Cluster analysis of multi-dimensional ozone lidar measurements in coastal environments toward evaluating simulations and advancing TEMPO product

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Introduction

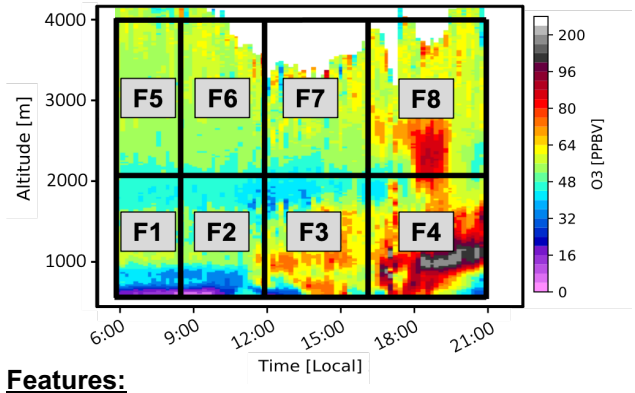
Coastal regions are subject to complex mechanisms, chemistry, and emissions that leads to frequently observed large tropospheric ozone (O_3) variations (vertically & diurnally).

Our goal is to characterize coastal O_3 variability by applying a clustering method to multi-dimensional lidar measurements from 3 recent campaigns: OWLETS 1 & 2, LISTOS.

We used the assigned lidar O_3 clusters to evaluate air quality model performance. The clusters help us pinpoint areas in which models fail to predict O_3 concentrations the most.

Clustering Method

Split days into "slabs" based on **altitude** & **time**.

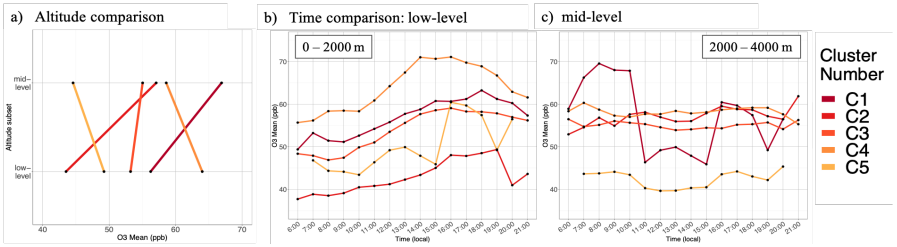


Features:

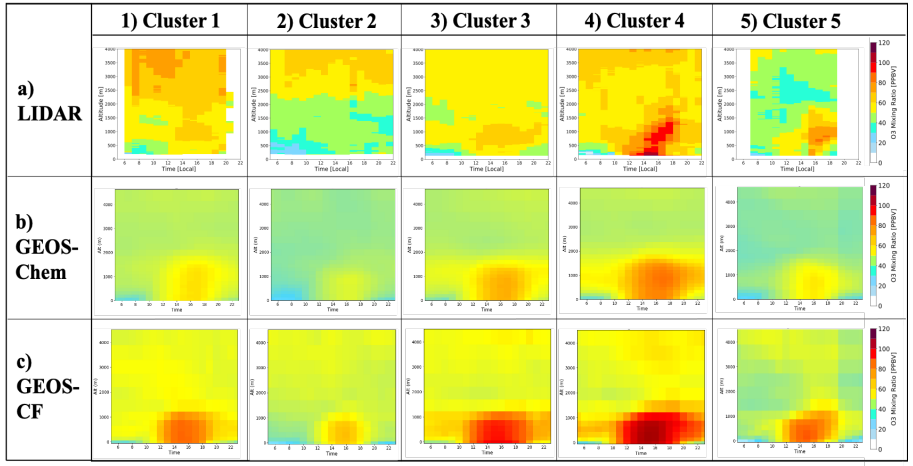
- **Altitude 2 sectors:**
  - 0 – 2000 m (low-level); 2000 – 4000 m (mid-level)
- **Time 4 sectors:**
  - 6:00 – 8:00; 8:00 – 12:00; 12:00 – 16:00; 16:00 – 21:00

Calculated average features into K-Means Clustering algorithm.

Cluster Results & Model Evaluation



Clustering method resulted in 5 distinct clusters. Average profiles above separated by low/mid-level altitude. Corresponds to figure a) below.

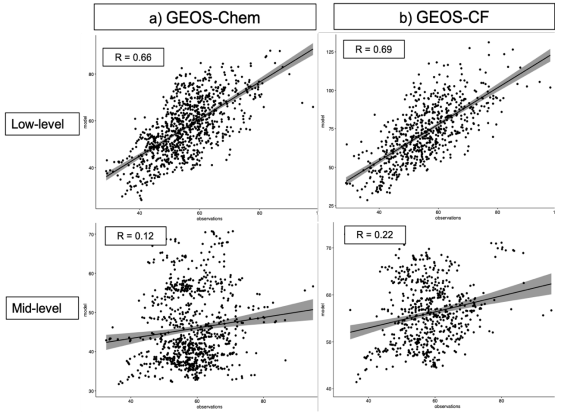


Mean O_3 vertical profile results for 5 clusters:
a) LIDAR; b) GEOS-Chem simulation; & c) GEOS-CF simulation.

Model set up:

- GEOS-Chem (MERRA2 meteorology) nested 0.5°x0.625° horizontal resolution ~ using 2°x2.5° global boundary conditions.
- GEOS Composition Forecasting (GEOS-CF) system data (https://gmao.gsfc.nasa.gov)
- Data only available for 2018 ~ analysis adjusted for this comparison

Overall Model Performance



Overall, GEOS-CF outperforms GEOS-Chem in simulating the vertical O_3 profiles for the 5 clusters.

Both models fail to simulate O_3 in the mid-level.

Bias varies by cluster for both models.

Conclusion & Future Work

- Developed clustering method for multi-dimensional O_3 data from 3 campaigns allowed us to characterize complex O_3 behavior (vertically & diurnally)
- 5 clusters provide simplified approach to evaluate air quality model performance
- GEOS-CF performs slightly better than GEOS-Chem but both models struggle to simulate mid-level O_3

~ Manuscript in progress

- Perform sensitivity tests to evaluate model performance
- Ahead of TEMPO: Investigate pseudo-TEMPO retrievals vs. *ideal* model simulations to understand TEMPO's potential ability to monitor O_3 over complex environments

Data & References

- Chan-Miller, et al., 2018: "Generation of Synthetic TEMPO L2 products". *Presentation. TEMPO Science Team Meeting.* June 5, 2018.
- Knowland, K.E., Keller, C.A., Lucchesi, R., 2019. 'File specification for GEOS-CF products', GMAO office note No. 17 (version 1.0). available from: https://gmao.gsfc.nasa.gov/pubs/office_notes.php, 32.

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