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Technology fusion for large scale terrestrial monitoring

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In terrestrial systems research, technologies related to observations, modeling, and data assimilation and analyses underwent considerable improvement in the past two decades. Simultaneously, the development of digital infrastructures related to cloud and high-performance computing, data storage and wireless technologies continue to advance at a very high speed. Surprisingly, given the challenges of global change and pressures on terrestrial resources and ecosystems, the potential of fusing all available technologies to characterize and forecast the terrestrial system with respect to the water, energy and biogeochemical cycles up to continental and global scales for the benefit of societies remains to be realized. Operational forecasting centers may be seen as an exception, but focus on more or less isolated compartments, such as the atmosphere, or extreme events e.g. floods and droughts. As a result, the current condition of the terrestrial system in terms of water, energy and nutrient states and fluxes is largely unknown, and seemingly simple questions cannot be answered. Here, we discuss the main aspects of technology fusion performed at the Centre for High-Performance Scientific Computing in Terrestrial System, Geoverbund ABC/J, focusing on groundwater-to-atmosphere simulations up to the continental scale and also on merging terrestrial models with observations in supercomputing environments to arrive at an experimental forecasting system running near real time. Well-known challenges related to observational data sets, and uncertainty are revisited. Based on our experience with an existing experimental system, we conclude that all technologies are currently available to construct a terrestrial monitoring system up to the global scale; and that, in the community, a push for technology fusion will provide additional motivation for data exchange and integration ultimately strengthening terrestrial systems research.