CHARACTERIZING EXTREME DIURNAL WARMING IN SATELLITE-DERIVED OPERATIONAL SEA SURFACE TEMPERATURE PRODUCTS

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INTRODUCTION/MOTIVATION

This work attempts to answer two specific questions:

- Can satellite-derived operational geostationary products be used to accurately quantify extreme diurnal warming?
- How large is extreme diurnal warming?

The questions are motivated by a desire to obtain a climatology of extreme diurnal warming events and a desire to better validate physical models of diurnal warming. Estimates of diurnal warming from geostationary satellites are already widely used, and the message presented has been that the specific estimation methods are not all that critical. We don't disagree when considering mean warming, but feel that caution is needed when looking at extremes and new sensors.

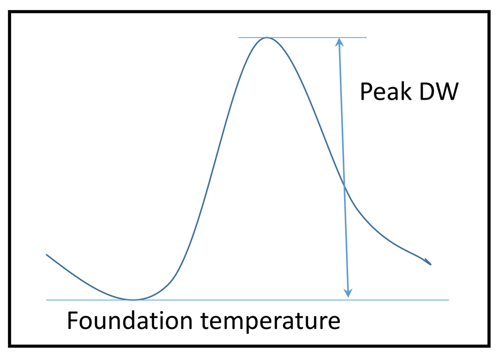
DATA AND METHODS

Diurnal Warming Methods

Evaluated Methods

- DW = Observed daytime SST – Foundation
- Foundation temperature
  - Temperature in absence of DW (pre-dawn)
  - Computed from different combinations of nighttime SST observations
  - Balance between inclusion of residual warming and obtaining sufficient data

Idealized SST Diurnal Cycle



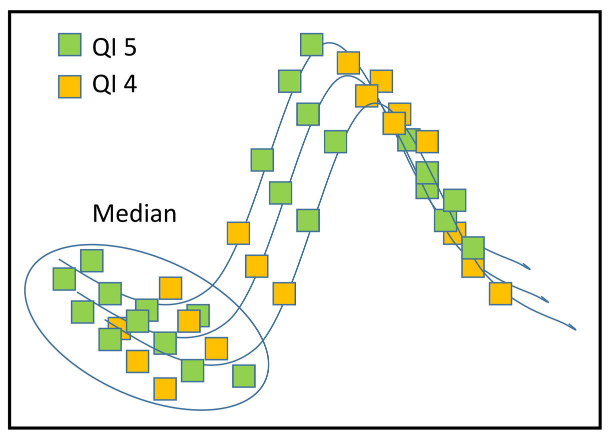
Reference for Evaluation

- DW derived directly from complete time series when sufficient continuity

Foundation Methods Compared

- QC5
  - Preceding night – highest quality data only
- QC45
  - Preceding night – Quality levels 4 and 5
- Multi-day
  - Combination of surrounding days – highest quality
- Merged
  - QC5 when available; Multi-day otherwise
- Profile – Reference
  - Peak DW derived directly from time series

Idealized SST Diurnal Cycle with Samples



Operational Geostationary Sensors

Meteosat-11 SEVIRI

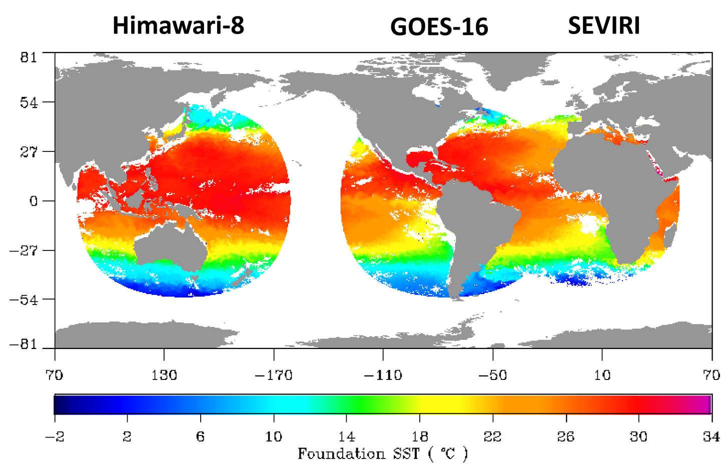
- OSI-SAF IFREMER, V1.0
- 0.05° resolution, hourly

GOES-16 ABI

- NOAA/NESDIS/STAR, V2.50
- 0.02° resolution, hourly

Himawari-8 AHI

- NOAA/NESDIS/STAR, V2.50
- 0.02° resolution, hourly



THE CHALLENGES

Initial Estimation

- Broad patterns make sense with peak warming > 4 K
- But is it real? See notable scatter and values in some regions where one wouldn't expect
- Is the absolute peak value the best way of viewing?

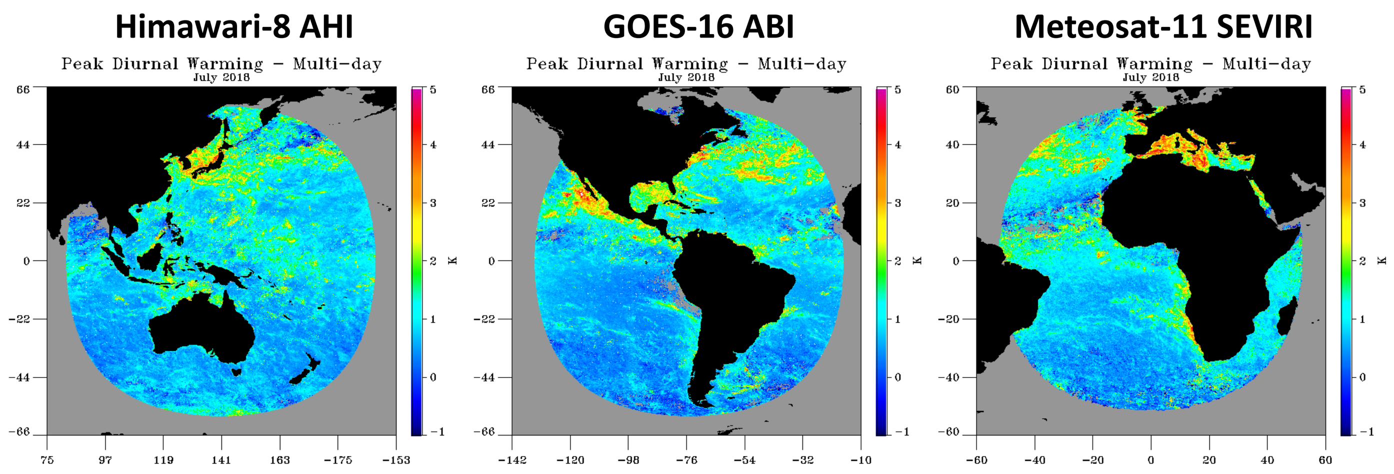
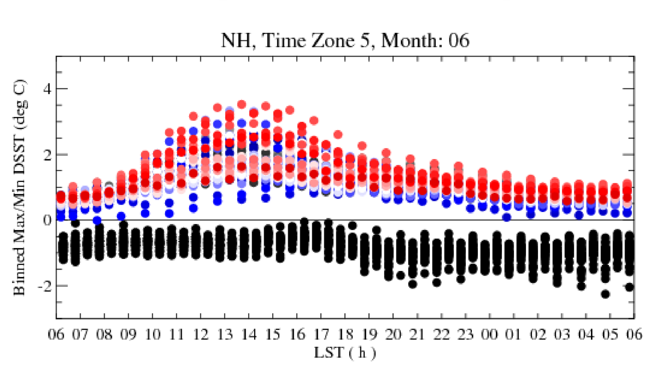


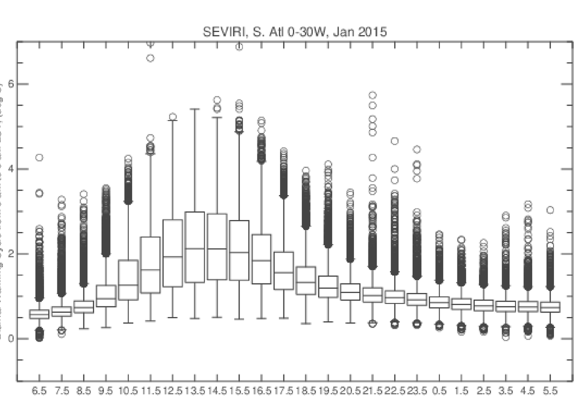
Illustration of the Challenges

- Left shows min (black) and max (colored) values from one month
  - See drop in min at night potentially consistent with unscreened clouds
- Right shows box plot of peak values
  - Medians reasonable but peaks show elevated values at unexpected times

Night Cloud Screening

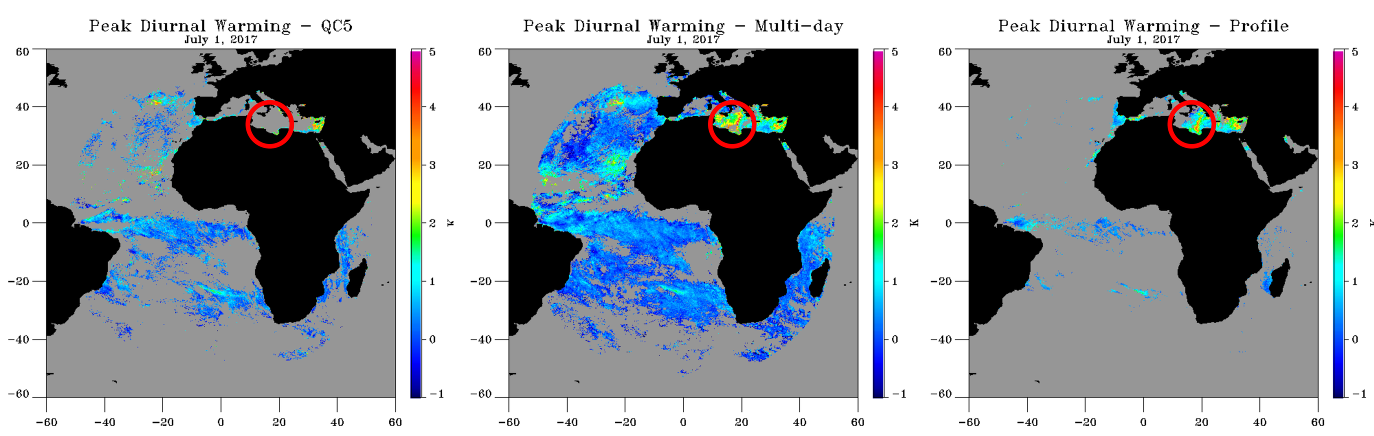


Outliers?



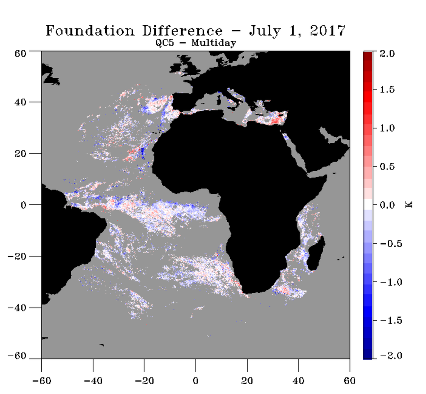
Impact of Data Availability

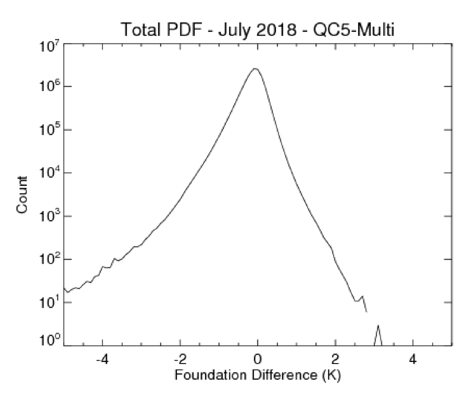
- Can miss significant events with only highest quality data
- Approach must balance quality and data availability



Differences in Foundation Values

- Differences highly significant relative to expected amplitudes
- Values up to 2 K are on order of larger DW events





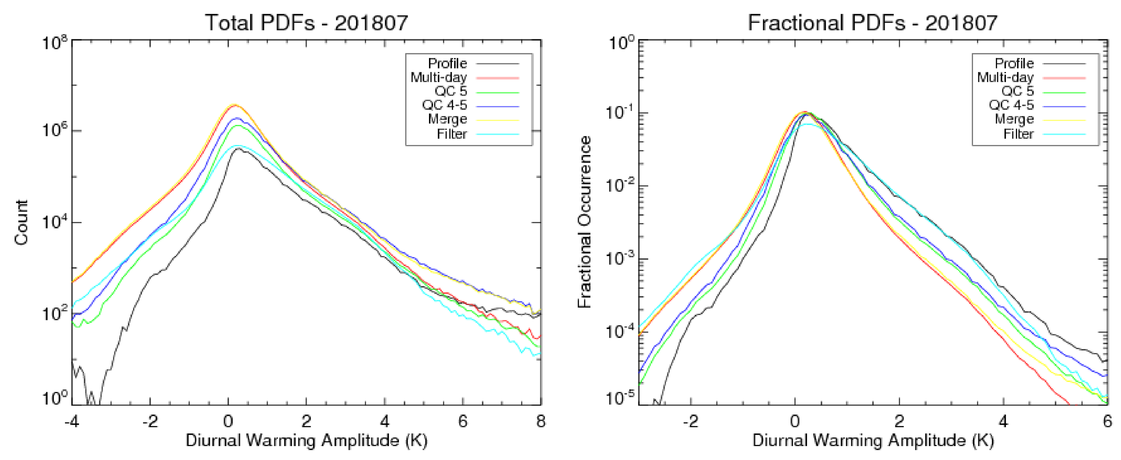
RESULTS

What is the Distribution of Diurnal Warming Events?

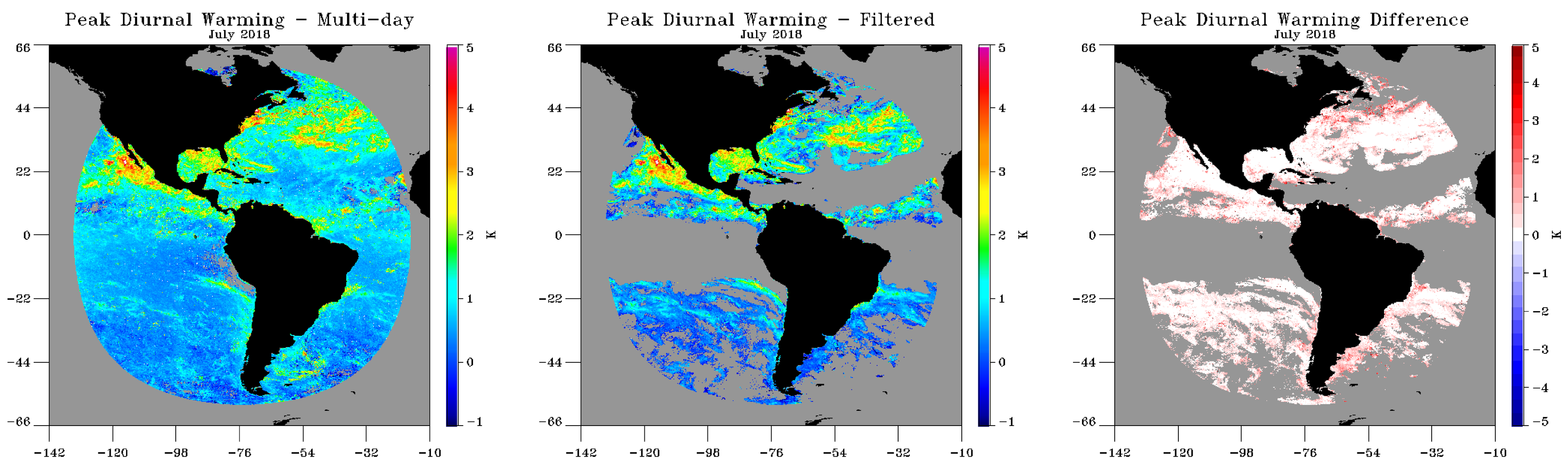
How frequent are the largest events?

- Method makes a difference
- Challenging to assign confidence to extreme events
- Distributions based on total and fractional occurrence differ
- Largest events preferentially clear sky
  - Want something to emulate reference at large DW values while having more observations
  - Introduced filtering

Comparison of DW Distributions
SEVIRI – July 2018

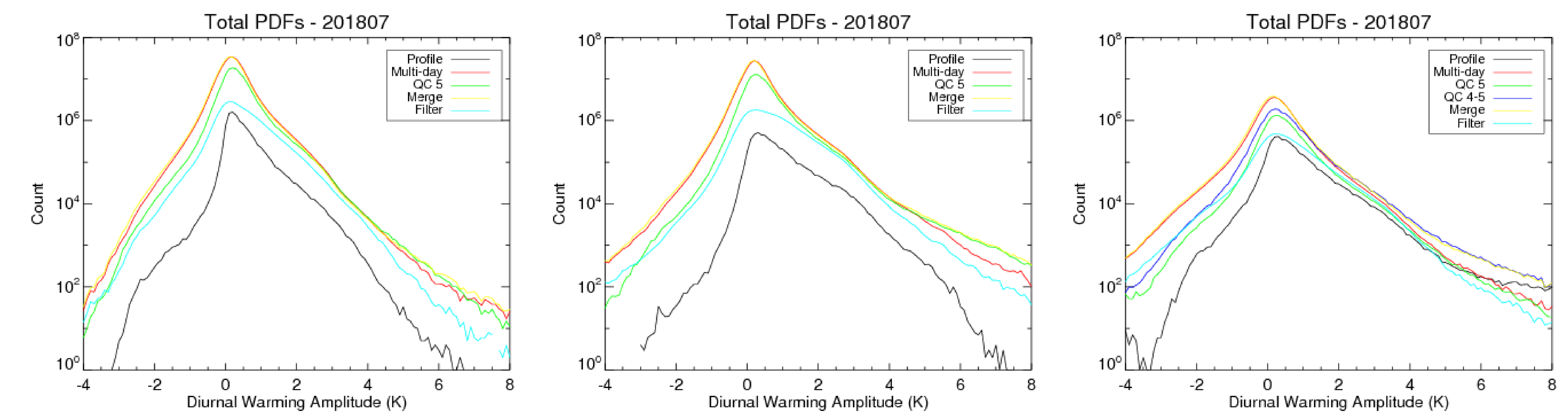


Impact of Filtering



- Employs multi-day foundation but retains DW only where wind speed < 3 m/s
- When exclude cases where otherwise wouldn't expect warming derived DW changes notable (Order 2 K)

Multi-Sensor Comparison of Distributions



- Cumulative composites for July 2018
- Broadly similar distributions across sensors lending confidence in each
- Filtered approach provides conservative estimate appropriate for our purposes
- Still, can highest values be trusted?

Comparison of Derived Diurnal Warming Percentiles

95th Percentile (for DW > 0.5 K)

Sensor	Profile	QC5	Multi-day	Merged	Filtered
SEVIRI	2.5 K	2.1 K	1.9 K	2.0 K	2.5 K
G16	2.6 K	2.1K	2.0 K	2.0 K	2.5 K
H8	1.9 K	1.8 K	1.7 K	1.7 K	2.1 K

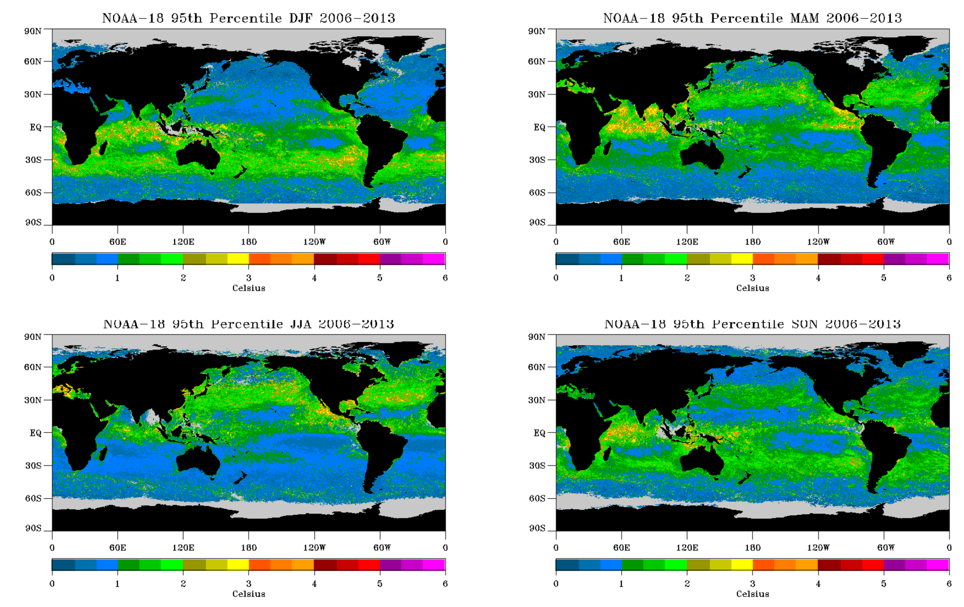
99th Percentile (for DW > 0.5 K)

Sensor	Profile	QC5	Multi-day	Merged	Filtered
SEVIRI	3.6 K	3.2 K	2.9 K	3.1 K	3.5 K
G16	3.4 K	3.1 K	2.9 K	3.0 K	3.4 K
H8	2.7 K	2.6 K	2.5 K	2.5 K	2.9 K

- Percentiles provide effective way of quantifying
- Filtered method agrees well with reference
- Good agreement across satellites

Comparison With Diurnal Warming Climatology from AVHRR

- Methodology can be applied and compared with polar satellites
- G16 and H8 records still growing, but can do percentiles by region and season for AVHRR
- Here compiled for 8 years of data
- AVHRR 95th percentile of 2 – 4 K agree roughly with the magnitudes of 2 – 3 K above
- This the ultimate direction for this work along with model comparisons



CONCLUSIONS

- **Estimates of extreme diurnal warming sensitive to computational methods.**
- **Issues can be sensor/processing dependent.**
- **Current operational geostationary sensors provide accurate diurnal warming estimates given sufficient care.**
  - **Filtering recommended to examine individual events**
  - **Multi-day foundation balances coverage with reasonable distribution**
- **Can quantify amplitudes of extreme DW with percentiles.**
  - **95th percentile of 2-3 K for all satellites**
  - **99th percentile of 3-4 K**
  - **Results help validate comparable values from polar-orbiting satellites**
- **Results need to be updated for latest product version.**