Ground-Based Pandora Observations in Support of Satellite-Derived NO_2 and HCHO

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What is the Pandora?

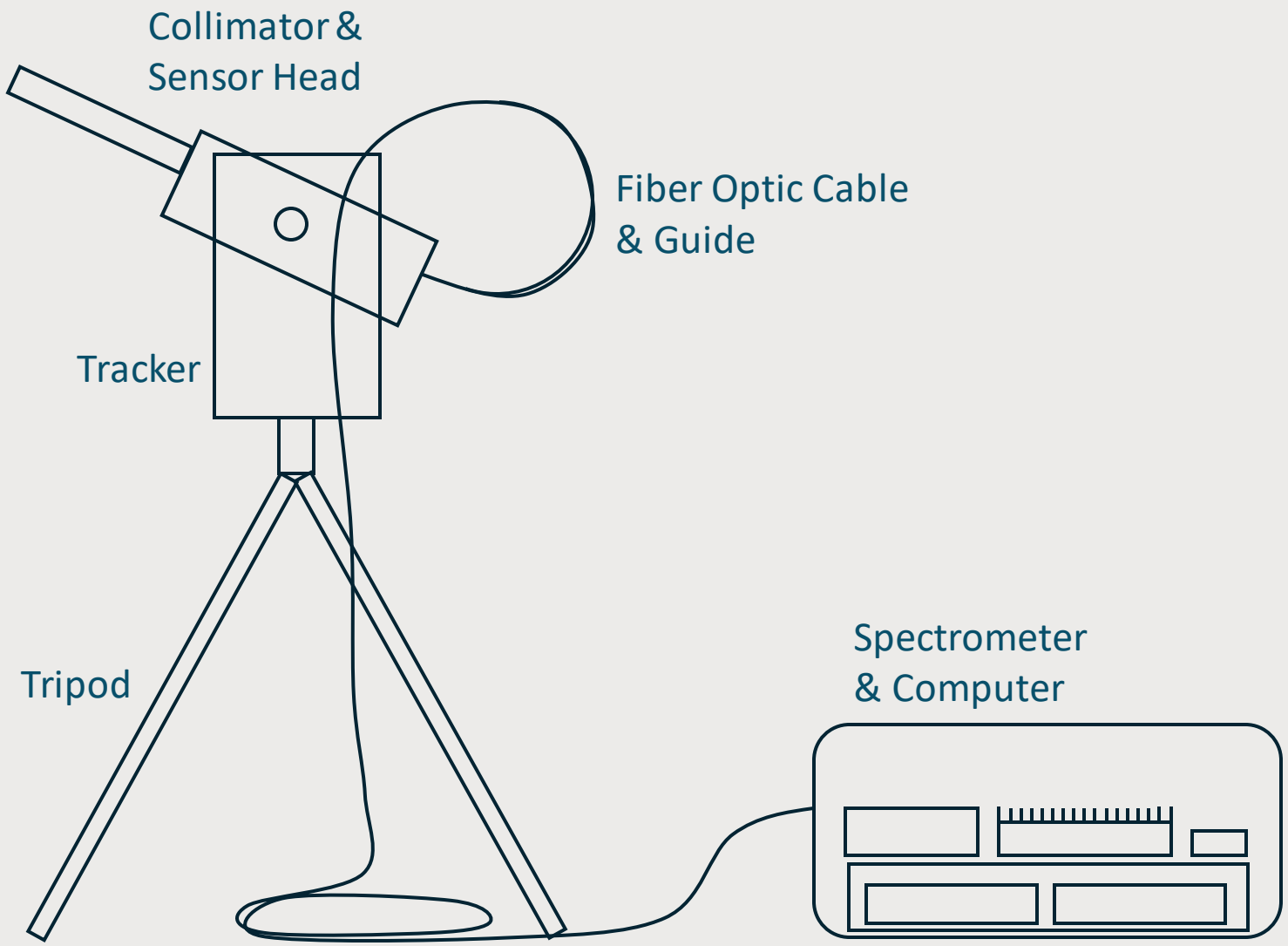
Collects **direct sun** or **diffuse sky** spectra, to retrieve trace gas column densities

Direct Sun:

- Negligible contribution from scattered radiation, equal sensitivity at all altitudes
- Well constrained retrieval that does not depend on prior assumptions

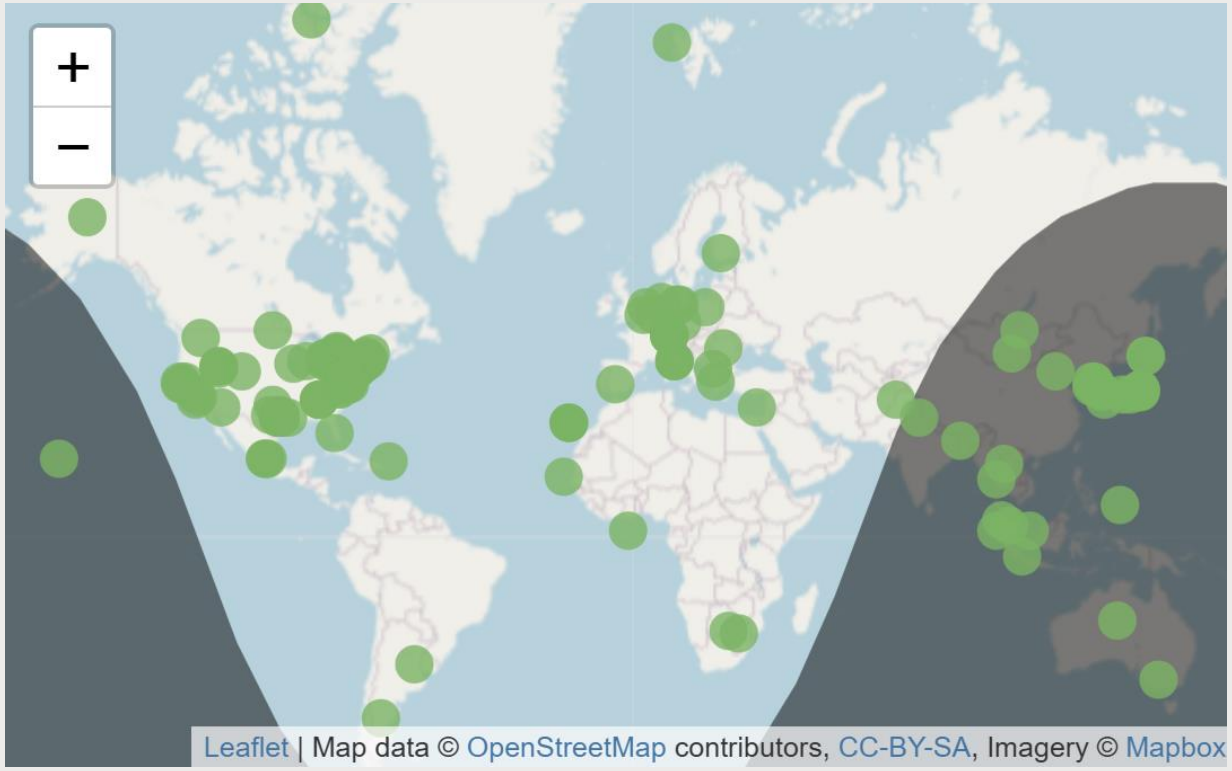
Diffuse Sky:

- Produces vertically resolved partial columns (including near-surface concentrations)
- Reliance on scattered radiation means retrieval requires some assumptions



The Pandonia Global Network (PGN)

https://www.pandonia-global-network.org/



Contact instrument PI for help interpreting files and to confirm data integrity before using data!

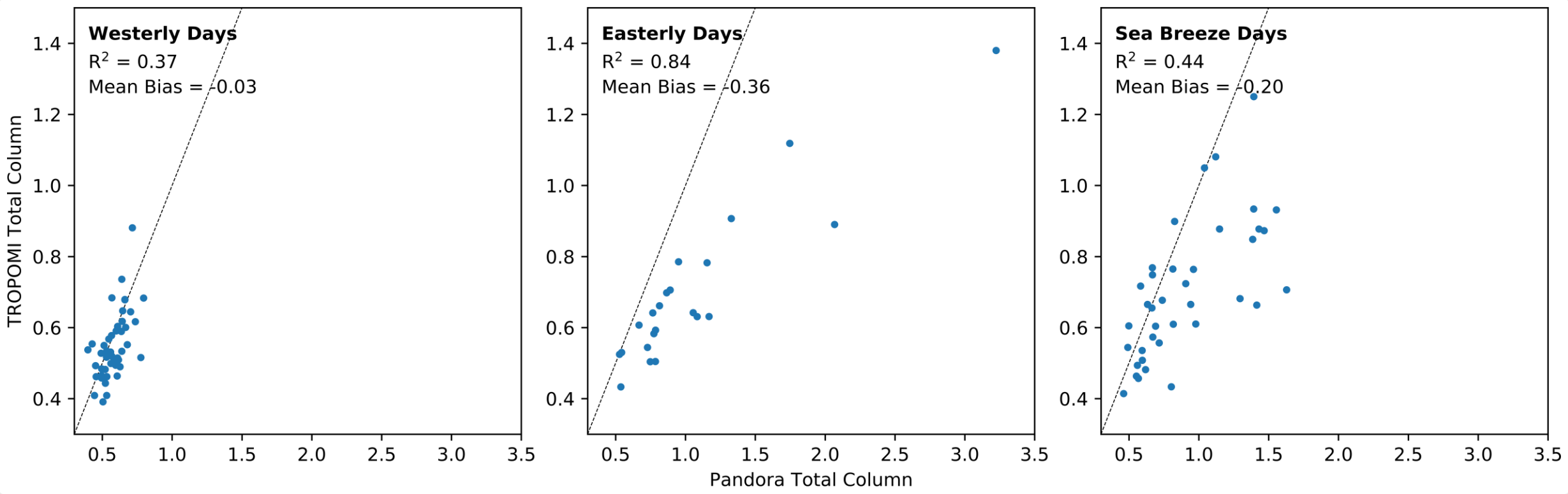
Stations

GreenbeltMD - 2
LabGSFC - 17
LabGSFC - 18
Busan - 20
Bremen - 21
HoustonTX - 25
Harvard - 26
LabGSFC - 27
Fajardo - 29
Innsbruck - 30
GreenbeltMD - 31
GreenbeltMD - 32
MountainViewCA - 34
Dakar - 36
HamptonVA - 37
BayonneNJ - 38
DearbornMI - 39
GreenbeltMD - 40
HoustonTX - 49
OldFieldNY - 51
RichmondCA - 52
Potchefstroom-METSI - 53
Seoul - 54
QueensNY - 55
MaunaLoaHI - 56
LabGSFC - 57
CharlesCityVA - 58
LabGSFC - 59
GreenbeltMD - 60
AldineTX - 61
LaPorteTX - 63
NewHavenCT - 64
Altzomoni - 65
LabSciGlob - 66
Cologne - 67
WrightwoodCA - 68
NewBrunswickNJ - 69
ChapelHillNC - 70
SaltLakeCityUT-Hawthorne - 72
Islamabad-NUST - 73
EdwardsCA - 74
Essex - 75
Dhaka - 76
Singapore-NUS - 77
Banting - 78
BeltsvilleMD - 80
Izana - 101
Downsview - 103
Downsview - 104
Helsinki - 105
Innsbruck - 106
Toronto-West - 108
LabGSFC - 109
LabLuftBlick - 110
Bucharest - 111
Broadmeadows - 112
Undefined - 114
Rome-ISAC - 115
Rome-SAP - 117
Cabauw - 118
Athens-NOA - 119
Innsbruck-FKS - 120
Izana - 121
Downsview - 122
LabGSFC - 123
ComodoroRivadavia - 124
BuenosAiresSMN - 125
LabGSFC - 127
ColumbiaMD - 128
AliceSprings - 129
Lindenberg - 130
Palau - 131
Berlin - 132
BristolPA - 134
ManhattanNY-CCNY - 135
Rome-IIA - 138
SouthJordanUT - 139
WashingtonDC - 140
MexicoCity-UNAM - 142
LibertyTX - 143
Eureka-PEARL - 144
Toronto-Scarborough - 145
Yokosuka - 146
SWDetroitMI - 147
Seoul-SNU - 149
Ulsan - 150
NyAlesund - 152
BostonMA - 153
SaltLakeCityUT - 154
GreenbeltMD - 155
HamptonVA-HU - 156
MexicoCity-Vallejo - 157
AtlantaGA - 158
Wakkerstroom - 159
Brussels-Uccle - 162
Tsukuba-NIES-West - 163
Seosan - 164
Durham - 165
PhiladelphiaPA - 166
GreenbeltMD - 167
Egbert - 169
StGeorge - 170
Beijing-RADI - 171
AtlantaGA - 173
FairbanksAK - 174
Tsukuba-NIES - 176
WestportCT - 177
LabGSFC - 178
CornwallCT - 179
ColumbiaMD - 180
SanJoseCA - 181
Tel-Aviv - 182
LondonderryNH - 183
CapeElizabethME - 184
EastProvidenceRI - 185
MadisonCT - 186
PittsburghPA - 187
LapwaiID - 188
Incheon-ESC - 189
Bangkok - 190
Tokyo-Sophia - 192
Tsukuba - 193
Tokyo-TMU - 194
Sapporo - 195
Sapporo - 196
Nagoya - 197
Kobe - 198
Fukuoka - 199
GrandForksND - 200
BoulderCO-NCAR - 204
LabGSFC - 205
BuffaloNY - 206
ArlingtonTX - 207

Pandora Observations in Support of Satellite Retrieval Interpretation

1. **Satellite Data Evaluation:** Simplicity of Pandora's direct sun retrieval make it a valuable "reference" measurement to compare with satellite data

E.g., Comparisons of TROPOMI NO_2 with Pandora NO_2 over Boston University



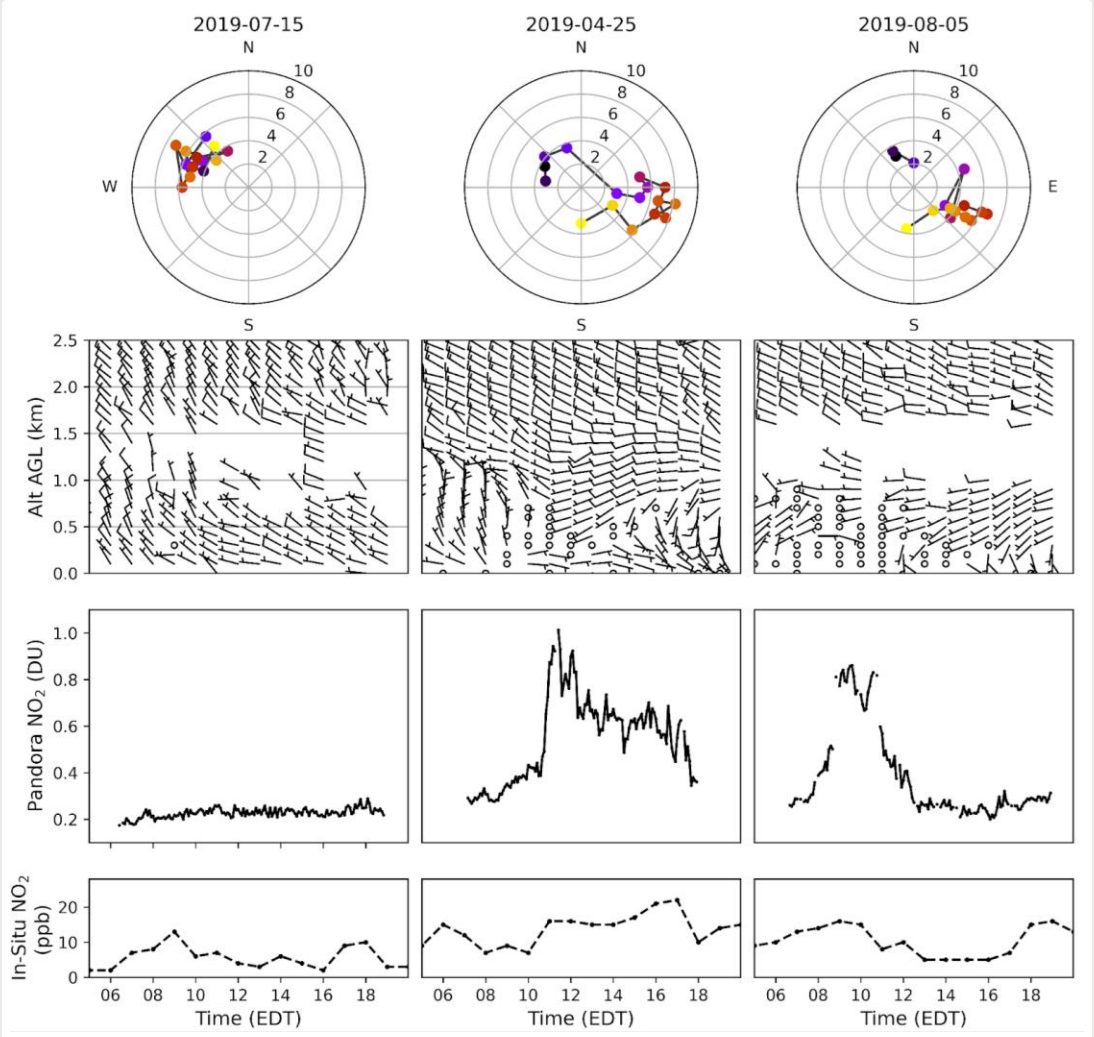
Adams et al. 2023 (JGR)

Pandora Observations in Support of Satellite Retrieval Interpretation

2. **Local Column-to-Surface Relationships:** Derive well-constrained local insight into how satellite measurements may relate to surface concentrations

E.g., Diurnal evolution of column NO_2 compared to surface NO_2 concentrations at Boston University

Asynchronous behavior during specific conditions due to dominance of different forcings on each measurement (horizontal advection vs. vertical entrainment)



Surface Winds

Horizontal Winds

Pandora NO_2

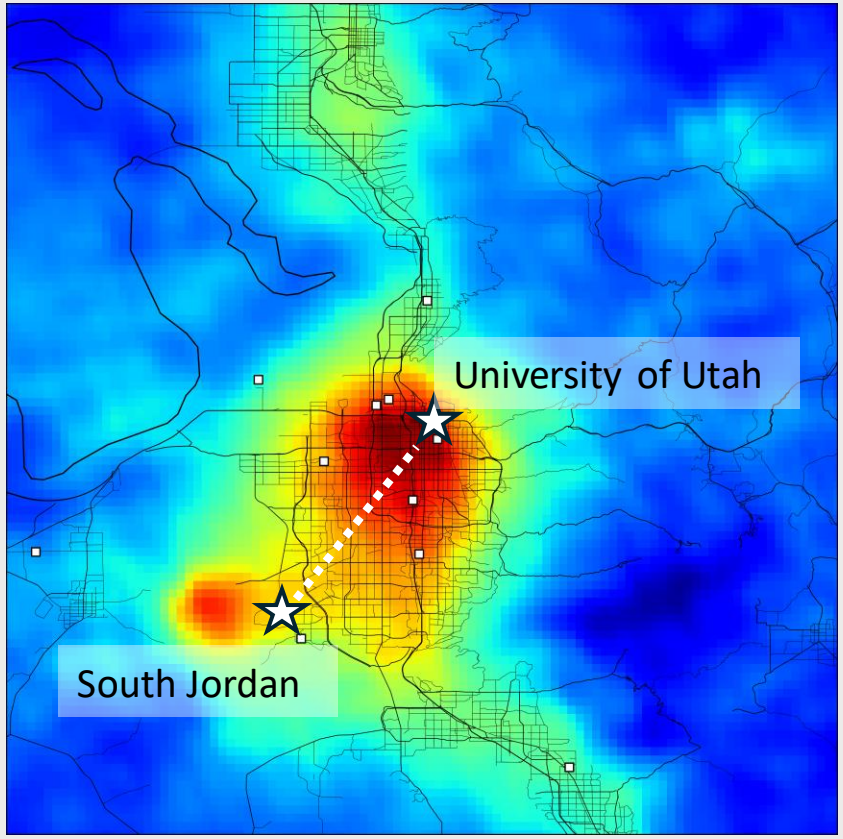
Surface Mixing Ratio

Adams et al. 2023 (JGR)

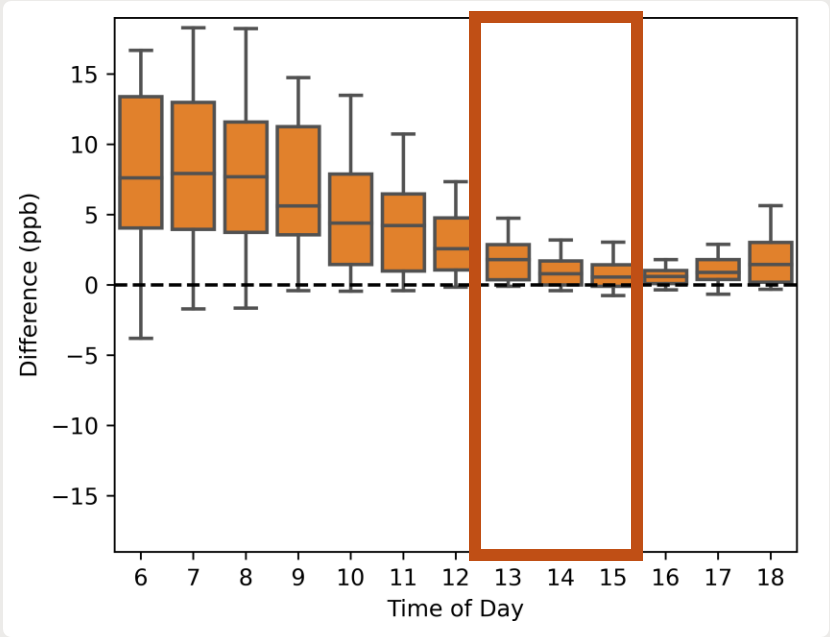
Pandora Observations in Support of Satellite Retrieval Interpretation

2. **Local Column-to-Surface Relationships:** Derive well-constrained local insight into how satellite measurements may relate to surface concentrations

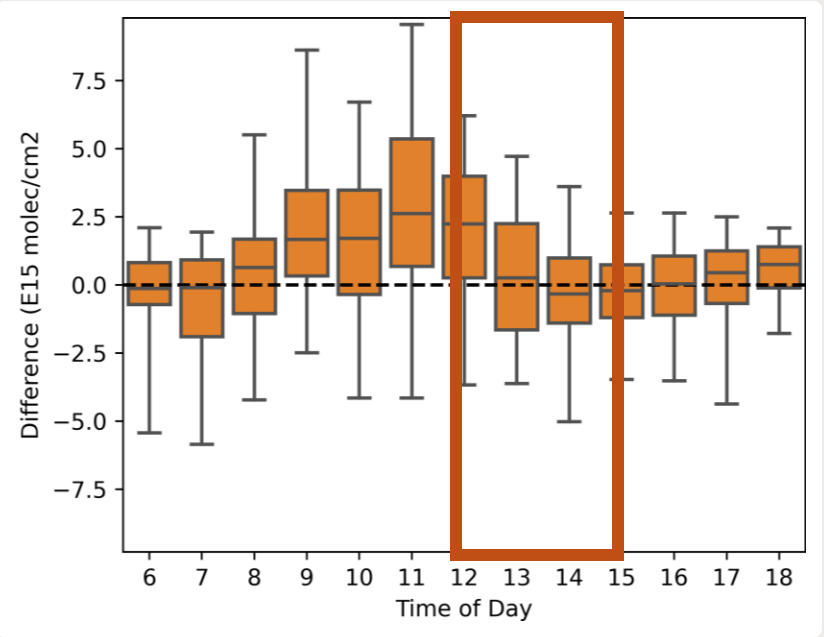
E.g., Confirming (or refuting) spatial gradients observed in the column vs. at the surface across Salt Lake City



Surface Concentration Gradient



Tropospheric Column Gradient

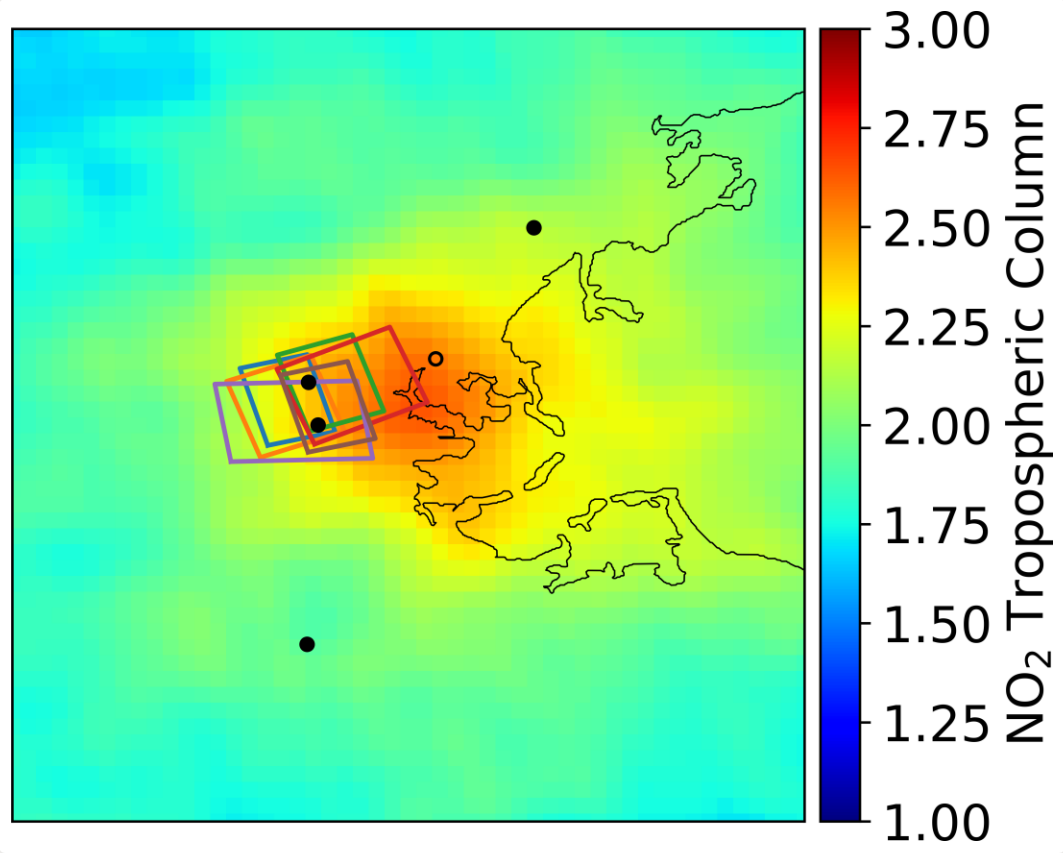


Geddes et al. (in prep)

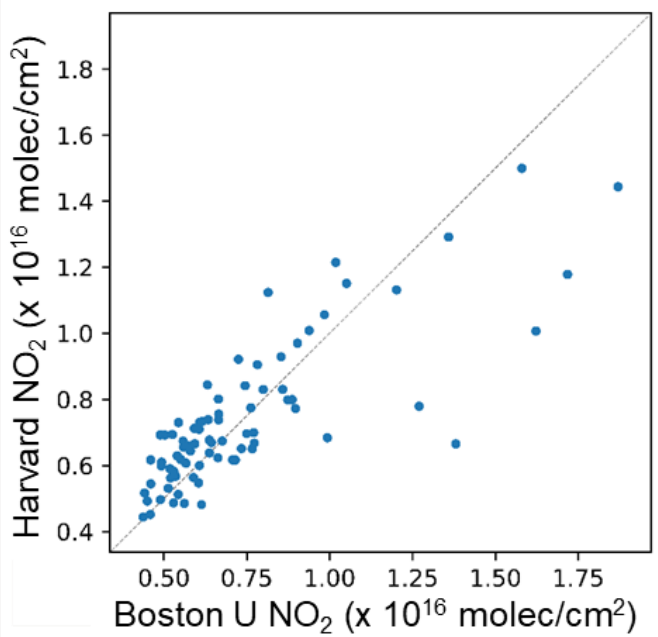
Pandora Observations in Support of Satellite Retrieval Interpretation

3. **Intra-Pixel Variability:** Directly measure how trace gas columns may vary within the spatial footprint of a satellite pixel

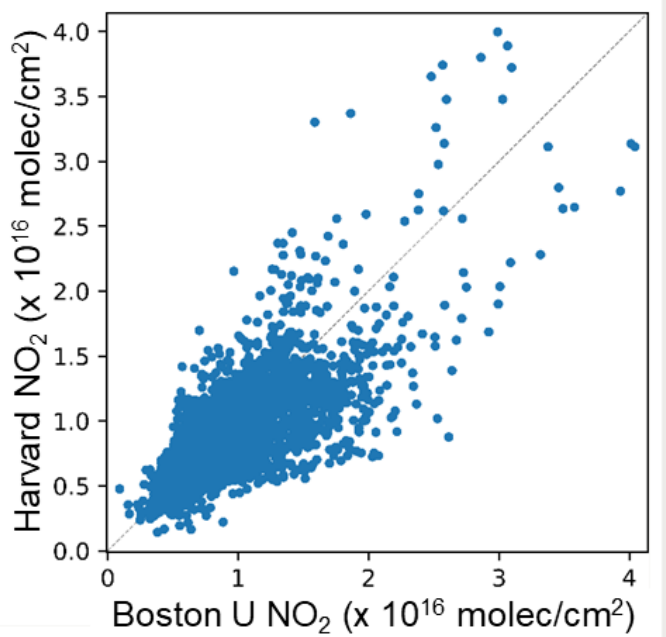
E.g., Boston University vs. Harvard University Pandoras (within same TROPOMI pixel ~50% of the time)



at overpass time



at all times



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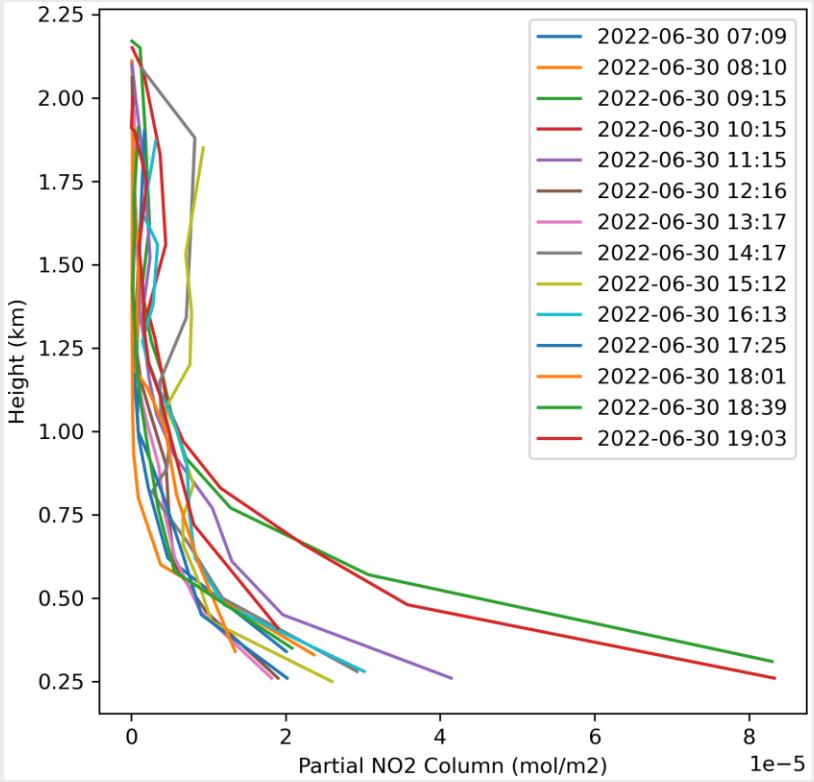
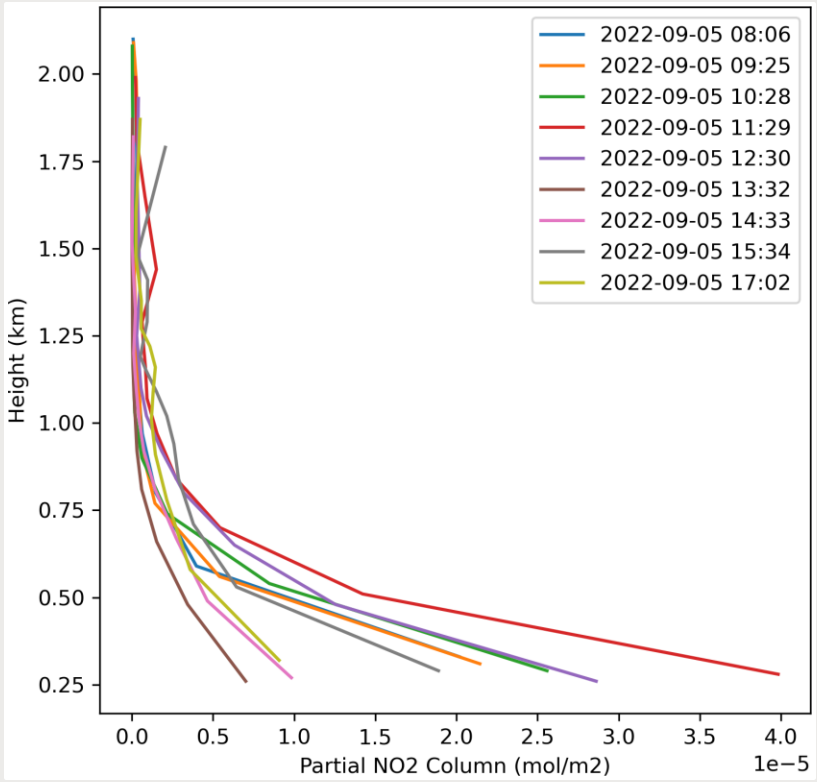
4. **Vertical Profile Information†:** Examine local variability in vertical distribution of trace gases throughout the day

E.g., Vertical profiles (retrieved up to about 2 km in altitude) in Salt Lake City

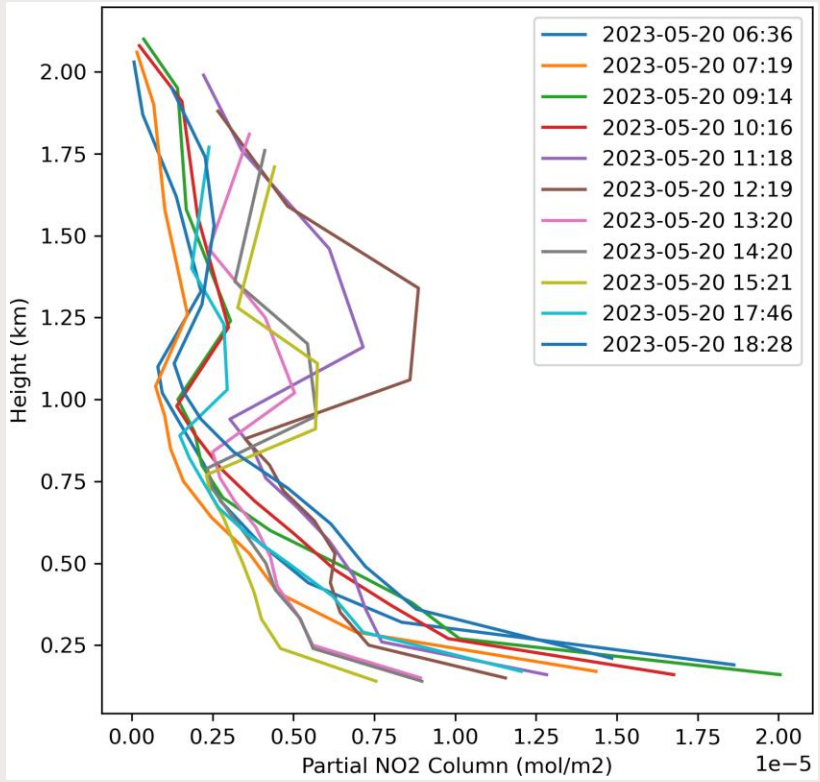
6/30/2022



9/5/2022



5/20/2023



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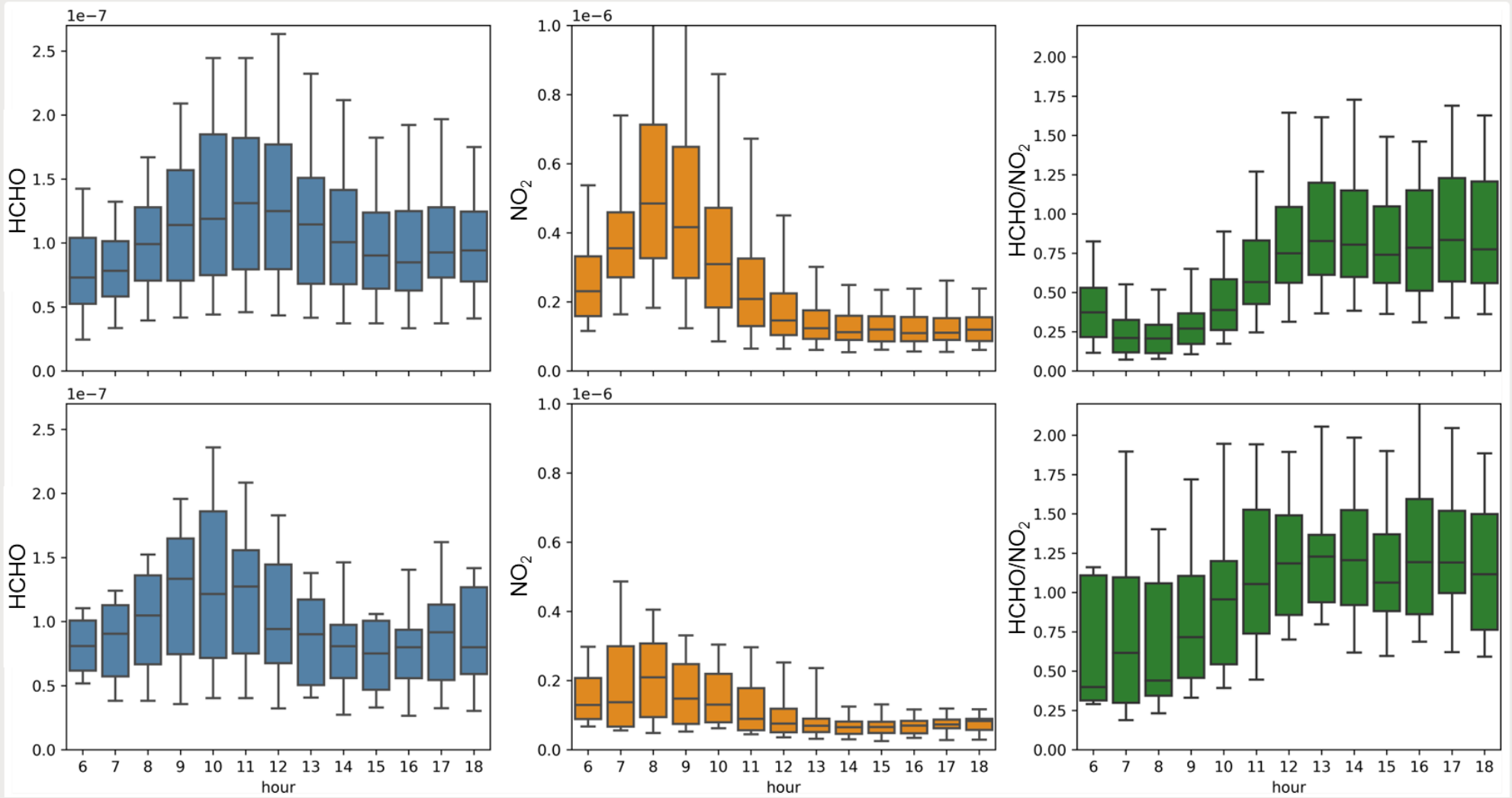
5. **Multi-Constituent Retrievals:** Examine colocated relationships between multiple pollutants (e.g., NO_2, HCHO, SO_2)

Summertime **Weekdays**

Summertime **Sundays**



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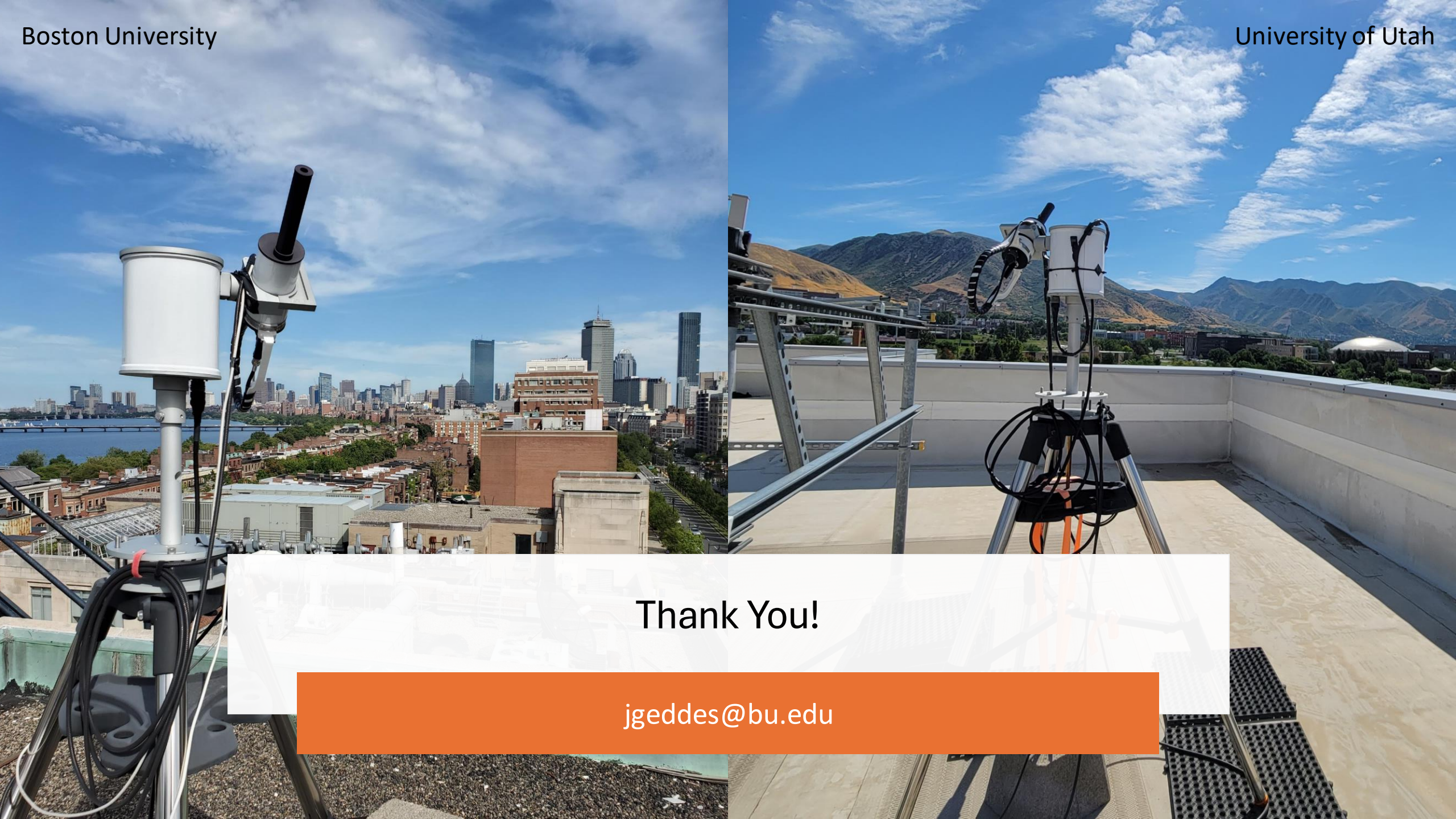
Challenges / Caveats

- Understanding the retrieval files can be a challenge, and requires some familiarity with measurement codes, local operations, and some knowledge of theoretical basis
- Network is made up of individual investigators who may operate instruments on intermittent schedules given research priorities, instrument performance, and funding
- Partnerships between local operators and investigators should be encouraged to understand conditions that may be important to data analysis

Data Usage Guidelines

The PI and local operators have invested considerable effort in the production of the data and they are entitled to be informed of any use of data produced by that site. We suggest consulting with the PI(s) of the instruments about the data to be used, if there are specific questions or apparent issues with the data. While we make an effort to ensure uniformly high data quality, each PGN instrument has a unique location that can affect the representativeness of the data. The PI may have information about the local environment of an instrument that is important in your analysis.



Thank You!

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