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Hyperion detection and characterization of the Aliso Canyon event

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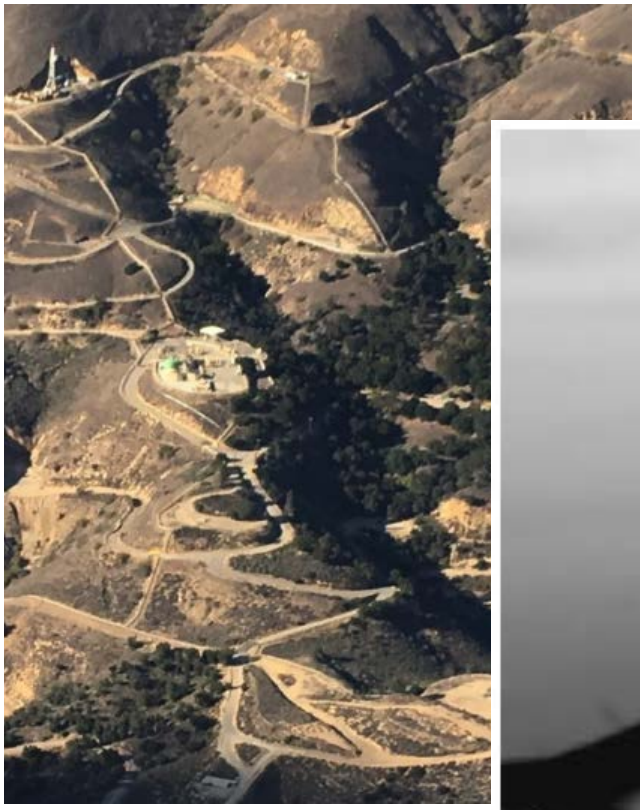
The Aliso Canyon CH_4 release

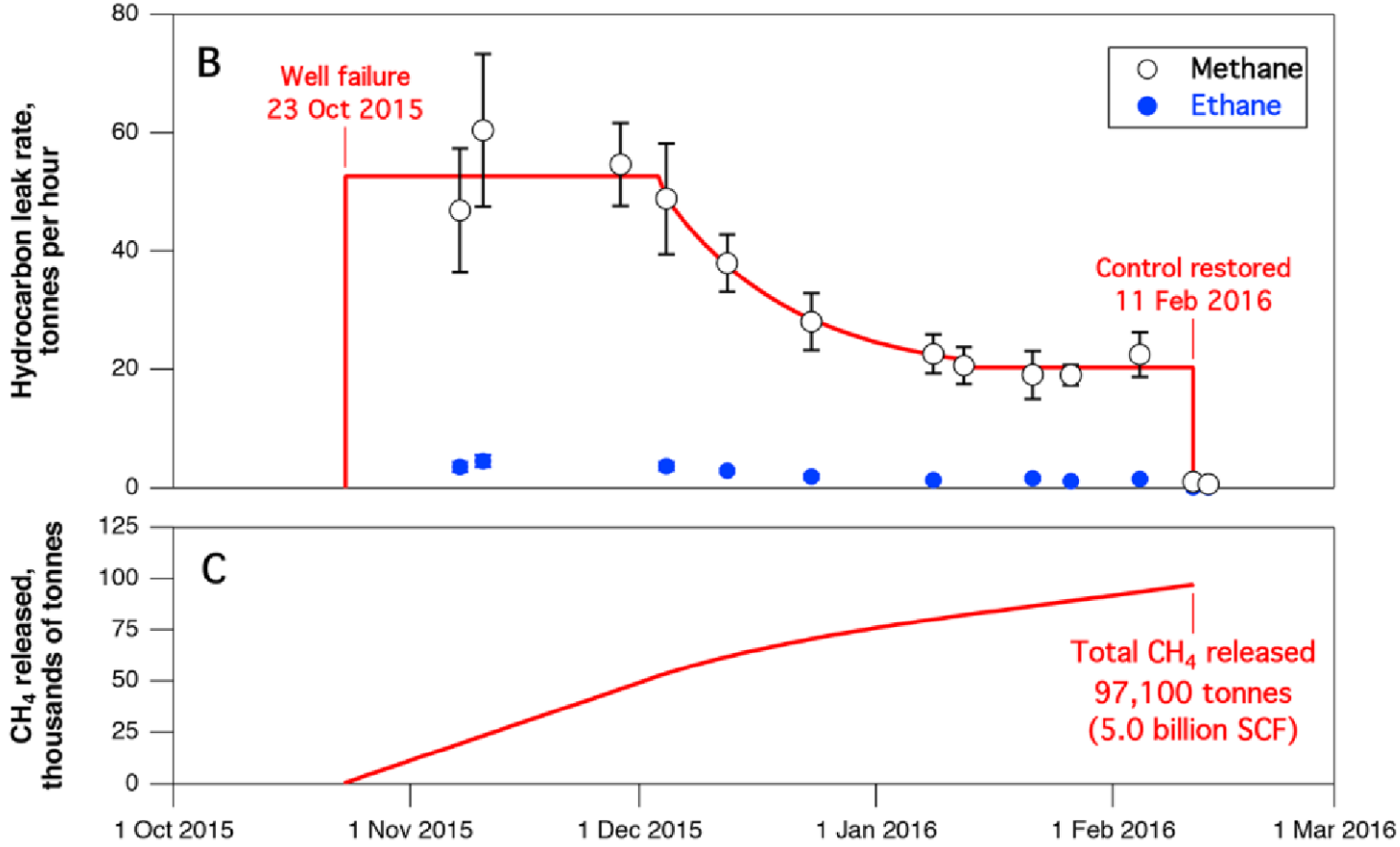


(NOAA)

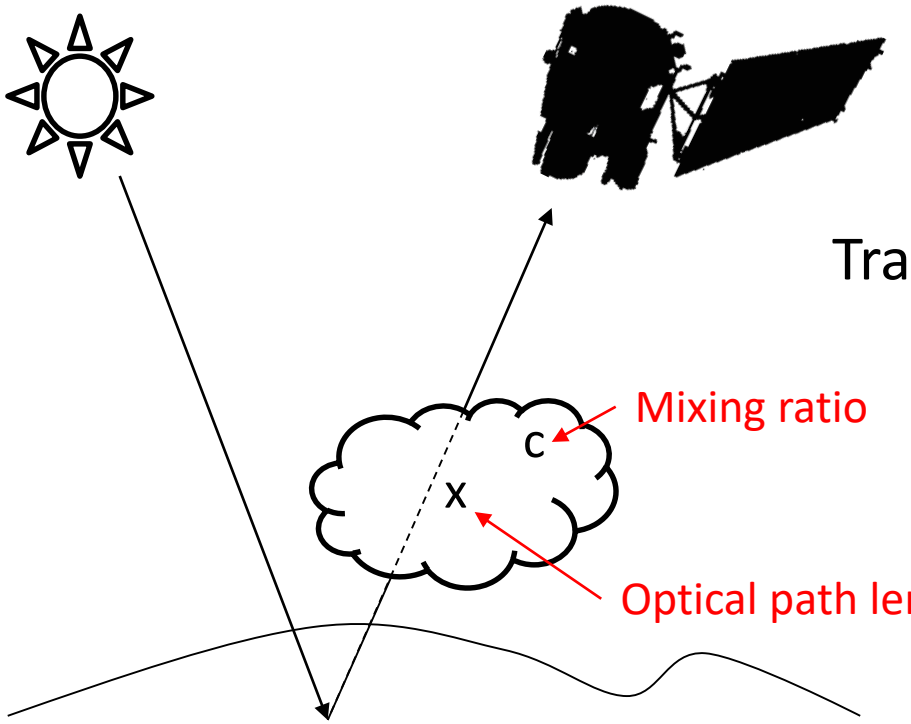
http://blogs.edf.org/

Leak rate estimated from airborne mass balance

Conley et al., *Science* 2016



What can we measure from Hyperion?



Mixing ratio
length in ppm m

$$\text{Transmission} \;\alpha\; e^{-\kappa c x}$$

Absorption coefficient

Detection via matched filter

Matched filter applied independently in each column

$$\hat{\alpha}(\mathbf{x}) = (\mathbf{x} - \mu)^T \Sigma^{-1} \mathbf{t} / (\mathbf{t}^T \Sigma^{-1} \mathbf{t})$$

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Mixing ratio length

Tested spectrum

Background mean

Background covariance

target

Detection via matched filter

Matched filter applied independently in each column

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Mixing ratio length

Tested spectrum

Background mean

Background covariance

target

Using the target signature

$$\mathbf{t} = \partial \mathbf{x} / \partial \ell = -\mu e^{-\kappa \ell} \kappa = -\mu \kappa$$

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Matched filter applied independently in each column

$$\hat{\alpha}(\mathbf{x}) = (\mathbf{x} - \mu)^T \Sigma^{-1} \mathbf{t} / (\mathbf{t}^T \Sigma^{-1} \mathbf{t})$$

Mixing ratio length

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Background mean

Background covariance

target

Using the target signature

$$\mathbf{t} = \partial \mathbf{x} / \partial \ell = -\mu e^{-\kappa \ell} \kappa = -\mu \kappa$$

Unit absorption coefficient

Integrated methane enhancement

- Total estimated above-background methane mass
- Inversely proportional to windspeed (Green et al., 1980)

$$IME = k \sum_{i=0}^{n} \hat{\alpha}(i) S(i)$$

Integrated methane enhancement

- Total estimated above-background methane mass
- Inversely proportional to windspeed (Green et al., 1980)

$$IME = k \sum_{i=0}^{n} \hat{\alpha}(i) S(i)$$

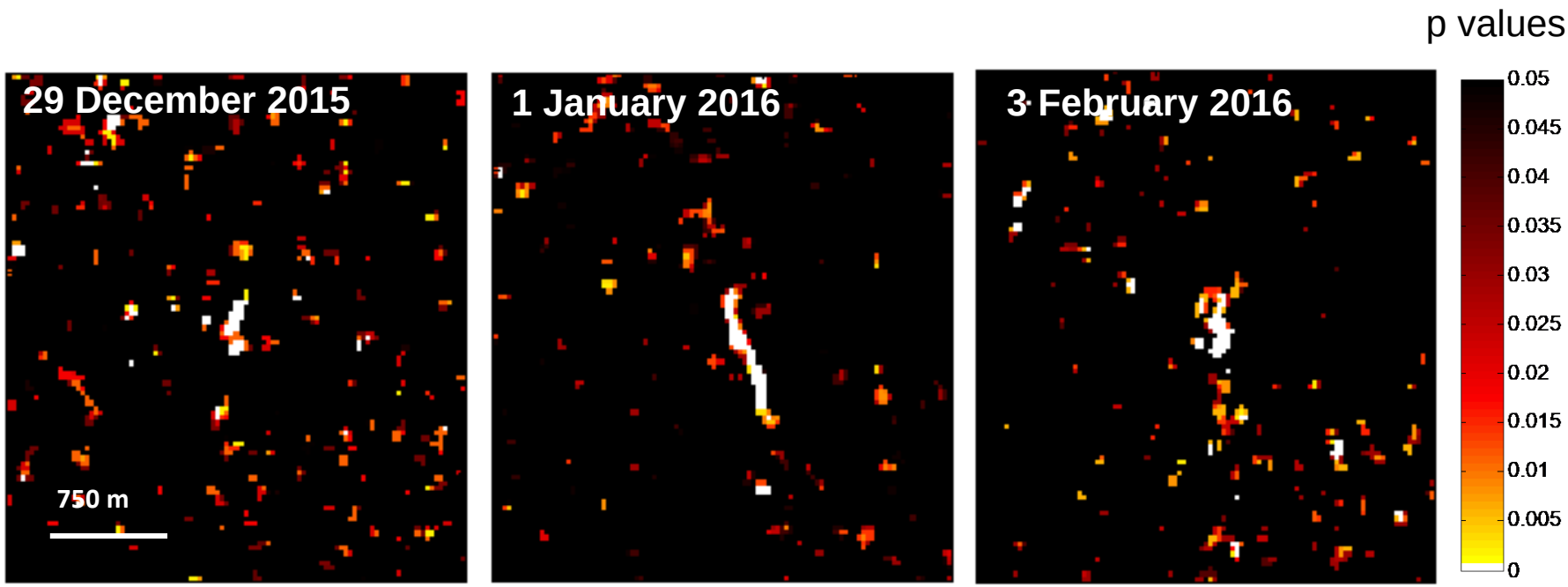
constant

Estimated mixing ratio length for pixel i

Pixel area

3 detections despite low illumination

Date	Solar Elevation	AMF	IME	Std. Error
29 Dec 2015	14.8°	5.0	710 kg	± 7.7 kg
01 Jan 2016	16.2°	4.6	1660	± 9.0
12 Jan 2016	17.0°	4.4	-	-
26 Jan 2016	20.6°	4.0	-	-
03 Feb 2016	21.1°	3.8	460	± 6.0
08 Feb 2016	19.5°	4.0	-	-
11 Feb 2016	21.8°	3.7	-	-
14 Feb 2016	24.1°	3.6	-	-

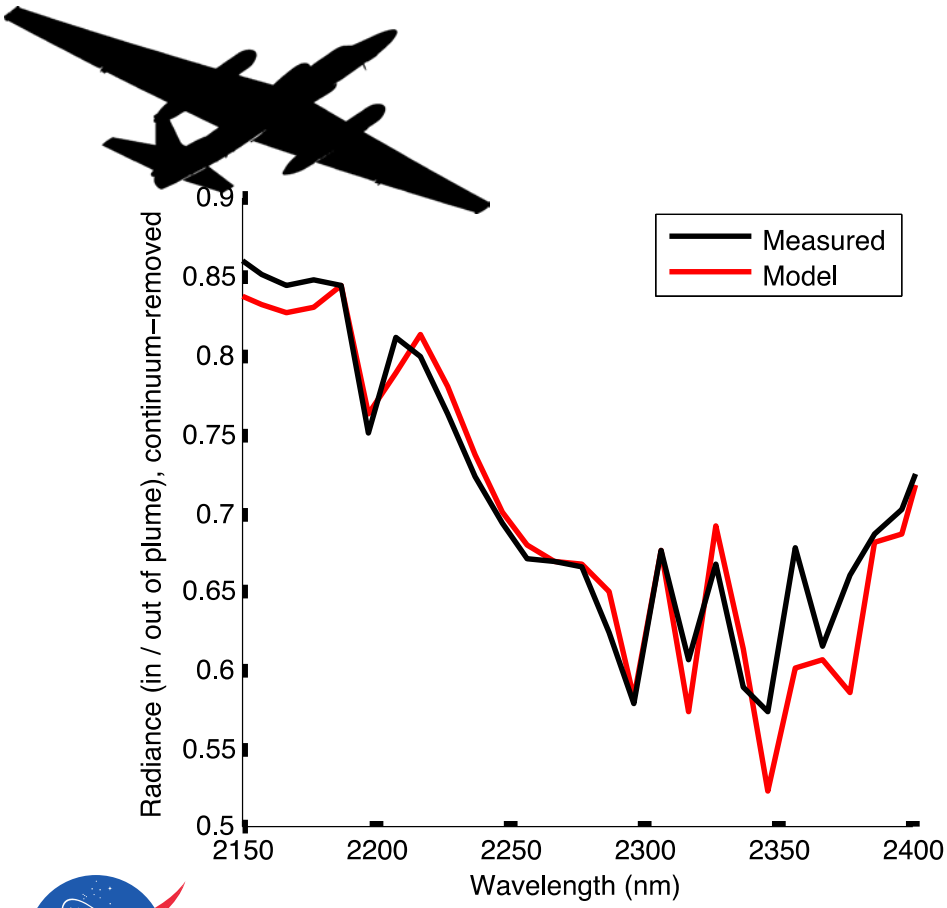


Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

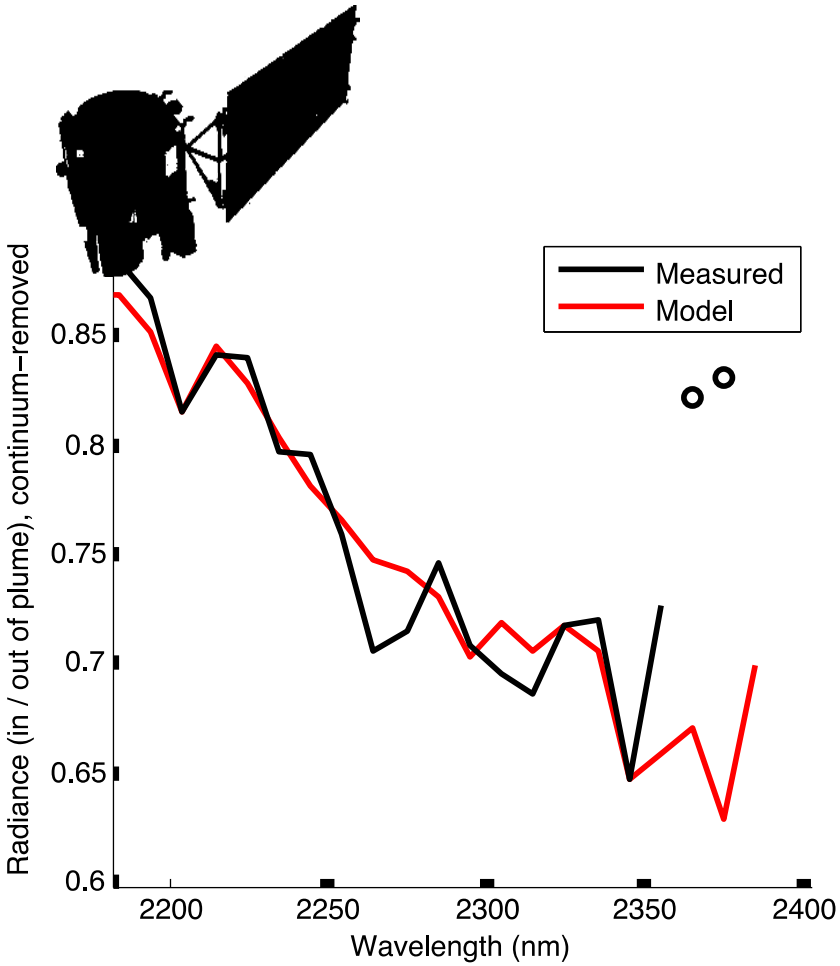
Spectrum matches

Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

ER-2 at 6.6 km altitude, 1/12/2016

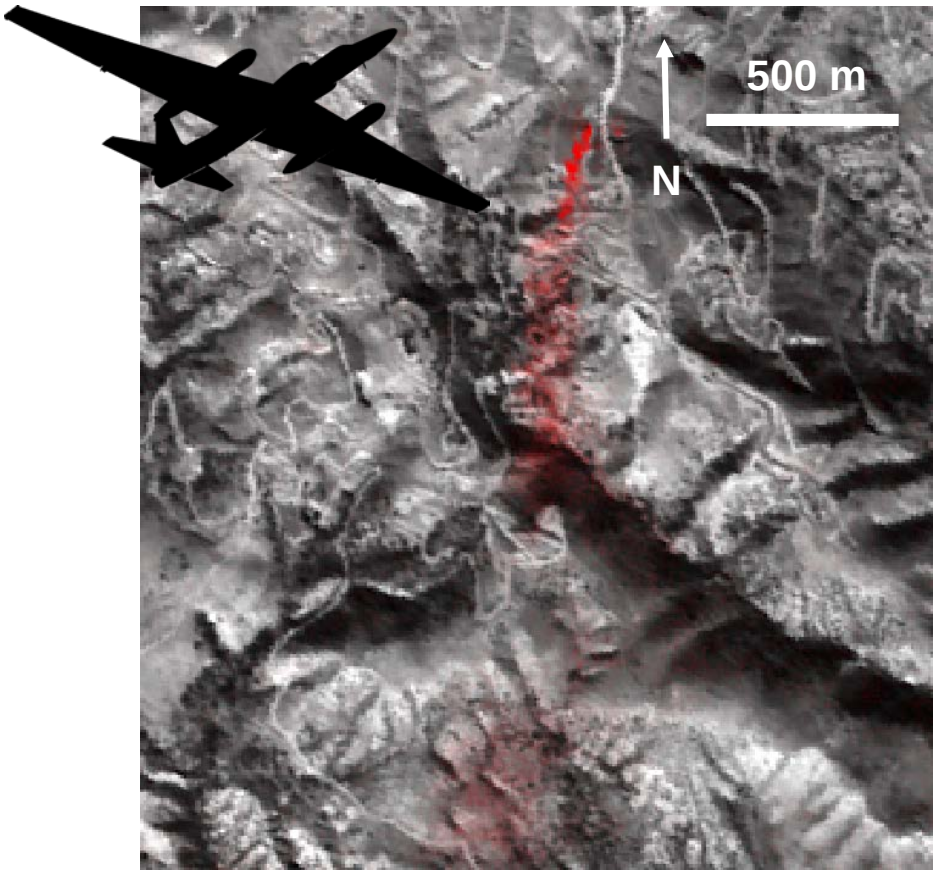


EO-1 Spacecraft at LEO, 1/1/2016

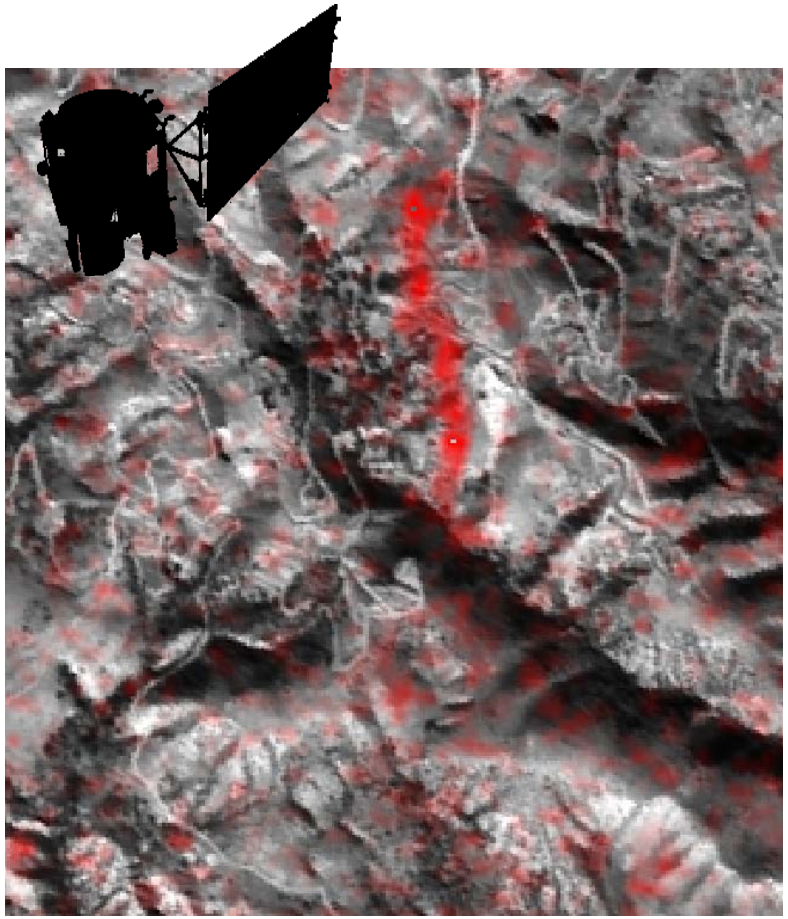


“Next morning” post-flight results

ER-2 at 6.6 km altitude, 1/12/2016

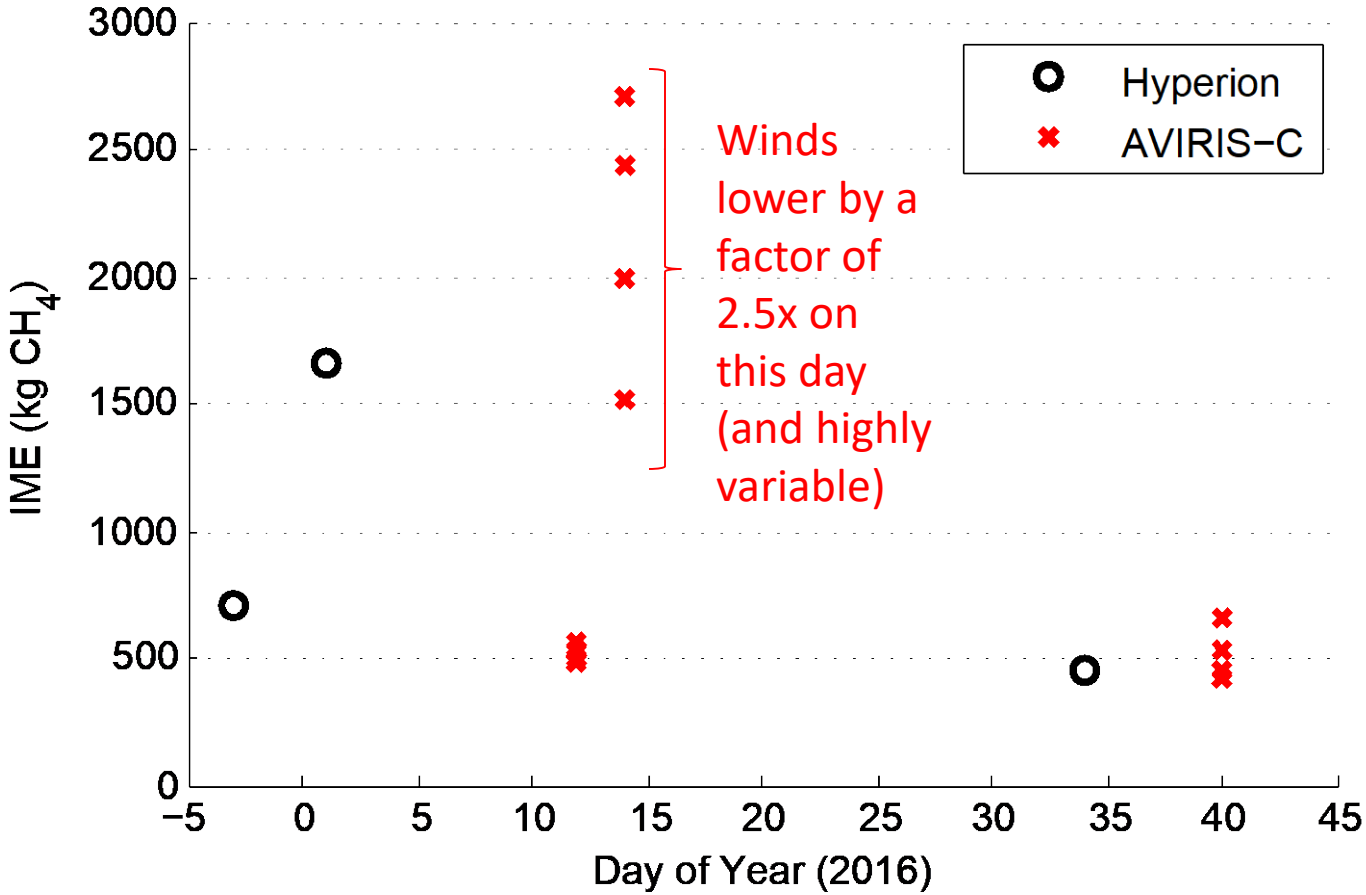


EO-1 Spacecraft at LEO, 1/1/2016



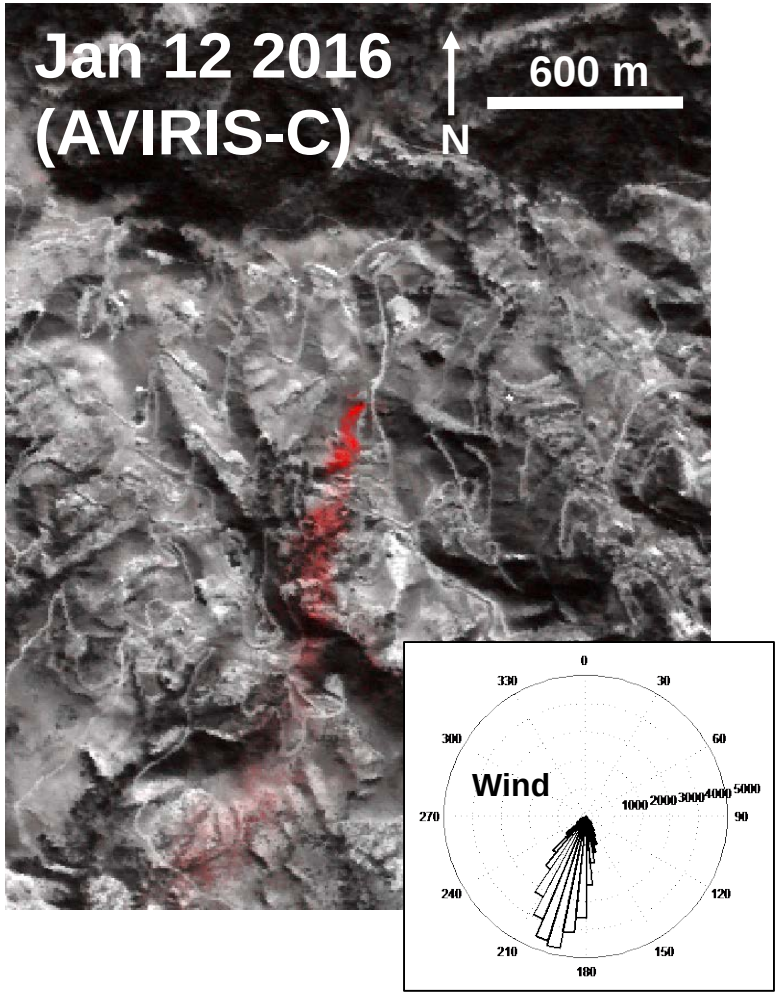
Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

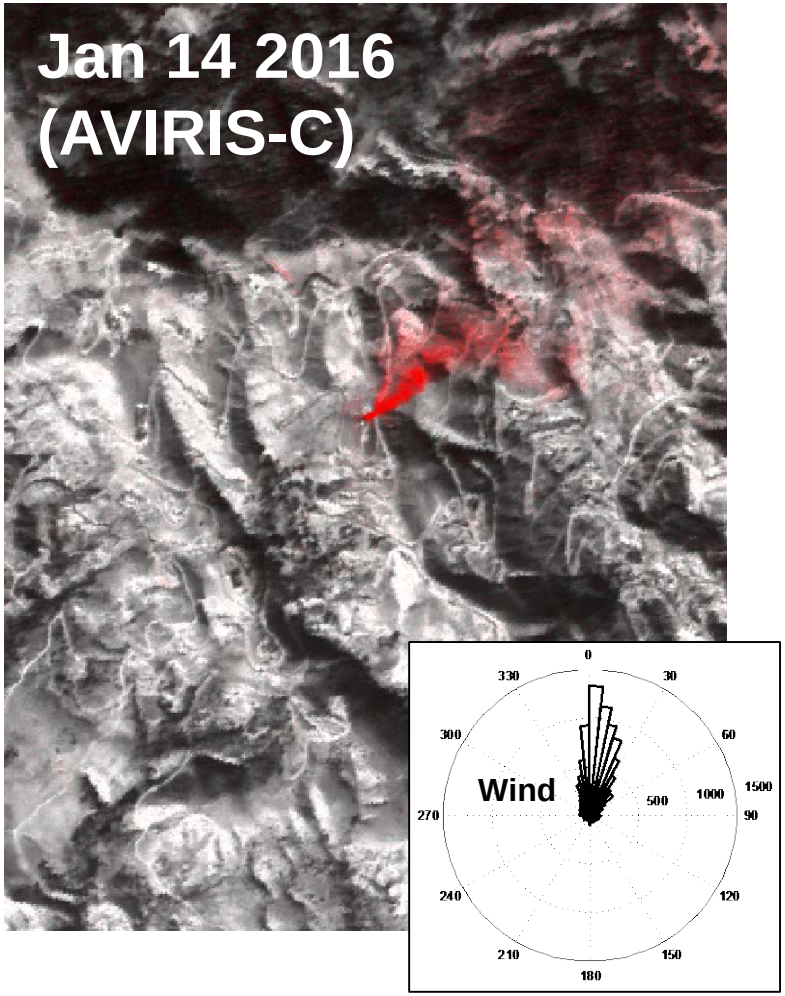
Integrated Methane Absorption



Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

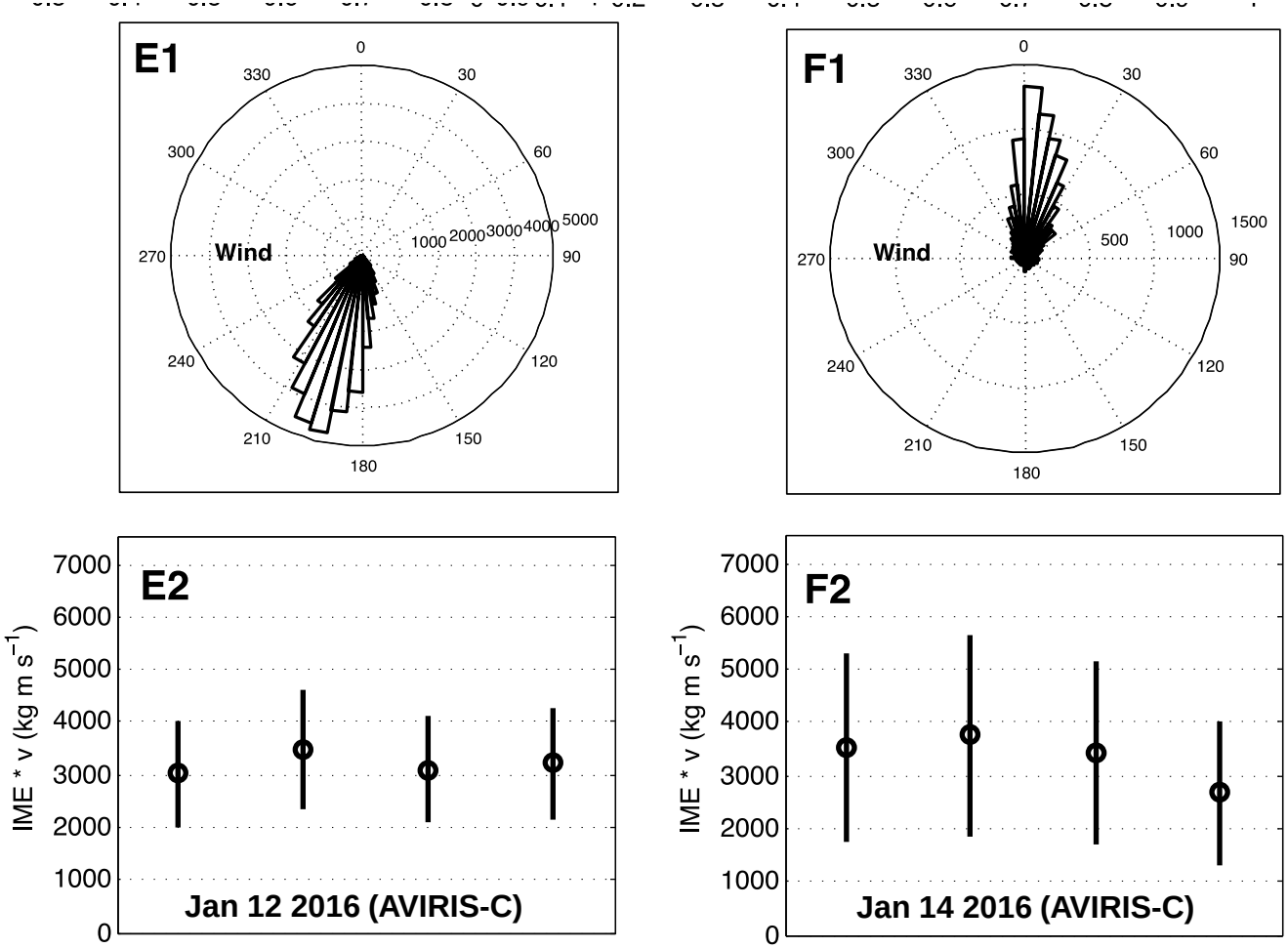
Wind directions





Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

Wind-corrected IME



Thompson et al., *Geophys. Res. Lett.* (2016, accepted)

Sensitivity comparison

Scenario	SNR	FWHM	GSD	NEMRL	NEIME	Reference
Hyperion, Aliso Canyon, 2016	20[a]	10 nm	30 m	1825 ppm m	1.17 kg	This work
AVIRIS-C, Aliso Canyon, 2016	70[a]	10	6.6	521	0.016	This work
AVIRIS-NG, Four Corners, 2015	200[a]	5	4	124	0.001	This work
EnMAP	180[b]	10	30	202	0.13	[*Guanter et al.*, 2015]
Landsat Swath Spectrometer	200[b]	6.8	30	146	0.09	[*Mouroulis et al.*, 2016]
AMPS Airborne	175[b]	1	1	54	0.0000383	[*Thorpe et al.*, 2016b]

Table 2. Sensitivity for current and proposed instruments under typical observing

[a] SNR estimated from scene [b] SNR estimate from instrument model

Conclusions

- First ever orbital detection of a CH_4 super-emitter plume
- Observations of other super-emitters are ongoing
- Presages possibilities for future orbital instruments