Data mining, Exa-Scale Work Flow and Financially Germane Carbon/Climate Weather on the Evening News

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Workshop on Understanding Climate Change from Data
University of Minnesota

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Take away climate simulation and observation data mining points

- Climate model-high-performance computational (HPC) platforms linked in real time with arrays of satellites
- Climate/carbon prediction needs to be tailored to each audience/effective monetized climate change
- Education of students in HPC, climate science and visualization techniques is occurring now and will accelerate

Outline

•Global Earth System Modeling (What that means now and in future)

•Fully Coupled Climate-Carbon-Chemistry- Models

•Financial impacts from changing climate and energy usage

•Treaty verification: Sources of atmospheric CO2 – Who is out of compliance today? Who will be out of compliance in 2030?

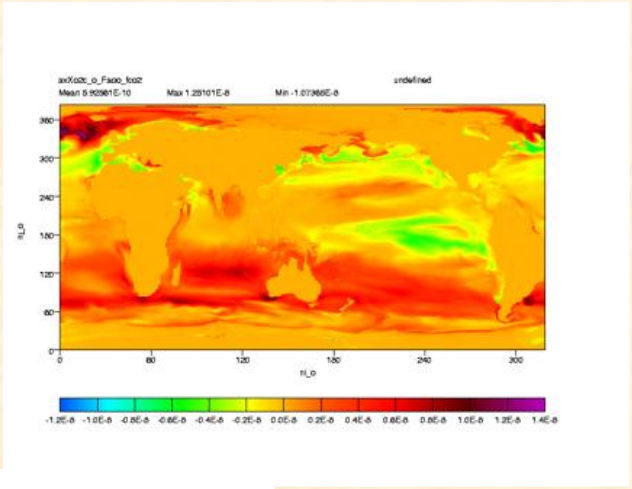
ESM/"Climate Model" 1.5 million lines of FORTRAN and $300M satellite data streams

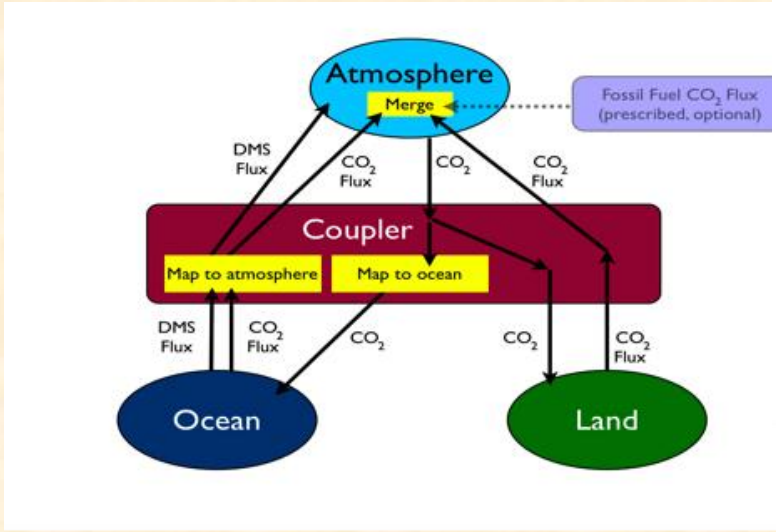
- Data mining in real time and to assess carbon sources and sinks
  - Satellite data streams into 10-1000 Peta flop machine
  - Solving primitive equations of planetary geophysical fluid dynamics with 100's of chemical and biological tracers in oceans and atmospheres
  - Simulations for fully coupled atmosphere, sea ice, land biology (carbon) and ocean dynamics and semi-implicit solvers

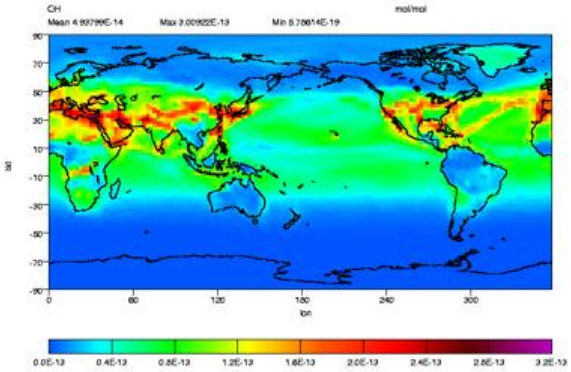
- **Create carbon/climate weather updates on the nightly news**

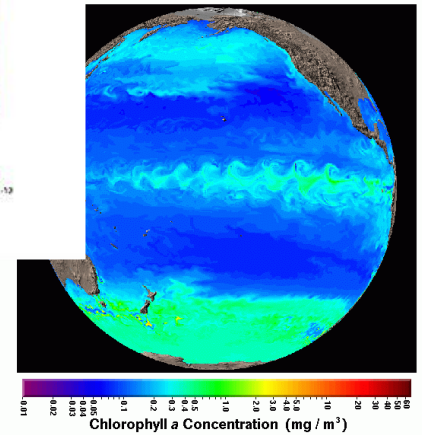
ESM/Chemistry/Carbon Climate Model

- **Components:**
  - **Processes for stratosphere through thermosphere**
  - **Reactive chemistry in the troposphere**
  - **Oceanic and terrestrial biogeochemistry**
  - **Isotopes of H_2O and CO_2**
  - **Prognostic natural and anthropogenic aerosols**
  - **Chemical transport modeling inside CCSM**
  - **Full land with CO_2**



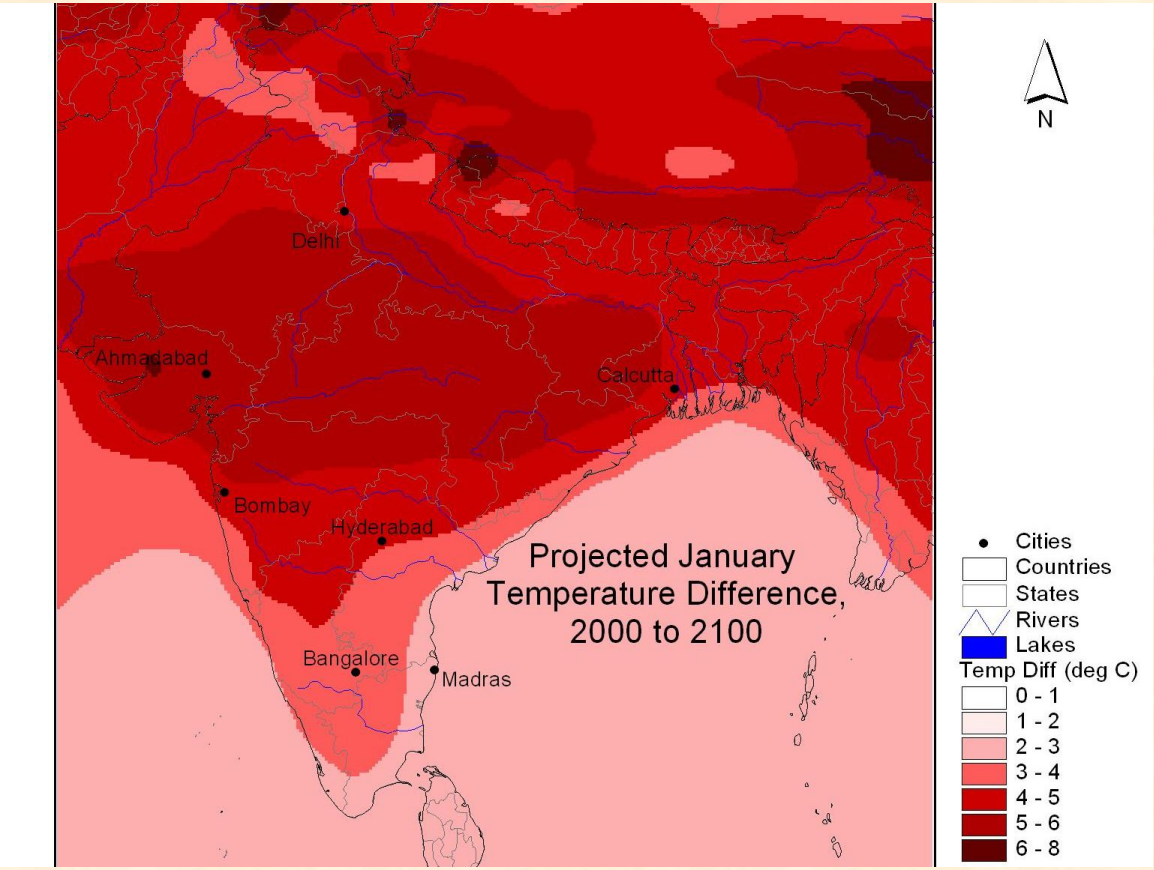




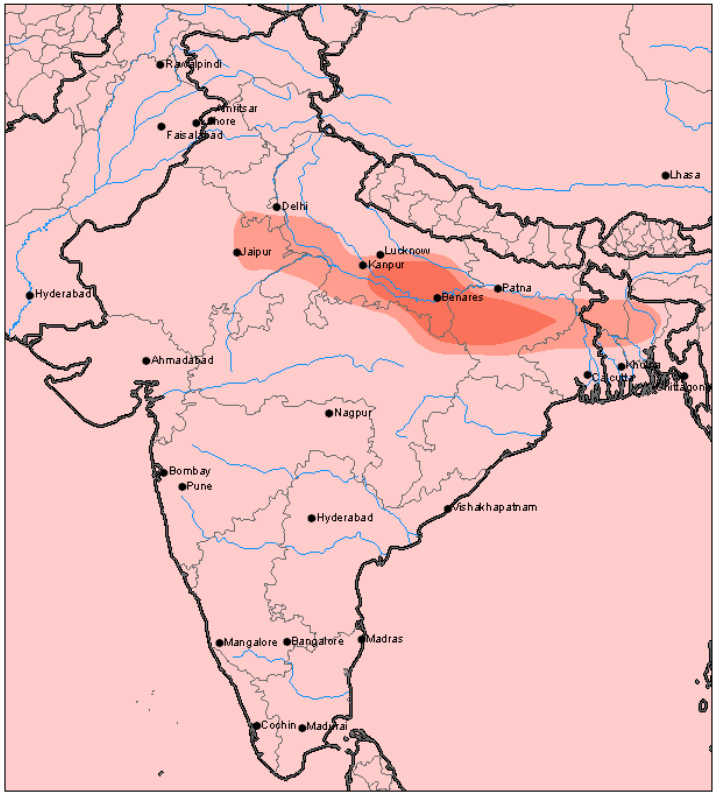


Climate/Carbon Extremes

- Temperature
- Precipitation
- Abrupt climate change
- Financial impacts from changing energy usage-Quantify costs of NOT doing anything
- Treaty verification: Sources of atmospheric CO_2



Ganguly, A. R., K. Steinhaeuser, D. J. Erickson III, M. Branstetter, E. S. Parish, N. Singh, J. B. Drake, L. Buja, "Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves", *Proceedings of the National Academy of Sciences of the United States*, 10.1073/pnas.0904495106, 2009.



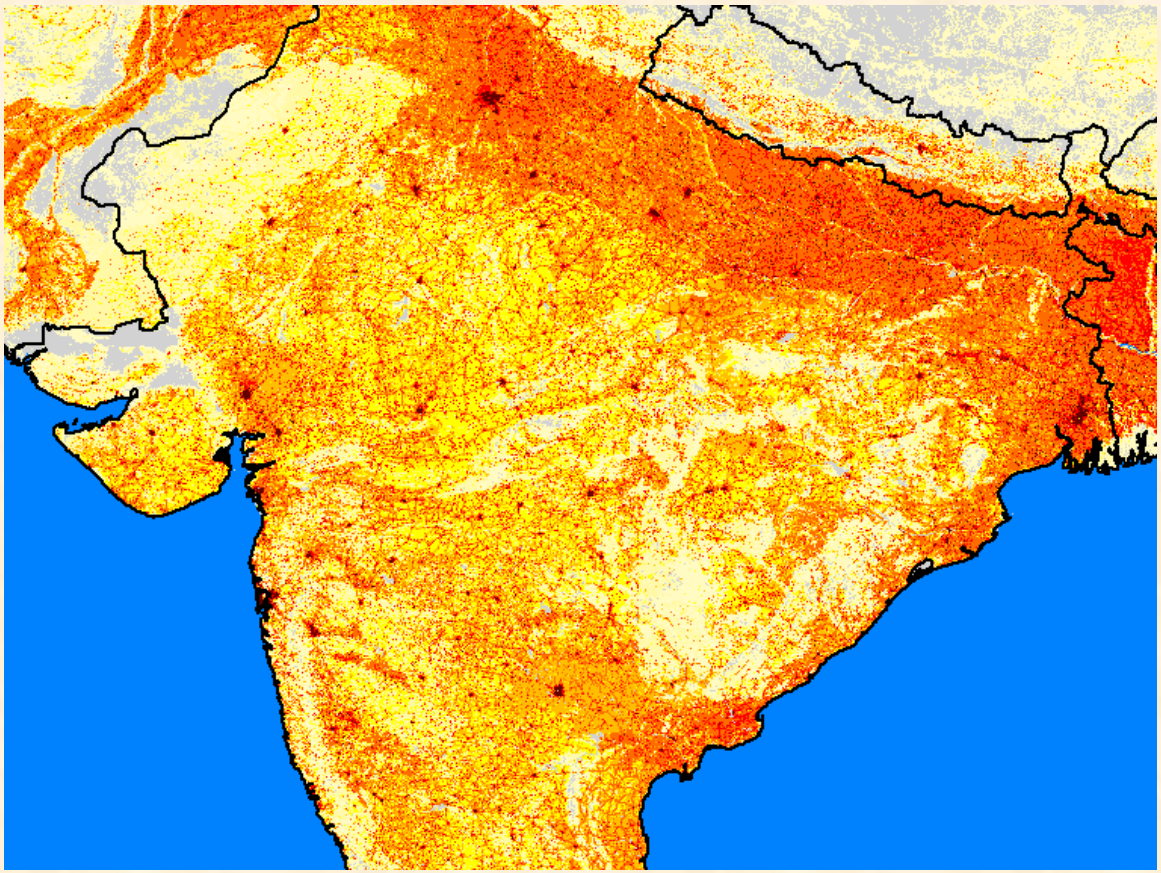
Extreme Temperature for July in India

- Cities
- Provinces
- Countries
- Rivers

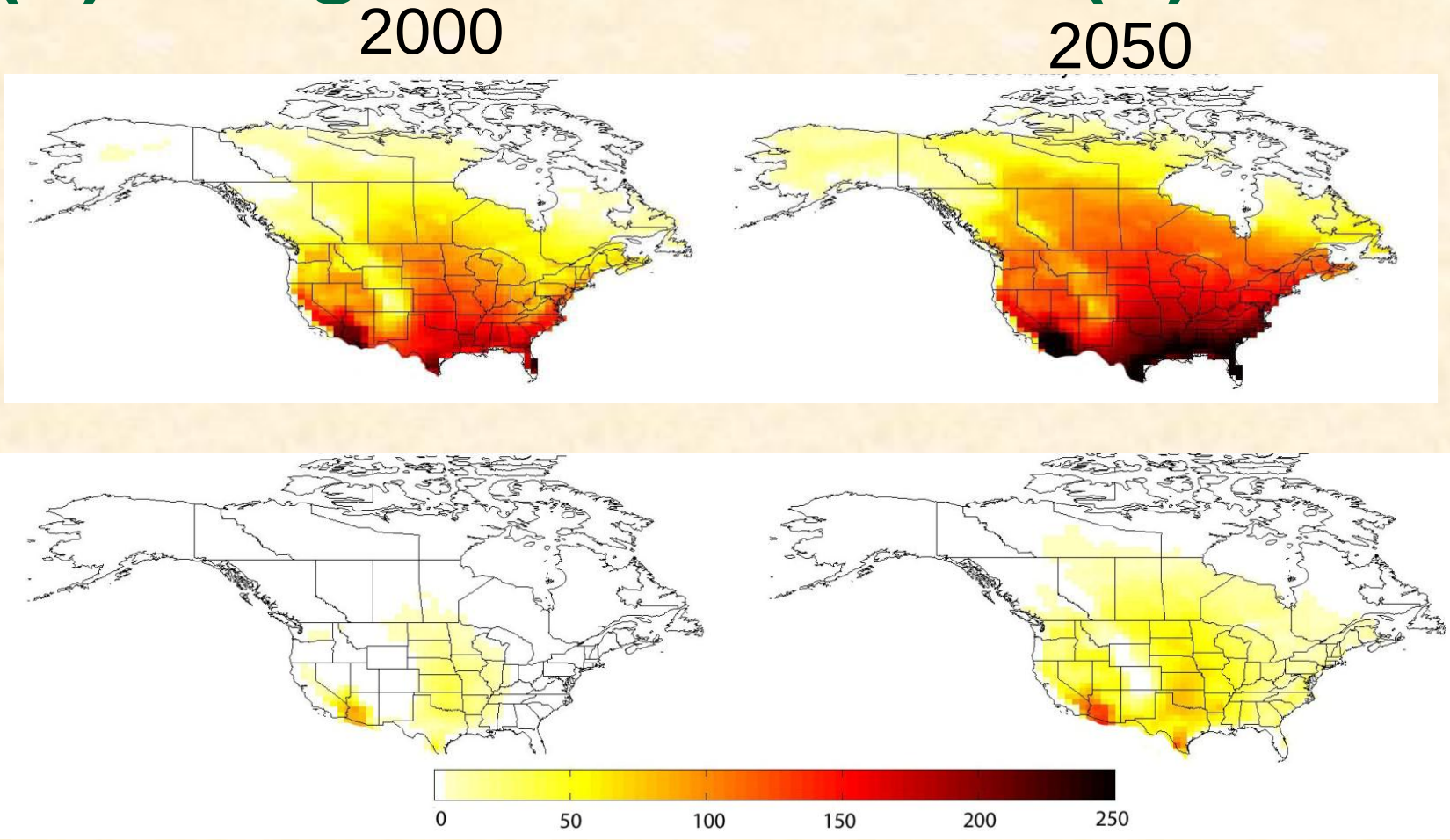
2000-2009

 # Days Exceeding 35 Deg C

- < 1
- 1-2
- 2-5
- 5-10
- 10+



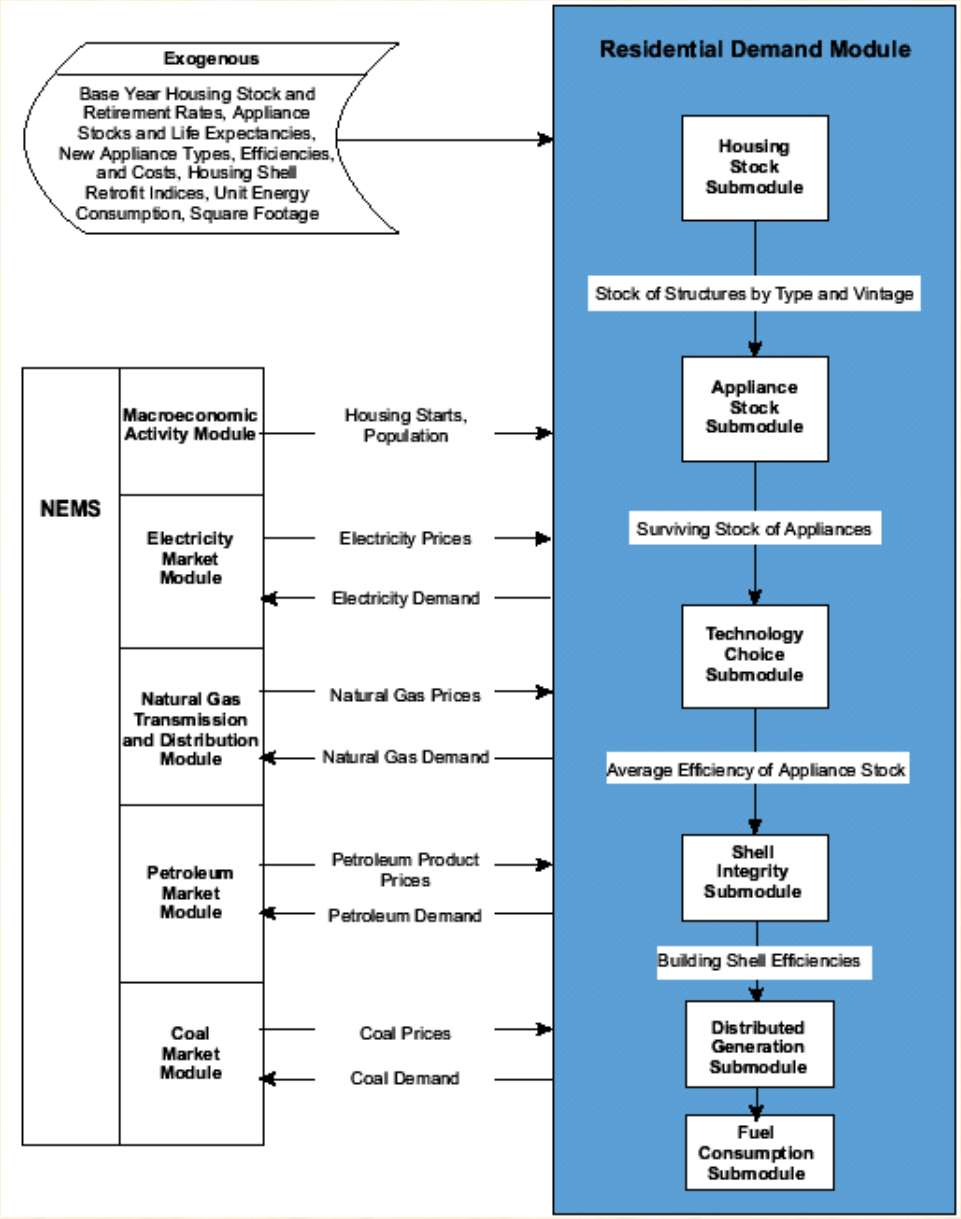
Number of days greater than 80°F (A) and greater than 100°F(B)



Financial impact of temperature change

- Creation of a unique, algorithmic, quantitative modeling structure that uses global ESM/GCM output to drive a state-of-the-art energy usage model
- Extreme events

- **Data mine satellite data streams that are embedded in state-of-the-art high resolution climate model to assess on the fly real time energy demand for the next 3 hours, day, week etc….**


Exogenous
Base Year Housing Stock and Retirement Rates, Appliance Stocks and Life Expectancies, New Appliance Types, Efficiencies, and Costs, Housing Shell Retrofit Indices, Unit Energy Consumption, Square Footage
Residential Demand Module
Housing Stock Submodule
Stock of Structures by Type and Vintage
Appliance Stock Submodule
Surviving Stock of Appliances
Technology Choice Submodule
Average Efficiency of Appliance Stock
Shell Integrity Submodule
Building Shell Efficiencies
Distributed Generation Submodule
Fuel Consumption Submodule
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Housing Starts, Population
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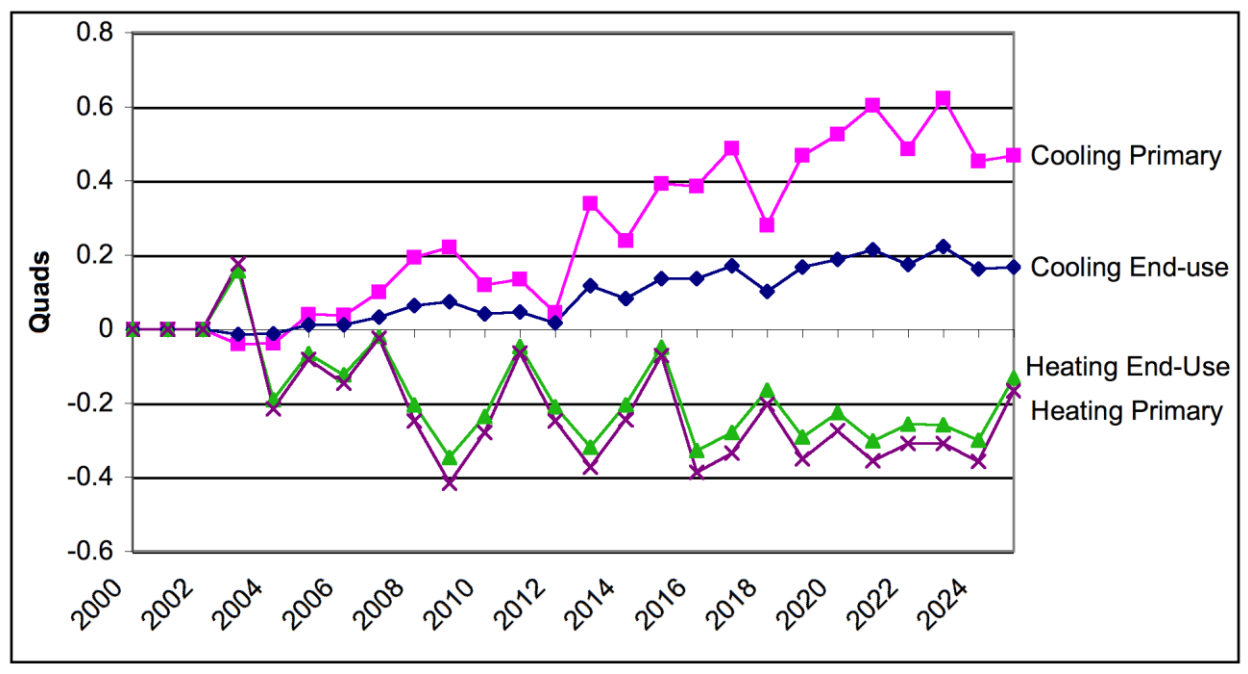
Coal Market Module
Coal Prices
Coal Demand

Change in heating and cooling end-use and primary energy



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Too hot to cool off?
The energy used to fuel air conditioners may be fueling global warming.

Credit: Getty Images

The Hotter It Gets, The Hotter It Gets

By Kim Krieger
*Science*NOW Daily News
3 August 2006

Think twice before you crank up that air conditioner--you just may be contributing to the heat. The fossil fuels that are burned to power our air conditioners fill the skies with the greenhouse gas carbon dioxide, leading to a warmer world--but the warming won't be enough to lessen heating needs in winter, according to a new climate model. The model is the first to show directly how climate change drives energy use, and the findings could make it easier for policymakers to qualitatively link energy policies to climate change.

Climate researchers typically model Earth on huge supercomputers. A standard experiment might look at the planet between the years 1800 and 2100, tweaking the carbon dioxide levels, sunlight, or cloud cover to understand precisely how these variables affect global and local temperatures. These climate models can suggest what would happen if there were slightly less carbon dioxide in the air, or if there were significantly more snowfall in the Arctic, but they have no way to link economic factors such as increased electricity use to climate change: a 2 degree rise in summer temperatures, for example.

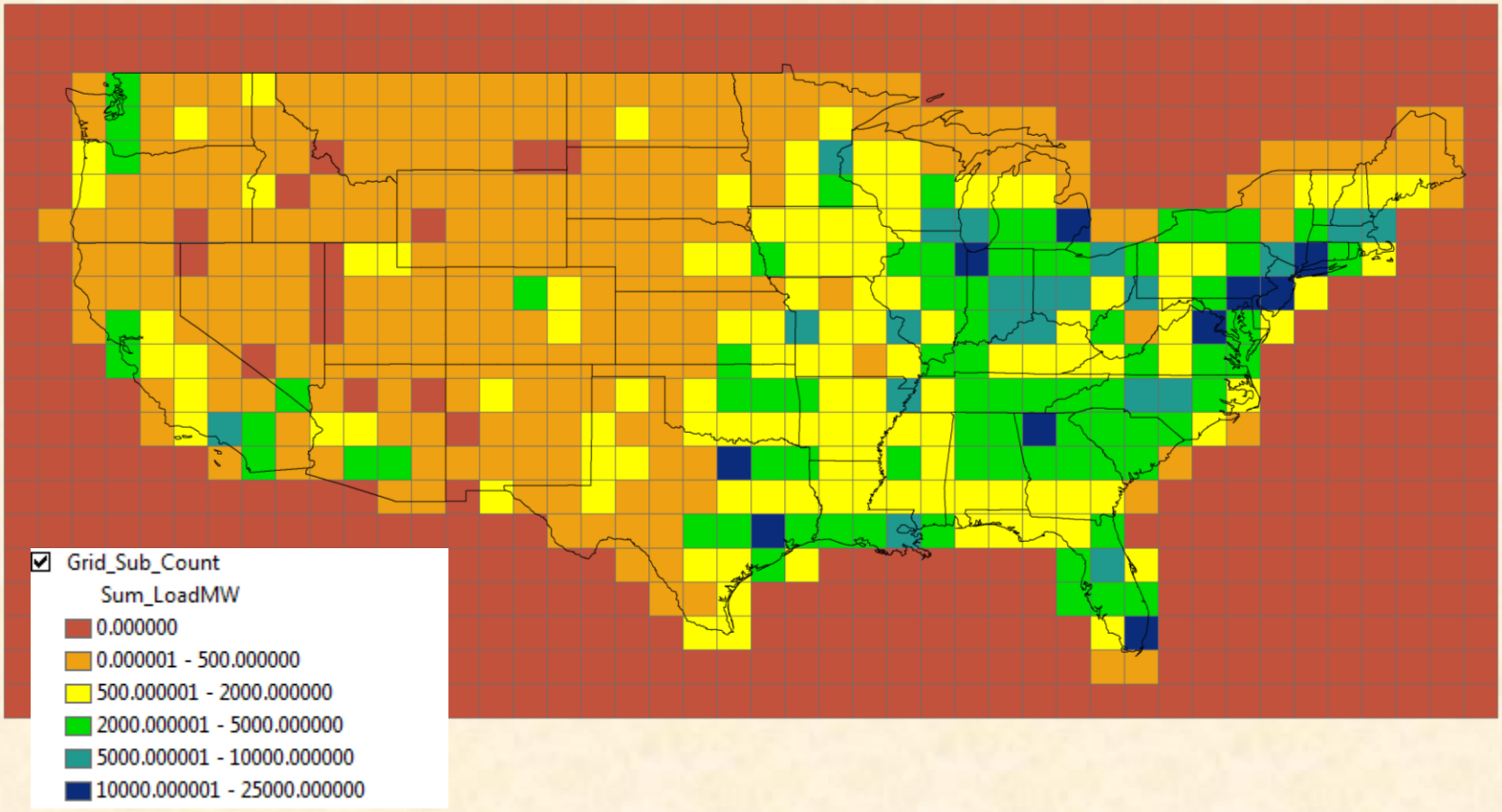
In the August issue of *Geophysical Research Letters*, David Erickson, a geophysicist at Oak Ridge National Laboratory in Tennessee, and colleagues in geophysics and economics make the connection. The team took temperature predictions for the years 2000 to 2025 from a standard climate model and plugged them into the National Energy Modeling System (NEMS) developed by the Department of Energy. The program calculates energy consumption due to heating and air conditioning by dividing the United States up by county and taking into account local climate, typical building styles, and the fuel sources for electricity and heat used in each locale. Part of the result was predictable: Carbon dioxide emissions will rise as more coal is burned when the southern and western United States crank up the air conditioning during their ever warmer summers. But the rest was surprising: The northeast didn't necessarily have warmer winters and, furthermore, tended to use heating oil or natural gas instead of coal-fired electricity for heat. The net result was a rise in carbon dioxide emissions over the 25 years.

The combination of regional climate modeling with state of the art economic modeling "makes this study the first of its kind," says Tom Wilbanks, a researcher at Oak Ridge National Laboratory and chair of the National Academy of Sciences' Committee on the Human Dimension of Global Climate Change, who was not involved in the study. The team says the next step is to feed the carbon dioxide trend back into the economic model to see whether ever

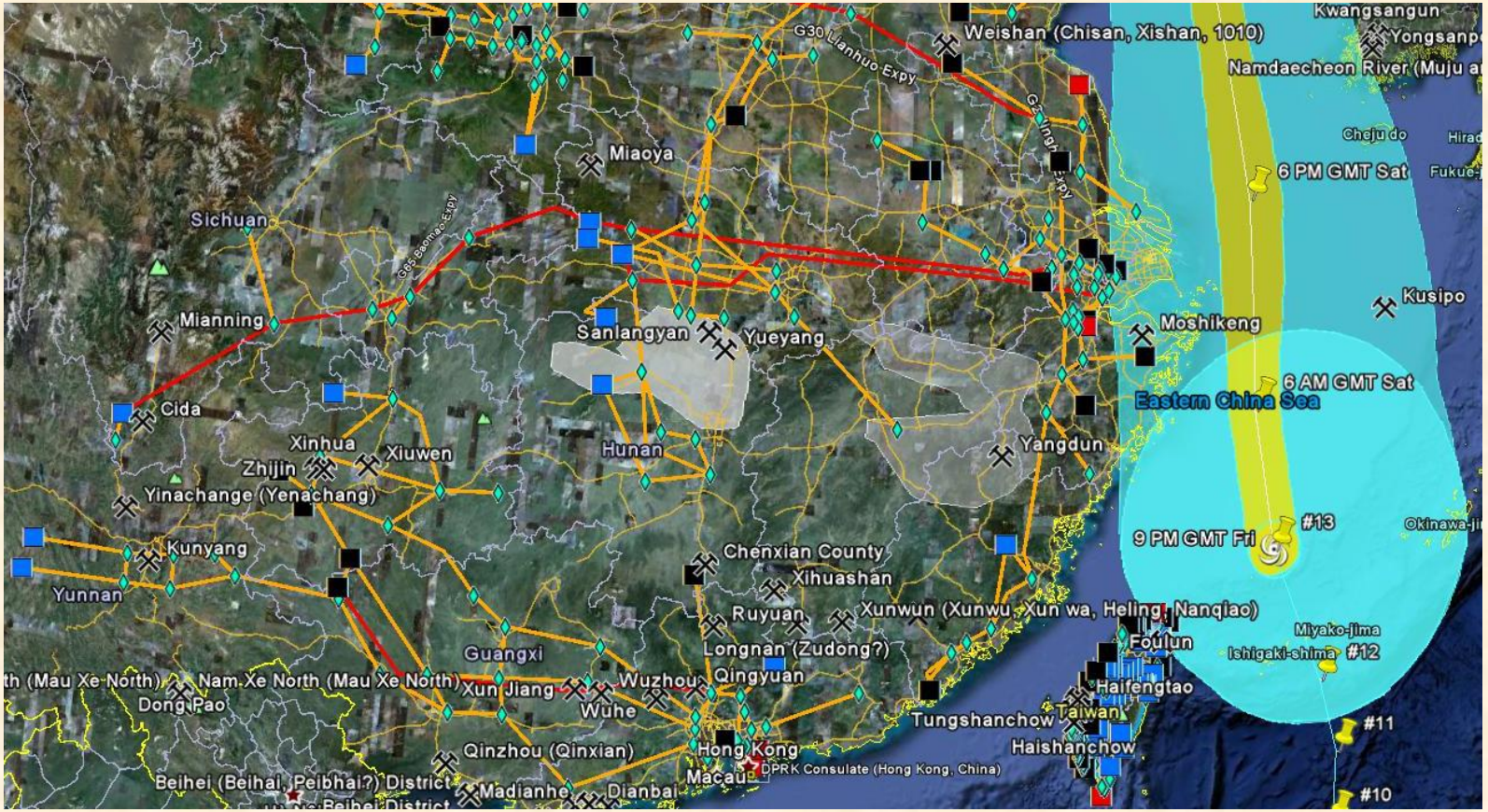
Climate change impacts on Energy Infrastructure

- 26,500 electric sub-stations, 6,000 power plants (T85 grid at the moment….)
- Ensembles of heat waves 2000-2050-2100
- Populations shifts/coal-oil supply
- How does energy requirements change?
- How would different energy generation portfolios alter energy requirements and CO_2 emission?

Total Substations Capacity per Climate Grid (MW)



Detailed electric grid interaction with cyclone in China Present and 2020-2040-2060



Summary

- Fully integrated climate/energy feedback models in “directed” visualizations/news reports
- Policy/economic/treaty verification application for 2030-2050-2070
- Global and regional climate modeling on high performance computational platforms
- Satellite data stream merge with climate models (Data mining-Real time)

i.e. Erickson III, D. J., D. Jamison, M. Allen, A. Ganguly, F. Hoffman, S. Pawson, L. Ott, E. Neilson, "Data Mining Geophysical Content from Satellites and Global Climate Models," Data Mining Workshops, 2009. ICDMW '09. IEEE International Conference on Data Mining, vol., no., pp. 214-216, 6-9 Dec. (2009).