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Reactive transport on multiscale networks: controls and drivers of large-scale cholera outbreaks

Andrea Rinaldo (1), Enrico Bertuzzo (1), Lorenzo Mari (1), Lorenzo Righetto (1), Marino Gatto (2), Renato Casagrandi (2), and Ignacio Rodriguez-Iturbe (3)

(1) Laboratoire d'Ecohydrologie ECHO/ISTE/ENAC, Ecole Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, (2) Dipartimento di Elettronica e Informazione, Politecnico di Milano, Milano, Italy, (3) Department of Civil and Environmental Engineering, Princeton University, Princeton (NJ), USA

In the spirit of the session, the Lecture reviews recent modeling concepts and techniques on the role of human mobility as a driver for long-range spreading of cholera infections, which primarily propagate through mechanisms operating at different spatial and temporal scales through hydrologically controlled ecological corridors. A multiscale, multiphysics parametrization combining different processes (here pathogen dispersion along hydrologic pathways and through human mobility coupled with local outbreak dynamics) is combined into a mechanistic spatially explicit model of disease epidemic. We present a two-layer network model that accounts for the interplay between epidemiological dynamics, hydrological transport and long-distance dissemination of the pathogen *Vibrio cholerae* due to host movement, here described by means of a gravity-model approach. We test our model against epidemiological data recorded during the extensive cholera outbreak occurred in the KwaZulu-Natal province of South Africa during 2000–2001 and for the ongoing Haiti epidemics. We show that long-range human movement is instrumental in quantifying otherwise unexplained inter-catchment transport of *V. cholerae*, thus playing a key role in the formation of regional patterns of cholera epidemics. We also show quantitatively how heterogeneously distributed drinking water supplies and sanitation conditions may affect large-scale cholera transmission.