

Diurnal sea surface temperature modeling with satellite data

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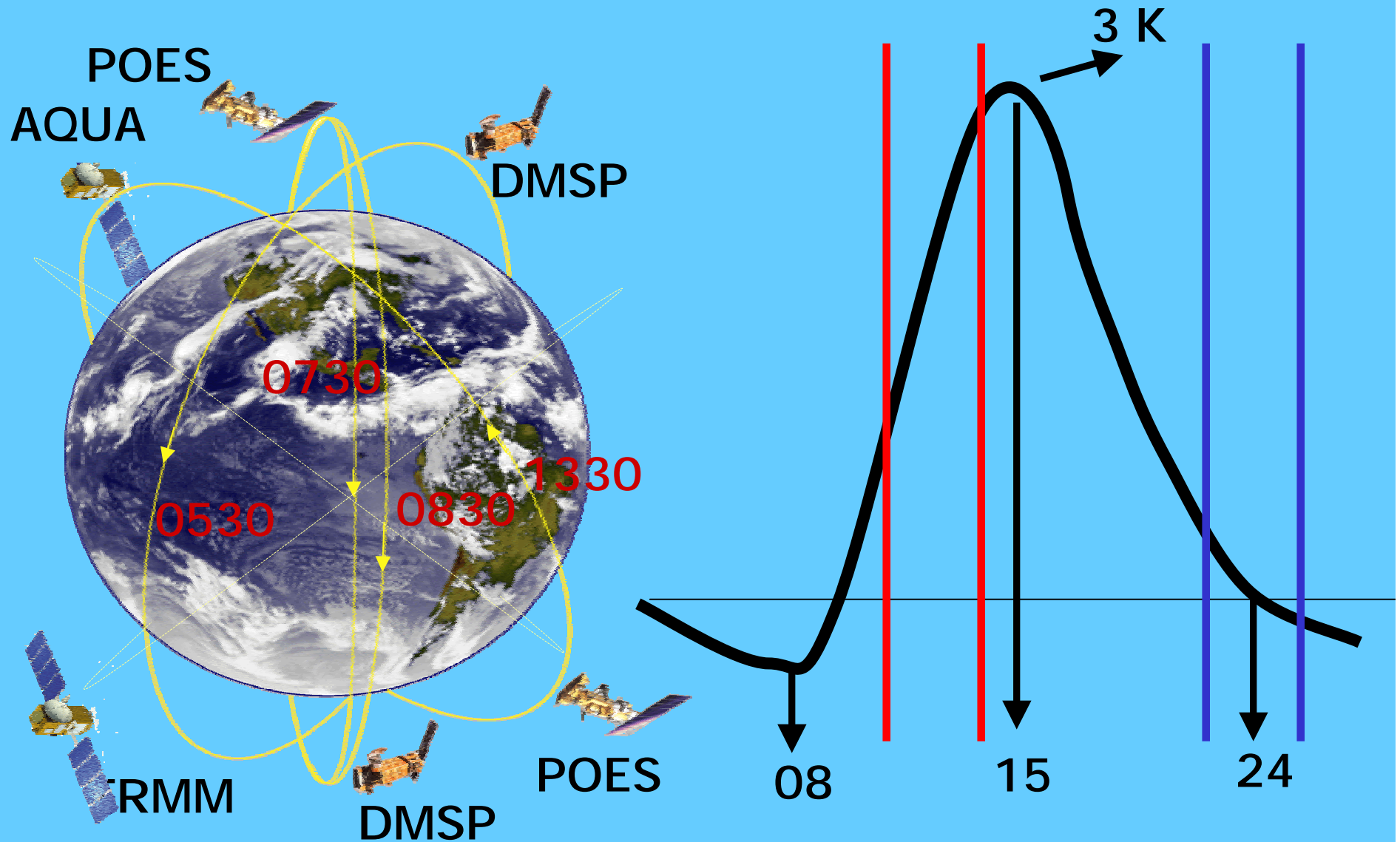


Outline

- Motivation for simplified model of diurnal warming
- Upper ocean thermal structure
- Diurnal warming model
- Global application
- Comparison to ROSSA data
- Comparison to Fairall Model
- Future Improvements



Daily SST from multiple satellites



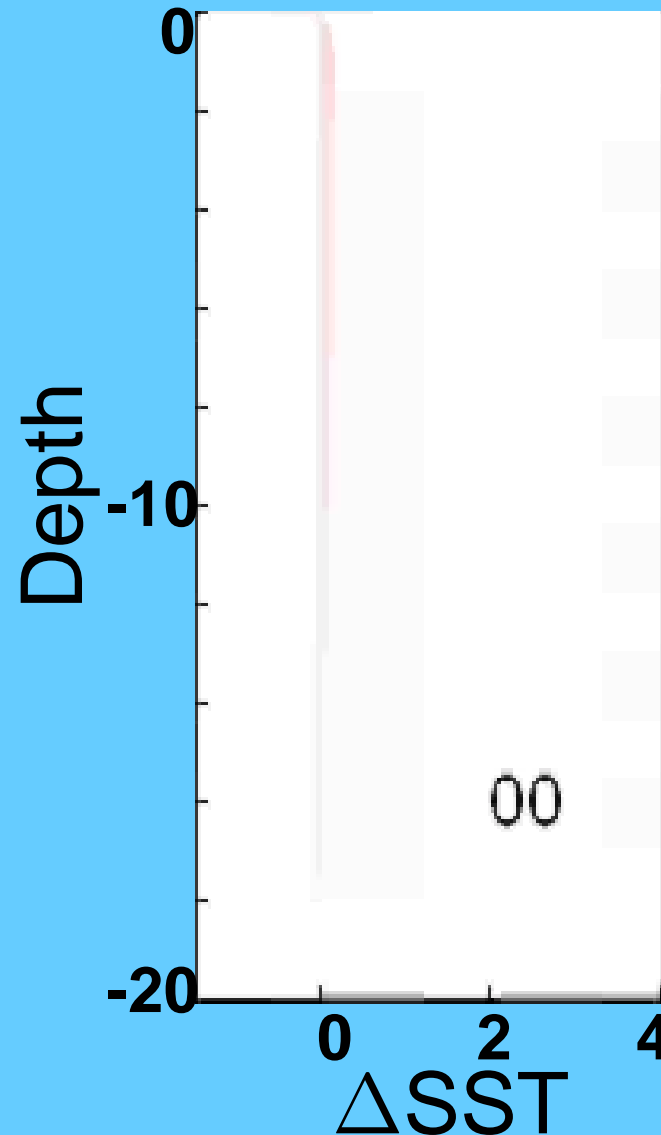


Upper Ocean Thermal Structure

Diurnal warming and nocturnal cooling

Buoy 1-m temperatures have diurnal cycle

A more complicated relationship that previously supposed for IR/MW/buoy SSTs





Calculation of Model

- **1998-2002 TMI**
- **1988-2001 PF AVHRR SSTs**
- **1990-2002 moored buoy SSTs (NDBC, PIRATA, & TAO)**
- **Wind speed:**
 - **TMI: simultaneous retrieval**
 - **PF: collocated with SSM/I daily ave wind speed**
- **Model Daily Average Insolation**
 - **$Q = \text{fnct}(\text{latitude}, \text{julian day})$**
- **Local Time:**
 - **TMI: Time of observation included**
 - **PF: Ascending node from ephemeris data**



Calculation of Model

Reynolds OI SST: **weekly** analysis does not resolve the diurnal cycle, so diurnal variability can be calculated as:

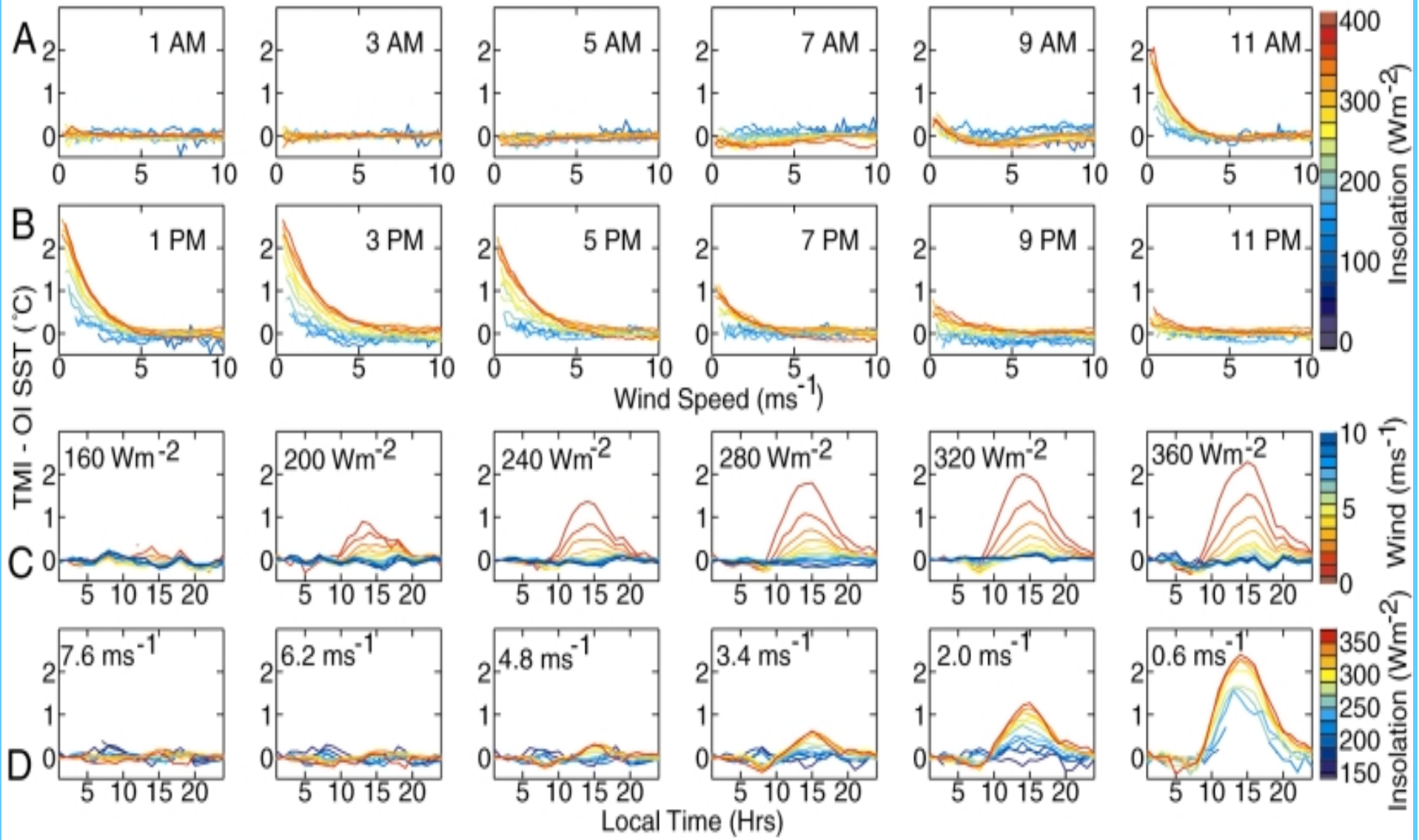
- $\Delta\text{SST} (t, Q, u) = \text{TMI} - \text{Reynolds}$
- $\Delta\text{SST} (t, Q, u) = \text{PF} - \text{Reynolds}$

Buoy diurnal cycle calculated as:

- $\Delta\text{SST} (t, Q, u) = \text{Buoy} - \text{Buoy}(08 \text{ LMT})$



TMI Diurnal Cycle





Empirical Model

$$\Delta SST_{tmi}(t, Q, u) = f_1(t) [(Q - Q_o^t) - 9.632 \times 10^{-4} (Q - Q_o^t)^2] e^{-0.53u}$$

$$\Delta SST_{pf}(t, Q, u) = 0.344 f_1(t) [(Q - Q_o^p) - 1.444 \times 10^{-3} (Q - Q_o^p)^2] e^{-0.29u}$$

$$\Delta SST_{buoy}(t, Q, u) = f_2(t) [(Q - Q_o^b) - 4.928 \times 10^{-4} (Q - Q_o^b)^2] e^{-0.28u}$$

where $\omega_1 = 0.2668 \text{hr}^{-1}$; $\omega_2 = 0.2652 \text{hr}^{-1}$;

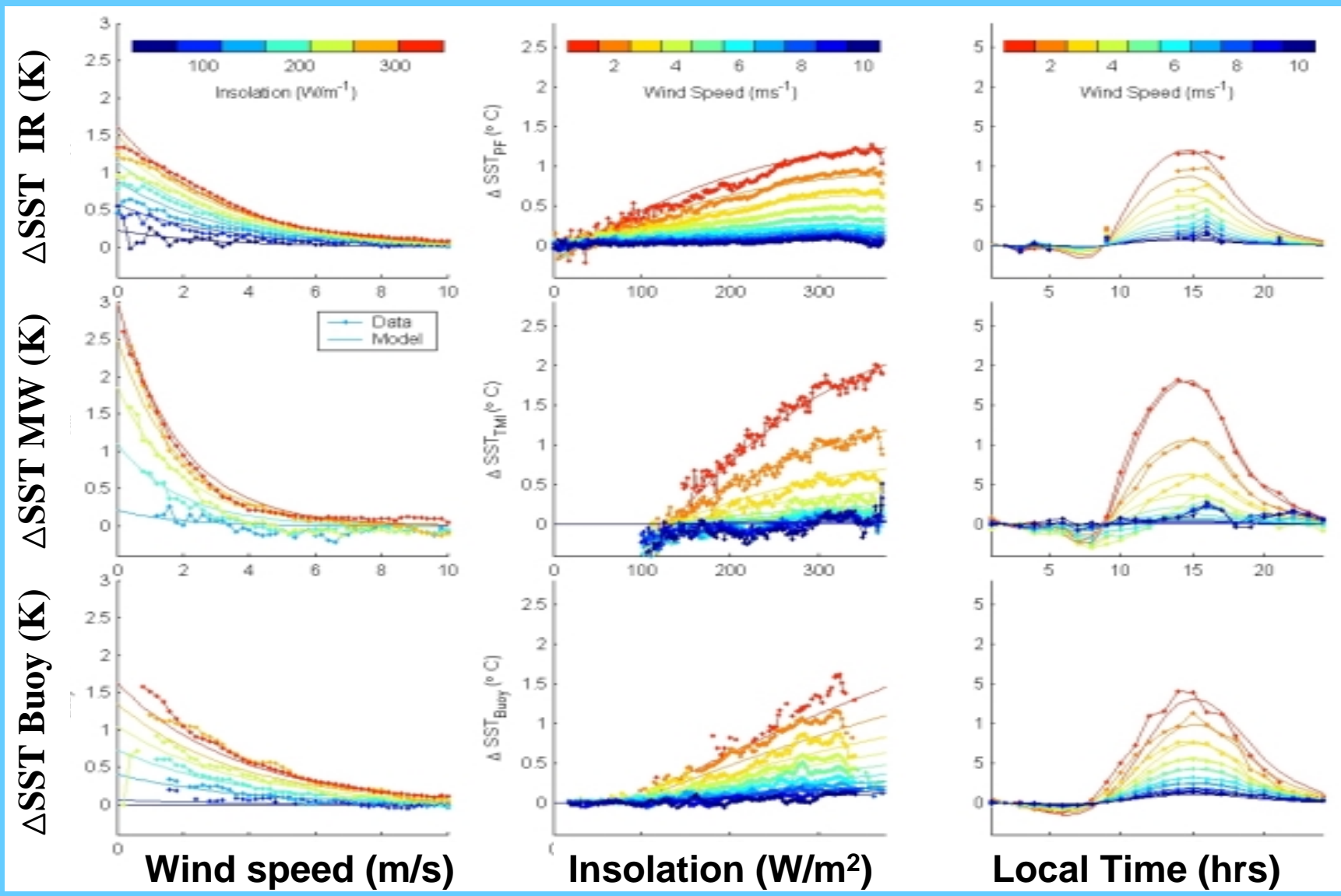
$Q_o^t = 132 \text{Wm}^{-2}$; $Q_o^p = 24 \text{Wm}^{-2}$; $Q_o^b = 44 \text{Wm}^{-2}$;

Insolation: quadratic

Wind speed: exponential

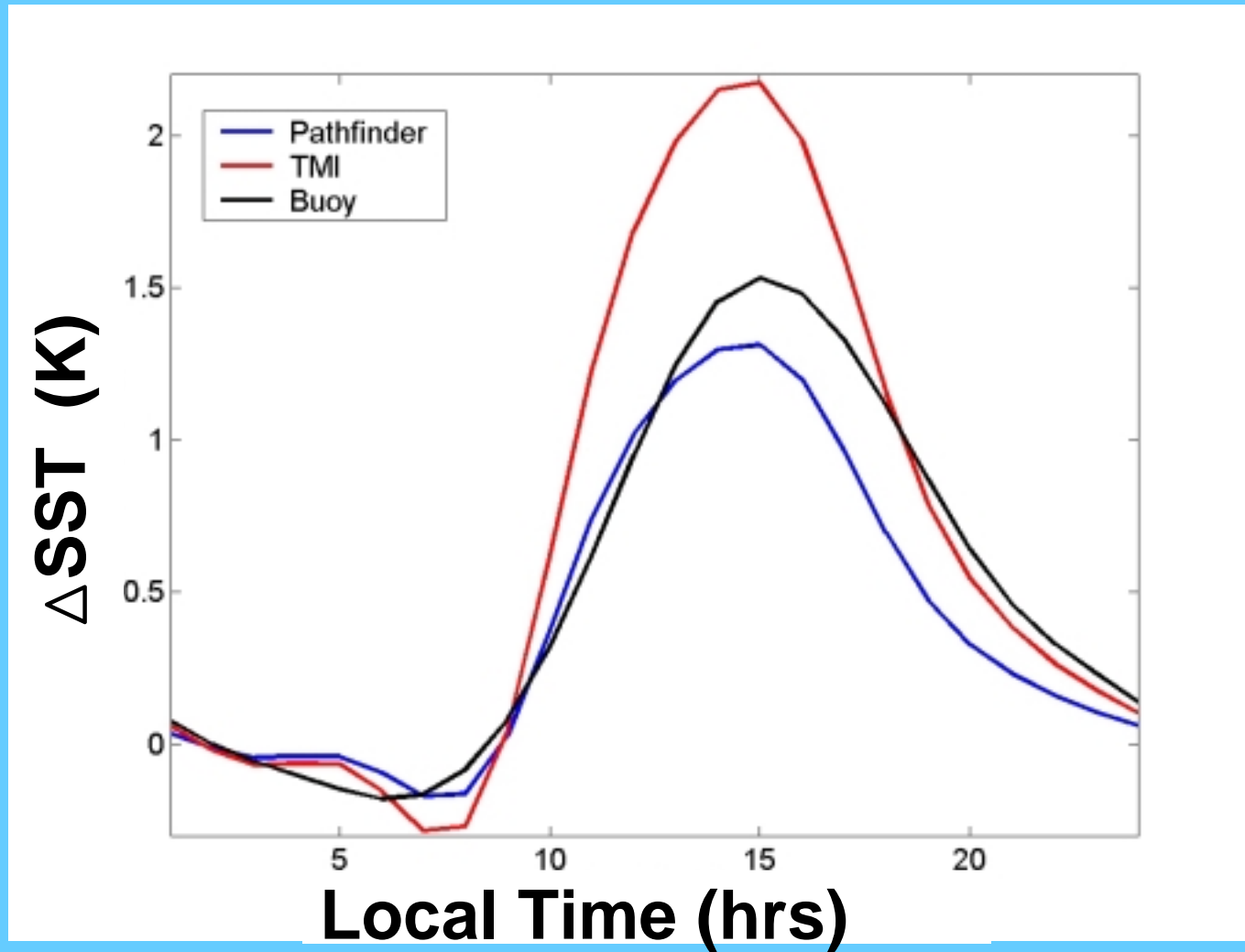


TMI/PF Model and Data





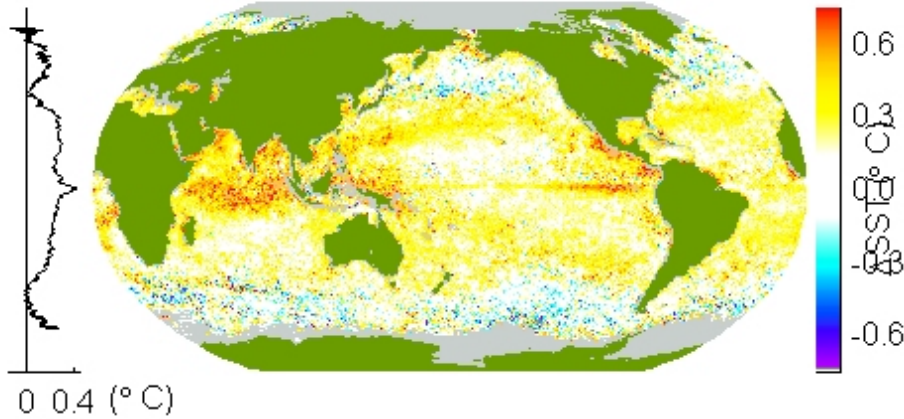
Global Model



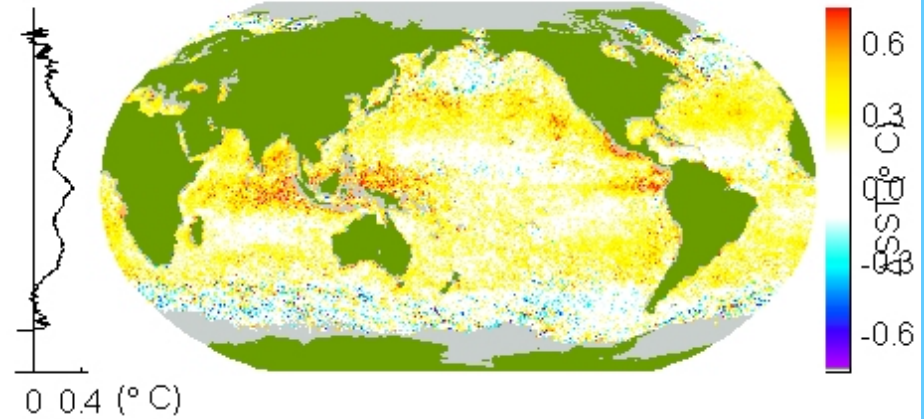


Global Correction

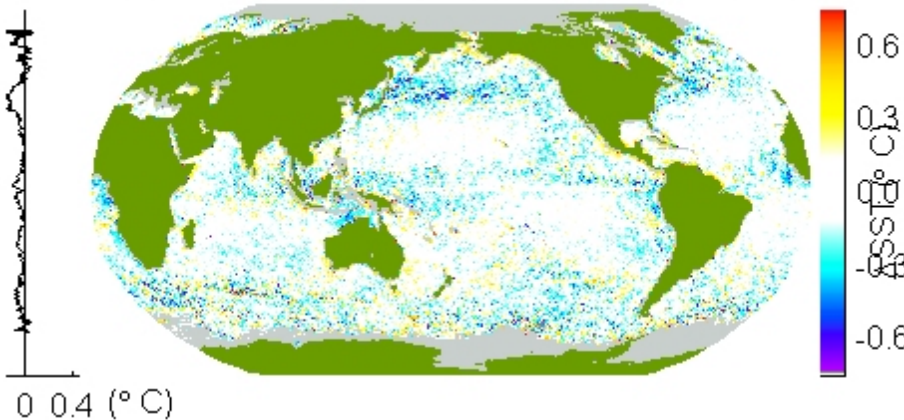
A: 1988 PF Day minus Night



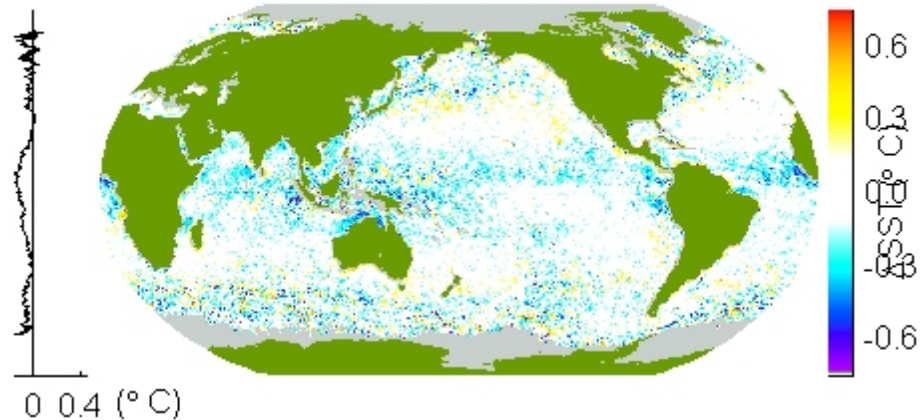
A: 1989 PF Day minus Night



D: PF Day minus Night minus Diurnal

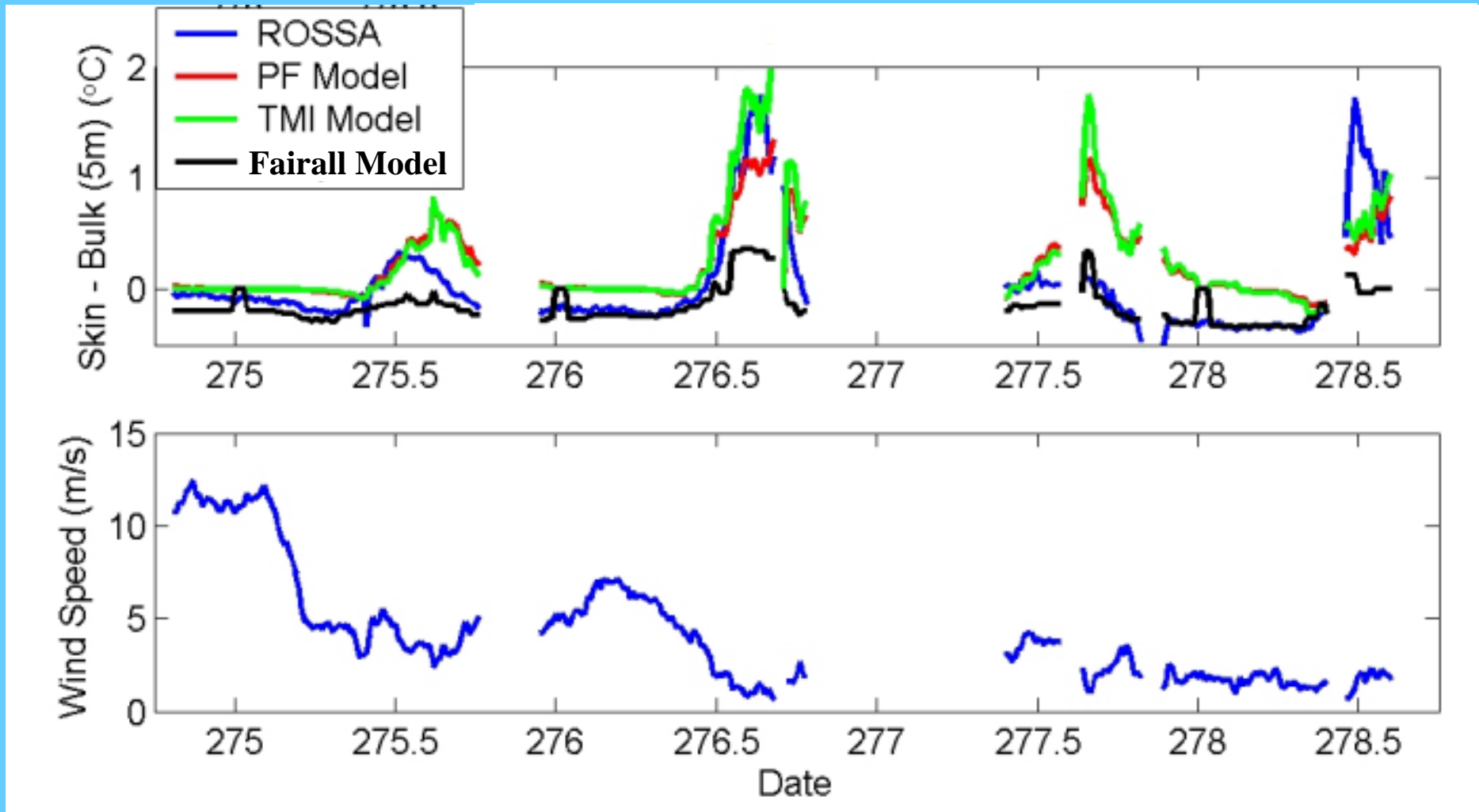


D: PF Day minus Night minus Diurnal



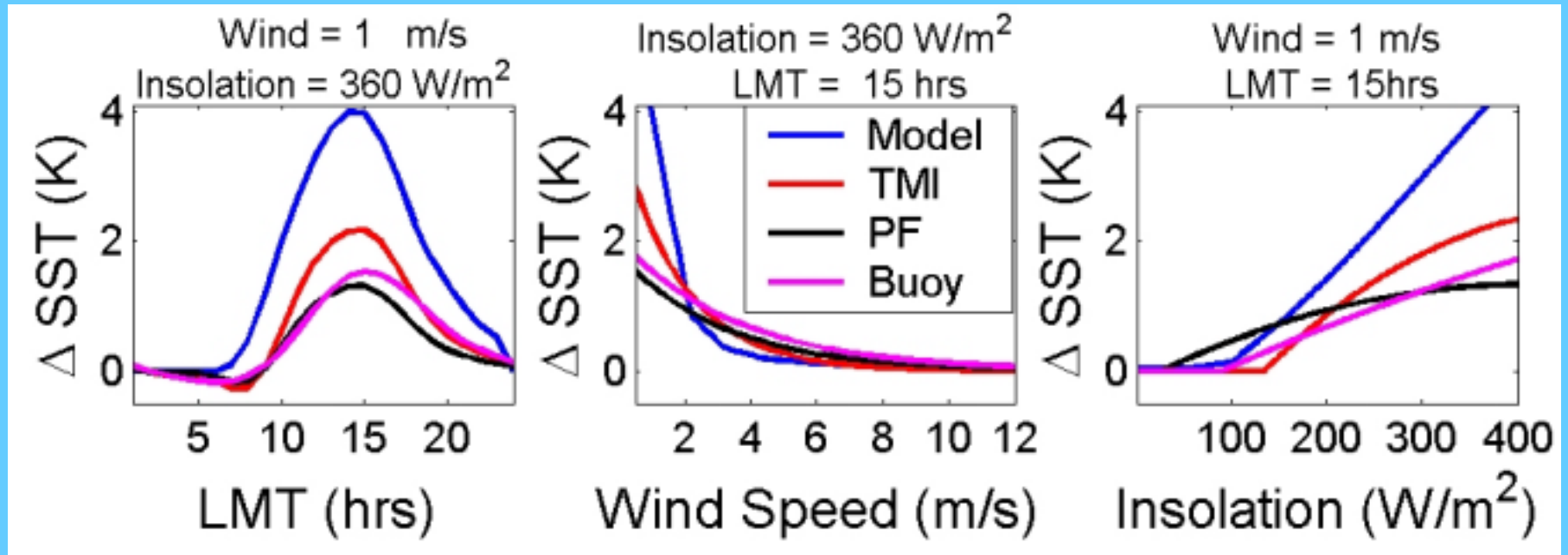


ROSSA Cruise & Model Comparison





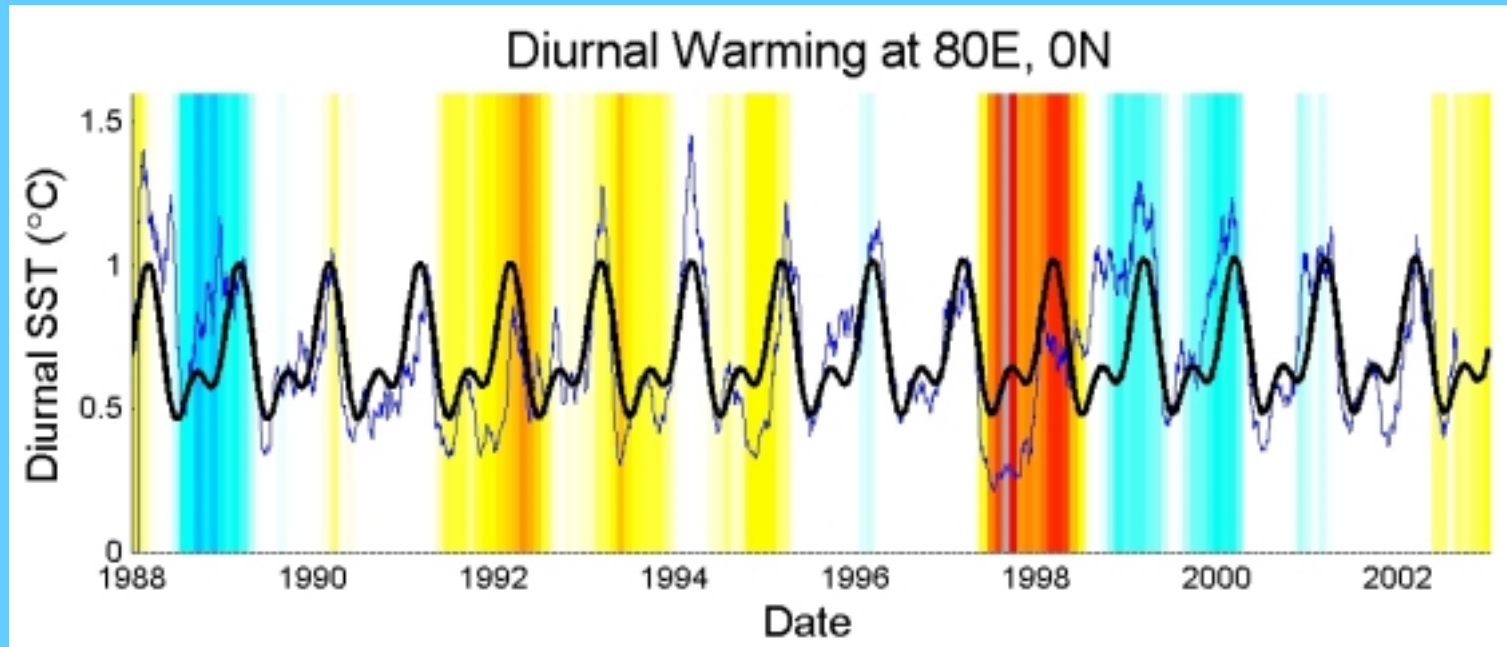
Comparison



- Fairall model too high
- Wind speed dependence wrong



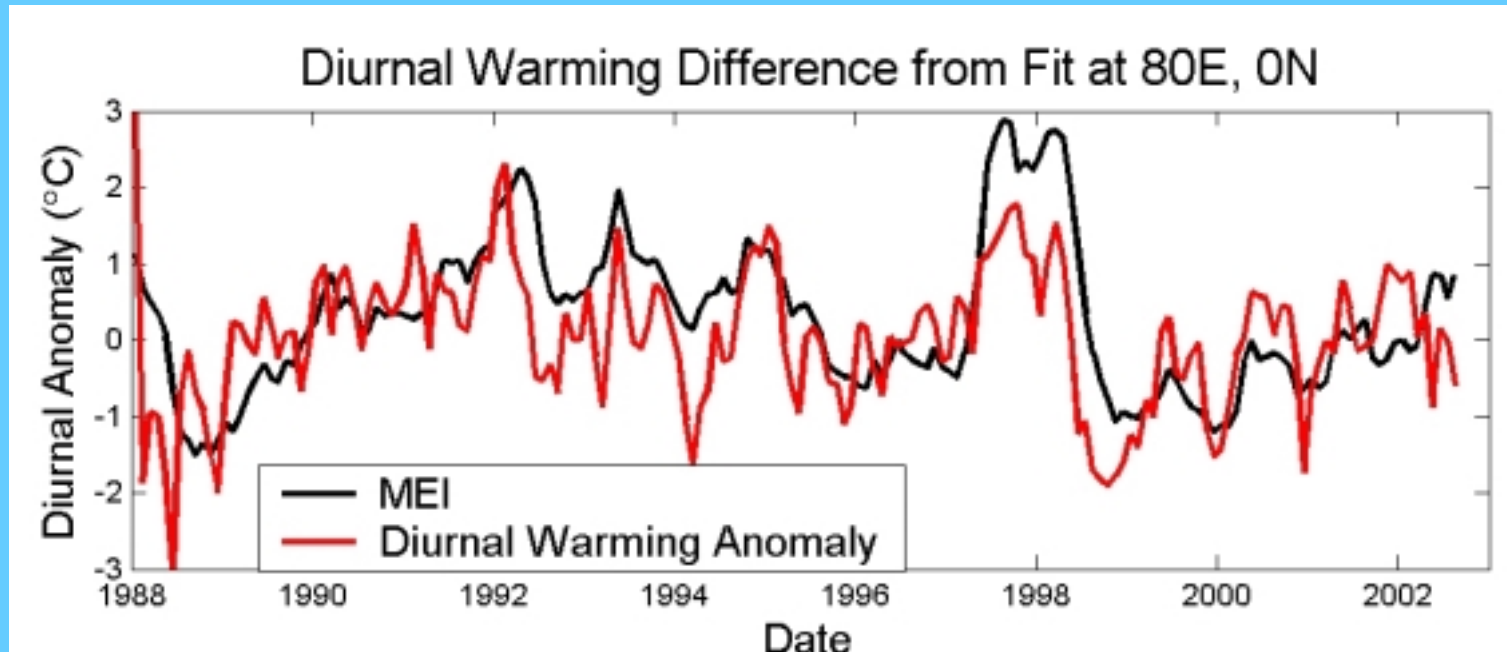
Diurnal Time series



- El Nino warm pool / stronger equatorial winds
- La Nina cold tongue / weaker equatorial winds



Diurnal Time series

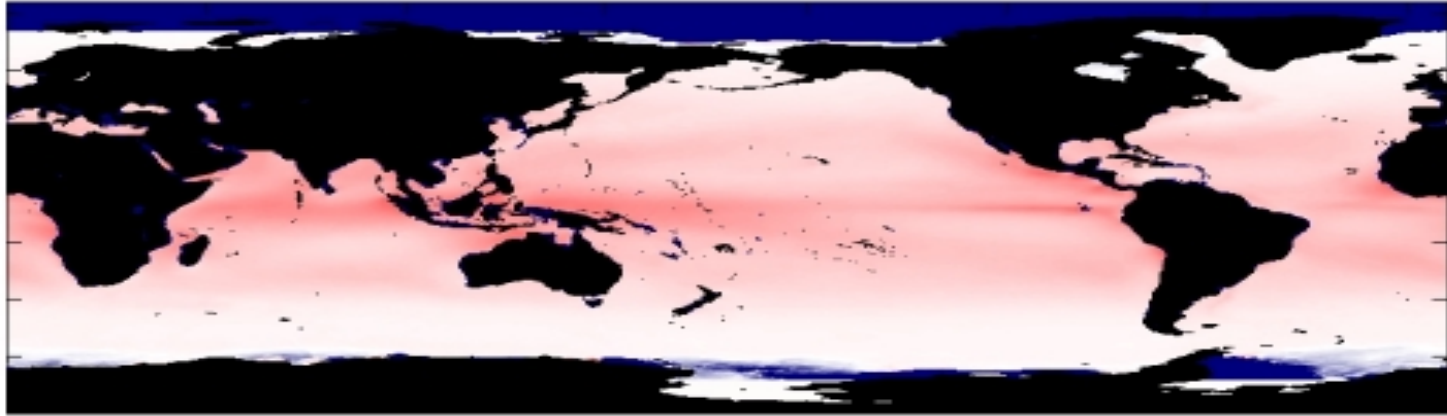


- El Nino warm pool / stronger equatorial winds
- La Nina cold tongue / weaker equatorial winds

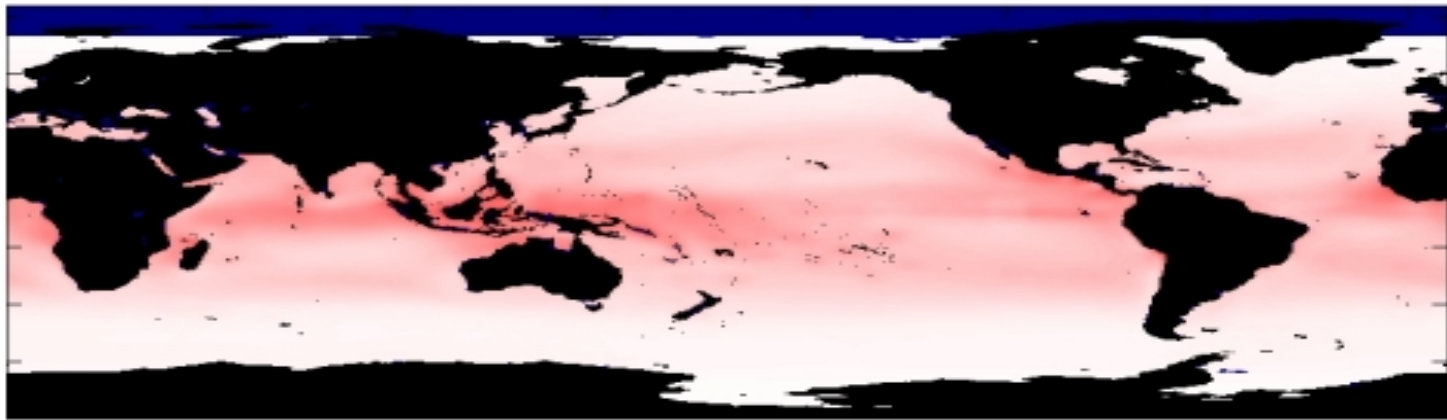


Diurnal Warming: Mean

SSMI Winds: Diurnal Mean



Model Winds: Diurnal Mean

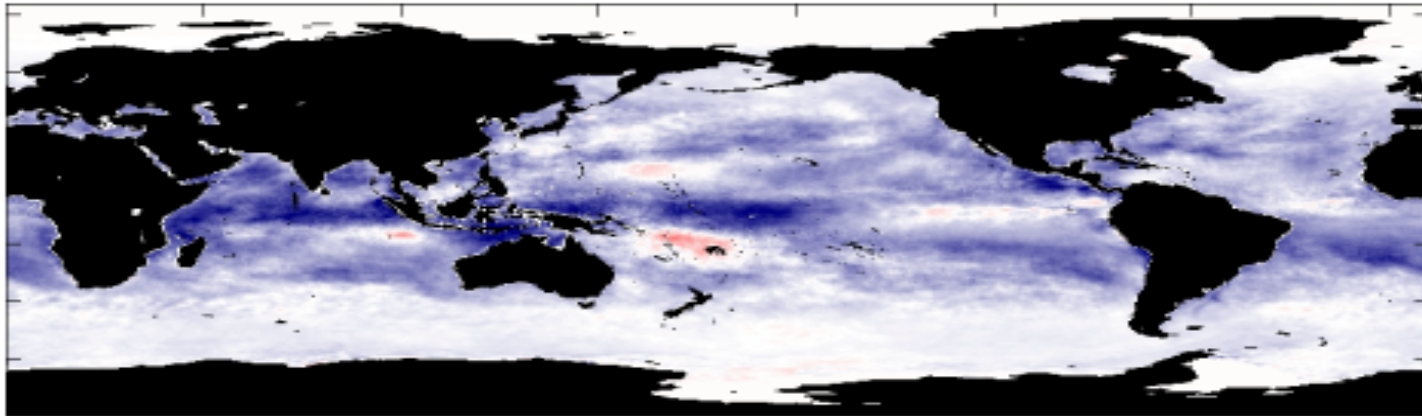


-1.5 -1 -0.5 0 0.5 1 1.5
Mean °C

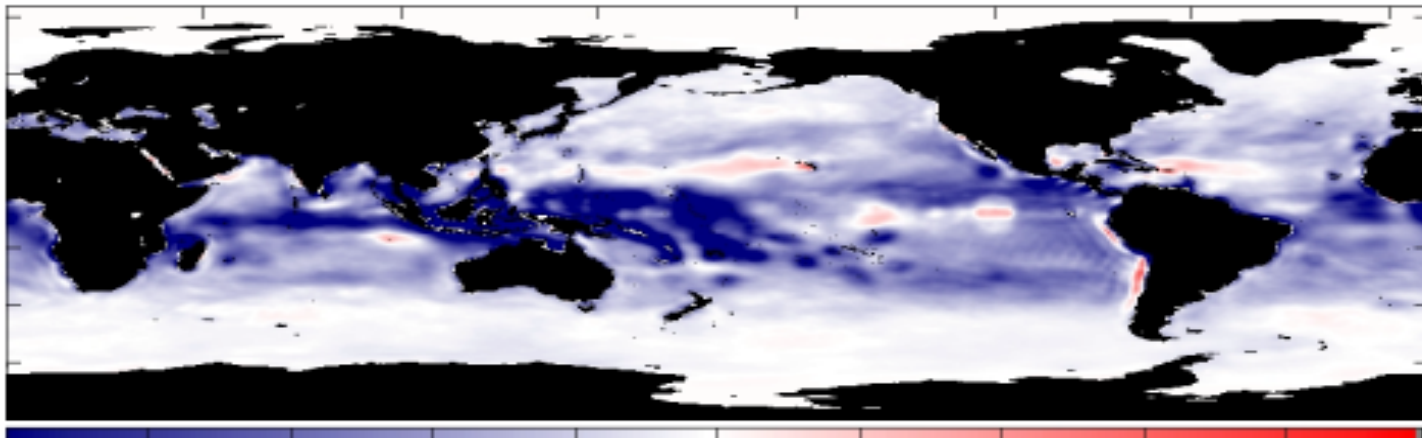


Diurnal Warming: Trend

SSMI Winds: Diurnal Trend



Model Winds: Diurnal Trend



-0.1 -0.08 -0.06 -0.04 -0.02 0 0.02 0.04 0.06 0.08 0.1
Trend °C/decade



Planned Improvements

- Calculate model using Kawai/Kawamura Insolation (GMS)
- Model Error:
Comparison to physical model and in situ measurements of skin/bulk SSTs
- Fnc_t(Cloud)
- *Fnc_t(Wind history) (is the wind increasing/decreasing; variance) (Alice Stuart-Menteth)*



GHRSSST Application

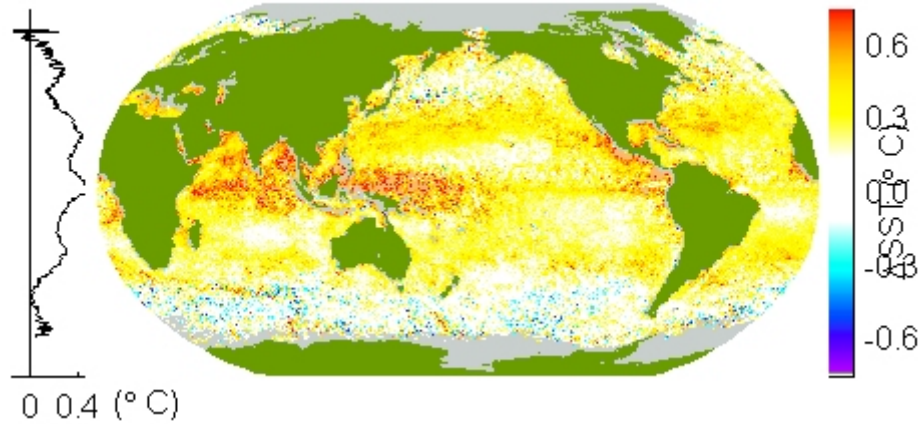
- Sensor specific empirical models
- Comparison of empirical models to physical models (adjustment)
- Calculate daily minimum SST (empirical model needed) and provide daily diurnal amplitudes (physical model – simplified to readily available datasets)



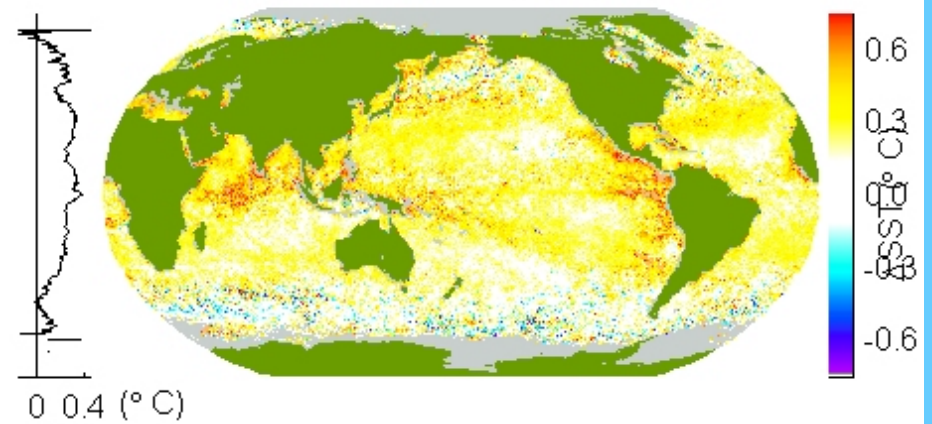


Global Correction

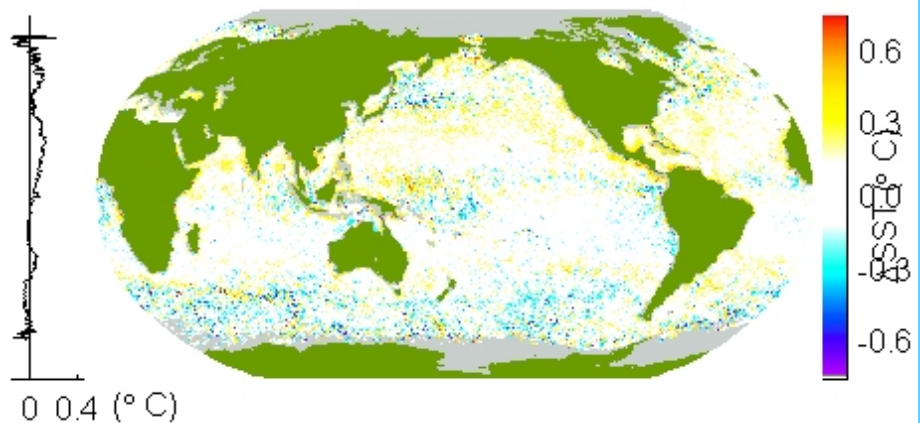
A: 1993 PF Day minus Night



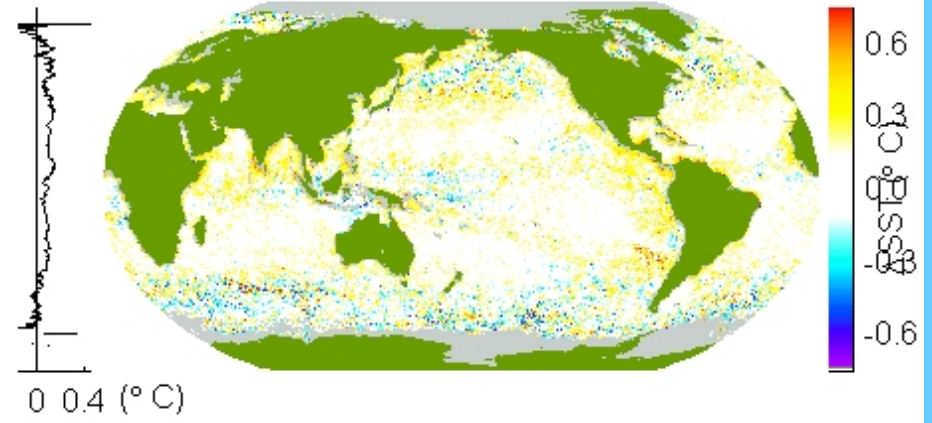
A: 1994 PF Day minus Night



D: PF Day minus Night minus Diurnal



D: PF Day minus Night minus Diurnal





ROSSA Data

