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Study on the complexity reduction of the input data for 3D numerical modeling of the hydrodynamics and sediment transport in a Brazilian reservoir

Investigation of the data resolution that stills allows a good representation of the hydrodynamics and sedimentation. Comparison with OD model approaches.

Context

The set up and calibration of good performing numerical models require a high quantity of input data with high temporal and special resolution. The complexity and the amount of data required are rarely measured in regular campaigns or with monitoring stations. The demand for data usually leads to the implementation of comprehensive measurement campaigns, which translates into personnel costs and time.

Objectives

- Investigation of the minimum temporal resolution for selected input data.
- Effect of the use of alternative data sources (e.g. ERA5 meteorological data) or "wrong" data.
- Exploration of 0D model approaches for evaluation of reservoir sedimentation

Study Area

The study area of this work is in the Metropolitan Region of Curitiba (MRC). The reservoir itself is around 11km long and has a mean depth of 9m with a maximum of 16.5m. The biggest contributions come from Passaúna river at the northernmost point of the reservoir and Ferraria river at the northwest part of the reservoir. Passaúna river reaches the reservoir at the buffer area, an inlet zone that acts as a pre-dam for the suspended particles and is the first sink area of the reservoir (see Figure 1).

Figure 1. *Overview of the study area. Edited from ESRI*

Methods

For the present study the Passaúna reservoir is used as a study case with high resolution measured datasets. Within the present study the data set resolution was reduced and the quality of the simulation was evaluated. The tables 1and 2 summarize the investigated parameters. Figure 2. compares the original resolution to the reduced resolution data for the main inflow discharge and its temperature.

For the investigation of the model dimensionality several 0D approaches were tested: Brune (1953)[1], Borland (1971)[2], Eysink and Vermaas (1981)[3] and van Rijn (2013)[4].

Table 1. Reduced resolution simulations used for hydrodynamics and temperature.

Parameter	Original value/ resolution	New values/ resolution
Rivers discharges	1 day	3 days
		7 days
Meteorological parameters	15 minutes	1 hour
		ERA5 reanalysis: 1 hour
Secchi depth	2 m	0.5 m
		3.5 m

Table 2. Reduced resolution simulations used for sediment transport

Parameter	Original value/resolution	New values/ resolution
Rivers discharges	1 day	3 days
		7 days
		1 hour
Wind	15 minutes	ERA5 reanalysis: 1 hour
Fictive turbidity current	Q Variable (from LARSIM model)	3 x Q (for specific dates)
	SSC Variable (from MoRE model)	3 x SSC (for specific dates)
Fictive sediment concentration	SSC Variable (from MuDak Project)	2 x SSC

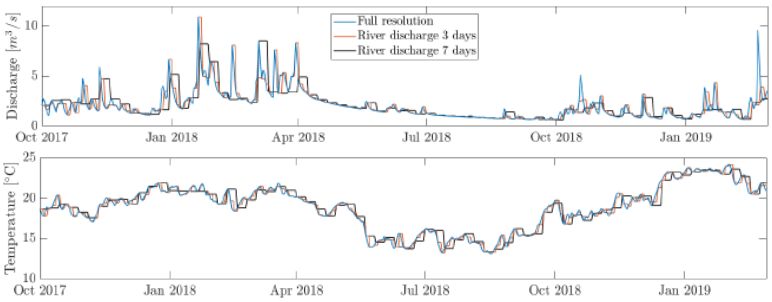

Figure 2. *Reduction of temporal resolution for flow discharge and temperature of Passaúna river.*

Results

Hydrodynamics: changing the resolution of the river discharges and temperatures and using one hour resolution meteorological data had little influence on the simulated velocities and temperatures. Using reanalysis data from ERA5 and employing "wrong" values for the secchi depth (see Figure 3) presented the highest mean errors when comparing the simulates velocities and temperatures to the high resolution simulation.

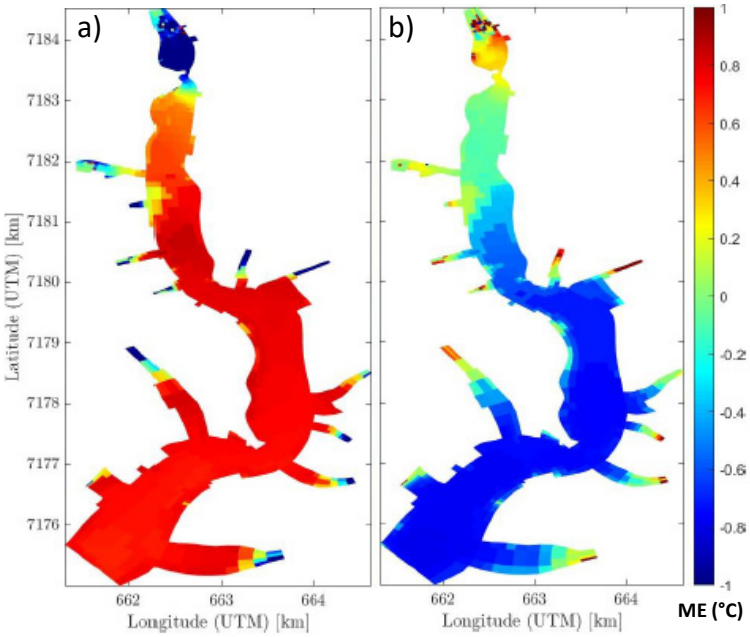

Figure 3. *Mean Errors (ME = reference simulation – reduced resolution simulation) for a) secchi depth 0.5 m and b) secchi depth 3.5m. Positive mean error: underestimation of the simulated temperatures with respect to the reference simulation.*

Sedimentation: when analyzing the numerical simulations showed in Table 2. the sediment volume deposition is very similar, with exception of simulation with fictive rating curves, which had doubled volume deposition in comparison to the reference, as expected. It may remind the modelers about the importance of the rating curve for reliable results. Regarding the sensitivity to the resolution reduction for the numerical simulations, river discharges and its inherent sediment inputs had an effect on the results which was not observed in the hydrodynamics. The implementation of a fictive turbidity current, as well as ERA5 data also showed influences on the performance of the simulation (see Figure 4).

Dimensionality: for the 0D analyses all of the four approaches studied (see Methods section) resulted in a trap efficiency between 96 and 100% for the Passaúna Reservoir. Table 3 below shows the calculated distribution of sediments in the sections of Figure. 5 according to the different methods.

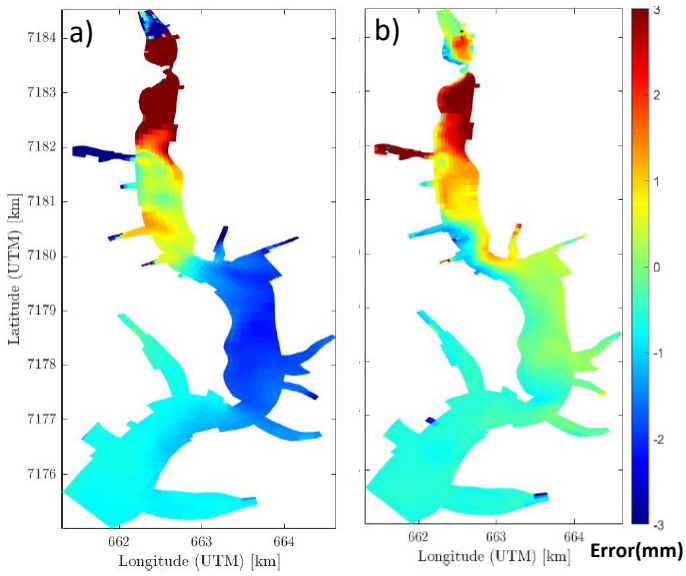

Figure 4. *Errors (reference simulation – reduced resolution) regarding the deposited sediment layer for a) fictive turbidity current and b) use of ERA5 data.*

Table 3. Deposition patterns for the 0D approaches

0D approach / Section	Borland (1971)	Eysink and Vermaas (1981)	Van Rijn (2013)
	deposited cohesive/non -cohesive sediment (%)		
1	18/100	26/100	11/100
2	70/100	100/100	99/100
3	77/100	100/100	100/100
4	82/100	100/100	100/100

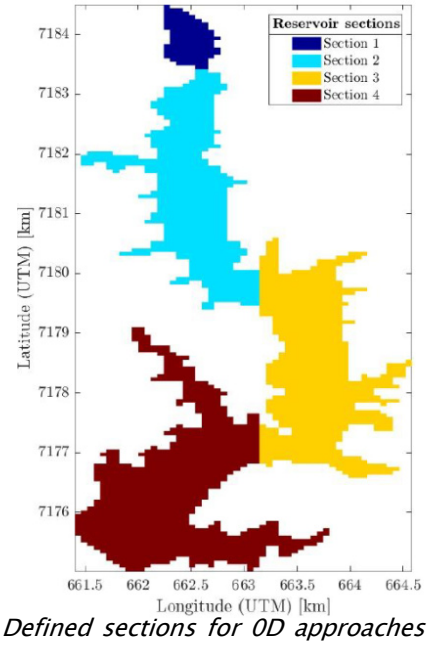

Figure 5. *Defined sections for 0D approaches to evaluate deposition patterns.*

Innovations

- Guide for field campaigns and recollection of field data
- Guide for modelers for the preprocessing phase previous to the calibration

References:

1. Brune, G. M. (1953): Trap efficiency of reservoirs. In Trans. American Geophysical Union 34 (3), pp. 407-418
2. Borland, W. M. (Ed.) (1971): Reservoir sedimentation. River Mechanics. Fort Collins: Water Resources Publications.
3. Eysink, W.; Vermaas, H. (1981): Simple methods for determination of sedimentation in dredged channels and harbour basins. In Report S151.
4. van Rijn, L. C. (2013): Sedimentation of Sand and Mud in Reservoirs in Rivers. Available online at http://www.leovanrijn-sediment.co, checked on 10 of November of 2019.

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