Comparison of GOES SST retrievals using various algorithms

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Methods

1. **REG : Regression(Statistical)**
   1. **Radiative transfer coefficients (REGR, OSPO implemented)**
   2. **Cal-val same buoy coefficients (REGB)**
2. **OEM : Optimal Estimation Method(Physical Statistical)**

$$(\mathbf{K}^T\mathbf{S}_e^{-1}\mathbf{K}+\mathbf{S}_a^{-1})^{-1}\mathbf{K}^T\mathbf{S}_e^{-1}\Delta\mathbf{y}_\delta$$

3. **MTLS: Modified Total Least Squares (Physical Deterministic)**

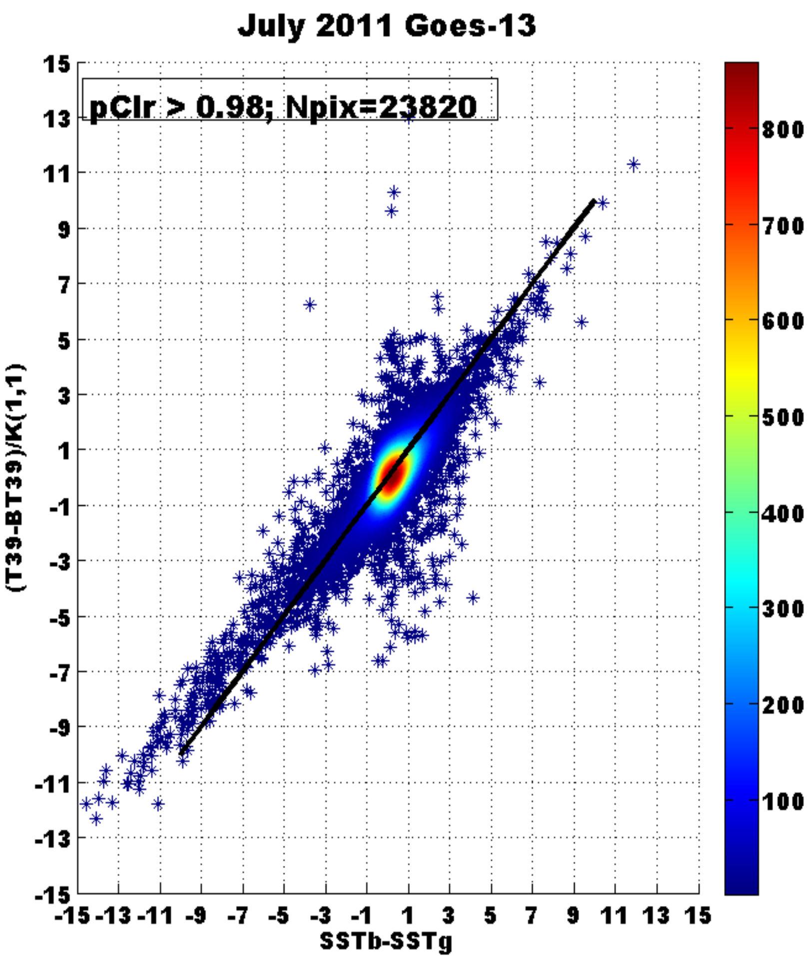
$$(\mathbf{K}^T\mathbf{K}+\lambda\,\mathbf{I})^{-1}\mathbf{K}^T\Delta\mathbf{y}_\delta; \quad [u\ \sigma\ v]=SVD([\mathbf{K}\ \Delta\mathbf{y}_\delta]);$$

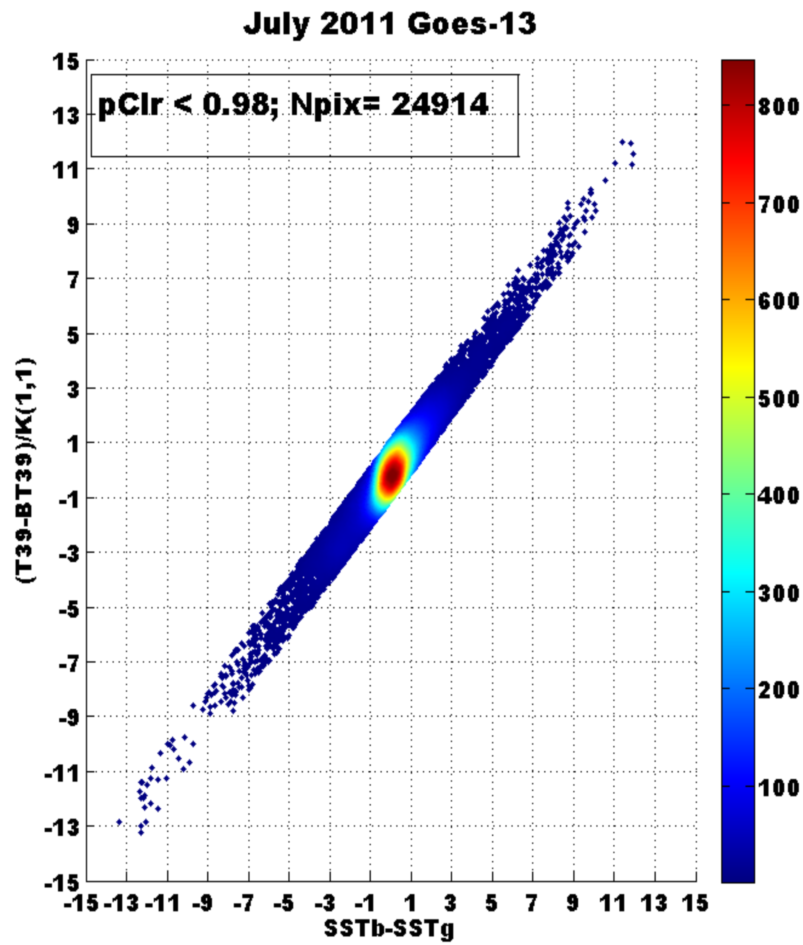
$$\|dx\|=\kappa\|dy\|; \qquad \lambda=2\log(\kappa)\,\sigma_{end}^2$$

Total error (used for EA): $\left\|(\mathbf{K}_{ps}^{inv}\mathbf{K}-\mathbf{I})\mathbf{x}_{rtv}\right\|+\left\|\mathbf{K}_{ps}^{inv}(\Delta\mathbf{y}_\delta-\mathbf{K}\mathbf{x}_{rtv})\right\|$

- $\mathbf{K}_{ps}^{inv}$ **Pseudo Inverse**
- κ **Condition number of Jacobian**
- $\Delta\mathbf{y}_\delta$ **Measurement - Model**

Verification of Bayesian Cloud Detection implemented at OSPO

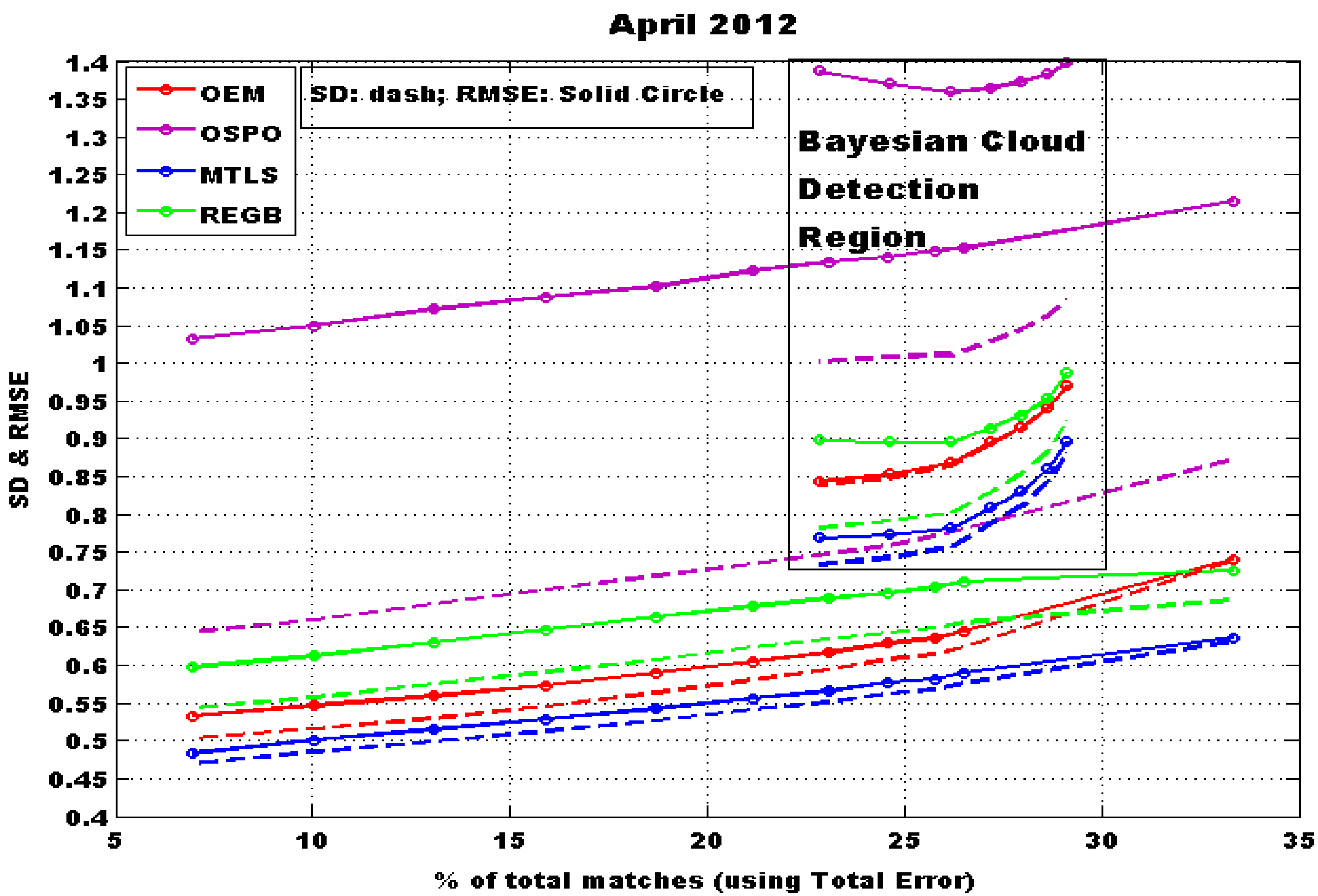




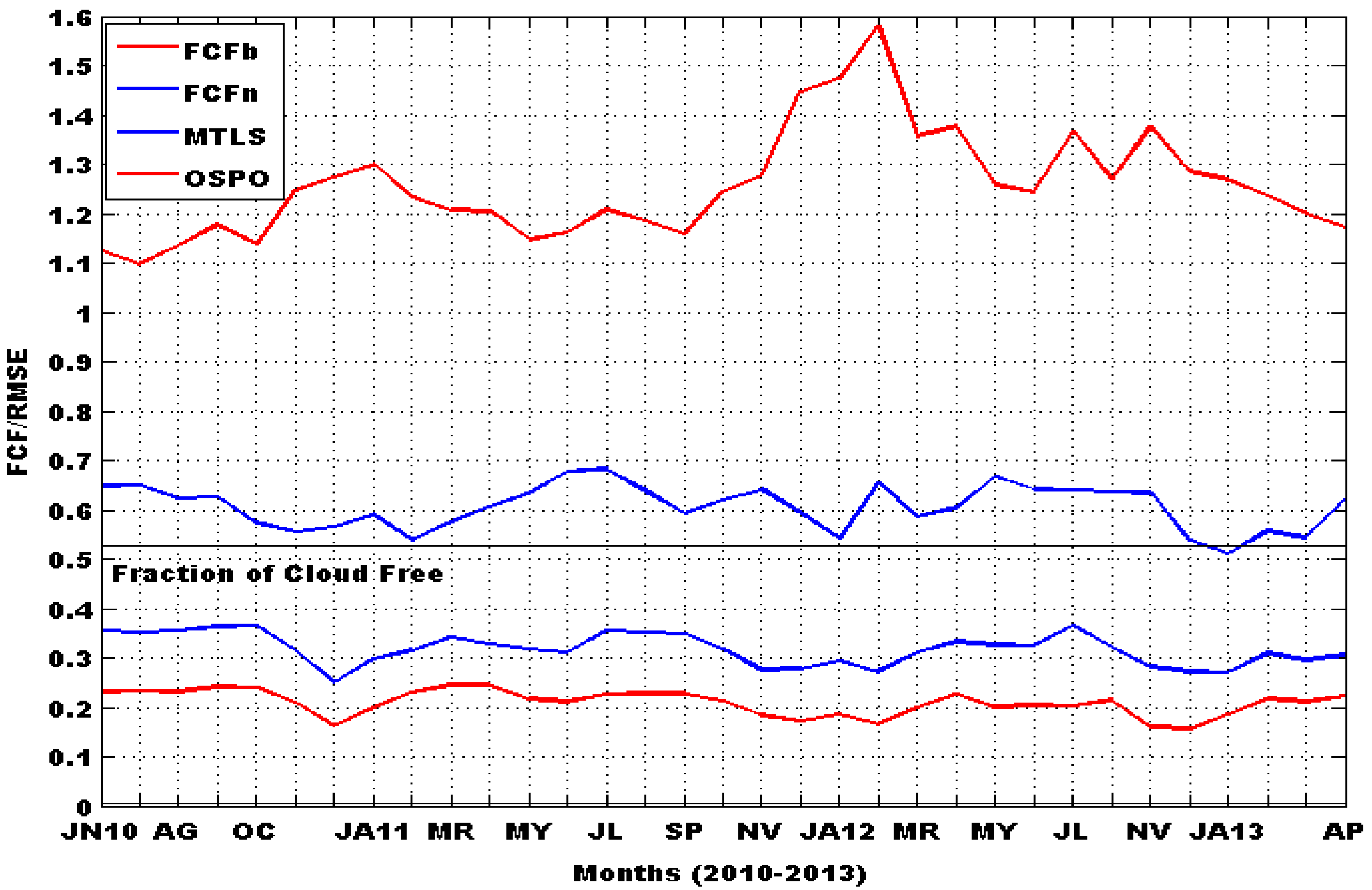
Error Masking (EM) Algorithm
(cloud + erroneous pixels)

- **High Cloud:**
  - **Dynamic threshold based Spectral Difference method (3.9, 6.7, 11 & 13.4 µms)**
- **Low Cloud, model error, glint, aerosol … :**
  - **Differences of single channel retrieval of 3.9 & 11µms**
  - **Spectral test using Nearest Neighborhood Measurements**

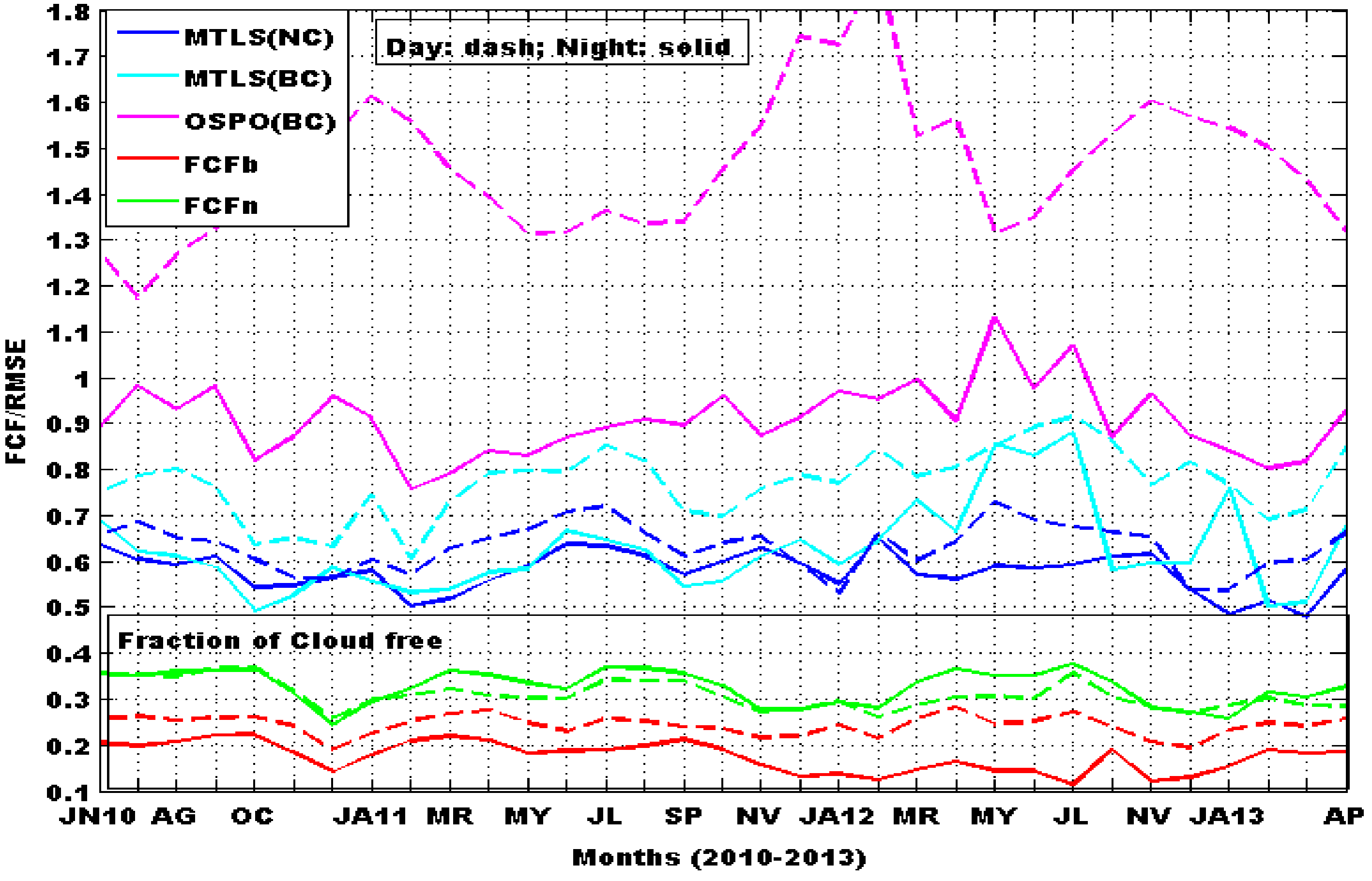
Comparative Analyses against buoy



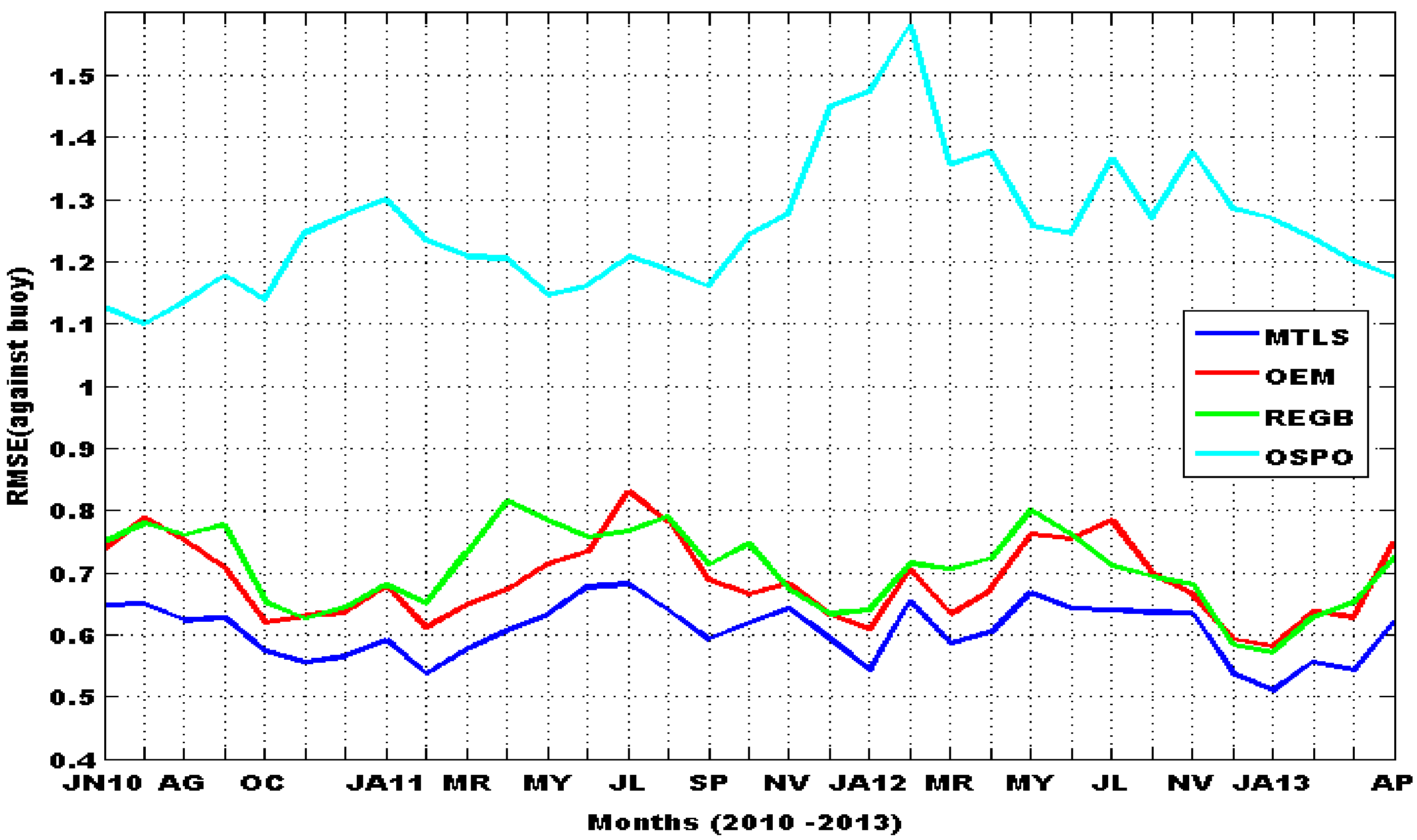
Time Series (OSPO vs MTLS) & (BC vs EM)



Day & Night Separation



Validation against buoy



Comparative TCM

Triple Collocation Method

$$\mathbf{R}_i = \mathbf{T} + \boldsymbol{\eta}_i \quad truth + noise\,(\sigma_i + b_i)$$

$$\mathbf{R}_1 - \mathbf{R}_2 - \overline{(\mathbf{R}_1 - \mathbf{R}_2)} = \sigma_1 - \sigma_2$$

$$\left(\mathbf{R}_1 - \mathbf{R}_2 - \overline{(\mathbf{R}_1 - \mathbf{R}_2)}\right)\left(\mathbf{R}_1 - \mathbf{R}_2 - \overline{(\mathbf{R}_1 - \mathbf{R}_2)}\right)$$

$$= \sigma_1^2 - \rho_{12}\sigma_1\sigma_2 - \rho_{13}\sigma_1\sigma_3 + \rho_{23}\sigma_2\sigma_3$$

Compare MTLS vs OEM, where OSPO & buoy common

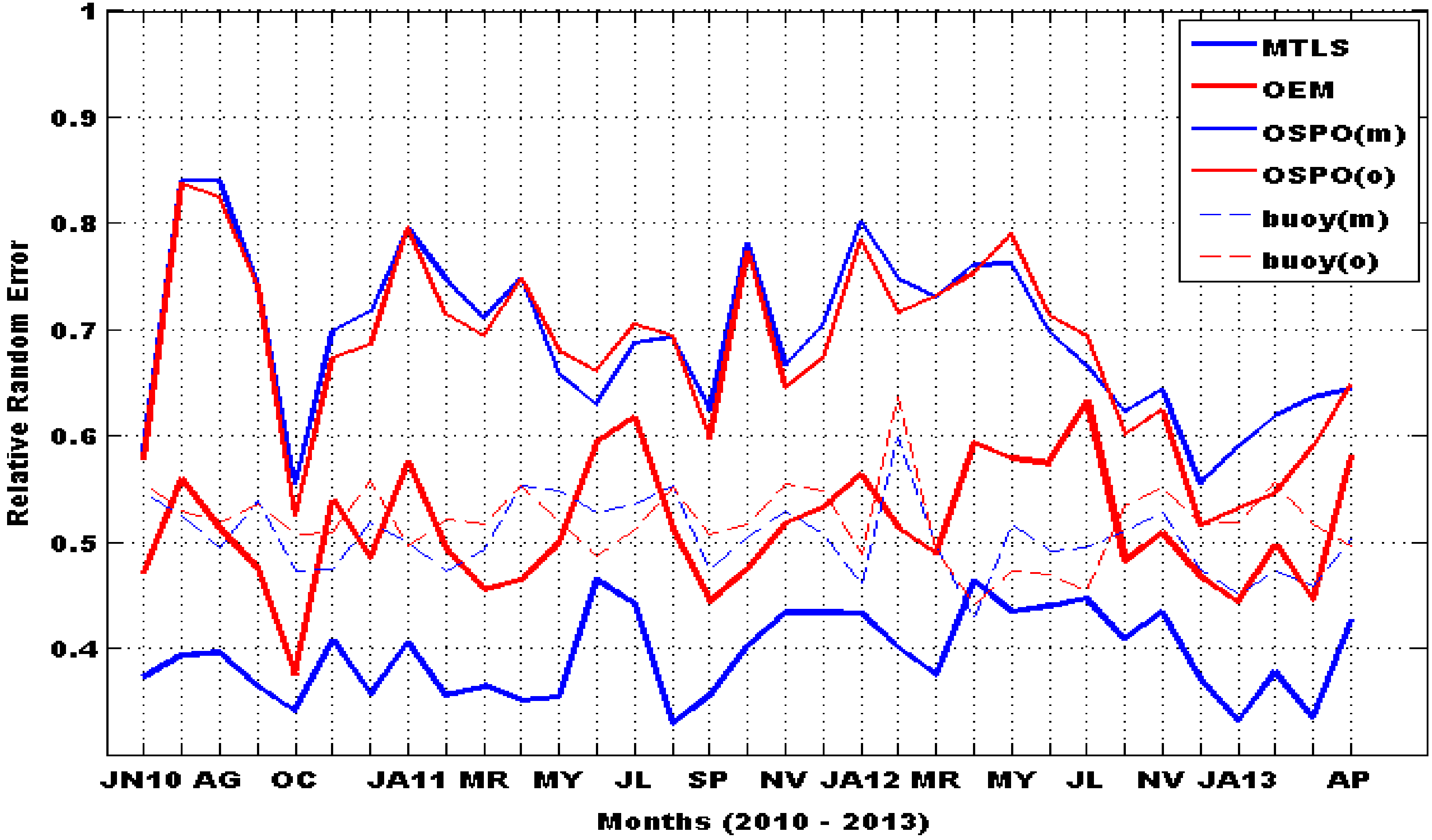
$$TCM\,(MTLS, OSPO\ \&\ buoy)$$

$$= \sigma_{mt}^2 - \rho_{mt\_os}\sigma_{mt}\sigma_{os} - \cancel{\rho_{mt\_bu}\sigma_{mt}\sigma_{bu}} + \cancel{\rho_{bu\_os}\sigma_{bu}\sigma_{os}}$$

$$TCM\,(OEM, OSPO\ \&\ buoy)$$

$$= \sigma_{oe}^2 - \rho_{oe\_os}\sigma_{oe}\sigma_{os} - \cancel{\rho_{oe\_bu}\sigma_{oe}\sigma_{bu}} + \cancel{\rho_{bu\_os}\sigma_{bu}\sigma_{os}}$$

MTLS vs OEM (OSPO, buoy)



MTLS vs OEM (REGB & buoy)

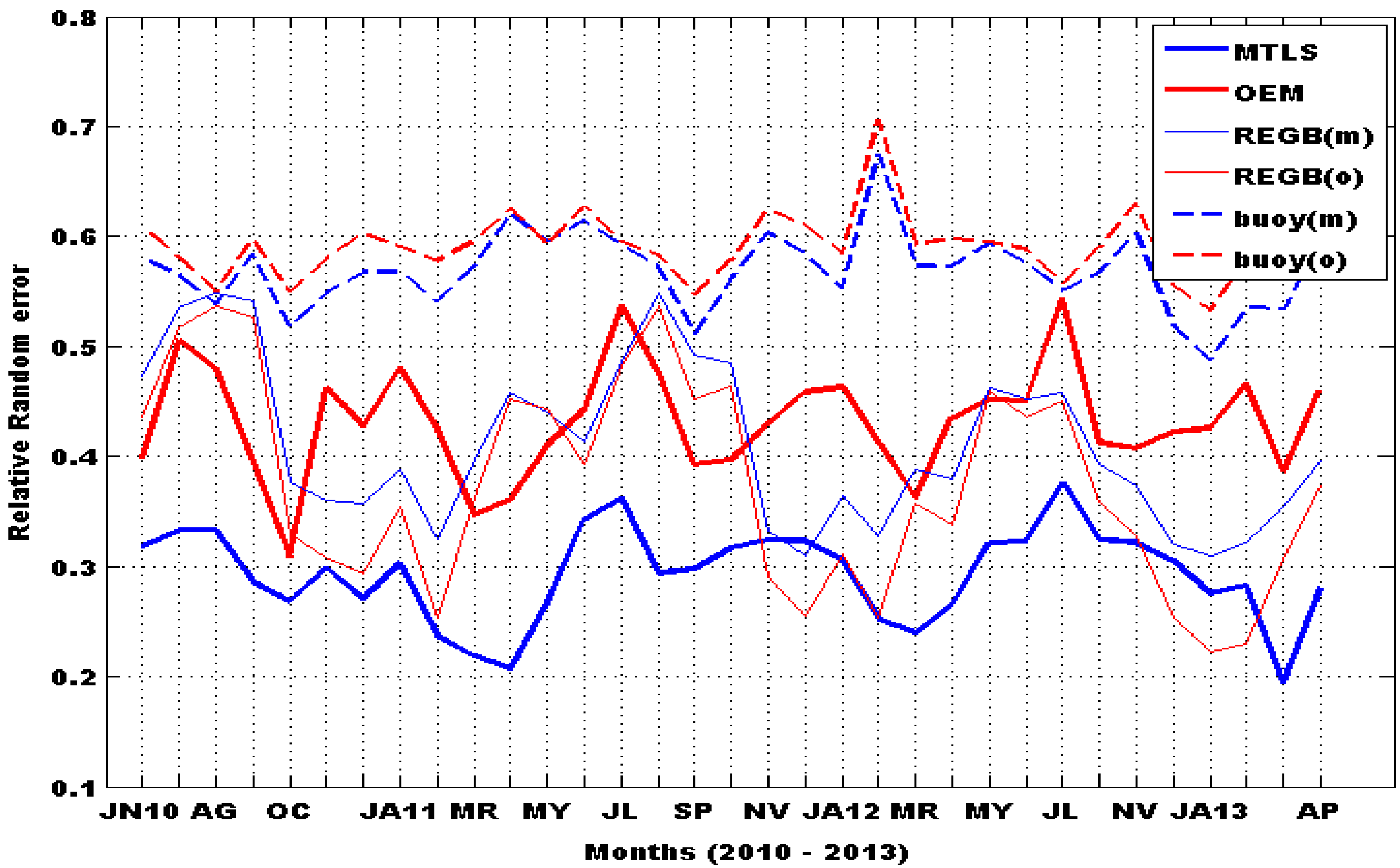
$$TCM(MTLS, REGB \ \& \ buoy)$$

$$= s_{mt}^{2} - r_{mt\_rb} s_{mt} s_{rb} - \cancel{r_{mt\_bu} s_{mt} s_{bu}} + r_{bu\_rb} s_{bu} s_{rb}$$

$$TCM(OEM, REGB \ \& \ buoy)$$

$$= s_{oe}^{2} - r_{oe\_rb} s_{oe} s_{rb} - \cancel{r_{oe\_bu} s_{oe} s_{bu}} + r_{bu\_rb} s_{bu} s_{rb}$$

MTLS vs OEM(REGB & buoy)



Conclusions

- MTLS, a physical deterministic inverse method, is useful for unambiguous SST retrieval with lowest error.
- MTLS does not require any ‘*a priori* error’ and ‘measurement error’ covariance matrices or *a priori*.
- OEM requires the knowledge of errors of measurements & *a priori as an input*, which is difficult in operational environment.
- New Cloud Detection can increase data coverage by 50%, with minimum cloud leakage, as compared to currently implemented Bayesian Cloud algorithm.

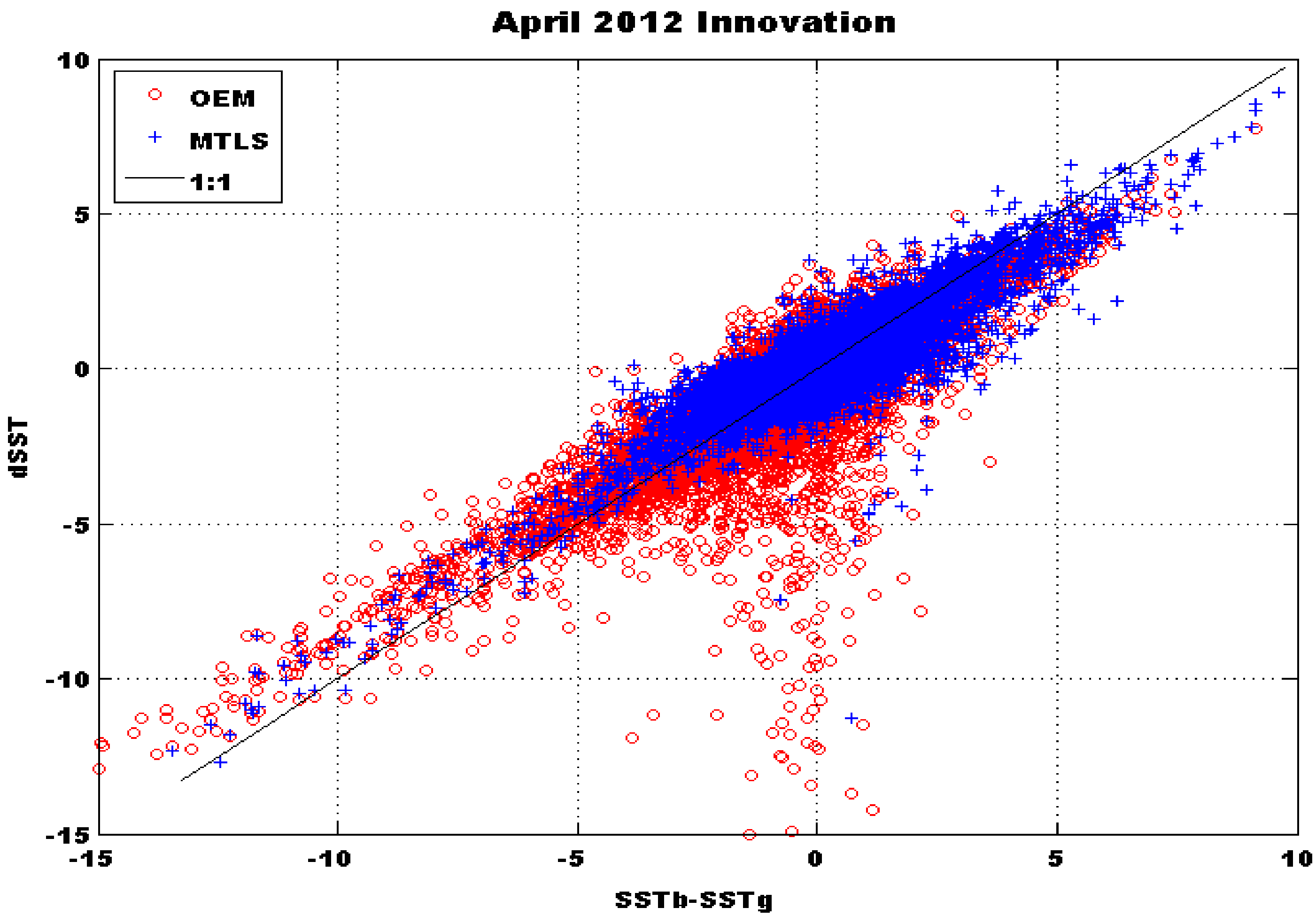
Calculations

- CRTM 2.1
- Channels= 3.9, 11 & 13.4 μm
- Variables = SST & TCWV
- σ_e = [0.05 0.05 0.06] at 300K
- σ_{crtm} = [.25 .15 .15]
- σ_a = [1 15%TCWV]

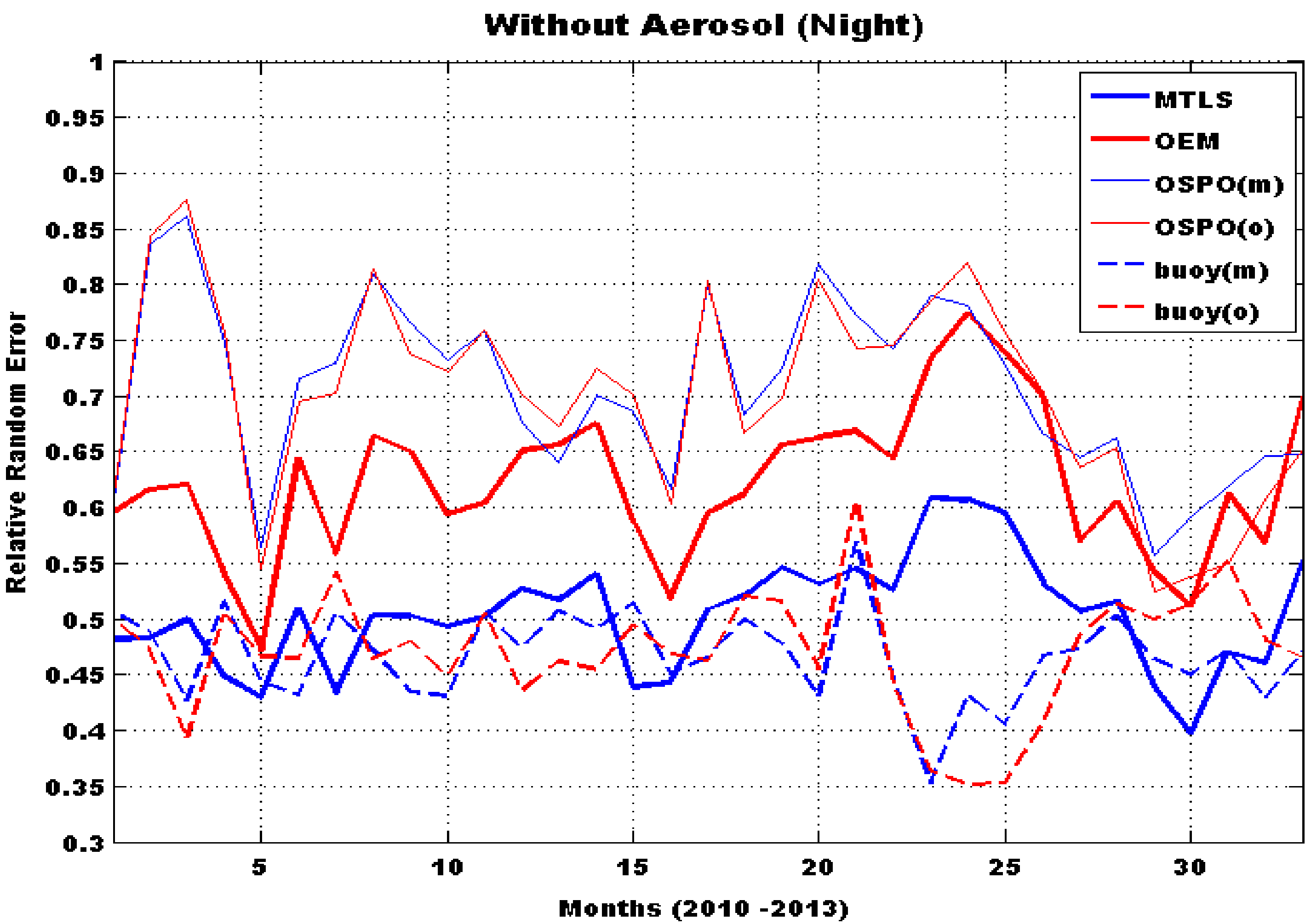
$$\Delta y_d - \delta y = K \Delta x$$

$$\Delta x = \left(K^T (\delta y)^{-2} K + (\Delta x)^{-2} \right)^{-1} K^T (\delta y)^{-2} \Delta y_d$$

Innovations



Without Aerosol Comparative TCM



Without Aerosol Comparative TCM