SWOT Science Team Meeting

Hydrology Splinter

Global Models Working Group

Chapel Hill, NC

June 20, 2024

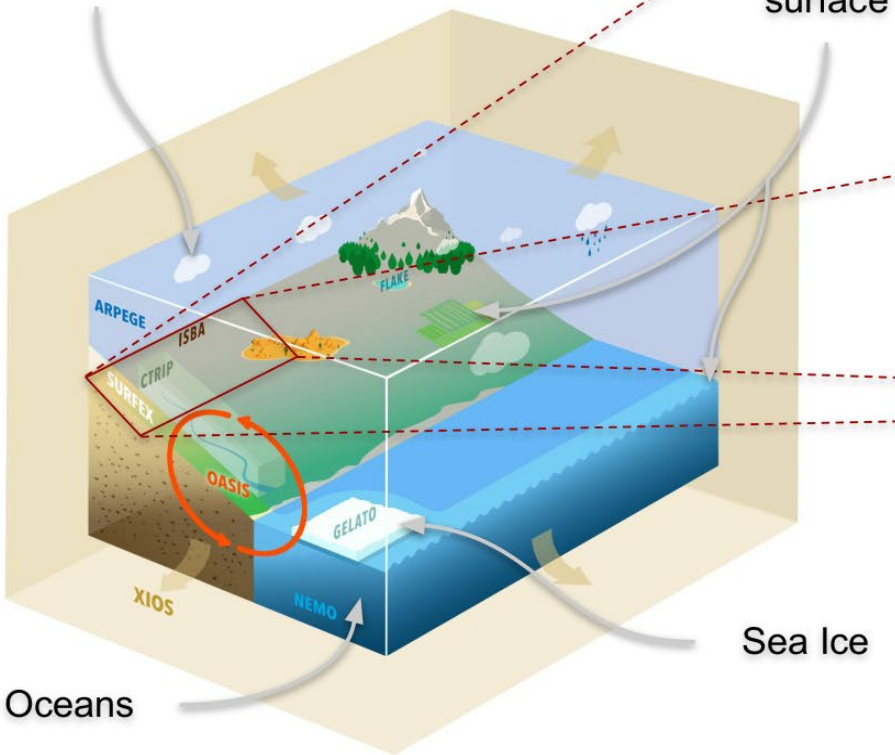
UCLA
DEPARTMENT OF
Geography

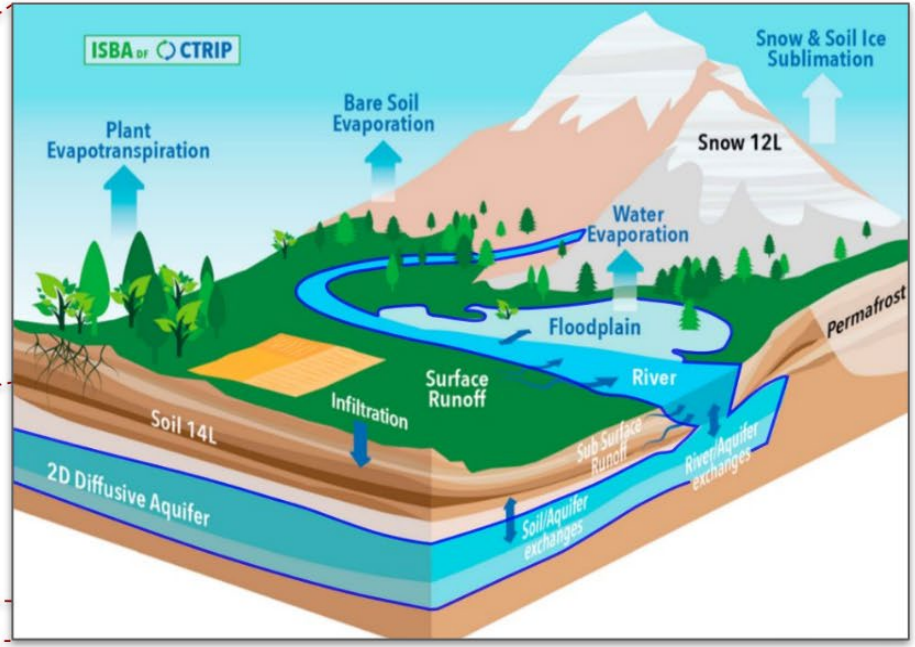
Discussion topic: Planning for a possible pilot activity utilizing SWOT data to evaluate the performance of lake and reservoir algorithms within Land Surface Models

Some key points:

- LSMs are now used in virtually all NWP and GCMs to represent the effect of the land surface on the partitioning of net radiation into latent, sensible, and ground heat flux
- Due to ET essentially being in both the energy and water balances, these models also balance water at the land surface
- As such, they represent inland water bodies (due to differences in albedo and other factors affecting water vs land-atmosphere exchanges), albeit with differing levels of sophistication
- While a number of model intercomparisons have evaluated the land components in LSMs, the inland water elements have not received as much attention due to lack of good data over large (e.g., continental or global areas)
- The latter should now be possible as SWOT data are becoming available

Continental water cycle in the CNRM Climate Model





Continental water cycle → Processes modelled by :

Land Surface Models (LSMs)

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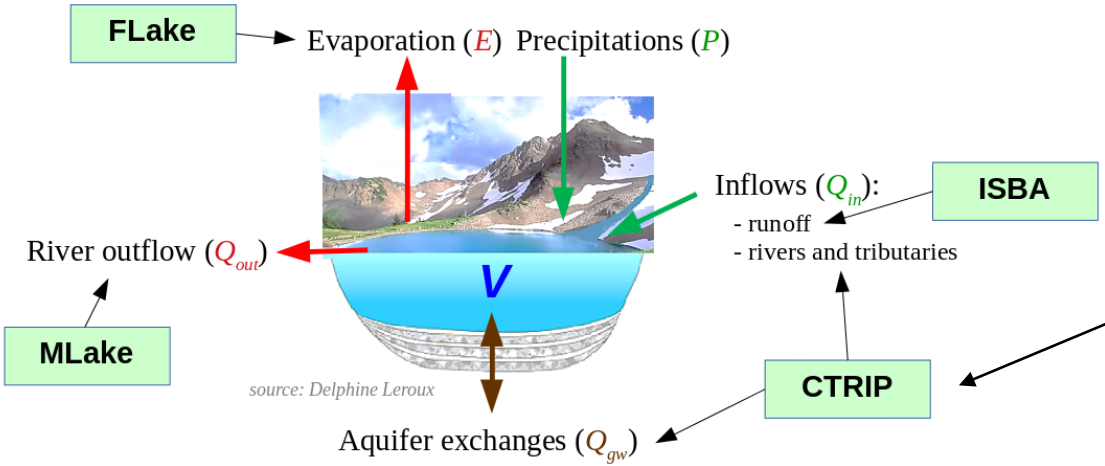
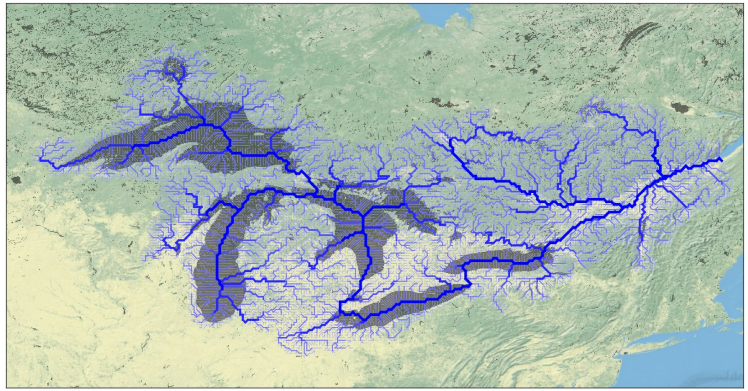
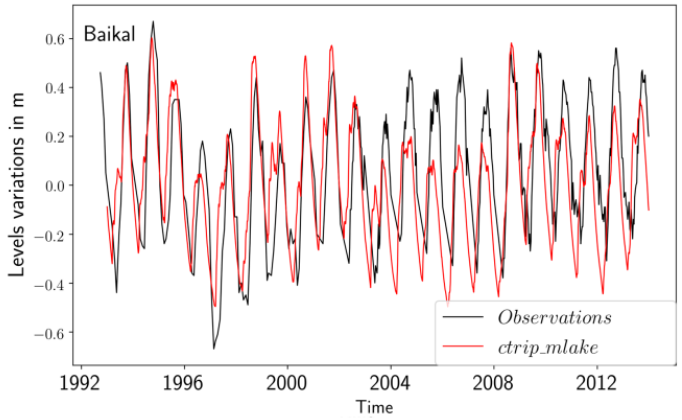
River Routing Models (RRMs)

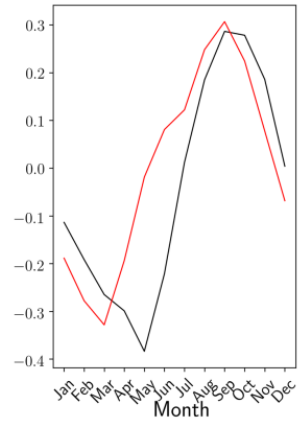
CTRIP – MLake (Mass Lake)



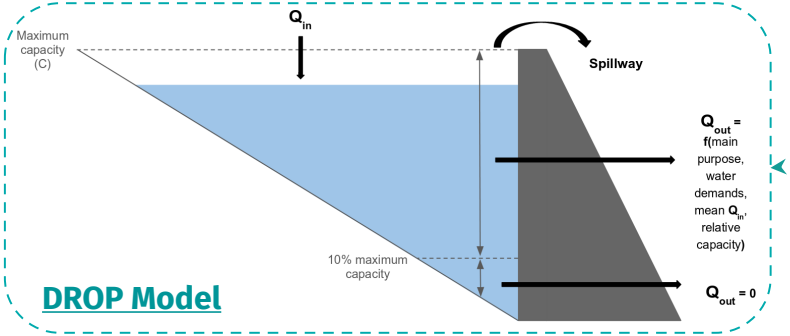


$$\frac{dV}{dt} = (P - E) * A_{lake} + Q_{in} - Q_{out} + Q_{gw}$$



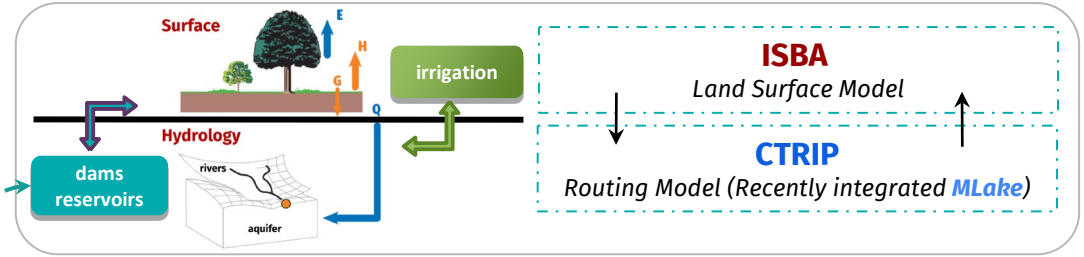


Dam-reservoir modeling



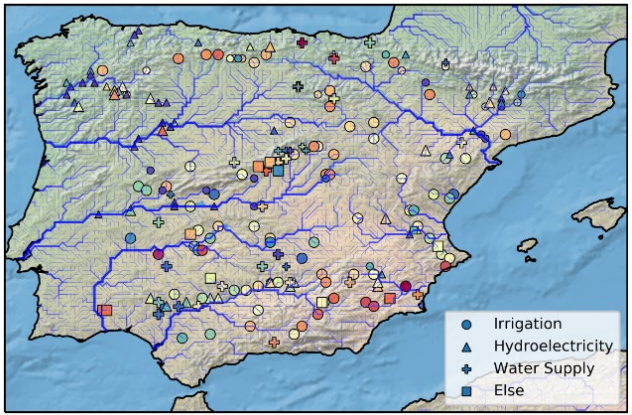
DROP Model

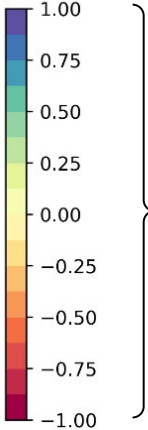
ISBA-CTRIP Model



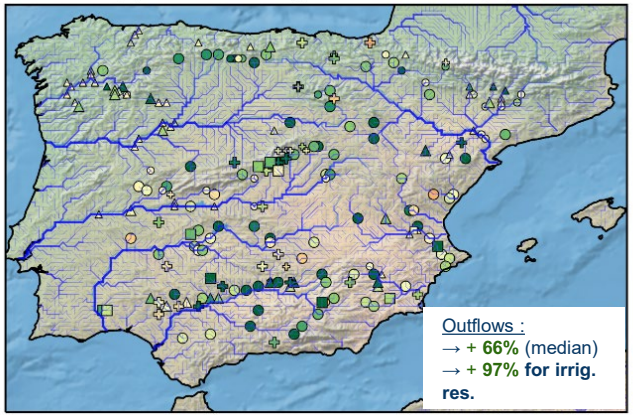
Fully parameterized reservoir model based on ***Hanasaki's scheme (Hanasaki N. et al., 2006)***
Difference between **irrigation** and **non-irrigation** reservoirs
Releases (Q_{out}) based on **inflows** (Q_{in}) and **water demands** (**irrigation model**)
Time step : weekly

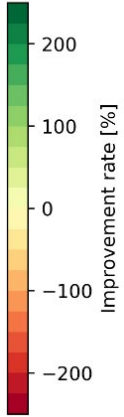
(a) Flow C2M of non-reservoir simulation





(b) Flow C2M Improvement rate (%)





Improving the representation of the **seasonal cycle** of **discharge** and **storage variation**, specifically for irrigation **large-storage capacity** reservoirs :

⇨ **Reproducing the seasonal shift between inflows and outflows caused by irrigation management rules**

Basic premise of a model evaluation project: We want to know how well (or poorly) a model is doing in reproducing observations (in this case, of lake/reservoir storage change)

Some key points:

- (Most) models are designed for use coupled with the atmosphere, which provides downward forcings (precipitation, and variables that control evapotranspiration), and these in turn produce the forcings (largely runoff and evaporative demand) that control lake water balance.

- Because these atmosphere-generated variables are subject to error, we would like not to convolve these errors with errors in the lake and wetland model.

- This is commonly done by replacing the fluxes from (and to) the atmosphere with gridded observations (of precipitation, temperature, downward longwave and solar radiation, surface wind, and vapor pressure deficit.

So, we need a gridded forcing data set. Considerations:

Domain: suggest North America or CONUS to start (makes data considerations below more manageable)

Time period: needs to be near-current, as out SWOT data set most likely will need to go up to real time (minus a month or two) in order to get a full year (hence full seasonal cycle)

What spatial resolution? Needs to be consistent with size of water bodies we hope to represent, arguably order 5 km or so.

Sources: reanalysis is too coarse (e.g., 31 km for ERA5). Some downscaled ERA5 (via WRF exist, e.g., Western U.S., but issues with time period (not current).

Also, reanalysis-based forcings may be ok for most variables, but perhaps not for precipitation (may want gridded observations) – for which various data sets exist, but generally aren't current.

Some other points:

- Forcing the LSM (that contains a lake/reservoir model) with gridded observations (or reanalysis) has the advantage that it allows production of output (lake/reservoir storage in particular) that can, in principle, be directly compared with SWOT observations.

- So arguably this should be done. However, there is an alternative, which is to force the lake/reservoir model with observations (primarily of surface inflows) that otherwise would be produced by the LSM.

- This sidesteps errors resulting from the LSM forcings.

- On a limited basis, we might identify lakes (and especially reservoirs) for which the inflows are known (e.g., in the U.S. measured by USGS gauges)

A possible path forward

1) Identify and initial target watershed (e.g., HUC-2, perhaps upper Mississippi (avoids topographic complications)
2) Determine a target spatial resolution (suggest range 1 – 5 km)
3) Identify and evaluation possible model forcing data sets (could include for instance USNWS QPE, AORC, downscaled (e.g., using WRF) reanalysis, etc.
4) Assemble SWOT data, filtered for quality to target lakes and reservoirs within the domain (note that we can afford to be conservative, lots of useful information about model performance from a subset of all lakes and reservoirs represented by the models).
5) Identify target reservoirs (and perhaps some lakes) for which inflows can be prescribed (hence separating storage errors associated with forcings vs model errors)
6) Implement the models using filtered SWOT data from 4) (perhaps for a few months) and conduct preliminary evaluations
7) Identify glitches, and resolve.