Detection and quantification of Methane (and CO_2) hot spots emissions with MAMAP (Methane Airborne MAPper) aircraft observations

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Motivation

- **Why CH_4?** → second most important anthropogenic greenhouse gas; better source quantification

- **Landfills and Waste**

- on ground measurements [*Amini et al., 2013*]
  → large extent (e.g., 2 km^2)
  → heterogeneously distributed emission
  → irregular topography
- 5 different methods [*Babilotte et al., 2010*]
  → disagreement by a factor of 5 to 10

- **Fossil fuel extraction**

- CH_4 emissions are by a factor of 4.9 higher than in EDGAR [*Miller et al., 2013*]
- ~40 of 50 studies show higher emissions than one would get by emission factors [*Brandt et al., 2015*]

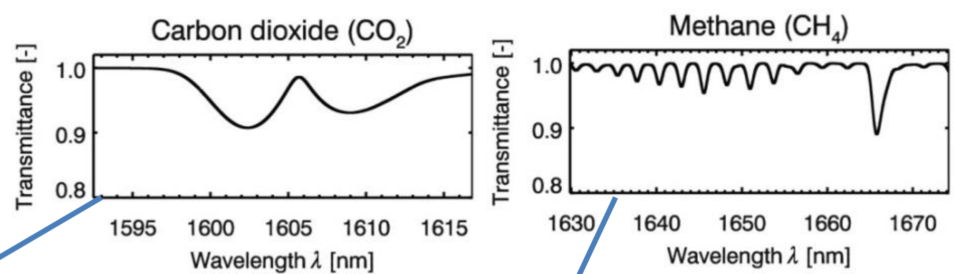
- **responsible for over 50% of anthropogenic CH_4 emissions** [*Kirschke et al., 2013*]
- **Why airborne based remote sensing?** → ~~difficult terrain or restricted access~~
  → proof of concept for future satellite missions

Airborne remote sensing instrumentation

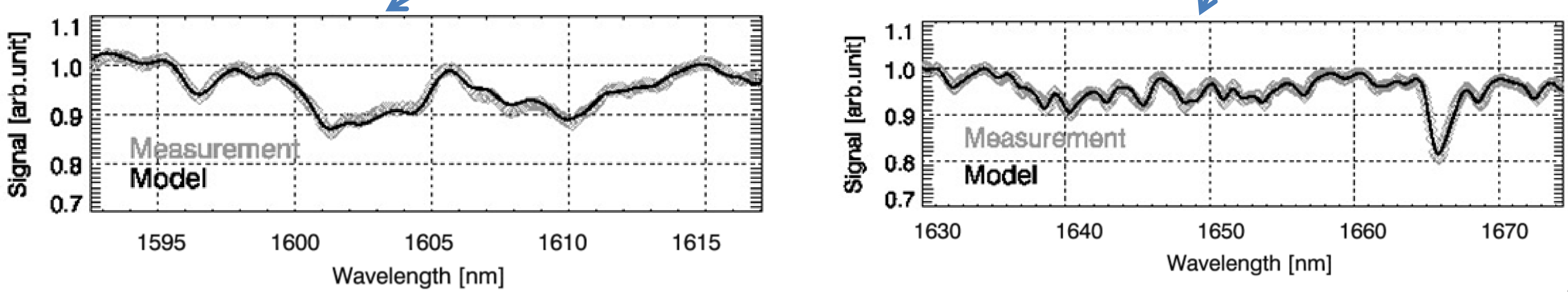
The Methane Airborne MAPper (MAMAP) [developed by University of Bremen and Geoforschungszentrum Postdam]

→ Passive airborne based remote sensing instrument using absorption spectroscopy

- spectral range: around 1590 nm to 1680 nm
- spectral resolution: 0.9 nm



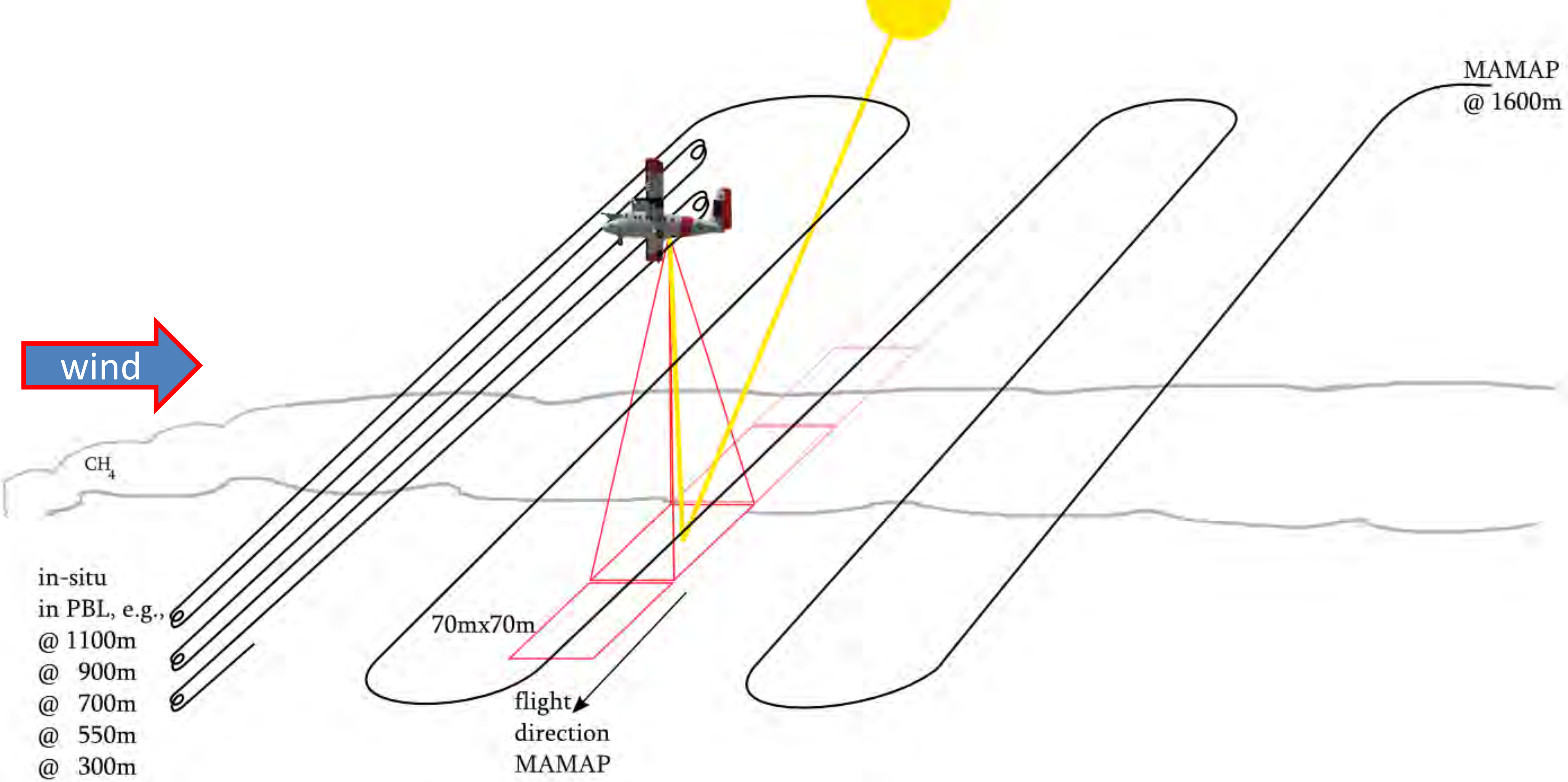
Real measurements / measured spectra



Measurement strategy and validation

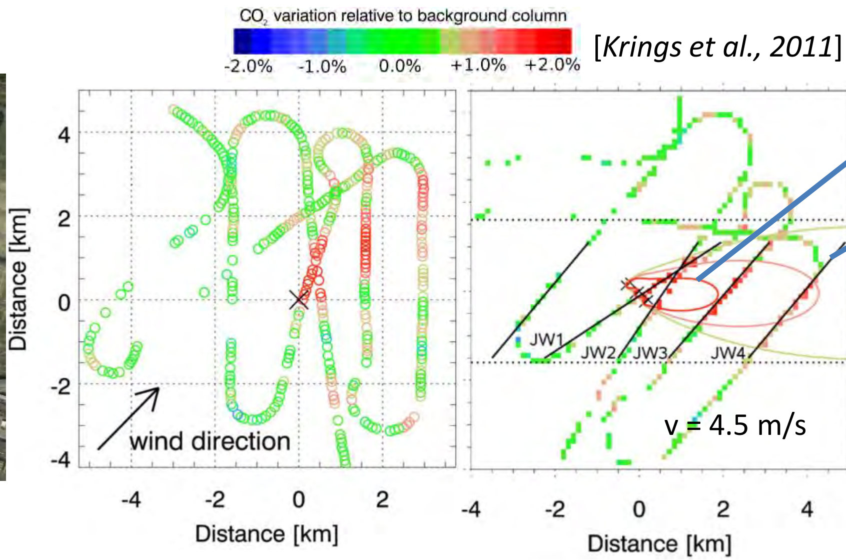
→ Passive airborne based remote sensing instrument using absorption spectroscopy

→ Airborne greenhouse gas in-situ analyzer for validation and flux comparison



Flux estimate: known targets

1) Power Plant (CO_2)



[*Krings et al., 2011*]

a) Gaussian Plume Model

b) Mass balance approach

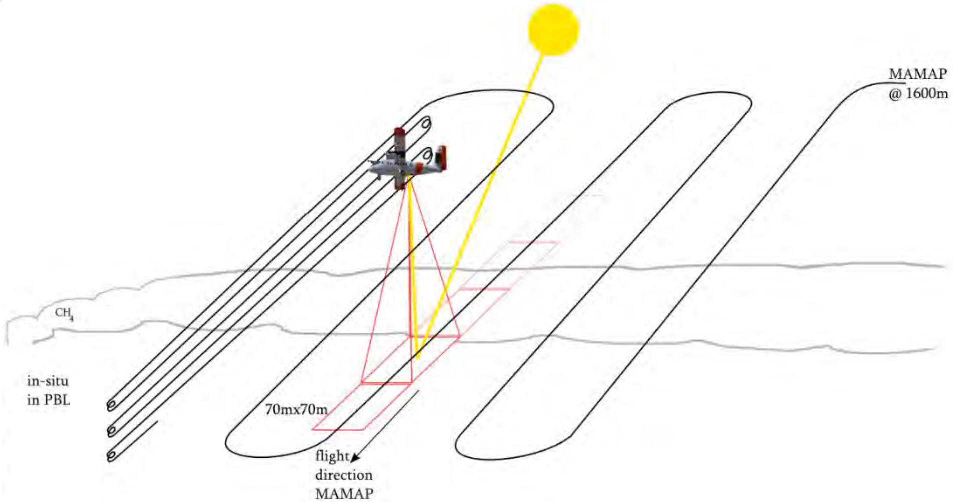
	$MtCO_2$/yr	approx. uncertainty
2007	26 (24)	22%
2007	24	reported

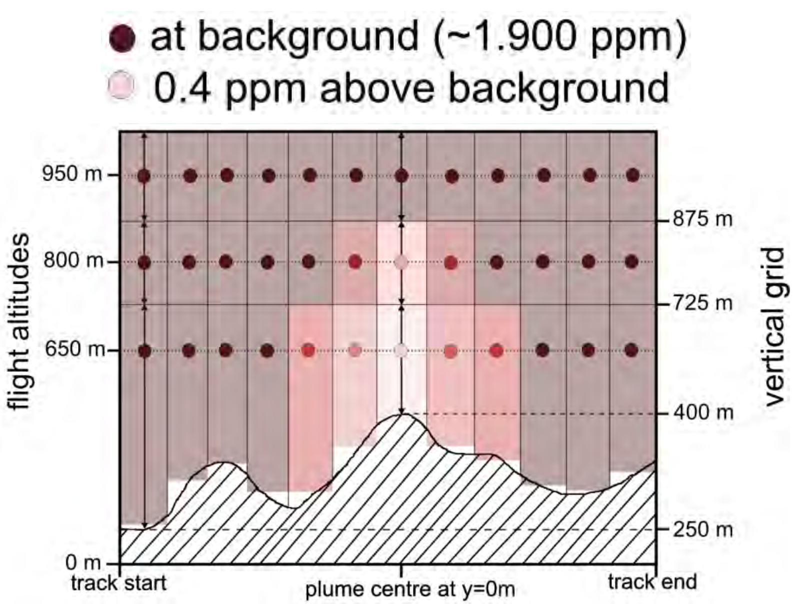
2) Coal Mine Ventilation Shafts (CH_4)

[*Krings et al., 2013*]

	$ktCH_4$/yr	approx. uncertainty
total	50	13.5%
total	50	reported

Airborne in-situ data





$$F = \sum_i MFaB_i * \frac{p_i}{T_i * k} * \Delta z_i * \Delta y_i * u_i * \cos(\alpha_i) * CF$$

CF = conversion factor: molec/s → g/s

$MFaB_i$ = mole fraction above background in grid box i [ppm]

p_i = pressure in grid box i [Pa]

T_i = temperature in grid box i [K]

k = Boltzmann constant [J/K]

u_i = wind speed in grid box i [m/s]

α_i = angle between wind direction and normal of length segment Δy_i [°]

F_{IS} = emission rate [g/s]

COMEX Campaign & Main Instrumentation

CIRPAS Twin Otter (Marina, CA)

Methane Airborne MAPper (MAMAP) [University of Bremen]

→ Passive remote sensing instrument, absorption spectroscopy

→ Column enhancements of CH_4 (or CO_2) relative to the background

Greenhouse gas in-situ analyzer / Picarro [NASA's Ames Research Center]

→ Mole fraction of methane (CH_4), carbon dioxide (CO_2) and water vapour

CIRPAS instrumentation

→ Wind speed and wind direction

→ Pressure, temperature

Twin Otter International

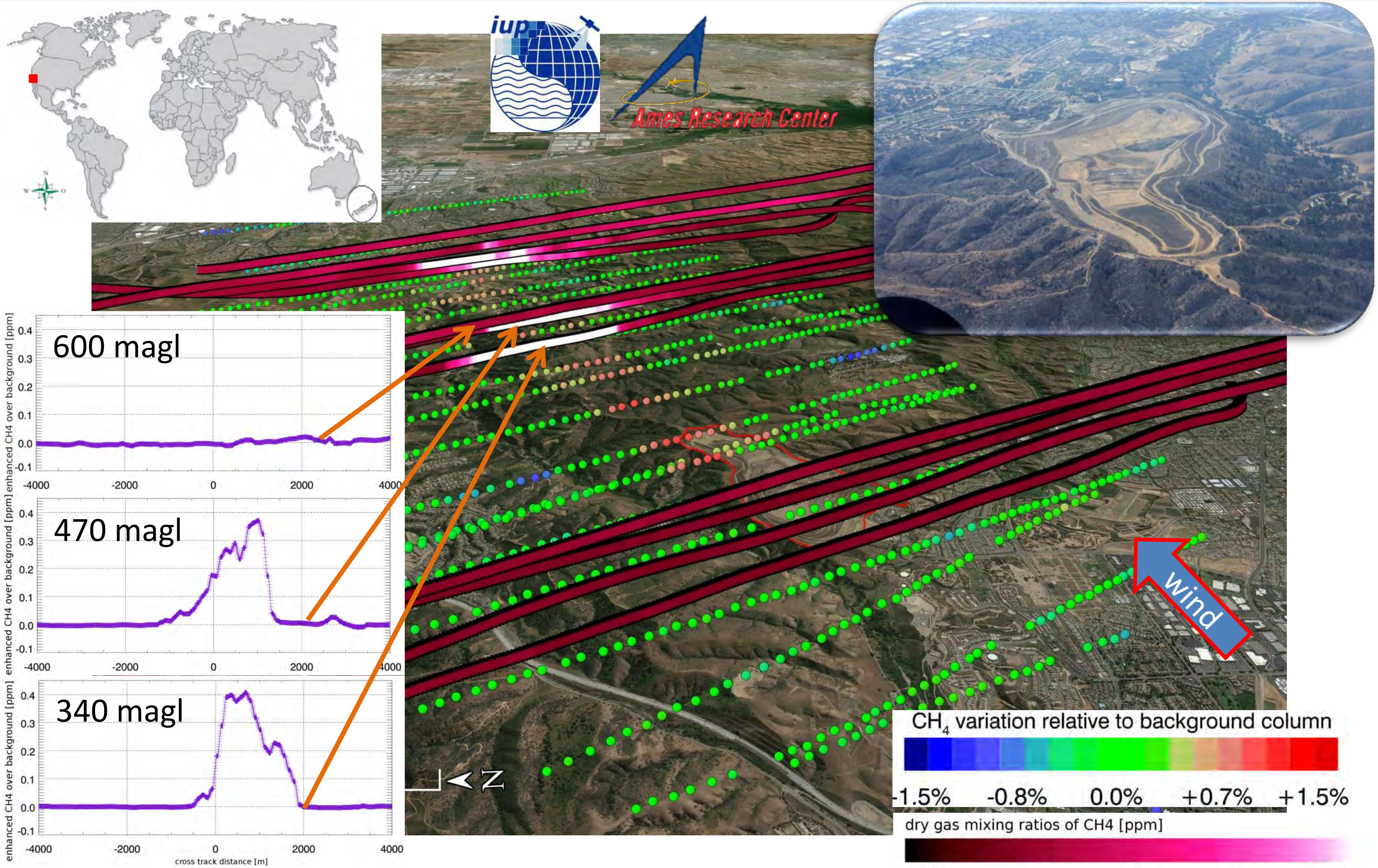
Airborne Visible/Infrared Imaging Spectrometer (AVIRISng) [JPL]

→ Passive remote sensing instrument, absorption spectroscopy

→ Qualitative enhancements of CH_4: flag for yes or no

→ Provided by David R. Thompson from JPL

Olinda Alpha Landfill



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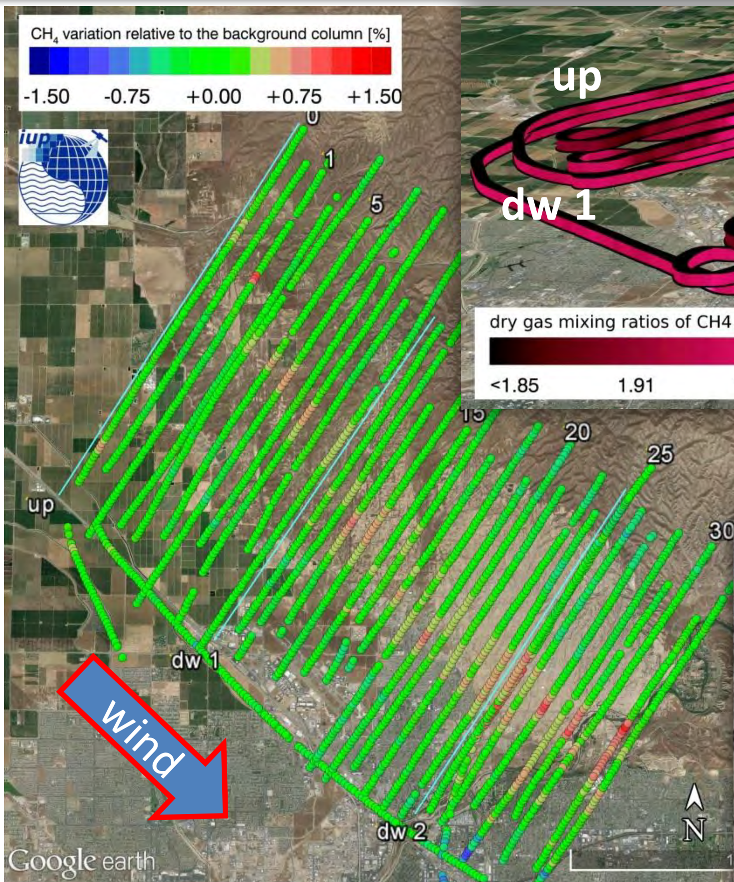
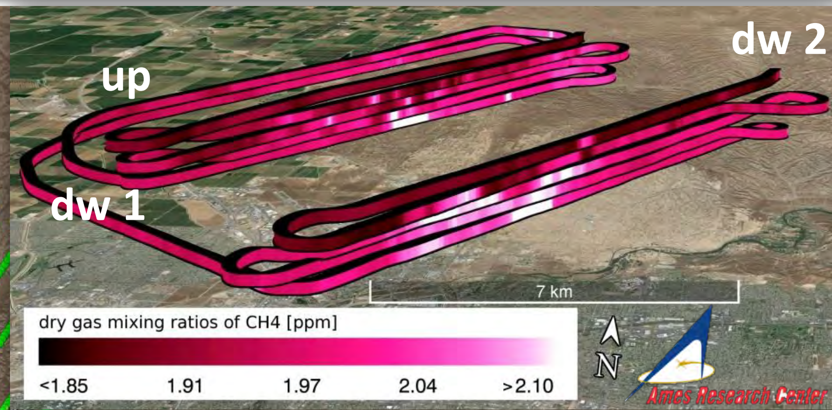
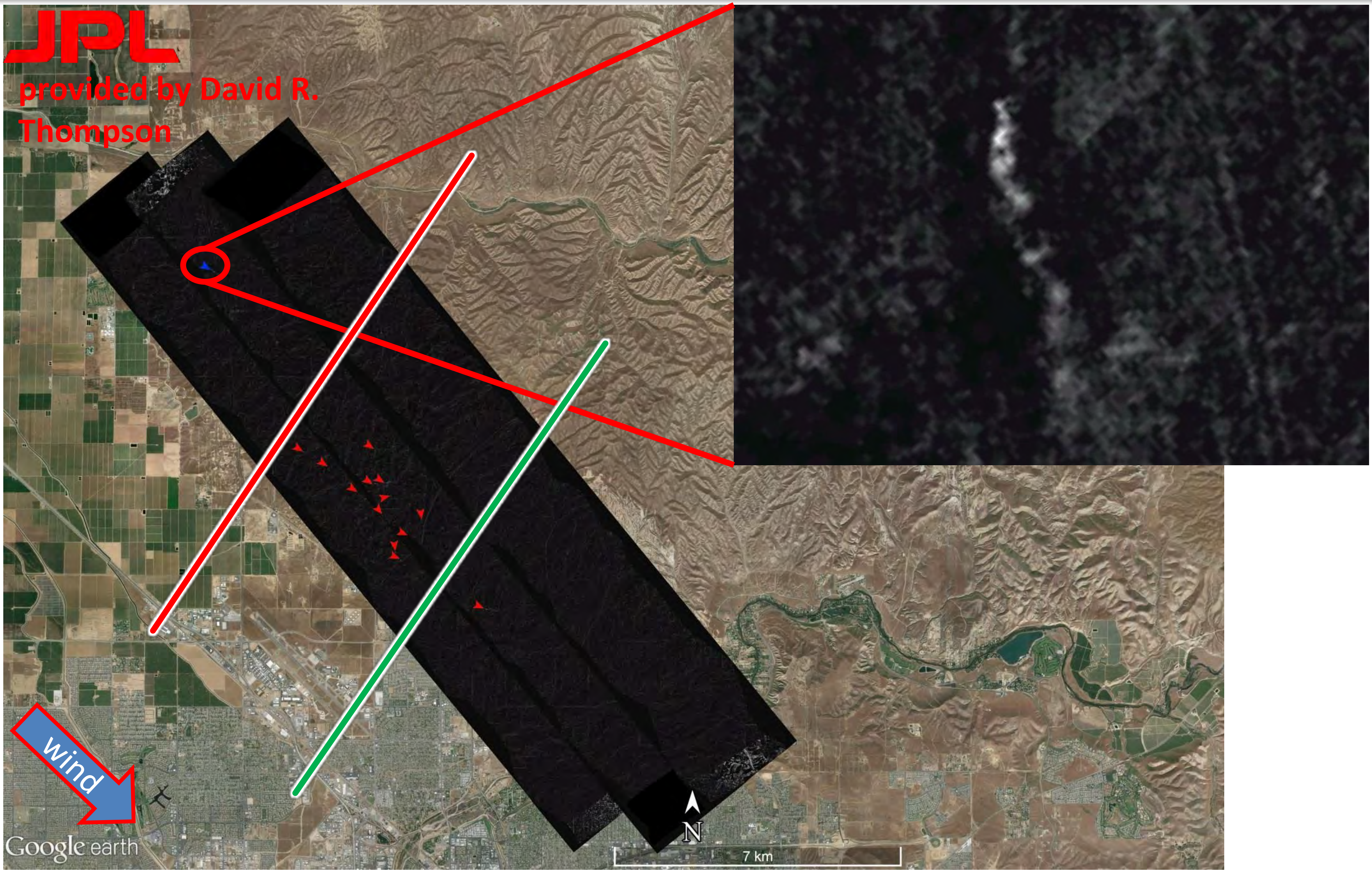
Kern Front, River, Poso Oil Field

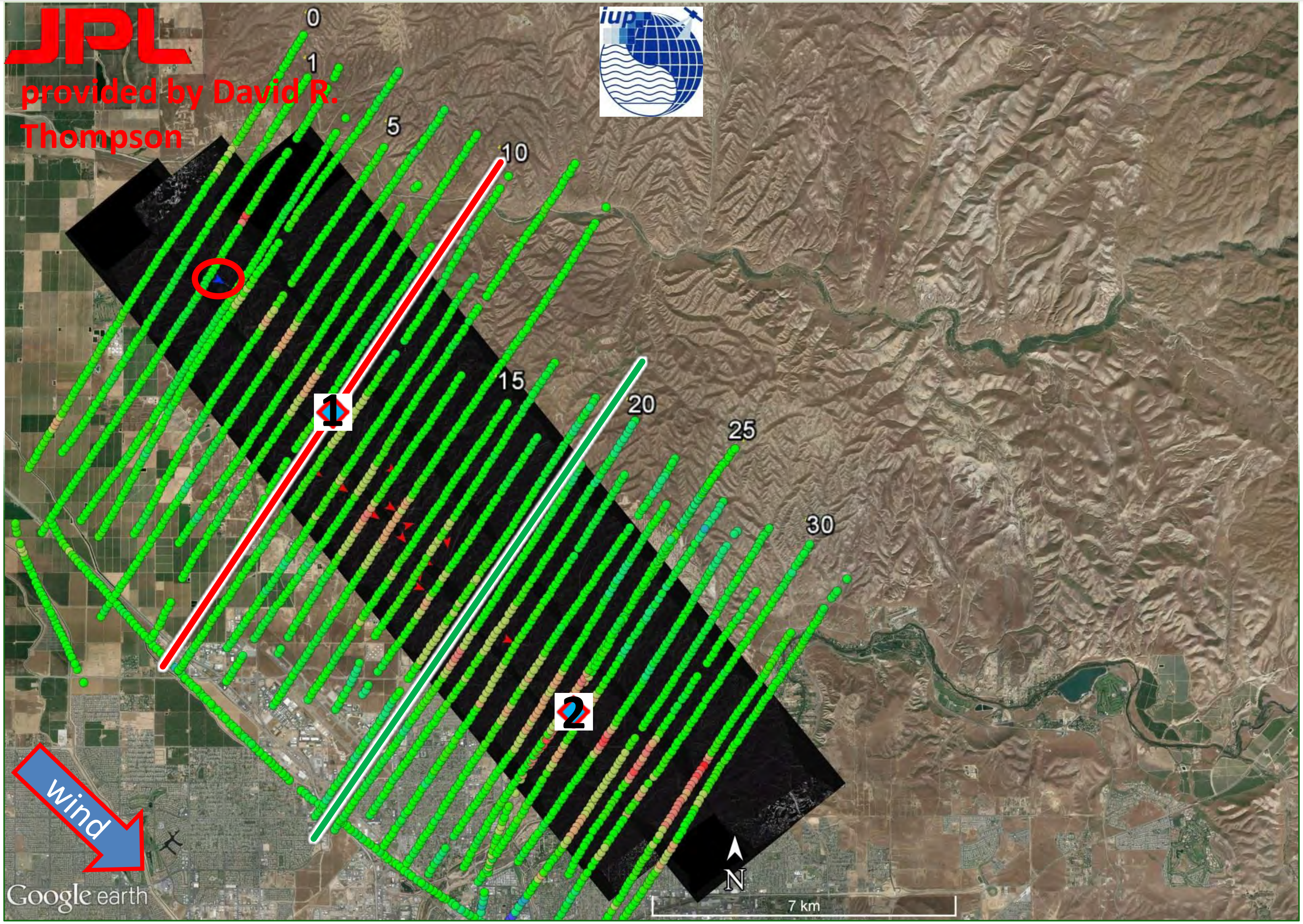




Kern Front, River, Poso Oil Field



Kern Front, River, Poso Oil Field



Summary

- MAMAP remote sensing measurements are well suited to measure CH_4 emissions from
  - areal sources like landfills or
  - extended areas containing numerous sources like oil fields

- Remote sensing measurements allow identification of single sources

- Flux estimates of remote sensing and in-situ measurements agree well

Thank you for your attention!

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- David R. Thompson [Jet Propulsion Laboratory (JPL)]
- Michael Eastwood [Jet Propulsion Laboratory (JPL)]

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