On Harmonizing the IR-Based Cloud Top Properties Between MODIS and VIIRS

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Goal: The lack of at least one IR absorption channel on VIIRS degrades the accuracy of the cloud top pressure/height and thermodynamic phase products. **However, *we can synthesize a high spatial resolution 13.3-µm CO_2 channel for VIIRS from a combination of VIIRS+CrIS (Cross, et al. 2013)*.** The creation of a 13.3-µm "pseudo-channel" at the imager spatial resolution is a unique opportunity, possible because the top-of-atmosphere radiances at this wavelength have a contribution from both the surface (about 1/3 of the signal) and the atmosphere, primarily from CO_2 (about 2/3 of the signal). The atmospheric contribution from CO_2 is uniform enough so that CrIS measurements at coarser spatial resolution (~14 km) can be combined with the VIIRS window channel measurements to synthesize a 13.3-µm channel at 750 m spatial resolution. The method is being developed and tested using MODIS and AIRS, since MODIS has measured 13.3-µm radiances for assessing the pseudo-channel. The same approach can be applied to Metop (e.g. AVHRR and IASI). *More information is available at* http://www.ssec.wisc.edu/suomi_npp/clouds/

Importance of having a single IR sounding channel

As we learned in the MODIS Collection 6 development of the IR-based cloud thermodynamic phase, supplementing the IR window channels with a single sounding channel greatly improved the discrimination of optically thin ice clouds as being ice phase rather than uncertain. With the addition of a single sounding channel, the cloud top height/pressure is also improved over that obtained from IR window channels alone. ***To achieve harmony between MODIS and VIIRS, we suggest replacing (or supplementing) the CO_2 slicing algorithm, which uses 4 channels within the broad 15-µm CO_2 band, with an optimal estimation approach.***

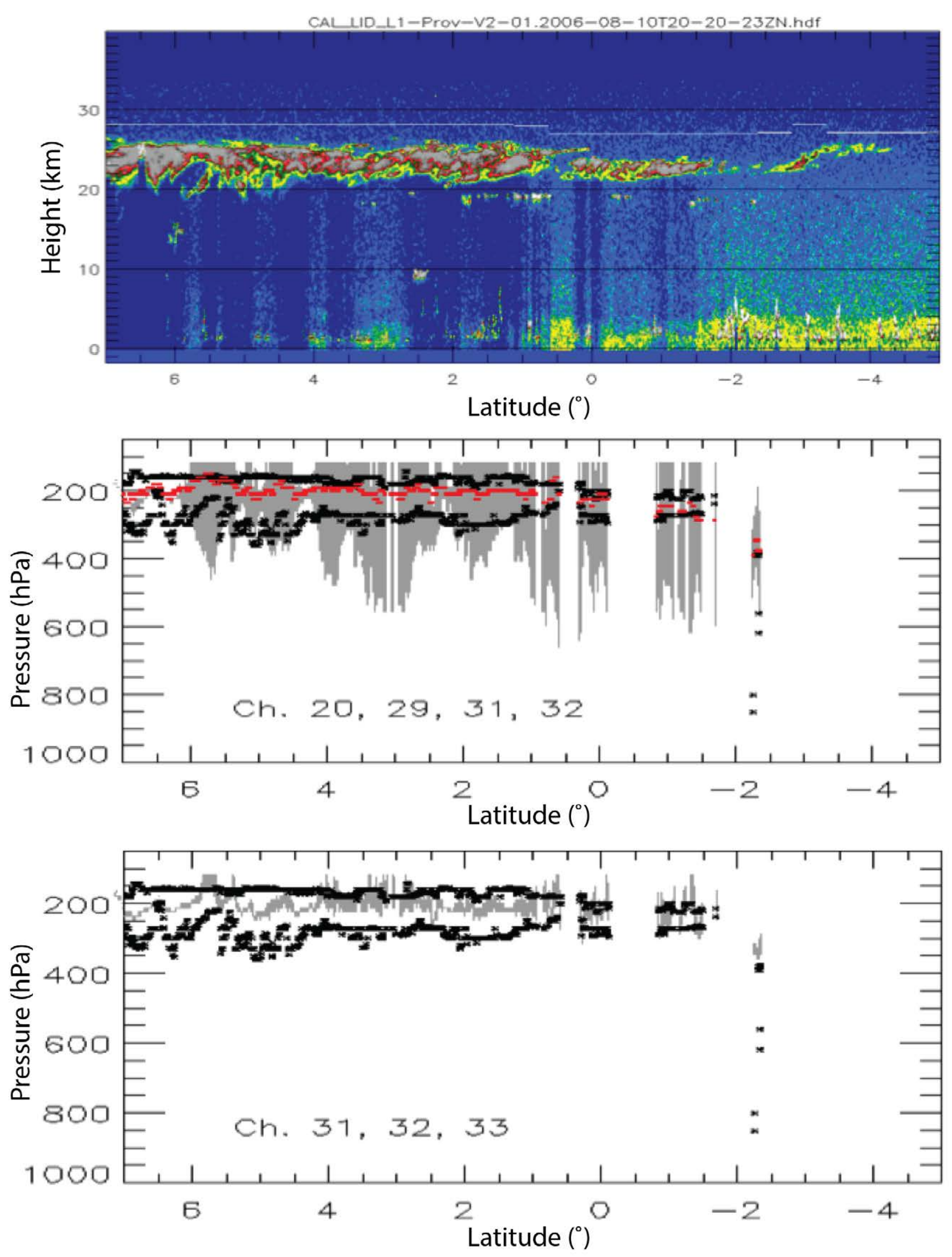

Figure 1: (top) backscattering measurements from CALIPSO from 10 August 2006, (middle) CALIPSO cloud boundaries for the ice cloud only are shown in black, MODIS cloud-top pressures in red, and the optimal estimation-based CTP solution space in gray (lower) with the addition of the 13.3-µm pseudo-channel, the solution space is much narrower and much closer to the MODIS retrievals. Figure from Heidinger et al. (2010).

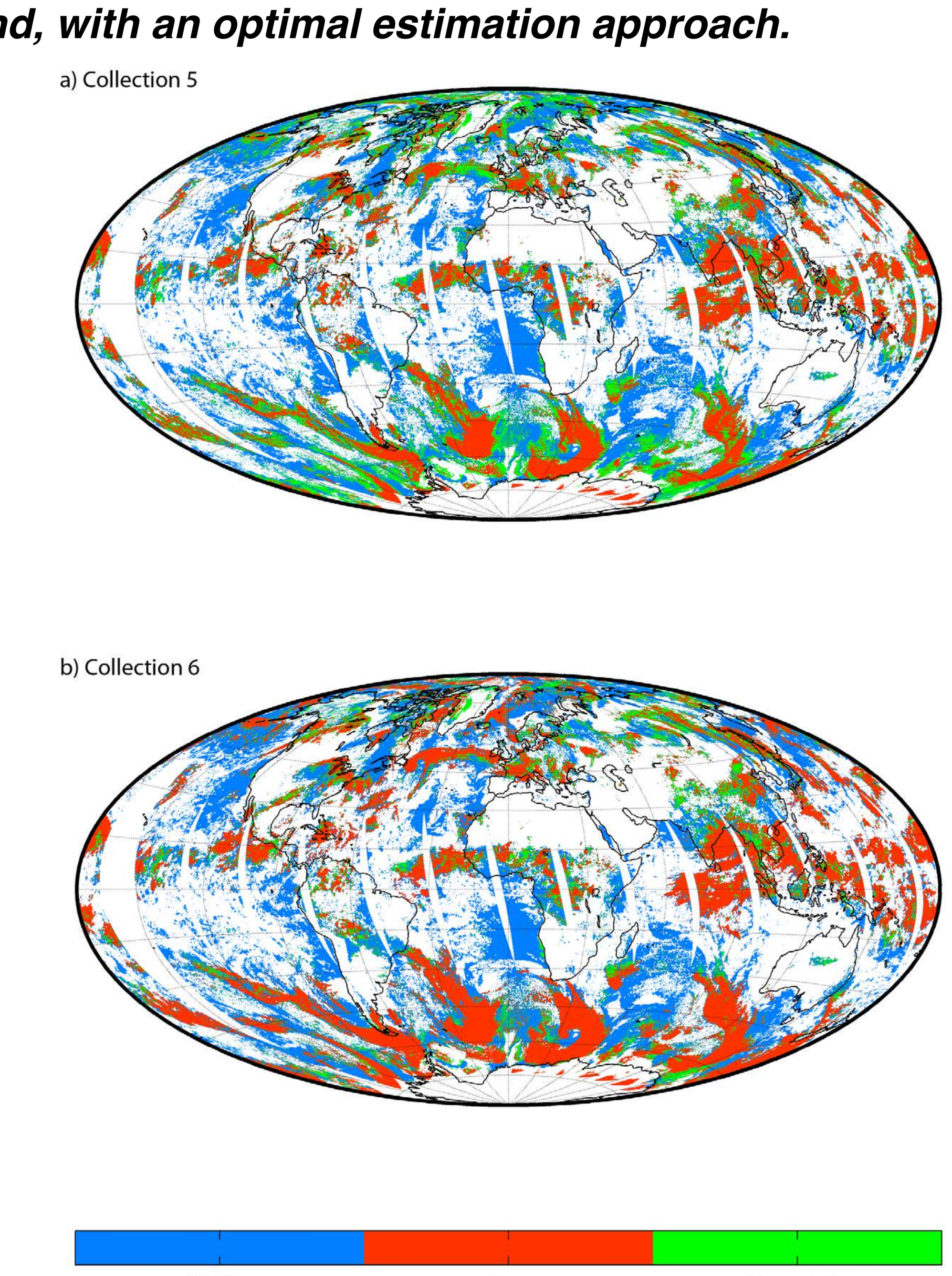

Figure 2: Results for IR cloud phase on 28 August 2006 (daytime, although it does not matter since only IR channels are used), for (a) Collection 5 IR phase algorithm, and (b) Collection 6 IR cloud phase. For the Collection 5 results, the "mixed-phase" pixels are merged into the "uncertain" category as is done with Collection 6. By introducing cloud emissivity ratio tests using a sounding channel, the discrimination of thin cirrus as being ice phase is much improved in Collection 6. The same approach can be adopted for VIIRS if there is a 13.3-µm channel to work with. Figure from Baum et al. (2012).

Relevant Publications

Baum, B. A., W. P. Menzel, R. A. Frey, D. Tobin, R. E. Holz, S. A. Ackerman, A. K. Heidinger, and P. Yang, 2012: MODIS cloud top property refinements for Collection 6. *J. Appl. Meteor. Clim.*, **51**, 1145-1163.

Cross, J. I. Gladkova, W. P. Menzel, A.Heidinger, and M. D. Grossberg, 2013: Statistical estimation of a 13.3 µm Visible Infrared Imaging Radiometer Suite channel using multisensor data fusion. *J. Appl. Remote Sens.* **7** (1), 073473. doi: 10.1117/1.JRS.7.073473.

Heidinger, A. K., M. J. Pavolonis, R. E. Holz, B. A. Baum, and S. Berthier, 2010: Using CALIPSO to explore the sensitivity to cirrus height in the infrared observations from NPOESS/VIIRS and GOES-R/ABI. *J. Geophys. Res.*, **115**, D00I15, doi:10.1029/2009JD012379.

Test: Comparison of Two Methods for Combining MODIS+AIRS

Two methods are considered:

1. Data fusion of imager+sounder (e.g. MODIS+AIRS; VIIRS+CrIS; AVHRR+IASI on Metop) to create high spatial resolution 13.3-µm channel as detailed in Cross et al. (2013).
2. Superimpose integrated 13.3-µm radiances from coarser spatial resolution sounder (AIRS, CrIS, IASI) onto higher spatial resolution imagery. This approach is adopted in the Intermediate File Format (IFF) developed at the Atmosphere PEATE.

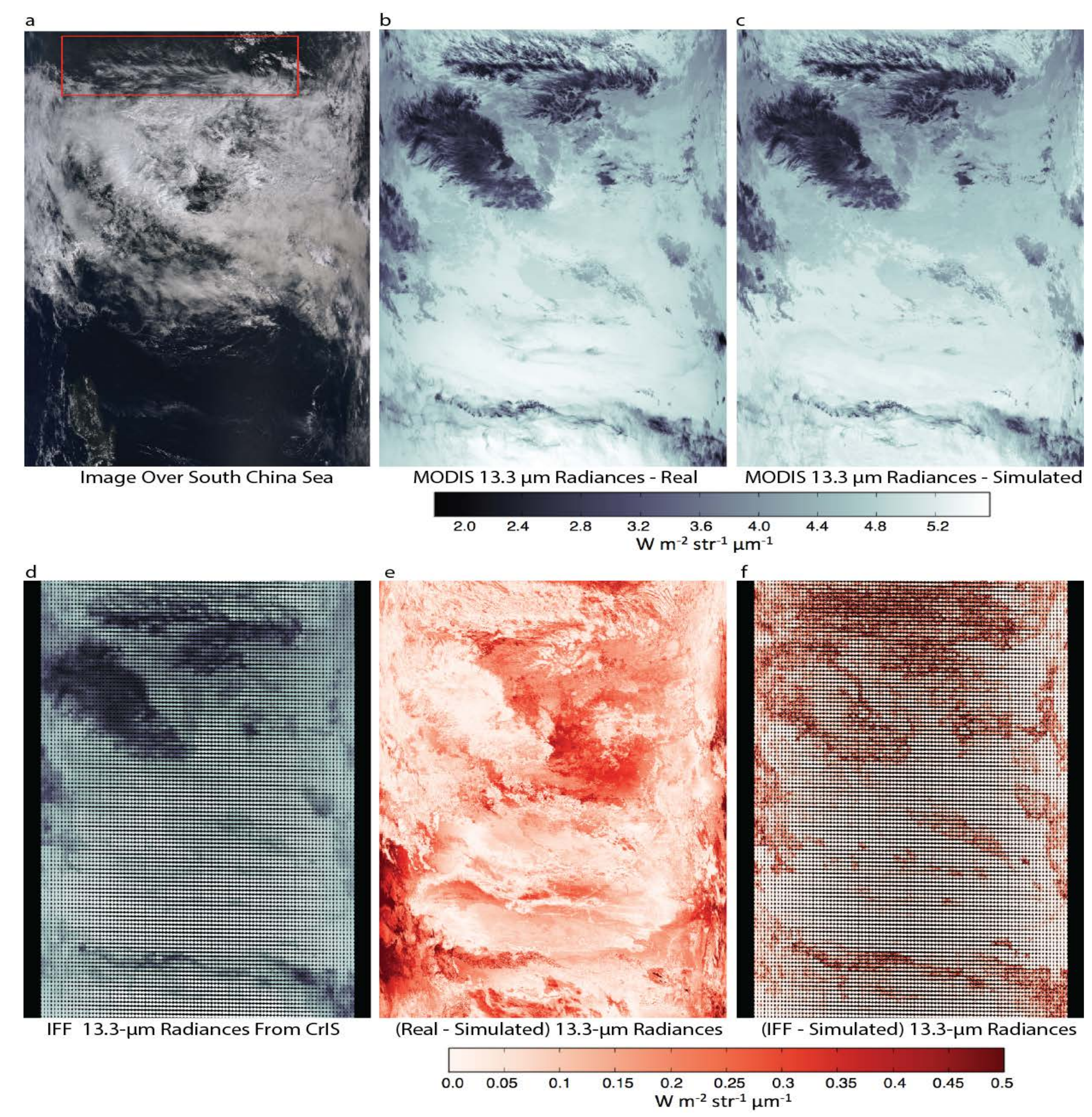

Figure 3: (a) RGB MODIS image over the south China Sea on 1 March 2013, (b) actual MODIS 13.3-µm radiances where cold clouds are dark, (c) multifusion pseudo-channel 13.3-µm radiances, (d) IFF 13.3-µm radiances from AIRS, (e) (real minus pseudo-channel) 13.3-µm radiances, (f) (real minus AIRS) 13.3-µm radiances. **For this scene, the pseudo-channel approach has a RMSE of 0.015 W m^{-1} str^{-1} µm^{-1} (or about 0.2 K) for all MODIS pixels.**

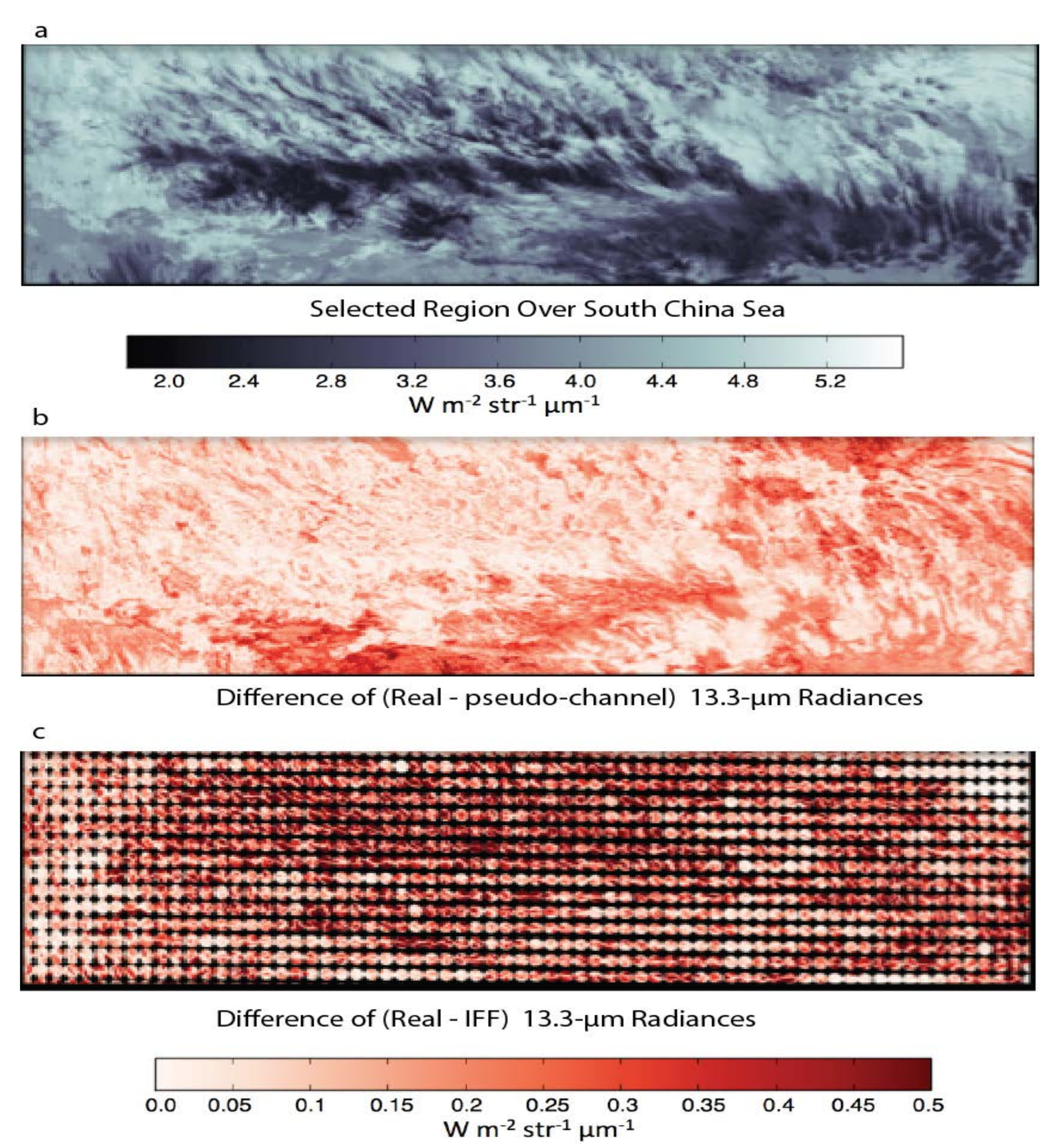

Figure 4: (a) The 13.3-µm image over a selected region of the south China Sea highlighted in Figure 3a. Note that cold clouds are dark while warm targets are gray/white. (b) the radiance differences between the MODIS measured and pseudo-channel 13.3-µm data, (c) the radiance differences between the real and IFF 13.3-µm data. Note that the IFF overlays data only from the AIRS footprint, which leaves gaps in spatial coverage.