19th International Emission Inventory Conference

"Emission Inventories – Informing Emerging Issues"

David Parrish, Jean-Francois Lamarque

Understanding Historical Ozone Trends at Northern Mid-Latitudes

Today:

- Present new data base of gridded global emissions: 1850-2000
- Review observed O_3 trends at northern mid-latitudes
- Compare modeled with observed O_3 trends

Acknowledgements:

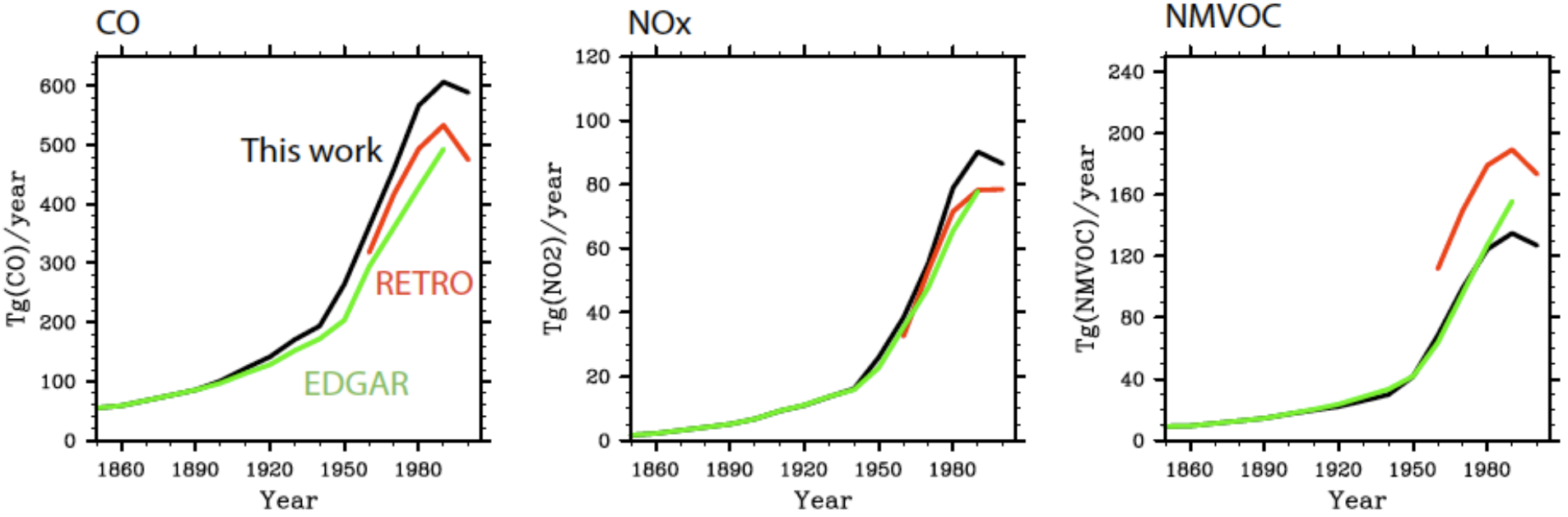
- Many have provided data sets
- Many contributed to model results

Atmos. Chem. Phys., 10, 7017–7039, 2010
www.atmos-chem-phys.net/10/7017/2010/
doi:10.5194/acp-10-7017-2010

Atmospheric Chemistry and Physics

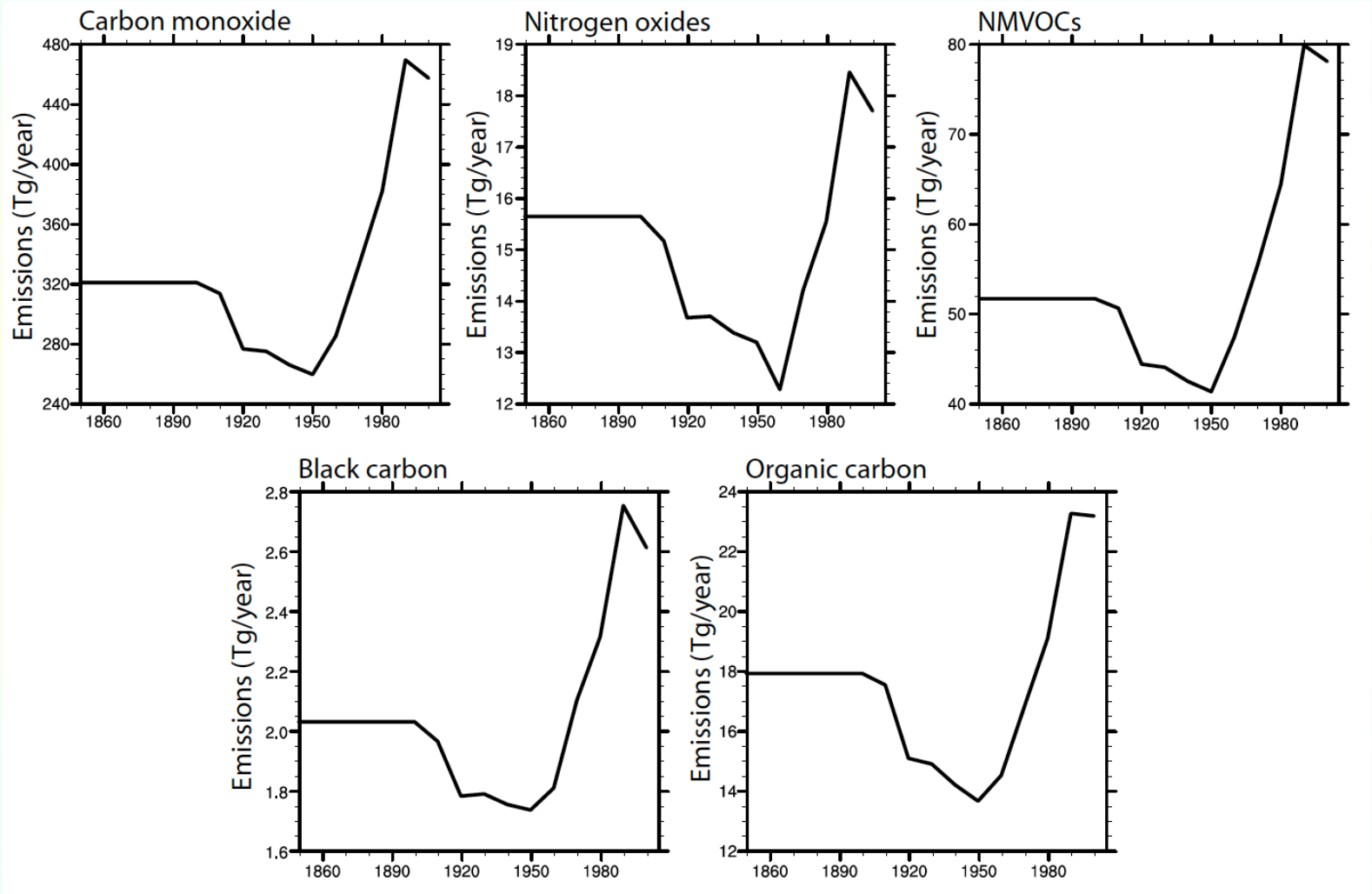
Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: methodology and application

J.-F. Lamarque[1], T. C. Bond[2], V. Eyring[3], C. Granier[4,5,6], A. Heil[7], Z. Klimont[8], D. Lee[9], C. Liousse[10], A. Mieville[6], B. Owen[9], M. G. Schultz[7], D. Shindell[11], S. J. Smith[12], E. Stehfest[13], J. Van Aardenne[14], O. R. Cooper[4], M. Kainuma[15], N. Mahowald[16], J. R. McConnell[17], V. Naik[18], K. Riahi[8], and D. P. van Vuuren[13]



Total land anthropogenic emissions, except for agricultural waste burning

Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: methodology and application



Total open biomass burning (forest and grassland)

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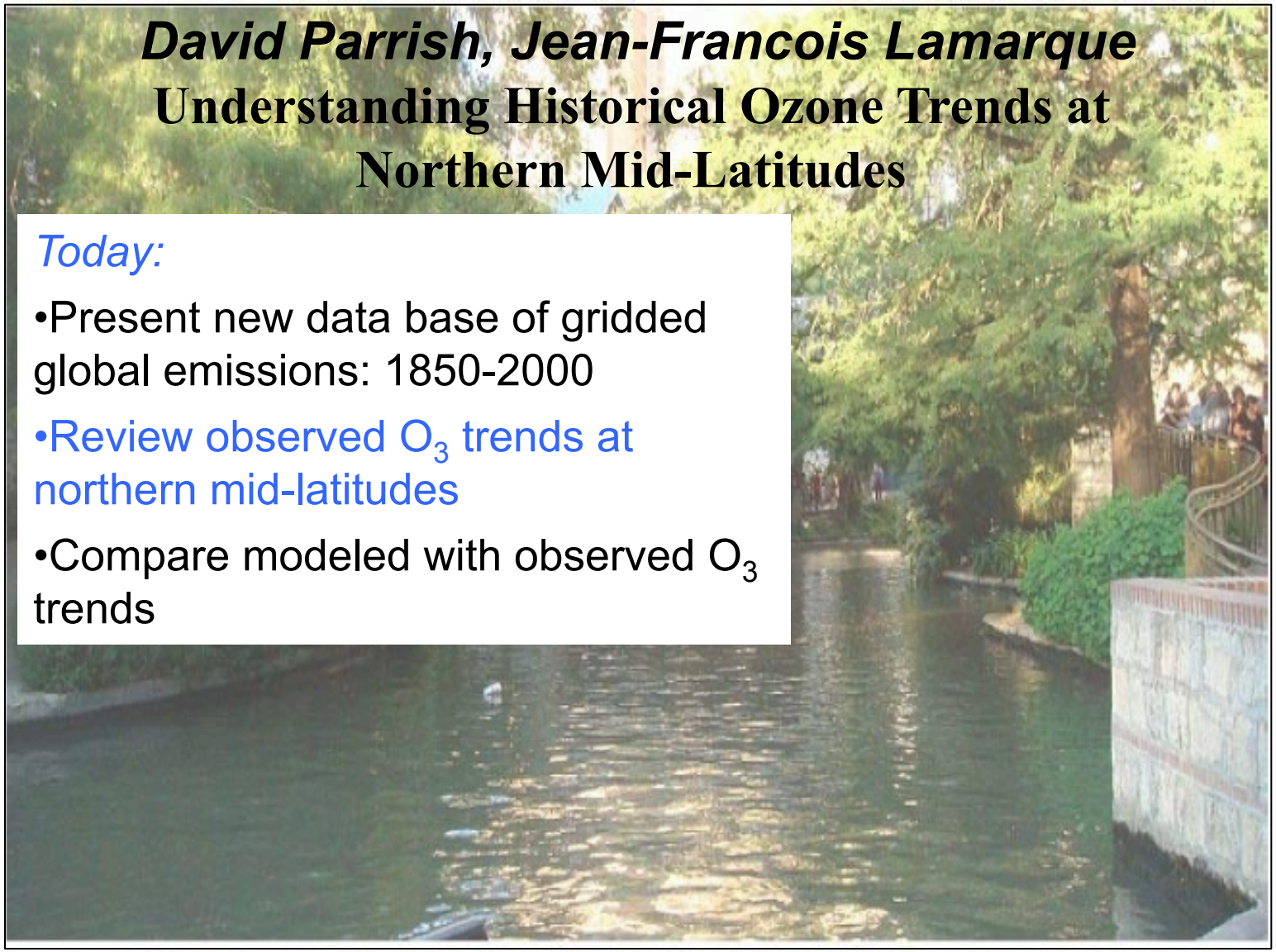

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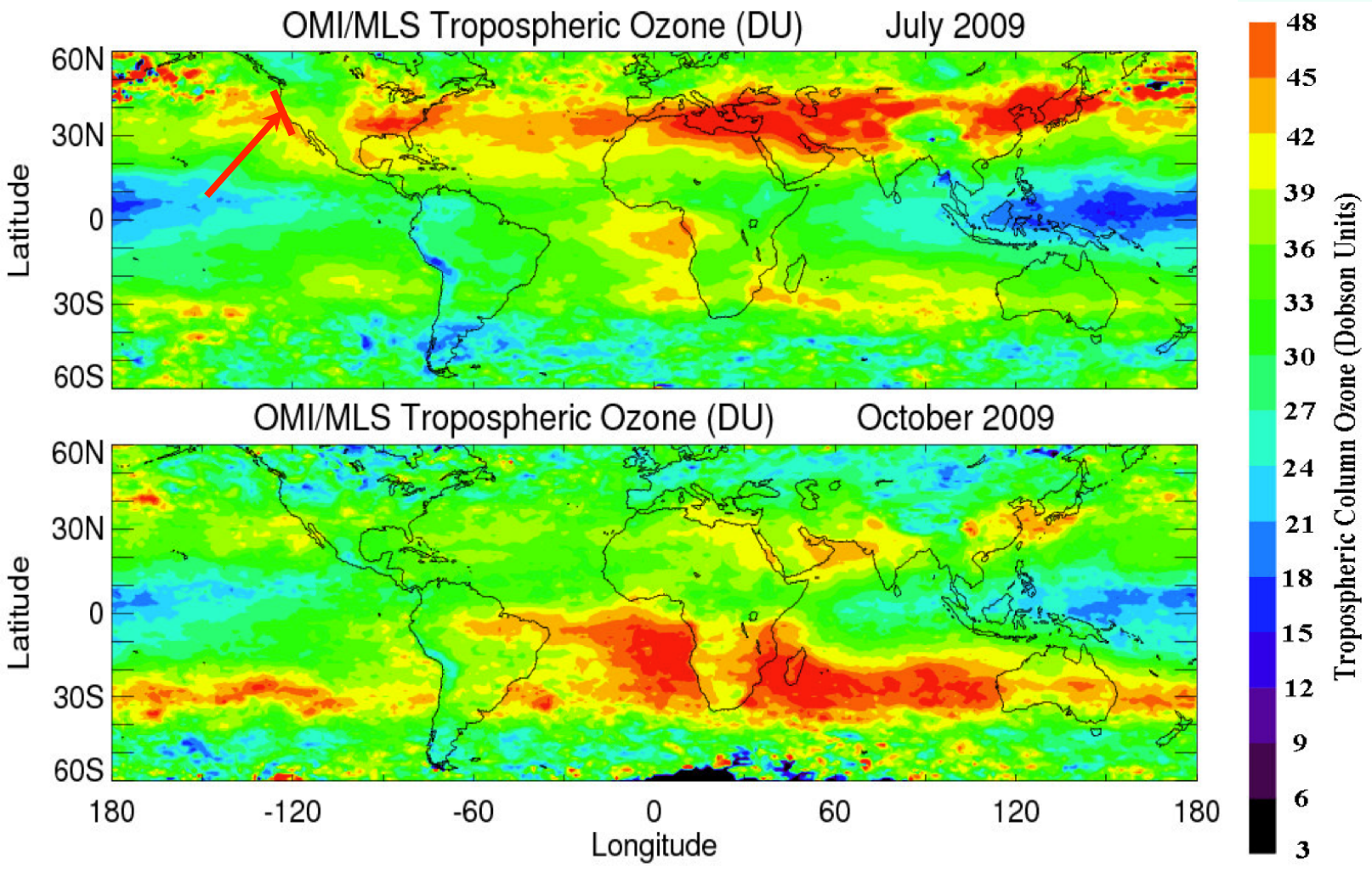
Transported "background" O_3

Ziemke et al. (2006), *J. Geophys. Res.*, *111*, D19303, doi:10.1029/2006JD007089



Anthropogenic emissions are centered at northern mid-latitudes. Hemisphere-wide enhancement of O_3 affects all NH continents.

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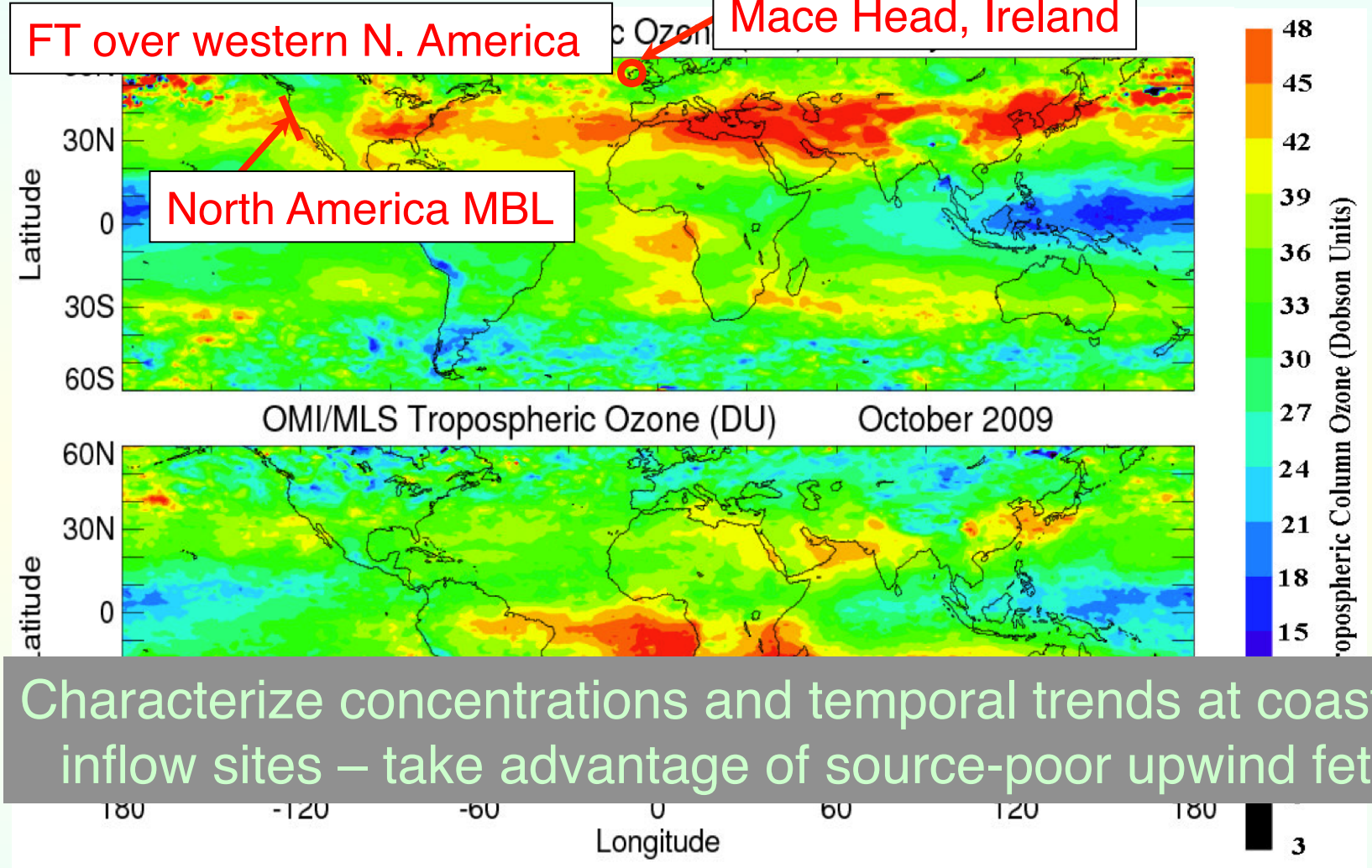


Characterize concentrations and temporal trends at coastal inflow sites – take advantage of source-poor upwind fetch.

Anthropogenic emissions are centered at northern mid-latitudes. Hemisphere-wide enhancement of O_3 affects all NH continents.

MBL Background O_3

O_3 trend consistent across all (limited) data sets, and statistically highly significant:

Winter

0.43 ± 0.17 ppbv/yr

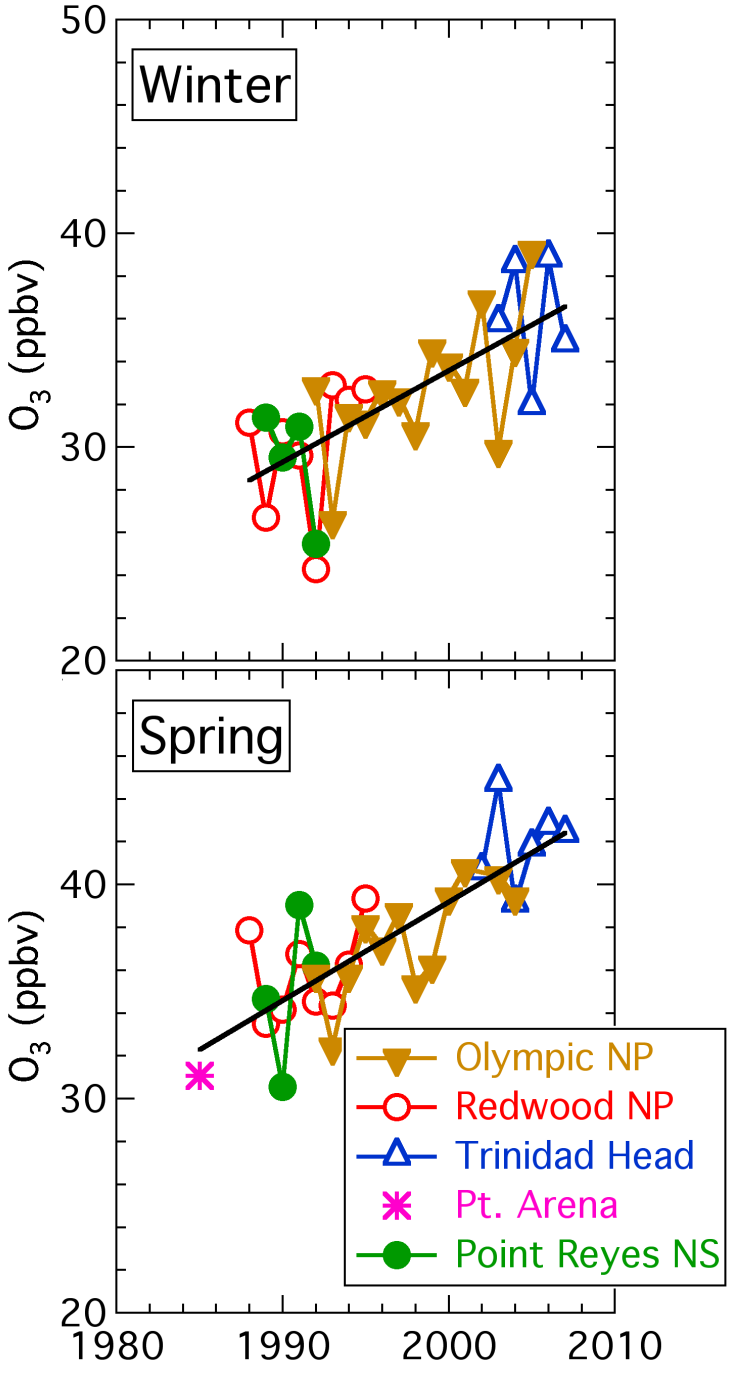
Spring

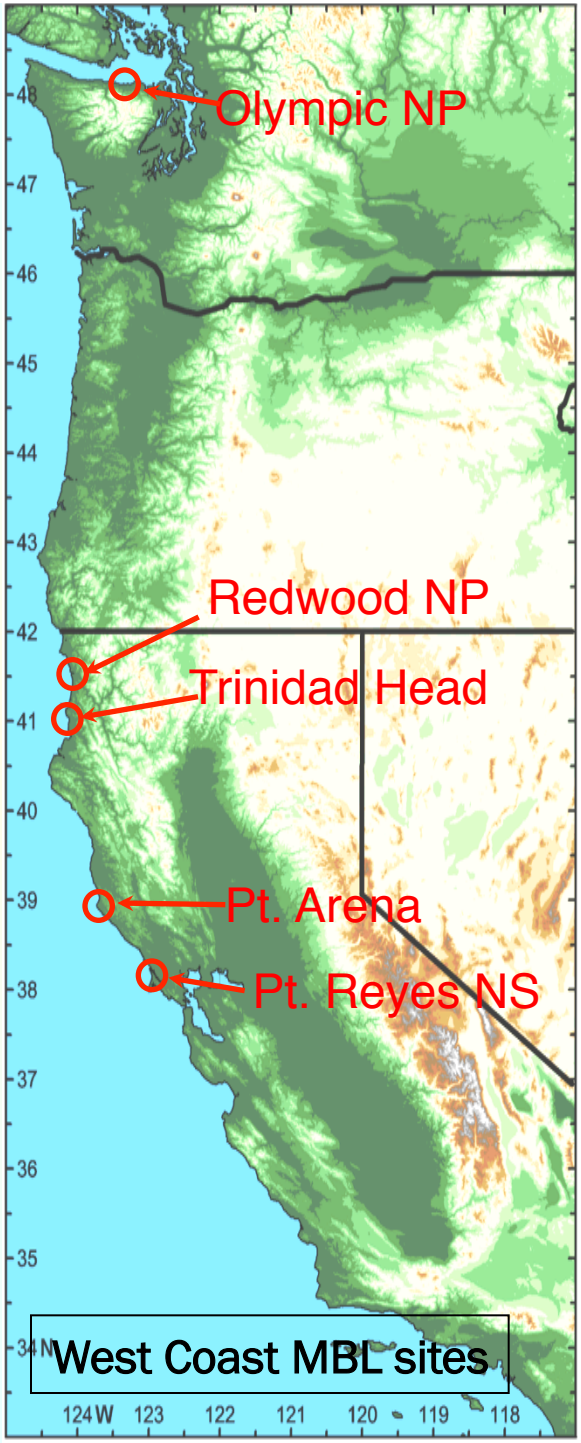
0.46 ± 0.13 ppbv/yr

Data selected for high onshore winds.

Correlations with continental tracers (Rn, MTBE, CO_2) indicate effective isolation of marine air.

Parrish, Millet and Goldstein, *Atmos. Chem. Phys., 9*, 1303–1323, 2009





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Similar O_3 trends at Mace Head, Ireland!

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0.55 ± 0.20 ppbv/yr

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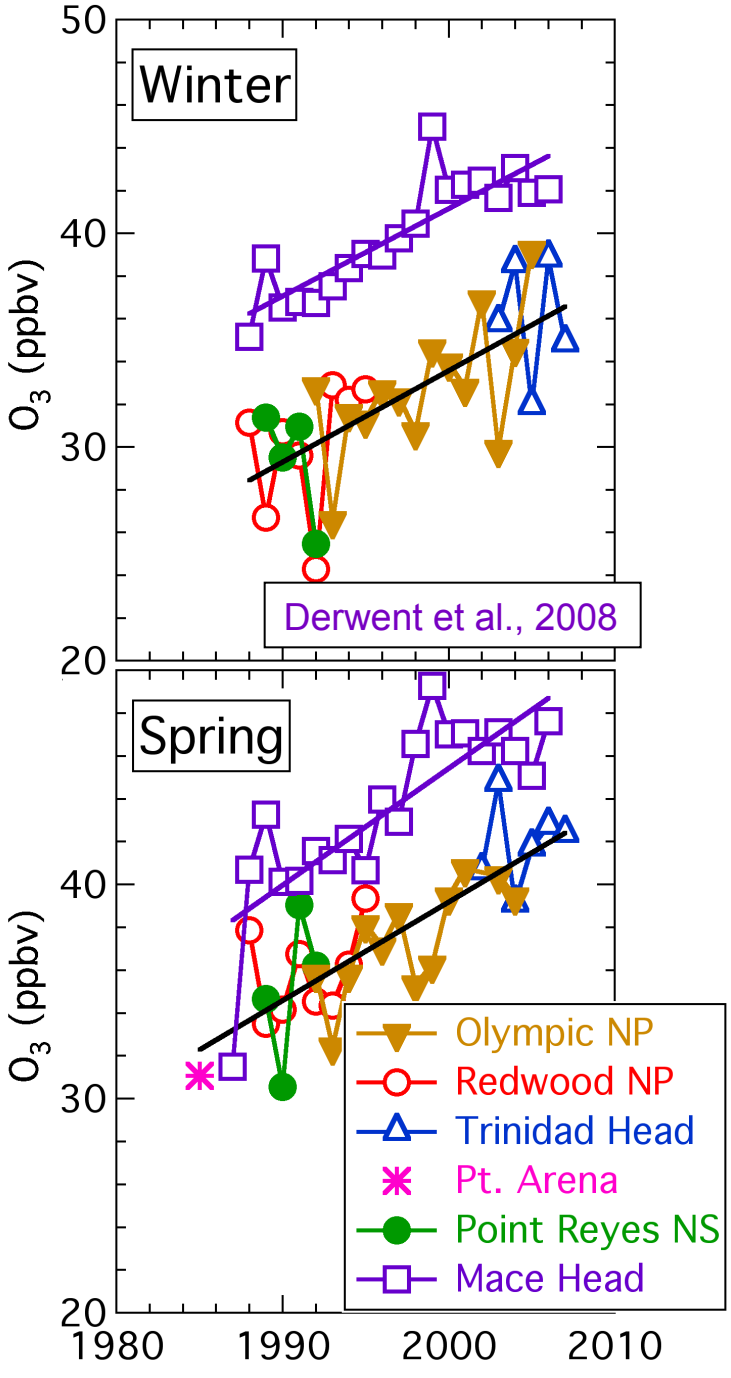

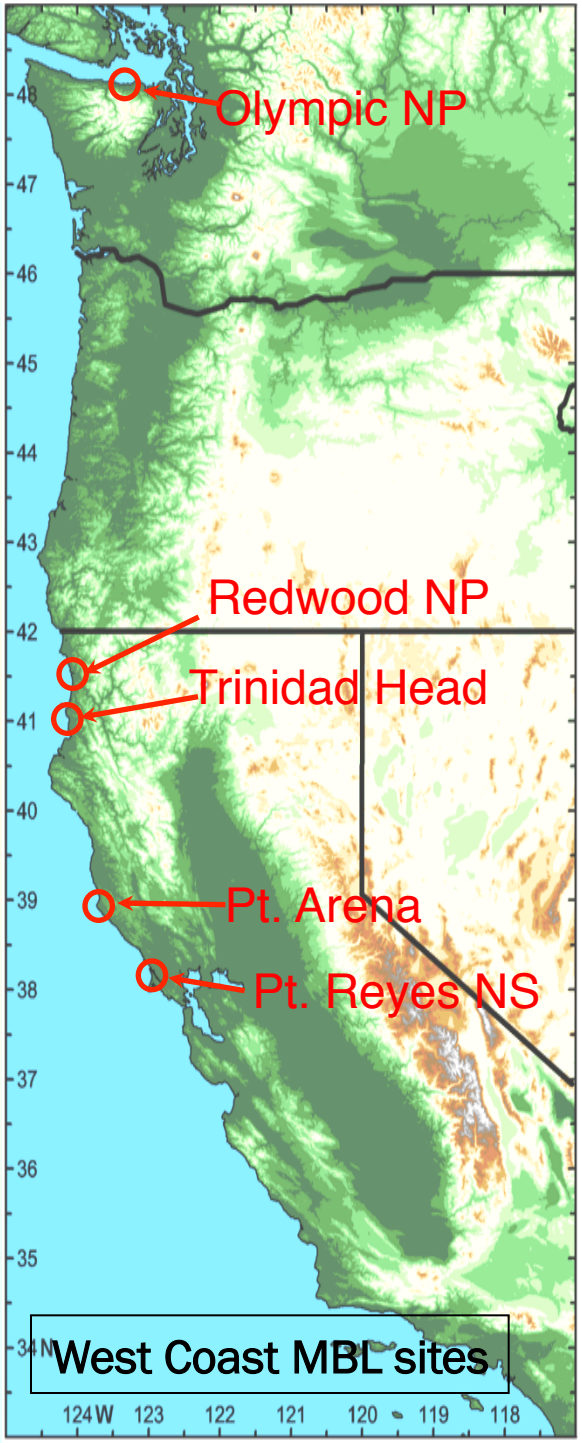

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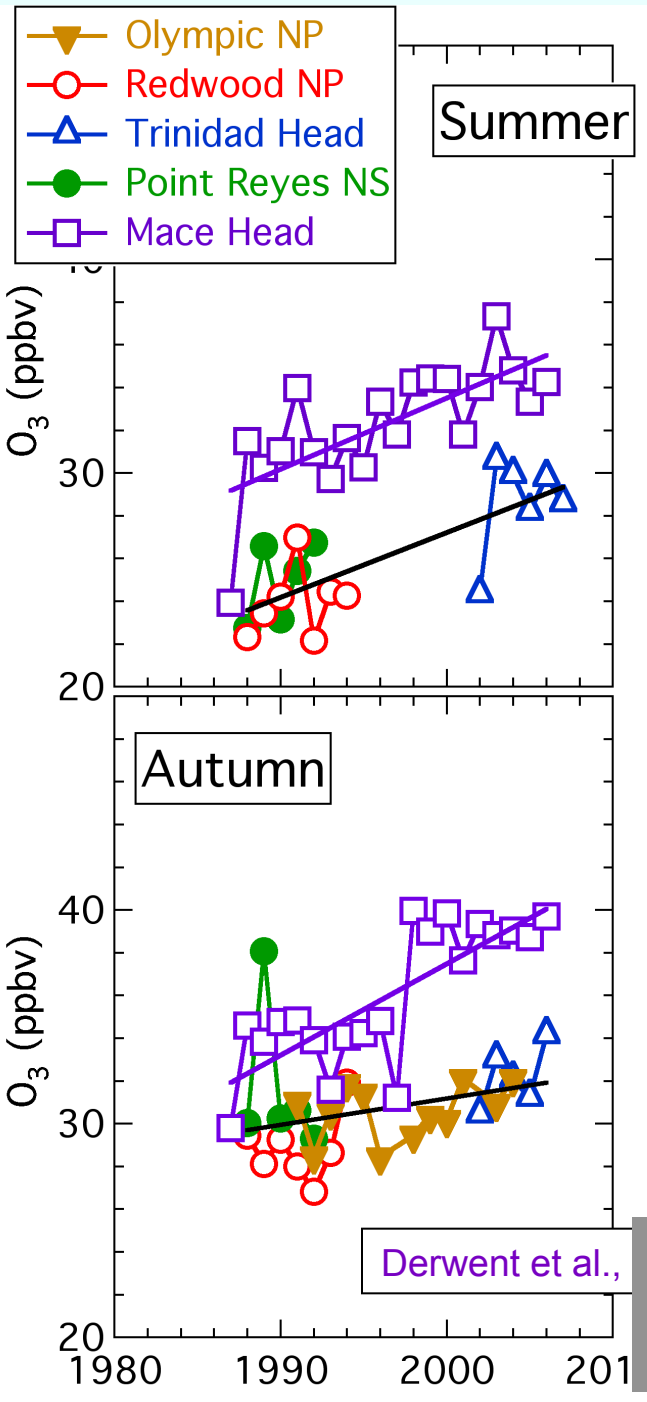
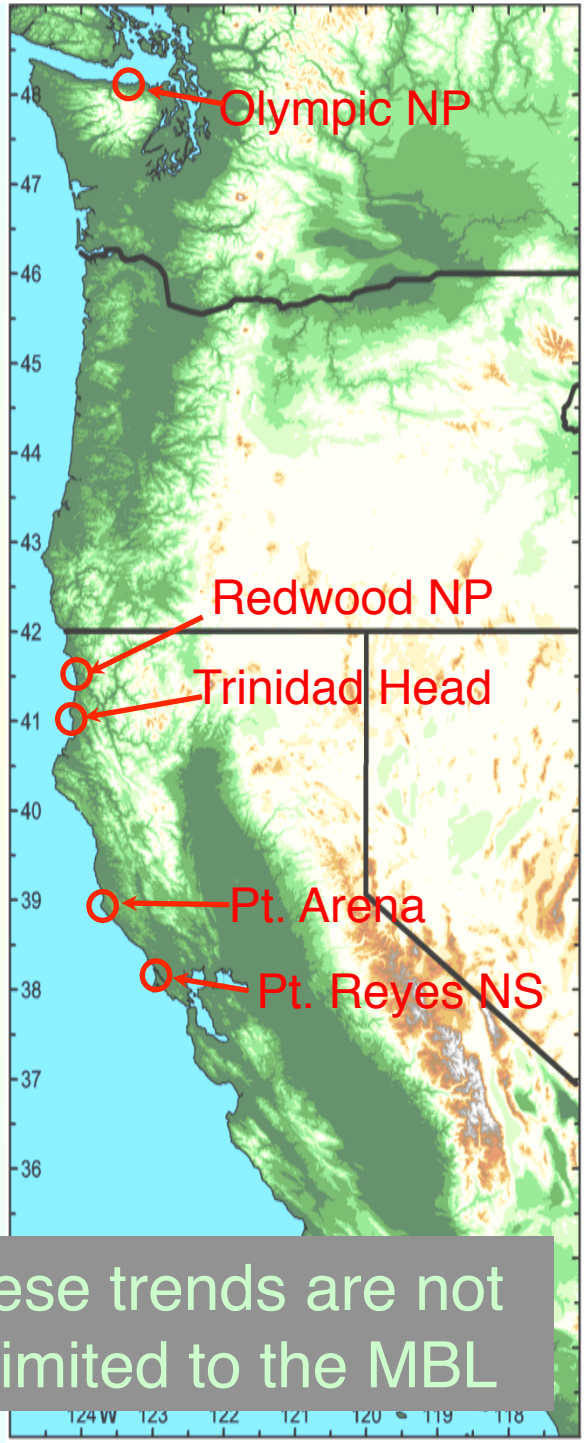
Similar trend in all seasons - some differences in autumn

Parrish, Millet and Goldstein, *Atmos. Chem. Phys., 9*, 1303–1323, 2009





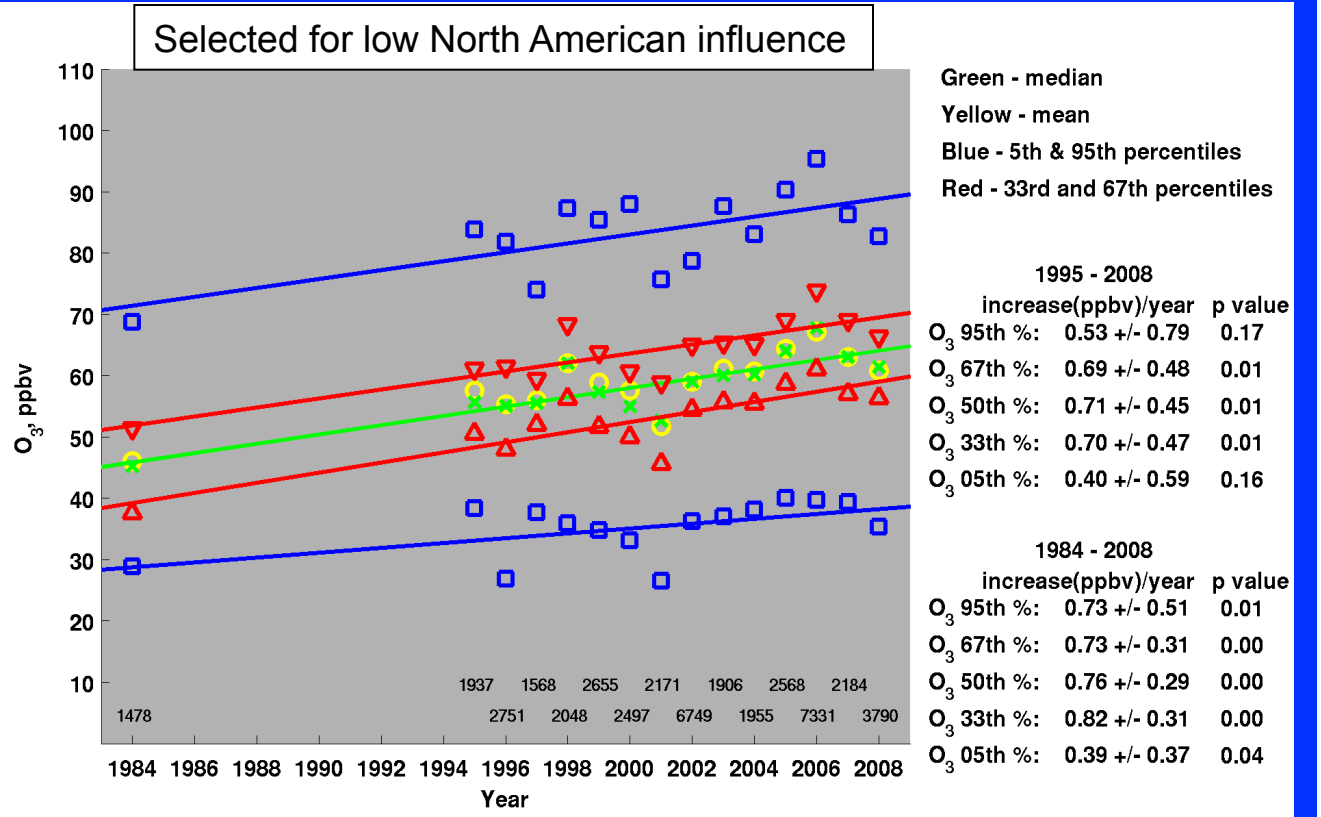
These trends are not limited to the MBL

Transported background O_3 increasing in free troposphere in marine air approaching North America

1984-2008:
0.76 ± 0.29 ppbv/yr
Springtime
3-8 km altitude average

Increasing Asian emissions of O_3 precursors likely play a major role.

(note: all confidence limits = 2 σ or 95%)



Cooper et al., "Increasing springtime ozone mixing ratios in the free troposphere over western North America" *Nature, 463*, 1303–1323, 2009

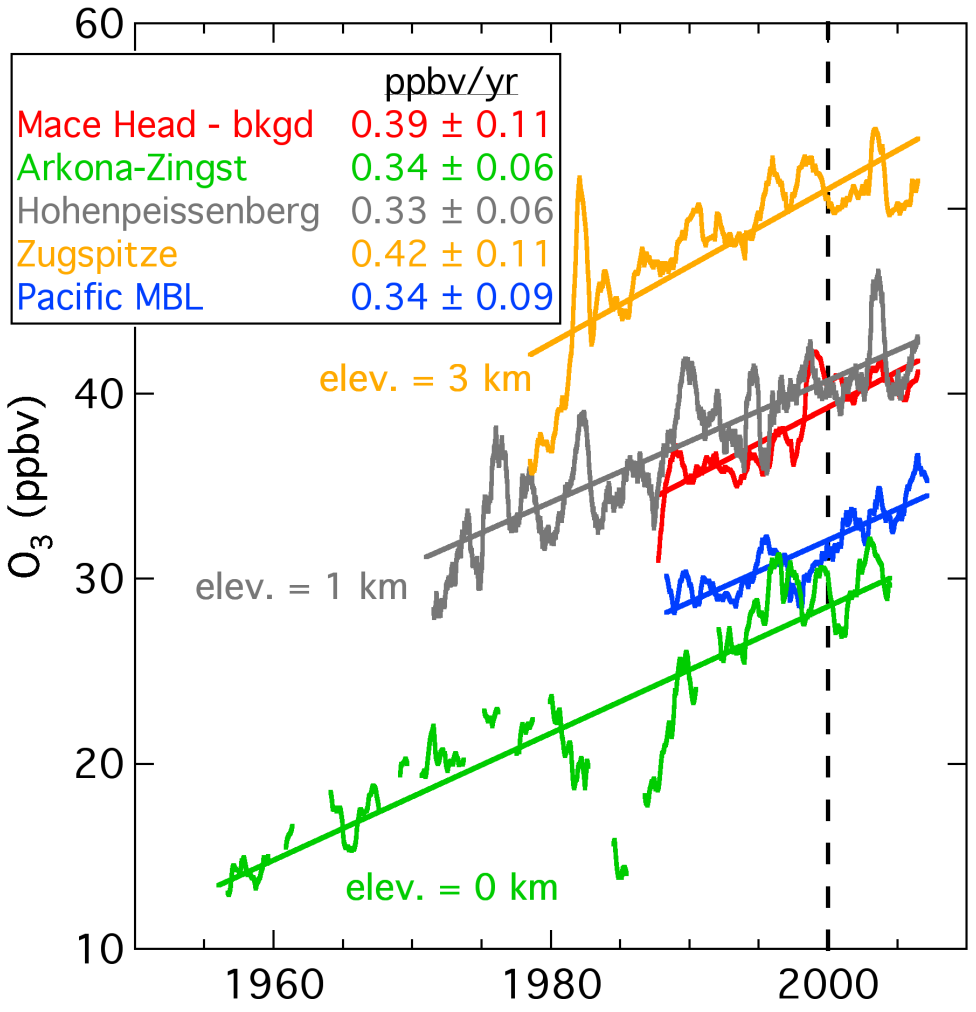
European Regional Sites

Similar O_3 trends over NA and Europe through lower troposphere.

Extremely high statistical confidence: all trends positive at > 7 σ

What about earlier?

12 month running means



Arkona-Zingst: Andreas Volz-Thomas
Hohenpeisenberg: Stefan Gilge
Zugspitze: Hans-Eckhart Scheel

All data included: not selected for baseline conditions, except Mace Head and Pacific MBL.

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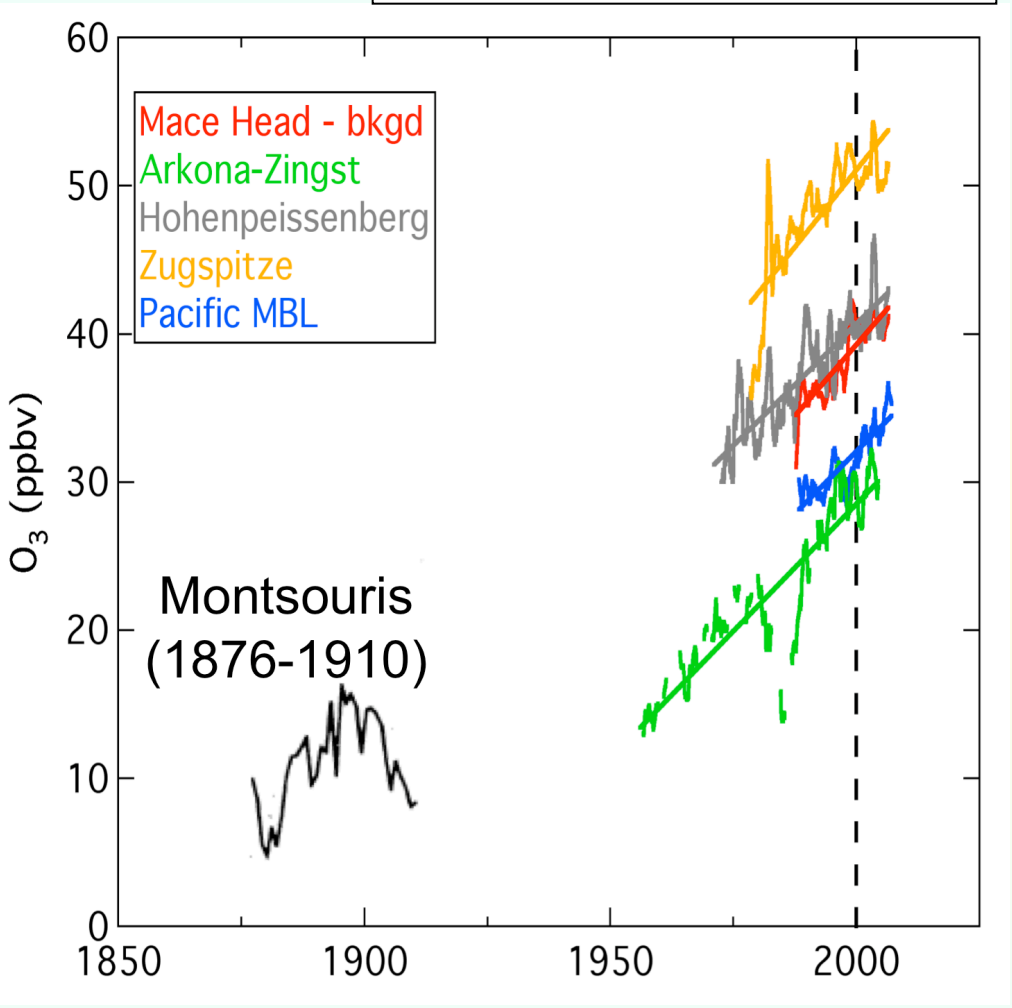
Semi-quantitatively the upward trend seems to have begun early in the last century.

Limited Asian data sets indicate similar or stronger trends.

12 month running means



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Volz, A., and D. Kley (1988), Evaluation of the Montsouris series of ozone measurements made in the nineteenth century, *Nature*, *332*, 240-242.

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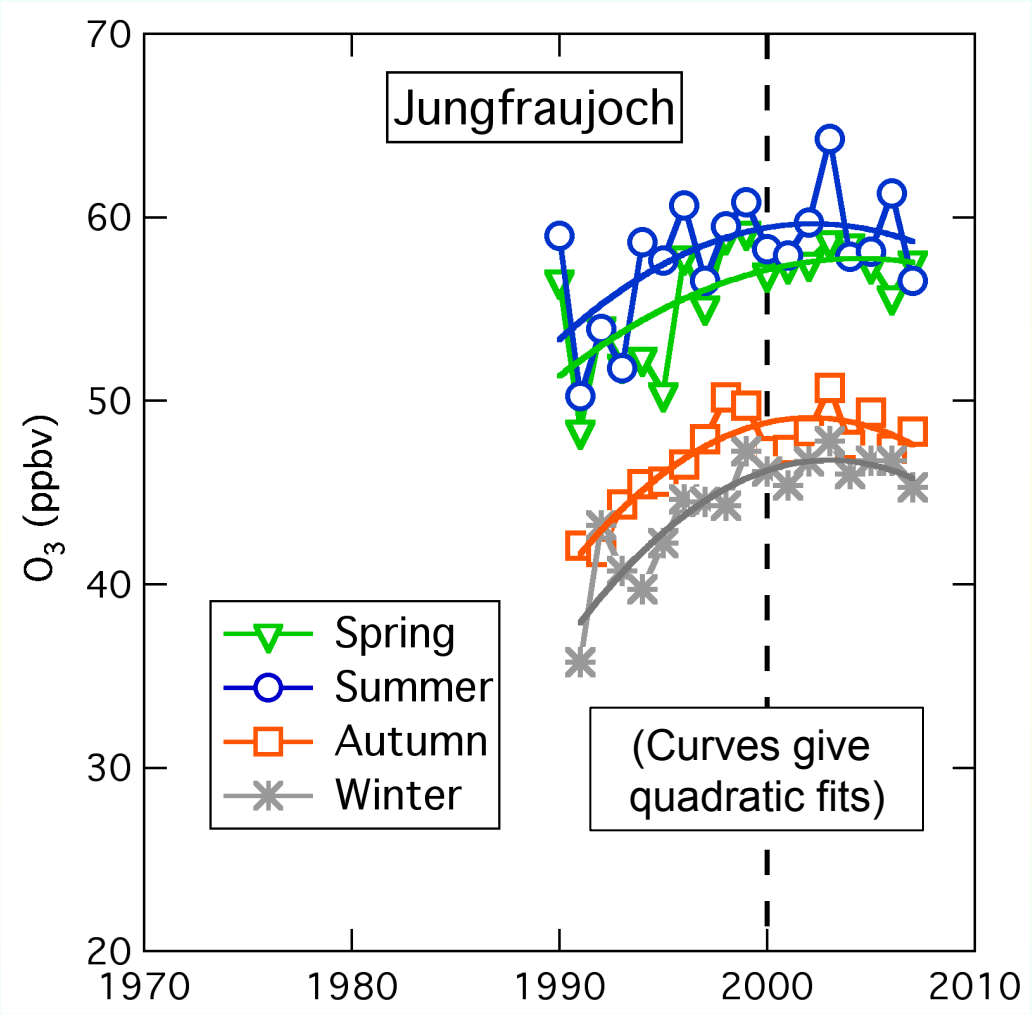
Since the mid-1990s, trend has decreased in the center of the European continent.

Trend has decreased in all seasons, …



Jungfraujoch: Cui Junbo

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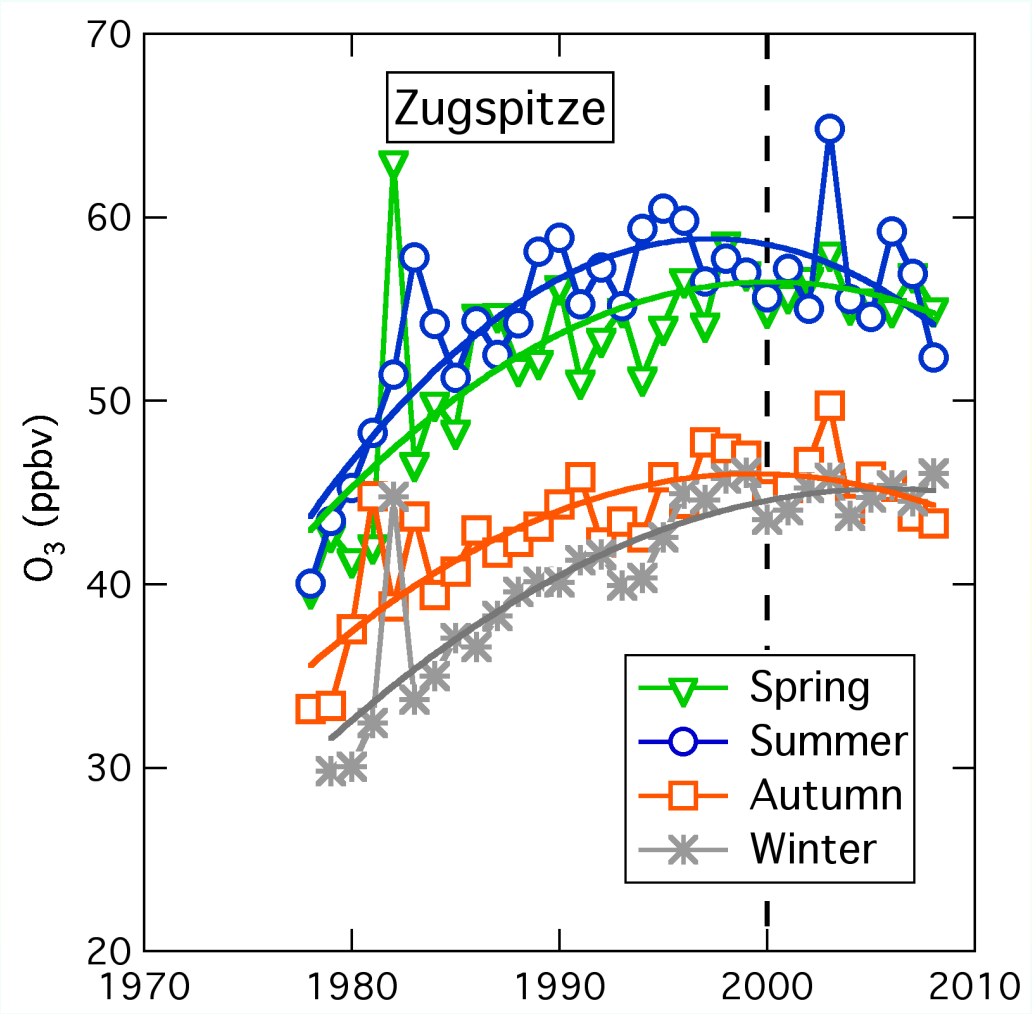
Trend has decreased in all seasons with some regional differences.



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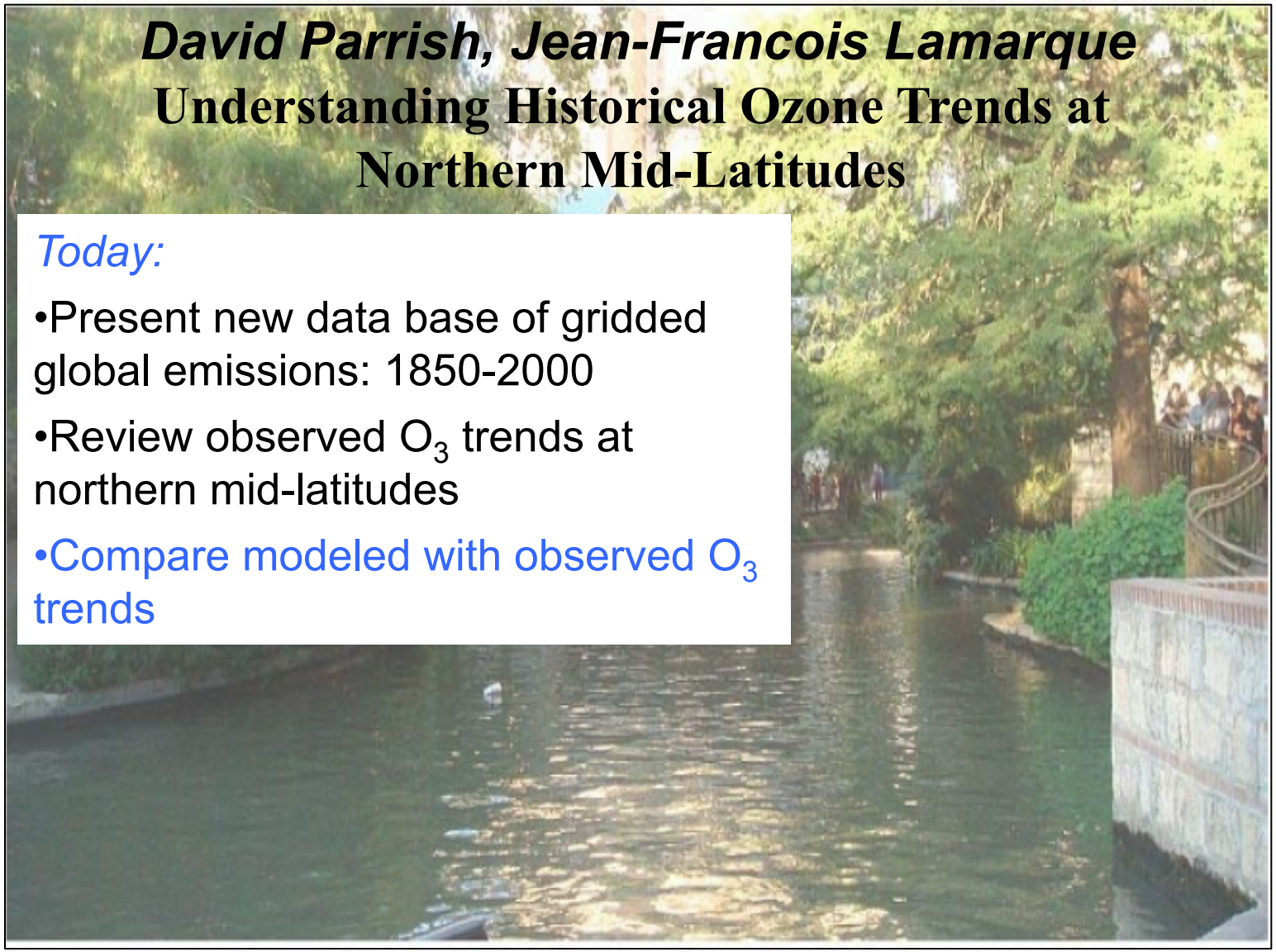

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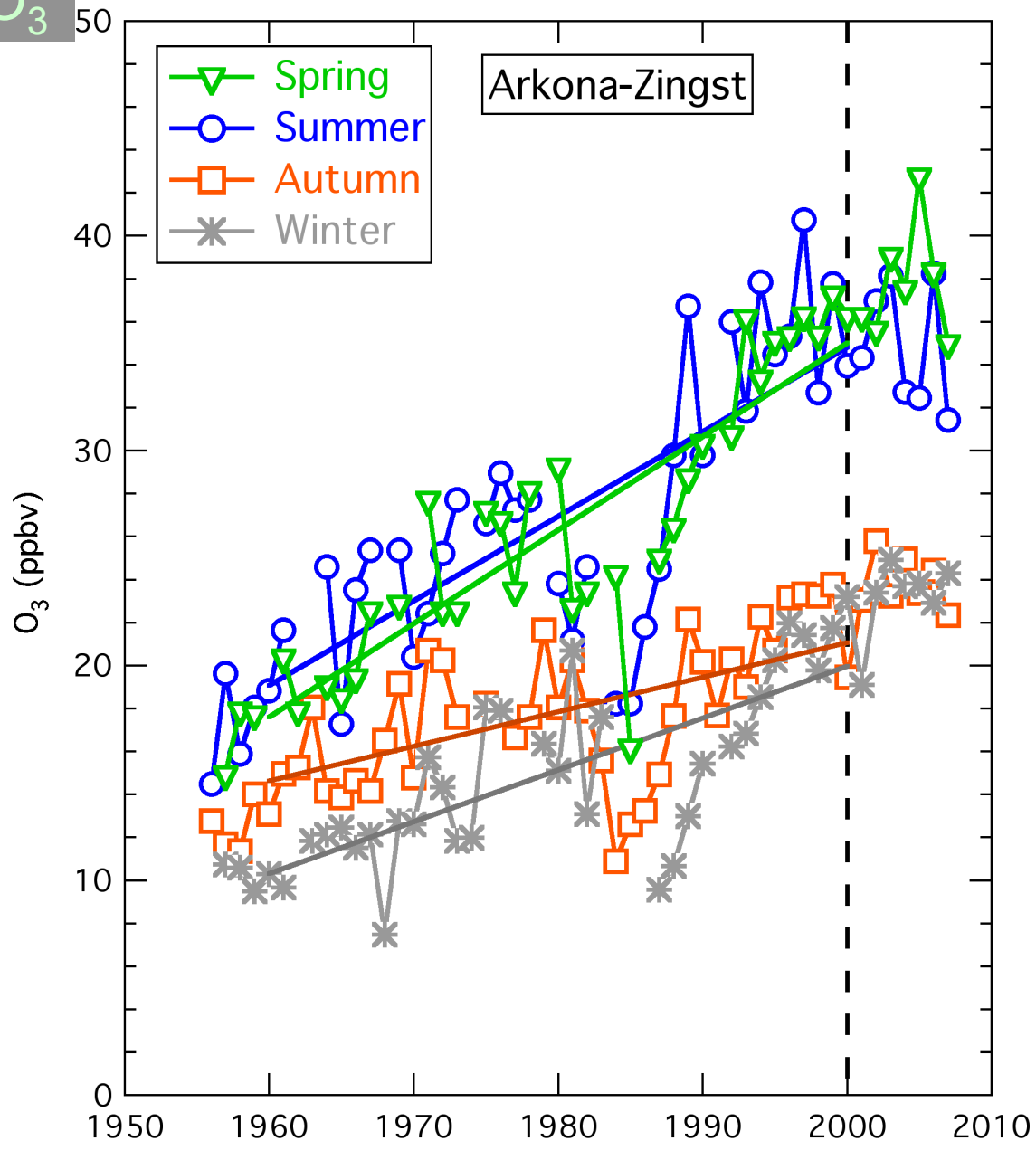
Transported background O_3

Average O_3 trend (ppbv/yr) (1960-2000)

Season	Meas.	Model
Spring	0.44 ± 0.10	
Summer	0.39 ± 0.13	
Autumn	0.16 ± 0.07	
Winter	0.24 ± 0.08	

J.-F. Lamarque et al., *Atmos. Chem. Phys. Discuss.*, *10*, 4963–5019, 2010



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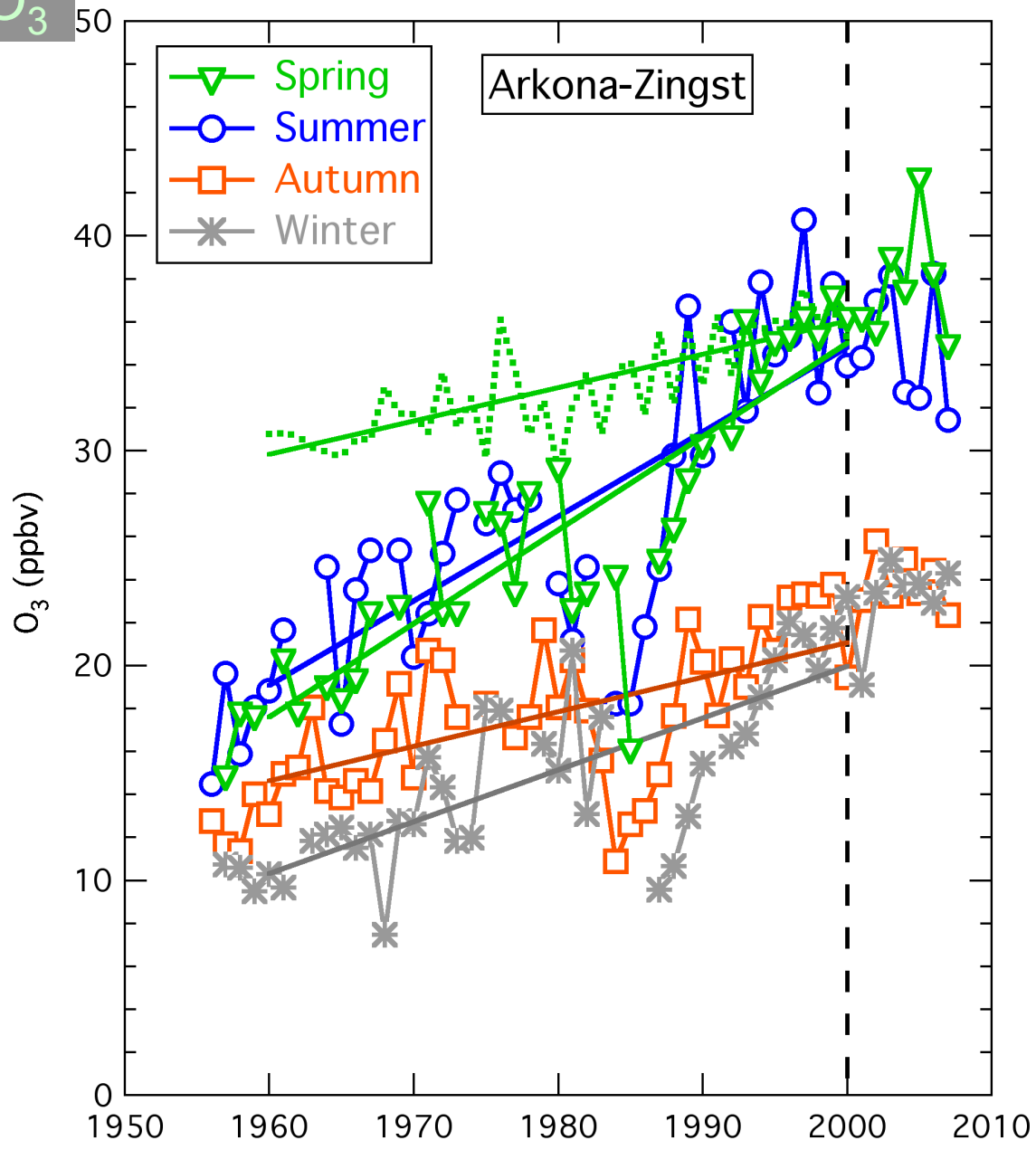

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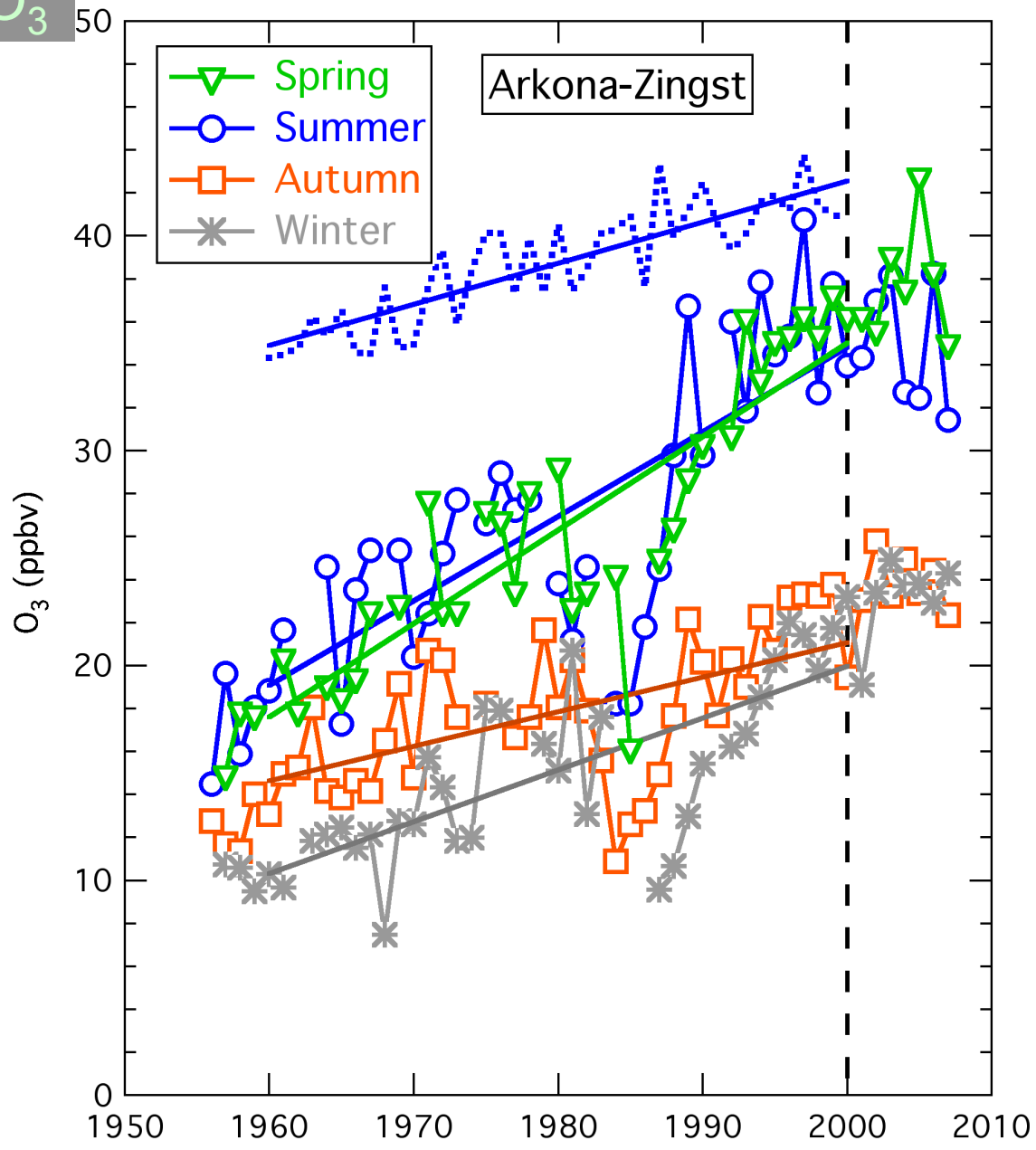

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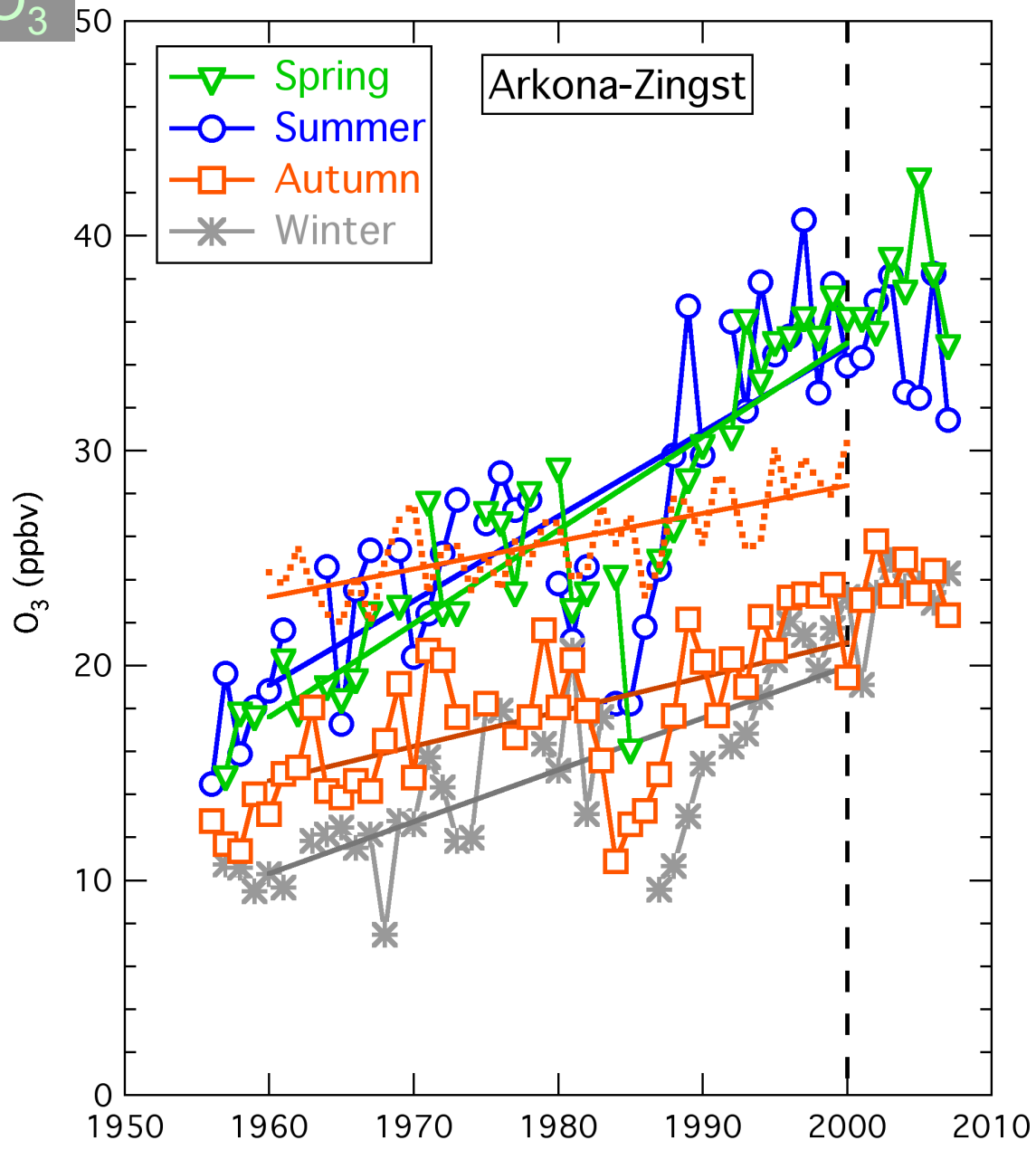

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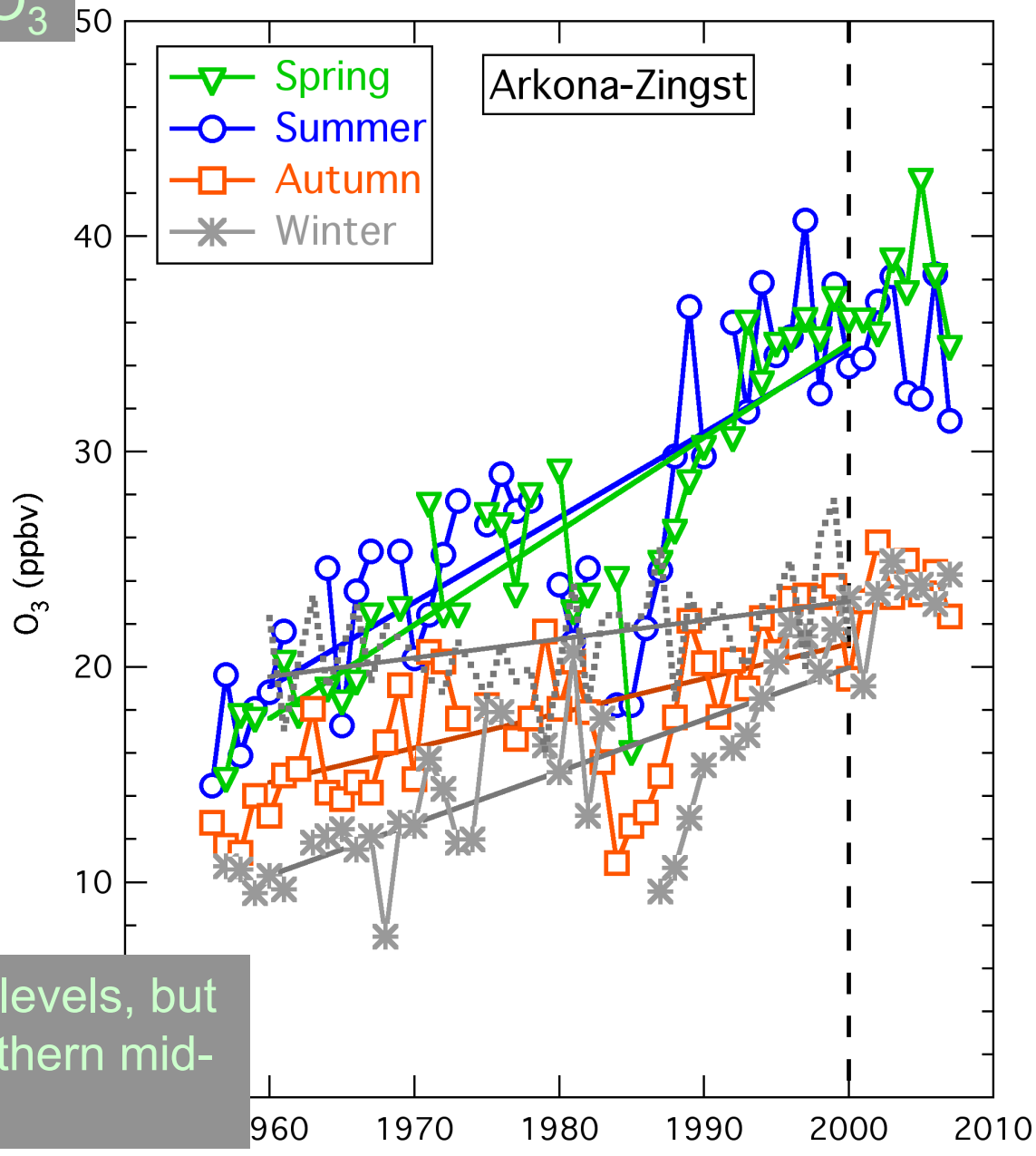
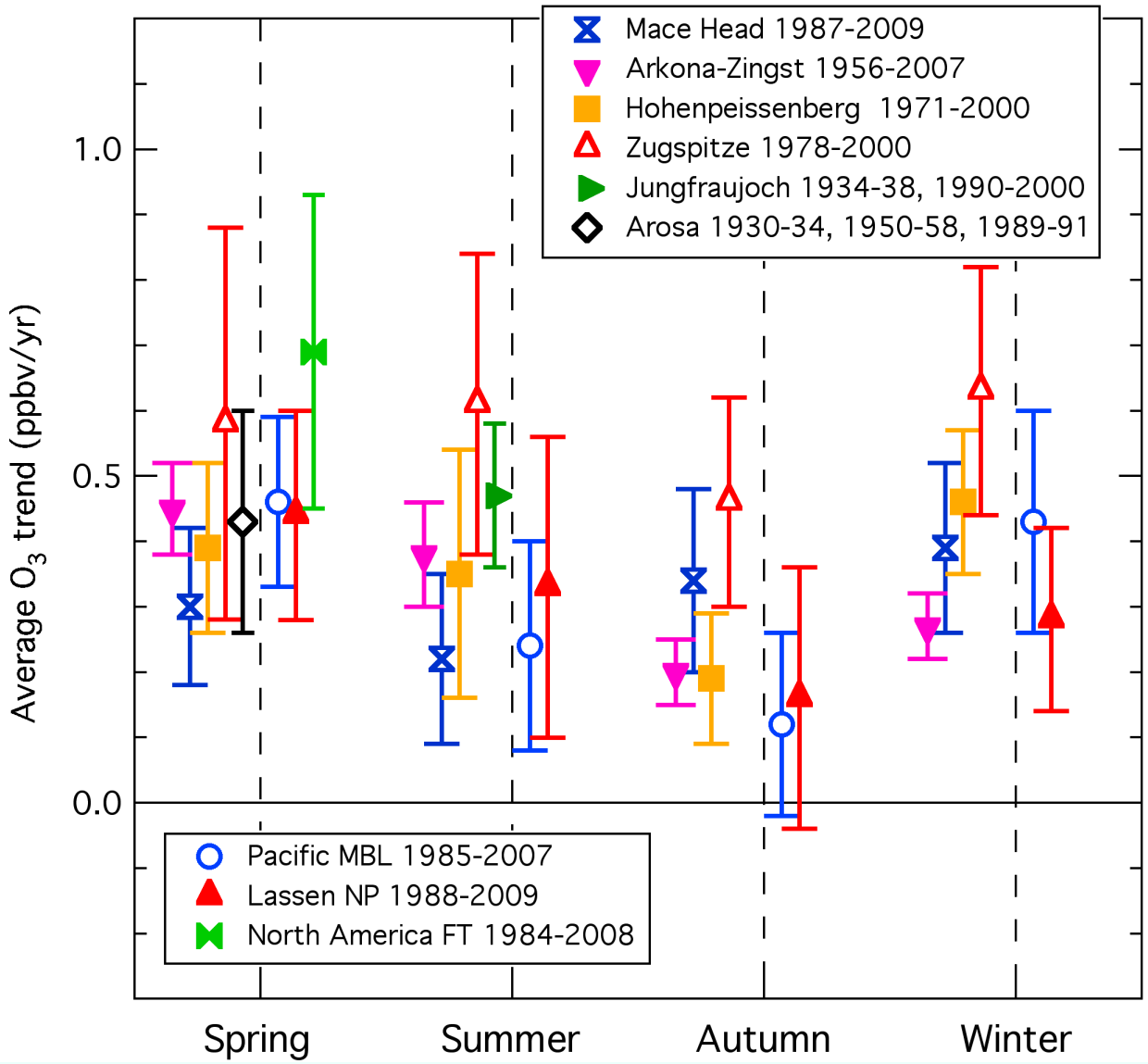


Models reproduce modern O_3 levels, but underestimate trends at northern mid-latitudes.

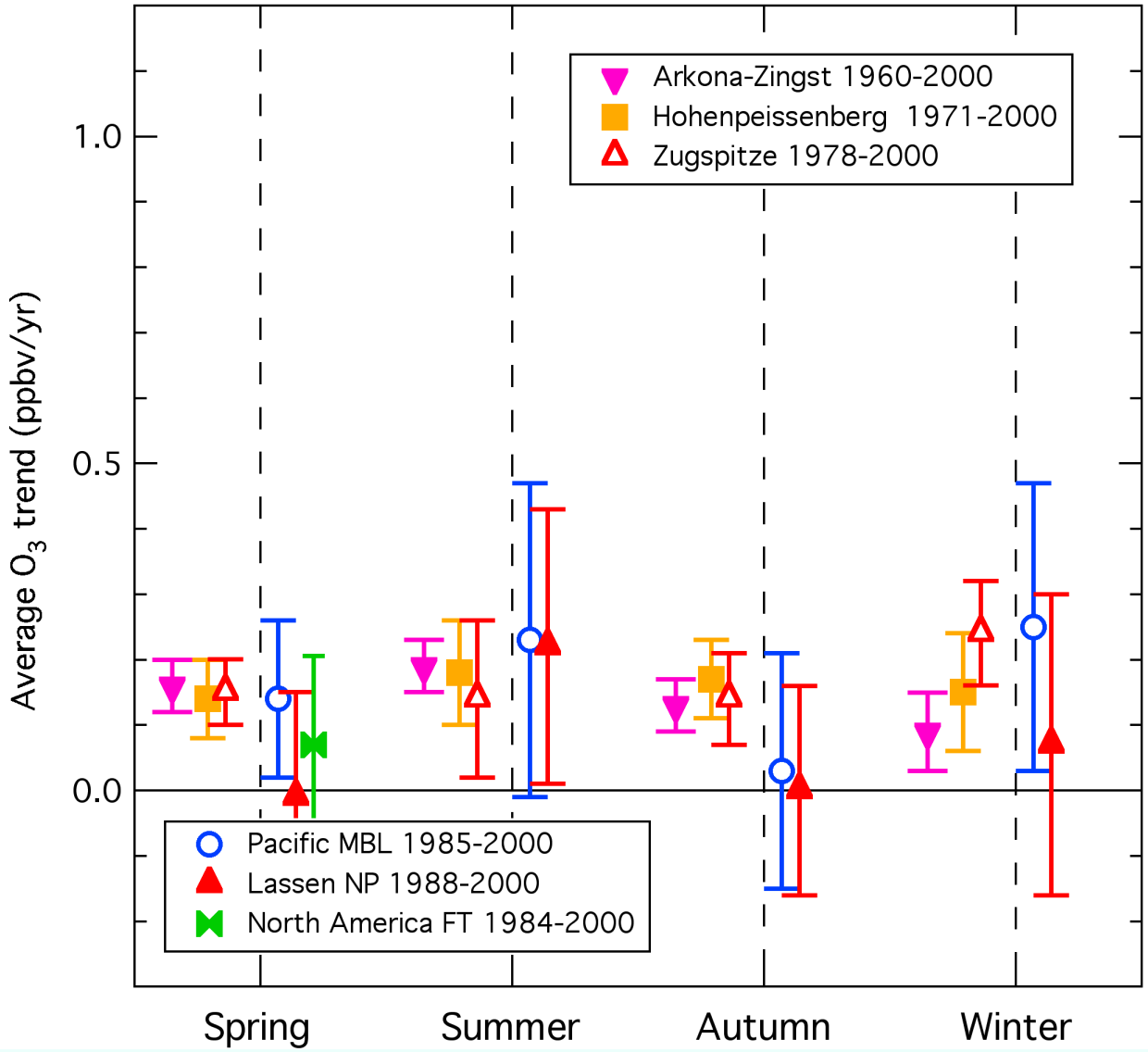
Transported background O_3

Measured trends: all available data



Transported background O_3

Modeled trends: 1960-2000



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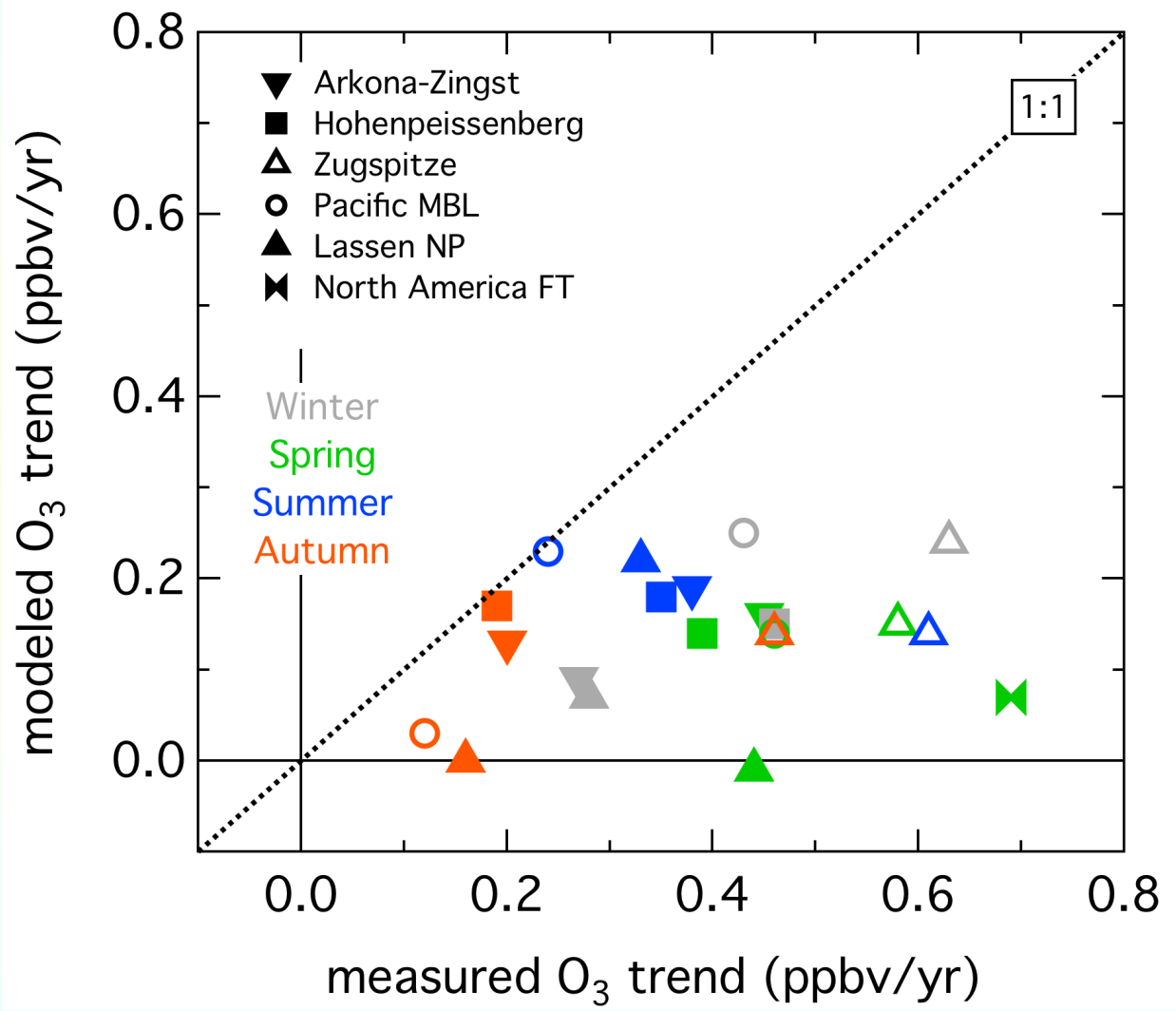

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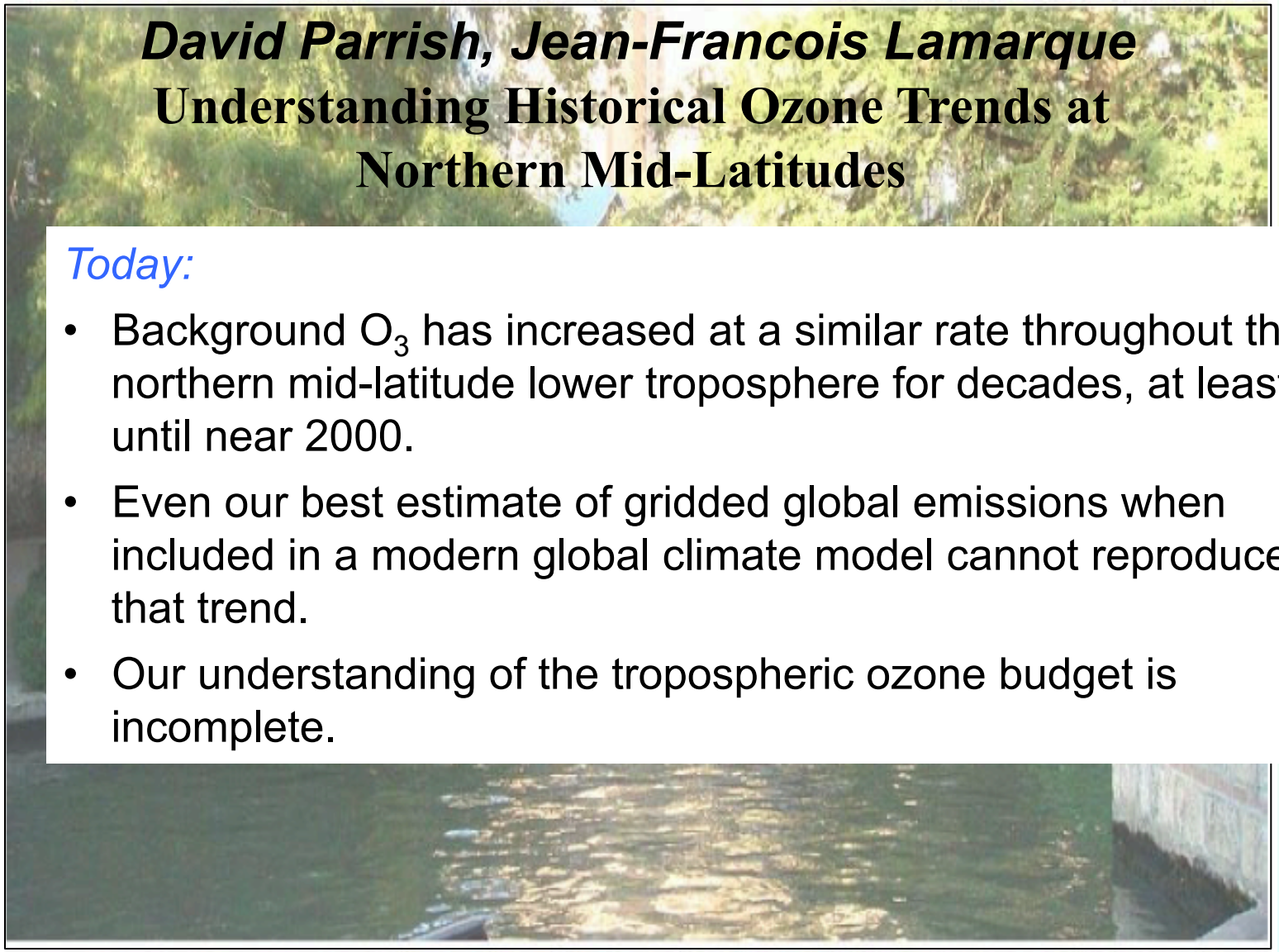

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- Our understanding of the tropospheric ozone budget is incomplete.

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- Our understanding of the tropospheric ozone budget is incomplete.
- Cause? Very difficult to see how to force emissions to reproduce the trend

Extra Slide

Transported background O_3

Measured trends: 1960-2000 data