SAND2013-10369P

# Outflow of Greenhouse Gases and Tracer Species from the San Francisco Metropolitan Area at a New Measurement Site in Livermore, California:

## *Seasonally and Diurnally Varying Atmospheric Transport*

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## Highlights

- ❑ 2920 backward Lagrangian particle dispersion model (LPDM) simulations using WRF + FLEXPART to characterize the seasonal and diurnal variations of the measurement '*footprints*', i.e., near-surface residence time of air masses sampled by the measurements during the past 24 hours (denoted as *24-hr footprint residence time* thereafter) for a new measurement site in Livermore, California.
- ❑ Simultaneous measurements of greenhouse gases and co-emitted trace species.

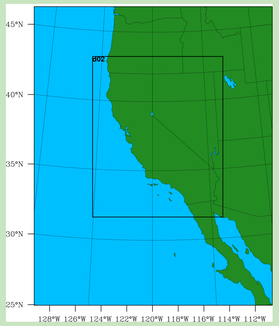
## Model Configurations

***WRF***

- ❑ Model version : WRF v3.5.1
- ❑ Simulation period : 2010 full year
- ❑ IC/BC/FDDA : ERA-Interim
- ❑ Domains : d01 (12km, 160 x 200)
  d02 (4km, 362 x 322 )
  50 vertical layers
- ❑ PBL scheme : MYJ-TKE
- ❑ Land surface model : NOAH
- ❑ Cumulus : KF-new eta

***FLEXPART***

- ❑ Domain : identical to WRF d02
- ❑ Release point : -121.7769, 37.6719 (Livermore)
- ❑ Release frequency : 3 hourly (2920 simulations in total)
- ❑ Simulation period : 24 hours backward in time
- ❑ Number of particles : 10000

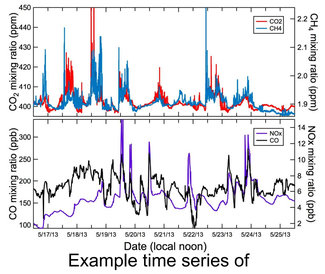



Map of WRF and FLEXPART (d02) domains

## Site Information

- ❑ **Location:** Livermore, CA, ~150 m above sea level, 64 km south-east of San Francisco
- ❑ **Tower:** Two inlet heights: 9 m, 27 m above ground level
- ❑ **Instrumentation:**

•Climate-controlled 30-ft mobile laboratory
•Air quality instruments for **$SO_2$, $NO_x$, $O_3$, CO**
•Cavity ringdown spectrometer for **$CO_2$, $CH_4$, $H_2O$**
•Quantum cascade laser spectrometer for **$CO_2$, $^{13}CO_2$, $^{18}OCO$, $H_2O$**
•Proton transfer reaction mass spectrometer for **volatile organic compounds**
•Particle photo-acoustic spectrometer for **soot** and **brown carbon**
•Drum sampler for **particle elemental composition**
•Condensation **particle counter**
•Non-dispersive infrared analyzer for **$CO_2$ fluxes**
•Thermal sensors for **soil fluxes**
•Weather station for **meteorological data**
•Ceilometer for **boundary layer height**

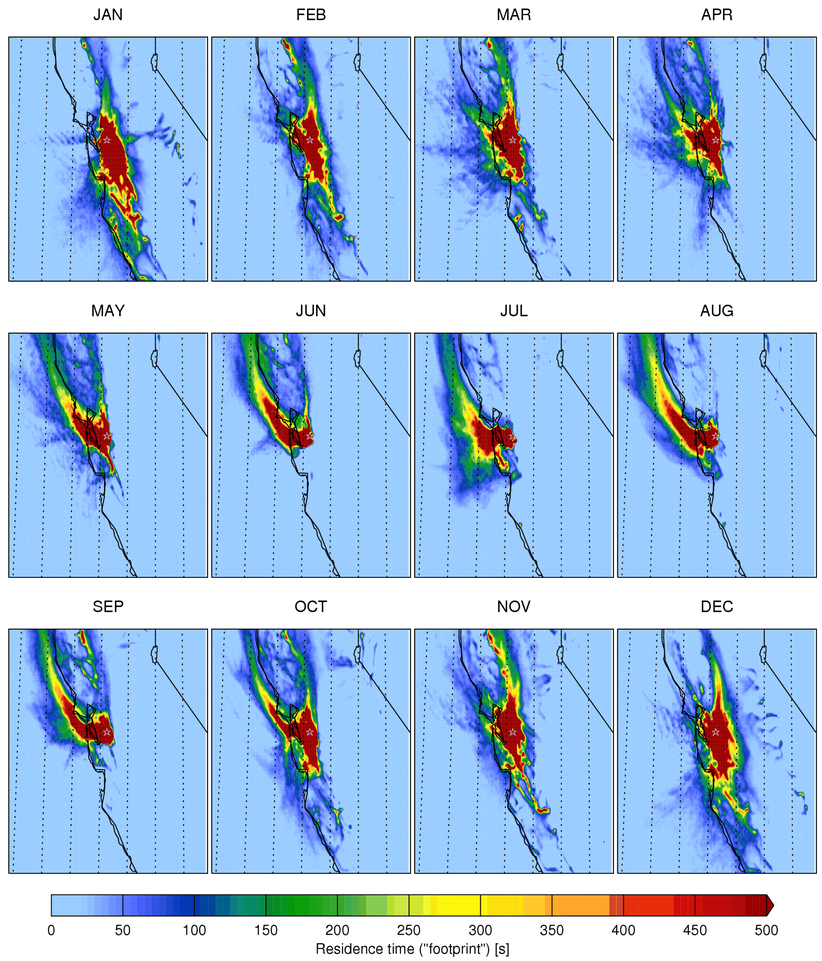



Example time series of measurements in Livermore

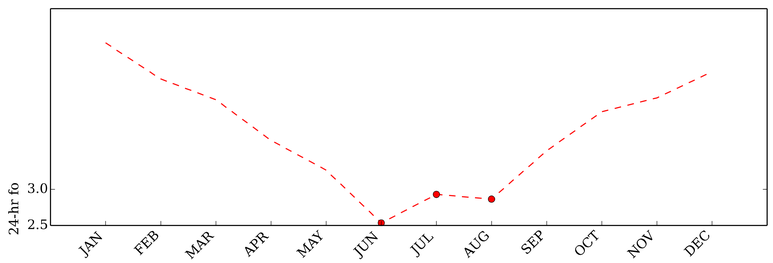
View looking west from top of truck

Truck and tower in Livermore

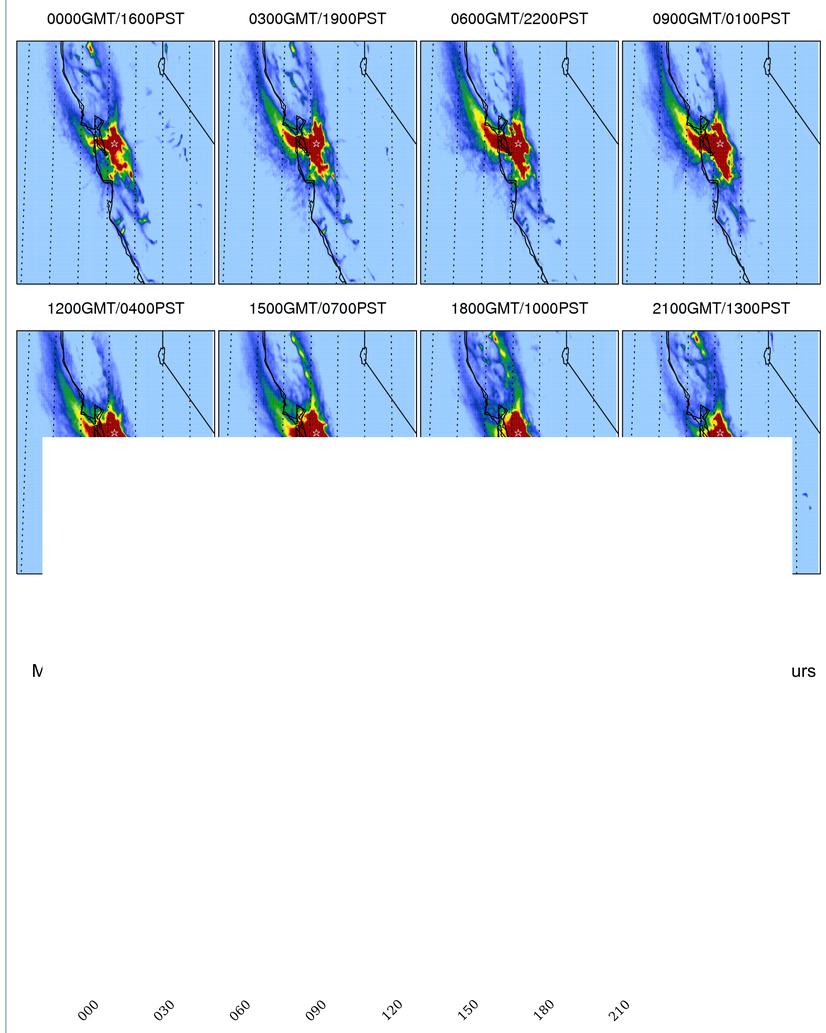
## Monthly varying footprints




Maps of mean 24-hr footprint residence time of air masses sampled at Livermore for different months (domain total footprint residence time is indicated along with the maps).




## Diurnally varying footprints




Diurnal variation of 24-hr footprint residence time of air masses sampled at Livermore.

## Acknowledgements

The work at Sandia National Laboratories was funded by the Sandia Laboratory Directed Research and Development (LDRD) Program. Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the National Nuclear Security Administration under contract DE-AC04-94-AL85000. We thank Andreas Stohl at Norwegian Institute for Air Research and Jerome Fast at PNNL for making the FLEXPART + WRF codes publicly available.