# An Advanced Full Radiance Transformation System For Spaceborne Microwave Instrument


**Hu Yang[1] and Fuzhong Weng[2]**

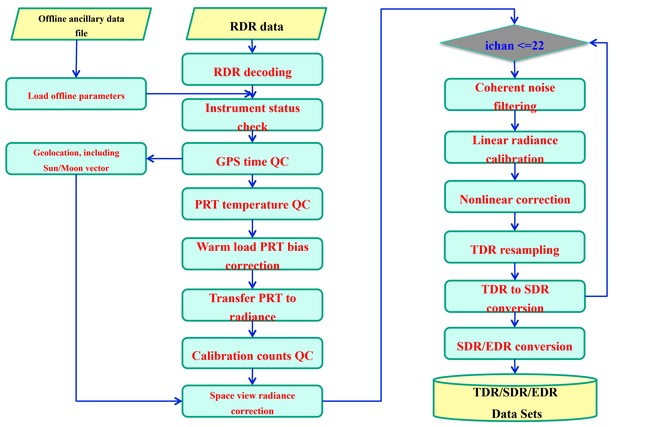
1. UMD/ESSIC, College Park, MD and 2. NOAA/NESDIS/STAR, College Park, MD



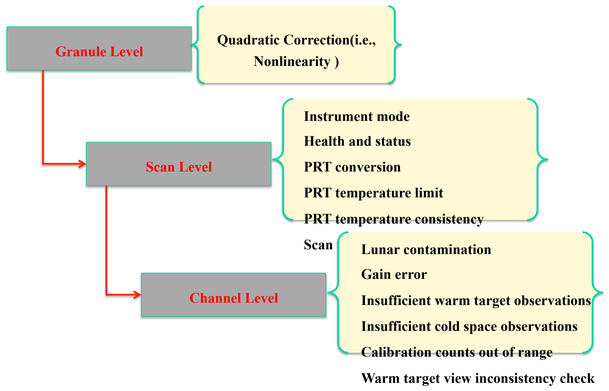
**Abstract:** **In history, NOAA operational calibration for microwave instruments was derived in radiance. In general, the radiance describes the amount of electromagnetic energy radiated by a blackbody in a** thermal equilibrium **as a function of its temperature and wavenumber through Planck's function. In the current IDPS, Suomi NPP ATMS calibration is derived in brightness temperature through Rayleigh–Jeans approximation which has biases in cold temperature and high frequencies. For JPSS ATMS TDR processing, a full radiance transformation system (ARTS) is being developed. From the lessons studied from Suomi-NPP ATMS calibration, several major improvements are also made for ARTS, which include FFT-based destriping algorithm for warm and cold calibration counts, scan bias correction for warm target and cold space radiance, and refined lunar contamination correction for cold space calibration counts. Using RDR as inputs to ARTS, TDR and SDR can be generated directly with a high quality for many applications such as radiance assimilation in NWP system.**


## ARTS System and Software Engineering

ARTS is designed as a robust, sustainable and scientifically defensible operational calibration system for future JPSS satellite. It is a Full radiance calibration system with consistent calibration algorithm for different sensors, capable of transfering raw observation data from counts to radiance/brightness temperature at different spatial resolutions



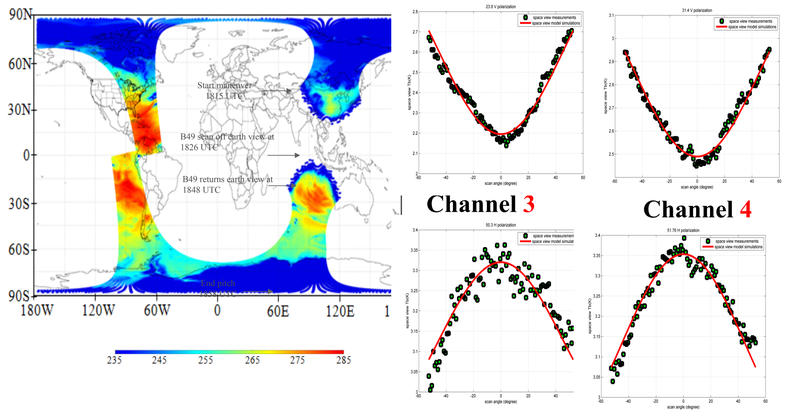

**Different level of Quality control with PCT as inputs makes system being sustainable**




## Full Radiance Calibration with Reflector Emissivity Correction

Normally, a scene temperature dependent term and a constant bias term are used in R-J calibration equation. However, after applying correction by them it will still have residual errors that are dependent to temperature and frequency in the corrected calibrated temperature. Especially, when the scene temperature is close to cosmic background temperature, large bias will present when applying the R-J calibration equation with Tc correction.

Calibration results for space view scene brightness temperatures in temperature space are not equal to the cosmic background temperature 2.73K. In addition, abnormal scan angle dependent feature is also observed in deep space observations




Antenna emission is modeled as function of scan angle and corrected in two-point calibration. For cold space and warm load calibration target, the radiation is corrected by equation below:

**For Vertical Polarization Channels:**

$$R_{Qv} = R_{rfl} + r_h\left(R_s - R_{rfl}\right) + [(R_s - R_{rfl})(r_h^2 - r_h)]sin^2\theta$$

**For Horizontal Polarization Channels:**

$$R_{Qh} = R_{rfl} + r_h\left(R_s - R_{rfl}\right) + [(R_s - R_{rfl})(r_h^2 - r_h)]cos^2\theta$$

***Rs:*** **Radiance of cold/warm calibration target**

$R_{rfl}$**:** **Radiance of antenna reflector**

$r_h$**:** **Antenna reflectivity**

$\theta$**:** **Scan angles of calibration target**

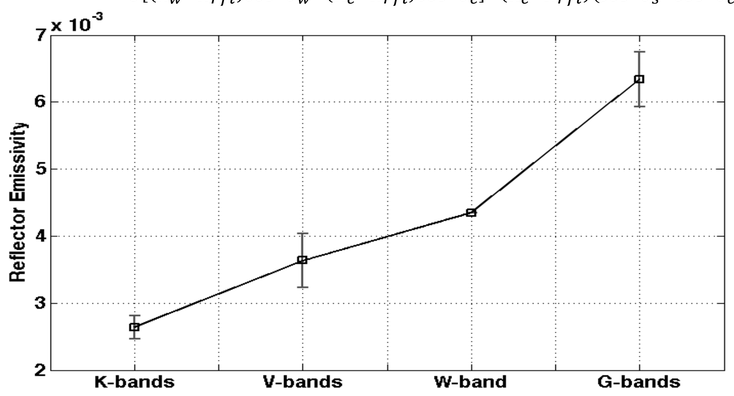
By applying two-point calibration equation, The reflector emissivity can be determined by equations below:

**For QV channels:**

$$\varepsilon = \frac{\delta(R_w - R_c)}{\delta[(R_w - R_{rfl})sin^2\theta_w - (R_c - R_{rfl})sin^2\theta_c] - (R_c - R_{rfl})(sin^2\theta_s - sin^2\theta_c)}$$

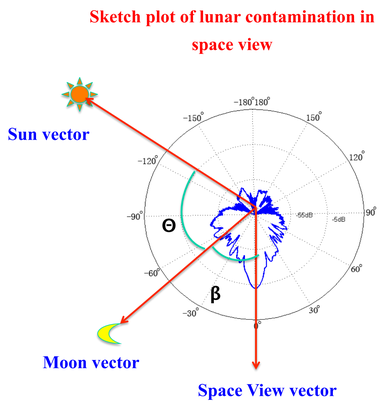
**For QH channels:**

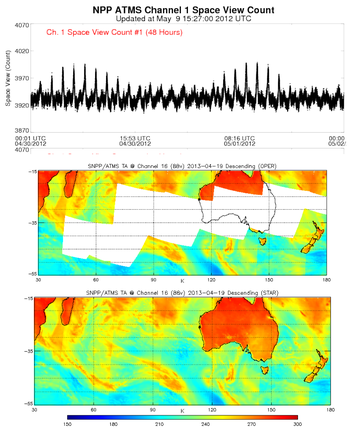
$$\varepsilon = 1 - (1 - \frac{\delta(R_w - R_c)}{\delta[(R_w - R_{rfl})cos^2\theta_w - (R_c - R_{rfl})cos^2\theta_c] - (R_c - R_{rfl})(cos^2\theta_s - cos^2\theta_c)})^2$$




## Lunar Contamination Correction

For ATMS, seperation angle between the Moon vector and space view vector determines magnitude of lunar contamination in cold calibration counts: when the moon approaches center of FOV, and the angle is in less than 1.25 3dB beam width, the lunar intrusion become significant. This can be used as metric for LI identification. The space view brightness temperature increment can be written as function of antenna response function, weight of moon, and brightness temperature the moon.

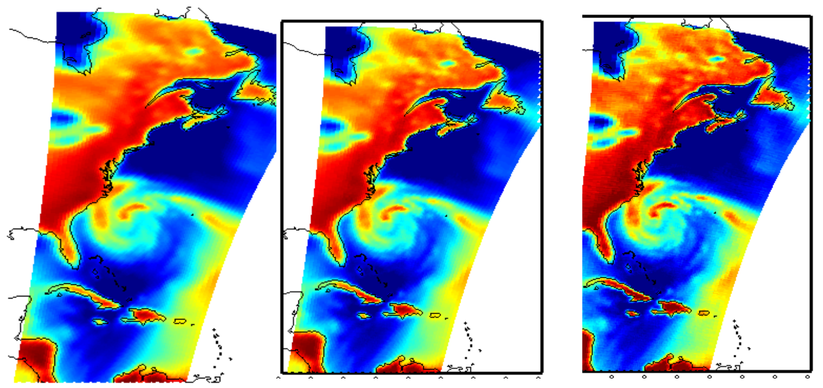



## Observation Remapping

Backus-Gilbert observation reconstruction algorithm is used to explore the potential of the oversampling characteristic of ATMS observations and generate observations at different frequencies with consistent FOV size. Remapping coefficients are tuned to ensure the remapped products are in best balance between noise and spatial resolution

**FOV 5.2°** **FOV 3.3°** **FOV 2.2°**



## Conclusion

- **ARTS is a full radiance calibration system designed for microwave sounding instruments. With new sciences developed from solid study of SNPP ATMS, the calibration accuracy of TDR products from future JPSS satellite will be improved**
- **ARTS is designed as a robust, sustainable and scientifically defensible operational calibration system for future JPSS satellite, and also can be used as test bed for developing new algorithm.**