Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA

S. Conley, G. Franco, I. Faloona, D.R. Blake, J. Peischl, and T.B. Ryerson

- Chemical composition from ground-based UCI WAS canister samples
- Flow rate from Scientific Aviation near-field airborne plume sampling

- Comparison of Aliso Canyon to routine emissions from other GHG sources
- Systems to quantify GHG emissions across a range of spatial and temporal scales

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The failure on 23 Oct 2015 of one of 115 wells connected to the Aliso Canyon underground storage facility in the San Fernando Valley of California released 97,100 metric tons of methane to the atmosphere before it was permanently sealed 112 days later

Here we describe atmospheric chemical sampling used to determine leaking chemical composition, quantify the leak rate, and track its evolution over time

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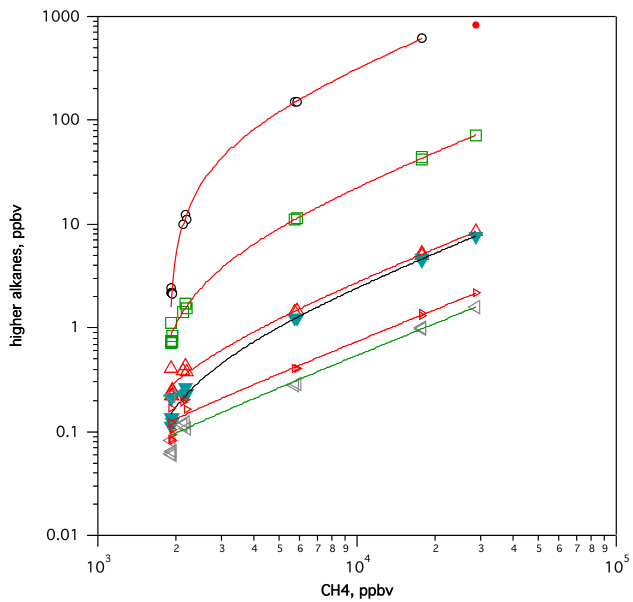
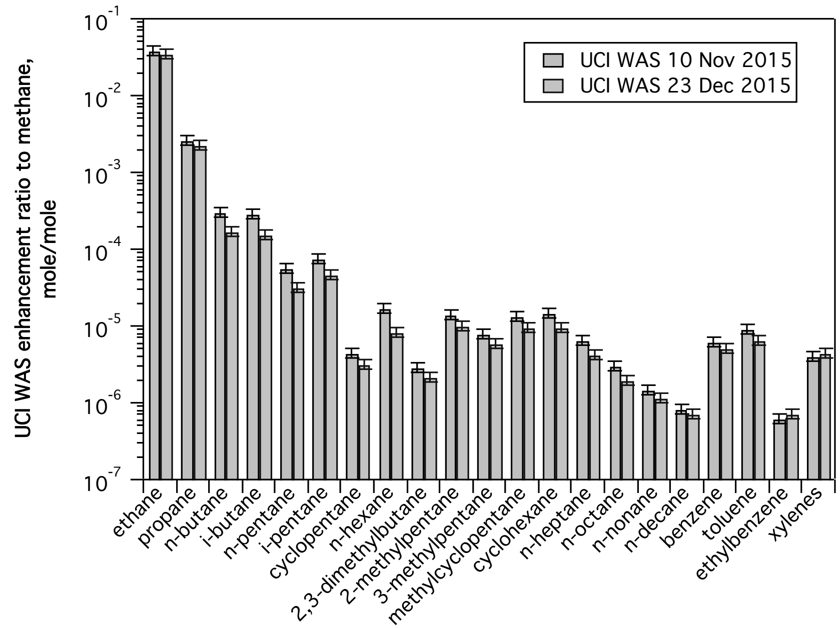
WAS canister samples on 10 November 2015 and 23 December 2015





Molar enhancement ratios from UCI WAS canisters taken ~6 weeks apart:

- *define chemical composition of leaking Aliso Canyon gas and oil*
- *are consistent with reports of "oily sheens" in affected areas downwind*
- *suggest leaking chemical composition was constant over time*
- *provide a means to estimate benzene levels from methane observations*

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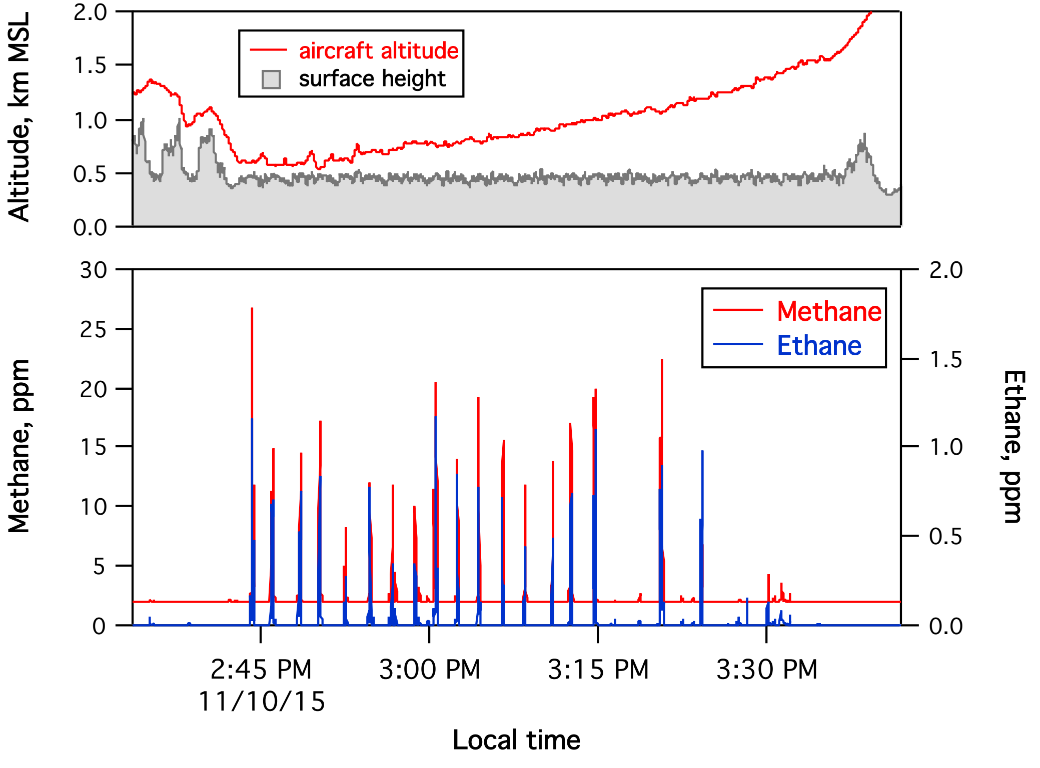
Scientific Aviation Mooney TLS aircraft



Mass fluxes were calculated from 13 flights for all horizontal crosswind transects downwind of the leak site

Two separate instruments measured methane, and one measured ethane, every 30 m along track

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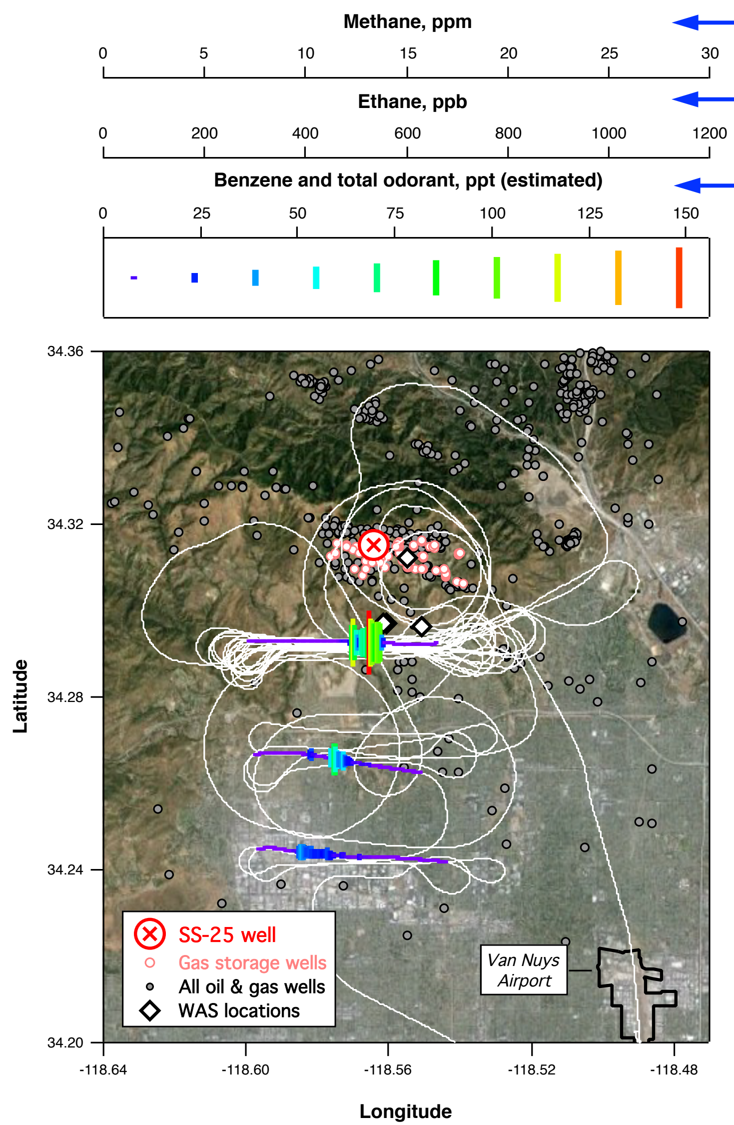
10 Nov 2015 flight example



Methane and ethane measured continuously aboard the aircraft

*Benzene and odorant **calculated** from known, or assumed, ERs relative to methane*

- Plume consistent with a single point source centered on the SS-25 wellpad within ±100m
- Rules out any substantial contribution from other local wells or upwind sites
- Exceptionally restricted airspace access (terrain, traffic, TFRs…) dictated an agile aircraft with FAA MSA clearance for 60m above ground
- Repeated transects at 34.295° latitude show the **aircraft captured the full horizontal extent** of the point source plume on each flight

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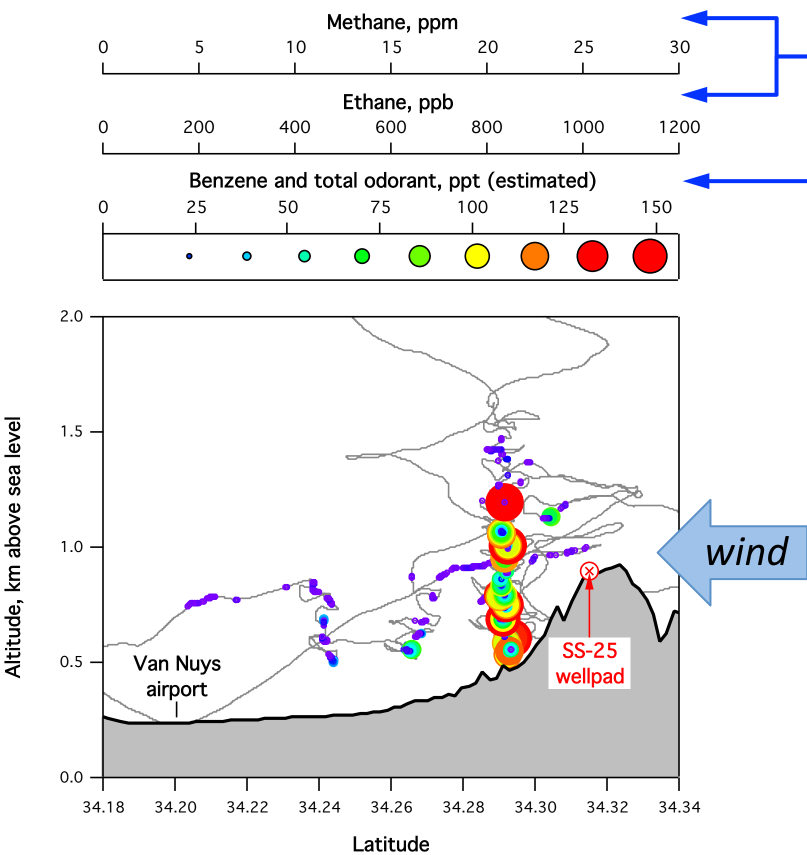
10 Nov 2015 flight example



Methane and ethane measured continuously aboard the aircraft

*Benzene and odorant **calculated** from known, or assumed, ERs relative to methane*

- Repeated transects at 34.295° latitude show the **aircraft captured the full vertical extent** of the point source plume on each flight
- simultaneous NOAA mobile van CH_4, CO_2, N_2O, CO, and wind vector measurements at the surface directly below the aircraft on 11 January 2016 show negligible concentration gradients below lowest aircraft flight altitude
- integrating horizontal fluxes in the vertical provides a **direct, accurate measurement of Aliso Canyon gas leak rate, with known uncertainties**

North-south topographical cross section at the SS-25 well longitude

Aircraft altitude (grey line) scaled by chemical data for CH_4 > 3 ppm

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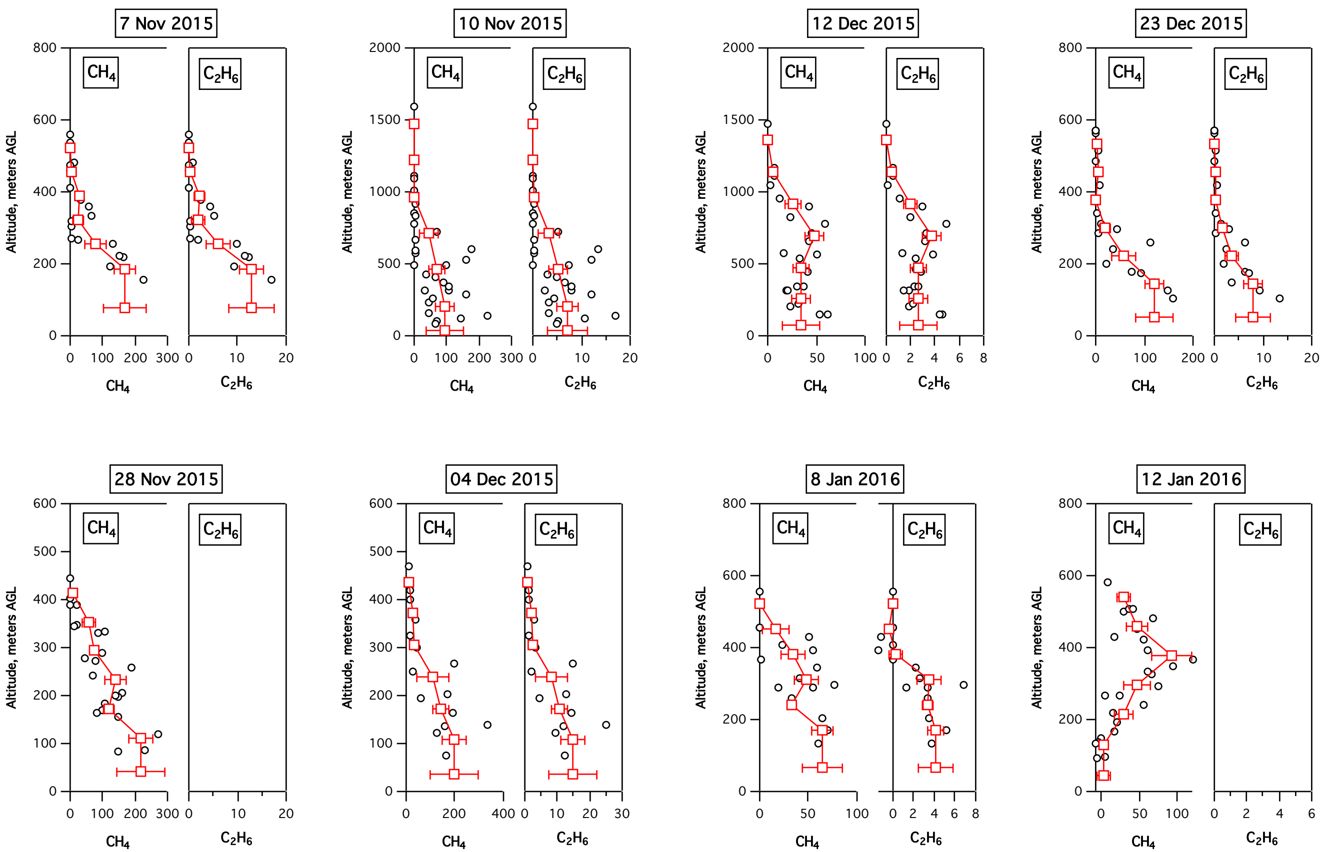
Aliso Canyon vertical profiles from 8 example flights



- largest uncertainty on leak rate comes from estimation of time-averaged vertical profiles (red lines) from mass fluxes measured during each crosswind transect (black squares)
- These data show the difficulty of estimating flux from surface observations alone
- These data provide **benchmark constraints** for vertical mixing in model simulations of the leak

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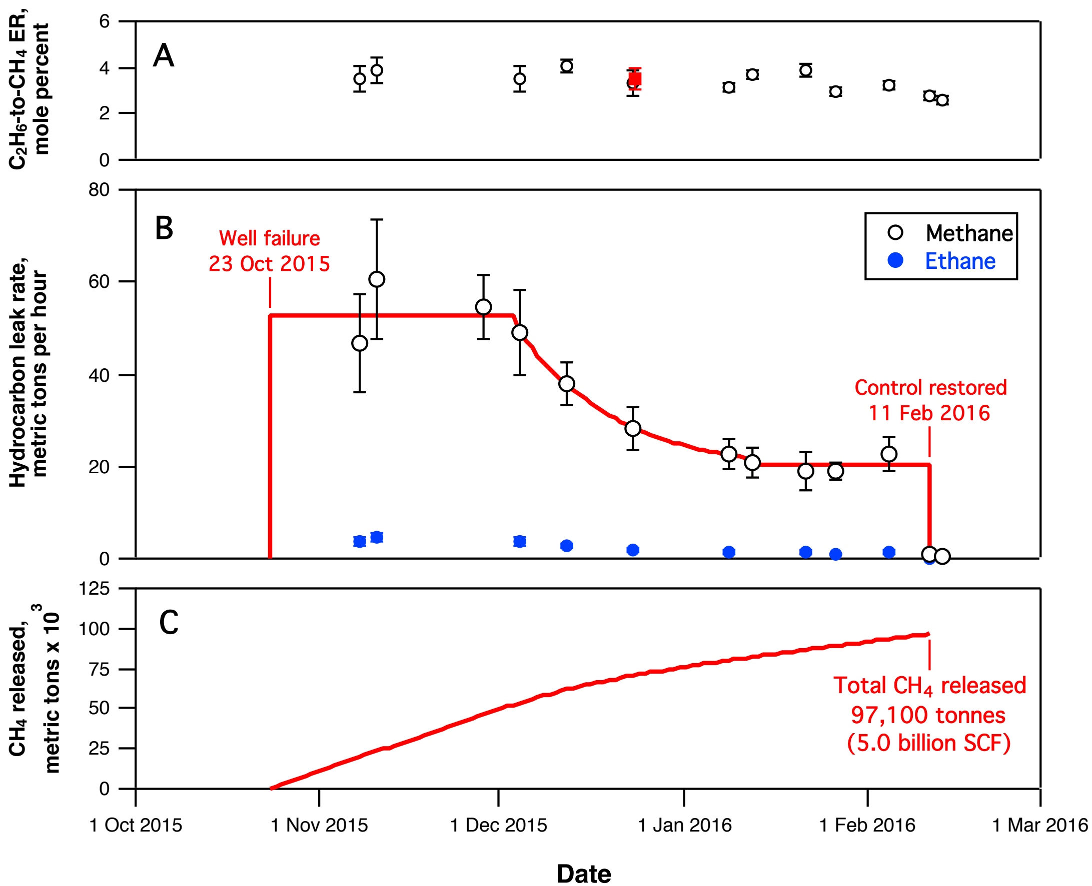

Red line in (B) is a fit to the airborne CH_4 data assuming an average leak rate from blowout to day 43, an exponential decrease between days 43 and 80, and an average leak rate thereafter to day 112 when control was restored.

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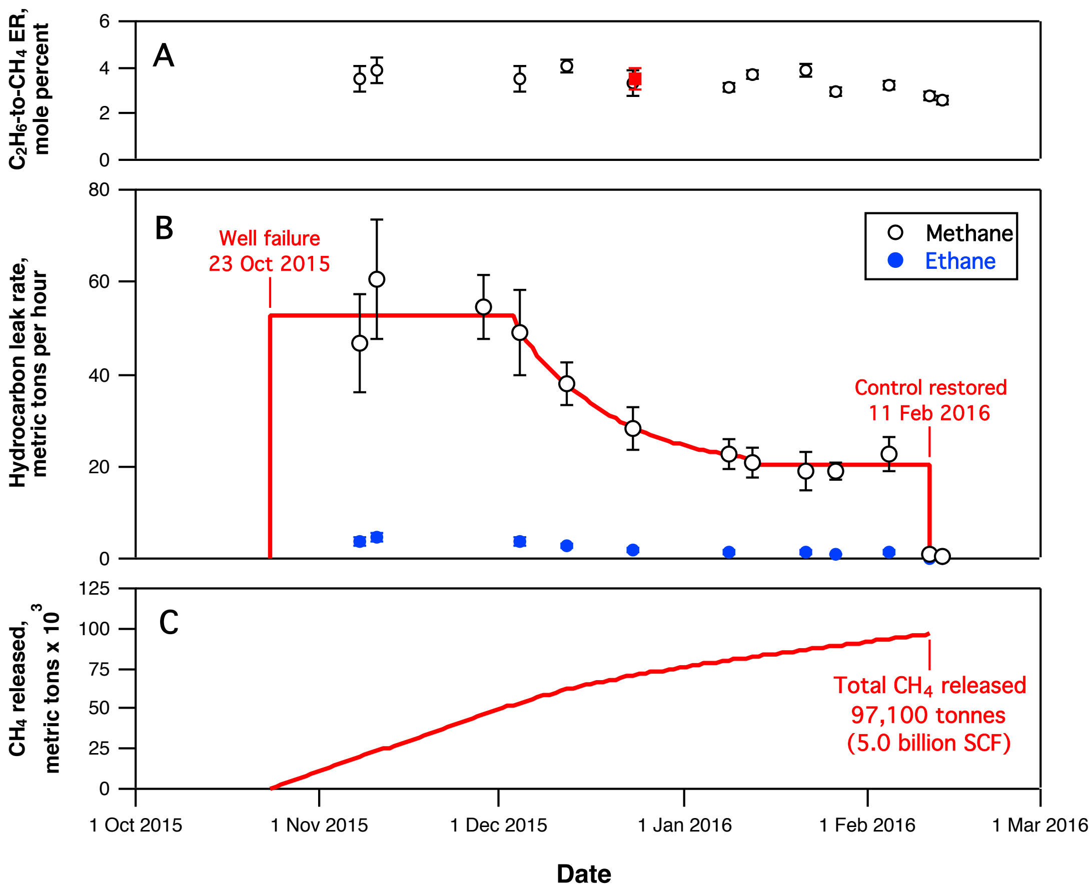
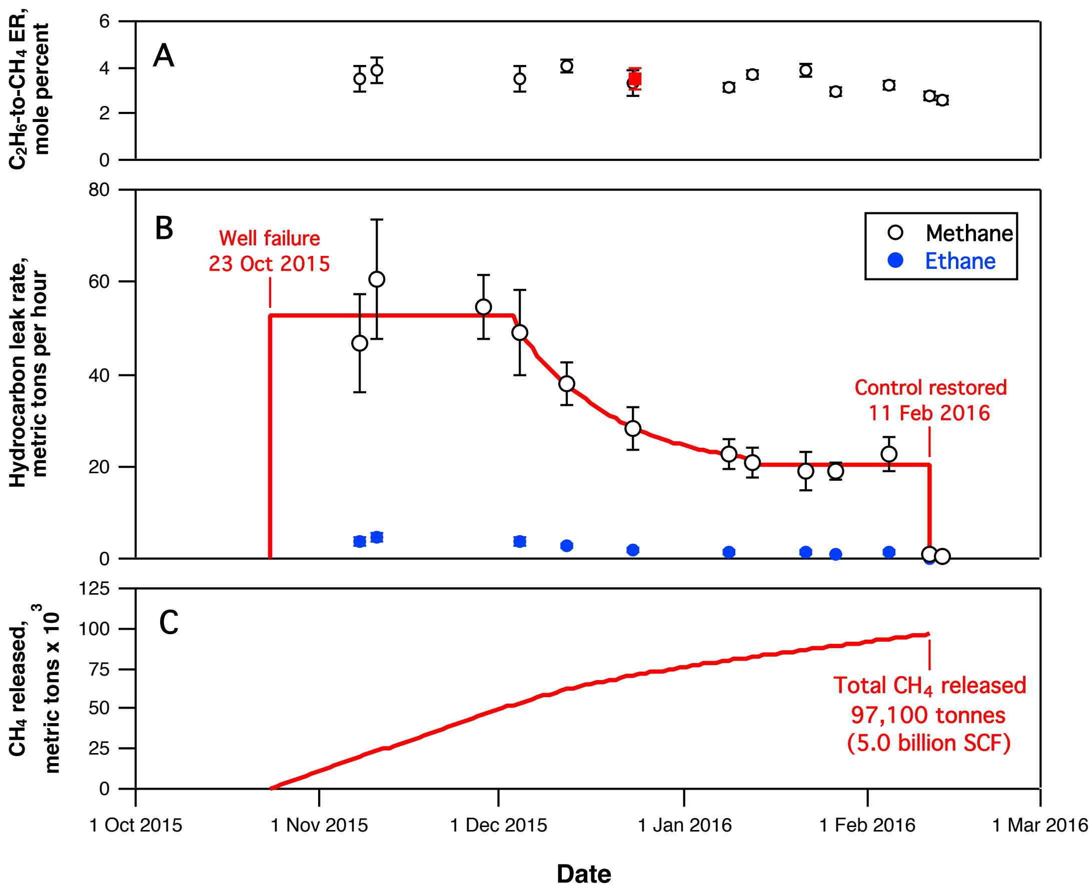


- The airborne data show that **97,100 metric tons of methane** were released to the atmosphere (only 3% of the total volume!)
- Derived flow rate is highly correlated with reservoir pressure, which was monitored continuously by SoCalGas throughout the leak
- These data provide robust constraints on flow rate for the majority of the event
- Provides a robust prior estimate for inverse model studies using ground-based, airborne, or orbital sensors

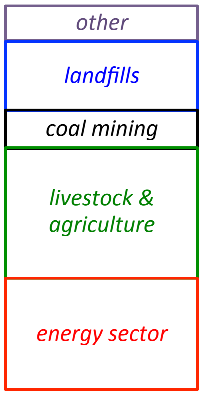
Aliso Canyon in perspective



- Equal to the annually-averaged leak rate from all other CH_4 sources in the Los Angeles Basin combined (Peischl *et al.*, **JGR**, 2013)
- Largest accidental CH_4 release in U.S. history
- Significant on the scale of California emissions reduction efforts mandated under the Global Warming Solutions Act of 2006 (AB32)
- Mitigation of the climate effect of Aliso Canyon methane will take a substantial effort

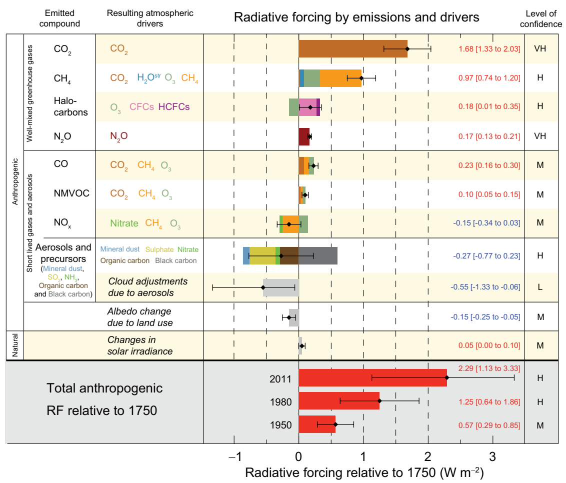
Aliso Canyon in bigger perspective

U.S. total CH_4 emissions



U.S. EPA inventory data

AR5 radiative forcing



- The climate impact of Aliso Canyon CH_4 is **dwarfed** by routine emissions from oil & gas, agriculture, & landfills
- The climate impact of CH_4 emissions (aside from its SLCF role) is **dwarfed** by routine emissions of CO_2
- Avoiding future natural gas blowouts is good, but *their complete absence* won't address any major climate issue

COP21 agreements include specific requirements for the Parties to account for anthropogenic GHG emissions with "accuracy and completeness"

Suggests a *robust and complementary observational and analysis system* is needed to quantify emissions across a breadth of spatial and temporal scales

GHG emissions monitoring and attribution requires a continuum of data

Targeted mobile observations

Point and area source snapshots; incident response

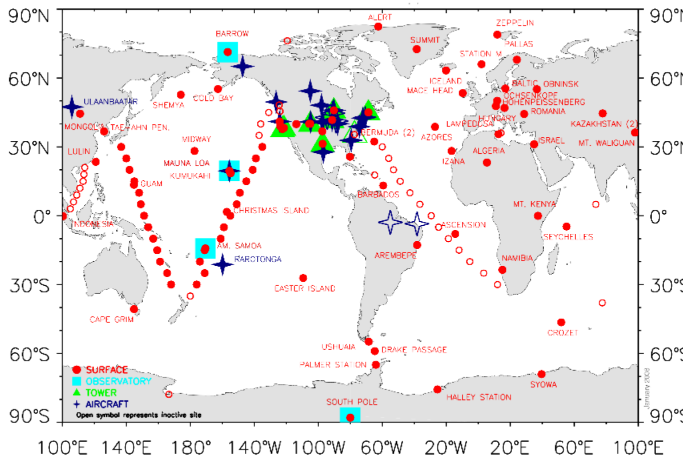
Research aircraft

Mobile laboratories

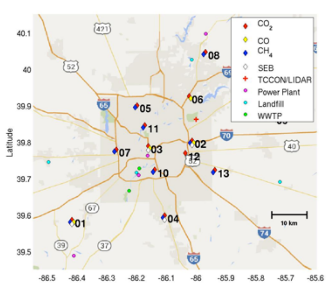
Long-term surface observations

Area, regional, and global source monitoring

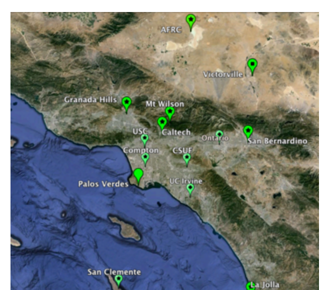
NOAA cooperative sampling network



INFLUX
(Indianapolis, IN)



Megacities Carbon Project
(Los Angeles, CA)



Long-term column observations

Area, regional, and global source monitoring

*NASA **OCO2***

*JAXA/NIES/MOE **GOSAT***

TCCON