NWP impact of Aeolus observation as characterized by Ensemble Data Assimilation experiments

Heiner Körnich (SMHI), Linda Megner (Stockholm University),
David Tan, Andras Horanyi, Lars Isaksen (ECMWF),
Gert-Jan Marseille, Ad Stoffelen (KNMI),
And VAMP and VHAMP teams

1 Introduction

ESA's Earth Explorer Atmospheric Dynamics Mission Aeolus carries a Doppler wind lidar which will provide global line-of-sight wind profiles.

The vertical sampling is limited to 24 range gates both in the Rayleigh and Mie receiver channels for the molecular and aerosol scattering respectively. Number and error of the observations depend upon various factors, such as air density, aerosol loading, visibility, and wind shear.

In this study, it is examined how both different vertical and horizontal sampling scenarios for Aeolus affect the impact on forecast quality in a global NWP system. Furthermore, changed instrument design moved the lidar operations from burst to continuous mode. Moreover the impact is estimated of a decrease in pulse energy of the laser from 110 mJ to 80 mJ. We investigate what effect these instrumental changes will have on the data and finally on the improvement of the weather forecast.

The assessment will be carried out with the 4D-variational data assimilation of the ECMWF operational system. ADM-Aeolus observations are generated artificially by short-range forecasts of the UK met office and with cloud and aerosol information from Calipso..

Design of experiments

ECMWF's ifs model cy35r2, T399L91 4

Ensemble of 10 members with perturbed observations

Time span: January 2007

1) Calibration test with radiosonde denial experiments.

2) Experiments for vertical sampling:

2A) ADM-LT with focus on lower troposphere (WVM2)

2B) ADM-UTLS with focus on upper UTLS region (WVM-et-zwc-2)

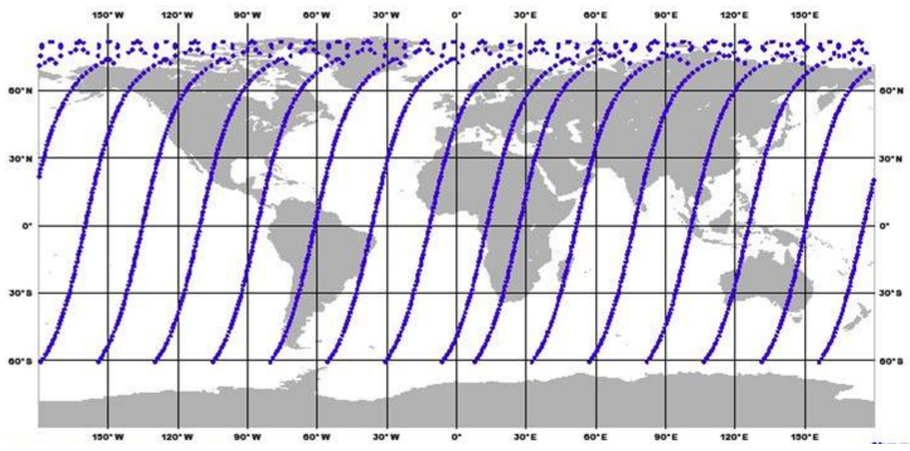
2C) ADM-strato with focus on stratosphere (WVM-stratosphere-nozwc, increased top-height of observations to 36.5 km)

3) Experiments with burst (BM110mJ, 50 km**) and continuous mode (CM110mJ,** 84 km**)**

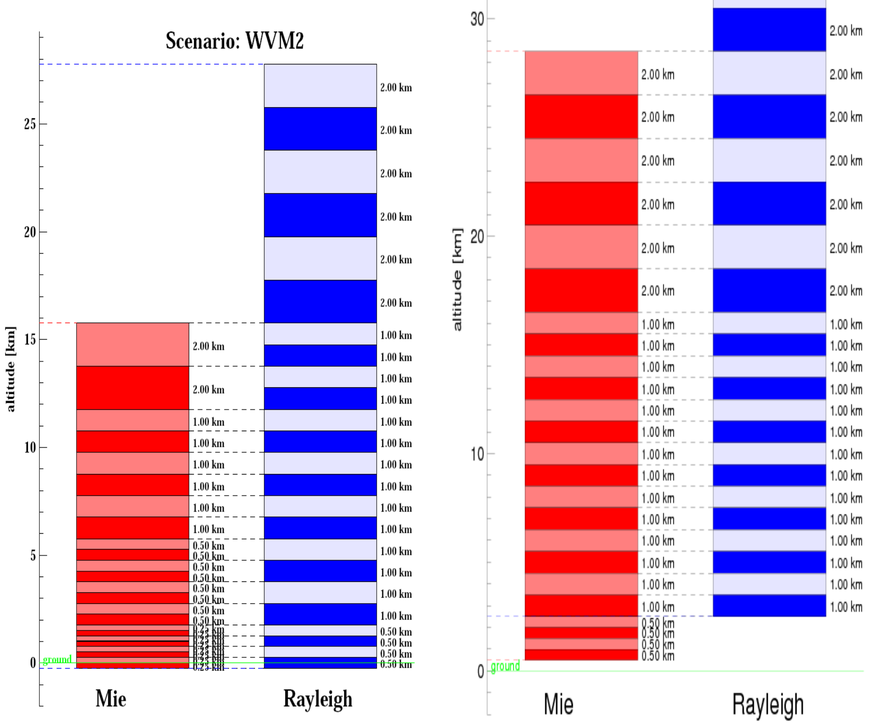
4) Experiment with reduced laser power to 80 mJ (CM80mJ)

5) Experiment with increased horizontal sampling length to 250 km (CM250km, 80 mJ**)**

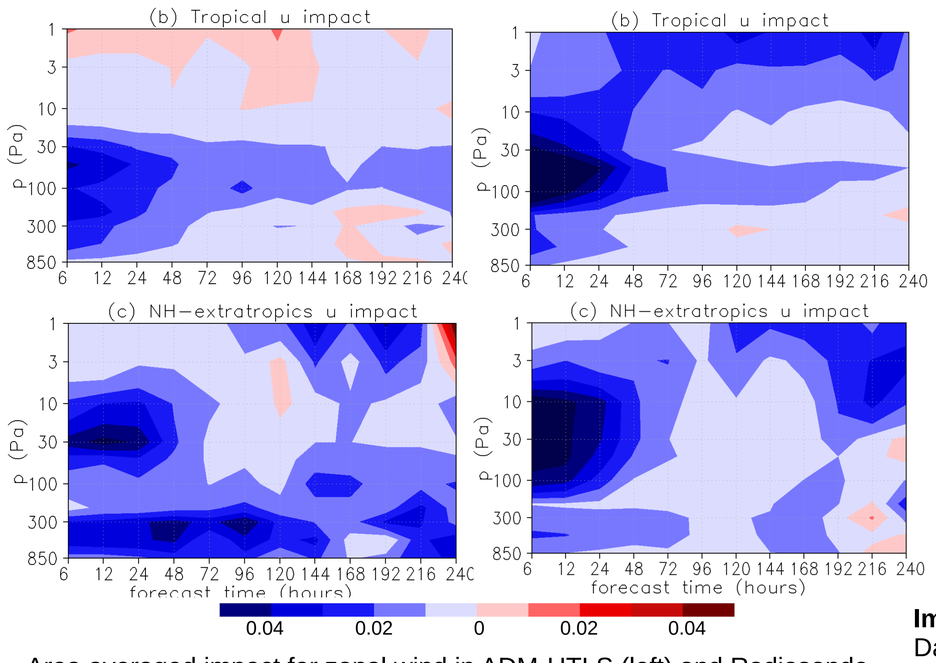
2 Simulated Aeolus data for one-day



Two test scenarios 5

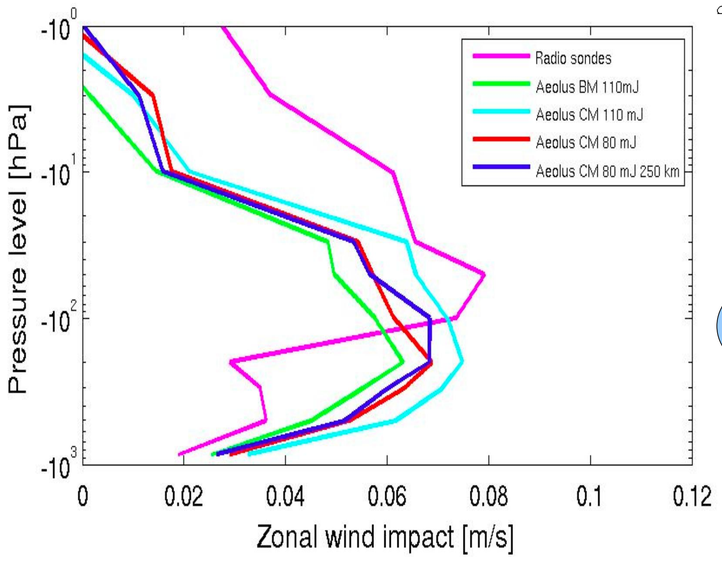


6 Impact: Aeolus vs radiosondes



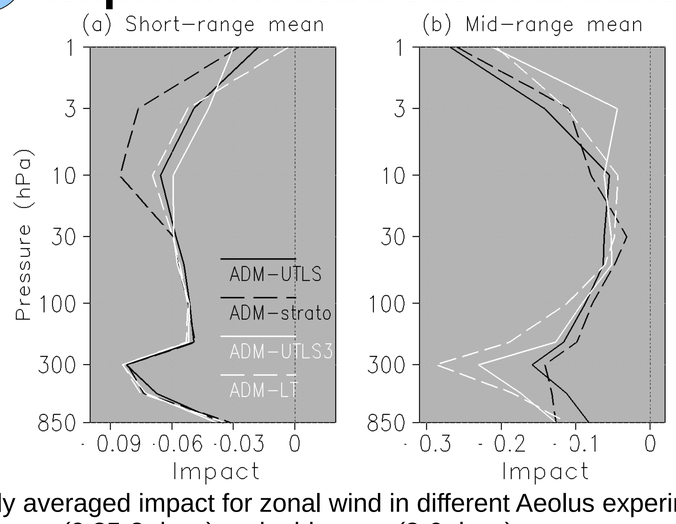
Area averaged impact for zonal wind in ADM-UTLS (left) and Radiosonde (right). Aeolus impact is doubled due to only half of expected sampling. Blue color indicates positive impact.

8 Aeolus global mean impact for different instrumental scenarios



Aeolus zonal wind impact on operational weather forecasts.
The impact of continuous mode is higher than burst mode. The impact is only slightly degraded when going from 110 mJ to 80 mJ laser pulse energy, or when going from 100 km to 250 km horizontal sampling.

9 Impact: Aeolus vertical sampling



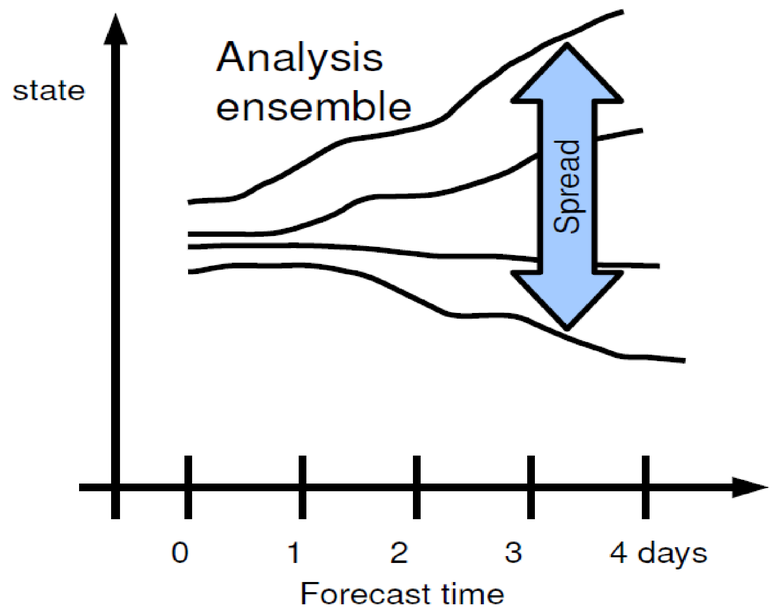
Globally averaged impact for zonal wind in different Aeolus experiments for short-range (0.25-2 days) and mid-range (3-6 days).

3 Method EDA: Data assimilation ensemble technique

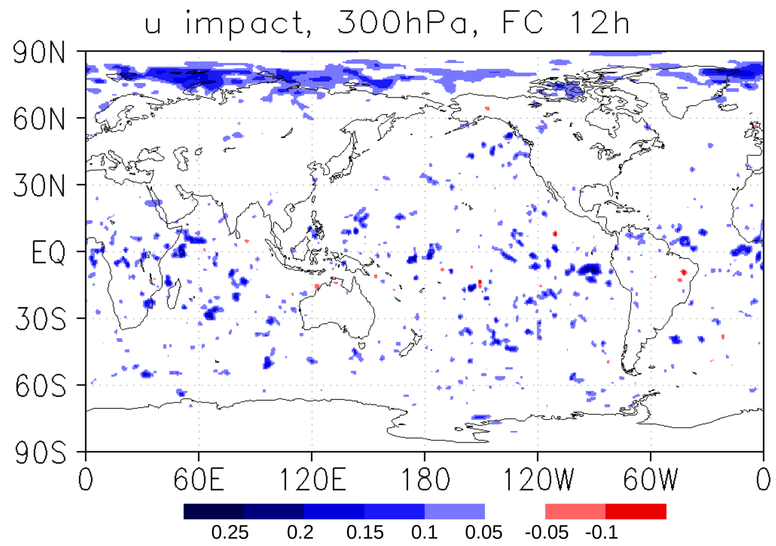
It was demonstrated that a data assimilation ensemble with **perturbed observations** can be used to sample the background and the analysis error. We use the ensemble spread to **estimate** the impact of a simulated observing system, ie. Aeolus.

Impact(new obs.) = Spread(Exp. without new obs)
minus
Spread(Exp. with new obs.)

Calibrating the impact of an observing system by comparing the ensemble spread with a reference case, e.g. impact of radiosondes.



Spatial map of impact 7



Zonal wind impact for ADM-UTLS at 300 hPa for 12 h forecast. Blue colors indicated positive impact.

Summary 10

Impact of new observing systems can be simulated with Ensemble Data Assimilation EDA experiments.

The simulated Aeolus impact is comparable in magnitude to the radiosonde impact.

Aeolus impact is expected especially in high latitudes, over the oceans and in the Tropics.

Higher sampling in the lower troposphere or in the stratosphere results in increased impact in the respective region.

The recent changes in Aeolus' instrumental design do not degrade strongly the impact in our experiments.

References

Stoffelen, A., H. Körnich, G.-J. Marseille, K. Houchi, and J. de Kloe, 2010: Assessment of Optical and Dynamical Atmospheric Heterogeneity. Technical Note, ESTEC, The Netherlands.

Körnich, H., and H. Schyberg, 2010: Impact of the Vertical Sampling Scenarios on NWP and Stratospheric Wind Analysis. Technical Note, ESTEC, The Netherlands.

Megner, L., Tan, D. G. H., Körnich, H., Isaksen, L., Horányi, A., Stoffelen, A. and Marseille, G.-J. (2014), Linearity aspects of the ensemble of data assimilations technique. Q.J.R. Meteorol. Soc.. doi: 10.1002/qj.2362

Marseille, G.-J., A. Stoffelen, H. Schyberg, L. Megner, and H. Körnich, 2013: Final Report: Vertical and Horizontal Aeolus Measurement Positioning. AE-FR-VHAMP_v1.0. Technical Note, ESTEC, The Netherlands