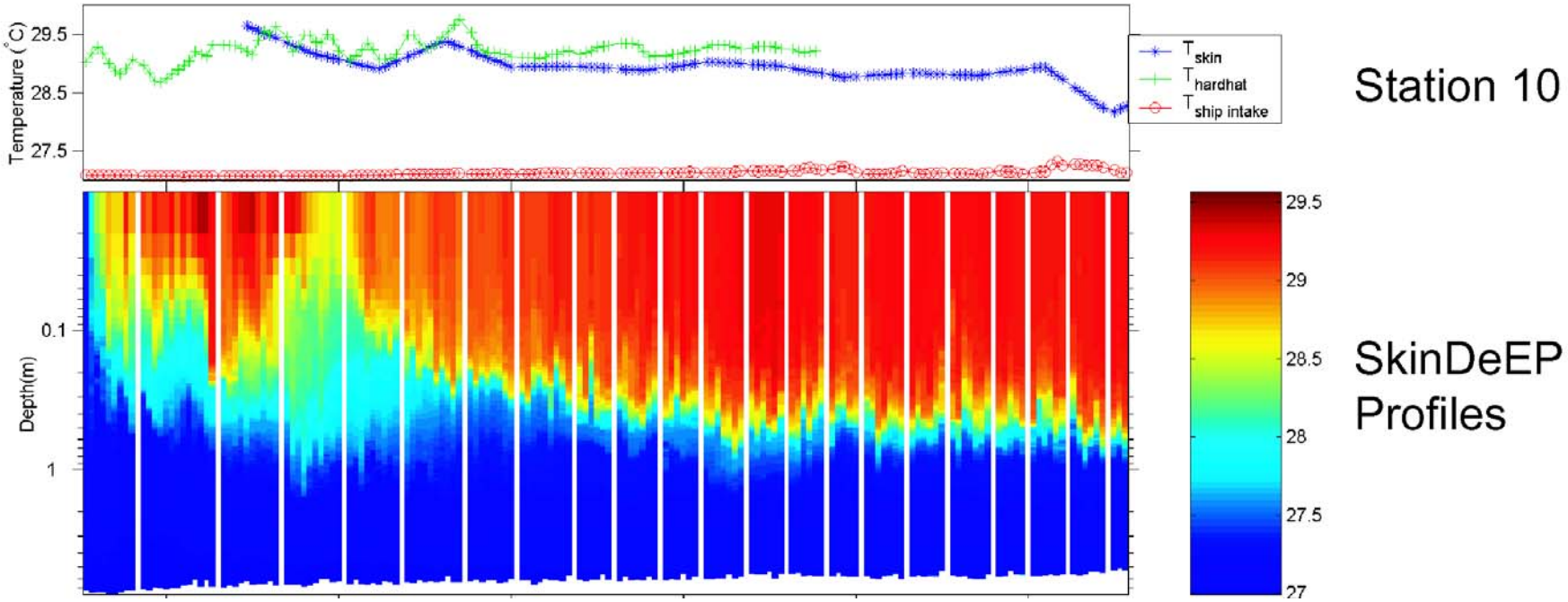
Improved Validation of Satellite SST for Climate Research

C.J. Donlon, P.J. Minnett, C.L. Gentemann, T.J. Nightingale, I.J. Barton, B. Ward, & M.J. Murray



Submitted to Journal of Climate, 3/9/2001

Operational strategy for validation of satellite-derived SSTs

1. VOS with high-quality skin radiometers
2. Buoy/Drifter in-situ

The bulk of validation retrievals will come from in-situ measurements located below the skin layer, but within the diurnal warm layer.

- Better characterization of the SST_{skin} and SST_{depth} relationship and its dependence on wind speed.

SST_{skin} and SST_{depth} relationship

The cool skin / warm layer effects are germane to:

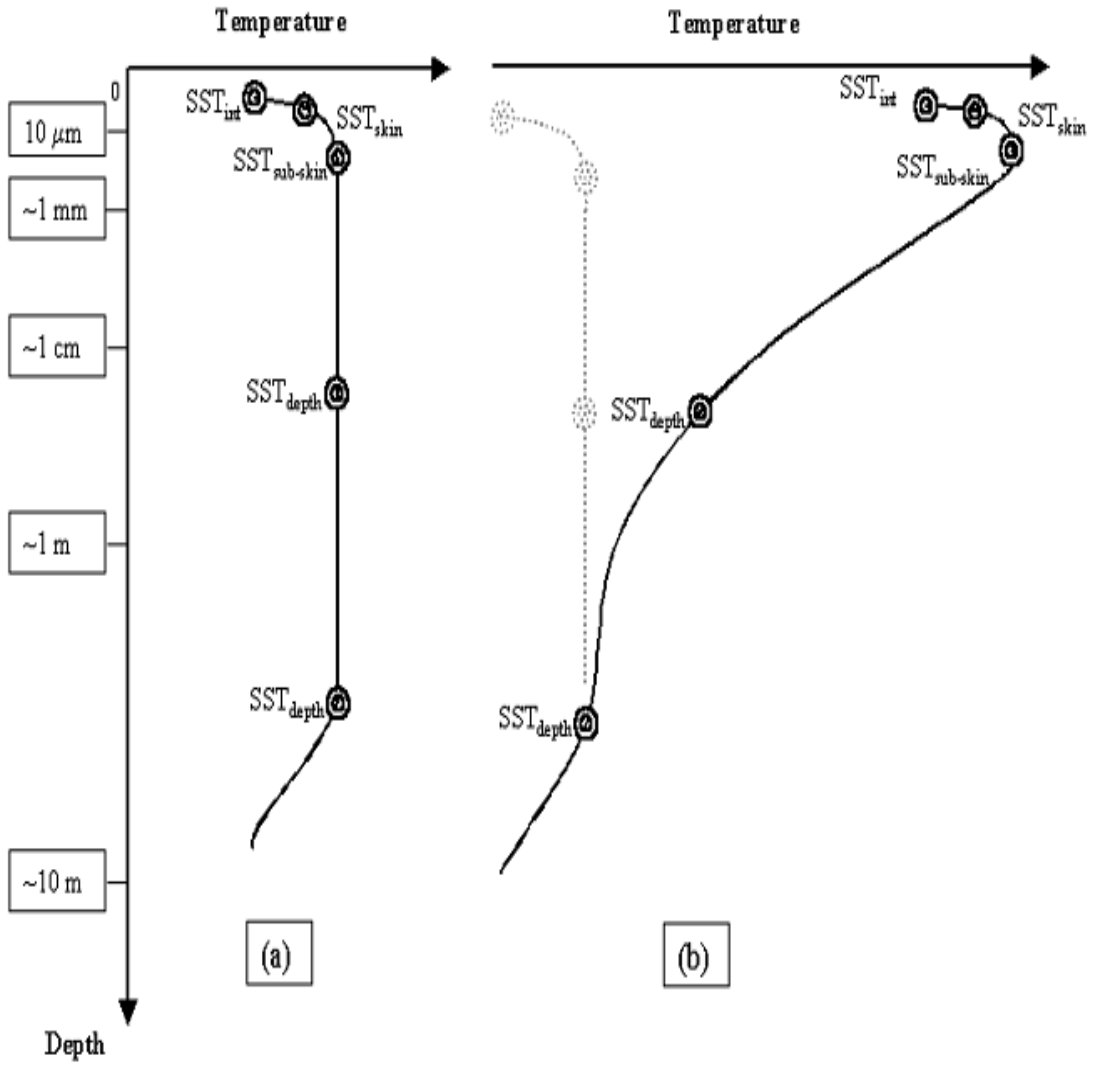
- Interpretation of SST used in calculation of air-sea fluxes, climate studies, NWP, & GCMs.
- Multi-sensor SST blending efforts (increased fidelity, consistency, and resolution)

Upper Ocean Thermal Structure

SST_{skin} ~500µm conductive and diffusive heat transfer processes dominate

$SST_{sub\text{-}skin}$ – 1mm, molecular and viscous heat transfer processes dominate

SST_{depth} – 1m, turbulent heat transfer processes dominate



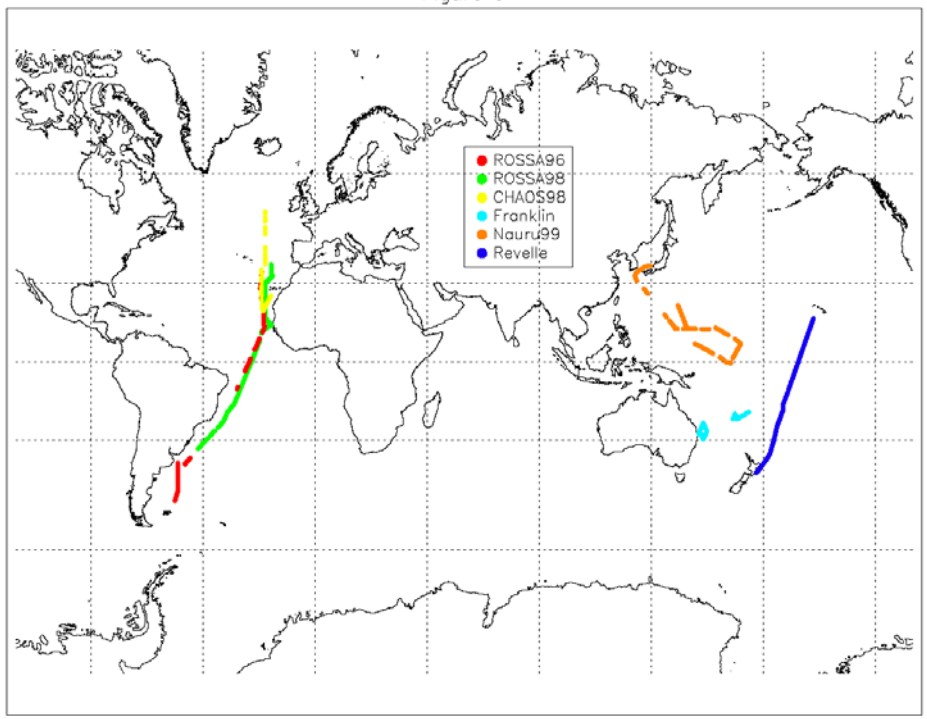
Cruise Tracks

M-AERI: Fourier-Transform infrared spectroradiometer

SISTeR: scanning infrared SST radiometer: skin measurement

Sonic anemometer: wind speeds

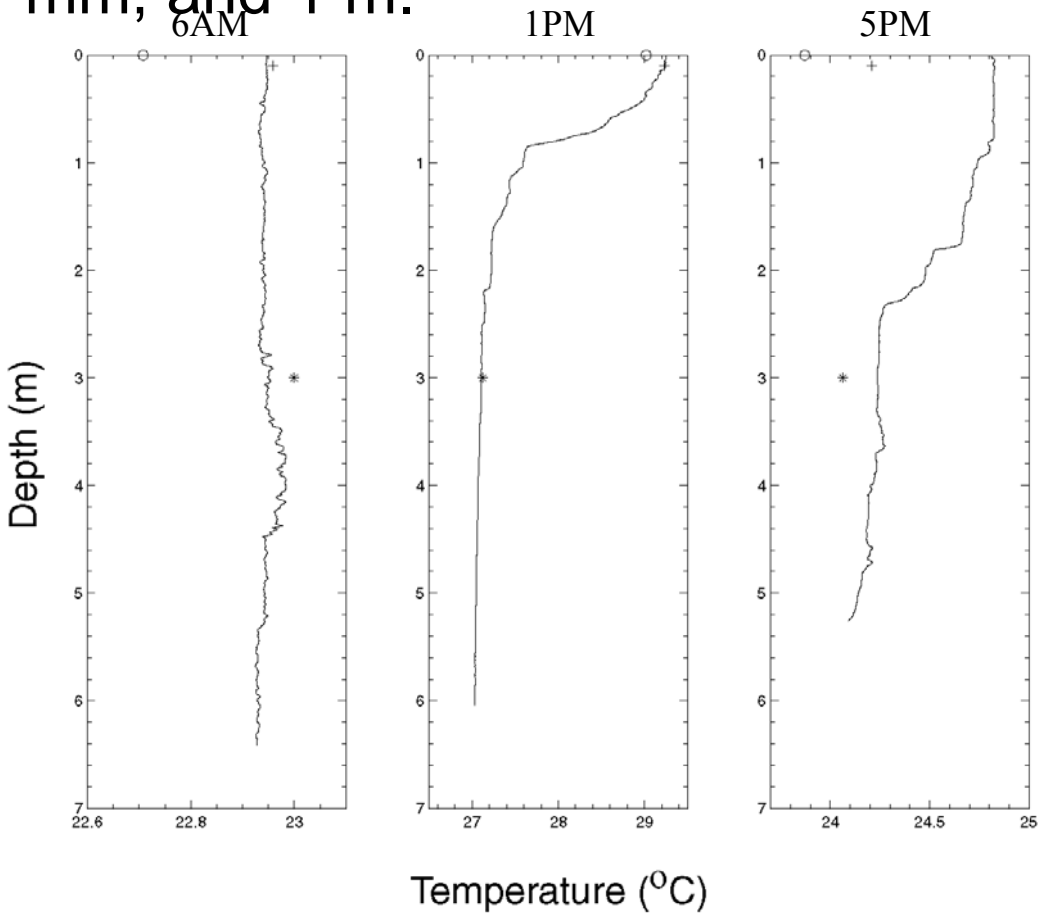
Figure 3



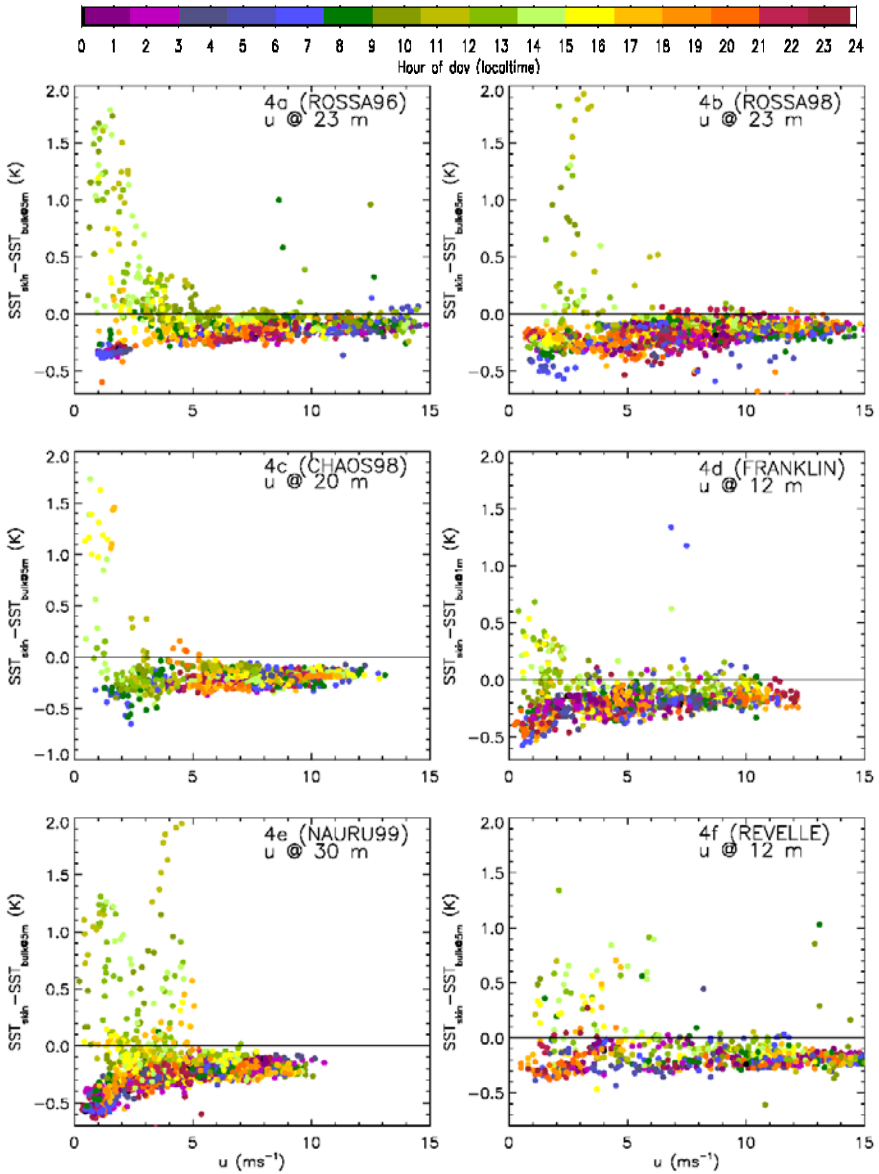
Diurnal Warm Layer

Thermal stratification can cause large differences between SST measured at 1 μm, 1 mm, and 1 m.

Three vertical profiles taken by SkinDeEP, showing the diurnal warm layer. Small circles are skin measurements from MAERI, showing cool skin.



Skin Bulk Differences



DAYTIME

U > 6 m/s : there exists a cool skin of 0.17 K ± 0.07 K RMS. SST_{depth}, corrected for this small bias, may be termed SST_{skin}.

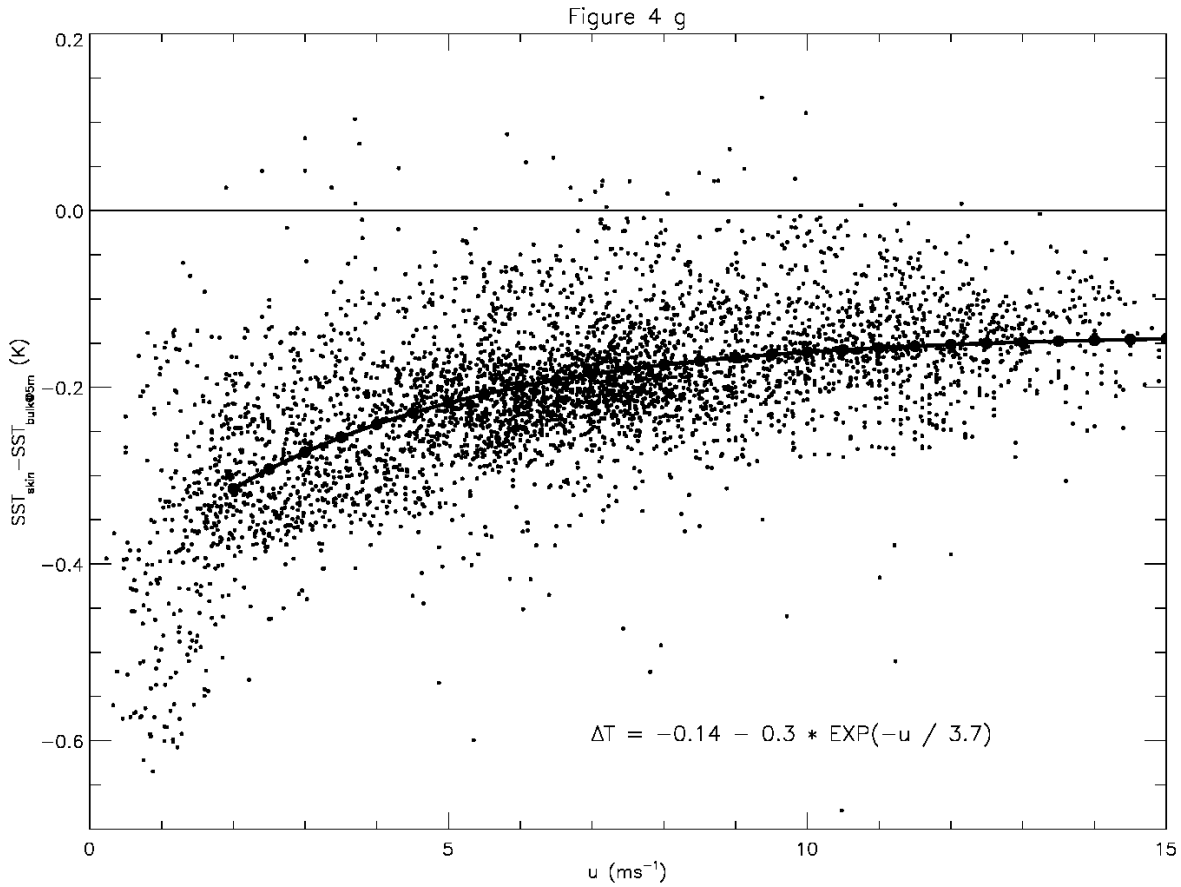
U < 6 m/s : modeling of diurnal warming and cool skin effects is clearly mandatory.

NIGHTTIME

U > ~2 m/s : there exists a cool skin of $0.14\ K + 0.30e^{(-U/3.7)}$

U < ~2 m/s : convective and molecular heat transfer processes dominate maintaining a significant temperature gradient.

Night Skin Bulk Differences



Validation Methodologies

Direct: (preferable)

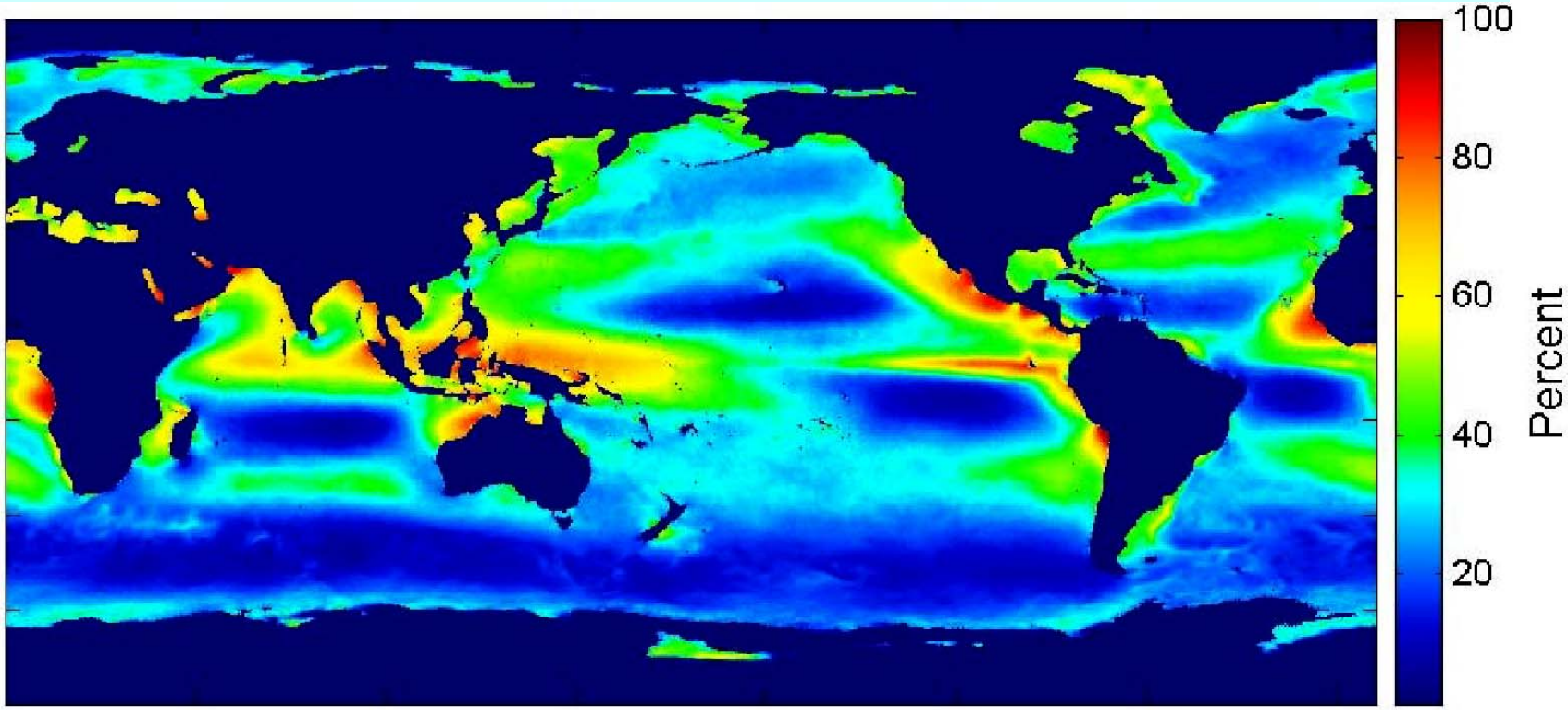
- Contemporaneous satellite and in situ SST_{skin} encompassing a range of ocean temperatures and atmosphere profiles.
- To meet sampling requirements, there should be ~15 deployed in situ SST_{skin} radiometers.
- Target low wind areas

Validation Methodologies

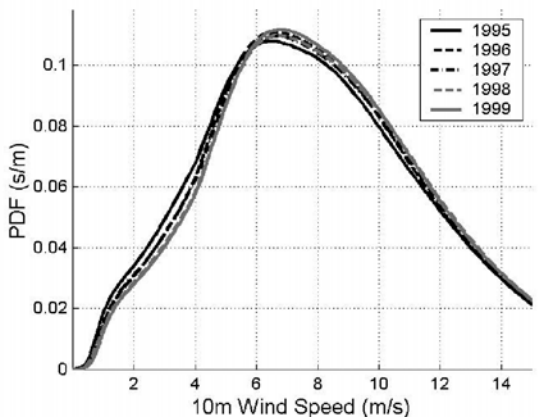
In-direct:

- Collocated satellite and in situ SSTdepth encompassing a range of ocean temperatures and atmosphere profiles
- Need contemporaneous wind retrievals
- Target regions with winds > 6 m/s

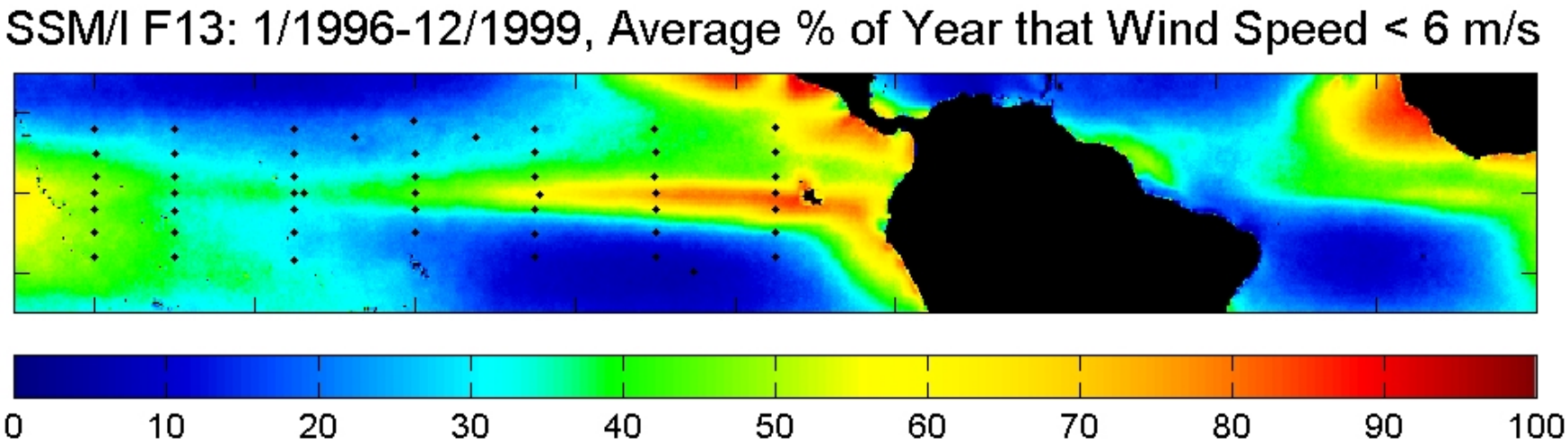
Percent of year winds < 6 m/s



SSM/I wind speeds 1995-1999 highlight regions where indirect validation should be targeted. Average wind speed is 8.3 m/s and 30% of winds are < 6 m/s. 3% of winds are less than 2 m/s.

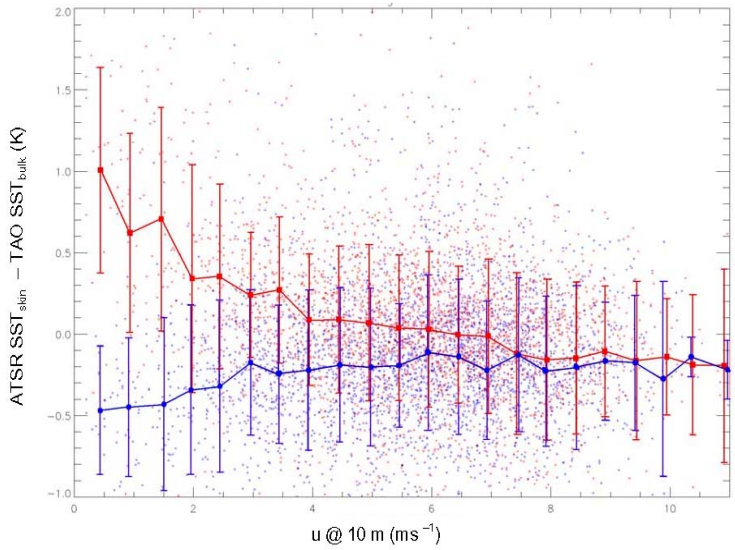


Low Winds in Tropics



- Most buoys are located in regions with a small chance of low wind speeds.

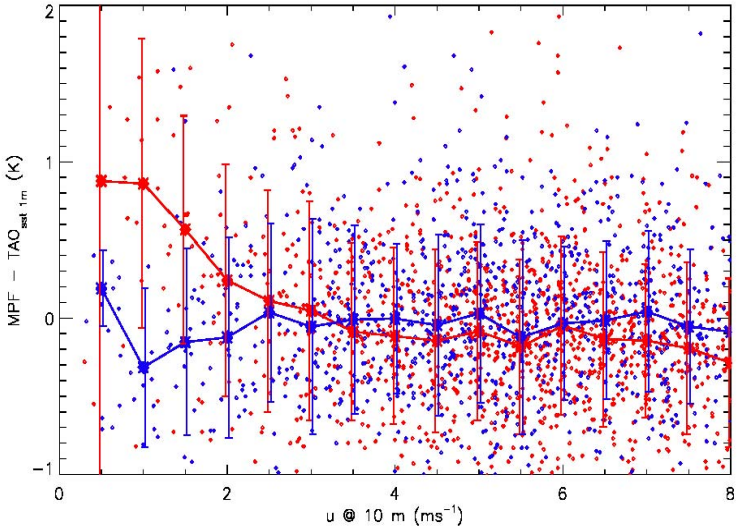
Skin Temperature IR SSTs



ATSR shows diurnal warming up to 7 m/s. Mean difference for U > 6 m/s :

Night: –0.17 K ± 0.46 K RMS

Day: –0.07 K ± 0.47 K RMS



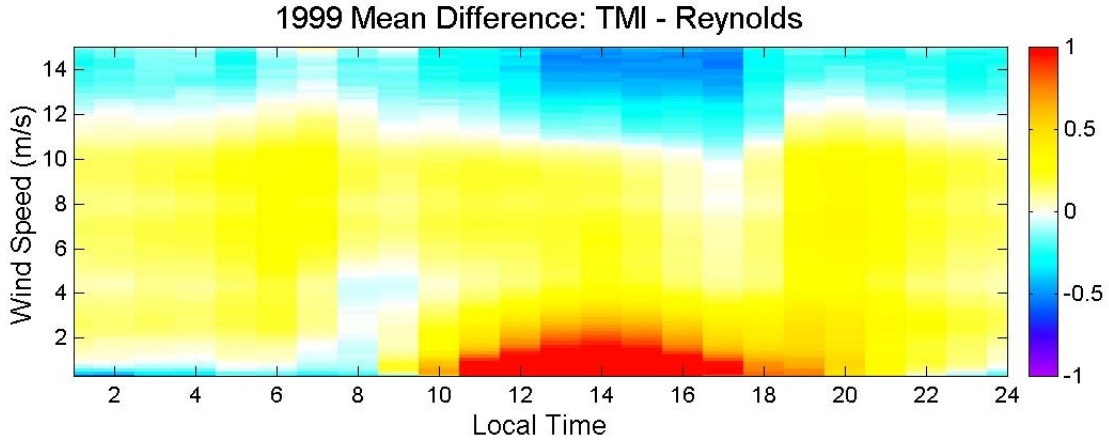
MPF shows diurnal warming up to 2.5 m/s. Mean difference for U > 2.5 m/s :

Night: –0.06 K ± 0.50 K RMS

Day: –0.15 K ± 0.53 K RMS

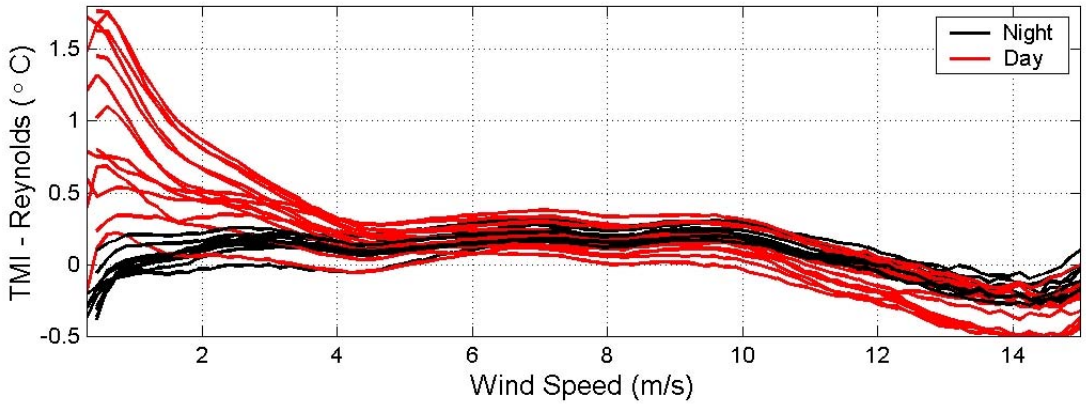
Diurnal warming of Microwave SST

Diurnal warming of skin SST as a function of wind speed.

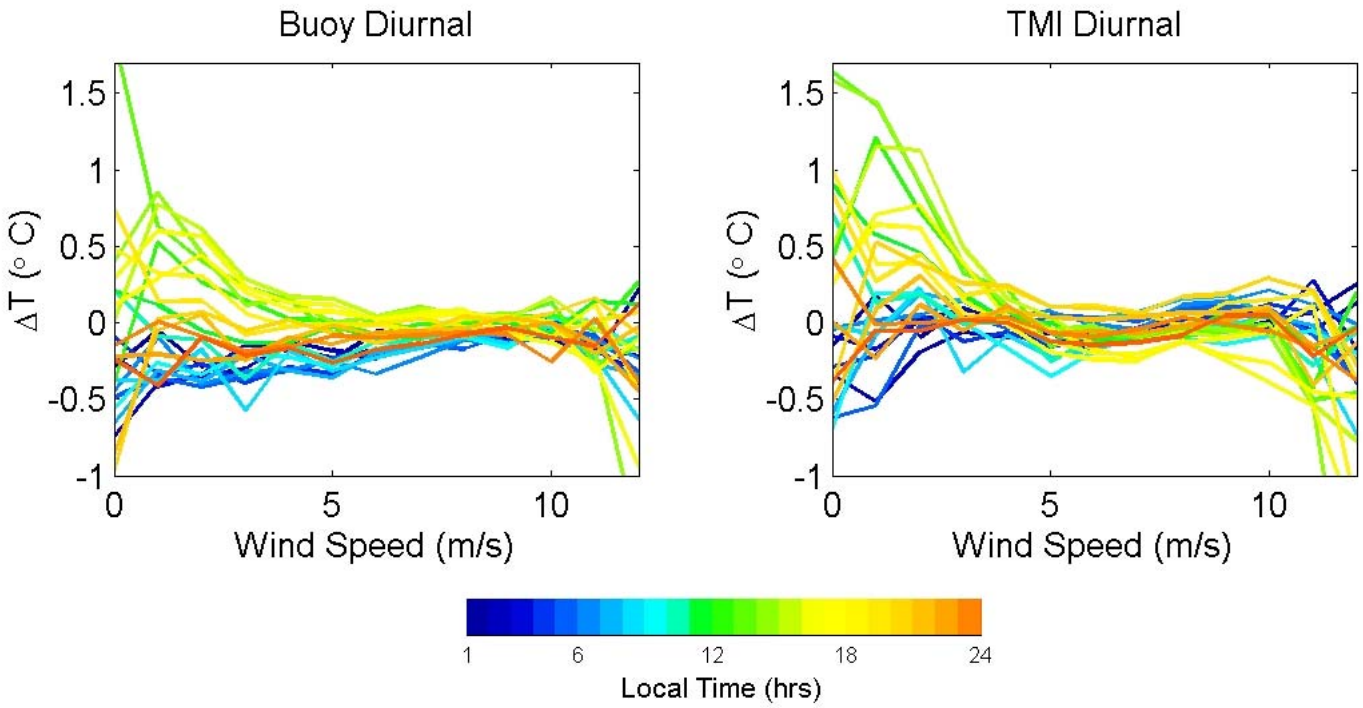


At wind speeds less than 5 m/s, diurnal warming of up to 2°C, peaking at 2pm.

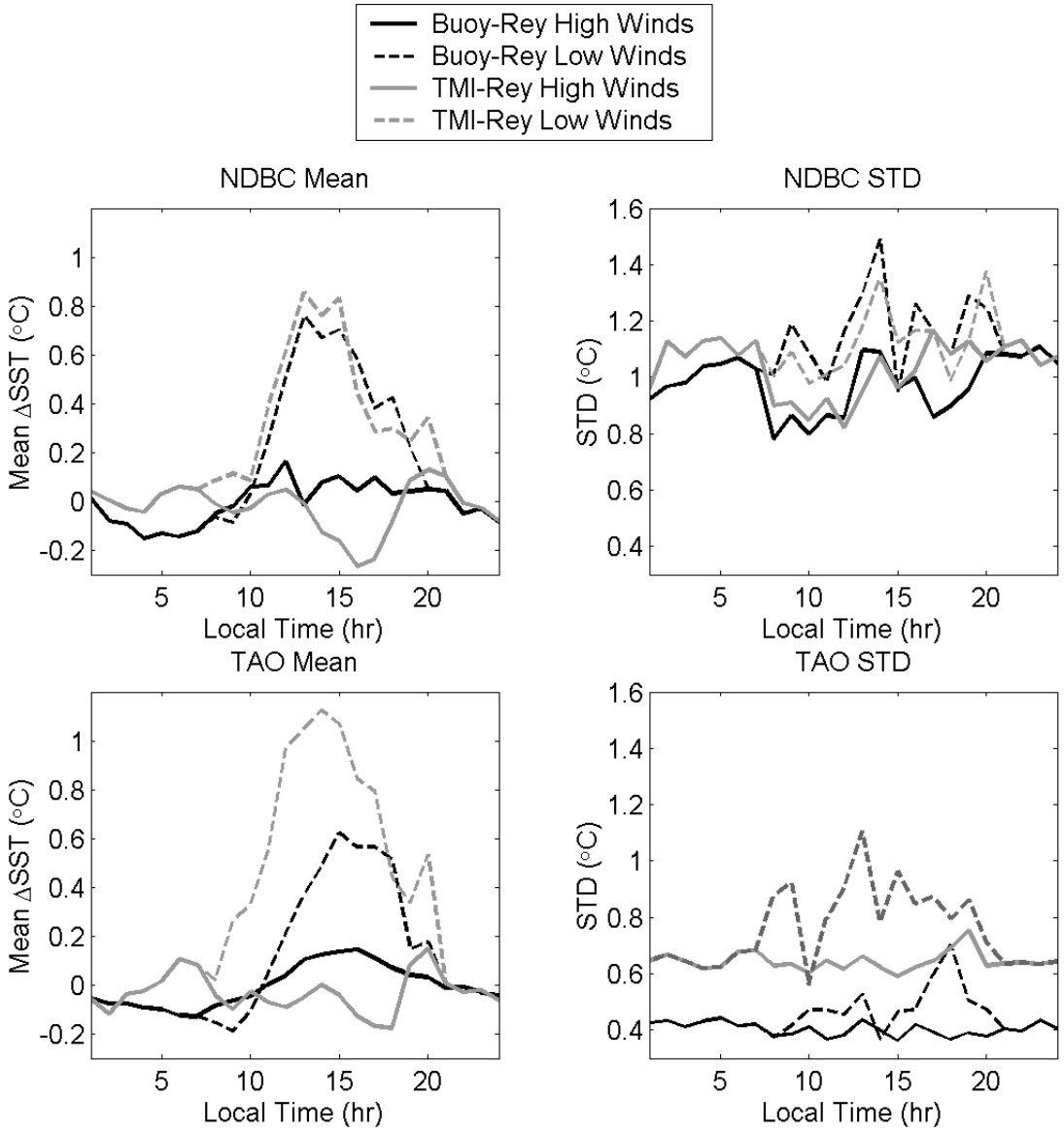
Cooling of skin during night at very low wind speeds.



Diurnal warming of Microwave SST



Diurnal warming of Microwave SST



Conclusions

We need a better characterization of upper ocean thermal structure

---

- Rigorous validation of satellite SSTs
- Fundamental to development of long-term multi-sensor SST blended products
- Vital parameterization for SST analyses that incorporate temperatures measured at different depths (satellite and in situ data).