Evaluation of MERRA-2-based Ozone Profile Simulations with the Global Ozonesonde Network
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O3 Hindcasts Using MERRA-2 (1980-2016)

- We use ozonesonde data from global networks to evaluate the O3 profiles in two model simulations (1980-2016) that use NASA's Modern-Era Retrospective Analysis for Research Applications, Version 2 (MERRA-2; Gelaro et al., 2017). Climate meteorology and Global Modeling Initiative (GMI) chemical mechanisms:
  - M2 GMI Replay (Orbe et al., 2017) 0.625°x0.5° horizontal resolution, 72 vertical levels
  - Driven by 3hr average MERRA-2 meteorology fields in a traditional offline CTM

Fig. 3: Latitude-height curtain of median O3 mixing ratio differences between M2 GMI Replay and M2 GMI CTM profiles. Blue lines indicate that the M2 GMI CTM O3 is unchanged from M2 GMI Replay. Overlain the blue lines are O3 levels at all latitudes.

- Model/Ozonesonde Comparisons
  - Fig. 2 shows the median differences between modeled and ozonesonde O3 at 38 sites from surface to UT/LS (Fig. 2, top) and GMI CTM bottom (Fig. 2, bottom)
  - Both models reproduce the longitudinal O3 pattern (Fig. 4, middle), but model biases are larger than 15 ppb (25%: Fig. 4 bottom) in the tropical Atlantic and midstratosphere, where biomass burning effects are common
  - Both models reproduce the longitudinal O3 pattern (Fig. 4, middle), but model biases are larger than 15 ppb (25%: Fig. 4 bottom) in the tropical Atlantic and midstratosphere, where biomass burning effects are common
  - This likely indicates that the model transport of O3 associated with the Walker Circulation is accurate, but that both models greatly underestimate biomass burning-produced O3. These low biases are unchanged over the last 20 years

Fig. 4: Latitude-height sections of the "Tropical Wave-One" O3 feature. The two panels provide a median ozone observations at several tropical (not all) locations. Blue lines highlight the median ozone differences for GMI CTM and M2 GMI replay (top). Green lines highlight the median ozone differences for M2 GMI Replay and M2 GMI CTM (bottom). Blue lines indicate that the median ozone has not changed from M2 GMI Replay. Overlaid the blue lines are O3 levels at all latitudes.

Assimilation Changes (ATOVS Transition)

- Compared to ozonesonde data (1980-2016), both M2 GMI Replay and GMI CTM show strong negative O3 biases in tropical tropospheric O3, though the modeled O3 is highly correlated with sondes data (not shown here). Model biases with ozonesondes generally become smaller in recent years in the model simulations.

Fig. 5: M2 GMI Replay near-surface O3 is biased high by 10-30% at all latitudes. An updated GMI chemical mechanism in the GMI CTM reduces the high O3 bias to near-zero. A new Model replay model running the updated mechanism will be completed soon to isolate the effects of CTM vs. Replay

Summary/Future Approaches

- The wave-one is a persistent, longitudinal feature in tropical tropospheric O3 (Fig. 4, top) that results from the ascending branch of the Walker Circulation (low O3) in the western Pacific, and seasonal biomass burning and descending air (high O3) over the Atlantic

The "Tropical Wave-One" O3 Feature

- Both models reproduce the longitudinal O3 pattern (Fig. 4, middle), but model biases are larger than 15 ppb (25%: Fig. 4 bottom) in the tropical Atlantic and midstratosphere, where biomass burning effects are common
- This likely indicates that the model transport of O3 associated with the Walker Circulation is accurate, but that both models greatly underestimate biomass burning-produced O3. These low biases are unchanged over the last 20 years

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Select References: