Global Burden of Disease – Major Air Pollution Sources (GBD – MAPS)

Estimates of emissions and $PM_{2.5}$ levels from Major Sources in China

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a place of mind
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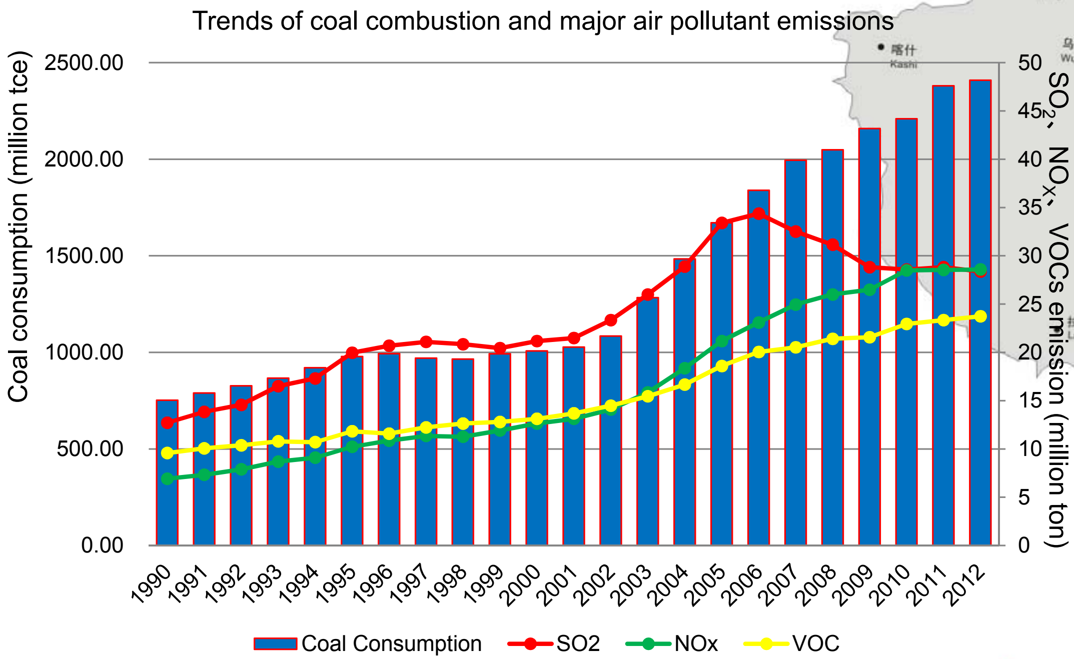
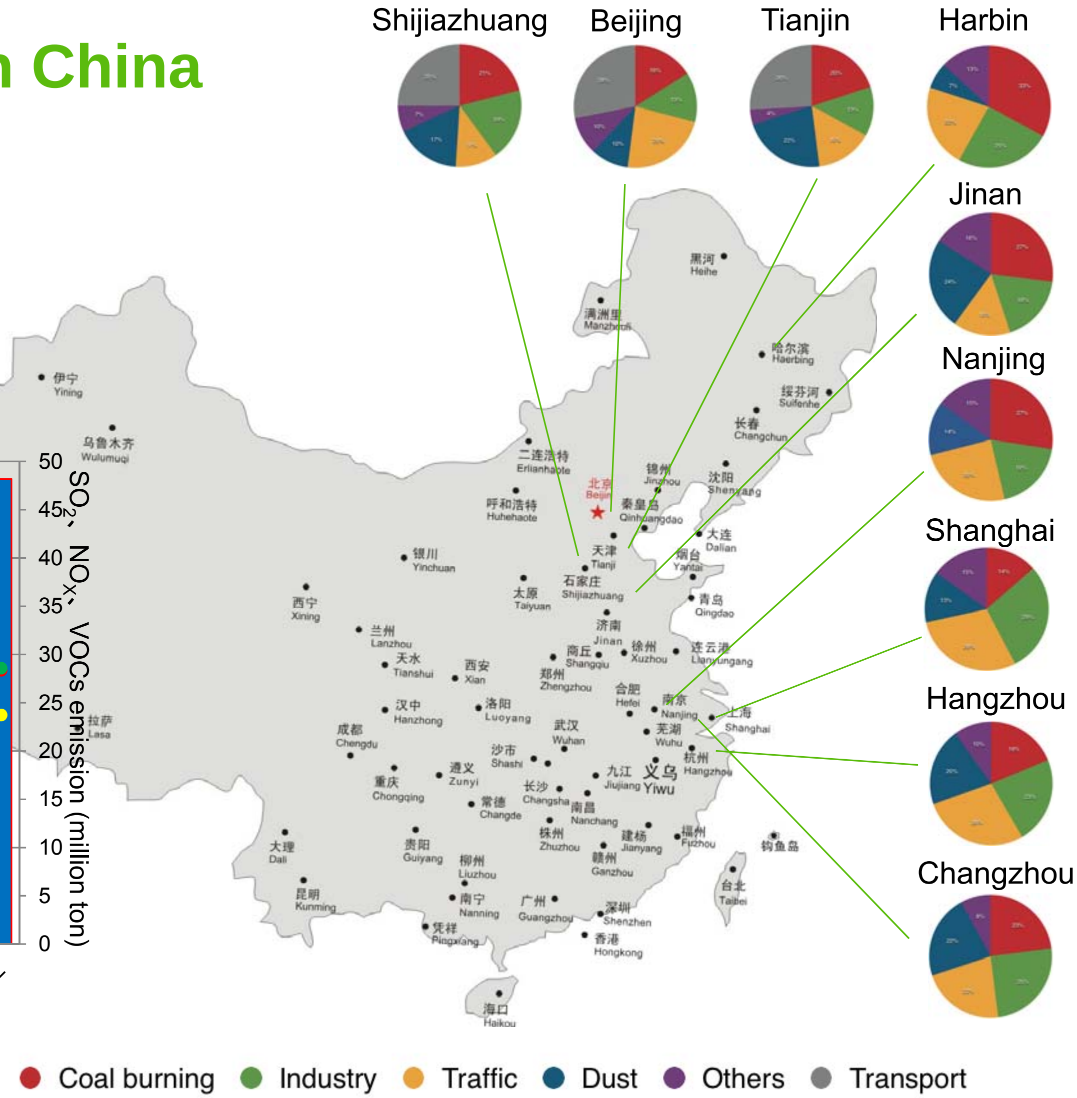
Background: All causes attributable to ambient PM pollution in 2013, DALYs per 100,000

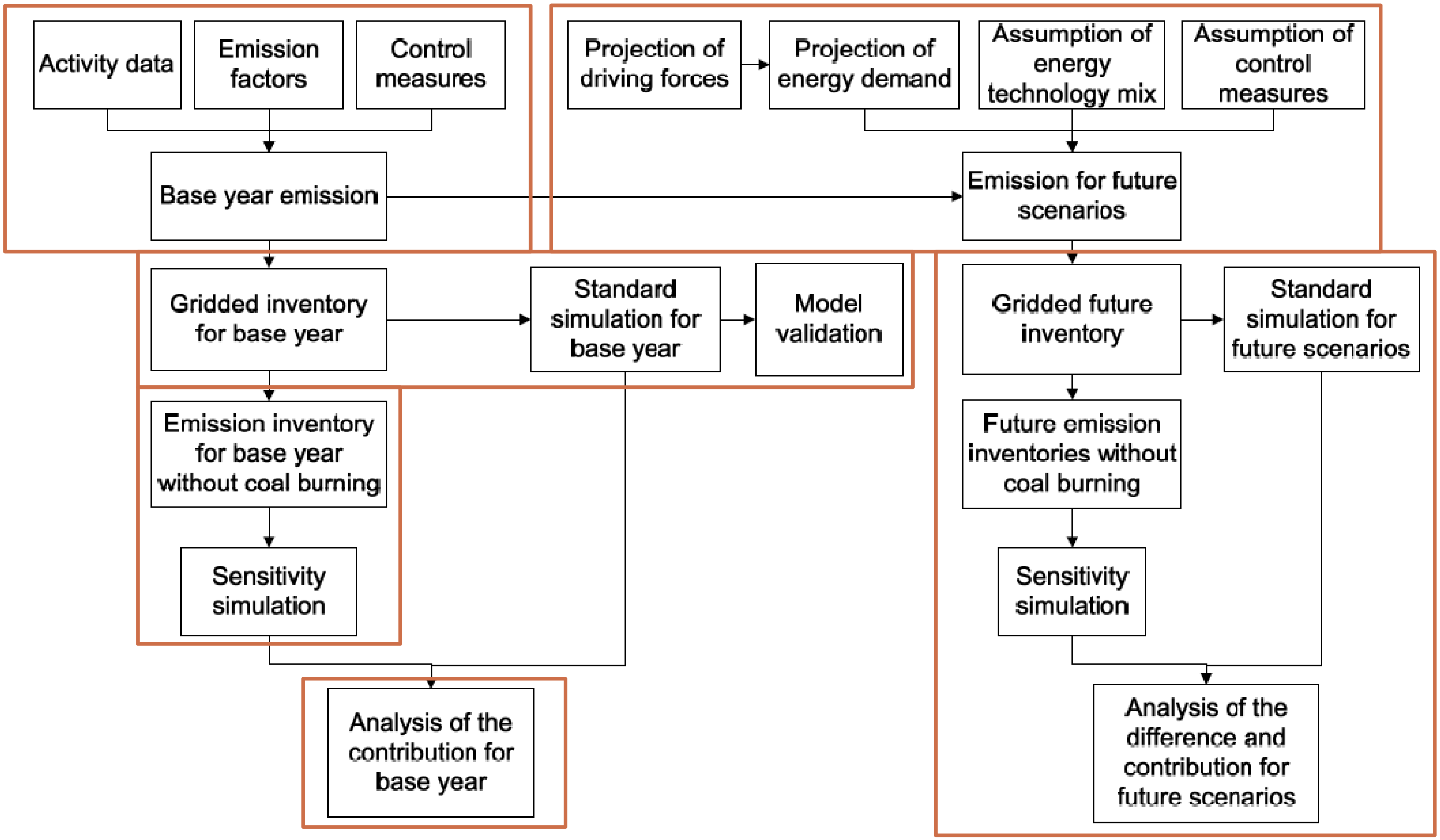
Major Sources of air pollution in China

- Air pollutant emission has a close relation with coal combustion (left)
- Coal combustion is a dominant source of ambient $PM_{2.5}$ (right)





Technology Roadmap



Emissions in base year

Specious:

SO_2

NO_X

PM

VOCs

Sectors:

Powerplant combustion

Industry combustion

Industry process

Domestic fossil fuel

Domestic biofuel

Traffic

Open burning

Solvent use

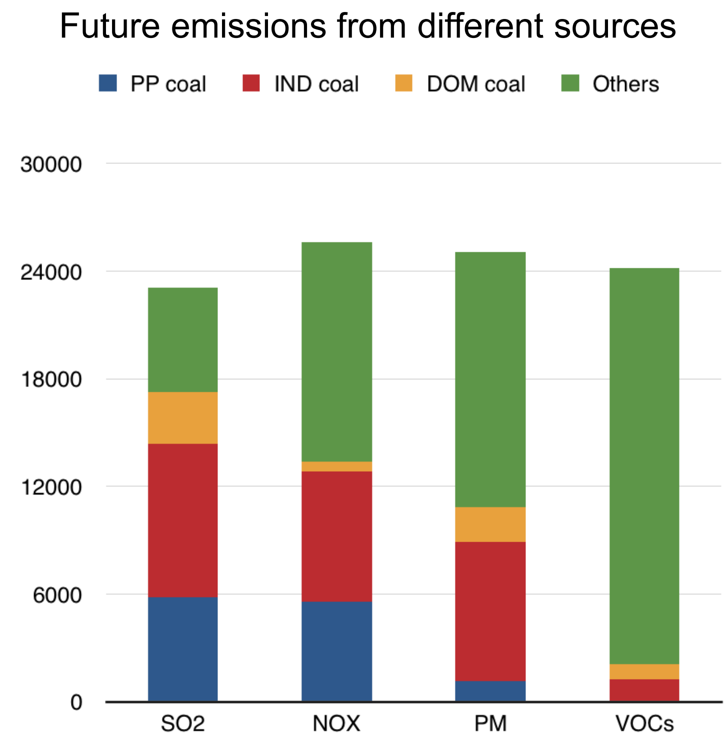
Emissions:

23 Tg

25.6 Tg

26 Tg

24 Tg



In the year of 2013, coal is responsible for 75% of the SO_2 emissions, 54% of the NO_X emissions, 40% of the primary PM_{10} emissions, and 35% of the primary $PM_{2.5}$ emissions.

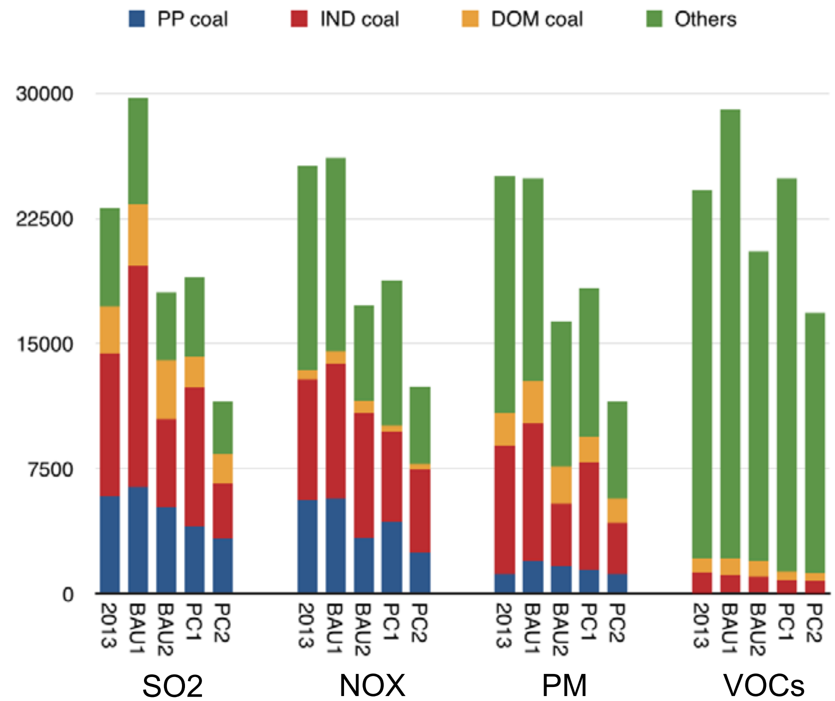
Future scenarios

Energy scenario	Description	Emission scenario	Description
Business as usual (BAU)	Current legislation & implementation status (to end of 2013)	BAU[1]	BAU energy policy End-of-pipe control strategy: Based on "12th Five-Year Plan for Environmental Protection"; New emission standards released during 2011-2013; progressively strengthened control policies afterwards.
		BAU[2]	BAU energy policy End-of-pipe control strategy: full implementation of technically feasible control technologies by 2030, regardless of cost
Alternative policy (PC)	New stringently enforced energy-policies including life style changes, structural adjustment & efficiency improvements.	PC[1]	PC energy policy Same end-of-pipe control strategy as BAU[1]
		PC[2]	PC energy policy Same end-of-pipe control strategy as BAU[2] Maximum feasible reductions of emissions

Future emissions

Future emissions in each scenario (Tg)

	2013	BAU1	BAU2	PC1	PC2
SO_2	23.0	29.7	18.1	19.0	11.5
NO_X	25.6	26.1	17.3	18.7	12.4
PM	26.0	24.9	16.4	18.3	11.5
VOCs	24.0	29.0	19.6	24.1	16.1



- Emissions in BAU1 increased compared to those in 2013 except for SO_2;
- Emissions in PC2 decreased by around 50%;
- Emissions in BAU2 and PC1 are comparable.

GEOS-Chem model

Region:

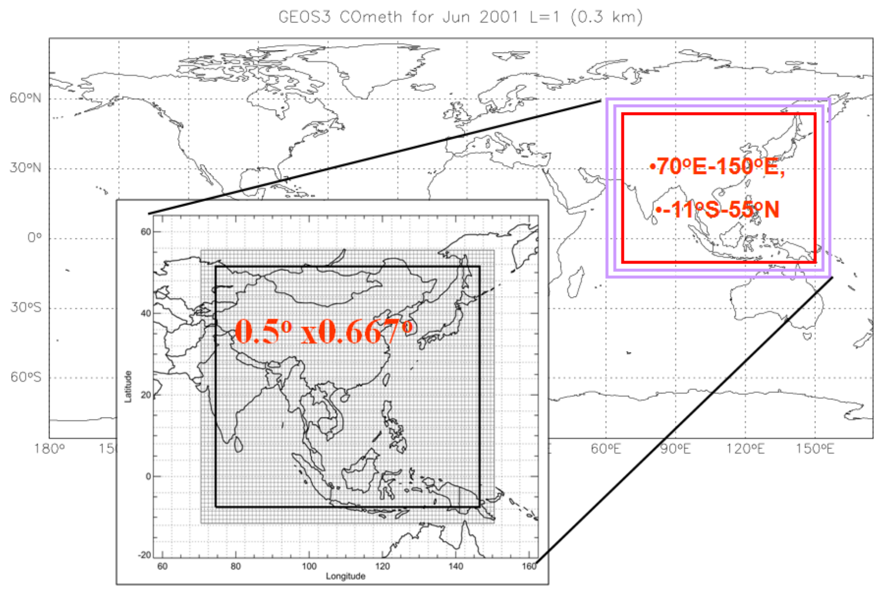
Nested domain for Asia (70°-150°E, -10°-55°N)

Resolution:

Horizontal resolution: 0.5 latitude by 0.667 longitude
47 vertical layers up to 0.01 hPa

Met fields:

GEOS-5 assimilated meteorological fields from the Goddard Earth Observing System of the NASA Global Modeling Assimilation Office

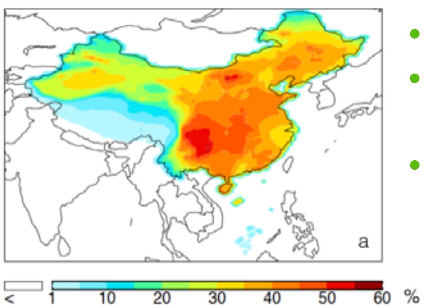


Boundary fields:

Tracer concentrations at the lateral boundaries are provided by a global GEOS-Chem simulation at 4 latitude by 5 longitude horizontal resolution and updated in the nested-grid model every 3 h.

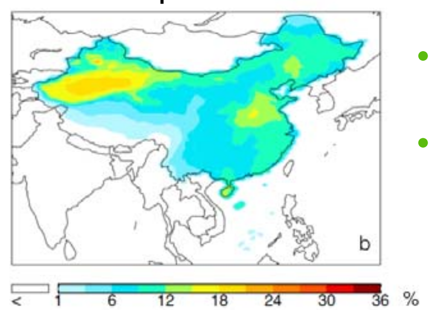
Simulated percentage contributions in the base year (2013) from coal burning

Total coal



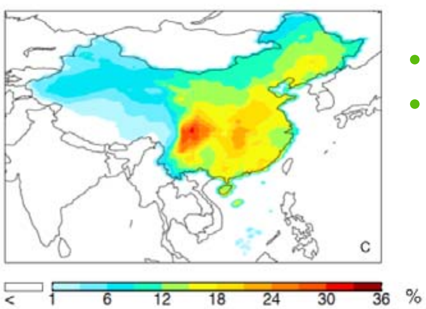
- Sichuan Basin: 50.19%;
- Inner mongolia: more than 50%
- More coal in middle west, backward technology…

Power plant coal



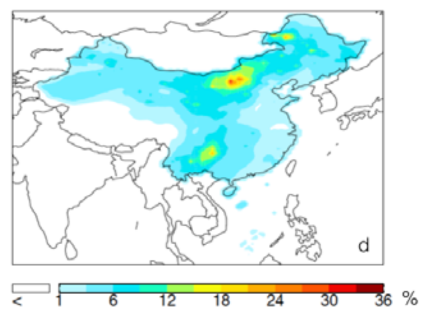
- North China Plain: 12.04%, larger number of power plants
- Xinjiang: few other sources

Industrial coal



- Sichuan Basin: 25.91%;
- North China Plain and Middle Yangtze River: 16.77% and 20.47%

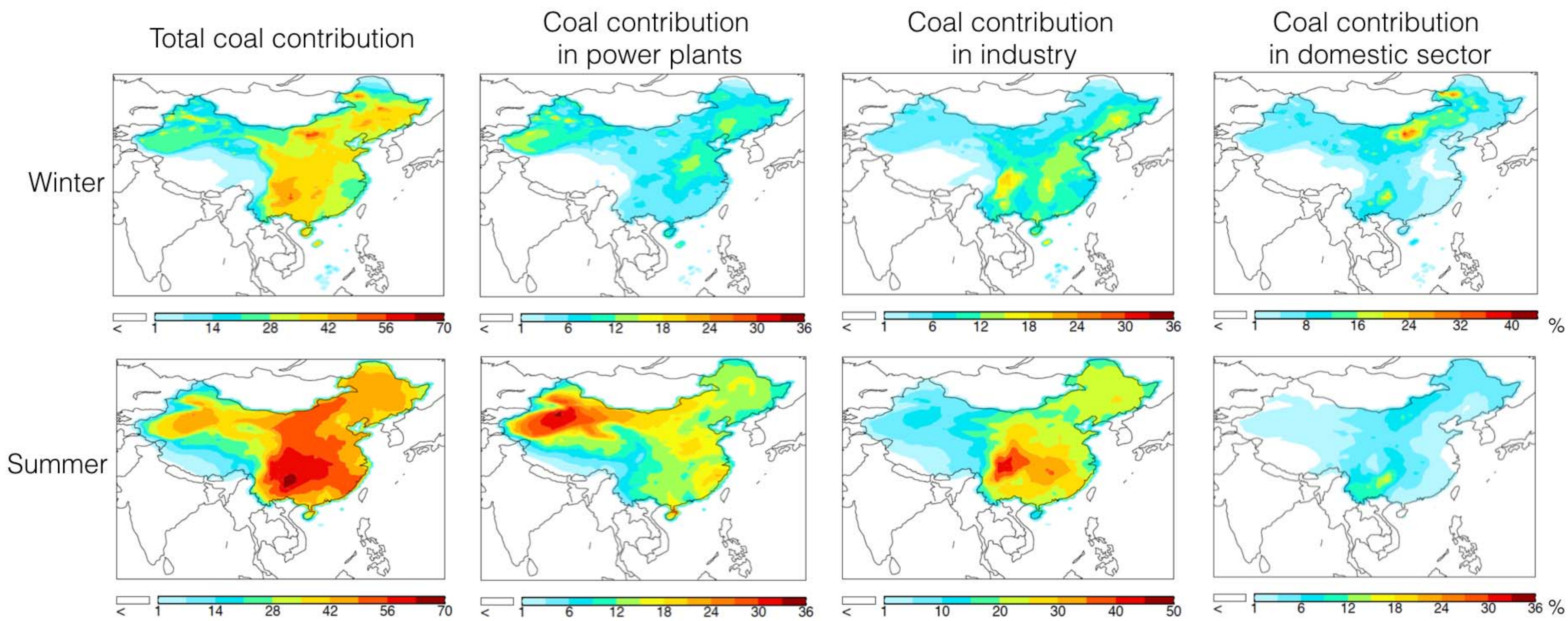
Domestic coal



- Inner mongolia: 25%, large amount of raw coal burning
- Guizhou: 15%, high sulfur content

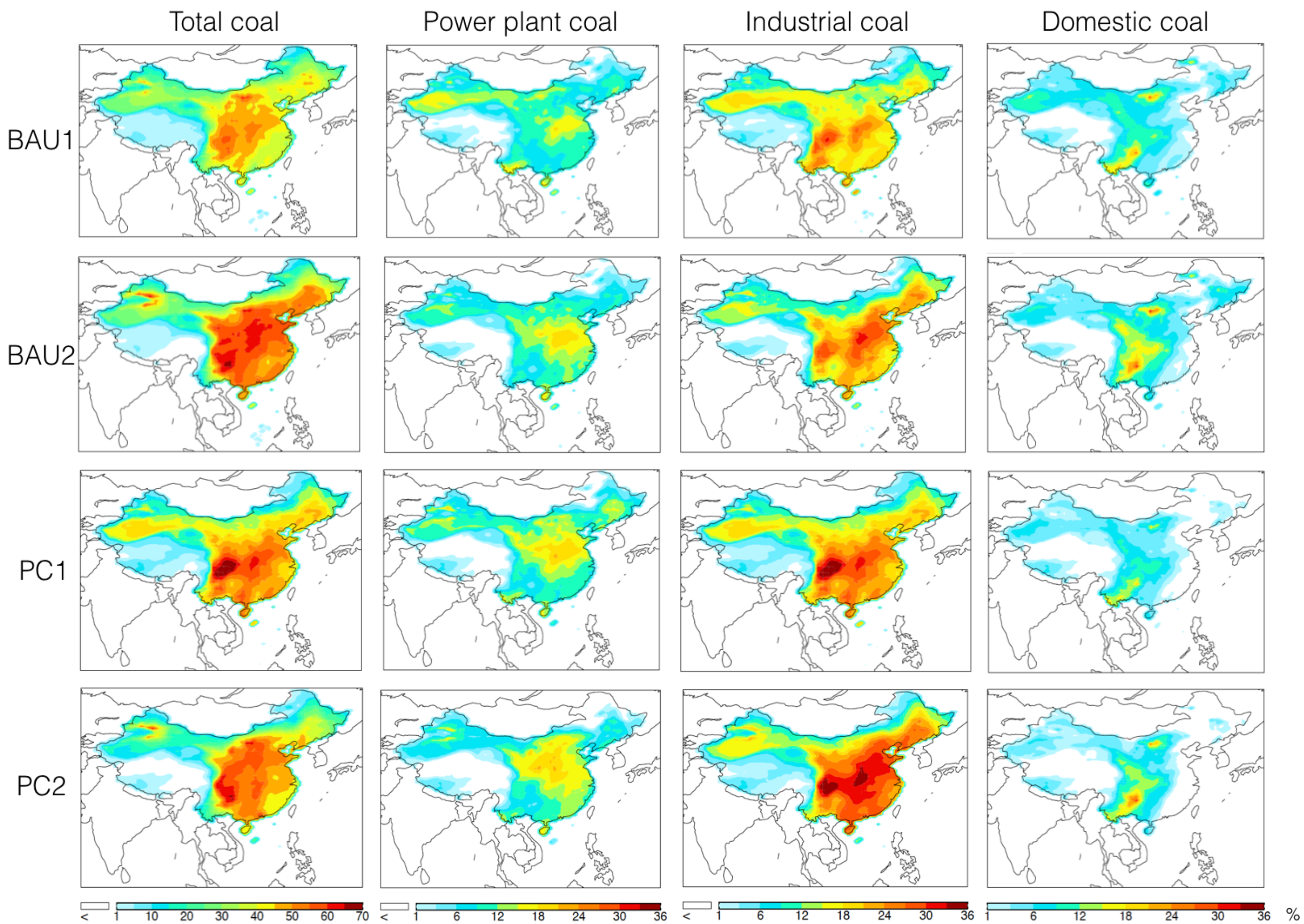
			Contributions from coal burning in		
	Mean $PM_{2.5}$	Total coal burning	Power plant	Industry	Domestic
National Average*	56.7	22.5 (39.6%)	5.6 (9.8%)	9.6 (17.0%)	2.2 (4.0%)

Seasonal variation of coal burning contribution

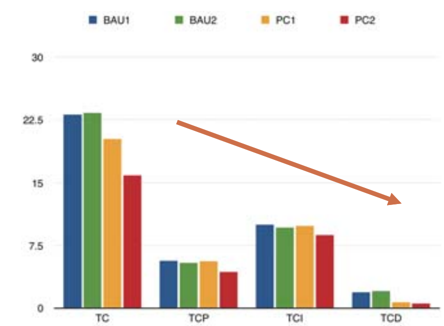


	Mean $PM_{2.5}$	Total coal burning contributions		Contributions from coal burning in: Power plant		Industry		Domestic	
Winter	79.6	28.2	35.40%	6.3	7.90%	9.4	11.80%	4.3	5.40%
Summer	38.4	17.8	46.20%	5.2	13.40%	9	23.40%	1	2.50%

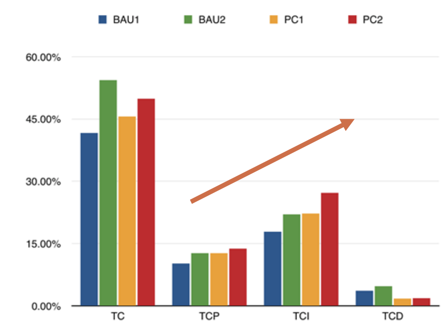
Coal burning contribution in future scenarios



Absolute contributions in 2030



Percentage contributions in 2030



Conclusions

- Coal combustion contributes 40% of ambient $PM_{2.5}$ concentration; Industrial coal: 17%, Powerplants: 10%, residential: 4%. Coal burning (especially industrial coal burning) should be prioritized in policies

- While absolute contributions of sources including coal burning in power plants and industry remain at a relatively constant level through out the year, the percentage contribution almost doubles from winter to summer, due to a larger reduction of emissions from non-coal sources including transportation and biomass burning.

- $PM_{2.5}$ levels and absolute contributions from major sources decrease in all future scenarios, as energy policies and emission control strategies is applied.

- Although absolute contribution decreases in the future, coal (especially industrial coal burning) remains as the single largest contributor and the proportion increases despite the effort toward emission reduction. Urgent need for even more aggressive strategies to reduce emissions from coal combustion (and other sectors).

GBD-MAPS general methodology

f_{coal}

- Estimate coal combustion/major source contribution to ambient $PM_{2.5}$
- Calculate fraction ambient $PM_{2.5}$ attributable to each source

$PM_{2.5\ coal}$

- f_{coal} x ambient $PM_{2.5}$ → ambient $PM_{2.5}$ attributable to each source

Disease Burden

- Use integrated exposure response functions and cause-specific mortality estimates in combination with **$PM_{2.5\ coal}$** → source contribution to disease burden

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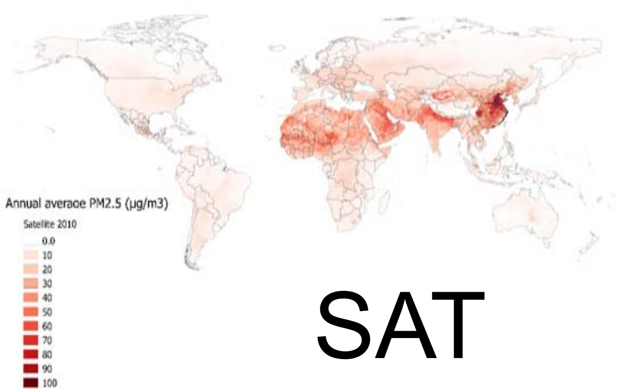
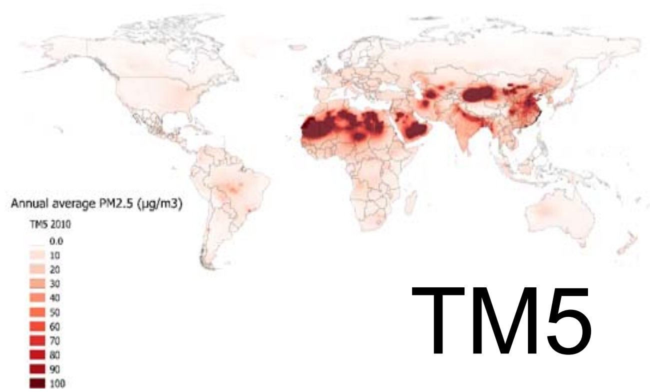
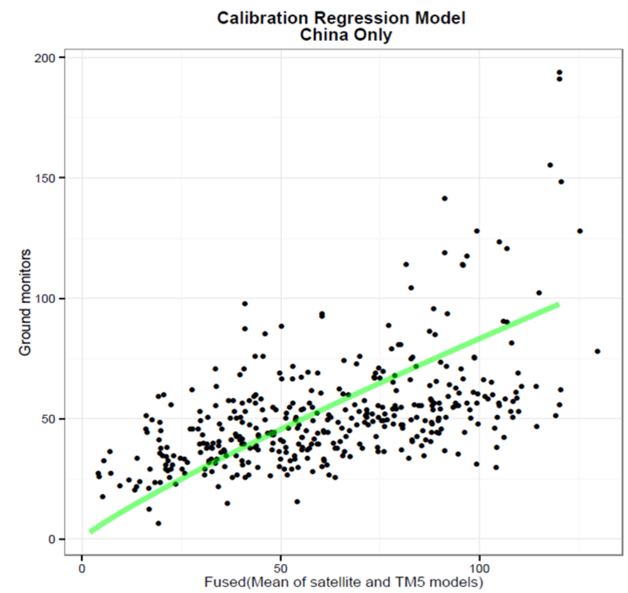
2. Estimating ambient $PM_{2.5}$ attributable to coal combustion

- Final estimates based on average of (1.4 million) grid cell values (SAT, TM5) and calibrated (regression model) with measurements
  - 0.1° x 0.1° resolution
  - extrapolated to 2013 using 2010-2011 trend in SAT
- Incorporate variance between two estimates and measurements in uncertainty assessment
- Unique contributions from each approach







Brauer et al., 2015

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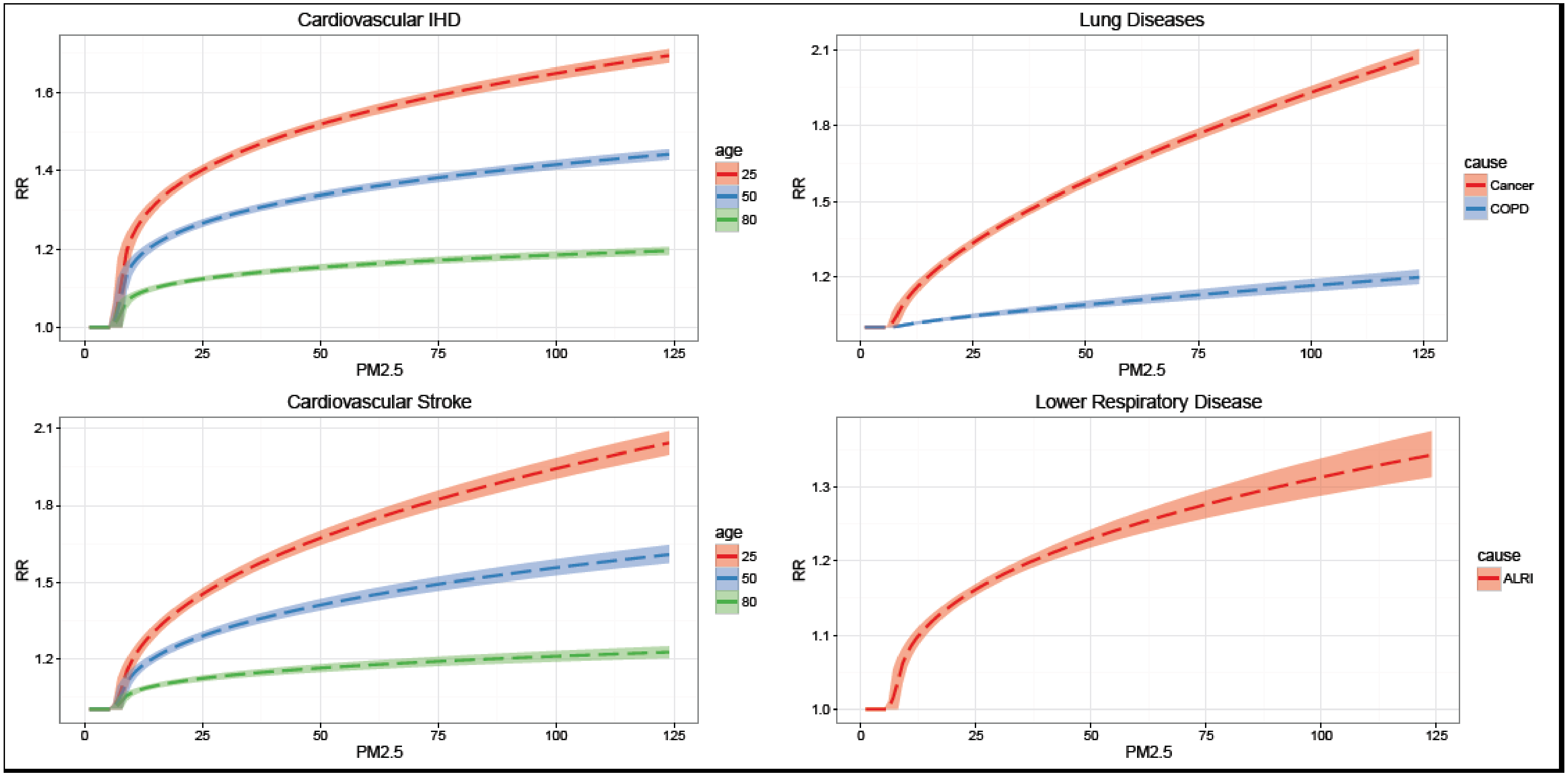
3. Integrated Exposure-Response Functions



Forouzanfar et al. 2015; Burnett et al. 2014

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GBD MAPS Working Group

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