Recent results from feasibility study of space-based Doppler Wind Lidar in Japan

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Abstract: Global wind profiling is important to improve initial conditions for numerical weather prediction or general circulation model. A working group for a future space-based DWL mission is studying a future space-based coherent DWL. NICT developed an end-to-end comprehensive simulator for wind measurement from space called ISOSIM-L (Integrated Satellite Observation SIMulator for a space-based coherent Doppler Lidar) in order to study measurement performances of a space-based Doppler lidar. Retrieved LOS wind data simulated by the ISOSIM-L are used for an Observing System Simulation Experiment (OSSE) system to investigate potential impacts on the numerical weather prediction. In the paper, we present recent results from feasibility study of space-based Doppler Wind Lidar with using the ISOSM-L and OSSE.

1. Introduction

Improvements of numerical weather prediction (NWP) is important for severe weather-related disaster prevention. Global wind profile observation is crucial to significantly improve the initial conditions essential for NWP, and various meteorological studies. Wind is one of the fundamental meteorological variables describing the atmospheric state, but current space-borne observing systems are biased to water-vapor- and temperature-related measurements in comparison with wind measurements (Baker et al. 2014). The World Meteorological Organization (WMO) Integrated Global Observing system technical report (WMO, 2012) states, "Development of satellite-based wind profiling systems remains a priority for the future global observing system.". Wind profiles are provided mainly by radiosonde networks and also by aircraft measurements. The radiosonde measurement is mainly performed over populated regions in the northern hemisphere (NH) but not in the southern hemisphere (SH). The number of weather stations observing the upper atmosphere has been decreasing. A lack of wind observations over oceans, SH, and other sparse areas causes non-uniform errors in NWP and subsequent analysis. Space-based wind profiling system with high vertical resolution, low bias, and high precision is necessary to fill the gap of current observations. The European Space Agency is planning to launch the first space-based Doppler Wind Lidar named ADM-Aeolus for obtaining global wind profiles (Stoffelen et al. 2005). The current target year of the launch is 2017. It will provide profiles of line-of-sight (LOS) wind speed.

In light of these circumstances, a working group for a future space-based DWL mission was organized in Japan in 2011 to discuss a space-based coherent DWL (CDWL) for vector wind measurement. The National Institute of Information and Communications Technology developed an end-to-end comprehensive simulator for wind measurement from space called ISOSIM-L (Integrated Satellite

Observation SIMulator for a space-based coherent Doppler Lidar) in order to study measurement performances of a space-based Doppler lidar (Ishii et al., 2016). ISOSIM-L uses a pseudo-truth atmospheric field created from Sensitivity Observing System Experiment (SOSE) (Marseille et al., 2008) and aerosol field computes backscattered signal, and then retrieves a line of sight (LOS) wind speed. Retrieved line-of-sight wind data simulated by the ISOSIM-L are used for an Observing System Simulation Experiment (OSSE) system based on the SOSE (hereafter, SOSE-OSSE, Ishibashi 2014) to quantitatively assess potential impacts on NWP. Numerical simulation flow from the ISOSIM-L to the SOSE-OSSE is shown in Fig.1. Recent results from feasibility study will be presented in this paper.

2. Lidar simulator

The ISOSIM-L is an end-to-end comprehensive simulator for wind measurement from space. It has been developed at NICT. It simulates each shot and each range gate backscattered power, signal-to-noise ratio (SNR), line-of-sight (LOS) wind speed, and LOS wind speed error. First objective in the development of the ISOSIM-L is to study performances of a space-based CDWL. Trade-off studies are very important to realize a space-based mission. Second objective is to evaluate the random error, sampling produced by laser beam and the configuration of the receiver, and bias in a non-turbulent atmosphere and in a turbulent atmosphere. Third objective is to collaborate with other universities and research institutes to combine results simulated using the ISOSIM-L with SOSE-OSSE. An example of down-looking observation geometry using two telescopes for measuring two orthogonal components of the horizontal winds in the same horizontal air slab is show in Fig. 2. Retrieval simulations have been conducted using ISOSIM-L for 1 month during 1-31 August, 2010. The percentage of good quality estimates is 40% at an altitude of <8 km. The percentage of good quality estimates at 8-20 km in the NH and SH is 20-50% and 10 %, respectively (Ishii et al., 2016).

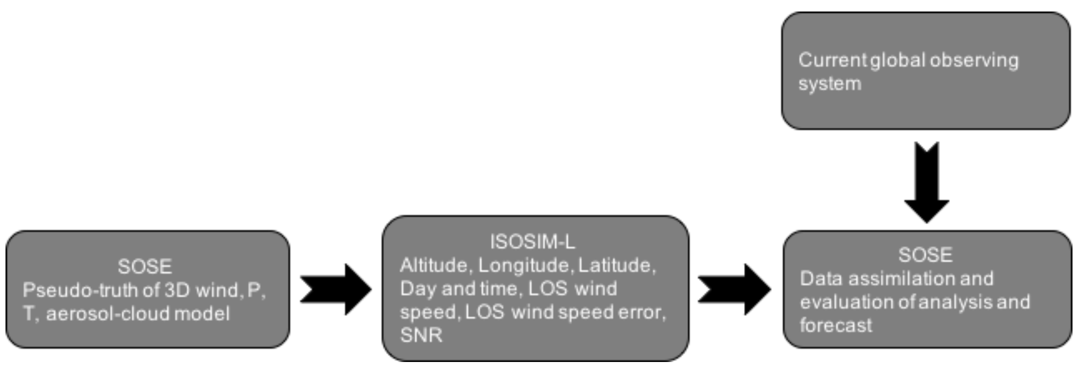

Figure 1. Numerical simulation flow from space-borne CDWL lidar simulator to

3. Potential impact on NWP

The SOSE-OSSE system is developed at the Meteorological Research Institute (MRI) using the global NWP system of Japan Meteorological Agency (JMA 2013). Pseudo-truth atmospheric field created by SOSE is used for ISOSIM-L simulations described in section 3. Preliminary results of one-month assimilation experiments using the SOSE-OSSE on polar orbit and low-inclination angle orbit showed positive impacts on short-range forecasts on wind speed at pressures of 850 and 250 hPa. We are conducting the assimilation experiments to perform robust impact studies.

4. Summary

A full-fledged lidar simulator was developed to study performances of a space-based CDWL. It is used for the feasibility and trade-off studies of the future space-based CDWL mission. The SOSE-OSSE is a useful tool to quantitatively assess potential impacts on NWP. Assimilation experiments are conducting at MRI. We will implement the simulations of space-based CDWL lidar and assimilation experiments in different seasons to investigate robust impacts.

5. Acknowledgements

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6. References

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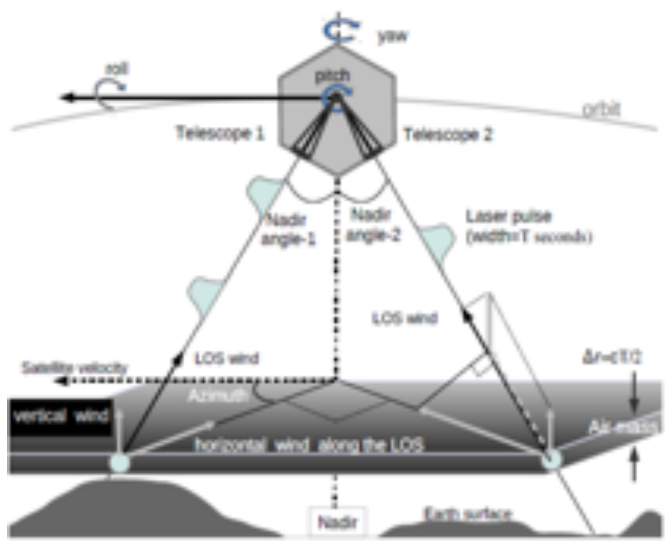

Figure 2. Down-looking observation geometry using two telescopes