ISDA-Online

February 5, 2021 / 7 – 9 am UTC
(8 – 10 am CET / 4 – 6 pm JST / 12 midnight – 2 am US MST)

“Satellite Data Assimilation”

Session chair: Takemasa Miyoshi, RIKEN

Program:

7:00 – 7:10 **Welcome**

7:10 – 7:30 **Assimilation of GPM DPR Spectral Latent Heating using Vertical Correlated Observation Error Covariance in Kalman Gain**
Yasutaka IKUTA

7:30 – 7:50 **Oversampling Reflectivity Observations from a Geostationary Precipitation Radar Satellite: Impact to Typhoon Forecasts within a Perfect Model OSSE Framework**
James Taylor, Atsushi Okazaki, Moeka Yamaji, Takuji Kubota, Riko Oki, Takemasa Miyoshi

7:50 – 8:10 **A tempered particle filter for jointly assimilating satellite soil moisture and flood extent maps into a flood inundation model**
Renaud Hostache, Patrick Matgen, Peter-Jan van Leeuwen, Nancy Nichols, Marco Chini, Ramona Pelich, Carole Delenne

8:10 – 8:30 **Role of Scatterometer Data Assimilation in the simulation of boundary layer flow of tropical cyclones**
Jyoti Bhate, Amit Kesarkar, Arpita Munshi, Govindan Kutty, and Sanjib Deb

8:30 – 8:50 **Experimental assimilation of space-borne cloud radar and lidar observations directly in the 4D-Var system used at ECMWF**
Marta Janisková, Mark Fielding

8:50 – 9:00 **Closing; Information on upcoming sessions**

Please note:

- The times in UTC are approximate. In case of technical problems, we might have to change the order of the presentations.
- When you login to the session before 7:00 UTC, and everything is quiet, this is most likely because we muted the microphones.

Assimilation of GPM DPR Spectral Latent Heating using Vertical Correlated Observation Error Covariance in Kalman Gain

Yasutaka IKUTA

Meteorological Research Institute, Japan Meteorological Agency

The observation error covariance matrix is often approximated with a diagonal matrix when assimilating observation data. However, observations about the vertical distribution of precipitation such as space-borne radars have an observation error correlation which cannot be ignored in the vertical. In addition, the structure of the correlation matrix depends on the environment of precipitation such as deep convection and stable stratification.

To incorporate this correlation and dependency, we directly calculated the Kalman gain including the correlated observation error using the Moor-Penrose inverse matrix for each precipitation type, and investigated the impact of full or diagonal observation error covariance matrix in a data assimilation system. In this study, we investigated the impact of assimilating GPM DPR Spectral Latent Heating (GPM-SLH) by a nudging method with Kalman gain including the correlated observation error. The NWP model used in the experiment was Local Forecast Model (LFM) operated by JMA for short range precipitation forecasts and aviation weather forecasts. As a result of the assimilation experiments, we found that the observation error covariance matrix of SLH has a characteristic structure depending on the precipitation type and plays an important role in the assimilation of dense observation data without vertical thinning.
Assimilation of SLH significantly improves the forecast of deep convective precipitation in the summer season. However, it was shown ineffective for shallow convective clouds over the ocean in the winter season. In this presentation, we will show the characteristics of the SLH observation error covariance matrix and demonstrate the detail of impacts on assimilation and prediction results.

Oversampling Reflectivity Observations from a Geostationary Precipitation Radar Satellite: Impact to Typhoon Forecasts within a Perfect Model OSSE Framework

James Taylor[1], Atsushi Okazaki[1], Moeka Yamaji[2], Takuji Kubota[2],
Riko Oki[2], Takemasa Miyoshi[1]

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For the past two decades, precipitation radars (PR) onboard low-orbiting satellites such as Tropical Rainfall Measuring Mission (TRMM) and Global Precipitation Measurement (GPM) Core Observatory have provided valuable measurements of global precipitation and contributed to major advancements in weather and climate research. Building on this success, planning has begun on the next generation of satellite-based PR instruments, with the consideration for a future PR in geostationary orbit (GPR), bringing the advantage of quasi-continuous observations that would lead to new insights into global rainfall variability and improvement in numerical weather prediction through data assimilation.

Following the successful demonstration by a recent study to obtain three-dimensional (3D) precipitation data from a GPR, this study investigates the impact of GPR observations on analyses and forecasts for a West Pacific typhoon within a perfect-model OSSE framework. 3D reflectivity observations are obtained for a GPR capable of achieving 20-km horizontal resolution at nadir with a range of beam sampling spans between 5-km and 20-km, following the finding that beam span is important in determining observation quality. Results showed improvement of the moisture field analyses for experiments assimilating observations with 5-km and 10-km beam sampling span compared to 20-km beam sampling (representing no-oversampling), with improved representation of key typhoon features, including the eye, eyewall and outer convective rainbands. Observations with finer beam sampling span resulted in improved minimum sea-level pressure error in forecasts at all lead times, while accumulated surface rainfall and maximum surface wind speeds forecasts also showed improvement when beam sampling span was reduced from 20-km to 5-km.

A tempered particle filter for jointly assimilating satellite soil moisture and flood extent maps into a flood inundation model.

Renaud Hostache[1], Patrick Matgen[1], Peter-Jan van Leeuwen[2,3], Nancy Nichols[2], Marco Chini[1], Ramona Pelich[1], Carole Delenne[4,5]

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The main objective of this study is to investigate how innovative satellite earth observation techniques that allow for the estimation of soil moisture and the mapping of flood extents can help in reducing errors and uncertainties in conceptual hydro-meteorological modelling especially in ungauged areas where potentially no or limited runoff records are available. A spatially distributed conceptual hydrological model is first developed allowing for the simulation of soil moisture and flood extent. Using as forcing of this model rainfall and air temperature time series provided in the globally and freely available ERA5 database it is then possible to carry out long-term simulations of soil moisture, discharge and flood extent. Next, time series of soil moisture and flood extent observations derived from freely available satellite image databases are jointly assimilated into the hydrological model in order to retrieve optimal parameter sets. For this assimilation experiment, we take benefit of recently introduced Particle Filters with tempering that circumvent some of the usual particle filter limitations such as degeneracy and sample impoverishment. As a proof of concept, we set up an identical twin experiment based on synthetically generated observations and we evaluate the performance of the calibrated model.

Role of Scatterometer Data Assimilation in the simulation of boundary layer flow of tropical cyclones

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Real-time prediction of track, intensity and structure of the tropical cyclones is a challenge due to sparse records of atmospheric and oceanic observations. The scatterometer observations of surface winds over the oceanic region found to be very useful; however, these observations are relatively less frequent. Data assimilation helps in generating a reanalysis dataset that can be used for understanding the evolution of tropical cyclones. In this paper, we have created a high-resolution analysis for five tropical cyclones that occurred over the north Indian ocean during 2016-2019. The analysis has been prepared by assimilating in-situ observations, scatterometer winds and satellite radiances. The high-resolution analysis generated using the mesoscale model WRF and En3DVar data assimilation system in a cyclic mode. The validation of track and intensity simulated in the analysis are compared with the IMD best track dataset. Also, model outputs are analyzed for simulation of lower-level convergence, spinup, upper air divergence, the formation of warm core and vorticity development. It is seen that the track and intensity of tropical cyclones simulate well with cyclic mode of data assimilation compared to that of control simulations. The details of the results obtained will be presented at the conference.

Experimental assimilation of space-borne cloud radar and lidar observations directly in the 4D-Var system used at ECMWF

Marta Janisková, Mark Fielding

European Centre for Medium-Range Weather Forecasts, Reading, UK

Active observations from profiling instruments, such as cloud radar or lidar, contain a wealth of information on the structure of clouds and precipitation, but have never been assimilated directly in global numerical weather prediction (NWP) models. Currently there are no fully functioning space-borne radar or lidar instruments, but historical observations from CloudSat and CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations), part of the NASA A-train constellation, provide useful datasets for feasibility studies. In the next few years, new satellite missions with cloud radar and lidar are planned, such as EarthCARE (Earth, Clouds, Aerosol and Radiation Explorer; a joint mission between ESA and JAXA). In preparation for EarthCARE, whose data will be available in near-real time, the ECMWF 4D-Var system has been adapted to allow a direct assimilation of such type of observations.

In this presentation, several important developments required to prepare the data assimilation system for the new observations of cloud radar reflectivity and lidar backscatter will be summarized. This includes an observation operator providing realistic model equivalent to the observations. Another important aspect is the definition of the errors assigned to observations. Since the observation error of cloud observations is highly situation dependent, a flow-dependent error was designed to account for both the spatial representativity error due to the narrow field of view of these observations and the uncertainty in the microphysical assumptions. In addition, an appropriate quality control strategy and bias correction scheme are required for the proper handling of observations in the context of an assimilation system. All these components will be discussed in the presentation. Finally, results from 4D-Var experiments demonstrating the impact of cloud radar and lidar observations on the analysis and subsequent forecast will be presented, together with suggestions for increasing their impact on weather forecasts.