Use of 3.9 μm channel for daytime sea surface temperature retrieval

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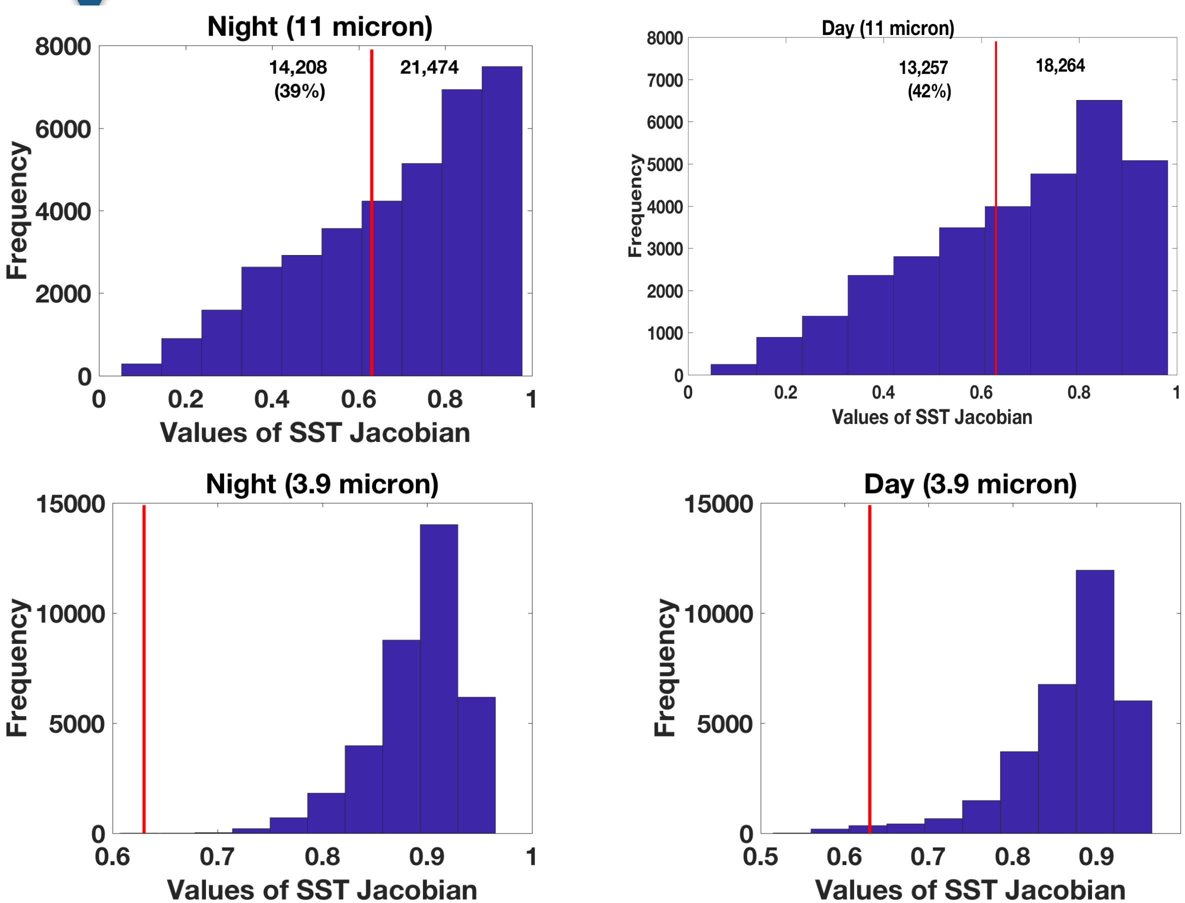
Data and Methods Used

- MODIS L2P SST: ftp://ftp.nodc.noaa.gov/pub/data.nodc/ghrsst/L2P/MODIS_A/JPL/
- MODIS L1b & Geo Loc: ftp://ladsweb.nascom.nasa.gov/allData/6/
- GOES-13: NOAA.
- GFS ftp://nomads.ncdc.noaa.gov/GFS/Grid4/
- Buoy data: http://www.star.nesdis.noaa.gov/sod/sst/iquam/
- NGAC Aerosol data: Personal communication with Jun Wang, NCEP, NOAA.
- CRTM : http://ftp.emc.ncep.noaa.gov/jcsda/CRTM/REL-2.1/
- TTLS: Truncated Total Least Squares
- MTLS: Modified Total Least Squares
- Regression:
  - Split window
  - Triple window

Why 3.9 μm channel important

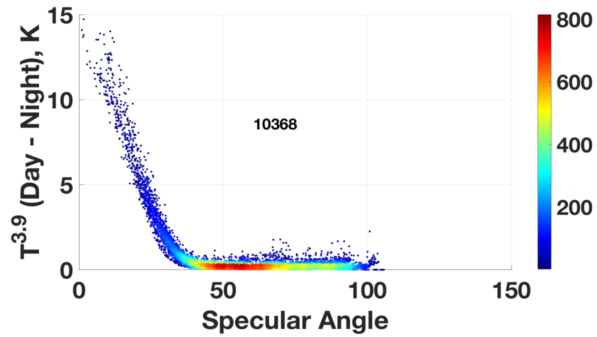


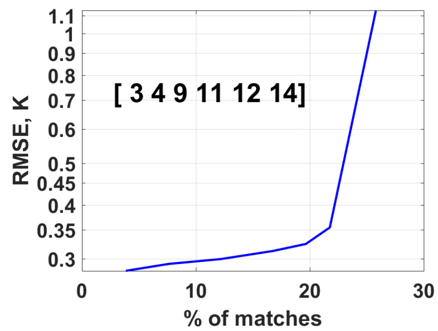
1. SST Jacobian is proportional to transmission.
2. One of the fundamental assumptions for Split window: 11 μm is window channel.
3. How to define window channel: using penetration depth concept.
4. Quality of SST retrievals using SW method is questionable.

~40% of measurements doesn't hold the fundamental assumptions of SW method.
TOA 3.9 μm measurement always hold the surface information.
Planck function 3.9 μm is steeper than that of ~11 μm.

Experimental Filter (Cloud Free)

$$abs\left(\mathbf{T}_b - \mathbf{T}_g - \mathbf{T}_{rtv}^{3.9}\right) < \frac{0.75}{K_{sst}^{3.9}} \; ; \mathbf{T}_{rtv}^{3.9} = \frac{T_m^{3.9} - T_s^{3.9}}{K_{sst}^{3.9}}$$

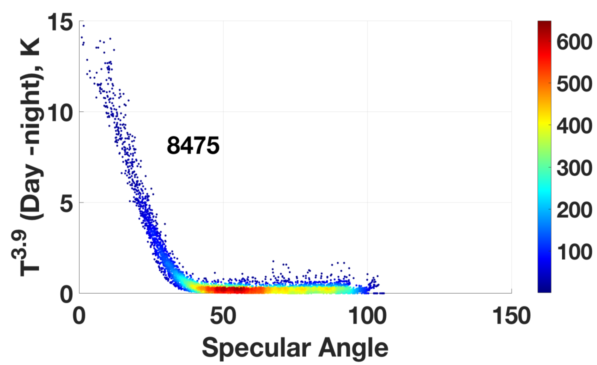


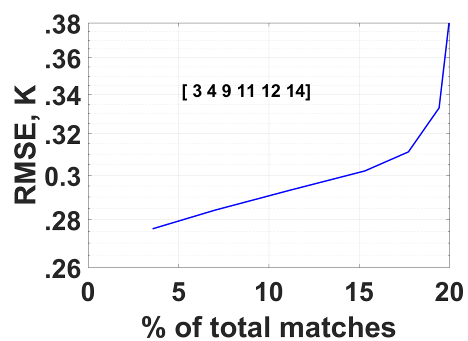


$$\theta_v = \cos(\theta_{slz})\cos(\theta_{stz}) + \sin(\theta_{slz})\sin(\theta_{stz})\cos(\theta_{raz})$$

$$\theta_{spec} = 180cos^{-1}(\theta_v)/\pi$$

Modified EXF: $abs\left(\mathbf{T}_b - \mathbf{T}_g - \mathbf{T}_{rtv}^{3.9}\right) < \frac{0.75}{K_{sst}^{3.9}}$ & $dd(T^{3.9}, T^{11}) < 3$





1. Specular component of CRTM is satisfactory.
2. Ocean surface is quasi-specular and BRDF component in CRTM has to be improved.
3. ~20% of measurements after discarding the pixels due to deficiency of CRTM are qualified for good retrievals, is higher than 7% of total matches is QL=5 in operation.
4. Nighttime SD~0.22K and bias ~0.17K, whereas Daytime SD ~0.3, which is comparable $\sqrt{(0.22^2 + 0.17^2)} = 0.28$

To use of 3.9 µm for daytime SST retrieval using physical model is undisputable.

Regression based Retrieval

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$$SW_{org} = a_0 + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3T_b(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12})$$

$$TW_{3.9} = a_0 + a_2\,T^{3.9} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12})$$

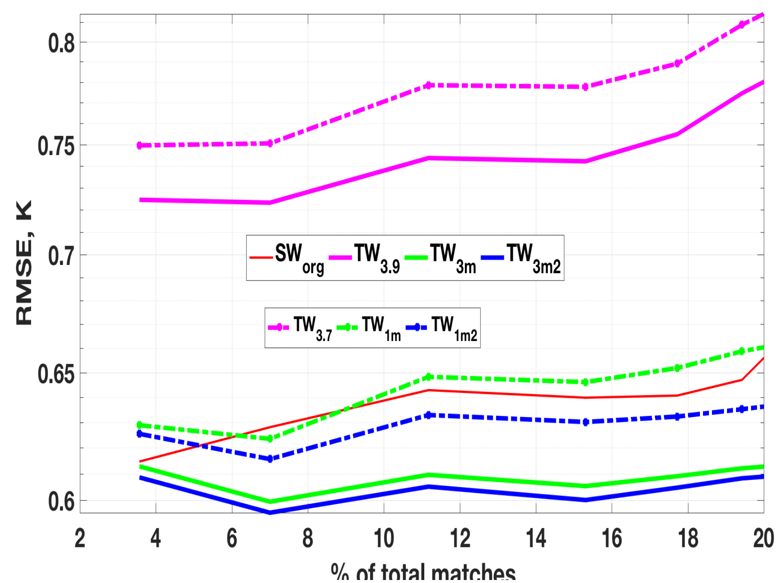
$$TW_{3.7} = a_0 + a_2\,T^{3.7} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12})$$

$$TW_{3m} = a_0 + a_2\,T^{3.9} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12}) + a_4\theta_{spec}(T^{3.9}-T^{11})$$

$$TW_{3m2} = a_0 + a_2\,T^{3.9} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12}) + a_4\theta_{spec}(T^{3.9}-T^{11}) + a_5\theta_{spec}(T^{3.9}-T^{4})$$

$$TW_{3m} = a_0 + a_2\,T^{3.7} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12}) + a_4\theta_{spec}(T^{3.7}-T^{11})$$

$$TW_{1m2} = a_0 + a_2\,T^{3.7} + a_1T^{11} + a_2(T^{11}-T^{12}) + a_3(\sec(\theta_{stz} - 1))(T^{11}-T^{12}) + a_4\theta_{spec}(T^{3.9}-T^{11}) + a_5\theta_{spec}(T^{3.7}-T^{4})$$

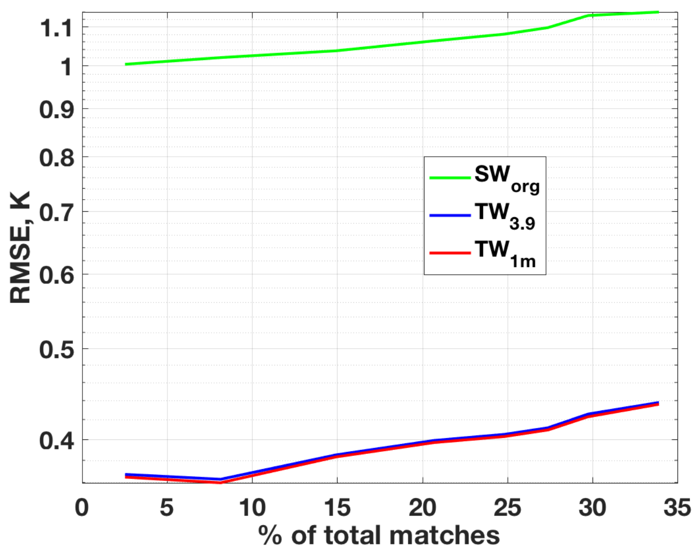


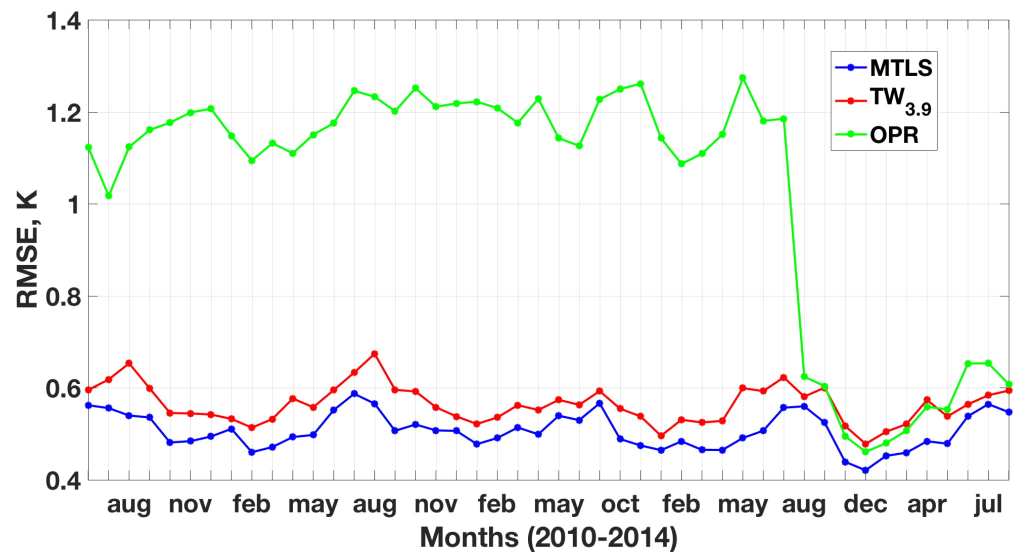
Comparison of GOES-13 daytime SST retrieval

$$SW_{org} = a_0 + a_1 T^{11} + a_2(T^{11} - T^{13.4}) + a_3 T_b(T^{11} - T^{13.4}) + a_3(\sec(\theta_{stz} - 1))(T^{11} - T^{13.4})$$

$$TW_{3.9} = a_0 + a_2\, T^{3.9} + a_1 T^{11} + a_2(T^{11} - T^{13.4}) + a_3(\sec(\theta_{stz} - 1))(T^{11} - T^{13.4})$$

$$TW_{1m} = a_0 + a_2\, T^{3.9} + a_1 T^{11} + a_2(T^{11} - T^{13.4}) + a_3(\sec(\theta_{stz} - 1))\,(T^{11} - T^{13.4})$$
$$+\ a_4 \theta_{spec}(T^{3.9} - T^{11})$$





Prabhat K. Koner, Andy R. Harris & Eileen Maturi, Hybrid cloud and error masking to improve the quality of deterministic satellite sea surface temperature retrieval and data coverage, Remote Sensing Environment, vol. 174, p. 266-278, 2016.

Conclusions:

- **SWIR channels is must for unambiguous SST retrieval.**
- **Daytime SST retrieval algorithm including 3.9 μm channel has already successfully implemented in operation using physical deterministic method.**
- **TW regression algorithm including 3.9 μm channel can be used for Geo-sensors.**
- **New TW algorithms including 3.9 μm or 3.7 μm channel for daytime is proposed for polar orbiters.**

Thank You

Questions?