- The objective is to quantify how well air quality modeling captures the relationship between ozone and meteorology
  - Observed ozone (AIRS) / ambient meteorology (ISD/IGRA/HYSPLIT)
  - Simulated ozone (CMAQ) / modeled meteorology (MM5/MCIP)

- Potential applications of analysis:
  - CMAQ model evaluation (phenomenological)
  - Assist in estimating effects of climate change on air quality at local scales

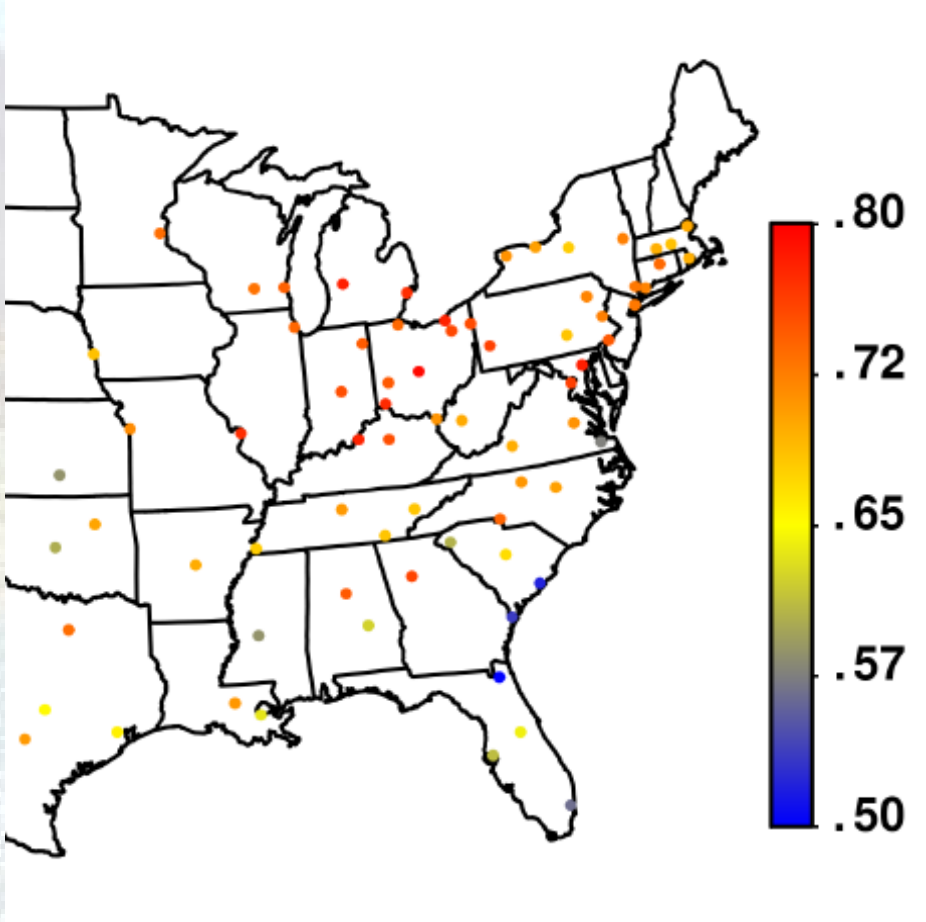
- Background
  - Work started in Fall 2007 (Davis/Cox/Reff/Dolwick)
  - Paper to be submitted to *Atmospheric Environment* (presently in review)

- Methodology:
  - Analysis of data from 2002-2006 "ozone seasons" (April – Sept)
  - 74 cities over the CMAQ EUS12 domain
  - Statistical model based on (not identical to) Camalier et al (2007)
  - CMAQ extractions of <u>8-hour max ozone</u> based on highest cell in nearest nine
  - MCIP extractions are taken from the actual cell in which met obs are made

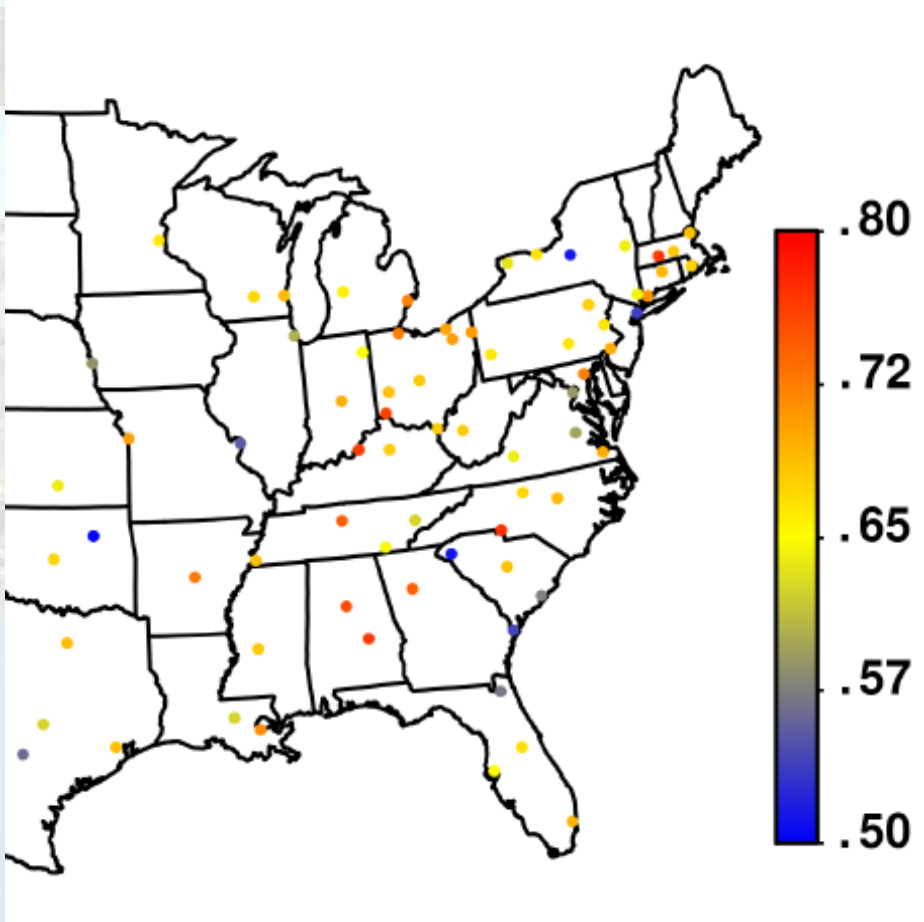
- Statistical modeling basics
  - Non-parametric regression models
  - Separate statistical model for each location, but met covariates unchanged
  - Meteorological covariates:
    - Daily maximum temperature
    - Daily average relative humidity
    - Morning stability metric (12Z temperature difference between surface & 850 mb)
    - 0700-1000 LST average wind speed, u-wind vector, & v-wind vector
    - 1300-1600 LST average wind speed, u-wind vector, & v-wind vector
    - Daily Total Precipitation
  - Other covariates:
    - Julian day factor
    - Year factor

- Predictive "skill" of statistical models:
  - Models based on ambient data typically have R^2 values ~ 0.70 (0.50-0.80)
    - North-south gradient
  - Models based on CMAQ data typically have R^2 values ~ 0.66 (0.50-0.77)
  - Tendency for both sets of models to underestimate peaks (overestimate minima)

R-squared values for the ozone/meteorological statistical models

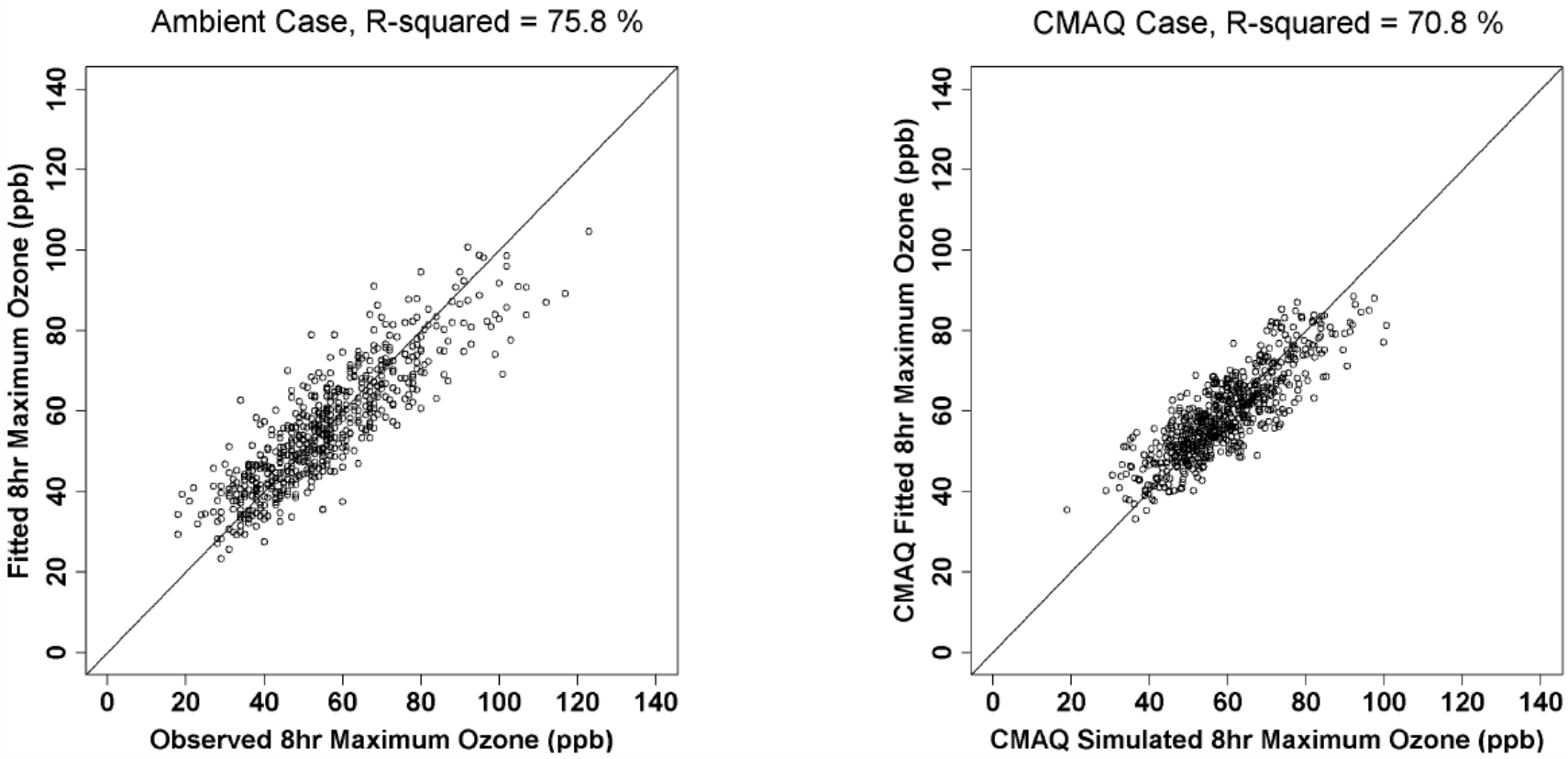


Ambient



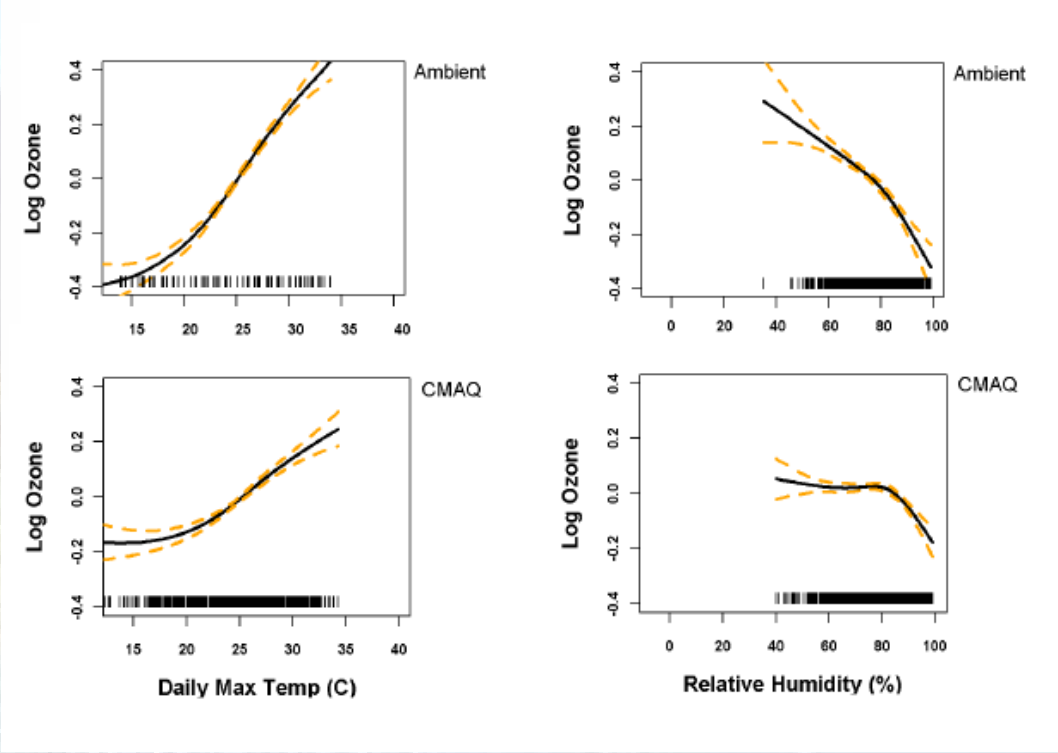
CMAQ

Sample results from regression models (Akron OH)



(a) Akron, OH

Comparison of response curves (Akron OH)



Dashed lines are 95% confidence intervals

Density of the data is indicated by the "rug"

- Camalier (2007) showed that temperature and RH were the two most important response meteorological variables for ozone over northern U.S.
- Within CMAQ for the Akron location, the same basic relationships hold between temperature/ozone and RH/ozone …
- … however the magnitude of the T and RH impacts are smaller
- The challenge is how to summarize this data over 74 sites and multiple meteorological covariates

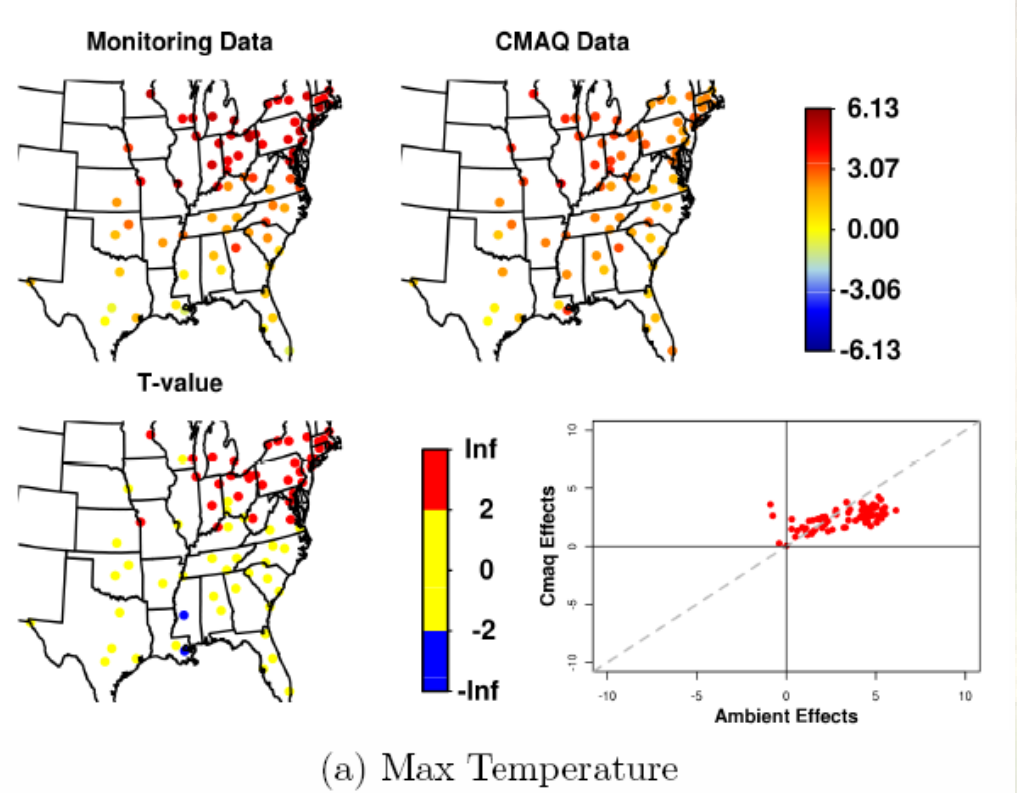
- Two key statistical concepts
  - "Effect of the variable"
  - "t-statistic"

- Effect of the variable = percent change in O3 response over the 25-75th percentile of met covariate

- t-statistic = effect difference (amb–cmaq) divided by average standard error

- The t-statistic is used to flag areas where met/O3 response is significantly different in CMAQ than in the ambient data.

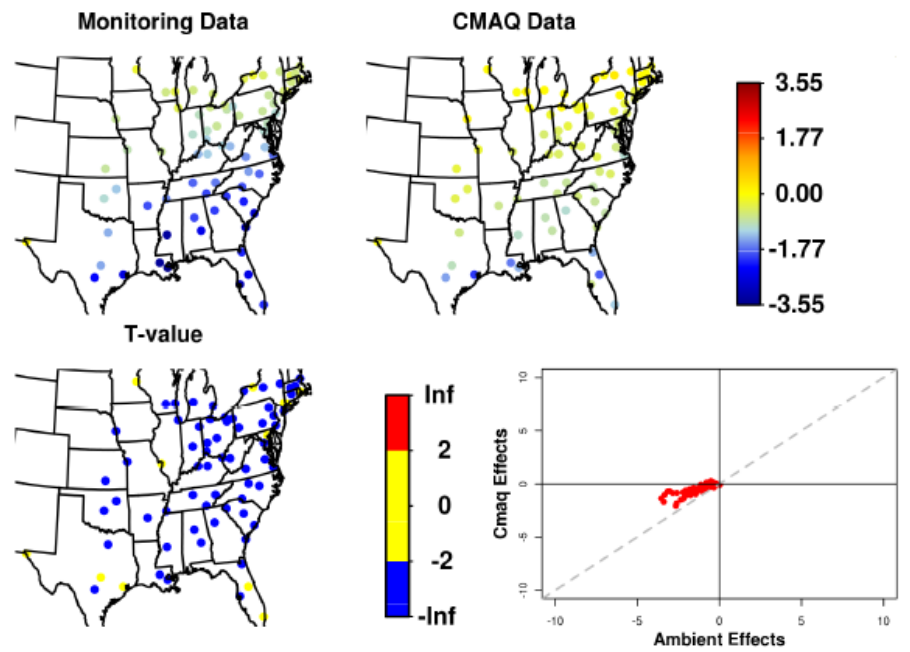
Effects & t-statistics (daily T max)



(a) Max Temperature

Conclusion from this plot: CMAQ model tends to underestimate the responsiveness of ozone to temperature over most of the U.S. These differences are "significant" in the northern tier of the U.S.

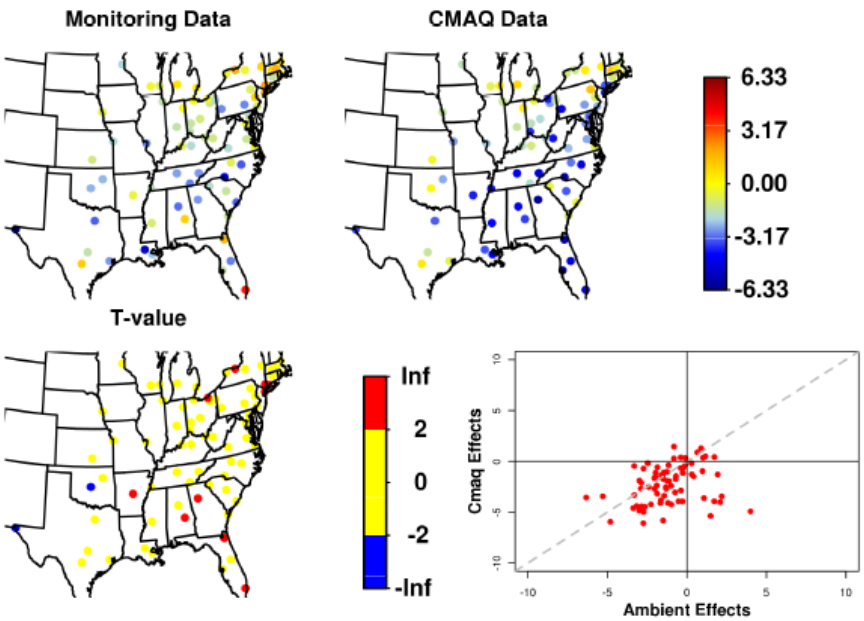
Effects & t-statistics (average RH)



(d) Avg RH

Conclusion from this plot: CMAQ model tends to underestimate the responsiveness (inversely related) of ozone to RH over majority of the U.S. Model does seem to pick up on north-south gradient in RH impacts

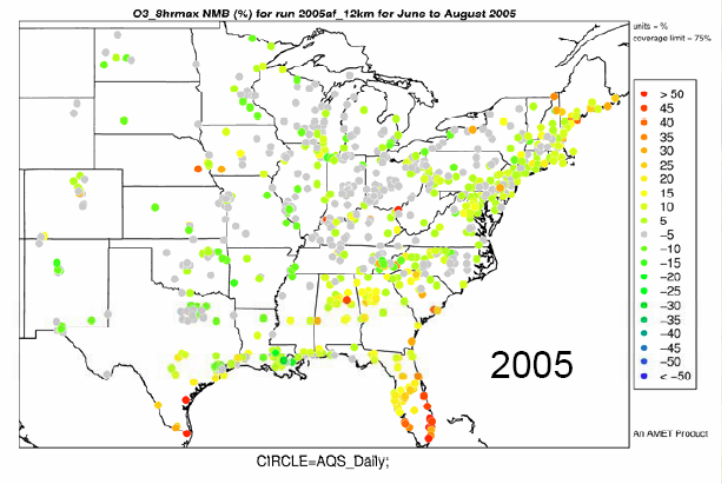
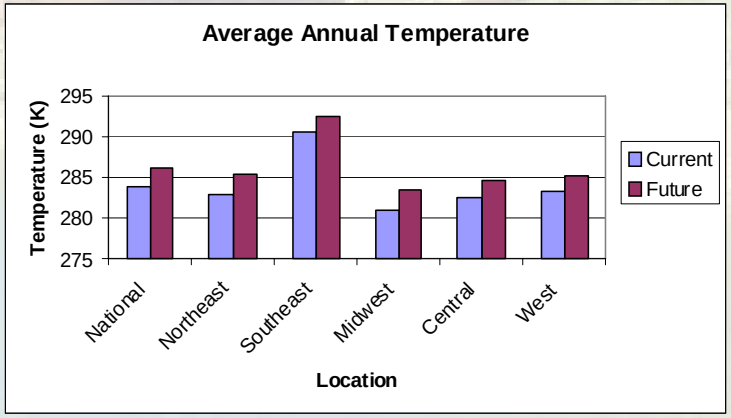
Effects & t-statistics (PM WSpd)



(c) PM Avg Wind Speed

Conclusion from this plot: CMAQ model tends to overestimate the responsiveness of ozone to light winds over the Southeast U.S. Because of the large errors associated w/ wind speeds, there differences are generally not statistically significant

- Conclusions:
  - Basic statistical relationships between ambient ozone and meteorology are **generally** preserved in the MM5/CMAQ simulations.
  - Model met/O3 response was found to be significantly different for daily max temperature and RH in some areas.

- Possible Applications:
  - CMAQ model evaluation: Why is model somewhat "under-responsive" to temperatures in the northern U.S. (emissions?, chemistry?)
  - Estimating effects of climate change: Downscaled GCM results w/ higher temperatures through CMAQ may result in an underestimate of the true climate impact on ozone

- Next steps?
  - Use same data set w/ speciated PM data?
  - Similar analysis in the west (either w/ 36km domain, or 2006-08 CMAQ when available)?
  - If anyone would like to informally review the paper, that'd be appreciated.