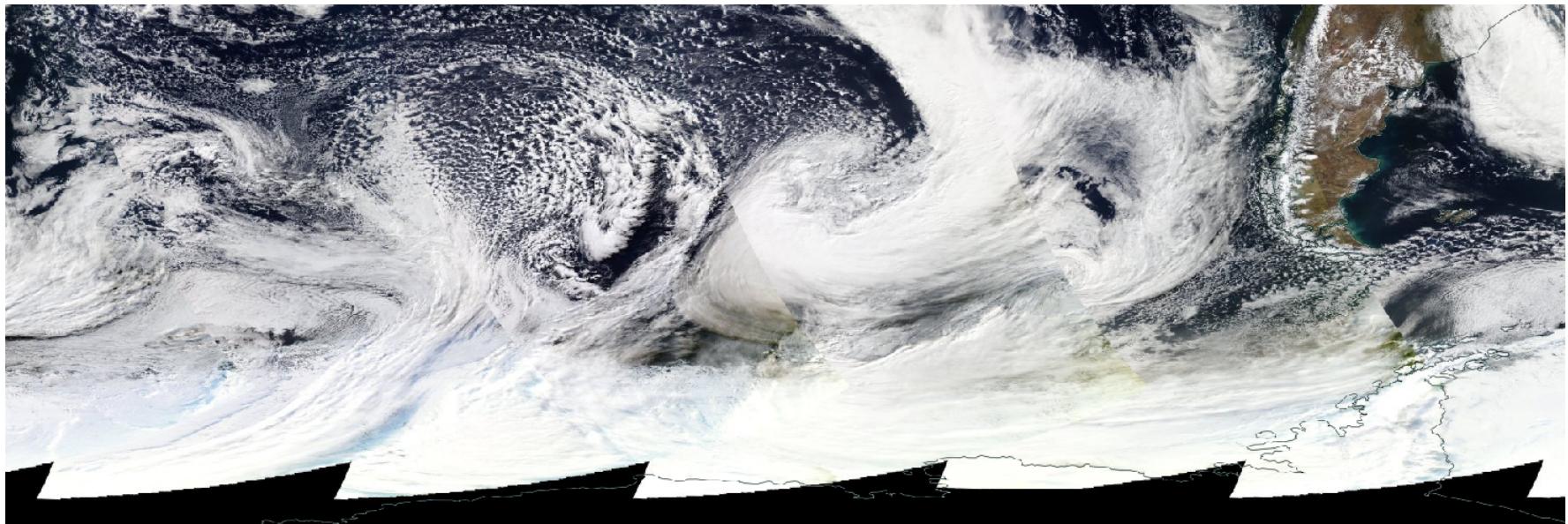


Marine cold air outbreaks: meteorology, clouds, and radiation



Jennifer Fletcher, Christian Jakob, and Shannon Mason
Monash University, Melbourne, Australia



NASA Worldview corrected reflectance from Aqua, 24 Aug 2012

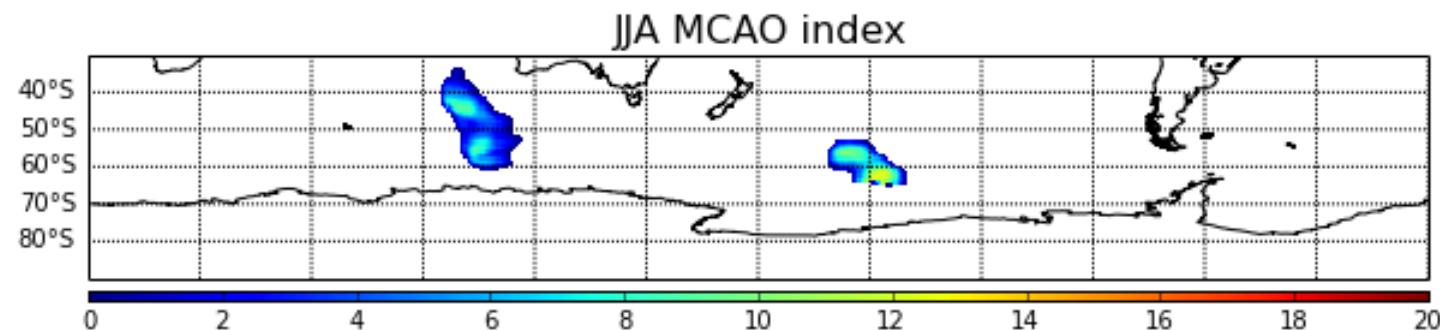
Southern hemisphere MCAOs

- ↗ Marine cold air outbreaks often come up in conversations about Southern Ocean clouds and climate model biases.
- ↗ Northern hemisphere cold air outbreak cases have been used to aid model development aimed at Southern Ocean cloud biases (e.g., Bodas-Salcedo et al, 2012).
- ↗ What are the characteristics of SH cold air outbreaks compared to those in the NH? Is the meteorology the same? Are the clouds the same? How important are they for shortwave radiation?

Marine cold air outbreak index

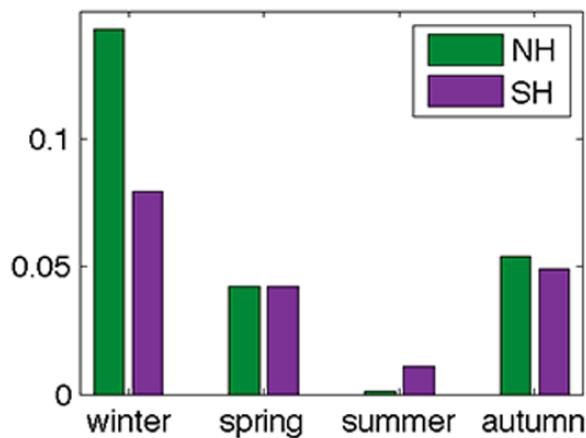
- ↗ $M = \theta_{SK} - \theta_{800}$ in ERA-Interim
 - ↗ $\theta_{SK} = T_{SK}(p_0/p_{msl})^{R/C_p}$
 - ↗ Similar to index developed for reanalysis/
climate models in Northern hemisphere
(Kolstad and Bracegirdle 2008)
- ↗ MCAO: when $M > M_{thresh}$ (usually 0)

Daily MCAO index one winter

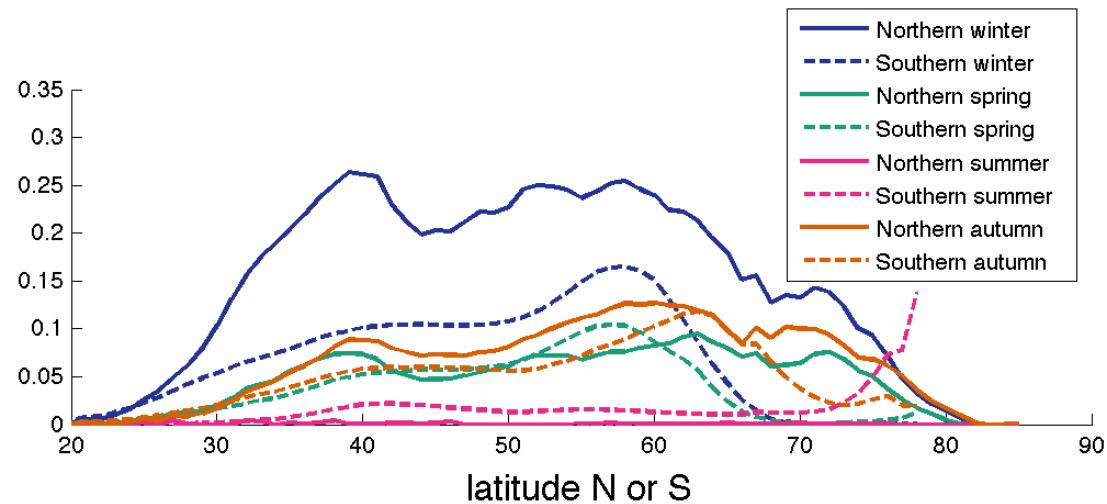


Cold air outbreaks are rare – especially in summer

a) hemisphere mean RFO



b) zonal mean RFO

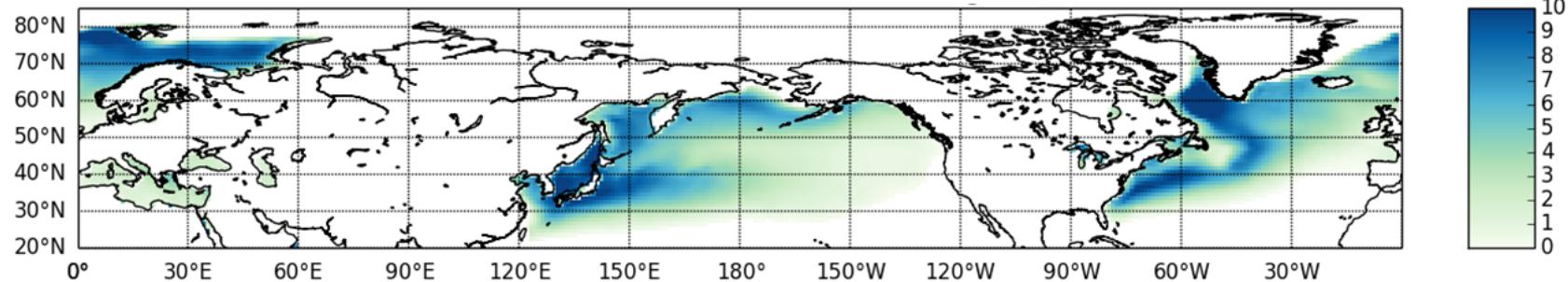


Cold air outbreaks are weaker in the SH than in the NH

95th percentile value of M [K] during winter

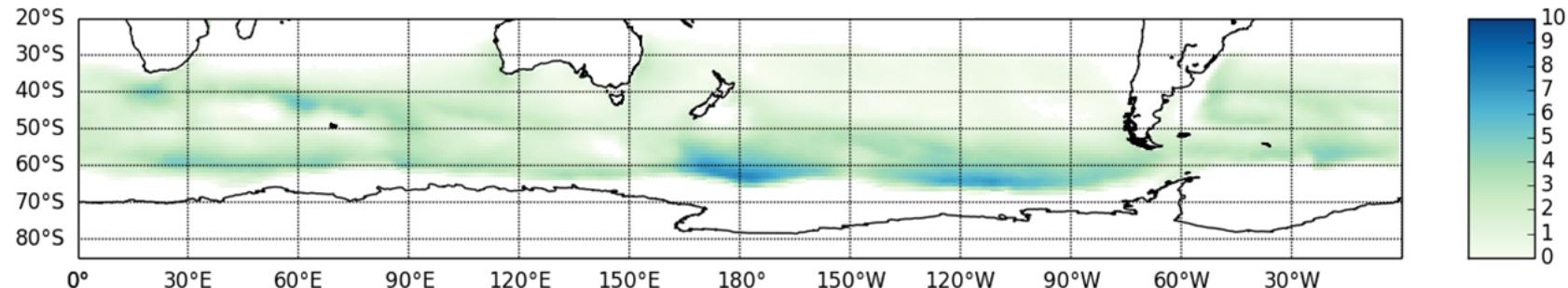
c)

DJF



d)

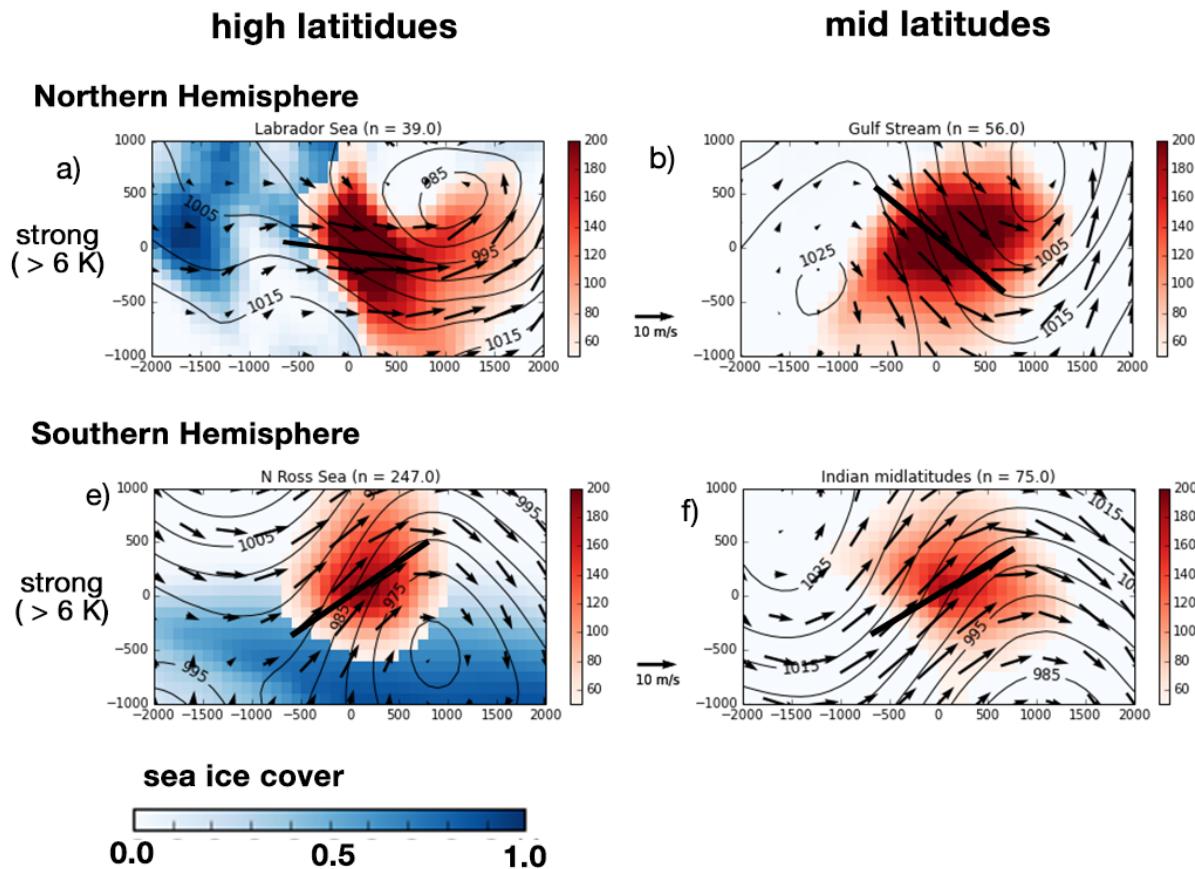
JJA



MCAO events

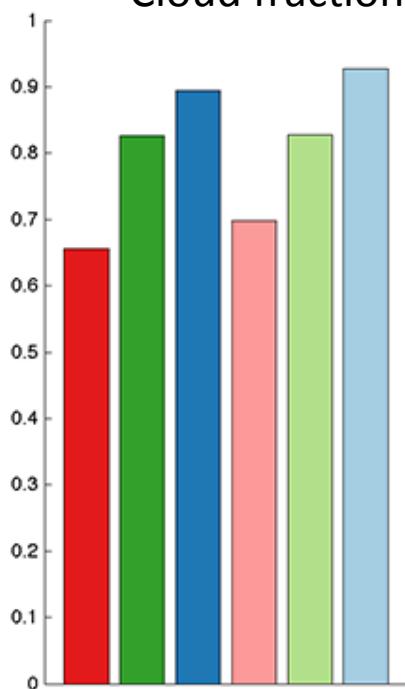
- ↗ Define an MCAO event as instantaneous closed contour where $M > 0$.
- ↗ Composite on events centered at the location of the maximum value of M within the contour.
- ↗ Only used events that are similar in size and magnitude (determined by maximum value of M).

They have similar synoptic conditions everywhere

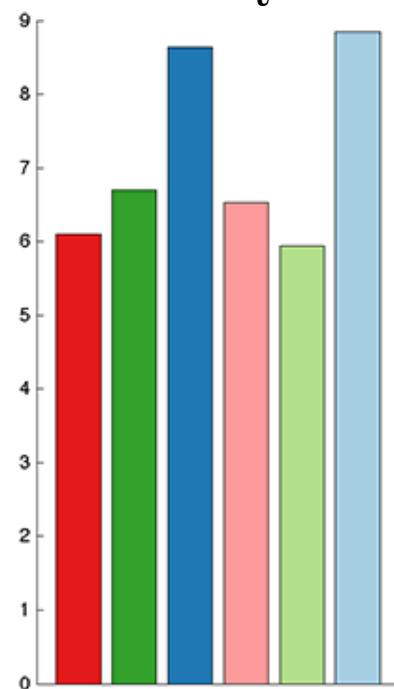


MCAOs – especially strong ones – have greater cloud fraction and τ than average

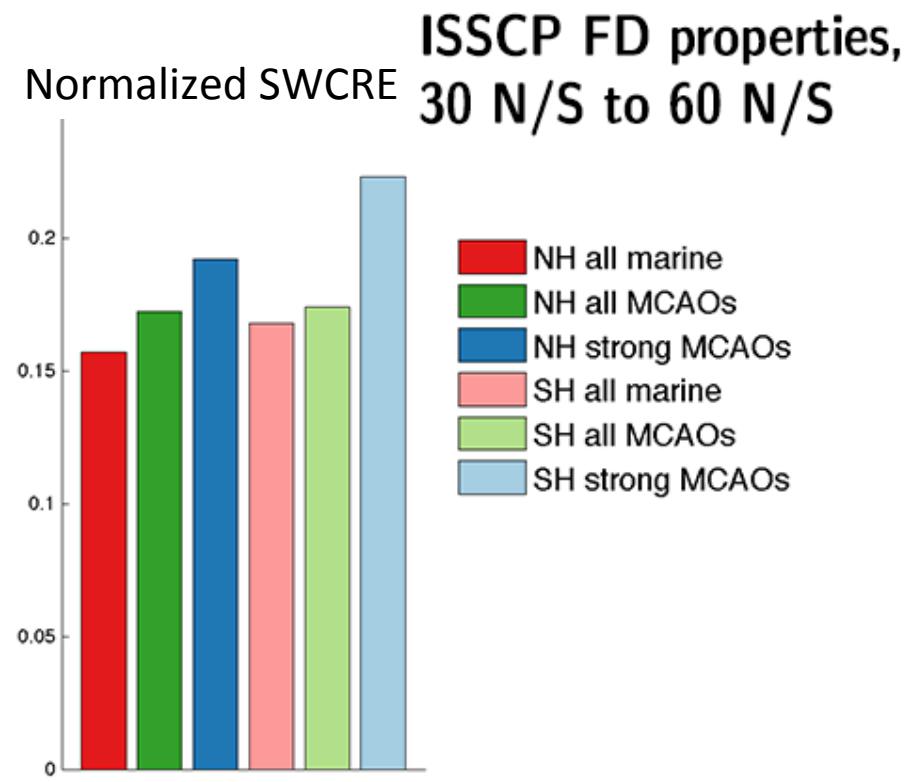
Cloud fraction



τ



Normalized SWCRE



**ISSCP FD properties,
30 N/S to 60 N/S**

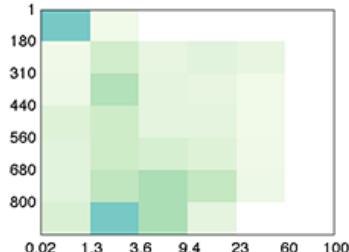
- NH all marine
- NH all MCAOs
- NH strong MCAOs
- SH all marine
- SH all MCAOs
- SH strong MCAOs

The stronger the MCAO, the deeper the cloud top and the more optically thick it is

ISCCP histograms in MCAOs

Ocean Mean

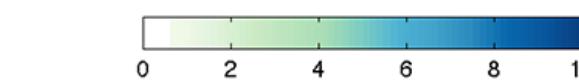
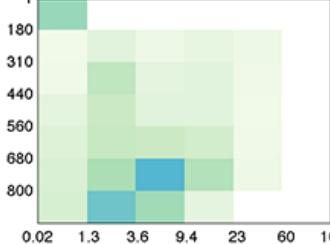
Northern hemisphere



MCAO Mean

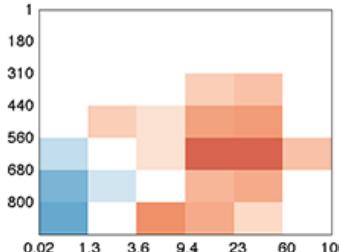
Southern hemisphere

Southern hemisphere



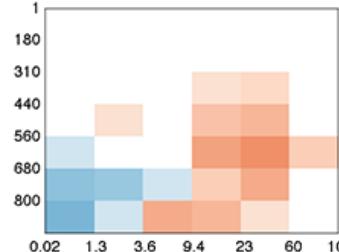
weak anomaly

$$0 < M \leq 3$$



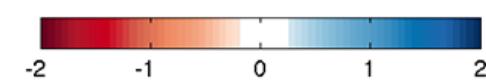
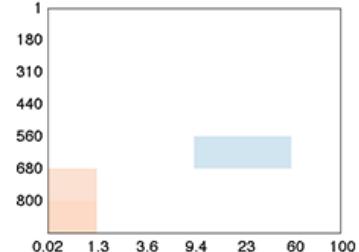
moderate anomaly

$$3 < M \leq 6$$

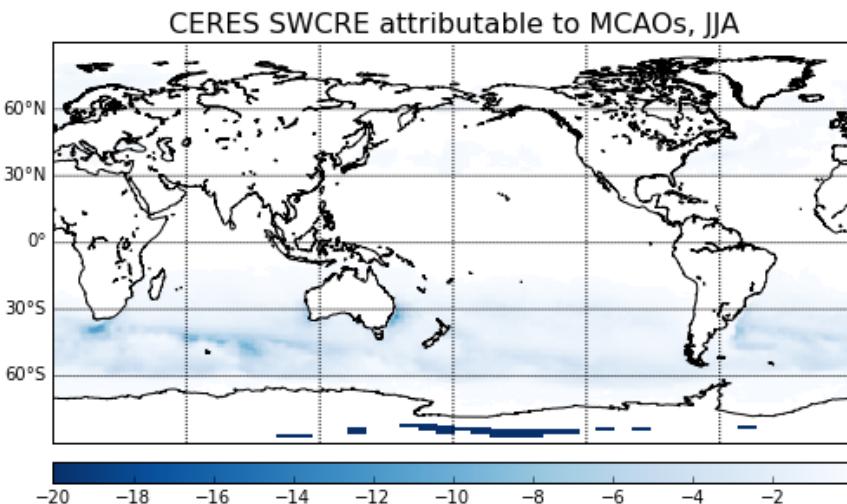
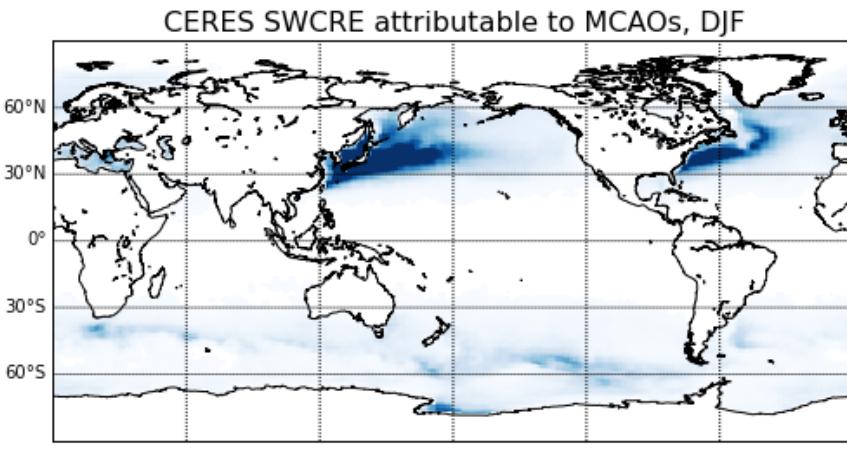


strong anomaly

$$6 < M$$



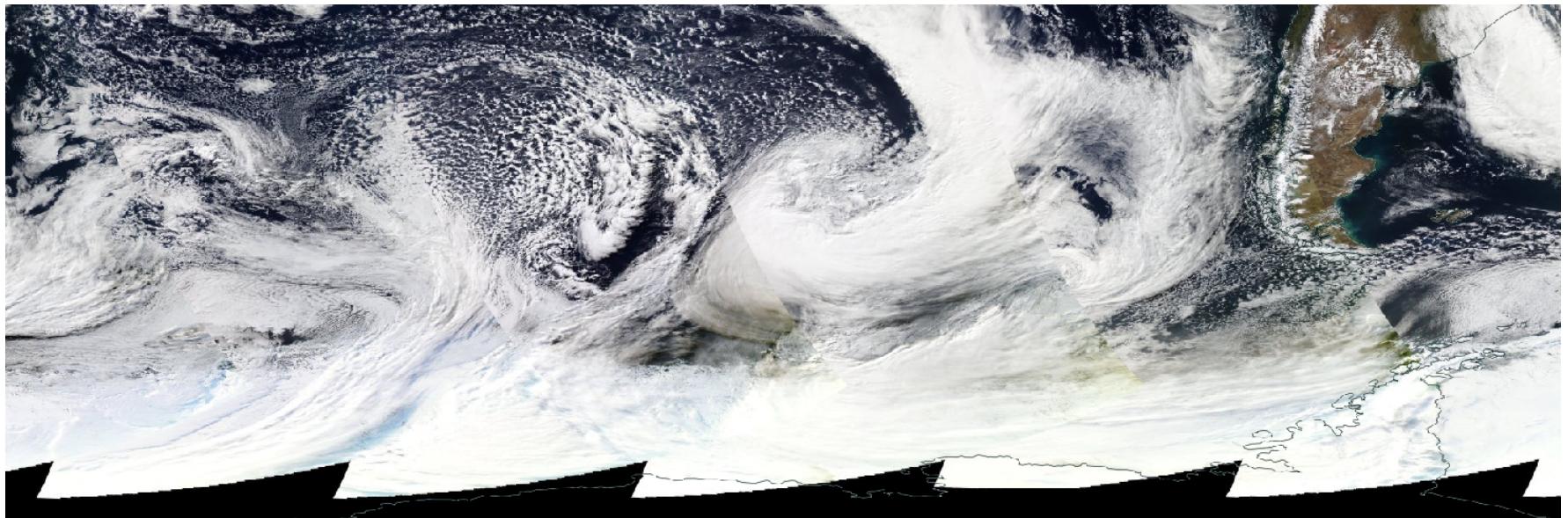
The contribution of MCAOs to extratropical SWCRE – what is the maximum bias?



- ↗ Do MCAOs matter for shortwave cloud forcing overall? No.
- ↗ Could they contribute substantially to SWCRE bias in models? Maybe.

Summary

- Cold air outbreaks have higher optical thickness, cloud fraction, and SWCRE than average for oceanic extratropics.
- But they are rare, so their contribution to SWCRE is small.

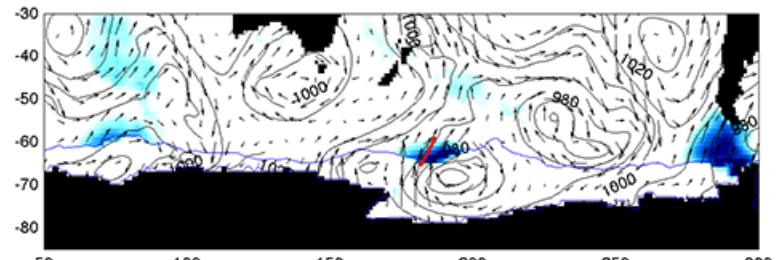


Corrected reflectance from Aqua, 24 Aug 2012

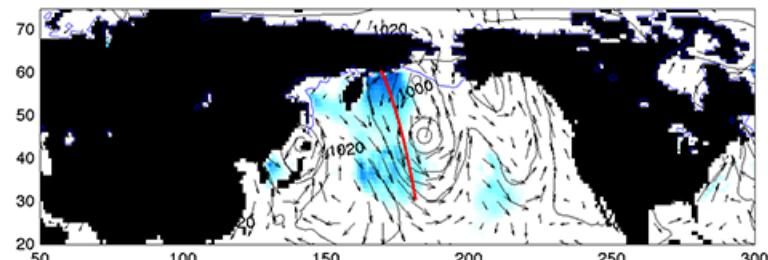
Next steps

- Composite profiles of ice water content and distributions of cloud phase in MCAOs from CloudSat/CALIPSO combined data.

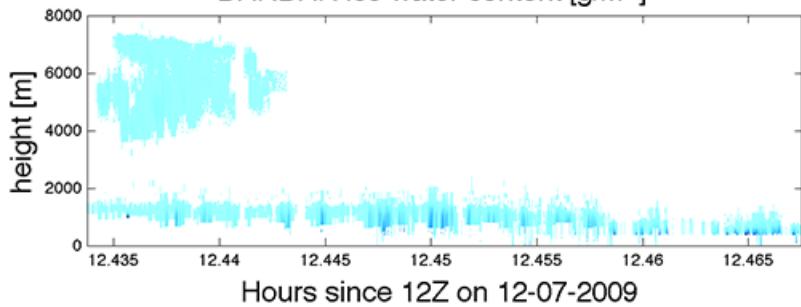
12Z on 12-07-2009



00Z on 19-01-2009



MCAO index [K]

DARDAR ice water content [g/m³]

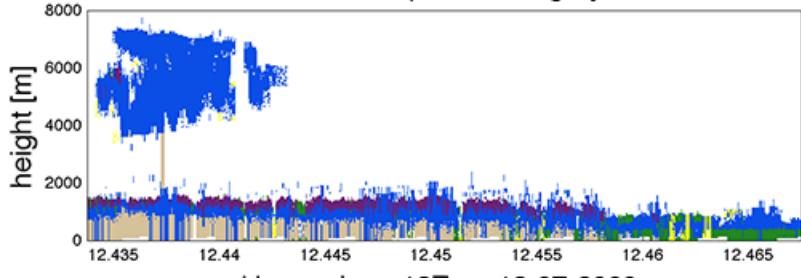
equatorward

poleward

equatorward

poleward

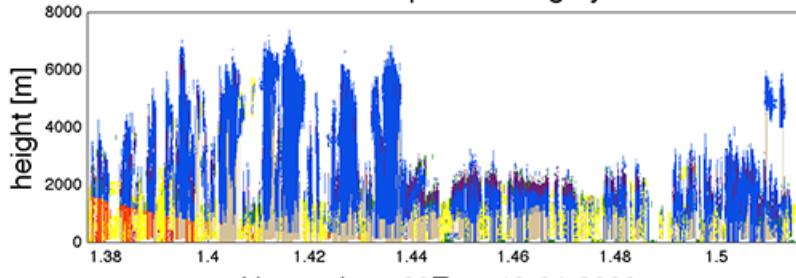
DARDAR phase category



Hours since 12Z on 12-07-2009

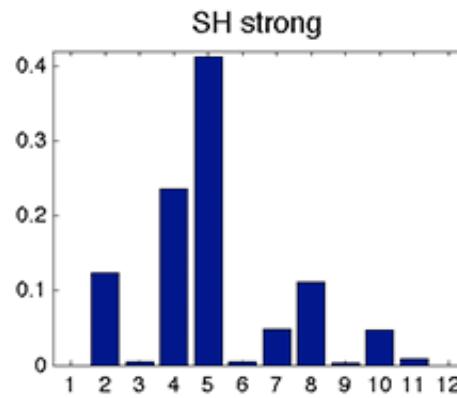
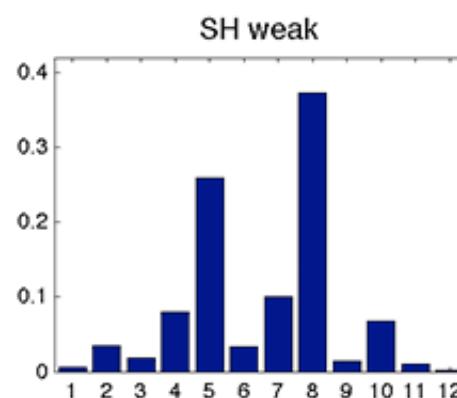
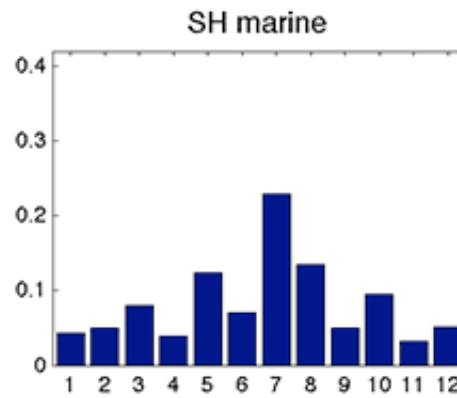
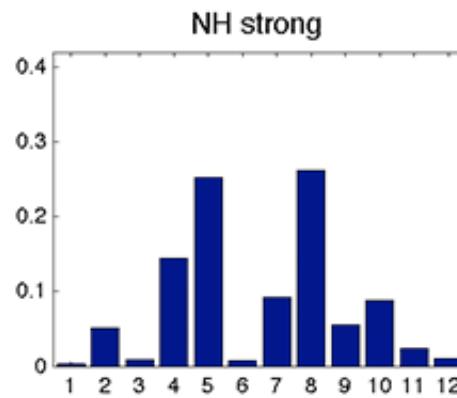
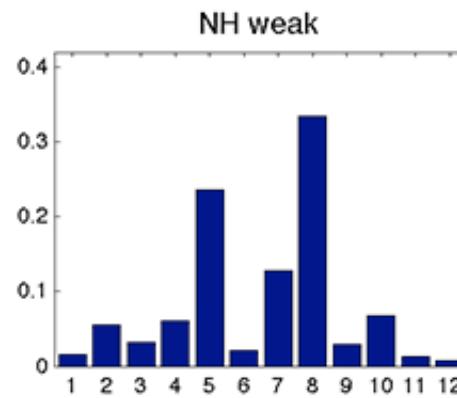
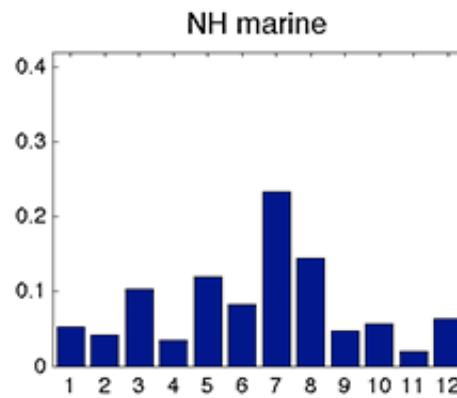


DARDAR phase category



Hours since 00Z on 19-01-2009

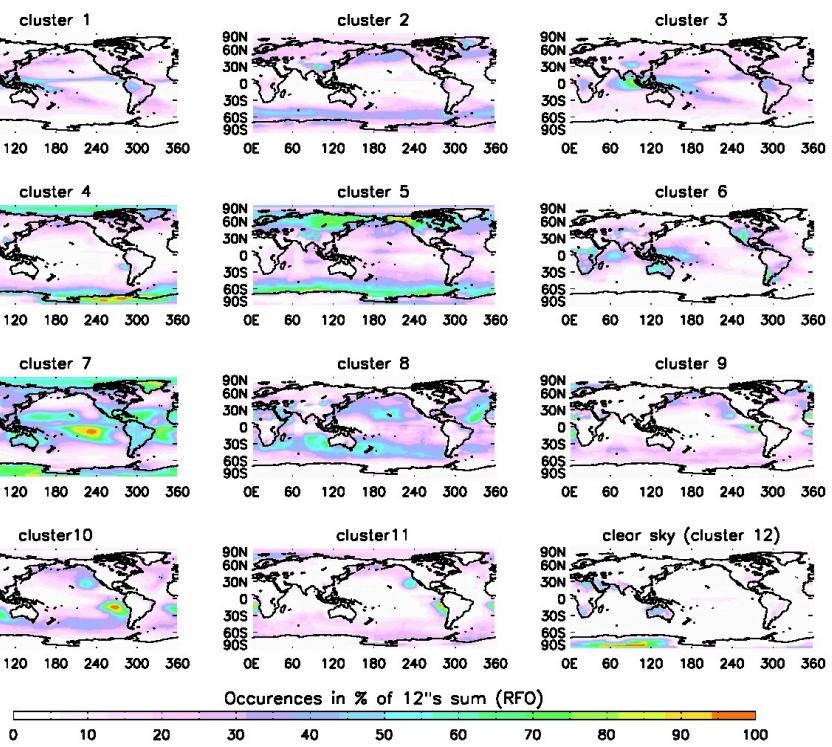
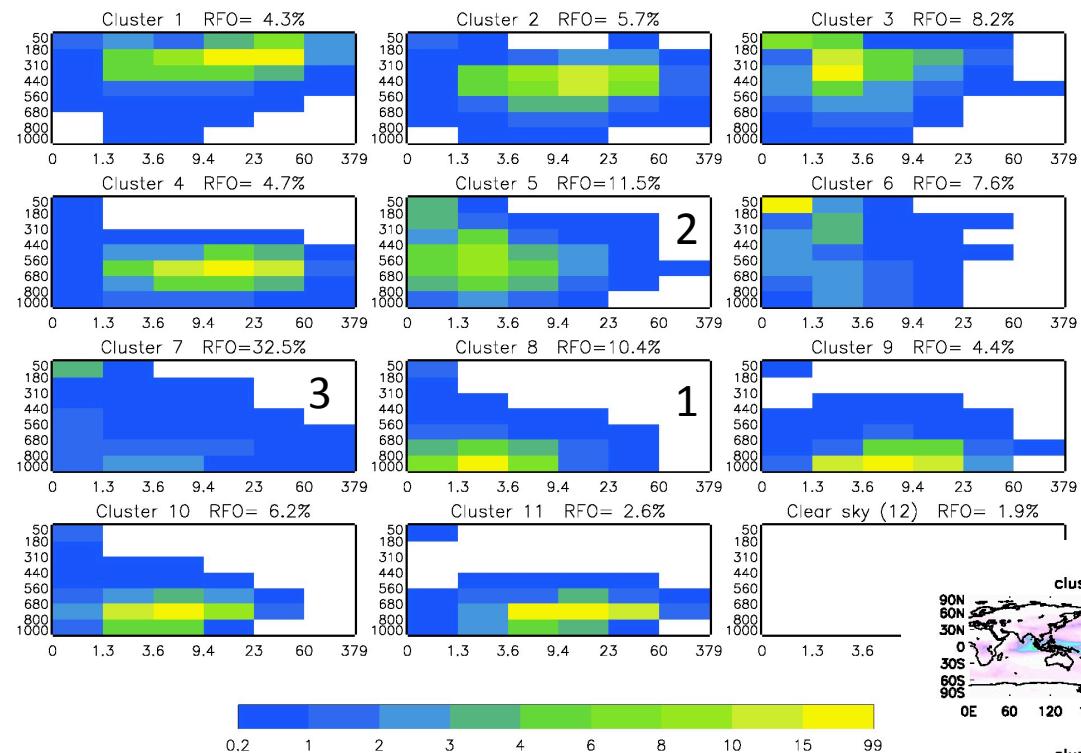
RFO of ISCCP global cloud regimes



Global clusters for reference

(from

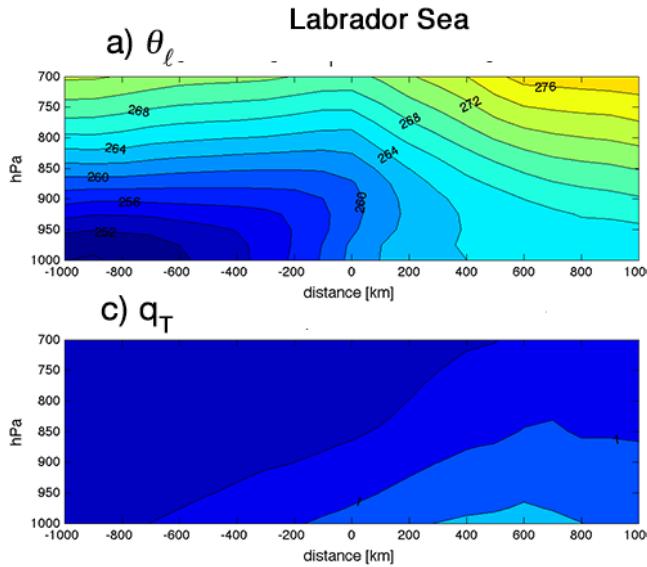
[http://crest.ccny.cuny.edu/rscg/
Products/WS/glcluster.html](http://crest.ccny.cuny.edu/rscg/Products/WS/glcluster.html),
originally in Tselioudis et al (2012))



high latitudes

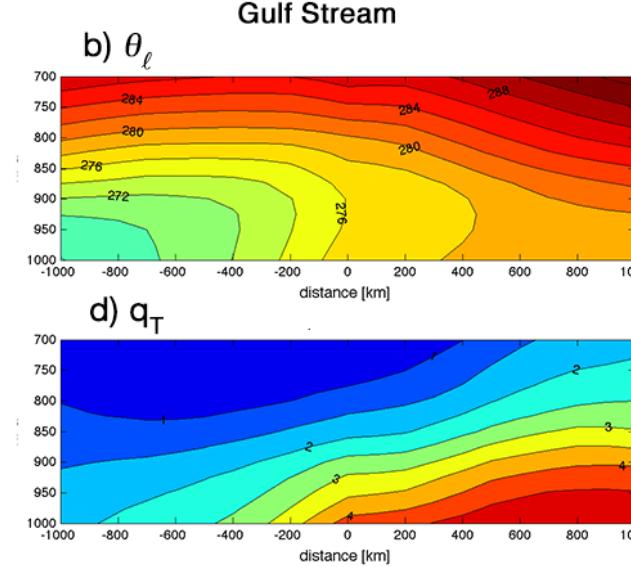
Northern Hemisphere

Labrador Sea



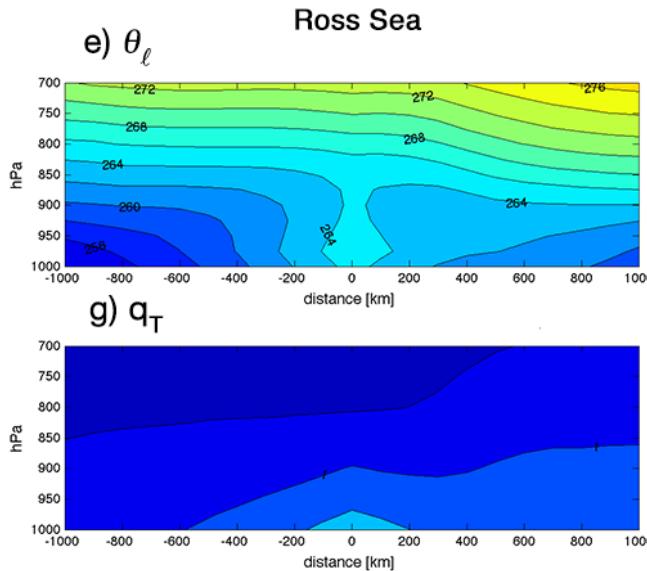
mid latitudes

Gulf Stream

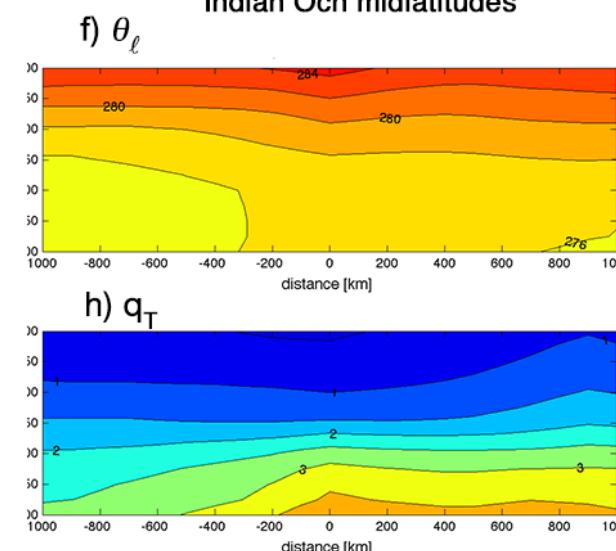


Southern Hemisphere

Ross Sea



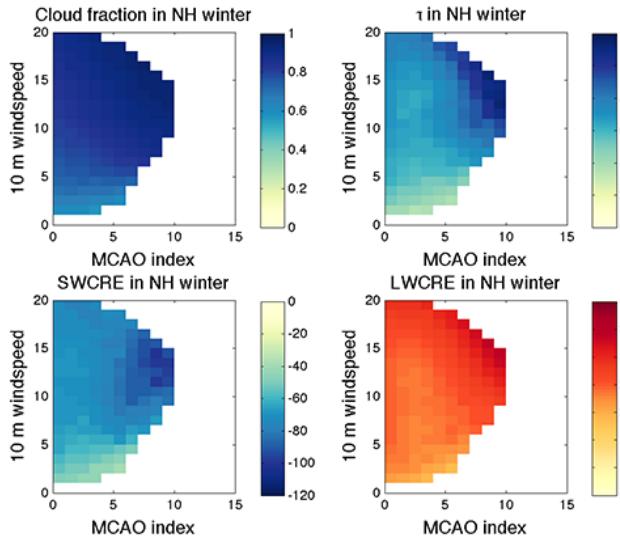
Indian Ocn midlatitudes



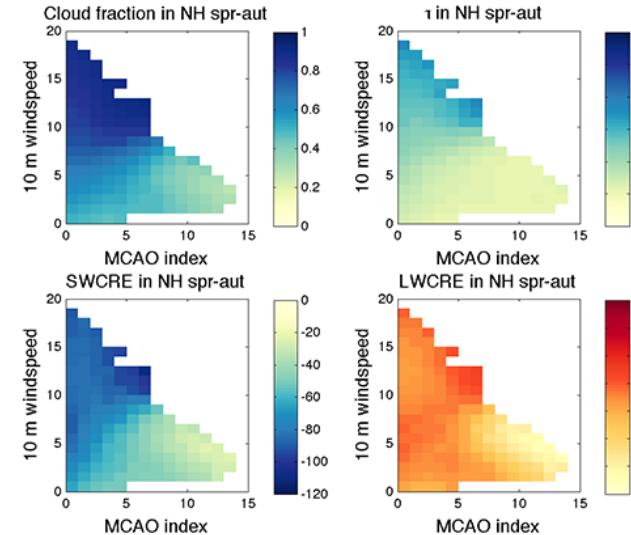
ISCCP cloud and radiation binned by MCAO index and 10 m wind speed

Northern Hemisphere

a) winter

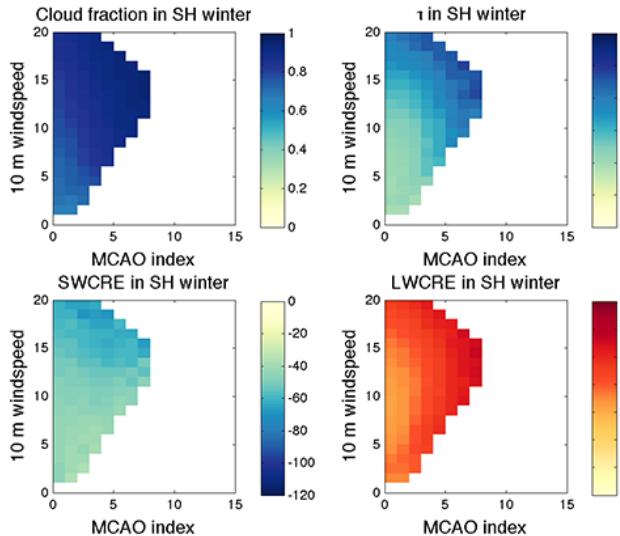


b) spring, summer, autumn



Southern Hemisphere

c) winter



d) spring, summer, autumn

