Incorporating the Oceanic-Atmospheric Climate Variables to Enhance Streamflow Reconstruction Skill

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Introduction

Streamflow is a vital source of water supply. Information about the historic streamflow helps understand the range of climate variability and develop sustainable water management strategies for the future. The available instrumental data is usually limited and thus might be insufficient to describe the long-term hydrologic patterns of a region. Streamflow reconstruction, by increasing the length of the hydrologic data, is an important tool to understand past hydrology.

Objective

Incorporating the oceanic-atmospheric climate variables of Pacific Ocean Sea Surface Temperature (SST), Pacific Decadal Oscillation (PDO), and Southern Oscillation Index (SOI) for improving streamflow reconstruction.

Study Area and Data

- Rio Grande River Basin (RGB) (Figure 1)
- Drainage Area = 870,240 km²
- Major sources of inflow for Upper RGB (semi-arid) are the mainstream Rio Grande (snowmelt), the Rio Chama (snowmelt), and the San-Juan Chama (San Juan River tributaries)
- Six unimpaired streamflow gages (1934-2011) from HCDN were selected for reconstruction
- Climate predictors of SST, PDO and SOI and tree ring chronology (TRC) are used in the study (Figure 2)

Methods

- Singular value decomposition (SVD) was used for identification of coupled regions of SST and streamflow at 90% significance (p≤ 0.1)
- Step-wise linear regression (SLR) was applied on predictor variables of (1) TRC (2) PDO, SOI and TRC (3) Smith & Reynolds SST and TRC (4) Evans-Instrument SST and TRC (5) Evans-Coral SST and TRC (6) Evans-Tree SST and TRC
- The performance of SLR was tested using the calibration R² and cross-validation R²

Results

Singular Value Decomposition (SVD)

- Pacific Ocean SST was longitude 120E—98W and latitude 20S–50N
- First mode of SVD explained 90.7% of the variability in streamflow (Figure 3)
- Significant SST regions (628 cells significant out of 2278 grid cells) were located in the equatorial, central and north Pacific Ocean

Step-Wise Linear Regression (SLR)

- Calibration and cross-validation R² (Figure 4) for the six models indicated that SST combined with TRC provide improved reconstruction skill compared to using TRC only or the predefine climate indices
- Satisfactory reconstructions for the six models were achieved for the period 1856-1998 (Figure 5)

Statistical Validation of Models

- Calibration and cross-validation R² results for the six SLR models for all six streamflow gage stations.

Conclusions

- SVD helped in identification of new SST regions. The SVD-SLR approach resulted in indicating that Pacific Ocean SST combined with TRC provide better streamflow reconstruction compared to using TRC only or predefine climate indices of PDO and SOI
- Future research could illustrate the effect of incorporating Atlantic Ocean SST data to improve the model skill
- Improving the resolution grid of Evans SST dataset could lead to improved and longer-spanned hydrologic reconstructions

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