Response of the manuscript "A Bias Correction Scheme for FY-3E/HIRAS-II Observation Data Assimilation (Chen and Guan, 2024)"

Thank you for your professional comments. We have also made corresponding revisions based on your professional comments. Below are the specific responses, highlighted in blue:

Major issues

1. Scan-angle bias origin unclear.

The paper shows a clear scan-angle bias in HIRAS-II data but does not clarify whether this originates from the satellite sensor, the radiative transfer model (e.g., RRTOV), or atmospheric mismatches between observations and simulations. Given that TOA radiances naturally depend on viewing angle (due to path length, surface emission angle-dependence, and atmospheric heterogeneity), the authors should systematically analyze and discuss these potential causes.

Re: Just as mentioned in the Line 101-104, HIRAS-II is a cross-track scanning instrument. The distribution of FY-3E/ HIRAS-II FOVs in a scan line is shown in Figure 1. The scan angle of each FOV gradually increases as the instrument scans to both sides (FOR1 and FOR28), inevitably causing a scan angle bias relative to the nadir.

"The field of view is susceptible to deformation as the scan angle increases when the satellite sensor performs a cross-track scanning to both sides of scan lines, which leads to unavoidable observation biases relative to the nadir FOV. The optical pathlength is longer as the scan angle increases, also leading to scan angle biases. In addition, although the fast radiative transfer models are become increasingly sophisticated and accurate, they can not only simulate the brightness temperature at the nadir, but also simulate the brightness temperature at other scan angles. However, atmospheric inhomogeneity increases with the increase of scan angle. If the model cannot fully simulate atmospheric inhomogeneity, it may also lead to bias in the simulated brightness temperature that depend on the scan angle." has been add to Line 161-167 to systematically analyze and discuss scan-angle bias origin.

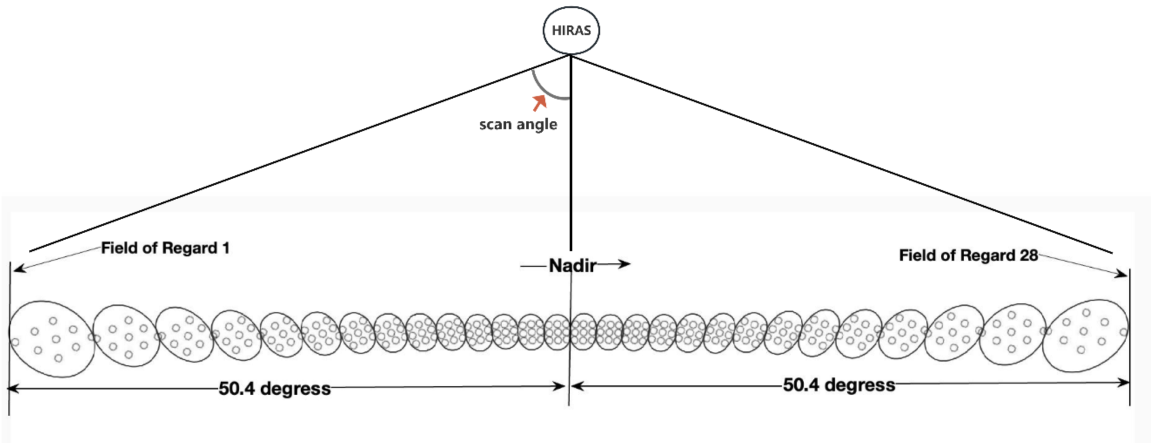

Figure.1. The distribution of FY-3E/ HIRAS-II field of views in a scan line.

2. Air-mass bias concept not well defined.

The introduction should better distinguish scan-angle bias (instrumental/geometric) from air-mass bias (systematic model error in representing specific air mass types). The use of predictors to correct O–B needs a clearer explanation: what physical aspects are being corrected—surface temperature, tropospheric composition, or something else?

Re: The "air-mass" is a professional term inherited from the past, referring to the collection of atmospheric state variables (e.g., temperature, water vapor, or pressure) related to O-B bias within the field of view.

“For a long time, satellite radiance data assimilation has mainly used a bias correction scheme that relies on “air-mass”, which use quantities related to "air state" as predictors to implement bias correction. Its theoretical basis is that there is a linear correlation between the spatial and temporal variations of the satellite observation biases and the predictors, and the higher the correlation, the more obvious the correction effect is” is added to Line 60-63 to define the air-mass bias correction.

Line 66-68 “It is worth……bias correction” is modified to “It is worth mentioning that Harris and Kelly (2001) proposed a revolutionary bias correction scheme that divides the bias into two parts: the unavoidable scan angle bias of cross-track scanning instruments and the air-mass bias caused by the NWP mode and the fast radiative transfer mode” to distinguish the scan angle bias and air-mass bias.

“The predictor p_1, p_2, p_5 and p_6 reflect the mode background-errors at different layers and various dependencies within the forward model. The predictor p_3 represents the systematic error of near-surface channels. In addition, it can compensate somewhat for the different emissivity characteristics of different surface types for these channels (Harris and Kelly, 2001). The water vapor is one of the main input components in the fast radiative transfer mode, the predictor p_4 can reflect the model simulated error to some extent” is added to Line 190-194 to explain the physical aspects corrected by each predictor.

3. Inconsistent description of data assimilation setup.

The abstract mentions NCEP-GSI, but the experiments use WRFDA v4.4. This inconsistency must be resolved. Also, the timeline of the assimilation period is contradictory (17–31 August vs. 1–31 August 2023). This needs clarification to maintain credibility.

Re: We used the airmass predictors of NECP-GSI as the control scheme, but the assimilation experiments are carried out in the WRFDA assimilation system. This is because the observation operator of GSI assimilation system is CRTM. Since the CRTM does not provide the coefficient files of Fengyun series satellites, we cannot obtain the coefficient file of HIRAS. The observation operators of WRFDA include CRTM and RTTOV. Therefore, we choose WRFDA to conduct the assimilation experiments. The error in the assimilation time has been corrected.

4. Lack of physical explanation for air-mass correction.

The correlation between the chosen predictors and O–B is shown, but there is no justification for why these predictors lead to better TOA radiance simulation. The study would benefit from showing how the air-mass correction improves key state variables (e.g., surface T, pressure, or humidity) and thereby reduces bias.

Re: Bias correction is not to better simulate radiance (B), but to meet the assumption that both observation and background errors are unbiased as required by the variational assimilation method. As mentioned in the Line 101-104, observation and background errors can be calculated by O-B. Therefore, the ultimate goal of bias correction is to make O-B distribution follows a Gaussian normal distribution with a mean of 0 (Figure 5). Independent ERA5 (ECMWF Reanalysis version 5) objective analysis fields are selected as the true value to further evaluate the impact of different FY-3E/HIRAS-II BC schemes on the data assimilation analyses, the analysis fields with different BC schemes are compared with ERA5 in the Figure 8. It can be seen from the figure that bias correction has a improvement for the temperature and humidity analysis (closed to ERA5).

Minor corrections:

Title: FY-3E/HIRAS-II (no space after /)

Re: The revision has been completed.

L26: “satellite radiations” --> satellite radiance.

Re: The revision has been completed.

L34-35: “The satellite launched …time window”. This sentence is unclear. FY-3E has an early morning overpass, so how would this fill a time gap within a 6-hour assimilation window? IASI also has a morning overpass.

Re: “the time gap of satellite observations” has been modified to “the data gap of satellite observations” and “ensuring 100% coverage…” has been modified to “ensuring almost 100% coverage…”. The equator crossing time (ETC) in local standard time of METOP-B/C is 0930, while that of FY-3E is 0530. Figure 2 shows that the data coverage of FY-3C (afternoon orbit) and FY-3F (morning orbit, similar to METOP-B/C) at different assimilation times. It can be seen from Figure 1 that there are data gaps at each assimilation time. Figure 3 shows the spatial coverage of FY-3C, FY-3F and FY-3E (early-morning orbit). It can be seen from Figure 3 that the three-orbit constellation can comprehensively increase the spatial coverage of polar-orbiting satellites, ensuring almost 100% coverage of satellite observations within the assimilation time window.

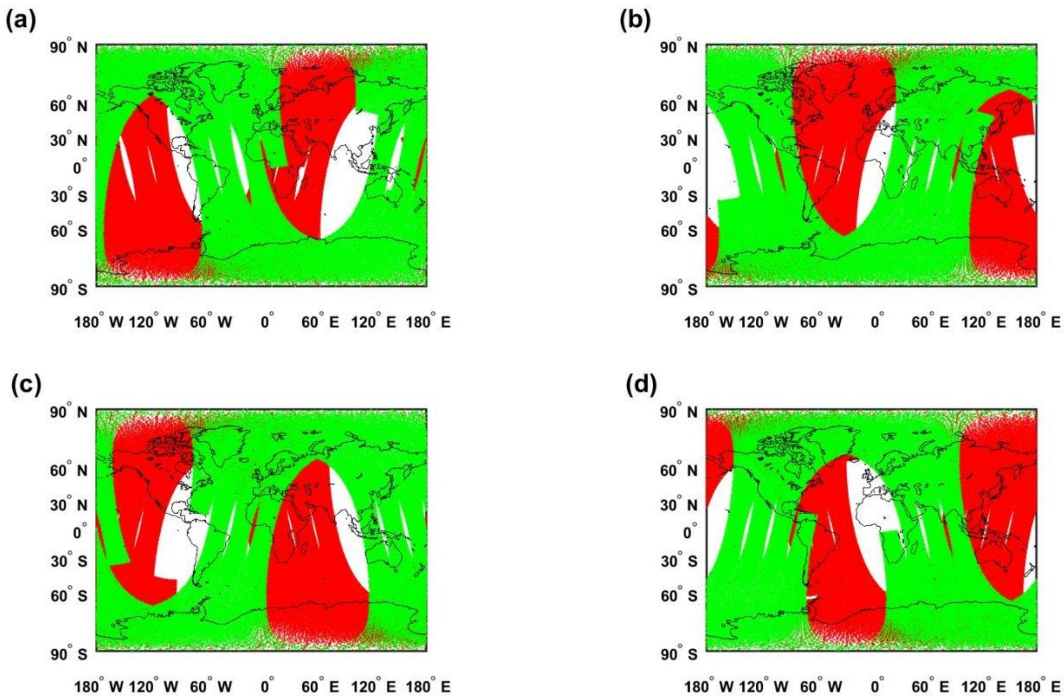

Fig. 2. The spatial coverage of FY-3C (red color) and FY-3F (green color) at assimilation time (a) 0000UTC, (b) 0600UTC, (c) 1200UTC and (d) 1800 UTC.

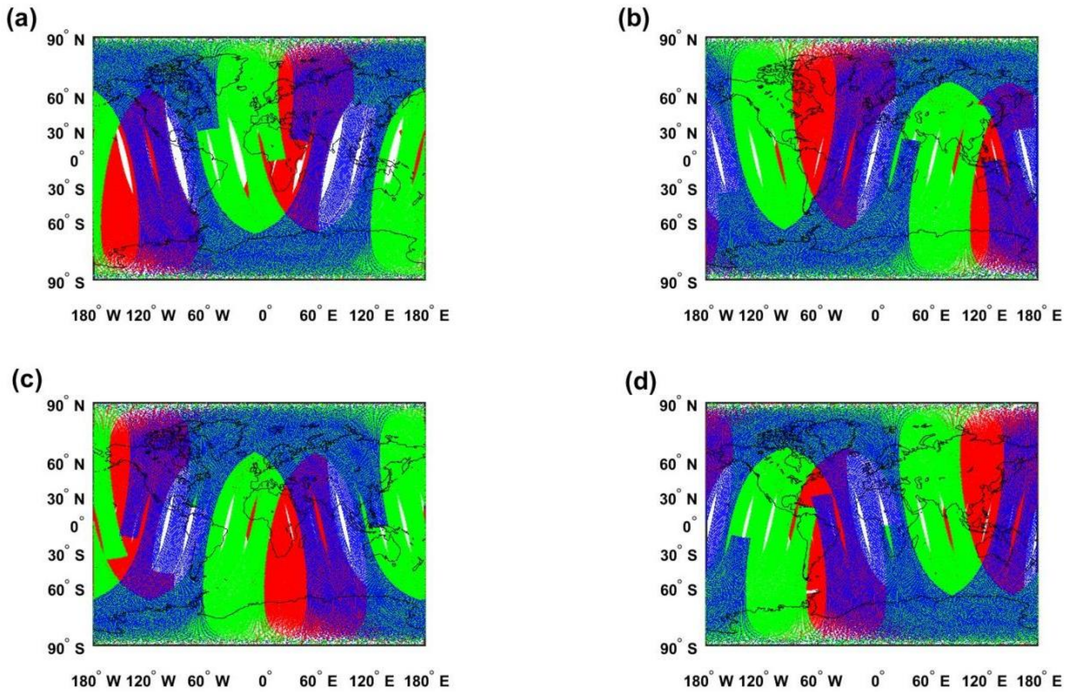

Fig. 3. The spatial coverage of FY-3C (red color), FY-3F (green color) and FY-3E (blue color) at assimilation time (a) 0000UTC, (b) 0600UTC, (c) 1200UTC and (d) 1800 UTC.

L46: “destroying the global NWP system” … this is oddly phrased. The system will surely not be destroyed, but the model state may be negatively influenced when biases persist in satellite observations. This should be rephrased.

Re: “destroying the global NWP system” has been modified to “affect the forecast accuracy of NWP”.

L108: Period missing after Saunders-reference.

Re: The revision has been completed.

L135: “exceeds”--> exceeding

Re: The revision has been completed.

L148: rephrase to ‘For each channel, the global …position *is calculated as:*’

Re: The revision has been completed.

L300: “The scatters” --> The scatter

Re: The revision has been completed.

L380: the colour bar in Figure 7 is unfortunate with green hue indicating no bias. Suggest to use a cold-white-warm colour scheme, where white corresponds to zero bias.

Re: The revision has been completed.

Thank you for your professional suggestions and concern about our manuscript again.