Evaluation of the Precision of Submesoscale Resolution Satellite-derived Sea Surface Temperature Fields

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Background

A great deal of attention has been focused on the temporal accuracy of satellite-derived sea surface temperature (SST) fields with little attention being given to their spatial precision. Specifically, the primary measure of the quality of SST fields has been the bias and variance of selected values minus co-located in situ values. Because of cloud cover and the paucity of in situ values, satellite-in situ matchups are generally widely separated in space and time hence provide little information related to the pixel-to-pixel uncertainty in the retrievals. But the main contribution to the uncertainty in satellite retrievals results from atmospheric contamination – the spatial scale of which is, in general, large compared with the pixel separation of infra-red sensors, hence the pixel-to-pixel uncertainty is often smaller than the accuracy determined from in situ match-ups. This makes selection of satellite-derived datasets for the study of submesoscale processes, for which the spatial structure of the upper ocean is significant, problematic.

The objective of this work is to develop an approach to evaluate the spatial fidelity of satellite-derived SST fields. We begin with a comparison of spatial spectra obtained from VIIRS and AVHRR SST fields with those obtained from a long time series of high spatial resolution in situ measures in the Sargasso Sea.

Data and Preprocessing

The study area is the Sargasso Sea between 63°-72°W and 32.5°-36°N. From fall 2007 to present MV Oleander carried an exterior mounted SBE 38 temperature sensor (TEX) (accuracy 0.0001 K, resolution 0.00025 K and response time 0.5s) sampling every ~75m on its weekly transects through the region. VIIRS SST fields based on the "Moderate Resolution Bands" of VIIRS (750m resolution at nadir)were obtained for the period 2012-2013 from NCEI/ NOAA. The fast Fourier Transform (FFT) was used to estimate spectra. The FFT requires gap-free equally spaced samples. For VIIRS SST level 2 product, on along-track and along-scan directions respectively, we picked the 256*0.75km long lines totally clear or with small scale gaps that can be filled, and then interpolate each line onto equidistant(0.75 km) line. Same processing, based on quality level 0 and 1 retrievals, was used to the full resolution AVHRR SST level 2 product with the lines are 256 km long.

Satellite-derived SST fields tend to be gappy due to clouds while the TEX data is gappy, although less so, due to bubbles. The picked lines in the study area was located for each satellite pass and then a second application of the Barnes filter was used to fill gaps in this region. Grid points with no good values within 1.5 km (for VIIRS, 2 km for AVHRR) were flagged as bad. Each gap-free lines in the region was then detrended, a Blackman window applied and a spectrum estimated. Finally, the spectra were ensemble averaged over all images. Similar processing was performed on the TEX data and the weekly spectra (2007-2013) were ensemble averaged. Although preferable, 2-d FFTs result in too few spectra from the satellite data due to cloud cover for smooth ensemble estimates.

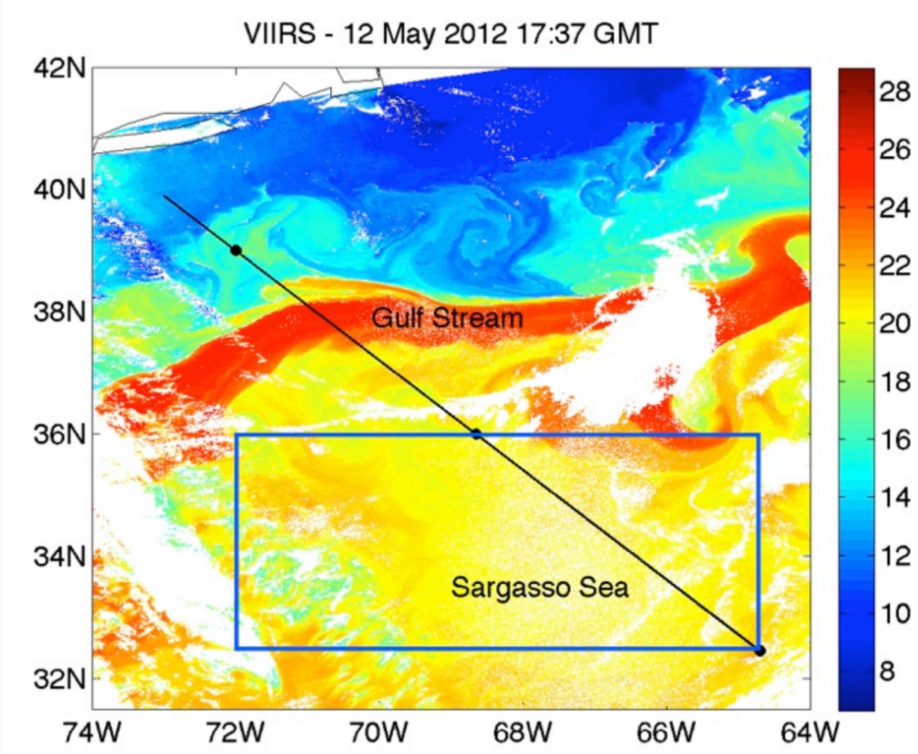
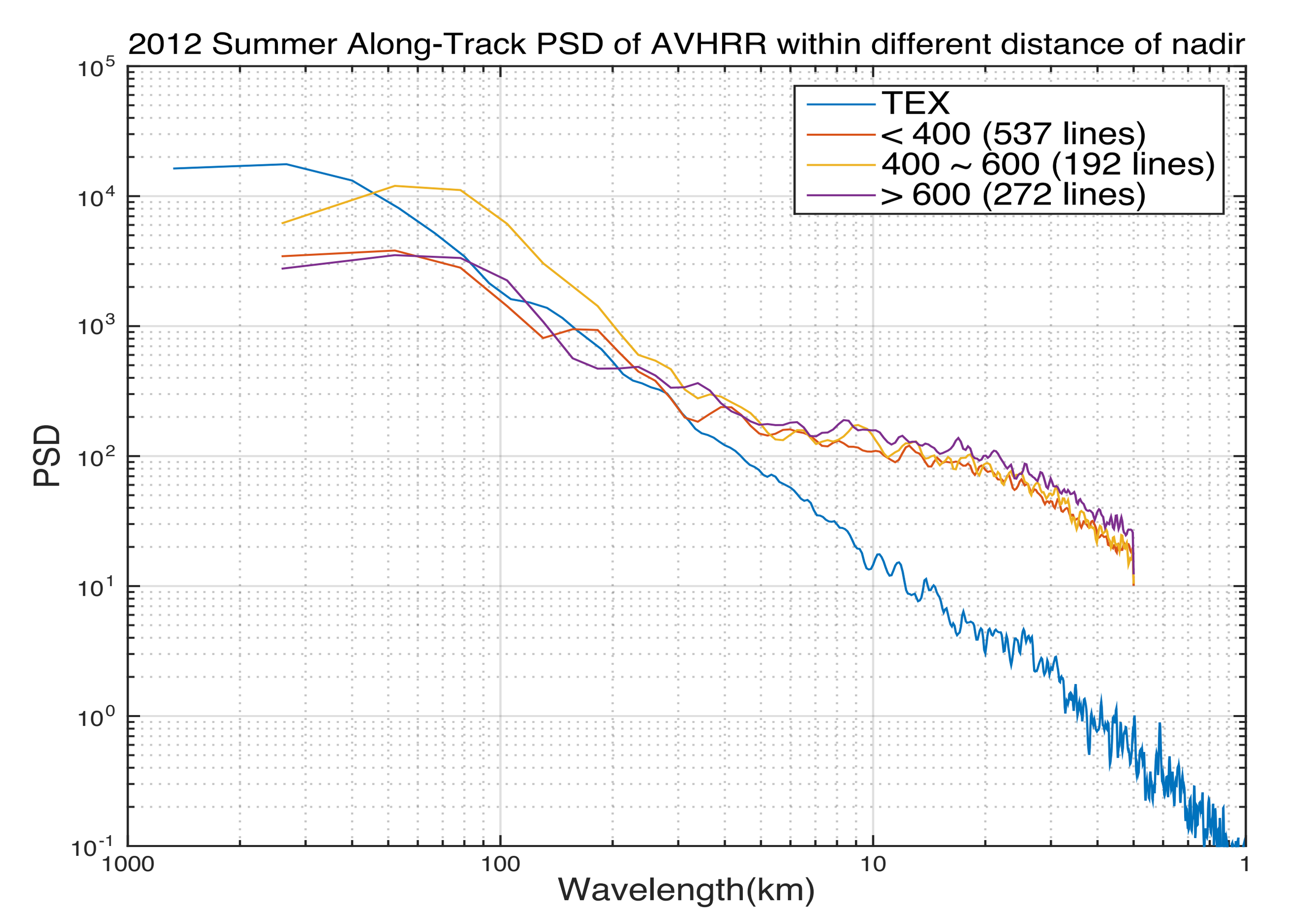
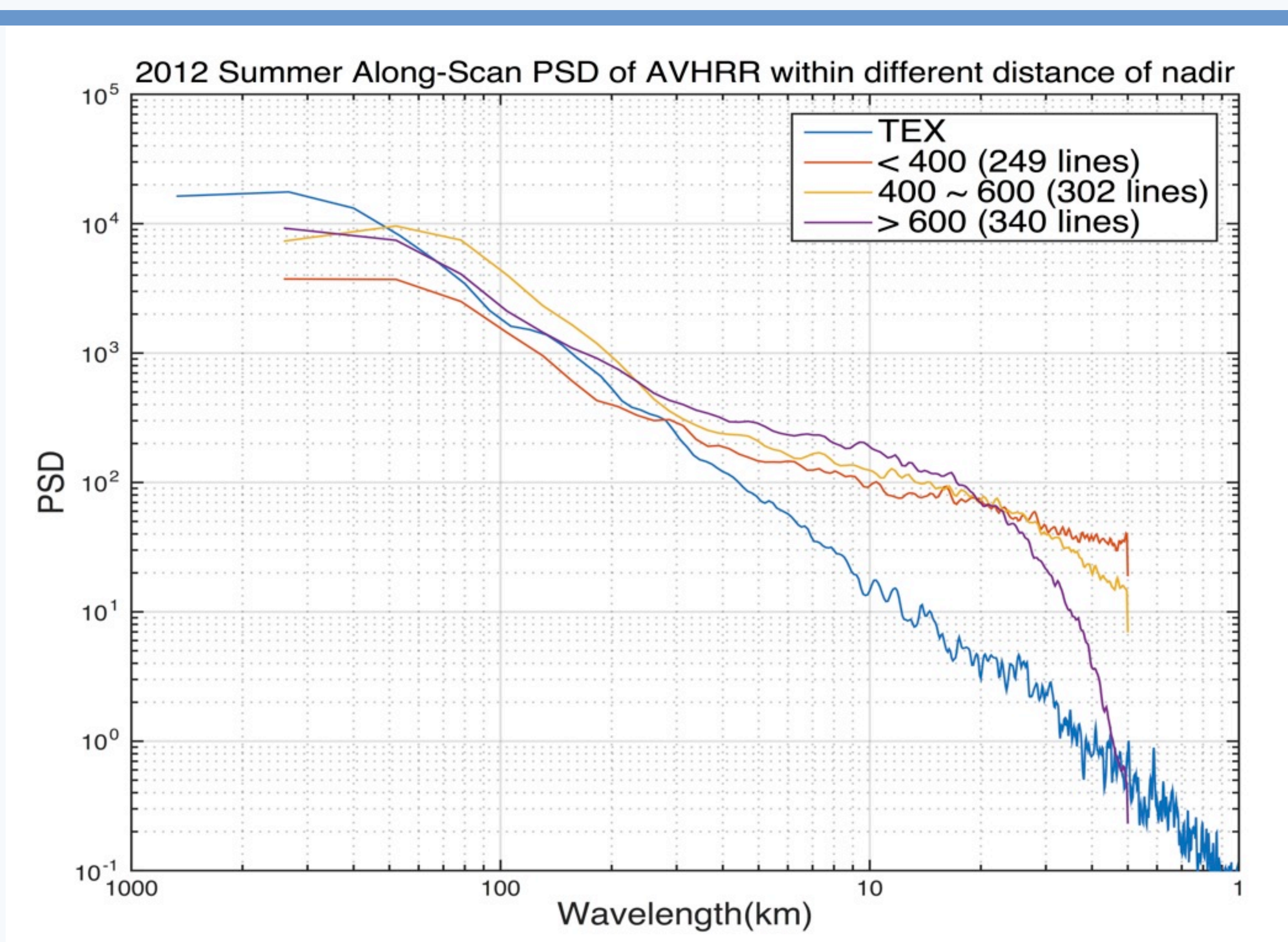
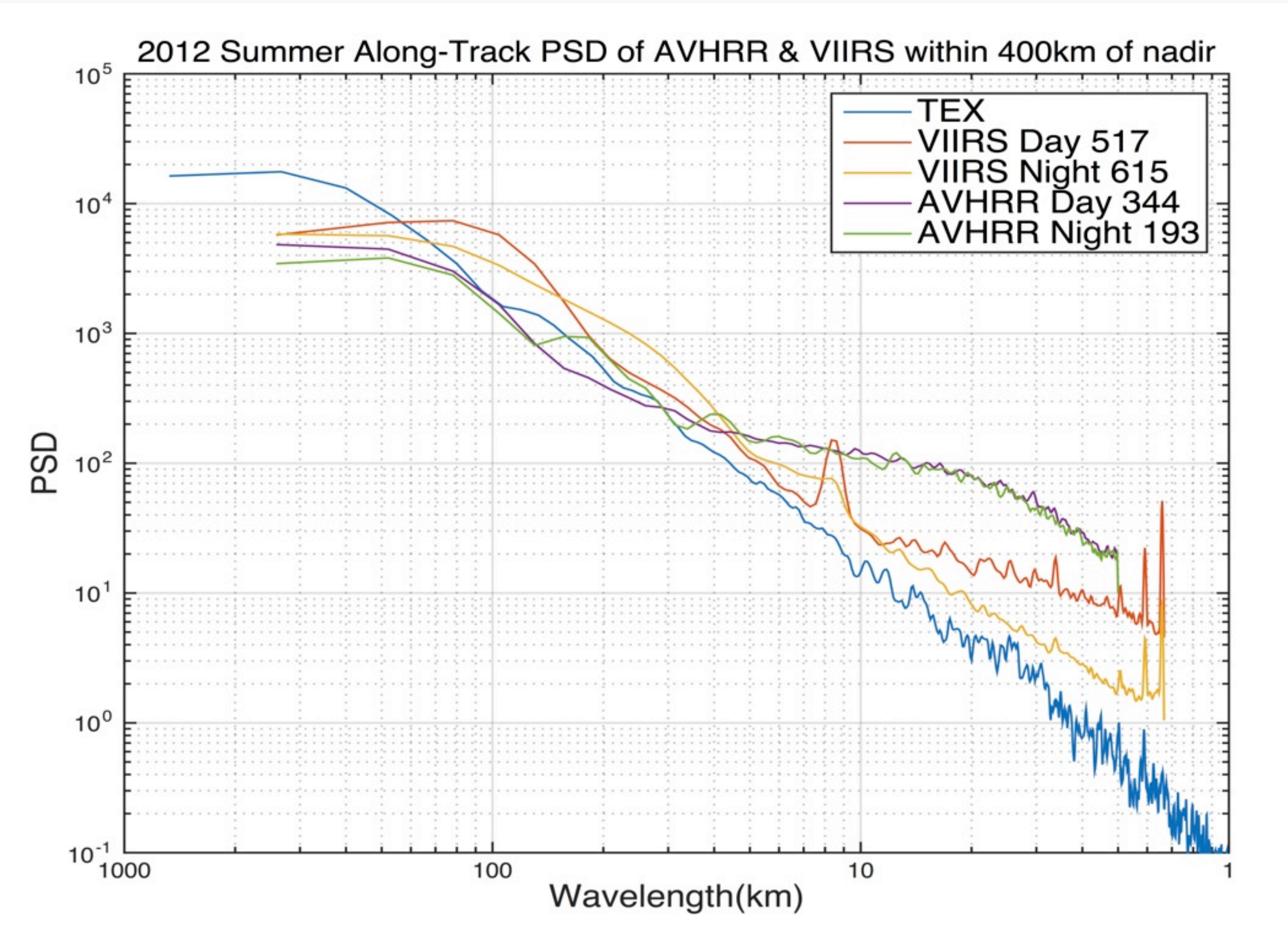


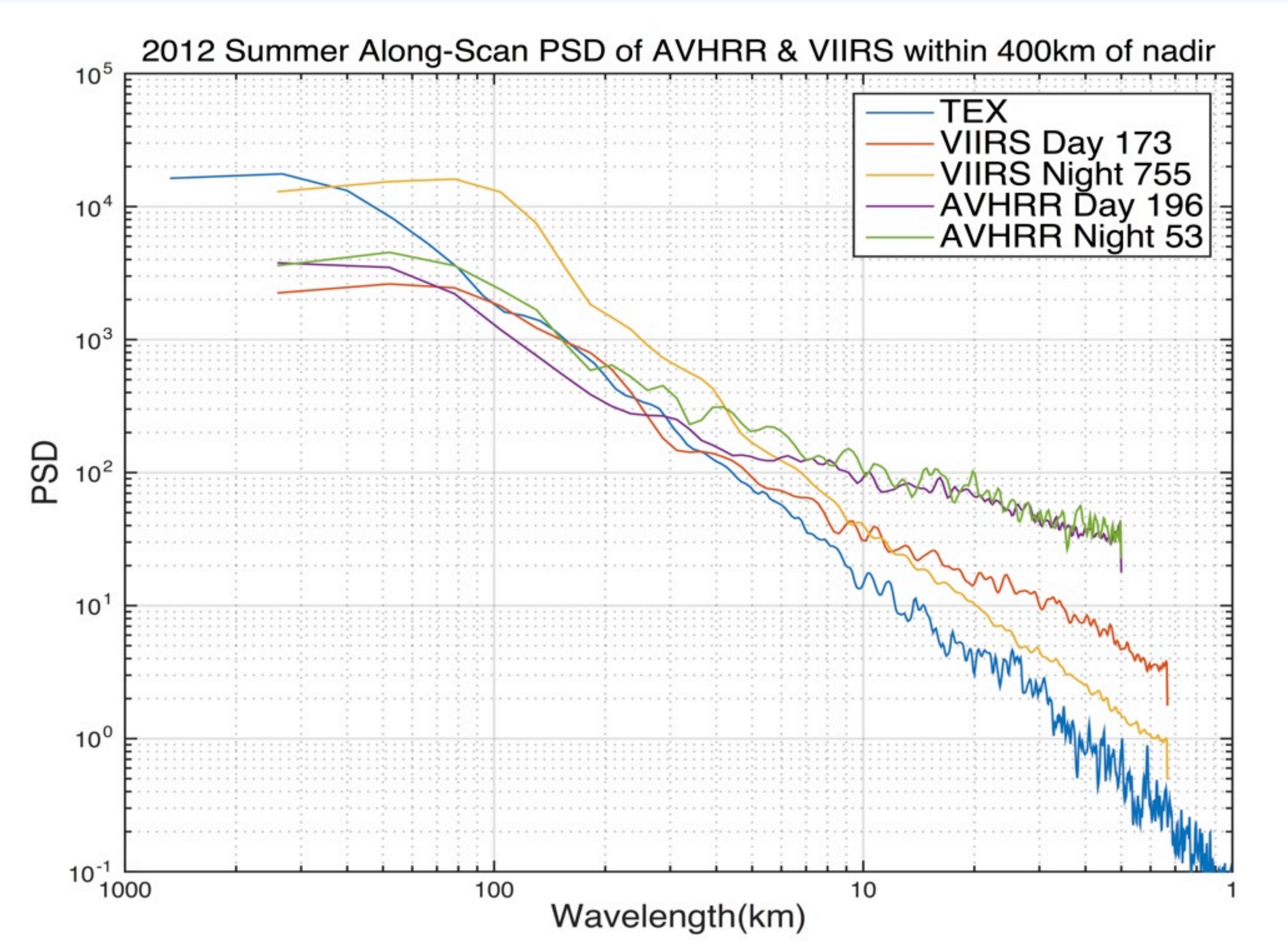
FIG. 1 VIIRS SST image from 12 May 2012. The black line indicates the nominal Oleander track, the blue box indicates the region of satellite data.





In Fig.1a, comparing AVHRR spectra at distances <400 km, between 400 and 600 km and >600 km from nadir, we see that the distance from nadir is relatively unimportant for spectra in the along-track direction. Bycontrast, Fig.1b shows that spectra in the along-scan direction are significantly affected by distance from nadir for scales <5km. This difference results from the difference in the increase in the along-scan and along-track direction as the swath edge is approached.





The above figure, comparing spectra for AVHRR and VIIRS for distances <400km from nadir, is rich in information.

a) For AVHRR, there is little difference between day and night spectra in both the along-scan and along-track direction.
b) By contrast, VIIRS shows a significant day/night difference for scales less than ~14km. Presumably AVHRR does not show a difference because the difference is below the noise level of the day/night difference.
c) AVHRR along-track spectra fall off faster than along-scan spectra for scales <5km. We do not understand this.
d) VIIRS along-track spectra show the effect of multiple detectors with a significant peak at ~12 km corresponding to the repeat distance of the detectors and several peaks separations of 3-5 pixels.

Conclusion

- VIIRS night along-scan spectra provide excellent estimates of the slope from 0.75 km ~ 50 km.
- VIIRS spectra show more energy at day than night, thought to be a result of diurnal warming in the summer.
- AVHRR spectra have elevated energy at the submesoscale (< 25 km), likely due to instrument noise but may be related to poor cloud-screening.
- Slopes of the AVHRR spectra are significantly affected by distance from nadir from less than 5km.

Acknowledgements This research was supported by the NSFC project (41376105), NSFC- Shandong Joint Fund for Marine Science Research Centers (U1406404) and The China Scholarship Council – The Science of VIIRS, Oleander and AVHR. Salary support for P. Cornillon was supplied by the State of Rhode Island and Providence Plantations.

June, 2016

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