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Cloud fraction in SH midlatitude cyclones: observational uncertainties

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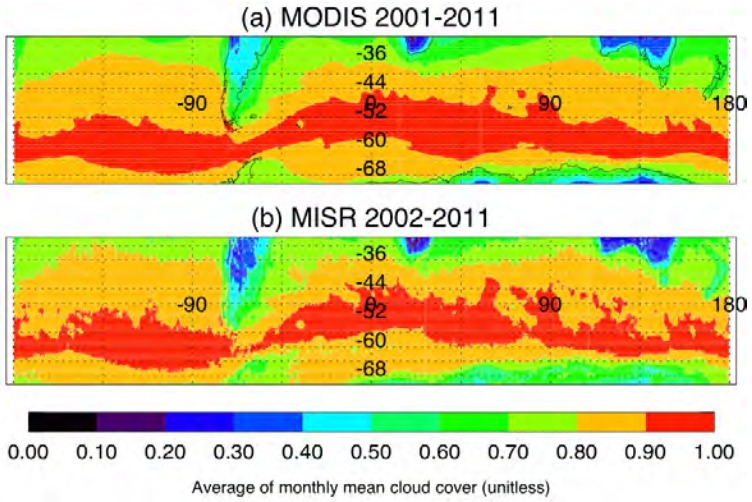
NASA-Terraqua NNX11AH22G, CloudSat NNX10AM20G

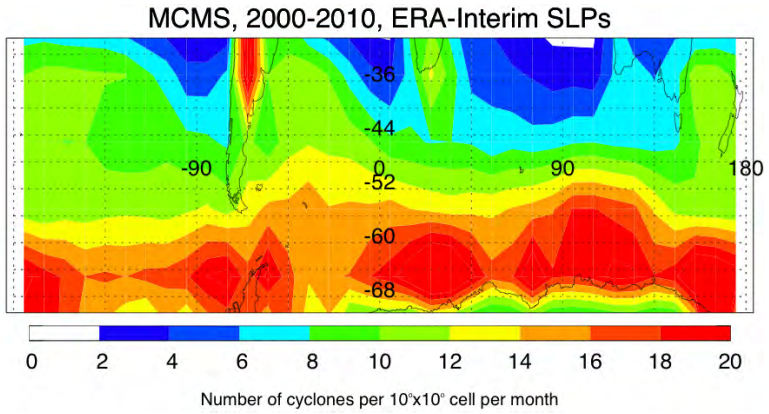
Models underestimate SH cloud cover

- Trenberth and Fasullo (2010): too much solar absorption in the southern oceans in CMIP3 models => less clouds when compared with ISCCP in 40-60°S band
- Cloud fraction exceeds 80% in most of SH oceans, so predicted increase unrealistic
- Large frequency of occurrence of extratropical cyclones in SH oceans=> can models represent cyclone cloud fractions?

MODIS-Terra & MISR, 10-year mean cloud cover



Cyclone number per month per 10°x10° region



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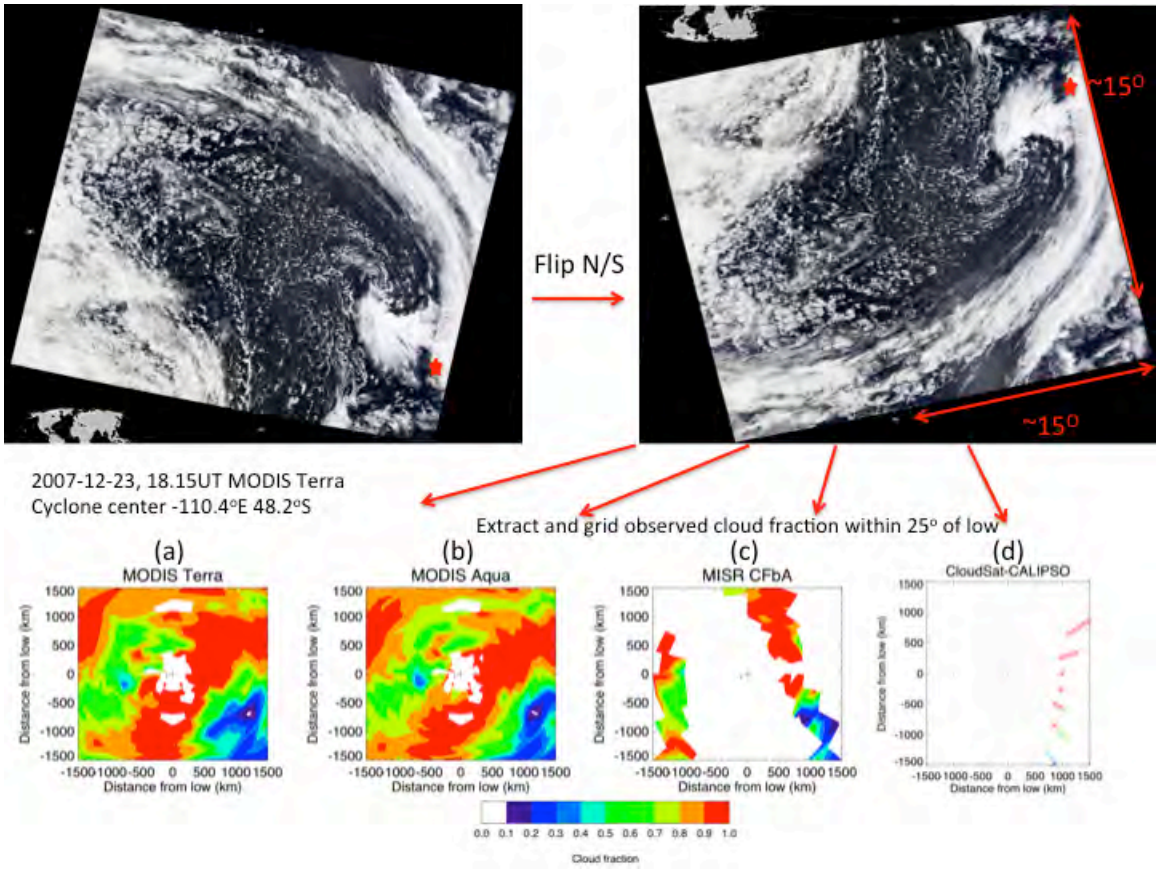
Method



- Useful tool: cyclone centered cloud fraction composites => how do they change with observational setup?
- Collect 4 seasons (NDJFM or MJJAS) of extratropical cyclone locations in SH and NH
- Use MCMS cyclone database
- Associate daily MODIS, MISR and L2 CloudSat-CALIPSO cloud fraction to each cyclone
- Average in cyclone centered grid

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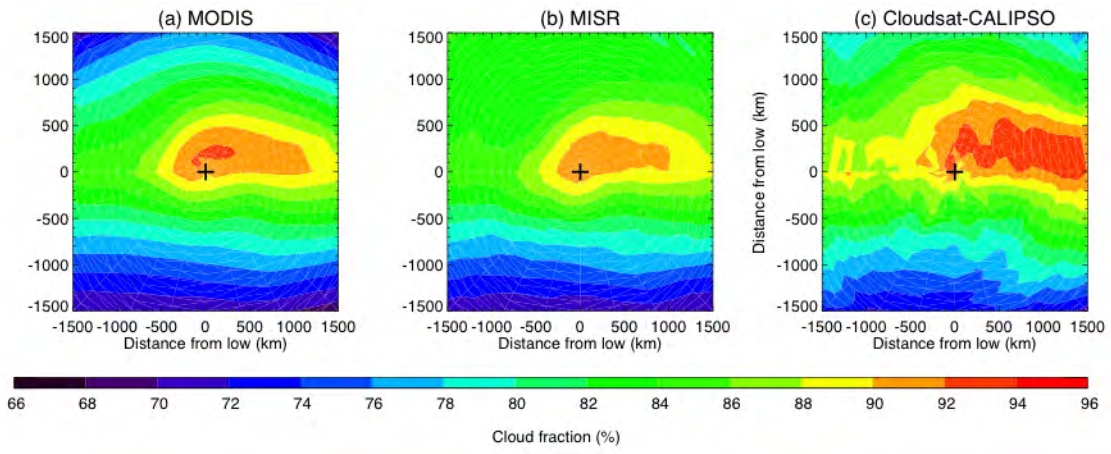
Cloud fraction in SH winter cyclones

Cloud fraction:

- At least 90% along warm front and poleward of the low
- At least 70% within cyclones

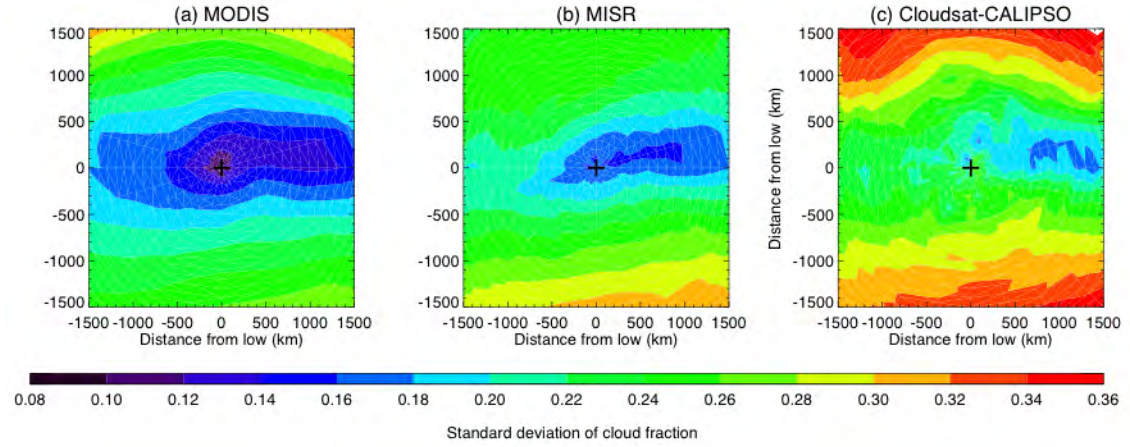
South pole

^



Equator

Standard deviation:
Impact of grid resolution & swath width on standard deviation =>



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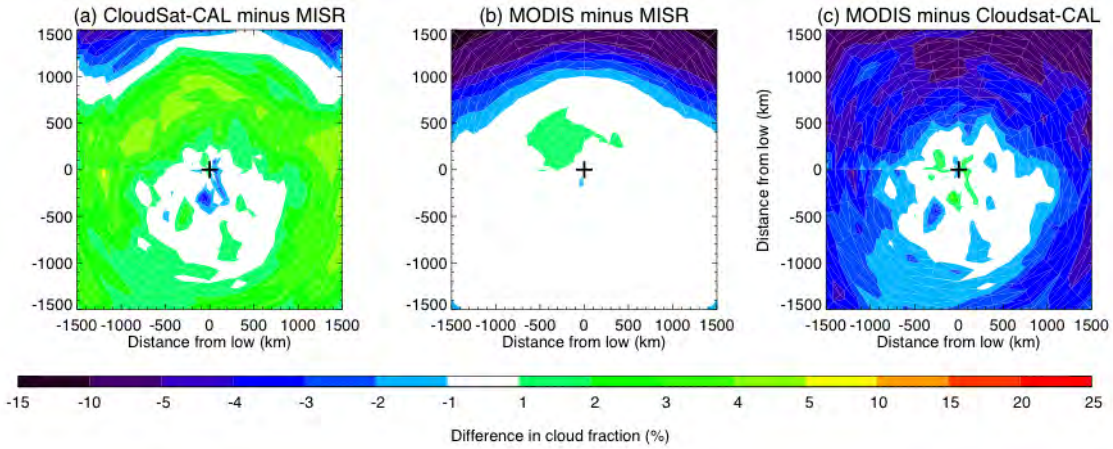
Differences

Inter-dataset differences:

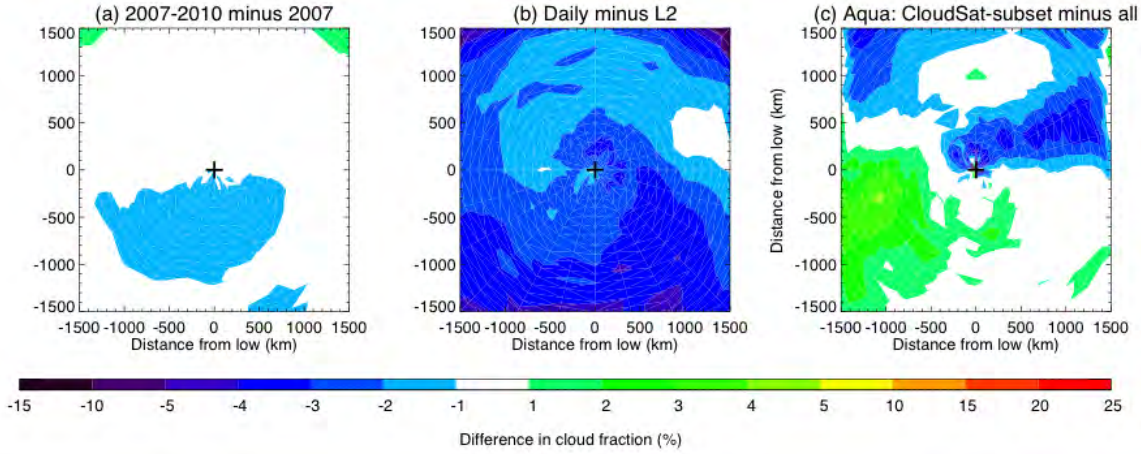
- MISR fraction greater (>5%) than other two datasets poleward of the low
- CloudSat-CALIPSO cloud fraction greater (<5%) than other two within most of cyclone=> except at and equatorward of the low



Differences between:

(a) MODIS 2007-2010 vs 2007 (b) MODIS daily vs L2 (c) MODIS cloudsat-subset vs all

(a) 4-years vs 1-year: sample size impact
(b) (b) 24 vs 3 hrs time delay between cyclones & obs.
(c) Time delay + swath width +sampling



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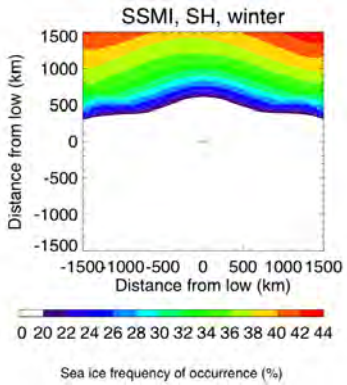
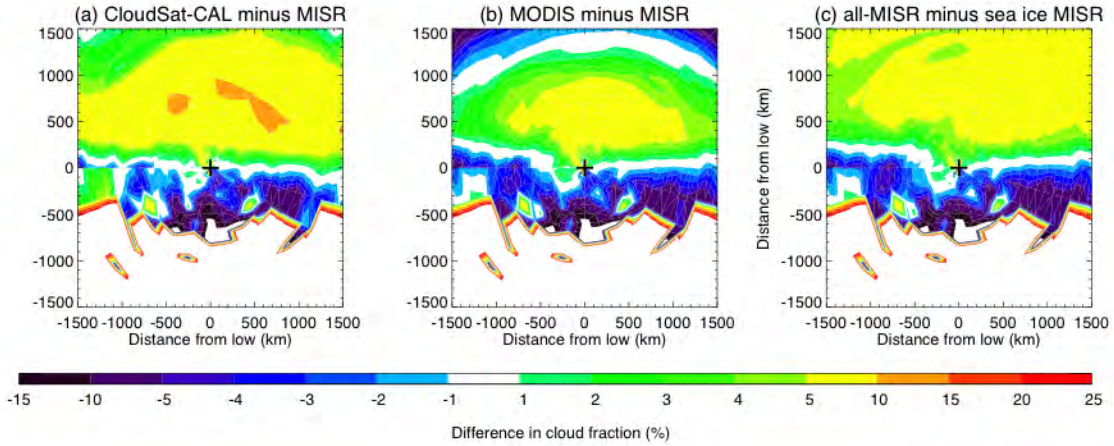
Impact of sea-ice

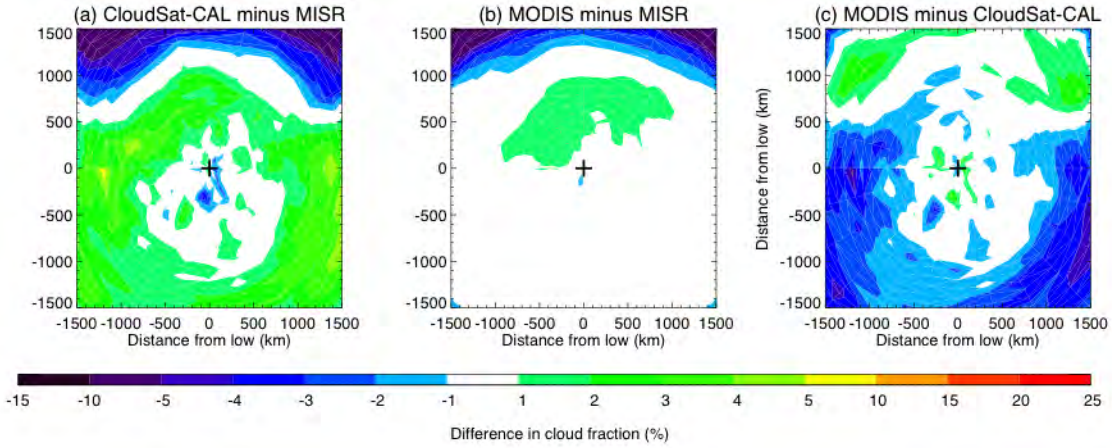
Differences where sea-ice concentration > 0





Where sea-ice>0:
MISR cloud fractions less than CloudSat-CALIPSO and MODIS, esp. near edge

Differences where no sea-ice (SMMR-SSM/I daily product)

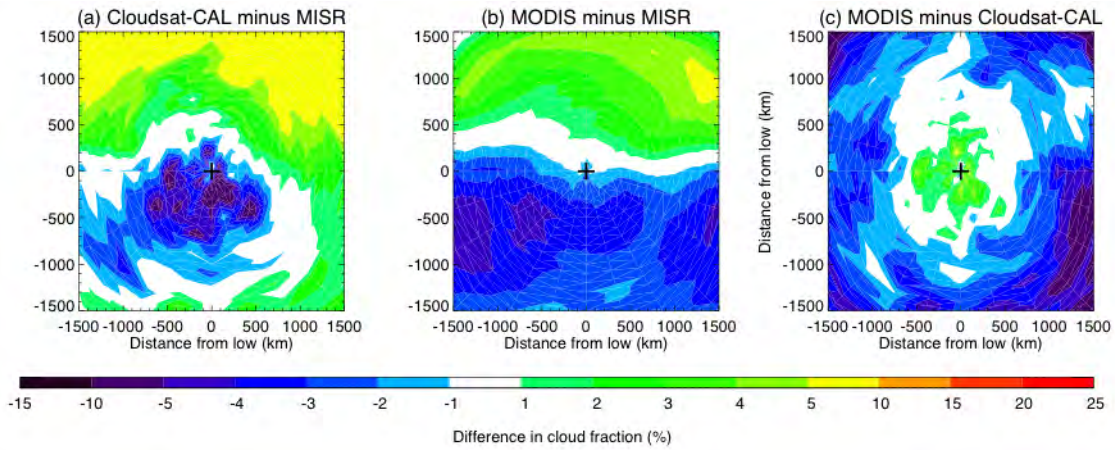


- MODIS and Cloudsat-CALIPSO cloud fraction poleward of the low virtually identical
- BUT MISR cloud fraction even larger than other 2 datasets

=> Problems with sea ice detection with SSMI/SMMR , or clouds mostly cumuli or day vs night issue?

SH summer cyclones

NDJFM, 2006-2010, SH oceans



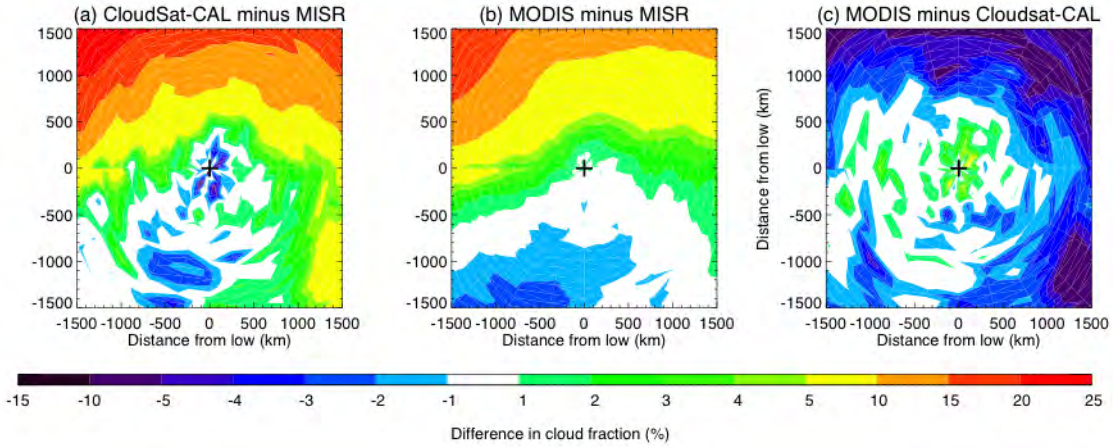
⇒ Poleward: MISR less than other two datasets

⇒ Equatorward: MISR > CloudSat-CALIPSO > MODIS

Impact of 1) optical thin clouds and 2) cumuli?

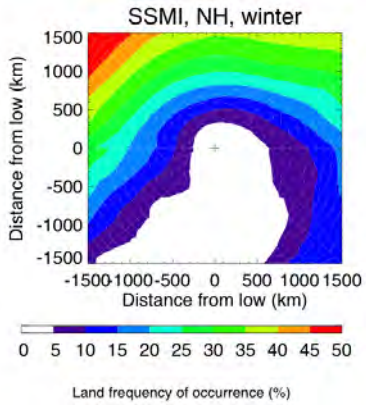
Overall: outside of poleward region, differences < 5%

NH NDJFM cyclones

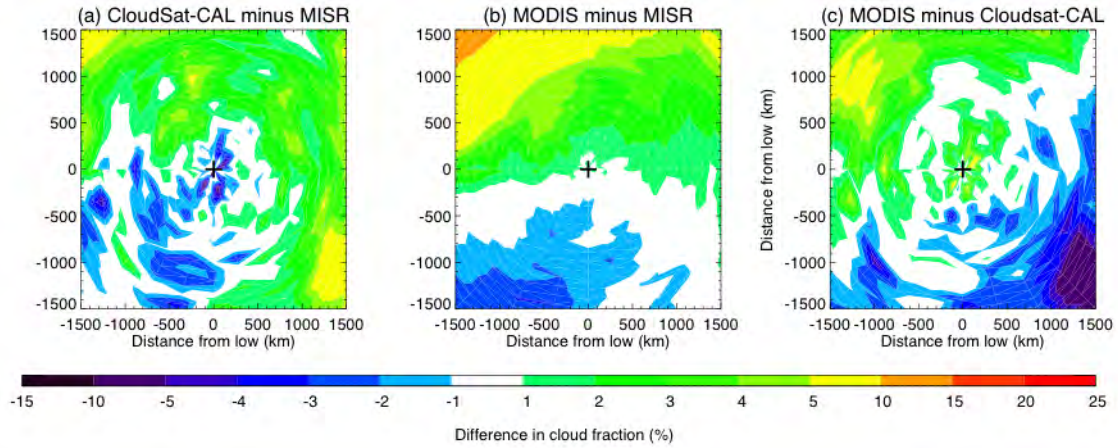


- Pole side: MISR < MODIS < Cloudsat-CALIPSO
- Equator side:
  west: all three within 5%
  east: CloudSat-CALIPSO more than other two (thin clouds?)

Impact of land:



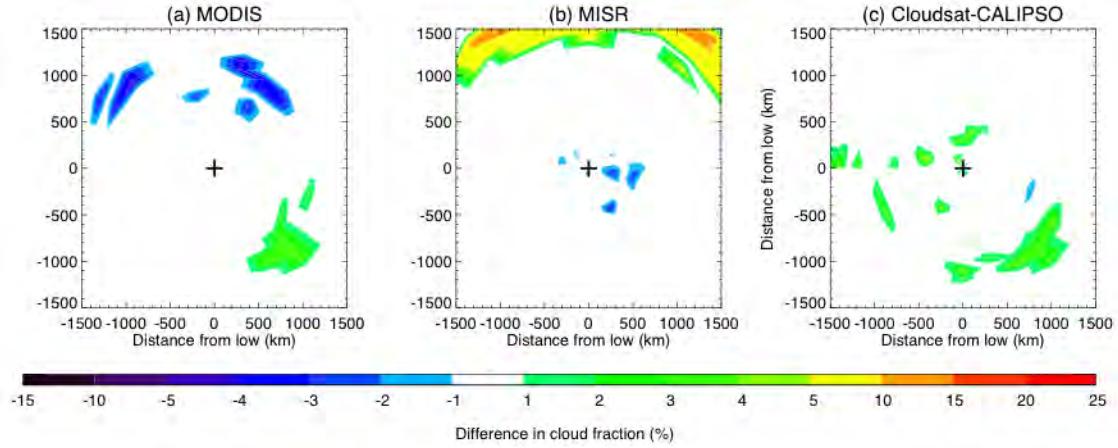
Difference over open-ocean



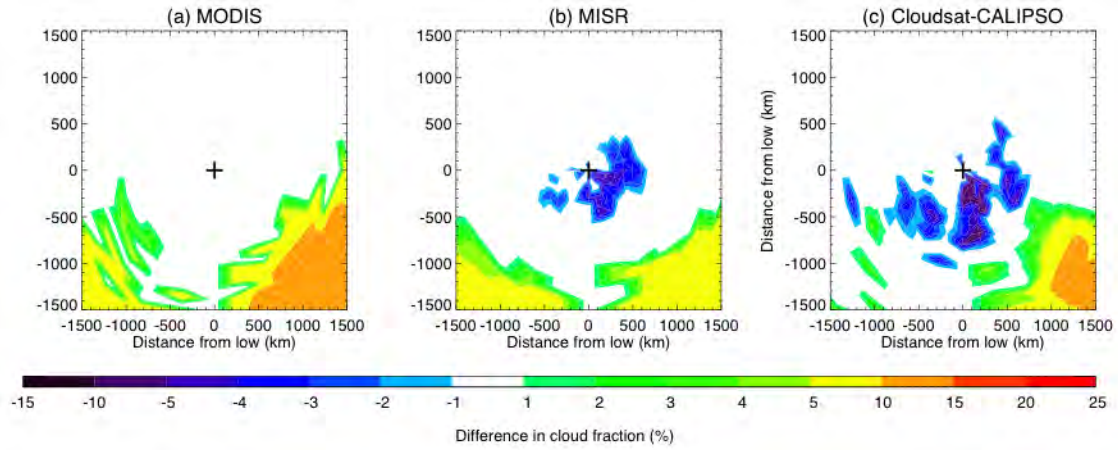
=> MISR & MODIS underestimate over land but MODIS > other two over open oceans

Winter vs. Summer contrast

Winter-summer difference where greater than max(difference) between 3 datasets



SH contrast: weak
Same magnitude as observations uncertainty



NH contrast:

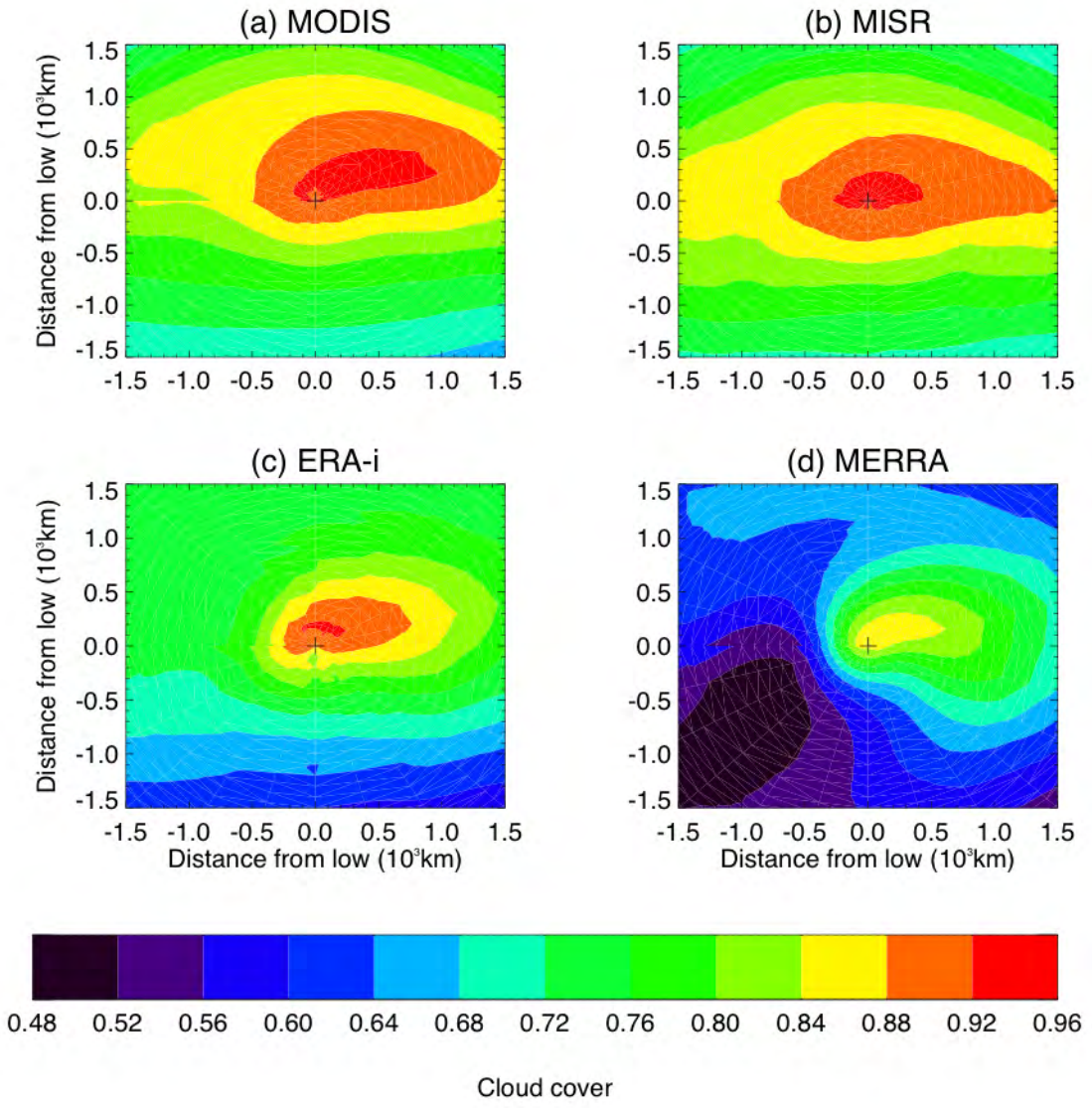
- Larger than uncertainty in observations
- Greater fractions in south-east quadrant in winter
- Lower winter fractions south and east of the low
- => correlates with difference in moisture flux

Comparison with ERA-interim and MERRA

- Apply same technique on 2D total cloud fraction from ERA-interim and MERRA (same period)
- Analyze SH summer cyclones
- Compare to MODIS and MISR

⇒ Frontal zone & west of low show lower cloud fractions in reanalysis than observations

⇒ MERRA cloud fractions lower than ERA-interim



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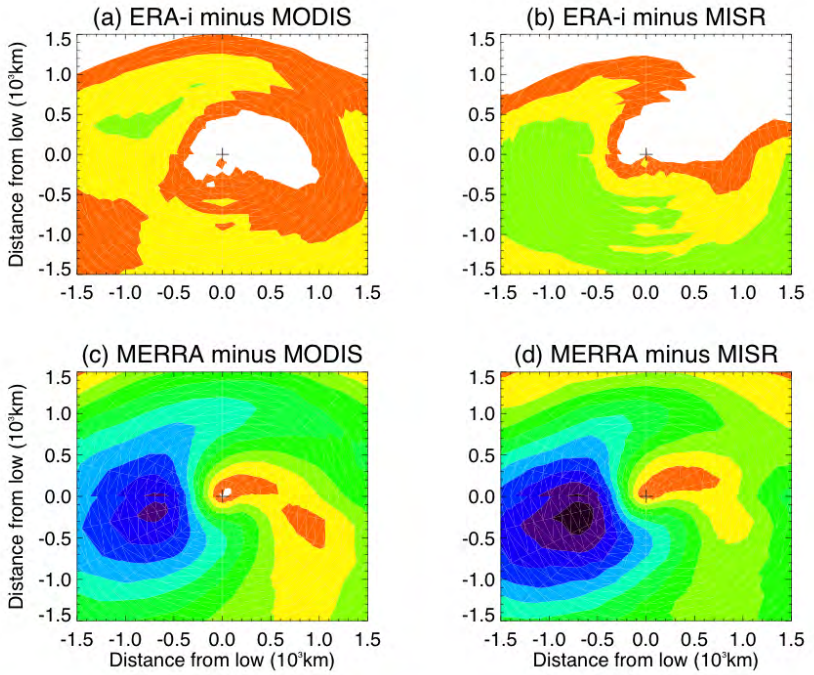
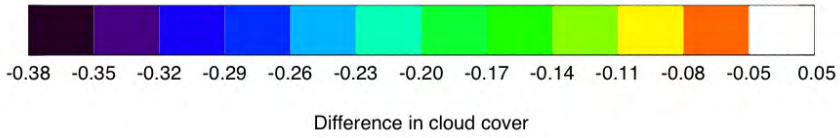
Difference in cloud fraction: SH summer





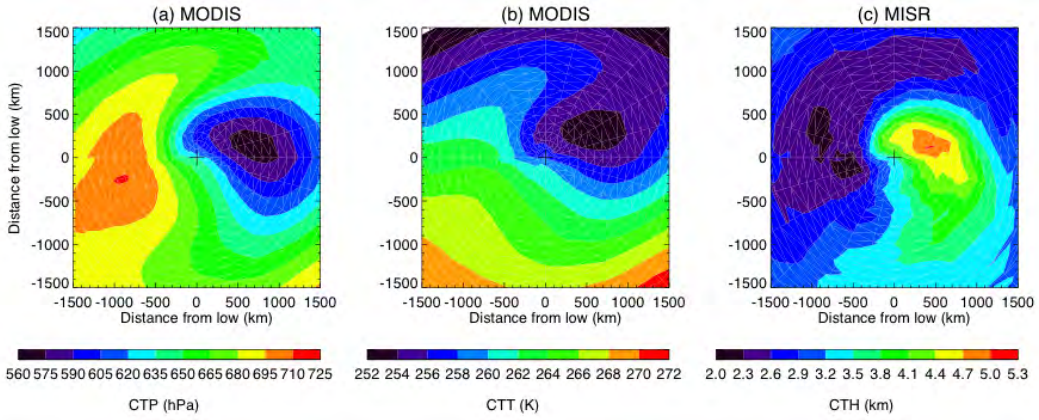
Differences where larger than diff(MODIS-MISR)

⇒ ERA-interim 8-14% underestimate, west and equatorward of the low

⇒ MERRA ~20-35%, largest to the west of the low

⇒ MODIS CTP, CTT and MISR CTH indicate spatial correlation between ERA-I bias and CTT and between MERRA bias and CTP/CTH

⇒ Difference with obs. and between each other=> Large scale issue or parameterization?



Conclusions and future work

- Investigate problems with modeled clouds: large scale vs. parameterizations?
- What happens in low-level cloud + non-cyclonic conditions?
- Test different versions of GISS GCM (new convection scheme, new PBL scheme).

Ref: Naud et al, 2013, submitted to JGR