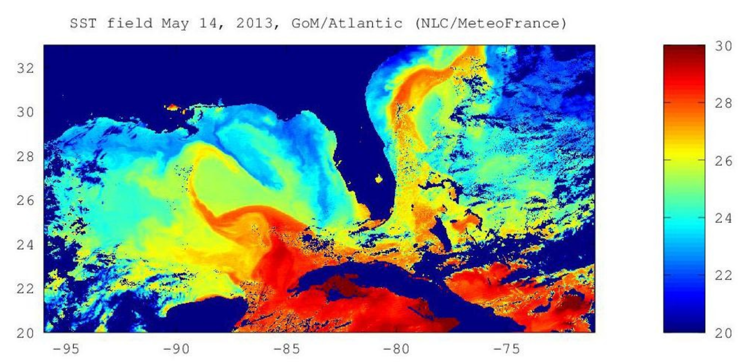
SST FIELDS

SST fields created with the NL53deg, NL+2, and NLC SST equations were all produced at NAVOCEANO with same minimal cloud detection. Coefficients derived at NAVOCEANO, and, provided by NOAA/STAR and Météo France were tested with the NLC equation.

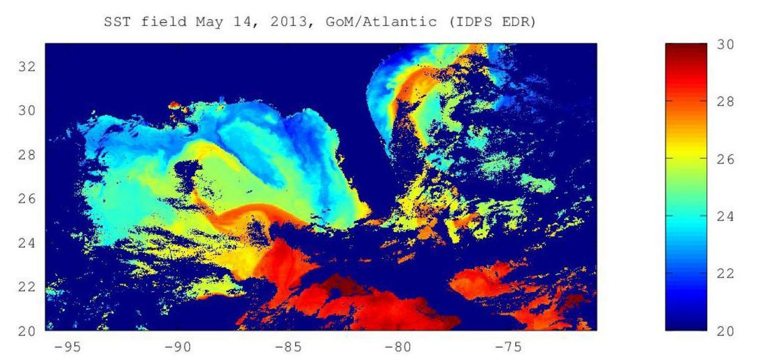


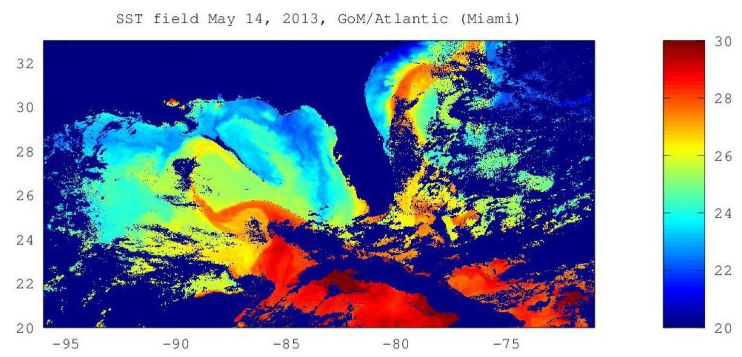






The IDPS EDR SST field comes from the Comprehensive Large Array-data Stewardship System. Only high quality SST are accepted: Except for the satellite zenith angle and the sun glint flags which are ignored, all other flags are clear. The Miami SST field was provided by the University of Miami/RSMAS, in that case only the best two quality levels are used.





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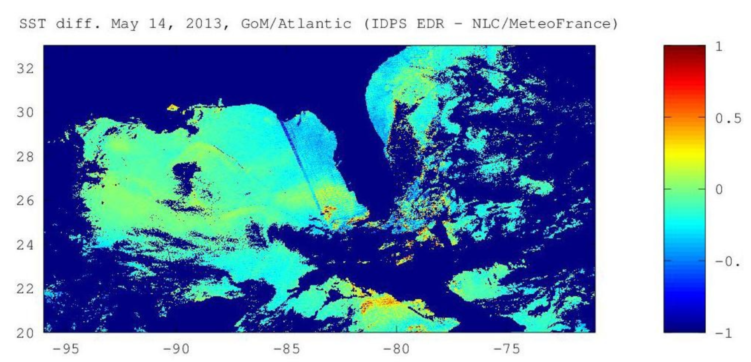
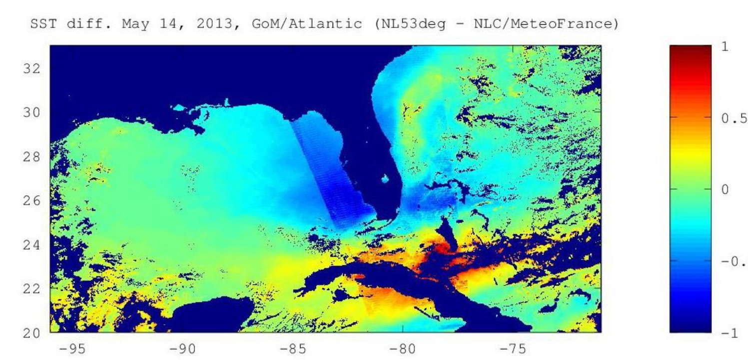
[4] Jackson, S.and Siebels, P.D. ,"Operational Algorithm Description Document. VIIRS Sea Surface Temperature (SST) EDR", http://npp.gsfc.nasa.gov/science/sciencedocuments/022012/474-00061_OAD-VIIRS-SST-EDR-SW_RevA_20120127.pdf (2011).

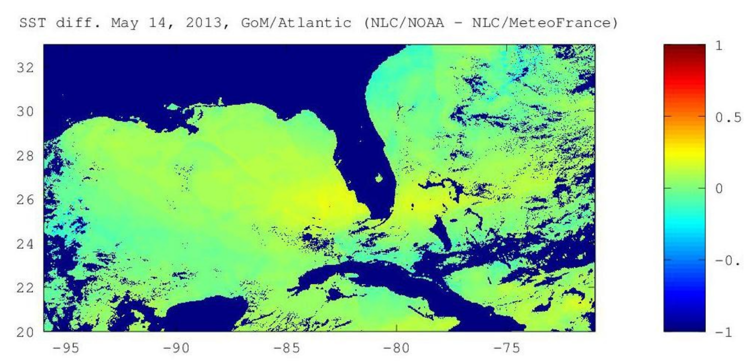
Comparison between SST FIELDS

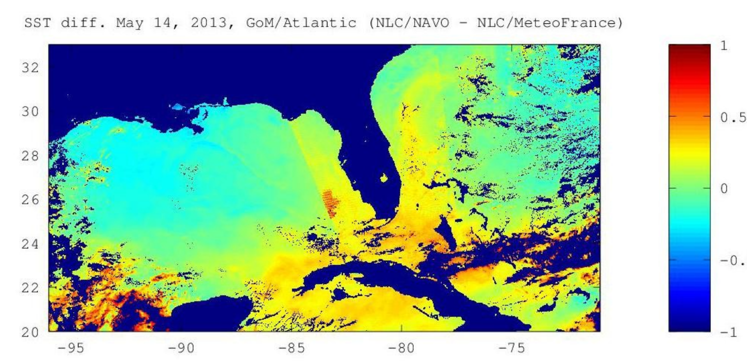
Both the IDPS and the NL53deg are designed to make SST retrievals at a maximum satellite zenith angle of 53 degrees, with IDPS flagging all data over 40 degrees as lower quality. Over that limit, their performance degrade rapidly. This is seen in the next two pictures of SST difference fields "IDPS minus NLC" and "NL53deg minus NLC" where we observe a cold bias in the swath overlap region.

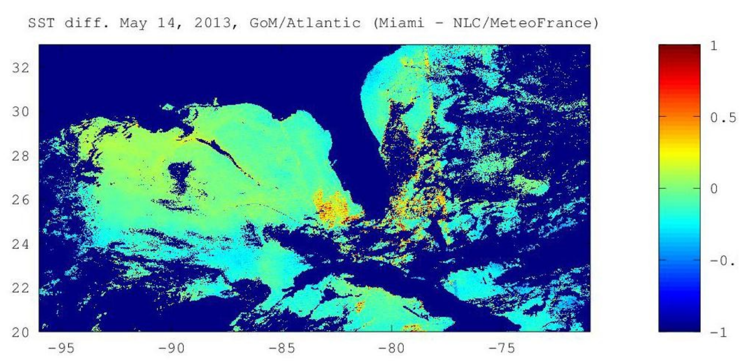




Between SST fields that are created with the NLC equation differences appear depending on which set of coefficients is used. There are relatively minor differences between fields with the Météo France and NOAA sets of coefficients. More significant differences are observed with the NAVOCEANO coefficients. In particular at high satellite zenith angle where the limb effect correction is more accentuated with the NAVOCEANO coefficients than with either the Météo France or NOAA coefficients.

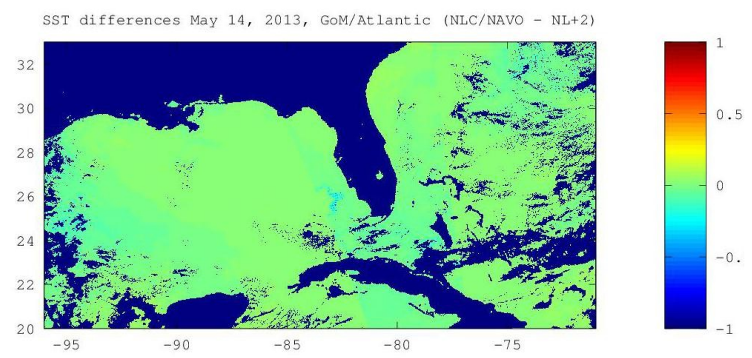


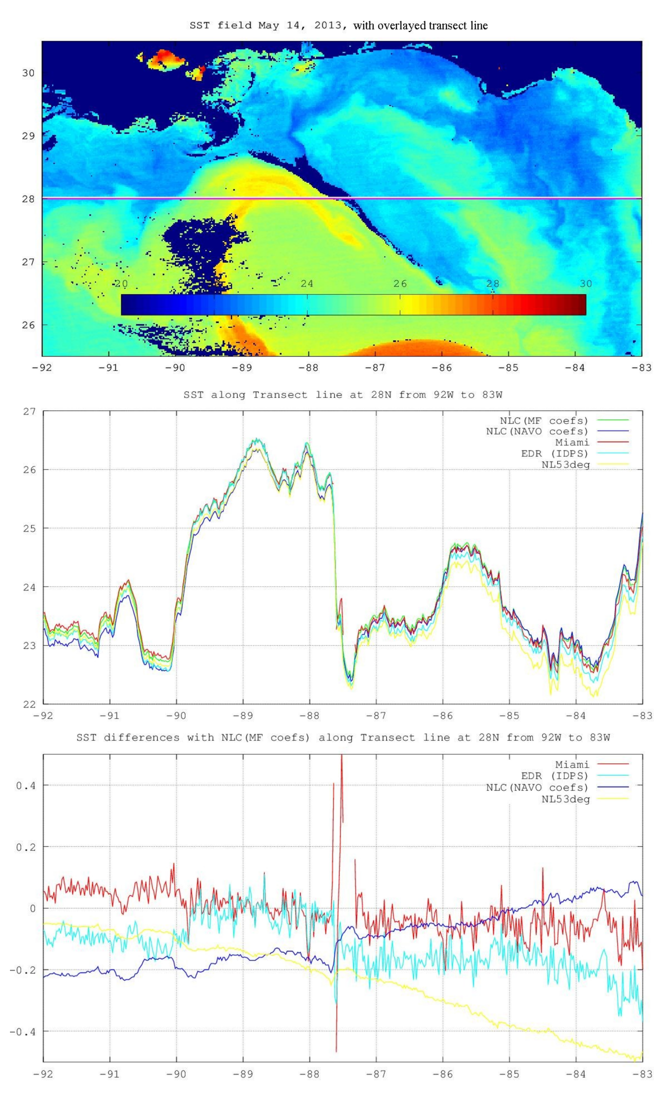




The Miami latitude bands algorithm produces fields which are close to those obtained the NLC equations and Météo France coefficients. This is surprising because the Miami algorithm relies on a standard NLSST equation like IDPS.

Comparison between the SST fields derived from the NLC and NL+2 equations, both with NAVOCEANO determined coefficients, show little differences, smaller than those observed with NLC with NOAA or Météo France coefficients.



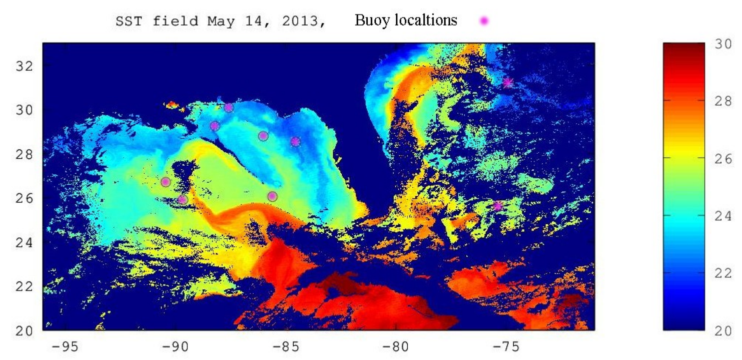


SST profiles along a transect line help better illustrate the behavior of the various SST equations on this particular scene. Using the NLC equation with Météo France as the reference, a look at Miami, NL53deg, IDPS and NLC with NAVOCEANO coefficients confirms the previous observations, namely:

- The Miami algorithm corrects the limb darkening effect almost as well as NLC(MF).
- The IDPS equation does not correct as much as NLC(Météo France).
- The NL53deg does not perform well at high satellite zenith angle, because of the equation, but also because its coefficients are derived from data within the 53 degree satellite zenith angle domain.
- The correction of the limb darkening effect is stronger for NLC with NAVOCEANO coefficients than for NLC with Météo France coefficients.

VALIDATION BY COMPARISON TO BUOYS

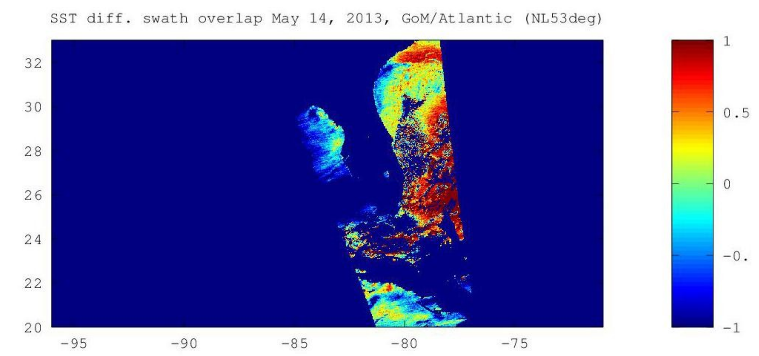
Because of the low number of buoys, results are not statistically significant. However they do offer a sanity check on all the SST fields. Of note, to better evaluate the SST equations and not the cloud detection, the closest SST retrieval to the buoy temperature, within the immediate neighborhood of the buoy, is selected as the match-up.

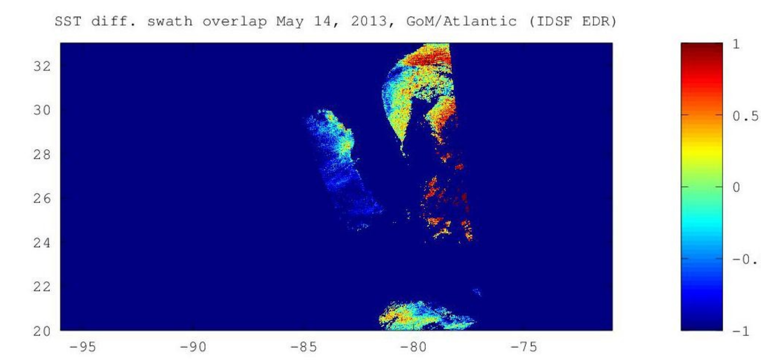


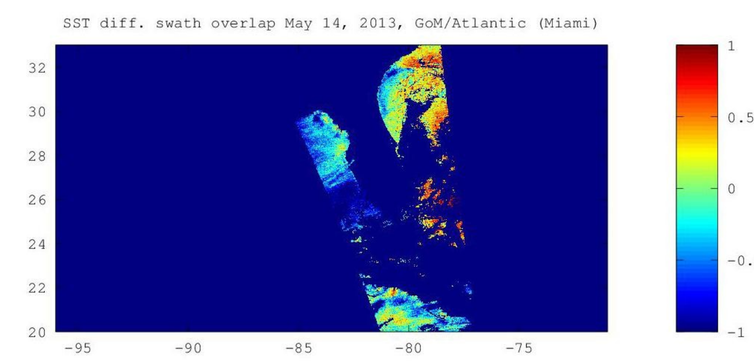
	Bias °C	Std Deviation °C
NL53deg(NAVO)	0.08	0.26
IDPS	0.04	0.31
Miami	0.04	0.29
NLC(NOAA)	0.11	0.26
NLC(MeteoFrance)	0.05	0.26
NLC(NAVO)	0.00	0.32
NL+2(NAVO)	0.01	0.33

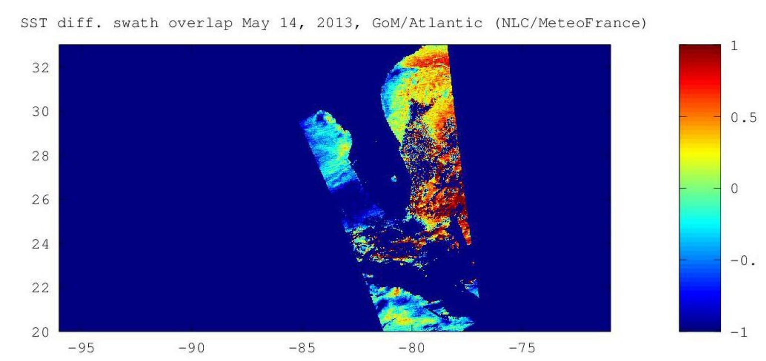
VALIDATION BY ANALYSIS OF OVERLAP BETWEEN SWATHS

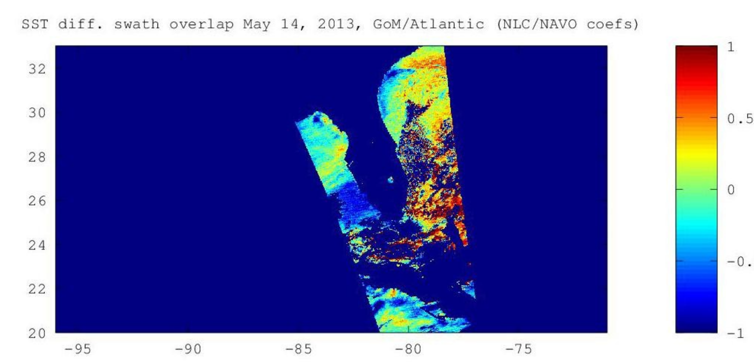
The overlap between two successive satellite swaths allows the view of a scene at an interval of about 1 hour and 36 minutes. Here, the SST field of the later orbit is subtracted from that of the earlier orbit, and as such, a small cold bias can be expected because of daytime warming. The uncorrected limb darkening effect appears as a cold bias on west side of the overlap region and a warmer bias on the east side. As expected the NL53deg and IDPS equations perform poorly in the swath overlap region as they were not designed to work at a high satellite zenith angle.

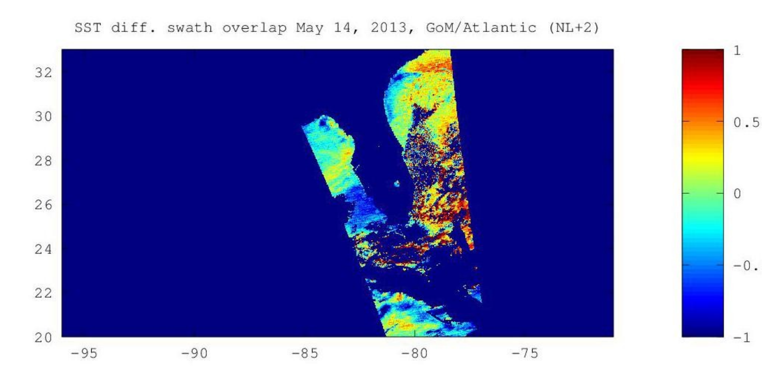












The mean bias and the mean absolute bias are estimated on a common set of retrievals that are cloud free in all SST fields. They confirm the good performance of NLC and the poor performance of NL53deg and IDPS at high satellite zenith angle. Results from a March 31, 2014 scene (same region but clouded west side) show IDPS better performance after the switch to the NLC equation.

May 15, 2013	bias °C	mean abs bias °C
NL53deg(NAVO)	-0.23	0.51
IDPS	-0.23	0.52
Miami	-0.15	0.39
NLC(NOAA)	-0.12	0.41
NLC(MeteoFrance)	-0.13	0.38
NLC(NAVO)	-0.09	0.27
NL+2(NAVO)	0.07	0.26

March 31, 2014	bias °C	mean abs bias °C
NL53deg(NAVO)	0.19	0.35
IDPS	0.14	0.30
Miami		
NLC(NOAA)	0.10	0.25
NLC(MeteoFrance)	0.18	0.32
NLC(NAVO)	0.10	0.27
NL+2(NAVO)	0.07	0.24

CONCLUSION

The NLC equation has been shown to perform well, although the choice of coefficients can significantly affect results. As expected NL53deg and IDPS (standard NLSST) perform poorly at high satellite zenith angles as they were not design to process such data. Full swath processing results in large regions where successive orbits overlap even at low latitude. Those overlap regions allow new ways to evaluate and analyze the SST fields. Beside Météo France; NOAA/STAR, IDPS and NAVOCEANO are using or plan to use the NLC equation.