Stability analysis of microwave emissivity in Simao Yunnan using SSM/I data

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Abstract: The Microwave Temperature Sounder, the Microwave Humidity Sounder and the Microwave Radiation Imager were flown on the new-generation polar satellite FY-3A in China. The microwave sensors' calibration after launch is a critical problem. Using the SSM/I data, and the surface and raob observations, the stability of microwave emissivity in Simao Yunnan is analyzed based on the microwave modeling in this article. The results show that its vegetation situation is very good, and the surface microwave emissivity is stable. The surface microwave emissivity has weak season-to-season variation in law of sines (the changing range is less than 0.02). It also has very small year-to-year difference, which can be corrected by modeling based on the surface and raob observations.

Key words: Simao Yunnan, microwave emissivity, stability analysis, SSM/I

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1 INTRODUCTION

The Microwave Temperature Sounder, the Microwave Humidity Sounder and the Microwave Radiation Imager were flown on the new-generation polar satellite FY-3A in China since May 2008. These microwave data may be used to retrieve the vertical structures of atmospheric temperature and humidity, cloud parameters, rain rate and the surface hydrometeorological parameters, etc. However, the excessive radiation observing error will not only make the retrieved products useless, but also affect the quantificational applications, especially the numerical model application. It is critical to make sure that the microwave data is accurate enough (Ulaby *et al*., 1981).

Before launch, the microwave sensor's calibration parameters were obtained via laboratory and vacuum calibration processes. As the difference of space environment from surface and the aging of instrument components, the microwave radiometer's characteristic will change, which will result in calibration error. There are ordinarily two ways to calibrate the microwave sensors after launch: the cross calibration (relative calibration) and field calibration (absolute calibration). The cross calibration uses the observation of similar microwave radiometer on board other satellites at the same time and same location. The absolute calibration is carried out by observing the surface target with known microwave characteristic, and comparing the observed and modeled satellite brightness temperature. Absolute calibration is also the primary aim of establishing the microwave calibration field. Many scholars studied the related issues and got some achievements (Wenz, 1997; Colton & Poe, 1999; Prigent *et al*., 2000; Eric *et al*., 2003; Earth Observation Research and Application Center, 2004; Wessel *et al*., 2008).

By widely examining the microwave remote sensing data, we found the best steady area of emissivity in China is in Simao, Yunnan. Based on microwave radiation transfer model analysis, the article further reviewed and analyzed quantificationally the microwave emissivity stability in Simao by use of DMSP SSM/I (Special Sensor Microwave/Image) (Wenz, 1997) data and the corresponding surface and raob data (Hollinger, 1990).

2 MODEL AND DATA

The article uses microwave radiation transfer model to analyze the stability of surface microwave emissivity in Simao in a long time. Given the surface and atmospheric parameters which are the input of the model, we could compute the microwave radiation and brightness temperature at a given surface emissivity. The retrieved surface microwave emissivity is got by changing the surface emissivity until the brightness temperature of modeled and satellite-observed are equal.

Long-time matched data is needed for the stability analysis of emissivity characteristics. The sounding time of raob data is

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0 and 12GMT, which is no more than 1 hour difference compared to DMSP F-13 time of flying over Simao, Yunnan. The SSM/I is a seven- channel passive microwave radiometer operating at four frequencies (19.35, 22.235, 37.0, and 85.5 GHz) and dual-polarization (except at 22.235 GHz which is V-polarization only) (Hollinger, 1990). For convenient the seven channels are noted as 19V, 19H, 22V, 37V, 37H, 85V and 85H. Table 1 gives the frequency, polarization, calibration accuracy and resolution of SSM/I. It shows that the calibration accuracy of SSM/I is very high (all channels are below 1K).

The F-13 SSM/I data was projected in 25km Ease-grid format. We picked up all the SSM/I observed data within 1º×1º range of Lincang, Simao, screened out the raining pixels, and averaged the pixels without rain as the matched satellite brightness temperature.

During the modeling of microwave radiation transfer, the atmospheric absorption is computed using the method of Phil Rosencranz to compute the absorption coefficient of Oxygen and water vapor, and then compute the atmospheric transmission based on temperature, pressure, humidity and some experimental coefficients. Because the surface characteristic of Simao is similar to tropical rain forest, it is reasonable to assume that the surface is isotropic Lambertine. The model VDISORT (Vector Discrete Ordination Radiative Transfer) is used for microwave radiation transfer modeling (Weng, 1992).

Table 1 The frequency, wavelength, polarization, and effective (3dB) spatial resolution for SSM/I

frequency /GHz	Wavelength /mm	Polarization	Calibration accuracy/K	Footprint Along /km	Footprint Cross /km
19.35	15.5	V	0.45	69	43
19.35	15.5	H	0.42	69	43
22.235	13.0	V	0.73	50	40
37.05	8.1	V	0.37	37	28
37.05	8.1	H	0.38	37	29
85.50	3.5	V	0.69	15	13
85.50	3.5	H	0.73	15	13

Based on the surface and raob data of 2003 and 2004, the emissivity is obtained when the brightness temperatures of modeled and satellite observed are equal, which is used to evaluate the stability of emissivity in and between a year. The surface temperature used is the 2m air temperature. The modeling of SSM/I ascending and descending brightness temperatures uses the observed atmospheric temperature and humidity profile at 12GMT and 00GMT.

3 THE ANNUAL VARIATION OF SIMAO MICROWAVE EMISSIVITY

The emissivity of Simao, Yunnan is computed in 2003 and 2004. We showed here the result of 2004 to investigate its annual variation. Fig. 1 to 3 are the emissivity of SSM/I seven channels using the above matched data. Fig. 4 draws the day rain amount and the emissivity of channel 19V in one figure to show the possible effect of rain to emissivity.

Before analyzing the above curves, we need to pay attention to the following two main error sources:

(1) The screening algorithm of SSM/I to eliminate raining pixels is very accurate, but it has some difficulty to screen out the pixels of very weak rain rate, and it is difficult to screen out

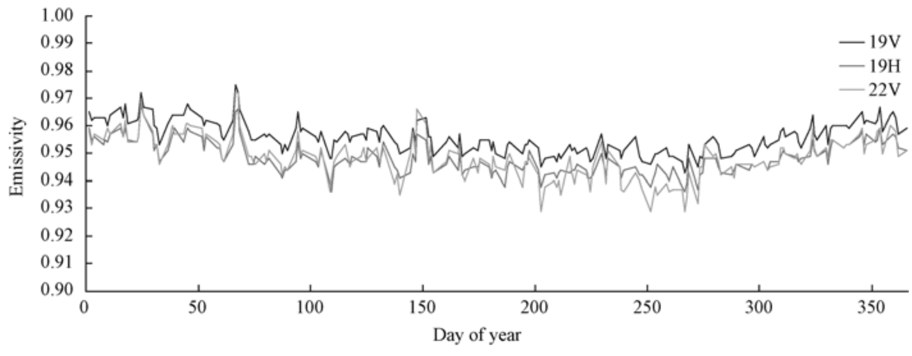

Fig. 1 The emissivity variation of channels 19V, 19H and 22V in 2004

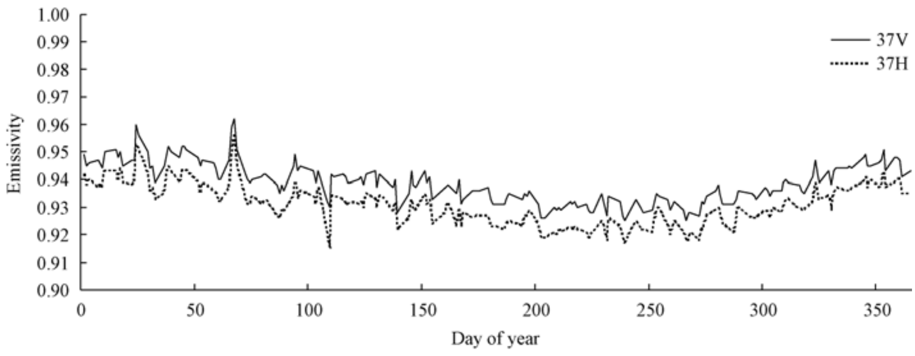

Fig. 2 The emissivity variation of channels 37V and 37H in 2004

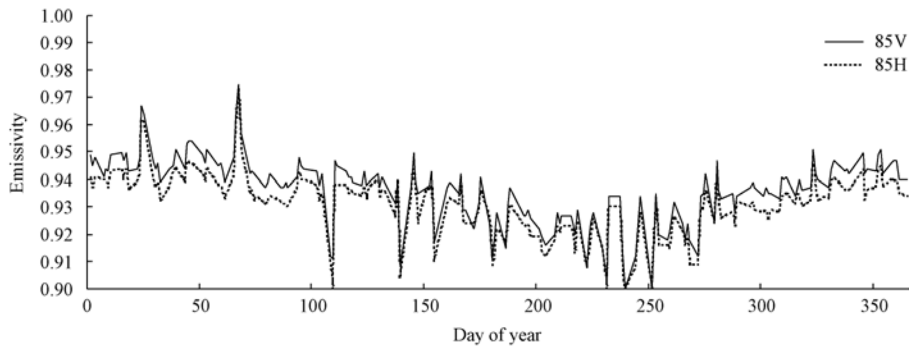

Fig. 3 The emissivity variation of channels 85V and 85H in 2004

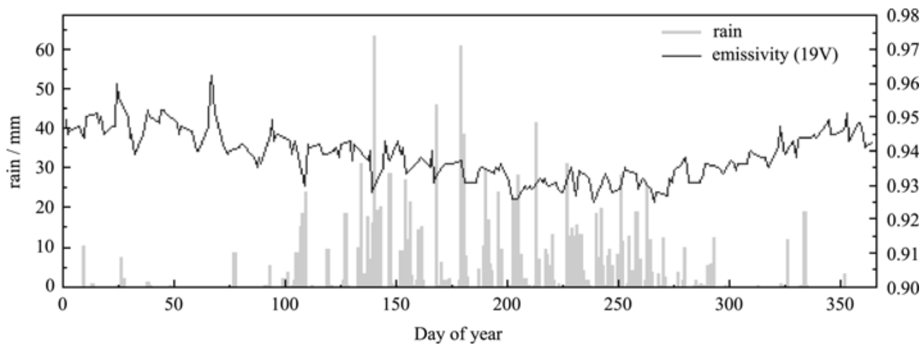

Fig. 4 The day precipitation amount and emissivity variation of channel 19V in 2004

cloudy pixels as it is penetration to cloud. So we used the cloudy data observed by meteorological station to help screen out the cloud.

(2) The 0cm surface temperature observed by the meteorological station of Simao, Yunnan can not represent the 0cm surface temperature of the total pixel area. As the resolution of microwave pixel is from several to several decade kilometers, one-point observation of surface temperature can not represent the average temperature of total pixel area. So we chose the 2m air temperature to represent the temperature of the pixel.

From Fig. 1 to 4, it is shown that:

(1) As can be seen from Fig. 1 to 3, the emissivity of 19.35GHz is 0.95—0.96, 22.235GHz 0.94—0.96, 37.0GHz 0.92—0.94, 85.5GHz 0.91—0.96. The emissivity of SSM/I's 4 frequencies are all high and over 0.9 except 85.5GHz with a few pixels under 0.9.

(2) As can be seen from Fig. 4, there are a lot of rain from April to September in Simao, Yunnan in 2004. During this period, the emissivity of most-sensitive-surface channel 19V is randomly distributed and not affected very much by the surface humidity, which means that the vegetation cover rate is very high and not affected by precipitation very much.

(3) The emissivity of 7 channels shows weak law of sine. The emissivity is highest in winter (from December to January), and lowest in Summer (from August to September).

(4) The emissivity variation range of 85.5GHz is larger than other frequencies. The reason is that the screening algorithm of SSM/I could not eliminate the cloudy and weak rain pixels which will affect the radiation of 85.5GHz.

To eliminate other affecting components such as weather, wind speed, and the random error of microwave instrument itself, the matched data was removed if daily rain amount is bigger than 5mm or wind speed is larger than 0.8m/s. Then the other matched data was averaged in 101 days (before and after 50 days). The averaged results are shown in Fig. 5 to 7.

The results of Fig. 5 to 7 are obtained after screening out the data of day rain amount bigger than 5mm or wind speed larger than 0.8m/s, which eliminate the errors caused by the representative of surface and raob data in the model. As can be seen from Fig. 5 to 7, the emissivity is very close to the averaged emissivity. The averaged emissivity may represent the climatic background emissivity of Simao, Yunnan. It can be seen that they have small weak law of sine, but the variation extent is very small (lower than 0.02), and change very slowly, which shows indirectly that the vegetation cover situation of Simao is stable.

Fig. 8 shows the difference of averaged and modeled emissivity at 4 vertical polarization channels at hour 12 in 2004. The emissivity difference is converted to brightness temperature difference as in Fig. 9. Fig. 8 shows that most emissivity difference is below 0.01, except that there are a few pixels of 85V reaching 0.017. Fig. 9 shows that the errors are within 2K by substituting averaged emissivity with actual ones, except that one point is 2.025K on 85V.

4 THE MICROWAVE EMISSIVITY DIFFERENCE BETWEEN YEARS IN SIMAO

For comparison of emissivity variation between years, we draw the averaged emissivity of 2003 and 2004 in one map in

Fig. 10 to 12. Because H polarization and V polarization is very similar, only the V polarization maps are given.

As can be seen from Fig. 10 to 12, the emissivity of 2003 and 2004 shows some difference (max difference is 0.008) from January to mid-April, but is very close at other time. The emissivity of 2004 is higher than 2003, which indicates that the surface vegetation condition of 2004 is better than 2003.

In order to more intuitively review the emissivity variation

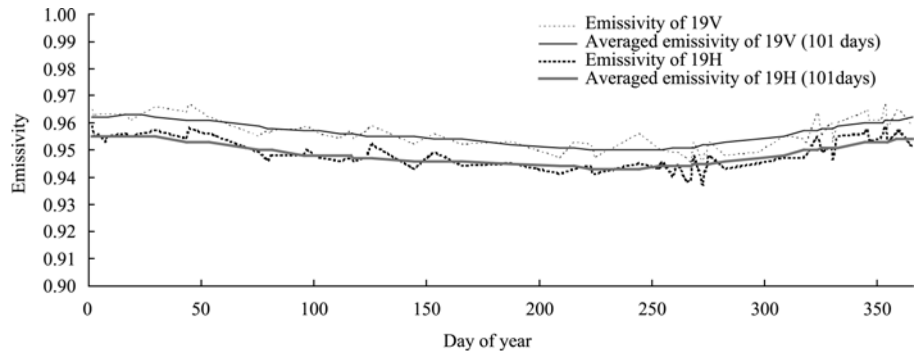

Fig. 5 Emissivity and averaged emissivity of channels 19V and 19H at hour 12 of 2004

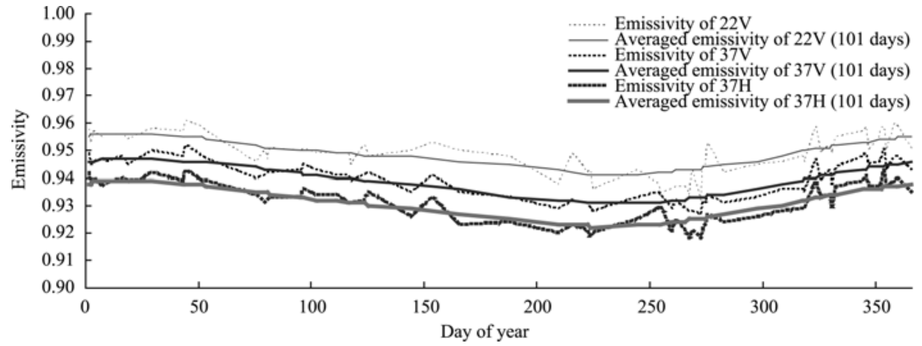

Fig. 6 Emissivity and averaged emissivity of channels 22V, 37V and 37H at hour 12 of 2004

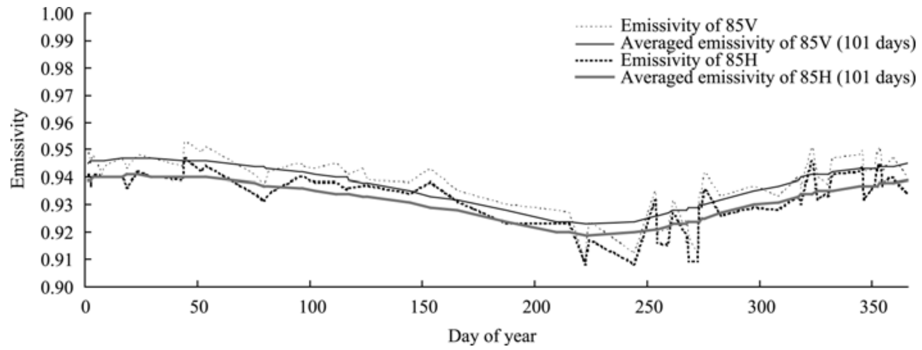

Fig. 7 Emissivity and averaged emissivity of channels 85V and 85H at hour 12 of 2004

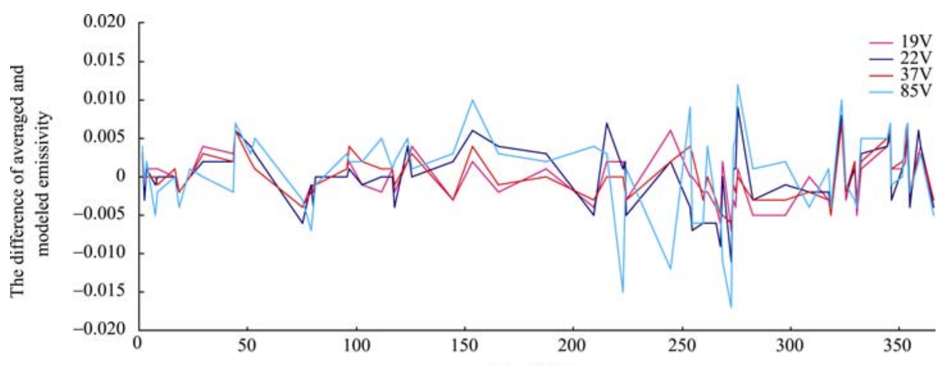

Fig. 8 The difference of emissivity and averaged emissivity at hour 12 of 2004

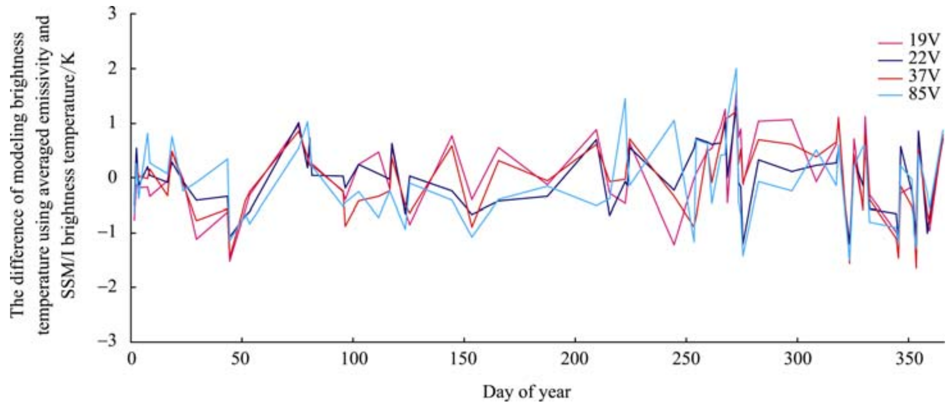

Fig. 9 The difference of modeling brightness temperature using averaged emissivity and SSM/I brightness temperature at hour 12 of 2004

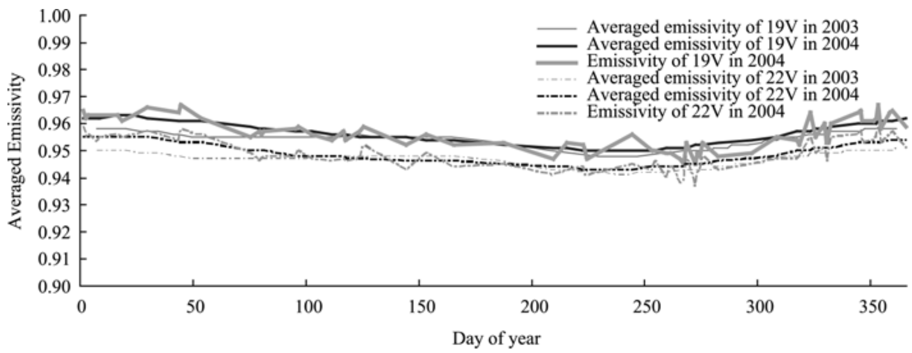

Fig. 10 Averaged emissivity in 2003 and 2004, emissivity in 2004 of channels 19V and 22V

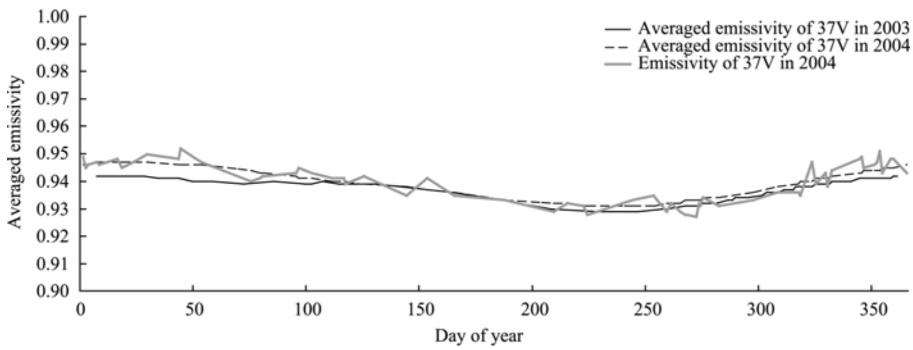

Fig. 11 Averaged emissivity in 2003 and 2004, emissivity in 2004 of channel 37V

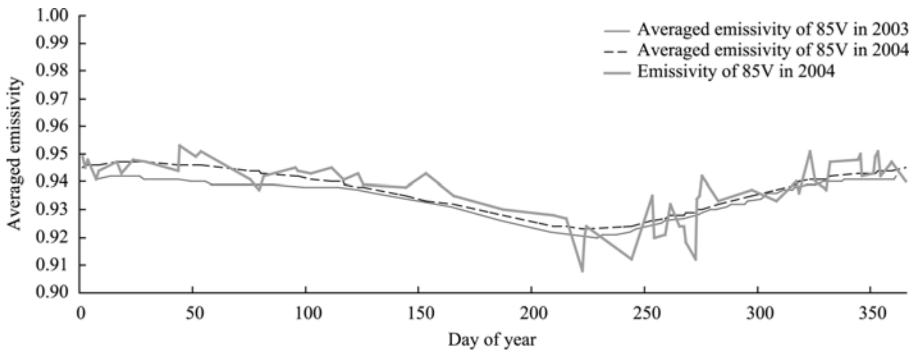

Fig. 12 Averaged emissivity in 2003 and 2004, emissivity in 2004 of channel 85V

between years, we linearly interpolated the averaged emissivity of 2003. Then we use the interpolated emissivity of 2003 and surface and raob data of 2004 to model brightness temperature of 2004, and compute the difference of this brightness temperature and satellite observed 2004 ones. The results are shown in Fig. 13 to 15. From these figures we can see that if we

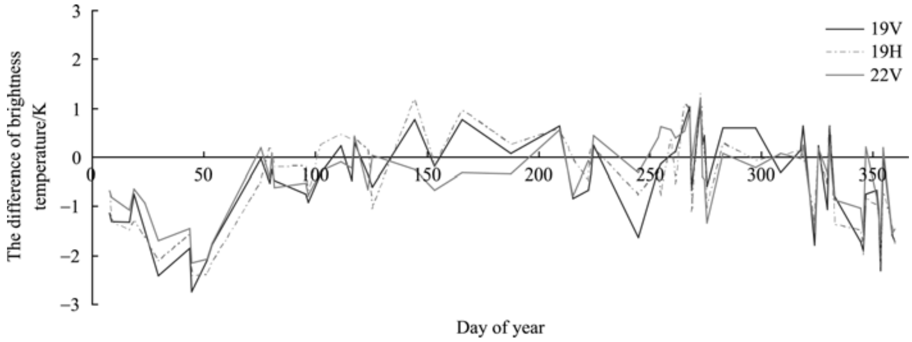

Fig. 13 Brightness temperature difference of channels 19V, 19H and 22V between the SSM/I observed brightness temperature and the modeling brightness temperature of 2004 using emissivity of 2003

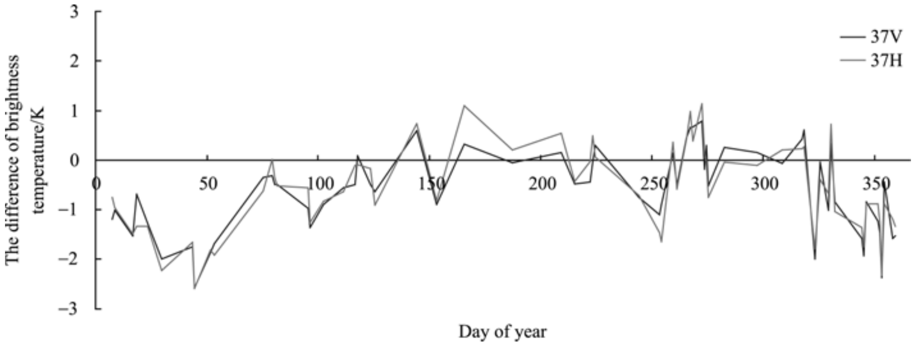

Fig. 14 Brightness temperature difference of channel 37V and 37H GHz between the SSM/I observed brightness temperature and the modeling brightness temperature of 2004 using emissivity of 2003

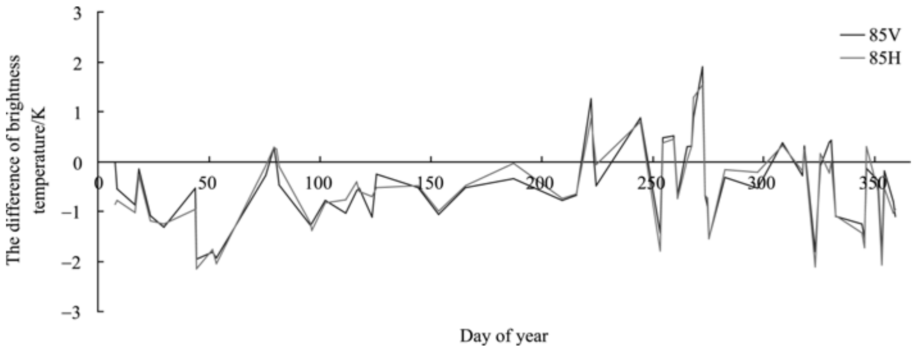

Fig. 15 Brightness temperature difference of channel 85V and 85H between the SSM/I observed brightness temperature and the modeling brightness temperature of 2004 using emissivity of 2003

use the linearly interpolated averaged emissivity of last year to compute the brightness temperature of this year at the same time, the difference of modeled and satellite observed brightness temperature is mostly under 2K.

5 CONCLUSIONS

Base on the microwave radiation transfer model, this study used SSM/I data of 2003 and 2004, surface and raob data from meteorological station, quantificationally analyzed the microwave emissivity variation in a year and between years. It was clear from the results that as a whole, the surface vegetation coverage of Simao is very good, the surface microwave emissivity is very stable. The emissivity shows weak law of sine (the variation extent is small than 0.02), and small variation between years from January to April (max emissivity difference is about 0.008). This can be corrected based on the surface and raob data modeling.

The vegetation coverage is higher, the microwave emissivity is higher, and vice versa. Although the vegetation coverage is very high, it changes a little with season and year. So the microwave emissivity in Simao changes a little, too. It is possible to track the microwave emissivity variation using the method of this study for the Fy-3 on-orbit calibration.

The above study establishes some kind of base for FY-3A on-orbit calibration. The on-going FY-3A on-orbit work put more surface observing instrument in Simao. So we will get more accurate surface observation and the result of this study will also be more accurate.

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SSM/I 的云南思茅微波发射率的稳定性分析

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摘 要: 利用装载于美国国防卫星上的特种微波成像仪 SSM/I 资料和相应的气象台站观测地面和探空资料, 在微波辐射传输模拟分析的基础上, 对云南思茅的微波发射率特性的稳定性进行定量分析。分析结果表明, 中国云南思茅地区地表植被覆盖度较好, 地表微波发射率稳定。地表微波发射率有弱的正弦季节变化(变化幅度很小, 最大不超过 0.02), 在 1—4 月有很小的年际变化(发射率最大差异约 0.008), 这些在有地面和探空观测的情况下, 可以通过模式模拟得到跟踪订正。

关键词: 云南思茅, 微波发射率, 稳定性分析, SSM/I

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1 引 言

中国新一代极轨气象卫星 FY-3A 于 2008 年 5 月发射, 星上首次装载微波温度计、微波湿度计和微波成像仪, 用于反演大气的温度和湿度垂直结构、云参数、降水参数以及陆地和海洋表面水文气象参数。但是, 过大的辐射观测误差不仅会使反演产品毫无意义, 有时还会由于观测误差的引入对某些定量应用、特别是数值模式应用产生负面影响。因此, 保证微波遥感数据具有足够的辐射观测精度(即具有足够的定标精度)对微波遥感应用产生很大的影响(Ulaby 等, 1981)。

在卫星发射前, 通过一系列的实验室和真空定标过程, 确定仪器的定标参数。在卫星发射后, 由于太空环境的变化、仪器元器件老化等问题, 导致微波辐射计的仪器性能发生变化, 产生定标误差。一般来说, 卫星发射后可以采用交叉定标(相对定标)或定标场定标(绝对定标)方法确定定标系数。交叉定标是通过与国际同类卫星上装载的微波辐射计观测进行匹配比较, 实现相对校准。绝对定标是通过在地面寻找或建立具有某种已知微波辐射特征的目标, 利用卫星对这些目标的观测进行遥感仪器在轨绝对标定, 这也是建立微波辐射校正场的首要目的。国际上一些学者进行了相关研究, 取得了一些成绩(Wenz, 1997; Colton & Poe, 1999; Prigent 等, 2000; Eric 等, 2003; Earth Observation Research and Application Center, 2004; Wessel 等, 2008)。

通过遥感普查, 我们找到了中国区域发射率较为稳定的区域位于云南思茅地区。为了进一步精细考察思茅微波发射率的稳定性, 利用公认定标精度较高的装载于美国国防气象卫星(Defense Meteorological Satellite Program, DMSP)上的特种微波成像仪(Special Sensor Microwave/Image, SSM/I)(Wenz, 1997)资料和相应的气象台站观测地面和探空资料, 在微波辐射传输模拟分析的基础上, 对该地的微波发射率特性的稳定性进行定量分析(Hollinger, 1990)。

2 模式和资料

为了分析思茅在较长时间内的微波地表发射率, 判断其稳定性, 首先需要得到该地区的微波地表发射率。根据实测的地表和大气参数, 输入到辐射传输模式, 计算得到设定地表发射率的微波辐射。调

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整地表发射率使得计算得到的微波辐射亮温与卫星观测亮温最接近，这个时候的地表发射率即为反演得到的地表发射率。

进行发射率特性稳定性分析需要较长时间的匹配数据。气象站的探空施放时间为世界时 00 和 12 时，DMSP F-13 卫星在云南临沧的过境时间与其相差不到 1h，因此选用了这颗卫星的 SSM/I 数据(Hollinger, 1990)。SSM/I 仪器有 7 个通道: 19.35, 22.235, 37.0 和 85.5GHz(1.55, 1.35, 0.81 和 0.35cm)。除 22.235GHz 只在垂直极化方向观测外，其余 3 个频率均在水平和垂直两个极化方向观测。本文把这 7 个通道分别记为 19V, 19H, 22V, 37V, 37H, 85V 和 85H。表 1 给出了 SSM/I 各观测通道所在的频率、极化方向、定标精度和空间分辨率。从表 1 可见，SSM/I 的定标精度是非常高的，各通道都小于 1K。

表 1　SSM/I 各观测通道的频率、波长、极化方向和有效(3dB)空间分辨率

频率/GHz	波长/mm	极化	定标精度/K	沿轨道 3dB 视场大小/km	横跨轨道 3dB 视场大小/km
19.35	15.5	V	0.45	69	43
19.35	15.5	H	0.42	69	43
22.235	13.0	V	0.73	50	40
37.05	8.1	V	0.37	37	28
37.05	8.1	H	0.38	37	29
85.50	3.5	V	0.69	15	13
85.50	3.5	H	0.73	15	13

利用 2003 年和 2004 年 25km Ease-grid 投影的 F-13 SSM/I 数据,提取包含云南临沧 1°×1°范围的所有数据，剔除降雨像元，将其余像元亮温平均后作为与模式模拟亮温匹配的卫星亮温。

在微波辐射传输的模拟中，大气中气体对微波的吸收采用 Phil Rosencranz 的方法，根据温度、气压、比湿和一些经验系数，得到氧气和水汽在不同频点的吸收系数，进而计算出大气透过率。由于思茅的地表特征接近热带雨林，因此在地表的处理上，可以假定其为各向同性的 Lambertine 体。微波辐射传输方程求解采用的是矢量辐射传输(Vector Discrete Ordination Radiative Transfer, VDISORT)模式(Weng, 1992)，根据离散纵标法求解辐射传输方程。

利用 2003 年和 2004 年气象台站观测的地表和大气探测数据，通过模式模拟得到模拟亮温与卫星亮温最接近时的发射率，从而评价思茅在 1a 当中和年际之间长时间的发射率的稳定性。其中模式模拟输入的地面温度数据选取气象台站观测的 2m 空气温度，SSM/I 升轨和降轨亮温模拟分别输入的是世界时 12 和 00 时的大气温度和湿度廓线。

3　思茅微波发射率的年变化

我们计算了 2003 年和 2004 年共 2a 的云南思茅地区的发射率。以 2004 年 12h 的结果为例，说明在云南思茅地区的发射率的年变化情况。如图 1—图 3

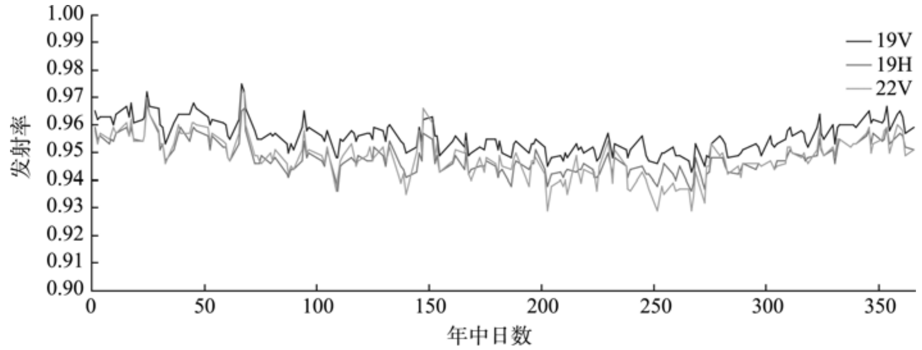

图 1　2004 年 19V、19H 和 22V 发射率随时间的变化

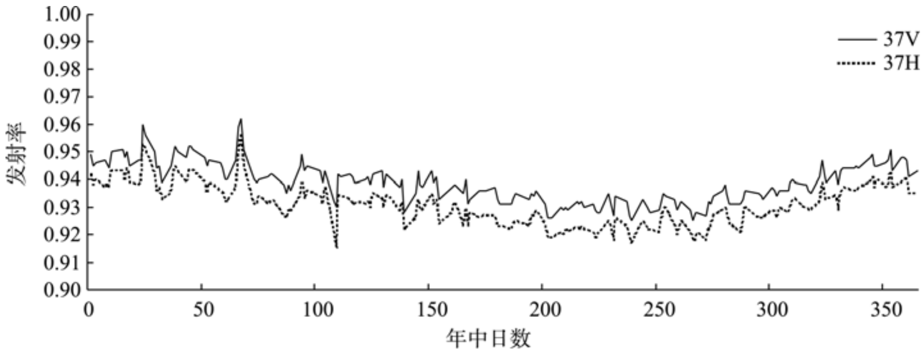

图 2　2004 年 37V 和 37H 发射率随时间的变化

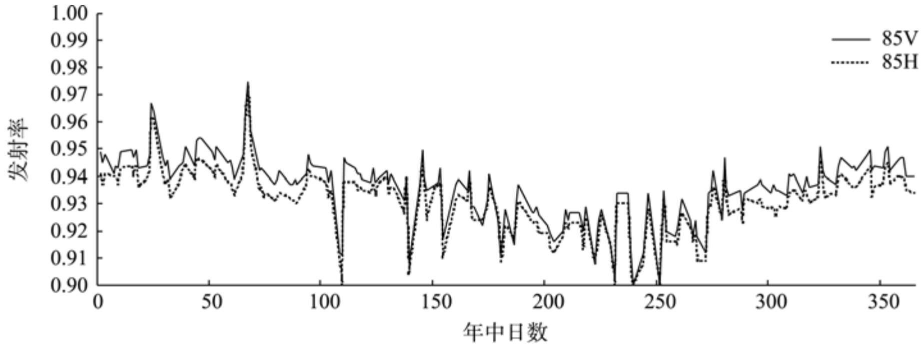

图 3 2004 年发射率随时间的变化

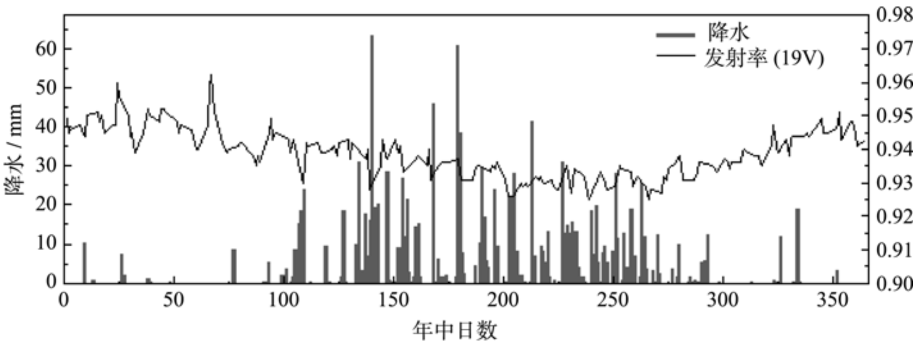

图 4 2004 年日降水量和 19V 发射率随时间的变化

是利用上述匹配资料计算得到的 2004 年 SSM/I 7 通道的发射率随时间的变化情况，图 4 把 24h 降水和 19V 发射率画到一张图上，以对比降水对该地区发射率的影响。

在分析上述曲线之前，我们首先要注意以下两个主要误差源:

(1) SSM/I 的降雨剔除算法只能剔除有较大降水的像元，对有云甚至弱降水的像元很难剔除干净。SSM/I 算法对有雨像元的判识是较准确的，但由于其通道对云的穿透性，很难判识出无降水的有云大气，因此会给研究的代表性带来一定困难，因此在研究中加入了地面台站观测云资料，以辅助判识;

(2) 模式模拟过程中，用云南思茅气象站测得的 2m 地表温度不能完全代表该地区的 0cm 地表温度。卫星观测到的辐射包括地表、大气和云雨的辐射，其中地表发射辐射是指地面发射的辐射，这是由地面亮温和发射特性决定的。由于微波像元的分辨率在几公里到几十公里范畴，地面一个观测点的地表温度不能代表整个像元的平均温度，所以用均匀性更好的 2m 空气温度来代表整个像元的温度。

从图 1—图 4 上可以看到:

(1) 从图 1—图 3 可以看出, 19.35GHz 发射率约 0.95—0.96, 22.235GHz 约 0.94—0.96, 37.0GHz 约 0.92—0.94, 85.5GHz 约 0.91—0.96，即 SSM/I 4 个频点的发射率较高，除 85.5GHz 有个别点在 0.9 以下外，其余在 0.9 以上;

(2) 从图 4 可以看出, 2004 年云南思茅地区 4—9 月属于降水较多的季节，在这段时间，分析对地表特性最为敏感的低频通道 19V 的发射率在降雨前后的变化, 19V 的发射率在降雨后有升有降，呈现随机分布，没有明显受到雨后地面湿度的影响，说明云南思茅的植被覆盖度较高，受降水导致的地面潮湿的影响不大;

(3) 7 个通道的发射率呈现出弱的正弦变化，在冬季(12 月到次年 1 月)发射率最高，在夏季(8—9 月)发射率最低;

(4) 85.5GHz 的发射率波动幅度较大，这是由于 SSM/I 的降雨剔除算法只能剔除有较大降水的像元，对有云甚至弱降水的像元很难剔除干净，而 85.5GHz 受这些因素的影响相对较大。

为了排除其余因素如天气、风速和微波仪器本身随机误差的影响，我们剔除了日降雨量大于 5mm、风速大于 0.8m/s 的匹配数据，并对剩下的像素发射率进行前后 101 天的滑动平均。滑动平均的结果见图 5—图 7。

从图 5—图 7 可以看出，剔除了日降雨量大于 5mm、风速大于 0.8m/s 的匹配数据后，排除了模式模拟中由于地表和大气的观测数据的代表性带来的

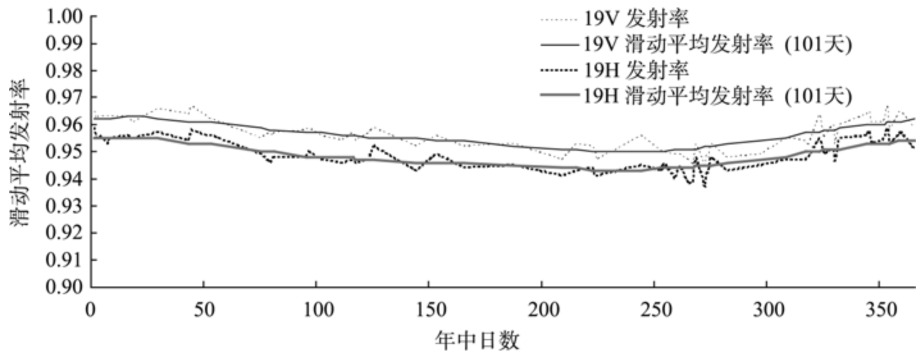

图 5　2004 年 12h 19V 和 19H 的发射率及其滑动平均发射率随时间的变化

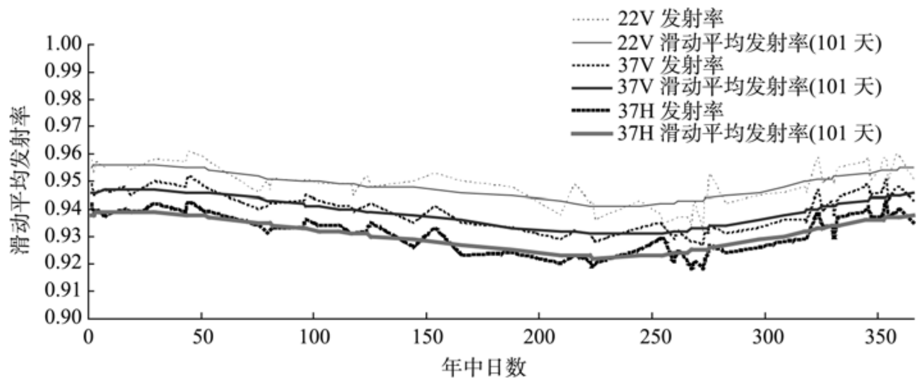

图 6　2004 年 12 h 22V、37V 和 37H 的发射率及其滑动平均发射率随时间的变化

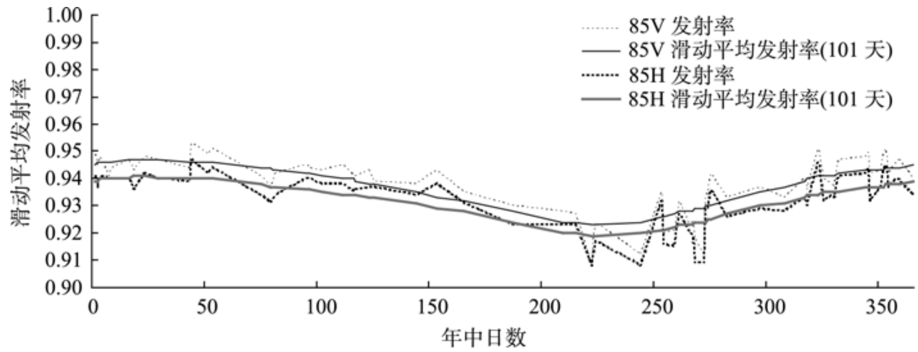

图 7　2004 年 12 h 85V 和 85H 的发射率及其滑动平均发射率随时间的变化

部分误差，得到的发射率与滑动平均发射率非常接近。滑动平均发射率代表着云南思茅地区的气候背景发射率，可以看出，尽管其在一年当中呈现出很明显的弱正弦变化，但变化幅度很小(最大不超过 0.02)，且是一个逐渐变化的缓慢过程，这也间接说明了云南思茅地区的植被覆盖状况较为稳定。

图 8 是 2004 年 12h 4 个垂直极化通道滑动平均发射率与实际模拟计算的发射率之差。把该发射率差换算成亮温差，得到图 9。从图 8 可以看到，除 85V 有个别点的发射率差达到 0.017，其余通道的发射率差在 0.01 以内。从图 9 可以看出，由用滑动平均发射率代替实际发射率带来的亮温误差除 85V 有一个点为 2.025K 以外，其余在 2K 以内。

4　思茅微波发射率的年际变化

为了比较发射率的年际变化，我们把 2003 年和 2004 年的滑动平均发射率画到一张图上，如图 10—图 12。H 通道和 V 通道特征类似，所以只给出了 V 通道图像。

从图 10—图 12 可以看出，1 到 4 月中旬前，2003 年和 2004 年的发射率有一些差异(最大差异约 0.008)，但在其余时间的差异很小，得到的地表发射率非常接近。其中 2004 年的发射率高于 2003 年，说

明云南思茅地区的地表状况相对 2003 年有所改善。

为了更为直观地考察云南思茅地区的年际变化，我们对 2003 年的滑动平均发射率进行线性插值，用该发射率、2004 年的地表和大气探空资料模拟计算 2004 年亮温，并计算该模拟亮温与卫星当日实测亮温的差，结果见图 13—图 15。从图上可以看出，即

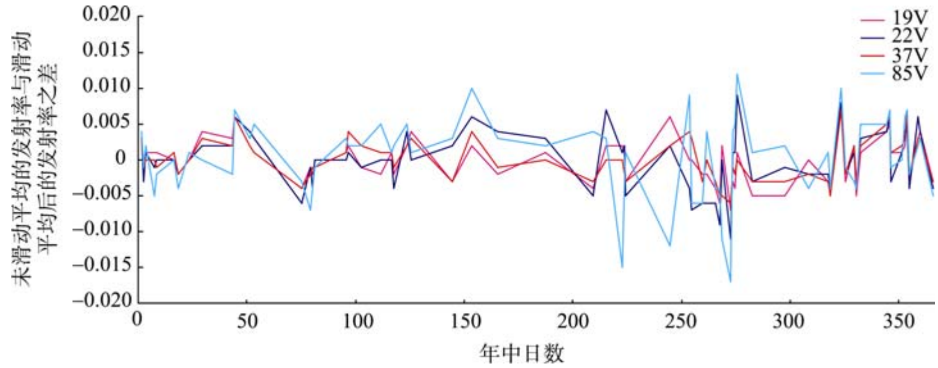

图 8　2004 年 12h 未滑动平均的发射率与滑动平均后的发射率之差随时间的变化

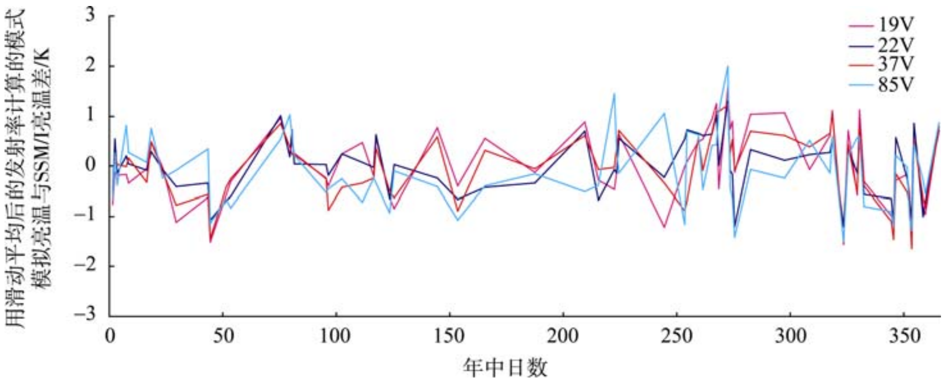

图 9　2004 年 12h 用滑动平均后的发射率计算的模式模拟亮温与 SSM/I 实测亮温差随时间的变化

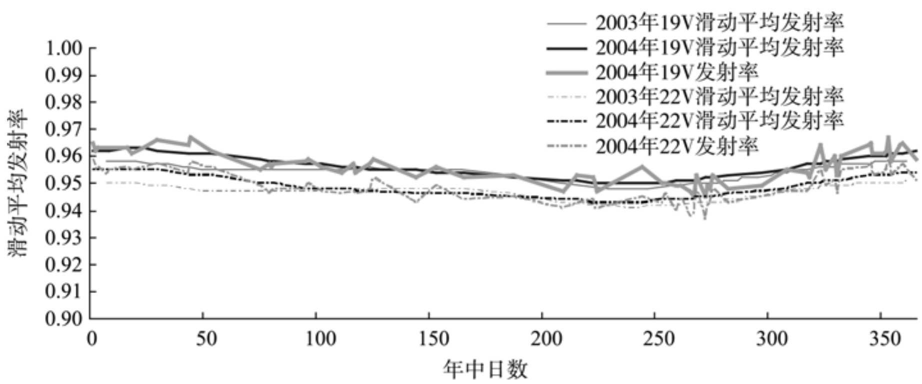

图 10　19V 和 22V 的 2003 年和 2004 年的滑动平均发射率、2004 年发射率随时间的变化

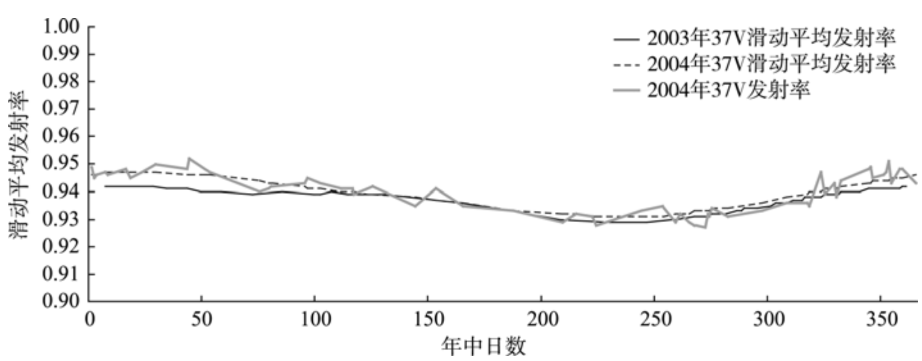

图 11　37V 的 2003 年和 2004 年的滑动平均发射率、2004 年发射率随时间的变化

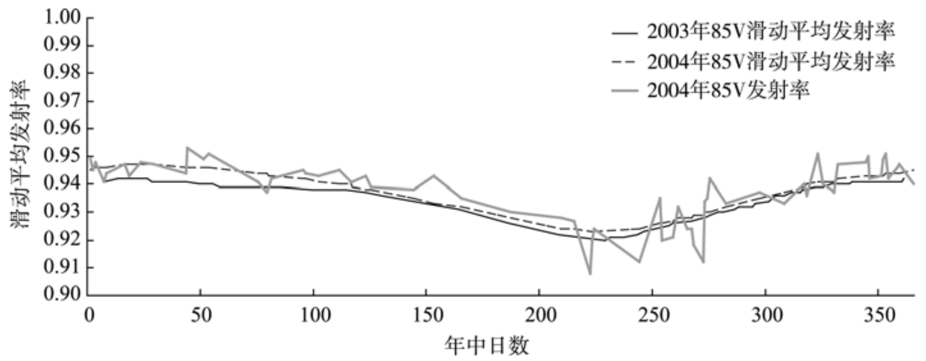

图 12　2003 年和 2004 年 85V 的滑动平均发射率、2004 年 85V 发射率随时间的变化

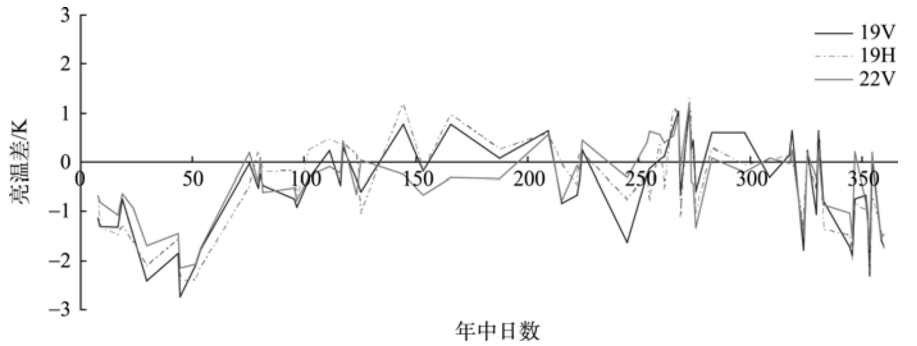

图 13　用 2003 年的发射率计算的 2004 年 19V、19H 和 22V 亮温与卫星相应通道亮温差

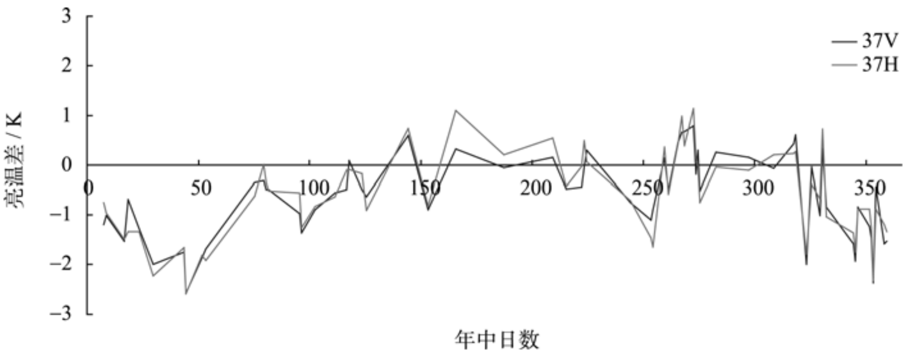

图 14　用 2003 年的发射率计算的 2004 年 37V 和 37H 亮温与卫星相应通道亮温差

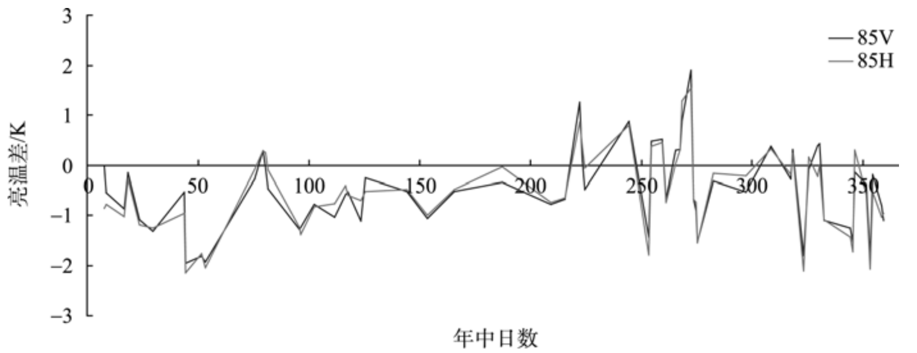

图 15　用 2003 年的发射率计算的 2004 年 85V 和 85H 亮温与卫星相应通道亮温差

使把 2003 年线性插值得到的滑动平均发射率直接用到 2004 年同期，其模拟计算的亮温与实测卫星亮温的差大多在 2K 以内。

5 结 论

利用 2003 年和 2004 两年的 SSM/I 资料和相应的气象台站观测地面和探空资料，在微波辐射传输模拟分析的基础上，对云南思茅的微波发射率的年变化和年际变化特性进行了定量分析。从以上分析可以看出，在中国云南思茅地区，地表植被覆盖度较好，地表发射率较为稳定。地表发射率有弱的正弦季节变化(变化幅度很小，最大不超过 0.02)，在 1—4 月有很小的年际变化(发射率最大差异约 0.008)，这些在有地面和探空观测的情况下，可以通过模式模拟得到跟踪订正。

植被覆盖度越高，微波发射率越高，反之越低。引起云南思茅地区微波发射率变化的原因是因为尽管思茅地区的植被覆盖良好，但是其植被覆盖度随季节和年度会有一定的变化，所以在进行 FY-3A 在轨定标时，可以用本方法跟踪云南思茅地区微波发射率的变化。

以上工作为中国 FY-3A 的在轨定标奠定了一定的基础。现在正在进行的 FY-3A 在轨定标在云南思茅地面施放了更多的地面观测仪器，地面总体观测数据更为准确，从而本方法得到的结果也会更为精确。

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