Surface Ozone and Climate Change

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Motivation

Surface ozone pollution will be a concern in the coming decades. We analyze modeled surface ozone's seasonal cycle variability, long-term variability, and its correlation to atmospheric circulation. We will show which effects are due to changing emissions of ozone precursors and which are due to meteorological changes.

Conclusions

•With and without changes in emissions, mean ozone decreases over the Pacific with climate change.

•Smaller jet speeds are linked to less surface ozone over the Pacific.

•With and without changes in emissions, ozone seasonality changes.

•Amplitude of the seasonal cycle depends on emission changes.

•Shift of seasonal cycle appears to be aligned with winds.

References

- Barnes, E. A., and A. M. Fiore (2013), Ozone variability, jet, and climate change, *Geophys. Res. Lett., 40,* 1-6.
- Meinshausen, M., et. al (2011), The RCP greenhouse gas concentrations and their extensions from 1765 to 2300, *Climatic Change, 109,* 213–241.
- Parrish, D. D., et. al (2013), Changing ozone seasonal cycle, *Geophys. Res. Lett., 40,* 1631-1636.

Acknowledgements

This work has been supported by the National Science Foundation Science and Technology Center for Multi-Scale Modeling of Atmospheric Processes, managed by Colorado State University under cooperative agreement No. ATM-0425247.

Results: Ozone Seasonality

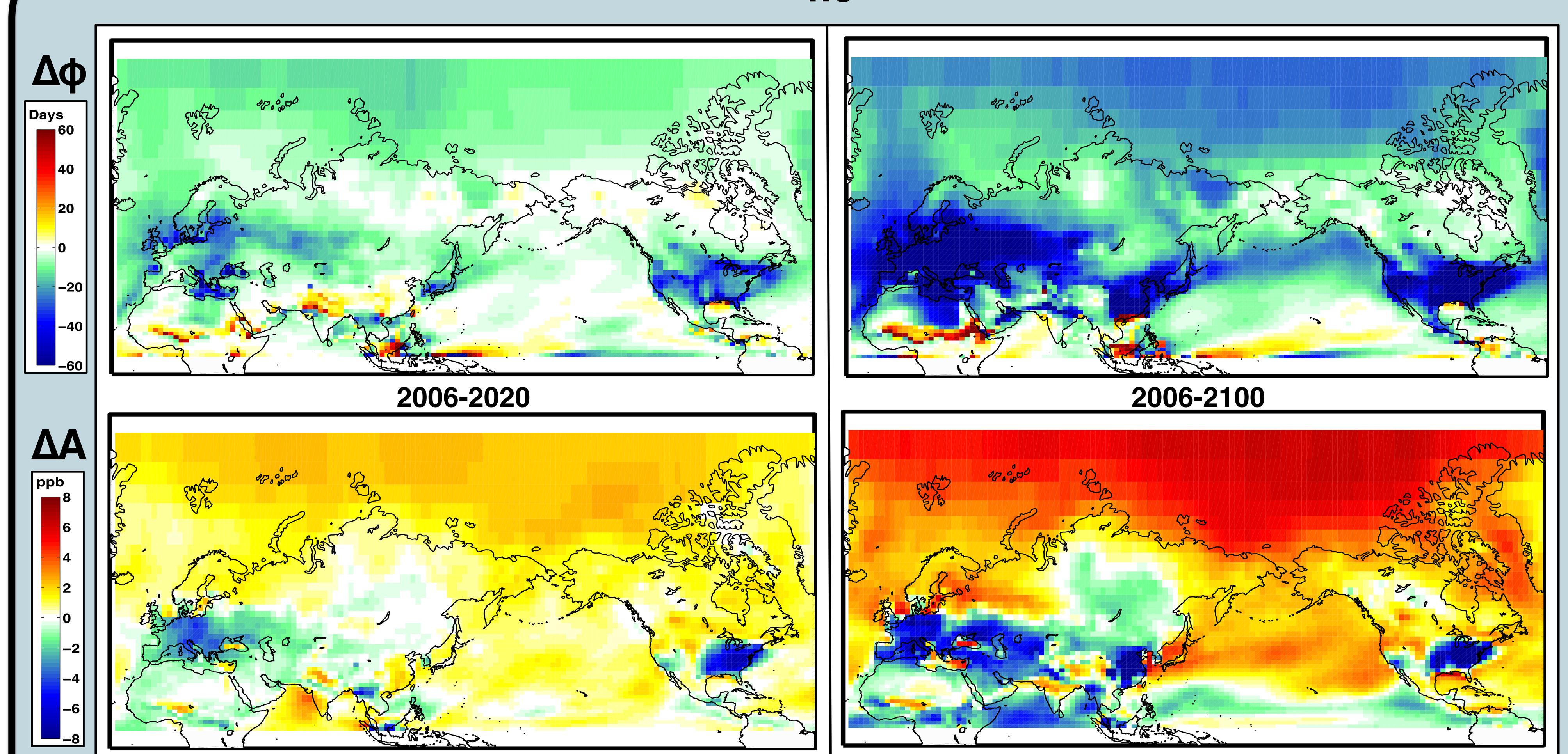

Figure 2: 4.5 seasonal cycle changes including short and long-term phase shifts (Δφ) and changes in amplitude. Negative values in Δφ denote shift of the seasonal cycle to earlier in the year, while positive values represent a shift to later.

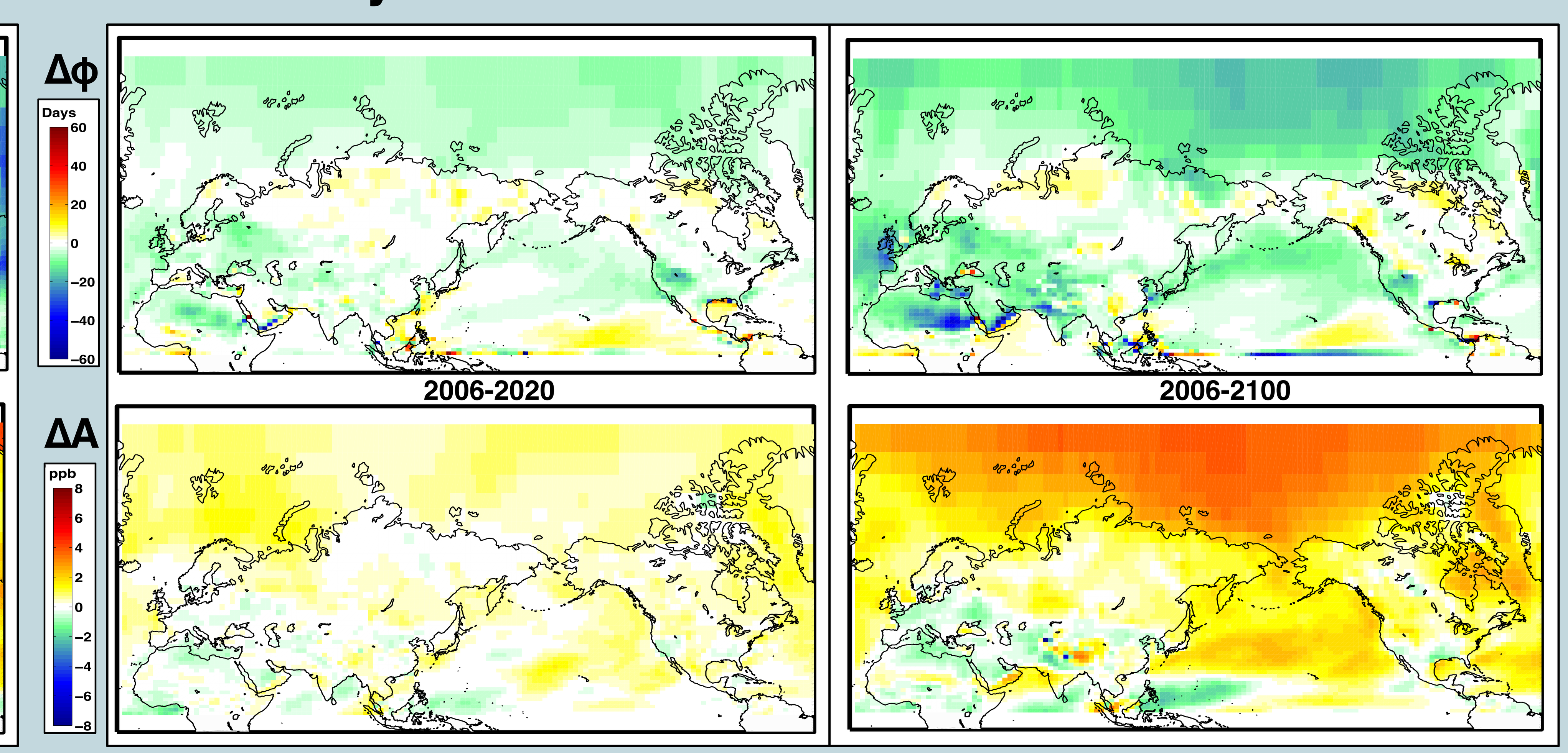

Figure 3: 4.5 seasonal cycle changes including short and long-term phase shifts (Δφ) and changes in amplitude.*

- **RCP 4.5:** Phase shift changes drastically over the continents, peaking over two months earlier in the year in some areas. The amplitude change shows that the seasonal cycle in these regions is not shifting, but rather is decreasing in amplitude such that the old maxima become the new minima.
- **RCP 4.5*:** Seasonal cycle shifts due to climate change. The small positive changes in amplitude in 4.5* confirm that this is a true shift rather than a case of amplitude changing the maxima of the cycle.

- Phase change patterns over the Pacific and other areas coincide with the winds in RCP 4.5*.
- Circulation could have a large role in affecting the seasonal cycle of ozone, but more research would be required to know to what degree.

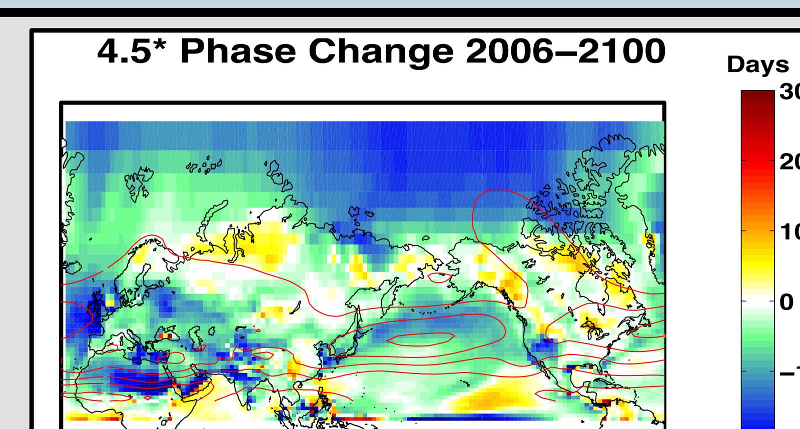

Figure 4: 4.5 long-term seasonal cycle. Wind contour in red. Colorbar adjusted to show detail.*

Background

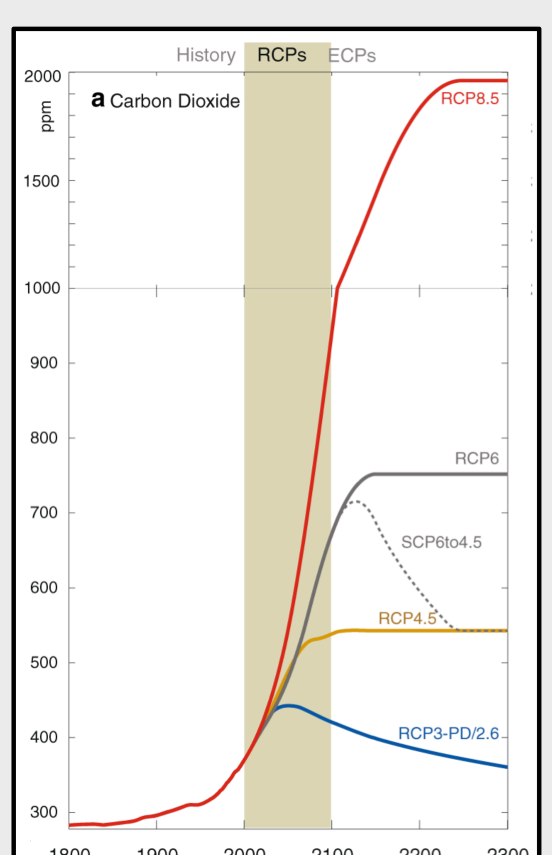

Figure 1: CO_2 RCPs of the CIMP5 model.

- Focus: Surface O_3 and 500mb zonal winds 2006-2100.
- Model used: GFDL coupled chemistry climate model (CM3) from IPCC's CMIP5.
- Representative Concentration Pathway (RCP) 4.5 and 4.5* used.

- 4.5*: Aerosol and ozone precursor emissions held fixed at 2005 levels to see effects due to emission changes and climate change.
- Three-member ensembles averaged together.

Results: Ozone and the Jet Stream

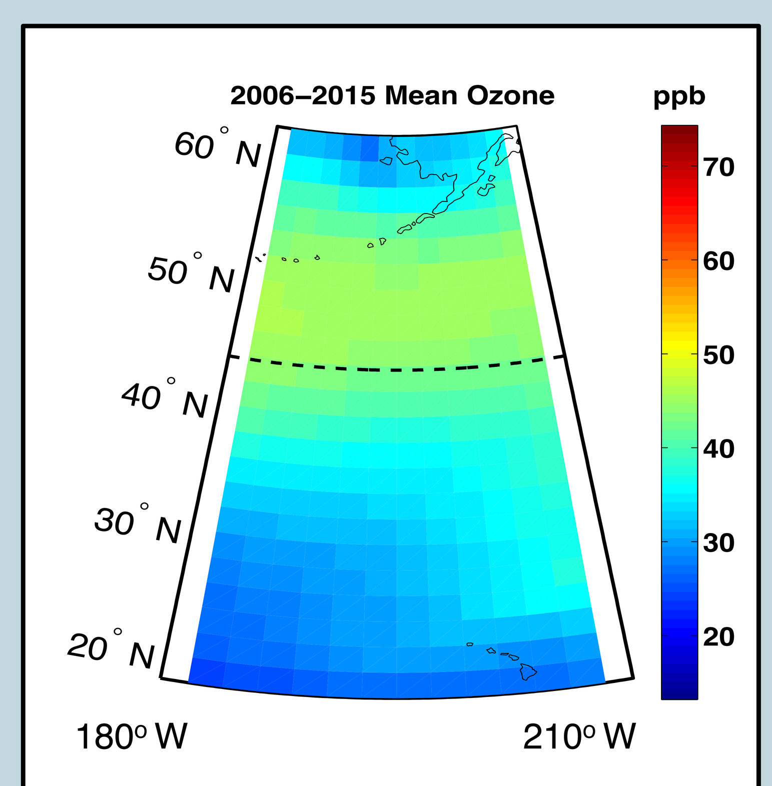

Figure 5: Ensemble 1 of 4.5 mean ozone in Pacific region during Decade 1. Line denotes mean jet latitude.*

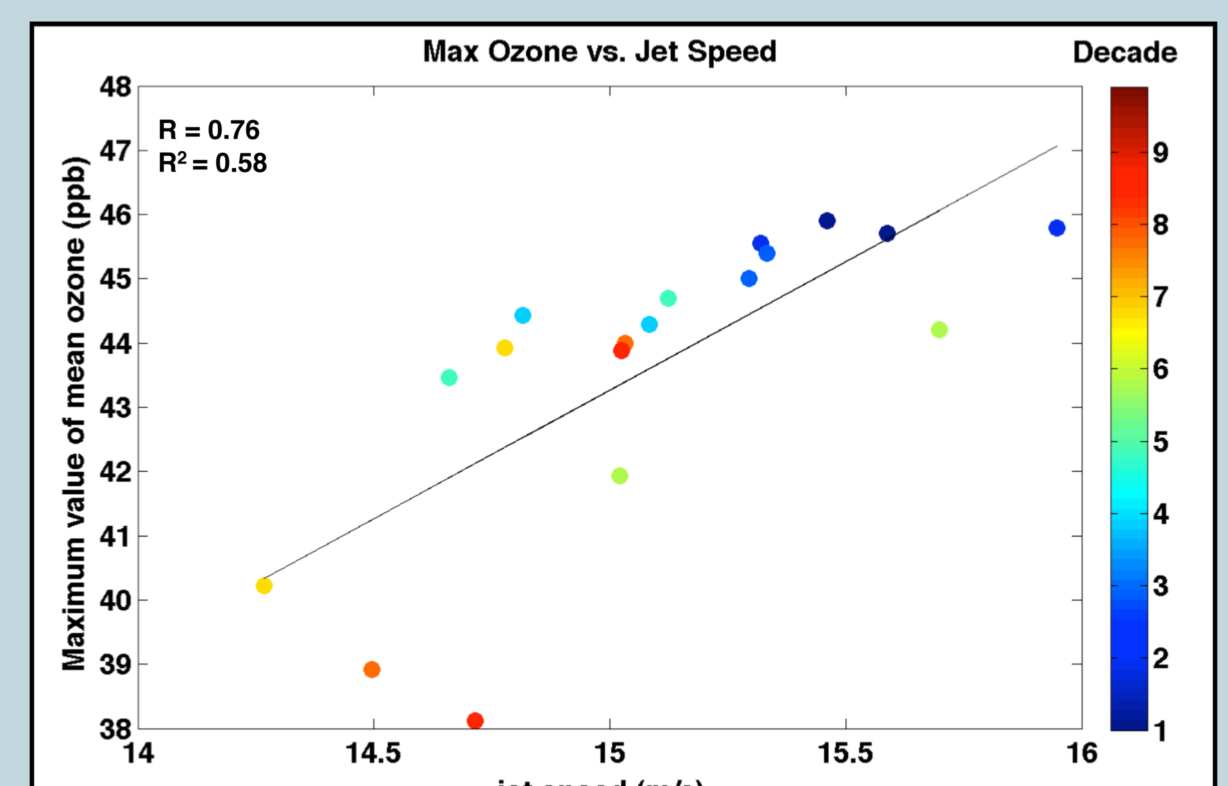

Figure 6: Maximum value of mean ozone scattered against jet speed in Pacific region. Ensembles were averaged together and both 4.5 and 4.5 were included. Colors denote decade.*

- Ozone variability is not correlated directly to the jet stream as it was in eastern North America by Barnes and Fiore (2013). The location of the jet stream (Fig. 5, 7) suggests that circulation still has a connection to ozone in the Pacific.
- Jet speed is correlated with the maximum amount of mean ozone, with a percentage of variance explained equal to 58% (Fig. 6). Relationship holds up for both 4.5 and 4.5*.
- Both jet speed and amount of ozone are decreasing between 2006 and 2100.

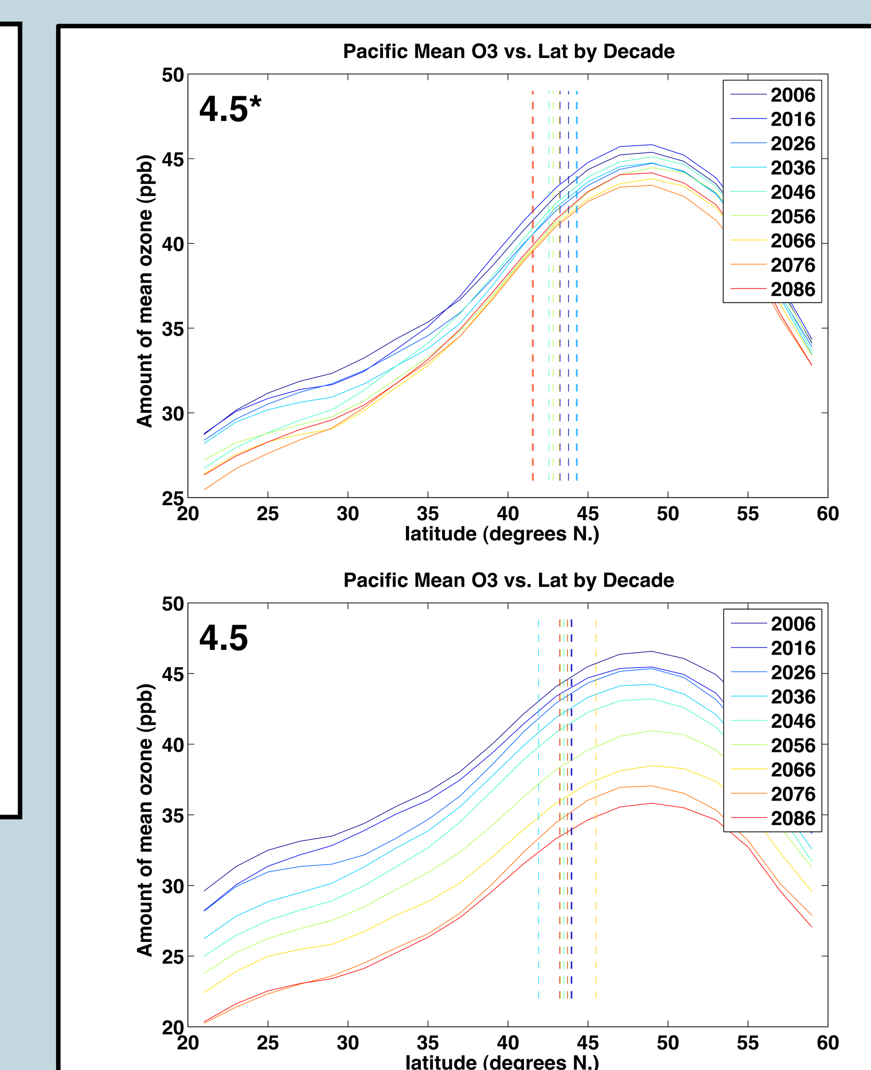

Figure 7: Ensemble 1 of 4.5 and 4.5 zonally averaged mean ozone vs. ozone latitude. Dotted lines are the jet latitude for each decade.*

In both 4.5 and 4.5* RCPs, mean ozone decreases by decade over the Pacific.