CHARACTERIZING ERA-INTERIM AND ERA5 SURFACE WIND BIASES USING ASCAT

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ABSTRACT

This paper analyses the differences between ECMWF Re-Analyses (ERA) for both ERA-Interim and ERA5 surface winds fields relative to ASCAT ocean vector wind observations, after adjustment for the effects of atmospheric stability and density, using stress equivalent winds (U10S), and air-sea relative motion using GlobCurrent ocean current velocities. In terms of instantaneous RMS wind speed agreement, ERA5 winds show a 20% improvement relative to ERA interim, and a performance similar to that of currently operational ECMWF forecasts. ERA5 also performs better than ERA-interim in terms of mean and transient wind errors, wind divergence and wind stress curl biases. Yet, both ERA products show systematic errors in the partition of the wind kinetic energy both into zonal and meridional, and in mean and transient components. ERA winds are characterized by excessive mean zonal winds (westerlies) with defective mean poleward flows at mid-latitudes, and defective mean meridional winds (trades) in the tropics. ERA stress curl is too cyclonic at mid and high latitudes, with implications for Ekman ocean upwelling estimates, and
lack detail in the representation of SST gradient effects (along the equatorial cold tongues and Westerly Boundary Current (WBC) jets) and mesoscale convective airflows (along the Inter-Tropical Convergence Zone (ITCZ) and the warm flanks for the WBC jets). It is conjectured that large-scale mean wind biases in ERA are related to their lack of high frequency (transient wind) variability, which should be promoting residual meridional circulations in the Ferrell and Hadley cells.

Ocean currents make a notable contribution to the mean differences between scatterometer and reanalysis winds. The ocean current correction relieves the zonal mean wind biases in the mid-latitude westerlies by up to 50%, and in the trade regions, but with almost no effect on meridional mean wind biases. After the ocean correction, model mean winds remain stronger than observations in the mid-latitudes, but appear weaker than observations in the tropics (mostly due to the missing meridional component). The correction for ocean current is introducing new error patterns in the tropics that are more consistent with the misrepresentation of SST gradient effects over the equatorial cold tongues, and the resolution of mesoscale
convection effects over the ITCZ. On the other hand, the ocean current correction is increasing the transient wind biases by subtraction of eddy kinetic energy from model wind variability via the modeled Ekman response. The signature of ocean current divergence is negligible, but the signature of ocean current curl is notable, and acts to enhance the mean stress curl differences between observations and model wind fields, particularly there where strong currents are sustained by strong SST fronts, and larger air-sea interaction effects are expected. In other words, a correction for ocean surface velocity is essential for the characterization of problems with the representation of air-sea interaction effects in ERA winds.

AN IN-SITU REFERENCE FOR HIGH AND EXTREME WINDS

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ABSTRACT

A particularly pressing requirement in the Ocean Surface Vector Wind (OSVW) community is to obtain reliable extreme winds in hurricanes (> 30 m/s) from wind scatterometers, since extreme weather classification, surge and wave forecasts for societal warning are a high priority in nowcasting and in numerical weather prediction (NWP). A main goal of the EUMETSAT C-band High and Extreme-Force Speeds (CHEFS) study is therefore to consolidate an in-situ wind reference for assessing scatterometer high and extreme-force wind capabilities.

Scatterometers have proven to have very good performances when retrieving low to moderate winds. However, measuring high and extreme winds is still challenging as vicarious calibration is needed and calibrated in situ reference winds are scarce.

Moored buoy data are usually used as absolute reference to calibrate the scatterometer Geophysical Model Functions (GMF), however, for very high and extreme winds above 25 m/s, moored buoys may not be reliable. Moreover, controversy exists in the OSVW satellite community on the quality of moored buoys above 15 m/s rather than 25 m/s. Hence,. the quality of buoy winds between 15 m/s and 25 m/s is thoroughly evaluated. The buoy wind performance, estimated with triple collocation analyses of buoy, ASCAT and ERA5 winds, shows that the quality of buoy wind vectors up to 25 m/s is within 2 m/s, indicating that buoy winds can indeed be used for wind scatterometer GMF calibration in the mentioned wind range.

The NOAA hurricane hunters fly into hurricanes to drop sondes, and thus obtain wind profiles in the lowest few kilometers of hurricanes and operate dedicated microwave instrumentation on aircraft to obtain detailed wind patterns in hurricanes, such as the Stepped-Frequency Microwave Radiometer (SFMR). Ideally, local dropsonde winds may be statistically used to calibrate SFMR as they have similar spatial representation ("footprint"). SFMR, in turn, after spatial aggregation to scatterometer footprints, may be used to calibrate satellite scatterometers and radiometers in overflights.

The so-called WL150 algorithm is operationally used to estimate 10-m surface winds from dropsonde wind profiles. The measured radiosonde 10-m winds are a more direct calibration resource for the 10-m surface wind than WL150 estimates. However, an improved assessment of the position of the sonde near the surface, where its deceleration is maximum, in needed.

The air mass density needs to be considered to calibrate scatterometer winds in hurricanes, as these mainly occur at low pressures and hence low air mass density, i.e., so-called stress-equivalent winds should be used for comparison.

Finally, ASCAT winds show sensitivity to high winds, but lack good GMF calibration due to the lack of a consolidated in-situ wind reference. The saturation of the GMF at extreme winds is somehow compensated by the high calibration stability of the ASCAT instrument. As a result, further backscatter calibration refinements will support the retrieval of good-quality ASCAT winds in extreme conditions.

In addition, GMF development and wind retrieval studies will be useful to improve high and extreme winds, in particular after a consolidated in-situ wind reference has been established.

SCATTEROMETER CONSTELLATION USER REQUIREMENTS

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ABSTRACT

The EUMETSAT Ocean and Sea Ice Satellite Application Facility (OSI SAF) performs development work in scatterometer processing at KNMI. In this presentation we inform the NWP users of the choices that we have in prioritizing this work and we are looking for discussion, confirmation and endorsement of these priorities. This is in particular relevant for the definition in 2020 of our work in the next project phase.

A prominent user requirement is in the time coverage of scatterometer winds, which is currently well expanded with the building of a virtual scatterometer constellation between Europe, India and China. The timely production of high-quality winds from all these scatterometers is our second concern. In terms of processing, KNMI puts priority in a standard output, where the processors for each instrument are based on common modules. In particular, Quality Control receives much attention, where rain screening for Ku-band scatterometers, sea ice screening, ship detection and RFI remain of interest. The operational routine furthermore uses a product quality flag, based on deviations from nominal of residual variable distributions. KNMI has put effort in spatial resolution enhancement and an ASCAT 5.6-km resolution processor is available. We foresee a similar enhancement procedure for the next generation European scatterometer SCA. Spatial resolution is mainly relevant for nowcasting of cyclones and mesoscale complexes, but less relevant for NWP in our experience. What must be relevant for NWP are bias detection methods and the consolidation of an in-situ wind reference for high and extreme winds. Moreover, KNMI has spend much effort in attributing wind differences to scatterometer, NWP model and in-situ measurement systems, both in variance and spatially. This aids strategies for mesoscale and global scale data assimilation in NWP. A very relevant area for marine studies concerns the coastal areas, which is often guided by downscaled NWP. The production of coastal winds presents particular challenges, which are being addressed, while the assimilation of coastal winds is not straightforward either. Besides taking care of many new instruments, KNMI produces Climate Data Records for (past) long scatterometer instrument series in order to profit from the most recent processor (module) developments. A new activity is to investigate and develop homogeneity of passive and active microwave winds.

More details will be provided at the IWW15 and we are looking for discussion, confirmation and endorsement of these priorities, where we welcome any suggestions for improvement of services.

BLUE FOR THE SCATTEROMETER CONSTELLATION

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ABSTRACT

High-resolution satellite-derived sea-surface wind data, such as those from scatterometers, are increasingly available for operational monitoring and forecasting of the ocean. In this presentation we present the scatterometer constellation and show first results that indicate that the scatterometer wind data assimilation process can be potentially much improved by bias correction.

Belmonte&Stoffelen (2019) documented large NWP model errors on both large and small scales and on all temporal scales. Trindade et al. (2019) succeeded to compute stable gridded NWP minus scatterometer differences over a few days, which were subsequently used to correct a time series of numerical weather prediction (NWP) outputs in a product that they called ERA. They verified ERA against independent wind measurements, which resulted in a reduction of the observation minus NWP field, so-called o-b, global variance of 20%. An o-b reduction of 20% is very substantial. Moreover, the reduction is due to bias correction, which helps to more closely fulfill the BLUE paradigm of NWP data assimilation. BLUE stands for Best Linear Unbiased Estimate and is necessary to well inform the atmospheric state variables of the NWP model.

Data assimilation of scatterometer data in NWP generally only resolves NWP spatial scales of ~150 km. Therefore, information on the wind-SST interaction, the diurnal wind cycle and the wind variability in moist convection areas is lost in such products. Moreover, known systematic NWP model (parameterization) errors and ocean currents contribute to local biases, which are rather time invariant. Such biases prevent to properly correct the meso- and large-scale NWP dynamical errors. Following ERA, a bias correction scheme may be implemented that takes out the slow biases in o-b mentioned above, that are mostly related to the local ocean state and not resolved in NWP models.

The corrections can be further used to attribute errors to the bias (and variability) source terms in order to improve the air-sea interaction modelling, which will be important in the coupling of atmosphere and ocean models of the future.

ASSIMILATION OF THE GOES-16/17 ATMOSPHERIC MOTION VECTORS IN THE HURRICANE WEATHER FORECASTING (HWRF) MODEL

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ABSTRACT

Atmospheric Motion Vector (AMV) data are an important observation type for both global and regional data assimilation systems. The AMVs are derived from observations made by the new Advanced Baseline Imager (ABI) onboard the Geostationary Operational Environmental Satellite GOES-16 on GOES-17 satellites. The former became operational as GOES-East on 2 January 2018 and the latter became GOES-West on 12 February 2019. The ABI is a state-of-the-art 16-band radiometer with spectral bands covering the visible, near-infrared and infrared portions of the electro-magnetic spectrum (Schmit et al, 2017), with four times the spatial resolution and five times faster coverage compared to instruments on earlier GOES. The utilization of the full resolution data (e.g. spatial, temporal and spectral) enables the generation of wind products with increase counts and significantly improves geographic coverage that should substantially increase the volume of information that will be available to the user community (Daniels et al, 2016). The AMVs are derived using the operational GOES-R nested tracking algorithm (Bresky et al, 2012; Daniels and Bresky, 2010).

The quality control procedures and assimilation techniques in HWRF are reviewed and revised to efficiently use these new AMVs. The impact of assimilating GOES-16 AMVs on forecasts of track and intensity for tropical cyclones in the 2018 hurricane season will be presented and discussed. The operational HWRF track and intensity forecasts will serve as the baseline for comparisons.

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EVOLUTION OF AN ATMOSPHERIC KÁRMÁN VORTEX STREET FROM HIGH-RESOLUTION SATELLITE WINDS: GUADALUPE ISLAND CASE STUDY

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ABSTRACT

Vortex streets formed in the stratocumulus-capped wake of mountainous islands are the atmospheric analogues of the classic Kármán vortex street observed in laboratory flows past bluff bodies. The quantitative analysis of these mesoscale unsteady atmospheric flows has been hampered by the lack of satellite wind retrievals of sufficiently high spatial and temporal resolution. Taking advantage of the state-of-the-art imaging capabilities of GOES-16 ABI and the nested tracking algorithm, we derived 2.5-km cloud-motion winds every 5 minutes over an 8-hr daytime period for a vortex street in the lee of Guadalupe Island on 9 May 2018. A novel MODIS–GOES joint wind product provided accurate stereo cloud-top heights and semi-independent wind validation data. The time series of geostationary winds, supplemented with snapshots of 6.25-km ocean surface winds from ASCAT, allowed us to capture the wake oscillations and measure vortex shedding dynamics for the first time from spaceborne observations.

The vortex street developed under atmospheric conditions conducive to coherent vortex shedding. The marine boundary layer had a well-mixed subcloud layer capped by a strong temperature inversion with a weaker stably stratified layer above. The Froude number related to the dividing streamline was typically below the critical value of 0.4, corroborating previous findings. The derived wind field around Guadalupe exhibited characteristics expected from laboratory flows past bluff bodies: flow splitting with deceleration on the windward side, lobes of acceleration on the flanks, and an oscillating wake with transverse jets at quasi-regular intervals set by a vortex shedding period of 2–4 hr. The retrievals revealed a markedly asymmetric vortex street, with cyclonic eddies having larger peak vorticities than anticyclonic eddies at the same downstream location. Vorticity generally decreased with time, that is with downstream distance, due to viscous diffusion but the rate of decrease was a factor of two higher for anticyclones. Drawing on the vast knowledge accumulated about laboratory bluff body flows, we argue that the asymmetric island wake arises due to the combined effects of Earth's rotation and Guadalupe's non-axisymmetric shape resembling an inclined flat plate under low angle of attack. The asymmetric vortex decay implies a three-dimensional wake structure where centrifugal or elliptical instabilities selectively destabilize anticyclonic eddies by introducing edge-mode or core-mode vertical perturbations to the clockwise-rotating vortex tubes.

IMPROVING THE RETRIEVAL OF VERTICALLY IN-HOMOGENEOUS CLOUD PROPERTIES FROM PASSIVE INSTRUMENTS AND HOW THIS IMPACTS THE ACCURACY OF ATMOSPHERIC MOTION VECTORS ESTIMATES FROM CLOUD TRACKING

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ABSTRACT

Accurate cloud properties retrieval from passive instruments are particularly challenging in presence of vertically highly in-homogeneous and/or multiple cloud layers because of the inherent lack of observational constraints for the vertical profile below the cloud top. The uncertainty in the estimate of the cloud top in these situations can result in large errors in the retrieval of tropospheric winds velocity from cloud tracking algorithms. The effective use of these estimates also rely on a good understanding of how the retrieved cloud top relates to the effective cloud motion height. These uncertainties can have negative consequences when atmospheric motion vectors are assimilated into numerical weather prediction models. We have been testing a version of the optimal estimation algorithm for cloud analysis developed at Eumetsat modified to better represent overlapping cloud layers and to introduce a vertically in-homogeneous cloud model. Tested using visible/near infrared and infrared observations from the Spinning Enhanced Visible and Infrared Imager (SEVIRI) aboard the Meteosat Second Generation (MSG), the modifications in this new algorithm show significant impacts in the quality of cloud top retrieval when evaluated against active instruments. Using a data set of collocated AMV estimates we discuss whether the retrieved cloud height, cloud optical thickness and associated implied cloud vertical structure could help us to better relate the retrieved cloud top to the effective AMV cloud motion height.

EUMETSAT ATMOSPHERIC MOTION VECTORS CLIMATE DATA RECORD FROM GEOSTATIONARY IMAGERY

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ABSTRACT

EUMETSAT owns a unique archive covering almost 40 years of meteorological geostationary satellite data. The imagery acquired by the geostationary Meteosat satellite series goes back to the beginning of the 1980s. These data are processed at EUMETSAT to derive Climate Data Records (CDRs) of geophysical parameters. One of these is the Atmospheric Motion Vectors (AMV) product.

EUMETSAT has a long history in estimating atmospheric winds and, along the time, it has developed a very robust algorithm for near real time generation of AMV from Meteosat Second Generation imagery. Such a retrieval scheme has been extended to Meteosat First Generation and applied to both, first and second generation, in order to produce a consistent data record spanning over few decades.

AMVs are generated at EUMETSAT mainly for assimilation in forecast models at the European Centre for Medium-Range Weather Forecasts (ECMWF) and at the Japan Meteorological Agency (JMA) to produce climate reanalysis. CDR of AMVs can also be exploited to follow the time evolution of climate variation patterns such as the North Atlantic Oscillation (NAO). The NAO is a large-scale atmospheric pressure see-saw steering the direction and strength of the polar jet. It has a direct impact on the weather evolution in US and Europe, particularly in wintertime. The jet streams are geostrophic winds; they only depend on the pressure gradient and the Coriolis force. They flow from west to east at a speed greater than 30 m/s and are located in the upper level of the troposphere, between 100 and 400 hPa. A positive NAO aims the jet stream northward, while a negative NAO pushes the winds southward.

The objective of this talk is to present in details the current status of the geostationary AMV CDR generated from Meteosat First and Second Generation and an application aiming to detect changes in the northern hemisphere jet streams.

RECENT WORK USING SATELLITE WINDS AT THE GERMAN WEATHER SERVICE

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ABSTRACT

Wind measurements derived from geostationary and polar-orbiting satellites are one of the most important data sources for global and regional NWP. Currently, the Deutscher Wetterdienst (DWD) uses satellite winds (AMVs) from five geostationary and several polar-orbiting satellites. Supplentary, scatterometer wind observations derived from the ASCAT instrument on board of Metop A/B/C and Ku-band scatterometer ScatSat are used routinely.

Monitoring of AMV wind vectors, product upgrades and the evaluation of new wind products which have the potential to improve the quality of analyses and forecasts, are an ongoing task at DWD. This presentation will give an overview of recent progress in the assimilation of AMV and scatterometer data. Since the last wind workshop, several new and upgrade AMV wind products became available. Additionally, data from the first wind lidar (Aeolus) in space became available. First results concerning the quality and impact of such data will be presented.

A new AMV bufr template was approved by WMO and first data sets from the new GOES 17 and NOAA 20 satellites are tested and first experiences will be presented. Additionally, the quality of a ISAI wind retrieval test data set provided by Eumetsat will be discussed.

Additionally, results of an impact study using the new available Ku-bad scatterometer wind product from the Chinese satellite HY-2B willl be presented.

AMV DATA DENIAL EXPERIMENTS AT THE MET OFFICE

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ABSTRACT

In a recent assessment of observation impact on the Met Office NWP system, data denial experiments were carried out for the period August – October 2019. The following sets of data were removed individually from the most recent global Met Office operational NWP configuration:

- all satellite-based microwave instruments (currently 17 instruments on 14 platforms)
- all satellite-based hyperspectral infrared sounders (5 instruments on 5 platforms)
- all atmospheric motion vectors (from 13 platforms)
- all surface wind estimates (from 4 platforms)
- in situ measurements from aircraft and radiosondes

This talk focusses on the results of removing the AMVs, and how this compares to removing the other instrument types. Comparisons are also made with a previous denial experiments carried out at the Met Office in 2016. Change in forecast skill is examined for a range of parameters, which, together with changes in the fit to background of remaining observations, are used to quantify the impact of each component.

USE OF DEEP-DIVE ANALYSIS TOOLS TO VALIDATE GOES-16/17 ATMOSPHERIC MOTION VECTORS

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ABSTRACT

Both GOES-16 and GOES-17 Atmospheric Motion Vectors (AMVs) are now being produced operationally at NOAA/NESDIS. Efforts to validate and characterize the quality of these AMVs continue, particularly in light of the GOES-17 ABI cooling system anomaly. To support this effort, a number of deep-dive analysis tools were developed. More specifically, a stand-alone tool has been developed that permits the generation of AMVs for selected target scenes and deep-dive analysis of individual AMVs on a case by case basis. This tool, capable of displaying detailed output from the two major components of the wind derivation process (height assignment and tracking), allows for a more thorough examination of individual AMV target scenes. An additional tool was developed that interrogates a database of collocated AMVs and rawinsondes to identify and isolate outlier AMVs for further study utilizing the stand-alone tool. The spatially and temporally collocated rawinsonde wind observation provides the necessary ground truth. The combination of these tools and others has been critical to understanding and characterizing errors associated with the derived winds and coordination between the Winds and Cloud AWGs on these cases has led to a better understanding and improvement of overall AMV quality. This poster will present the latest in depth GOES-16/17 case study results from the use of all the validation and deep-dive tools noted above.

STATUS OF ICWG CLOUD HEIGHT INTERCOMPARISONS

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ABSTRACT

The International Cloud Working Group (ICWG) and the IWWG maintain a shared activity of assessing the cloud height products from the operational agencies for their use in assigning heights to derived motion wind vectors. This presentation will summarize the current state of the height algorithms from the ICWG participants and their plans for development. The ICWG has implemented a best-fit analysis that uses wind fields from the IWWG participants and NWP models to derive wind vector height estimates. These are then compared to the products from the agencies which participate in the ICWG intercomparisons. This analysis will be applied to the Golden Days shared among the IWWG and ICWG. The analysis will attempt to establish the level of agreement among the algorithms and identify scenarios where their performance may negatively impact the derived motion winds application.

RETRIEVAL AND APPLICATIONS OF ATMOSPHERIC MOTION VECTORS (AMVS) DERIVED FROM INDIAN GEOSTATIONARY METEOROLOGICAL SATELLITES INSAT-3D/3DR: PRESENT STATUS AT ISRO

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ABSTRACT

Two advanced Indian geostationary meteorological satellites INSAT-3D and INSAT-3DR launched on 26 July 2013 (placed at 82^0E) and 06 September 2016 (placed at 74^0E) are providing continuous coverage at every 15-minute over the Indian Ocean region. The different spectral channel data from these satellites has enhanced the scope for better understanding of the different tropical atmospheric processes over this region. The atmospheric motion vectors (AMVs) from INSAT-3D/3DR are derived operationally at Space Applications Centre (SAC), ISRO, Ahmedabad and India Meteorological Department (IMD) New Delhi. The retrieval techniques and accuracy of AMVs has also improved with the availability of improved spatial resolution data along with more options of spectral channels in the INSAT-3D/3DR imager. The different AMV products derived from INSAT-3D/3DR at every 15-minute are used in the numerical model for real-time weather forecast at different operational forecasting centres both in India as well as abroad. It is also noted that from 2019 onwards, experimentally INSAT-3DR is configured in rapid-scan mode (5-minute interval) during the formation of tropical cyclone over the Indian Ocean region for taking frequent observations over cyclones. This experiment gives the enhanced opportunities to understand the extreme weather event using rapid scan observations.

Since IWW-14, two significant improvements have taken place in INSAT-3D/3DR AMV retrieval algorithm, one is retrieval of high-resolution low-level visible AMVs from INSAT-3DR high-resolution (1 km) images and second is retrieval of rapid-scan AMVs (RS-AMVs) from INSAT- 3DR images during tropical cyclones. After successful testing and assessment, the first-one is made operational, while the second one is yet to be operational. In the present study, initial results from both these developments are demonstrated. To assess the initial applications, sensitivity studies have been performed by assimilating the newly retrieved AMVs in the numerical model to understand the impact of high-resolution low-level visible AMVs and RS-AMVs against operational INSAT-3D retrieved AMVs. Results suggest noteworthy improvements in track prediction when RS-AMVs are used for assimilation as compared to operational INSAT-3D AMVs. Also, assimilation of high-resolution visible AMVs has improved the forecast, especially at upper levels.

SCATTEROMETER WINDS USE IN MÉTÉO-FRANCE

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ABSTRACT

An intense activity is underway around the scatterometer winds, no less than 6 instruments are flying currently around the earth, which is an unedited configuration. The operational numerical weather prediction model of Météo-France assimilates the ASCAT winds from MetOp-A and MetOp-B satellites (EUMETSAT) for many years. ScatSat-1 (ISRO) was successfully added during the last upgrade of the model in July 2019. ASCAT from MetOp-C is currently evaluated by the Operations and should become operational by January 2020. The evaluation of the last two new ones, HY-2B (NSOAS) and CFOSAT (CNSA/CNES), is ongoing with first assimilation experiments in a research context. At the same time, improvements in the assimilation of all these data is sought. The work and the results around this activity will be presented.

OPTICAL-FLOW 3D WINDS FROM CRIS ON SUOMI-NPP AND NOAA-20

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ABSTRACT

Because radiosondes are less common at high-latitudes, atmospheric motion vectors derived from satellites have the potential to dramatically improve knowledge of the wind in these regions. In particular, polar 3D winds derived from hyperspectral sounders could be beneficial for both data assimilation and model-independent scientific analysis. Polar-orbiting satellites produce frequent observations and the hyperspectral instruments retrieve 3D fields of water-vapor and ozone on pressure levels above clouds and clear sky. These hyperspectral data complement cloud features, as they can be produced at altitudes both higher and lower than tracked clouds and also in cloudless regions.

The spatial resolution of the 3D fields can be maintained at the native resolution of the sounder using the University of Wisconsin dual regression single field-of-view retrieval.
Here, we demonstrate 3D winds using data from the Cross-track Infrared Sounder (CrIS) instruments aboard Suomi-NPP and NOAA-20. These satellites share the same orbital plane, which creates a large amount of swath overlap and frequent overpasses.

However, tracking mixing ratio features is different from tracking clouds because they are much more uniform and lack interest point features that constrain a given parcel in space at multiple times. They suffer from the aperture problem, where only the component of motion aligned with field gradients can be measured. Motion normal to gradients or in uniform regions must be inferred using nonlocal information, a priori assumptions, or a different data source. We will provide a report on the development of optical-flow based tracking and demonstrate the successful (and less successful) methods applied to address these issues in a satellite context.

HEIGHT ASSIGNMENT FROM LEO-GEO STEREO TECHNIQUE

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ABSTRACT

Height assignment is the leading uncertainty of atmospheric motion vectors (AMVs) measurements from LEO and GEO satellite sensors. The methods with IR brightness temperature are known for some problems when applied to: (1) the AMVs derived from visible imagery, a mismatch that works poorly for semi-transparent multi-layer clouds; (2) atmospheric regions of little or reversed vertical thermal gradient (e.g., planetary boundary layers); and (3) multi-pixel feature patterns of which the height is neither at the coldest nor at the brightest IR temperature. Here we provide a solution to the AMV height assignment problem with LEO-GEO stereo image matching. The matched image pairs have a similar spectral channel, to mitigate problem #1 in the above. The stereo technique, producing geometric height, does not require any a priori knowledge about atmospheric thermal structure, and hence avoid problem #2. Finally, we argue that the stereo height is the best representation of AMV height, because the pattern matchers used the stereo method is same as one used by the AMV algorithm for feature tracking. We will illustrate the LEO-GEO stereo technique for the improved AMV height and winds retrievals with MODIS-GOES data, and show differences among the retrieved temperature lapse rates from each of the 14 LEO-GEO channel pairs. For semi-transparent cloud cases, the problem by assigning IR height to visible AMVs, as seen in these temperature-height relationship plots, stand out as erroneous outliers. Hence, for future AMV remote sensing we advocate proliferation of LEO-GEO pairing to produce channel-matched stereo heights for more accurate AMV height assignment.

LATEST PROGRESS OF CHINESE BUFENG-1A/B SATELLITE SYSTEM

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ABSTRACT

Abstract: Sea surface wind speed is an important part of ocean dynamics research. In recent years, the emerging GNSS-R technology has been widely studied and applied due to its characteristics of high efficiency, broad dynamic retrieval range and high accuracy. In June 2019, China has successfully launched the BuFeng-1A/B satellites, which are a group of remote sensing satellite that use GNSS-R technology to monitor global sea surface wind speed, With the solar synchronous regression orbit, the dual-satellite can meet the needs of sea surface wind speed within 45° north and south latitude, and the dynamic range of wind speed remote sensing is up to 2 to70 m/s. At present, the on-orbit data processing work has been completed, including L0 data reception and processing, the L1 data calibration, and obtained the normalized bistatic radar cross section (NBRCS) associated with wind field observation, such as through empirical geophysical model functions (GMFs) and neural algorithm to get the surface wind speed. The wind speed retrieval root mean square error (RMSE) is better than 2 m/s and 10% when they are ≤20 m/s and >20 m/s, respectively. The launch of BuFeng-1A/B satellite mark a step forward in the application of navigation satellites in China, which enrich measurement methods of sea surface wind speed and improve the range and accuracy of ocean remote sensing, which is of great significance for global ocean and meteorological monitoring.

GNSS-R SEA SURFACE WIND SPEED RETRIEVALS BASED ON MACHINE LEARNING

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ABSTRACT

The sea surface wind speed is key component for Numeric Weather Prediction and disaster monitoring. The Global Navigation Satellite System-Reflectometry (GNSS-R satellite could provide rapid global coverage using small satellite constellations.

BuFeng-1 (BF-1) is the first Chinese Global Navigation Satellite System-Reflectometry (GNSS-R) satellite mission, which using the empirical geophysical model function (GMF) for wind retrievals. In this paper , the an new approach which apply machine learning (ML) algorithm for sea surface wind speed estimation will be discussed, the new algorithm I inter-comparison with GMF related method and the validation will be presented.

ASSIMILATION OF AEOLUS HORIZONTAL LINE OF SIGHT WIND SPEED AT THE MET OFFICE

Gemma Halloran, Mary Forsythe, James Cotton

Met Office

ABSTRACT

As members of the Calibration and Validation community, the Met Office began assessment of Aeolus Horizontal Line of Sight (HLOS) wind speeds in January 2019. Using the Met Office global Numerical Weather Prediction (NWP) Model background to generate Observation minus Background (O-B) statistics, we have investigated the bias characteristics of Aeolus HLOS winds, on a routine basis, both to contribute to the Cal/Val effort and to help inform our own assimilation strategy.

We made an initial assessment of the impact of assimilating Aeolus HLOS wind speed from laser A, into our global NWP model using 4D-VAR, using a 1-month period during the early part of the mission. These experiments show Aeolus to have an impact on forecasts which is similar to the magnitude of assimilating surface winds from scatterometers. Assimilation of Aeolus HLOS wind speeds have most impact on the wind analysis in the tropics, southern and northern polar regions at all levels, and in the southern hemisphere at upper troposphere-lower stratosphere levels. Improvements to the O-B standard deviation of most other observation types were seen in these experiments. Further assimilation impact experiments have begun, for a 3-month period using HLOS wind speeds from laser B. Results from these experiments will be presented.

AEOLUS – THE FIRST DOPPLER WIND LIDAR IN SPACE - HOW WELL DOES IT PERFORM?

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KNMI

ABSTRACT

Aeolus was launched by the European Space Agency (ESA) on 22 August 2018. Aeolus is an ESA Core Explorer mission dedicated to measuring atmospheric dynamics. It is a unique mission in that it provides wind profiles from space for the first time in history. According to the World Meteorological Organisation, lack of wind profile information is the biggest gap in the global observing system (GOS). Aeolus is a next step to start closing this wind data gap.

Aeolus carries a Doppler wind lidar (DWL), which is operated in the ultra-violet part of the electromagnetic spectrum at 355nm laser wavelength. At this wavelength, Aeolus measures winds in clean air conditions, from the molecular or Rayleigh channel, and in conditions with cloud and/or aerosol loading, from the Mie channel.

The quality of Aeolus winds can be assessed, among others, by comparing against wind data from an independent data source. To build statistics over a relative short time span requires a dense network of independent wind data to minimize the temporal and spatial separation of co-located winds from both data sources. Mode-selective (Mode-S) enhanced surveillance (EHS) derived winds from aircraft data are a suitable candidate with a dense network of winds over parts of Europe with observations separated by 1 km along the aircraft tracks, at ascent, descent and at cruise level.

Statistics of Aeolus winds versus Mode-S EHS winds are presented as a function of observation separation in time and space. It shows biases in Aeolus winds, changing over time, and provides an estimate of the observation error standard deviation. Bias-free observations and a correct error standard deviation estimate are prerequisites for observations to be beneficial for numerical weather prediction. Bias correction schemes can be tested using Mode-S EHS winds.

STRUCTURE OF AMV CROSS CORRELATION MATRICES

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ABSTRACT

This study explores the structure of the cross-correlation matrices that are used to compute the initial trajectories at the beginning of the AMV process. A simple method based on identification and separation of the first two maxima. This gives a measure of the AMV quality.

This study used the AMV processing code from the NWCSAF package together with a large sample of AMV innervations from the Met Office meso model for validation.

INTER-COMPARISON OF ATMOSPHERIC MOTION VECTOR BETWEEN GK2A AND MTG-FCI ALGORITHM USING GK2A/AMI DATA

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ABSTRACT

The GEO-KOMPSAT-2A (GK2A) satellite provides observational images from 25 July 2019 operationally. The National Meteorological Satellite Center (NMSC) of the Korea Meteorological Adminisatration (KMA) has started to disseminate Atmospheric Motion Vectors (AMVs) of GK2A since 25 October 2019.

In order to evaluate height assignment methods including CCC with cloud top pressure of GK2A AMV algorithm and derive improvements for the calculation of AMVs through the inter-comparison of GK2A and Meteosat Third Generation (MTG) satellites, we selected a golden date (15 August 2019) for case study which available GK2A datasets with triplet of images and cloud products such as cloud mask and cloud top pressure.

The main results of this study are summarized as follows: (1) the distribution of wind speed, direction, and height are compared. While speed and direction are similarly distributed, height distributions of both institutions are quite different. (2) The quantitative and qualitative validation were performed using radiosonde, numerical weather prediction model, and Cloud-Aerosol Lidar and Infrared Pathfinder Observations (CALIPSO) data. (3) GK2A AMV using rapid scan images with 2 minutes intervals, and MTG high resolution wind (HRW) were also compared.

OPERATIONAL WIND PRODUCTS AT NOAA/NESDIS

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ABSTRACT

This paper summarizes the status of the operational wind products at NOAA/NESDIS. Recent improvement, new additions, processing changes and monitors, future plans of the operational Atmospheric Motion Vector (AMV) product suite will be discussed. The current satellite constellation for operational AMV winds processing includes new GOES-16/17, VIIRS from S-NPP and NOAA-20, AVHRR from NOAA and MetOp series, and MODIS from Terra and Aqua. Besides the currently operational AMV products, several improvements in NOAA/NESDIS AMV products have been and will be implemented. These improvements include the transition from heritage BUFR template to new BUFR template, the GTS distribution of NOAA AMV BUFR products, enhancement of VIIRS AMV, and MODIS and AVHRR AMV products by using GOES-R/VIIRS AMV algorithms. Updates on the status of these AMV products, new AMV BUFR template, data access policy, and other future plans like the migration to Cloud system will be presented. In addition, an overview of the operational ASCAT and ongoing SCATSAT ocean surface wind products at NOAA/NESDIS is also presented.

UPDATES ON AMV DATASETS AND THEIR USE AT NCEP GSI

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ABSTRACT

In the last few years a number of imaging instruments were replaced with newer imagers of similar capabilities providing global coverage. Himawari-8, Meteosat-8 and 11, GOES-16 and 17 are almost identical in terms of spatial and spectral potential. AMVs retrieval algorithms keep up to respond to instrumental and imagery improvements. Continuously evolving NWP models adapt to product change as well.

NCEP GSI has been updated to assimilate geostationary GOES-16 and GOES-17 AMVs, and polar NOAA-20 VIIRS. We will present the work introducing these two data streams, and results from evaluating and improving the AMVs Observation operator in NCEP GSI, addressing changes in the AMV products.

We will also present results from evaluating Leo-Geo winds, showing strong potential for positive impact in DA, and preliminary results from investigating ESA's Aeolus Doppler Lidar wind profiles.

AEOLUS FOLLOW-ON CONFIGURATIONS

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ABSTRACT

The ESA Earth Explorer mission Aeolus partly fulfills the well-expressed need for wind profile observations to initialize Numerical Weather Prediction (NWP) models. Aeolus has proven beneficial in particular over regions void of wind profile observations in the troposphere and lower stratosphere, particularly over the oceans, tropics and southern hemisphere. Although successful, Aeolus only partly fills the data gap following the requirements on data coverage, data quality and timeliness. These requirements are generally well captured by the World Meteorological Organization (WMO) Observing Systems Capability Analysis and Review (OSCAR) and Rolling Requirements Review (RRR).

With the success of Aeolus the moment has come to look forward to future vertical wind profiling capability to fulfil the rolling requirements in operational meteorology. Already in 2005 ESA initiated a study on potential Aeolus follow-on missions. Options studied included an Aeolus type instrument, but measuring profiles of the complete wind vector, rather than a single wind component like Aeolus. In addition, the benefits of a constellation of a number of Aeolus instruments was studied. It was shown that given a fixed number of observations doubling the coverage of single wind components, through the positioning of two Aeolus satellites in the same orbit, is more beneficial for NWP than a single satellite measuring the complete wind vector. A third Aeolus-type satellite in the same orbit further adds to NWP, although first indications of impact saturation emerged when distributing more satellites in the same sun-synchronous orbit.

This paper provides an overview of the methodology used to assess the potential impact of Aeolus follow-on missions and first conclusions on optimal wind profile sampling for NWP in the context of the WMO RRR.

A CLOSER LOOK AT GOES-16/17 ATMOSPHERIC MOTION VECTORS DERIVED FROM THE ADVANCED BASELINE IMAGER (ABI)

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ABSTRACT

GOES-16 and GOES-17 Atmospheric Motion Vectors (AMVs) are now generated and distributed operationally at NOAA/NESDIS. GOES-17 AMVs continue to be closely evaluated by the GOES-R Algorithm Working Group (AWG) winds product team in light of the GOES-17 ABI cooling system anomaly. GOES-16/17 AMVs provide key wind observations to operational Numerical Weather Prediction (NWP) data assimilation systems (global and regional) and to field forecasters (e.g., NWS WFOs and National Centers) for situational awareness. The higher spatial and temporal resolution of the ABI imagery enables more winds to be produced while also capturing motion at smaller scales. Cloud-top properties (e.g., height, type, phase, cloud overlap) derived by upstream cloud algorithms are used by the winds algorithm to aid in the selection of viable targets/features to track, and most importantly, to assign representative heights to the AMVs. This talk will characterize the performance of the GOES-16 and GOES-17 AMVs to available reference/ground truth wind measurements from rawinsondes and commercial aircraft. As part of this characterization, assessments of several case studies that demonstrate AMV performance will be presented.

GEO-GEO AND GEO-LEO STEREO 3D WINDS

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ABSTRACT

Stereo observing can provide accurate height assignments for Atmospheric Motion Vectors (AMVs) by purely geometric means as opposed to relying on IR temperatures and a model atmosphere. Our paper reviews recent work at NOAA and NASA using one GOES-R satellite paired with either a second GOES-R satellite or the NASA Terra or Aqua spacecraft. The method does not require synchronized observing between the two platforms, only a means of time tagging the pixels from each. The method does require highly accurate georegistration, which is now available from the GOES-R series thanks to its advanced Image Navigation and Registration (INR) capabilities. Stereo observing with two GOES-R spacecraft can in principle be performed using all 16 bands of the ABI. When using MODIS, one can use 14 of the 16 ABI channels that are close spectral matches with MODIS, including window IR and water vapor bands. MISR, on the Terra satellite, is also well suited to observing in tandem with a GOES-R spacecraft but only in daylight. Our approach to GEO-GEO stereo 3D Winds involves a multitemporal set of scenes from both satellites. We pick one scene from which to identify features to use as tracers. Feature matching identifies the locations of each tracer in successor and predecessor scenes from the same satellite and scenes from the other satellites. The apparent disparities in locations between paired scenes are interpreted by a retrieval algorithm as an AMV with a height for each tracer. Cross-satellite disparities combine motion and parallax to provide observability of the height. The method for GEO-LEO stereo 3D Winds is similar. In the MISR case, we can take advantage of the multi-angle looks at each tracer from up to nine MISR cameras. The extra looks provided by the GEO platform are helpful separating in-track motion from parallax, which is a known challenge for MISR AMVs. Using MODIS, instead of MISR, is advantageous because of its wider swath and nighttime IR capabilities but it provides only a single look at each tracer. We present results for GOES-GOES, GOES-MISR, and GOES-MODIS cases, including validations and inter comparisons with operational products, and discuss future applications of the stereo technique.

CHARACTERISING AMV ERRORS USING THE NWP SAF MONITORING

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ABSTRACT

The NWP SAF (Satellite Application Facility for Numerical Weather Prediction) atmospheric motion vector monitoring aims to improve our understanding of AMV errors in order to enable improvements to the AMV derivation and their impact in NWP.
https://www.nwpsaf.eu/site/monitoring/winds-quality-evaluation/amv/

The monitoring provides a long-term archive of observation minus background (O-B) statistics which compare the observation with a short-range NWP model forecast, interpolated in space and time to the observation location. The NWP SAF maintains an archive of several years of O-B statistics against both the Met Office and ECMWF global models.

On a two-yearly basis, a thorough evaluation of the AMV monitoring is documented in a series of analysis reports (AR). Discrepancies between the AMVs and the models are described and catalogued. Where appropriate, detailed case studies are used to try and identify the cause of the bias and any actions that could help resolve or mitigate the problem, either in the derivation or in the assimilation.

The analysis reports are published to coincide with International Winds Working Group meetings. In this paper we present a summary of the latest analysis report (AR9) published in 2020. Topics covered in AR9 include the influence of orography on AMV quality, Meteosat-8 AMVs tracking low cloud and fog near the coast of Africa, and further investigations in the Indian Ocean. We also document O-B differences in the GOES AMVs as a result of changes introduced by NOAA/NESDIS.

EVALUATION OF GOES-17 AND OTHER NEW AMV DATA SETS WITHIN MET OFFICE NUMERICAL WEATHER PREDICITON (NWP)

James Cotton, Mary Forsythe, Amy Doherty, Adam Martins

Met Office

ABSTRACT

In this paper we present an evaluation of the new AMV data sets distributed since the last International Winds Working Group meeting in 2018.

The most significant change to the global observing system has been the introduction of GOES-17 as the operational GOES-West satellite in February 2019. GOES-17 operated in parallel with GOES-15 through until December 2019 offering a substantial overlap for testing the data in NWP systems. GOES-17 uses the same ABI instrument and winds algorithm as GOES-16 and offers improved data coverage in the southern hemisphere region compared to its predecessor. A key part of the evaluation has been to assess the impact of the ABI loop heat pipe cooling problem on the quality of the AMVs and what mitigation strategies are required. The impact of assimilating GOES-17 in the Met Office global model has been assessed through a set of observing system experiments. When compared to a no GOES-West baseline, there are clear beneficial impacts from adding GOES-17 AMVs, particularly for temperatures and winds at 250 hPa in the tropics. Versus a GOES-15 baseline, the switch to GOES-17 results in 13% more AMVs assimilated. GOES-17 shows benefits in the southern hemisphere and northern hemisphere, whilst GOES-15 remains more beneficial in the tropics.

The use of GOES-16 AMVs has been expanded through the addition of the visible and short-wave infrared channels and these are also used for GOES-17.

Additional AMV data sets for evaluation include VIIRS polar winds from NOAA-20, Meteosat Second Generation AMVs distributed with heights and quality indicator (QI) from OCA, data using the Common QI, and demonstration 3D IASI winds from EUMETSAT.

METOP-C ASCAT AND OTHER SCATTEROMETER IMPACT STUDIES

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ABSTRACT

Metop-C launched in November 2018 and ocean surface wind vectors from the Advanced Scatterometer (ASCAT) instrument have been received at the Met Office since March 2019. Data monitoring has confirmed the data quality is very similar to ASCAT on Metop-A and Metop-B. Here we present results from global data assimilation experiments using Metop-C ASCAT (ASCAT-C) winds. An initial trial assimilating ASCAT-C showed beneficial impacts on tropical wind forecasts but degraded background fits (O-B) for surface radiance channel fits. Changing the thinning to ensure a maximum of 2 ASCAT per thinning box improves the background fit to other observations. Overall forecast impacts are neutral with a PS43 baseline, but improvements are seen at short-range for low level winds. ASCAT-C is scheduled for inclusion in Parallel Suite 44, due to become operational around September 2020.

Changes to the ASCAT quality control (QC) have been tested in order to allow more observations to be used closer to land and relaxing the maximum likelihood estimator (MLE) screening.

Additional scatterometer data from the Chinese HY-2B satellite are being monitored but are not yet suitable for operations due to issues with data timeliness.

A scatterometer data denial experiment has been conducted as part of a coordinated global impact study for all observation types. We present results of the combined impact of ASCAT, ScatSat-1 and WindSat on global scores and compare relative to other observing systems such as AMVs.

MULTI-ANGLE RETRIEVALS OF MACROSCOPIC CLOUD-TOP PROPERTIES FROM SLSTR-TANDEM AND A VERY HIGH RESOLUTION (<1M) POINT-AND-STARE SATELLITE VIDEO VISIBLE SYSTEM IN THE CONTEXT OF THE FUTURE EE10 HARMONY THERMAL MULTI-ANGLE PAYLOAD.

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ABSTRACT

Results on cloud-top height and winds from SLSTR onboard Sentinel-3a and S3b with 9 spectral bands using a conical scanner are shown using stereo photogrammetric techniques previously demonstrated with ATSR2-AATSR tandem observations at IWW-12 by the first author. The potential for operational application will then be described. Results on cloud macroscopic properties derived from the UK Carbonite-2 test system with ≈1m multi-angle imagery (±35º) will also be shown using a new retrieval method for a number of typical cloud scenarios. The ESA EE10 HARMONY mission is primarily an interferometric SAR mission in tandem with Sentinel-1. In order to investigate atmosphere-surface processes, a thermal IR multi-angle system based on the FLIRt system described in IWW13 is being considered for deployment on the tandem convoy and results from simulations based on SLSTR-tandem will be shown.

NWCSAF/HIGH RESOLUTION WINDS AMV SOFTWARE – STATUS IN 2020

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ABSTRACT

The "High Resolution Winds product (HRW)", developed inside the "Satellite Application Facility on support to Nowcasting and very short range forecasting (NWCSAF)" standalone "software package for geostationary satellites (NWC/GEO)", provides a detailed calculation of Atmospheric Motion Vectors (AMVs) and Trajectories locally and in real time by its users.

The latest operational version of the software (v2018.1) is being released to users in the autumn 2019. The main improvements related to "NWC/GEO-High Resolution Winds product" are the option to calculate AMV and Trajectories with GOES-R satellite series (GOES-16 satellite for the moment), and the inclusion of the new "International Winds Working Group BUFR AMV output (sequence 310077)" for the writing of the AMV output.

After this, considering suggestions from AMV users in the Scandinavian countries, "High Resolution Winds product" is being extended to run also with polar satellites, inside "NWCSAF software package for polar satellites (NWC/PPS)". The processing will consider images from different NOAA and Metop satellites and NWC/PPS cloud products, after reprojection inside a static region. A preliminary version of NWC/PPS-HRW product is expected to the ready for testing by beta users in 2020-2021. The AMV calculation process here will be equivalent to the one for geostationary satellites, although some simplifications can be considered for this preliminary version.

CORRECTION FOR THE CIRRUS CLOUD TOP HEIGHT OF MODIS BASED ON CALIPSO IN BEIJING-TIANJIN-HEBEI REGION

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Abstract

Cirrus plays an important role in atmospheric radiation. It affects weather system and climate change. Satellite remote sensing has great advantage in cirrus detection, relative to traditional observation. As a passive remote sensing instrument, large deviations are found at thin cirrus cloud top height from MODIS. Comparatively, CALIOP as an active remote sensing instrument can acquire more accurate characteristics of thin cirrus cloud.

There are total 5 years matched data from 2013 to 2017. Four years data were used as training data for modeling, and one year was used as testing data for validation. Linear regression and cross-validation were used to analysis the relationship between cloud top heights of MODIS and CALIPSO and to establish correction model. Based on the model, MODIS cirrus cloud top height was corrected. The results showed that the linear regression of cirrus cloud top height between MODIS and CALIPSO was well. The model got the 0.01 significance level. The probability distribution demonstrated that the cloud top height of CALIPSO was higher than MODIS, which respective highest frequency was around 10～11 km(CALIPSO) and 9～10 km(MODIS). After correction, probability distribution of corrected MODIS was closer to CALIPSO and the deviation between the two is obviously reduced. The distribution range of the difference between MODIS original value and CALIPSO is - 3 ~ 2km, and the peak value is about - 0.8km. After correction, the distribution curve of MODIS cloud top height and CALIPSO difference shifted to the right, with the distribution range of - 2.0-2.5 km, and the peak value concentrated near 0.2 km. The correction effect of cirrus cloud top height varies with cloud top height and cloud optical thickness. The correction effect is obvious at different heights, and the correction range of cirrus cloud in lower layer is larger. For the thin cirrus cloud with small optical thickness, the correction effect was more obvious.

STUDY OF AMV SPEED BIASES IN TROPICS

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ABSTRACT

An important diurnal cycle in convection, cloudiness and surface temperature exists for all regions of the tropics. It is currently not fully clear how these tropical specificities affect AMVs extracted from satellite imagery. Recent reports (e.g. Horvath et al, 2017; Warrick, 2016) revealed the existence of a positive Observation-minus-Background (O-B) speed bias in the tropical region of the upper troposphere for most satellite-channel combinations from both geostationary and polar-orbiting satellites. O-B speed biases are commonly explained by erroneous altitudes assigned to AMVs. However, fast speed biases are found for AMVs that are set already very high in the troposphere and it does not appear very realistic to consider that they are set too low.

A study is presented that aims exploring how the dynamics and physics underlying the tropical atmosphere affect AMVs extracted from satellite imagery. Monthly statistics of 1 yr of data of AMVs derived by EUMETSAT from IR imagery from Meteosat-10 (Met10) and Metop-A/B satellites against hourly ECMWF forecast wind fields are derived. Furthermore, the Meteosat-10 AMV performance over desertic areas is studied in more detail. Results reveal a good agreement between satellite and model winds for pressures $\leq$ 250 hPa. Between 300-500 hPa, altitudes assigned too low lead, in conjunction with vertical wind shear and generally fast winds, to AMVs being frequently more than 5 ms^{-1} faster than ECMWF. In contrast, height assignment errors unlikely explain why Dual-Metop AMVs are faster than model winds over the Boiler-Box region (Indonesia, Papua-New Guinea). AVHRR brightness temperature fields indicate that due to the large temporal gap of 50 minutes between two images and due to the strong convection, that alters the shape of clouds, the feature to be tracked is difficult to relate accurately between two AVHRR images. The brightness temperature fields of AVHRR image pairs further reveals generally low spatial correlation between target box and its location in the search area. Above findings are further investigated using wind profiles from HLOS ADM-Aeolus. A brief discussion on recommendations on AMV extraction in tropics based on such cases will be given.

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GENERATION AND APPLICATION OF LOCAL HIGH RESOLUTION MULTICHANNEL AMVS FOR OPERATIONAL NWP

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ABSTRACT

The Australian Bureau of Meteorology (BOM) has used Himawari geostationary satellite data in support of many operational applications. In one application the Himawari navigated and calibrated imagery has been used in the BOM since 1992 to operationally generate Atmospheric Motion Vectors (AMVs) over the full earth disk viewed from the satellite. These local AMV data are still used in the BoM's operational forecast systems. Each vector is error characterised, including the assignment of an Expected Error and Quality Indicator and information from the results of other tests. To further enhance the use of the current 10 minute high temporal and spatial density AMVs in the current operational assimilation systems whose horizontal resolutions now go down to 1.5 km, their spatial, temporal and error distribution has been analysed and improved. The data have subsequently been used with the full BOM operational database to provide forecasts with current operational forecast models and also nested tropical cyclone forecast models. Results indicate locally generated Himawari-8 and 9 AMVs, which are available every 10 minutes, are of a density and quality which have the ability to improve NWP model initialisation and forecasts.

The results also providing an indication of the latency/processing requirements, temporal density, spatial density and data selection methods appropriate for effective application of these high resolution data in an expanding high resolution, shorter cut off environment.

WIND ERROR ASSESSMENT WITH TRIPLE AND QUADRUPLE COLLOCATION ANALYSIS

Jur Vogelzang and Ad Stoffelen

KNMI

ABSTRACT

Ocean surface vector winds are measured by moored buoys and an increasing number of spaceborne scatterometers. These measurements are assimilated into NWP models on a routine base, and it is therefore important to know their error characteristics. The triple collocation method was introduced by Stoffelen in 1998 and applied to triplets of measurements by buoys, ERS scatterometer, and NWP forecasts in order to simultaneously obtain linear intercalibration coefficients and error variances of wind velocity components. The method has since been applied for assessing the accuracy of a number of scatterometers: ASCAT -A, -B, and -C scatterometers on board the MetOp series of satellites (Europe), SeaWinds on board QuikScat and RapidScat on ISS (USA), and OSCAT on Oceansat-2 and the scatterometer on ScatSat (India). These instruments have different design and therefore different processing, resulting in different error characteristics.

In 2016 the Indian ScatSat was launched in the same orbital plane as ASCAT-A and ASCAT-B but in a slightly lower orbit. As a result, ScatSat underpasses ASCAT-A and ASCAT-B at regular times, resulting in a large number of collocated measurements. Combined with NWP forecasts this yields large triple collocation data sets that enables one to study the error characteristics of the instruments in much more detail than is possible with buoy collocations.

Another possibility is to construct quadruple collocated measurements of buoys, ASCAT (A or B), ScatSat, and NWP forecasts. The triple collocation formalism can easily be generalized to any number of collocated measurements. A quadruple collocation analysis allows one not only to calculate the relative calibration coefficients and the error variances of the four systems involved, but also two additional error covariances. However, these are not easily interpreted as there are twelve possible ways to solve the quadruple collocation equations. The interpretation is facilitated by comparing the quadruple collocation results with those of triple collocation on subsets of the data set.

In this presentation some triple and quadruple collocation analyses will be presented, and their interpretation will be discussed.

INVESTIGATION OF LOW LEVEL AMV HEIGHT ASSIGNMENT

Katie Lean and Niels Bormann

ECMWF

ABSTRACT

Atmospheric Motion Vectors (AMVs) provide single-level wind estimates derived by tracking cloud features in image sequences from geostationary and polar orbiting satellites. They are established inputs to global as well as regional Numerical Weather Prediction (NWP) systems. Nevertheless, determining the heights of the winds as well as the assumption that clouds are passive tracers remain key sources of uncertainty in the use of AMVs. These aspects are often very difficult to examine, primarily due to a lack of independent wind observations over large parts of the oceanic regions. Recent work at ECMWF has focused on investigating possible height assignment issues, particularly inspired by a study in the Indian Ocean which highlighted challenging regions for the assimilation of low level AMVs in tropical inversion regions. These regions are often associated with relatively sharp changes in the wind speed in the vertical, leading to a particular sensitivity to AMV height assignment errors.

Here we present the results from investigation into errors in the height assignment of which the initial focus has been on the low level AMVs. Potential connections between the assigned heights and model cloud parameters are explored with the aim of identifying a systematic correction or improved quality control procedures. Analysis of first guess departure statistics (comparison of observations with the model background) showed that AMVs placed above the model cloud could potentially have a more detrimental impact than those placed unrealistically close to the surface. However, simply screening these observations resulted in negative impacts in assimilation experiments. Reassigning the AMV pressure using model cloud height information showed it was possible to achieve improvements in Root Mean Square Vector Difference (RMSVD) and speed bias. Assimilation experiments while showing positive impact in the verification against own analysis, showed mostly neutral changes in the fit of independent conventional wind observations to the model background. In addition, the recent launch of Aeolus provides a very valuable source of wind profile information which we will start to use here to better characterise these height assignment uncertainties.

EVALUATION OF GOES-17 AMVS

Katie Lean and Niels Bormann

ECMWF

ABSTRACT

GOES-17 is the second new generation satellite in the GOES-R series, after GOES-16, carrying the Advanced Baseline Imager (ABI) from which the Atmospheric Motion Vectors (AMVs) are derived. With carrying the same imaging instrument and using the same AMV derivation method, it would be reasonable to expect the data quality of GOES-17 to be very similar to GOES-16. However, onboard issues with the cooling system were found to be degrading the performance of the GOES-17 infrared channels which are essential to the production of AMVs. The problem leads to periods where the imager data are unusable during local night-time with variable data quality during transition times. During times unaffected by the cooling issues, there is a large increase in the number of AMVs and changes in data characteristics compared to its predecessor, GOES-15. Similar changes were observed in earlier work when moving from GOES-13 to GOES-16. Analysis using first guess departure statistics (difference between observations and model background) further shows that there is good agreement in the overlap region with GOES-16 while the instrument is operating normally. However, during times transitional times where onboard cooling issues are in effect there is decline in AMV numbers and a noticeable degradation in the quality. There are large differences in the assigned pressure of the AMVs between GOES-17 and GOES-16 indicating that the degradation in the infrared channels has a significant impact in the performance of the optimal estimation height method.

Assimilation experiments show that GOES-17, even with strict screening of potentially affected hours, has a positive impact, also greater than for GOES-15, in verification against own analysis. Small positive changes were also present in the fit of independent observations to the model background such as conventional wind over the Americas and humidity sensitive channels on the Advanced Technology Microwave Sounder (ATMS) in the southern hemisphere.

AMV RESEARCH ACTIVITIES AT ECMWF

Katie Lean and Niels Bormann

ECMWF

ABSTRACT

An overview of recent research activities and the status of the operational assimilation of Atmospheric Motion Vectors (AMVs) at ECMWF will be presented. In particular, we will focus on the evaluation of data from Metop-C and NOAA-20.

Metop-C, launched on 7th Nov 2018, is currently operationally assimilated at ECMWF as part of the single satellite product (tracking features in consecutive images from the same satellite) and the dual product (using consecutive images from two different satellites). Using first guess departure statistics (differences between the observations and model background), Metop-C single product AMV data were assessed and shown to have very similar quality to Metop-A and -B as expected. Assimilation experiments showed a largely neutral impact while the additional data provide more resilience to the coverage of polar AMVs, particularly as Metop-A data will cease soon. Consequently, Metop-C single winds were added operationally from 25th June 2019. The different Metop satellite pairs used in the dual product were also evaluated with the addition of Metop-C. Dual Metop AMVs (Metop-A/B and B/C pairs) have been actively assimilated since 17th Jan 2019. In contrast to the single product, a surprisingly significant variation in data quality was found across the different pairs. The quality appears linked to the degree of similarity in viewing geometry of the orbits. The best overlap of coverage, with the most similar viewing angles for the same scene, occurs between the Metop-C and -A pair. Metop-C/A also shows the best agreement with the model background of the three possible pair combinations. Metop-A/-B showed the least agreement however the quality of this pair remained very similar to the earlier data when the satellites were still 55 minutes apart.

Early results from the assessment of AMVs from the VIIRS instrument on NOAA-20, launched 18th Nov 2017, will also be discussed. With the same instrument and derivation process as for the S-NPP satellite the data are expected to be very similar.

ADVERSE EFFECTS OF USING A FORECAST-DEPENDENT QUALITY INDICATOR FOR AMV QUALITY CONTROL IN NUMERICAL WEATHER PREDICTION

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ABSTRACT

There are two types of quality control indicators for AMV data. One is QI that takes into account the consistency between the first guess and AMV (QI1). The other is QI without first guess consistency check (QI2). The QI1 which JMA uses for quality control has dependency on first guess fields of NWP model. But NWP centres need to assimilate not first guess information of other NWP centres but observation information from AMV. Therefore, it is important to study how the first guess information in QI1 affects forecast skill through the quality control with QI1.

To investigate this issue, we performed a data assimilation experiment (TEST) to use QI1 recalculated with the first guess from JMA global NWP model and QI2 reported by AMV providers. For comparison, the other experiment (CNTL) to use original QI1 was also performed. Same QI thresholds as the JMA operational NWP were applied to both TEST and CNTL.

In comparison of TEST and CNTL, a large change of forecast error which continues for more than seven days was confirmed mainly in the tropics. The change was significant in the observation area of Meteosat. On the other hand, the change was smaller in the observation area of Himawari and GOES than those of the Meteosat.

In current JMA's AMV usage, the QI thresholds are set as relatively higher value for Meteosat and Himawari AMV, and set as lower value for GOES AMV. Therefore, it is reasonable that the difference was smaller in the GOES region where the thresholds were originally set as smaller value, or in the Himawari region where similar first guesses from same model were used in AMV production for TEST and CNTL. The significant difference in the Meteosat region was due to higher thresholds for QI1 and difference of NWP model used in AMV production. It suggests that differences of first guess and NWP model in QI1 calculation process make a large influence on forecast accuracy if quality control uses a high weight on QI1. As a result, it is considered that the quality control using QI1 does not accurately assimilate real observation information from AMV.

Another problem in regard to QI1 is that QI1 is computed with the first guess from “operational NWP”. In development work for data assimilation, accuracy of the first guess from NWP system in development stage is expected to be better than those of operational NWP system. In this case, quality control using QI1 considered to affect adversely in the development NWP system because only winds close to first guess of operational NWP system are tend to be selected and assimilated. This is a disadvantage for NWP system in development stage. Typical examples indicating this problem are presented in the workshop.

CURRENT STATUS AND PLANS OF OPERATIONAL HIMAWARI-8/9 WIND PRODUCTS AT JMA/MSC

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ABSTRACT

JMA's latest geostationary meteorological satellites, Himawari-8 and -9 were successfully launched in 2014 and 2016 respectively, and are operationally executed for the missions. Both satellites are positioned at around 140.7° E and cover the same region over the eastern part of Asia and the Western Pacific. Himawari-9 has been suspended its observation operation as a backup satellite for currently operational Himawari-8 and will continue the succession of the observation until 2029 after the Himawari-8's observation operation is terminated. Himawari-8/9 carry the Advanced Himawari Imager (AHI), which can provide 16 bands satellite images from visible to infrared with 0.5-2 km horizontal resolutions and scan the full-disk and regional areas every 10-min and 2.5-min, respectively.

JMA/MSC has derived Atmospheric Motion Vectors (AMVs) from the Himawari-8/AHI's multi bands and highly frequent imagery since July 2015, and has disseminated the full-disk AMVs (VIS; 0.64μm, IR; 10.4μm and WV; 6.2/6.9/7.3μm) every hour via the Global Telecommunication System (GTS). JMA/MSC has been also deriving higher resolution AMVs from Himawari-8/9 full-disk and the regional area images than AMVs provided via GTS. The higher resolution AMVs have been utilized for weather monitoring and research purposes including data assimilation (DA) experiments on local NWP model by internal or off-line users so far. Sea-surface wind product which is estimated from the Himawari-8/9 high resolution AMVs has been utilized for tropical cyclones analysis at the RSMC Tokyo – Typhoon Center. This product has been distributed to National Meteorological and Hydrological Services (NMHSs) for tropical cyclones monitoring via the JMA Data Dissemination System (JDDS) on trial since July 2019.

In this presentation, the current status of the JMA/MSC's Himawari-8/9 wind products and the upgrade plans for data provisions, including the higher resolution AMVs dissemination, will be presented.

DERIVATION OF ATMOSPHERIC MOTION VECTORS FROM PROJECTED LOW EARTH ORBIT IMAGES

Kevin Barbieux[1], Olivier Hautecoeur[2], Manuel Carranza[3], Régis Borde[1]

[1] EUMETSAT
[2] Exostaff
[3] GMV Insyen

ABSTRACT

Atmospheric Motion Vectors (AMVs) are an important input to many Numerical Weather Prediction (NWP) models. EUMETSAT derives AMVs from several of its orbiting satellites, including the geostationary satellites (METEOSAT), and its Low-Earth Orbit (LEO) satellites. The algorithm extracting the AMVs uses pairs or triplets of images, and tracks the motion of clouds features or water vapour features from one image to another. Currently, EUMETSAT LEO satellite AMVs are retrieved from georeferenced images form the Advanced Very-High-Resolution Radiometer (AVHRR) on board the MetOp satellites. In the future EUMETSAT plans to derive operational AMVs from the Sea and Land Surface Temperature Radiometer (SLSTR) on board the Sentinel-3 satellites and from the Visible and Infrared Imager (VII) on board the future generation of polar satellites, EPS-SG. A new framework adaptable to any radiometer on board a LEO satellite is presently under development where the images are first projected on an equal-area grid, before applying the AMV extraction algorithm. This approach has multiple advantages. First, individual pixels represent areas of equal size, which is crucial to ensure that the tracking is consistent throughout the images, and from one image to another. Second, this allows to track features that would otherwise leave the frame of the reference image, so more AMVs can be derived. Third, the same framework will be used for any LEO satellite allowing an overall consistency of EUMETSAT AMV products. In this work, we present the results of this method for SLSTR and simulated images of VII by comparing the AMVs to the forecast model. We validate our results against AMVs currently derived from AVHRR, and we present a timeline for the implementation of these new AMVs and their operational derivation.

MISTiC WINDS, A MICRO-SATELLITE CONSTELLATION APPROACH TO HIGH RESOLUTION OBSERVATIONS OF THE ATMOSPHERE USING INFRARED SOUNDING AND 3D WINDS MEASUREMENTS: A COMPARISON OF AIRBORNE OBSERVATIONS WITH RADIOSONDE OBSERVATIONS

Kevin R. Maschhoff

BAE Systems

Abstract

MISTiC® Winds is an approach to improve short-term weather forecasting based on a miniature high resolution, wide field, thermal emission spectrometry instrument that will provide global tropospheric vertical profiles of atmospheric temperature and humidity at high (3-4 km) horizontal and vertical (1 km) spatial resolution. MISTiC's extraordinarily small size, payload mass of less than 15 kg, and minimal cooling requirements can be accommodated aboard an ESPA-Class micro-satellite. Low fabrication and launch costs enable a LEO sun-synchronous sounding constellation that would collectively provide frequent IR vertical profiles and vertically resolved atmospheric motion vector wind observations in the troposphere. These observations are highly complementary to present and emerging environmental observing systems, and would provide a combination of high vertical and horizontal resolution not provided by any other environmental observing system currently in operation. The spectral measurements that would be provided by MISTiC Winds are similar to those of NASA's Atmospheric Infrared Sounder that was built by BAE Systems and operates aboard the AQUA satellite. Key technical risks have been reduced through laboratory and (NASA ER2) airborne testing under NASA's Instrument Incubator Program and BAE Systems IR&D, and through an OSSE performed by NASA GMAO. A summary of the airborne test results and a comparison with concurrent and co-located radiosonde observations will be presented.

CURRENT STATUS OF THE EUMETSAT MTG-FCI AMV PROTOTYPE

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[1] GMV Insyen
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ABSTRACT

The launch of the first Meteosat Third Generation Imaging (MTG-I) satellite is currently scheduled for the fourth quarter of 2021. It will be followed by subsequent MTG-I launches in 2025, 2028 and 2032, with the aim at providing operational services for over 20 years. The Flexible Combined Imager (FCI) instrument on board the MTG-I satellites is the evolution of the very successful Spinning Enhanced Visible and Infrared Imager (SEVIRI) instrument on board the MSG satellites, and it will be used to derive Atmospheric Motion Vectors (AMVs) in a wide range of frequencies, from visible to infrared.

The MTG-FCI AMV prototype has been developed at EUMETSAT based on the current operational MSG AMV processor, with a few significant changes and improvements. Thorough technical and scientific verifications of the MTG-FCI AMV prototype have been carried out using MSG data. In the framework of the L2PF activities, the algorithm has been adapted to simulated MTG-FCI data. During the two upcoming years, AMVs extracted with the prototype code will serve as reference data to validate the outputs of the operational AMV code developed by the industry and to be integrated in the future MTG ground segment.

The algorithm has also been successfully adapted in order to process Himawari-8 and GEO-Kompsat-2A data for a more scientific validation. Indeed, the data these satellites provide have spatial and temporal resolutions comparable to those of the FCI instrument, and then constitute very good proxy data to estimate the future MTG-FCI capabilities. It is intended to further adapt the prototype to data from the GOES-R series of satellites, thus making it capable of processing data from most imaging instruments in the new generation of geostationary satellites.

In this paper, the latest changes in the MTG-FCI AMV prototype will be presented. The first results using simulated MTG data will also be shown, as well as results using Himawari-8 and GEO-Kompsat-2A data.

QUALITY ASSESSMENT OF AMVs USING THE CORRELATION SURFACE

Manuel Carranza [1], Régis Borde [2], Olivier Hautecoeur [3], Kevin Barbieux [2]

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ABSTRACT

The main steps in the derivation of Atmospheric Motion Vectors (AMVs) from satellite imagery are typically: target identification, tracking, height assignment, and quality control. The height assignment step is widely regarded as the most challenging one in an AMV extraction algorithm and it is a traditional source of errors, leading to undesired speed biases when comparing the generated AMVs with forecast data and radiosonde observations. However, the tracking step is also an important source of error, and it is a long standing AMV user's request to separate in the AMV production the errors coming from the height assignment from those coming from the tracking step. The final cross-correlation coefficient associated to each AMV cannot be used alone to define the quality of the matching because several solutions might exist in the correlation surface. Previous studies have suggested considering the correlation surfaces themselves in order to estimate the quality of the tracking, using for example the number of peaks and the magnitude of the main peak. This information may then be used to build a specific quality index for the tracking step.

This poster presents preliminary results of the recent investigation done at EUMETSAT to estimate the quality of the AMV tracking step based on the use of the correlation surface. Data from the Meteosat Second Generation satellites are used to illustrate the results.

CLIMATE DATA RECORD OF ATMOSPHERIC MOTION VECTORS AT EUMETSAT: STATUS AND PERSPECTIVE

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ABSTRACT

Since the launch of its first generation of geostationary satellites, EUMETSAT has developed its own unique algorithms to derive atmospheric motion vectors (AMVs). These algorithms are providing real time AMVs using images acquired from instruments on-board both polar and geostationary satellites. These AMVs are routinely assimilated into weather forecast models. EUMETSAT has also archived all the images providing a suitable data source for climate research and allowing producing AMV climate data records (CDRs) over the entire period.

In the framework of the Copernicus Climate Change Service (C3S), a CDR from geostationary AMVs was produced, using the unique EUMETSAT algorithm adapted for climate purposes for first and second generation satellites and the complete series of MVIRI and SEVIRI images from Meteosat-2 to Meteosat-10.

Using the full resolution images (Local Area Coverage (LAC)) from the Advanced Very High Resolution Radiometer (AVHRR) on-board the polar orbiting Metop-A and -B satellites, a CDR was generated containing polar AMVs from single satellite retrieval and global AMVs from the combined A/B dual retrieval. An adaptation of the EUMETSAT retrieval algorithm to use Global Area Coverage (GAC) data also allowed retrieving polar AMVs from the entire series of AVHRR instruments flying on the NOAA satellites since 1978.

A PostgreSQL database was setup at EUMETSAT to allow a rapid and smooth validation of the data records also using other data sources such as model, radiosondes and MODIS AMV. All reprocessed AMV data records are suitable for usage in the coming reanalyses (e.g. ERA-6) and climate research.

This presentation will give an overview of the different data records, the validation and EUMETSAT's plan for AMV reprocessing in the coming years.

AMV SUPEROBBING AT THE MET OFFICE

Mary Forsythe, Adam Martins, Howard Berger, James Cotton
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ABSTRACT

In 2003 an AMV superobbing scheme was developed at the Met Office by Howard Berger, a visiting scientist from the University of Wisconsin - CIMSS. Initial trials were slightly negative, and the work was put on hold. More recently we have looked at this option again. We wanted to trial applying the superob approach without additionally reducing the observation errors. We also expected that the expanding AMV data volumes could enhance the benefits from superobbing.

In this paper we will show results of recent trials at the Met Office using AMV superobbing. We will also discuss follow on work to investigate the option of a combined superob/thinning scheme. The idea of this approach is to superob in most regions, but to revert to thinning if there is more variability in wind speed or direction. Potentially this idea could be extended to enable use of AMVs at higher resolution in regions of interest.

IMPROVED ASSIMILATION OF WIND RETRIEVALS AT MET NORWAY

Máté Mile(1), Roger Randriamampianina(1), Gert-Jan Marseille(2)

1)- Norwegian Meteorological Institute
2)- Royal Netherlands Meteorological Institute

ABSTRACT

The variational assimilation system (including 3D- and 4D-Var) of HARMONIE-AROME is widely used for research and operational NWP purposes in Europe. In most cases, the HARMONIE-AROME model and its data assimilation are run on higher resolution (corresponding to around 2.5km grid or smaller) than the effective resolution of scatterometer observations. In order to eliminate the representativeness error of scatterometer observations, a supermodding (footprint) operator is developed in the variational framework to improve satellite data assimilation. In this part of the study, diagnostic and verification scores are shown with AROME-Arctic model configuration which uses many satellite wind observations including scatterometer.

PREPARATORY ACTIVITIES TOWARDS THE ASSIMILATION OF AEOLUS WINDS IN THE MÉTÉO-FRANCE GLOBAL NWP MODEL

Vivien Pourret, Matic Savli, Christophe Payan, Jean-François Mahfouf

CNRM, Météo-France

ABSTRACT

This presentation will summarize ongoing activities on monitoring and assimilation of AEOLUS L2B HLOS winds in the global operational Numerical Weather Prediction model ARPEGE of Météo-France. A first assessment of L2 wind products generated by ECMWF against model counterparts will be provided in terms of global and regional statistics. Preliminary results from assimilation experiments of AEOLUS winds in ARPEGE will be shown in terms of quality of enhanced analyses and resulting forecasts.

AN ASSESSMENT OF THE IMPACT OF AEOLUS DOPPLER WIND LIDAR OBSERVATIONS FOR USE IN NUMERICAL WEATHER PREDICTION AT ECMWF

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ABSTRACT

The European Space Agency's Aeolus mission, which was launched in August 2018, provides profiles of horizontal line-of-sight (HLOS) wind observations from a polar orbiting satellite. The European Centre For Medium-Range Weather Forecasts (ECMWF) began the operational assimilation of Aeolus Level-2B winds on 9 January 2020 in their global NWP (Numerical Weather Prediction) model, 1 year and 4 months after the first Level-2B wind products were produced in near real time via ESA's ground processing segment. This achievement was possible because of the production of good data quality, which was met through a close collaboration of all the parties involved within the Aeolus Data Innovation and Science Cluster (DISC) and via the great efforts of ESA, industry and ground processing algorithms pre- and post-launch.

Through the careful assessment of the statistics of differences of the Aeolus winds relative to the ECMWF model, the Level-2B Rayleigh winds were found to have large systematic errors. The systematic errors were found to be highly correlated with ALADIN's (Atmospheric Laser Doppler Instrument) primary mirror temperatures, which vary in a complex manner due to the variation in Earthshine and thermal control of the mirror. The correction of this source of bias in the ground processing is underway, therefore in the meantime a bias correction scheme using the ECMWF model as a reference was developed for successful data assimilation; the scheme will be described.
We will present the results of the Aeolus NWP impact assessment which led to the decision to go operational. Aeolus' second laser (FM-B, available since late June 2019) provides statistically significant positive impact of moderate to large amplitude, of similar magnitude to some other important and well-established observing systems (such as IR radiances, GNNS radio occultation and Atmospheric Motion Vectors). Observing System Experiments demonstrate reduction of forecast errors in geopotential and vector wind of around 2% in the tropics and 2-3% in the southern hemisphere for short-range and medium range forecasts (up to day 10). This positive impact is particularly impressive given that Aeolus provides less than 1% of the total number of observations assimilated, showing the value of direct wind observations for global NWP.

AMV REPROCESSING ACTIVITY FOR JRA-3Q AT JMA/MSC

Miki Abe (1), Kenichi Nonaka (1) and Kazuki Shimoji (2)

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ABSTRACT

Long-term homogeneity and high quality observation datasets are essential for climate related work, but they are not homogeneous practically because the quality of data changes year to year with the improvement of derivation algorithms and the development of computer technology. Meteorological Satellite Center of Japan Meteorological Agency (JMA/MSC) creates a homogeneous Atmospheric Motion Vector (AMV) dataset by reprocessing past satellite data using the latest derivation algorithm.

JMA has a long-term reanalysis project called JRA (Japan ReAnalysis), and has implemented the Japanese 25-year Reanalysis (JRA-25, 1979 to 2004) and the Japanese 55-year Reanalysis (JRA-55, 1958 to 2012) before. JMA plans the next long-term reanalysis, Japanese 75-year Reanalysis (JRA-3Q) and AMVs are reprocessed by JMA/MSC for using as the input data for JRA-3Q. AMV datasets are calculated using the latest derivation algorithm for Himawari-8 from GMS-5 (1995~) to MTSAT-2 (~2015).

This presentation will report the validation results for the reprocessed AMVs for JRA-3Q. The AMVs for JRA-3Q are compared against the both of JRA-55 analysis field values and rawin sonde observations, and the AMVs for JRA-3Q are also compared against the ones for JRA-55. Additionally, I will introduce the preliminary results of assimilation experiments using the reprocessed AMVs.

VERIFICATION OF MULTI-PLATFORM SATELLITE WINDS AND ITS USE IN THE NCMRWF GLOBAL ASSIMILATION AND FORECAST SYSTEM

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ABSTRACT

NCMRWF routinely receives satellite-derived winds from different space based platforms and the same are assimilated operationally in its global and regional Numerical weather Prediction (NWP) Models. Both Meteosat-8 and INSAT-3D have the nearly same geographical coverage area over India and surrounding oceanic regions. Winds from these two satellites are routinely validated and assimilated in NCMRWF models and errors in these winds observations are found to be within globally acceptable limit. Recently NCMRWF started receiving Chinese (Feng-Yun (FY-2G and FY-2H)) and Korean (GEO-KOMPSAT (GK-2A)) geostationary satellite winds which also cover Indian land and surrounding Oceanic regions. The geostationary satellite winds from these two Chinese satellites and one Korean satellite are validated against existing satellite winds (Meteosat-8 and INSAT-3D), in-situ observations like Radio sonde and pilot balloons, aircraft observations and model first guess/analysis. After validation, they are ingested in to the NCMRWF Unified Model (NCUM) assimilation System. The existing NCUM operational data assimilation system in which, all observations except from FY-2G, FY-2H and GK-2A are considered as baseline experiment. The winds from Chinese and Korean satellites are assimilated on the top of the baseline experimental set up. This paper discusses the validation of FY2H, FY2G and GK2A satellite winds and their impact in NCUM global assimilation and forecast system with respect to the baseline experiment.

AN ASSESSMENT OF WIND IMPACT FROM SEVERAL OBSERVING SYSTEMS IN THE ECMWF ANALYSIS

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ABSTRACT

This presentation characterises the impact on wind analyses arising from several observing systems in ECMWF's 4D-Var assimilation system. This is done using so-called re-initialisation experiments, in which every assimilation cycle starts from a background obtained with the full observing system, but then assimilates only one selected observation type (e.g., AMVs, scatterometer data, MW or IR radiances, etc). This allows a detailed characterisation of the impact of each observing system on its own, and we will here focus primarily on the influence of each observation type on the wind analysis.

The study shows that in the ECMWF system a wide range of observations contributes to the wind analysis, with strengths of different observing systems in certain areas complementing each other. Radiance observations presently provide overall the largest impact, due to balance effects and implicit tracing of atmospheric structures in 4D-Var. Other observing systems complement this impact, particularly AMVs in the tropics or scatterometer data over ocean surfaces. The complementarity of information provided by Aeolus to the present operational global observing system will also be addressed.

MACHINE LEARNING CLOUD TOP HEIGHT; AN OPPORTUNITY OR CHALLENGE FOR THE WIND COMMUNITY?

Nina Håkansson[1], Javier Garcia Pereda[2], Anke Thoss[1]

SMHI[1]
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ABSTRACT

Within the cloud community the usage of Machine Learning techniques to retrieve cloud products is growing. The high accuracy datasets for active sensors like CALIOP or CPR (CloudSat) can be co-located with imager data and used to train imager cloud products with higher quality compared to traditional methods. Traditional methods of cloud top height would typically return the optical cloud top height, meaning the height at optical depth around 1.0 down in the cloud. Artificial neural network methods can retrieve the actual physical cloud top with higher accuracy. This improvement of cloud products, might cause problems for wind retrievals. But with communication between the communities it can be turned into an opportunity, as ML techniques can as well be trained to predict the optical height of clouds if the benefit of it is identified.

There is ongoing work in NWCSAF to adapt the high resolution winds algorithm used in the GEO software for instrument SEVIRI to the PPS software for polar orbiting imager instruments (AVHRR, MODIS, VIIRS, MERSI-2, MetImage). The GEO software uses a traditional cloud top height, and PPS uses a neural network one. Preliminary results or lessons learnt from this ongoing work will be presented if available. In the presentation also differences between the new neural network cloud top height of PPS and traditional methods will be described, and validation results will be shown.

VALIDATING ATMOSPHERIC MOTION VECTORS WITH A GEOSPATIAL DATABASE

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ABSTRACT

EUMETSAT is committed to support the operational monitoring of climate and the detection of global climate change. As part of this commitment, EUMETSAT provides consistent atmospheric climate data records from its operational satellites in low earth and geostationary orbits. Product validation is an important step when generating these records, and involves the comparison with independent data from various sources such as models, ground based measurements, and satellite products.

Both climate data records and validation data are distributed as numerous files on disk. Reading and processing such data is time consuming, and requires considerable software development so that data sources can be brought to identical spatial and temporal scales for comparison. In contrast to that, a geospatial database provides a single and direct access point to all data sources, and offers additional tools for spatial analysis, time series statistics, and webmapping.

In order to exploit such benefits, we recently developed a PostgreSQL (v11) database that facilitates the validation of atmospheric motion vectors at EUMETSAT. The database uses the PostGIS extension for spatial analysis. We found that spatially indexing and partitioning the database (per product and year) is essential to speed up query performance. Currently, there are ~4 TB or 16.4 billion rows of AMV data in the database, which we derived from polar and geostationary satellite orbits covering several decades. We routinely use the database for collocations with radiosondes, time series statistics, and bias analysis. Query speed is variable but generally within a few minutes of response time. We also developed a webmapping tool, which uses Geoserver to query the database in order to put AMV data on interactive maps for monitoring and validation.

Here, we will present the generic database structure, content and typical use cases. We will conclude with a demonstration of the database's webmapping capabilities.

EXTRACTION OF 3D WIND PROFILES FROM HYPERSPECTRAL IASI LEVEL 2 PRODUCTS

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ABSTRACT

Atmospheric Motion Vectors (AMV) commonly provide information of cloud motions at a single level in the troposphere. However, the vertical wind shear impacts the dynamic meteorology of the troposphere, and the assimilation of horizontal wind at different levels in NWP models is still a critical gap in user requirements. Apart from a direct measure using a wind profiler, such wind vertical profiles may theoretically be estimated from temperature and humidity profiles retrieved from hyperspectral sounding, for which the height information is already available together with the retrievals. Time sequences of extracted water vapour fields become in this approach the “imagery” for tracking winds.

Recent studies involving 3D optical flow Technics (Heas and Mémin, 2008) to extract AMV from humidity fields have been realised by EUMETSAT and have clearly shown the potential benefits of these methods. The latest version of the algorithm has been adapted to ingest both Metop/IASI level 2 humidity, temperature and ozone fields, and can extract dense wind fields from a pair of IASI data taken consecutively by Metop A and Metop B satellites over high latitudes areas (poleward 45 deg). The use of ozone field allows the extraction of wind fields in the lower stratosphere when the humidity fields are the main tracer used for the troposphere.
A one month demonstration period has been produced (June 2017). Comparison of 3D IASI winds against "classical" Atmospheric Motion Vectors extracted using AVHRR data, against forecast fields and winds retrieved by the algorithm from ECWMF forecast fields have been done to understand better the current performances and limitations of this technique.

The results are still in a preliminary stage but show the potential of these wind profile retrievals. We will also propose a way forward for future improvements.

MITIGATION OF ERRORS IN GOES-17 ATMOSPHERIC MOTION VECTORS IN NAVGEM

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ABSTRACT

The quality control of atmospheric motion vectors (AMVs) in NAVGEM, the U.S. Navy's global numerical weather prediction system, applies processes to mitigate errors in several steps. This presentation will examine the ability of these processes to mitigate the errors present in GOES-17 AMVs that result from the malfunctioning loop heat pipe and the resulting saturation of key channels during nighttime hours, especially within a few weeks of the equinoxes. During these times, AMVs become fewer in number and use less optimal height assignment methods; the six-hour window centered on 1200 UTC is the most impacted.

The quality control processes discussed in this presentation include (1) the superob procedure, which averages AMVs only when they are sufficiently similar, (2) the imposition of vertical limits, which was found to be necessary to mitigate the low speed bias at upper levels in GOES-16 AMVs as well as GOES-17 AMVs (and which is unrelated to the loop heat pipe problem), and (3) the exclusion of poorly performing channels. Results from two experiments will be presented in terms of mean vector differences, forecast system observation impacts (FSOI), and anomaly correlations (AC). The first experiment used the NESDIS GOES-17 AMVs in addition to GOES-15 AMVs from both NESDIS and CIMSS. The second experiment compared model runs with only GOES-17 NESDIS/CIMSS AMVs and with only GOES-15 NESDIS/CIMSS AMVs. Both model runs used the same conventional data, radiances, and satellite-derived winds from other satellites.

USE OF WIND RETRIEVALS IN REGIONAL REANALYSIS

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ABSTRACT

Copernicus Arctic Regional Re-Analysis (CARRA) is a regional reanalysis covering the years 1997 until present and Copernicus European Regional Re-Analysis (CERRA) is regional reanalysis covering the years 1981 until present. Both data sets are in production and are not yet completed. CARRA is produced with a non-hydrostatic mesoscale NWP model, AROME, on a grid mesh with 2.5km spacing. CERRA uses a hydrostatic model, ALADIN, with 5km horisontal resolution.

Both CARRA and CERRA analyse upper air parameters with a 3D-Var technique and use Atmospheric Motion Vectors (AMV) and scatterometer wind retrievals throughout the whole reanalysis period. Use of AMV can be done due to the availability of reprocessed data sets archived at ECMWF. For scatterometer winds, reprocessed Climate Data Records provided by EUMETSAT Satellite Application Facility on Ocean and Sea Ice are utilised.

This presentation will give an overview of the reanalysis systems and their use of AMV and scatterometer wind retrievals. Performance metrics such as forecast verification statistics and data assimilation departure statistics will also be presented.

STATUS OF OPERATIONAL AMV PRODUCTS AT EUMETSAT

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ABSTRACT

At EUMETSAT, AMVs are currently derived operationally from the Meteosat geostationary satellites and from the Low Earth Orbit Metop satellites. The current EUMETSAT contribution to the global AMV production covers Meteosat disks at 0 and 41 deg longitudes, the northern and southern high latitude (Poleward 50 deg.) areas with Metop A, Metop B and Metop C single AVHRR wind products, and a global coverage using the Dual AVHRR wind products extracted from the 3 Metop satellites presently placed in Tristar configuration.

In the upcoming years, the transition from current EUMETSAT operational programs Meteosat Second Generation (MSG) and Earth Polar System (EPS) to new generation programs Meteosat Third Generation (MTG) and Earth Polar System Second Generation (EPS-SG) creates some scientific and technical challenges. The strategy adopted for AMV development considers several critical aspects such as the continuity of current operation capabilities, and the development of new capabilities to fulfil increasing user needs. These last ones mainly concern algorithms under development for EPS-SG/METImage and Sentinel 3 Sea and Land Surface Temperature Radiometer (SLSTR) instruments, but also the recent investigation in the extraction of 3D wind profiles from Infrared sounders level 2 products like Metop **Infrared** Atmospheric **Sounding** Interferometer (IASI) or the future MTG Infrared Sounder (MTG-IRS) instruments.

This paper will give an overview of the current status of AMV products at EUMETSAT together with information on mid-term perspectives and developments. Emphasis will be given on the expected benefits of the new MTG and EPS-SG instruments capabilities on AMV production.

CLIMATE DATA RECORD AMVs FROM LEO-SATELLITES

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ABSTRACT

Within the Copernicus Climate Change Service (C3S), EUMETSAT generated Climate Data Records (CDRs) for Atmospheric Motion Vectors (AMVs) using EUMETSAT's own algorithm adapted from near real time operations to CDR productions. We produced CDRs for several EUMETSAT geostationary and polar orbiting satellites. EUMETSAT AMV CDRs are planned to be assimilated into the 6th European Re-Analysis (ERA6) at the European Centre for Medium range Weather Forecast (ECMWF) as well as in the European regional reanalysis.

EUMETSATs Metop-A was launched in 2006, joined by Metop-B in 2012, allowing more than a decade of polar coverage from single satellite. AMVs are available from high resolution Local Area Coverage (LAC) from the Advance Very High Resolution Radiometer (AVHRR) data. Since the launch of Metop-B, LAC dual AVHRR AMVs covering the entire globe are also available. LEO AMVs are keys as they fill gaps in existing GEO data records.

The NOAA-AVHRR CDR contains polar coverage in the lower resolution Global Area Coverage (GAC) format for nearly 40 years that were used to generate polar AMVs CDR. Long-term analysis shows the quality of the data records making it an import source of wind information for re-analysis projects.

As mentioned, these CDRs can be assimilated in models but also used for the analysis of wind regimes especially in the Polar Regions, such as changes in the northern hemispheric jet stream and the North Atlantic Oscillation (NAO).

This talk will feature the AMV CDRs for AVHRR data on board Metop, NOAA and TIROS-N, ranging from 1979 to 2019, providing an overview of the status, validation results and plans for future reprocessing activities.

RELATIVE IMPACT OF POLAR WINDS IN HARMONIE-AROME

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ABSTRACT

In the framework of the Applicate project (https://applicate.eu), ECMWF (European Centre for Medium-Range Weather Forecasts) performed several observation denial experiments. Access to the results of these experiments opens a good opportunity for us to accomplish the tasks described in our Alertness project to study the impact of Arctic observations with our operational regional Arctic model AROME-Arctic, which is based on the HARMONIE-AROME numerical weather prediction system.

This presentation discusses the relative impact of the polar winds in HARMONIE-AROME regional model through observing system experiments (OSE) during YOPP Arctic winter and summer special observing periods (SOP); The relative impact of observation is assessed through local data assimilation as well as through lateral boundary conditions.

ASSIMILATION OF AEOLUS HLOS WINDS IN HARMONIE-AROME AT MET NORWAY

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ABSTRACT

The wind observations from the ESA Earth Explorer satellite mission Aeolus is tested in the HARMONIE-AROME 3D-VAR data assimilation system. The Aeolus measures the horizontal line of sight (HLOS) wind from the space both in the clear sky and cloudy conditions from the ground up to 30km in the atmosphere. Such observations are important for the initialization of meso-scale weather features in the LAM NWP models. We will show the result from data denial and sensitivity trials for our Arctic domain operational forecasting system, AROME-Arctic, and present tuning and quality control strategies to improve the impact of Aeolus wind data assimilation on the analysis and short range forecasts.

COMPARISON OF METEOSAT AMVS AND AEOLUS HORIZONTAL LINE-OF-SIGHT WINDS

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After more than one year of operation, ESA's Doppler Wind Lidar mission Aeolus has absolutely proven its ability to measure global vertically resolved wind profiles in clear air and at the top of clouds. First validation studies with independent observations indicate a very good performance of the L2B horizontal line-of-sight (HLOS) wind speed, particularly for those retrieved from the Mie backscatter component.

While Aeolus provides instantaneous observations of the vertically resolved horizontal wind velocity in clear air and from the top of clouds, geostationary imagers, as for instance SEVIRI onboard Meteosat Second Generation, can monitor the spatiotemporal evolution of clouds. By tracking cloud and water vapor features in sequential visible and infrared images, Atmospheric Motion Vectors (AMVs) can be derived, which provide a wind estimation at cloud top. These AMVs are an essential source of global wind observations for assimilation in Numerical Weather Prediction (NWP) models. However, several studies demonstrate that the vector height assignment is the major source of uncertainty for AMVs. Aeolus global direct wind measurements are expected to fill a significant gap in global wind observations in the assimilation context, especially in the cloud-free atmosphere, and to further help characterizing these uncertainties in AMVs.

In this presentation, an overview of the Aeolus L2B HLOS wind product and its initial data quality assessment is presented. Comparisons between the Aeolus L2B Mie component and collocated AMVs will be shown. Aeolus winds are used to compare the heights in which collocated wind observations are placed. The results will be presented particularly from a two week period in November 2019, when the vertical range bin setting of Aeolus wind profiles has been optimized for AMVs studies. Finally, the influence of cloud type and microphysical properties on these results will be discussed.

LATEST UPDATES IN THE ASSIMILATION OF WIND PRODUCTS AT ENVIRONMENT CANADA

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ABSTRACT

Since the last major upgrade to AMV data processing and assimilation in September 2018, AMVs from recently-launched geostationary and polar-orbiting satellites were implemented operationally in the global and regional prediction systems. More specifically, AMVs from GOES-17 replaced those from GOES-15 and AMVs from VIIRS on board NOAA-20 were added. GOES-17 AMV data affected by the loop heat anomaly are excluded in the data assimilation by performing tight quality control and data thinning. Marine wind vectors retrieved from the ASCAT instrument on board of MetOp-C were also introduced.

The situation dependent observation error calculation scheme for AMVs, developed by Forsythe and Saunders (2008, IWW10), was implemented in 2017. The UK Met Office graciously provided the height errors for both geostationary and polar-orbiting satellites and were not updated since that implementation. For an optimal assimilation of the new AMV products, all assigned height errors were estimated using a similar approach described in Salonen et al. (2015), which uses difference between assigned pressure minus model best-fit pressure statistics. These statistics were calculated for the different satellites, channels, height-assignment methods and surface types (land/sea/ice).
The impact of all these changes on forecasts will be presented.

STATUS OF OPERATIONAL ATMOSPHERIC MOTION VECTOR FROM GEO-KOMPSAT-2A (GK2A) AT KMA

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ABSTRACT

The GEO-KOMPSAT-2A (GK2A) satellite provides observational images from 25 July 2019 and Atmospheric Motion Vector (AMV) products from 31 October 2019 operationally. The GK2A AMV products has been evaluated through intercomparison study with EUMETSAT as well as conventional validation process using radiosonde and NWP model data. And also, the Korea Meteorological Adminisatration (KMA) is doing in preparation for the GK2A AMV data assimilation in KMA NWP model. The National Meteorological Satellite Center (NMSC) of KMA plans to disseminate GK2A AMV with new BUFR template via the Global Telecommunication System (GTS) from end of 2019 and stop to disseminate COMS AMV in March 2020. In this paper, we will present the status of GK2A and COMS AMV products and the plans of the algorithm improvement.

LAGRANGIAN COHERENT STRUCTURES IN HIGH-FREQUENCY SATELLITE WINDS OF AN ATMOSPHERIC KÁRMÁN VORTEX STREET

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ABSTRACT

Cloud-motion winds derived from ABI imagery hold great potential for the study of unsteady geophysical flows, because their high temporal and spatial resolution enables the application of analysis techniques that are well-known in dynamical systems theory, but which have largely been overlooked in applied meteorology. We demonstrate such advanced analysis and visualization methods through the example of an atmospheric Kármán vortex street observed in Guadalupe's wake. Our input wind dataset was extracted from GOES-16 imagery and comprises 2.5-km cloud-motion winds sampled every 5 minutes over an 8-hr period.

The analysis of time-dependent dynamical systems and fluid flows is quite challenging, since many feature definitions are reference frame dependent. In this work, we extract two classes of Lagrangian Coherent Structures (LCS) from observational cloud motion data. First, we locate material lines, that is temporally-coherent sets of particles with exceptional properties, along which the normal separation is maximized over time. These extremal lines are known as hyperbolic LCS, which can be approximated through the finite-time Lyapunov exponent (FTLE). The FTLE estimates the maximal expansion rate of a virtual sphere in a dynamical system, which is extremal along material boundaries. Depending on whether the expansion is measured in forward-time or backward-time, this gives rise to repellors or attractors in the flow. Such material boundaries are of great significance in Lagrangian transport analysis, since they divide the domain into compartments of coherent flow behavior that order the flow. For instance, they separate vortices from each other. In observational data, vortex detection algorithms are often sensitive to noise. By taking a Lagrangian perspective, we integrate the instantaneous vorticity deviation along particle trajectories, which gives rise to elliptic Lagrangian Coherent Structures. Similar to the aforementioned LCS, this approach is invariant to rotations and translations of the frame of reference. Due to the relativity between observer and the observed feature, this formally guarantees that translating and rotating flow structures can be faithfully extracted.

ASSIMILATION OF WIND PROFILING RADAR DATA IN GRAPES-MESO MODEL SYSTEM

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ABSTRACT

Based on observational datasets of the wind profiling radars (WPR) in China during July 2015, a two-step quality control procedure for the WPR data is developed. Firstly, we start from the five-beam radial velocity, and recalculate the horizontal winds. After a series of processes including the spatial consistency check, time consistency averaging and vertical wind shear check, the hourly-resolution wind datasets were finally generated with quality indicator (QI) labels. We then use the ECMWF reanalysis data and radiosonde data to evaluate the newly generated WPR data. Results show that the method used for the QI labeling performs well. When its value is greater than 50, the root mean square error of u and v components are 2.29m/s and 2.37m/s respectively. This is consistent with previous research conclusions, and confirms the reliability of the pre-processing algorithm. Secondly, a second–round quality control based on the data assimilation is conducted. This procedure includes (1) removing the wind filed data located below the GRAPES model terrain, (2) configuring the effective height, (3) background check and (4) vertical thinning. The distributions of the innovations corresponding to observations after the QC are more close to a Gaussian distribution. The WPR observations after the QC were used in one-month continuous experiments based on the GRAPES modeling system. Results show that the assimilation of wind profiling radar data can effectively improve the wind state in the initial conditions. The corresponding 0-24h forecast of wind performs better. An analysis of 6-hourly verification scores like ETS and BIAS of the precipitation field suggests that the assimilation of wind profiling radar data makes a positive contribution to the rainfall forecast, especially in the short–range forecasting within 12 hours. The impact of assimilating WPR data on the case of typhoon "Linfa" is also investigated in this study. Results show that assimilating WPR data can effectively adjust the dynamic structure and water vapor conditions over the typhoon precipitation area, forming more favorable conditions for development of convective system and improving the forecast skill of precipitation.

Key words: Wind profiling radar, Quality control, GRAPES-3DVAR, Impact experiment

IMPACT OF THE GOES-17 ABI COOLING SYSTEM ANOMALY ON THE QUALITY OF DERIVED ATMOSPHERIC MOTION VECTORS

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ABSTRACT

During post-launch testing of the GOES-17 ABI instrument, engineers discovered that the system that cools the ABI instrument was not working up to its designed capacity. Under certain seasonal conditions (spring and fall equinoxes), and at certain times of the day, the anomaly causes seven of the infrared detectors to heat up faster than they can be cooled. If the warming is strong enough it can overwhelm the signal that the detectors are designed to measure and can cause partial or total loss of imagery. Warming of the infrared focal plane impacts the quality of many of the L2 products derived from ABI imagery. Because the Derived Motion Winds (DMW) algorithm relies on output from the GOES-R cloud algorithms, and requires a series of images for tracking, it is particularly impacted by the infrared focal plane anomaly. This poster will describe the ongoing work to quantify the impacts of the anomaly on the DMW product quality and will discuss mitigation strategies for limiting the loss of AMV data during warm episodes.

STATUS OF AMVS FROM FENGYUN SATELLITES

ZHANG Xiaohu, XU Jianmin, LU Feng, JIANG Lingfeng, WANG Sujuan

ABSTRACT

This paper briefly introduces status of operational AMVs at NSMC/CMA. Recent improvements, new additions, processing changes and monitors, future plans of the Atmospheric Motion Vector (AMV) product suite will be discussed. The current satellite constellation for operational AMVs processing includes FY-2G (99.5$_{o}$E), FY-2H (79$_{o}$E) and FY-4A(104.7$_{o}$E). FY-2H, the 8th (last) unit of the FY-2 series satellites, was operational in October 2018 and FY-4A, the first unit of FY-4 series (CMA new-generation geostationary meteorological satellite series), was placed into operation in May 2018. Several new enhancements in the NSMC/CMA AMVs operational processing are implemented and being implemented. These main enhancements include replacement of 6-hour FY-2H AMV to 30-minute in northern hemisphere, and of FY-4A 6-hour FY-2H AMV to 3-hour in full disk. Updates on the status of these enhancements and other plans will be presented. Meanwhile, polar wind products from FY-3D satellite are being developed and will be operational in 2020.

THE APPLICAITON OF FY-4A ATMOSPHERIC MOTION VECTORS IN GRAPES

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ABSTRACT

With the launch of the Chinese next-generation geostationary meteorological satellite FY-4A in December 2016, it is necessary to evaluate the quality of FY-4A AMVs for the analysis field and precipitation forecast in GRAPES at CMA. In this study, by comparing with the background field based on NCEP FNL data, the qualities of FY-4A AMVs were assessed. It was found that the distribution of FY-4A was stable, and the quality of FY-4A infrared AMVs was better than FY-4A water vapor AMVs. Based on GRAPES-4DVar global assimilation system, the contrast numerical experiments are conducted from 00UTC 1st June, 2019 to 00UTC 30th June. The experiments show neutral to positive impact on wind and height analysis field. Due to the improvement of the initial fields for the model prediction, the performance of anomaly correlation coefficient (ACC) and root mean square error (RMSE) are slightly improved. Finally, ongoing research and future plans are also discussed.

RADAR RADIAL WIND QUALITY CONTROL AND ASSIMILATION IN GRAPES_MESO 10KM SYSTEM

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ABSTRACT

Radar radial wind assimilation will improve the model forecasting skill with focus on precipitation, temperature and wind forecasting. Firstly, operational GRAPES_MESO10KM system was introduced, then introduced the geometric relationship between radar radial wind and horizontal wind field, and horizontal radial wind observation operator in GRAPES_MESO10KM 3DVAR assimilation system was also presented. Secondly, radial wind preprocess method was introduced, which include data quality control and data thinning scheme. Finally, radial wind assimilation was tested. Results indicate that, (1) the analysis innovation is proved to be reasonable by single point ideal test, which means the radial wind operator was implanted correctly in GRPAES_MESO10KM 3DVAR system. (2) Radial wind preprocess procedure can solve the radial wind noisy problem and establish a radar elevation plane coordinate to do thinning work. (3) Precipitation forecasting skill is greatly improved through one month experiments in May 2017, especially for decreasing the precipitation forecasting bias. And temperature and 10m wind forecasting skills are also improved.

CFOSAT WIND SCATTEROMETER DATA CHARACTERISTICS AND WIND RETREIVAL EVALUATION WITH NWP OCEAN CALIBRATION

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KNMI

ABSTRACT

Chinese-French Oceanography Satellite (CFOSAT) was launched on 29 October 2018 (00:43 UTC). The goal of this joint mission is to monitor the ocean surface winds and waves in order to provide data on related ocean and atmospheric applications. The SCAT on board of CFOSAT is the first Rotating Fan-beam Scatterometer (RFSCAT). The slowly rotating fan beam of SCAT sweeps over the swath and results in multiple views overlapping in individual WVC. The number of views in a WVC depends on its location in the swath and the rotating speed of the fan beam. The WVCs located at outer and nadir swath contain a smaller number of views and less azimuth diversity due to the scanning geometry, which lead to a degraded wind retrieval performance. The scanning geometry, on the contrary, leads a diverse geometry and more views at the other parts of the swath (named sweet swath), which result in a better wind retrieval performance comparing to nadir and outer swath. The geometry distribution of the real L1B data is in line with the simulated data with minor differences.

It is essential for scatterometers to use corrections to improve the quality of the wind product. The NWP (Numerical Weather Prediction) Ocean Calibration (NOC) is defined to find absolute corrections of measured backscatter σÅã and simulated σÅã from NWP model winds with the GMF. The NOC as a function of incidence angle (NOCinc) and the NOC as a function of antenna pointing angle and incidence angle (NOCai) are tested. Both of them are able to improve the wind retrieval performance. The statistics of these two wind retrieval results are quite similar except for the sweet WVCs. The cone distance of the NOCai result is smaller than the result of NOCinc, which means a better fitting of the GMF of the NOCai. It is also the region with the most diverse antenna pointing direction distribution, which means the NOCai works better with more complete antenna pointing directions. It tends to over correct if the antenna pointing angles are concentrated in a certain range.

In conclusion, the advantages of the rotating fan-beam are the increased geometry diversity and the number of views in individual WVC and they lead to a better wind inversion and wind retrieval performance varies across the track. The NOC is able to improve the wind retrieval performance as expected.

ESA'S WIND LIDAR MISSION AEOLUS, STATUS AND EARLY EXPLOITATION AFTER 1.5 YEARS IN FLIGHT

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ABSTRACT

The European Space Agency (ESA) wind mission, Aeolus, hosts the first space-based Doppler Wind Lidar (DWL) world-wide. The primary mission objective is to demonstrate the DWL technique for measuring wind profiles from space, intended for assimilation in Numerical Weather Prediction (NWP) models. The wind observations will also be used to advance atmospheric dynamics research and for evaluation of climate models. Mission spin-off products are profiles of cloud and aerosol optical properties.

Aeolus was launched on 22 August 2018, and the Atmospheric LAser Doppler INstrument (Aladin) switch-on was completed with first high-energy output in wind mode on 4 September 2018. The on-ground data processing facility worked excellent, allowing L2 product output in near-real-time from the start of the mission. First results from the wind profile product (L2B) assessment showed that the winds were of very high quality, with random errors in the free Troposphere within (cloud/aerosol backscatter winds: 2.1 m/s) and larger (molecular backscatter winds: 4.3 m/s) than the requirements (2.5 m/s), but still allowing significant positive impact in first preliminary NWP impact experiments. During commissioning phase and early operation, a number of anomalies were found by ESA, industry and the Aeolus Data Innovation Science Cluster (DISC). The DISC scientific partners from DLR, DoRIT, ECMWF, KNMI, MétéoFrance and PSol, were tasked to investigate the instrument calibration and perform product verification and validation implementing a number of corrective measures in the on-ground data processing. ESA and DISC investigations included e.g. estimates of the lower than specified atmospheric and ground return signal (probably caused by clipping in the instrument receive path), analysis of the instrument output energy and alignment drifts, elevated dark currents on individual CCD pixels, bugs in the on-board satellite velocity calculations etc. After 10 months in-flight, the output energy of the first flight laser had dropped below an acceptable level w.r.t. instrument safety and data quality, and the redundant laser was switched on. After a few months of stabilization, the second flight laser is currently providing a stable output energy at an acceptable energy level of 60 mJ. Investigations by the DISC partner at ECMWF, which also hosts the Aeolus L2B processing facility, also revealed that the Aeolus telescope thermal control is not working as well as expected. Corrections for this and other major L2B wind bias contributors have or are, at the time of writing, being implemented in the on-ground data processing. Public release of the Aeolus L2B data product is expected in spring 2020. The atmospheric optical properties product (L2A), containing amongst others extinction and backscatter coefficient and inverse lidar ratio profiles, is being compared e.g. to NWP model clouds, air quality model forecasts, and collocated ground-based observations. Features including optically thick and thin particle and hydrometeor layers are clearly identified and are being validated. Layers of smoke from Siberian fires in the summer of 2018 and Australian fires in January 2014 are examples of case studies looked into by the L2A algorithm developer MeteoFrance. Public release of the Aeolus L2A product is expected in the second half of 2020.

In this presentation, the status of the Aeolus mission and its data products will be presented together with first results from the mission CAL/VAL and exploitation.

COMPARING WILDFIRE GOES-BASED STEREO-PLUME HEIGHTS, WINDS, AND AEROSOL PROPERTIES FROM 3D-WIND AND MAGARA ALGORITHMS TO CMAQ SIMULATIONS: A 2018 CAMP FIRE STUDY

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ABSTRACT

We compare use two new geostationary satellite-based algorithms to quantify constraints on wildfire plume modeling simulations. Our approach is twofold. Combining NASA's legacy MODIS products with the GOES Advanced Baseline Imager imagery, the state-of-the-art 3D-Wind algorithm, we first compare satellite-based detected wildfire plume injection heights with CMAQ, a chemical transport model. The validated GOES-MODIS 3D-Wind algorithm provides plume dynamics data with < 200 m vertical resolution for plume height and < 0.5 m/s for plume speed. Secondly, we compare aerosol type observations from the novel Multi-Angle Geostationary Aerosol Research Algorithm (MAGARA) to constrain modeled smoke hotspots and dispersion patterns of aerosols. Consistently modeled meteorology and extensive satellite coverage combine to produce more accurate plume injection heights and dispersion patterns, especially in areas where ground measurements are limited or absent. We compare the results of the two novel algorithms, 3D-Wind and MAGARA, to the 2018 Camp Fire event CMAQ runs. Geostationary satellite wildfire plume-attribute products provide spatiotemporal context and can decrease errors in plume characterization. According to the EPA, wildland fires contributed approximately 30 percent of directly emitted fine particulate matter, linked to premature death from heart and lung disease. By capturing the dynamic wildfire plume dispersion, height, and winds, we can determine if fire plumes stay within or shoot above the planetary boundary layer and constrain modeling results. Improved accuracy, coverage, and characterization of plume injection height data increase the effectiveness of management methods that reduce and estimate smoke exposure.

SHORTWAVE INFRARED AND DAY-NIGHT BAND VIIRS POLAR WINDS

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ABSTRACT

The properties of winds from visible/near-infrared/thermal infrared satellite imagers – speed, direction, and altitude – are derived by tracking clouds in data from the Visible and Infrared Imaging Radiometer Suite (VIIRS), the Moderate Resolution Imaging Spectroradiometer (MODIS), and the Advanced Very High Resolution Radiometer (AVHRR), and by tracking water vapor with MODIS. However, polar clouds are notoriously difficult to detect and characterize with satellite imagers because of the similarities between their temperature and reflectance properties and those of the underlying snow and ice surface. Ubiquitous lower-tropospheric temperature inversions in winter and nearly isothermal temperature profiles in summer result in a very small temperature contrast between low, stratiform clouds – the most common cloud type over much of the Arctic Ocean – and the surface. In visible imagery, clouds and snow/ice are similarly bright, again resulting in very low contrast. This lack of contrast means that there are fewer good features to track, yielding fewer and/or lower quality wind vectors.

In the shortwave infrared (SWIR) portion of the spectrum the scattering properties of liquid-phase clouds and snow/ice are significantly different. Clouds are much brighter than the underlying snow or ice surface and the contrast between low clouds and the surface is large in SWIR bands around 1.6, 2.2, and 3.7 μm. This fact that has been exploited in polar cloud detection algorithms at least since the early 1990s. AVHRR, MODIS, and VIIRS all have bands at 1.6 and 3.7 μm; MODIS and VIIRS also have bands at 2.1-2.2 μm. In theory, SWIR data will provide more good features for cloud tracking and atmospheric motion vector derivation in the presence of sunlight (daytime), especially for liquid clouds over snow and ice. The VIIRS day-night band (DNB) provides another unique source of spectral information: reflected radiation at night in the presence of moonlight.

Here we report on the advantages of utilizing these new spectral bands to extend the current VIIRS polar winds products. Tests using a MODIS SWIR band have demonstrated that additional wind information can be obtained, particularly lower in the atmosphere. The DNB has not previously been employed for winds, though it is currently being successfully employed for sea ice motion.

TANDEM WINDS FROM S-NPP AND NOAA-20

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ABSTRACT

The Visible and Infrared Imaging Radiometer Suite (VIIRS) polar winds product is currently operational for the Suomi National Polar-orbiting Partnership (S-NPP) and NOAA-20 satellites, providing wind speed, direction, and pressure of cloud-tracked features at high latitudes, both Arctic and Antarctic. The S-NPP product has been operational since May 2014. The VIIRS winds are being assimilated in the Naval Research Lab (NRL) forecast system and are currently being monitored in NCEP's pre-operational model. They are also used by a number of numerical weather prediction centers worldwide.

The VIIRS, Moderate Resolution Imaging Spectroradiometer (MODIS), and Advanced Very High Resolution Radiometer (AVHRR) wind products use three successive orbits (100-minute time step) from a single satellite to derive cloud motion. Since JPSS-1 – now NOAA-20 – is in a similar orbit as S-NPP but delayed by ½ orbit in time, there is an opportunity to track clouds from the NOAA-20/S-NPP tandem. This will reduce the time interval between images to approximately 50 minutes, which will result in reduced latency in product availability, potentially higher quality winds due to the shorter time interval for tracking, and global rather than only high-latitude coverage. The NOAA-20/S-NPP orbit configuration is similar to that of Metop-A/-B. EUMETSAT has exploited this orbit configuration and developed a Metop-A/-B wind product. Metop-A/-B case studies done by the authors and EUMETSAT's own analyses show that the tandem winds are in good agreement with single-satellite winds at high latitudes. There are, however, larger uncertainties in the tropical regions.

VIIRS tandem winds are now being routinely generated as a research product. Statistical comparisons with rawinsondes and VIIRS single-satellite winds show the tandem winds product to be of high quality. Some factors that impact the accuracy of winds are still being investigated. These include the impact of parallax in the tropics, and the increased uncertainty in winds derived at short time scales and with only two orbits. Results of these investigations and early results from the NOAA-20/S-NPP tandem will be presented, both for orbit pairs and orbit triplets.

IMPROVED MONITORING OF THE RAPIDLY-EVOLVING UPPER-TROPOSPHERIC WIND FIELDS OVER THE CORE OF HURRICANES FROM HIGH SPATIOTEMPORAL RESOLUTION GEOSTATIONARY SATELLITE OBSERVATIONS

David Stettner, Chris Velden, Steve Wanzong, Jaime Daniels, Wayne Bresky

ABSTRACT

This project utilizes the rapid-scanning capabilities of the new generation of geostationary satellite imagers for the derivation of high spatiotemporal AMVs during targeted hurricane events. We expect this effort will fill an important observational gap in hurricane analyses, as storm-scale dynamical information at the top of hurricane core and outflow regions is currently lacking and needed to intrinsically tie in convective processes with environmental interactions that can modulate intensity. The added data will not only improve our observation and understanding of hurricane behavior (e.g. intensity and size fluctuations), but provide key vortex-scale information to rapidly-advancing data assimilation methodologies leading to improved hurricane model predictions. Specifically, what we are working on/towards: 1) Complete the refinement and testing of recently-developed processing strategies (presented at IWW14) that have been optimized to extract maximum AMV information content in hurricane environments from GOES-16 meso-sector scans; 2) Tailor and test these strategies to operate with GOES-17 and Himawari-8/9; 3) With NWP collaborators, continue to investigate approaches to more effectively assimilate the enhanced AMV data into operational hurricane prediction models (i.e. Hurricane WRF (HWRF)) to maximize the information content getting into the initialized analyses and leading to improved forecasts; 4) Assist in the transition of this research to NESDIS and NCEP for operational testing and implementation in collaboration with STAR, JCSDA and EMC colleagues.

These objectives are being accomplished by advancing the current NESDIS operational (enterprise) AMV algorithms and building on novel data processing approaches developed at CIMSS to enhance those strategies, by demonstrating the end-to-end capabilities via real-time testing, and by transitioning the methodologies to STAR (collaborative partner) for seasonal real-time operational testing (JCSDA). In tandem, the data treatment and assimilation strategies will be honed for maximum HWRF model analysis impact through close collaboration between the data providers and users (NOAA/HRD and NCEP/EMC). While a primary objective will be the application of the enhanced AMVs to support NWP models, NWS/National Hurricane Center forecasters should also benefit from the enhanced AMV datasets (viewed on AWIPS) in their analyses of rapidly-evolving storm conditions. This poster reports on the status and progress of the project.