Poster 14-16

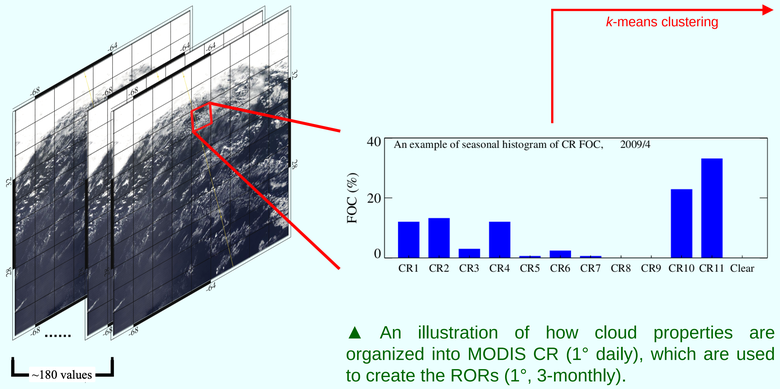
Understanding Global Cloudiness through Regimes of Regimes

Jackson Tan[1,2], Nayeong Cho[1,2], Lazaros Oreopoulos[1], Dongmin Lee[1,3]

[1]NASA Goddard Space Flight Center, Greenbelt, MD, USA [2]University of Maryland Baltimore County, Baltimore, MD, USA [3]Morgan State University, Baltimore, MD, USA

What are Regimes of Regimes?

Regimes of Regimes (RORs) are based on MODIS Cloud Regimes (CR), which are discrete categorizations of the distributions of cloud properties at the mesoscale (1° daily). Specifically, CRs are derived by applying a *k*-means clustering algorithm on joint-histograms of cloud top pressure and cloud optical thickness as observed by the MODIS sensors (on board the low-Earth-orbit Terra and Aqua satellites). Further applying the *k*-means clustering algorithm on the occurrence of the CRs over a three-month period at each 1° grid box produces these RORs.



▲ An illustration of how cloud properties are organized into MODIS CR (1° daily), which are used to create the RORs (1°, 3-monthly).

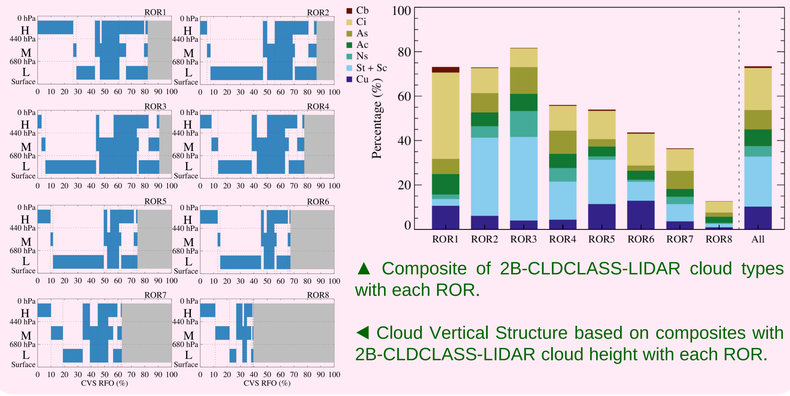
Environments Represented by the RORs

Based on their cloud (CR) properties and global distributions at different seasons, the possible environmental conditions represented by each RORs are:

ROR1: convectively active environment associated with frequent rainfall
ROR2: mid-latitude oceanic storm track
ROR3: high latitude cloudy environment
ROR4: mid-latitude continental baroclinic environment
ROR5: low marine cloud environment
ROR6: subtropical shallow convectve environment
ROR7: convectively supressed environment associated with fair weather
ROR8: arid environment

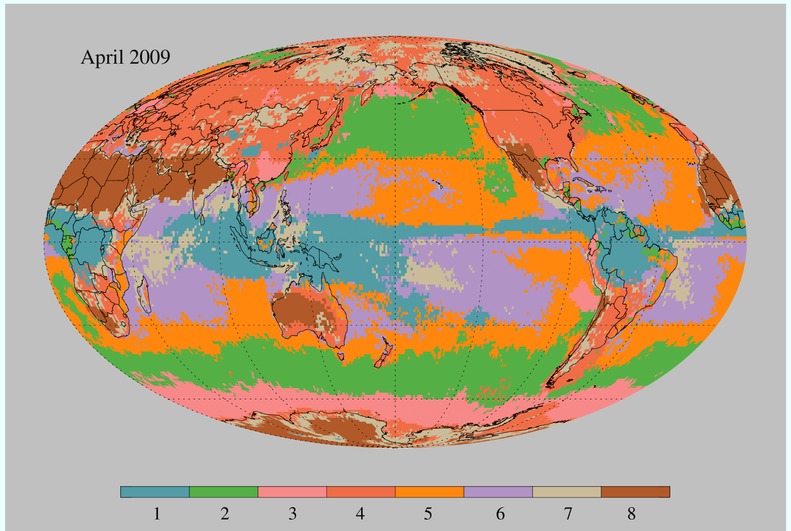
Keep in mind that the RORs represent seasonal (3-month) conditions.

Evaluation with CloudSat-CALIPSO



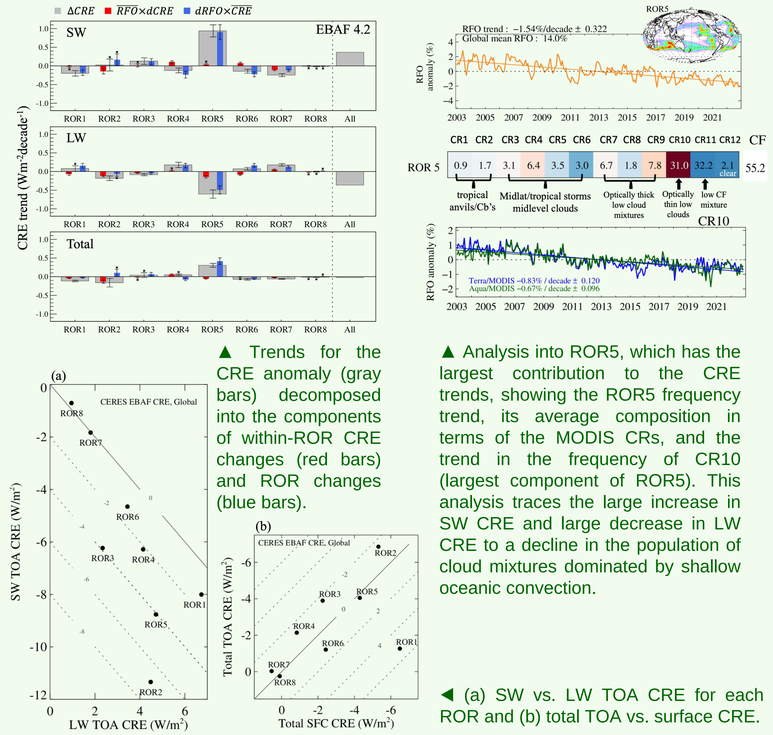
▲ Composite of 2B-CLDCLASS-LIDAR cloud types with each ROR.

◄ Cloud Vertical Structure based on composites with 2B-CLDCLASS-LIDAR cloud height with each ROR.



Regimes of regimes (RORs) are coherent classifications of the main modes of global cloudiness on the 1° seasonal scale and correspond to distinct environmental conditions.

ROR Application: Cloud Radiative Effect



▲ Trends for the CRE anomaly (gray bars) decomposed into the components of within-ROR CRE changes (red bars) and ROR changes (blue bars).

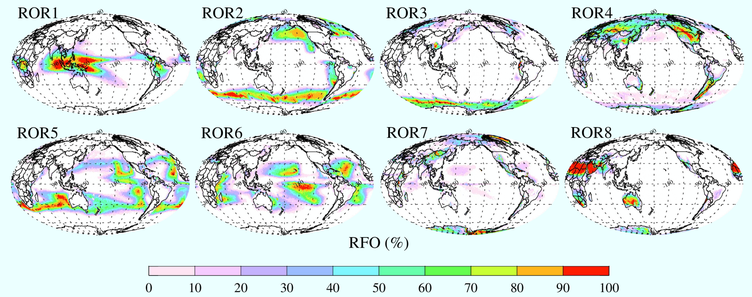
▲ Analysis into ROR5, which has the largest contribution to the CRE trends, showing the ROR5 frequency trend, its average composition in terms of the MODIS CRs, and the trend in the frequency of CR10 (largest component of ROR5). This analysis traces the large increase in SW CRE and large decrease in LW CRE to a decline in the population of cloud mixtures dominated by shallow oceanic convection.

◄ (a) SW vs. LW TOA CRE for each ROR and (b) total TOA vs. surface CRE.

ROR Centroids & Distributions

	CR1	CR2	CR3	CR4	CR5	CR6	CR7	CR8	CR9	CR10	CR11	Clear	CF	RFO
ROR 1	11.8	13.8	4.4	13.3	2.4	3.3	0.8	0.1	1.1	7.8	39.7	1.6	59.3	11.7
ROR 2	0.5	0.3	5.5	5.3	9.6	7.1	9.2	10.9	15.6	15.9	18.9	1.2	69.7	15.2
ROR 3	0.5	0.1	3.2	2.1	12.0	20.8	20.2	6.7	7.0	8.5	17.4	1.3	73.3	7.5
ROR 4	0.4	0.2	2.9	4.1	8.2	12.9	6.8	5.3	4.8	5.0	42.0	7.4	53.8	15.0
ROR 5	0.9	1.7	3.1	6.4	3.5	3.0	6.7	1.8	7.8	31.0	32.2	2.1	55.2	18.5
ROR 6	1.3	3.3	1.7	5.6	1.8	1.9	2.2	0.4	2.2	23.8	52.8	3.1	44.5	15.5
ROR 7	0.5	0.9	0.7	2.4	3.1	6.5	1.5	1.8	1.1	2.3	66.0	13.3	37.2	9.5
ROR 8	0.1	0.6	0.6	2.3	1.7	2.7	0.7	0.2	0.4	1.4	35.1	54.1	19.1	7.0

The *k*-means clustering gives the above average CR composition (in %) for each ROR, from which the mean cloud fraction (CF) and the relative frequency of occurrence (RFO) of the RORs globally can be calculated. The RORs have distinct compositions of cloud mixtures as represented by the CRs. Their global distributions show the distinct geographical preferences of the RORs, most prominently by land/ocean and latitude.



Summary & Future Work

Regimes of Regimes (ROR) are a seasonal classification of global cloudiness and thus atmospheric conditions at the 1° seasonal scale. Distinct and coherent, they are climatological essence of the MODIS CRs. Their cloud profiles are characterized using coincident active observations and an example application in analyzing CREs is provided.

Future work will focus on applying these RORs in an Earth System Model and examining its utility in understanding the global water and energy cycle.

References

MODIS Cloud Regimes: 10.5067/MEASURES/MODISCR/EQANGD/DATA301
Regime of Regimes: 10.5281/zenodo.11099765
Cho, N., J. Tan, and L. Oreopoulos, 2021: Classifying planetary cloudiness with an updated set of MODIS Cloud Regimes. *J. Appl. Meteorol. Climatol.*, **60**, 981–997, doi:10.1175/JAMC-D-20-0247.1.

Acknowledgments

This work is supported by the NASA's CloudSat-CALIPSO Science Team and the MEaSUREs program.

View my Poster

Contact
Jackson Tan
jackson.tan@nasa.gov