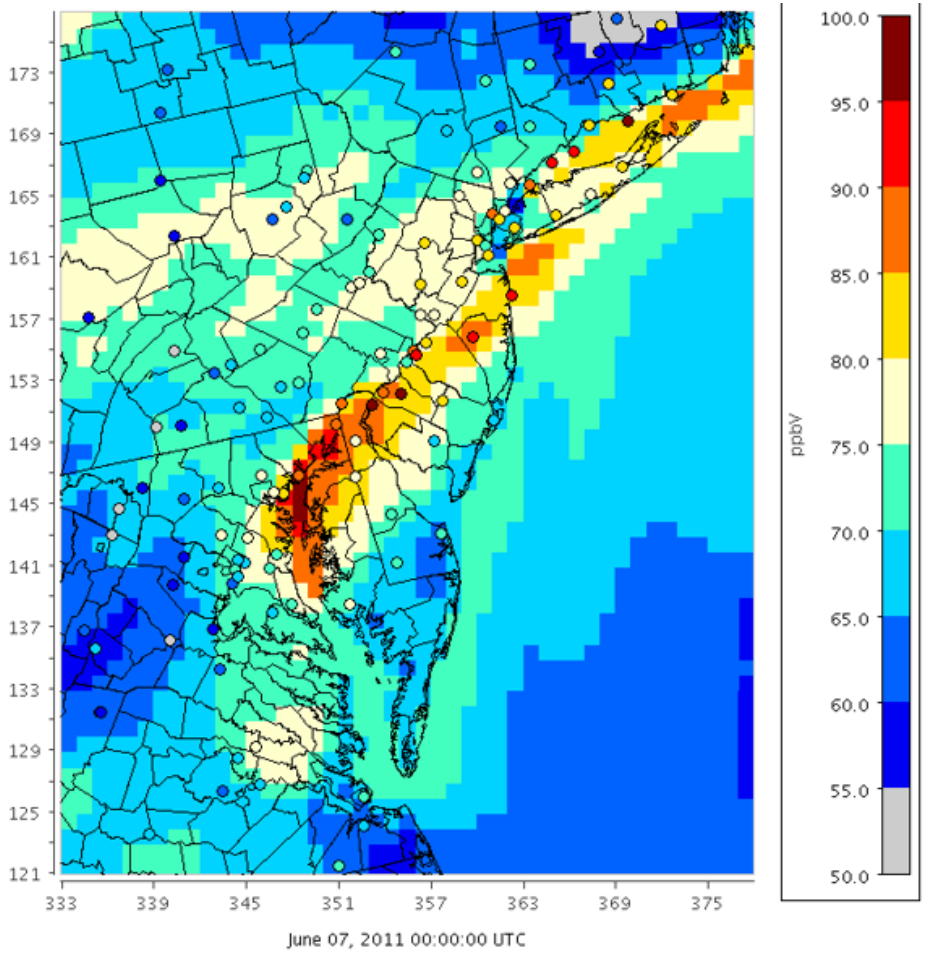
MLH issues in EPA OAQPS national modeling

- EPA's Office of Air Quality Planning and Standards utilizes photochemical grid models at the national scale to support a variety of Federal/State actions.
- As noted in Kevin and Jim's presentation in December, there are a number of concerns with respect to the model's ability to properly replicate the diurnal evolution of the mixed layer heights (MLH):
  - Depth of MLH and spatial variability
  - Diurnal evolution of MLH
    - Rate of rise of ML in the morning
    - Timing and duration of the evening transition back to the nocturnal layer
  - Impacts of multiple inversions within a single column and other issues
- Detailed model evaluation of MLH can be limited due to lack of data at national scale.
- New ceilometers coming online with PAMS network enhancements will be beneficial.

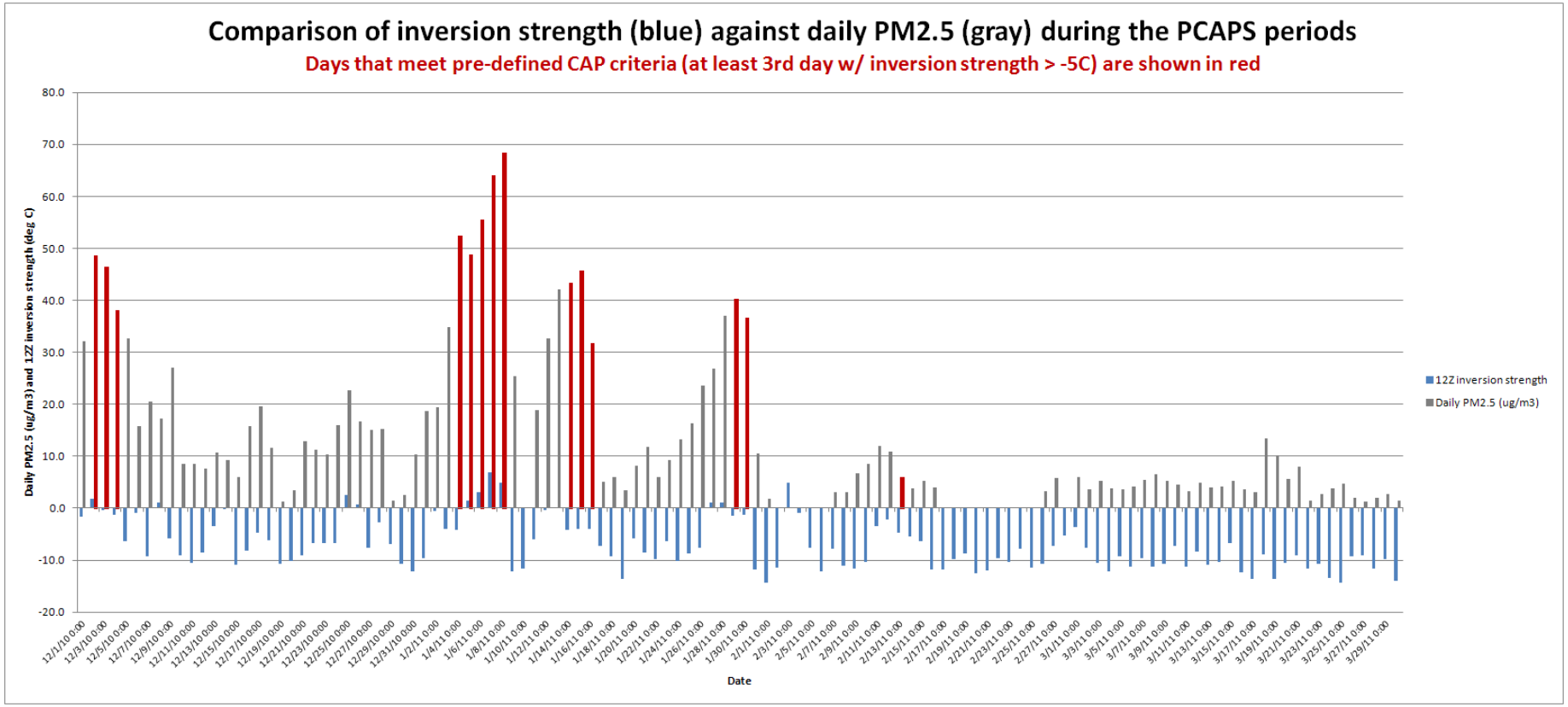
Depth of MLH and spatial variability (Example 1)

- As peak ozone levels have decreased across the U.S. over the past two decades, the locations with the highest monitored ozone levels in the EUS tend to be at sites with significant emissions near land/sea interfaces where significant MLH gradients may occur.
  - Examples: Long Island Sound, Chesapeake Bay, Lake Michigan, Galveston Bay.
- Plot on the right shows CAMx MDA8 O3 model performance for a sample day in 2011
  - Note high observations at some coastal locations
  - Note model preference for highest O3 over water (lower MLH, possible shipping influence)



Observed (circles) and model-estimated (gridded) maximum daily 8-hour O3 in the Northeast U.S.

Depth of MLH and spatial variability (Example 2)

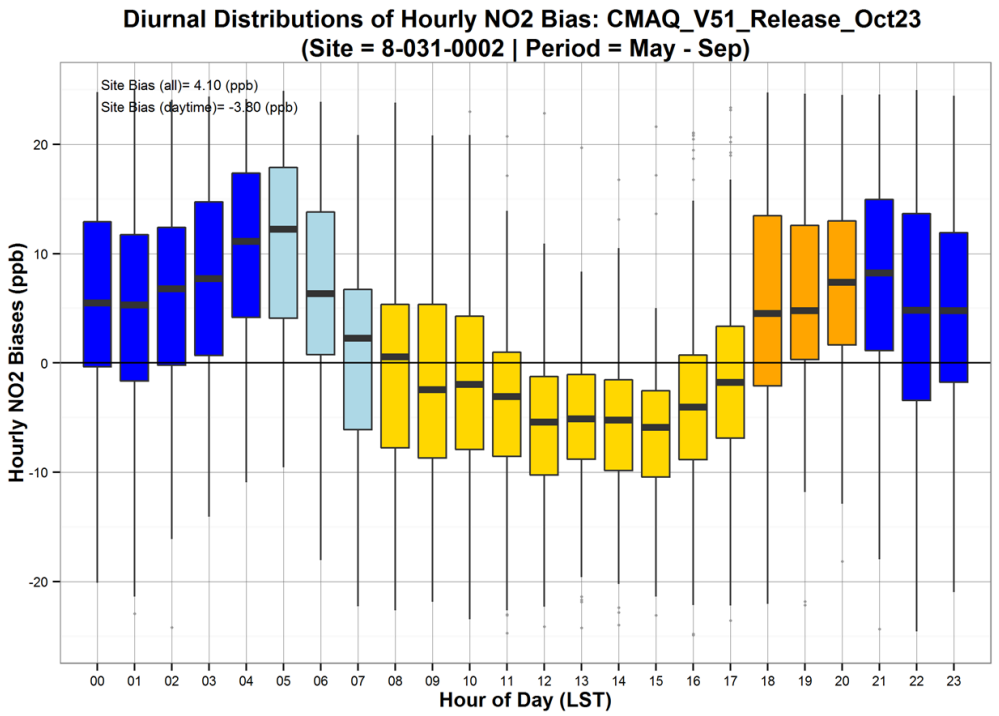


Time series of 12Z "inversion strength" (blue bars) and daily average PM2.5 concentrations (gray or red bars) for December 1st, 2010 – March 31st, 2011

- Some of the worst PM2.5 problems occur when emissions are co-located with shallow cold pools in the winter.
- Plot on the left shows correlation between high PM2.5 episodes in Salt Lake City and periods with extended shallow temperature inversions

Diurnal evolution of MLH (1/2)

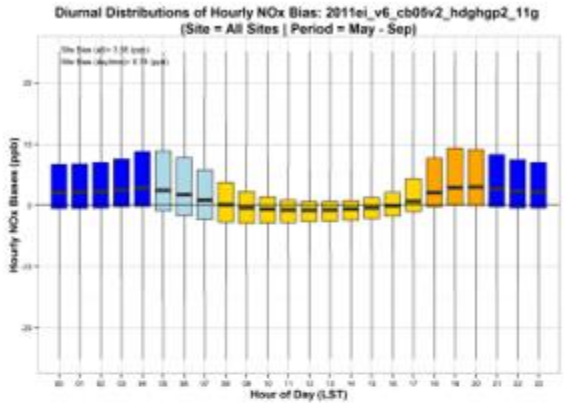
- It has been speculated that mobile emissions may be over-estimated in recent EPA modeling exercises (especially in urban locations).
- A variety of evidence has been introduced that suggests that characterization of mixing may also play a role in model over prediction, including plots like the one to the right which shows model NO_2 biases are greatest in early-morning and evening hours.
  - The time periods of greatest bias are roughly correlated with "rush hour" emissions, but they are also correlated with transitional periods in the daily mixing layer cycle.
  - One challenge has been how to tease out what portion of the detected model bias is due to possible improper evolution of the MLH cycle in the model.



Boxplots of hourly model NO2 bias in a 2011 CMAQ run averaged over a May – September period at a site in Denver

Diurnal evolution of MLH (2/2)

- Evidence supporting role of MLH in model bias:
  - Biases are highest at night and during ML transitions.
  - Incorporation of revised model mixing algorithms from Jon Pleim improved NO2 biases in 2011 model simulation in transition hours (see plots to the left)
- Evidence against role of MLH in model bias:
  - Similar bias is seen in multiple modeling systems with differing meteorological inputs.
  - In some locations, the model bias is less on weekends with reduced emissions but unchanged (on average) MLH.
- As PAMS ceilometer measurements become available in 2018/2019, we will be able to perform better evaluation of model MLH.
  - Otherwise relying on limited LIDARs, limited field study data, and/or limited rawinsonde observations.



CMAQ v 5.02

CMAQ v 5.1

Boxplots of hourly model NO2 bias for two 2011 CMAQ runs (May–Sep, all site average)

Closing thoughts re: MLH & national AQ model simulations

- More routine MLH measurements will improve evaluation of the meteorological inputs and correspondingly should lead to improvements in AQ model performance
  - Will need to have close collaborations between modelers and measurement experts to ensure that we are comparing like quantities when we do these evaluations.
  - Modelers will also need to understand the precision/quality of the MLH data.
  - Beyond assisting in better model performance evaluations, we also anticipate that well-sited MLH measurements will improve conceptual models describing conditions in which poor AQ occurs.

- Measurements may be more valuable in some areas than in others.
  - Areas with poor AQ in coastal environs or complex terrain (conducive to shallow inversions) would likely benefit most from measurements of MLH magnitudes and evolution.

- EPA OAQPS looks forward to continued interaction with the community of experts that comprise this ad-hoc group.