

Fall 2022 CERES Science Team Meeting, October 12-14, 2022, Hamburg, Germany



Comparison between MODIS and CALIPSO-CloudSat Cloud Amounts and Their Trends Depending on the Cloud Threshold

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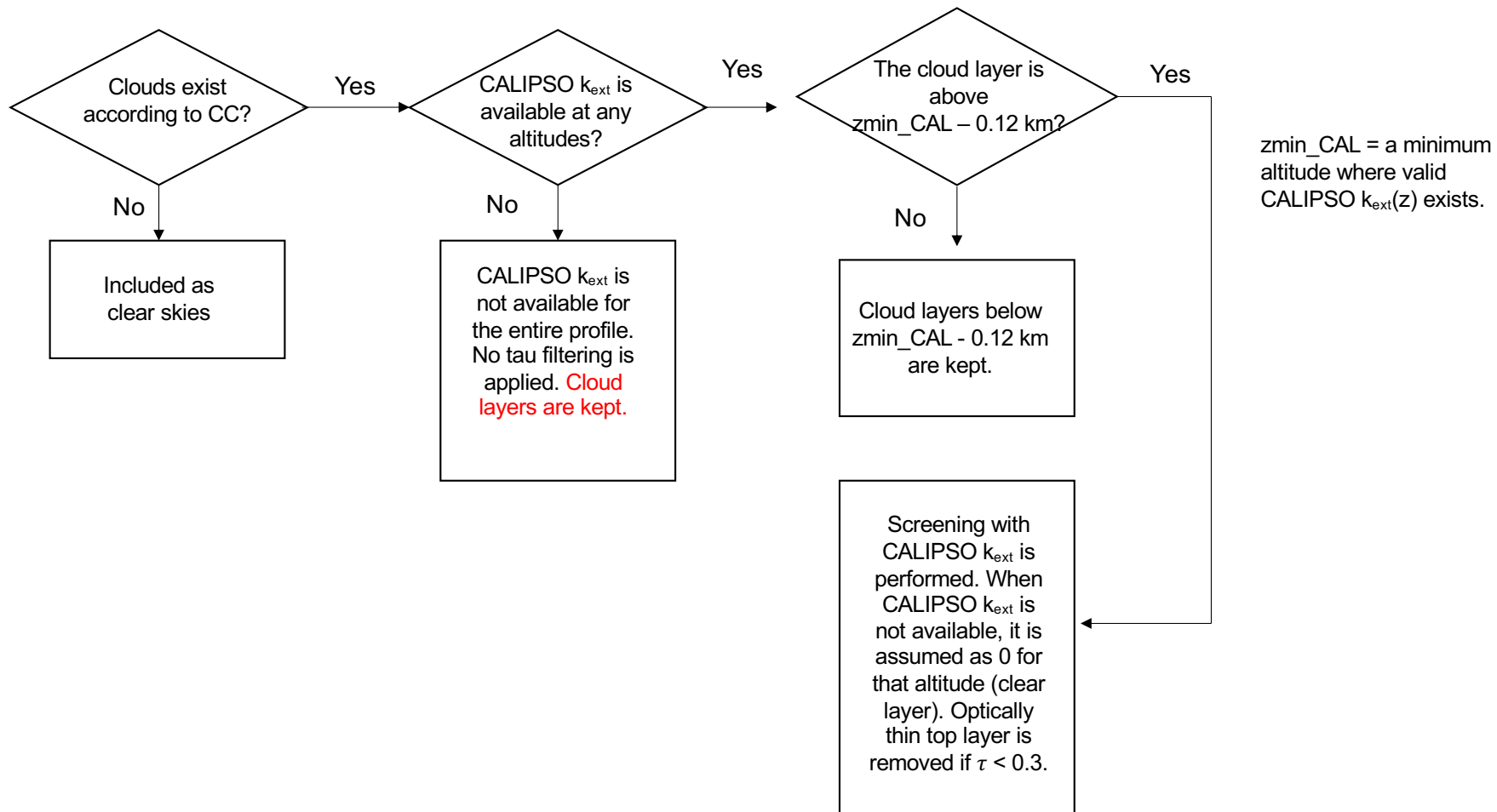
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Comparison between SSF Ed4 MODIS and CALIPSO-CloudSat (CC) total cloud fractions

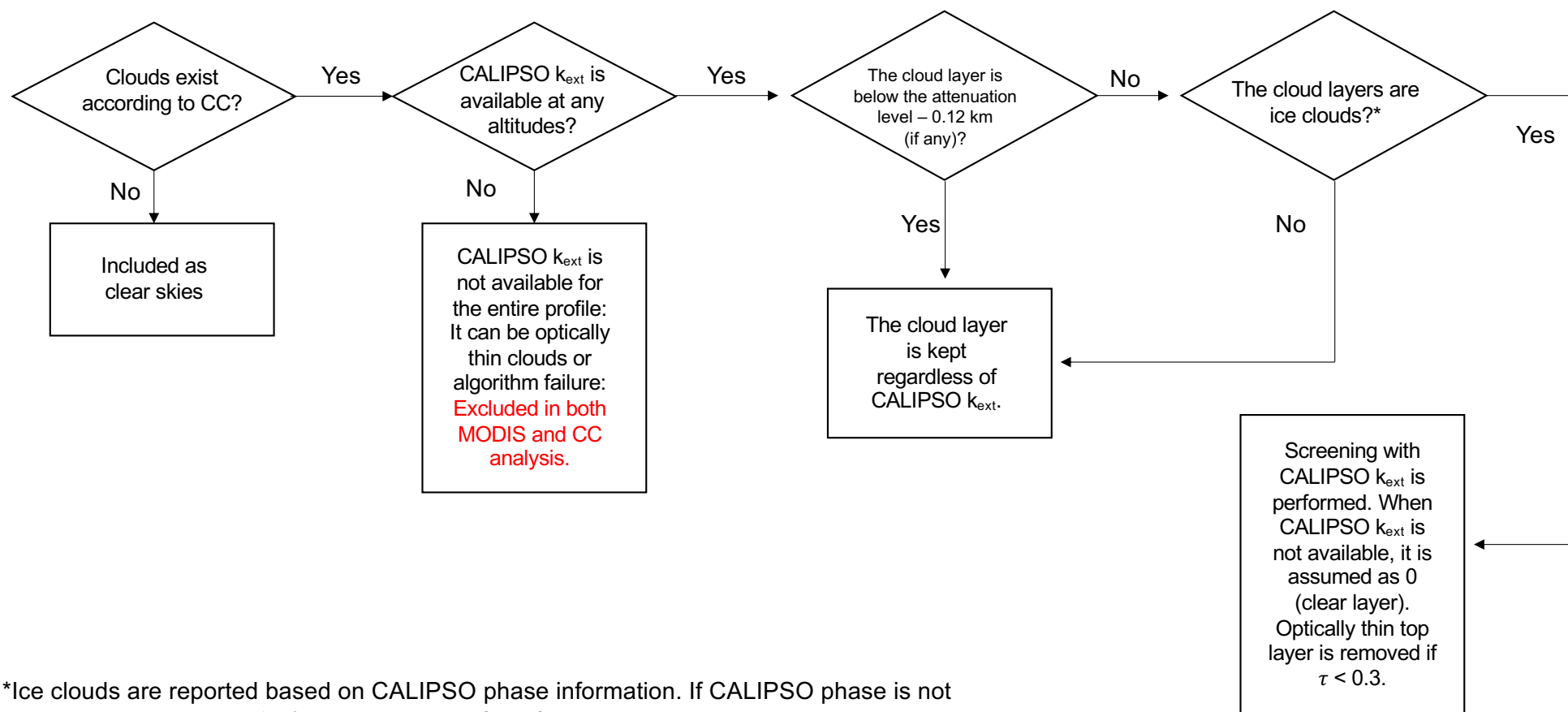
- In these slides, MODIS cloud fractions are from SSF Ed4 product. This is different from the previous results since MODIS Ed4B (modified version of Ed4, somewhere between Ed4 and Ed5) cloud fractions contained in CCCM ReID1 product were previously used. For CC cloud fractions, the same method is used; CC cloud fractions from ReID1 CCCM product.
- The CERES footprints commonly contained in both CCCM ReID1 and SSF products are only used for CC and MODIS analyses. This reduces the number of CERES footprints in CCCM ReID1 product by half.
- The CALIPSO k_{ext} is needed to remove optically thin top cloud layers in CC measurements that may not be detected in MODIS measurements. In CCCM ReID1 product, when CALIPSO cloud extinction coefficient (k_{ext}) is not available, there is no distinction whether it is due to the algorithm failure, or it is due to clear skies. Therefore, there exist multiple options how to handle this type of cases. In these slides, two τ filtering methods (v2 and v5) are considered for CC cloud fractions. The v2 τ filtering is the method used for earlier studies. The v5 τ filtering method is a new way that generates better consistency between MODIS and CC.
- By adjusting τ filtering method, it is possible that at least total cloud fractions from MODIS and CC measurements are more comparable (v5 τ filtering). This is a good sign that both measurements see the cloudy columns in a consistent way. However, due to the inherent characteristics of passive and active sensors, it is also expected that MODIS and CC detect different altitudes of the cloud layers.
- MODIS clouds are also filtered with MODIS τ ; i.e., cloud layers with $\tau < 0.3$ are removed and treated as clear skies.

v2 τ screening for CC cloud fractions – "Old Method"



When CALIPSO k_{ext} retrieval fails, it can be i) optically thin clouds or ii) algorithm failure.

v5 τ screening for CC cloud fractions – “New Method”

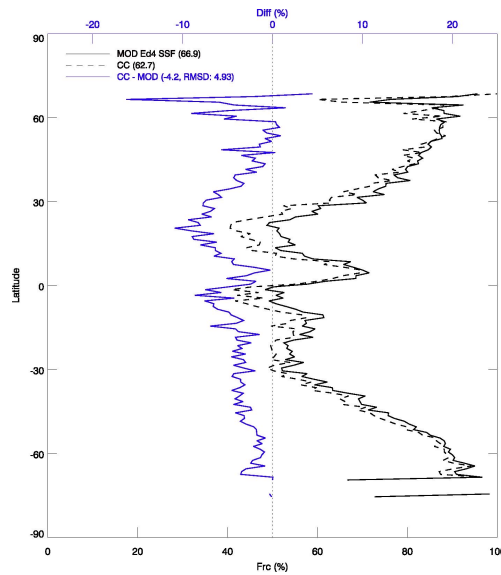


*Ice clouds are reported based on CALIPSO phase information. If CALIPSO phase is not available, the answer is 'no' in the question of the flowchart. This might be a problem when there is an optically thin cloud layer and CALIPSO phase is not available.

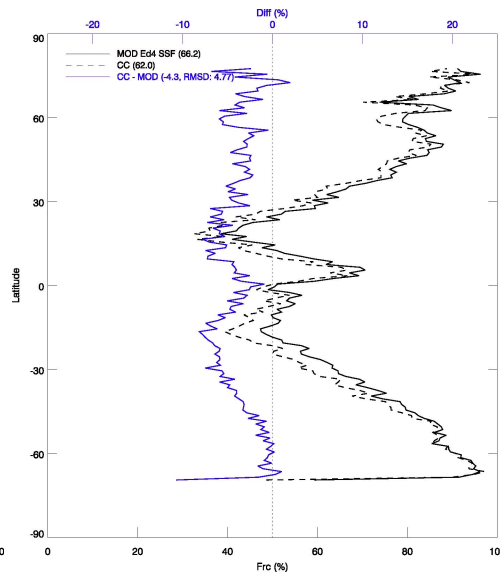
ReID-beta3, Day

**v2 τ filtering for CC cloud fractions
(MODIS clouds with $\tau < 0.3$ are also filtered out)**

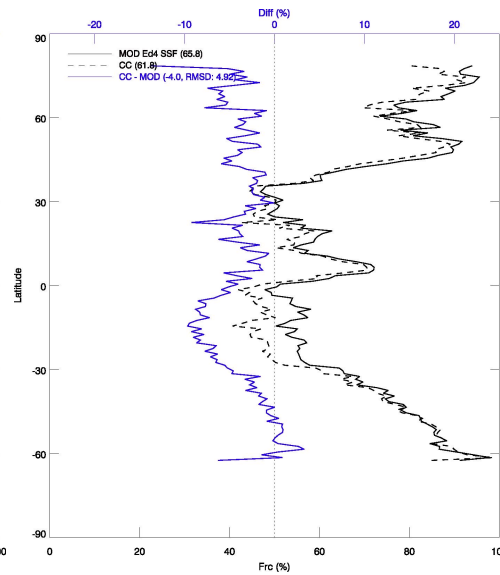
200801



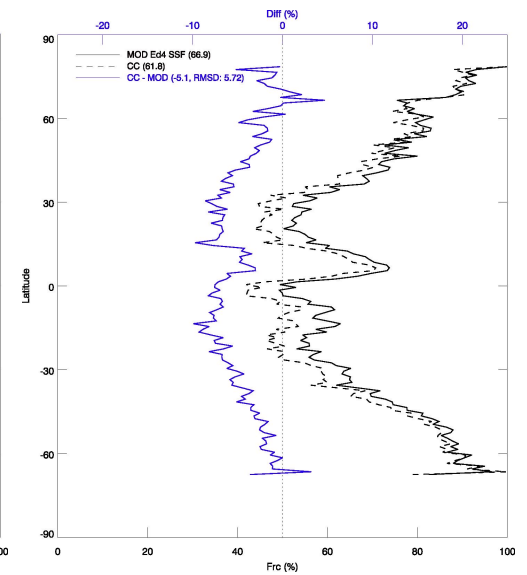
200804



200807



200810



Black lines are total cloud fractions from MODIS
(solid line) and CC (dashed line).
Blue lines are CC minus MODIS cloud fractions.

ReID-beta3, Day

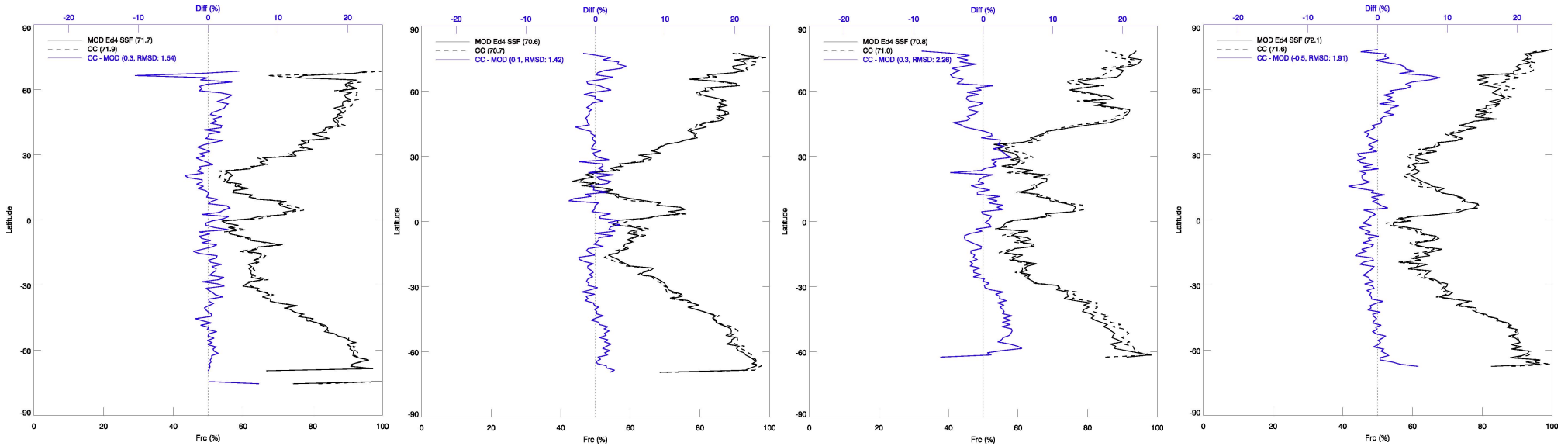
**v5 τ filtering with $CAD \geq 20$ for CC cloud fractions
(MODIS clouds with $\tau < 0.3$ are also filtered out)**

200801

200804

200807

200810

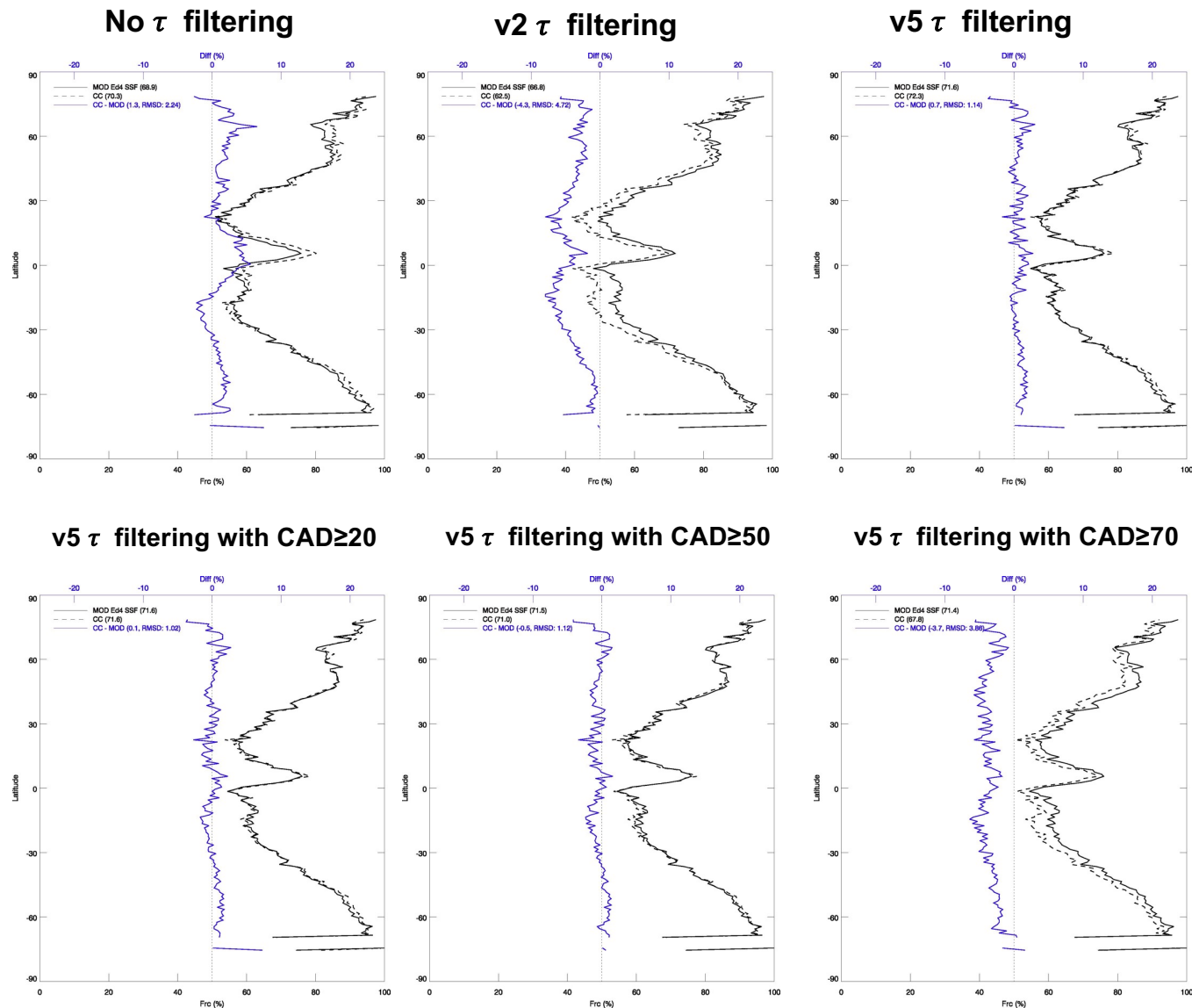


Total cloud fractions are better agreed between SSF Ed4 MODIS and CC with v5 τ filtering with $CAD \geq 20$, compared to the results with v2 τ filtering. Since the cases where CALIPSO kext is not available for the entire profile are removed in both CC and MODIS analyses (likely increase the cloud fractions), the MODIS cloud fraction in v5 τ filtering is different from that with v2 τ filtering.

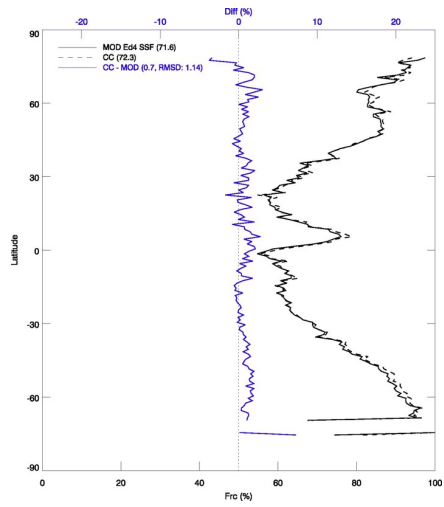
ReID-beta3, Day Ocean
Jan/Apr/Jul/Oct 2008

A higher CAD score threshold decreases CC total cloud fraction. The impact seems to be similar for all latitudes (shifting effect).

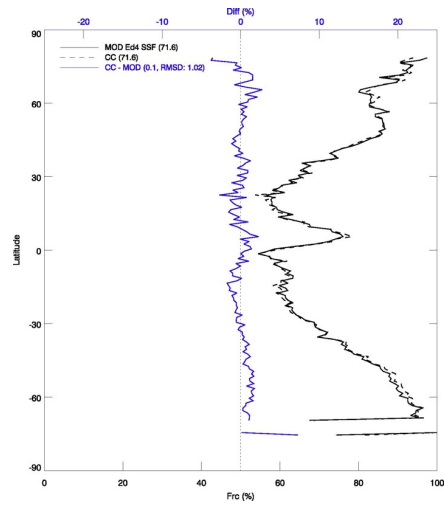
When one kind of τ filtering is applied to CC cloud fractions, MODIS clouds are also filtered with MODIS $\tau < 0.3$.



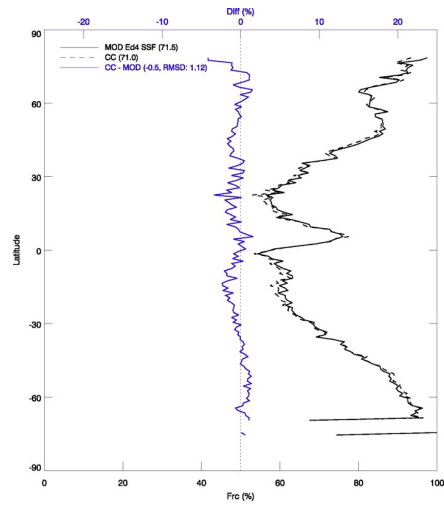
v5 τ filtering



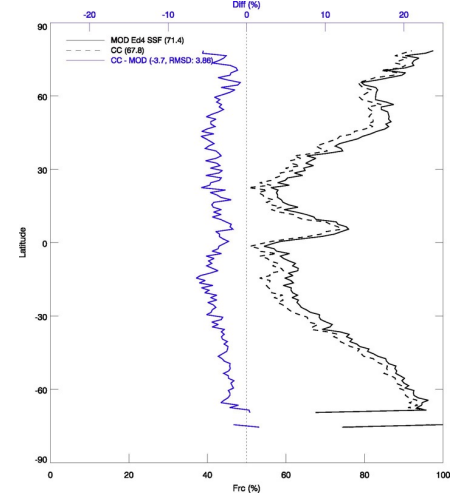
v5 τ filtering with CAD $\geq$ 20



v5 τ filtering with CAD $\geq$ 50



v5 τ filtering with CAD $\geq$ 70



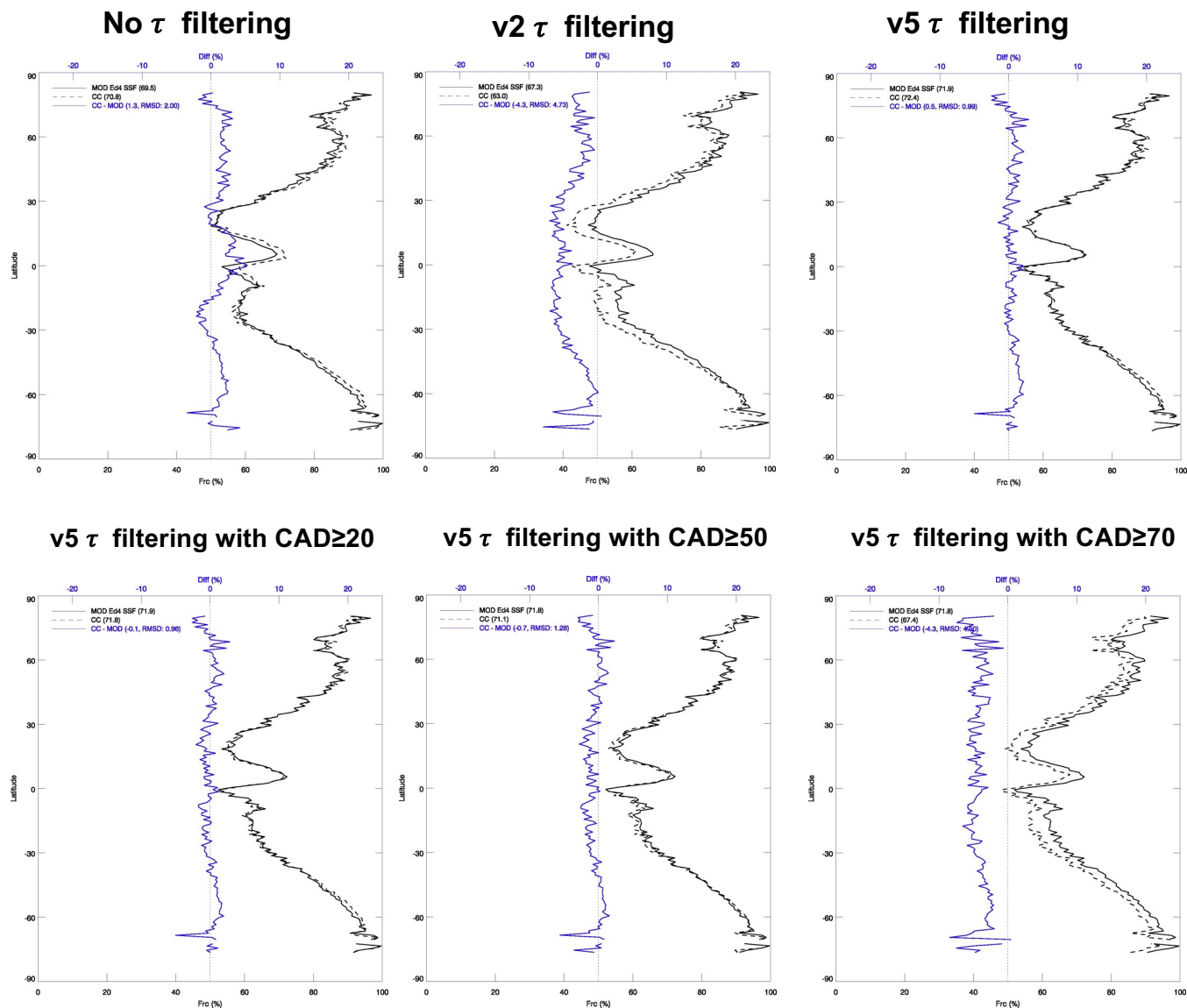
v8 τ filtering

v8 τ filtering with CAD $\geq$ 20

v8 τ filtering with CAD $\geq$ 50

v8 τ filtering with CAD $\geq$ 70

ReID-beta3, Day Ocean
Jan/Apr/Jul/Oct 2016



In both years (2008 and 2016), v5 τ filtering produces better agreement between MODIS and CC total cloud fractions, compared to v2 τ filtering.

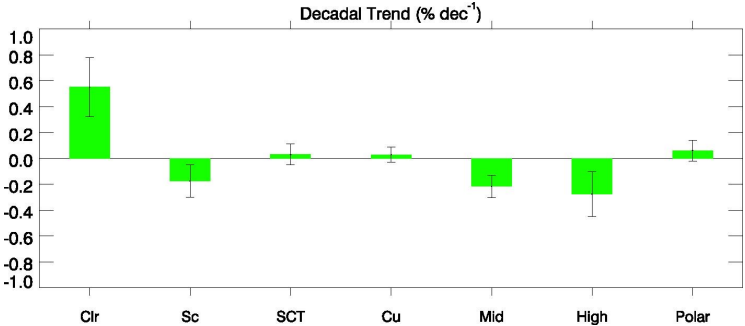
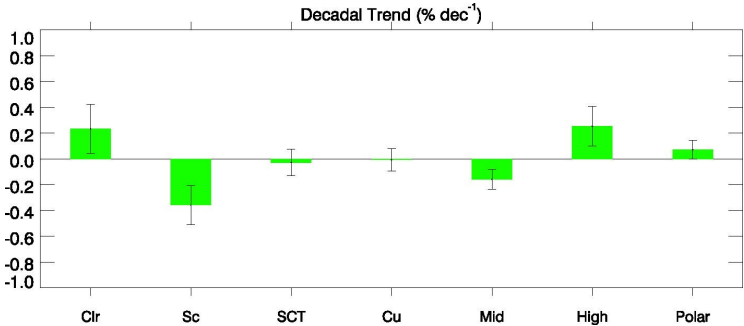
v2 τ filtering
all CADs

MOD (from CCCM ReID1 product; Ed4B)

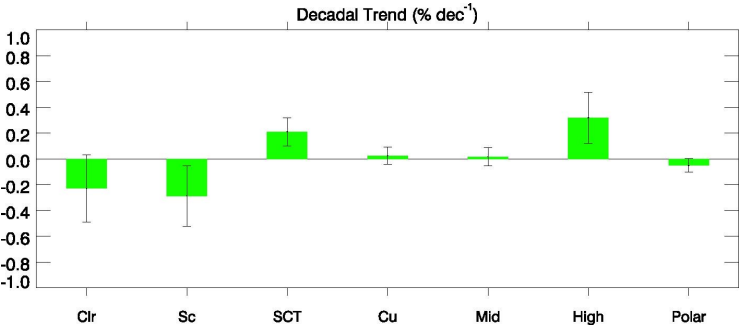
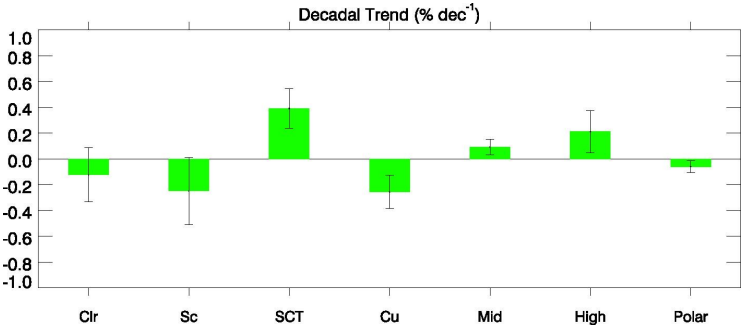
CAL+CS (CCCM ReID1)

Day

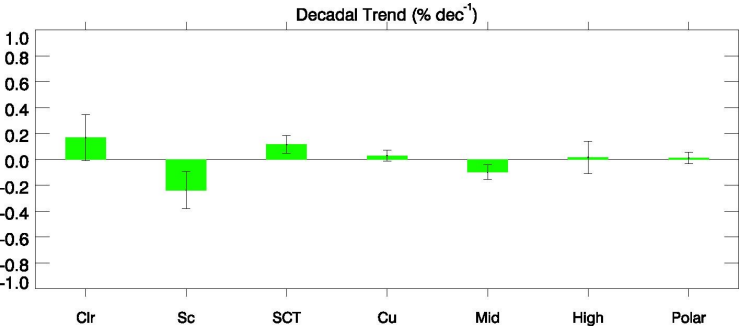
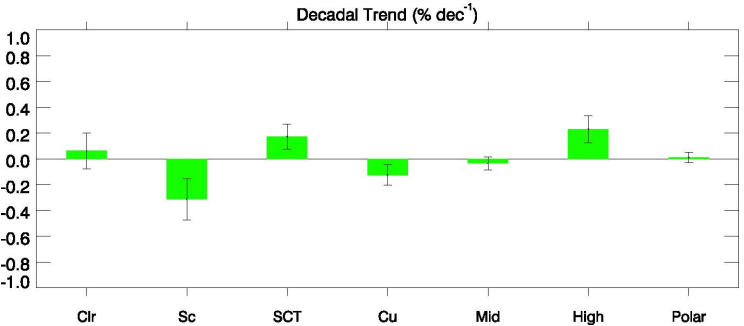
NH



SH



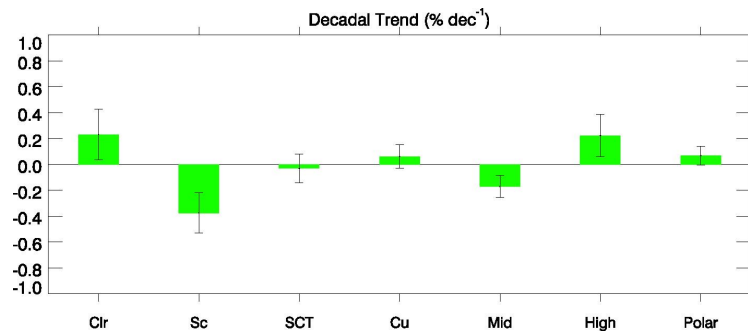
Glo



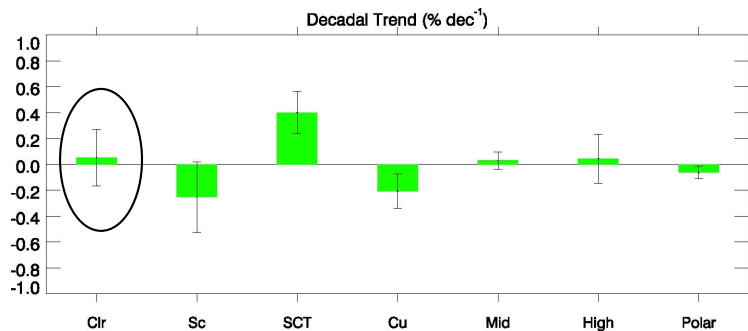
v5 τ filtering
CAD ≥ 20

MOD (from CCCM ReID1 product; Ed4B)

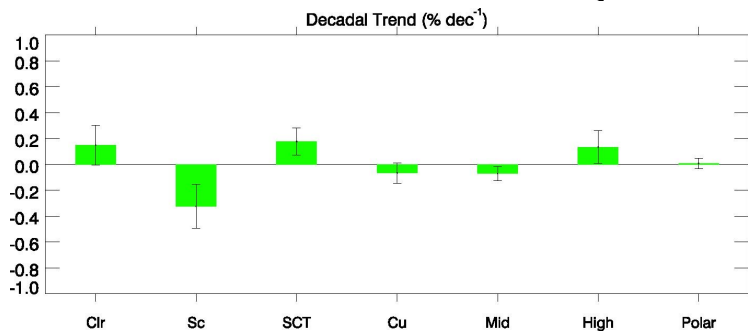
NH



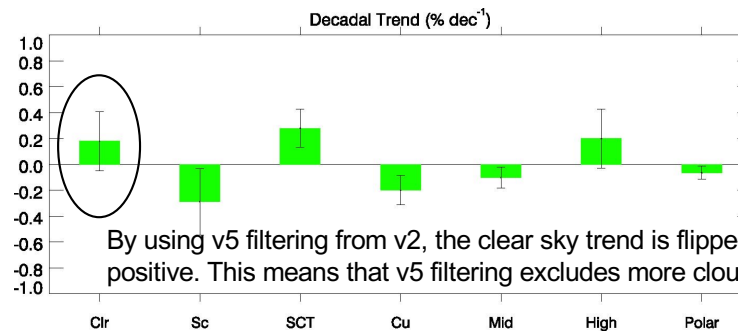
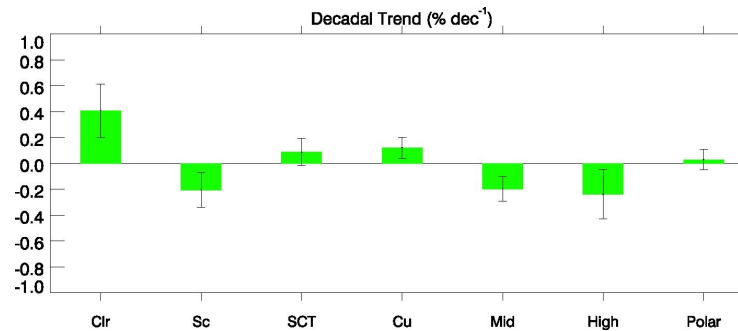
SH



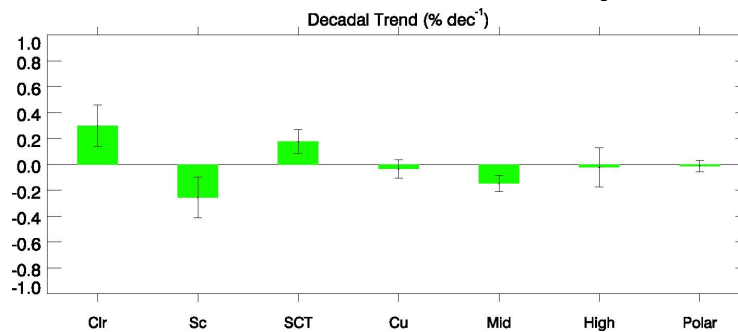
Glo



CAL+CS (CCCM ReID1)



By using v5 filtering from v2, the clear sky trend is flipped from negative to positive. This means that v5 filtering excludes more cloudy skies over time.

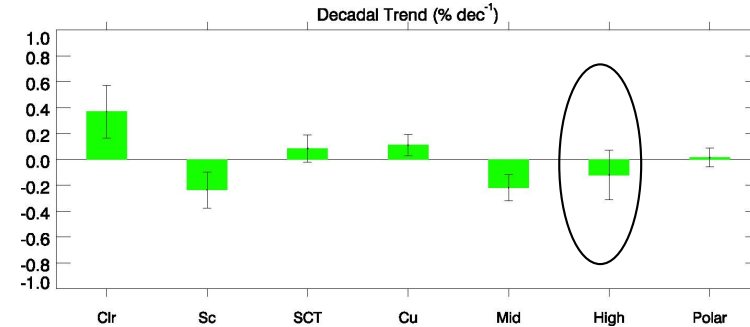
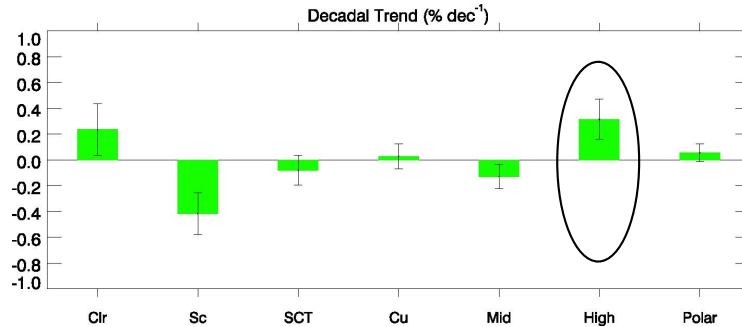


v5 τ filtering
CAD ≥ 20

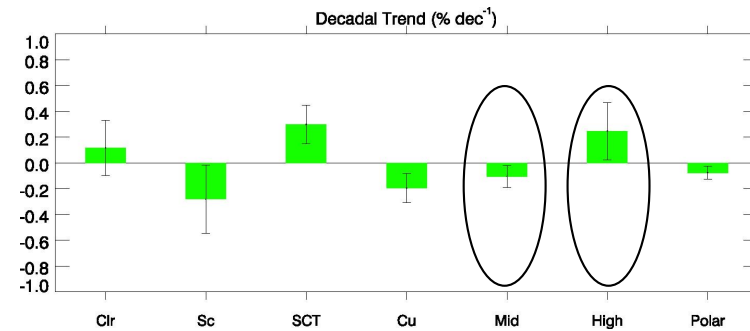
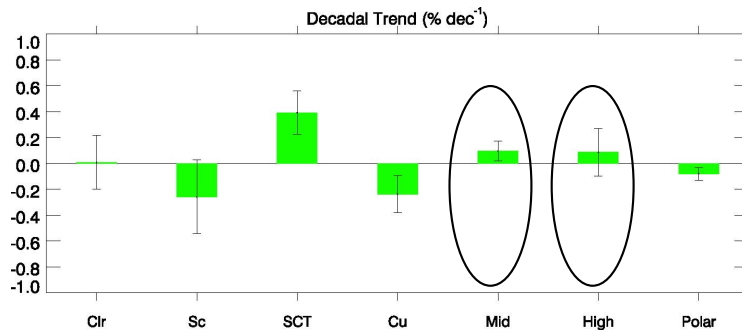
Collocated SSF Ed4 MODIS

Collocated CAL+CS (CCCM ReID1)

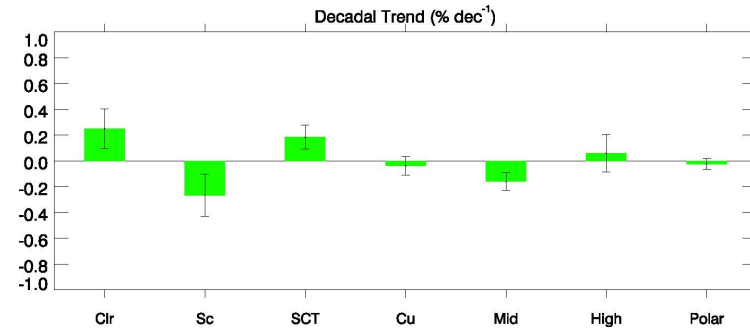
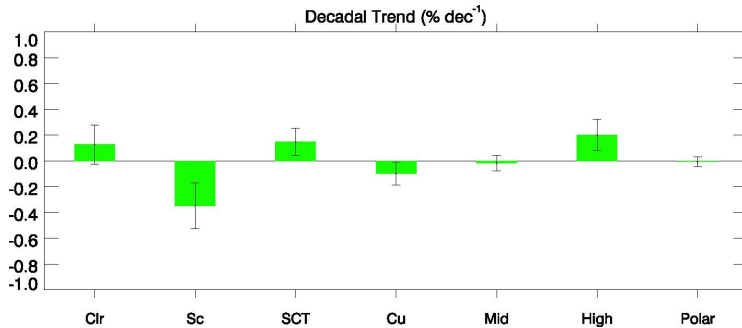
NH



SH



Glo



- Selecting common set of CERES footprints in SSF and CCCM product slightly changes CC cloud trends.
- The changes in MODIS clouds are most likely due to the different versions.
- Good agreements are shown for low clouds between CC and MODIS. The differences are larger for mid and high clouds.

Summary

- By adjusting cloud selection conditions, a better agreement can be achieved between CC and MODIS total cloud fractions. This gives a better justification that MODIS and CC similarly see cloudy columns, even though their cloud heights are different.
- The new filtering method (v5) excludes cases when the CALIPSO cloud extinction coefficient is not available for the entire profile. This will likely exclude very thin clouds or near-clear cases many times. As a result, total cloud fractions in CC and MODIS with the new filtering are larger than those from the previous v2 filtering. This exclusion is performed for the sampling of both CC and MODIS analyses. The exclusion of clear skies perhaps decreases over time, and the exclusion of cloudy skies increases over the southern hemisphere, and further examination is needed (when switching from v2 to v5 filtering, the sign of clear sky trend is flipped in SH).
- By using the v5 filtering method, clear and low (Sc, SCT, and Cu) cloud trends are more comparable between CC and MODIS, compared to the results from v2 filtering.