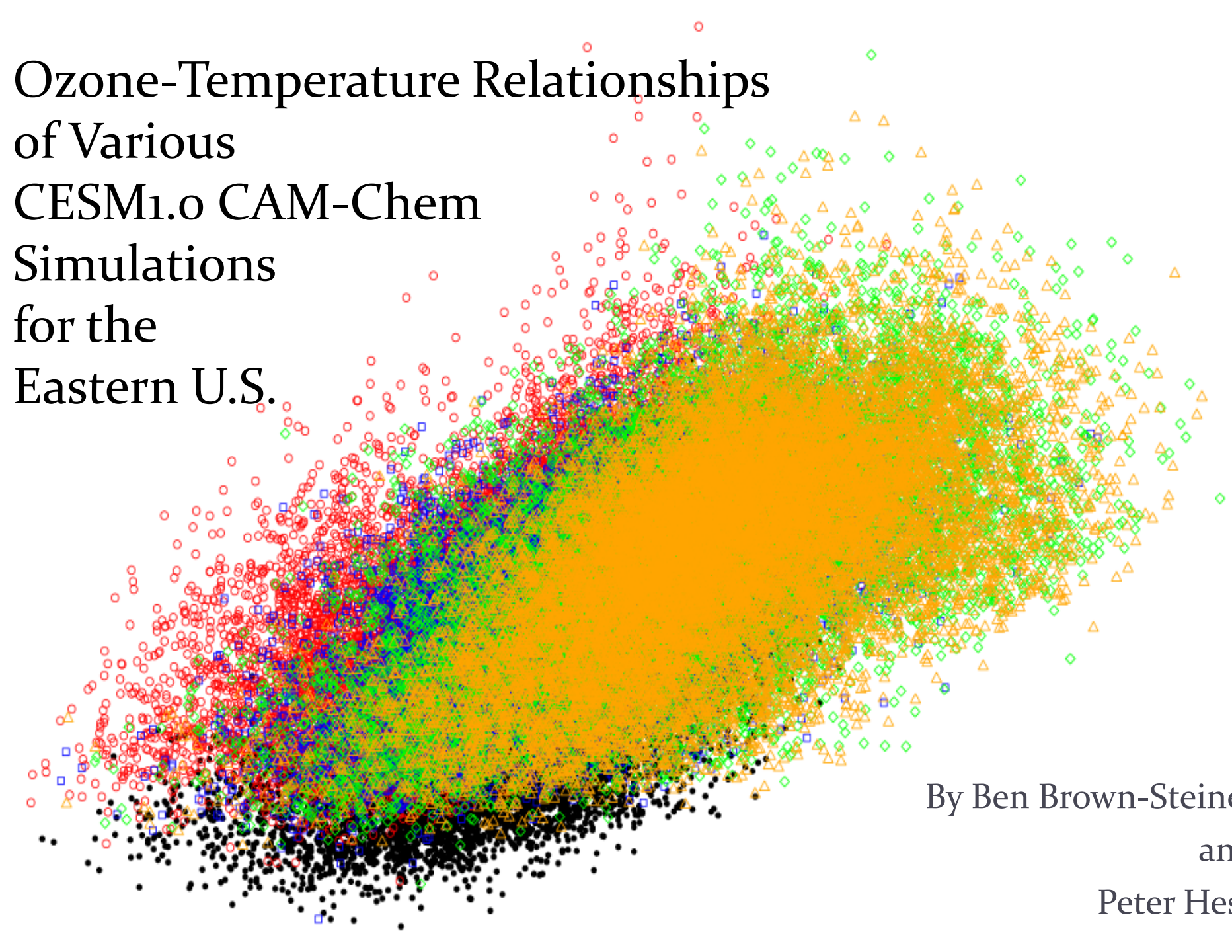
Ozone-Temperature Relationships of Various CESM1.0 CAM-Chem Simulations for the Eastern U.S.



By Ben Brown-Steiner
and
Peter Hess

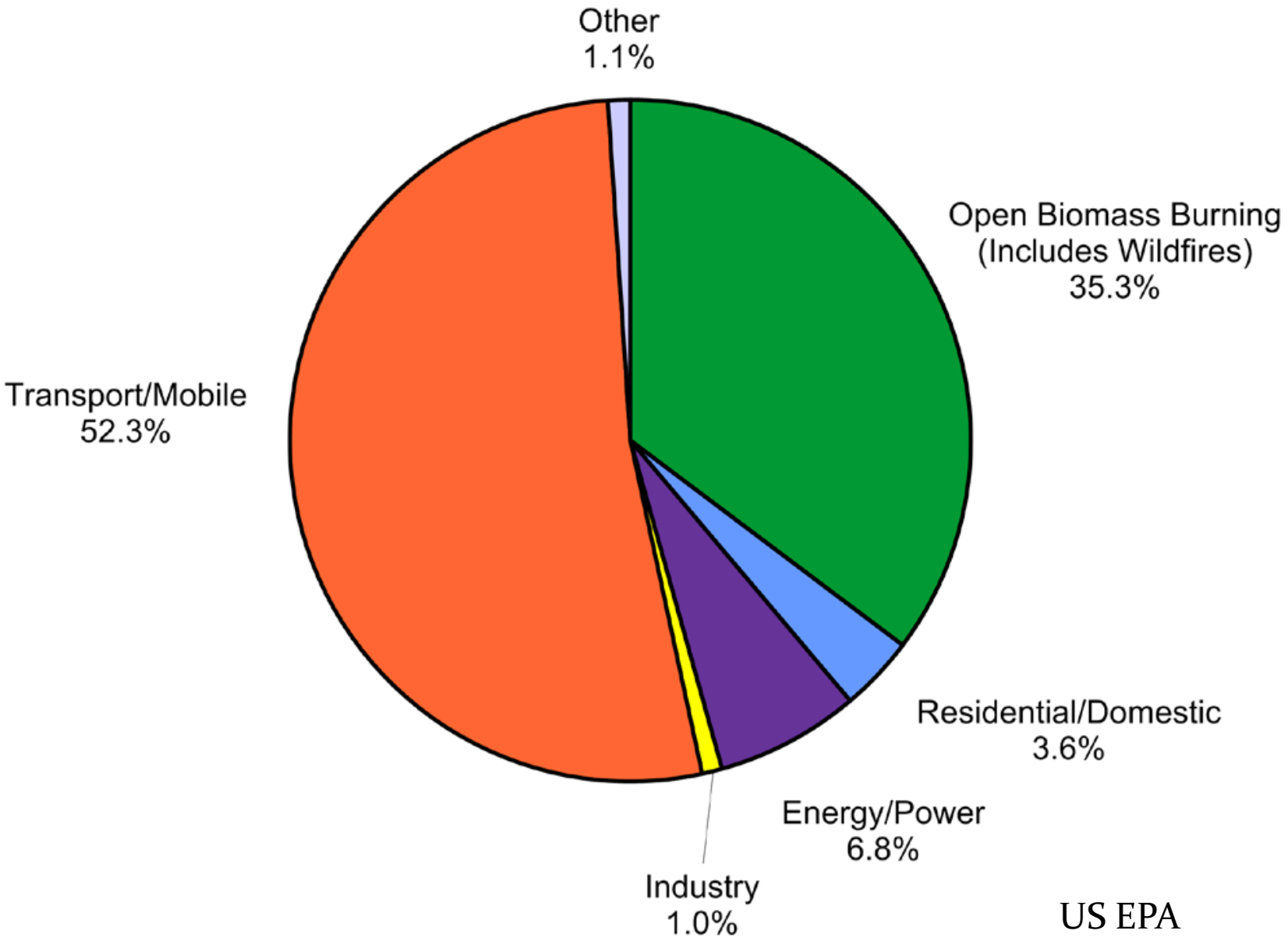
The volume of freight movement (in value terms) for all distances has been increasing at a faster annual rate, 6.6%, than GNP.

Distance Shipped (1) (Based on Great Circle Distance)	Value		
	2007 (million $)	2002 (million $)	Percent change
All distances	11,684,872	8,397,210	39.2
Less than 50 miles	3,851,545	2,503,895	53.8
50 to 99 miles	1,074,137	757,601	41.8
100 to 249 miles	1,777,031	1,329,245	33.7
250 to 499 miles	1,606,034	1,221,437	31.5
500 to 749 miles	1,019,498	844,880	20.7
750 to 999 miles	720,623	548,768	31.3
1,000 to 1,499 miles	730,366	501,419	45.7
1,500 to 1,999 miles	494,992	353,663	40.0
2,000 miles or more	410,646	336,302	22.1

Source: Bureau of Transportation Statistics

-Industries exploit economies of scale and scope by dispersing activities
-Semi-finished goods are shipped from one specialized establishment to another.
-Just in time inventory management efforts

U.S. BC Emissions in 2005 (0.64 Million Tons)



US EPA

Emission determination (Kieran Donaghy)

Develop dynamic structural-equation behavioral model:

- Cost Minimization for Shipper

  Inter-Regional/Industry Freight Movement: determines annual increments in prices, capital, labor and freight movement

- Profit Maximization for Carrier

  Shipment Pricing and Route Selection: determines the charge of shipping and route of shipment for the next period

- Solution determined by non-cooperate equilibrium between representative shipper and carrier

Overall Project Description

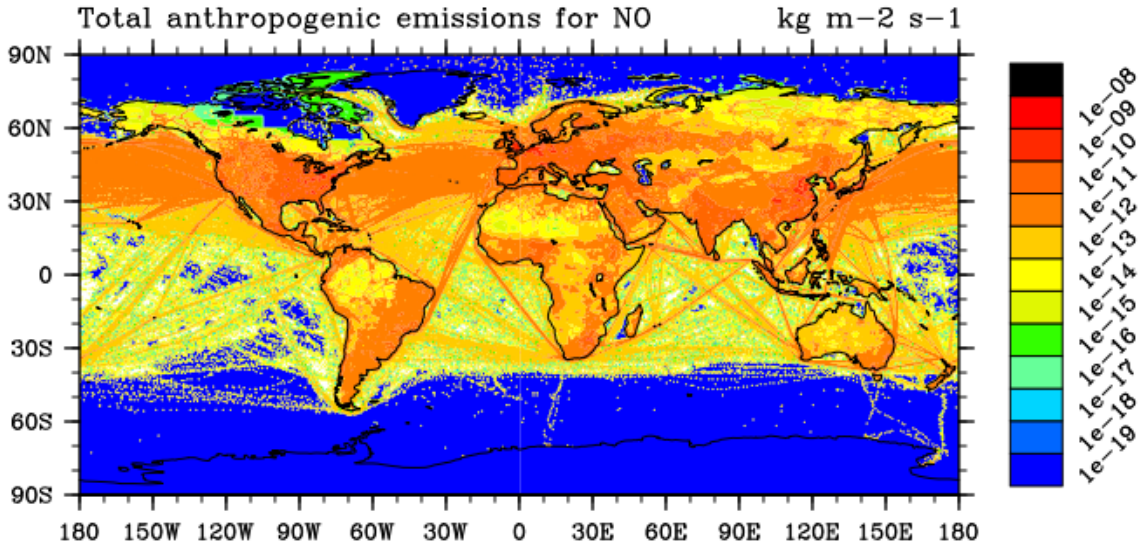
- Task 1: Generate Scenario Trajectories
- Task 2: Generate Emissions
- Task 3: Run Simulations
- Task 4: Sensitivity Analysis / Synthesis

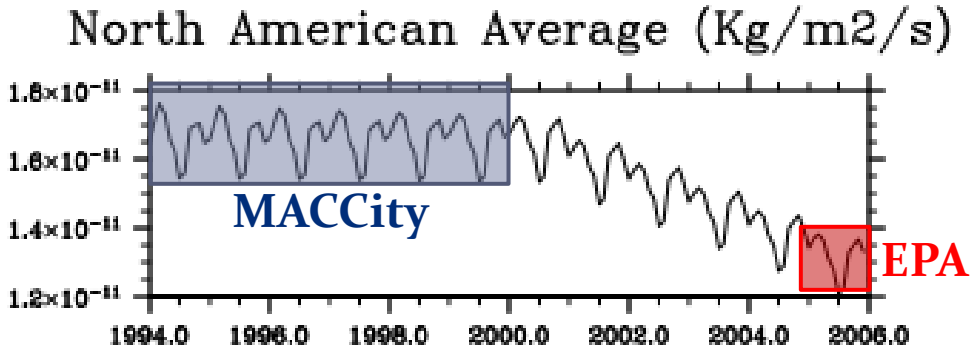
This Study: Baseline Run (present day)

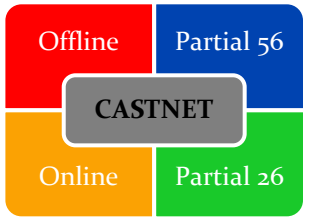
1. Emissions
2. Configurations
3. Simulation Results

Description of Emissions: 1994 - 2005

- 21 MOZART-4 species from:
  - **MACCity for 1994 – 2000**
  - **EPA NEI for 2005**
- Linear interpolation between MACCity and EPA NEI for 2001 - 2004
- Seasonal cycles taken from MACCity
- NO_x decrease (shown) starting in 2000 a result of the 1998 NO_x S.I.P.
- Biogenic emissions from MEGAN simulated online for isoprene and $C_{10}H_{16}$



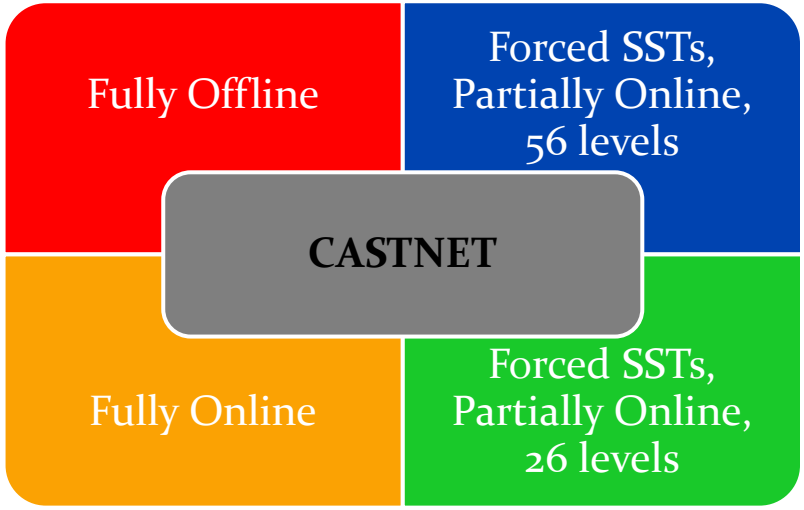




Overview of the Four Simulations

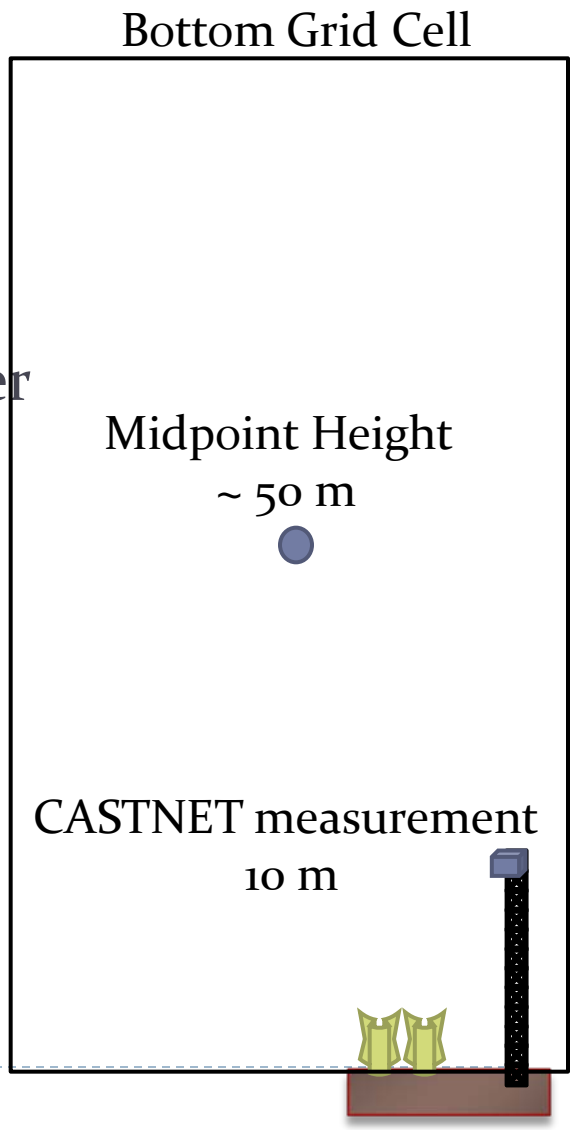
- 1 Fully Offline, 2 online (forced SSTs), 1 Fully Online
- Purposes:
  - Examine online/offline simulation biases to observations
  - Examine difference in paramaterizations due to # of levels
- Emissions, Chemistry, Paramaterizations, and time (1994 – 2005) identical for each simulation

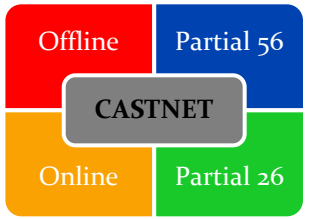
Simulation	Meteorology	SSTs	# of Levels
Fully Offline	MERRA	Forced	56
Partially Online, Forced SSTs, 56 levels	calculated online	Forced	56
Partially Online, Forced SSTs, 26 levels	calculated online	Forced	26
Fully Online	calculated online	Simulated online, POP2	26



Quick Note about Results

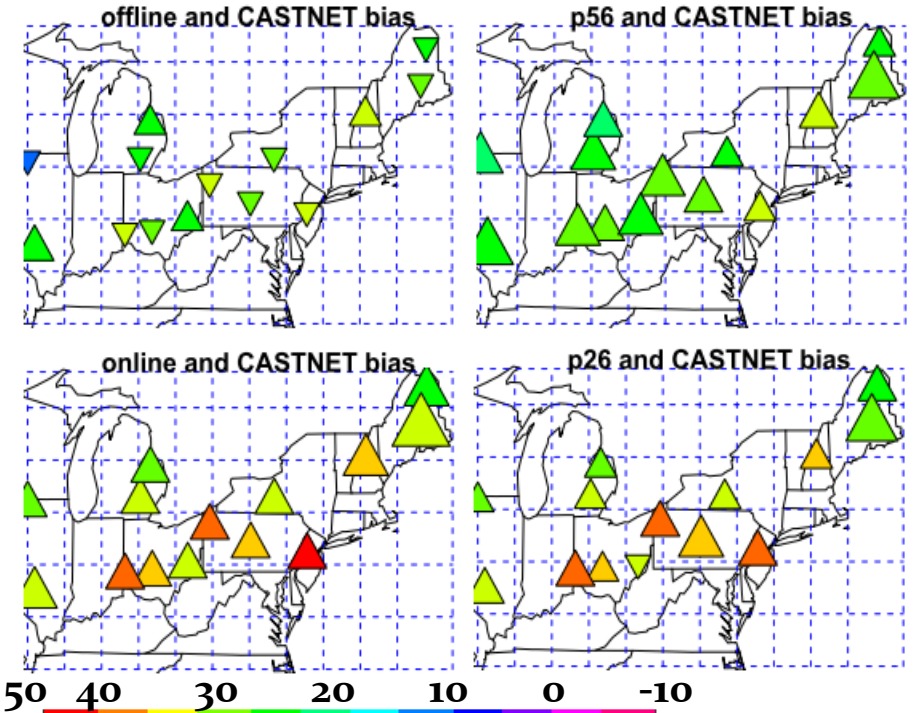
- Following Slides Show:
  - Daily Maximum 8-hour Ozone (DM8H O_3)
  - Daily Maximum Temperature (DMT)
  - Unless otherwise noted, regional statistics computed first at each site, then averaged over the region
  - Ozone was interpolated from grid cell midpoint to the height of each CASTNET measurement (10 meter) using method described by Dingenen et al. [2009]

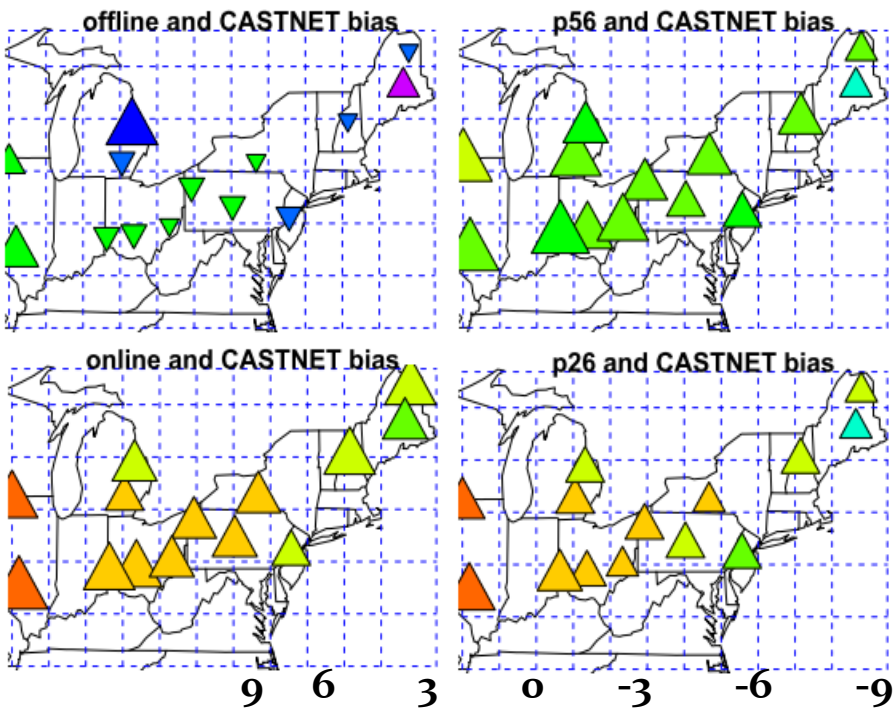




DM8H O_3 (left) & DMT(right) Biases

- Higher DM8H O_3 bias in Ohio/Pennsylvania region
- All of the online simulations show a higher SD in both DM8H O_3 and DMT than the offline simulation



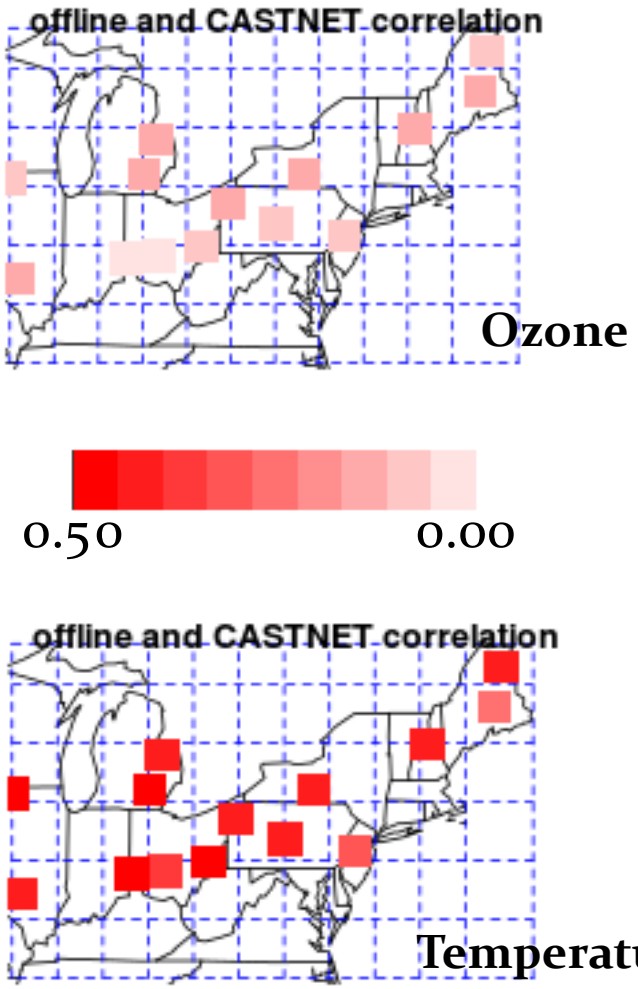


Standard Deviation

¼ ½ ¾ 1 1.25 1.50 1.75 2.00 2.50

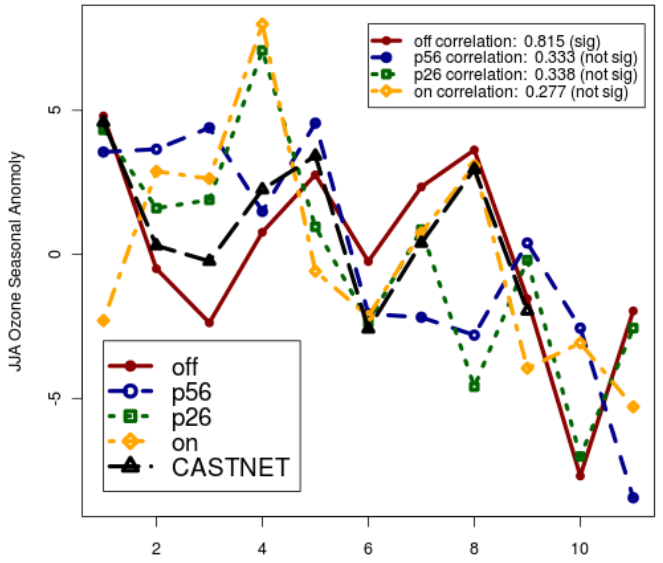
Simulation Correlations with CASTNET

- DM8H O_3 (top) and DMT (bottom) correlations with CASTNET
- Every summer day from 1995 – 2005 (92 days x 11 years = 1,012 days)
- The offline simulation is the only simulation with significant correlations
  - DM8H O_3: ~ 0.15
  - DMT: ~ 0.42

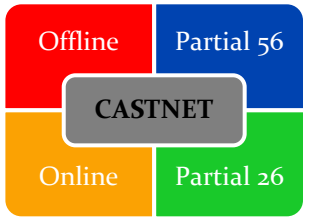


Summertime Interannual Variability

- The only simulation that has a significant DM8H O_3(shown) and DMT (not shown) interannual correlation is the offline simulation
- Table summarizes the correlations, * indicates significance
- All simulations show a general decreasing trend, attributed to decreasing NO_x emissions



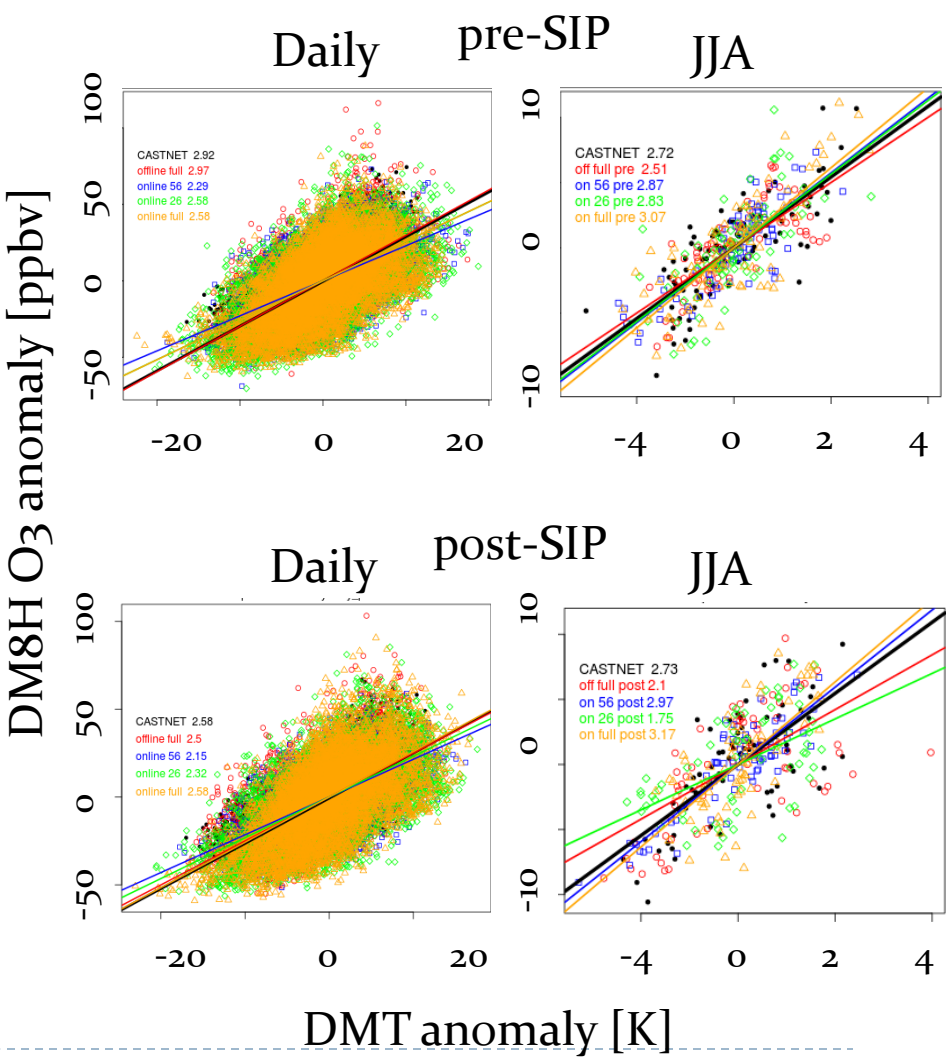
Simulation Correlations	DM8H O3	DMT
Fully Offline	0.82*	0.89*
Partially Online, Forced SSTs, 56 levels	0.33	0.055
Partially Online, Forced SSTs, 26 levels	0.33	0.17
Fully Online	0.28	-0.15



Climate Penalty Factor, comparisons

- Climate Penalty Factor (CPF) is the slope of the DM8H O3 and DMT relationships
- Pre- and Post-SIP results are significantly different for daily statistics

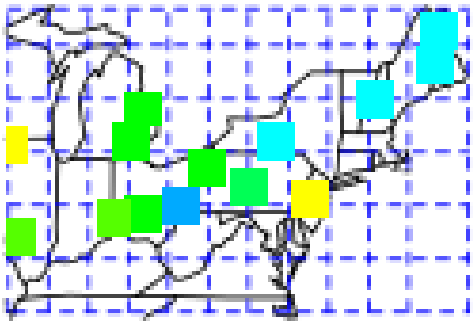
CPF [ppbv /K]	daily pre-SIP	daily post-SIP	JJA pre-SIP	JJA post-SIP
CAST NET	**2.92 ± 0.044**	**2.57 ± 0.044**	2.72 ± 0.23	2.73 ± 0.36
off	**2.97 ± 0.043**	**2.50 ± 0.039**	2.51 ± 0.23	2.11 ± 0.32
p56	**2.29 ± 0.041**	**2.15 ± 0.042**	2.87 ± 0.21	2.97 ± 0.20
p26	**2.58 ± 0.039**	**2.32 ± 0.038**	**2.83 ± 0.32**	**1.75 ± 0.34**
on	**2.58 ± 0.042**	**2.58 ± 0.043**	3.07 ± 0.25	3.17 ± 0.41



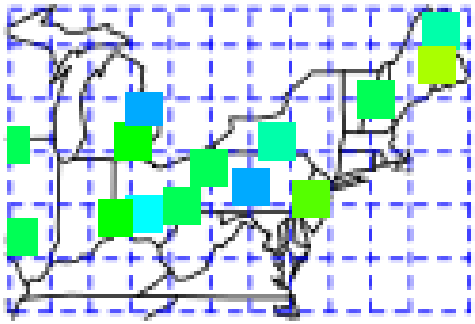
Offline | Partial 56 | CASTNET | Online | Partial 26

Daily Climate Penalty Factor

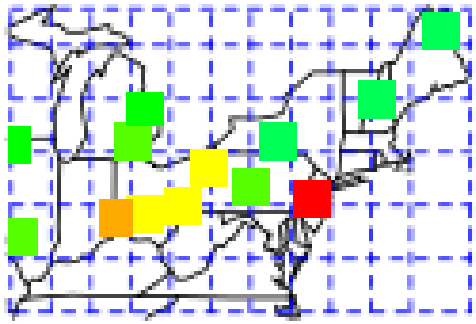
CASTNET JJA CPF



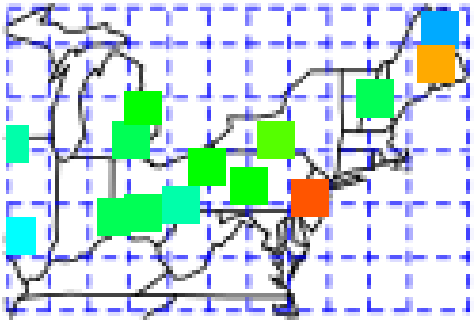
off JJA CPF



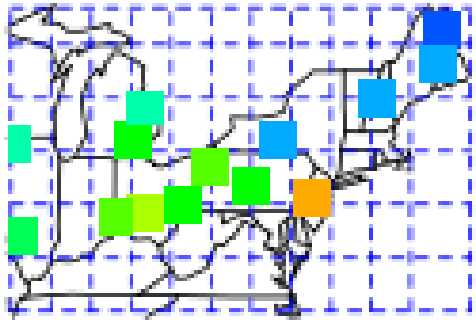
p56 JJA CPF

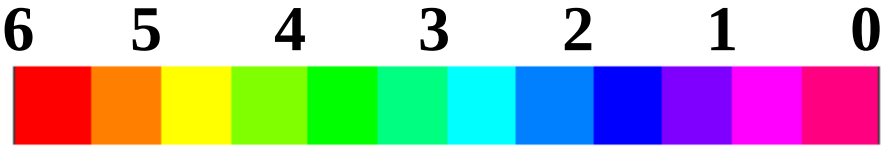


p26 JJA CPF



on JJA CPF



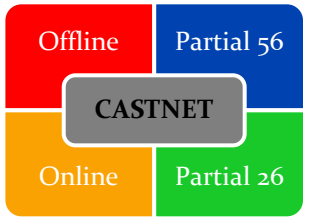


Can simulation biases explain CPF?

- We can remove the offline bias for DM8H O3 and DMT for the online simulations and see how this changes the CPF
- This table shows the change in CPF for daily and JJA CPF
- For p56 temperature does not explain the bias, while for p26 and online temperature may explain part of the bias
- More needs to be done to understand these relationships

$$\frac{\left[O_{3,bias,sim} - O_{3,bias,offline}\right]}{\left[T_{bias,sim} - T_{bias,offline}\right]}$$

CPF change [ppbv/K]	summer
p56	**-1.2 ± 1.7**
p26	**1.3 ± 0.60**
on	**1.3 ± 0.54**



Future Work

- Expand beyond the Northeastern U.S.
  - Select regions based upon simulation bias/correlation with CASTNET observations
  - Utilize the entire CASTNET network
- Use the emissions produced through the Donaghy group to simulate future emissions in the Northeastern U.S. under various economic and technological scenarios