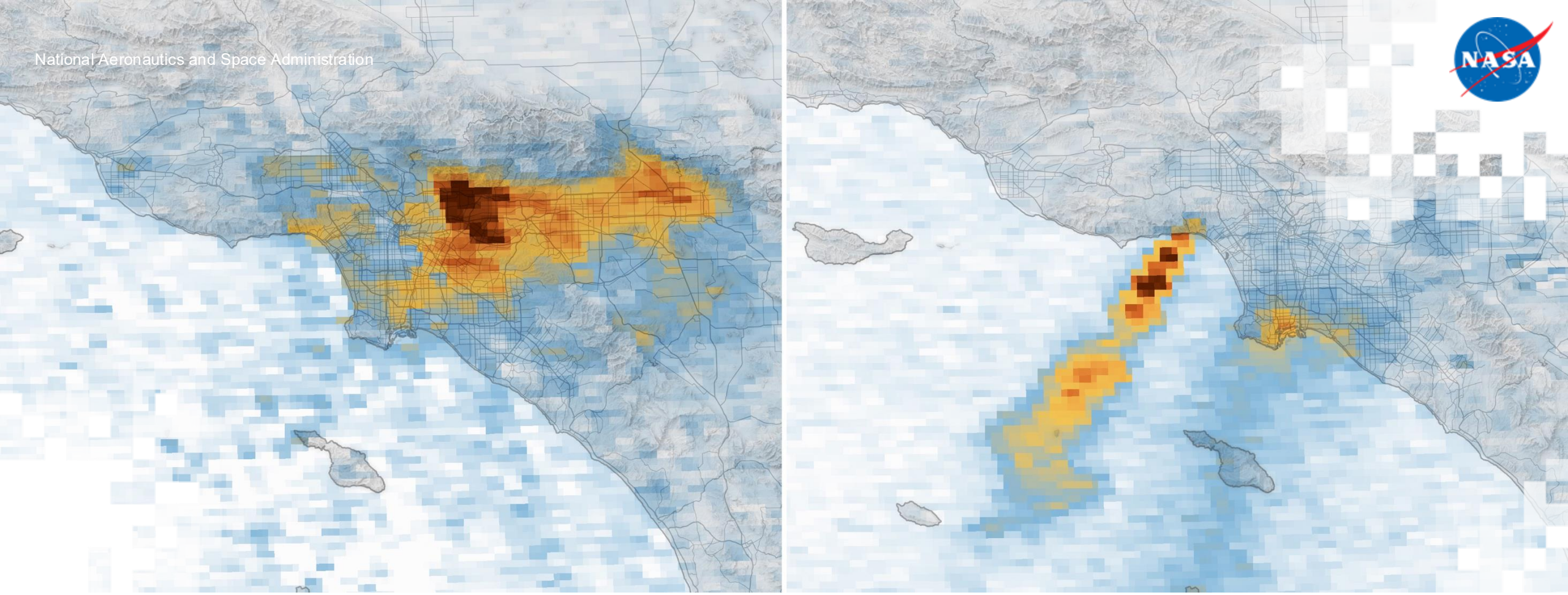
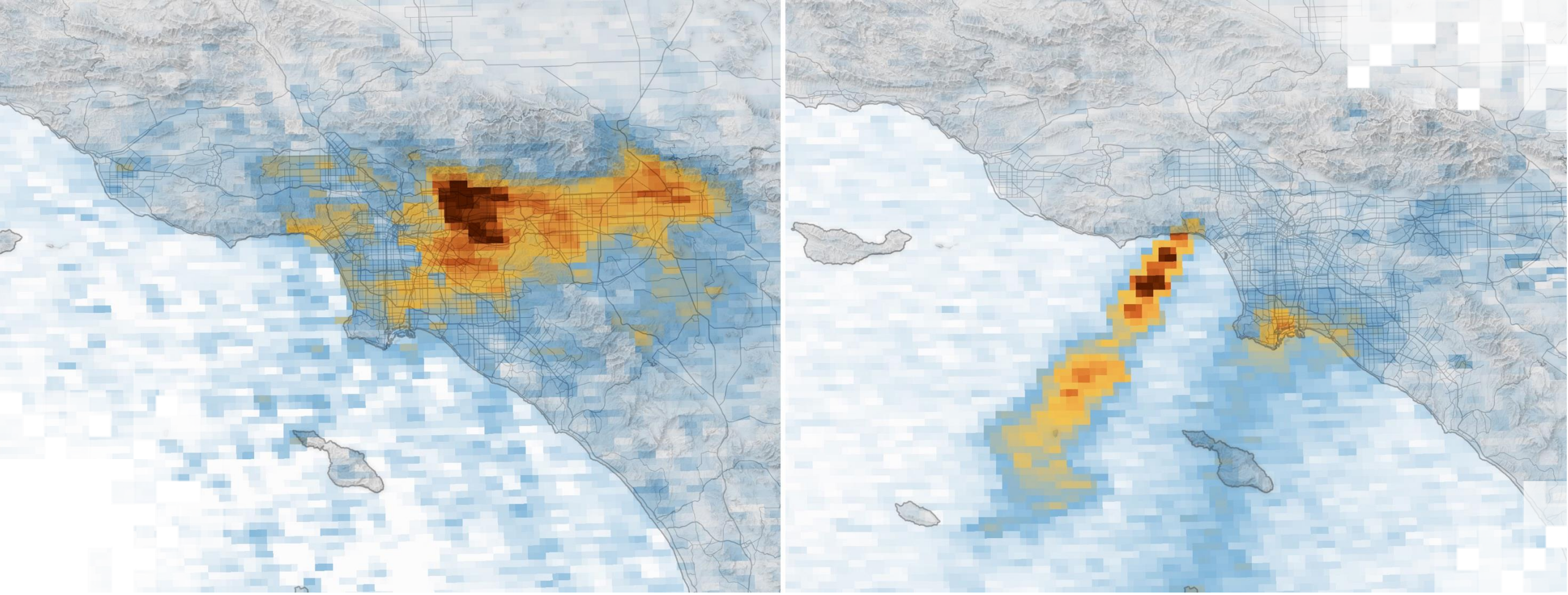


Introduction to Geostationary Observations for Air Quality Applications in the Western US

Day 2, Part 5: Use Case: Surface Air Quality Estimation

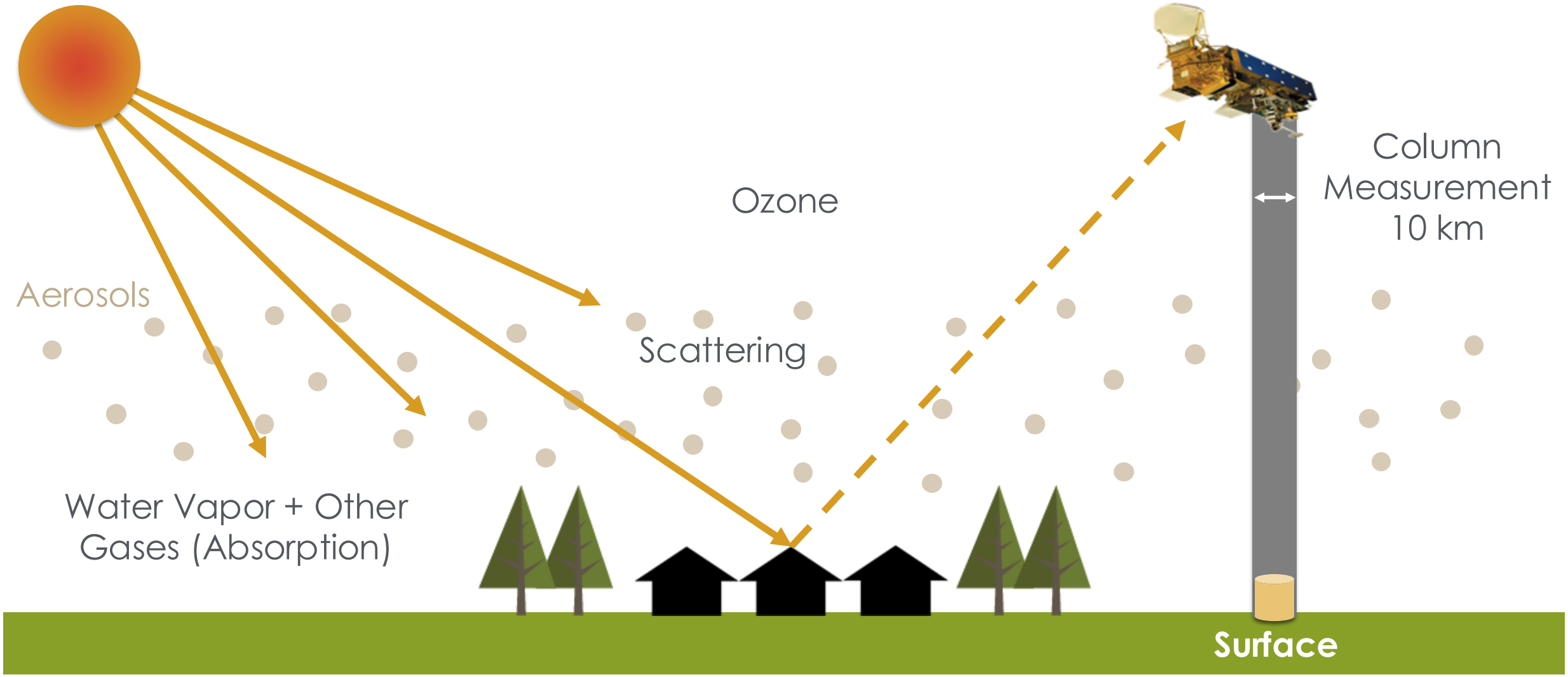
Carl Malings (ARSET)

August 5, 2025



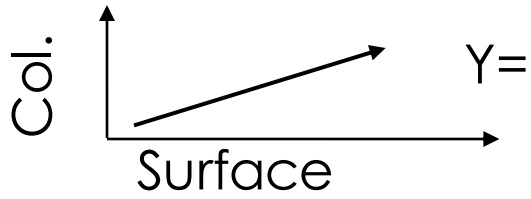
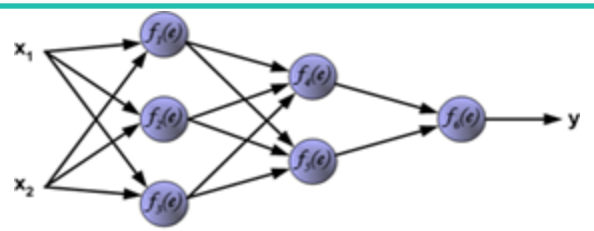
Day 2, Part 5:
Use Case: Surface Air Quality Estimation

Estimating Surface-Level Concentrations with Satellite Data

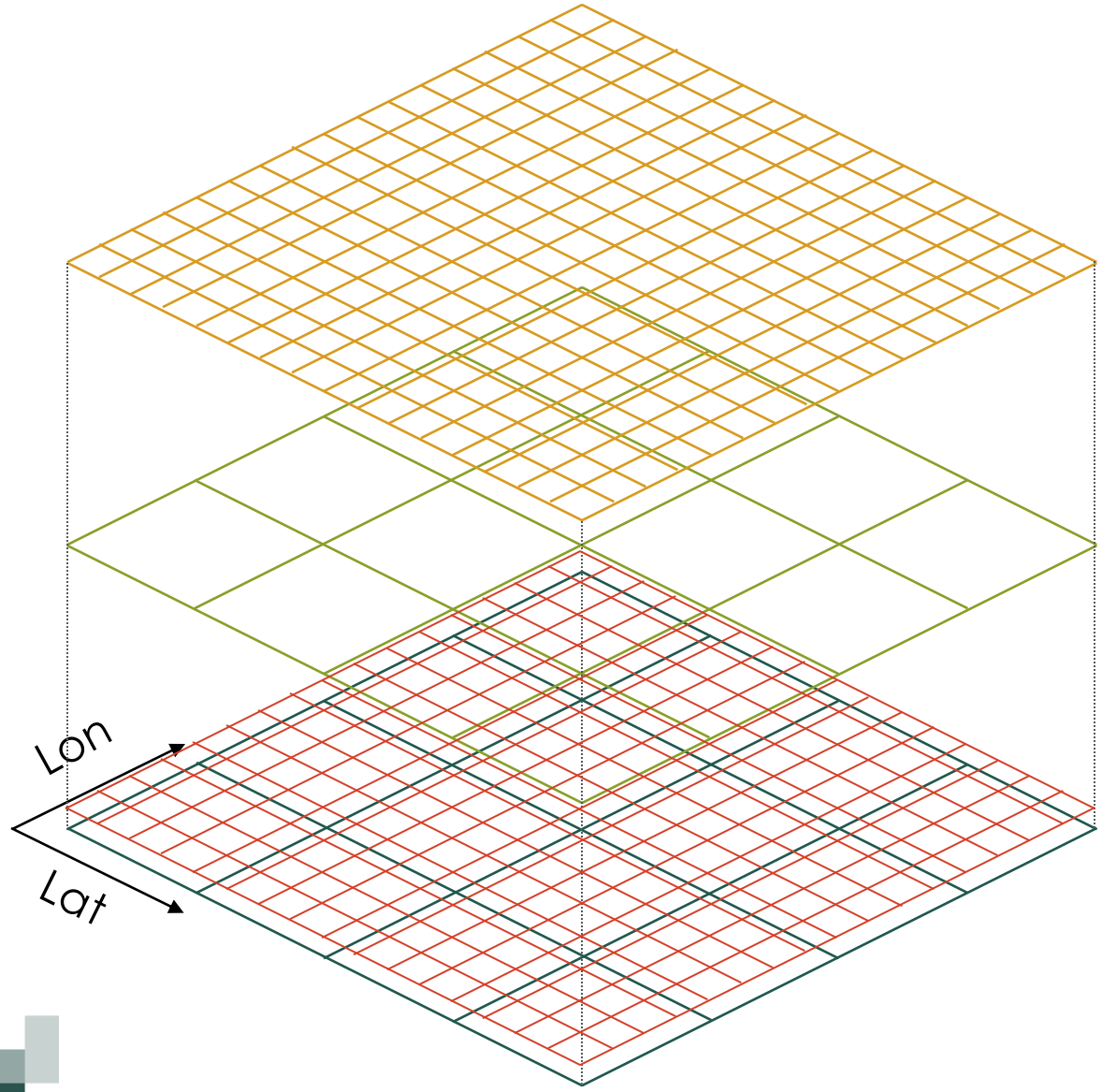


How can we relate satellite columns to surface concentration?

Require In-Situ Data for Calibration

Linear Regression	
Multi-Variable Regression	$\text{Surface} = \beta_0 + a \times \tau + \sum_{n=1}^{m} (\beta_n \times M_n)$
Artificial Intelligence	
Modeled Ratios	$\text{Surface} = \frac{\text{Model Surface Concentration}}{\text{Model Column Concentration}} \times \text{Satellite Column}$

Modeled Ratios for Translating Column to Surface Concentration



C_{sat} Satellite Column Concentration

C_{mod} Model Column Concentration

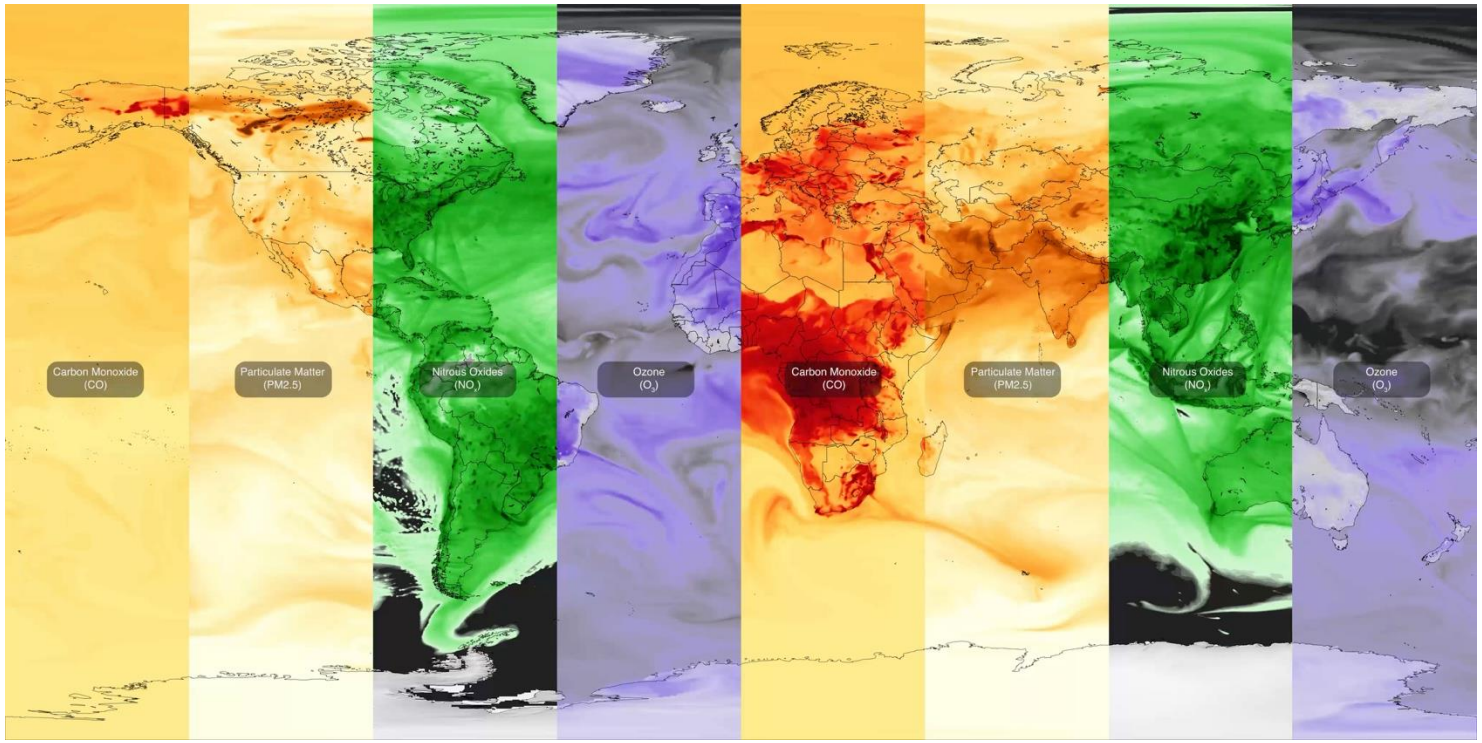
S_{sat} Satellite-Estimated Surface Concentration

S_{mod} Model Surface Concentration

$$S_{sat} \approx \left(\frac{S_{mod}}{C_{mod}}\right) \times C_{sat}$$

Goddard Earth Observing System – Composition Forecast (GEOS-CF)

- Combine GEOS meteorology with GEOS-Chem chemistry
- Aerosols + 250 chemical species
- Hourly temporal resolution
- 0.25 degree (25 km) spatial resolution
- Global coverage
- Daily 1-day replay and 5-day forecast
- **Used as prior in TEMPO retrievals**
- Publicly Accessible Output



Sources: Keller, C., et al. (2021) "Description of the NASA GEOS Composition Forecast Modeling System GEOS-CF v1.0". *Journal of Advances in Modeling Earth Systems*, 13:4. https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020MS002413
NASA Scientific Visualization Studio https://svs.gsfc.nasa.gov/5518/

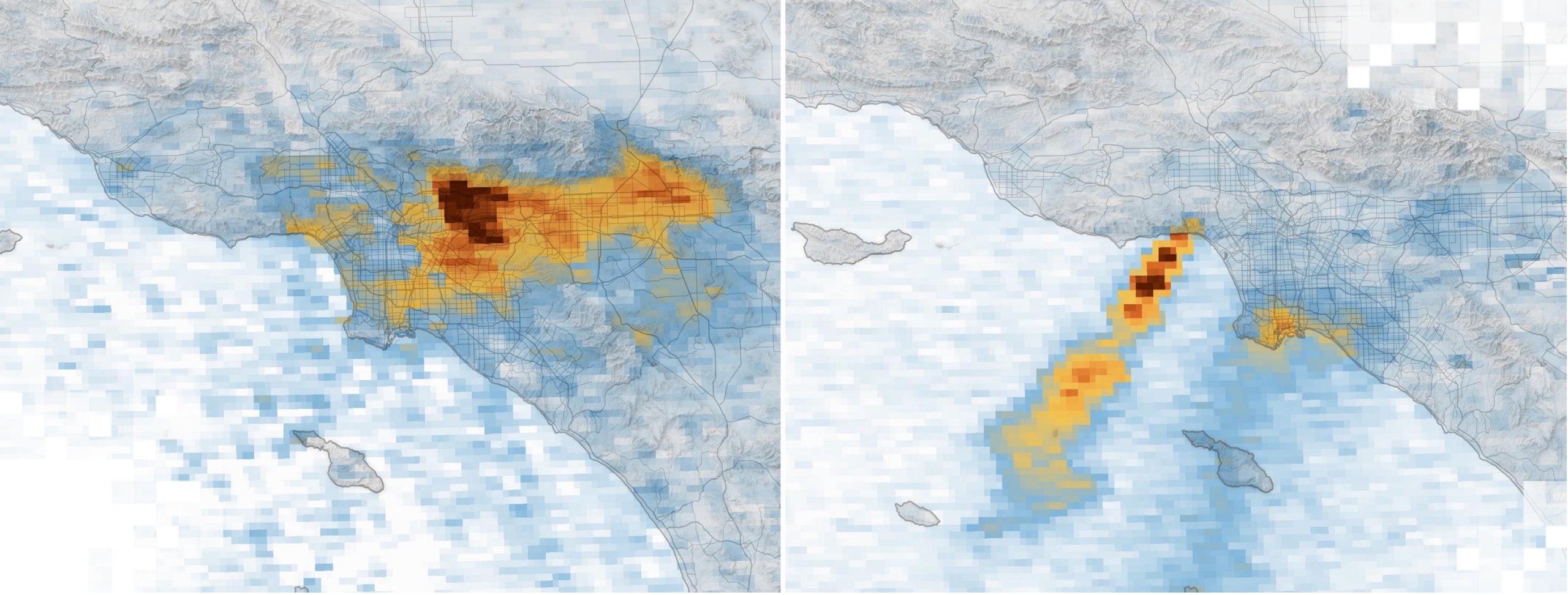
Key Questions & Caveats

- Is the surface-to-column relationship always linear?
- Do we have enough in-situ measurements to establish an empirical relationship?
- Does this relationship change in space and time?
- Does this relationship change with other factors?
- How does meteorology drive this relationship?
- How does the vertical distribution of pollutants in the atmosphere impact these estimates?
- How does the varying sensitivity of the satellite's retrieval compare with the model's simulation?
- How does column retrieval uncertainty impact estimation of air quality?

Exercise

- Reproduce a spatial map of estimated surface-level NO_2 concentrations using data from TEMPO and GEOS-CF
  - Download Level 3 TEMPO Tropospheric Column NO_2 data for the region of interest
  - Download GEOS-CF Model data for the same region and time
  - Compute surface-to-colmn-NO_2-concentration ratios from GEOS-CF
  - Multiply by the TEMPO NO_2 column to estimate surface-level NO_2
  - Plot the resulting estimate on a map

- Compare the estimated surface concentrations with in-situ NO_2 monitor data
  - Download AirNow NO_2 monitor data for the same region and time (using pyrsig)
  - Extract the TEMPO-derived NO_2 estimates at the same times and locations as the monitors
  - Create time-series plots comparing these data



Exercise Time

Summary and Key Takeaways

- TEMPO can help map spatial & temporal pollutant patterns over a wider area than in-situ monitors.
- There are some existing products for estimating surface-level concentrations from TEMPO datasets (e.g., NOAA TEMPO-ABI $PM_{2.5}$ product).
- In other cases, they are under development, or you may need to make your own.
- The method showcased here is crude, but broadly applicable.
- Extensive verification & validation with in-situ data is needed to support the use of such products.


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!