Motivation Quantitative Precipitation Forecasting

- Precipitation has a strong influence on our economy and general livelihood.
- Especially, the forecast of small-scale severe precipitation events is among the most difficult tasks in meteorology.
- Radiosondes and passive remote sensing are the major source of observations used operationally.
- More sophisticated observing systems, e.g., lidar, radar, or GPS, will be available operationally in the future.
- However, interfaces between the observations and the assimilation systems are hardly available.

Hypothesis

Short-range QPF is significantly improved by the assimilation of high-resolution observations of the 4-d distribution of water vapor, temperature, and wind.

Status of WRF and WRF 4DVAR

- Current release is WRF V3.0.1.1 from August 2008
- New 2-moment cloud microphysics scheme available since WRFv3
- Direct use of ECMWF model level data (including cloud water+cloud ice) to reduce interpolation errors
- Possibility to run WRF as a global model with user specified resolution
- WRF 3DVAR system in version 3.1.1 released in August 2008
- Operators for upper air observations, surface observations, GPS/PW, GPSJRF, GPS ZTD, satellite observations (winds and radiances), and radar measurements (reflectivity and radial velocity) available in the 3DVAR system
- Quality checks are performed for outliers in a user specified range
- Surface observations are rejected if the observation is more than 100m below or above model topography
- The user can define observation types used for the assimilation via namelist
- Background Error covariance matrix not diagonal as in MM5 3DVAR/4DVAR
- WRF 4DVAR system still in beta status
- 4DVAR will contain the same operators as 3DVAR including full vertical diffusion
- Official release of 4DVAR is planned for March 2009 with WRF 3.1

First intercomparison of MM5 and WRF for COPS IOPs 8b,9c

Since it is the aim to switch from MM5 to WRF for impact and process studies, a first important step is to compare the forecasting performance of MM5 and WRF for well documented COPS IOPs.

Model configuration for MM5 and WRF:

- 3 domains with 18-6-2.5km resolution with 2-way nesting
- 36 vertical levels up to 100hPa
- KF/KF-ETA cumulus scheme on 18 and 6km
- MRF/YSU-PBL scheme and Reinsen/Thomson cloud microphysics
- 5-layer soil model NOAH-LSM (WRF)
- Initialization from ECMWF model levels (including cloud water and cloud ice) at 00 UTC

Future Plans

During the next two years we focus on the extension and improvement of the assimilation system. This includes the transition from MM5 to WRF as the working horse. This system will be used to perform high-resolution impact and process studies for selected COPS IOPs. The aim is to understand the processes evolving in the model and finally try to improve the model physics (e.g. boundary layer and cloud microphysics).

The assimilation system currently available for the WRF model shall be extended to use observations of scanning lidar systems and radial velocities of the German Weather Service (DWD) radar network (e.g. paper of Hans-Stefan Bauer and talk of Florian Zus).

Privacy & Security

- WRF experimental 3DVAR/4DVAR system.
- WRF 3DVAR/4DVAR system includes radial velocities in the assimilation scheme.
- WRF 4DVAR will contain the same operators as 3DVAR including full vertical diffusion.
- Official release of 4DVAR is planned for March 2009 with WRF 3.1

Contact: Thomas Schwitalla and Hans-Stefan Bauer, Institute of Physics and Meteorology, University of Hohenheim, Garbenstrasse 30, 70599 Stuttgart, Germany

Thomas Schwitalla¹, Hans-Stefan Bauer¹, Florian Zus¹, Matthias Grzeschik¹, Volker Wulfmeyer¹
¹Institute of Physics and Meteorology, University of Hohenheim
²Laboratoire d’Aerologie, Toulouse

Status of WRF and WRF 4DVAR and its application within the SPP1167 project COPS-GRID

The WRF model system developed by NCAR is the successor of the MM5 whose development was frozen in 2004. It contains improved physical parameterizations originating from MM5 as well as completely new developments. The WRF/WPS model package contains preprocessors for various input datasets and the model system is optimized for scientific as well as operational applications. The WRF system at ECMWF runs more than three times faster than the MM5.

Figure 1: Severe Weather situation in Germany.

Figure 2: Flow chart of WPS/WRF model packages.

Figure 3: Comparison of various features of MM5 and WRF.

Figure 4: 24h precipitation during IOP 14b. Lower panel: Radar radial velocities of the DWD radar network (see poster of Hans-Stefan Bauer and talk of Florian Zus).

Figure 5: From left to right: diurnal cycles of grid-scale precipitation, total precipitation, 10m wind speed and 2m mixing ratio compared with SYNOP observations (red lines).

Figure 6: Diurnal cycle of CAPE (left panel), PBL height (middle panel) and sea level pressure (right panel).

Figure 7: MJO HVI Images (top) and corresponding radar reflectivities (bottom) from 12 UTC of IOP 8b (left) (air mass connection) and IOP 8c (right) (WRF free forecast).

Figure 8: Diurnal cycle of 2m temperature and humidity for IOP 8b (top) and IOP 8c (bottom).

Figure 9: 24h precipitation differences of IOP 8b compared to REGNIE.

Figure 10: WRF CAPE values for IOP 8b with the 5-layer soil model (left) and NOAH-LSM (right).

Figure 11: Domain averaged diurnal cycle of latent (LH) and sensible (SH) fluxes of IOP 8b (WRF) and IOP 8c (right).

Figure 12: Lidar water vapor mixing ratio [ppm] derived from WRF model output using the forward operator for scanning lidar systems.

Figure 13: Steps to be carried out for the high-resolution process studies

Figure 14: Comparison of water vapor mixing ratio measured by the UNIC DIAL system (top) and the free forecast based on the MM5 4DVAR initial state (bottom).

Figure 15: Comparison of water vapor mixing ratio measured by the UNIC DIAL system (top) and the free forecast based on the MM5 4DVAR initial state (bottom).

Figure 16: WRF CAPE values for IOP 8b with the 5-layer soil model (left) and NOAH-LSM (right).

- Both models had problems simulating 2m humidity with the 5-layer soil model (also observed during other studies) — result of wrong moisture initialization or a PBL problem?
- Use of NOAH-LSM weakened this problem
- WRF tends to overestimate 10m wind speeds starting 18UTC
- On cloud free days both MM5 and WRF underestimate 2m temperatures
- Much higher CAPE values were simulated when using the NOAH-LSM instead the of 5-layer soil model

Figure 17: Example of the performance of the radar-radiology velocity operator developed for the MM5 4DVAR. The left panel shows the radar velocity of the DWD Radar at Feldberg (DF) at the location of the Feldberg Radar. In the upper panel the model after the assimilation of the artificial radar scan is shown. The radar operator for velocity and reflectivity is already available in the WRF 2DVAR/4DVAR system.