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Out of sight, out of mind: Gaps and inconsistencies in terrestrial hydrosphere conceptualizations and implications for major water-related challenges

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From ancient to present times, explorers have "followed the water" to find necessary conditions for life on Earth and elsewhere (NASA Fact Sheet: http://www.nasa.gov/vision/earth/everydaylife/jamestown-water-fs.html). Now in the Anthropocene epoch, we should also be able to follow (represent and forecast) how human-driven changes to freshwater fluxes, availability and quality propagate through the terrestrial hydrosphere and impact on health and wellbeing of humans and our societies as well as other organisms and ecosystems. However, this ability is limited by fragmented study and understanding of change drivers and impacts on water quantity and quality in different parts of this hydrosphere (soil water, groundwater, streams, lakes, wetlands, as well as engineered water infrastructure and water-using/affecting sectors). As fundamental examples of such fragmentation, this paper analyzes historic to recent conceptualizations of terrestrial water structure and function, which is e.g. used in different chapters of advanced Earth system science literature. These convey various views and reflect a lack of common cross-disciplinary consideration and understanding of the terrestrial hydrosphere as an integrated whole. Overall, the analyzed conceptualizations have not considered-visualized: (i) the natural catchment-wise (topographic) structuring and (continuity based) balancing of large-scale flows of terrestrial water; or the key change drivers, impacts and feedbacks implied by the interaction (pathways) between: (ii) engineered and natural water parts of the terrestrial hydrosphere; and (iii) freshwater and seawater in (the often most densely populated) coastal zones of the terrestrial hydrosphere. Furthermore, conceptualizations differ in whether and how they represent the interaction (pathways) between: (iv) subsurface and surface water; and (v) water and solid material in the subsurface (soil/rock/sediment matrix). Such gaps and inconsistencies may underlie current, practically important misunderstanding and neglect of large-scale, long-term human-driven changes, impacts and feedbacks, and call for a conceptualization paradigm shift. To better support and improve models, strategies, plans and solutions, new conceptualization should promote consistent representation and visualization (and thereby understanding, across disciplines) of the terrestrial hydrosphere as an integrated whole. This needs to include and visualize the wide spatiotemporal spectrum of component inter-linkages within the hydrosphere, including the interaction pathways between its human-driven and natural parts, and with other geospheres, on relevant large scales of major water-related challenges worldwide.