REQUEST FOR A SPECIAL PROJECT 2012–2014

MEMBER STATE: Sweden

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Project Title: Aeolus' impact estimation for different sampling scenarios using EDA experiments

If this is a continuation of an existing project, please state the computer project account assigned previously.	**SP** ________________	
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2012	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2012-2014: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2014.)	**2012**	**2013**	**2014**
High Performance Computing Facility (units)	12,000,000		
Data storage capacity (total archive volume) (gigabytes)	13,500		

An electronic copy of this form ***must be sent*** *via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):

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Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Heiner Körnich

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Extended abstract

The Earth Explorer Atmospheric Dynamics Mission (Aeolus) is a unique space-borne Doppler wind lidar that will yield vertical profiles of line-of-sight wind observations with global coverage (Stoffelen et al. 2005). The launch of the polar-orbiting satellite is planned for late 2013. The current global observing system lacks precise wind observations over large areas, especially the oceans, the Tropics and the Southern Hemisphere in general. Aeolus is designed to mend this deficiency. In this project, we are aiming to optimze the impact of the satellite mission on Numerical Weather Prediction (NWP). The project contributes to the ESA study ”Vertical and Horizontal Aeolus Measurement Positioning” (VHAMP) that consists of collaboration between KNMI, the department of meteorology at Stockholm University (MISU) and Met.No. Specifically, in the proposed project, it is examined how different spatial sampling scenarios of the satellite affect Aeolus' impact on NWP given both the technical constraints of the satellite and the current global observing system.

Background

The vertical sampling of Aeolus is contrained by 24 useful range gates both in the Rayleigh and Mie receiver channels for backscattered light by molecules and particles, respectively. The maximum height for a range gate is about 30 kilometers. The distribution of the vertical sampling can be changed several times during each orbit allowing the sampling to adjust for different climate zones.

The possibilities for horizontal sampling have recently widened due to a change in the instrument design. Previously, the Basic Repeat Cycle (BRC) of the Doppler-wind lidar was planned to alternate between 7 seconds operation and 21 seconds switched off. This so-called burst mode was planned to provide wind observations averaged over 50 kilometres and spaced at 200 km distance. For that instrument design a separate ESA-study was conducted entitled “Vertical Aeolus Measurement Positioning” (VAMP). The aim of the previous study was to optimize the distribution of the vertical range gates for weather forecasting. The final report was delivered to ESA in November 2010 (Marseille et al. 2010).

The current change in instrument design means that the Doppler-wind lidar will now operate continuously providing the possibility for a larger amount of observations that are more densely spaced. However, these new options come a cost. On the one hand, the continuous operation reduces the instrument’s power over the above-mentioned 28 seconds or 200 km, i.e. the spatial integration required for a given measurement precision covers a longer distance for the new instrument design than for the old. On the other, directly neighbouring observations will have correlated representativeness errors requiring additional attention when these observations are introduced into a data assimilation system.

In the new study VHAMP, different sampling scenarios for Aeolus will be proposed taking into account the expected representativeness error deduced from observations and the spatial background error correlations of current NWP systems. That part will be conducted by KNMI, met.no and MISU. The impact of the proposed sampling scenarios on NWP will then be estimated in the here presented contribution to the project. To this end, an Ensemble Data Assimilation (EDA) technique will be employed.

The EDA method is founded on the forecast error estimate in terms of ensemble forecast spread as proposed in Žagar et al. (2005). The ensemble is created by perturbing the observations with random errors drawn from the distribution of the observation error. In Tan et al. (2007), the EDA is used to estimate the impact of the future observing system Aeolus, also for the old instrument design.

For the impact estimation, two EDA experiments have to be performed, one containing the observing system in question, one without. The impact results then from the difference of the ensemble forecast spread for the two experiments. A reduction of ensemble forecast spread is equivalent to a reduction in forecast error and thus, a beneficial impact of the new observing system. For future observing systems, the observations have to be simulated as in Tan et al. (2007). As an alternative to a full-blown Observing System Simulation Experiment (OSSE), the EDA technique provides a relatively simple tool for impact estimation of a future observing system.

Scientific plan

1. Reliability of the EDA tool as an alternative to an OSSE

In the first part of the project it will be investigated how reliable the EDA tool is for the given task. This point will be examined on basis of radiosonde observations as the observing system in question. The radiosonde impact on NWP will be calculated by two methods: an Observing System Experiment (OSE) and the EDA estimate. These experiments have already been conducted for the time period January 2007. The impact will be compared for different forecast times up to 10 days and for different regions.

Additionally, we will examine the linear assumptions underlying the EDA impact estimation, namely that the ensemble forecast spread approximates the forecast error as suggested in Žagar et al. (2005). Two EDA experiments will be performed: one with the current global observing system, one radiosonde denial experiment. In difference to the previous experiments the observations will be perturbed randomly by only 10% of their observation error. We expect that the ensemble forecast spread will be reduced accordingly. These experiments might be run over a reduced time period.

Further issues of the EDA tool will be examined: 1) The data usage in the EDA experiments, i.e. how the randomly perturbed observations affect the usage of observations during the assimilation, and 2) the relatively coarse horizontal resolution of the EDA tool as compared to the IFS operational system. The first issue can be examined with the suggested observations, while the second issue will require additional EDA experiments, also over a reduced time period.

2. Impact of Aeolus' new instrument design

In the second part of the project, the impact of the new Aeolus instrument design will be explored. Three different Aeolus sampling scenarios that will be suggested by VHAMP will serve as an input to EDA experiments. In order to be able to compare the impact estimates from these experiments, it will be vital to define the representativeness error for the different sampling scenarios consistently.

The experiments require simulated Aeolus observations that should be as realistical as possible in terms of number, quality, spatial distribution, and innovation (O-B) statistics. To this aim, we will combine aerosol observations by CALIPSO (Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation) with short-range wind forecasts by the UK met office in the tool LIPAS (LIdar Performance Analysis Simulator). This method was successfully applied in Marseille et al. (2010) for the previous study VAMP. However, only nighttime CALIPSO data could be used due to the strong noise of the daytime measurements. This resulted in only half-orbits of simulated Aeolus observations in VAMP. In order to strengthen the significance of the EDA impact, the total number of Aeolus observations shall be increased to the full orbit for the new experiments. Therefore, Aeolus measurements will be assimilated for dawn and dusk using the same nighttime aerosol observed by CALIPSO. The simulation period will be January 2007 as in Marseille et al. (2010).

One additional EDA experiment will be performed using the old Aeolus instrument design. This experiment will be used to compare the performance of the old design with the new one under the same model configuration, i.e. full orbits and comparable representativeness error statistics.

Work

1. Investigate the reliability of the EDA ensemble spread as a measure for the impact of an

observing system. This requires two EDA experiments with only 10% observation perturbations, one control, one radiosonde denial. The EDA experiments with 100% observation perturbations are already available from VAMP.

2. Aeolus horizontal line-of-sight wind simulation from LIPAS using CALIPSO and Uk met office data for January 2007.
3. Run EDA experiments for January 2007 using three sampling scenarios defined in VHAMP and full Aeolus orbits.
4. One additional EDA experiment for old instrument design with comparable setup to new experiments.
5. Analysis of the ensemble spread results.

Input

- LIPAS + UKMO "truth"
- ECMWF EDA environment
- LIPAS simulated observations for the selected sampling scenarios

Output

Technical Note for ESA project VHAMP, summarizing the results from the investigations into the EDA ensemble spread as a measure for the Aeolus observation impact on the ECMWF IFS, the experiments run with the EDA tool, the analysis and discussion of the results. Input to the Aeolus observation requirements.

Required computer resources

In order to use the EDA experiments of impact estimation, sufficient statistics are required. The important parameters are the length of the time period and the size of the ensemble. We would like to use the same configuration as in the previous experiments for the VAMP study (Marseille et al. 2010):

- 1-31 January 2007
- 10 ensemble members + 1 control member
- IFS CY35R2
- Resolution T399 with 91 levels
- Long forecast up to 10 days, starting twice every day at 00/12 UTC

One example of such an experiment is experiment id fds3. From this experiment, the following resources for one EDA experiment were determined: 2,400,000 billing units, 2,700 gigabytes.

A total of 5 EDA experiments are included in the above proposal, requiring 12,000,000 billing units and 13,500 gigabytes.

Code to be used

The IFS part of this proposal requires two additional components, which were not officially implemented in CY35R2. Two existing IFS branches were combined: mpi_CY35R2_ENDA_trim_tendph_RVP by Lars Isaksen providing the capability of the EDA experiments and dat_CY35R2_SingleObs_20100212 by David Tan for including simulated HLOS observations. Additional fine-tuning of the branch increased the computational stability and resulted in the final branch dat_CY35R2_EnDA_hlos20100715. This IFS version will be used for the proposed experiments.

The simulated Aeolus observations will be generated by the program LIPAS that is developed at KNMI. The Aeolus instrument design requires some changes of the LIPAS-code that will be done by Gert-Jan Marseille (KNMI) as part of VHAMP.

References

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