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all times are in UTC
Data rescue of national and international meteorological observations at Deutscher Wetterdienst

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Abstract

Historic observational data records are an important contribution for climate reconstructions and analysis of past weather events. Particularly in remote and data sparse regions, such as the open ocean, newly rescued data can significantly improve the knowledge about weather and climatic conditions in earlier decades and centuries. Deutscher Wetterdienst (DWD) holds several collections of original historical weather records from land stations and ships. They comprise not only observations from Germany, but also of the global oceans and land stations in many parts of the world.

All German state-owned meteorological observations beginning with the Prussian Meteorological Institute in 1848 are collected in the main archive of DWD in Offenbach.

DWD’s branch office in Hamburg holds the marine archive starting with the collections of the German Naval Observatory, 'Deutsche Seewarte', which existed from 1874 to 1945. It includes marine data records from ships, as well as land stations in many parts of the world (e.g. from former German colonies) and signal stations situated at the coasts of the North and Baltic Sea.

The documentation, digitisation and quality check of the enormous quantity of handwritten journals of all four data archives is still ongoing. The digitised data will be freely accessible to all interested scientists and are also continuously submitted to international data archives, such as ICOADS and ISPD. Through these data sets, the data are also an important input for regional and global reanalyses.

The presentation will give an overview of the historical archives of Deutscher Wetterdienst and will show the recent progress of the digitization efforts and ongoing analysis of the data.

Keywords: observations, data rescue, digitisation
Modeling impact of climate warming on cotton growth and phenology in Pakistan from 1961 to 2010 based on provincial data

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Abstract

The general circulation models (GCM) estimated an average increase in the global surface temperature of about 2.9-5.5°C by the end of this century. The increases in temperature and shift in the rainfall cycle affect cotton growth and threaten cotton production and quality in the region. The rise highly influences cotton growth and development in weather and changes in rainfall cycles. Climate data (1980-2020) were used as model input resulted that the escalating temperature increases evapotranspiration rates, sometimes causing severe water stress and fruit abscission, thus reduce the plant growth and yield. APSIM-cotton model projections of 15-agrometeorology stations showed that the growing duration during the sowing-boll opening stages and drilling-harvesting were reduced by was reduced 2.30-5.66 days decade-1 and 4.23 days decade-1. Temperature rise has advanced the planting dates, sowing-emergence, 3-5 leaves, budding-anthesis, full-bloom, cleft-boll, boll-opening, boll-opening filling by 24.42, 26.19, 24.75, 23.28, 22.62, 15.75, 14.58, 5.37, 2.85, 8.04 days. Further, our findings exhibited that climate stop-growing becomes 2.16 days premature, and the time-scale has been delayed for 8.2, 2.4, and 5.3 days in the 1970s, 1980s, and 1990s. APSIM and DSSAT quantification revealed that sowing-emergence and anthesis-maturity stages were negatively linked with temperature -2.03, -1.93, -1.09, and -0.42 days°C. The negative impact might be mitigated by adaptation to the climate-smart cotton production system by improving agrotechnological services.

Keywords: agricultural system, crop modeling, agrometeorology services, data assimilation
Assessment of past and present human biometeorological environment over WB, India based on observations and Era-Interim

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Abstract

Research works are scanty on the validation of long-term trend of human thermal stress over West Bengal (WB), India. Therefore, this study focuses on the past and present human bio-meteorological environment in WB reproduced from Era-Interim and observed station data respectively. To account for the prolonged thermal stress periods, the duration of three UTCI stress categories such as strong heat stress, very strong heat stress, and extreme heat stress are counted as an event. An event is classified as a strong or very strong event if the corresponding stress category turns up in consecutive days for more than or equal to five days and less than twelve days. Extreme events are numbered when the extreme stress class renews for more than or equal to 2 days and less than five days. No extreme heat stress events/year are identified for any of the study stations in WB for past (Era-Interim) and present (IMD) bio-climate conditions. For strong heat stress, number of events/year ranges from (41-48) past 40 years (Era-Interim) at 12 hr for all the stations except Darjeeling. In the same stress category, for the last two years, observed station data (IMD) at 11:30 am, computes (23-53 events/year) for all the stations except Darjeeling. At 12 hr, the highest number for very strong heat stress class occurs in Alipore and Dum Dum for last four decades ranging from 2-3 events/year whereas observed station data identifies Diamond Harbour (11.5 events/year) for the last two years and no other observed station identifies such events/year at 11:30 am.

Keywords: UTCI, RayMan

*Speaker
Assessment of temperature extremes based on departures from long-term reanalysis and high-resolution ensemble forecasts over Indian region

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Abstract

Extreme weather prediction requires the resolution of the models to be sufficiently high in order to resolve the small-scale features of the events. Medium range ensemble prediction of extreme events helps assess the forecast uncertainty well ahead in time, enabling risk assessment and effective planning for disaster management. The global ensemble prediction system at NCMRWF (NEPS-G) features one control and 22 perturbed members with 12 km horizontal resolution and 70 vertical levels. NEPS-G is used for predicting extreme temperature events (heatwaves, coldwaves, warm nights and cold days) in the year 2019-2020 in this study. The daily gridded surface maximum (Tmax) and minimum (Tmin) temperature dataset developed by India Meteorological Department (IMD) have been used to verify the probabilistic temperature forecasts. A high-resolution regional atmospheric reanalysis data named the Indian Monsoon Data Assimilation and Analysis (IMDAA) is recently generated by NCMRWF and Met Office, UK, in collaboration with IMD under the National Monsoon Mission project. The daily climatology for Tmax and Tmin is calculated from IMDAA reanalysis data between 1988 and 2018. It has been used for calculating departures for identifying the temperature extremes over Indian regions. The probabilistic skill of the EPS medium-range forecasts of extreme day-time and night-time temperatures is examined with reference to long-term climatology from IMDAA reanalysis. The continuous ranked probability score (CRPS) shows a better correspondence between forecasted and observed cumulative distribution in the summer season than that in the winter season.

Keywords: Ensemble, extreme events, reanalysis, medium, range, skill

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Early results of the evaluation of the JRA-3Q reanalysis

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Abstract

The Japan Meteorological Agency (JMA) is conducting the third Japanese global atmospheric reanalysis named Japanese Reanalysis for Three Quarters of a Century (JRA-3Q) using the JMA operational data assimilation system that has been upgraded and improved since the Japanese 55-year Reanalysis (JRA-55) was conducted. For the evaluation of the JRA-3Q, several kinds of observational datasets based on satellite observation are used: precipitation provided by Global Precipitation Climatology Project (GPCP), radiation fluxes from the clouds and the Earth’s radiant energy system project (CERES), spectral latent heating from the Global Precipitation Measurement (GPM) mission by Japan Aerospace Exploration Agency (JAXA), and water vapor retrieved from Global Navigation Satellite System Radio Occultation (GNSS-RO) and the Earth Observing System Microwave Limb Sounder (MLS). The early results show that both overestimation of precipitation in the tropics and dry bias in the middle troposphere are diminished compared with those in JRA-55, and the representation of diabatic heating rate is also improved. In addition, biases of surface heat fluxes and radiation fluxes at the top of the atmosphere are also reduced.

Keywords: JRA, 3Q, evaluation, satellite observation

*Speaker
A kriging method for a gridded quantitative precipitation estimate over Alaska with uncertainty bounds

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Abstract

In collaboration with the National Weather Service (NWS) Alaska and the Alaska-Pacific River Forecast Center, a gridded quantitative precipitation estimate (QPE) has been developed to provide a precipitation analysis for Alaska, which is a challenge because of Alaska’s size, sparse population, and limited access to observations. Gridded quantitative precipitation forecasts (QPF) from high-resolution numerical weather prediction models are merged with rain gauge data through kriging - a geostatistical interpolation technique which provides the best linear unbiased estimate at each gridpoint along with an estimated error variance. The error variance is further inflated and refined through cross-validation to produce an empirically tuned 5% and 95% confidence bounds on QPE. A 6-hour accumulated QPE was produced for the period August 01 2019 - July 31 2020, and skill scores are presented for multiple formulations of QPE to identify the value-added by a QPF first-guess compared to a climatological first-guess.

Keywords: precipitation, analysis, Alaska, kriging, numerical weather prediction

∗Speaker
The Panama Bight Index: a new index for the Eastern Tropical Pacific

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Abstract

This paper presents the Panama Bight Index (PBI), a new climate variability index for the Eastern Tropical Pacific, based on the Sea Surface Temperature (SST) anomaly of an area of the central Panama Bight (PB). The PB includes the waters of Costa Rica, Panama, Colombia, and Ecuador. The extent to calculate the PBI was defined as the homogeneous region between -1 and 1 standard deviation of the first Empirical Orthogonal Function (EOF) of an analysis of the regionalization of the Remote Sensing Reflectance (Rs 412 and Rs 488 Modis-Aqua, 2002-2020; Rs 412 and Rs 490 SeaWiFS, 1997-2010). The SST from the ERA5 reanalysis dataset (1950-2020), of the European Centre for Medium-Range Weather Forecasts (ECMWF), was used to generate the PBI. For calculating the SST anomalies, we used the NOAA’s Climate Prediction Center for El Niño region indices (Niño 4, Niño 3.4, Niño 3, Niño 1+2 y ONI). The PBI is dominated by the interannual variations of the SST associated with El Niño and La Niña (EN/LN), which presents a high correlation with El Niño 1+2 index and the ONI Index, and allows identifying the mode of variability associated with the annual cycle. Although there are other metrics to monitor ENSO, they do not adequately fit the PB’s processes in the oceanic zone. Therefore, this PBI will allow the study of the interannual climatic variability of the POT associated with EN/LN and evaluate the occurrence and intensity of the Eastern Pacific El Niño.

Keywords: ERA5 reanalysis, Climate Index, Climate Variability, Eastern Tropical Pacific

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Analysis of the Wind Fields Based on Radar Network in the East Asia Reanalysis System

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Abstract

The V-IVAP method (Liang et al., 2019) were proposed to retrieve wind fields based on the radial wind of weather radar. The V-IVAP method is insensitive to the alias of radial wind. Using the V-IVAP method, the wind fields were analyzed using the observations of the radar network. The weather radar network of China (CINRAD: China New Generation Weather Radar) includes 224 radars of S or C band. The wind fields have horizontal resolution of 0.12°×0.12°, vertical resolution of 0.5 km from 0.5 km to 7.5 km. A dataset of wind fields from 1st Jan 2008 to 31st Dec 2018 were established based on the radar observations with time interval of 3 hours.

The errors of the winds were analyzed using the radiosonde observations. The analyzed winds have a good correlation with the radiosonde observations. The RMSE of u and v are 4.15 ms-1 and 4.9 ms-1 respectively from 0.5 km to 7.5 km height.

Reference
Liang Xudong, Y. Xie, J. Yin, Y. Luo, D. Yao, and F. Li, 2019: An IVAP-based dealiasing method for radar velocity data quality control. J. Atmos. Oceanic Technol., 36: 2069-2085.

Keywords: Weather Radar, Wind Analysis

*Speaker
Abstract

Ocean reanalyses are becoming increasingly important to reconstruct and provide an overview of the ocean state from the past to the present-day. In the scope of the Copernicus Marine Environment Monitoring Service (CMEMS), the Black Sea reanalysis (BS-REA) is produced by using an advanced variational data assimilation method to combine the best available observations with a state-of-the-art ocean general circulation model. The hydrodynamical model is based on Nucleus for European Modeling of the Ocean (NEMO), implemented for the Black Sea (BS) domain with horizontal resolution of $1/27^\circ$ x $1/36^\circ$, and 31 vertical levels. NEMO is forced by ECMWF ERA5 atmospheric reanalysis and climatological precipitation. The model SST is relaxed to daily objective analysis fields from CMEMS SST TAC. The model is online coupled to OceanVar, a 3D-Var ocean data assimilation scheme, to assimilate sea level anomaly (SLA) along-track observations from CMEMS SL TAC and available in situ vertical profiles of temperature and salinity from both SeaDataNet and CMEMS INS TAC products. Temperature fields present a continuous warming in the layer between 25-150 m, within which the BS Cold Intermediate Layer resides. SST shows a basin-wide positive bias. The root mean square difference (RMSD) can reach 0.75 °C along the Turkish coast in summer. SLA has the largest RMSD close to the shelf due to the high mesoscale activity along the Rim current. The system has produced very accurate estimates which makes it suitable for understanding the BS physical state in the last decades. Nevertheless, in order to improve the quality of the BS-REA, new developments in ocean modelling and data assimilation are still important, and sustaining the BS ocean observing system is crucial.

Keywords: variational data assimilation, eddy resolving reanalysis, Black Sea cold intermediate layer

Speaker
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Evaluation of the latest Japanese Reanalysis for three quarters of a century (JRA-3Q) during a pre-satellite era

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Abstract

This study evaluates the latest Japanese Reanalysis for Three Quarters of a Century (JRA-3Q) conducted by the Japan Meteorological Agency (JMA), focusing on a semi-period of pre-satellite era of 1960s and 1970s. JRA-3Q, which is based on the JMA’s operational system with 6-hourly 4D-Var data assimilation as of December 2018, is the third Japanese global atmospheric reanalysis spanning late 1940s onwards, using an atmospheric model with a reduced horizontal resolution of TL479 and 100 vertical layers up to 0.01 hPa. Because only few global-covered observational datasets during the pre-satellite era are available, the JRA-3Q is mainly evaluated in reanalysis intercomparison and about temporal consistency and spatial homogeneities. Emphasis of this evaluation during the non-satellite era is placed on the representation of tropical circulation, the time consistency of reanalysed fields between the pre-satellite and satellite eras, and the quality of the stratospheric ozone and water vapor. The surface circulation over the tropical Africa is improved by reducing spurious anticyclonic circulation anomalies found in JRA-55. Stratospheric ozone is also improved by incorporating adequate ozone depletion substances, sea-surface temperature as well as the development of the ozone model. The quasi-biennial oscillation is not as good as that in JRA-55 with a shorter period of around one year in the middle stratosphere and diminished amplitude in the lower stratosphere.

Keywords: reanalysis, quality evaluation, pre satellite era

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Advances in the Downscaling of Extreme Hydro-Events in South America

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Abstract

Reconstructions of climatological features in the tropical areas of South America may be proven challenging due to the scarcity of reliable, long-term data records. To address this problem, retrospective analyses – aka (re)analyses – are regularly used to provide spatially continuous, long-term time series of several atmospheric and land-surface variables in studies of South American climate. Overall, reanalysis comprehends forecast models and data assimilation systems. Data assimilation in a global reanalysis comprises computationally expensive techniques to generate initial conditions used in the embedded forecasting systems. Global reanalysis products also offer a wide range of opportunities to monitoring atmospheric conditions at regional scales, for instance, providing initial and boundary conditions to regional downscaling. The downscaling of a global reanalysis in the tropical-to-subtropical South America by a regional numerical model may as well be enhanced by means of empirical methods, such as spectral (dynamic) nudging and satellite-based precipitation assimilation, both employed in the present study. Examples of the combined application of the two methodologies in regional downscaling will be illustrated through the reconstruction of extreme events that occurred in the continental South America depicted by the interannual variability of South American monsoon precipitation, and the severe weather episodes near the Brazilian coastline.

Keywords: precipitation assimilation, extreme events, regional downscaling, monsoon, South America

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Evaluation of (regional) reanalysis data using the Free Evaluation System Framework

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Abstract

COSMO-REA6 is a regional reanalysis for Europe based on the COSMO model. The data set is widely used, especially in the sector of renewable energies. A new version of the regional reanalysis is currently under development with boundary conditions from ERA5. To assess the quality of the data, the output can be compared to the former version and to global reanalyses as well. Among different evaluation methods, the comparison of the regional reanalysis data with station data (of the DWD observation network) is part of the evaluation suite.

To make the software and data available to a larger user group, we take advantage of the Free Evaluation System Framework (Freva) which is currently in use at DWD, FU Berlin and DKRZ. In this way, the software is available for various applications and projects. Freva was developed at FU Berlin and DKRZ to provide an infrastructure for cooperative and efficient use of standardized data and tools.

REALISTIC ("Reanalysis Station Comparison") is developed as a plugin within the Freva framework. The tool compares reanalysis or other gridded data with station data by different metrics (e.g. bias, correlation, MAE). REALISTIC is based on CDO (Climate Data Operators) that are used to find the nearest neighbor of the station locations in the model grids to make pointwise comparisons. The results are plotted on a map, showing the values of the metrics at the different station locations.

Keywords: regional reanalysis, evaluation system, station data

∗Speaker
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The stratospheric Brewer-Dobson circulation in ERA5 and ERA-Interim reanalyses

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Abstract

The stratospheric Brewer-Dobson circulation (BDC) is a key element in the climate system as it controls variations in ozone and other trace gases which impact the radiation budget. We investigate the BDC in the new ERA5 meteorological reanalysis and compare with results from its predecessor ERA-Interim, based on residual circulation diagnostics and on simulations of stratospheric age of air with the transport model CLaMS. Our results show a substantial uncertainty in the representation of the BDC in reanalyses regarding both the climatology and trends. In particular, the BDC is significantly slower in ERA5 than in ERA-Interim, manifesting in weaker tropical upwelling, diabatic heating rates and larger age of air, mainly related to weaker subtropical gravity wave drag. In the tropical lower stratosphere, heating rates are 30-40% weaker in ERA5 than in ERA-Interim, likely correcting a bias in ERA-Interim. At 20km and in the NH stratosphere, ERA5 mean age values are around the upper margin of the uncertainty range from historical tracer observations, indicating a somewhat slow-biased BDC. The stratospheric age of air trend in ERA5 over 1989-2018 is negative and is related to an increase in tropical upwelling. However, the age decrease is not linear but steplike, potentially caused by multi-annual variability or changes in the observations included in the assimilation. Particularly regarding trends on decadal time scales, the different reanalyses can largely differ.

Keywords: stratospheric circulation, atmospheric composition, trends, reanalysis, ERA5, ERA, Interim

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Development and Quality Evaluation of an Operational Ensemble-based Regional Reanalysis System

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Abstract

In 2011 the development of a regional reanalysis began at DWD together with partners from the Universities of Bonn and Cologne within the HErZ initiative. In the meantime, the continuous processing has been transferred to DWD. The regional reanalysis system COSMO-REA6 was used to produce data sets covering the period 01/1995 – 08/2019 and Europe in a spatial resolution of 6 km. The data sets have proven high quality as shown within different activities, in particular in the project UERRA or in applications by external users especially from the sector of renewable energies. Despite the good results, COSMO-REA6 represents no longer the state of the art and will be superseded in the next years by an ensemble-based reanalysis system based on ICON and up-to-date data assimilation schemes. The new system was designed to run both a global and a regional reanalysis together in a coupled approach. In regular time intervals, the system is initialized by IFS fields from ERA5. We are going to apply reprocessed observations from ECMWF. Several production sites are taken into account.

Here we present the concept of the new system and the current state of the development.

Keywords: reanalysis, regional, ensemble, based, ICON, observation

*Speaker
Assessment of ERA-5 wave characteristics with in-situ measurements in Southern Baltic

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Abstract

Commonly used methods of obtaining wave characteristics data, such as in-situ measurements, satellite or cruise (r/v) data, are becoming insufficient in the era of contemporary climate change and the resulting need for more accurate recognition of the spatial and temporal variability of the sea state. In such a context, reanalysis data may constitute a valuable source of information. The research aimed to assess and compare the ability of ERA5 to reproduce wave characteristics for two selected points of in-situ measurements in the Baltic Sea, both of differing oceanographical characteristics (offshore and nearshore). The temporal scope of the research covered a period from June 2018 until June 2020 (nearshore) and from 2017 until 2020 (offshore) with 3 hourly temporal resolution. Two wave characteristics were taken into account: significant wave height and mean wave period.

Significant wave height from ERA5 shows a high correlation (r = 0.86) for the point representing the deepwater (offshore) zone (Petrobaltic rig) where data are acquired with an AWAC device. In a nearshore location (Pomeranian Bay), the compliance is lower with a correlation coefficient of 0.67. For the mean wave period, the concordance is much lower. The analysis shows that ERA5 reanalysis, under some conditions, can be a reliable source of information in the long-term, large-scale marine analyses and may serve as a supplementary source of data on hydrodynamic parameters.

Keywords: Southern Baltic, assessment of ERA5, wave

*Speaker
Ocean Data Impacts on the Reanalysis of Atlantic Meridional overturning circulation in the Next Generation Global Ocean Data Assimilation System (NG-GODAS)

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Abstract

The Atlantic Meridional Overturning Circulation (AMOC) involves a northward movement of warm upper waters accompanied by a southward movement of cold waters at depth, and carries up to 25% of the northward global atmosphere–ocean heat transport in the northern hemisphere. The natural variations in the AMOC can affect climate over decadal timescales, so there is an obvious need for better, more quantitative, forecasts of the future behavior of the AMOC. An accurate AMOC prediction system could potentially provide a valuable early warning of imminent climate change. As part of ongoing efforts to improve forecasting, the NCEP’s Environmental Modeling Center (EMC) is developing the prototype version of the Next Generation Global Ocean Data Assimilation System (NG-GODAS). The NG-GODAS uses JEDI-based SOCA (Sea-ice Ocean Coupled Assimilation) as its ocean data assimilation component, and an advanced ocean model (MOM6) is used. The following satellite and in-situ observation data are assimilated in current system: satellite sea surface temperature/sea surface salinity, in-situ temperature and salinity, absolute dynamic topography, and sea ice concentration. The AMOC at 26.5°N will be investigated using the prototype NG-GODAS, and a comparison would be presented of ocean reanalyses with different observing networks, to the observations and transport estimates from the RAPID mooring array across 26.5°N in the Atlantic.

Keywords: ocean reanalysis, AMOC, NGGODAS
Intercomparison of surface temperature estimates from IMDAA reanalysis with ERA5 and in-situ observations at selected locations over India

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Abstract

Indian Monsoon Data Assimilation and Analysis (IMDAA) is the currently available highest resolution (12 km), long-term (40 years, 1978-2018, extended to 2020), satellite era regional reanalysis over south Asian monsoon region. National Centre for Medium Range Weather Forecasting (NCMRWF), Ministry of Earth Sciences, Government of India distributes the IMDAA reanalysis through reanalysis web portal, https://rds.ncmrwf.gov.in/. This study illustrates location specific verification of surface temperature estimates from IMDAA and its comparison with ERA5 global reanalysis at the selected locations over Indian landmass for 19 years during the 21st century, from 2000 to 2018. Fourteen stations selected, such that (i) they are representatives of different homogenous temperature regions of India, and (ii) continuous in-situ surface observations are available during the period of study with minimum gap. Verification of surface temperature estimates (maximum, minimum and mean) shows that, quality of IMDAA is better over the Tropics and coastal regions (south of 20°N), whereas ERA5 outperforms over extra-tropics (north of 20°N). This could be due to better representation of global circulation in the global reanalysis ERA5, and local effects more effectively in the regional reanalysis IMDAA. High resolution feature of IMDAA (12 km) compared to ERA5 (31 km) better captures surface temperature over the orographic region. Surface maximum and minimum temperature estimates show that IMDAA has a comparatively hot summer and cool winter over north India, whereas the reverse in the ERA5. In general, ERA5 shows better correlation with in-situ observations than IMDAA; however, the mean of the three datasets differs significantly ($p < 0.05$)

Keywords: IMDAA, ERA5, Surface temperature, Regional reanalysis, Global reanalysis, NCMRWF, Verification Evaluation and model performance, Tropics, Extra tropics, Orography, India

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Evaluation of multi-parameter dependencies in reanalyses

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Abstract

Reanalyses are an unparalleled source of data for the evaluation of climate and its variability providing 4-dimensional reconstructions of multiple meteorological parameters describing the atmospheric's system state. Yet, the vast majority of evaluation studies focus on the evaluation of single parameters in time and space without looking at the statistical dependence between two parameters. But this is necessary especially if you are interested in specific events where two or more parameters are involved, i.e., so called compound events. Recent studies have therefore investigated the representation of natural hazards such as wildfires, heat stress, droughts by evaluating corresponding indices based on two or more parameters. We employ a more sophisticated approach by using copula theory. With this method, we aim at evaluating the multivariate statistical distribution between two parameters separately from their marginal distributions. In a second step, we can related misrepresentations of meteorological indices in model simulations to deficiencies of the model to represent either the marginal distribution or the interdependencies between the contributing variables.

We will present results for a joint copula-based evaluation of temperature and humidity related to the natural hazards mentioned above.

Keywords: evaluation, multivariate, copula, heat stress, compound events

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The NCEP Reanalysis Observation Archive Contents and Formats

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Abstract

Beginning in 1992, NCEP has been conducting reanalysis projects with ever evolving observation capacity and complexity. Many historical archives of weather observations have been supplied to NCEP by NCAR, NCDC, NCEI, ECMWF, JMA, among other organizations. NCEP now has BUFR archives for land surface data back to the 1930’s, for marine and upper air data sets the archive reaches back to 1948.

This report will detail the contents of the archive, and to document the chain of processing which prepares and integrates observations from all different sources into a common form of the NCEP BUFR dumpfile format. For conventional data types, these files are inputs to make prepbufr files for NCEP DA reanalysis processing.

Ocean surface and subsurface observations are especially important for running coupled reanalysis. A focus on archive development is increasing the historical holdings for this type of data. CFSR used subsurface ocean data back to 1979, but there was much less data in the 1980’s and 1990’s then there is now. Combining ocean obs from several reanalysis development streams could help ocean subsurface coverage after Y2K. Finding subsurface data prior to 1980 is challenging.

With the volume of the satellite datasets dominating the last twenty years of DA observations, compact and compressed datasets like the dumpbufr format are convenient for storage. The satellite datasets are by far the biggest members of the archive, starting from several NOAA-n platforms in the early 1970’s, all the way to now. The NCEP satellite observation archive contains big data.

Keywords: Reanalysis, observations, BUFR, satellites, historical archive

∗Speaker

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The ORAP6 ocean and sea-ice reanalysis: description and evaluation on climate and forecasts

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Abstract

Ocean and sea-ice are two essential components of Earth system models. By providing initial conditions of these two system states, ocean and sea-ice analysis play a vital part in the coupled forecasting system of NWP service. Ocean and sea-ice reanalyses also provide invaluable information for climate monitoring, and for long-term prediction such as decadal or climatic projections. The Ocean ReAnalysis Pilot system-6 (ORAP6) is a new ocean and sea-ice reanalysis that has been developed based on the ECMWF operational OCEAN5 system. ORAP6 uses ERA5 Atmospheric forcing and is produced with the most up-to-date reprocessed observation datasets. The data assimilation system has been updated, including: i) assimilation of L3 sea-ice concentration data; ii) a new flow-dependent SST nudging scheme; iii) refined off-line bias correction term for both temperature and salinity. In addition, observation error covariance settings have been revised. Production of ORAP6 for the full ERA5 period (1979-2019) has been completed. Preliminary evaluation suggests that, in a general sense, ocean and sea-ice states are improved in ORAP6 w.r.t to its predecessor ORAS5, partially due to its more realistic large-scale overturning circulations in the pre-Argo period. The ORAP6 sea-ice performance is better in the sense of both climate signals and spatial distributions of sea-ice thickness and concentration. The ocean heat content tendency in ORAP6 also correlates better with variations of global net energy input derived from independently observed TOA radiation data. Initializing from ORAP6 instead of ORAS5 leads to slightly improved performance in the ECMWF seasonal forecasting system-S5.

Keywords: ocean and seaice reanalysis, bias correction, ERA5, seasonal forecasts

*Speaker
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Accuracy assessment of TRMM precipitation product in different Agro-Climatic Zones of Tamil Nadu, India

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Abstract

In this study, the accumulated precipitation of TRMM data over different Agro-climatic Zones of Tamil Nadu was analyzed using statistical analysis, which showed an accountable variation during the study period from 2015 to 2017. Minimum precipitation of 144.31, 34.40, and 75.01 mm was recorded with TRMM during NEM of 2015, 2016, and 2017, respectively. The corresponding maximum values were 1400, 251, and 687 mm whereas the automatic weather station (AWS) recorded a minimum of 151.65, 31.82, and 73.29 mm during the NEM of 2015, 2016, and 2017, respectively. Maximum values of 1755.31, 450.39, and 939.58 mm were recorded for the corresponding years. TRMM data was found to have higher R2 values of more than 0.8 in all the North East Monsoon (NEM) seasons of 2015, 2016, and 2017 irrespective of the Agro-climatic zones assessed. During NEM 2016, TRMM estimated maximum rainfall in High Altitude and Hilly Zone (HAHZ) and low rainfall in North Western Zone (NEZ), which revealed that the TRMM product performance was high and dependable for use. Even though RMSE values were found to be high in HAHZ and NEZ and the other Zones recorded less value, the agreement of the data with (AWS) values was found to be more than 80 percent which indicated the high correlation of the data with ground truth. It concludes TRMM product provides a lot of scope in climate research studies. Overall, the performance of the rainfall-based satellite product TRMM – 3B42 over Tamil Nadu is promising for further application in the supplement of rain gauge station.

Keywords: North, East Monsoon, Satellite precipitation, Validation, statistical indices, Tamil Nadu

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Assessment and Evaluation of Commercial GPS Radio Occultations in the NCEP Global Forecast System

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Abstract

The United States Weather Research and Forecasting Innovation Act of 2017 permits the National Oceanic and Atmospheric Administration (NOAA) to purchase weather data from the private sector. Through Delivery Order 1 (DO-1), NOAA obtained 30 days of commercial space-based radio occultations (RO) from Spire and GeoOptics, and through Delivery Order 2 (DO-2), NOAA obtained six months of RO observations from GeoOptics. Impact experiments were performed with data from DO-1 to test configurations for the operational assimilation of commercial RO from DO-2. Assimilation of commercial RO is planned to become operational in the Global Forecast System (GFS) in May 2021. An initial experiment was run, applying the operational GNSS-RO quality control and observation errors to the commercial RO. Two follow-up experiments tested alternate quality control and observation errors for the commercial RO observations. This presentation will detail the assessment of the quality of the commercial RO data, as well as the impacts of their assimilation in the GFS.

Keywords: commercial gnssro, gpsro, radio occultation, spire, geooptics

∗Speaker
Variational quality control of Aeolus satellite wind LiDAR observations

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Abstract

Given the positive impact by the assimilation of Aeolus horizontal line of sight wind profiles particularly in the tropics at several operational centers around the world, we want to specifically investigate how beneficial this new observation type is for the initialization of tropical cyclones (TCs) in NOAA’s Finite Volume Cubed Sphere Global Forecasting System (FV3GFS). To maximize the benefits of Aeolus, several key aspects that make data assimilation in the vicinity of TCs complicated, need to be addressed. By having inaccurate a-priori estimates of the state of the atmosphere under complex flow structures combined with the use of suboptimal quality control (QC) procedures can have detrimental impacts to the analysis. Static QC and background checks, which are based on blacklisting and fist-guess rejections can make it arbitrary to take decisions, such as keeping observations with initially large departures from the model background or how much weight should be given to an observation during the analysis update stage. To address suboptimal quality controls, we implemented the assimilation of Aeolus Mie-cloudy and Rayleigh-clear observation regimes with additional Variational Quality Control (VarQC) on NOAA’s FV3GFS. This VarQC algorithm can assign adaptive weights and address non-Gaussianity aspects of Aeolus observations. VarQC can also be beneficial to TC analysis and forecast as it considers information about the local TC flow, the a-priori estimates of relevant sources of error, and the analysis state in a synergistic manner. In this presentation, we describe the benefits of applying VarQC to the Aeolus observations for improving the quality of the analysis and forecast in NOAA’s FV3GFS during TC activity.

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Extending a forward operator for visible satellite channels by near-infrared and aerosol capabilities

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Abstract

Satellite images in the solar spectrum provide high resolution cloud and aerosol information and thus present a promising observation type for data assimilation and model evaluation. While visible channels contain information on the cloud distribution, cloud optical thickness and cloud structure, near-infrared channels are in addition more sensitive to cloud microphysical properties and can be used to distinguish between water and ice clouds. Moreover, solar channels are sensitive to aerosols, so their assimilation can be expected to improve forecasts of cloud and aerosol distribution, and thus also solar radiation.

However, mainly due to a lack of sufficiently fast forward operators for visible and near-infrared radiances, operational data assimilation systems so far use only the thermal channels. With recent development of MFASIS, a 1D radiative transfer (RT) method that is similarly accurate but orders of magnitude faster than conventional RT solvers for the solar spectrum, it has become possible to utilize visible channels. Here we discuss MFASIS’s limitations preventing it from simulating near-infrared channels accurately and present a solution increasing the accuracy significantly for near-infrared channels. Furthermore, it will be demonstrated that replacing MFASIS’s look-up table by a neural network reduces computational costs significantly, thus allowing for additional input parameters. Those parameters enable us to describe the vertical aerosol distribution for multiple species. This extends the application of MFASIS towards the assimilation of aerosol-affected radiances. The new approaches presented are tested using IFS and ICON model output.

Keywords: forward operator, satellite observation, near infrared, aerosol, neural network, radiative transfer

\textsuperscript{*}Speaker
Surveying ecology from UAV data using convolutional neural networks in hazard situations

Content

Many ecosystems around the world are especially prone to natural hazards like extreme weather events and seismic occurrences. Extreme weather events, particularly, are increasing in frequency and severity due to the progression of climate change. Therefore, to study biodiversity and the impact of natural disasters on ecological populations, it is crucial to have computational methods for assessment. Automated remote sensing, enabled by machine learning techniques, has emerged as a key asset in assessing the impact on wildlife and developing pipelines to rescue ecosystems and allocate resources and personnel when necessary. In this work, we propose an approach predicated on a convolutional neural network (CNN) framework, of the AlexNet architecture, to harness drone (UAV) imagery in a multitemporal context to understand changes in environments resultant from natural disasters. The classifier outputs a category representing the prediction of the severity of damage incurred. The CNN we develop serves as a baseline for future work improving efficacy and exploring interpretability, which are equally important in the view of the authors.

Primary author: CHEN, Thomas (Academy for Mathematics, Science, and Engineering)

Presenter: CHEN, Thomas (Academy for Mathematics, Science, and Engineering)

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Impact of Satellite Radiance data assimilation on the prediction of extreme rain events in the haor basin area

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Abstract

An attempt has been taken to investigate the impact of satellite radiance assimilation in simulating the extreme rainfall formed over the haor basin region. In this study, the Weather Research and Forecasting (WRF) model and three-dimensional variational (3D-Var) data assimilation system is used. The Global Forecast System (GFS) model of the National Centers for Environmental Prediction (NCEP) data has used as an initial condition. WRFDA is assimilated with Advanced Microwave Sounding Unit-A (AMSU-A) radiance data and NCEP Global surface and upper-air observations (NCEP PREBUFR). Overall, the results suggest that assimilating both NCEP PREBUFR together with Radiance observations into the mesoscale model enhanced the initial condition. The results also indicate that assimilating both NCEP PREBUFR together with Radiance observations into the WRFDA system reliability is better than the control experiments.

Keywords: WRFDA, Haor basin, Heavy Rainfall, 3DVar.

∗Speaker
Bayesian Inference of Oil Spill Source Parameters from Image Contours

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Abstract

Oil spills at sea pose a serious threat to the coastal environment. To control and limit unreported spills, it is essential to identify pollution sources, and satellite imagery can be an effective tool for this purpose. We present in this work a Bayesian inference approach to identify the source parameters of a spill from contours of oil slicks detected by satellite images. The approach adopts an observation error model based on a non-local measure of the dissimilarity between the predicted and observed contours. A Markov chain Monte Carlo (MCMC) technique is then employed to sample the posterior distribution of five parameters of interest: the x and y coordinates of the source of release, the time and duration of the spill, and the quantity of oil released. To make the estimation of the posterior distribution computationally feasible, a Polynomial Chaos-based surrogate of the oil spill model is used within MCMC. To that end, a feature-based object localization method based on image moments is proposed to approximate contours, or binary images, in the form of integral quantities, for which surrogate models can be built. Two synthetic experiments of a spill released from a fixed point source are investigated, where a contour is completely observed in the first case, while two contours are partially observed at different times in the second case. In both experiments, the proposed framework is able to provide good estimates of the source parameters along with a level of confidence reflected by the uncertainties within. In the case of partial observations, the estimated parameters can be used to reconstruct the missing parts of an observed slick from which an oil spill model can be initiated to better forecast the spread of oil.

Keywords: Oil spills, Source identification, Remotely sensed imagery, Bayesian estimation, Markov chain Monte Carlo, Uncertainty quantification

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Radar-measured near-surface refractivity: a rare representative constraint on the lower boundary layer

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Abstract

In addition to measuring properties of hydrometeors and their motion, radars are capable of measuring the average refractive index between the radar and ground targets, or rather its temporal change. This measurement, physically similar to the GNSS refractivity, is focused on the first tens of meters of the atmosphere and on a few tens of kilometers around the radar, and are available under all weather conditions. Radar-measured refractivity data are mind-bogglingly precise and are very sensitive to humidity changes, as well as being representative of conditions at meso-beta scales instead of at a point. Because refractivity measurements are difficult to interpret by people, they have not seen much use in the forecaster-centric world of operational radars. But they have the potential of being particularly useful to constrain surface properties and humidity in the lower boundary layer. In this poster, examples of measurements and applications of radar-measured refractivity will be presented.
Operational direct assimilation of radar reflectivity volumes with KENDA at Arpae-SIMC

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Abstract

In convective-scale data assimilation, the high resolution of numerical weather prediction (NWP) models demands dense observations at a suitable temporal and spatial resolution. On this respect, radar reflectivity volumes are of great value since they provide a large amount of observations of a vast volume of atmosphere, typically every 5 or 10 minutes. In most operational NWP models, these observations are assimilated indirectly, employing estimated precipitation, e.g. via latent heat nudging (LHN), latent heat tendencies or relative humidity profiles. The direct assimilation of reflectivity volumes in an operational framework has been achieved just recently. This was done, first, at Deutscher Wetterdienst (DWD) and at the Hydro-Meteo-Climate Structure of the Regional Agency for Prevention, Environment and Energy of Emilia-Romagna region (Arpae-SIMC) in Italy, using the local ensemble transform Kalman filter (LETKF) as assimilation scheme. Arpae-SIMC runs the Consortium for Small-scale Modeling (COSMO) model at 2.2 km horizontal resolution, while DWD employs the icosahedral nonhydrostatic weather and climate model (ICON) at the same resolution. In both cases, reflectivities are assimilated in combination with fields of estimated precipitation via LHN. The implementation adopted at Arpae-SIMC will be described here, reporting verification results for precipitation and for upper-air and surface variables.

Keywords: radar, reflectivity volumes, convective scale, operational

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Evaluation of multiple GNSS radio occultation observation operators with JEDI

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Abstract

Multiple observation operators for Global Navigation Satellite System (GNSS) Radio Occultation (RO) data are provided in the Unified Forward Operator (UFO) component of the Joint Effort for Data assimilation Integration (JEDI) system, JEDI-FV3 1.0.0, that was released in October 2020. JEDI is developed by the Joint Center for Satellite Data Assimilation (JCSDA) and its stakeholders ((NOAA, NASA, DoD, and UKMO). Specifically, UFO includes a refractivity operator, a one-dimensional bending angle operator replicating the NCEP Bending Angle Model (NBAM) used in operations at NOAA, as well as a one-dimensional and a two-dimensional bending angle operators incorporated through the Radio Occultation Processing Package (ROPP) adopted by ECMWF and NRL in their operations. Thanks to the unified feature of the JEDI UFO, for the first time, GNSS RO data impacts can be evaluated using multiple operational operators within the same framework. In this study, we will conduct a series of one-month numerical experiments by applying these operators for GNSS RO data assimilation to the NCEP operational FV3-GFS forecasts. We will compare the performances of the operators and evaluate RO data impact in terms of a number of metrics. The fitting of model background and analysis to RO observations in observation space, such as COSMIC2 and other RO data; as well as a series of month-long statistical results will be presented.

Keywords: JEDI, GNSSRO, data assimilation

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Ensemble-Based Data Assimilation of GPM DPR Reflectivity into the Nonhydrostatic Icosahedral Atmospheric Model NICAM

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Abstract

This study aims to improve the precipitation forecasts from numerical weather prediction models through effective assimilation of satellite-observed precipitation data. We have been developing a global atmospheric data assimilation system NICAM-LETKF, which comprises the Nonhydrostatic ICosahedral Atmospheric Model (NICAM) and Local Ensemble Transform Kalman Filter (LETKF). This study pioneers to assimilate radar reflectivity measured by the Dual-frequency Precipitation Radar (DPR) onboard the Global Precipitation Measurement (GPM) core satellite into the NICAM. We conduct the NICAM-LETKF experiments at 28-km horizontal resolution with explicit cloud microphysics of a single-moment 6-class bulk microphysics scheme. To simulate GPM DPR reflectivity from NICAM model outputs, the Joint-Simulator (Hashino et al. 2013; JGR) is used. Our initial tests showed a better match with the observed reflectivity by assimilating GPM DPR reflectivity into NICAM forecasts. However, the results from a 1-month data assimilation cycle experiment showed general degradation by assimilating GPM DPR reflectivity. For better use of GPM DPR reflectivity data, we estimated a model cloud physics parameter corresponding to snowfall terminal velocity by data assimilation. Parameter estimation reduced the snowfall terminal velocity, and successfully mitigated the gap between simulated and observed Contoured Frequency by Altitude Diagram (CFAD). The estimated parameter also improved temperature and humidity fields in the mid- to lower troposphere, and precipitation forecasts.

Keywords: GPM DPR, LETKF, parameter estimation, cloud microphysics

*Speaker
DWD pilot station – Evaluating ground-based remote sensing systems for future observing networks

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Abstract

The current surface-based observing network has an insufficient density to fully characterize atmospheric processes at scales of Meso-β (and below). It is therefore unable to capture many relevant meteorological phenomena, especially in the boundary layer. Space-based measurements are unlikely to resolve this deficiency. A new generation of ground-based remote sensing instruments, often called “profilers”, has meanwhile become commercially available. These instruments are able to provide continuous measurements of kinematic, thermodynamic and cloud/aerosol particle related variables, mostly in the form of vertical profiles. Benefits of assimilating such data were recently seen in field campaigns. It is therefore timely to ask whether such profilers can also be used successfully in an operational setting.

The presentation will give an overview of the project ”Pilotstation” at DWD, which is investigating various options for a qualitative extension of the surface-based observing network. A testbed approach is employed to assess data availability, quality, observation impact as well as operational sustainability for the following profilers: Doppler lidar, microwave radiometer, water vapor broadband-DIAL, cloud radar and Raman lidar.

Keywords: Ground based profilers, operational networks

∗Speaker
Validation of the active microwave sensor module within the RTTOV-SCATT radiative transfer model

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Abstract

Space-borne radar observations are currently emerging as an observation kind important to consider within Numerical Weather Prediction applications. Like for the forward simulation of passive microwave observations, radar data simulations require to make multiple assumptions including on the scattering properties of hydrometeors. With the objective of simulating both active and passive microwave instruments within a single framework using the same radiative transfer assumptions into a widely-used tool in the NWP community, a first version of active sensor module has recently been released within Version 13 of the RTTOV software by the EUMETSAT NWP SAF. This initial version supports the simulation of both the GPM/Dual frequency Precipitation Radar and the Cloudsat/Cloud Precipitation Radar. Simulations of the GPM/DPR, performed with RTTOV V13 and the ARPEGE global model running operationally at Météo-France will be shown. Comparisons will be performed with observations, both on a case study as well as on a large number of samples. In particular, a sensitivity of the simulations to the hydrometeor fraction profile specifications will be discussed.

Keywords: GPM/DPR, RTTOV, ARPEGE

∗Speaker
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3D Precipitation Nowcasting: RESNet applied to Highly Dense PAWR Data

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Abstract

Sudden heavy rain may lead to disasters like flooding and loss of life and property. To reduce the risk, predicting sudden downpours is of key importance. However, predictability of such events is limited to only for a very short range within an hour or shorter because of their abruptness. In this case nowcasting is an effective approach. Detecting sudden heavy rain even 10 minutes before it occurs can reduce the damage drastically. Precipitation nowcasting is the process of short-range prediction based on observation data. In the case of sudden rainfalls, this process is difficult due to the fast evolution of the rain and its chaotic nature. Therefore, we need innovative techniques.

The novel Phased-Array Weather Radar (PAWR) offers dense 3D images of reflectivity every 30 seconds. We took advantage of this big data to perform nowcasting using neural networks. We use Residual Neural Networks (RESNet) to compress the images and extract information relevant for the prediction. Next, we use a Convolutional Neural Network (CNN) to make the prediction. Afterwards, we use the same RESNet to map the forecast to the original domain. The RESNet and the CNN are trained jointly for the compression to maximize the prediction accuracy. Our first results show that in most cases we can predict precipitations up to 30 minutes, with an error rate (false positives + false negatives) of 8%. The use of the RESNet allowed to alleviate the memory load and the computational complexity of the prediction. Moreover, training the RESNet and the CNN jointly reduced immensely the prediction noise in non-precipitation regions and improved the accuracy in precipitation regions.

Keywords: Weather Forecasting, Neural Networks, Precipitation Nowcasting

∗Speaker
Impact of ground-based water vapour and temperature lidar profiles on short-range forecast skill by means of hybrid 3DVAR-ETKF data assimilation

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Abstract

Assimilation of ground-based thermodynamic lidar observations has augmented numerical weather prediction capabilities from nowcasting to the very short-range, short-range, and medium-range. In this study, temperature and water vapour profiles obtained from the temperature Raman lidar and the water vapour differential absorption lidar, respectively, of the University of Hohenheim are assimilated into the Weather Research and Forecasting (WRF) model through a new forward operator. The operator directly incorporates the water vapour mixing ratio, avoiding undesirable cross sensitivities to temperature, enabling complete observation concerning the water vapour contents to be propagated into the model. The assimilation was performed with the three dimensional variational DA system and with the hybrid 3DVAR Ensemble Transform Kalman Filter approach at a convection-permitting resolution. The 3DVAR-ETKF experiment resulted in a 50% smaller temperature and water vapour RMSE than the 3DVAR experiment. The planetary boundary layer height (PBLH) of the analyses also showed improvement compared to available ceilometer data. A single lidar vertical profile impact spreads over a 100 km radius, promising future assimilation of water vapour and temperature data from operational lidar networks. Forecast improvement with respect to PBLH was observed for about 7 hours, while an improvement of integrated water vapour lasts for 4 hours. We also present some significant collaborative effort with the Raman lidar for meteorological observation (RALMO) from the MeteoSwiss. Also, some initial results from the assimilation Atmospheric Raman Temperature and Humidity Sounder (ARTHUS) data will be shown.

∗Speaker
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A statistical evaluation of Bayesian inversions from infrared and microwave cloudy observations for future instruments MTG-FCI, MSG-MWI and MSG-ICI

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Abstract

Infrared (IR) and Microwave (MW) satellite observations are widely used in data assimilation for Numerical Weather Prediction. The so-called "1D-Bayesian + 4D-Var" assimilation method (Duruisseaux et al., 2019) is used for the all-sky MW observations at Météo-France. It consists of a Bayesian inversion of the brightness temperatures, that retrieves atmospheric profiles. The resulting relative humidity is then assimilated in the 4D-Var of the global model ARPEGE.

This study focuses on future instruments onboard MTG-I (Meteosat Third Generation) and MSG-B (MetOp Second Generation): the Flexible Combined Instrument (FCI), the MicroWave Imager (MWI) and the Ice Cloud Imager (ICI). Due to their different spectral ranges, they are sensitive to various and complementary quantities within clouds and precipitation.

The objective is to identify the key components of the assimilation system for reaching a synergistic use of these observations in an all-sky context.

The ability of the Bayesian inversion to provide complementary information is quantified with simulations from radiative transfer model RTTOV v.13 and lagged forecasts for the observations and the background.

Statistical results based on a wide sample of profiles from the ARPEGE forecast model will enable to build a global evaluation for IR and MW observations, and thus measure the degree of consistency and the differences in the retrievals from IR and MW observations.

Two steps are followed: (i) considering a perfect forward model to understand the source of differences from the retrieval method and the spectral range ; (ii) introduction of errors in the radiative transfer model to understand the differences introduced by the hypotheses used.

Preliminary results will be shown.

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Impact of Atmospheric River Reconnaissance Dropsonde Data on GFS Precipitation Forecasts: A Case Study

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Abstract

Atmospheric rivers (ARs) are long narrow corridors of water vapor transport that serve as the primary mechanism to advect moisture into mid-latitude continental regions, including the U.S. West Coast. They are responsible for most of the horizontal water vapor flux outside of the tropics and a source of precipitation. Although the advancements in satellite data assimilation has greatly improved global model forecast skill, including the NCEP global forecast system (GFS), forecasting the AR features remains a challenge due in part to their formation and propagation over the ocean, where in-situ and ground-based observations are extremely limited. The AR Reconnaissance (AR Recon) Campaigns provides additional data by supplementing conventional data assimilation with dropsonde observations of the full atmospheric profile of water vapor, temperature, and winds within ARs. In this study we used NCEP GFS version 16 (GFSv16) to examine the impact of the AR supplemental observations dropsonde data on GFS forecast. The dropsonde data used were from the AR Recon 2021 campaigns, including 29 intensive observation periods (IOPs) from Jan 17 to Mar 18. Global denial experiment was conducted near real-time by denying the dropsonde data in the GFSv16 from January 17 to March 25 for both DA and model forecast. Preliminary analysis indicates that there is significant improvement for the precipitation prediction over California during January 27-29 for an AR landfall event when the dropsonde data were used. This is a first case AR Recon provides six consecutive IOPs from January 23 to 28. The AR supplemental observations have helped to fill the data gap that is needed for the data assimilation to provide better GFSv16 model initial condition.

Keywords: Atmospheric river, Global Forecast System, Dropsonde, Intensive observation period, Precipitation

*Speaker