Energy Options and Health Benefits for China Case Study

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2006.04.21

Contents

- Introduction
- Methodology
- Modeling work
- Preliminary results
- Discussion and future work

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Background of the Project

- **Integrated Environment Strategy researches in China**
  - **Pursue to a Statement of Intent (SOI) signed by Administrator Xie Zhenhua of SEPA and Administrator Carol Browner of EPA, in 1999**
  - **One of ten projects initiated at that time in conjunction with the China-US Forum on Environment and Development**
  - **Four Components**
    - Shanghai Case Study, 1999-2001
    - Beijing Case Study, 2002-2005
    - National Assessment, 2003-2006
    - National Co-control Research, 2005-2006

Objectives

- Establish a co-benefits analysis framework for China
- Quantify the co-benefits of energy policies
  - Energy Demands and Supply
  - Local and Regional Pollutant Emissions Reduction
  - Air Quality Improvement
  - GHG Mitigation
  - and Health Benefits
- Provide scientific support for a comprehensive air pollution control policy making
- New modeling tools application in China

Team

- **Coordinators**
  - State Environmental Protection Administration of China (SEPA)
  - Environmental Protection Agency, U.S.A. (USEPA)
  - National Renewable Energy Laboratory, U.S.A (NREL)
- **Research Team**
  - Department of Environmental Science and Engineering, Tsinghua University
  - School of Public Health, Peking University
- **Technical Assistance**
  - Collin Green, National Renewable Energy Laboratory
  - Carey Jang, Environmental Protection Agency
  - Aaron Halberg, Abt Associates, U.S.A.

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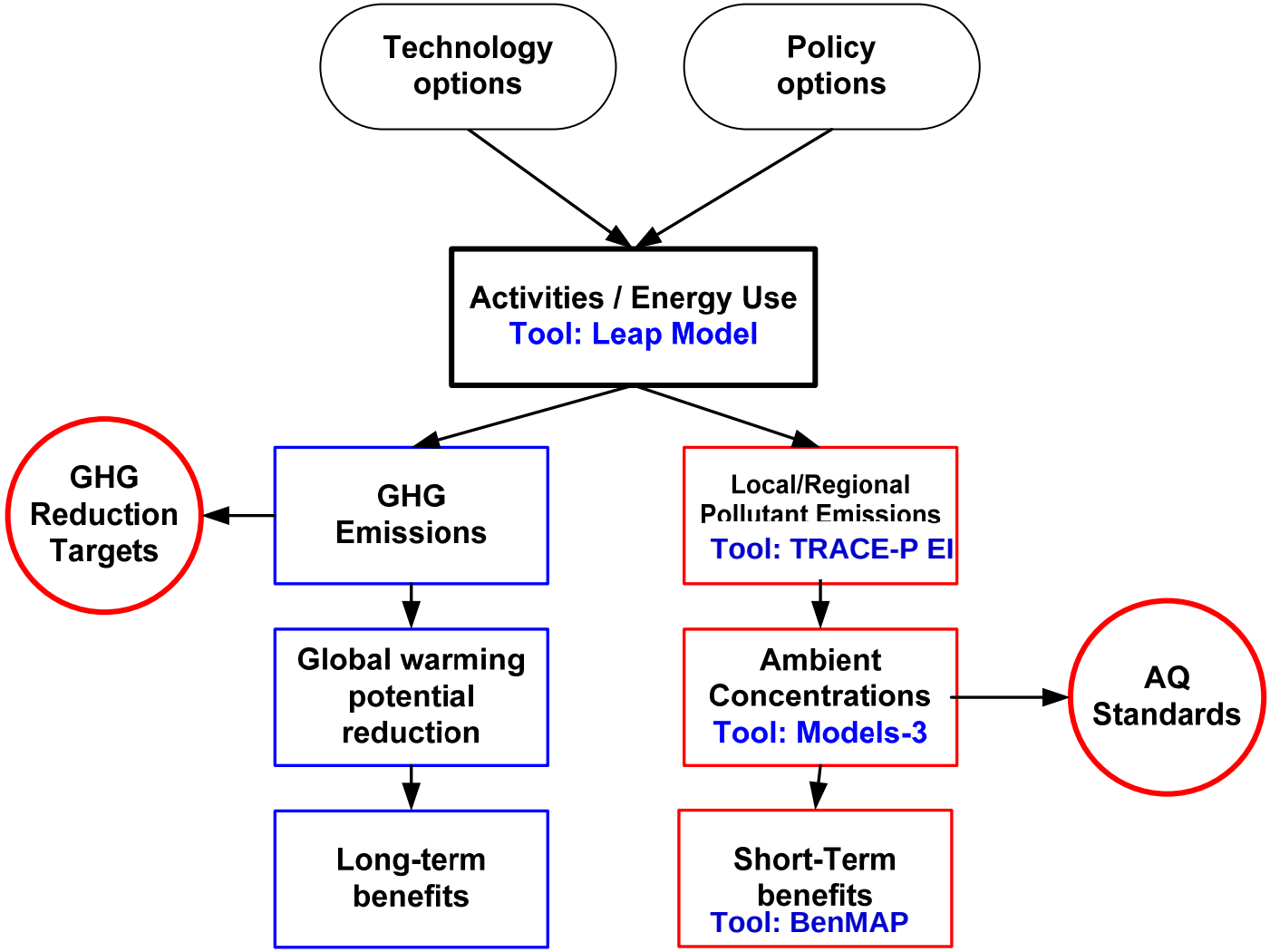
Work Scope

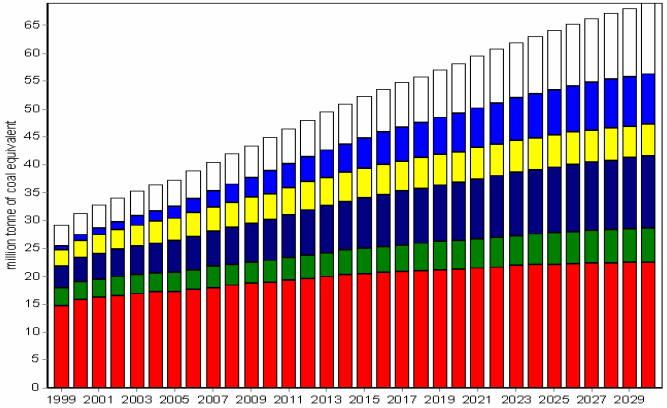
- **Spatial Scope:** China National Level
- **Time Step:** 2000 (Base Year), 2005, 2010, 2020 and 2030
- **Sectoral scope:** agriculture, industry, power plant, construction, and transportation, commercial and residential
- **Environmental indicators:** SO_2, NO_x, CO, PM_{10}, $PM_{2.5}$ and CO_2
- **Basic Information:** Activity data for 3- E

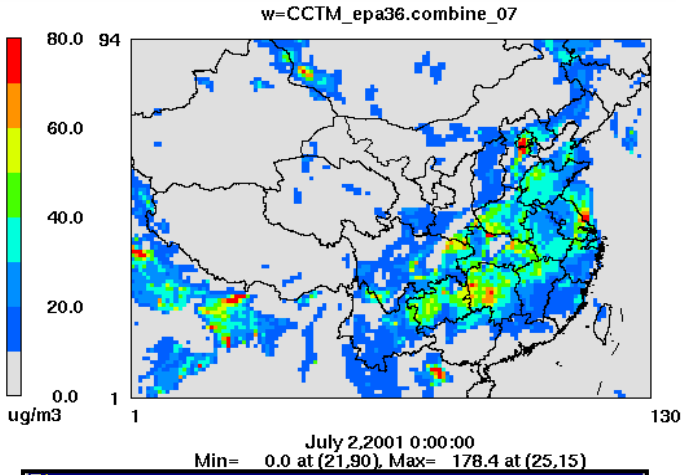
Framework of the Project

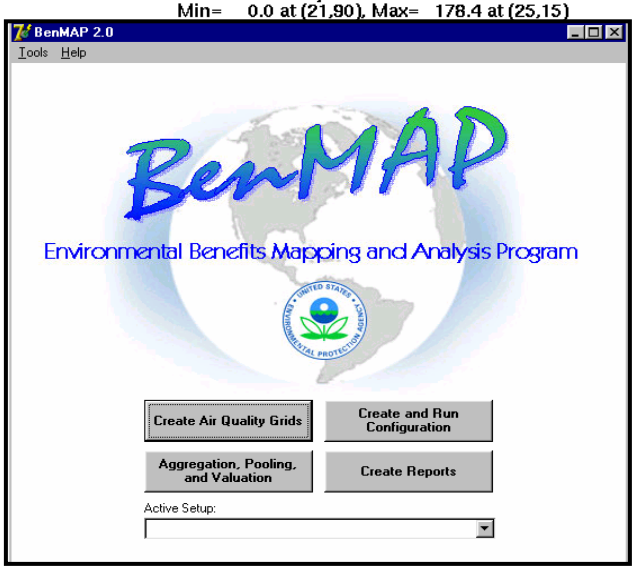


Modeling Tools

- **Leap**
  - Generate energy scenarios
- **Models-3**
  - Estimate air quality under different scenarios
- **BenMAP**
  - Evaluate the health impact

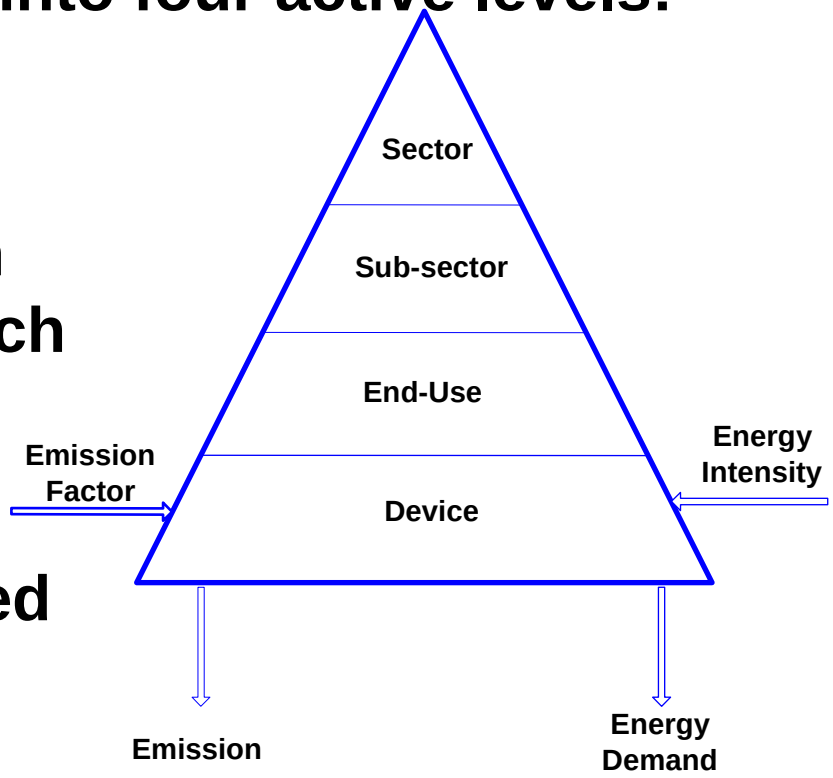






Methodological framework of LEAP

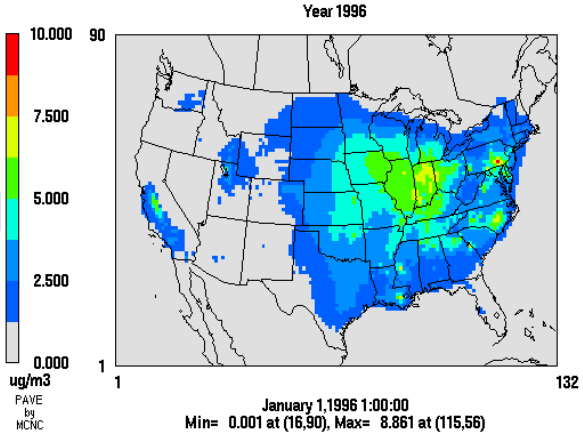
- The problem is disaggregated into four active levels:
  1.Sector 2. Sub-sector
  3.End-use 4. Device
- Energy intensity and emission factors are associated with each device at the level 4
- Total energy demand and emission amount are calculated



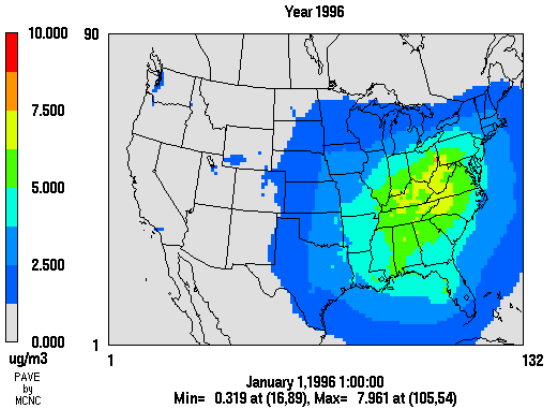
Models-3/CMAQ System

- 3rd generation air quality model
- Basic concept: ”One Atmosphere”
- Integrated atmospheric physics and chemical process
- Advanced computer/GIS technology

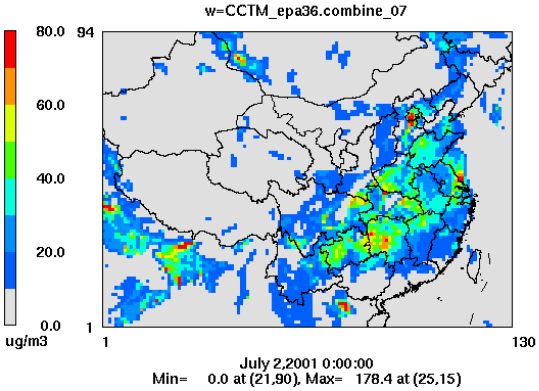
Nitrate PM



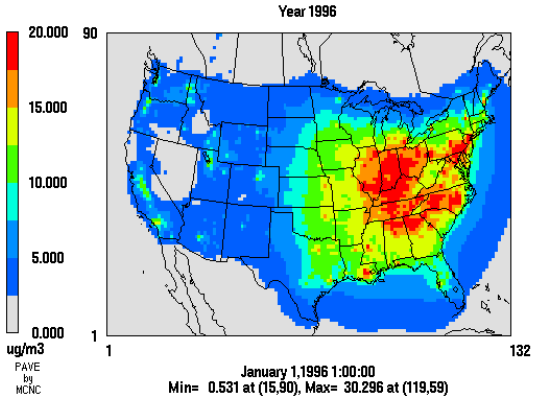
Sulfate PM



PM 2.5

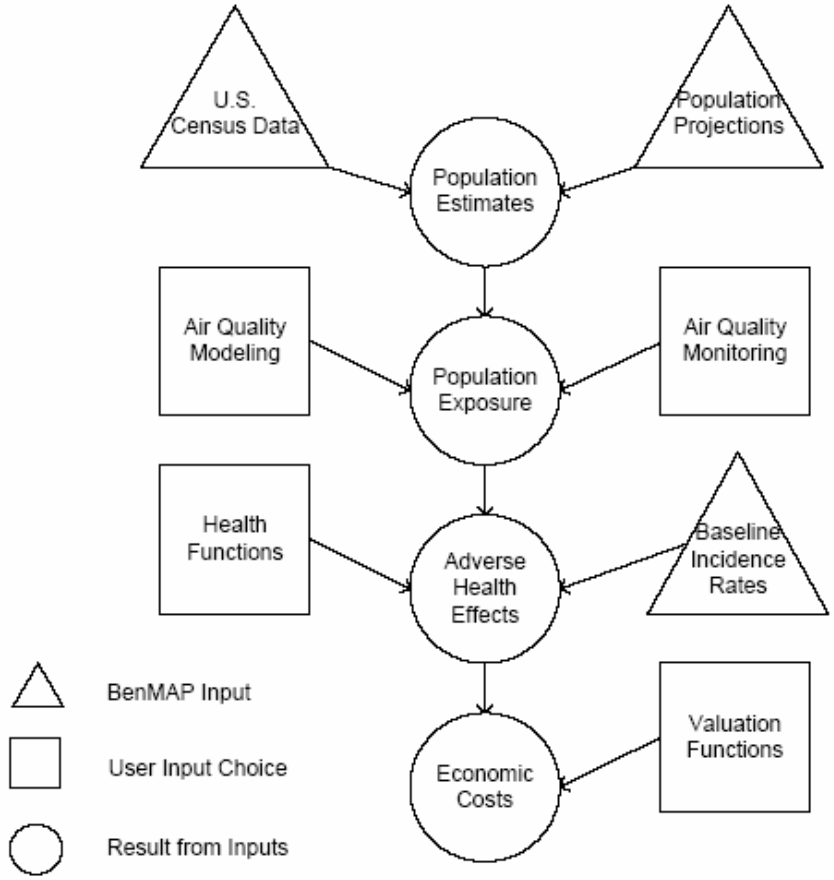


PM 2.5 (Annual Average)



Regulatory Benefits Model: BenMAP

- A population based geographic information system
- Accepts air quality information as inputs
- Uses predefined concentration-response functions and valuation estimates to estimate changes in health endpoints and the value of those changes
- Can produce estimates at the population grid scale, county, state, or national level



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1. Scenario Design

- **Scenario Definition**
  - **Business As Usual (BAU)**
  - **Scenario I (BAU+CCP)**
    - **BAU** with additional **Climate Change Policies**
  - **Scenario II (BAU+CCP+PCP)**
    - **BAU** with additional **Climate Change Policies** and **Pollution Control Policies**
- **Scenario Development**
  - **LEAP model applied**
  - **Technology and Fuel was distinguished at "device" level for following emission assumption**

Scenario Definition: BAU

- Based on the “10th 5-year plan” and other long range develop program mapped out by government
- “Sustainable Energy Scenarios towards 2020” developed by ERI was referenced
- Relatively optimistic hypothetic scenario
- Policies and regulations to ensure sustainable development can be well implemented

Scenario Definition: CCP

Policies	Indicators	Indicators in BAU
Households energy saving	Energy saving lamp increases to 45% in 2010, and 70% in 2030 in urban households. 24% in 2010, and 53% in 2030 in rural households.	Urban: 34% in 2010, and 45% in 2030. Rural: 20% in 2010 and 40% in 2030
Industry energy saving	Energy intensity decreases: Iron and steel: 1.72% per year, Nonmetal minerals: 3.2% per year, Chemical products: 3.5% per year, Manufacturing and processing: 3.5% per year, etc.	Iron and steel: 1.62% per year, Nonmetal minerals: 2.9% per year, Chemical products: 3.25% per year, Manufacturing and processing: 2.5% per year, etc.
Building energy saving	Public building: Terminal heating loading (W/m^2) decreases to 54.4% of current value in 2010, and 32.8% in 2030. Residential building: Terminal heating loading (W/m^2) decreases to 55.5% of current value in 2010, and 36.1% in 2030.	Public building: 68.4% in 2010 and 51.8% in 2030. Residential building: 70.6% in 2010 and 54.0% in 2030.
Vehicle energy efficiency improvement	Energy efficiency of light buses and cars increase 87% before 2030	Energy efficiency increase 46% before 2030

Scenario Definition: PCP

Policies	Indicators	Indicators in BAU
Improvement of rural cooking condition	Biomass consumption in cooking decreases to 50% in 2010 and 19% in 2030	53% in 2010 and 26% in 2030.
Switching heating boilers and stoves	Urban: 24% of heating boilers uses natural gas in 2010, and 50% in 2030. Rural: Biomass stoves contribute 50% in 2010, and 10% in 2030	Urban: 20% in 2010, and 45% in 2030. Rural: Biomass stoves contribute 45% in 2010, and 5% in 2030
Vehicle emission standard	Implement EURO IV in 2010, and EURO V in 2015	EURO IV in 2012, and EURO V in 2018
Two control zone policy	New power plants install FGD (flue gas desulfurization), and eliminate power plants over 30 years old. New power plants install SCR (Selective Catalytic Reduction) from 2012.	New power plants install FGD. New power plants install SCR (Selective Catalytic Reduction) from 2015.
PM control in industry	Bag house installed with 20% of CFB (Circulating Fluidized Bed) boiler in 2010, and 75% in 2030; with 2% of grate furnace in 2010, and 30% in 2030	With CFB: 15% in 2010 and 60% in 2030; with grate furnace: 1% in 2010, and 20% in 2030

2. National Emission Inventory

- **Develop base-year emission inventory based on the initial one applied for TRACE-P developed by Dr. David Streets**
  - **Base year: 2001**
  - **Similar methodology with Trace-P inventory**
  - **Top-down method, but technical based emissions**
  - **More technical splits within sectors**
- **Translate LEAP results into activities data for emission inventory**
- **Estimate the controlled emission factor under policies**
- **Develop emission inventories for all scenarios in scope years**
- **Translate this emission inventory as input to air quality model**

3. Air Quality Modeling

- **Pre-process**
  - Meteorology data preparation
  - Emission data preparation
    - Spatial distribution
    - Chemical speciation
    - Temporal allowcation
- **Modeling by CMAQ**
  - Domain: 36km (167*94)
  - Meteorology: MM5 (V.3.5)
- **Post Process**
  - Translate the data into input data for BenMAP

4. Health benefit estimation

- **Draw upon data from existing and past studies on ambient air pollution and mortality/incidence of disease**
- **Explore the use of USEPA's BenMAP model to calculate health effects of air pollution**
- **Finally develop a national air pollution health benefits assessment model for China based on the BenMAP model, and estimate the**
  - Public health effects
  - Economic benefits of the health effects

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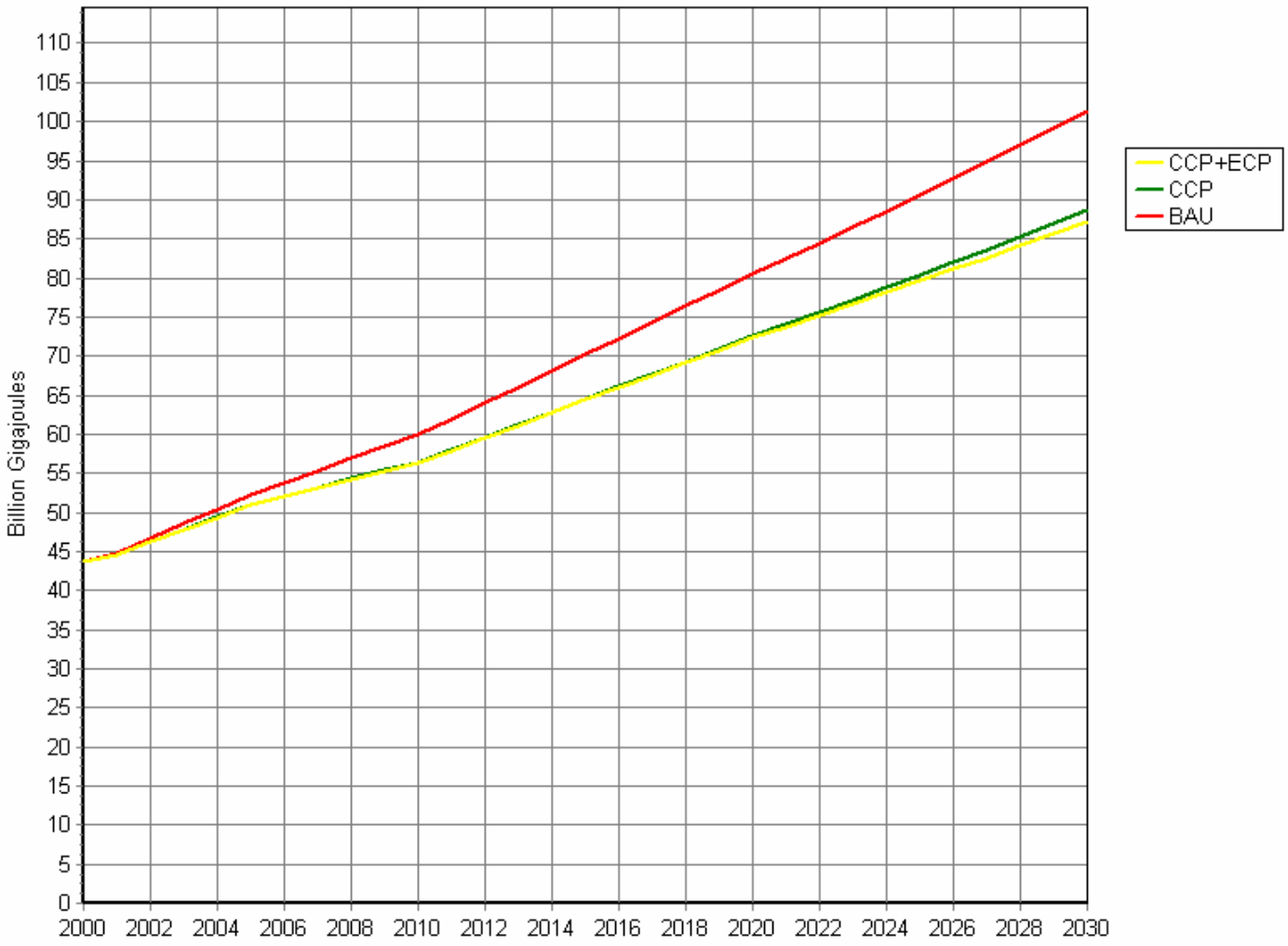
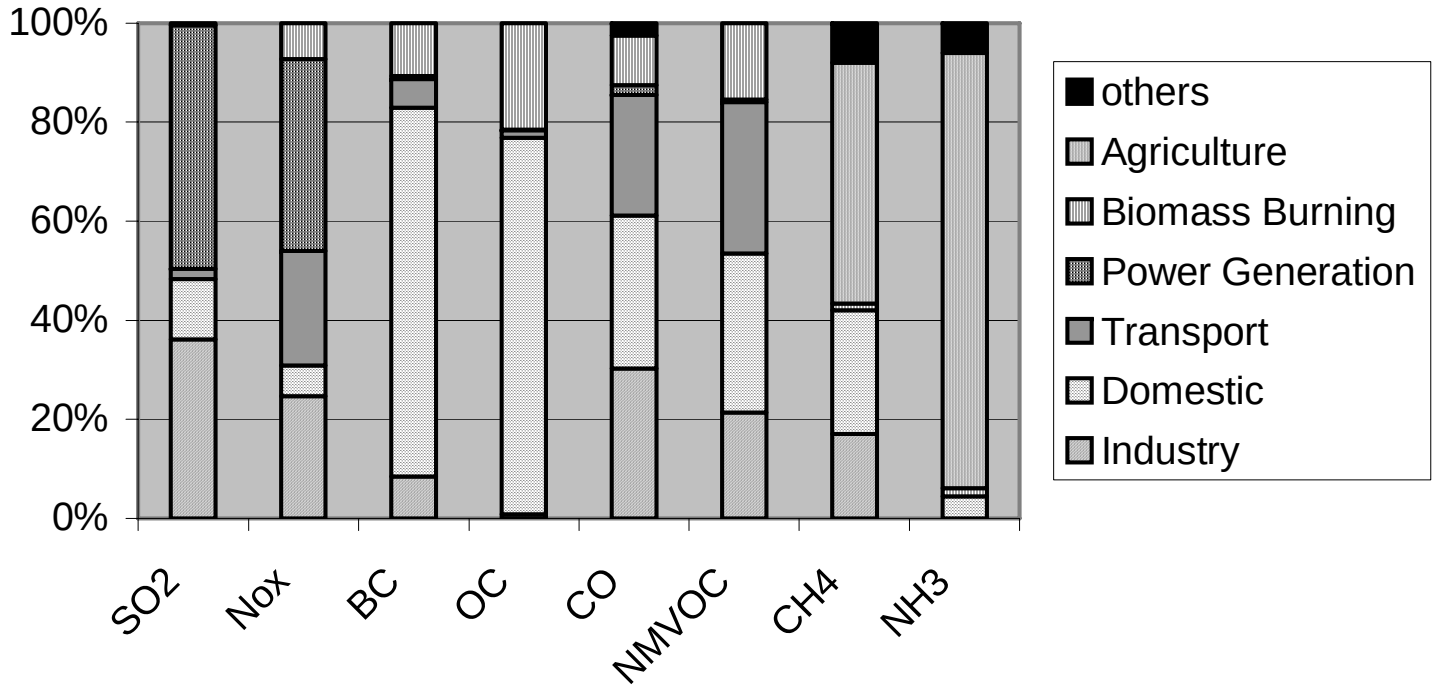
Primary Energy requirements, by scenarios

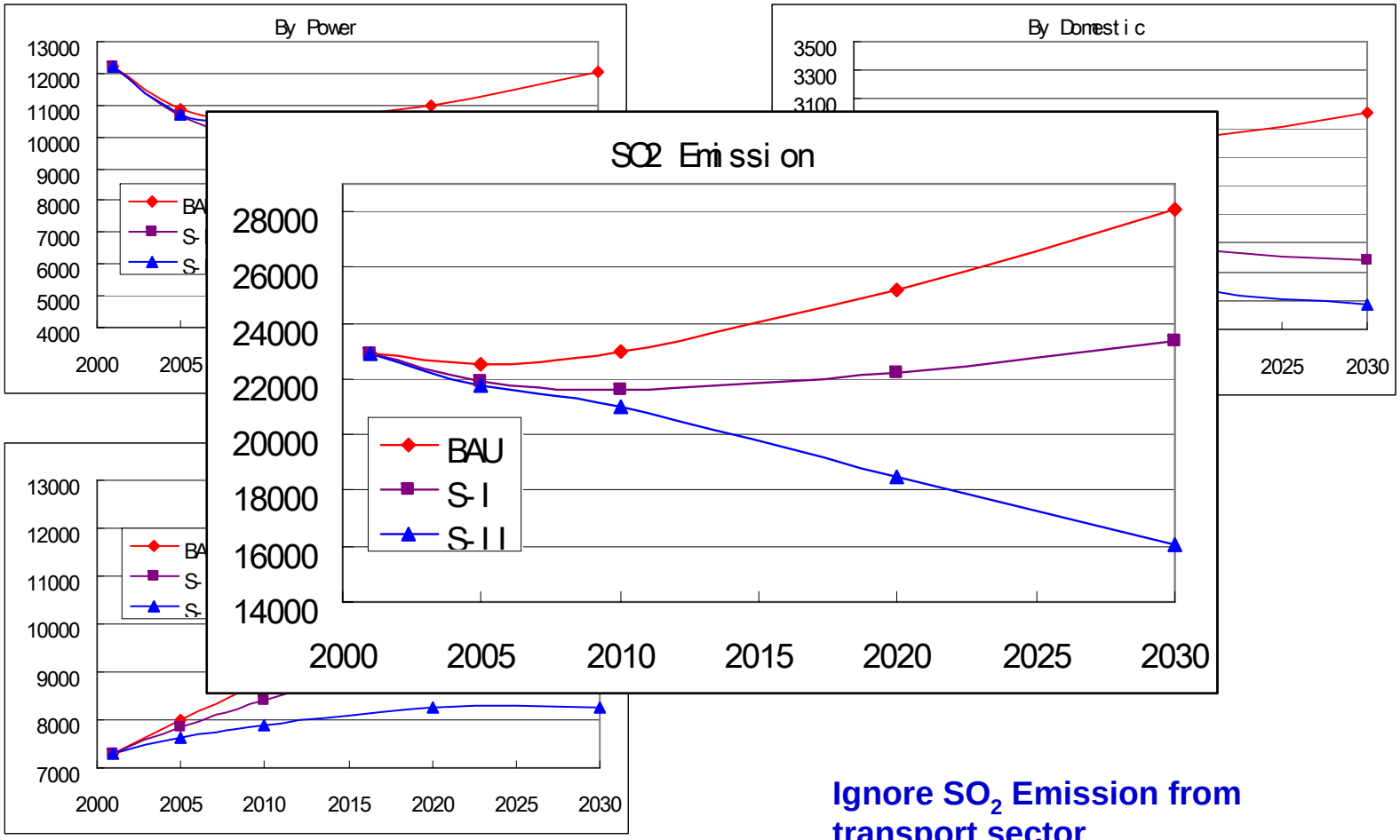


Sector Distribution of Updated 2001 Inventory



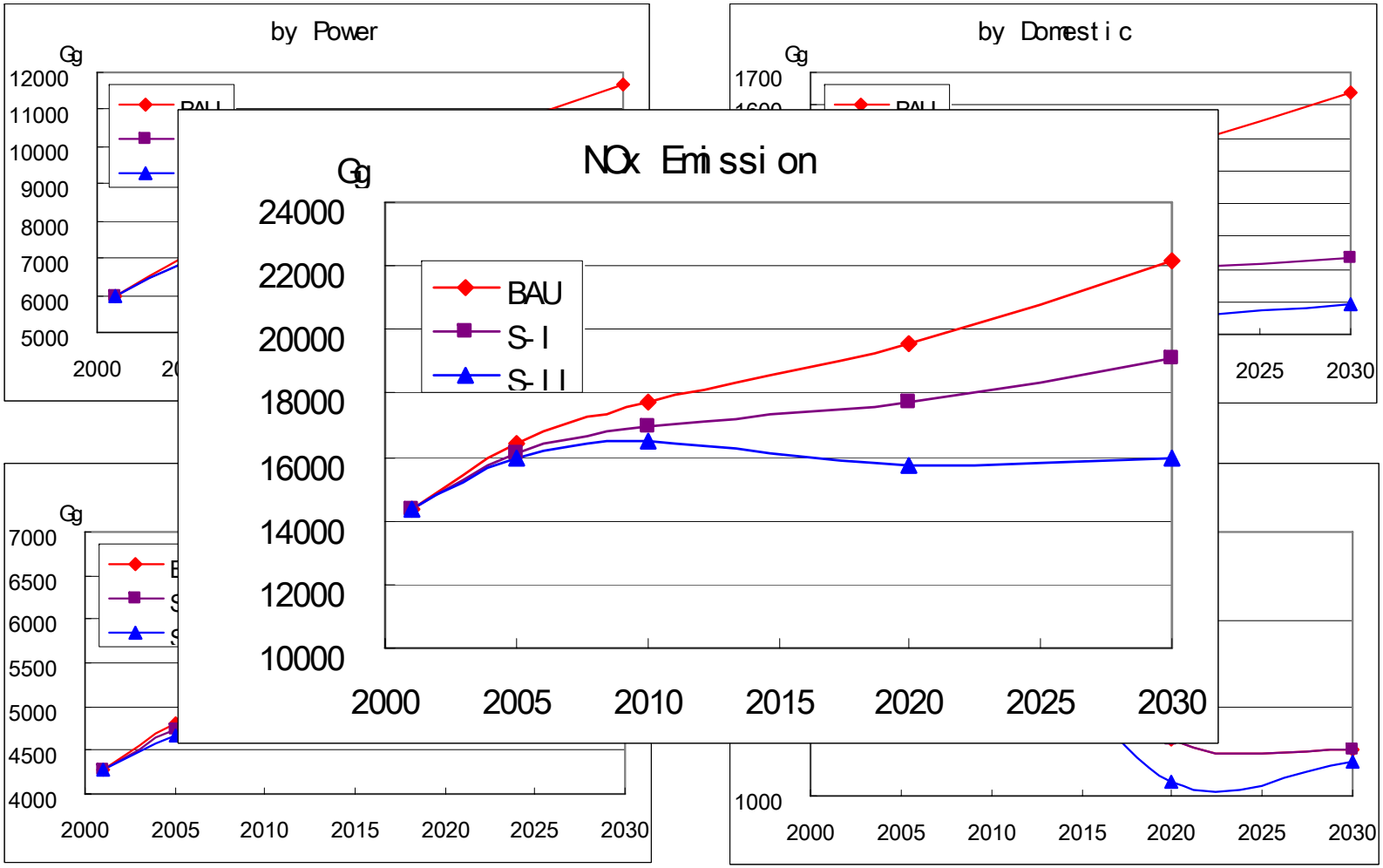
The distribution characteristics varies a lot among the different type of primary air pollutants.

Emission Trend: SO_2

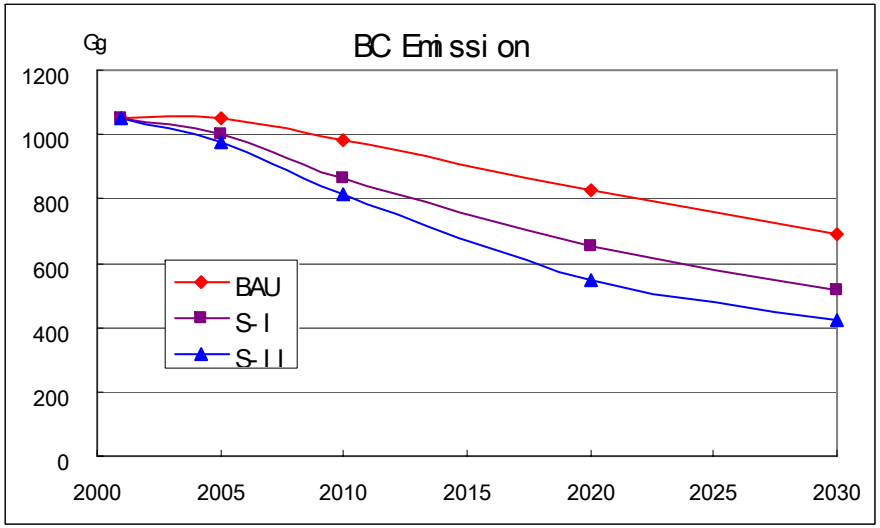


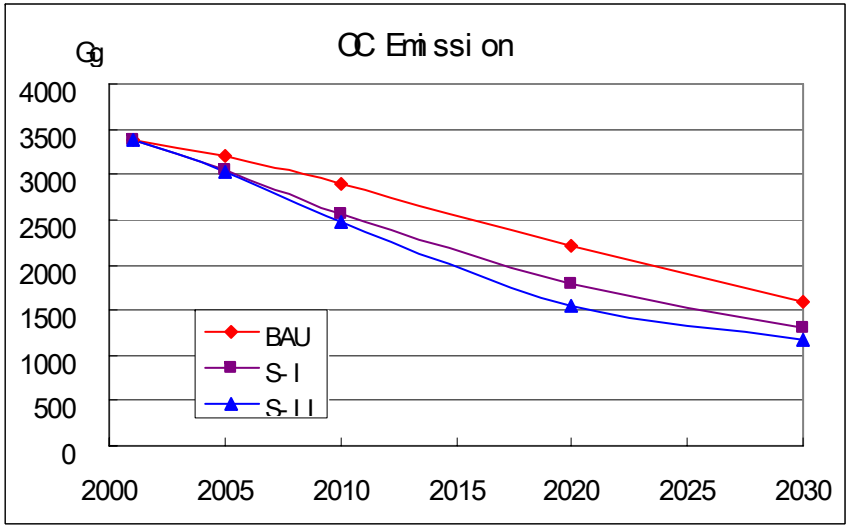
Ignore SO_2 Emission from transport sector

Emission Trend: NOx



Emission Trend: BC and OC





Black Carbon and Organic Carbon represent PM in TRACE-P Inventory

Emission Summary

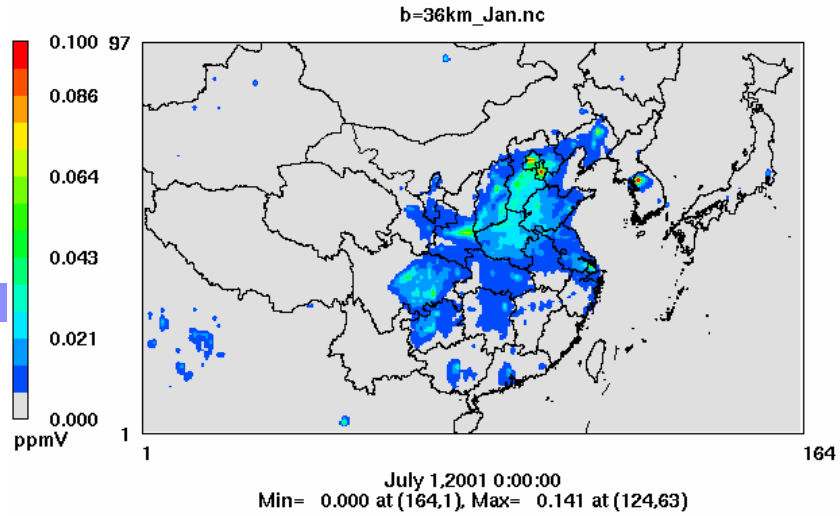
- **Emissions in 2001**

SO_2 (Kt)	NO_x (Kt)	BC (Kt)	OC (Kt)	CO (Kt)	NMVOC (Kt)	CO_2 (Mt-C)
20385	11347	1049	3385	155566	17441	878

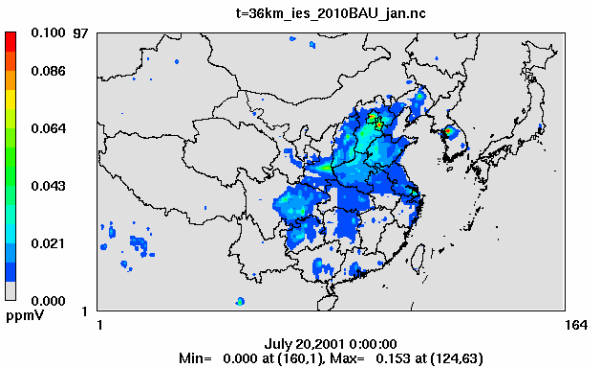
- **Emissions Trends:**

	SO_2	NO_x	BC	OC	CO	NMVOC	CO_2
2010							
BAU/2001	1.13	1.23	0.94	0.85	1.01	1.08	1.34
S 1/2001	1.06	1.18	0.82	0.76	0.96	1.04	1.25
S 2/2001	1.03	1.15	0.78	0.73	0.93	0.98	1.24
2030							
BAU/2001	1.38	1.54	0.66	0.47	0.83	0.97	2.15
S 1/2001	1.15	1.33	0.49	0.38	0.75	0.87	1.78
S 2/2001	0.79	1.11	0.40	0.34	0.72	0.72	1.73

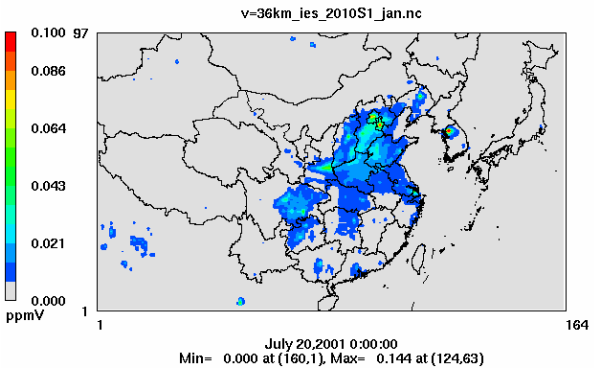
CMAQ result: SO_2



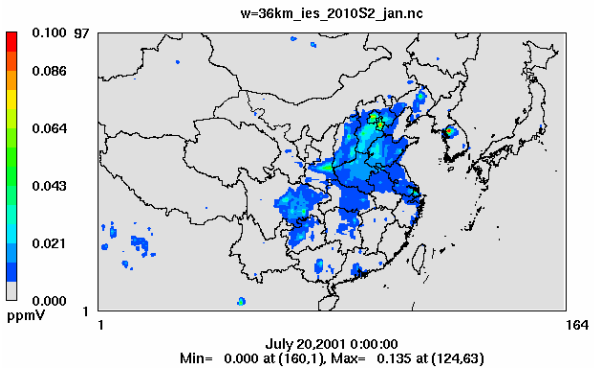
2001



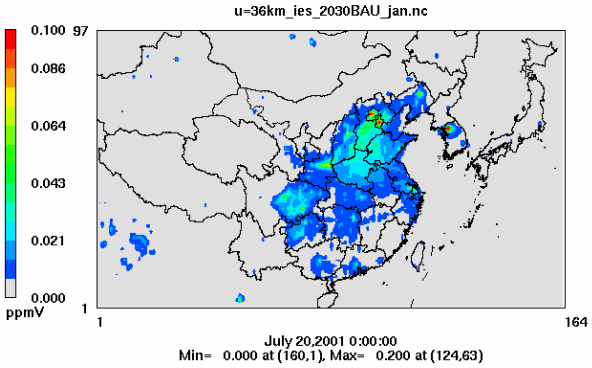
2010BAU



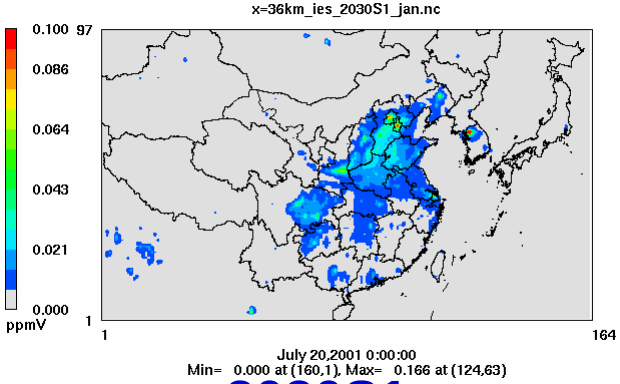
2010S1



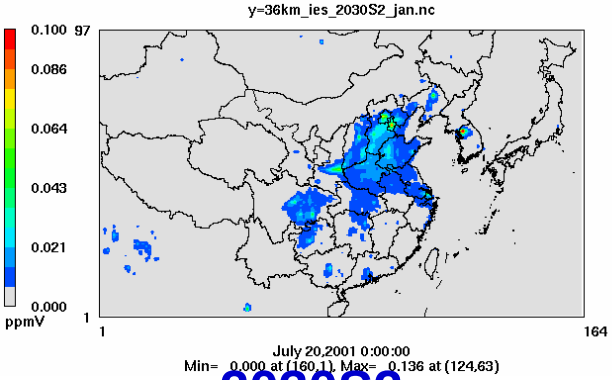
2010S2



2030BAU

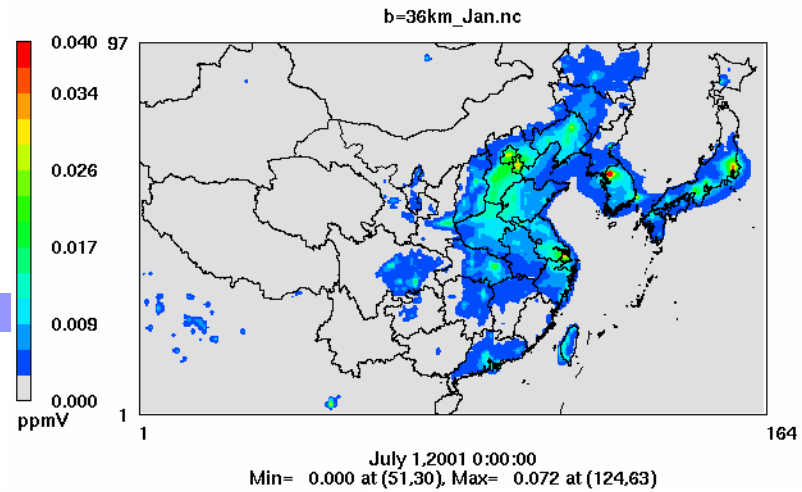


2030S1



2030S2

CMAQ result: NO_2



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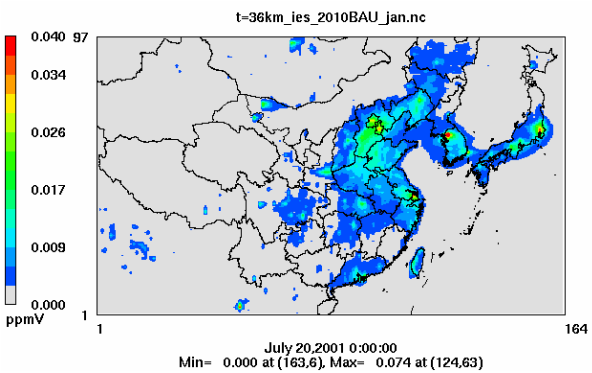

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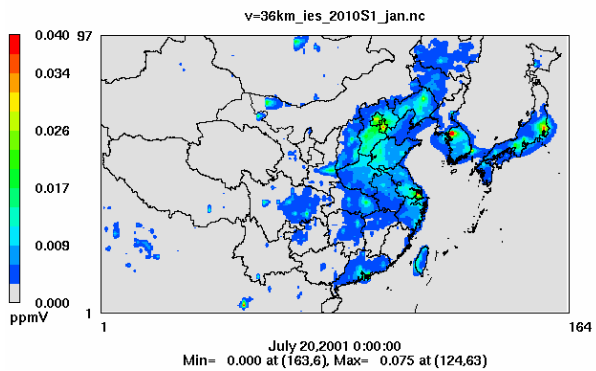
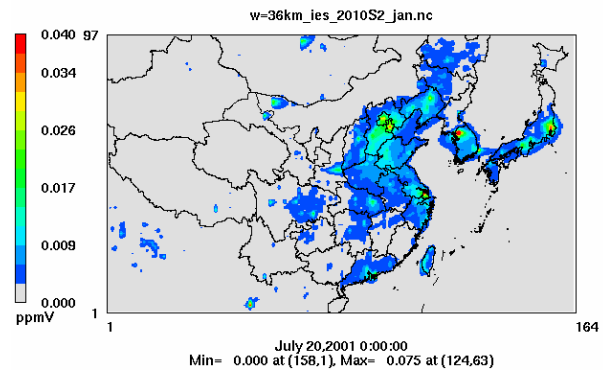
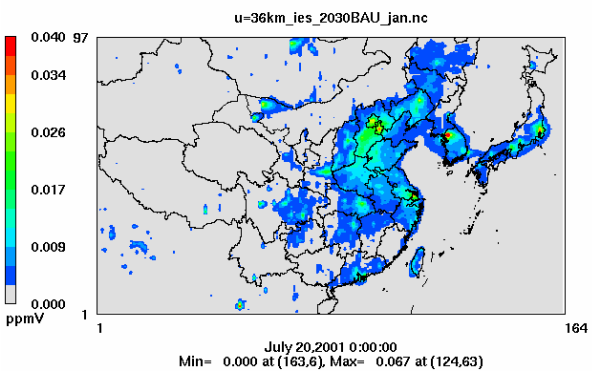


2010S1



2010S2



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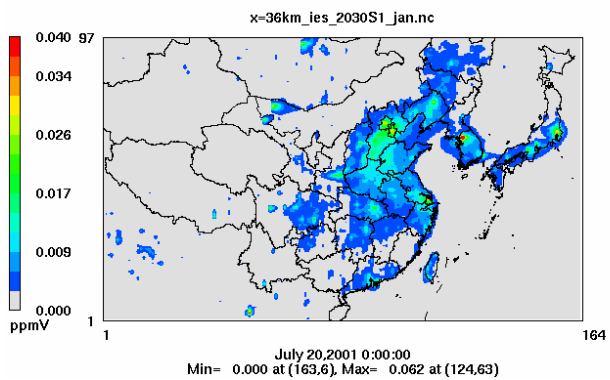

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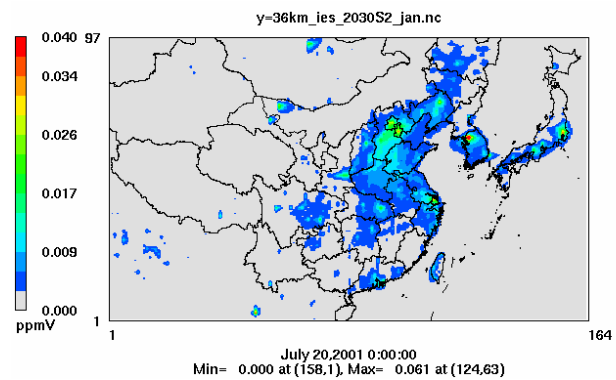
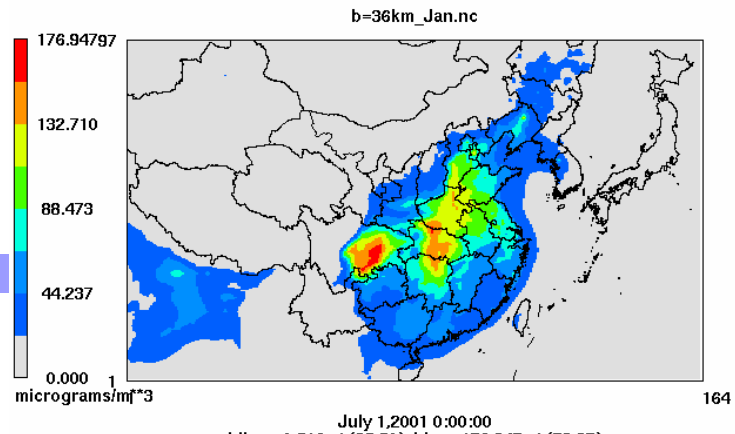


2030S2

CMAQ result $PM_{2.5}$



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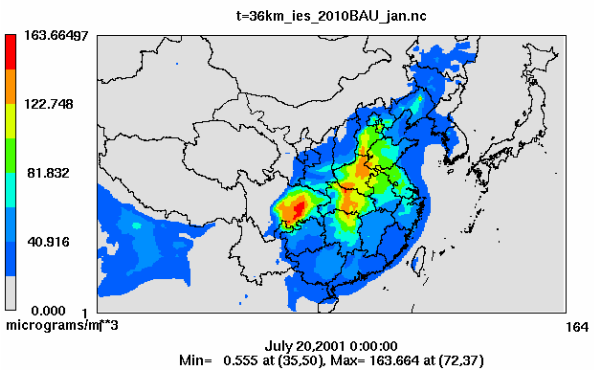

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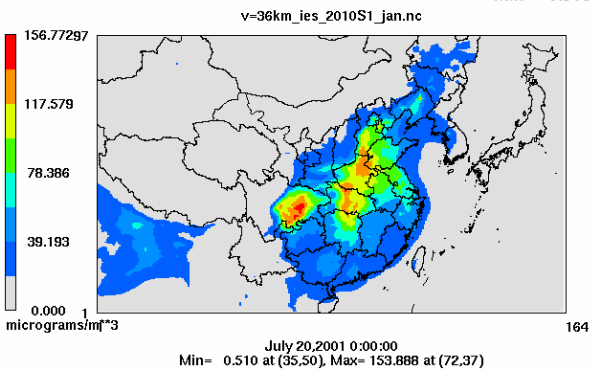

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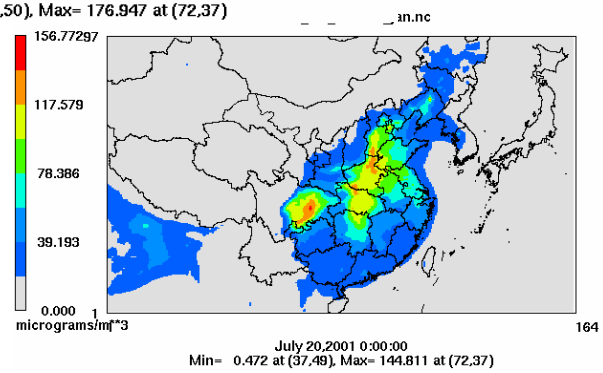

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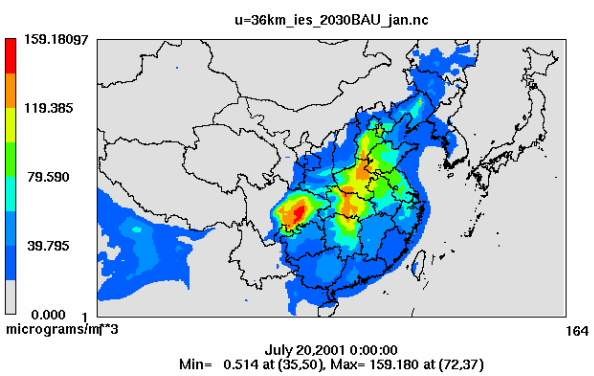

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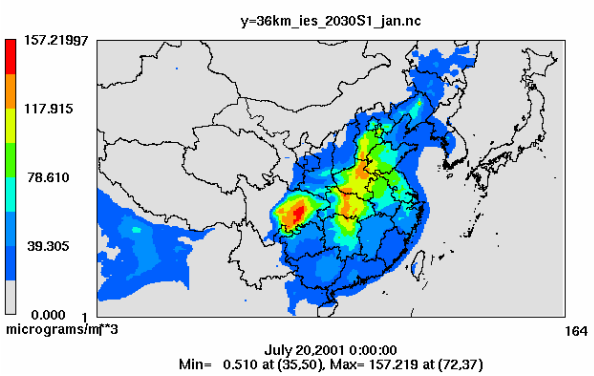

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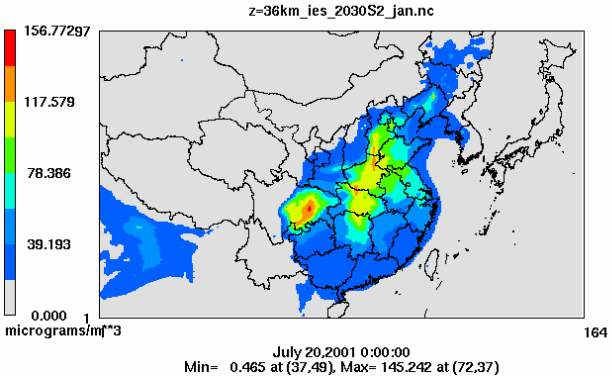

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Discussion

- Positive energy policies can generate co-benefit
- Multiple pollutants control is necessary

Future work

- In IES project
  - Continue conduction health benefit by using BenMAP modle
  - Cost-effect analysis
- Other than IES
  - Application of CMAQ to control regional complicated pollution
  - Development and application of policy supporting system by combining energy model, environment model, and health model
  - ……

Thanks