SST Analysis in GEOS GCM

Abstract: #463

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Abstract

An analysed Sea Surface Temperature (SST) will provide improved estimates of surface fluxes in order to better predict short timescale weather features such as tropical cyclones and also yield balanced-initial conditions for longer climate predictions.

Here we present improvements to skin SST modeling in the GEOS AGCM, which includes modeling of a cool-skin layer and diurnal warming layer. In addition, preliminary results from assimilation of brightness temperature (T_b) using the Gridpoint Statistical Interpolation (GSI)-highlighting the observation-minus-forecast obtained using AVHRR T_b are also presented.

Motivation

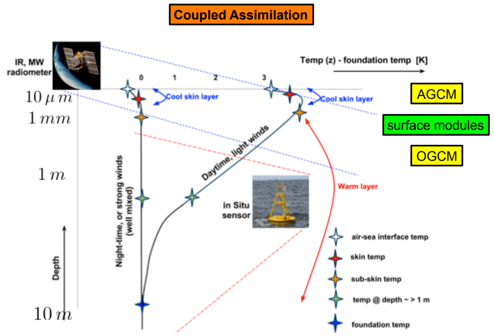
Current Status of Skin SST:

- AGCMs typically use a 'bulk SST' which is a blend of satellite retrievals calibrated based on *in-situ* measurements.
- 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:

- Model diurnal variation of temperature near the air-sea interface
- Assimilate for the vertical profile of temperature: T(z)
- Estimate the sea surface skin temperature (T_s); Use T_s to compute air-sea fluxes

Modeling T(z) Profile



- **Cool-skin layer:** In the upper surface (few mm) molecular (thermal) diffusion is dominant. It is due to the combined effects of net longwave radiation and sensible and latent heat fluxes.
- **Warm Layer:** mm to few meters thick, follows diurnal warming
- Cool layer is always persistent (day & night)
- Warm later builds up due to solar heating
- Clouds and strong winds erode stratification
- Warm layer can persist into the night or the next day
- Turbulent diffusion dominates molecular diffusion effects in the warm layer

IR & MW sat. retrievals ➡ temperature decrease due to cool-layer

***In-situ* measurements** ➡ diurnal warming w.r.t. foundation temperature

Our T(z) profile model is based on:

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

GSI Analysis for Skin Temperature

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

IR: AVHRR, AIRS, HIRS, IASI, Sounders, Imagers, etc, ➡ Z_{ob} = 15mm
MW: AMSUA, AMSUB, MHS, SSMI, AMSRE, etc, ➡ Z_{ob} = 1.25 mm
in-situ observations have $\mathbf{z_{ob}}$ recorded

- Given $\mathbf{Z_{ob}}$, time, and location of the observation, background temperature is:

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

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

Entire **T(z)** profile shifts to accommodate the change in $\mathbf{T_s}$

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

Experiment Settings

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

- Resolution: 2° X 2.5°
- 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 (N-18, 19, METOP-A)

Comparison with Buoys

- *In-situ* measurements clearly show diurnal variability- dominated by diurnal warming
- Bulk SST products such as the weekly Reynolds do not resolve this variability
- Our diurnal skin temp model is able to simulate diurnal warming
- Though the *in-situ* data was not assimilated, $\mathbf{T_s}$ **Analysis (Exp)** most closely follows measured temp; however significant differences can be seen.

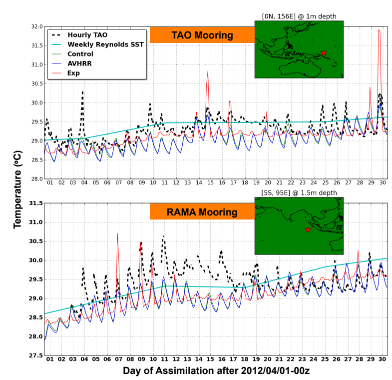


Figure 1: Time-series of Temperature at Two Mooring Locations

Results: RMS of OMF AMSUA and AVHRR

Figure 2 shows the time-series of AMSUA and AVHRR N-18 RMS OMF for one month.

- Neutral or no change to surface peaking MW window channels
- Systematic reduction in RMSE of OMF for AVHRR indicates better simulation of T_b during day & night

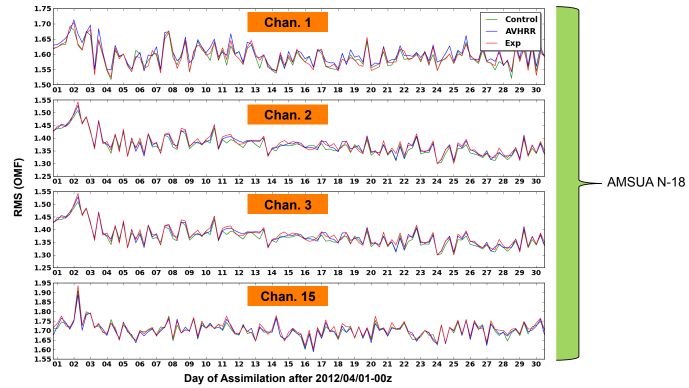


Figure 2.1: Time-series of RMS OMF for AMSUA N18

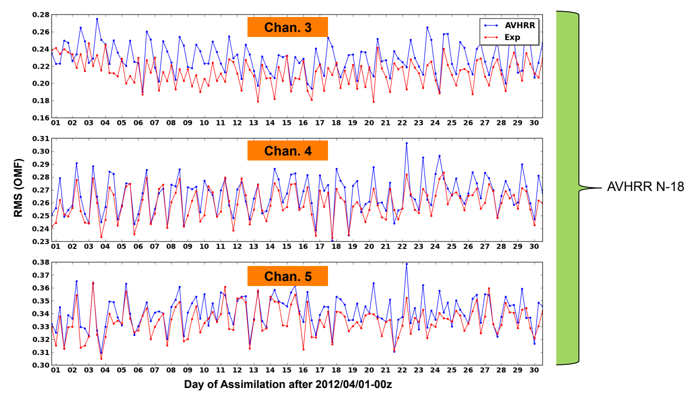


Figure 2.2: Time-series of RMS OMF for AVHRR

Summary & Work in Progress

- Accurate modeling & estimation of skin temperature requires modeling and analyses of T(z) profiles
- Within the GEOS we now model the vertical temperature profile including diurnal warming & cool-skin layer
- T_s analysis components using the GEOS & GSI are ready
- Work is in progress to use in-situ observations (modsbufr) in analysis
- We are reformulating and tuning the diurnal warming model to be in-sync with the *in-situ* data
- Adding TRMM-TMI T_b to the observing system