GC51D-0831: A Study of the Impact of Dams on Sediment Retention in the Mekong River Basin

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Abstract

Dam construction in the Mekong Basin has many cascading effects on the ecology, economy, and hydrology of the surrounding region. The focus of this study is to utilize the Soil Water Assessment Tool (SWAT), developed at Texas A & M, a rainfall-runoff hydrologic model to determine change in sedimentation in the Mekong Basin after the construction of dams. This study uses land cover and land use and reservoir data created by the NASA SERVIR-Mekong Regional Land Cover Monitoring System and Dam Inundation Mapping Tool as inputs into the model. The study also builds on the equation from Brune (1953), rewritten by Kummu & Varis (2007), to calculate Sediment Trapping Efficiency (STE) of dams and estimate change in sediment concentration downstream. The outputs from this study can be used to inform dam operation policies, study the correlation between dams and river fisheries, which are all pressing issues in the Mekong region.

Objectives

- Perform hydrologic modeling of Lower Mekong Basin from year 2000 to 2017 to simulate pre-dam construction scenario
- Estimate wet season and dry season storage capacities for reservoirs in the Lower Mekong Basin constructed after year 2000
- Estimate theoretical sediment trapping efficiency of reservoirs in the Lower Mekong Basin constructed between 2000 and 2017
- Estimate potential sediment trapping of planned reservoirs

Study Area

- Lower Mekong River Basin (LMB) in Southeast Asia
- Includes Thailand, Vietnam, Cambodia, Laos, and Myanmar
- 800,000 km² dominated by forest cover and agriculture
- Over 625 currently operational reservoirs, almost 200 more planned
- 41 reservoirs selected for this study
- Built between 2000 and 2017

Earth Observations and Input Data

- NASA SRTM Digital Elevation Model
- NASA TRMM precipitation data
- SERVIR-Mekong Land Cover Monitoring System
- ESA Sentinel-1 Synthetic Aperture Radar imagery
- WLE-Mekong Reservoir Dataset
- Mekong River Commission Water Quality Monitoring Dataset

Methodology

1. SWAT Hydrologic Modeling
   - Gather and reclassify input datasets into SWAT readable format
   - Delineate watershed and sub-basins
   - Input soil, slope, and land use rasters
   - Filter through Sentinel 1 synthetic aperture radar (SAR) imagery for months dry season (Dec-Mar) and wet season (May-Aug)
   - Find median SAR pixel value for each season
   - Run model from 1975-2100 with 25 year warm-up period to get streamflow and sediment data

2. Reservoir volume calculation on Google Earth Engine
   - Create buferd polygon around reservoir shape
   - Find median SAR pixel value for each season
   - Apply speckle filter
   - Examine histogram and set water pixel threshold
   - Subtract DEM value from max elevation and multiply by area of pixel
   - Find sum of new raster within each reservoir surface area mask

3. Sediment trapping efficiency by sub-basin calculation (Brune, 1953; Kummu & Varis, 2007)
   - TE = 1 - \(\frac{q_2}{q_1}\)
   - Find cumulative sum of reservoir volume by sub-basin
   - Input sub-basin reservoir volume and streamflow data into above equation

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