ISDA-Online

April 16, 2021 07 – 09 UTC

"Convective-Scale Data Assimilation"

Organizers: *Tobias Necker (University of Vienna, Austria)*
Martin Weissmann (University of Vienna, Austria)
Jeffrey Anderson (NCAR, Boulder, US)
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Program:

07:00 – 07:10	**Welcome**
07:10 – 07:30	**Exploring Particle Filtering Strategies for Convective-scale Weather Forecasting** Joshua McCurry, Jonathan Poterjoy, Kent Knopfmeier, Louis Wicker
07:30 – 07:50	**Assimilation of Radial Winds with Observation Error Correlated in Time and Space** Tadashi Fujita, Hiromu Seko, Takuya Kawabata, Ken Sawada, Daisuke Hotta, Yasutaka Ikuta
07:50 – 08:10	**Using visible satellite images in convective-scale data assimilation** Leonhard Scheck, Stefan Geiss, Lilo Bach, Alberto de Lozar, Martin Weissman
08:10 – 08:30	**An observation operator for geostationary lightning imager data assimilation in storm-scale numerical weather prediction systems** Pauline Combarnous, Felix Erdmann, Olivier Caumont, Éric Defer
08:30 – 08:50	**AROME-France 4DEnVar: A data assimilation system for NWP at convective scale** Pierre Brousseau, Etienne Arbogast, Loïk Berre, Yann Michel, Thibaut Montmerle
08:50 – 09:00	**Closing: Information on upcoming sessions**

<u>Please note:</u>

- When you login to the session before 07:00 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**: 07 – 09 UTC
  08 – 10 am BST (London) | 09 – 11 am CEST (Berlin)
  03 – 05 pm CST (Shanghai) | 04 – 06 pm JST (Tokyo) | 05 – 07 pm AEDT (Sydney)
  00 – 02 am PDT (San Fran.) | 01 – 03 am MDT (Denver) | 03 – 05 am EDT (New York)

Exploring Particle Filtering Strategies for Convective-scale Weather Forecasting

Joshua McCurry[1], Jonathan Poterjoy[1,2],
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As ensemble sizes become large, particle filter (PF) based approaches to data assimilation (DA) promise improvements for weather forecast skill, particularly due to the reduction of “transient adjustment” phenomena caused by Gaussian assumptions in contemporary parametric DA methods. For applications of this type, the affordability of PFs follows from approximations such as localization. Localized PFs limit the spatial influence of update steps in a manner similar to that of covariance localization in Gaussian DA methods, such as ensemble Kalman filters (EnKFs), which has proven to be a tractable way of overcoming steep computational costs usually associated with PFs for high dimensional domains.

Here, we present results of DA experiments performed with a localized PF implemented in the NCAR Data Assimilation Research Testbed (DART). This filter is revised from the local PF presented in Poterjoy et al. (2019), and now includes additional strategies to reduce sampling error, such as regularization and tempered transitions. We will discuss experiments performed using the Weather Research and Forecasting (WRF) model within an ensemble prediction testbed adapted from the NOAA National Severe Storms Laboratories’ experimental Warn on Forecast system (WoFS), designed for the prediction of severe convective storms. Assimilated observations include 10cm radar reflectivity and radial velocity from NOAA’s NEXt-Generation RADar (NEXRAD), as well as rawinsonde, satellite wind, mesonet, ACARS and METAR data from NOAA’s Meteorological Assimilation Data Ingest System (MADIS). We generate forecast verifications for several severe-outbreak test cases using initial conditions from DA cycling with the local PF, and compare against an EnKF baseline. This work represents the first step in a multi-year project aimed at exploring non-parametric DA and forecasting techniques using ensemble sizes beyond what is currently affordable for warn-on-forecast oriented applications.

Assimilation of Radial Winds with Observation Error Correlated in Time and Space

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Radial wind from Doppler radar is one of the important sources of observational information on detailed atmospheric conditions, often related to severe weather events. This study is aimed at effectively utilizing radial wind observations densely distributed in time and space to initialize a forecast model. It is important to appropriately handle correlation of the observation error in data assimilation of these high-resolution data. Spatial and temporal correlations of the observation error are statistically diagnosed using the method by Desroziers et al. (2005). The statistical samples are generated running a 3-hourly 4D-Var cycle using the experimental system based on the Meso-scale Analysis operated at Japan Meteorological Agency as of 2018 applying the JNoVA 4D-Var (Honda et al. 2005, JMA 2019). The correlation range is found to increase with the beam range and the forecast time, suggesting contributions from errors in the observation operator and the forecast model. The spatial and temporal correlation of the observation error is incorporated into the 4D-Var to consistently assimilate radial wind data without applying a severe thinning in a real case experiment based on the Meso-scale Analysis. In order to extract more information from the dense observation data, the flow-dependent background error generated using the Ensemble of Data Assimilations method (EDA; Isaksen et al. 2010) also is introduced by extending the 4D-Var into the hybrid 4D-Var. Verification of the forecast in the case study shows the flow-dependent background error contributes to effectively utilize the high-resolution and high-frequency radial wind observations. Investigations are also carried out on sensitivity of the performance to the EDA ensemble configuration, influence from the sampling of perturbations added to observations in EDA, and effect from an enhancement in the ensemble control variables.

Using visible satellite images in convective-scale data assimilation

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Imagers on geostationary satellites provide high-resolution information on the state of the atmosphere that is well-suited for convective-scale data assimilation. So far only the thermal infrared channels have been utilized operationally, and mainly to correct humidity and temperature errors. However, there is a rising interest to use also the cloud signal. The channels in the solar part of the sprectrum are also sensitive to clouds and contain additional, complementary information. Visible channels can provide better information on the water and ice content of clouds than thermal infrared channels, have no problems to detect low clouds and contain also information on the cloud microphysics and the cloud top structure. Moreover, visible reflectances are strongly correlated with the solar irradiation at the surface and thus their assimilation has a clear potential to improve also radiation forecasts.

So far visible satellite images have not been assimilated directly for operational purposes, as multiple scattering dominates in the visible spectral range and makes radiative transfer (RT) computations with standard methods complex and slow. Only recently, we developed a sufficiently fast and accurate forward operator that relies on a compressed reflectance look-up table (LUT) computed with slow standard RT methods. Here we report on two ways to use the forward operator to improve forecasts. First, we show that observed and synthetic visible 0.6μm Meteosat SEVIRI images can be used to detect systematic errors in the model clouds that can cause severe problems for data assimilation. Second, based on assimilation experiments using the ICON-D2 model and the local ensemble transformation Kalman filter (LETKF) implemented in DWDs data assimilation coding environment (DACE) we demonstrate for test periods of several weeks that errors in the cloud distribution and the surface radiation can be significantly reduced. A beneficial impact is still present after 24 hours.

An observation operator for geostationary lightning imager data assimilation in storm-scale numerical weather prediction systems

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In spite of the continuous improvement of numerical weather prediction (NWP) systems, thunderstorms remain hard to predict with accuracy. This difficulty partly results from a lack of observations to describe the initial state of the atmosphere. Total lightning is a good indicator of convective activity and lightning data assimilation could improve the prediction of thunderstorms, especially in regions where storm-related observations are scarce.
The Lightning Imager (LI) onboard the Meteosat Third Generation (MTG) satellites will provide total lightning observations continuously over Europe with a spatial resolution of a few kilometers. This makes it a rich potential data source for convection-permitting NWP.
To prepare the assimilation of the 10-min flash extent accumulation (FEA) measured by LI in the French storm-scale regional AROME NWP system, a lightning observation operator is required to convert the model variables into a product comparable to the observations. Since LI observations are not available yet (launch planned in the forthcoming years), pseudo-LI FEA observations were generated from a ground-based lightning detection system (Erdmann et al., in revision for JTECH). This study focuses on the evaluation of different FEA observation operators from various proxies encountered in the literature and calculated from the outputs of 1 h AROME-France forecasts for 27 storm days in 2018. The data are processed as distributions over the whole domain and time period since a pixel-to-pixel comparison exhibits a rather poor correlation.
Different regression techniques, linear regression as well as machine learning models, are used to relate the synthetic FEAs and the modeled proxies. The training of observation operator is performed on 25 days of the dataset and 2 days are used for validation. The observation operator is finally evaluated by computing Fraction Skill Scores for simulated FEAs. The performance of a principal component analysis is also examined.

AROME-France 4DEnVar: A data assimilation system for NWP at convective scale

Pierre brousseau[1], Etienne Arbogast[1], Loïk Berre[1],
Yann Michel[1], Thibaut Montmerle[1]

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AROME-France is the operational convective-scale NWP system used by Meteo-France since the end of 2008. It uses a 3D-Var continuously cycled data assimilation scheme in order to determine its initial conditions at a horizontal resolution of 1.3km. The period of this assimilation cycle was reduced from 3h to 1h in April 2015 to allow for the assimilation of more observations informative at convective-scales (such as radar measurements for example) with a higher temporal frequency.
In order to use further these high temporal frequency observations, 4D schemes are now investigated in the EnVar framework to benefit from flow-dependent background error co-variances managing the temporal dimension without tangent linear and adjoind versions of the forecast model . A prototype of a 4DEnVar system has been developed at 1.3km horizontal resolution, with 15 minutes timeslots in a hourly cycle, using perturbations from a 3.2km EDA.
A description of this 4DEnVar system and preliminary results obtained from the simulation of strong convective events will be discussed. Particularly, the handling of the temporal dimension within the assimilation window by the background error temporal correlations deduced from the EDA will be investigated. The contribution of these temporal correlations to the analysis increments will be highlighted thanks to original diagnostics.