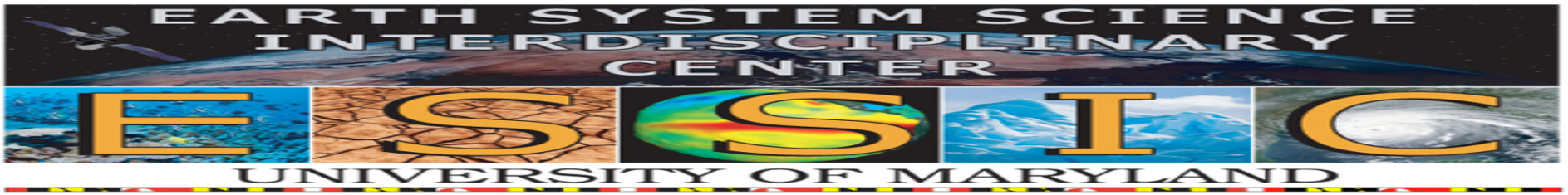
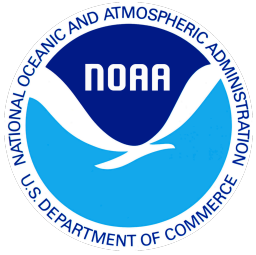


A novel cloud detection for infrared SST application using VIIRS radiances

Prabhat K. Koner & Andy Harris



Presented: CICS Science Conference: Nov 29-Dec 1, 2016

Acknowledgement: This work was funded under NASA Grant number NNX14AP64A

Introduction

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.

A quasi-deterministic hybrid cloud and error mask (CEM) is demonstrated using both functional spectral differences (FSD) and RT calculations (DD) for GOES-13 imager IR measurement.

Prabhat K. Koner & Andy R. Harris, Improved quality of MODIS sea surface temperature retrieval and data coverage using physical deterministic methods, Remote Sens. 2016, 8(6), 454; doi:10.3390/rs8060454.

Improved CEM is proposed using same FSD with GOES-13 derived coefficients and RT based tests are altered due to more channels available in MODIS. SST is retrieved using same MTLS.

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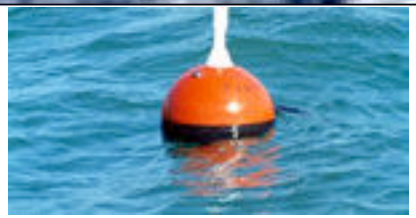
Test for Cloud algorithm performance



$$abs(\mathbf{SST}_b - \mathbf{SST}_g - \mathbf{rtv}_{3.9}) \le 1; \mathbf{rtv}_{3.9} = \frac{\mathbf{T}_{3.9}^{m} - \mathbf{T}_{3.9}^{s}}{\mathbf{K}_{3.9}^{SST}}$$

Brief history of Cloud detection

Saunders & Kriebel: APOLLO (1988)

Spectral Differences (11 & 12 µms)

Ackerman et al. : MODIS (~2000)

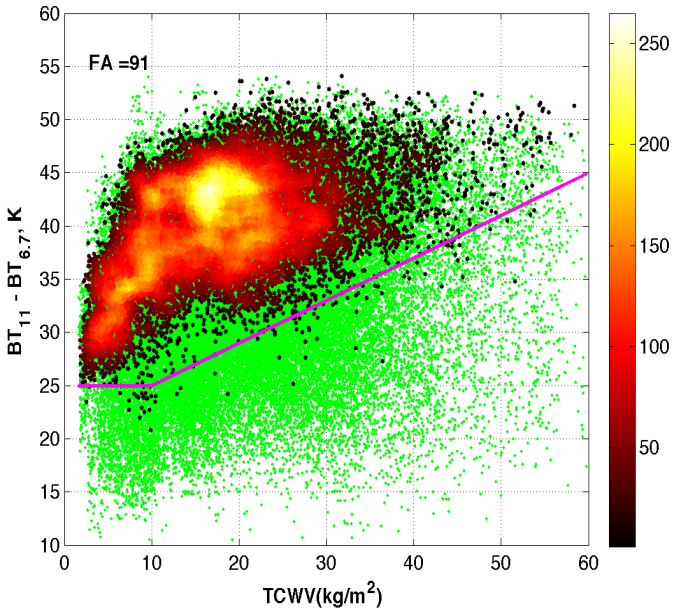
Spectral Differences (6.7 & 11 µms)

Jedlovec : GOES13 (2008)

Spectral Differences (3.9 & 11 µms)

Walker et al: GOES13 (2012)

Spectral Differences (11 & 13.4 µms)



Spectral differences techniques alone cannot completely separate out the cloudy pixels. We introduce double-difference of spectrum using RT calculation.

Data and Software downloaded

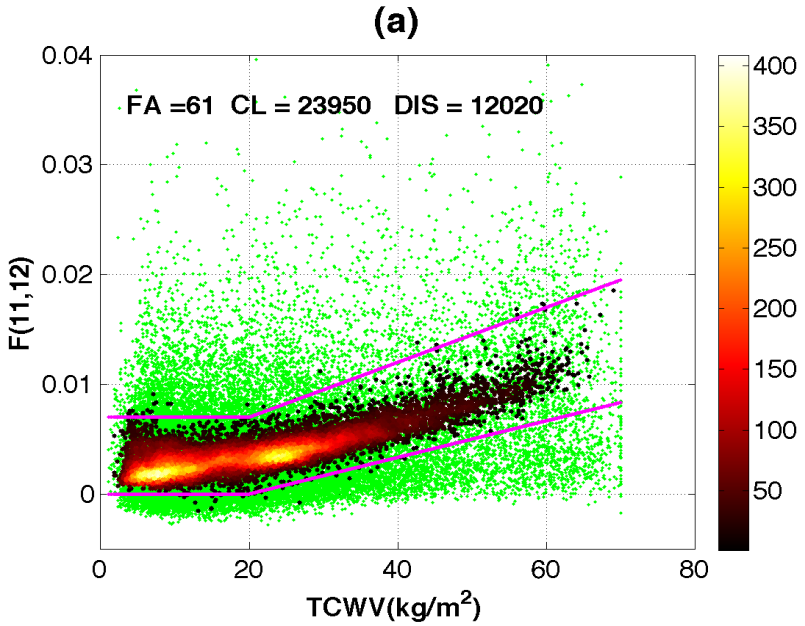
- VIIRS L2 NAVO SST: ftp://podaac-ftp.jpl.nasa.gov/allData/ghrsst/ data/GDS2/L2P/ VIIRS_NPP/NAVO/v1 or v2/
- VIIRS L2 OBPG SST: http://oceandata.sci.gsfc.nasa.gov/VIIRS/L2/
- VIIRS-A L1b & Geo-Loc: SCDR, NOAA.
- GFS ftp://nomads.ncdc.noaa.gov/GFS/Grid4/
- Buoy data: http://www.star.nesdis.noaa.gov/sod/sst/iquam/
- CRTM : http://ftp.emc.ncep.noaa.gov/jcsda/CRTM/REL-2.1/
- NGAC Aerosol data: Personal communication with Jun Wang, NCEP, NOAA.

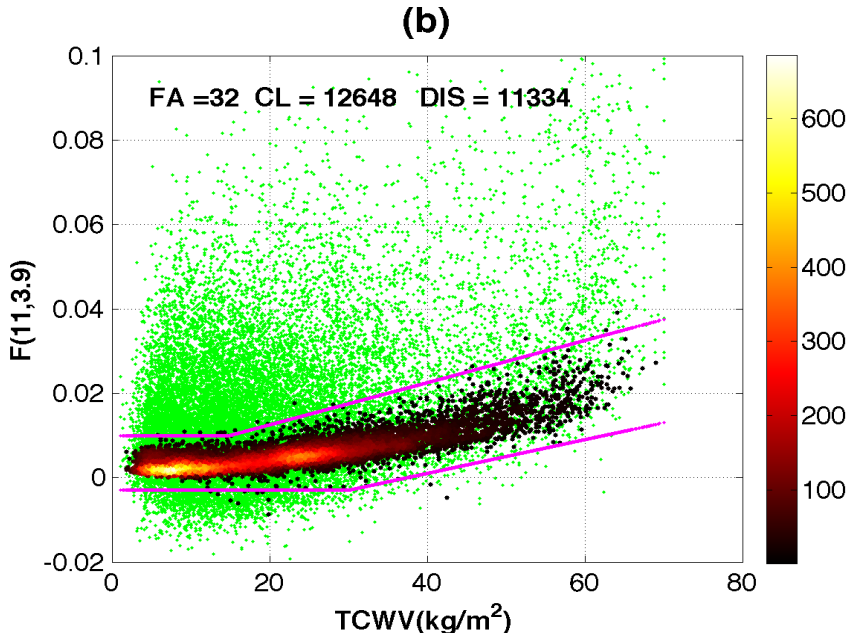
Data and Forward model specifications

- Forward model using ver. CRTM2.1
- Monthly point matchups
- Buoy (coastal, Moore & drifters)
- iQUAM quality control *in situ* data
- GFS for profile data including surface
- NGAC aerosol profiles
- Night time scenarios
- TTLS inverse method

VIIRS Functional Spectral differences

$$\frac{2(T_x^m - T_y^m)}{(T_x^m + T_y^m)} > a_{xy} + \max\left(\frac{TCWV - b_{xy}}{C_{xy}}, 0\right) \qquad \frac{2(T_x^m - T_y^m)}{(T_x^m + T_y^m)} < a_{yx} + \max\left(\frac{TCWV - b_{yx}}{C_{yx}}, 0\right)$$

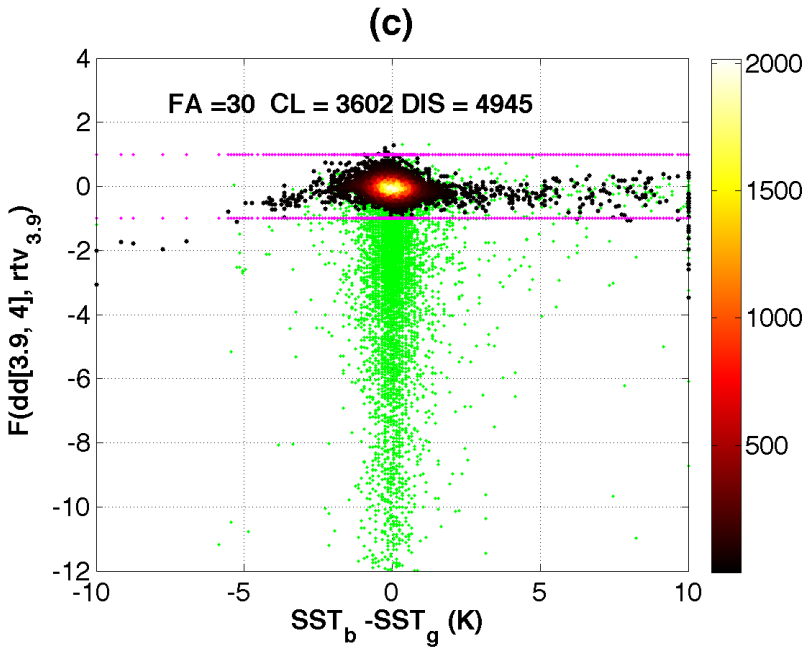


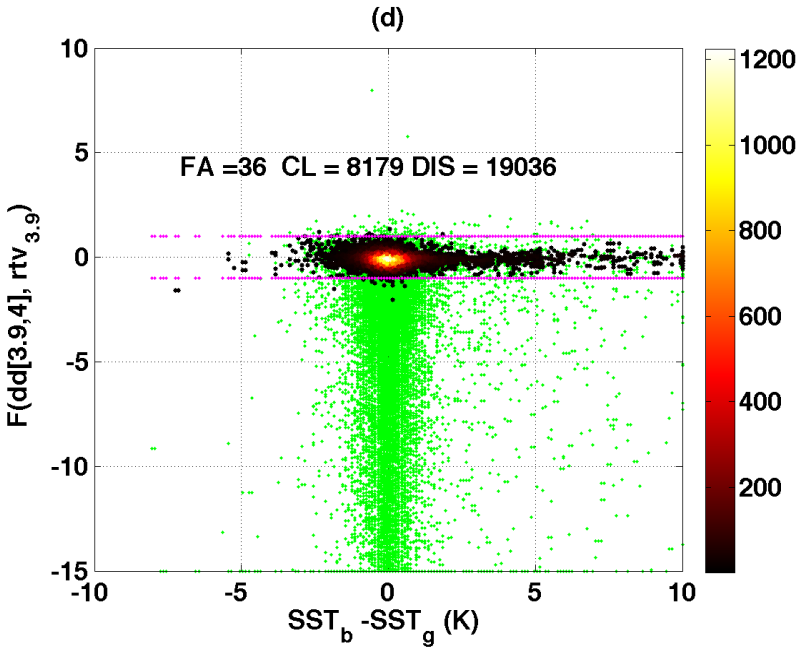


Difficulties: VIIRS does not have 13.4 and 6.7 µm Channels

RT based Double differences Tests

$$abs\left(\left(T_{3.9}^{m} - T_{4}^{m}\right) - \left(T_{3.9}^{s} - T_{4}^{s}\right)\right) \le 0.8*\left(0.1 + \frac{\max(S_{3.9}, 2)}{10} + \frac{\min(S_{3.9}, -1)}{3}\right)$$

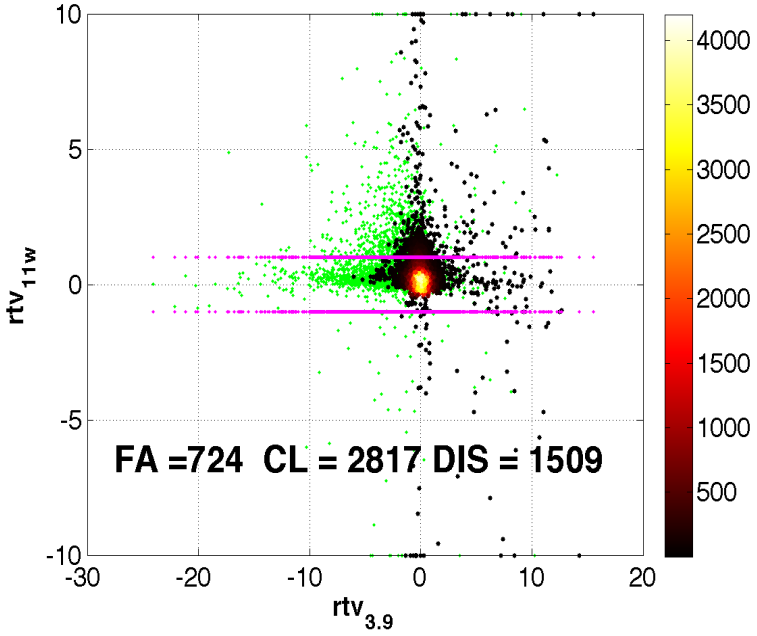


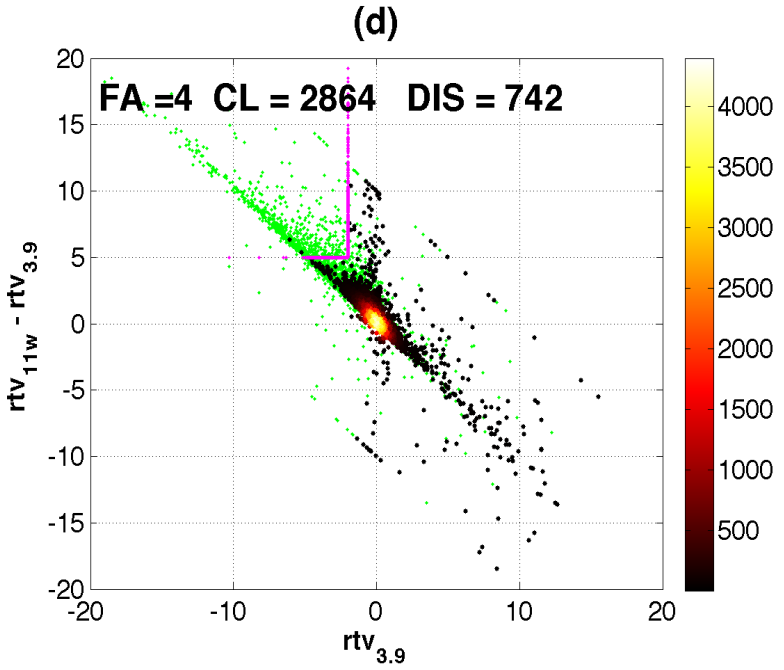


RT based Water vapor threshold Test

$$rtv_{TCWV} = \frac{T_{11}^{m} - T_{11}^{s} - K_{11}^{sst} rtv_{3.9}}{K_{11}^{TCWV}}$$

$$rtv_{11w} - rtv_{39} <= 5 \text{ or } rtv_{39} > -2$$





Spatial test

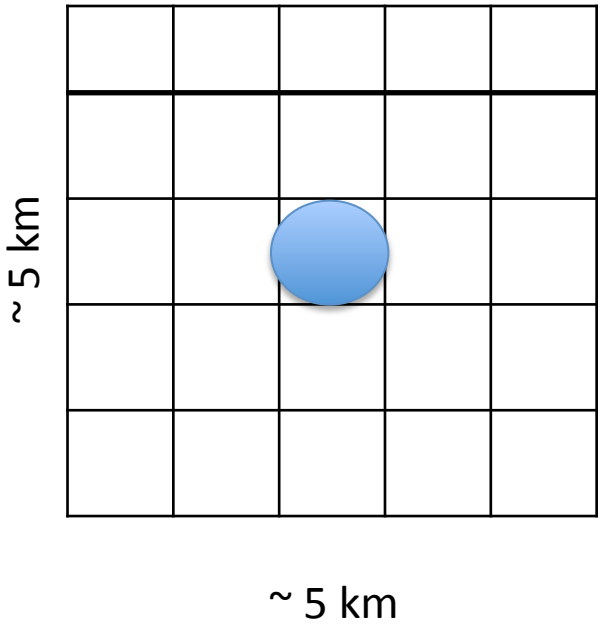
5x5 grid box:

Max – Cpix < 0.6 K

Problem:

more the 0.3 K/km temperature gradient will be screened out.

Need improvement of this test.

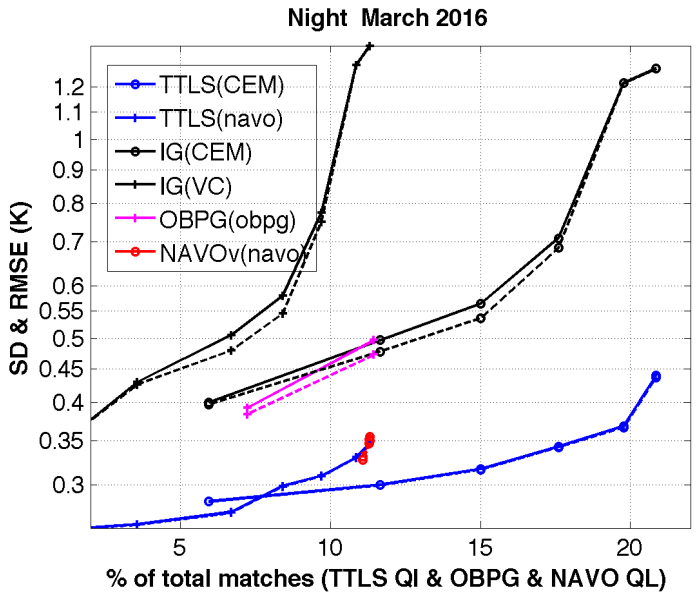


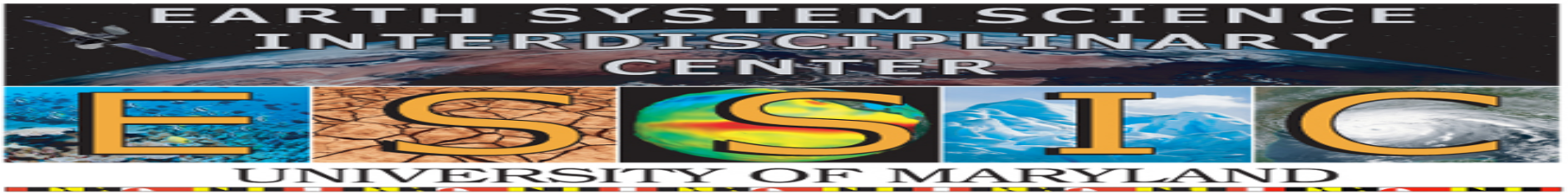
Comparative Results on SST retrievals

- **TTLS** developed for 3-parameter retrieval

$|\Delta \boldsymbol{y}| \le 1$: $\lambda = (\sigma_{end-1})^2$ $|\Delta \boldsymbol{y}| > 1$: $\lambda = (\sigma_{end-1}/\log(|\Delta \boldsymbol{y}|))^2$

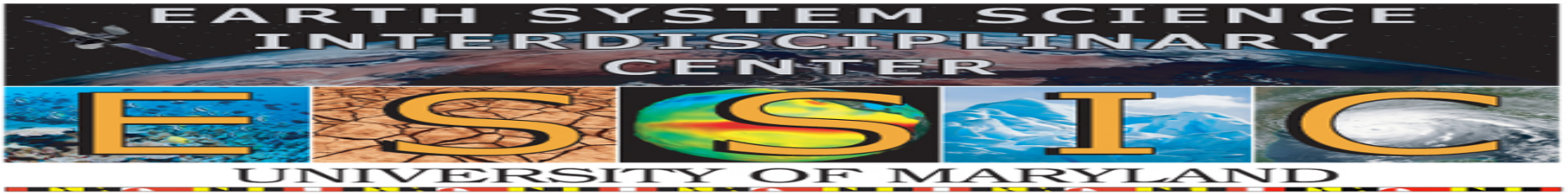
*RMSE: 0.33 K NAVO (QL=5)
0.36 K TTLS
o.39 K OBPG (QL=5)
*Additional Cloud detection
*Additional Quality Flag
*Mutual inconsistence between CEM & TTLS
*Absence of 13.4 µm channel





Summary and conclusions

- CEM is an original and innovative Quasi-deterministic cloud detection Algorithm.
- The coefficients used for CEM are independent of locations (Ocean), Seasons and sensors.
- TTLS and MTLS can perform additional cloud detection at solution time.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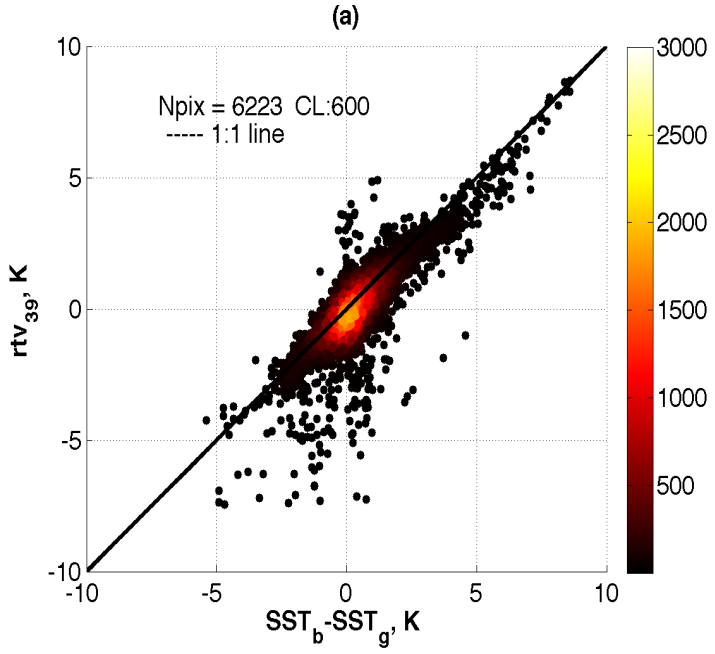
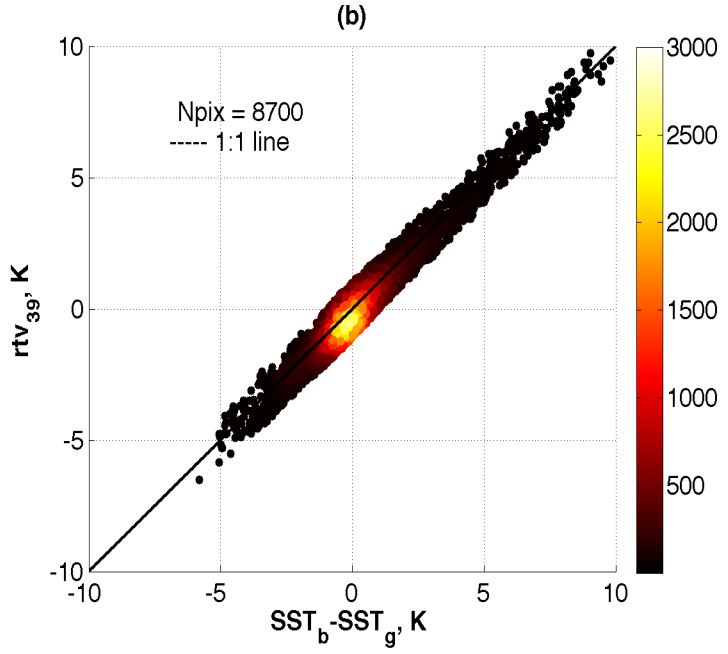
Thank you

Validation of Bayesian Cloud Algorithm

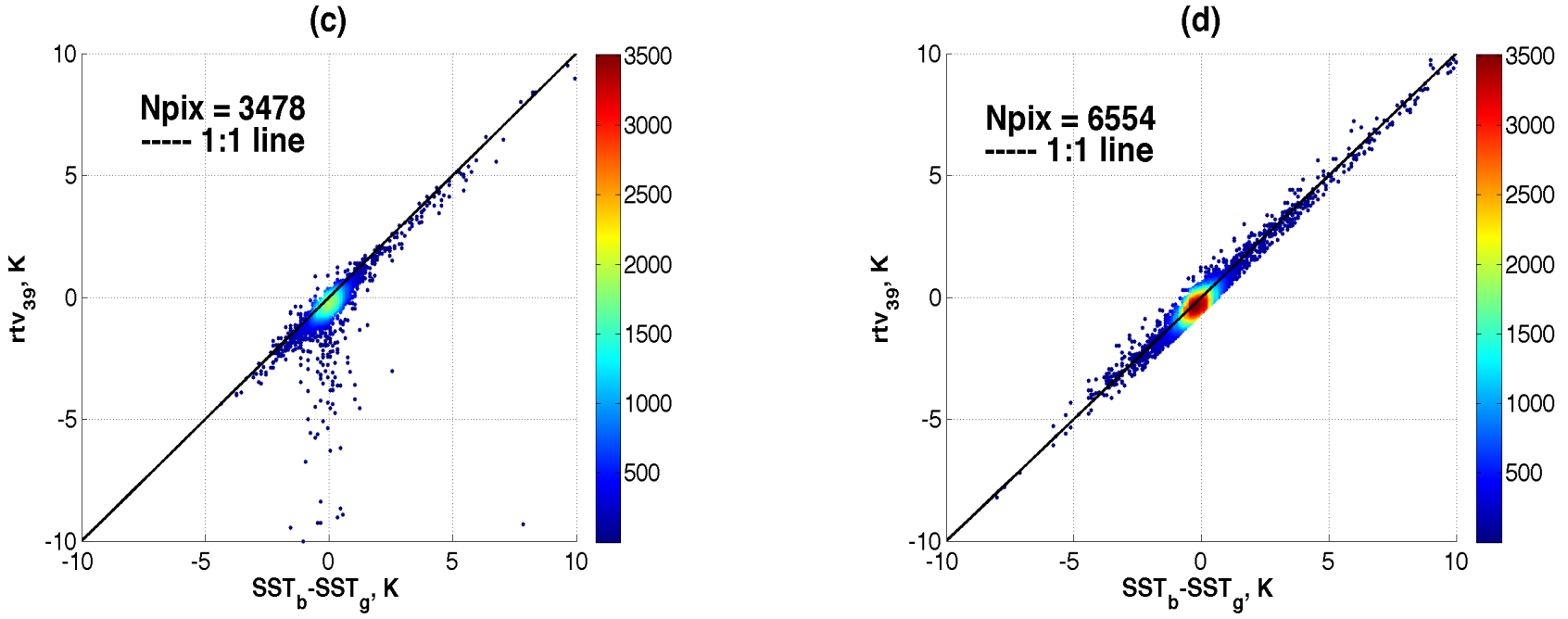




pClr > 0.98 (Cloud Free)

pClr <= 0.98 (Cloudy)

Validation of MODIS Cloud Algorithm



It is not MOD35. MODIS cloud considers as QF=5 of MODIS operational SST database, where quality control imposed top of the MODIS cloud.