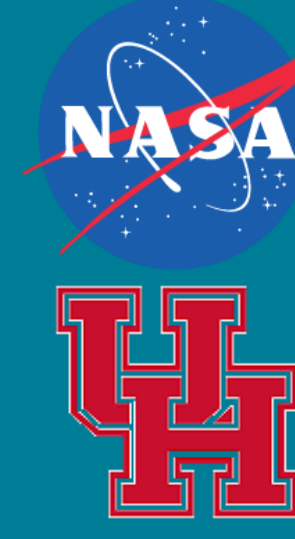


TEMPO & CLASP: CLustering of Atmospheric Satellite Products

Observing the Spatiotemporal Variability of NO₂ in Houston, TX (USA)



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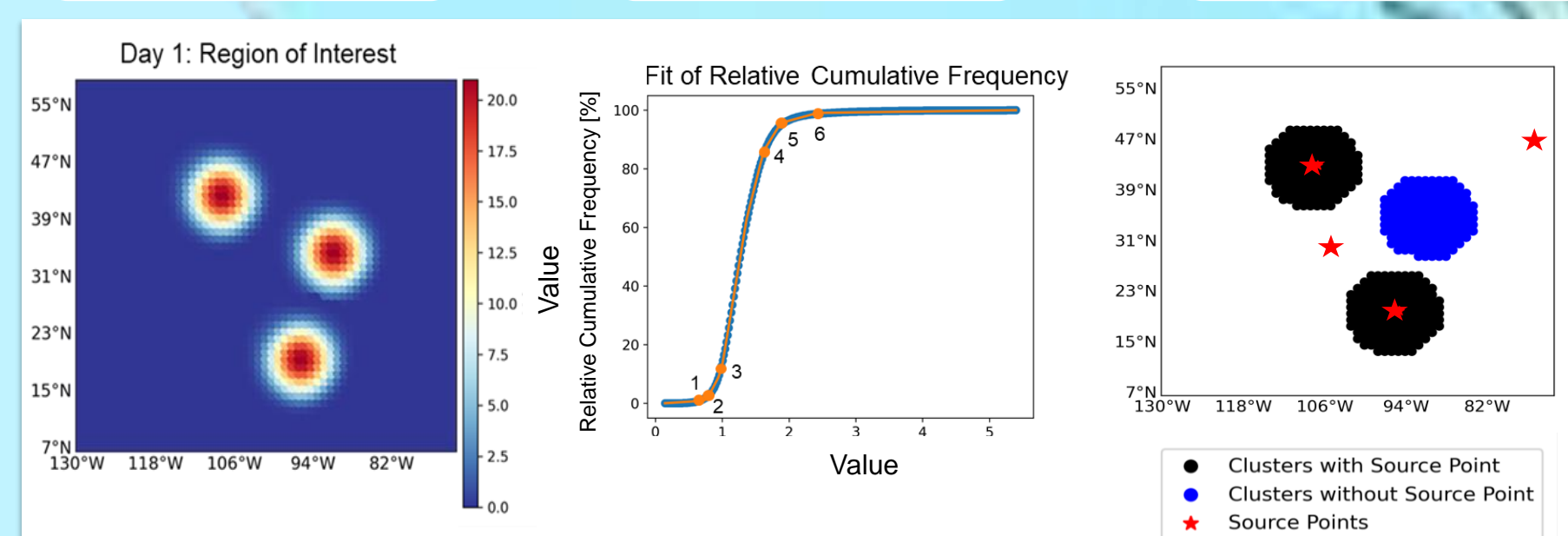
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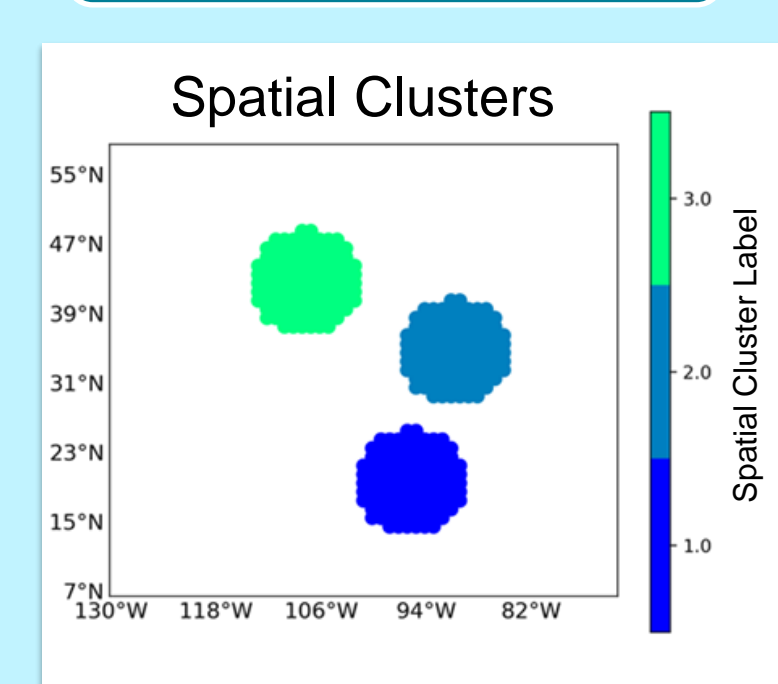
Motivating Questions

- Can features be identified with no prior knowledge of any domain or time frame?
- Can fine feature variability be preserved?
- Can temporally frequent or infrequent emission sources be reproducibly identified?
- What can we see with TEMPO that we've not seen before?

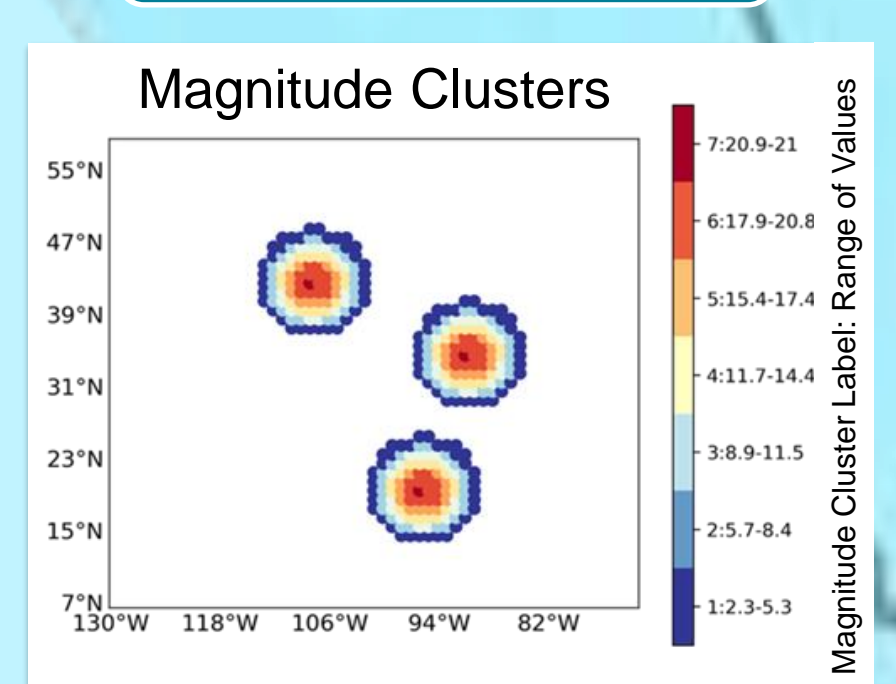
CLASP: Algorithm Structure



3. Spatial Variability Identification

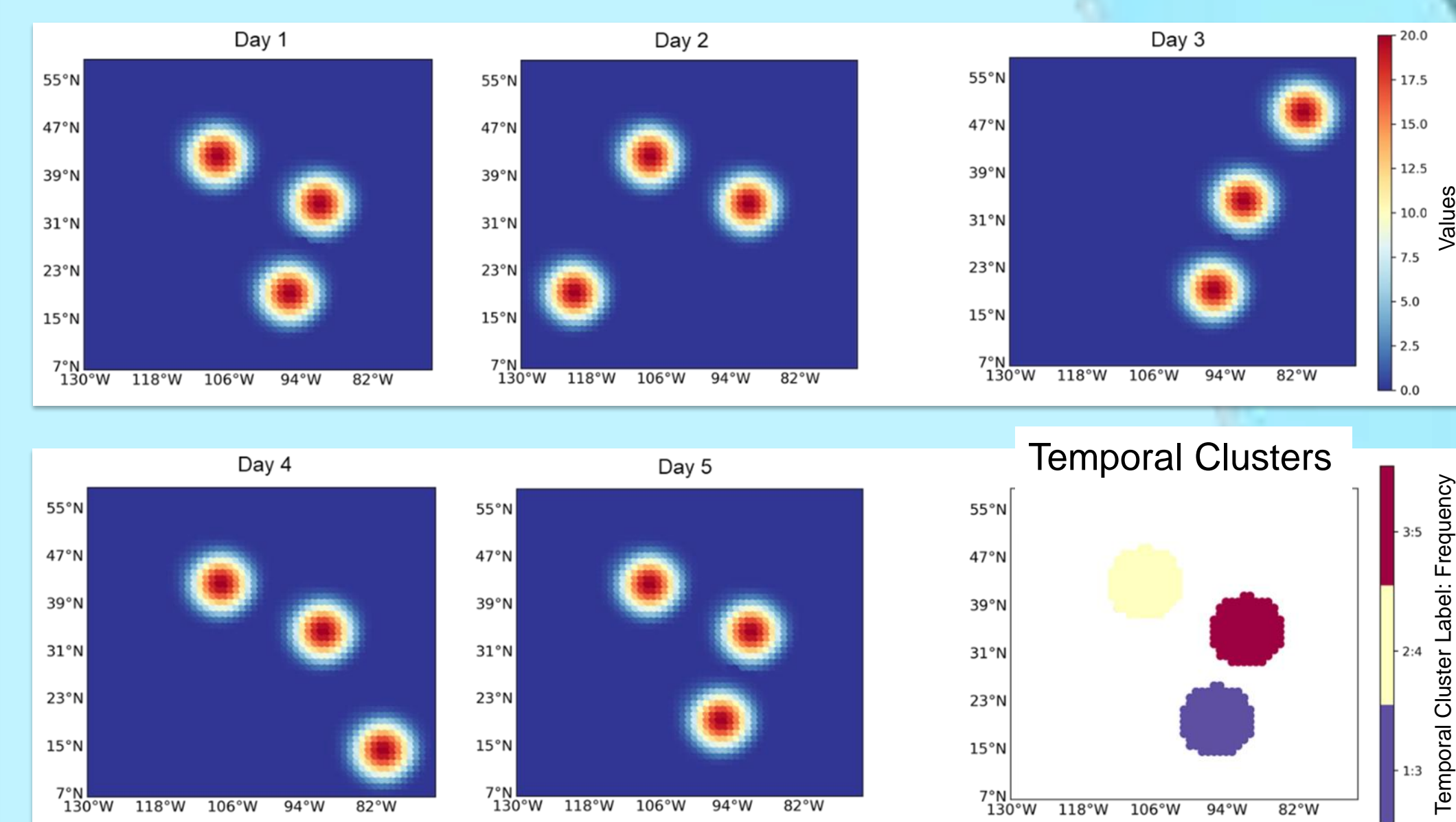


4. Feature Magnitude Classification



5. Frequency Identification

End CLASP



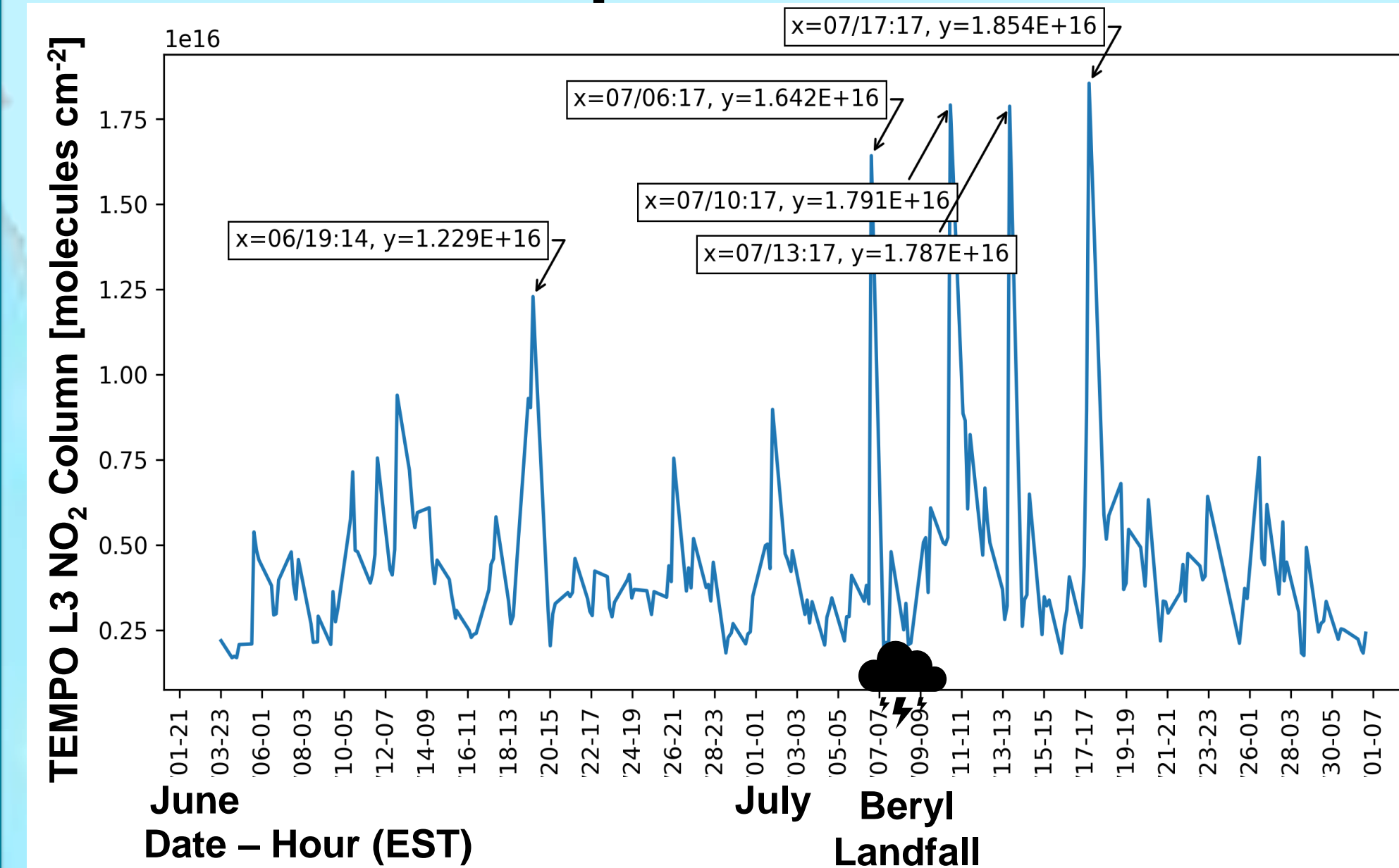
CLASP outputs a data set that carries the set of observations and spatial, magnitude, and temporal cluster label descriptions for each identified feature to help understand features within a region

CLASP can be employed for data sets of other trace gases (i.e., methane, sulfur dioxide, ozone, etc.), other satellite observations (GEMS, TROPOMI, OMI, etc.), and different identification scenarios

Implications

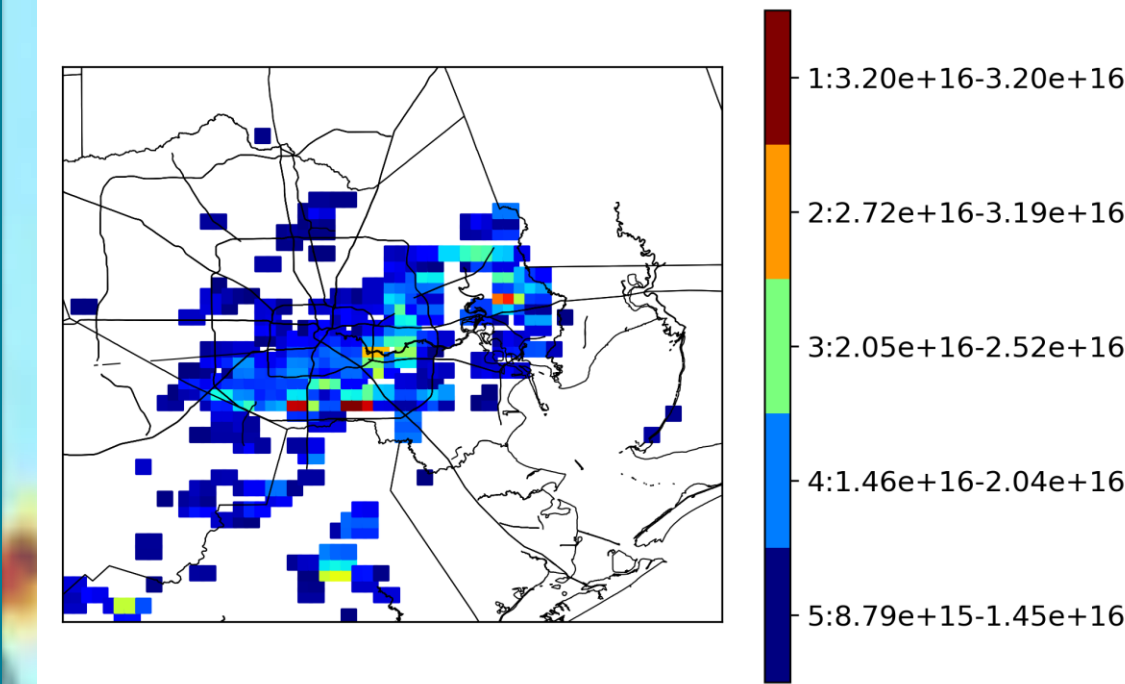
- CLASP (CLustering of Atmospheric Satellite Products) can identify irregular signals in satellite products and describe them on a (1) Spatial, (2) Magnitude, and (3) Temporal axis
- With the use of CLASP, the spatial and temporal information on identified features can be used in studies to better understand processes, identify disparities, and allow for quantification using top-down methods to take place
- With TEMPO and CLASP overlooked locations and time periods can have their air quality assessed

CLASP Magnitude Clusters Identified Recovery Spikes After Hurricane Beryl



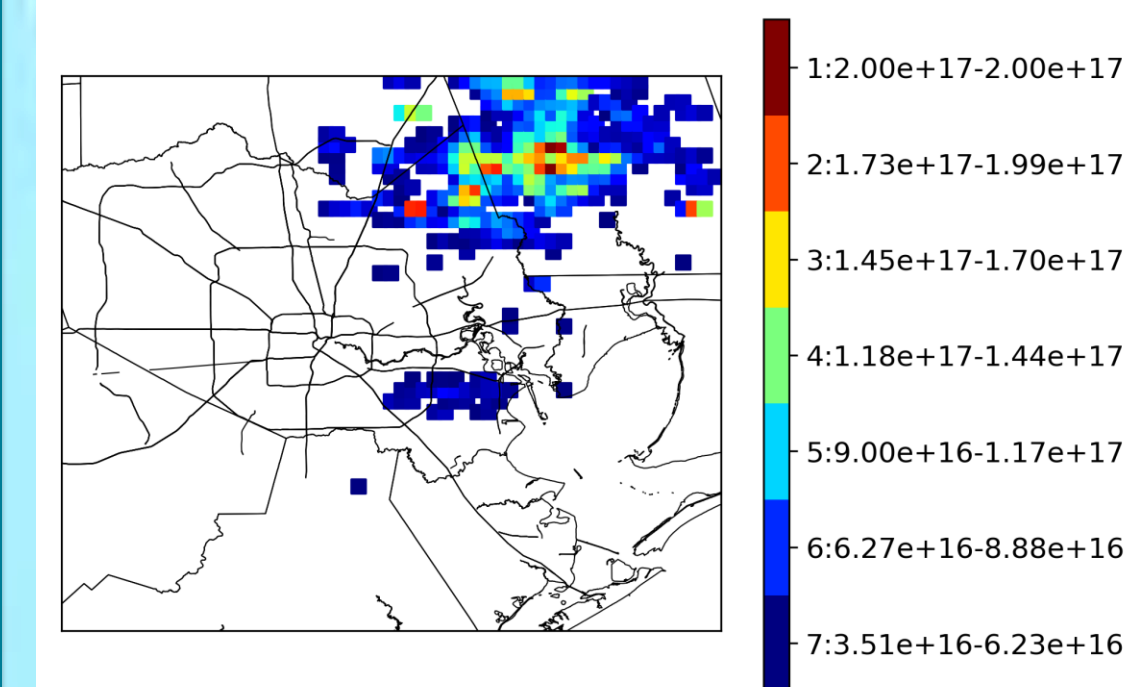
With no prior knowledge, CLASP magnitude clusters identified anomalous NO₂ concentrations in the recovery period Post-Hurricane Beryl

TEMPO-CLASP Magnitude Cluster: July 10th 6:00pm (CST)



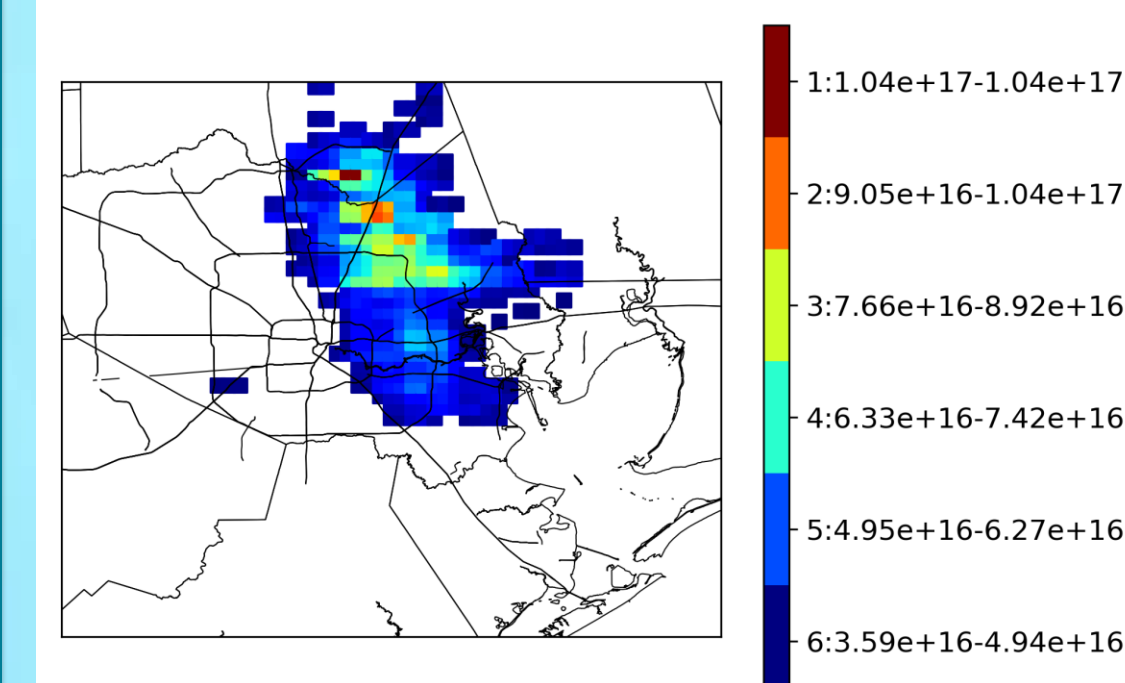
Hurricane Beryl made landfall July 8th, 2024, in the Houston, TX (USA) region

TEMPO-CLASP Magnitude Cluster: July 13th 6:00pm (CST)



CLASP magnitude clusters derived from 3-hourly averaged L3 TEMPO NO₂ identified anomalous NO₂ spikes in the Recovery- and Post-Beryl period on July 10th, 13th, and 17th, 2024

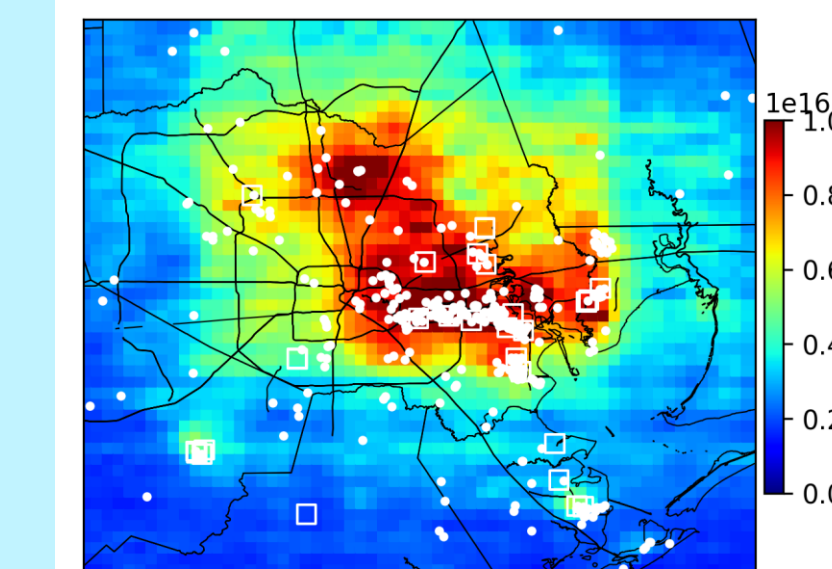
TEMPO-CLASP Magnitude Cluster: July 17th 6:00pm (CST)



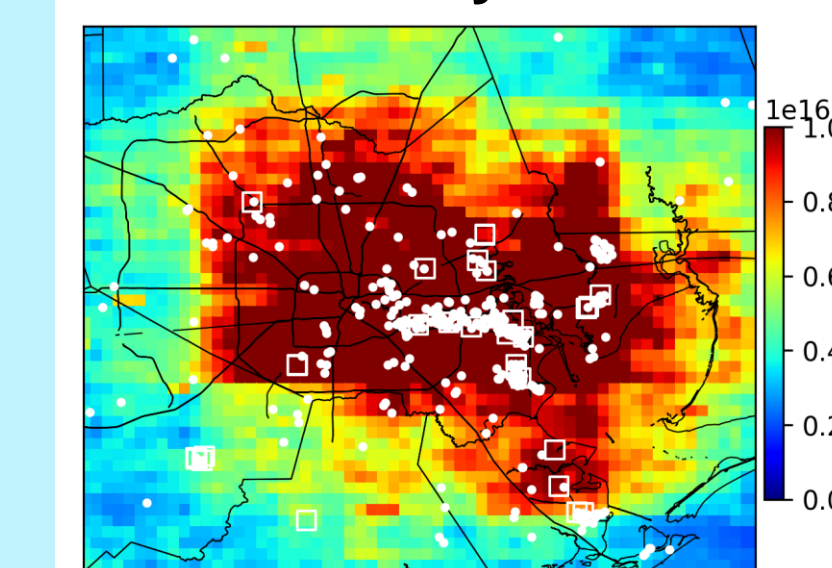
Each color represents a different cluster corresponding to the magnitude of the plume identified by CLASP, as indicated in the color bar where the cluster number is shown with the range of magnitude observed by L3 TEMPO NO₂

The Recovery-Beryl period sees increased NO₂ concentrations compared to that of Pre- and Post-Beryl on an hourly basis

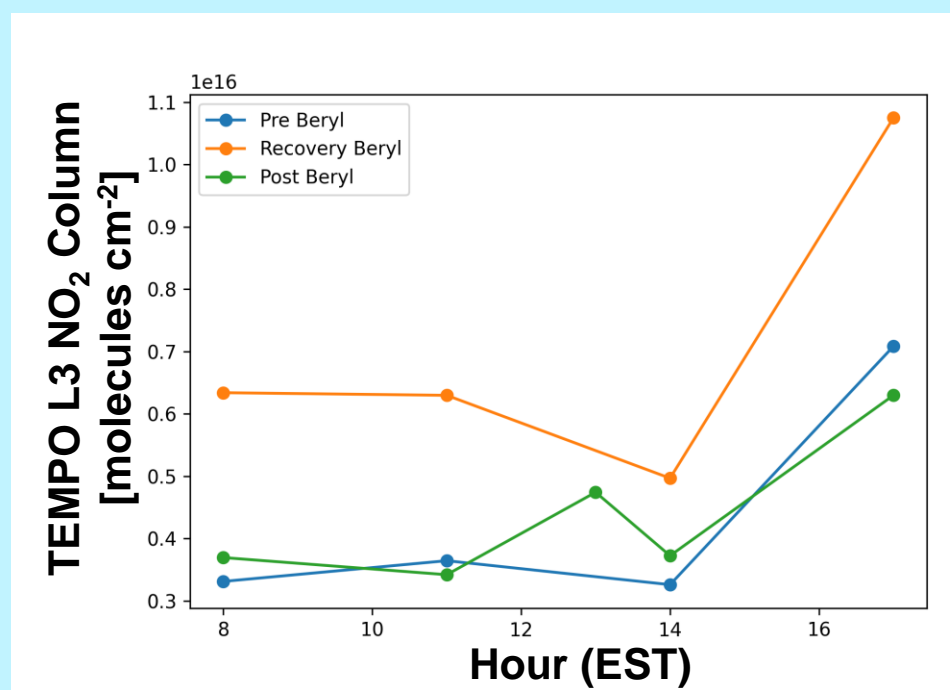
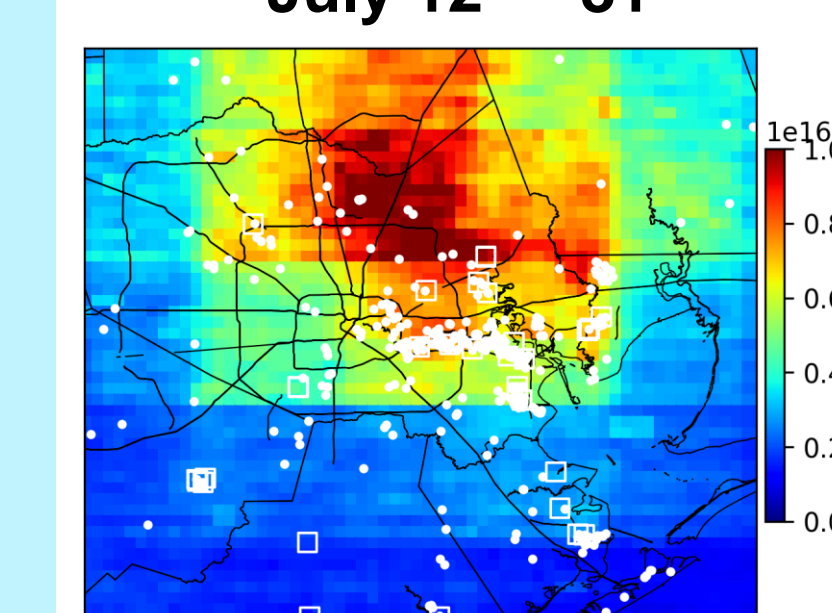
TEMPO Pre-Beryl Mean: July 1st - 7th



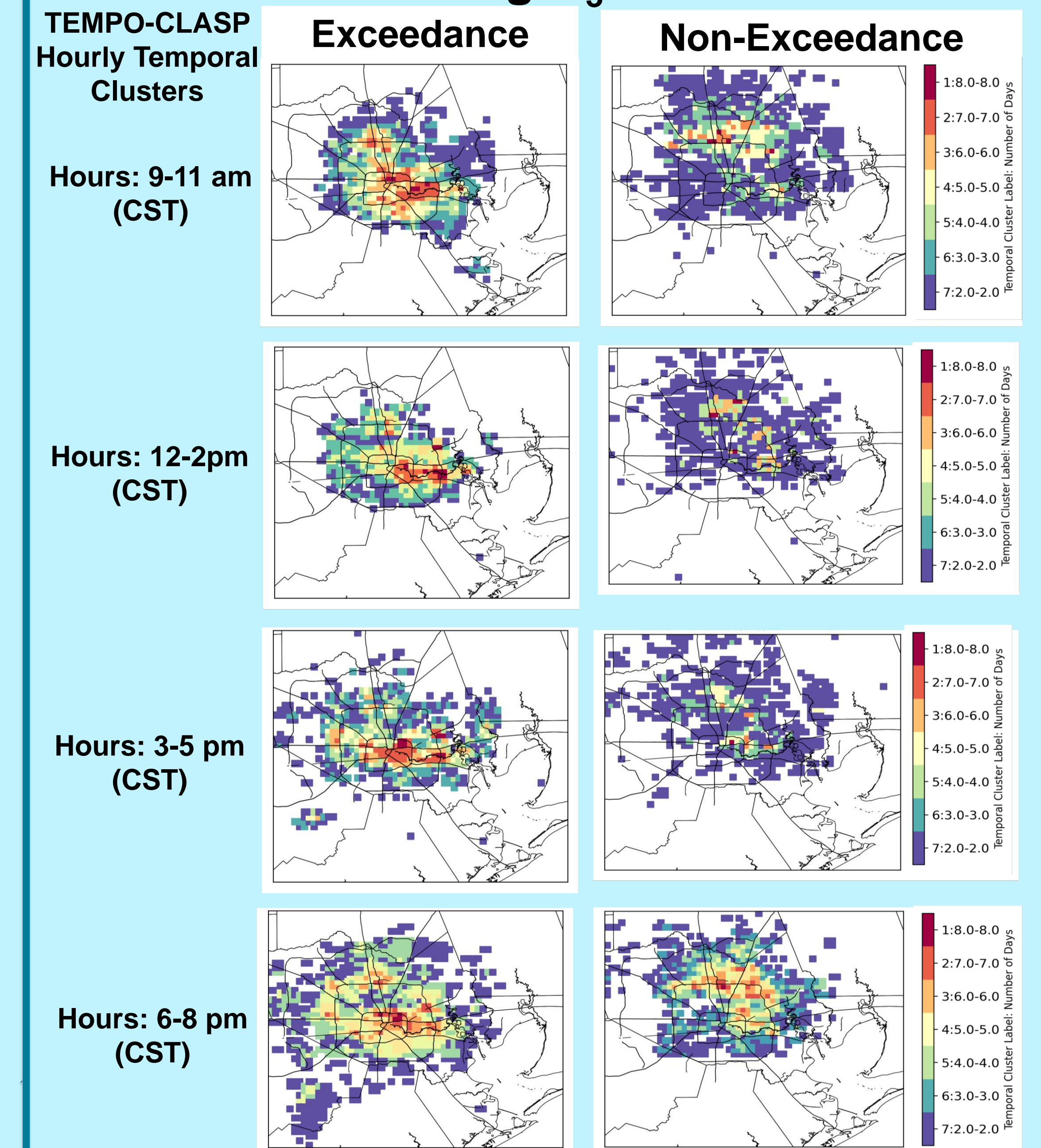
TEMPO Recovery-Beryl Mean: July 8th - 11th



TEMPO Post-Beryl Mean: July 12th - 31st

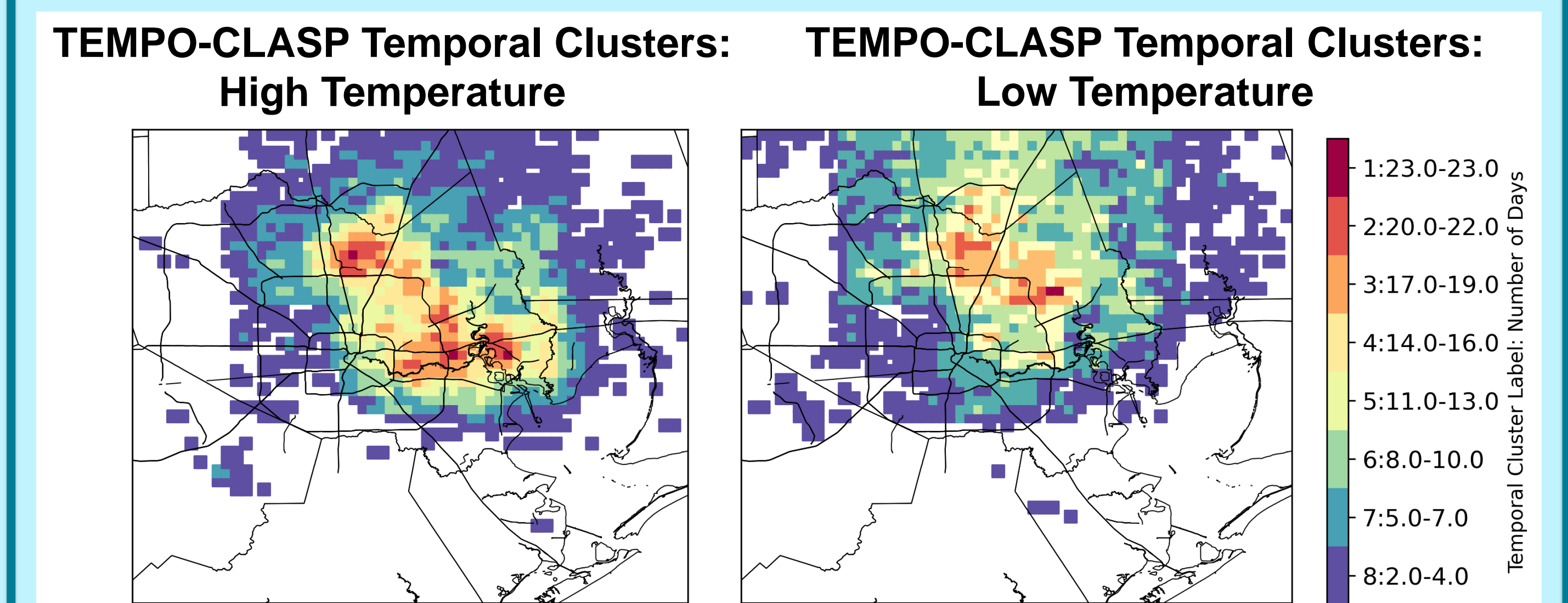


CLASP Observed the Hourly Variations of NO₂ during O₃ Exceedances



CLASP temporal clusters derived from 3-hourly averaged TEMPO NO₂ in the Houston, TX area for O₃ Exceedance and Non-Exceedance days in June 2024. Each color represents a different cluster corresponding to the number of dates a plume was identified by CLASP, as indicated in the color bar where the cluster number is shown with the number of days or quality L3 TEMPO NO₂ retrievals

CLASP can Detect NO₂ Changes on High Temperature Days



CLASP temporal clusters derived from 3-hourly averaged TEMPO NO₂ in the Houston, TX area for High and Low Temperature days in May - August 2024. High temperature is defined as greater or equal to the 90th percentile of maximum station temperature from NOAA's Climate Data observations. Each color represents a different cluster corresponding to the number of dates a plume was identified by CLASP, as indicated in the color bar where the cluster number is shown with the number of days or quality L3 TEMPO NO₂ retrievals

CLASP's temporal clusters were able to identify and preserve the variations in NO₂ signals on an hourly basis

With TEMPO and CLASP we can see fine features in an urban setting, and observe how these features change throughout the day to determine where frequent features occur

Acknowledgments

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Image Credit: TEMPO_NO2_L3_V01_20231230T225114Z_S011



References

1. Lee and Wang. (2023). *Journal of Geophysical Research: Atmospheres*, 128, e2023JD038887. <https://doi.org/10.1029/2023JD038887>