TCEQ

Characterization of Gulf Background Ozone Concentrations

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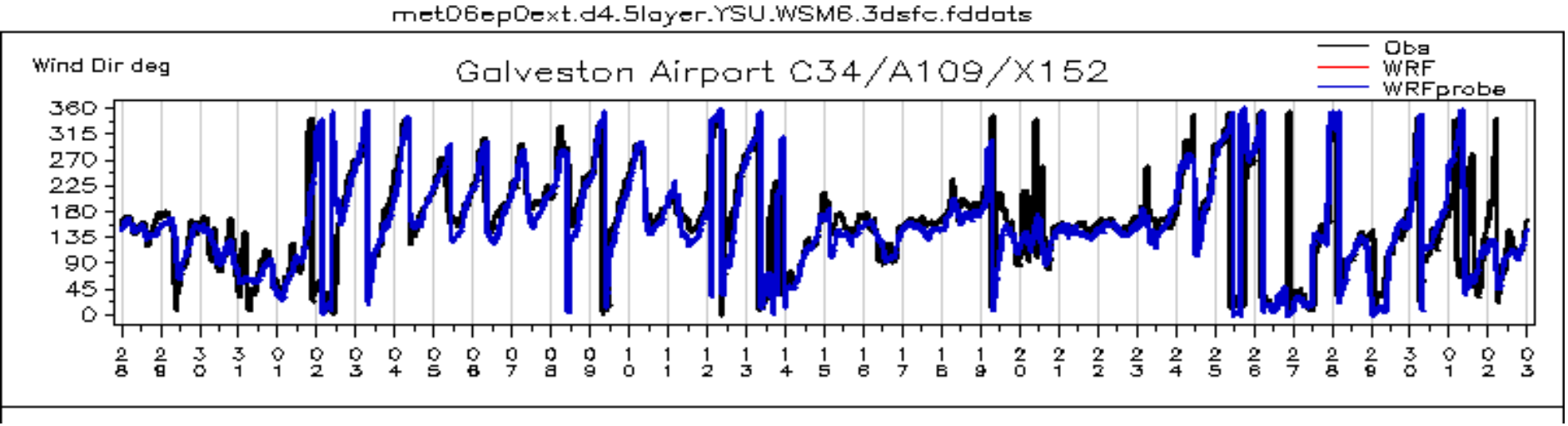
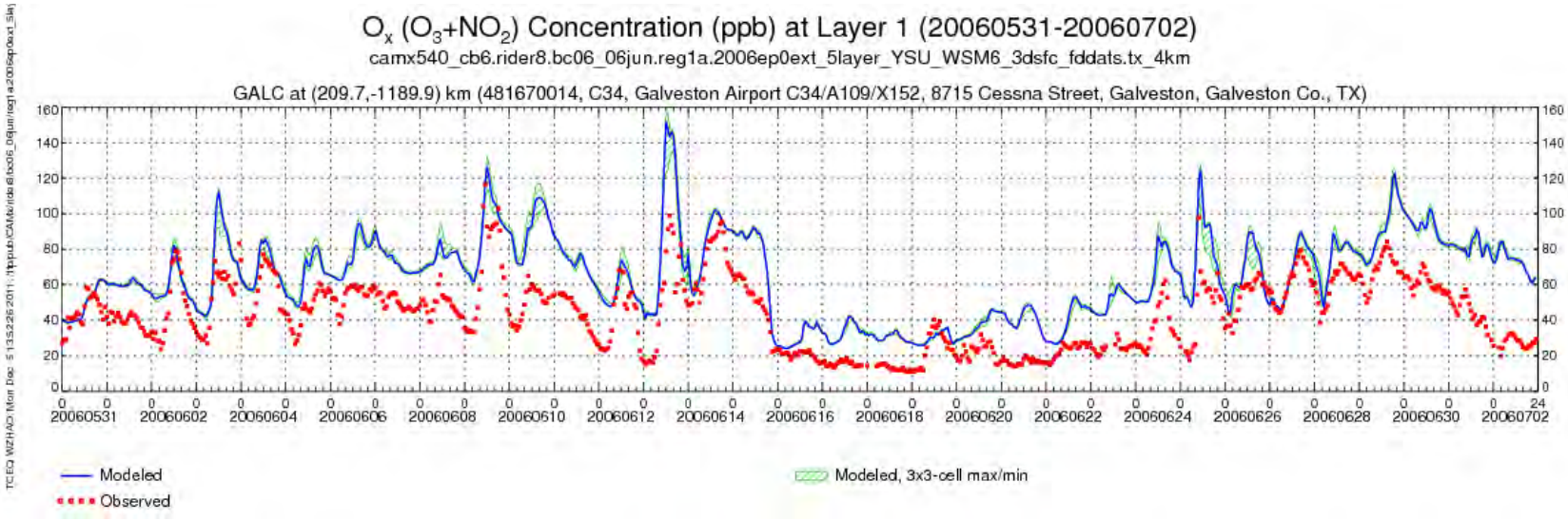
Presented to Southeast Texas Photochemical Modeling Technical Committee
April 25, 2012

Purpose

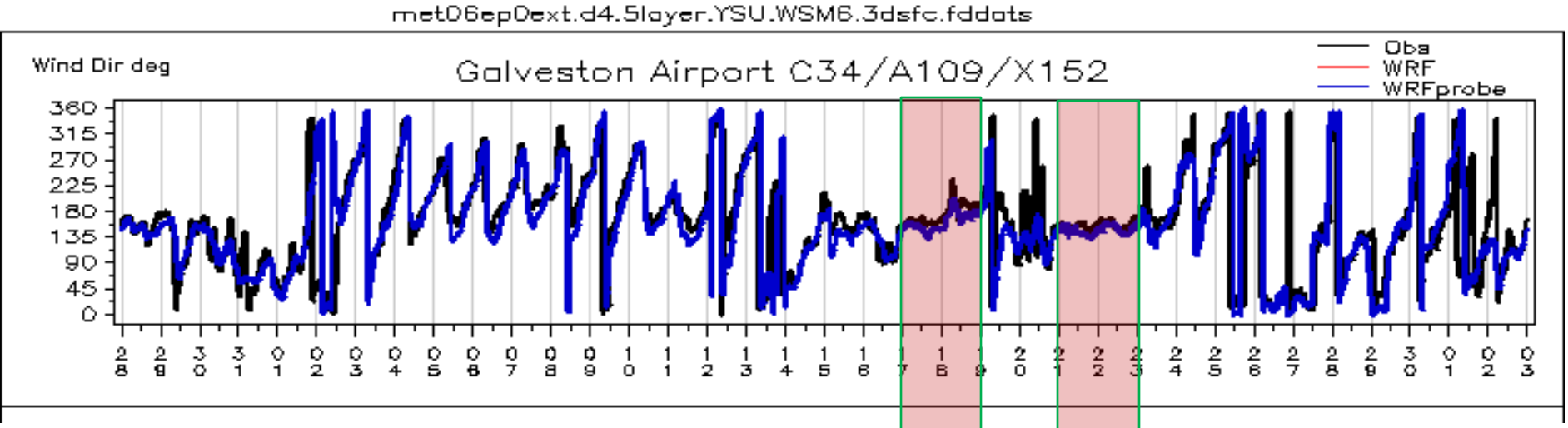
- One of the perplexing model performance issues is the frequent over-prediction of ozone concentrations in air arriving from the Gulf.
- This work attempts to characterize the air masses arriving at a near-shore site (Galveston 99th Street Pier, C-1034) by calculating back-trajectories, associating each with observed Galveston ozone levels, and finally using a clustering algorithm to characterize groups of like trajectories.

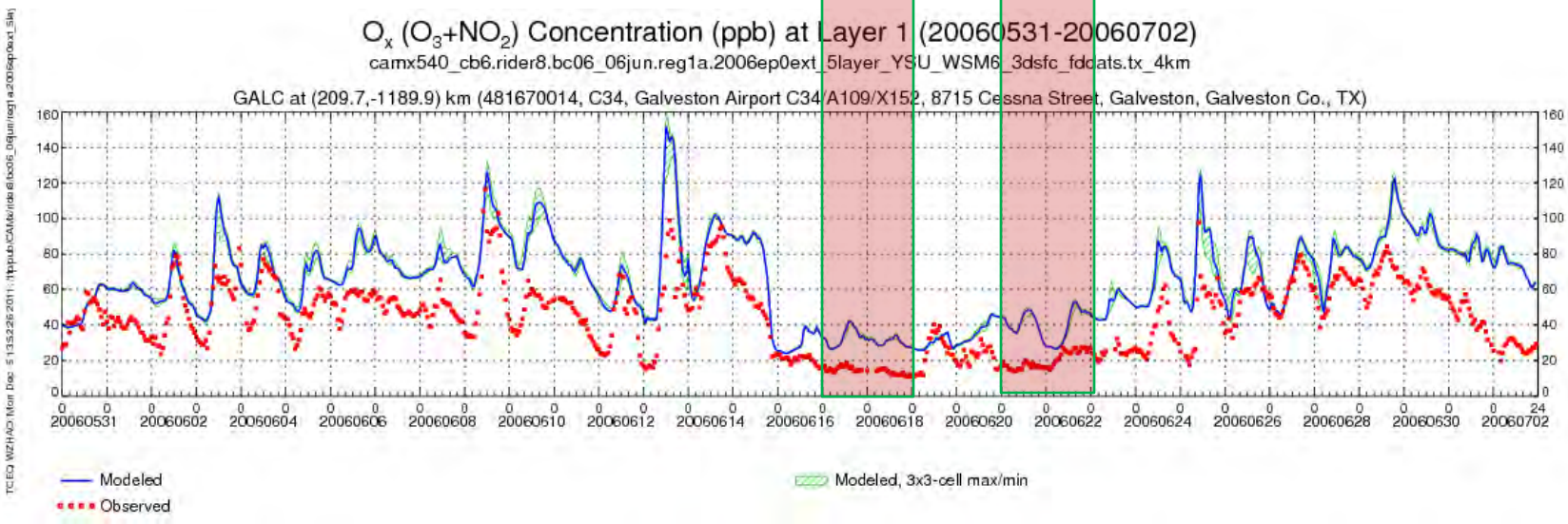
Observed and Modeled Galveston Ozone Concentrations, June 2006





Observed and Modeled Galveston Ozone Concentrations, June 2006





Methodology

- Back trajectories for five ozone seasons: May-September, 2007-11
- Endpoint was the Galveston 99th Street Pier monitor, C-1034
- Hybrid Single Particle Lagrangian Integrated Trajectory (HySPLIT) Model:
  - EDAS-40 km Meteorological data set
  - Termination at 100 M
  - 48 Hour trajectory length
  - End hours: 1,3,5,7,9,11,13,15,17,19,21 and 23
- Total of 8,792 trajectories

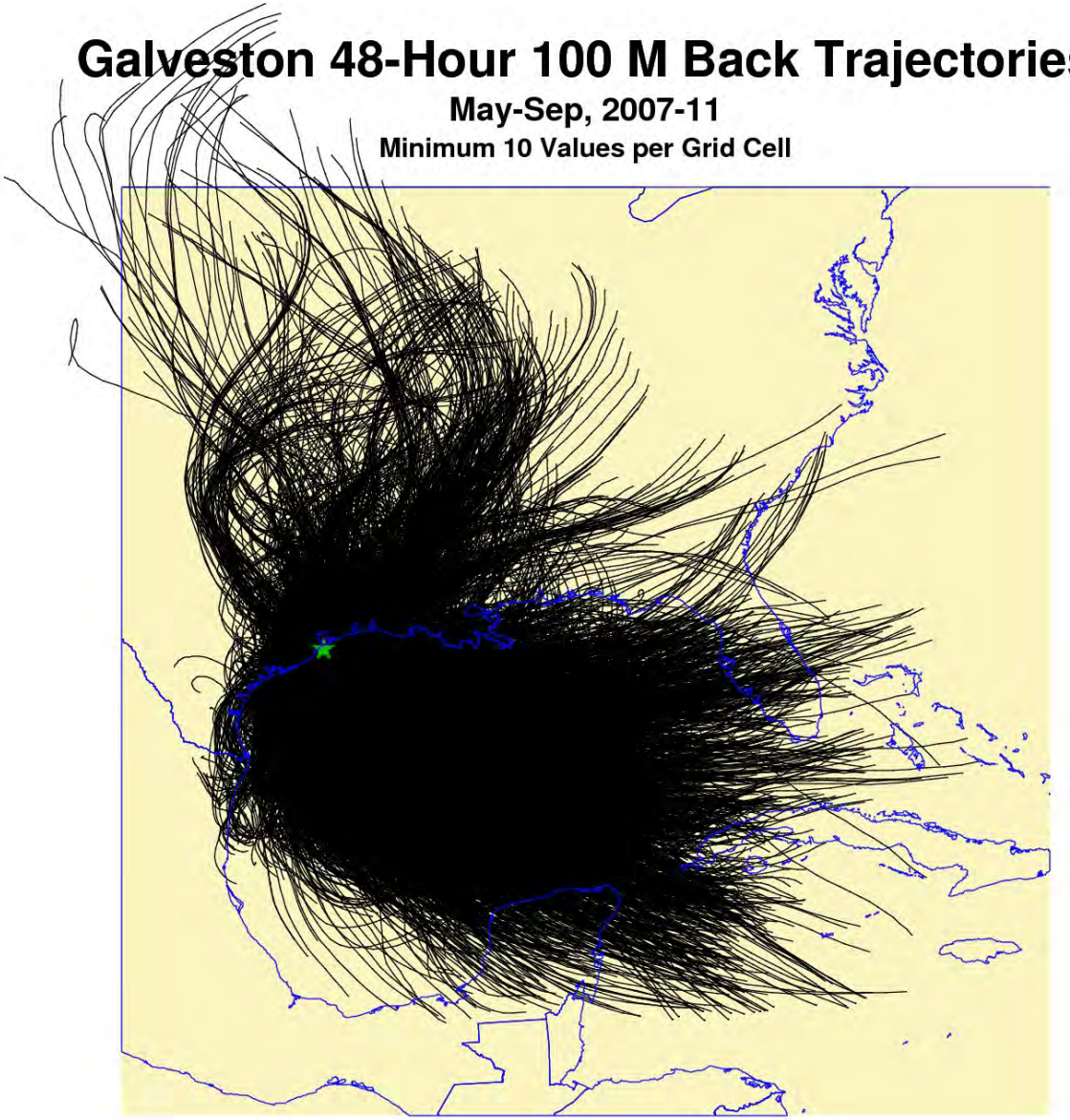
Methodology

- Next, each trajectory point was assigned the value of the ozone concentration monitored in Galveston at the time it arrived there.
- A 36x36 km grid was overlaid across the trajectory field and the terminal ozone concentrations of trajectory points falling in each grid cell was tabulated.
- For grid cells with enough (10+) trajectory points, cell median values were color-coded on top of the trajectories.

Galveston 48-Hour 100 M Back Trajectories

May-Sep, 2007-11

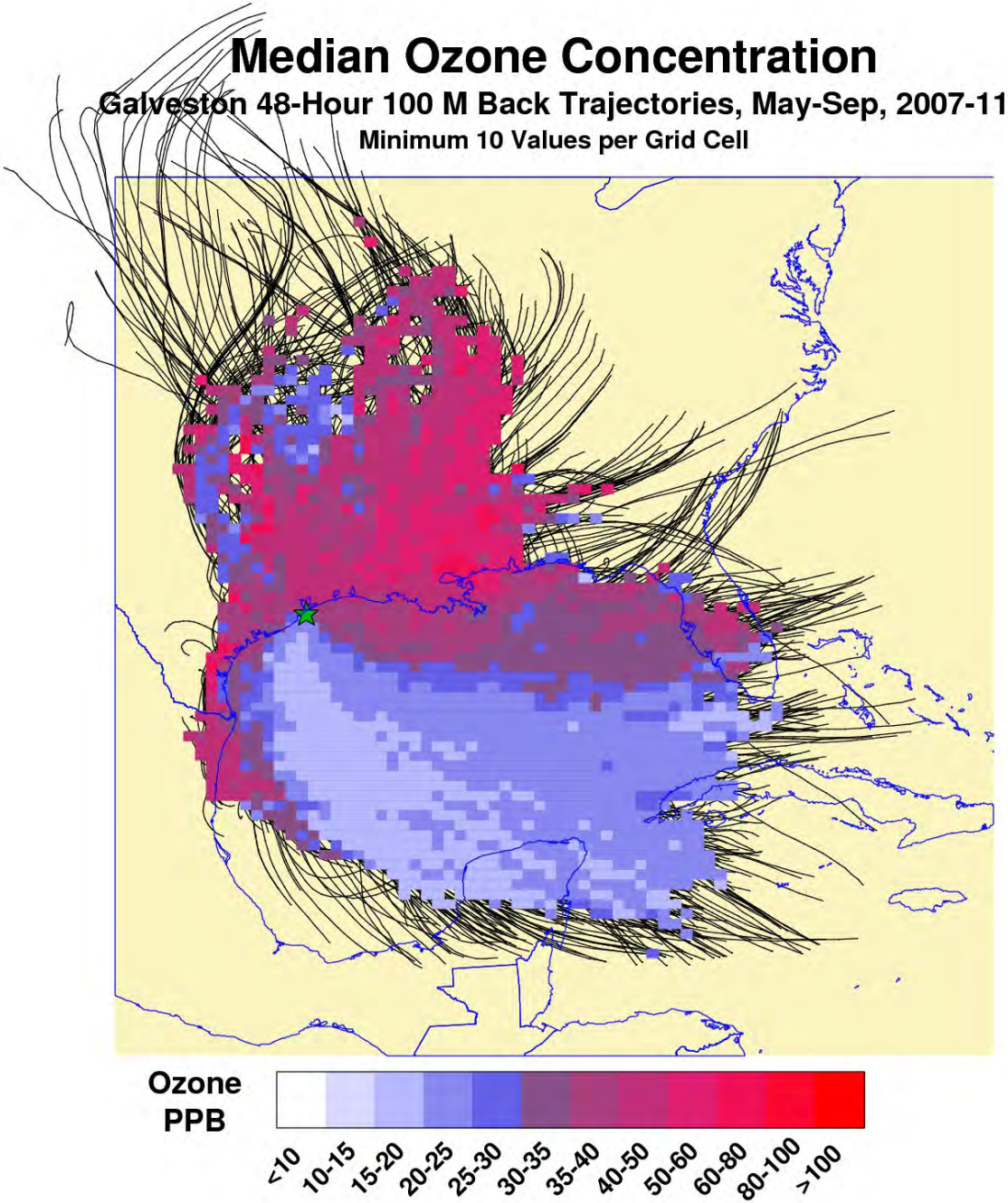
Minimum 10 Values per Grid Cell



Median Ozone Concentration

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell



Methodology

- To further study the trajectories, a clustering algorithm was used to find groups of similar clusters. This analysis included the vertical component of each trajectory point.
- Each trajectory was characterized as a 144-dimensional vector (X_1-X_{48}, Y_1-Y_{48}, Z_1-Z_{48}), then normalized to give each of the 144 components equal weight.

Methodology

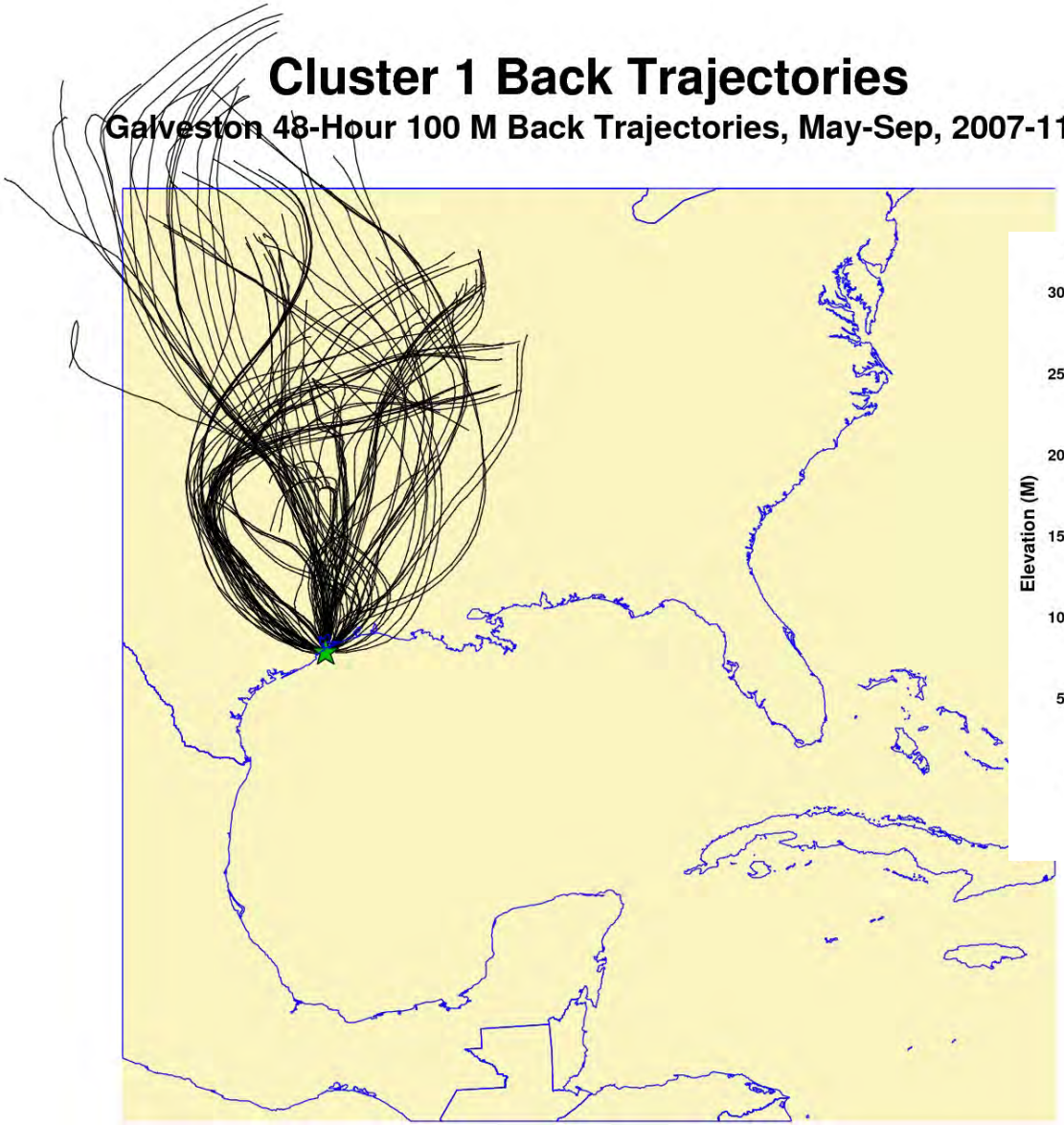
- The SAS FASTCLUS procedure was used to define 8 clusters of back trajectories.

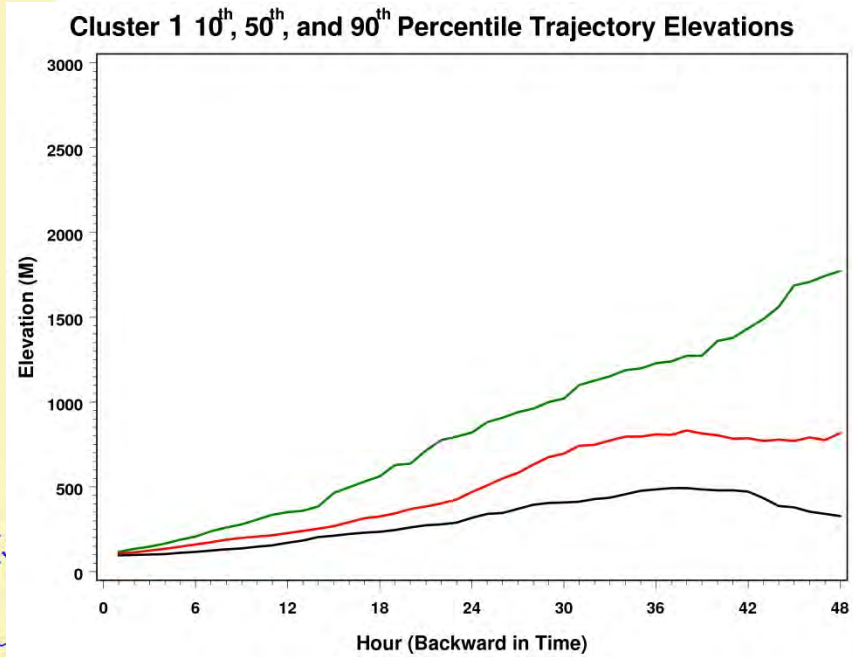
```
Proc Standard Data=Trajedy Out=Stand Mean=0 Std=1;
            Var X1-X48 Y1-Y48 Z1-Z48;
Proc FastClus Noprint Data=Stand  Out=Clust MaxClusters=8;
            Var X1-X48 Y1-Y48 Z1-Z48;
Run;
```

- A color coding scheme like that used earlier for the full set of trajectories was employed for each cluster.

Cluster 1 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

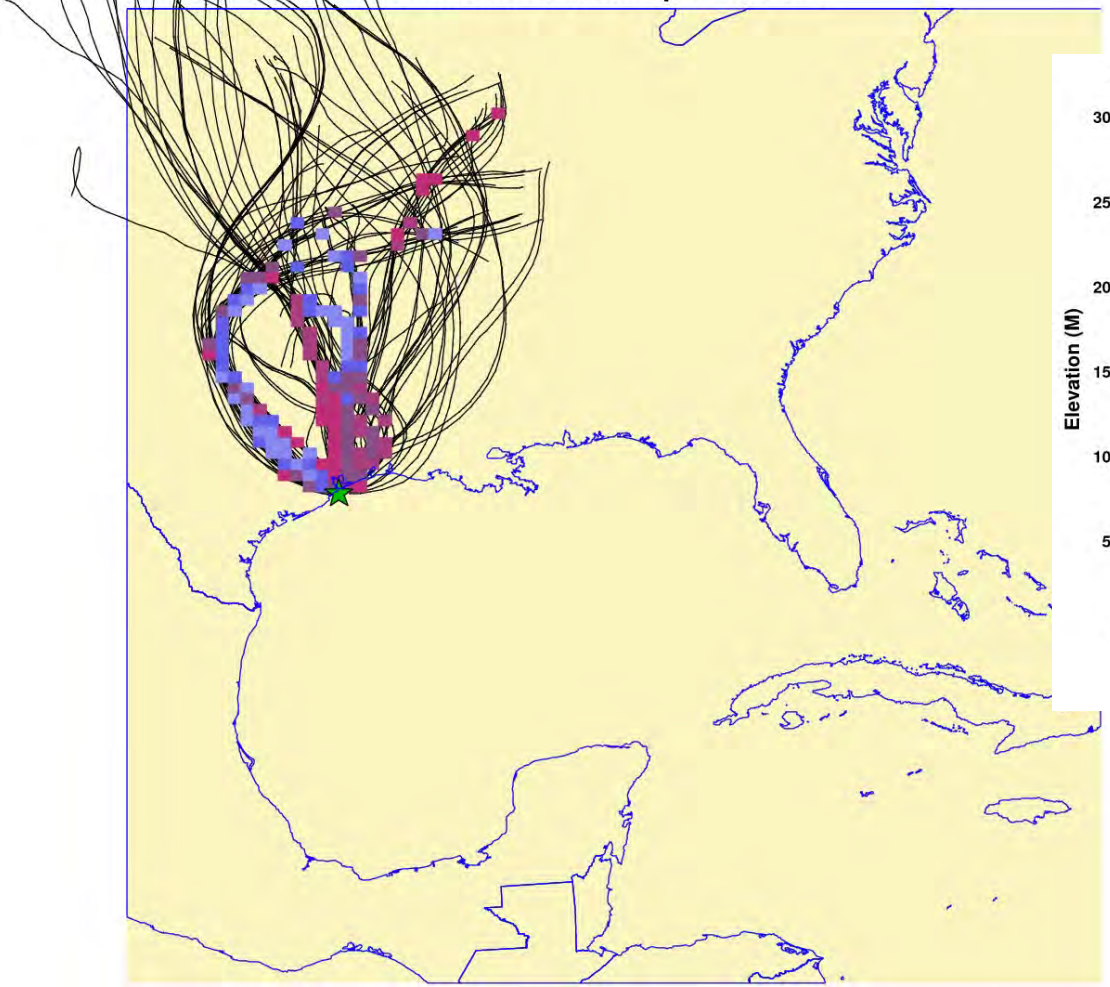


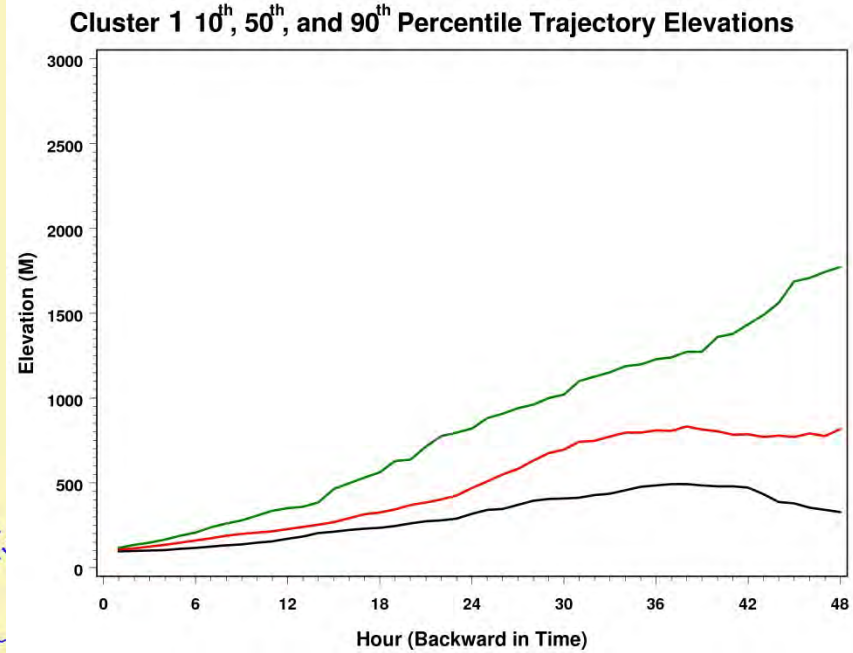


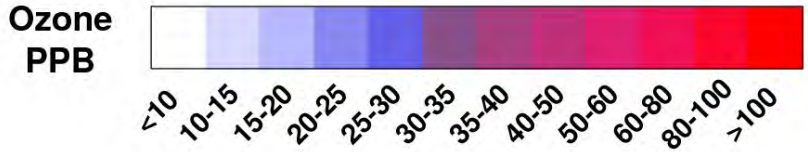
Cluster 1 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell





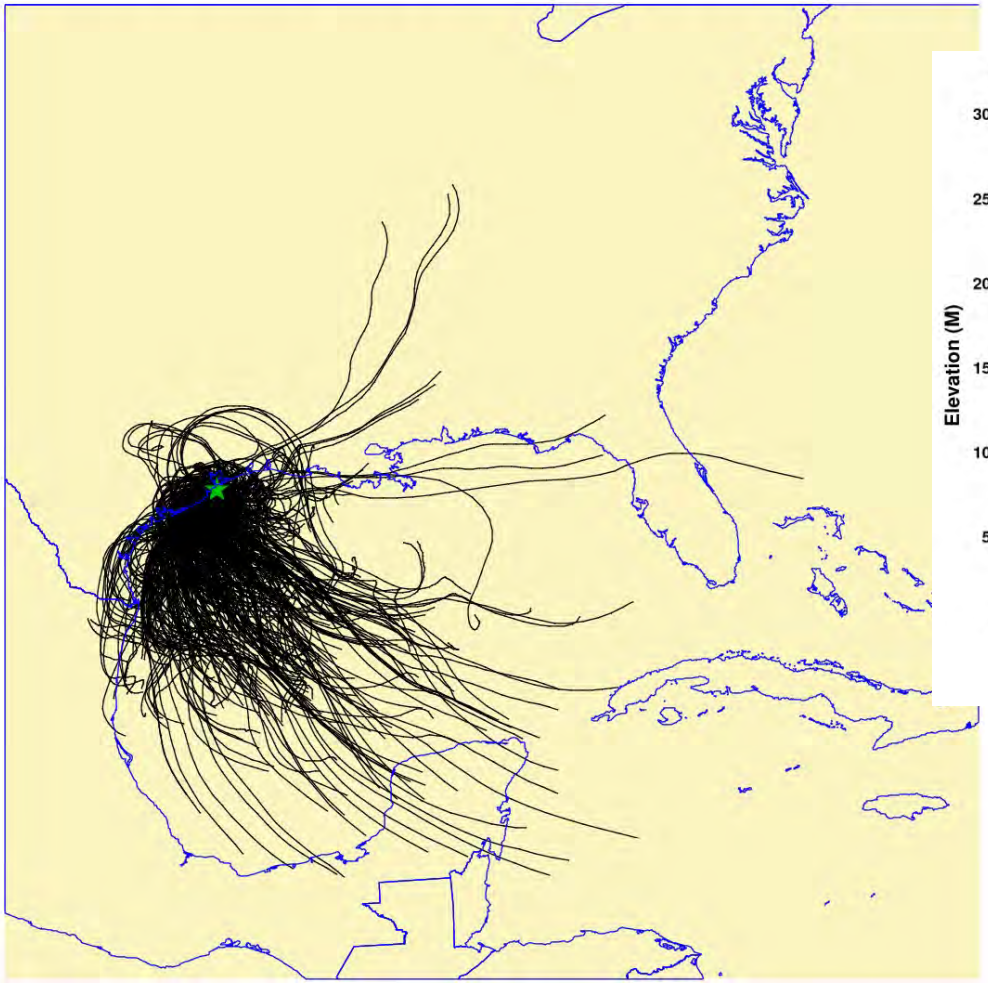


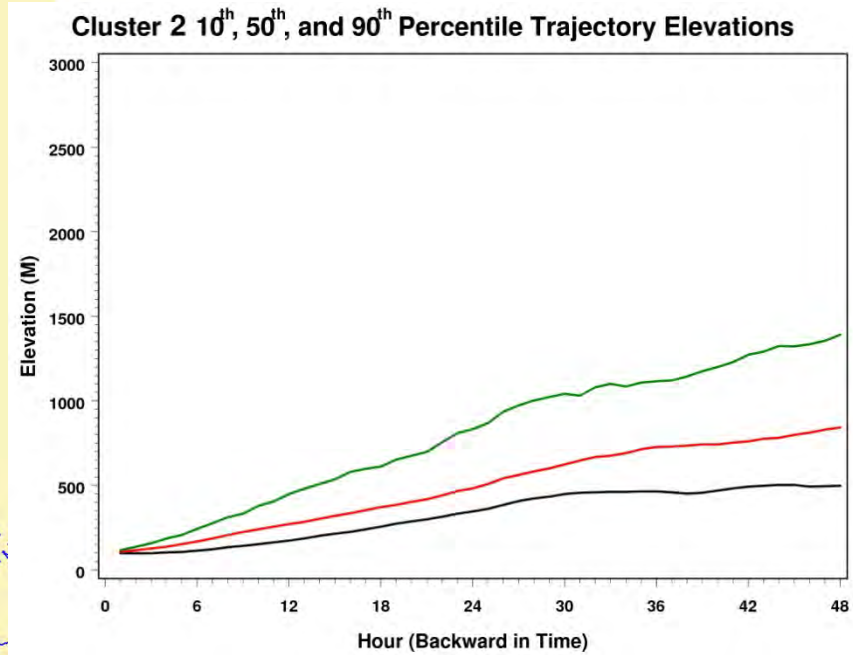
Cluster 1: 104 Trajectories
Terminal Ozone Concentrations:

10th Percentile	20 ppb
Median	34 ppb
90th Percentile	49 ppb

Cluster 2 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

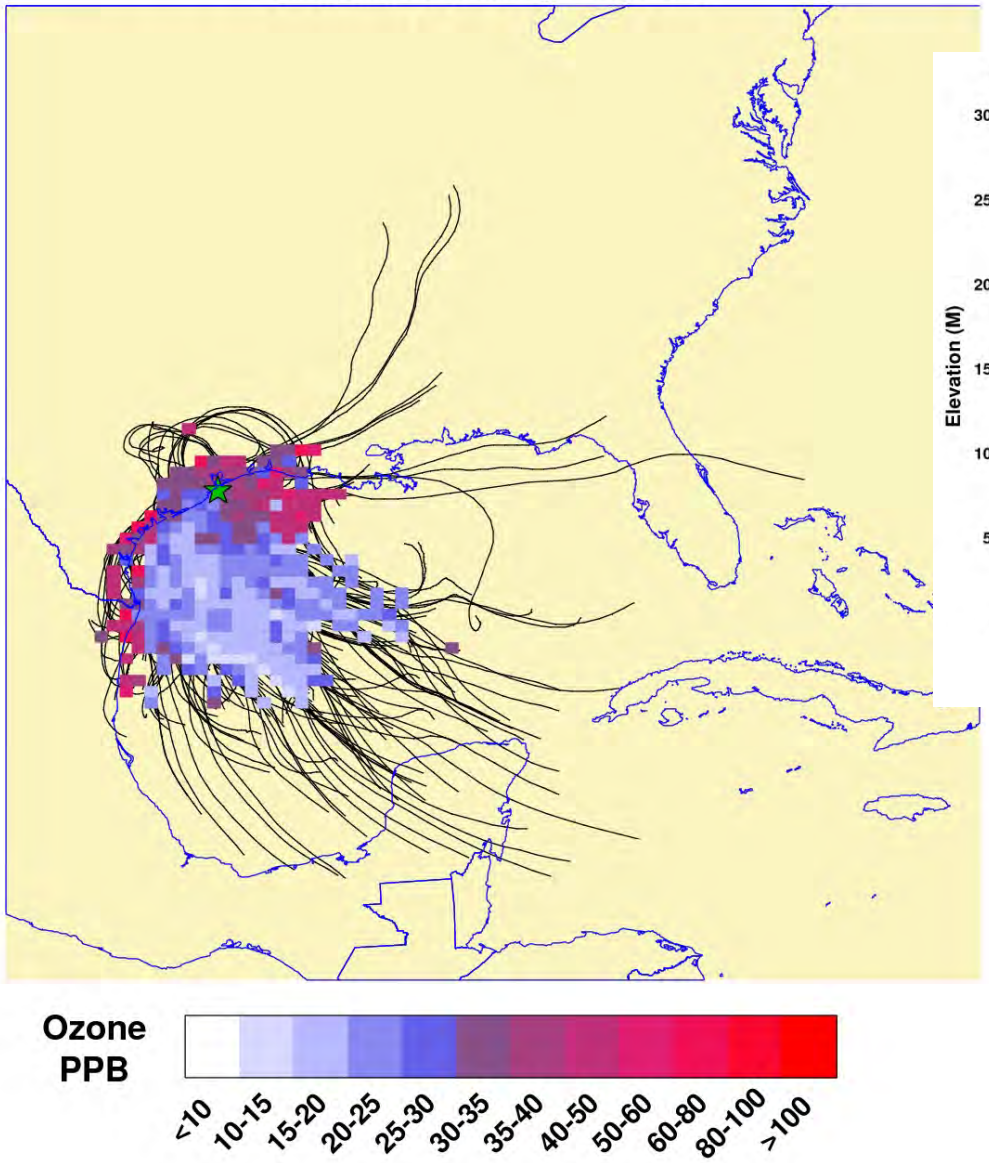


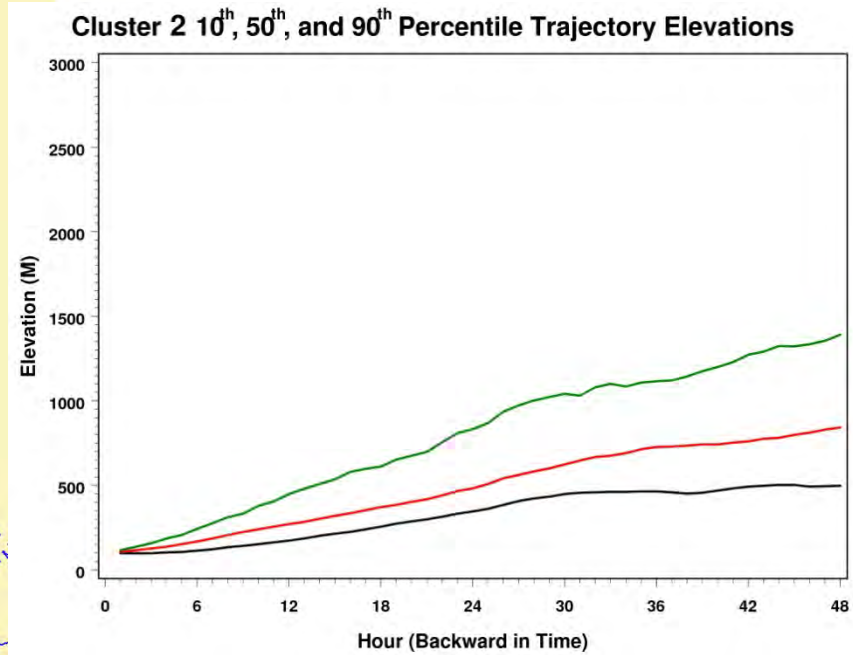


Cluster 2 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell



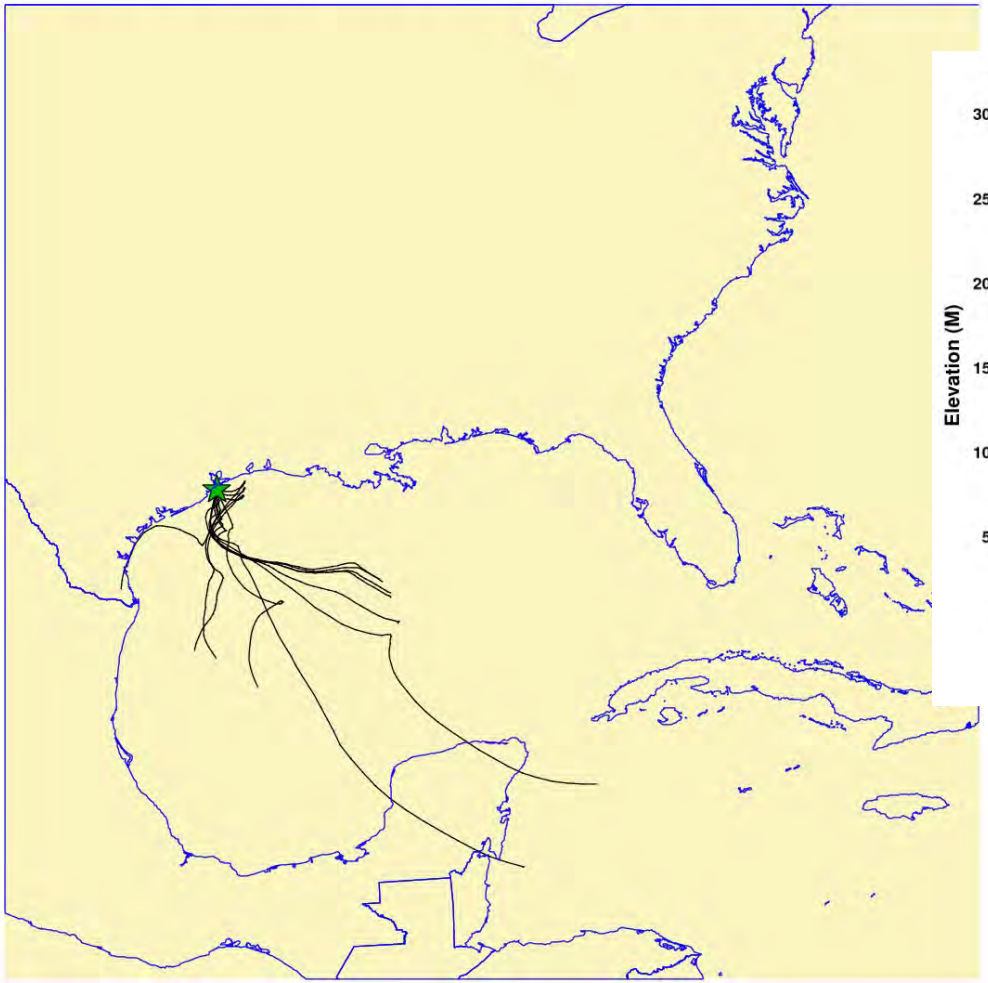


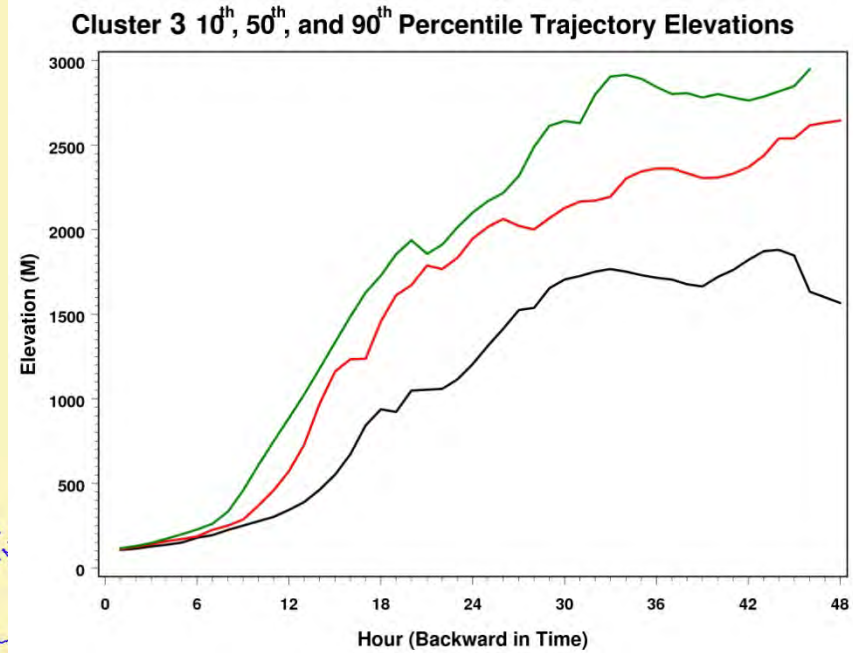
Cluster 2: 417 Trajectories
Terminal Ozone Concentrations:

10th Percentile	13 ppb
Median	24 ppb
90th Percentile	49 ppb

Cluster 3 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

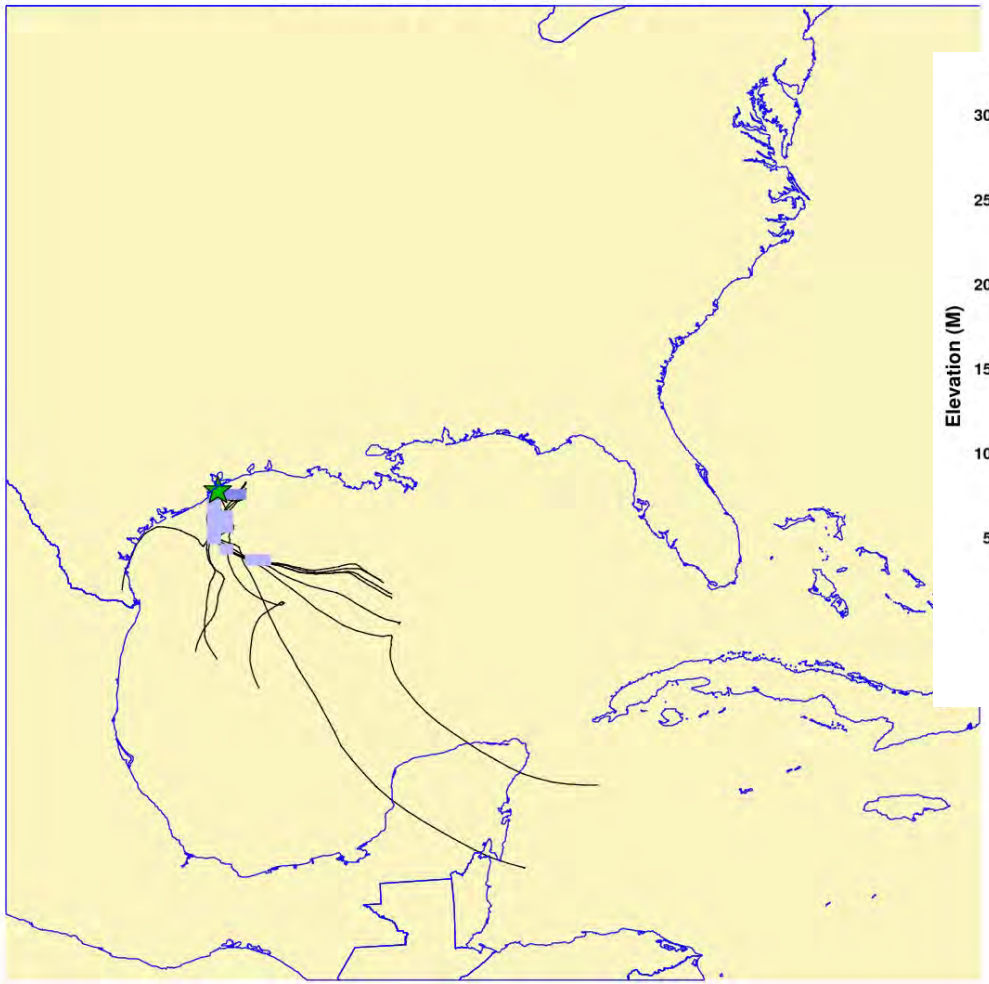


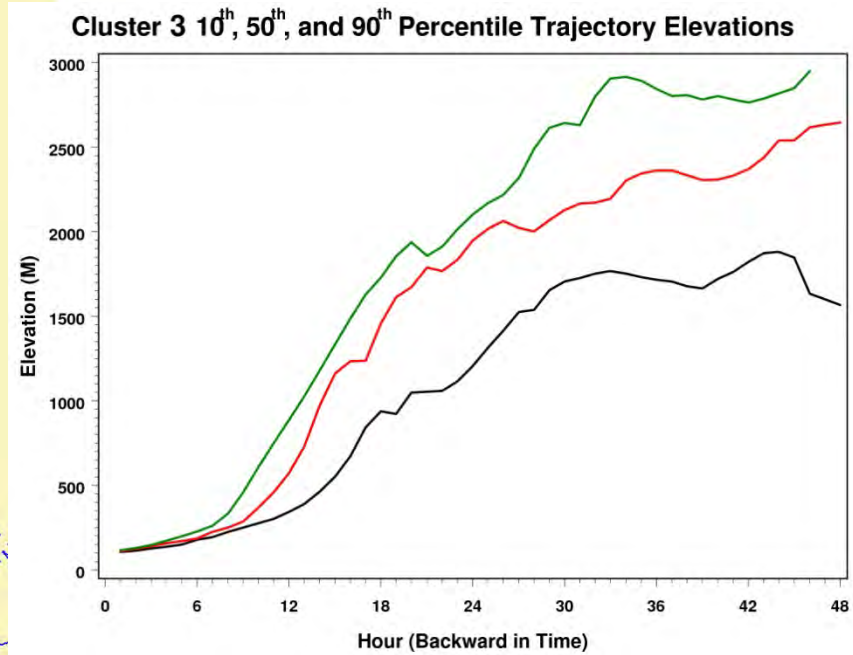


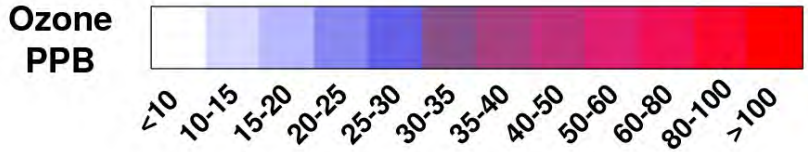
Cluster 3 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell





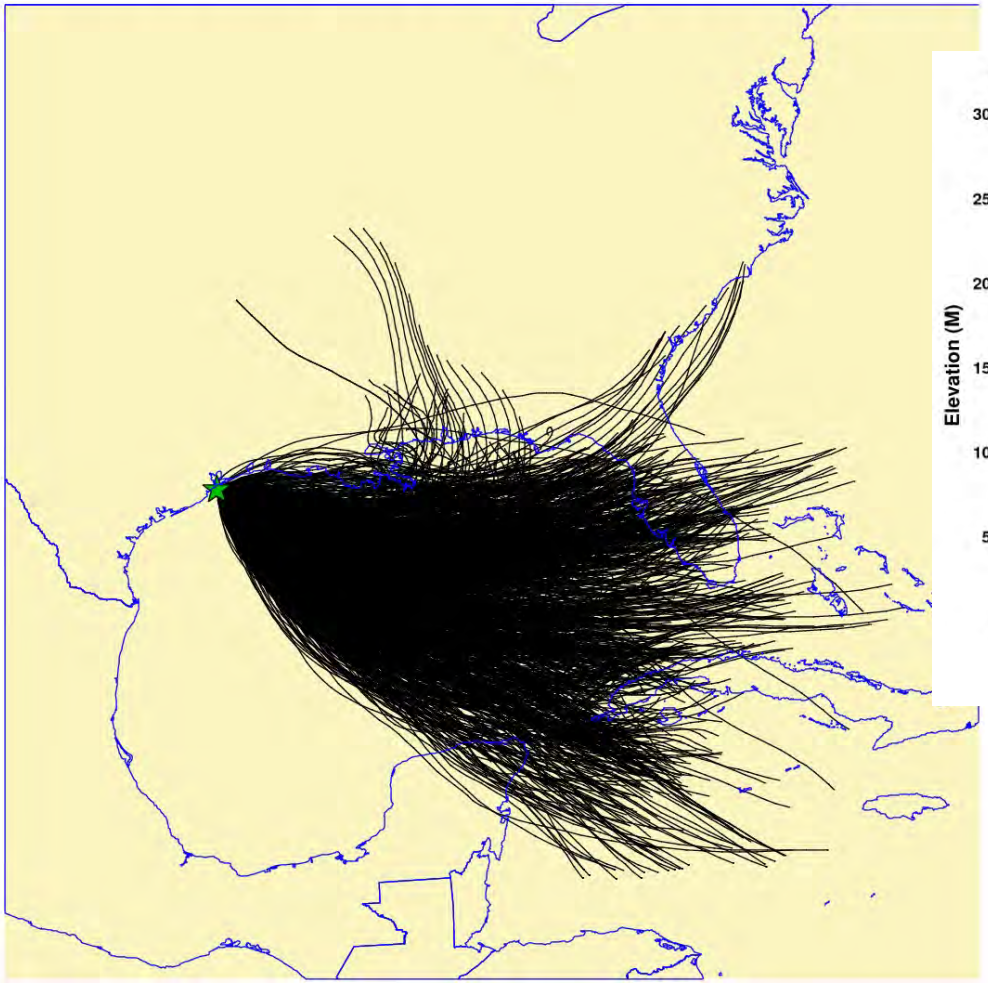


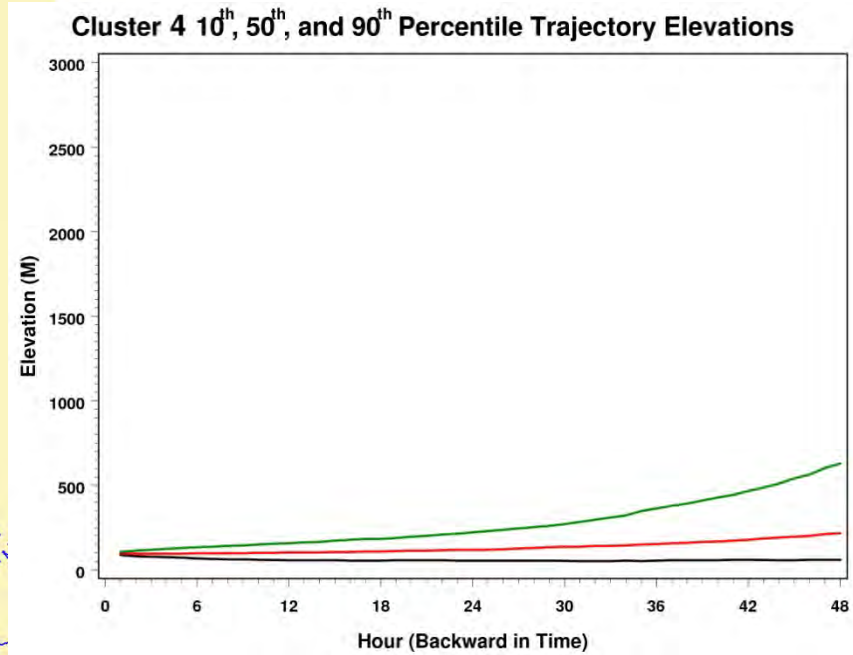
Cluster 3: 11 Trajectories
Terminal Ozone Concentrations:

10th Percentile	16 ppb
Median	18 ppb
90th Percentile	24 ppb

Cluster 4 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

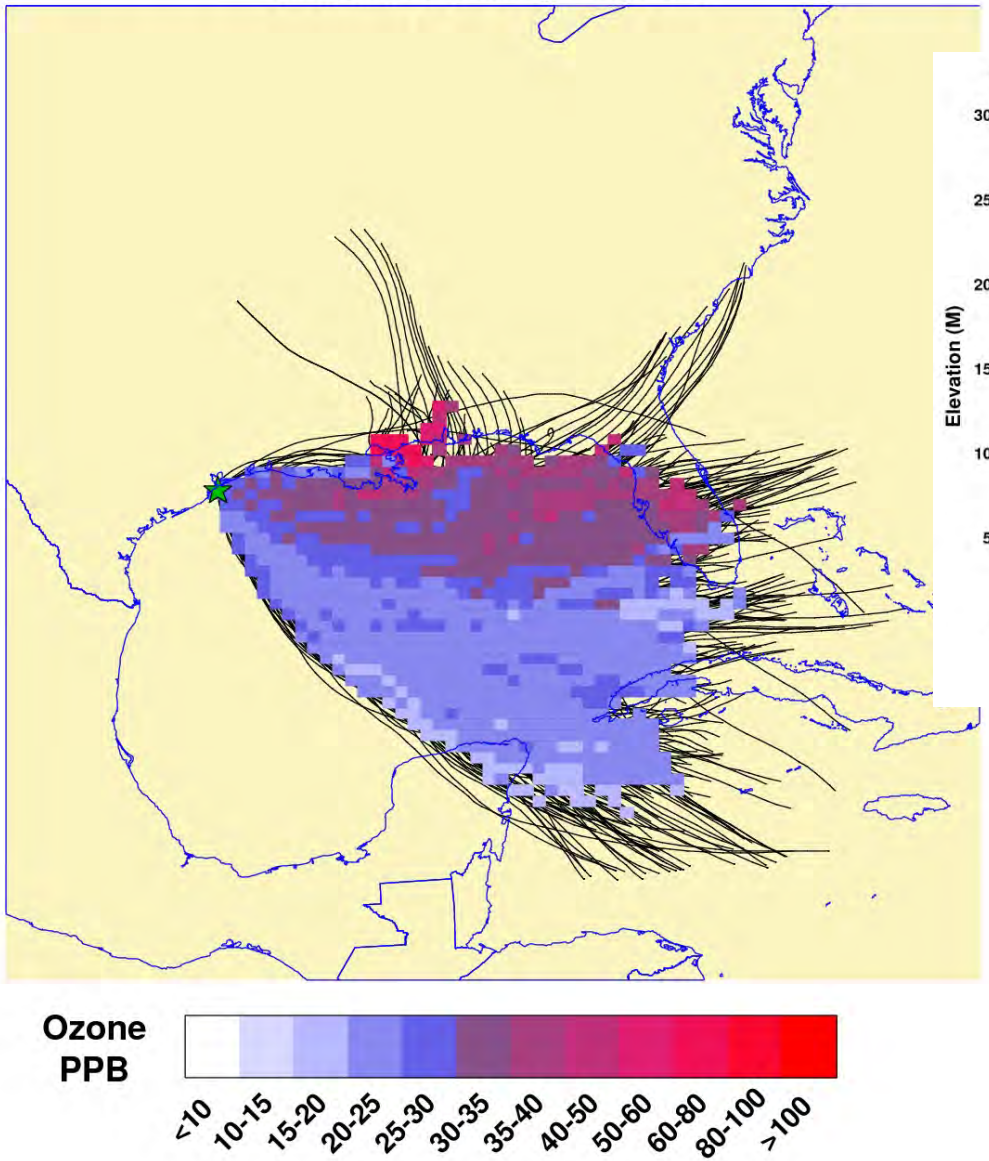


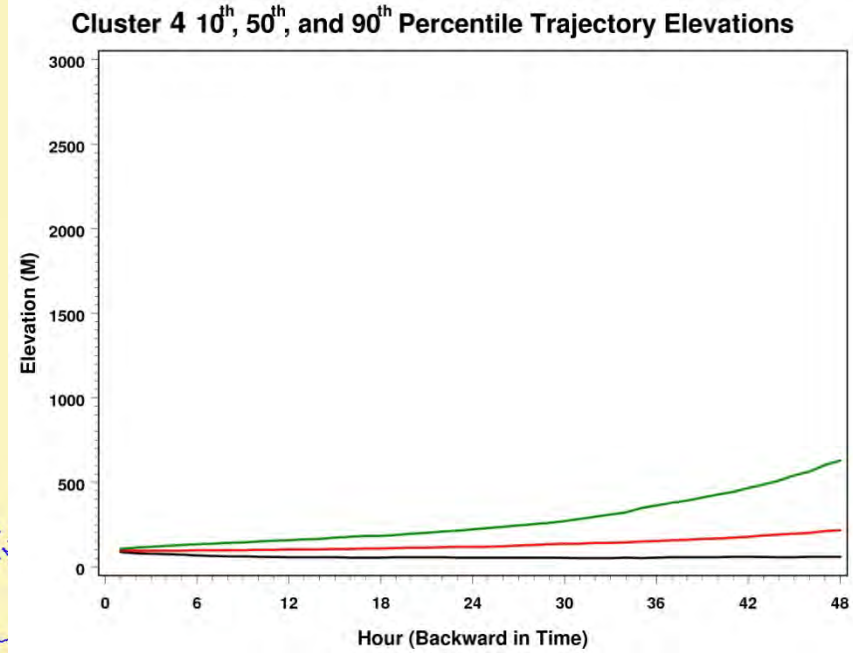


Cluster 4 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell



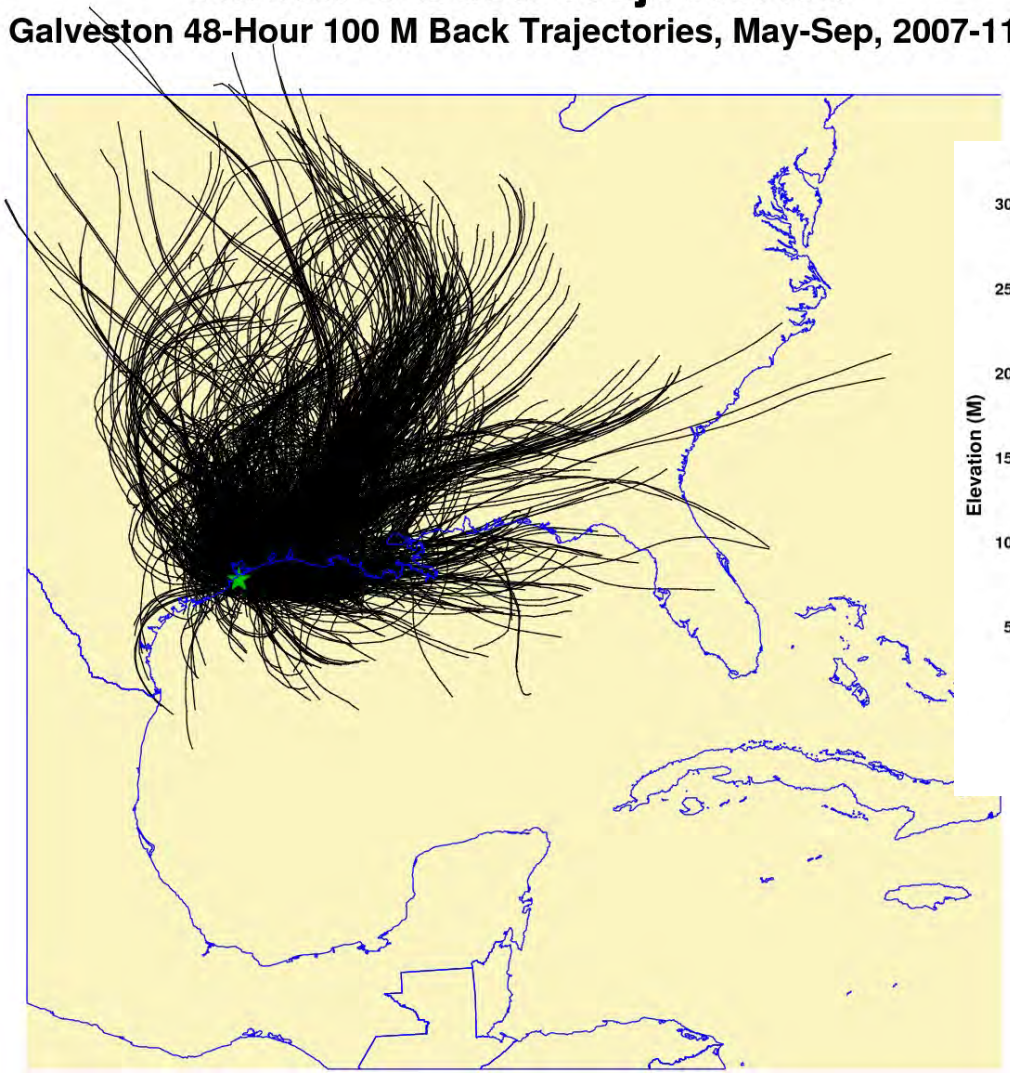


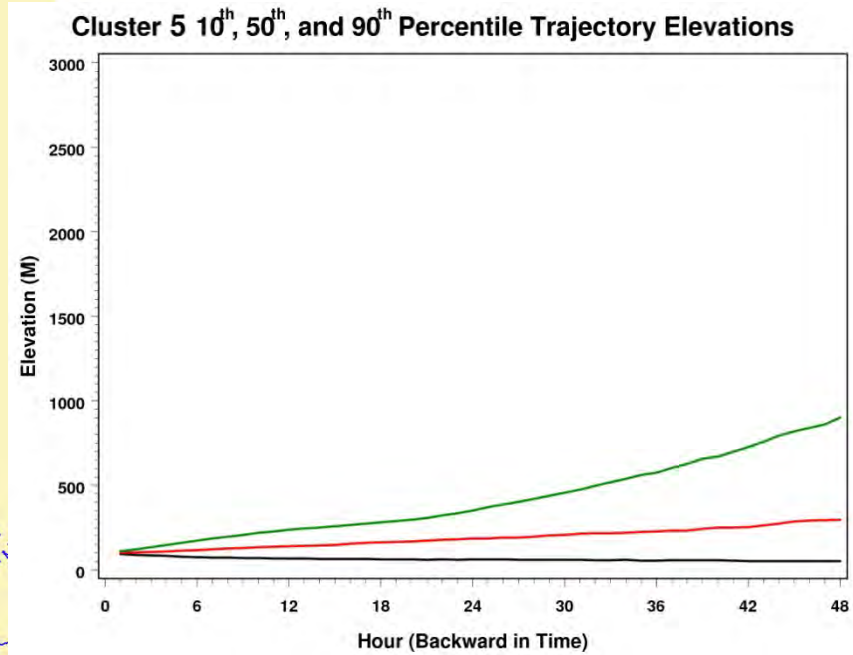
Cluster 4: 1095 Trajectories
Terminal Ozone Concentrations:

10th Percentile	17 ppb
Median	26 ppb
90th Percentile	44 ppb

Cluster 5 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

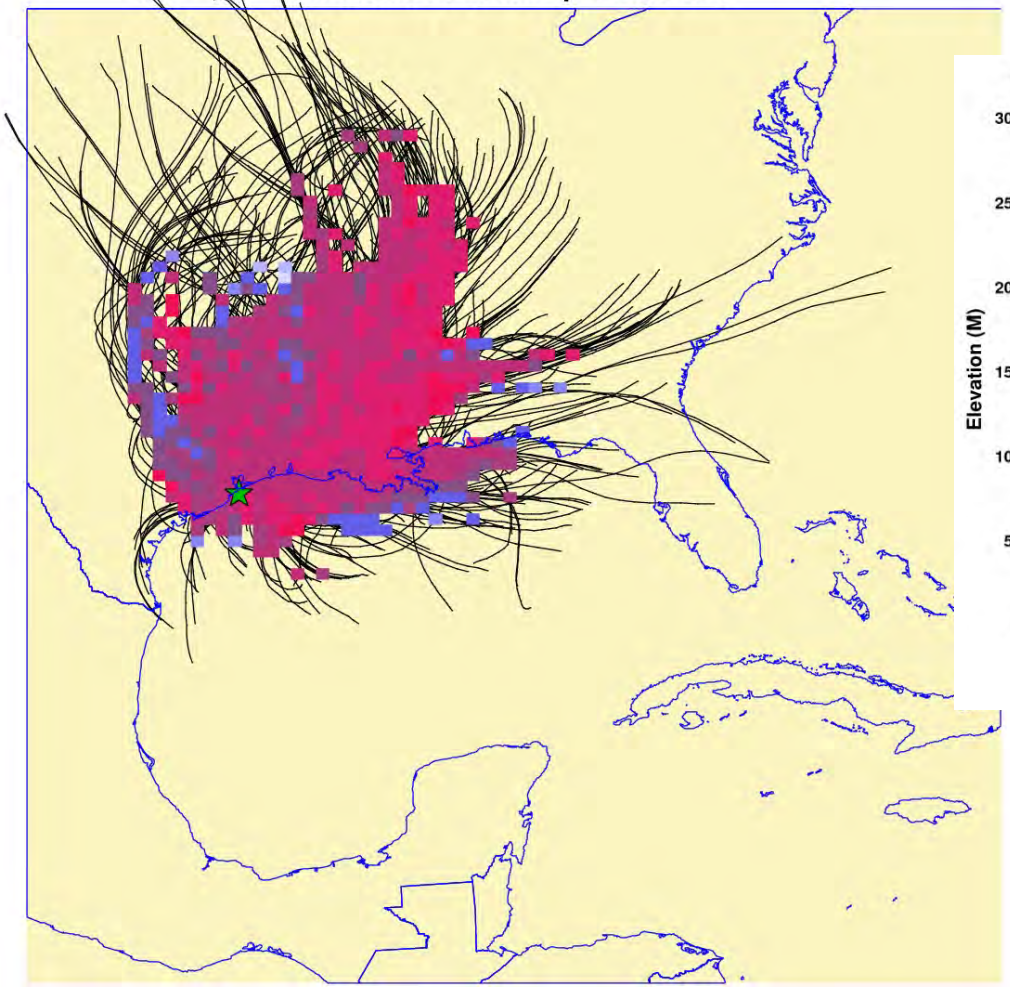


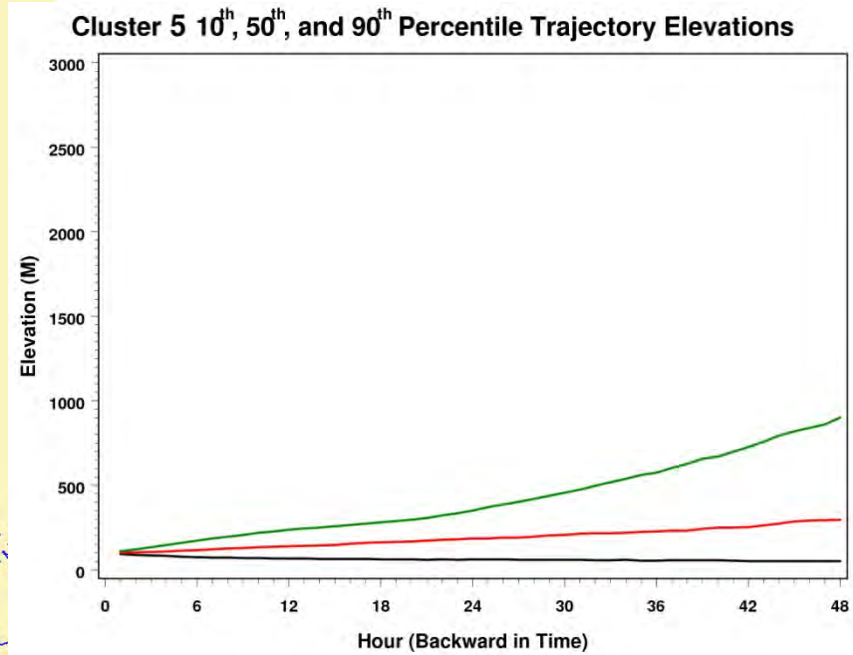


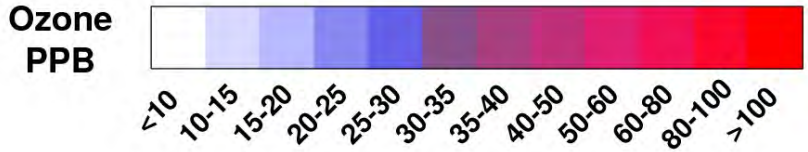
Cluster 5 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell







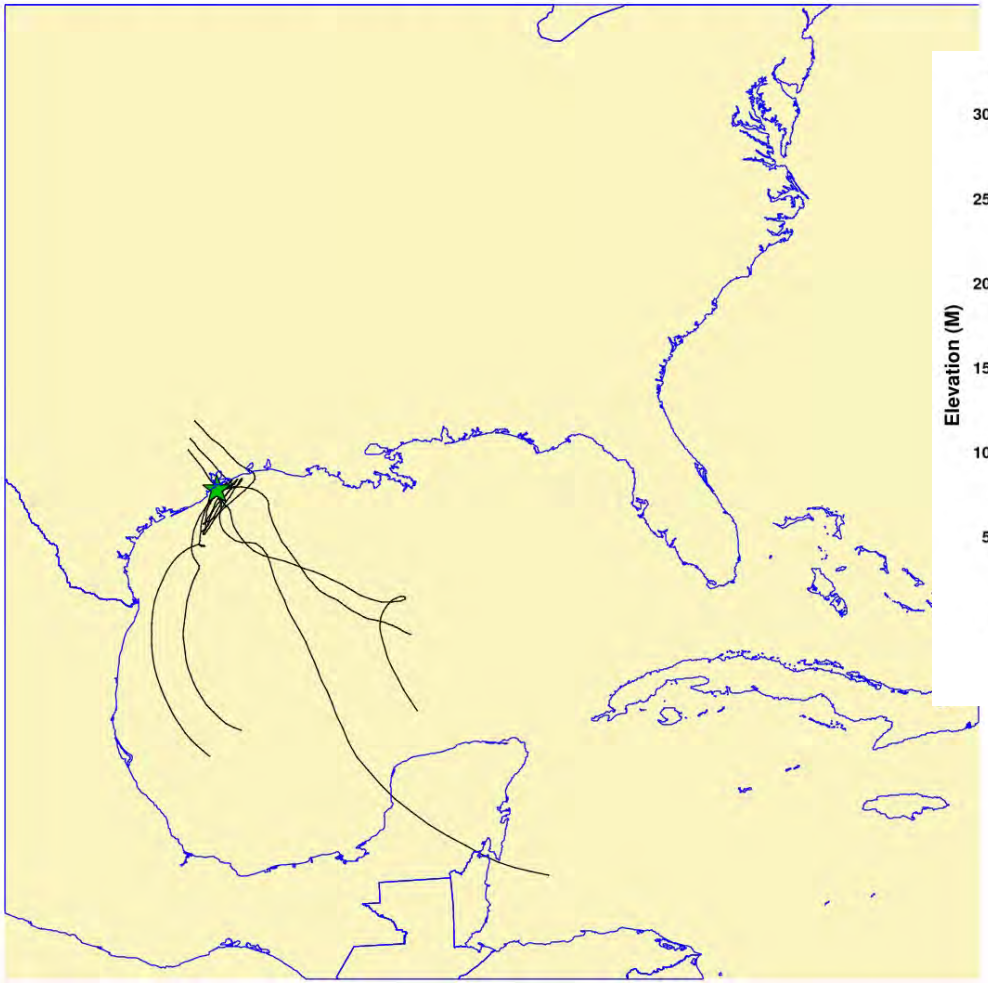
Cluster 5: 1058 Trajectories

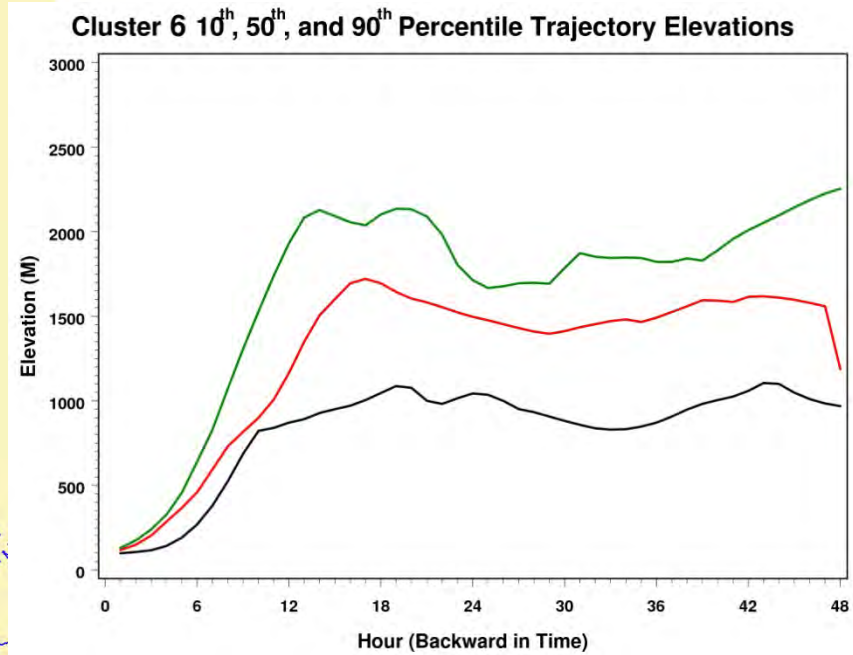
Terminal Ozone Concentrations:

10th Percentile	20 ppb
Median	46 ppb
90th Percentile	69 ppb

Cluster 6 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

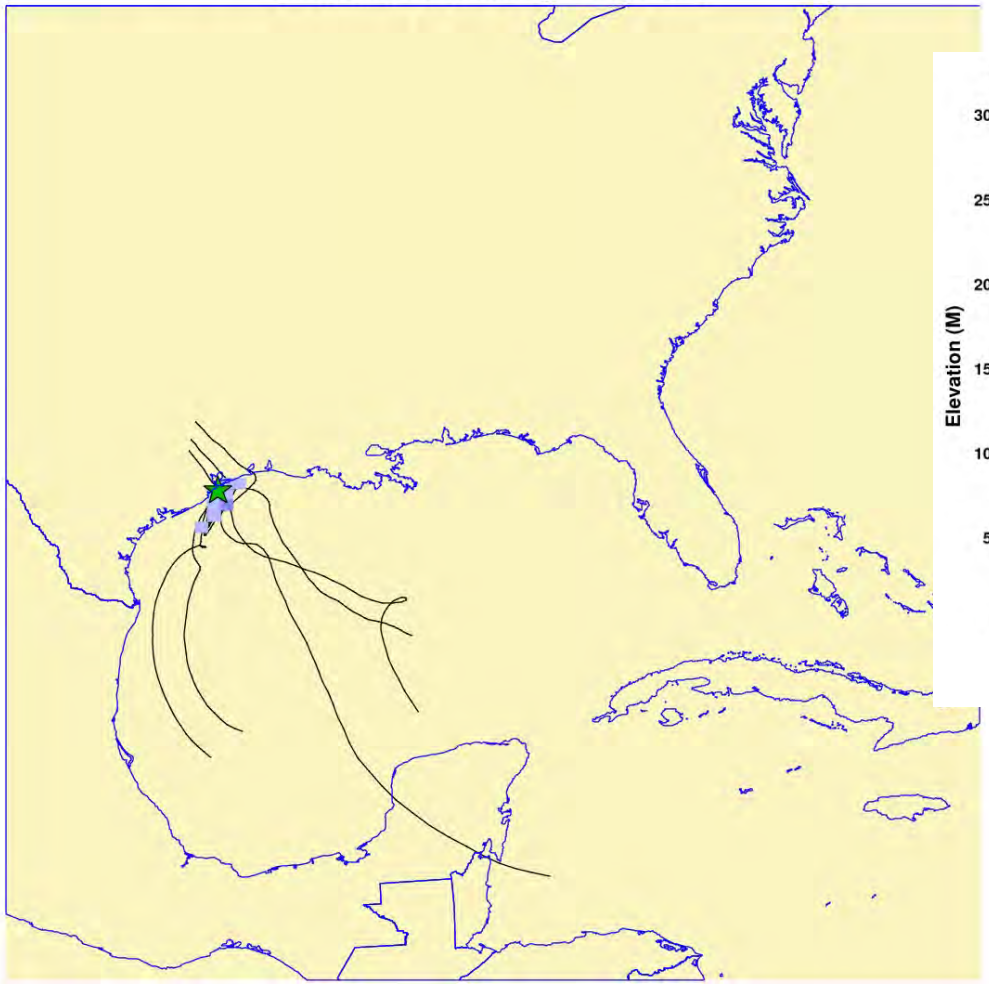


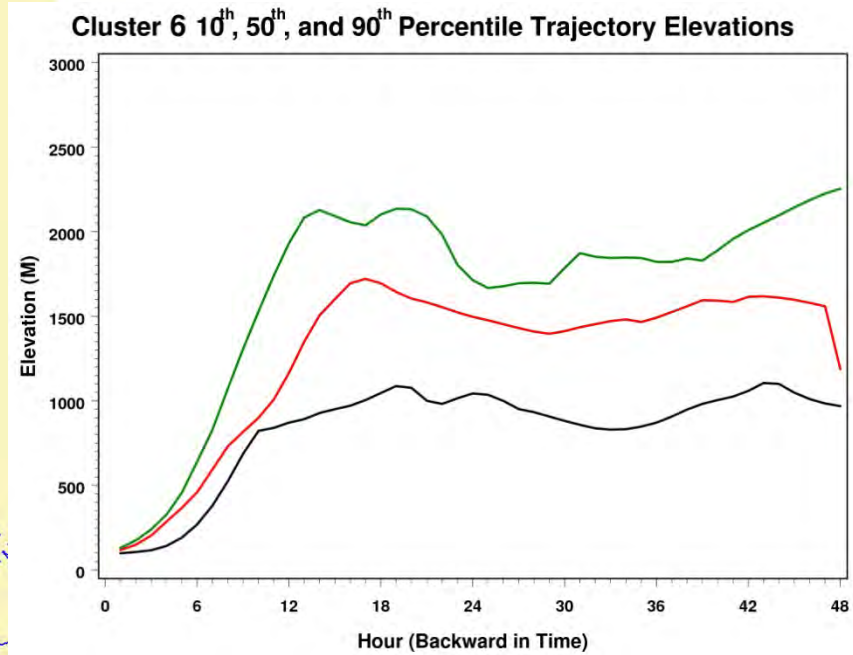


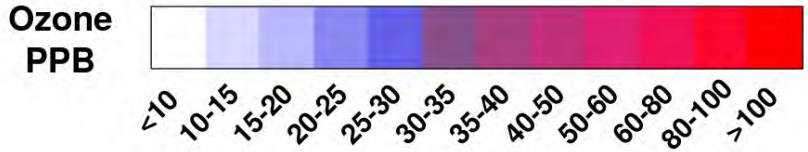
Cluster 6 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell





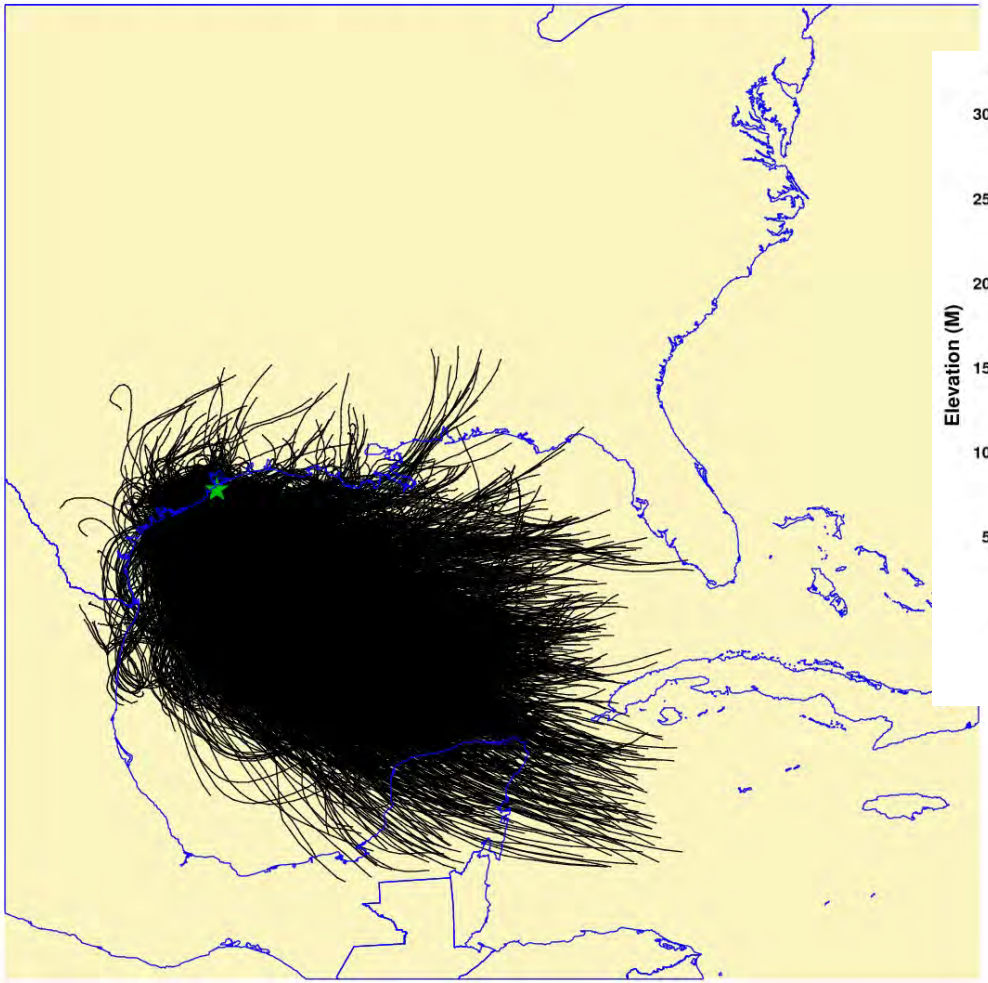


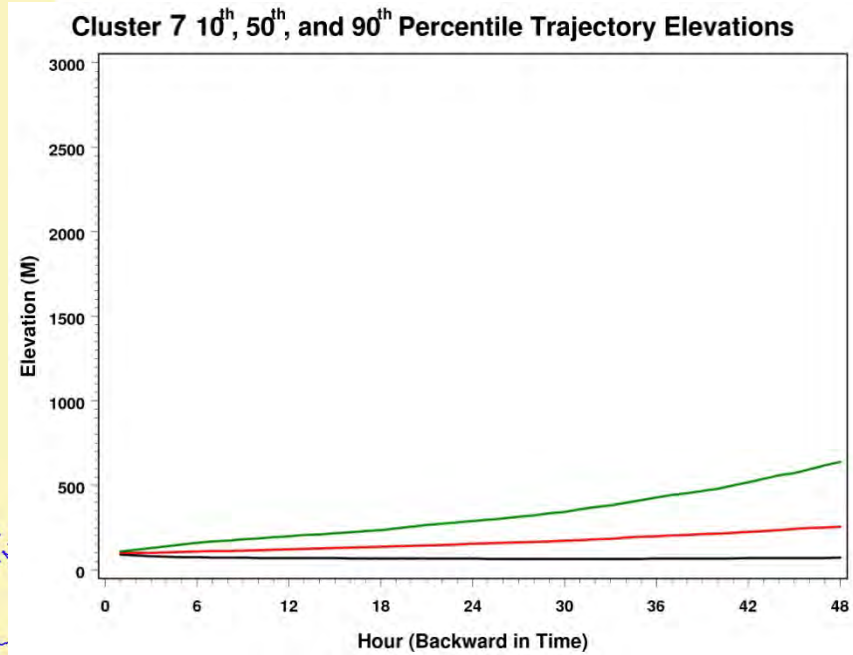
Cluster 6: 8 Trajectories
Terminal Ozone Concentrations:

10th Percentile	6 ppb
Median	19.5 ppb
90th Percentile	26 ppb

Cluster 7 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

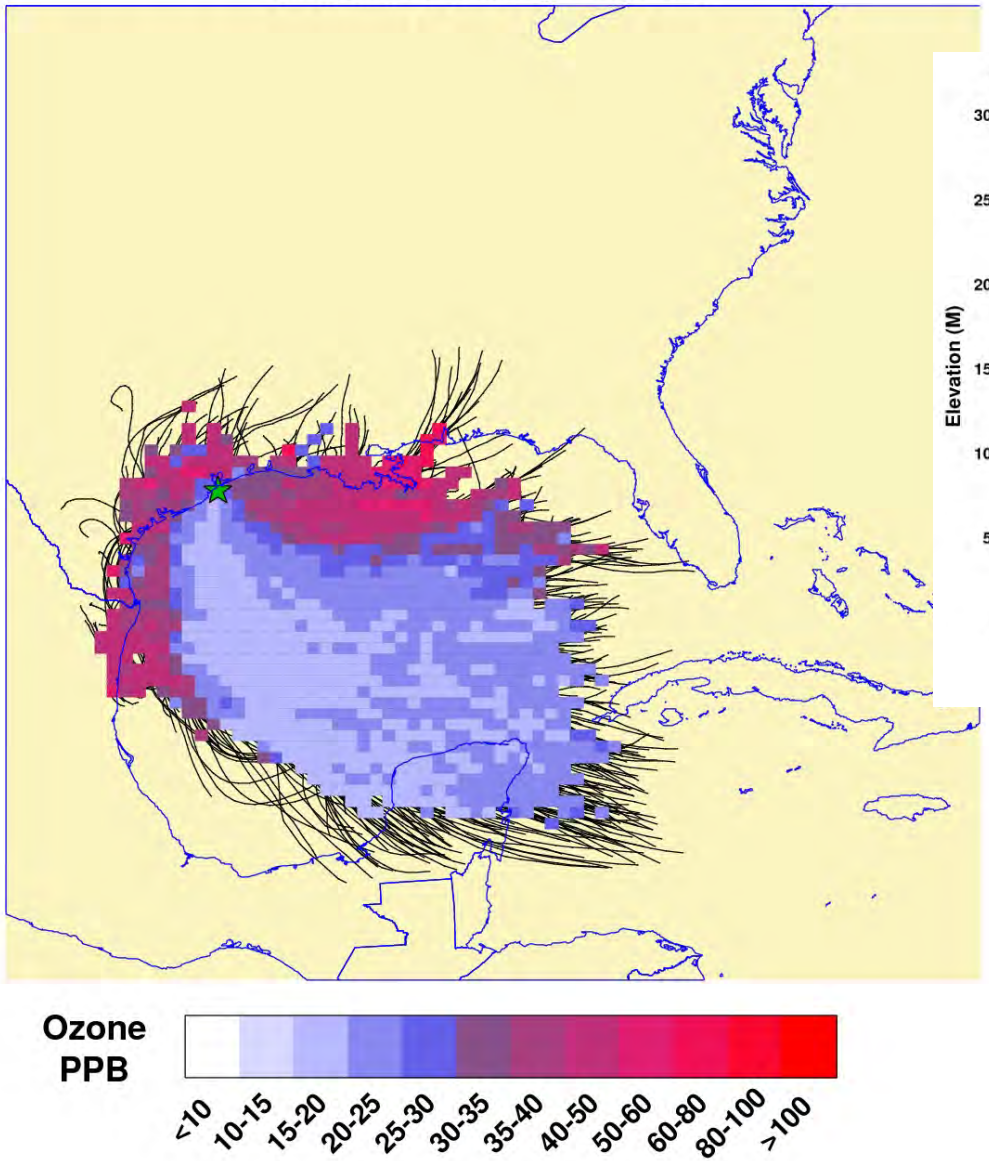


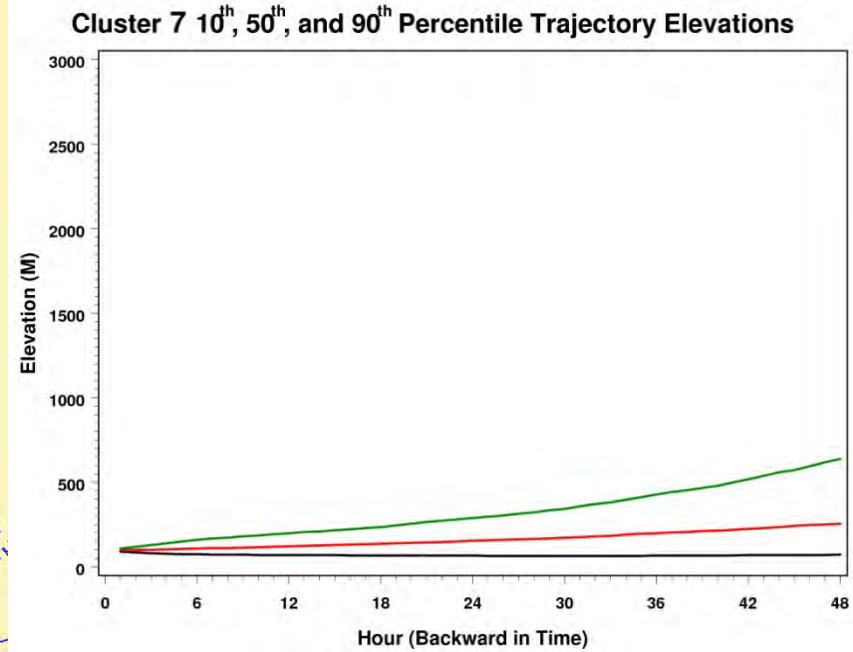


Cluster 7 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell





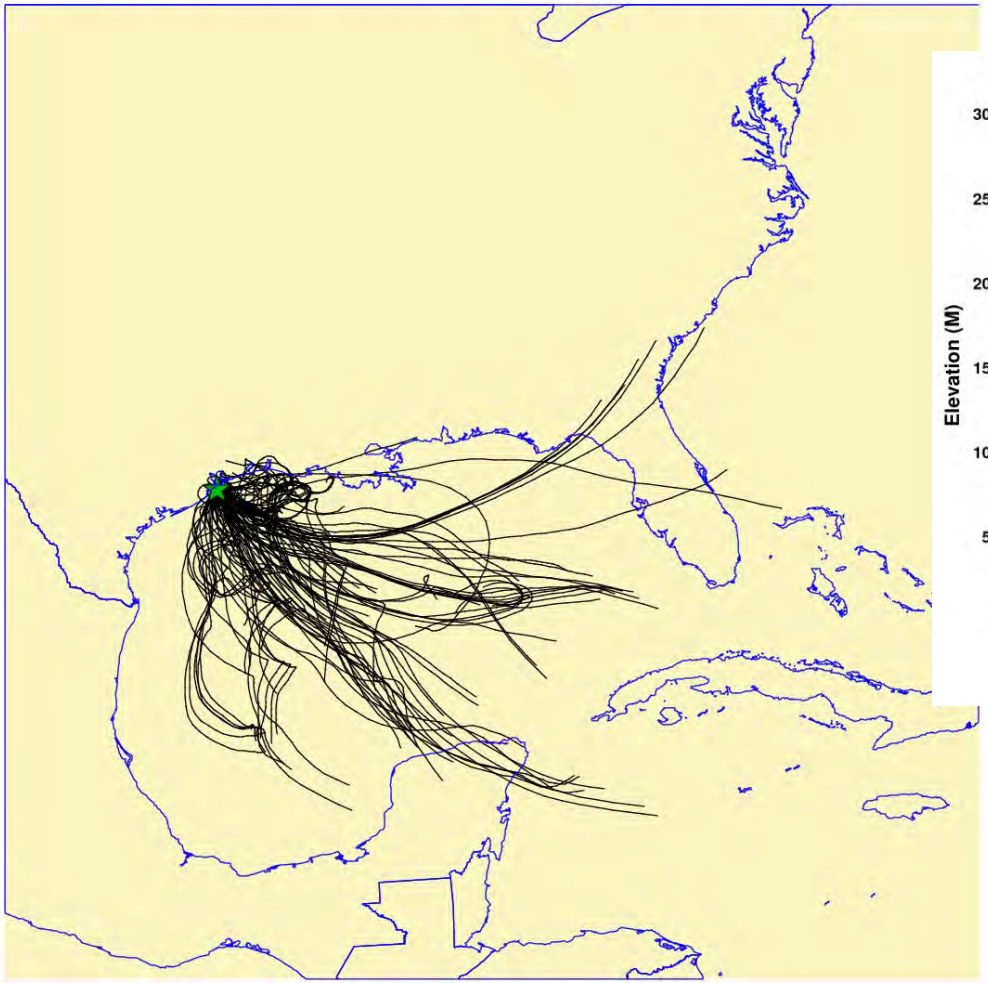
Cluster 7: 3638 Trajectories

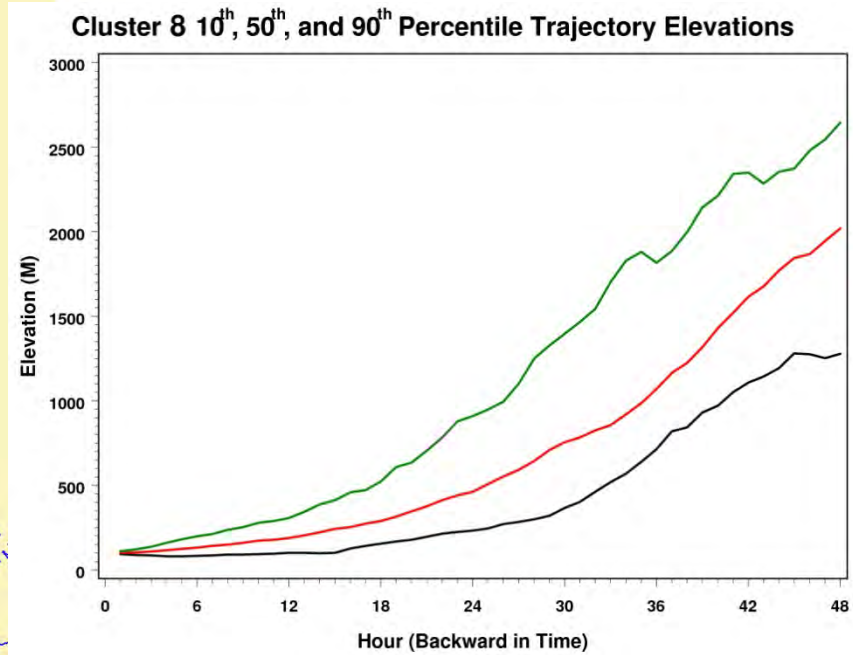
Terminal Ozone Concentrations:

10th Percentile	14 ppb
Median	21 ppb
90th Percentile	45 ppb

Cluster 8 Back Trajectories

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

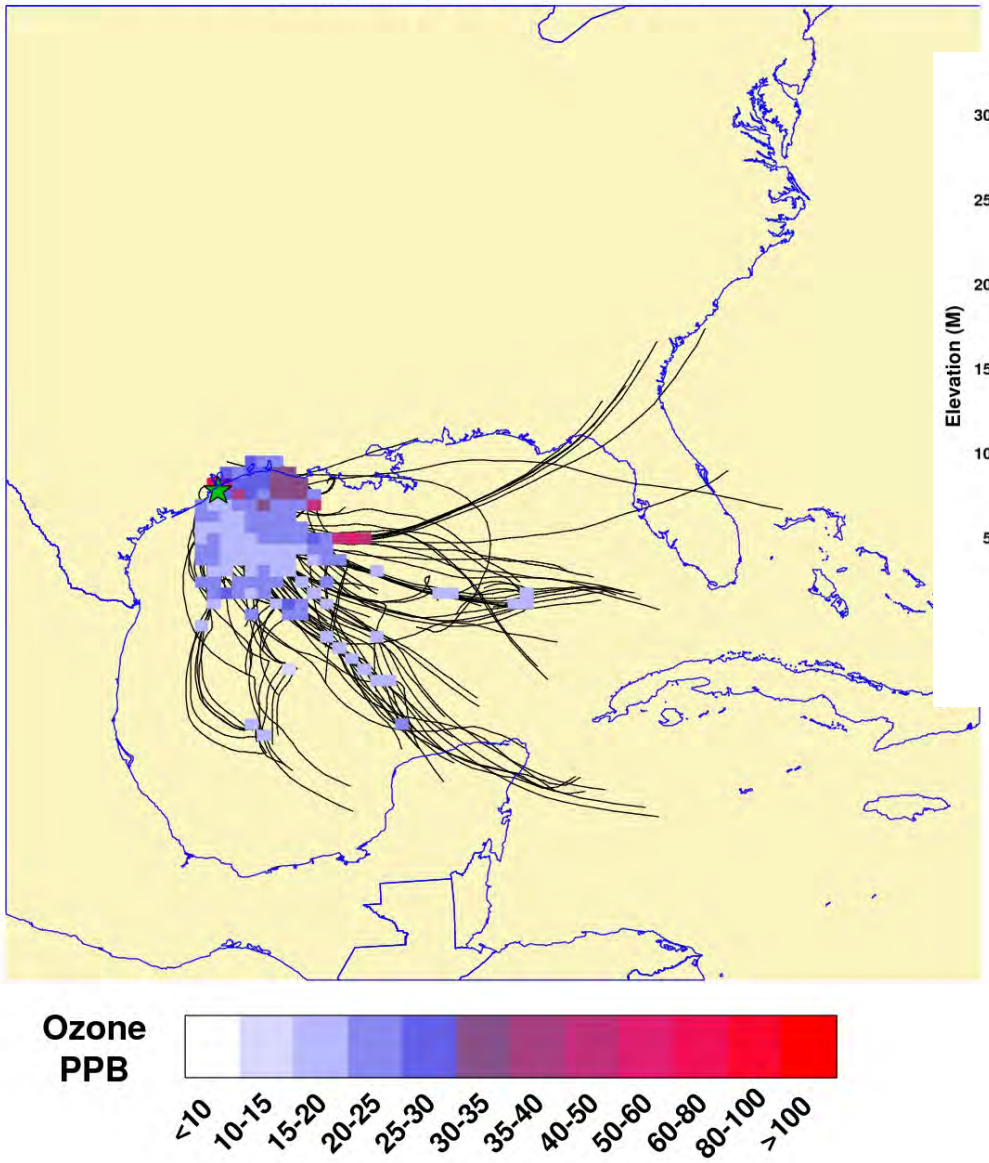


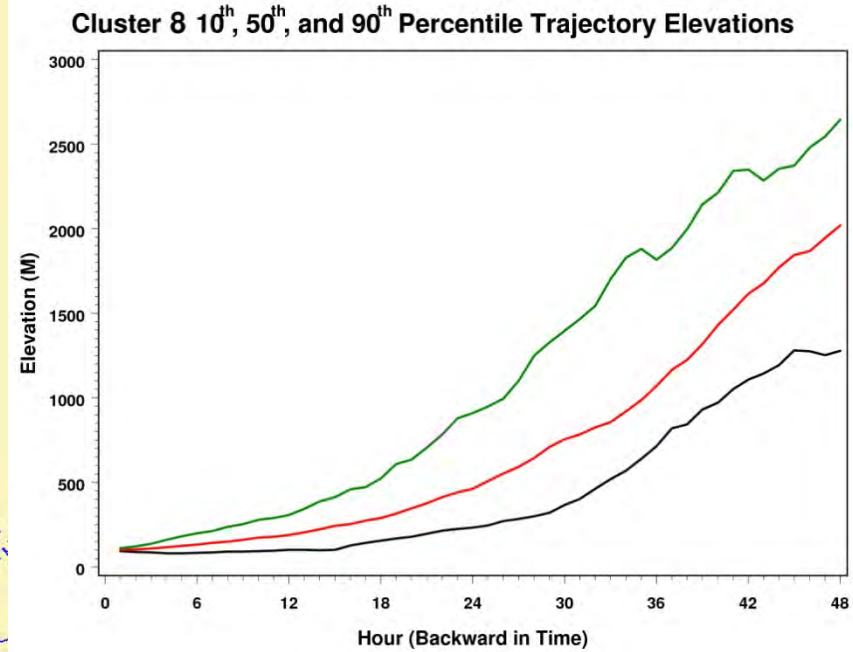


Cluster 8 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11

Minimum 10 Values per Grid Cell



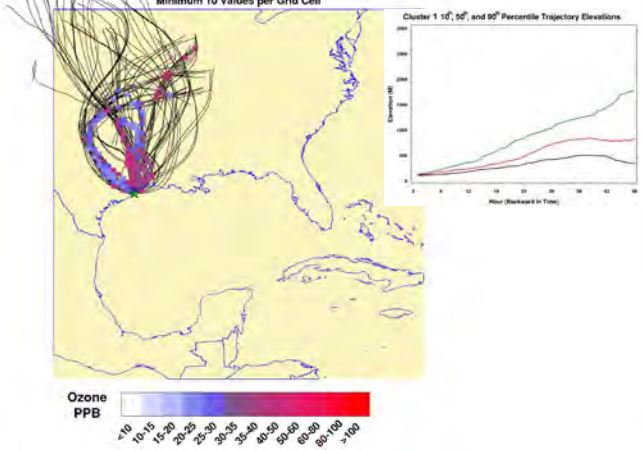


Cluster 8: 104 Trajectories
Terminal Ozone Concentrations:

10th Percentile	16 ppb
Median	21 ppb
90th Percentile	42 ppb

Cluster 1 Median Terminal Ozone Concentrations

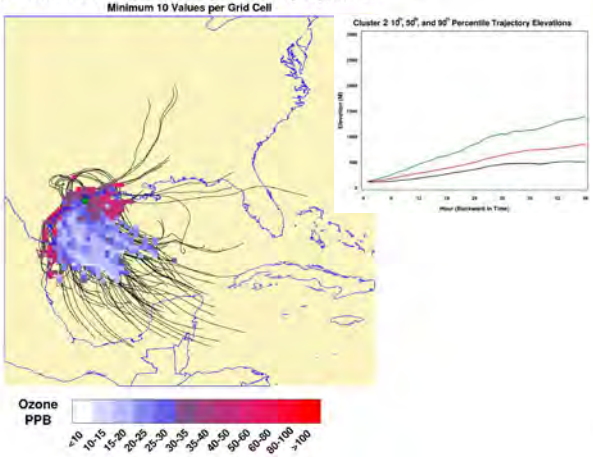
Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



104 Trajectories
10th Percentile O_3 20 ppb
Median O_3 34 ppb
90th Percentile O_3 49 ppb

Cluster 2 Median Terminal Ozone Concentrations

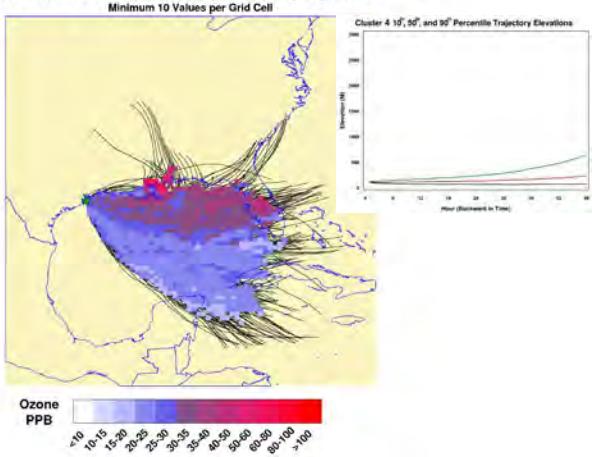
Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



417 Trajectories
10th Percentile O_3 13 ppb
Median O_3 24 ppb
90th Percentile O_3 49 ppb

Cluster 4 Median Terminal Ozone Concentrations

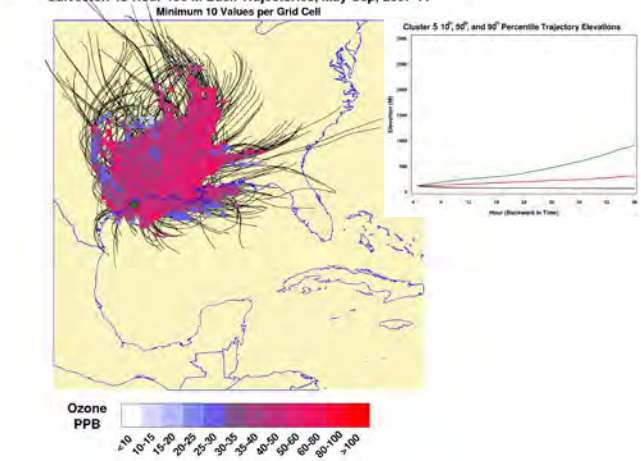
Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



1095 Trajectories
10th Percentile O_3 17 ppb
Median O_3 26 ppb
90th Percentile O_3 44 ppb

Cluster 5 Median Terminal Ozone Concentrations

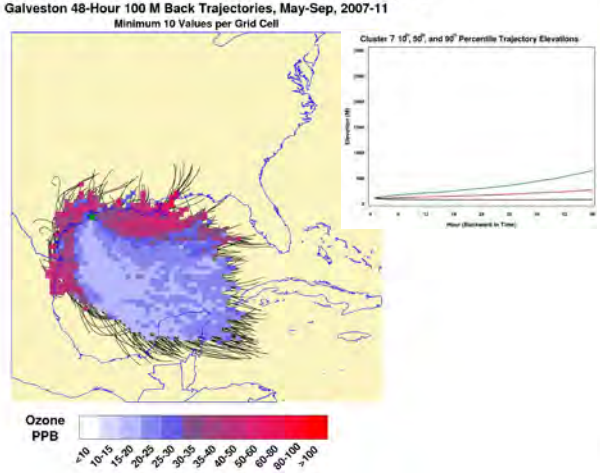
Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



1058 Trajectories
10th Percentile O_3 20 ppb
Median O_3 46 ppb
90th Percentile O_3 69 ppb

Cluster 7 Median Terminal Ozone Concentrations

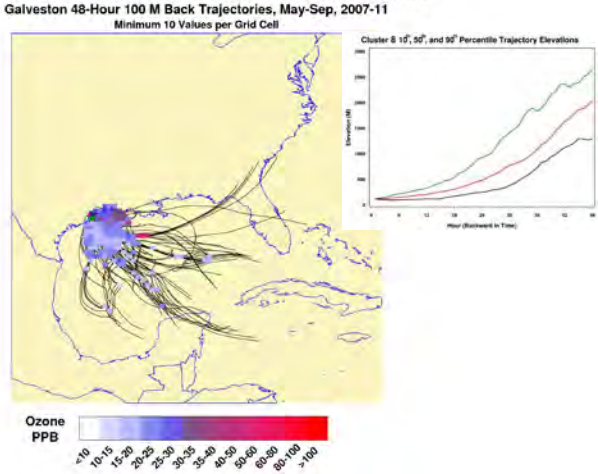
Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



3638 Trajectories
10th Percentile O_3 14 ppb
Median O_3 21 ppb
90th Percentile O_3 45 ppb

Cluster 8 Median Terminal Ozone Concentrations

Galveston 48-Hour 100 M Back Trajectories, May-Sep, 2007-11
Minimum 10 Values per Grid Cell



104 Trajectories
10th Percentile O_3 16 ppb
Median O_3 21 ppb
90th Percentile O_3 45 ppb

Conclusions

- Associating back-trajectories with terminal ozone concentrations provides an intuitive means for understanding the origins of transported ozone.
- Clustering the trajectories helps to further identify sources of high and low background, and provides insight into the vertical component of the transport path.

Conclusions

- The lowest ozone concentrations are associated with trajectories that remained over the central Gulf for at least 48 hours.
- Higher concentrations are associated with trajectories that pass close to the northern and western Gulf Coast.
- The highest concentrations are associated with trajectories that remain primarily over land.

Acknowledgement

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