Sensitivity Evaluation of TANSO-FTS/GOSAT Using Principal Component Analysis

Yu Someya[1] and Yukio Yoshida[1]

[1] Center for Global Environmental Studies, National Institute for Environmental Studies

Introduction

It is known that the sensitivities of the SWIR bands of TANSO-FTS have been degraded. Yoshida et al. (2012) evaluated these degradations by considering the wavenumber dependencies for each band using the solar calibration mode data. The degradation models estimated by Yoshida et al. (2012) have been used for the processing of the SWIR L2 products. Since September 2014, the pointing error had been large. Therefore, the pointing system was switched from the preliminary system (PM-A) to the back-up system (PM-B) on January 26, 2015. Due to this incident, it is needed to correct the degradation models by considering reflection function distribution. In addition, we found that there are some spectral dependencies of the time-independent variations of spectra. This study proposes a new algorithm based on principal component analysis (PCA) to evaluate the degradations and the degradation models of TANSO-FTS applicable for a whole period of the GOSAT observation was constructed.

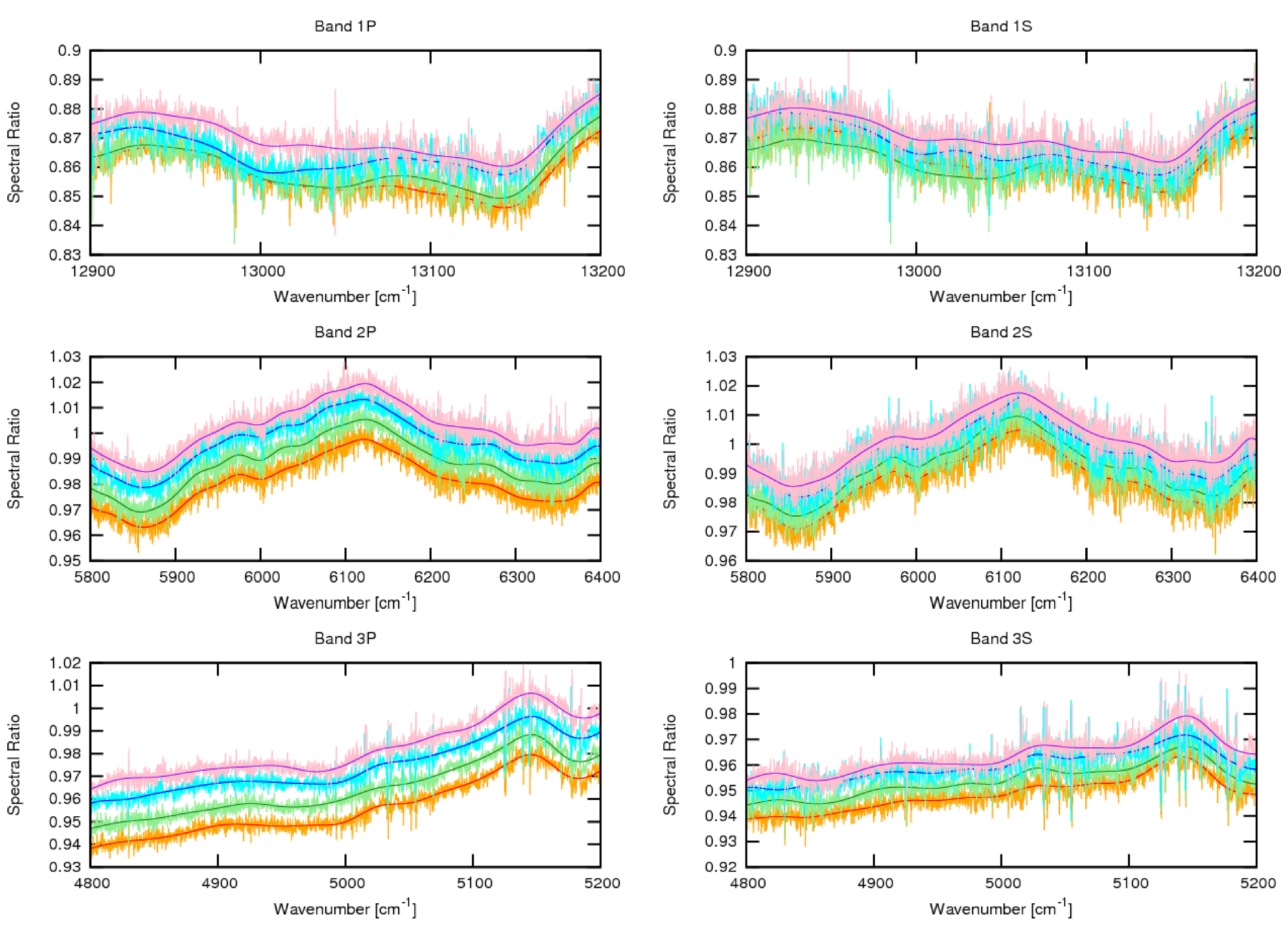
Strategy of constructing degradation model

Data selection

In this work, the solar calibration data with the back side of the diffuser plate of the product version V210.210 was used. To avoid the contamination from the terrestrial atmosphere, the data with the angle between the vector of the Earth to the satellite and that of the Earth to the sun is $105 \pm 0.5°$ was selected same as Yoshida et al. (2012).

1. Normalizing and interpolating spectra

The observed spectra were normalized by the calculated spectra and interpolated at every 25 cm^{-1}.



The normalized spectra and the interpolated spectra with $\theta_{in} = 42°$ on 29 January 2015 (purple), $\theta_{in} = 40°$ on 26 February 2015 (blue), $\theta_{in} = 36°$ on 25 March 2015 (green), $\theta_{in} = 32°$ on 27 April 2015 (red)

2. Decomposing dataset into PC scores and eigenvectors

The datasets composed with the normalized spectra were decomposed into the principal components (PC) and eigenvectors by singular vector decomposition (SVD).

$$\boldsymbol{x_i} = \frac{\boldsymbol{x_{obs_i}}}{\boldsymbol{x_{cal_i}}} - \frac{\boldsymbol{x_{obs_0}}}{\boldsymbol{x_{cal_0}}}$$

i : observation index

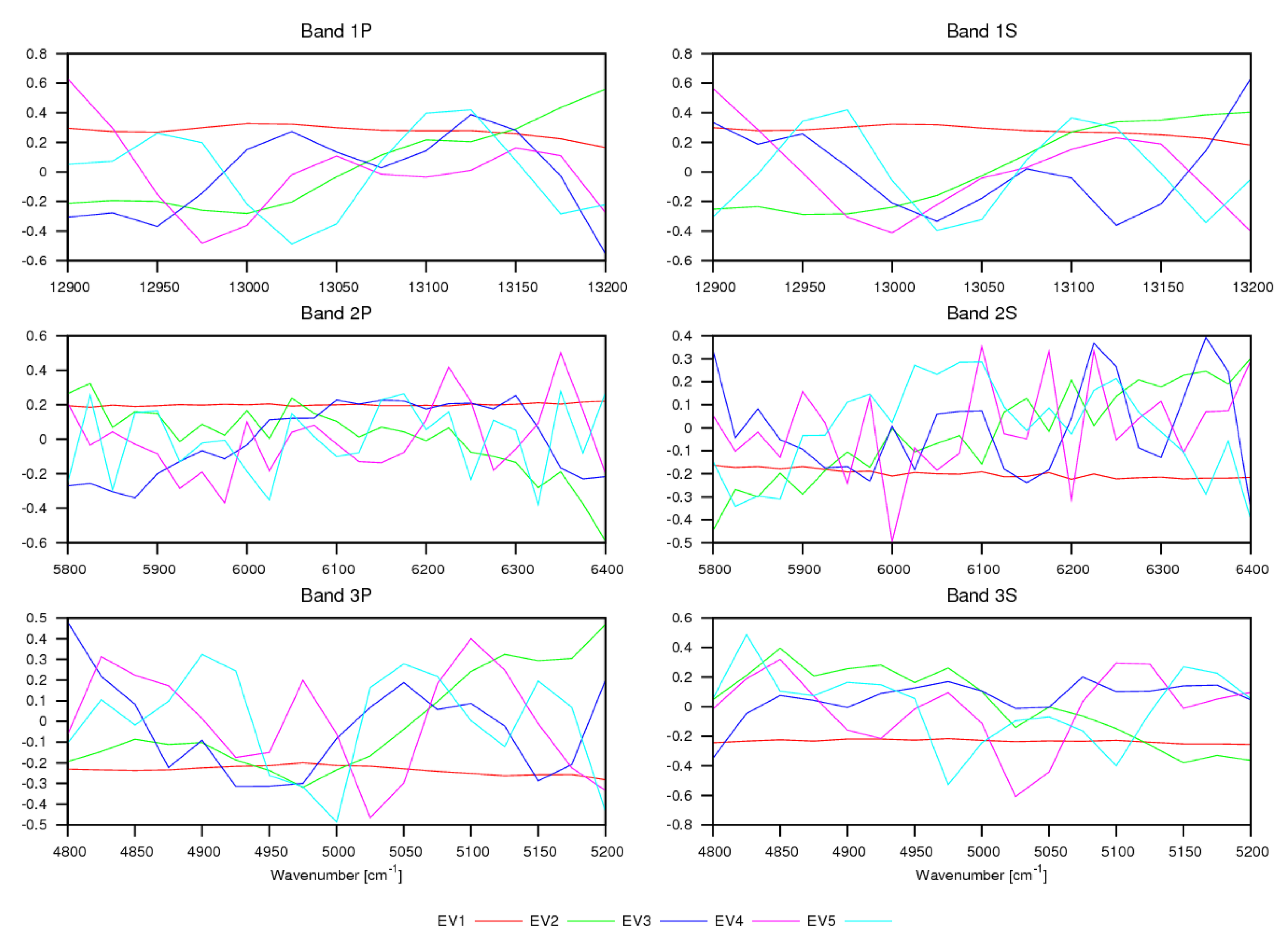
0: reference spectra obtained on March 4, 2009 with the incident angle to the diffuser plate (θ_{in}) is 33°

$$\boldsymbol{X} = \begin{pmatrix} \boldsymbol{x_1} \\ \vdots \\ \boldsymbol{x_N} \end{pmatrix}$$

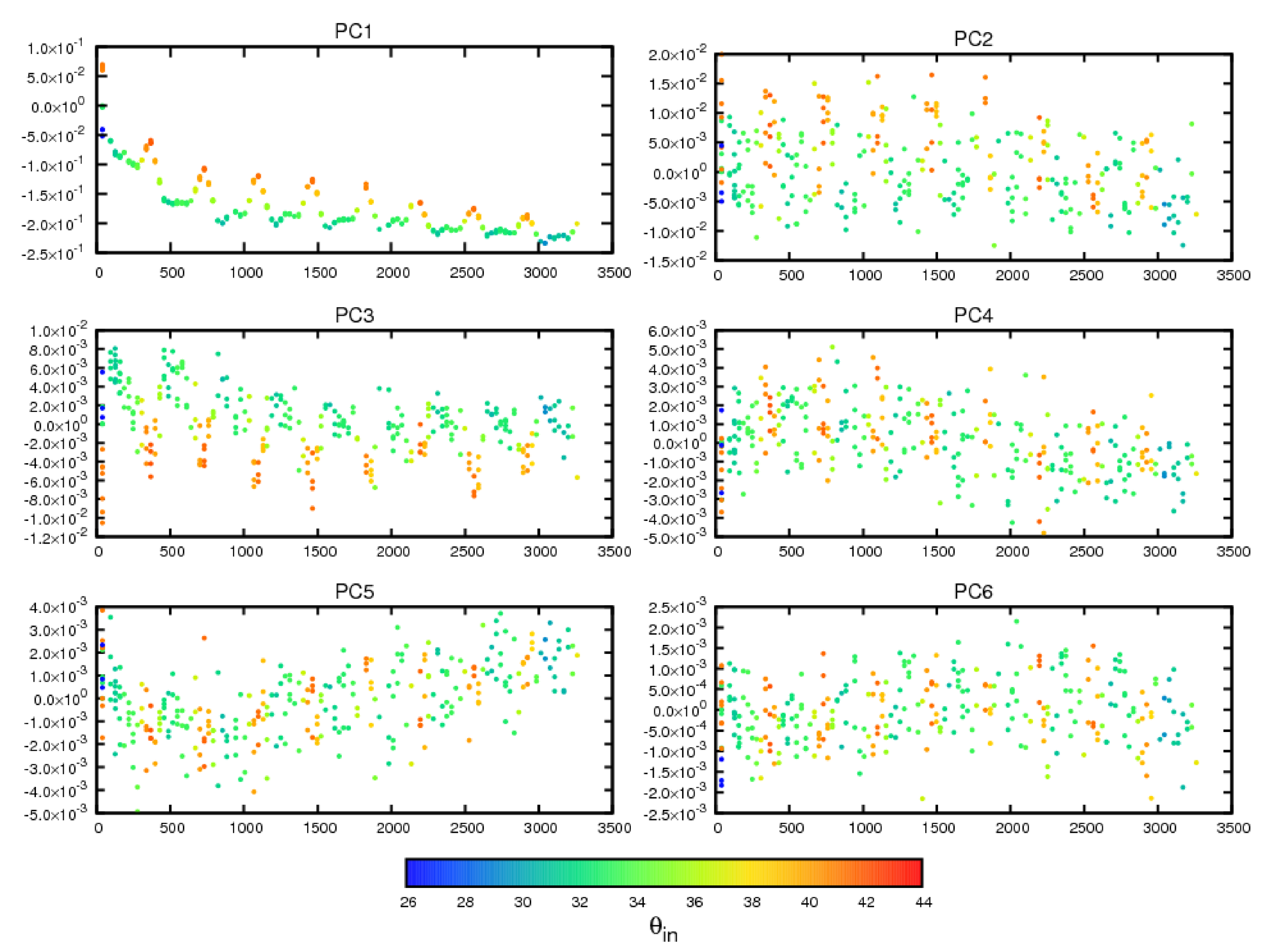
SVD : $\boldsymbol{X} = \boldsymbol{U\Sigma P^T}$

Columns of $\boldsymbol{P} \rightarrow$ Eigenvectors

PC scores : $\boldsymbol{T} = \boldsymbol{XP}$



1st to 5th eigenvectors (EV1 – EV5) for each band



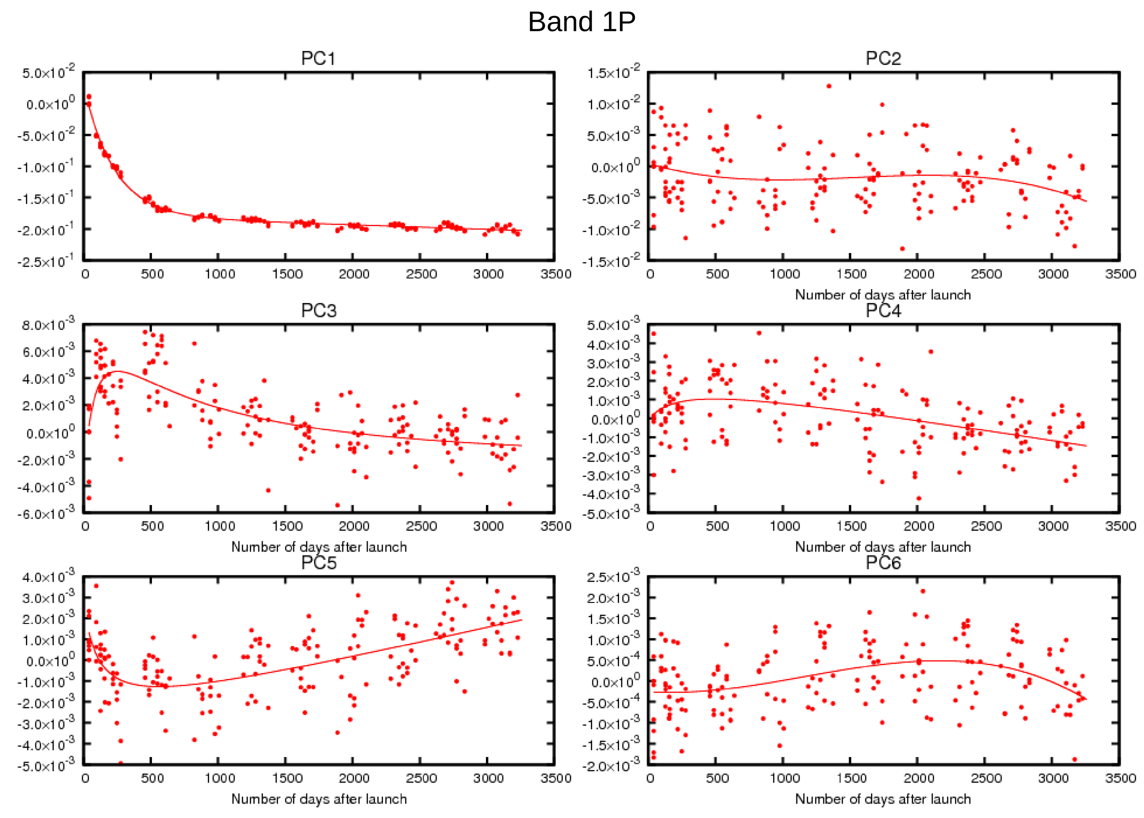
Time series of PC scores of PC1 – PC6 of the band 1P

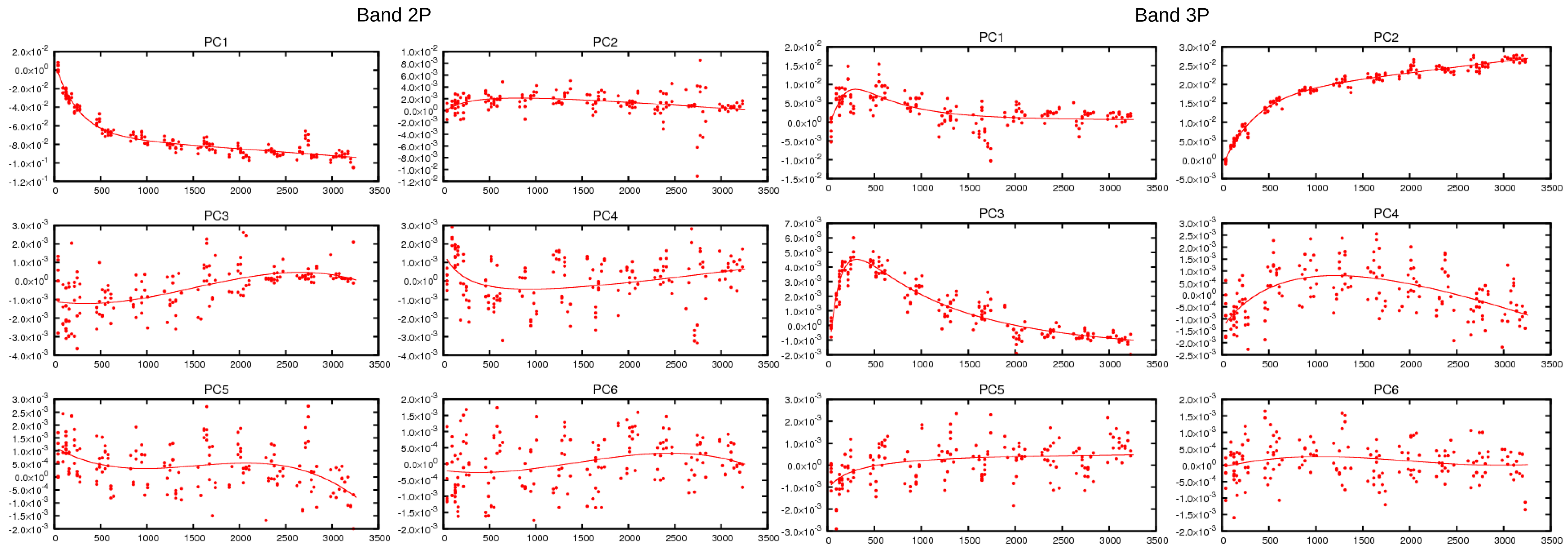
3. Correcting angular dependencies

The obtained time series of PC scores have annual variations related to the incident angle into the diffuser plate (θ_{in}). These angular dependencies were corrected. The variations were fitted by second order polynomials using the data obtained on May 20, 2009 and the values are corrected to those corresponding to $\theta_{in} = 33°$. The dependencies obtained for PM-B was corrected to those for PM-A before the operation.

4. Fitting temporal variations of PC scores

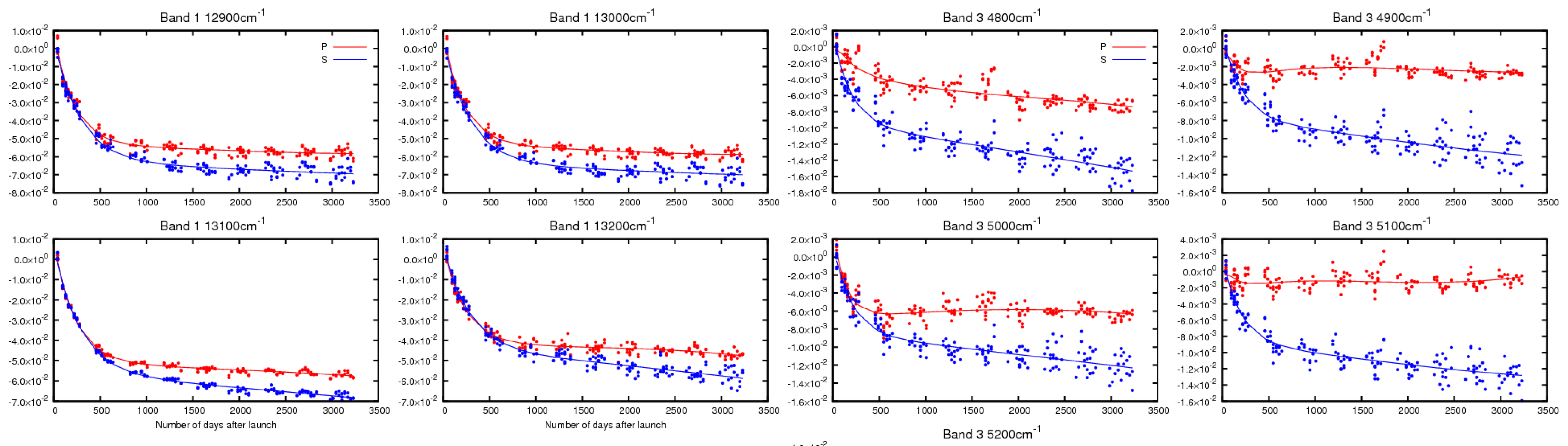
The corrected temporal variations of PC scores were fitted with the appropriate functions. Here, we used only the data with $\theta_{in} < 35°$. PC score matrix $\boldsymbol{T}$ was replaced to $\boldsymbol{T'}$ which is composed with the values estimated by the fitting functions.

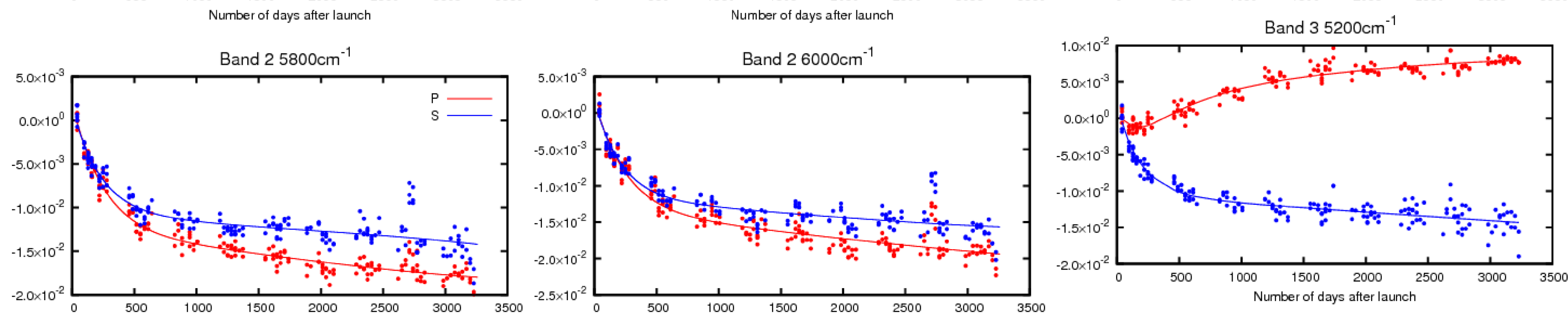


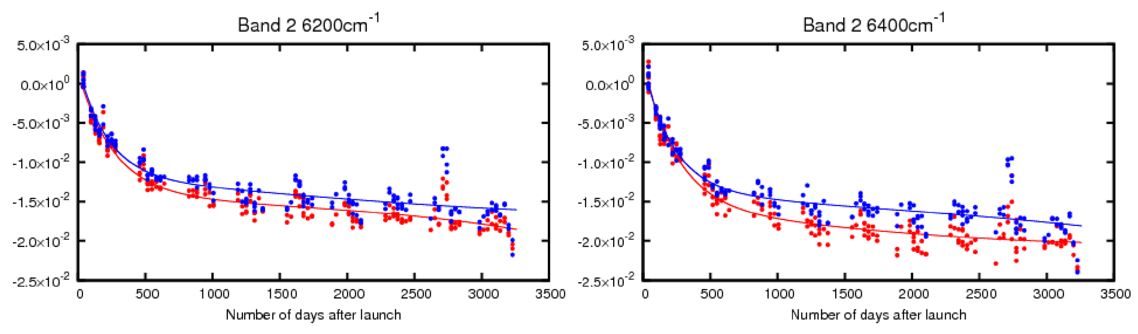


The corrected temporal variations of PC scores and fitting curves of PC1 – PC6 for band 1P, 2P, 3P

5. Reconstructing degradation model







Reconstructed change of sensitivities based on the data at March 4, 2009 using fitting curves for P and S polarizations at several points of each band (solid line) and the observed ones with θ_{in} correction.

The degradations were reconstructed by the equation:

$$\widehat{\boldsymbol{X}} = \boldsymbol{T'P'^T}$$

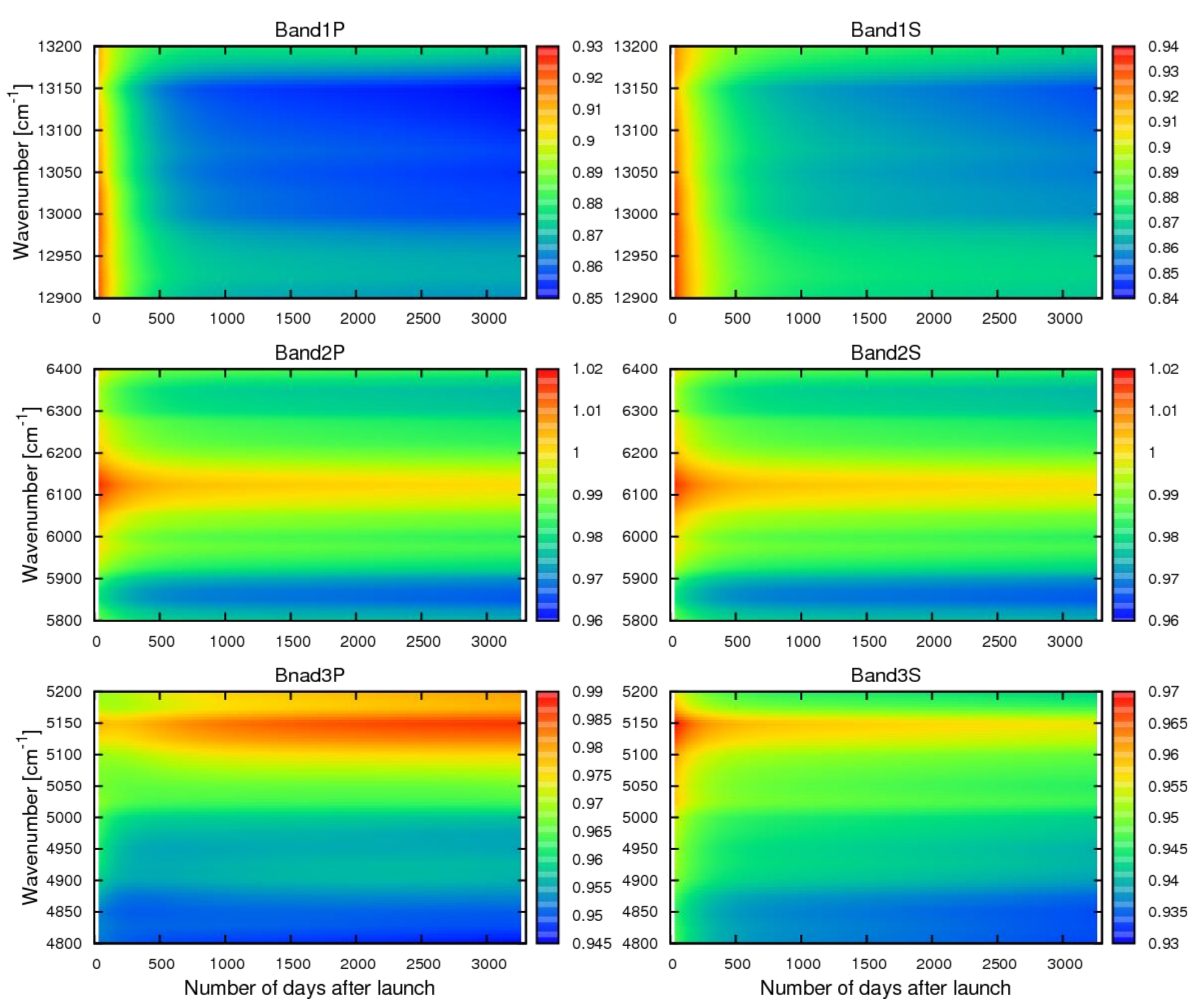
$\boldsymbol{T'}$: the reconstructed PC scores

columns of $\boldsymbol{P'}$: eigenvectors whose cumulative proportions account for exceeding to 0.95

The characteristics of the obtained degradation models are as follows.

- Sensitivities are exponentially decreased with time except to band 3P
- Magnitude of degradations are large in band 1
- That of band 3P is increasing

These are consistent with the report of Yoshida et al. (2012).



Reconstructed degradation models for each band

Future works

The new degradation model will be applied to the L2 retrieval system and the accuracy of the results will be evaluated with the TCCON measurements.

Reference

Yoshida et al. (2012), *Atmos. Meas. Tech.*