Spatial and Temporal Variability of Trace Gases over the Eastern United States derived from regional model output

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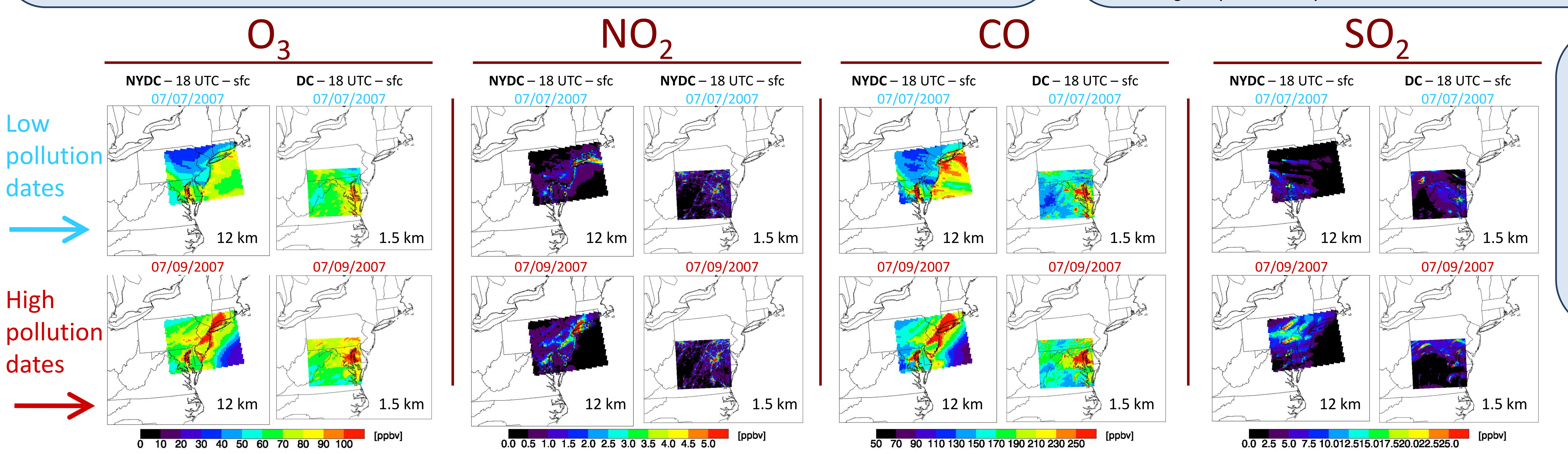
Motivation

- Due to its geostationary orbit, the GEOstationary Coastal and Air Pollution Events (GEO-CAPE) mission will have the capability of both high temporal and spatial resolution.
- In order to specify the temporal and spatial resolution needed to properly monitor O_3, NO_2, CO, and SO_2 we have used regional model output to calculate the decay of horizontal, vertical, and temporal correlations in space and time.
- We have chosen a high pollution day and a low pollution day from each run on which to do our calculations

Data

•WRF/Chem (Weather Research and Forecasting model)
- •12 km domain over entire Eastern United States, nested in a 36 km domain covering the entire US
- •31 levels in the vertical up to 110 hPa, one hour output interval
- •Subsetted to the New York to Washington DC region (**NYDC** run)

•CMAQ (Community Multiscale Air Quality Model)
- •1.5 km over Baltimore/Washington, DC and areas upwind, nested in a 4.5 km domain, nested in a 13.5 km domain
- •30 levels in the vertical up to 90 hPa, one hour output interval
- •Entire 1.5 km domain used for analysis (**DC** run)



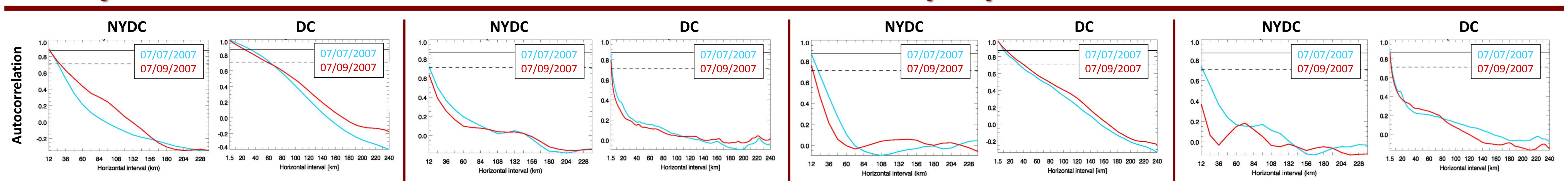
•Each figure shown is 18 UTC, corresponding to 1 pm local standard time

•On each autocorrelation and correlation plot, two lines are drawn.

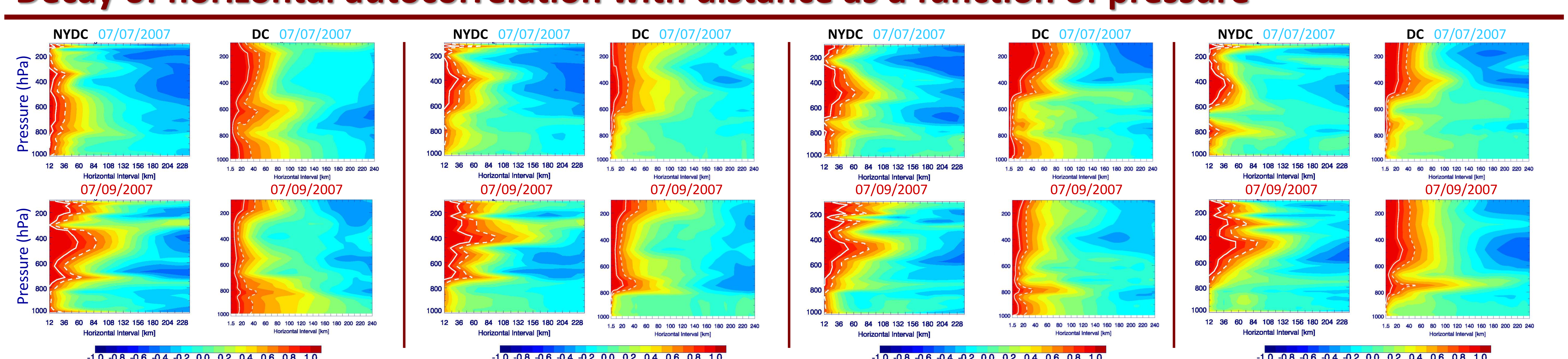
•**The dashed line is the 0.7 contour, representing the ~50% explained variance (EV) threshold**

•**The solid line is the 0.87 contour, representing the ~75% explained variance threshold**

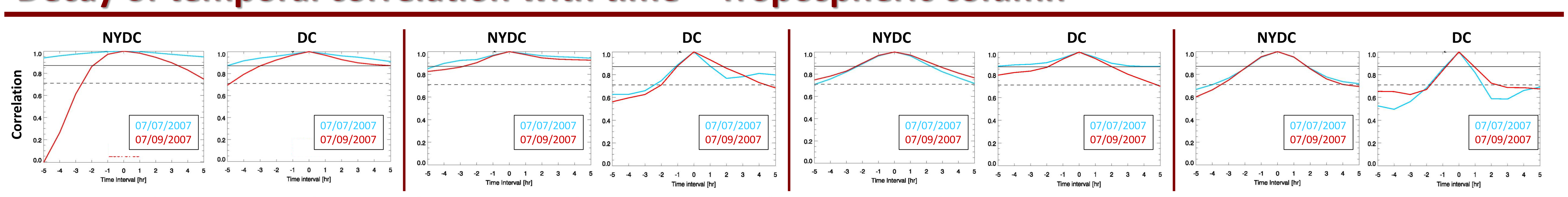
Decay of horizontal autocorrelation with distance – Tropospheric column



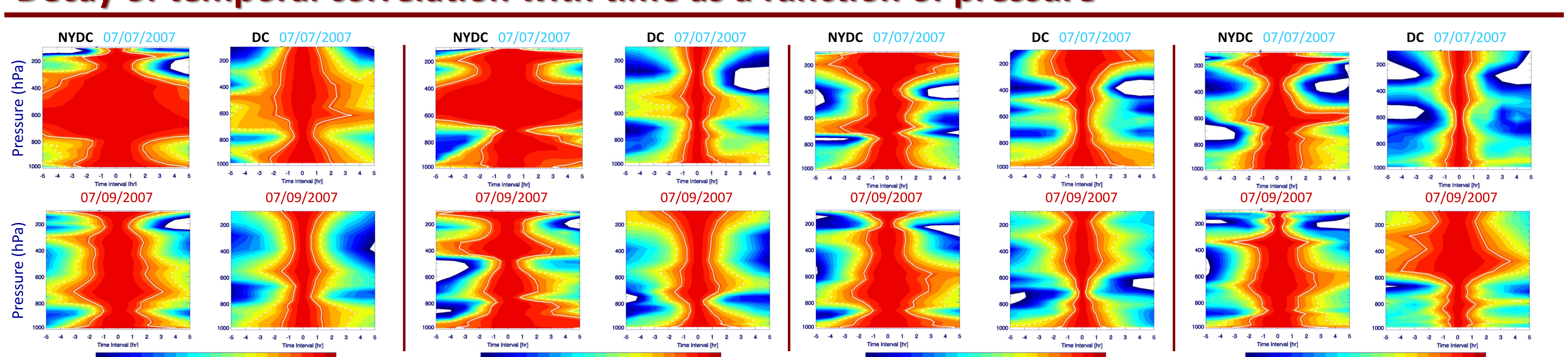
Decay of horizontal autocorrelation with distance as a function of pressure



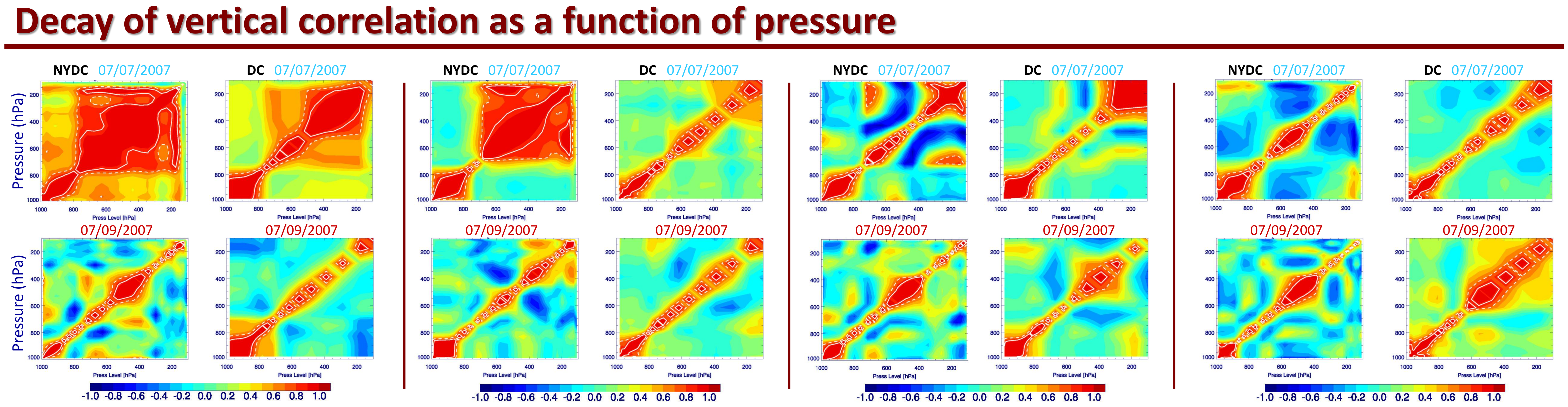
Decay of temporal correlation with time – Tropospheric column



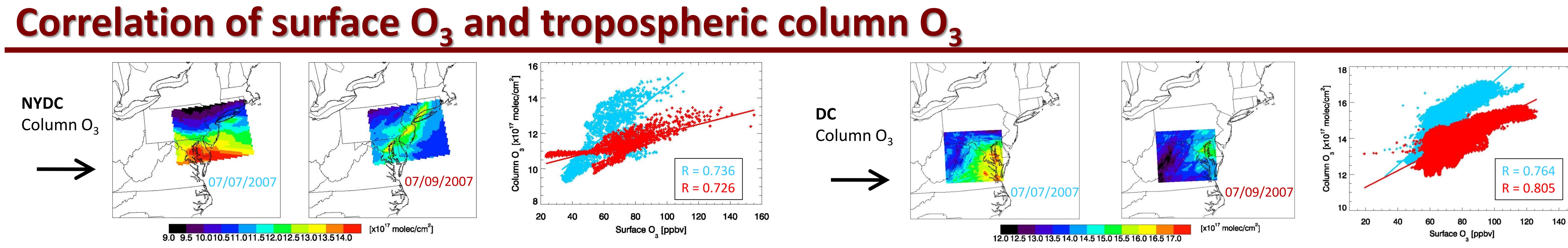
Decay of temporal correlation with time as a function of pressure



Decay of vertical correlation as a function of pressure



Correlation of surface O_3 and tropospheric column O_3



Conclusions

- ▪The NYDC results show that **better than 12 km resolution is needed if at least 75% EV is desired**. Ozone and CO on a low pollution day display better than 50% EV, however NO_2 and SO_2 require finer resolution for this threshold.
- ▪**The 1.5km DC run indicates that O_3 and CO, with CO as the limiting species, can be observed with 10 km horizontal resolution for a 75% EV limit, and 30 km for 50% EV. The results for NO_2 and SO_2 however barely reach 75% EV, even at the 1.5 km resolution of the model run.** Both begin above the 50% EV threshold, and then rapidly fall off, crossing at 3 km.
- ▪If a 90% EV threshold were desired, the DC run shows O_3 would need a horizontal resolution of 12 km for low pollution days, and 8 km for high pollution days. CO requires 4 km for both low and high pollution days.

- ▪Both the 12 km and 1.5 km runs show a dramatic gradient in the autocorrelations for NO_2 and SO_2 going from the boundary layer (BL) to the free troposphere (FT).
- ▪In the mid – upper troposphere (~500 hPa), the NYDC run shows 75% EV at a 48 km horizontal resolution for all four species on the high pollution day.
- ▪The DC run shows 75% EV out to 30 km for O_3 in the upper troposphere (UT), and out to 50 km for CO in the UT for the low pollution day.

- ▪The NYDC 12 km results indicate that on low pollution days, this resolution can capture O_3 and NO_2 variability on timescales of five hours. However **on a polluted day, O_3, CO, and SO_2 required temporal resolutions of two hours for 75% EV**. For a 50% EV threshold, O_3 appears to be the limiting species, needing a resolution of three hours for this pollution event.
- ▪**NO_2 and SO_2 are the limiting species for the DC 1.5 km results. Both require a temporal resolution of one hour for 75% EV**, and two hours for 50% EV.
- ▪The temporal resolution needed for 90% EV for O_3 is ~2 hours for a low pollution day, and ~1 hour for a high pollution day. CO, NO_2, and SO_2, would require temporal resolutions of 0.5, 0.5, and 0.25 hours, respectively, for both low and high pollution cases.

- ▪In the NYDC run, O_3 and NO_2 show the slowest decay in the FT on the low pollution day.
- ▪Overall, the DC 1.5 km run appears to show a faster decay of temporal correlation as a function of pressure than the NYDC 12 km run. The most rapid decay is seen in SO_2 and NO_2 on the low pollution day, throughout the troposphere.

- ▪The NYDC run shows O_3 and NO_2 are very well mixed throughout the FT on the low pollution day. All other species and times indicate fairly rapid decay.
- ▪In the DC run, O_3 and CO are better mixed throughout the BL than NO_2 and SO_2. All four species, excluding O_3 on the low pollution day, show rapid decay in the FT.

- ▪**The higher resolution model run yields better correlations between surface O_3 and tropospheric column O_3**
- ▪**The highest EV (65%) is seen in the 1.5 km DC run, for the high pollution day**