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Hydrology and Earth System Sciences Discussions

Interactive comment on "Searching for the Holy Grail of Scientific Hydrology: $Q_t = H(\overleftarrow{S}\overleftarrow{R})A$ as closure" *by* K. Beven

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Some time has elapsed since the REW concept was first published and it is noteworthy that several research groups have picked up the concepts and are approaching the problem of mass and momentum flux closure from different angles and philosophical perspectives. Novel and perhaps promising hydrological measurement techniques at large-scales are being explored in this context.

The present discussion around this paper opens a window on how different research groups are currently tackling the problem. The paper by K. Beven is not a scientific paper in the classical sense, but rather an philosophical essay and has as such a significant merit in its own.

I do not see the paper as taking a pessimistic point of view, but rather a genuine reminder for people to remain realistic as far as the closure of hydrological fluxes is concerned.

The REW approach was first developed with the idea to identify hydrologically significant control volumes and to integrate point-scale conservation equations for the thermodynamic properties mass, momentum and energy from the point scale to the scale of the volume, thus transforming local spatial gradients into boundary interaction terms (fluxes) and the properties into their respective volume-averages, with the aim to express - as in the fluid mechanics discipline - the boundary interactions in terms of the spatial average properties. The ergodicty assumption and the respective constraints on the volume size (as mentioned in the comment by E Zehe) must obviously hold for such theory to be applicable.

If a purely fluid mechanic theory-based closure approach is relaxed, the REW formulation becomes indeed independent of spatial scale. This may be necessarily the case for several hydrological fluxes given the extreme heterogeneity of the problem. A classical (fluidmechanics type) closure approach can still be pursued for some system fluxes such as on the landsurface-atmosphere interface, where the boundary conditions can be specified with some degree of certainty.

With the necessity to provide some practical hydrological applications of the REW method, the original lofty idealism had to give way to some practically driven empiricism aimed at getting first REW-based models going (e.g. Reggiani and Rientjes 2005, Varado et al. 2005) and to give a demonstration of the novel principle of breaking the landscape down into interconnected prismatic control volumes with hydrologically meaningful sub-zones.

I do agree with the author that that some proposed closures schemes that have appeared in recent literature and are still being investigated are nothing else but point-scale theory applied to the REW scale and do as such not represent any significant innovation on the hydrological horizon.

However, the author neglects the fact that some parts of the system have indeed been studied by proposing flux closure (but still leaning on Darcian parameterization) directly at the REW-scale. For example the lateral distribution of groundwater fluxes using a resistor network approach (Reggiani and Rientjes, 2005) and resolving the lateral distribution of water in the aquifer (mantle fluxes) through iterative approximations (Hardy-Cross method) is an example of how mass and momentum flux closure can be solved directly at the scale of interest by applying mass and piezometric head conservation (energy) along closed loops between REW volumes.

This approach requires of course knowledge of mass fluxes along the external watershed groundwater boundary and recharge fluxes at the REW scale. These could be derived successfully from long-term water balance studies that were available for the particular study catchment (an exception rather than the rule).

Given recent progress with remote sensing techniques, there is hope to estimate mass and energy land surface exchange fluxes at the REW scale, by correcting parameterized landsurface fluxes through sequential assimilation of realistically available observations (surface soil moisture, stream discharges, saturated areas, groundwater volume estimates) into the model (see work by Francois et al 2002, Raichle and Koster, 2005). To find closed-form expression of these fluxes for general situations will however remain elusive.

I do agree with the author that there is little to no hope in measuring a range of other hydrological fluxes internal to the system for the foreseeable future. It remains worthwhile continuing to experiment with novel observation techniques, while consciously steering clear form reverting back to point-scale formulations.

Even finding a single closed-form parameterization for a mass outflow formulation as stated in the paper will be elusive and perhaps also unnecessary for practical purposes because of the non-stationary behavior of many systems and the tendency of natural systems to readjust to changing boundary conditions, that unlike continuum mechanic

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systems, are too heterogeneous to be parameterized simply.

In summary I consider the paper interesting as it has the potential to trigger fruitful discussion on the subject (the interventions on the HESSD forum are a good example) I therefore recommend it to be published. I find however the second part of the title "Qt=H(SR)A as a closure" too limiting. The reduction of the closure of hydrological fluxes should not be restricted to the hillslope problem. I suggest the paper to be revised in this context.

References

Francois, C., Quesney, A., and Ottlé, C. (2003). Sequential assimilation of ERS-1 SAR data into a coupled land surface-hydrological model using an extended Kalman filter, J. Hydrometeorol., 4, 473-487.

Reichle, R., R. D. Koster, (2005). Global Assimilation of Satellite Surface Soil Moisture Retrievals into the NASA Catchment Land Surface Model. Geophys. Res. Lett, 32. DOI:10.1029/2004GL021700.

Reggiani, P., and T. H. M. Rientjes (2005), Flux parameterization in the representative elementary watershed approach: Application to a natural basin, Water Resour.Res., 41, W04013, doi:10.1029/2004WR003693.

Varado, N., Braud, I., Galle, S., Le Lay, M., S'eguis, B., Kamagate, B., and Depraetere, C.: Multicriteria assessment of the Representative Elementary Watershed approach on the Donga catchment (Benin) using a downward approach of model complexity, Hydrol. Earth Syst. Sci. Discuss., 2, 2349-2391, 2005. 30

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