# Open Classification of Regimes in the Southeast USA (OpenCrums USA): An open source framework for classifying aerosol and meteorological regimes in the Southeast USA.

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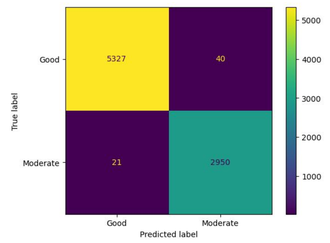
## Motivation

- Categorizing long term climate data into different aerosol/meteorological regimes crucial for studying aerosol-cloud climate interactions.
- Machine learning (ML) techniques provide new opportunity to discover regimes in large climate datasets. [1] used self-organizing maps (SOMs) to sort cases from TRacking Aerosol Convective Interactions Experiment (TRACER): post-trough, pre-trough, transitional, and anticyclonic
- Goal: investigate different ML techniques for classifying aerosol/meteorological regimes over Houston/ARM Southeast USA
- Explainable AI: physical basis for classifications/guide ARM instrument deployments

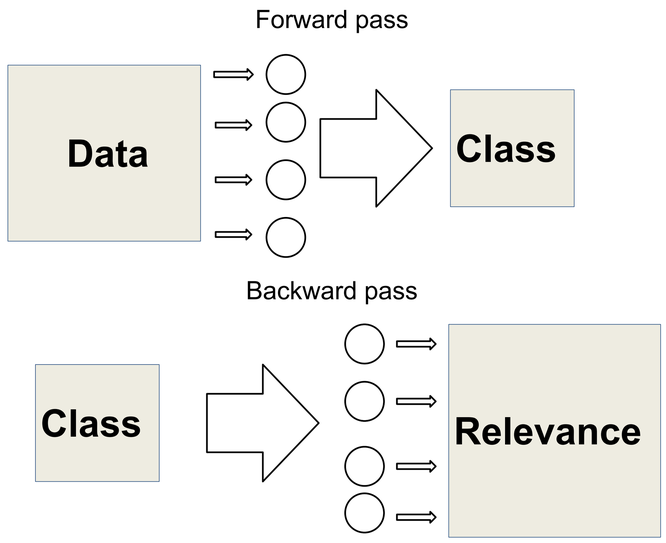
## Classification

- MERRA2 aerosol parameters 2010-2022 (1 hr)
- EPA AirNow PM2.5 Air Quality Index (AQI) (Good, Moderate)
- Develop parallel CNN classifier from MERRA2 aerosol surface mass concentrations (dust, black/organic carbon, sea salt, sulfate) over Houston region to classify EPA AirNow state
- 97% prediction accuracy → CNN well predicts AQI



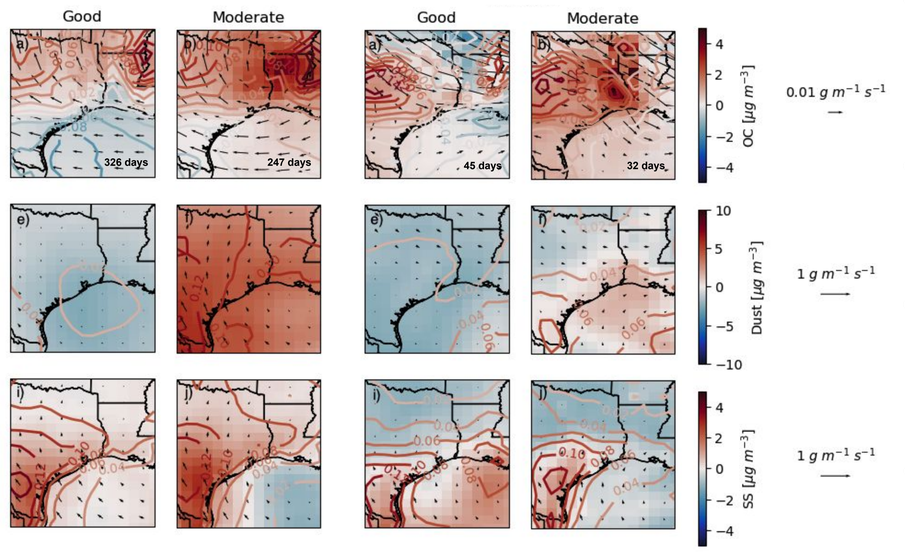

Confusion matrix of true vs. predicted labels for validation dataset

## Layerwise Relevance Propagation (LRP) [2]




Check out OpenCRUMS cookbook here!

## JJAS surface PM2.5 mass anomalies (00-12 UTC)

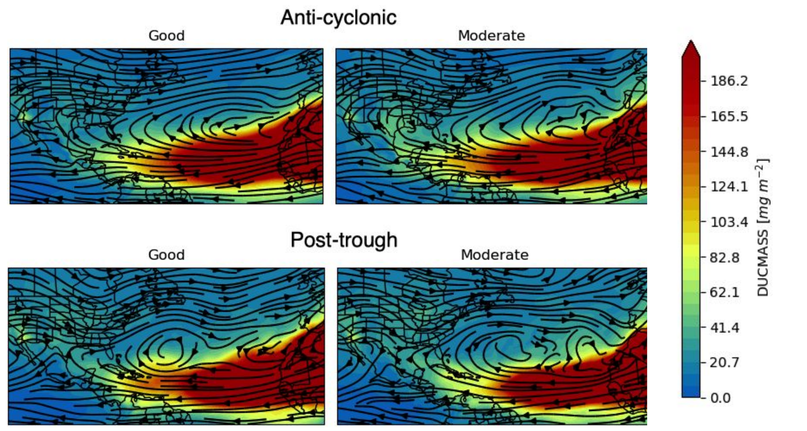



Mean surface PM2.5 concentration anomaly for top 3 most relevant features. Contours = mean normalized relevance. Arrows = column fluxes.

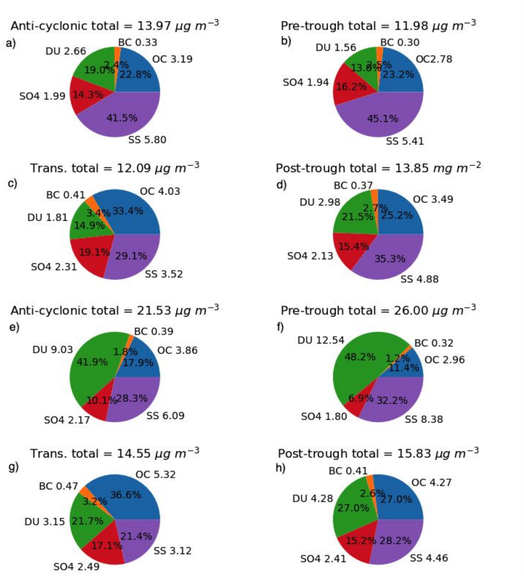
- Organic carbon most important predictor of Moderate AQI for pre-trough moderate conditions.
- Sea salt and dust more important predictors of Moderate AQI during anti-cyclone days.
- More onshore flow in anti-cyclonic conditions from high pressure/seabreeze → more sea salt, but dust?
- Offshore flow in post-trough explains lower importance of sea salt in these conditions.

## Look at Saharan Dust

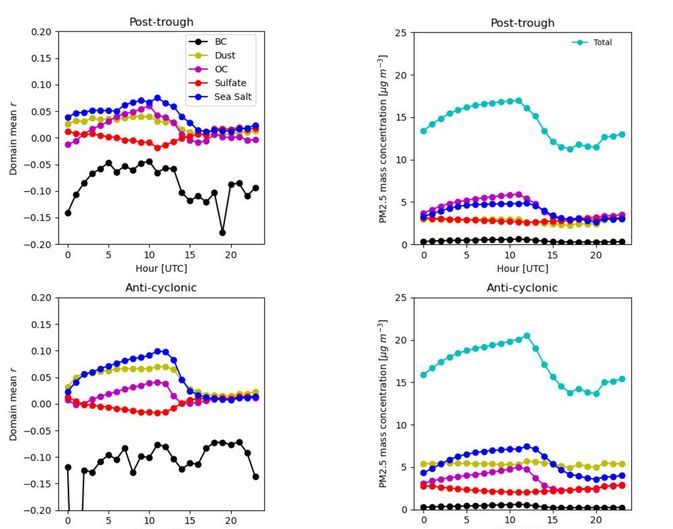
- Dust from Sahara Africa can be transported to Houston via the Intertropical Convergence Zone (ITCZ) and the Bermuda High.
- More dust reaches Houston from Sahara in Moderate conditions during anti-cyclone days: High pressure system transports dust from Sahara over ITCZ to Houston.
- Trough blocks flow of dust in post-trough conditions.




## Average Houston MERRA2 surface PM2.5 concentrations




## LRP recognizes aerosol diurnal cycle




Mean normalized relevance vs. time of day

Mean surface PM2.5 concentration vs. time of day

## Conclusions

- CNN can accurately predict EPA PM2.5 Air Quality Index over Houston
- Layerwise Relevance Propagation shows that CNN recognizes diurnal cycles of aerosols over Houston, organics/sea salt peaking before dawn
- Anti-cyclonic/pre-trough regime: CNN recognizes sea salt, dust, and organics as most important predictors. Onshore flow of Gulf moisture, dust from Sahara consistent with dust/sea salt importances.
- Post-trough/transitional regime: Organics most important, offshore flow → sea salt/dust less important for classification. Trough blocks flow of dust from Sahara.

## References

[1] Wang, D., Jensen, M. P., Taylor, D., Kowalski, G., Hogan, M., Wittemann, B. M., et al. (2022). Linking synoptic patterns to cloud properties and local circulations over southeastern Texas. J. of Geophy. Res. Atmos., 127, e2021JD035920. https://doi.org/10.1029/2021JD035920

[2] Toms, B. A., Barnes, E. A., & Ebert-Uphoff, I. (2020). Physically interpretable neural networks for the geosciences: Applications to Earth system variability. Journal of Advances in Modeling Earth Systems, 12, e2019MS002002. https://doi.org/10.1029/2019MS002002

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## Contact/Questions

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