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Numerical daemons of hydrological models are summoned by extreme precipitation

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Here, the numerical methods used by the surveyed modeling codes are detailed. The references which explain the numerical method for each code are listed in Appendix A of the associated manuscript. This literature review was performed in the first half of 2020; codes have possibly been updated since then. In the following, “Category” can be A, B, or C and corresponds to categories of Fig. 10 in the manuscript. Note that Euler methods are first order.

Model: HBV light
Category: C
Remarks: This model uses the fixed step explicit Euler method, placing it in category C. It uses operator splitting.

Model: dynamic TOPMODEL
Category: C
Remarks: This model uses a fixed time step, placing it in category C. It uses an implicit method where the default time step is divided into substeps (with a default time step of 1 hour and a default of 4 sub steps per time step). While the small default time step, fixed substepping, and implicit method might be able to constrain numerical errors, this model does not employ adaptive substepping.

Model: GR4J
Category: B
Remarks: Adaptive implicit Euler has been implemented. This model uses the state-space formulation, rather than operator splitting.

Model: VIC
Category: C
Remarks: This model uses a fixed time step, placing it in category C. It uses sequential solving, as it uses the fixed step explicit Euler method for some fluxes and the fixed step implicit method for others.

Model: Sacramento SMA
Category: C
Remarks: This model uses a fixed time step, placing it in category C. Some fluxes use implicit methods and others explicit; therefore this model employs operator splitting.

Model: mHM
Category: C
Remarks: This model uses the fixed step explicit Euler method for most of the model fluxes, placing it in category C, although its routing routine is adaptive. Therefore it is also operator splitting.

Model: PRMS
Category: C
Remarks: This model uses a fixed (daily) time step, placing it in category C, and apparently uses an explicit method.

MMF: FUSE
Category: A
Remarks: FUSE employs simultaneous (rather than operator-splitting) solutions, has first and second order solvers, has implicit, explicit, and semi-implicit methods, and has adaptive substepping. It contains a second order explicit adaptive method.

MMF: SUMMA
Category: B
Remarks: SUMMA employs simultaneous differential equation solving, has explicit and implicit solvers, and has adaptive substepping. It does not however have a higher order method than 1.

MMF: MARRMoT
Category: C
Remarks: Fixed step implicit or explicit Euler methods are available. This MMF employs a state-space (rather than operator splitting) formulation of its equations.

MMF: SUPERFLEX
Category: C
Remarks: this MMF employs the fixed step implicit Euler method. This MMF employs a state-space (rather than operator splitting) formulation of its equations.

MMF: Raven
Category: B
Remarks: This MMF is capable of using a second order implicit adaptive numerical method, and hence is place in category B. It does not have a second order explicit adaptive method. It also has the option for operator splitting, where specific numerical methods can implemented per flux, but also has the option for space state formulation. It also has the explicit Euler option.