Seasonality in Fossil Fuel Industrial Emissions based on Surface and Satellite Transcontinental Data

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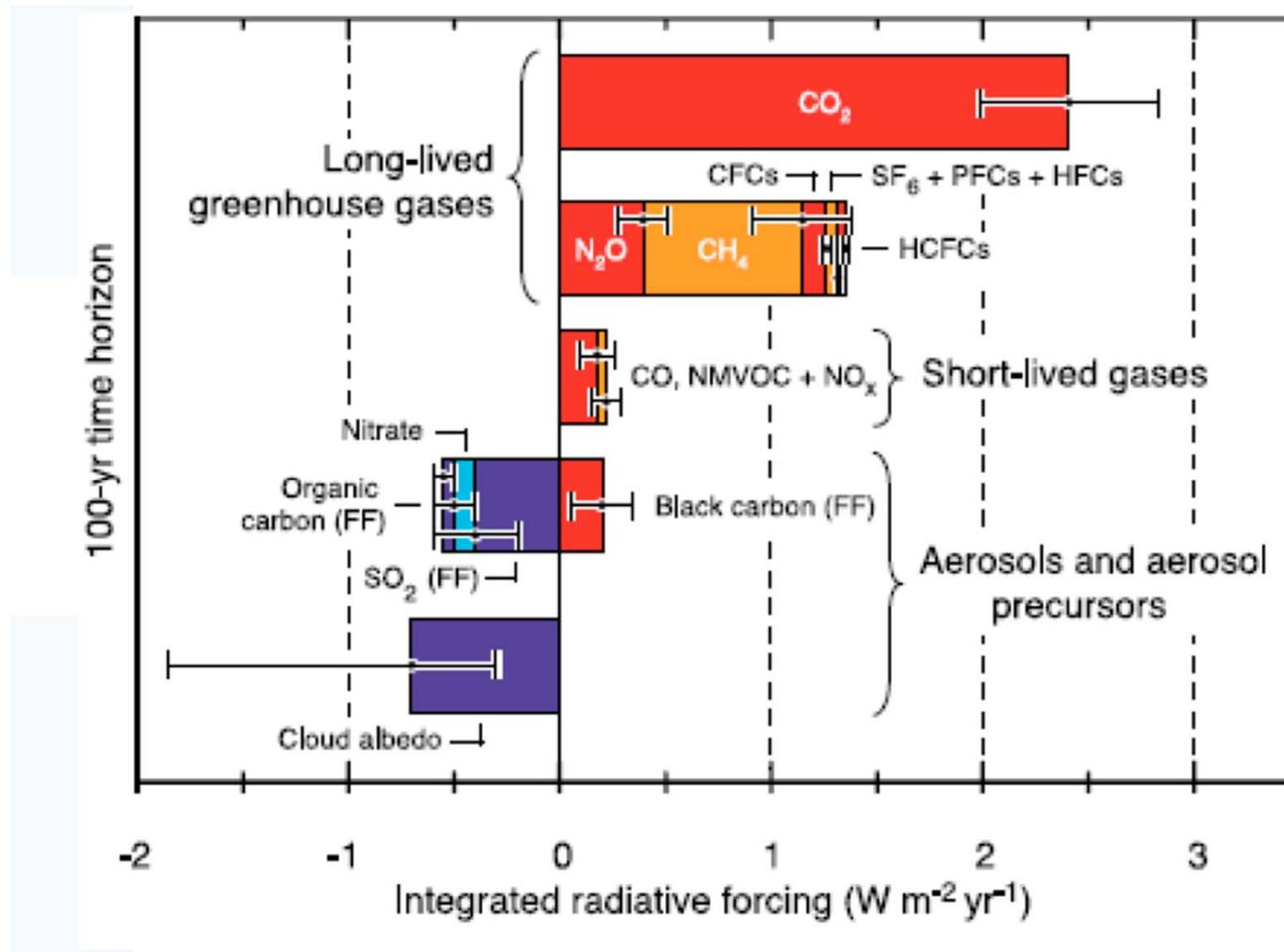
Why Methane ?

Methane is a greenhouse gas with **26 times** the **Global Warming Potential of carbon dioxide on a 100-year time horizon.** (IPCC4, Ch2, Fig.2.21, 2007)

Why Methane ?

Figure: Integrated radiative forcing (W m⁻² yr⁻¹) on a 20-yr time horizon for various agents including long-lived greenhouse gases (CO_2, N_2O, CH_4, CFCs, HCFCs, SF_6 + PFCs + HFCs), short-lived gases (CO, NMVOC + NO_x), and aerosols and aerosol precursors (Nitrate, Organic carbon (FF), SO_2 (FF), Black carbon (FF), Cloud albedo).
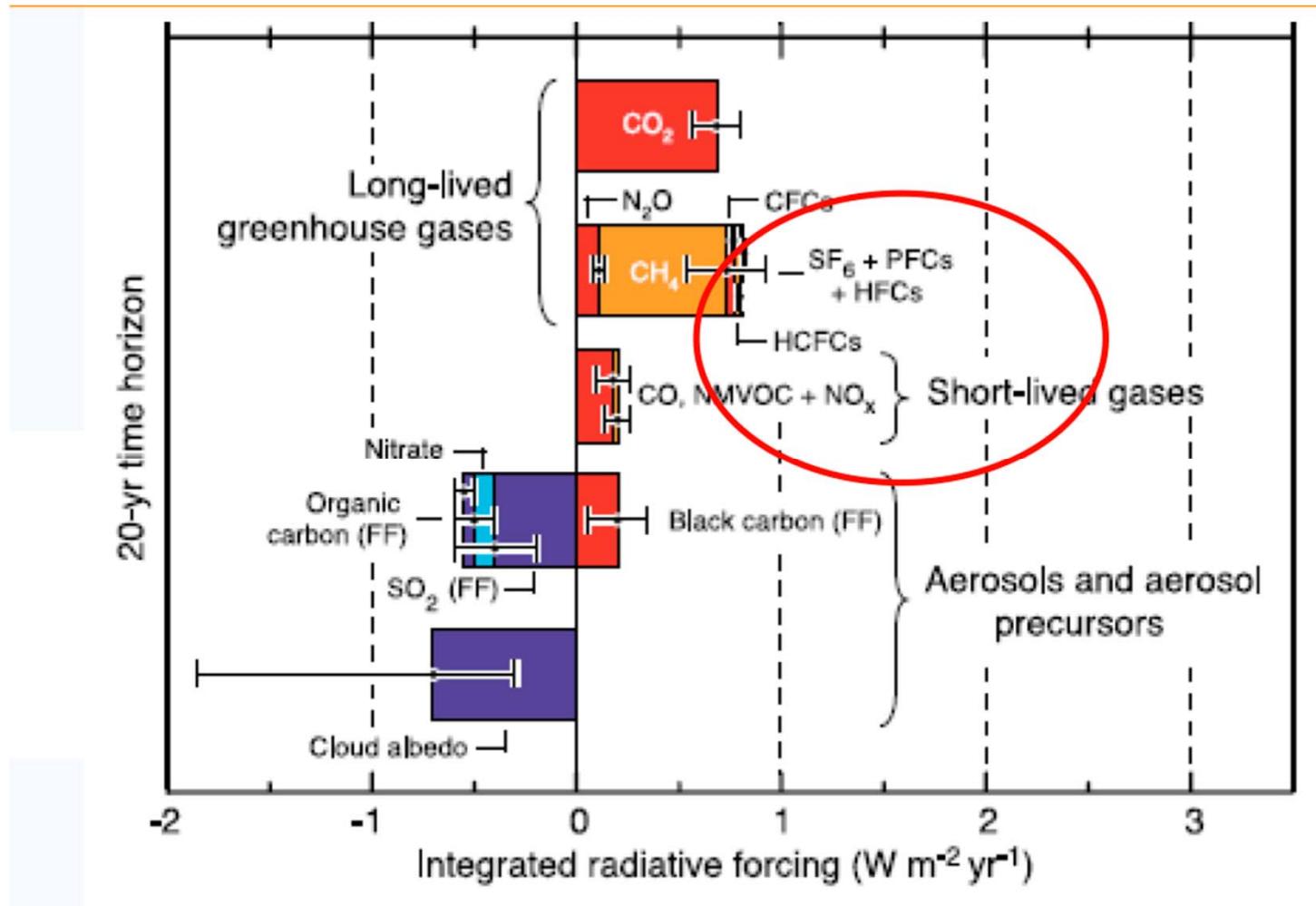
On a 20-year time horizon methane has even 72 times the GWP of carbon dioxide. (IPCC4, Ch2, Fig.2.22, 2007)

Why Methane ?

Stable since ~1750

!?

Recent increase

Increase until ~2000

!?

Again stable ~2000-2006
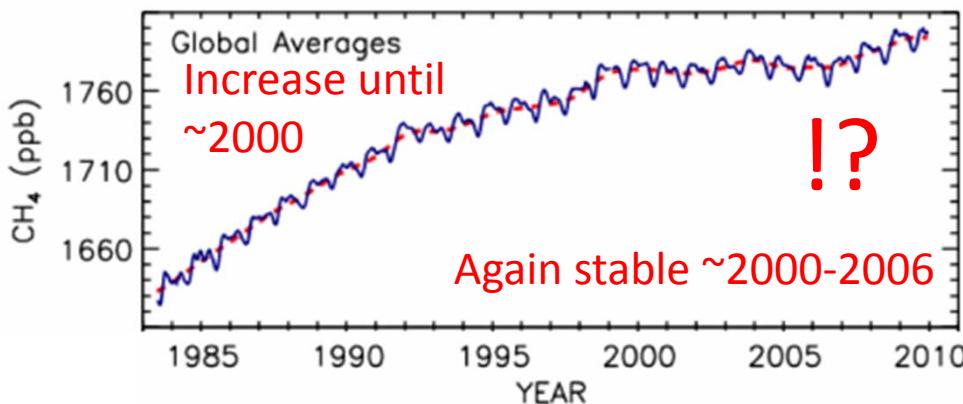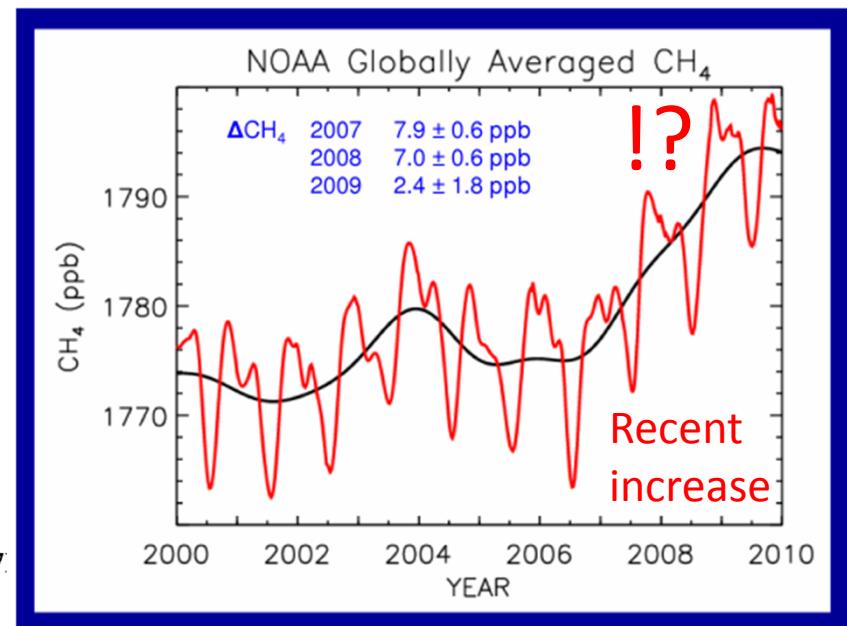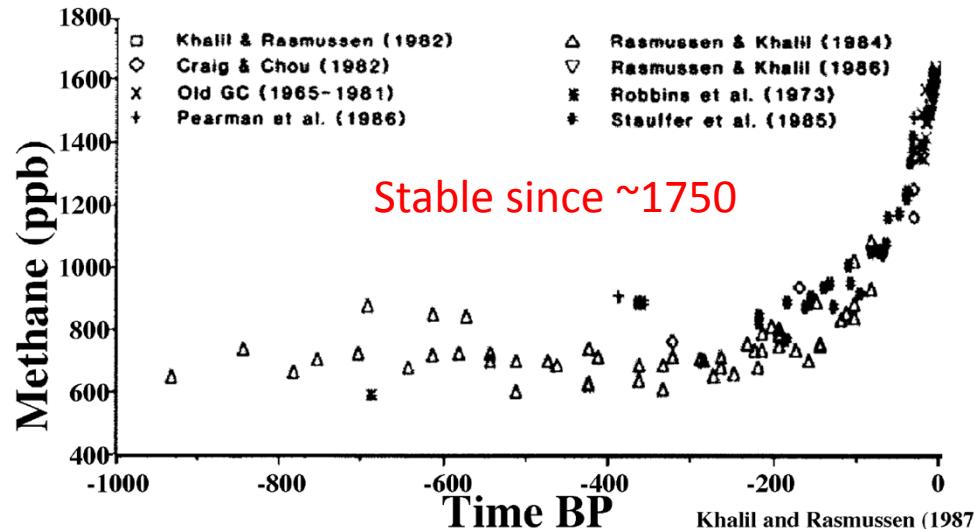
*Dlugokencky et al. A Long-term Perspective on Recent Increases in Atmospheric CH4 Abundance, Global Monitoring annual Conference, 18-19 May 2020, Boulder CO.*

Methane – Human Sources
(bottom up inventory estimates)
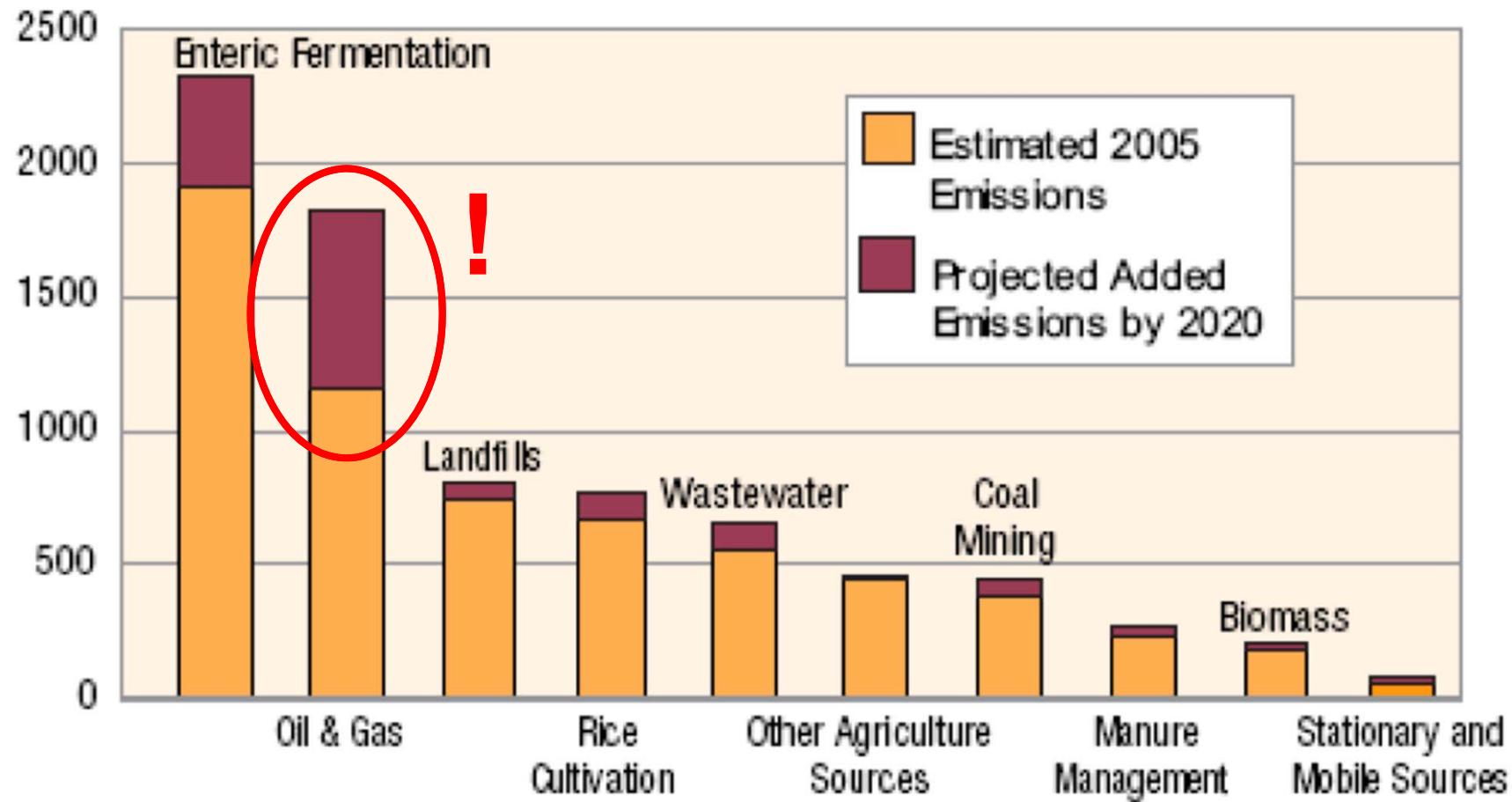
Fossil Fuel Industrial (FFI)= oil&gas+coal

http://www.asiapacificpartnership.org/pdf/CFE/meeting_seoul/workshop_presentations/09_M2M-APP_CFETF.pdf

Ira Leifer & RV ... crossing the Mississippi River

Recreational Vehicle-based, mobile GC/FID measurements; since 2012 with Picarro

RV-based, mobile GC measurements (2010)

Since 2012 with Picarro
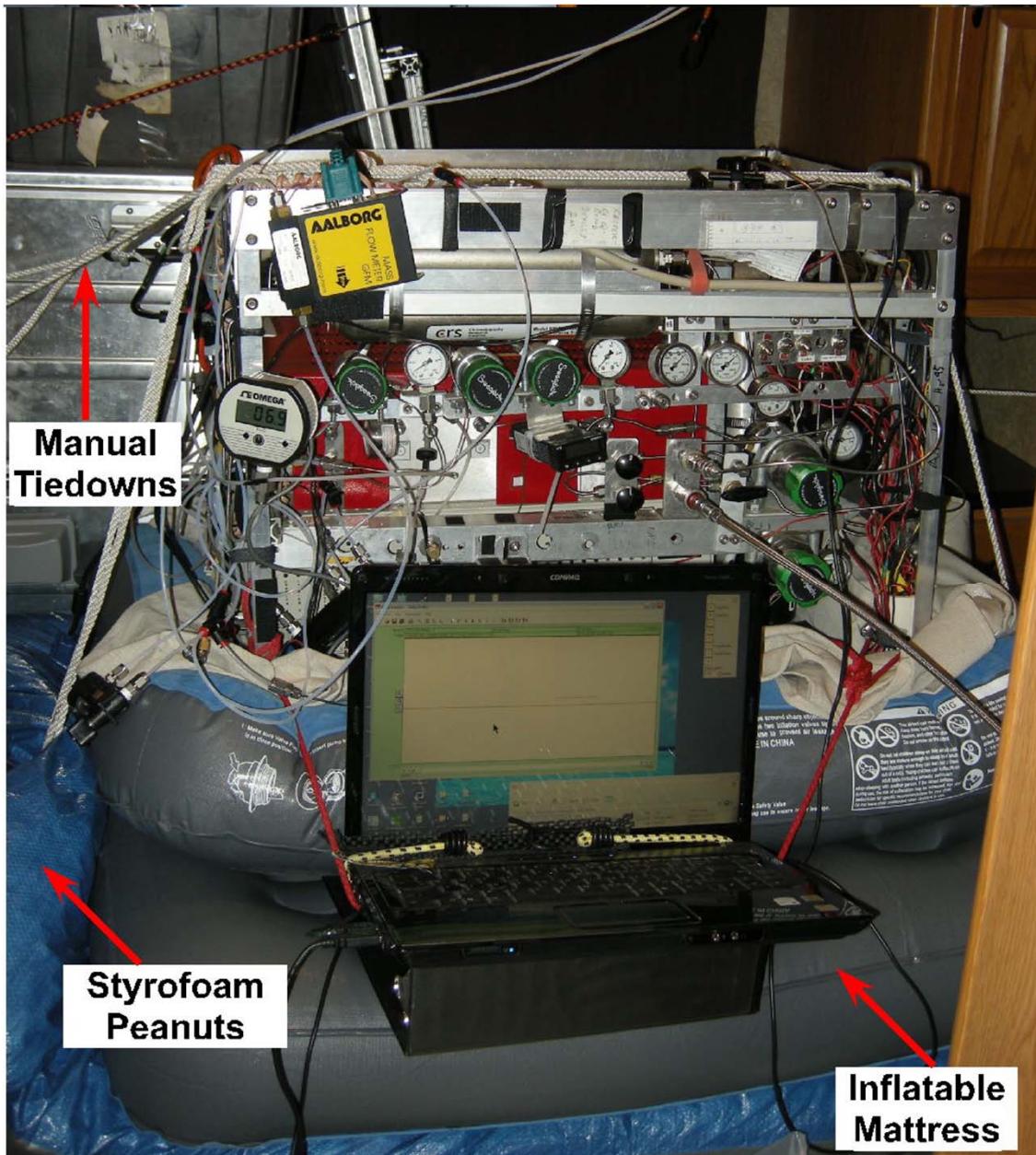
Used for several US trancontinental surveys California - Florida

Noise vibrations are a serious problem with making mobile gas chromatography measurements on American highways. Here, a half deflated air mattress rests on a styrofoam peanut bed. Additional gel pads are under the GC and the entire system is connected to walls by bungee cords.

Labels on image: Manual Tiedowns, Styrofoam Peanuts, Inflatable Mattress

US methane surveys 2010 & 2012
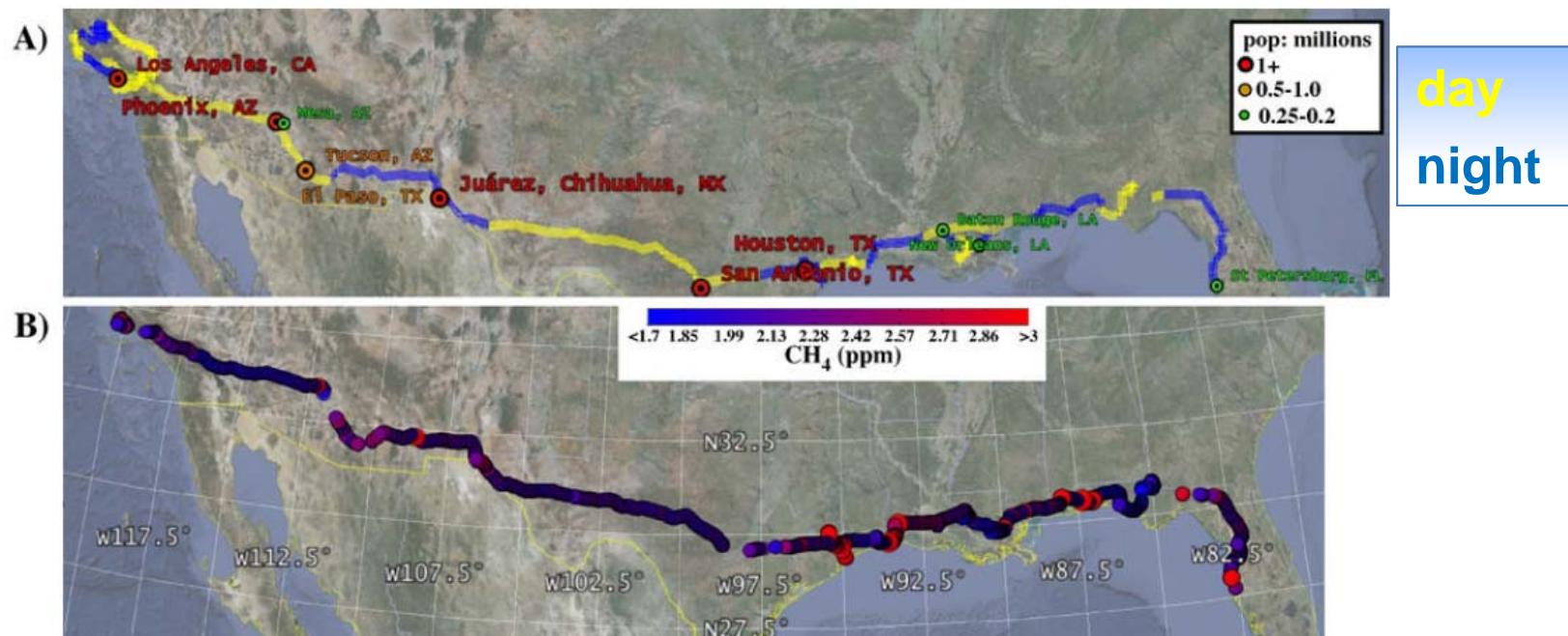
Fig. 1. A) Map showing survey path (yellow day, blue night) including major urban centers for 2010 and 2012. City population key on figure. B) Measured survey methane, CH_4, values for 2010. Note truncated color scale to emphasize near background variations. Surface image from GoogleEarth. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Transcontinental methane measurements: Part 1. A mobile surface platform for source investigations

Paige Farrell, Daniel Culling, Ira Leifer*

Marine Science Institute, University of California, Santa Barbara, CA 93106, United States

Farrell et al., 2013

8

Some results discussed in detail in …

Leifer et al., Atmospheric Environment, 2013
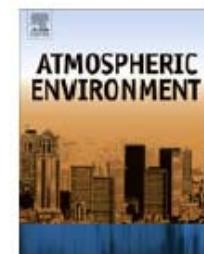
Transcontinental methane measurements: Part 2. Mobile surface investigation of fossil fuel industrial fugitive emissions

Ira Leifer [a,*], Daniel Culling [a], Oliver Schneising [b], Paige Farrell [a], Michael Buchwitz [b], John P. Burrows [b]

[a] Marine Science Institute, University of California, 1642 Elm Ave, Santa Barbara, CA, USA
[b] Institute of Environmental Physics (IUP), University of Bremen, FB1, Bremen, Germany

… are presented in the following

Many methane emission hot spots detected …

… often twice the background - or even much higher - detected over extended regions (e.g. several km)

Coal loading terminal

Mobile Bay
Alabama

CH_4 (ppm)
<1.7 1.85 1.99 2.13 2.28 2.42 2.57 2.71 2.86 >3

Natural gas power plant & pipeline

N 5 km

Pensacola Bay, Florida
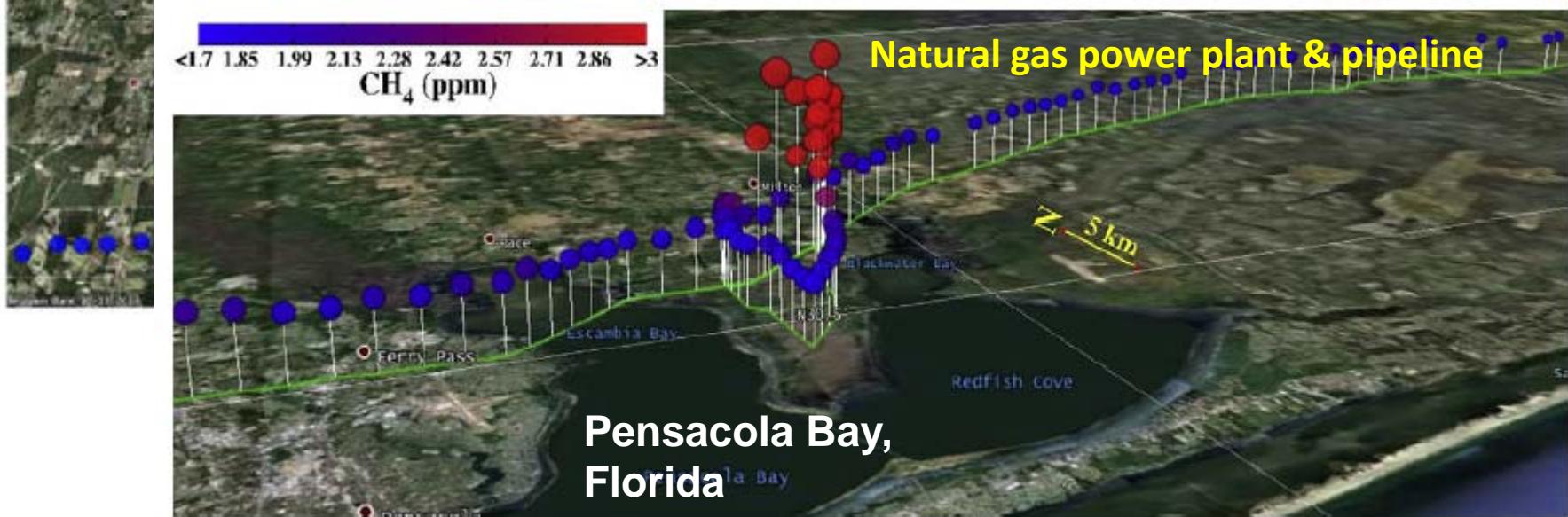
Fig. 5. Methane, CH_4, mixing ratios north of Pensacola bay, W. Florida. Size scale, direction, color bar on figure.

Leifer et al., Atmos. Environ., 2013

Kern River Oil Field (near Bakerfield, CA)

Leifer et al., Atmos. Environ., 2013
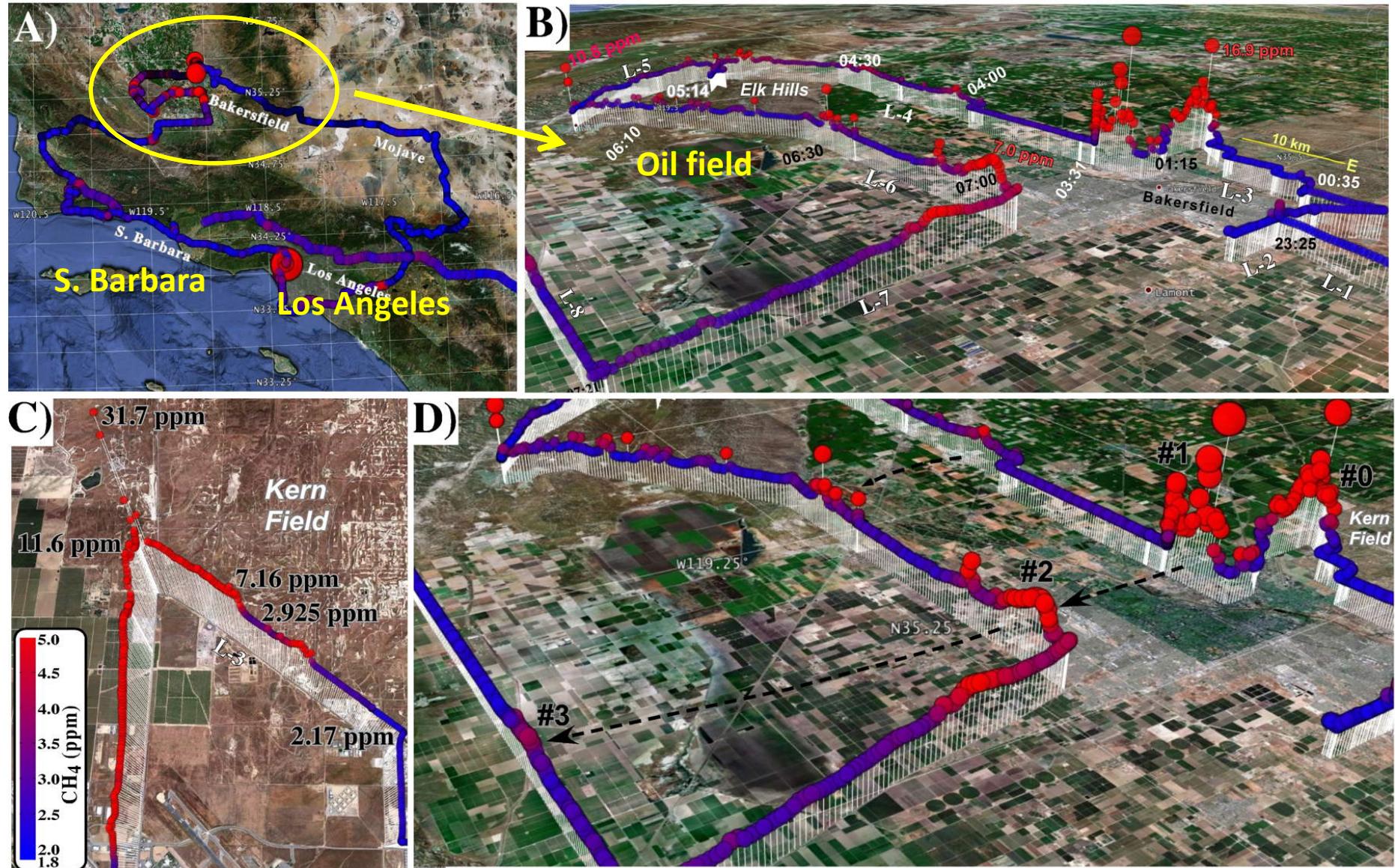
# Kern River Oil Field: Surface methane
Many strong plumes:

Leifer et al.,
Atmos. Environ., 2013
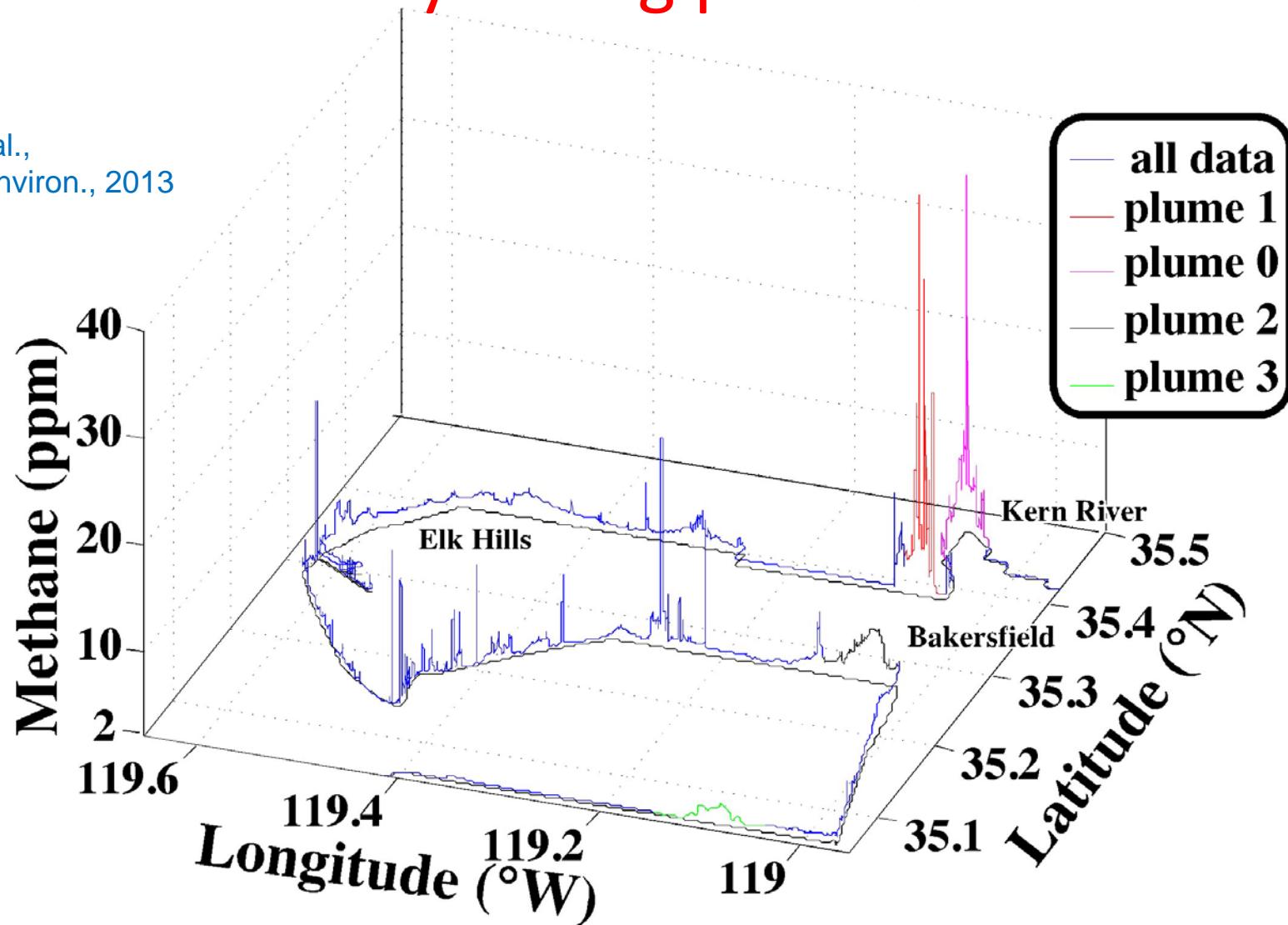
Gaussian Plume Model Inversion



Kern River Oil Field

Leifer et al.,
Atmos. Environ., 2013
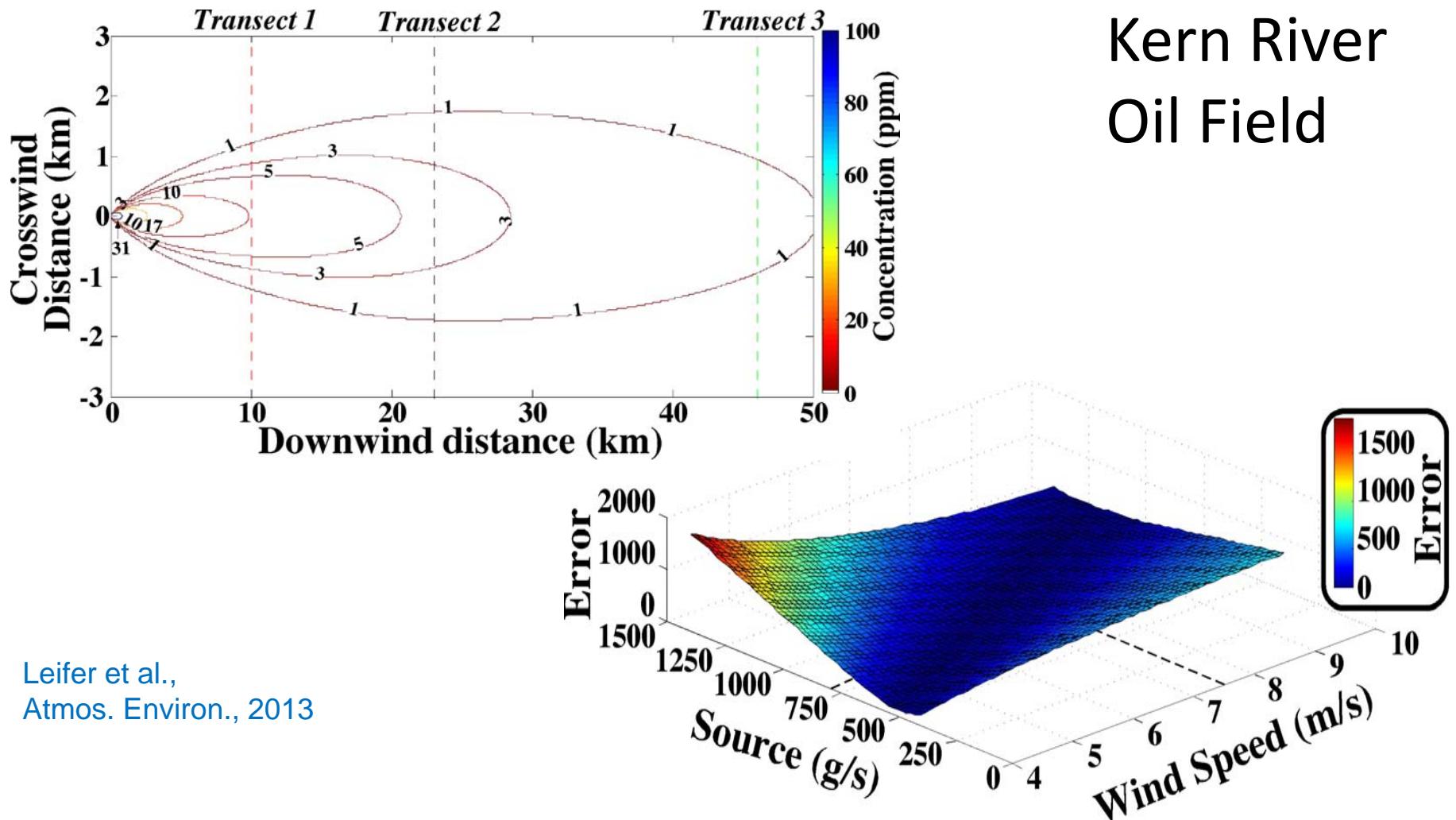
Error Minimization suggests 24.6 kTon yr^{-1},
and an effective wind speed of 7.5 m/s

A Transcontinental Surface Dataset

2010

Leifer et al.,
Atmos. Environ., 2013
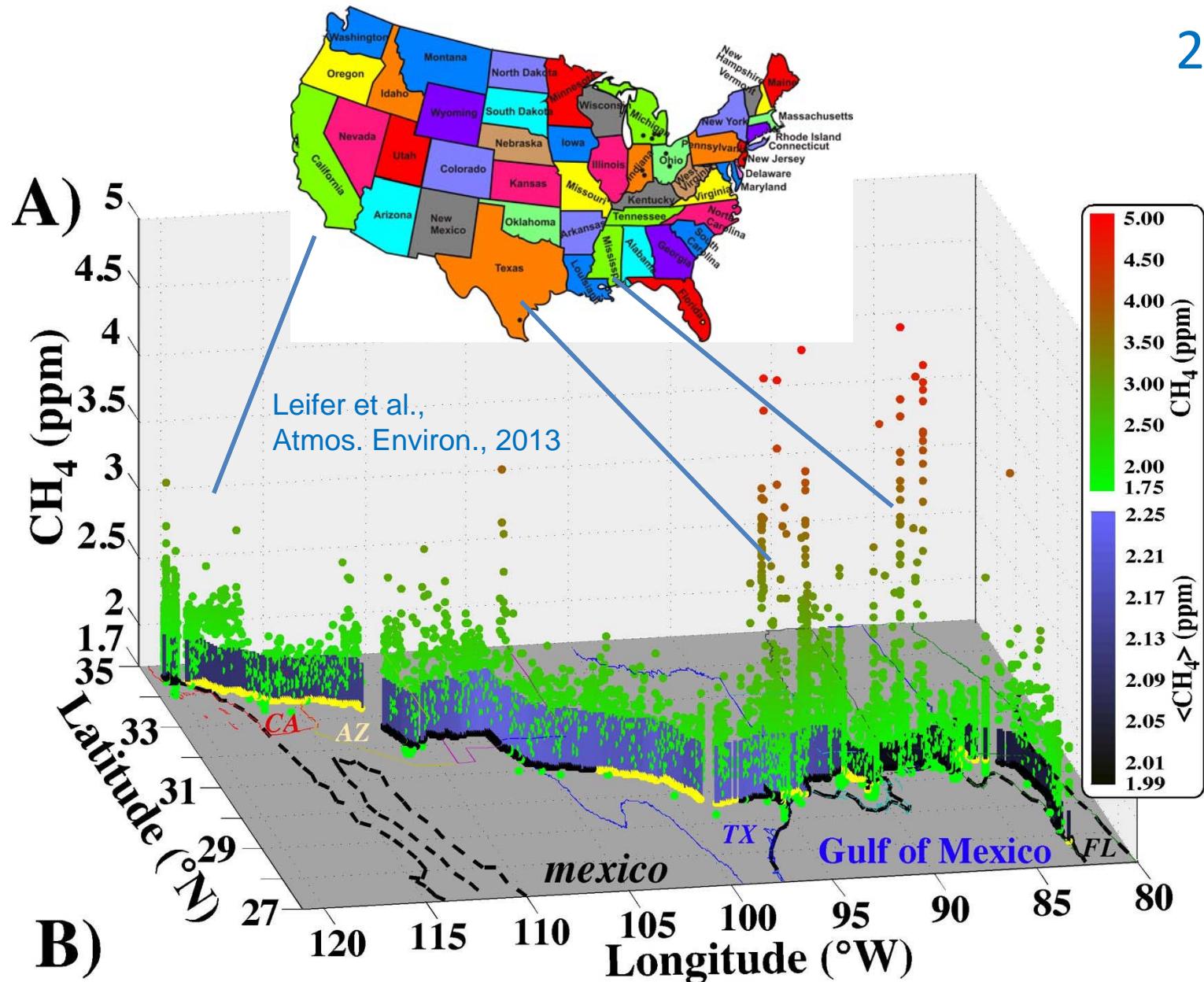
Methane spatial pattern from satellites

A)

Florida

Mississippi

Louisiana

Cantarelle
Oil Field

Mexico

Houston

Texas

3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.70

Surface CH$_4$ (ppm)

1740   1754   1768   1782   1796   1810
2003-2005 Methane (ppb)
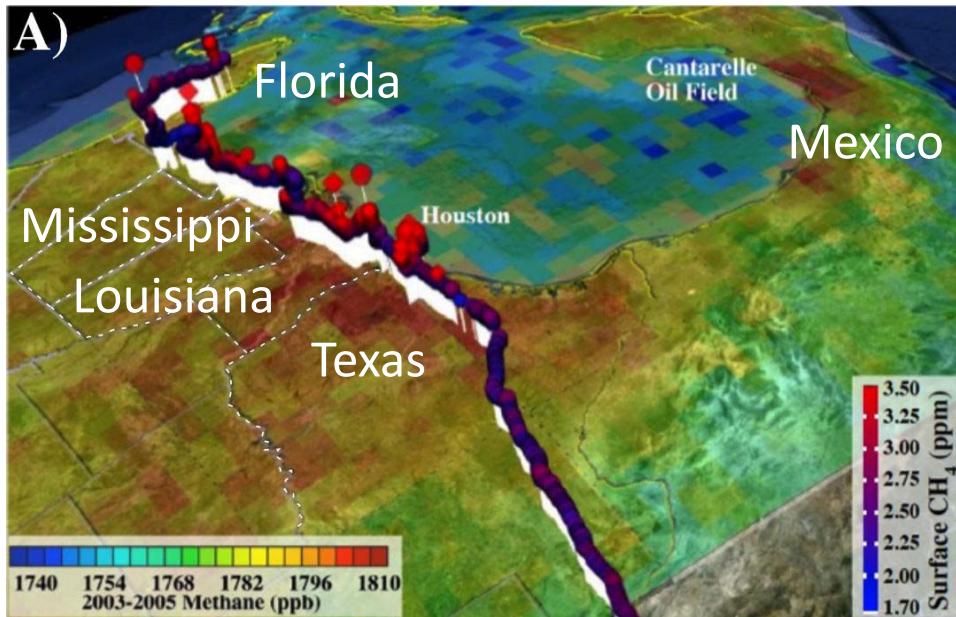
SCIAMACHY/ENVISAT
(2003-2005)

TANSO-FTS/GOSAT
(2009-2011)

B)

FL

Gulf of Mexico

GA
AL
MS   LA

Texas

Mexico

1.84
1.82
1.80
1.78
1.76
1.74
1.72
1.70
1.68

xCH$_4$ (ppm)
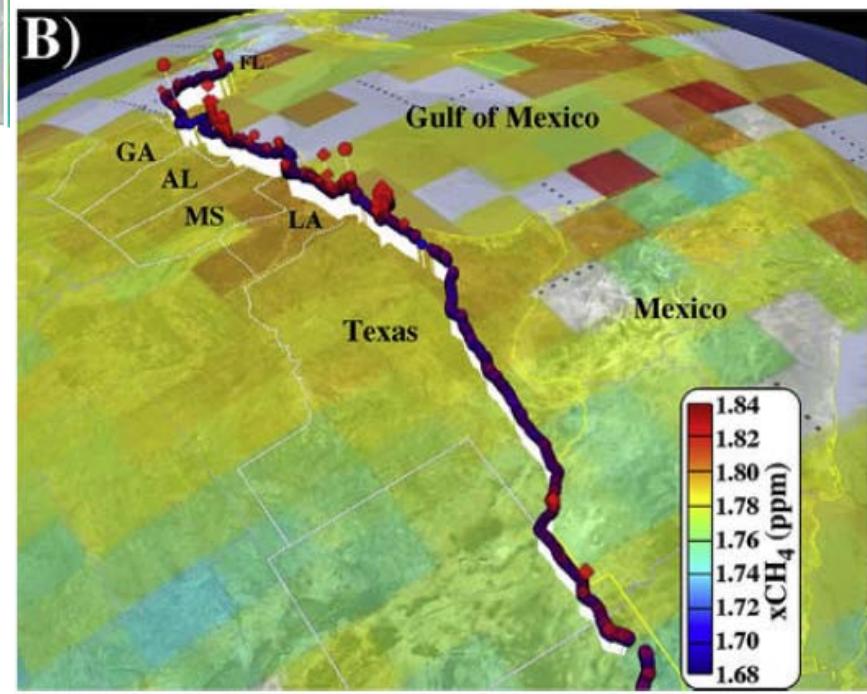
Methane highest around Texas /
Louisiana / Mississippi area in
the US

(but high values also over large
parts of Mexico, eg, Cantarell Oil
Field)

Leifer et al.,
Atmos. Environ., 2013

Seasonal dependence spatial pattern

Anthropogenic
(Annual)

SCIAMACHY
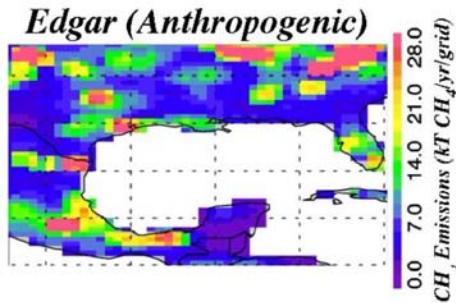
Wetlands

Winds


SCIAMACHY pattern seasonal dependent mixture of anthropogenic and wetland methane emissions

Leifer et al.,
Atmos. Environ., 2013
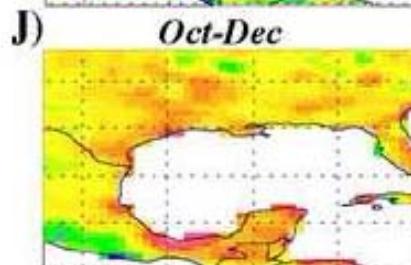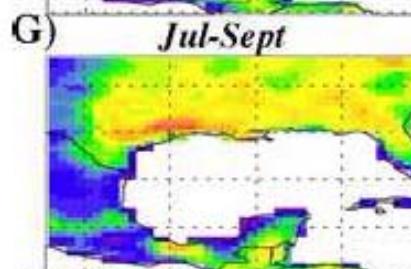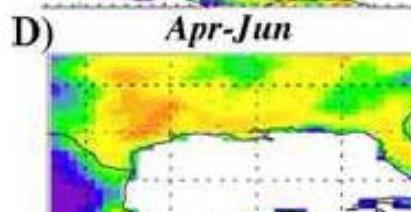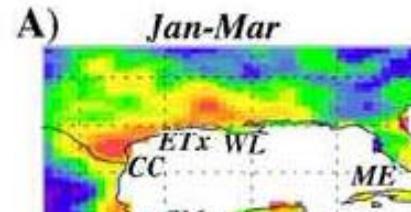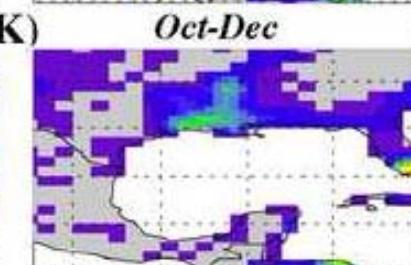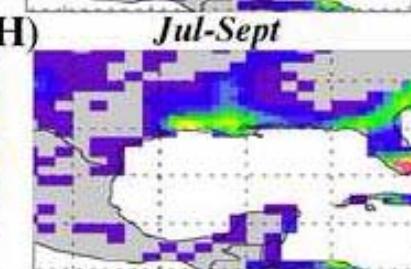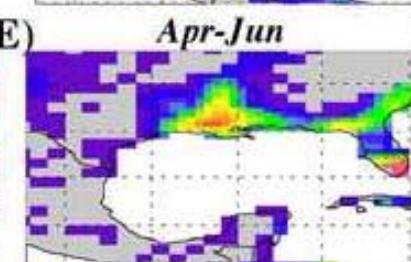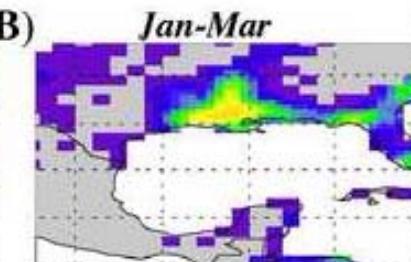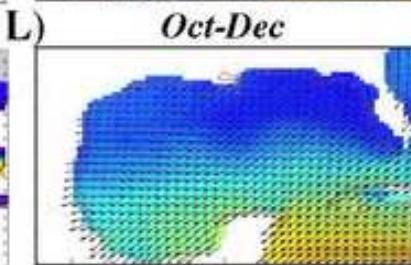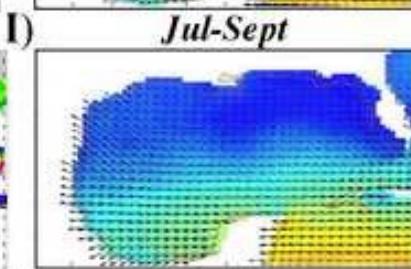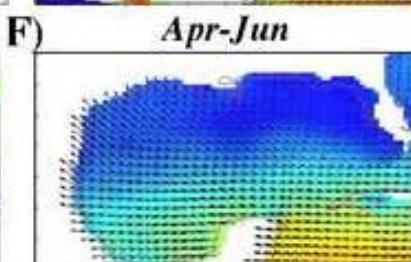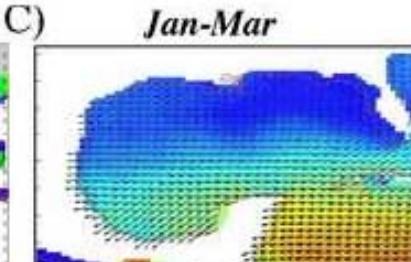
CC - Corpus Christi ETx - East Texas WL - West Louisiana ME - Miami/Everglades CM - Cantarelle, Mexico

Other regions: Mexico (e.g., Cantarell Oil Field)
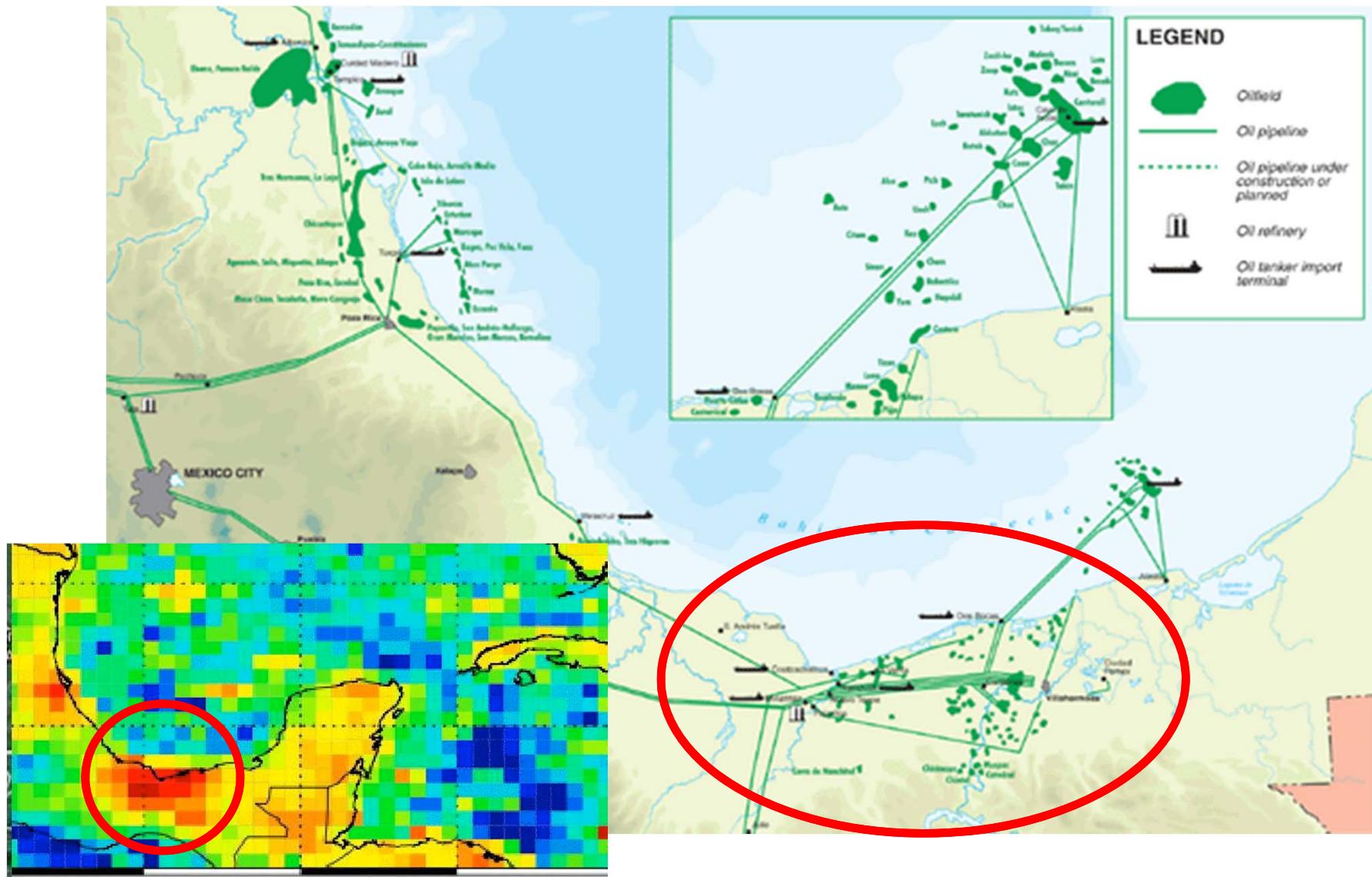
SCIAMACHY

Summary & conclusions

Methane is a key greenhouse gas especially on relatively short ("political") time scales (< 20 yrs)

Surface methane measurements, particularly using an adaptive survey approach including situational awareness of winds and potential area sources can investigate in detail diverse sources and estimate source strength via inverse modeling

Findings: Methane concentrations decreased to the east and west from the greater Houston area, center of US refining and distribution of petroleum hydrocarbons. Oil fields and refineries sometimes very strong sources.

Satellites together with ground-based observations and modelling critical to get the full picture. Requires good spatio-temporal coverage and resolution (e.g., CarbonSat)

Ongoing next steps: Planning for COMEX aircraft campaign

CO$_2$ and CH$_4$ aircraft campaing „COMEX"

A NASA/ESA collaborative remote sensing study in support of the future satellite missions

HyspIRI and CarbonSat

Campaign and Support Team:

Ira Leifer[1], Konstantin Gerilowski[2], Matthew Fladeland[5],Sven Krautwurst[2], Thomas Krings[2], Laura Iraci[5], John Burrows[2], Chuanmin Hu[3], Michael Buchwitz[2], Robert Green[4], Liane Guild[5], Heinrich Bovensmann[2], Jack Kaye[6], Woody Turner[6], Dirk Schuettemeyer[7], Roy Woods[8], et al.

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[4] Jet Propulsion Laboratory (JPL)
[5] NASA Ames, Earth Science Division (Ames)
[6] NASA, Earth Science Directorate
[7] European Space Agency, Mission Science Division (ESA)
[8]Center for Interdisciplinary Remotely-Piloted Aircraft Studies, NPS (CIRPAS)

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