Progress in COSP LIDAR Simulator Development using ALADIN dataset and Prospective Applications for ATLID

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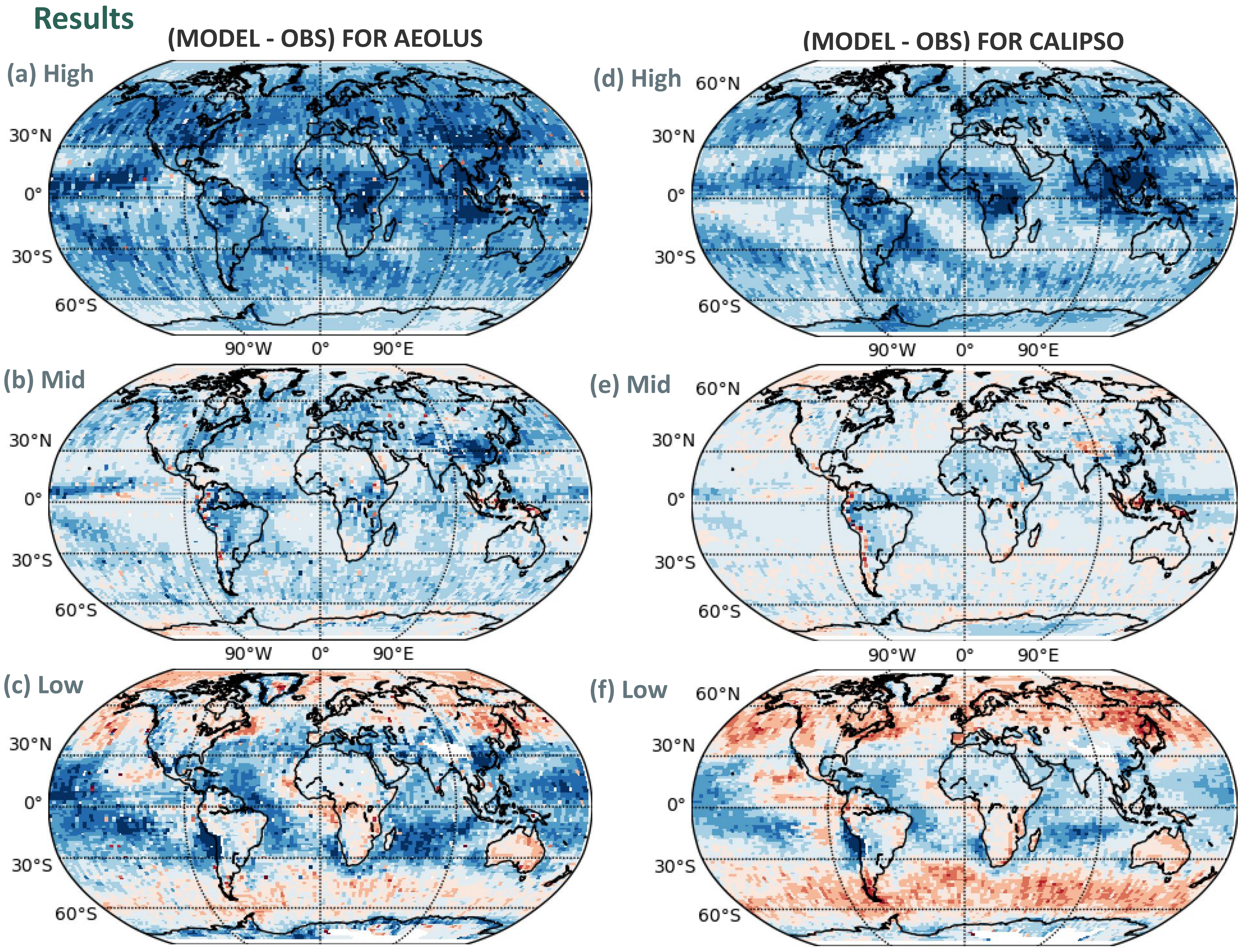
Introduction

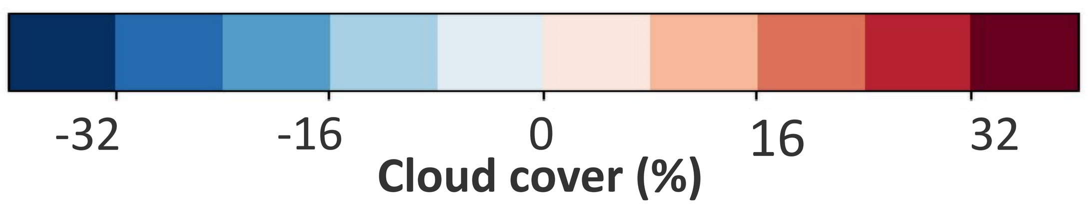
Evaluating clouds in models using observations is complex : discrepancies due to cloud definitions, model resolutions and spaceborne instruments configurations are significant. Using a tool like COSP (CFMIP Observation Simulator Package – Bodas-Salcedo et al. 2011, Swales et al. 2018) helps overcome these challenges. It replicates the measurements as they would have been made by the instrument above the atmosphere modelled.

Building on previous work for CALIPSO's LiDAR (CALIOP) (Chepfer et al. 2008, Bonazzola et al. 2023), we have updated the COSP algorithm to enhance the simulator's capabilities for the 355nm Doppler LiDAR onboard AEOLUS (ALADIN) from 2018 to 2023. This new work allows for long-term simulations of cloud measurements from various spaceborne instruments and further evaluations of the cloud description in CMIP models and multi-model analysis (Cesana et al. 2012, Konsta et al. 2022). These developments will also benefit the routine dedicated to the EarthCARE LiDAR (ATLID) due to their shared characteristics (355 nm, HSRL) (Reverdy et al. 2015, Feofilov et al. 2023).

Results



Absolute difference between simulated and observed cloud covers at **(a,d)** high (8-18km) **(b,e)** mid (4-8km) and **(c,f)** low (0-4km) levels. Model for AEOLUS means LMDZ+COSP/AEOLUS simulations. Model for CALIPSO means LMDZ+COSP/CALIPSO simulations. Negative value implies under-estimation by the model.



LMDZ underestimates cloud cover at all levels and on a global scale compared to AEOLUS measurements and also compared to CALIPSO measurements.

Despite a smaller global bias for low cloud (1 to 8% under-estimation), specific regions as the Warm pool and Indian ocean have significant bias in LMDZ (more than 10% and up to 29% under-estimation).

Absolute difference of cloud cover (global mean)	MODEL - OBS AEOLUS	MODEL - OBS CALIPSO	OBS AEOLUS - OBS CALIPSO
High	-19	-16	3
Mid	-9	-3	5
Low	-8	-1	7

Stratocumulus regions are best represented than Cumulus regions in LMDZ at low levels.

Materials and methods

Our new developments consist of a COSPv2 module specific to AEOLUS (**COSP/AEOLUS**). Its cloud component is similar to the historical one for CALIPSO (**COSP/CALIPSO**) but it takes into account the 35° inclination and 355 nm wavelength. A routine to simulate the winds measured by ALADIN, containing a cloud mask (based on the algorithm developed for aerosols by Bonazzola et al. 2023) has also been added.

Modeling data used as input in the simulator (**LMDZ+COSP**) are coming from daily 2008 outputs of the LMDZ climate model in CMIP6-amip configuration.

AEOLUS (Titus et al. in preparation) and CALIPSO (Chepfer et al. 2009) measurements are used respectively for 2020 and 2008.

Conclusions & Future work

LMDZ under-estimates cloud-cover with respect to AEOLUS measurements, consistently with the CALIPSO comparisons done here (also with previous studies: Madeleine et al. 2020). This bias is large enough to make up for differences between the two LiDARs, supporting the use of AEOLUS as an alternative to CALIPSO for cloud evaluation in models.

A more detailed analysis of the impact of the detection threshold and horizontal resolution used for clouds in COSP/AEOLUS (which also differs from that used for CALIPSO) on our results has to be conducted.

For AEOLUS, wind-cloud interactions will be studied and evaluated in models (Titus et al. in preparation) thanks to this preliminary work. For EarthCARE, the cloud component at 355 nm is functional in COSP and will be directly used in the routine for ATLID.

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Further information

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To access to CMIP6-LMDZ dataset:
https://esgf-node.ipsl.upmc.fr/
More information about COSP, and its algorithm:
https://www.cfmip.org/tools-and-data/cosp
https://github.com/CFMIP/COSPv2.0