Analysis for Skin SST using the GEOS model and GSI: preliminary results[1]

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Outline

1. Motivation
2. Introduction to vertical temperature profile & modeling
3. GSI Analysis for skin temperature
4. Experiment setting
5. Results
6. Summary & work in progress

Motivation

Accurate modeling and estimation of air-sea fluxes requires accurate representation of SST (Saunders, 1967; Fairall et al., 1996).

Ocean surface vertical Temp. is highly variable within a day (Donlon et al., 2002, Ward, 2006)

Current Status...

- AGCMs typically use a weekly averaged blend of in situ measurements (depth of few cm – meters) and satellite retrievals (Reynolds et al., 2002)
- OGCMs consider SST to be the 'mean' temperature of the surface of the ocean (for e.g., top layer of the model, typically 1–5 m thick)

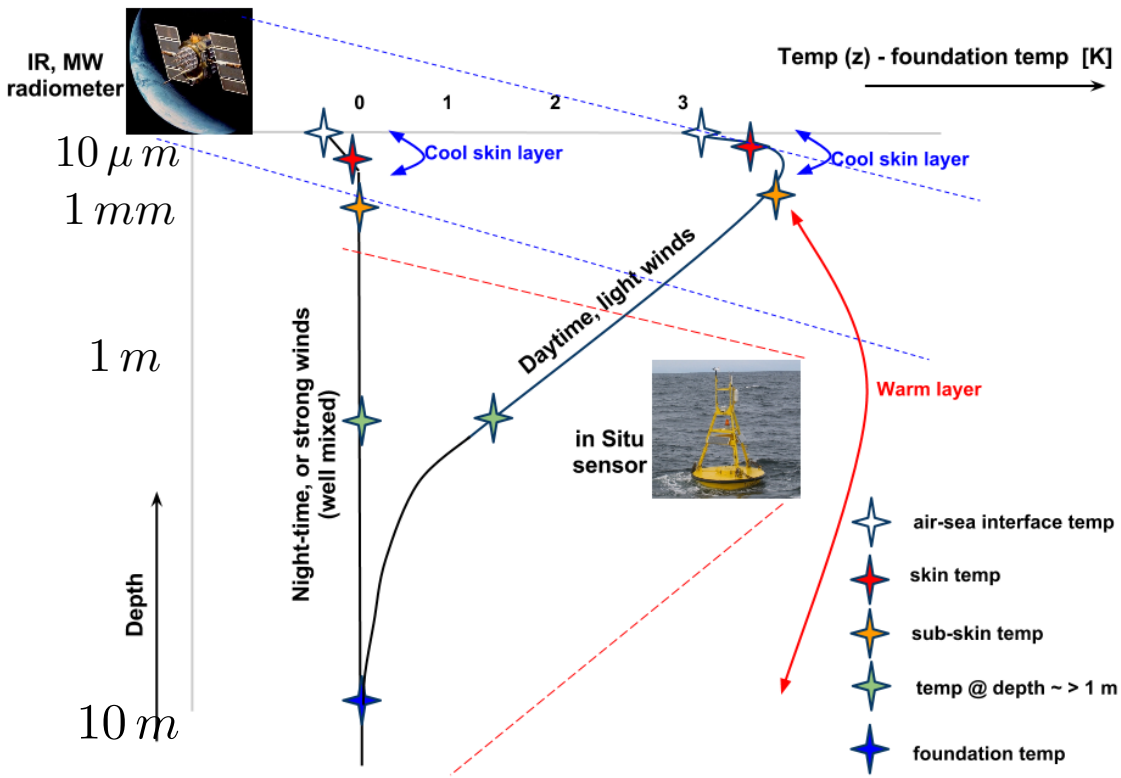
Our Objectives:

1. Model the diurnal variation of SST (Takaya et al., 2010 and Zeng & Beljaars, 2005)
2. Assimilate for the vertical profile of temperature: $T(z)$
3. Estimate the sea surface skin temperature (T_s); Use T_s to compute air-sea fluxes

Utimately

improved surface modules $\rightarrow$ AGCM $\oplus$ OGCM $\Rightarrow$ coupled assimilation

Introduction- $T(z)$ profile



See GHRSST for details:
https://www.ghrsst.org/ghrsst-science/sst-definitions

Introduction- Modeling $T(z)$ profile

- Cool-skin layer: In the upper surface (few mm) molecular (thermal) diffusion is dominant. It is due to combined effects of net longwave radiation, sensible and latent heat fluxes

- Warm layer: mm to few meters thick, follows diurnal warming.

- Cool layer is always persistent (day & night)
- Warm layer builds up due to solar heating
- Clouds, strong winds (erode stratification)
- Warm layer can persist even into night or next day (Gentemann et al., 2009)
- Turbulent diffusion dominates molecular diffusion effects in the warm layer

IR & MW sat. retrievals $\longrightarrow$ temperature decrease due to cool-layer
in Situ measurements $\longrightarrow$ diurnal warming w.r.t. foundation temperature

Our $T(z)$ profile is based on

- diurnal warming model of Zeng & Beljaars, 2005
- cool-skin layer of Fairall et al., 1996

GSI Analysis for skin temperature

- Read in additional background fields to compute temp. $T(z_{ob})$ at any z_{ob}
- Observation (or penetration) depth (z_{ob}) for radiance measurements

  IR AVHRR, AIRS, HIRS, IASI, Sounders, Imagers, etc, $\longrightarrow 15\mu m$
  MW AMSUA, AMSUB, MHS, SSMI, AMSRE, etc, $\longrightarrow 1.25mm$
  in Situ observations have z_{ob} recorded

- Given z_{ob}, time and location (lat, lon) of the observation, background temperature is computed as

$$T(z_{ob}) = \begin{cases} T_d + dt_w - (1 - \frac{z_{ob}}{\delta})dt_c & \text{if } 0 \leq z_{ob} < \delta \rightarrow \textbf{COOL LAYER} \\ T_d + dt_w - [\frac{z_{ob} - \delta}{z_w - \delta}]^{\mu} dt_w & \text{if } \delta \leq z_{ob} < z_w \rightarrow \textbf{WARM LAYER} \end{cases} \quad (1)$$

- CRTM surface requires specification of the Jacobian $\frac{\partial T(z)}{\partial T_s}$, it is currently set to 1

  $\Rightarrow$ Entire T(z) profile shifts to accomodate the change in T_s

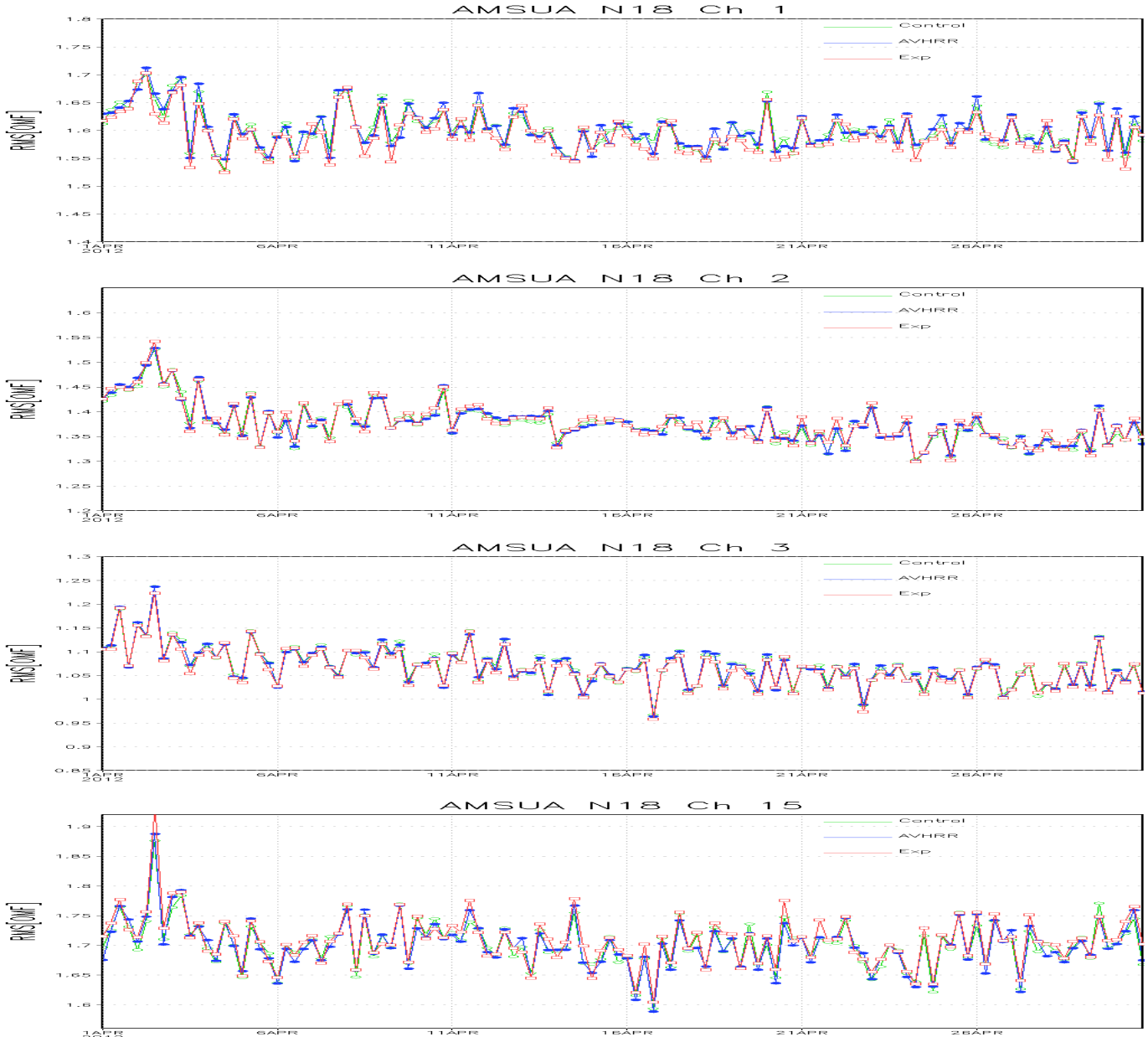
- Analysis writes out analyzed T_s^{ana} and the model applies $T_s^{ana} - T_s^{bkg}$ increment through an IAU mechanism

Experiment Setting

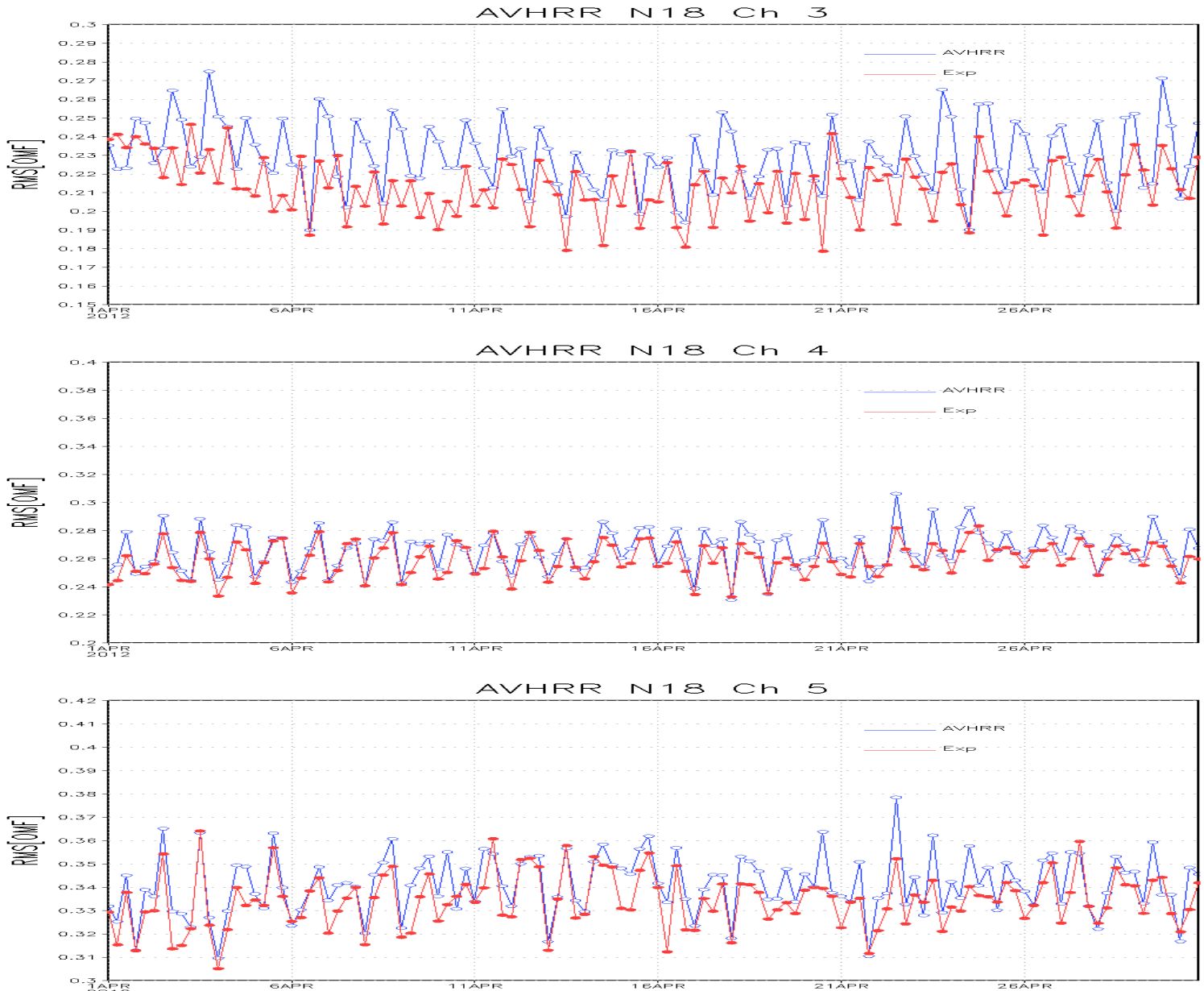
Exp. Name	AVHRR	T_s Analysis
Control	☐	☐
AVHRR	☒	☐
Exp	☒	☒

- Resolution: $2^o \times 2.5^o$
- Foundation SST and sea-ice concentration are from weekly Reynolds
- All experiments have an active diurnal model for skin temperature computation
- DAS cycling experiment for April 2012
- *Additional* relevant observations are from AVHRR

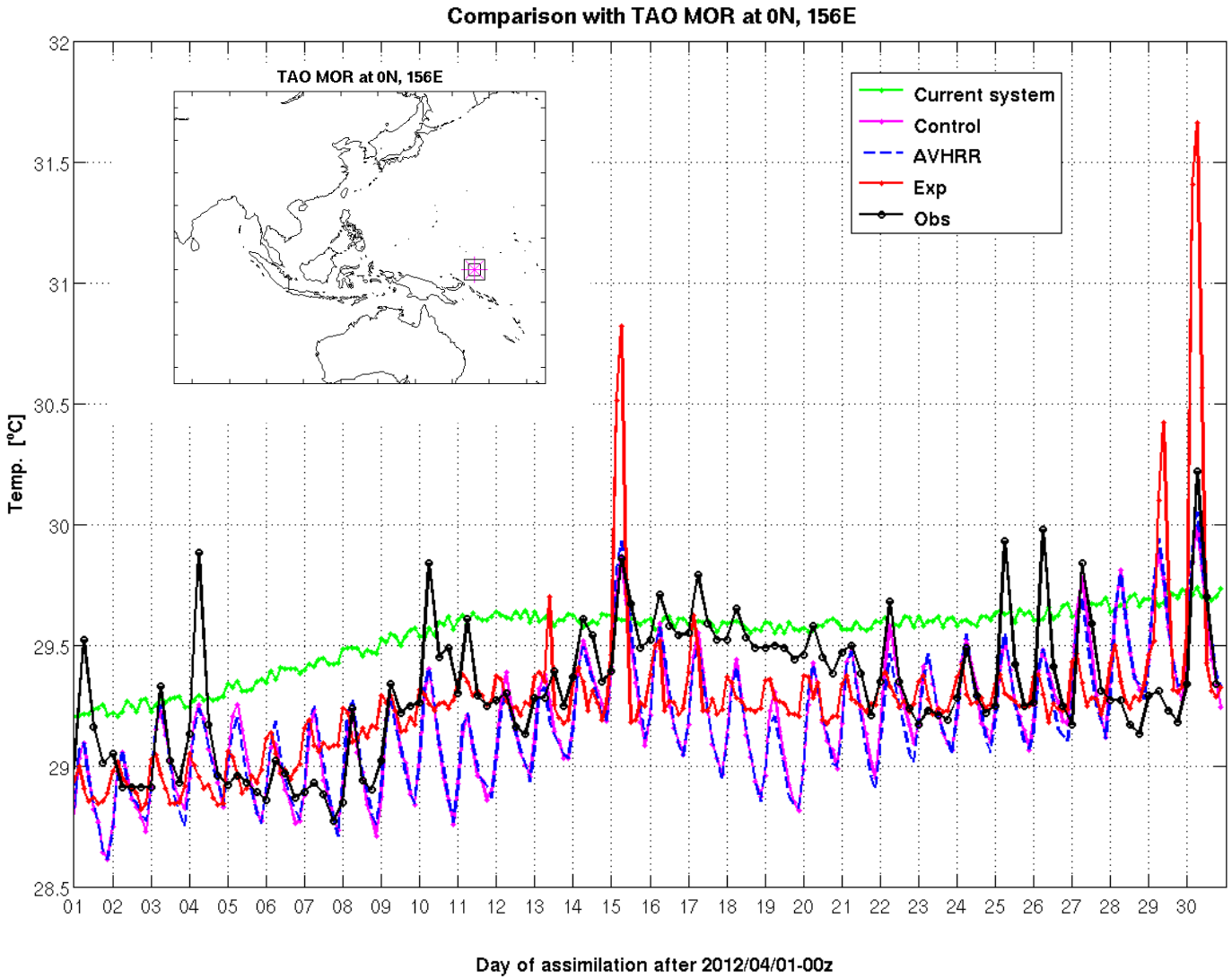
Results- RMS of OMF AMSUA N18- Ch: 1, 2, 3 & 15



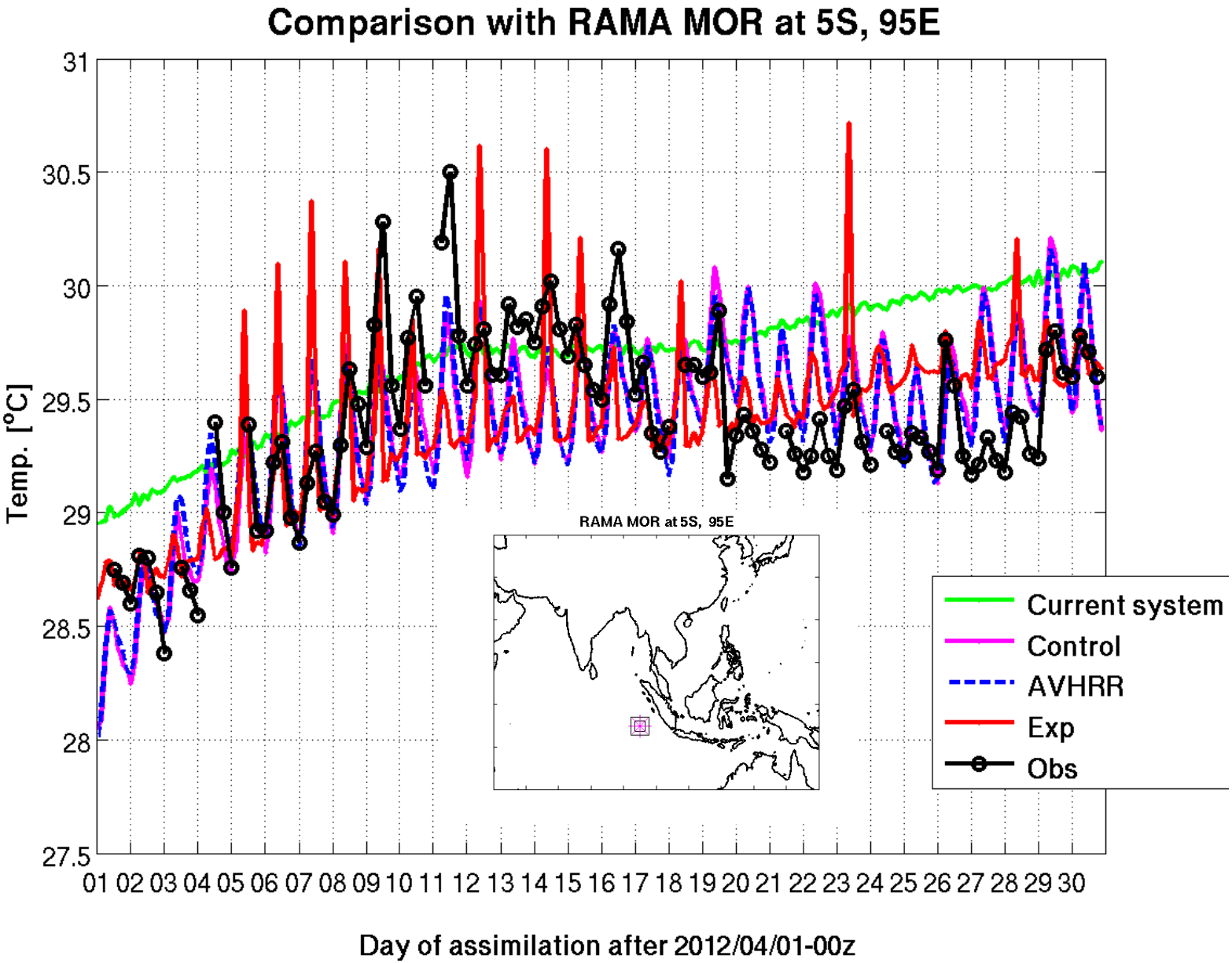
Results- RMS of OMF AVHRR N18- Ch 3, 4 & 5



Results- Comparison with in Situ buoy measurements



Results- Comparison with in Situ buoy measurements



Summary & work in progress

1. Accurate modeling & estimation of skin temperature requires modeling and analysis of $T(z)$ profile
2. Within the GEOS we now model the vertical temperature profile including diurnal warming & cool-skin layer
3. T_s analysis components using the GEOS & GSI are ready
4. Work is in progress to use in Situ observations (*modsbufr*) in analysis
5. Currently we are evaluating and tuning performance for various observing systems

References

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