Applying coupled Noah-MP and RAPID in reservoir level simulation: a case study in Lake Buchanan

Water Forum III

October 14th, 2013, Austin, Texas

Peirong Lin[1], Zong-Liang Yang[1], Cédric H. David[2], Ron Anderson[3], Xitian Cai[1]

Affiliations: *1. Department of Geological Sciences, UT-Austin; 2. University of Hydrologic Modeling Center, UC-Irvine; 3. Lower Colorado River Authority, TX*

Outline

- ❖ 1. Motivation and research questions
- ❖ 2. Modeling framework
- ❖ 3. A case study for Lake Buchanan
- ❖ 4. Conclusions and discussions

Research questions

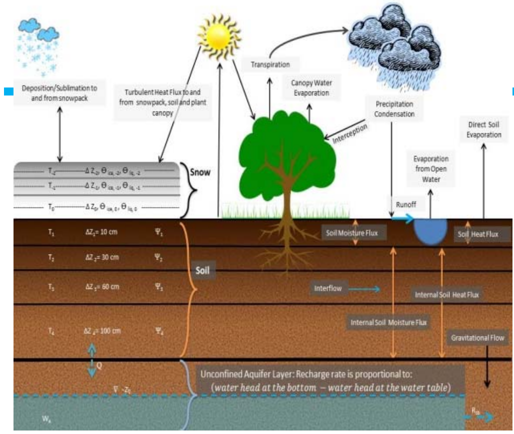
- How can the state-of-the-art climate models that represent the best physical knowledge facilitate decision making?

- How can a modeling framework that incorporates both grid-based information and vector-based information be applied to local-scale studies?

- What are the uncertainties in the modeling framework?

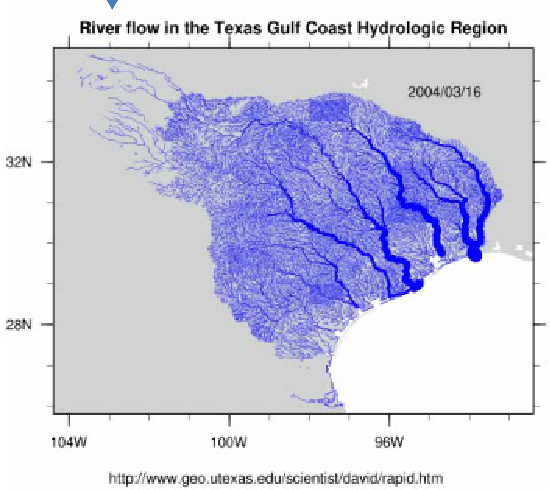
- What are the future implications?

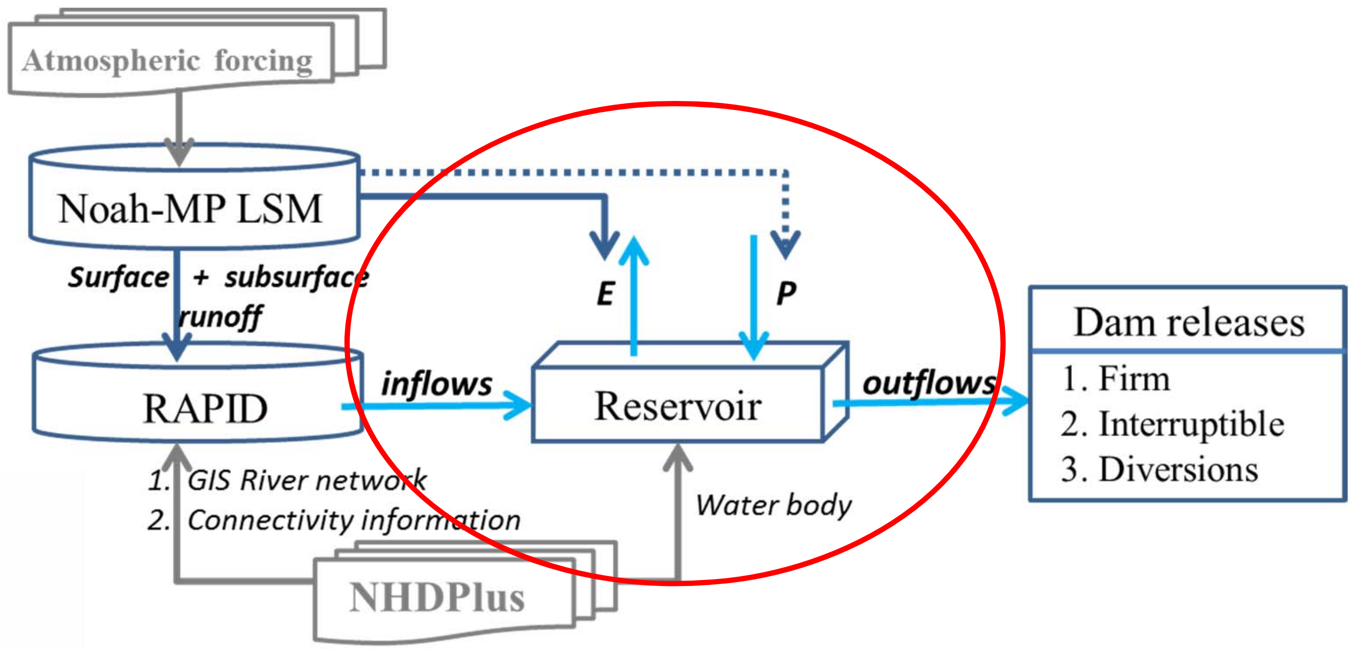
Modeling framework



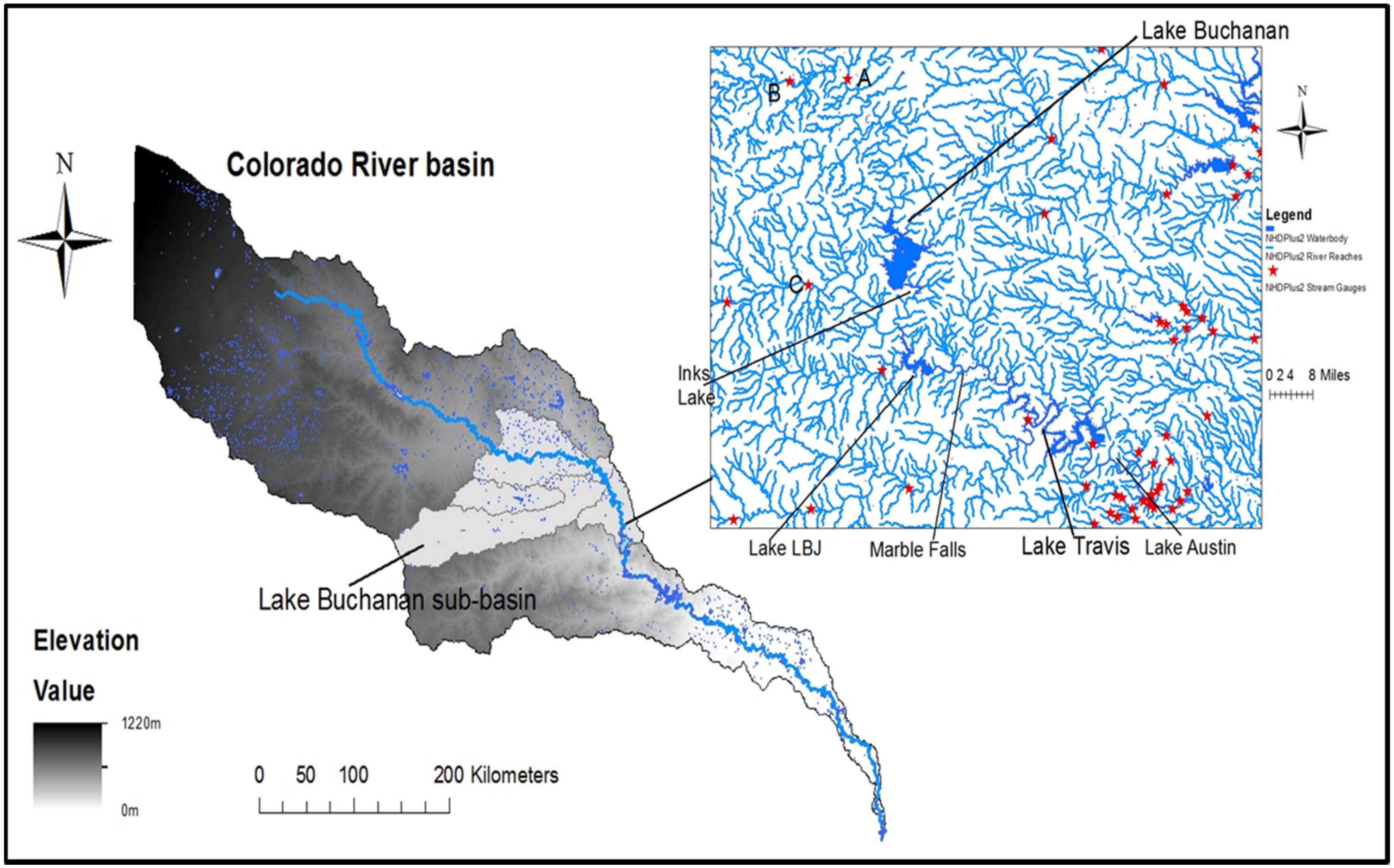
Runoff generation

Horizontal river routing: grid to vector coupling



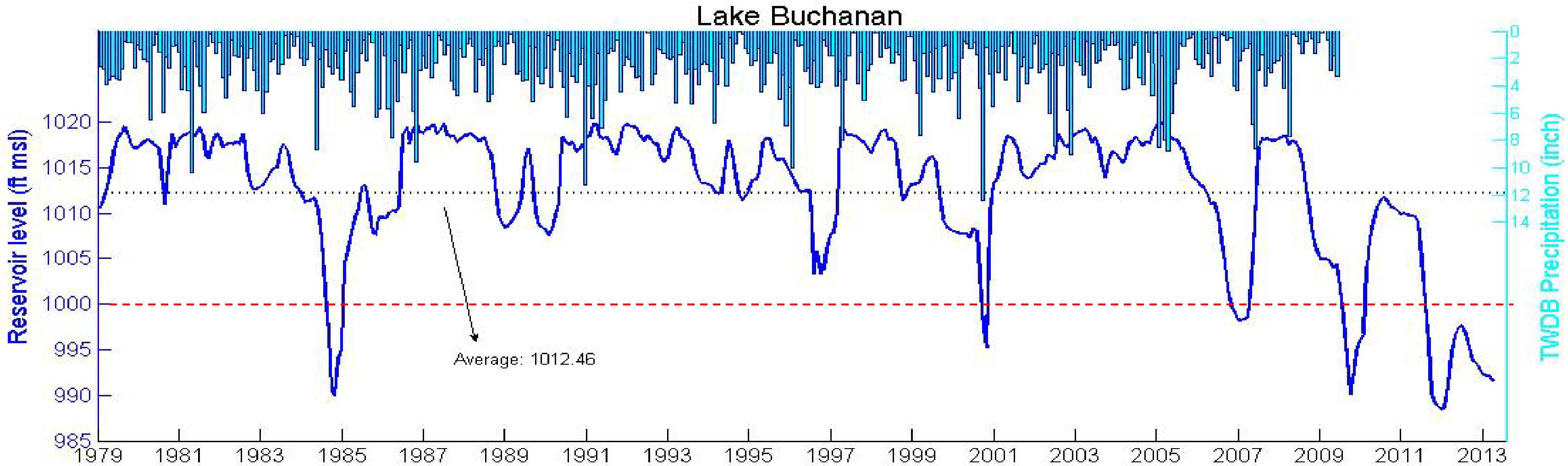


Highland Lakes in RAPID model



❖ Being able to simulate gauged and ungauged river reaches

A case study for Lake Buchanan level reconstruction

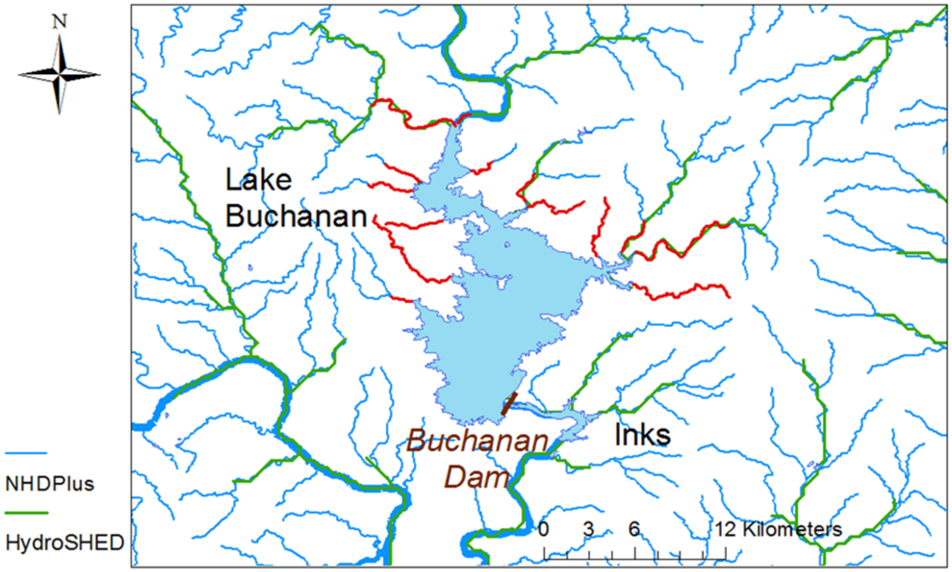


- Locates at the most upstream of highland lakes catchment; has the biggest surface area; together with Lake Travis, it supplies water for more than 1 million people
- Major droughts:
  - 83-84; 99-00; 05-06; 07-09; 2011

- Satellite altimetry mission Topex/Poseidon, Jason-2, Envisat etc. **does not** monitor because of its relative smaller size

A case study for Lake Buchanan: data

- Data
  - 2000-2007
  - RAPID river flow on Noah-MP surface and subsurface runoff: 4.5-km
  - Noah-MP forcing set: precipitation at 12.5-km NLDAS
  - Noah-MP output: evaporation at 12.5-km
  - Buchanan dam: monthly turbine release, gate release, diversions



NHDPlus at 1:100,100 scale

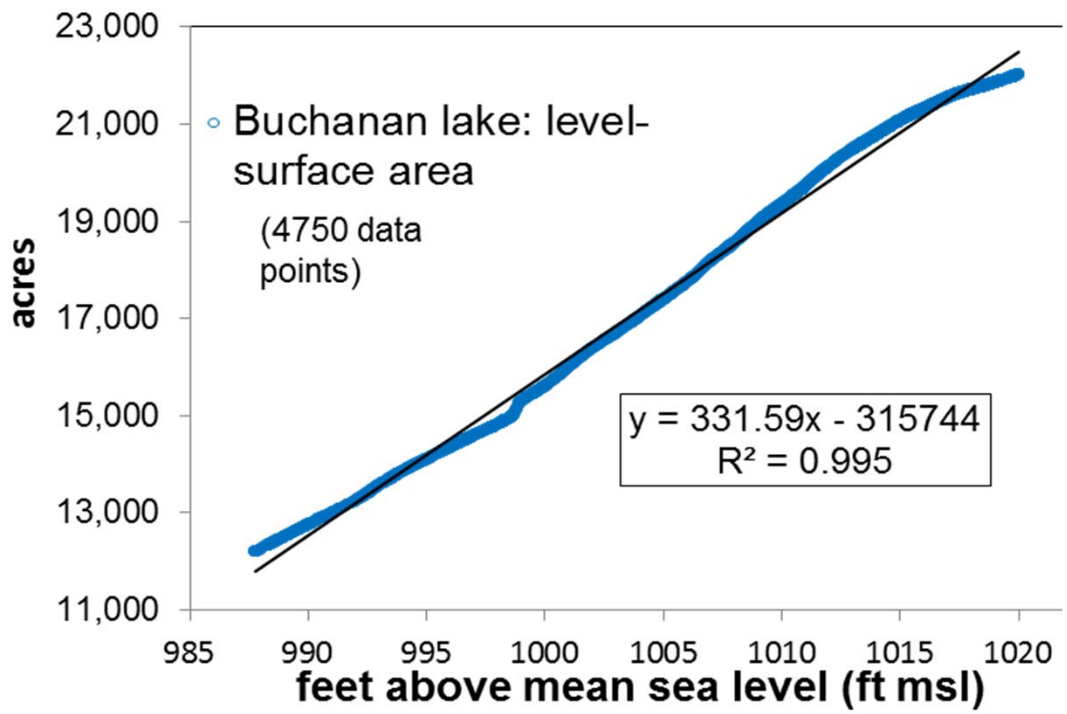
A case study for Lake Buchanan: method

❖ Mass balance model in re-constructing lake level:

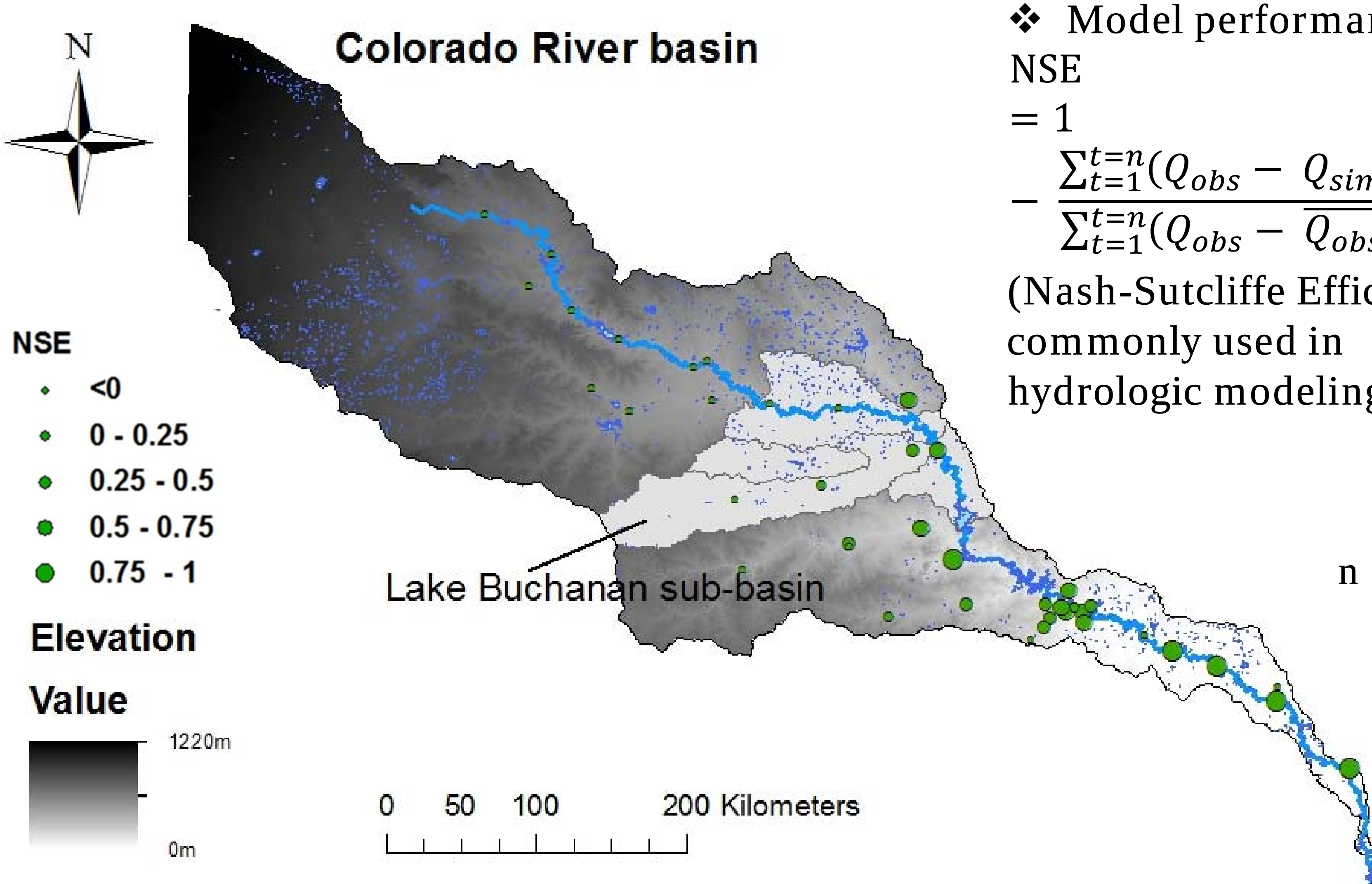
$$\Delta \boldsymbol{L}(t) = \frac{\boldsymbol{f}_{\boldsymbol{in}}(t) - \boldsymbol{f}_{\boldsymbol{out}}(t)}{\boldsymbol{A}(t)} + [\boldsymbol{P}(t) - \boldsymbol{E}(t)]$$

✓Lake bathymetry

$\boldsymbol{A}(t)$ = 331.59 $\boldsymbol{L}(t)$ - 315744



A case study for Lake Buchanan:
inflow uncertainties



❖ Model performance:

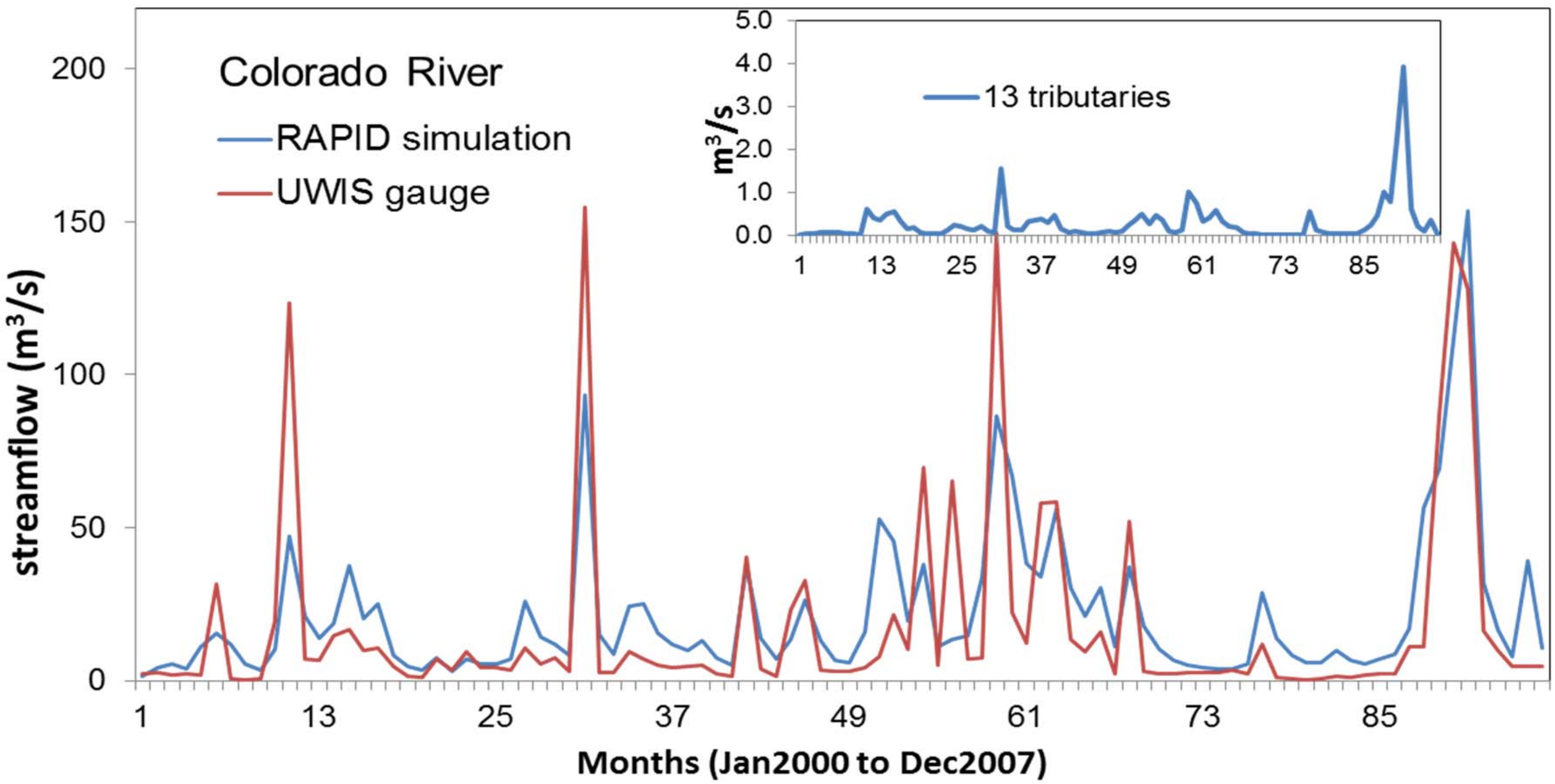
$$NSE = 1 - \frac{\sum_{t=1}^{t=n}(Q_{obs} - Q_{sim})^2}{\sum_{t=1}^{t=n}(Q_{obs} - \overline{Q_{obs}})^2}$$

(Nash-Sutcliffe Efficiency, commonly used in hydrologic modeling)

n = 144

A case study for Lake Buchanan:
inflow uncertainties

❖ Model performance (time series analysis of inflow estimation)



A case study for Lake Buchanan:
precipitation and evaporation uncertainties

Lake polygon on Noah-MP grids:

Value 16: water

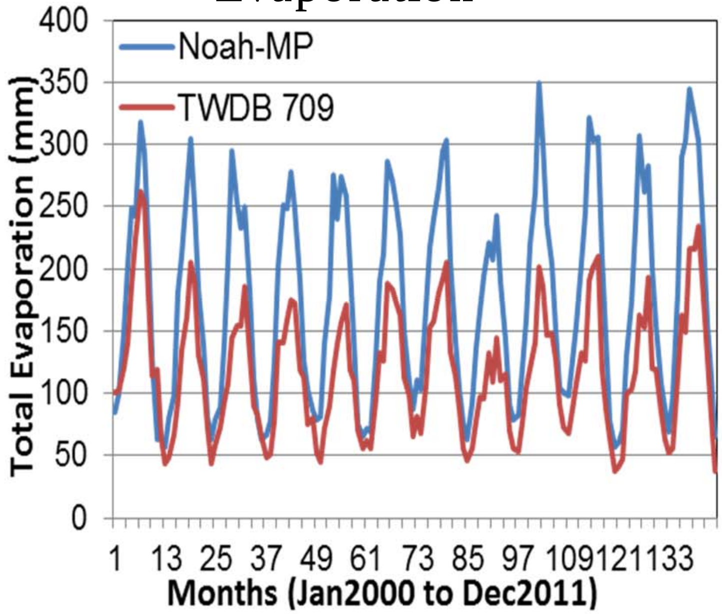
Value 5: cropland and grassland mosaic

❖ Penman equation:
- Saturation vapor pressure,
- Aerodynamic resistance,
- Density of air,
- Relative humidity,
- Wind,

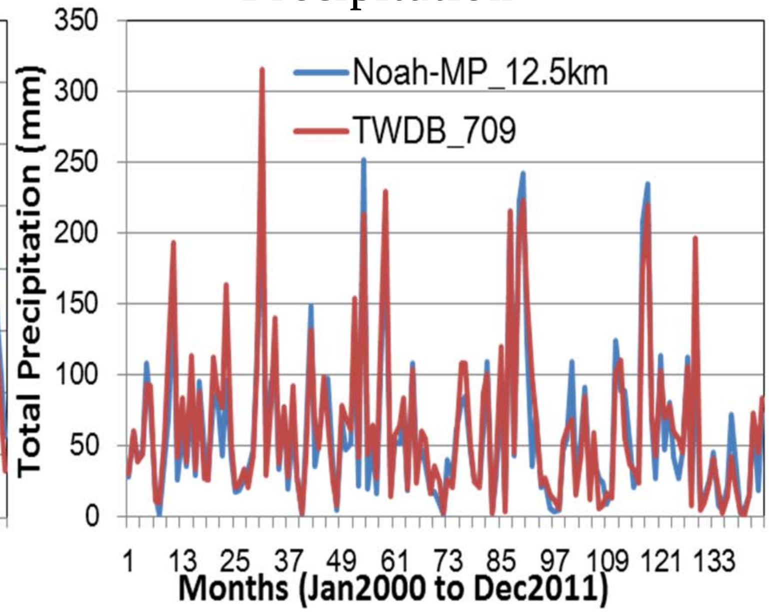
are taken into account for calculation.

A case study for Lake Buchanan:
precipitation and evaporation uncertainties

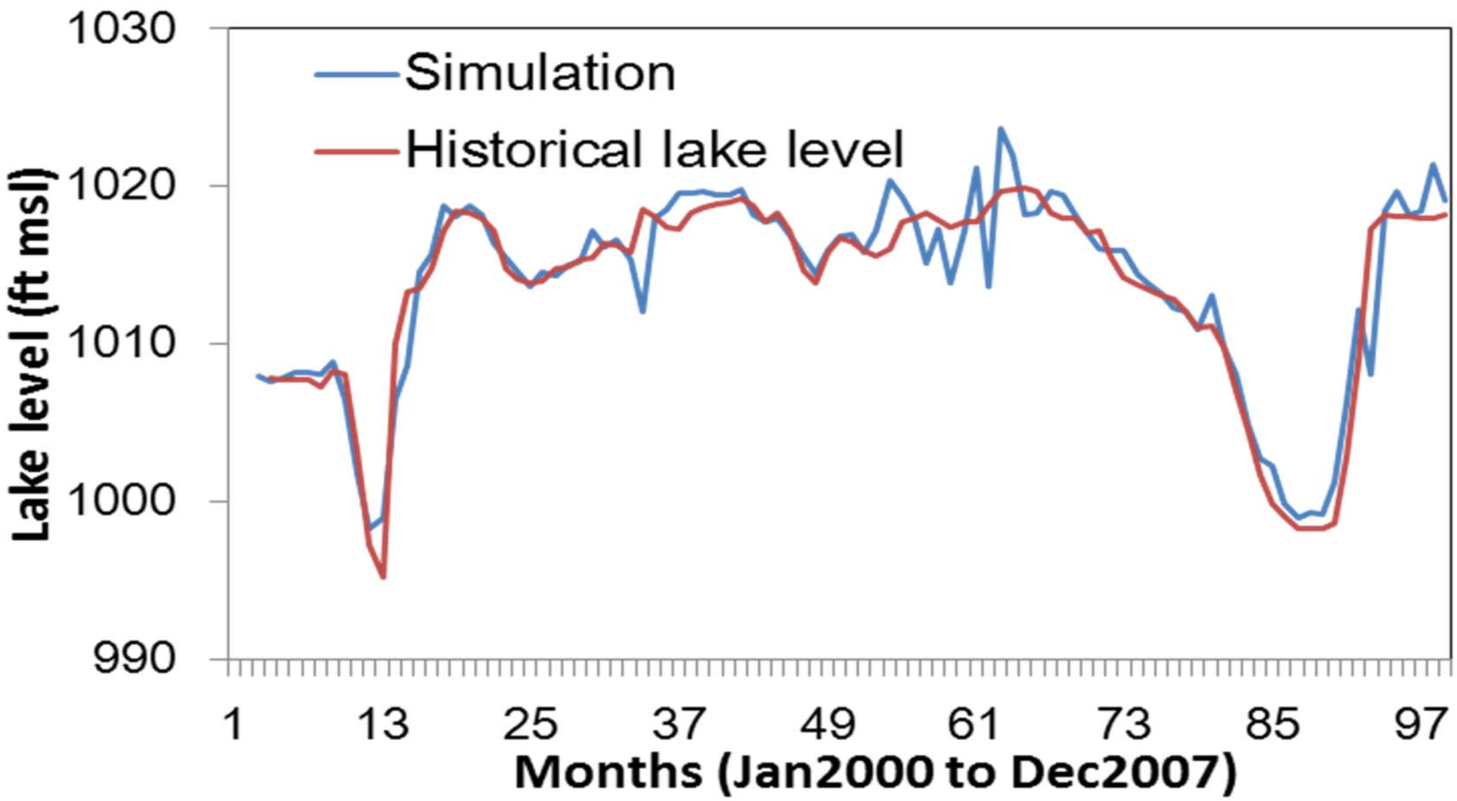
Evaporation



Precipitation



A case study in Lake Buchanan: results



- Model cumulative errors would occur after 4 years of simulation, it is essential to re-initiate the model equal to or less than every year, to ensure good performance of lake level reconstruction

Conclusions

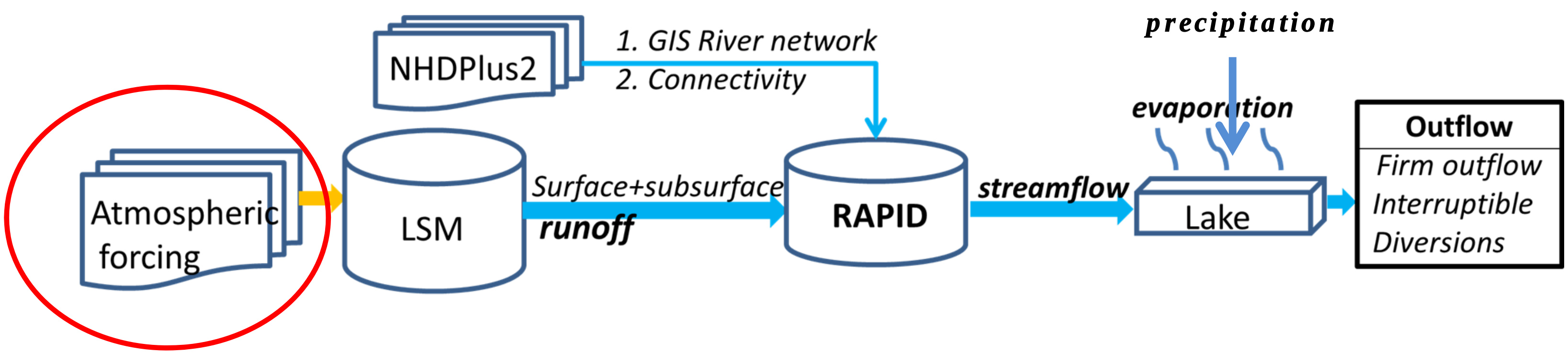
- The proposed modeling framework provides an alternative to monitor and forecast small- or medium-sized lake/reservoir level changes based on mass balance equation;

- Even though land surface models (LSMs) and river routing models are designed for large-scale (continental or global) studies, it can be applied to local-scale applications due to its vectorized environment;

- A case study is conducted while broader applications can be envisioned

Discussions

- Groundwater-surface water interactions are not taken into account in the current modeling framework;
- Improvements of model physics and parameterization;
- Coupling with the operational meteorological forecasts to provide short-term (several days to one season) or long-term (almost a year's lead time) hydrologic predictions



Thanks for attention!

- ❖ Questions?