MODELING NITROGEN DYNAMICS IN THE TIOUGHNIOGA RIVER, NEW YORK

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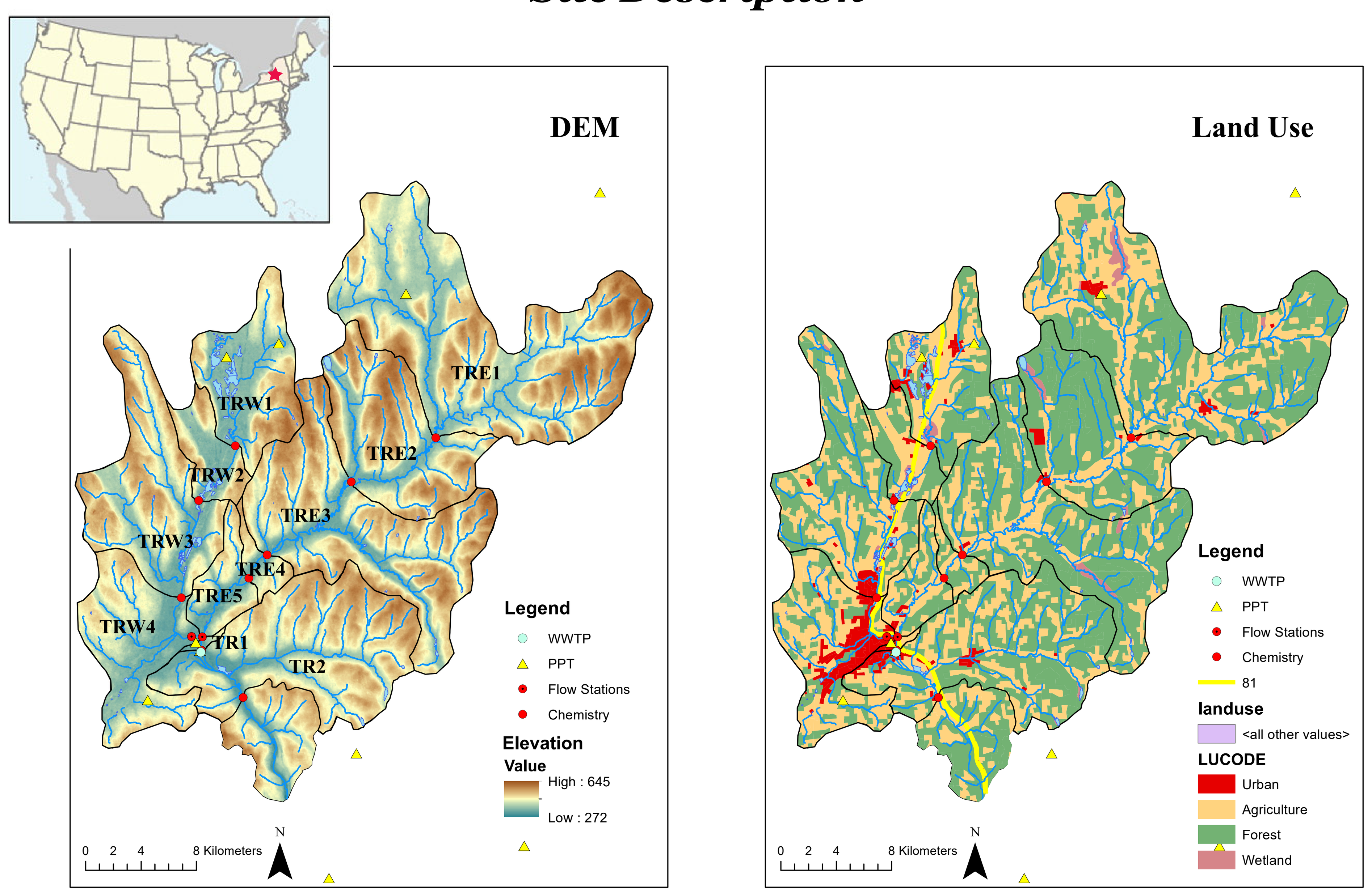
Abstract

Elevated nutrient concentrations such as nitrogen have led to serious problems of surface water eutrophication and groundwater contamination in many places around the world. Chesapeake Bay has been the subject of intensive research on eutrophication and nutrient input reductions. Tioughnioga River, the headwater to the Susquehanna River and Chesapeake Bay, plays an important role in controlling the transport of nutrients downstream. In this study, an integrated catchment nitrogen model (INCA-N) is used to simulate in-stream nitrate concentrations in the headwater of Tioughnioga River which begins as two branches with contrasting land use characteristics. The model is calibrated using the weekly nitrate concentrations at the mouths of two branches and monthly nitrate concentrations from multiple locations along the two branches from 2012 to 2014. Preliminary modeling results suggest the main drives of the in-stream nitrate concentrations are nitrogen levels in atmospheric deposition and groundwater. The model is sensitive to nitrogen process-reparameters e.g. denitrification rates and plant uptake rates. Projected climate change effects in the Tioughnioga River using the INCA-N model will be explored in future studies.

Site Description



DEM map and land use map for Tioughnioga River Watershed with flow station, water quality station, precipitation stations.

Tioughnioga River Catchment Basic Characteristics:

Size: ~900 km^2

Geology:
River - unconfined glacial-outwash comprised of sand and gravel with till-covered bedrock hills.
Aquifer - Upper to Middle Devonian bedrock consisting predominantly of shale interbedded with siltstone, sandstone, and limestone.

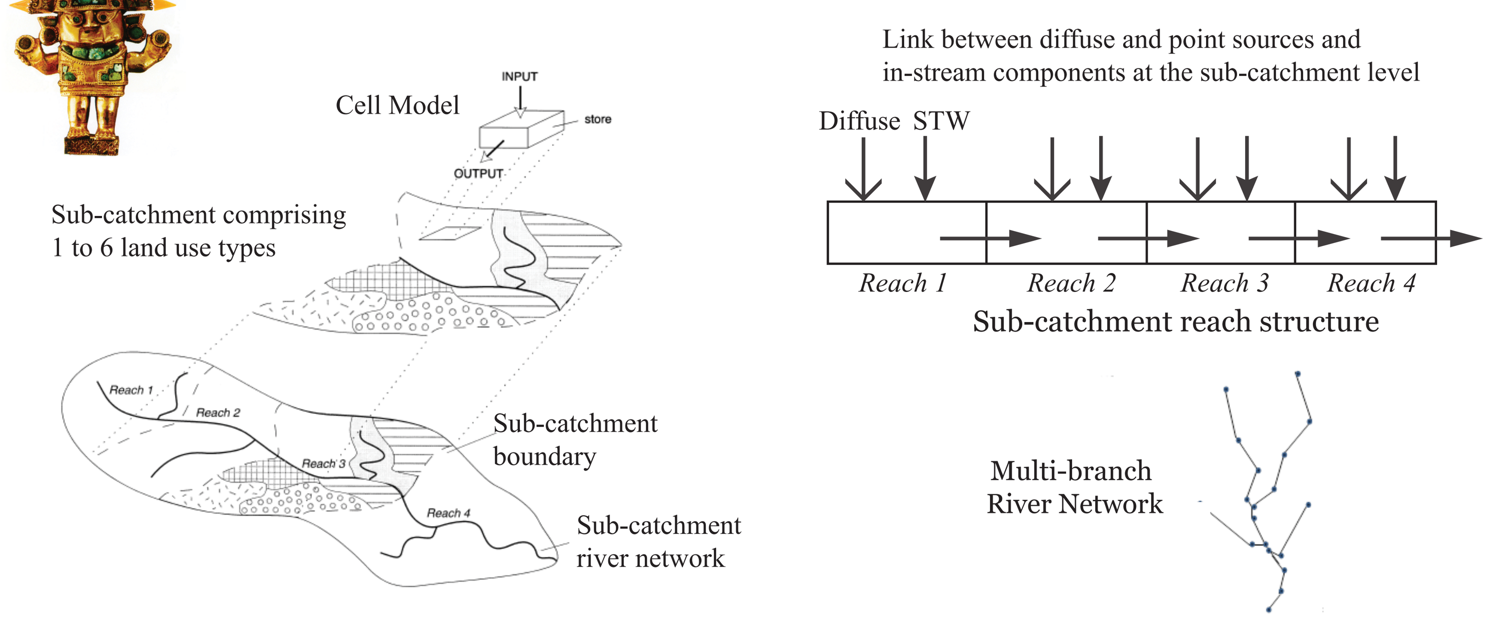
Land use:
primarily agricultural and forest with urban concentrated at the bottom of the watershed

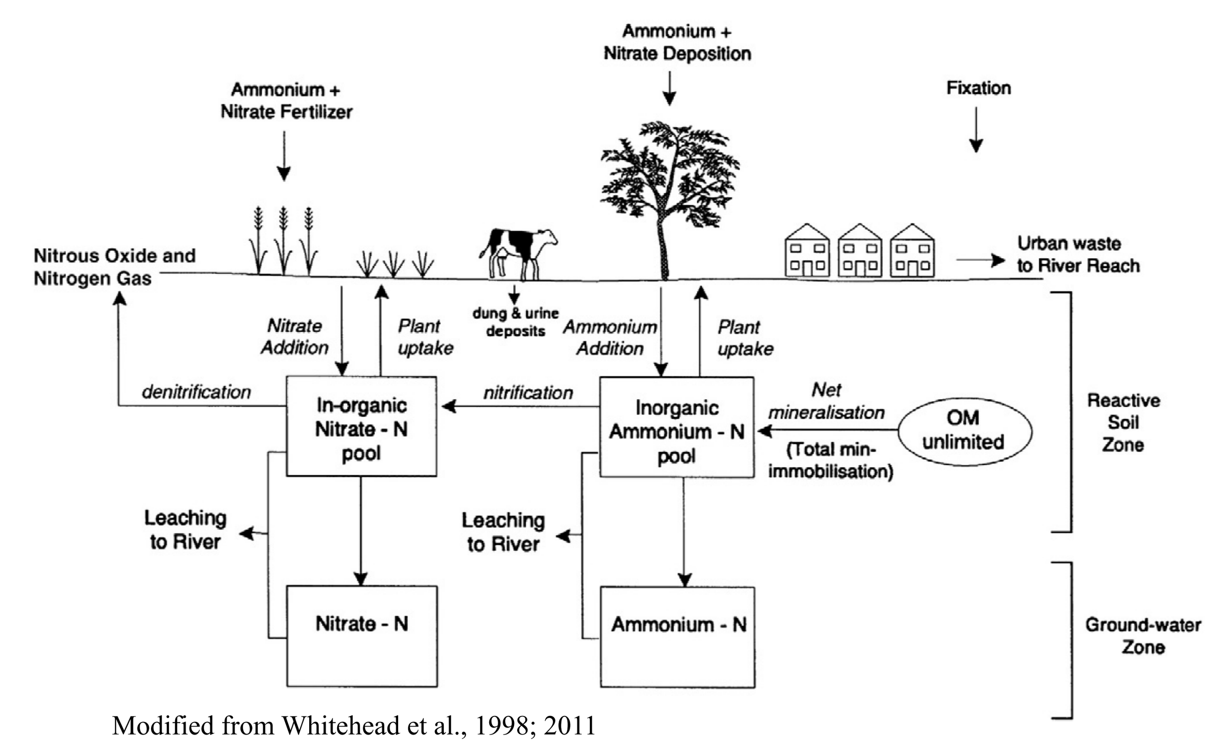
				Land Use Class (%)				
Name	Reach No.	Subcatchment Area (km2)	Reach Length (m)	Urban	Highway	Agriculture	Wetland	Forest
TRE1	1	219.22	26634	1.21	0.00	42.87	2.01	53.90
TRE2	2	93.66	10578	1.51	0.00	24.65	2.22	71.62
TRE3	3	147.84	13847	0.31	0.00	30.51	1.45	67.72
TRE4	4	10.74	2847	0.00	0.00	47.99	0.41	51.60
TRE5	5	24.32	7190	3.16	0.00	52.77	0.00	44.07
TRW1	6	65.36	12166	2.61	3.33	42.27	5.98	45.80
TRW2	7	25.83	3293	1.07	4.42	42.41	6.09	46.01
TRW3	8	100.93	6274	2.79	1.79	42.02	1.56	51.83
TRW4	9	73.40	4918	17.45	1.58	52.11	0.00	28.86
TR1	10	3.17	947	25.96	6.71	2.02	0.00	65.31
TR2	11	130.17	4956	3.72	0.87	37.44	0.28	57.70
East Branch		**495.77**		**1.24**	**0.00**	**39.76**	**1.22**	**57.78**
West Branch		**265.53**		**5.98**	**2.78**	**44.70**	**3.41**	**43.13**

Data Collection:

Nitrate: weekly sampling at TRW4 and TRE5 from 2012-2014; Monthly-bimonthly sampling at all sites in 2014
Flow: daily flow data from USGS flow station
Precipitation: Daymet data and individual stations from neighboring area

Integrated Catchment Model (INCA)



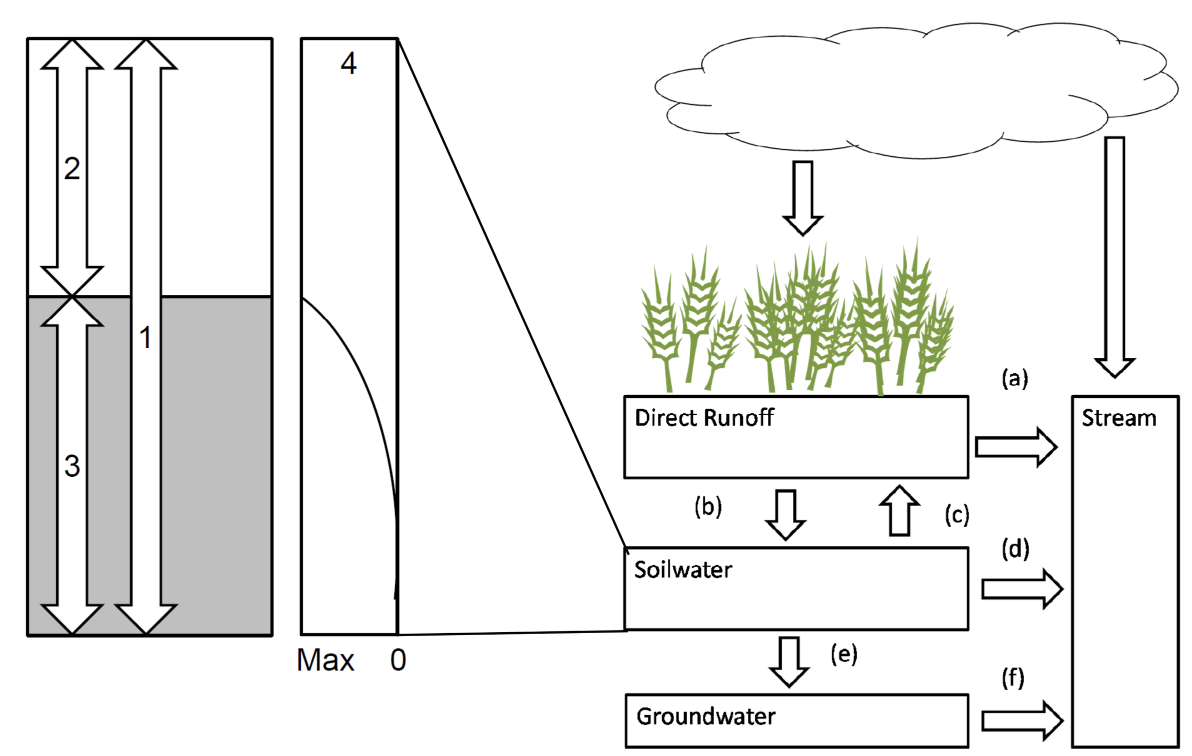


Modified from Whitehead et al., 1998; 2011

List of basic data need for INCA

- *Reach and sub-catchment characteristics:* reach length, area, etc (derived from DEM using GIS)
- *Land use data:* up to 6 different land use types
- *Hydrological inputs (SMD and HER from PERSiST):*
  - daily precipitation and temperature
  - soil moisture deficit (SMD)
  - hydrological effective rainfall (HER)
- *N inputs:*
  - atmospheric N inputs to the whole catchment
  - N inputs as fertilizer and manure to agriculture land
  - N inputs to the stream (point source-STW)
- *Observations:*
  - flow
  - water chemistry (nitrate)

Rainfall-runoff Model-PERSiST



Data input for PERSiST

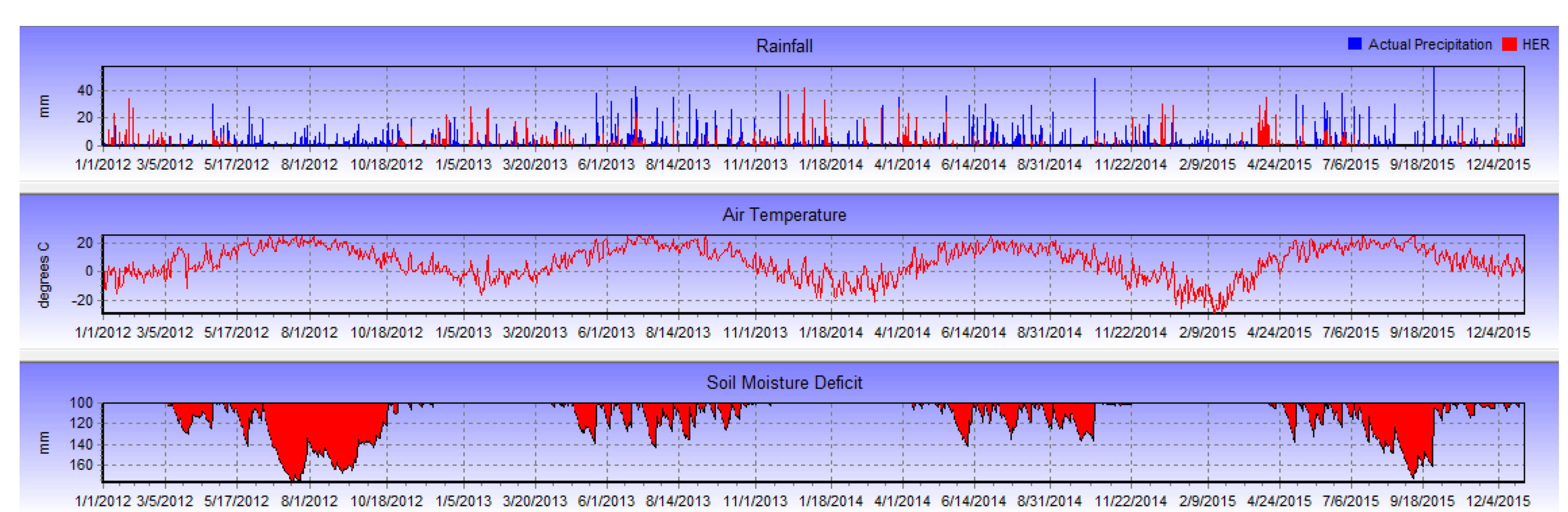
Hydrological inputs:
- Daily precipitation
- Daily temperature

Observation:
- Flow

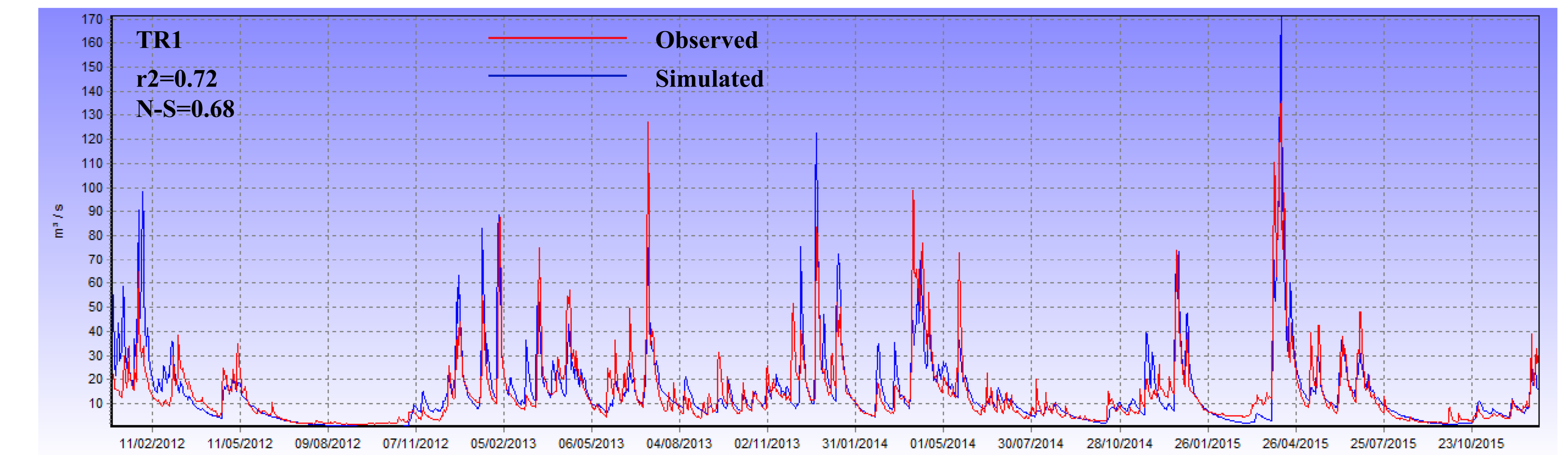
Left: Generic bucket structure and relative evapotranspiration rate as a function of water depth

Right: Hydrologic response units with each subcatchment

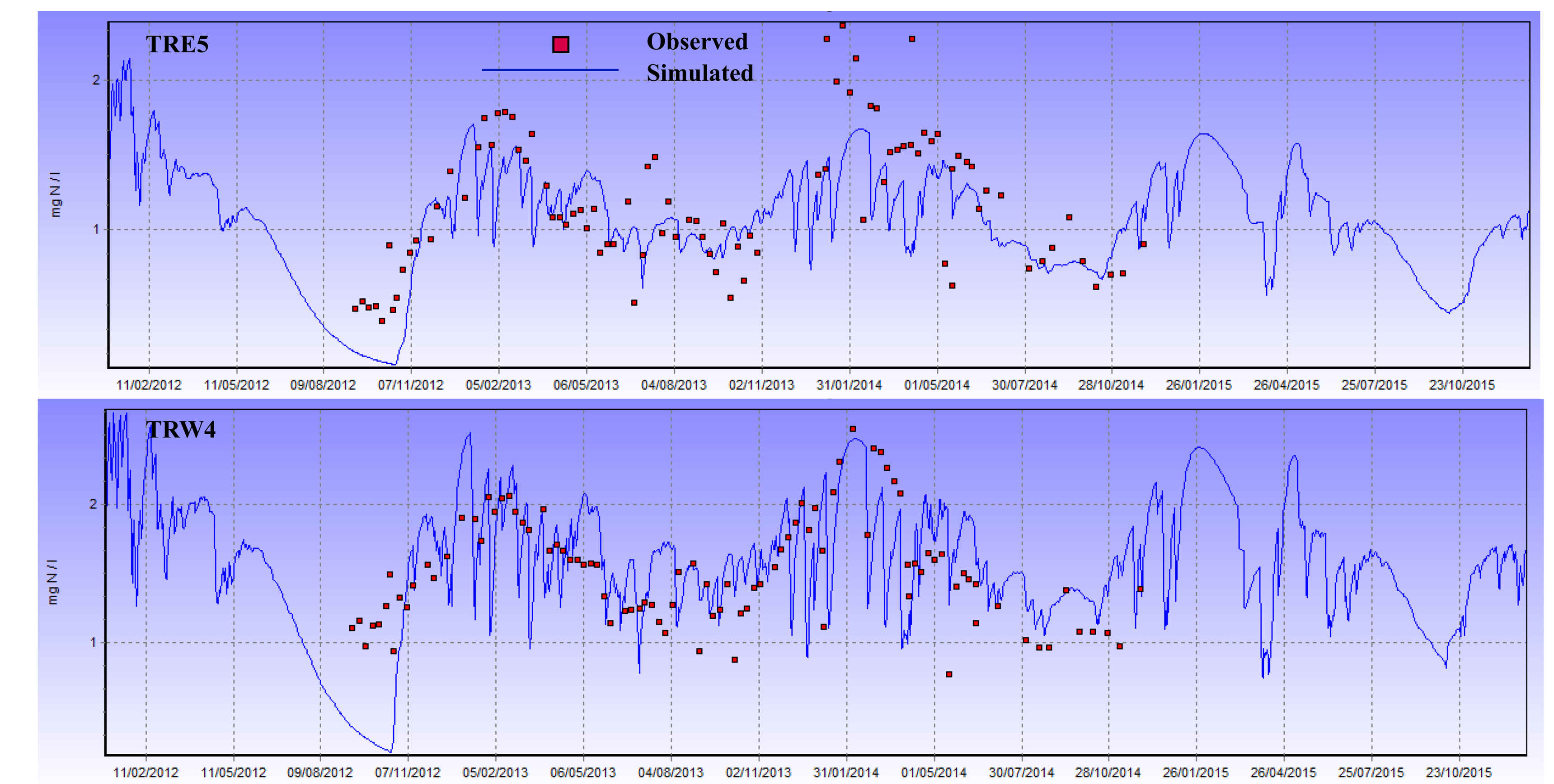
Modified from Futter et al., 2014.

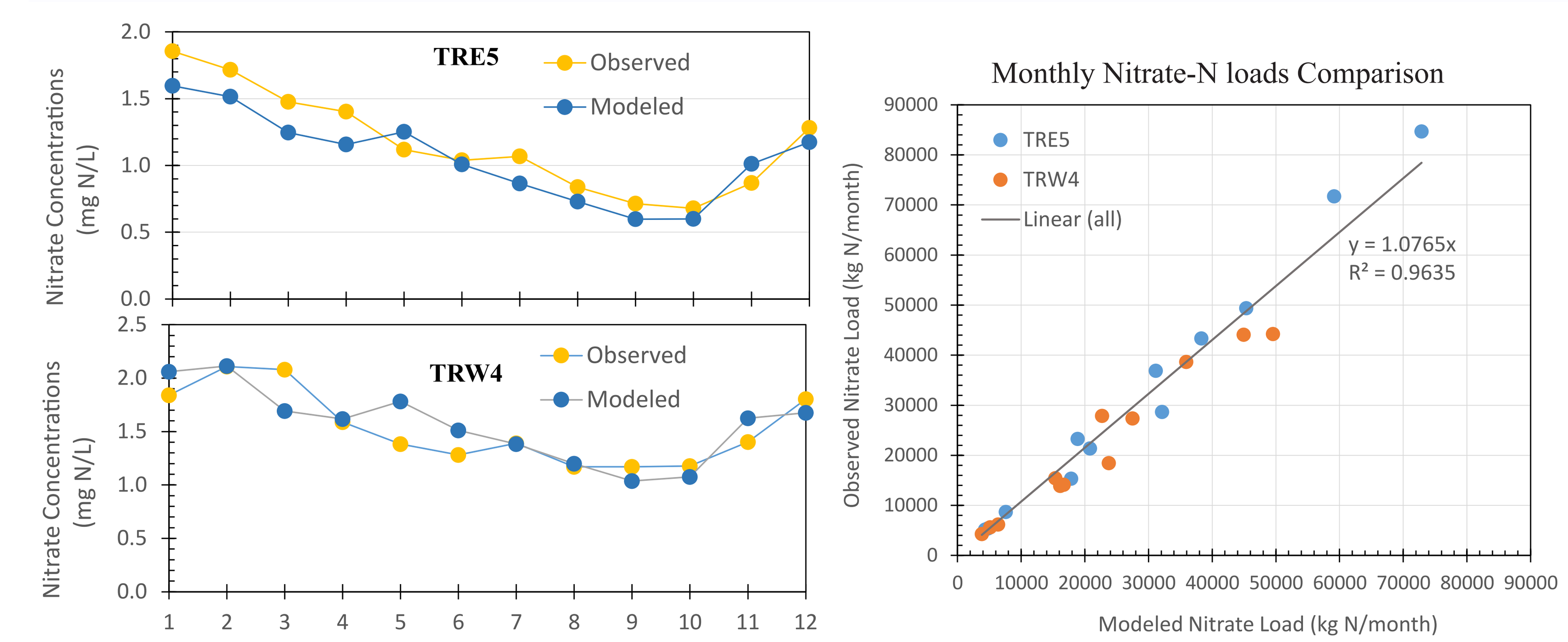


INCA Flow Results



INCA Nitrate Results





Monthly Nitrate-N Concentration Comparison

Conclusions

- Nitrate concentrations are generally low at both West Branch and East Branch of Tioughnioga River. West Branch has slightly higher nitrate concentrations comparing to the East Branch.
- Nitrate concentrations follow a seasonal pattern reaching the lowest values in the summer and early fall due to high denitrification rates and plant uptake.
- PERSiST and INCA-N models catch flow dynamics at both high flow and low flow conditions. Timing and magnitude of snowmelt peaks are well simulated.
- INCA-N model simulates nitrogen reasonably well in this snow-dominated catchment. Model is sensitive to atmospheric deposition, groundwater concentrations and nitrogen-process related parameters such as denitrification, mineralization and plant uptake.

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References
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