

Characterizing methane emissions using remote sensing

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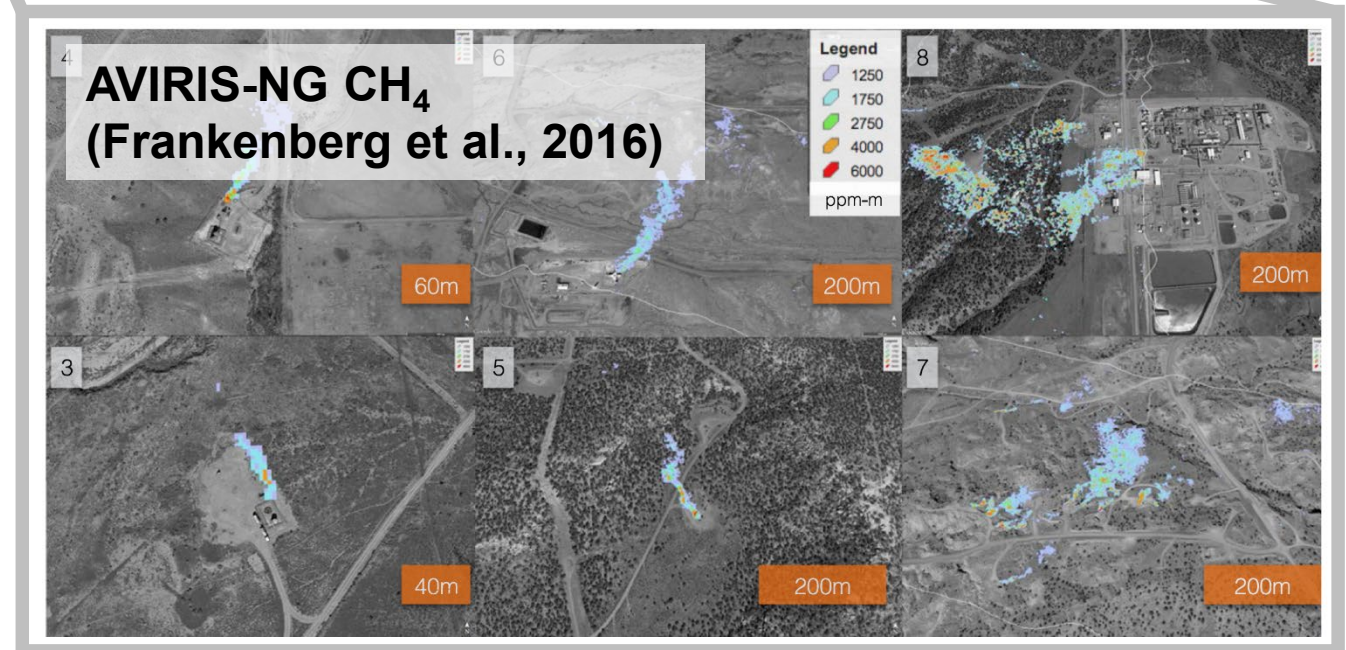
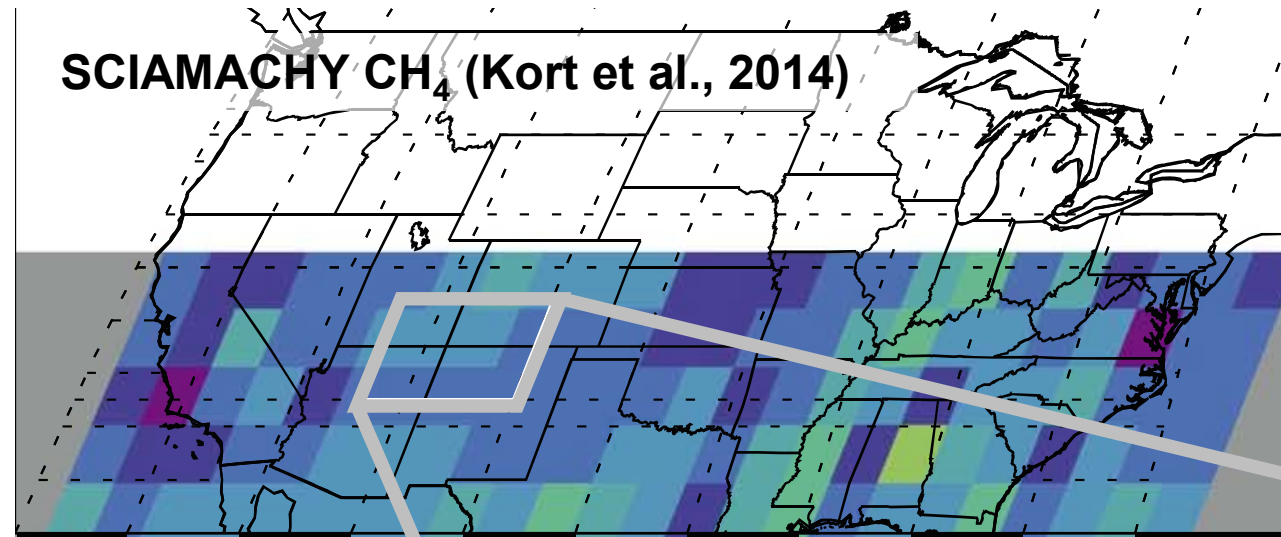
²University of Arizona

³California Institute of
Technology

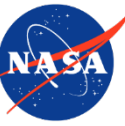
*Andrew.K.Thorpe@jpl.nasa.gov



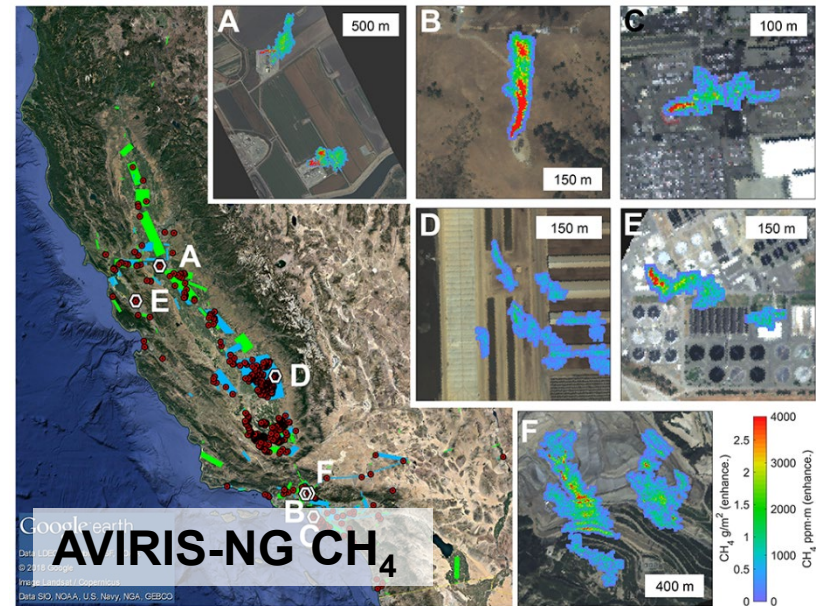
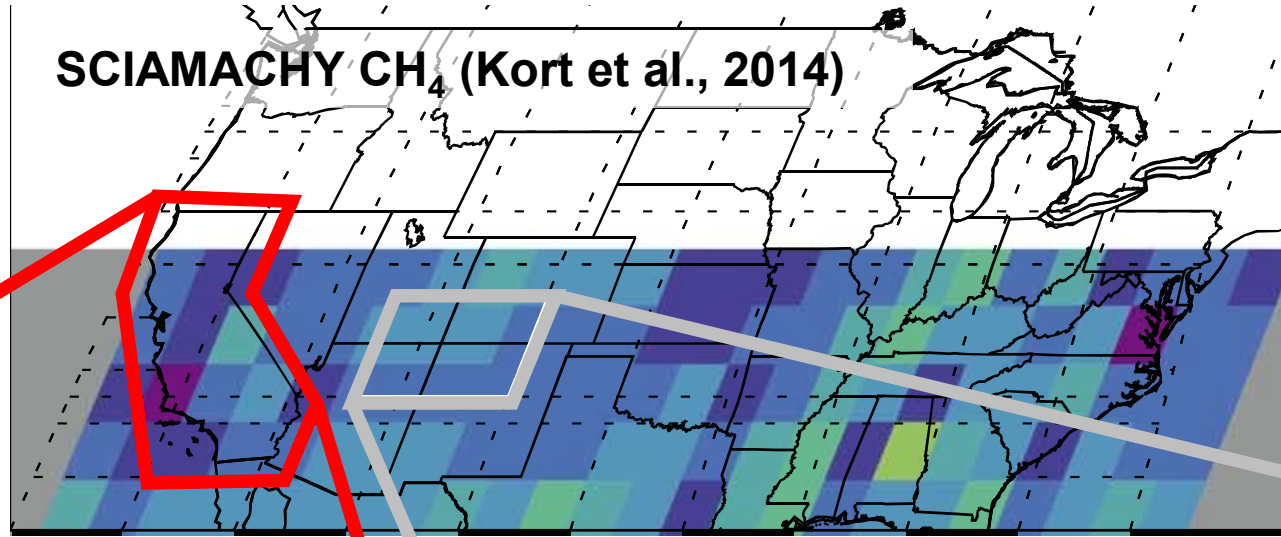
Multi-tiered observations



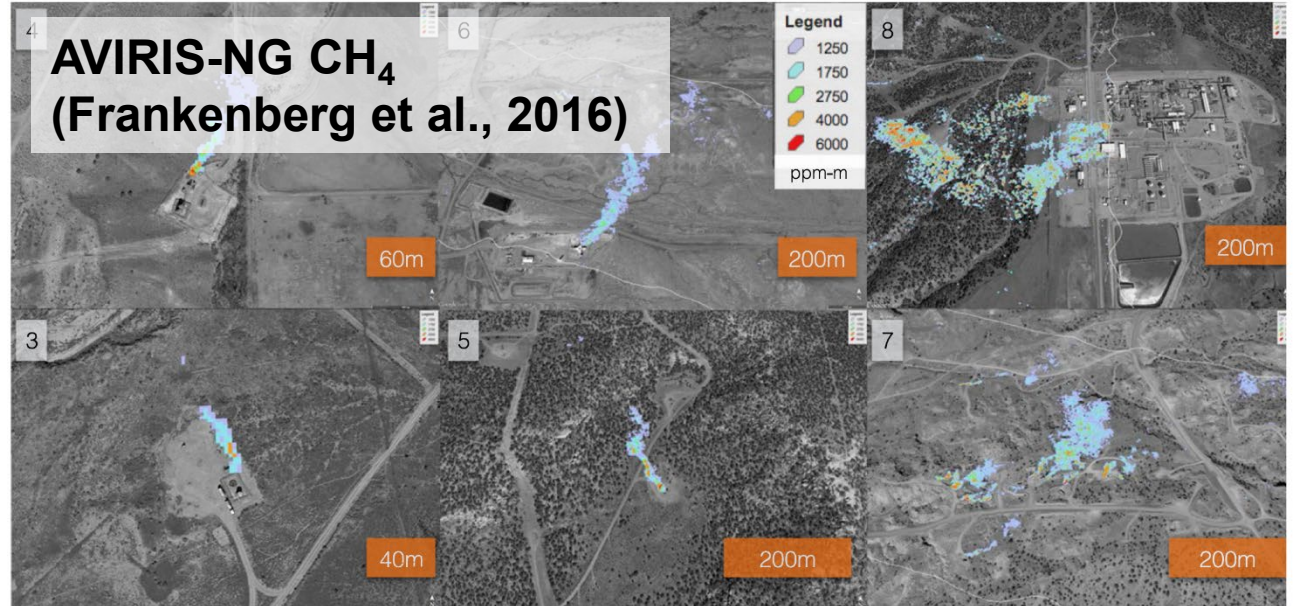
Multi-tiered observations



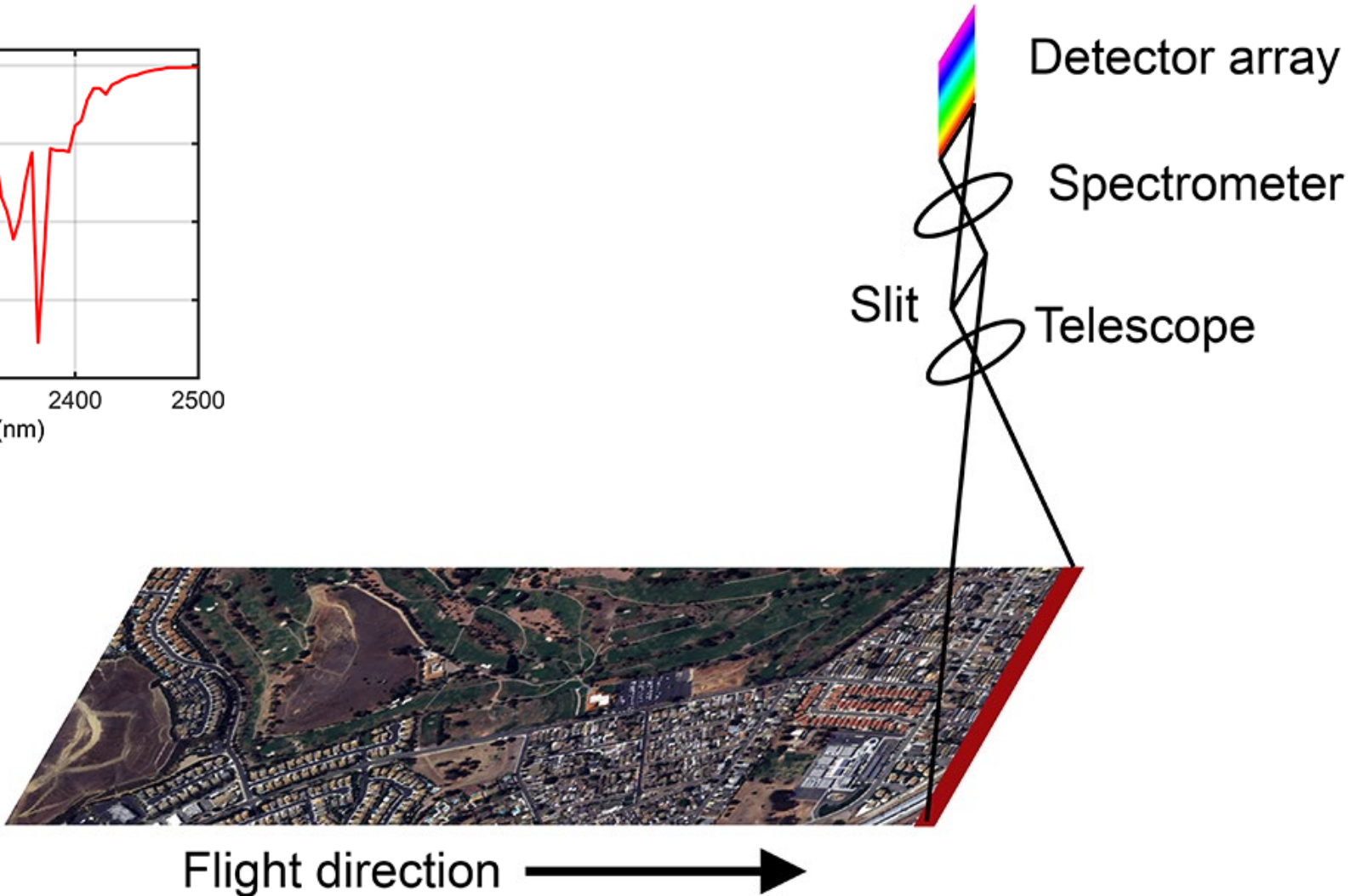
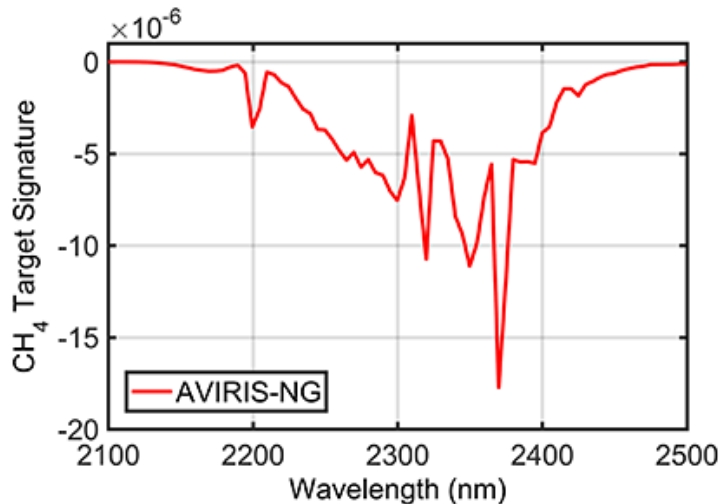
SCIAMACHY CH₄ (Kort et al., 2014)



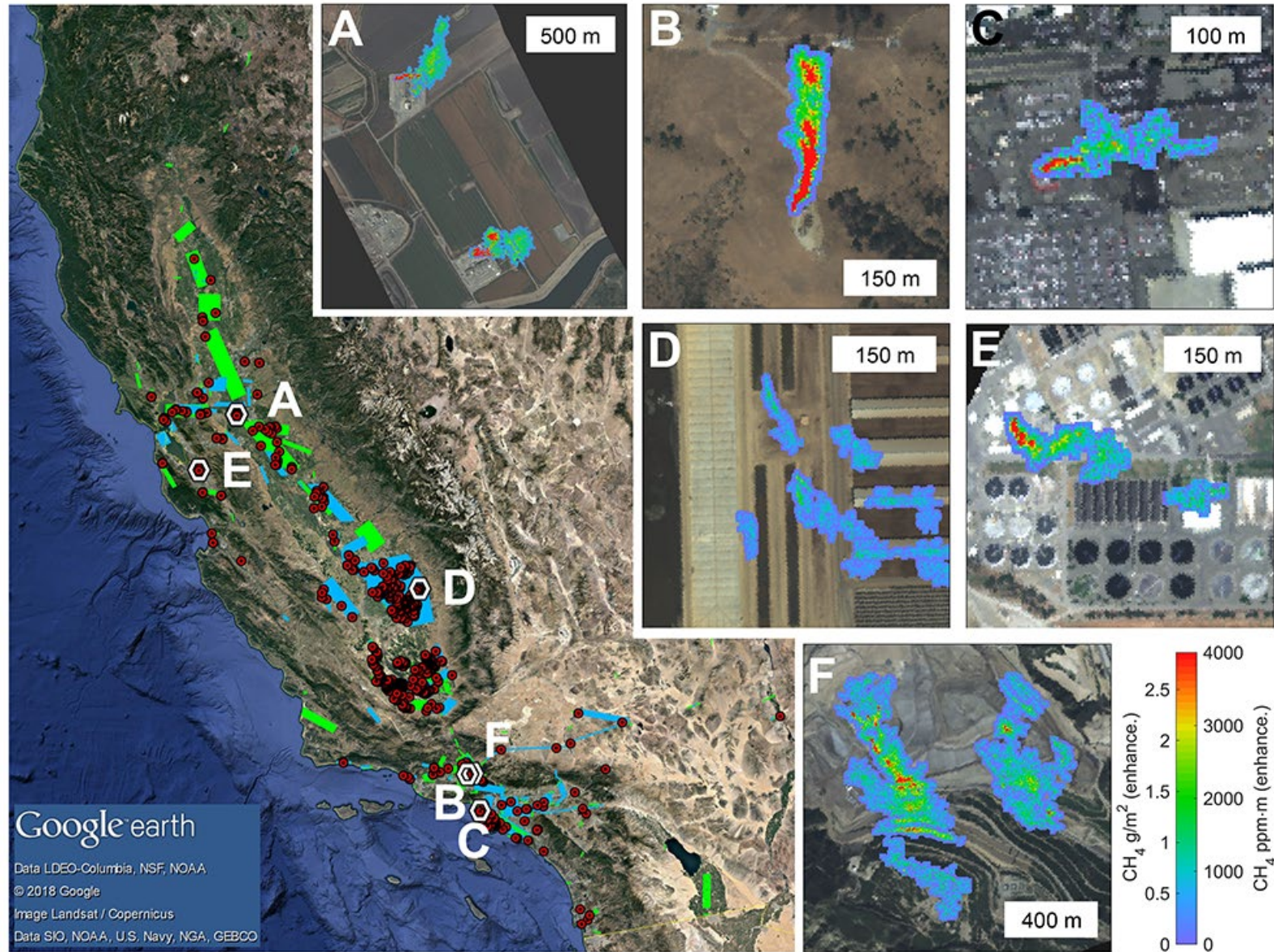
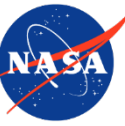
AVIRIS-NG CH₄ (Frankenberg et al., 2016)



Next Generation Airborne Visible/Infrared Imaging Spectrometer (AVIRIS-NG)

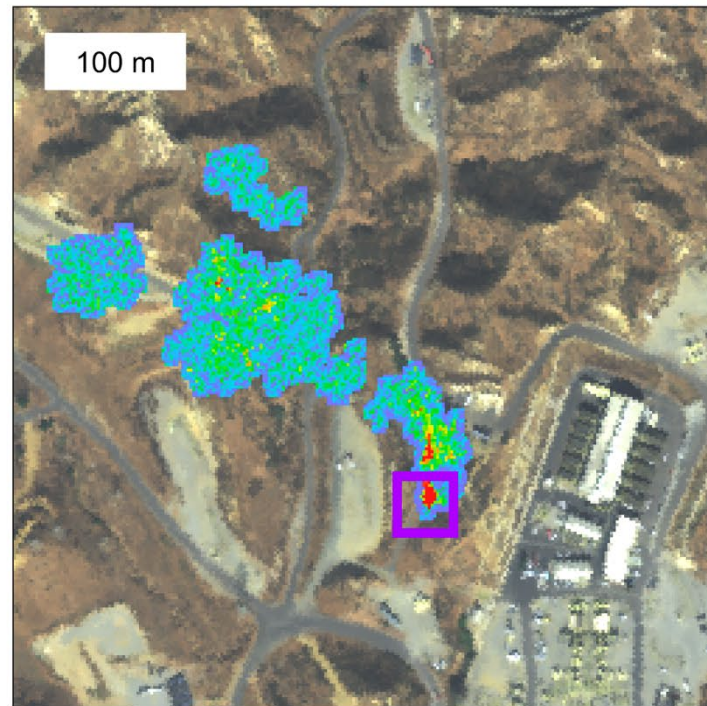


California Methane Survey

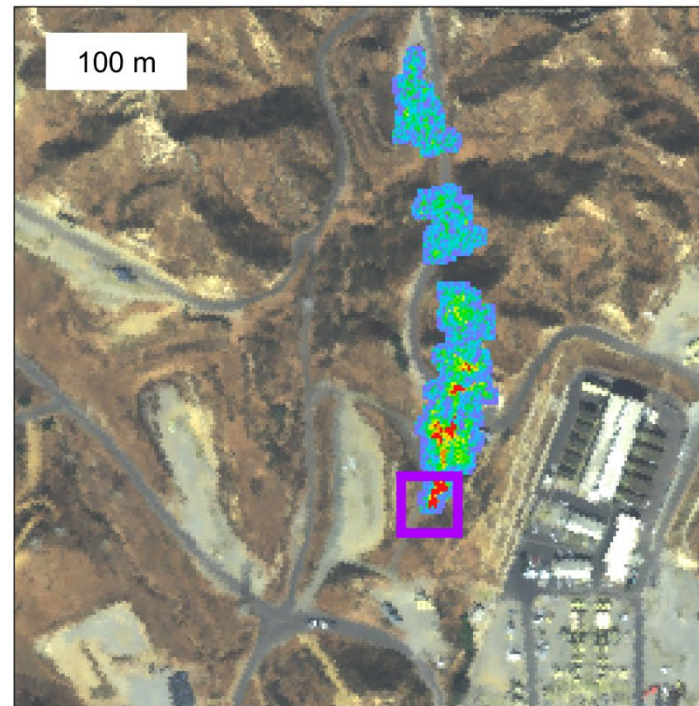


(Duren et al., 2019)

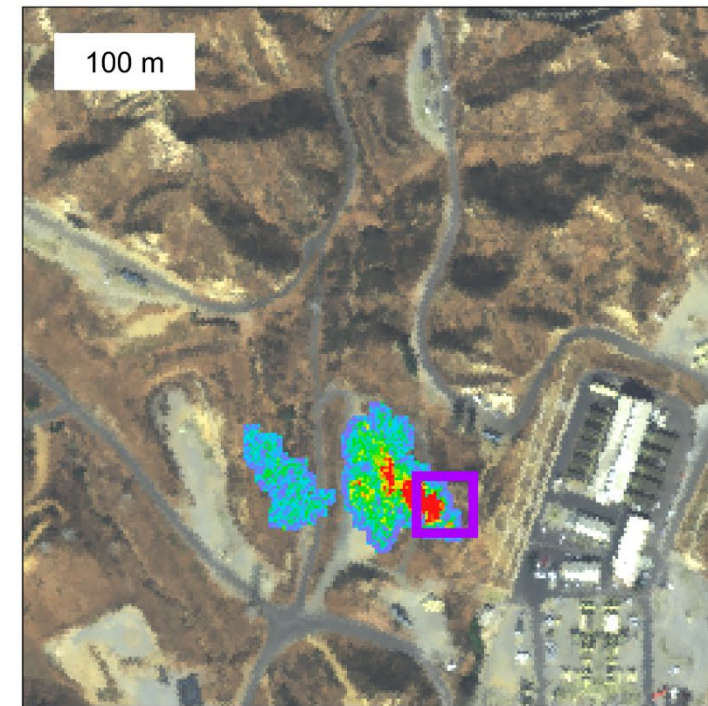
Reducing emissions at a gas storage facility



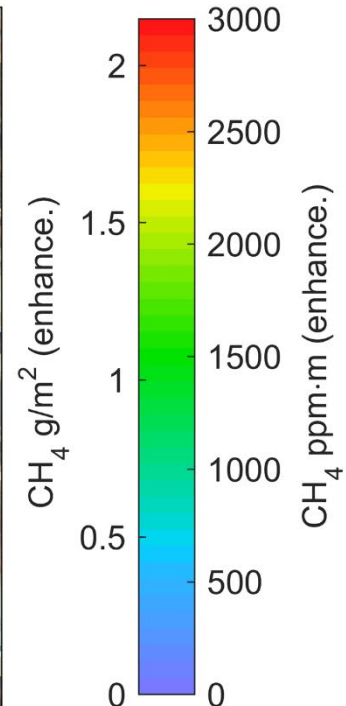
Oct. 26 2017, 19:21:42 UTC



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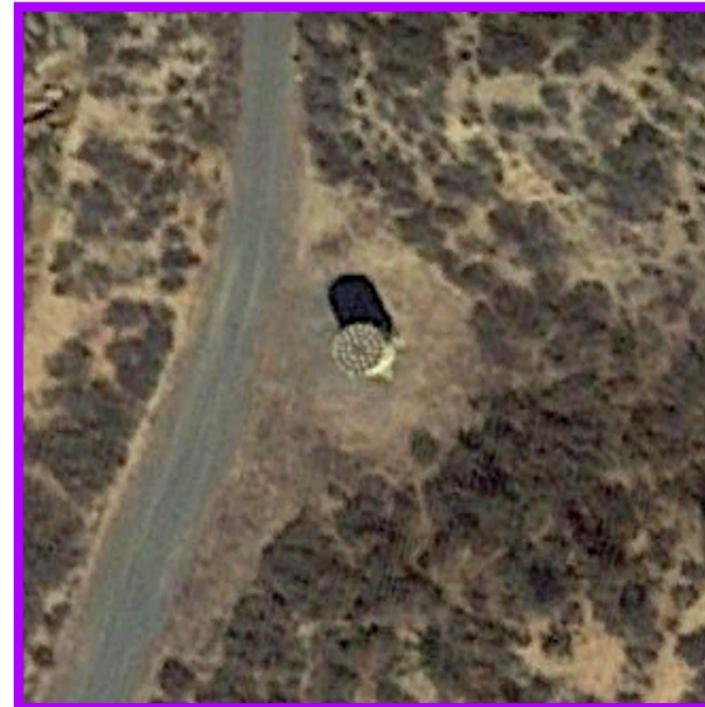
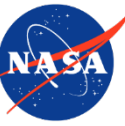


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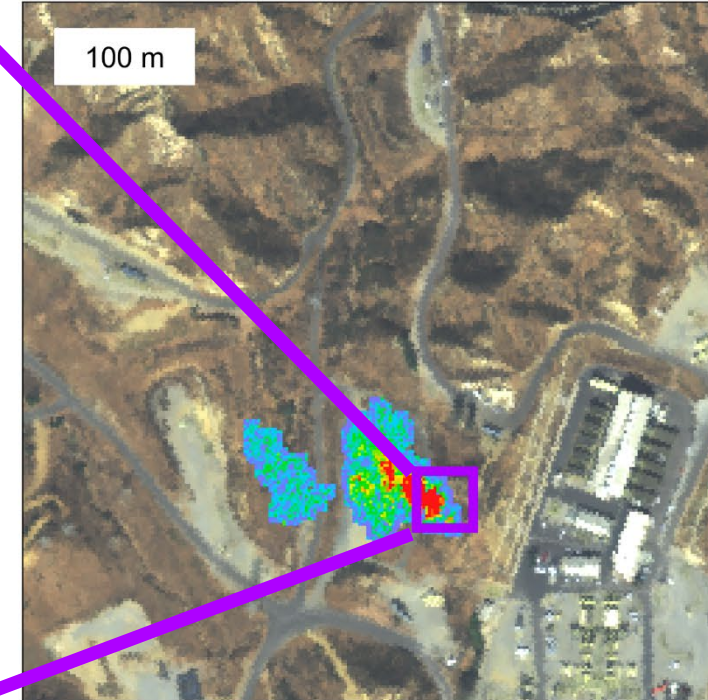


(Thorpe et al., submitted)

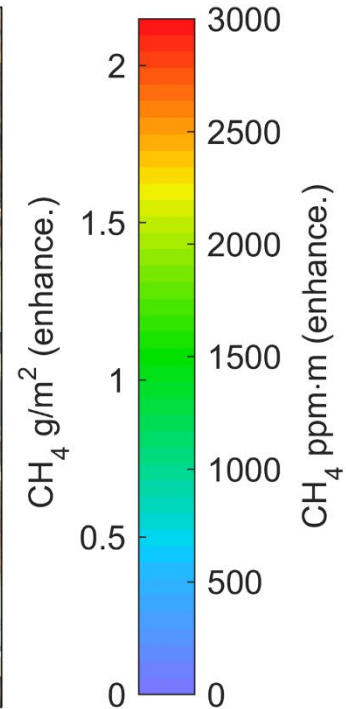
Reducing emissions at a gas storage facility



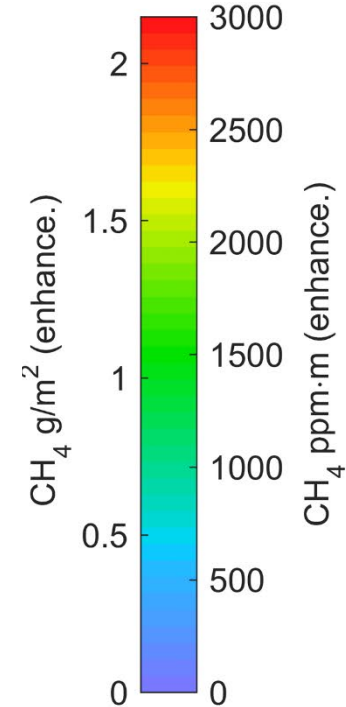
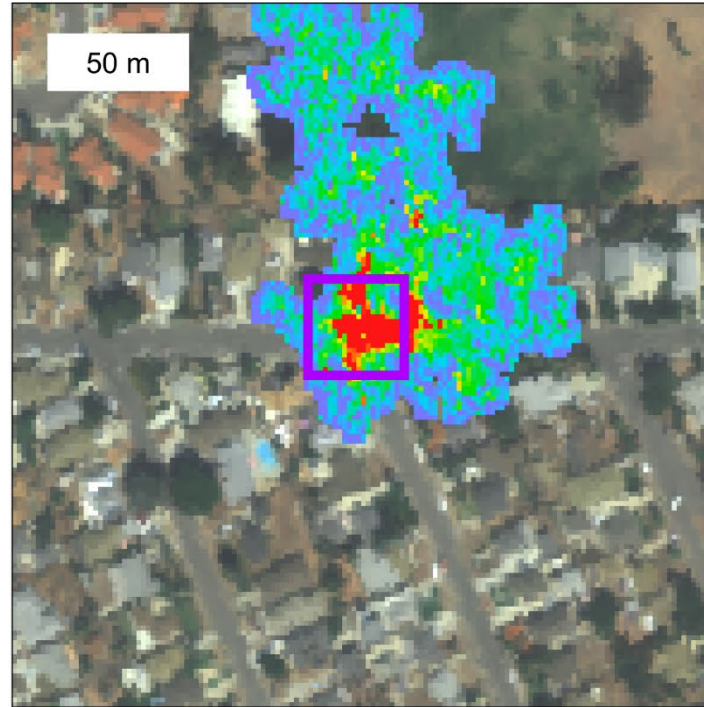
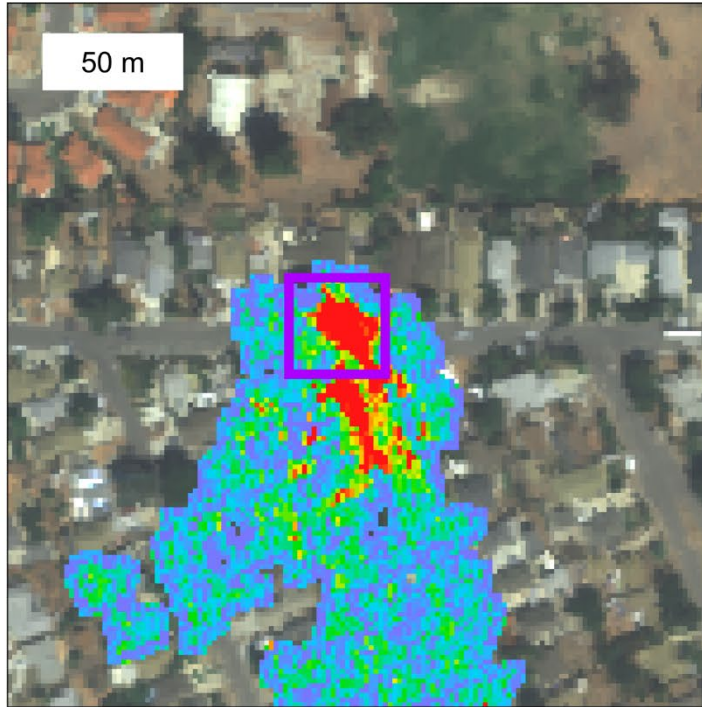
Google Earth, Oct. 2 2016



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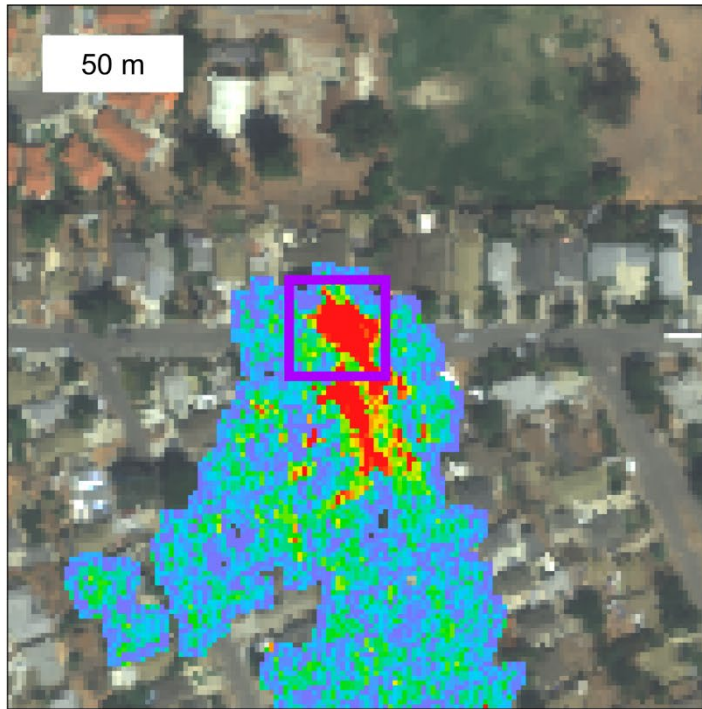
Natural gas leak mitigation



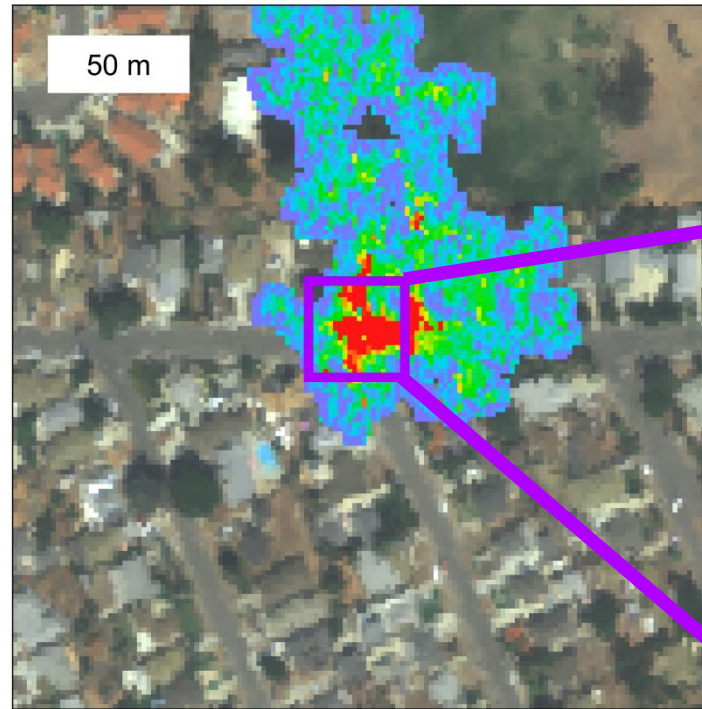
Sept. 15 2016, 18:52:10 UTC

Sept. 15 2016, 19:09:43 UTC

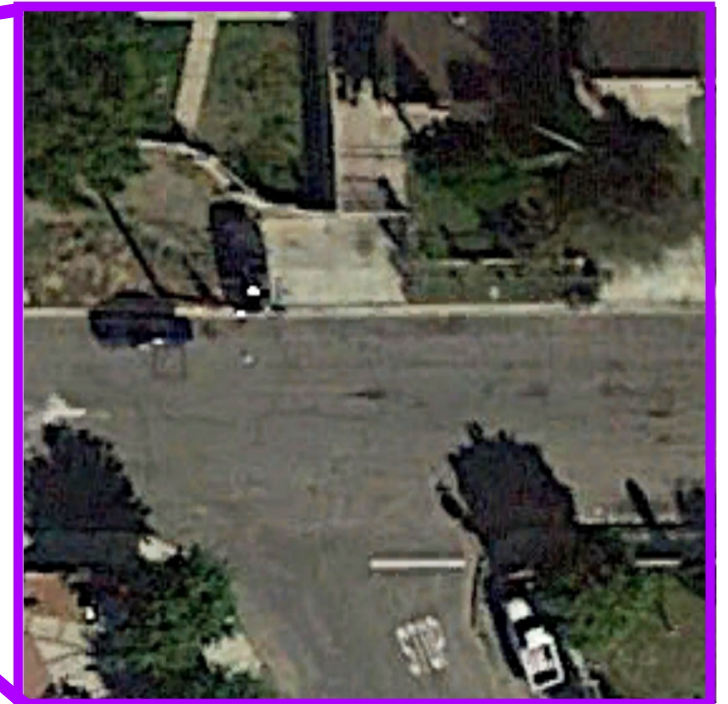
Natural gas leak mitigation



Sept. 15 2016, 18:52:10 UTC

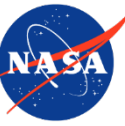


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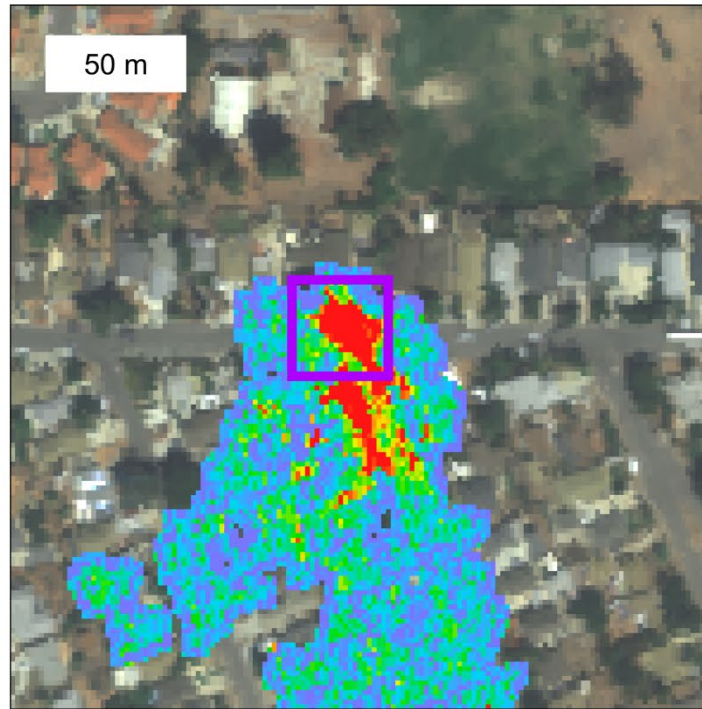


Google Earth, Feb. 2 2016

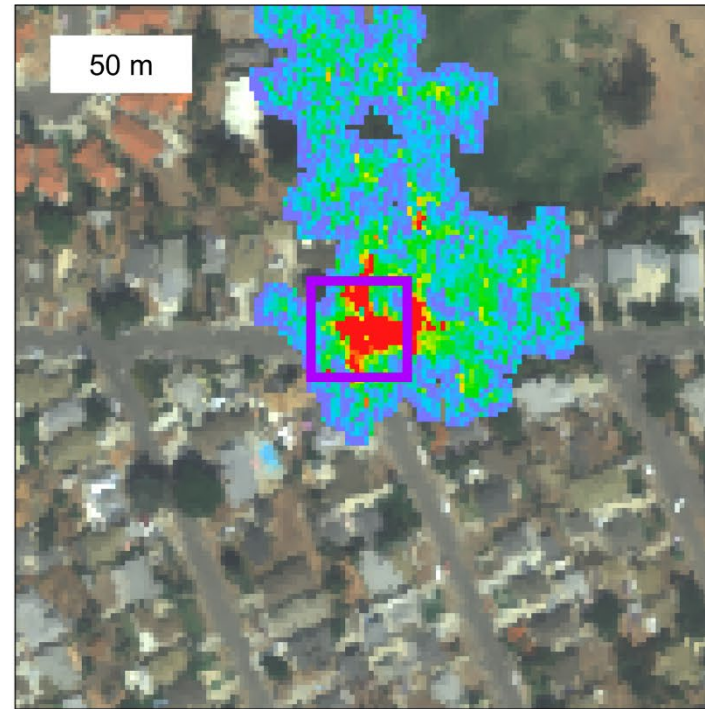
Natural gas leak mitigation



Natural gas leak mitigation



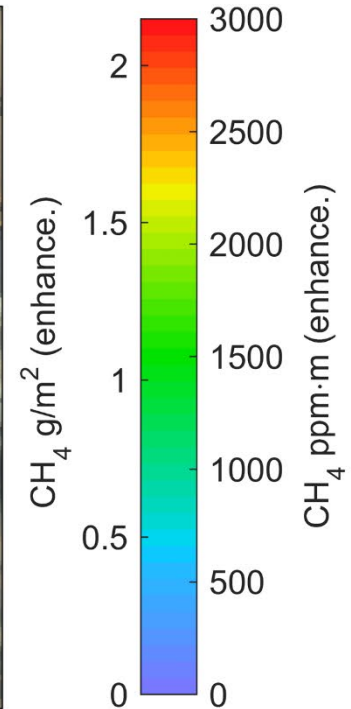
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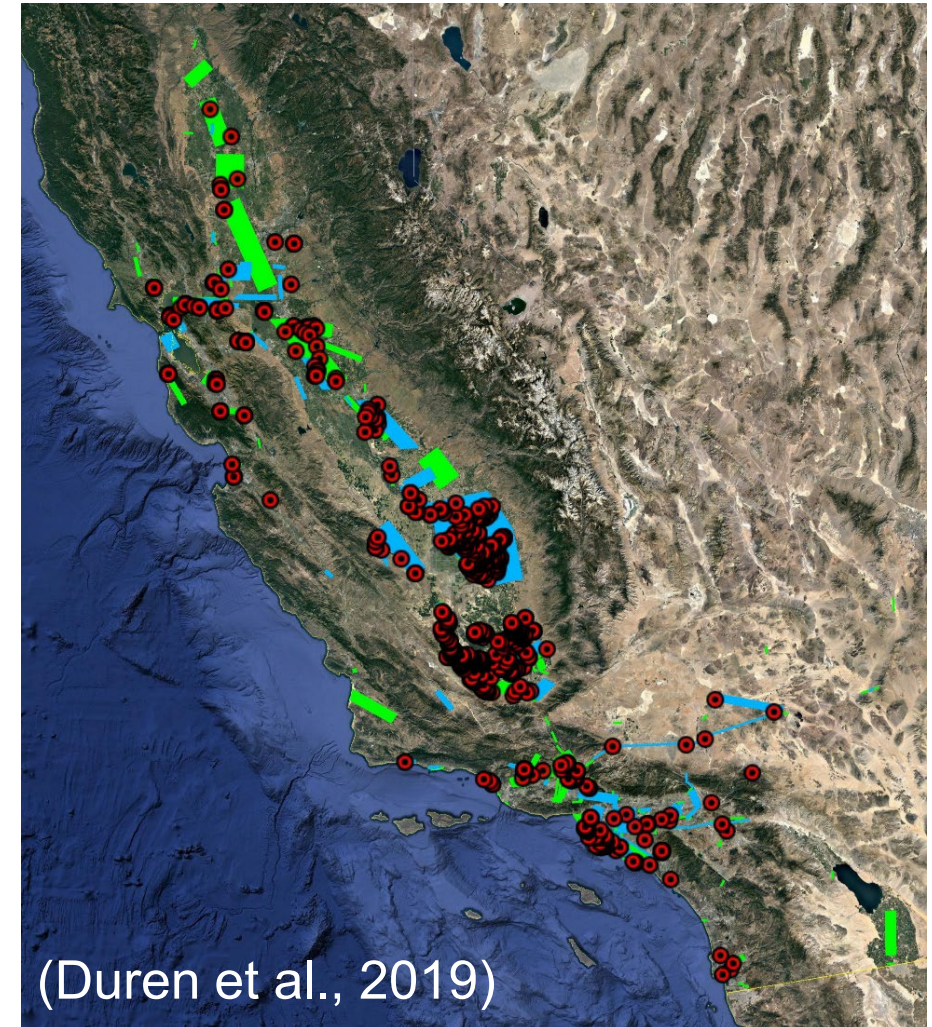


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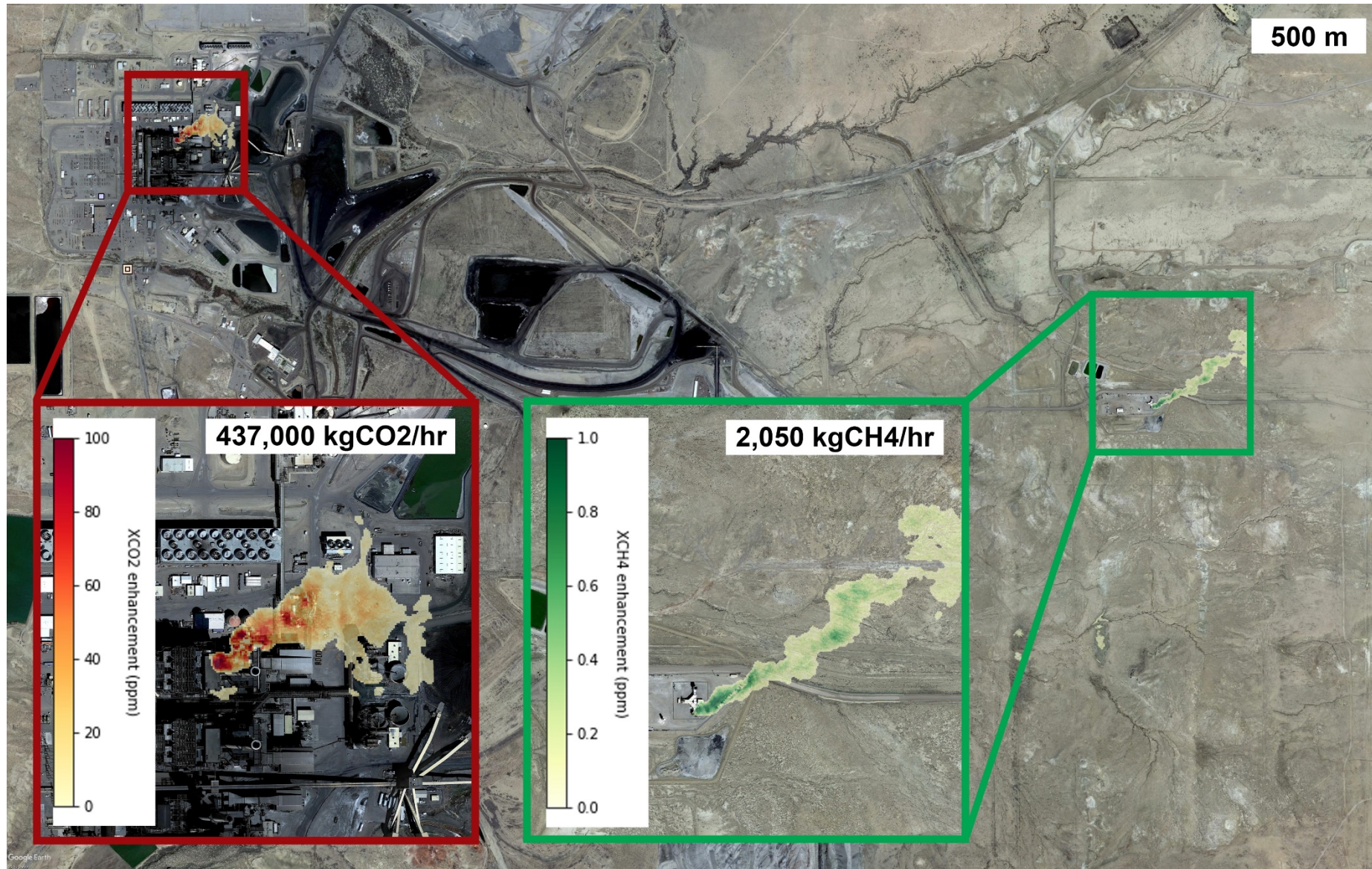


California Methane Survey results

- 1) Multiple revisits of facilities permitted assessment of persistence:
 - Oil & gas, dairy: 20-35% (mean) persistence.
 - Landfills: 100% persistence.
- 2) Emissions were calculated for 564 methane point sources.
- 3) Estimated emissions from methane point sources in California:
 - $0.618 \text{ TgCH}_4 \text{ yr}^{-1}$ (95% confidence 0.523-0.725).
 - Equivalent to 34-46% of 2016 methane inventory.
- 4) Super-emitter activity occurs in every surveyed sector (10% of point sources contributed ~60% of point source emissions).

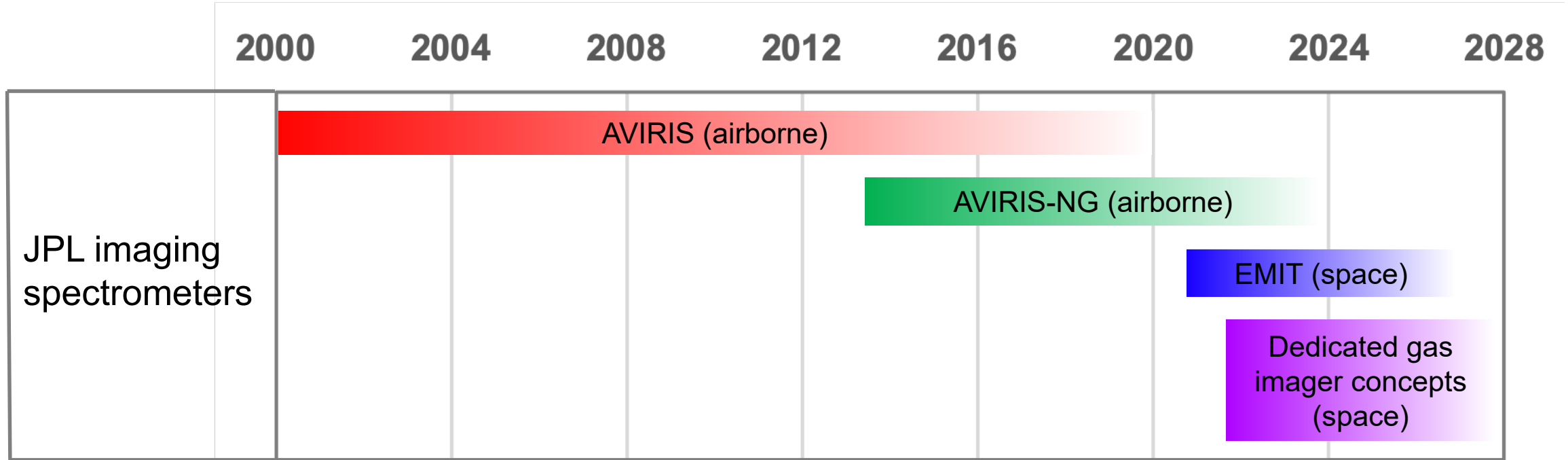


AVIRIS-NG CO₂ and CH₄ (complete carbon footprint)

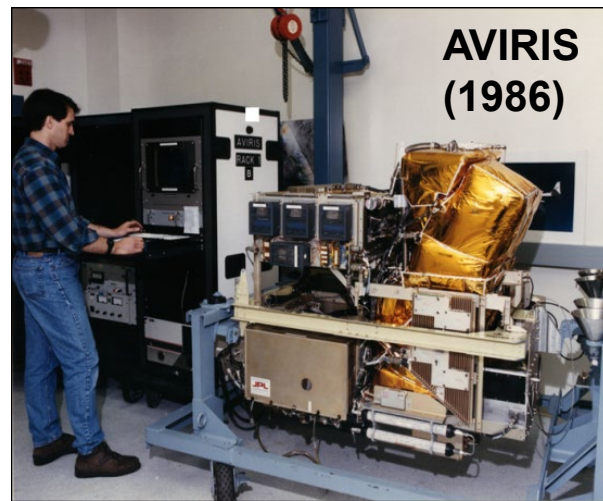


(Cusworth et al., in prep)

JPL technology overview for point source mapping



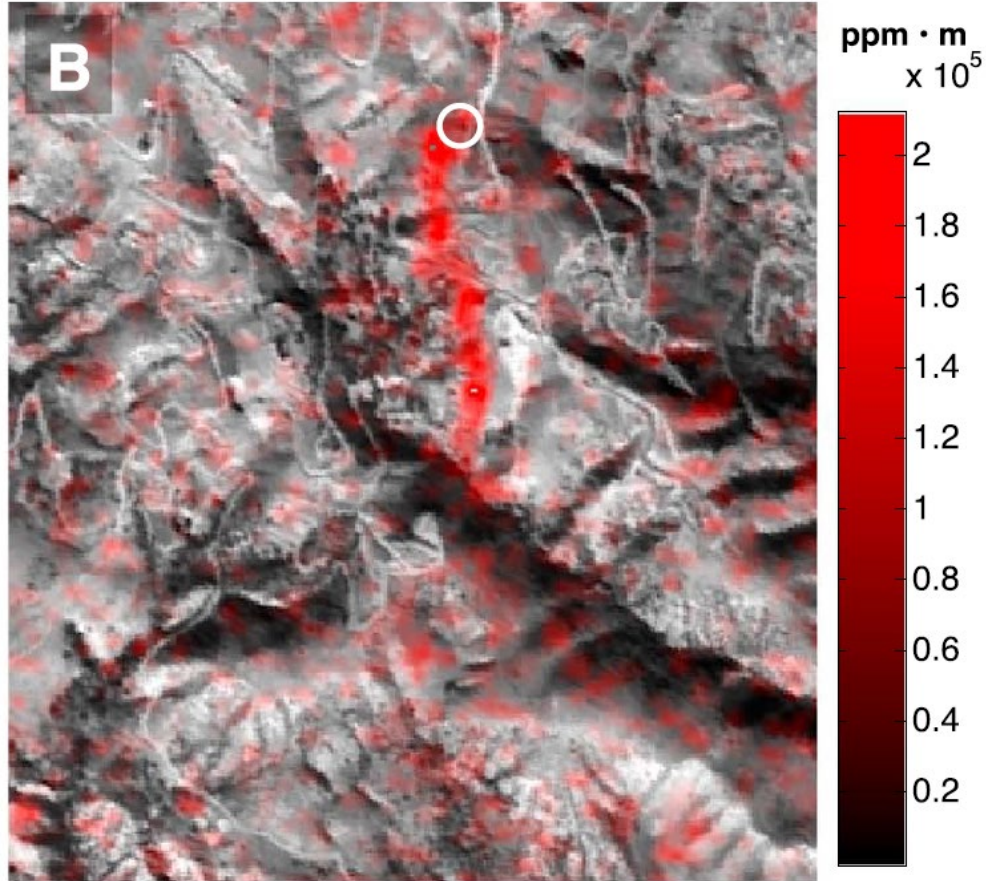
JPL imaging spectrometers



Potential for spaceborne imaging spectrometers



Aliso Canyon blowout
Hyperion (10 nm): 1/1/16, 16:39 UTC



(Thompson et al., 2016)

Atmospheric
Measurement
Techniques
Discussions

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Potential of next-generation imaging spectrometers to detect and quantify methane point sources from space

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²Atomic and Molecular Physics Division, Harvard Smithsonian Center for Astrophysics, Cambridge, MA, USA

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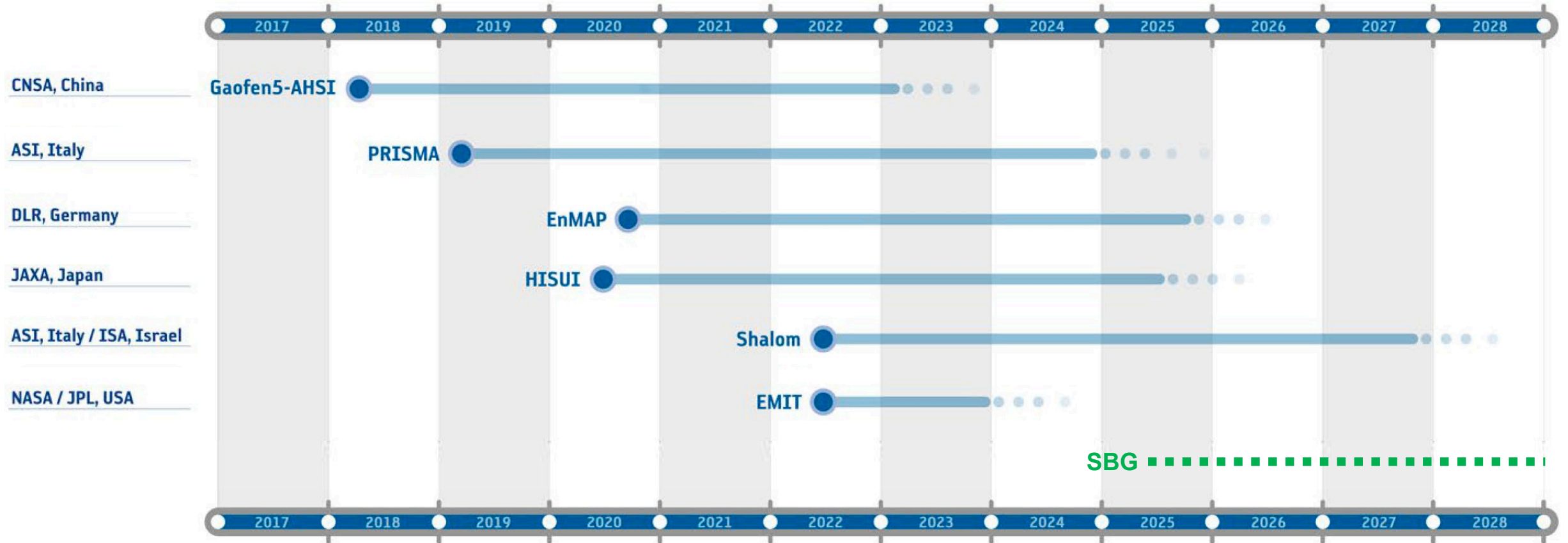
⁵Centro de Tecnologías Físicas, Universitat Politècnica de València, Camí de Vera s/n, 46022 València, Spain

⁶ExxonMobil Research and Engineering Company, Annandale, NJ, USA

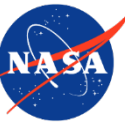
Potential for spaceborne imaging spectrometers (public sector)



- While not designed for this purpose, instruments will have methane sensitivity



Modified from Rast & Painter (2019)



Key takeaways

- Imaging spectrometer technology and science is mature
 - Four years of AVIRIS-NG methane flight campaigns
 - A decade of scientific publications
- Super emitters across all sectors offer great potential for mitigation
- Intermittent nature of emissions requires frequent observations (satellites)
- Characterizing methane emissions with imaging spectrometers complements and offers follow-up to high emitting areas detected by global mappers