

The Use of ATOVS Microwave Data in the Grapes-3Dvar System

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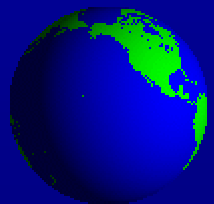
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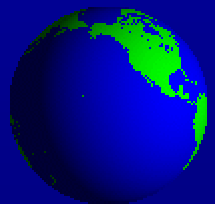
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1. Introduction

🌐 Numerical weather forecast plays a more and more important role in the operational and research fields. It is a special focal point how to utilize a variety of observational data, especially unconventional observations to improve the accuracy of numerical weather prediction. The use of satellite observation, among them, is now being of great importance.

🌐 The way of using satellite data has already migrated from to assimilate the retrieved temperature and moisture profiles to the assimilation of the radiance data from the satellite directly. At the same time, the assimilation scheme also concentrates on the frame of variational data assimilation system (3Dvar or 4Dvar).



1. Introduction

It has been shown that the impact on medium range weather forecasts from using ATOVS data in numerical weather prediction now exceeds that from the radiosonde network. The potential impact in the assimilation of ATOVS data in local area models, yet it is still in the early stages.

The use of ATOVS Microwave Data in the Grapes-3Dvar System, a three-dimensional data assimilation system developed by the Research Center for Numerical Meteorological Prediction, Chinese Academy of Meteorological Sciences, to mainly investigate its impact on short range numerical weather forecasts in local area model is presented.



2. Several main components for the use of ATOVS microwave data

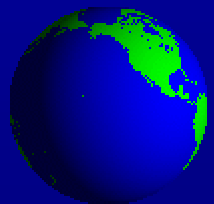
1) The Grapes-3Dvar system

- ☒ Latitude-longituded grid space consistent with the Grapes prediction model.
- ☒ Non-staggered Arakawa-A grid for the horizontal arrangement of the analysis variables and analysis conducted in standard pressure level. Incremental approach is adopted.
- ☒ The model variables are wind (U and V), temperature (T) or geopotential height (Φ) and RH or q. The analysis variables are defined as ψ, χ, Φ_u, RH or q.



1) The Grapes-3Dvar system

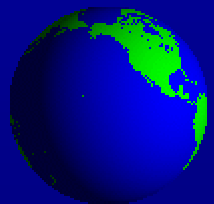
- The recursive filter is approximately used for the background error horizontal correlation and the EOFs is used for the vertical correlations.
- A simple geostrophic relationship or a linear balance equation for the mass/wind balance.
- Limited memory BFGS method for optimization of the algorithm.



2) The fast radiative transfer model

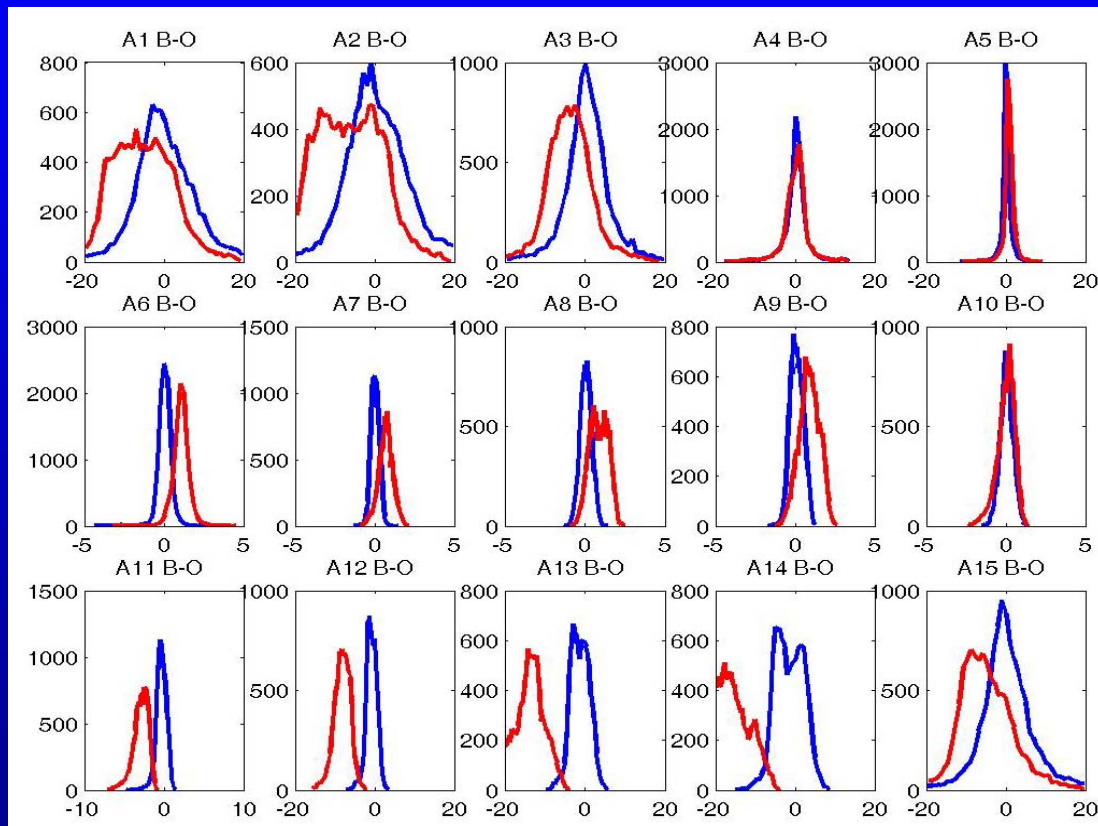
The fast radiance transfer model RTTOV 7 is currently being used. Four modules are included:

- SetupRtm □ Call subroutine RTTVI for initializing □
- RtmTov □ Call subroutine RTTOV for calculation of simulated observation □
- RtmTovTL □ Call subroutine RTTOVTL for tangential linear calculation □
- RtmTovAD □ Call subroutine RTTOVAD for adjoint calculation □

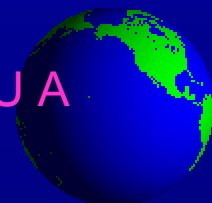


3) Bias correction scheme

A independent bias correction scheme following the method proposed by Harris and Kelly (2001) is supplied to correct the bias.



The distribution of the observation departure from first guess for AMSU A channels 1-15. Red: without bias correction; Blue: with bias correction



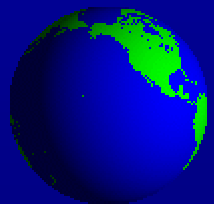
4) Quality control and channel selection

Quality control: three steps are conducted to reject the bad radiance data before they are passed to channel selection.

Gross check: the brightness temperature data outside of the interval 150-350K are rejected;

Background profile check: background profile outside limits and unphysical is rejected;

Innovation check: the data whose departure between the simulated observation and actual value outside certain threshold are rejected.

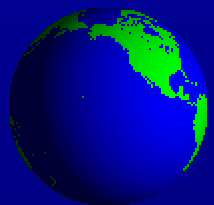


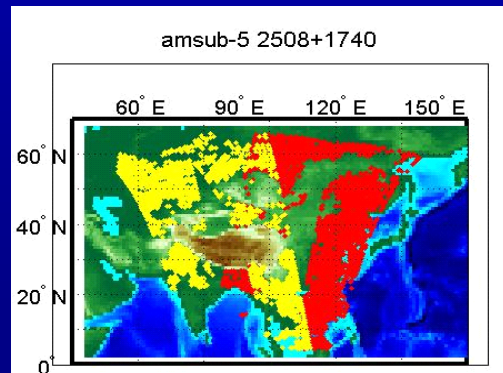
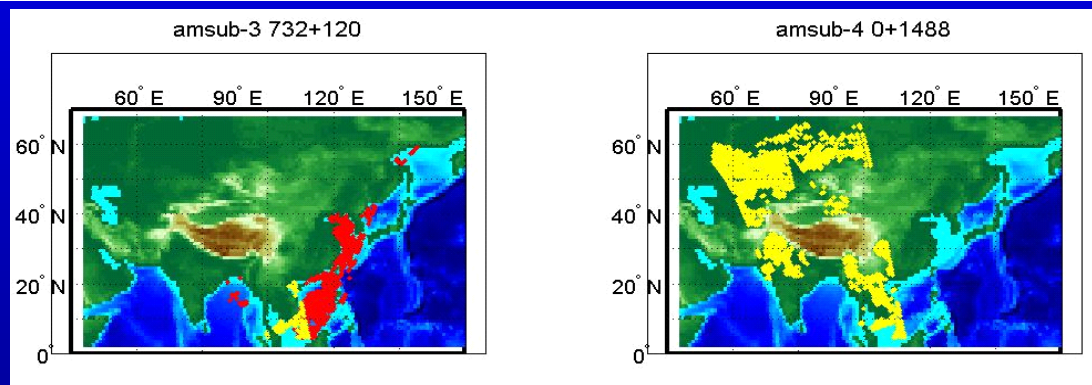
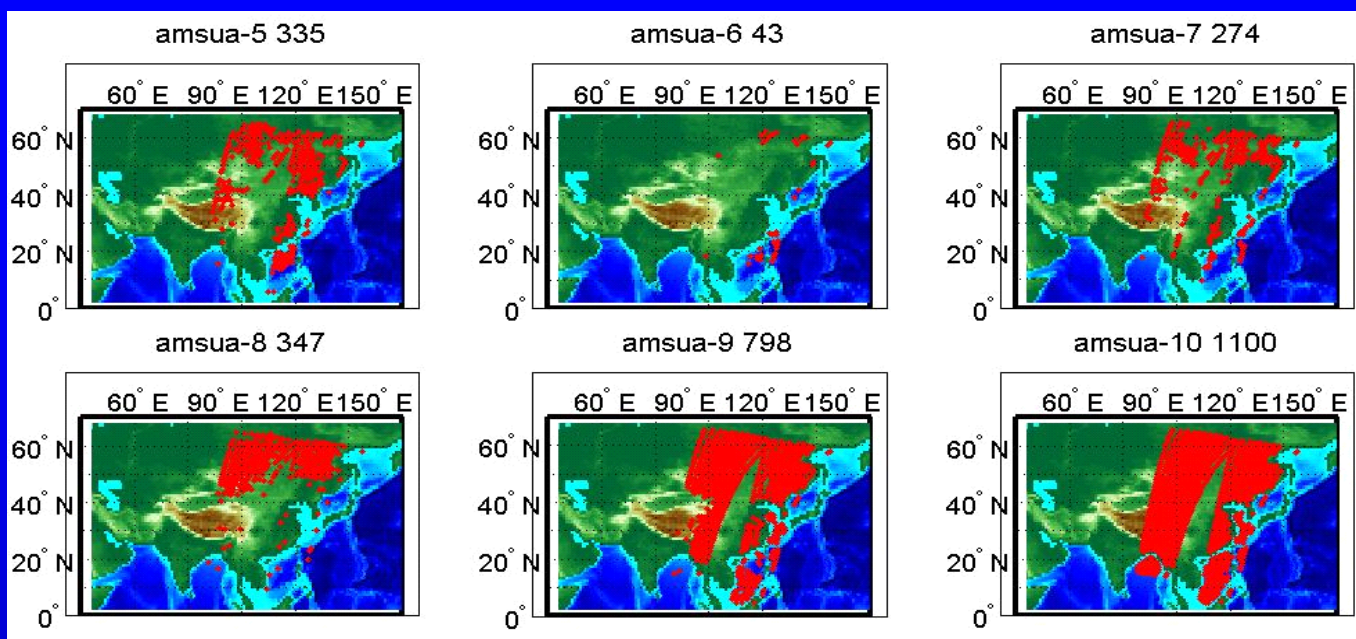
4) Quality control and channel selection

Channel selection: The use of certain channel is determined by the conditions of each channel. Now it is almost the same as that at Météo-France.

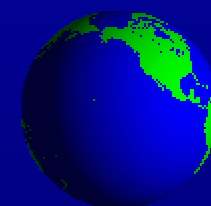
In general, channels 1-4, 15 of AMSU A and channels 1-2 of AMSU B are currently not used because of uncertainties on the description of the surface properties. Channels 12-14 of AMSU A are also excluded for the lack of information above the model top.

For the channels used, special caution is given to low peaking channels over land and over sea ice, also in cloudy condition.



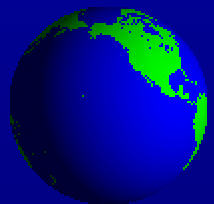


An example of the used data coverage. Red: noaa16; Yellow: noaa17



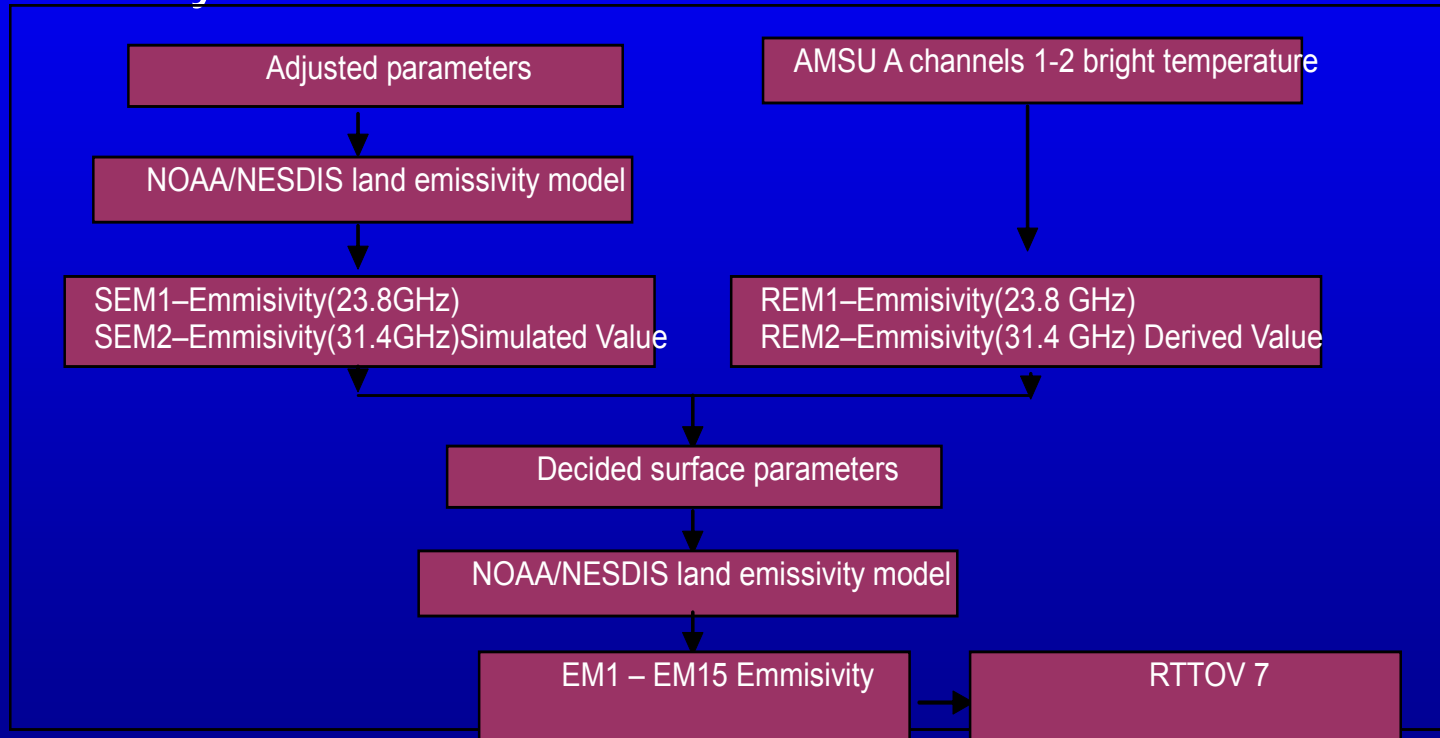
5) Land emissivity model

To improve the calculation of land surface emissivity in the fast radiative transfer model, the NOAA/NESDIS microwave land emissivity model developed by F. Weng (2001) is introduced into the Grapes-3Dvar to replace the previous scheme in RTTOV. However, the microwave land emissivity model needs some surface parameters, which are crucial for the accuracy of calculation. These surface parameters are produced from a global data assimilation system (GDAS) including a boundary layer model in NOAA/NESDIS.

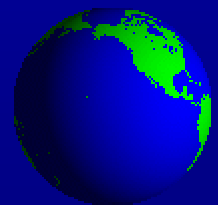


5) Land emissivity model

An adjusted parameter scheme is designed to provide the surface parameters for using of the microwave land emissivity model.



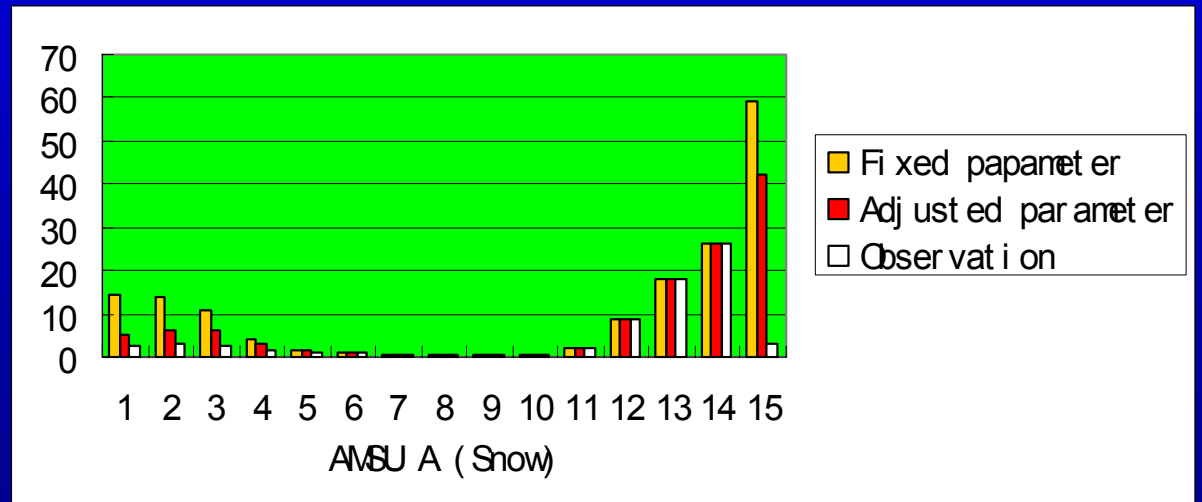
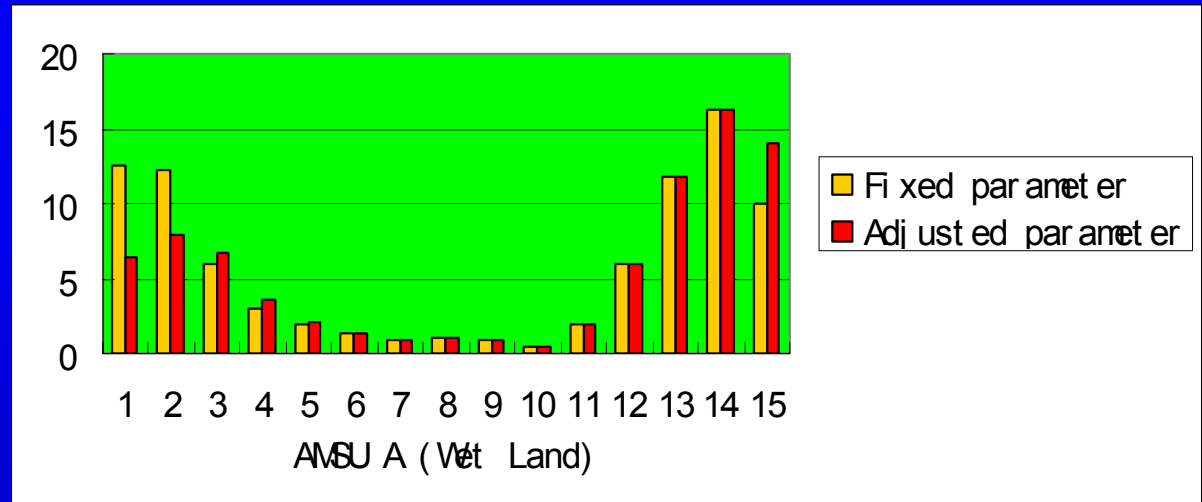
The flow chart of the adjusted parameter scheme for using of the microwave land emissivity model.



5) Land emissivity model

The microwave land emissivity model then could be used under the circumstances that no surface parameters are provided;

The Observation scheme developed by F. Weng (2003) is applied for two complex land surface types snow and ice. Much improvement could be seen.



The observation departure from first guess calculated from differ land surface emissivity scheme for AMSU A channels 1-15. (Top: wet land; Bottom: snow)



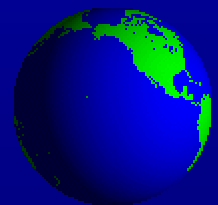
6) Verification scheme

Use \checkmark	Analysis	Forecast
Fit to the satellite data	\checkmark	
Fit to the radiosonde	\checkmark	\checkmark
Against analysis		\checkmark
Ts		\checkmark

The fit to the satellite or radiosonde data is to compare the fits to the brightness temperature or radiosonde for the background fields with analyses using the radiance data.

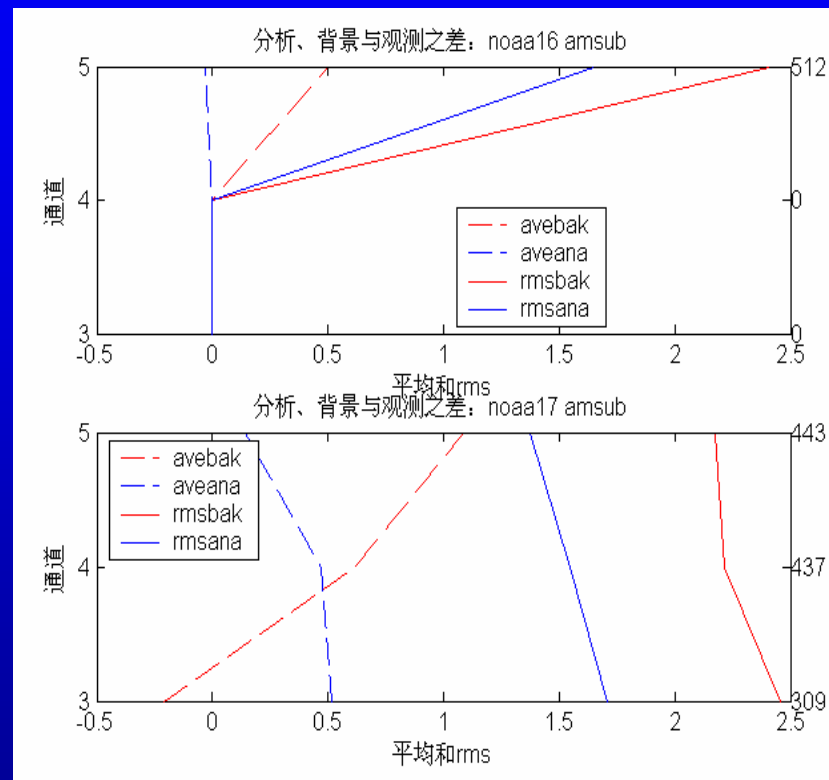
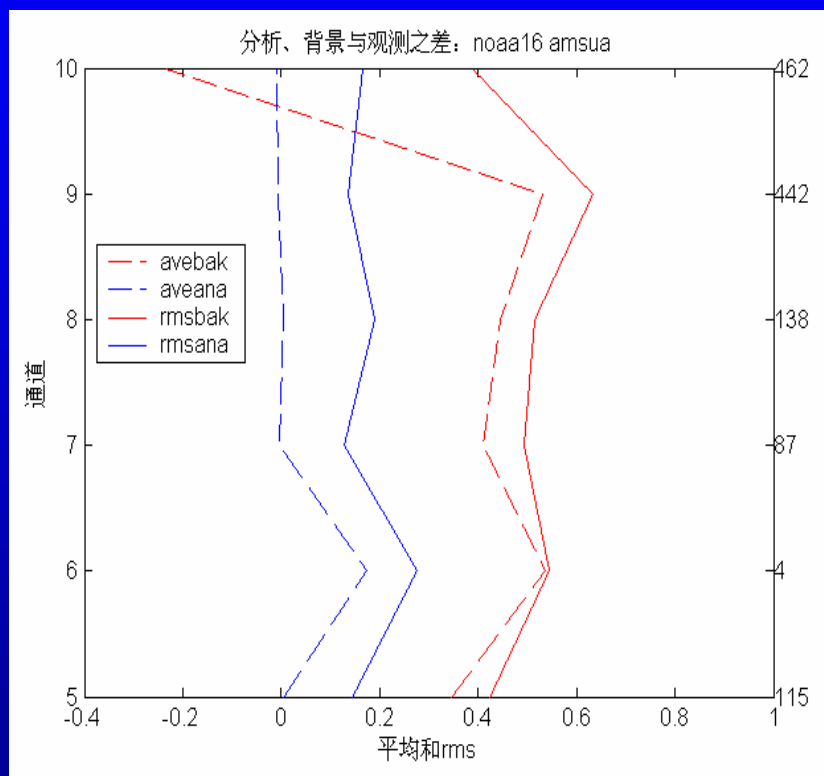
The forecasts are measured by comparing forecasts against their own analyses.

Ts is taken to evaluate the forecast precipitation.



3. Preliminary result

The fits to the brightness temperature

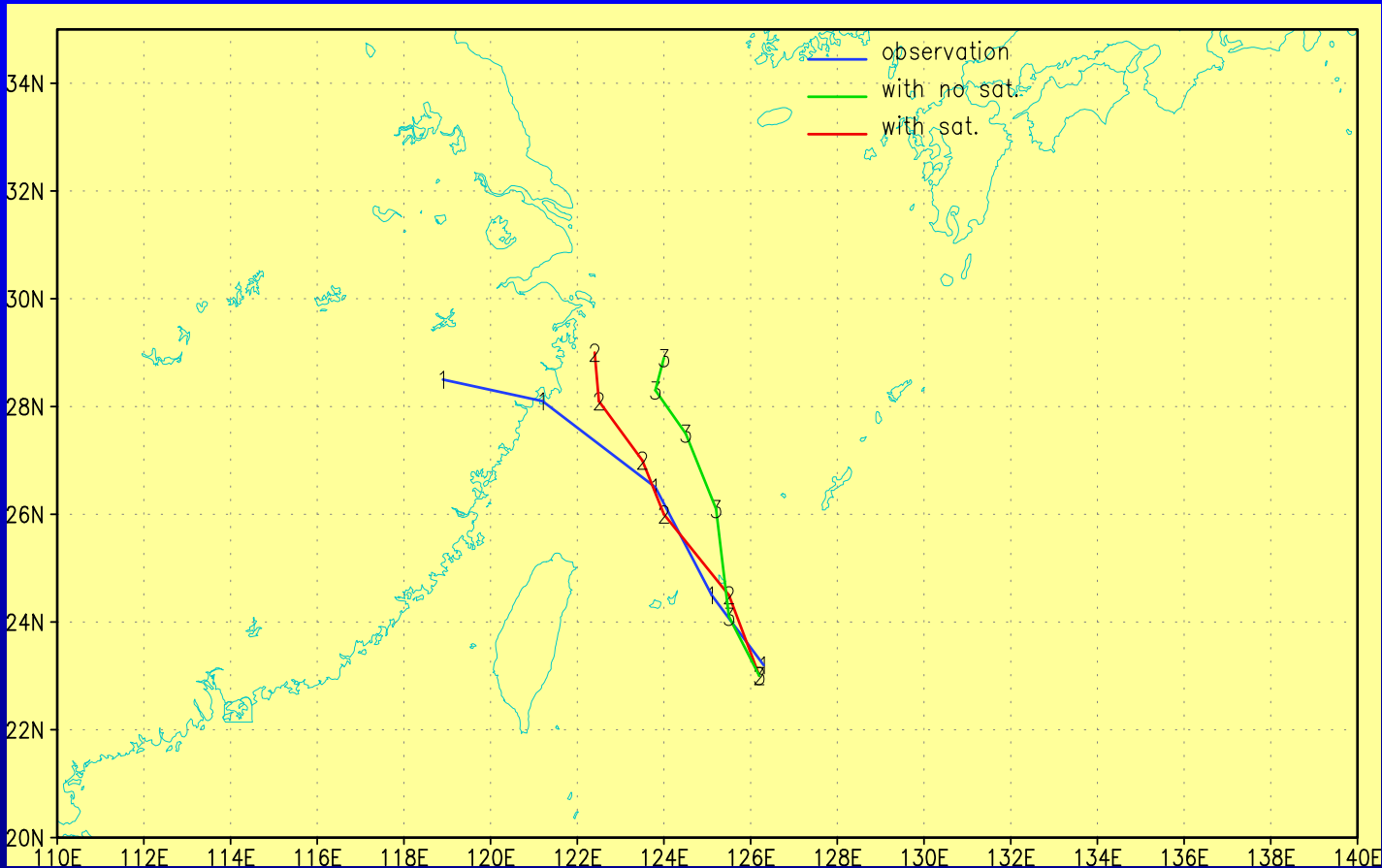


The fits to the brightness temperature for the background fields and analyses using the radiance data. (Left: AMSU A; Right: AMSU B)

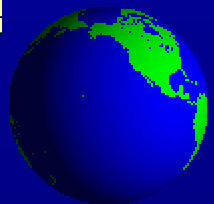


3. Preliminary result

An example of the track forecast of Typhoon Ranim 2004

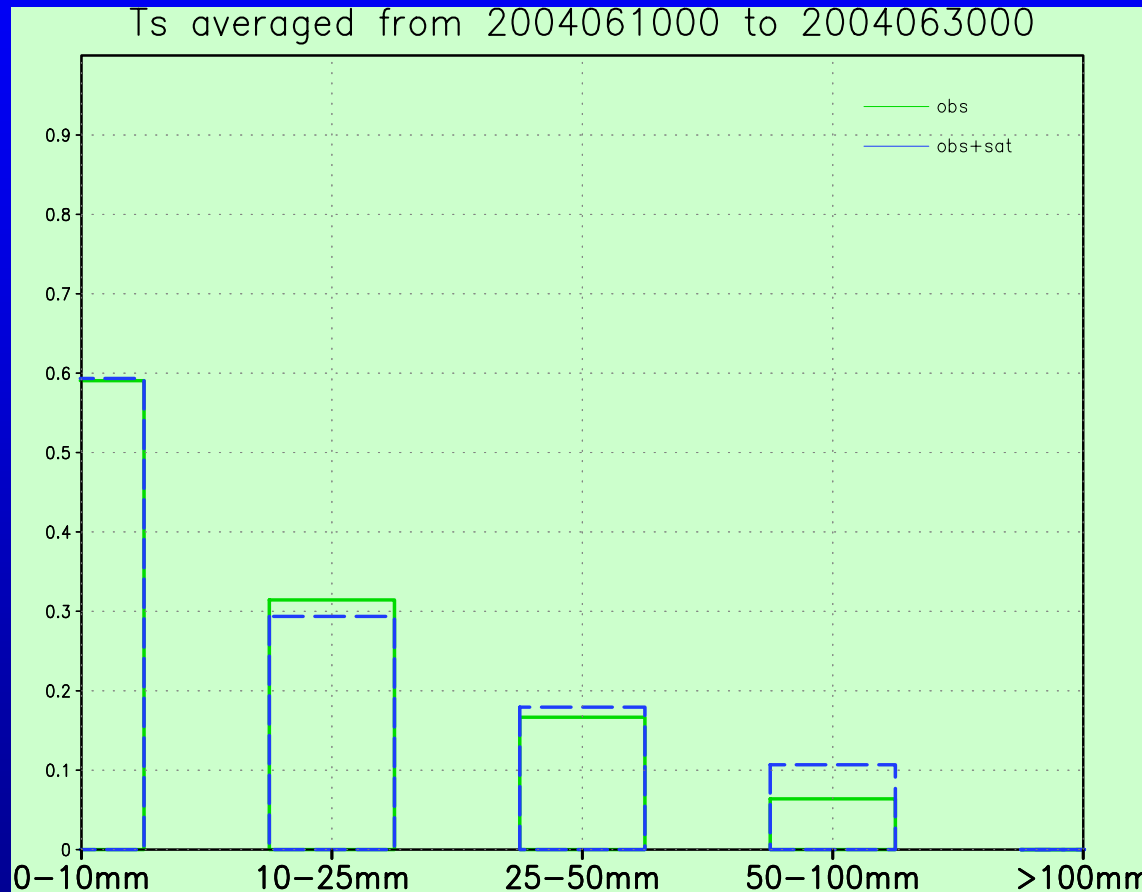


Tracks of Typhoon Ranim 2004.

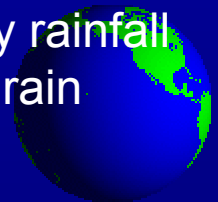


3. Preliminary result

One example of forecast of precipitation on Meiyu front

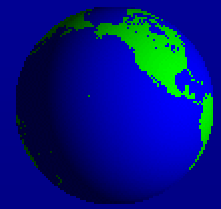
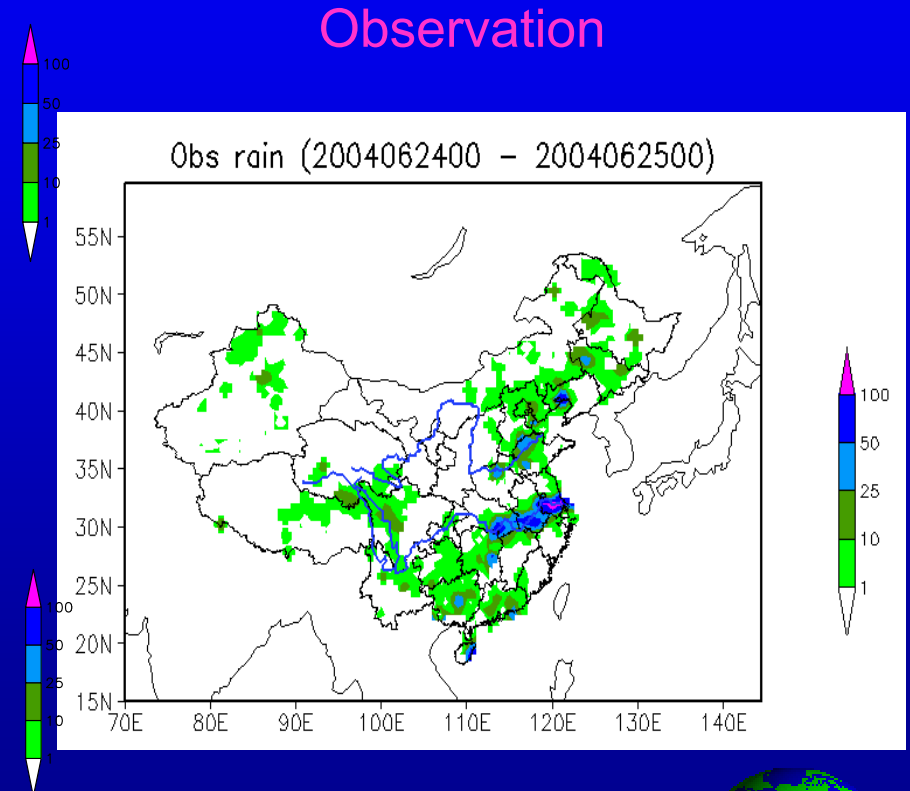
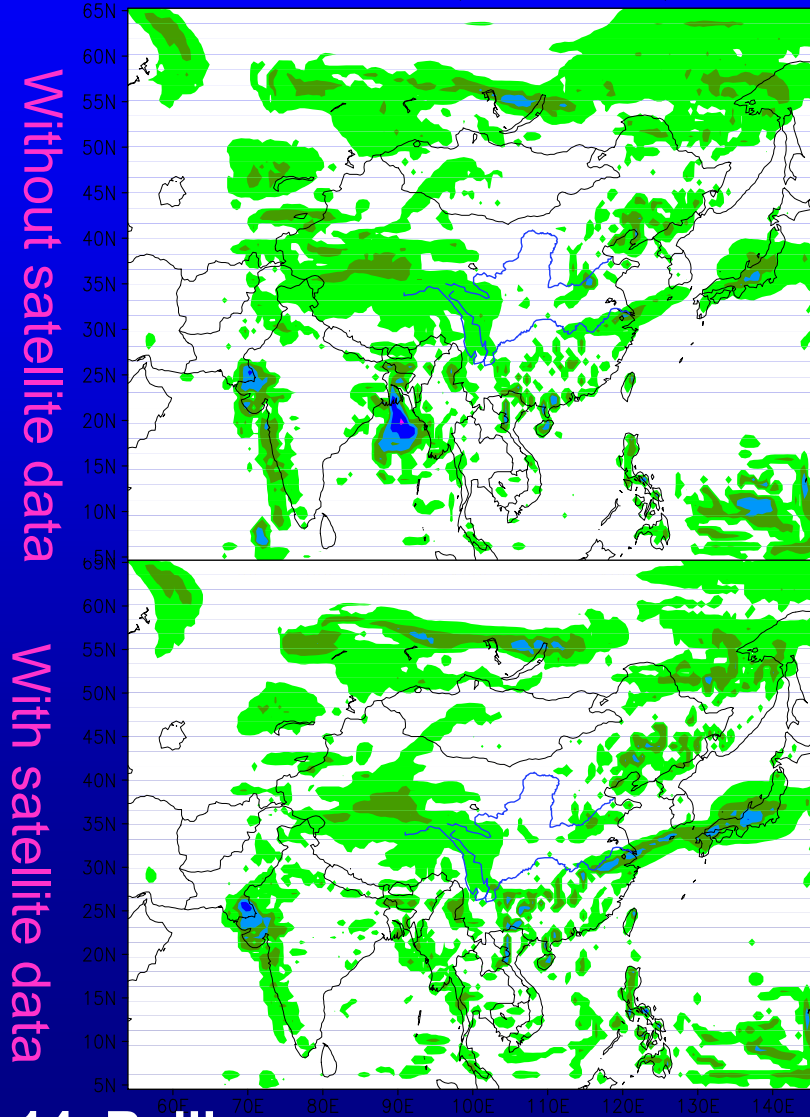


Twenty days averaged Ts is improved for the 24h prediction of heavy rainfall (25-50 mm) and torrential rain (50-100 mm) except that of moderate rain (10-25 mm), whose Ts is a little degraded.





3. Preliminary result


One case of forecast of precipitation on Meiyu front



4. Discussion

 ATOVS microwave data is currently being used in the Grapes-3Dvar system. Preliminary result indicates that the use of satellite data in the short range numerical weather forecast is promising. However, the impact is mixed. More work need to be carried out further.

 The NOAA/NESDIS microwave land emissivity model developed by F. Weng is introduced into the Grapes-3Dvar. The calculation of land emissivity is improved by the adjusted parameter scheme designed companying with Observation scheme. Those satellite observations strongly affected by surface emissivity could be utilized into assimilation system to investigate their impacts.

 Some issues will be emphasized in the future research. E.g., the introduction of surface temperature to control variable in order to improve the description of surface properties and use of more channels in the assimilation system. Measure of the impacts of the satellite data will be investigated further.



Thanks For Attention !

International TOVS Study Conference, 14th, ITSC-14, Beijing, China, 25-31 May 2005.
Madison, WI, University of Wisconsin-Madison, Space Science and Engineering Center,
Cooperative Institute for Meteorological Satellite Studies, 2005.