Spectral Longwave Cloud Radiative Forcing As Observed By AIRS

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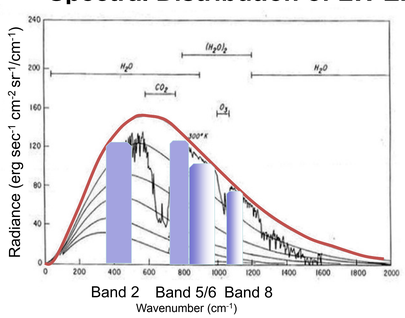
Abstract

AIRS V6 products contain the spectral contributions to Outgoing Longwave Radiation (OLR), clear-sky OLR (OLR_{CLR}), and Longwave Cloud Radiative Forcing (LWCRF) in 16 bands from 100 cm^{-1} to 3260 cm^{-1}. We show climatologies of selected spectrally resolved AIRS V6 products over the period of September 2002 through August 2016. Spectrally resolved LWCRF can better describe the response of the Earth system to cloud and cloud feedback processes. The spectral LWCRF enables us to estimate the fraction of each contributing factor to cloud forcing, i.e.: surface temperature, mid to upper tropospheric water vapor, and tropospheric temperature. This presentation also compares the spatial characteristics of LWCRF from AIRS, CERES_EBAF Edition-2.8, and MERRA-2. AIRS and CERES LWCRF products show good agreement. The OLR bias between AIRS and CERES is very close to that of OLR_{CLR}. This implies that both AIRS and CERES OLR products accurately account for the effect of clouds on OLR.

AIRS Spectral Bands and % of Total Fluxes

Band Frequency	Range	Clear Sky OLR (%)	OLR (%)	LWCRF (%)
1	100 – 350	13.03	14.14	1.65
2	350 – 500	16.06	16.84	8.09
3	500 – 630	14.58	14.99	10.41
4	630 – 700	3.85	4.22	0.06
5	700 – 820	12.12	11.94	13.96
6	820 – 980	17.51	16.40	28.83
7	980 – 1080	6.32	5.96	9.96
8	1080–1180	6.62	6.05	12.44
9	1180–1390	6.41	6.04	10.20
10	1390–1480	0.91	0.93	0.72
11	1480–1800	1.10	1.14	0.70
12	1800–2080	0.89	0.83	1.53
13	2080–2250	0.30	0.26	0.69
14	2250–2380	0.02	0.02	0.00
15	2380–2600	0.16	0.14	0.44
16	2600–3260	0.13	0.10	0.34

Spectral Distribution of LW Emission Spectrum

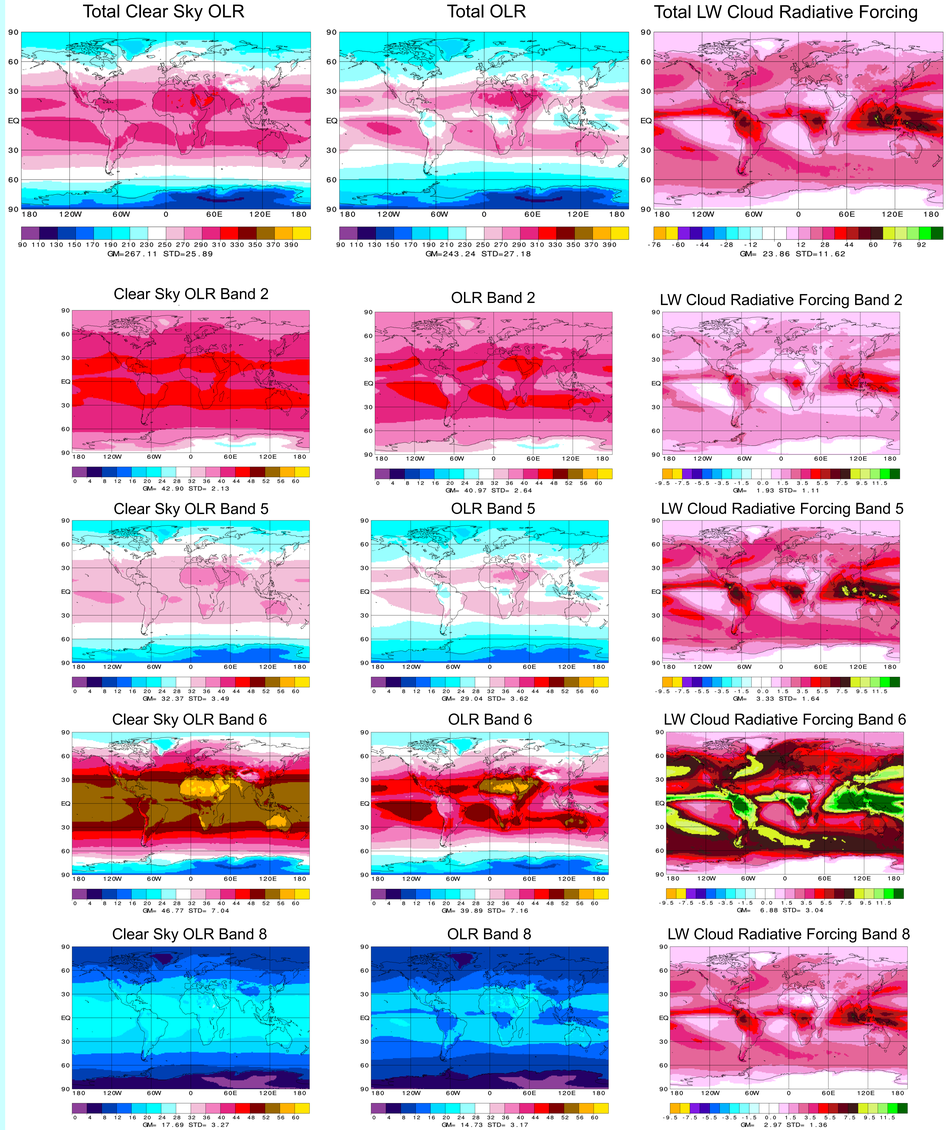


Band 2: Mid to upper tropospheric water vapor: less sensitive to cloud cover

Band 5: Tropospheric temperature and some surface temperature: more sensitive to cloud cover

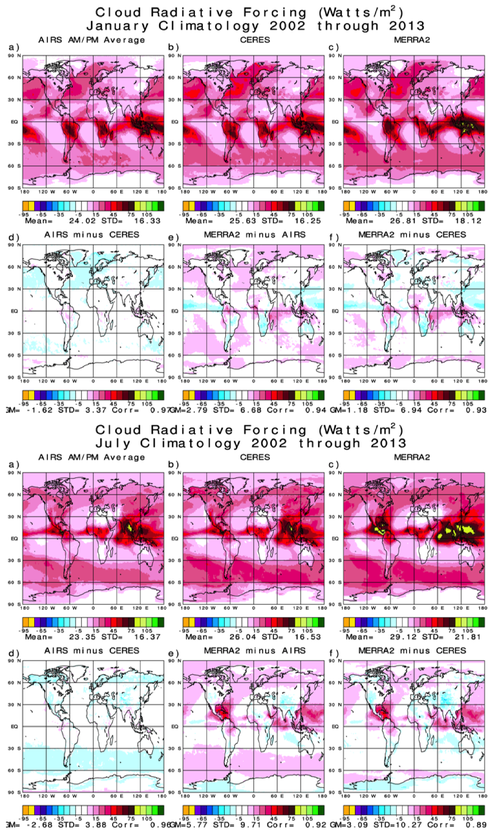
Band 6 and 8: Atmospheric window highly sensitive to cloud cover

Relative Contributions of Different Spectral Bands to LW Radiative Fluxes and LW Cloud Radiative Forcing



The spatial patterns of band contributions to LWCRF all look similar because they all respond to the presence of high cloud cover, albeit differently.

Comparison of Cloud Radiative Forcing from AIRS, CERES, and MERRA-2



- All data sets show that LWCRF is up to 75 W/m^2 over the tropics, with maxima in oceans when the sun is overhead.
- AIRS LWCRF agrees extremely well with CERES almost everywhere, but is biased low over oceans in mid-latitudes in local winter.
- In MERRA-2, cloud forcing is higher than that of AIRS and CERES, in regions where it is largest.

Summary

The contributions of spectral bands to cloud radiative forcing, relative to those of clear and cloudy fluxes, are highly band dependent. AIRS spectral bands 6 and 8, which cover spectral regions of atmospheric windows, account for less than 30% of the total OLR, but more than 40% of the total LWCRF. Because OLR is highly sensitive to cloud cover in atmospheric window regions, the presence of clouds strongly affects the cloud radiative forcing in these spectral regions. In contrast, spectral band 2, sensitive to mid-upper tropospheric water vapor, contributes more than 16% of the total OLR but only accounts for 8% of the total LWCRF because this band is less sensitive to cloud cover as a result of increased atmospheric attenuation. Spectral band 5, which is sensitive to mid-lower tropospheric temperature, falls midway between these bands with regard to its relative contributions to LWCRF and OLR.