Response to Interactive comment by C. Westbrook for 'Application of infrared remote sensing to constrain in-situ estimates of ice crystal particle size during SPartICus' by S. J. Cooper and T. J. Garrett

We thank Dr. Westbrook for his interesting and supportive comments. We also agree that the Westbrook and Illingworth (2009) Doppler lidar technique described in his comments could be of great use in the determination of whether ice clouds are composed of 'small' or 'large' crystals. As such, we have added a specific reference to Westbrook and Illingworth (2009) in our conclusion section.

It may be useful to put these results in context of other remote-sensing approaches which have been taken to this problem. Mitchell et al (2010, J. Atmos. Sci. 67 1106-1125) also used 11 and 12 micron emissivity difference from satellite measurements to try and quantify the presence of small ice crystals. This is key to establishing the consistency between the in-situ and remotely-sensed effective radii.

We are great admirers of the work of Mitchell et al (2010). Their technique differs from our approach, however, in that it uses a heavily parameterized and 'tuned' retrieval scheme (i.e. makes very specific assumptions of real-world cloud properties) to estimate ice particle size. Their work finds that particles must be 'large' based upon observations from two TC4 cirrus test cases and one TWP-ICE cirrus test case. We do not doubt their conclusions for their test cases. But we do not see any great need to place our results for SPartICus test cases in context of their retrieval results for these other field campaigns with different locations (tropics vs. mid-latitudes) and very possibly different cloud formation mechanisms or cloud lifetime stage, etc. We think it is more important simply to show that we find 'small' particles where the in-situ measurements suggest 'small' particles etc. and to avoid broad generalizations to different remote sensing techniques and different clouds than those in this paper. It, of course, would be interesting to jointly apply our schemes to common conditions in a future field campaign.

Coming back to your comparison, the in-situ estimates of effective radius are of course linearly sensitive to your choice of mass-area relationship. How confident are you of this choice? The relation in Baker et al was derived for particles hundreds of microns to millimetres in size - have you thought about how well this extrapolates to small sizes?

We agree the accuracy of the in-situ estimates of effective radius is very sensitive to choice of mass-area relationship. Uncertainties in the Spec Inc. shattering algorithm assumptions used to produce final cloud properties indeed may cause the slight discrepancy between our bi-spectral technique and the 2D-S for the intermediate case.

As stated for other reviewers, the purpose of this paper is to show how our bi-spectral technique can be applied to in-situ campaigns through use of SPartICus Spec Inc. provided data and to provide a first order estimate of instrument/ algorithm performance.

It is not to present the definitive study on the veracity of either instrument results or Spec Inc. cloud property algorithms. In a future paper, we would be more than happy to work with Spec Inc. to examine the sensitivity of cloud property estimates to the Spec Inc. assumptions that are used (assuming mutual interest with Spec Inc.) But such work was beyond the scope of our work for this paper.

To stress the fact that we do not aim to rigorously define instrument performance, we added the following sentence in the last paragraph of the introduction,

'However, given the limited number of good test cases for our technique during the campaign, and the fact that our infrared technique was not considered for design of the campaign, we cannot present either a broad characterization of SPartICus cloud properties or a definitive analysis of in situ instrument performance.'

A final comment: You mention in your paper that you can find no evidence of shattering effects in the FSSP data. I wonder if it might be helpful to: - quantify what level of shattering would be required for you to be able to conclude that shattering is occurring; - point out the previous literature which HAS found evidence of shattering to put your results in context.

Based upon this and other reviewer comments, we now realize we included an un-necessarily argumentative sentence in our abstract in regards to previous work involving shattering in the FSSP: 'There is no evidence to support that an FSSP-100 with unmodified inlets produces measurements of *r*e in cirrus that are strongly biased low, as has been claimed.' This sentence gives the un-intended impression that we feel previous efforts may have been wrong. In our paper, we had previously pointed out the Korolev and Isaac (2005) demonstrated that ice particles will shatter in the FSSP for some test conditions. We simply meant that we found no definitive evidence for shattering based upon our bi-spectral technique and given SpartICus test cases. We do not doubt the findings of previous works for their specific test cases.

So we have re-written this offending sentence, adding in 'For our test cases,' and removing 'as has been claimed', …

'For our test cases, there is no evidence to suggest that an FSSP-100 with unmodified inlets produces measurements of re in cirrus that are strongly biased low.'