Creating a high spatial resolution CO_2 sensitive 13.3 µm channel for AVHRR and VIIRS

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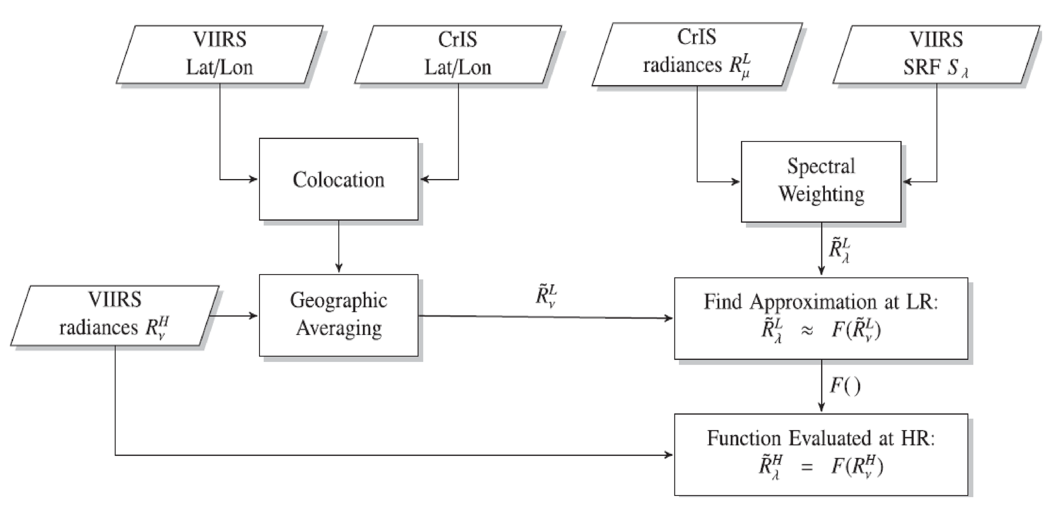
Abstract

The lack of any CO_2 absorption channel on AVHRR and VIIRS degrades the accuracy of the cloud top pressure/height and thermodynamic phase products. **However, *a high spatial resolution 13.3-µm CO_2 channel can be synthesized for AVHRR and VIIRS from a combination of imager and sounder radiances.*** 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 sounder measurements (HIRS or IASI or CrIS) at coarser spatial resolution (~20 or 14 km) can be combined with the imager (AVHRR or VIIRS) window channel measurements to synthesize a 13.3-µm channel at imager spatial resolution (1 km or 750 m). The multi-fusion approach 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 NOAA, S-NPP, and Metop.

Fusion Approach (detailed in Cross et al. 2013).



Sensor	Platform	FOV (km)	Swath Width (km)
AVHRR	NOAA	1	2800
HIRS		20	2200
MODIS	Aqua	1	2330
AIRS		13.5	1650
VIIRS	S-NPP	0.75	3040
CrIS		14	2200
AVHRR	Metop A/B	1	2800
IASI		12	2200

The importance of a single CO_2 sensitive channel

MODIS Collection 6 development of an IR-based cloud thermodynamic phase found that supplementing IR window channels with a single sounding channel greatly improved discrimination of optically thin ice clouds as being ice phase rather than uncertain. Addition of a single sounding channel has also been shown to improve cloud top height/pressure estimation over that obtained from IR window channels alone. See examples below.

To achieve consistency from AVHRR, MODIS, and VIIRS, it is suggested to create a pseudo 13.3µm channel and to infer cloud properties with an optimal estimation approach.

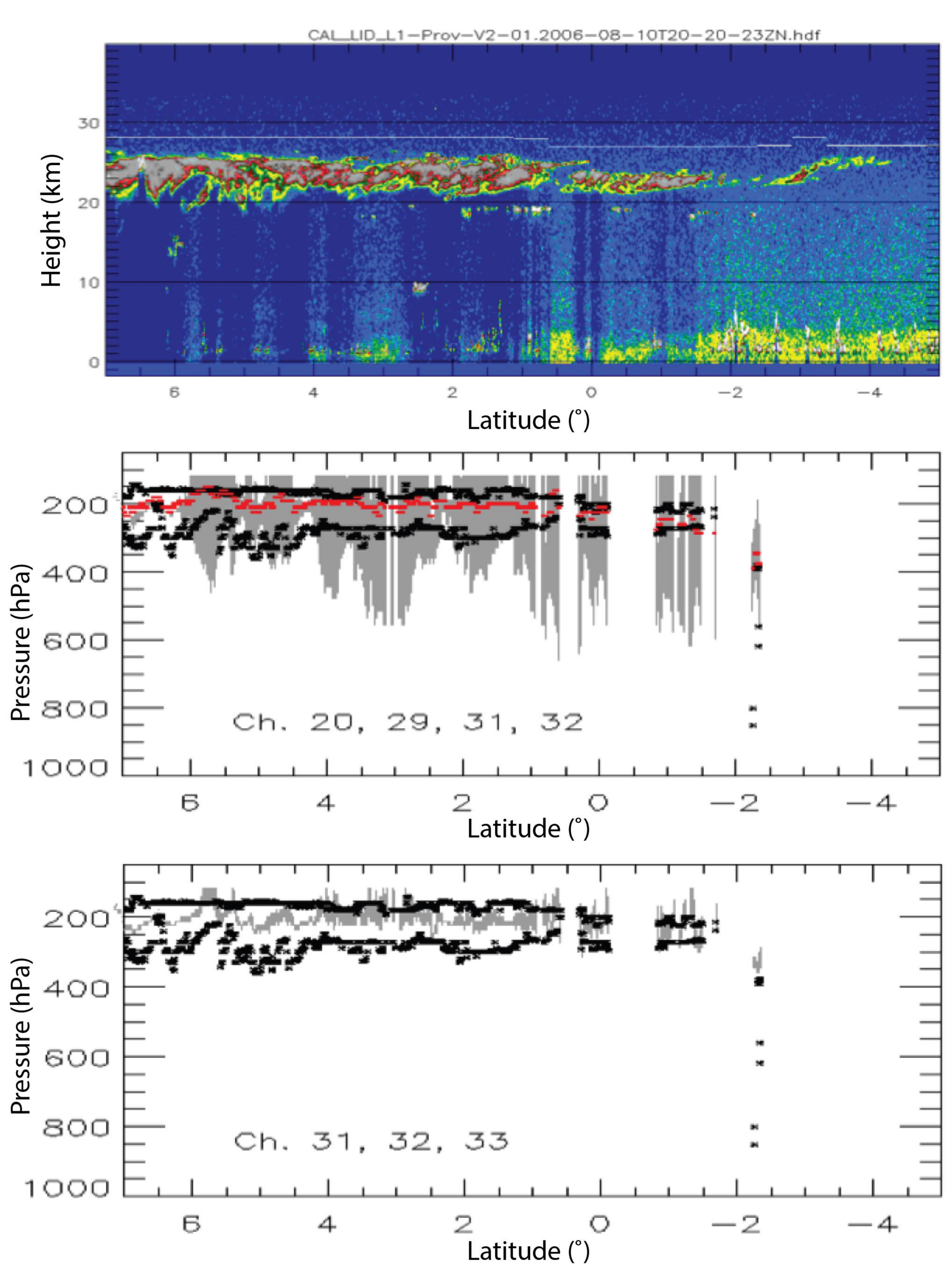


Figure 1: (top) backscattering measurements from CALIPSO from 10 August 2006, (middle) CALIPSO cloud boundaries for the ice cloud only are shown in black, MODIS cloud-top pressures in red, and the optimal estimation-based CTP solution space in gray (lower) with the addition of the 13.3-µm pseudo-channel,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

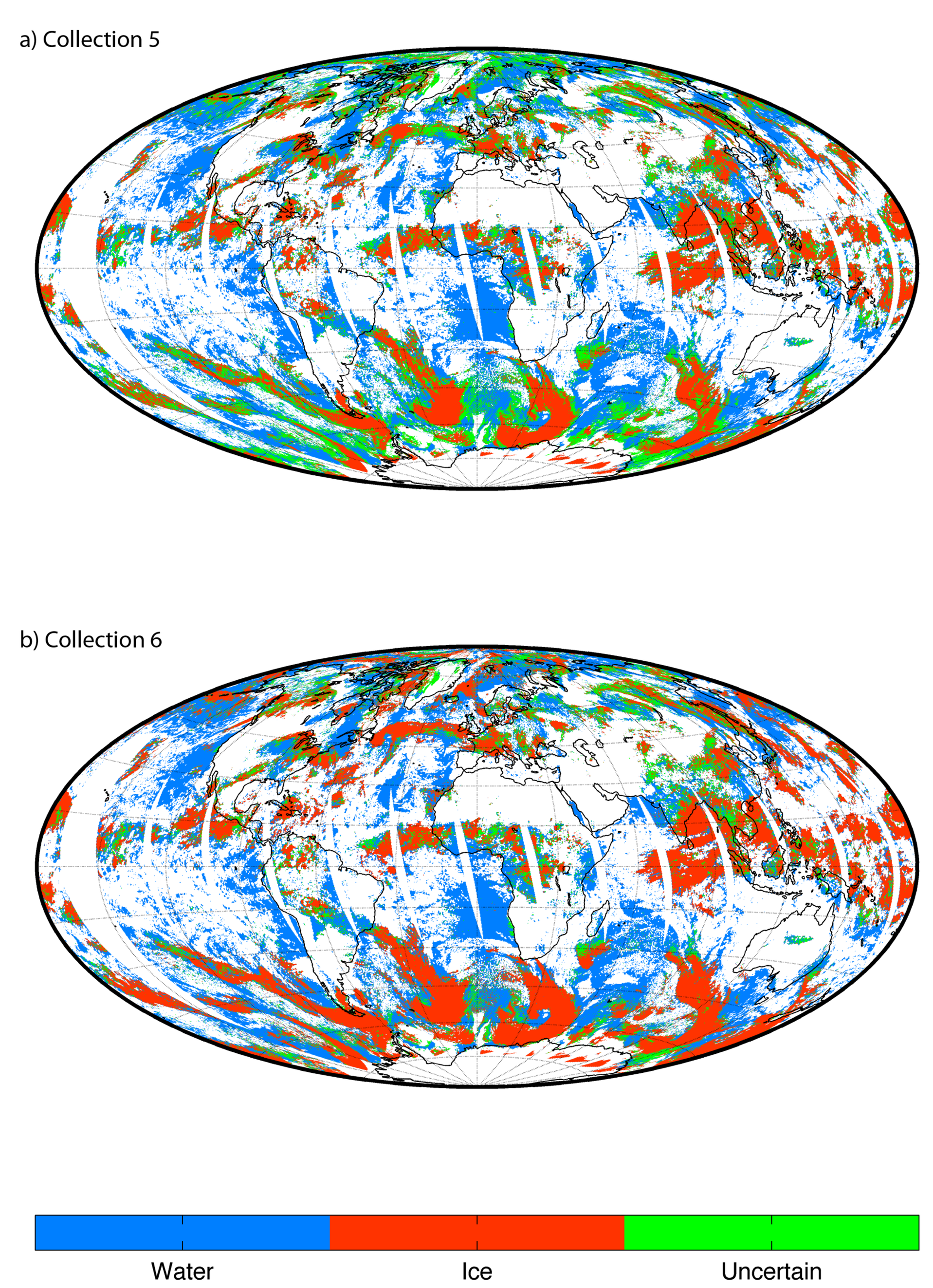


Figure 2: IR cloud phase on 28 August 2006 for (a) Collection 5 and (b) Collection 6. Collection 5 "mixed-phase" pixels are merged into the "uncertain" category as is done with Collection 6. Introducing cloud emissivity ratio tests using a sounding channel improves discrimination of thin cirrus as being ice phase in Collection 6. The same approach can be adopted for AVHRR or VIIRS when a 13.3-µm channel is added. Figure from Baum et al. (2012).

MODIS plus AIRS Test Demonstration

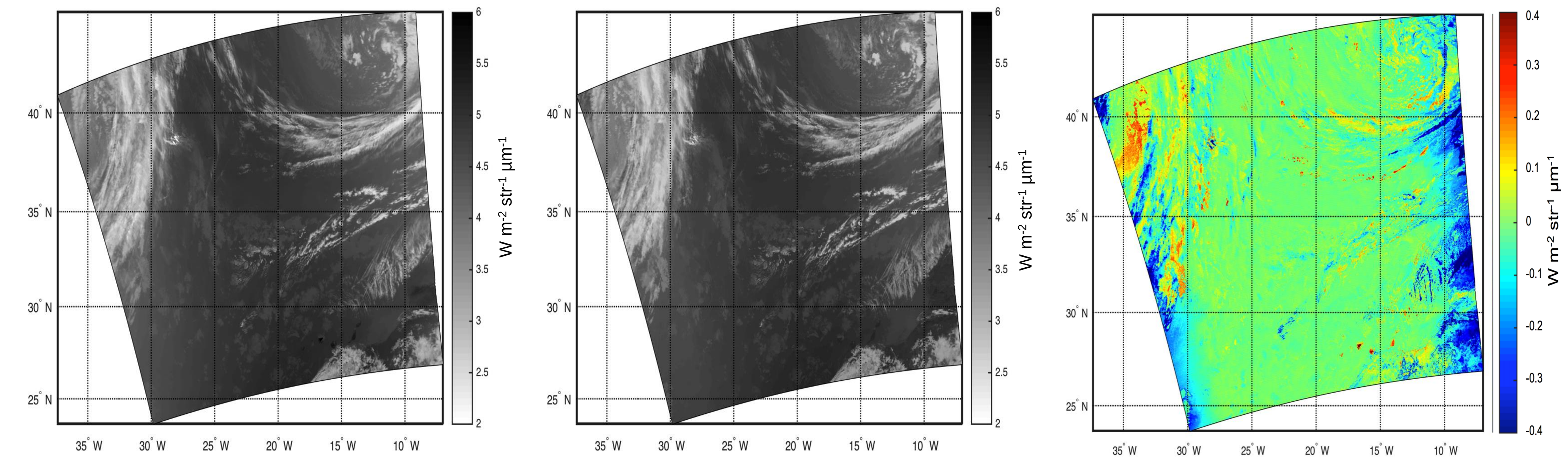


Figure 3: Aqua example from 17 April 2015 at 1435 UTC; (left) measured MODIS 13.3-µm radiances, where cold clouds are bright, (middle) fusion pseudo-channel 13.3-µm radiances created from MODIS IR windows and AIRS convolved 13.3- µm measurements, (right) real minus pseudo-channel 13.3-µm radiances. **For this scene, the pseudo-channel has a RMSE of 0.015 W m^{-1} str^{-1} µm^{-1} (or about 0.2 K) for all MODIS pixels; global RMSE for this day (for zenith angles less than 55 degrees) is less than 0.01 W m^{-1} str^{-1} µm^{-1} .**

VIIRS plus CrIS Example

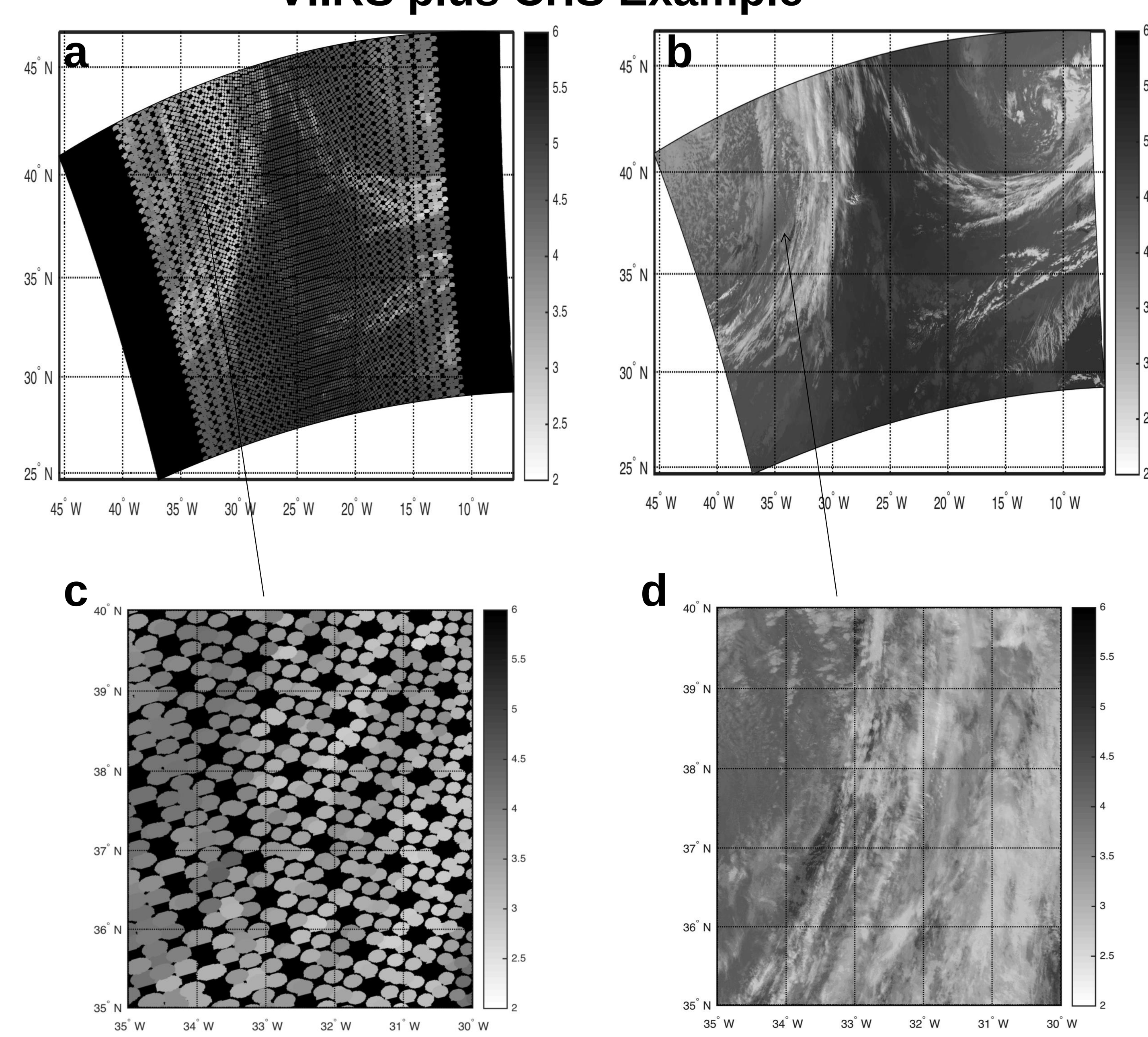


Figure 4: S-NPP example from 17 April 2015 at 1440 UTC; (a) CrIS FOVs superimposed on the VIIRS swath, (b) fusion pseudo-channel 13.3-µm radiances created from VIIRS IR windows and CrIS convolved 13.3-µm measurements – note good comparison with MODIS 13.3-µm image above from 5 minutes earlier, (c) close-up of CrIS 13.3-µm, and (d) close-up of VIIRS pseudo channel 13.3-µm.

AVHRR plus HIRS Example

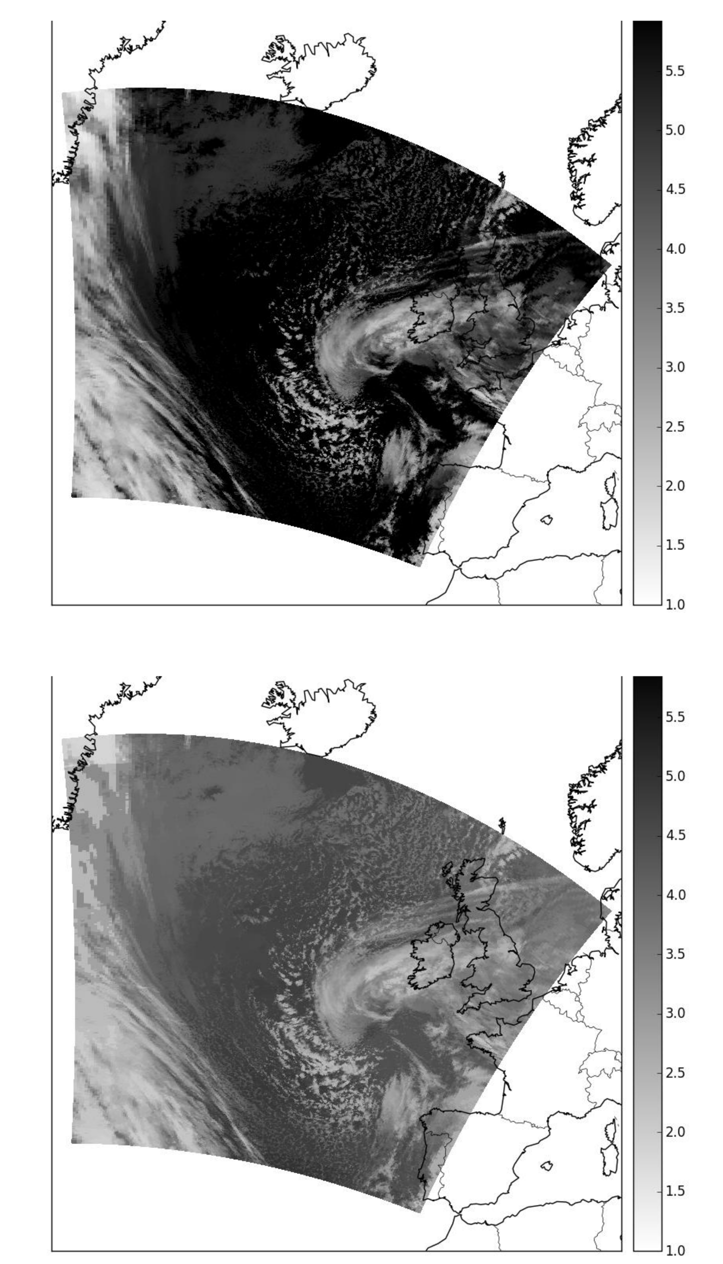


Figure 5: NOAA-18 example from 31 Dec 2014 at 400 UTC; (top) AVHRR 11-µm radiance image and (bottom) fusion pseudo-channel 13.3-µm radiances created from AVHRR IR windows and HIRS convolved 13.3-µm measurements.

Conclusions

- Creating an imager pseudo-channel at 13.3 µm from co-located imager and sounder radiances has significant implications for future imager spectral channel selection and instrument design; imager spectral range can be curtailed at 12.5-µm when a sounder is on the same platform.
- There is the opportunity for a consistent cloud data record from 1978 onwards using LEO imager data (AVHRR, MODIS, VIIRS) supplemented by LEO sounder 13.3-µm radiances.
- A similar opportunity exists for a volcanic ash detection / height assignment data record (Pavolonis et al., 2013)

References

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