Implications of alpine warming on biogeochemical cycling in Green Lakes Valley, Colorado Front Range, USA

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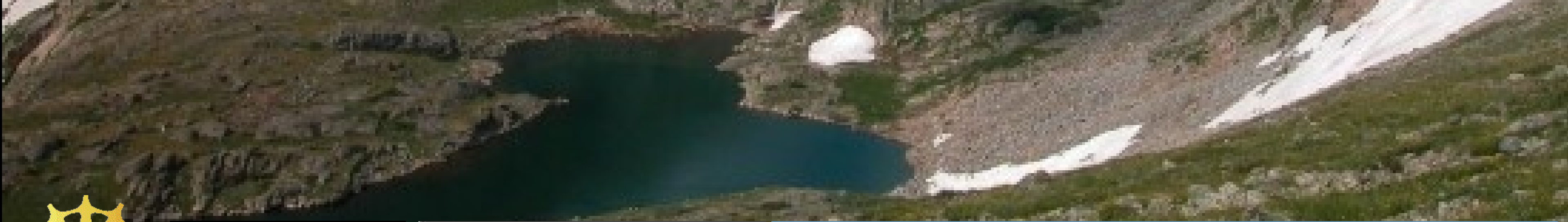
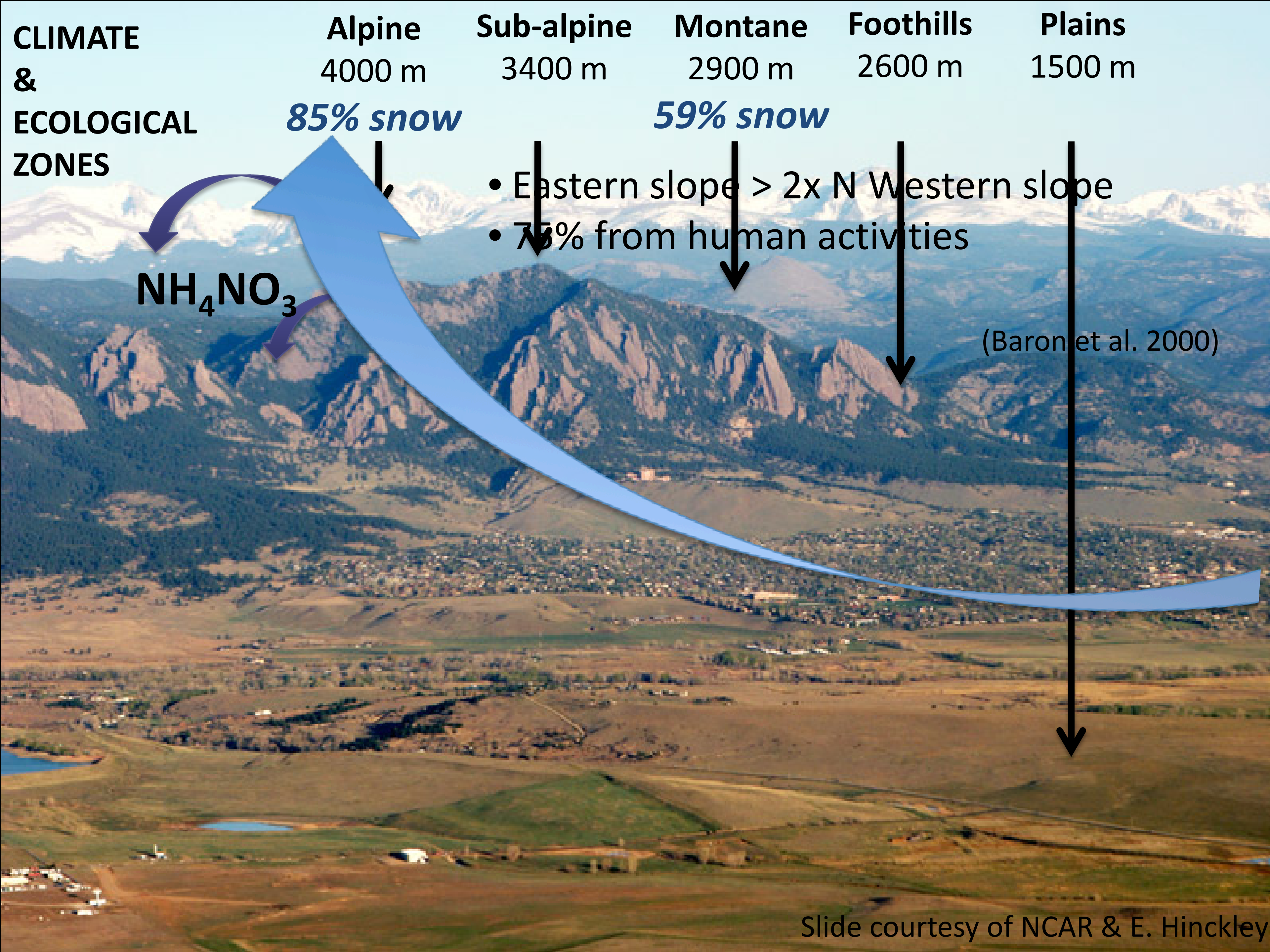
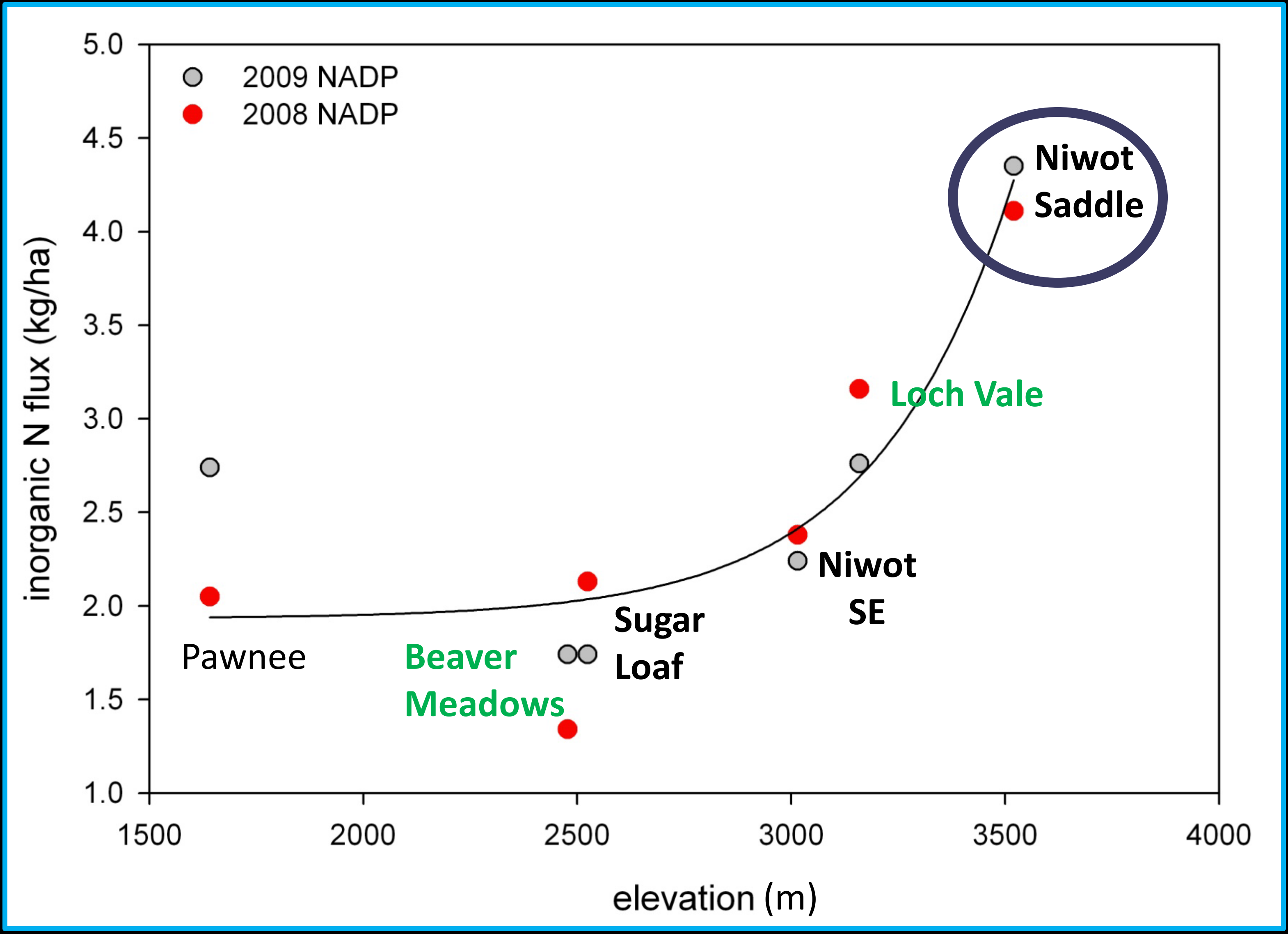


NSF USGS science for a changing world CZO BOULDER CREEK CRITICAL ZONE OBSERVATORY Niwot Ridge Long-Term Ecological Research Site



CLIMATE
&
ECOLOGICAL
ZONES
Alpine
4000 m
85% snow
Sub-alpine
3400 m
Montane
2900 m
59% snow
Foothills
2600 m
Plains
1500 m
• Eastern slope > 2x N Western slope
• 75% from human activities
NH4NO3
(Baron et al. 2000)
Slide courtesy of NCAR & E. Hinckley

NADP in the Front Range



N deposition & Climate Change

- Climate conditions are the overarching control on ecosystem processes at the broad scale

(Ollinger et al. 2003)

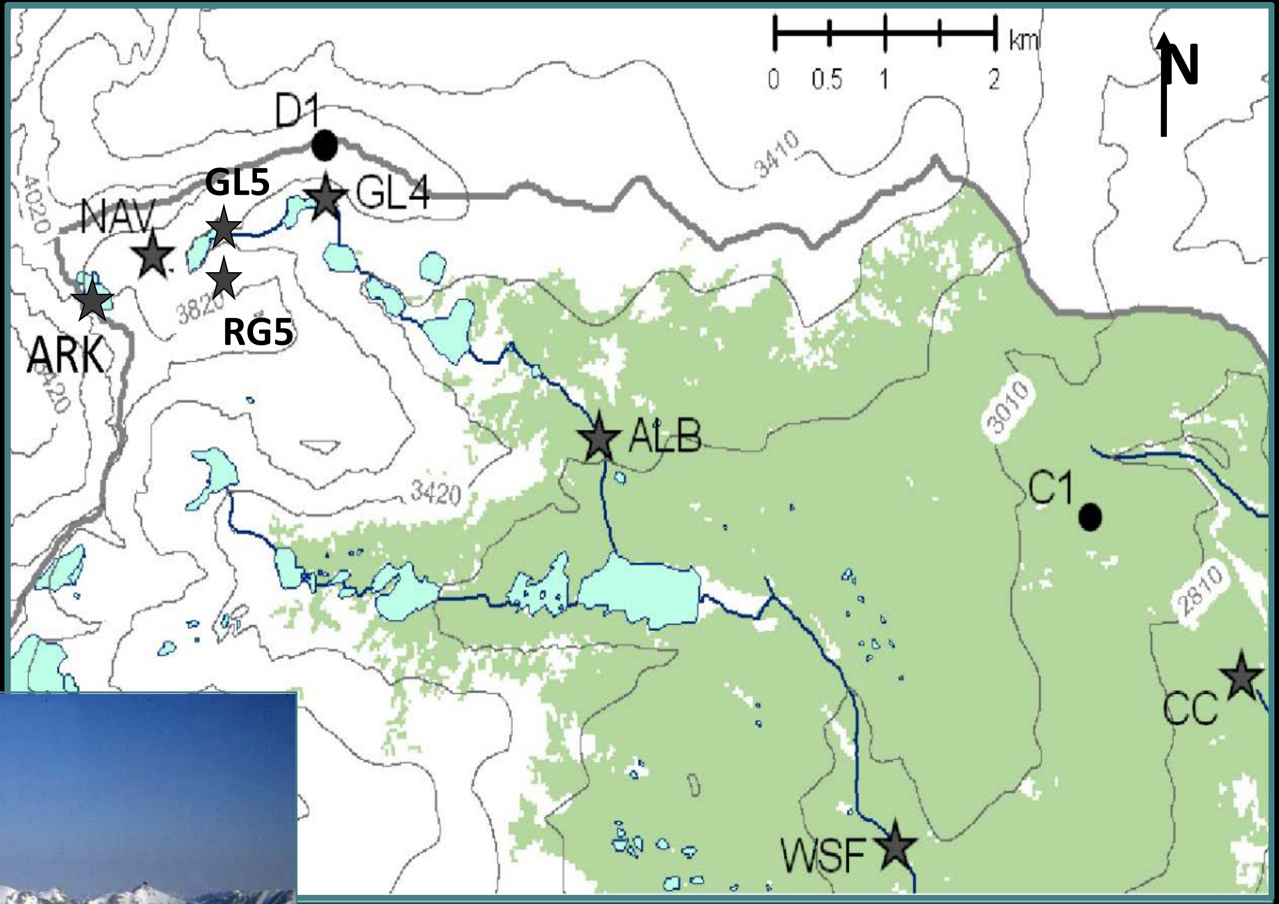
- In mountain areas climate effects may exceed those of atmospheric deposition

(Meixner et al. 2004, Rogora et al. 2007)

- Recent increases in N export from the alpine are due to melting cryosphere & flushing of N from newly barren soils

(Baron et al. 2009)

Green Lakes Valley

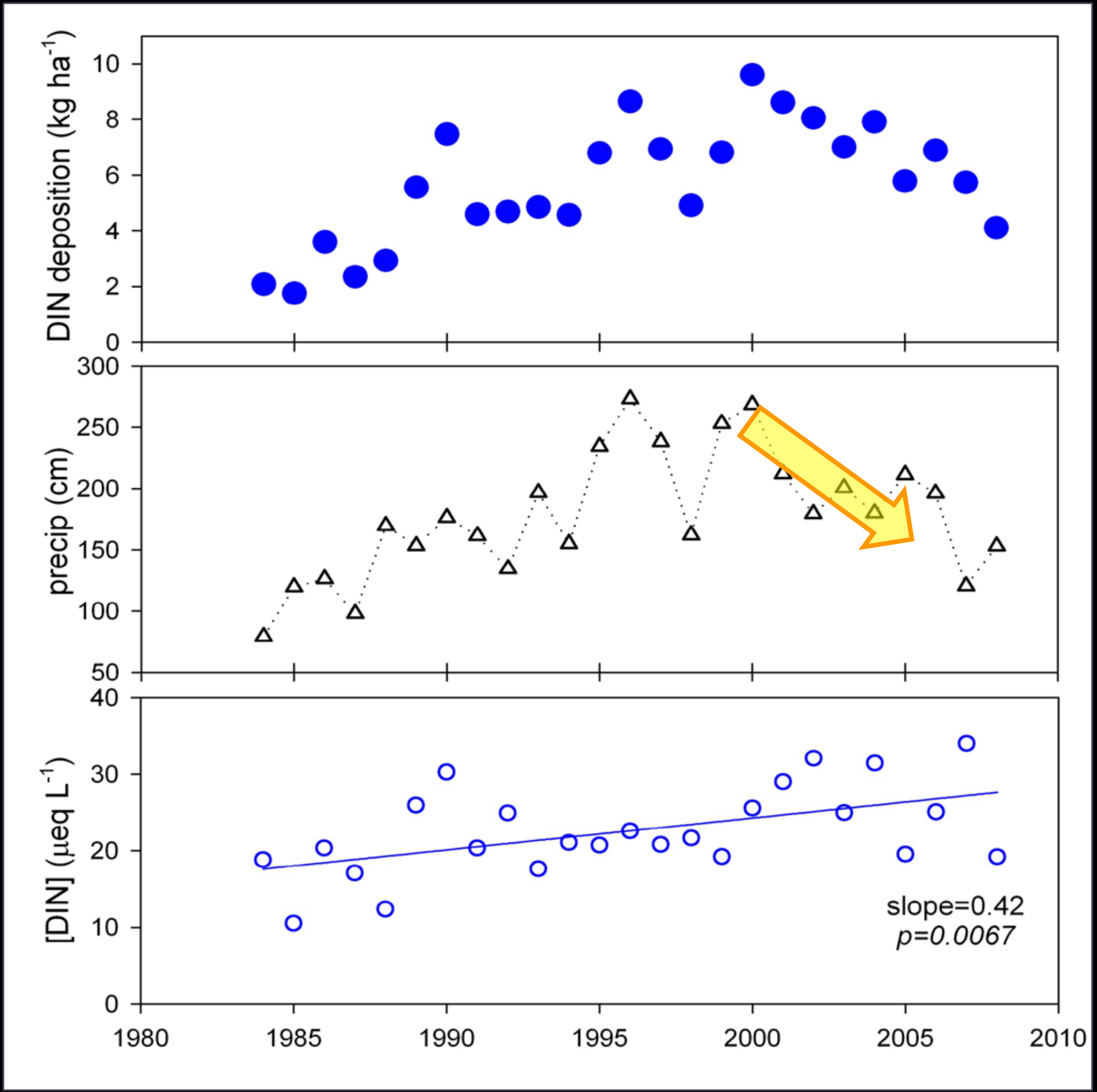


N deposition

DIN in wet deposition peaked in 2000
~ 10 kg/ha

Summer droughts started in 2000

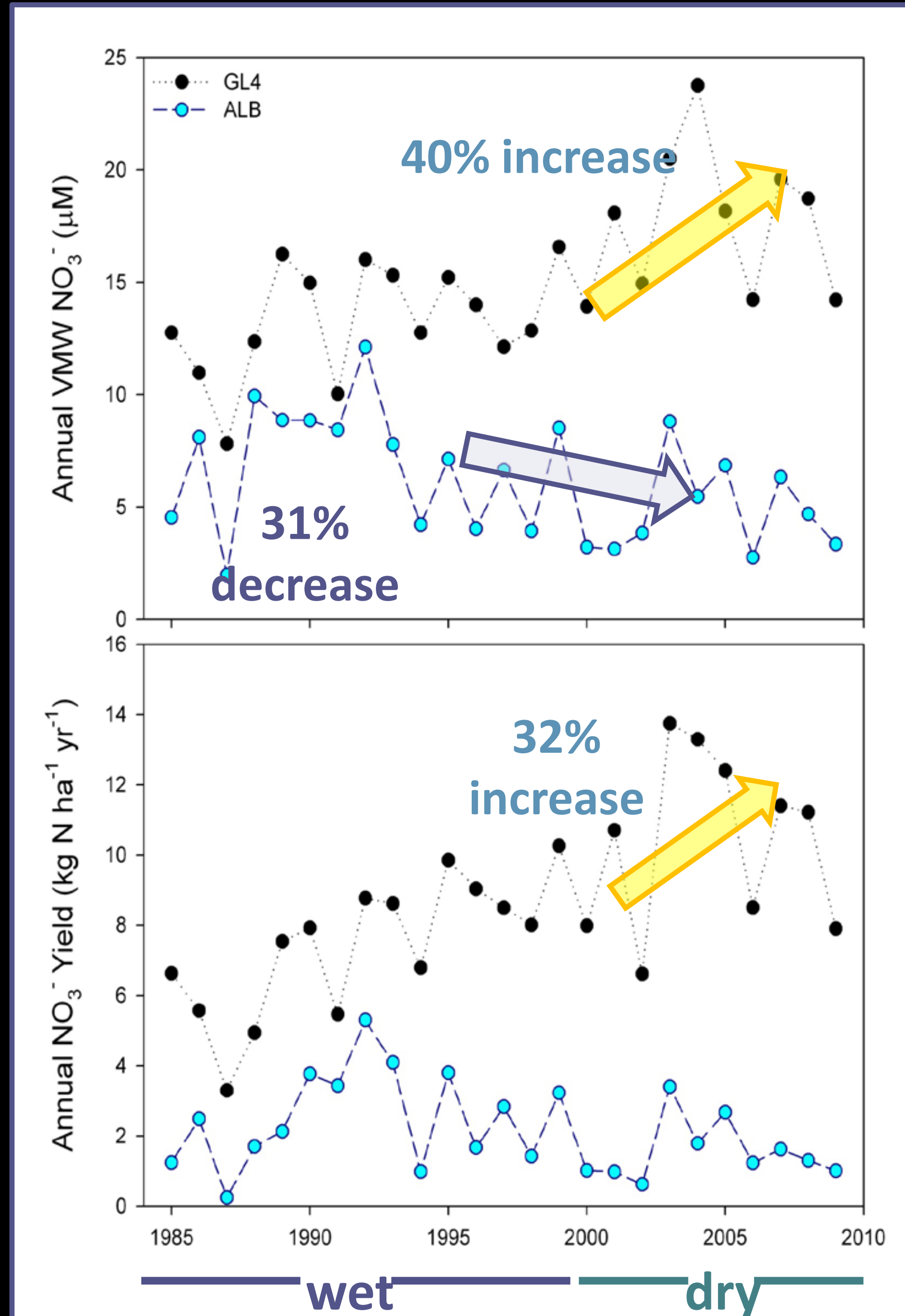
[DIN] in wet deposition continues to increase



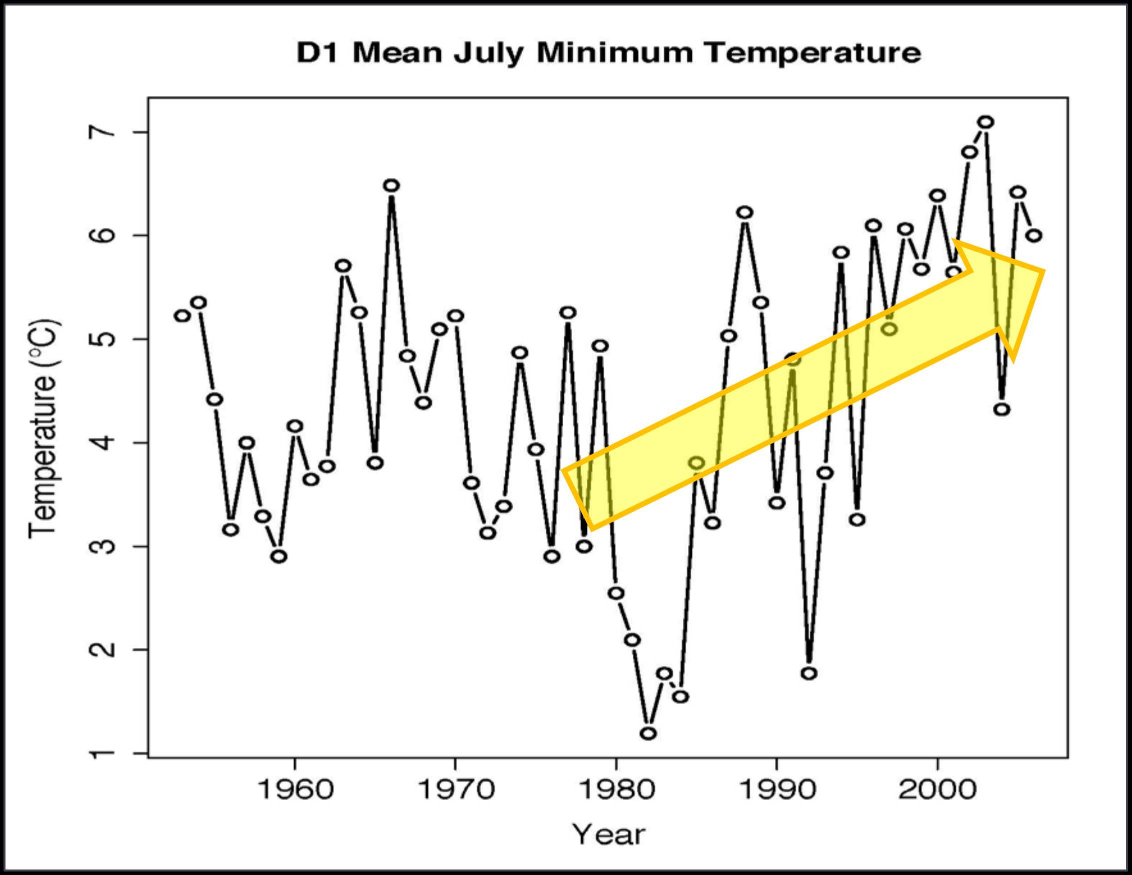
Stream NO_3^- response

GL4 – alpine
ALB – subalpine

Similar increases reported for Loch Vale watershed
50% increase in $[NO_3^-]$
28% increase in N export
Baron et al. 2009 (GCB)



Warming temperatures

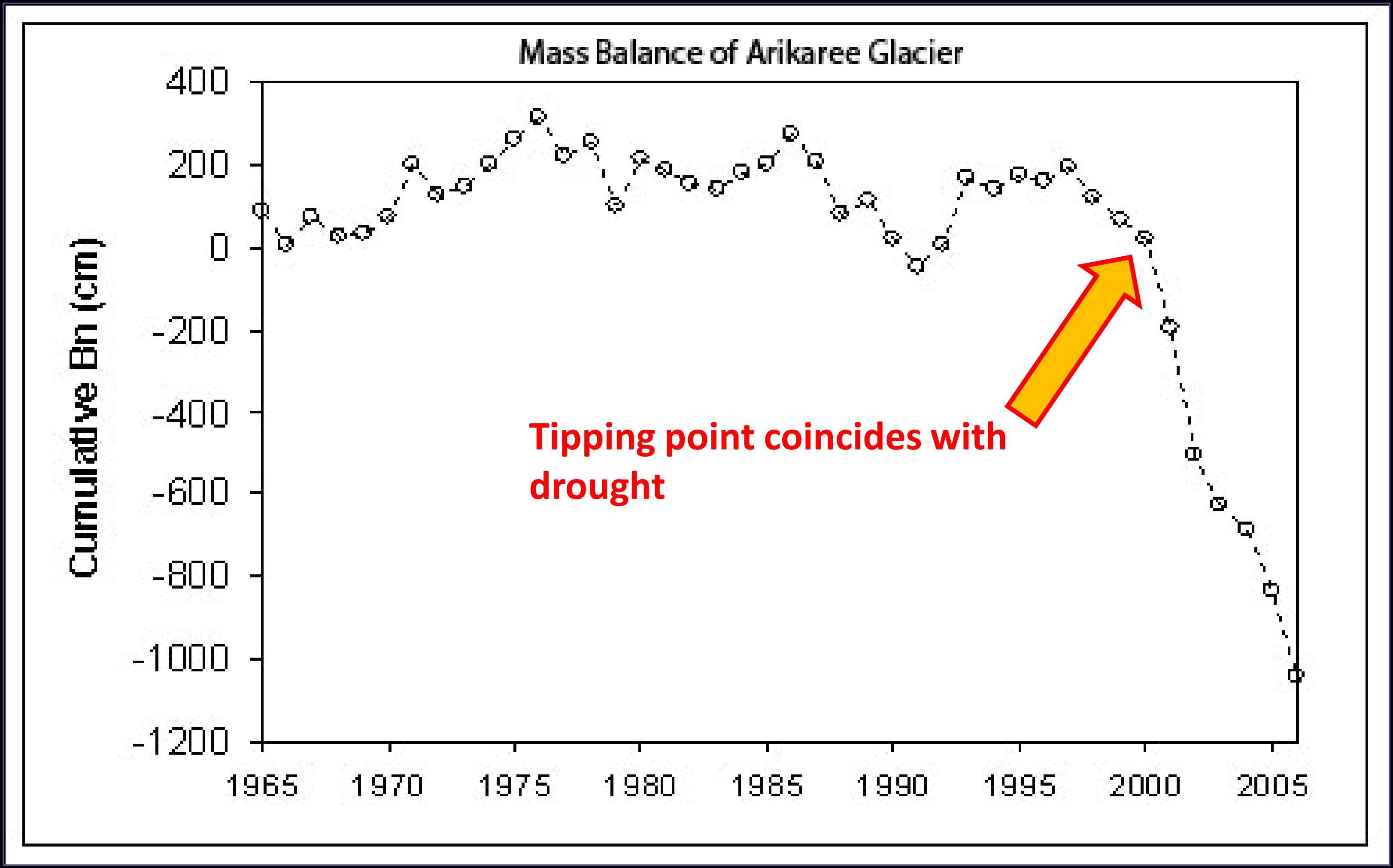


Increasing air temperatures

1.1 °C /decade at C1
1.0 °C /decade at D1
1.3 °C /decade at Loch Vale

Clow 2010 (J of Climate)

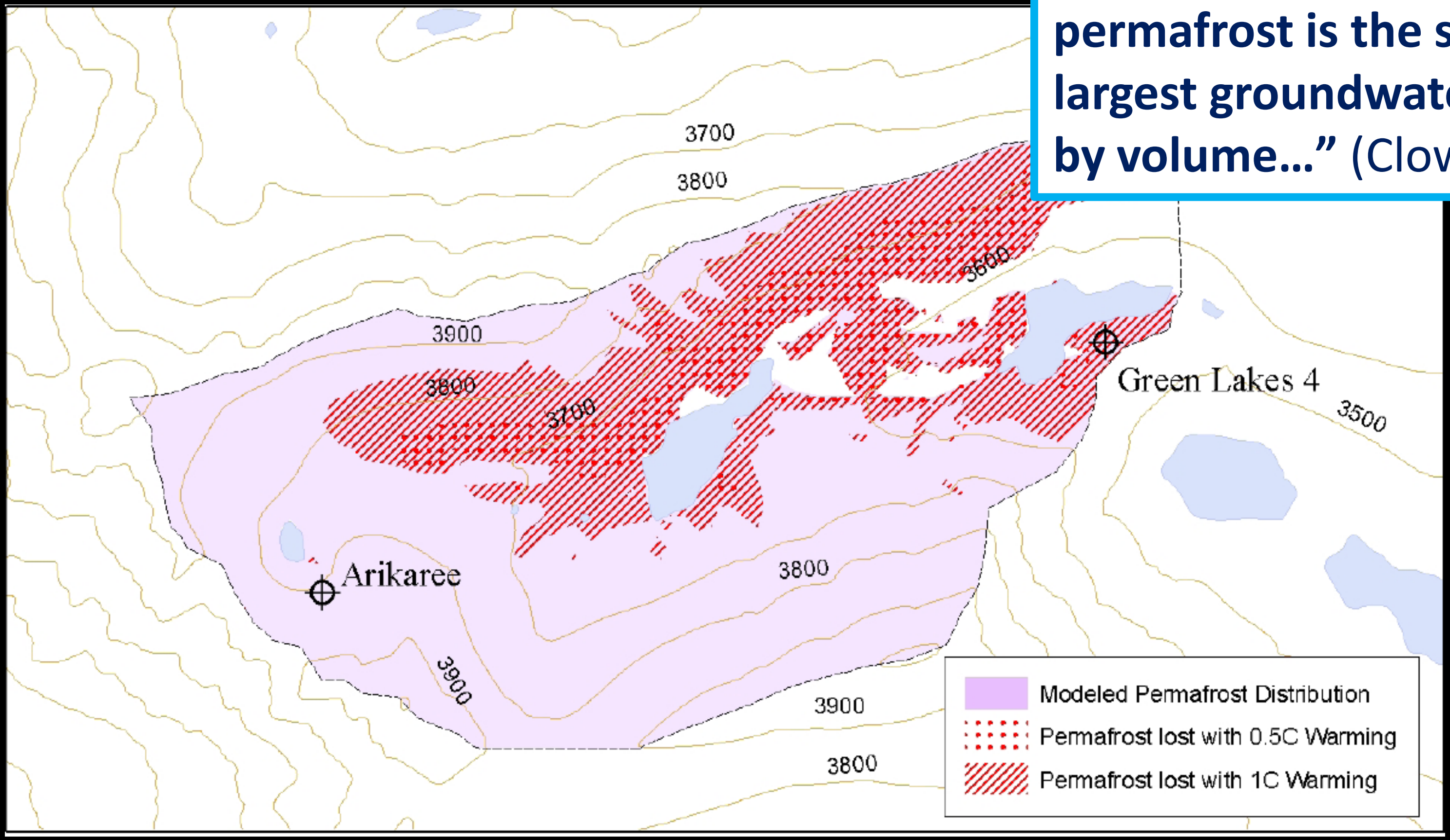
Shrinking glacier



Mass balance of Arikaree Glacier, cm of water equivalent

Thawing permafrost

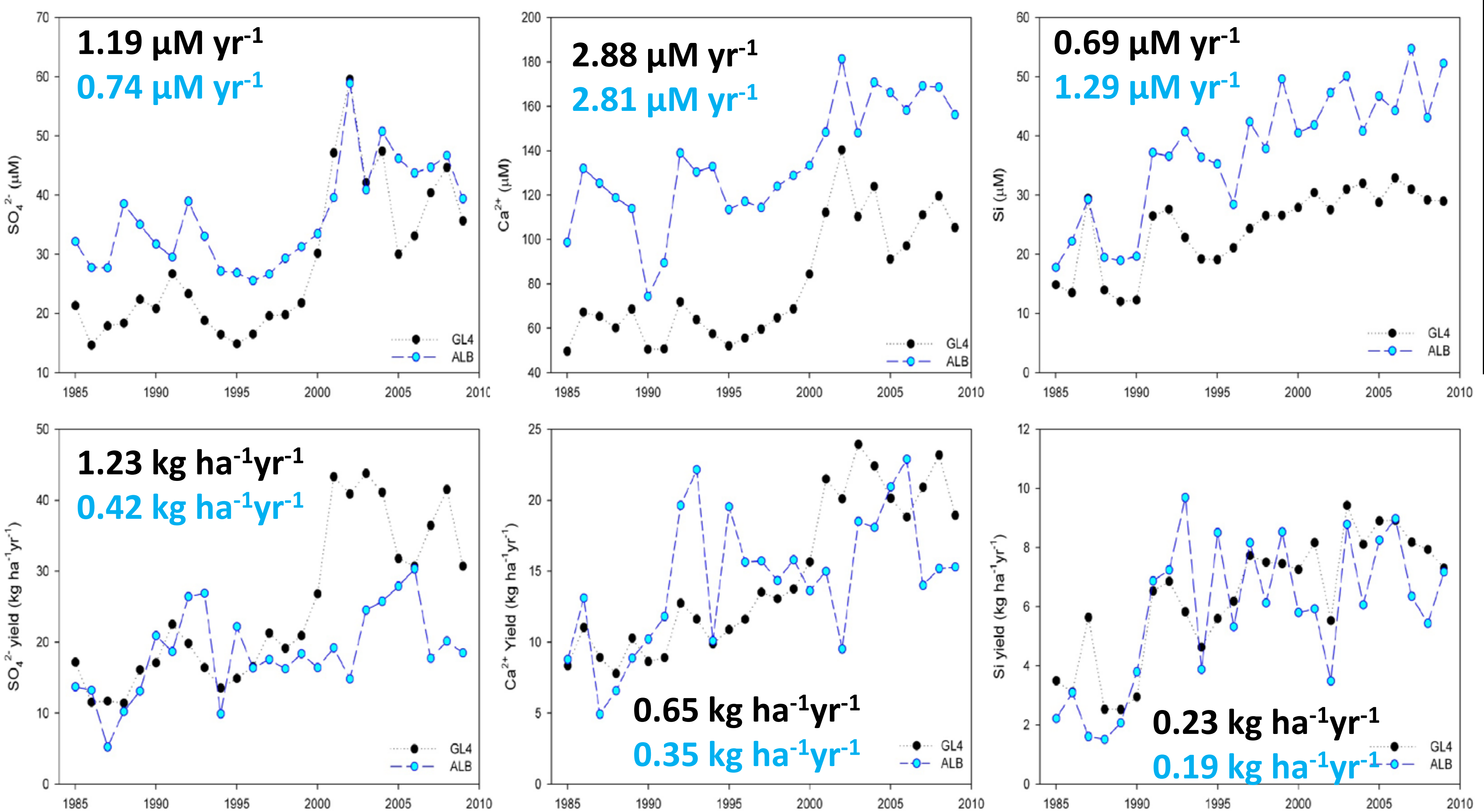
"Water stored in ice and permafrost is the second largest groundwater reservoir by volume…" (Clow et al., 2003)



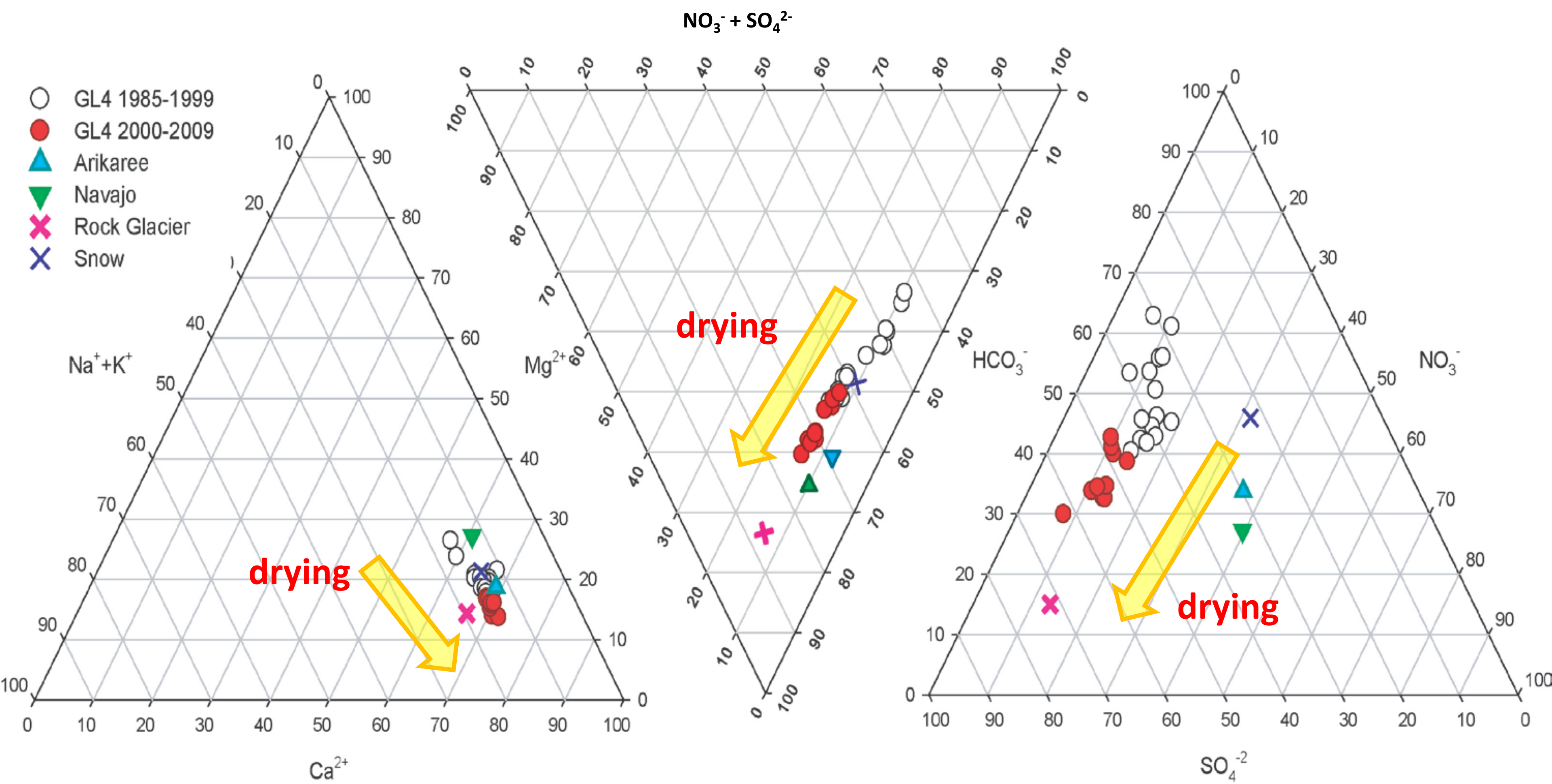
Janke 2005

Currently 89% of GL4 is modeled as probable permafrost, with 1°C warming permafrost area would decrease by 31%

Increase in weathering products



Warmer, drier conditions → Increased weathering rates & thawing permafrost

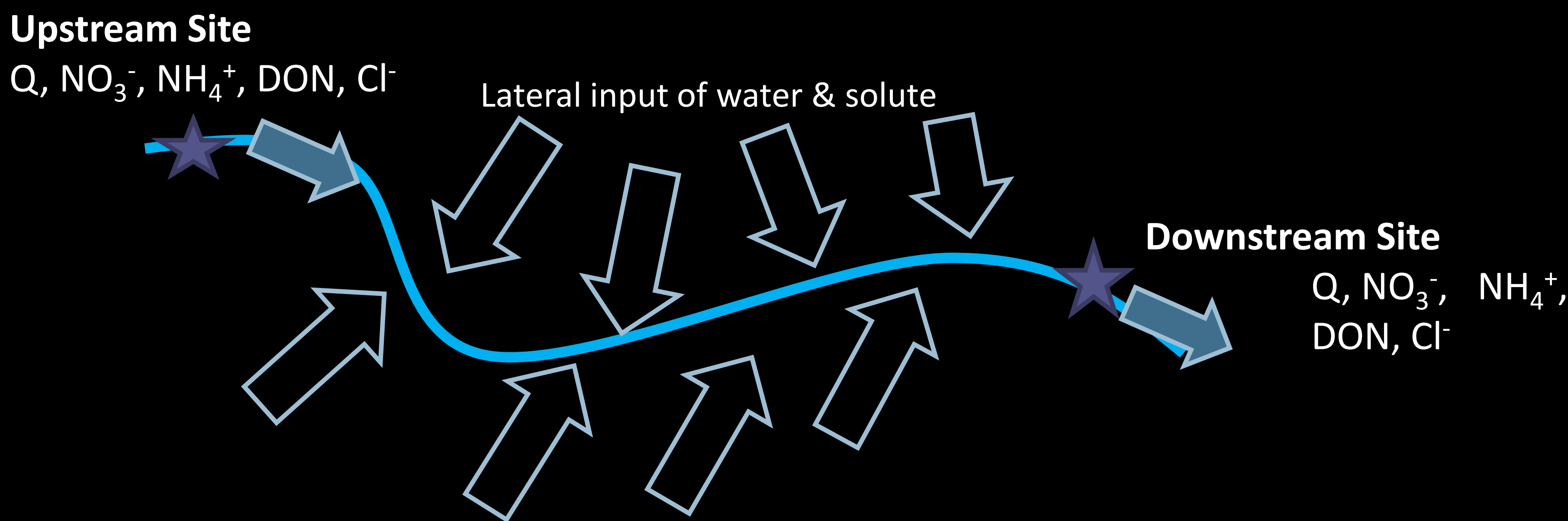


Where is the NO_3^- coming from?

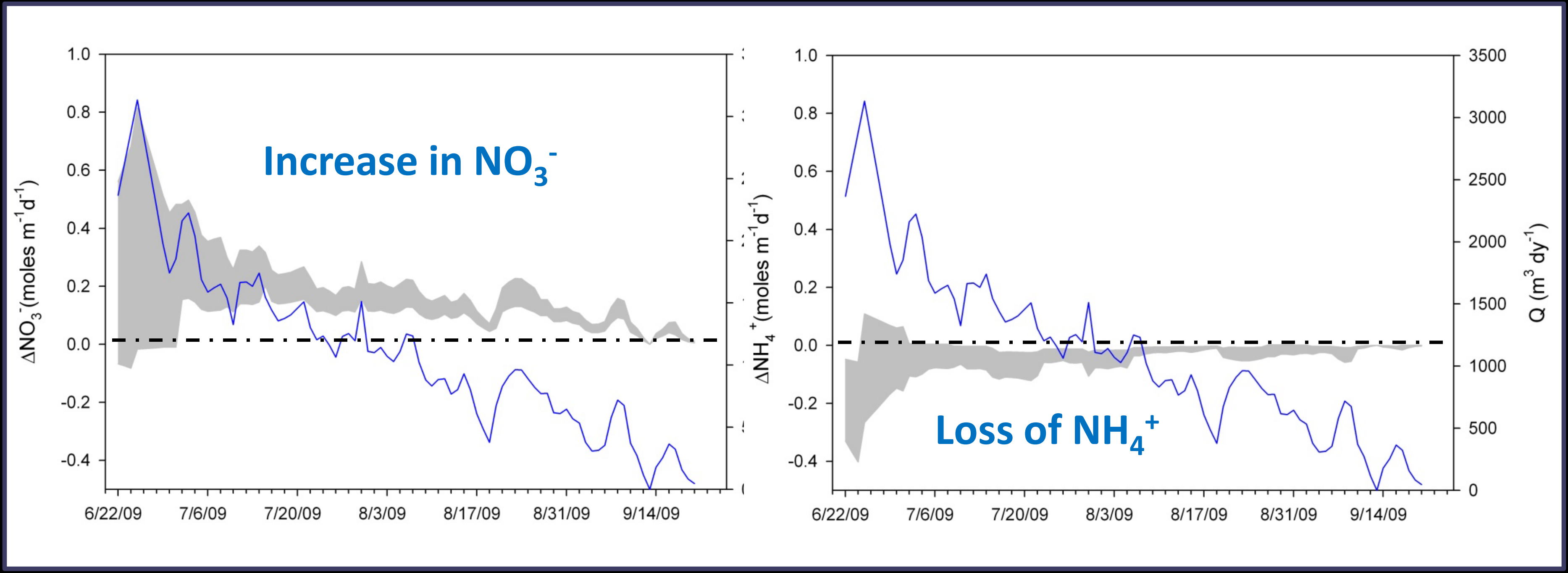
$$S_i = Q_{ds}C_{ds} - Q_{us}C_{us}$$

and

$$S_i = Q_{ds}C_{ds} - (Q_{us}C_{us} + \Delta QC_{us})$$



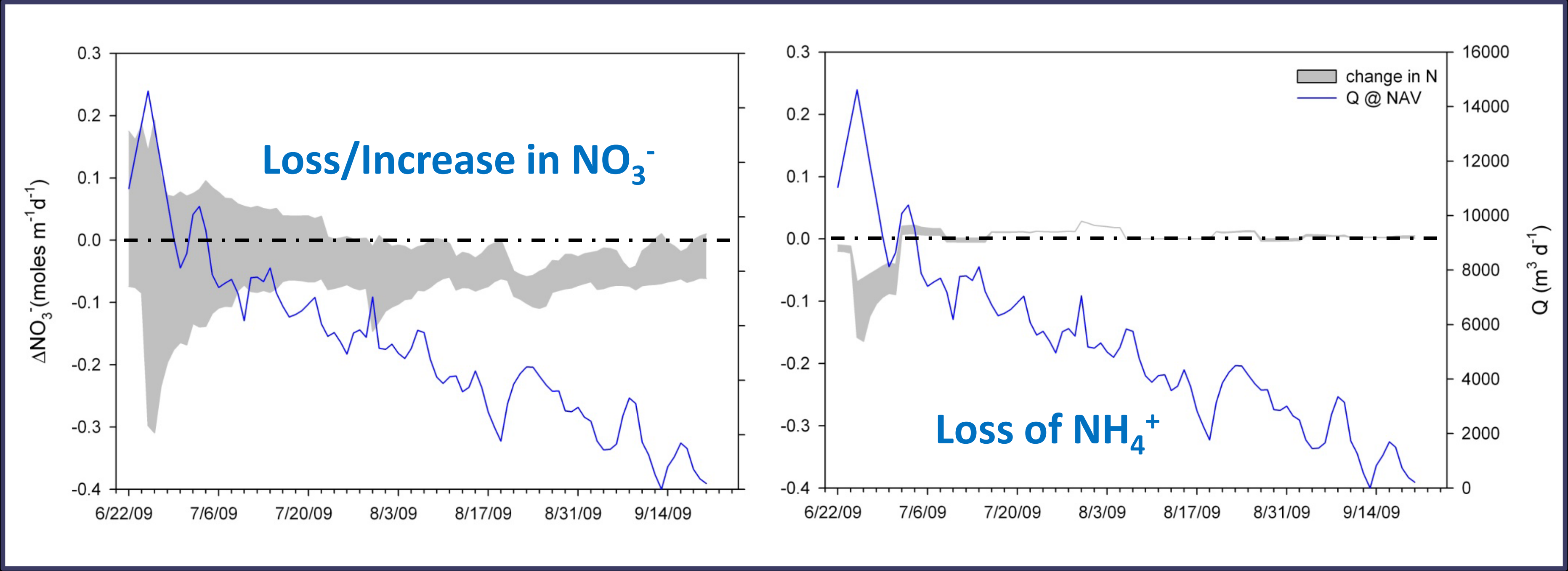
Model Output: Arikaree to Navajo



Change in NO_3^- and NH_4^+

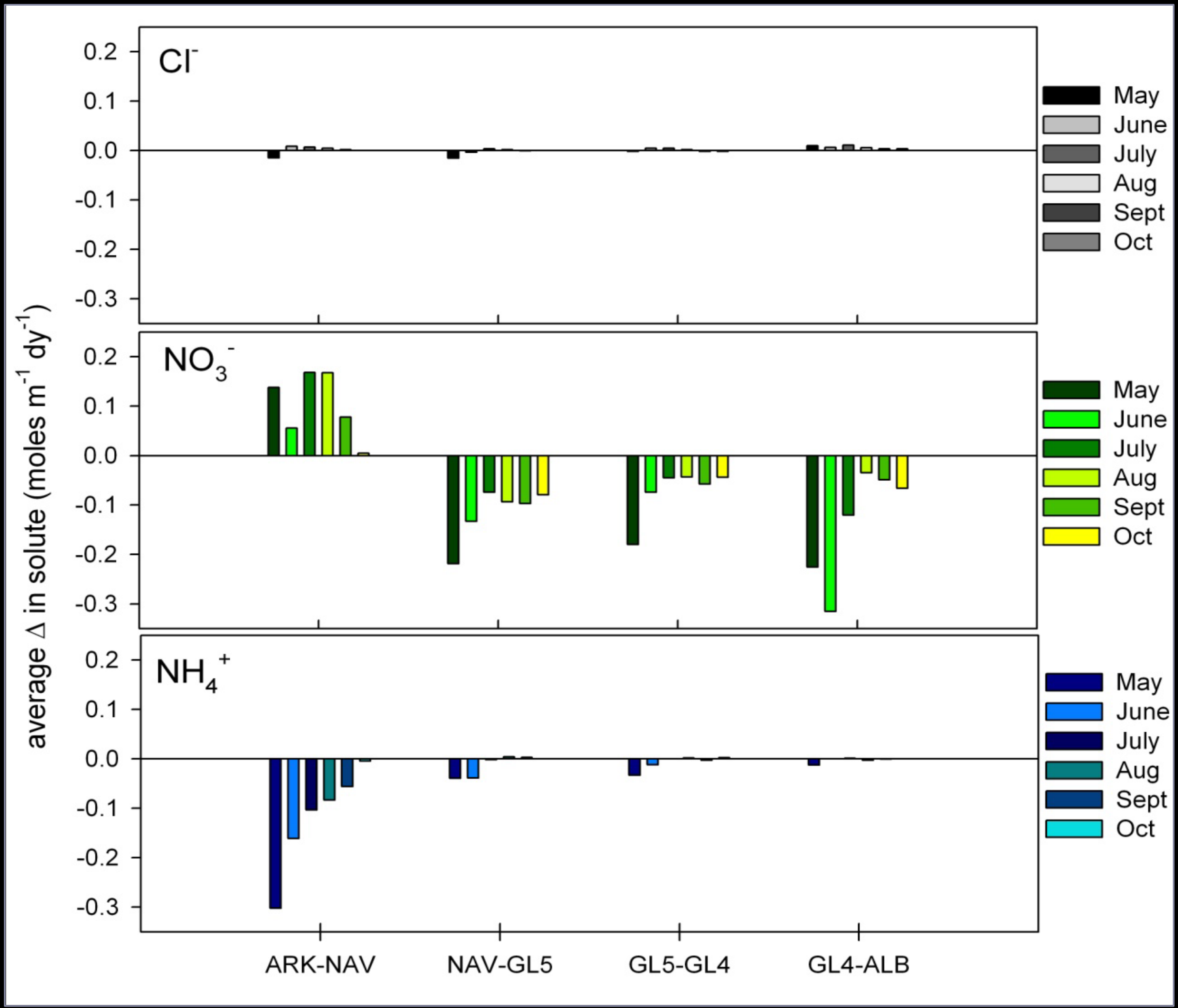
June through October 2009

Model Output: Navajo to GL5

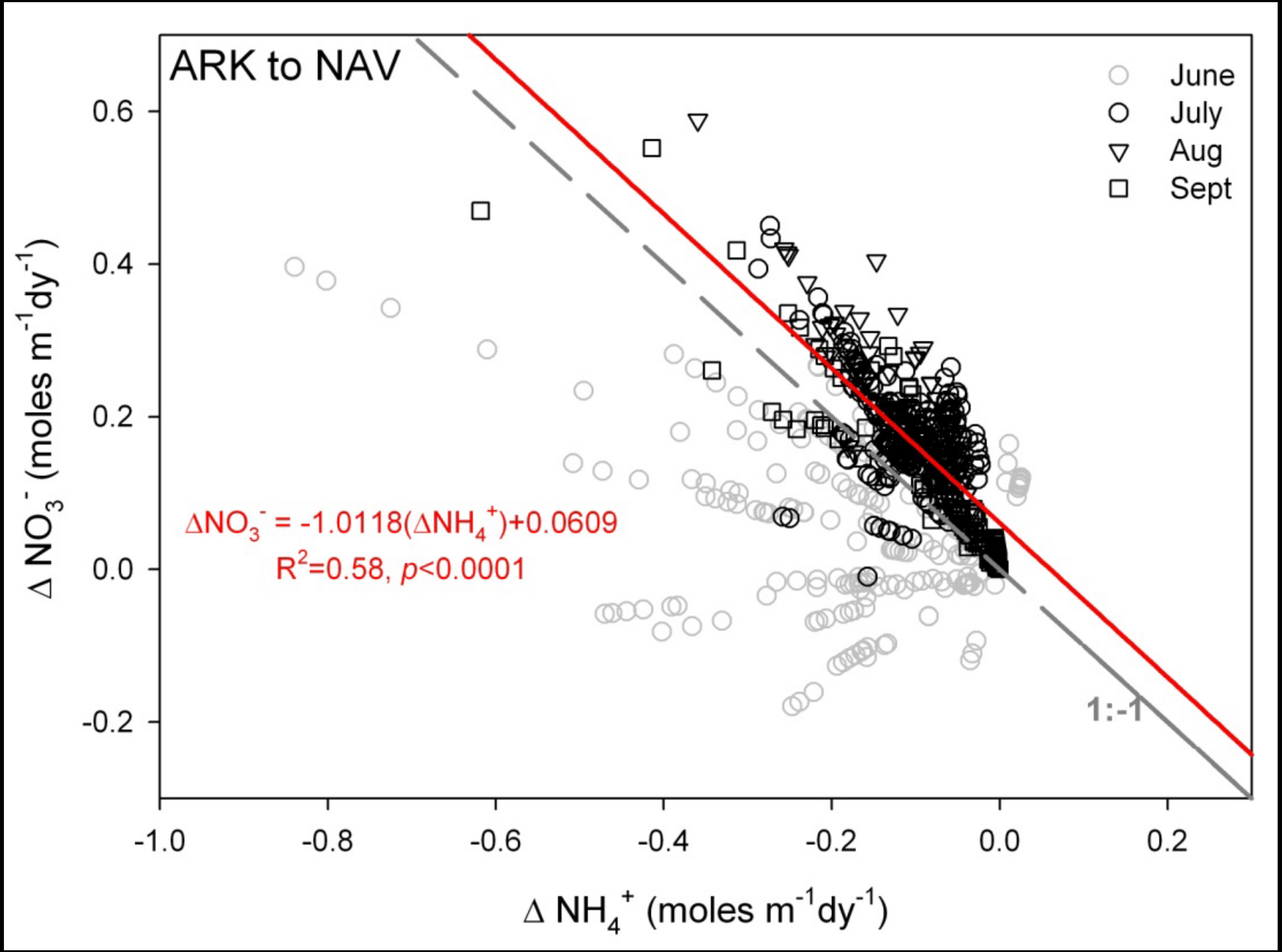


Change in NO_3^- and NH_4^+
June through October 2009

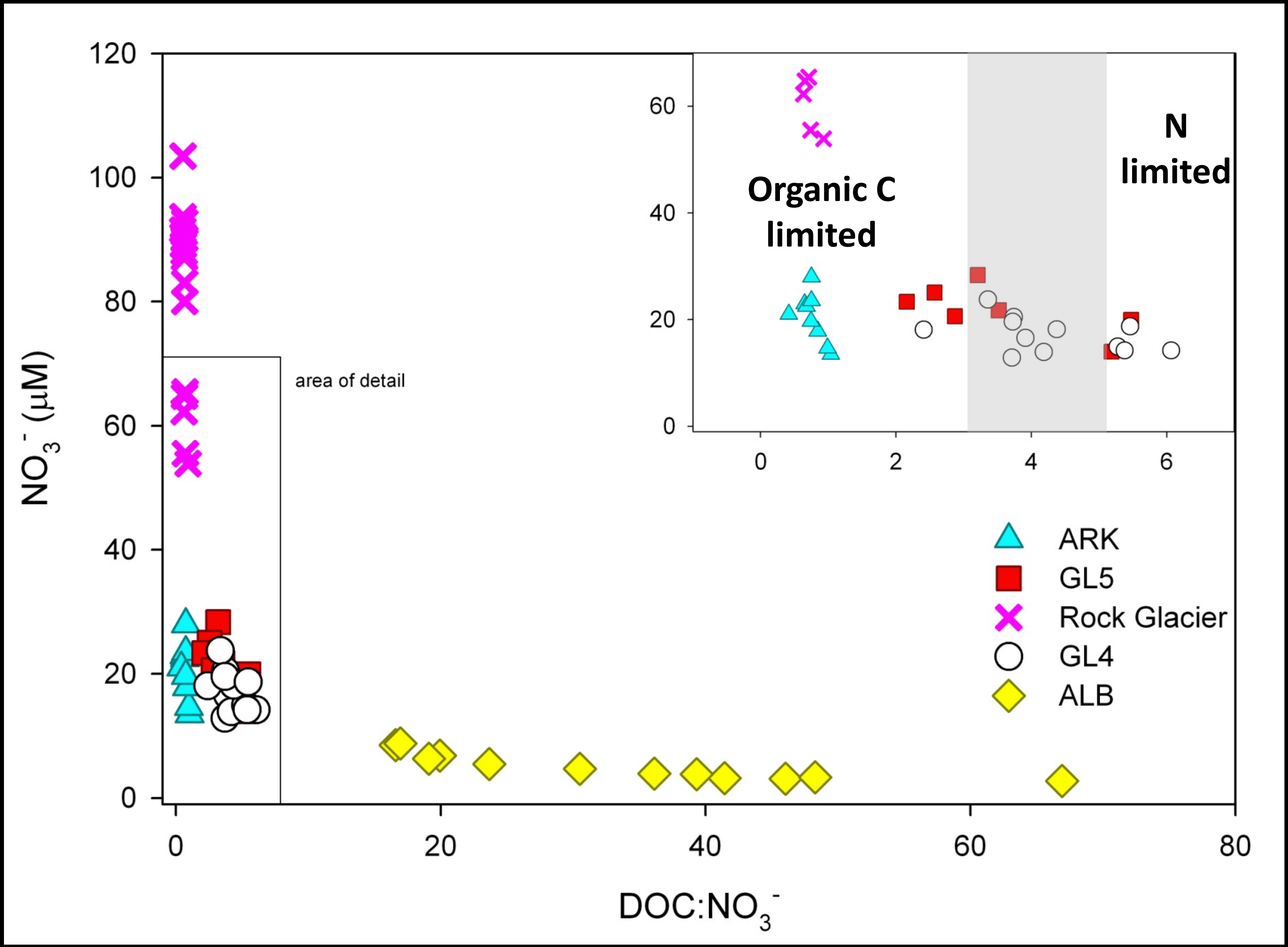
Model Output for 2000-2009



Converted to NO_3^- by Navajo site



organic C limited → nitrification



atmospheric deposition & warming