

The Dust Transport Application at the Air Force Weather Agency: Products and Verification

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Abstract

Dust storm forecasting is a critical part of theater operations in Iraq and Afghanistan as well as other strategic areas of the globe. The Air Force Weather Agency (AFWA) has been using the Dust Transport Application (DTA) as a forecasting tool since 2001. Initially developed by The Johns Hopkins University Applied Physics Laboratory (JHUAPL), output products include dust concentration and reduction of visibility due to dust. Verification of these products has been performed almost exclusively by subjective, manually intensive analysis out of necessity. Typically, periods of intensive data collection for verification were geared around seasons and about three months in length. However, serious drought conditions have substantially increased dust storm frequency where troops remain precariously in harm's way, thus our most recent intensive collection period has been one long continuous endeavor the past three years. Additionally, we have added many new products (e.g., ensemble-based) and versions of DTA over the past two years as well.

I will present an introduction of our dust products and verification efforts to date. Subsequently, I will discuss the particularly difficult verification challenges inherent to these forecast products. In summary, I come to this workshop seeking any quality automated verification procedures (e.g., object oriented approaches, etc) that can be applied to our dust verification efforts with reasonable success, given our unique challenges.

Application of Spatial Verification Methods to Ensembles

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Abstract

A brief overview will be provided on application of spatial verification techniques covered in the ICP Special Collection to ensemble forecasts. More extensive discussion will focus on applications of the CRA and MODE object-based spatial verification methods to ensemble precipitation output. CRA and MODE both have been applied to two different sets of ensembles to compare the behavior of several object parameters for 6 hour precipitation accumulations to traditional spread and skill measures. The two sets of ensembles included two 8 member 15 km WRF ensembles, one using mixed physics and dynamic cores alone, and the other perturbed initial and lateral boundary conditions alone. The second set of ensembles included 5 members of a 4 km convection-allowing ensemble and 5 members of a 20 km convection-parameterizing ensemble. In addition, results will be shown from application of CRA to 24 hour precipitation forecasts from an ECMWF ensemble over Australia for heavy rainfall events. Preliminary results suggest that object-based techniques could provide useful information to forecasters, and may provide useful verification information avoiding some of the problems associated with traditional measures.

Cloud Verification: A review of methodologies and recent developments

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Abstract

NWP models' representation of cloud is intimately linked with processes that are often responsible for the development of high-impact weather event. The vertical properties of cloud and optical properties play an important role in the radiative transfer and temperature distribution. Therefore, it is essential that the model's representation of cloud be as accurate as possible. A set of verification methods and observational databases is crucial to assess strengths and weaknesses of forecasting systems.

The 3D nature of clouds makes the assessment of their forecasts challenging. Up to very recent years the observations only provided a 2D description of clouds: therefore cloud forecasts could be verified as 2D slices. The advent of new satellites has made possible the verification of the vertical structure/properties of clouds as complement to the standard verification approaches.

The talk will be a review of current verification methods used to assess cloud forecasts as well as a discussion on the availability of conventional and satellite observations. New verification methods, requiring the use of the modern satellite data, will be presented.

Probability and Ensemble Forecasts: How do we evaluate their skills?

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Abstract

Probability and ensemble forecasts have been used for several years in operational centers and verification strategies have been developed to assess their quality for both modelers and forecasters' use. Existing verification methods have been adapted to cope with the special problem of matching numerous alternative forecasts (ensembles) with a single observation available for one location at one time.

The quest for verification methods for probability forecast is ongoing and new ideas or re-visited methods are proposed to the scientific community. The present talk will review the standard verification methods used in operational centers and highlights some of the issues faced when verifying probability and ensemble forecasts. The talk will include the discussion of more recent ideas and current issues.

On the Use of Synthetic Satellite Imagery to Evaluate Numerically Simulated Clouds

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Abstract

Typically numerically simulated atmospheric flows are evaluated by comparing simulated surface fields--temperature, dewpoint, pressure, ect--with observed surface fields. Radar reflectivity can be used to evaluate regions of simulated precipitation; while upper air soundings can be used to evaluate simulated soundings. Simulated clouds, on the other hand, are difficult to evaluate. As a result, these fields are given less attention compared to surface fields.

Recent advancements in computer power and radiative transfer has led to the development of models that can produce synthetic satellite images of a simulated domain. This talk will contain the procedure to produce a synthetic satellite image of a simulated cloudy atmosphere. Examples of synthetic GOES-12, GOES-R, and NPOESS imagery will be presented.

An Evaluation of Various WRF-ARW Microphysics Using Simulated GOES Imagery for an Atmospheric River Event Affecting the California Coast

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Abstract

Significant precipitation events in California during the winter season are often caused by land-falling “atmospheric rivers” associated with extratropical cyclones from the Pacific Ocean. For this type of events previous studies indicated a large sensitivity of simulated precipitation amounts to the choice of microphysical schemes used in numerical models for weather prediction. The main focus of the present study is to assess differences in performance among various microphysics by utilizing synthetic satellite imagery. The simulated brightness temperatures will be compared by using histogram matching technique to observations available from GOES-10 satellite. For this purpose simulations of an atmospheric river event that occurred on December 30, 2005 were used. The simulations were performed by using four different microphysical schemes (Lin, WSM6, Thompson, Schultz and Morrison).

Lessons Learned from the CSU Cloudy Data Assimilation Research

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Abstract

CSU has had several years of experience assimilating cloudy satellite radiances within a four-dimensional variational (4DVAR) atmospheric mesoscale data assimilation system (RAMDAS). In addition, we have extensive experience working with satellite cloud diagnostic tools. This talk will present an overview of those experiences and note areas of improvement and of potential collaboration to bridge the satellite and model communities as future verification concepts are discussed. In particular I will suggest how both communities could leverage and focus their activities into joint activities resulting in an expanded systematic verification analysis domain.

I will emphasize from our own research experience the things that satellite cloud algorithms do well, and what data assimilation systems do rather crudely at this time, and vice-a-versa. The intent will be to foster a discussion, and encourage a prioritization of the low-hanging fruit for an enlarged DTC effort to serve the NWP data center and Satellite acquisition efforts. Common tools and the ability to insert satellite capabilities within the NCAR MET tool will be discussed. Areas of particular usefulness and synergy will be in the area of radiative boundary condition estimates, related cloud state variables, observational data probability distribution tests, radiative convergence tests, satellite diagnostic algorithms, and application of these tools into the context of a DTC verification framework, including an identification of what is hard, and what is easy to do. Selected performance analysis results will be shown to indicate where the initial payoff may merit additional future work and joint activities for the verification community.

Sky Cover Forecast Verification in the National Weather Service

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National Weather Service

Abstract

The National Weather Service (NWS) has begun verifying sky cover forecasts. Forecast data come from the Point Forecast Matrices (PFM) so this is a point-based verification system. With the lack of surface observation data above 12,000 feet at most METAR points, sky cover verification is challenging. The satellite (GOES) cloud product is used to estimate these clouds for verification. The results of an October 2008 to May 2009 Beta test will be presented. A brief description of the skill scores computed from the contingency tables will also be presented.

Use of COSMIC GPS RO Data for Verification of Moisture Prediction

Bill Kuo

UCAR COSMIC Project

Atmospheric limb sounding technique making use of radio signals from the Global Positioning Systems (GPS) has evolved as a robust global observing system. The GPS radio occultation (RO) soundings obtained from such technique are found to be of high accuracy, high vertical resolution, and capable of taking measurements in all weather conditions. In particular, they are not affected by clouds and precipitation. The raw measurements are the phase and amplitude of radio signals, which can be inverted to derive vertical profiles of bending angles and atmospheric refractivities. Refractivity is a function of pressure, temperature and moisture. Through one-dimensional variational retrieval, one can derive vertical profiles of temperature and moistures. With the launch of COSMIC mission in April 2006, approximately 2,000 GPS RO soundings are routinely available from UCAR COSMIC Data Analysis and Archive Center (CDAAC), uniformly distributed around the globe, to support research and operation. GPS RO data are particularly useful for verification of moisture analysis and prediction over the ocean, where there are few traditional observations. In this paper, I will give a brief introduction of the GPS RO measurement technique. I will then show how GPS RO data can be used to evaluate moisture prediction from the model, and to assess the accuracy of other satellites and radiosonde measurements. The COSMIC soundings also provide information on the height of the atmospheric boundary layer, which is also an important variable for verification.

Characterizing Timing Errors in Hydrologic Forecasts to Support Diagnostic and Real-Time Verification

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Errors in hydrologic forecasts comprise two distinct components, i.e., timing (or phase) errors and amplitude errors that may originate from different sources of uncertainties in the forecasting process (e.g., meteorological forcing, initial soil moisture states, and hydrologic model structure and parameters). Hence, a distinction between timing and amplitude errors in hydrologic verification can provide useful diagnostic information that will guide targeted improvements on the forecast system. It can also benefit forecasters in their real-time forecast process (and forecast users in their decision making) by providing specific timing error information as well as information on the amplitude error (or the “more meaningful” magnitude error with timing error removed). This distinction however has been typically ignored in hydrologic verification. In this presentation, we discuss recent progress made in the US National Weather Service (NWS) on characterizing timing errors in hydrologic forecasts using the cross-wavelet transform (XWT) technique. The XWT technique transforms a forecast time series and the verifying observations into a two-dimensional scale-time space and provides information on scale-dependent localized timing differences between the two paired series. Initial results from applying XWT to streamflow simulations and forecasts in a number of test basins in the United States will be presented. We expect the process discussed here for characterizing timing errors in streamflow forecasts can easily be extended for use in spatial verification (e.g., of precipitation) to evaluate location or position errors.

Could Data Assimilation Be Useful for Cloud Verification?

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Abstract

Data assimilation (DA) system combines the model background and a variety of observations to obtain an optimal initial condition for subsequent model forecast. An important step within the DA procedures is to calculate the departure of observations minus background at the observation space. This capacity can be extended to calculate the difference of observations minus model forecasts, as did in WRFDA-based verification. The advantage of using DA system for verification is that the build-in observation operators facilitate the comparison between model and observations, particularly for those non-conventional observations from satellites and radar.

The presentation will show the traditional verification results from WRFDA system for usual U, V, T and Q fields and compare to MET verification results. Non-traditional verification using satellite radiance, radar and GPSRO data within WRFDA will be also demonstrated and discussed for further extension addressing cloud verification. Finally, the synergy between WRFDA-based and MET-based verification will be also discussed.

Verification of Eastern Pacific Cloud Forecasts

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Abstract

Operational eastern Pacific cloud forecasts generated by the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS(r)) were evaluated against Geostationary Operational Environmental Satellite (GOES) water path retrievals. Uncertainties in the observations were mitigated by using condensed total water path as a proxy for deep cloud cover. Multiple statistics were collected, ranging from simple correlations and histograms to more sophisticated fuzzy and composite statistics. The results show that synoptic scale systems were generally well predicted to at least 48 hours, with the primary error being an over estimation of deep cloud occurrence. Smaller sub-synoptic systems were subject to spatial and timing biases in that a number of the forecasts were lagged by 3-6 hours. Despite the bias, 60-70% of the forecasts of the mesoscale phenomena displayed useful skill.

Verifying Ensemble Forecasts Using A “Neighborhood” Approach

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Abstract

Horizontal grid spacing in numerical weather prediction (NWP) models has decreased substantially within the past decade, and model configurations with horizontal grid lengths less than 4-km are now common. However, as forecasts on finer grids are more heavily penalized for displacement errors than coarser-resolution forecasts, traditional “point by point” verification approaches, when applied to high-resolution NWP output, may yield statistics that contradict perceived forecast-value.

As a result of this potential (and often-seen) disparity, a variety of “neighborhood” approaches have been developed to verify high-resolution model output. These methods relax the requirement that a forecast point-value match an observation exactly in order for the forecast to be considered correct. Until now, these neighborhood techniques have mainly been used to verify single deterministic forecasts.

This presentation describes a simple way of applying a neighborhood verification approach to an ensemble forecasting system. In addition to schematically illustrating this technique, examples using real data are drawn from high-resolution, large-domain ensemble forecasts produced during the 2007 NOAA Hazardous Weather Testbed Spring Experiment.

Cloud Model Verification at the Air Force Weather Agency

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Abstract

Three cloud models are currently run at the Air Force Weather Agency: the Advect Cloud (ADVCLD) model, the Diagnostic Cloud Forecast (DCF) model, and the Stochastic Cloud Forecast Model (SCFM). These models are run worldwide and cover hemispheres and smaller domains of interest to military operations. All three models produce forecasts of total cloud amount at each grid point across their respective domains.

These cloud amount forecasts are verified using a ground truth field known as the World Wide Merged Cloud Analysis (WWMCA). WWMCA is built from a combination of satellite data, surface and upper air observations, and specialized, gridded analyses, and depicts cloud coverage on a 16th mesh, hemispheric domain.

A discussion of the challenges in using these models' forecasts, as well as the WWMCA observational data, will be presented. Results of recent verification will also be shown, including user-defined summary statistics as well as output obtained from MET.

Verification of Ensemble Forecasts: A look to the future

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Abstract

The practice of verification of ensemble forecasts is now beginning to settle down towards some standard measures. The rank histogram continues to be used to assess the average parameters of ensemble forecast distributions, and the continuous rank probability score and its corresponding skill score are used for the verification of the ensemble distribution against observations. When probability forecasts are extracted from the ensemble distribution, many standard verification measures for probability forecasts are used, for example the Brier Score and skill score, reliability diagrams and the relative operating characteristic curve. In addition to these commonly used verification measures, others have been proposed which are not widely used.

Recently, much attention has been paid to neighbourhood methods for the verification of deterministic forecasts. To a large extent, these methods recognize uncertainty in the location of forecast and/or observed features on a map, and are designed to give credit to being “close” in space to the observed feature. Whether these methods could or even should be adapted to the verification of ensemble forecasts is unclear, but some rudimentary spatially-oriented verification applications to ensembles are beginning to appear.

Beginning with a summary of the current status in the practice of ensemble verification, this presentation focuses mainly on issues and new ideas in ensemble verification methodology.

Validation of Cloud Top Height Using A-Train Observations

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Abstract

The A-Train is a group of polar orbiting remote sensing instruments launched to provide detailed views of clouds and the atmosphere. It carries a cloud radar (CloudSat) that can be combined to give a two-dimensional vertical profile of cloudy areas with no information on cloud phase.

The NCAR Current Icing Product (CIP) produces diagnoses of the probability and severity of aircraft icing conditions aloft over the CONUS and southern Canada. The CIP algorithm includes a scheme for identifying cloud tops and distinct cloud layers. These are based on a combination of model data with observations from satellite and surface stations. Validation of these schemes has been difficult in the past because of a lack of observational truth data. Cloud tops and bases and information on cloud layers are seldom reported by pilots, and existing reports can be unreliable.

CloudSat provides regular observations of cloud layers that can be used to validate this scheme. The CIP tends to be overly conservative in cloud top estimation, resulting in higher cloud tops than those observed and a greater volume of icing-warned airspace than needed. More accurate cloud tops will reduce the volume of icing produced, which increases the efficiency of the algorithms and decreases the amount of overforecasting. This improvement can also improve diagnoses of the vertical extent of precipitation, which can have a large effect on the diagnosed icing conditions.

An explanation of the current and future CIP cloud top algorithms will be presented along with a description of the CloudSat instrument and the results of a validation exercise. A new method to identify cloud placement errors and refine the observed cloud top height from CloudSat by combining the data with retrievals from a cloud lidar (CALIPSO) in the A-Train will also be shown.

Ensemble Based Probabilistic Forecast Verification

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Abstract

NCEP ensemble verification system has been developed to evaluate ensemble based probabilistic forecast since 90s. This system is mainly to focus on two attributes (reliability and resolution) for NCEP ensemble based probabilistic forecast in addition to the traditional measures, such as Anomaly Correlation (AC) and Root Mean Square (RMS) error for ensemble mean, rank histogram, outlier and et al. The events definitions for probabilistic scores are based on 1) defined thresholds, 2) climatological percentiles and 3) defined by ensemble members. The probabilistic skill scores are based on NCEP/NCAR 40-year reanalysis climatology. Currently, this system generates Brier Skill Scores (BSS) with reliability and resolution, Ranked Probability Skill Score (RPSS), Continuous Ranked Probability Skill Score (CRPSS), Relative Operational Characteristics (ROC), Relative Economic Value (REV) and etc to apply to upper atmospheric variables, such as 500hPa height, 850hPa temperature, and near surface variables, such as 1000hPa height, 2-meter temperature, 10-meter wind. Meanwhile, the ensemble precipitation forecast has been evaluated by calculating Continuous Ranked Probability (CRP) and ensemble spread. Recently, this system has been upgraded to apply for Northern American Ensemble Forecast System (NAEFS), too.