Cloud trends (and processes) from 15 years of Atmospheric Infrared Sounder observations

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ICWG-2

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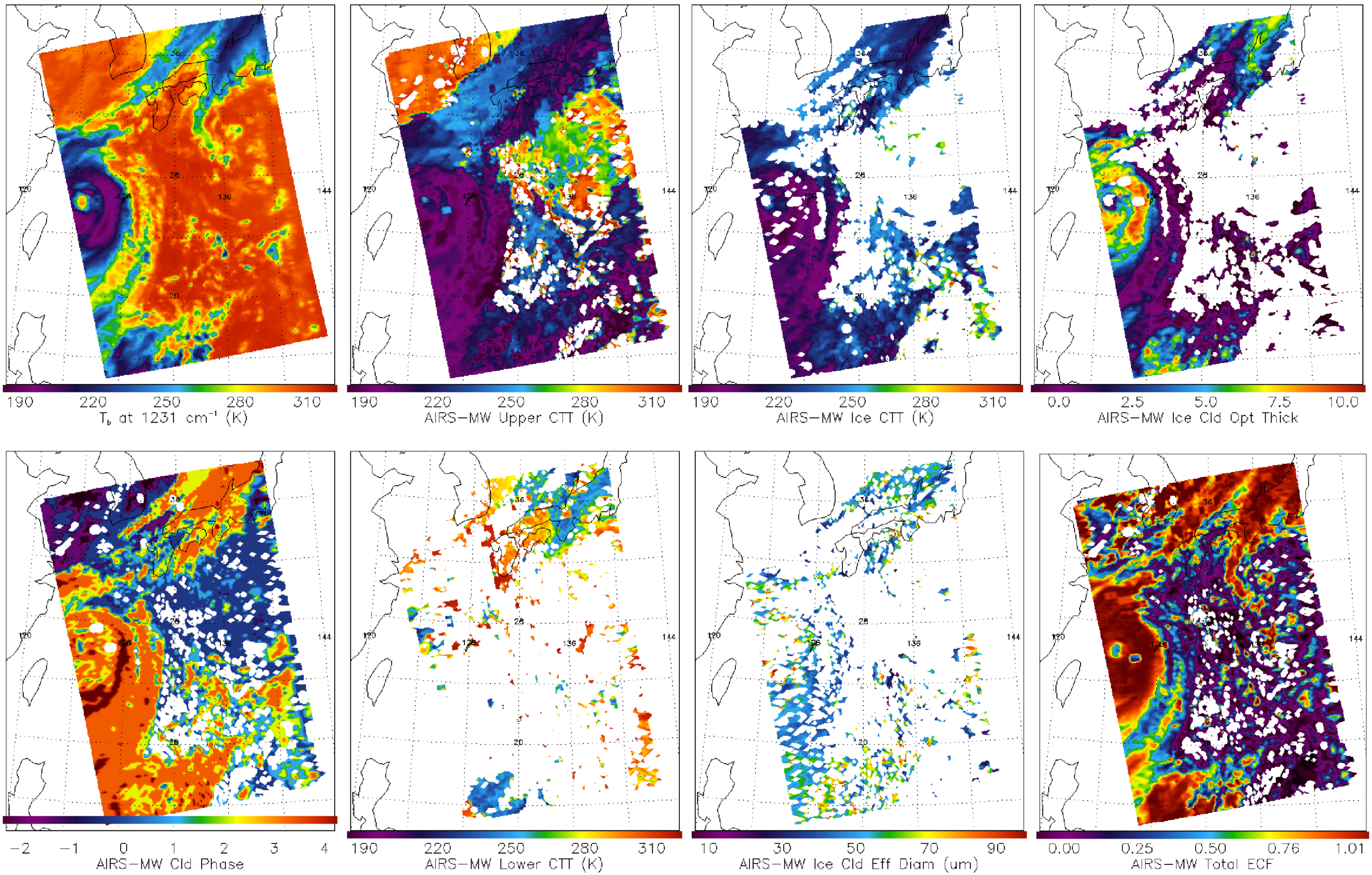
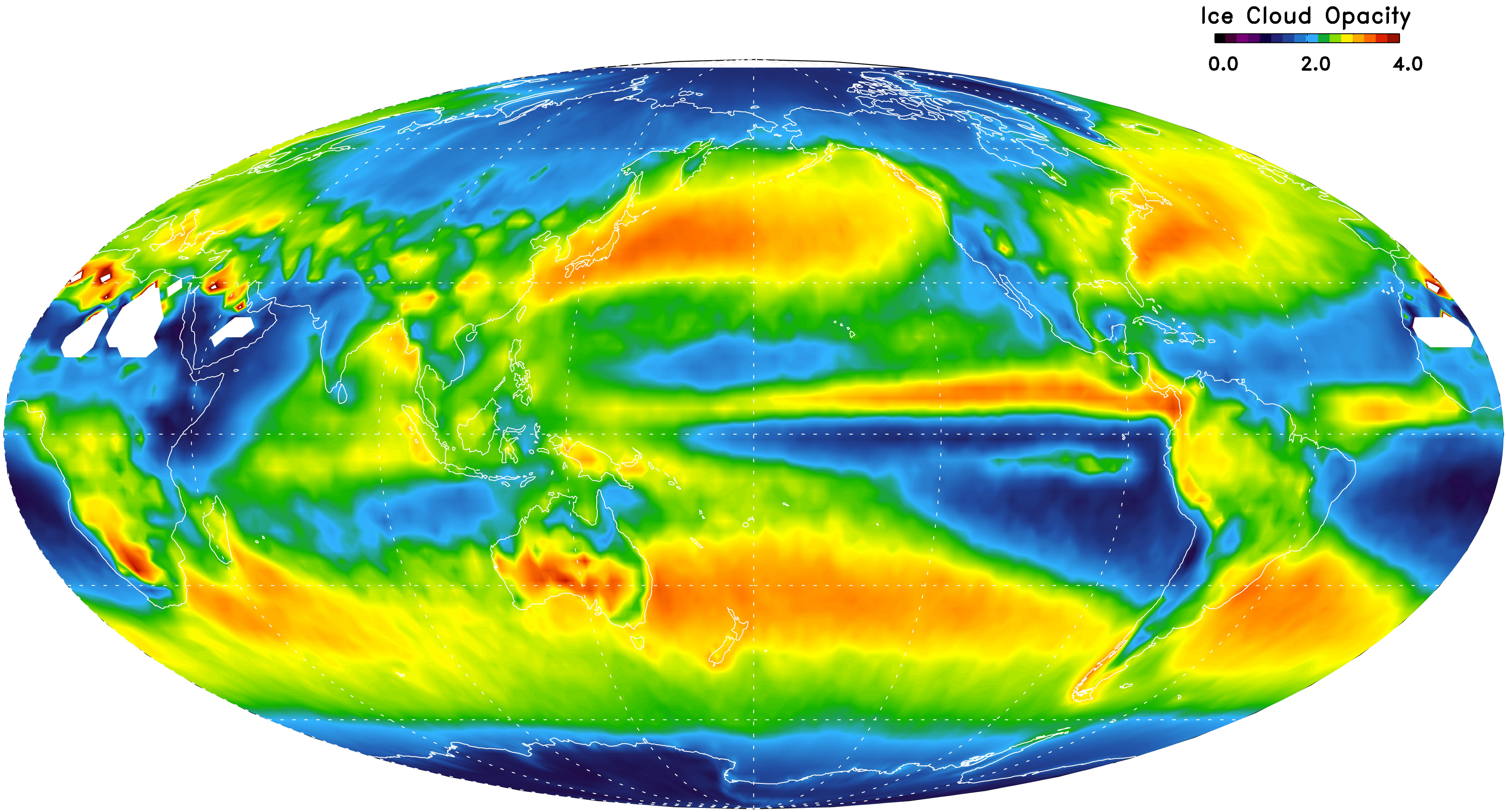
Example six minute AIRS granule on September 6, 2002

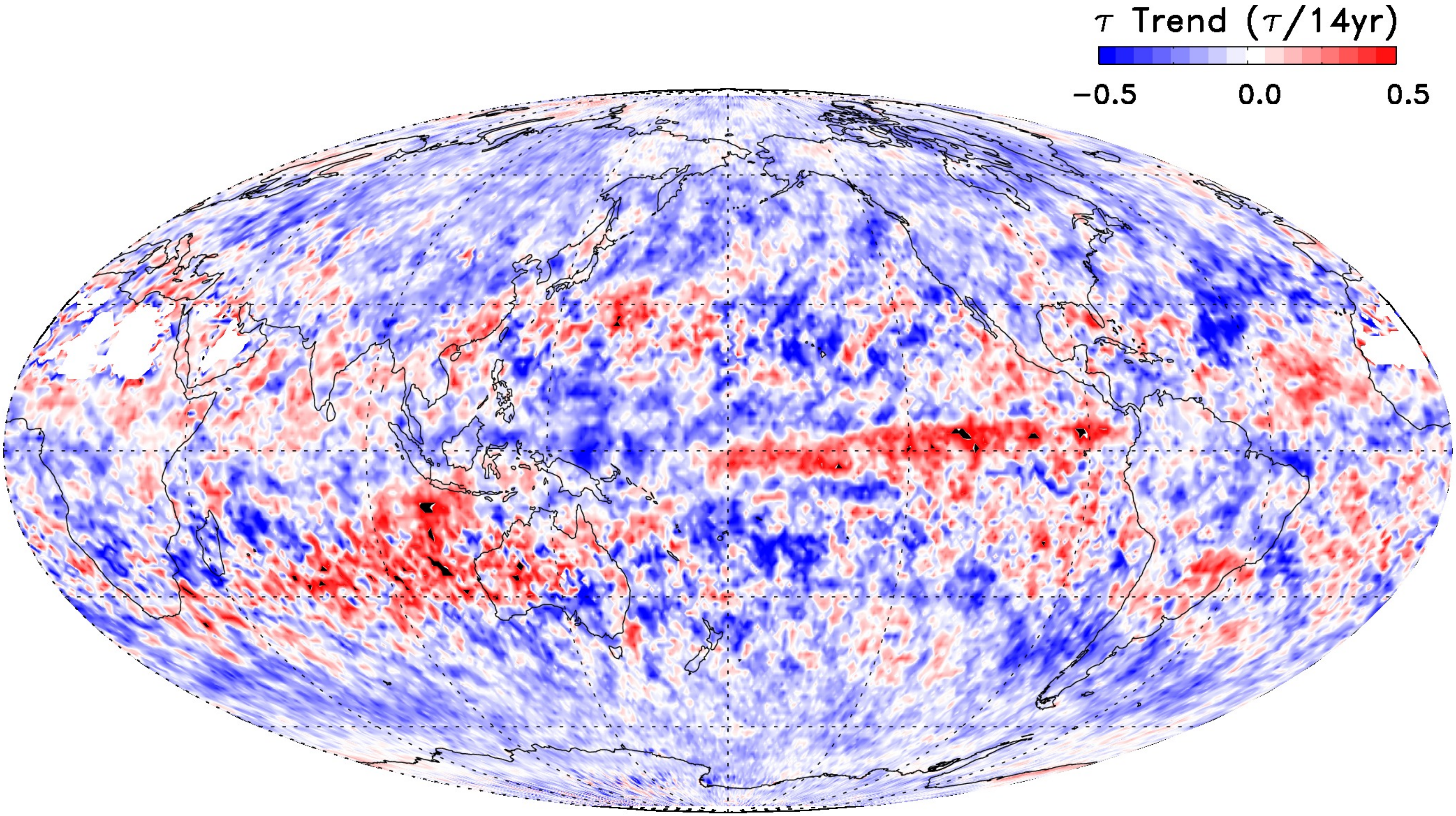


Trends

2002-2016 average ice cloud optical thickness

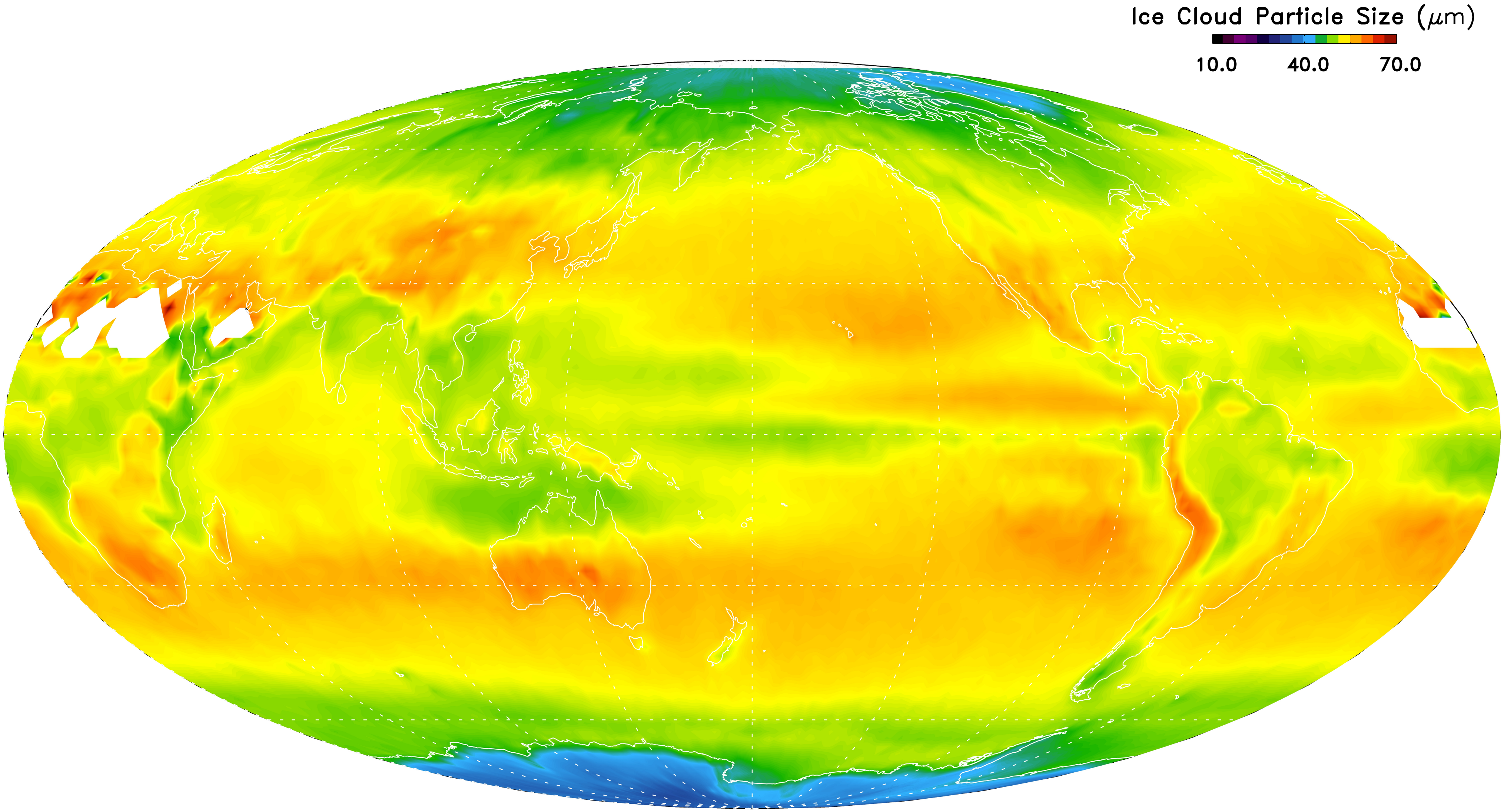


26.5% of all AIRS FOVs

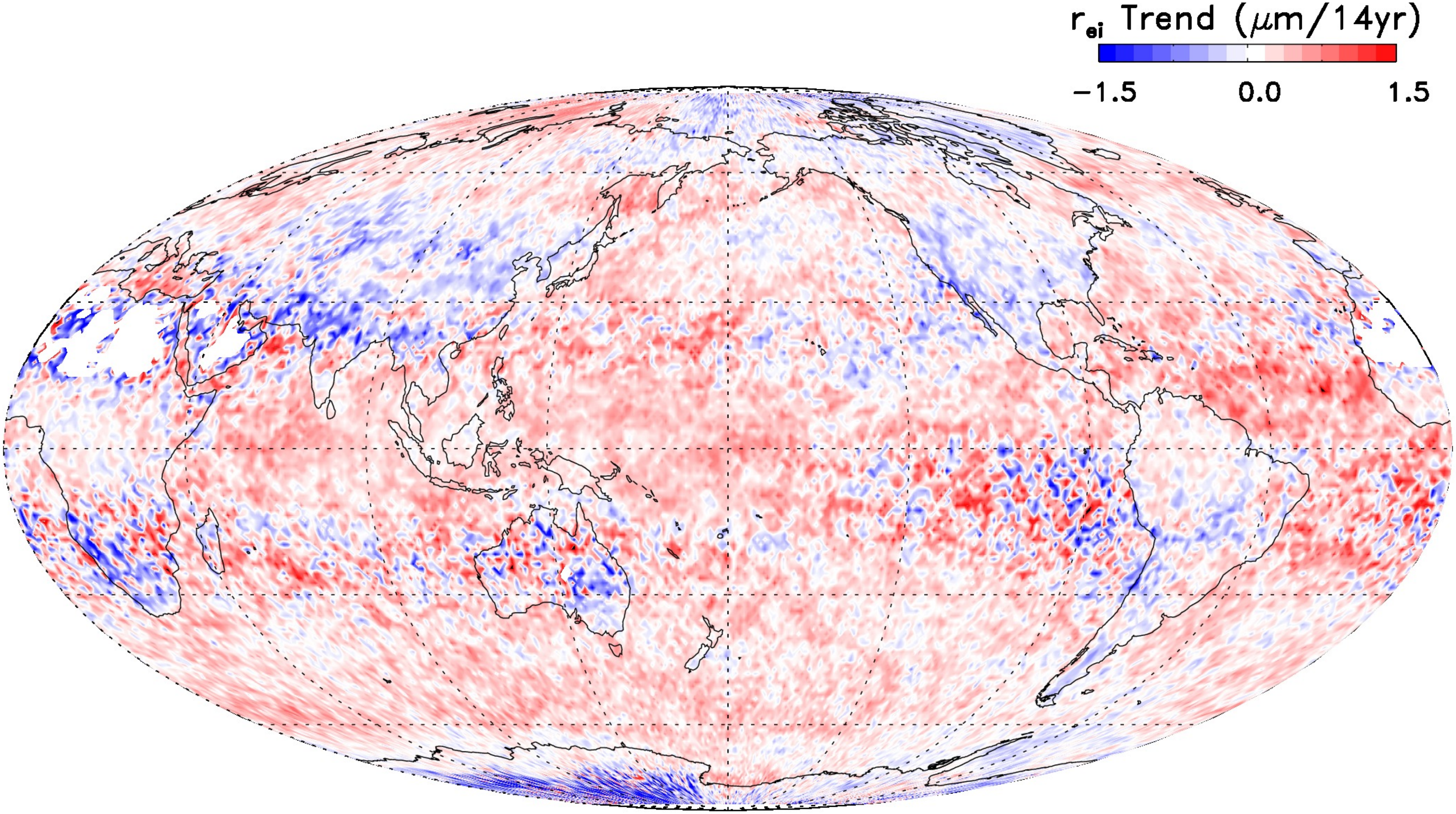


Kahn et al, 2018, ACPD

2002-2016 average ice cloud effective diameter

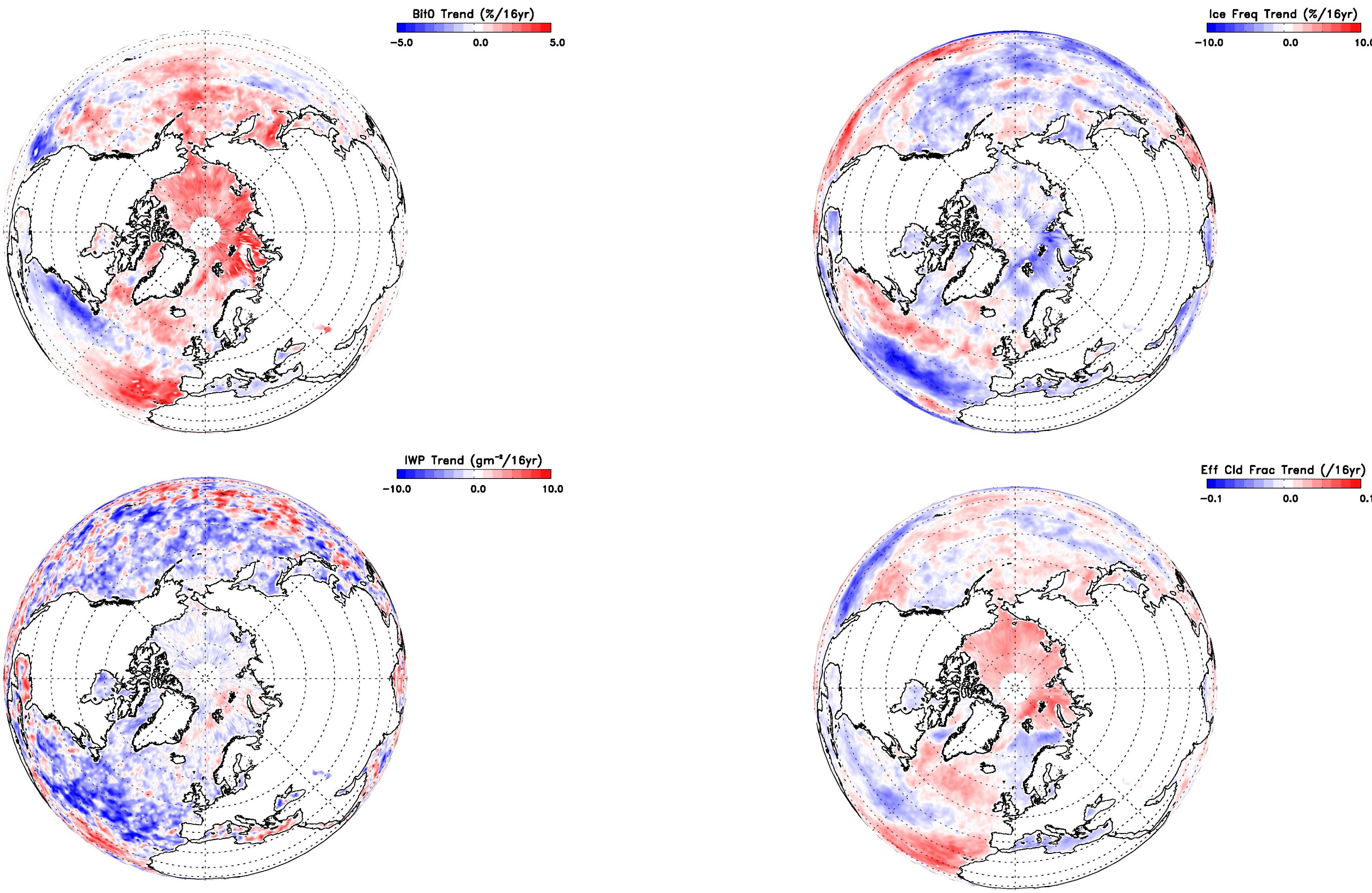


26.5% of all AIRS FOVs contain ice

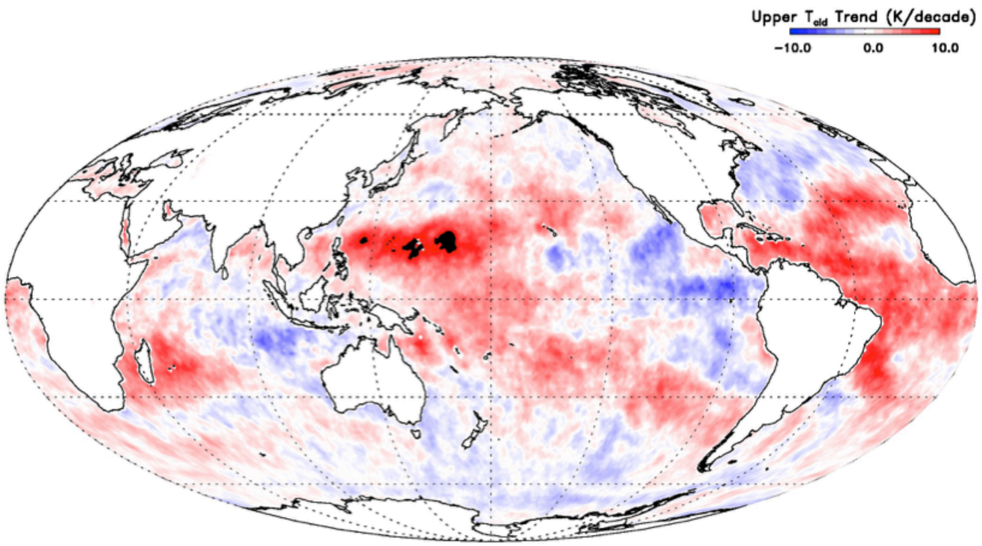


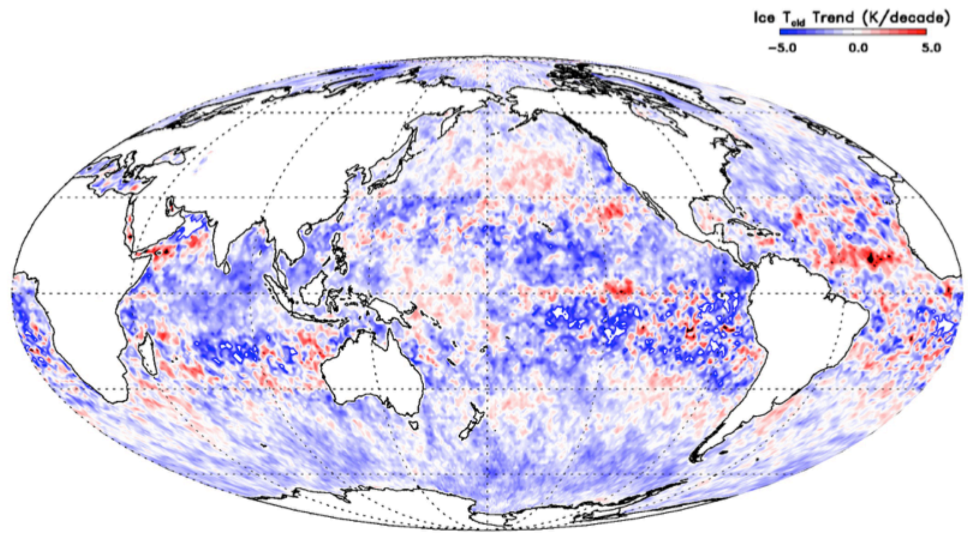
Kahn et al, 2018, ACPD

Rapid cloud property changes in Arctic

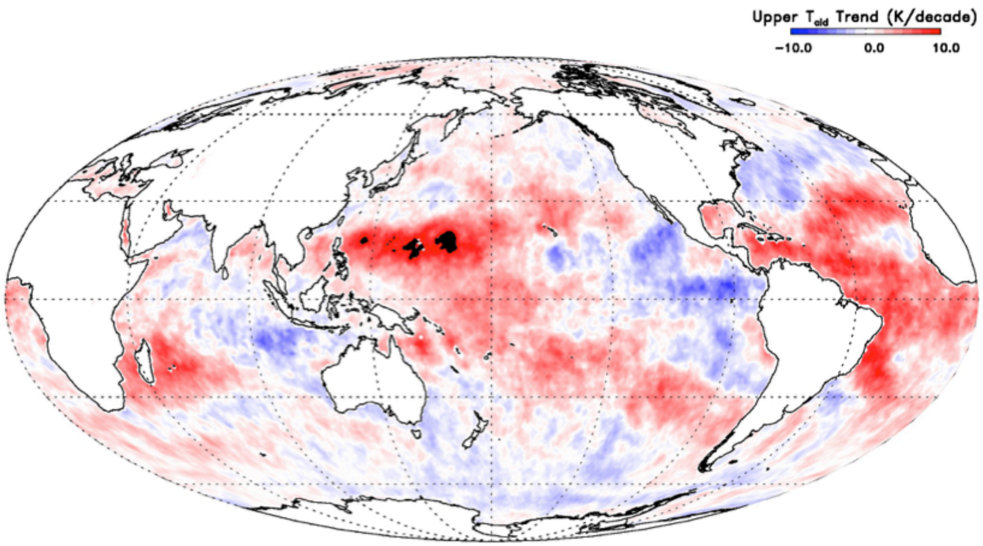


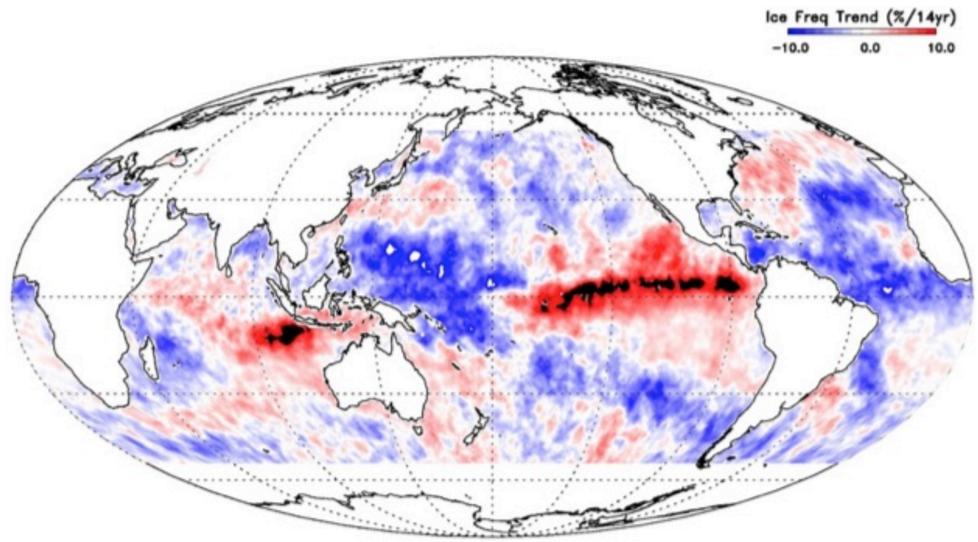
Phase matters: trends in cloud top temperature are vastly different for ice/liquid clouds



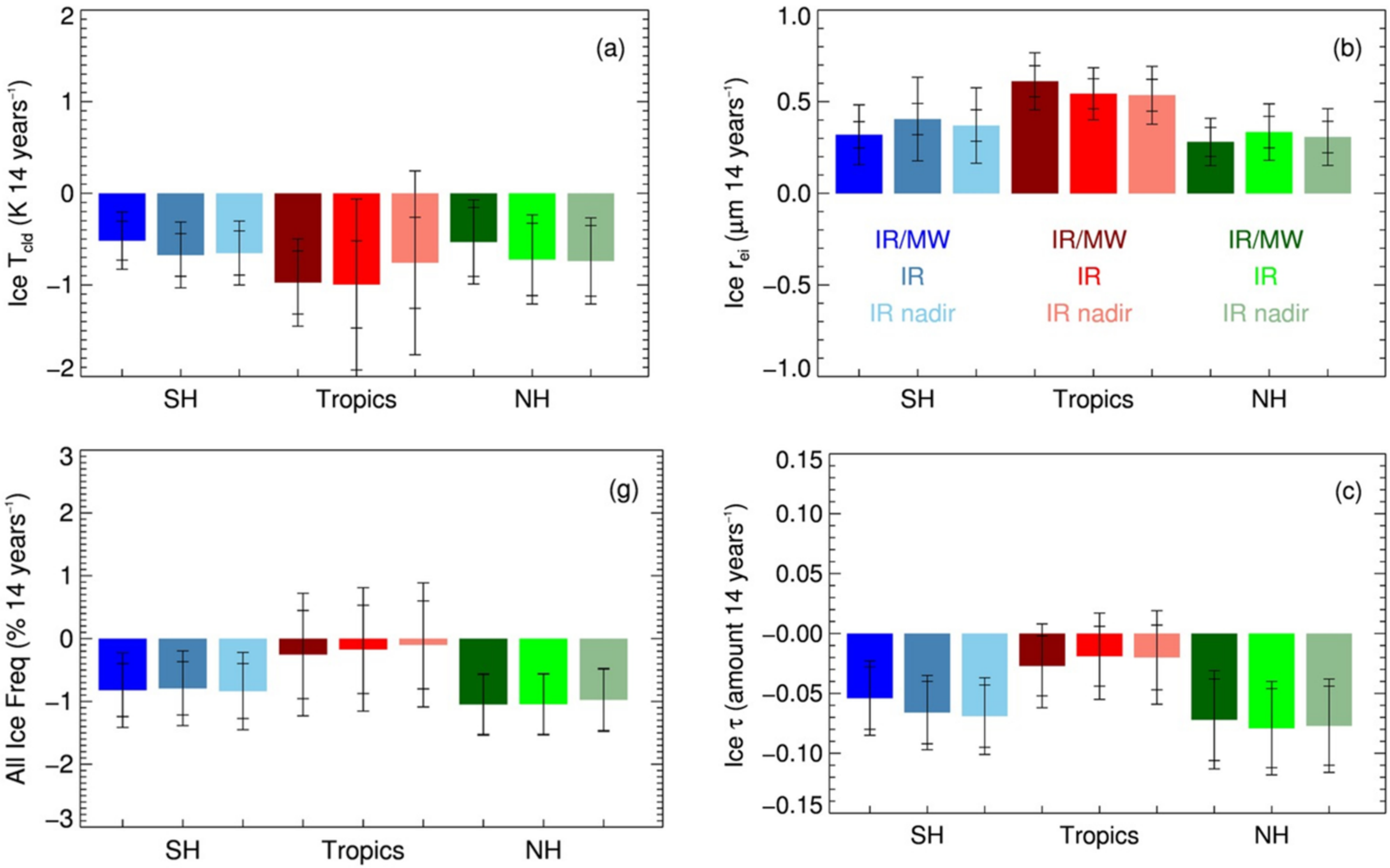


Sampling matters: trends in cloud top temperature are impacted by cloud frequency changes





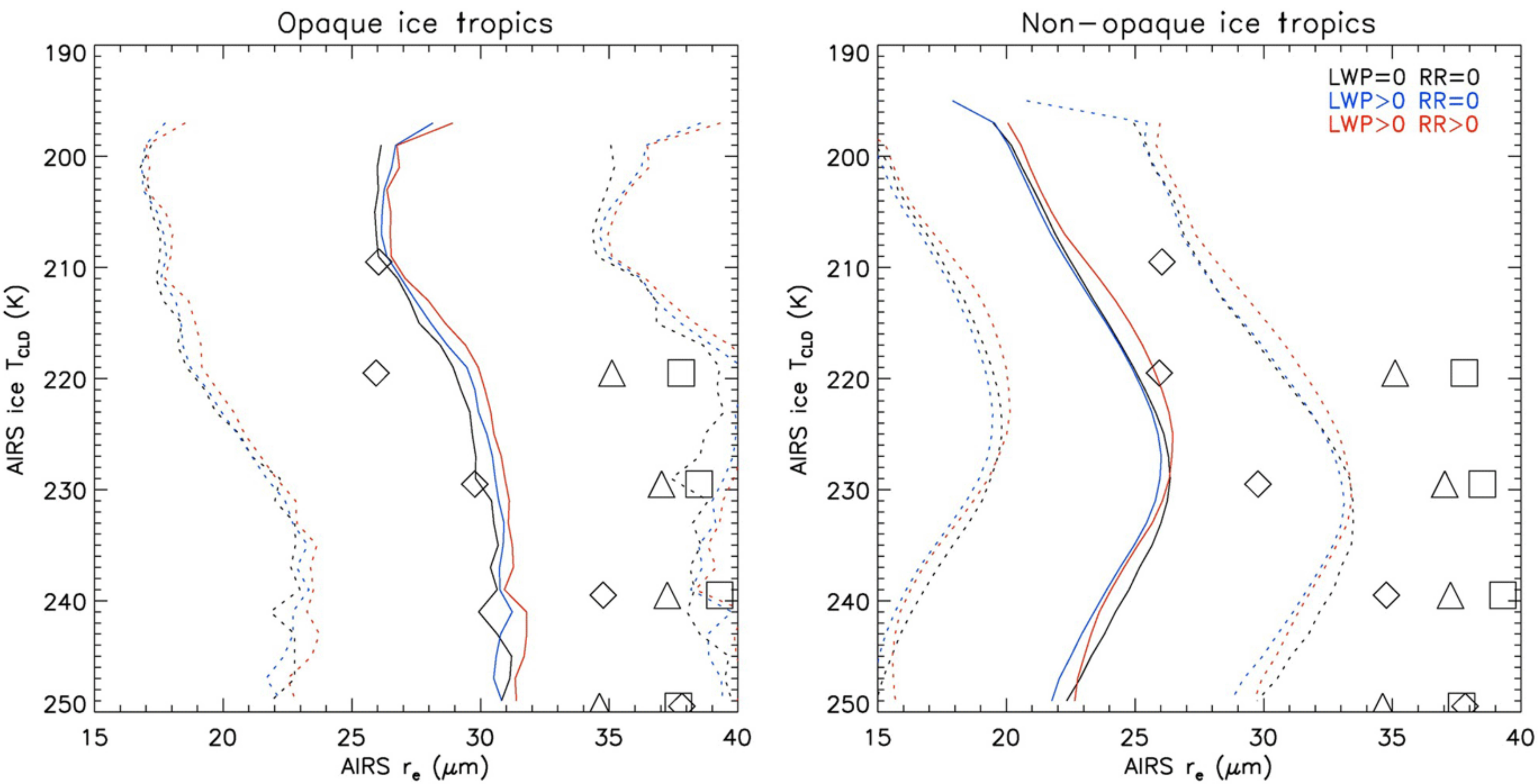
Statistically significant trends emerge for zonal bands (54S-18S, 18S-18N,18N-54N oceans)



Kahn et al., 2018, ACP

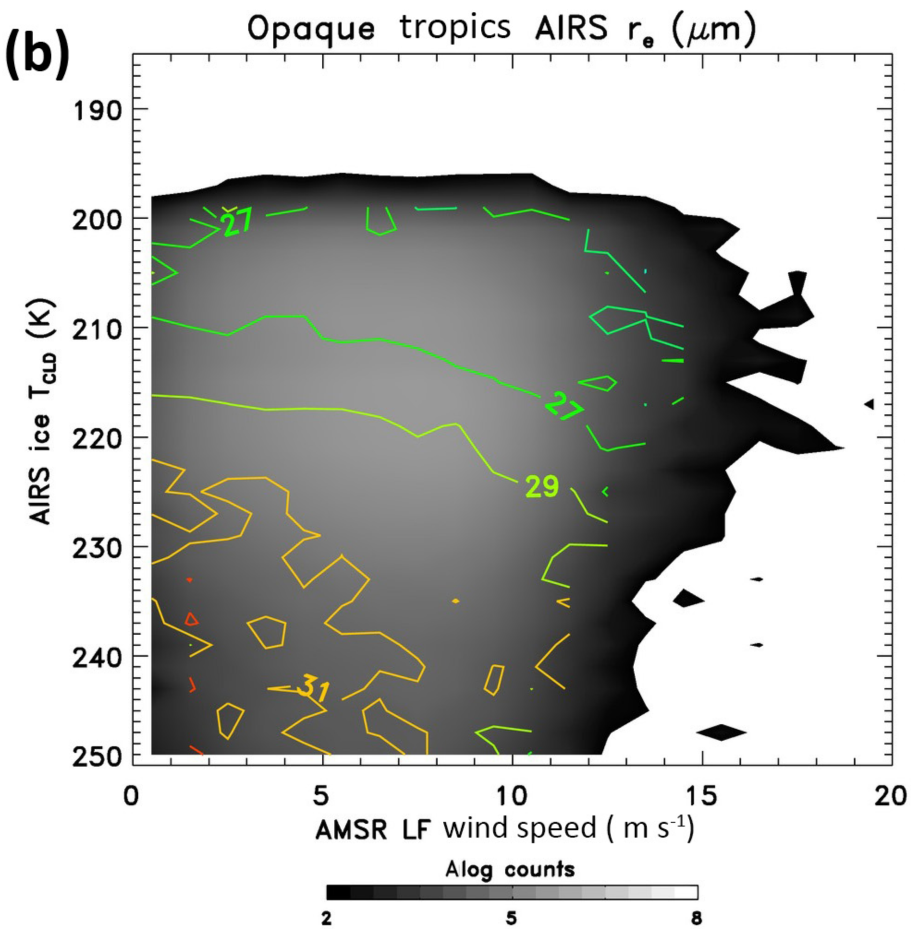
Processes: what is causing increase in CER?

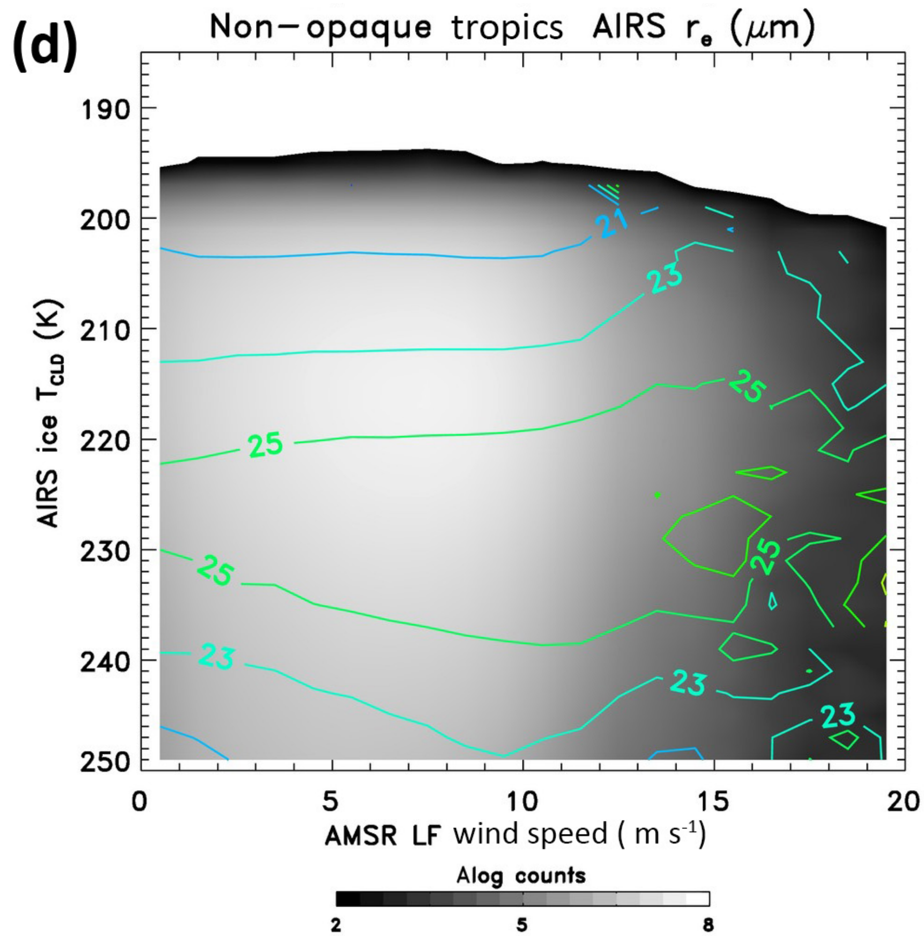
Opaque/precipitating clouds have larger cloud top CER



Kahn et al., 2018, ACP

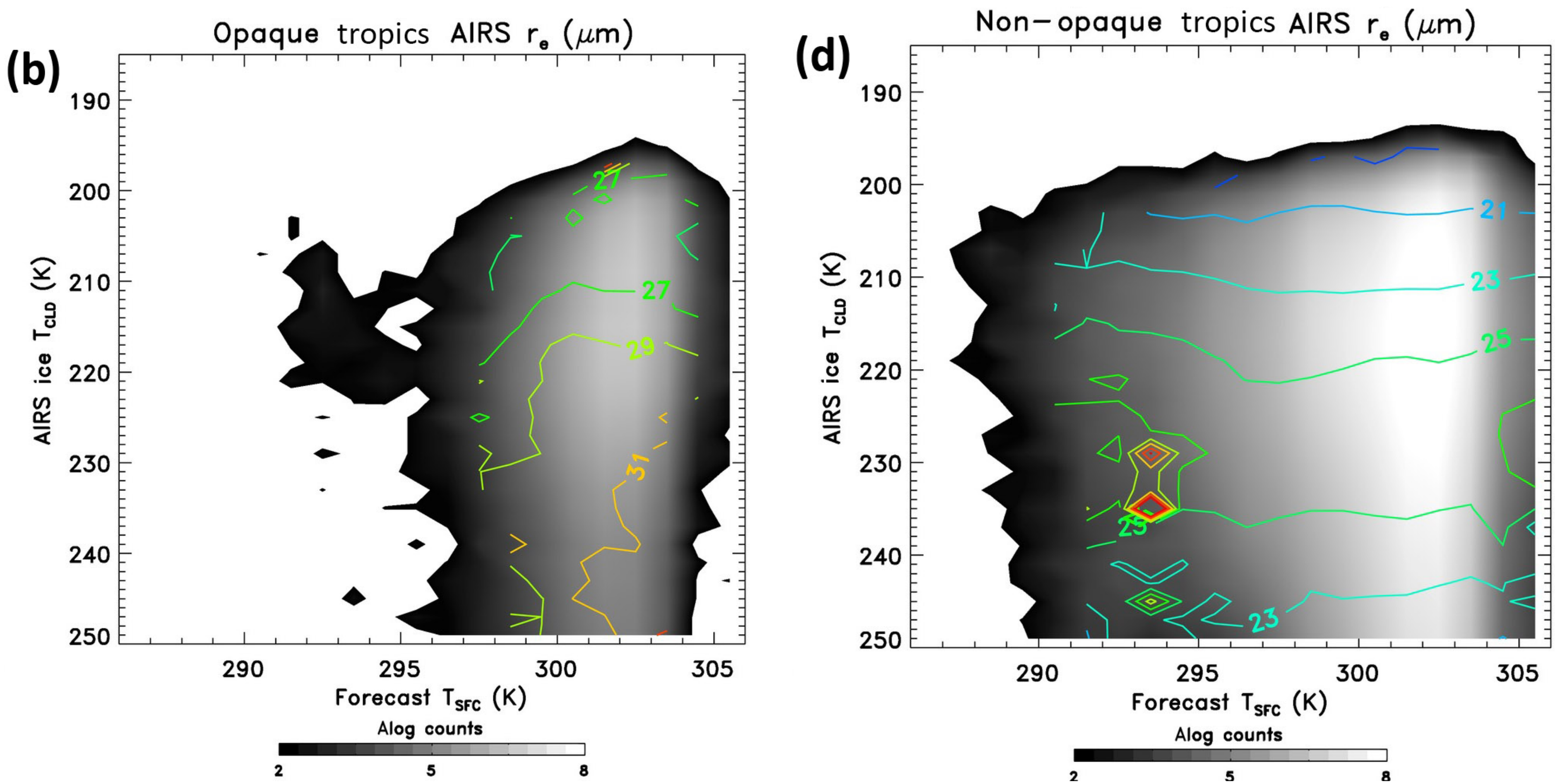
Cloud top CER responses to surface wind speed





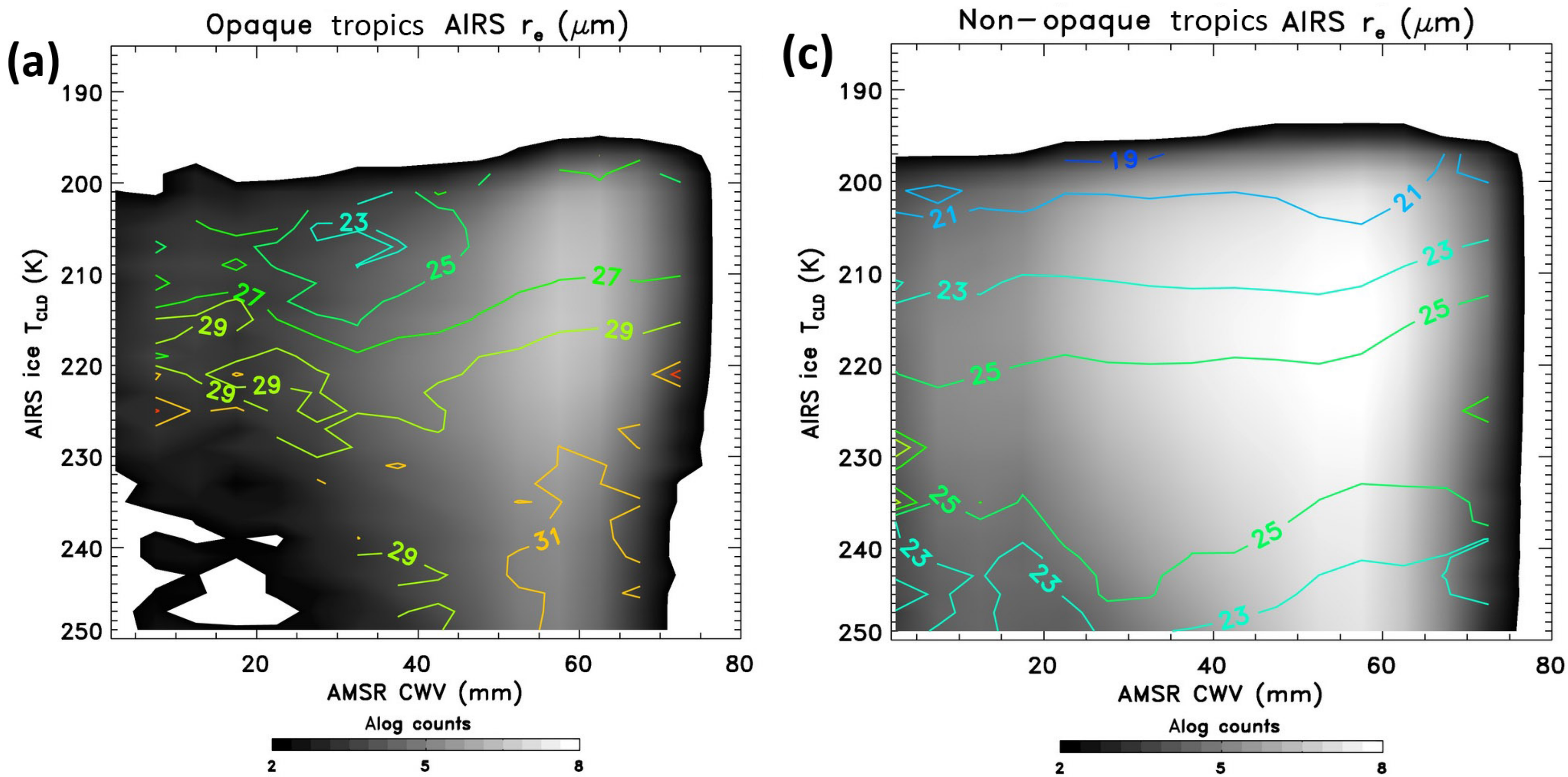
Kahn et al, 2018, ACPD

Cloud top CER responses to SST



Kahn et al, 2018, ACPD

Cloud top CER responses to CWV



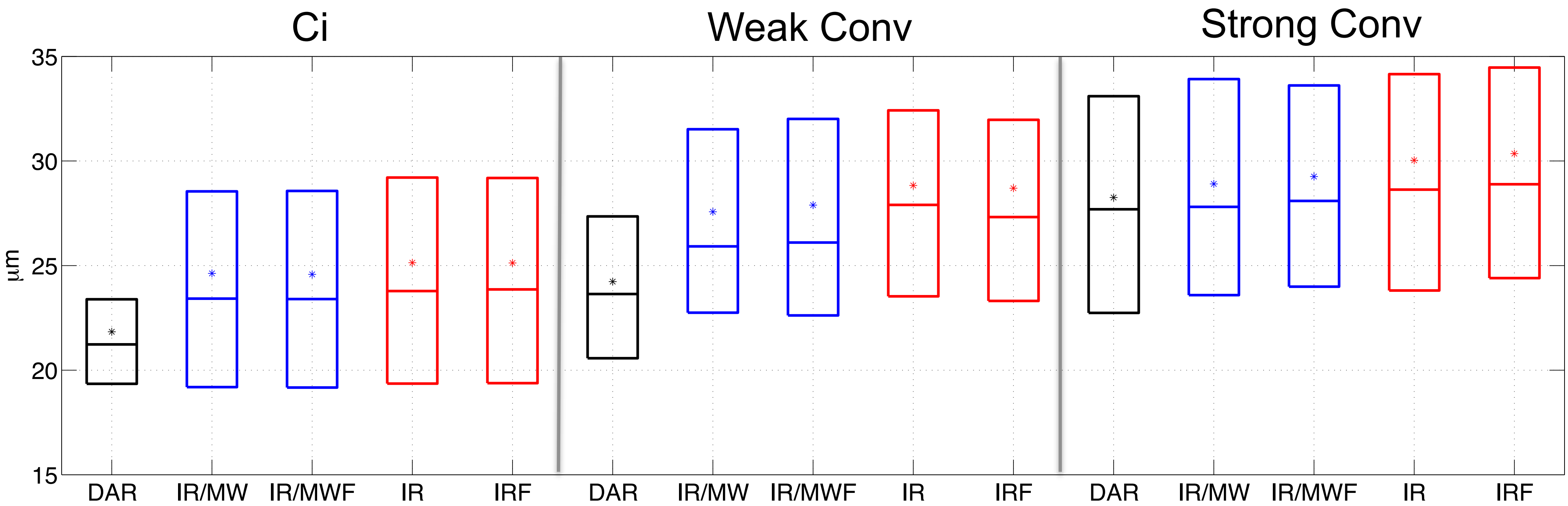
Kahn et al, 2018, ACPD

Larger CER in precipitating opaque/convective clouds with high SSTs, larger CWV, and weak/east surface winds

Use collocated CloudSat reflectivity profiles to classify convective intensity

Compare to DARDAR retrievals of CER

Stronger convection has larger CER at same CTT



CTH<tropopause height
cloud base temperature<200K
cirrus geometrical thickness <1km

ETH at 10dBZ<5km

ETH of 10dBZ>10km

Kahn et al, 2018, ACPD

Evidence of larger CER when lower layer cloud enhances radiative cooling (Stephens, 1983, JAS)

Evidence of larger CER with lofting of larger particles in convection?

Is there a trend in the pdf of vertical velocity that explains AIRS CER trends?

Ice cloud property differences are consistent with expectations for various cloud types

Cloud type	Single cloud type proportion	Mean τ_i	τ_i relative error	τ_i averaging kernel	% passing QC for τ_i	Mean r_{ei}	r_{ei} relative error	r_{ei} averaging kernel	% passing QC for r_{ei}	χ^2 residual fit
ci	25.2	1.94	1.99	0.99	96.5	25.7	2.6	0.99	73.6	4.1
As	26.6	2.55	5.55	0.94	97.7	25.0	4.6	0.98	80.2	2.9
Ac	5.5	1.60	5.94	0.92	94.3	22.2	3.6	0.99	57.0	4.2
Sc	22.2	1.36	14.17	0.72	78.5	20.3	6.7	0.96	48.4	3.4
Cu	1.0	3.27	5.29	0.96	93.5	27.9	7.1	0.96	68.8	3.5
Ns	15.4	2.52	8.21	0.89	97.8	23.9	5.6	0.98	86.7	2.5
Dc	4.0	5.54	3.54	0.98	98.4	27.2	7.2	0.96	72.5	3.1

Guillaume et al, 2018, AMTD, to be submitted

Convective aggregation may be operating mechanism underlying both ideas

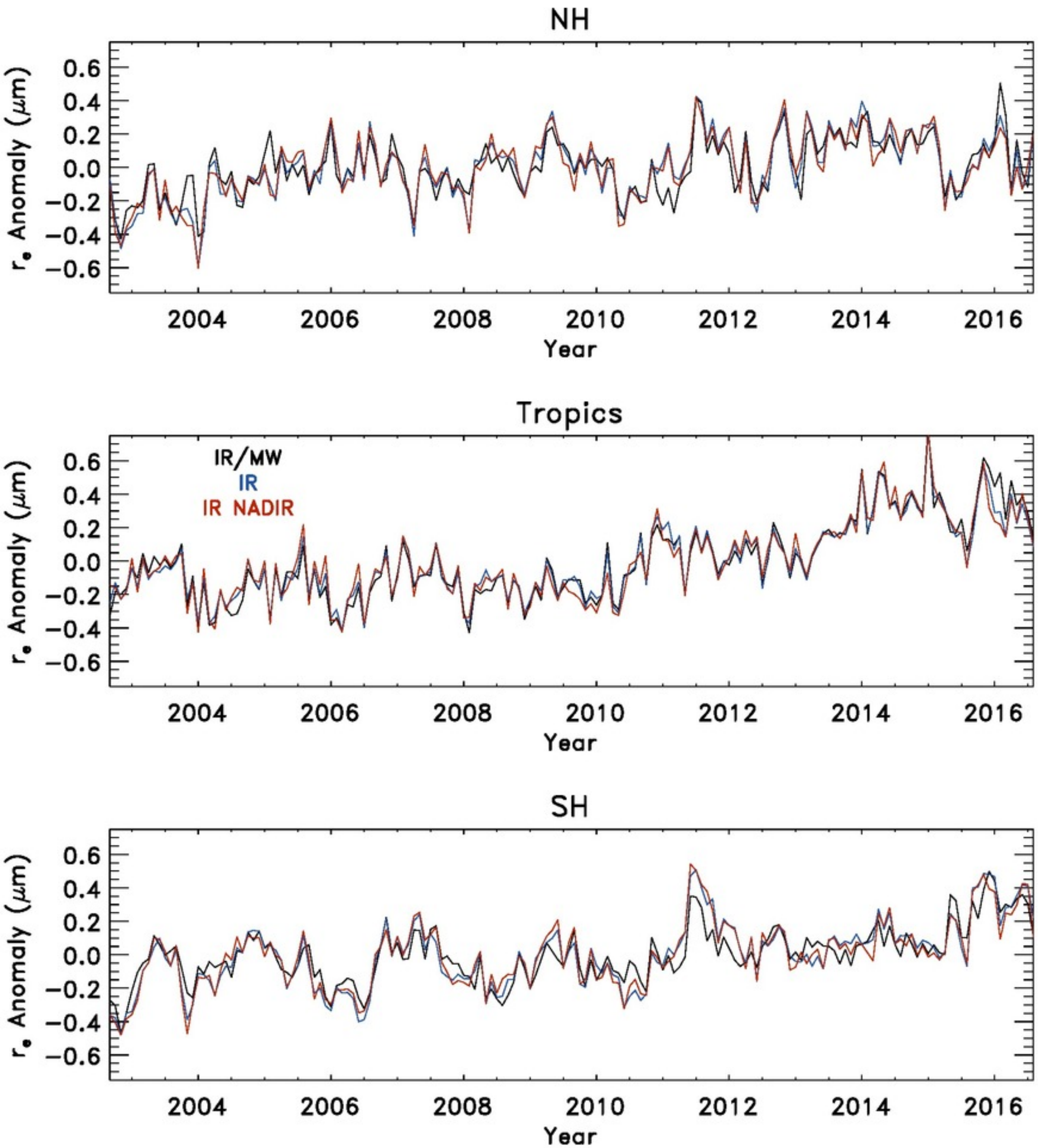
Increased cloud overlap along with reduced thin cirrus and anvil size (e.g., Bony et al., 2016, PNAS; Satoh and Matsuda, 2009, JAS)

Change in vertical velocity profiles, change in microphysics pathways, larger particles at cloud top (Chen et al., 2016, J. Climate)

Backup slides

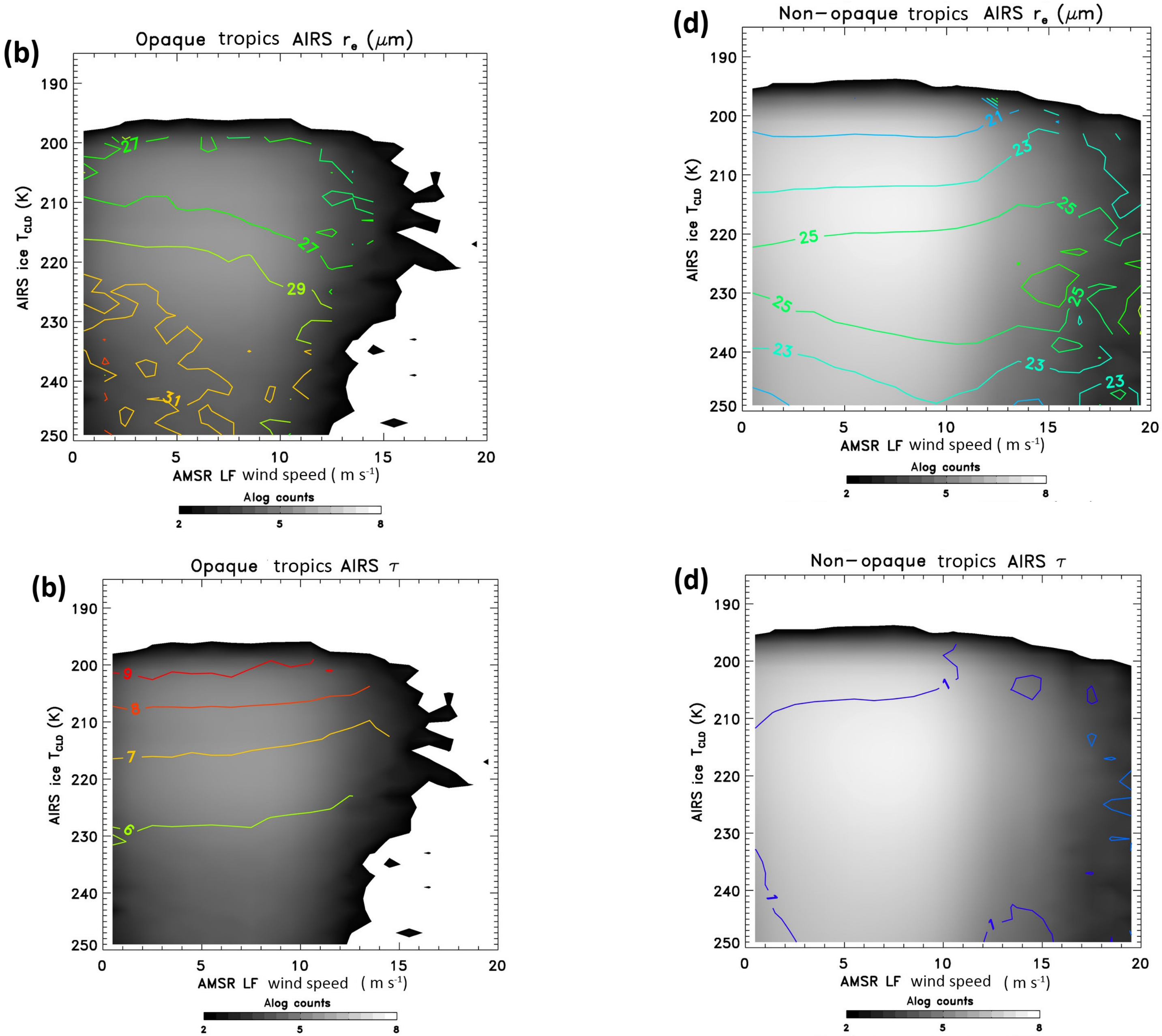
Slide on cloud type comparisons/error estimates

AIRS



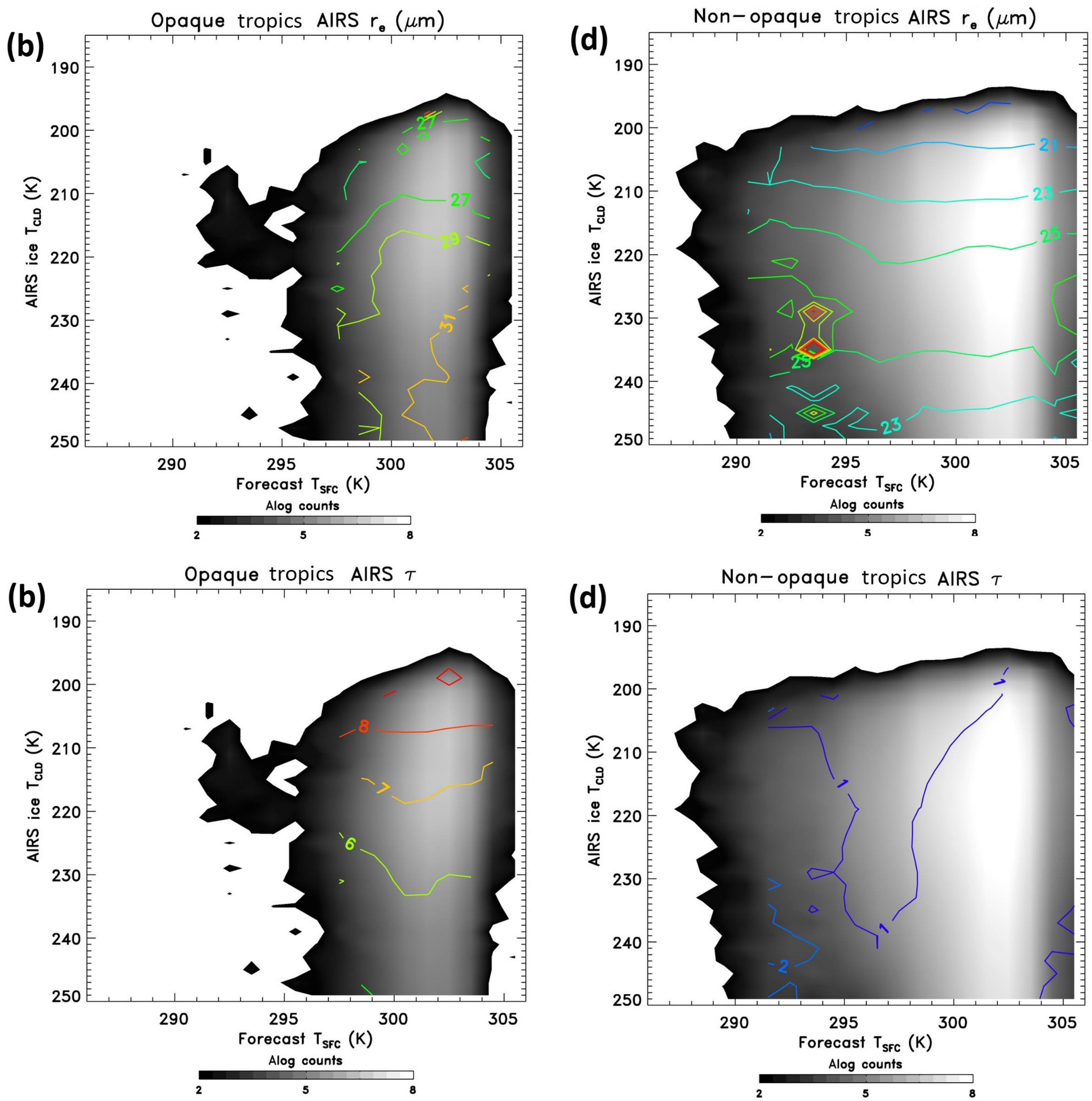
Kahn et al, 2018, ACPD

Cloud top CER and COT responses to surface wind speed



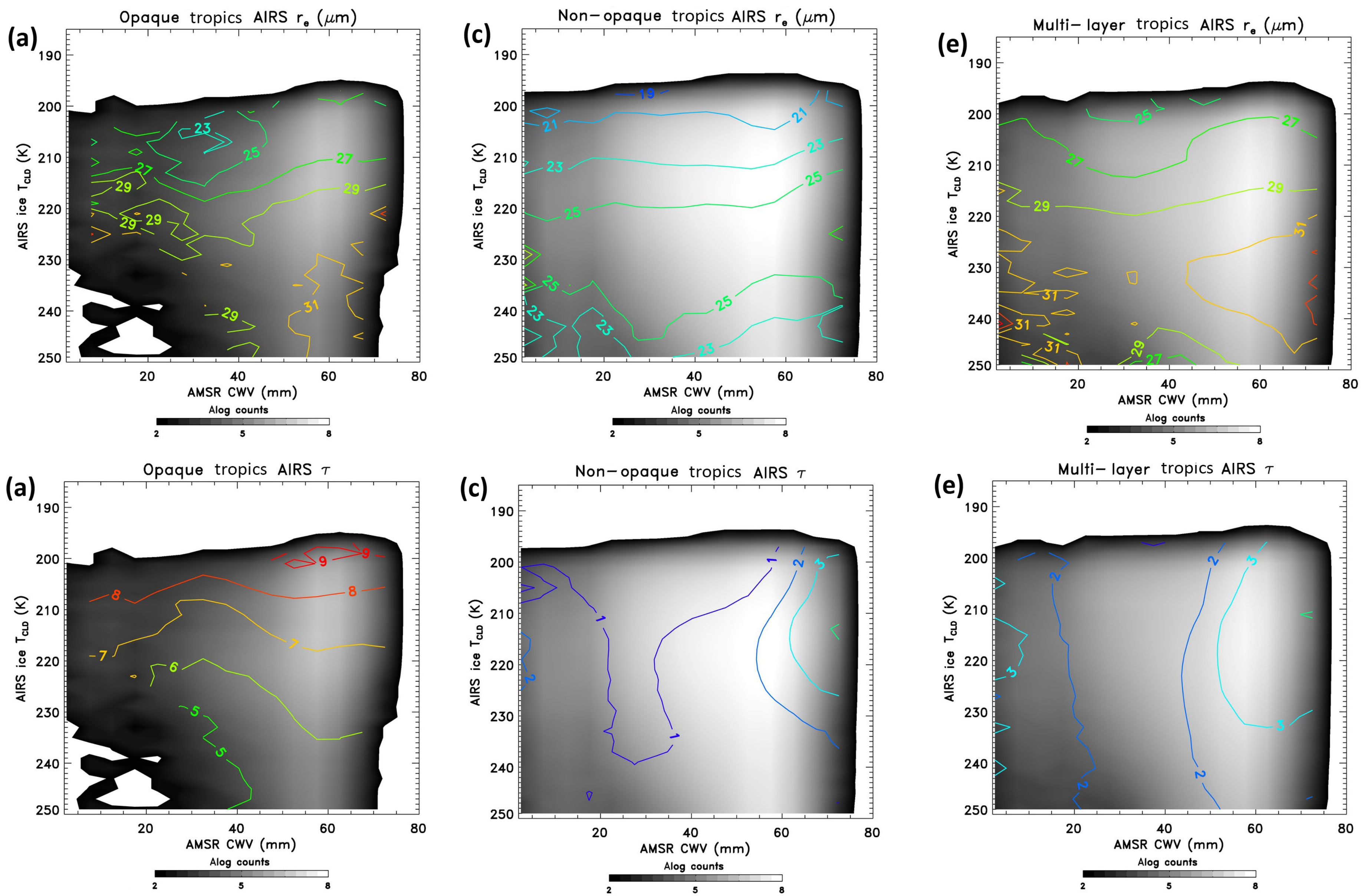
Kahn et al, 2018, ACPD

Cloud top CER and COT responses to SST



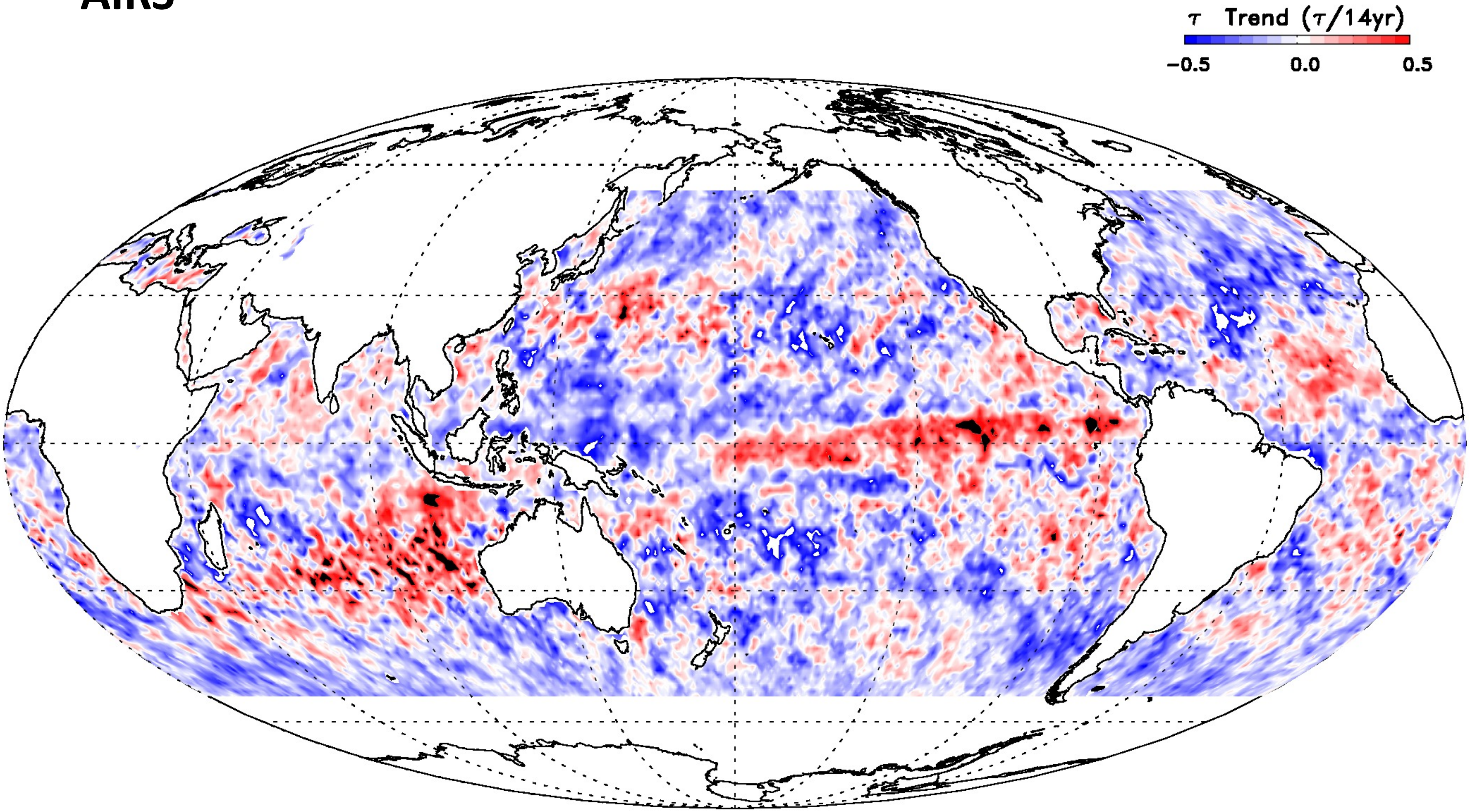
Kahn et al, 2018, ACPD

Cloud top CER and COT responses to CWV

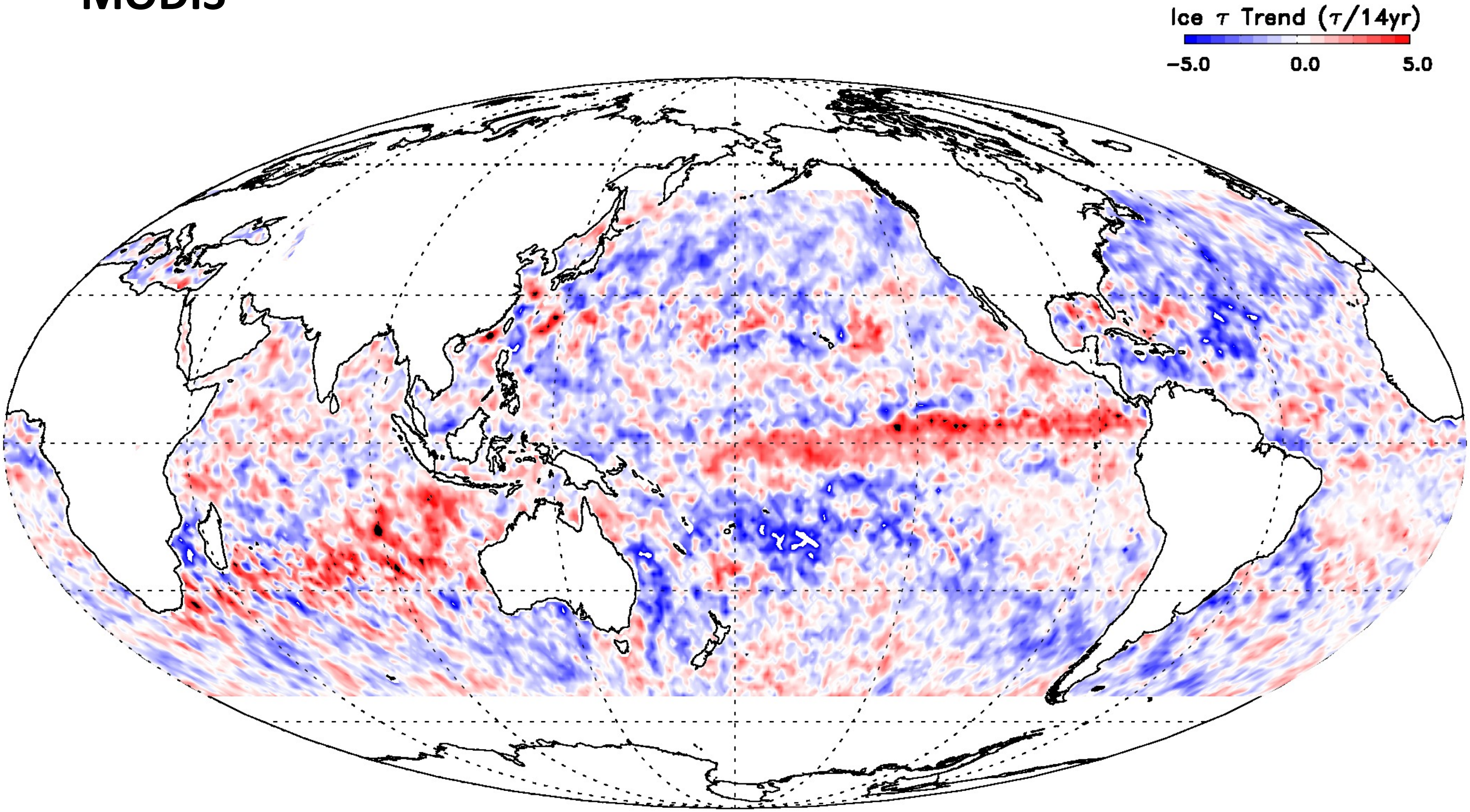


Kahn et al, 2018, ACPD

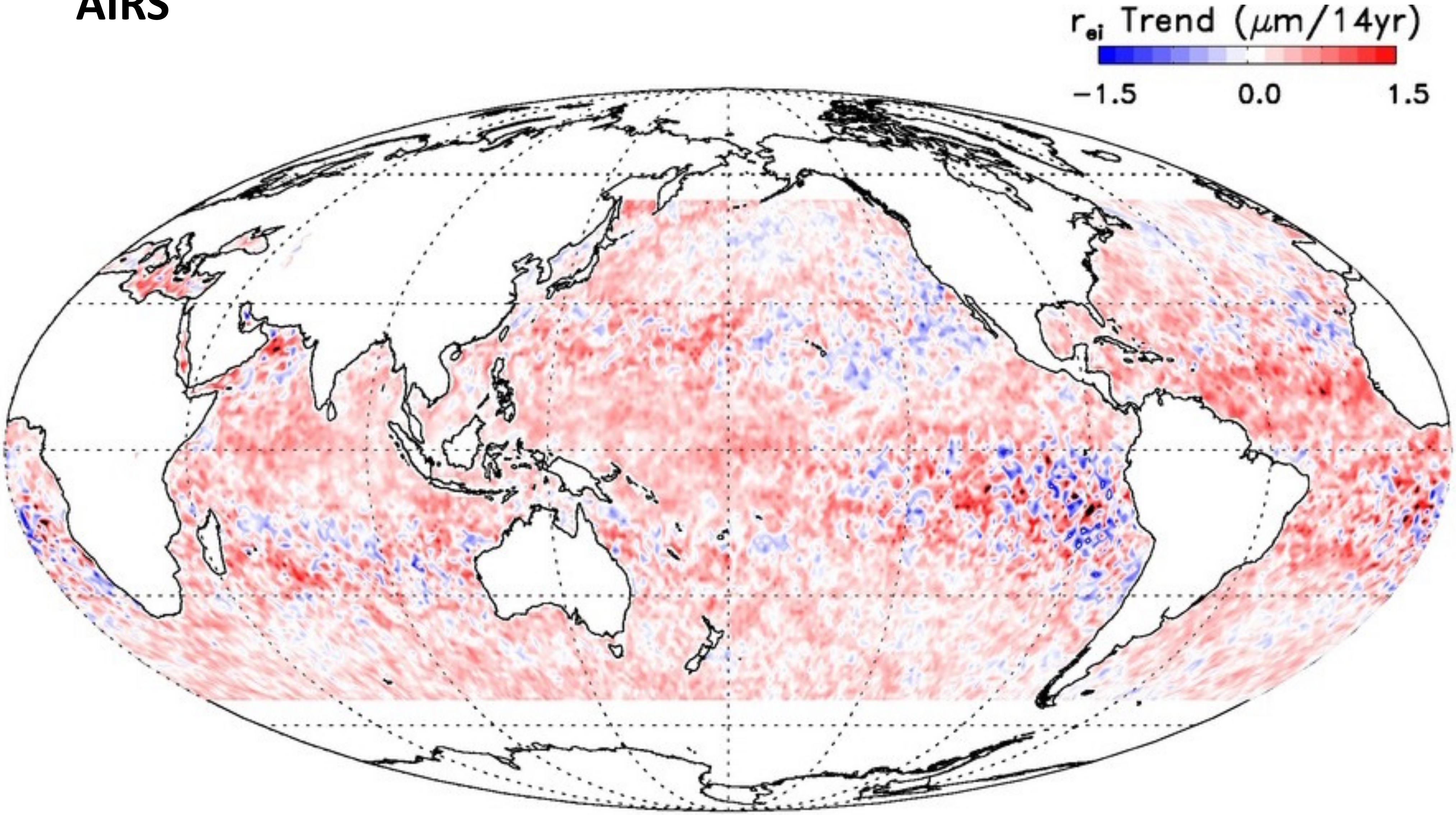
AIRS



MODIS



AIRS



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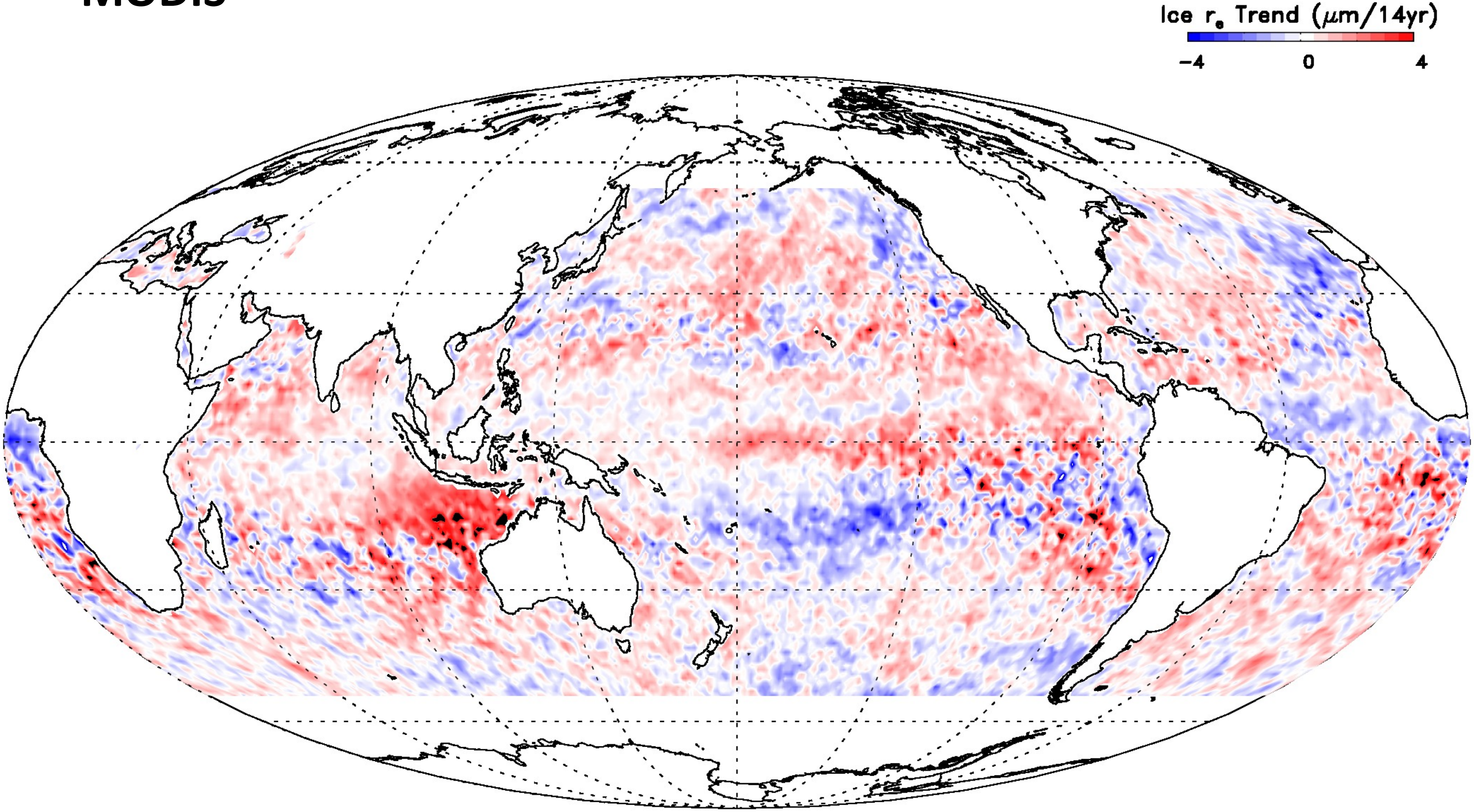

Leroy et al., 2017, J. Tech.

HAIC-HIWC campaign