SST improvements in the NASA GMAO Weather Analysis and Prediction System

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Motivation

- SST has a diurnal cycle: Diurnal Warming and Cool-Skin layer.
- IR and MW measurements are sensitive to SST, hence to Diurnal Warming and Cool-Skin.
- SST serves as the lower boundary condition for any Atmospheric Model.
- Numerical Weather Prediction, Coupled predictions are highly sensitive to SST.

Objectives

The NASA Global Modeling and Assimilation (GMAO) is developing a coupled Atmosphere- Ocean (AO) Data Assimilation System (DAS) to

- Improve long-range forecasts (≥ 10 days) of near-surface fields.
- Obtain balanced air-sea interface states and fluxes in a reanalysis (MERRA) context.

Central to this AO-DAS is the ability to directly assimilate brightness temperatures for interfacial states: SST and sea-ice.

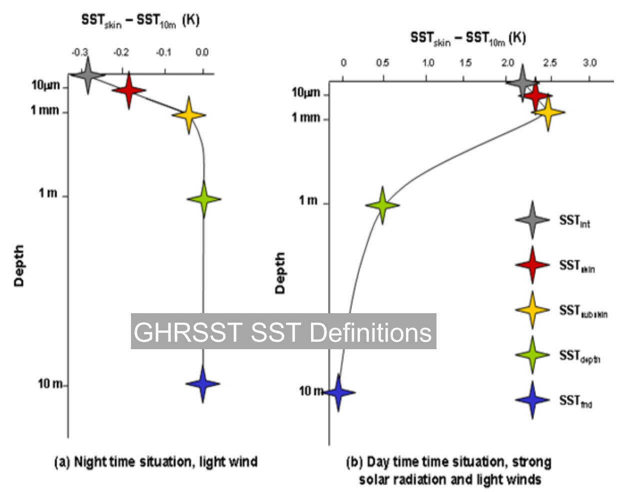

Figure 1: A schematic of vertical temperature profile through the ocean surface layer during (a) night time and/or high winds, and (b) day time with solar heating with low winds

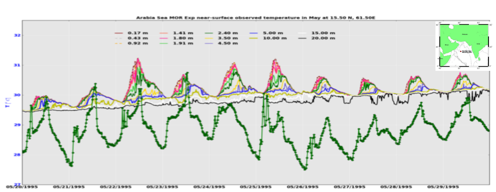

Figure 2: Time-series of observed temperatures (ºC) during the Arabian Sea Mooring experiment

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SST representation in the NASA GMAO Model and DA System

1) SST (T_b) and sea-ice fraction are prescribed from OSTIA

2) **Skin SST,** $T_s = T_b + \Delta T_w - \Delta T_c$; dT_w & dT_c are changes in temperature due to diurnal warming and cool-skin respectively: Fig. 3(a), (b)

3) **Additional observations IR:** 10−12μm AVHRR- N18 & MetOp-A

4) **Analysis:** Hybrid 4D-EnVar using the Grid-point Statistical Interpolation (GSI) and the ensemble square-root filter (EnSRF).

T_s is estimated along with the atmospheric state (u, v, p_s, T, q); see [ATS2017] for details.

The analysis increment in T_s is applied by the interface layer module: Fig. 3(c)

► Though small compared to the modeled variables (ΔT_w and ΔT_c), the analysis increment *tries* to warm T_s. Therefore information from the observations is *trying* to correct a known diurnal warming model bias which tends to *cool-off* too fast in late-evening to sunset [GA2018, ATS2017].

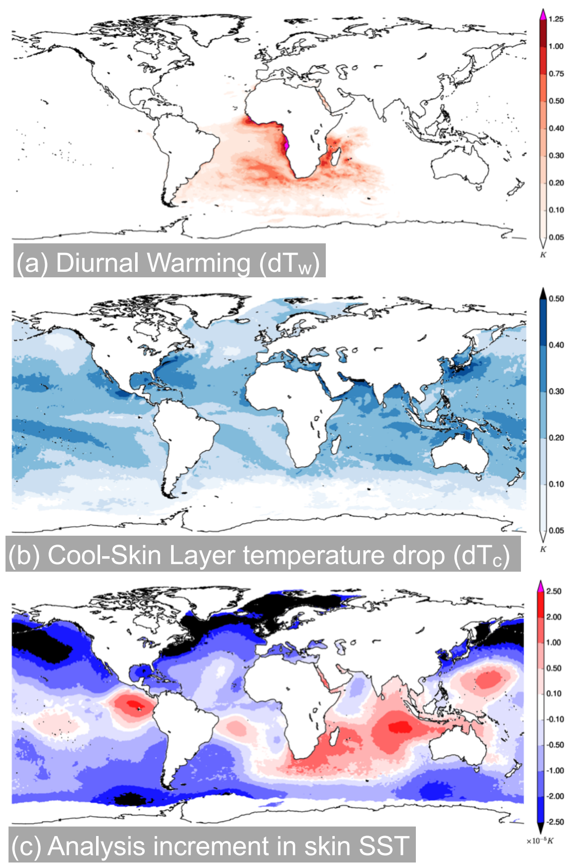


Figure 3: Contributions to the 12UTC, Dec 2017 mean skin SST within the GMAO Weather Analysis & Prediction System

Improvements to the diurnal cycle representation

Comparison with an independent data set, such as SEVIRI on Meteosat-10, Fig.4 shows good agreement. With following drawbacks:

- For low wind speeds, the modeled diurnal warming is (too) high
- There is a rapid decay in diurnal warming, right after sunset [GA2018].

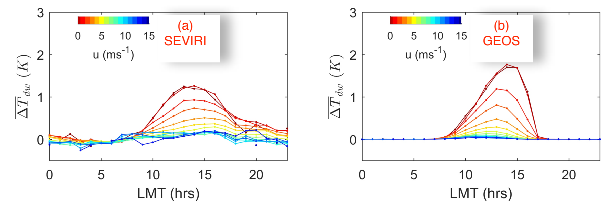
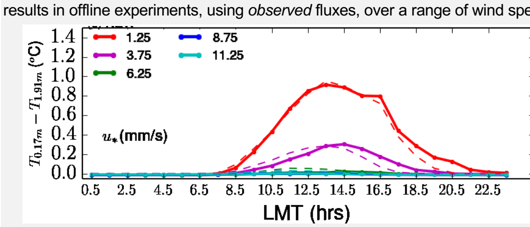


Figure 4: Comparison of monthly mean diurnal warming from (a) SEVIRI retrieved SST, (b) GEOS for September, 2015.

A modification of the turbulent diffusivity in the diurnal warming model shows promising results in offline experiments, using *observed* fluxes, over a range of wind speeds.



Comparison of modeled (dashed lines) versus observed (solid lines) diurnal warming for the Arabian Sea Mooring Experiment

Summary and Future Work

- The GEOS Weather Analysis & Prediction System currently assimilates for skin SST.
- Hourly 0.125º near-real time Skin SST, diurnal warming, cool-skin layer fields are publicly available.
- As always, atmospheric 3-D fields of aerosols, temperature (T), moisture (q), winds (u, v), and (2-D) surface pressure are also available from https://gmao.gsfc.nasa.gov/GMAO_products/NRT_products.php
- Next generation of NASA GMAO reanalysis, i.e., a follow on to the MERRA-2 could provide Skin SST, diurnal warming and cool-skin layer fields for the EOS period.

References

[GA2018] Gentemann, C. L. and Akella, S., 2018: Evaluation of NASA GEOS-ADAS modeled diurnal warming through comparisons to SEVIRI and AMSR2 SST observations. JGR Oceans, 123. doi: 10.1002/2017JC013186

[ATS2017] S Akella, R Todling and M Suarez, 2017: Assimilation for skin SST in the NASA GEOS atmospheric data assimilation system. Q.J.R. Meteorol. Soc, 143: 1032– 1046. doi:10.1002/qj2988

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