1. GFDL Chemistry-Climate Model


2. Reversal in surface O₃ seasonal cycle over NE USA by 2100

AM3 ACCMIP simulations (10 years each with decadal average SSTs)
1) 2000 SSTs (+ 2000 emissions + WMGG + ODS)
2) 2100 SSTs (+ 2100 RCP8.5 emissions + WMGG + ODS)

- Extreme warming with aggressive NOx controls implies shift in regional vs. background O₃.
- How well represented are surface O₃ impacts of (1) strat-to-trop O₃ transport and (2) climate warming, particularly in light of base-state biases?

- Below are first steps to evaluate key processes in GFDL AM3/CM3

3. Influence of stratospheric intrusions on surface O₃

Western U.S. is a particularly active region for deep stratospheric intrusions in present climate [Spengler and Wernik, 2003]
Spring 2010 NOAA field campaign provides a wealth of in situ data to evaluate AM3 (pressure-dependent nudging to reanalysis winds)

Evaluation of upper level dynamics associated with a deep stratospheric O₃ intrusion (21:00UTC May 27, 2010)
The view from space
AM3 “nudged high-res” (~50km)

4. O₃-temperature relationships

Evaluation of monthly mean MDAs O₃ vs. Tₚ_a
AM3 model driven by observed sea surface temperatures and sea ice for 1961-2000

We average over all NE USA CASTNet sites (one value per year for each month) to isolate the regional response of O₃ to temperature

MDAs O₃-Tₚ_a seasonal cycle

Despite MDAs O₃ bias, sensitivity to year-to-year variations in Tₚ_a is broadly reproduced by GFDL AM3 over NE USA.

We estimate impacts of Tₚ_a biases on MDAs O₃ biases, assuming a regional mean relationship of 3 ppb K⁻¹

5. Summertime cyclone frequency over NE USA

Leibensperger et al. [2009] show a strong anti-correlation in summer between (a) number of migratory cyclones over Southern Canada/NE U.S. and (b) number of stagnation events and associated NE USA high-O₃ events. These stagnation episodes are a major driver of the observed surface O₃-T correlation over the NE USA [e.g., Jacob et al., 1993]. Following Leibensperger et al. [2008], we diagnose cyclones from 6-hourly sea level pressure with MCMSS software from Mike Bauer, (Columbia U/GISS).

Evaluation of summertime cyclone location and frequency

Changes in storm frequency under an extreme climate warming scenario

Number of storms each summer (JJA) in GFDL CM3, RCP6.2

Relationship between high-O₃ events and storms (Leibensperger et al., 2008)

Additional high-O₃ events due to impact of climate warming on storm frequency

- Trend significant relative to model internal variability (~95% control simulation; 100-year “chunks”: 0.66 ± 0.88, 0.81±0.62 ±)
- Not clear yet whether this finding is robust across models

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