# The ADM-Aeolus Workshop

# Summary

26 to 28 September 2006 ESA/ESTEC Noordwijk, The Netherlands

European Space Agency
Agence spatiale européenne

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# ESA/ESTEC, 26-28 September 2006

## Introduction

ESA is currently implementing the Doppler Wind Lidar (DWL) mission 'ADM-Aeolus' in its Living Planet Programme. The mission is a demonstrator for future operational missions providing vertical profiles of the tropospheric and lower stratospheric wind field for the improvement of numerical weather prediction and atmospheric research. Through ADM-Aeolus, tropical circulation and the more general transport properties of the troposphere and lower stratosphere will be better determined. The mission is described in detail in ESA SP-1233(4) and in Stoffelen et al, 2005 ('The atmospheric dynamics mission for global wind measurement', *Bull. Amer. Meteorol. Soc.*, **86**, 73-87).

The objectives of the workshop were to bring ADM-Aeolus engineers and scientists together for the first time to provide an overview of the status of the technical preparation, present the scientific preparations for the mission, analyse the research potential of the mission, start a dialogue on how the mission products should be validated, assess the operational potential of the mission, and start a discussion on ways to implement follow-on missions. Papers are invited for publication in a special issue of TELLUS with a submission deadline of 31 December 2006.

The workshop focused on the overall science objectives of the mission, the algorithms, the products, and their potential application. It also addressed the ADM-Aeolus system as well as other wind lidar concepts. The workshop was split into seven sessions focusing on the ADM-Aeolus mission, DWL research and applications, user organisations, related observing systems and future concepts, ADM-Aeolus Validation, and summary and conclusions. The session chairs, summarizing the major findings and discussions during the various sessions, came up with the conclusions and recommendations listed below.

## The Expected Benefits of ADM-Aeolus

The primary goal of the ADM-Aeolus mission is to provide vertical profiles of the wind field for the improvement of atmospheric analyses, serving both climate research and numerical weather prediction (NWP). NWP analyses are an important intermediate step as the observations (horizontal line of sight winds, HLOS) are difficult to be used directly.

ADM-Aeolus data is expected to improve atmospheric analyses in the Southern Hemisphere, in the tropics, over the oceans and in Polar regions. It is further expected to i) improve climate datasets, ii) provide direct cloud/aerosol observations, iii) improve the modelling of stratospheric transport, and iv) possibly assist in improving gravity wave parameterization in models. However, once in space the real potential of ADM-Aeolus will be demonstrated.

ADM-Aeolus will fill many of the data gaps of wind profiles in the present Global Observing System (GOS). According to some estimates ADM-Aeolus may have an impact on forecast quality comparable to that of radiosondes. ADM-Aeolus should lead to synergies with Atmospheric Motion Vector (AMV) products and should support the validation of operational height assignment concepts for AMVs. Studies in THORPEX (THe Observing system Research and Predictability EXperiment) with a limited amount of aircraft DWL targeted observations showed a forecast impact.

The Tropics is the region where independent wind profile observations are most urgently needed. An accurate background error covariance (B) matrix is needed for full exploitation of ADM-Aeolus data to improve atmospheric analyses. The non-geostrophic tropical dynamics is governed by waves and cloud-radiation interaction. It may also be challenging to measure vertical profiles of the zonal wind component in the tropics due to the presence of clouds and the thermally driven strong vertical motions causing strong vertical wind shears. In clear spots in-between clouds, ADM-Aeolus will therefore see a mixture of the mean flow and small-scale cloud dynamics. More study is needed on these issues.

## Further Scientific Studies

It was agreed to launch a study carefully looking into the optimization of the ADM-Aeolus vertical sampling, taking into account observations in heterogeneous cases with aerosol and cloud contamination and strong vertical wind shears, and acknowledging the need for aerosol detection for accurate wind retrievals in the stratosphere. First results of CALIOP, the lidar on-board of CALIPSO, were presented. Findings like unexpectedly strong PSC's (Polar Stratospheric Clouds) close to the South Pole could be very useful for the testing of ADM-Aeolus vertical sampling strategies.

New studies focusing on the benefit of ADM-Aeolus for non-NWP applications should be initiated. When deciding upon which scientific questions could be answered by the use of ADM-Aeolus data, the accuracy and sampling strategy for the data products must be established. On the other hand, the scientific needs, not only for operational NWP purposes, will also be considered when deciding upon the sampling strategy. During the workshop it was suggested to launch scientific studies looking into i) the usefulness of ADM-Aeolus data for stratospheric research and ii) the potential use of the ADM-Aeolus aerosol and cloud products. Winds are badly needed in the stratosphere as the zonal stratospheric flow, the Brewer-Dobson circulation and the QBO (Quasi Biannual Oscillation) need to be better observed and analysed. The usefulness of present stratospheric analyses is limited due to the lack of wind data and the lack of good balance criteria in the tropics.

The impact of ADM-Aeolus on NWP at mid-latitudes had been demonstrated in studies performed by KNMI and ECMWF. However, the need for calibration of new concepts like SOSE (Sensitivity Observing System Experiment), ensemble-based methods (ECMWF), and OSRE (Observation System Replacement Experiment) was expressed. This was needed in order to achieve a more absolute impact measure.

The question was posed whether it is necessary to perform further sophisticated impact studies involving NWP assimilations. The expectation from uniformly distributed global wind observations from ADM-Aeolus, considering the large impact of winds from the current inhomogeneous radiosonde system and considering the ADM-Aeolus OSE-type experimentation, this appears beneficial. Moreover, a number of participants considered that, given the relative closeness of the launch, expensive impact studies were unjustified. The effort should be spent to assimilate real data and demonstrate their impact. It was agreed that OSSEs (Observing System Simulation Experiments) are still desirable with state-of-the-art assimilation systems and based on presently available observations, in particular for simulations of follow-on missions.

It was recommended to contact relevant bodies within WMO for cooperation, e.g. GEWEX (Global Energy and Water cycle EXperiment) and the Global Climate Observing System (GCOS).

## The Preparedness for the Use of ADM-Aeolus Data and Operational and Scientific Outreach

ESA asked how prepared NWP centres, beyond those institutes represented by Mission Advisory Group (MAG) members, are to validate and use ADM-Aeolus wind data when they become available. American colleagues expressed a strong interest in receiving the ADM-Aeolus data as soon as possible after launch. It was further suggested to support (e.g. EUMETSAT) ADM-Aeolus data assimilation in the HIRLAM/ARPEGE limited-area NWP models.

It was proposed that next years ECMWF seminar in early September could have an ADM-Aeolus session to better prepare users.

A reduction of data latency is an important issue for operational NWP applications. All near-real-time users of the ADM-Aeolus Level 1b data will receive the data in BUFR format within 3 hours after sensing. The spacecraft and ground segment design allows for a minimum data delivery time of 30 minutes after sensing, provided that an adequate network of X-band ground stations and corresponding on-ground data link capacities are available. ESA explained that, at a modest cost, a global latency of 65 minutes can be achieved by using e.g. the Troll Station in Antarctica. The usage of Fairbanks could reduce the operational uncertainty associated with some passes over Svalbard. User organizations were asked to look into the necessity and possibility for such upgrades to the data distribution.

For various international organisations ADM-Aeolus is seen as a very important extension of the Global Observing System (GOS). For GCOS, ADM-Aeolus is a key demonstration project contributing to climate products through wind analyses, cloud and aerosol. Data assimilation is seen as an important tool for the exploitation of ADM-Aeolus by SPARC (Stratospheric Processes And their Role in Climate – part of the WCRP, the World Climate Research Programme).

## ADM-Aeolus Validation

ECMWF, in conjunction with ESA, plans immediate post-launch performance monitoring and validation studies. Pre-launch ground-based and airborne campaigns with the ALADIN Airborne Demonstrator (A2D) are planned. A French consortium is established for the validation of ADM-Aeolus data using ground-based, aircraft (WIND/LNG) and stratospheric balloon measurements. NOAA and NICT offered support for ADM-Aeolus validation, for example within their NWP GOS data monitoring system.

ESA has scheduled an Announcement of Opportunity for ADM-Aeolus validation proposals for issue in 2007.

## Future Concepts and ADM-Aeolus Follow-on

ESA presented a post-ADM plan with 4 satellites. Though beneficial, extra perspectives and changes in Equator crossing times may not be compatible with the desire to avoid data gaps. An early follow-on mission would need to rely on small and simple changes to the already existing design. A scenario was tabled where one would avoid a data gap between ADM-Aeolus and e.g. post-EPS (EUMETSAT Polar System). Such a concept found interest and support.

EUMETSAT has incorporated a DWL in their post-EPS concept with high priority. User-related missions, discussed in the post-EPS time-frame, may not necessarily be implemented by only one agency. Moreover, in the WMO Space Program proposals for follow-on DWL missions from contributing space agencies are solicited through CGMS. Some participants suggested a joint European/US approach to post-ADM DWLs. The American, European, and Asian DWL efforts could be strengthened through closer cooperation between the relevant executive bodies.

SWIFT, if launched in 2010, would provide complementary data to ADM-Aeolus as it would measure stratospheric winds vectors between 20 and 45 km.

## Recommendations

It was **recommended**

- To establish a plan for comprehensive research beyond the end of life of ADM-Aeolus to make optimal use of the data. This would include e.g. B-matrix, cloud dynamics, vertical and horizontal sampling.

- To establish contacts with relevant expert bodies, such as the working group on convection within the GEWEX Cloud System Studies (GCSS) and the Working Group on Numerical Experimentation (WGNE).

- To investigate the performance of ADM-Aeolus with state-of-the-art assimilation systems based on presently available observations. This might also be advisable for follow-on missions using OSSE's.

- For ESA to formally commit to make data from ADM-Aeolus available to WMO member states. WMO would then seek support to reduce data latency.

- For ESA to educate potential users in WMO member states on ADM-Aeolus data and products pre-launch.

- To make data available to NWP groups as soon as possible after launch and commissioning.

- To urgently select the ADM-Aeolus validation science steering group, one of the major tasks being the development of a validation plan.

- To rely on previous new instrument validation efforts (i.e., LITE, CALIPSO) and benefit from the "lessons learned".

- To present ADM-Aeolus issues including follow-on and data latency at the next EUMETSAT Science Working Group (SWG) of the STG (Scientific & Technical Group) scheduled for March 2007.

- To closer cooperate with laser and impact analysing scientists outside Europe.

WCRP welcomes the promotion of research studies on ADM-Aeolus by ESA.

GCOS had previously formally recommended an early planning of an ADM-Aeolus follow-on mission.

The wishes expressed by WMO/WCRP/GCOS suggest to start preparations for an early follow-on.

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