The influence of large dams on surrounding climate and precipitation patterns

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[1] Understanding the forcings exerted by large dams on local climate is key to establishing if artificial reservoirs inadvertently modify precipitation patterns in impounded river basins. Using a 30 year record of reanalysis data, the spatial gradients of atmospheric variables related to precipitation formation are identified around the reservoir shoreline for 92 large dams of North America. Our study reports that large dams influence local climate most in Mediterranean, and semi-arid climates, while for humid climates the influence is least apparent. Clear spatial gradients of convective available potential energy, specific humidity and surface evaporation are also observed around the fringes between the reservoir shoreline and farther from these dams. Because of the increasing correlation observed between CAPE and extreme precipitation percentiles, our findings point to the possibility of storm intensification in impounded basins of the Mediterranean and arid climates of the United States.
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1. Introduction

[2] Large dams (according to the International Commission on Large Dams (ICOLD), a large dam is defined as one with an embankment height of more than 15 meters or a storage volume exceeding 3 million m^3) and their impounded reservoirs are types of infrastructures that trigger most often a large-scale change in land use and land cover (LULC) due to the multiple purposes they serve. With the construction of a dam, more arable land may be irrigated with impounded surface water and the downstream regions may become more urbanized due to a reduced risk of flooding and the increased availability of products and electricity. Such systematic changes to land cover can lead to increased availability of local moisture and significantly impact mesoscale circulation [*Niyogi et al.*, 2010; *Takata and Yasunari*, 2009]. Herein, we refer to mesoscale as essentially 'local' and between the ranges of 10–100 km. One such local effects of LULC change can be a modification of rainfall [*Avissar and Liu*, 1996; *Cotton and Pielke*, 2007; *Pielke et al.*, 2009]. Thus, if dams are regarded as a catalyst for systematic change in LULC, then it is physically plausible to expect a gradual change in the local climate and rainfall patterns in the impounded river basin attributed directly to the multiple land use development that reservoirs produce.

[3] While the impact of climate variability and change on artificial reservoirs has been studied at local/regional scales for some time [see, e.g., *Hamlet and Lettenmaier*, 1999; *Christensen et al.*, 2004], the converse (impact of reservoirs on local/regional climate) has not been explored as much. It has been recently argued that very little is known on how artificial reservoirs (hereafter interchanged with 'dam') modify storms under certain atmospheric conditions and the consequential implication on hydrology and dam safety [*Hossain et al.*, 2010; *Hossain*, 2010]. Dam design in engineering assumes as "stationary" the design parameters of extreme rainfall during its service span, a practice that is now being increasingly questioned and researched for better methods [*Milly et al.*, 2008; *Villarini et al.*, 2009]. Understanding the influence exerted by large dams on the surrounding (local) climate is therefore key to establishing if artificial reservoirs inadvertently modify precipitation patterns in impounded river basins. In this study we therefore seek an answer to the open question – *What is the influence of large dams on local climate and the probable effect on precipitation patterns?*

2. Study Region, Data and Methods

[4] Using a database of dams from the Global Water Systems Project Digital Water Atlas [*GWSP Digital Water Atlas*, 2008], we studied ninety-two (92) large dams located in various Koppen-Geiger climate zones of the United States (Figure 1) [*Peel et al.*, 2007]. To understand the potential land cover changes near the dams, we also identified the main purpose of each dam as belonging to one of three broad categories (irrigation, hydropower and 'other'). Here, 'other' includes applications such as flood control, domestic water supply and recreation. Our premise is that the existence of a dam is a necessary (if not sufficient) indicator of land cover change near reservoirs and can therefore help explain features of our observational findings. For example, irrigation-based dams result in intensified agriculture near reservoirs, whereas hydropower dams most likely contribute to only sporadic land cover change through urbanization.

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