Quantification of Agricultural Ammonia Emissions by Satellite and Airborne Hyperspectral Thermal-Infrared Spectrometry

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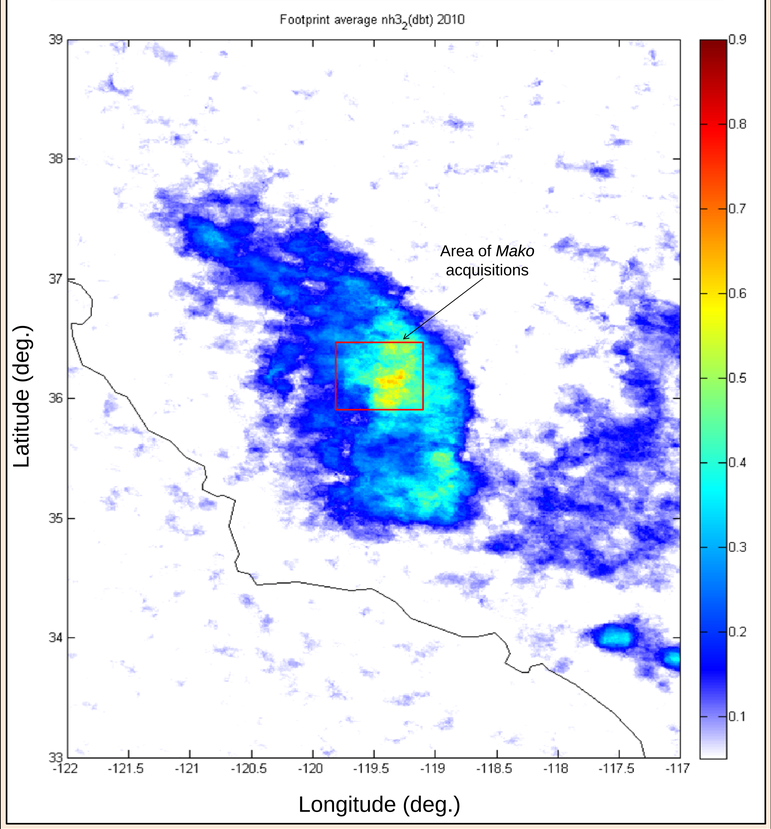
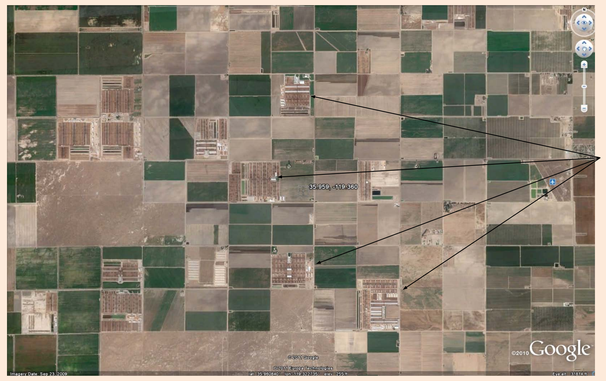
A new airborne sensor with the requisite spatial, spectral, and radiometric resolution to characterize "point" sources of ammonia (NH_3) emission has been used to characterize agricultural emissions. The instrument (*Mako*) is a whiskbroom hyperspectral imager operating in the thermal infrared at 7.6-13.2 μm and has been described previously (Warren *et al.*, 2010; Hall *et al.*, 2011). Flights were conducted over California's San Joaquin Valley (SJV), which is a region of intensive agriculture and animal husbandry that has been identified as one of the single largest sources of atmospheric free ammonia worldwide (Clarisse *et al.*, 2009, 2010).

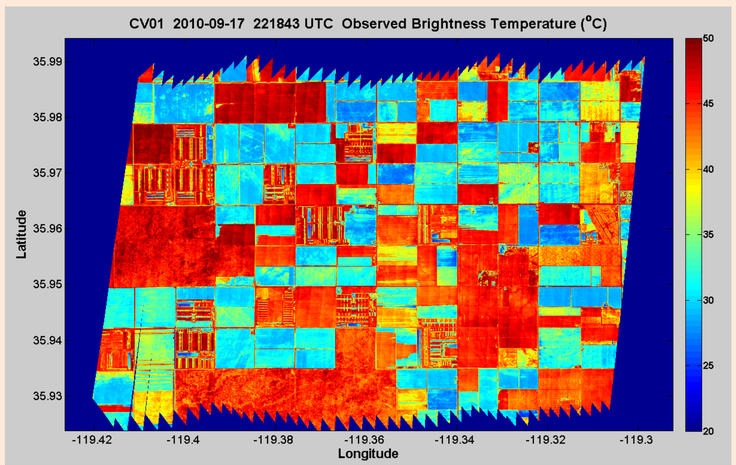
Airborne data acquisition operations were coordinated with daytime and nighttime overpasses of the Infrared Atmospheric Sounding Interferometer (IASI) aboard the European Space Agency's MetOp-A platform. IASI is capable of measuring total columns of ammonia (Clarisse *et al.*, 2009, 2010) and the primary purpose of this investigation was to cross-compare and co-validate the IASI ammonia product against high-spatial-resolution airborne retrievals acquired contemporaneously over the same footprint.

IASI annual average NH_3 in the SJV for 2010

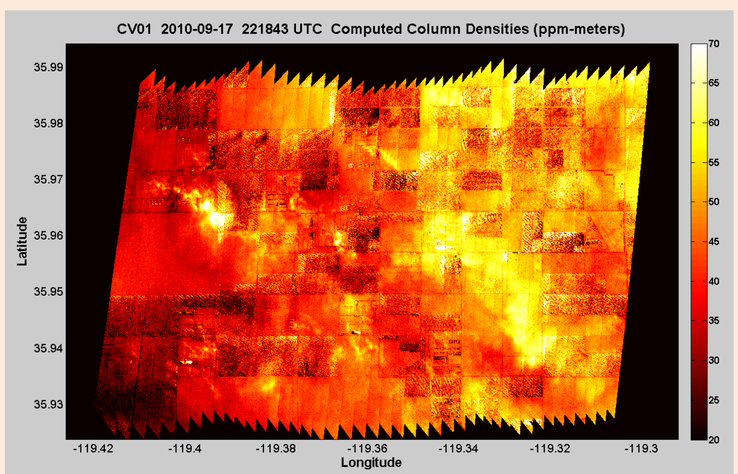




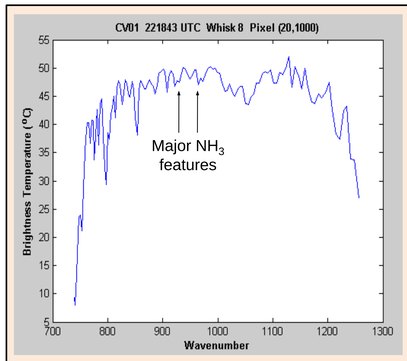
Overhead view of mixed arable plots, uncultivated land, and dairy feedlots near Pixley in Tulare County, California. The feedlots are distinguishable by the presence of elongated rectangular structures.



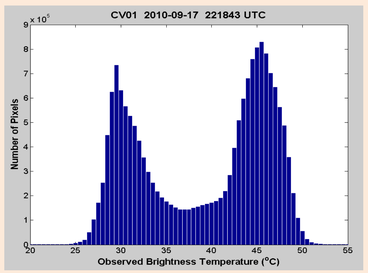
Mako brightness temperature map at 10.7 μm of an 11-km x 6.5-km region. Data were acquired from an aircraft altitude of 12,500 ft (3.8 km) AGL.



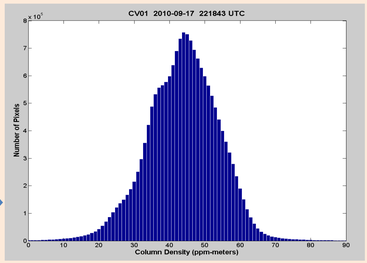
Retrieved ammonia column densities over the corresponding area, showing association of the most intense plumes with proximity to dairy feedlots.



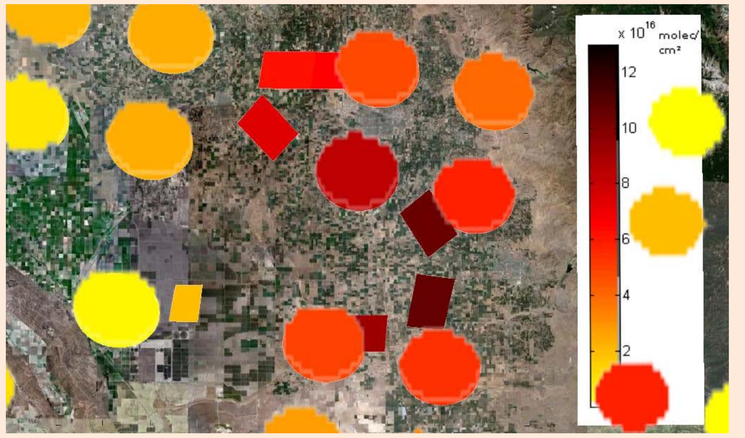
Sample pixel spectrum from the scene at left, highlighting the presence of NH_3 spectral fingerprint features.



Average column density is 43.7 ppm-meters (NH_3 temp. 24.5 C). For NH_3 temp. = 27.0 C, average column density increases to 55.6 ppm-m.



Regional comparison between IASI and *Mako* NH_3



(IASI: Ellipses; *Mako*: Parallelograms)

The nominal 2-m pixel size of the airborne data revealed variability of ammonia concentration at several different scales within the ~12-km IASI footprint. At this pixel size, well-defined plumes issuing from individual dairy facilities could be imaged and their dispersion characteristics resolved. Retrieved ammonia concentrations in excess of 50 ppb were inferred for some of the strongest discrete plumes.

References

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