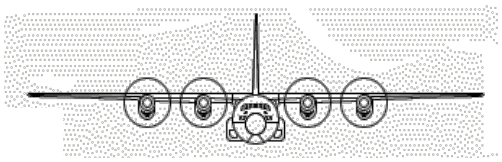
Validating CERES Arctic Radiative Fluxes with Airborne Radiative Flux Measurements from the ARISE Campaign

Joseph Corbett[1], Seiji Kato[2], Anthony Bucholtz[3], Bill Smith[2], and the ARISE Science Team

1. SSAI
2. NASA Langley
3. NRL Monterey

3rd September 2015, CERES Science Team Meeting, Seattle, WA

ARISE Science Objectives



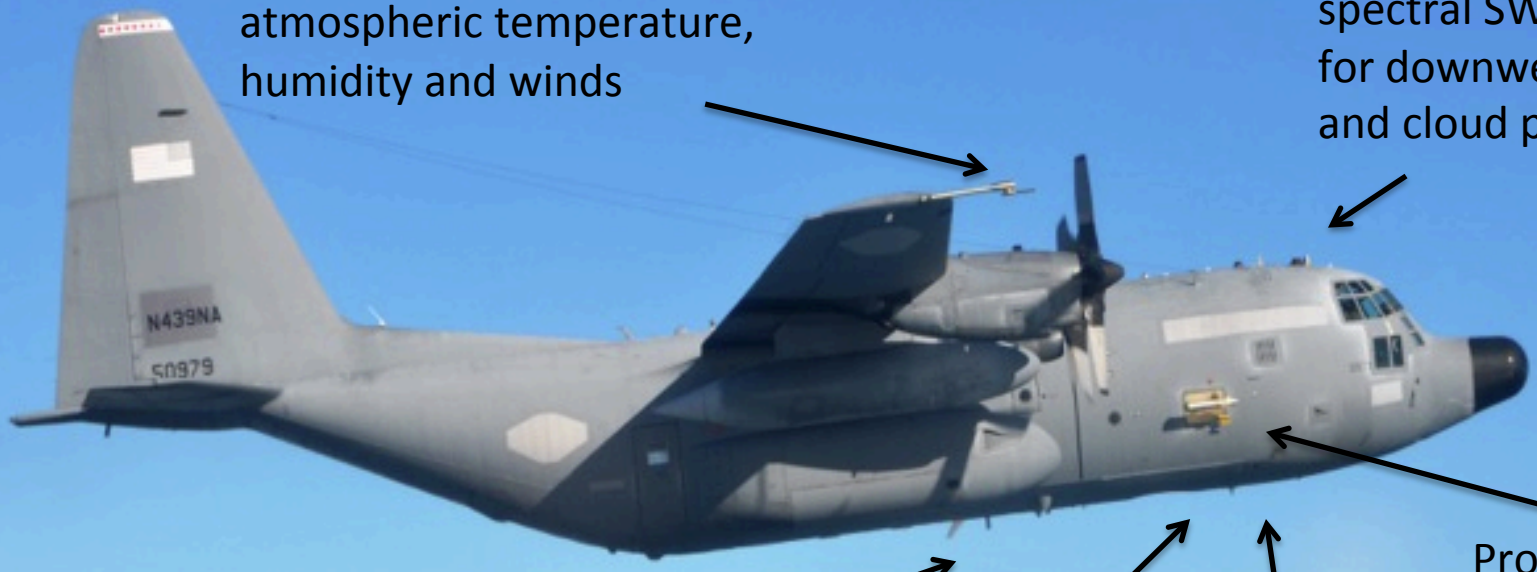
Arctic Radiation-IceBridge Sea & Ice Experiment (ARISE)

Based in Fairbanks, Alaska during September 2014

Specific Objectives:

1. From the NASA C-130:
    - Measure spectral and broadband radiative flux profiles
    - Quantify surface characteristics, cloud properties, and other atmospheric state parameters under a variety of Arctic atmospheric and surface conditions
    - Coinciding with satellite overpasses as much as possible
2. Acquire detailed measurements of land and sea ice characteristics to help fulfill the NASA Operation IceBridge (OIB) mission objectives and support radiation experiments.

NASA C-130: An airborne radiometer (thermometer) with in-situ probes and a laser altimeter to characterize the surface, atmosphere and radiative effects of sea-ice and clouds



Wing-tip probe for atmospheric temperature, humidity and winds

Broadband SW and IR, spectral SW radiometers for downwelling radiation and cloud properties aloft

Probes to measure cloud properties directly

Broadband SW and IR, spectral SW radiometers for upwelling radiation and cloud properties below

Laser Altimeter to characterize sea and land ice properties

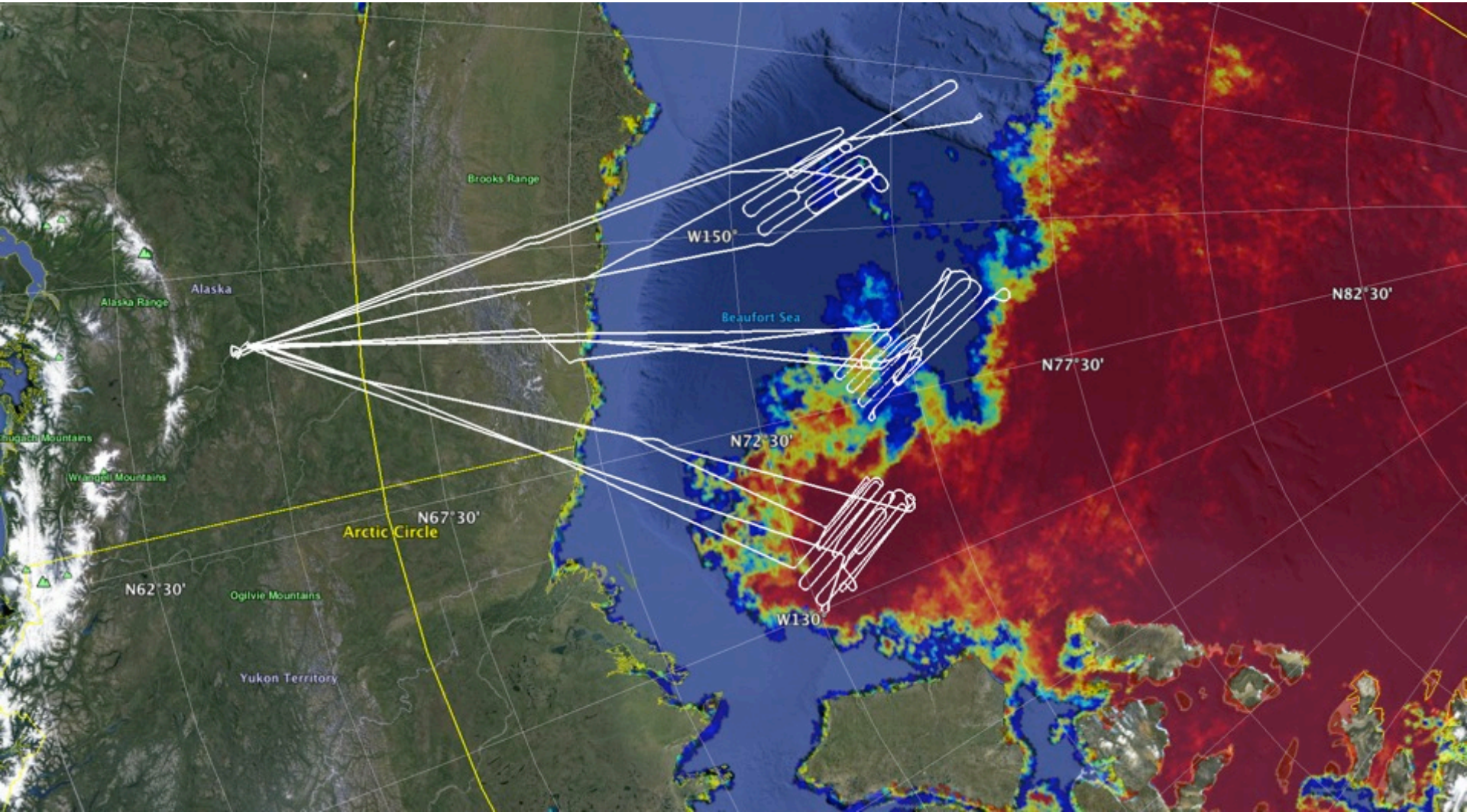
Digital Camera System

NASA C-130 PAYLOAD

Instruments	Measurement	Characteristics	Products
Broadband Radiometers (BBR) **A. Bucholtz, NRL**	SW and LW fluxes (↑, ↓) SW total, direct & diffuse (↓)	SW: modified K&Z CM-22 (0.2-3.6 µm) LW: modified K&Z CG-4 (4.5-45 µm) TDDR: Delta-Devices SPN-1 (0.4-2.7 µm)	Net SW, LW Irradiance, direct/ diffuse SW partitioning, absorption, heating rates Surface albedo, cloud albedo
Spectral Solar Flux Radiometer (SSFR) **S. Schmidt, U. of Colo.**	Spectral SW fluxes (↑, ↓)	370-2170 nm, Resolution: 8-12 nm Leveling platform	Spectral fluxes, albedo Cloud properties
Spectral Sun-photometer 4STAR **J. Redemann, NASA ARC**	Spectral radiances (↓) Modes: direct beam, sky scanning, zenith	380-1700 nm	aerosols, gases, cloud properties above aircraft
Heitronics KT-19 **D. Van Gilst, NSERC/UND** **A. Bucholtz, NRL**	IR window radiance (↑, ↓)	9.6-11.5 µm	Skin temperature, sky and cloud temperature
Land, Vegetation, and Ice Sensor (LVIS) **B. Blair, M. Hofton, GSFC**	Geo-located waveform vector	1064 nm Scanning: 20 minute footprint, 2 km swath from 10 km Full waveform recorded	Surface elevation, Sea-ice freeboard, Melt-pond distribution Cloud top height

CERES Grid-box Experiments

Replicate CERES Level 3 grid-boxes
Timed to coincide with multiple satellite overpasses
Perform surface and TOA measurements



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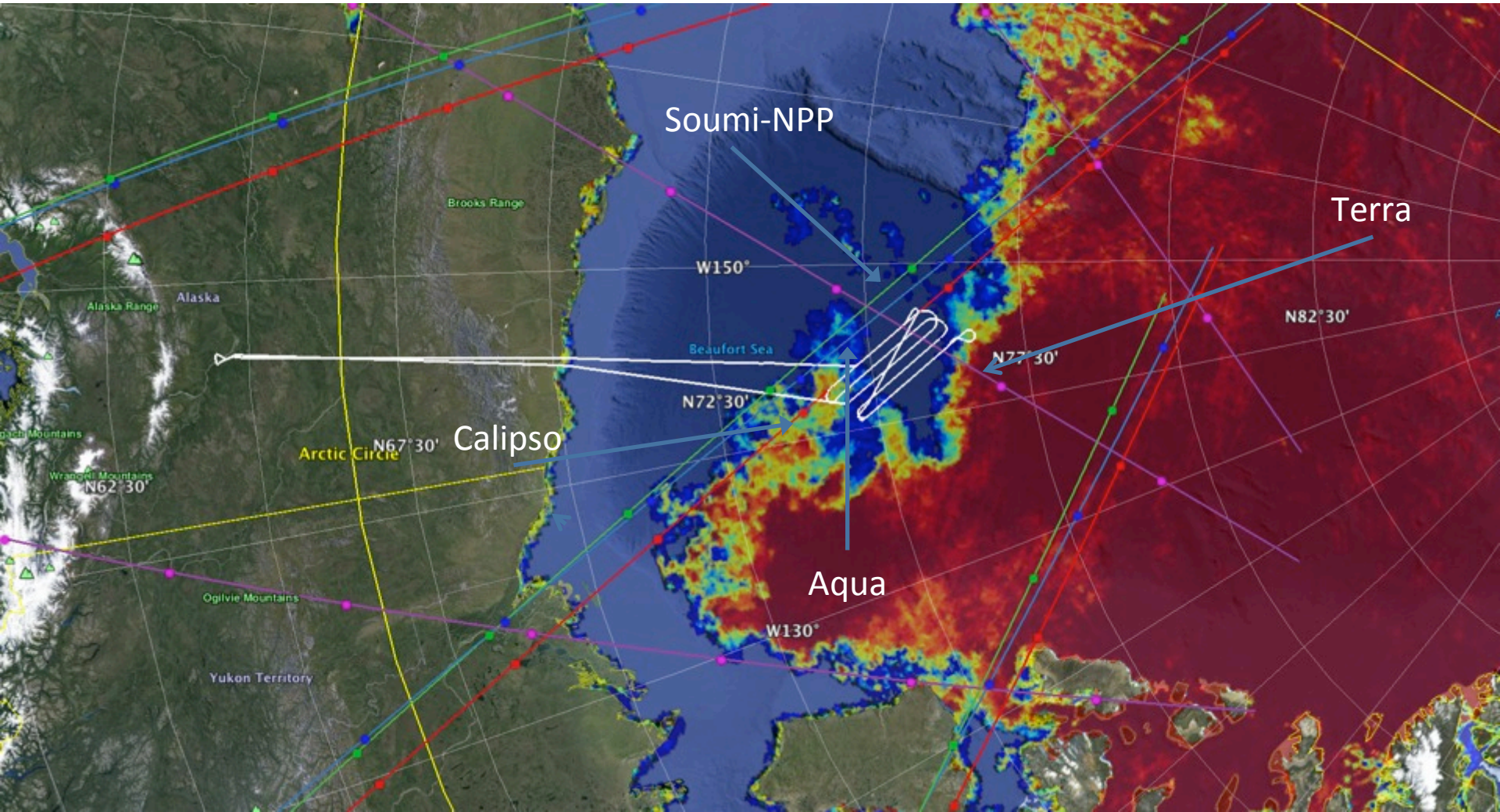
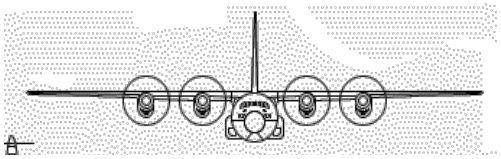


Comparison Method

Top-of-Atmosphere

FM1 (Terra)
FM3 (Aqua)

BBR



~ 6 km

Flight Pattern (top down)

~100km

Surface

~200 km

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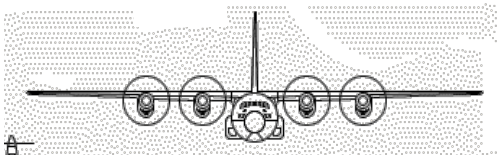

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Need to account for:
LW - absorption
SW - scattering/absorption

Fu-Liou Radiative transfer model:

- Atmospheric state information from GEOS 5.4
- Cloud property information from MODIS (CERES cloud group)
- Surface information from the AMSR2 ASI 3.5km sea ice concentration dataset (Uni. Hamburg)

$$BBR_{TOA} = \frac{F_{model}(TOA, BBR)}{F_{model}(6km, BBR)} BBR$$

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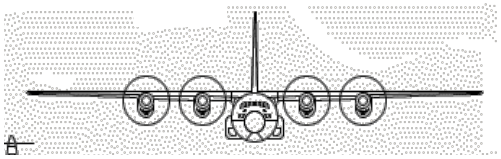

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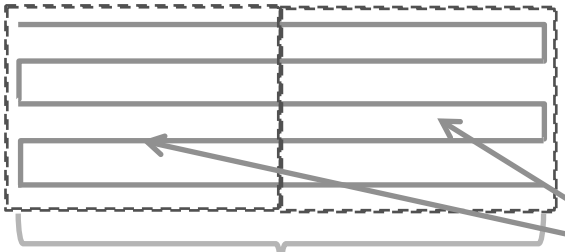


~100km

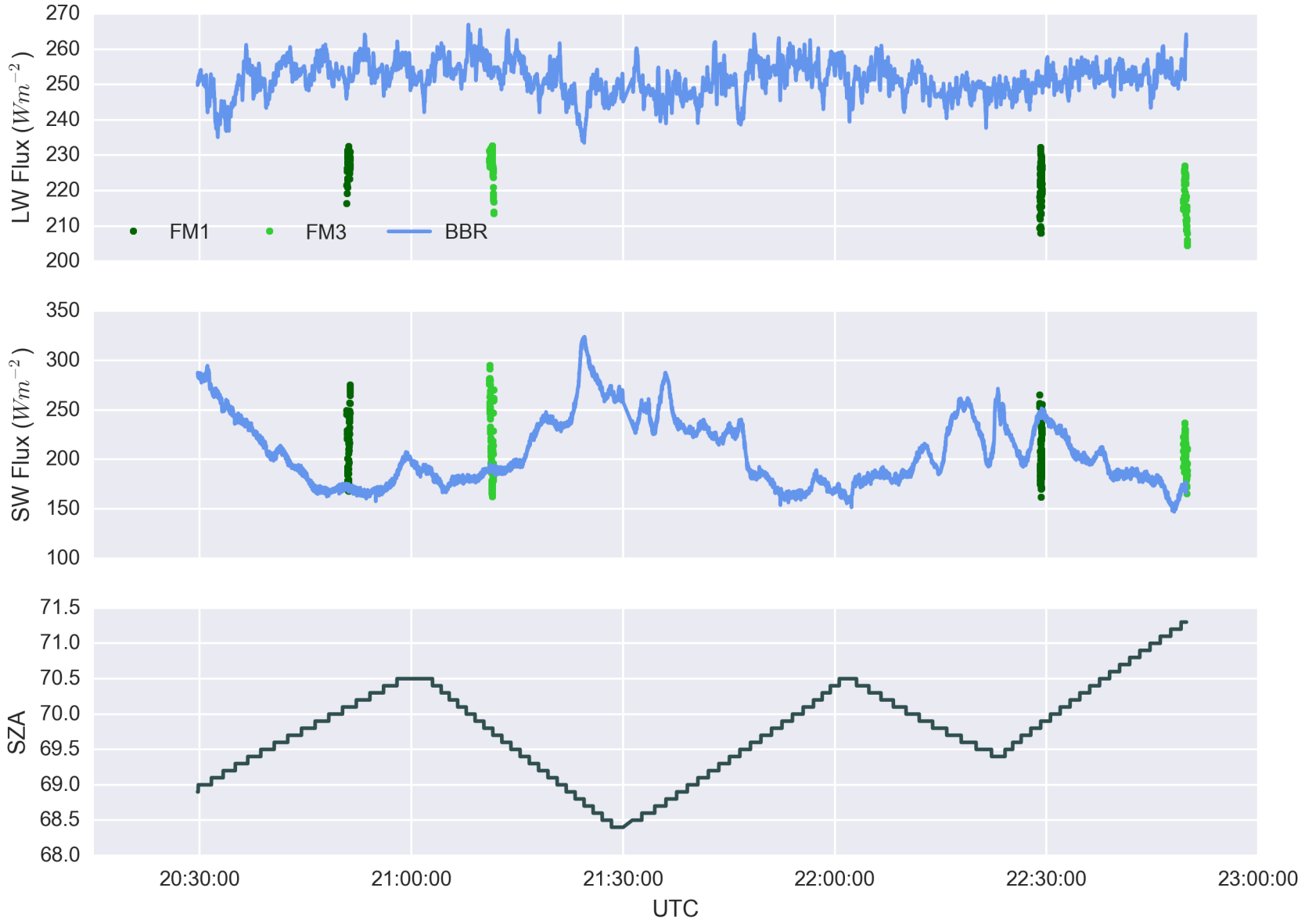
$$BBR_{TOA} = \frac{F_{model}(TOA, BBR)}{F_{model}(6km, BBR)} BBR$$

Compare mean BBR TOA and mean CERES fluxes for each gridbox

Surface

~200 km

7th September 2014



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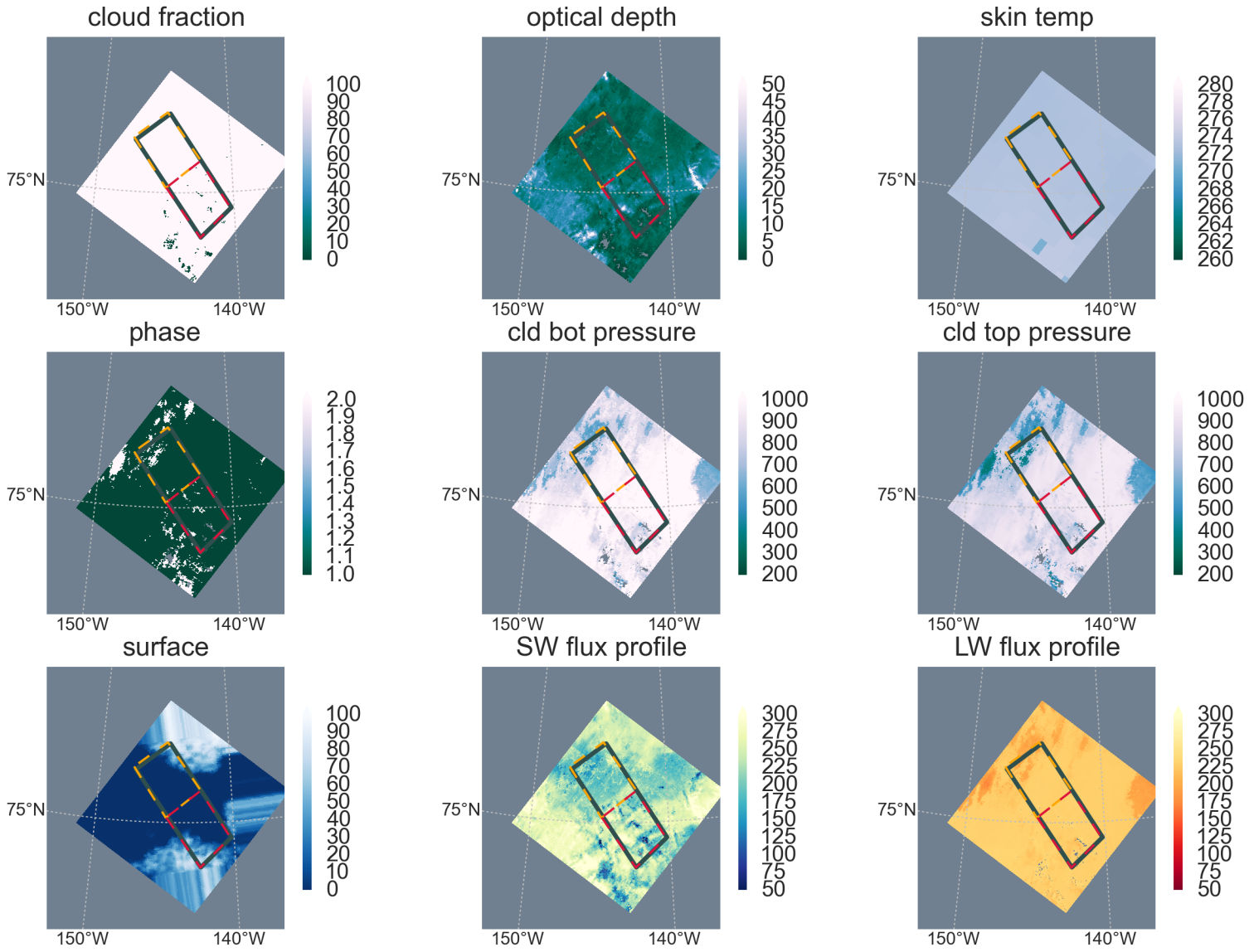
Terra Overpass 22:00 hours



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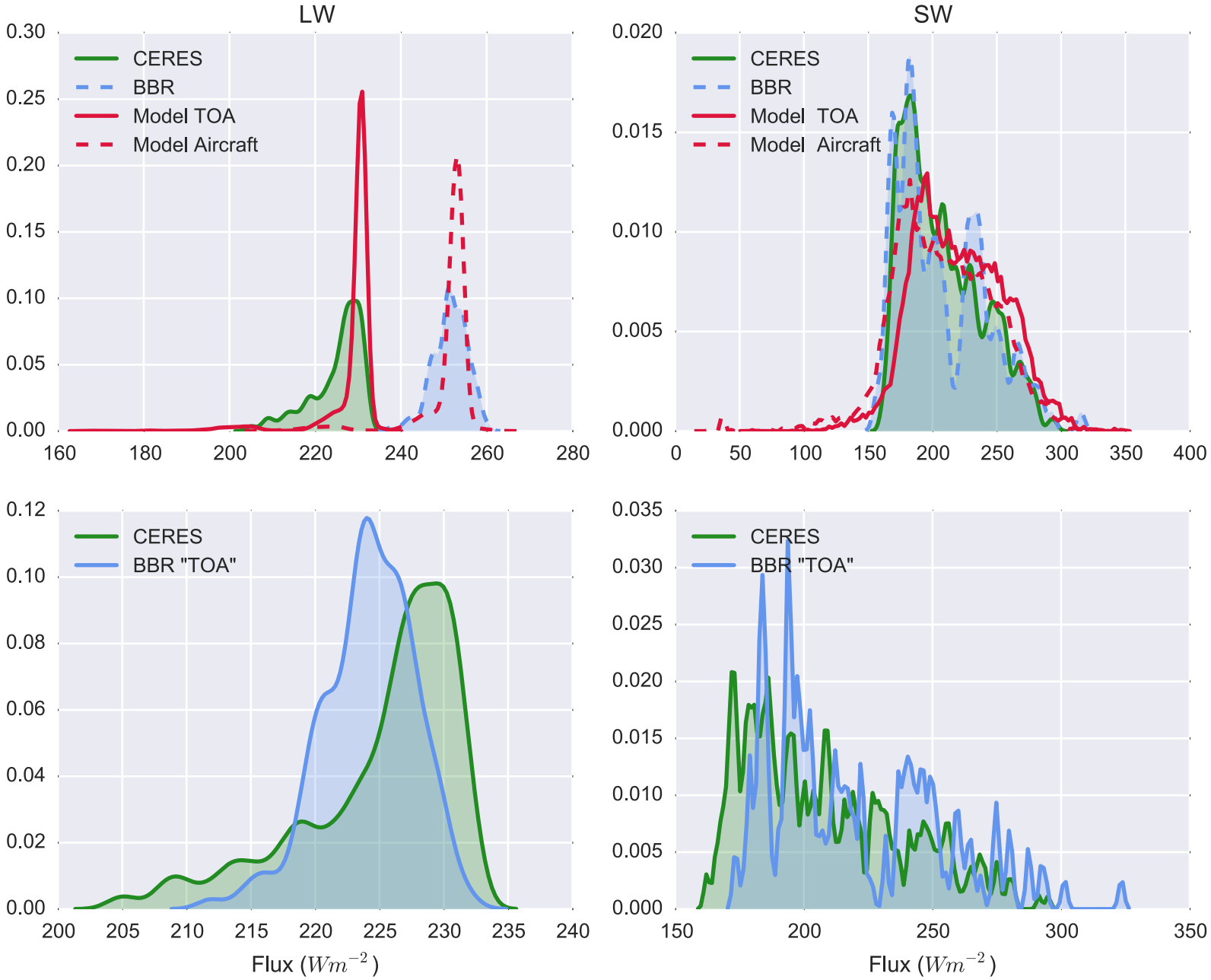

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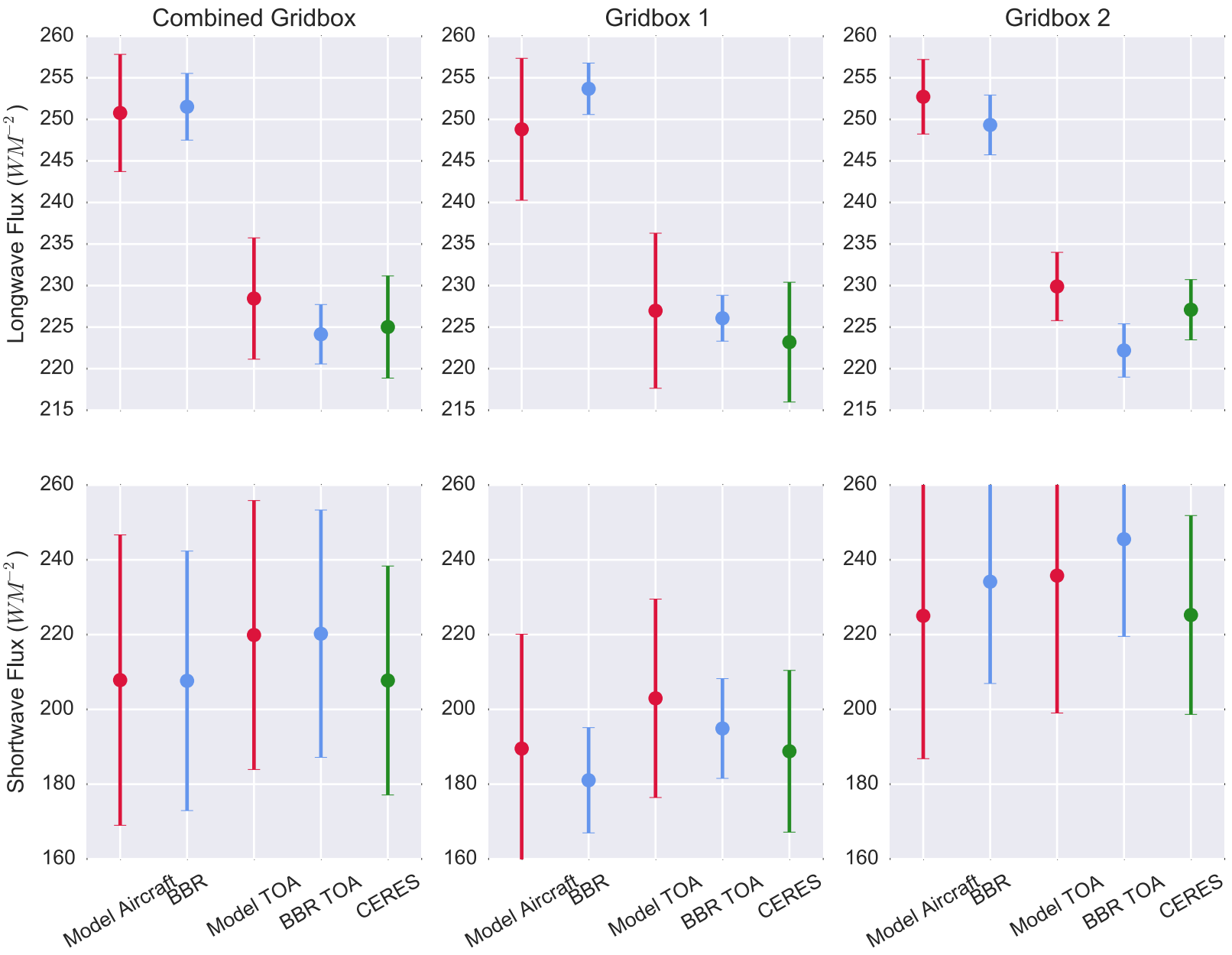

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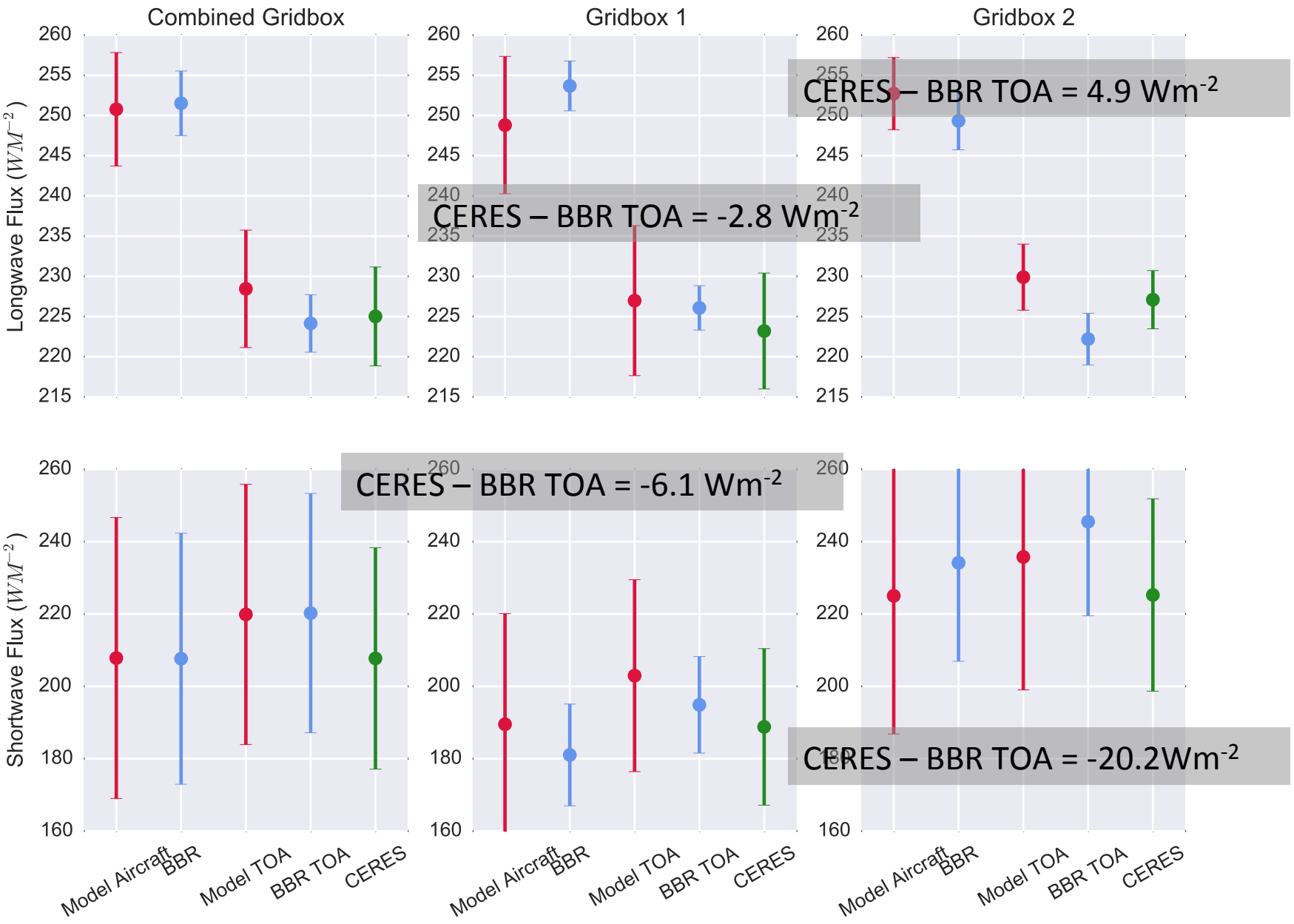
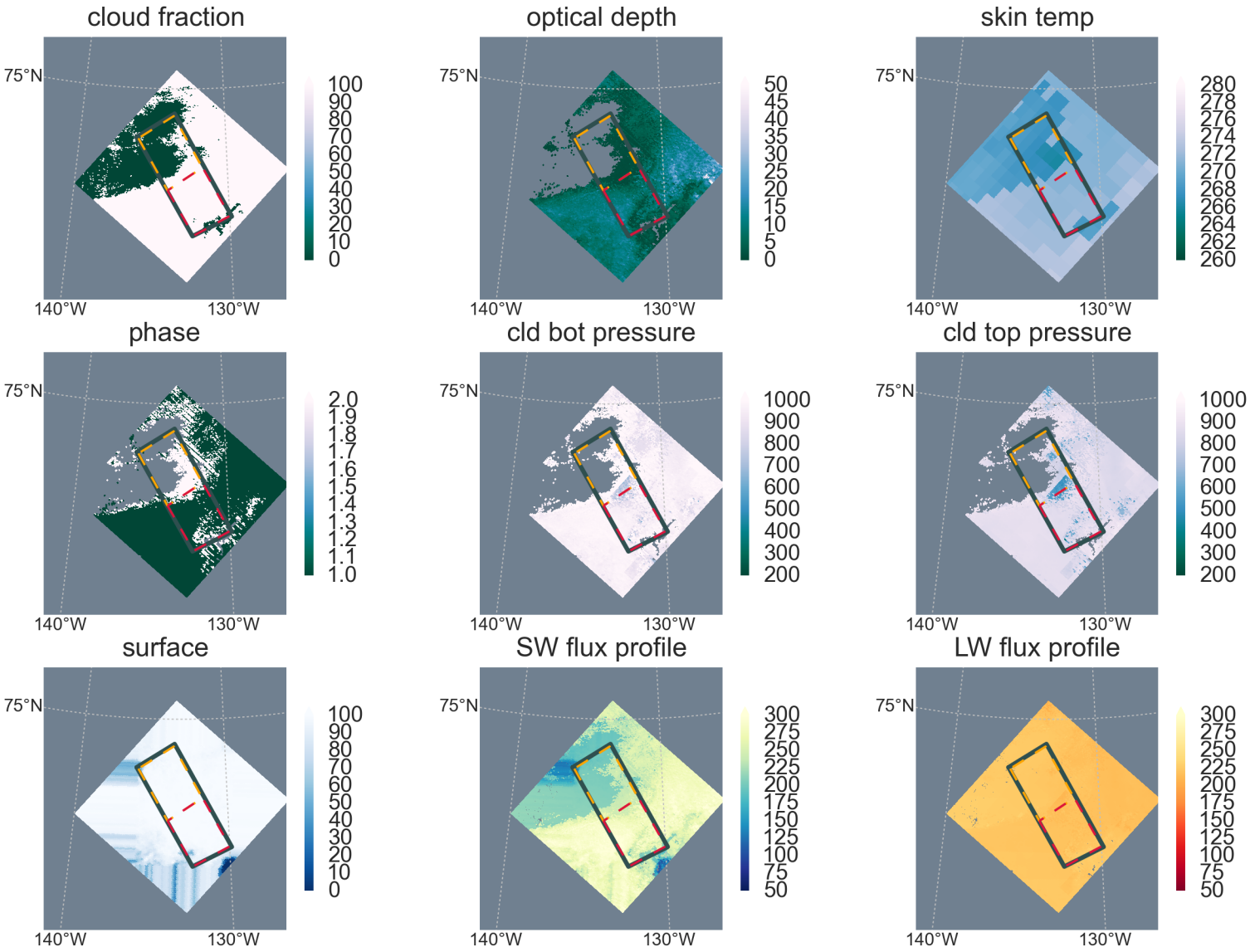


11th September 2014

Terra Overpass 22:00 hours



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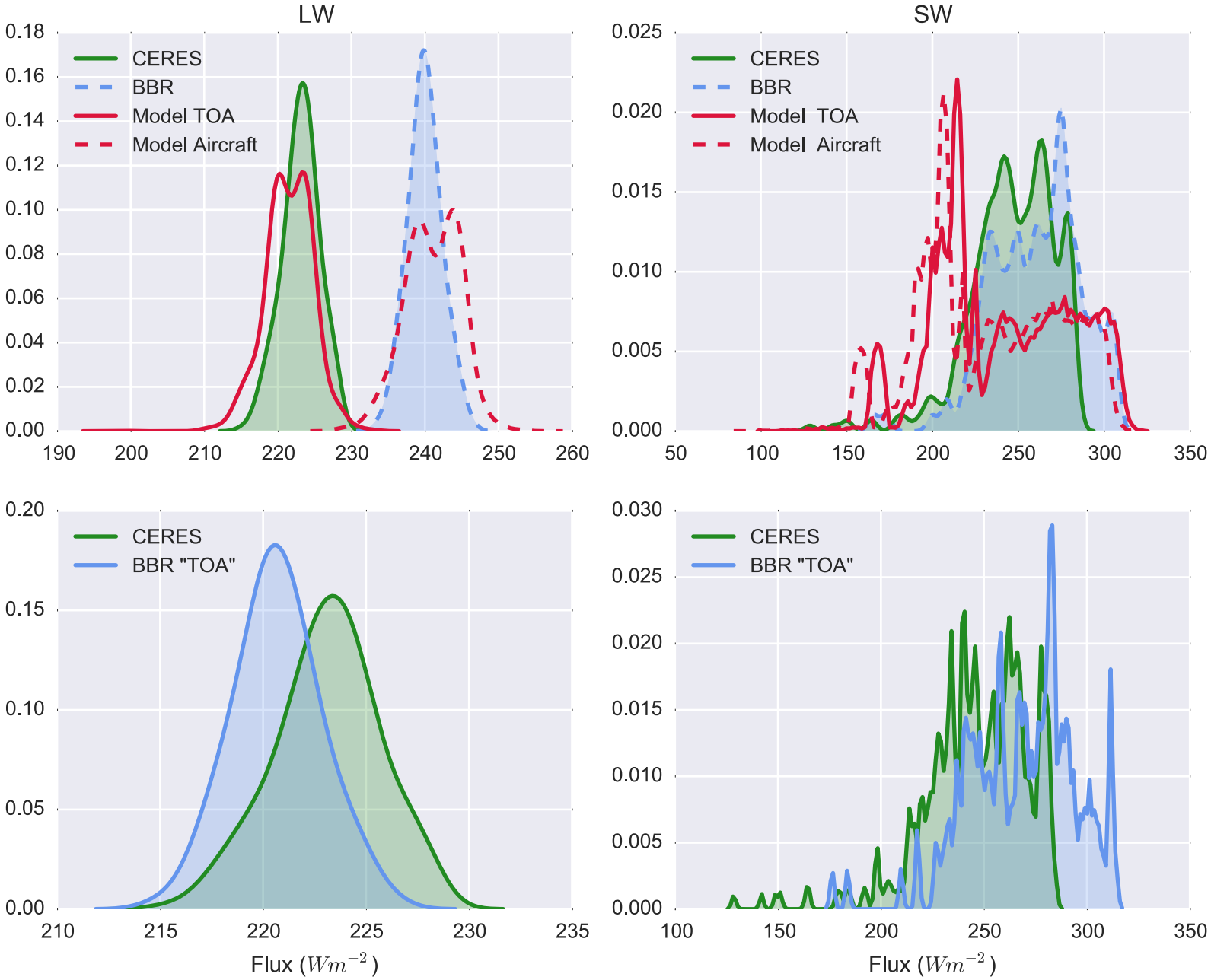

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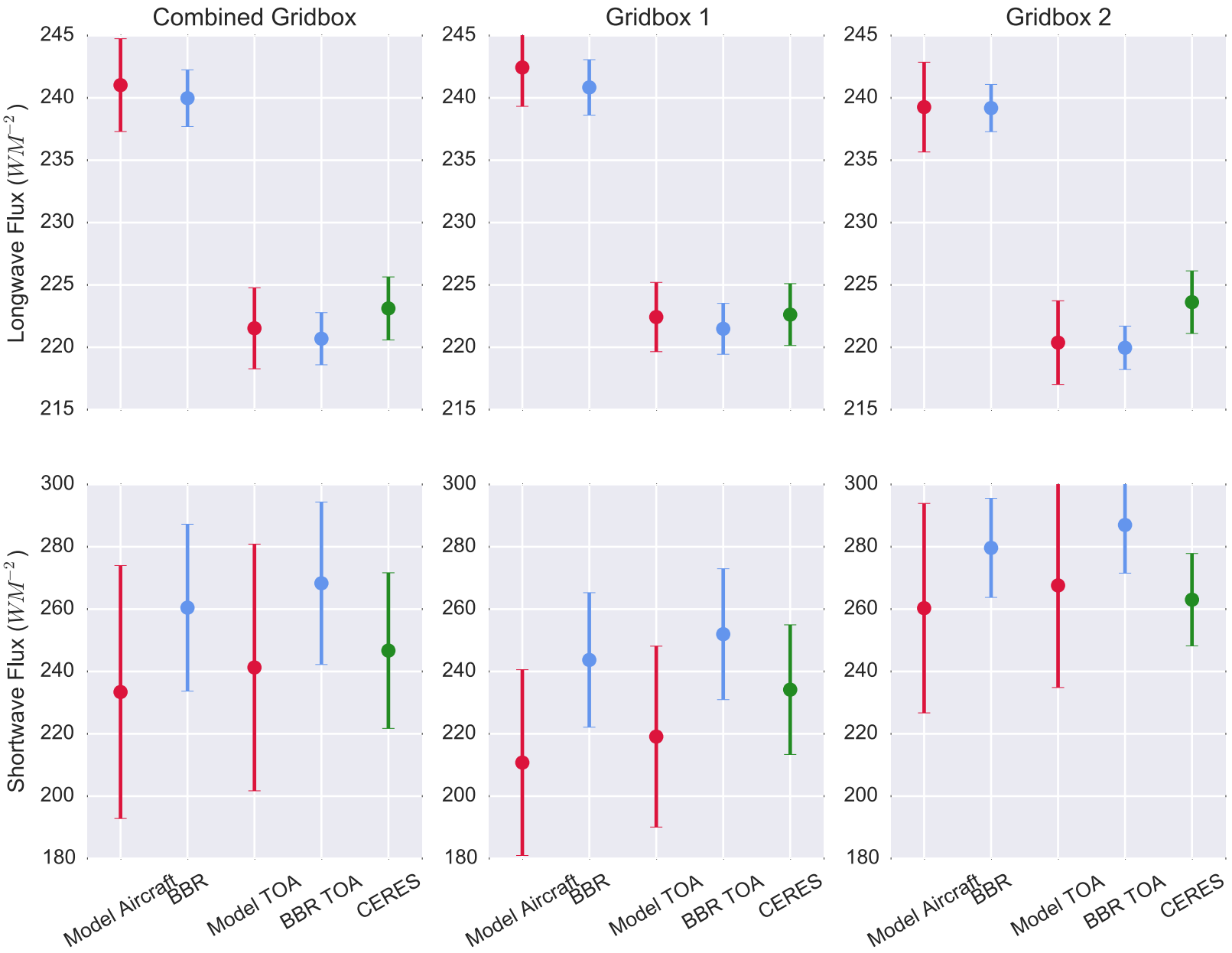

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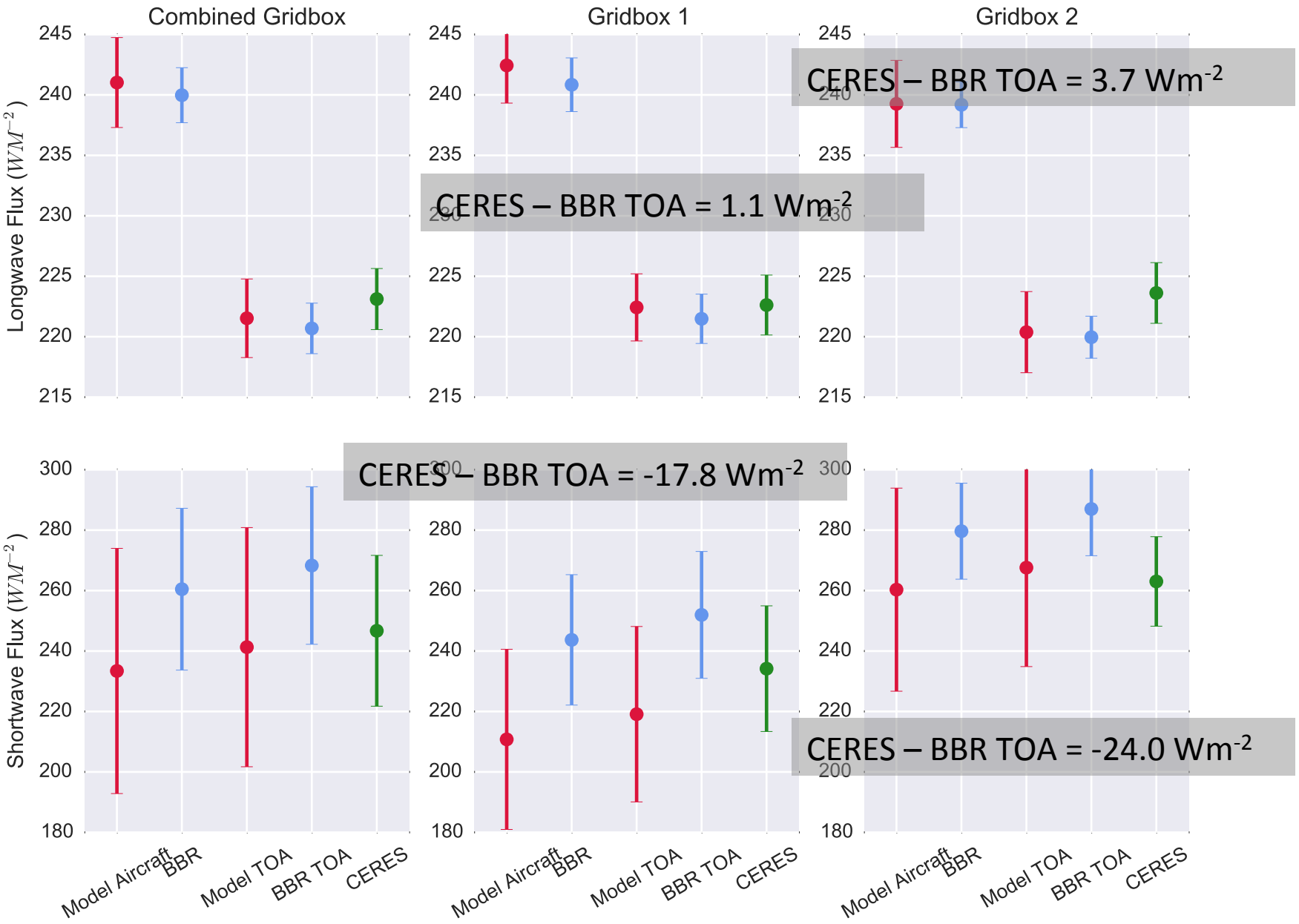

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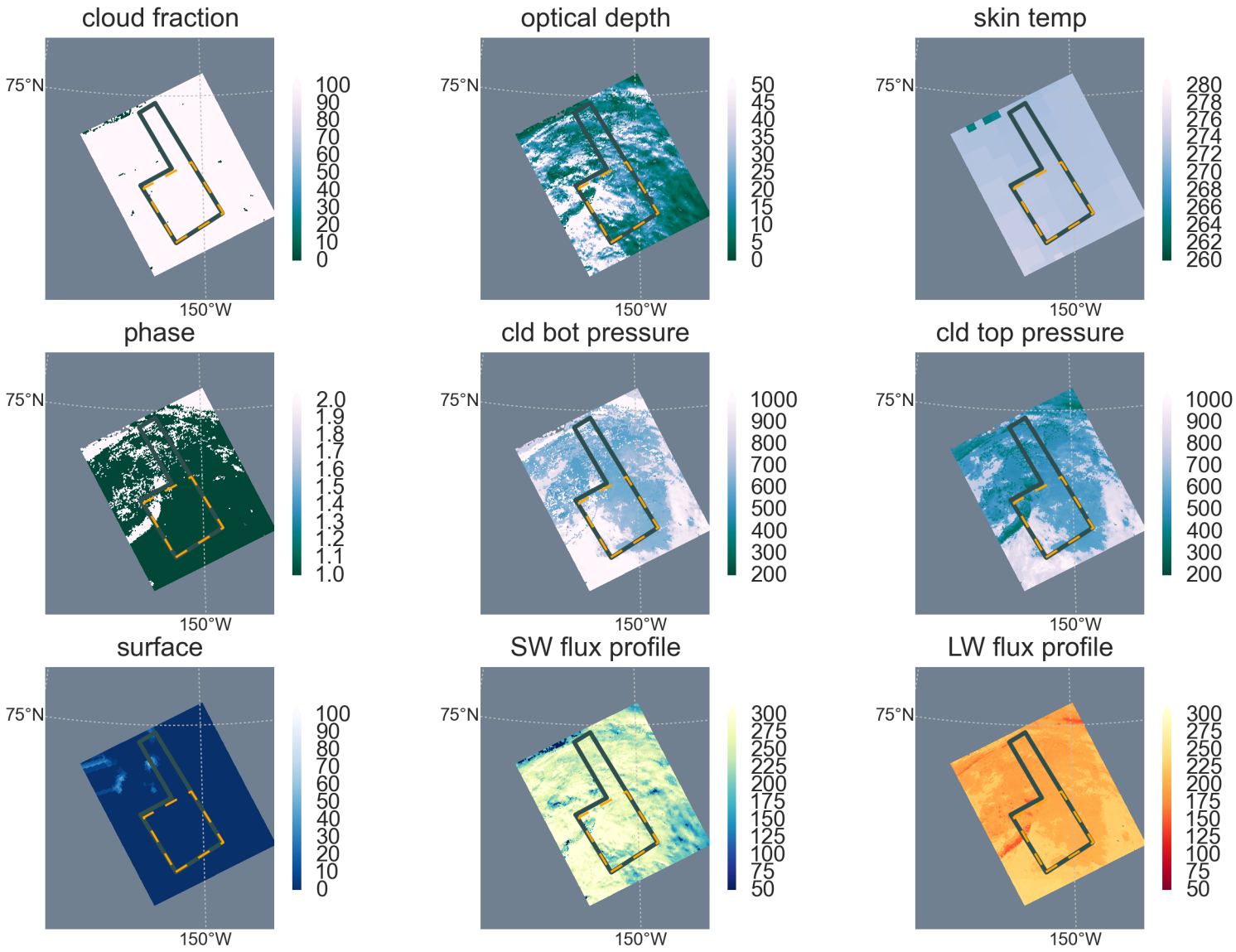
Aqua Overpass 22:00 hours



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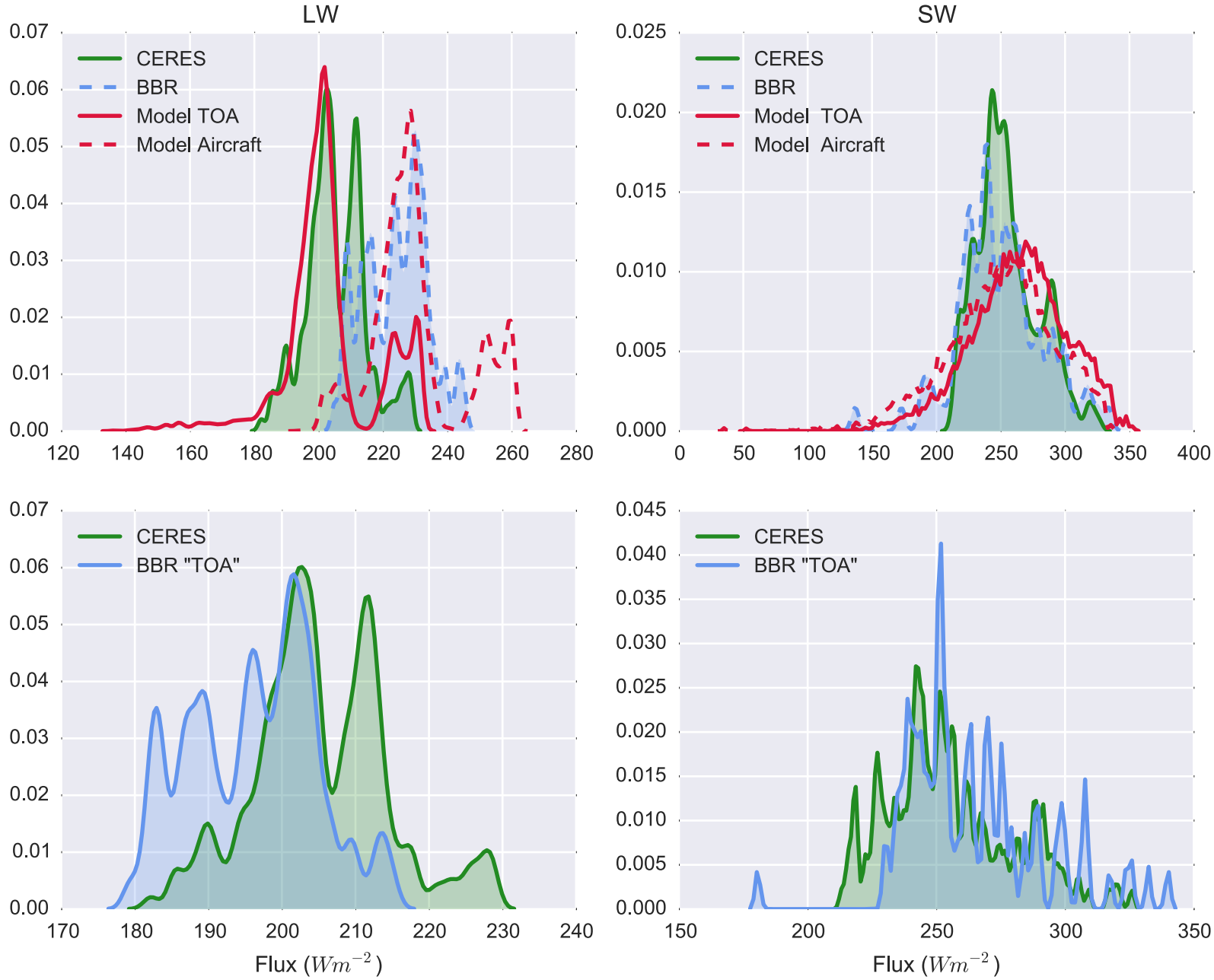

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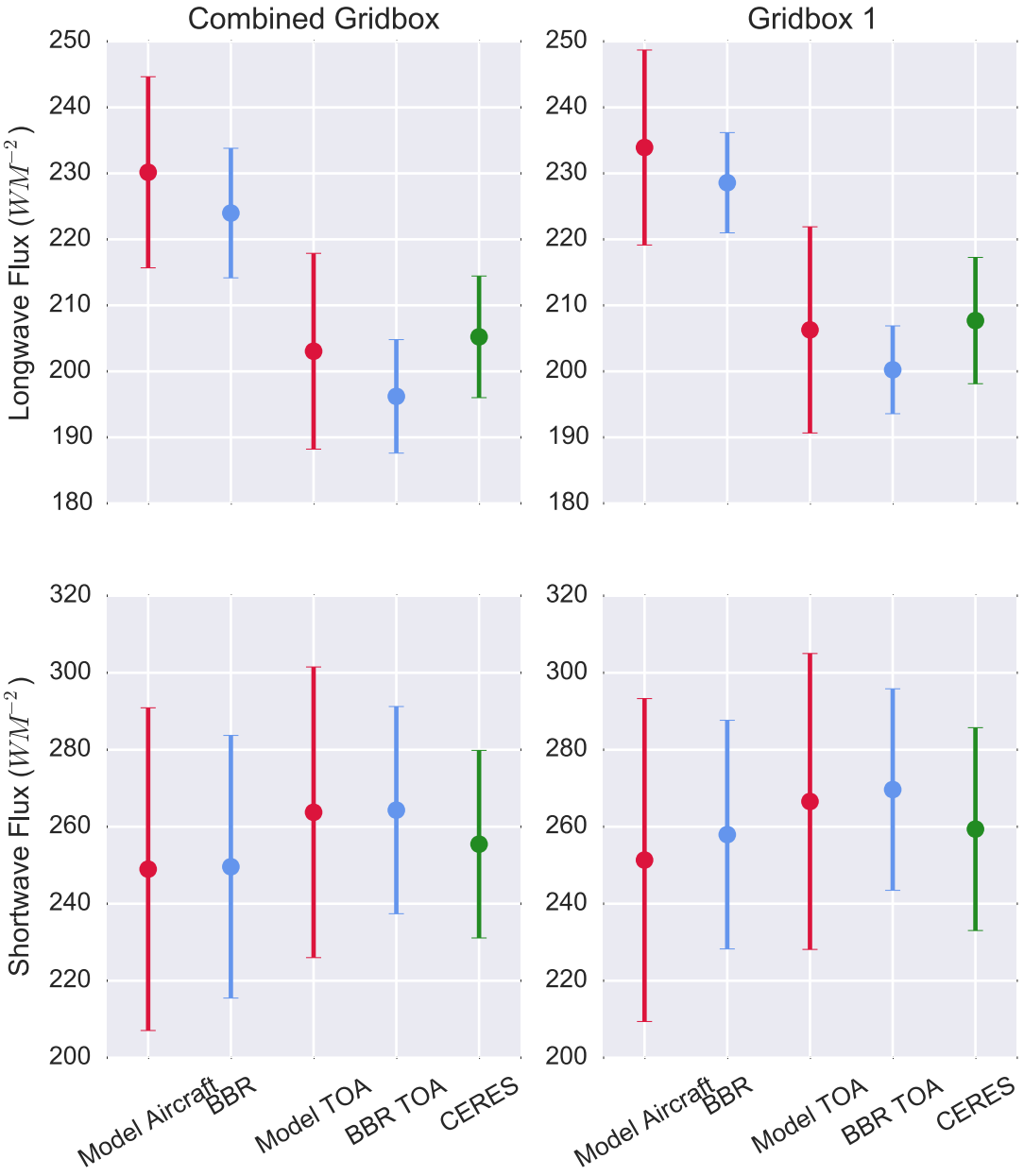

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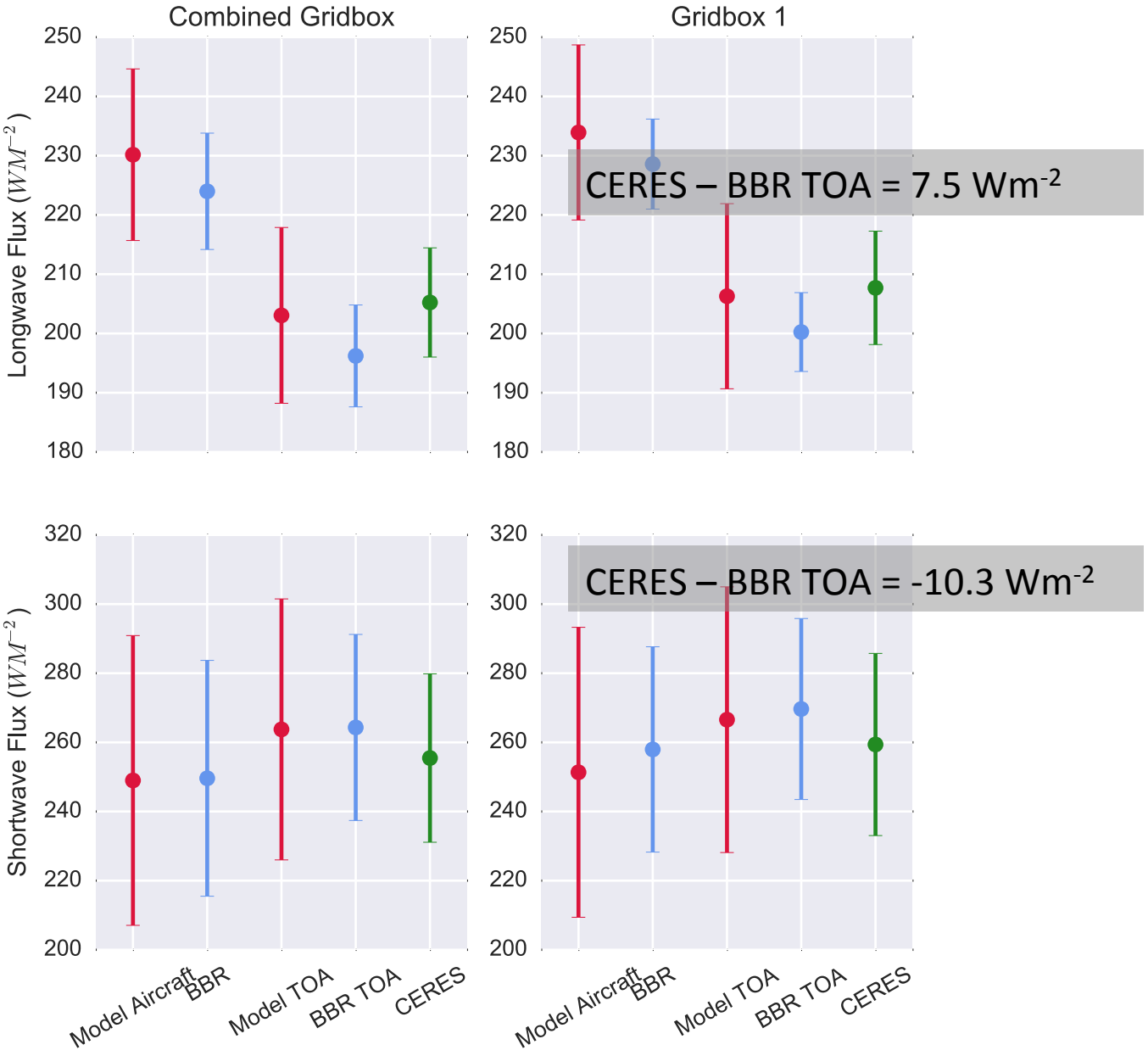
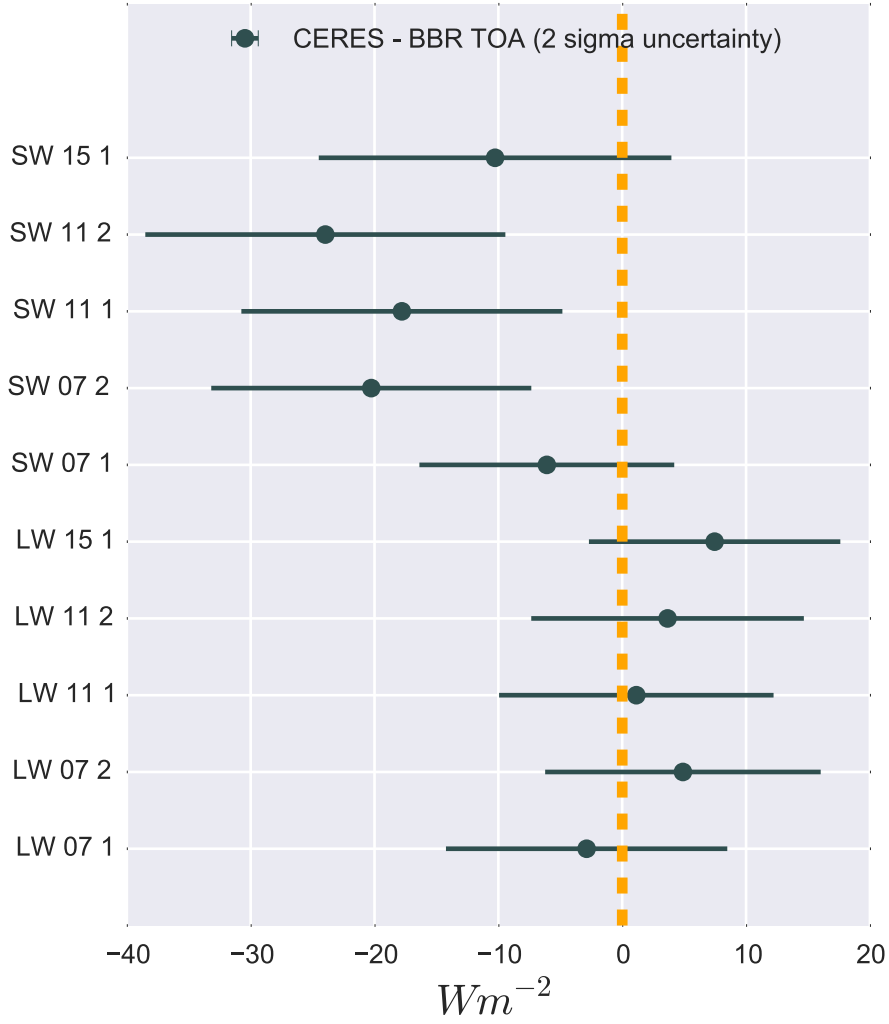


Summary (preliminary)

Assuming a 5% 2 sigma uncertainty in the radiometer measurements and the uncertainty of the CERES mean is the standard error:

- 5/5 longwave grid box results are within the combined uncertainty.
- 2/5 shortwave grid box results are within the combined uncertainty.
  - -> these 2 were over ocean
  - -> 2 of the remaining 3 were over sea ice
  - -> The other was over marginal sea ice

- Possible contributors to the discrepancy
  - -> cirrus contamination
  - -> Aircraft to TOA transfer model
  - -> scene ID
  - -> ADMs (radiance to flux inversion)

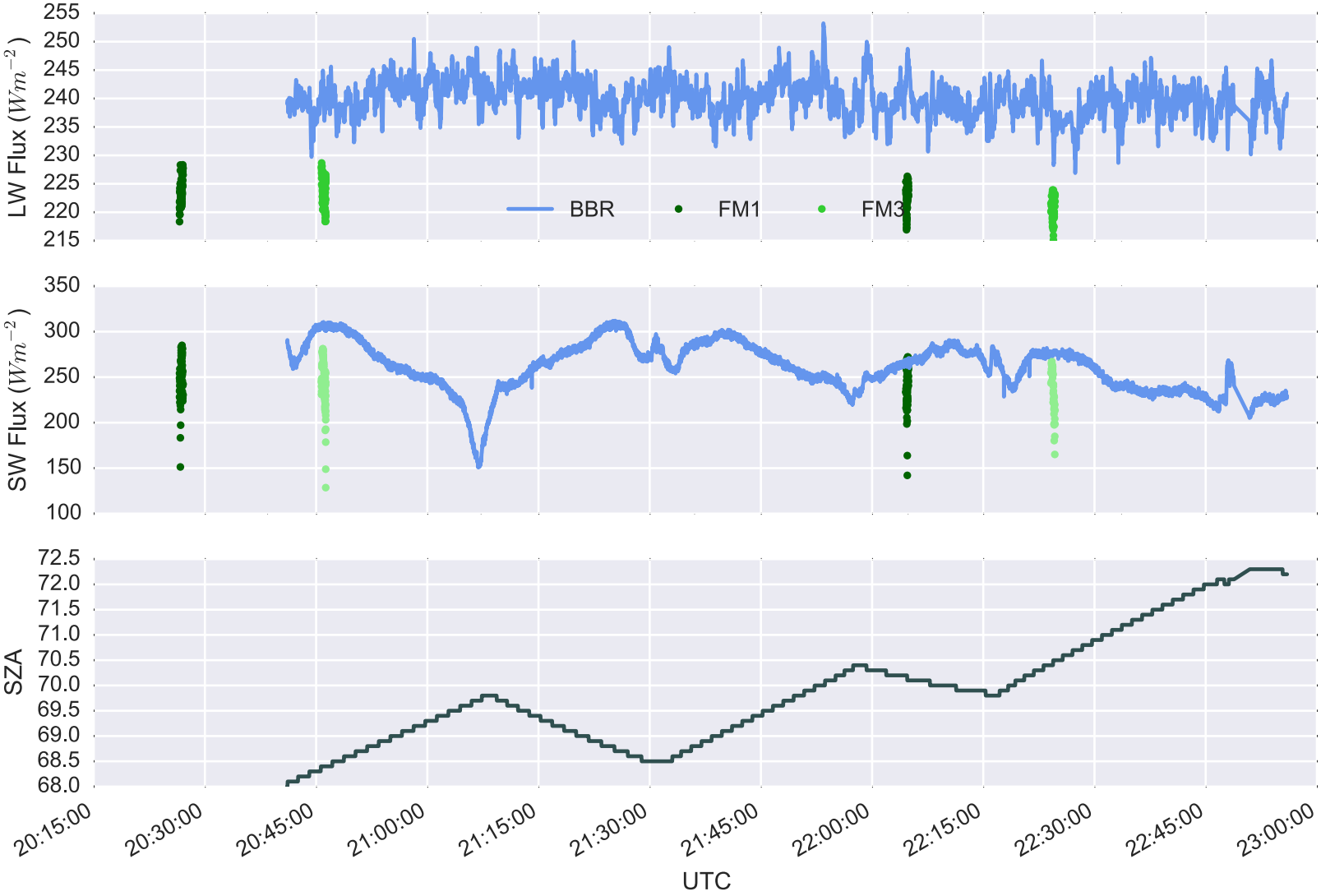
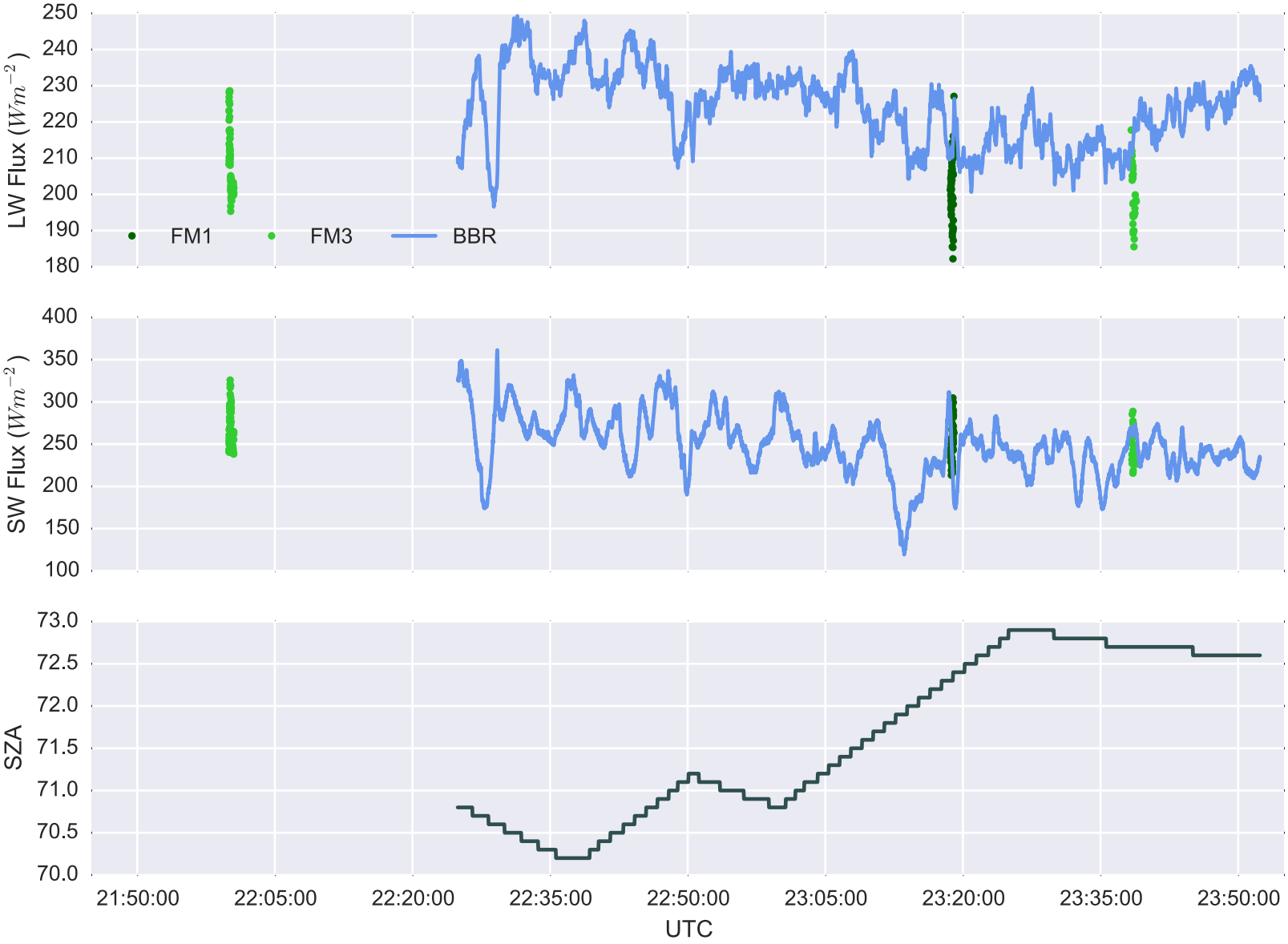


Thank you!

ARISE FLIGHT PROFILES

- Specific flight lines for IceBridge
  - high altitude surveys of sea/land ice with LVIS)
  - fly repeat lines from previous campaigns
- New lines for IceBridge and to support radiation experiments
  - characterize changing sea-ice conditions across MIZ during ARISE
- CERES gridbox experiments (1-2 degree regions)
  - map radiative fluxes from C-130 to test CERES gridded TOA and SFC products over wide range of arctic surface conditions
  - acquire other data (clouds, sea-ice, T(z), q(z), Tsfc) to test algorithm inputs
- Vertical profiles focused on low clouds (above, below, within)
  - radiative closure studies
  - test satellite/aircraft cloud retrievals and model parameterizations
- Surface albedo experiments
  - diffuse vs clear sky, test TOA calculations

11th September 2014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