COMPARISON OF AVERAGED EXTINCTION PROFILES FROM CALIPSO AND BSC-DREAM8B DUST MODEL OVER GREECE

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ABSTRACT

In this paper, the averaged extinction profiles of Saharan dust as simulated by the BSC-DREAM8b dust modeling system for two years (2008-2009), are evaluated over eleven locations in Greece using active remote sensing observations from CALIPSO. The mean extinction profiles simulated by BSC-DREAM8b are in good agreement with the mean extinction profile retrievals from CALIPSO measurements in the free troposphere, with a tendency of CALIPSO to underestimate the extinction in the PBL.

1. INTRODUCTION

The Mediterranean area is strongly affected by the presence of desert dust due to its proximity to North Africa. Limitations on the description of the dust cycle are mainly related to the lack of enough dense and regular measurements, but also due to the incomplete understanding of dust processes such as production, transport, physical and chemical evolution, optical properties and removal of dust [1]. Several regional models for simulation and prediction of the atmospheric dust cycle have been developed over the past decade [e.g.2]. These models are essential to complement dust-related observations and to understand the dust cycle. In this context, the BSC Dust Regional Atmospheric Model (BSC-DREAM8b) has reached a level of delivering reliable operational dust forecasts (http://www.bsc.es/projects/earthscience/DREAM/) capable of predicting all the major dust events over the Mediterranean region [3].

In order to implement new model versions for operational applications there is a need for extensive checking and validation with observations. High resolution vertical profiling observations can be only achieved from ground-based and satellite lidar measurements. CALIOP (Cloud-Aerosol LIdar with Orthogonal Polarization) onboard the NASA/CNRS CALIPSO satellite provides a first opportunity to study in detail the performance and the scientific value of a space-borne aerosol lidar during a long term mission. CALIOP lidar onboard CALIPSO, provides information on the vertical distribution of aerosols and clouds as well as on their optical properties over the globe with unprecedented spatial resolution [4].

In this study, the mean extinction profile of dust, as estimated by the BSC-DREAM8b dust modeling system for two years (2008-2009), is validated over eleven locations in Greece using active remote sensing observations from CALIPSO. The comparison is focused on pure dust observations of CALIPSO retrievals, in order to avoid the impact of “clean air” occurrences.

The main objective of the study is to present a validation method for the dust optical properties simulated by BSC-DREAM8b, using active remote sensing techniques from space. The driving force behind this study is the fact that aerosols over Greece originate from different sources, including a mineral dust component mainly due to the proximity to North African deserts, an anthropogenic component (local and long-range pollution), and a marine component (mainly sea spray) [5], making the model evaluation from ground-based or space observations a challenging task. Using the extinction profiles of pure dust cases from CALIPSO, the BSC-DREAM8b extinction profiles validation can become more quantitative and accurate.

2. METHODOLOGY

3.1. Satellite measurements

The Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) mission (http://www-calipso.larc.nasa.gov/), is an Earth Science observation mission that launched on April 28, 2006 and flies in nominal orbital altitude of 705 km and an inclination of 98 degrees as part of a constellation of Earth-observing satellites known as the "A-train". The CALIPSO mission provides crucial lidar and passive sensors to obtain unique data on aerosol and cloud vertical structure and optical properties. CALIPSO is an elastically backscattered lidar operating at 532 and 1064 nm, equipped with a depolarization channel at 532 nm, providing high-resolution vertical profiles of aerosols and clouds [6].

The Level 2 V3.01 (Version 3.01) extinction profile product is used in this paper, screened according to the Level 3 V1.00 CALIPSO's Quality Statements release (http://eosweb.larc.nasa.gov/PRODOCS/calipso/Quality_Summaries/CALIOP_L3AProProducts_1-00.html). Figure 1 shows the eleven locations used for the comparison and the 1x1 degree spatial cells used for the CALIPSO retrievals.

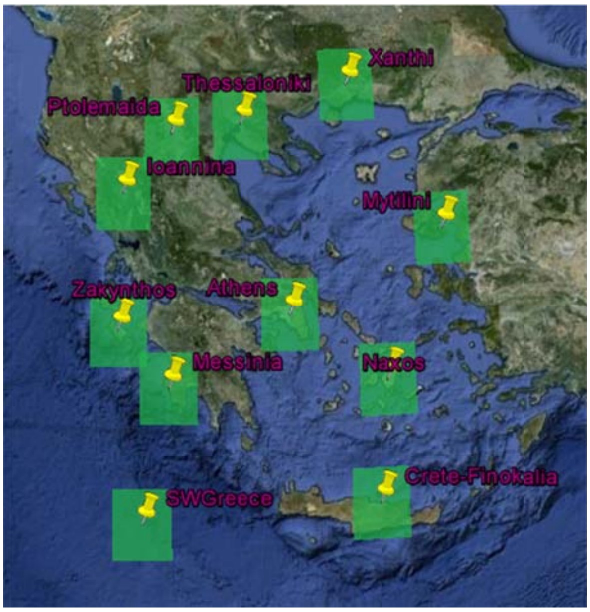

Figure 1. The 11 chosen locations over Greece and the 1x1 degree spatial cells used for the CALIPSO retrievals.

Figure 2 shows the percentage of pure dust occurrences for CALIPSO used in the analysis, for each of the 11 locations in Greece (with the stations of Ioannina, Ptolemaida, Thessaloniki and Xanthi at the north, Zakynthos Messinia Athens and SWGreece in the south-west and Mytilini, Naxos, and Finokalia in Crete in the south-east of the country). The numbers in the parentheses are the total profiles acquired from the 2 years (2008-2009) CALIPSO overpasses.

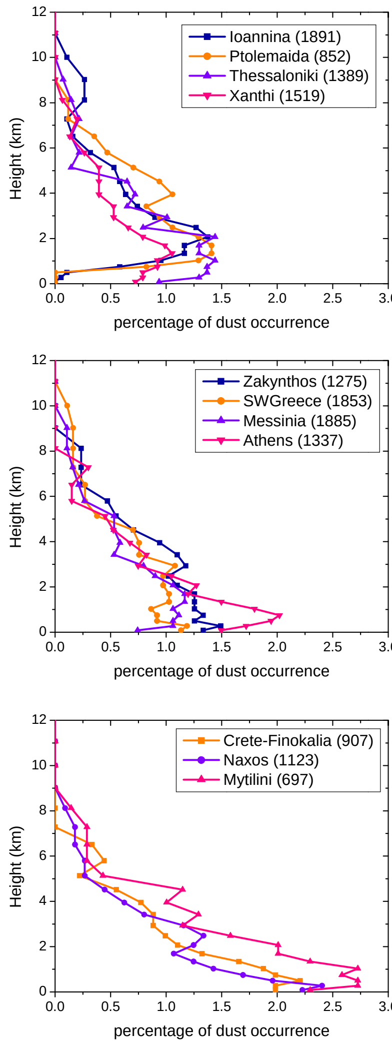

Figure 2. "Dust" recordings on CALIPSO data examined over 11 locations in Greece during the time period 2008-2009 (in parentheses the total number CALIPSO profiles used are denoted).

3.2. The BSC-DREAM8b model

BSC-DREAM8b [3] is a regional model designed to simulate and/or predict the atmospheric cycle of mineral dust aerosol. The Barcelona Supercomputing Center maintains dust forecast operations with BSC-DREAM8b and conducts modeling research and developments for short-term prediction (currently at www.bsc.es/projects/earthscience/DREAM/). During model integration, calculation of the surface dust injection fluxes is made over the model grid points declared as deserts. Once injected into the air, dust aerosol is driven by the atmospheric model variables: by turbulent parameters in the early stage of the process when dust is lifted from the ground to the upper levels;

by model winds in the later phases of the process when dust travels away from the sources; finally, by thermodynamic processes (atmospheric water phase changes producing clouds, rain and dust wet scavenging) of the atmospheric model and land cover features which provide wet and dry deposition of dust over the Earth surface.

The main features of BSC-DREAM8b, described in [3], are a source function based on the arid and semi-arid categories of the 1 km USGS land use data set, 8 size bins within the 0.1 – 10 μm radius range according to [7] are used to describe the size distribution of dust and dust radiative feedbacks [3].

For the present study, a dust simulation of the BSC-DREAM8b model is used for the period between 1 January 2008 and 31 December 2009 over Northern Africa, the Mediterranean and the Middle East. The initial state of the dust concentration in the model is defined by the 24-hour forecast from the previous-day model run because there are not yet satisfactory three dimensional dust concentration observations to be assimilated. Only in the "cold start" of the model on 23 December 2009 is the concentration set to zero permitting the model several days before the dust event started to spin-up the concentration. The Final Analyses of the National Centers of Environmental Prediction (FNL/NCEP; at 1° x 1°) at 0 UTC are used as initial meteorological conditions and boundary conditions at intervals of 6 hours. The resolution is set to 1/3° (~50 km) in the horizontal and to 24 layers extending up to approximately 15 km in the vertical.

The domain of simulation covers the whole extent of Greece.

3. RESULTS AND DISCUSSION

3.1. Evaluation of BSC-DREAM8b mean vertical extinction profile

In Figure 3, we present the intercomparison of the modelled two-year mean vertical profiles of extinction at 550 nm, with the two-year mean vertical profiles of extinction at 532 nm retrieved from CALIPSO observations, classified as pure dust, for the six of the eleven locations under study, with focus only in the days of dust recordings according to CALIPSO aerosol classification scheme. The model seems to follow well the vertical distribution of the dust optical properties for the free troposphere (heights greater than 2km). Within the PBL, CALIPSO indicates a dust contribution much higher than that of BSC-DREAM8b.

The agreement between lidar and model results in the free troposphere could be considered as very good, except for Athens and Thessaloniki sites where CALIPSO underestimates BSC-DREAM8b's simulations. Large differences are observed for almost all of the sites at the PBL. This is maybe attributed to the fact that CALIPSO's classification algorithm attributes as "dust" all the aerosol particles with large depolarization ratios. Thus, anthropogenic activities that produce dust near the surface are not excluded from the calculated profiles from CALIPSO.

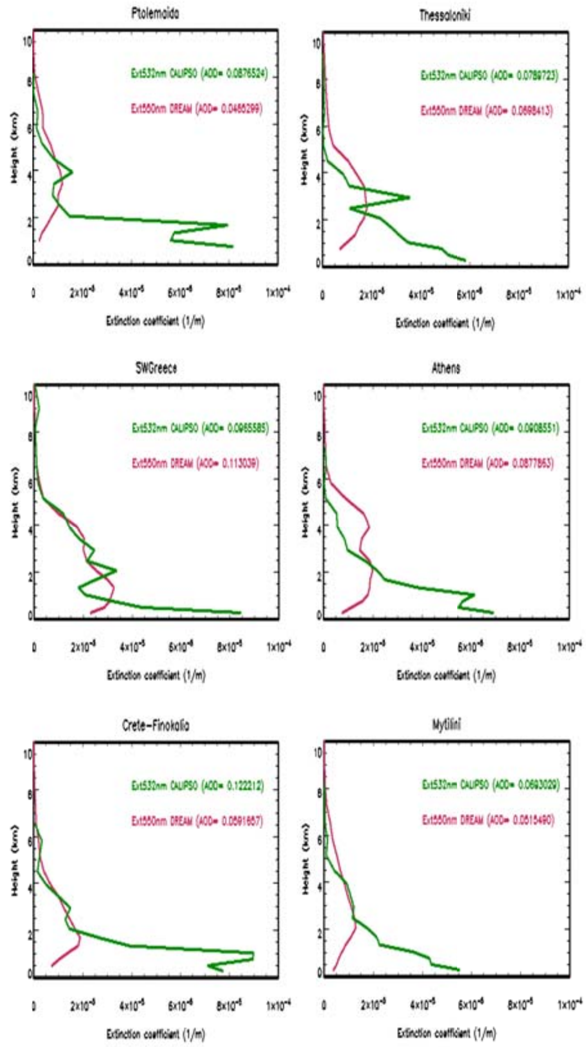

Figure 3. Comparison of the two-year averaged extinction profiles simulated by BCS-DREAM8b (red), with the two-year averaged extinction profile retrieved from CALIPSO observations for cases classified as "dust" (green), over six of the eleven locations examined over Greece.

3.2. Validation of BSC-DREAM8b mean AOD

Model's capability to estimate the dust layer optical characteristics, is further evaluated by the calculation of the two-year mean AOD for each location at 550 nm estimated by BSC-DREAM8b and its comparison with the corresponding AOD retrieved from CALIPSO at 532 nm (Figures 4a,b), only for dust cases. The mean AOD (derived from the mean AODs of each of the days used) in figure 4a reports to the AOD of the column from the first 180m up to 15km (as the first 180m of CALIPSO's retrievals is not to be trusted according to CALIPSO's quality summaries) while in figure 4b reports to the AOD only for the free troposphere from 2km up to 15km.

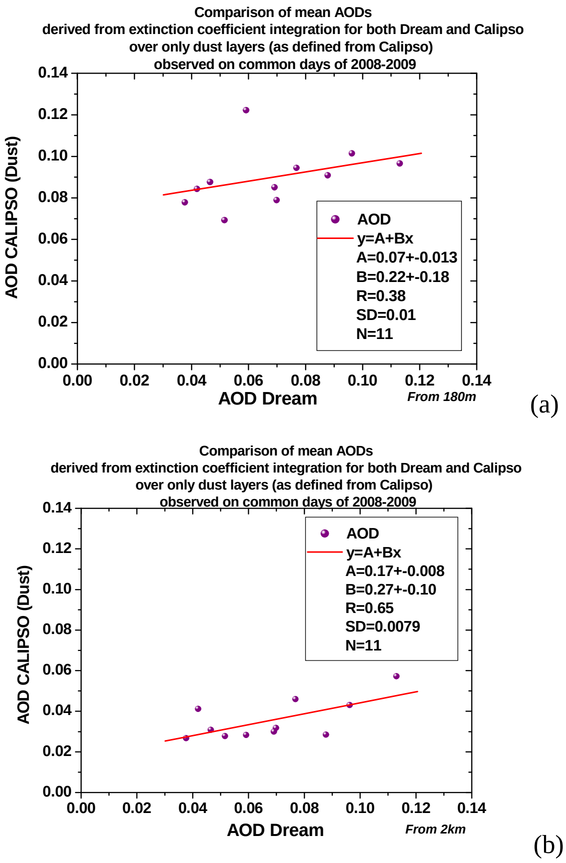

Figure 4. Comparison of two-year mean AOD at 550 nm estimated by BSC-DREAM8b, with the two-year mean AOD at 532 nm retrieved from CALIPSO observations, for eleven locations in Greece (a) from 180m up to 15km and (b) from 2km up to 15km.

4. SUMMARY AND CONCLUSIONS

The mean BSC-DREAM8b extinction profile and AOD at 550 nm were compared with the corresponding mean extinction profile and AOD at 532 nm retrieved from CALIPSO observations, for eleven stations in Greece during the period of 2008-2009. The mean extinction profiles simulated by BSC-DREAM8b are in good agreement with the mean extinction profile retrievals from CALIPSO measurements in the free troposphere, with a tendency to underestimate the extinction in the PBL. Future work will include an in-depth analysis on the differences observed, using datasets covering greater time periods.

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