CGMS-XXVII WP-08
Prepared by PRC
Agenda Item: II/2

The Inter Calibration between FY-2A and NOAA

Summary

This paper presented here is about inter calibration between the radiometer on FY-2A and the radiometer of AVHRR channel 4 on NOAA-14. Inter calibration method relies on the simulation relationship corresponding to the radiance of FY-2A IR channel and the radiance of NOAA AVHRR IR channel. These two kinds of sensors have almost the same spectrum responsive function. So it is possible to make the use of the same scene from both satellites with the same satellite zenith angle and the nearest scanning time, to build up the matched database after screening out the clouds and being uniformed the spatial resolution. After that, the inter-calibration relationship of these two corresponding IR channels' radiance can be acquired in according to the different satellite zenith angle. The results of inter calibration can help us to assess the errors in the calibration procedure of FY-2A IR channel, and can make it into practice to merge the data from multiple satellite sensors of different kinds. This kind of inter calibration method seems to be very sensitive, accurate and tractable. None needs of any kinds of in situ experiments, can it be auto-operationally controlled.

1 Introduction

In the quantity application and the analysis of merged data, we should make inter calibration for the radiometer data with dissimilar spectrum respond function and dissimilar spatial resolution from different satellites, so as to make the better use of their predominance both of their time-space and spectrum resolutions. The results of inter calibration can not only help us to assess the errors in the calibration procedure and reduce calibration uncertainty, but also to determine the fluctuations associated with seasonal cycle for the sensor of geostationary meteorological satellite, and day-night cycle for the sensor of polar-orbiting meteorological satellite.

In our research work, by using of the radiation transmission model of Lowtran 7, we have achieved the radiation simulation equation, and by using of iso-secant observations of the same scene from both satellites we have build up the matched database. And then we have actualized the inter calibration between IR channel of FY-2A and AVHRR channel 4 of NOAA. The principle used here is also the same with other infrared radiometer sensor's inter calibration.

2 The Rationale of the Radiation Simulation

Inter calibration method relies on the simulation relationship corresponding to the radiance of FY-2A IR channel and the radiance of NOAA AVHRR channel 4. Spectral response differences are accounted here.

The radiant energy reaching the top of a plane-parallel stratified atmosphere overlying a black surface at pressure P_0 can be calculated as follows:

$$R(\nu) = B(\nu, T_0)\tau(\nu, P_0, \theta) + \int_{P_0}^{0} B[\nu, T(P)]\frac{d\tau(\nu, P, \theta)}{dP}dP \qquad (1)$$

Where B is the Plank function at frequency ν and temperature T, τ is the atmospheric transmission at frequency ν from the pressure P to the satellite, θ is the zenith angle for the observed scene, T (P) is the profile of temperature variety with pressure P.

The mean radiance R measured in a spectral interval ν_2 to ν_1 is obtained from:

$$R(\nu^*) = \int_{\nu_1}^{\nu_2} R(\nu)f(\nu)d\nu \Big/ \int_{\nu_1}^{\nu_2} f(\nu)d\nu \qquad (2)$$

Where f (ν) is the normalized spectral response function of the radiometer in the interval

ν_2 to ν_1 .

To simulate the radiometric observation of the same scene by FY-2A and NOAA AVHRR channel 4, synthetic radiance computations were performed on the basic radiation transmission model of Lowtran 7.

If two infrared radiometers on different satellites have the similar normalized spectral response functions, we can achieve many groups of radiation pair of $R(\nu_2^*)$ and $R(\nu_1^*)$ corresponding to a lot of atmospheric profiles in different zenith angles, here $R(\nu_2^*)$ for FY-2A and $R(\nu_1^*)$ for NOAA AVHRR channel 4. Then we can obtain the simulation relationship of $R(\nu_2^*)$ to $R(\nu_1^*)$:

$$R(\nu_2^*) = a_0 + a_1 R(\nu_1^*) + a_2 R(\nu_1^*)^2 \qquad (3)$$

This equation is the foundation of following research work.

3 The Procedure of Matching Data

First of all, the measurements from the two sensors must be collocated in space and time, so we select the same scene from FY-2A and AVHRR, but their time interval is confined in 30 minutes.

On the second step, the spatial resolution differences must be considered. The sampling boxes that we use to mitigate the data from both sensors is 25km*25km, so we match 5*5 FY-2A pixels up with 25*25 AVHRR pixels.

And the third step, we should minimize the viewing angle differences of two sensors. For the geostationary satellite FY-2A, the iso-viewing-angle lines are a set of concentric circularity. But for the NOAA satellite, the iso-viewing-angle lines are a set of parallel beeline. We minimize the viewing angle differences into 0.05° .

The forth step we must put the day night differences in calibration into our consideration. We just try to set up two inter calibration equations for day and night orbit.

After all of the considerations above, we must consider the cloud contamination of the radiance and the scene uniformity. By using of thresholds method of multiple channels, we can screen out the cloud, and get clear sky scene. The pixel number that contaminated by cloud is under 10%. For the consideration of the scene uniformity, we confine the max absolute value difference of pixel count minus mean count to 10.

At the same time, the inter calibration of two sensors requires that statistical significance of the sample must be adequate.

Then we can get the relationship of two sensor's digital count I_θ（ν_1^*）、I_θ（ν_2^*）.

4 Result of inter calibration

Now, we have got the equation of two sensor's radiance and the relationship of two sensor's digital count. Additional with the in-flight calibration of AVHRR, we can get the inter calibration equation of FY-2A infrared radiometer:

$$R（\nu_2^*）= c_0^* + c_1^* I(\nu_2^*)$$

5 Conclusion

The method we used here for the in-fling calibration of FY-2A radiometer from calibrated radiometer of NOAA-14 is mainly characterized by the fact that it is very sensitive, accurate and tractable. The inter calibration line of FY-2A may be obtained daily from the beeline least-squares fit on numerous calibration points. No needs of any kinds of in situ experiments, can it be auto-operationally controlled. The results of inter calibration can help us to assess the errors in the calibration procedure of FY-2A IR channel, and can make it into practice to merge the data from multiple satellite sensors of different kinds.