Limb Correction of Infrared Imagery in Cloudy Regions for the Improved Interpretation of RGB Composites

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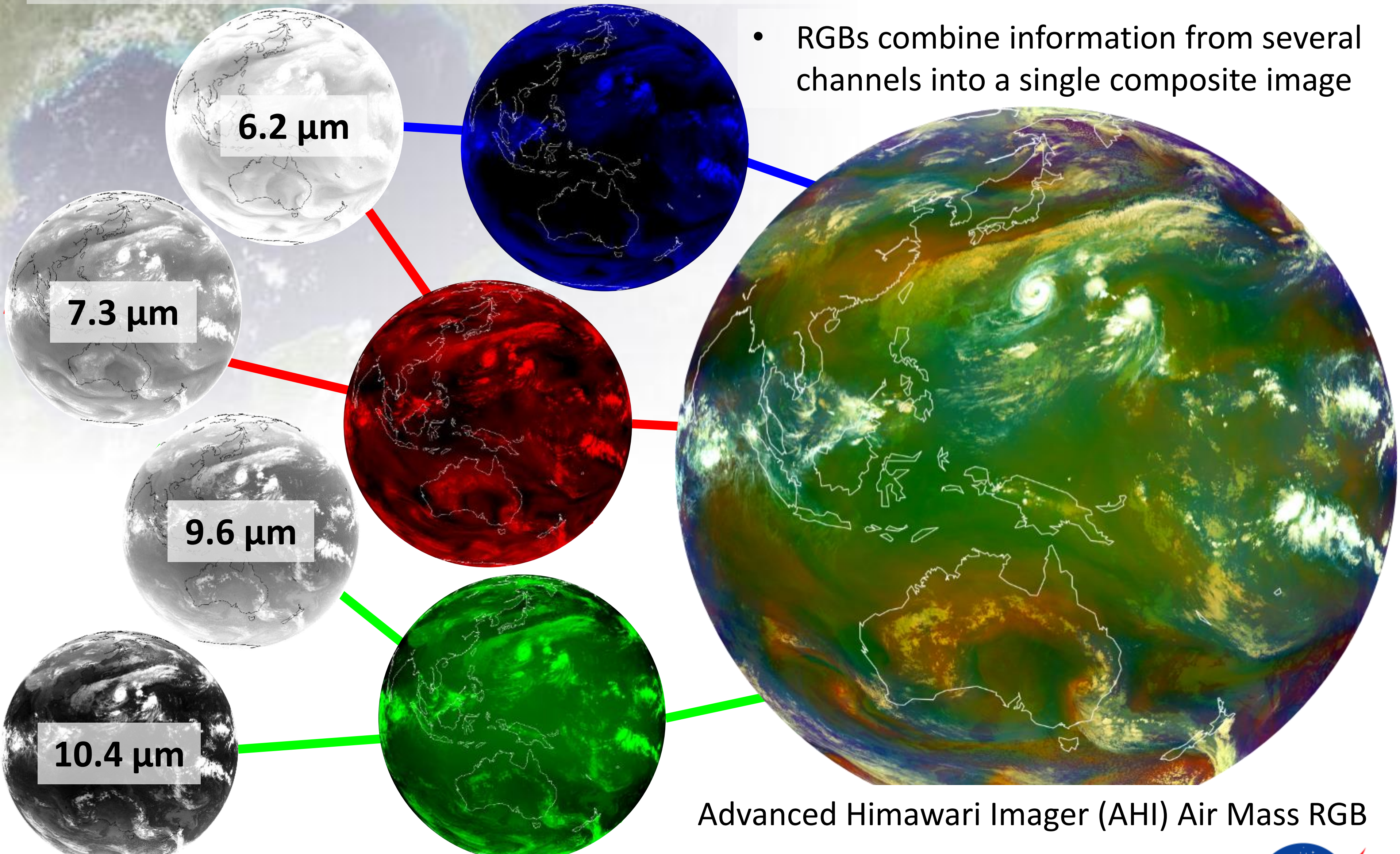
RGB Composites

- RGBs combine information from several channels into a single composite image



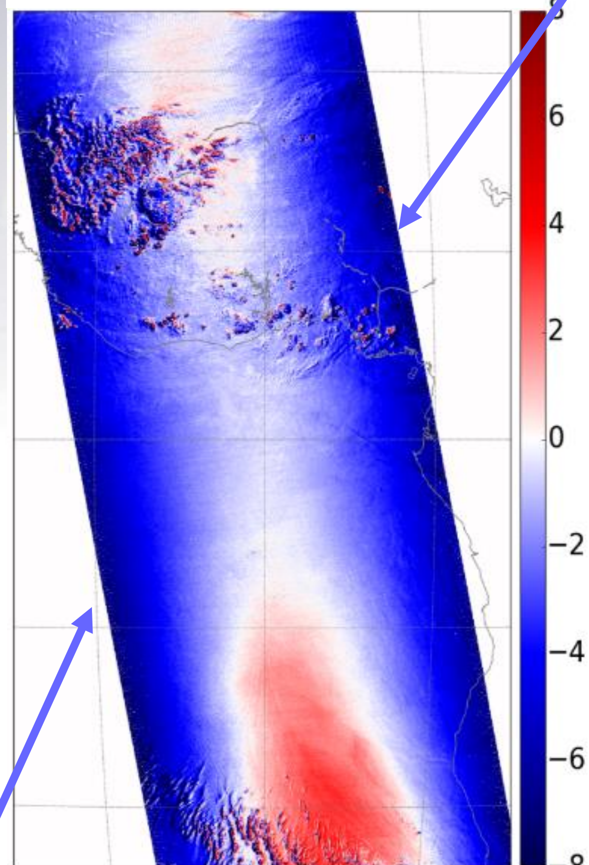
Advanced Himawari Imager (AHI) Air Mass RGB

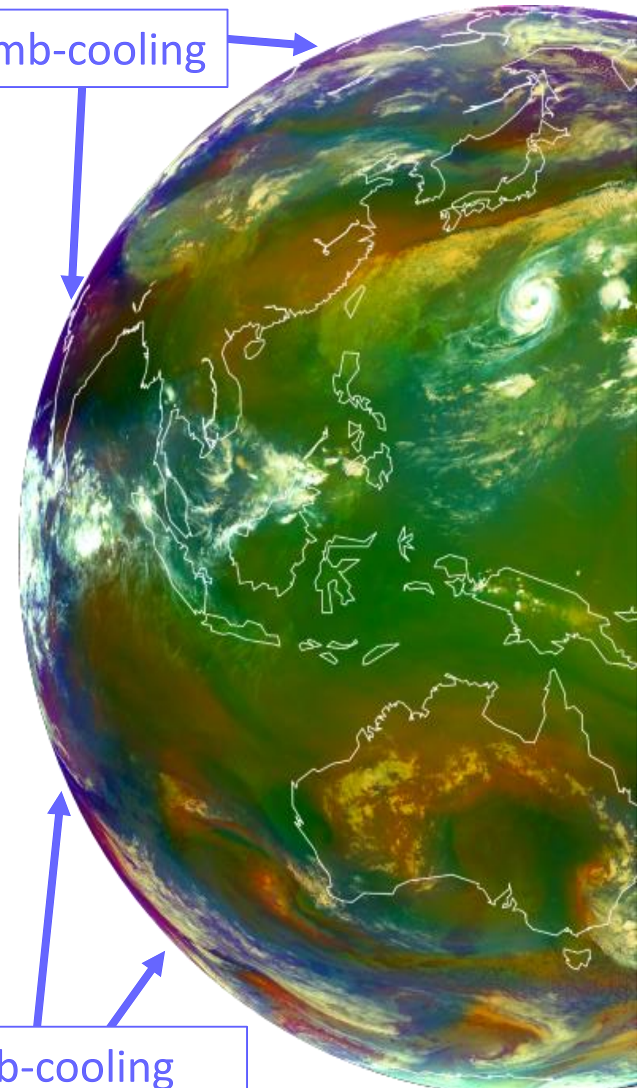
Limb Effect (Limb-Cooling)

- **Limb-cooling** occurs as the viewing zenith angle (θ_Z) increases, increasing the optical path length of the absorbing atmosphere (Goldberg et al. 2001; Joyce et al. 2001; Liu and Weng 2007)

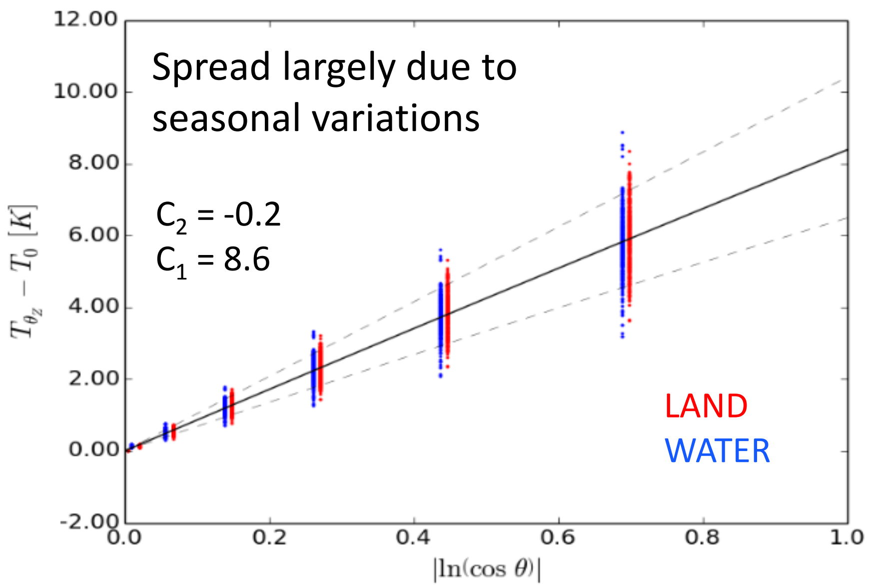
- Limb effects interfere with qualitative interpretation of RGB composites at large θ_Z (both polar-orbiting and geostationary sensors)

Aqua MODIS minus SEVIRI brightness temperature difference (6.7 µm)





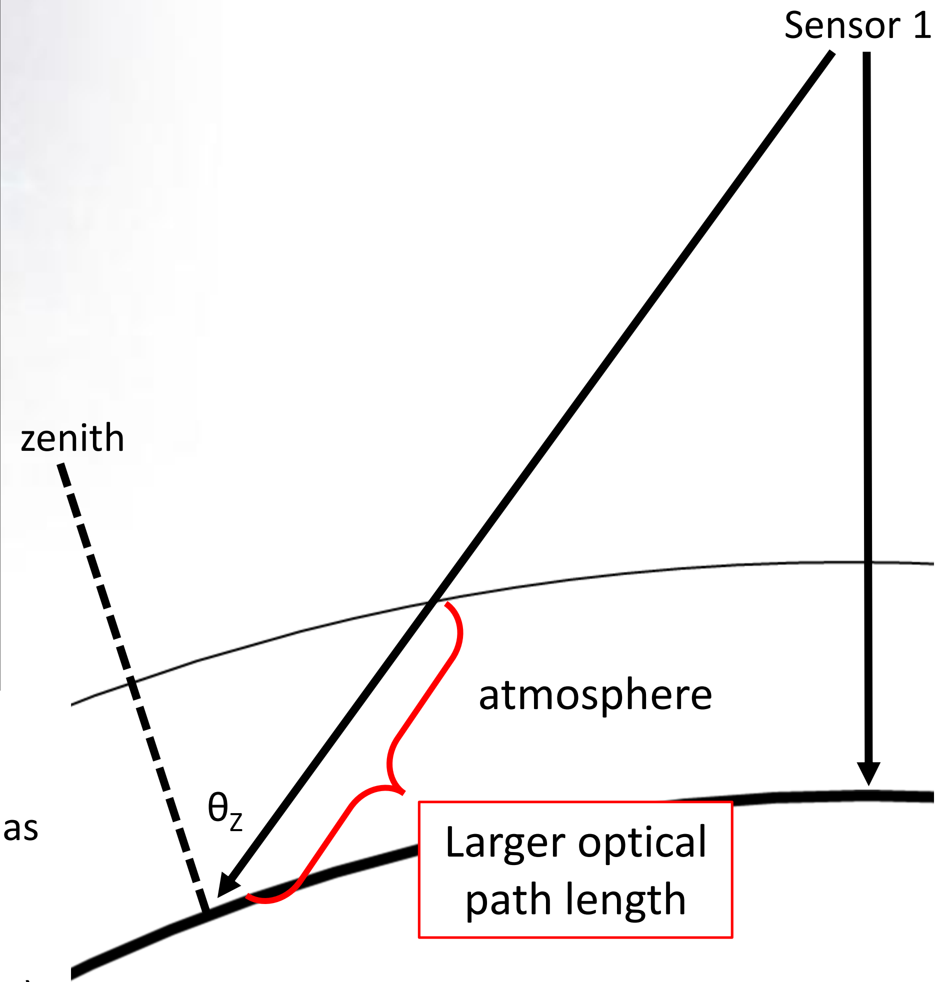
Limb Correction in Clear Regions



Limb-cooling in MODIS band 27 (6.7 µm) for midlatitudes (45°-60°)

$$T_{\theta_Z} - T_0 = C_2|\ln(cos\theta_Z)|^2 + C_1|\ln(cos\theta_Z)|$$

- Least-square fit parameters, C_1 and C_2, are defined as the limb correction coefficients
- **Correction coefficients vary latitudinally and seasonally** (Joyce et al. 2001; Elmer et al. 2015, 2016)



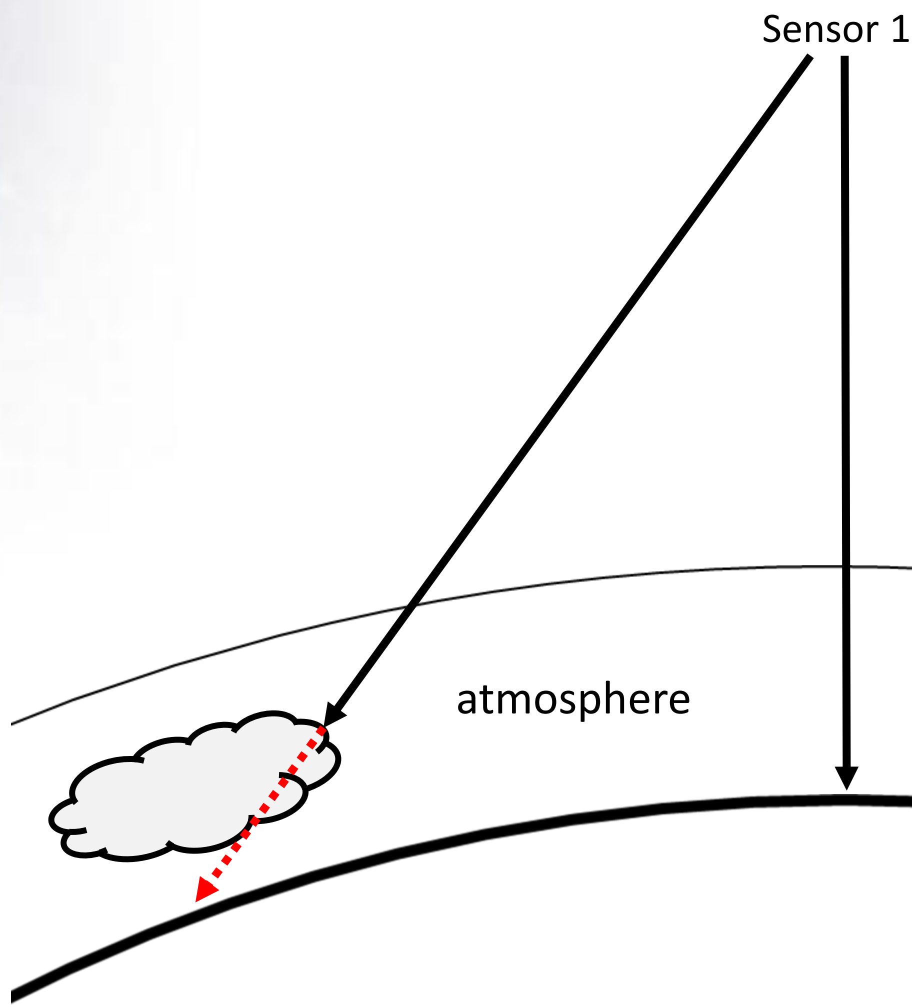
Cloud Effects

- Clouds contribute to limb effect:

  1) **Cloudy scenes have shorter optical path length than clear scenes**

  2) Different parts of cloud likely have different emissivities and temperatures

- If limb correction performed without accounting for cloud effects, limb correction will be inaccurate in cloudy regions



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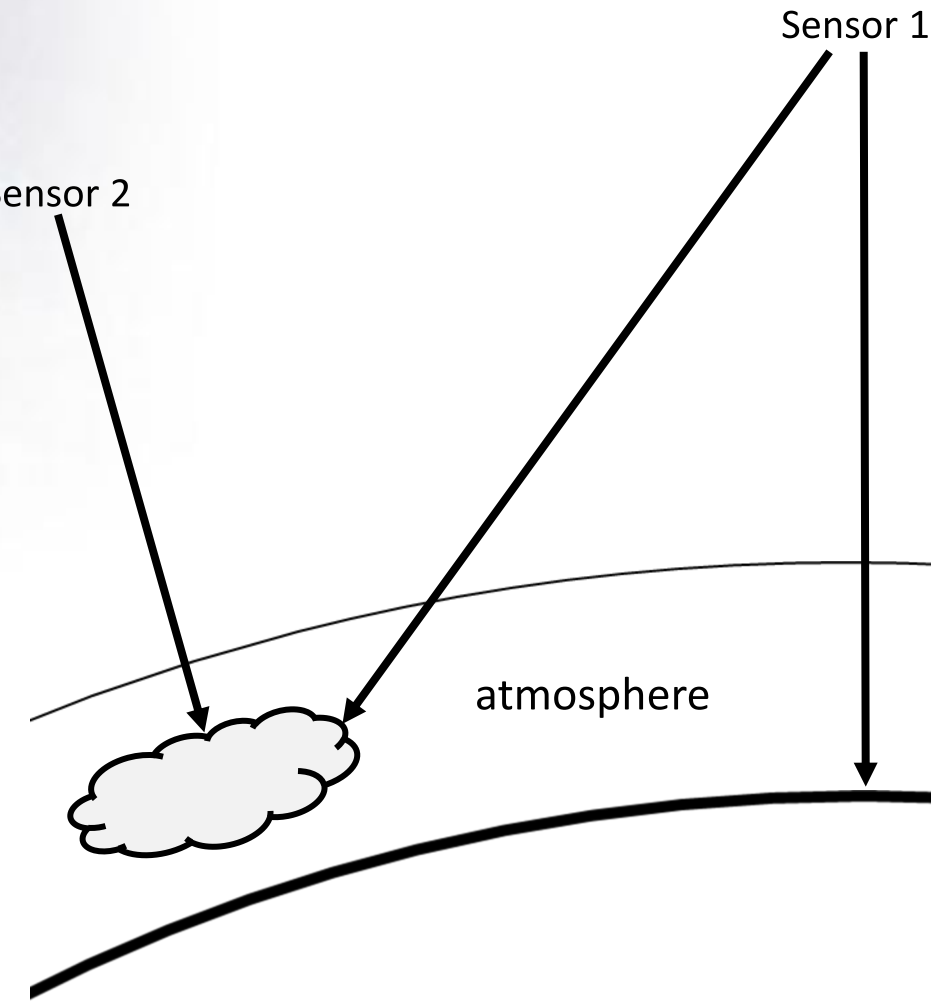


Limb Correction in Cloudy Regions

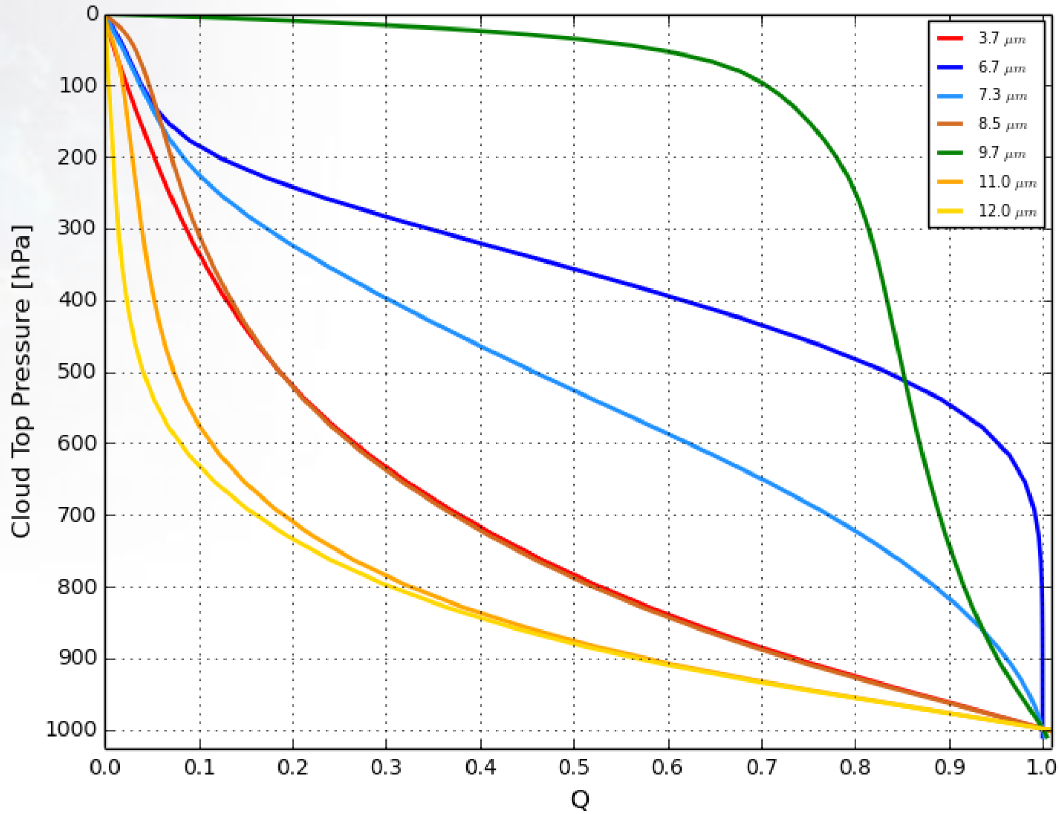
- Layer optical thickness (τ_l) calculated from JCSDA Community Radiative Transfer Model (CRTM; Han et al. 2006)
- Cloud correction coefficient (Q) calculated from τ_l :

$$t_l(p) = e^{-\tau_l(p)}$$

$$t(p) = t_l(p)\, t(p-1)$$

$$Q(p) = \frac{t(0) - t(p)}{t(0) - t(p_s)}$$

- For clear regions, Q=1
- **Q varies latitudinally and seasonally**, similar to limb correction coefficients C_1 and C_2



Cloud correction coefficient (annual global mean)

Limb Correction

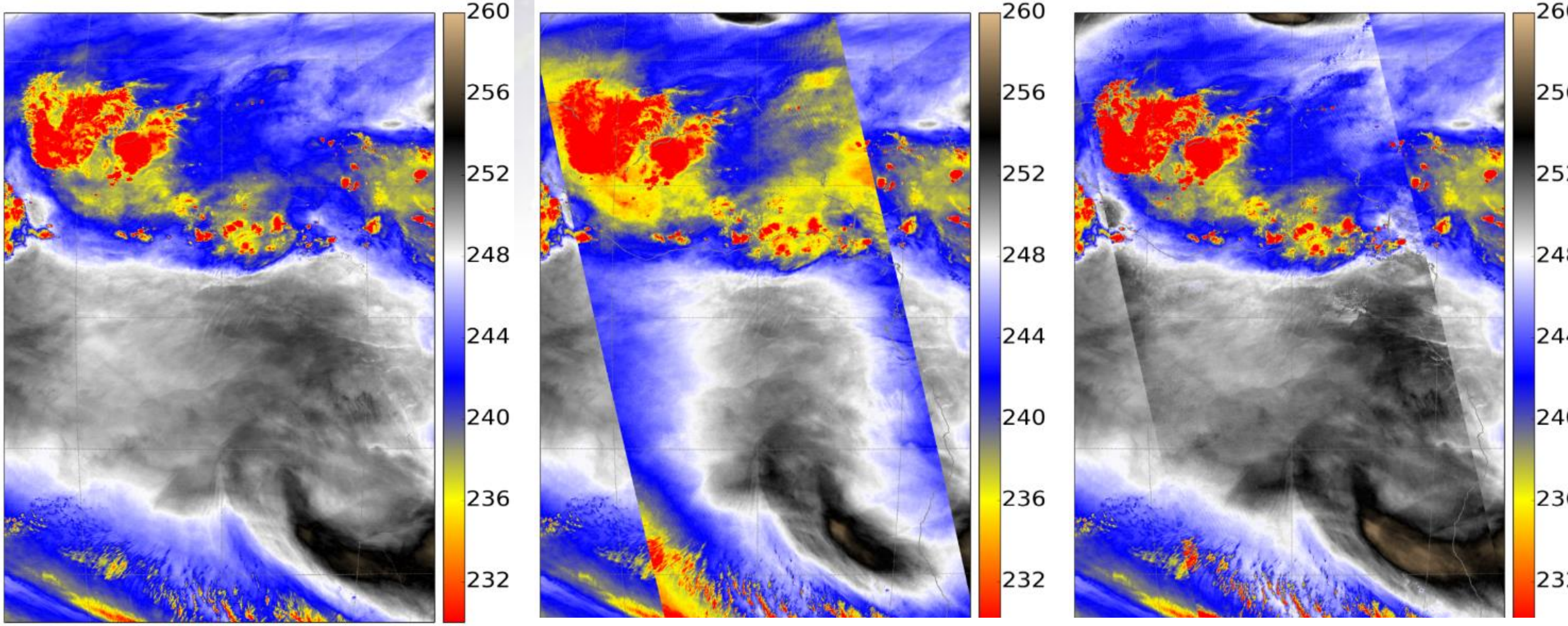
- Limb Correction Equation:

$$T_{CORR} = T_B + Q\left[C_2\, ln(cos\theta_Z)^2 - C_1\, ln(cos\theta_Z)\right]$$

(Elmer et al. 2016)

- Applicable to both polar-orbiting and geostationary sensors

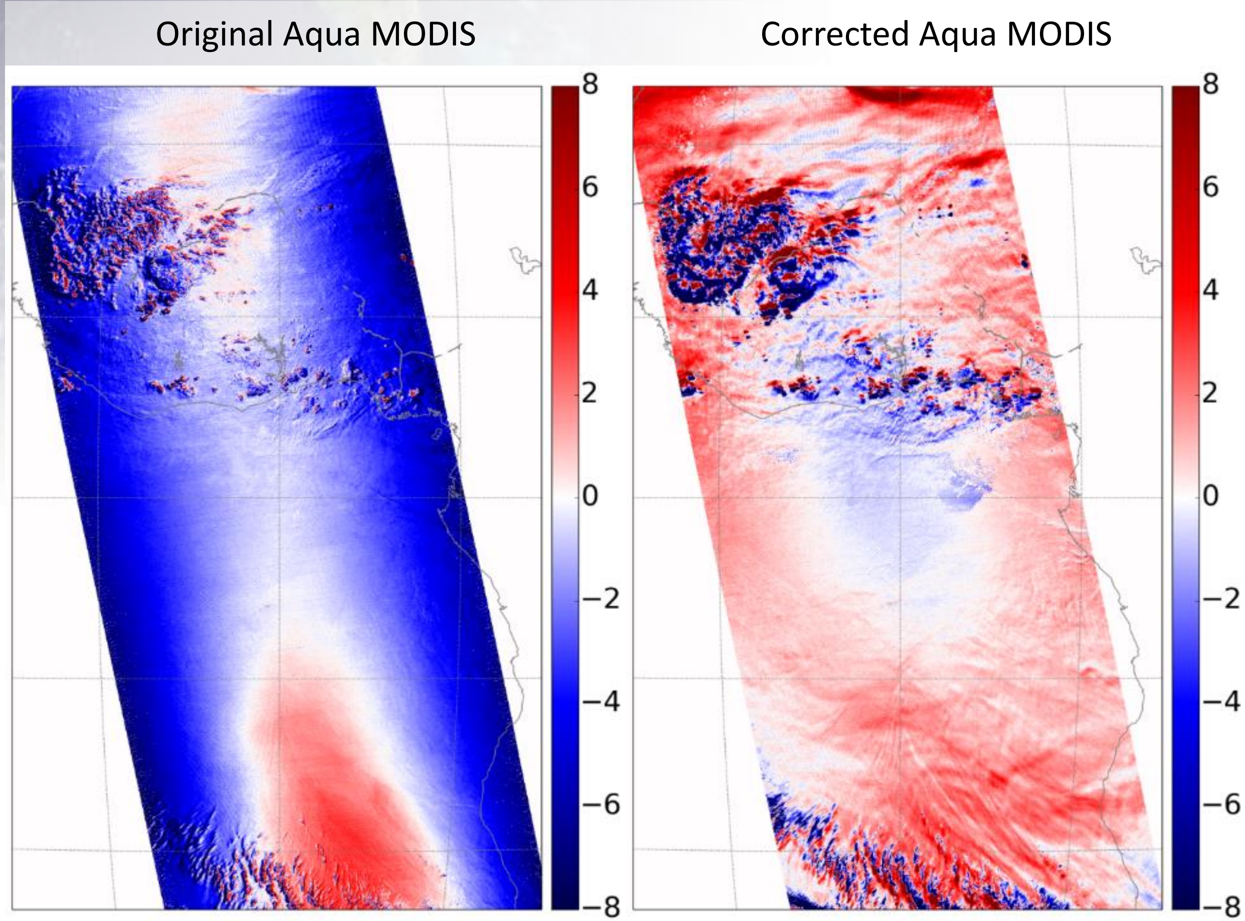
SEVIRI (6.2 µm) Original Aqua MODIS (6.7 µm) Corrected Aqua MODIS (6.7 µm)



1330 UTC 28 June 2015 Aqua MODIS 6.7 µm and SEVIRI 6.2 µm brightness temperature

Limb Correction

- Correction reduces errors due to limb and cloud effects in single band imagery

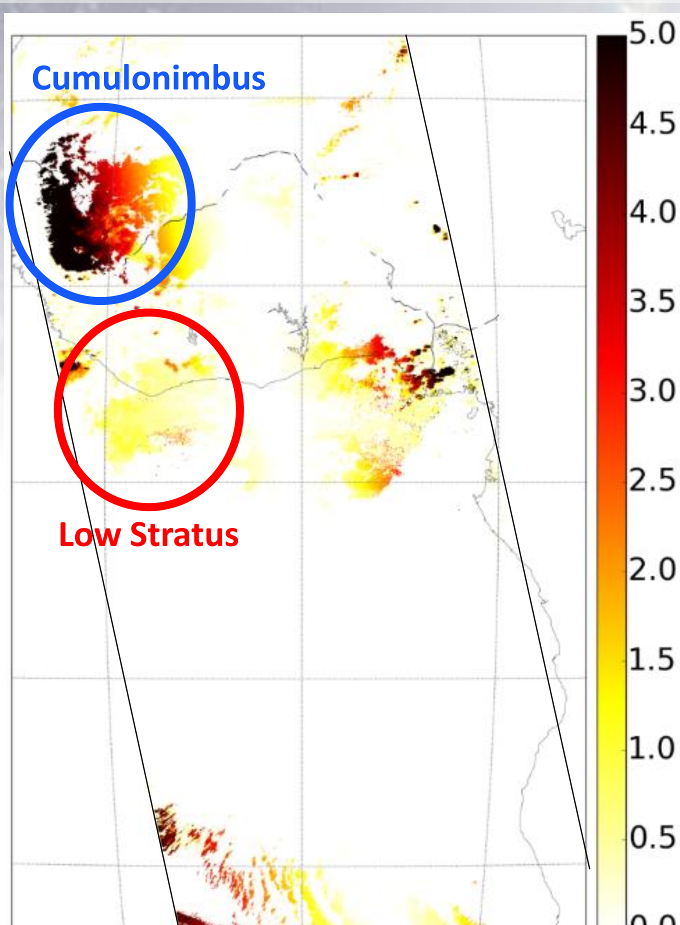


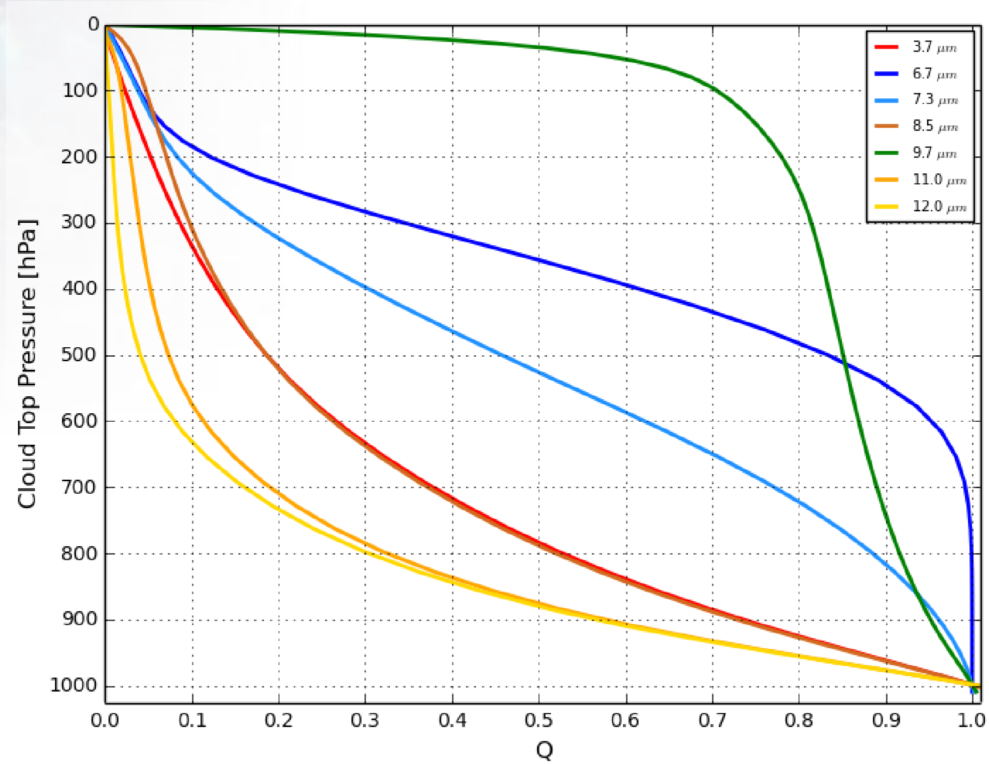
1330 UTC 28 June 2015 Aqua MODIS minus SEVIRI brightness temperature difference

Impact of Cloud Effects

- Difference between correction with and without accounting for cloud effects, i.e.,

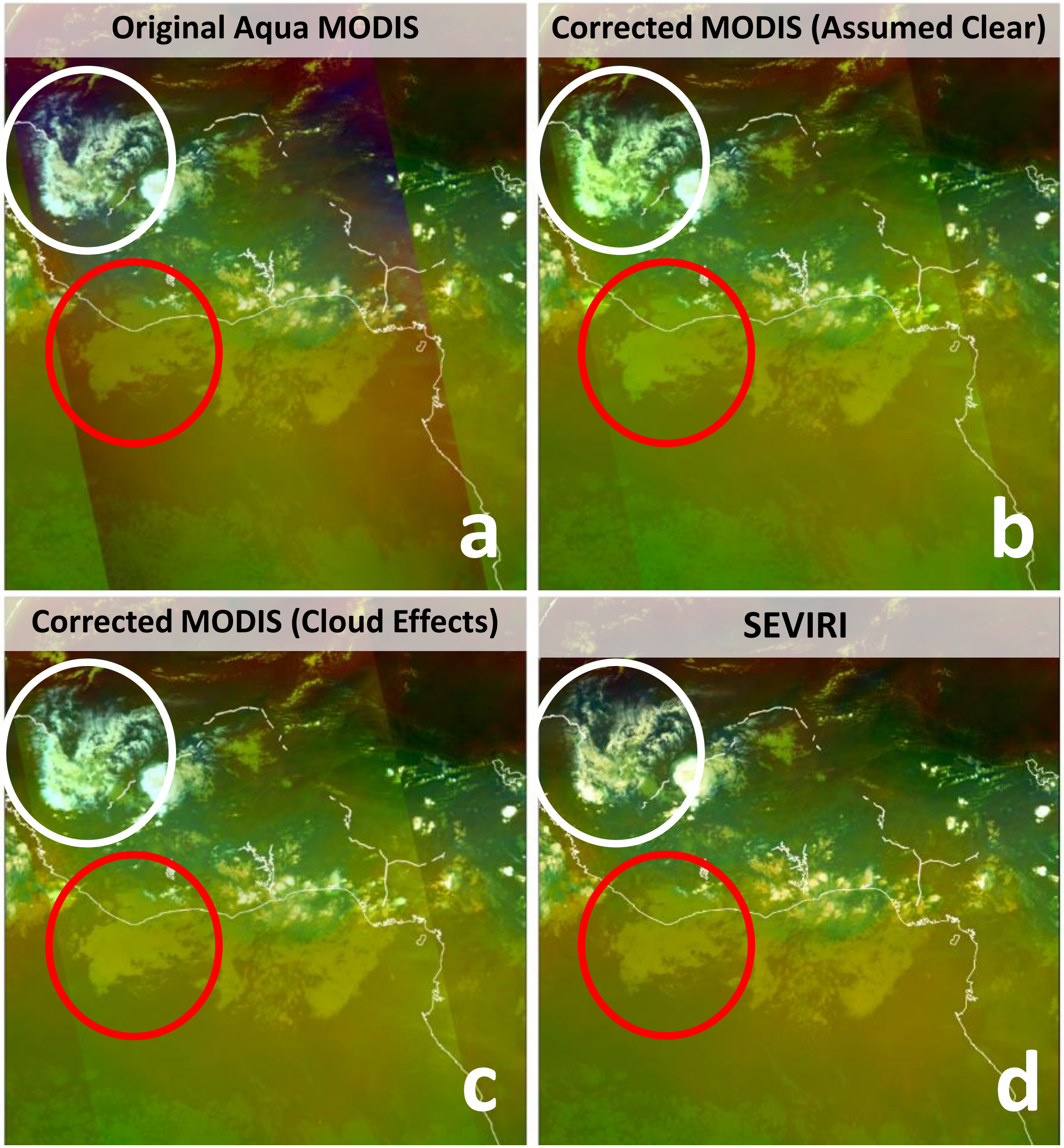
$$(1 - Q)\left[C_2\, ln(cos\theta_Z)^2 \;-\; C_1\, ln(cos\theta_Z)\right]$$





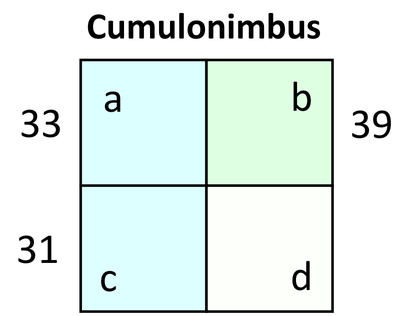
Cloud correction coefficient (annual global mean)

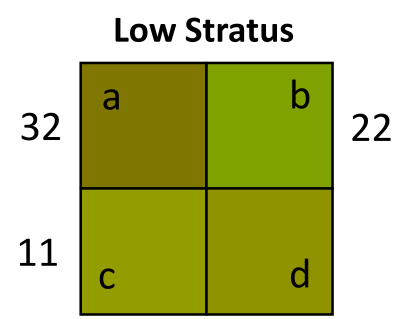
Air Mass RGB Aqua MODIS/ SEVIRI



1330 UTC 28 June 2015 Aqua MODIS and SEVIRI Air Mass RGB

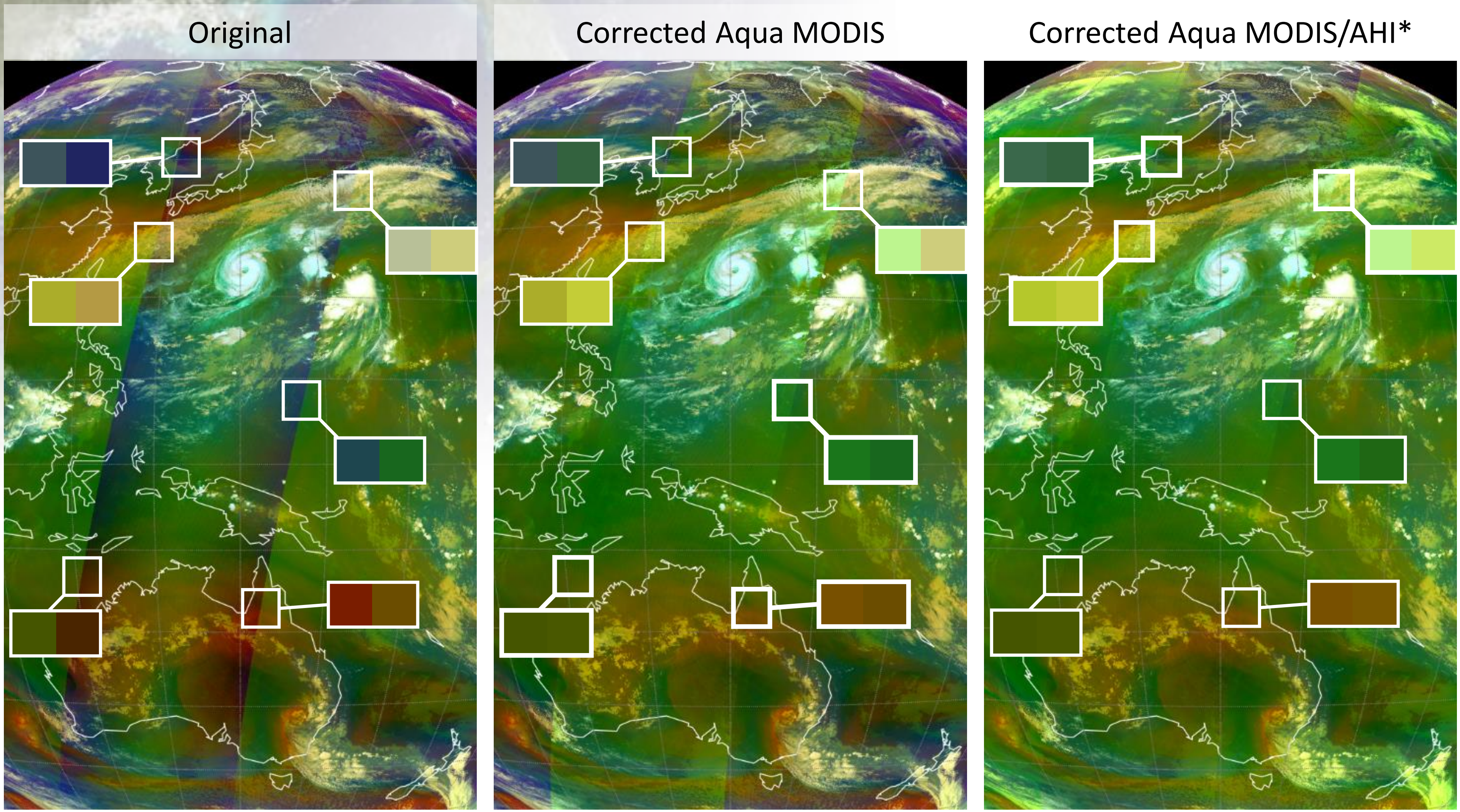
- Limb correction in cloudy regions improves interpretation of both high and low clouds





*Values indicate Euclidean distance from (d) in RGB space

Air Mass RGB – Aqua MODIS/AHI



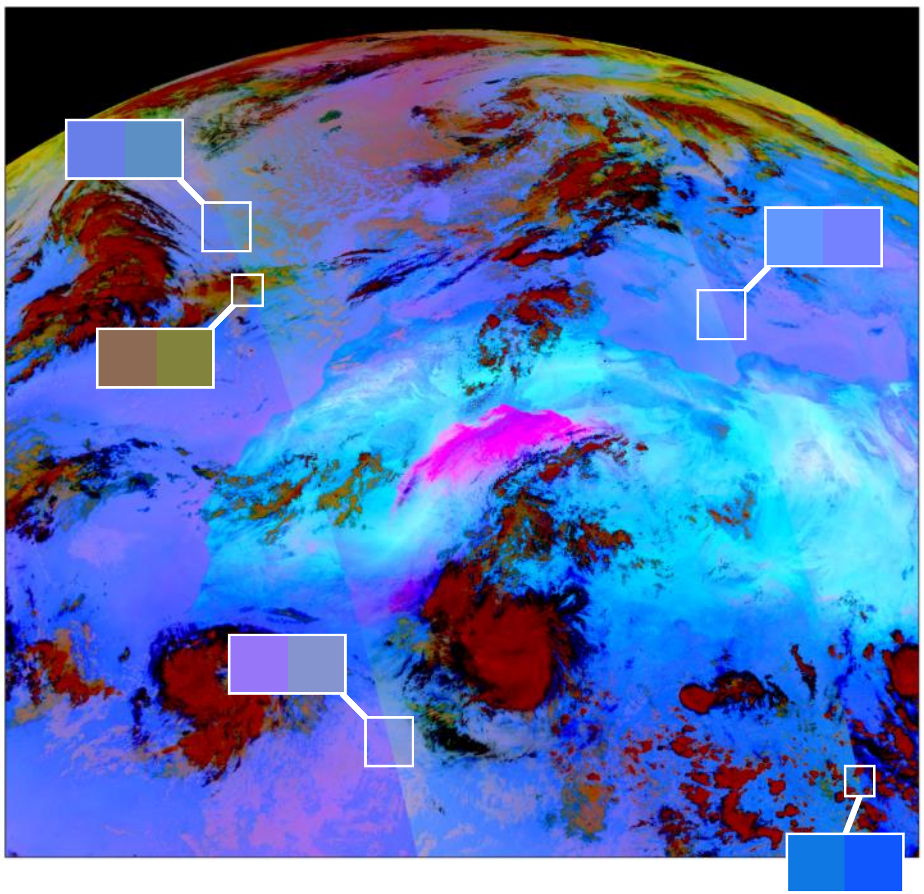
1640 UTC 21 October 2015 Aqua MODIS and AHI Air Mass RGB

*Cloud effects not accounted for in AHI imagery

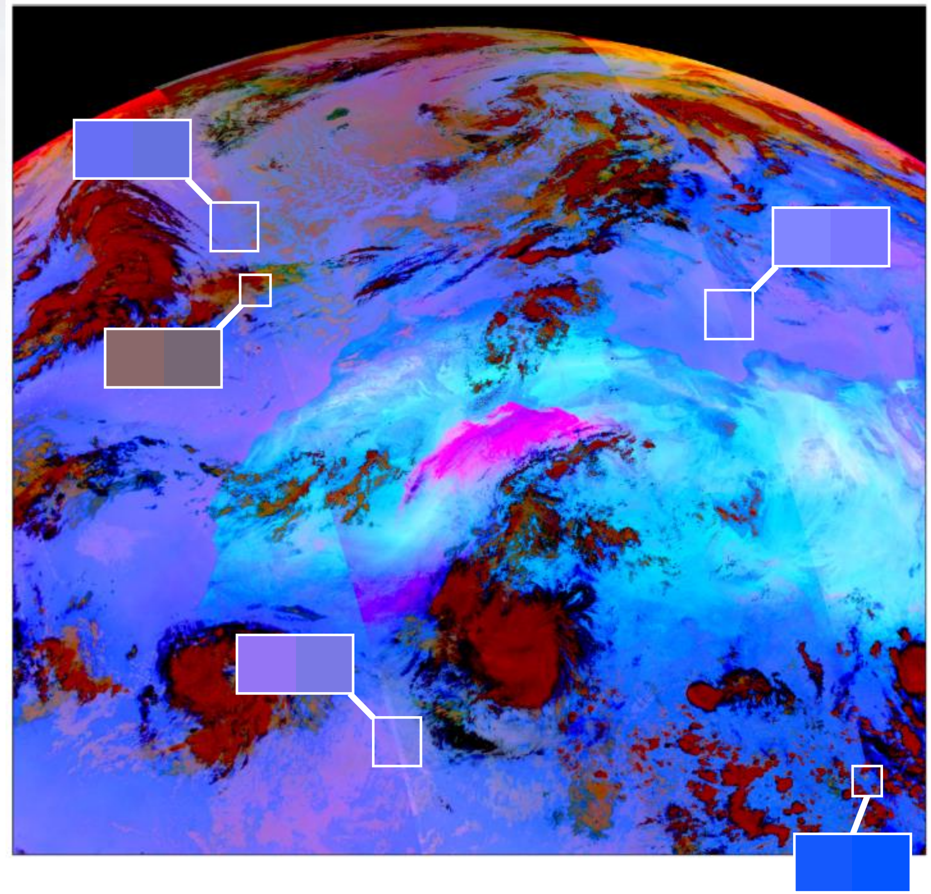
Dust RGB – VIIRS/SEVIRI

- Dust RGB (8.7, 11, 12 µm) less sensitive to limb effects, but correction still improves interpretation in clear and cloudy regions

Original



Limb-corrected*



1245 UTC 3 September 2015 VIIRS and SEVIRI Dust RGB
*Cloud effects not accounted for in SEVIRI imagery

Summary

- Limb effects and some cloud effects can be removed from infrared imagery using latitudinally and seasonally dependent correction coefficients
- Limb correction in cloudy regions is a function of atmospheric transmittance from cloud top to sensor
- Required parameters for limb correction: **viewing zenith angle, latitude, and cloud top pressure**
- Corrected RGB composites **increase confidence in interpretation of RGB features and improve situational awareness**
- Corrected MODIS and VIIRS RGB composites are currently produced by NASA SPoRT for operational use
- Correction can be easily applied to future sensors, including **GOES-R ABI** imagery when data becomes available

Questions

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References

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