ANOMALOUS TRANSPORT AS A DRIVER FOR INCOMPLETE MIXING AND ANOMALOUS REACTIONS

Diogo Bolster, University of Notre Dame, (574) 631-0965, dbolster@nd.edu

1. Diogo Bolster, University of Notre Dame
2. David Benson, Colorado School of Mines
3. Tanguy Le Borgne & Pietro de Anna, Universite de Rennes
4. Alexandre Tartakovsky, Pacific Northwestern National Lab
5. Marco Dentz, Spanish National Research Council

Anomalous transport, or transport that does not follow Fick's Law of diffusive behaviour, is common in a variety of hydrological and geophysical systems with heterogeneous velocity fields and can reflect nonlocal effects. Fields of interest where such anomalous behavior occurs include solute transport in surface and subsurface water systems, turbulent environmental flows, sediment transport in rivers and mechanical transport of soil constituents.

To date, most studies looking at anomalous transport have focused on c onservative transport. However, many constituents of interest in hydrological systems do not behave conservatively, and their reactive character should be included. Predicting reactive transport in porous media for example can be quite challenging (see the recent review article by Dentz et al. 2011). Classical transport and reaction equations based on the assumption of perfect mixing fail to properly predict reactions within systems ranging from laboratory-scale in homogeneous material to large-scale heterogeneous systems. The deviations from classical reaction predictions can arise for example due to incomplete mixing, which must be accounted for in the correct upscaled model.

In this work we focus on t he link between anomalous transport and anomalous reactions. In particular we focus on how anomalous transport changes the characteristics of incomplete mixing in a system and how this in turn affects where and how quickly reactions take place. To this end we consider models that reflect spatial, temporal and spatio-temporal nonlocal behaviour. We consider models that display both subdiffusive and superdiffusive behaviour to encompass a broad class of anomalous transport scenarios. We focus on two types of mixing driven chemical reactions, namely

(i) Bimolecular equilibrium instantaneous precipitation reactions

(ii) Kinetic irreversible bimolecular reactions

For case (i) we demonstrate that anomalous transport can significantly affect where and how much reaction occurs, while for case (ii) anomalous transport can change the nature of incomplete mixing and thus lead to a wide range of anomalous kinetics.