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Retrieval of aerosol parameters from the oxygen A band in the presence of chlorophyll fluorescence

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Chlorophyll in terrestrial vegetation is known to exhibit fluorescence at wavelengths near the O_2 A band. Fluorescence emissions are spectrally smooth contributions to the upwelling radiance field at the surface. It has been argued that retrieval of aerosol parameters from the O_2 A band will be significantly biased if fluorescence emissions are ignored in the forward model (Frankenberg et al. 2011) —a finding which we have confirmed. In this study, however, we will show that aerosol parameters and fluorescence parameters can be independently retrieved from the O_2 A band.

Our approach is based on analysis of spectral derivatives. For various atmospheric states, observation geometries and instrument models, we calculate derivatives of the forward model to propagate the measurement noise and calculate errors in fit parameters. If spectral derivatives with respect to some fit parameters (e.g. aerosol and fluorescence parameters) become strongly linearly dependent, precision of these parameters will become poor. This, however, is not the case: precision of aerosol parameters is good, even when simultaneously retrieving fluorescence parameters.

Two mechanisms contribute to the fluorescence signal at the O_2 A band. First, absorption by oxygen provides information, because fluorescence emissions pass through the atmosphere once before reaching the detector, while solar radiation passes twice. Second, filling-in of Fraunhofer lines provides information as well, since fluorescence emissions are only slowly varying with wavelength. To provide a better understanding of the fluorescence signal at the O_2 A band, we have investigated the relative contribution of each mechanism as a function of spectral resolution.

These results are important for (future) algorithms employing hyperspectral observations of the O_2 A band to retrieve aerosol parameters, either for the sake of aerosol retrieval or for the sake of an aerosol correction as part of a more convolved trace gas retrieval (e.g. CO_2, CH4).