Evaluating SNPP CrIS Spectral Noise from 2012 to 2015 with Allan Deviation

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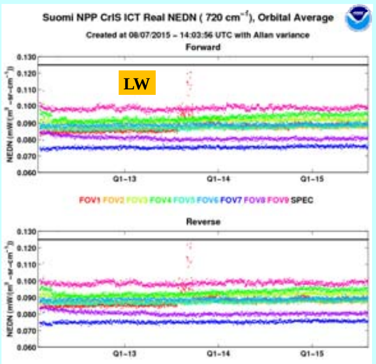
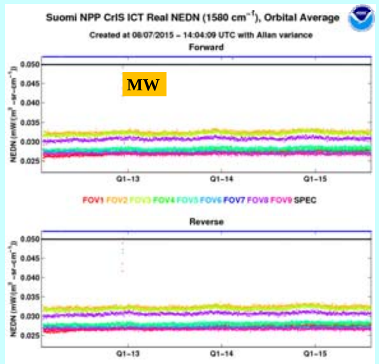
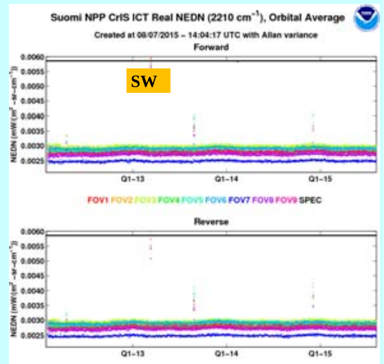
Abstract

The Cross-track Infrared Sounder (CrIS) onboard the S-NPP (Suomi National Polar-orbiting Partnership) satellite has been running for about three and a half years. The spectral noise and response are analyzed in this presentation. The Allan deviation , which is effective in removing drifting trend in a time series, is used to calculate the spectral noise for each orbit. CrIS has three bands (LW/MW/SW). Each band has 9 field-of-views (FOVs) scanning in two directions. Four wavenumbers of each band are selected to show the temporal evolution: 650/720/830/1050 cm^{-1} for LW, 1240/1375/1580/1710 cm^{-1} for MW, 2150/2210/2355/2515 cm^{-1} for SW. It is found that the real part noise of the hot reference has almost no change since the beginning of the mission, indicating a sustainable stable sensor status. The imaginary part noise of the cold reference is very sensitive to the stability of the platform.

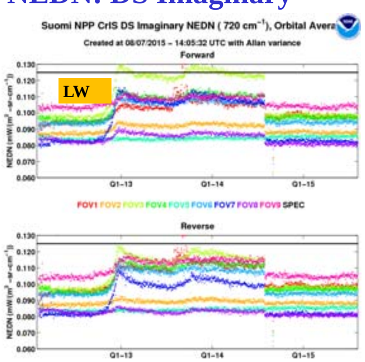
NEDN: ICT Real

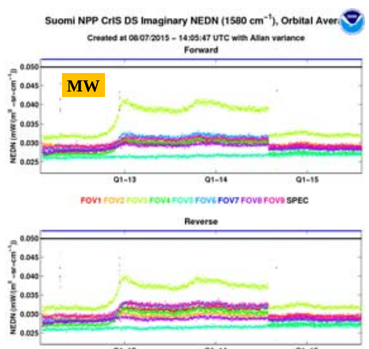


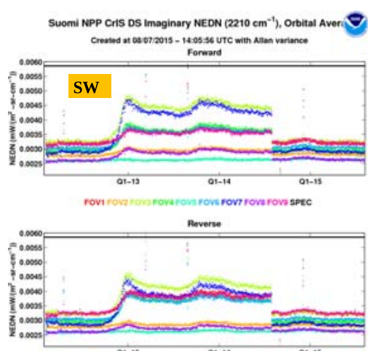




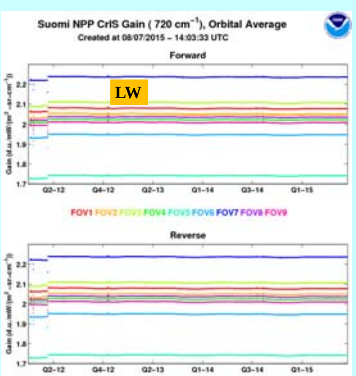
NEDN: DS Imaginary

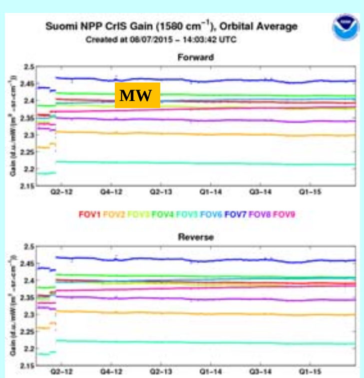


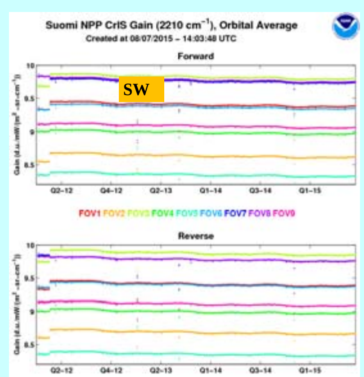




Gain







Method:

Step 1: Derive Gain of each orbit:

$$Gain = \frac{<S_{ICT}> - <S_{DS}>}{<P_{ICT}>}$$

where S is the spectral count per scan; DS and ICT represent the cold and hot reference, respectively; P is the blackbody radiance; <> is the orbital average operator.

Step 2: Derive the radiance of reference target per scan:

$$R_{ICT} = \frac{S_{ICT} - <S_{DS}>}{Gain}$$

$$R_{DS} = \frac{S_{DS} - <S_{DS}>}{Gain}$$

where R_{ICT} and R_{DS} and are complex value.

Step 3: Derive the NEDN with Allan deviation:

$$\sigma_y^2(\tau) = \frac{1}{2}\langle(\bar{y}_{n+1} - \bar{y}_n)^2\rangle = \frac{1}{2\tau^2}\langle(x_{n+2} - 2x_{n+1} + x_n)^2\rangle$$

Conclusions:

The CrIS spectral noise is analyzed with Allan variance method. Most of the drifting effect is removed and it is found that CrIS sensors have very stable noise features in term of the hot reference, except the LW FOV1 which suffered a sudden jump of noise between July and Sept. of 2013, before returning back to normal status. All of the sensors, except the MW FOV7 which is known very noisy before launch, have much lower noise relative to the specification. The imaginary part noise of the cold reference, however, is sensitive to the shaking of the satellite platform, especially for the corner FOVs. ATMS main motor shaking in the late 2012 and the satellite orbital inclination angle adjustment on July 31, 2014 are two major events triggering the significant change of DS imaginary part noise.

The spectral response is also evaluated. It is found that the LW sensors have almost no degradation since the mission. The MW sensors have noticeable but different changes among difference sensors. All of the SW sensors have suffered a 2~3% degradation.