ON THE COARSE-GRAINING OF HYDROLOGIC PROCESSES WITH INCREASING SCALES

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Abstract

In this presentation it is argued that the heterogeneity of a hydrologic attribute which may seem to be nonstationary at one scale, may become stationary at a larger scale. The fundamental reason for transformation from nonstationarity to stationarity with the increase in scale is the phenomenon of coarse-graining of the hydrologic processes with increasing scale. Due to the phenomenon of aliasing, a particular scale hydrologic process heterogeneity which is observed as a nonstationary process at that scale, may be observed as a stationary process at a higher(larger) scale whose size is bigger than the stationarity extent of the lower scale heterogeneity. As one goes through a hierarchical sequence of larger and larger scales for observations, one would eliminate nonstationarities which emerge at some lower scales at the expense of losing information on the high frequency fluctuations of the lower scale heterogeneities which will no longer be observed at the larger sampling scales. We call this phenomenon as the "coarse-graining in hydrologic observations".

In this presentation, it is also argued that by the coarse-graining of hydrologic processes due to the averaging and aliasing operations at increasing scales, the conservation laws corresponging to these scales may still be quite parsimonious, and need not be more complicated as the scales get larger. It is shown that when a higher(larger) scale process is formed by averaging a lower(smaller) scale process in time or space, the high frequency components of the lower scale process will be eliminated by the averaging operation.

Thereby, the resulting average hydrologic dynamics, free from the effects of the high frequency components of the lower scale process, can still be quite simple in form. This is demonstrated by means of some recent upscaling work on the solute transport conservation equation for heterogeneous aquifers. By menas of this solute transport example, it is also shown that for the ensemble average form of a hydrologic conservation equation to be equivalent to its volume-average form at any scale, the parameter functions of that conservation equation at the immediately lower scale must be ergodic.