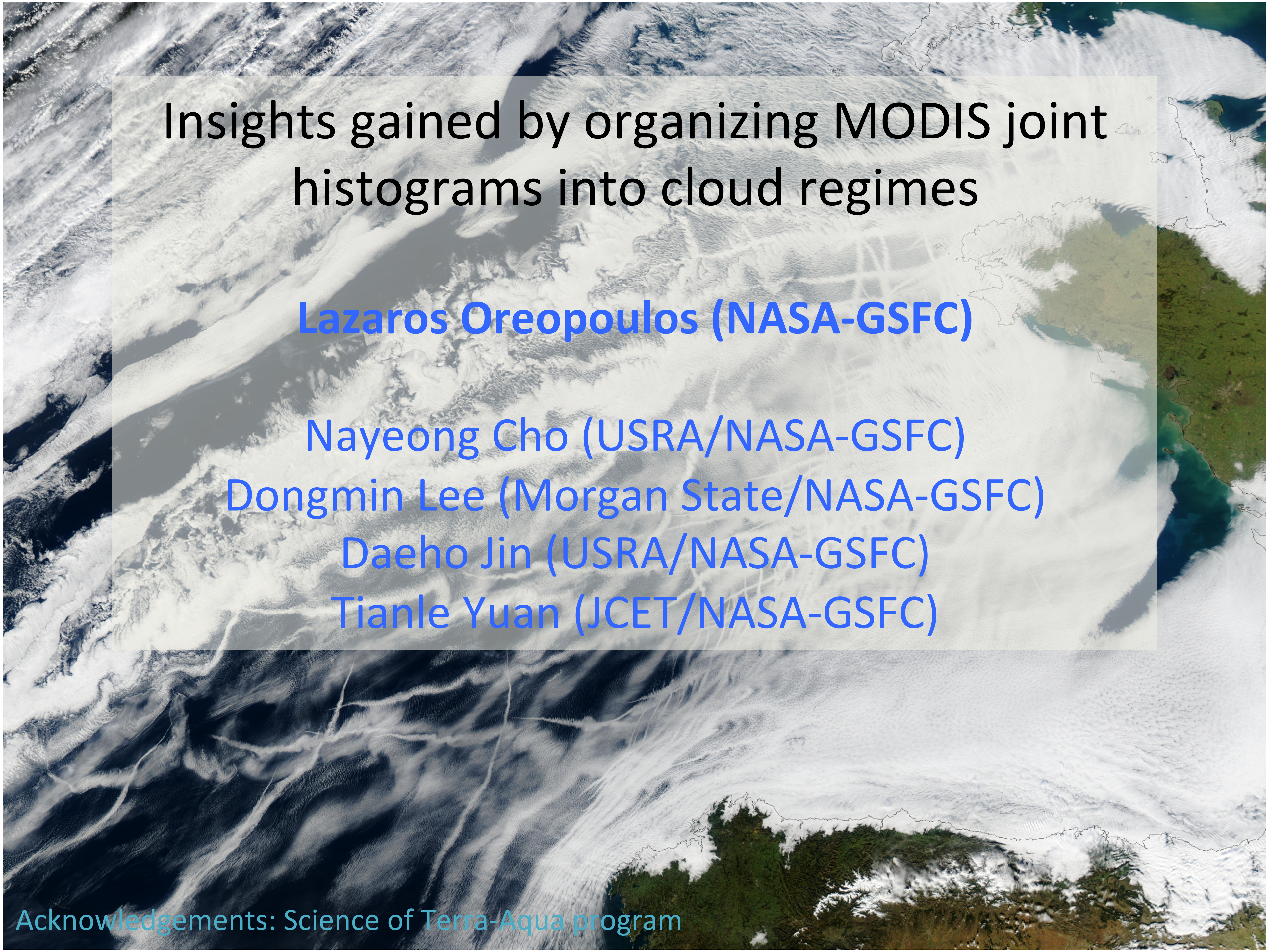


Insights gained by organizing MODIS joint histograms into cloud regimes

Lazaros Oreopoulos (NASA-GSFC)

Nayeong Cho (USRA/NASA-GSFC)
Dongmin Lee (Morgan State/NASA-GSFC)
Daeho Jin (USRA/NASA-GSFC)
Tianle Yuan (JCET/NASA-GSFC)

Acknowledgements: Science of Terra-Aqua program

Motivation

- Study processes by "cloud type"
- "Cloud type" from MODIS is quite ambiguous
- Water phase or CTH (low-middle-high) perhaps too simplistic for distinguishing between cloud types
- In areas ~$(100\text{km})^2$ multiple cloud types may exist
- Therefore it may make more sense to talk about cloud "mixtures", the most dominant of which are "regimes"
- Regimes obtained by clustering analysis applied to cloud property co-variations

MODIS cloud regime (CR) analysis so far

- How CRs look from active sensors (CloudSat/CALIPSO)
- CR Thermodynamic environment from AIRS
- Breakdown by CR of precipitation and radiation budget
- Aerosol effects on clouds and precipitation by CR
- Horizontal cloud inomogeneity by CR
- How CRs will change with C6

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2013JD021409

Key Points:
- Cloud systems observed by passive sensors can be decomposed into cloud regimes
- The regimes have distinct structures

An examination of the nature of global MODIS cloud regimes

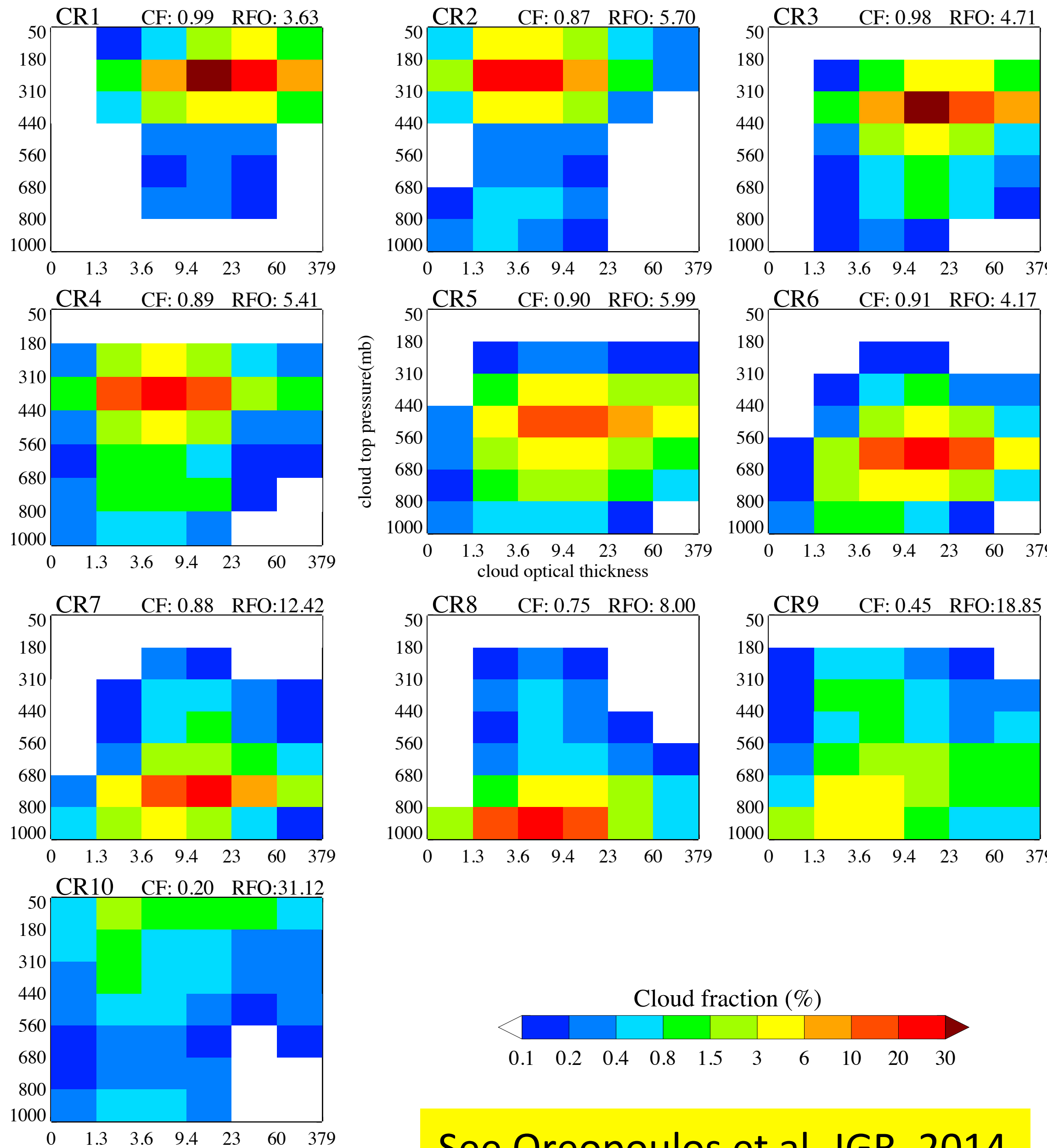
Lazaros Oreopoulos[1], Nayeong Cho[1,2], Dongmin Lee[1,3], Seiji Kato[4], and George J. Huffman[1]

[1]NASA-GSFC, Earth Science Division, Greenbelt, Maryland, USA, [2]USRA, Columbia, Maryland, USA, [3]GESTAR, Morgan State University, Baltimore, Maryland, USA, [4]NASA-LARC, Climate Science Branch, Hampton, Virginia, USA

MODIS dynamical cloud regimes (CRs)

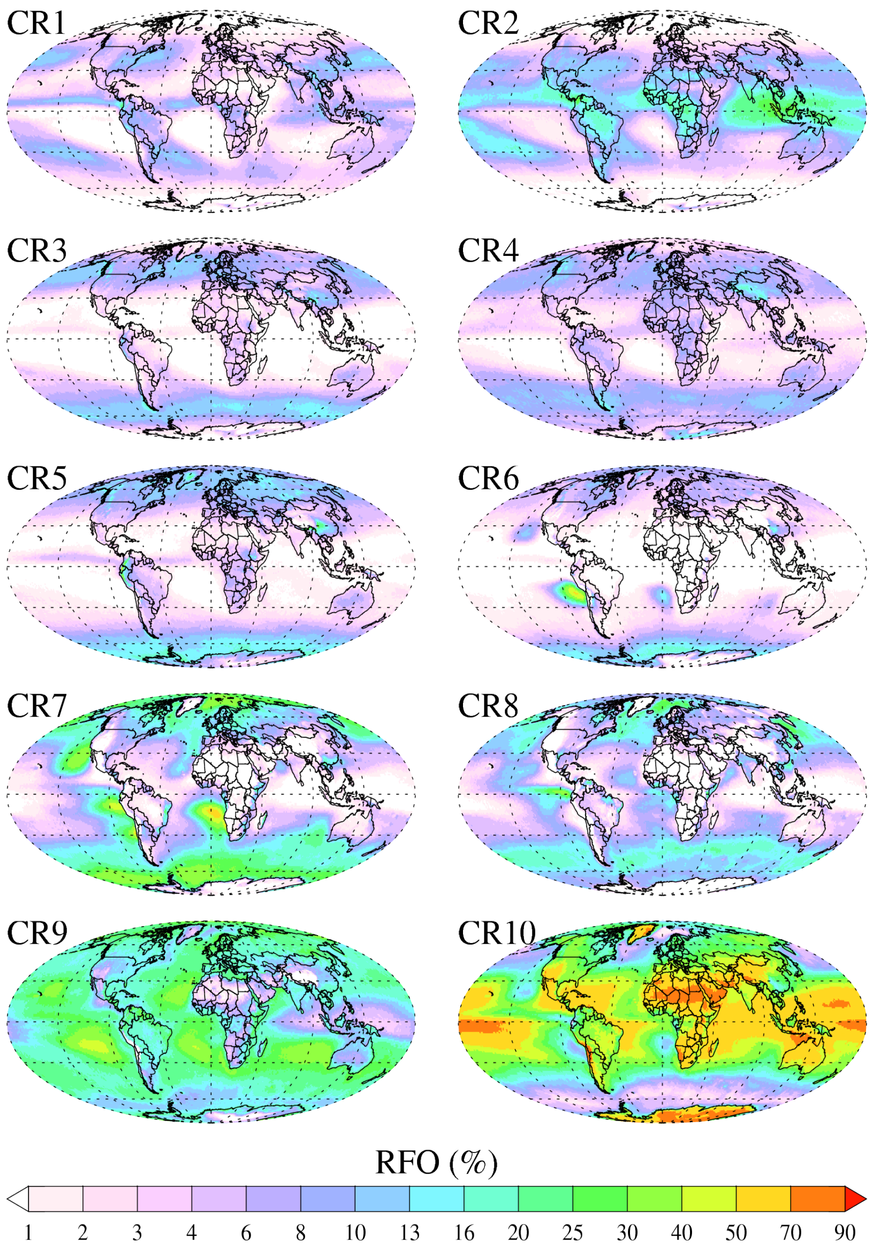
Systematic patterns in co-variations of cloud extinction and vertical location according to MODIS

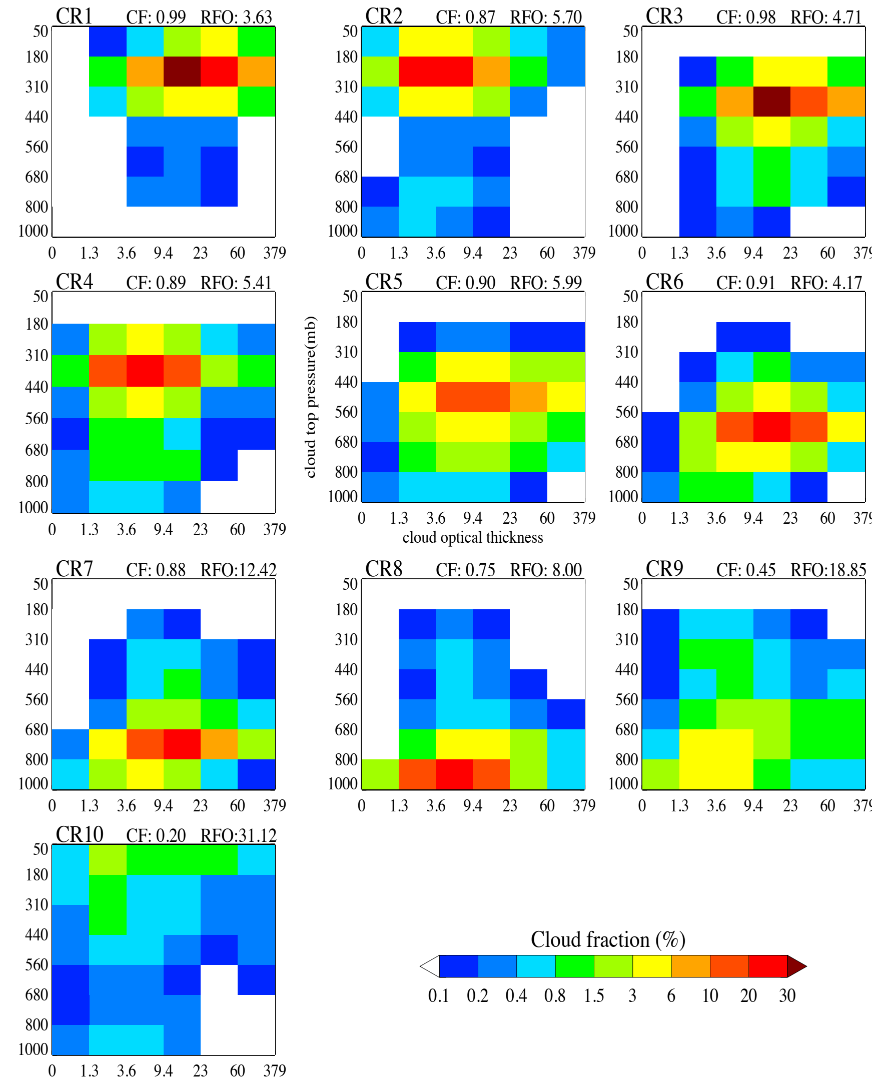
L-3, daily data,Terra and Aqua



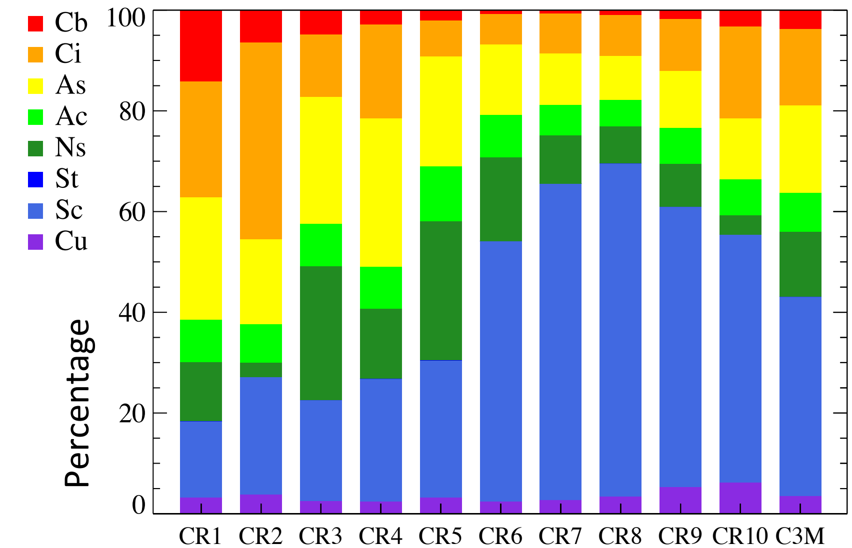
See Oreopoulos et al. JGR, 2014

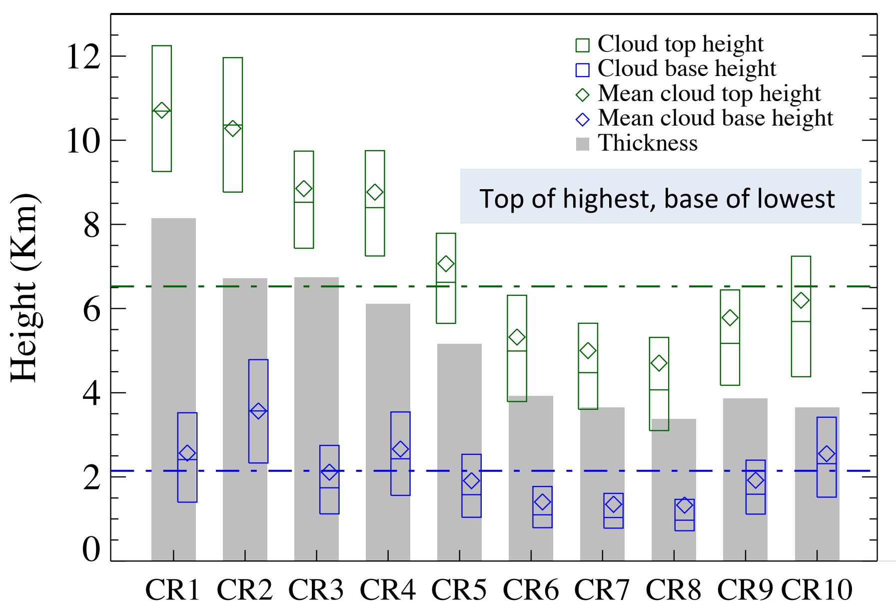
Where the dynamical CRs occur

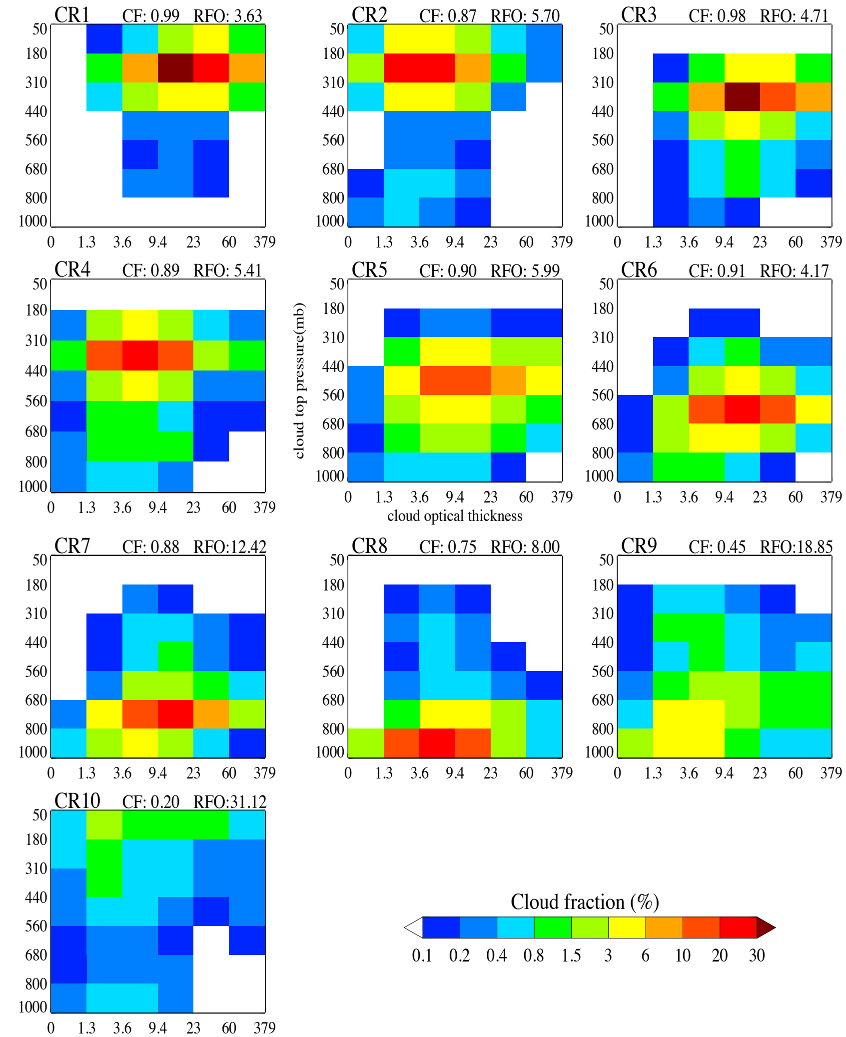




Breakdown of Aqua dynamical CRs by CloudSat cloud type



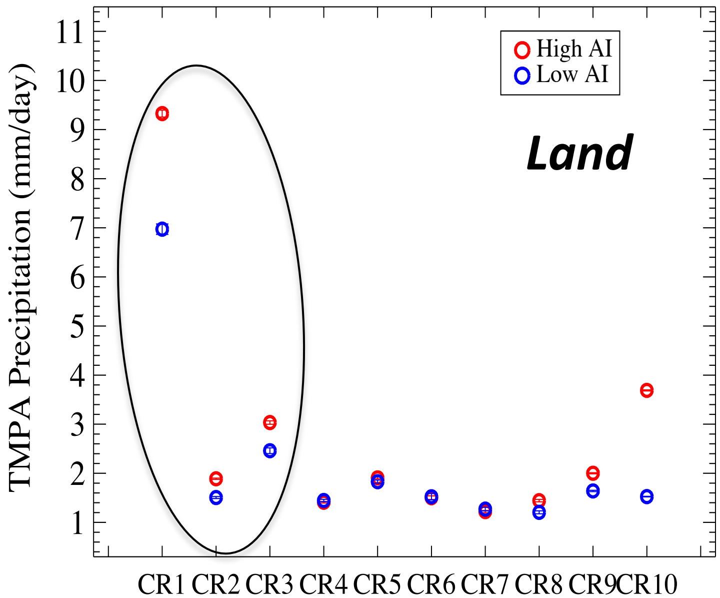


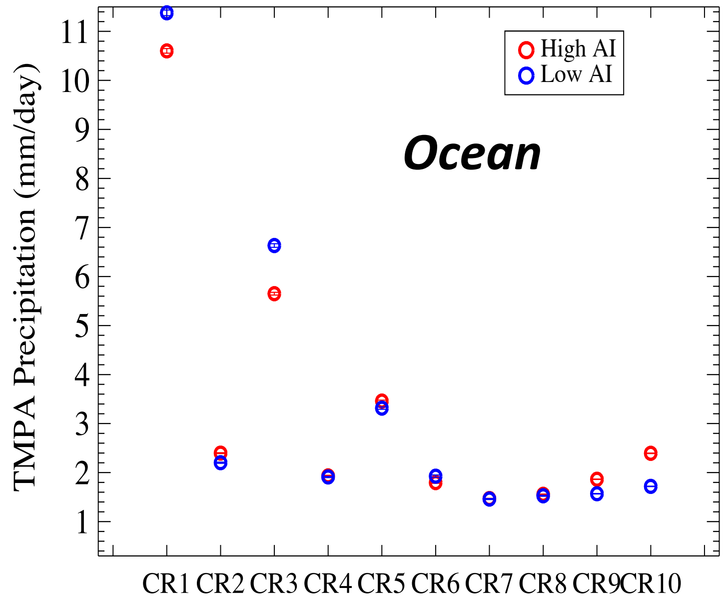


Aerosol effects on clouds and precipitation

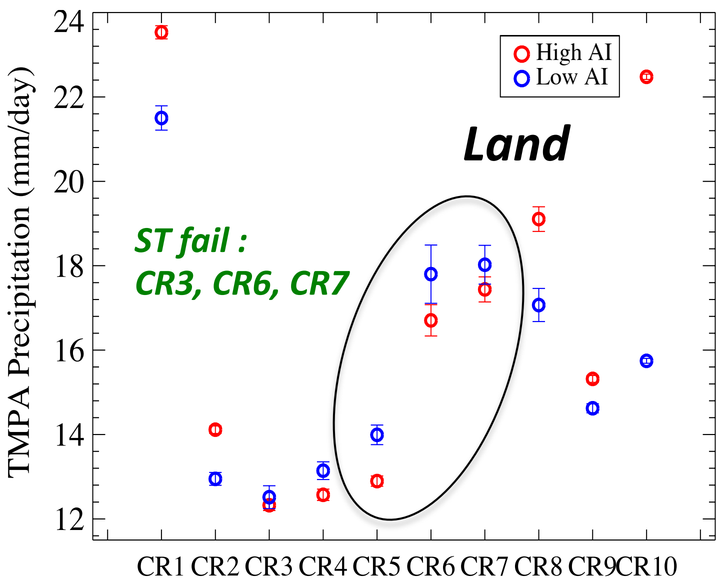
- Level-3 C5.1 MODIS Aqua and Terra daily data
- TMPA surface precip 3-h 0.25° data; match with MODIS
- For each MODIS 1° gridcell with an AOD (from either Terra or Aqua) we calculate the AI (=AODxAngstrom); AI relates to aerosol column number. We calculate gridcell seasonal AI distributions for each gridcell and perform composite by CR and AI percentile.
- We often focus on the upper (3Q, "high" aerosol) and lower (1Q, "low" aerosol) quartile and perform statistical significance tests
- Land/ocean separation helpful
- High latitudes (>50°) are excluded from the analysis (no precip available from TMPA)

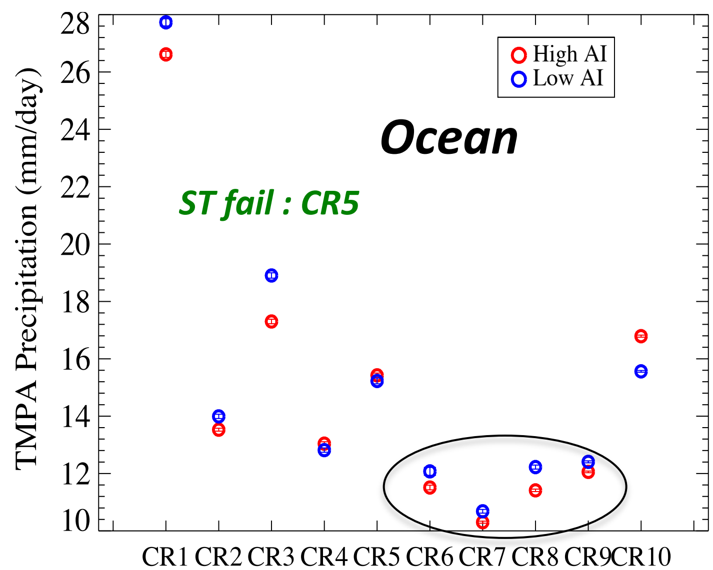
3Q vs 1Q precipitation (50S-50N)





Zero precipitation <u>included</u>

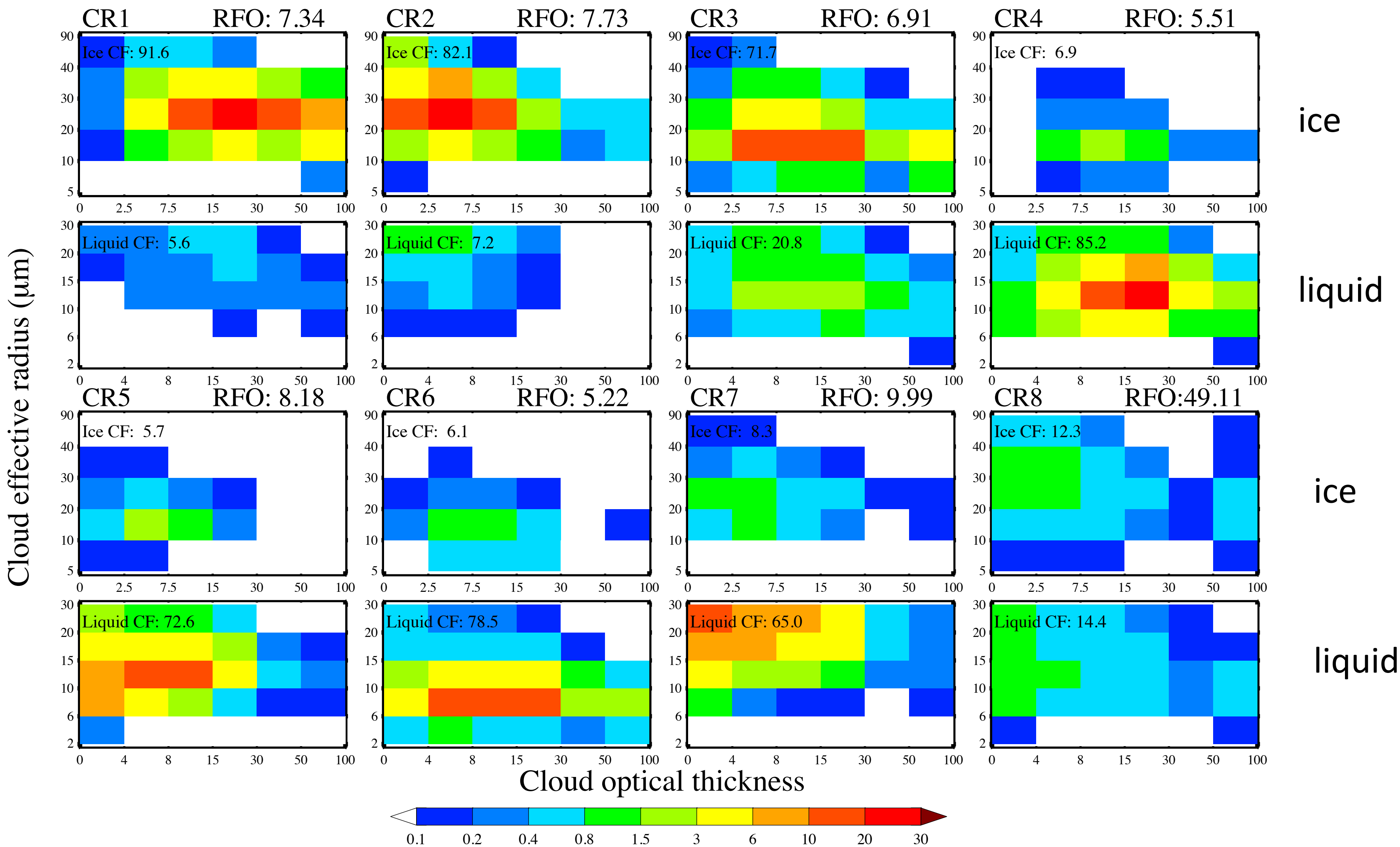




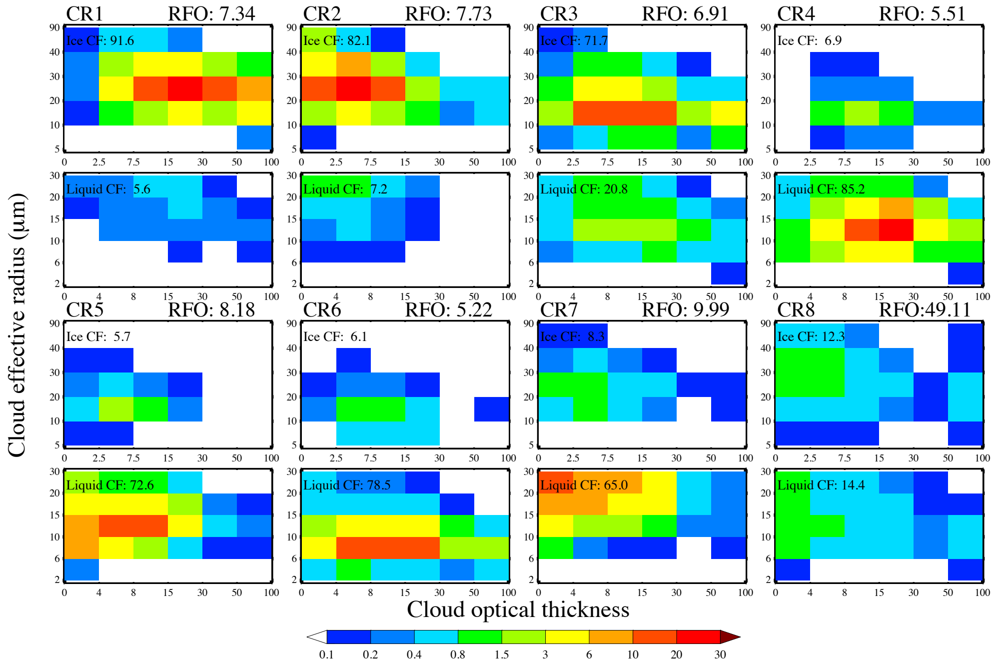
Zero precipitation <u>excluded</u>

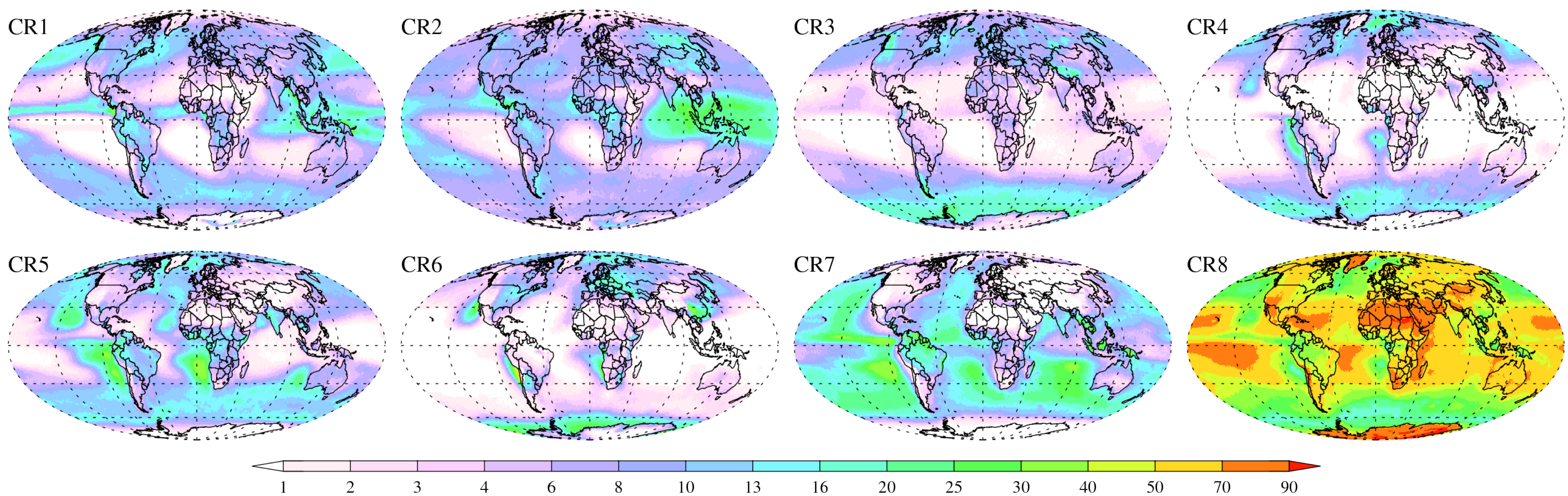
Microphysical regimes

MODIS microphysical regimes (C5.1)



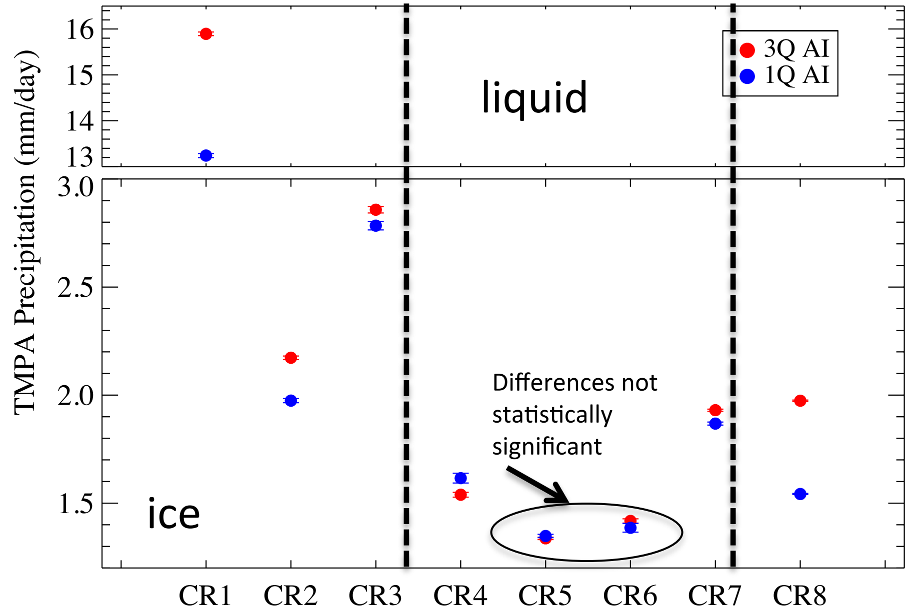
C5.1 MODIS microphysical regimes





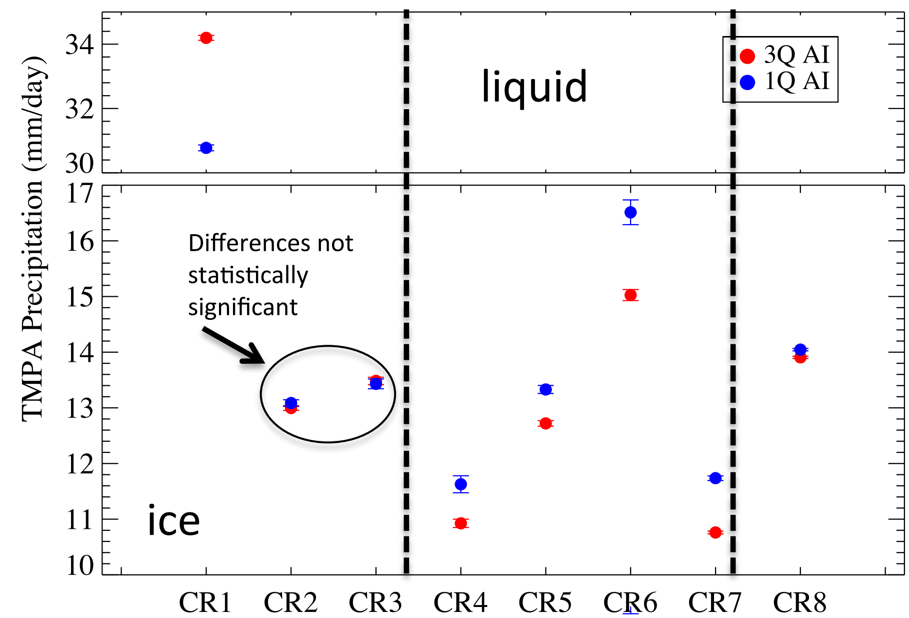
3Q vs 1Q precipitation (50S-50N)

Zero precipitation included



3Q=high aerosol
1Q=low aerosol

Zero precipitation excluded



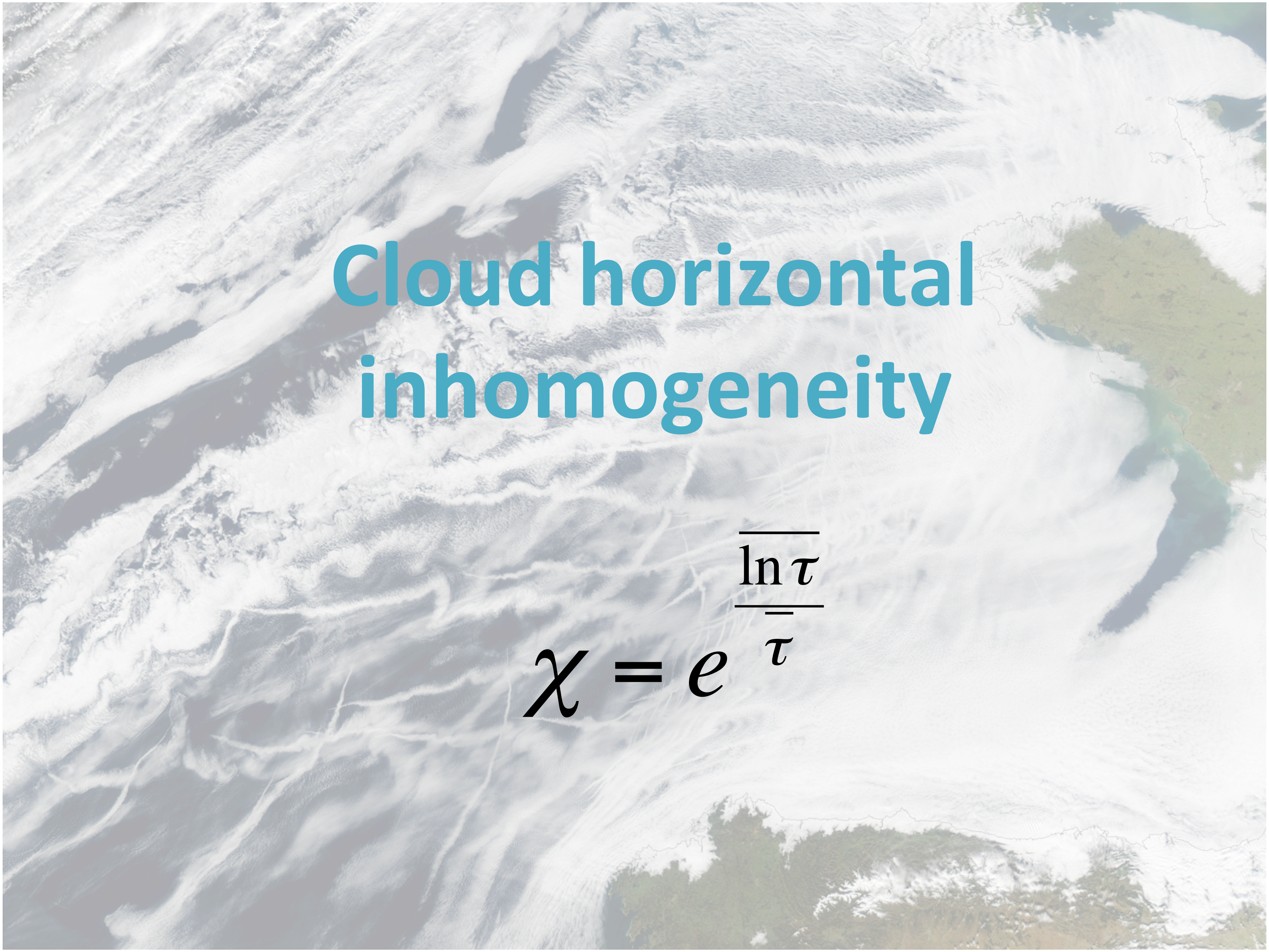
Summary

From low to high AI

DCR=dynamical regimes; MCR=microphysical regimes

<table>
<tr><th rowspan="2"></th><th colspan="2">DCR_{ice} Land/Ocean</th><th colspan="2">DCR_{liq} Land/Ocean</th><th rowspan="2">DCR_{10}</th><th rowspan="2">MCR_{ice}</th><th rowspan="2">MCR_{liq}</th><th rowspan="2">MCR_{8}</th></tr>
<tr><th>Land</th><th>Ocean</th><th>Land</th><th>Ocean</th></tr>
<tr><td>Prcp</td><td>⇑</td><td>⇓</td><td colspan="2">–</td><td>⇑</td><td>⇑</td><td>–</td><td>⇑</td></tr>
<tr><td>CF</td><td colspan="2">–</td><td colspan="2">⇑</td><td>⇑</td><td>–</td><td>⇑</td><td>⇑</td></tr>
<tr><td>CTH</td><td colspan="2">⇑</td><td>⇑</td><td>–</td><td>⇑</td><td>⇑</td><td>–</td><td>⇑</td></tr>
<tr><td>Tau</td><td>⇑</td><td>⇓</td><td colspan="2">⇑</td><td>⇑</td><td>⇓</td><td>⇑</td><td>⇑</td></tr>
<tr><td>Re</td><td>⇓</td><td>–</td><td colspan="2">⇓</td><td>⇑</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>PrcpNZ</td><td>⇑</td><td>⇓</td><td>–</td><td>⇓</td><td>⇑</td><td>⇑</td><td>⇓</td><td>–</td></tr>
</table>

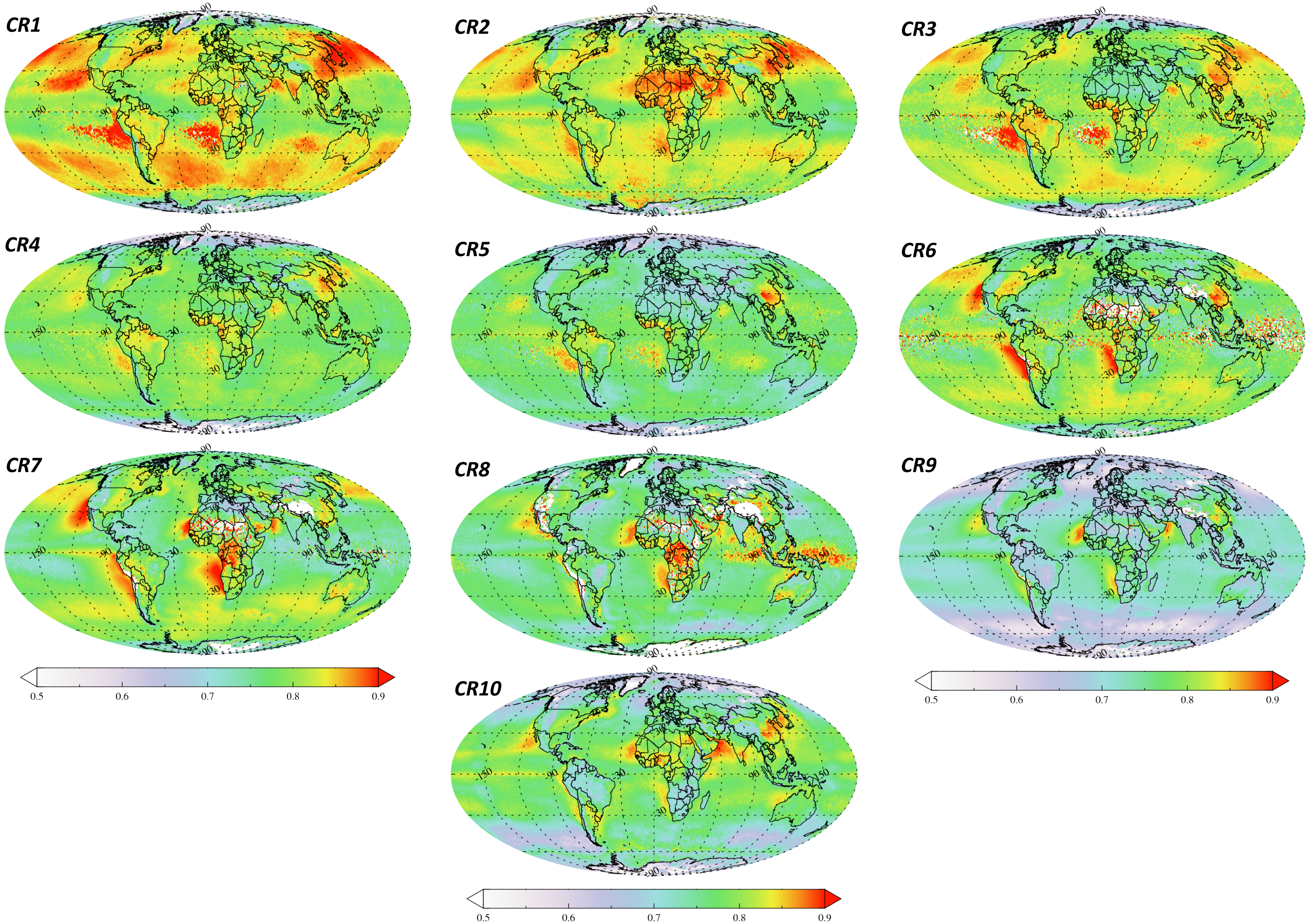
red arrow: consistent with invigoration; blue arrow: consistent with 1st and 2nd indirect effect



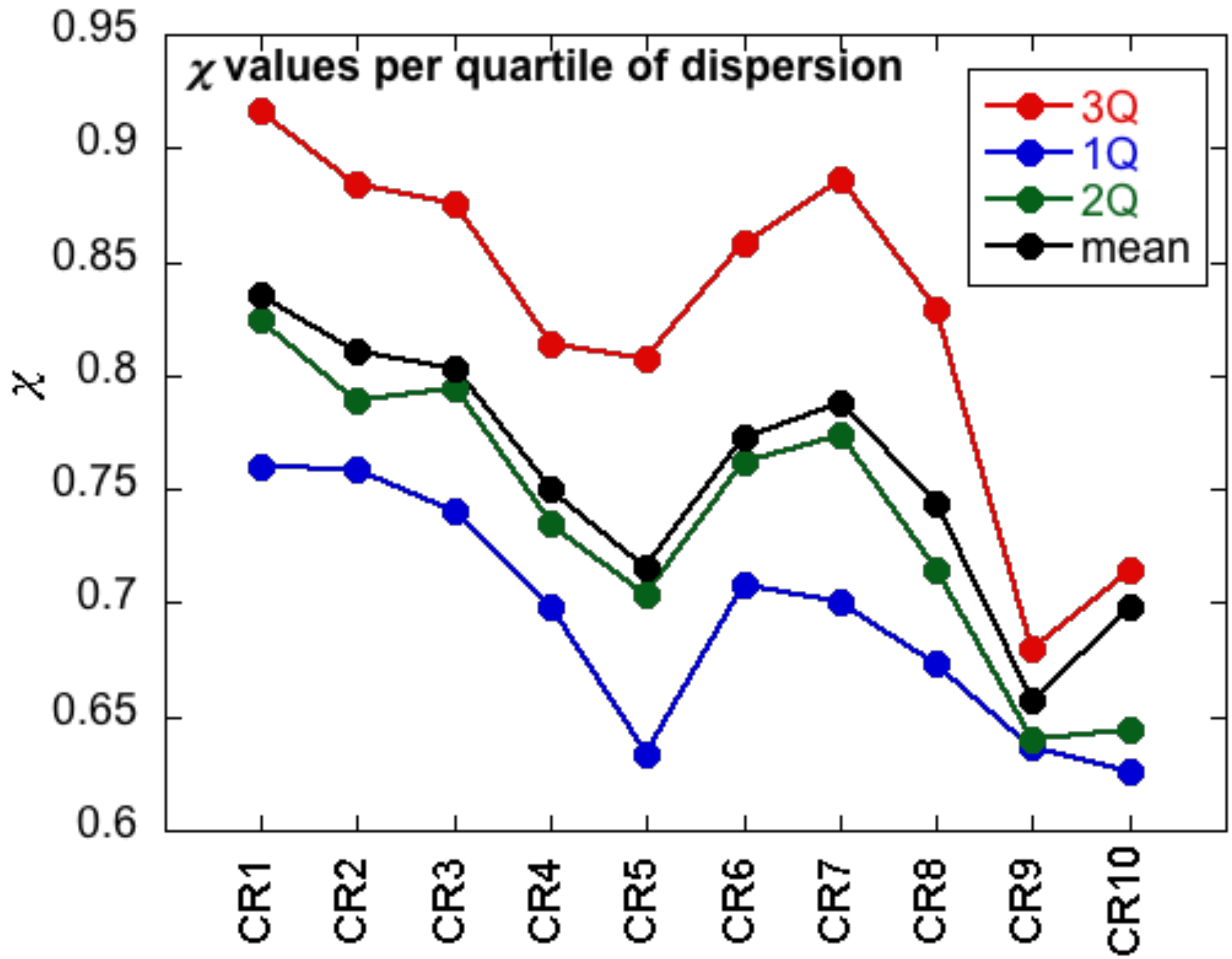
Cloud horizontal inhomogeneity

$$\chi = e^{\frac{\overline{\ln \tau}}{\overline{\tau}}}$$

Global mean values for inhomogeneity parameter



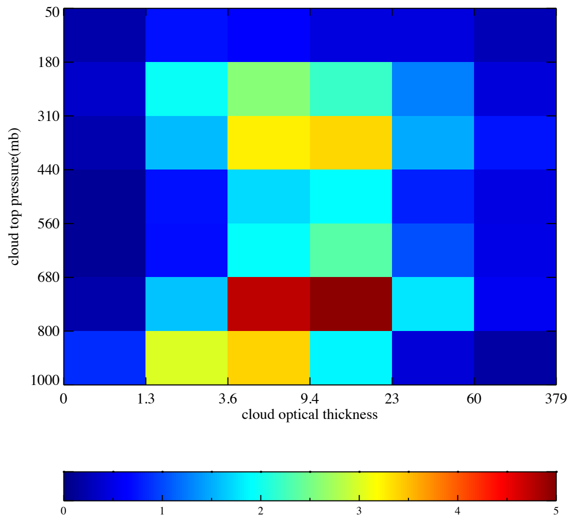
Inhomogeneity by and within CRs



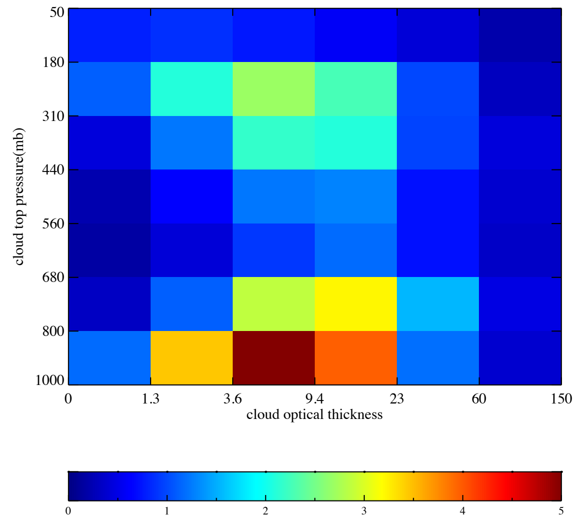
Collection 6 impacts

Dynamical CRs will change with Collection 6

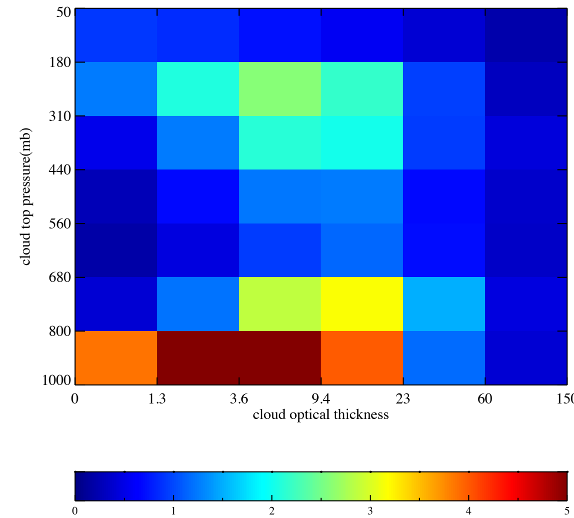
C5.1



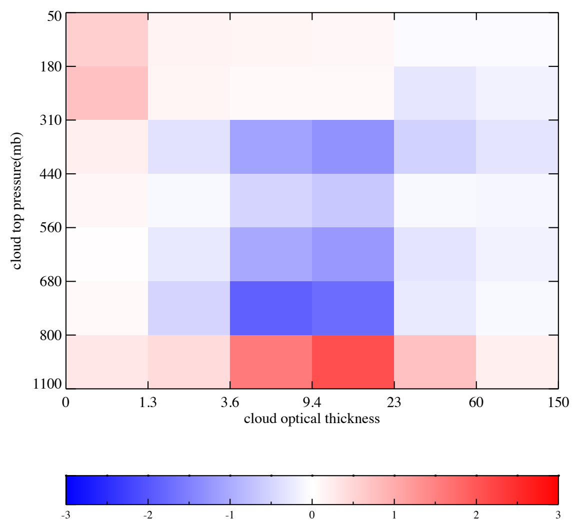
C6



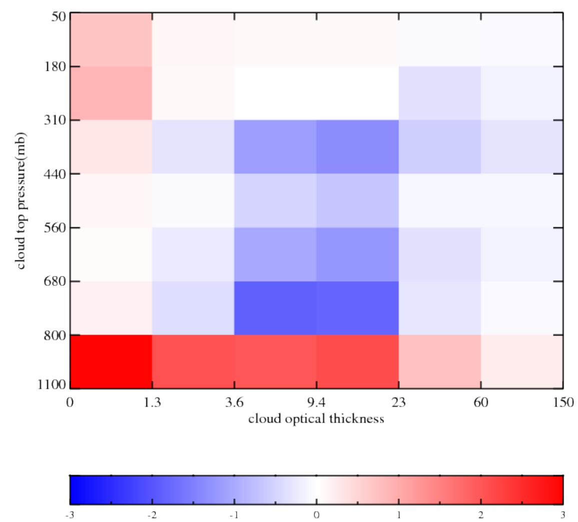
C6 with PCL



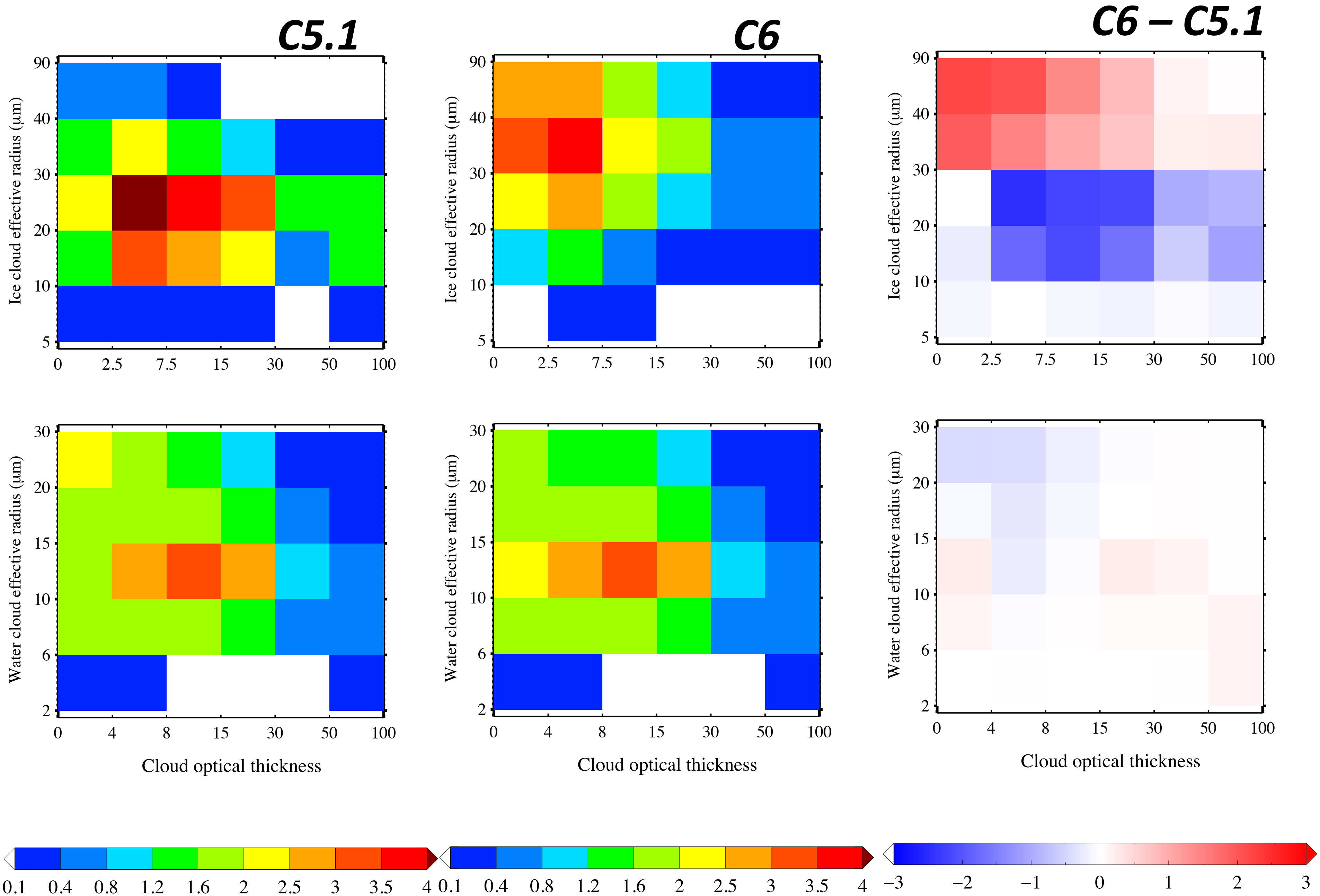
C6 – C5.1



C6 with PCL – C5.1

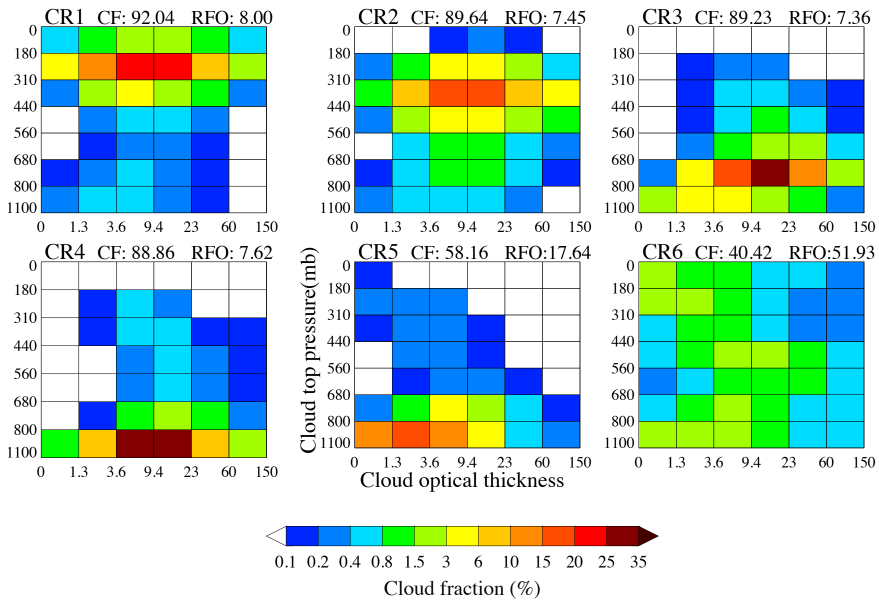


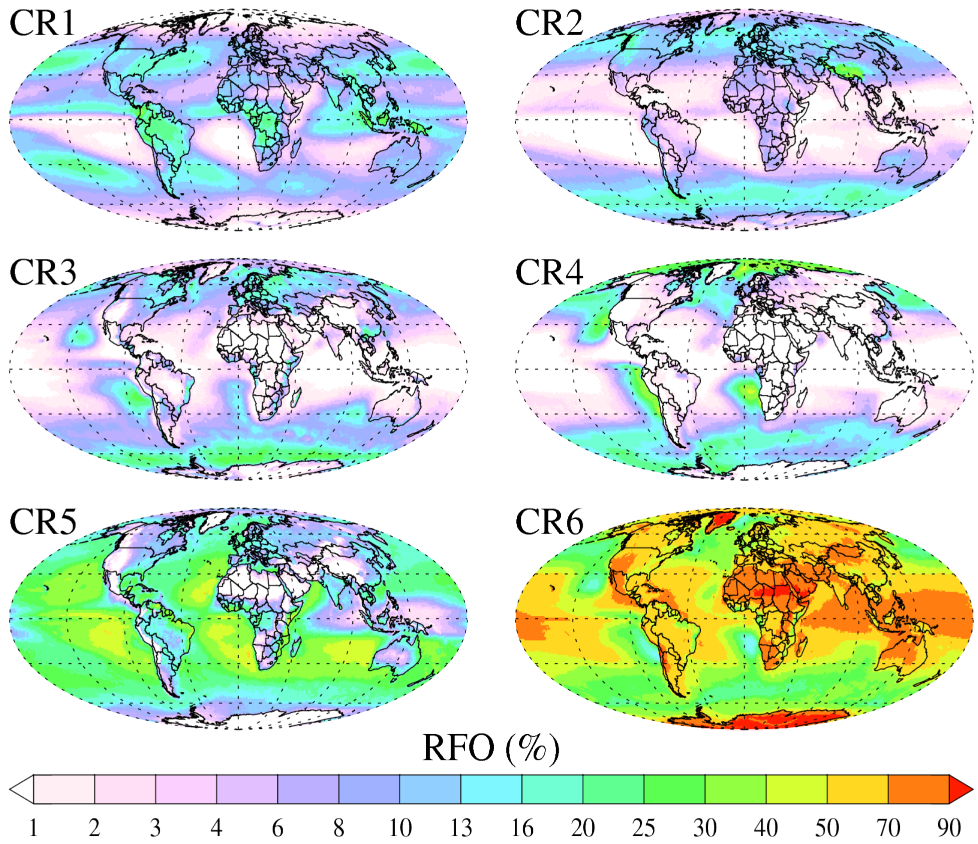
Ice microCRs will change with Collection 6



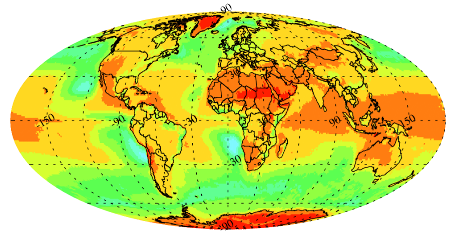
Preview of Collection 6 dynamical CRs

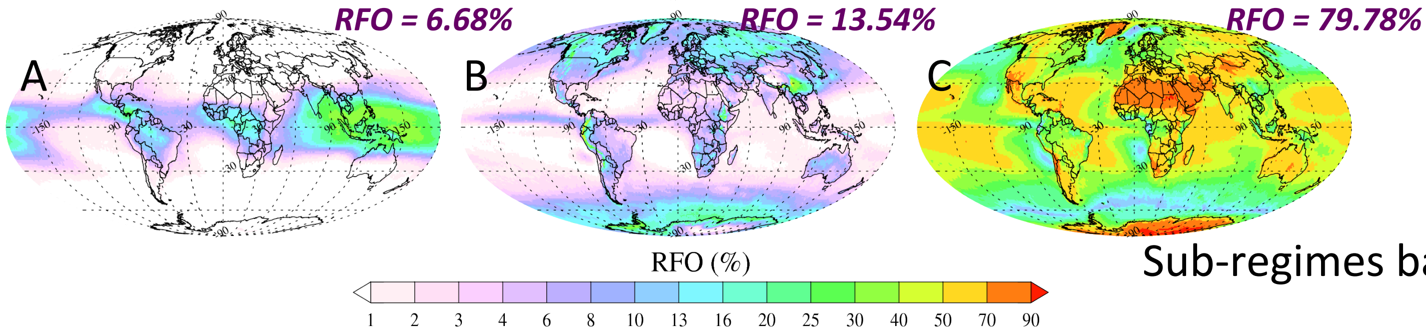
C6 PCL





Breaking into “sub-regimes”





Map correlation coefficient

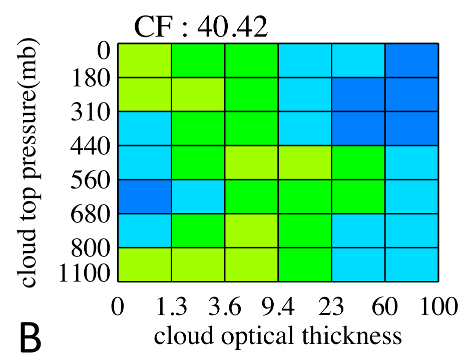
A-B : -0.37

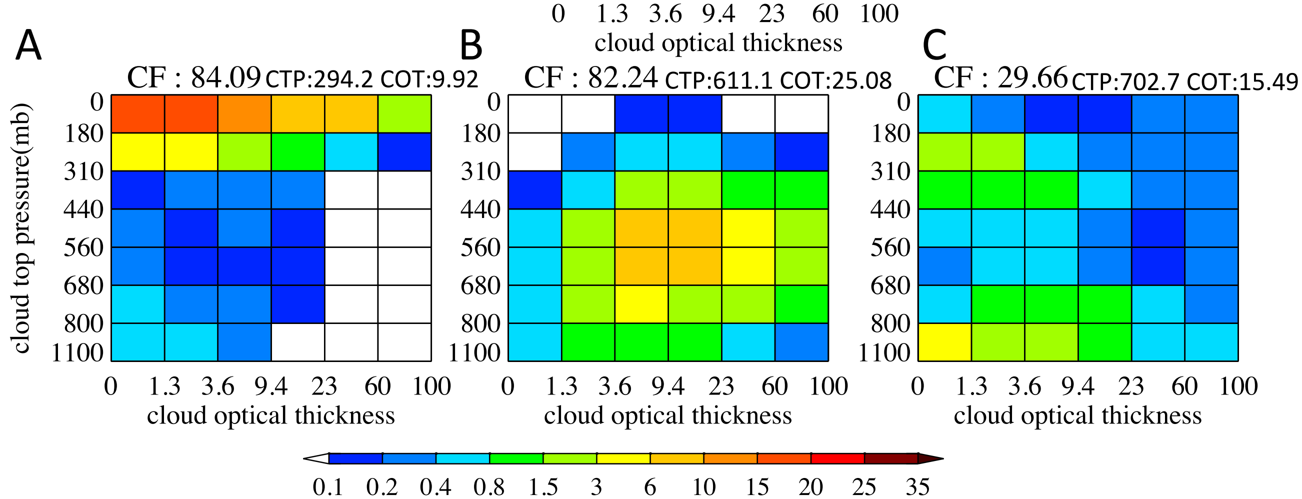
A-C : 0.06

B-C : -0.09

Sub-regimes based on re-clustering

Repeatability = 18/20





Regime correlation coefficient

A-B : -0.32

A-C : -0.14

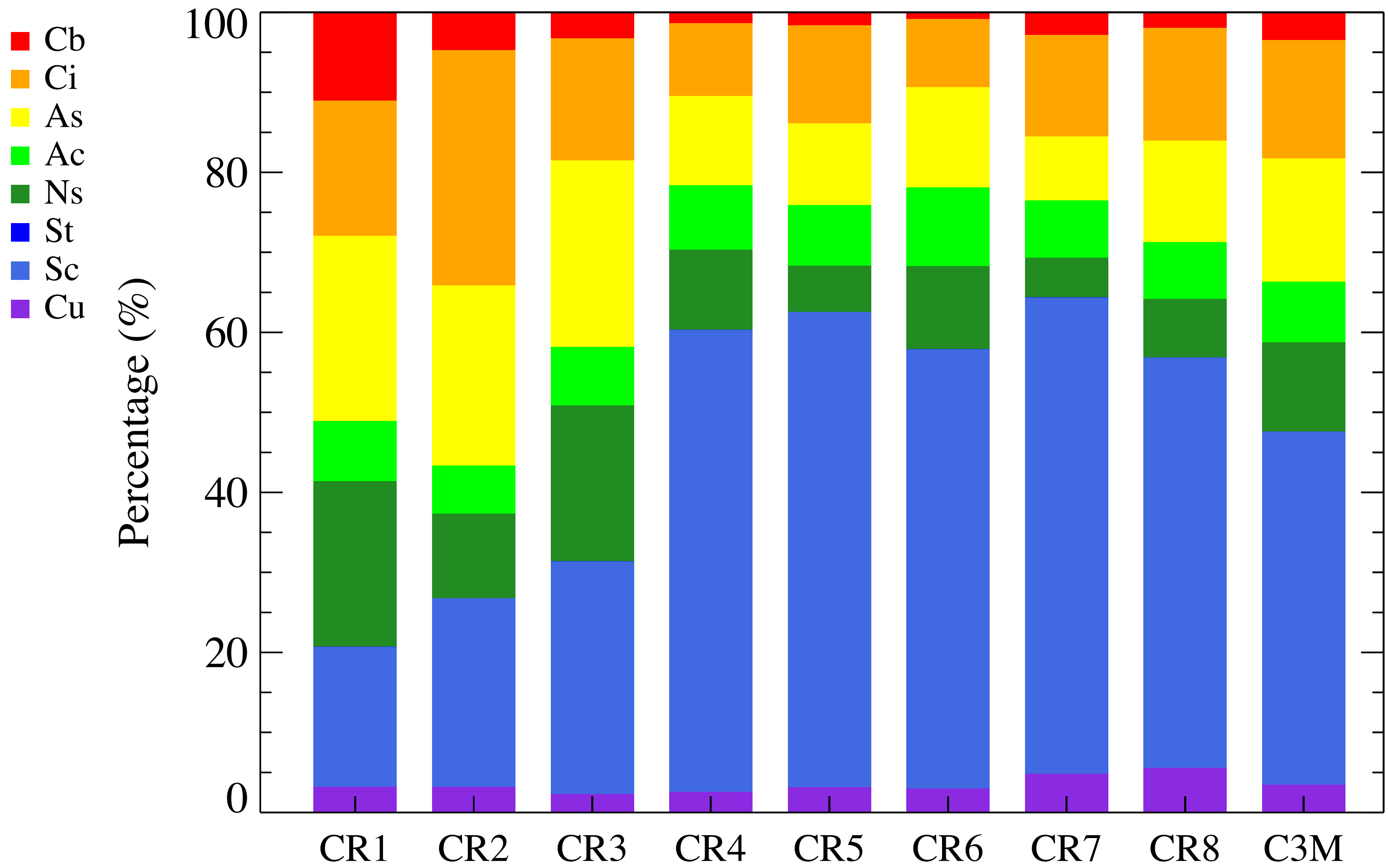
B-C : -0.14

Take home messages

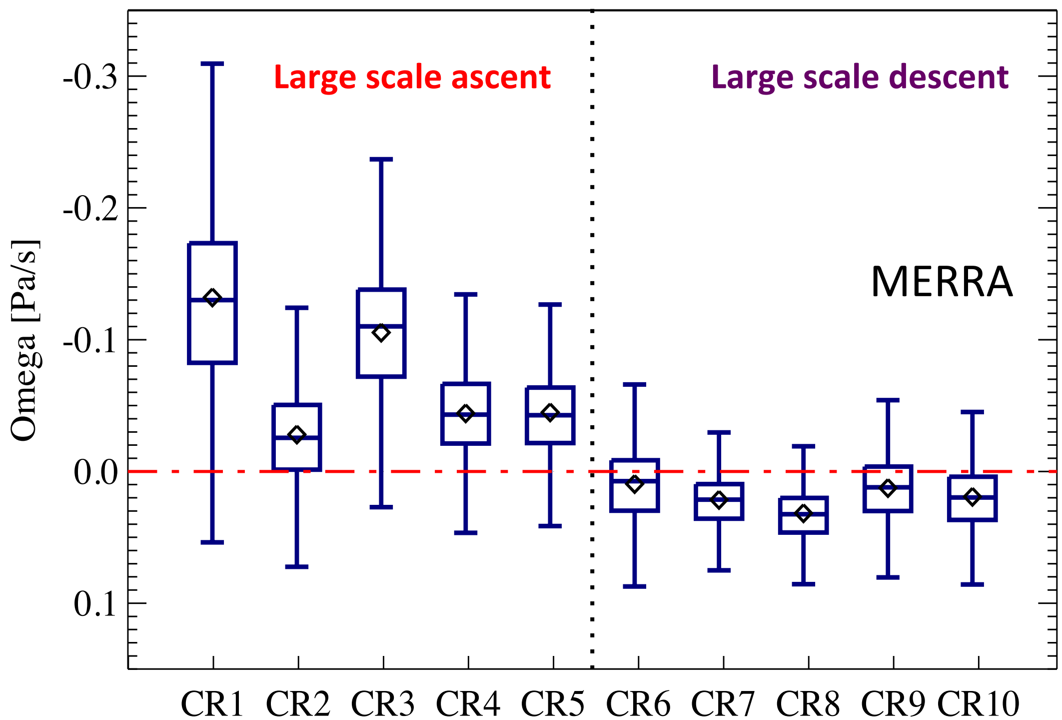
- A regime-based approach adds insight to many studies involving clouds
- Cloud regimes can be defined to be more closely associated with either dynamics or microphysics
- With MODIS simulator implemented in GCMs, a CR-based model validation becomes possible (work underway with ISCCP CRs and CMIP5 data)
- Robustness of CRs is important issue. C5.1 to C6 transition is expected to have impact

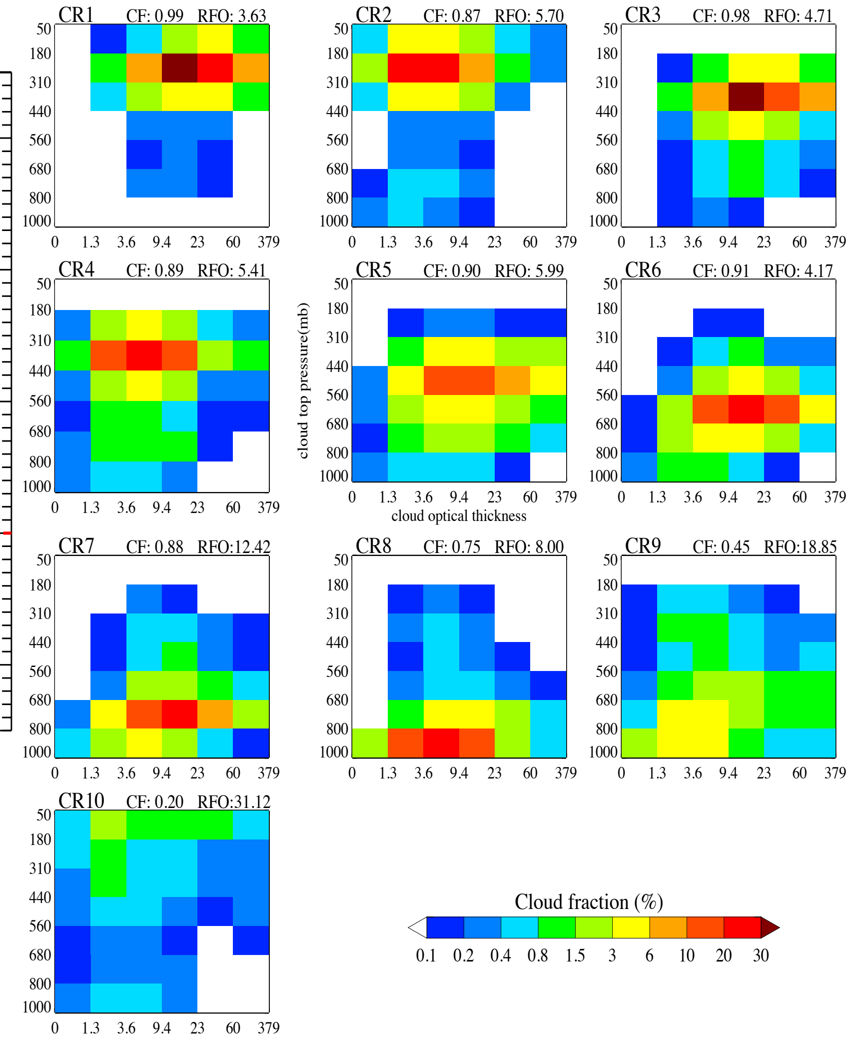
Additional slides

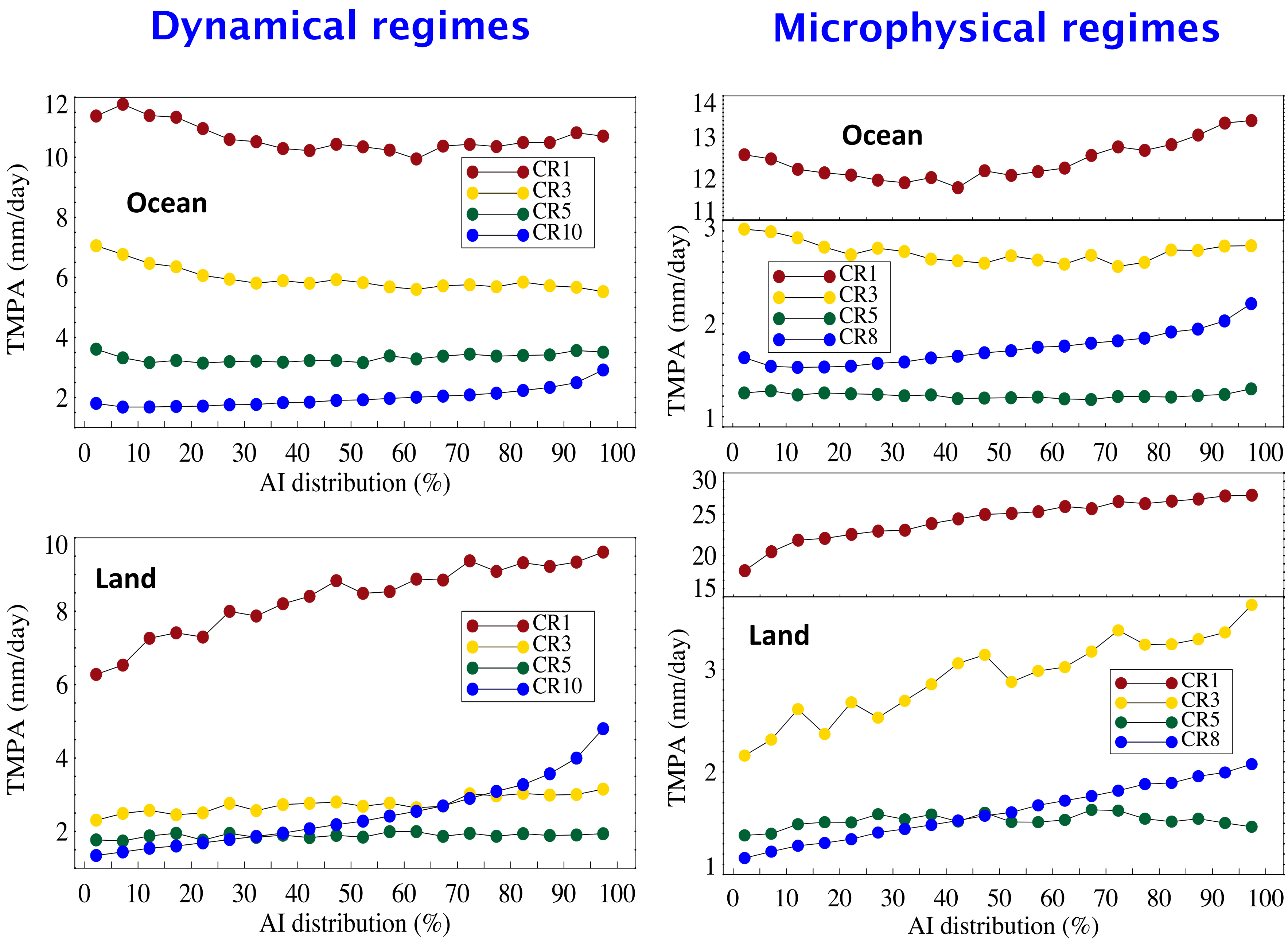
Breakdown of Aqua microCRs by CloudSat cloud type



Why dynamical






Dynamical regimes
Microphysical regimes
Ocean
Land
TMPA (mm/day)
AI distribution (%)
CR1
CR3
CR5
CR10
CR8
0
10
20
30
40
50
60
70
80
90
100