The Development and Simulation of Doppler Wind Lidar Measurements and Assimilation Methodologies in Preparation for ADM-Aeolus and 3D-Winds

W. McCarty, R. Errico, M. McGill, R. Yang, R. Gelaro, and M. Rieneker

Introduction

• The next generation of remotely sensed observations will include measurements from spaceborne doppler wind lidars.

• In its decadal survey, NASA presented the 3D-Winds demonstration mission as a Tier-3 mission aiming for dual-components line of sight (LOS) winds

• The European Space Agency Atmospheric Dynamics Mission (ADM) Aeolus mission will predate any NASA mission, providing single component LOS wind measurements from both molecular and aerosol backscatter

• This study demonstrates efforts being performed at the GMAO to both simulate the 3D-Winds system as well as prepare the GSI analysis system for LOS wind assimilation

Measurement Simulation

• Efforts are currently underway at the GMAO to simulate observations from the Joint OSSE system

• Currently, the infrastructure to simulate individual LOS measurements from the Nature Run is under development

• As a first step, a data set with no addition of error and crude assessment of cloud structure has been generated using an ADM-like orbit

• The GSI has been updated to properly read and assimilate these Level-2 measurements

• The proper simulation of these measurements requires the realistic characterization of clouds and aerosols in the Nature Run

  • Clouds exist as part of the run, though the realism of their distribution will need to be considered for realistic observation simulation and throughput

  • Aerosols do not exist inherently within the Nature Run, but efforts are underway at the GMAO (A. da Silva) to replay the nature run locally with aerosol emission sources and transport to create a four-dimensional characterization of the aerosol state

Future Work

• These initial steps will provide the infrastructre to instrument simulators, both in-house for 3D-Winds OSSE studies as well as ADM potentially.

  • The proper utilization of the data fields from the nature run as well as the Aerosol NR replay are essential for generating realistic observations

• The preparation of the GSI to handle LOS observations is essential for ADM, which will only measure a single component, and for 3D-Winds simulations, as the multi-component retrievals would be correlated if projected to u and v

• Properly characterizing the measurement yield and associated errors are essential to the proper preparation for spaceborne DWL observations

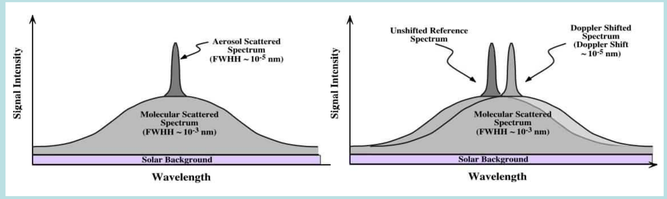
• As an active instrument, ADM will have a relatively short (~3 year) lifespan due to predictable battery life.

• Even though ADM is not considered operational, it has potentially high impact

• Therefore, the proper procedures in development in this work are essential to the exploitation of ADM, both as a risk-reduction activity for future DWL systems as well as to exploit the full capability of the observations during its active lifespan.

Doppler Wind Lidar Theory

• Line of sight wind measurements are determined by measuring the doppler shift of a backscattered signal of an active lidar system



• Error in the wind retrieval is a function of the measured backscatter intensity

• For molecular backscatter, the retrieval error is a function of atmospheric density, with accuracy peaking in the mid-troposphere

• For aerosol backscatter, the retrieval error is at a minimum in the presence of a scattering agent, typically near the top of clouds or an aerosol layer

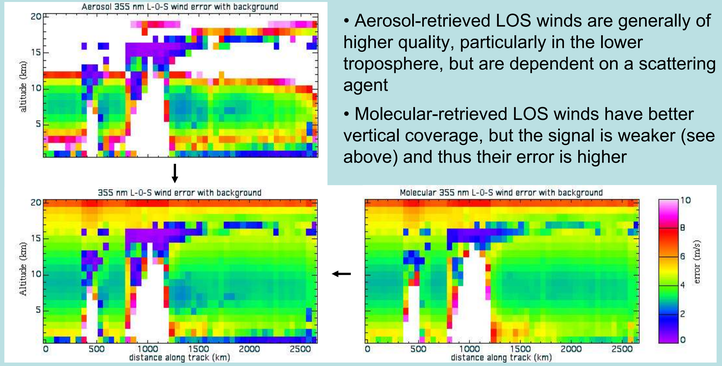
• Boundary layer aerosols result in more accurate measurements of near-surface winds

• Signal attenuation is also of concern, though, as optically thick clouds will typically result in inadequate signal measured near the surface for a successful retrieval

  • Lower tropospheric retrieval yield can be a function of Instrument design (direct versus coherent measurement techniques)

  • Efforts are being made at Goddard (S. Braun) using CALPISO data to determine the likelihood of backscatter retrievals down to the surface

• The estimated error of simulated LOS wind observations is shown below



• Aerosol-retrieved LOS winds are generally of higher quality, particularly in the lower troposphere, but are dependent on a scattering agent

• Molecular-retrieved LOS winds have better vertical coverage, but the signal is weaker (see above) and thus their error is higher

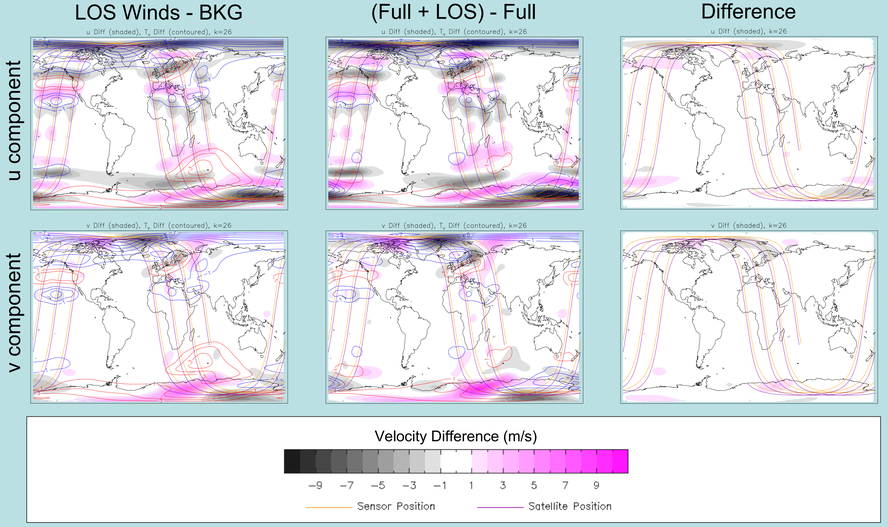
Assimilation Status

• The horizontal LOS operator within the GSI has been developed and tested. Single HLOS observation adjustments, not shown, are consistent with single wind observation impacts.

• The infrastructure to simulate “Level 2” observations from the Joint OSSE nature run in undergoing development and testing

  • A simulated “ADM-like” orbit (~400 km) has been generated using the STK system, with an off-nadir looking instrument with a 45° elevation angle (ADM will actually be 35°) and 90° azimuth angle relative to the satellite’s path

  • The current setup allows easy modification to account for multiple angles/LOS measurements from the same platform



• Above, the analysis increments of u, v, and T_v in an assimilation considering only the LOS winds derived from the Nature run (left). Increments to the temperature field are in line with what was seen in the single observation experiments (not shown).

  • The changes in the wind field are primarily in u towards the equator, in line with the viewing geometry

  • As the simulated instrument approaches the poles, the LOS observations become a more-balanced function of both u and v.

• Also shown is the difference between a full assimilation, utilizing simulated conventional and radiance observations, and that considering the LOS winds in addition to the full stream (center) as well as the difference between the full system and the LOS-only system (right)