A Model of Polarization Correction for the Hyperspectral Infrared Atmospheric Sounder (HIRAS-II) of FY-3E

Zhiyu Yang[1], Chunyuan Shao[1], Mingjian Gu[1], Chunqiang Wu[2]

1. The Shanghai Institute of Technical Physics (SITP) of the Chinese Academy of Sciences (CAS), Shanghai,China
2. National Satellite Meteorological Center of China Meteorological Administration, Beijing, China

Background

- **What is the change from FY-3D to FY-3E?** The Hyperspectral Infrared Atmospheric Sounder (HIRAS) is a key payload instrument on-board FY-3 satellites. It is mainly used to retrieve atmospheric temperature and humidity profiles for numerical weather forecast and global climate change assessment etc. Compared with HIRAS, HIRAS-II of FY-3E has improved ground detection coverage (from 2x2 array of Field of Views to 3x3 array), spectrum and radiation calibration accuracy, and radiation detection sensitivity while maintaining the spectral band and spectral resolution unchanged.

- **Why should we focus on the polarization?** The polarization is one of the reasons that affect the accuracy of radiation calibration. As we all know, the reflection on slopes will always cause polarization effects. For HIRAS-II, the polarization of the scan mirror couples with that of the aft optics for spectral separation produces radiometric errors.

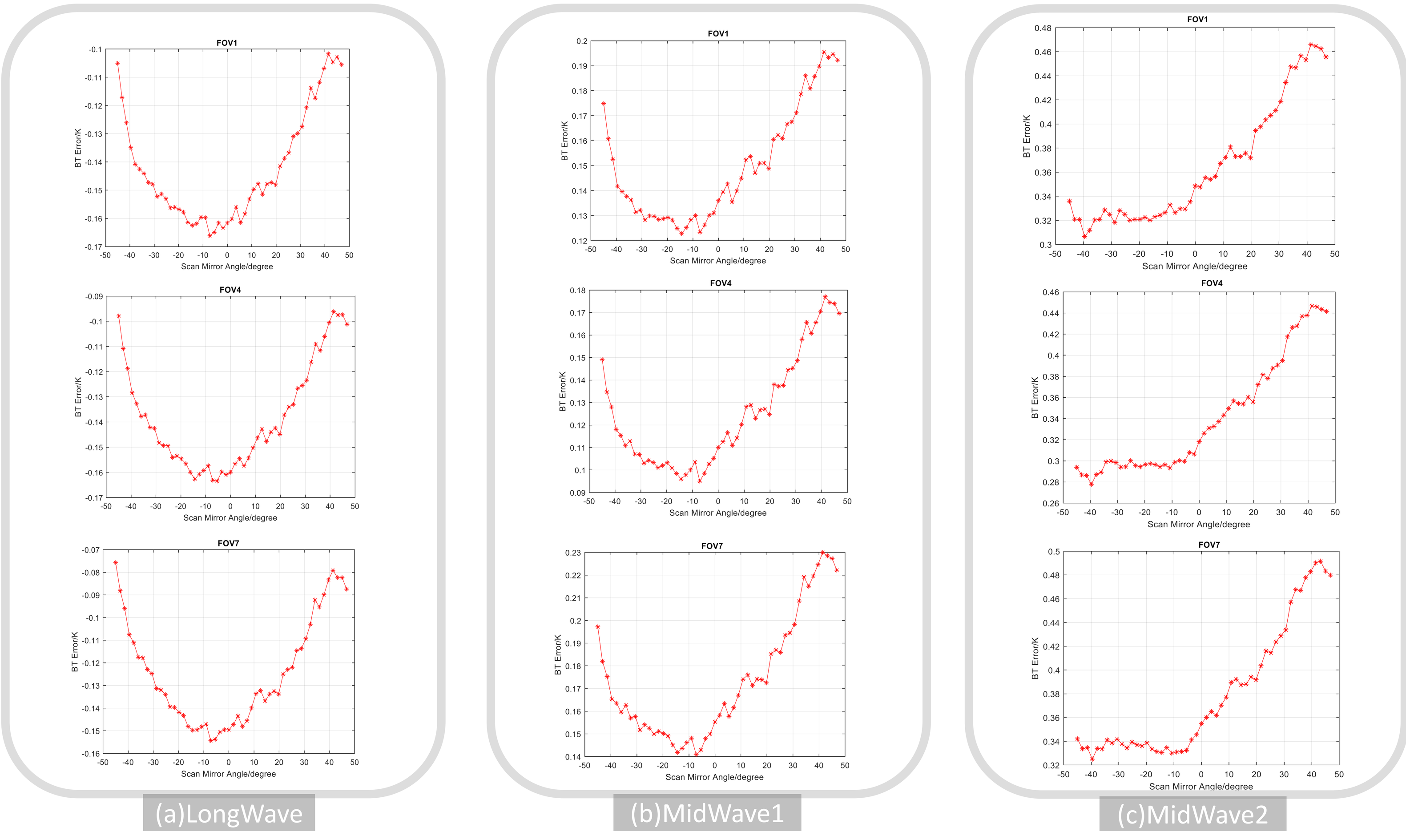

Fig.1 (a), (b), and (c) show the change of brightness temperature of FOV1, FOV4, and FOV7 with scan mirror angle in the LongWave (from 650 cm^{-1} to 1135 cm^{-1}), MidWave1 (1210 cm^{-1} to 1750 cm^{-1}), and MidWave2 (2155 cm^{-1} to 2550 cm^{-1}) band, respectively.

Methodology

This work applies a polarization correction model by using the measured data to refine the bias of the radiation calibration.

The Source of the Data: The observation data was obtained by rotating the scan mirror and the sub-stellar black body simultaneously by 1.8 degrees each time in the range of - 46.8˚ to + 46.8˚, and then observing the inner black body and the cold space respectively until all angles were rotated.

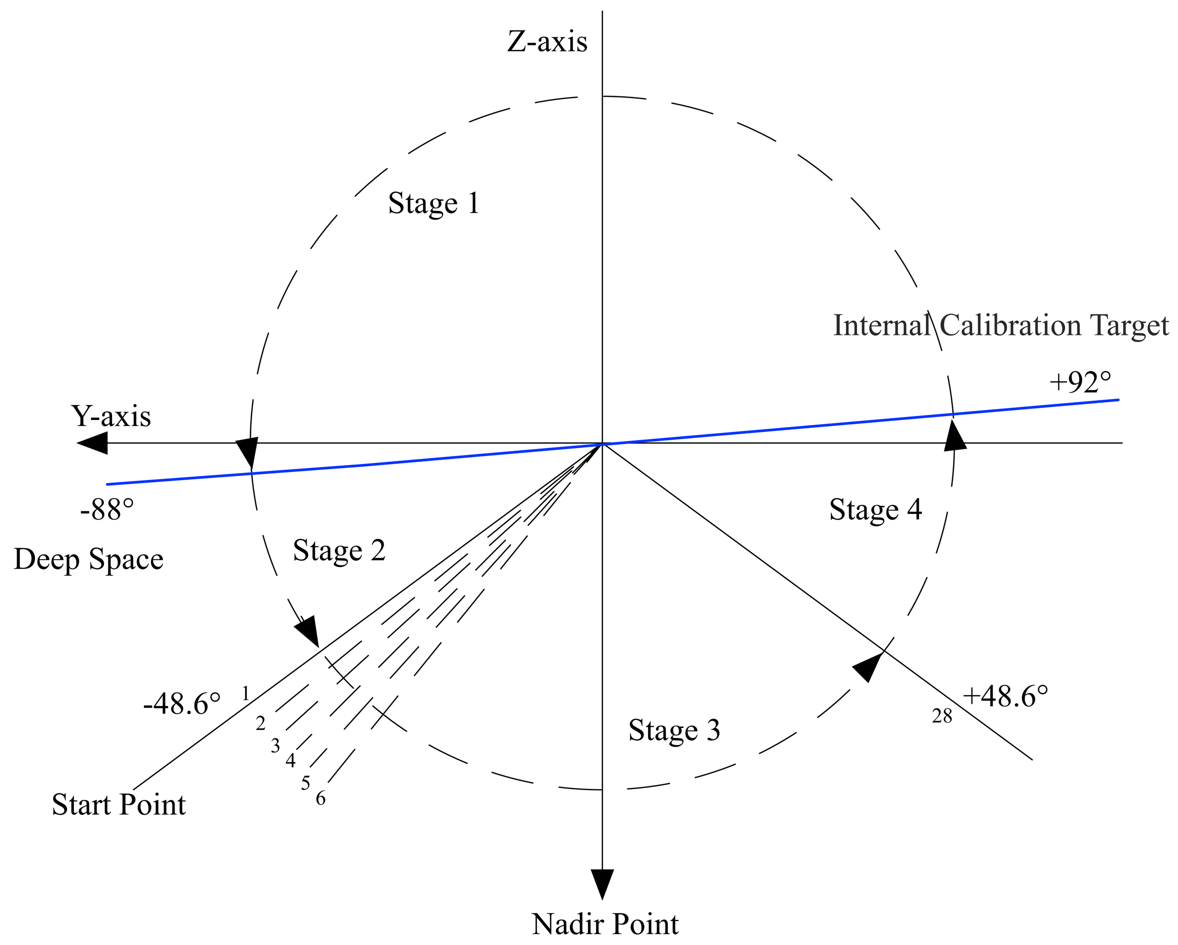

Fig.2 The diagram of experimental process.

Model: The model of the polarization correction was based on the work of the CrIS team.

$$E_{p,\delta_s}(v) = L_{\delta,Es}(v) - L_{Es}(v)$$

$$E_{p,\delta_S}(v) = p_r \cdot p_t \Big\{ R_S\cos[2(\delta_S-\alpha)] - R_{ICT}\left(\frac{R_S-R_{DS}}{R_{ICT}-R_{DS}}\right)\cos[2(\delta_{ICT}-\alpha)] - R_{DS}\left(\frac{R_{ICT}-R_S}{R_{ICT}-R_{DS}}\right)\cos[2(\delta_{DS}-\alpha)]$$
$$-B_{SSM}\left[\cos[2(\delta_S-\alpha)] - \left(\frac{R_S-R_{DS}}{R_{ICT}-R_{DS}}\right)\cos[2(\delta_{ICT}-\alpha)] - \left(\frac{R_{ICT}-R_S}{R_{ICT}-R_{DS}}\right)\cos[2(\delta_{DS}-\alpha)]\right] \Big\}$$

Solve: We used least square method to obtain the parameters, that are $\widehat{p_r p_t}$, $\hat{\alpha}$.

Where δ is SSM scan angle.

$$\widehat{p_r p_t}, \hat{\alpha} = \underset{p_r p_t,\alpha}{argmin} \sum_{\delta=1}^{n}[L_{\delta,Es}(v) - E_{p,\delta}(v) - L_{Es}(v)]^2$$

Results

The parameters are shown as follows.

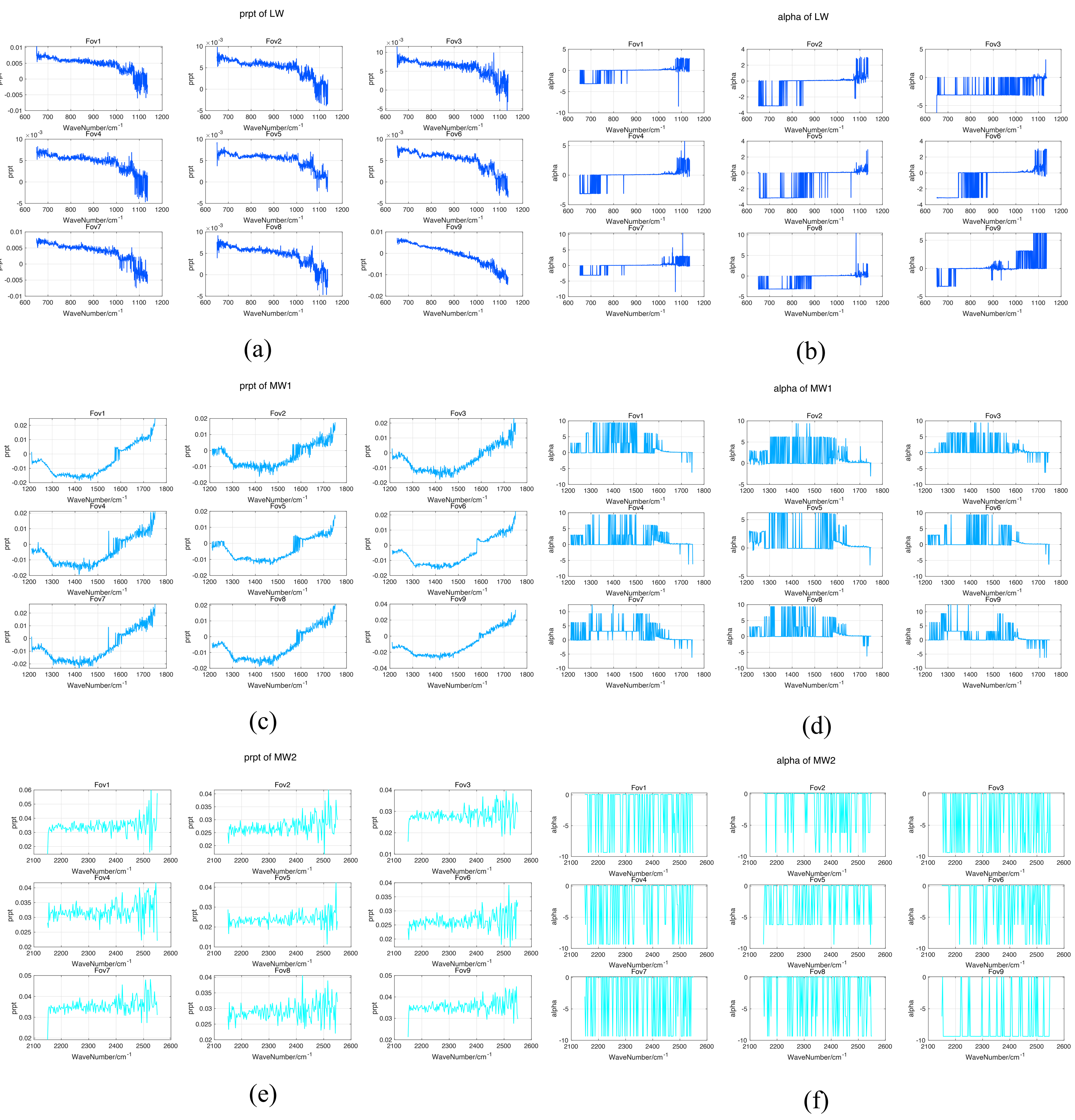

Fig.1 (a), (c), and (e) show the change of prpt of FOVs with the LongWave (from 650 cm^{-1} to 1135 cm^{-1}), MidWave1 (1210 cm^{-1} to 1750 cm^{-1}), and MidWave2 (2155 cm^{-1} to 2550 cm^{-1}) band, respectively; (b), (d), and (f) show the change of alpha of FOVs with the LongWave (from 650 cm^{-1} to 1135 cm^{-1}), MidWave1 (1210 cm^{-1} to 1750 cm^{-1}), and MidWave2 (2155 cm^{-1} to 2550 cm^{-1}) band, respectively.

Conclusion

- According to the results, the polarization correction in MW1 is better than the other two bands.
- The result depends to some extent on the initial values of the parameters given to the model.
- The relative brightness temperature bias due to polarization is about 0.1K. We found that this deviation increases as the absolute value of the angle increases.
- The results suggest that the scan angle-dependent polarization effect gives rise to a radiometric offset.
- Besides, the polarization effect is different at different FOVs and wavelengths.

Future

- Future refinements will focus on the impact of the polarization of the aft optics and build some physical models.
- We will validate these corrections during the in-orbit validation experiment.

References

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Corresponding author : yangzhiyu95@mails.ucas.ac.cn