Airborne observations of far-infrared upwelling radiance in the Arctic

Quentin Libois et. Al.

Review of above manuscript:

The main aim of this paper is to evaluate the performance of the FIRR instrument under field campaign conditions. This is done successfully with overall performance shown to agree with laboratory performance within limitations imposed by the operational and environment conditions. Improving our understanding of the distribution and radiative effects of cirrus clouds in Arctic climates is highly important and TICFIRE a very worthwhile endeavour. Testing and improving the underlying technology for TICFIRE through the FIRR instrument is therefore crucial and this paper highly relevant.

Of the four main objectives mentioned at the end of the introduction I would suggest that the measurements described are not strictly a radiative closure experiment, the atmospheric state is not sufficiently well known to allow this. Similarly for the verification of the spectral signatures of cloud radiance. The work does assess the FIRR radiometric performance and demonstrates the sensitivity of FIRR measurements to atmospheric characteristics.

The inclusion of the section on atmospheric cooling rates is not helpful for the objectives of the paper a fact emphasised by the lack of zenith view data. This can be omitted without impact on the paper.

I would like more detailed information on the in-flight variability of the ancillary data set, such as local humidity and ambient temperature, particularly at fixed flight levels. Please see additional text below.

Suggested changes to text:

Replace F-IR with FIR throughout text

Page2

line4: “~~host~~ includes the **strongly absorbing** pure rotation band of water vapor” and coincides with a maximum in the water vapour continuum strength.

Line 8: “The **emission** maximum of Planck’s function…”

Line 11: Reference to the Mars climate sounder is not relevant.

Line 32-33: This is a little confused, the wording may be clearer. “uttermost in Arctic regions because as discussed proportionately more energy is emitted from these

colder surfaces at FIR wavelengths while the same time lower water vapour column increases atmospheric transmission.

Page 3

Line 22: vignetting by the chimney edges? I assume

Line 28: “One **spectral** measurement thus corresponds to a 0.8 s…”

Page 4:

There needs to be specific reference to the fact that the measurements are comprised from the average of all pixels in the 15 pixel diameter area illuminated by the scene footprint.

The authors highlight the advantages of fast scanning and the high radiometric accuracy of their instrument but in the operational configuration described individual spectral band measurements are, if I understand the text correctly, off-set temporally and hence spatially. This should be made clear at this stage and placed in context to the along track averaging.

The sequence described indicates 0.8 s averaging per band, 9 bands per filter wheel rotation totalling 7.2 s observation time for all bands. Given 3 scene views and 2 calibration scans per cycle that equates to 36 s. The Authors indicate that one complete sequence last 210 s, there is therefore some considerable time unaccounted for, can the Authors expand on this and explain the implications, if any, for high variability scenes such as that observed in the cirrus observations.

Page 5:

Figure 1 does not add a lot to the text and can be omitted
Table 1 would be more informative replaced with a spectral plot showing the filter transmission, similar to that of figure 2a in the Author’s earlier paper, “A microbolometer-based far infrared radiometer to study thin ice clouds in the arctic”

Page 6/7:

The description of the flight paths for the aircraft lacks detail, the longitudes indicated on figure 2 (left panel) are wrong (75/60/45 degrees being 15 degrees out). Choose one flight and expand to show detail of the profile track more clearly.

Alternatively a more detailed figure of the flight path could be included with the case details.

Page 8:

Line 6: Is the KT19 spectral response known and has this been applied derive surface temperature with the assumption of a spectrally flat surface emissivity of 0.995, be more explicit.

Line 25-30:

How was the trend in ice temperature over the 30 minutes established, was this correlated against the KT19 data set for validation or was the KT19 data used to establish the trend?

Page 9:

Line3: “To further investigate the reduced **thermal** resolution observed…”

Line 21/22:

“the KT19 was -32.6C **while** a maximum of -24 C **was observed in the atmospheric temperature profile between** 1 and 2 km…”

Line 23: I do not believe you can justify suggesting no cloud above the aircraft from CALIPSO measurements made 3 hours previously, are there MODIS cloud cover products that are nearer in time that you can use.

Line 25: A plot of the atmospheric transmittance vs altitude for each channel may help interpretation.

Page 11:

Figure 4: 4c should indicate how the irradiance measurements were obtained.

Page 12:

Line 1: Be more specific about what feature you are referring to.

Fig 5. Can the Authors include error bars on the simulations using realistic uncertainties applied to the atmospheric data set used in the radiative transfer model.

Page 13:

Lines 19-34: It would be informative to see the spectrally resolved MODTRAN radiance output plotted as brightness temperature with the filter responses superposed, for the 11th, 20th and 21st April at the maximum aircraft altitude. Again uncertainties on the simulation BT’s would be informative for figure 6.

Page 15:

Figure 7 shows a 2-D image footprint for a 0.8 s scan, can the Authors include the relative positions for all 9 band observations along track for a single filter wheel rotation and indicate the position offsets between filter wheel cycles

Line 3: “This question is le**f**t to future work…”

Line 5-6: You have no uncertainties placed on the MODTRAN simulations so stating the deficiencies here is not justified, for instance what is the along track variation in the measured humidity.

Page 16:

Line 6: ", ~~consistently~~ with relatively large particles seen **consistently** by the 2D-c probe"

Page 18:

Line 15:

Inferences made from reference to figure 10 would be enhanced with inclusion of a linear plot of relevant data sets as a function of aircraft altitude vs time (location). Co-located MODIS cloud optical depth/height can be superposed for reference.

Page 19:

Line 4: "making them ~~somehow~~ somewhat redundant….."

Page 20.

Atmospheric cooling rates:

Mlynczak et al 2011, The INFLAME design is such that the net flux is measured directly thus allowing instantaneous cooling rates to be established. It is my understanding that FIRR would require combinations of sequential measurements of zenith and nadir views, similar spectrally resolved measurements of atmospheric cooling rates in the far-infrared have in fact been measured, Harries 2008.

Line 10: "The net flux was computed from broadband sensors". What sensors are these?

The inclusion of this section on cooling rates does not benefit the overall interpretation of the FIRR instrument performance. In itself it is not new nor does it expand on existing work. The "measured" broadband cooling rates are not detailed and the lack of FIRR zenith data is a hindrance.

In my opinion this section should be omitted entirely.

Page 22:

Line 1: "field of ~~fiew~~ view…."

Line 16: "instrument resolution" What aspect of instrument resolution are you referring to, spectral, spatial, thermal.