ISDA-Online

Friday, June 07, 2024 from 15 – 17h UTC

“Convective-scale Data Assimilation”

Organizers: Maud Martet (Météo-France, France)
Prashant Kumar (Space Applications Centre, ISRO, India)
Nora Schenk (DWD, Germany)

Delve into the dynamic world of Convective Scale Data Assimilation, a pivotal area shaping the precision and effectiveness of regional weather forecasting. This session zeroes in on the challenges and innovations at the convective scale, where the fusion of fine-scale data and advanced assimilation techniques holds the key to unraveling complex highly non-linear weather phenomena. We'll explore how enhancing data assimilation at this scale can lead to significant improvements in predicting localized, high-impact weather events. Join us for a dialogue that seeks to push the boundaries of meteorological understanding and forecasting accuracy at the convective scale.

Program: (All talks: 15’ + 3’ Q&A)

15:00 – 15:03 **Welcome**

15:04 – 15:22 **Developed a Rapid Update Cycle Data Assimilation system for Prediction of Severe Convective Weather Events**
Ashish Routray, D. Dutta, K. B. R. R. Hari Prasad, V. S. Prasad

15:23 – 15:41 **Added value of assimilating near-ground observations from personal weather stations in AROME-France system**
Alan Demortier, Olivier Caumont, Vivien Pourret, Marc Mandement

15:42 – 16:00 **Enhancing Regional Forecasting Through Assimilation of Lightning and Nowcast Objects in ICON-LAM**
Lisa Neef, Klaus Stephan

16:01 – 16:19 **Tropical Cyclone Forecasting: Impact of Convective Scale Data Assimilation**
Meenakshi Shenoy, V. S. Prasad, D. Srinivas, Suryakanti Dutta, K.B.R.R. Hari Prasad, P. V. S Raju

16:20 – 16:38 **Ambiguity and nonlinearity in the assimilation of visible and infrared observations**
Lukas Kugler, Martin Weissmann

16:39 – 16:57 **High-resolution Data Assimilation and the Structure Function for the Copernicus Arctic Regional Second Generation Reanalysis**
Swapan Mallick, Jelena Bojarova, Xiaohua Yang

16:57 – 17:00 **Closing / Outlook**

Please note:

- When you login to the session before 15:00 UTC, and everything is quiet, this is most likely because we muted the microphones.
- The times in UTC are approximate. In case of technical problems, we might have to change the order of the presentations.
- **Time Zones**: 15 – 17 UTC
  04 – 06 pm BST (London) | 05 – 07 pm CEST (Berlin)
  11 – 01 am CST (Shanghai) | 00 – 02 am JST (Tokyo) | 01 – 03 am AEDT (Sydney)
  08 – 10 am PDT (San Fran.) | 09 – 11 am MDT (Denver) | 11 – 01 pm EDT (New York)

Developed a Rapid Update Cycle Data Assimilation system for Prediction of Sever Convective Weather Events

Ashish Routray[1], D. Dutta[1], K.B.R.R. Hari Prasad[1], V. S. Prasad[1]

[1]National Centre for Medium Range Weather Forecasting (NCMRWF), India

The National Centre for Medium-Range Weather Forecasting (NCMRWF) has set up a two 1hrly updated 1.5 km High-Resolution Rapid Refresh (HRRR) Data Assimilation (DA) system with regional NCUM-R and WRF forecast models that are configured over the Indian domain. The main objective of the present study is to demonstrate the assimilation of DWR observations in the HRRR DA system for the simulation of convective systems over Indian region. Two set-up numerical experiments viz CTL (without DA) and HRR (Assimilation of radial velocity and reflectivity observations along with other observations in 1hrly 4DVAR HRRR DA system) are carried out. The location and distribution of rainfall are better simulated in the HRR experiment than in the CTL simulation. However, the CTL simulated high rainfall that slightly shifted northeastward, corresponding to the observations. The peak rainfall is well brought out in the HRR simulation with a minimal time lag while compared with the CTL simulation. The CTL simulation shows a high amount of rainfall during the early hours which may be due to the model spin-up. The temporal evolution of the convective system is well captured by the HRR with a higher correlation than in the CTL experiment. Various statistical skill scores at different rainfall thresholds clearly show an improvement in the HRR simulation than the CTL simulation. The forecast skill (%) of HRR concerning the CTL is more at higher rainfall thresholds. It is deduced that the HRR experiment well simulates the high intensity of precipitation than the CTL experiment. The present study results suggested that the hourly updated cyclic assimilation in the high-resolution modeling approach with the assimilation of DWR observations has a beneficial impact on such convective weather systems.

Added value of assimilating near-ground observations from personal weather stations in AROME-France system

Alan Demortier[1], Olivier Caumont [2], Vivien Pourret[1], Marc Mandement[1]

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Networks of personal weather stations (PWSs) are emerging, such as Netatmo's, providing surface observations of pressure, temperature and relative humidity at a spatial density previously unattainable with standard weather stations (SWSs). The limited area numerical weather prediction (NWP) model AROME-France, with a horizontal grid spacing of 1.3 km, is sub-constrained by current observations near the surface, in the atmospheric boundary layer, where phenomena associated with strong pressure, temperature and relative humidity gradients occur.

Despite the large number of PWS stations, the quality of their observations is very heterogeneous and their metadata limited. A pre-processing method is therefore necessary. It consists of a bias correction specific to each sensor and a quality control capable of distinguishing fine scale meteorological patterns from observational errors.

Once pre-processed, PWS observations are assimilated as conventional observations, using the same observation operator. Monitoring experiments are initiated to diagnose observation errors and correlated observation errors, to adjust and to discuss the need to apply a thinning method.
The added value of PWS data is inferred using an Observing System Experiment (OSE) framework over one month. OSEs were performed independently and then jointly for the three aforementioned types of PWS observations.

The OSE results show the limitations, with their current settings, of both the 3DVar scheme for altitude analysis and the OI scheme for surface analysis, respectively, and the positive behaviour of the 3DEnVar altitude analysis scheme when assimilating the new observations, both in the AROME-France analysis and in the short-range forecasts.
Case studies of a heatwave and a fog event demonstrate the ability of the PWS observation assimilation to bring the analysis closer to the SWS observations, and, in fine, to improve their surface representation in both the analysis and the forecast.

Enhancing Regional Forecasting Through Assimilation of Lightning and Nowcast Objects in ICON-LAM

Lisa Neef[1], Klaus Stephan[1]

[1]Deutscher Wetterdienst, Germany

We present experiments assimilating both lightning and nowcast objects into the regional forecast model ICON-LAM using the LETKF system of the German Weather Sevice, and aiming to enhance the accuracy of convection forecasts. The assimilation of object-based information in particular shows promising improvements in forecasting convection events following the assimilation.

However, integrating object-based information into the model poses challenges, particularly in handling the irregularity of object locations. To address this, we employ a method where the information is sorted onto a regular grid and allocated to specific grid points based on neighborhood criteria. We demonstrate the effectiveness of this approach in improving forecast skill, particularly in predicting convective events.

Tropical Cyclone Forecasting: Impact of Convective Scale Data Assimilation

Meenakshi Shenoy[1], V. S. Prasad[1], D. Srinivas[1], S. Dutta[1],
K.B.R.R. Hari Prasad[1], P. V. S Raju[2]

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This study investigates the impact of convective scale data assimilation (CDA) on forecasting tropical cyclone events using the Weather Research and Forecasting (WRF) model at a 9-kilometer resolution. Advanced assimilation techniques were applied to integrate radar, satellite, and surface observations, refining the model's initial conditions to improve the representation of convective-scale features crucial for accurate prediction. Utilizing a 3D-variational approach, all conventional and satellite observations were assimilated to enhance the accuracy of the initial atmospheric state, particularly within convective scales vital for tropical cyclone dynamics. Evaluation of the assimilation impact included a detailed analysis of model performance metrics specific to the tropical cyclone event, encompassing assessments of structure at initial, mature, and landfall stages.

Furthermore, this study explores the effects of both vortex initialization and non-vortex initialization on CDA. Vortex initialization involves initializing the model with a predefined vortex structure based on observed or model data. A comparative analysis of these initialization methods is conducted to assess their respective impacts on convective data assimilation and subsequent forecast accuracy.

The findings reveal notable improvements in the accuracy of the convective processes at every stage of the cyclone. The assimilation of diverse observational datasets significantly enhanced predictive capabilities, with variations observed between vortex and non-vortex initialization approaches. Overall, this comparative analysis underscores the significant impact of vortex representation on convective data assimilation, highlighting the importance of accurately capturing the vortex structure to enhance the accuracy of numerical weather prediction models for high-impact weather events such as tropical cyclones.

Ambiguity and nonlinearity in the assimilation of visible and infrared observations

Lukas Kugler[1], Martin Weissmann[1]

[1]University of Vienna, Austria

Infrared and visible observations are promising sources of information for convective-scale data assimilation. However, a number of issues question their value for data assimilation, such as, ambiguity regarding the vertical structure (cloud types) and the nonlinearity of the observation operators.

The first part of the talk adresses the ambiguity regarding the vertical structure of clouds: High values of visible reflectance can result from both - shallow cumulus or cumulonimbus. Similarly, low infrared brightness temperature can stem from cirrus or cumulonimbus. This ambiguity can lead to erroneous increments and can limit the effectiveness of assimilation. However, we found that when both channels - infrared and visible - were assimilated in combination, the ambiguity was mitigated and the cloud analysis and forecast metrics were improved.
The second part of the talk follows up on the study of Scheck et al. (2020), who found undesired analysis deviations compared to the expected Kalman posterior due to the nonlinearity of the observation operator. We evaluate systematic deviations of the ensemble-mean increment and the ensemble-variance adjustment. What implications does this have for the consistency of spread-error relationship? Can we compensate for the systematic deviations in the future?

The results are based on idealized observing-system simulation experiments (OSSE) using the Weather Research and Forecasting model (WRF) at 2-km grid resolution, the radiative transfer model RTTOV/MFASIS, and the Ensemble Adjustment Kalman Filter (EAKF) in the Data Assimilation Research Testbed (DART).

High-resolution Data Assimilation and the Structure Function for the Copernicus Arctic Regional Second Generation Reanalysis

Swapan Mallick[1], Jelena Bojarova[1], Xiaohua Yang[2]

[1]Swedish Meteorological and Hydrological Institute (SMHI), Sweden
[2]Danish Meteorological Institute (DMI), Denmark

Effectively characterizing the forecast error structure of a model poses a considerable challenge in the integration of variational data assimilation within a high-resolution convective-scale model. The aspect of model forecast error structure has been overlooked in comparison to parameter and observation errors. In this study, we will discuss the derivation and the importance of background error statistics (B-matrix) over the Copernicus Arctic Regional Reanalysis Second Generation (CARRA2) region. CARRA2 is a ECMWF reanalysis product that extends the domain to a larger area (spatial resolution 2.5 km and 2880 x 2880 grid points) to provide pan-Arctic coverage. All the assimilation, forecasts, and error statistics are computed using the Harmonie ensemble prediction system (HarmonEPS). The limited area HarmonEPS system is a convection-permitting ensemble prediction system developed and maintained by the HIRLAM consortium. Forecast error covariances are estimated using a spectral approach and from a group of ensemble forecast differences. Autocovariances are calculated using a nonseparable method, and multiple linear regressions are employed to formulate cross-covariances. Multiple sensitivity experiments have been performed for multiple years and seasons to assess the impact and variation of statistics of the error structure that affected subsequent weather forecasts over the CARRA2 region. In addition, the results and the impact of the seasonal variation of B-matrix on short-term forecasts will be discussed.