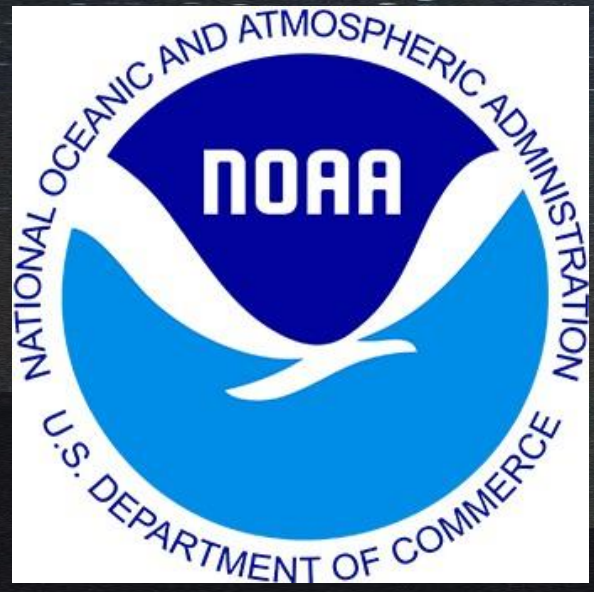


The All-sky Radiance Assimilation of GMI GPM in the NCEP Global Forecast System



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ABSTRACT The Global Precipitation Measurement (GPM) microwave imager (GMI) in all-sky conditions is assimilated into the National Centers for Environmental Prediction (NCEP) Forecast System (GFS) to enhance precipitation representation. In the current GFS operational system, the microwave sounders such as the Advanced Technology Microwave Sounder (ATMS) and the Advanced Microwave Sounding Unit-A (AMSU-A) are assimilated under all-sky conditions. However, all-sky microwave imager observations which bring unique information on water vapor, clouds, and precipitation, particularly in the lower most troposphere, GMI is expected to be the first microwave imager assimilated operationally in GFS. GMI's unique scan configurations pose challenges, with one scan containing two swaths with different geolocations: one from the high-frequency (HF) sensors and the other from the low-frequency (LF) ones. For consistency, the co-registered level-1C data which collocates the HF field-of-view (FOV) to bring them as close to the corresponding LF FOV position as possible are used for assimilation. In addition, spatial averaging of GMI footprints is also applied to obtain a common field of view and to reduce noise. In this presentation, the methods of assimilating GMI including data pre-processing, channel selection, quality control, observation error assignment, and bias correction strategy will be described and discussed in detail. The impact of GMI to forecast and analysis is discussed.

Conclusions:

- The precipitation forecasts in the model are reasonable after GMI assimilation.
- The scorecards show the impacts of GMI assimilation are neutral.
- EXP2 is better outside tropics compare both to the control run and EXP1.

In summary, NCEP global forecast system with GMI assimilation is ready for use in various applications.

Model Setup

State and Control variable

- All five hydrometeors from forecast model are included in CRTM to calculation simulated observation and sensitivity to model state variables (Jacobians) over the ocean
- All five hydrometeors are analysis (control and state) variables

Background Error Covariance

- Ensemble-based flow-dependent background error covariables are extended to include all five hydrometeors
- The static B is defined 5% of the background value with reduced correlation lengths
- Weight given to static and ensemble contribution is 1:7

Two Experiments (Channel Selection)

- EXP1: Following the selections from GMAO this experiment includes: channels 5 (24GHz), 6-7 (37V/H for cloud content), 10 (116 GHz), 12-13 (183 V GHz), sounding at different vertical levels.
- EXP2: This experiment includes all channels.

Channel Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Frequency	10V	10H	19V	19H	24V	37V	37H	89V	89H	166V	166H	183V	183H
GMAO	x	x	x	x				x	x			x	
ECMWF	x	x					x			x	x	x	

Channels Assimilated

Observations

- High-frequency (HF) and low-frequency (LF) channels look at different location, Largely overlapped between scans (noisy), The footprint size varies with channels
- Spatial averaging (super-obbing) to a common field-of-view size is required (Gaussian averaging) for consistency and noise reduction
- Superobbing results the superobbing radius increase when the std decrease consistently

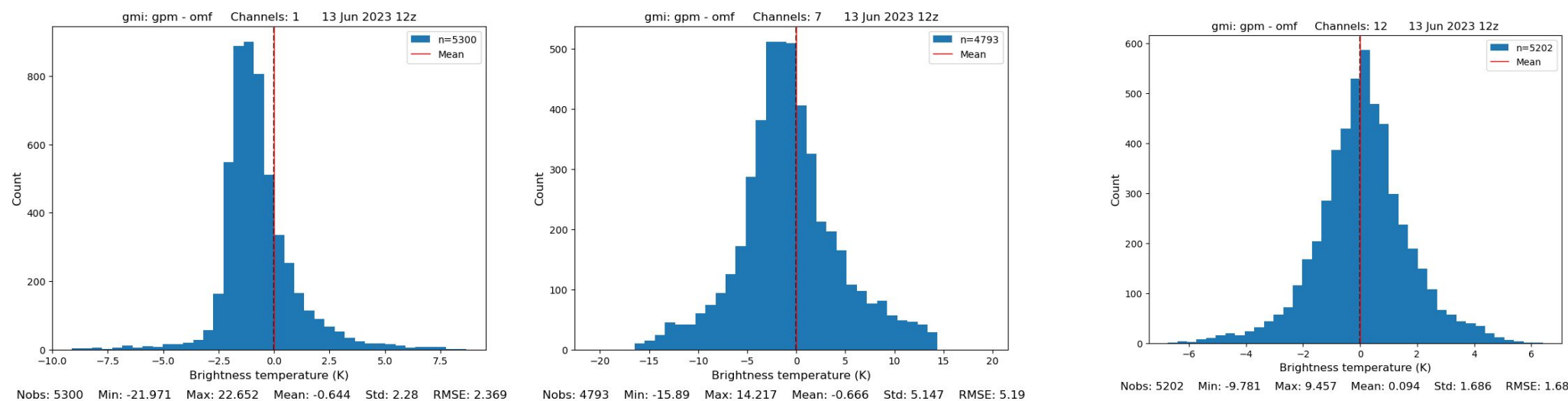
std	1	2	3	4	5	6	7	8	9	10	11	12	13
no	3.49	5.72	5.15	9.17	4.04	6.16	12.4	5.66	11.0	7.57	9.11	3.42	5.61
20	3.24	5.35	4.69	8.37	3.69	5.58	11.3	5.10	9.80	6.80	8.20	3.05	5.01
30	3.14	5.16	4.47	7.98	3.52	5.32	10.8	4.86	9.36	6.43	7.77	2.85	4.71
40	3.07	5.03	4.32	7.7	3.42	5.14	10.4	4.70	9.09	6.19	7.48	2.72	4.50

Bias correction

- Only samples with consistent cloud information from background and observation are used in updating VarBC coefficients
- At observation location, both background and observation indicate clear or cloudy
- When both cloudy, the difference in cloud amount must be less than 0.005 kg/m²

CRTM - version 2.4.0

- **Cloud optical table** - constructed based on the model cloud microphysical parameters.
 - **Effective radius** - calculated at each FOV based on collocated model background and microphysical parameters
 - **Fractional cloud coverage** in cloudy simulation, cloud faction profile at each FOV is calculated using the same diagnostics from the forecast model
- All these results in a better OmF results in the model (see below)



Observation Error Estimation

- Initial observation Error is characterized as a function of averaged cloud amount retrieved from observation and background to ensure Gaussianity. Some examples are shown below.

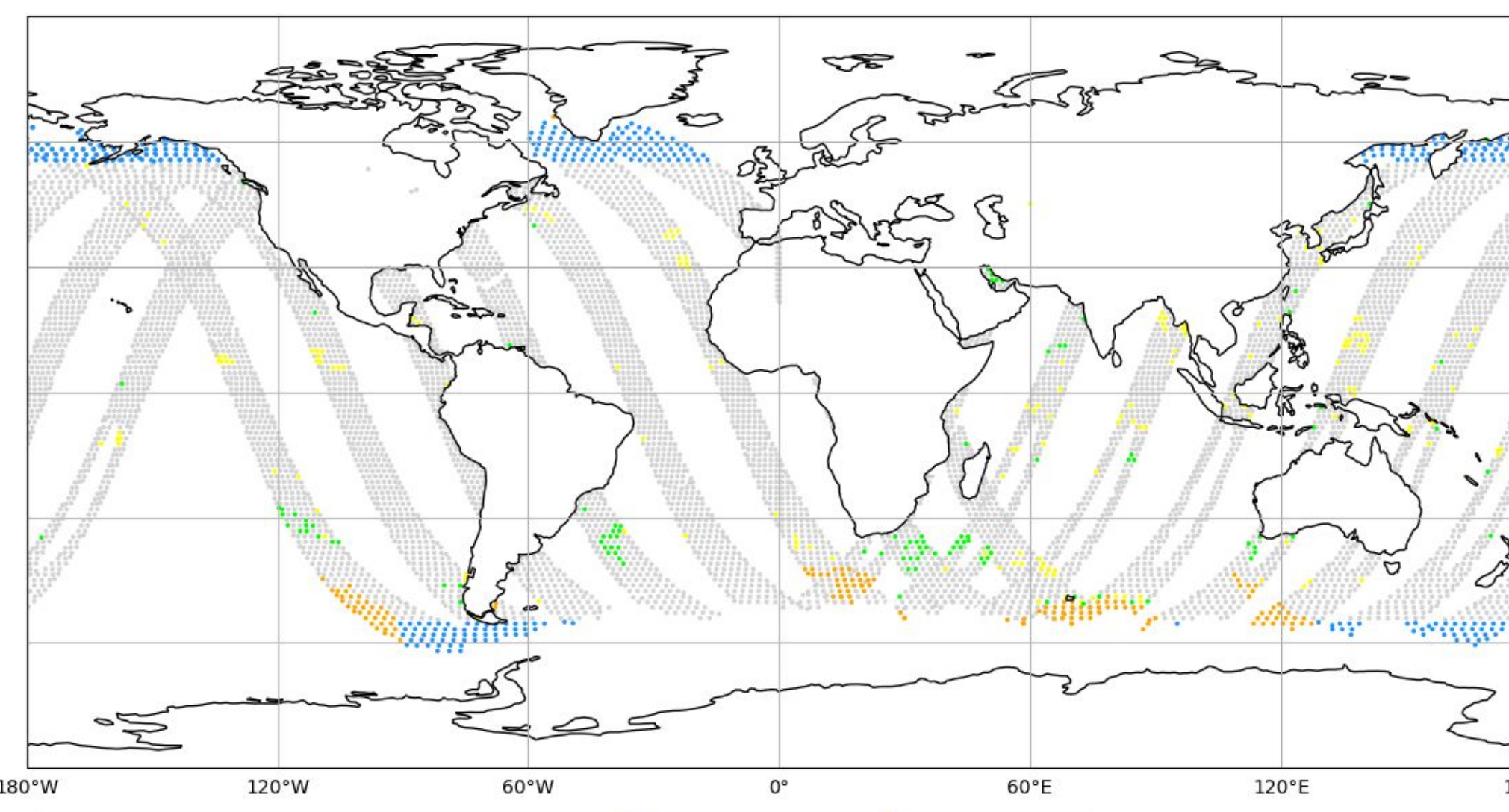
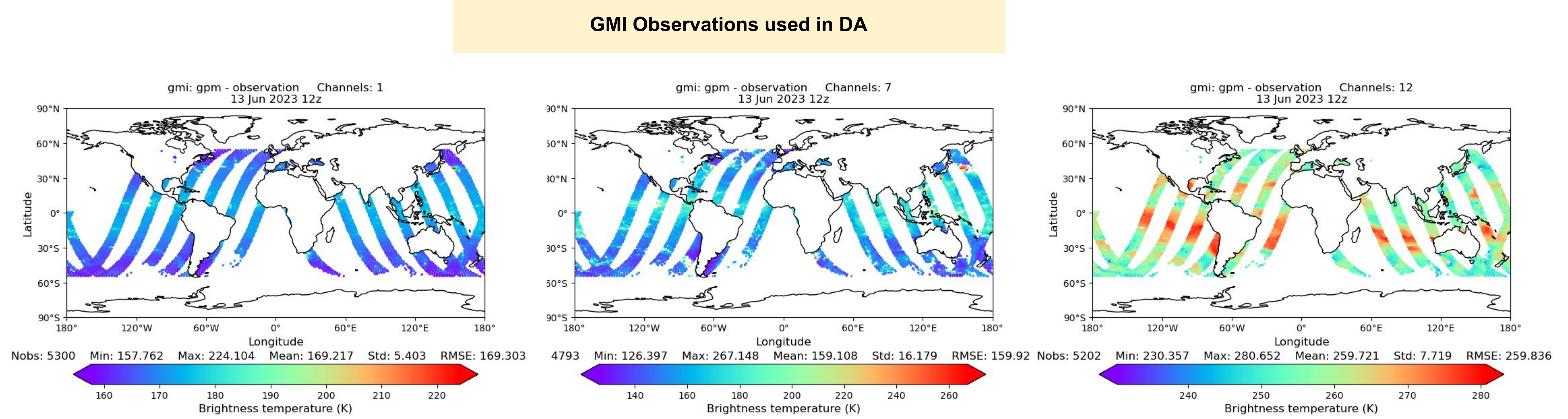
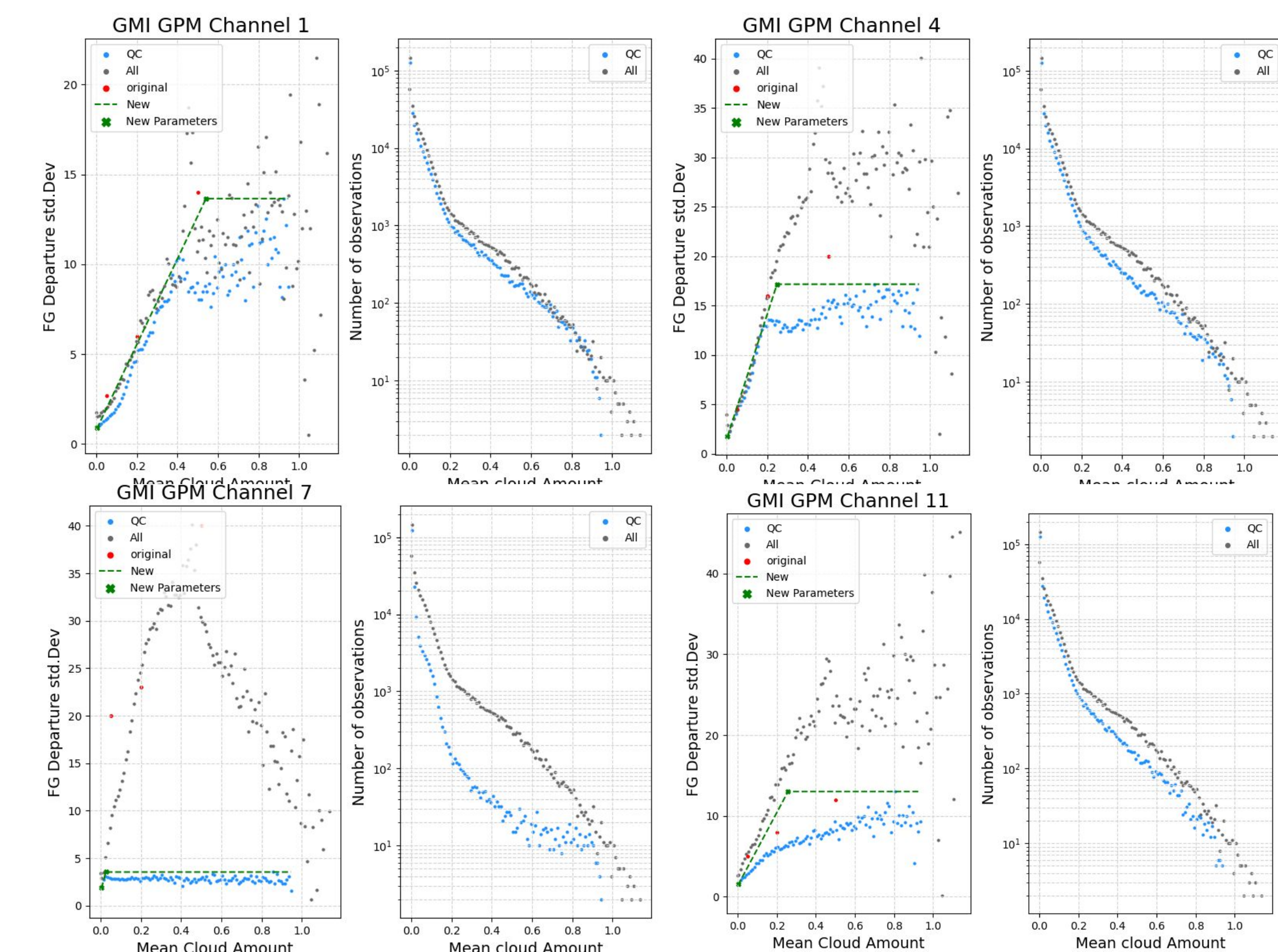
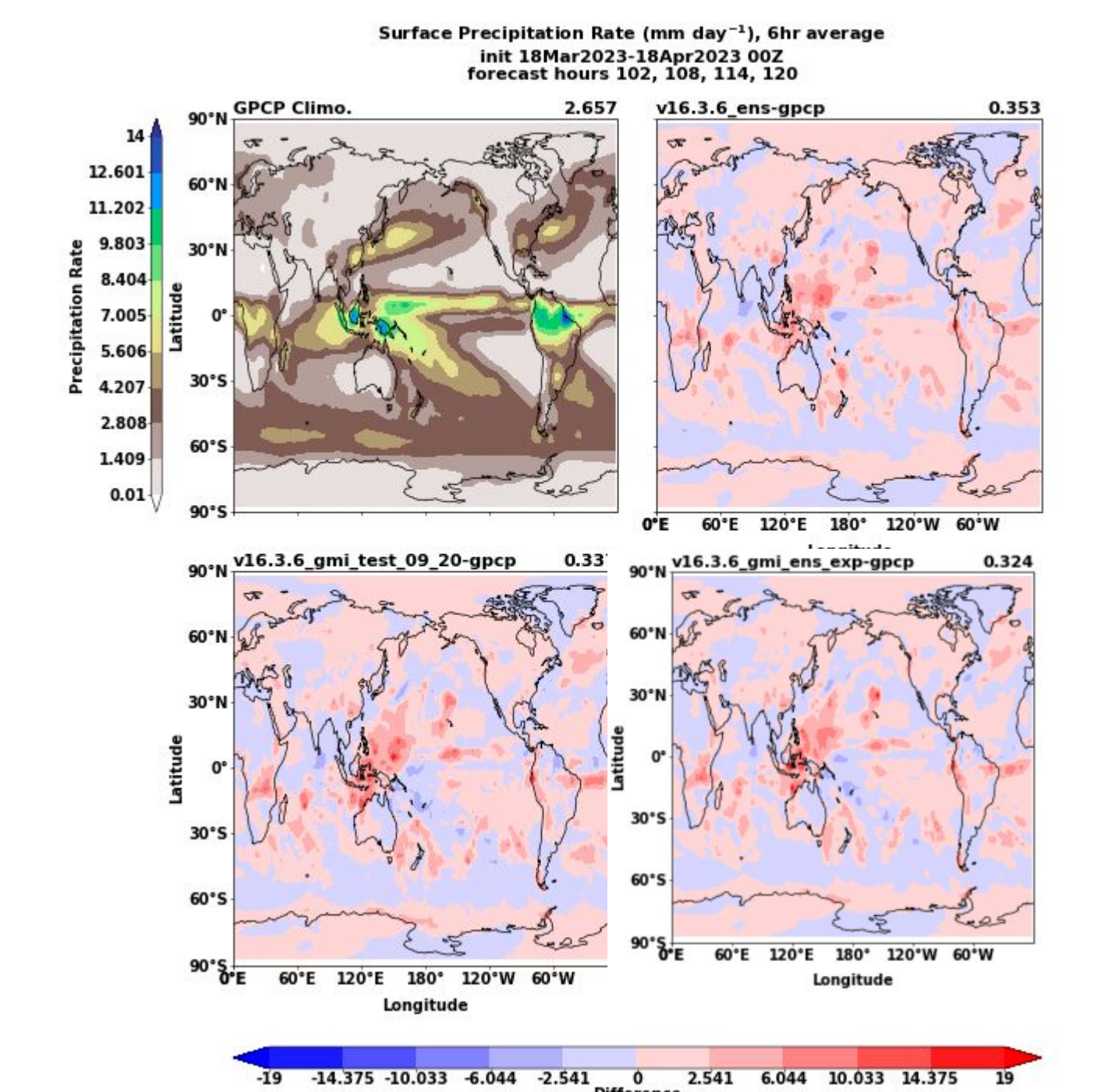


Figure: QC flag for experiment of EXP2, channel 4

NOTES:

- Control Run: v16.3.6_ens
- EXP1: v16.3.6_gmi_ens_exp
- EXP2: v16.3.6_gmi_test_09_20

Precipitation Forecast



Scorecard

		N. America				N. Hemisphere				S. Hemisphere				Tropics			
		Day		Night		Day		Night		Day		Night		Day		Night	
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Anomaly Correlation Coefficient	Heights																
	250hPa																
	500hPa																
	700hPa																
	1000hPa																
	Vector Wind																
RMSE	Heights																
	250hPa																
	500hPa																
	700hPa																
	1000hPa																
	Temp																
Bias	Heights																
	250hPa																
	500hPa																
	700hPa																
	1000hPa																
	Temp																

Scorecard Symbol Legend

▲ v16.3.6_gmi_test_09_20 is better than v16.3.6_ens at the 99% significance level	▼ v16.3.6_gmi_test_09_20 is worse than v16.3.6_ens at the 99% significance level
▲ v16.3.6_gmi_ens_exp is better than v16.3.6_ens at the 99% significance level	▼ v16.3.6_gmi_ens_exp is worse than v16.3.6_ens at the 99% significance level
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▲ v16.3.6_gmi_ens_exp is better than v16.3.6_ens at the 95% significance level	▼ v16.3.6_gmi_ens_exp is worse than v16.3.6_ens at the 95% significance level
□ No statistically significant difference between v16.3.6_gmi_test_09_20 and v16.3.6_ens	□ Not statistically relevant

Dates: 20230318-20230518

Scorecard

		N. America				N. Hemisphere				S. Hemisphere				Tropics			
		Day		Night		Day		Night		Day		Night		Day		Night	
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
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