Diagnosis and Prognosis of Effects of Changes in Lake and Wetland Extent on the Regional Carbon Balance of Northern Eurasia

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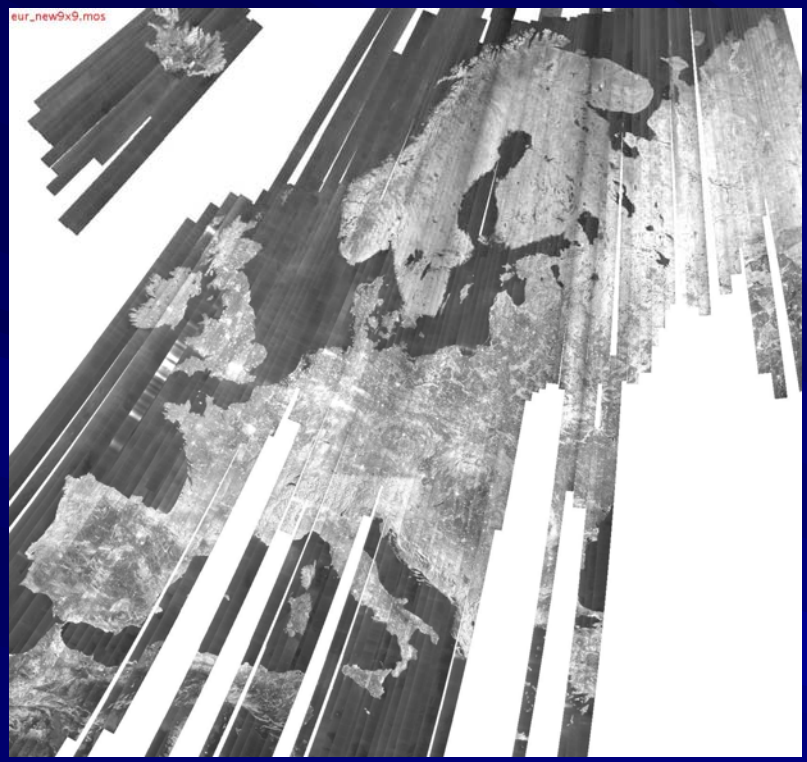
Outline

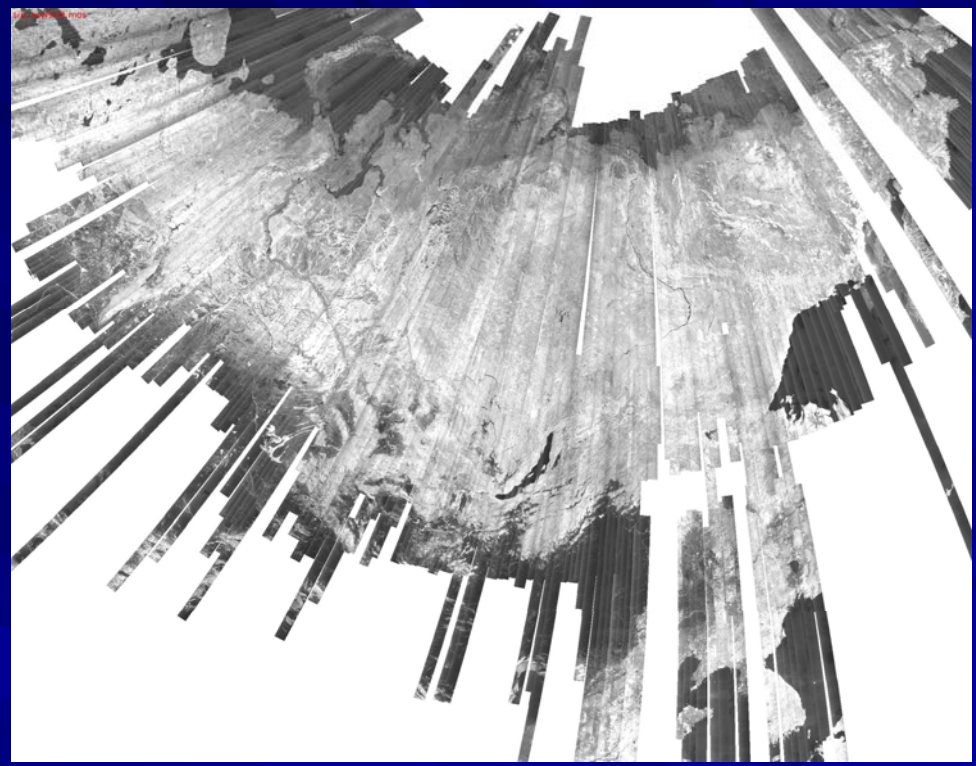
- Observations
  - Satellite
  - In situ
- Modeling
  - Lake/wetland extent
  - Carbon cycling

Satellite Data

- JERS-1 SAR
- Classification

High-Resolution Synthetic Aperture Radar Imagery

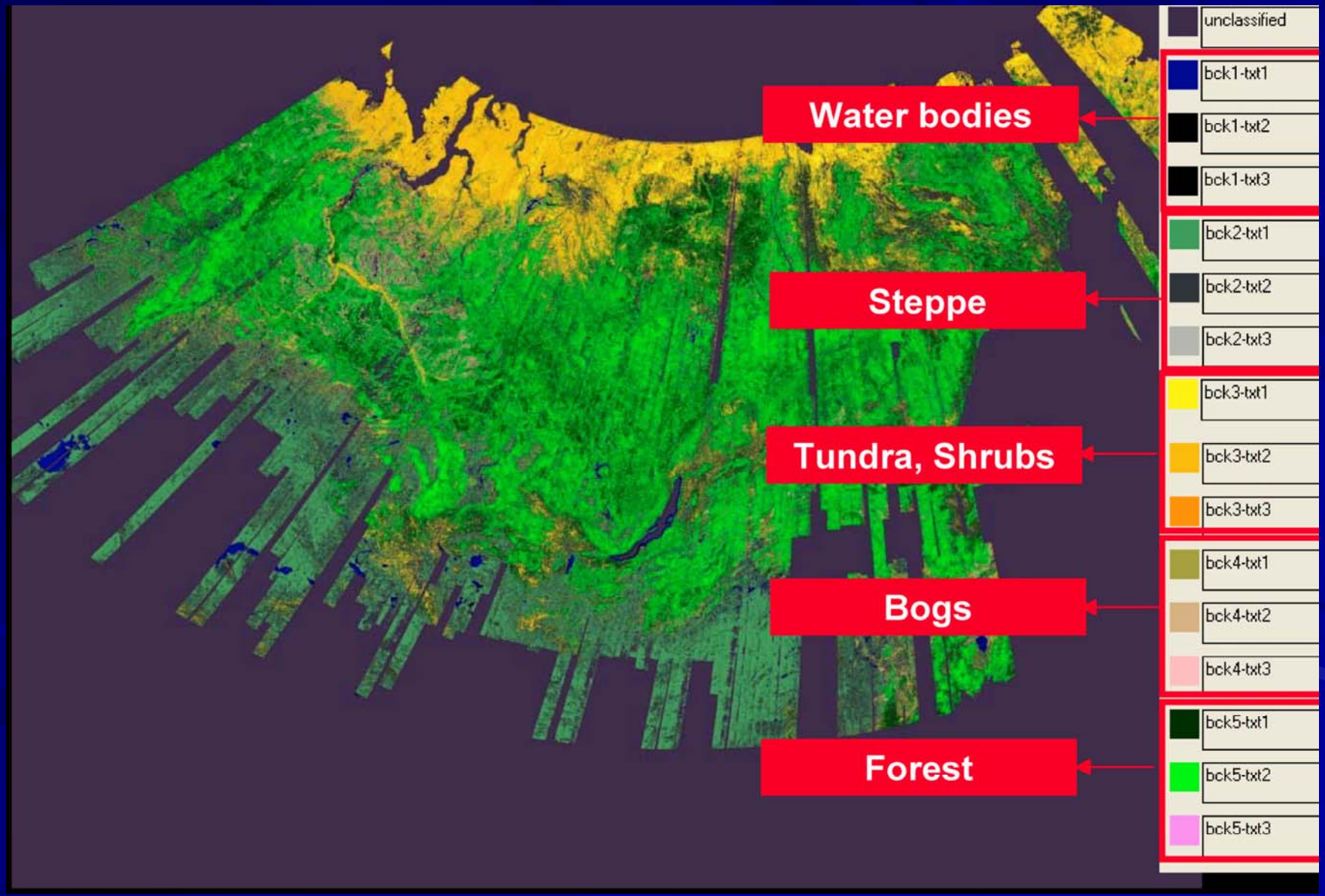




Global Boreal Forest Mapping Project

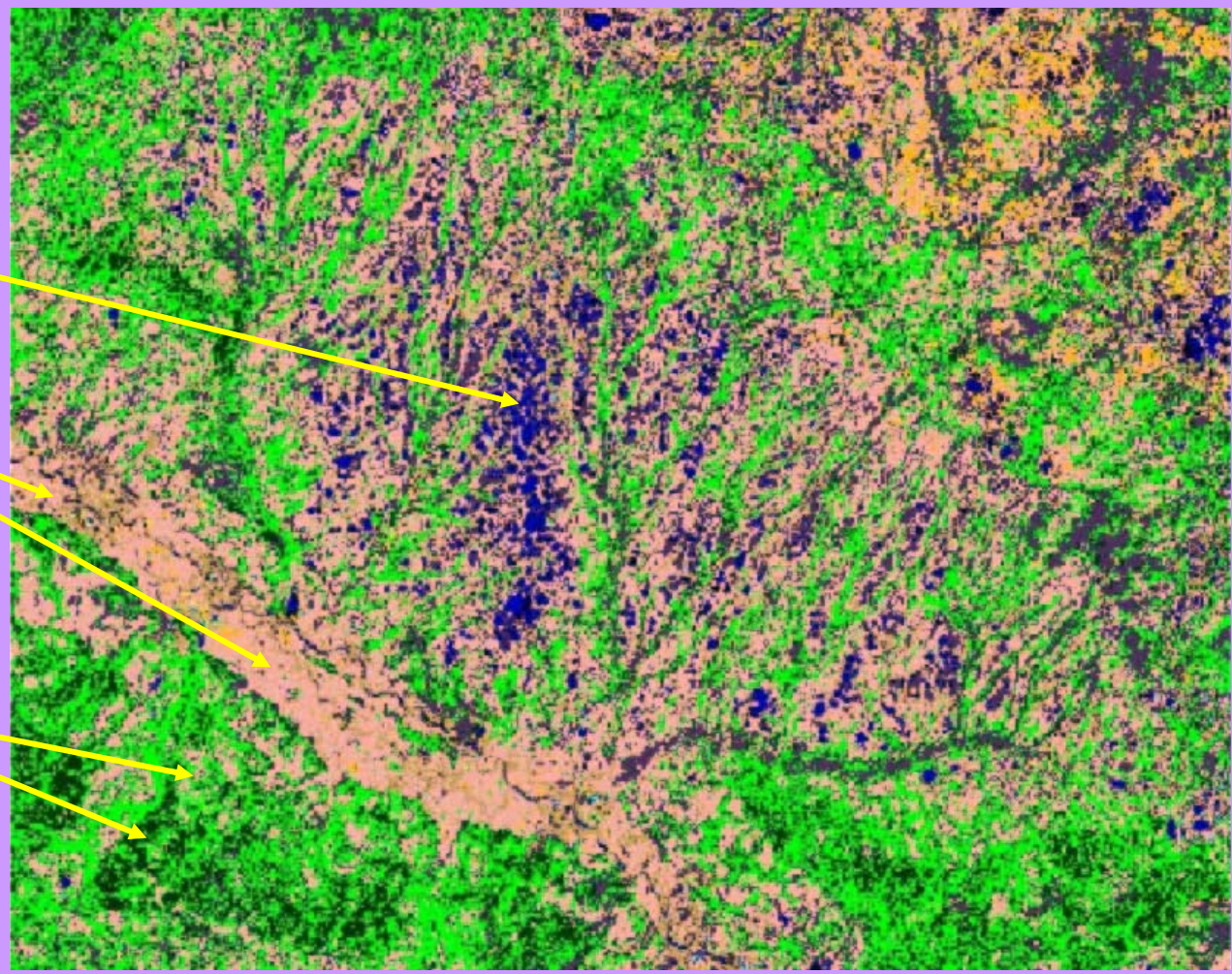
- **JERS-1 SAR L-band mosaics**
- **100 meter resolution**
- **Data acquired mostly in 1997-1998**

JERS SAR Mosaic Radiometric Classification



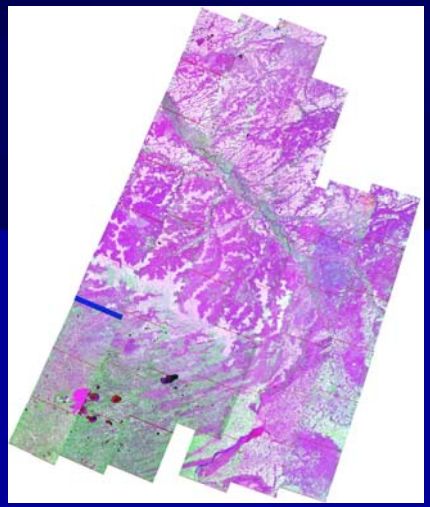
High-Resolution Synthetic Aperture Radar Imagery

JERS SAR Mosaic Backscatter Amplitude and Texture Classification

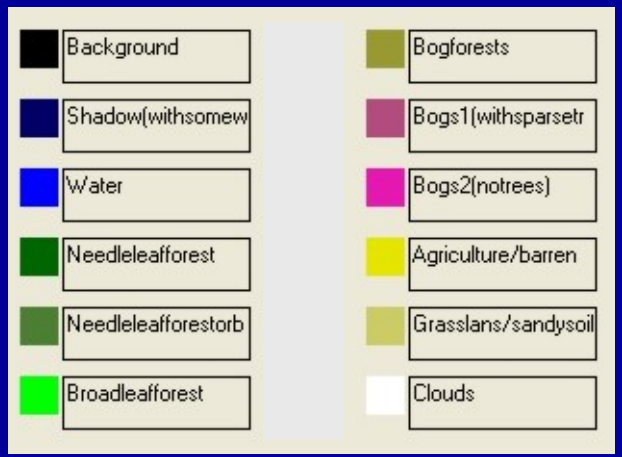


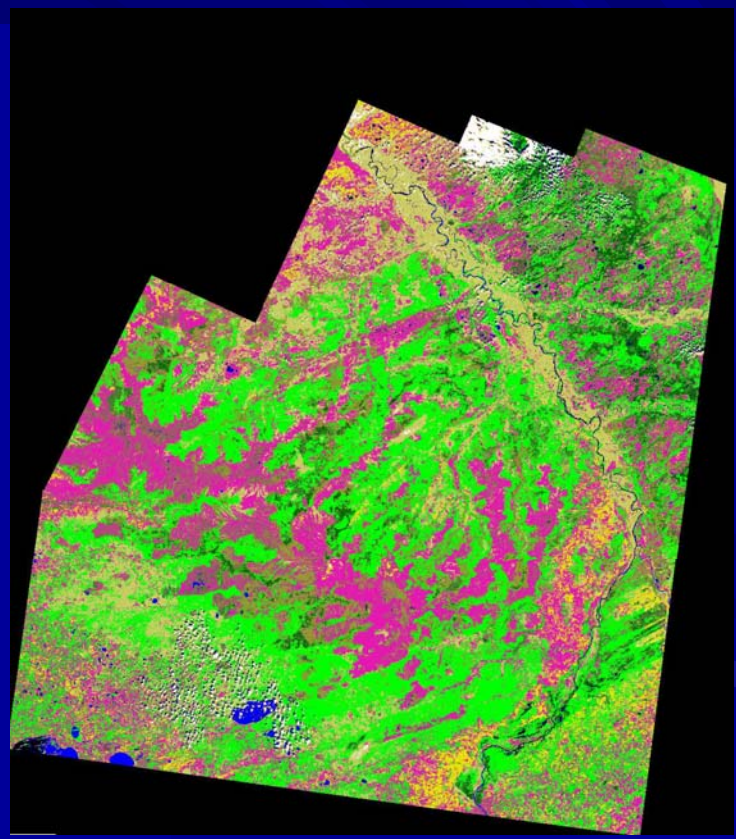
JERS SAR Classification North of Ob River

High-Resolution Synthetic Aperture Radar Imagery



ERS-1 and ERS-2 SAR Tandem Data
Backscatter and coherence map





ERS SAR Classification of Ob River Mosaic

In Situ Data

- Dynamics of open water surface area, and forest and bog areas for European Russia from the 1950s through the 1990s
  - water and vegetation inventories performed every 3 to 5 years (archived at the Russian State Hydrological Institute)
  - quantitative assessments of landscape elements are available for 54 regions with areas from 3900 to 161,000 km^2

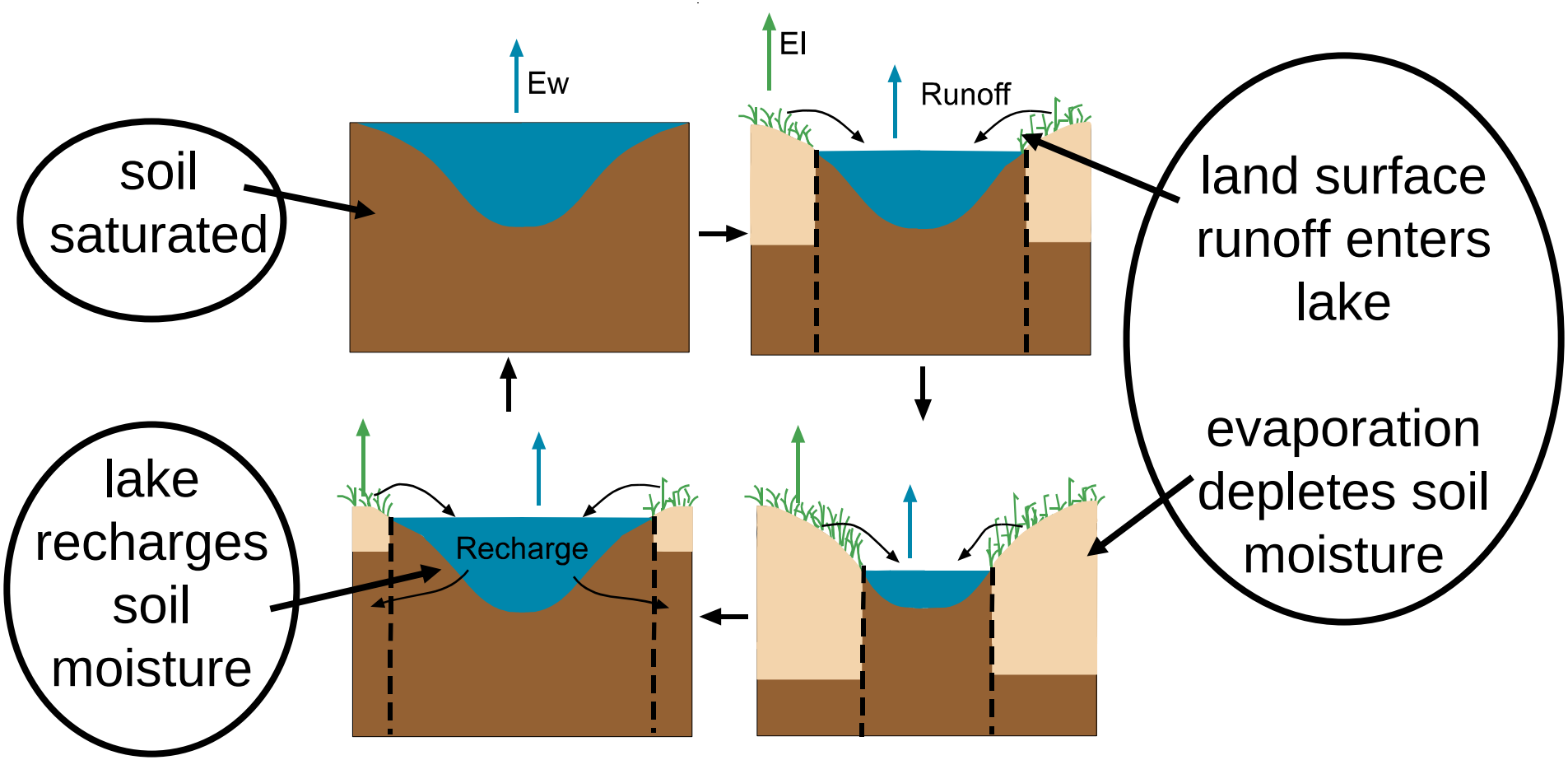
- Monthly evaporation from open water and soil surfaces during the warm months:
  - weighing lysimeter data available at 60 sites
  - pan evaporation observations available at 103 sites
  - soil moisture and temperature data also available

- Tower flux and related observations:
  - Central Forest Biosphere Reserve (CFBR)

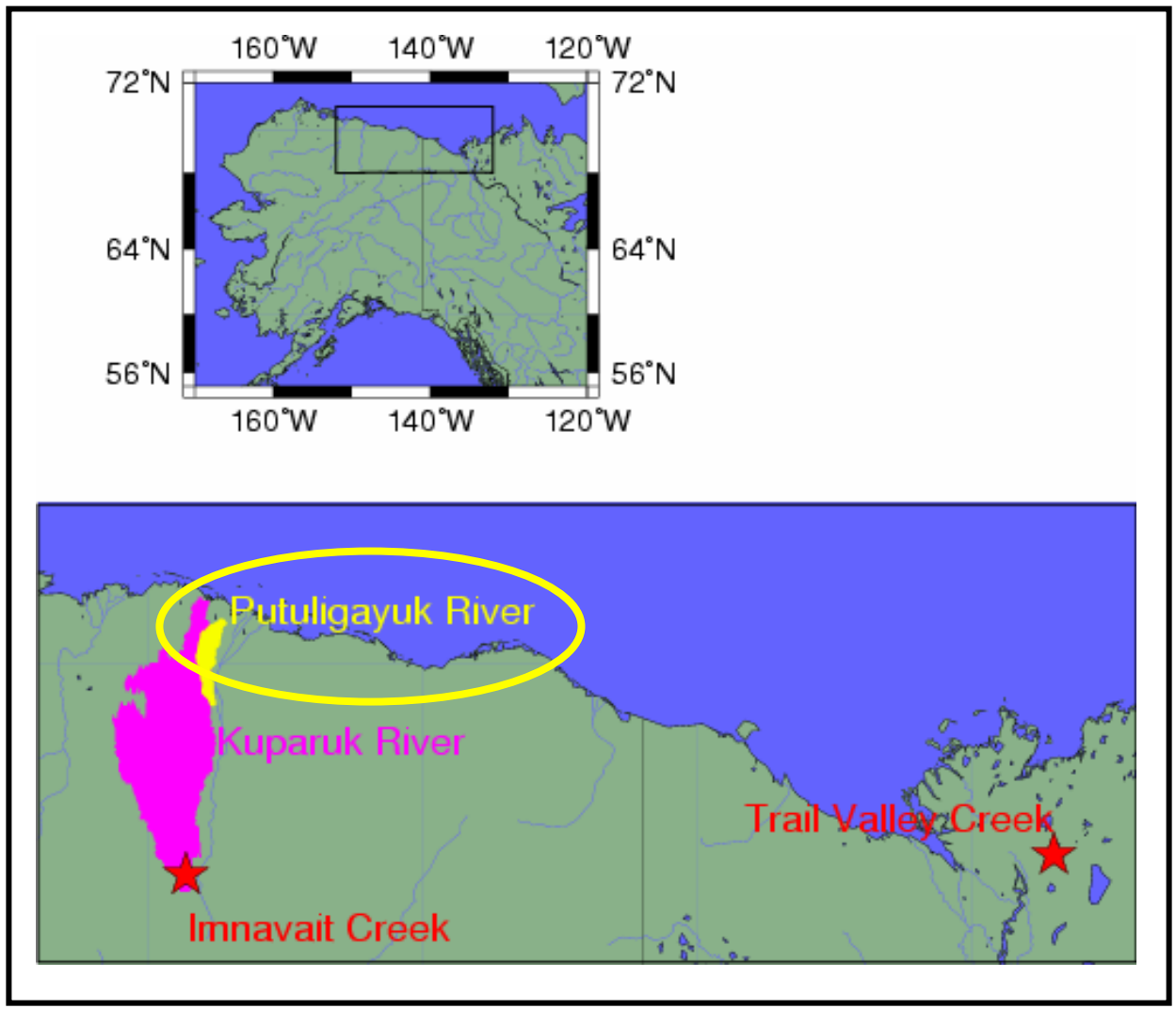
Modeling

- Extensions to VIC lake/wetland model
  - Enabling lakes/wetlands to expand without restriction
  - Sensitivity of hydrograph to freely-expanding lakes/wetlands

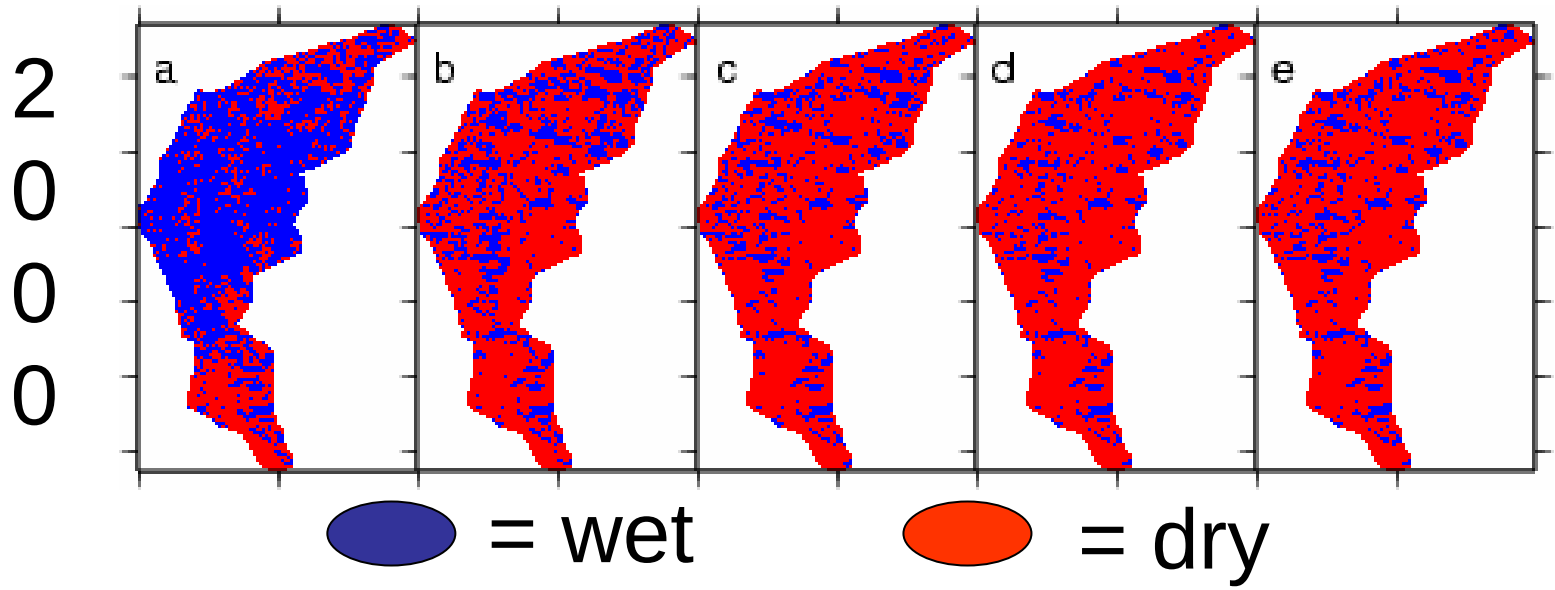
Wetland Algorithm

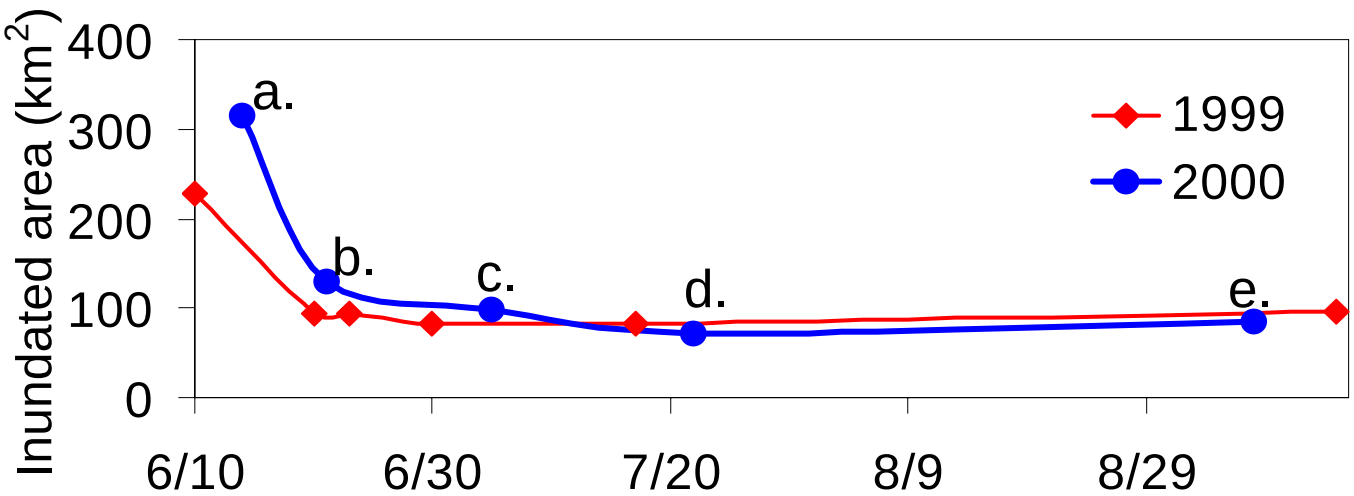


Location of Lake Extent Sensitivity



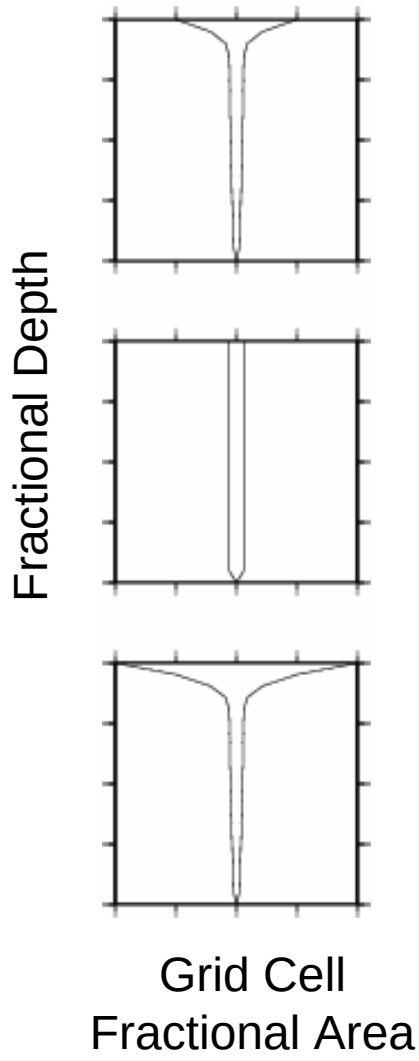
Saturated extent 1999 and 2000



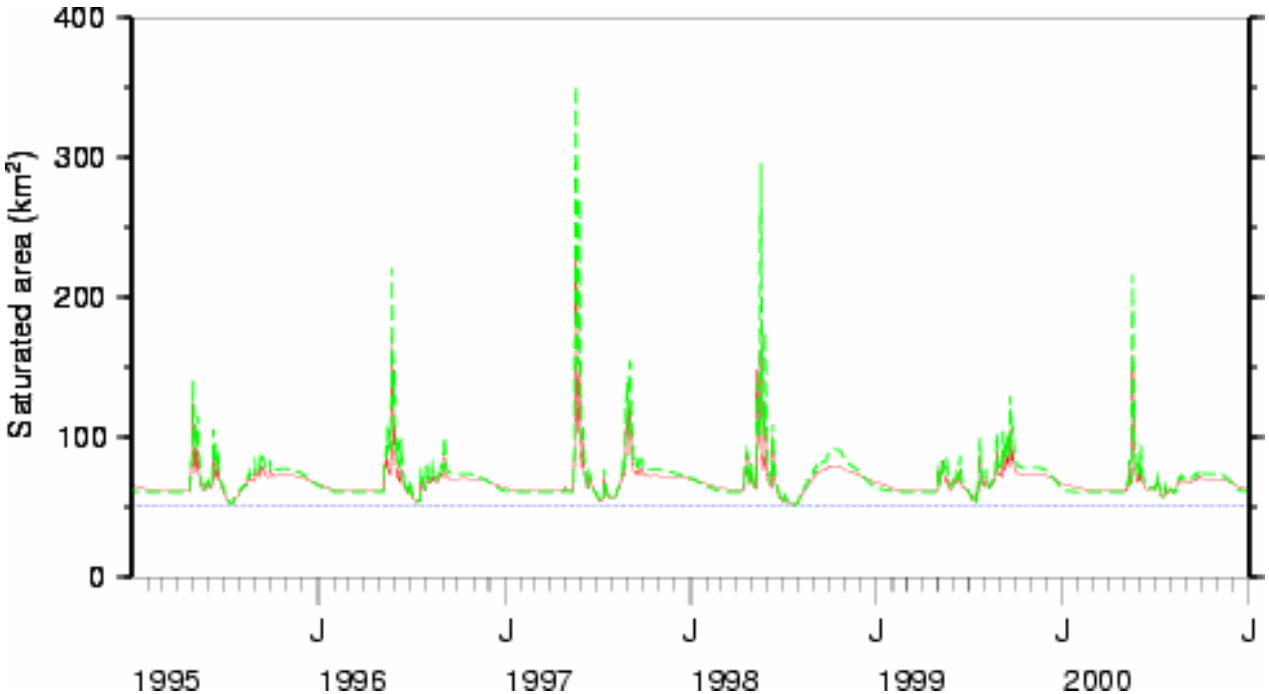


Lake extent scenarios

- Three scenarios defined:
  1) Variable extent/defined maximum, e.g. as defined by Bowling et al. (2002)
  2) Constant extent, as used by Su et al. (2005)
  3) Variable extent/unlimited growth
- Maximum depth adjusted such that scenarios 1 and 2 have equal volume

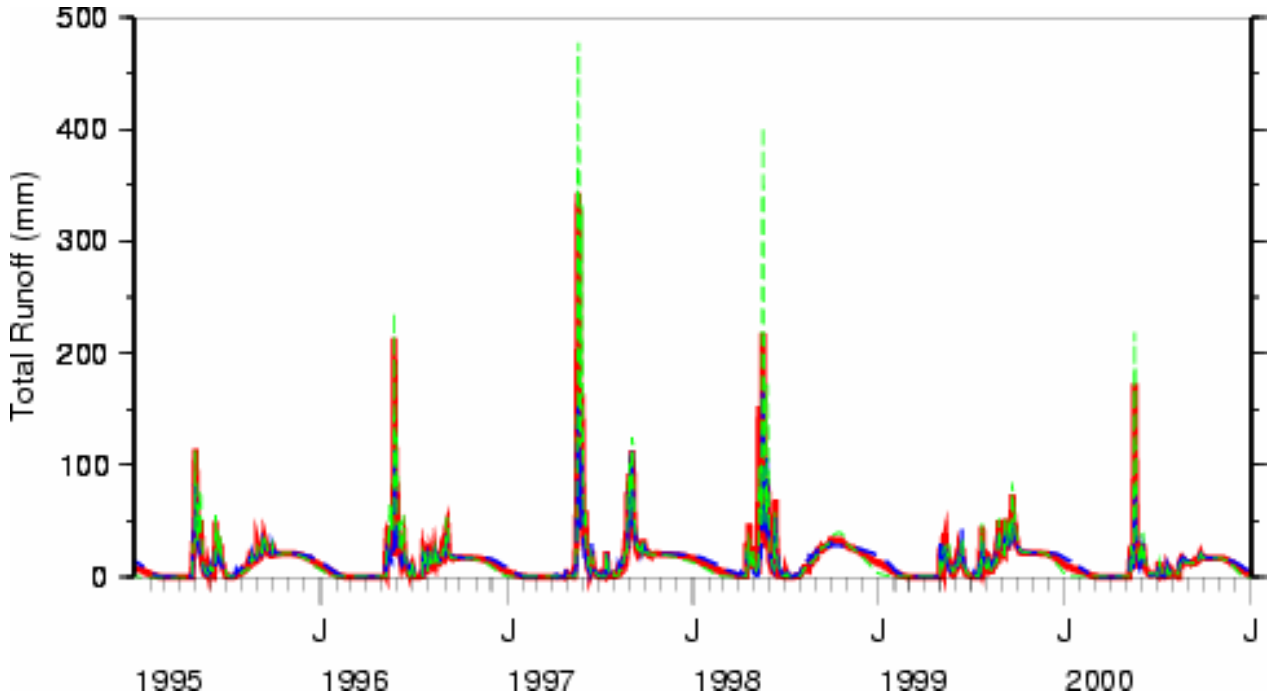


Change in open water extent



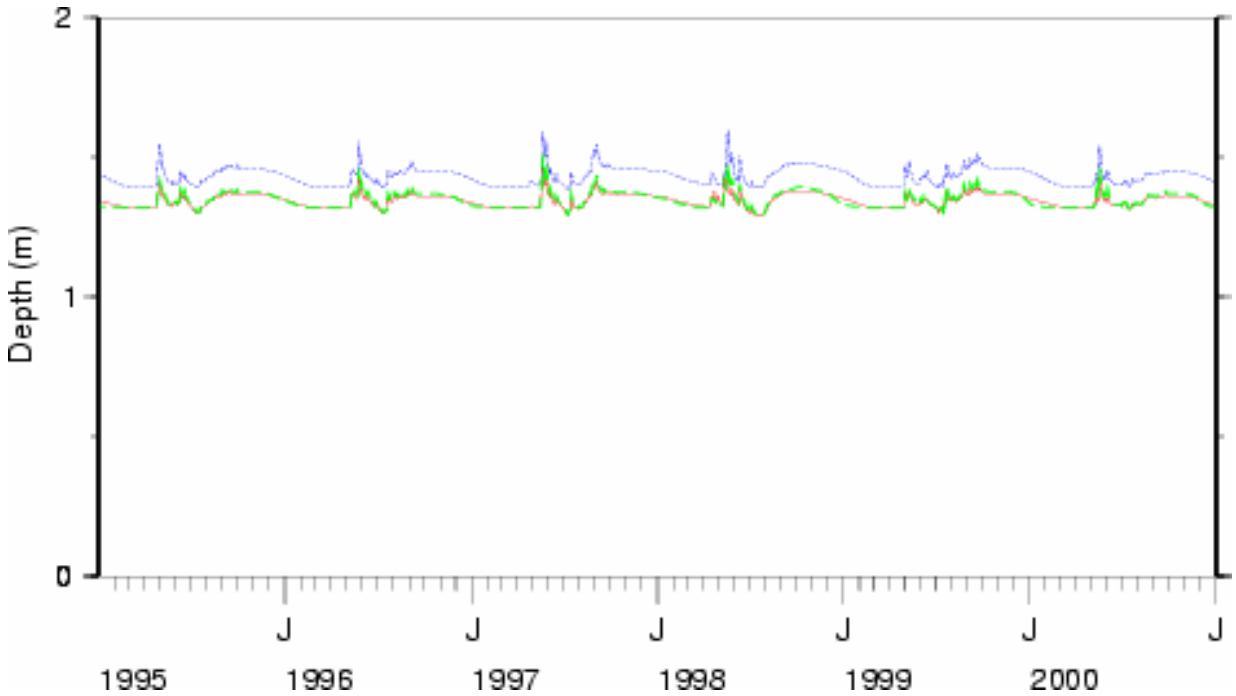
Scenario 1 Scenario 2 Scenario 3

Runoff + Baseflow (unrouted)



Scenario 1 Scenario 2 Scenario 3

Lake Depth

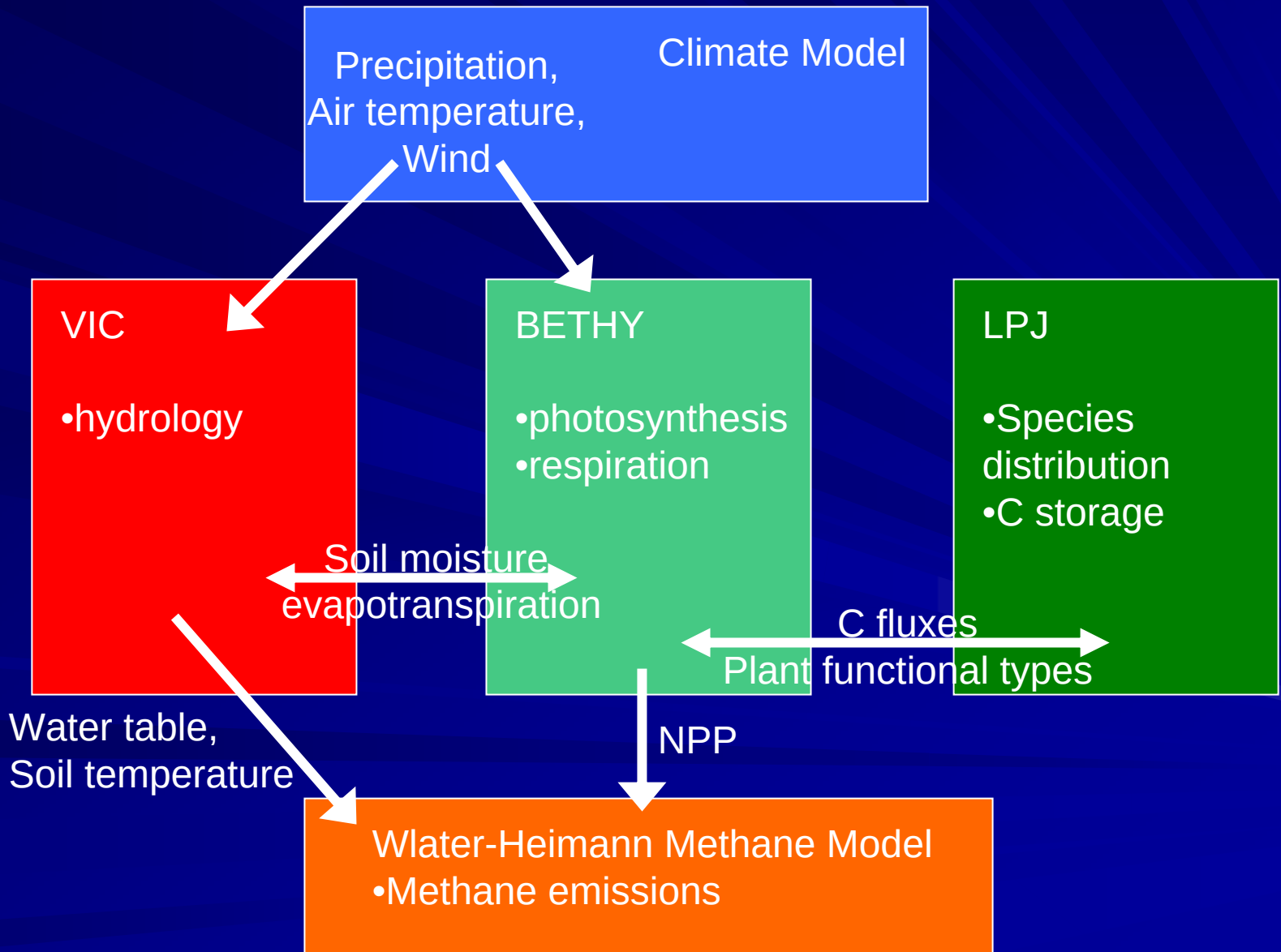


Scenario 1 Scenario 2 Scenario 3

Summary

- Maximum extent used in Scenario 1 is based on observed Radarsat data from 2000.
- Allowing wetlands to grow unrestricted does cause the maximum extent to increase in 1996, 1997, 1998 and 2000; 1997 and 1998 probably should be greater than 2000
- Relative lake depth will change because of differences in storage volume, with the variable scenarios being shallower than the constant scenario (scenario 2)
- Smallest runoff peaks for scenario 2, followed by scenario 1, then scenario 3
- This is somewhat counterintuitive since runoff rate is proportional to depth; need to reevaluate runoff formulation

Model Integration



Linking of hydrology, methane

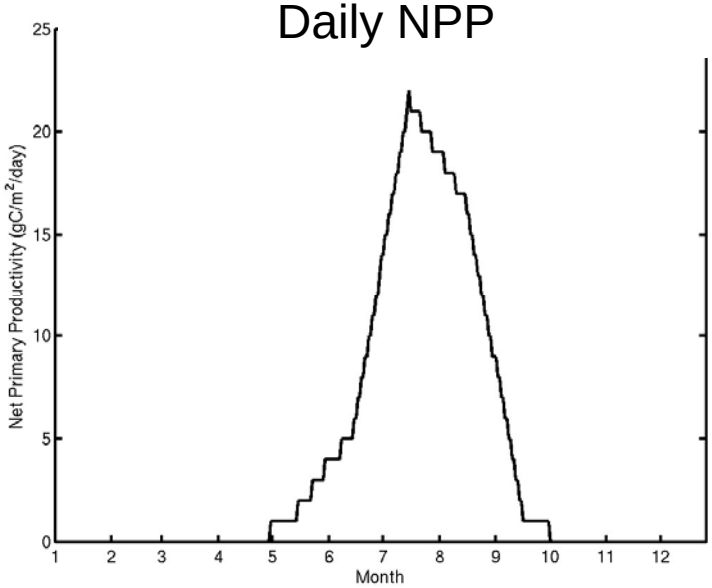
- Methane emissions depend on
  - Temperature
  - Water table depth
  - NPP (proxy for organic C storage in soil)

Supplied by VIC

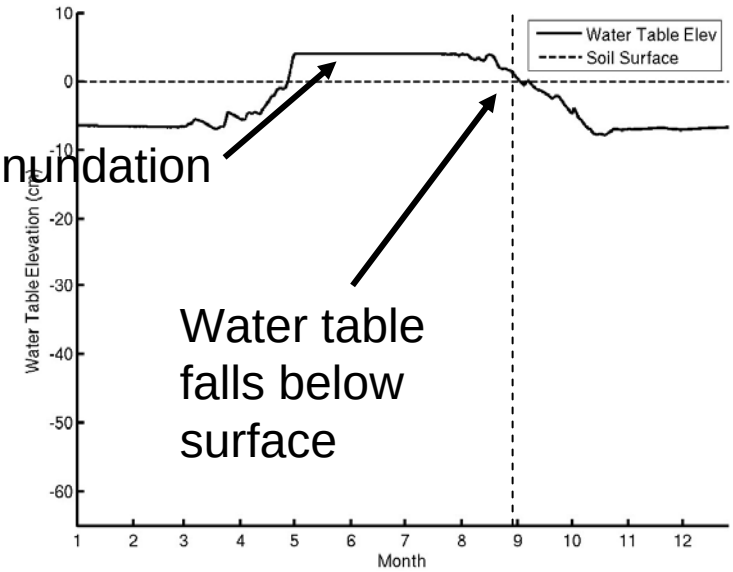
Supplied by LPJ/BETHY; taken from previous global modeling for now

Wetland : Wet Year

Daily NPP



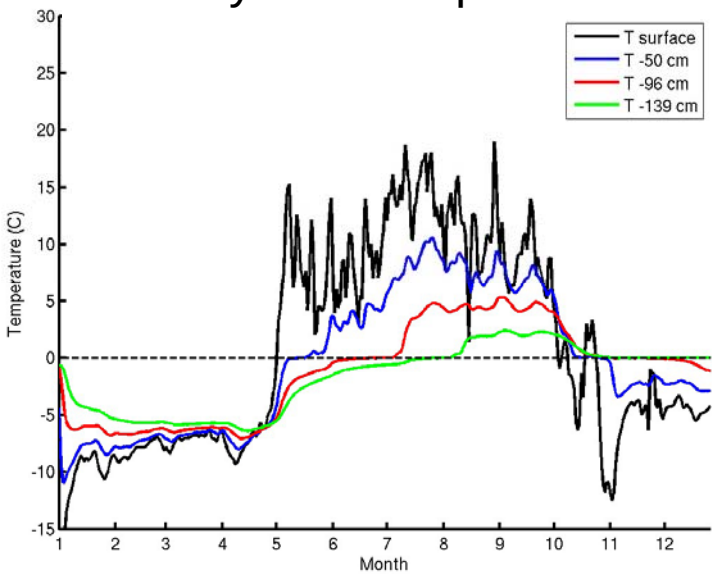
Daily Water Table



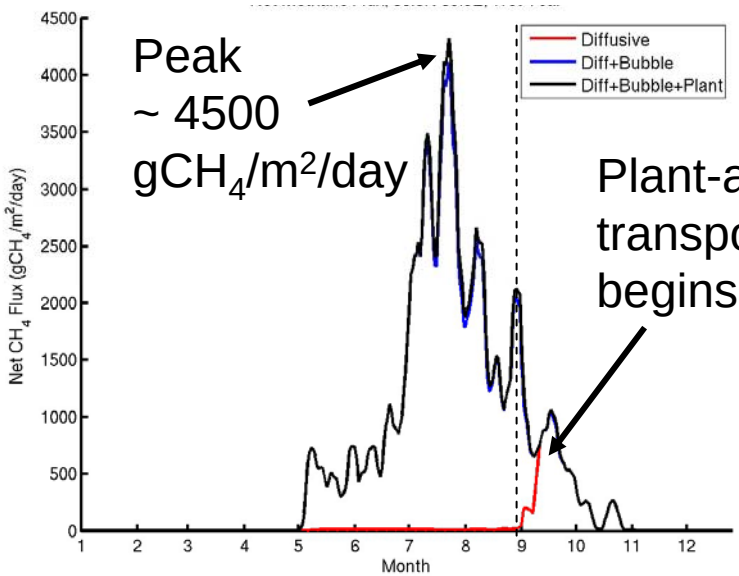
Inundation

Water table falls below surface

Daily Soil Temperature



Daily Methane Flux

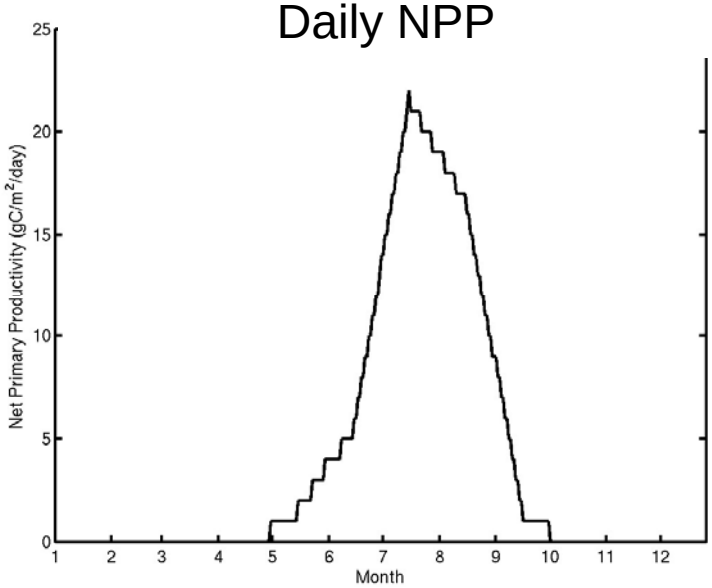


Peak ~ 4500 $gCH_4/m^2/day$

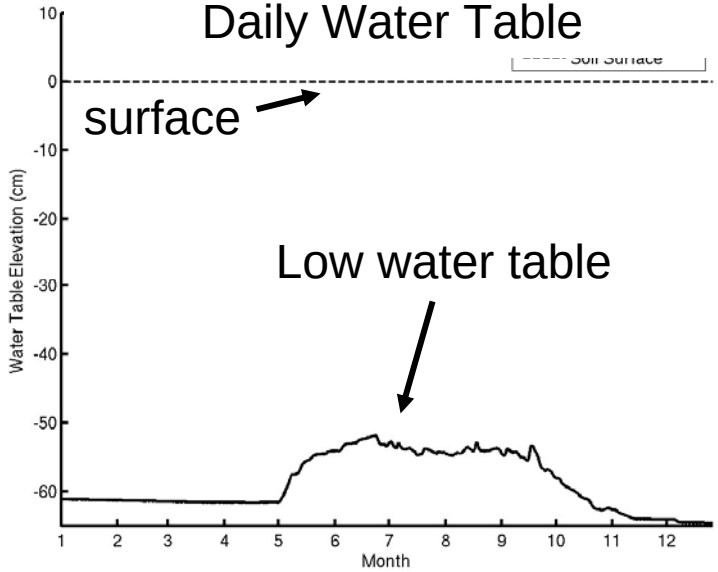
Plant-aided transport begins

Wetland : Dry Year

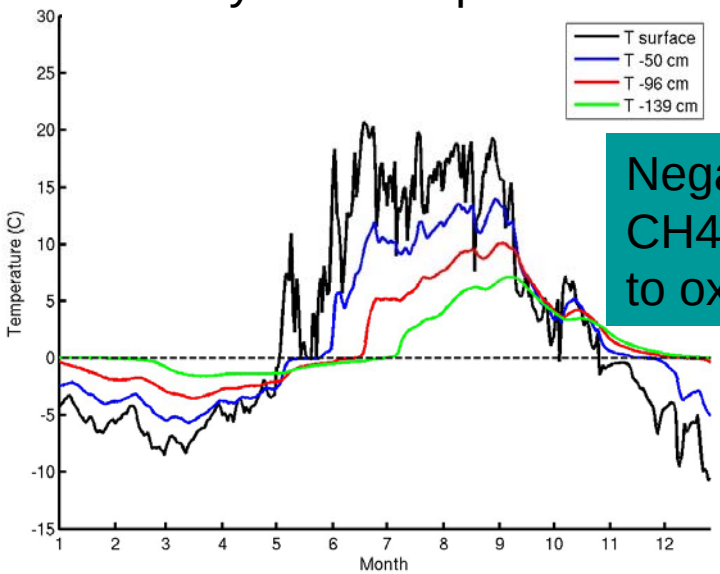
Daily NPP



Daily Water Table

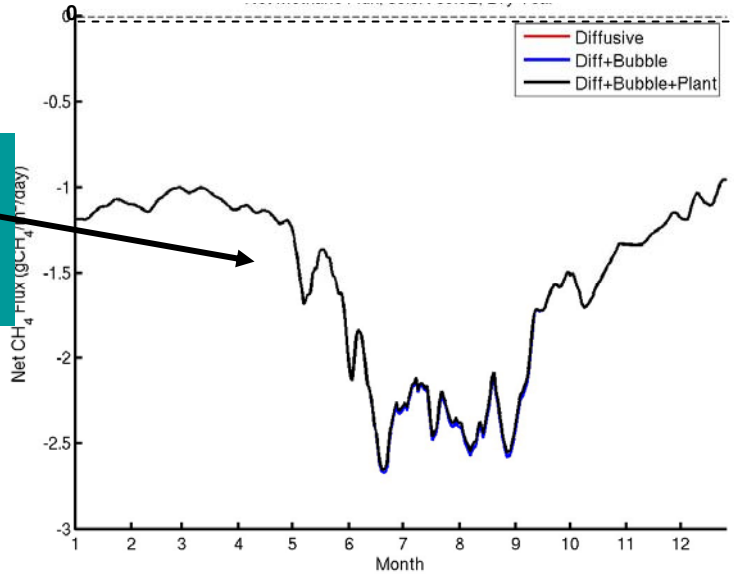


Daily Soil Temperature



Negative net CH4 flux due to oxidation

Daily Methane Flux



Summary

- Methane production is plausible, but needs calibration
- Need to link VIC with BETHY, LPJ
  - Supply LPJ/BETHY NPP to methane model