ISDA-Online

Friday, July 5, 2024 / 7 – 9h UTC

"Verification and Diagnostics for Data Assimilation"

Organizers: ***In-Hyuk Kwon*** *(KIAPS, Korea),* ***Nabir Mamnun*** *(Mercator Ocean International, France),* ***Olaf Stiller*** *(DWD, Germany),* ***Lars Nerger*** *(AWI, Germany)*

When applying DA, the verification of its outcome is of prime importance. With ensemble methods in DA, this implies to also access the performance of the whole ensemble. Aspects are for example the representative of the ensemble, the skill of the DA to incorporate the observational information in a multivariate way and its ability to produce skillful forecasts initialized from the analysis. For this event, we invite contributions on all types of diagnostic and verification methods and their application in DA.

Program:

7:00 – 7:05 Welcome

(25min invited talk + 5 min Q&A)

7:05 – 7:35 Innovation-based Diagnosis of Error Covariances
Loïk Berre

(13min contributed talks + 3min Q&A each)

7:35 – 7:51 The Fractions Skill Score for Ensemble Verification
Tobias Necker, Ludwig Wolfgruber, Lukas Kugler, Martin Weissmann, Manfred Dorninger, Stefano Serafin

7:51 – 8:07 Diagnostics on 2m Temperature assimilation in the KENDA-CH1 system at MeteoSwiss
Krishnamoorthy Chandramouli, Daniel Leuenberger, Claire Merker

8:07 – 8:23 EnFSOI-Jof: An Objective Approach for Computing Observation Impact in Observation Space
Giovanni Conti, C. Cardinali, G. De Goncalves

8:23 – 8:39 Verification and diagnostic issues illustrated by the assimilation of Mode-S aircraft data
Bruce Ingleby

8:39 – 8:55 Can we diagnose/assess localization functions directly with observations?
Olaf Stiller

8:55 – 9:00 Closing / Outlook

Please note:

- 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)
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Innovation-based diagnoses of Error Covariances

Loïk Berre

Météo France, France

Several methods for diagnosing error variances and correlations have been proposed and applied in the litterature. Some of these methods and their properties will be presented, including the method based on covariances of analysis residuals (Desroziers et al 2005). Relationships with optimality criteria and filtering properties will be discussed. Applications of these diagnostics will also be illustrated.

The Fractions Skill Score for Ensemble Verification

Tobias Necker, Ludwig Wolfgruber, Lukas Kugler
Martin Weissmann, Manfred Dorninger, Stefano Serafin

Universität Wien, Vienna, Austria

Verifying clouds, hydrometeors, or precipitation in ensemble data assimilation and forecasting systems presents a challenge due to the inherent complexity of these phenomena. For example, when assessing the outcome of assimilated remote sensing observations, double-penalty errors complicate verification by penalizing minor spatial or temporal discrepancies to observations twice. Neighborhood verification approaches enable a fair assessment of deterministic fields by mitigating double-penalty errors, however, correctly integrating ensemble information is not straightforward. Our study explores the Fractions Skill Score (FSS) for ensemble verification to address these challenges.

The FSS is a neighborhood verification method originally designed to verify deterministic fields of binary events. Previous studies employed different approaches for computing an ensemble-based FSS for probabilistic verification. We show that the formulation of an ensemble-based FSS substantially affects verification results. Comparing four possible approaches, we determine how different ensemble-based FSS variants depend on ensemble size, neighborhood size, and forecast event frequency of occurrence. We demonstrate that only one ensemble-based FSS, which we call the probabilistic FSS (pFSS), is well-behaved and reasonably dependent on ensemble size. Furthermore, we derive a relationship that allows one to predict how the pFSS behaves with ensemble size. The proposed relationship is similar to a known result for the Brier Skill Score. Given this analogy, we further discuss parallels between BSS and pFSS. Our study uses high-resolution 1000-member ensemble precipitation forecasts from a high-impact weather period. The large ensemble enables us to study the influence of ensemble and neighborhood size on forecast skill by deriving probabilistic skillful spatial scales.

Diagnostics on 2m Temperature assimilation in the KENDA-CH1 system at MeteoSwiss

Krishnamoorthy Chandramouli, Daniel Leuenberger, Claire Merker

MeteoSwiss, Switzerland

Realistic representation of the physical processes over complex topography is an area of active research in the NWP community. This is largely related to the difference between the model and real-world topography, numerical approximations and parametrizations. The SwissMetNet surface observation network operated by MeteoSwiss provides a dense coverage of near-surface measurements in the highly complex terrain of Switzerland. To overcome some of the above-mentioned challenges, MeteoSwiss has started the operational assimilation of dense 2m temperature and humidity measurements from the SwissMetNet stations into the COSMO-KENDA system in September 2021. The same setup is being used for the soon to be operational ICON-KENDA system. Although, overall, the assimilation of screen-level observations has brought significant improvements of the thermodynamical state throughout the planetary boundary layer, we suspect that we do not yet make optimal use of them. Therefore, we have implemented a new cross-validation (CV) diagnostic tool by Stiller (2022). Using this tool, the impact of the different observations on the 1km analysis is being studied in detail. With directions from the CV tool, along with other model and observation space diagnostics, we are able to derive useful information about some of the tunable parameters of the KENDA system. In this contribution, we will present some of the results from the above mentioned diagnostics pertaining to the assimilation of 2m temperature observations in ICON-KENDA system.

EnFSOI-Jof : An Objective Approach for Computing Observation Impact in Observation Space

Giovanni Conti, C. Cardinali, G. De Gencalves

CMCC Foundation - Euro-Mediterranean Center on Climate Change, Italy

In the domain of data assimilation, understanding the objective impact of observations on analysis and forecast is crucial for enhancing forecast systems and observation networks. Introducing effective methods to address these challenges is paramount. In this study, EnFSOI-Jof, a novel tool for estimating the observation impact on the forecast using an objective functional independent of the model is presented. This approach enables disentangling analysis degradation from model bias and observation effects, with computation in observation space to reduce complexity. Two formulations linking the observation influence in the analysis to its impact on the forecast is established. The first formulation provides insights into the factors influencing the forecast impact and can be extended to variational systems. In contrast, the second formulation utilizes ensemble statistics to simplify computation, enabling the utilization of quantities exclusively defined in observational space. Through systematic examination, including background and observation error cross-covariance terms, we gain insights into factors shaping forecast accuracy. Results underscore the importance of considering diverse factors beyond the observation influence alone, such as the innovation vectors and the observation correlations. The findings, illustrated through numerical examples, emphasize the need for a holistic perspective en- compassing model capability and observation effects. This holistic approach is critical in determining the ultimate outcomes of impact computation and the influence of observations on analysis and forecast.

Verification and diagnostic issues illustrated by the assimilation of Mode-S aircraft data

Bruce Ingleby

ECMWF, UK

The variance of observation-minus-background (O-B) differences is a standard assimilation diagnostic, but when shown on maps there can be noise from various sources tending to obscure important signals. Observation-minus-analysis (O-A) differences are generally flatter - helping in the detection of anomalies. Two examples will be shown, one of them from summer 2022 was a maximum in Mode-S wind O-A in central Europe. It was suspected and then proved that this was due to excessive numbers of Mode-S winds assimilated there causing ill-conditioning in 4D-Var. (The data were introduced operationally in Summer 2020 when the numbers were depressed by the Covid pandemic.)

In response a more robust aircraft thinning algorithm was introduced - for all aircraft data - and Mode-S data were reintroduced operationally in late 2023. The verification results clearly show that short-range verification against own analysis can be quite misleading. Over Europe the reintroduction of Mode-S (with revised thinning) is very beneficial when verified against radiosondes but apparently harmful when verified against own analyses. Over North America where the thinning change reduced the numbers of AMDARs assimilated the change was more positive against own-analyses than against radiosondes. Reducing (increasing) analysis increments tends to give positive (negative) signals when verified against own analyses at short-range - regardless of the real merits of the change.

Can we diagnose/assess localization functions directly with observations?

Olaf Stiller

Deutscher Wetterdienst, Germany

Central for the success of ensemble data assimilation is covariance localization which removes or damps spurious correlations and at the same time increases the effective number of degrees of freedom represented by the ensemble. Choosing appropriate localization functions is crucial and a lot of work has been devoted including some theoretical studies addressing the sampling error (related to the finite ensemble size) as well as different kinds of tuning procedures. In recent years cross-validation (C-V) diagnostics have been proposed which allow a direct comparison between the background error covariances employed in the DA system and a corresponding estimate of this quantity obtained directly from the observations.

This talk recalls some foundations of this C-V method and then explains how it can be used for determining optimal localization factors which maximize a verification or impact function. Working with the LETKF of DWD, the method is applied to the error covariance estimation of zonal velocity for which both radiosonde and aircraft give measurements which are generally treated as unbiased and with uncorrelated errors when assimilated in our DA systems. Comparing results for the localization function obtained with these observing systems, good agreement is found for the length scale related to the function's first strong decrease. Differences are mainly observed at larger scales where error correlations related to radiosonde measurements exhibit a much broader tail.

Generally, the magnitude of the derived localization scales appears roughly consistent with the values used operationally at DWD but are considerably smaller than what has been proposed from studies regarding the impact of the ensemble-size-related sampling error. This raises the question whether the most eminent reason for applying covariance localization in our system is really this sampling error or rather a more general ensemble deficiency of overestimating the correlation length scale.