TOWARD A SPACE–TIME FRAMEWORK FOR INTEGRATED WATER AND SOCIETY STUDIES

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The notion of spatial and temporal scales is inherent to water governance, often at the junction of physical and social science. One of the central objectives of water governance is the development of management processes and infrastructure systems that control the space–time variability of water availability in both quantity and quality to meet the different space–time scales of demand patterns. The question of how physical and social processes interact through scales and how we can transport results from one scale to another is both fundamental to our understanding and operationally important for decision making in an appropriate and timely fashion. Hydrologists have long since developed models of the water cycle dynamics where human-induced water resources management activities are prescribed as external forcing, often under the assumption of stationarity (Milly et al. 2008). However, the cascading effects of climate change, the escalating complexity of water systems, and the persistent uncertainty in forecasting extreme events all establish relations between social and natural processes across scales. It is now well accepted that cultural and natural life-support systems operate on many space–time scales and need to be studied as complex systems (Holling 2001; Liu et al. 2007; Creutin et al. 2009). The study of complex systems also brings together diverse fields and connects different ways of thinking about theoretical and practical problems. Water systems consist of multiple interacting components: social, biophysical, and technological. Configurations of the

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WHAT: Seventeen early-career scientists, doctoral candidates, and operational partners from 10 nations met to develop a new integrated approach based on "scaling" to better understand the physical and social processes governing water resources.
WHEN: 8–13 May 2011
WHERE: Les Houches, France

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integrated water and social system generally reflect hegemonic political, social, and cultural preferences, as made clear since the seminal work of Wittfogel (1957). Understanding how to manage such evolving systems and how to anticipate new opportunities and potential risks requires taking an approach that differs from the reductive focus on isolated components. This means that the appropriate scales for science, management, and decision making cannot be unambiguously derived from physical characteristics of water resources. Scales of interest are a joint product of social and biophysical processes.

The main objective of the 2011 Water and Society Summer School was to invite early-career people with various academic backgrounds—meteorology, climatology, hydrology, human geography, history, sociology, and political science—to address integrated studies through space–time scale analysis. Three main questions were considered: 1) With regard to water governance challenges, what are the interactions and links between the spatial and temporal dynamics of the physical processes and the dynamics of the society? 2) How can current and new water resource observation strategies for geophysical and social components build a more robust understanding of these links? 3) What are the best short- and long-term actions for developing a new spatial and temporal conceptual model for truly conducting integrated studies dealing with "water and society"?

A common reading of a synthesis paper by Holling (2001) helped students and teachers to share a basic vocabulary and understanding of interdisciplinary issues. The concepts and examples given in the paper were assumed to provide the students with a methodological framework describing how the components of natural and social systems interact through scales.

The school gathered 17 early-career scientists and professionals from both social (10) and physical sciences (7) and with various cultural backgrounds (10 nationalities) in the scenic landscape of the Chamonix Valley and Mont-Blanc (France). Their schedule alternated mornings of lectures and the construction of a case study during three afternoons. The seven lectures covered a variety of methodological concepts (from time geography to panarchy) and applied topics (from climate to flooding) intended to provoke interdisciplinary exchanges. Students also had the opportunity to better understand the space–time complexity of operational management strategies through a one-day field trip led by local stakeholders. The participants formed five groups, mixing cultural backgrounds and disciplines. Each group was required 1) to construct an idealized case study merging the experiences of the members, thus combining social and natural facets; and 2) to explain to what extent the various interacting components operate at different space–time scales. Short oral presentations showed the daily progress of the groups.

The case studies covered a range of issues related to flood risks and governance, water resources management, and water quality. The difficulty in sharing a rather complex conceptual framework stimulated de facto interdisciplinary discussion and cooperation. Each group made visible efforts to take a "through scales" view of its selected case in an attempt to separate elementary processes according to their characteristic scales. The space–time framework helped to focus the exchanges within and among the groups.

Differences between groups were mainly attributed to the level of common understanding of the proposed framework. The relationship between water governance and space–time scales was generally well understood, even though the notion of cascade or embedded structure was sometimes difficult to formulate. A prevalent difficulty emerged with the time scale regarding the difference between chronology and pace. A chronological approach (e.g., dam construction followed by consequences on the water use and the river biota and morphology) was often preferred to defining the different paces of the governing processes (daily to seasonal variability of water uses, decadal to centennial evolution of river biota and morphology, etc.). Identification of the temporal scale of social and natural processes added to this difficulty.

During their free afternoons, the teachers made their own examination of the students' case studies. Being from different disciplinary backgrounds, the students had to work in a team setting and were often confronted with different approaches to conceptualizing ideas. The discussions indicated that the social theorists and physical scientists have different concepts of space–time scales and scaling. It was acknowledged that the proposed space–time framework allows clarifying the relationships between natural and social scientists.

In summary, the discussions emphasized that physical, social, and economical processes can be more readily observed at some scales than at others, and these may vary considerably in terms of duration and extent. Furthermore, it was observed that social organization has more or less discrete levels, such as household, community, and regional distinctions, that correspond broadly to particular scale domains in time and space. In terms of governance, the choice of certain scales instead of others is not

politically neutral. It can implicitly favor certain types of information, systems of knowledge, and social groups.

The discussions following the case-study illustrations indicated that many coupled social–water problems originate from the mismatch between the scale at which physical processes occur and the scale at which subsequent decisions are made. Outcomes at a given scale are often critically influenced by interactions of hydrological, socioeconomic, and political factors from other scales. Focusing solely on a single scale is likely to miss such interactions, which are critically important in understanding biophysical determinants and their implications for human well-being.

Participants agreed to maintain connections through conference sessions, collaborative proposals, and papers. The Water and Society Summer School is planned again for 2014 with a focus on socioeconomic processes and their inherent space–time scales.

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