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Simultaneous physical retrieval of atmospheric and surface state from Martian spectra: the ϕ MARS algorithm and application to TES

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Abstract.

The problem of fully simultaneous retrieval of surface and atmosphere has been satisfactorily addressed as far as Earth is concerned in many works (Masiello et al. 2009; Carissimo et al. 2005), especially for high-resolution instruments. However, such retrieval know-how has been not completely implemented in other planetary contexts. In this perspective, we present a new methodology for the simultaneous retrieval of surface and atmospheric parameters of Mars. The methodology, fully explained in Liuzzi et al. (2015) is based on a non-linear, iterative optimal estimation scheme, supported by a statistical retrieval procedure used to initialize the physical retrieval algorithm with a reliable first guess of the atmospheric parameters. The forward module Liuzzi et al. (2014) is fully integrated with the inverse one, and it is a monochromatic radiative transfer model with the capability to calculate genuine analytical Jacobians of any desired geophysical parameter. We describe both the mathematical framework of the methodology and, as a proof of concept, its application to a large sample of data acquired by the Thermal Emission Spectrometer (TES). Results are drawn for the case of surface temperature and emissivity, atmospheric temperature profile, water vapour, dust and ice mixing ratios. Some work has also been done for revisiting the claims of methane detection with TES data (Fonti and Marzo 2010; Fonti et al. 2015). Comparison with climate models and other TES data analyses show a very good agreement and consistency. Moreover, we will show how the methodology can be applied to other instruments looking at Mars, simply customizing part of the forward and reverse modules.

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