Implementation and Evaluation of MG microphysics in FV3GFS

Cheng[1] A., S. Moorthi[1], Y. Hou[1], A. Gettelman[2], H. Morrison[2], F. Yang[1], J. Wang[1], R. Sun[1], D. Barahona[3], S. Lu[4], S.-P., Chen[4], J. Kain[1], and V. Tallapragada[1]

1. IMSG&EMC/NCEP, 2. NCAR, 3. GMAO/NASA, 4. Ualbany

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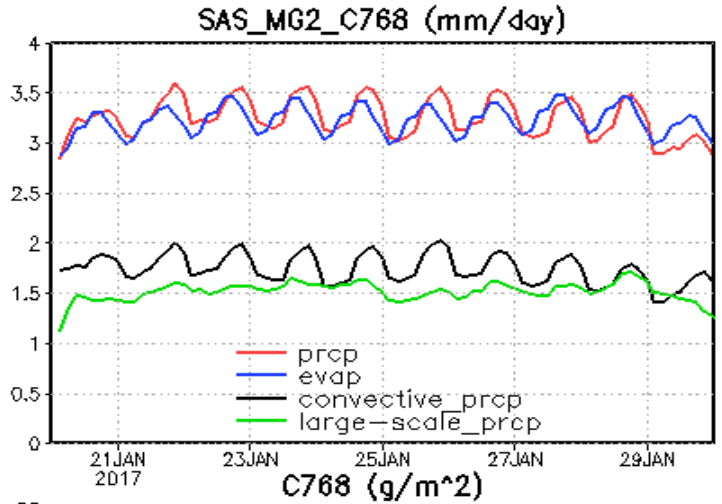
Outline

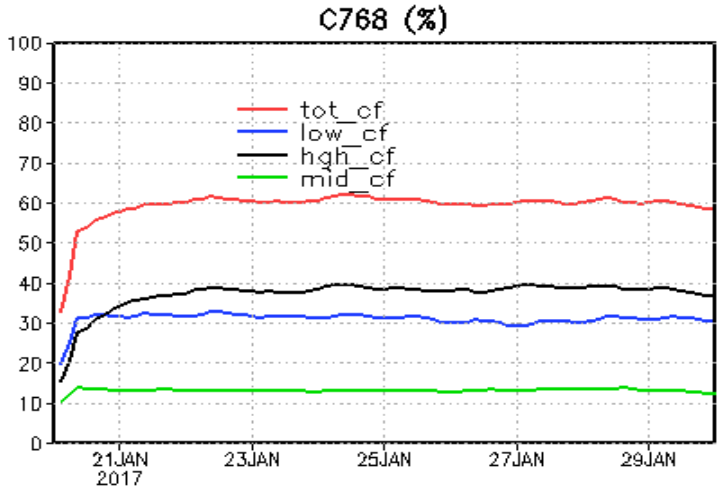
- A brief description and comparison of state-of-the-art Morrison-Gettleman (MG) double moment, Zhao-Carr (operational), and GFDL one moment microphysics.
- FV3GFS C768L65 5day forecast run starting from 2016/01/01 to 2017/03/01 from MG2 and Zhao-Carr, with winter and summer only results from GFDL microphysics.
- Time series, cross section, some 2D plots on OLR, PWAT, and cloud fractions etc. from a case study.
- Extensive comparison of ACC and precipitation score.

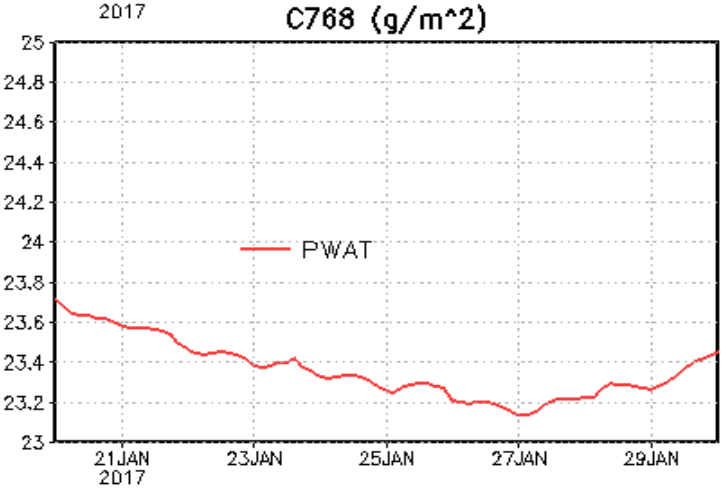
Microphysics Scheme Comparison

	MG1 (JUL 2015)	MG2 (OCT 2017)	MG3 (FEB 2018)	Zhao-Carr (operational)	GFDL (pre-operational)
prognositic variables	qv, ql, qi, nl, ni (5 in total)	qv, ql, qi, qs, qr, nl, ni, ns, nr (9 in total)	qv, ql, qi, qs, qr, qg, nl, ni, ns, nr, ng (11 in total)	qv, qc (2 in totdal)	qv, ql, qi, qs, qr, qg (6 in total)
Condensation and evaporation	Gaussian pdf and partial cloudness	Gaussian pdf and RHC controlled evaporation	Gaussian pdf and RHC controlled evaporation	Delta pdf and partial cloudness	Delta pdf and partial cloudness
Cloud fraction in radiation	Consistent treatment as above			Xu and Randall (1996)	GFDL cloud fraction
mixed-phase clouds	Yes	Yes	Yes	No	Yes
precipitation sedimentation	5 tracers	9 tracers	11 tracers	1 tracers	6 tracers
Subgrid microphysics	No	Yes	Yes	No	No
Options for subcolumns	No	Yes	Yes	No	No
Precipitation fraction	In_cloud	Incloud and max_overlap	Incloud and max_overlap	No	No
Coupling with aerosol	Prescribed IN/CNN, MERRA2 climatology aerosol, GOCART, MAM7			Constant aerosol (implicitly)	Constant aerosol for ocean and land

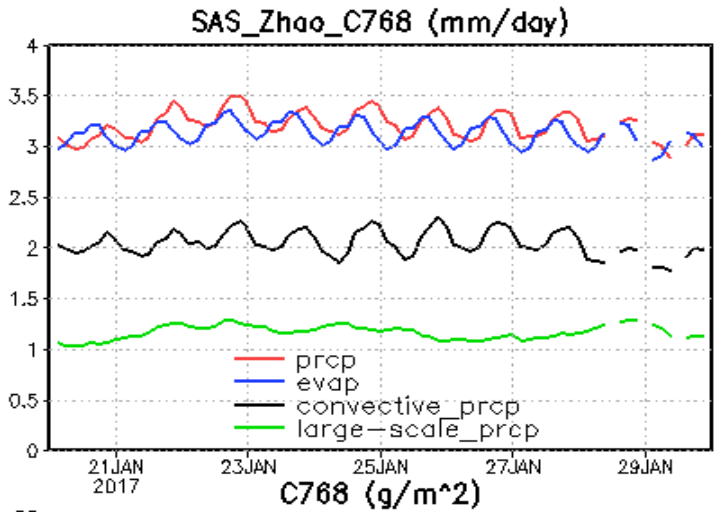
Time Series MG2 (2017/01/20)

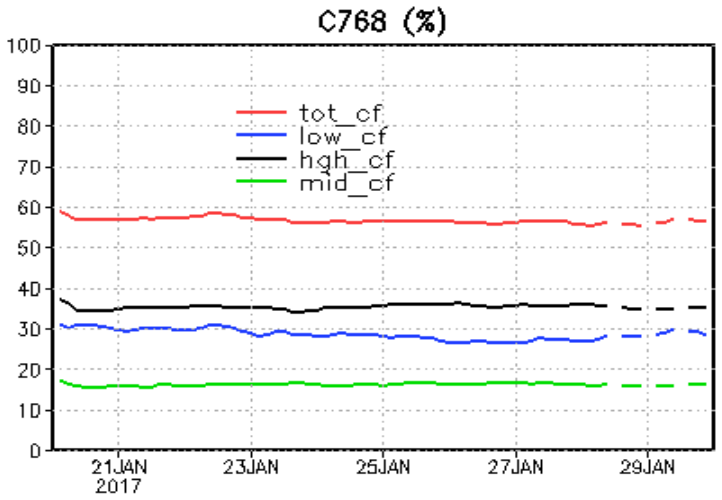


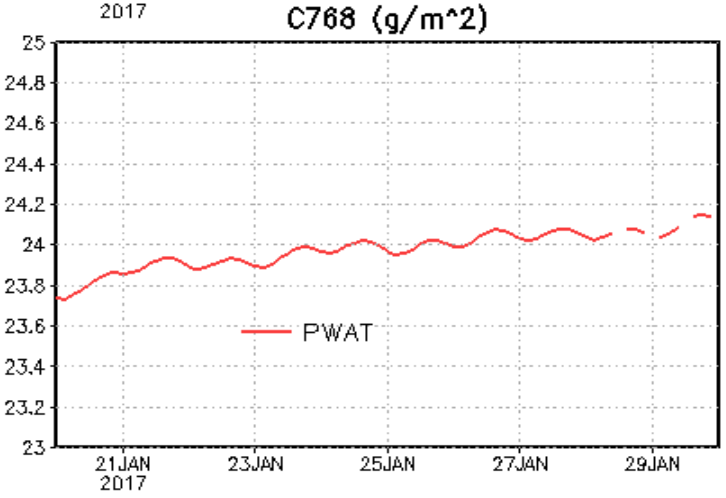




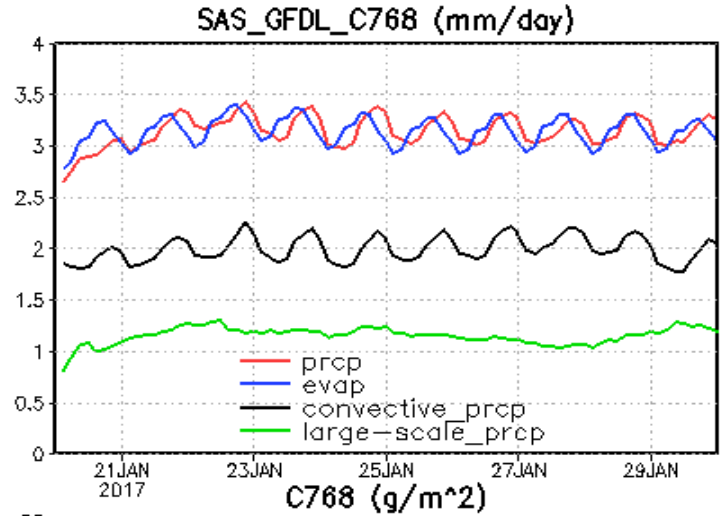
Time Series Zhao-Carr (2017/01/20)

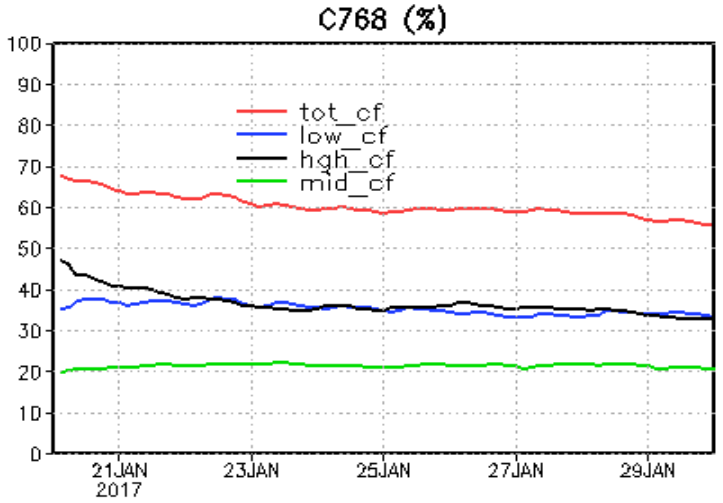


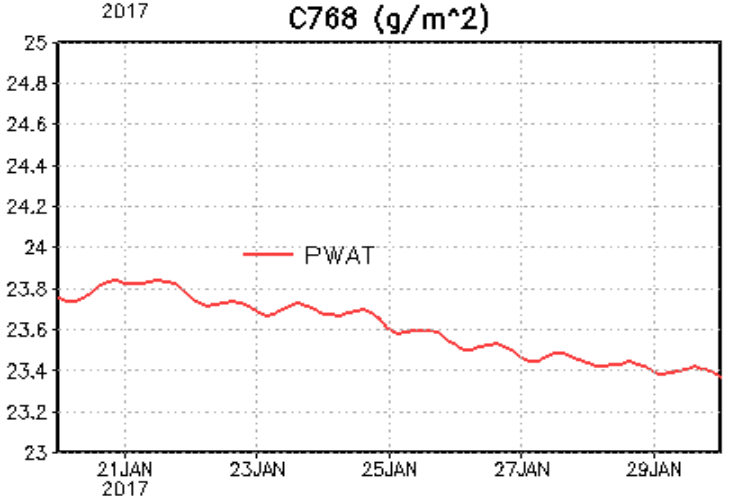




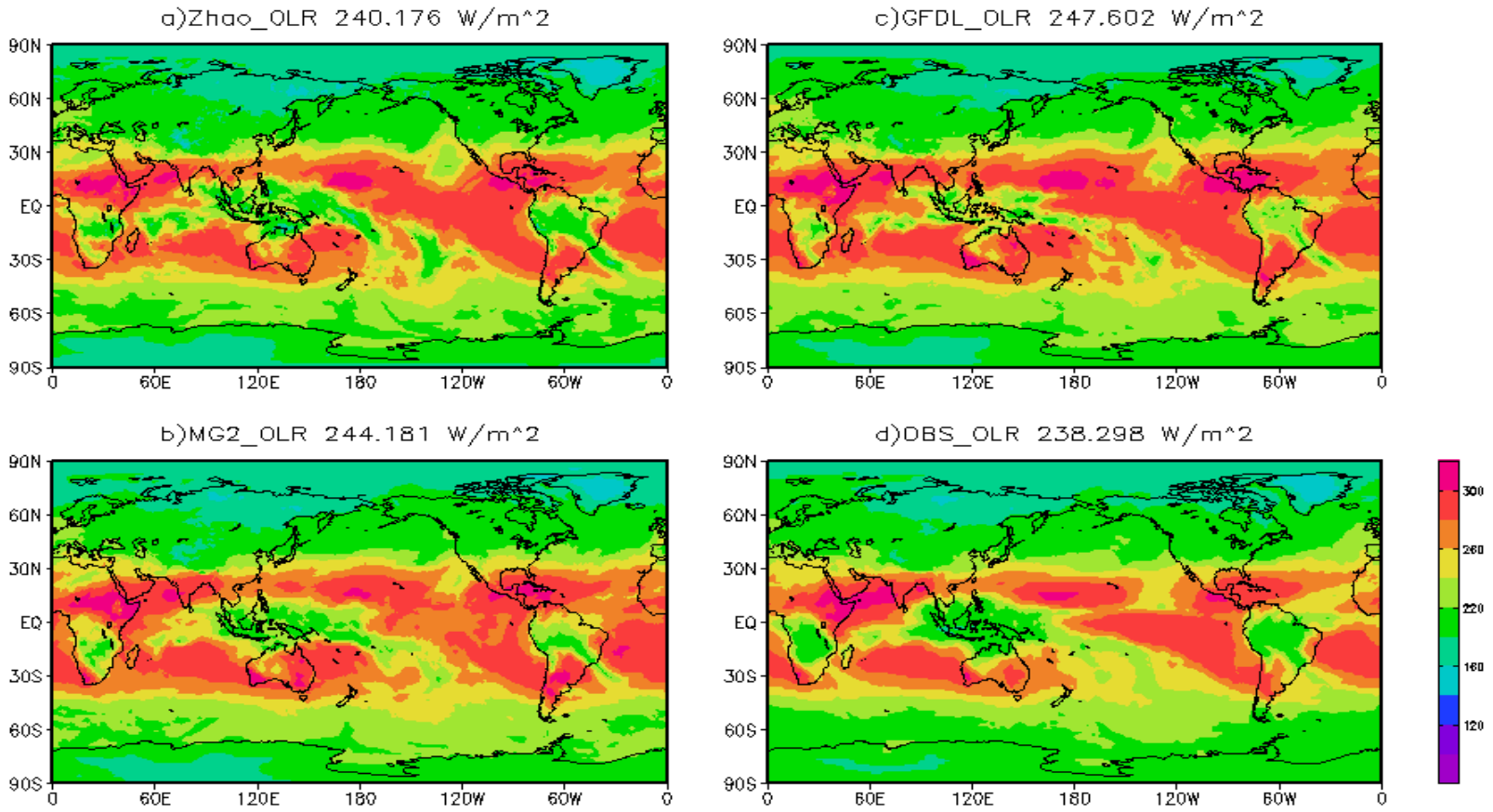
Time Series GFDL (2017/01/20)







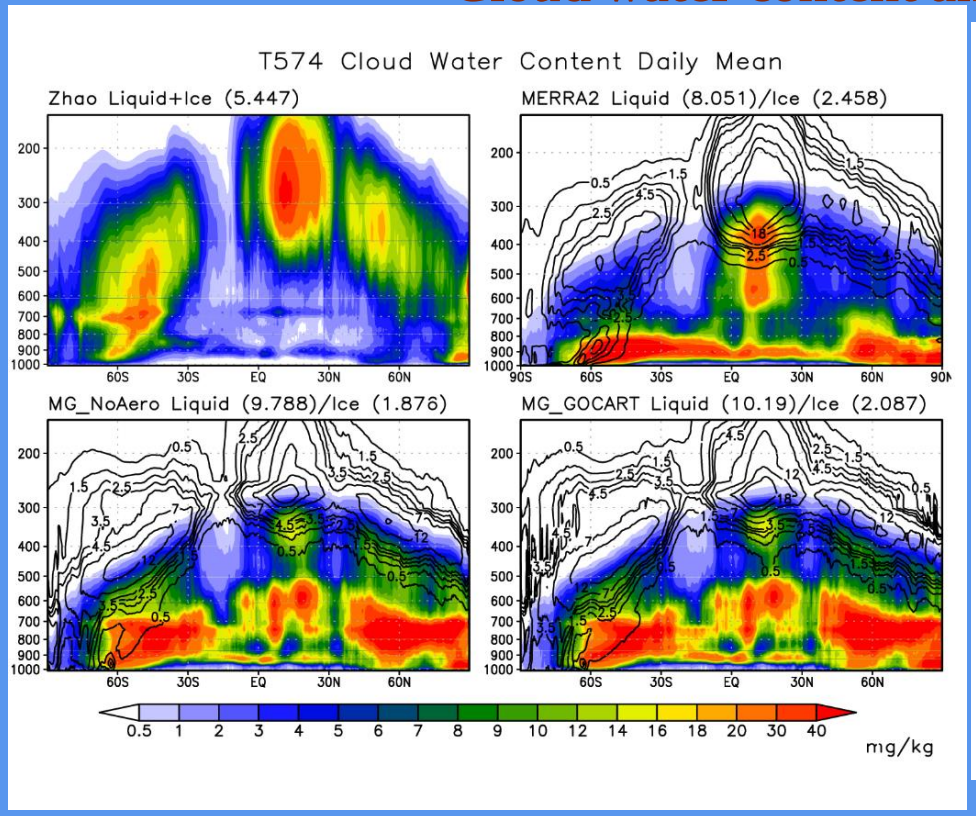
OLR 10 day forecast mean (2017/01/20)

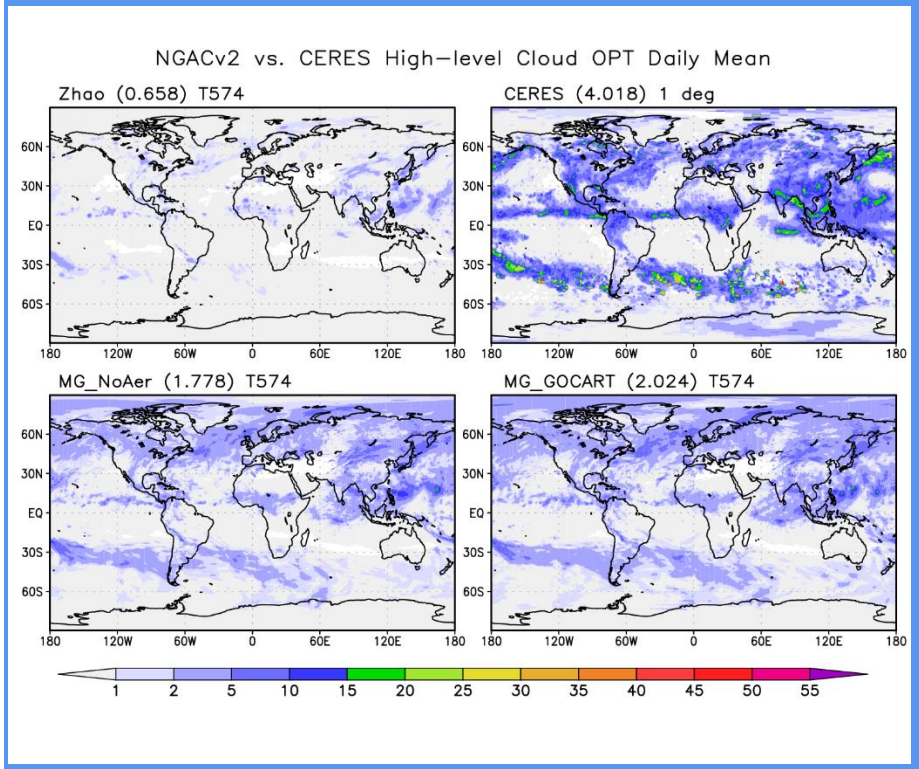


Aerosol awareness of MG (MG1-GOCART results)

Zhao vs MG1 without aerosol feedback vs MG with aerosol feedback
Verified against reanalysis (MERRA2) and satellite products (CERES)

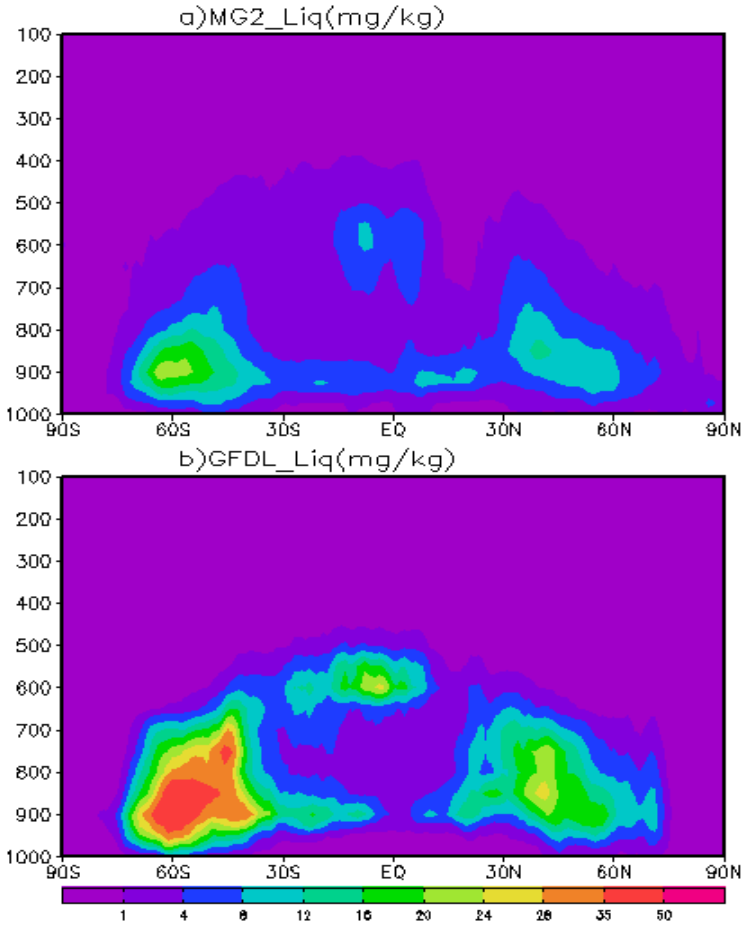
Cloud water content and cloud optical depth



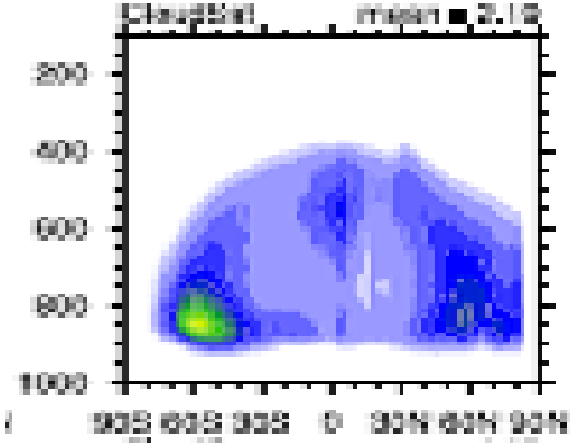


Lesson learned: Need a diagnosis tool (satellite simulator) that mimics the observational process by converting model variables into pseudo-satellite observations

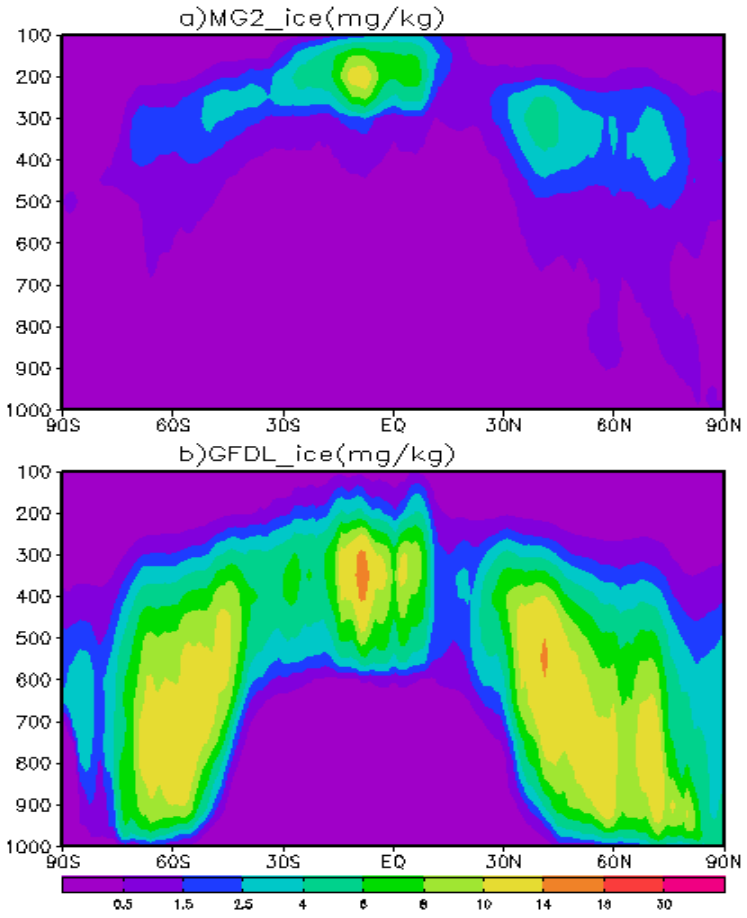
Liquid 10 day forecast mean (2017/01/20)



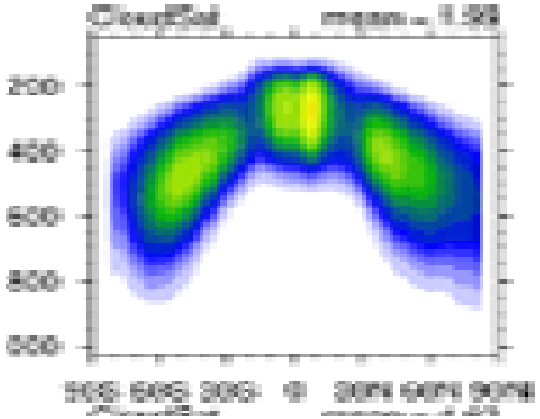
CloudSat OBS



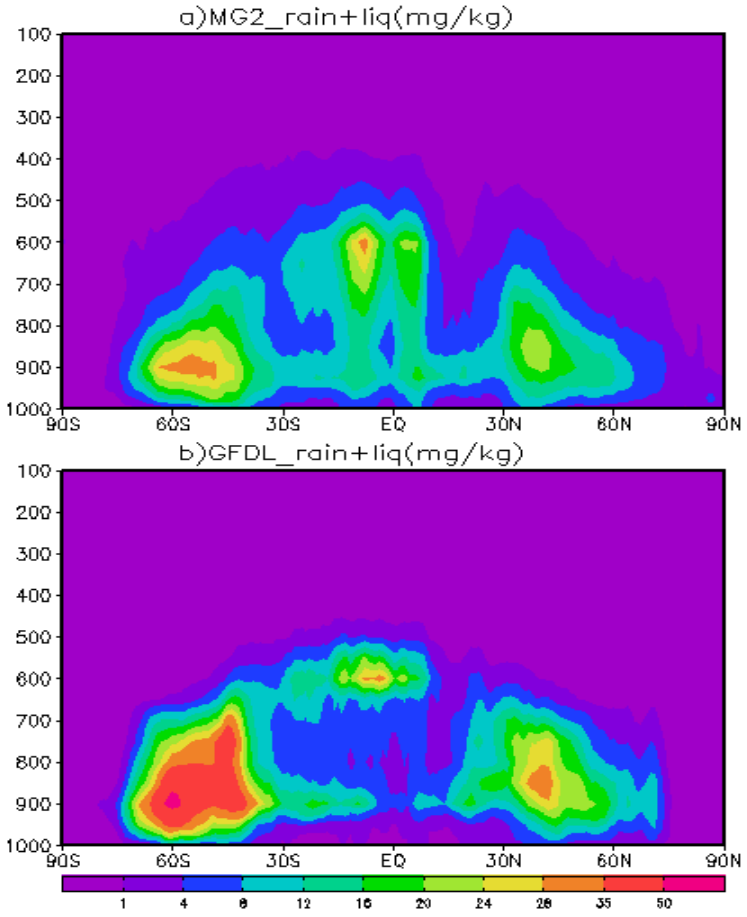
Ice 10 day forecast mean (2017/01/20)



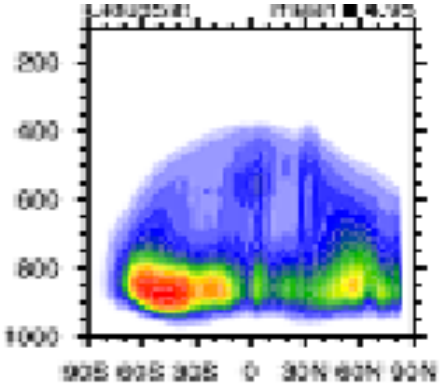
CloudSat OBS



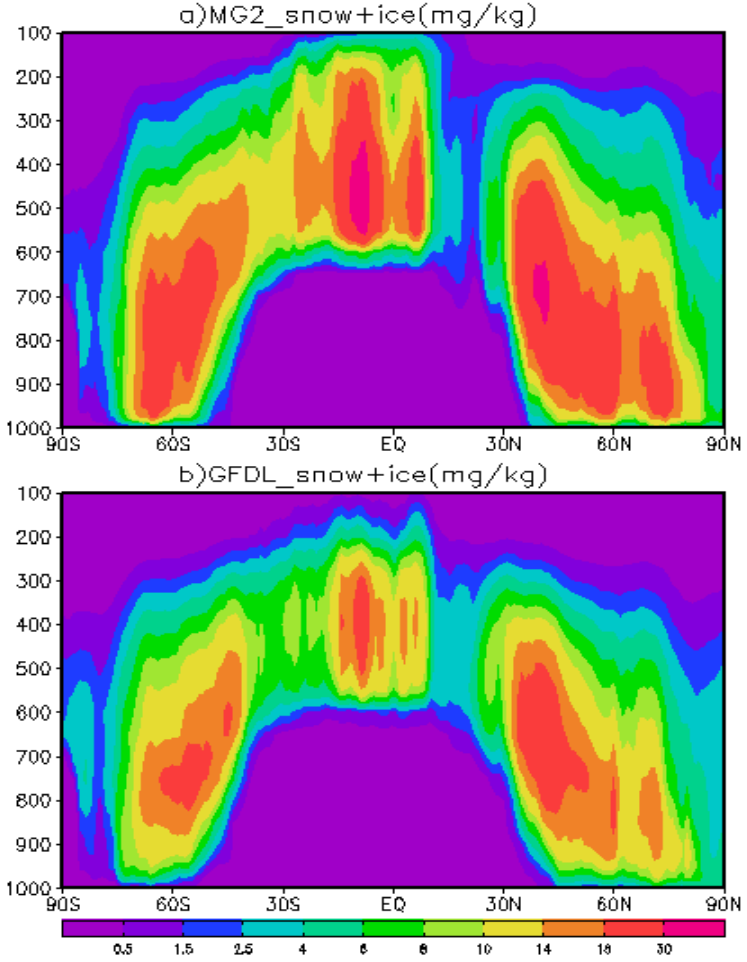
Rain+Liq 10 day forecast mean (2017/01/20)



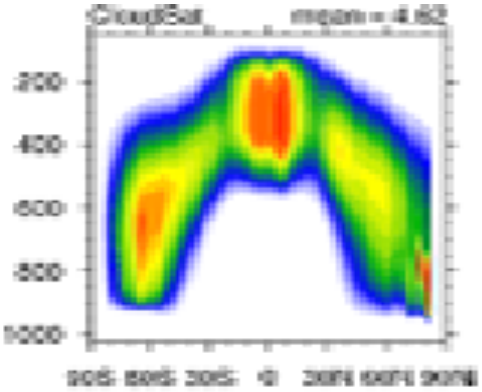
CloudSat OBS



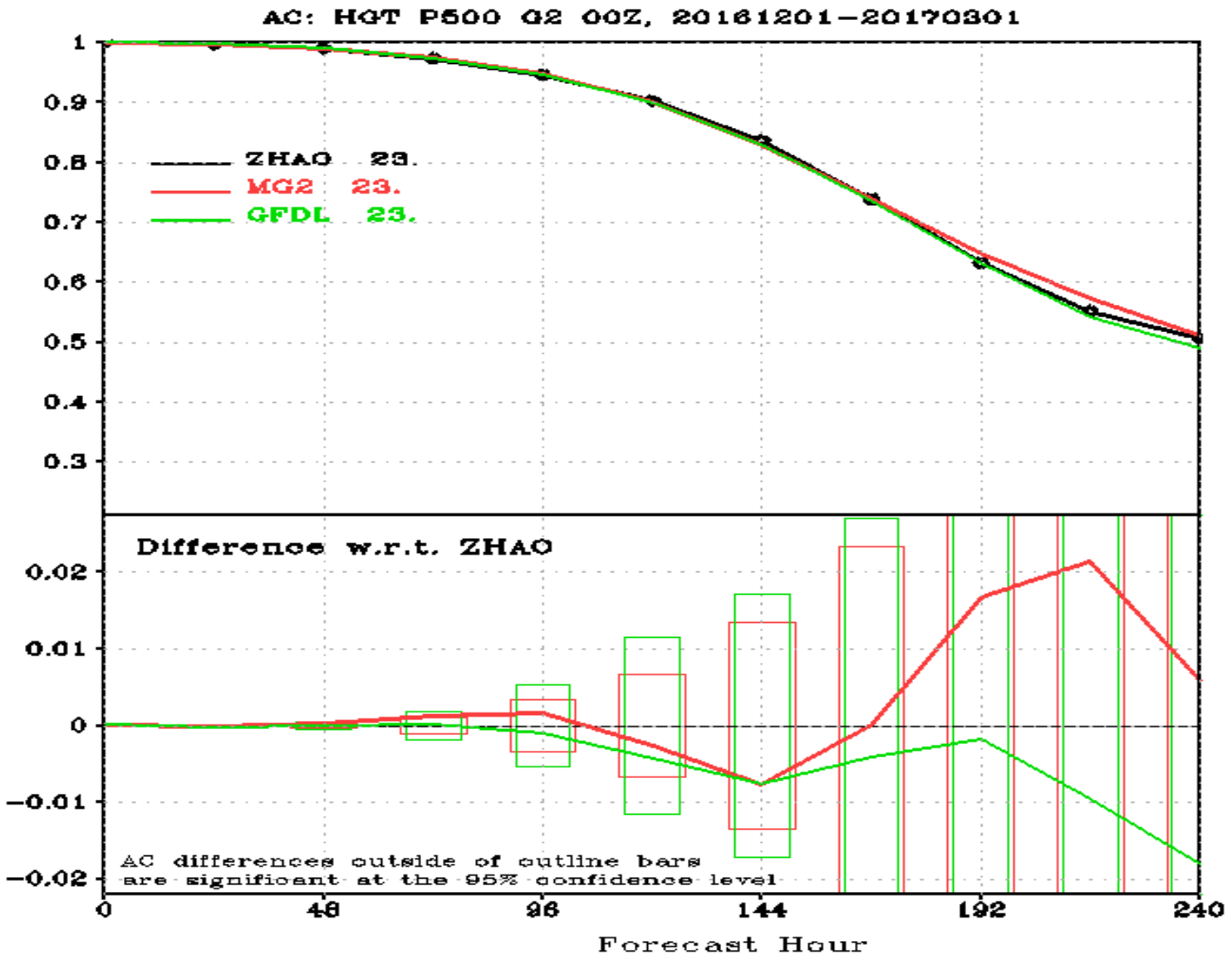
Snow+ice 10 day forecast mean (2017/01/20)



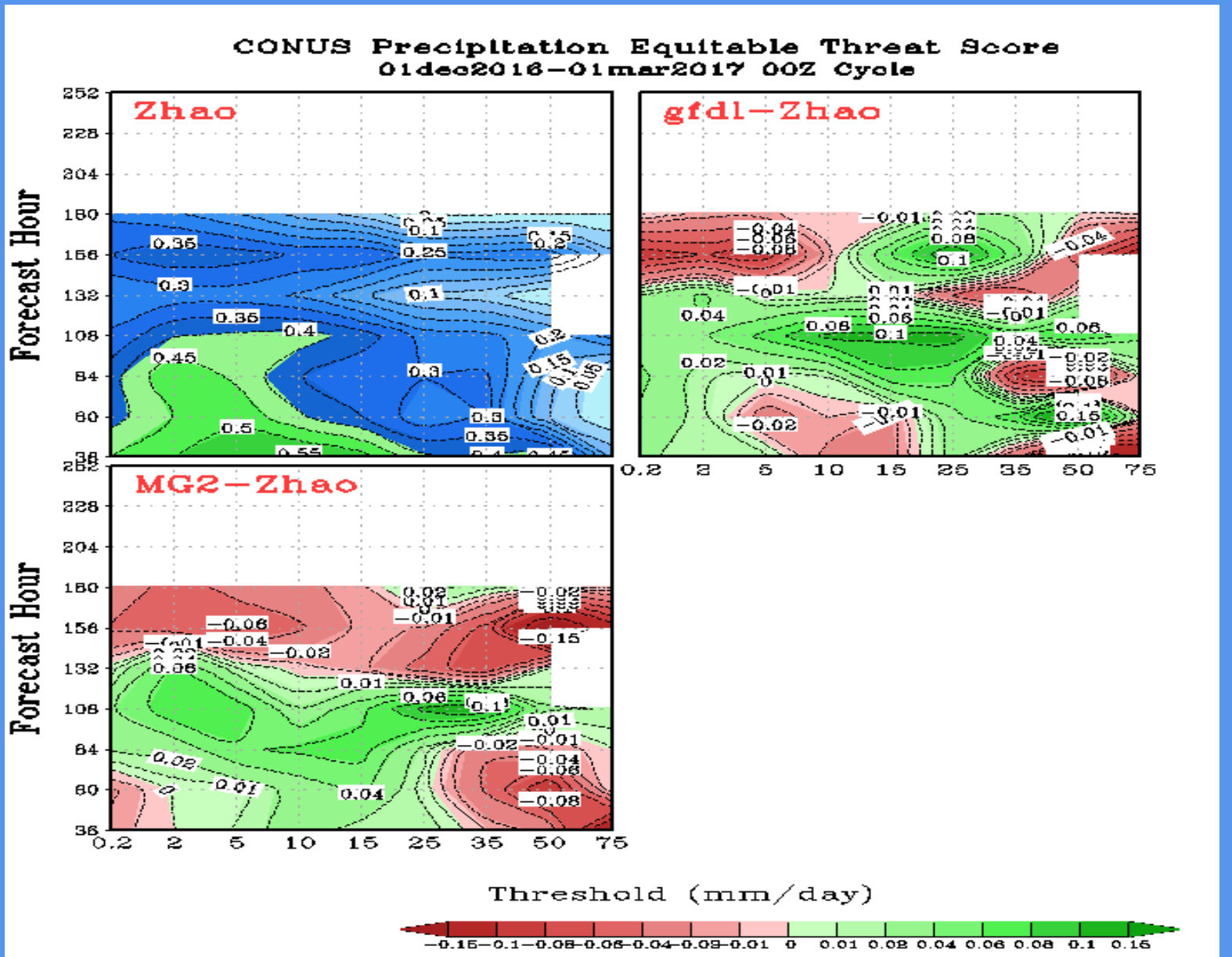
CloudSat OBS



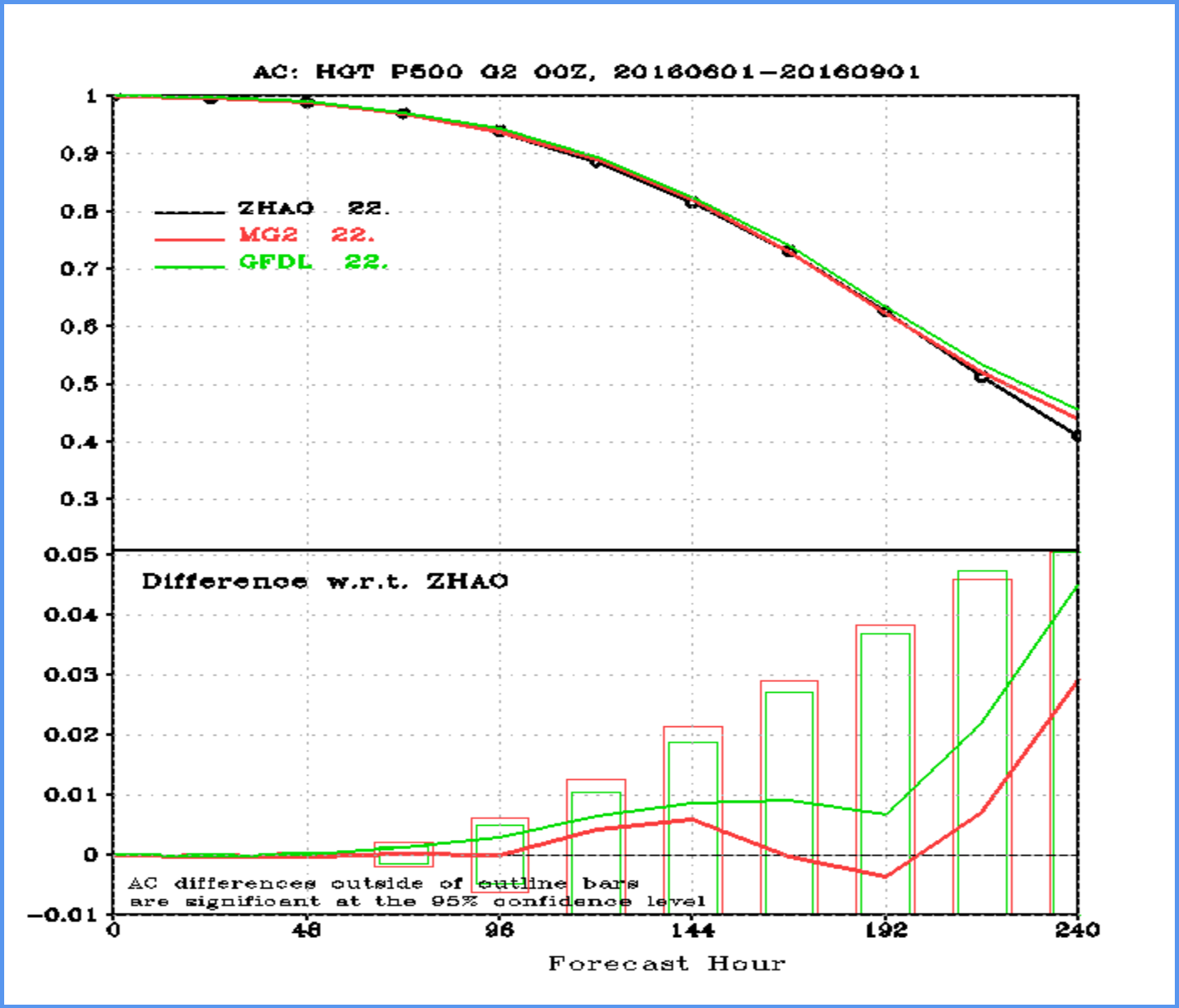
Winter ACC


AC: HGT P500 G2 00Z, 20161201-20170301
ZHAO 23.
MG2 23.
GFDL 23.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
Difference w.r.t. ZHAO
0.02
0.01
0
-0.01
-0.02
AC differences outside of outline bars
are significant at the 95% confidence level
0
48
96
144
192
240
Forecast Hour

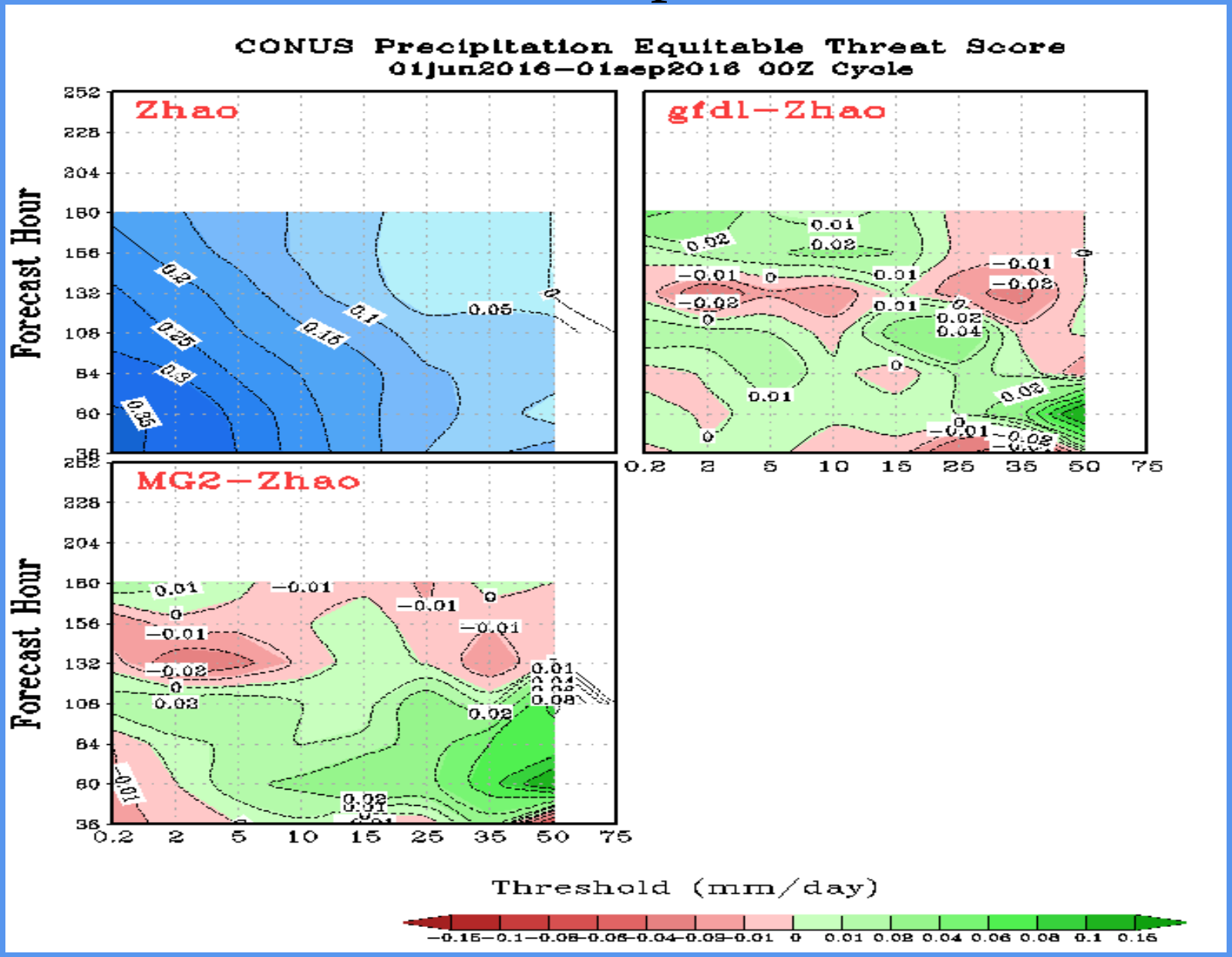
Winter Precipitation Score



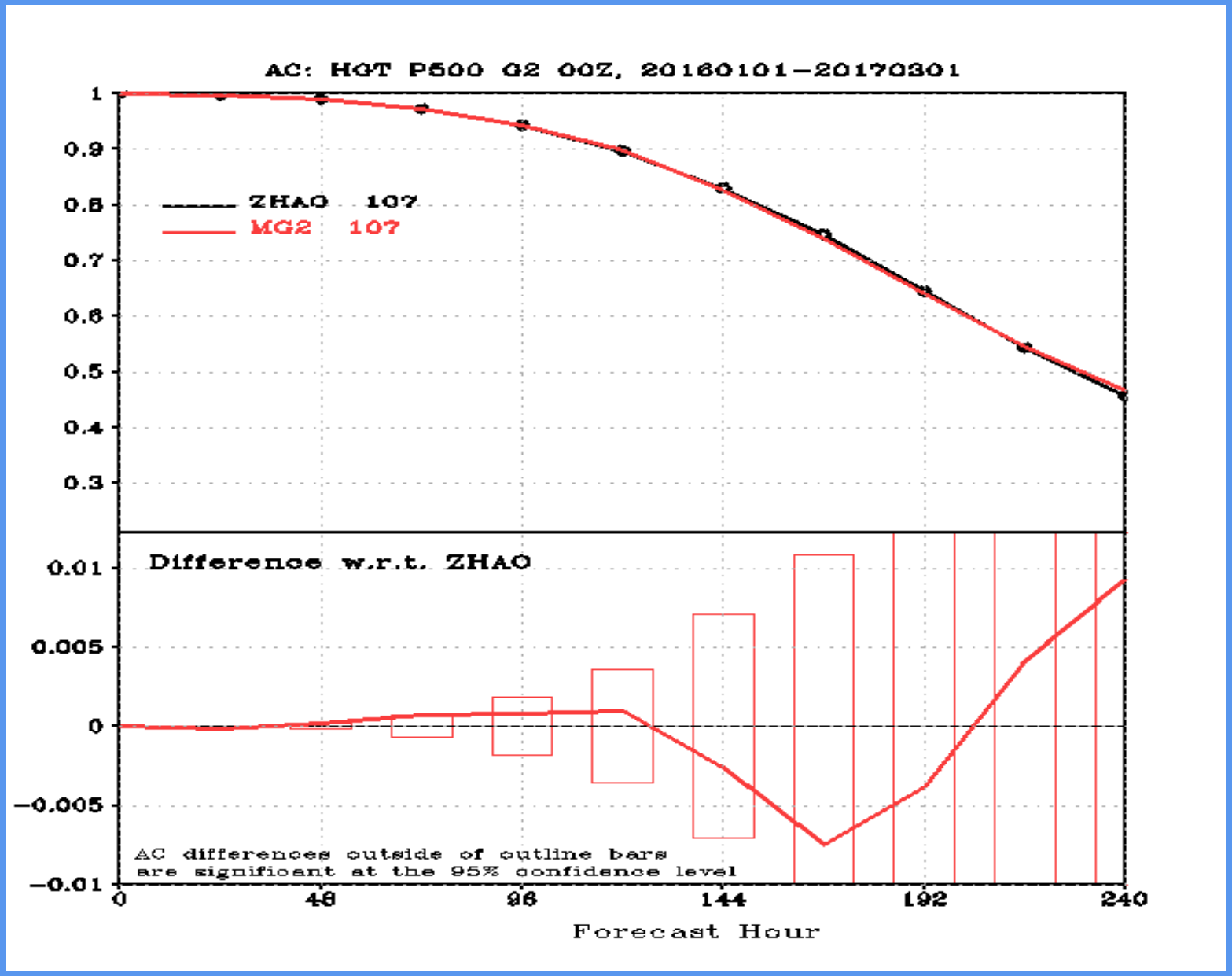
Summer ACC


AC: HGT P500 G2 00Z, 20160601-20160901
ZHAO 22.
MG2 22.
GFDL 22.
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.05
0.04
0.03
0.02
0.01
0
-0.01
Difference w.r.t. ZHAO
AC differences outside of outline bars
are significant at the 95% confidence level
0
48
96
144
192
240
Forecast Hour

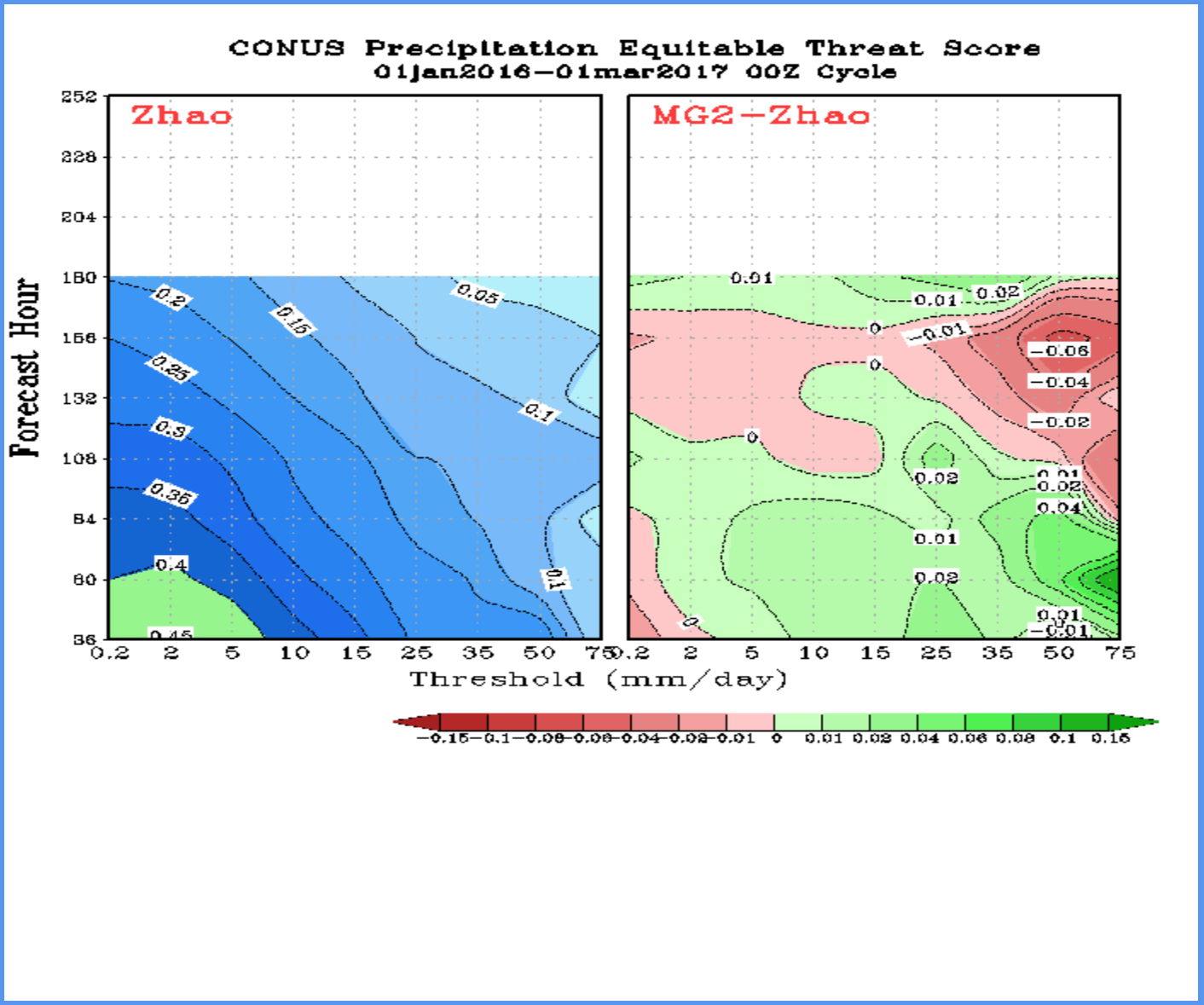
Summer Precipitation Score



14-Month ACC


AC: HGT P500 G2 00Z, 20160101-20170301
ZHAO 107
MG2 107
Difference w.r.t. ZHAO
AC differences outside of outline bars
are significant at the 95% confidence level
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.01
0.005
0
-0.005
-0.01
0
48
96
144
192
240
Forecast Hour

14-Month Precipitation Score



Conclusions and Discussions

- MG2 has better ACC score than Zhao globally for the first five days and the last two days from the 14 month forecast test. The first three day forecast passes the 95% significant confidential test. MG is a promising scheme given the short time on implementation and almost no tuning.
- MG2 have the best ACC score in winter globally, while GFDL has the best in summer.
- The CONUS precipitation score is consistent with ACC. MG2 has better score for the first five days and the last two days. The precipitation score of GFDL is close to MG2.
- GFDL keep more ice and liquid, but less snow and rain than MG2 . The cloud fraction and high level ice cannot explain the unrealistic large OLR from GFDL. More analysis on optical depth and emissivity is needed.

Future work

- Test and evaluate MG3 and parameter tuning.
- Test and evaluate different combination with MG3 and choose one with the best score, such as CS-AW-MG3-SHOC, CS-AW-MG3-EDMF, SAS-MG3-SHOC, SAS-MG3-EDMF, RAS-MG3-EDMF, and RAS-MG3-SHOC.