

Integration of data from dust aerosol profiles from EARLINET/ACTRIS lidar observations and DREAM dust model (IDEAL-DREAM)

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Introduction and motivation

Benefit in using lidar data in dust modeling is important for two main reasons: (1) they provide vertical distribution of the dust concentration, which is useful in model verification, and (2) when assimilated in the initial field of the model forecast, they could improve dust forecast.

Scientific objectives

Passive ground-based (e.g., AERONET) or space-borne observations (e.g. MODIS, MISR or OMI) have been used to evaluate the 2D distribution of particles, but the vertical distribution cannot be evaluated using these observations. The vertical distribution of aerosol is of particular importance because it is a combined signature of atmospheric transport patterns, residence times in the atmosphere, and the efficiency of the vertical exchange. Lidar techniques are capable of identifying, locating, and characterizing aerosols in the vertical. Only recently, lidar-based dust profiling (from e.g. EARLINET, CALIPSO) started to be used to validate simulated dust vertical structure and/or to assimilate such observations in dust models.

Beside distribution of the dust sources and atmospheric dust driving parameters, dust models do not have available any other input information related to the dust transport. Common approach is that initial field of dust concentration for the model run is inherited from the previous dust forecast. Following the same methodology as in weather forecast, dust field should be initialized using available measurements of atmospheric dust concentrations. Version of the coupled atmospheric-dust model NMM-DREAM, which is operational in RHMSS/SEEVCCC and is a part of the WMO SDS-WAS intercomparison project, uses dust analysis from MACC/ECMWF project for assimilation of MODIS AOD data in order to improve initial field of dust concentration. Adding lidar data in assimilation process will provide information about observed vertical distribution of the dust concentration in order to improve initial field for the dust forecast.

Reason for choosing station

CIAO infrastructure provides the unique combination of instrumental synergy for dust monitoring and characterization plus the expertise about dust model vs. observation comparison. During the TNA access to CIAO, the visiting scientist had the opportunity to visit the atmospheric observatory and to discuss with all the CIAO personnel. The visiting scientist gained knowledge about the different instruments capabilities accessing the infrastructure. Open discussion with all the CIAO personnel allowed on the other side to explore many synergy/integration possibilities in the wide field of observation-model a combined approach.

Method and experimental set-up

The purpose of this project was to provide a basis for performing systematic long-term comparison of dust profiles from EARLINET stations and the DREAM dust model, extending so the initial study of Mona et al. (2013) lidar/model comparison. The applicant from Belgrade (Serbia) modeling group visited Potenza for one week and worked with the CNR/IMAA group. During the project scientist presented their knowledge and experience in dust modeling and in use of lidar observations, and defined tasks for the future collaboration. Collaborators agreed on principles for collection and formatting data from the model and observation for long-term comparison and analysis, and selected special observed cases for future modeling case studies, which will include introduction of lidar data in assimilation process. DREAM model simulation will be performed for the period 2010-2013, for the North Africa – Europe region (12N-68N; 17W-47E) resolution 1/5 degrees. Dream forecast will be done once per day at 00UTC initial time for 24h, using ECMWF initial and boundary conditions for the atmospheric model. DREAM will inherit the dust

concentration at 00UTC from the previous forecast, which will provide continuous dust concentration results over the 4 years period. Output results, available on every 3h for the whole period, will be interpolated in the sites with observations in horizontal, and on every 100m altitude, beginning from sea level to 12km, in vertical. Interpolated data will be prepared in ascii format. For the purpose of assimilation of lidar data into the initial dust concentration field for the model run are selected two cases, 5-11 April 2011 and 9-12 July 2012, with substantial dust transport over the Europe region. In the next period, for selected cases simulations will be done with and without assimilated lidar data in the initial dust field for the model run. Verification of the results will provide information of the potential benefit of the lidar data use for improvement of the dust forecast, by improving initial 3D dust field.

Preliminary results and conclusions

During the project dust modeling and lidar observation groups defined tasks for future collaboration. The most recent DREAM version, which ran operationally at SEEVCCC of the Serbian Hydrometeorological Service, is used for historical long-term simulations. This model version also includes, in addition of dust concentration as a tracer, fractions of major mineral groups' characteristic for the Saharan deserts, as well (Nickovic et al, 2012; Nickovic et al, 2013). These data will be used for the evaluation and integration with EARLINET data. For selected cases with increased dust transport from Sahara to Europe, and available lidar observations, special modeling tests will be done. Lidar data will be assimilated in the dust concentration initial field for the dust forecast, and quality of forecast will be compared with regular model set-up. Open discussions between modeling and lidar group during the visit raised new topic for the future research – ice formation during the dust events. It is decided to select cases from the lidar data with formation of the clouds with present atmospheric dust, and modeling group will introduce component for ice particle formation on the dust particles in the DREAM, using both DeMott et al. (2012) and Niemand et al. (2012) empirical parameterizations.

Outcome and future studies

Project initialized collaboration between DREAM modeling group from Belgrade and CIAO lidar group from Potenza, and enabled future work on improving quality of dust forecast using lidar observations. The Belgrade modeling group is already finalizing a 4 year dust model simulation of dust profiles in selected EARLINET sites. In collaboration with the CNR/IMAA group, preliminary results of the model-lidar comparison will be presented in the coming ACTRIS annual meeting in 2014. Also, results will be reported at the International Conference on Atmospheric Dust (DUST 2014) to be held in Italy, June 1 - 6, 2014. In collaboration with CIAO personnel, further analysis about lidar data assimilation, and ice nucleation in presence of Saharan dust events will be carried out. Results of these studies will be reported in a future publication.

References

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