CGMS-XXXII
PRC-WP-06
Prepared by CMA
Agenda Item:II/2

CALIBRATION FOR FY METEOROLOGICAL SATELLITES

Summary and purpose of paper

This paper briefs on the calibration approaches for FY meteorological satellites, geo-stationary and polar-orbiting. The conclusion is that field calibration and inter calibration are reliable approaches of post launch calibration for FY satellites. Operational update of calibration coefficients is realized for polar-orbiting meteorological satellite FY-1. Access to timely NOAA satellite data for operational use of inter-calibration method for the FY-2 satellite is the major concern.

CALIBRATION FOR FY METEOROLOGICAL SATELLITES

1. INTRODUCTION

CMA/NSMC operates two series meteorological satellite: FY-1, the sun-synchronous polar-orbiting satellite series, and FY-2, the geo-stationary satellites. The FY-1 satellites are 3-axis stabilized and the FY-2 spin-stabilized. The payload instrument onboard the FY satellites are the multi-channel visible and infrared scan radiometer (MVISR). Calibration for the instrument is implemented before and after launching the satellite.

Pre-launch Calibration

Pre-launch calibration for visible channel of MVIST is conducted outdoor in carefully selected areas in Kunming and Dali, Yunnan Province of China. There is usually considerable error with the result of field calibration because of inconsistent outdoor condition that influences the calibration, for instance, the changing solar angle, and air qualities (water vapor contents, aerosol etc.).

For infrared channels, the pre-launch calibration is done in a vacuum container simulating the space environment. The instrument is calibrated with reference to the black body.

Post launch Calibration

For FY satellite that has already been operating in the orbit, two approaches are mainly relied on to calibrate the instrument: one is by the field radiation calibration, and the other is inter-calibration.

2. CALIBRATION

2.1 Calibration for Visible Channels

As there is no calibration unit for visible channels onboard the FY satellite, pre-launch calibration is largely relied on and often used as a standard for other calibration methods.

For visible channel of FY geo-stationary satellite, the solar image at midnight is taken with a triple prism. However, as it’s difficult to obtain the albedo accurately from the solar image before the satellite is launched, the solar image is only taken as a reference to monitor the attenuation of visible sensors.

Post-launch calibration for visible channel is by taking the measurement on the calibration field (Dunhuang Calibration Site), and making comparison with the synchronous satellite observation. The measurements include the surface reflectivity, atmosphere optical thickness, and water vapor content. Processing of the measured data is with 6S model to calculate the incoming radiation at the satellite, which is further used to calculate the calibration coefficients.

The field calibration is implemented for visible sensors on geo-stationary satellite, as well as on the polar-orbiting satellite, because chances can always be found for polar-orbiting satellite to leave the sub-point footprint on the calibration site. The 47^{o} zenith angle of FY-2 operational geo-stationary satellite (normal position 105E) is relatively unchanged to the calibration site. As it exceeds the 30^{o} limit, the BRF correction is carried out in data processing for the calibration site.

2.2 Calibration for Infrared Channel

There is a black body calibration system on the satellite, so it is possible to make on-orbit calibration for infrared channels.

The FY-1 polar-orbiting satellite is with a 3-axis stabilized structure. The optical path of the black body signal is consistent with the optical path of the object; the obtained black body calibration is called absolute calibration, with which the relationship is setup between the telemetry black body temperature, and the readout of black body digital count value.

The FY-2 geo-stationary satellite is with a spin-stabilized structure. The sensor takes signal from the black body regularly. However, the input signal from the black body and the input signal from the object share only part of optical paths with each other. The fact that two signals take different optical paths traveling through to the sensor makes it impossible to get absolute calibration value for IR channels. Though theoretically, equivalent coefficients can be derived for this 'two optical paths system' by pre-launch calibration, the actual orbit condition often makes that effort invalid. The on-orbit calibration relies on the electric signal calibration, and the quantitative relation between the two processes established before satellite is launched.

Post-launch calibration for IR sensors is also provided on the Qinghai Hu Lake Calibration Site for both polar-orbiting and geo-stationary satellites. The measurements of radiation over the lake water surface, the atmospheric optical thickness and air water vapor content are taken. MOTRAN model is used to calculate the satellite incoming radiance. For FY-1 satellites, the zenith angle must be less than 30^{o} to be selected for calibration. The zenith angle of FY-2 geo-stationary satellite is 36^{o}. But the Qinghai Hu Lake is still used for geo-stationary satellite calibration on the account that IR measurement is not largely dependent on direction.

2.3 Inter Calibration

The operation-oriented inter-calibration study uses NOAA satellite data to calibrate FY-2 geo-stationary satellite. The GAC data of AVHRR channel 4 from NOAA-16, 17 were used for calibrating FY-2 long-wave IR channel. The CH12 (WV) of HIRS/3 of NOAA-17 was used to calibrate WV channel of FY-2.

The experiment achieved an ideal result, and now the effort is being spent on using this method operationally for FY-2B satellite. The only concern in doing it operationally is that there is no timely AVHRR data for FY-2 calibration. NOAA/GAC data by Internet is one or two days old for operational inter-calibration at NSMC.