1.5.2 Limb Correction of SEVIRI and AVHRR Infrared Channels in Clear and Cloudy Regions for the Improved Interpretation of RGB Composites

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1. Challenges with RGB Composites

- **Limb effects interfere with qualitative interpretation of RGB composites** as satellite zenith angle (SZA) increases (Fig. 1)
- **Cause anomalous cooling on the limb of 5-12 K** in water vapor and ozone channels and 1-5 K in window channels, depending on channel sensitivity to atmospheric absorbers (Elmer et al. 2016)
- Strong need to remove limb effects from infrared bands in order to improve RGB composite interpretation on the limb

2. Limb Correction

- **Limb correction adjusts brightness temperatures (BT) at large SZA to a nadir view**
- Clouds effectively shorten the optical path length, complicating limb correction
- **Elmer et al. (2016) developed limb correction technique** to remove limb effects in real-time from Terra/Aqua MODIS and Suomi-NPP VIIRS infrared channels, but correction can be applied to all sensors
- Limb effect a function of latitude, Julian day, SZA, and cloud top pressure (for cloudy regions only)
- Limb-corrected MODIS, VIIRS, and NOAA AVHRR RGB composites currently used operationally within the United States by multiple Weather Forecast Offices

3. Methodology

- This work extends Elmer et al. (2016) limb correction to include MSG SEVIRI and Metop-A/B AVHRR
- MSG Optimal Cloud Analysis (EUMETSAT 2016) provides cloud top pressure for SEVIRI for SZA < 75°
- Unlike MODIS and SEVIRI, limb correction for AVHRR does not currently account for cloud effects
- Limb-corrected Aqua MODIS used to validate SEVIRI limb correction
- MODIS and AVHRR inter-calibrated with SEVIRI prior to limb correction to account for sensor differences, following methodology in Elmer et al. (2016)

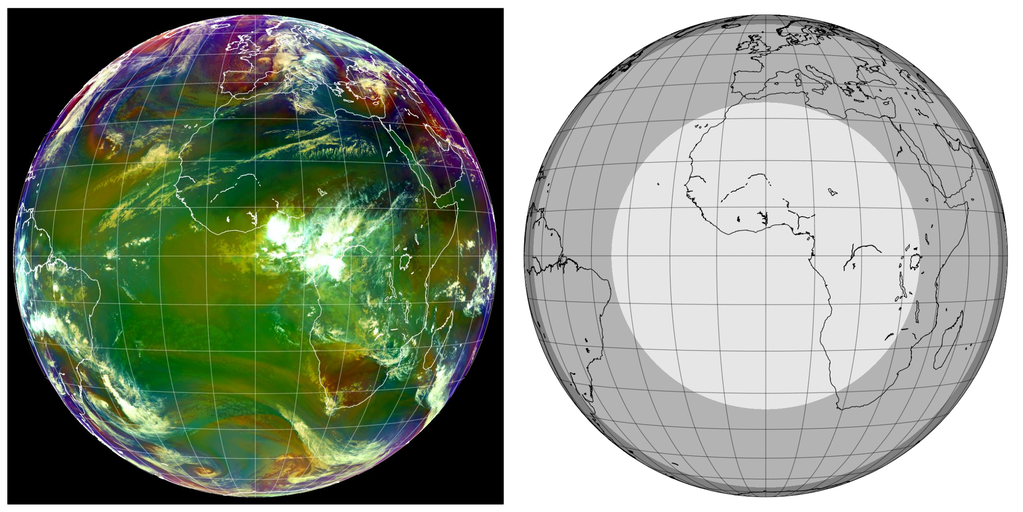


Figure 1. (left) Evidence of limb cooling in the SEVIRI Air Mass RGB is indicated by a reduction in green coloring and increase in blue coloring as the SZA increases radially from the center of the image. (right) SZA contoured at 40° and 75°. Limb effects are minimal for SZA < 40° (light gray), but can adversely affect interpretation for 40° < SZA < 75° (medium gray). For SZA > 75° (dark gray), the limb effect is substantial.

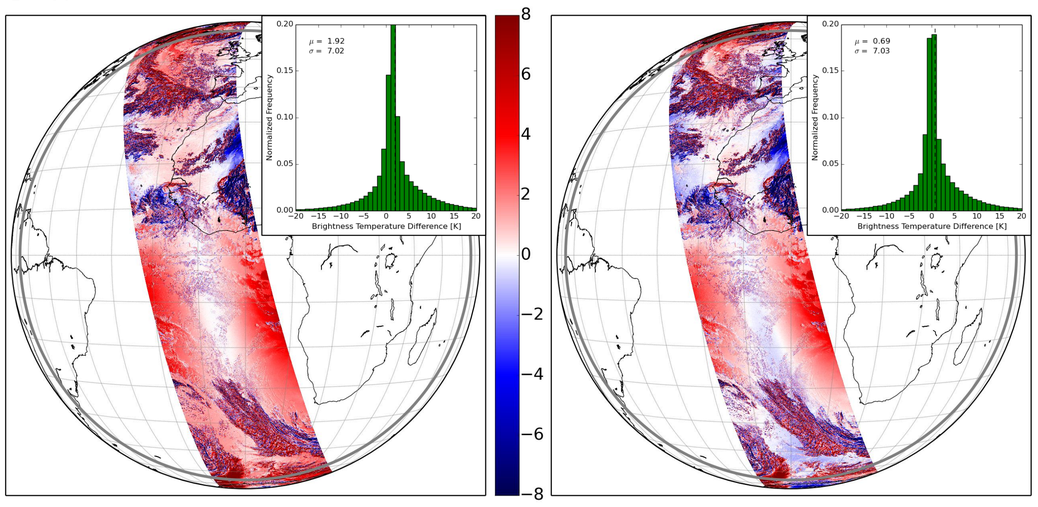
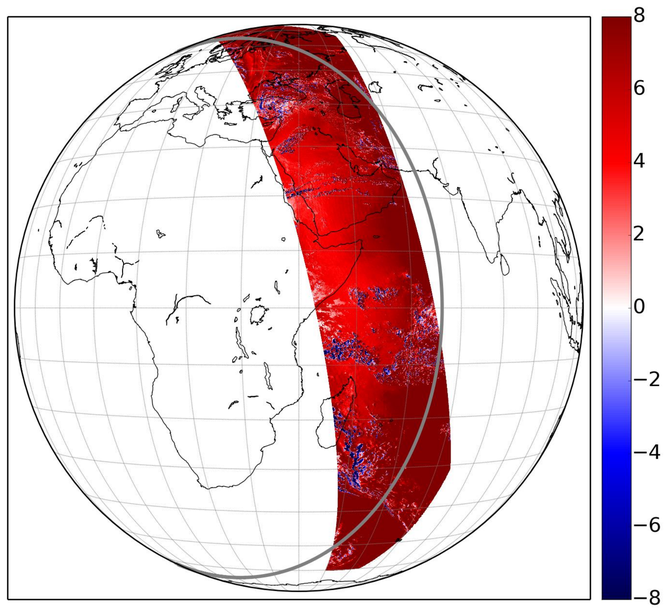


Figure 2. 3 September 2015 Metop-A AVHRR (2150 UTC) band 4 (10.8 μm) minus SEVIRI (2200 UTC) band 9 (10.8 μm) brightness temperature difference (BTD; Kelvin) at common points for (left) uncorrected AVHRR/SEVIRI and (right) limb-corrected AVHRR/SEVIRI.



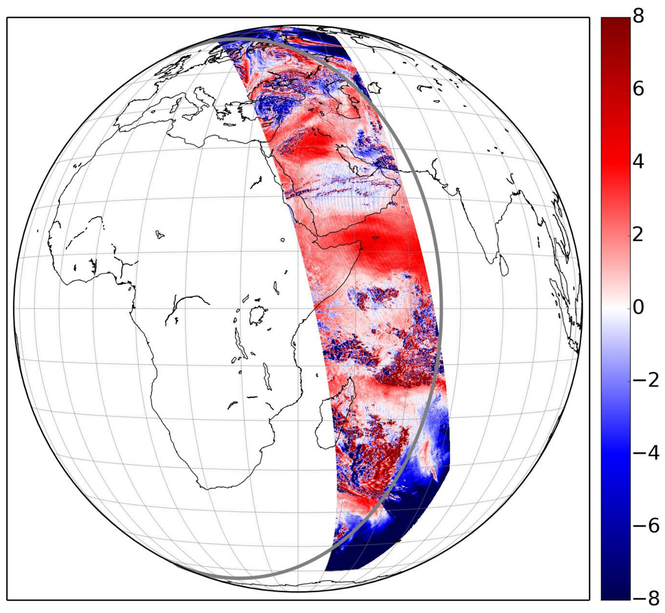


Figure 3. 5 March 2016 limb-corrected Aqua MODIS (0945 UTC) band 28 (7.33 μm) minus SEVIRI (1000 UTC) band 6 (7.35 μm) BTD (Kelvin) at common points for (top) uncorrected SEVIRI and (bottom) limb-corrected SEVIRI. The gray line indicates SZA = 75°. Note large differences in cloudy regions due to cloud motion.

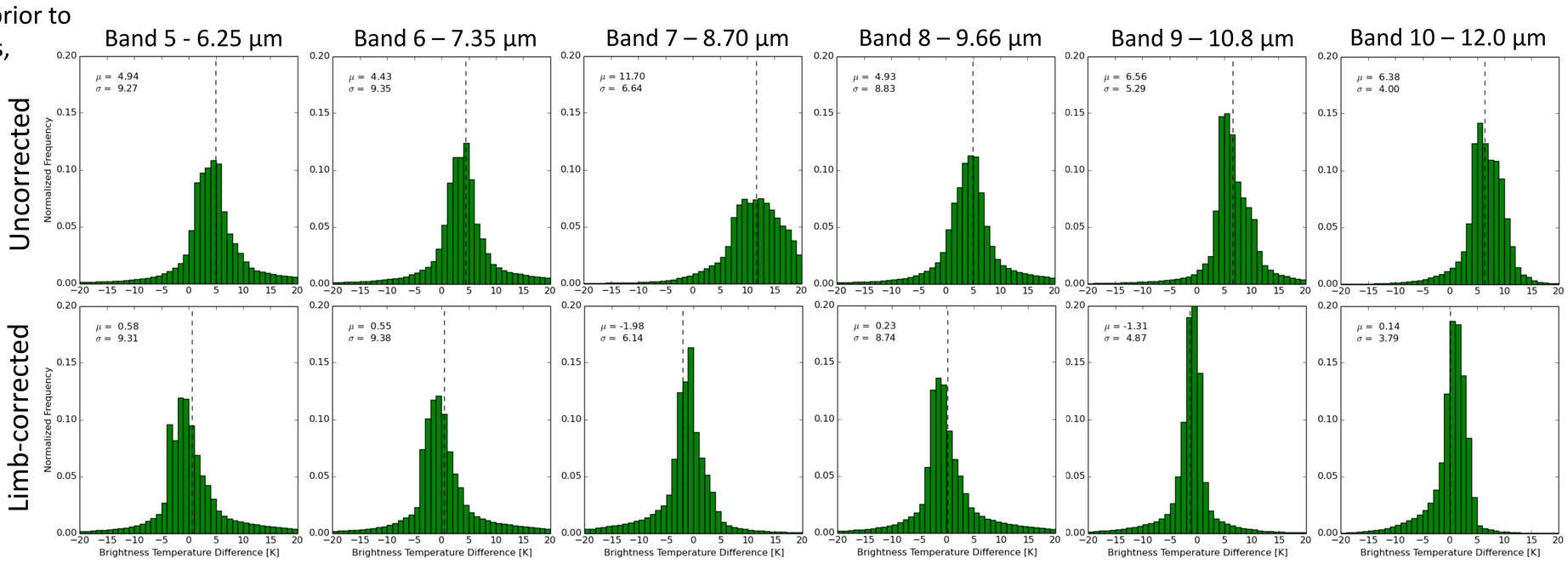
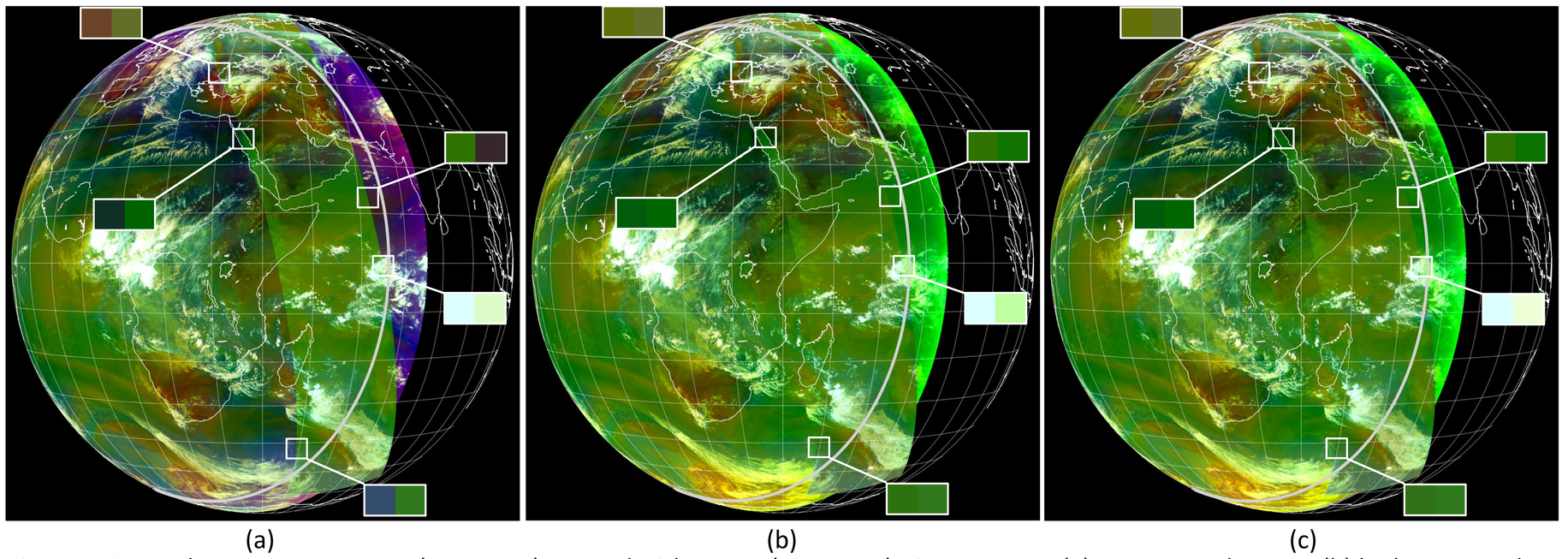


Figure 4. Histograms representing departure of SEVIRI BT from the verification BT before (top row) and after (bottom row) limb correction for SEVIRI bands 5-10 at SZA < 75°, corresponding to case shown in Fig. 3. The tails of the distributions are attributed to cloud movement.



(a) (b) (c)

Figure 5. 5 March 2016 Aqua MODIS (0945 UTC) merged with SEVIRI (1000 UTC) Air Mass RGB. (a) uncorrected SEVIRI, (b) limb-corrected SEVIRI not accounting for cloud effects, and (c) limb-corrected SEVIRI accounting for cloud effects. The gray line indicates SZA=75°.

4. Results

- Limb correction reduces anomalous cooling on the limb in AVHRR band 4 by 1-2 K, but cloud effects still apparent (Fig. 2)
- **Reduction of SEVIRI BT error from 4-12 K to 0-2 K for all IR bands (Fig. 3-4)**
- **Limb-corrected SEVIRI Air Mass RGB shows coloring consistent with observed features in the Aqua MODIS Air Mass RGB for both clear and cloudy regions**
- SEVIRI limb correction cannot be calculated for SZA>75° due to substantial limb effects (SEVIRI only detects upper atmosphere) and unavailable cloud top pressure data (only available for SZA < 75°)
- SEVIRI, MODIS, and AVHRR IR channels were limb corrected independently, but depict very similar limb-corrected BT at all SZA
- Results indicate that Elmer et al. (2016) correction technique robustly removes limb effects from infrared imagery for both polar-orbiting and geostationary sensors
- By removing limb effects, RGB composites derived from multiple sensors can be used jointly for analysis

5. Future Work

- Improve verification statistics for SEVIRI limb correction by assessing more case studies
- Extend the limb correction methodology to other geostationary sensors, including Himawari AHI, GOES-R ABI, and MTG FCI.

References

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