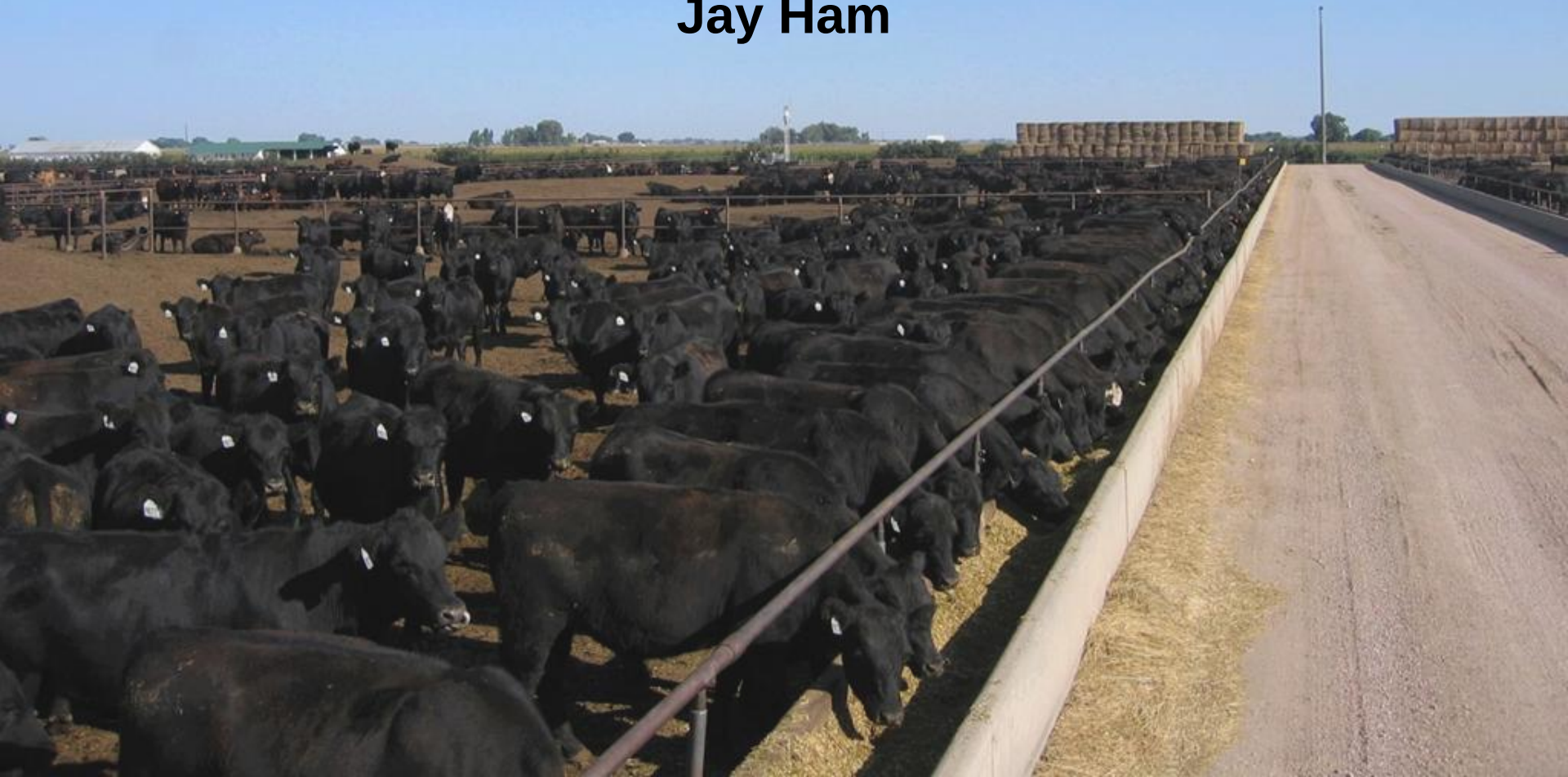
Ammonia Research Update

RMNP Agric. Subcommittee Meeting

Feb. 11, 2015

Jay Ham



Outline

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- **Ammonia Emissions from Beef Feedlots**
  - Measurement Technology
  - Emissions and Nitrogen Balances
  - Feed Management
- **Source Apportionment**
  - Soil Emissions within RMNP
  - Isotope Studies of Livestock Sources
- **NIFA /NRI Robotics Project**
  - New MRI NH_3 Laser
  - Implementation at Dairies
- **New Research / New Questions**
  - Local Deposition of NH_3 near Feedlots and Dairies

Implications for RMNP

Beef Feedlot Ammonia

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Cooperating Feedlot

- 20,000 head
- Collected data for over 2 years
- Some measurements were continuous
- Used wide range of technologies to measure NH_3 emissions
- Compared NH_3 losses to feeding data
- Modeling
- FRAPPE site

Measurement Technology

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Measurement Technology

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Measurement Technology

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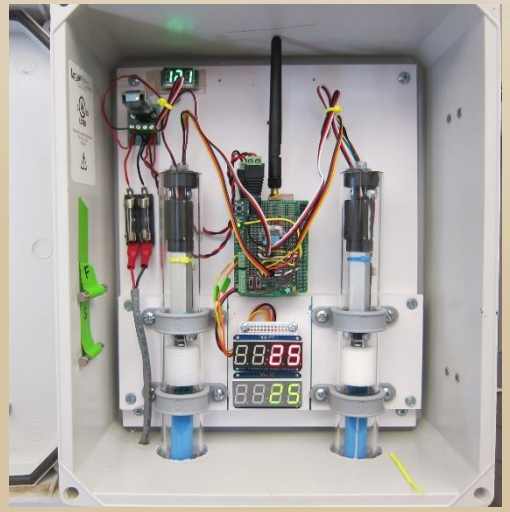

Measurement Technology

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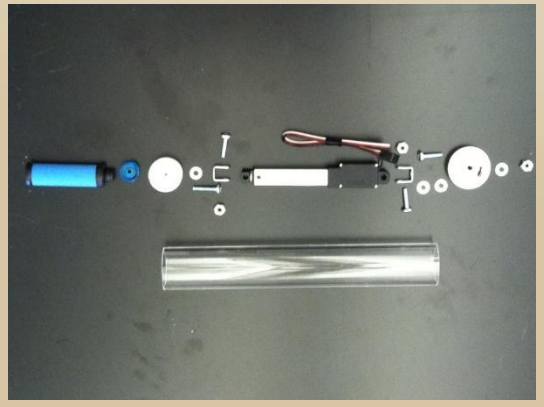

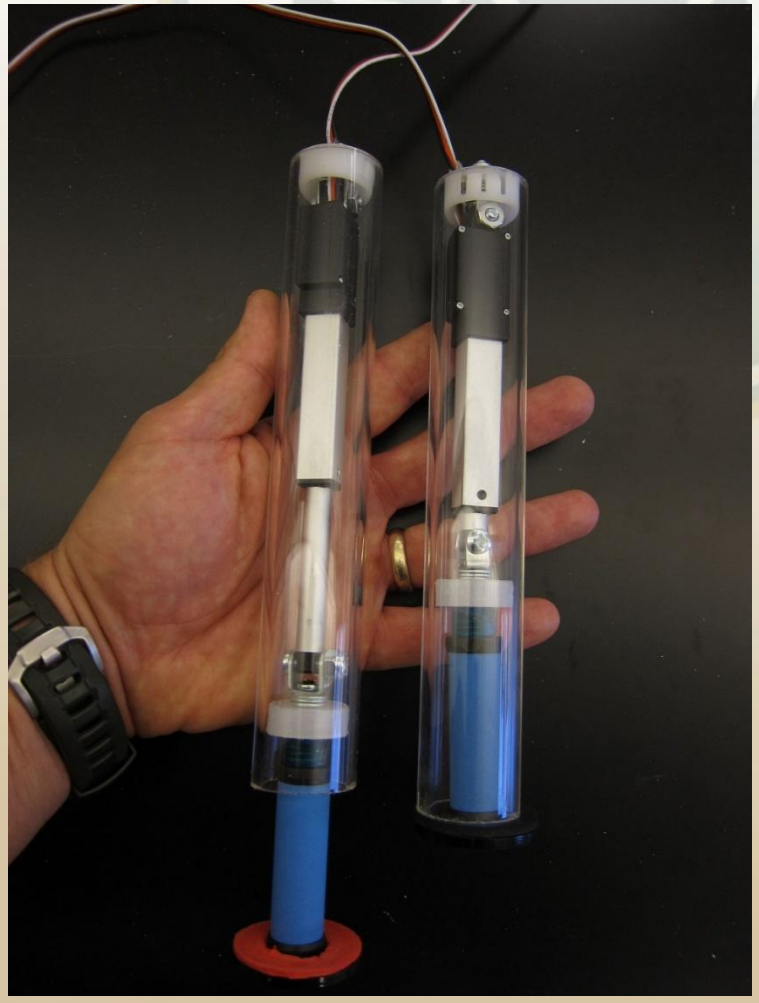

Measurement Technology

- Emissions Calculations
  - NH_3 concentrations
  - Meteorological Data
  - Feedlot/Cattle Characteristics

  - Estimate Emissions with Inverse Models
  - Compare losses to the Atmosphere to Feeding and N Excretion Data

Feedlot NH3 Concentrations

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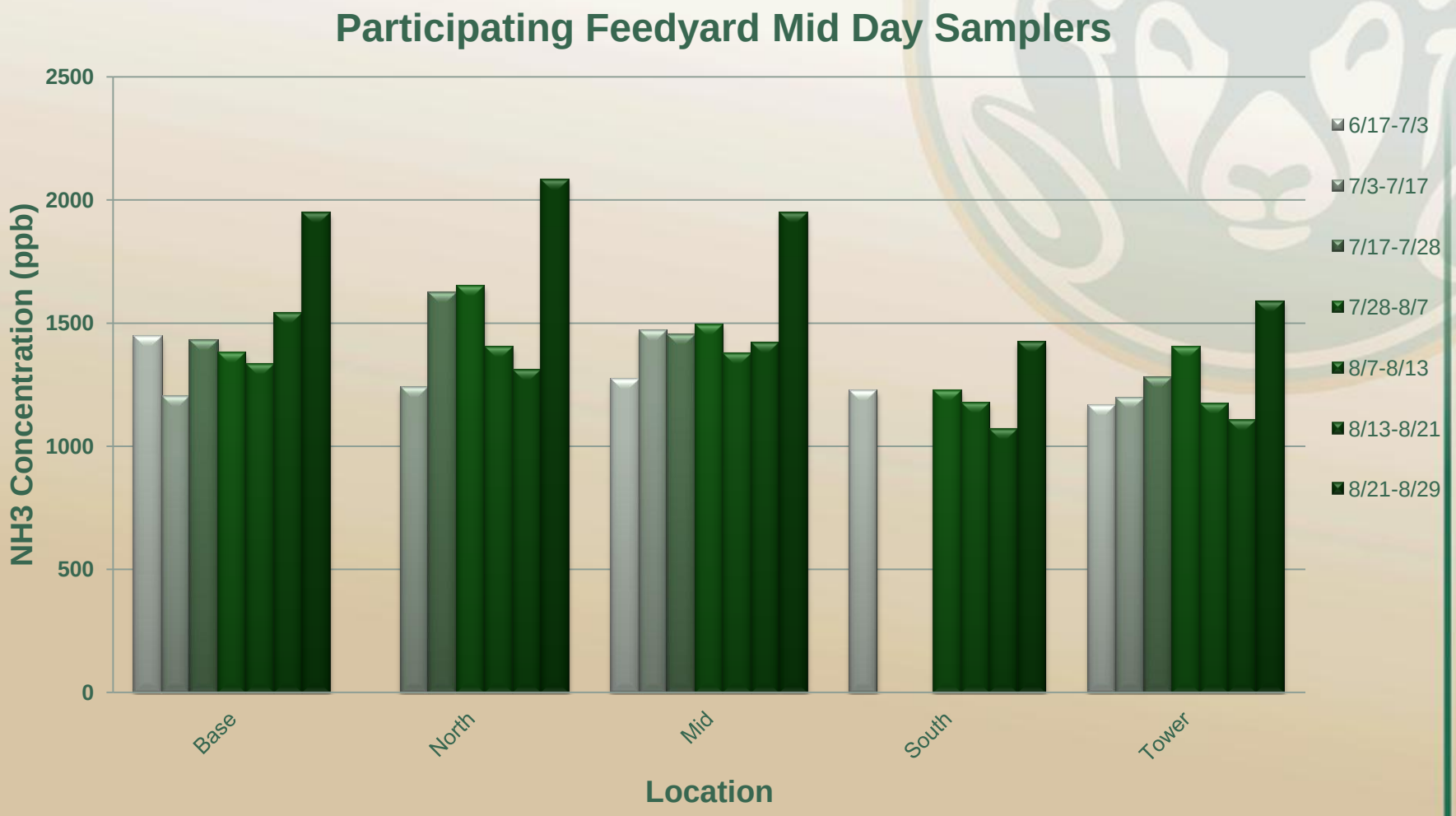

Feedlot NH3 Emissions

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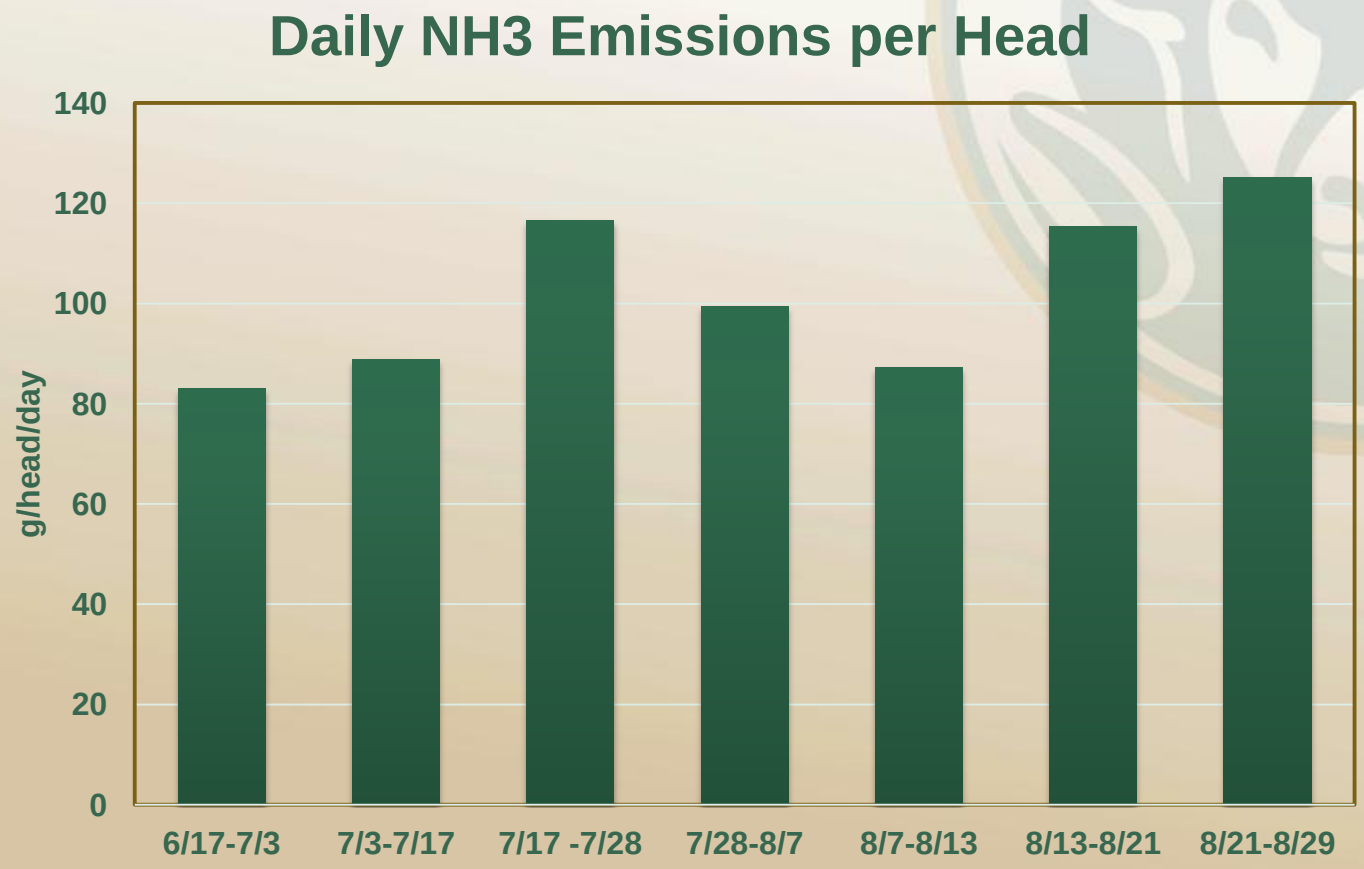

Avg. Summer Emissions = 84 g N $head^{-1}$ day^{-1}

Average N Retention and Excretion, Feedlot vs. Published Averages*

	Feedlot	Published	Feedlot	Published
	N, g/d/head	N, g/d/head	% N Intake	% N Intake
N intake	186			
Retained N	51			
Total N Excretion	135			
Urinary N	83			
Fecal N	52			

84/186 x 100 = 45 % of fed Nitrogen lost the atmosphere.

Lower than values reported from TX feedlots. Todd et al. (2008) reported 60 to 70 % of fed N lost in summer.

*using meta-analysis values from Waldrip, et al. 2013. J Anim Sci

Feedlot Ammonia

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- Results
  - Avg. summer daily NH_3 emissions in 2014 were 84 g N $head^{-1}$ or 102 g NH_3 $head^{-1}$
  - Emissions represent 45% of fed nitrogen, lower than values reported in TX feedlots in summer (Todd et al., 2008).
  - NH_3 Emissions were almost equal to excreted urinary N
  - Wintertime emissions were significant – did not decline with temperature as much as expected.
  - Likely NH_3 volatilization occurs quickly from urine patches, making it difficult to reduce emissions with pen cleaning and manure management strategies.

In-Park Ammonia Emissions

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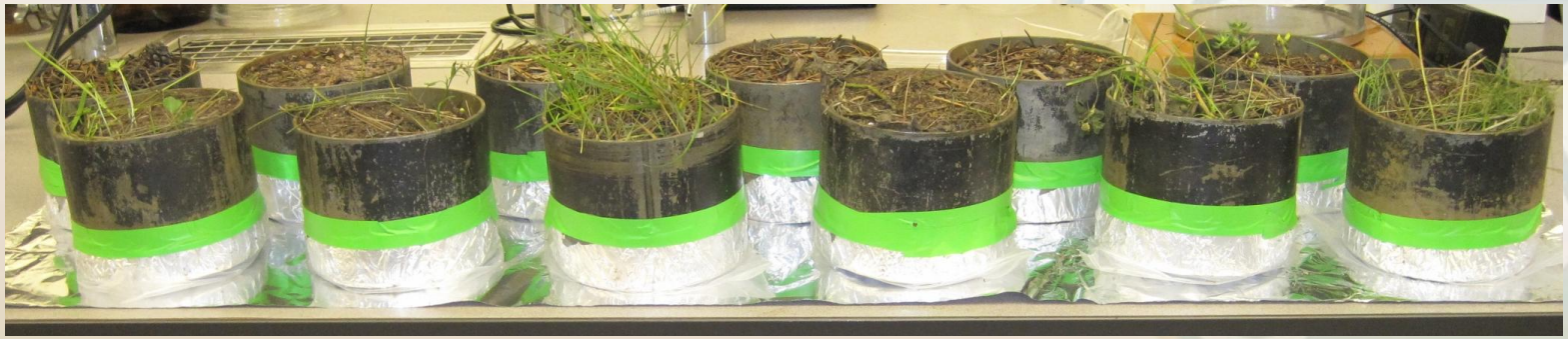
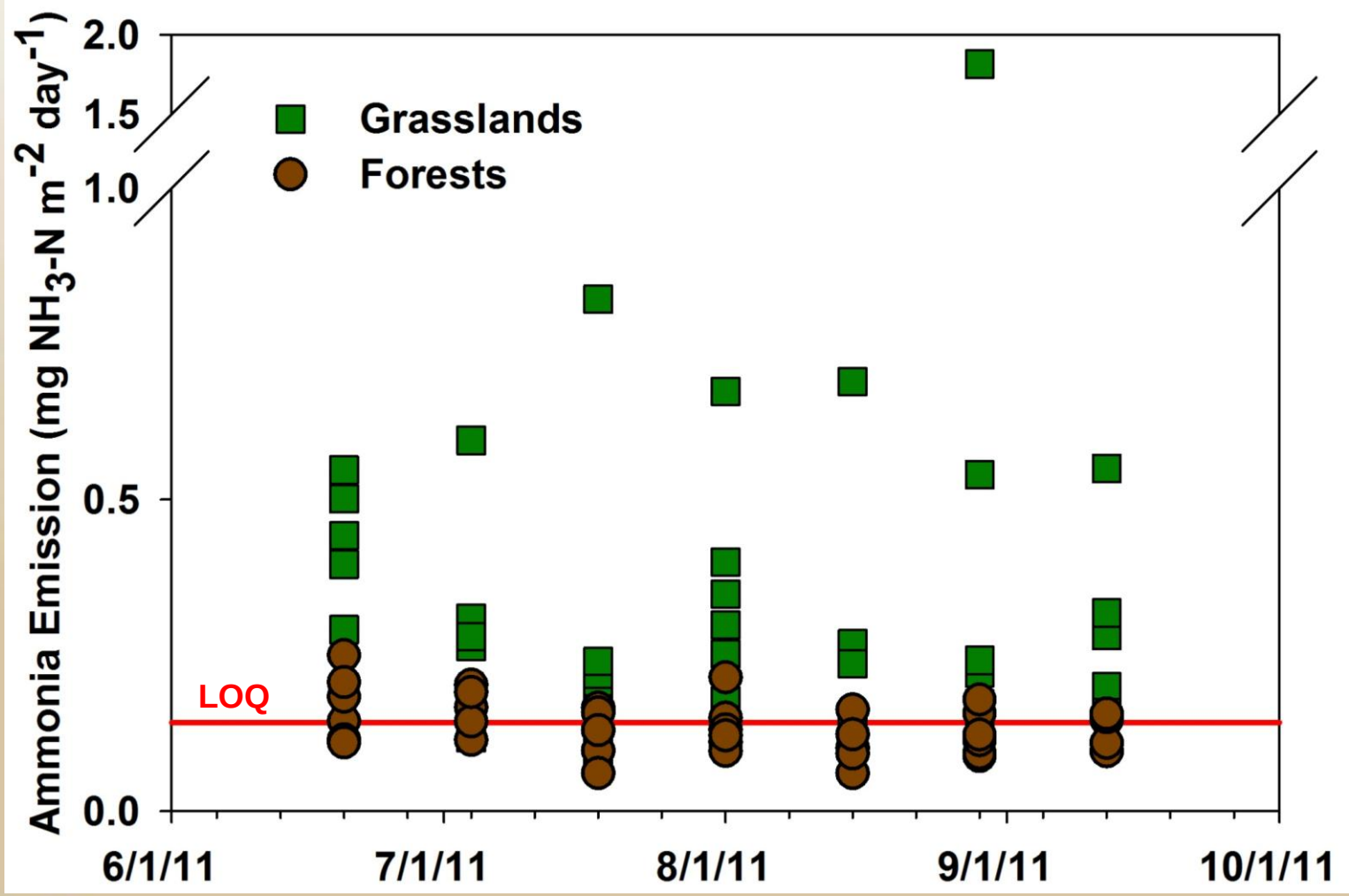


Ammonia Lost from Native Soils



In-Park Soil Ammonia Emissions

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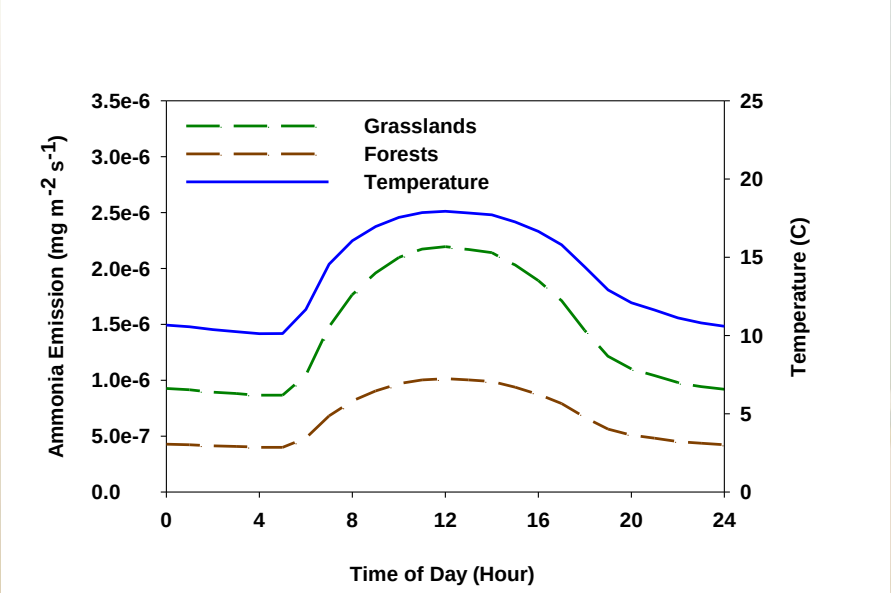
Results

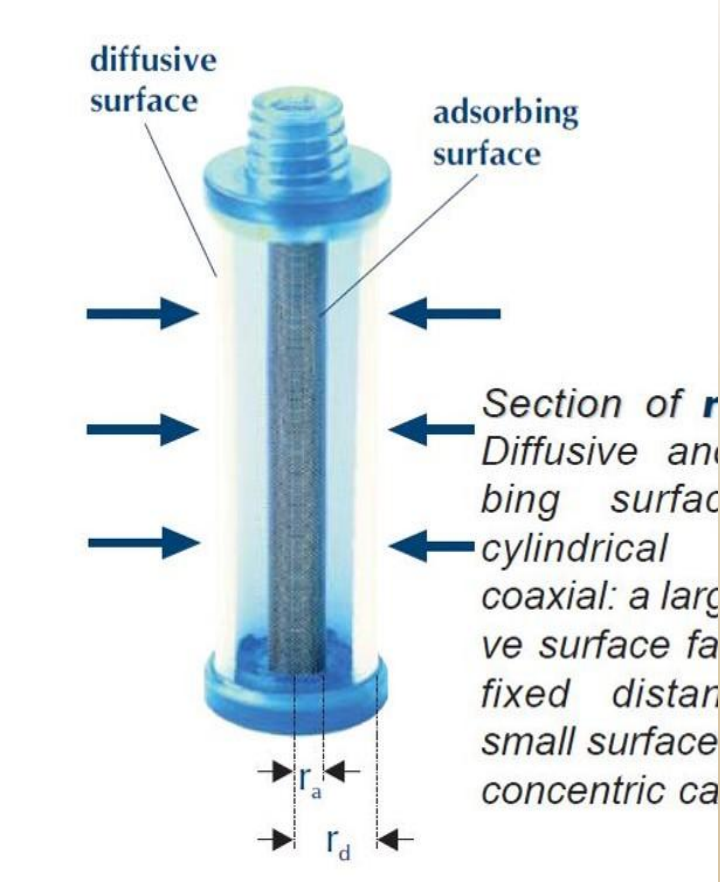
- Soil emissions were very small
- Equal to about 5% of the wet deposition of NH_3 during the same period.

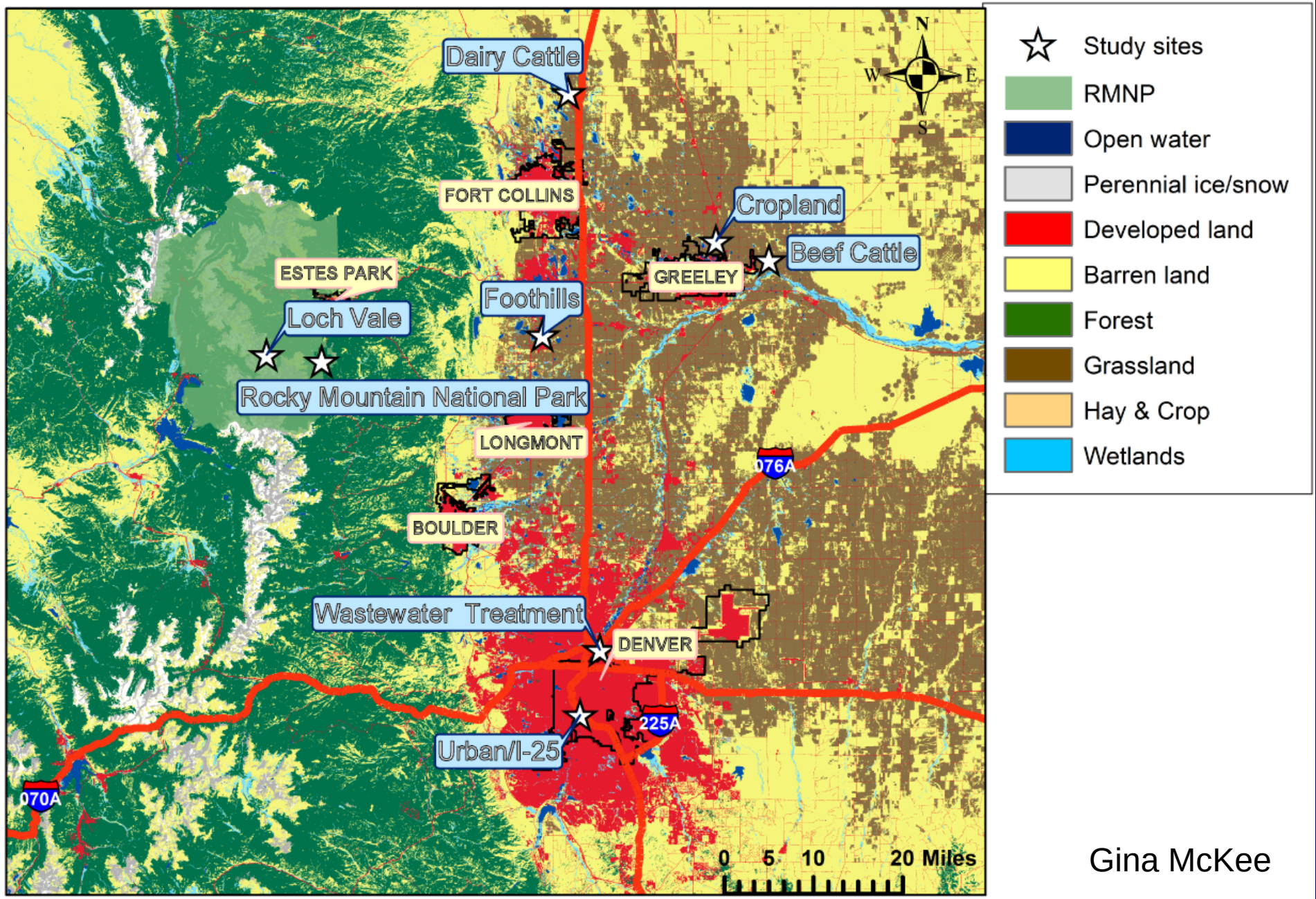


Ammonia Emissions from Sub-Alpine Forest and Mountain Grassland Soils

Joshua J. Stratton[1], Jay Ham[2, *], and Thomas Borch
(in preparation for J. Env. Quality)

Isotope Studies





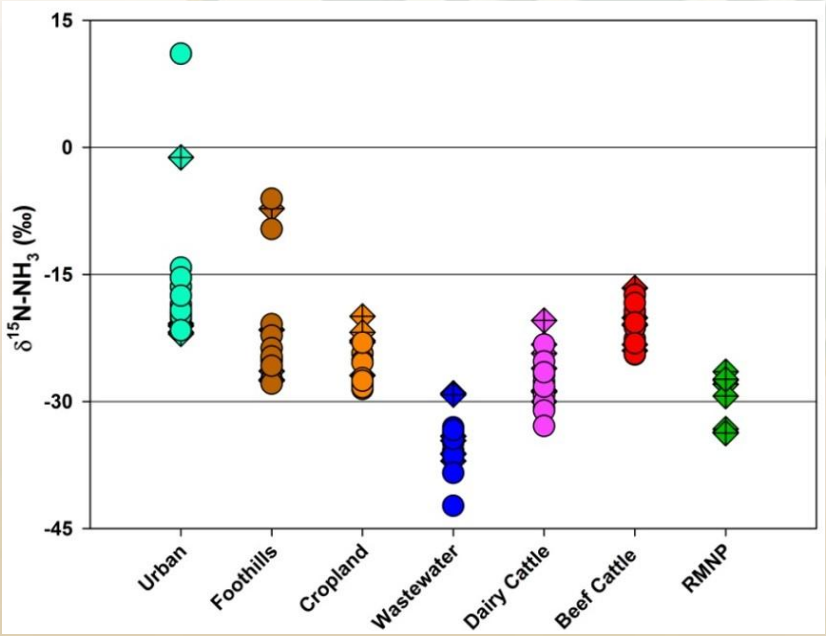
Gina McKee

Stratton, J., Ham, J. M., Williams, C, Benedict, K. B., Chen, D., Roosendaals, D., Collett, Jr., J.L.., and Borch, T.· Assessing the Efficacy of Nitrogen Isotopes to Distinguish Colorado Front Range Ammonia Sources Affecting Rocky Mountain National Park. *Atmospheric Environment*. Internal Review 201_.

Isotope Studies

Results

- There were some small differences in isotope fractionation, but most sources were similar.
- Additional fractionation occurred in the atmosphere while in transit to RMNP
- Isotopes cannot be used as a “fingerprint” to identify the source of N deposited in the park



Robotics Project

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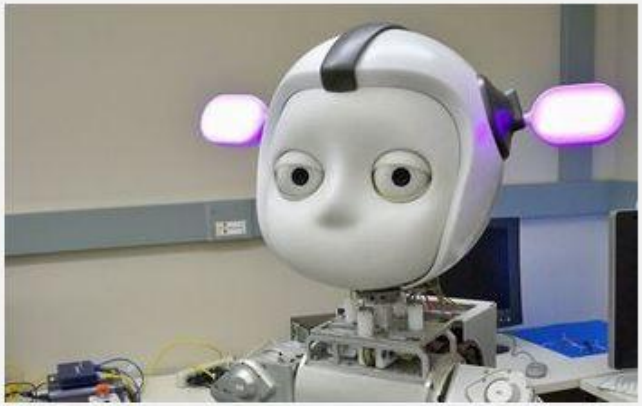
National Robotics Initiative invests $38 million in next-generation robotics

NSF, NIH, USDA and NASA fund development of robots that collaborate with humans for enhanced productivity



Simon the robot, developed by Georgia Tech researcher Andrea Thomaz, learns from human users.
Credit and Larger Version

"The goal of the National Robotics Initiative is to accelerate the development and use of robots in the United States that work beside, or cooperatively with, people."

Robotics for Managing Air Emissions of Ammonia at Livestock Operations. USDA. Ham et al. $605,000

Robotics for Managing Air Emissions of Ammonia at Livestock Operations

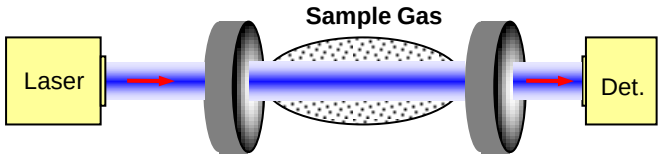
J. Ham, A. Yalin, S. Archibeque, M. Carolan, and K. Kummerow

Colorado State University

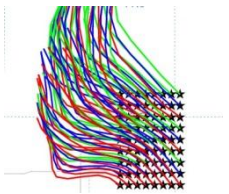
Goal: Develop a robotic air-quality management system for dairies and cattle feedlots that will help managers reduce ammonia emissions

Rationale: Livestock in cattle feedlots and dairies are the nations largest source of atmospheric ammonia. The reactive nitrogen can be deposited back the surface during precipitation events and have negative environmental consequences, especially in pristine alpine ecosystems like Rocky Mountain National Park, Colorado. New technology is needed to help livestock producers reduce the impact of NH3 emissions.

- Design new low-cost laser sensor for real-time NH_3 monitoring
- Develop a wireless NH_3 sensor network



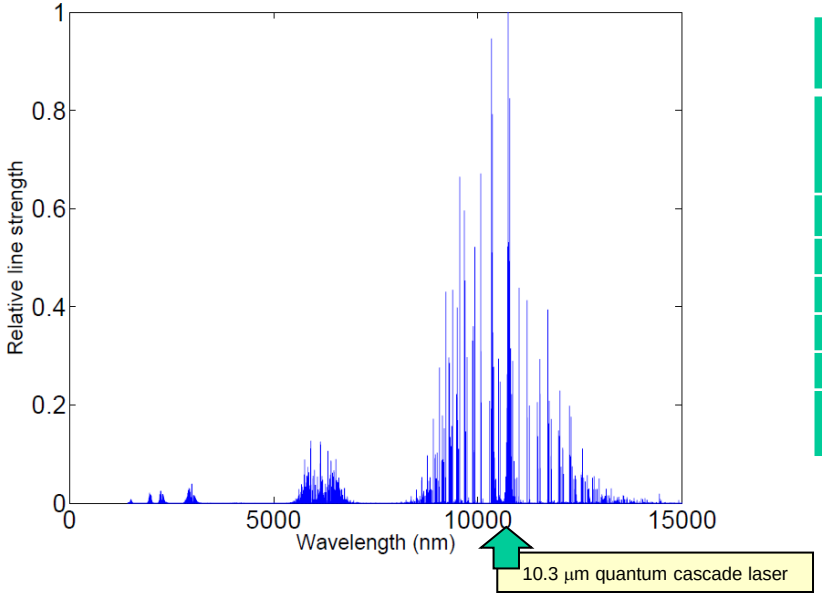
- Design weather forecast retrieval system to predict NH_3 emissions and transport in advance.



Open Path CRDS NH_3 Laser Sensor

Approach: We are developing a low power (<100 W), lightweight (<5 kg) laser based sensor for measurement of ammonia (NH_3) concentration. We employ a novel open-path cavity ring-down spectroscopy (CRDS) configuration. CRDS is an attractive technique for concentration measurements owing to its high sensitivity (~20 ppbv precision) and quantitative nature. In contrast to commercial CRDS instruments , the sensor we are developing is open-path, meaning that the flow cell and vacuum pump are not required, which removes "inlet effects" and is enabling for a low-power, lightweight package.

Higher Absorption at 9-10 μm (MIR)



Comparison with State of the Art

Specification: Model:	Picarro[a]	Boreal[b]	Los Gatos	CSU[c]
Model	G2103	Gas Finder 2	Ammonia Analyzer – Econ. (NH3, H2O)	
NH_3 Precision (1 Hz)	2.2 ppbv	10 ppbv	0.2 ppbv	0.02 ppbv
Frequency	0.3 Hz	1 Hz	5 Hz	10 Hz
Power	260 W	24 W	300 W	80 W
Mass	32 kg	5 kg	60 kg	5 kg
Size	46 L	8 L	170L	7 L

(a) 1 ppbv precision at 0.2 Hz, scaled by inverse square root to 1 Hz; (b) 1000 ppbv-m precision, scaled for 100 m path length; (c) currently under development

CSU Laser Lab

Colorado State University

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Center for Laser Sensing and Diagnostics (CLSD)

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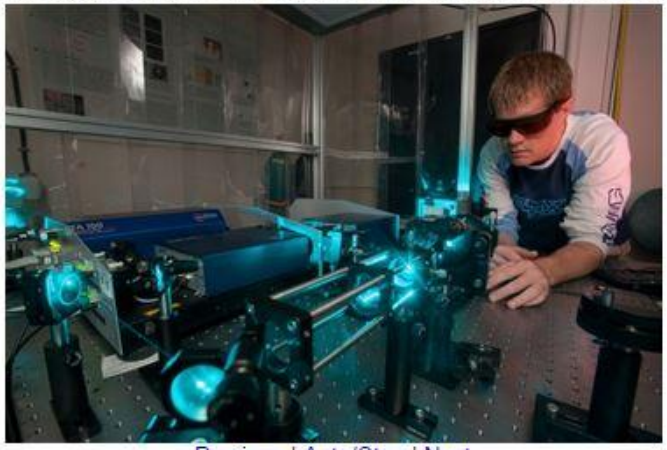
Welcome

Our research focuses on laser-based measurement of gases, plasmas, and plasma-surface interactions (for plasma science and electric propulsion applications). Interests also include laser ignition of engines, laser combustion diagnostics, high-power fiber delivery, and laser sensing for environmental and health applications.



Previous | Auto/Stop | Next

Azer Yalin Research Group

Implementation at Dairies

New Research / New Questions

- Local Dry Ammonia Deposition
  - What fraction of NH_3 emissions from a feedlot or dairy are deposited back the surface locally (1-3 km) downwind of the site (i.e., not subject to long distance transport).

Research Article

Meteorological and Back Trajectory Modeling for the Rocky Mountain Atmospheric Nitrogen and Sulfur Study II

Kristi A. Gebhart,[1] William C. Malm,[2] Marco A. Rodriguez,[3] Michael G. Barna,[1] Bret A. Schichtel,[1] Katherine B. Benedict,[4] Jeffrey L. Collett Jr.,[4] and Christian M. Carrico[3]

Chapter 15

Ammonia Deposition Near Hot Spots: Processes, Models and Monitoring Methods

Benjamin Loubet*, Willem A.H. Asman, Mark R. Theobald, Ole Hertel, Y. Sim Tang, Paul Robin, Mélynda Hassouna, Ulrich Dämmgen, Sophie Genermont, Pierre Cellier, and Mark A. Sutton

Deposition of NH_x within 1 km from hot spots ranges from 2% to 60% of emitted NH_x, and is mainly due to dry deposition of NH_3, since wet deposition, in a temperate climate, is evaluated as less than 5% recapture of the emitted NH_x. Moreover, photochemical reactions and chemical reactions with gaseous acids are unlikely to greatly affect local dispersion and deposition of NH_x near hot spots.

New Research / New Questions

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