Innovations in projecting emissions for air quality modeling

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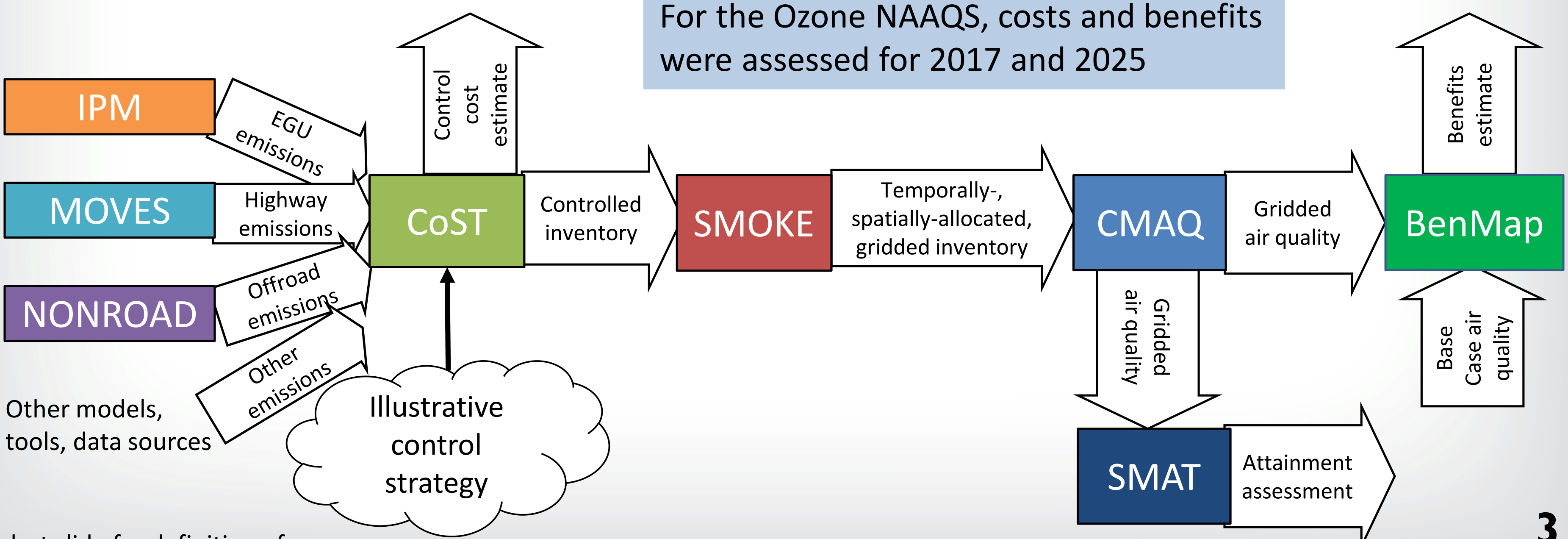
Forward

- **Objectives of this presentation**
  - Serve as a discussion starter on the topic of how emission projection methods could be improved
- **Intended audience**
  - Emissions and air quality modelers at the CMAS Conference
- **Disclaimers**
  - The views expressed in this presentation are those of the author and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency.
  - All results are provided for illustrative purposes only.

Example context: Regulatory Impact Analysis (RIA)

- **Method**
  - Assess costs and benefits in a future year by comparing:
    - Base Case – All "on the books" rules included
    - Control Case – Base Case plus illustrative control strategy for new rule
- **Models**

For the Ozone NAAQS, costs and benefits were assessed for 2017 and 2025



See last slide for definition of acronyms.

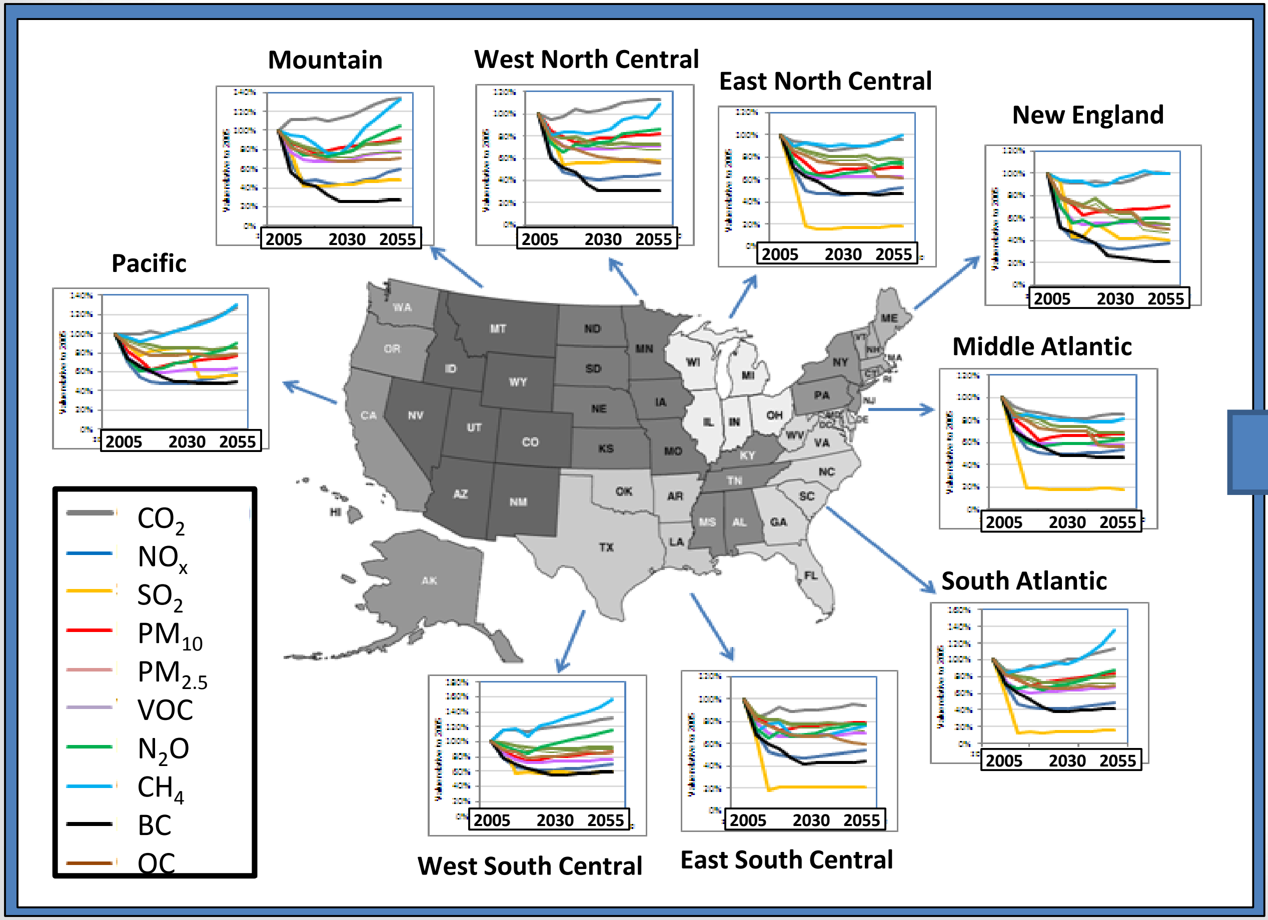
Emission projection challenges

- **Consideration of climate change and greenhouse gas emissions mitigation introduces the need for multi-decadal modeling**
- **Questions to be addressed may include:**
  - How do we project emissions several decades into the future, accounting for expectations regarding population, economic growth, climate change, land use change, behavior and policy?
  - How can we account for uncertainty in these factors?
  - How do we predict and then take into account spatial and temporal changes in emission profiles?
  - How do we identify important cross-sector and/or cross-media interactions?
  - How can we meet multi-pollutant objectives efficiently and robustly?

Emission projection methods

Loughlin, D.H., Benjey, W.G., and C. Nolte, C. (2011). ESP v2.0: Methodology for exploring emission impacts Of future scenarios in the United States. *Geoscientific Model Development*, 4, 287-297.

Energy system models can be used to develop emission projections



Future-year growth and control factors for SMOKE

Sector	NO_x	SO_2	PM_{10}
Electric	0.56	0.19	0.88
Industrial	1.69	0.93	1.05
Commercial	1.25	0.79	1.19
Residential	0.89	0.39	0.91
Light duty	0.12	0.21	0.41
Heavy duty	0.21	0.06	0.19
Aircraft	1.29	0.97	0.67
Marine	0.81	0.05	0.86
Nonroad	0.35	0.05	0.33
Railroads	0.48	0.02	0.21

Illustrative results

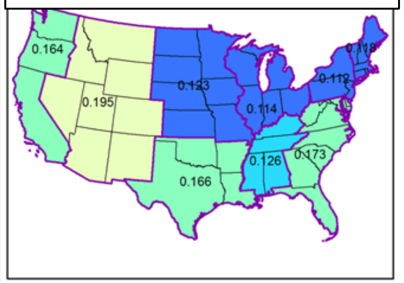
Spatial emission distribution

Ran, L., Loughlin, D.H., Yang, D., Adelman, Z., Baek, B.H., Nolte, C., and W.G. Benjey (2015). ESP2.0: Revised Methodology for exploring emission impacts of future scenarios in the United States – Addressing spatial Allocation. *Geoscientific Model Development*, 8, 1775-1787.

Land use models can be used to spatially allocate future emissions

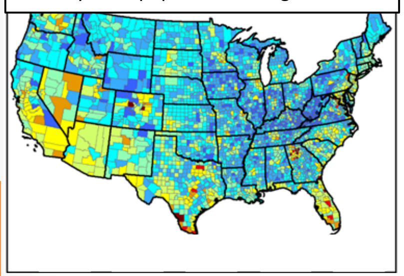
Energy model

Regional emission growth factors

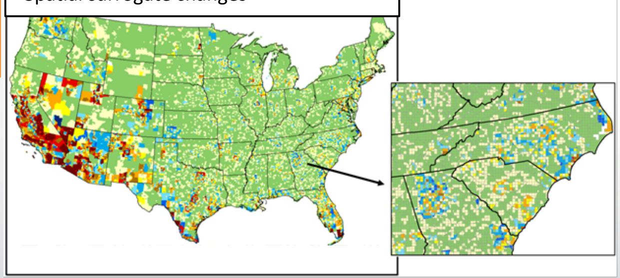


Land use model

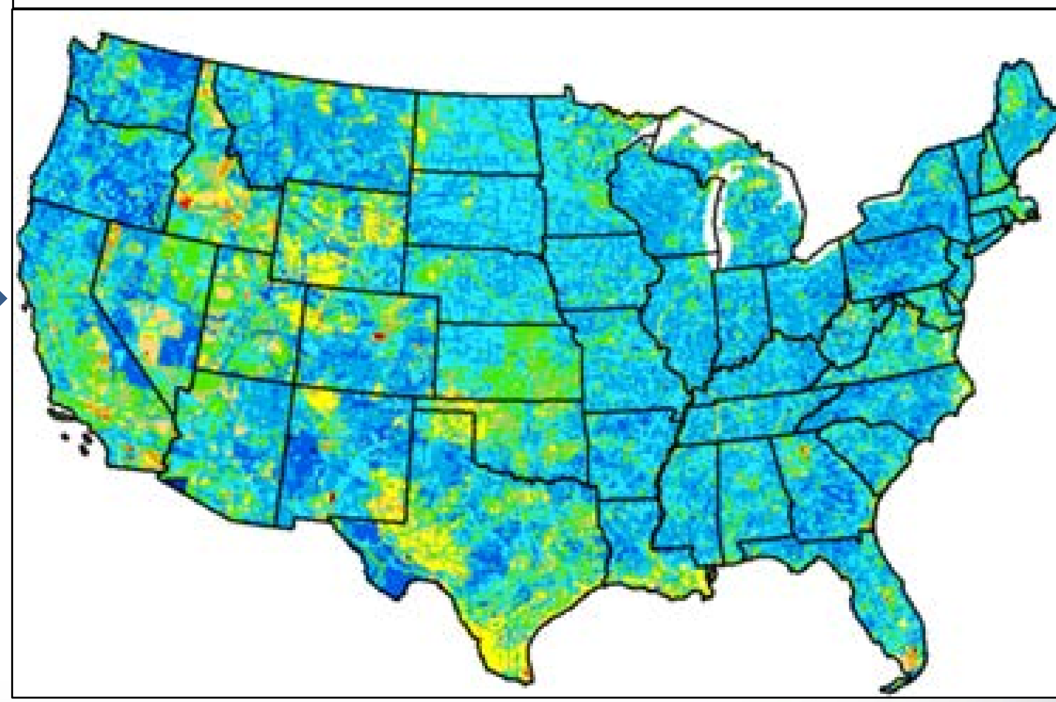
County-level population changes



Spatial surrogate changes



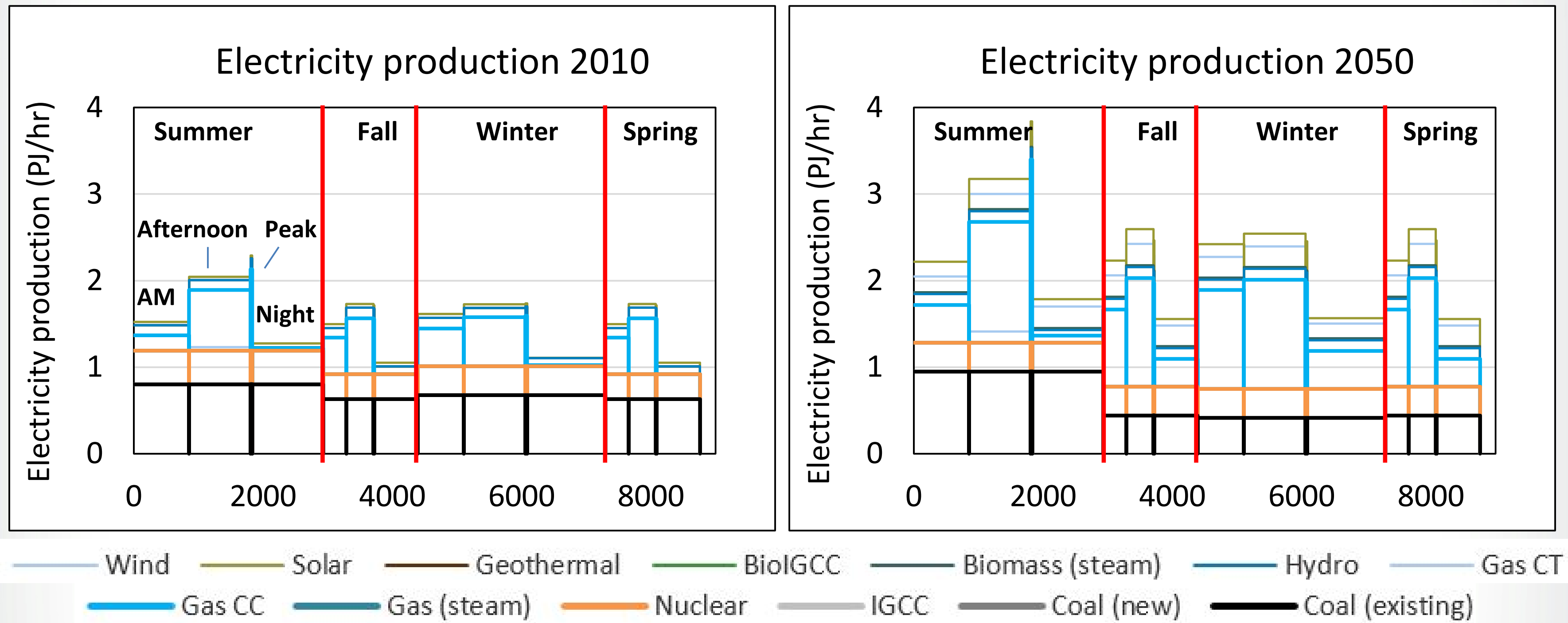
Future-year, spatially re-distributed inventory



Illustrative results

Temporal emission distribution

Energy model projections of technology and fuel use can inform temporal profiles



Observations:

- Coal shifts from relatively constant output to higher use in summer and reduced use in other seasons.
- Gas use expands in all time slices, but night-time use in fall, winter and spring increases dramatically.

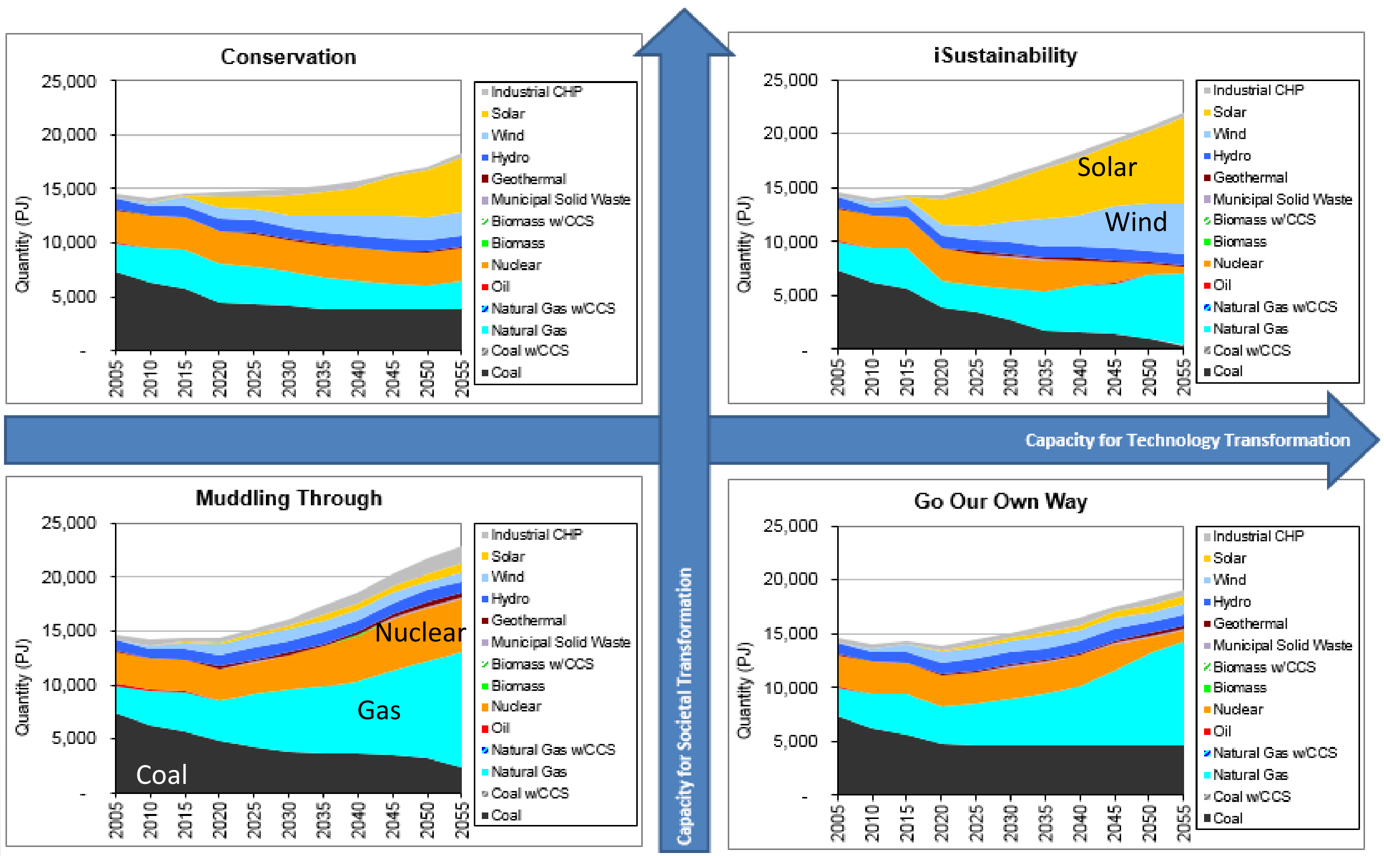
Historic temporal profiles would not capture these potentially important shifts.

Illustrative results

Addressing future uncertainty via scenarios

Scenario development techniques can be used to generate very different visions of the future. How can these alternatives be used effectively (and efficiently) in supporting air quality management?

Electricity production projections for alternative scenarios of the future



Illustrative results

Future directions?

What other aspects of emissions modeling could be addressed to improve emission projections?

Abbreviations

- BenMAP – Benefits Mapping model
- CCS – carbon capture and sequestration
- CHP – Combined heat and power
- CMAQ – Community Model for Air Quality
- CMAS – Community Model and Analysis System
- CoST – Control Strategy Tool
- CT – Combustion turbine
- IGCC – Integrated gasification combined-cycle
- IPM – Integrated Planning Model
- MARKAL – MARKet ALlocation energy system optimization model
- MOVES – Mobile Vehicle Emissions Simulator
- NONROAD – Nonroad mobile source emissions model
- NO_x – nitrogen oxides
- ORD – Office of Research and Development
- PM_{10} – Particulate matter of diameter 10 microns or less
- RIA – Regulatory Impact Analysis
- SMAT – Speciated Modeled Attainment Test
- SMOKE – Sparse Matrix Operator Kernel Emission processor
- SO_2 – Sulfur dioxide