# ATML:
# An Atmospheric and Terrestrial Mobile Laboratory for GHG Attribution

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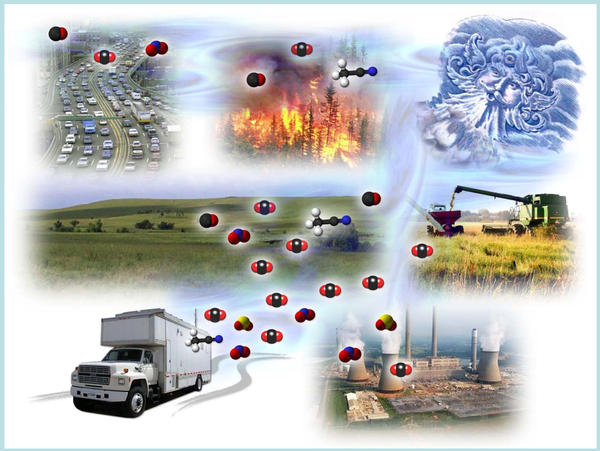
## ATML for greenhouse gas (GHG) measurement and attribution



**ATML: New capabilities for measurement and attribution of:**

- **Fossil-fuel combustion:** $SO_2$, NOx, $^{14}CO_2$ , $C_2H_2$, CO, soot, toluene, benzene
- **Biomass burning:** CO, $CH_4$, PAH, $C_2H_4$, $C_2H_2$, $CH_3CN$, $O_3$, soot
- **Agriculture/grasslands:** $^{13}CO_2$, $CH_4$, methanol, methylbutenol, acetone, acetaldehyde
- **Forests:** Isoprene, monoterpenes, methanol, acetone

**ATML: State-of-the-art instrument suite**

- Real-time measurements of C, O, and H isotopes in $CO_2$ and water vapor, volatile organic compounds, multiple GHGs and other trace species, and meteorological parameters
- Ground-based Fourier Transform Spectrometry (FTS) measurement of column GHG and other sensors to support verification and scaling to satellite-based column measurements
- Flask sampling system to support air sampling for $\Delta^{14}C$ and balloon-lofted portable tall tower

**ATML: Project goals**

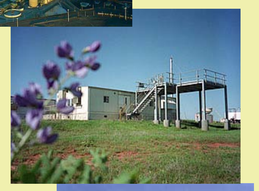
- Develop new mobile lab for GHG measurement and attribution
- Deploy ATML and solar-tracking FTS for pilot field studies of multi-tracer GHG source signatures
- Scaling of ground- to satellite- based measurements
- Couple data gathering with WRF model and analysis to develop and refine attribution techniques
- First detailed assessment of seasonal distribution of $\Delta^{14}C$ over the contiguous US to help quantify fossil fuel related $CO_2$

## Planned pilot studies and sites

**LANL semi-arid woodland site**
*$CO_2$ and $H_2O$ isotope measurements for biogenic attribution*

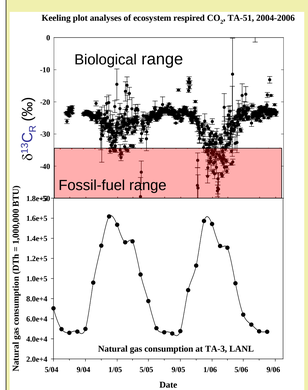
**Four-corners area**
*FTS deployment and satellite overflight for scaling*

**ACRF SGP site**
*Multi-tracer campaign and inverse modeling for attribution*



**Multiple sites/aircraft**
*Inventory of $\Delta^{14}CO_2$ in the PBL for fossil-fuel attribution*

## Real-time isotope measurements for C attribution and carbon-cycle science




Coupled, high frequency isotopic measurement of ecosystem-respired $CO_2$ and water vapor detects fossil-fuel emissions and will improve our understanding of biosphere-atmosphere interaction.

*Left:* Keeling-plot intercepts of eco-system respired $CO_2$ measured by tunable diode laser shows winter fossil fuel $CO_2$ source at LANL field site. (McDowell et al. 2009 *EOS*)

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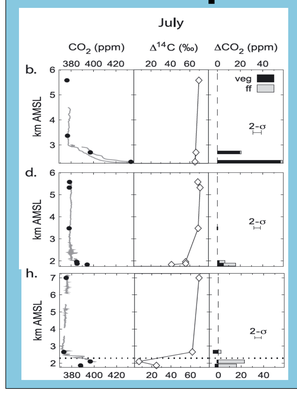
## Vertical profiles of $\Delta^{14}C$ for attribution




Measurements of $\Delta^{14}C$ in atmospheric $CO_2$ effectively separate $CO_2$ additions from fossil fuel and biospheric sources or sinks of $CO_2$.

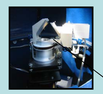
*Left:* Distinct differences between vertical profiles of $CO_2$ and $\Delta^{14}C$ in rural (b) and urban settings (d,h) in recent study from Colorado.

Graven et al (2009) *Tellus*

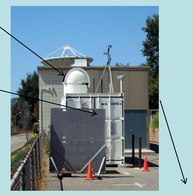
## Data scaling and integration of ground- and space-based measurements

Coordination of Fourier transform spectrometry with satellite overpass data (GOSAT, others) at Four Corners, NM will allow verification and scaling between ground- and satellite-based column measurements of GHG.

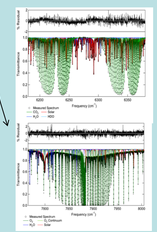
Solar tracker



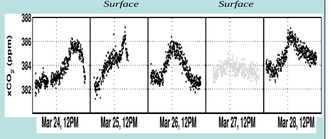
JPL-Pasadena 2008 deployment

$CO_2$ and $O_2$ spectral fit for retrieval



$$X_{CO_2} = \int_{Surface}^{\infty} [CO_2]dz \Big/ \int_{Surface}^{\infty} [M_{Dry}]dz$$

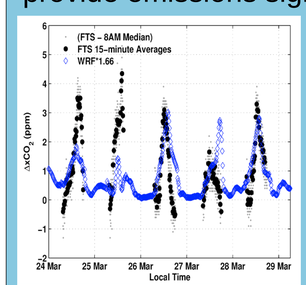



Columnar $X_{CO2}$ (dry mixing ratio, ppm) (Wunch et al. 2009 *GRL*)

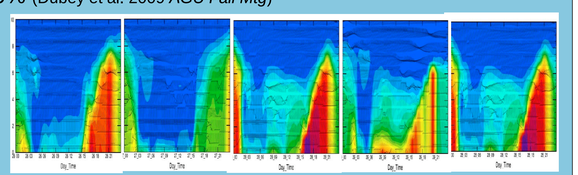
The solar tracking FTS records direct solar spectra every ~2min for retrievals of column GHGs; the FTS spectra of signature gases extends from near-IR to vis-UV.

## Regional modeling for attribution and scaling

ATML data from the ARM-SGP site will demonstrate methods for assimilation of multiple sources with WRF-CHEM-VPRM model to provide emissions signatures from specific locations.




*Left:* In previous Los Angeles case study, WRF model using Vulcan $CO_2$ emissions is lower than FTS data by 70% (Dubey et al. 2009 *AGU Fall Mtg*)



*FTS observations, Los Angeles:* Vertically resolved increases in $CO_2$ (ppm) vs time (local time=UTC - 7 hrs)