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Uses of rain-affected microwave observations to improve hurricane model initialization

F. Weng (1) and T. Zhu (2)

(1) NOAA/NESDIS/Office of Research and Applications, 5200 Auth Road, Camp Springs, MD, 20746, USA(2) CIRA/Colorado State University at Joint Center for Satellite Data Assimilation, 5200 Auth Road, Camp Springs, MD, 20746, USA

In the past two decades, much progress has been made in the utilization of satellite microwave data in numerical weather prediction (NWP) models and is attributed to the improvement in satellite instrumentation, continued increase in the computational power and related improvements in the numerical models and data assimilation techniques. Remotely sensed microwave data for atmosphere, land, and oceans provide critically pertinent information to better understand and predict the effects of both weather and climate, and are now a major component of the global environmental observing system. The advanced microwave sounding unit (AMSU) on board a series of NOAA satellites has significantly increased the accuracy of global medium-range forecasts. Today, the five-day forecast accuracy is about the same as that of the three-day forecast ten years ago.

Recently, new satellite microwave data are available from Windsat, SSMIS, AMSR-E and MHS. These instruments provide unprecedented observations of the Earth's environments and offer some unique opportunities to further improve our understanding on weather and climate change and benefit significantly the numerical weather prediction. The Windsat provides four Stokes channel components at 10, 18 and 37 GHz and allow for simultaneous retrievals of wind speed and direction over oceans. The SSMIS the first time observes the atmospheric temperature from a conical scanning mode. Both SSMIS and MHS have some channels in millimeter wavelengths ranging from 89 to 191 GHz, which is vital for improvement in precipitation analysis and estimation. The observations from AMSR-E and Windsat at 6 and 10 GHz over land are distinctly linked to soil moisture content and other land surface parameters.

However, our current knowledge is not adequate for understanding all observed phenomena from these advanced microwave instruments. Windsat data signify cloud and precipitation boundary well from its third and fourth Stokes channels whose intensities could be the same as or stronger than those produced from ocean rough surfaces. In Greenland and Antarctic regions, these Windsat channels also display pronounced surface features related to ice topography and inhomogenuity and azimuthally dependent scattering. In the instrument calibration area, the systematic biases occur at the SSMIS sounding channels and within several latitudinal zones and presumably result from its main reflector emission or scattering, and solar contamination on the warm calibration targets.

Current satellite microwave measurements from polar-orbiting platforms are constellated well by offering a good coverage for synoptic scale weather systems. A major observational gap remains for sub-synoptic, mesoscale and convective systems whose temporal evolution is so rapid and for which the performances of the current sounding algorithms and the data assimilation techniques are degraded due to clouds and precipitation. Direct assimilation of satellite microwave radiance data for these events has proved to be very promising. In 2005, the US Joint Center for Satellite Data Assimilation (JCSDA) began its experimental uses of rain-affected microwave radiances for hurricane model initialization. Using a hybrid variational scheme (HVAR) which is a combination of 1dvar and 4dvar, we are able to assimilate the AMSU rain affected radiances into the mesoscale forecast models and produce much improved analyses for all stages of hurricane life cycle (see Figures). Note that for Hurricane Katrina, the warm core at 250 mb is well depicted after assimilation of rain-affected AMSU sounding channel radiances. The improvements at surface in sea surface winds are due primarily to assimilation AMSR-E measurements at 6 and 10 GHz from EOS Aqua satellite.

The advantages of HVAR over 3dvar or 4dvar are 1) uses of both sounding and imaging channels in 1dvar which effectively takes into account of effects of emission and scattering of clouds on sounding channels through improved radiative transfer models and 2) analysis of cloud and precipitation hydrometeors outside 4dar which is limited by the cloud microphysics in the mesoscale models otherwise.

It should be pointed out that from a cross track instrument such as AMSU the warm core feature associated with hurricanes is clearly delineated from retrieved temperatures because the feature of AMSU radiance measurements are initially predominated by its scan angle. However, for a conically scanning microwave sounding instrument like SSMIS, the radiance at its sounding channels can directly depict hurricane warm cores without retrievals. Note from Figure 2 that Hurricane Katrina maintains its significant intensity and illustrated by an SSMIS warm core after it landfalls at New Orleans at 14:45 GMT on August 29, 2005 (see the upper right panel). This new sounding imager offers forecasters a new diagnostic capability of direct analysis on tropical storm intensity. For more quantitative applications of the SSMIS data for storm intensity and track predictions and global forecasts, we can also inherit the AMSU radiance assimilation algorithms which include advanced radiative transfer modeling, surface effects models and HVAR scheme. These algorithms allow for improving the data utilization rate in polar regions as well as in violent storm conditions.

References

Weng, F., Y. Han, P. Dels, Q. Liu, T. Kleespies, B. Yan and J. Marshall, 2005: JCSDA Community Radiative Transfer Model (CRTM), *The preprint 14th International TOVS Study Conference*, Beijing, China, May 23-28, 2005.

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Figure 1. The temperature and wind fields at 250 hPa from (a) NCEP GFS (Global Forecast System) Data Assimilation System (GDAS) analysis, (b) Hybrid Variational Scheme (HVAR), and the temperature and wind fields at surface level from (c) GDAS analysis, and (d) HVAR for Hurricane Katrina at 0600 UTC 25 August, 2005.

Figure 2. The warm core evolution associated with hurricane Katrina detected from Special Sensor Microwave Imager Sounder (SSMIS) 54 GHz channel during August 28 to 30, 2005.