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A Summary of IP3 Research in the Subarctic Canadian Shield

IP3 Northern Water Research Workshop

Yellowknife, NWT

C. Spence

October 5, 2010

IP3

Improved Processes & Parameterisation for Prediction in Cold Regions

Acknowledgements

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- **AGRG** – Chris Hopkinson

Centre for Hydrology

AGRG Applied Geomatics Research Group
Centre of Geographic Sciences
Middleton | Nova Scotia | Canada

Geological Survey of Canada

NSERC CRSNG

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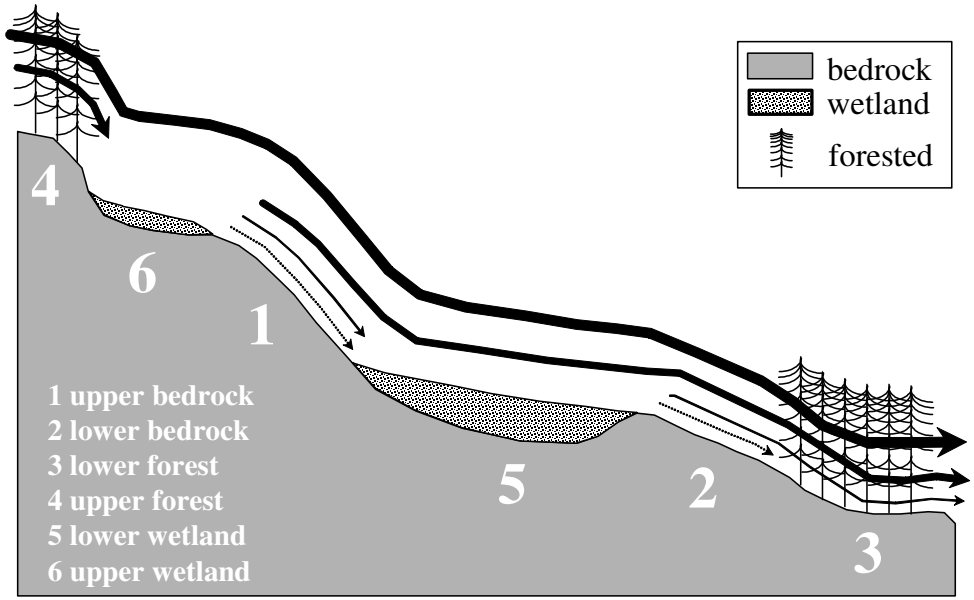
Headwaters



Spence and Woo, 2006

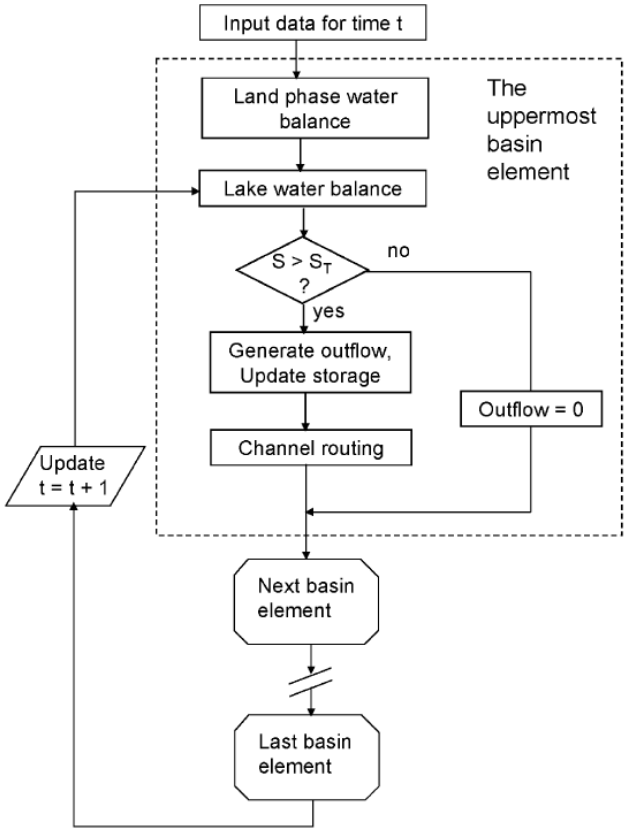
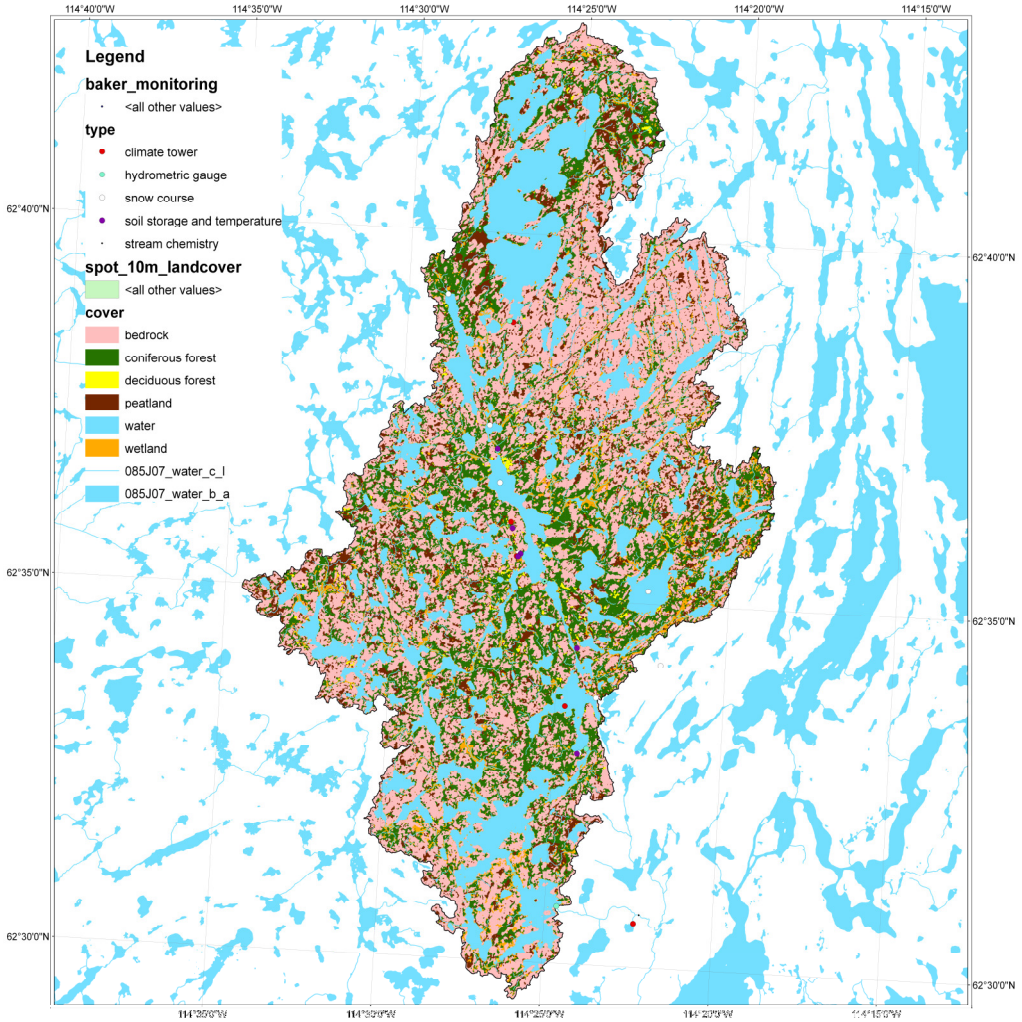


Figure 6. Flow-chart showing the simulation of land-phase and channel-phase linkages in a lake-stream network

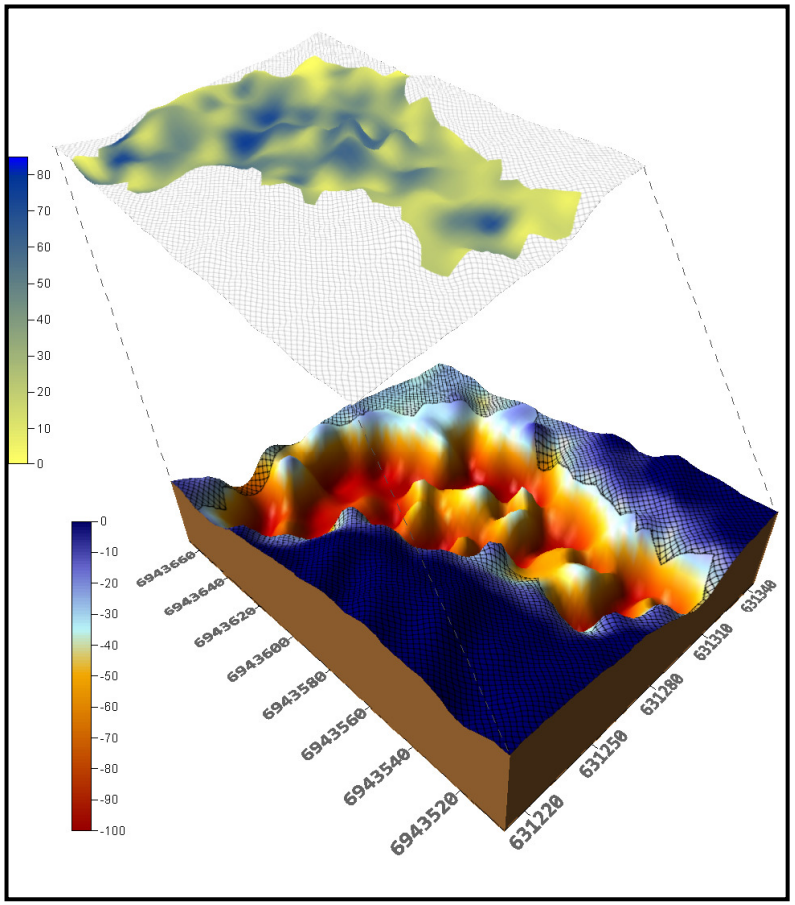
Woo and Mielko, 2007

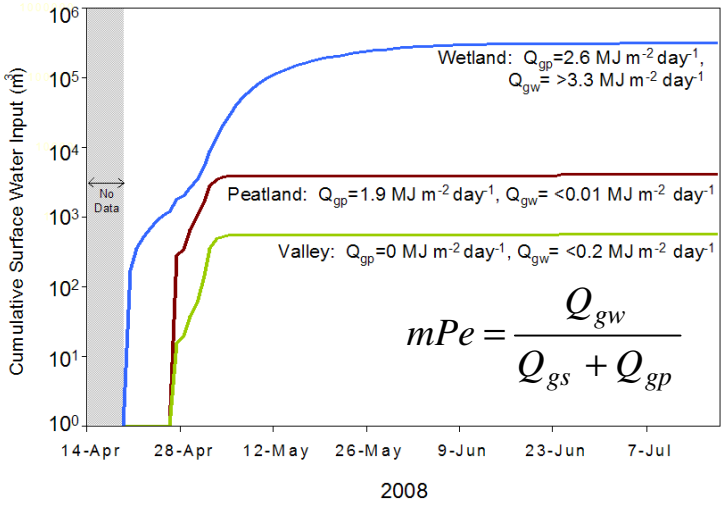
Baker Creek

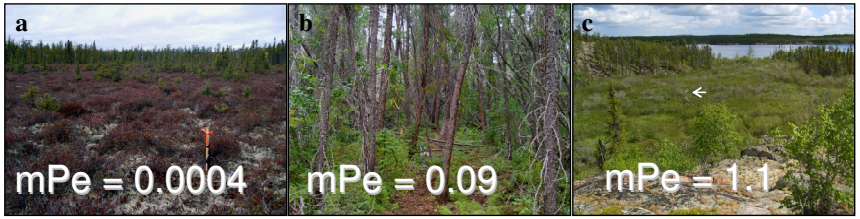


- The Baker Creek Research Basin drains runoff from ~155 km^2 (~170 km^2 at the mouth).
- It is located in the Great Slave High Boreal Ecoregion and Slave Structural Province of the Precambrian Canadian Shield.
- Land cover is dominated by exposed bedrock (40% of basin area) with substantial portions of wetlands (16%) and coniferous forest (21%).
- There are 349 lakes in the basin that occupy 23% of the area.
- Permafrost is discontinuous; absent from bedrock, well drained areas and water courses.

HRU scale

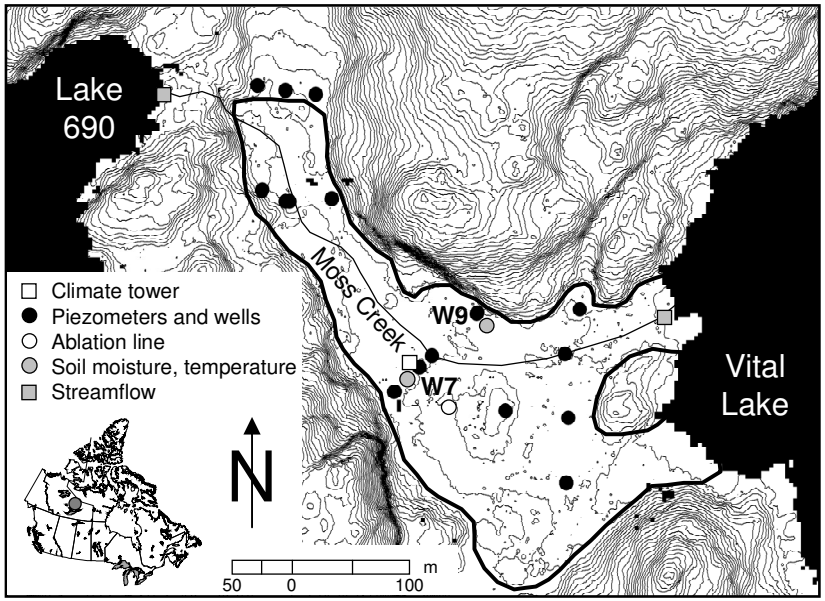


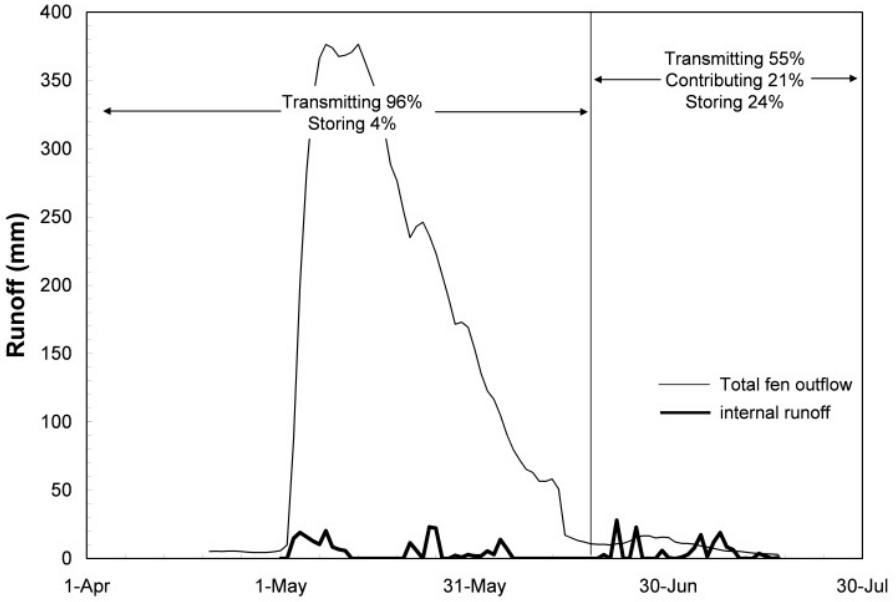




Guan et al, 2010

HRU scale





Spence et al, 2010

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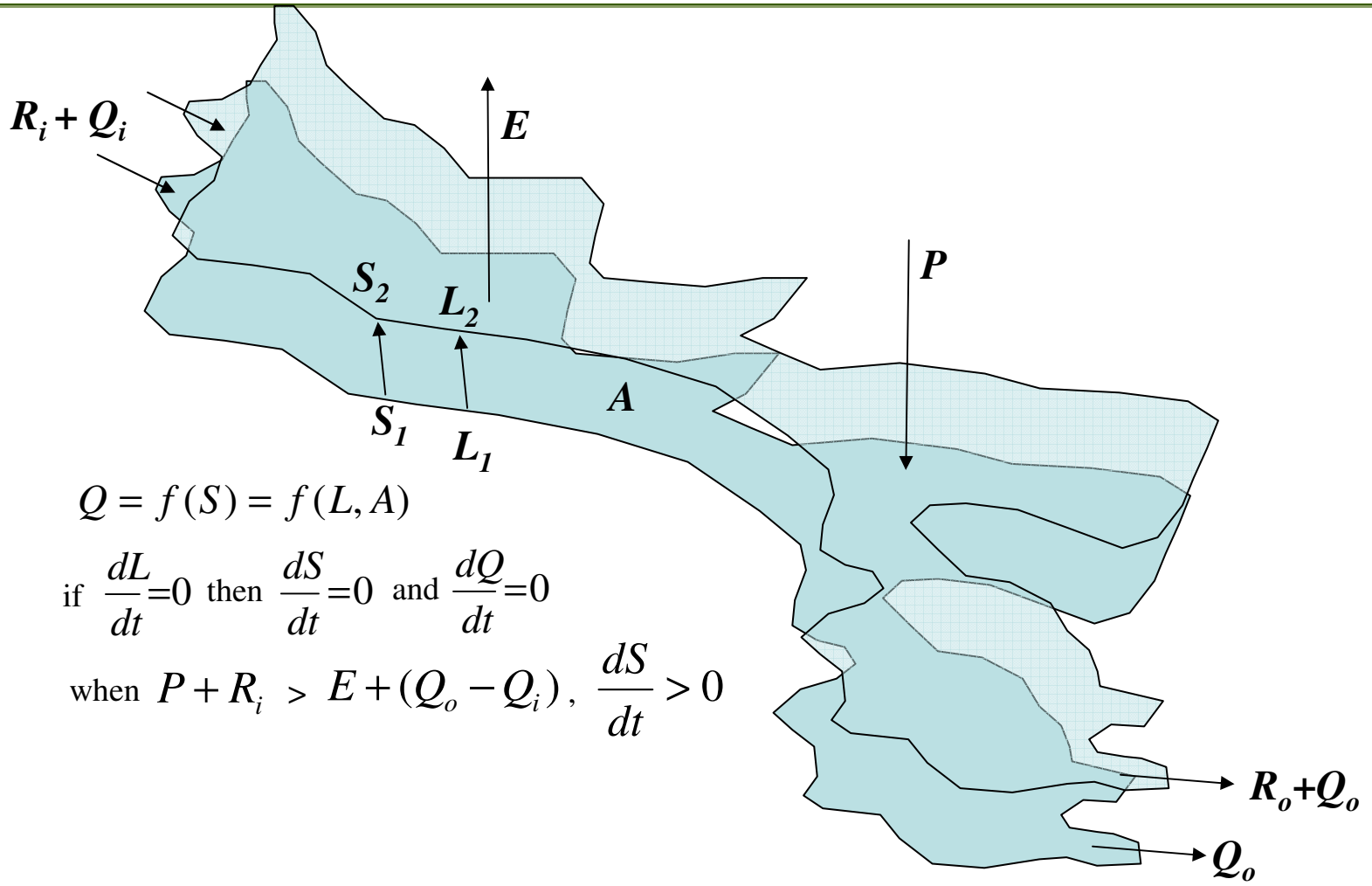
Lake dominated watercourses

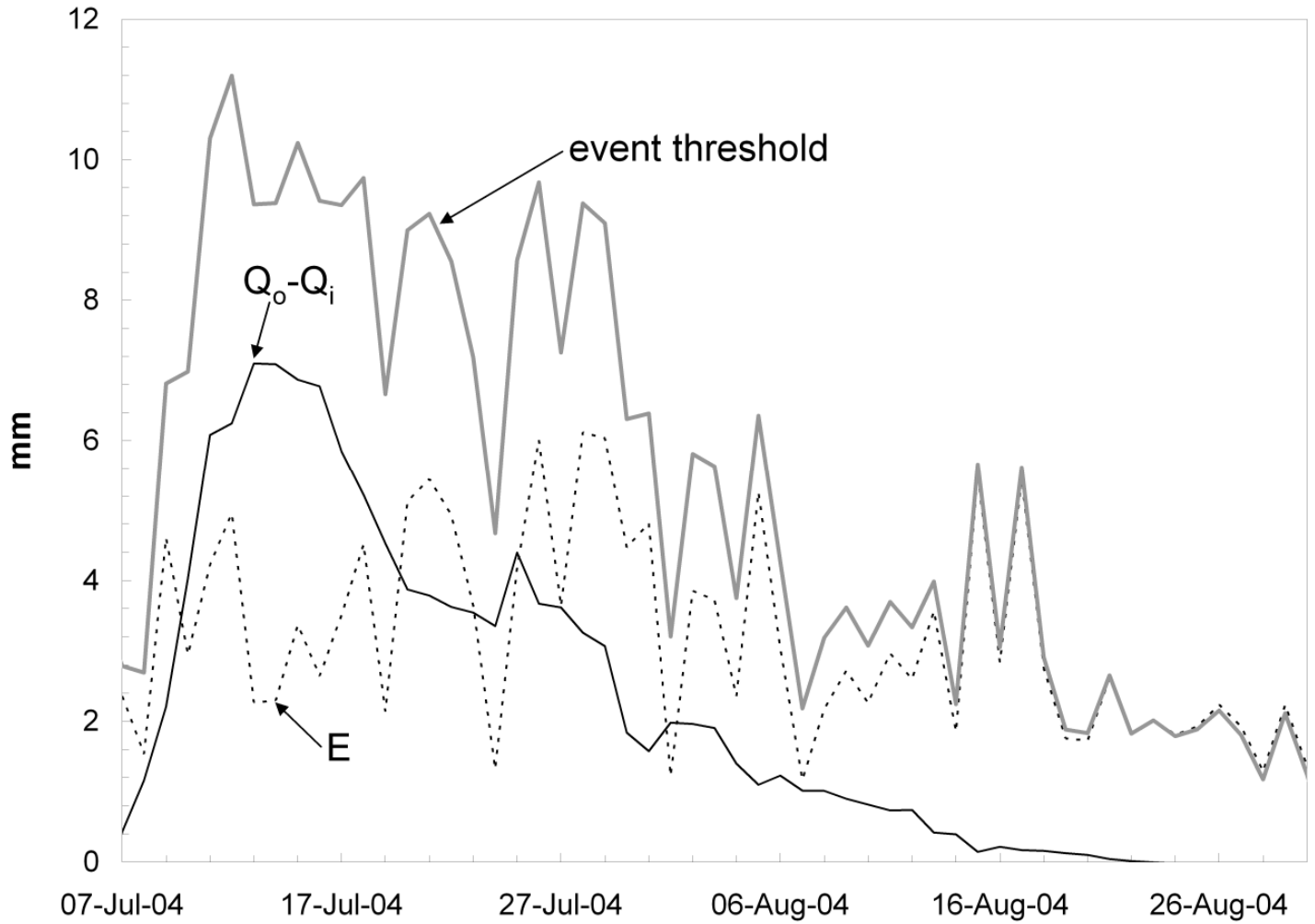


$$Q = f(S) = f(L, A)$$

if $\frac{dL}{dt} = 0$ then $\frac{dS}{dt} = 0$ and $\frac{dQ}{dt} = 0$

when $P + R_i > E + (Q_o - Q_i)$, $\frac{dS}{dt} > 0$

Lake dominated watercourses

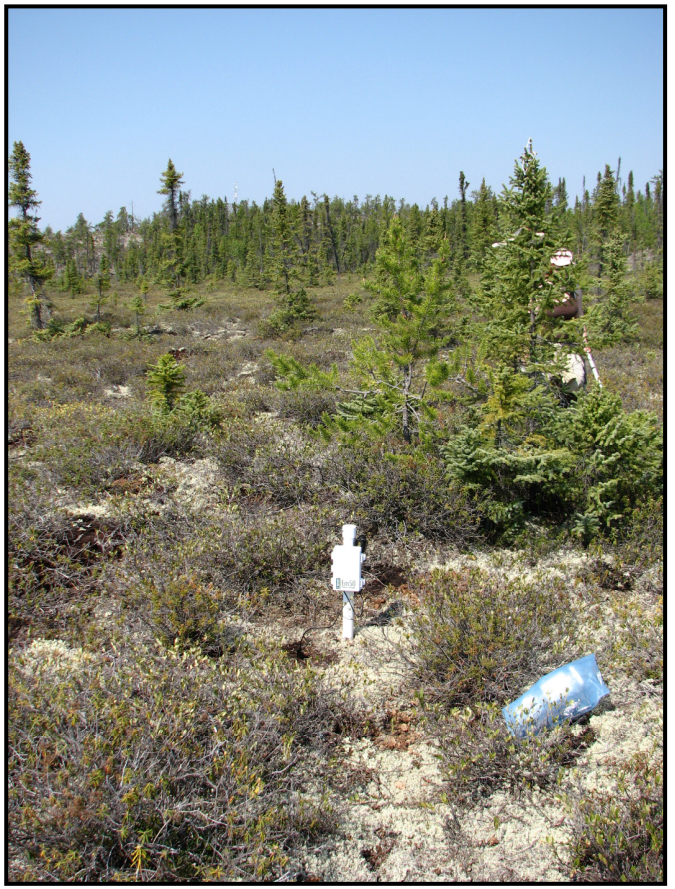


Spence, 2006

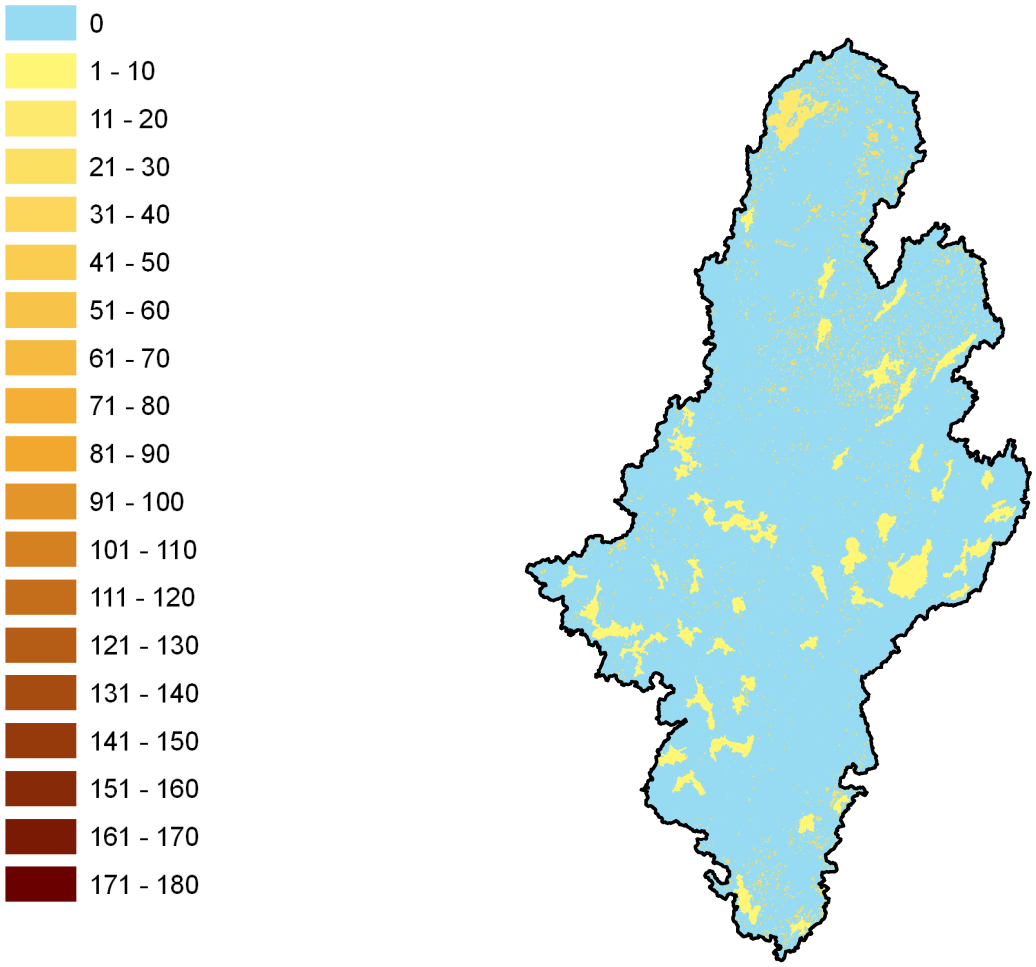
Upscaling to the catchment

- Prior to IP3 the influence of small scale storage processes on catchment scale runoff response had not been fully investigated.
- The objective of much of the IP3 efforts in Baker Creek was to determine how small scale processes upscaled to the catchment, and evaluate their significance and potential influence on runoff generation.

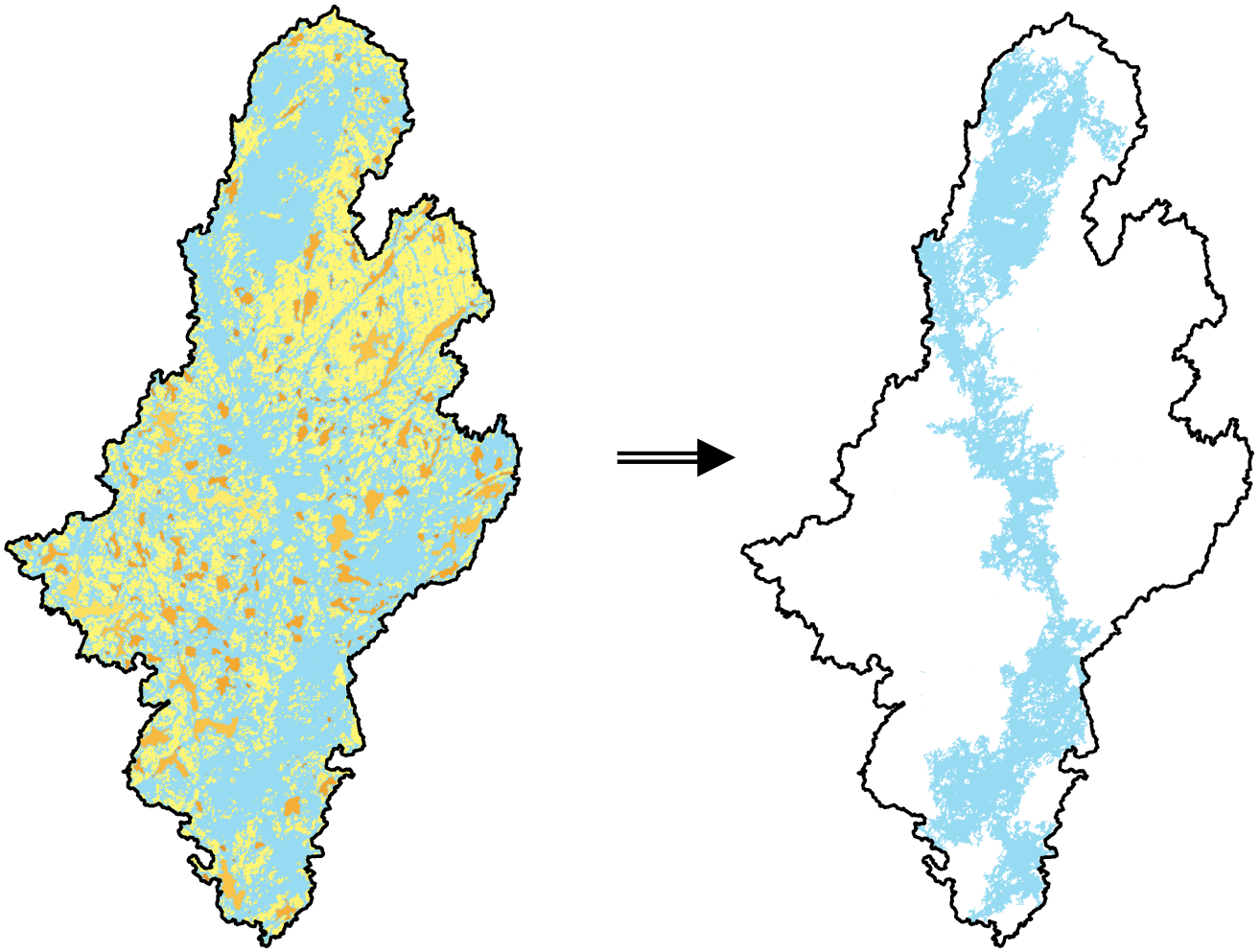
Storage measurements



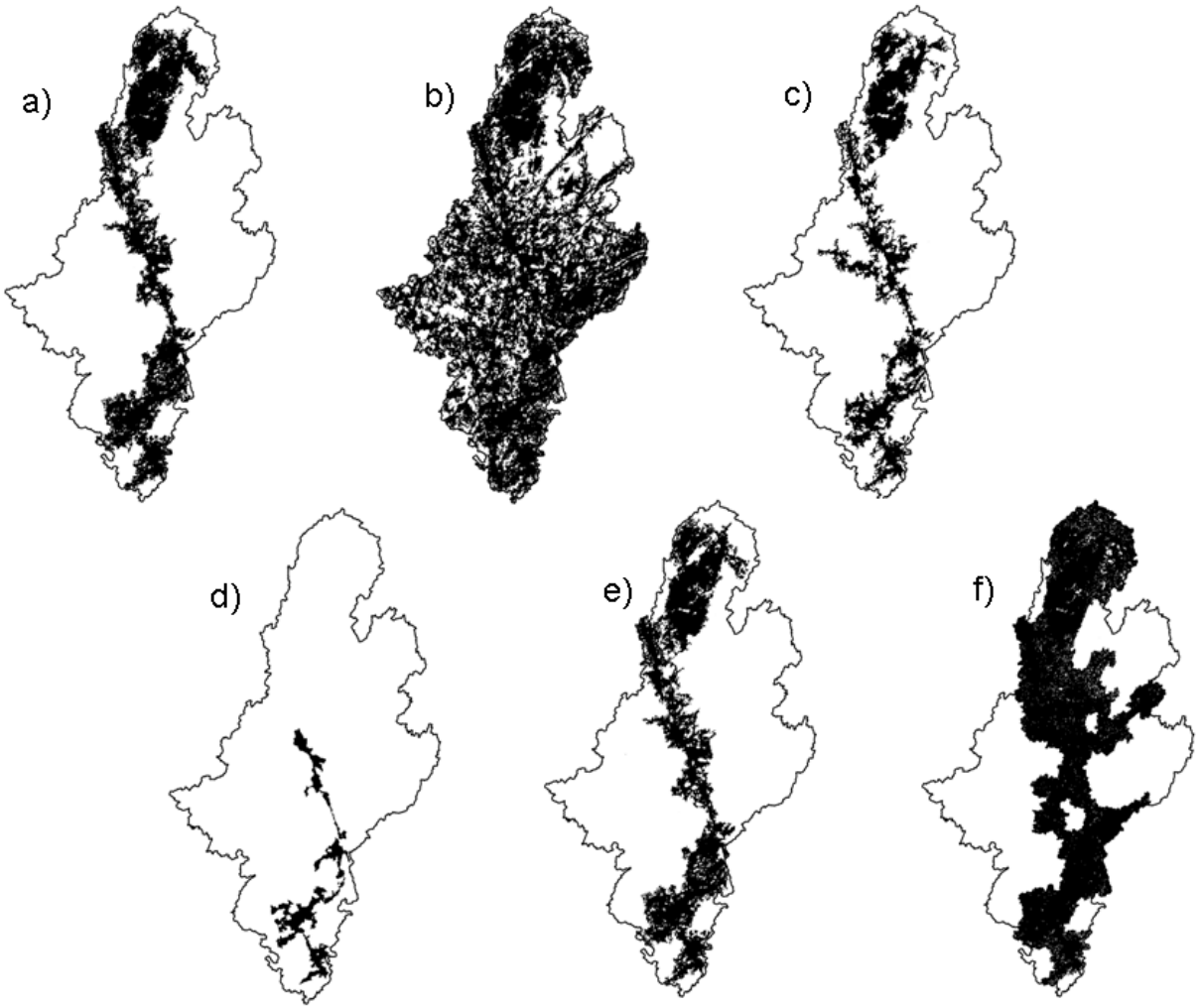
Storage dynamics over space



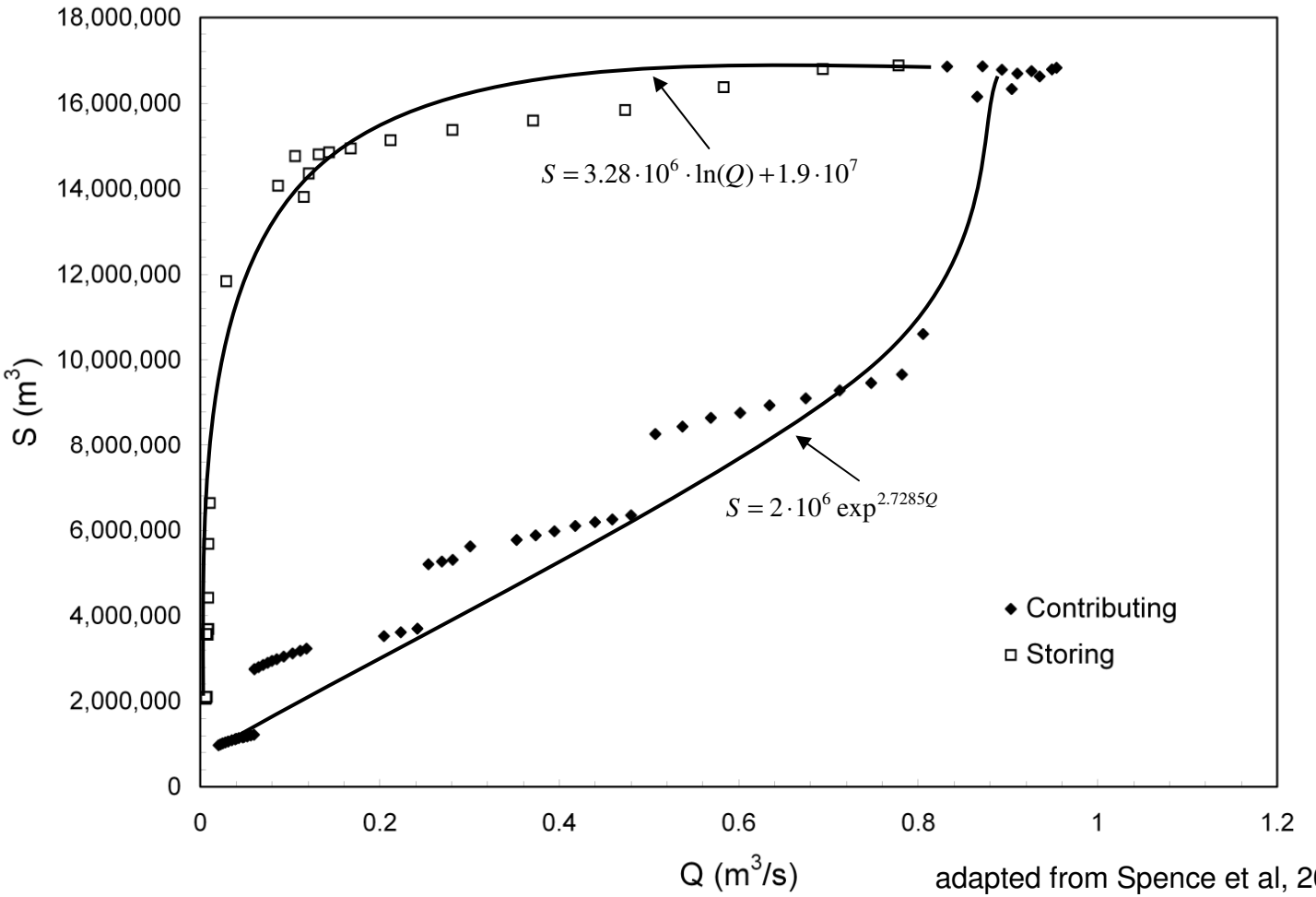
Catchment scale



Catchment scale

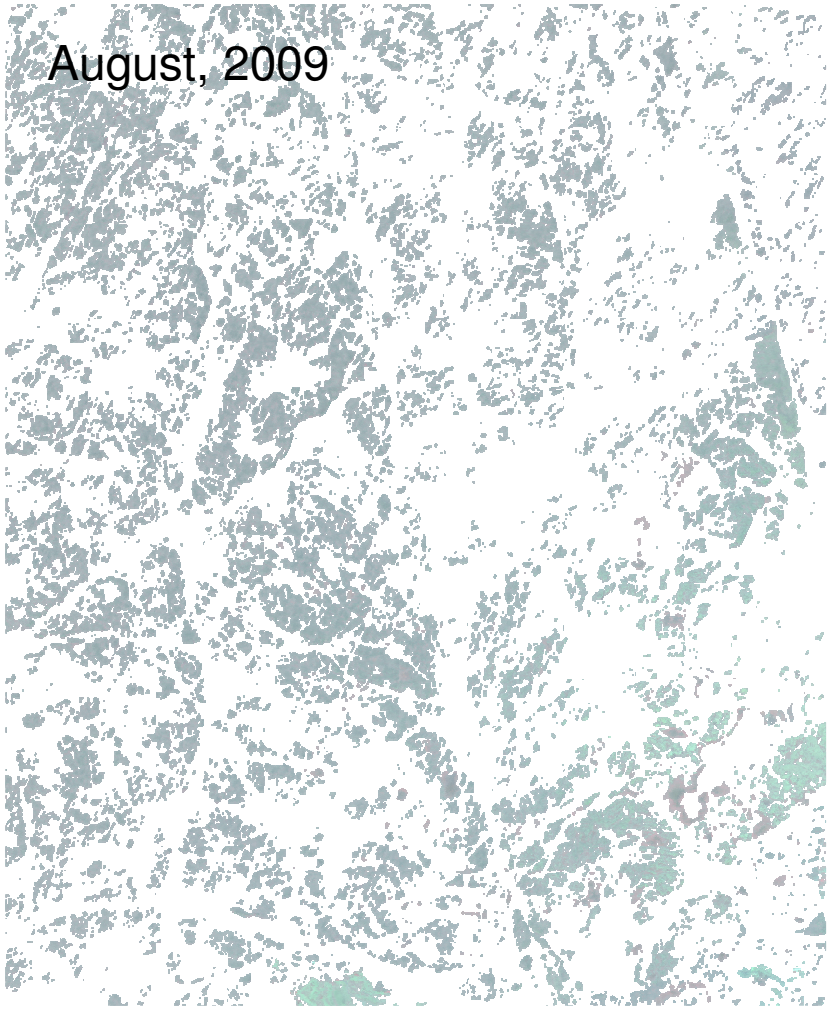


Characteristic S-Q catchment curves



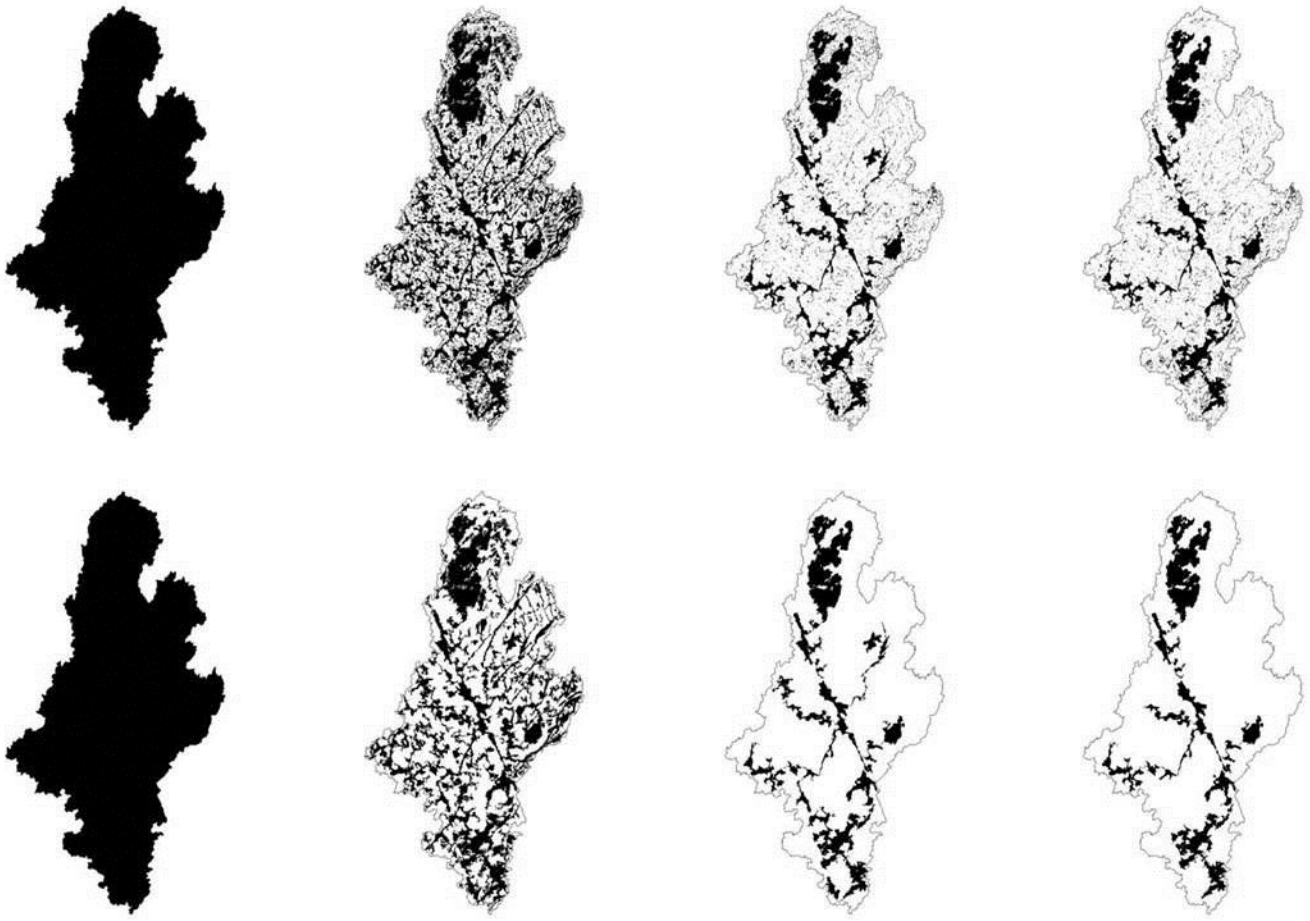
adapted from Spence et al, 2010

Remote sensing of contributing areas

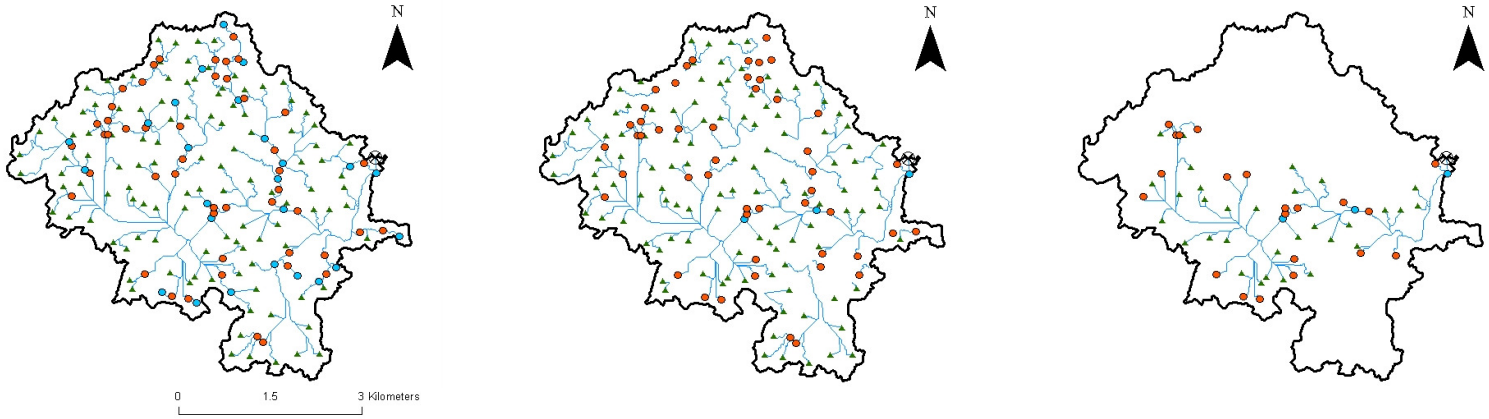


May, 2009

Remote sensing of contributing areas

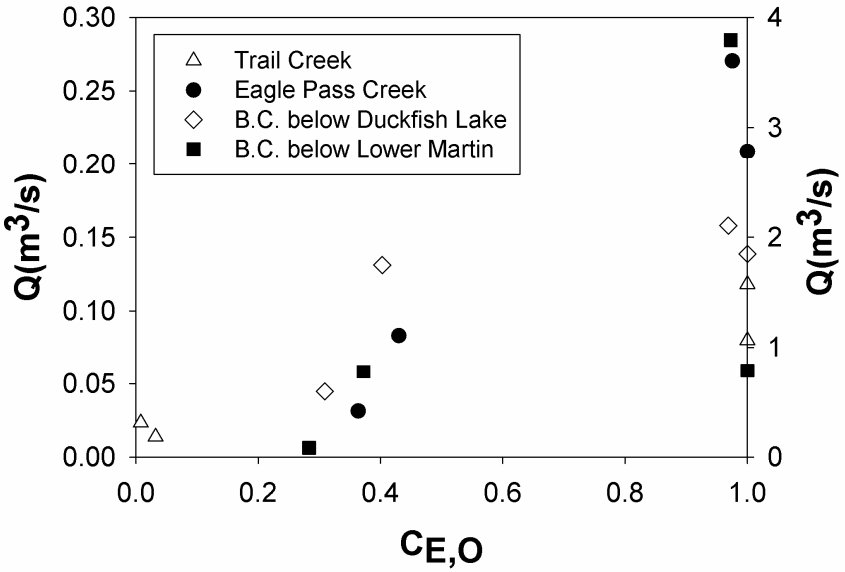


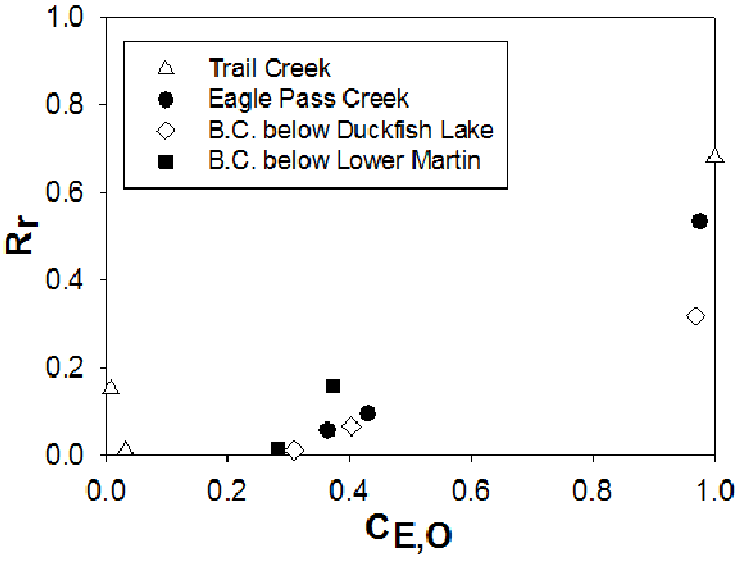
Connectivity



$$C_{E,O} = \frac{E_c}{E_p}$$

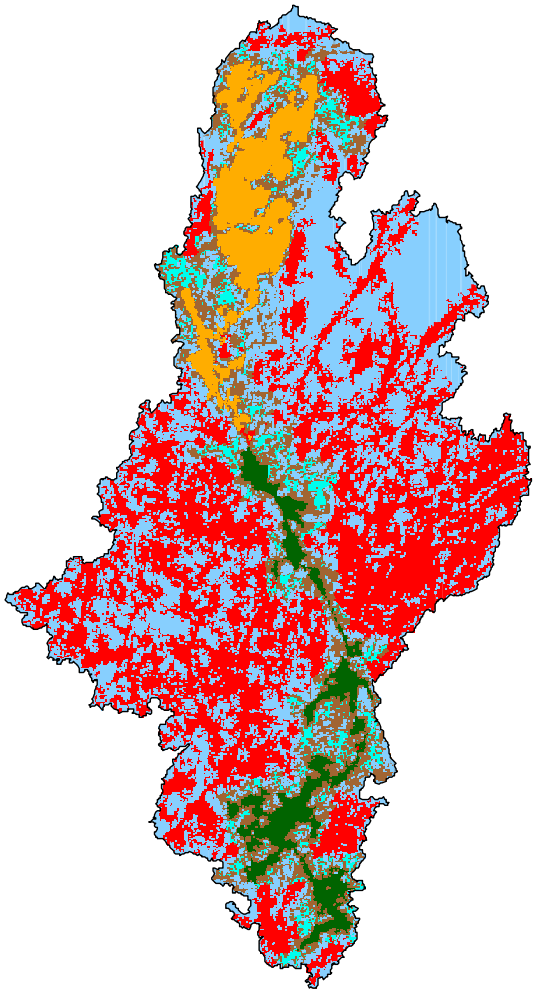
Connectivity

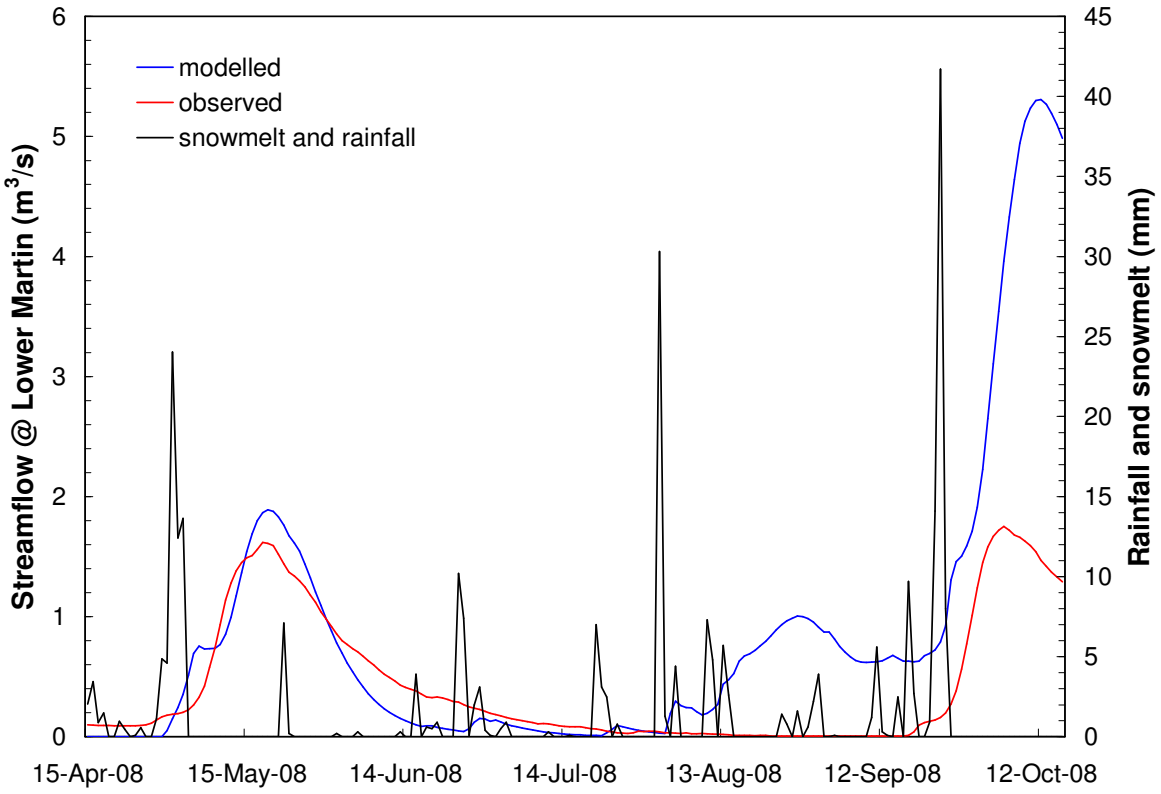




Phillips et al, 2010

Prediction - CRHM





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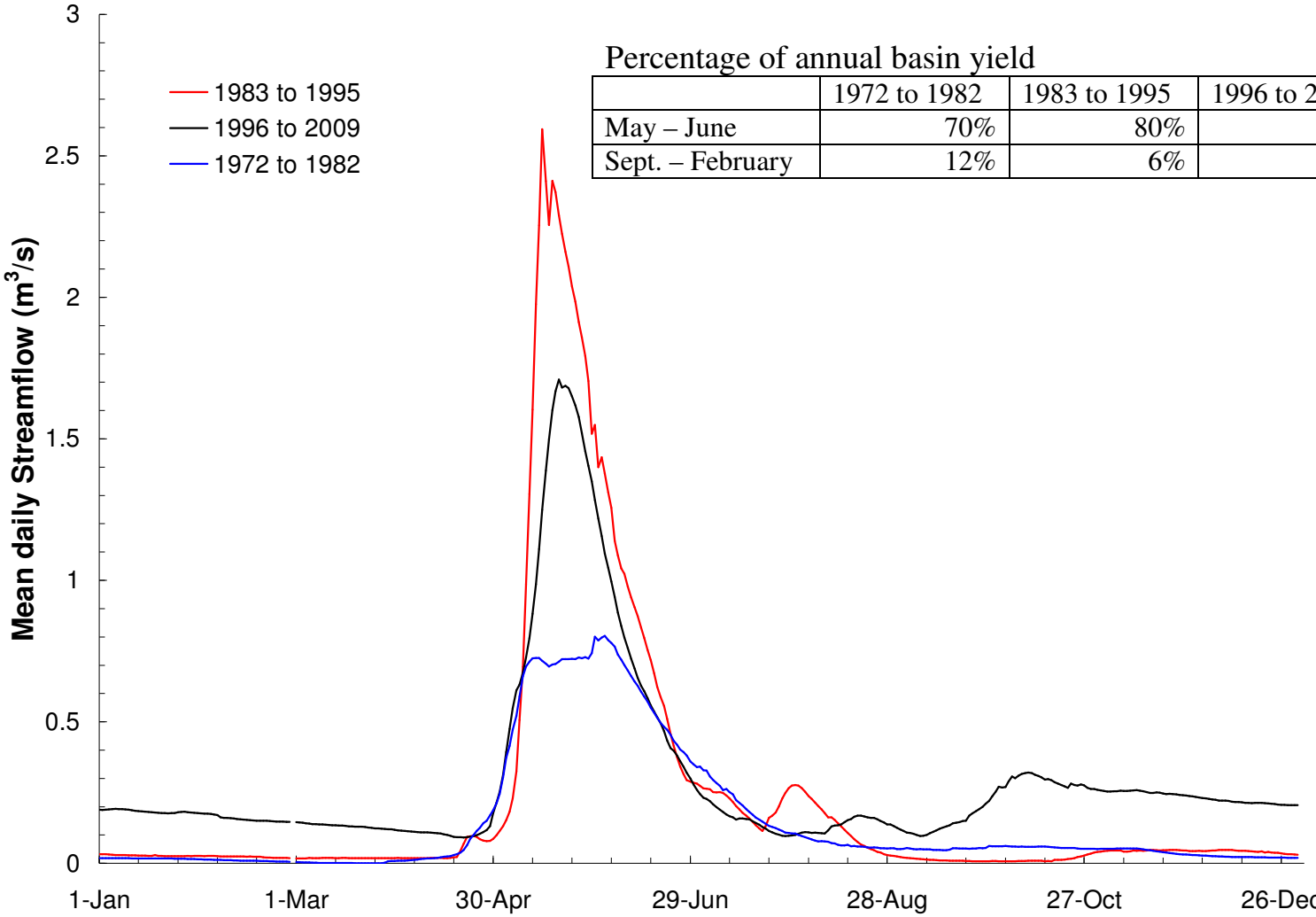
Changing hydrologic regime



Percentage of annual basin yield

	1972 to 1982	1983 to 1995	1996 to 2009
May – June	70%	80%	50%
Sept. – February	12%	6%	39%

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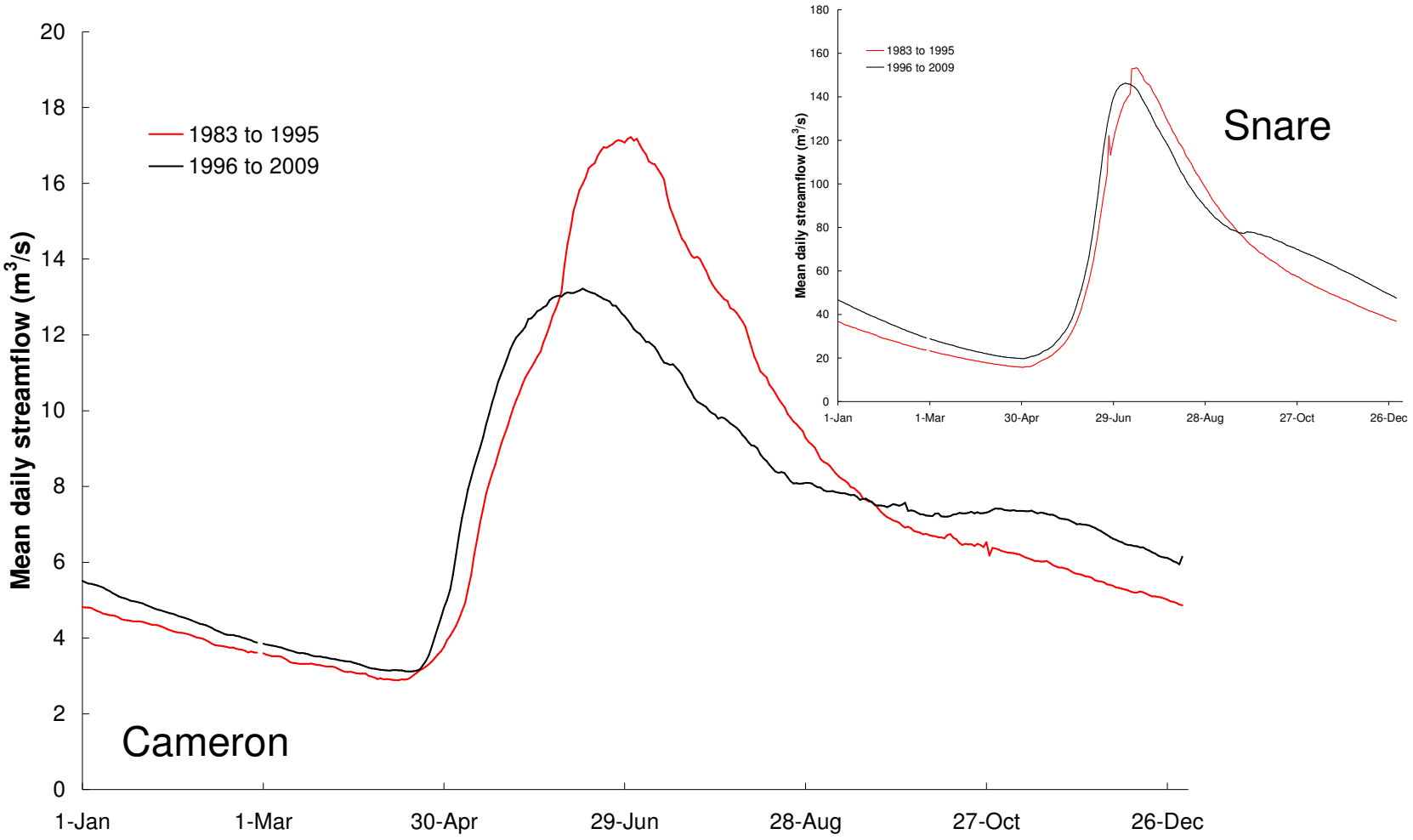
Regional scale changes



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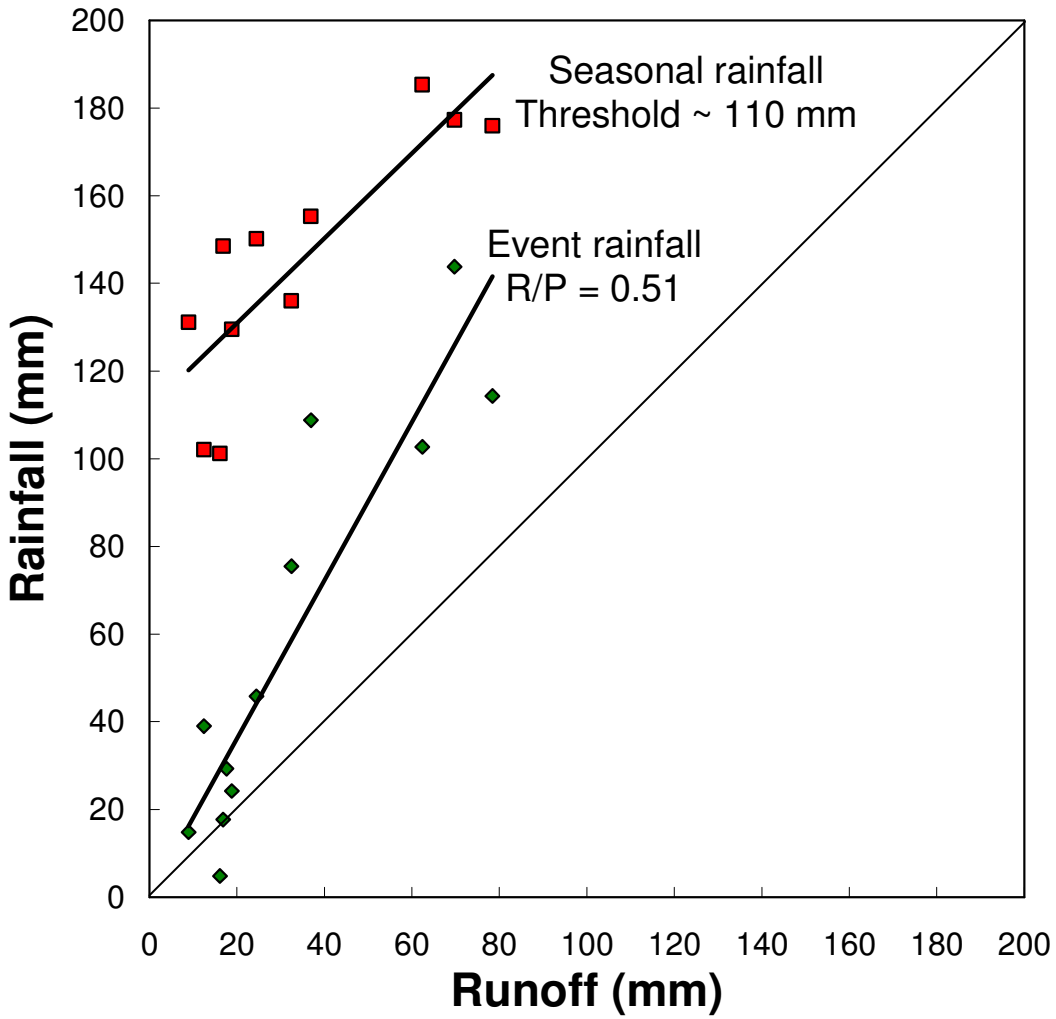
Ecosystem implications

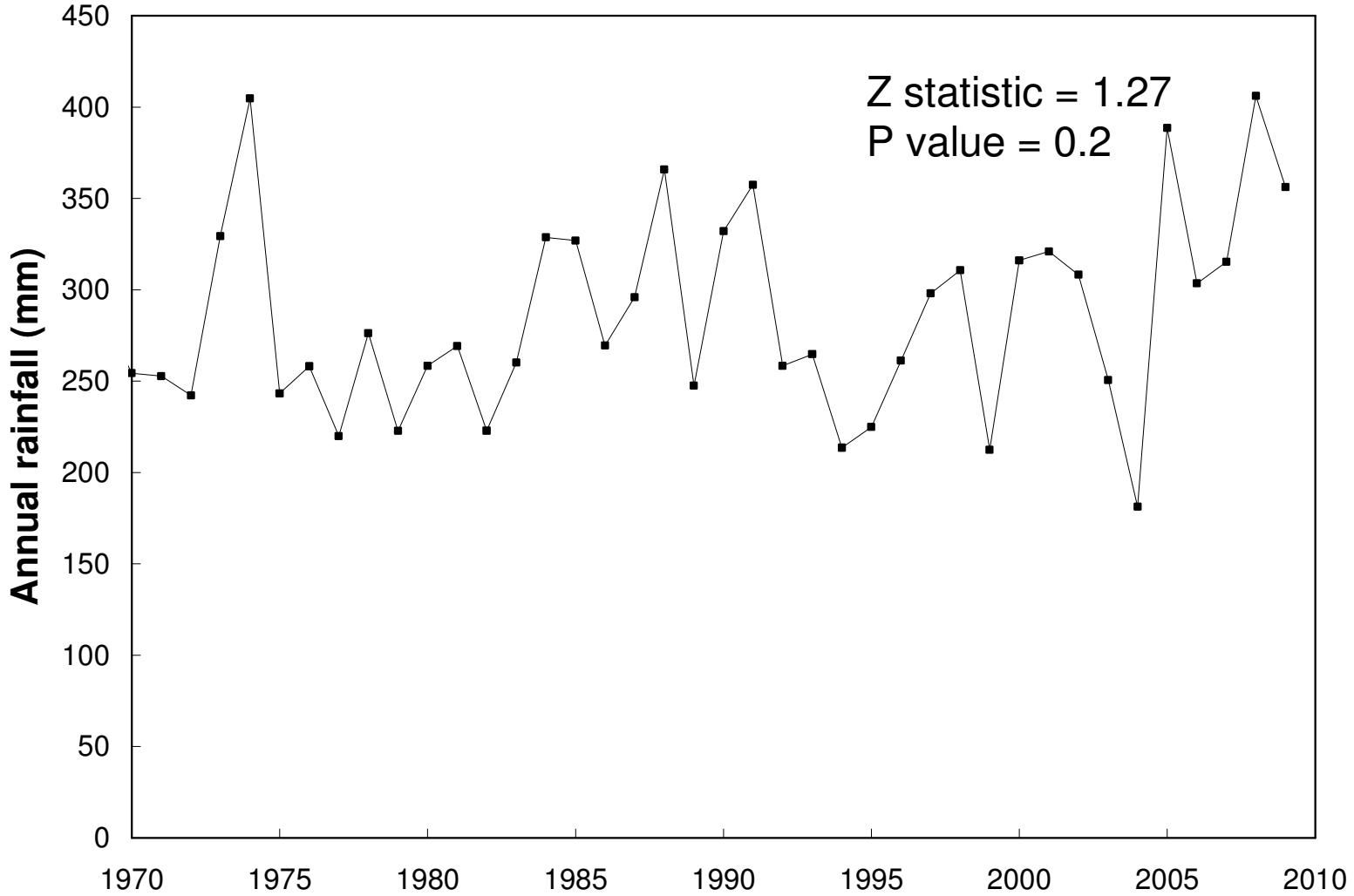
Summary

- New parameterization:
  1) the “Guan” number incorporates the relative influence of topology and advective heat on frost table depth and, in turn, hillslope storage capacity.
  2) there are characteristic catchment storage-discharge curves.
  3) connectivity is related to streamflow and controls the runoff ratio
- Model testing continues with representation of response units reflective of observed hydrological behaviour.
- This knowledge could be important as changing hydrological regimes in the region test decision making ability.

Fall runoff events



Precipitation trends - Annual



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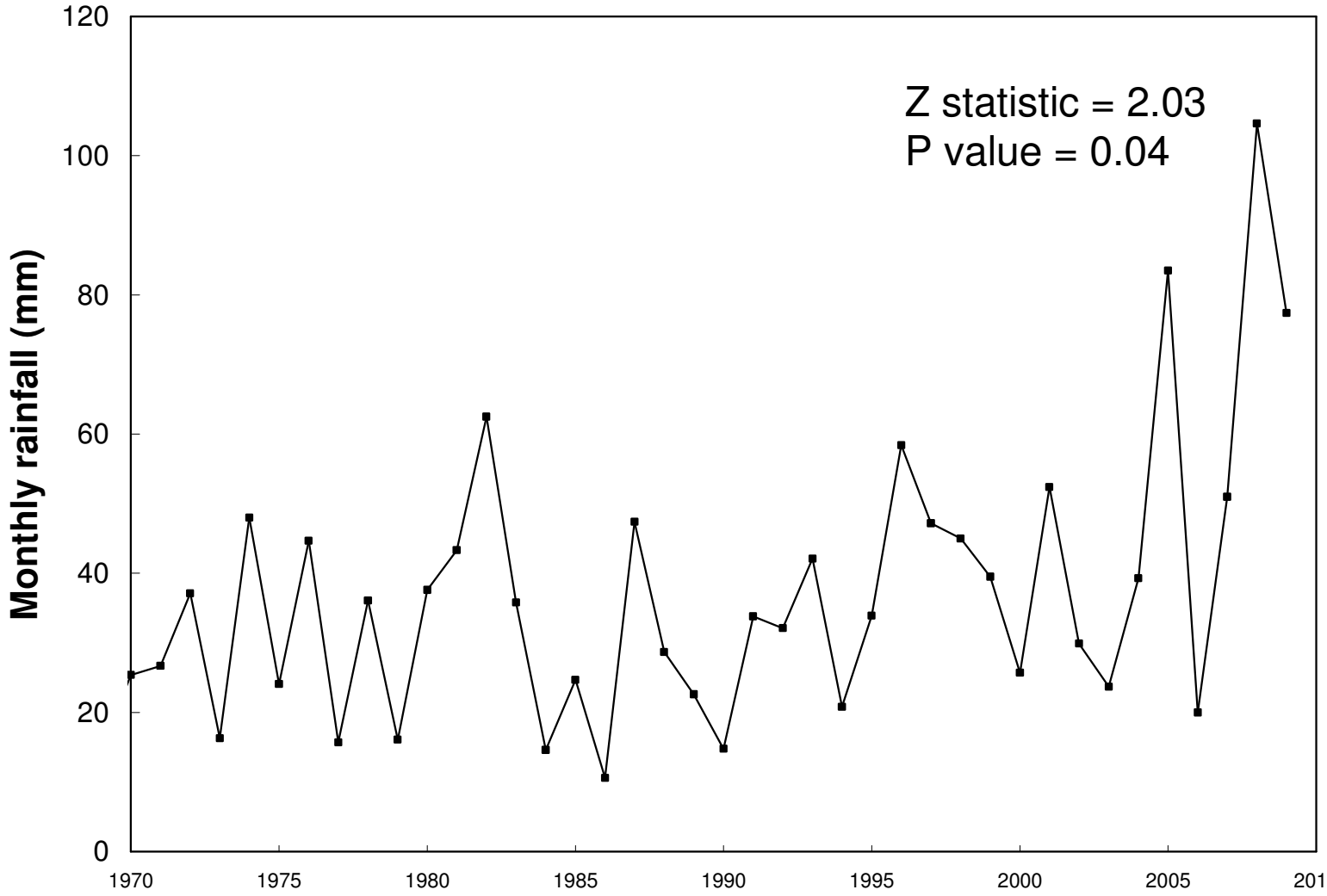
Precipitation trends - September



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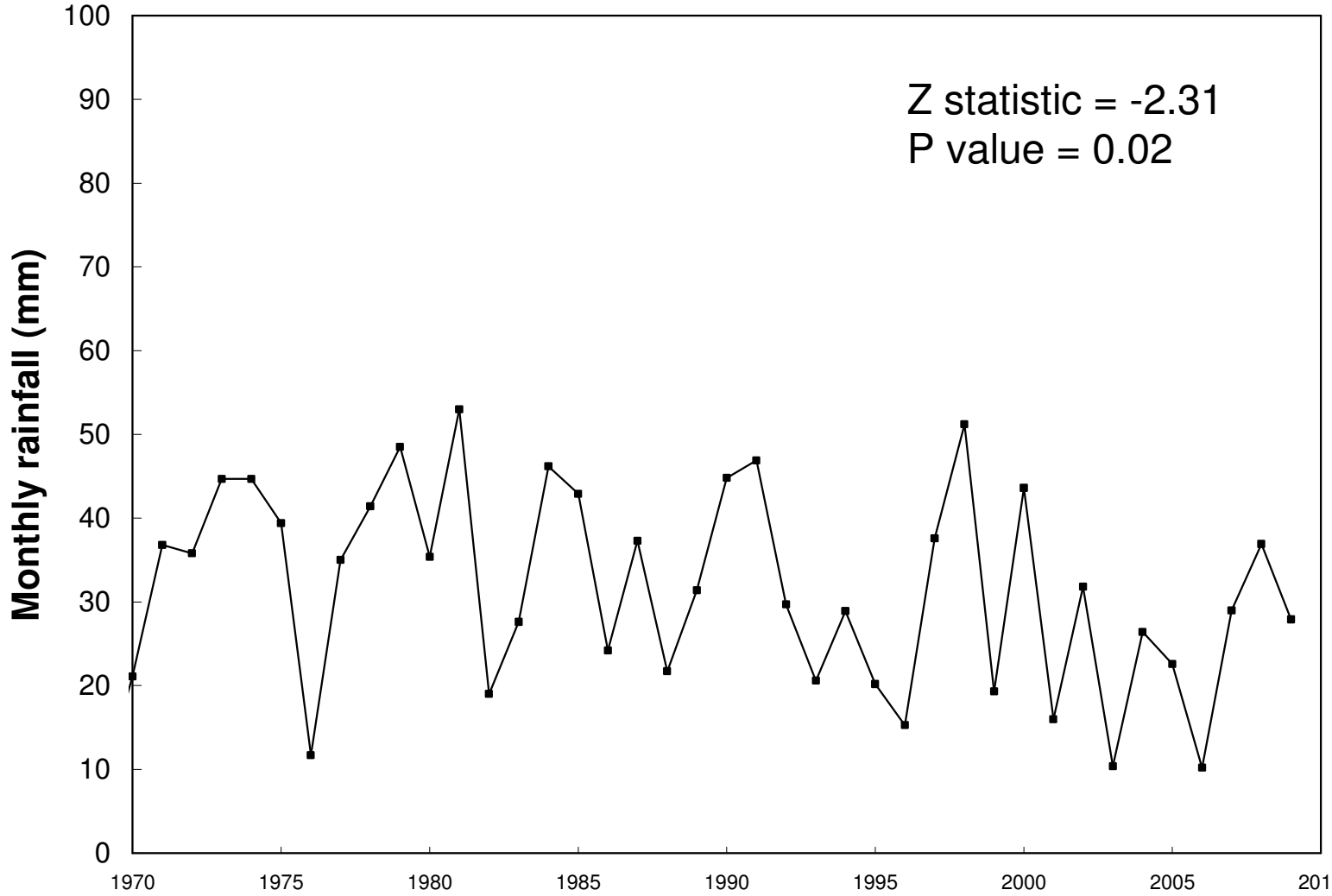
Precipitation trends - October



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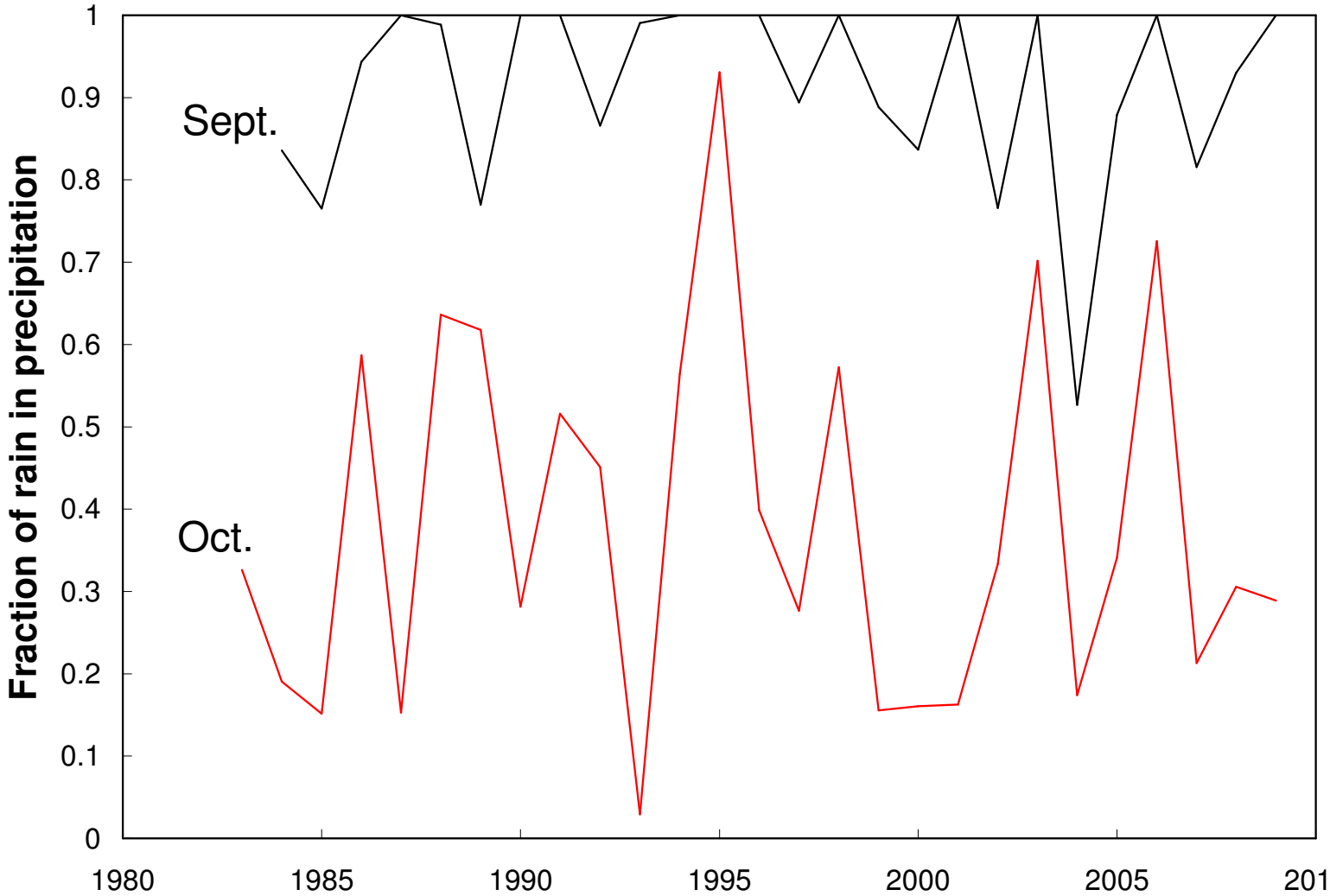
Fraction of rain



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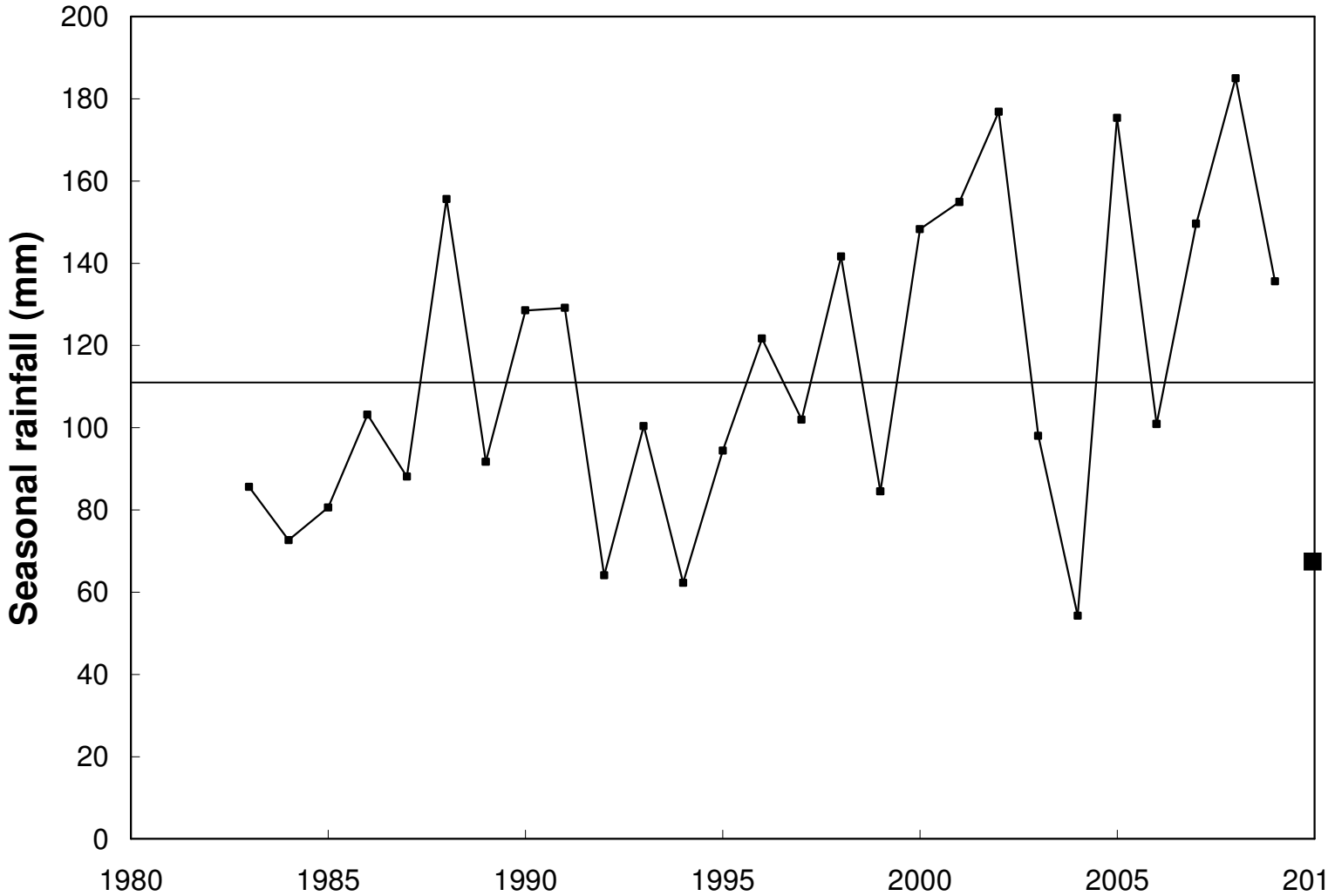
Frequency of exceedance



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