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Hydrology and Earth System Sciences
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Discussions

Interactive comment on "The Future of Earth Observation in Hydrology" *by* Matthew F. McCabe et al.

Anonymous Referee #1

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This paper is an admirably comprehensive overview of how changes in sensing platforms, data providers of spaceborne applications, enable new data sources, and thus, presumably, new breakthroughs in hydrology. No single paper can be expected to comprehensively cover the entire possible 'future of hydrology' and thus this provides a somewhat biased view (about which a caveat in the text would be useful). Nevertheless, the authors have done a remarkably thorough job in terms of capturing the various exciting opportunities available. I particularly appreciate the high number of references across such a diverse paper. Nevertheless, some increased focus and streamlining would significantly improve the paper and is necessary. Many of the points made in the current paper are likely to be lost on the reader without it.

Specific Comments: 1) Section 2 isn't clearly tied to the rest of the paper. Section 2.1 is a haphazard mix of challenges that can be addressed by using a wider diversity

of platforms, commercial or otherwise, highlighted in Sections 3 and 4 (e.g. the risk of launches and focusing on single large instruments), and ones that are unrelated (e.g. greater multi-mission integration could be achieved also with space agencies and traditional large LEO or geostationary satellites), and ones that may even be made worse if traditional EO platforms break down (e.g. the perception that remote sensing data are magic and ignorance about reliance on retrieval algorithms may become worse with people using more commercial solutions that, for reasons of competition with other companies, are far more likely to keep their technological and retrieval details secret). Additionally, the challenges and opportunities mentioned for each variable in Section 2.2 are somewhat haphazard. It would be useful to specifically link each of the variables to opportunities mentioned in the rest of the paper.

2) Section 4 comes across too much as an advertisement for EO start-ups in Silicon Valley and a list of problems with space agency-built sensors (as also mentioned in Josh Fisher's non-reviewer comment). The challenges associated with commercial data are mentioned either as an aside that belies the serious nature of the issue (unknown and most likely lacking calibration relative to scientific standards in most cases) , or not at all (data continuity, data costs, the fact that Cubesat orbits aren't always perfectly predictable a priori because of the way in which they are launched). The lower budgets of these startups are presented as being due to the nimbleness of commercial industry, but don't reflect the fact that launching lots of small satellites is inherently cheaper, or that SpaceX has relied on massive amounts of capital investments and has a high failure rate. This is a dis-service not only to government agencies as a source of EO data, but also to the points raised in Section II (which are lost in the process) and to the fact that, in reality, and the fact that future models and analyses efforts are likely to be best aided by a combination of both single-sensor satellites that provide reliable data at perhaps coarser spatial resolution and high resolution data from Cubesats. This section would be significantly aided by a summary table of pros and cons for a) government vs. commercial observing systems. The enormous potential of commercial systems (rightfully highlighted) would go to waste if the community cannot also

think and overcome their related challenges. If space is an issue, such a table would therefore be more useful than e.g. table I, which summarizes established knowledge.

Relatedly, the authors may also want to consider renaming the paper “Opportunities and challenges for the future of remote sensing” to further highlight that a world where hydrologists predominantly use data from the start-ups and new platforms identified in this paper would be great but is not guaranteed if the challenges mentioned throughout are overcome.

3) Section 3.2 only has one subheading, and it is unclear why UAVs deserve their own subheading but balloons and solar planes do not.

4) It would be useful to have a short summary section somewhere that explicitly summarizes challenges to the community and how it operates. E.g. the need to move towards cloud more, publish processed datasets to the same cloud platform rather than keeping them behind user accounts, think about how to engage with commercial agents, building data ingestion systems that are based on more haphazard temporal and spatial coverage, etc. Such issues are now mentioned as asides throughout and may seem less important, although they are arguably among the most potentially actionable results of the paper.

5) Several sections have noticeably lower added value than others, and may be best deleted to keep the paper length manageable and make the rest of the paper clearer. For example, the historical introduction about ground measurements in Section 3.6 (p. 25) only barely links up to the rest of the section (except maybe through the “Internet of Things” reference, but even that is only useful to someone who has already spent time thinking about the IoT and will grasp the connection immediately). Similarly, discussion of the declining trend in ground observations in Section 2.1 breaks the flow and is somewhat out of place. The section on potential new airborne measurements for commercial aircraft (p. 27) is far too vague – what variables could possibly be easily added? Airborne instrumentation for radar, fluorometry or even optical measurements

requires extensive retrofitting of the aircraft and e.g. instrument protection in the form of a radome. By contrast eddy covariance measurements are difficult to calibrate.

Minor Specific Comments:

* Section 3 title: It would be useful to include the phrase “data sources” or “platforms” somewhere in this section title, as that is the focus of many of the sub-headings.

* Page 4, Line 9: The A-Train efforts and large number of sensors aboard Aqua have been useful so some care with phrasing is needed here.

* Page 7, Point 4: The first sentence here provides far too limiting a view of the possible uses of hydrological data. It does not include, for example, the use of hydrologic earth observation data (without further assimilation) in carbon-cycle or biogeochemical studies, epidemiological ones, or even ones on social science implications of variations in water availability (e.g. Muller et al, PNAS, 2016 "Impact of the Syrian refugee crisis on land use and transboundary freshwater resources"). It would be more correct to delete the first sentence and rephrase that the ability to have long-term trends is useful for many studies instead of being so definitive.

* Page 7, Line 19: Su et al, Geophysical Research Letters, 2016 (“Homogeneity of a global multi-satellite soil moisture climate data record”) may be a helpful citation in the discussion of multi-sensor merging

* Page 12, Line 3: Note that e.g. Konings and Gentine, Global Change Biology, 2017 (“Global variations in ecosystem-scale isohydricity”) is a noteable exception here.

* Page 15, line 14: NASA/DLR rather than NASA/German

* Page 36, Line 13: The Chinese WCOM mission may be worth mentioning as an exception here, though it is still in the early phases

* You may want to mention that Planet was recently sold

* The 220 MB multimedia supplement may not be worth its large file size. Although it is

difficult to note the cars moving unless looking for it. If the authors really want to include it, it may be worth cropping to a smaller area that focuses more on the highways.

* A few informal abbreviations have slipped in throughout: tech rather than technolog, ‘till, jet Propulson lab rather than laboratory, etc..

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