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The contribution of EE-11 CAIRT candidate to clouds properties retrieval

Clouds are of great importance for climate studies. They strongly influence the Earth radiative budget, and the knowledge of their macro and microphysical properties is necessary for a correct modelling of their radiative effects. In this regard, limb sounding instruments can play an important role. Thanks to a high vertical resolution, limb observations allow to detect multiple layers cloud structures and the thinnest cirrus clouds, invisible to nadir instruments.

The Changing-Atmosphere InfraRed Tomography (CAIRT) is one of the two ESA EE-11 candidates. It is a limb-sounder imager designed to measure the atmospheric radiance across the thermal infrared spectral region from 4.55 μm to 13.93 μm, with a targeting resolution of 0.2 cm-1. Its main feature is the improved vertical and horizontal resolutions, achieved through a 2-dimensional array detector capable to simultaneously acquire an elevated number of spectra, with a nominal horizontal sampling of 50 by 50 km and a vertical sampling of 1 km.

Within the CAIRTEX project, observations of the Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA) [1], a prototype of CAIRT, acquired during the HEMERA 2022 balloon campaigns (Timmins, 23-24/08/22), have been used to test the feasibility of clouds properties retrievals from CAIRT observations. Limb emission radiances acquired by GLORIA showed contamination of two clouds at two different altitudes. Six vertically aligned spectra from the same vertical sequence, representative of the cloudy scenario, have been simultaneously fitted, and an effective cloud top altitude and thickness have been retrieved for each of the clouds considered. The use of more than one vertical sequence as would be for CAIRT, will enable to independently retrieve all the cloud geometrical extents [2].

A second study has been carried out within the PerReC project to explore the application of CAIRT observations for the detection of volcanic ash clouds [3]. The radiance field of a realistic volcanic eruption as observed by CAIRT and SEVIRI has been simulated [4, 5] and used for the retrieval of ash cloud thickness and columnar abundance, respectively. CAIRT simulated radiances have also been merged to SEVIRI simulation of the same scenario to estimate the ash concentration.

These two case studies demonstrate that CAIRT measurements contaminated by clouds can be exploited to retrieve clouds properties, enlarging the expected level 2 products of the mission.

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[2] Castelli, E., et al. “Retrieving cloud geometrical extents from MIPAS/ENVISAT measurements with a 2-D tomographic approach.” Optics Express 19.21 (2011): 20704-20721.

[3] Guerrieri, Lorenzo, et al. “Volcanic clouds characterization of the 2020–2022 sequence of Mt. Etna lava fountains using MSG-SEVIRI and products’cross-comparison.” Remote Sensing 15.8 (2023): 2055.

[4] Dinelli, Bianca Maria, et al. “GBB-Nadir and KLIMA: Two Full Physics Codes for the Computation of the Infrared Spectrum of the Planetary Radiation Escaping to Space.” Remote Sensing 15.10 (2023): 2532.

[5] Masiello, Guido, et al. “The new σ-IASI code for all sky radiative transfer calculations in the spectral range 10 to 2760 cm-1: σ-IASI/F2N.” Journal of Quantitative Spectroscopy and Radiative Transfer 312 (2024): 108814.

Topic

Upcoming Earth observation limb and occultation instruments

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