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Comment on hess-2021-406

Anonymous Referee #2

Referee comment on "The influence of vegetation water dynamics on the ASCAT backscatter–incidence angle relationship in the Amazon" by Ashwini Petchiappan et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-406-RC2, 2021

General Comment:

The submitted manuscript presents the analysis of ASCAT time series data (backscatter, slope & curvature) over the greater Amazon region with regards to water dynamics and two drought events. Additional meteorological (e.g. precipitation from GPCP) and water dynamics (from EWT – GRACE) information are incorporated into the analyses for visual and chart comparison. The following comments & suggestions are raised concerning study setup, additional analyses and hopefully useful suggestions to improve the manuscript:

Major Comments:

- The study analyses are based on very small changes in backscatter (sometimes well below 0.1 dB in variation). This puts a massive demand on radiometric stability (and NESZ) of the ASCAT sensor. Please elaborate on this topic and include justifying statements. How far are these small backscatter variations showing significant and stable correlations to variations in environmental properties in the Amazonian vegetation? Is there a lower limit in sensitivity? The reviewer thinks it would be

reasonable to define a lower limit.

- The study shows mainly a chart/map comparison of the included observations, like in Figures 4, 5 & 6 However, there is no quantitative statistical analysis (tables) of the spatial correlations of the different observations. In addition, Figures 3,8, 12, 13 and 15 show interesting spatial patterns (maps) of the observables and their anomalies. But, geo-statistics (spatial statistics) and their analysis are not undertaken. It would be interesting to look at a spatial correlation map of different fields (e.g. EWT vs. backscatter/slope/curvature). Please add spatial correlation statistics (maps) to the analyses of the manuscript.
- There is a lack of direct validation as backscatter, slope and curvature are "low level observables" concerning water dynamics in plants and cannot directly serve as vegetation parameters: Anyhow is a validation somehow, even in a future setup, possible? Please elaborate or discuss how a first-order validation could be conducted, potentially in an add-on study within a controlled environment. An improved understanding of the slope and curvature and how they are affected by environmental factors, here water dynamics in the Amazon, is needed to fully exploit the potential of the method. Curvature and slope are no direct indicators of plant density, phenology and structure. This is hard to link directly. Can we have an easier link? The reviewer likes to foster more discussion and outlook kind of statements in the later sections of the manuscript showing how to overcome the limited understanding of the spatio-temporal dynamics of slope/curvature compared to the environmental ones.
- Another fundamental question is: How much are backscatter, slope and curvature correlated in space and time? How much can be simply explained by only backscatter? This may have been addressed before (maybe in Steele-Dunne et al., 2019), but a statement/paragraph would be beneficial to justify the analysis of the derivatives (slope, curvature). This could be also supported by EM modelling efforts.
- Another point to discuss: How far is the presented water dynamics analysis transferable from Amazonas to somewhere else, e.g. other climates/biomes and regions of the world? More explanation would help to shape the potentials and limitations of the approach in the discussion section.
- Concerning vegetation penetration one major point is when the C-band EM waves start to interact with anything but not vegetation, like soil under vegetation: How far are soil influences on the backscatter signal playing a role, especially for lower vegetated or dry areas (e.g. Cerado)? Please evaluate and discuss potential non-vegetation influences on the signal, like soil scattering. Is there a criterion or threshold-based approach to find and exclude regions and/or times when non-vegetation effects, like from soil, have a too distinct/significant influence?
- There is a spatio-temporal scale gap as well as a sensing volume gap (C-band EM wave penetration vs. 3D gravity field dynamics) between GRACE EWT and ASCAT observations. Hence, the reviewer has doubts that (lines 181-183)"…in each ecoregion, there is clear agreement between the seasonality of EWT and backscatter. This indicates that backscatter is influenced by moisture availability in terms of total terrestrial water storage, which includes groundwater storage." This is a strong statement and "a clear agreement" is not really statistically quantified. Please add some statistical or more quantitative analysis for justification of this agreement. Moreover, please explain and/or discuss the scale gap and sensing volume gap of the two remote sensing observations.

Minor Comments:

- Lines 171-172:

"The Guianan savanna, with sparse vegetation, has low mean slope values. The Cerrado, on the other hand, shows mean values higher than the evergreen forests. This is unexpected since slope is generally considered a measure of "vegetation density", and the evergreen forests are much denser than savannas."

The forest/vegetation density that microwaves "see" can be twofold. Density can come from dry biomass/structure, which is dry matter based, or come from vegetation water, which is wet matter based. This comment may help to review the above-mentioned paragraph.

- Figures 5 & 6:

These Figures contain four y-axes and show an overview how the incorporated parameters/variables behave along time. This is a first overview along time. What is missing is a statistical evaluation of the temporal correlation.

- Lines 258-263 and lines 351-352:

"This is due to multiple scattering between the water surface and the vegetation." In terms of scattering mechanism characterization: Should this be double bounce scattering (water-vegetation)? What kind of scattering mechanism could this be?

- Lines 261-263:

"…the curvature changes considerably and even changes sign during the flooded period. This illustrates that the curvature includes useful information on changes in the scattering

mechanisms, which are related to physical changes at the land surface." Is there a way to link the curvature more directly to the physical variables? Could the authors try modeling or anything similar? It would be interesting to couple a forward model with the slope and curvature metric to investigate sensitivities and dependencies. Could references (if done) or an outlook statement (if not yet done) be included in the manuscript?

- Figures 12 & 13:

Can Figures 12 and 13 be shown in a way that they are jointly together and their similarity or difference in pattern can be understood intuitively? Maybe an add-on figure might be an option or a replacement of Figs. 12 & 13. For most of the domain, especially the evergreen forests, high values in EWT coincide with negative diurnal differences in backscatter and vice versa. In the moment, the comparison of two 6-pannel figures (12 & 13) appears complicated.

- Figure 14:

Figure 14(a) is indicative of the seasonal variations observed across the evergreen forest ecoregions. Note that the diurnal differences are very small (< 0.06 dB). These seem to be really small differences.

How about signal stability in terms of radiometric resolution? i.e. How noise-prone are these subtle differences? Please add an explanatory paragraph and some discussion about this point.

- Lines 294-296:

"One possible explanation for this unusual seasonal cycle is that it is related to a change in the relative dominance of the forests and grasslands in the backscatter signal. The transition from positive to negative curvature values during the EWT peak indicate an increased contribution from tree patches and shrubs during the wetter period." How can this be justified? This sounds quite speculative. Should the statement be softened?

- Lines 331-332:

"However, the current study is the first to relate the spatial and temporal variations in slope and curvature to moisture availability and demand." Are we really seeing a relationship that is statistically significant? Please add more statistical (correlation) analyses to support the statement.

- Lines 335-336:

"Strong temporal consistency was found between ASCAT backscatter and GRACE EWT, with the maximum backscatter coinciding with periods of maximum moisture availability." Please quantify this statement.

- Lines 336-337:

"Spatial patterns in mean and range of slope reflected spatial patterns in vegetation density." Please quantify this statement.

- Lines 350-351:

"Temporal consistency between the curvature and meteorological data suggests sensitivity to events such as litterfall and leaf flushing." How solid is this finding? Are their dates and periods reported where litterfall or leaf flushing happened? Please try to show more content how the authors arrive at this finding.

- Lines 355-357:

"Diurnal differences in backscatter during the dry season are dominated by transpiration losses. Long-term monitoring of these diurnal differences could provide insight into moisture availability and its influence on transpiration and vegetation functioning." Can this really be concluded with the presented analyses? Please add some reference or explanation.

- Lines 366-368:

"… by vegetation structure and water content, and interactions between the soil and vegetation is essential to improve our ability to interpret and optimally use VOD derived from ASCAT." Is there forward modelling on VOD from ASCAT? Maybe even a sensitivity study? Please add references or a statement of future work at this point in the manuscript.

Technical Comments:

- 15 & 16 should be placed within the section where they refer to and before starting of the next section (conclusions). Please review the document for further "late appearance" of figures.
- Figure 16 caption: lines are dashed-dotted and not dotted. Please adapt caption text.