water resources management representation for integration into earth system models

Voisin, N., Li, H., Ward, D., Huang, M., Wigmosta, M., and Leung, L. R.: On an improved sub-regional water resources management representation for integration into earth system models, Hydrol. Earth Syst. Sci. Discuss., 10, 3501-3540, doi:10.5194/hessd-10-3501-2013, 2013.

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Integrated water resources management models

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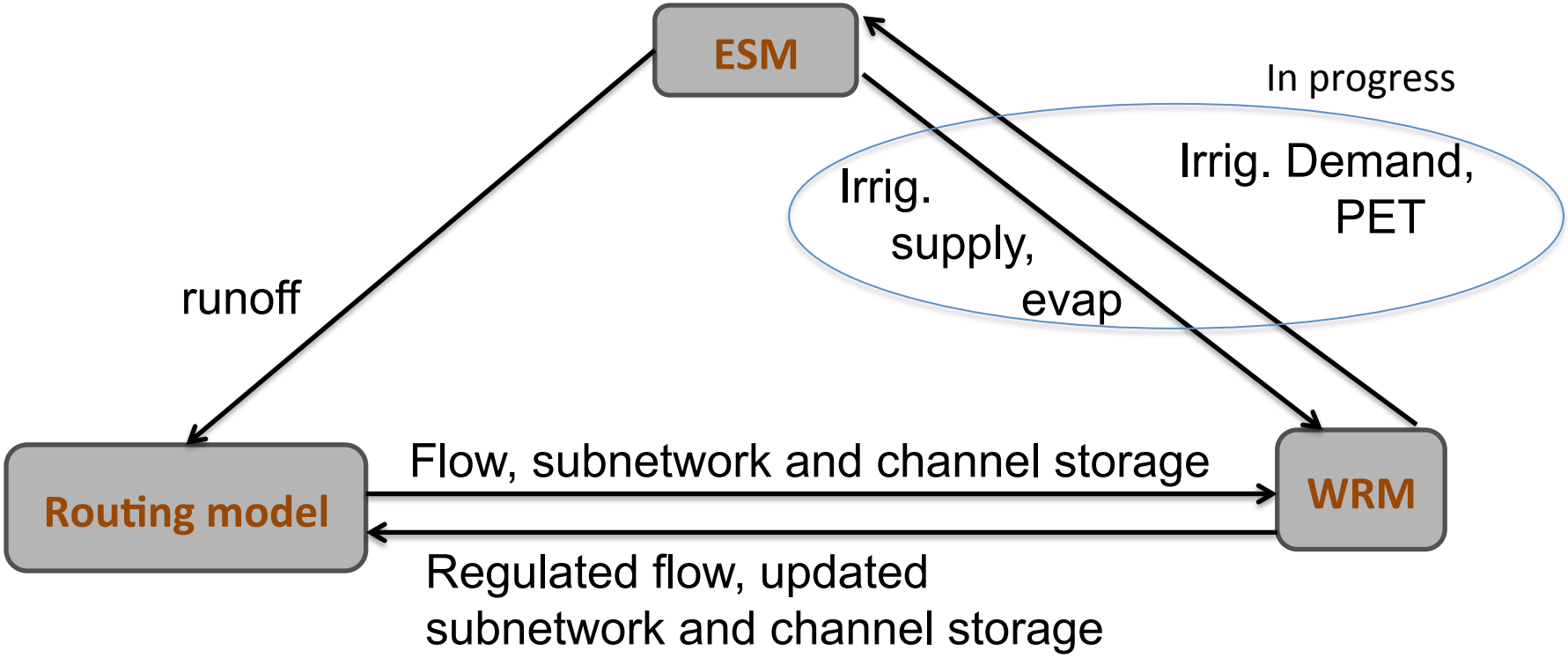

Integrated water resources management models

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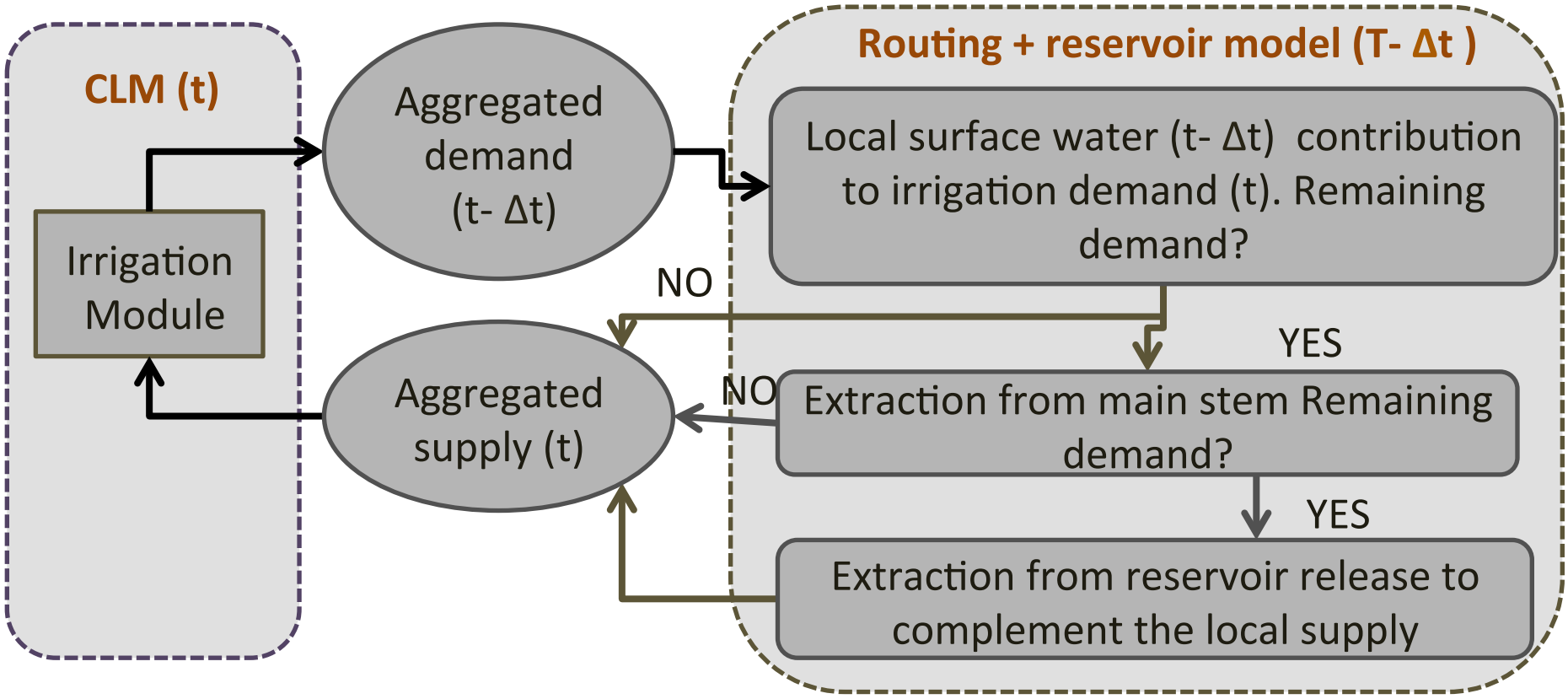


Integrated water resources management models

- Generic operating rules:
  - Hanasaki et al. (2006), WaterGap (Doell et al. 2009), EU WATCH (Biemans et al. 2011), Pokhrel et al. (2012)
  - No dynamic optimization, no knowledge of future flow
  - Long term simulations using limited computational resources
  - Global domain, finer temporal scale
  - Irrigation rules:

$$r'_{m,y} = \frac{i_{mean_{nat,m}}}{10} + \frac{9}{10} \cdot i_{mean} \cdot \frac{d_{mean,m}}{d_{mean}} \quad if\ d_{mean,m} \geq 0.5\, i_{mean}$$

$$r'_{m,y} = i_{mean} + d_{mean,m} - d_{mean} \quad if\ d_{mean,m} < 0.5\, i_{mean}$$

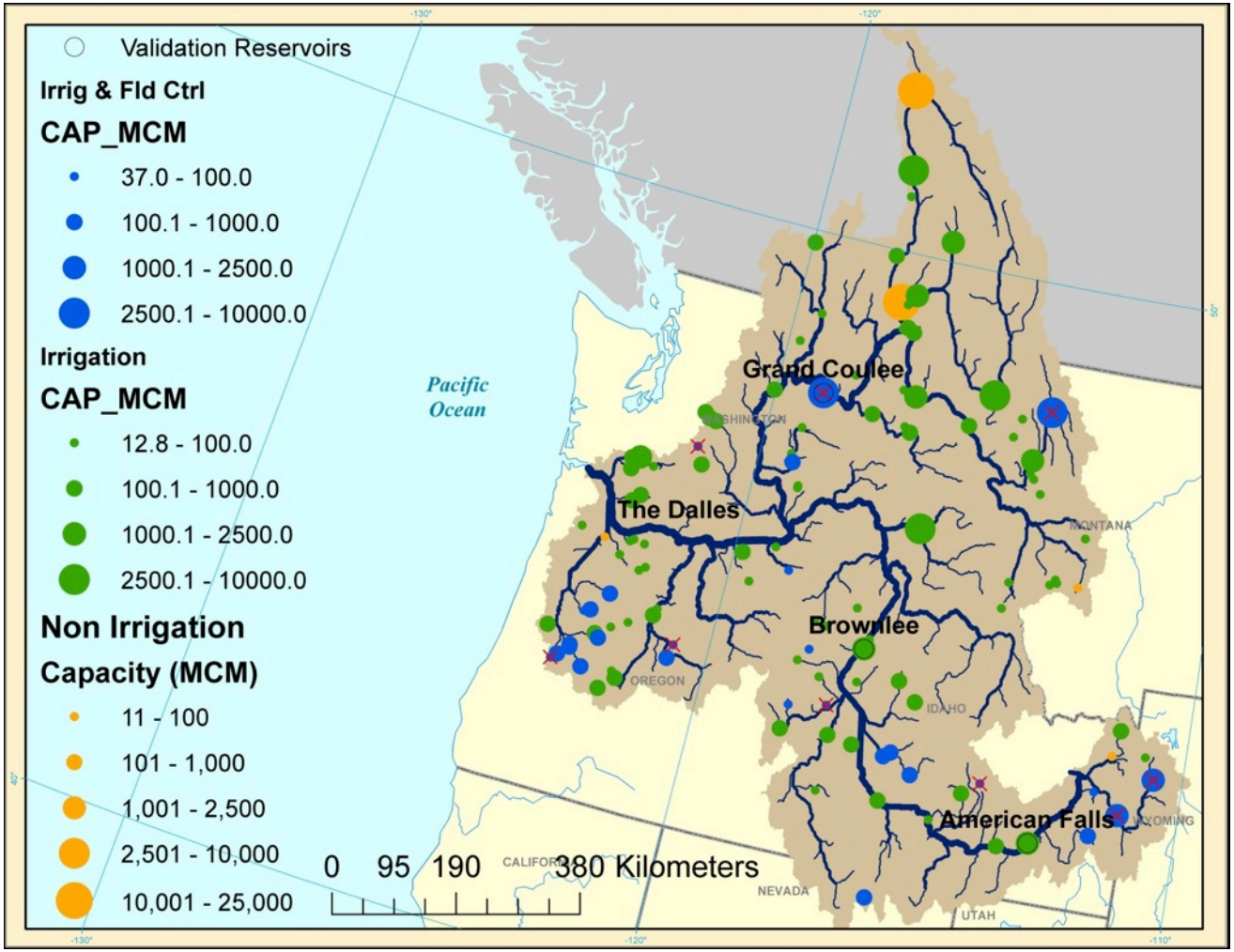
$$d_{mean,m} = d_{dom,m} + d_{ind,m} + d_{irr,m} + d_{liv,m} + d_{min,m} + d_{pub,m} + d_{thermo,m}$$

  - All others : hydropower, domestic, recreation, navigation

$$r'_{m,y} = i_{mean}$$

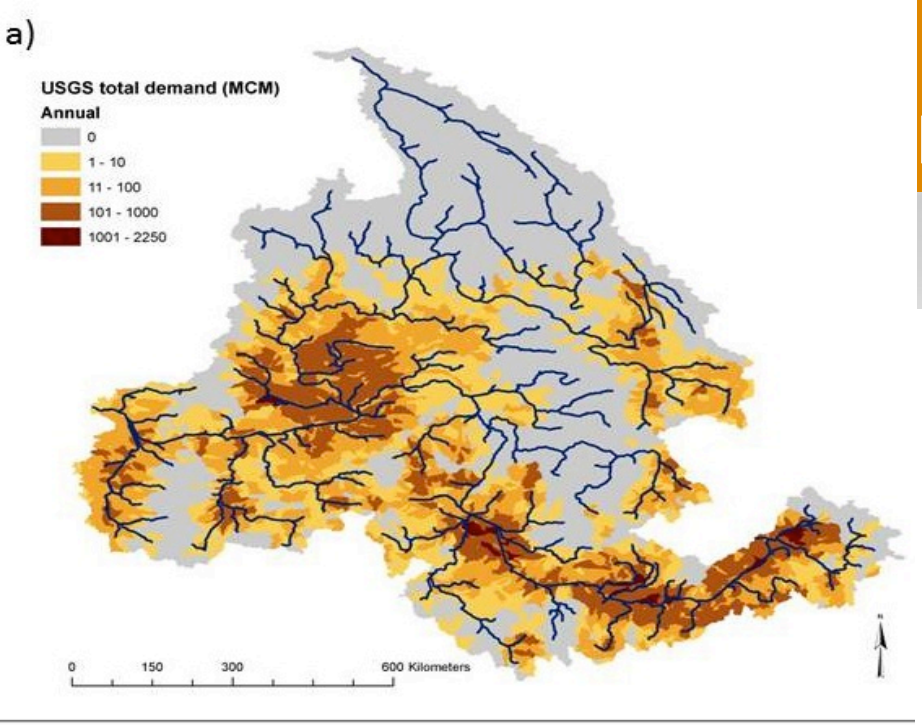
  - Further improvement with storage targets for combining flood control and irrigation release targets.

Columbia River Basin

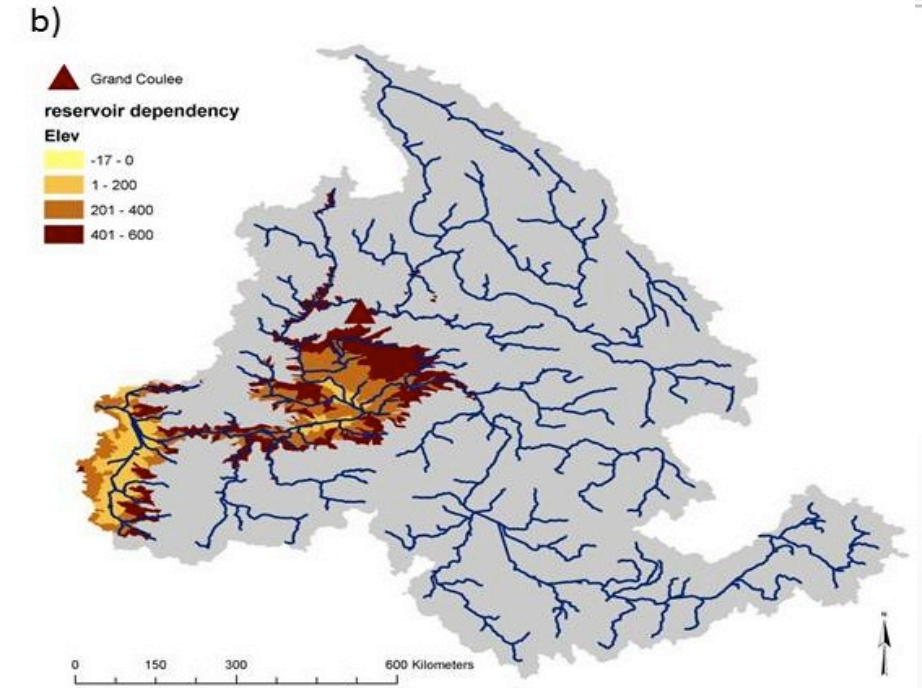


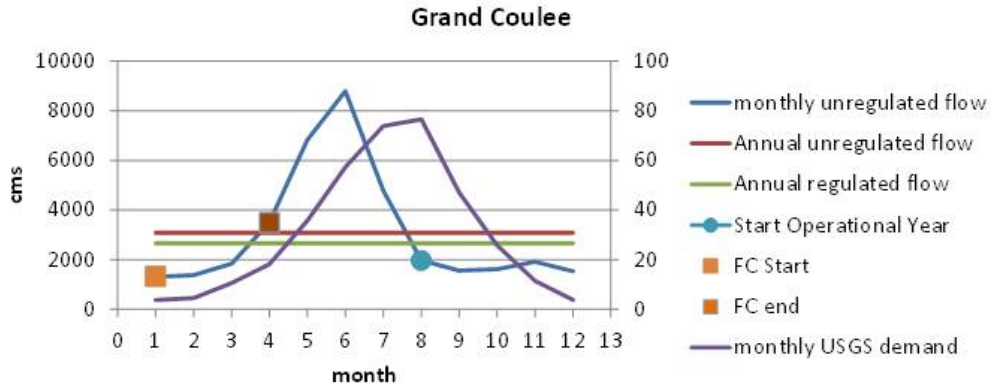
Dependency database

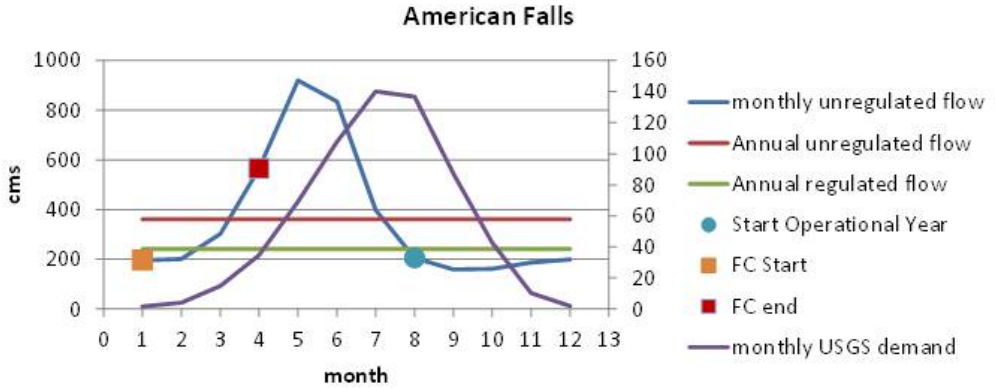
a)



b)







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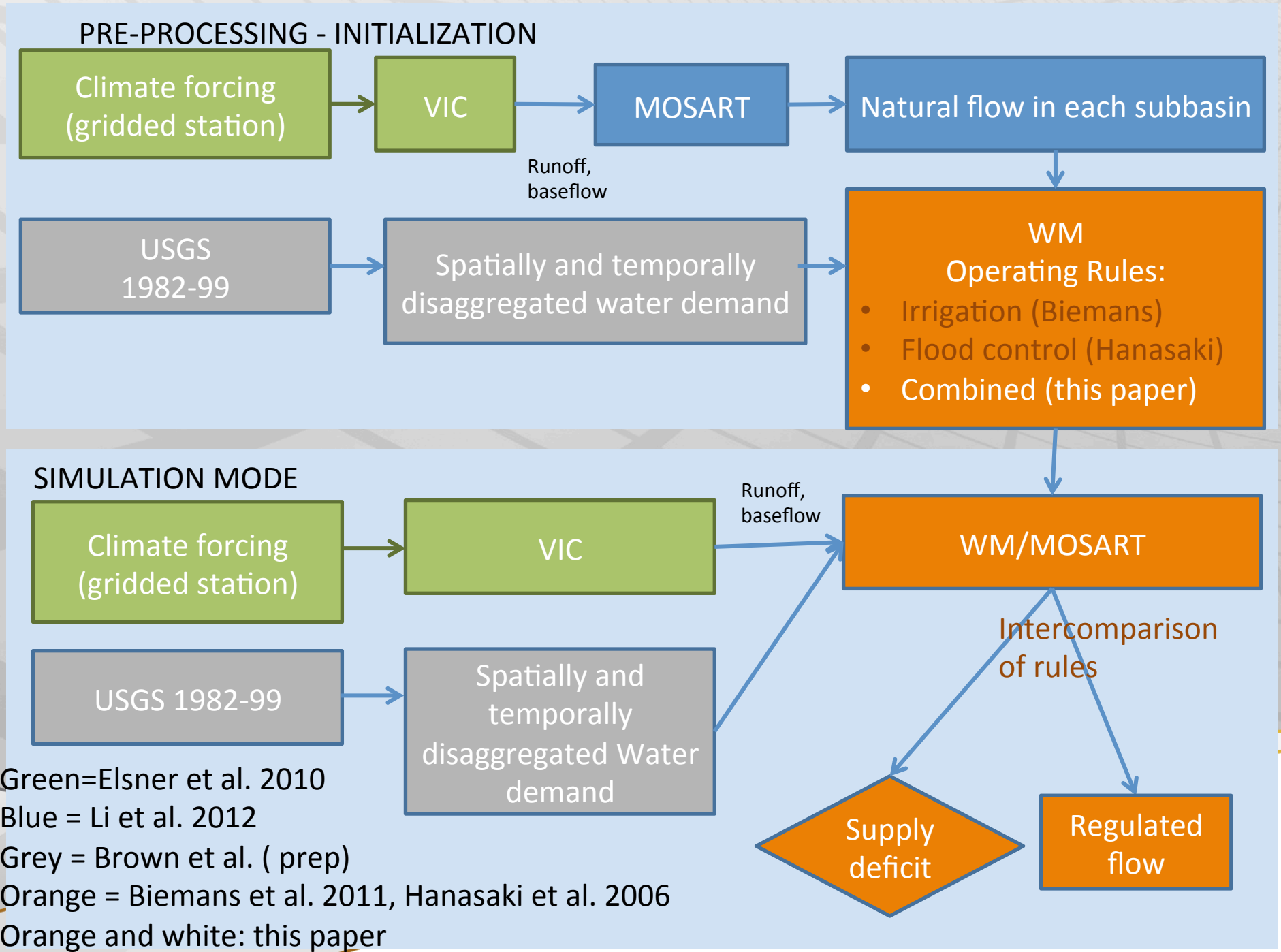
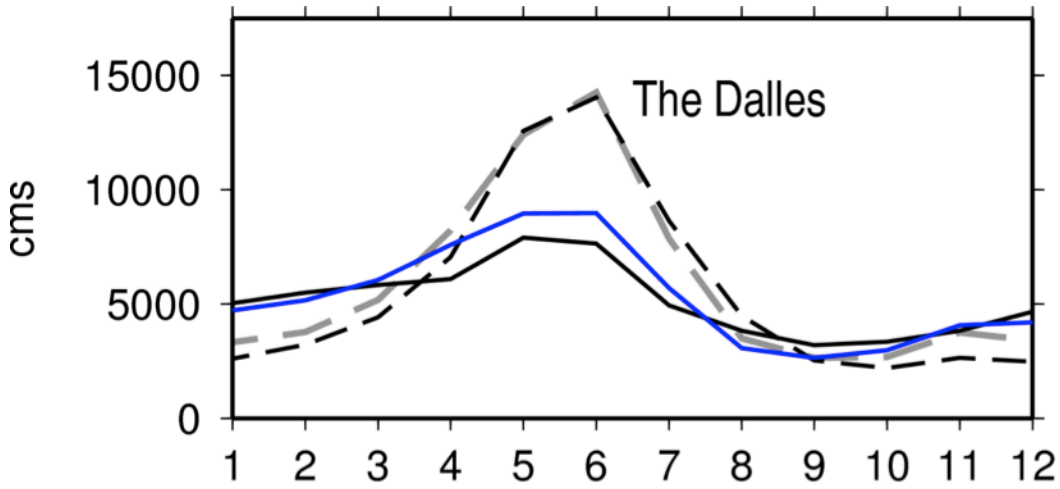

PRE-PROCESSING - INITIALIZATION
Climate forcing (gridded station)
VIC
MOSART
Natural flow in each subbasin
Runoff, baseflow
USGS 1982-99
Spatially and temporally disaggregated water demand
WM
Operating Rules:
• Irrigation (Biemans)
• Flood control (Hanasaki)
• Combined (this paper)
SIMULATION MODE
Climate forcing (gridded station)
VIC
Runoff, baseflow
WM/MOSART
USGS 1982-99
Spatially and temporally disaggregated Water demand
Intercomparison of rules
Supply deficit
Regulated flow
Green=Elsner et al. 2010
Blue = Li et al. 2012
Grey = Brown et al. (prep)
Orange = Biemans et al. 2011, Hanasaki et al. 2006
Orange and white: this paper

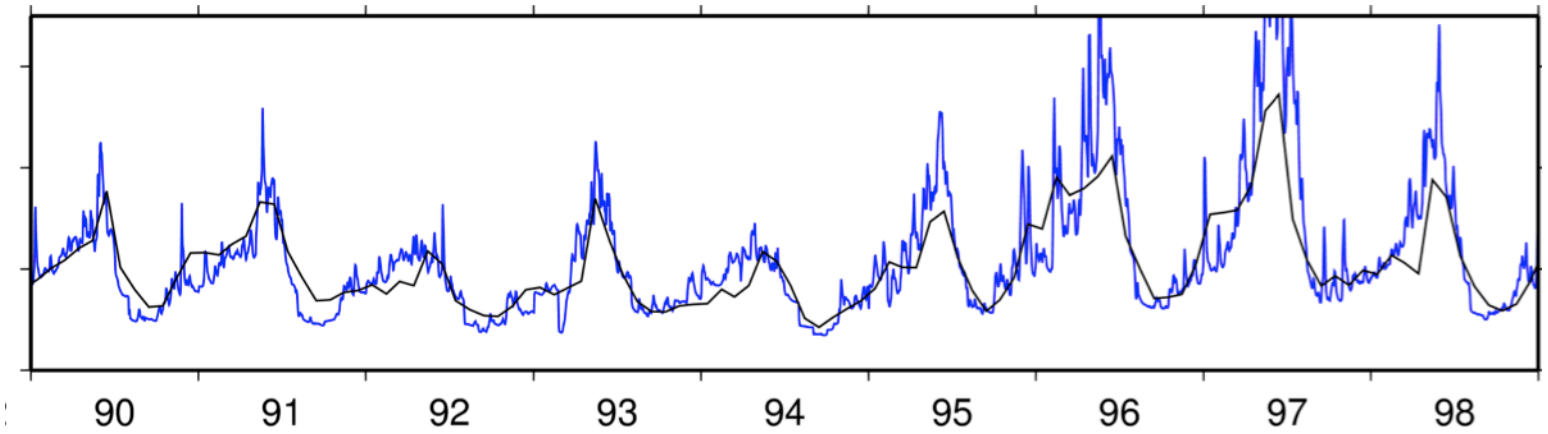
Validation at the regional scale:

- Simulated regulated flow



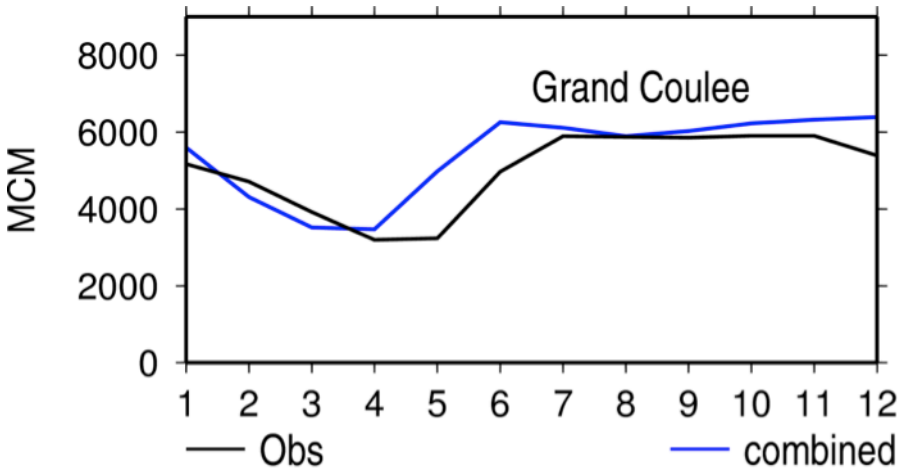
Blue: simulated regulated flow
Dashed gray: simulated natural flow
Black: Observed regulated
Dashed black: Observed naturalized

1984-99 period



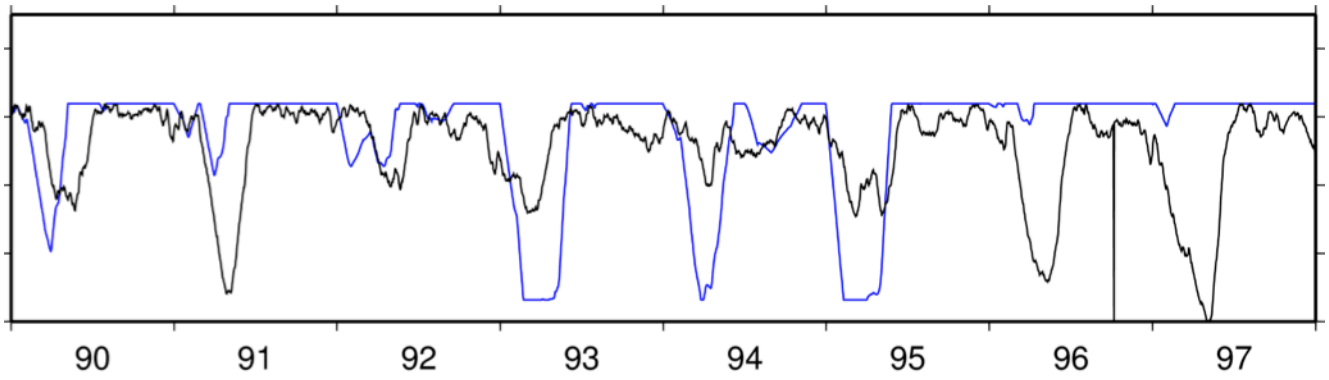
Validation at the regional scale:

- Simulated storage at Grand Coulee



Blue: simulated storage
Black: Observed storage

1984-99 period



Validation sub-regional scale

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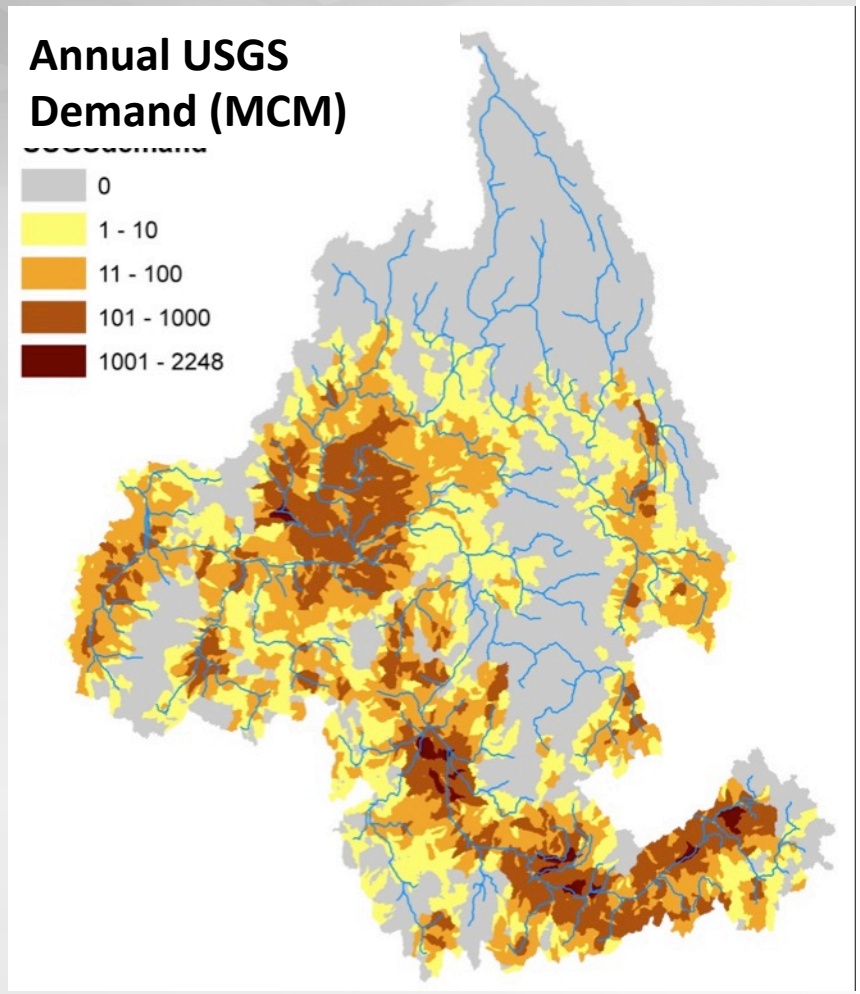
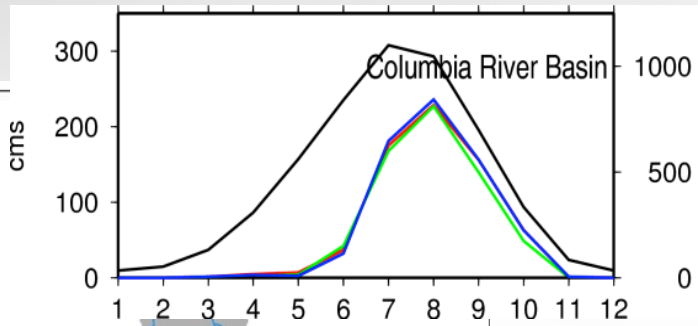
- Do we meet the observed consumptive demand?





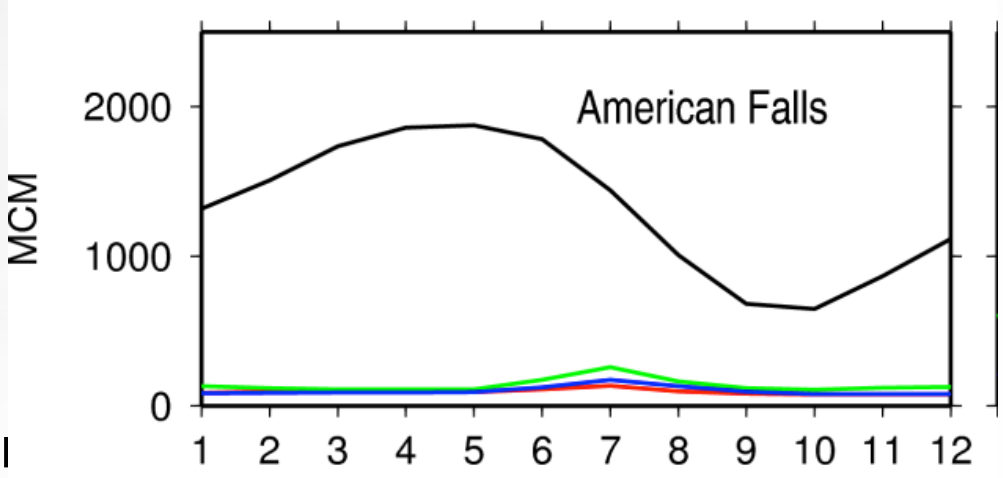
Publications

- Voisin, N., Li, H., Ward, D., Huang, M., Wigmosta, M., and Leung, L. R.: On an improved sub-regional water resources management representation for integration into earth system models, Hydrol. Earth Syst. Sci. Discuss., 10, 3501-3540, doi:10.5194/hessd-10-3501-2013, 2013. (In revision)
- One-way coupling of an integrated assessment model and a water resources model: evaluation and implications of future changes over the U.S. Midwest , N. Voisin, L. Liu, M. Hejazi, T. Tesfa, H. Li, M. Huang, Y. Liu, R.L. Leung. Submitted to HESS.

Remaining challenge

- Use of groundwater to complement the surface water system in places with large withdrawals with respect to the annual flow:
  - No groundwater
  - Assume all remaining water demand met through groundwater

Reservoirs remain dry.



Need to address how to esti
demand that should be met, in priority, by groundwater before drying up the surface water system for certain applications only (hydropower, water quality): Use GCAM

Additional slides

Improving generic operating rules

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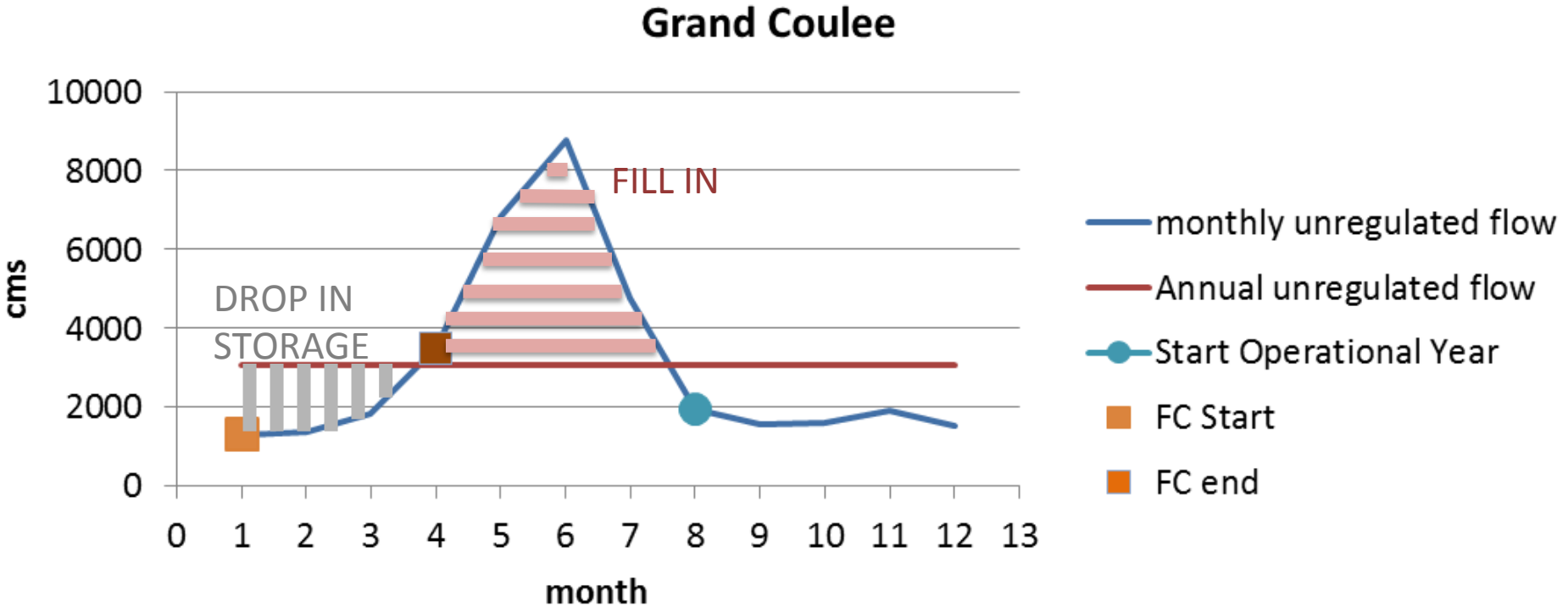
- Flood Control Period



$$r_{m,y} = r_{m,y} + \frac{Drop}{Ndrop}$$

$$r_{m,y} = \begin{cases} i_{mean} + \frac{(Fill - Drop)}{Nfill} & if\ (Fill \geq Drop) \\ i_{mean} & if\ (Fill < Drop) \end{cases}$$