NASA Science in the Middle of Nowhere:

Measuring Greenhouse Gases in Railroad Valley, NV

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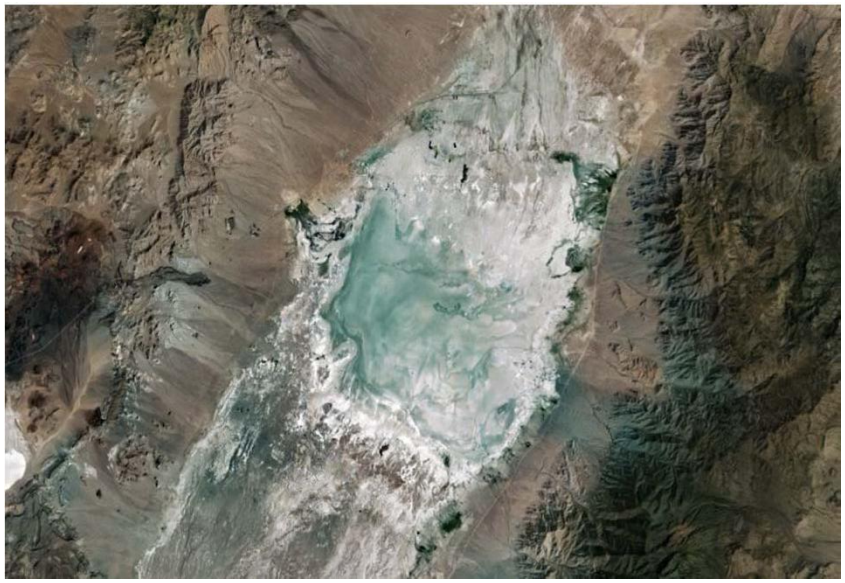
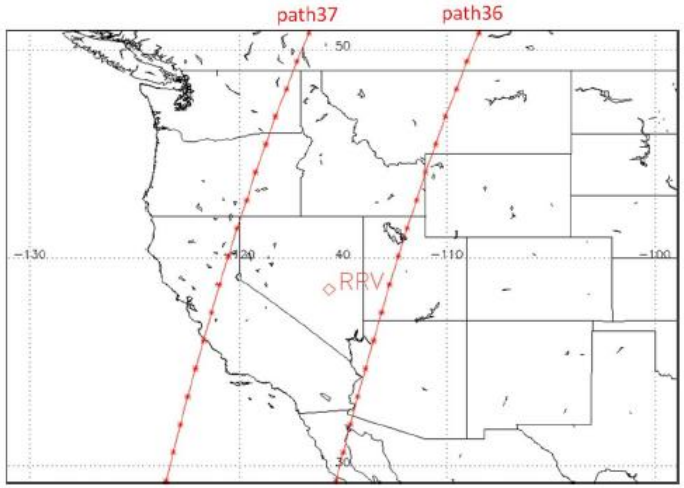
Why Railroad Valley?

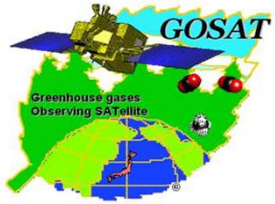


- Multi-year history of JPL campaigns to calibrate radiance measurements
- RRV Playa (dry salt lake)
  - High reflectance, spectrally flat
  - Playa larger than footprint (10.5km)
  - Very low aerosol optical thickness
  - Very low population and vegetation
  - High clear sky ratio.
- Other RRV participants: JPL, JAXA, ColoState; Univ Wisconsin



ARC Railroad Valley: June 17-26 2011

- Measure Greenhouse Gas (GHG) vertical profiles from Alpha Jet and SIERRA Unmanned Aircraft System (UAS)
- Provide data to support calibration of GOSAT
- Explore local sources of carbon dioxide (CO_2) and methane (CH_4)



Alpha Jet

SIERRA UAS

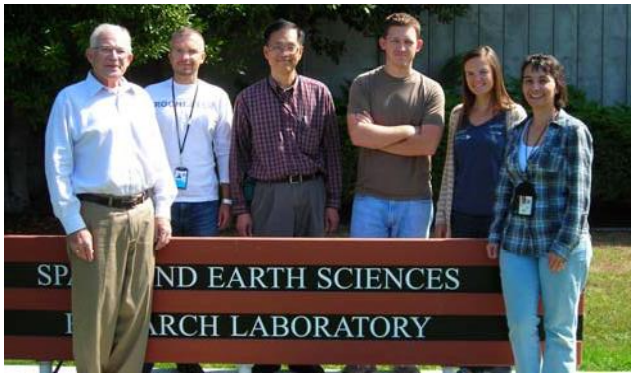
Study Area

- Play a Google Earth "tour" from ARC to RRV, then down into the Alpha data spiral, then out to SIERRA mapping field. (approx 45 sec)

Measuring GHG Vertical Profiles

- Commercial optical instrument
  - Picarro G2301-*m* CRDS
  - Reconfigured for flight
- Alpha Jet fighter trainer
  - 25,000 ft spiral down to 100 ft agl
  - instruments suspended in wing pod
  - also carries ozone instrument
  - vertical profiles under GOSAT
    - June 22, 23, 25, 26

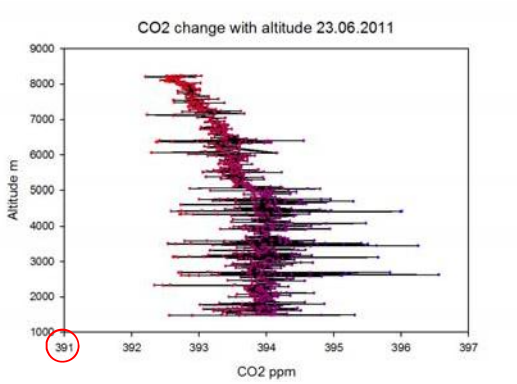
Picarro G2301-*m*
repackaged for flight

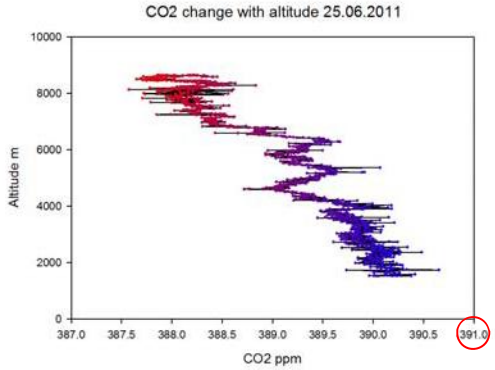


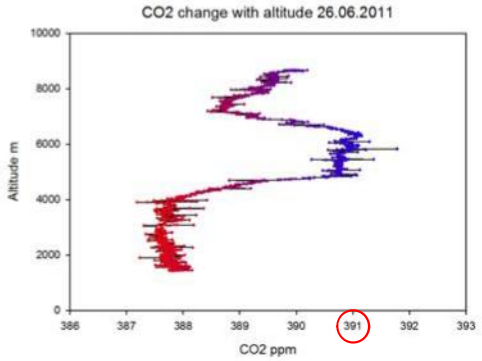
ARC Team includes (from left) Max Loewenstein, Jovan Tadic, Warren Gore, Ryan Walker, Emma Yates, Laura Iraci

Measuring GHG Vertical Profiles

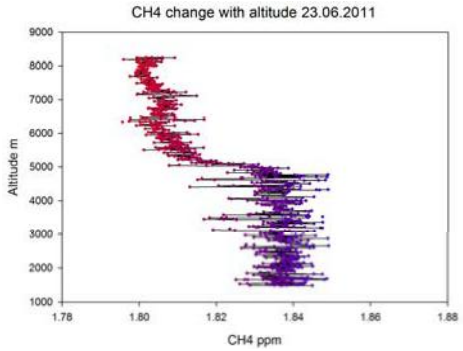
CO_2

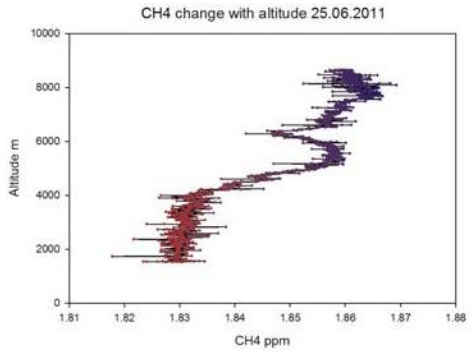


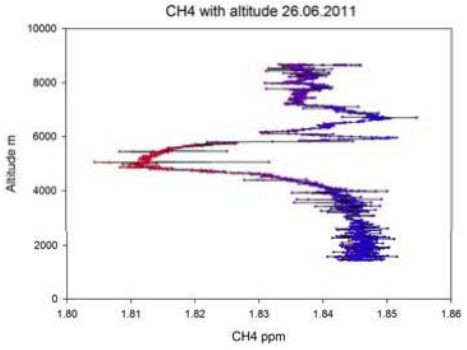




CH_4







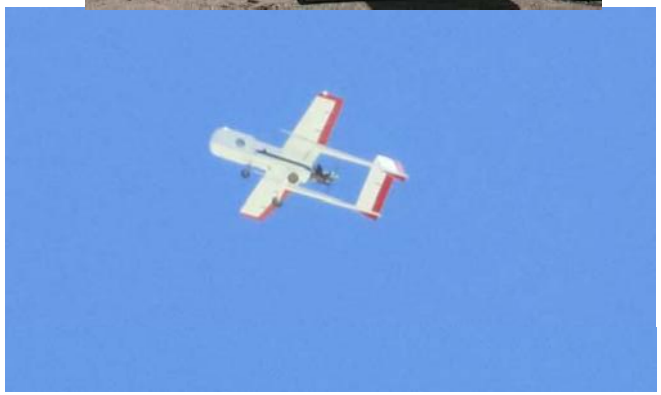
Blue = more CO_2, CH_4 Red = less CO_2, CH_4

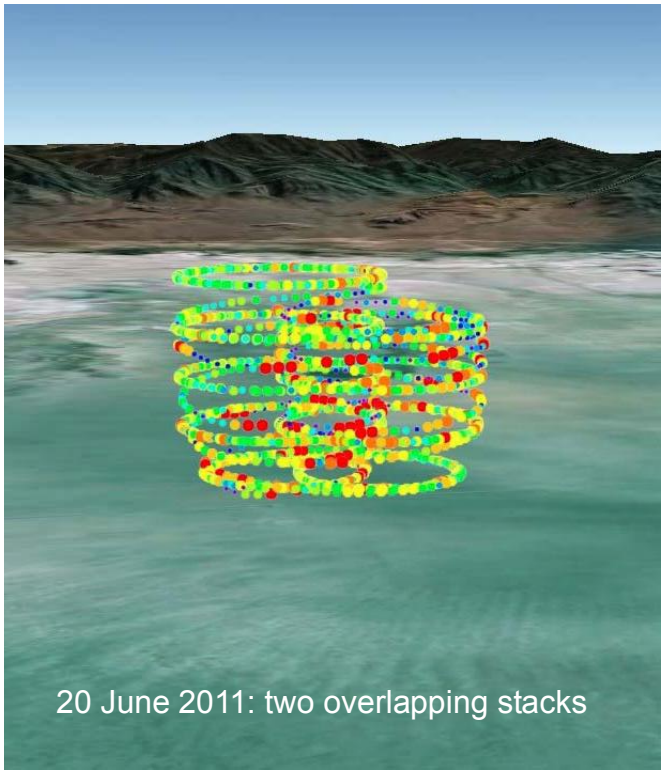
Measuring GHG Vertical Profiles

- show video from Alpha (45 - 60 sec)

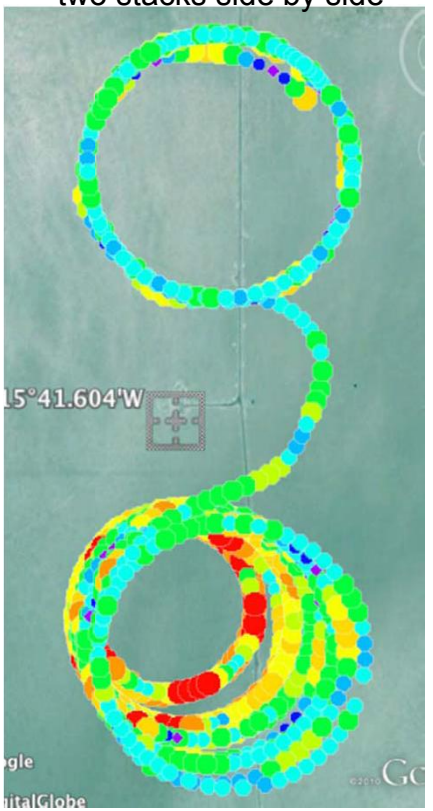
CO_2 Near-Surface columns from SIERRA

- Remotely piloted to extend data collection and reduce risk
- Flew stacked circles up to ~2500 ft agl
- Carries Picarro G2301-*f* CRDS CO_2/CH_4 sensor
  - modified for flight
  - also 3-D wind measurements for flux determination





22 June 2011:
two stacks side by side



Supporting GOSAT with CO_2 Data

- JAXA's GOSAT
  - carries TANSO-FTS
  - reports XCO_2 (column average dry mole fraction)
- ARC in-situ GHG data
  - ground truth for comparison to remote measurement

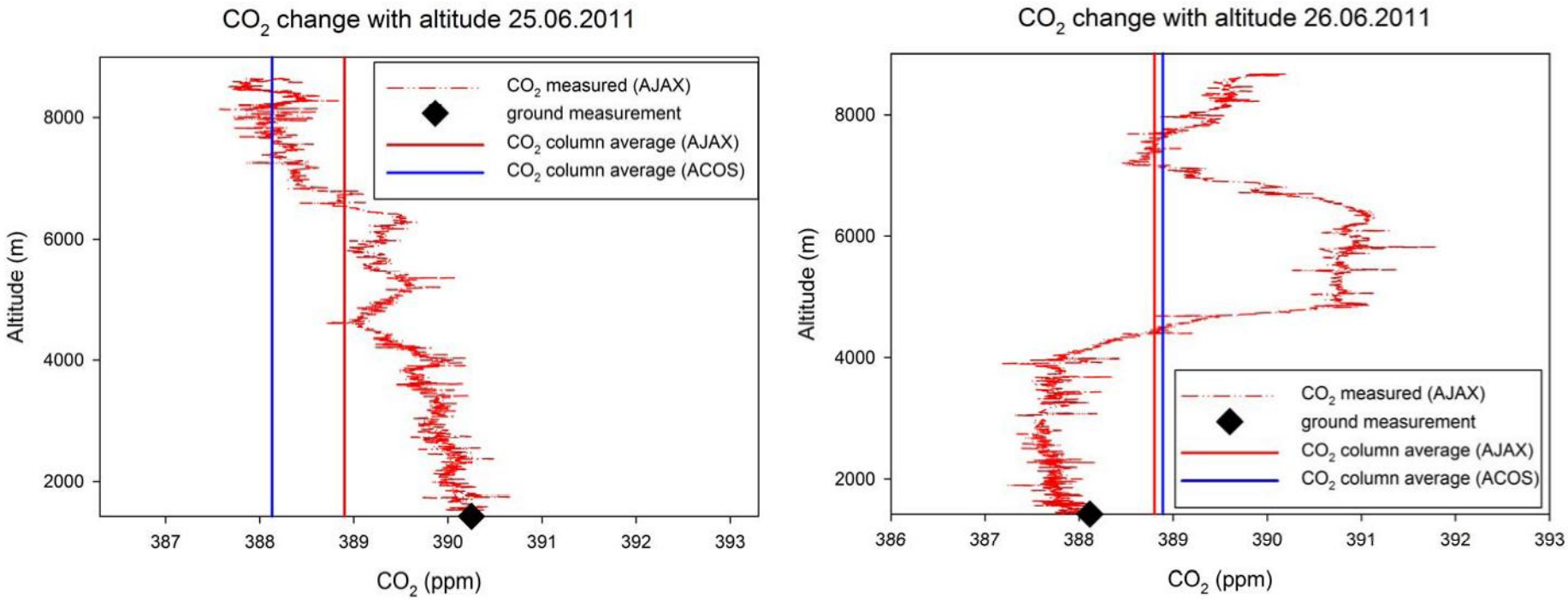
JPL/JAXA Field campaign organized by (left to right): A. Kuze, M. Helmlinger, C Bruegge

Supporting GOSAT with CO_2 Data

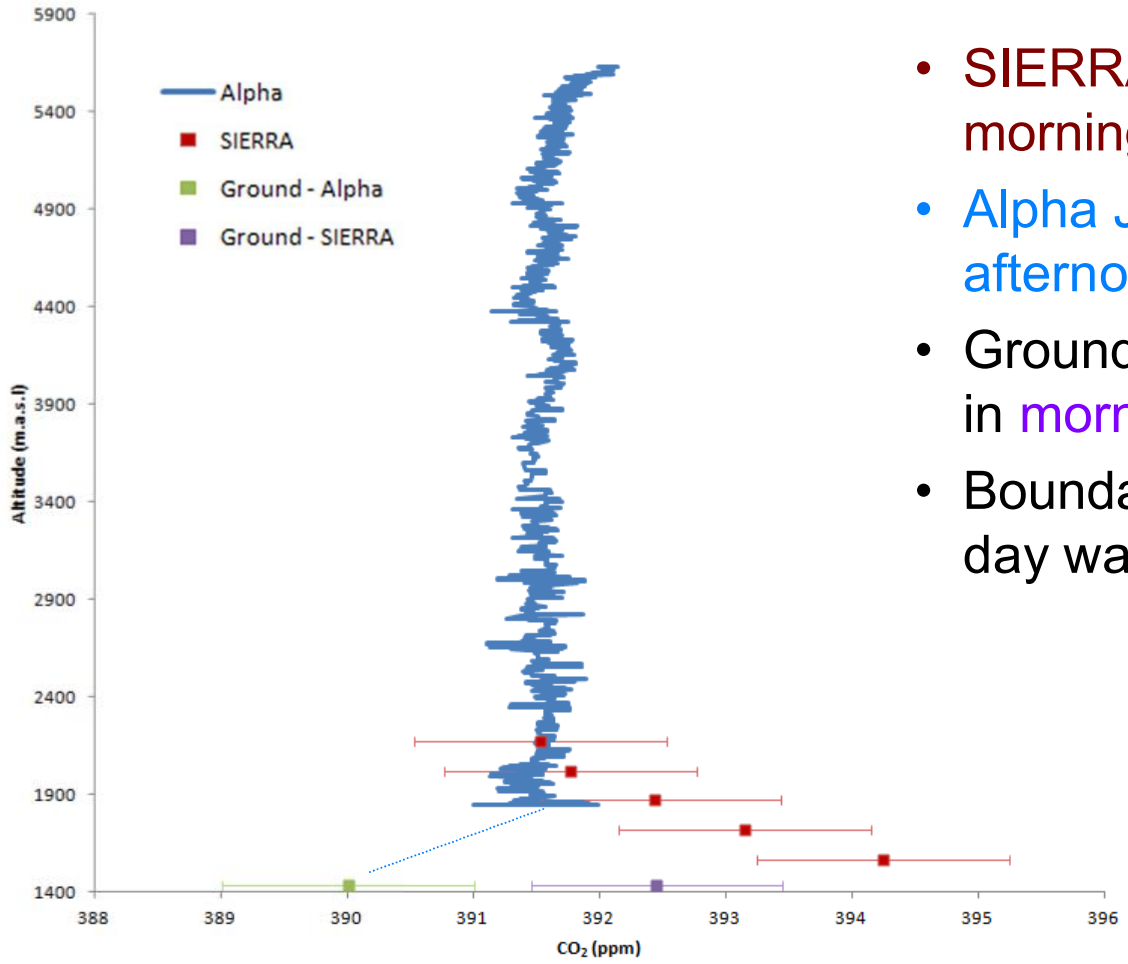
- CO_2 and CH_4 measurements during each GOSAT overpass
  - ground-based Picarro model G2311-*f*
  - sonic anemometer

Supporting GOSAT with CO_2 Data

- Pressure-weighted average of in-situ data, compared to satellite retrievals



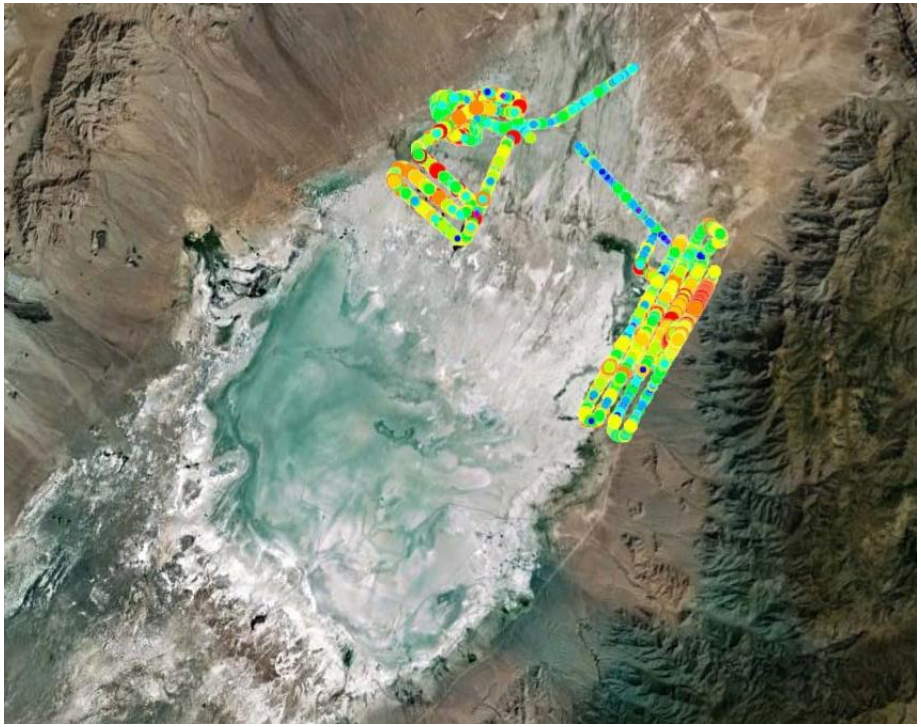
Daytime Evolution of Boundary Layer



- SIERRA sampled in the morning (8 am)
- Alpha Jet sampled in the afternoon (2 pm)
- Ground based measurements in morning and afternoon
- Boundary layer mixes as the day warms up

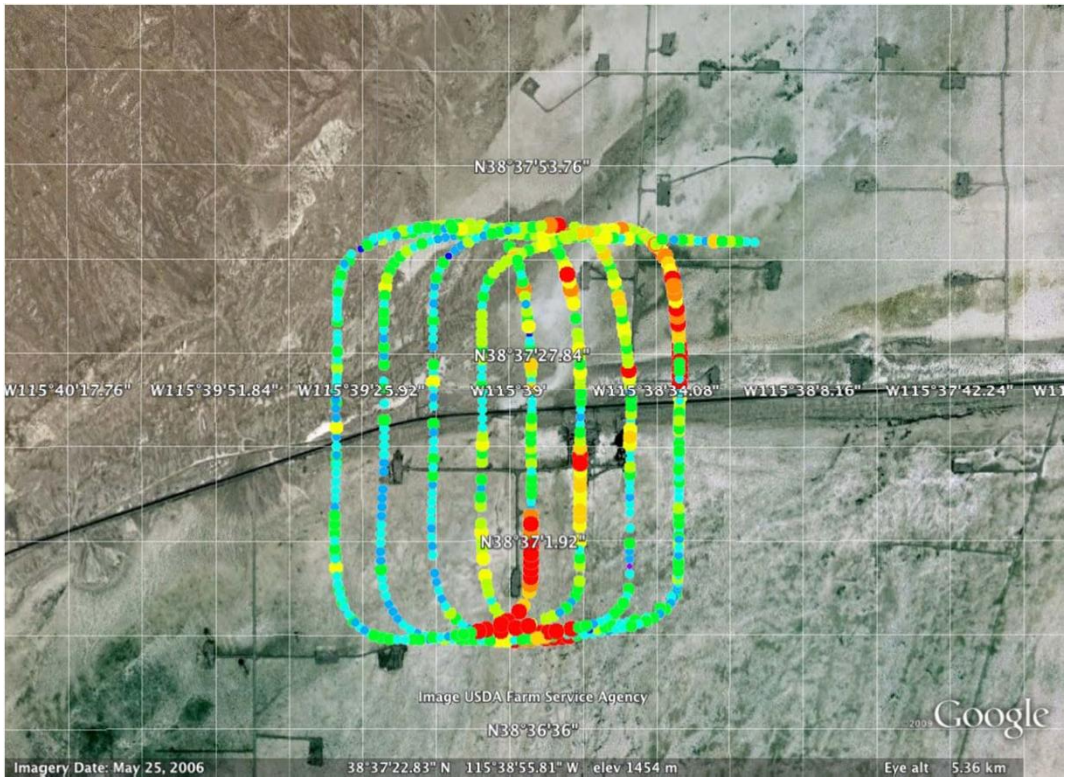
Exploring Local Sources of Methane

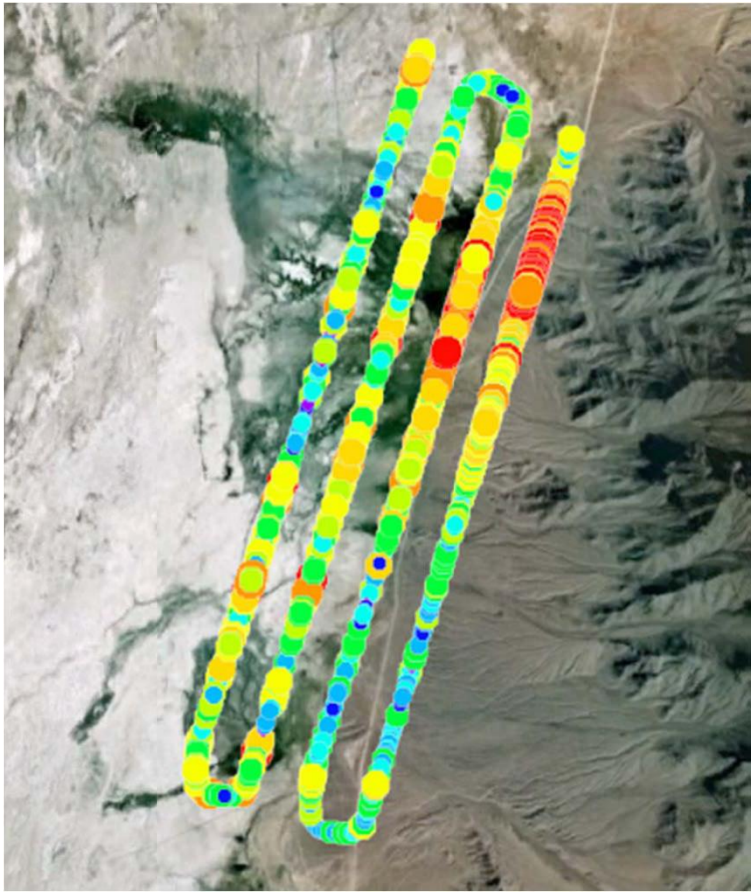
- SIERRA takes off for a mapping mission
  - http://vimeo.com/26199759 (58 sec)



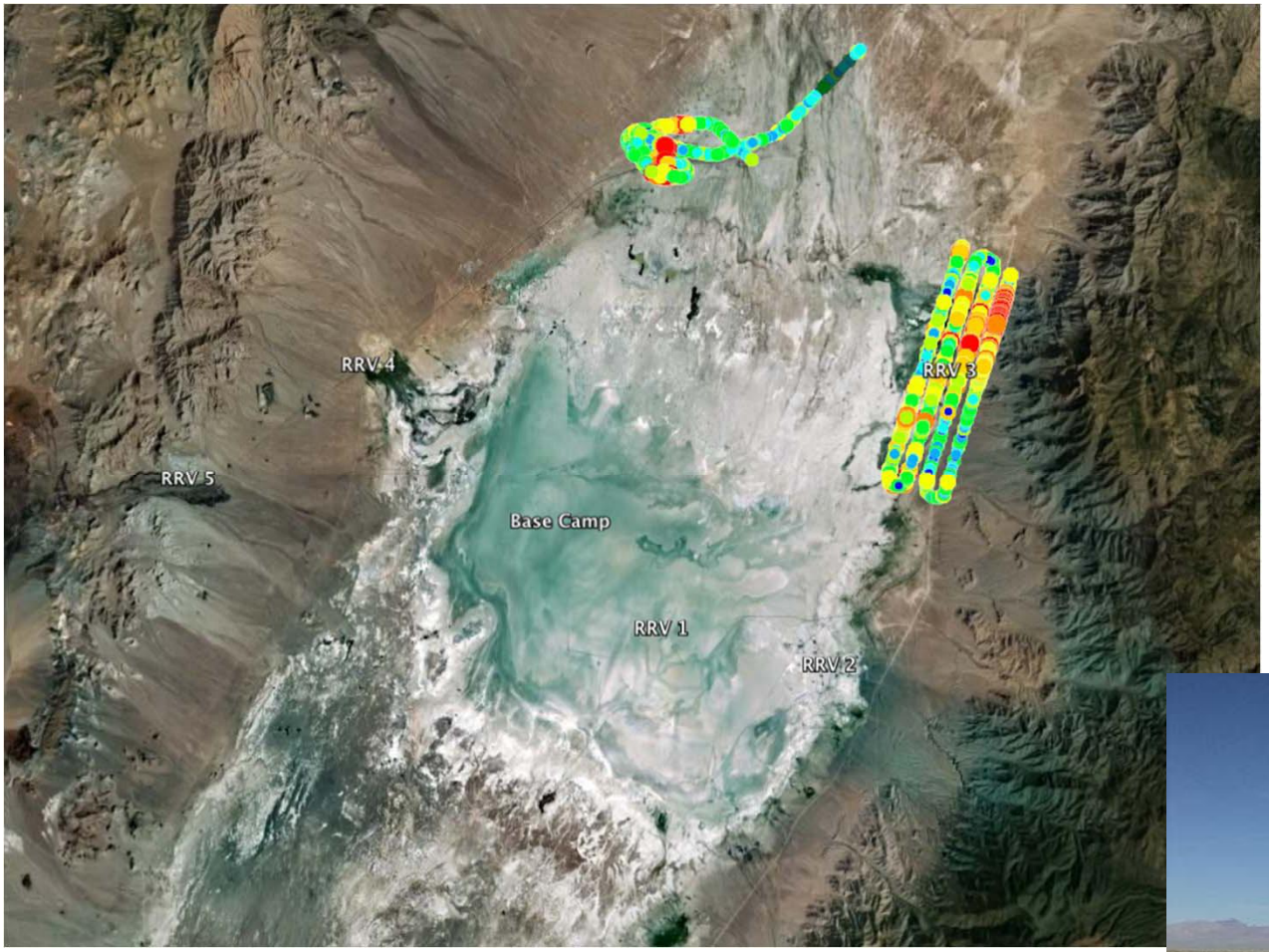
Exploring Local Sources of Methane

- Hot Spot Identification:
  - cold springs (right)
  - oil infrastructure (below)
  - level flights at XXX m above ground level
  - red = more CH_4, blue = less



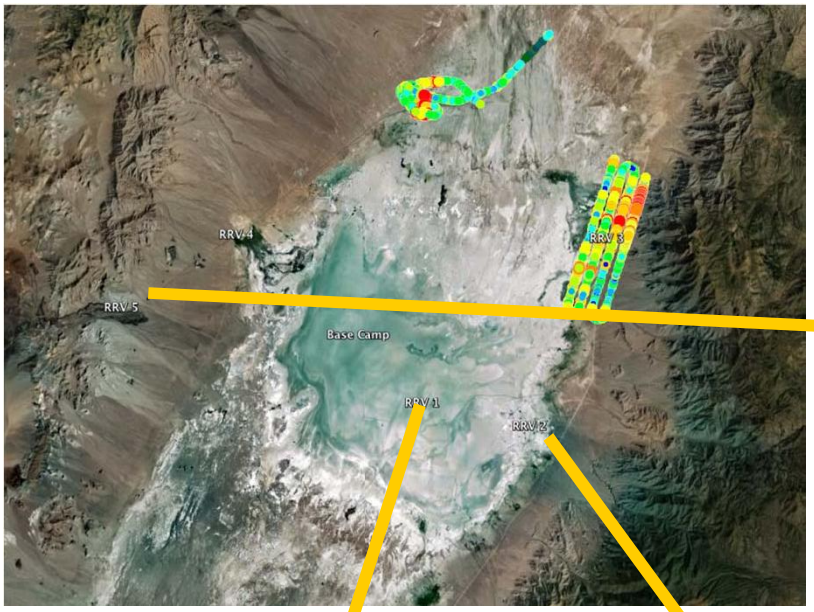


Ground-Truthing Methane Hot Spots



- Mobile GHG lab deployed from Base camp to RRV 3 and RRV 6
- Soil gas and microbiology measurements taken to determine the source of methane

Determining Methane Origins



Hydrothermally altered rocks at Pancake Ridge

Edge of playa; more vegetated

Playa (inactive oil derrick)

Kate Springs (RRV3)

- Cold spring
- Collected bubbles
- CH_4 = 84.32 ± 0.13 %
- C_2H_6= 7.88 ± 0.16 ppm
- C1/C2 = 105000

Black Rock Station (RRV 4)

- Geothermal spring (37°C)?
- Collected bubbles
- CH_4 = 69.38 ± 9.21 %
- C_2H_6 = 3.46 ± 0.3 ppm
- C1/C2 = 183000

- Conclusions:

- Methanogens are present and active in springs, but not prominent on crust or subsurface layers of the playa
- $\delta^{13}C$ of CH_4 from bubbles collected in the natural springs (RRV3 and RRV4) fall in the biogenic range

Co-Authors & Many Thanks

- ARC ground based team: E Yates, K Schiro, E Sheffner, A Detweiler, C McKay, J DeMarines, C Kelley (U. Missouri)
- ARC Alpha jet team: M Loewenstein, J Tadic, W Gore, A Trias, E Quigley, R Walker
- SIERRA team: M Fladeland, R Berthold, M Sumich, R Kolyer
- H211 / Alpha crew
- JPL / JAXA: C Bruegge, A Kuze, M Helmlinger
- Others at Base Camp: F Schwandner
- Data analysis and other assistance: D Wunch, C Frankenburg, B Bebout, C Thomas

Come Join Us!

- NASA Postdoctoral Program (nasa.orau.org)
- Ames has four open civil service slots with airborne, satellite, instrumentation, and modeling foci
- Undergrad Interships: http://intern.nasa.gov/
- Laura.Iraci@nasa.gov

Learn More:

- Today
  - A33C-0234. In situ measurements of carbon dioxide (CO2), methane (CH4), and ozone (O3) over the Sierra Mountains of central California and western Nevada; Rebekah A. Olson
  - A33C-0236. An Observing Architecture for Synthesis of Multi-platform Observations of Carbon Dioxide over Railroad Valley, NV; Laura T. Iraci
  - A33C-0240. Development of a new platform for airborne measurements of atmospheric CO2 and CH4 and comparison with GOSAT measurements at Railroad Valley playa, Nevada; Jovan Tadic
  - A33C-0241. Automated network at Railroad Valley, Nevada, for providing radiometric calibrations of OCO2; Carol J. Bruegge
  - A33C-0237. Retrieval of surface albedo over the Railroad Valley playa from AVIRIS measurements; Thomas Taylor
  - A33C-0207. Validation of the GOSAT Thermal Infrared (TIR) Band using the University of Wisconsin airborne Scanning High-resolution Interferometer Sounder (S-HIS) and ground-based Atmospheric Emitted Radiance Interferometer (AERI) at Railroad Valley, Nevada; Robert Knuteson
- Tomorrow
  - A41B-0089. In-Situ Greenhouse Gas Measurement Comparisons in Railroad Valley, NV to Identify Local Point Sources and Quantify their Influences on Observed Background Concentrations; Kathleen A. Schiro
  - A41B-0090. Spatial and temporal variability in atmospheric CO2 and CH4 at Railroad Valley playa, a mid-latitude desert site; Emma L. Yates
  - A42D-07 (ORAL).Vicarious calibration and validation campaign of the GOSAT sensors at Railroad Valley; Akihiko Kuze (room 3008)
- Friday
  - B51G-0486. Ground truthing for methane hotspots at Railroad Valley, NV - application to Mars; Angela M. Detweiler
- Yesterday: B14A-06 (ORAL). SIERRA-Flux: measuring regional surface fluxes of carbon dioxide, methane, and water vapor from an unmanned aircraft system; Matt Fladeland
- Picarro booth #1401