A comparison of AMoN measurements with localized, arrayed passive NH_3 samplers in Northern Utah

Dr. Randal S. Martin

Dept. of Civil and Env. Eng.

Utah Water Research Laboratory

Utah State University

Utah Climate Center

8200 Canyon Road

Logan, UT 84322-8200

randy.martin@usu.edu

(435) 797-1585

Dr. Munkh Baasandorj

Utah Division of Air Quality

Utah Dept. of Env. Quality

and, Dept .of Atmospheric Sciences

University of Utah

Salt Lake City, UT

mbaasandorj@utah.gov

(801) 536-4407

UtahStateUniversity

Utah Water Research Laboratory UWRL

UTAH DEPARTMENT of ENVIRONMENTAL QUALITY

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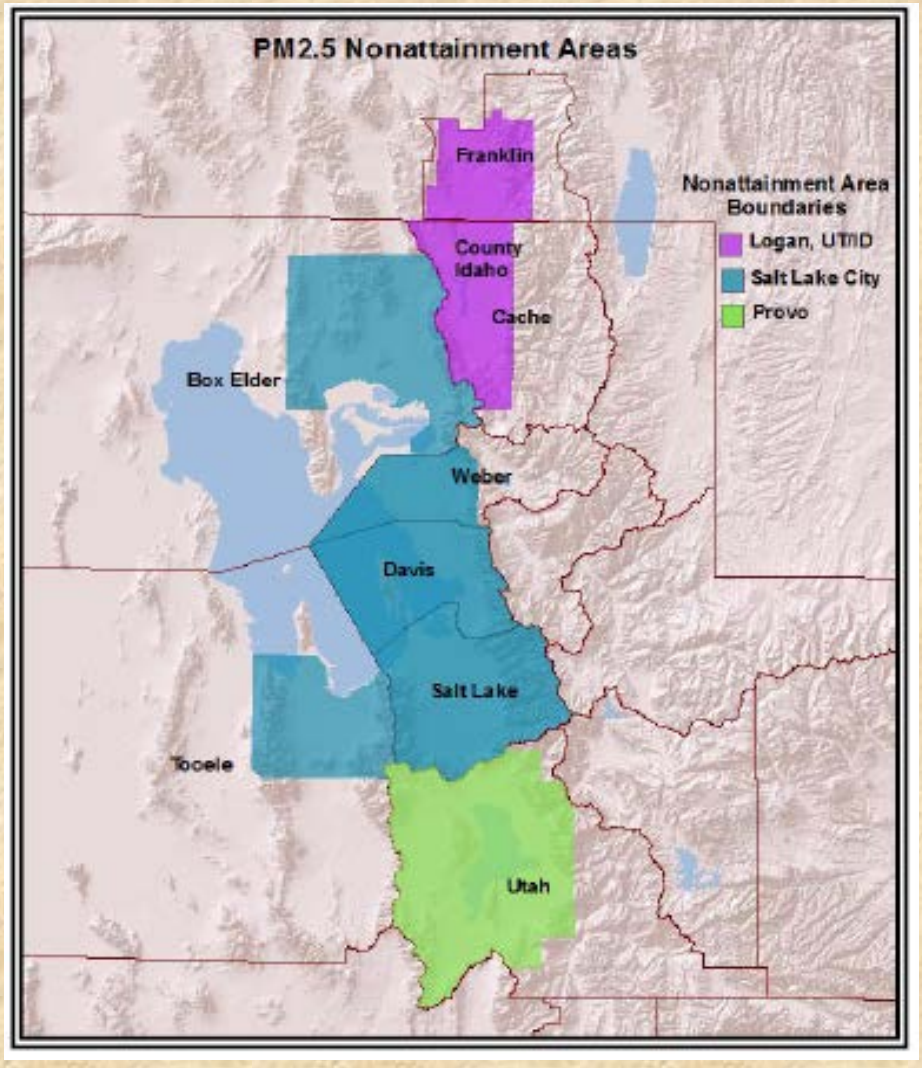
Why the concern with gas-phase ammonia in Northern Utah (and SE Idaho)

Utah (and SE Idaho) $PM_{2.5}$ Non-Attainment Areas



"State of the Air"

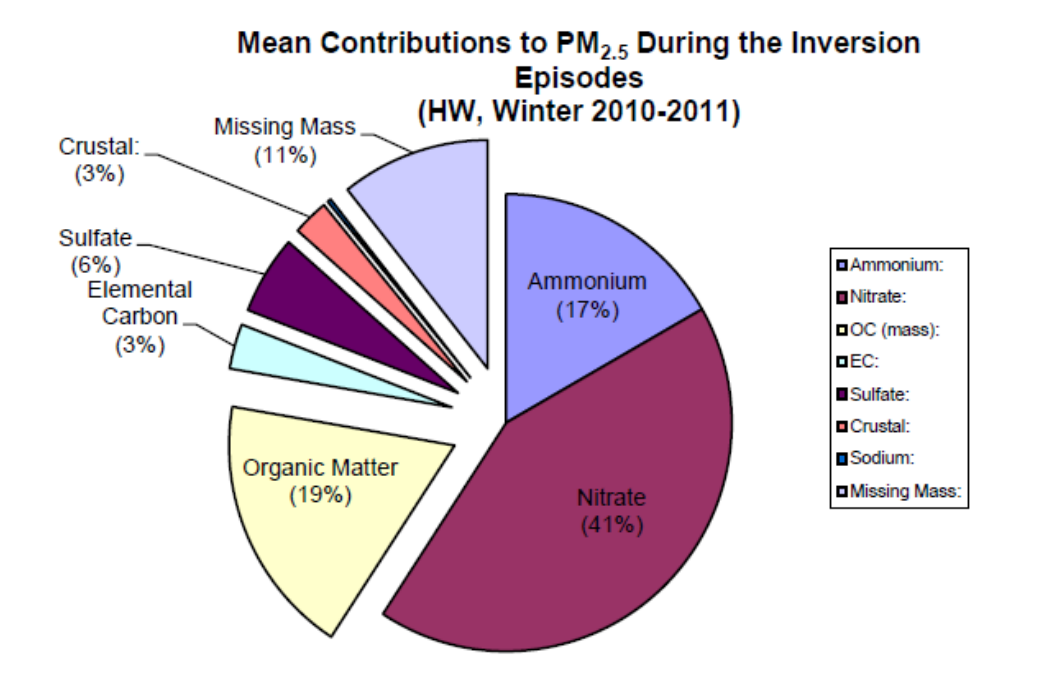
American Lung Association

- ***Top Polluted U.S. Cities (24-hr $PM_{2.5}$)***

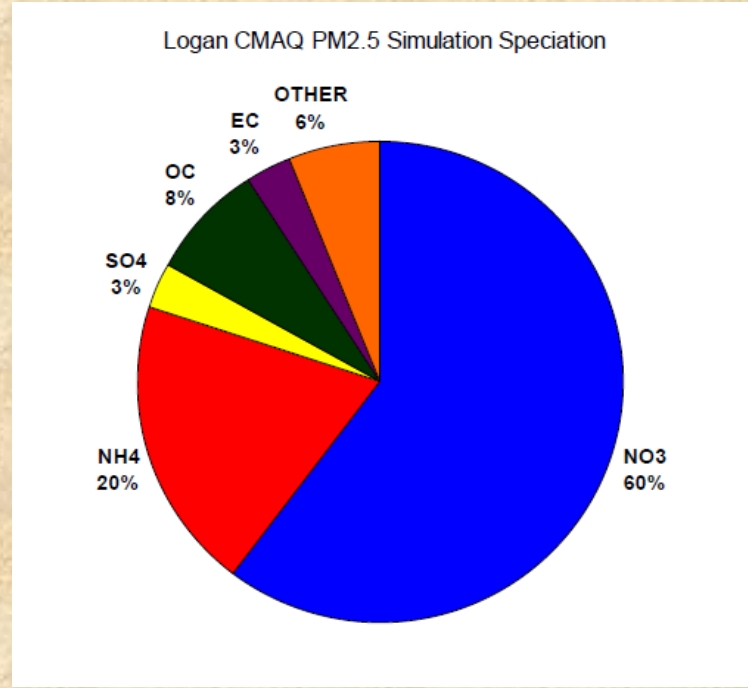
2013 (2011-2013 data) *- April 2014 report -*	2014 (2011-2013 data) *- April 2015 report -*	2015 (2012-2014 data) *- April 2016 report -*
(1) Fresno-Madera, CA	(1) Fresno-Madera, CA	(1) Bakersfield-Delano, CA
(2) Visalia-Porterville-Hanford, CA	(2) Bakersfield-Delano, CA	(2) Fresno-Madera, CA
(3) Bakersfield, CA	(3) Visalia-Porterville, CA	(3) Visalia-Porterville, CA
(4) LA-Long Beach, CA	(4) Modesto-Merced, CA	(4) Modesto-Merced, CA
(5) Modesto-Merced, CA	(5) LA-Long Beach-Riverside, CA	(5) Fairbanks, AK
(6) Pittsburgh, PA-OH-WV	(6) San Jose-SF-Oakland, CA	(6) SLC-Orem-Provo, UT
(7) Fairbanks, AK	(7) SLC-Ogden-Clearfield, UT	(7) Logan, UT-ID
(8) SLC-Orem-Provo, UT	(8) Logan, UT-ID	(8) San Jose-SF-Oakland, CA
(9) El Paso, Las Cruces, TX-NM	(9) Fairbanks, AK	(9) LA-Long Beach-Riverside, CA
(10) San Jose-SF-Oakland, CA	(10) Pittsburgh, PA-OH-WV	(10) Missoula, MT
(11) Logan, UT-ID		

Salt Lake and Cache Valley $PM_{2.5}$ Composition

- For both SLC and CV airsheds, ammonium nitrate (NH_4NO_3) averages > 50% of wintertime $PM_{2.5}$ mass
  - modeled & measured
- During elevated $PM_{2.5}$ episodes in CV, NH_4NO_3 accounts for 80-95% $PM_{2.5}$ mass

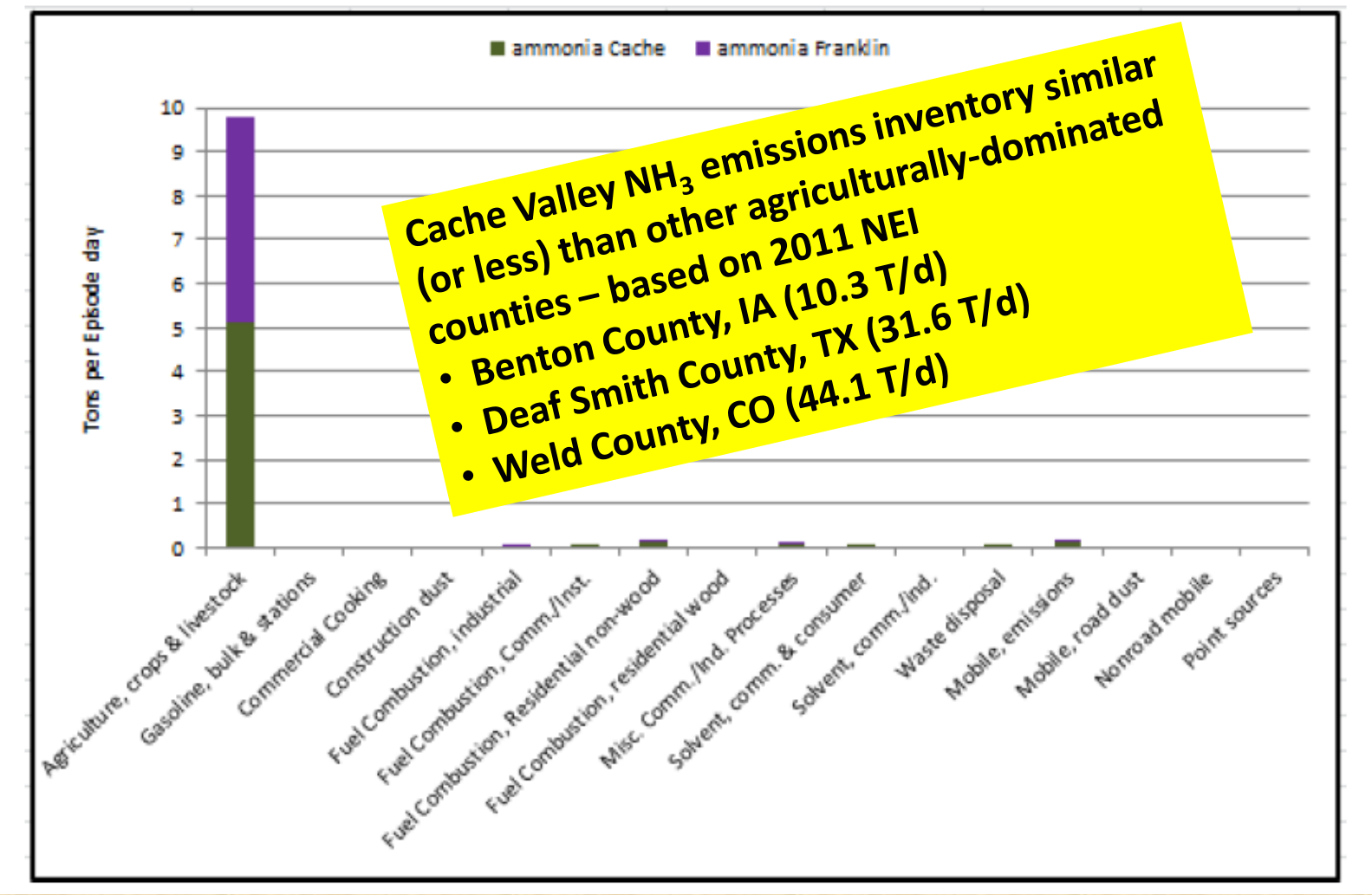


UDAQ SIP observed $PM_{2.5}$ speciation for SLC's Hawthorne site (Dec. 2014)



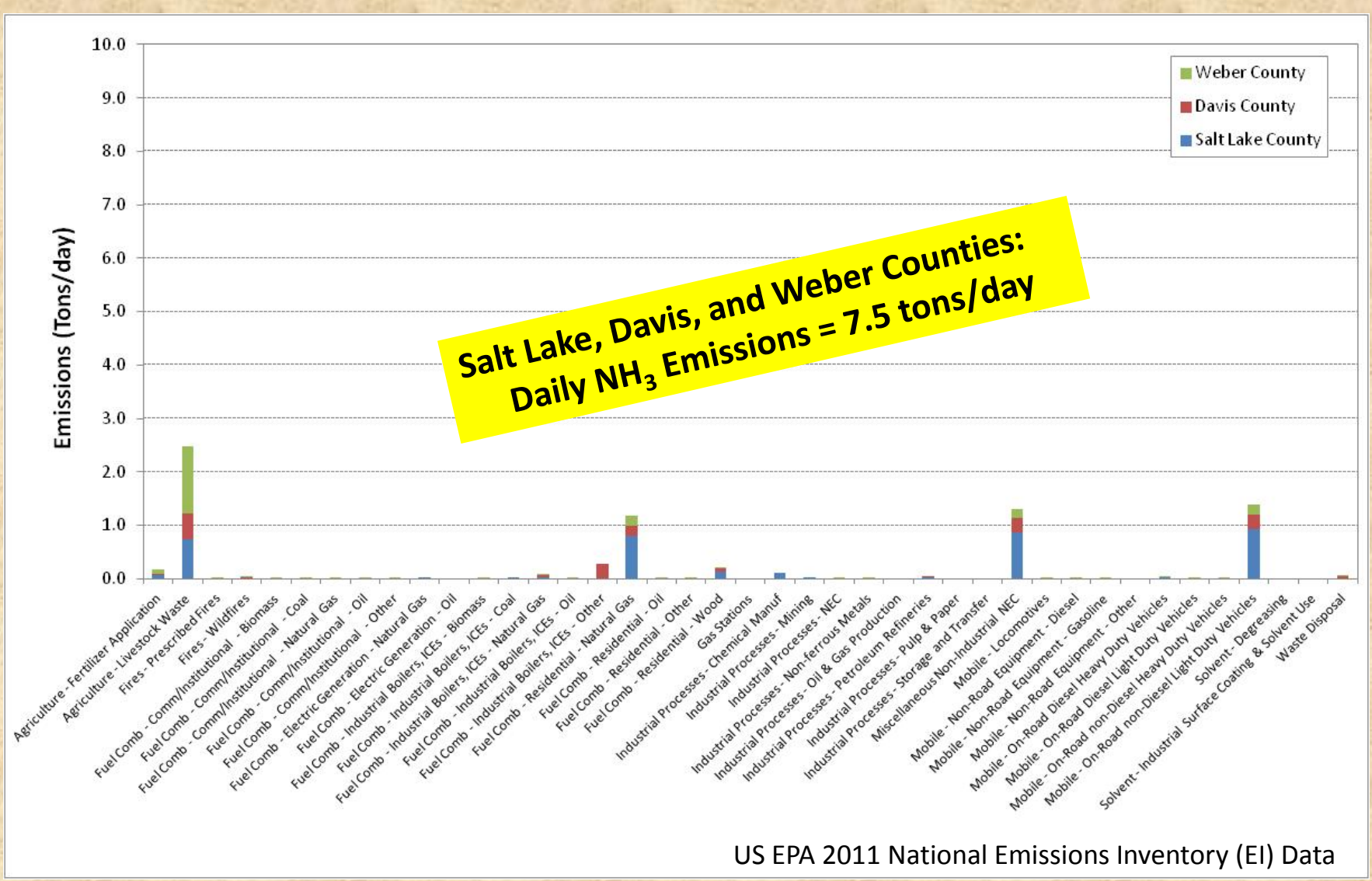
UDAQ SIP modeled $PM_{2.5}$ speciation for Cache Valley (Dec. 2014)

Cache Valley SIP NH_3 Emissions Inventory



Idaho DEQ, Cache Valley Idaho $PM_{2.5}$ Nonattainment Area SIP, Dec. 2012

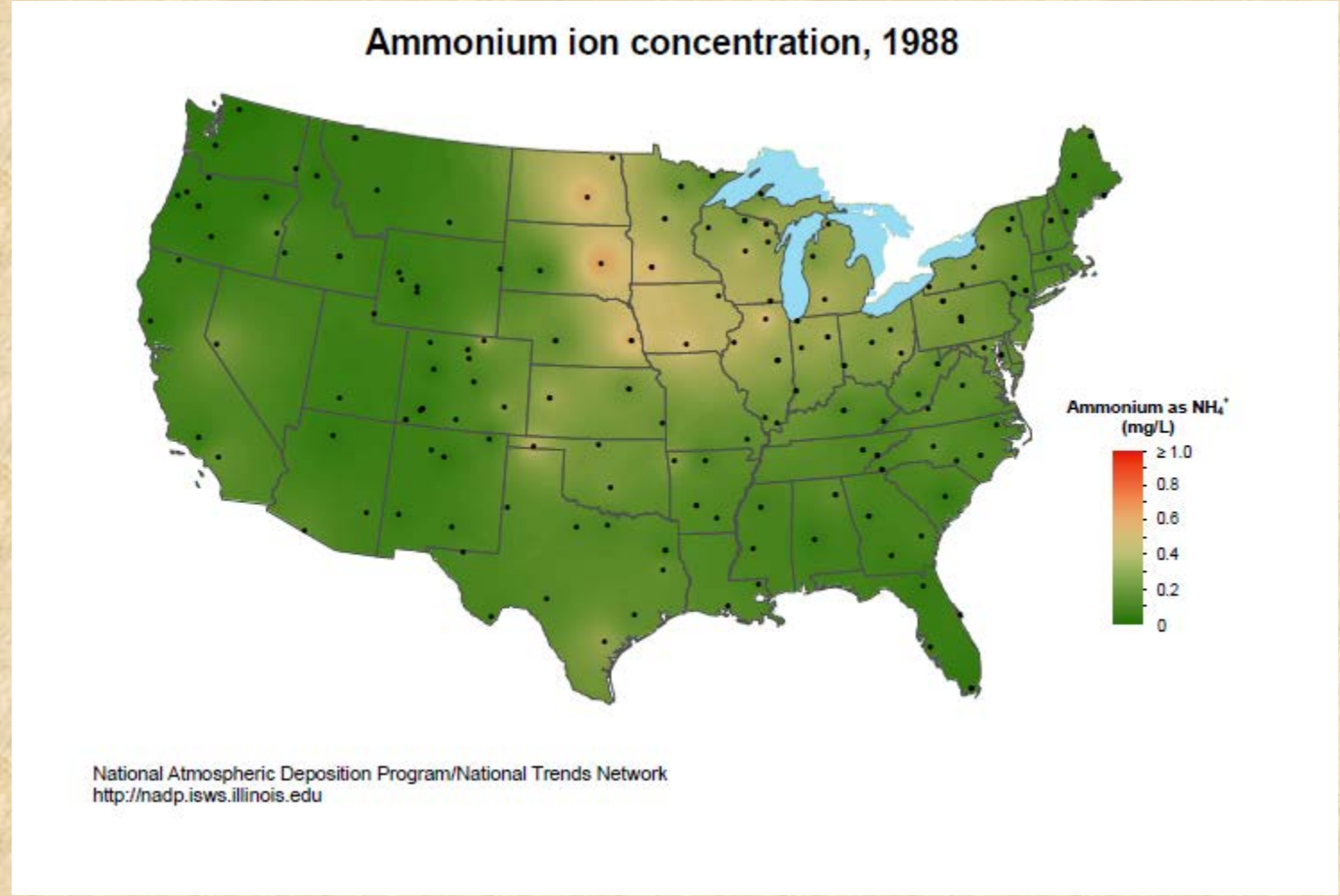
Salt Lake Valley NH_3 Emissions Inventory



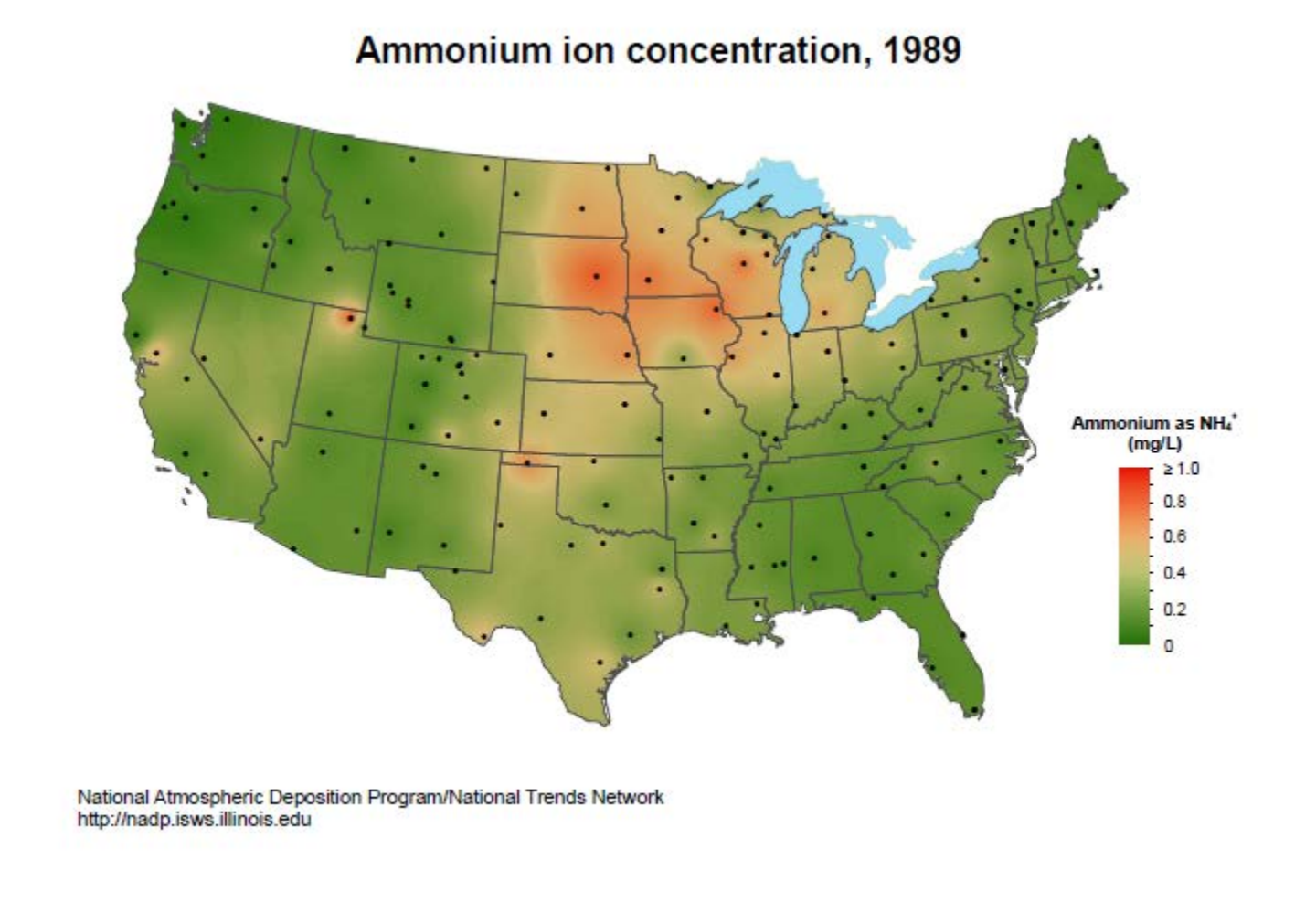
US EPA 2011 National Emissions Inventory (EI) Data

So…how much ammonia is available in the region's airsheds?

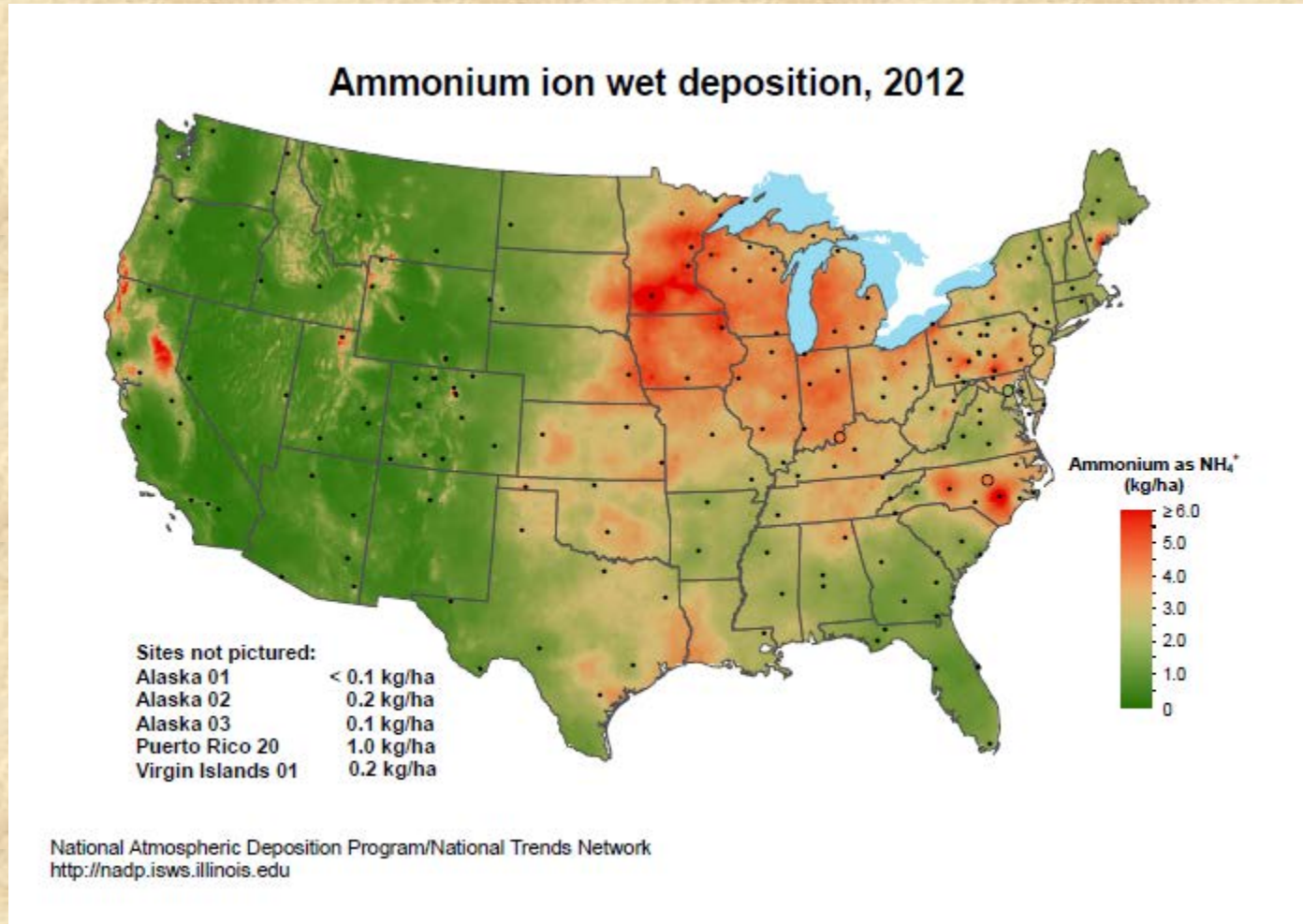
NADP's Nation Trends Network (NTN) Ammonium Ions (1988)



NADP's Nation Trends Network (NTN) Ammonium Ions (1989)



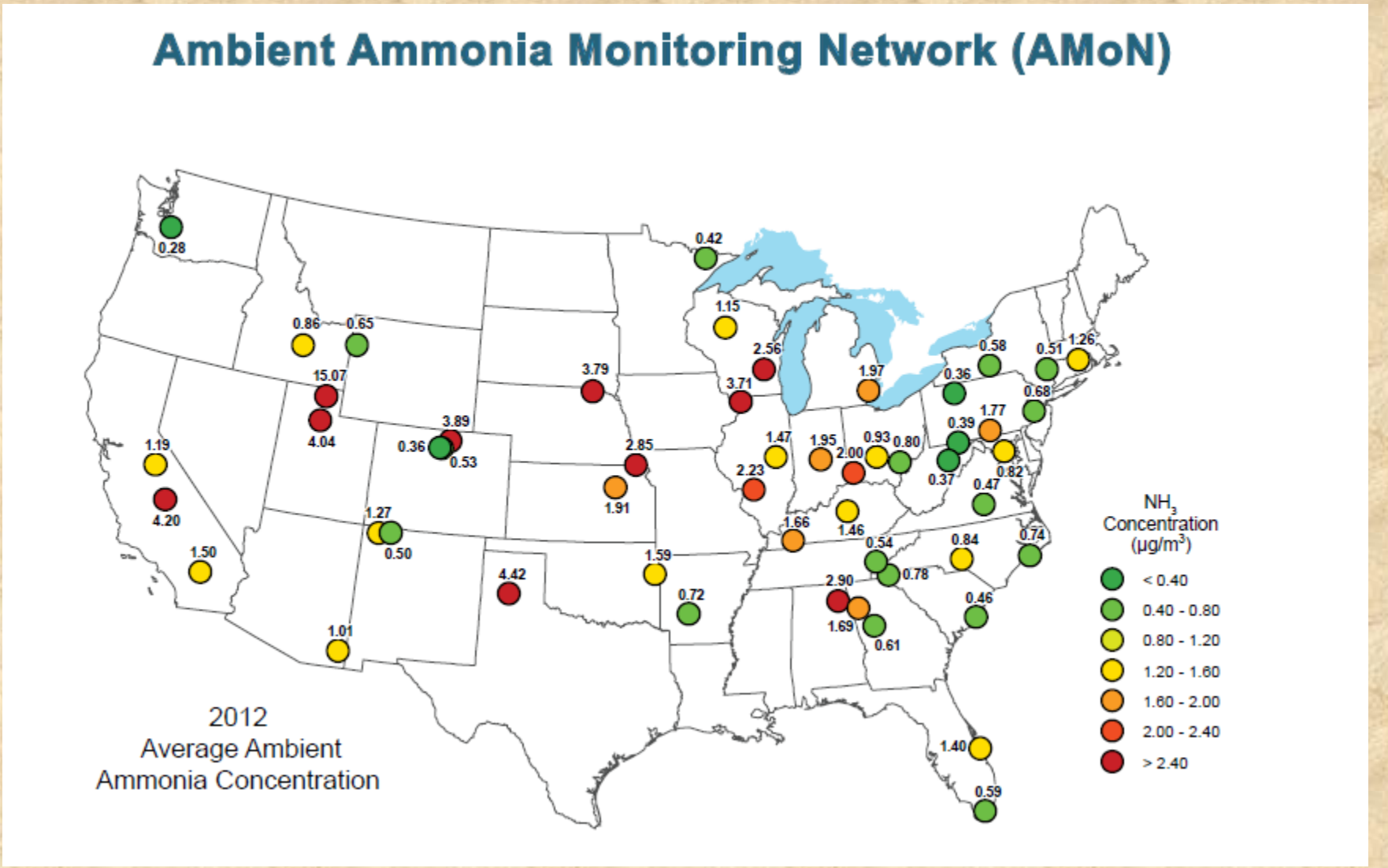
NADP's Nation Trends Network (NTN) Ammonium Ion Wet Deposition



Utah Sites in NADP's Ammonia Monitoring Network (AMoN)

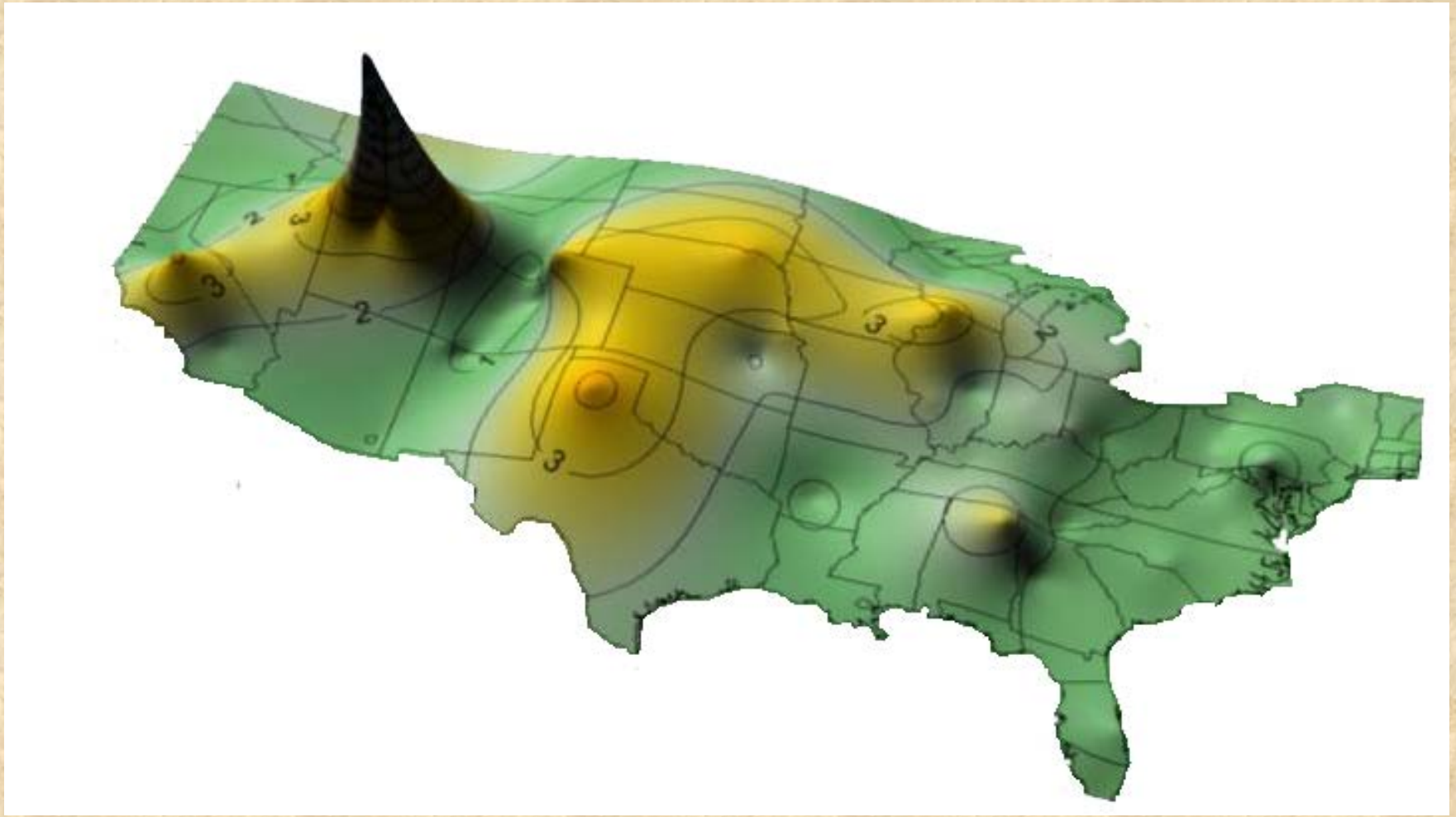
- Established under NADP in Oct. 2007
  - Passive (Radiello), 2-wk duration gas-phase ammonia (NH_3) samplers
- 3 AMoN cites currently in Utah
  - NADP NTN UT01 (Cache Valley) est'd AMoN Nov. 2011
  - NADP AMoN UT97 (Salt Lake City) also est'd Nov. 2011
  - NADP AMoN UT09 (CNP – Island in the Sky) est'd May 2014
    - Class I area, collocated with a long-established IMPROVE site

NADP's Ammonia Monitoring Network (AMoN)



"The Super Volcano"

(gaseous NH_3; AMoN 2012 data, µg/m³)




NO WARNING. NO ESCAPE.
CACHE VALLEY NH_3

But…are the seemingly high AMoN sites representative for the local airsheds?

Northern Utah Ambient NH_3

- Dec. 2002 – March 2004 (CV)
  - week-long denuder & filter samples at Logan city sampling site
- Nov. – Mar. 2004/2005 (CV)
  - hourly chemilumenescent measurements at Logan (urban) and Amalga (rural)
- Winter (Jan.-Mar.) and Summer (Jun.-Jul.) 2006 (CV)
  - valley-wide network of 17 arrayed passive Ogawa NH_3 samplers
  - three, 5-7 day sample periods during each season
- UT01 AMoN site initiated in Oct. 2011 (CV)
  - 2-week duration passive sampling
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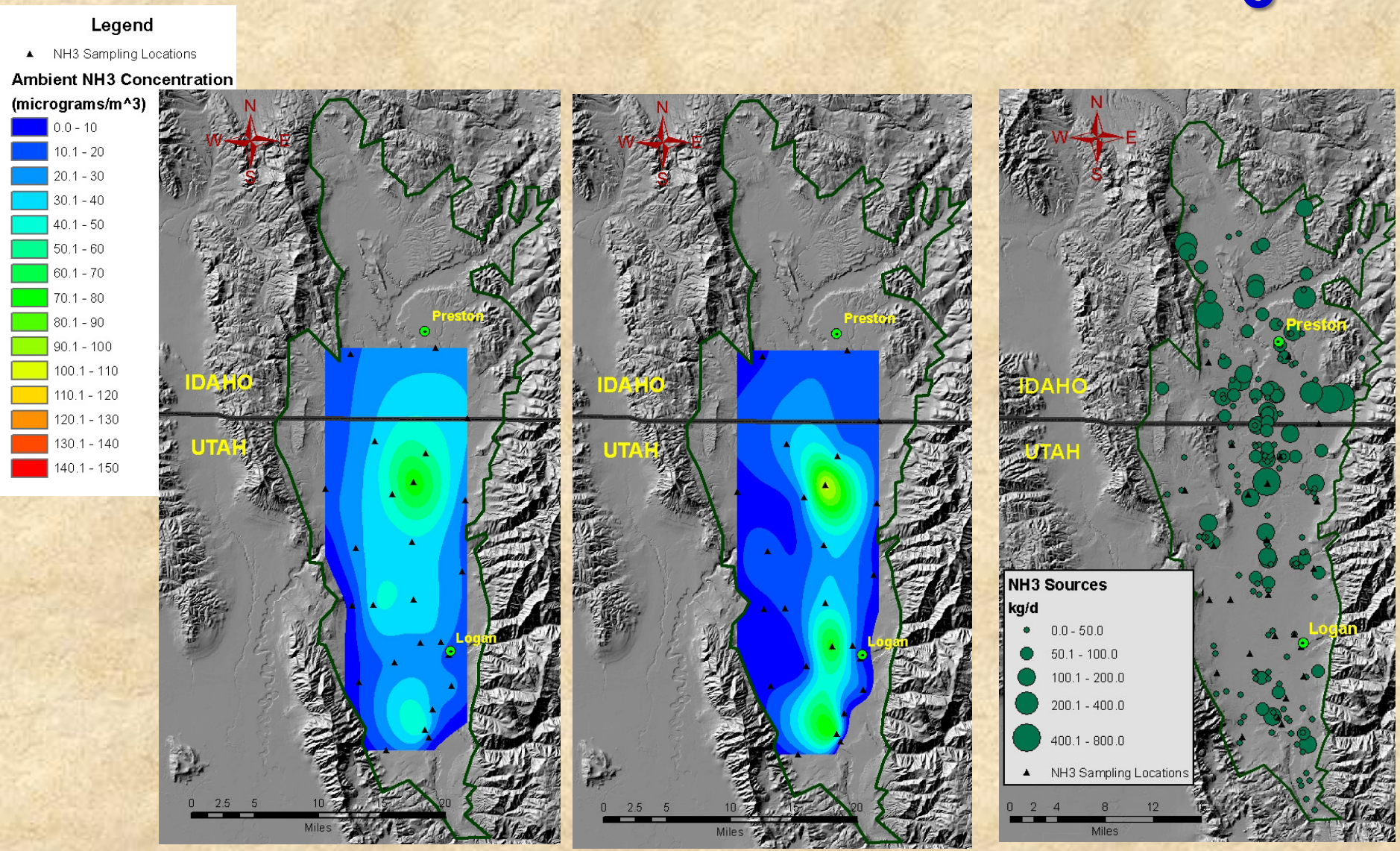
2006 Passive Ambient NH_3



Winter
(29.1 µg/m³)

Summer
(24.7 µg/m³)

NH_3 Source Density

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  - (SLC) annual [NH_3] avg = 4.2 µg/m^3; Jan.-Feb 2016 [NH_3] avg = 3.9 µg/m^3
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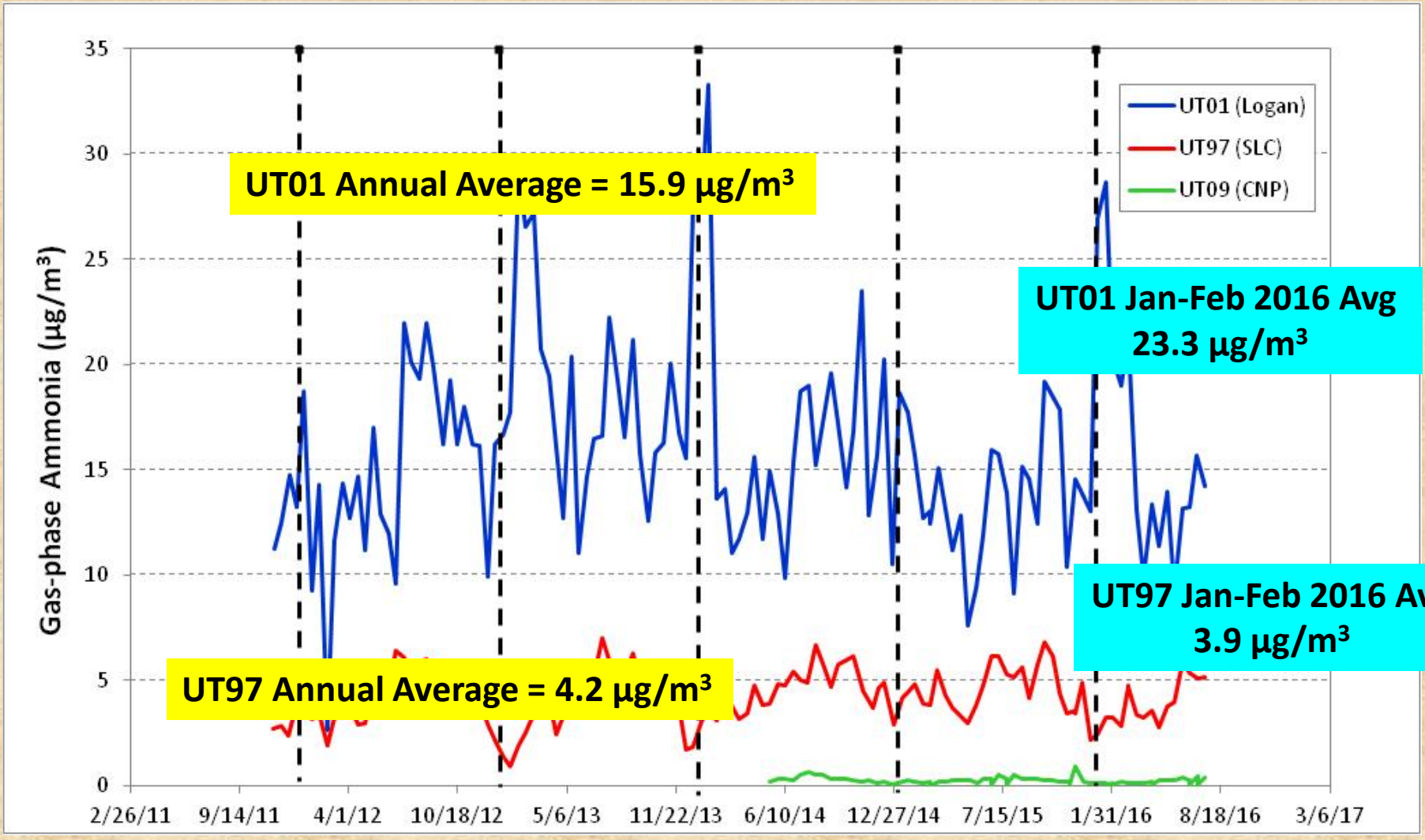
AMoN Annual Utah NH_3 (2011-2016)



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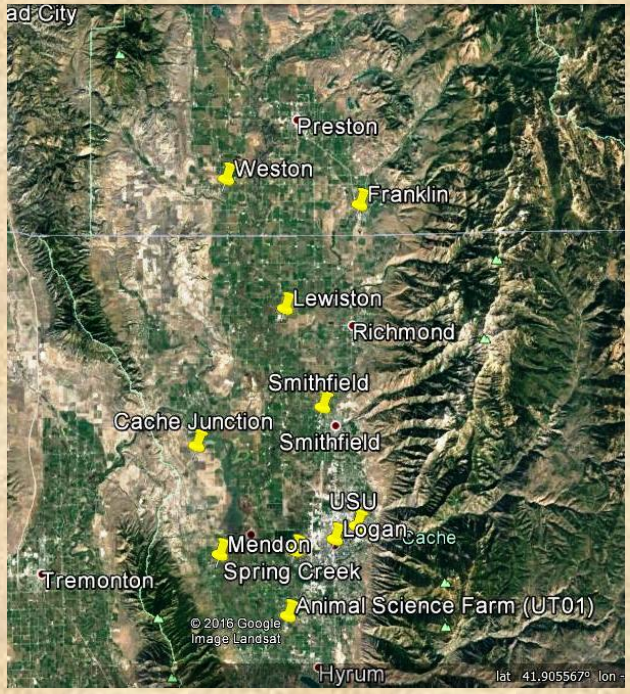
  - valley-wide networks (10 each) of arrayed passive Ogawa NH_3 samplers
  - five, 7 day sample periods during each season

Jan/Feb 2016 Passive Ambient NH_3

- USU Animal Science Farm (UT01)

- Salt Lake City (U of U campus)

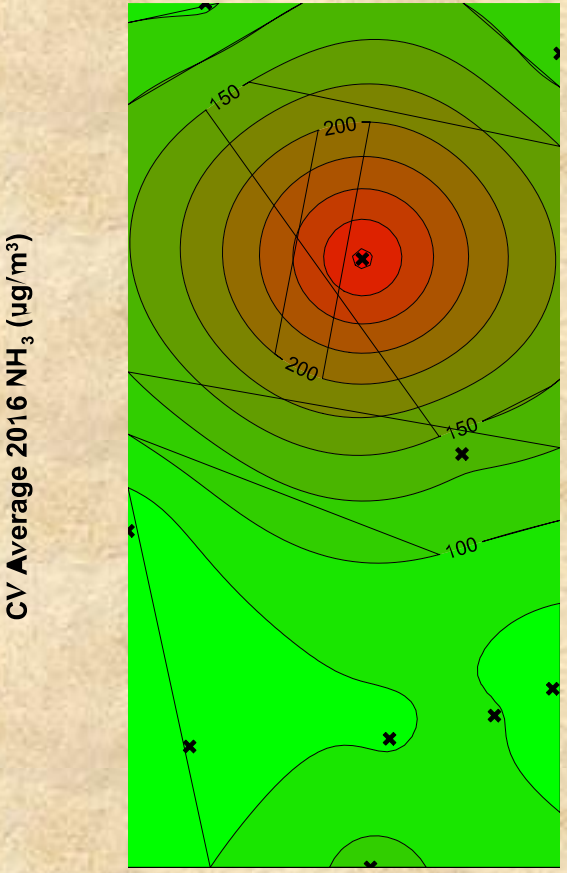
Jan/Feb 2016 Passive Ambient NH_3



Cache Valley 2016 NH_3 Network
(roughly 55 km x 20 km)

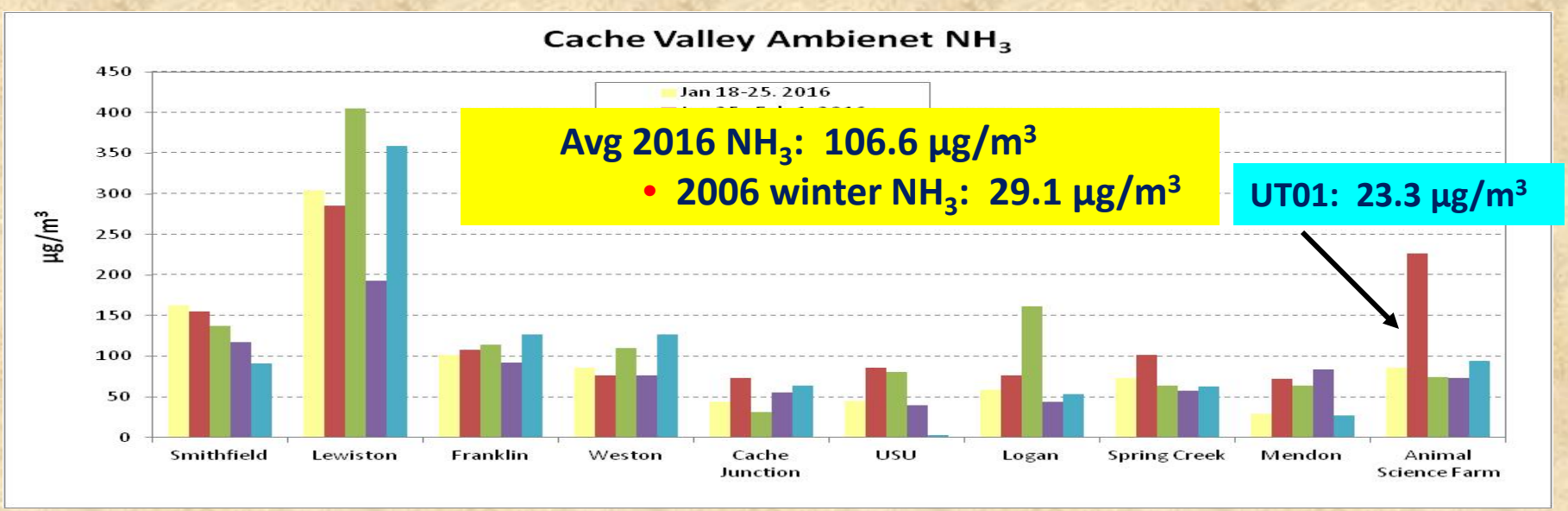
Wasatch Front 2016 NH_3 Network
(roughly 90 km x 25 km)

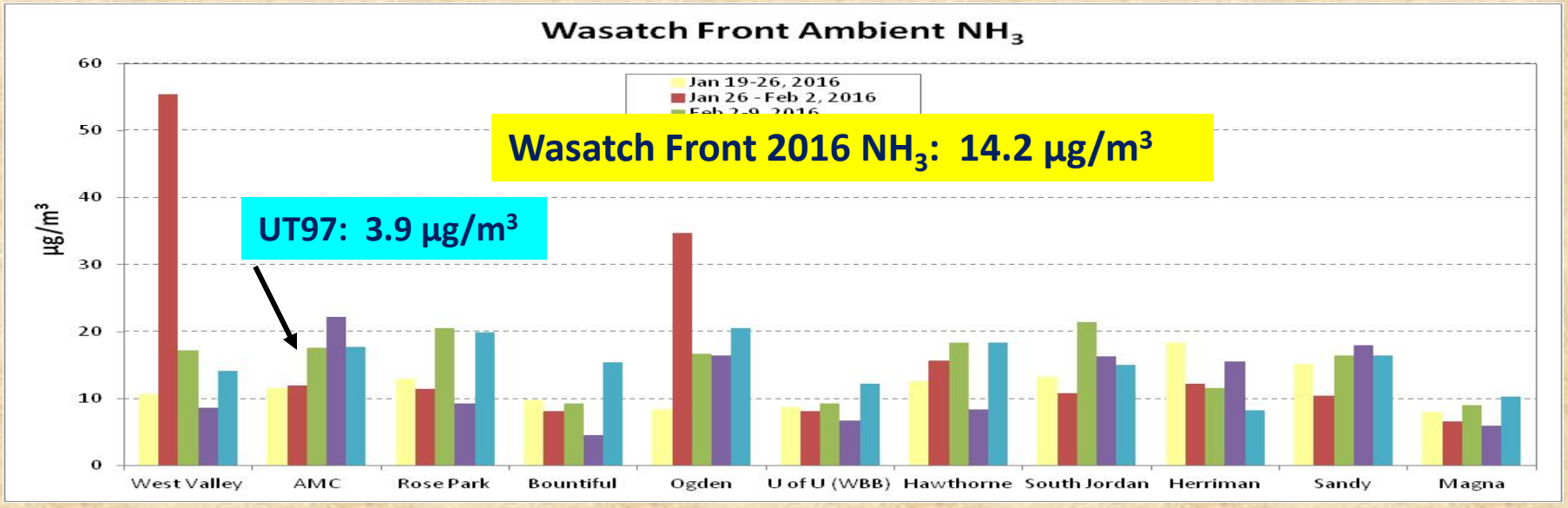
Jan/Feb 2016 Passive Ambient NH_3



- Wasatch Front 2016 NH_3: 14.2 µg/m^3

2016 Passive Ambient NH_3





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  - CV [NH_3] avg = 106.6 µg/m^3; Animal Science Farm [NH_3] avg = 111.1 µg/m^3
  - SLC [NH_3] avg = 14.2 µg/m^3; AMC 2016 [NH_3] avg = 16.2 µg/m^3

Summary

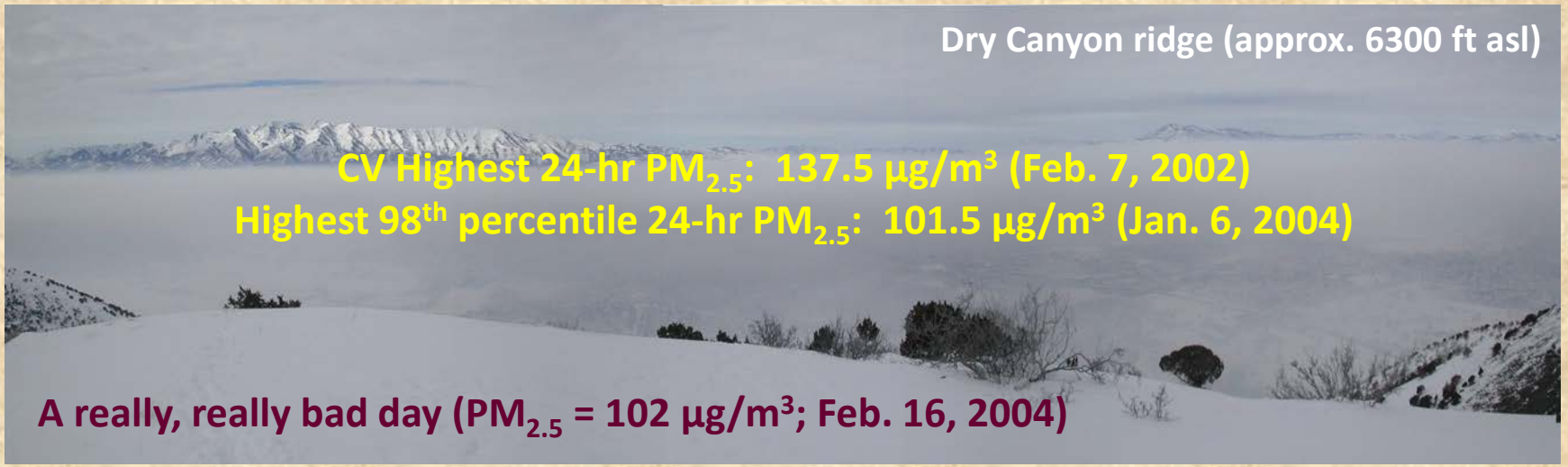
- Cache Valley (UT01) "Ammonia Super Volcano" is not a myth!
  - 3-4x higher at UT01 than other continental AMoN sites
    - the Cache Valley NH_3 Super Volcano is real!
    - local hotspots exist, but abundant gas-phase NH_3 is ubiquitous
  - SLC (UT97) among "next tier" of highest concentration areas
- NADP's AMoN location s(UT01 and UT97) seem representative for the Cache Valley and Wasatch Front
  - separate 2016 network study showed approx 4x times higher at each location
  - even though UT01 within a few hundred yards of livestock (NADP footnote "B")
- Relatively consistent ambient measurements across several different measurement campaigns/protocols

Acknowledgements

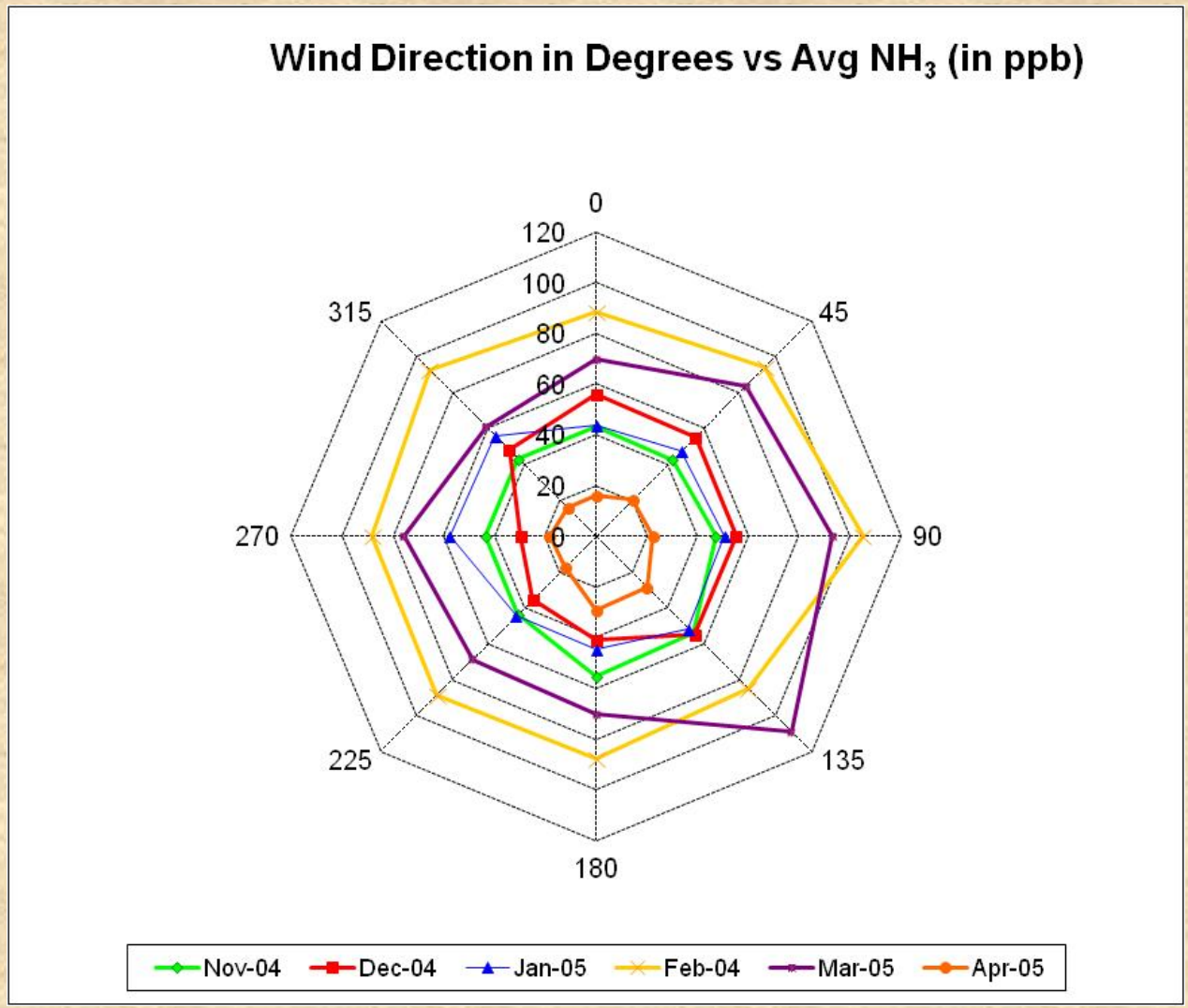
- Utah Division of Air Quality (UDAQ) and the Utah Air Monitoring Center (UAMC)
- Utah State University (USU) and the Utah Water Research Laboratory (UWRL)
- Utah Climate Center (UCC)
- Bear River Health Department (BRHD)
- Idaho Division of Environmental Quality (IDEQ)
- National Atmospheric Deposition Program (NADP) and the Ammonia Monitoring Network (AMoN)
- And way too many colleagues, students, and friends to mention…

$PM_{2.5}$ in Northern Utah

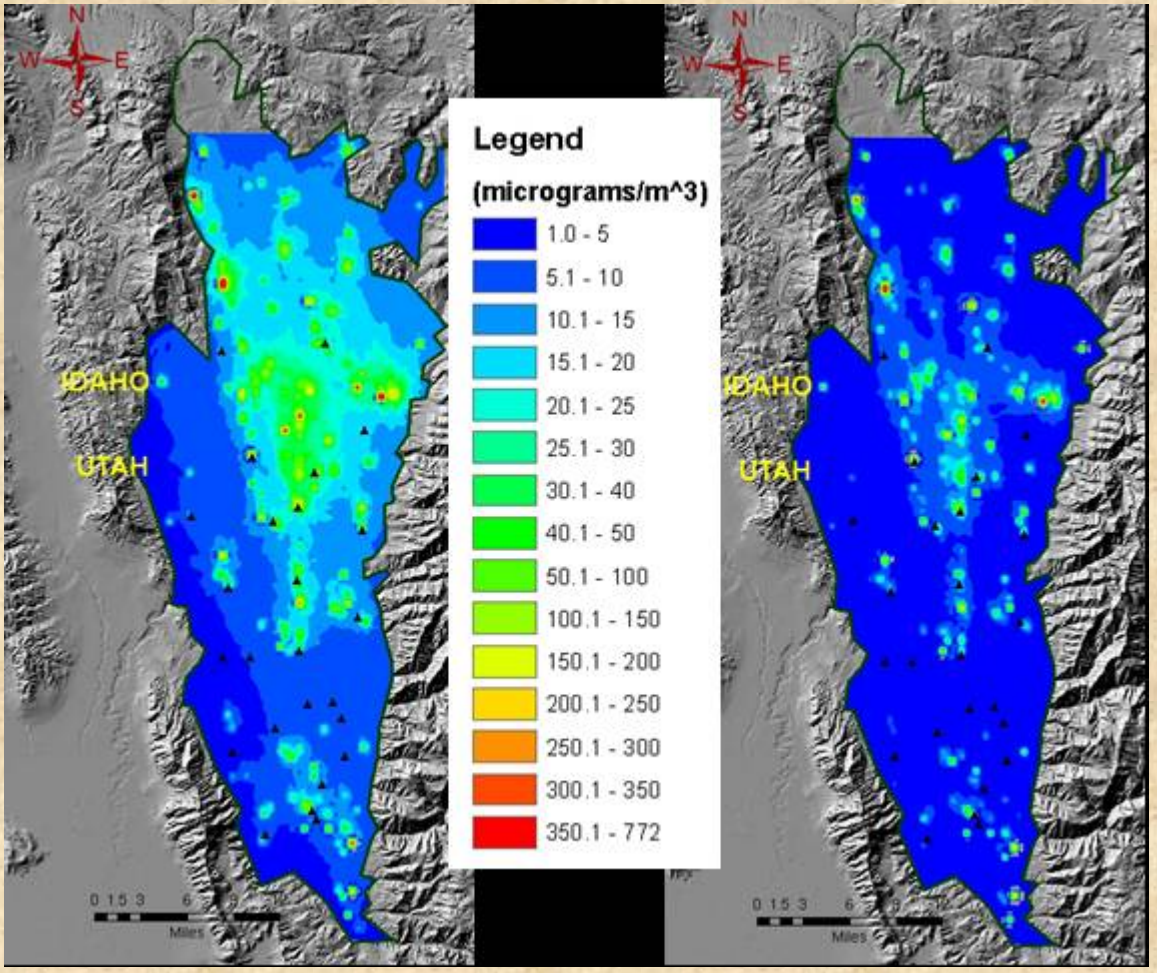
A very bad day ($PM_{2.5}$ = 82 µg/m³; Jan. 27, 2010)



04-05 Amalga (rural) NH_3 compared to Wind Direction

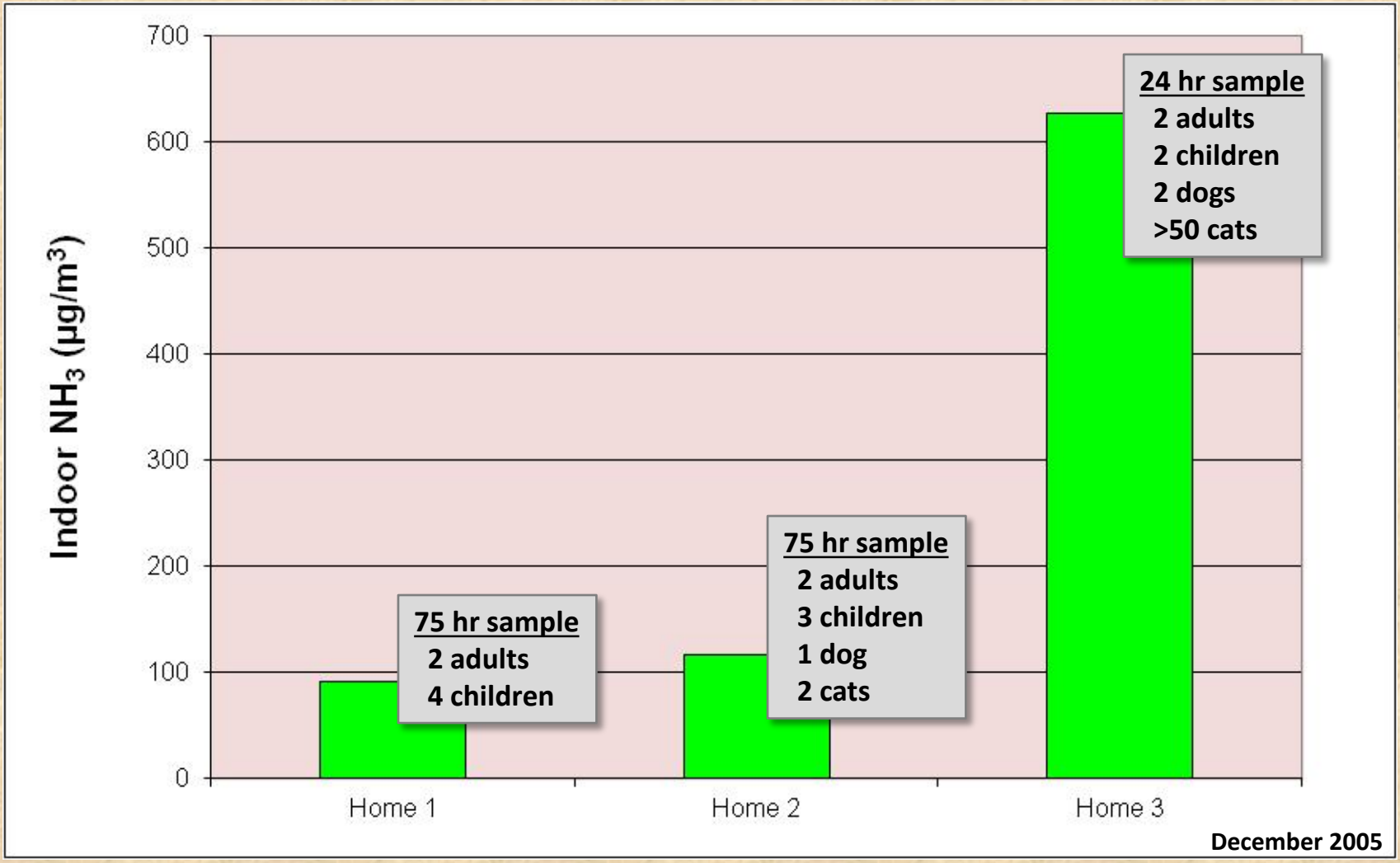


Modeled Ambient NH_3



- **Box Model: Overall NH_3 average = 4.5 µg/m³**
  - **summer: 7.5 µg/m³**
  - **winter: 1.7 µg/m³**
- **ISCST3 Model: Overall NH_3 average = 19.6 µg/m³**
  - **summer: 12.0 µg/m³**
  - **winter: 27.2 µg/m³**

Passive Indoor NH_3



UT01 NH_3 and Cache Valley $PM_{2.5}$