Impact of Climate Variability, Change, and Damming in Streamflow of the Mekong River

Introduction

The hydroclimate and hydrology of the Mekong River Basin were analyzed in order to relate changes in streamflow with changes in the hydroclimate variables and dams built. In this analysis, changes in long-term means (or climatologies) of water-balance variables (precipitation, evapotranspiration, and surplus), their volume contribution to the river streamflow, and streamflow itself were analyzed and put in context of the growing number of dams. An examination into regional trends and the impact of global climate phenomena on rainfall complemented the research. This analysis was a follow up of a previous research that found a decrease in the normal climatological streamflow at a river station in Pakse, Laos, in September from 1946 to 2005. The null hypothesis was that dams are responsible of the reduction in streamflow.

Methods

Connected a personal laptop (Dell Inspiron) to connect from home with the main computer (a DELL PowerEdge R815 machine that has 64 cores 2.1GHz Xeon E5420 64-bit with a total available RAM and SWAP space of 32GB.) at the Atmospheric and Oceanic Science Department of the University of Maryland. The computer was used to operate and use the open access software called GrADS under a Linux environment. This software was used to make calculations and display the results via a graphic environment. The following flow chart displays the steps taken in this research:

Access the database to become familiar with: 1) the normal climate, or climatology, of the region via water-balance variables like rainfall (P), evapotranspiration (ET), their difference (P-ET) and the runoff or surplus water left for the river (S=P-ET-∂w/∂t, the last term is the storage of soil moisture); and 2) the behavior of the streamflow of the Mekong River.

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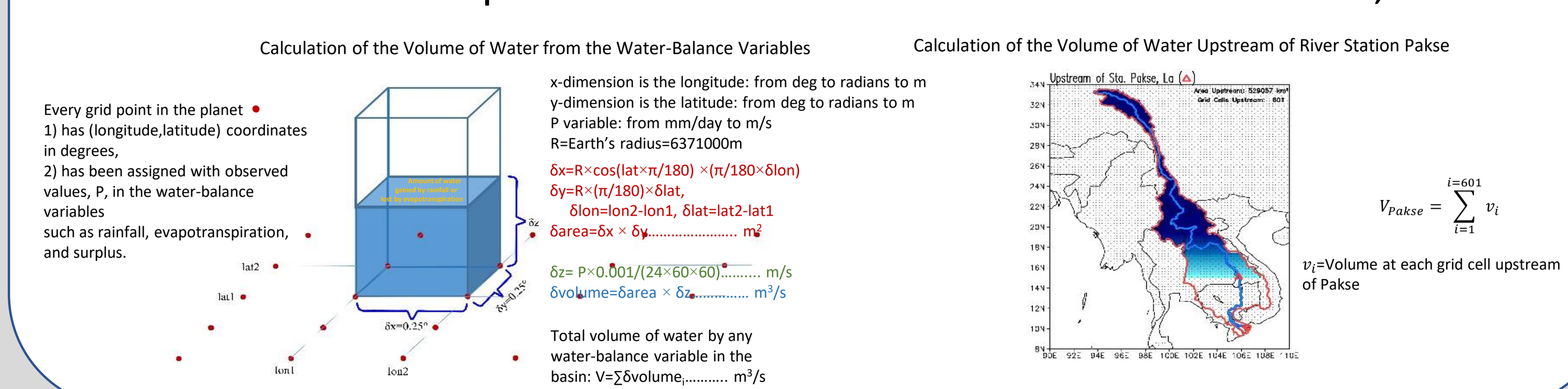
Learn how to calculate: (left) the volume of water gain or loss by the water-balance variables from the University of Delaware data set (given on a global grid of 0.25° in latitude and longitude); (right) the accumulated volume of water upstream of river stations like the one in Pakse, Laos.



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Identify changes in climatology and linear trends via the least squares method in several sub-periods within the period 1925-2005.

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Identify the impact on the regional rainfall of climate phenomena like El Niño, Decadal Variability in the Pacific Ocean and the Global Warming Trend.

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Alfredo Ruiz-Malca

Findings

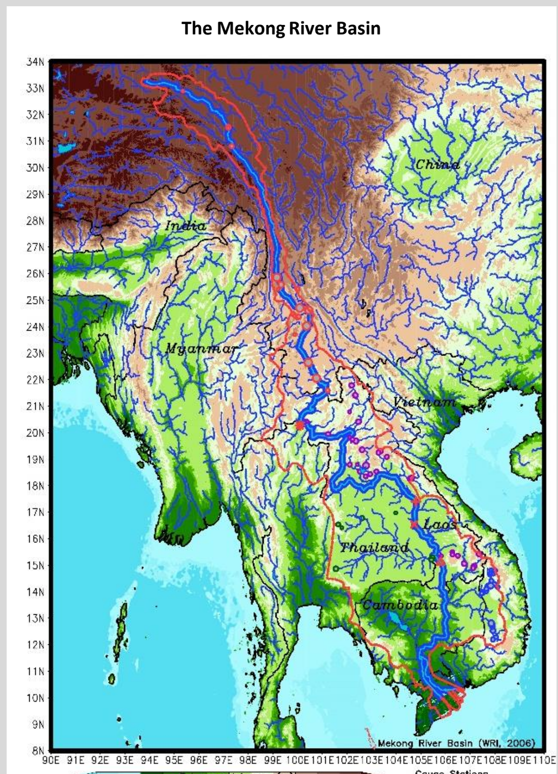


Figure 1. The Mekong River is the largest river in the Indochina Peninsula and the management of its waters is very important for the countries in the region: Thailand, Laos, China, Cambodia, Vietnam, Myanmar. It is generally divided into the Upper Basin at elevations larger than 1000 m, and the Lower Basin largely at elevations under 500m

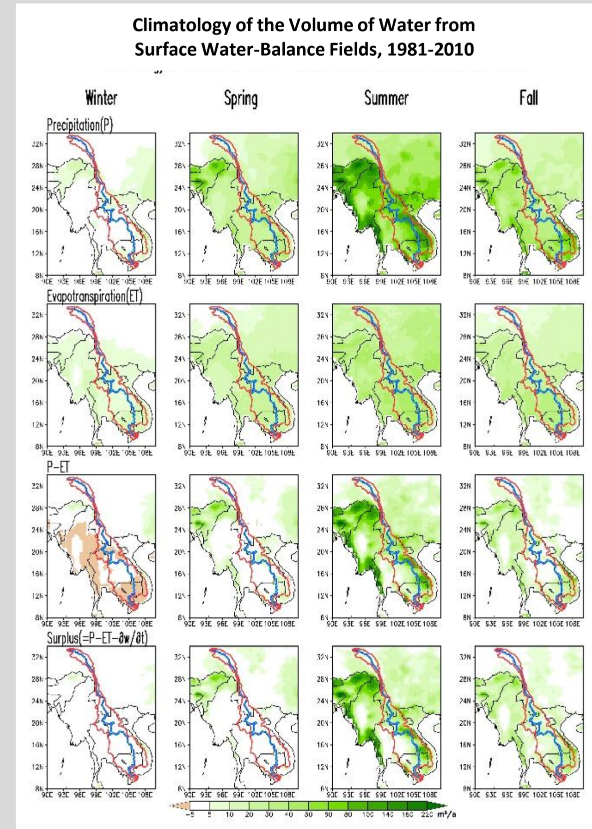
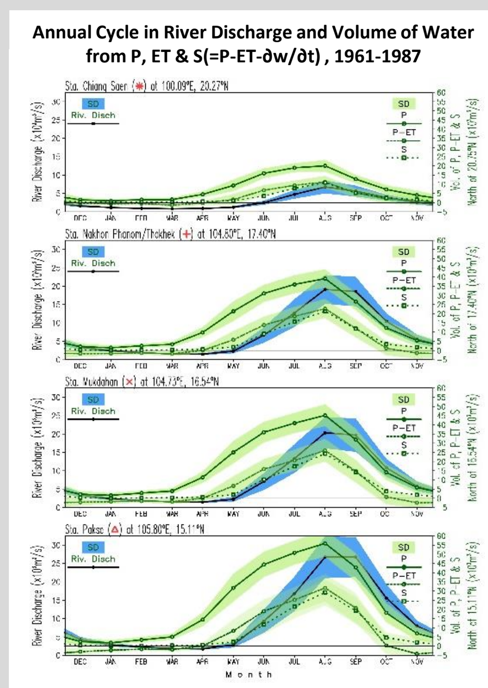
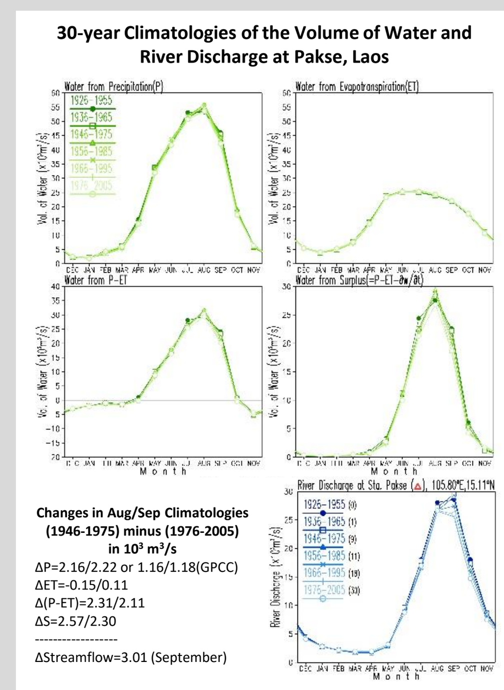
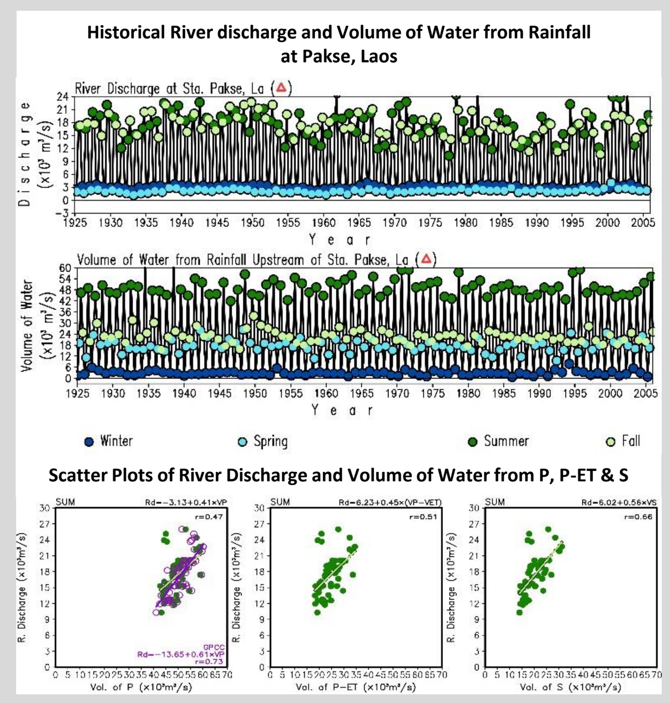


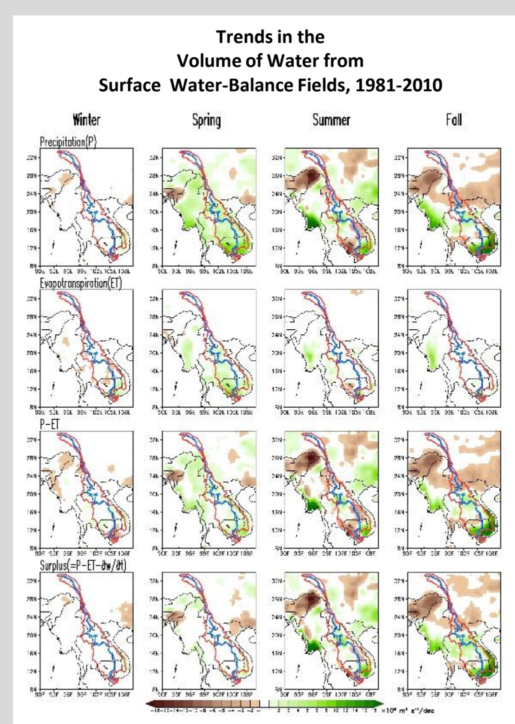
Figure 2. Summer is when rains the most but it is also the season when more water is lost by evaporation and transpiration. Summer is also the season that is left with the most water as surplus (or runoff) to feed the river, after accounting for the natural water storage at the surface and subsurface.

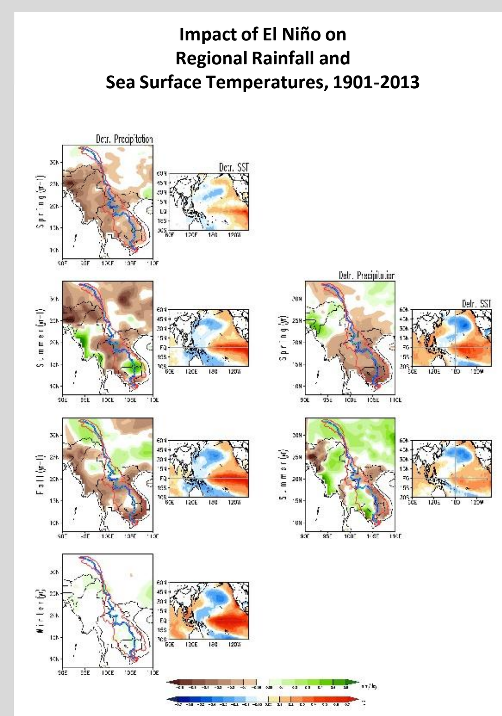


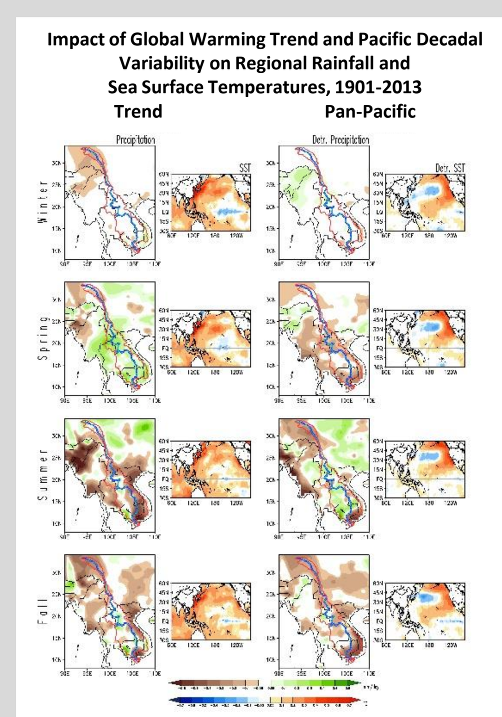




Figures 3, 4, 5. The wet, rainy, season starts in April and ends in October. Streamflow reacts two months later, in June, after the start of the rainy season but one month after the peak. Analysis of 30-year climatologies for the period 1925-2005 at Pakse, Laos, shows that streamflow used to be maximum in September but it is maximum in August now; decreased water from rainfall in August and September is not enough to explain the decrease in streamflow, as water from evapotranspiration has not changed. Analysis of the historical data at Pakse indicates that even though surplus could be used to estimate or model streamflow, rainfall is a more realistic variable to estimate it as rainfall is more readily measured, and predictable, through the region than surplus; the modeling of streamflow via rainfall improves with improved rainfall data sets such as the GPCC.







Figures 6, 7, 8. Recent trends in water from rainfall, and the water available for the river within the Mekong River Basin, are not homogeneous with decreased trends in the upper basin and very small increasing trends in the middle. On the other hand, phenomena such as El Niño, Decadal Variability in the Pacific Ocean and the Global Warming Trend impose stress on the water resources of the region by imposing anomalous rainfall over the region (from linear regressions).

Conclusions

The Mekong River Basin is a region sensitive to climate phenomena and man-made changes in the environment. The results showed that both decreased water from water-balance variables, and from dams were responsible for the decrease in river flow in the Lower Mekong River, so the null hypothesis was not rejected. The mentioned decrease in the climatological water from rainfall can be due to natural or man-made causes. Future research should test the effects of the planned increase in dams along the river in the present decade upon the health of the ecosystem, as well as on the delicate balance between human activities benefiting from the river and a healthy ecosystem.