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MODWT-based outflow decomposition and individual contribution of regulation sites over Paranapanema river basin

Thais Fujita[1,6], Luz Adriana Cuartas[2,6], Juliana Andrade Campos[3,6], Caluan Rodrigues Capozzoli[1,4], Jorge Alberto Martins[5], Edmilson Dias de Freitas[1], and Cintia Bertacchi Uvo[6,7]

[1]Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo, São Paulo, Brazil (thais.fujita@usp.br)
[2]National Center for Monitoring and Early Warning of Natural Disasters, São José dos Campos, Brazil (adriana.cuartas@cemaden.gov.br)
[3]Institute of Hydraulic Research, University of Rio Grande do Sul, Porto Alegre, Brazil (juliana_esa@outlook.com)
[4]Geological Survey of Brazil, São Paulo, Brazil (caluan@usp.br)
[5]Graduate Program in Environmental Engineering, Federal University of Technology—Paraná, Londrina, Brazil (jmartinseae@gmail.com)
[6]Division of Water Resources Engineering, Lund University, Lund, Sweden (cintia.bertacchi_uvo@tvrl.lth.se)
[7]Finnish Environment Institute, Helsinki, Finland (cintia.uvo@syke.fi)

The viability of hydropower production depends on water and energy distribution, storage capacities, and technical constraints. Understanding the sensitivity of runoff variability to hydroelectricity production is a step to better assess its potential and add value to society. In this study, we explored the decomposition of hourly outflow data of hydropower power plants (HPP) operation for a 22-year period into scale-dependent coefficients using the maximal overlap discrete wavelet transform (MODWT) over the Paranapanema river basin. The wavelet analysis of the historical time series shows that the operational coordination of the cascade hydropower system leads the watershed to behave as a space-time filter. This filtering is applied to the process of temporal aggregation of rainfall into the generation of runoff and results in periodic fluctuations due to retention and release of outflow in regulation sites, from run-of-river facilities and regulation dams. These regulated patterns manifest over several scales, dominated by hydropeaking, and diminished seasonal signals.

We found that MODWT effectively describes the broadband of sub-daily and weekly flow cycles from fluctuating electricity demand. The decomposition analysis, which partitions the signal's energy across detail coefficients and scaling coefficients, also showed that the recognition of site-specific, each HPP, infers the individual filtering contributions of regulation points and provides a complementary metric to identify the practices and policies that affect outflows across the watershed. The increase in total energy by scales, the sum of decompositions, from upstream to downstream indicates the presence of spatial and temporal relationships with outflow magnitude. In addition, it highlights the coordination of the joint operation and how its cumulative effects serve energy generation, which implies matching consumer demand and supply.