ISDA-Online

November 04, 2022, 07 – 09 UTC

"Observation Impact"

Organizers: *Nikki Privé (Morgan State University/NASA/GSFC, US)*
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Hristo Chipilski (NCAR, US)
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Knowledge of the influence of observations is crucial for improving observing, data assimilation and forecasting systems. Today, a large variety of instruments provides millions of observations per day and the number of observations is steadily increasing. However, only a limited amount of these measurements can be assimilated due to algorithmic, computational, and research limitations. All this calls for better methods for estimating the actual and potential impact of observations. This session aims to discuss different aspects of observation impact assessment such as the results from recent OSSE and FSOI studies as well as new observational and methodological developments. We are looking forward to all contributions.

Program: (First & last talk: 17' + 3' Q&A – Other talks: 12' + 3' Q&A)

07:00 – 07:05 **Welcome**

07:05 – 07:25 **Running Ensemble of Data Assimilation Experiments – using GNSS-RO and MW sounding data**
Katrin Lonitz, Sean Healy, Katie Lean, Niels Bormann

07:25 – 07:40: **Seasonality of the impact of stratospheric observations at high latitudes**
Bruce Ingleby, Inna Polichtchouk

07:40 – 07:55 **Impacts of Assimilating Infrared Sounders from Geostationary Orbit**
Erica L. McGrath-Spangler, Nikki C. Privé, Bryan M. Karpowicz, Isaac Moradi, Joel McCorkel, Will McCarty

08:05 – 08:20 **Ensemble Forecast Sensitivity to Observations Impact (EFSOI) applied to a regional data assimilation system over Argentina**
Gimena Casaretto, Maria Eugenia Dillon, Yanina Garcia Skabar, Juan Ruiz

08:20 – 08:35 **Using ensemble sensitivities to estimate the benefit of wind lidars**
Philipp Griewank, Ulrich Löhnert, Tobias Necker, Tatiana Nomokonova, Takemasa Miyoshi, Martin Weissmann

08:35 – 8:55: **Covariance based impact diagnostics for cross-validating the consistent use of different observation types**
Olaf Stiller

08:55 – 09:00 **Closing: Information on upcoming sessions**

Please note:

- 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

Europe: 07 – 09 am GMT (London) | 08 – 10 am CET (Berlin)
Asia/Australia: 03 – 05 pm CST (Shanghai) | 04 – 06 pm JST (Tokyo) | 06 – 08 pm AEDT (Sydney)
Americas: 00 – 02 am PDT (San Fran.) | 01 – 03 am MDT (Denver) | 03 – 05 am EDT (New York)

Running Ensemble of Data Assimilation Experiments – using GNSS-RO and MW sounding data

Katrin Lonitz [1], Sean Healy[1],
Katie Lean[1], Niels Bormann[1]

[1]ECMWF

At ECMWF we have performed ensemble of data assimilation (EDA) experiments and Observing System Experiments (OSEs) using real and simulated data of GNSS-RO. In the EDA framework, the benefit from changes to the observing system can be measured through reducing the spread of the ensemble members which reflects improvement to the uncertainties in the forecast and analyses. By also carrying out complementary OSEs which allow the forecast error to be calculated, we can study the spread-skill relationship. EDA experiments with real data also allow comparison to previously performed theoretical studies investigating the potential impact from increasing numbers of GNSS-RO observations.

Running EDA experiments with a different number of GNSS-RO observations show that adding real data from different GNSS-RO data set (Spire or COSMIC-2) reduces the spread for temperature, with the larger reductions happening in the stratosphere. Comparing this reduction in ensemble spread by adding new GNSS-RO data with fits to radiosonde observations, it can be seen that both measures are qualitatively consistent. The ensemble spread reduction when adding real and simulated GNSS-RO data behaves comparably. Sensitivity experiments show that a change in observation errors of the simulated GNSS-RO data has an impact on the reduction in ensemble spread.

The EDA method has also been recently employed to evaluate the impact of different potential future small satellite constellations carrying microwave (MW) sounding instruments. Here, using existing MW data, the relationship between EDA spread and forecast error was also assessed using a similar method applied to the GNSS-RO observations. In both studies, evidence of strong links between reductions in EDA spread and reduction in standard deviation of forecast error gives confidence to the EDA method. Results also support the known under-dispersive nature of the EDA i.e., the ensemble spread is smaller than the corresponding forecast error.

Seasonality of the impact of stratospheric observations at high latitudes

Bruce Ingleby[1], Inna Polichtchouk[1]

[1]ECMWF

The northern extratropical stratosphere shows huge variability during an extended winter period and very little variability in summer. FSOI estimates of the impact of high level radiosonde and satellite data are much larger in winter than summer (despite radiosonde burst height being lower in the winter). Observing system experiments show less seasonality in the impact of radiosonde data, the reasons for this are explored. Both techniques suggest that radiosonde winds are more important than radiosonde temperatures in the stratosphere - partly presumably because satellites provide much more temperature than wind information. In the southern extratropical stratosphere the maximum variability is in the Austral spring and there is a less clear-cut variation in radiosonde impact, but a clear maximum then in the FSOI of high-peaking satellite channels.

Impacts of Assimilating Infrared Sounders from Geostationary Orbit

Erica L. McGrath-Spangler[1], Nikki C. Privé[1], Bryan M. Karpowicz[2],
Isaac Moradi[3], Joel McCorkel[4], Will McCarty[5]

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A set of observing system simulation experiments (OSSEs) was used to assess the impact of assimilating hyperspectral infrared (IR) radiances from geostationary platforms. This was done in preparation for the propopsed National Oceanic and Atmospheric Administration (NOAA) Geostationary eXtended Observations (GeoXO) Sounder (GXS), expected to launch in the 2030s, using the National Aeronautics and Space Administration (NASA) Global Modeling and Assimilation Office (GMAO) OSSE framework. From a numerical weather prediction (NWP) perspective, a global "ring" of geostationary IR sounders was found to improve both the analysis and forecasts and provide beneficial impacts as measured by the forecast sensitivity observation impact (FSOI) metric.

Ensemble Forecast Sensitivity to Observations Impact (EFSOI) applied to a regional data assimilation system over Argentina.

Gimena Casaretto[1], Maria Eugenia Dillon[2],
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Observations that are assimilated into numerical weather prediction systems are conformed by numerous data sets and their impact should be objectively evaluated. This can be efficiently achieved by the Forecast Sensitivity to Observation Impact (FSOI) methodology. In this study we explore the application of the ensemble formulation of FSOI (EFSOI) in a regional data assimilation system over Argentina, a data sparse region, and evaluate the observation networks that result beneficial and detrimental for the forecast. We focus on the analysis of both conventional and nonconventional surface weather stations' impact.

To achieve this, the Weather Research and Forecasting model coupled with the Local Ensemble Transform Kalman Filter is used with 20 members. The experiment was carried out during 30 days of the intensive observing period of the RELAMPAGO-CACTI field campaign that was conducted during the 2018-2019 austral warm season in the center of Argentina. 20 km resolution analyses were obtained every 6-h, assimilating data from soundings, aircrafts, GOES derived motion winds, AIRS retrievals and conventional and nonconventional surface weather stations (CSWS and NSWS). It is shown that, considering the entire period, all the observation sources had a positive impact on the 6-hour forecasts. However, when each variable is distinguished, a negative impact arises from the surface pressure observations from both CSWS and NSWS, on average.

This methodology was the first approximation to quantify the impact of each individual observation on the forecast over the region. The results of this (and future) work can help to identify observation data sources detrimental for the data assimilation system, suggesting data selection criteria to assess improvements in this regional system, which suffers from data sparse conventional networks but has many non-conventional networks.

Using ensemble sensitivities to estimate the benefit of wind lidars

Philipp Griewank[1], Ulrich Löhnert[2], Tobias Necker[1],
Tatiana Nomokonova[2], Takemasa Miyoshi[3] , Martin Weissmann[1]

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Convective-scale forecast systems require a dense observing network that captures deep and fast-evolving convective systems. Many new observation types have recently become available that could extend existing observing networks, but efficiently expanding the network requires information on how the observations would benefit the forecast. Consequently, methods are needed to evaluate the potential benefit of hypothetical observations. For an ensemble forecasting system, this can be achieved by assuming a linear sensitivity between the background ensemble perturbations and a forecast quantity of choice. This linear sensitivity enables estimating how much the ensemble variance of a chosen forecast quantity would be reduced for an arbitrary combination of observation locations and types without running additional forecasts. But explicitly calculating the linear sensitivity requires regularizing and inverting the background ensemble covariance matrix.

In this presentation, we will introduce a new method to estimate the potential benefit of observations and apply it to wind lidars. We first use a 1D toymodel to illustrate the problem and evaluate our method quantitatively, focusing on the regularization needed to compute the sensitivity. We then apply the method to a real-world NWP forecast to estimate the benefit of wind lidars for 1-3 hour surface-wind forecasts compared to surface observations. We find that for both applications, our method is only weakly sensitive to the precise amount of regularization applied.

Covariance based impact diagnostics for cross-validating the consistent use of different observation types

Olaf Stiller[1]

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Central for the impact which an observations type has in today's operational data assimilation (DA) systems are background error covariances (BGECovs) employed by the respective DA scheme. Recently a new type of impact diagnostics has been proposed which is based on the fact that these BGECovs can be tested in observation space against a true estimator obtained directly from the observations' first guess departures (obs-fg). Alternatively, these new diagnostics can be derived from the well known FSOI verification function assuring their relevance to the impact on the DA process.

More specifically, these new diagnostics test the consistency of the DA system's employed BGECovs with the obs-fg increments from two different observation types. Two major applications arise where (i) the adequacy of the BGECovs can be tested by comparing it with two trusted observation types (here insitu aircraft and radiosonde measurements are used). Secondly, (ii) by using a trusted observation type as verifying data, the performance of the other observations can be tested by comparing its impact (when processed with the DA system's BGECovs) with the impact which would be obtained if the theoretical assumptions inherent to the DA system were fully correct.

After motivating the theoretical foundations, this talk discusses several applications obtained with a new diagnostic tool that has been established at DWD which produces such diagnostics for a large variety of statistical bins. Results include a suboptimality found for atmospheric motion vectors (consistent with previously reported height assignment problems). Also, a group of biased aircraft data over the north Atlantic has been identified (blacklisting led to significant forecast improvements). Some further applications illustrate that the new diagnostics are particularly suited for testing height assignment and localization parameters for non-locally correlated observations (like satellite radiances or surface pressure).