

C41D-0753 Validating CERES Radiative Fluxes in the Arctic with Airborne Radiative Flux Measurements from the ARISE Campaign

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Motivation

The Clouds and the Earth's Energy System instruments provide the only long-term record of top-of-atmosphere (TOA) shortwave (SW) and longwave (LW) radiative fluxes over the Arctic region (figure 1).

The accuracy and consistency of this dataset is important as it allows for monitoring of changes in the energy budget as changes in surface and atmospheric properties occur.

CERES does not actually measure flux – it measures radiance, which is then converted to a flux by a scene-dependent angular dependence model.

As it is the only satellite borne instrument providing a flux measurement in the high latitudes validation of retrieved fluxes can be difficult, previously we only had indirect validation.

Using airborne broadband SW and LW radiometer data taken during the Arctic Radiation, Ice, and Sea ice Experiment (ARISE) campaign in September 2014 we are able to attempt a direct validation of CERES fluxes.

The ARISE campaign was based in Fairbanks, Alaska, utilizing a suite of radiometer instruments aboard NASA C-130 aircraft (see poster C41D-0724 for more details about the ARISE campaign).



Figure 2: Inset box shows location of measurements made during the ARISE campaign.

Method

Instead of attempting to match instantaneous satellite and aircraft measurements we designed a set of flight patterns that allow us to compare time and space averaged fluxes.

The aircraft flew in a lawnmower pattern with five legs of 200 km spaced 20 km apart at 6km altitude. We can then compare the average radiometer flux in ~100 x 100 km grid boxes with the corresponding CERES flux grid box averages from multiple satellite overpasses.

Three flights were performed using this approach; the first over overcast marginal ice on the 7th, the second over clear and cloudy high sea ice concentration on the 11th, and a third over overcast ocean on the 15th.

In order to perform a relevant comparison we adjust the broadband radiometer (BBR) measurements from the measurement altitude to the TOA. To do this we use the Langley Fu-Liou radiative transfer model to create a look-up table of the ratio of model flux at TOA to that at 6 km that is a function of the flux at 6 km (figure 3).

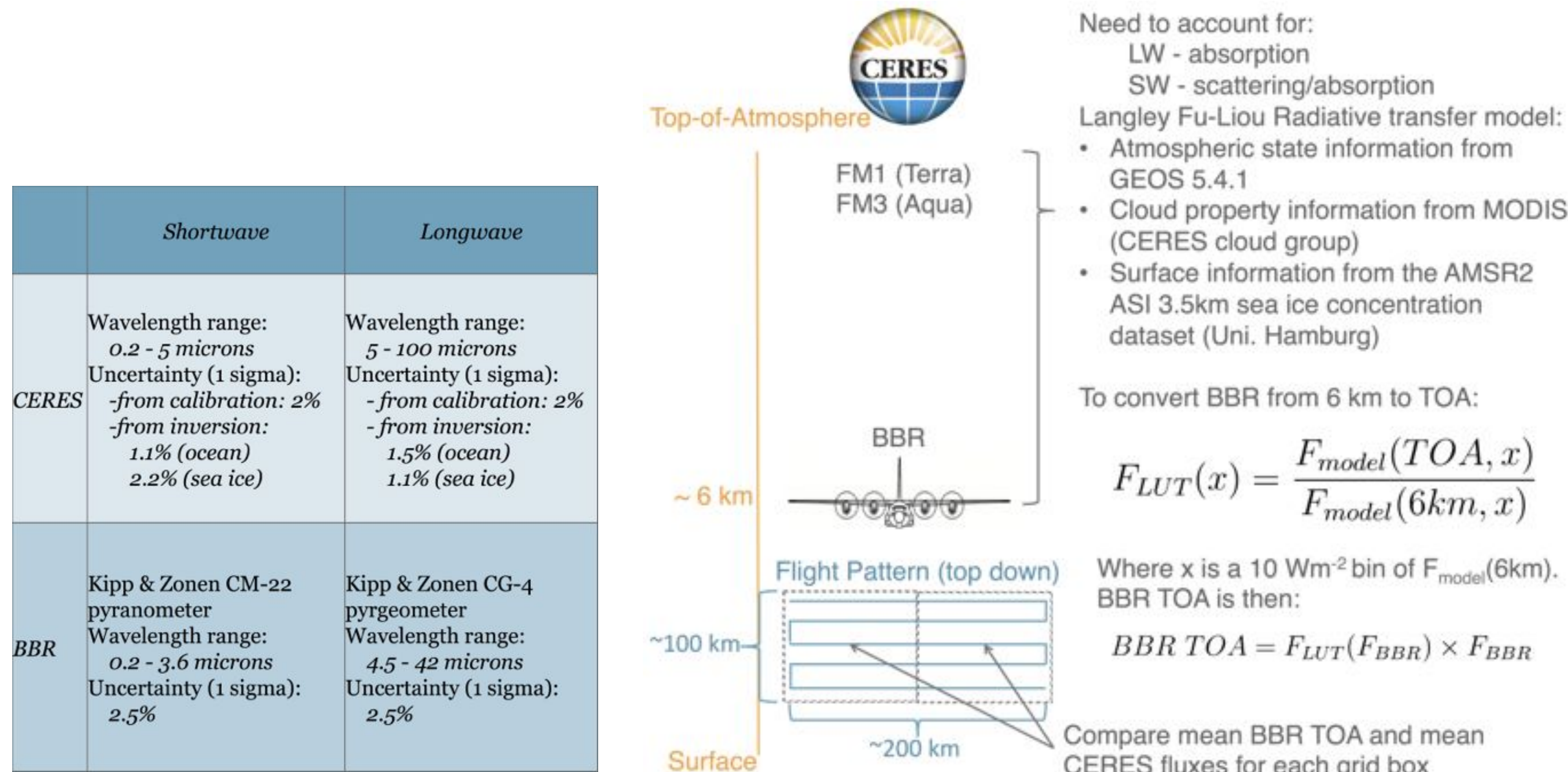


Table 1: Wavelength ranges and uncertainties of the CERES and broadband radiometer (BBR) instruments used in this study.

Figure 3: Schematic showing the measurement strategy and the method used to adjust the radiometer measurements from the aircraft level to the TOA where the satellite measures

Results: 7th

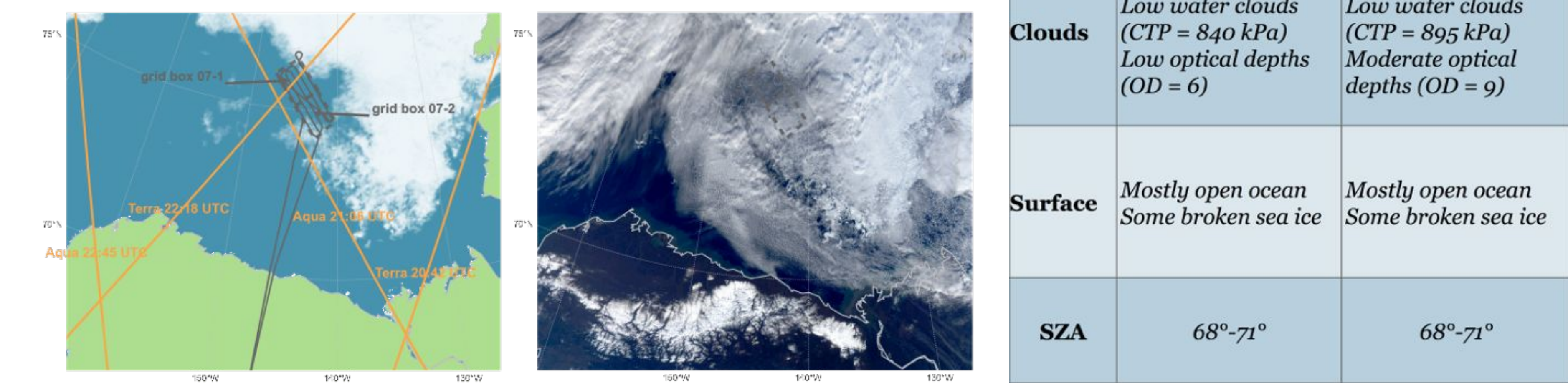


Figure 4: a) Aircraft flight path, satellite tracks and over pass times, and sea ice conditions during the flight on September 7th 2014. The grid boxes are labeled. b) True color image from the MODIS instrument on the Aqua satellite (21:08 UTC overpass) showing cloud conditions in the measurement areas. Table 2: summary of sea ice, cloud, and solar zenith angles in each of the grid boxes. OD = mean optical depth, CTP = mean cloud top pressure.

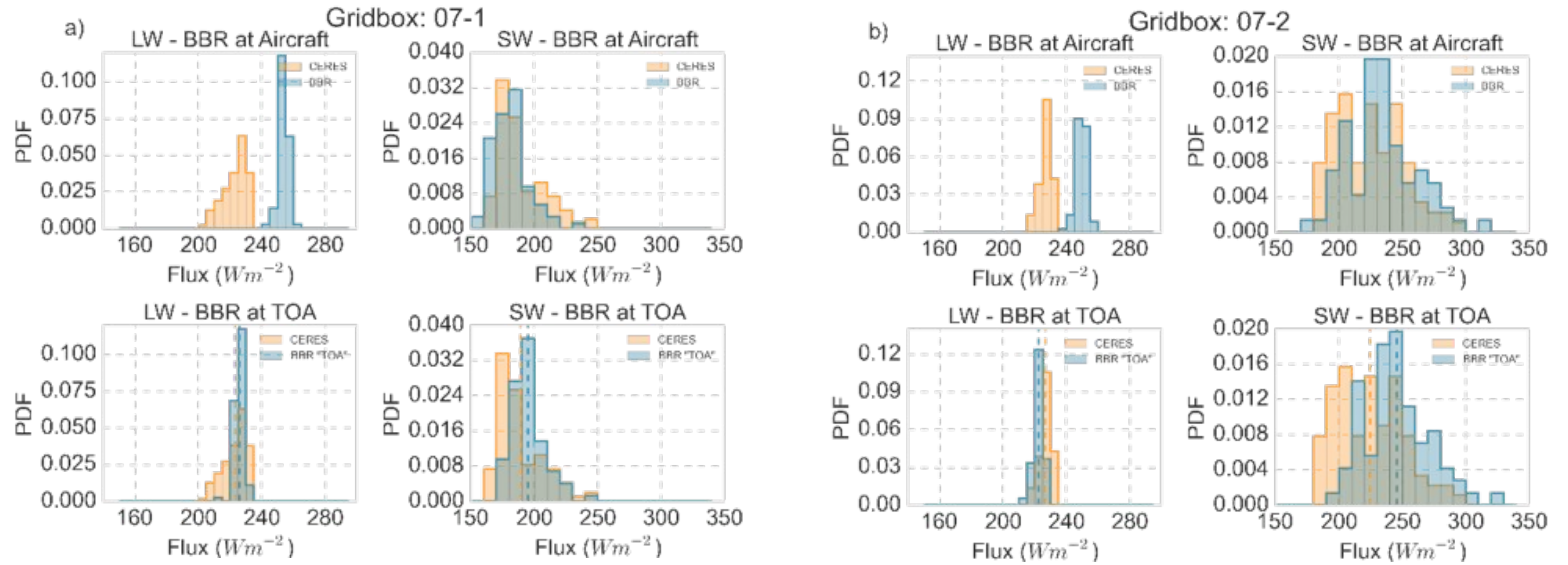


Figure 5: a) top left: distribution of CERES LW and measured BBR LW in grid box 07-1. Top right: distribution of CERES SW and measured BBR SW in grid box 07-1. Bottom left: distribution of CERES LW and BBR LW adjusted to the TOA in grid box 07-1. Bottom right: distribution of CERES SW and BBR SW adjusted to the TOA in grid box 07-1. The dashed lines show the means of each distribution that are used to calculate the difference (see Figure 10). b) same as a) but for grid box 11-2

Results: 11th

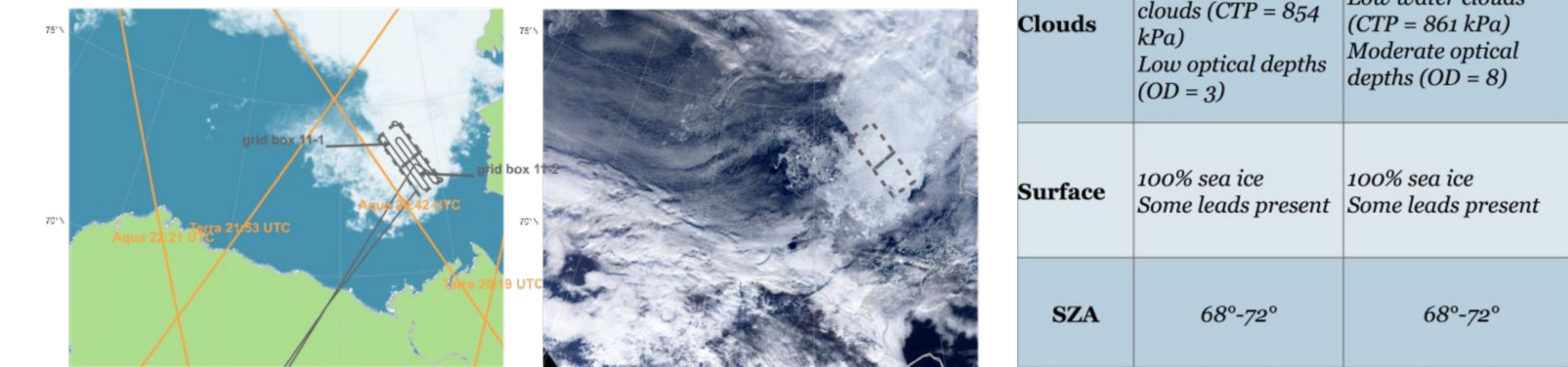


Figure 6: a) Aircraft flight path, satellite tracks and over pass times, and sea ice conditions during the flight on September 11th 2014. The grid boxes are labeled. b) True color image from the MODIS instrument on the Aqua satellite (20:42 UTC overpass) showing cloud conditions in the measurement areas. Table 3: summary of sea ice, cloud, and solar zenith angles in each of the grid boxes.

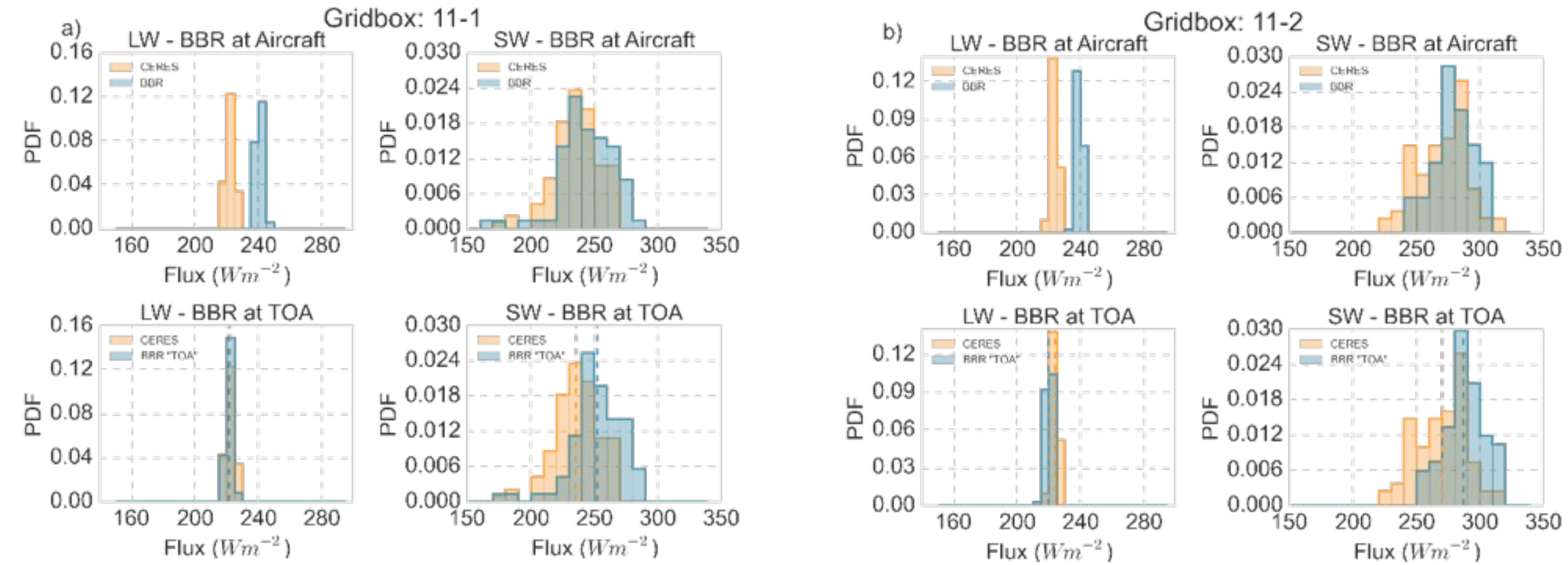


Figure 7: a) top left: distribution of CERES LW and measured BBR LW in grid box 11-1. Top right: distribution of CERES SW and measured BBR SW in grid box 11-1. Bottom left: distribution of CERES LW and BBR LW adjusted to the TOA in grid box 11-1. Bottom right: distribution of CERES SW and BBR SW adjusted to the TOA in grid box 11-1. The dashed lines show the means of each distribution that are used to calculate the difference (see Figure 10). b) same as a) but for grid box 11-2.

Results: 15th

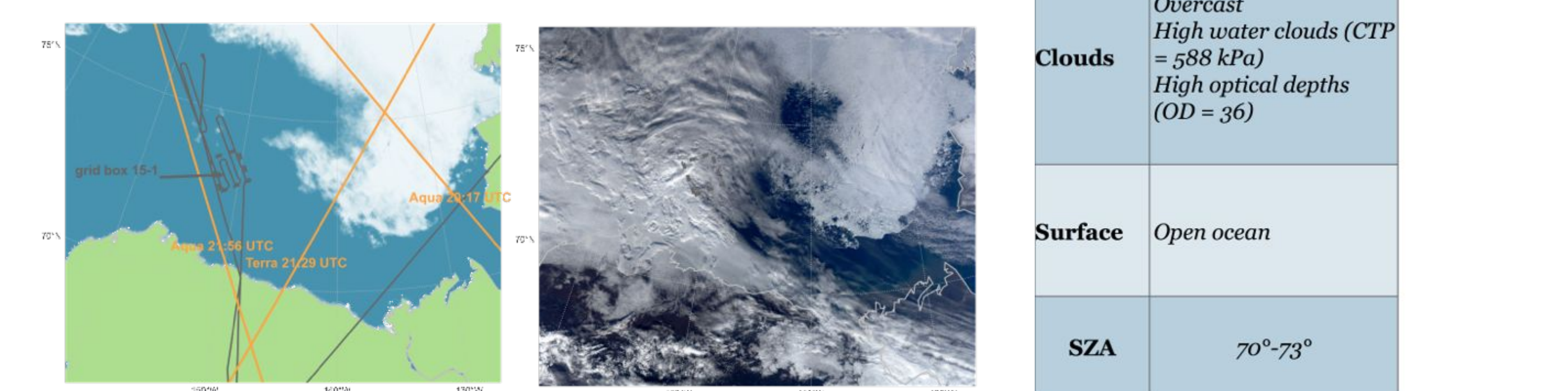


Figure 8: a) Aircraft flight path, satellite tracks and over pass times, and sea ice conditions during the flight on September 15th 2014. The grid boxes are labeled. b) True color image from the MODIS instrument on the Aqua satellite (21:56 UTC overpass) showing cloud conditions in the measurement areas. Table 4: summary of sea ice, cloud, and solar zenith angles in the grid box.

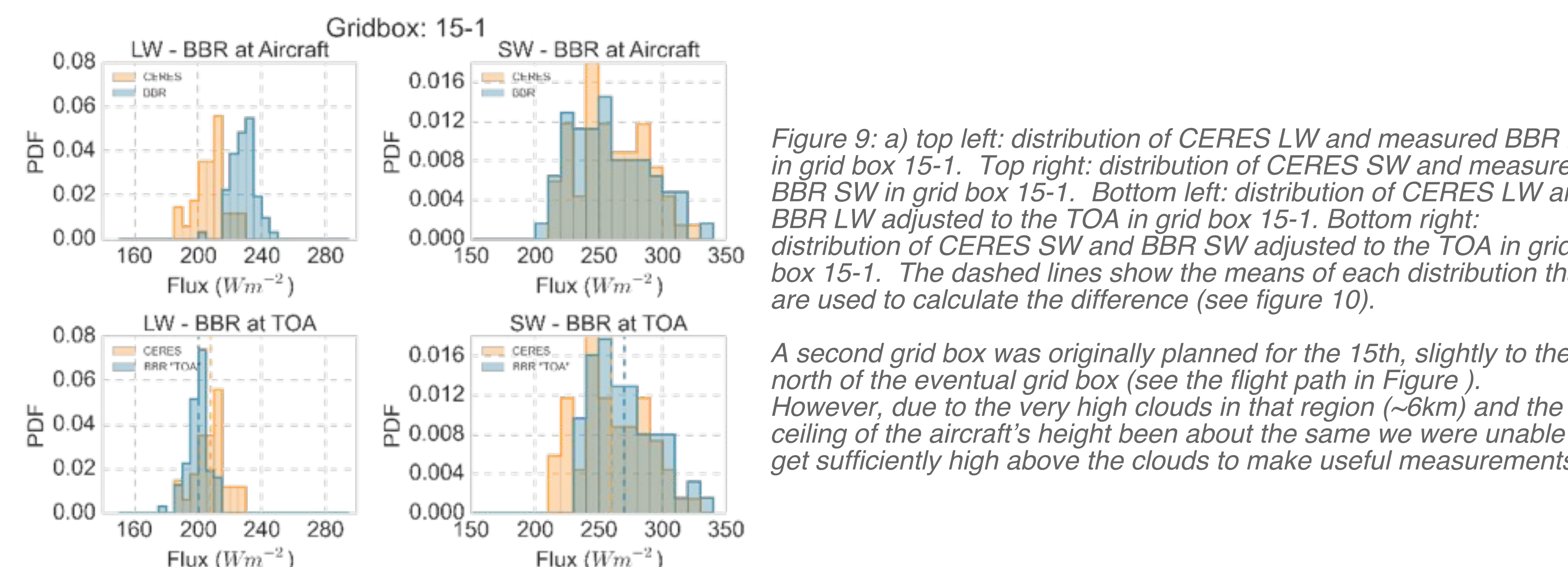


Figure 9: a) top left: distribution of CERES LW and measured BBR LW in grid box 15-1. Top right: distribution of CERES SW and measured BBR SW in grid box 15-1. Bottom left: distribution of CERES LW and BBR LW adjusted to the TOA in grid box 15-1. Bottom right: distribution of CERES SW and BBR SW adjusted to the TOA in grid box 15-1. The dashed lines show the means of each distribution that are used to calculate the difference (see figure 10).

A second grid box was originally planned for the 15th, slightly to the north of the eventual grid box (see the flight path in Figure). However, due to the very high clouds in that region (~6km) and the ceiling of the aircraft's height been about the same we were unable to get sufficiently high above the clouds to make useful measurements.

Conclusion

The longwave fluxes show good agreement for all the grid boxes.

The shortwave fluxes show agreement to within the uncertainty for four of five of the grid boxes.

The best agreement occurs for the two overcast over open ocean scenes on the 7th and 15th.

The two 100% sea ice grid boxes agree at the edge of the uncertainty.

Grid box 07-2 does not agree to within the uncertainty. As this grid box was over a regional of marginal sea ice the reason for this discrepancy could be related to scene identification errors from incorrect cloud or surface properties leading to incorrect ADM selection.

Interestingly, the SW differences are all negative, indicating that CERES is underestimating the SW flux compared to BBR. The reason for this is unclear, and requires further investigation of the data and methods.

Having only five data points limits our ability to make definitive claims about the CERES fluxes. However, it is encouraging to see such good agreement in the LW and fairly good agreement in the SW. Further validation experiments could provide additional confidence in the CERES flux measurements.

Further Information

Contact: joseph.g.corbett@nasa.gov
For more information about CERES: <http://ceres.larc.nasa.gov>
To access the CERES datasets: http://ceres.larc.nasa.gov/order_data.php
To access the data from the ARISE campaign: <https://www-air.larc.nasa.gov/cgi-bin/ArcView/arise>

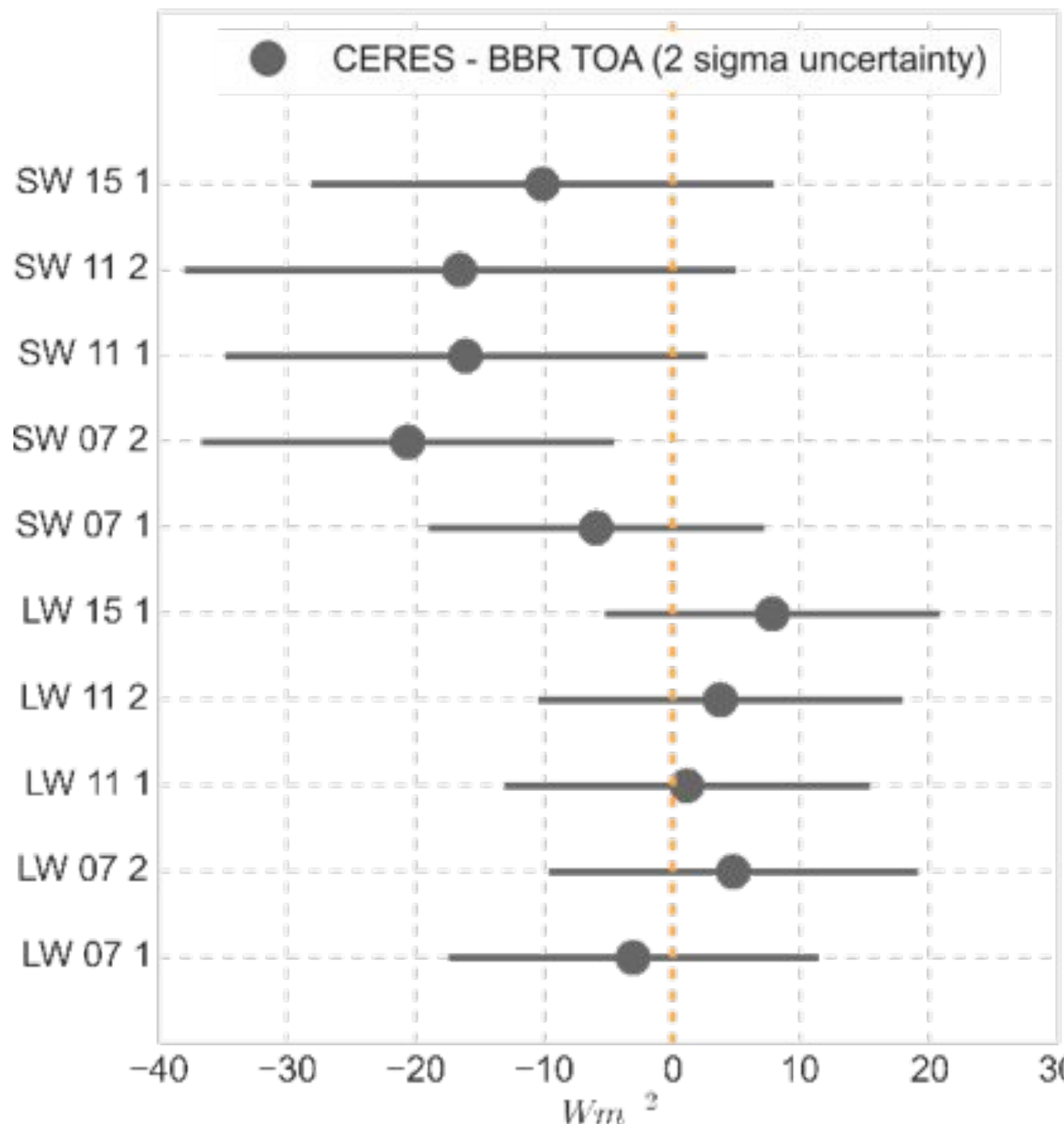


Figure 10: The difference between the mean CERES and mean BBR TOA flux values for each grid box and the shortwave (SW) and longwave (LW) measurements. The uncertainty is calculated using the values given in Table 1.