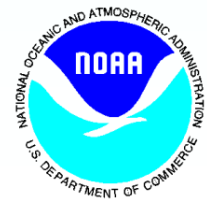


# A Facility for Near-Real Time Estimation and Evaluation of Diurnal Warming

Gary A. Wick

NOAA ESRL/PSD



# Outline

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- Motivation
- Overview of modeling approach
- Validation exercise
- Illustration of web interface

# Motivation

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- Provision of global diurnal warming estimates at multiple depths to complement foundation analyses
- Facility for regular intercomparison and validation of diurnal warming models
- Component of NESDIS effort to incorporate diurnal warming compensation in SST analysis

# Approach

- Computation of hourly estimates of diurnal warming at multiple depths
  - Subskin
  - 20 cm
  - 1 m
  - 5 m
- Physically based models
  - Kantha-Clayson model with wave effects
  - COARE
  - ...
- Forcing with numerical weather prediction inputs
- Source for data access

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## Modeled Diurnal Warming Amplitude

Application to GFS Forecast Fields  
Images available starting on November 16, 2014

Year  Month  Day  Depth  [View Selected Diurnal Analysis](#) [View Latest Diurnal Analysis](#)

### Diurnal Warming on November 17, 2014 at Skin

UTC Hour	Kantha-Clayson Wave Model	COARE	Wind Forcing	Insolation Forcing
Peak Amplitude				
00Z	Wave_00	COARE_00	Wind_00	Insolation_00
01Z	Wave_01	COARE_01	Wind_01	Insolation_01
02Z	Wave_02	COARE_02	Wind_02	Insolation_02
03Z	Wave_03	COARE_03	Wind_03	Insolation_03
04Z	Wave_04	COARE_04	Wind_04	Insolation_04
05Z	Wave_05	COARE_05	Wind_05	Insolation_05
06Z	Wave_06	COARE_06	Wind_06	Insolation_06
07Z	Wave_07	COARE_07	Wind_07	Insolation_07
08Z	Wave_08	COARE_08	Wind_08	Insolation_08
09Z	Wave_09	COARE_09	Wind_09	Insolation_09
10Z	Wave_10	COARE_10	Wind_10	Insolation_10
11Z	Wave_11	COARE_11	Wind_11	Insolation_11
12Z	Wave_12	COARE_12	Wind_12	Insolation_12
13Z	Wave_13	COARE_13	Wind_13	Insolation_13
14Z	Wave_14	COARE_14	Wind_14	Insolation_14
15Z	Wave_15	COARE_15	Wind_15	Insolation_15
16Z	Wave_16	COARE_16	Wind_16	Insolation_16
17Z	Wave_17	COARE_17	Wind_17	Insolation_17
18Z	Wave_18	COARE_18	Wind_18	Insolation_18
19Z	Wave_19	COARE_19	Wind_19	Insolation_19
20Z	Wave_20	COARE_20	Wind_20	Insolation_20
21Z	Wave_21	COARE_21	Wind_21	Insolation_21
22Z	Wave_22	COARE_22	Wind_22	Insolation_22
23Z	Wave_23	COARE_23	Wind_23	Insolation_23

Download Day's Data [Wave\\_NetCDF\\_file](#) [COARE\\_NetCDF\\_file](#)  
Access All Data [Wave\\_NetCDF\\_dir](#) [COARE\\_NetCDF\\_dir](#)

The GFS data are provided courtesy of NOAA/NCEP.

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Earth System Research Laboratory | Physical Sciences Division

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# Model Inputs

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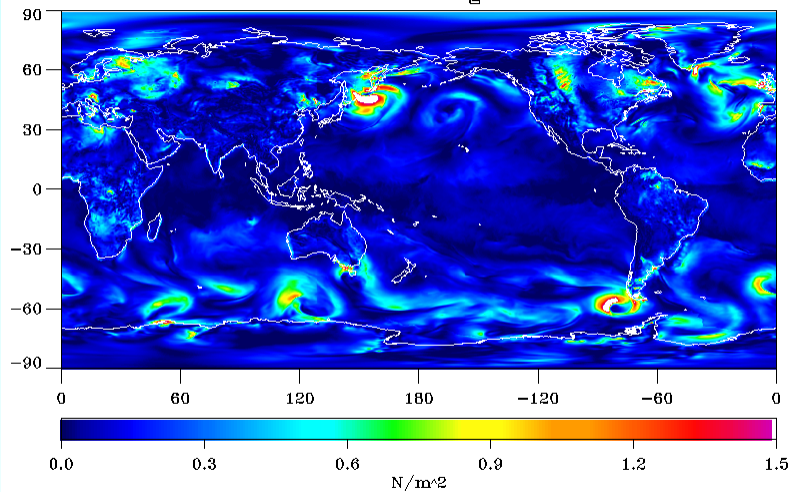
- GFS analysis fields, 6 hourly, 0.5 degree
  - Wind stress
  - Radiative and turbulent fluxes
  - Sea surface temperature
  - Specific humidity and air temperature for heat flux modulation
- Wave Watch III Wave Model
  - Wave period, direction, and significant wave height
  - Stokes Drift velocity estimated assuming Pierson-Moskowitz spectrum

# Sample Model Forcing Fields

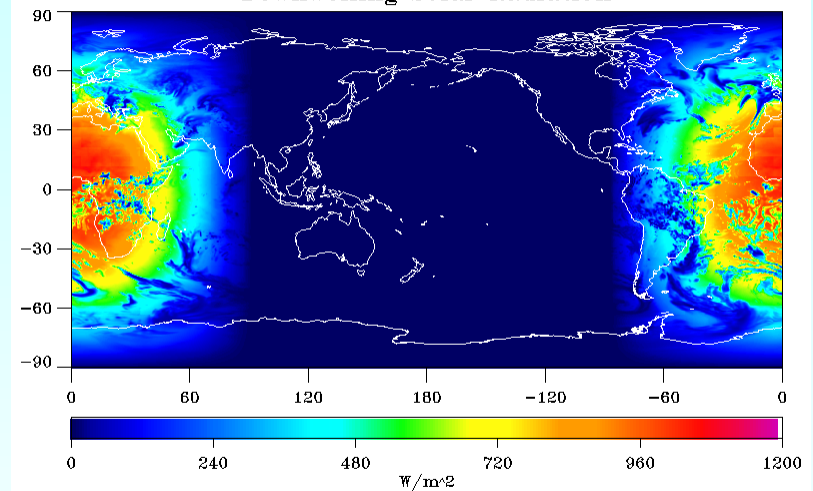
21 March 2013, 1200 UTC



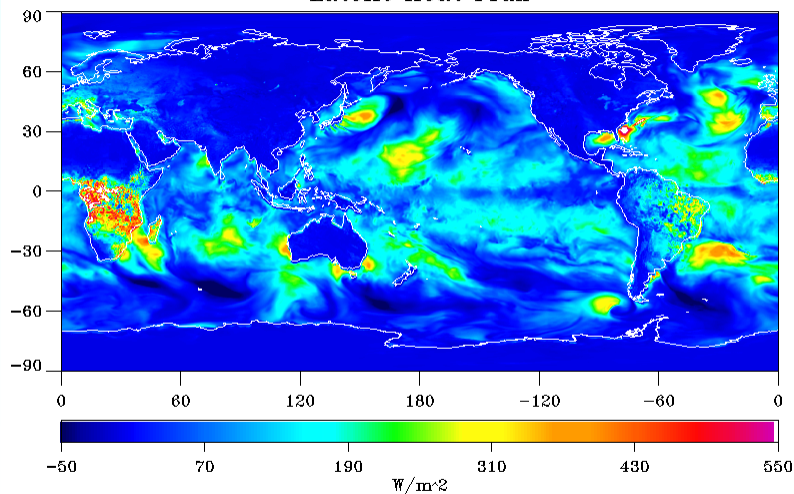
Wind Stress Magnitude



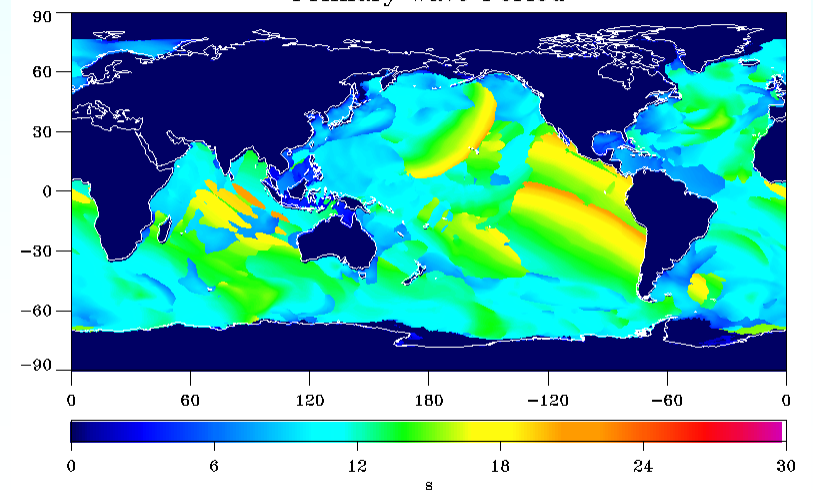
Downwelling Solar Radiation



Latent Heat Flux



Primary Wave Period



# Model Practicalities

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- Models initialized based on SST
- Fluxes interpolated to model time step
- Model run globally for 2 days with output taken from the second day
- Run with one day lag

# Kantha-Clayson Model Validation

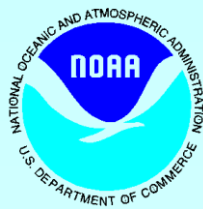
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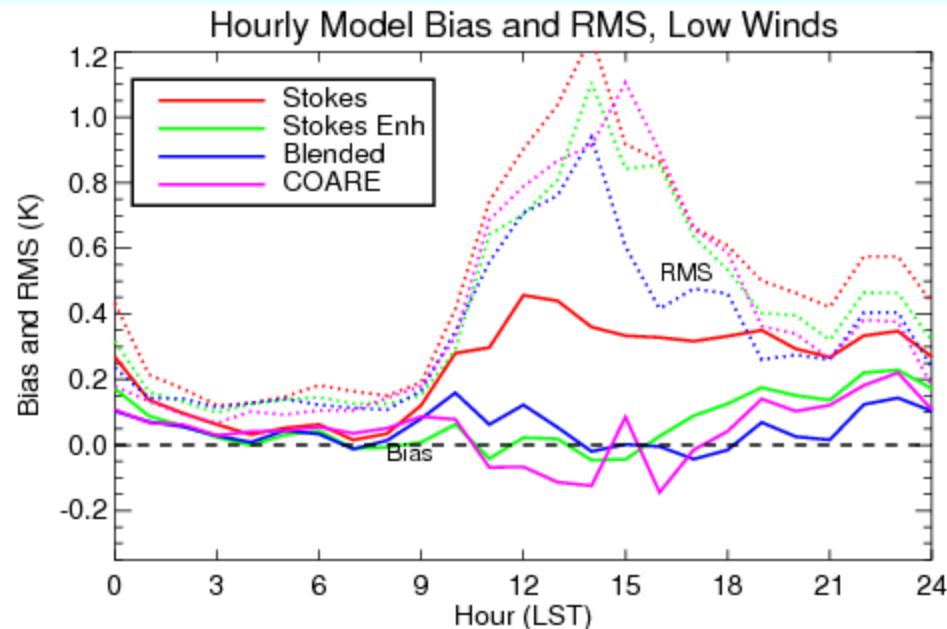
- Application to direct cruise forcings
- Evaluation with NWP forcing
  - SEVIRI validation
  - Daytime SST – foundation value computed from previous night



# Validation Against Ship-Based Observations



- Modeled diurnal warming at the subskin compared with observations from cruises in multiple geographical regions
- Bias and RMS difference in estimated warming stratified as a function of local solar time for cases with wind speeds  $< 4$  m/s
- Bias largely removed, but note RMS variability



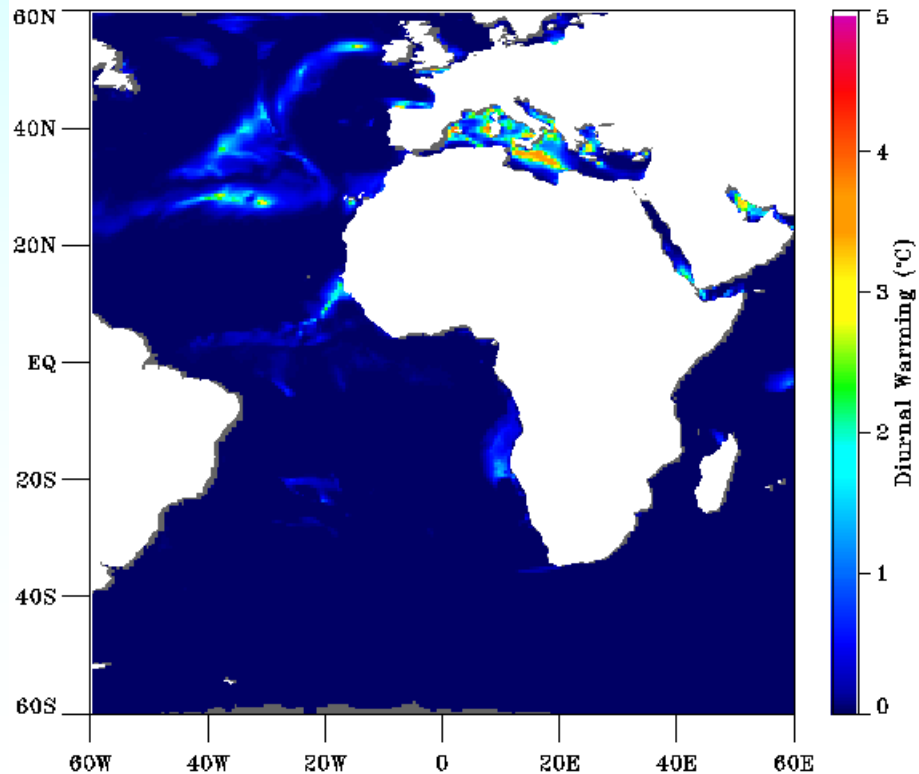
# NWP Forcing / SEVIRI Validation



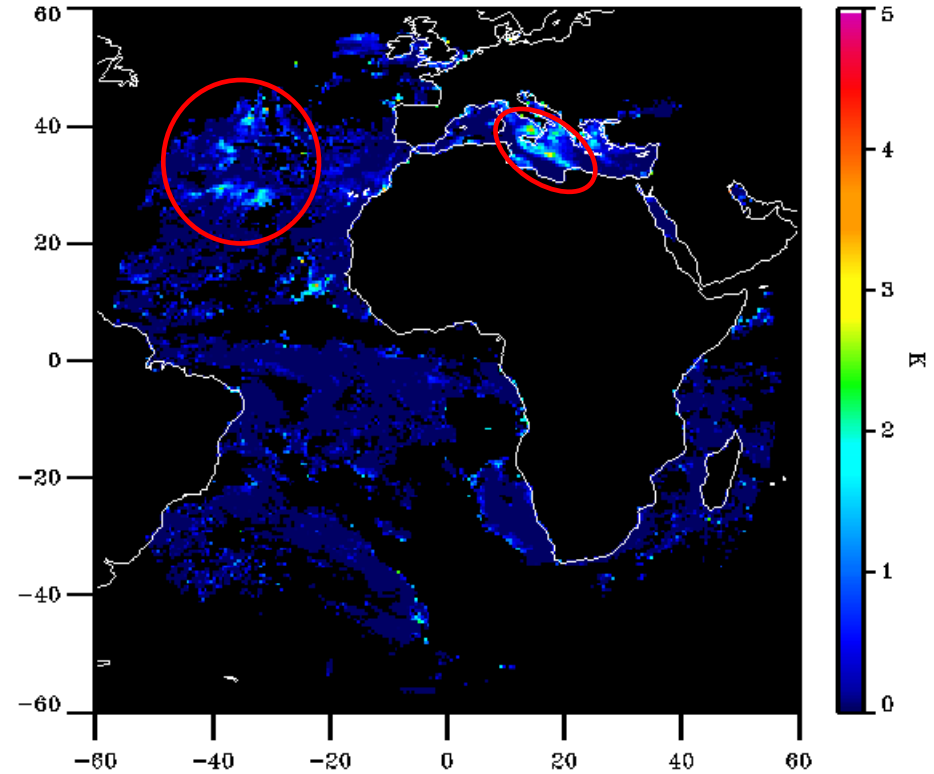
- Patterns look good...

June 21, 2014, 1400 UTC

Model



SEVIRI



# NWP Forcing / SEVIRI Validation

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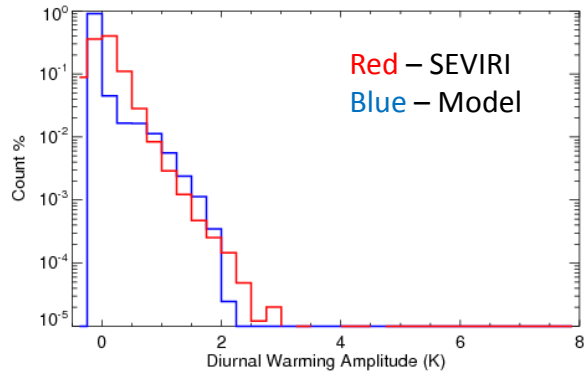
- Patterns look good...
- Closer investigation shows apparent overestimation of warming
  - Apparent in COARE as well

# Comparison of Observed and Modeled Diurnal Warming

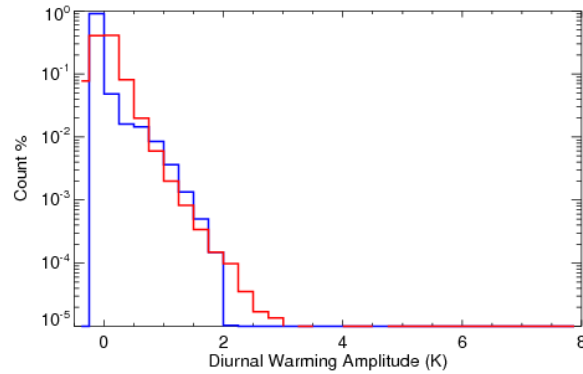
SEVIRI Domain – 21-30 June 2014

Kantha Clayson Model with Stokes Drift

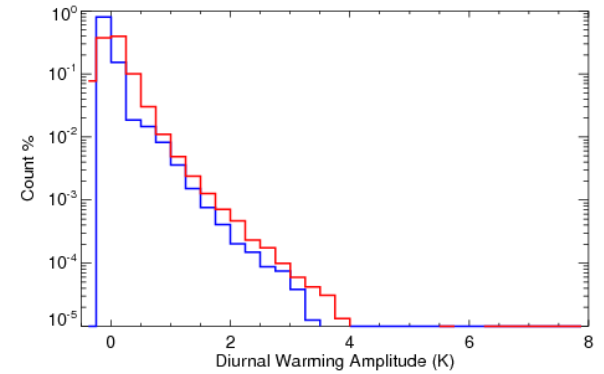
0200 UTC



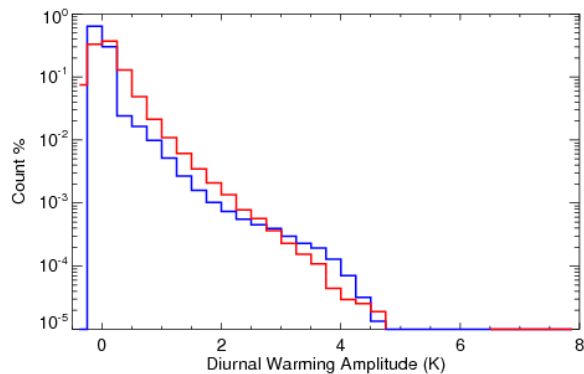
0600 UTC



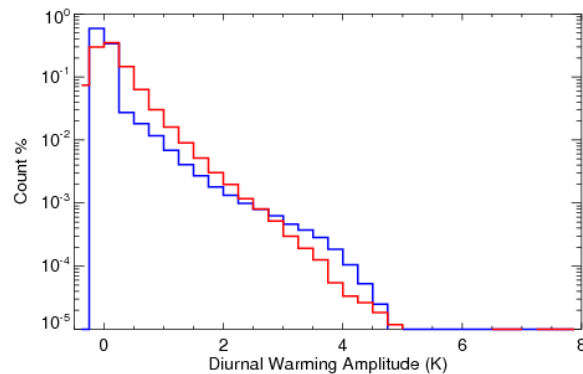
1000 UTC



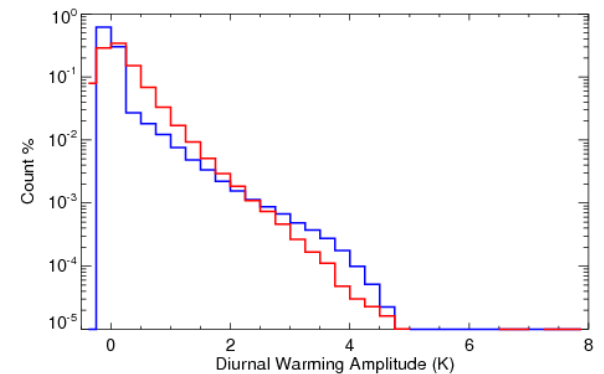
1400 UTC



1800 UTC



2200 UTC

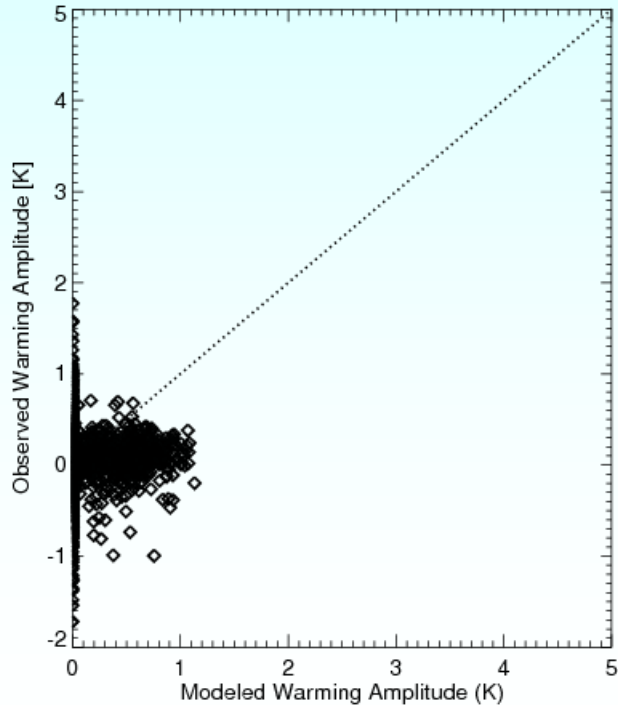


# Direct Comparison of Warming Estimates

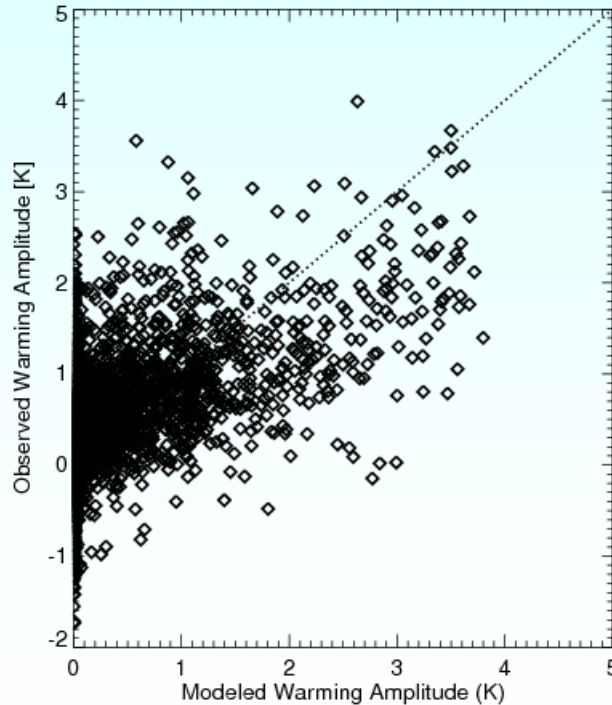


June 21, 2014

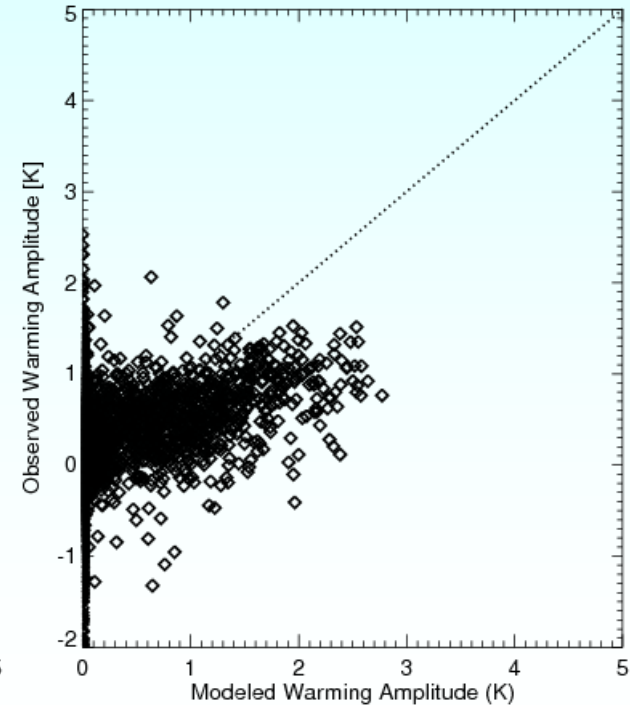
0400 UTC



1400 UTC



2200 UTC



# What is the Problem?

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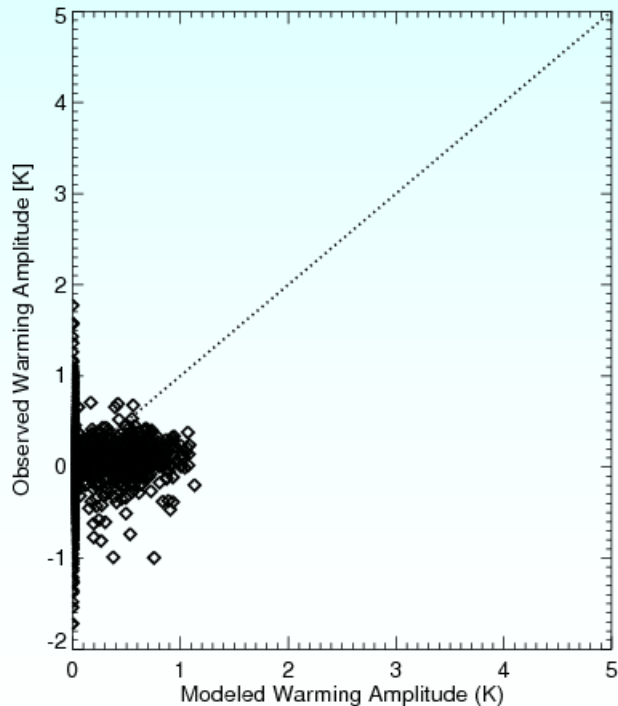
- Clearly tied to 6-hourly NWP inputs
- Overestimation of insolation?
  - Integrated insolation compared with Weller moorings
  - Values fall within observed distribution
- Issues with lack of wind variability?
  - Low wind speeds persist for multiple hours with interpolation approach
  - Magnifies diurnal warming
- Solution?
  - Implementation of wind gustiness factor

# Direct Comparison of Warming Estimates

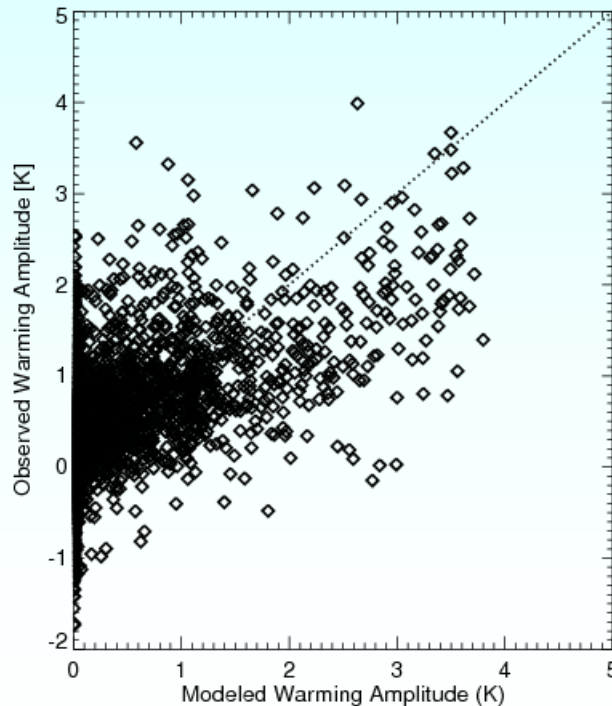


June 21, 2014

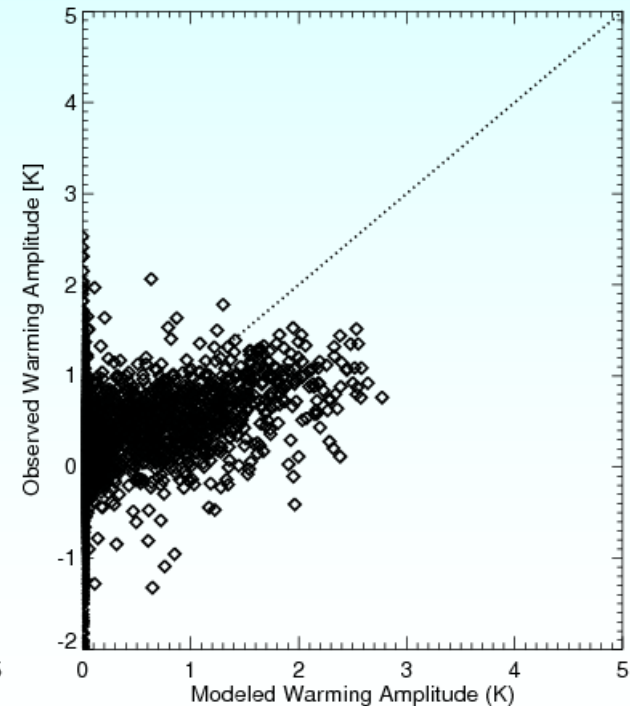
0400 UTC



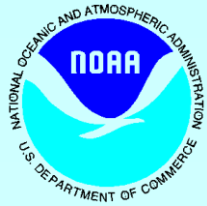
1400 UTC



2200 UTC

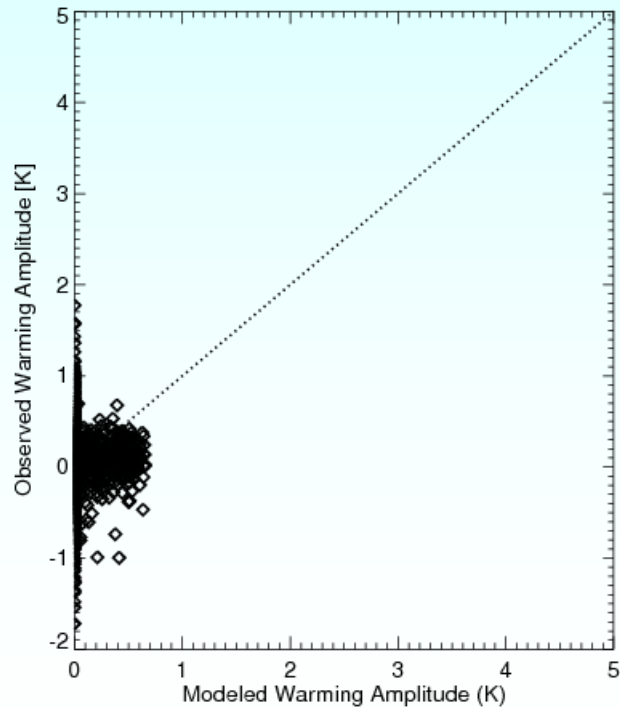


# With Gustiness

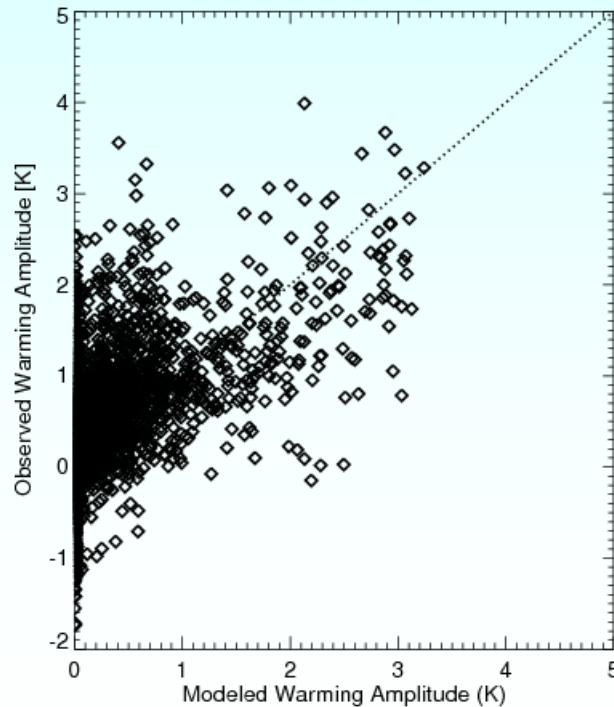


June 21, 2014

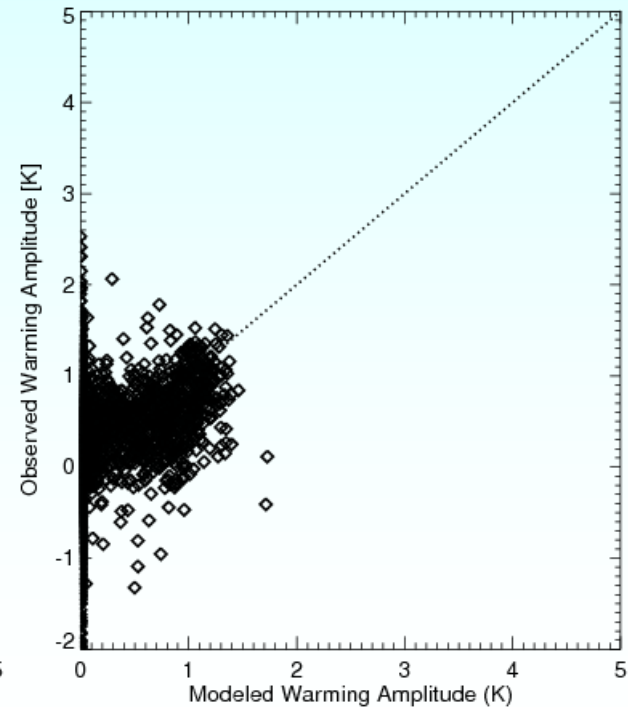
0400 UTC



1400 UTC

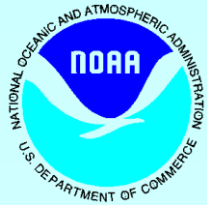


2200 UTC





# Illustration of Web Interface

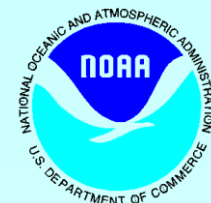


[http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/diurnal\\_sst\\_analysis.php](http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/diurnal_sst_analysis.php)

The screenshot displays the NOAA Earth System Research Laboratory Physical Sciences Division website. The main heading is "Modeled Diurnal Warming Amplitude" with a sub-heading "Application to GFS Forecast Fields" and a note "Images available starting on July 1, 2015". Below this are interactive dropdown menus for Year, Month, Day, and Depth, along with buttons for "View Selected Diurnal Analysis" and "View Latest Diurnal Analysis".

The main content area is titled "Diurnal Warming on July 18, 2015 at Skin" and features a grid of four global maps showing diurnal warming at 14Z for different models: Kantha-Clayson Wave Model, COARE, Wind Forcing, and Insolation Forcing. Each map includes a color scale for diurnal warming in degrees Celsius. Below the maps is a table listing UTC hours (00Z to 03Z) and corresponding file names for each model.

UTC Hour	Kantha-Clayson Wave Model	COARE	Wind Forcing	Insolation Forcing
Example (14Z)				
00Z	Wave_00	COARE_00	Wind_00	Insolation_00
01Z	Wave_01	COARE_01	Wind_01	Insolation_01
02Z	Wave_02	COARE_02	Wind_02	Insolation_02
03Z	Wave_03	COARE_03	Wind_03	Insolation_03



## Modeled Diurnal Warming Amplitude

### Application to GFS Forecast Fields

Images available starting on November 16, 2014

Year  Month  Day  Depth

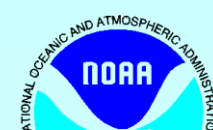
- Skin
- 1m
- 5m

### Diurnal Warming on November 17, 2014 at Skin

UTC Hour	Kantha-Clayson Wave Model	COARE	Wind Forcing	Insolation Forcing
Peak Amplitude				
00Z	<a href="#">Wave_00</a>	<a href="#">COARE_00</a>	<a href="#">Wind_00</a>	<a href="#">Insolation_00</a>
01Z	<a href="#">Wave_01</a>	<a href="#">COARE_01</a>	<a href="#">Wind_01</a>	<a href="#">Insolation_01</a>
02Z	<a href="#">Wave_02</a>	<a href="#">COARE_02</a>	<a href="#">Wind_02</a>	<a href="#">Insolation_02</a>
03Z	<a href="#">Wave_03</a>	<a href="#">COARE_03</a>	<a href="#">Wind_03</a>	<a href="#">Insolation_03</a>
04Z	<a href="#">Wave_04</a>	<a href="#">COARE_04</a>	<a href="#">Wind_04</a>	<a href="#">Insolation_04</a>
05Z	<a href="#">Wave_05</a>	<a href="#">COARE_05</a>	<a href="#">Wind_05</a>	<a href="#">Insolation_05</a>
06Z	<a href="#">Wave_06</a>	<a href="#">COARE_06</a>	<a href="#">Wind_06</a>	<a href="#">Insolation_06</a>
23Z	<a href="#">Wave_23</a>	<a href="#">COARE_23</a>	<a href="#">Wind_23</a>	<a href="#">Insolation_23</a>

Download Day's Data    [Wave\\_NetCDF\\_file](#)    [COARE\\_NetCDF\\_file](#)  
 Access All Data    [Wave\\_NetCDF\\_dir](#)    [COARE\\_NetCDF\\_dir](#)

The GFS data are provided courtesy of NOAA/NCEP.



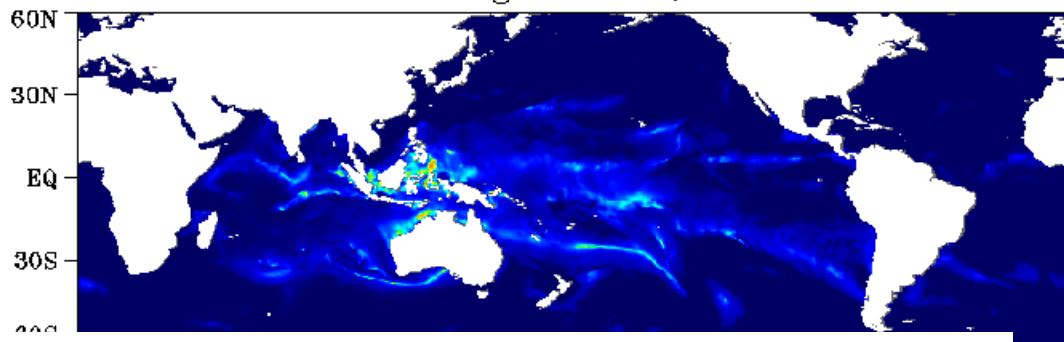
## Modeled Diurnal

Application to  
Images available sta

Year  Month  Day  Depth

Diurnal Warming of

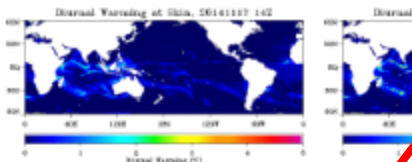
Diurnal Warming at Skin, 20141117 05Z



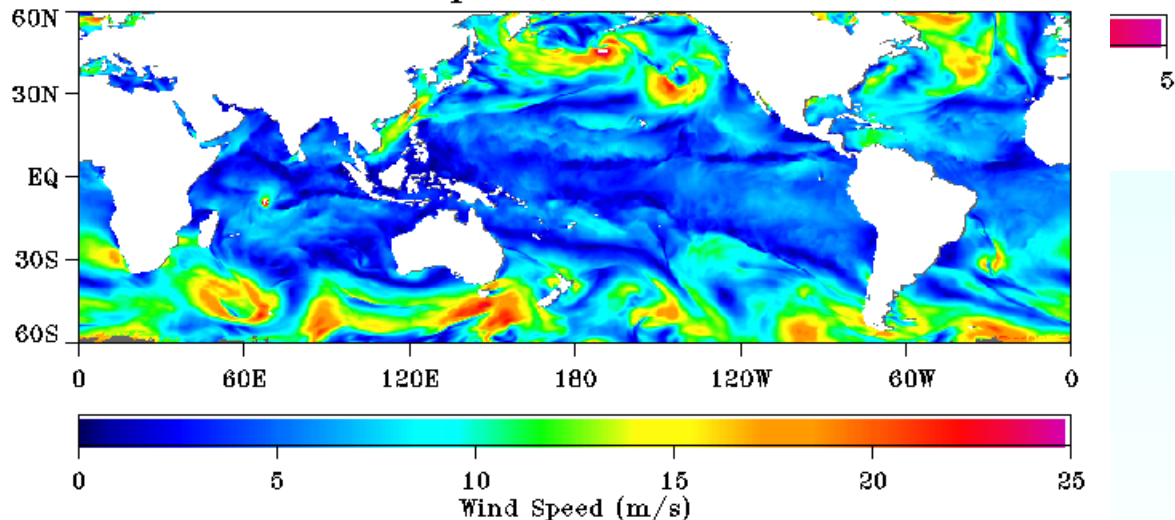
UTC Hour

Kantha-Clayson Wave Model

Peak Amplitude



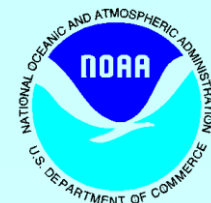
Wind Speed, 20141117 05Z



- 00Z Wave\_00
- 01Z Wave\_01
- 02Z Wave\_02
- 03Z Wave\_03
- 04Z Wave\_04
- 05Z Wave\_05
- 06Z Wave\_06
- 23Z Wave\_23

Download Day's Data [Wave\\_NetCDF\\_file](#) [COA](#)  
 Access All Data [Wave\\_NetCDF\\_dir](#) [COA](#)

The GFS data are provided courtesy of NOAA/NCEP.



## Modeled Diurnal Warming Amplitude

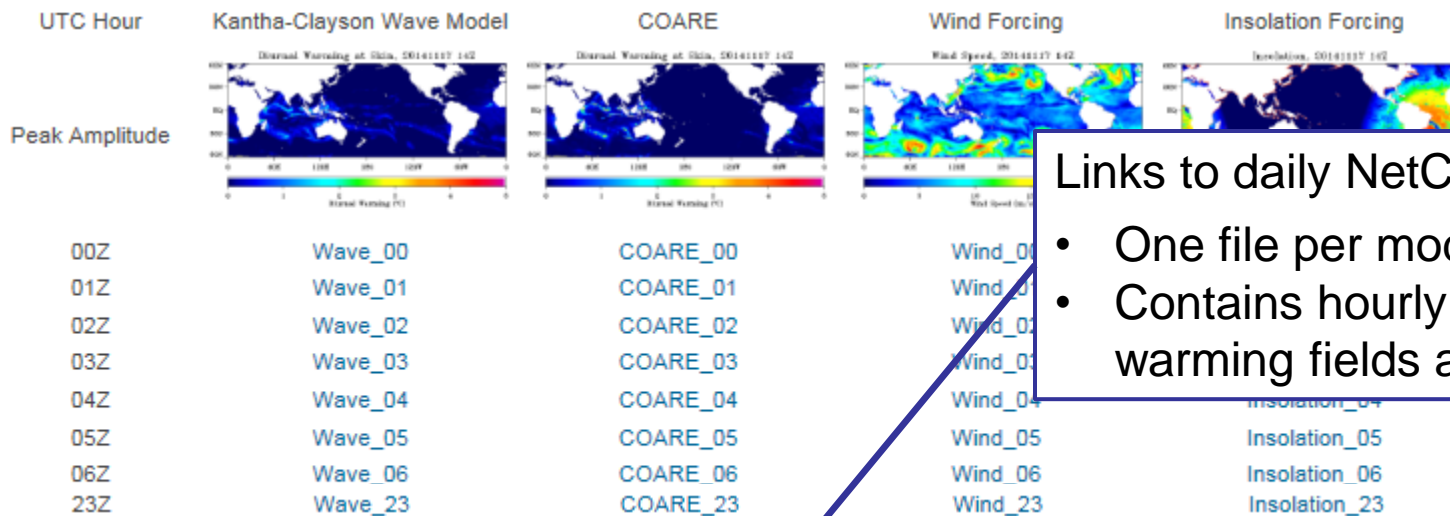
### Application to GFS Forecast Fields

Images available starting on November 16, 2014

Year  Month  Day  Depth

- Skin
- 1m
- 5m

Diurnal Warming on November 17, 2014 at Skin



Links to daily NetCDF file

- One file per model per day
- Contains hourly diurnal warming fields at all depths

Download Day's Data [Wave\\_NetCDF\\_file](#) [COARE\\_NetCDF\\_file](#)  
 Access All Data [Wave\\_NetCDF\\_dir](#) [COARE\\_NetCDF\\_dir](#)

Links to directory listing with data files from multiple days

The GFS data are provided courtesy of NOAA/NCEP.

# Conclusions

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- New facility available for access and evaluation of global diurnal warming estimates to complement foundation analyses
- Hourly diurnal warming estimates at multiple depths
- Data to be available for download
- Enhanced validation capabilities coming, but initial results promising
- Feedback invited