Impact Assessment of Himawari-8 AHI radiance assimilation and VarBC application in the ACCESS-C model

The Bureau of Meteorology

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1 Introduction & Motivation

- The clear sky AHI radiance is currently assimilating operationally into the Bureau's global Numerical Weather Prediction (NWP) system. However, the assimilation of AHI products is essential to perform in a limited area model (LAM) as these products have high resolution and scan frequency that can provide valuable mesoscale information for quickly developing convective weather.
- This study assimilates full spatial resolution AHI and examines these products' impact under the Bureau's hourly cycling high-resolution LAM (ACCESS-C).
- We also investigate independent radiance bias correction for LAM in this study. Currently, the operational ACCESS-C system uses variational bias correction (VarBC) coefficients from the global model (VarBC_G), ACCESS-G. We assessed the impact of applying independent VarBC (VarBC_C) for the limited area model compared with the operational bias corrections.

2 System Configuration and Methods

The Bureau's ACCESS NWP systems are based on the Met Office model.

- Global: ACCESS-G [6-hour cycle, 4 times per day]
- LAM: ACCESS-C [1-hour cycle, 24 times per day, over 7 regional domains]
- Study Area: Sydney domain, shown in blue in Figure 1 [1-2].

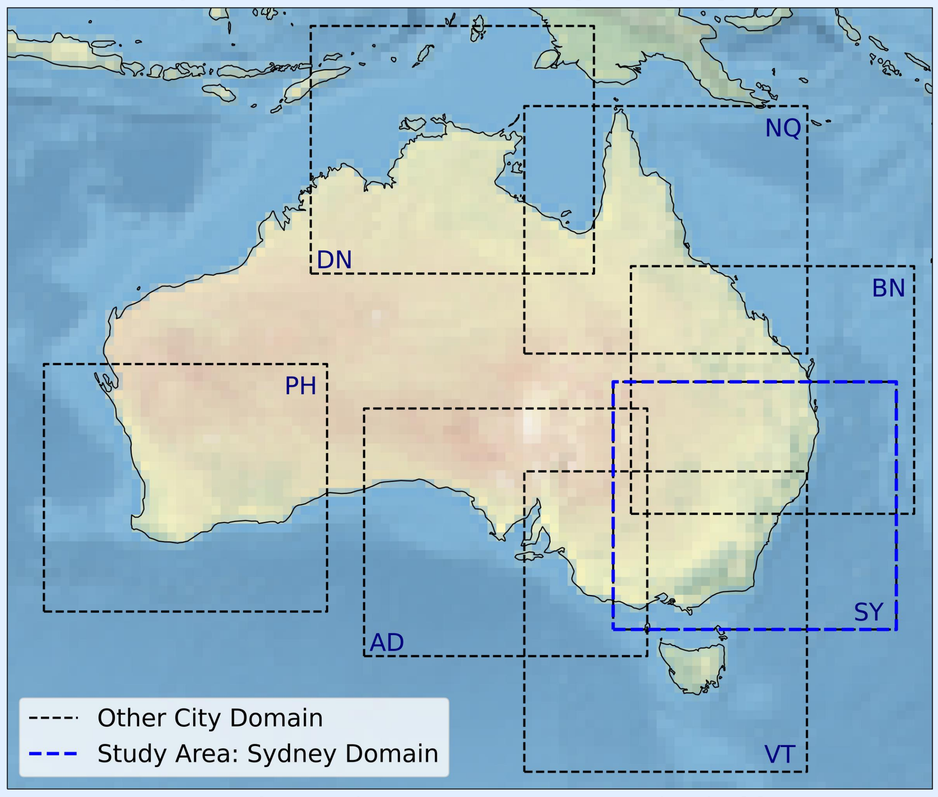


Figure 1: The Bureau ACCESS-C system domains [1].

Experiment details:

Experiment	Details
Control	All the conventional, radar and satellite data used in Bureau ACCESS-C system [2]
AHICSR_G	Control + AHIClr/CSR (clear sky) + VarBC_G
AHICSR_C	Control + AHICSR + VarBC_C
AHIASR_G	Control + AHICSR + AHIASR (all sky) + VarBC_G
AHIASR_C	Control + AHICSR + AHIASR + VarBC_C
Trial Period	1st Feb – 15th April 2020
DA System	4D-VAR

3 Use of AHI data in ACCESS-C

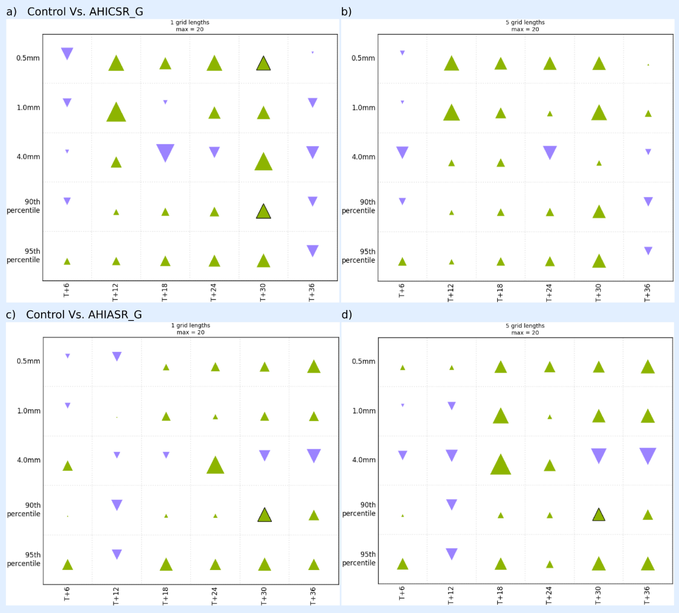


Figure 2: ΔFSS Hinton diagrams for 1-hr precipitation accumulation.

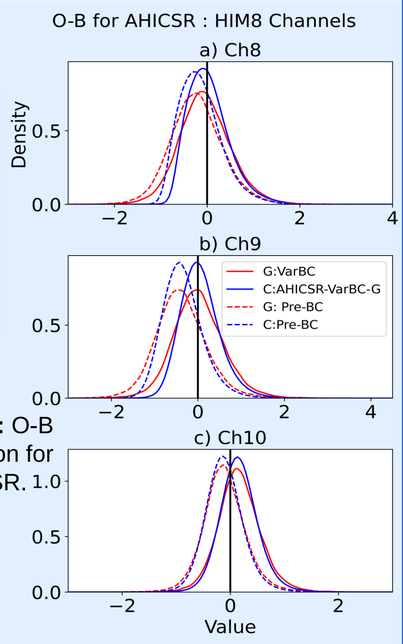
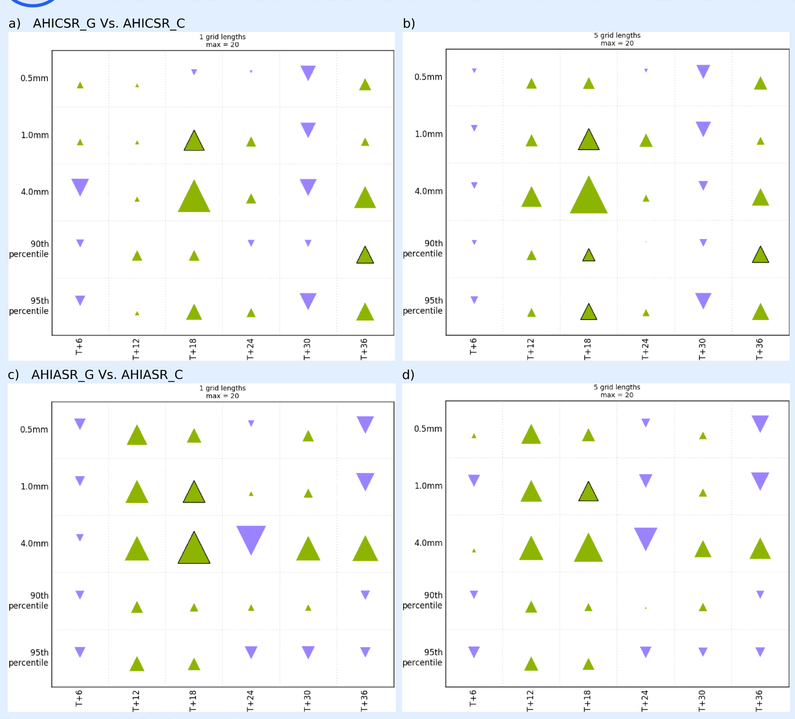


Figure 3: O-B distribution for AHICSR.

Verification Metrics:

- Improvements and degradations in ΔFSS are represented by green and purple triangles. The FSS indicated mixed impacts for adding AHI to ACCESS-C (Figure -2).
- Figures 3 shows O-B normality distributed when add AHI. However, Ch10 looks positively skewed after correction (Figure 3).

4 AHI assimilation with VarBC in ACCESS-C



- The ΔFSS in Figure 4 improves when applying independent VarBC in LAM for AHICSR and AHIASR cases.
- Noticeable improvement occurs at the T+12 forecast cycle for the AHIASR case.
- The O-B distribution of AHICSR and AHIASR water vapour channels [ch8-ch10] shows no significant difference, suggesting a neutral impact for the bias-corrected observations (Figure 5).

Figure 4: ΔFSS Hinton diagrams for 1-hr precipitation accumulation with VarBC-LAM.

- An improvement can notice in ch10 after independent VarBC (Figure 5c), previously "+" skewed distribution (Figure 3c) shift towards zero or normality.

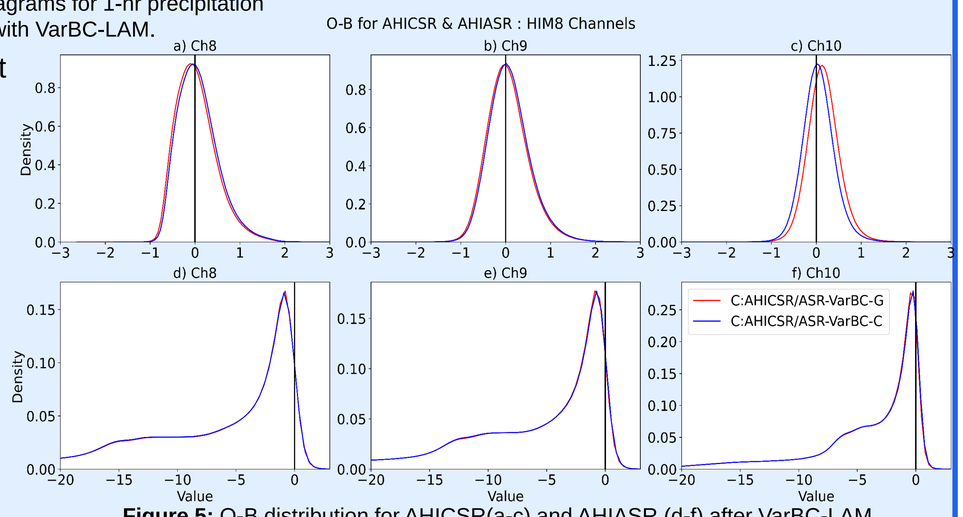


Figure 5: O-B distribution for AHICSR(a-c) and AHIASR (d-f) after VarBC-LAM

How well does VarBC in ACCESS-C work?

Channel: AHICSR	RMSE [K]			STD(O-B) [K]			U-Stat
	Global	AHICSR-G	AHICSR-C	Global	AHICSR-G	AHICSR-C	AHICSR-G Vs. AHICSR-C
5	0.47	0.41	0.41	0.47	0.40	0.40	0.95
7	0.53	0.44	0.44	0.51	0.43	0.44	0.97
8	0.56	0.45	0.46	0.56	0.45	0.45	0.98
9	0.58	0.47	0.47	0.58	0.46	0.46	0.98
10	0.43	0.39	0.36	0.40	0.36	0.35	0.88
AHIASR	AHIASR-G		AHIASR-C	AHIASR-G		AHIASR-C	AHIASR-G Vs. AHIASR-C
5	9.49		9.52	6.81		6.82	0.99
7	10.22		10.25	7.25		7.25	0.99
8	10.35		10.37	7.37		7.37	0.99
9	9.39		9.39	6.78		6.78	0.98
10	6.19		6.17	4.76		4.75	0.98

- No significant difference is noticed in statistics for the trials, which means that applying VarBC does not lead to a degradation in the model fit. However, based on U-statistics, ~12% improvement notice in Ch10 after VarBC-C in LAM for AHICSR.

Further O-B examination for AHIASR:

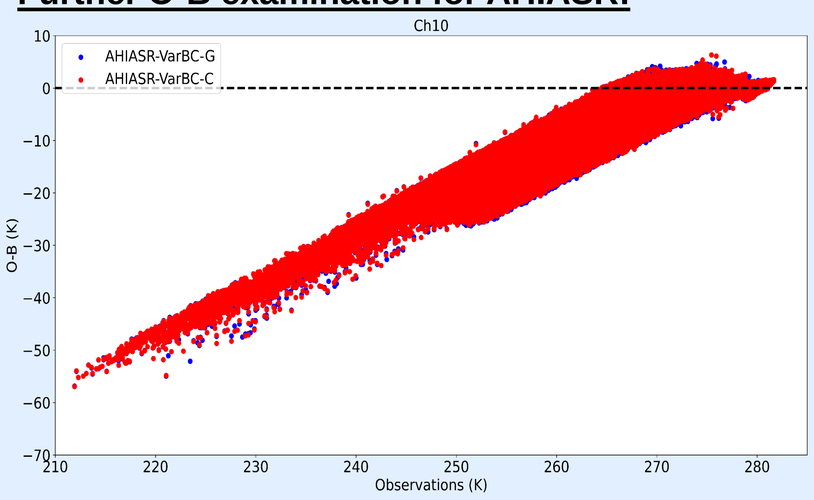


Figure 6: O-B plot over observations for Ch10 AHIASR.

- In Figure 6, Ch10 for AHICSR shows negative bias distribution with both VarBC-G and VarBC-LAM; this result is consistent with the study in [3] for the global model. It might be due to thick ice clouds, followed by thin ice and multilayer clouds. And indicates that the model can hardly reproduce brightness temperature in thick ice clouds.

5 Conclusions and future work

- AHICSR and AHIASR assimilation in ACCESS-C shows a neutral impact. However, a significant negative bias notice in BT for the AHIASR, and this might be for the following reasons: 1) Radiation and cloud interaction might induce uncertainties in satellite observations based retrieval of cloud parameters. 2) The model can't reproduce BT in thick ice clouds. 3) Cloud contamination adjacent pixels.
- VarBC is applied to all radiances in these trials. Overall, this study suggests that the impact of using VarBC_C in LAM is neutral. The impact of VarBC_C on other radiance in ACCESS-C are described in [2].
- This is an early attempt; in the future, we intend to run more assimilation experiments with different configurations and methods over extended periods.

Plain Language Summary:

Satellite data are essential for NWP operation and make up more than ~70% positive impact. So using more high-resolution and frequent satellite data can increase this impact on global and regional scales. In this study, we add high-resolution Himwari-8 satellite radiance products to Bureau regional model and find the neutral impact on the forecast. Further, we test the bias correction scheme for the radiance as these products exhibit biases that restrict their direct use. The real-time bias correction approach is widely used for the global system, but there are still open questions regarding its use in the regional system. We investigate the performance of independent real-time bias correction in the regional system. Our investigation overall exhibited a neutral forecast impact.

Acknowledgements and References:

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[3] Okamoto, K., Hayashi, M., Hashino, T., Nakagawa, M. and Okuyama, A., 2021. Examination of all-sky infrared radiance simulation of Himawari-8 for global data assimilation and model verification. Quarterly Journal of the Royal Meteorological Society, 147(740), pp.3611-3627.