Does the early bird catch the plume?

Choosing the optimal overpass time for targeting anthropogenic point sources

Criterion	Before noon	After noon
Cloud cover	✓	
Plume detectability	✓	
Wind speed		✓
Land-sea breeze		✓
Emission quantification	?	?

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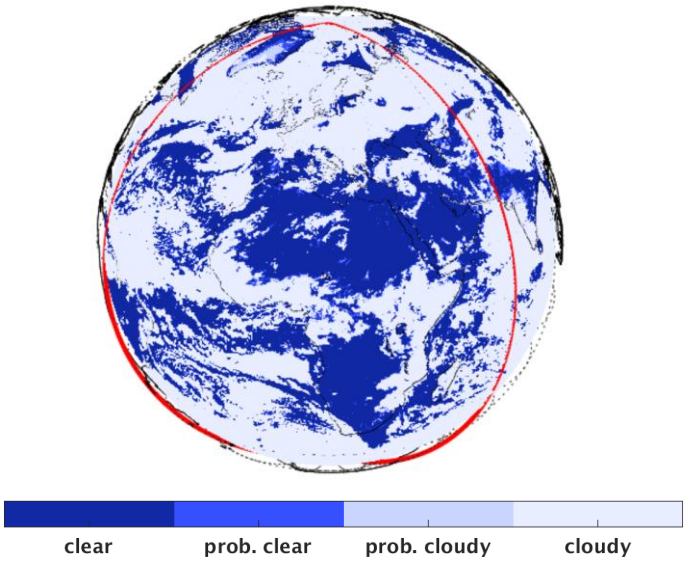
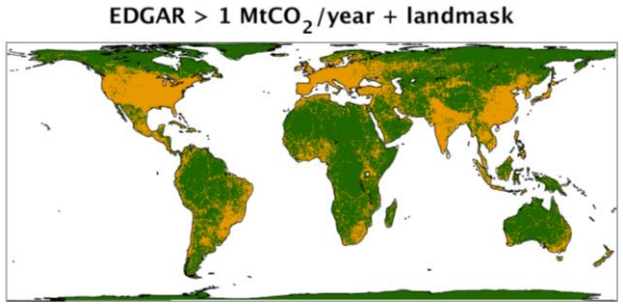
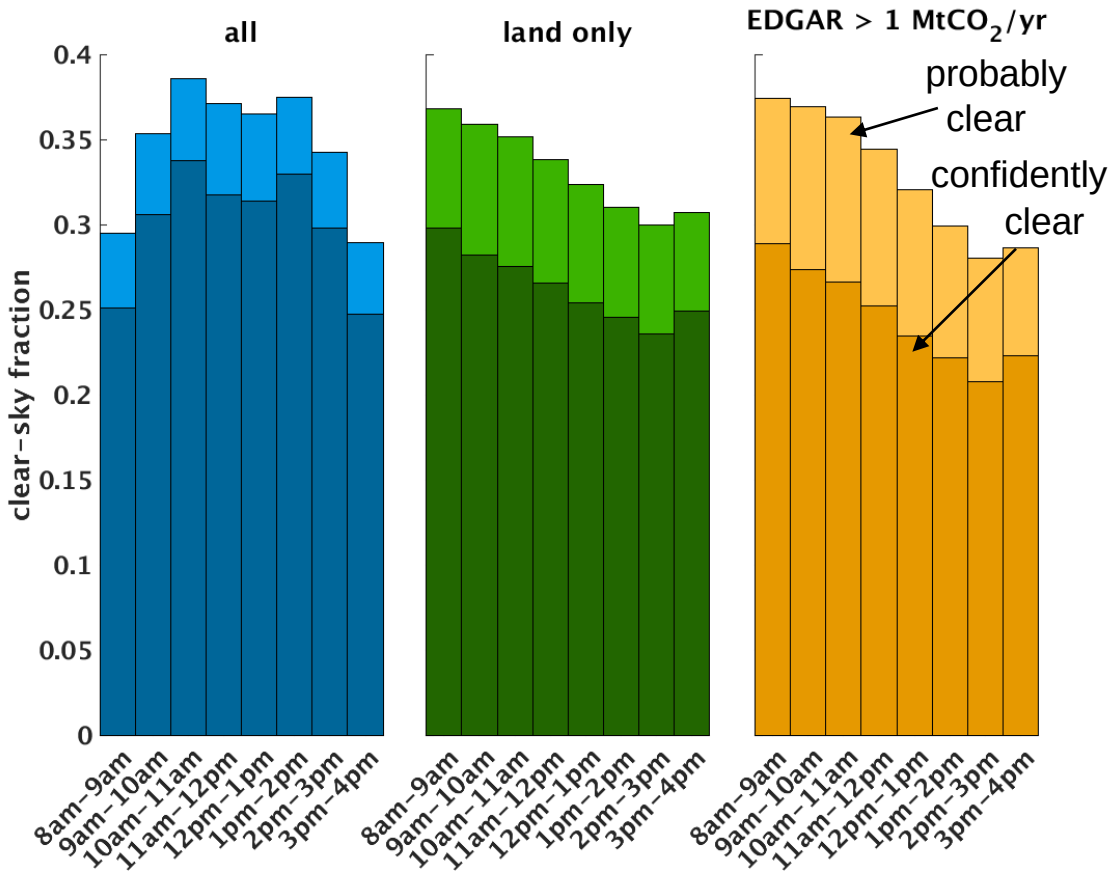
Cloud cover data from EPIC:

- Earth Polychromatic Imaging Camera at L1 point
- Provides images of the sunlit half of the earth
- Data every 1-2 hours: less frequent than geostationary, but globally consistent
- Assessment of cloud fraction for local overpass times from 8:00-16:00
- 8-km resolution at nadir
- Analysis at 0.1° resolution using data from 2017-2018



Example scene from June 14, 2018, 11:40 UTC

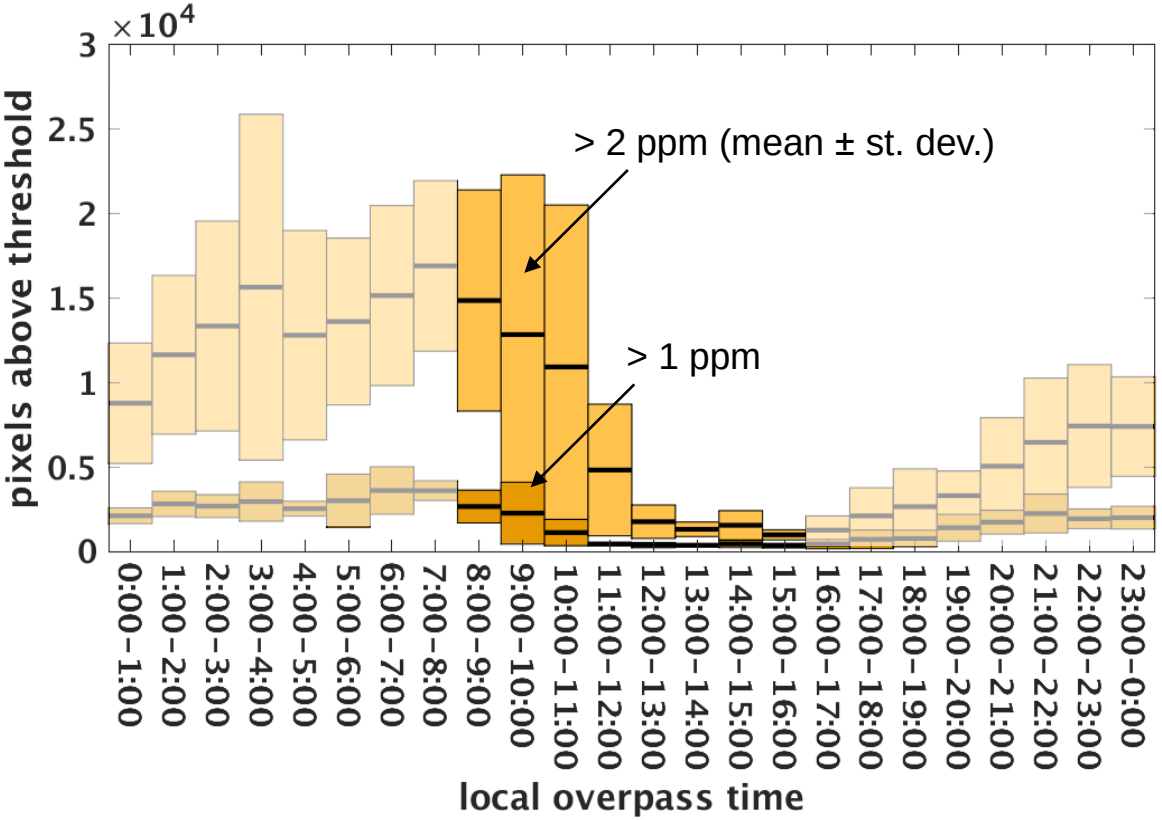




Morning overpasses have more cloud-free scenes over land targets.

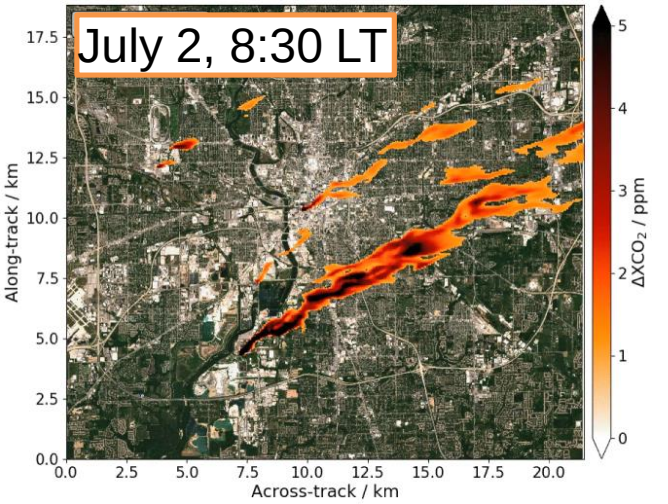
Plume detectability based on LES simulations for Indianapolis

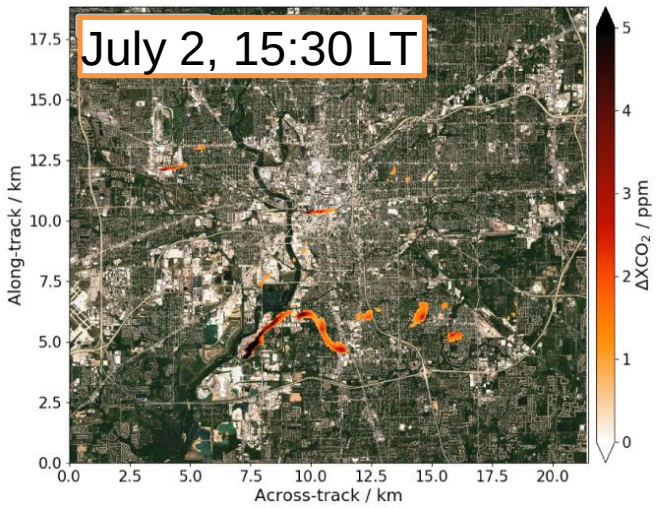
- 50-m ground resolution with ICON
- Emissions from HESTIA (K. Gurney)
- Simulations here for three days in July, 2019
- Summing pixels with concentrations above the indicated levels, comparing by hour
- No cloud filtering



Earlier overpasses have more detectable pixels.

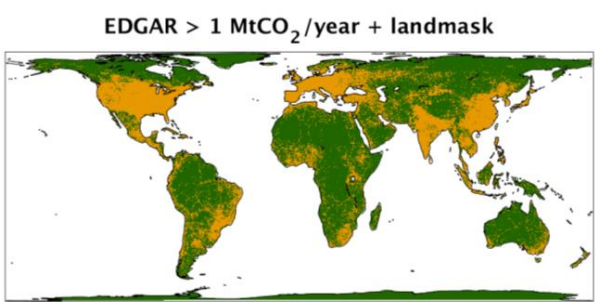
- Developing turbulence and deepening PBL over the day disperses the plumes

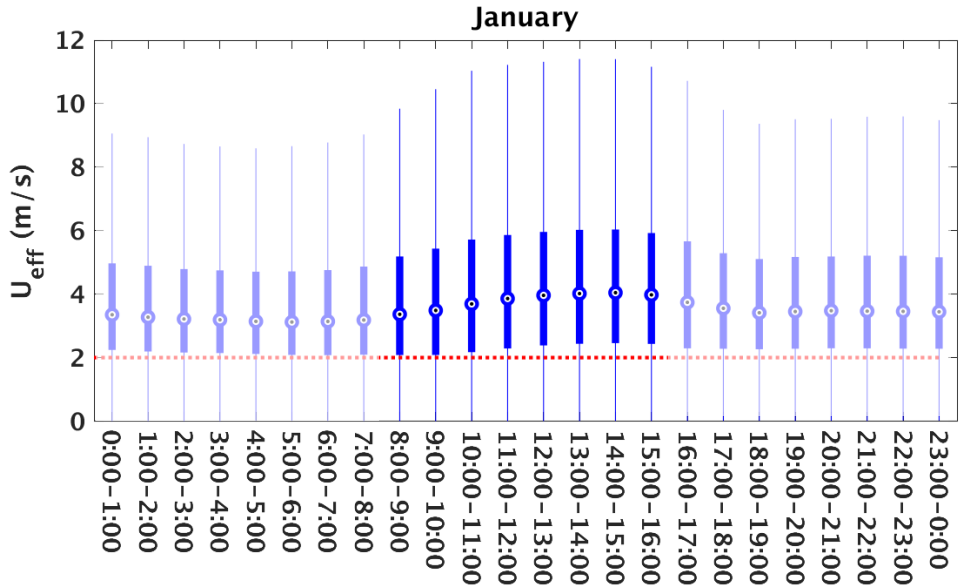


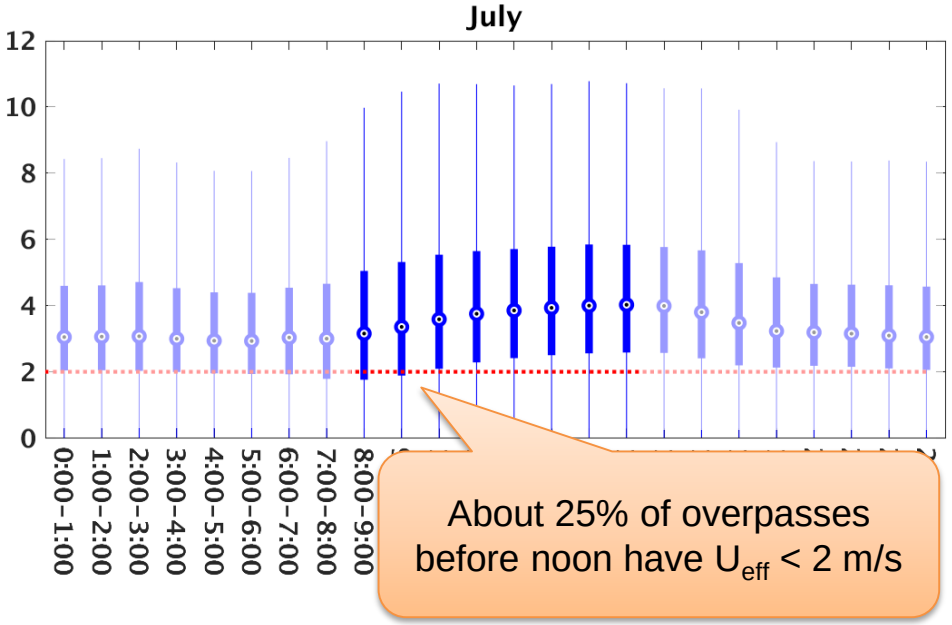


Wind speed analysis as a function of time of day

- Based on ERA5 10-m wind speed for 2019, applying empirical multiplicative factor of 1.4 for effective wind speed U_{eff} (based on Varon et al., 2018; Reuter et al., 2019)
- Analysis restricted to land regions with emissions > 1 $MtCO_2$/year in 0.1° EDGAR pixel
- Wind speed should be greater than 2 m/s:
  - Lower wind speeds good for detection but bad for source quantification
  - Higher wind speeds lead to lower in-plume enhancements



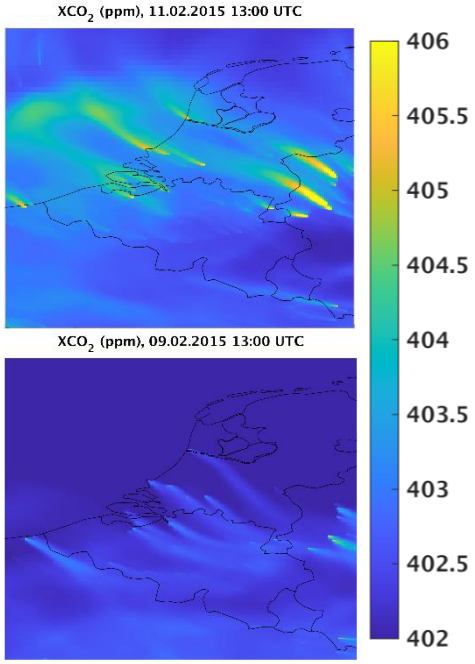




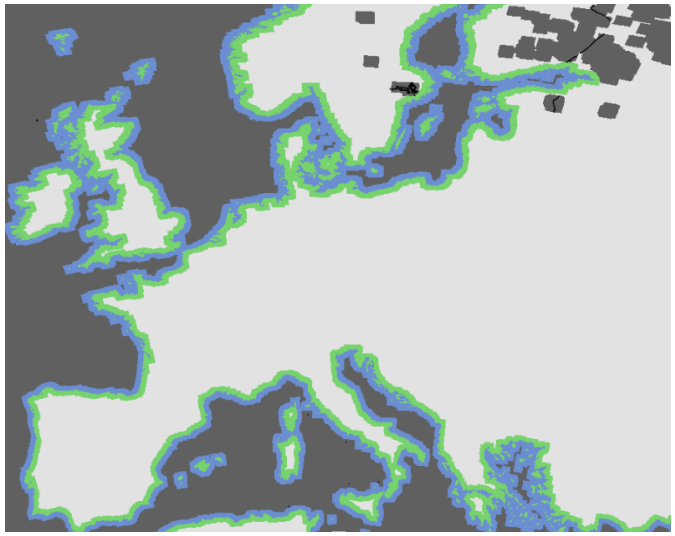
The difference is small, but there are more low-wind-speed scenes early.

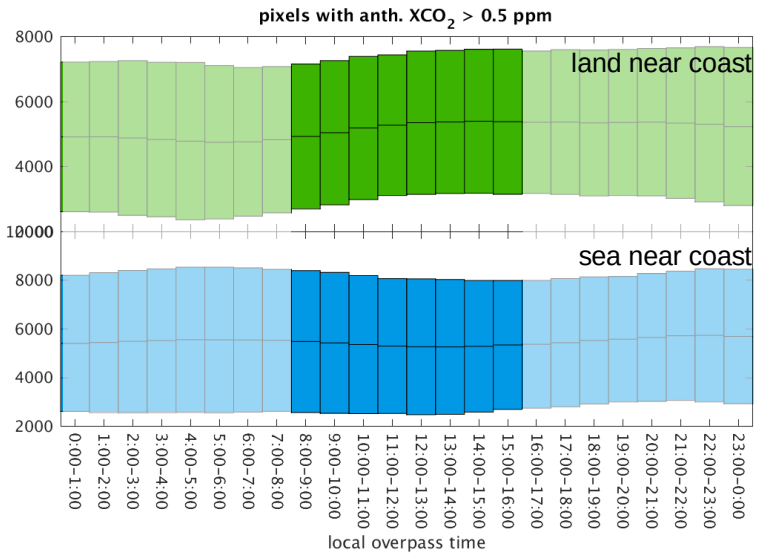
Consider land-sea breeze for coastal point sources

- If plumes from coastal point sources are advected over water, glint mode may be required for viewing (for e.g. CO2M), or plume may simply not be seen (for e.g. CO2Image)
- Land-sea breeze circulation can impact diurnal wind direction near the coast: on-shore during the day and off-shore at night
- Analysis based on European “Nature run” simulations from CHE project at 5-km resolution, looking at anthropogenic XCO2 signal in coastal land and sea pixels (within ~30 km of coast)



Example of offshore (top) and onshore (bottom) flow in Benelux for two days in February, 2015





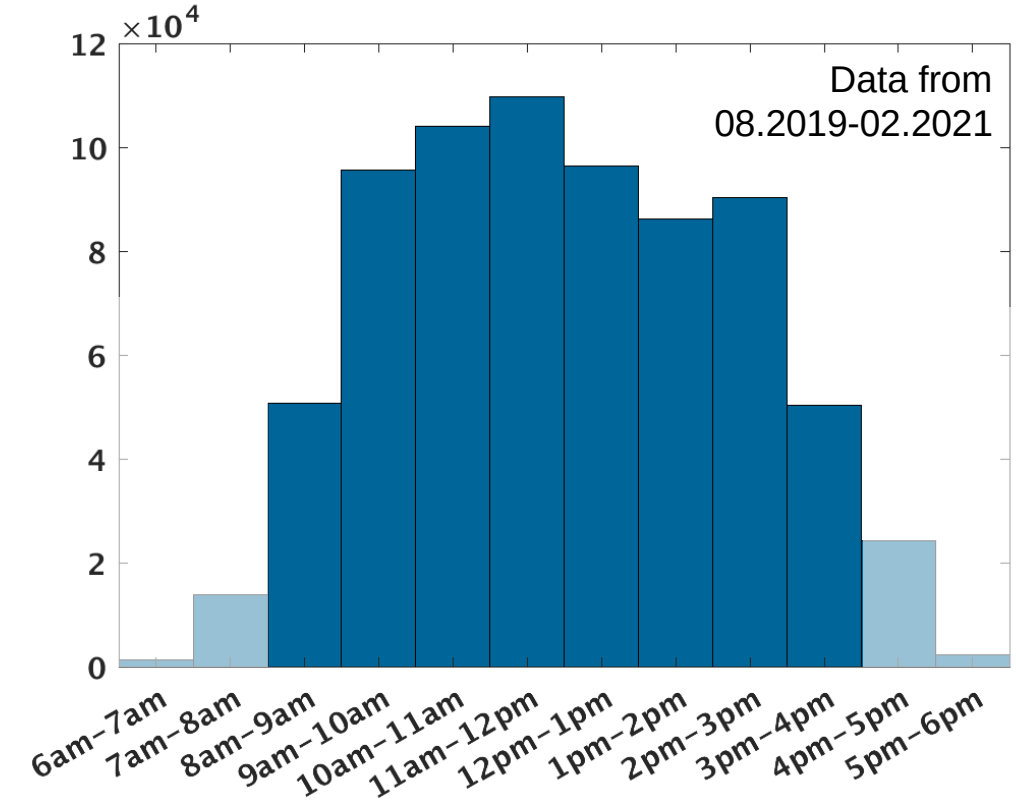
Afternoon overpasses appear to have a very slight advantage for coast-adjacent land soundings in July (shown), but this effect does not persist across all months.

Essentially identical as seen at this scale for this region.

Emission estimation as a function of overpass time

- What really matters is the impact on L4 emissions estimates – more difficult to assess
- Working towards OSSEs based on LES simulations
- OCO-3 snapshot scenes also provide some "real-world" scenes, given variable local overpass time – assessment is ongoing…

Number of good OCO-3 SAM soundings as a function of local time



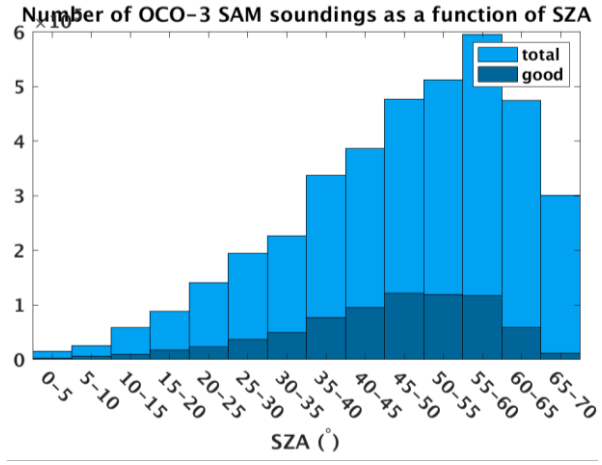
Before noon	After noon
More cloud-free scenes	More clouds
More detectable plumes	More turbulence and mixing
Slightly lower wind speeds	Slightly higher wind speeds
Residual layer interference?	Well-developed mixing layer

More "good" retrievals in snapshot mode before noon… but what can we say about the fluxes?

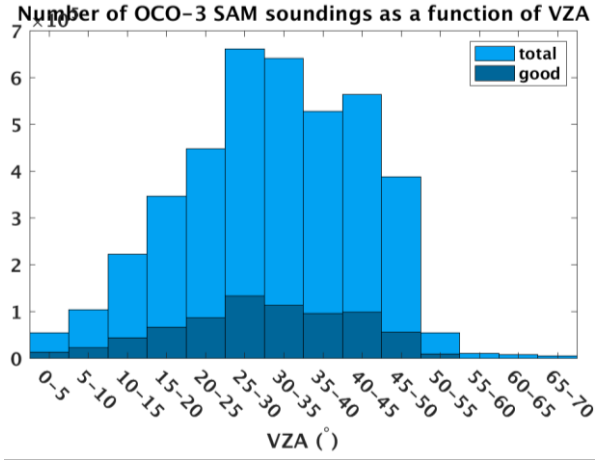
More hints from OCO-3 in snapshot mode (in answer to Arronne's question)

Data from 08.2019-02.2021

Solar Zenith Angle (SZA)



Viewer Zenith Angle (VZA)



airmass