1. Introduction
- Methane (CH₄) emissions control can be a cost-effective strategy for abating both global surface ozone (O₃) and greenhouse warming [West and Fiore, 2005; see also poster by West et al.]
- previous modeling studies used fixed CH₄ concentrations and globally uniform changes, but CH₄ is observed to vary spatially and temporally
- The major sink of CH₄ is reaction with tropospheric OH; emissions of CH₄ are shown in Section 2
- Surface CH₄, rose by ~6 ppt y⁻¹ from 1990-1999, then leveled off (Section 3), likely reflecting:
  (1) source changes of CH₄ [e.g. Langenfelds et al., 2002; Wang et al., 2004] or other species that influence OH [e.g. Karlsson et al., 2000]
  (2) meteorologically-driven changes in the CH₄ sink [e.g. Warwick et al., 2002; Dentener et al., 2003; Wang et al., 2004]
(3) an approach to steady-state with constant lifetime [Dlugokencky et al., 2003]

What is driving observed CH₄ trends? Does CH₄ source location influence the O₃ response?

2. Methane in the MOZART-2 CTM
Sensitivity simulations applying different CH₄ emission inventories:

- BASE: Constant emissions (1990)
- ANTH: Time-varying anthropogenic emissions
- ANTH + BIO: Time-varying anthropogenic and wetland emissions

3. Influence of Sources on Surface CH₄ Distribution and Trend
- Mean model bias and correlation with 1990-2004 monthly mean surface GMD observations
- Surface CH₄ concentrations at selected GMD stations
- BASE captures observed rate of increase 1990-97 and leveling off after 1998
- ANTH improves CH₄ vs. OBS post-1998
- ANTH+BIO best captures measured abundances
- BASE too low post-1998
- ANTH improves CH₄ in tropics
- ANTH+BIO improves the correlation with observations at high northern latitudes
- ANTH+BIO: Best captures the CH₄ interhemispheric gradient
- BASE captures observed rate of increase of CH₄ post-1998
- ANTH+BIO best matches the observed CH₄ seasonality, interhemispheric gradient, and global mean trend

4. Meteorologically-driven Changes in the CH₄ Lifetime
- Global mean surface CH₄ in BASE simulation (constant emissions)
- BASE capture the CH₄ emissions for cases shown below
- Lateral distribution of 1990 CH₄ emissions with observed bias shown below
- CH₄ lifetime against tropospheric OH
- Deconstruct x from 91-95 to 00-04 into individual contributions by varying T and OH separately

5. Ozone Response to CH₄ Emission Controls
- Tropospheric O₃ response to anthropogenic CH₄ emission changes is approximately linear
- Simulations of anthropogenic CH₄ emission reductions (relative to BASE)
- Change in summertime U.S. afternoon surface O₃
- MAX daily difference

6. Conclusions
- Ozone response is largely independent of CH₄ source location
- 30% decrease in global anthropogenic CH₄ emissions reduces JJA U.S. surface afternoon O₃ by 1-4 ppbv
- BASE simulation (constant emissions) captures observed rate of CH₄ increase from 1990-1997, and leveling off post-1998
- ANTH emissions improve modeled CH₄ post-1998
- Wetland emissions in ANTH+BIO best match the observed CH₄ seasonality, interhemispheric gradient, and global mean trend
- TCH₄ decreases by ~2% from 91-95 to 00-04 due to warmer temperatures (35%) and higher OH (65%), resulting from a ~10% increase in lightning NO₃ emissions

Future research should:
- consider climate-driven feedbacks from fire and biogenic emissions on TCH₄
- develop more physically-based parameterizations of lightning NO₃ emissions to determine whether higher emissions are a robust feature of a warmer climate

REFERENCES