Biogeosciences Discussions

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Reply on RC1

Anam M. Khan et al.

Author comment on "Reviews and syntheses: Ongoing and emerging opportunities to improve environmental science using observations from the Advanced Baseline Imager on the Geostationary Operational Environmental Satellites" by Anam M. Khan et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-454-AC1, 2021

The article revisits a number of applications of geostationary-based observations in environmental sciences, focusing primarily on the ABI instrument on-board the current generation of GOES satellites. Geostationary platforms provide high-frequency observations, which are widely used in Meteorology and Nowcasting. However, other fields that value more spatial resolution, even if at the expense of revisiting times, as is often the case of environmental monitoring applications, greatly under explore those observations. Given the high quality of the instruments on the current geostationary satellites – such as the GOES-R series, but also those operated by European and Asian agencies – I find this article to be very timely. I think that aspects related with the actually added-value of high frequency observations, synergies with observations from other geostationary and/or polar-orbiting platforms should be further revised. I consider the manuscript should be subject to a moderate revision before being accepted for publication.

Author response: We want to thank Referee 1 for the time they took to complete a thoughtful and insightful review of our manuscript. We are glad that our manuscript is timely for the environmental science community given the recent updates to geostationary imagers.

1) High frequency observations may be of great use for many different reasons: to follow rapidly evolving phenomena, such as weather systems; for surface monitoring purposes, high frequent observations in visible/infrared bands may be important in areas which are frequently cloud-covered, by increasing the probability of acquiring clear-sky observations; variables with strong diurnal cycles may not be properly represented by low-frequency observations; identification of rapid changes, such as phenology. Although the article touches some of these aspects, I think they should be further systematized and clearer with further examples of applications where GOES-R observations play a significant role.

Author response: Thank you for this point. Our manuscript continuously points to the advantage of the availability of clear observations throughout the year in almost every section where the point is applicable. We will include some more specific examples for the importance of capturing rapid changes during phenological transitions. There are some existing figures from various papers that we cite that illustrate the advantage that geostationary imagers provide for phenology. In the revised manuscript we will specifically note these key figures in the interest of comprehensively reviewing the existing literature.

2) It is acknowledged that some of the issues that one needs to deal with when using ABI or other similar instruments on geostationary satellites to monitor the Earth's surface are well covered – parallax, atmospheric correction, increasing pixel size towards the disk's edge. The article then lists a number of products that may be derived from ABI followed by a few examples of relevant applications of those data. Here, I suggest that the actual added-value of ABI observations/products with respect to other commonly used data should be further highlighted, namely:

2.1) the use of GOES/ABI observations and products, including LST, to derive evapotranspiration is well-known. Here I would expect to see an example of such an application including the input satellite data/products and respective evaporative fluxes. Showing the on-set of drought conditions highlighting the advantages of high frequency data would be of interest to users.

Author response: We will use the example of detecting flash droughts and further elaborate on this application to illustrate the advantage of thermal observations with high temporal resolution. We will also include a more detailed explanation of the process of going from the input required data to the output product and finally the product's use in detecting drought conditions.

2.2) Landscape fires usually present significant diurnal cycles and therefore high frequency observations are better positioned for their full characterization. However, small agricultural fires aimed at burning agricultural waste, are known to cause a significant amount of emissions and pollution, but often these are too small and weak to be "seen" by the relatively coarse geostationary satellites. This is especially the case as we move away from the sub-satellite point, as the minimum detectable fire radiative power scales with pixel area. Please consider these problems and address the potential benefits of the combined use of ABI/GEO's observations with higher spatial resolution.

Author response: Thank you for this point. The WildFire Automated Biomass Burning Algorithm for GOES is an effort to detect sub-pixel fires and estimate their sub-pixel area and temperature. We will note that GOES is more suitable for detecting larger fires and discuss the importance of detecting small fires in burned area estimates as recently discussed in Ramo et al. (2021). We will also address opportunities for spatiotemporal fusion between ABI and higher spatial resolution for potentially improving the detection of very small sub-pixel fires.

2.3) the coarse resolution of vegetation products/indices derived from geostationary observations is a major caveat as often pointed by users, especially when compared with the same type of variables derived from MODIS or VIIRS. The phenology example presented is relevant application, but again the actual advantage of ABI with respect to other more commonly used data is far from being clear. The authors show two cases presenting post-fire disturbances and vegetation recovery in California. However, the comparison with MODIS is only shown for one of them; the time-series do not cover the full growing season. Furthermore, I would say that the most relevant contribution of geostationary/ABI observations would be to map phenological cycles in a consistent way (given the high number of observations) over large areas. So although zooming at a relatively small area affected by fires may be of interest, I think that that is not the most appropriate example to illustrate the benefits of those types of observations, especially when compared with others.

Author response: Interestingly, the spatial scale of many ABI bands is similar to many

MODIS bands but we all agree that finer spatial detail is beneficial for remote sensing applications. We can add a comparison on MODIS on all time series. The time series includes all seasons although they are not in the usual order from Jan - Dec. Instead the time series runs from March 2019 to March 2020. This was done to capture the time before and after the Kincade fire. We can expand on some phenology examples published in the literature to highlight the advantage of using geostationary observations in capturing phenological transitions.

2.4) Following the above, it should be noted that only TOA vegetation indices are shown, while several atmospherically corrected and BRDF-corrected vegetation properties can be also derived from both ABI (geostationary) and MODIS or VIIRS (polar-orbiting) instruments. Why not using those types of indices – in principle less noisy – than TOA values?

Author response: We have written about various efforts currently underway for atmospheric correction of TOA observations from geostationary imagers in the paper. The purpose of sticking to TOA MODIS values was to compare TOA ABI values with TOA MODIS values. We can add NDVI values from the existing MODIS NDVI product which is generated from atmospherically corrected data as an added comparison.

3) The combined use of multiple geostationary satellites is only very briefly mentioned. Given the high quality of current sensors, there's a great potential to build nearly global high frequency fields and derived products. The combination of geostationary data with high spatial resolution observations (from MODIS/VIIRS to Sentinel-2/Landsat) targets a different set of users and applications, with the latter usually more focused on regional-to-local applications. Both global (or large scale) and regional/local scale applications are relevant and worth addressing.

Author response: Thank you for pointing this out. We will look for some more examples in the literature that combine geostationary sensors and elaborate on how this can be advantageous in other applications covered in our paper.

4) I would encourage the authors to improve the examples given in section 5 and to better link these to section 6. Evapotranspiration and energy fluxes are deeply linked to plant's carbon up-take and ecosystem dynamics. A brief reference is already made to "diurnal land attributes" – I suggest the authors further explain what is meant by that and how ABI observations can address those.

Author response: We can link section 6 and section 5 more completely by elaborating on the application of geostationary observations for studying carbon-water-energy fluxes together, as alluded to in Anderson et al. (2000). This link can be drawn through stomatal conductance which is the linking mechanism between assimilation and transpiration and in section 6.1, we can discuss models that can estimate canopy latent heat and assimilation fluxes with stomatal, boundary layer, and aerodynamic resistances (Anderson et al. 2000)

5) Editorial

Author response: Thank you for the careful read, we will address all of these important editorial details in the revised manuscript.

- line 51 – please clarify what is meant by "diurnal behavior of land surface function".

- line 280 – by "effective surface temperature" do the authors mean brightness temperature? I find it unclear what the authors are mean as a physical surface temperature. Whatever temperature you consider, it will most likely have a physical meaning, being radiometric temperature, aerodynamic temperature, brightness temperature, …

- line 314 – S. Ha et al, 2020?

- lines 379-380 – this is not shown here, sicne the time-series does not cover April.

-line 391 – please refer to European satellites as “Meteosat” instead of METEOSAT.

- line 449 – Fig. 2 is called after Figs 3 and 4 – so why this figure order?

Author response references

Anderson, M. C., Norman, J. M., Meyers, T. P., and Diak, G. R.: An analytical model for estimating canopy transpiration and carbon assimilation fluxes based on canopy light-use efficiency, Agricultural and Forest Meteorology, 101, 265–289, https://doi.org/10.1016/S0168-1923(99)00170-7, 2000.

Ramo, R., Roteta, E., Bistinas, I., Wees, D. van, Bastarrika, A., Chuvieco, E., and Werf, G. R. van der: African burned area and fire carbon emissions are strongly impacted by small fires undetected by coarse resolution satellite data, PNAS, 118, https://doi.org/10.1073/pnas.2011160118, 2021.