

***Interactive comment on “Chlorophyll fluorescence remote sensing from space in scattering atmospheres: implications for its retrieval and interferences with atmospheric CO<sub>2</sub> retrievals” by C. Frankenberg et al.***

**W. Verhoef**

verhoef@itc.nl

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First I would like to apologize for the fact that some phrases in my initial comments were perhaps a bit emotionally colored. But my purpose was that some obvious misunderstandings about the FLEX mission should be cleared away, and I am glad that you are willing to make some changes to the initial paper to relax some statements about FLEX.

What remains are a few points that we still do not agree on:

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1) The difficulty of disentangling aerosol, albedo,  $F_s$  and surface pressure effects in the O2 A-band.

I agree with you that this is not an easy job, but in your mentioned paper and in one of L. Guanter et al., titled "Developments for vegetation fluorescence retrieval from spaceborne high-resolution spectrometry in the O2-A and O2-B absorption bands", JGR, Vol. 115, 2010, the Jacobians are shown only in graphical form, and no numerical quantification of the degree of ill-posedness to be expected is given. In your "disentangling" paper, Figure 1, the Jacobians are also presented graphically, and from this one may conclude that all are quite similar, but there are subtle differences as well, so I think that solely from the graphics one cannot draw any quantitative conclusion. What one can observe visually at least in the mentioned paper of L. Guanter et al. (2010) is that the Jacobian of  $F_s$  differs from all the other ones on the spectral scale of the whole window from 750 - 770 nm, thereby including both the solar Fraunhofer line region and the actual O2-A absorption region. This suggests that in principle all quantities should be retrievable on this spectral scale. I do not understand the claim in your reply that discarding a spectral region like the O2-A absorption region could be of any help in improving the retrieval of  $F_s$ . How can discarding data ever be helpful in this respect?

2) Saturation in the O2-A band.

Of course this a matter of definition, and I agree that the core of the absorption lines is totally absorbed, but at a lower spectral resolution one can still find a much higher transmittance for the one-way path (the one used by  $F_s$ ) than for the two-way path (the one used by the albedo), so in this sense the band is not saturated at all. By using the word saturation you seem to suggest again that this region would be useless, which indicates the presence of some biased position.

3) The fixed  $F_s$  spectral shape by means of A1 and A2.

With my remark in my first comments I wanted to provoke some discussion on the impact of the first  $F_s$  peak at 685 nm on measurements at 755 nm. The second peak

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at 740 nm is more related to photosystem I, and there is evidence (unfortunately not yet in the peer-reviewed literature that I am aware of) that this peak is less responsive to photosynthetic activity. Modeling results indicate that the second peak mainly responds to chlorophyll concentration in the leaves, so it might turn out that the GOSAT results are actually maps of leaf chlorophyll concentration, not of photosynthetic activity...

#### 4) Fs and photosynthesis through clouds.

To clarify this point I should first state that I agree with your claim that the total transmittance in the 755 nm region will decrease only slowly with aerosol optical thickness if it is non- or only weakly absorbing. However, detection of Fs in this region using solar Fraunhofer lines is already a challenge for cloudfree regions, demanding simultaneously a high signal-to-noise ratio and a high spectral resolution, so detection of Fs through clouds would even be a greater challenge. But my main point is the next step, namely the one suggesting that Fs would be a proxy for photosynthesis. This relationship is certainly not as direct as you seem to suggest, and for the 755 nm region it is even doubtful whether Fs can actually be related to photosynthesis, see point 3) above. So altogether your picture of sensing photosynthesis through clouds is imaginative but also based on much speculation I am afraid.

#### 5) Non-isotropic Fs.

You did not reply on this issue so far. Nadir observations underestimate total hemispherical Fs, since (according to model simulations with the SCOPE model) Fs radiance in large viewing zenith directions is much larger than in nadir direction. You gave no comments on how we should deal with this.

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