A taxonomy of satellite remote sensing for detection and quantification of methane emissions

Ritesh Gautam

Lead Senior Scientist, MethaneSAT LLC

Washington DC

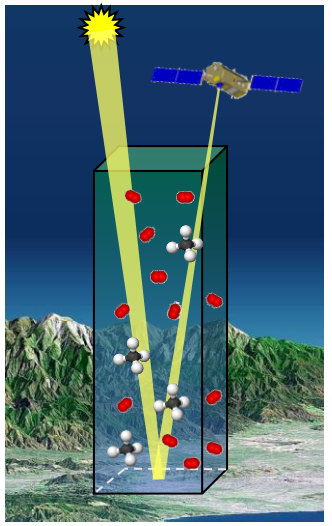
Measuring methane emissions from space

- *To acquire data from global oil and gas sector and other anthropogenic sectors, remote sensing from space provides an effective way for systematic monitoring globally.*

- *To detect and quantify emissions, remote sensing measurements characterize methane concentrations that arise from emissions by quantifying the excess above the background.*

- *Satellite remote sensing enables measurements of methane, restricted to narrow wavelength intervals, which must be viewed against complex scenes and atmospheric transmission.*

- *Quantifying emissions from regional sources is different than detecting point sources. Both diffuse and large point emissions are important.*



Spectral measurements

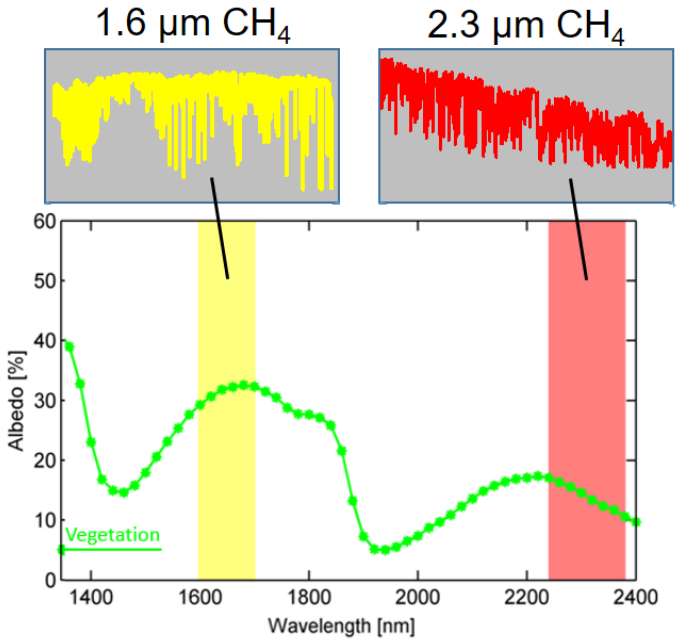


Image courtesy – Kang Sun/U. Buffalo

Three essential parameters relevant to satellite remote sensing of methane

1. Swath width

- The broader the better (covers more area and enables better revisit frequency)

2. Pixel size

- The finer the better (does a better job at attributing individual sources of emissions)

3. Precision

- More precise the better (sensitivity to detecting concentrations, in turn quantifying emissions)

An example satellite simulation of methane concentrations over the Barnett Shale

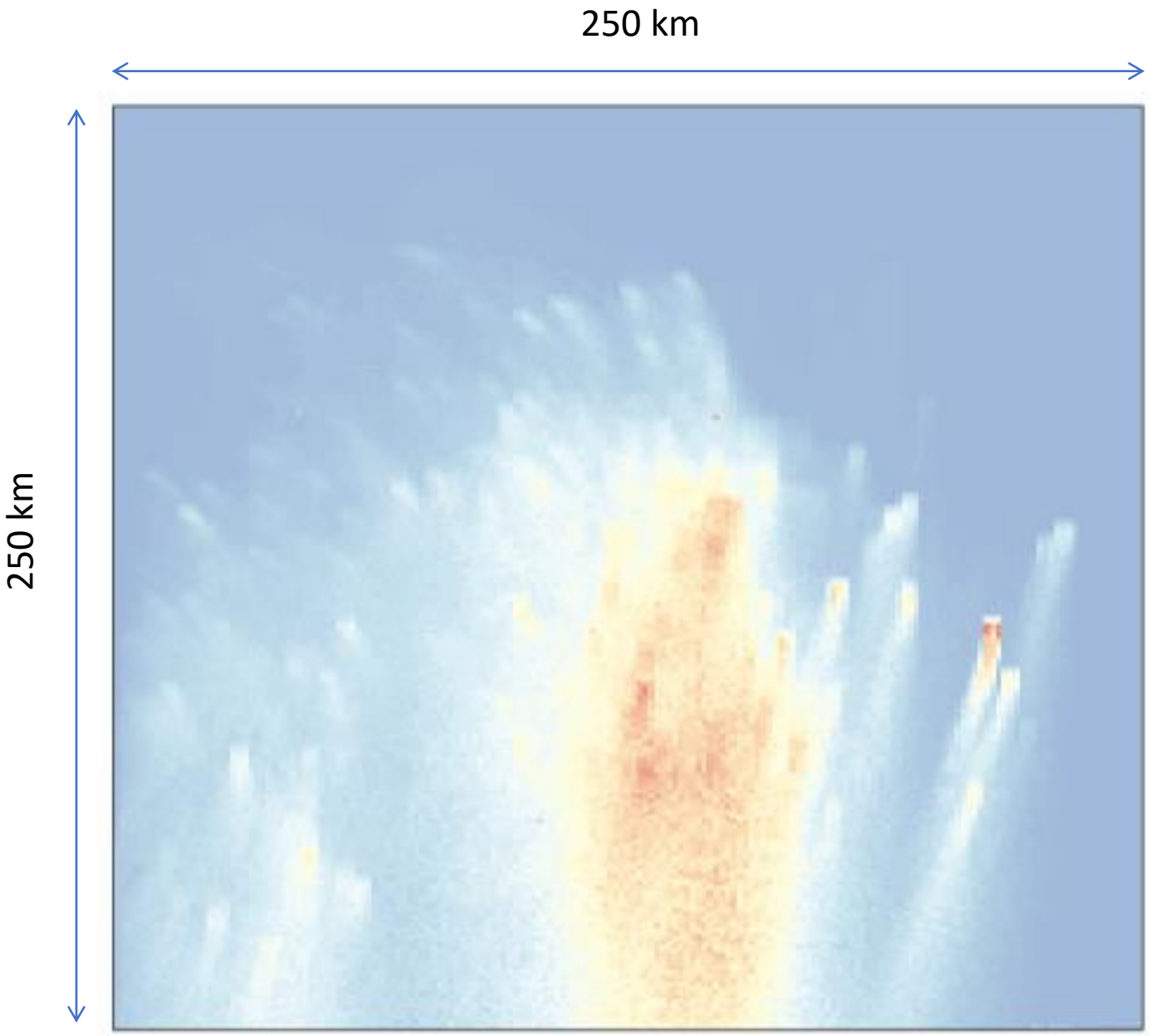
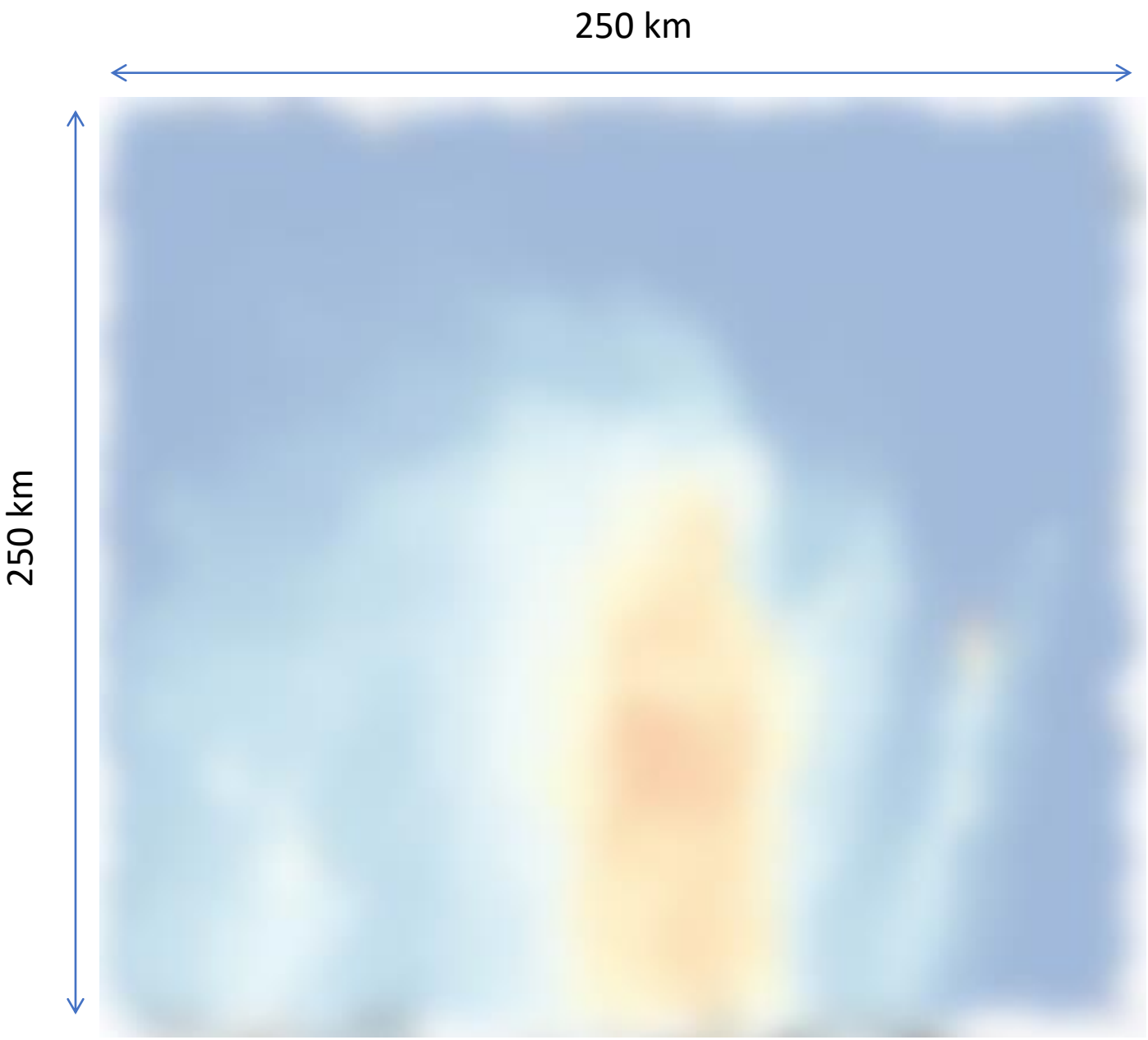


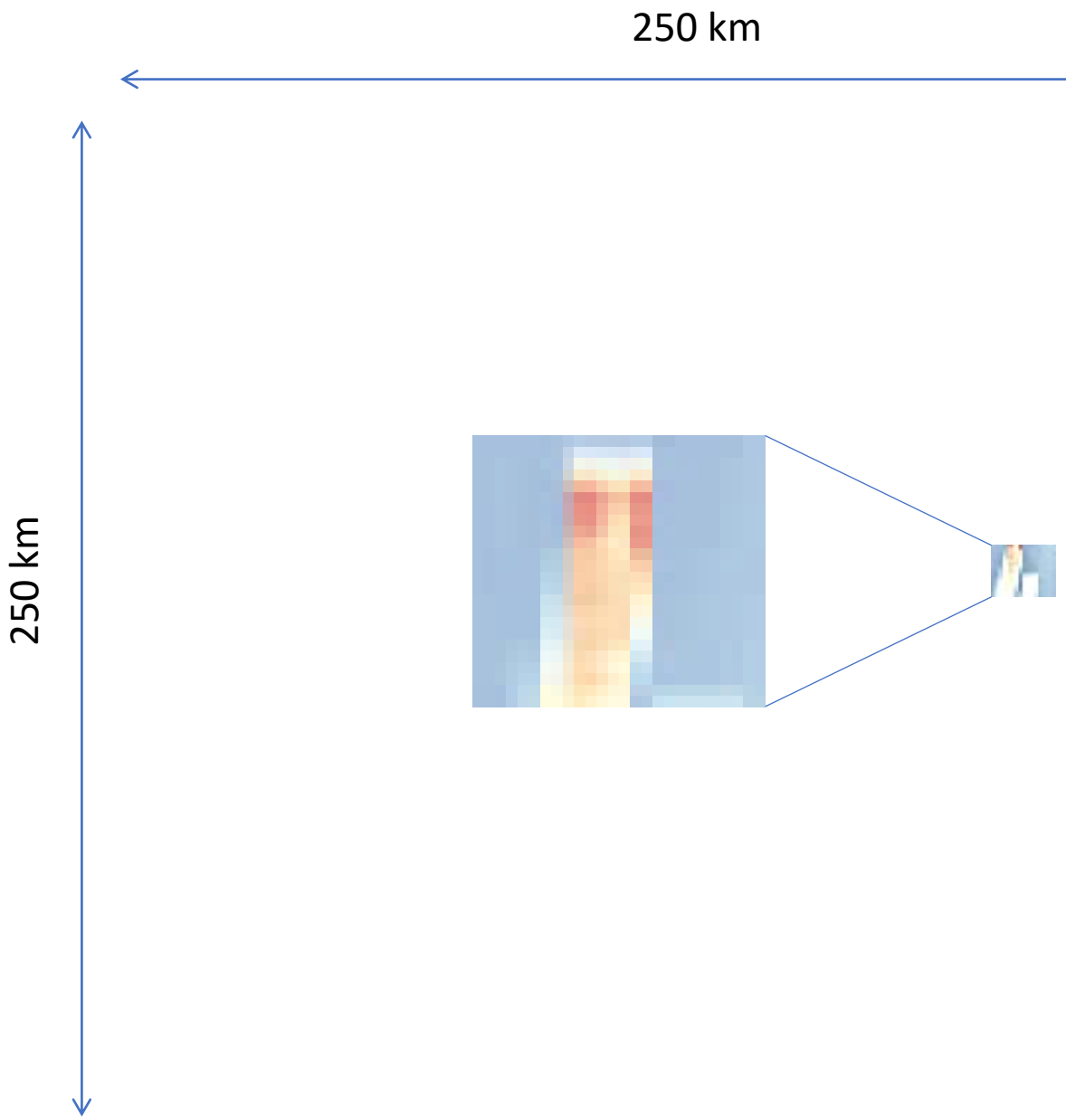
Image courtesy – J. Benmergui/Harvard

- Wide swath of 250 km enables full view of Barnett shale area.
- High precision enables ability to detect fine-scale gradients across methane plumes and enhancements.
- High pixel resolution enables ability to attribute emission sources.
- warm colors – high methane concentrations and vice versa



An example satellite simulation of methane concentrations over the Barnett Shale

- Wide swath of 250 km enables full view of Barnett shale area.
- Low precision and low pixel resolution limits the ability to distinguish emission sources and detection/quantification of emissions.



An example satellite simulation of methane concentrations over the Barnett Shale

- High pixel resolution effectively enables ability to detect and attribute emission sources.
- Very limited swath only captures a very small portion of the Barnett Shale.

Three essential parameters relevant to satellite remote sensing of methane

1. Swath width

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3. Precision

- More precise the better (sensitivity to detecting concentrations, in turn quantifying emissions)

- *No single spec will help quantify total methane emissions.*

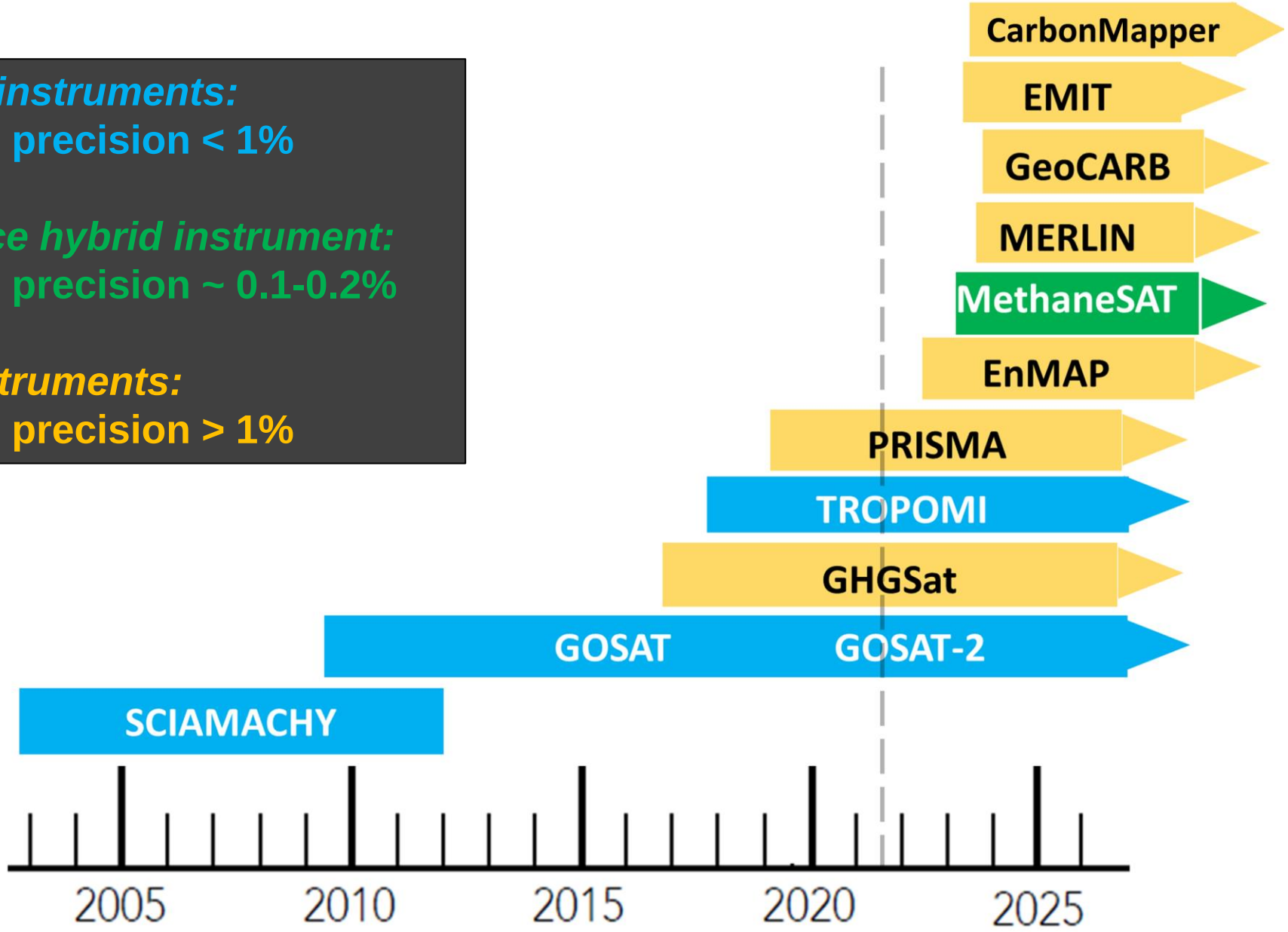
- *It is really the combination of the three parameters, which will make the observing system effective and enable actionable data.*

Methane satellites: past, present and future

Regional/global instruments:
- pixels > 1 km, precision < 1%

Area/Point source hybrid instrument:
- pixels ~ 1 km, precision ~ 0.1-0.2%

Point source instruments:
- pixels < 50 m, precision > 1%



Global mapping

*7,000 m x 5,500 m pixels
across 2,600 km swath

- ✓ **Global & large-scale regions**
- ✓ **Large point sources**

Area mapping

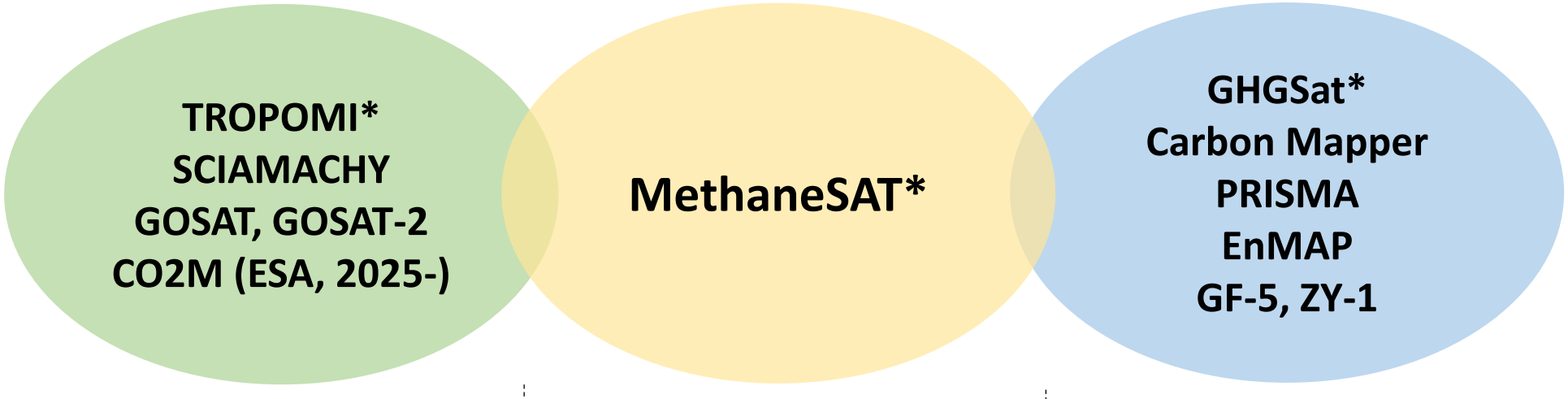
*130 m x 400 m pixels
across >200 km swath

- ✓ **Area sources**
- ✓ **Point sources**
- ✓ **Sector-wide quantification**

Location mapping

*30 m x 30 m pixels
across >10 km swath

- ✓ **Point sources**
- ✓ **Facility level attribution**



- Moderate precision
- Global mapping
- Quantify large-scale regions
- Quantify large point sources
- Guidance from other satellites to interpret point source emissions

- High precision
- Detect & quantify area sources
- Sector-wide quantification
- Detect & quantify high-emitting point sources
- Fills observing & data gaps between location and global mapping missions.

- Low precision
- Detect & quantify moderately high-emitting point sources
- Constellations can enable frequent site revisits.
- Guidance from other satellites to inform target acquisition

MethaneSAT: a new satellite mission to quantify methane emissions

- Launch: Q4 2022 – Q1 2023
- Sensor: Imaging Spectrometer, operated in target mode
- Lifetime: 5 years or more
- Objective: produce quantitative data on methane emissions from global oil and gas production (also view other areas/sectors incl. agriculture)
- Data characteristics-
  - 200 km swath width,
  - ~1 km spatial resolution (100m x 400m native pixel size),
  - 2-4 ppb methane concentration retrieval precision
- Science, Mission Ops, Data Platform teams at Harvard, SAO, NIWA/New Zealand, MethaneSAT LLC and EDF
- MethaneAIR is an airborne precursor mission for MethaneSAT, which has flown across several major oil/gas basins in the US.

Image courtesy of Ball Aerospace

An ecosystem of methane-detecting satellites is rapidly emerging, each with distinct capabilities – which make them complementary for addressing methane emissions globally

- Stakeholders can use multi-sensor data to develop a clearer, more comprehensive understanding of the emissions landscape.
- Multi-sensor satellite-derived emissions information can also be used to intercompare, integrate, assess and reconcile data with bottom-up inventories and field measurements.
- Measurements from a point-source instrument like Carbon Mapper or GHGSAT combined with the more sensitive data and wider area coverage of MethaneSAT, will enable improved emission source detection and attribution capabilities (“tip and cue”).
- Daily global coverage offered by TROPOMI will continue to be a useful way to spot high emission events, and as a tool to look for possible targets for other satellites.