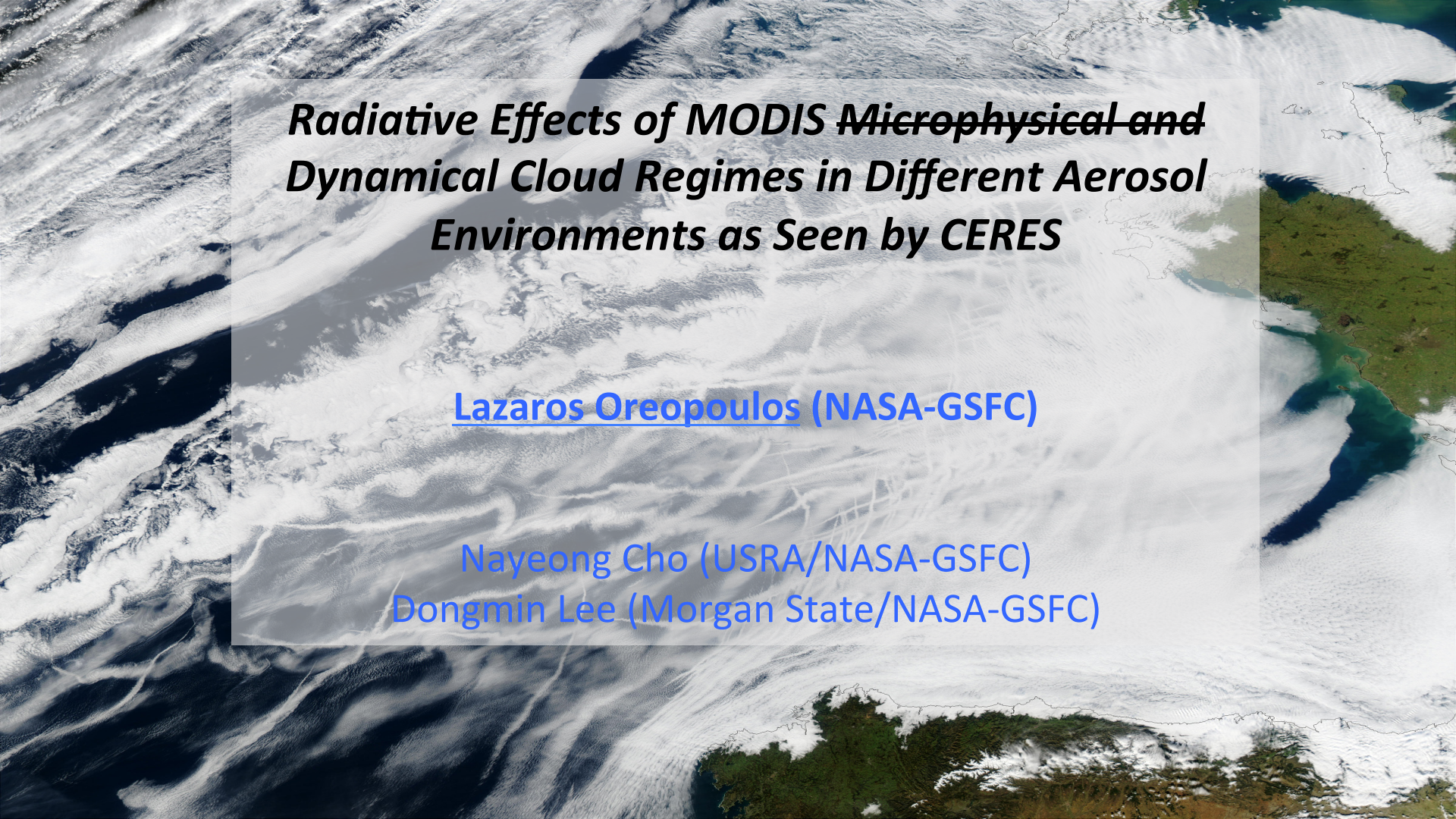


Radiative Effects of MODIS ~~Microphysical and~~ Dynamical Cloud Regimes in Different Aerosol Environments as Seen by CERES

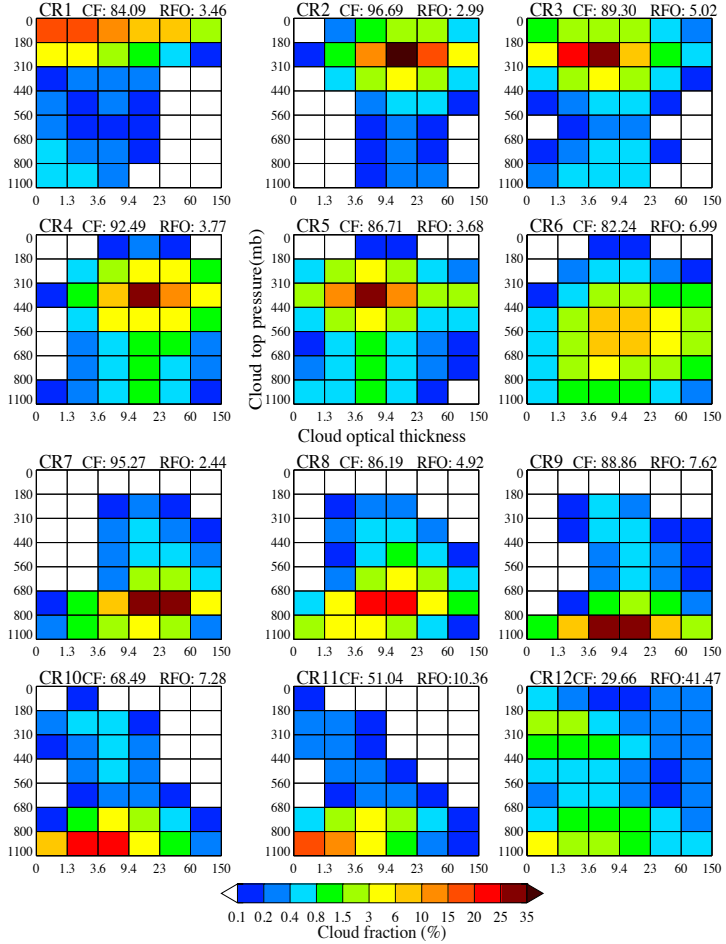
Lazaros Oreopoulos (NASA-GSFC)

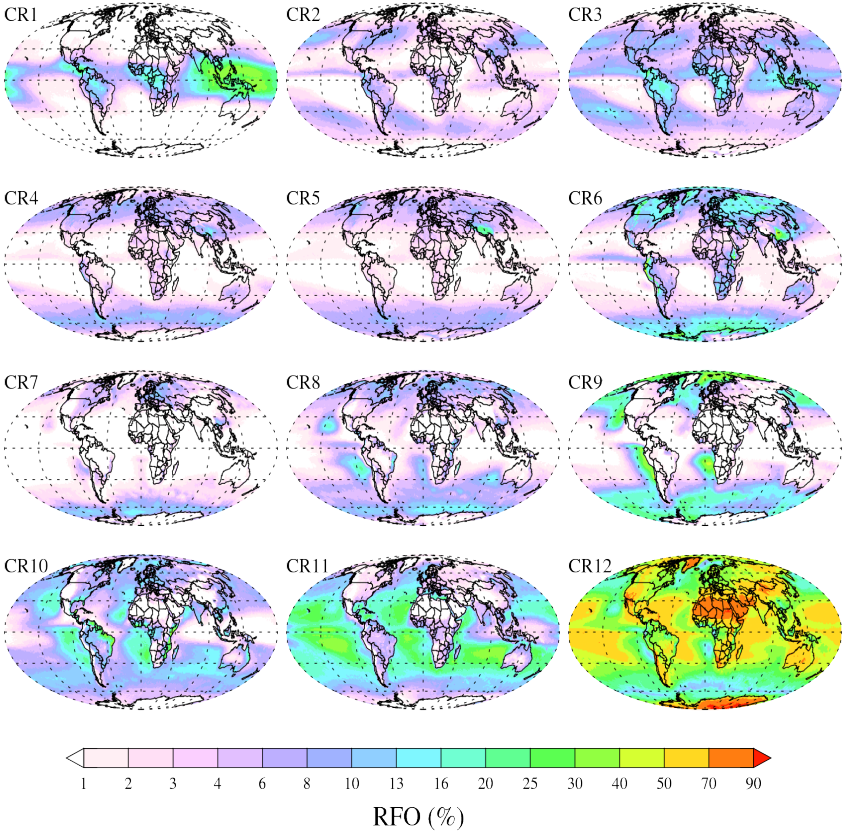
Nayeong Cho (USRA/NASA-GSFC)
Dongmin Lee (Morgan State/NASA-GSFC)

Motivation and approach

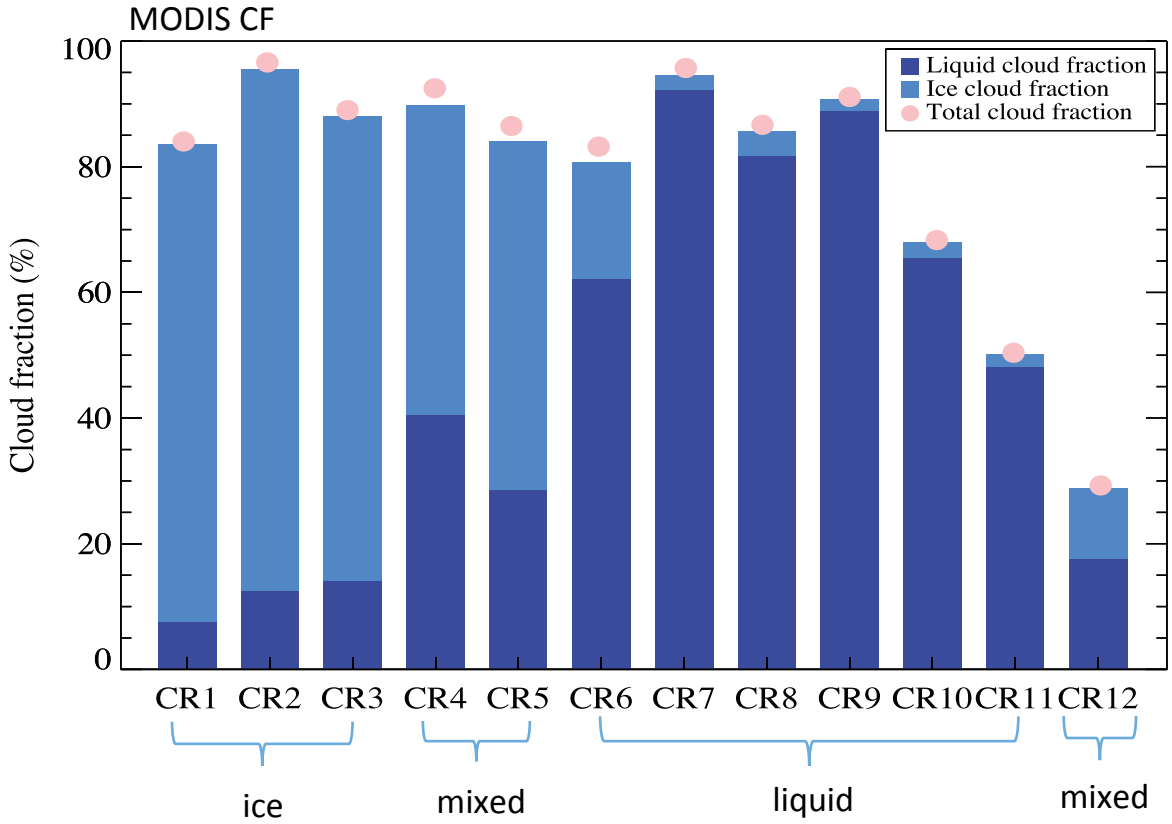
- Interpretation of aerosol-cloud interactions from space is difficult.
- How to separate aerosol from all other effects?
- Nevertheless, apparent systematic relationships can perhaps be diagnosed at *global* scales, especially with respect to radiative signals
- Breakdown by “cloud regime” (representative of similar cloud conditions) may help streamline the analysis
- How to define regimes?
  - Exploiting cloud appearance from space is one option
  - Should pose some constraint on environmental conditions
- Our “Cloud Regime” (CR) of choice is based on CTP-COT joint histograms
  - From MODIS (you may also know ISCCP “Weather States”)
- Radiative signals primarily from CERES

MODIS Collection 6 Cloud Regimes (CRs)





CR thermodynamic phase

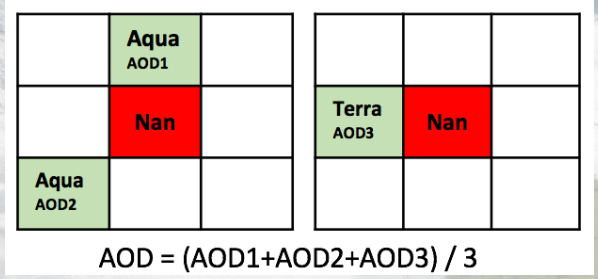


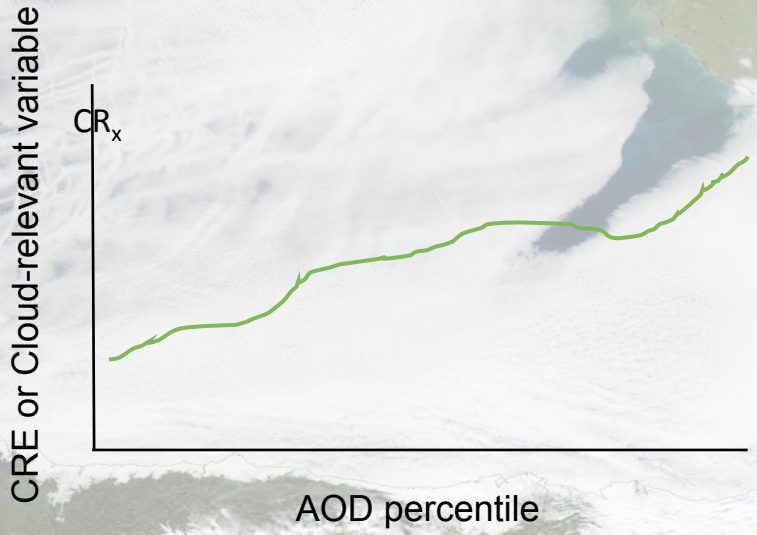
Datasets

- ***12 years*** of Aqua-Terra L-3 daily (D3) 1° data
  - Collection 6
- Joint histograms of CTP-COT
  - MODIS CRs from *k-means* clustering:
- CERES SYN1deg-daily clear and all-sky fluxes; CREs
  - AIRS L3 spectral cloudy and clear OLRs
- Other cloud variables from MODIS: CF, CTP (CTH), COT
- MODIS "Dark Target" AOD (no AI over land, no CCN)
  - 50°S-50°N
- "High volume" study

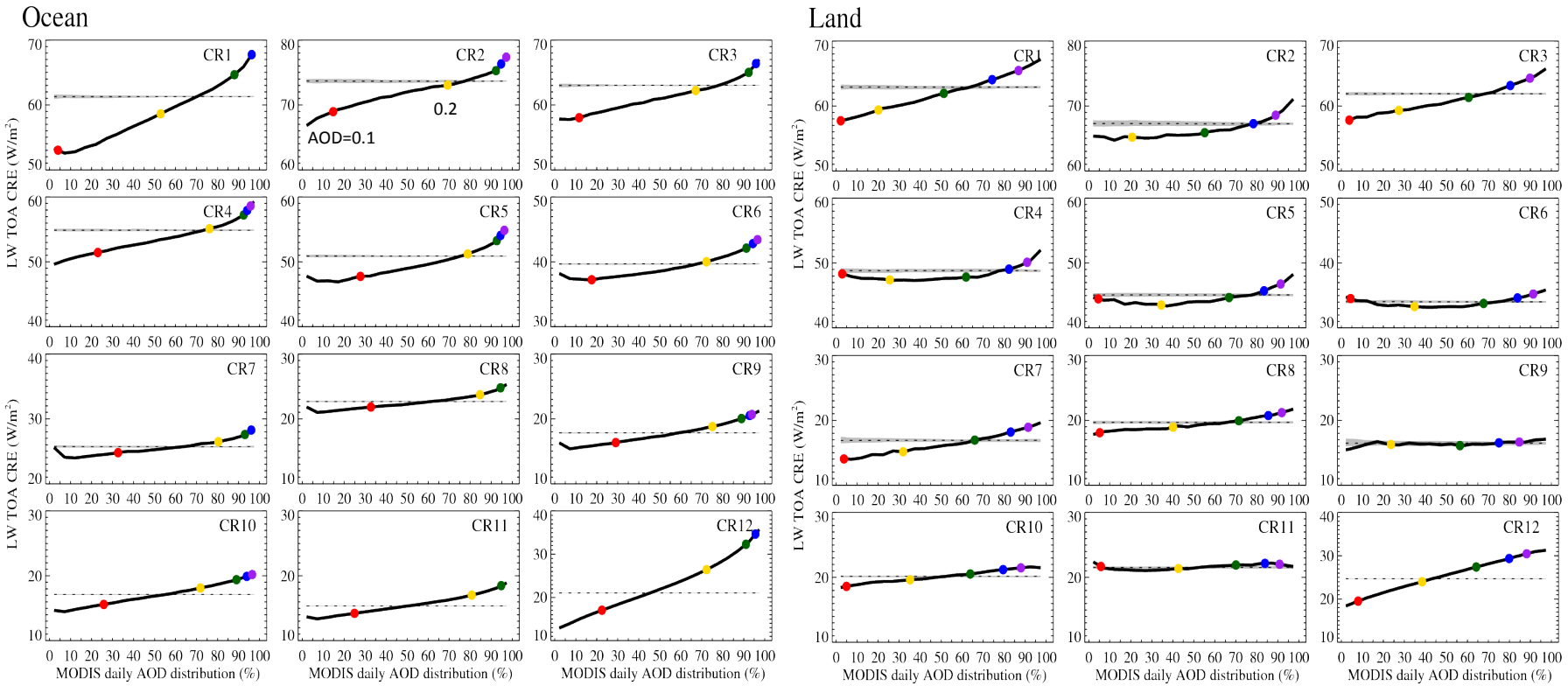
Methodology

- Daily MODIS aerosol AOD defined for each gridcell from Terra and Aqua (neighboring grid cells can be used)
- Define relative AOD (position within distribution for *that location/gridcell and season,* independent of CR)
- Identify **CRE**, CF, CTP, COT, CER vs collocated aerosol for *each* CR occurrence
- Average all values within the same AOD percentile and for the same CR
- CERES SYN1deg fluxes are daily averages, AIRS at 1:30 pm
- Generally different CRs for Terra and Aqua for the same day and gridcell

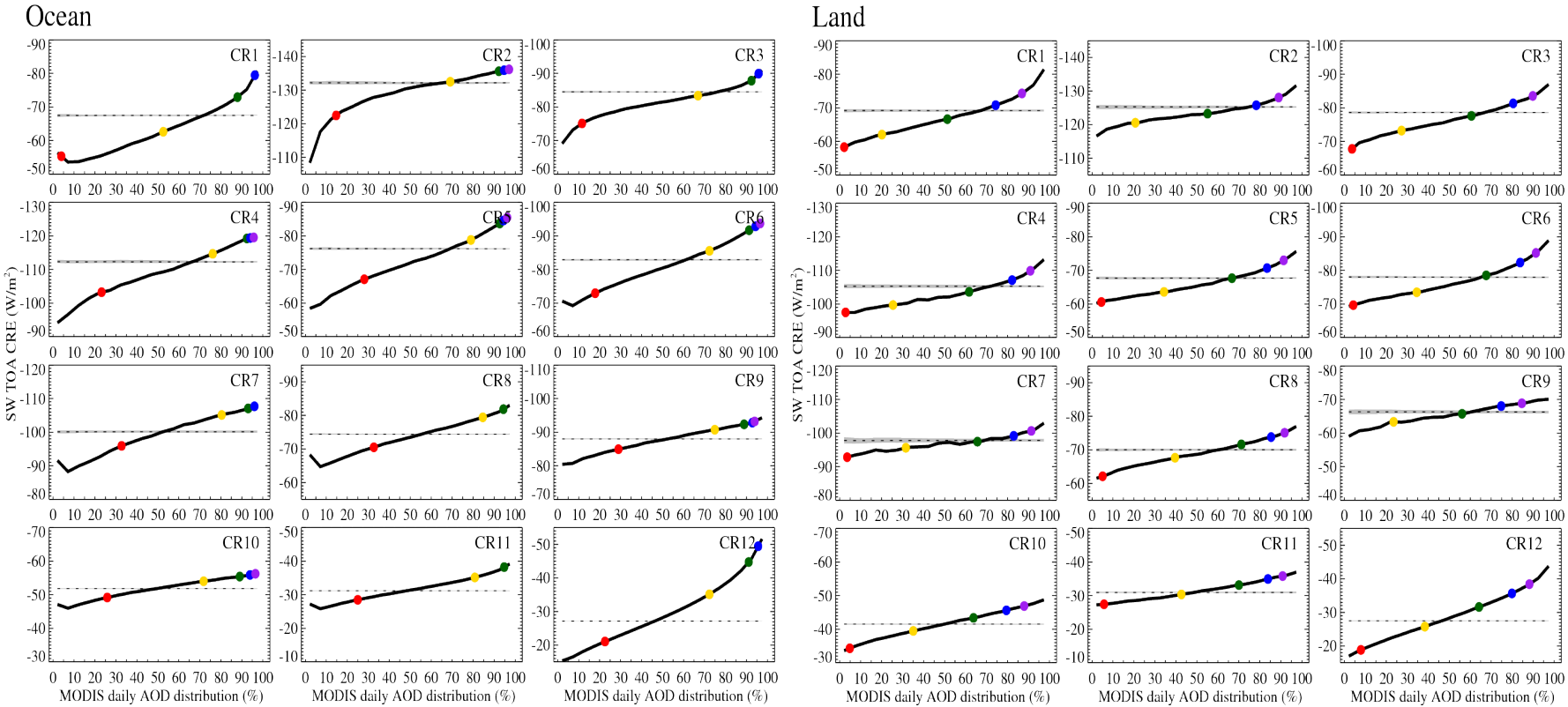




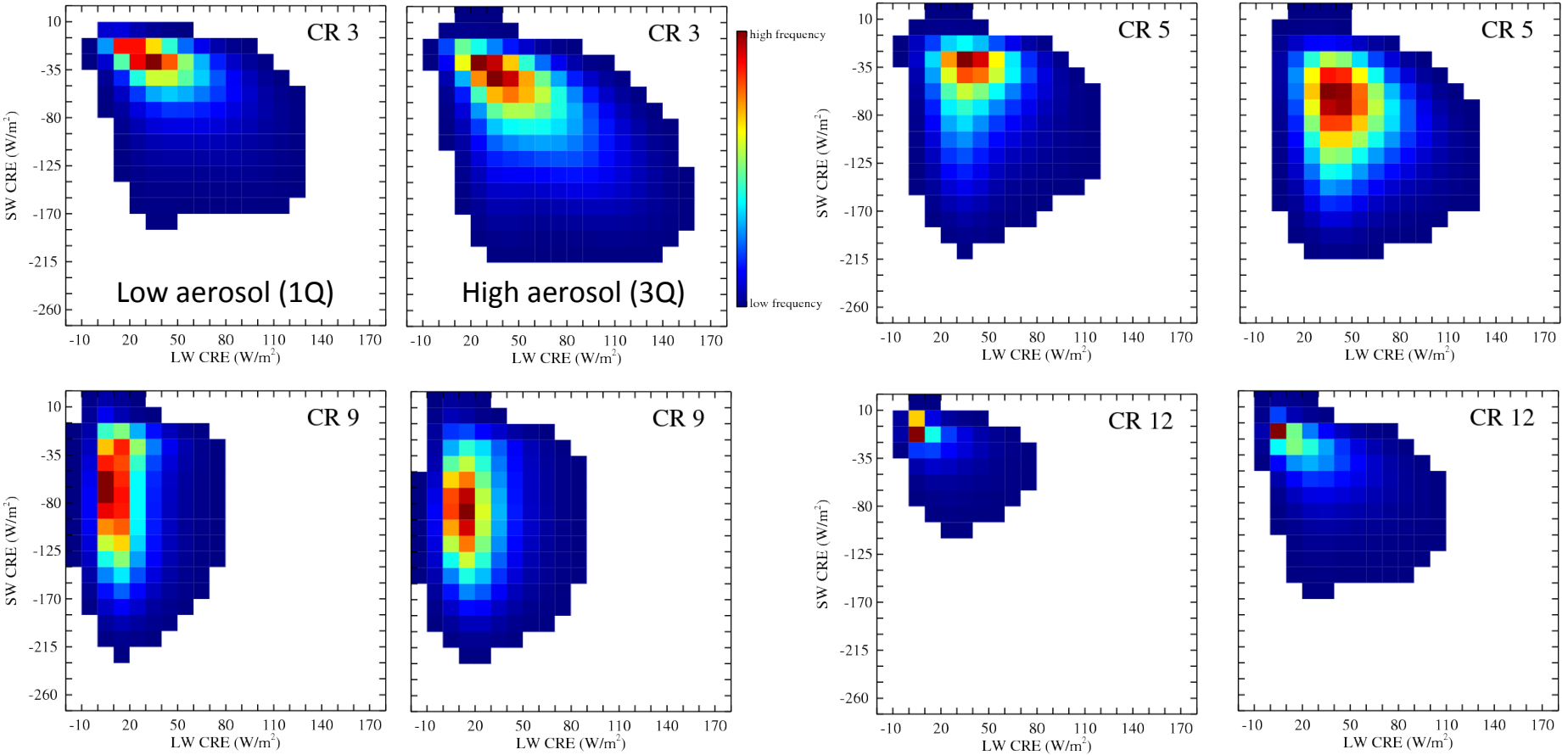
LW CRE increases with AOD almost always



SW CRE increases with AOD almost always



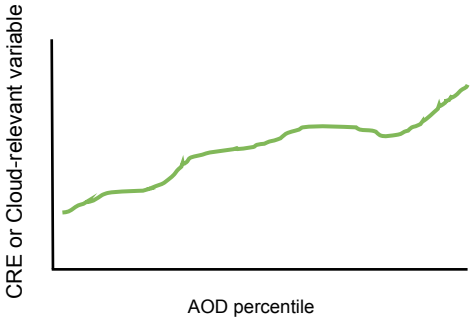
Joint PDFs of LW and SW CRE (ocean): peaks shift towards higher values and distributions widen



CRE changes are generally consistent with cloud property changes

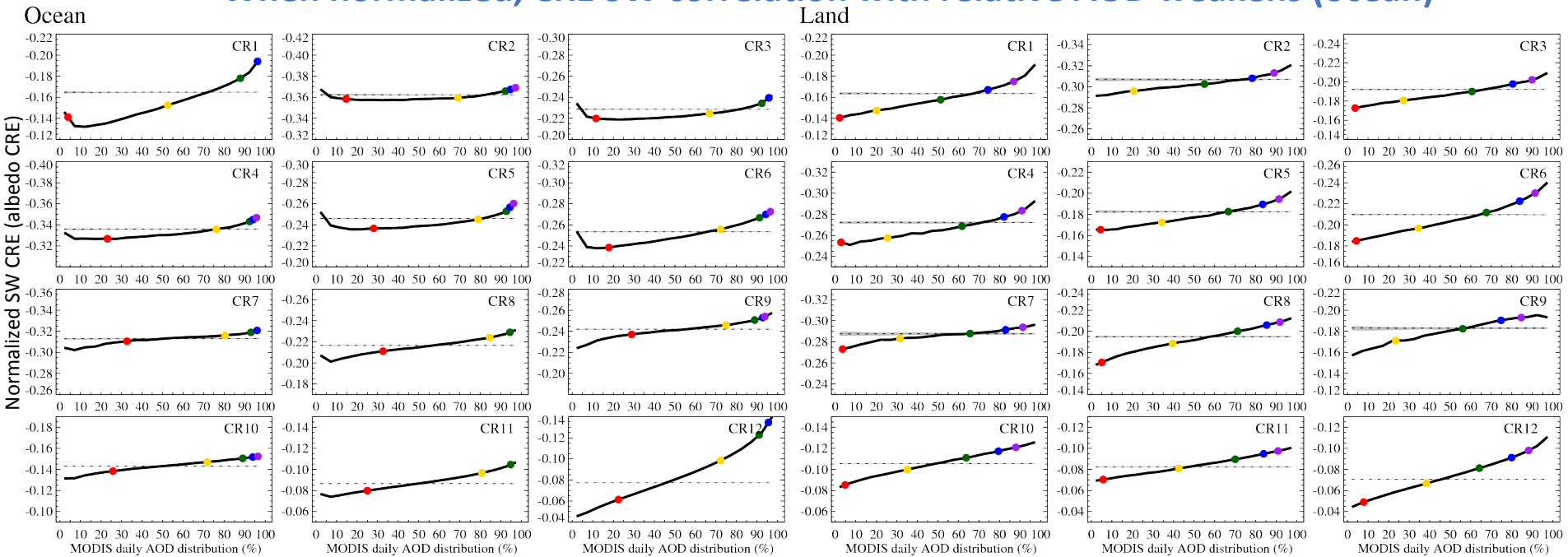
$$CRE_{LW,\,SW} = CF[F_{clr}(AOD) - F_{ovc}(COT,\,CTH)]$$

	Ice (CR1-CR3)		Liq (CR6-CR11)		Mix (CR4-CR5)		CR12	
	Ocean	Land	Ocean	Land	Ocean	Land	Ocean	Land
CF	⇑		⇑		–		⇑	
COT	–	⇑	⇑		⇓	⇑	⇑	
CTH	⇑		⇑		⇑	⇓	⇑	
SW CRE	⇑		⇑		⇑		⇑	
LW CRE	⇑		⇑		⇑		⇑	

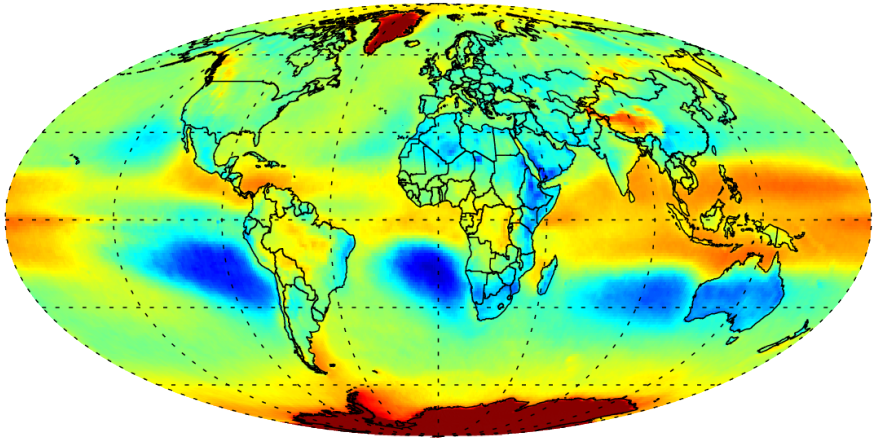


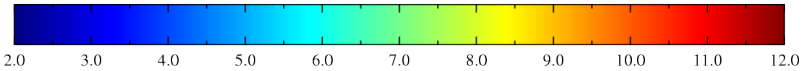
red arrow: consistent with invigoration
blue arrow: consistent with 1st and 2nd indirect effect

When normalized, CRE SW correlation with relative AOD weakens (ocean)

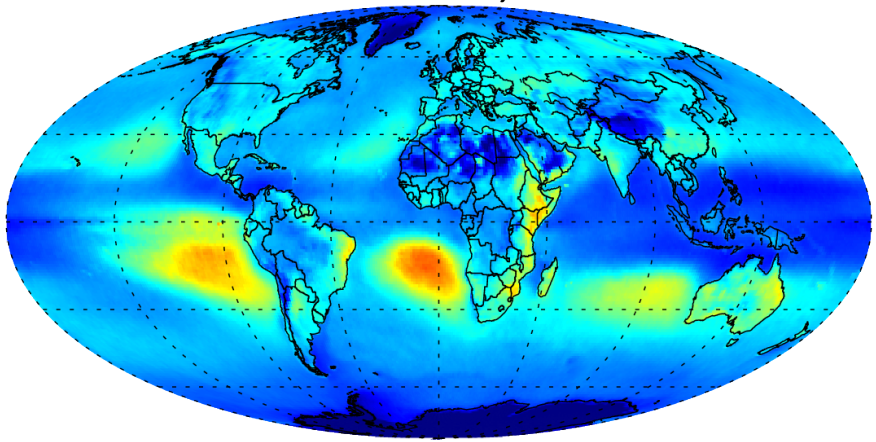


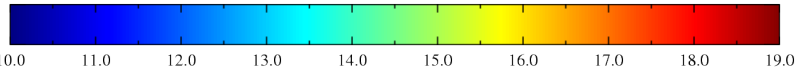
AIRS RRTM band 2, 350-500 cm^{-1}





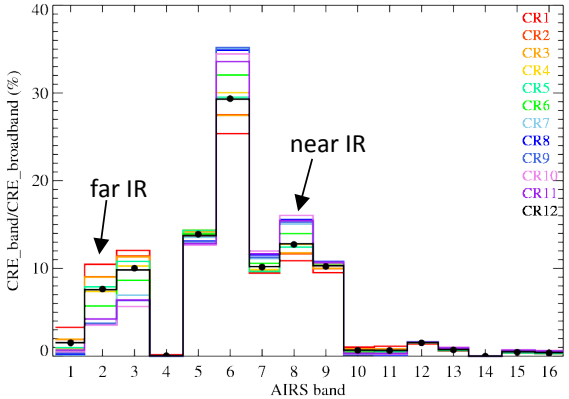
AIRS RRTM band 8, 1080-1180 cm^{-1}





Global spectral CRE fraction by MODIS CR

$$f_{\Delta\nu} = \frac{OLR_{clr}(\Delta\nu) - OLR_{ovc}(\Delta\nu)}{OLR_{clr} - OLR_{ovc}}$$

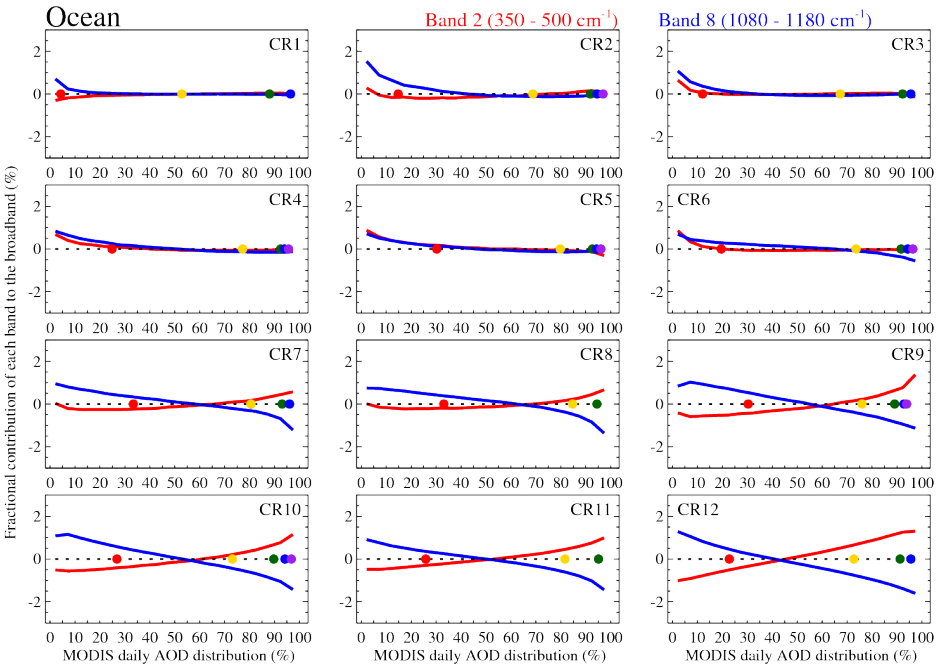


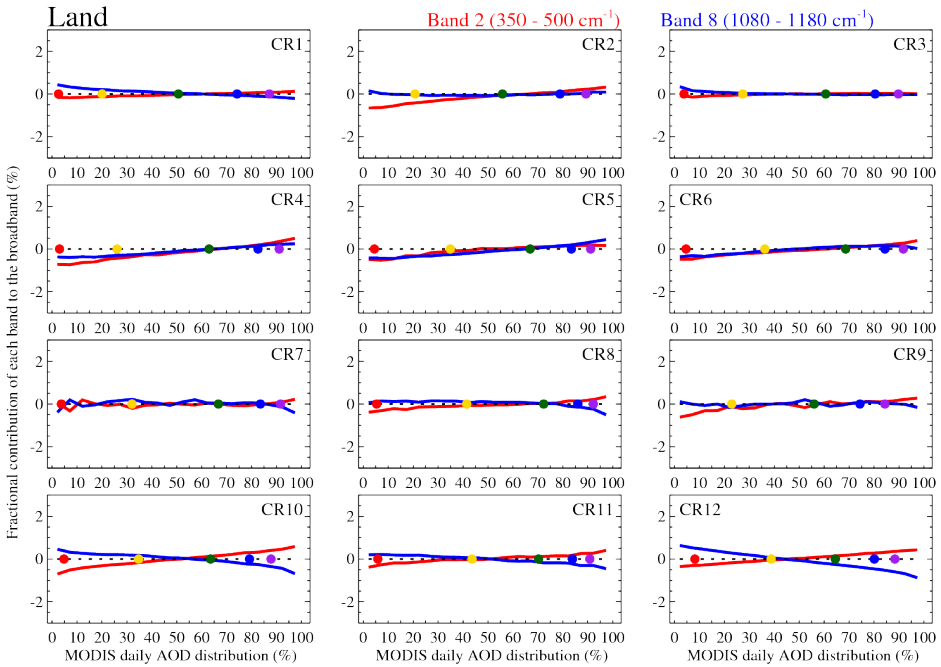
Band	Spectral Interval (cm^{-1})
1.	100 – 350
2.	350 – 500
3.	500 – 630
4.	630 – 700
5.	700 – 820
6.	820 – 980
7.	980 – 1080
8.	1080–1180
9.	1180–1390
10.	1390–1480
11.	1480–1800
12.	1800–2080
13.	2080–2250
14.	2250–2380
15.	2380–2600
16.	2600–3260

cloud tops rising:

- far IR ratio increasing
- near IR ratio decreasing

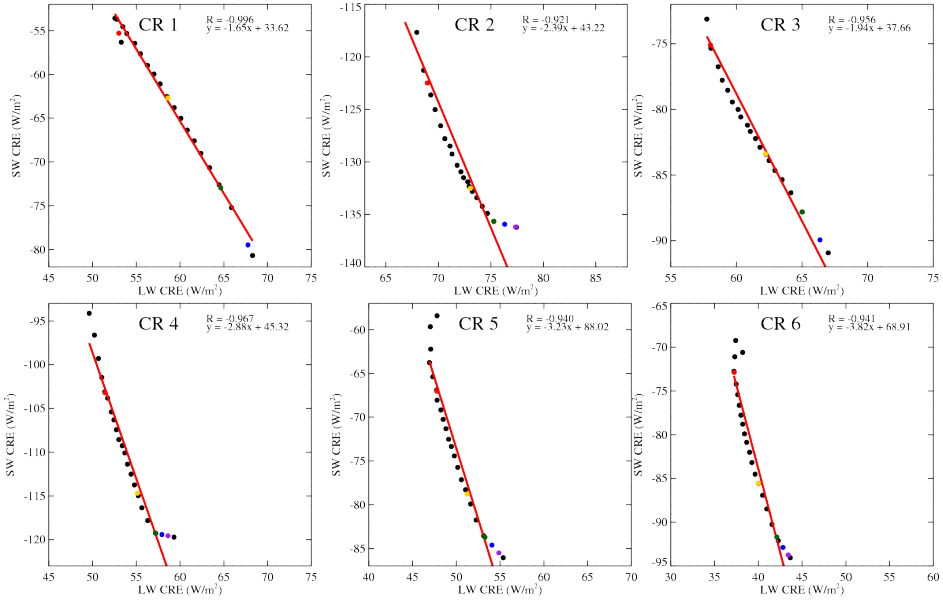
No spectral CRE ratio signals for high-cloud CRs



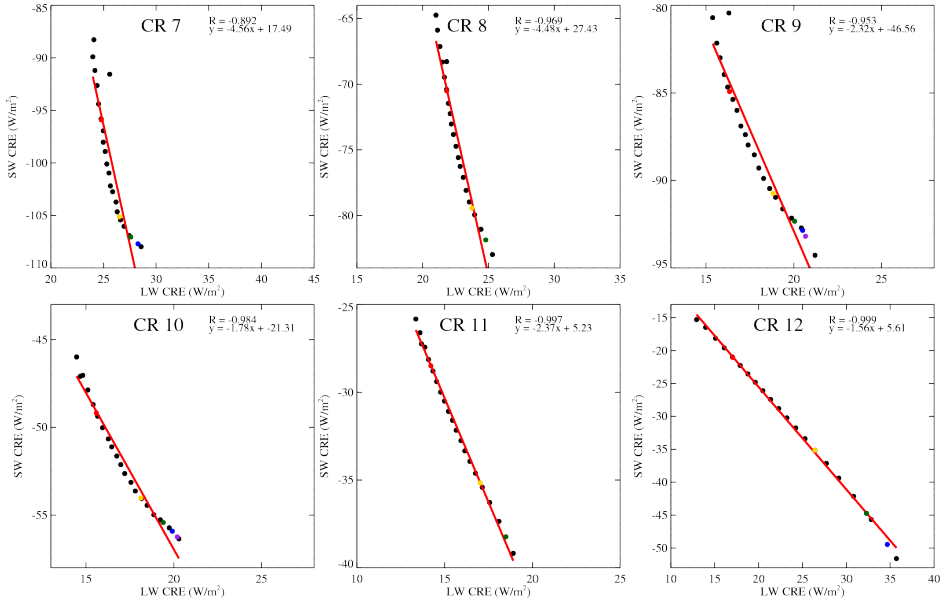


cloud tops rising:

- far IR increasing
- near IR decreasing

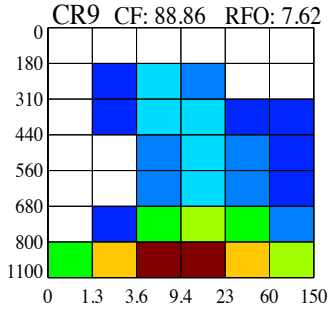


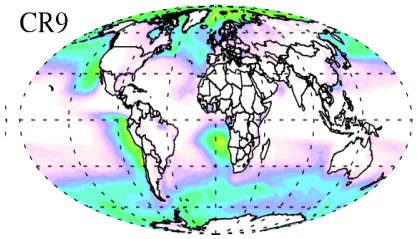
Ocean only

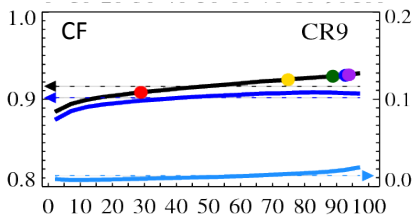


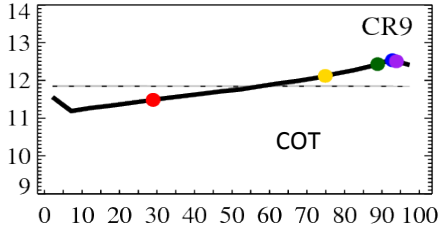
Deviations from straight line
indicative of non-CF cloud changes

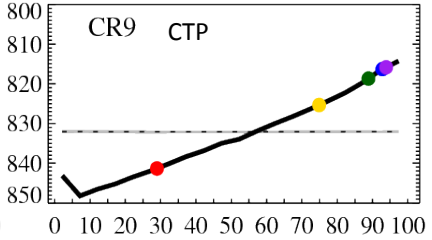
The full picture for a low-cloud regime (ocean)

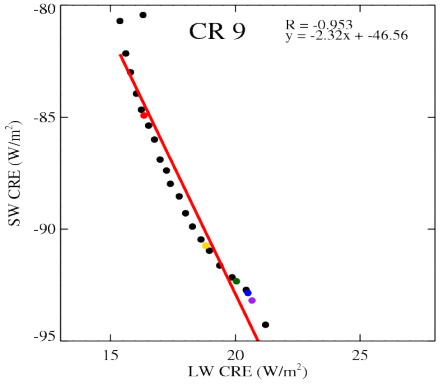


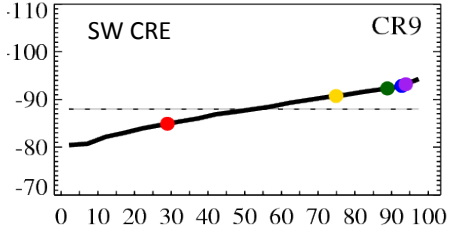


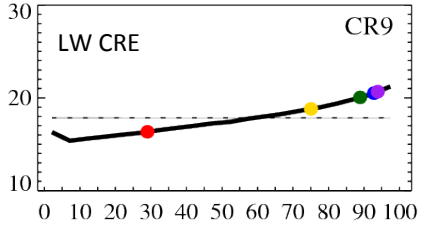


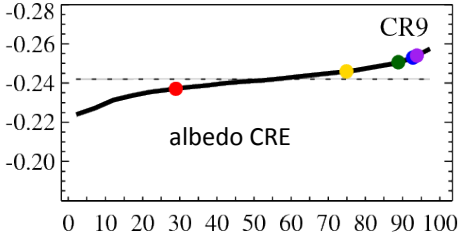


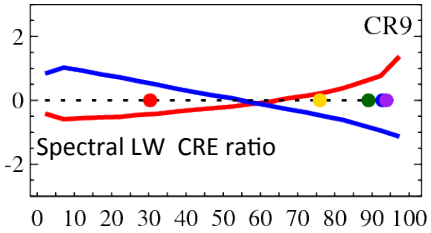












Take-home messages

- Regime-based approach is suitable for *diagnosis* of aerosol-cloud interactions at (near) global scales
- CRE variability with AOD seems very systematic (”good looking” curves) and largely consistent with cloud property changes. Interpretation challenges remain
- CRE variability consistent with invigoration, 1st and 2nd indirect effects
- Despite use of relative values, effects of any AOD retrieval biases under varying cloud conditions remain.
- More details in Oreopoulos et al. JGR (2017).

Questions?