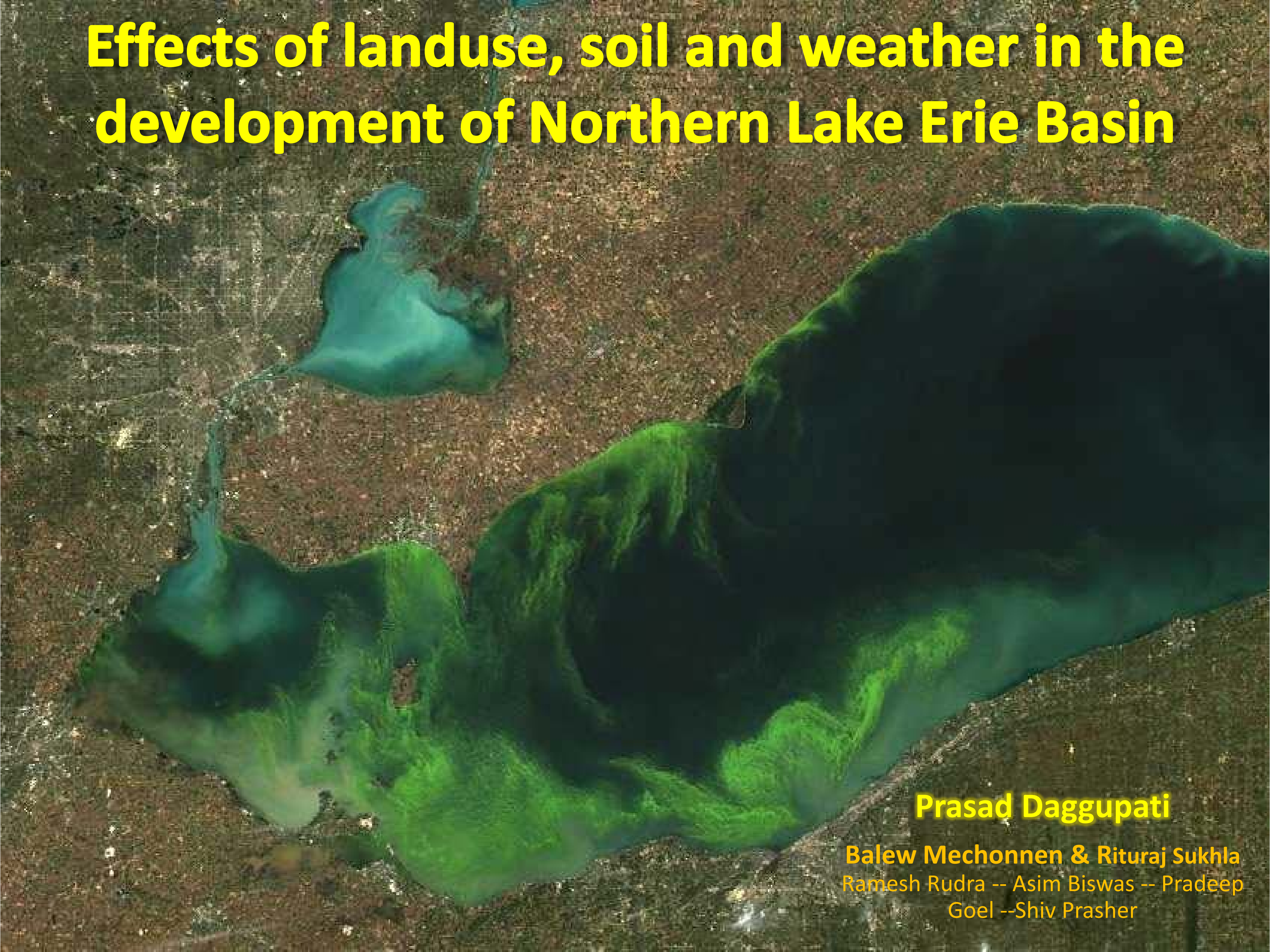
Effects of landuse, soil and weather in the development of Northern Lake Erie Basin



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Introduction

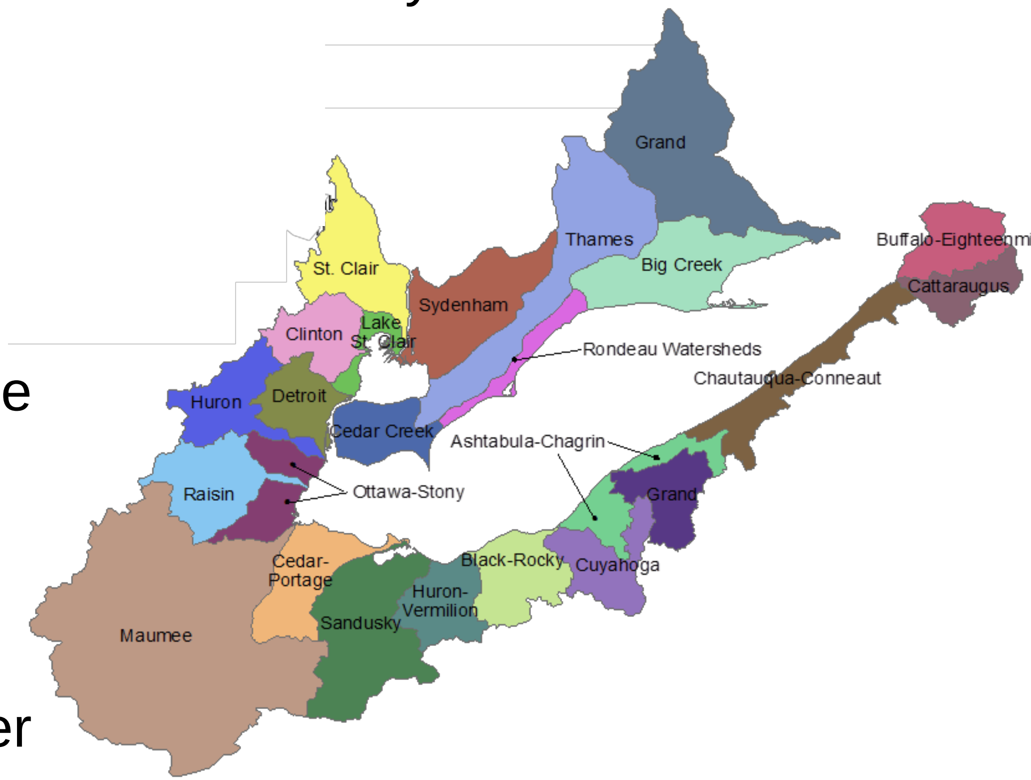
- The Great Lakes bordering US and Canada, holding one-fifth of all the freshwater on earth, are an unparalleled treasure for Canada
  - Provides water to 10 million Canadians
- In the last decade, the health of the Great Lakes has come under serious threat
  - increased levels of harmful pollutants and rising levels of phosphorus

Introduction

- The phosphorus-induced algae bloom levels in **Lake Erie** (one of the Great Lakes) were 50 times above the World Health Organization limit for safe bodily contact in 2011.
- The summer of 2015 produced the largest algae bloom in **Lake Erie** in 100 years.
- Province of Ontario and United States signed the Lake Erie Collaborative Agreement committing to a 40% reduction in phosphorus entering Lake Erie by 2025

Introduction

- Models in combination of monitoring can be used make better management decisions to solve emerging phosphorus and water quality issues
- Watersheds (e.g. WLEB) contributes to Lake Erie from USA side was modeled using SWAT and is being used for various decision making
- In Ontario, Thames River basin and Grand River basin which are major contributors to Lake Erie are simulated individually with different models
- In addition several small scale watersheds are simulated in greater details
  - GLASSI priority subwatersheds
- There is a need to simulate entire contributing basin to the Lake Erie from Ontarian side to understand the spatio-temporal differences
  - Use the model to make better management decisions



Introduction

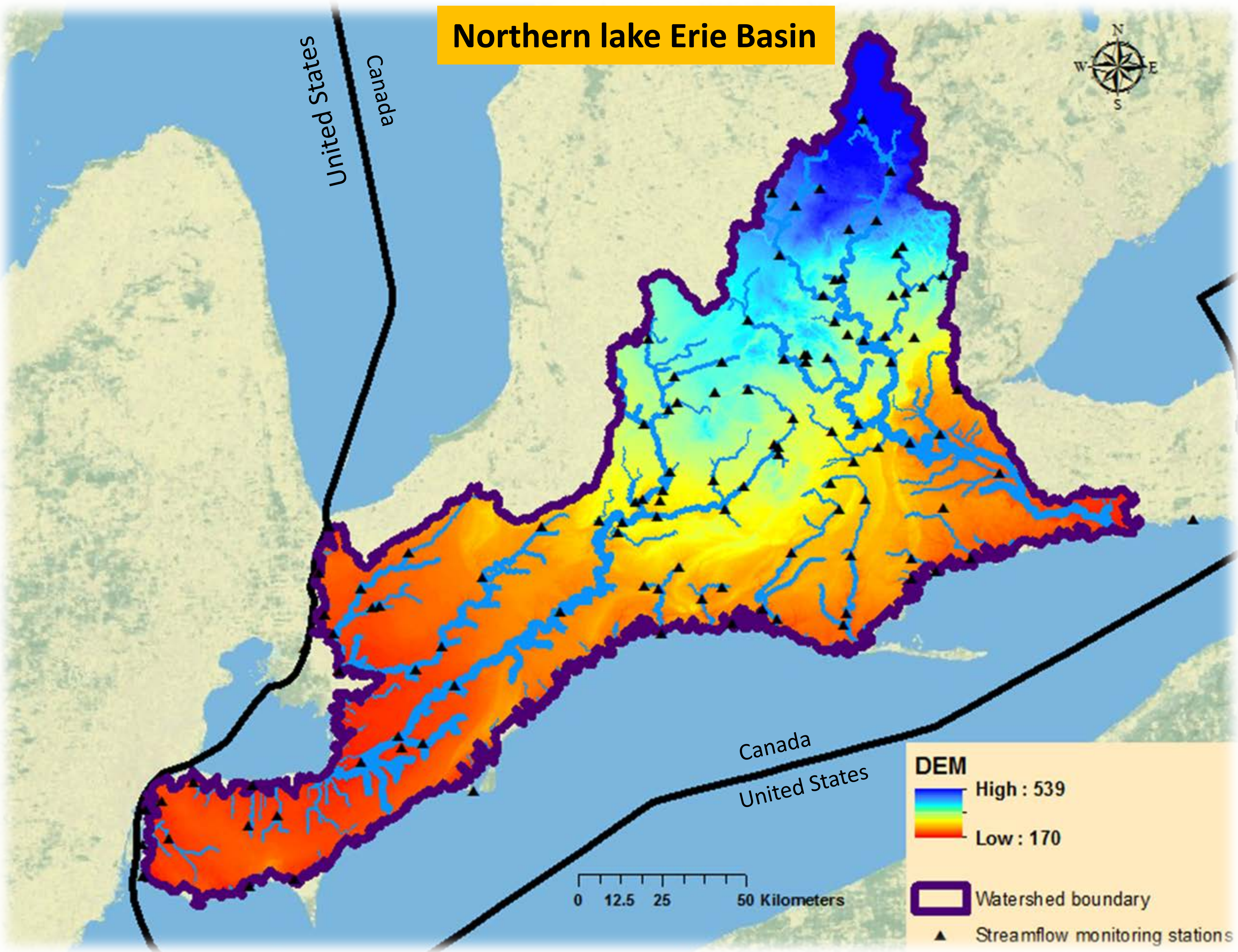
- The accuracy of a model output is greatly dependent upon the quality of the input data including their spatial and temporal resolution
- Inputs typically used in models are digital elevation models (DEMs), landuse and land management, soils and precipitation
- Input data available from difference sources and in different resolution
  - **Global** – coarse resolution –Less HRUs – faster simulation time
    - E.g. FAO soils, GLCC landuse
  - **Local** – finer resolution – higher HRU's – Lower simulation time
    - E.g. SLC soils, SOLARIS landuse
- Need to critically analyze the data sources and resolution needed for large scale modeling in Ontario
  - In USA, several studies performed input data analysis and have provided recommendation

Objectives

Overall goal is to evaluate the impacts of various data inputs on watershed hydrological processes and streamflow in Northern Lake Erie Basin

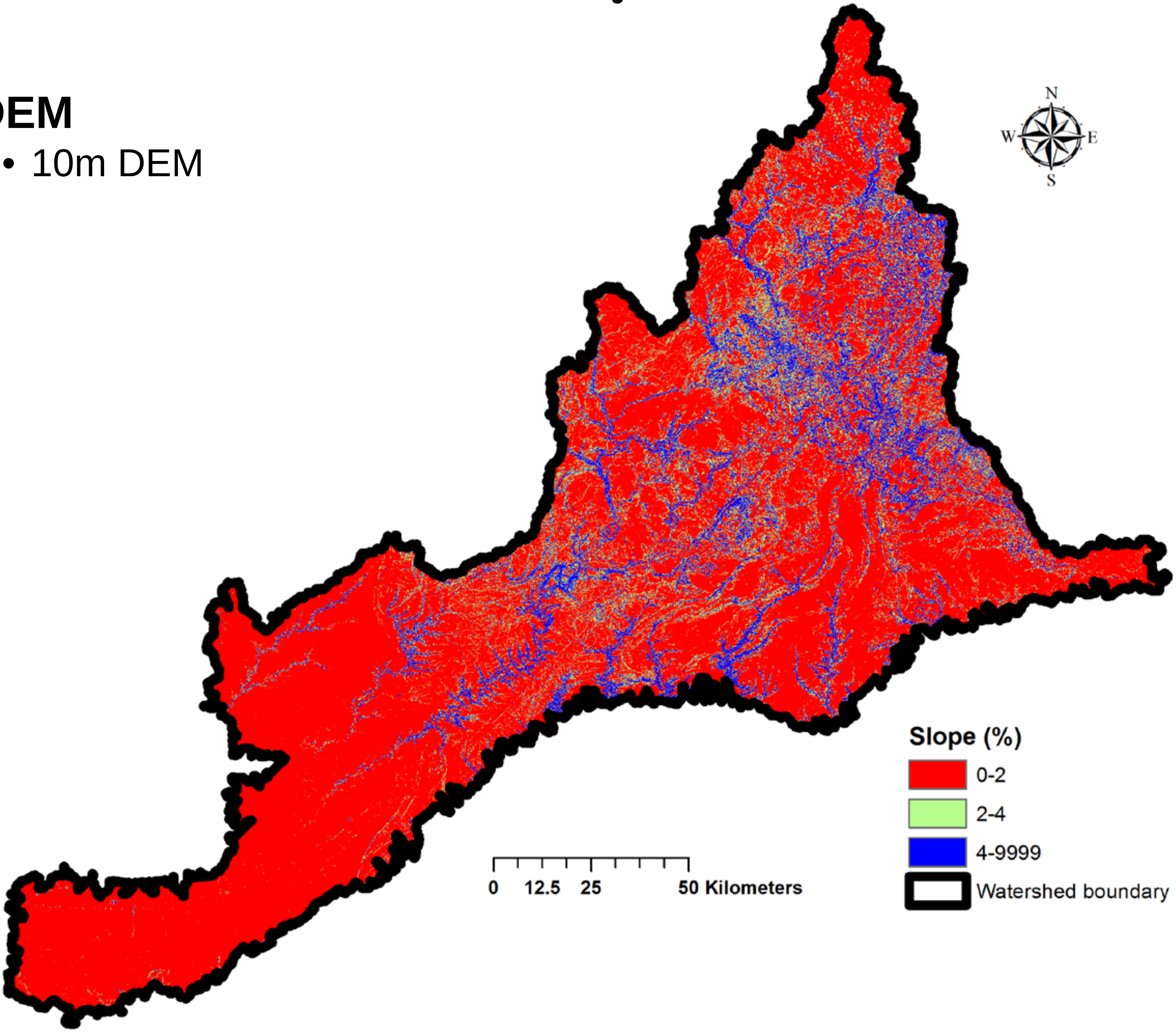
Objectives are
- Prepare various inputs from different sources in SWAT format
- Develop SWAT model for Northern Lake Erie Basin in Ontario that contributes to Lake Erie
- Investigate the impacts of landuse, soil and weather

Study Area


Northern lake Erie Basin
United States
Canada
Canada
United States
N
W
E
S
0 12.5 25 50 Kilometers
DEM
High : 539
Low : 170
Watershed boundary
Streamflow monitoring stations

Inputs

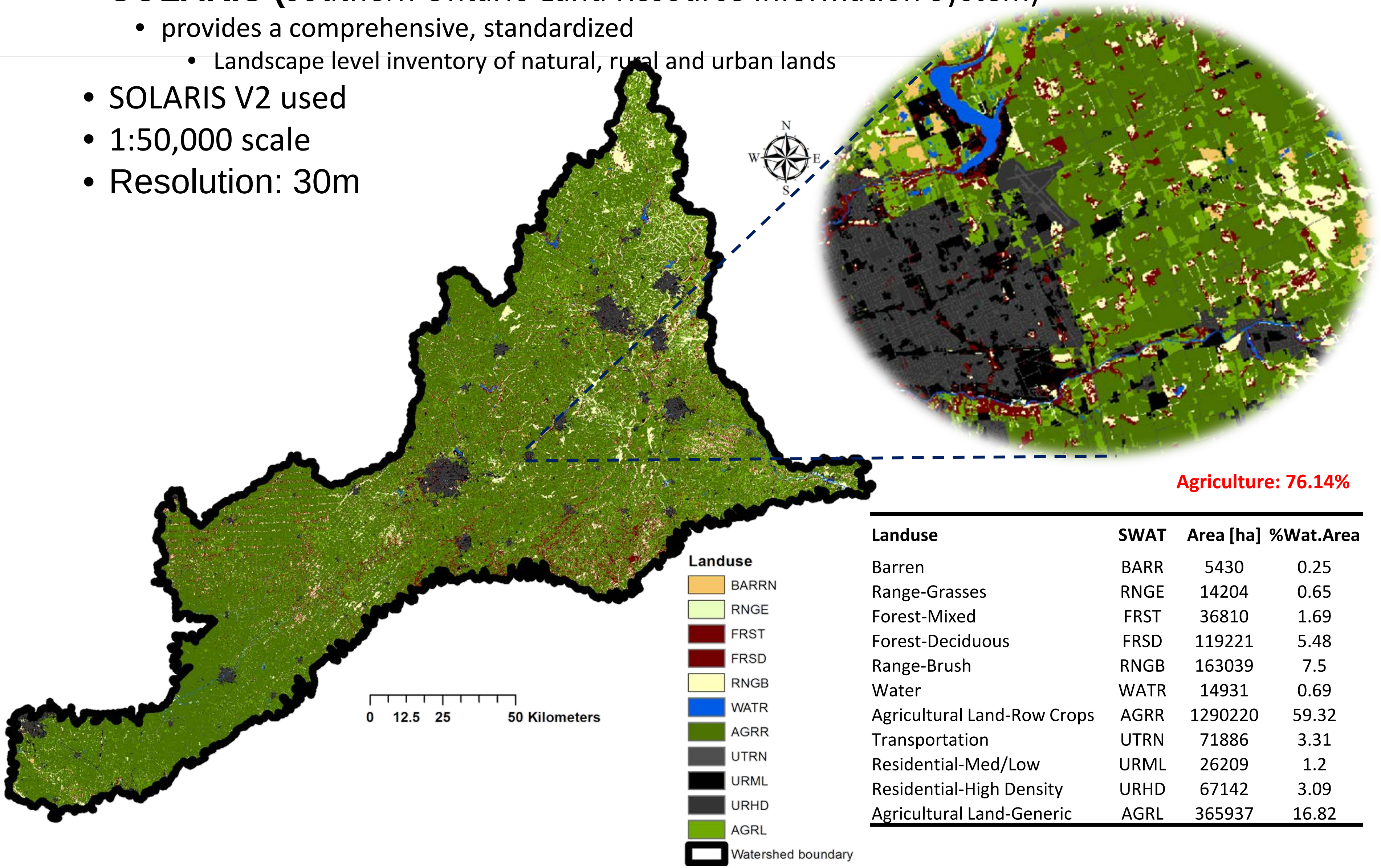
- **DEM**
  - 10m DEM



Inputs

Landuse

- **SOLARIS (**Southern Ontario Land Resource Information System)
  - provides a comprehensive, standardized
    - Landscape level inventory of natural, rural and urban lands
- SOLARIS V2 used
- 1:50,000 scale
- Resolution: 30m



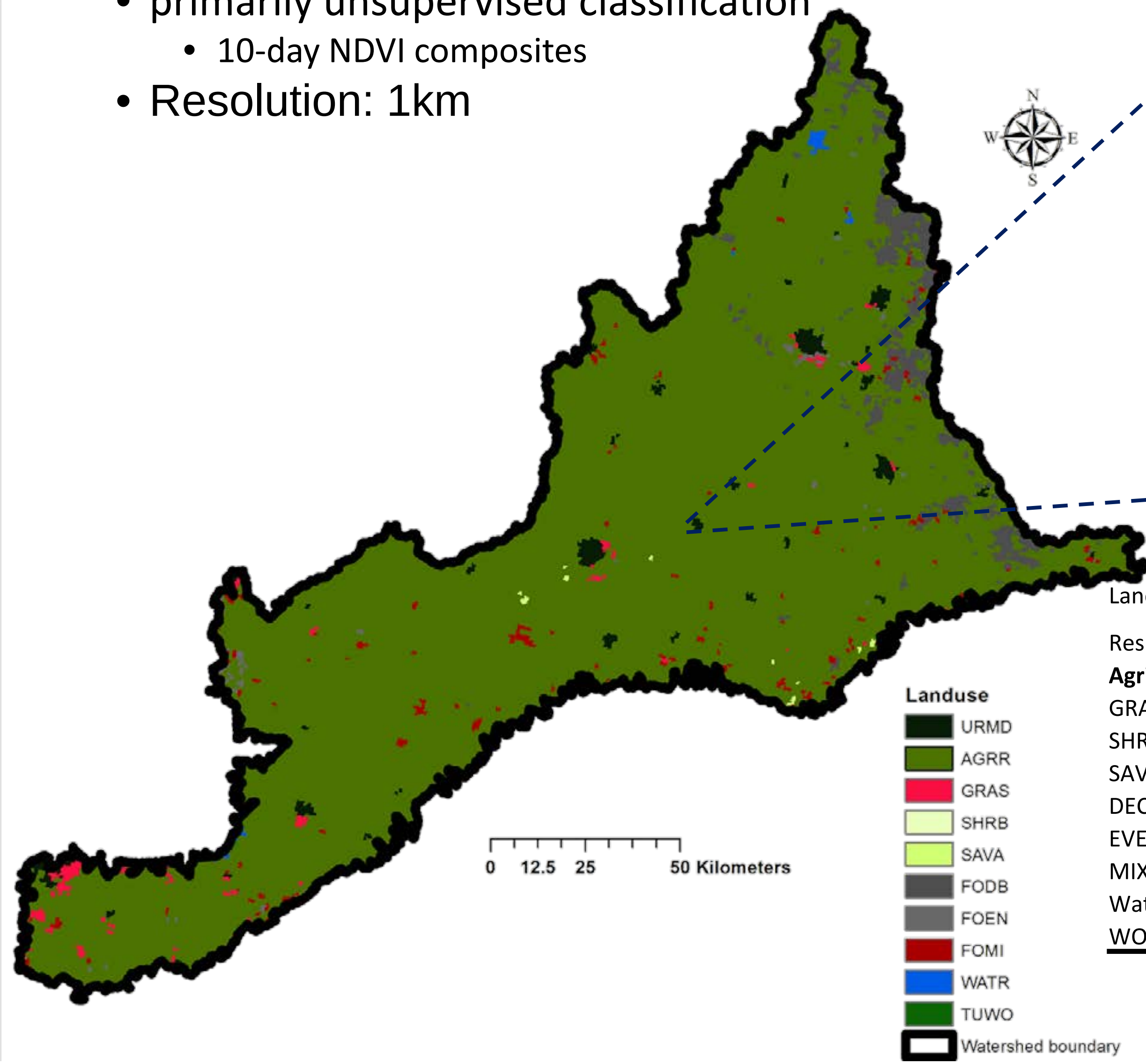
Agriculture: 76.14%

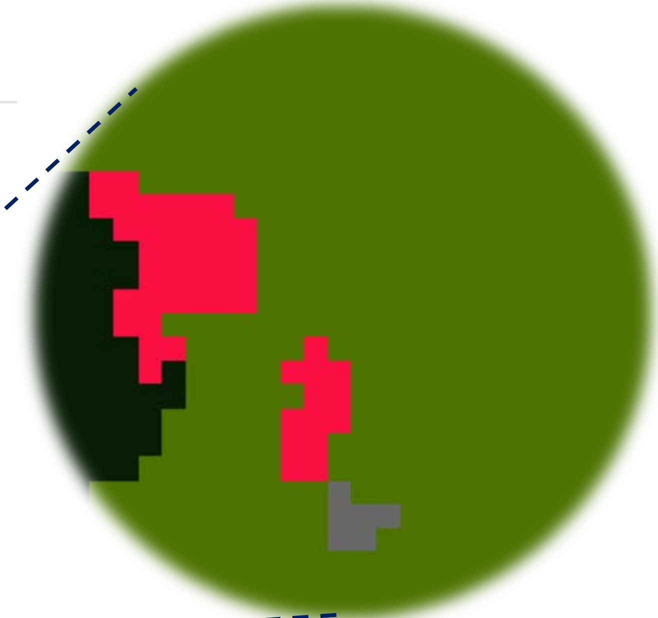
Landuse	SWAT	Area [ha]	%Wat.Area
Barren	BARR	5430	0.25
Range-Grasses	RNGE	14204	0.65
Forest-Mixed	FRST	36810	1.69
Forest-Deciduous	FRSD	119221	5.48
Range-Brush	RNGB	163039	7.5
Water	WATR	14931	0.69
Agricultural Land-Row Crops	AGRR	1290220	59.32
Transportation	UTRN	71886	3.31
Residential-Med/Low	URML	26209	1.2
Residential-High Density	URHD	67142	3.09
Agricultural Land-Generic	AGRL	365937	16.82

Inputs

Landuse

- **GLCC** (Global Land Cover Characterization)
- primarily unsupervised classification
  - 10-day NDVI composites
- Resolution: 1km

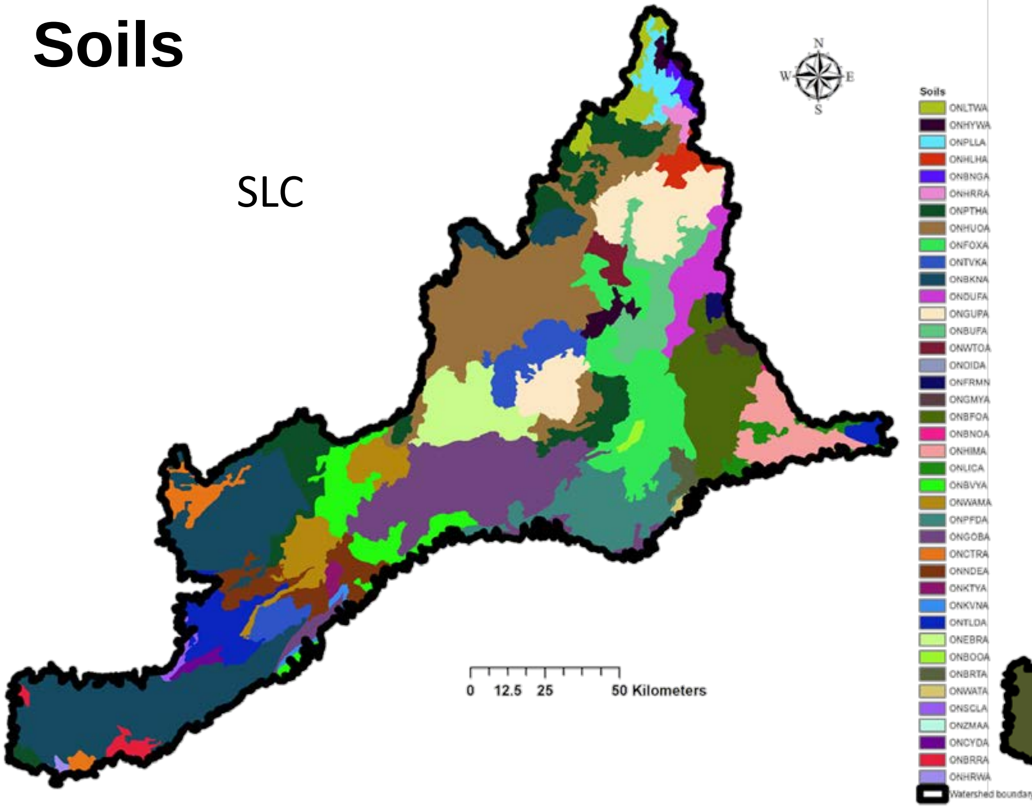


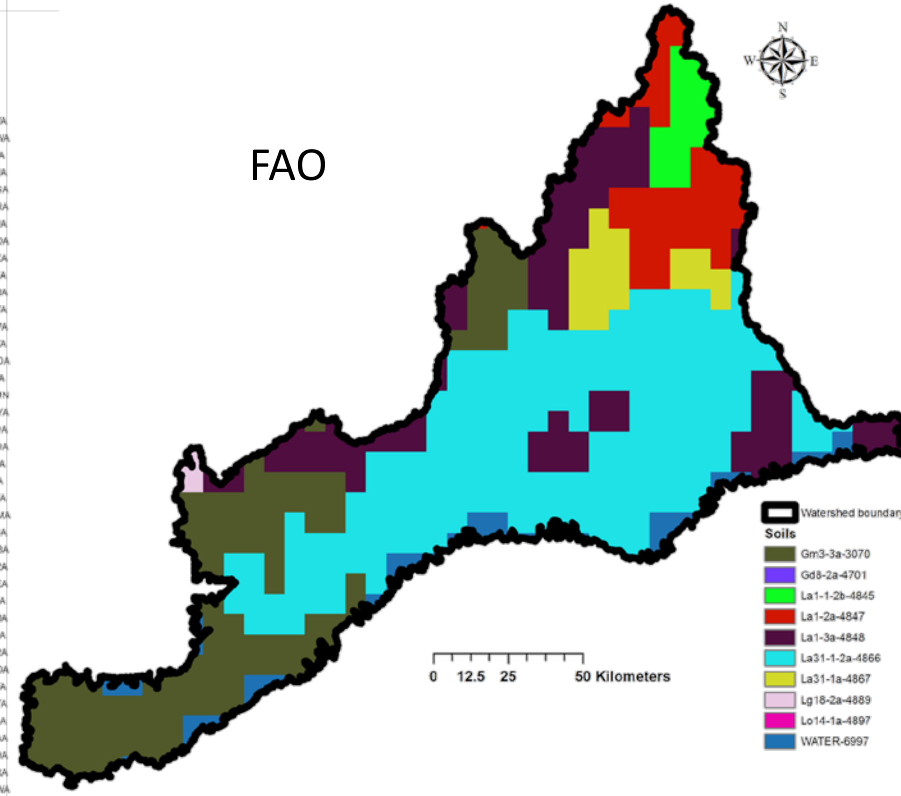


Landuse	SWAT Code	Area [ha]	%Wat.Area
Residential-Medium Density	URMD	30273.73	1.39
Agricultural Land-Row Crops	**AGRR**	**2009463**	**92.39**
GRASSLAND	GRAS	15314.33	0.7
SHRUBLAND	SHRB	16.5627	0
SAVANNA	SAVA	1649.973	0.08
DECIDUOUS BROADLEAF FOREST	FODB	79695.97	3.66
EVERGREEN NEEDLELEAF FOREST	FOEN	8242.396	0.38
MIXED FOREST	FOMI	22371.95	1.03
Water	WATR	7421.01	0.34
WOODED TUNDRA	TUWO	579.6061	0.03

Inputs

Soils





SLC: Soil Landscapes of Canada (SLC) version 3.2

- Contains soil map of Canada together with major characteristics of soil for the whole country.
- Resolution of 1:1 million
- Prepared by Agriculture and Agri-Food Canada.
- Each polygon on the map describes a distinct type of soil and its associated characteristics.

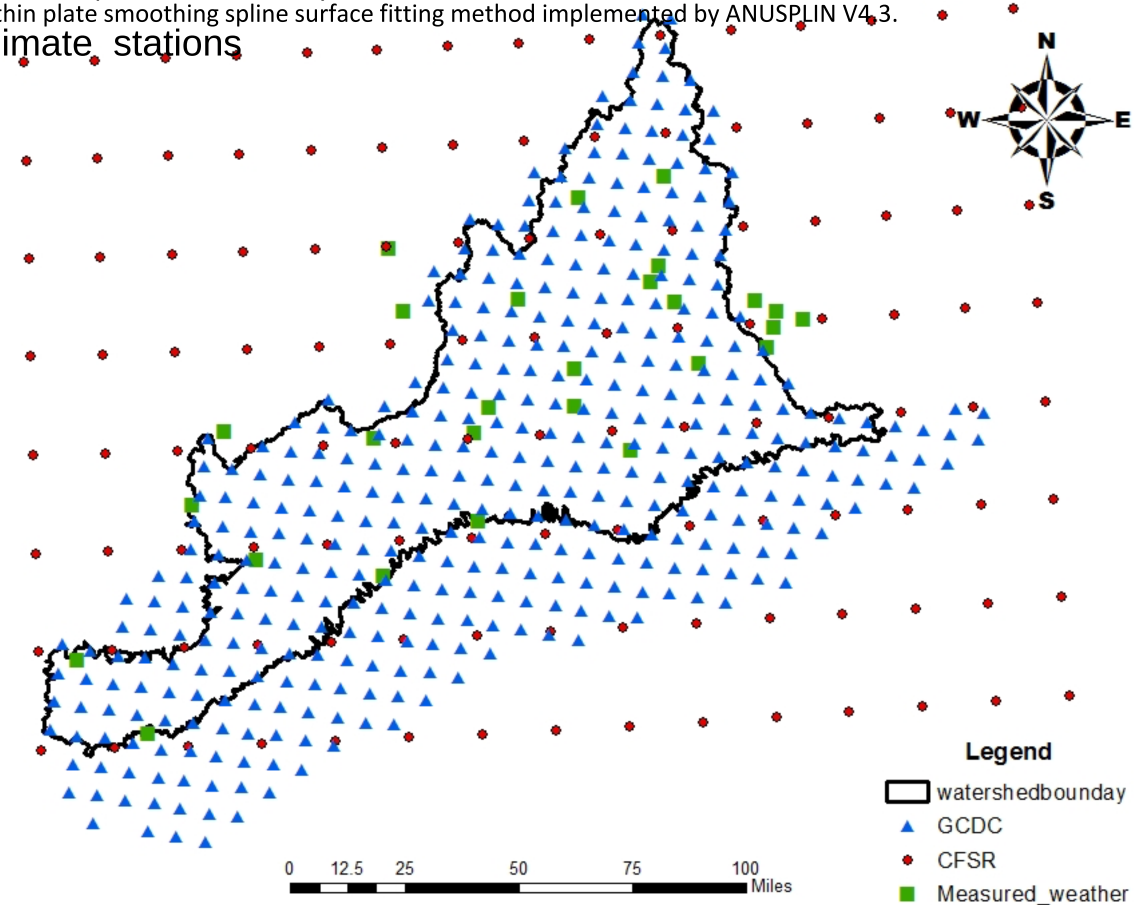
FAO Soil (Global database of soils)

- Joint FA0/Unesco Soil Map
- Resolution 1: 5 million
- MWSWAT has soils database in SWAT format

Inputs

Weather

- **CFSR** (Climate Forecast System Reanalysis): a global, high resolution, coupled atmosphere-ocean-land surface-sea ice system
  - Provides the best estimate of the state of these coupled domains over this period
  - Resolution: 38 sq. km
  - 1979 to 2014
- **GCDC** (Gridded Climate Dataset for Canada):
  - Prepared by Agriculture and Agri-Food Canada (AAFC)
  - Resolution: 10 km gridded
  - Period of 1961-2003.
  - The data were interpolated from daily Environment Canada climate station observations
    - using a thin plate smoothing spline surface fitting method implemented by ANUSPLIN V4.3.
- **Measured:** climate stations



Methods

- Developed SWAT models with combinations of inputs
  - 10m DEM, SLC soil, SOLARIS landuse – Model 1
  - 10m DEM, SLC soil, GLCC landuse – Model 2
  - 10m DEM, FAO soil, SOLARIS landuse – Model 3
  - 10m DEM, FAO soil, GLCC landuse – Model 4
    - Weather (measured, CFSR, GCDC) inputs added separately in each model
- HRU delineation
  - 0-2, 2-4,4-9999
  - Threshold: 5/5/5 – landuse/soil/slope

  Model 1: 3831 Model 2: 1470 Model 3: 2961 Model 4: 1159
- Tile Drainage
  - All agricultural lands in 0-2% slope (Daggupati et al., 2015)
    - Ddrain: 1000
    - Gdrain: 48
    - Tdrain:24
    - D_IMP: 2100
    - Daily curve number calculation method: Plant Based ET
    - CNCOEFF = 0.5
- Land management
  - Corn – Soybean rotation based on Heat units
  - Auto fertilization
- No calibration

Methods

Various scenarios developed

Model 1

- **SC1:** SLC soil, SOLARIS landuse, GCDC
- **SC2**: SLC soil, SOLARIS landuse, CFSR
- **SC3**: SLC soil, SOLARIS landuse, Measured

Model 2

- **SC4:** SLC soil, GLCC landuse, GCDC
- **SC5**: SLC soil, GLCC landuse, CFSR
- **SC6**: SLC soil, GLCC landuse, Measured

Model 3

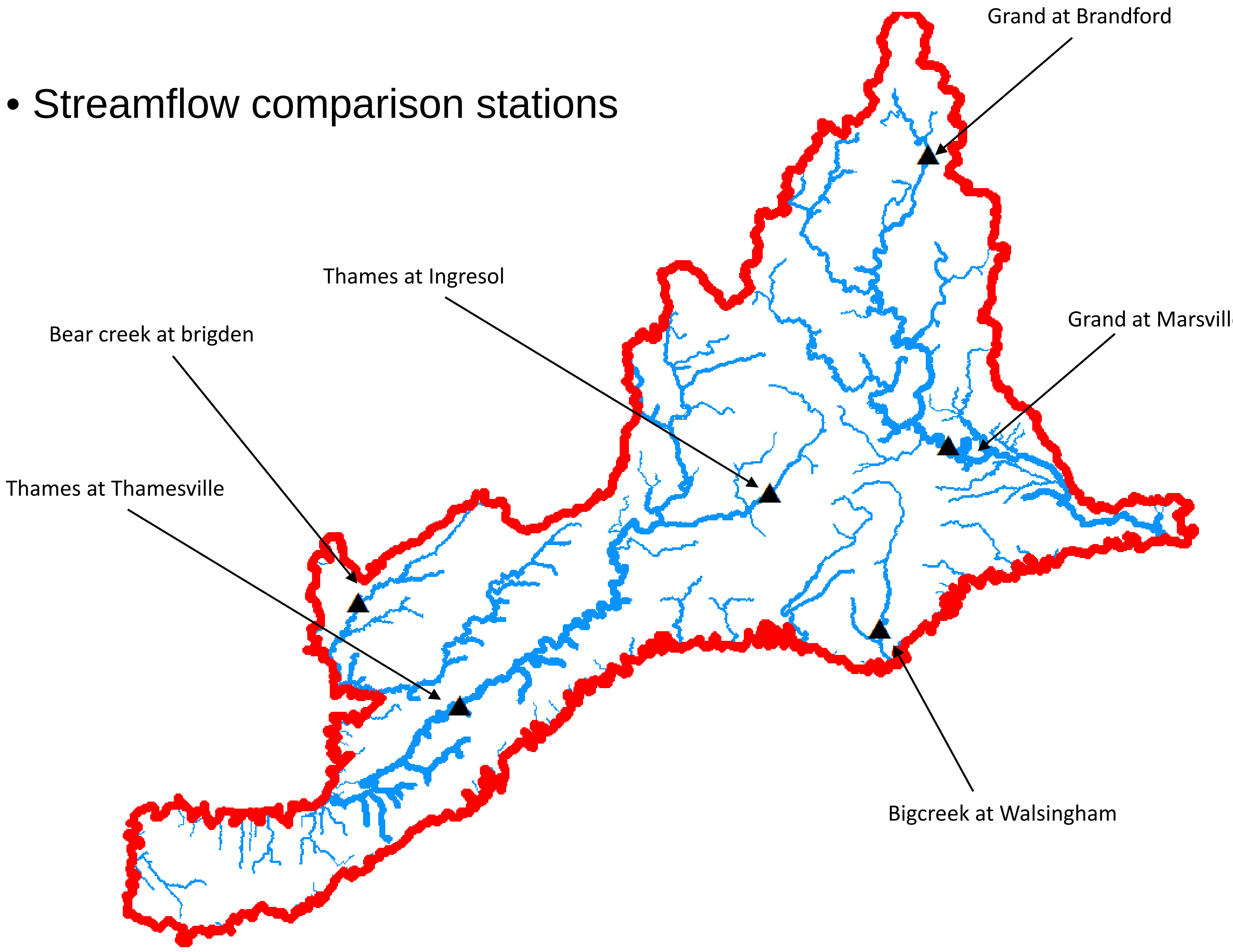
- **SC7:** FAO soil, SOLARIS landuse, GCDC
- **SC8**: FAO soil, SOLARIS landuse, CFSR
- **SC9**: FAO soil, SOLARIS landuse, Measured

Model 4

- **SC10:** FAO soil, GLCC landuse, GCDC
- **SC11**: FAO soil, GLCC landuse, CFSR
- **SC12**: FAO soil, GLCC landuse, Measured

Methods

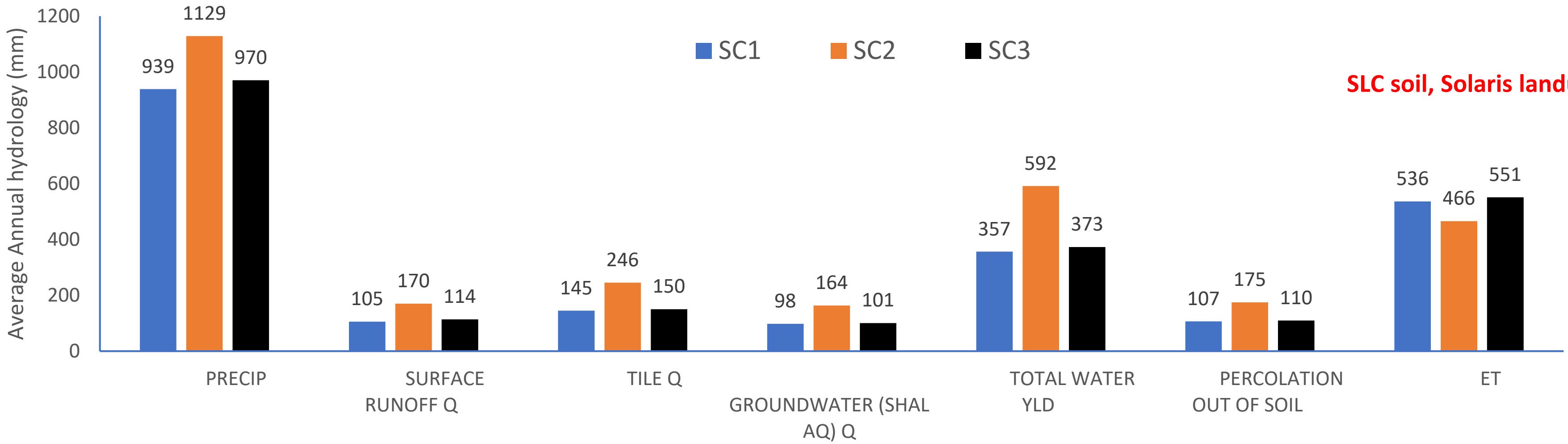
- Streamflow comparison stations



Results

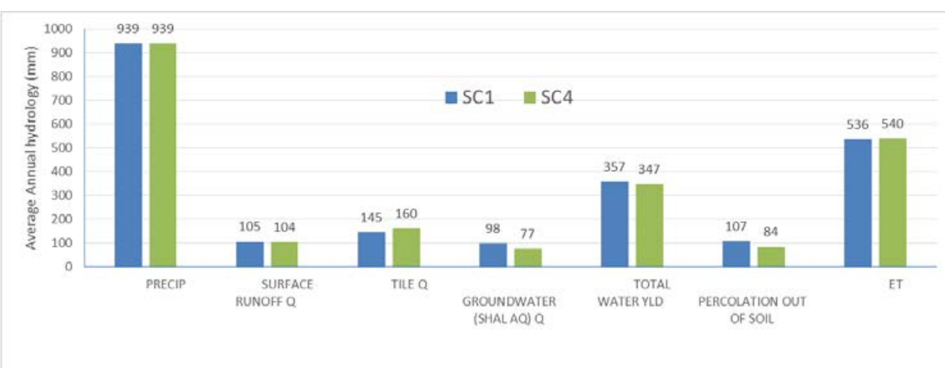
Hydrological budget

- Compare weather (GCDC vs. CFSR vs. Measured)

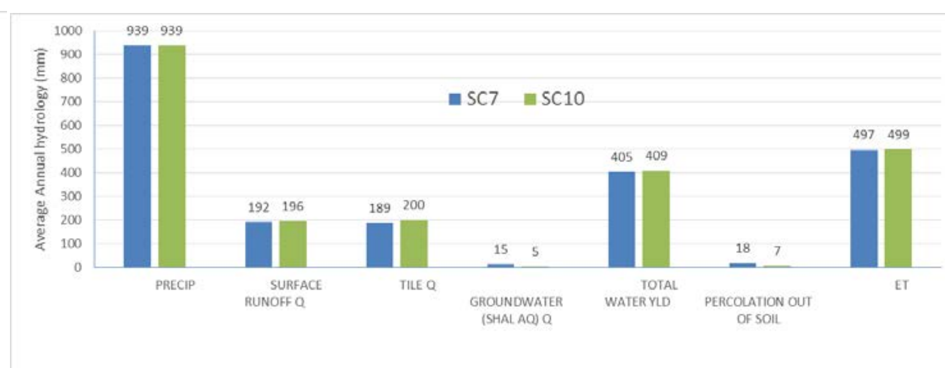


SLC soil, Solaris landuse

- Compare landuse (Solaris vs GLCC)



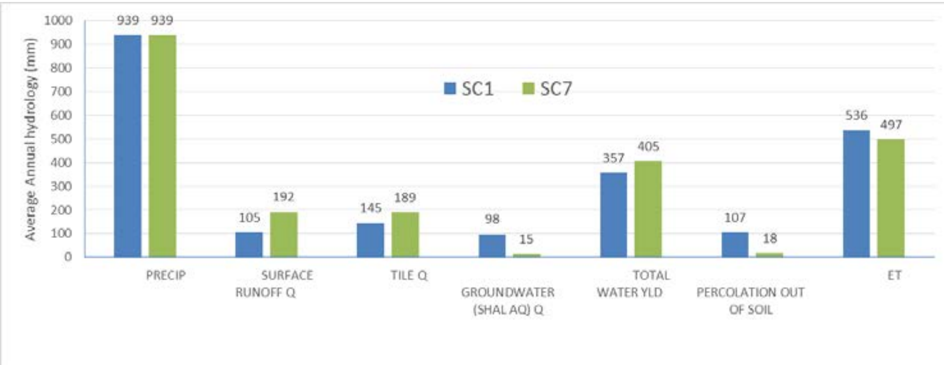
SLC soil, GCDC weather



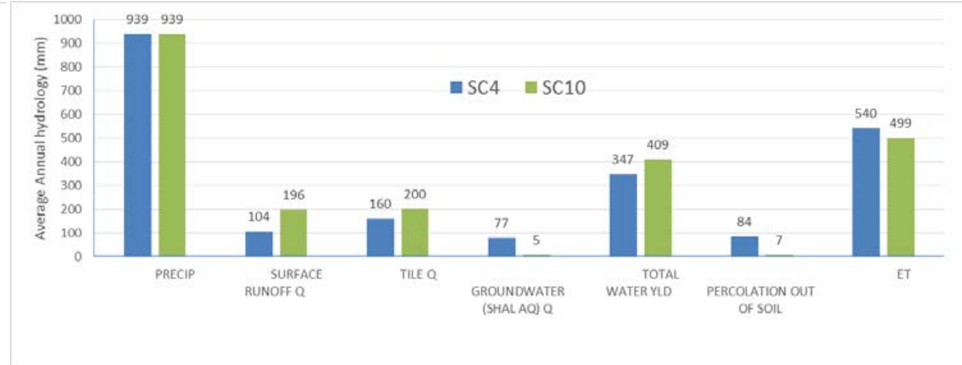
FAO soil, GCDC weather

Results

- Compare Soils (SLC vs FAO)

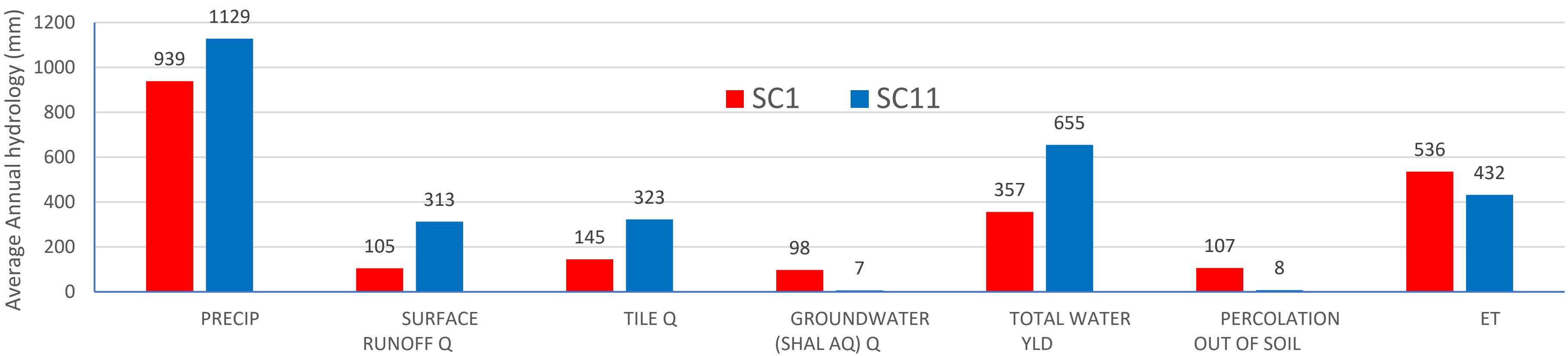


SOLARIS landuse, GCDC weather



GLCC landuse, GCDC weather

- Compare fine resolution vs coarse resolution datasets

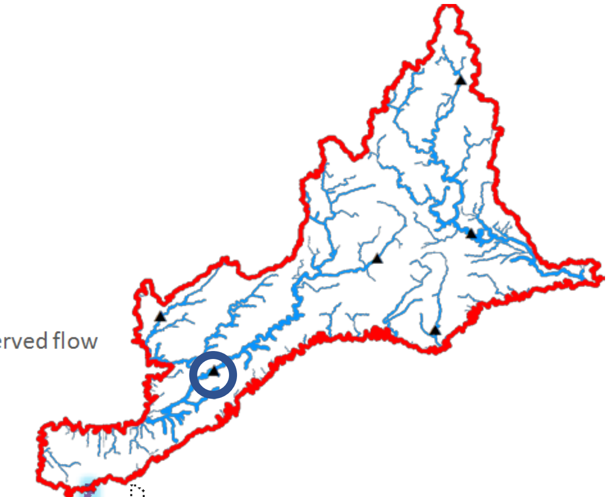


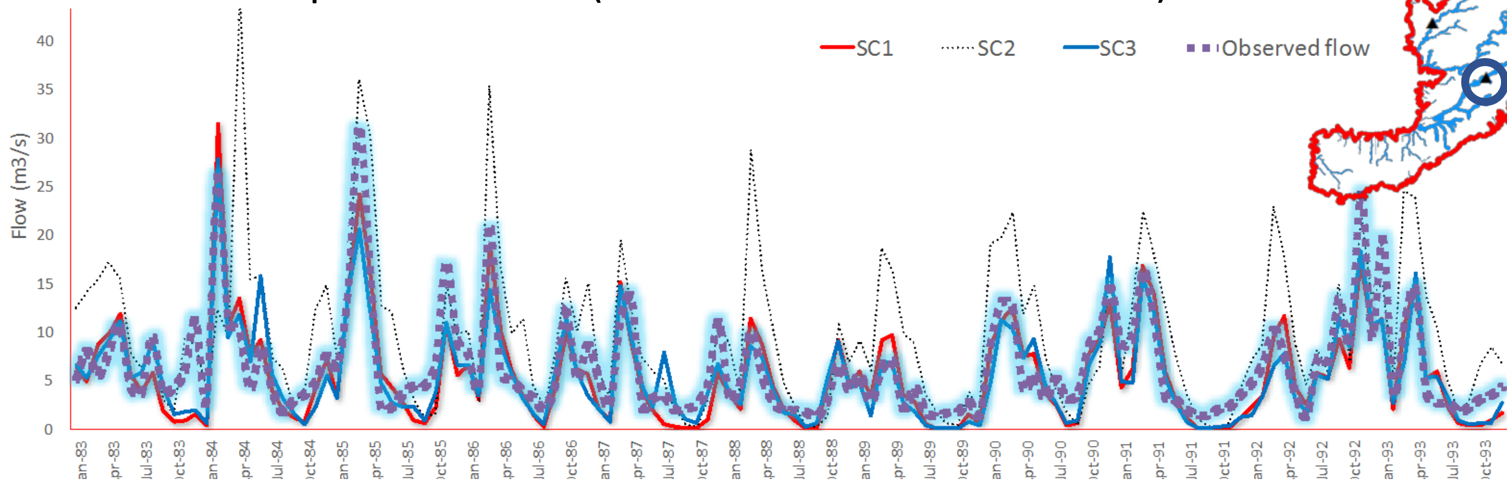
SLC soil SOLARIS landuse, GCDC weather **VS** FAO soil, GLCC landuse, CFSR weather

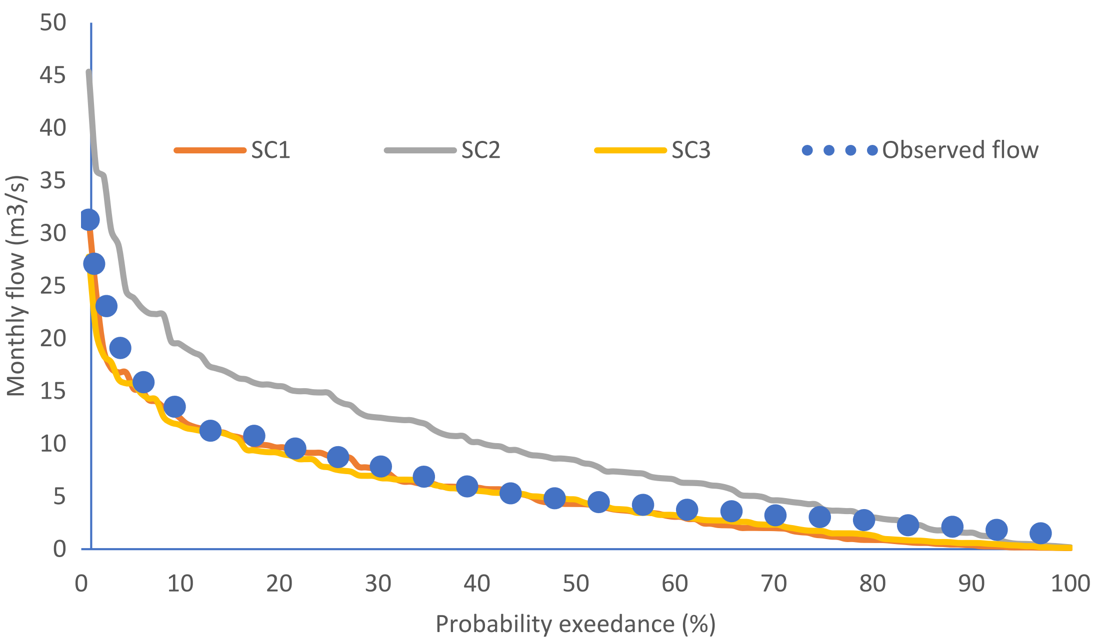
Results

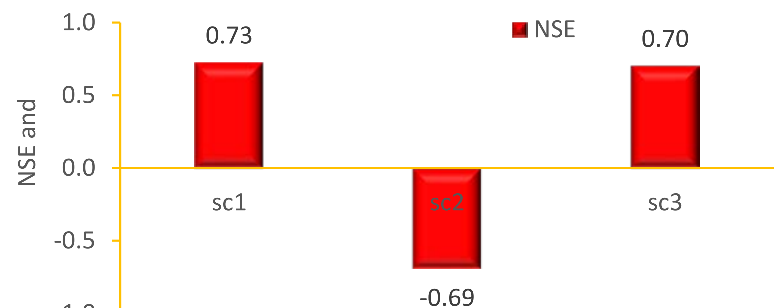
Streamflow @ Thames at Ingresol

- Compare Weather (GCDC vs. CFSR vs. Measured)



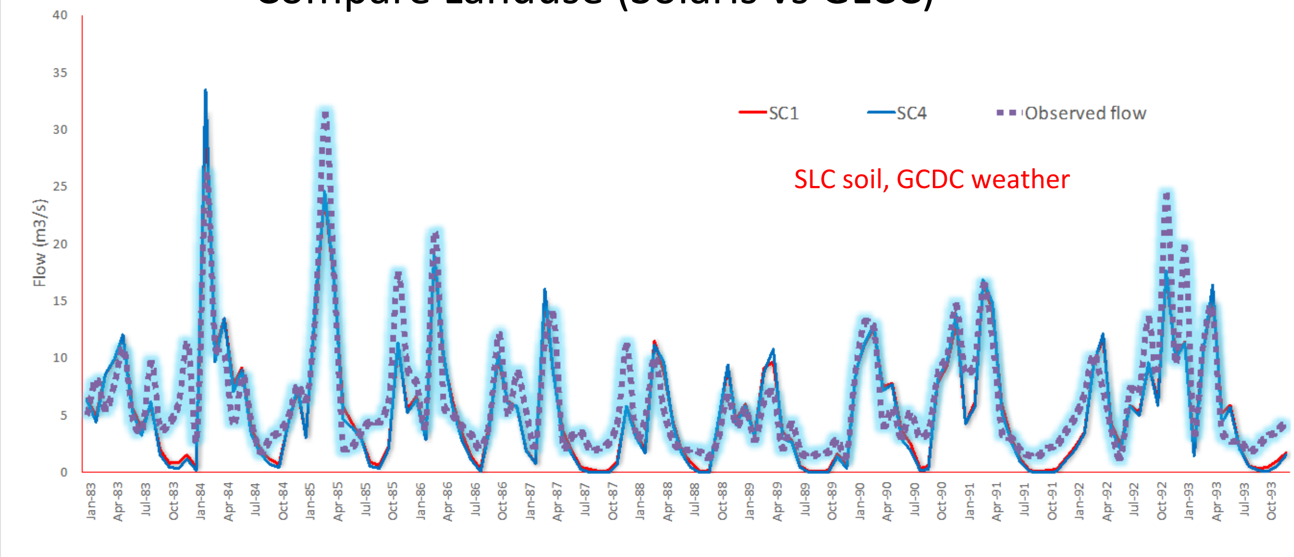


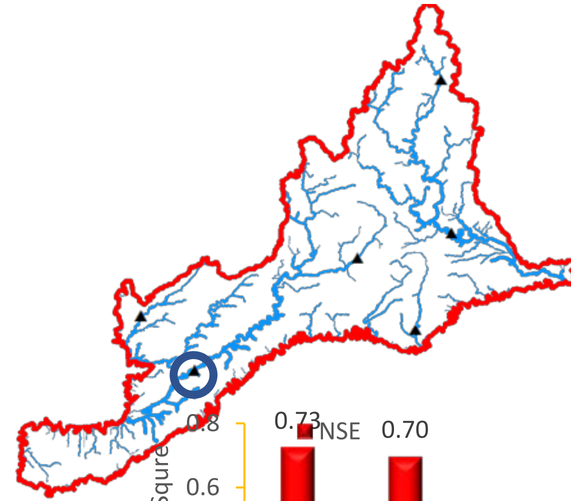


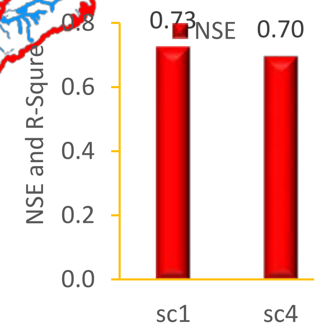


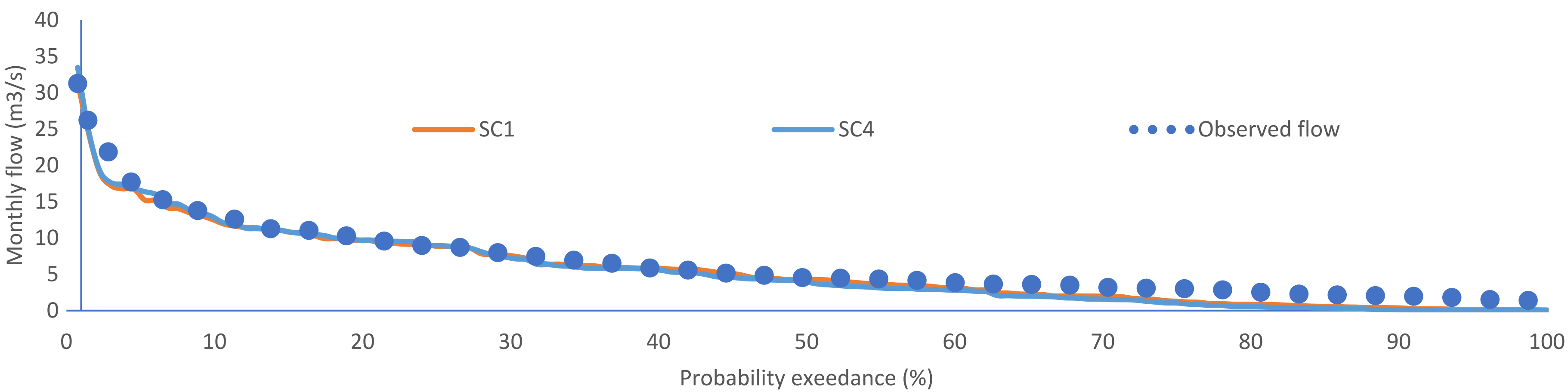
Results

- Compare Landuse (Solaris vs GLCC)



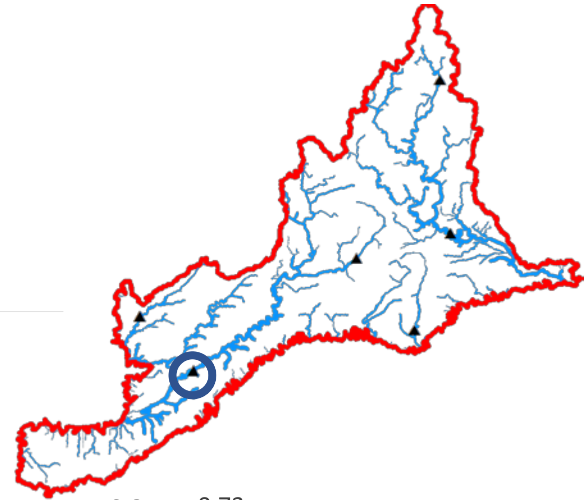




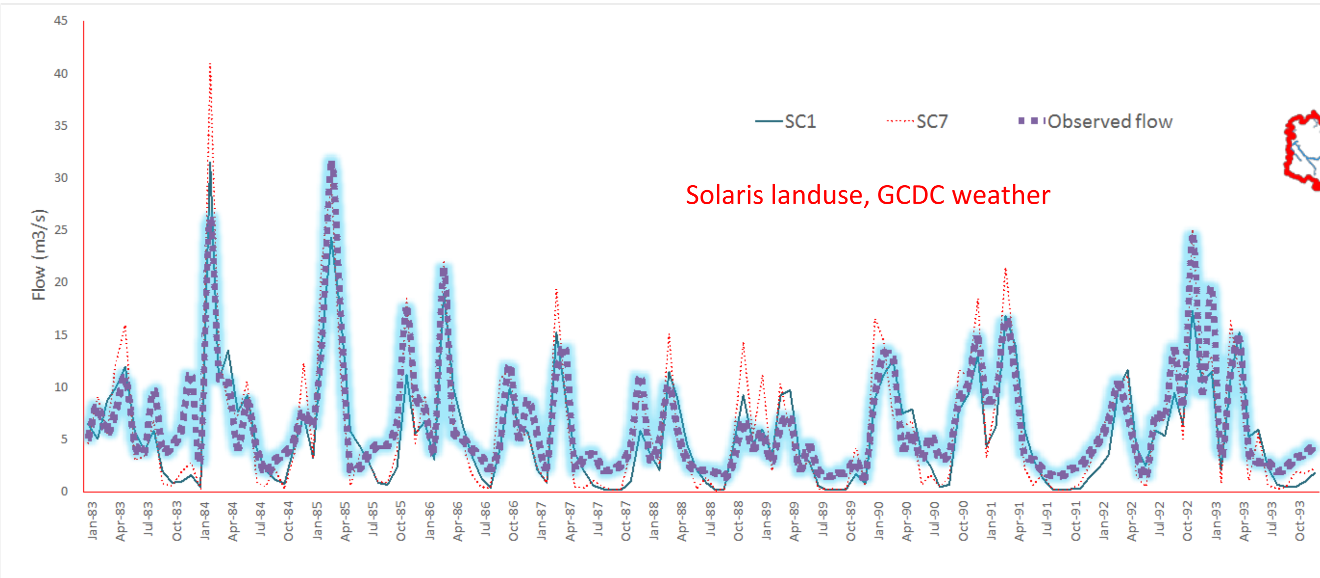


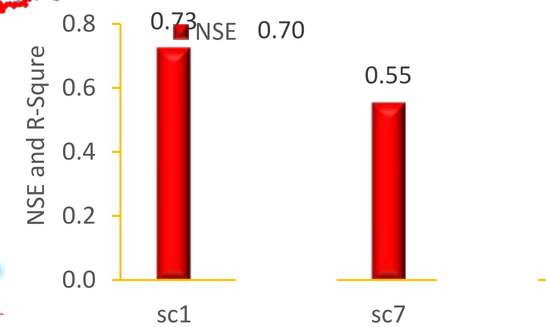
Similar results were also seen in Sc 7 and SC10 when comparing Solaris and Global landuse for similar FAO and GCDC/CFSR/Measured weather

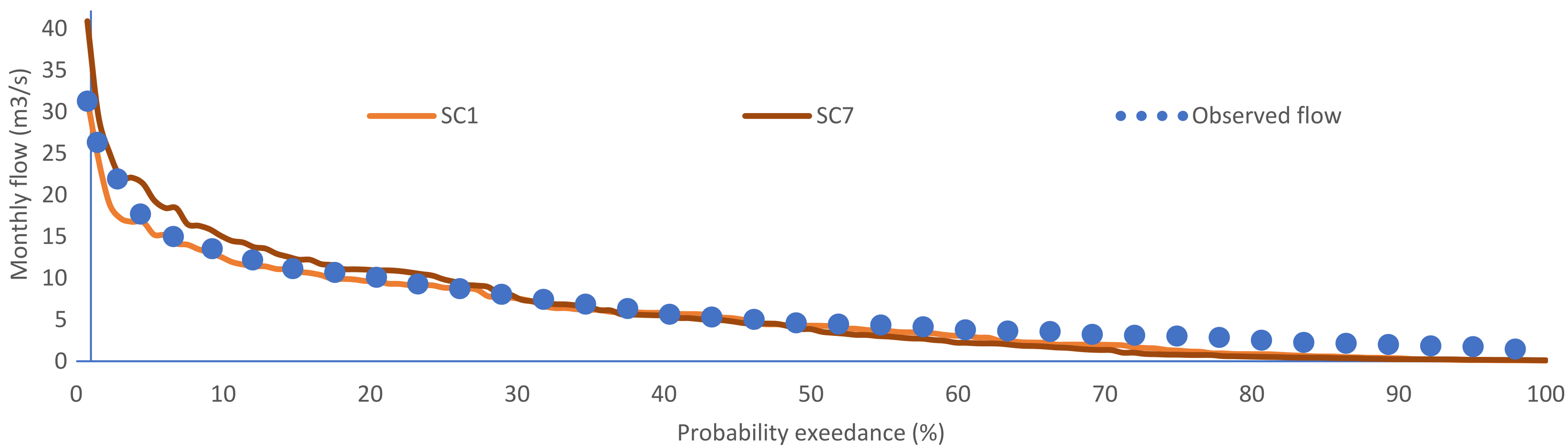
Results



- Compare Soils (SLC vs FAO)





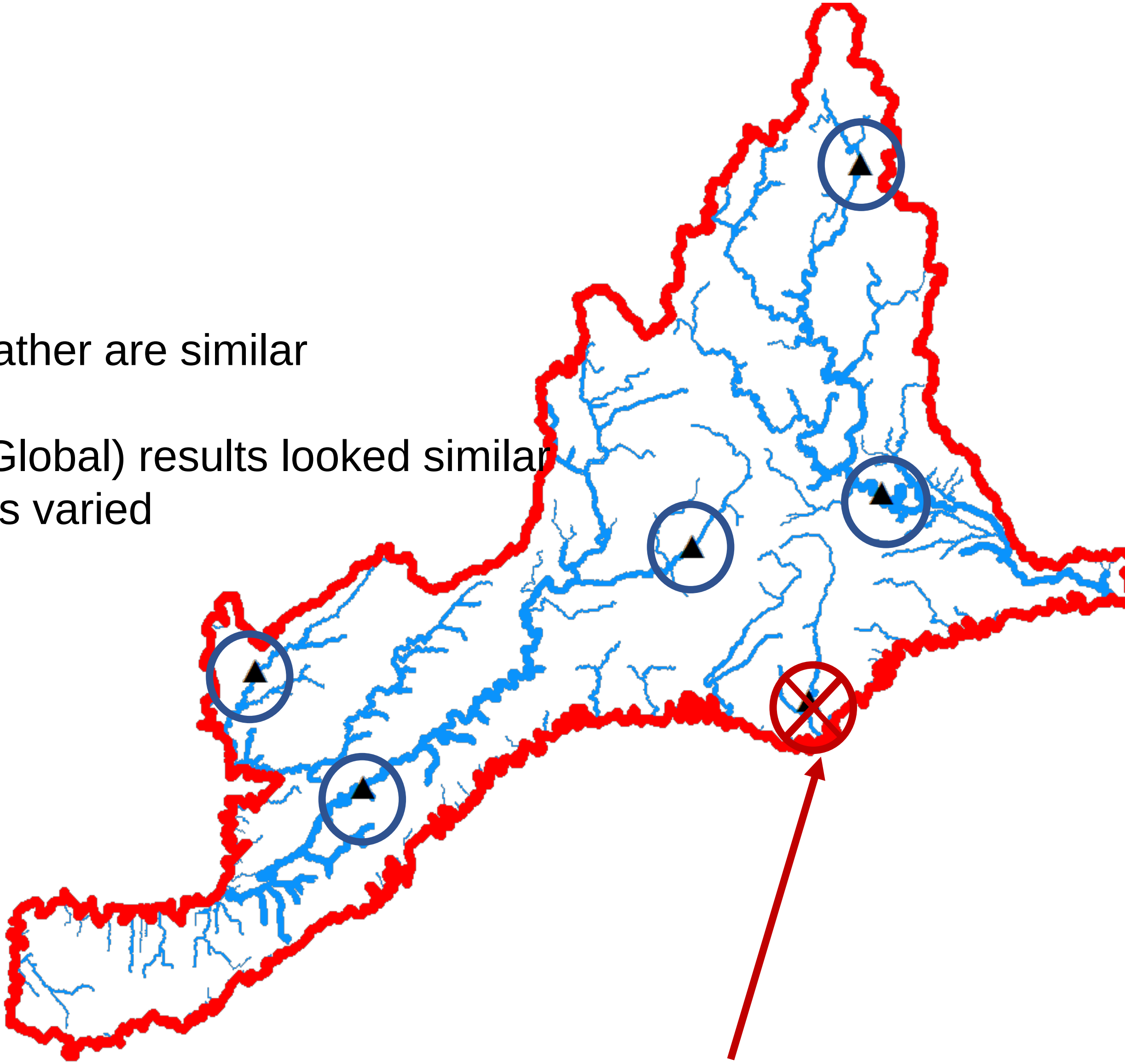


Similar results were also seen in SC 4 -SC10 when comparing SLC and FAO soils for similar Global landuse and GCDC/CFSR/Measured weather

Results

Similar results in

- Thames at Thamesville
- Grand at Brantford
- Grand at Marseville
- Bear creek at Bridgton
  - GCDC and Measured weather are similar
  - CFSR over estimated
  - Landuse (SOLARIS and Global) results looked similar
  - Soils (SLC vs FAO) results varied

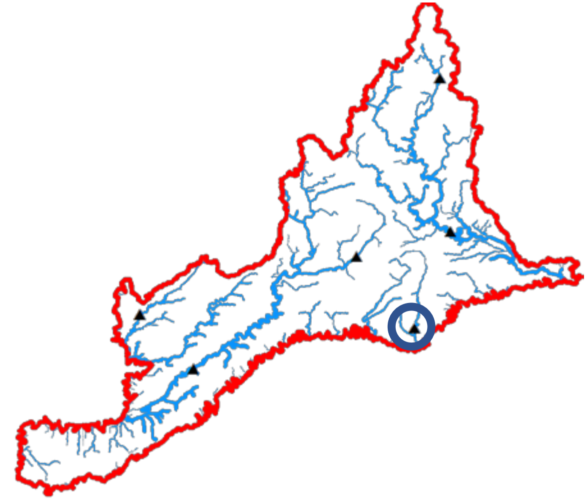


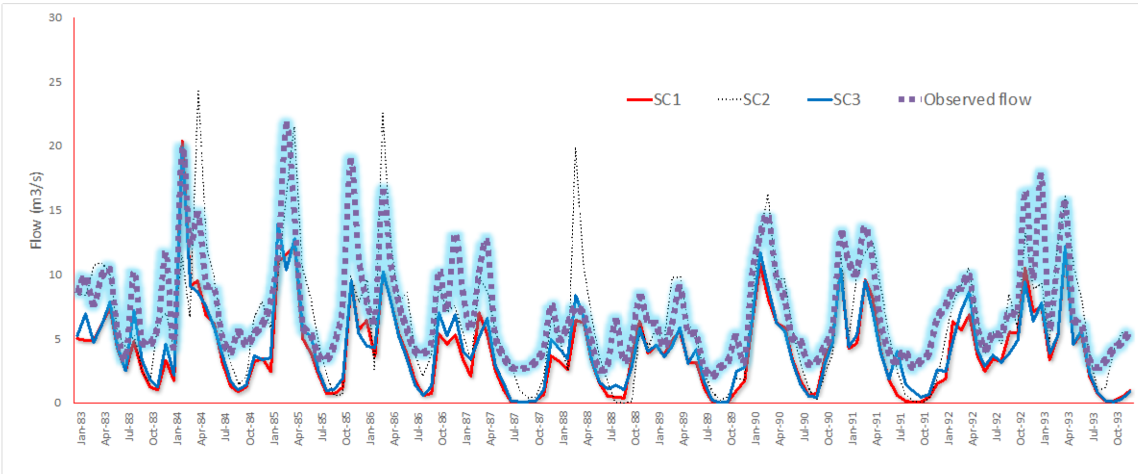
- Observed and simulated differ significantly (next slide)
- But the overall trends of weather, landuse, soil are similar

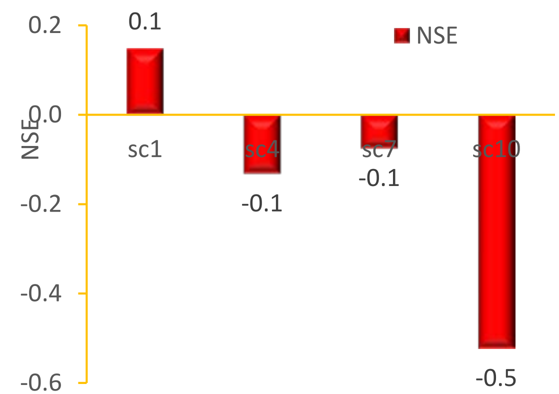
Results

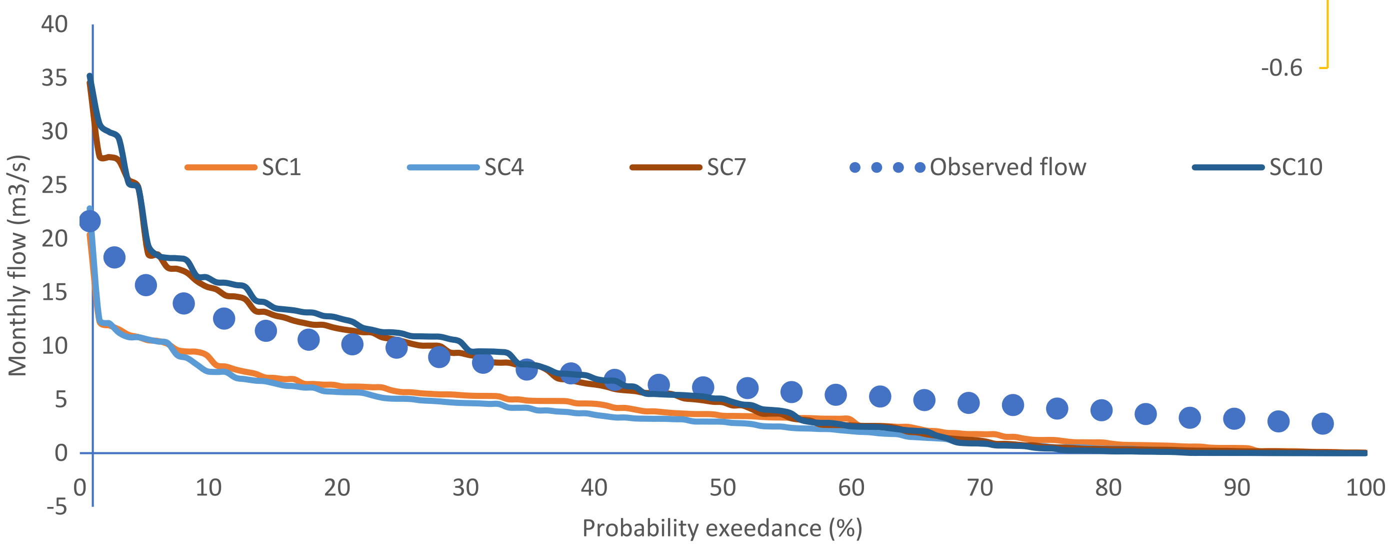
Streamflow @ Bear creek at Bridgton

- Compare Weather (GCDC vs. CFSR vs. Measured)



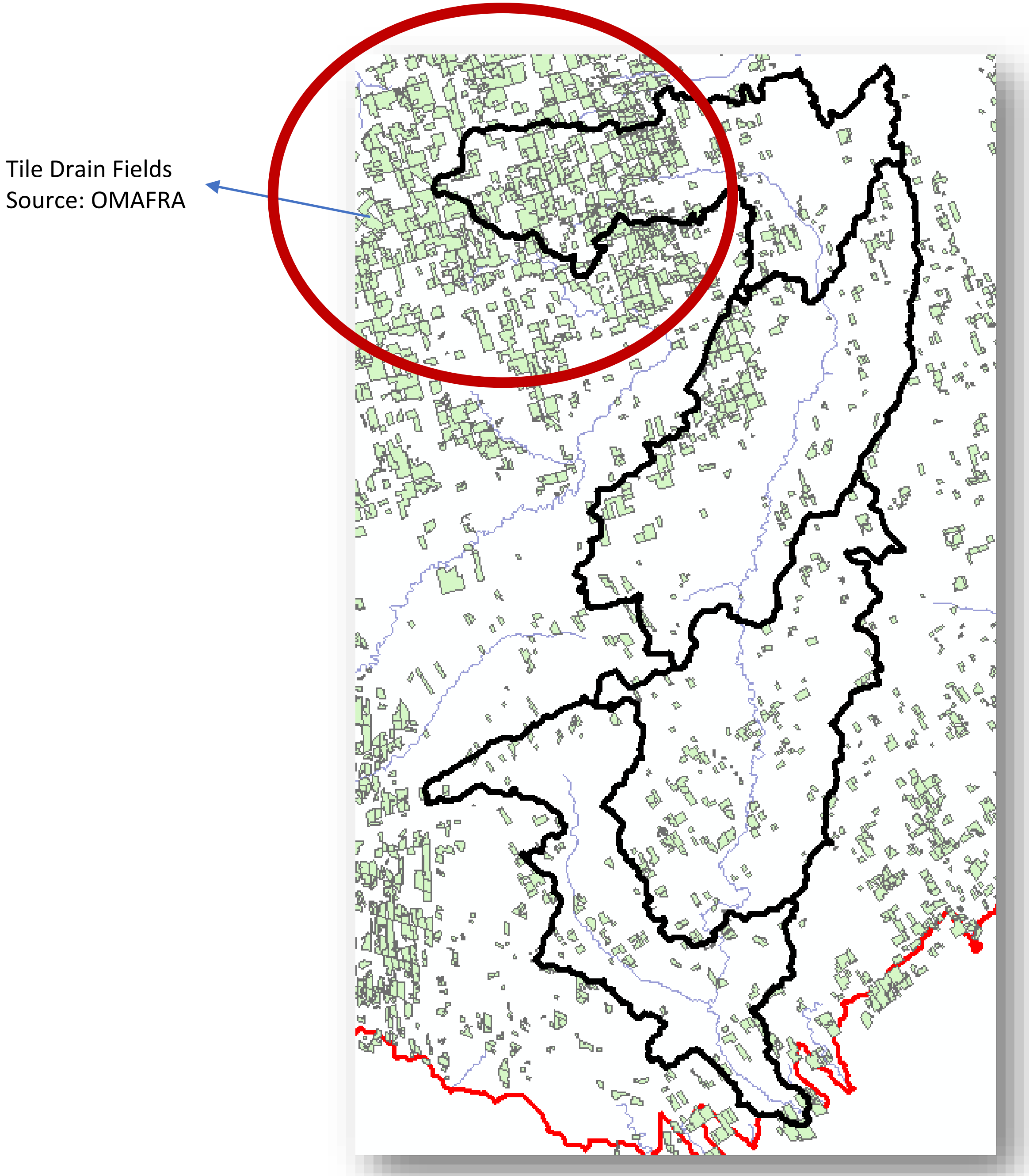






?????????

Bear creek watershed



- Not many fields in the watershed have tile drainage
- But we represented all agricultural lands in 0 to 2% have tile drainage and therefore the results differ
- Spatial representation of intra-watershed processes very important

Conclusion

- SWAT model developed for Norther Lake Erie basin
  - Contributing basin to the Lake Erie from Canadian side
- Various inputs were analyzed using hydrological budgets and streamflow at various locations
  - Weather
    - GCDC and Measured are similar
    - CFSR over predicted
  - Landuse
    - SOLARIS and GLCC are similar
  - Soils
    - Differences in FAO and SLC
      - SLC performed better
  - Representing intra-watershed processes in the model is important
    - Tile drainage


Thanks