An Improved Hydrologic Modeling Framework for Flood Simulations in Connecticut

Xinyi Shen, Emmanouil Anagnostou

University of Connecticut

Civil & Environmental Engineering

UCONN

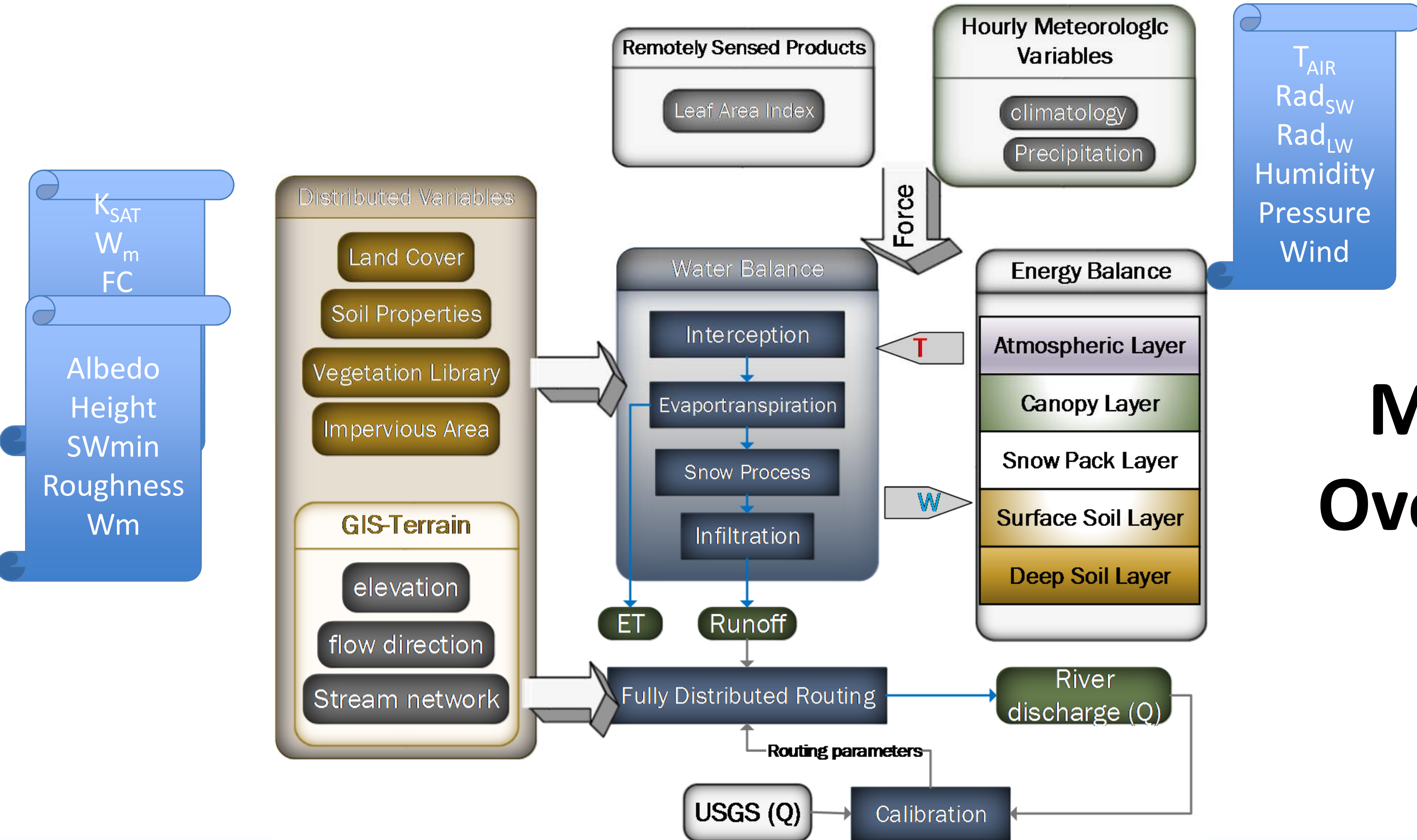
CIRCA Connecticut Institute for Resilience and Climate Adaptation

Connecticut Energy Environment

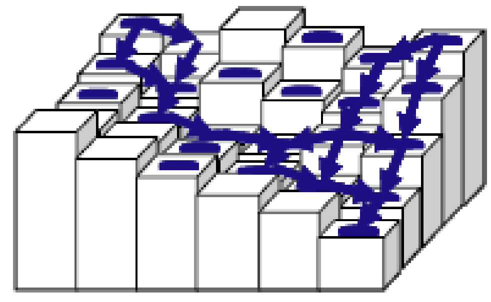
Key features for an improved CT hydrologic model:

- Main
  - a fully Distributed Linear Reservoir Routing (DLRR)
  - an energy & water balances coupled scheme for ET and snow process
  - distributed parameters from 1km soil map, 500m land cover maps 1km LAI (Leaf Area Index) product
- Extended
  - multi-site calibration based on multi-objective optimization.
  - flood inundation mapping using 1 meter LiDAR-derived DEM
  - include hydraulic structures for selected towns

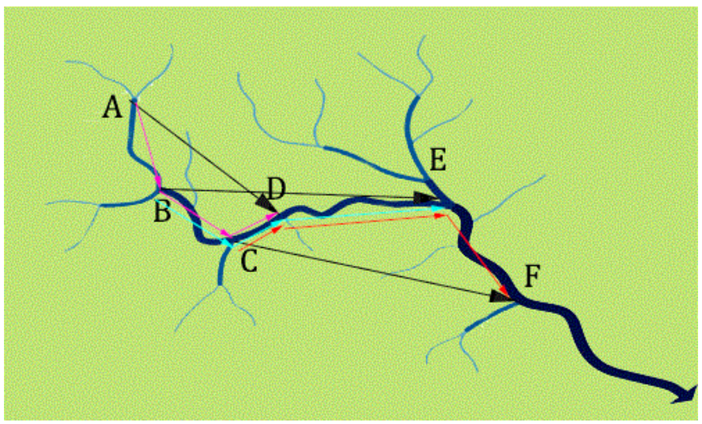
Model Overview

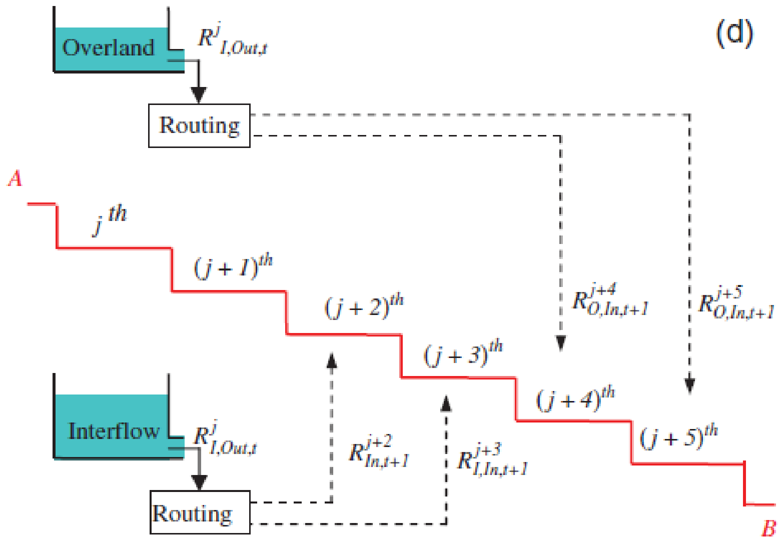


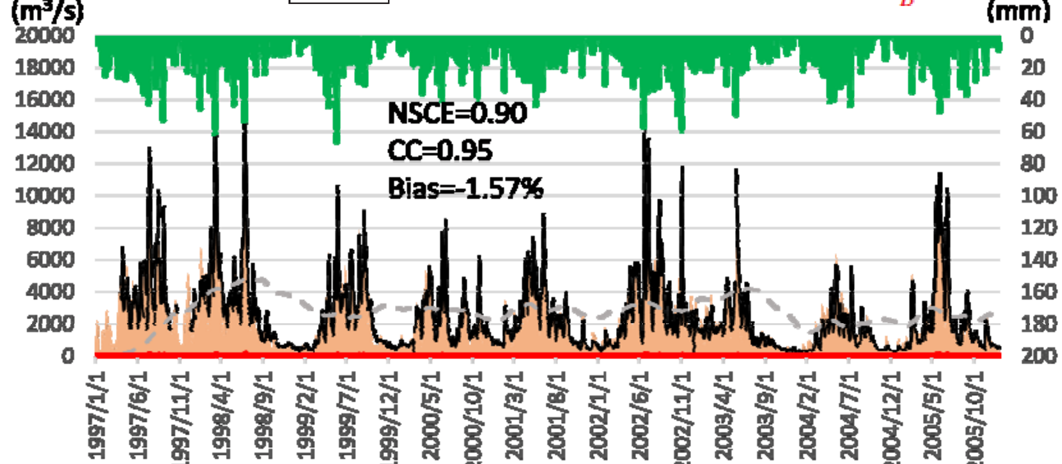
Cell-To-Cell Routing



Fully Distributed Linear Reservoir

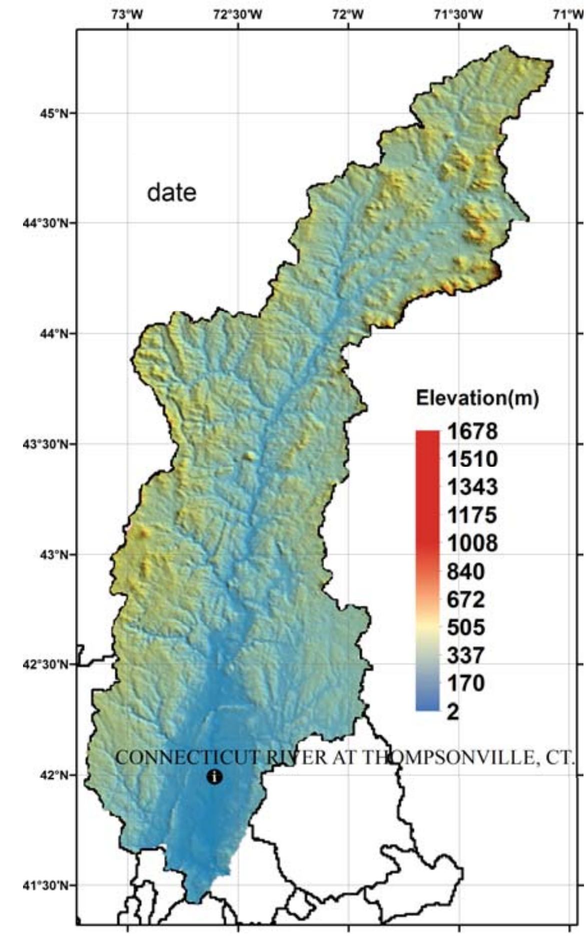






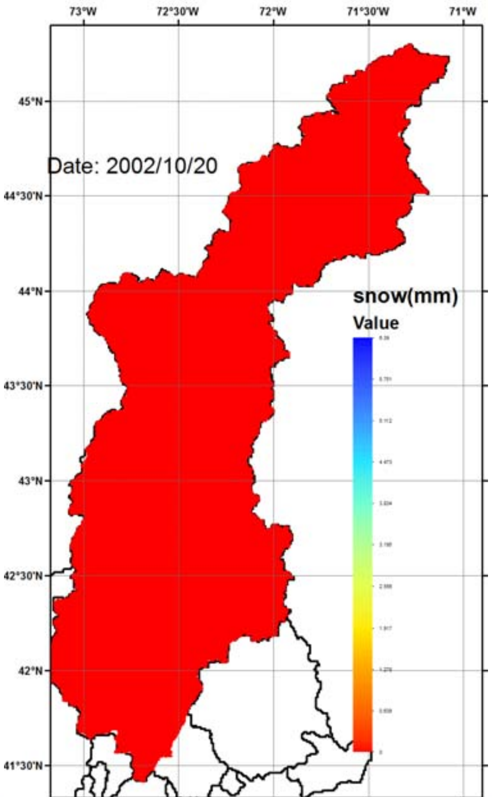
Experiment Design

- Time Period: Jan. 1, 2002- Dec. 31, 2007
- Connecticut River, CT
- Forcing data
  - NLDAS Reanalysis (14km $\times$ 14km,Hourly)
  - Stage IV Precipitation(4km $\times$ 4km, Hourly)
  - MODIS LAI(1km $\times$ 1km, 8-day)
- Land Cover: Satellite data (MODIS: 500m $\times$ 500m)
- Soil Texture Map
  - Soil Grids 1k (1km $\times$1km, 6 layers,0-2m depth)
  - http://www.soilgrids.org/

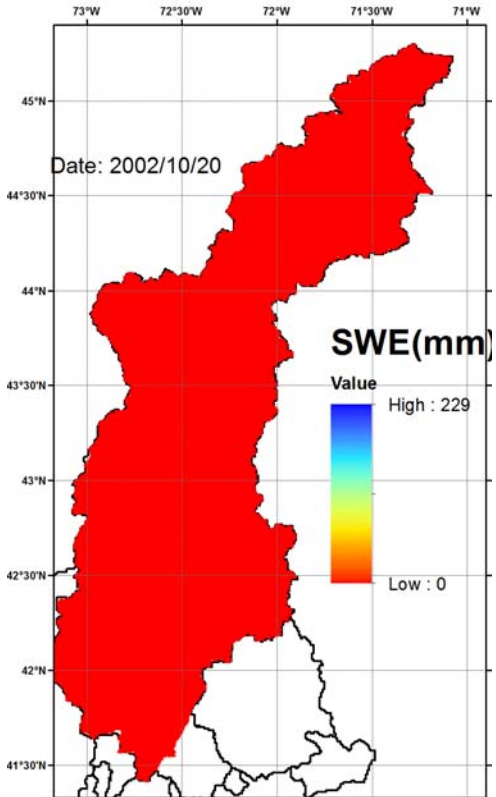


SNOW & SWE (Snow Water Equivalence)

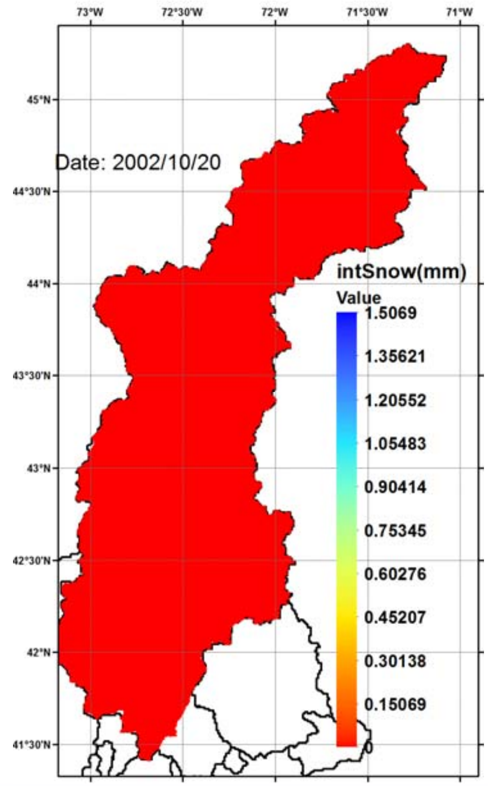
Snow fall



SWE of the snow pack on the ground

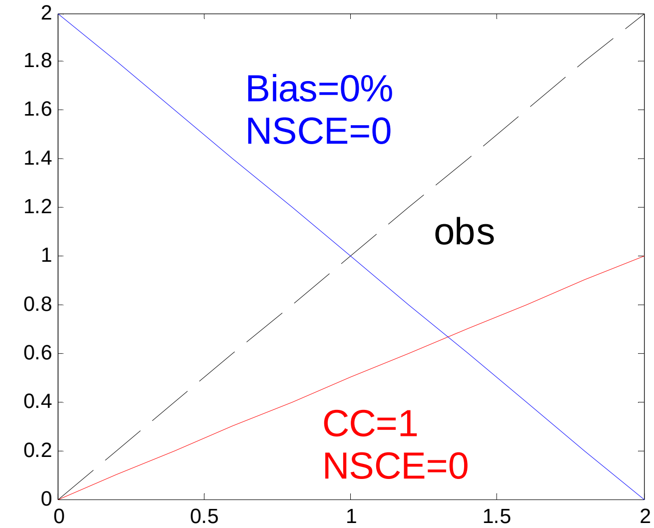


Intercepted snow by canopy

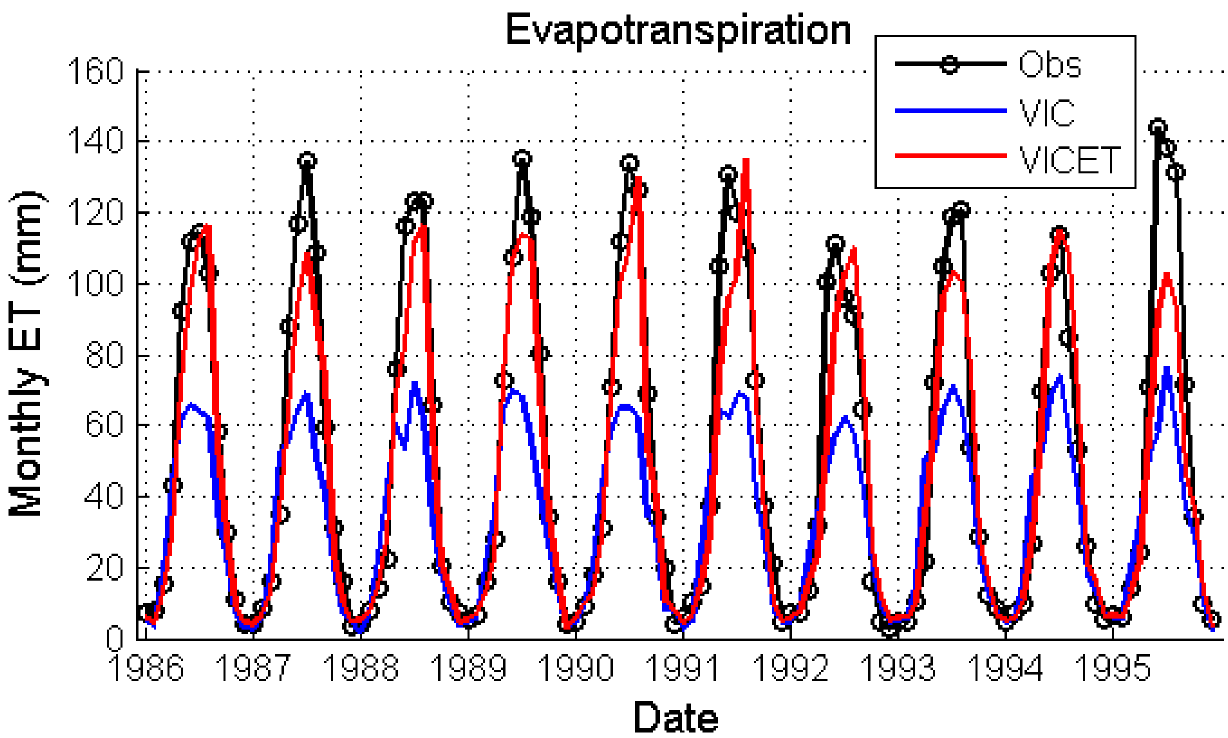


Hydrologic Statistics

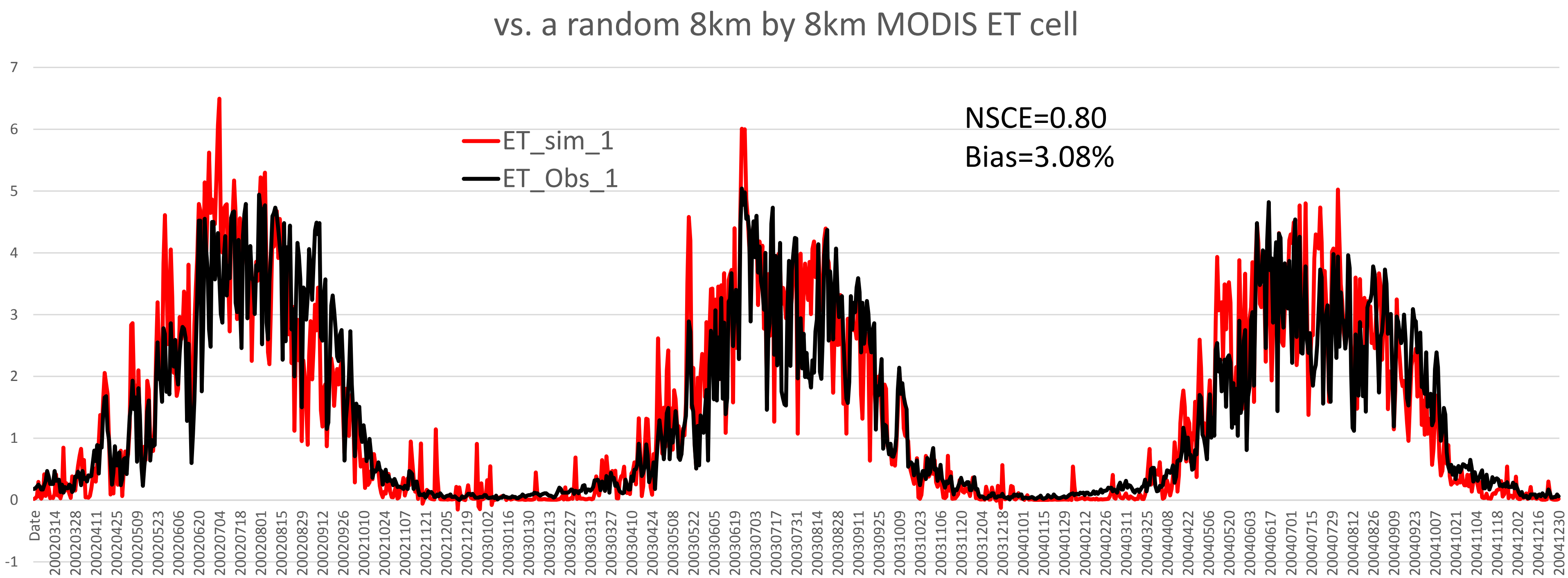
- $NSCE = 1 - \frac{\sum_{t=1}^{T}\left(X_{obs}^{t} - X_{m}^{t}\right)^2}{\sum_{t=1}^{T}\left(X_{obs}^{t} - \overline{X_{obs}}\right)^2} \in [-\infty, 1]$
- $CC = \frac{\sum_{t=1}^{T}\left(X_{m}^{t} - \overline{X_{m}}\right)\left(X_{obs}^{t} - \overline{X_{obs}}\right)}{\sqrt{\sum_{t=1}^{T}\left(X_{obs}^{t} - \overline{X_{obs}}\right)^2 \sum_{t=1}^{T}\left(X_{obs}^{t} - \overline{X_{obs}}\right)^2}} \in [-1,1]$
- $Bias = \frac{\sum_{t=1}^{T}\left(X_{obs}^{t} - X_{m}^{t}\right)}{n\overline{X_{obs}}} \times 100\%$



VIC's ET Result in CT River



CELL-To-CELL Validation



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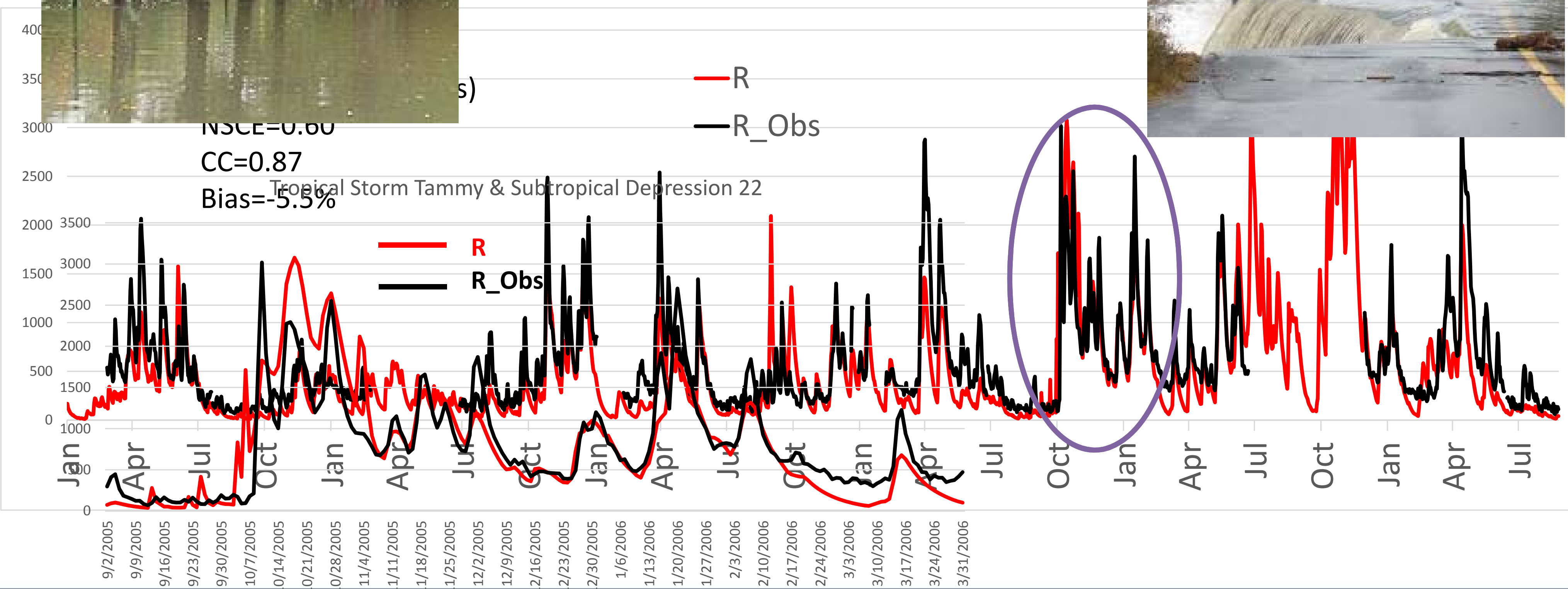
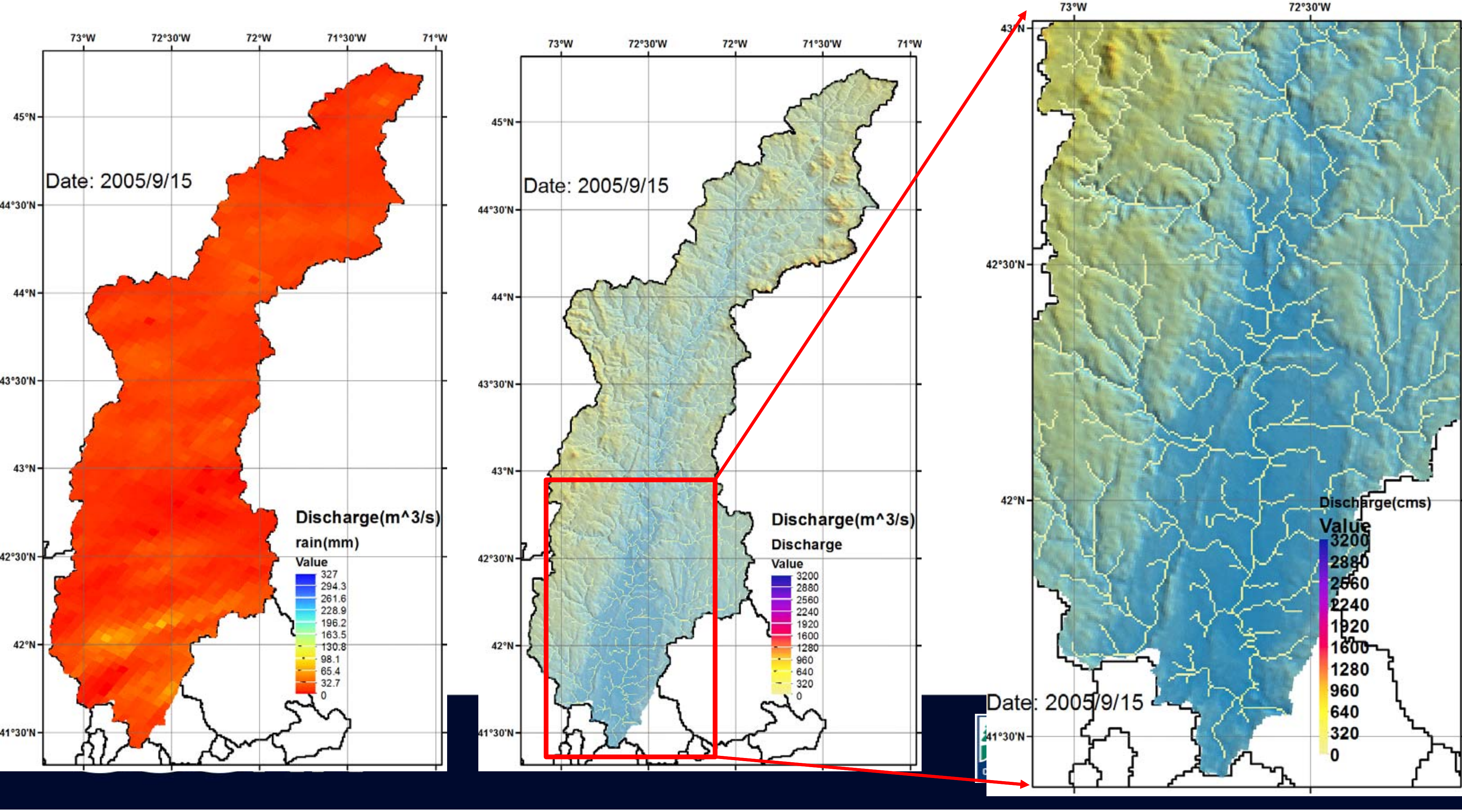
River Discharge



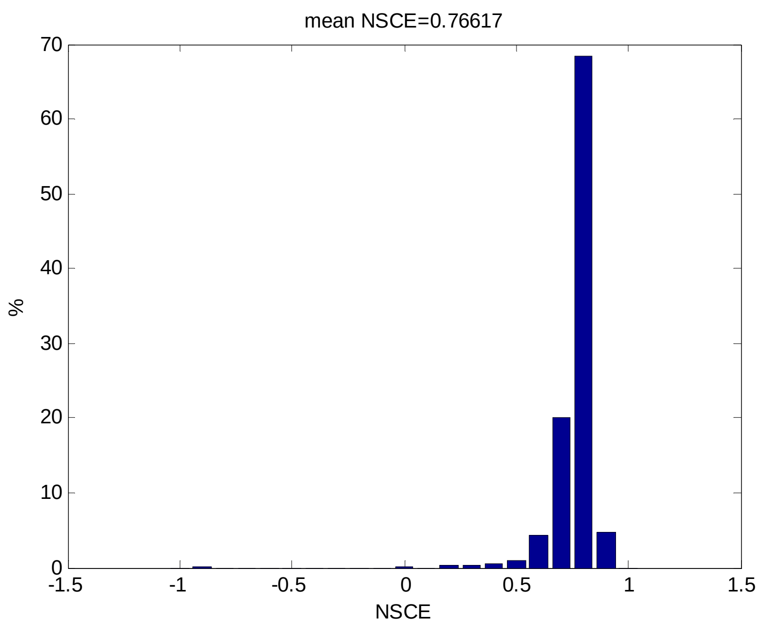


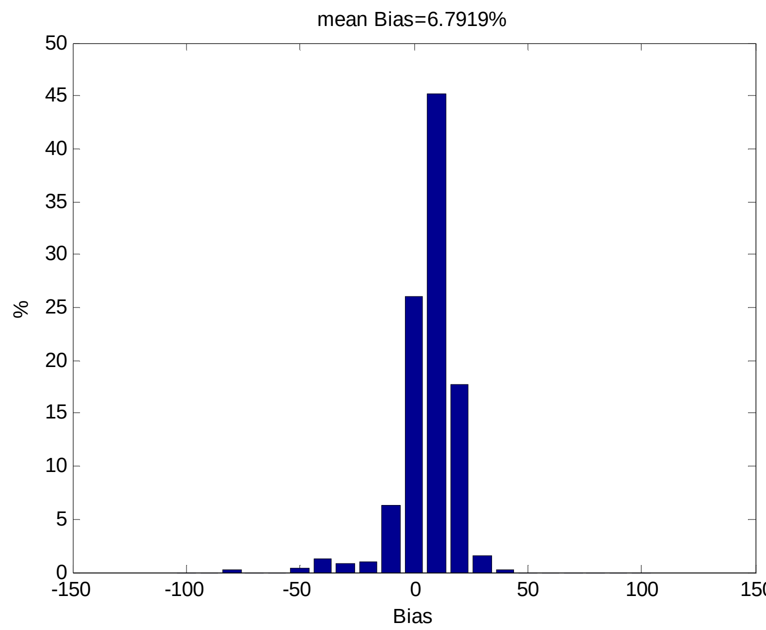
73°W
72°30'W
72°W
71°30'W
71°W
45°N
44°30'N
44°N
43°30'N
43°N
42°30'N
42°N
41°30'N
Date: 2005/9/15
Discharge(m^3/s)
rain(mm)
Value
327
294.3
261.6
228.9
196.2
163.5
130.8
98.1
65.4
32.7
0
Date: 2005/9/15
Discharge(m^3/s)
Discharge
Value
3200
2880
2560
2240
1920
1600
1280
960
640
320
0
73°W
72°30'W
43°N
42°30'N
42°N
41°30'N
Discharge(cms)
Value
3200
2880
2560
2240
1920
1600
1280
960
640
320
0
Date: 2005/9/15

Conclusions

- We have developed a computationally efficient and physically consistent distributed hydrologic model that can be used for hydrologic studies in mid-latitude basins.
- The model was tested in the CT river basin with high simulation accuracy of ET without prior calibration as well as river runoff.
- The model will next be used for evaluating snow process effects on river flooding and to derive flood frequency maps over CT for current and future (end of century) climate conditions.

Cell-to-cell Evaluation vs. MODIS Long-term ET Over CT River





Ke Zhang, et.al.,(2010). “A continuous satellite-derived global record of land surface evapotranspiration from 1983 to 2006”,WRR (the reference ET Product)

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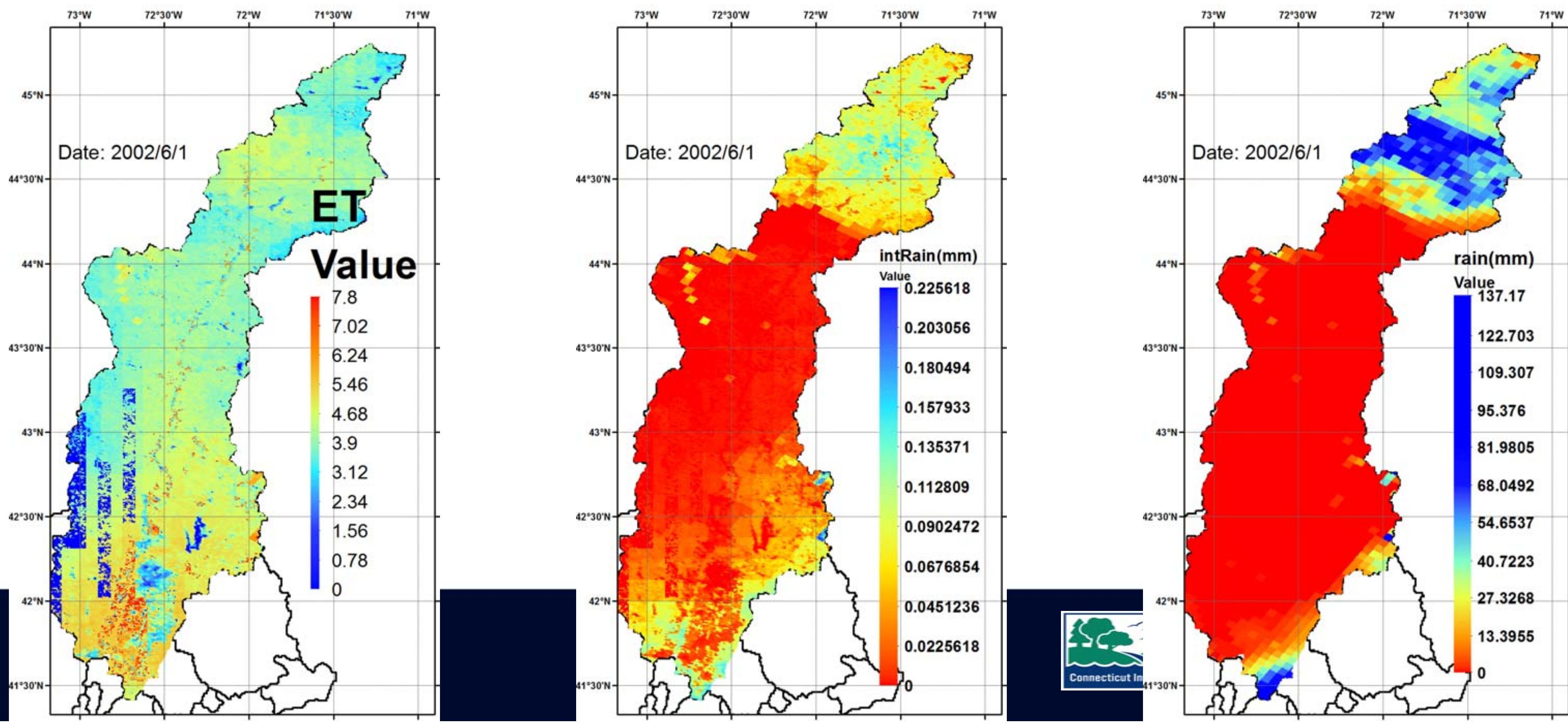
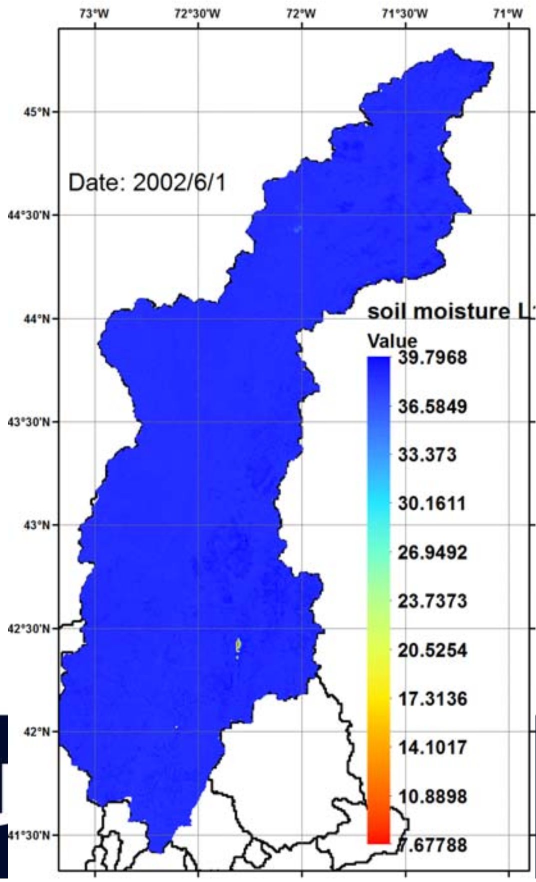
ET & Rain & Intercepted Rain

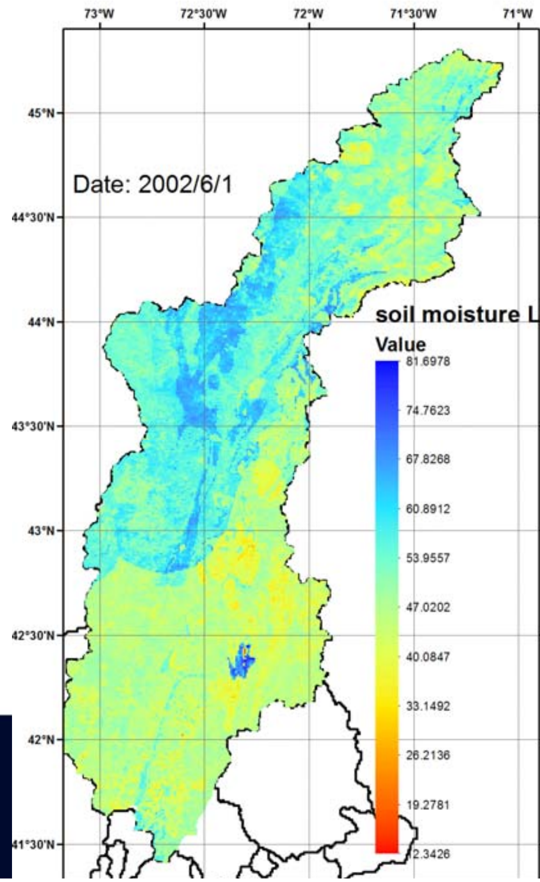


Soil moisture

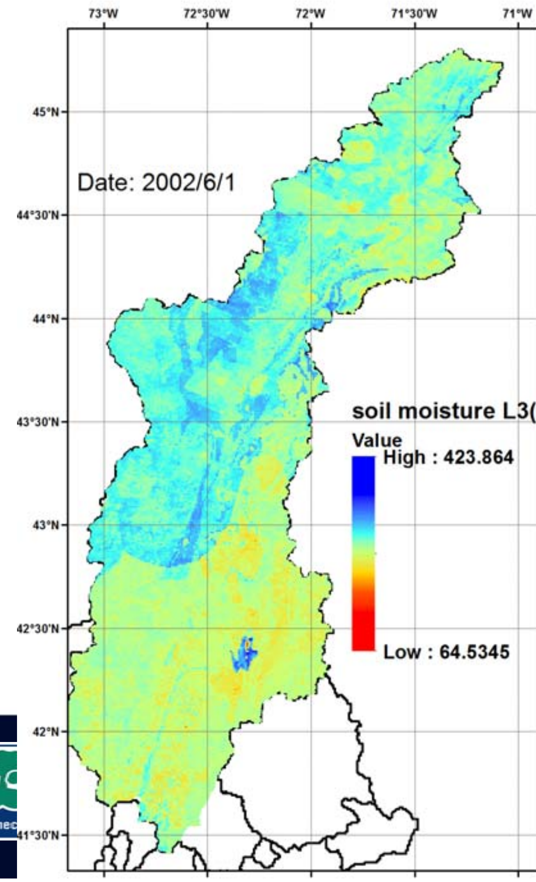
D1=10 cm



D1=10 cm



D1=180 cm



Land surface Process

- Energy Balances & SNOW PROCESS (upgraded in v3.0)