

Introduction

Vegetation fires emit important amounts of trace gases and aerosols in the atmosphere, which can be harmful for humans. For this reason, it is important to be able to predict the transport of dense fire plumes. Knowing the exact altitude of the plume is in particular crucial for dispersions models. The altitude also impacts the lifetime of the emitted species and therefore the formation of secondary pollutants along transport; in that respect it is a critical input to chemistry transport models.

The goal of this research is to obtain information on the altitude of emitted or transported fire plumes, using the information contained in the hyperspectral measurements of IASI, which has the advantage of a bidaily global coverage over active sounders, such as CALIPSO, or MISR, which are traditionally used for this purpose. We specifically exploit the carbon monoxide (CO) lines in the IASI spectra, as CO is one of the best tracer for fire plumes.

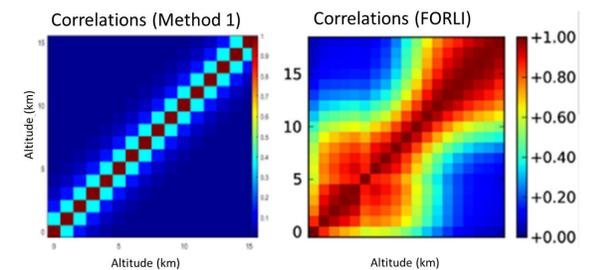


Method

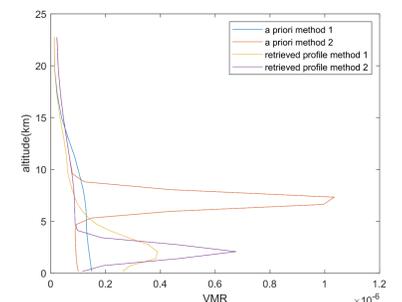
Vertical profiles of carbon monoxide (CO) are retrieved from IASI spectra in fire plumes with the maximum possible resolution in such a way to also estimate the plume altitude. To this end, we rely on the Optimal Estimation Method (OEM), which consists in fitting a calculated spectrum to the measured one iteratively, by putting constraints on the state of the atmosphere. Two separate methods using the OEM framework have, however, been developed and compared:

- In the first (*method 1* in the figures below), a traditional CO profile retrieval is achieved with the OEM but with constrain –introduced in the Sa covariance matrix– voluntary chosen to minimize the correlations between different altitudes.

The correlation matrix is shown here next and compared to that used for the operational CO retrievals with the FORLI software. With this method we assume that the altitude at which we find the maximum difference between the CO retrieved profile and the a priori corresponds to the fire plume height.

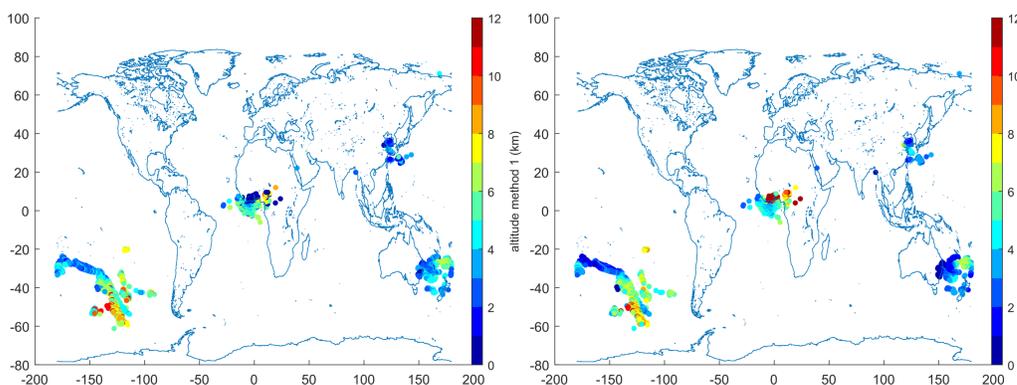


- In the second (*method 2*) we assume that the CO profile can be represented by a Gaussian on top of the background profile. In the retrieval only the altitude and the amplitude of the Gaussian are fitted.



Results

To investigate the advantages and drawbacks of the two methods, we have selected one day of IASI measurements where large fire plumes were observed over ocean (January 4, 2020); these mainly originate from Australia. Note that the CO profile retrievals have only been performed for pixels characterized by a CO total column (from FORLI processing) larger than 3.10^{18} molec/cm². The results of the 2 methods are shown below as spatial distribution of altitudes.

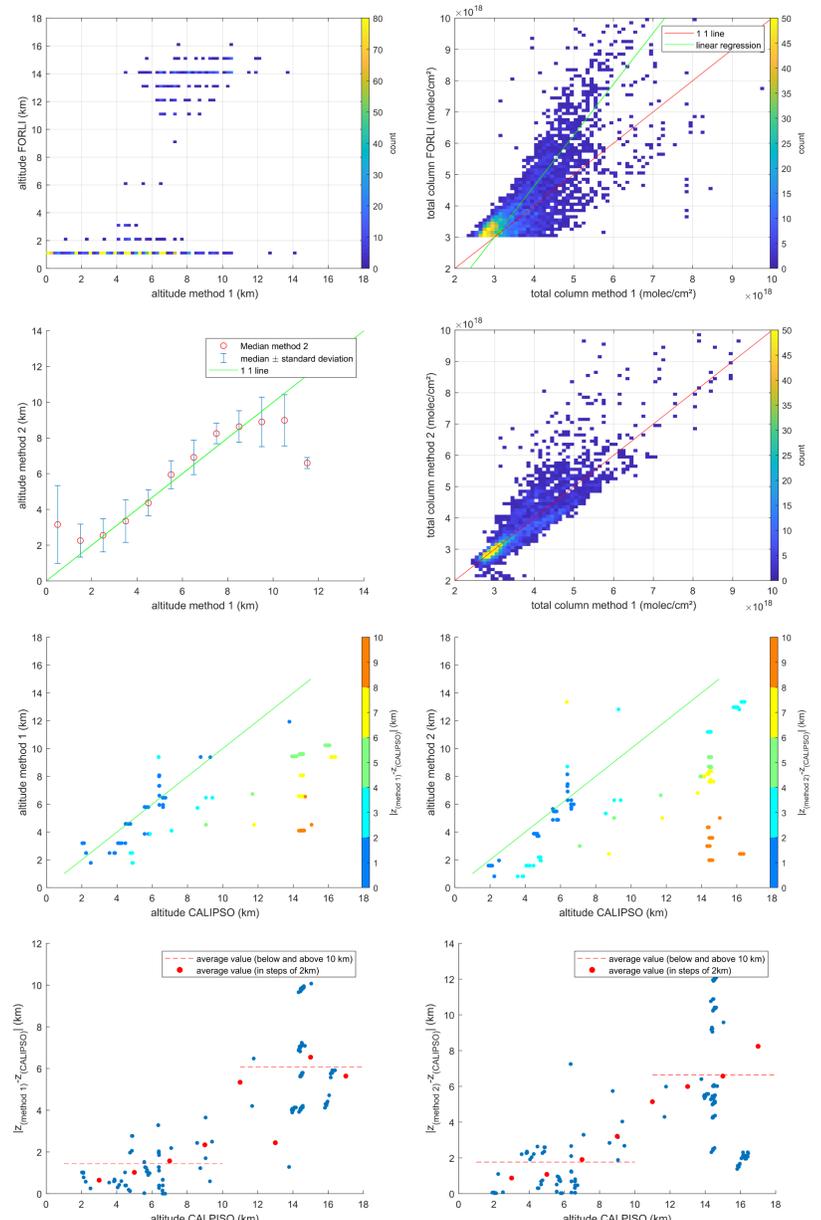


The Figures on the right compare the results in terms of CO columns and altitudes from:

- The two methods against one another
- The two methods against the operational FORLI processing

The results (Figures from the first row on the right) suggest that FORLI tends to overestimate the CO total column in the fire plumes and is mostly not capable of estimating consistently the plume height. Methods 1 and 2 are in good agreement (second row), both for the CO total column and the plume altitude.

In addition to the above, we have performed a first validation of the retrieved plume altitude by comparing these, whenever possible, to those from CALIPSO. The comparisons are shown on the right bottom (third and fourth row). A good agreement is found with CALIPSO (differences less than 2 km), with a slightly better results for method 1 for plumes below 10 km. For plumes found above 10 km by CALIPSO, however, our methods seem to provide less robustness.



References

1. D. Hurtmans, P. F. Coheur, C. Wespes, L. Clarisse, O. Scharf, C. Clerbaux, J. Hadji-Lazaro, M. George, and S. Turquety. FORLI radiative transfer and retrieval code for IASI. *Journal of Quantitative Spectroscopy and Radiative Transfer*, 113(11) : 1391–1408, jul 2012. doi : 10.1016/j.jqsrt.2012.02.036.