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Combining MODIS and MISR cloud-top heights for cloud overlap detection

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Rationale: MISR cloud-top heights (CTH) are assigned to the layer of higher contrast which tends to be the lowest cloud layer in cases where thin cirrus overlies low-level clouds. MODIS cloud top heights tend to indicate the upper cloud layer. We expect that the difference in CTH between MODIS and MISR could indicate areas where more than one cloud layer is present. Verification is achieved by comparing the (MODIS-MISR) CTH with ground-based radar at Chilbolton UK (51.15N-1.43W) and ARM SGP (36.62N-97.5W). Pavolonis and Heidinger (JAM 2004) methodology is used to detect cloud type and overlap from 5 MODIS channels.

Approach:

•MISR cloud-top height product with wind correction is not always available, so product without wind correction (less accurate) used if it is not.

•MISR cloud-top height at 1km resolution, so median CTH is computed for 0.02° box (~5km resolution) centered on each 5km MODIS latitude-longitude points.

•MISR and MODIS cloud-top heights extracted as median in 0.2° box centered on radar and compared to CTH of each layer detected by radar.

•MODIS cloud type (water, mixed-phase, opaque ice, cirrus or overlap) also sampled in same box and histogram of cloud type is produced for comparison with radar.

•MODIS cloud type used over entire scene to select pixels and get corresponding distribution of MODIS-MISR differences.

Difference MODIS-MISR CTH as a function of cloud type for all scenes

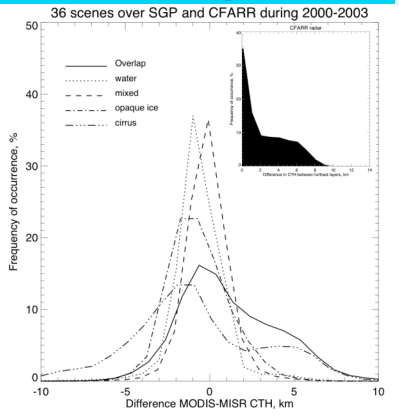
Water clouds: MISR CTH slightly higher than MODIS CTH by ~1 km

Mixed phase: Difference close to 0 km (slight negative bias at SGP)

Opaque ice: MISR CTH slightly larger than MODIS, but large spread and skewed for areas where MISR<MODIS

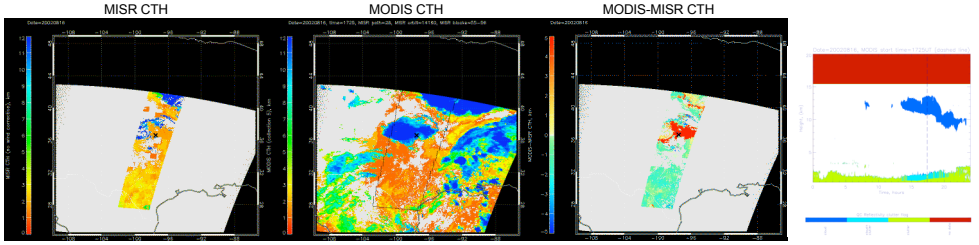
Cirrus: bimodal, usually MISR CTH > MODIS CTH, but secondary maximum means either poor surface height assignment where MISR does detect cirrus or overlap that is not detected by Pavolonis& Heidinger method

Overlap: Bimodal, small difference in CTH when either contrast of highest layer large enough for MISR or when MODIS CTH also refer to lowest layer or if the separation is small

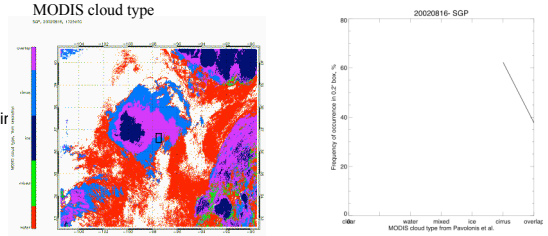


Inserted plot: Layer separation frequency= difference in radar CTH between highest and lowest cloud layers. CFARR 2000-2003

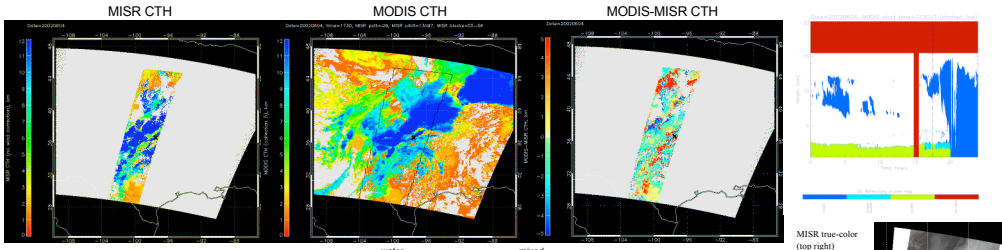
Comparison with radar: SGP 2002-08-16



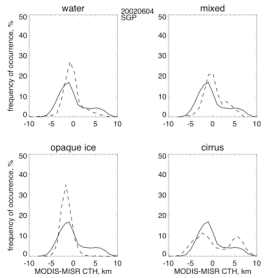
Radar and MODIS-MISR CTH agree on overlap
Radar CTH1=13.6 km (2 layers), CTH2=1.5 km
MODIS= 11 km
MISR= 1.7 km (no wind)
Eff. Emiss.= 58%
Large area covered by cirrus detected by MODIS but not detected by MISR, which detects low-level cloud embedded in clutter. Both layers are optically thin as indicated by the effective emissivity.
Far right: cloud type distribution in 0.2° box around site



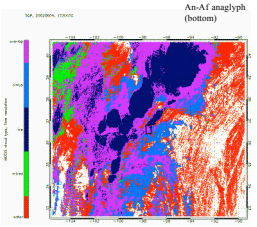
MISR CTH > MODIS CTH: SGP 2002-06-04



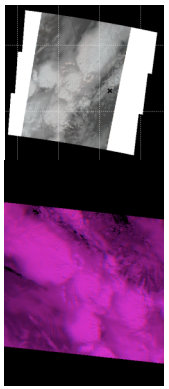
Radar CTH1=12.1 km (2 layers), CTH2= km
MODIS= 11 km
MISR= 12.6 km (no wind)
Eff. Emiss.= 80%



Difference for each cloud type (dashed) for entire scene. It shows MISR CTH > MODIS CTH for all cloud types (except 5km difference when overlap (solid) & cirrus)



MISR CTH indicates thin high cloud but MODIS CTH at top of opaque ice cloud: thin cirrus above Cb?



Conclusions:

Multilayer clouds: good agreement between MODIS CTH and radar CTH for highest layer and same between MISR CTH and radar CTH for lowest layer

Disagreement if:
- Highest cloud layer displays enough contrast for MISR to detect
- possibly occurs when highest layer too thin for MODIS to detect

Single layer clouds: MISR CTH > MODIS CTH for all cloud types within 1km, with standard deviation increasing with increasing CTHs.

Combination of MODIS and MISR CTH for improved CTH product and overlap flag with value added CTH of lower cloud layer. Issue: MISR reduced spatial/temporal coverage.