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Fathoming the hydrosphere (Henry Darcy Medal Lecture)

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As Lord Kelvin observed: "If you can not measure it, you can not improve it." Measurement is the start of all scientific knowledge. Measurement sets science apart from metaphysical speculation. Measurement is not the last word in science but it is the first. In hydrology, progress in measurement methods has not been as rapid as in sister Earth sciences such as meteorology, oceanography, or geodynamics. Of the hundreds of scientific satellites, only one has hydrology as its main mission at the time of this writing (hopefully two at the time of the lecture). The closest we come to a large measurement infrastructure is an experimental watershed. Nothing wrong with an experimental watershed but it does not compare to, say, the Square Kilometer Array with its exabyte per day output. We tend to give up quickly because we will always have to work with effective parameters that can not be measured directly. We will never be able to know all stomata in a tree and how they interact with the turbulent flow through the canopy. We will never be able to know all pores in a soil and how water moves through them. But also effective parameters have to be measured, be it indirectly.

No surprise then that my presentation will focus on measurements in hydrology and water management. First, the fun aspects and intellectual challenges of developing new measurement methods will be highlighted. From weighing trees to listening to rain to taking a stream's temperature, we have had many interesting experiences over the years. Second, the balance between model complexity and data availability will be discussed. Although there is a generally recognized need for parsimonious models in hydrology, formal approaches to finding the correct level of complexity are rare. Some complexity control approaches, borrowed from computer science, will be presented together with a hydrological application. As it turns out, these methods seem to predict nicely the onset of equifinality or the statistical illposedness of the inverse problem of finding effective parameters. Finally, an ambitious program will be presented that aims to shed light on Africa's climate and water resources, the TransAfrican HydroMeteorological Observatory or TAHMO. TAHMO's aim is to deploy and operate 20,000 hydroclimatological stations throughout subSaharan Africa. There are many aspects that are novel from the design of the stations, to deployment at schools, and a business model that should fund the system for decades to come. Given the global need for finding the water needed to produce our food by 2050 and the fact that Africa will have to play a major role in this effort, TAHMO addresses a scientific challenge of great societal importance.