The Rocky Mountain Airborne Nitrogen and Sulfur Study (RoMANS)

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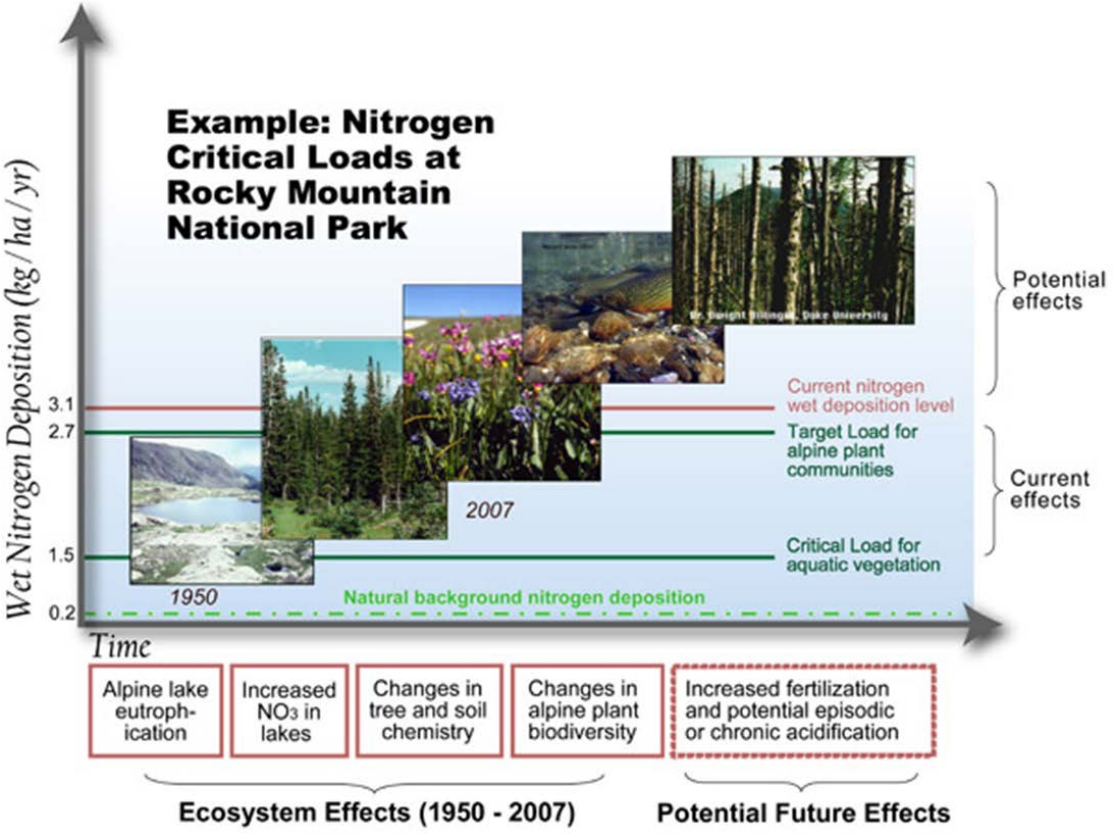
RoMANS objectives

- Characterize N and S species concentrations and spatial gradients in Rocky Mountain NP and across Colorado

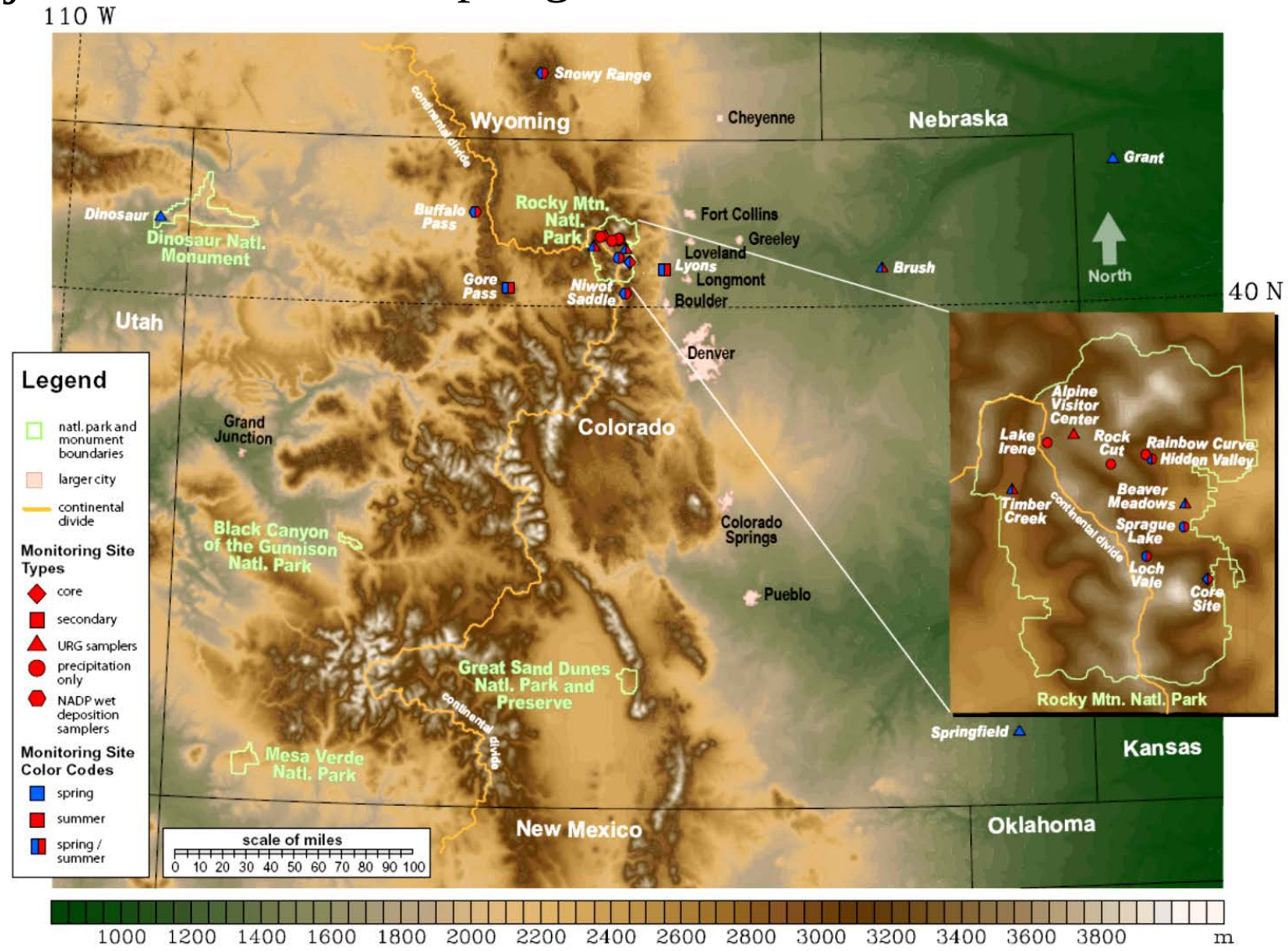
- Determine contributions of various N deposition pathways
  - Wet and dry dep
  - Oxidized and reduced N

- Determine source contributions to reactive N and its deposition in RMNP
  - East vs. west of RMNP
  - Within vs. outside Colorado



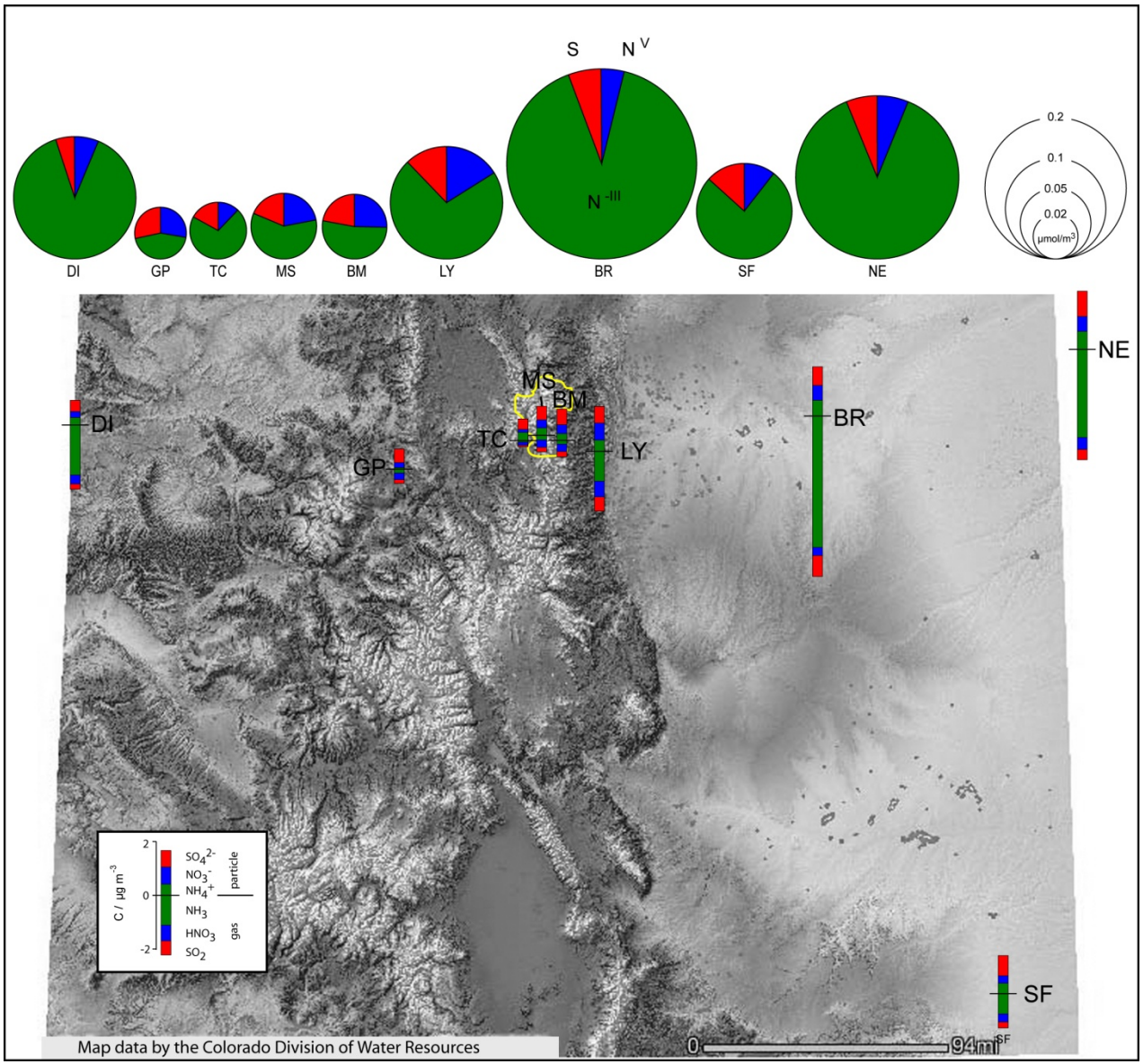
RoMANS

- Major field studies: Spring and Summer 2006 & 2008-09

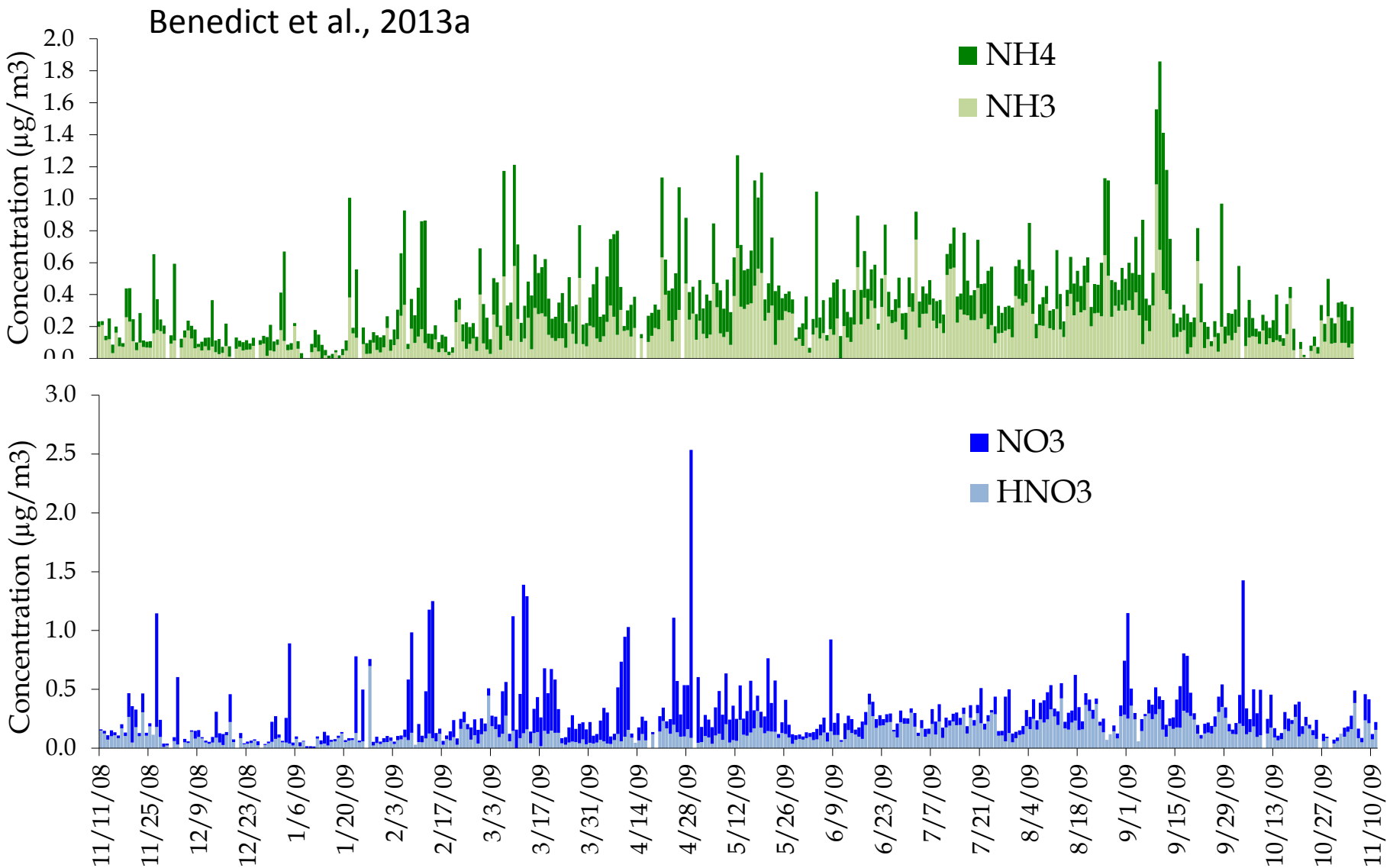


Spring overview

- Strong concentration gradient
- Low concentrations west of RMNP
- High concentrations east of RMNP
- Ammonia peaks in NE Colorado

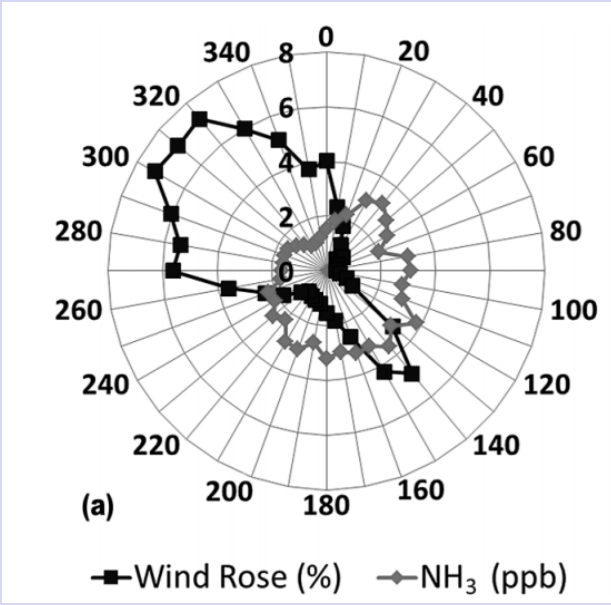


RMNP reactive N concentrations

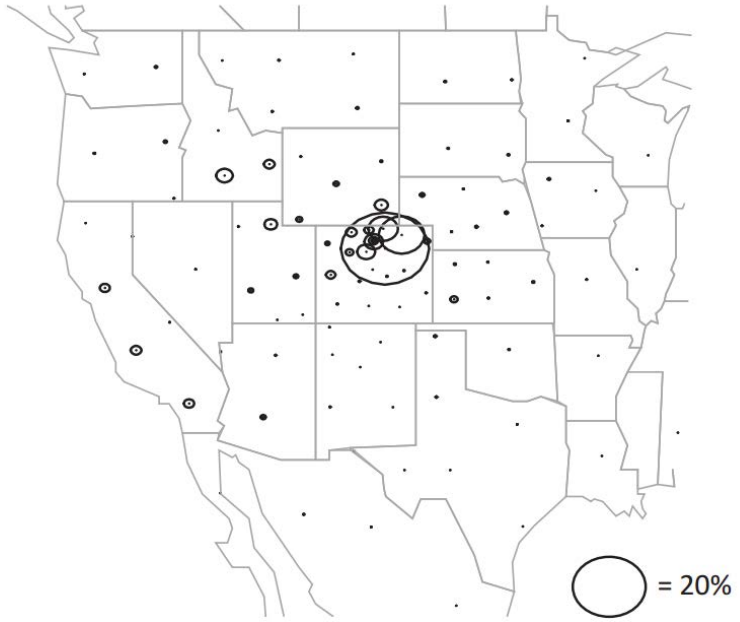


Ammonia source apportionment

- Ammonia concentrations are higher during transport from eastern CO but wind blows mostly from NW
- About half of RMNP NH_3 is estimated to come from within CO and half from outside, mostly from the west
- Contributions from NE CO increase during warmer seasons when ammonia dry deposition in RMNP also increases

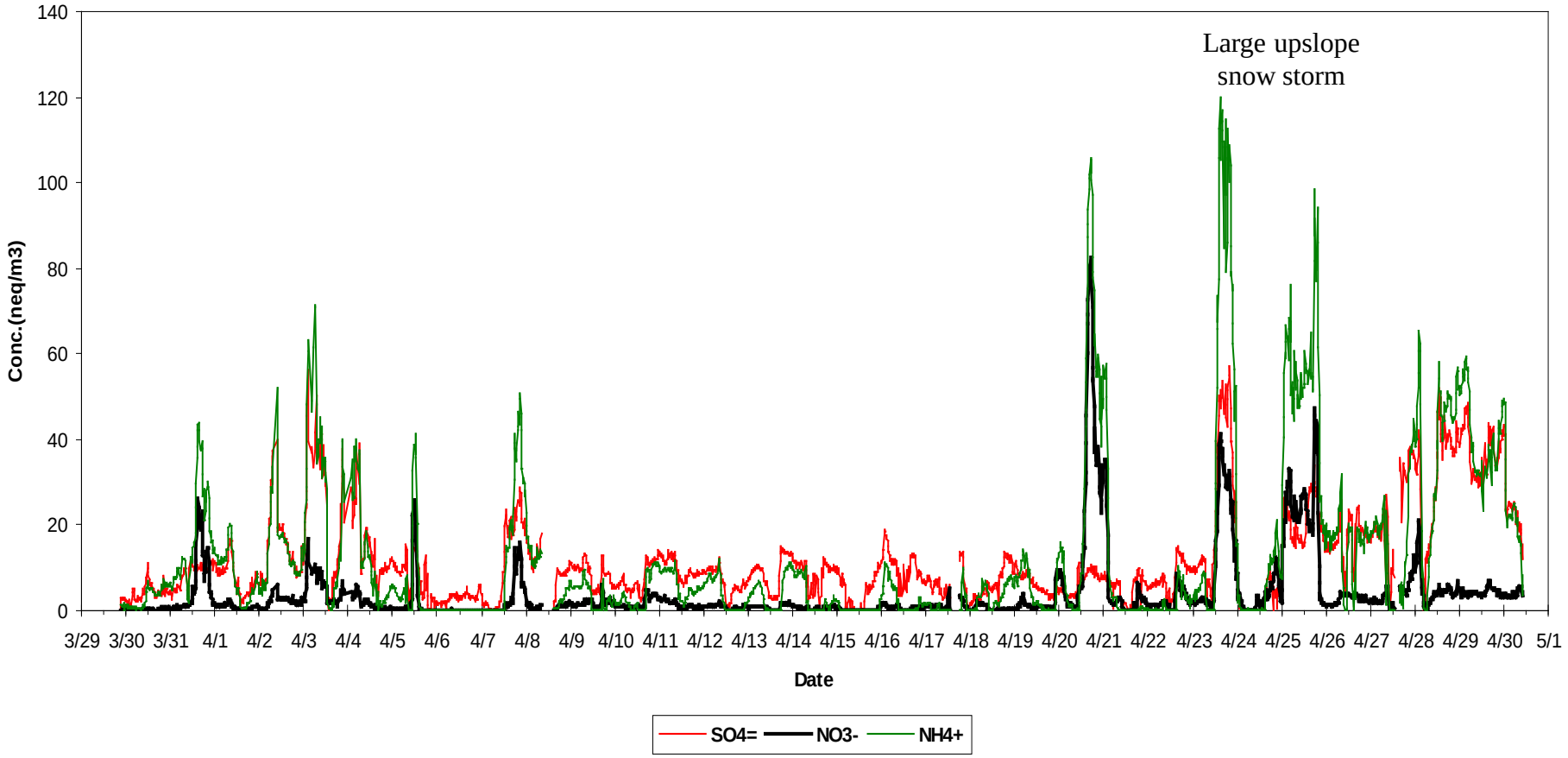


Malm et al. (2013)



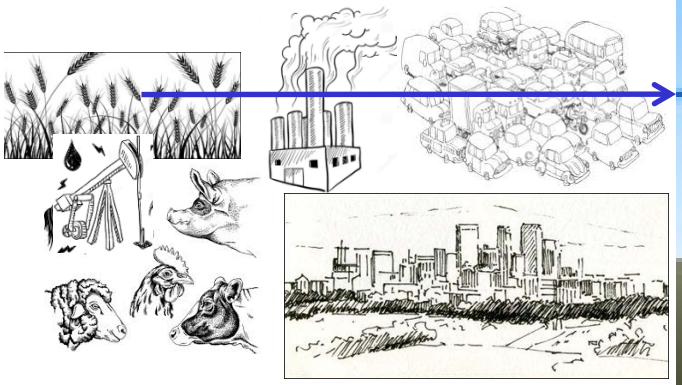
RMNP PM2.5 timelines

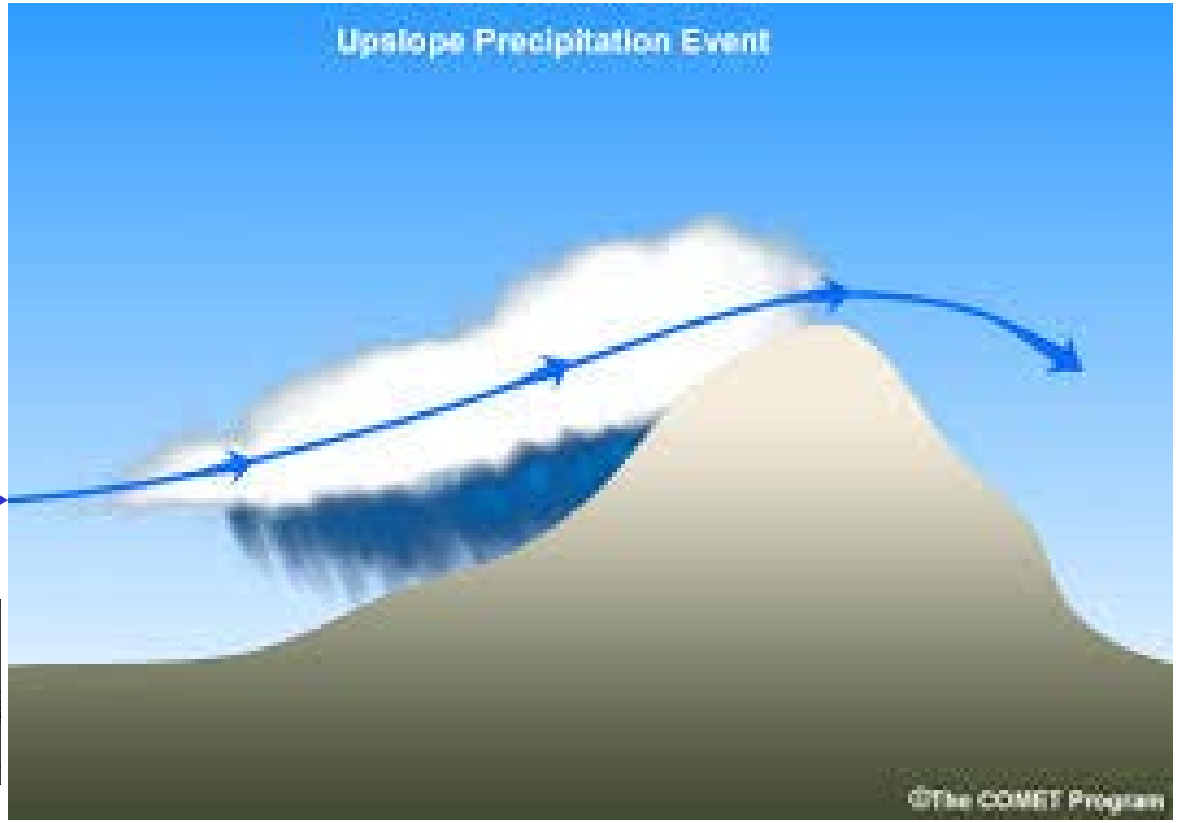
- Highly variable concentrations
- Highest concentrations during upslope flow from the east



Anatomy of a big wet N deposition event

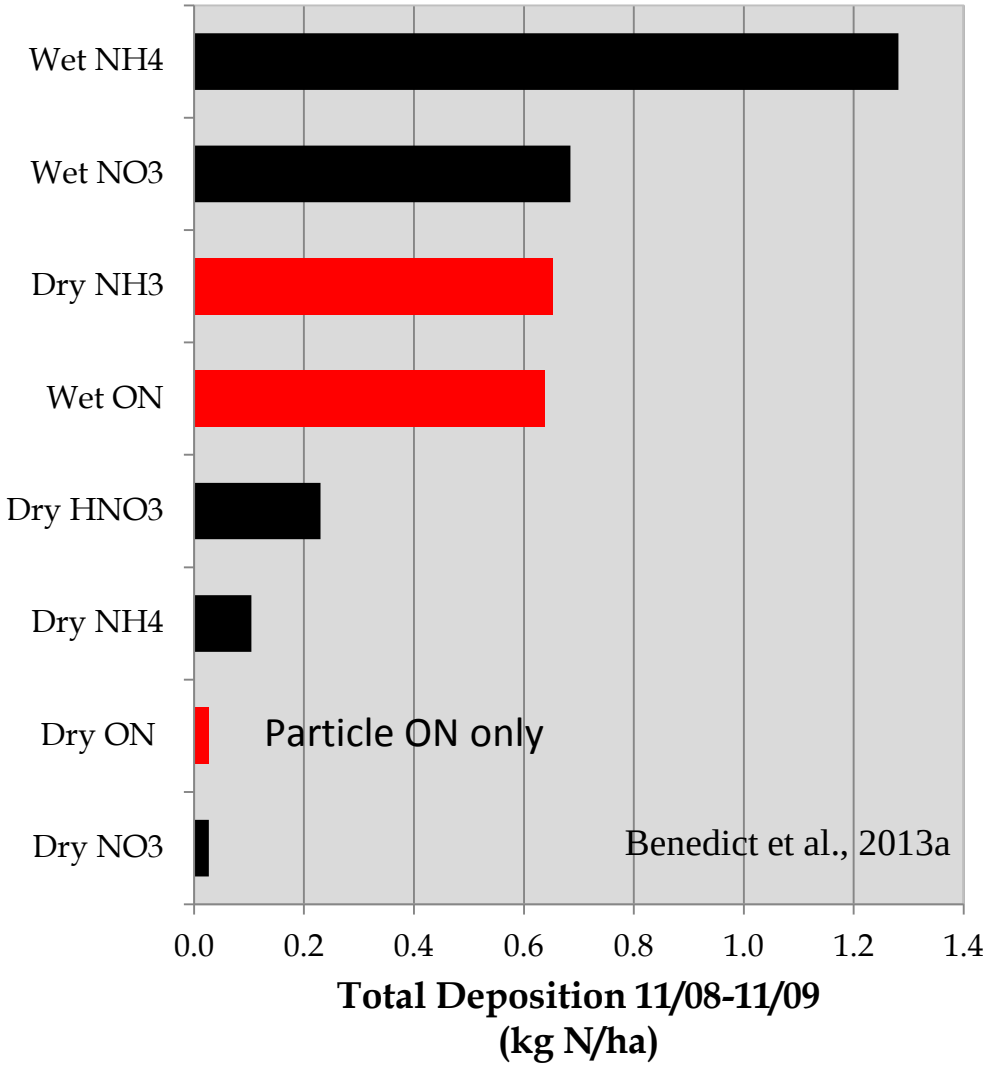
- Although RMNP winds come from the east < 20% of the time, > 50% of RMNP wet N dep is associated with this upslope transport





RMNP N deposition – annual budget

- Wet deposition biggest contributor to N deposition
- Dry deposition strongly dominated by NH_3



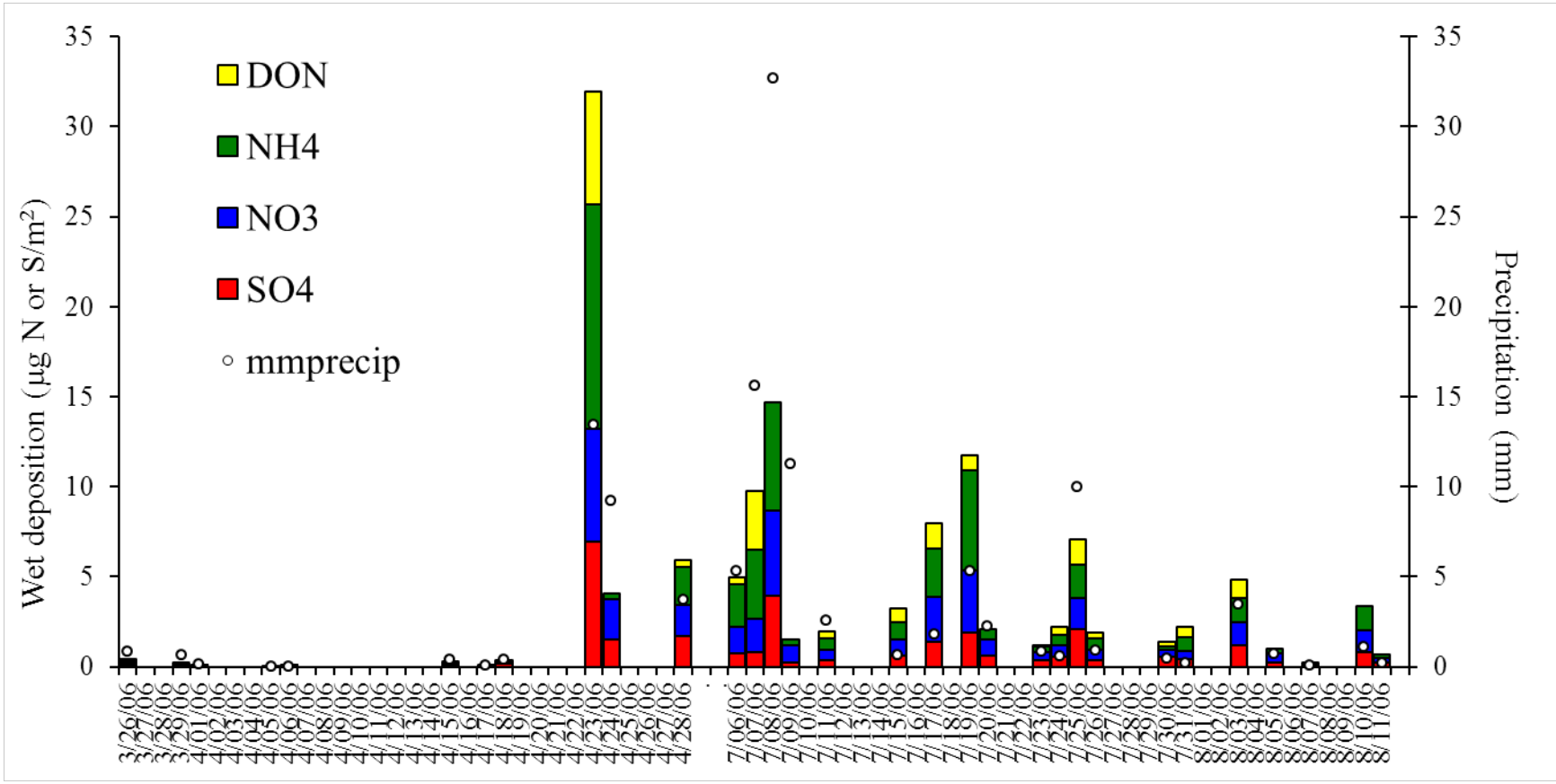
RoMANS Findings Summary

- Wet deposition of ammonium, nitrate, and organic N and ammonia dry deposition are largest N deposition pathways

- High concentrations of oxidized and reduced N are observed in RMNP when air comes from the east
  - Ammonia concentrations average ~50:50 from inside:outside CO
  - Contributions from NE CO increase during warmer season

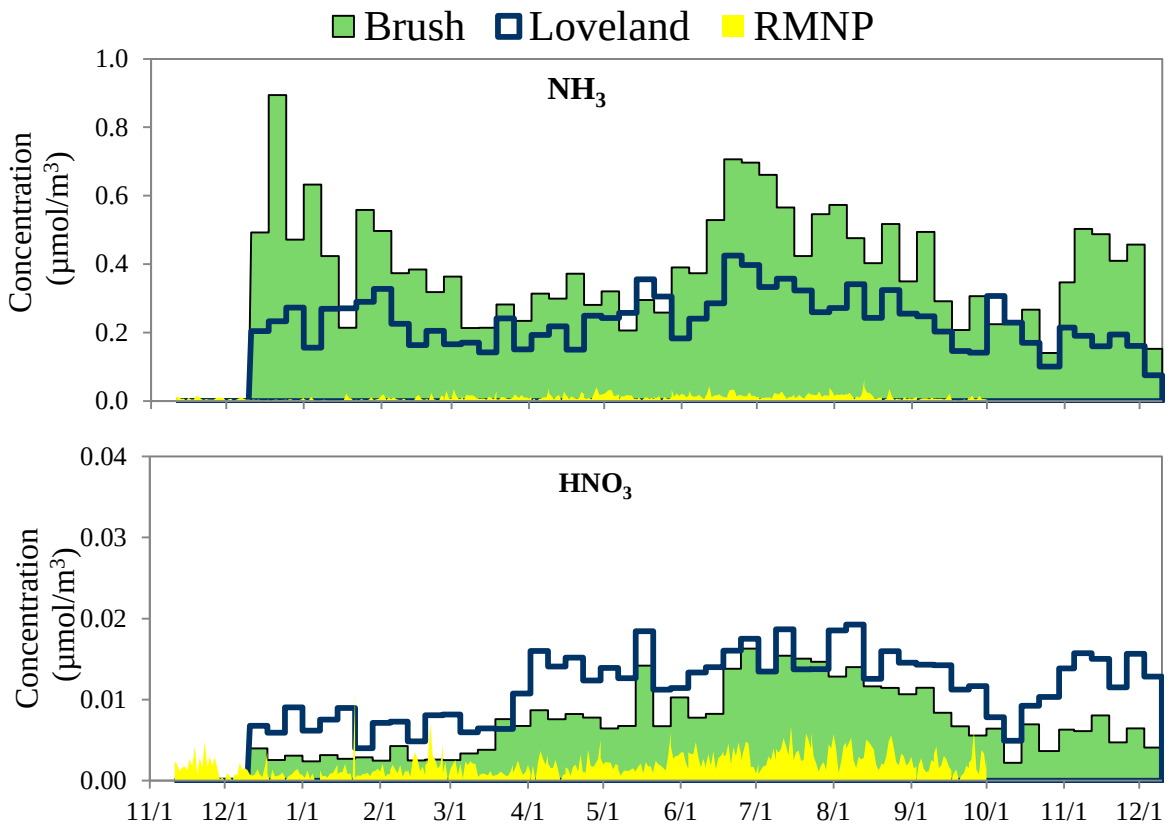
- Upslope flow from east brings pollutants to RMNP and produces heavy precipitation that scavenges and deposits those pollutants into RMNP ecosystems
  - Although RMNP winds blow from the east <20% of the time, >50% of the N wet deposition is associated with these episodes
  - Early warning system targets such events

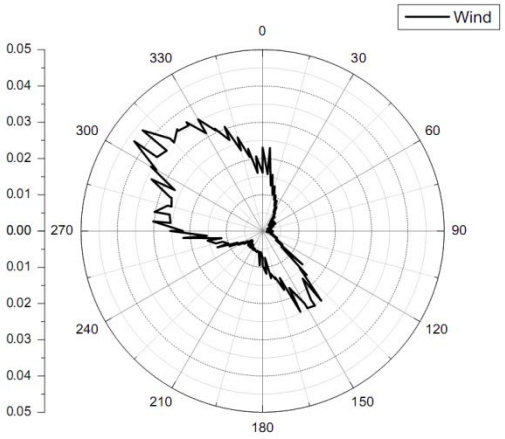
RoMANS 2006 wet deposition

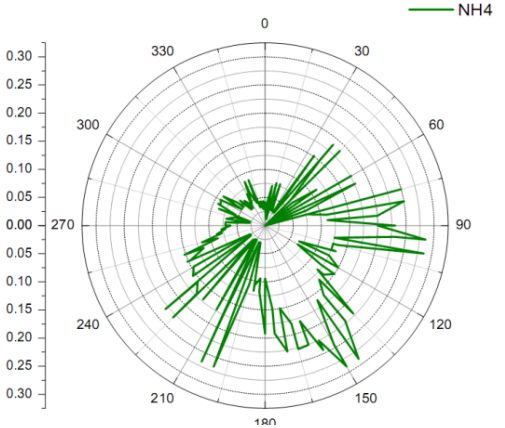


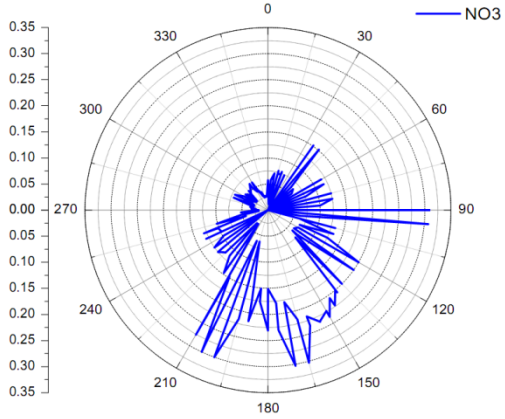
- Spring flux dominated by single event -- summer flux contributed by several events
- Substantial oxidized, reduced, and organic N

Annual mountain to plains gradient

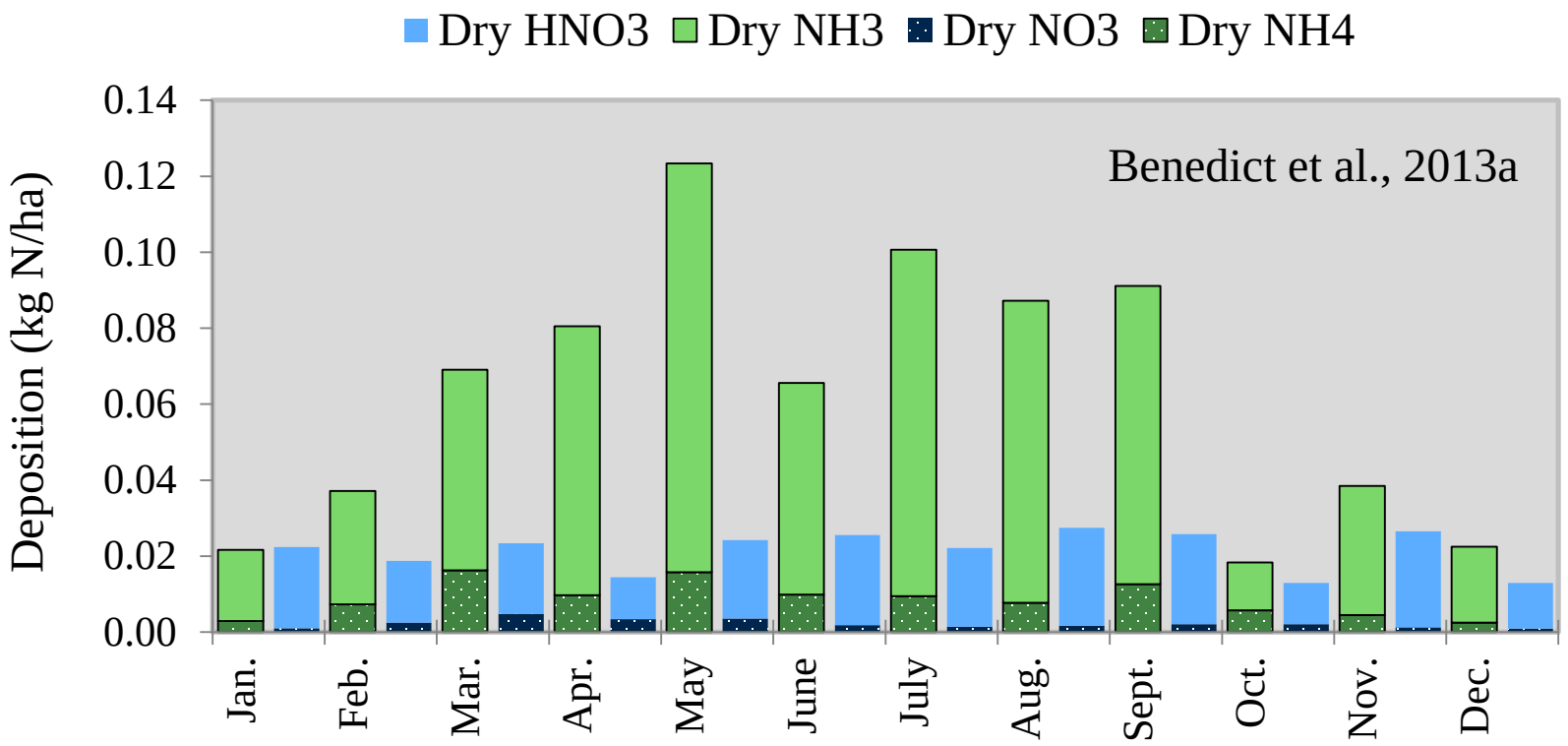








RMNP seasonal dry deposition budget



- Ammonia deposition most important; spring and summer peaks

A closer look…

- Ammonium nitrate episodes associated with upslope flow from east of RMNP