ISDA-Online

Thursday, February 12, 2026, from 7-9h UTC

“Topic: Earth system applications”

Organizers: Philipp Griewank *(University of Vienna, Austria),*
Theresa Diefenbach *(DWD, Germany)*

Invited Speakers: Sarah Dance *(University of Reading, UK)*

Program (UTC):

07:00 – 07:40	**Actionable information for flood risk mitigation - data assimilation as a tool for Forecast-based Financing** Sarah Dance
07:40 – 08:00	**Concurrent data assimilation of methane concentrations and fluxes** Niklas Becker, Niels Keil, Valentin Bruch
08:00 – 08:20	**Chemical data assimilation over the Megalopolis of Central Mexico** [pre-recorded] Victor Almanza, Gilberto Maldonado-Pacheco, Arthur Mizzi, Agustín García-Reynoso, Wolfgang Stremme, Michel Grutter, Luis Gerardo Ruiz-Suarez
08:20 – 08:40	**Evaluation of GNSS-ZTD and OSSE Framework for dense network over the Indian region** Smrati Purwar, S Indira Rani, Gargi Rakshit, Srinivas Desamsetti
08:40 – 09:00	**Outer loop land-atmosphere coupled DA** Christoph Herbert, Peter Weston, Patricia de Rosnay, Sébastien Massart

<u>Please note:</u>

- The times in UTC are approximate, please plan with +- 5 min. 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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Advances in Variational Bias Correction (VarBC) for All-Sky Satellite Data Assimilation to Improve GFDL SHiELD Analysis and Forecasts

Niklas Becker, Niels Keil, Valentin Bruch

German Meteorological Service

We use atmospheric inverse modelling to provide observation-based estimates of methane emissions at the European scale. We apply the Eulerian model ICON-ART to obtain an ensemble of methane concentrations by varying the meteorology, the lateral boundary conditions and emission fields. By comparing to ground based observations of the ICOS network, we employ a 4D LETKF to assimilate both the concentrations and emissions. We create an ensemble of emissions in two ways: We can perturb the underlying emission field with a gaussian random field, or we can separate it into regions and emission sectors and scale these. We compare the two approaches and the resulting emission estimates to national greenhouse gas inventories and synthesis inversion results with a focus on Germany. The first results are presented for 2021.

Chemical data assimilation over the Megalopolis of Central Mexico

Victor Almanza (1), Gilberto Maldonado-Pacheco (1), Arthur Mizzi (2,3), Agustín García-Reynoso (1), Wolfgang Stremme (1), Michel Grutter (1) and Luis Gerardo Ruiz-Suarez (1).

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The Megalopolis of Central Mexico is a region undergoing rapid economic and demographic growth. It covers Mexico City and its six surrounding states. Despite notable progress in air quality management, significant challenges persist due to the limited availability of observations at the Megalopolis scale, particularly in rural areas with reduced monitoring capacity. Because air quality standards are frequently exceeded, the development of better pollution forecasting applications is essential to support air quality management and public health decision-making, providing clear societal benefits.

This work presents one of the first applications of chemical data assimilation (CDA) in Mexico using the WRFDA-Chem and WRF-Chem/Chem-DART systems. First, we describe the development of an operational CDA forecasting system based on the assimilation of surface observations of ozone, carbon monoxide (CO), and nitrogen dioxide (NO_2), together with conventional meteorological variables, using a three-dimensional variational (3DVAR) approach. We assess the quality of the assimilation, model performance, and chemical species increments to support near–real-time modeling of ozone episodes in Mexico City. Finally, we present the assimilation of high–spatial-resolution satellite observations of CO and NO_2 from the TROPOMI (Sentinel-5P) and OMI sensors, combined with conventional meteorological data, over the Megalopolis region using 6-hour assimilation cycles with the Ensemble Kalman Filter (EnKF) method. We discuss the proof of concept, key challenges, and the operational applicability of an ensemble-based system in Mexico.

Evaluation of GNSS-ZTD and OSSE Framework for Dense Network over the Indian region

Smrati Purwar (1), S Indira Rani (1),
Gargi Rakshit (2), Srinivas Desamsetti (1)
(1) *National Centre for Medium Range Weather Forecasting, India (NCMRWF)*
(2) India Meteorological Department

Global Navigation Satellite System- zenith tropospheric delay (GNSS-ZTD) plays a major role in precise GNSS positioning as well as improving initial conditions for numerical weather prediction through data assimilation. The comprehensive validation of ZTD derived from ERA5 and two analysis datasets from the National Centre for Medium-Range Weather Forecasting (NCMRWF), NCUM, and NGFS, using observations from 28 India Meteorological Department (IMD) and 7 International GNSS Service (IGS) GNSS stations over India during June–September 2024, is conducted. Results indicate that NGFS consistently performs better compared to the other datasets, achieving the lowest root mean square errors of 0.021 m and 0.033 m at IMD and IGS stations, respectively, and the highest correlations (r = 0.943 and 0.968). To ensure the findings of this study are robust and not regionally biased, additional analyses are conducted over Japan using 46 RJTD GNSS data. Similar result is observed at RJTD stations in Japan, with a mean RMSE of 0.025 m and a correlation of 0.981 for NGFS analysis data, which underscores the robustness and wide applicability of NGFS-derived ZTD across diverse geographical regions. Further, the experiment is conducted with the assimilation of the existing IMD GNSS station ZTD data in the NCUM-G model. As previous studies suggested, the impact of per-station assimilation of GNSS ground-based observations is larger compared to traditional data sources (Bonafoni et al., 2019; Thundathil et al., 2025). Since these IMD GNSS stations are very few and also concentrated in the northern regions of India. To address this, an Observations Simulation System Experiment (OSSE) of GNSS-ZTD is conducted. This experiment is carried out with approximately 300 synoptic observation (SYNOP) locations, which are distributed all over India and have a mean minimum distance between stations of 58.98km. The Nature Run used in the OSSE was taken from the NGFS reanalysis.

Outer loop land-atmosphere coupled DA

Christoph Herbert, Peter Weston, Patricia de Rosnay, Sébastien Massart

European Center for Medium-Range Weather Forecasts (ECMWF)

Current state-of-the-art NWP systems generally rely on weakly coupled DA, where atmospheric and land-surface analyses are carried out using separate approaches and coupling between Earth-system components is achieved via cycling with the coupled forecast model. This limits the exchange of updated conditions and the effective use of observations when they are assimilated differently across components within the same DA window. At ECMWF, a ‘quasi-strongly’ coupled assimilation framework has been developed based on outer loop land-atmosphere coupling, leveraging the incremental 4D-Var formulation of the atmospheric analysis. Outer loop coupling allows to update land and atmospheric states jointly at each outer loop iteration, enabling information from one component to influence the other.

Within the Copernicus Climate Change Service Evolution (CERISE) project for future Earth system reanalysis and seasonal prediction, this work presents the implementation of outer loop coupling within the ECMWF Integrated Forecasting System (IFS). Enhanced coupling is investigated by iterating outer loops combined with the eXtended Control Variable (XCV) framework. Hereby, topsoil temperature is included in the atmospheric analysis as an extended variable and the XCV analysis fields are then used as ‘pseudo-observations’ within the land DA system. The aim is to exploit the untapped land-surface information embedded in observations already assimilated into the atmospheric 4D-Var, as well as to make use of the value of surface-sensitive satellite observations that are typically filtered and underutilized. We describe the methodology, the experimental setup, and the numerical experimentation, and we analyze the resulting impact on both atmospheric forecast skill and the physical realism of land-surface states. The results demonstrate that, compared to a weakly coupled approach, outer loop coupled land-atmosphere DA provides a more consistent initialization of the coupled system.