Title: **Monitoring the observation impact with Taiwan Central Weather Bureau operational analysis/forecast system**

Xin Zhang and Xiang-Yu Huang

Recently NCAR has developed a powerful tool, known as FSO (Forecast Sensitivity to Observations), to assess the impact of observing systems on forecast error. By defining a forecast error norm, the adjoint of the WRF forecast model (WRFPLUS) and the adjoint of WRFDA analysis can calculate the forecast error sensitivity to each observation used by the analysis. From there, the impact of observations on forecast error can be computed. By doing this for every data assimilation cycle on a routine basis, the results can be very useful for monitoring the operational observing systems. Statistics over a longer period can provide quantitative guidance for improving the forecast scores. Supported by Taiwan Central Weather Bureau (CWB), the FSO was coupled with CWB OP23 operational analysis/forecast system to assess the impact of the observation data on the 24-hour WRF forecast error verified against ECMWF re-analysis. The preliminary observation impact diagnosis with CWB OP23 system shows that the SOUND is the most important observation to reduce the forecast error in terms of the summation of impact from all observations for each observational type, followed by GeoAMV, SYNOP and GPSRF. In 0600UTC and 1800UTC, the greatest forecast error reduction is due to the GeoAMV instead. However, in terms of impact per observation, GPSREF is the most efficient observation type to reduce the 24h forecast error, followed by SONDE SFC, SYNOP and SOUND. It is worth to noting that the GPSRF shows a steady and consistent positive impact on CWB OP23 system in all times. However, the time series of FSO diagnosis shows that, in 0600UTC and 1800UTC, many cycles show positive error contribution for almost every kind of observations.

Abstract

Title:
Impact of upper-air and near-surface observations on short-range forecasts from an hourly assimilation cycle (RUC and Rapid Refresh)

Authors:
Stan Benjamin, Haidao Lin, Steve Weygandt, Susan Sahm, David Dowell
NOAA Earth System Research Laboratory, Boulder, CO

The hourly updated model/assimilation cycles in the United States, the Rapid Update Cycle (run operationally at NCEP through Jan 2011) and its GSI/WRF-based successor, the Rapid Refresh, both provide a unique perspective for examining observation impact on very short-range (1-18h) forecasts. One initial study has been carried to examine relative impact of aircraft, profiler, rawinsonde, VAD wind, GPS-precipitable water, surface-METAR, and mesonet (non-METAR) data. In this OSE study (Benjamin et al., Monthly Weather Review, 2010), it was found that aircraft observations had the strongest impact on short-range forecasts, followed by rawinsonde, and then followed by GPS-PW and surface observations. The impact of surface observations was much larger than originally anticipated due to augmentation of near-surface data via pseudo-innovations in the boundary layer.

More recent regional OSE results using 1-h intermittent assimilation will be presented at the Workshop using the new Rapid Refresh (to be implemented at NCEP in January 2012 replacing the RUC). This paper will be accompanied by a study specifically on overall impact from radar reflectivity and radial wind assimilation in the same hourly assimilation RUC and Rapid Refresh assimilation systems.

Regional aspects of a European upper-air network redesign study: results obtained with the ALADIN limited-area model at the Hungarian Meteorological Service

András Horányi, Edit Adamcsek and Gergely Bölöni
(horanyi.a@met.hu, adamcsek.e@met.hu, boloni.g@met.hu)

The main objective of the presented study was to provide input for the definition of a European-wide network of ground-based upper-air observing systems with special emphasis on regional aspects as provided by regional limited-area models. A former study (conducted by EUCOS: EUMETNET Composite Observing System programme) indicated that the radiosonde and aircraft observations play important role with respect to the satellite observations for regional numerical weather prediction. The recent work was concentrating on the possible refinement of the upper-air measurement network with special emphasis on the radiosonde and aircraft data as regards their optimal spatial and temporal distribution. For that purpose, six different observing system scenarios have been specified, varying from a full operational-like data usage (control scenario) to a baseline scenario, which is characterised by radical decrease of the number of radiosonde and aircraft profiles. The intermediate scenarios are focusing on the different thinning distances for the radiosonde and aircraft data, implying a stepwise degradation of their quantity in terms of spatial resolution. The Observing System Experiments (OSEs) based on the abovementioned scenarios were performed by the global NWP centre ECMWF and some National Meteorological Services (NMS) running limited-area models.

In Hungary the ALADIN/HU model was applied in its hydrostatic version with 8 km horizontal and 49 levels vertical resolution covering a large part of Europe. Concerning the data assimilation setup, an upper-air three-dimensional variational data assimilation (3d-var) and an optimal interpolation (OI) surface assimilation scheme have been used with 6-hours cycling frequency. The assimilated data consisted of surface, radiosonde, aircraft, windprofiler and satellite (Atmospheric Motion Vectors and ATOVS/AMSU and MHS) measurements. For the impact studies 00 UTC and 06 UTC forecast runs were performed with 54 and 48 hours integration times, respectively.

Most of the observation denial experiments led to a degradeation in the forecast skill with respect to the control scenario, especially up to +18 hours. An exception is a scenario when 00 UTC radiosonde observations were kept unchanged and only 06, 12 and 18 UTC radiosondes were thinned. This fact indicates that in case of optimisation of the European observational network one can consider a partial reduction in the 06, 12 and 18 UTC radiosonde ascents (probably thanks to the growing availability of the aircraft profiles) but not those at 00 UTC.

Regional impact studies performed in the COSMO community

Alexander Cress, Klaus Stephan, Christoph Schraff, Hans-Juergen Bitzer
Deutscher Wetterdienst, 63004 Offenbach, Germany

Abstract

The principle objective of COSMO model-system development is the operational forecasting of mesoscale weather, especially high impact weather. It should allow the direct simulation of convective systems as well as the consideration of the effects of small-scale topography. Two application of the COSMO model system, the regional model COSMO-EU and the convection-resolving model COSMO-DE, together with the global model GME, form the Numerical Weather Prediction (NWP) model chain at DWD. The COSMO-EU covers the Eastern Atlantic and Europe with 50 vertical layers and a grid resolution of 7 km. The COSMO-DE covers Germany, Switzerland and Austria and has a grid resolution of 2.8 km and 50 vertical layers.

Observation nudging is the standard data assimilation algorithm for the COSMO-model. It is currently used in all convective-scale and larger-scale implementations. The nudging scheme can cope with highly non-linear physical processes in the model and with non-Gaussian distributions and is able to continuously assimilate asynoptic and high-frequency data. At present, direct observations from radiosondes, aircraft, wind profilers, Synop stations, ships and buoys are used operationally, in both COSMO-EU and COSMO-DE. For the assimilation of radar-derived precipitation rates, a latent heat nudging scheme is applied operationally at the convective scale.

Data assimilation on the km-scale require high resolution atmospheric data (temporal and spatial) in order to initiate small scale atmospheric processes This presentation will give a summary of recent progress in assimilation of radar-derived rain rates, VAD wind profiles, vertical integrated water vapour content of the atmosphere, derived from GPS signals. In addition, first results of using Doppler radial winds and cloud information over land, derived from satellite and in-situ observations will be addressed. In an effort to use more satellite information in our regional models, a 1D-Var modul has been developed for temperature and humidity retrievals from ATOVS, IASI, SEVERI satellite radiances. First results will be presented.

One major finding is, that the use of radar-derived rain rates exerts a high impact on the forecast quality of precipitation in the first three to six hours. Thereafter, the impact decreases gradually. Using data from wind profilers and VAD estimates depict a small positive impact on the forecast quality of the COSMO models, The use humidity information from GPS signals have a positive impact in summer and first results of Doppler radial winds indicate a substantial improvement of the flow regime in rainy conditions. So far, satellite radiances show only neutral to slightly positive impacts.

Operational use of high resolution observations for very short term numerical forecasting

Siebren de Haan, KNMI, The Netherlands

High resolution numerical nowcasting will benefit from high spatial and temporal observations. Short delay in the arrival of observations is essential in order to be able assimilate these observations in a very short term numerical weather model (focused on the short range (0-9h)).

At KNMI, an hourly 3dvar model cycle has been set up at a grid resolution of 10 km to produce operationally 4D weather information for use by Air Traffic Control Schiphol (Amsterdam) to assist in their Continuous Descent Approach. Currently AMDAR wind and temperature, ModeS wind, GPS Zenith Total Delay, radar radial wind and surface pressure observations are available within 10 minutes in the KNMI observation database and are assimilated. In experimental mode, wind profiler and sodar onservations are assimilated, and a cloud forcing scheme based on MSG and cloud-base observations is under investigation. This paper discusses the use and impact of these observations with respect to forecasts of wind, temperature, humidity and rainfall.

Impact of different observation types in the HIRLAM/ALADIN-LACE regional weather forecasting models

Roger Randriamampianina and more co-authors

Abstract
As a benefit from the common observation pre-processing system OPLACE (Observation Pre-processing for Limited Area modelling (LAM) in Central Europe), the data assimilation module of the ALADIN model became available in more and more LACE countries (in Slovenia, Czech Republic, Austria for example). The HIRLAM consortium is planning to carry out a comprehensive observation impact study between the end of 2011 and summer 2012. According to the plans, the impact study will be accomplished using the HARMONIE (LAM model based on ALADIN/AROME cores) model with a common well specified domain. In our presentation we will discuss and summarize the impact of different observation types in the HARMONIE/ALADIN-LACE limited area model analyses and forecasts.

Please, note that depending on the volume of the material, this presentation can de divided into two parts.

Evaluation of data impact in the mesoscale AROME 3D-Var system at Météo-France

Jean-François Mahfouf, Pierre Brousseau, Eric Wattrelot, Vincent Guidard, Patrick Moll
Météo-France/CNRS, CNRM/GAME, GMAP

The 3D-Var data assimilation system for the convection permitting model AROME (2.5 km resolution) is operational at Météo-France since November 2008. In addition to conventional and satellite observations used in global data assimilation systems, dedicated observations for the mesoscale are assimilated : total zenith delays from ground based GPS stations and radar measurements (radial winds and reflectivities). The impact of the various observation types on AROME analyses and forecasts is assessed using a randomization technique proposed by Desroziers et al. (2005) that is complementary to other diagnostics such as DFS. Diagnostics on the reduction of background error variances reveal the important contributions of radar and aircraft measurements. A posteriori diagnostics are performed on the AROME 3D-Var in order to retune observations error variances for several data types and identify observation error correlations. Impact studies are run with modified observation error specifications and data thinning for radar, satellite and GPS observations.

Observing System Impact Studies in ACCESS

Chris Tingwell, Peter Steinle, John le Marshall, Elaine Miles, Yi Xiao, Rolf Seecamp, Jin Lee, Susan Rennie, Xingbao Wang, Justin Peter, Alan Seed and Belinda Roux

Centre for Australian Weather and Climate Research
Bureau of Meteorology
Australia

The Australian Community Climate and Earth System Simulator (ACCESS) provides the Australian Bureau of Meteorology with a suite of NWP systems that incorporate data assimilation and forecast model components developed by the Met Office and adapted for local use by the Centre for Australian Weather and Climate Research (CAWCR).

The ACCESS global, regional and national systems feature 4D-Var assimilation of conventional and remotely sensed data including satellite data not available previously to Bureau NWP systems; e.g. radiance data from the infrared sounder AIRS. As well as generating its own forecasts, each ACCESS system provides the nesting conditions for the next higher resolution ACCESS system. Currently, non-assimilating city based ACCESS systems nest with the regional system. The operational implementation of the ACCESS NWP suite has provided the Bureau with a significant improvement in forecast skill over that previously available. CAWCR is currently engaged in a significant upgrade of the ACCESS system with the intention of providing NWP forecast skill comparable to that of leading NWP centres. A major part of this upgrade will be the increased use of satellite data, with significant new observation sources in the form of hyper-spectral IR data from the IASI instrument, and GPS-RO data.

In addition, as part of a major effort to upgrade the Bureau's use of weather radar, data assimilation is being extended to the high resolution city based ACCESS configurations, with the medium term goal of operationally assimilating data from the Bureau's upgraded radar network. Early work has focussed on latent heat nudging derived from radar reflectivity observations in 1.5km resolution ACCESS systems with 3dVAR assimilation. Impact studies have examined the effect on precipitation forecasts as compared to those from the operational ACCESS systems, in several significant rainfall events.

A number of studies have also been conducted to test and optimise the impact of both conventional and remotely sensing observing systems on ACCESS forecast skill, in each of the ACCESS domains. In particular, studies have evaluated the impact of the Australian radiosonde network and AMDAR observations on forecast skill in the ACCESS global, regional and national domains. Conventional observations are, however, relatively sparse in the Australian region, and the Southern Hemisphere generally, and satellite observing systems are a major source of forecast skill. Studies have evaluated the impact on ACCESS forecast skill of GPS-RO data, IASI radiances, and locally generated high resolution AMV observations derived from the MTSAT geostationary platforms over most of the available full disk.

We will present and discuss some of the results from these impact studies, and outline plans for future work.

S3 AMDAR

Dr Ralph Petersen from the University of Wisconsin.

ABSTRACT

Over the past two decades the Aircraft Meteorological Data Relay (AMDAR) Programme has rapidly and consistently grown as it has expanded from producing several thousands observations of wind and air temperature over a limited coverage, to one that now produces nearly three hundred thousand observations per day with considerably enhanced and expanded global coverage and includes a growing number of moisture observations. Such a growth in the output of a particular observing system has had a significant and evolving impact on NWP systems and operational forecasting applications that has been tested and gauged at various times over this period. This talk will present a summary of the results and conclusions of the observing systems tests and applications assessments of AMDAR data and make recommendations for future work in this area.

Marginal benefit of higher resolution analysis and mesoscale observing networks in the UK Met Office operational convective scale model

Gareth Dow, Mark Weeks, Bruce Macpherson, Dale Barker

Met Office, UK

ABSTRACT

The UK Met Office runs operational UK models at 4km and 1.5km resolution nested within a global model with resolution 25km at mid-latitudes. The global model has a 6-hourly data assimilation cycle and a 4DVAR assimilation scheme. Global forecasts are run off data times of 00, 06, 12, 18 UTC. The UK models have a 3-hourly assimilation cycle and 3DVAR assimilation scheme. UK forecasts are run off data times 03, 09, 15, 21 UTC driven by global lateral boundary data. The UK models have some extra observations not available to the global model: radar rainfall and radial winds, satellite and surface cloud reports, visibility observations and denser networks of screen level temperature and humidity.

Relative impact from the full UK data assimilation system comes from several sources: from the higher resolution of the model and analysis grid, from extra observing systems, and from the offset start time of the UK forecast which allows use of some later observations than those available to the global model. We present results of experiments to measure the marginal benefit of the UK assimilation system and the relative contribution of different sources. The experiments include UK forecasts run from interpolated global model analyses, UK forecasts from data times coincident with global analyses and OSEs where we withdraw extra observing systems from the UK run. Impact is measured for key surface variables of temperature, wind, cloud, rainfall and visibility.

Global and regional impact studies at JMA

Yoshiaki Sato
Japan Meteorological Agency

ABSTRACT

JMA has conducted many impact studies to improve the forecast skills for the global and meso-scale NWP systems. With the confirmation of the positive impacts, the tested observations have been introduced into the NWP operational system.

In the recent 4 years after the last workshop, JMA started the assimilation of clear sky radiance (CSR) from 5 geostationary satellites, ASCAT ocean surface winds, COSMIC refractivity, and AMDAR temperature in the global NWP system. CSR reduced dry bias in the mid-troposphere. ASCAT brought the better analysis especially of tropical cyclones over the open ocean. COSMIC refractivity provided positive impact especially on the stratosphere. About the AMDAR temperature data, each aircraft has its own bias, so that the bias correction scheme for each aircraft was implemented. The quality control is very important for using the aircraft data.

In the meso-scale NWP system, JMA started using Doppler radial velocity data from additionally upgraded radar sites. It extended coverage of the data and provides positive impact especially on the analysis of wind shear. The ground-based GPS integrated precipitable water (IPW) assimilation was also started and it brought the better water vapor analysis over the Japan Islands. The relative humidity retrievals from the radar reflectivity assimilation were implemented and it was confirmed that the assimilation can relocate the rain band positions appropriately. Finally, satellite radiance assimilation was started instead of the retrieval assimilation. For the satellite radiance assimilation in the meso-scale model, the coordination of the regional ATOVS retransmission service (RARS) is very important for the quick acquisition of the data.

On the other hand, JMA is still testing hyper-spectral infra-red sounders such as AIRS and IASI. Moreover, JMA is currently preparing to use the world's ground-based GPS-IPW, SSMISs, FY-3/MWTS, AVHRR polar winds, and coming NPP/CrIMSS.

Such activities will be presented in the workshop.

The role of assimilating satellite data over South America using LETKF

José Antonio Aravéquia, Bruna Silveira , Maria das Dores da Silva Medeiros

jose.aravequia@cptec.inpe.br

Affiliation: CPTEC/INPE – Brazil.

Rodovia Dutra, km 39, Cachoeira Paulista – SP, 12630-000 Brazil

ABSTRACT

The impact of assimilating Satellite Radiances over land in South America is examined under the approach of LETKF for the CPTEC's AGCM. In this study we examine the benefit of assimilating AMSU-A level 1B brightness temperature data from the Earth Observing System (EOS) Aqua spacecraft over land in South America. In the numerical experiments we explore how the changes in the setup of the LETKF, as thinning, inflation factor and in the number of ensemble members impacts the RMSE reduction when compares with conventional only data experiment. The results indicate that the careful choice of the values for those parameters can increase the impact of the use of satellite observation.