Detecting large methane point sources with the US Geostationary Operational Environmental Satellites (GOES)

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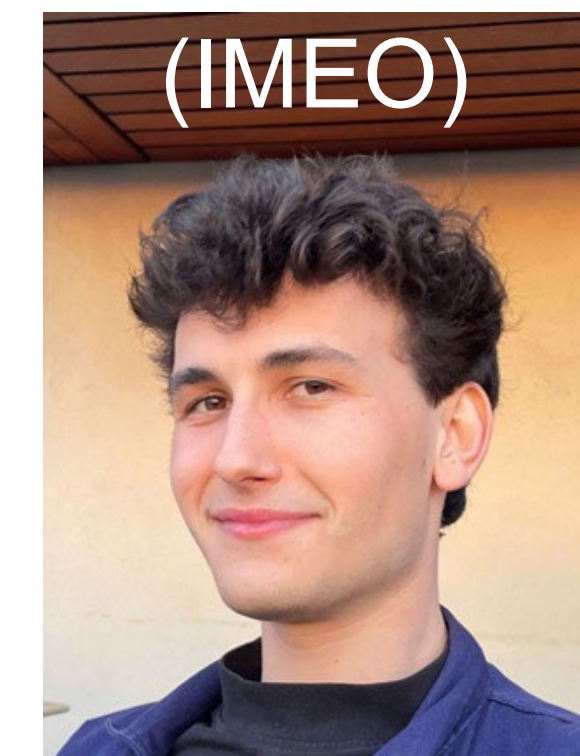
Marc Watine
(IMEO)

Relevant publication:

Preprint:

Watine-Guiu, M., Varon, D. J., Irakulis-Loitxate, I., Balasus, N., and Jacob, D. J.: Geostationary satellite observations of extreme methane emissions from a natural gas pipeline, [preprint] in review, 2023
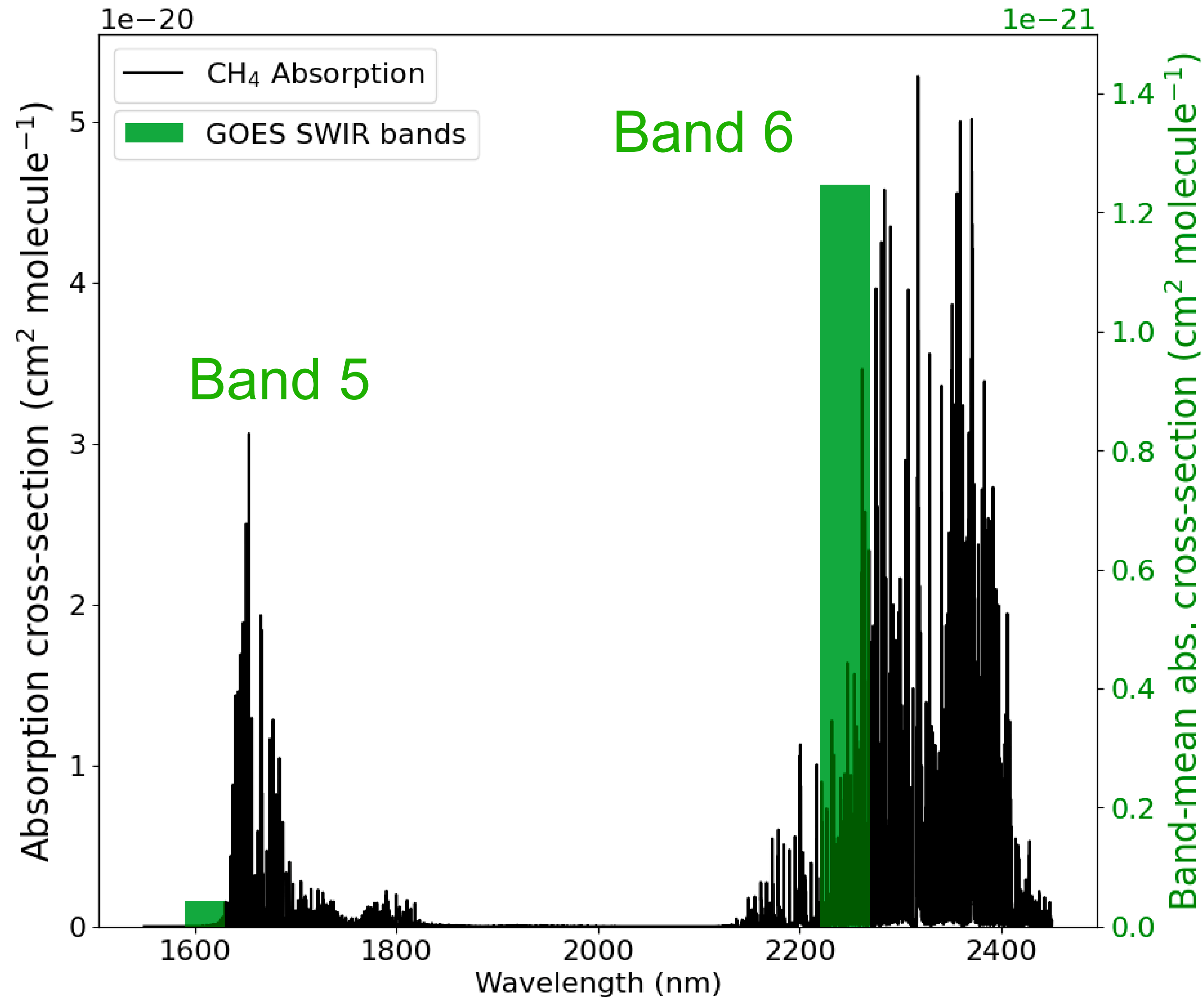
# GOES has similar SWIR bands to Sentinel-2, Landsat

Band 6 (SWIR):

- 2 km pixel resolution

- Snapshots of the Americas every 5-10 minutes

- Widening or shifting the band to the right would improve methane sensitivity

- Retrievals require a methane-free reference image
  = band 6 on another pass OR band 5 on the same pass OR both.

= "multiband-multipass" (MBMP) method

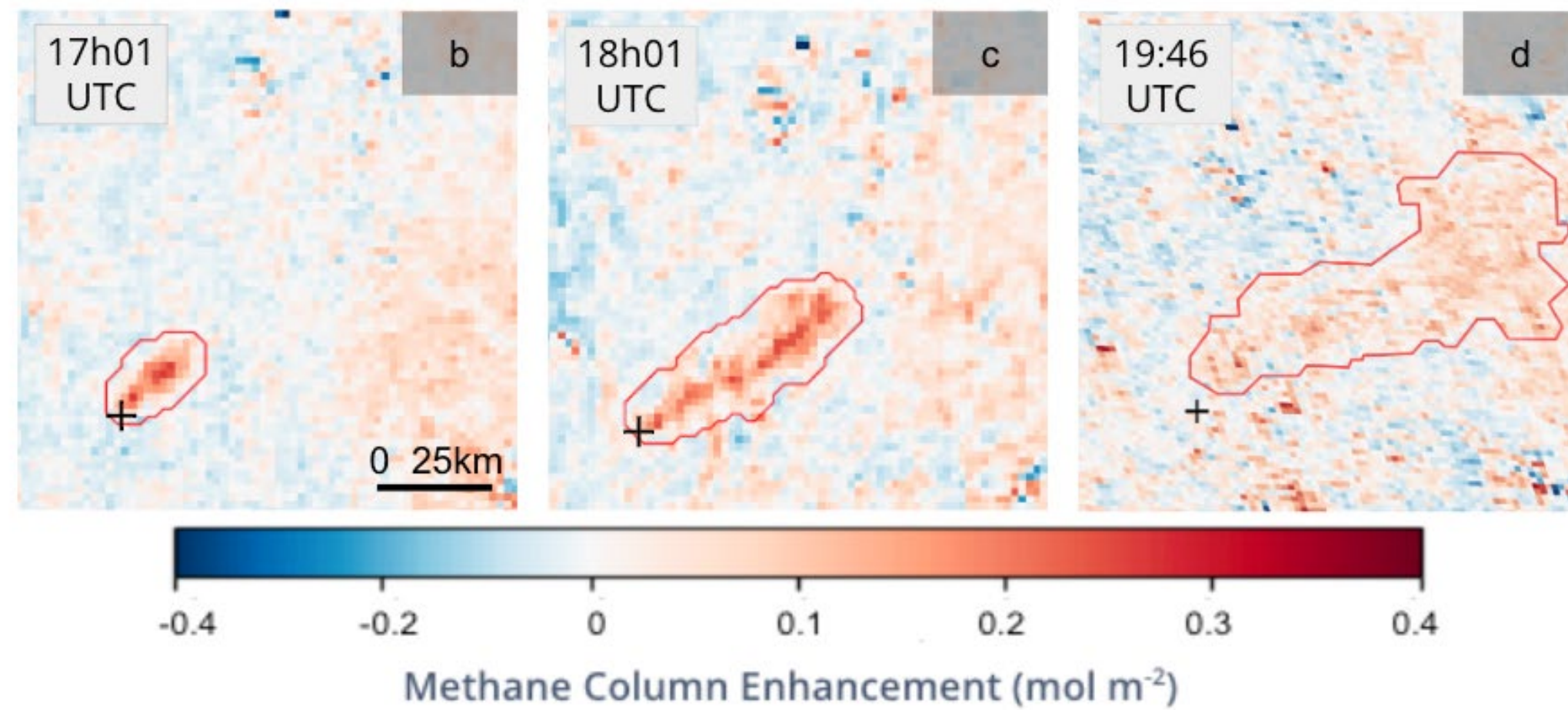# Demonstration: GOES detects large release observed by TROPOMI over Mexico

TROPOMI Detection 12 May 2019

Pipeline block station

Sentinel-2 on 11 May
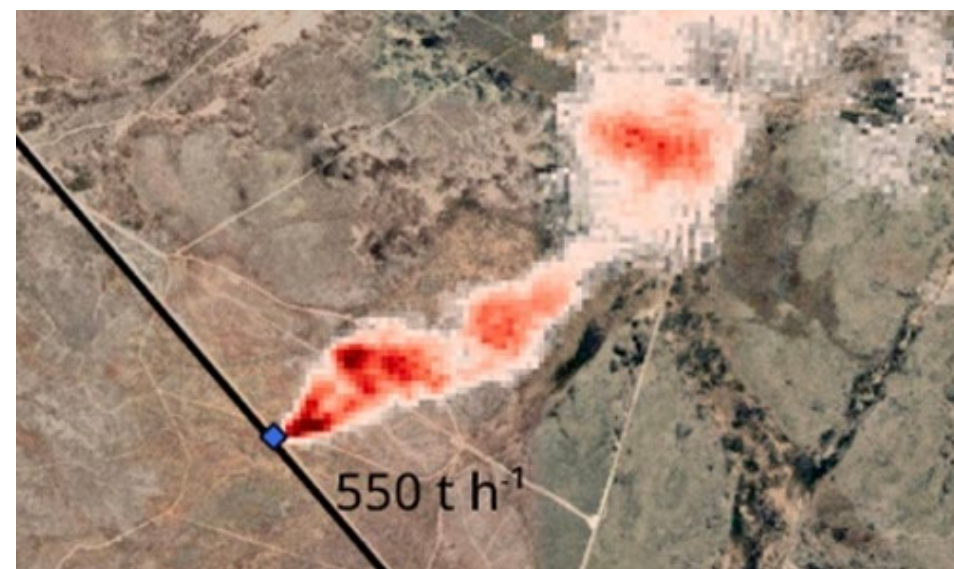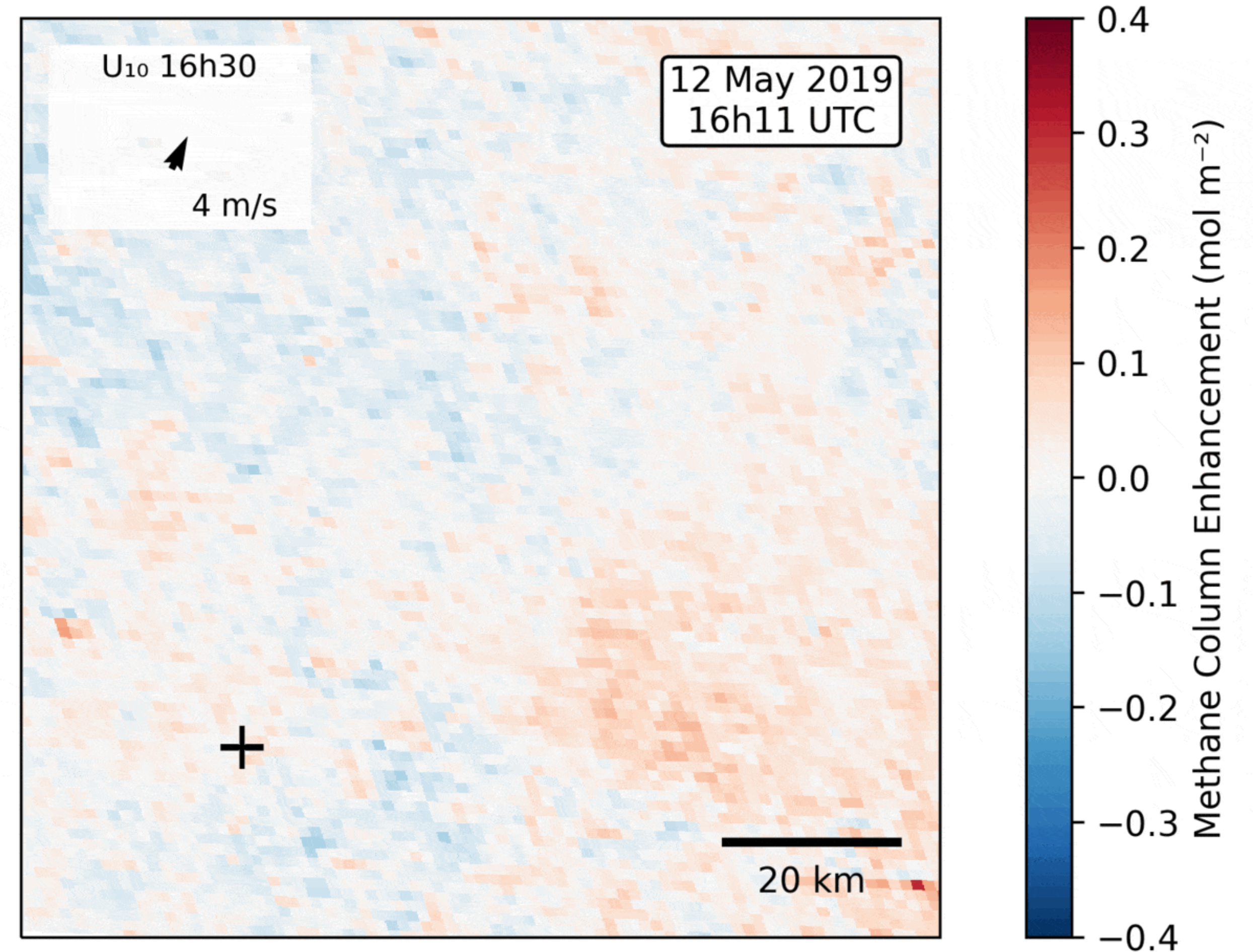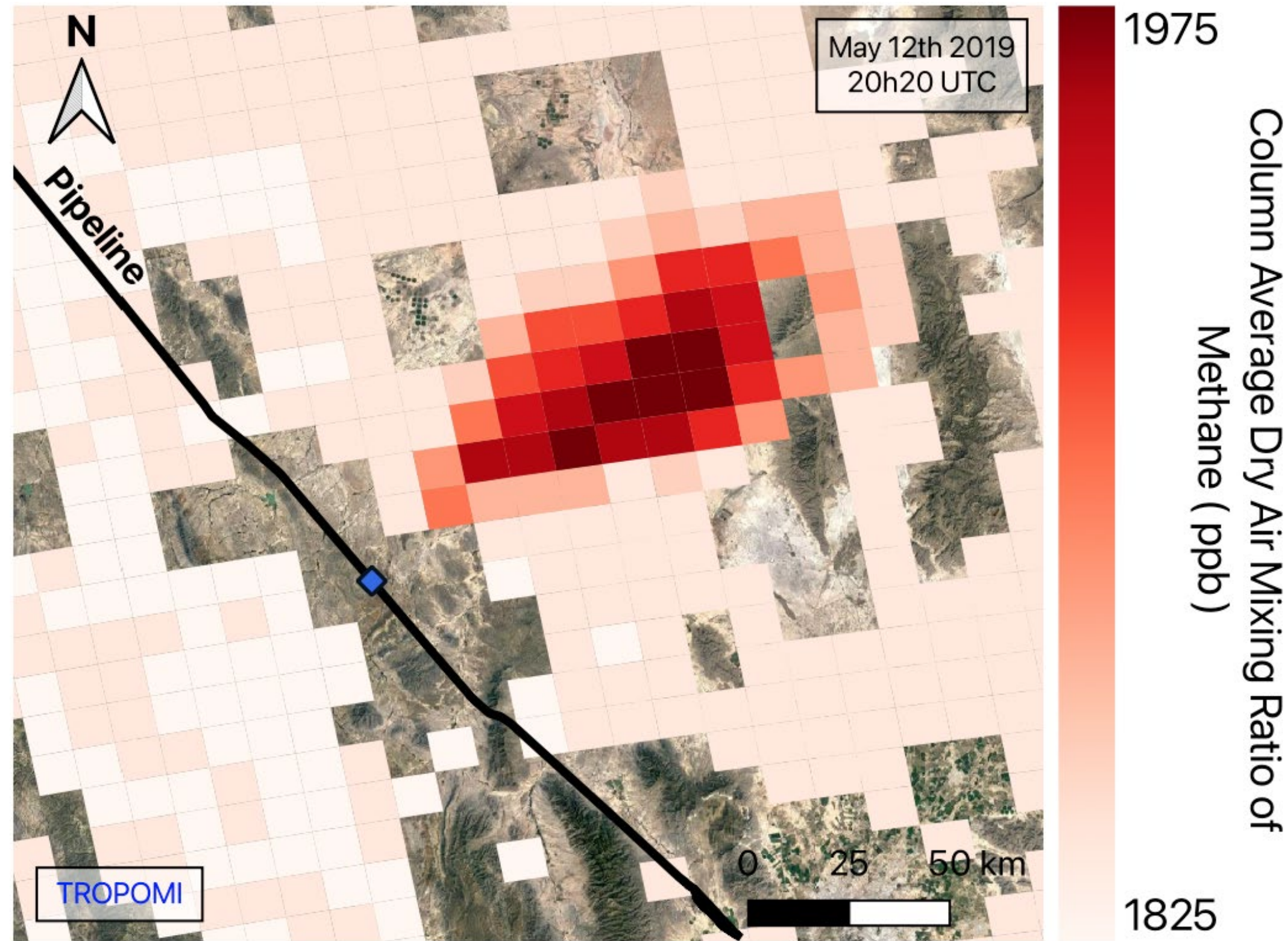
El Encino — La Laguna (EELL) pipeline in Durango
Transports Permian gas to Mexican markets

Demonstration: GOES detects large release observed by TROPOMI over Mexico

Q = 250-550 t h^{-1}
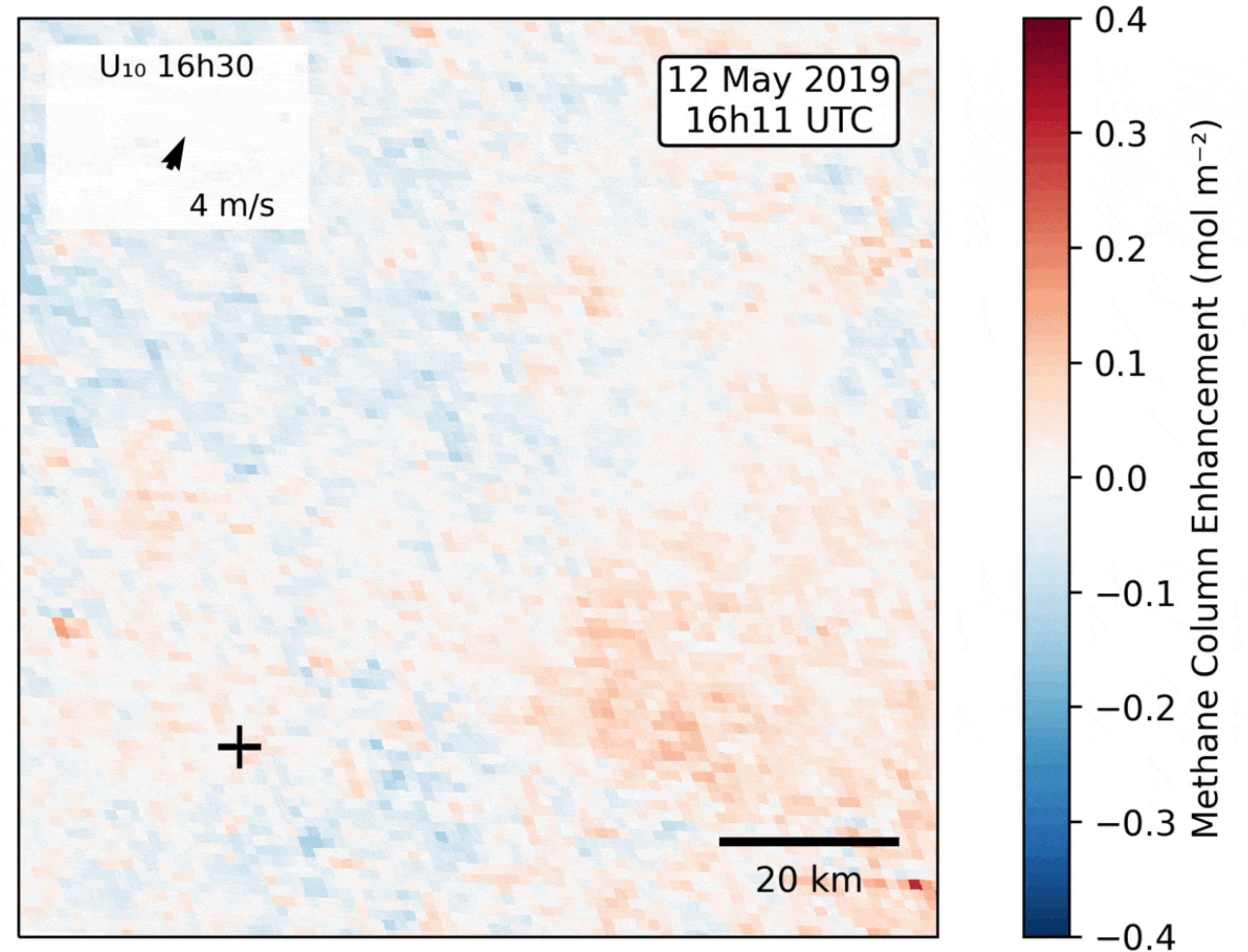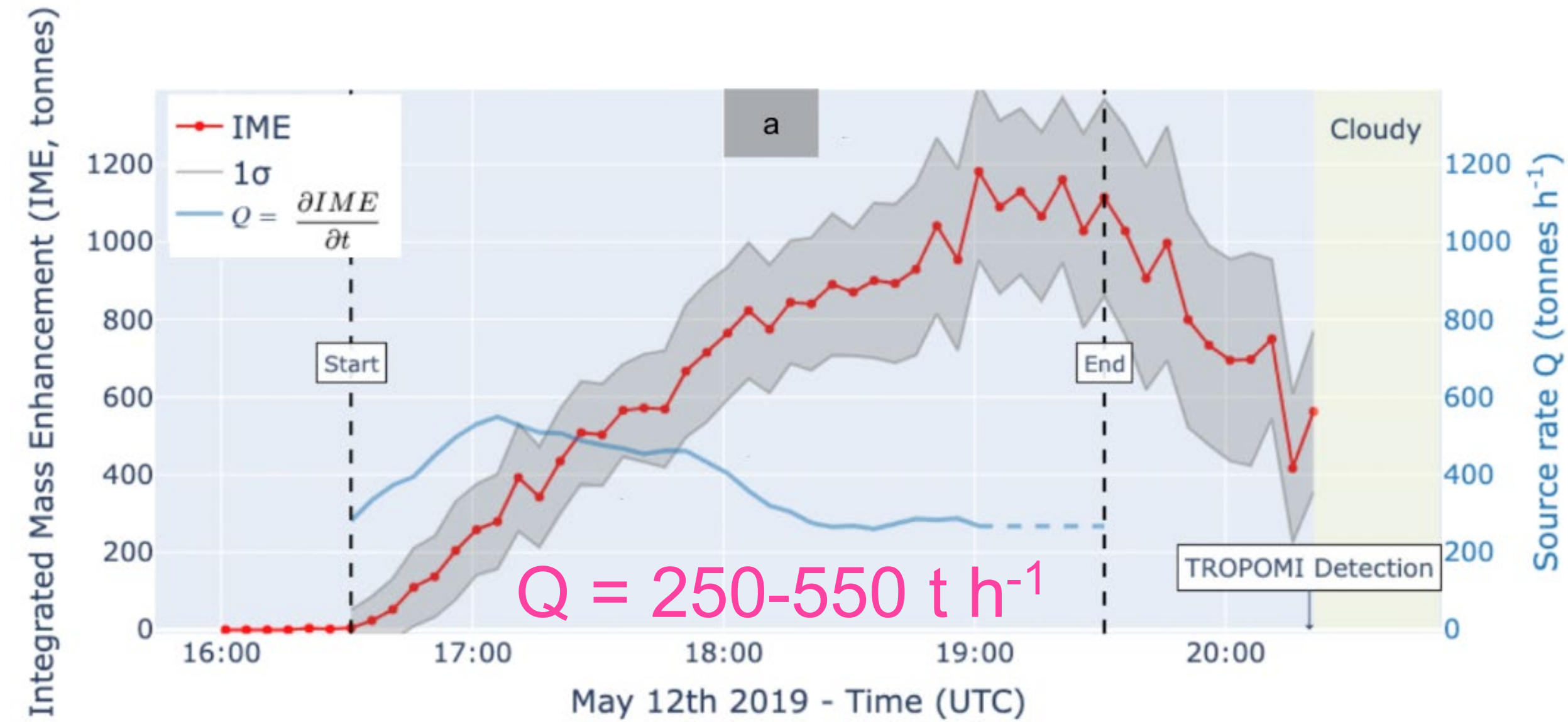
1100-1400 t released over 3 hours

GOES can quantify variable source rate and total release duration/mass

GOES solves TROPOMI mystery over Indiana/Illinois
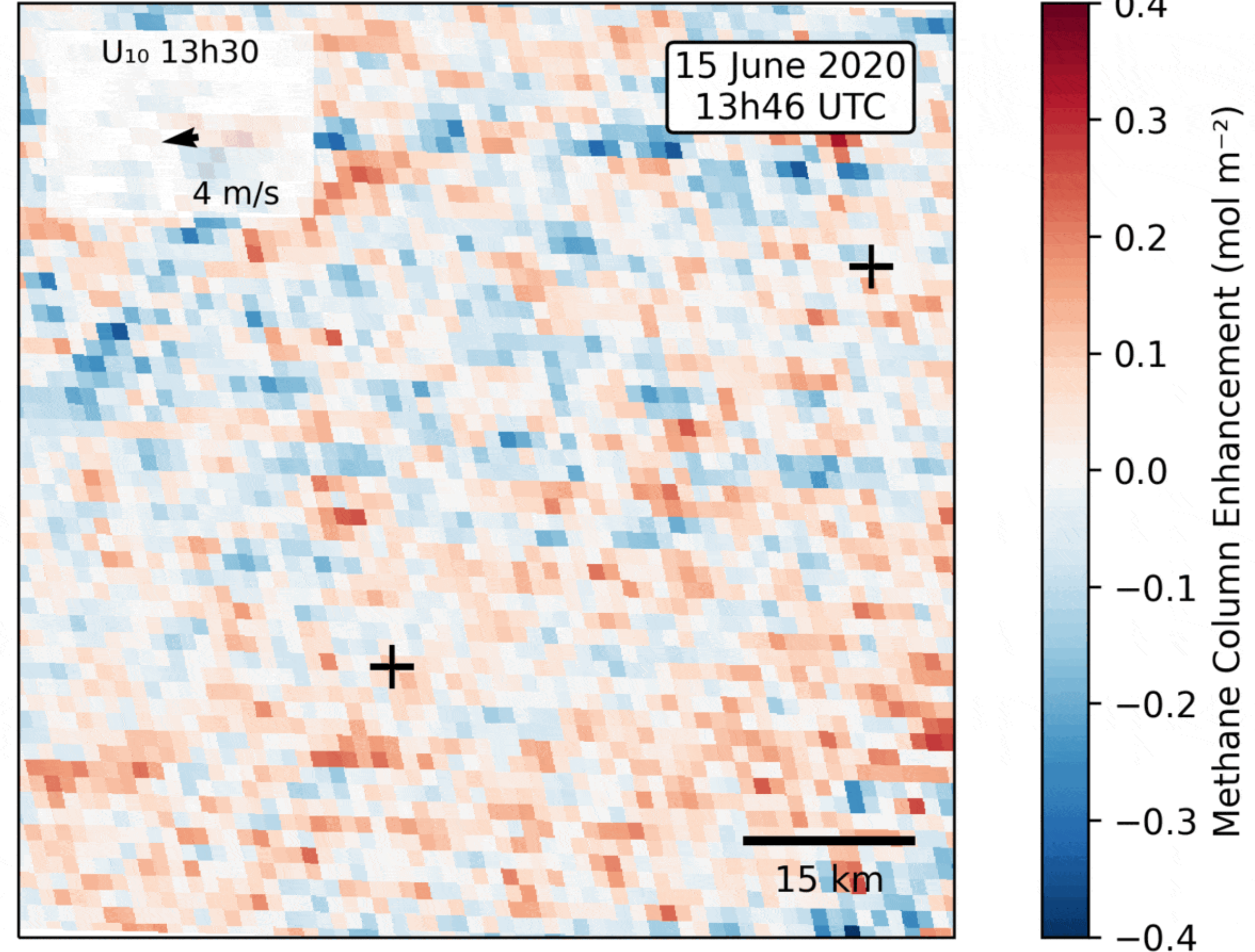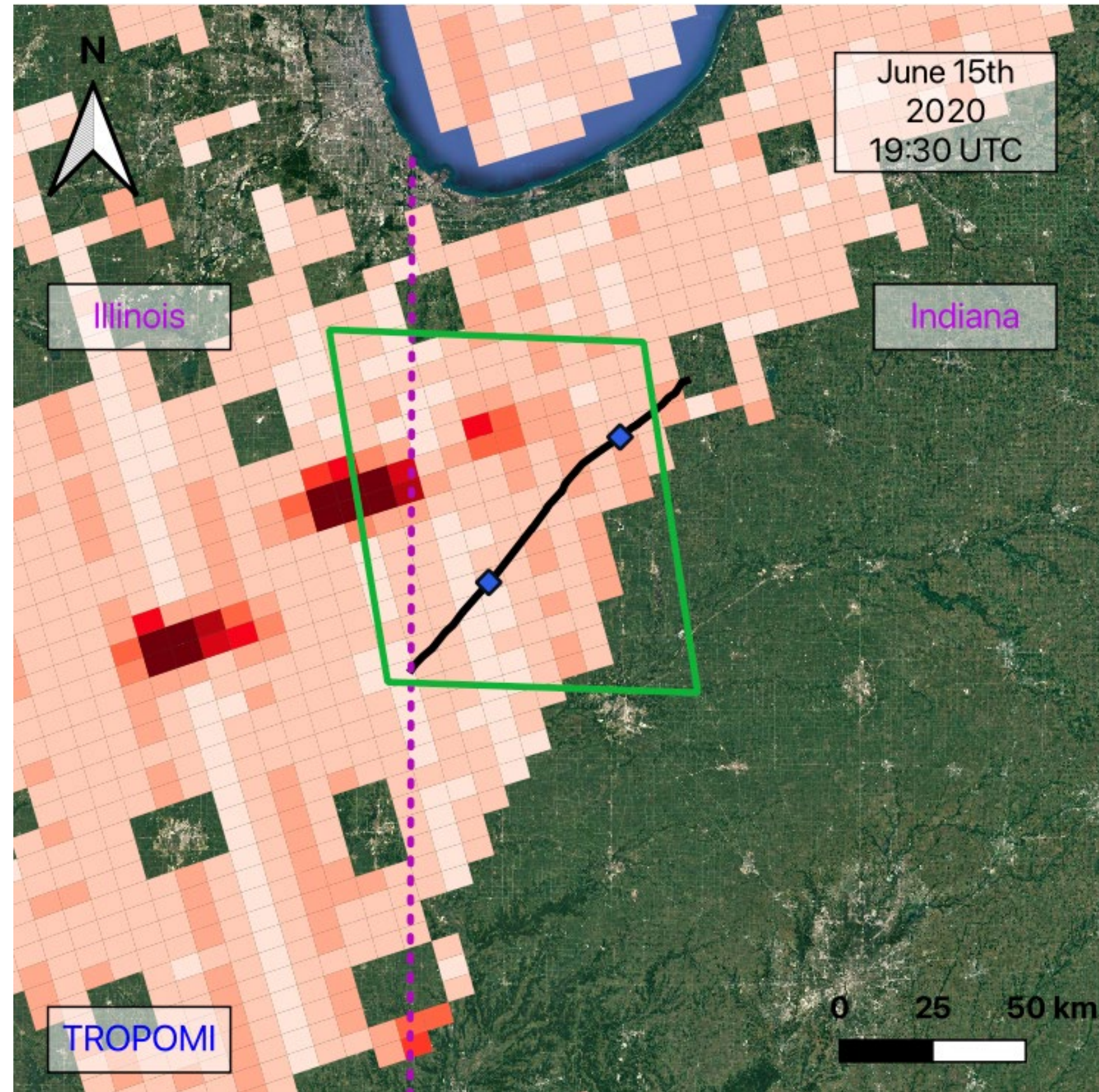
Block valve station
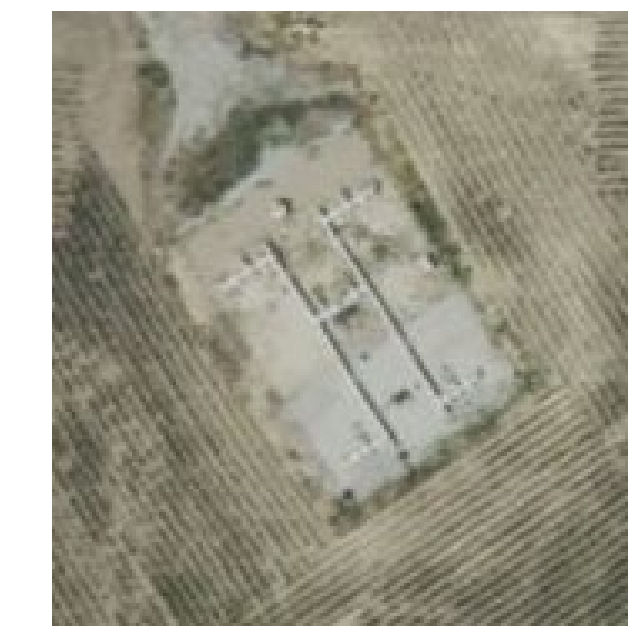
Block valve station

GOES enables better source localization and monitoring of large transient releases

GOES detects large transient releases in the Permian basin <u>independently</u>

Manual GOES monitoring of a 100x100 km^2 region of the Permian Basin for January 2023
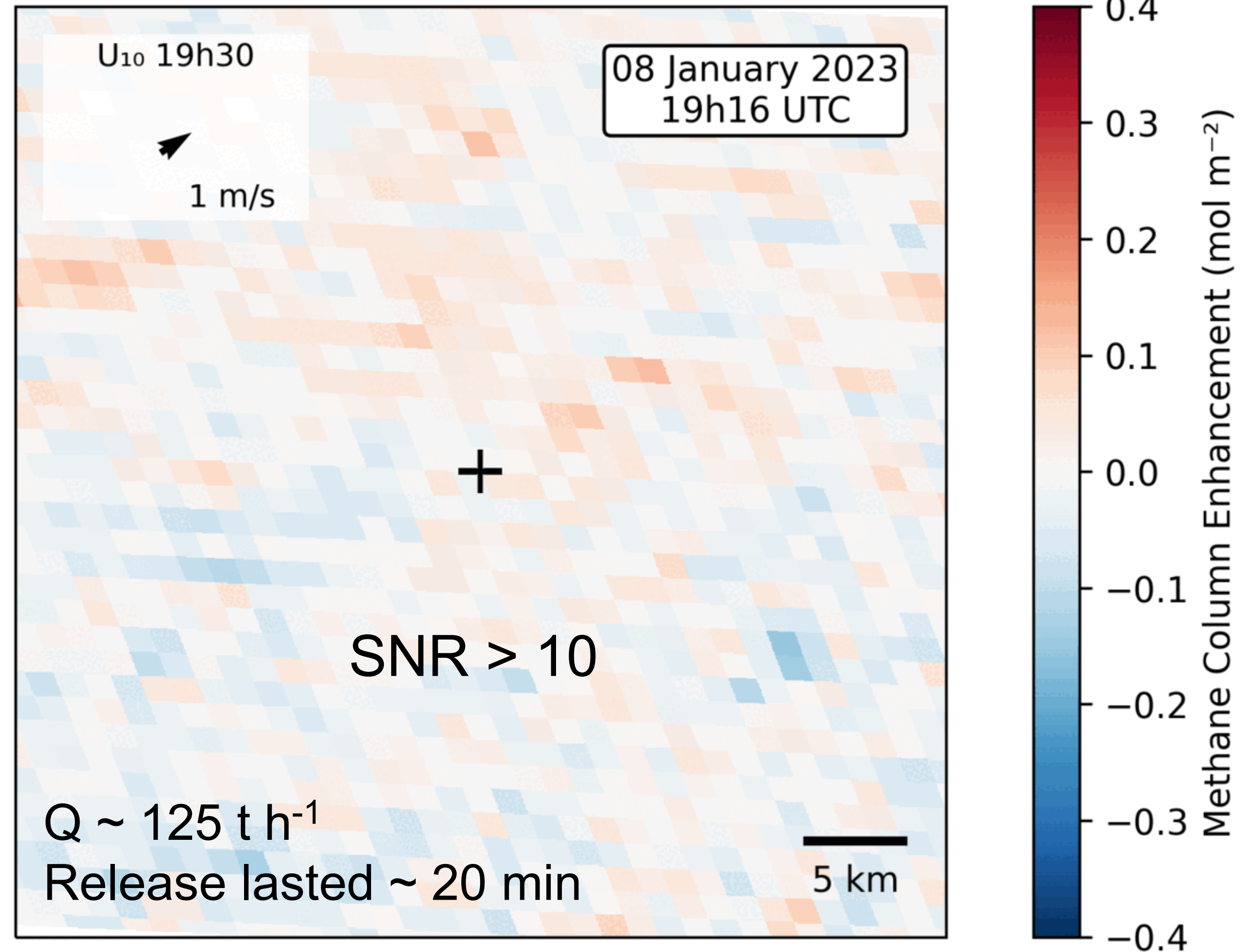
Minimum detection limit is in the range 10-100 t h^{-1}

Ongoing work

1. Cross-reference GOES with TROPOMI
   (Detect 17/62 large TROPOMI plumes documented
   by Kayrros from 2019-2022)

	date	s5p_latitude	s5p_longitude	s5p_emirate	s5p_source	s5p_time	s5p_path_s3	potential	GOES_result
9	11/7/2022	40.430199	-78.936798	120	Kayrros_4363			High	NoDetection
10	10/28/2022	32.2686	-108.289497	56	Kayrros_4320			High	Detection
11	9/13/2022	32.2477	-93.696899	98	Kayrros_4112			High	NoData
12	4/4/2022	20.5016	-97.569901	45	Kayrros_3789			Medium	NoDetection
13	3/19/2022	33.5439	-89.1091	53	Kayrros_3743			Medium	NoDetection
14	3/17/2022	28.5937	-99.4095	147	Kayrros_3727			High	Detection
15	1/21/2022	32.2523	-92.514503	105	Kayrros_3496			High	NoDetection
16	11/13/2021	33.384998	-95.332497	89	Kayrros_3216			Medium	Detection
17	11/13/2021	33.257099	-94.854599	53	Kayrros_3217			Medium	NoDetection
18	10/22/2021	36.868599	-100.129402	116	Kayrros_3081			High	Detection
19	10/22/2021	34.0564	-87.641403	57	Kayrros_3082			Medium	Unclear
20	8/11/2021	38.519199	-97.948601	56	Kayrros_2772			Medium	Detection
21	7/4/2021	33.335098	-87.412697	45	Kayrros_2610			Medium	NoDetection
22	4/20/2021	51.596699	-113.392601	78	Kayrros_2398			High	Detection
23	4/6/2021	50.781601	-109.975899	68	Kayrros_2370			High	Detection
24	3/28/2021	17.882	-94.130898	56	Kayrros_2356			Medium	NoDetection
25	3/13/2021	44.785702	-90.873398	48	Kayrros_2321			High	NoDetection
26	3/10/2021	31.8939	-106.891502	161	Kayrros_2302			High	NoDetection
27	3/8/2021	30.745399	-86.395103	91	Kayrros_2298			High	Detection
28	12/10/2020	33.383301	-93.834198	50	Kayrros_1774			High	Detection
29	11/24/2020	25.5697	-98.860497	76	Kayrros_1745			High	Detection
30	11/9/2020	39.932899	-80.241402	79	Kayrros_1716			Medium	NoDetection
31	11/3/2020	37.762001	-99.3713	104	Kayrros_1696			High	Unclear
32	11/3/2020	30.5457	-96.3666	48	Kayrros_1705			High	NoDetection
33	10/31/2020	40.080399	-109.554298	79	Kayrros_1685			Medium	NoDetection

2. Improve retrieval precision & detection limit
   …via machine-learned reference images (~30% noise reduction so far)

Regular MBMP method

MBMP method with ML-based reference images

3. Extend capability to other operational geostationary systems
   GOES, Meteosat Third Generation (MTG), Himawari-8

Summary

- GOES is sensitive to methane in its SWIR band 6 (2 km pixels, 5-10 min revisits

- Capabilities:

  - Detect large methane point sources down to 10-100 t h^{-1}
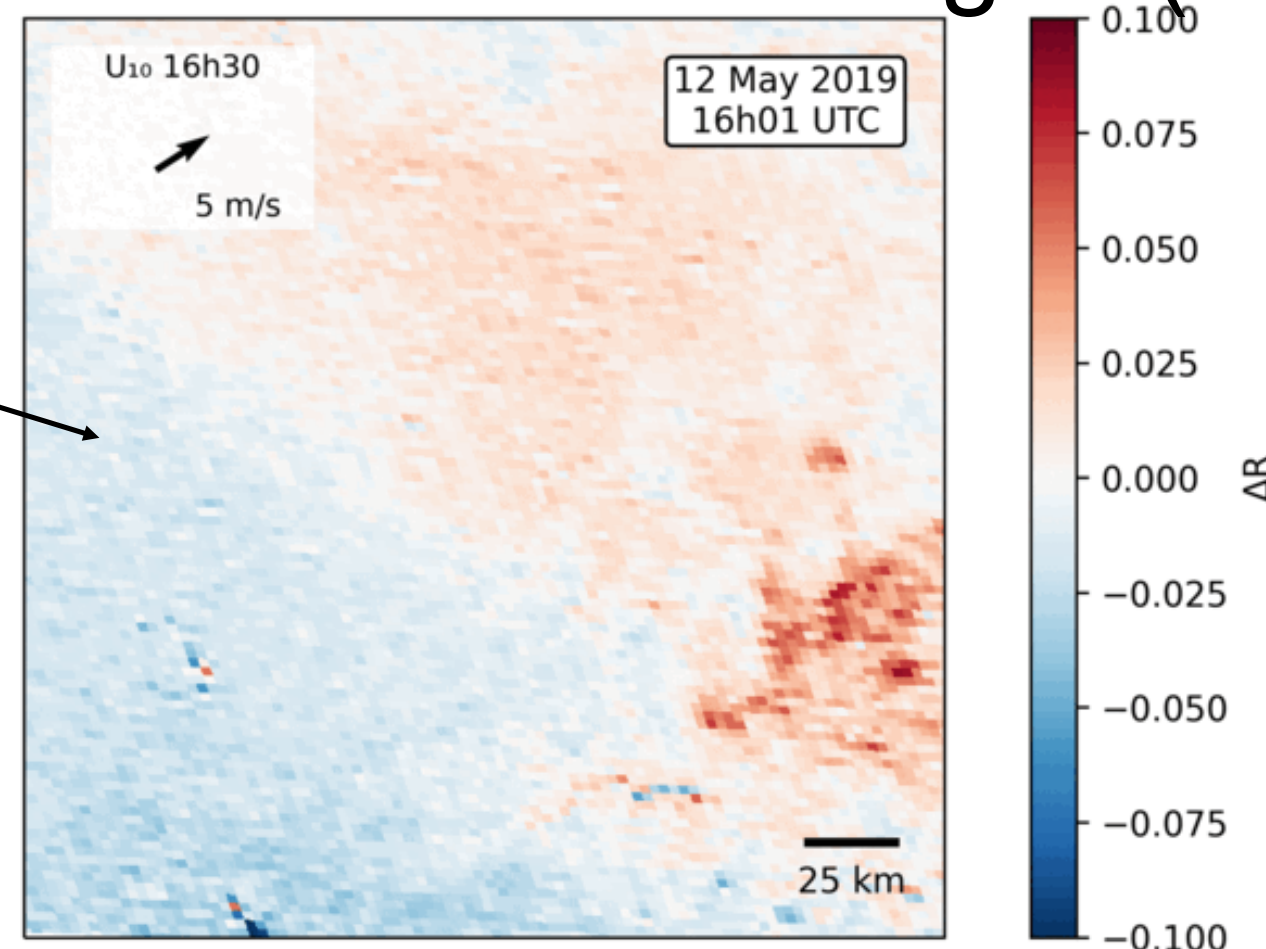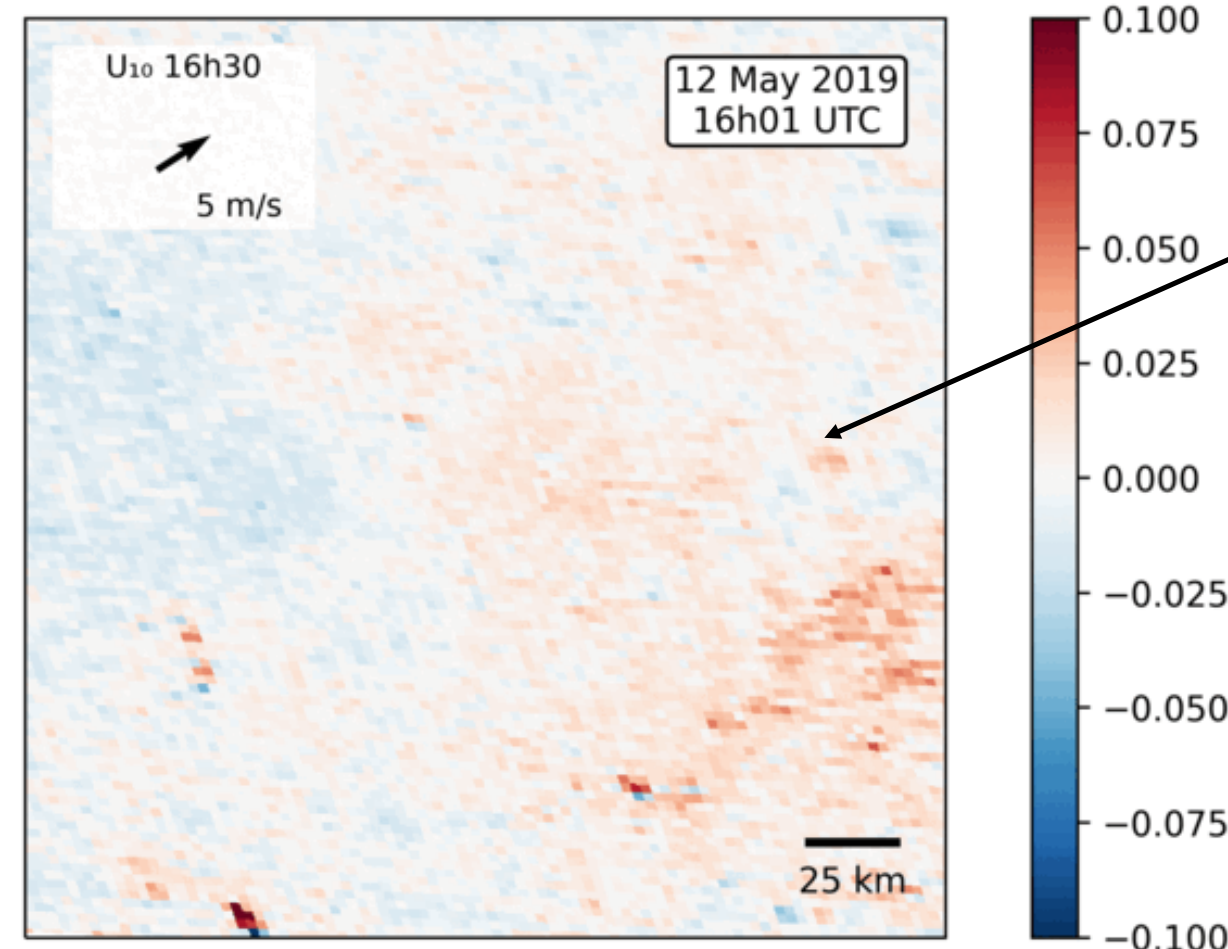
  - Quantify **variable source rate** and **total release duration/mass**

  - Improved **source localization**

  - Potential for **NRT monitoring** of large methane releases

- Next steps:

  - Cross-reference GOES with the TROPOMI record

  - Improve retrieval precision, detection limit via ML

  - Extend capability to MTG, Himawari

Preprint: