Reply to Magnani et al.: Linking large-scale chlorophyll fluorescence observations with cropland gross primary production

The derivation of the first global maps of sun-induced chlorophyll fluorescence (SIF) from Greenhouse Gases Observing Satellite (GOSAT) data in 2011 (1, 2), and later from Global Ozone Monitoring Experiment-2 (GOME-2) (3), was perceived as a milestone in the fields of vegetation remote sensing and carbon modeling. As stated by Magnani et al. (4), space-borne SIF measurements are intrinsically related to photosynthetic activity and therefore have the potential to trigger a new era in the monitoring of vegetation functioning. In fact, the first results from the analysis of the GOSAT and GOME-2 global SIF datasets are confirming the expected link between SIF and the gross primary productivity (GPP) of terrestrial ecosystems (e.g., ref. 2). In particular, our specific study on the potential of SIF observations to monitor crop photosynthesis (5) empirically demonstrates a strong linear relationship between SIF and GPP for croplands and grasslands at 0.5° and monthly scales.

We appreciate the positive feedback from Magnani et al. (4), and agree with their comment that process-based models should be used to exploit the full potential of SIF data to characterize photosynthetic processes. We are indeed fully aware of the generally complex relationships between top-of-canopy SIF and photosynthesis, as we note in our report, for example, in the statement "despite the complicated photosynthesis–SIF relationships and the convolution of the signal with canopy structure…" (5). We would like to clarify, however, that we do not base our analysis "on the assumption of a constant ratio between photosynthetic and fluorescence light use efficiencies," as stated by Magnani et al. (4), but simply speculate on such an assumption (which we actually expect to hold, especially for well-irrigated and fertilized crops) to partly explain our empirical findings. Nevertheless, we do not discard that the observed linear relationship between cropland SIF and GPP may be highly driven by the fact that our SIF measurements provide a very good proxy for the photosynthetically active radiation absorbed by the green component of the canopy, which is in turn close to GPP for healthy, highly efficient crops. Spatial scaling issues are likely to occur in our comparisons between 0.5° data and flux tower GPP estimates, but the reported large GPP differences between croplands and grasslands are actually shown by the flux tower data, and can therefore not be attributed to spatial scaling, as suggested by Magnani et al.

We would like to point out that the SIF retrievals used in this study have been obtained from space-borne instruments that were not originally intended for (and not optimal for) measurement of SIF. Considering the coarse-resolution of available data, the many assumptions to be taken at the global level, and the technical limitations to the use of such data in process-based models, we are convinced that an empirical approach to extract statistical relationships between SIF and GPP best fits our global crop productivity study (5). We feel that our results provide strong validation for proposals for dedicated satellite missions to measure SIF and share the hope of Magnani et al. that this initial demonstration will pave the way for more refined studies.

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Author contributions: L.G., Y.Z., M.J., J.J., M.V., J.A.B., C.F., A.R.H., P.Z.-T., J.-E.L., M.S.M., G.P.-C., C.B., G.C.-V., N.B., D.G., K.K., A.C., J.M.B., and T.J.G. wrote the paper.

The authors declare no conflict of interest.

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