ROMEX results at the Central Weather Administration of Taiwan

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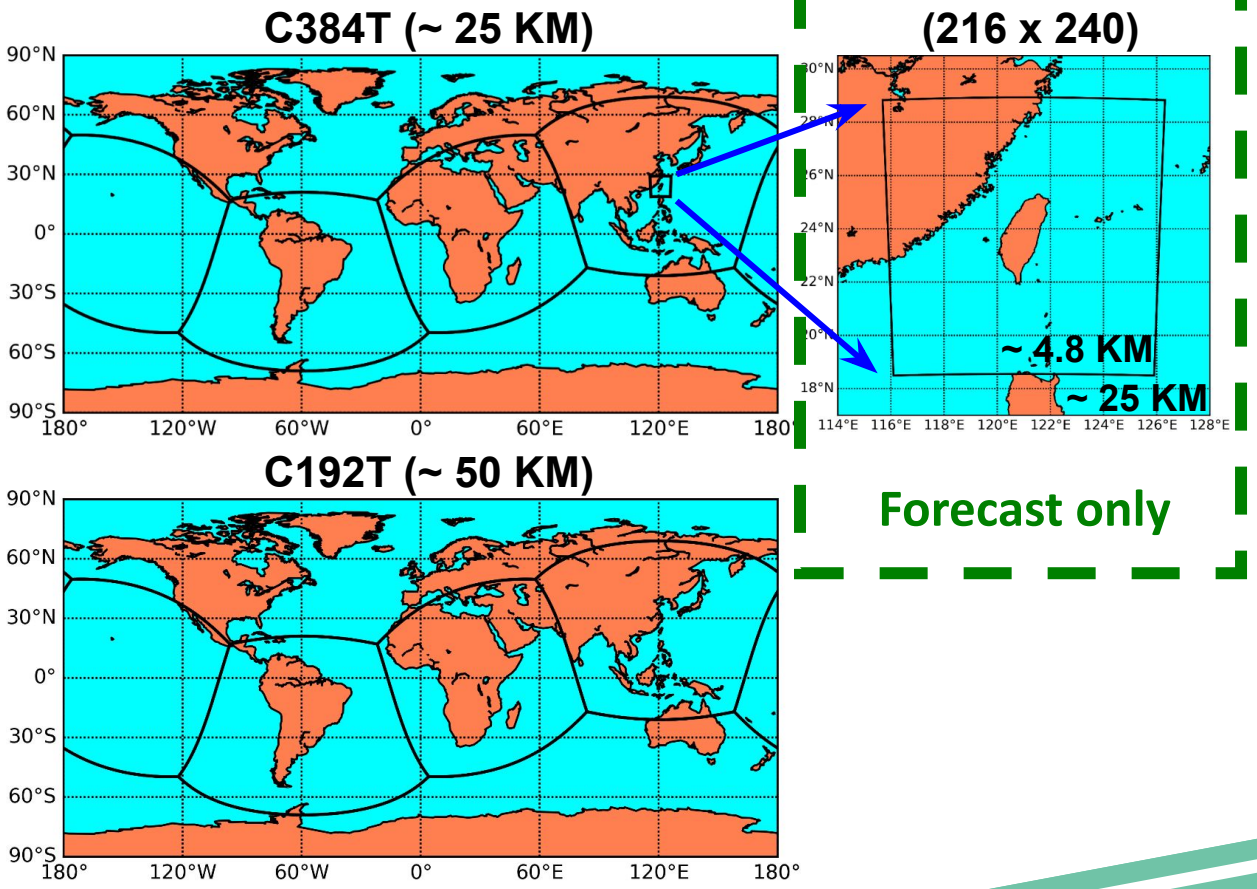
Global NWP system used in ROMEX: TGFS

- **CWA Taiwan Global Forecast System (TGFS) v1.1**
  - Adapted from NCEP GFS/GSI v15.1, with several local modifications
  - Finite-Volume Cubed-Sphere (FV3) Dynamical Core
  - 25-km (C384T) resolution *(cf. NCEP GFS: 13 km)*
  - Hybrid 4DEnVar data assimilation

Deterministic system
hybrid 4DEnVar
using time-lagged ensemble (global domains)

Ensemble system
EnKF
(32 members)



Experimental design – RO data used

Mission	TGFS operation (for reference)	NoRO	CTL	ROMEX
GRAS	V		V	V
COSMIC-2	V		V	V
KOMPSAT-5	V		V	V
PAZ	V		V	V
TerraSAR-X	V		V	V
TanDEM-X	V		V	V
Sentinel-6			V	V
Spire				V
PlanetiQ				V
GeoOptics				V
Fengyun3				V
Yunyao				V
Tianmu				V
Total # (profiles /day)			**~ 8,700**	**> 30,000**

Experimental design – Experiment list

Experiment	RO QC in the assimilation	Radiance VarBC coefficient update	Data processing	Days already run
NoRO	–	Online	–	28
CTL	All default **(*1)**	Online	EUMETSAT	**91**
ROMEX_t1	All default (*1)	Online	EUMETSAT	26
ROMEX	Stricter QC for ROMEX additional data **(*2)**	Online	EUMETSAT	**91**

Notes:

(*1) For all RO data, use the same QC as TGFS' next operational version ("default").

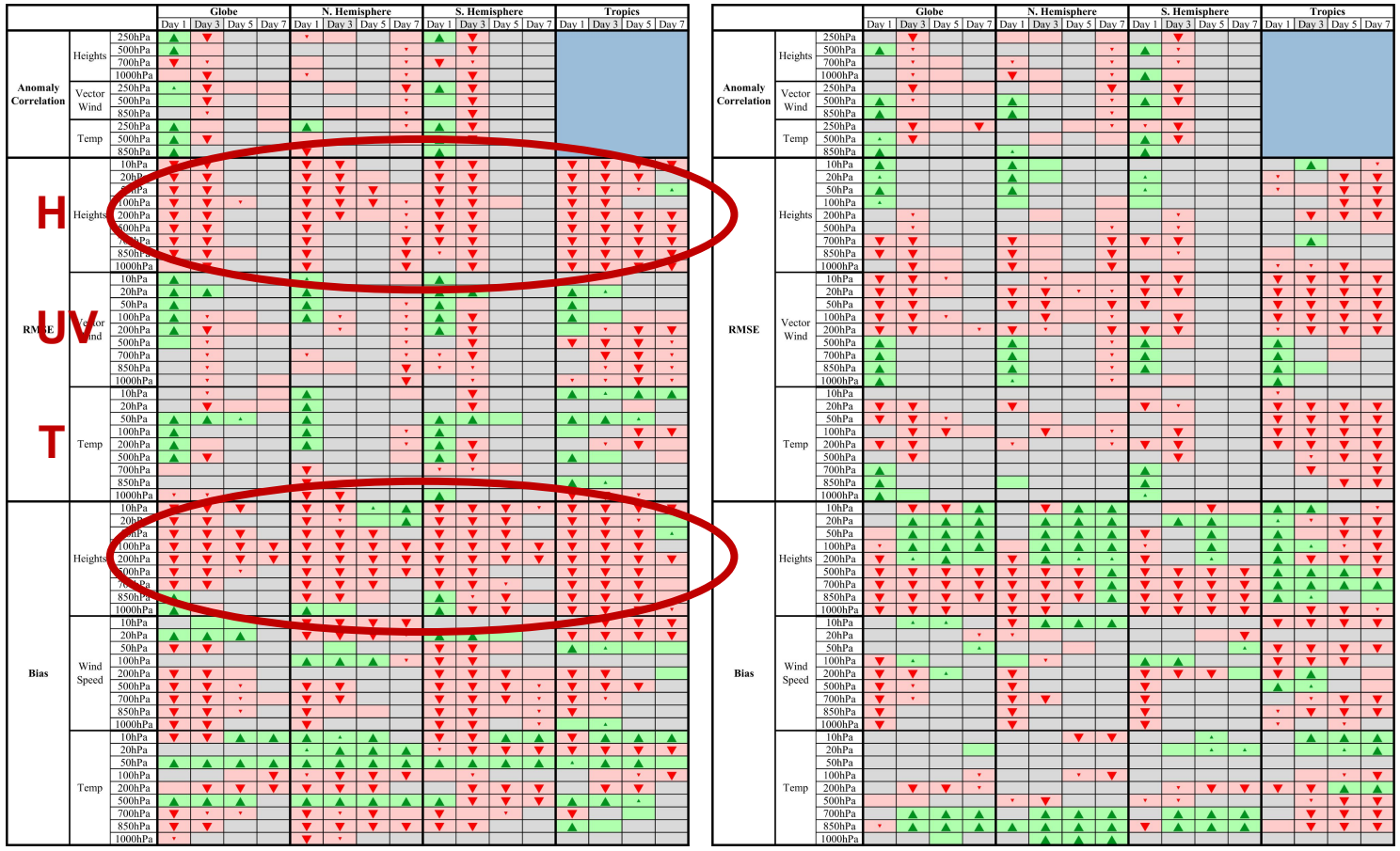
(*2) For ROMEX additional data (Spire, PlanetiQ, GeoOptics, Fengyun3, Yunyao, Tianmu), use a stricter QC (stricter gross error check; do not use data above 30 km) than "default."

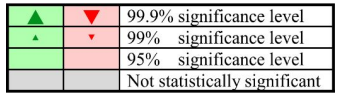
CTL vs. ROMEX (91 days)

Green/Red : ROMEX is better/worse than CTL

Verified against ERA5

Verified against self analysis

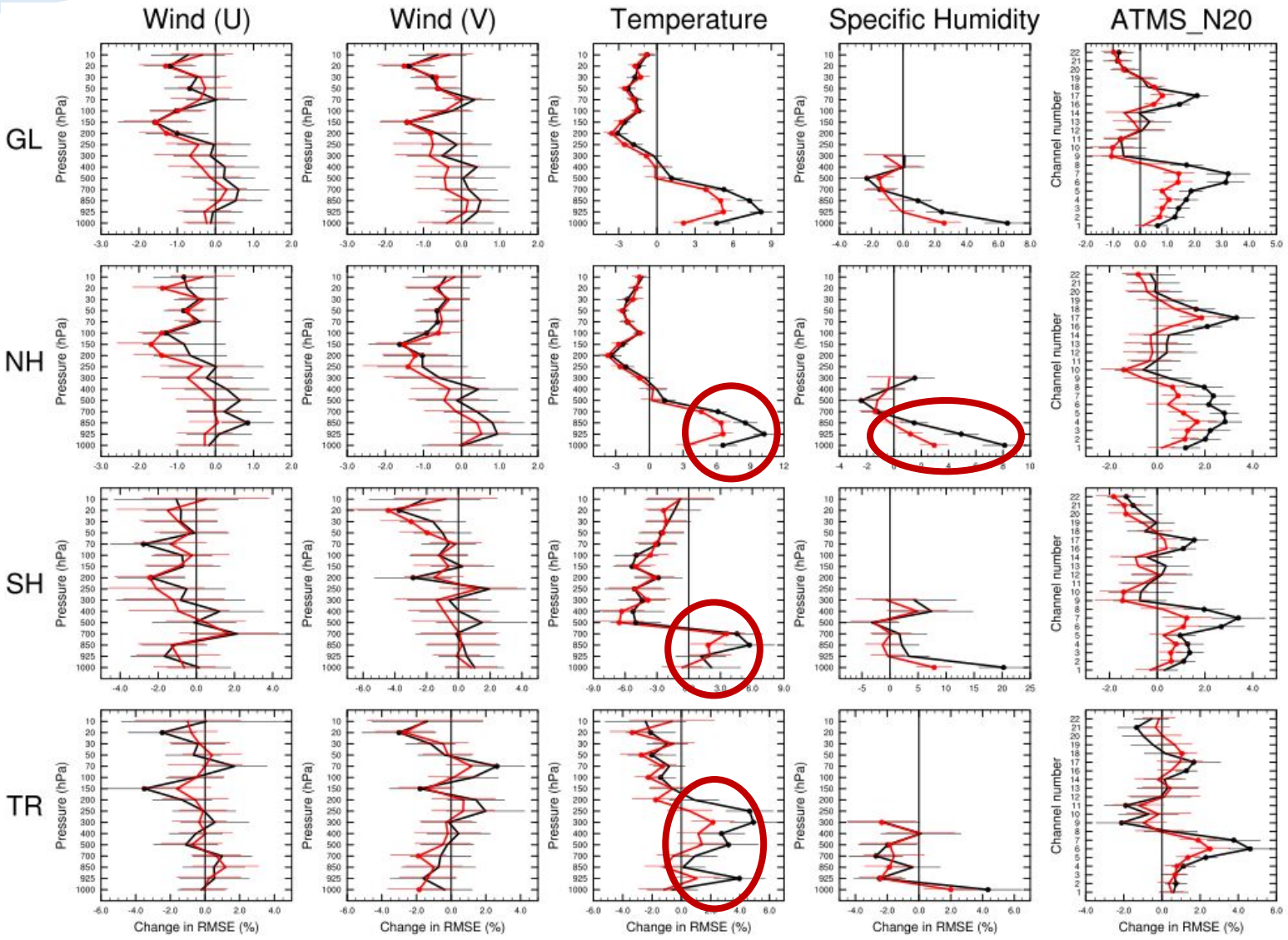




(1 Sep – 30 Nov 2022)

- Significantly degraded height biases especially at mid-to-high levels, which also causes significantly degraded RMSE.
- Limited improvements found in temperature RMSE above 500 hPa and wind RMSE above 200 hPa (against ERA5).
- Also degraded anomaly correlation.

CTL vs. ROMEX_t1 vs. ROMEX (26 days)



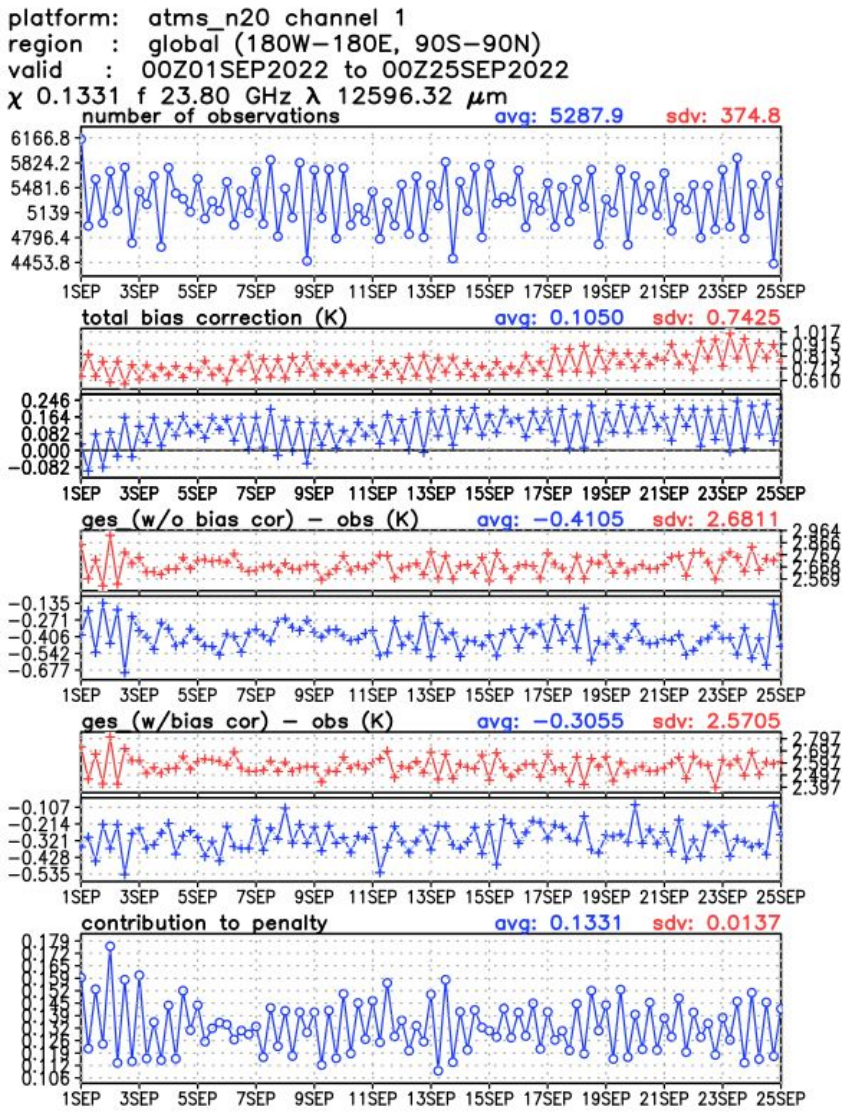
← Lower is better

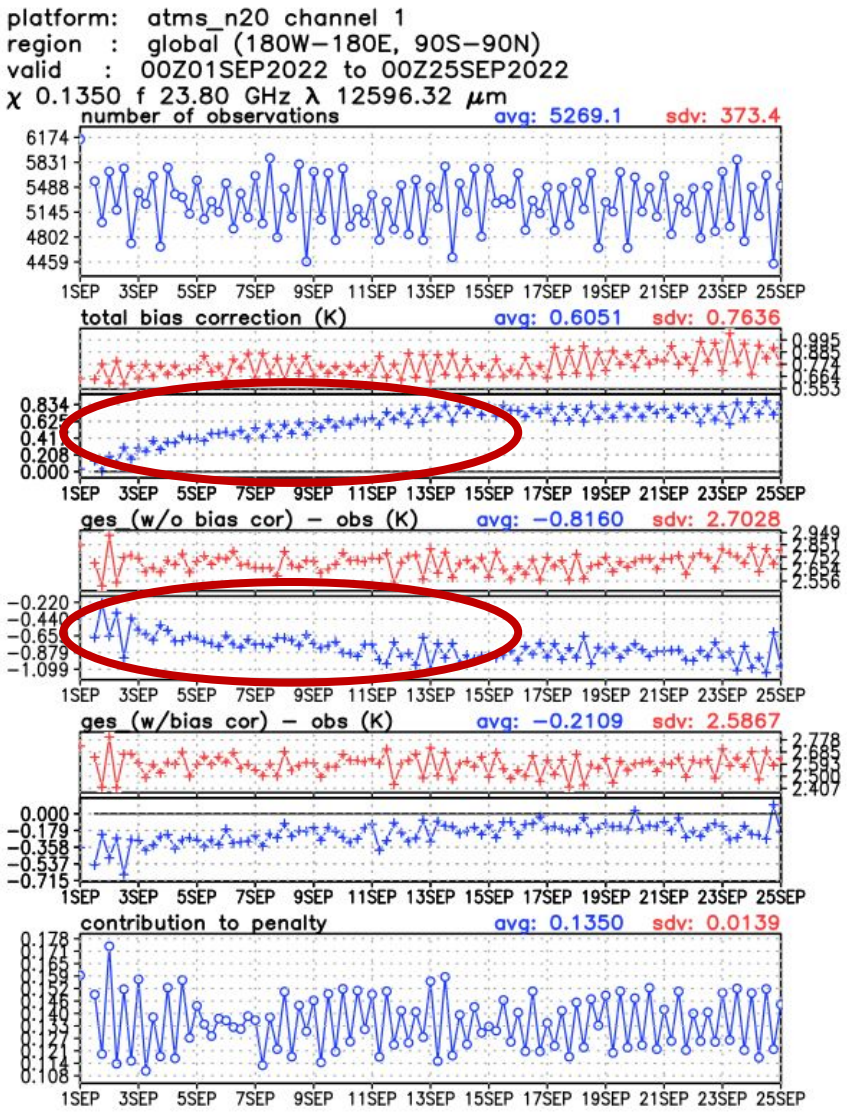
Background (6-h forecast) fit to observation:
Radiosonde (U, V, T, Q) & ATMS radiances

Reference (zero lines): **CTL**
Black : **ROMEX_t1**
Red : **ROMEX**

- Significantly degraded low- to mid-level temperature and low-level humidity globally.
  - Consistent with the model-based verification.
- With a stricter QC for ROMEX additional RO data (**ROMEX**), the degradation in temperature and humidity is already mitigated (compared to **ROMEX_t1**), but not completely solved.

CTL vs. ROMEX – Satellite VarBC





- The satellite VarBC coefficients and thus their total corrections **drift from their normal values (as in CTL) rapidly** in the ROMEX experiment.

Experimental design – Experiment list

Experiment	RO QC in the assimilation	Radiance VarBC coefficient update	Data processing	Days already run
NoRO	–	Online	–	28
CTL	All default **(*1)**	Online	EUMETSAT	**91**
ROMEX_t1	All default (*1)	Online	EUMETSAT	26
ROMEX	Stricter QC for ROMEX additional data **(*2)**	Online	EUMETSAT	**91**
ROMEX_passive	Stricter QC for ROMEX additional data **(*2)**	Offline (passive) based on CTL **(*3)**	EUMETSAT	**61** (ongoing)

Notes:

(*1) For all RO data, use the same QC as TGFS' next operational version ("default").

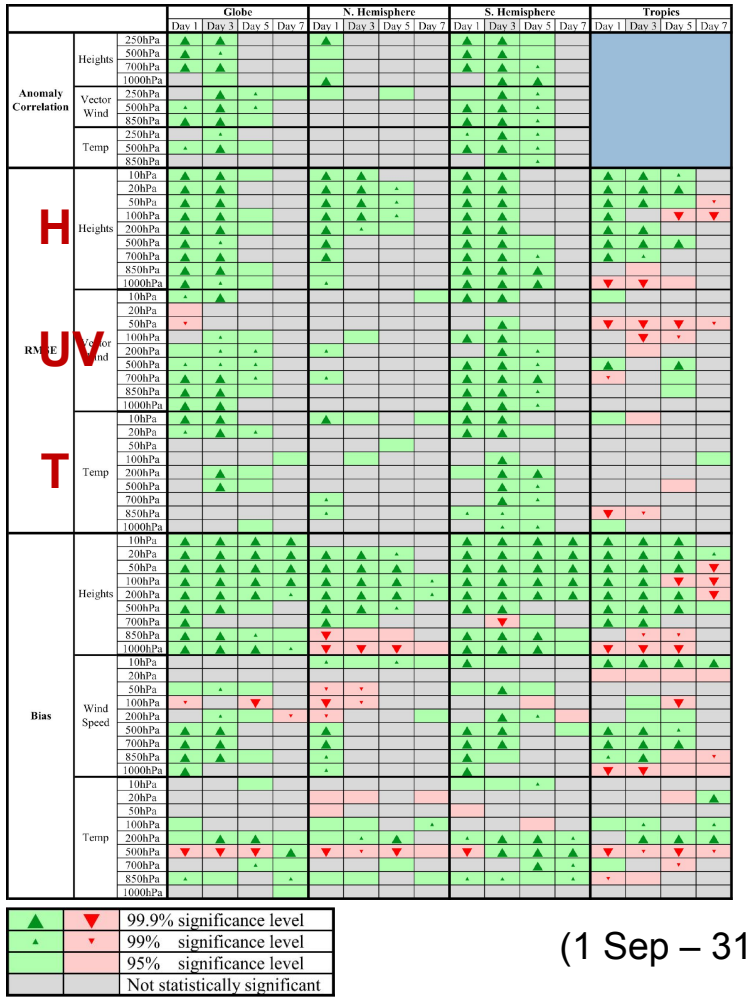
(*2) For ROMEX additional data (Spire, PlanetiQ, GeoOptics, Fengyun3, Yunyao, Tianmu), use a stricter QC (stricter gross error check; do not use data above 30 km) than "default."

(*3) In satellite radiance assimilation, use the VarBC coefficients from "CTL" experiment, which means not allowing the ROMEX additional data to update the radiance VarBC coefficients.

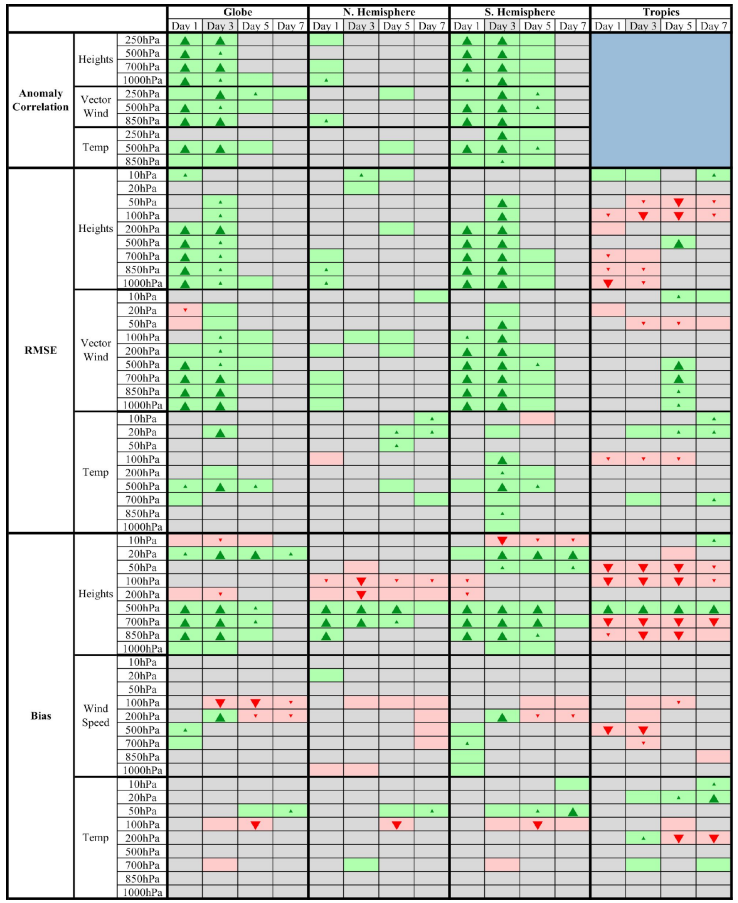
ROMEX vs. ROMEX_passive (61 days)

Green/Red : **ROMEX_passive** is **better/worse** than **ROMEX**

Verified against ERA5



Verified against self analysis



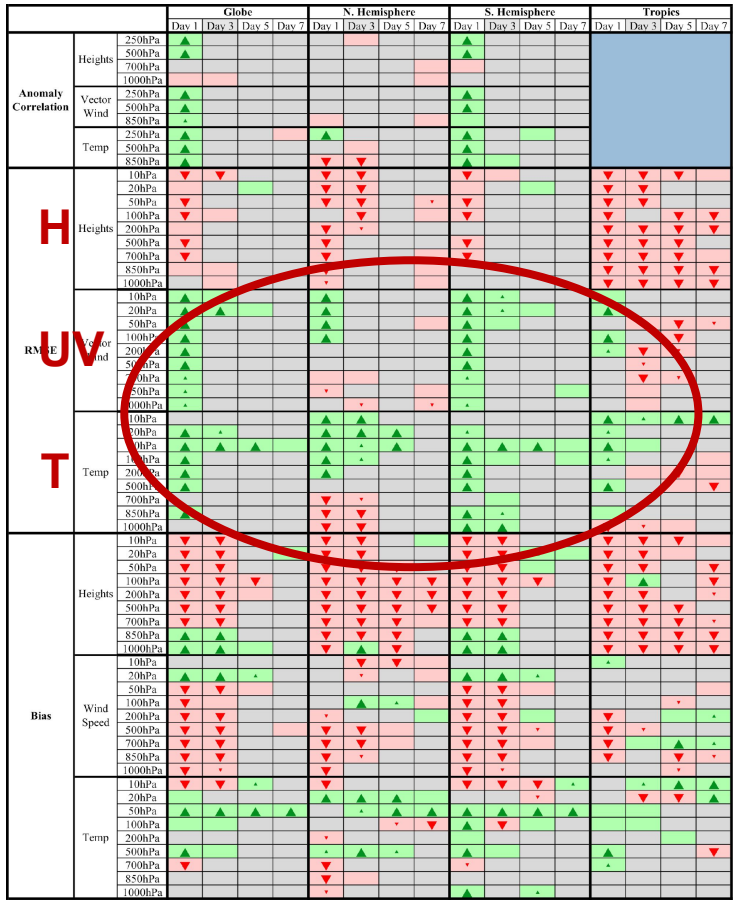
(1 Sep – 31 Oct 2022)

- Conducting the ROMEX RO assimilation in a **"passive mode"** (do not allow the ROMEX additional data to change the radiance bias correction) **leads to a much better result *!!***
- This suggests that, for some reason, the current VarBC configuration may NOT work well with the large amount of the RO data.

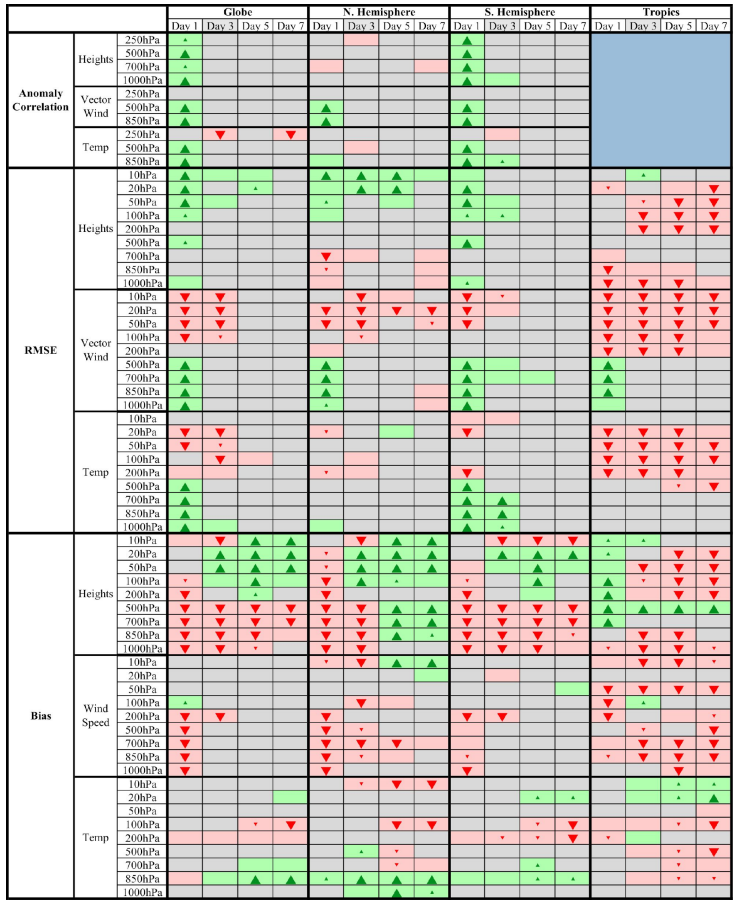
CTL vs. ROMEX_passive (61 days)

Green/Red : ROMEX_passive is better/worse than CTL

Verified against ERA5



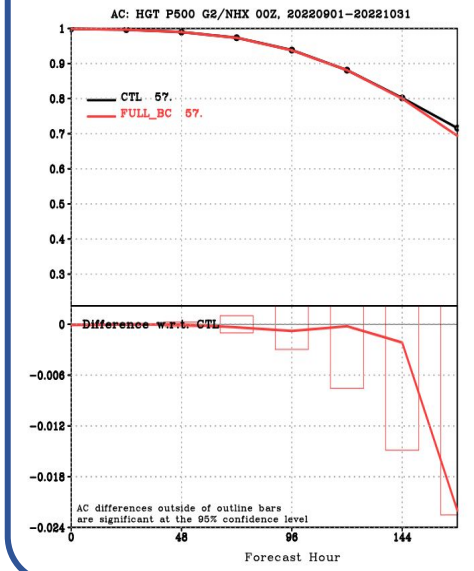
Verified against self analysis



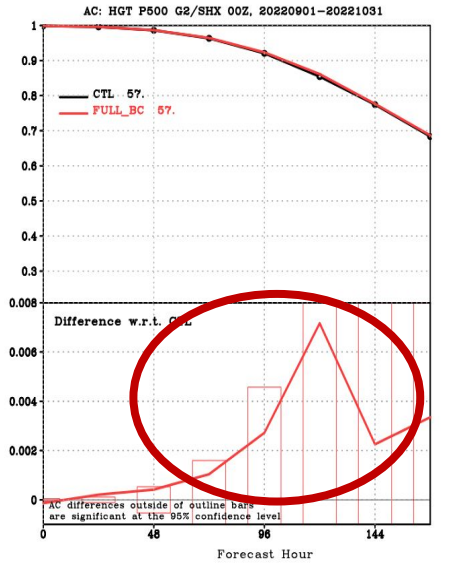
(1 Sep – 31 Oct 2022)

Anomaly Correlation Coefficient (ACC)

NH

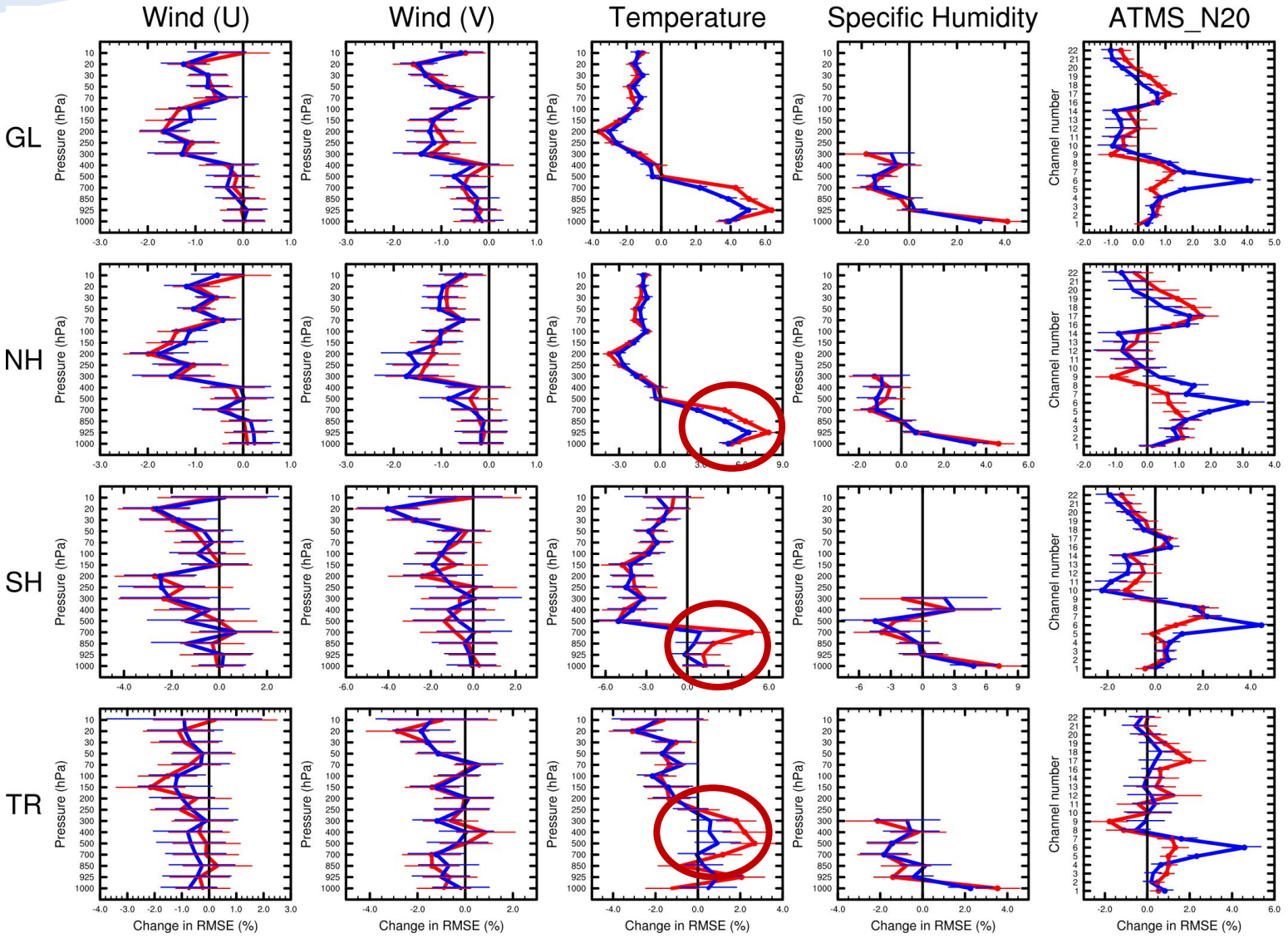


SH



- Compared with **CTL**, **ROMEX_passive** show improvements in temperature and winds, and also anomaly correlation in SH.
  - However, there are still significant degradations in height biases.

CTL vs. ROMEX vs. ROMEX_passive (61 days)



← Lower is better

Background (6-h forecast) fit to observation:
Radiosonde (U, V, T, Q) & ATMS radiances

Reference (zero lines): **CTL**
Red : **ROMEX**
Blue : **ROMEX_passive**

- **ROMEX_passive** is qualitatively similar to **ROMEX**, but it mitigates some degradations in **ROMEX** over **CTL** (e.g., low-level temperature).
- Degradations in NH temperature below 700 hPa is still notable even in **ROMEX_passive**.

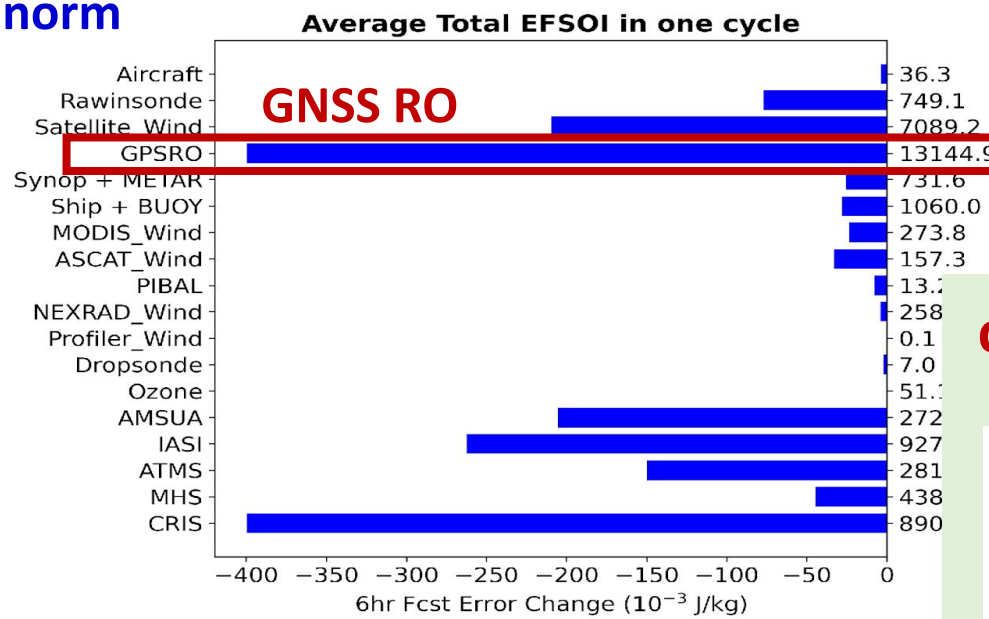
Ensemble Forecast Sensitivity to Observation Impact (EFSOI) In ROMEX experiment (ROMEX_t1)

00 UTC 5 Sep – 12 UTC 27 Sep 2022

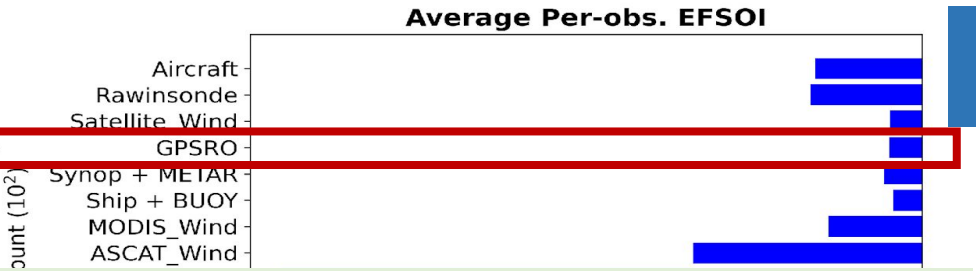
Moist total energy norm

All observations

Total EFSOI

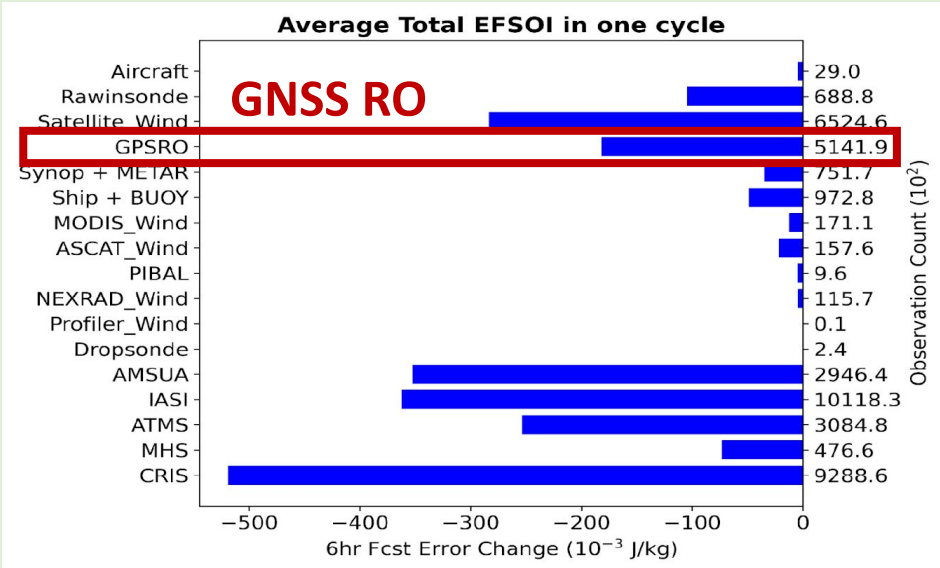


Per-Obs EFSOI (= Total EFSOI / # obs)



cf. EFSOI from CWA TGFS operation

(21 Jan – 21 Feb 2023, moist total energy norm)



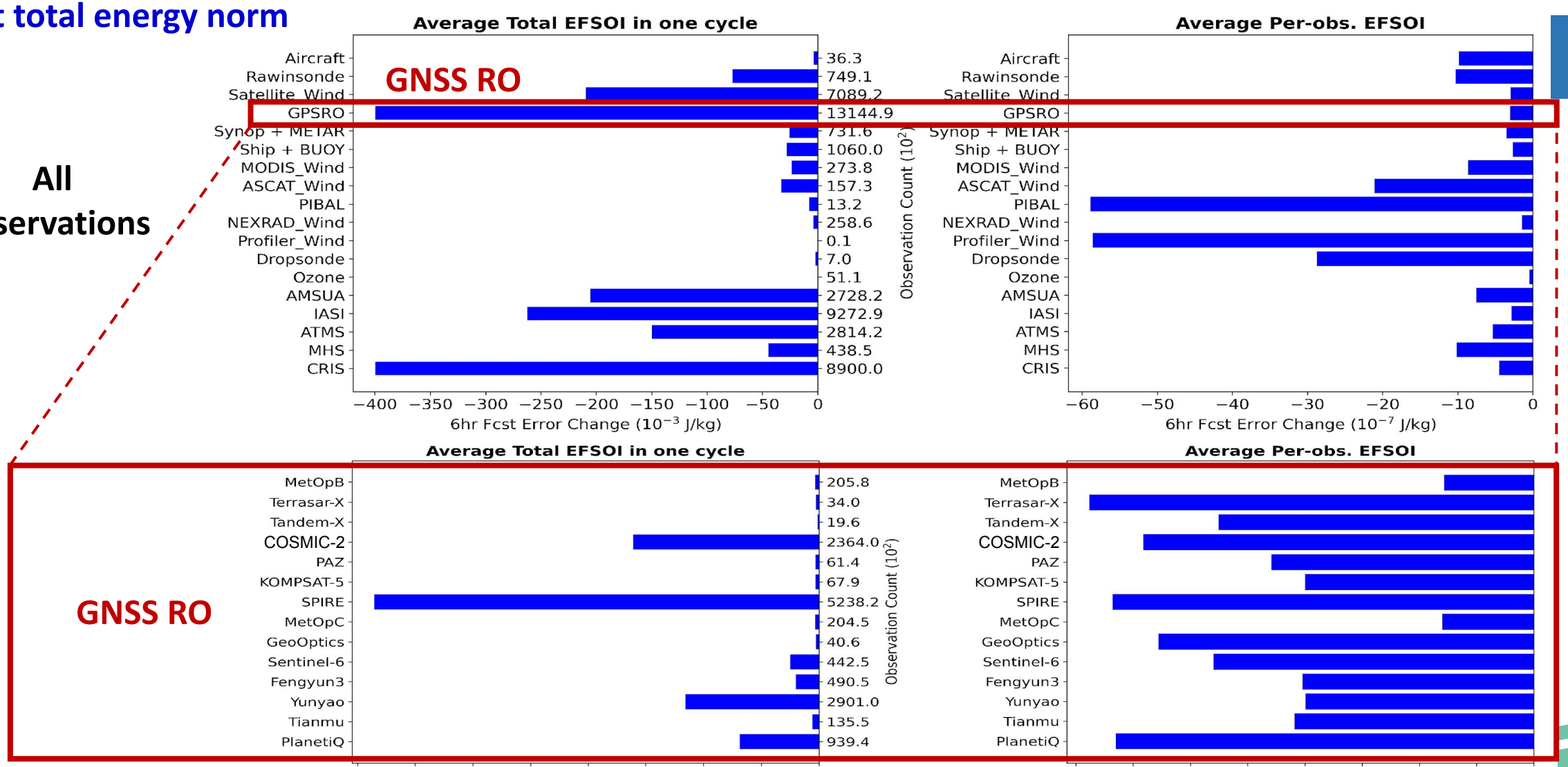
Ensemble Forecast Sensitivity to Observation Impact (EFSOI) In ROMEX experiment (ROMEX_t1)

00 UTC 5 Sep – 12 UTC 27 Sep 2022

Moist total energy norm

Total EFSOI | **Per-Obs EFSOI (= Total EFSOI / # obs)**

All observations



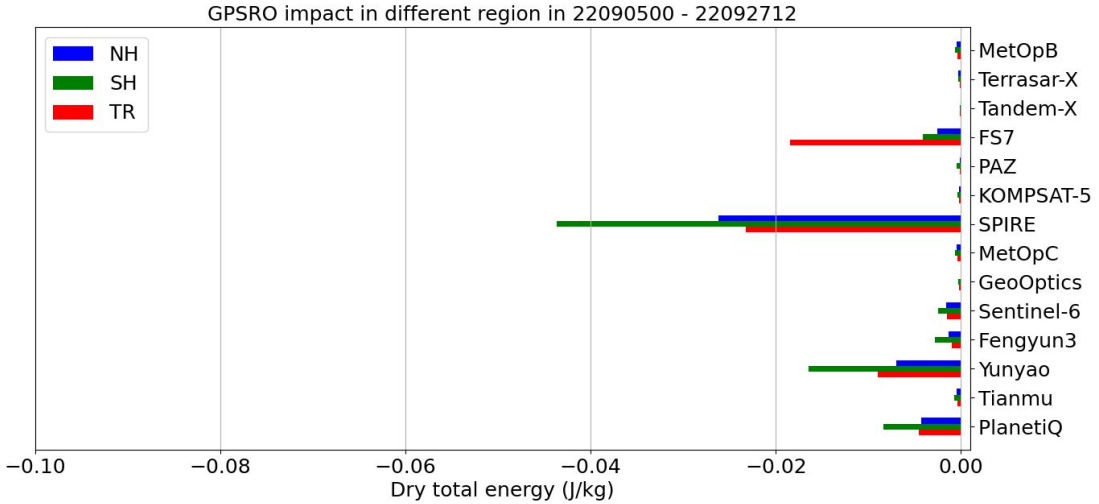
EFSOI wrt. Geographic regions (NH, SH, TR)

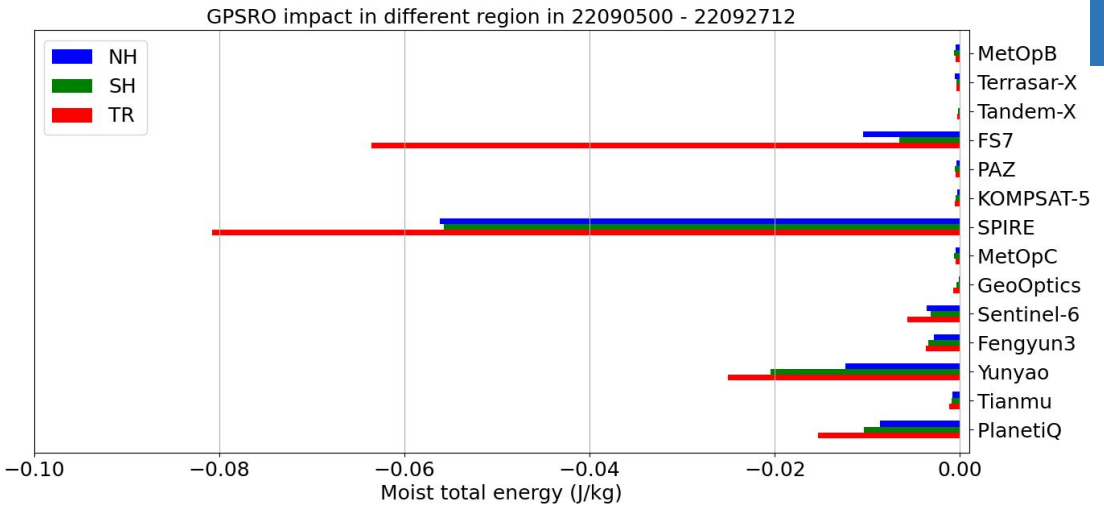
00 UTC 5 Sep – 12 UTC 27 Sep 2022

Dry total energy norm

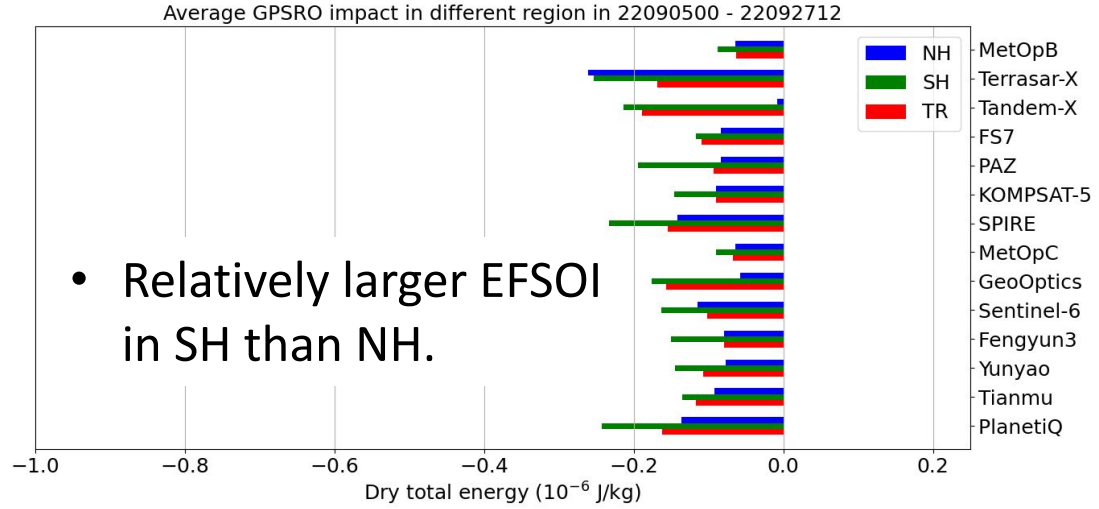
Moist total energy norm

Total EFSOI

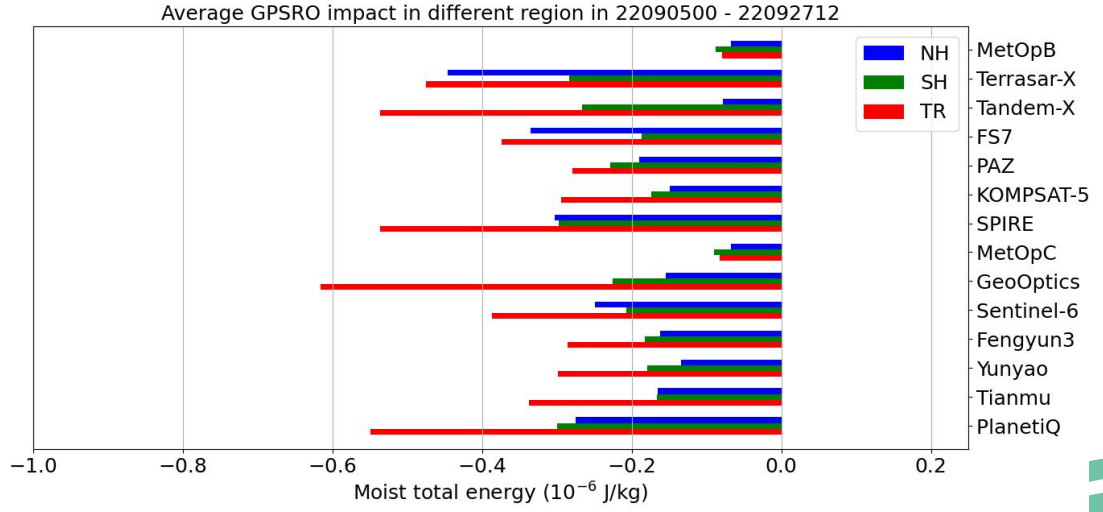




Per-Obs EFSOI



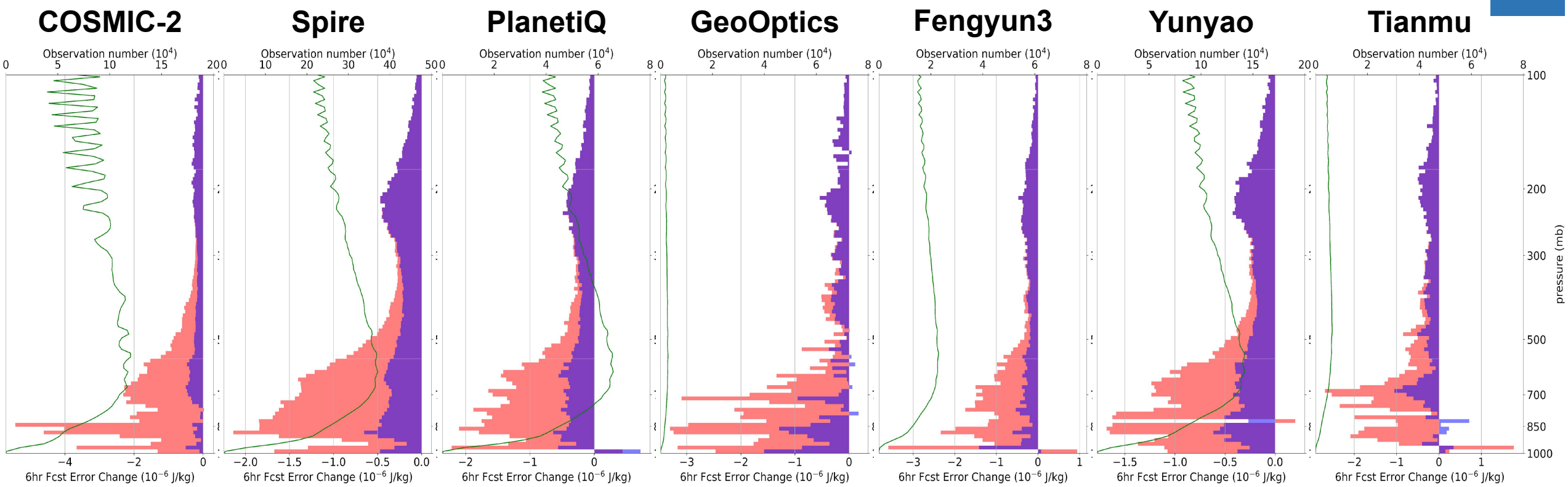
- Relatively larger EFSOI in SH than NH.



EFSOI wrt. Height (pressure level)

00 UTC 5 Sep – 12 UTC 27 Sep 2022

Dry total energy norm (purple) & Moist total energy norm (pink)



- Although ROMEX is significantly worse than CTL in the model and observation verifications, the EFSOI still estimate **all positive impacts** in all RO satellites and in all regions & almost all height levels.
  - Conjecture: The EFSOI may not be good at detecting the “indirect impact” via satellite radiance VarBC. (??)

Concluding remarks

- CWA has completed some of the required experiments and verification in ROMEX.
- The current results show more degradations than improvements:
  - Significantly degraded height biases especially at mid-to-high levels.
  - Limited improvements in temperature RMSE above 500 hPa and wind RMSE above 200 hPa.
- With a ROMEX assimilation experiment in a “passive mode” (do not allow the ROMEX additional data to change the radiance bias correction), a much better result is obtained, although there are still some mixed results compared to CTL.
  - It implies that the current satellite radiance VarBC configuration may not work well with the large amount of the RO data in ROMEX, so the “indirect effect” of RO data assimilation via satellite radiance VarBC degrades the results.
    □ This sheds some light for improving the results, but further investigation is needed.
  - We also think that this indirect effect may not explain all sources of the degradation. More investigation on the RO data quality may also be needed.