Nonlinear bias correction of FY-4A GIIRS radiance observations based on EEMD-MLP method

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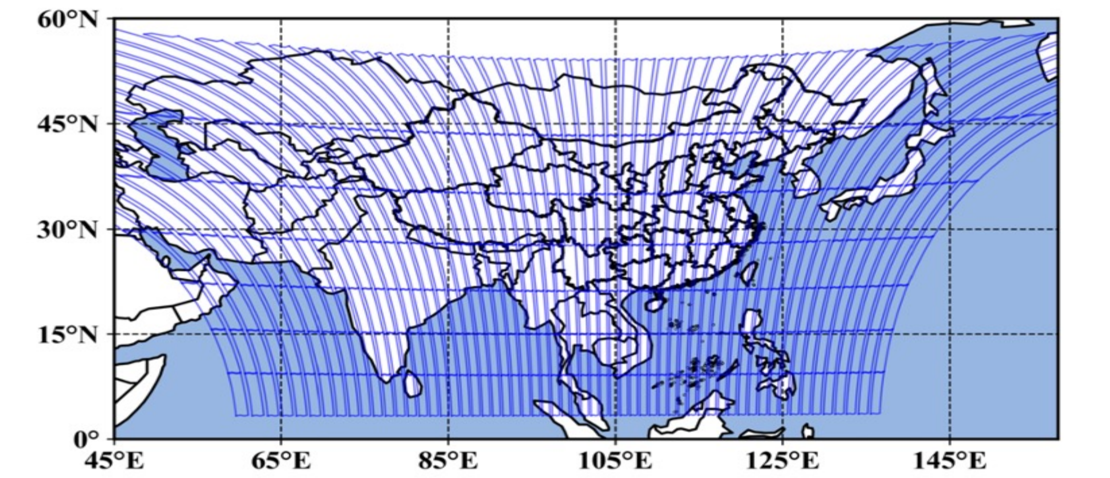
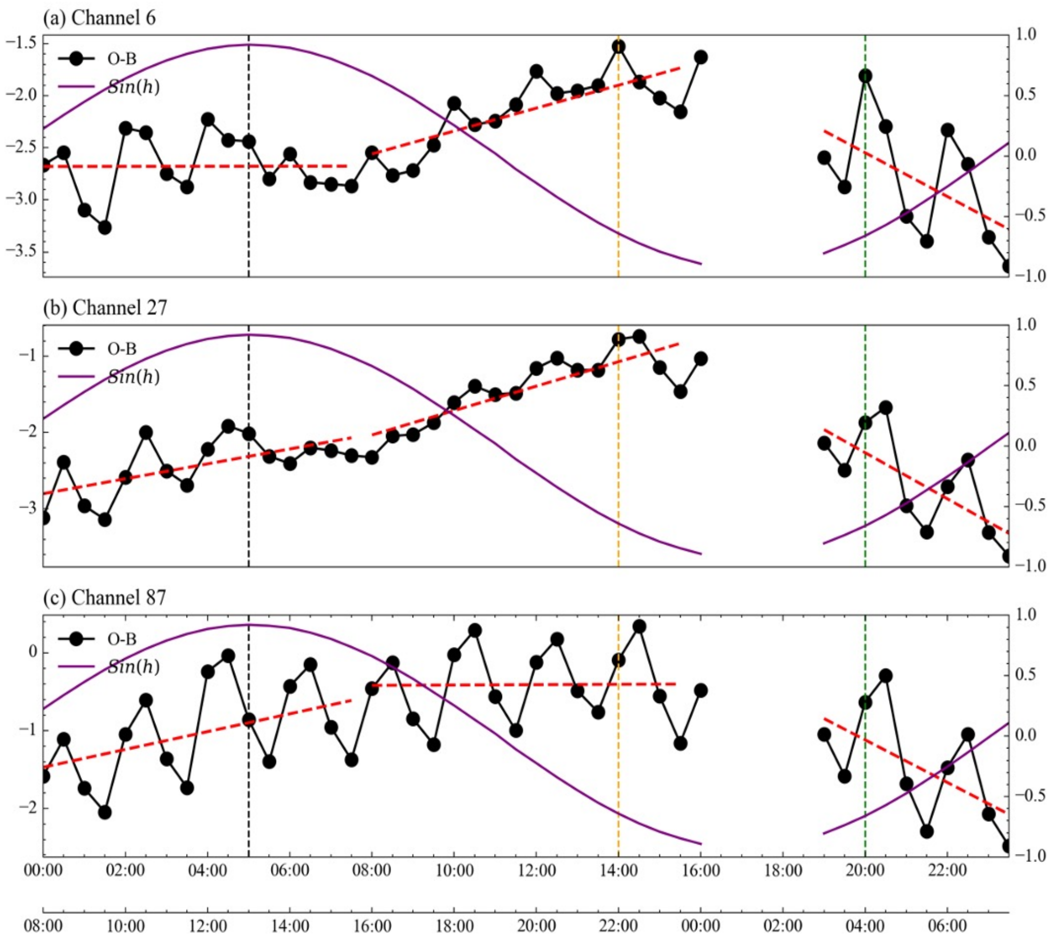
Abstract

Goal: Correcting non-linear diurnal variations of FY-4A GIIRS.

The adequate treatment of systematic errors in the assimilation of satellite radiance is an essential precondition for their successful use. In geostationary orbit, instruments tend to exhibit nonlinear diurnal bias characteristics due to the influence of solar radiation and other aspects. However, most bias correction methods, relying on linear combinations of predictors at fixed observation time, which could not effectively correct the nonlinear diurnal bias characteristics due to their limit capability to take the temporal cumulative effects into account. In this study, the nonlinear diurnal bias characteristics of the GIIRS temperature channels are analyzed, and the linear static method and methods based on deep learning model are compared. The nonlinear diurnal bias characteristics are discussed in three typical channels, channel 6, channel 27 and channel 87 of GIIRS, which correspond to the upper, middle and lower troposphere layers respectively. In all three channels, Observation minus background (O-B) show obvious diurnal variations, although their regularities differ. In addition, as the GIIRS observe the regional area (in two hours), bias tends to exist oscillation. The cosine of the satellite zenith angle and sine of the solar altitude angle are selected as predictors of the bias correction model because of their correlations with the bias. Three methods(linear, MLP and EEMD_MLP) are considered as bias correction model respectively. In the EEMD-MLP-based model, The mode of diurnal variation of the deviation was subtracted using the EEMD method.The results show that the EEMD-MLP-based model provides the greatest improvement in GIIRS bias correction. Compared with the linear static model, the corrected O-B mean of the EEMD-MLP-based model is closer to zero, and the standard deviation is smaller. From the spatial distribution of O-B, the phenomenon of stripe noise is reduced.

Bias characteristics of GIIRS





Method

Algorithm:

Algorithm 3 EEMD-MLP Bias Correctio Method for FY-4A GIIRS

Input: OMB(t)

Output: $C_{i,j}(\tau^{0\sim 24h})$ by 1 minute resolution; $MLP_{i,j}(t)$

for $i \leq$ number of assimilated channels: **do**

  for $i \leq$ number of detectors: **do**

    Perform the ensemble empirical mode decomposition on the $OMB_{i,j}(t)$ sequence, and the $eIMF^{max}$ with the largest variance contribution rate (the average period is one day also) is extracted: $eIMF^{max}_{i,j} = EEMD(OMB_{i,j}(t))$

    Average the extracted $eIMF^{max}_{i,j}$ to each minute of one day: $C_{i,j}(\tau^{0\sim 24h})$

    Reduce the components $C_{i,j}(\tau^{0\sim 24h})$ that characterize the mode of diurnal variation on the OMB sequence: $f_{i,j}(t) = OMB_{i,j}(t) - C_{i,j}(\tau^{0\sim 24h})$

    For each observation, prepare the corresponding predictors: q_t, p_t

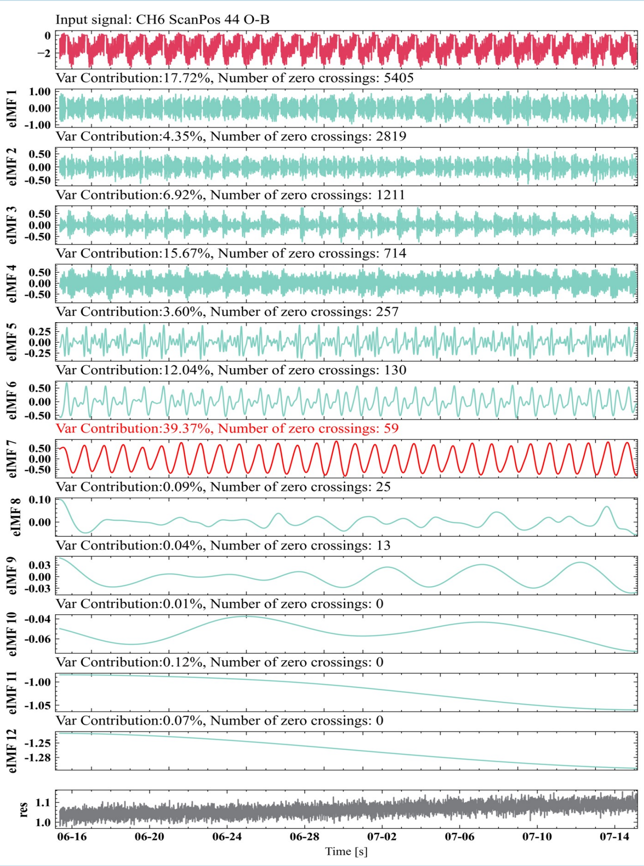
    Fitting $f_{i,j}(t)$ with predictors q_t, p_t based on Multi-layer Perceptron: $MLP_{i,j}(q_t, p_t) = f_{i,j}(t)$

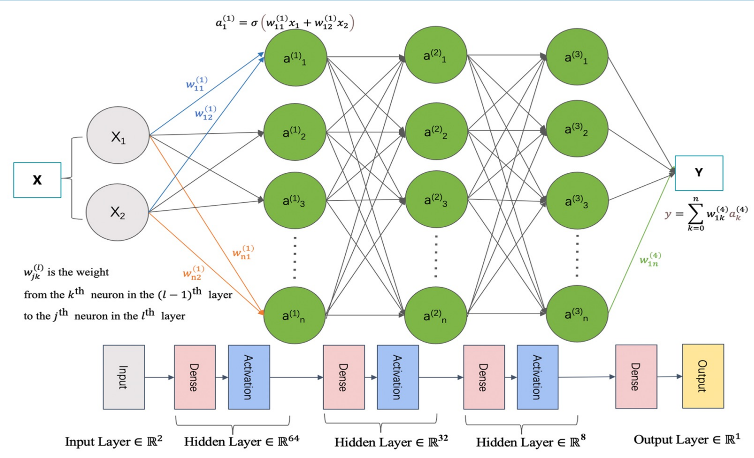
  end for

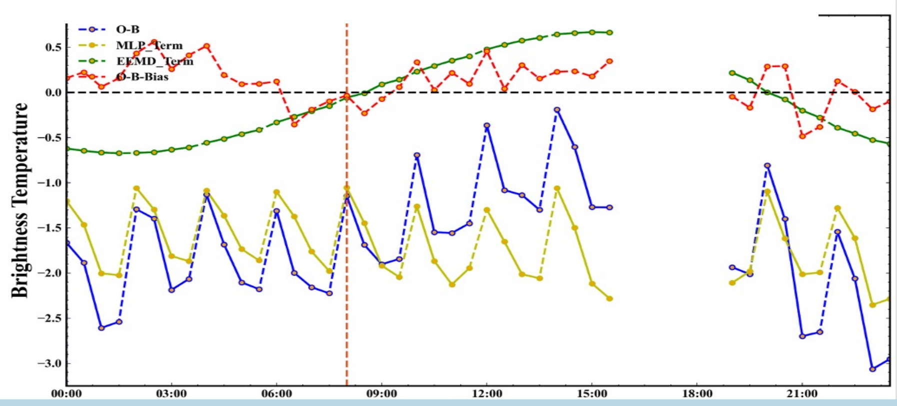
end for

the $OMB_{i,j}(t)$ sequence can be reconstructed using the formulation:

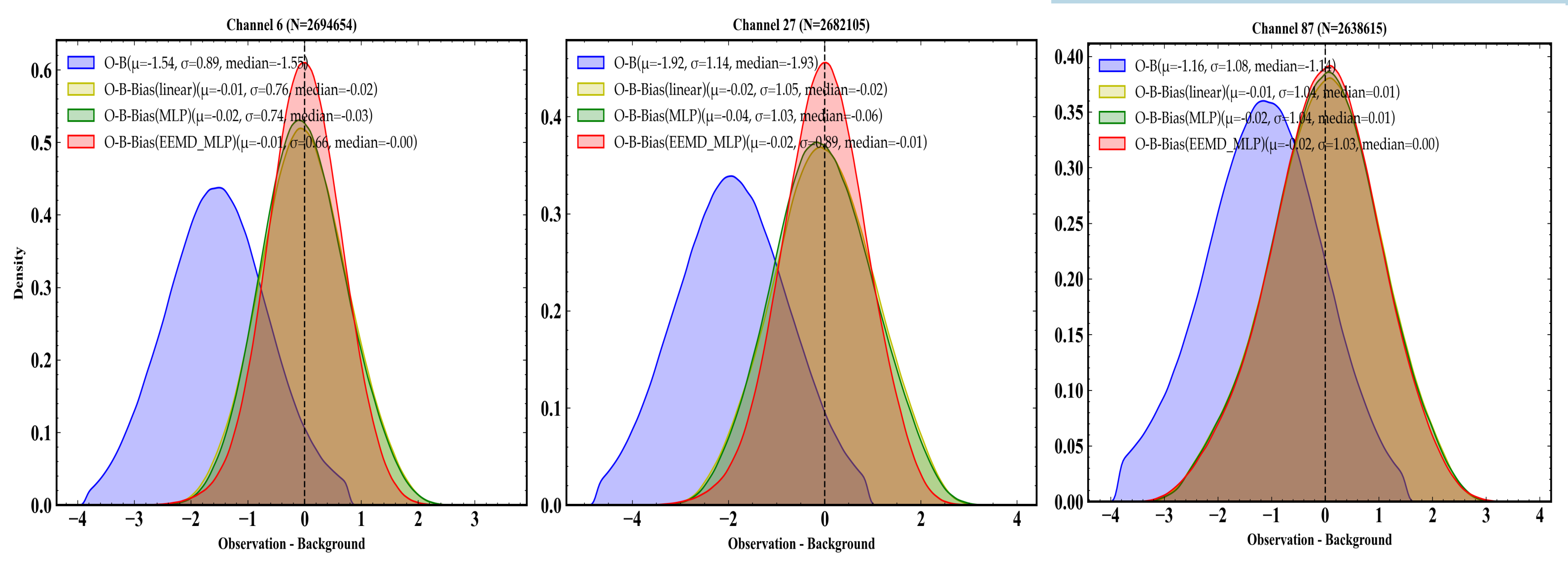
$$OMB_{i,j}(t) = MLP_{i,j}(q_t, p_t) + C_{i,j}(\tau^{0\ 24h})$$

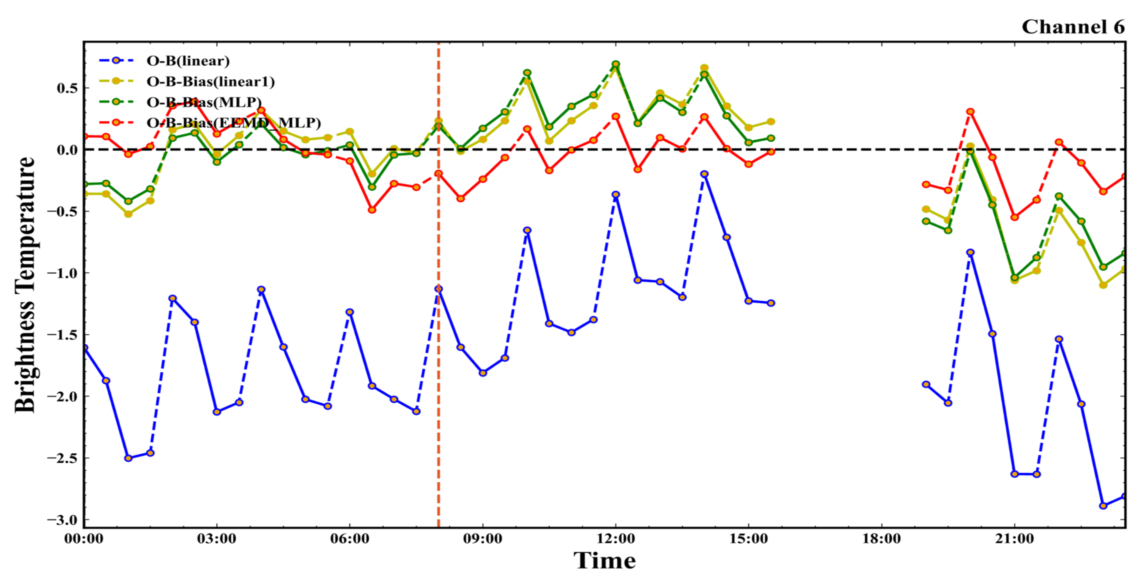


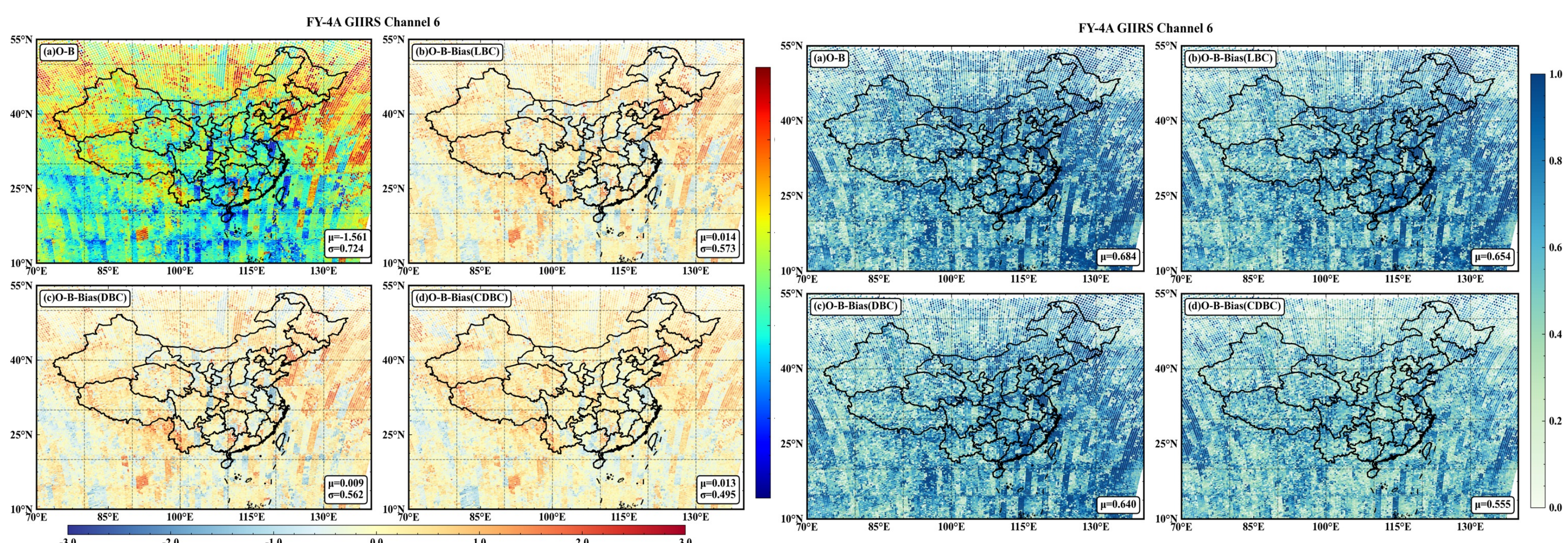




Experiments & Results







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