

MICS-Asia Phase III

(Modeling and Emission Inventories)

“Multi-scale model (Global, regional, urban)”

Current Status

Scales: Mega-cities, City clusters:

China (Beijing-Tianjin-Hebei: haze issue, Pearl River Delta: Hundred-Million Yen Project, Shanghai-EXPO2010)

Japan (Tokyo and Osaka Metropolitan areas)

Increase of ozone conc. despite of NO_x and VOC reduction,

Thailand (VOCs emission is controlled by Environmental Standard and then photochemical ozone; biomass burning)

Scales: Regional and global

Source/Receptor analysis at regional scales

Regional haze and transport

Increase of annual average concentration of ozone and haze

Decline of crops and forests (AOT40)

Global warming

Passive sampler campaign (Workshop and observation in EANET sites)

Collaborating with HTAP (joint meeting on 22-23 May, 2014)

MICS-Asia Phase III - Current Status

Meteorology: 45 km(D1); 15 km (D2); 5 km (D3):

WRF model performance is done and data is ready

CAS/IAP; ACAP; Univ. Tennessee

Emission: 0.25° x 0.25°

Regrid to 45 km is ongoing (modelers can make it themselves)

Participating models:

Global models: provide IC/BC

CHASER (2.8° x 2.8°) and GEOS-Chem v9-1-2 (2° x 2.5°); 3-hour outputs

Regional models:

CAMx

CUACE

LOTUS-TNO

NAQPMS

RAMS-CMAQ

RAQM2

STEM-2011

TAQM

GEOS-Chem nested for 0.5° x 0.666°

WRF-CMAQ (4.7.1; 5.0.1)

WRF-Chem

MICS Meeting will be held at Nanning, Guangxi, China on 20-21 February 2014

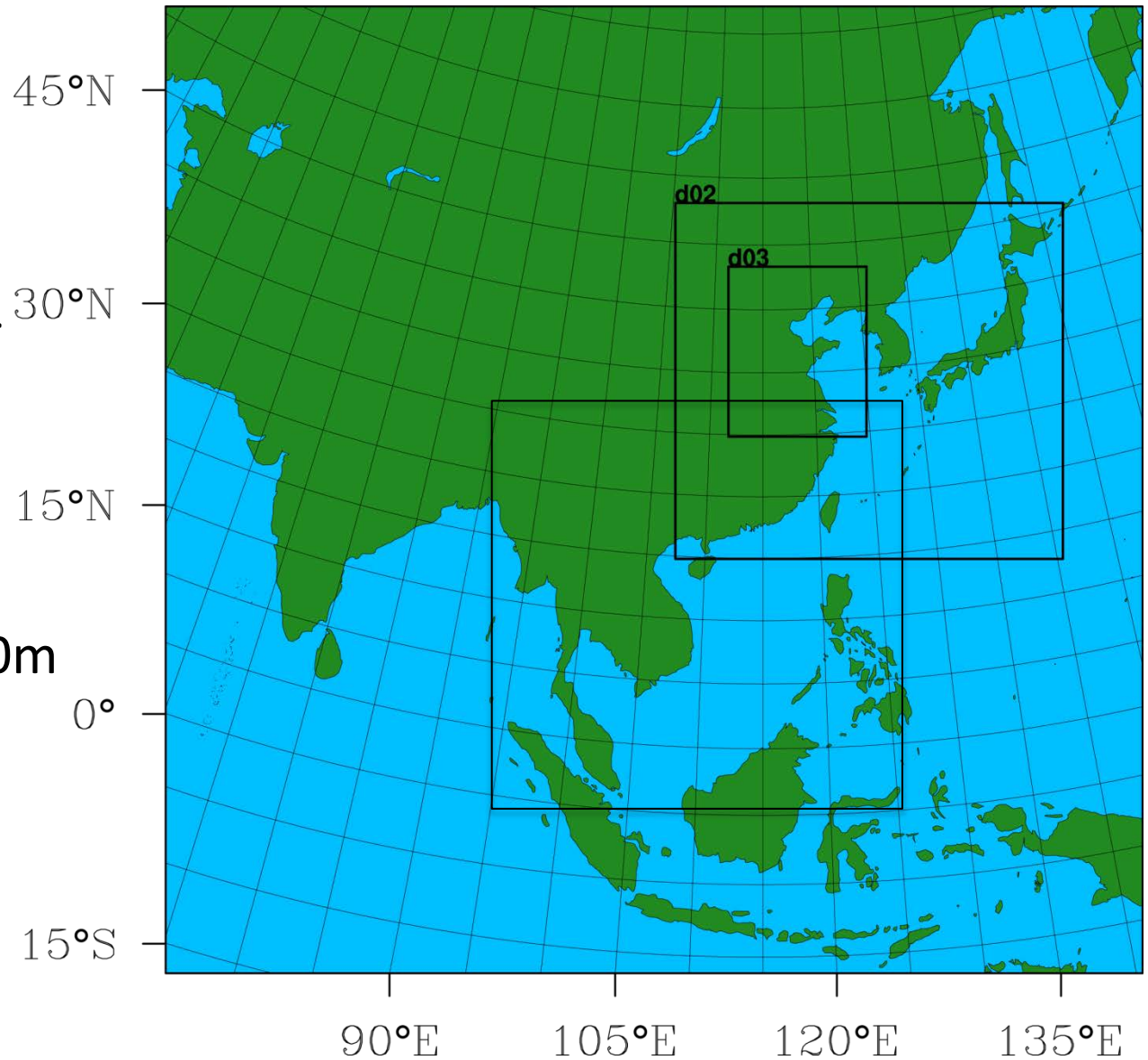
Modeling Domains

D1 (45km): 185*183

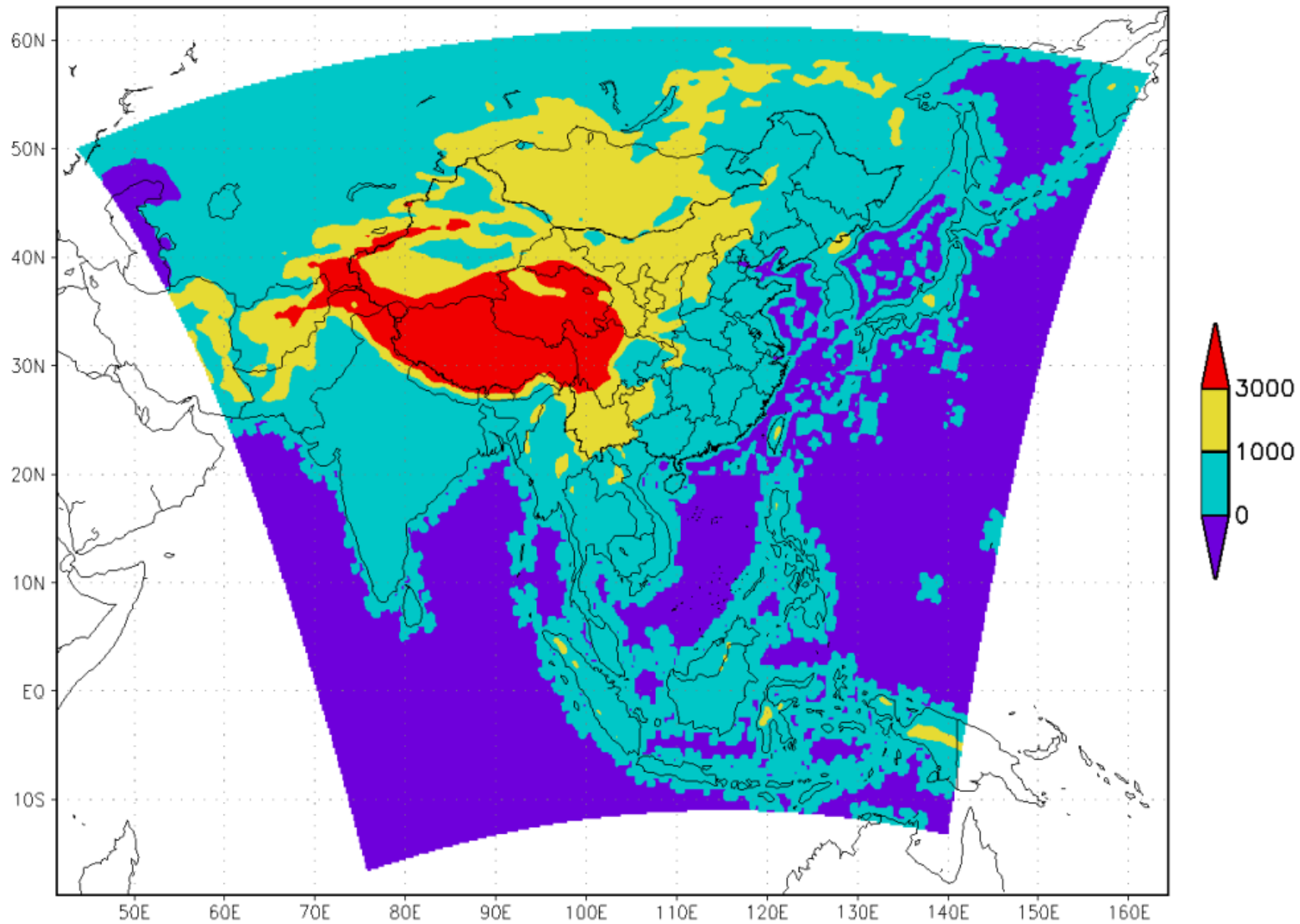
D2 (15km) : 220*202

D3 (5km): 226*283

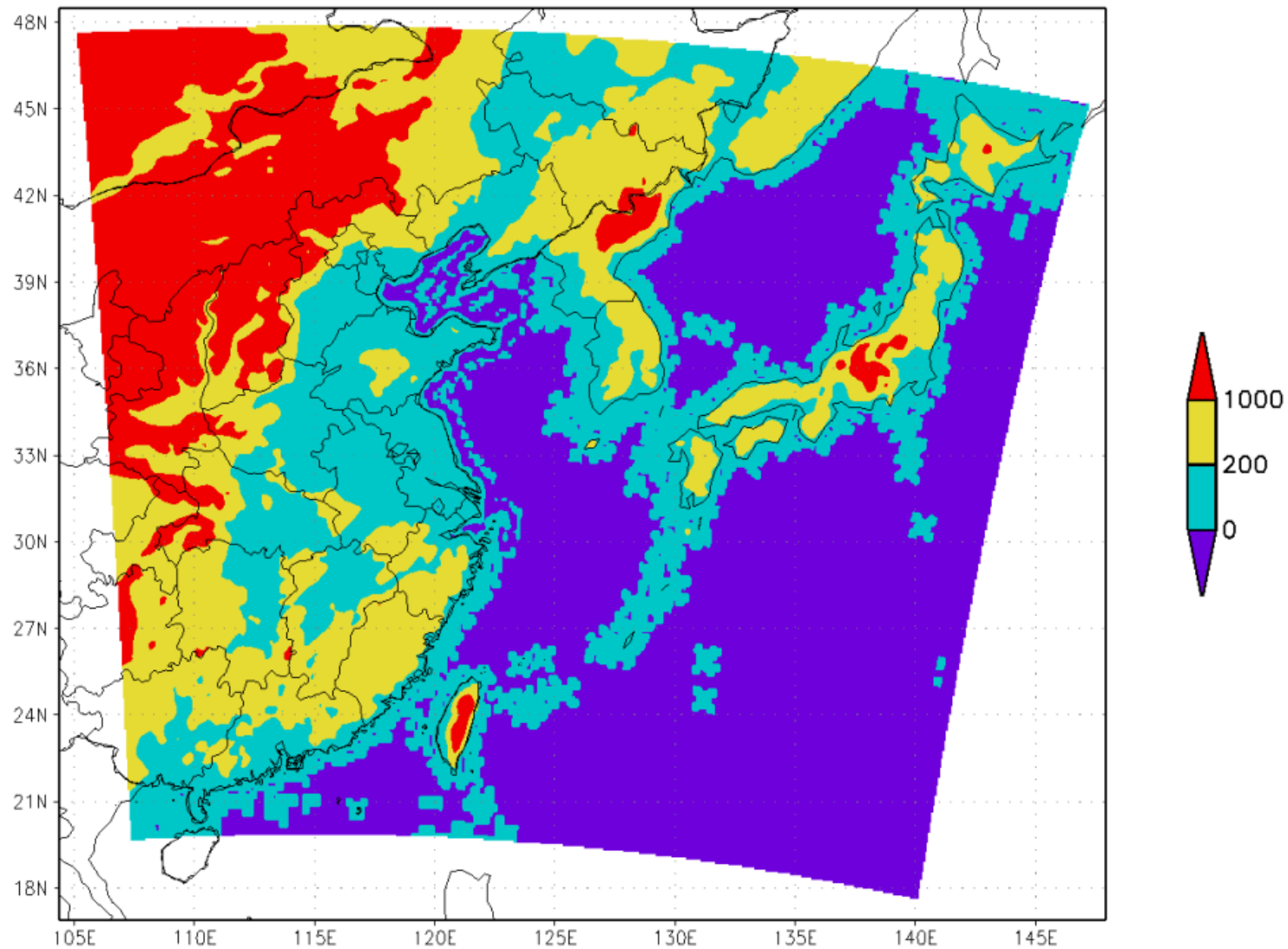
Vertical: 40 layers
with 20 layers < 2000m



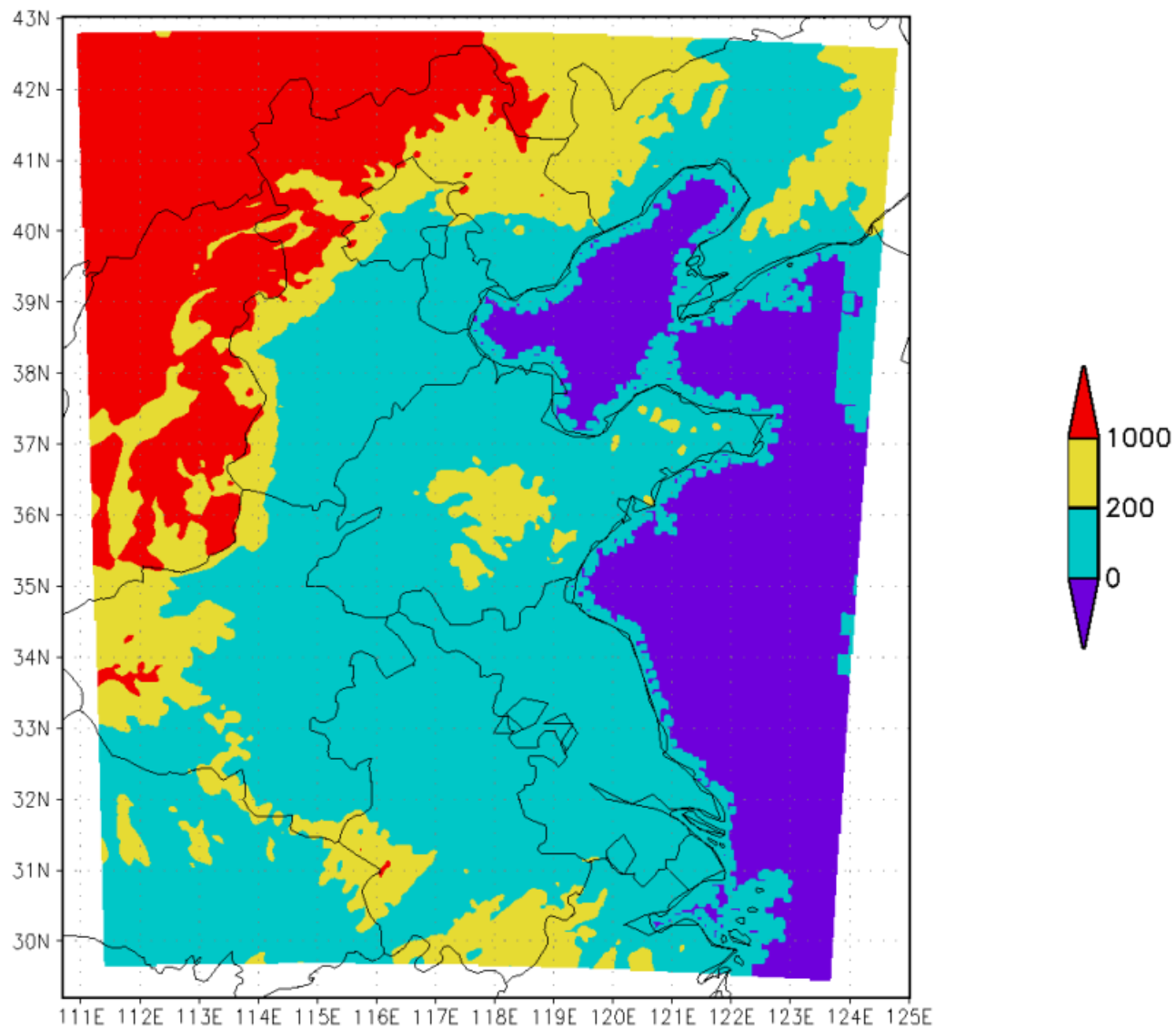
Domain 1



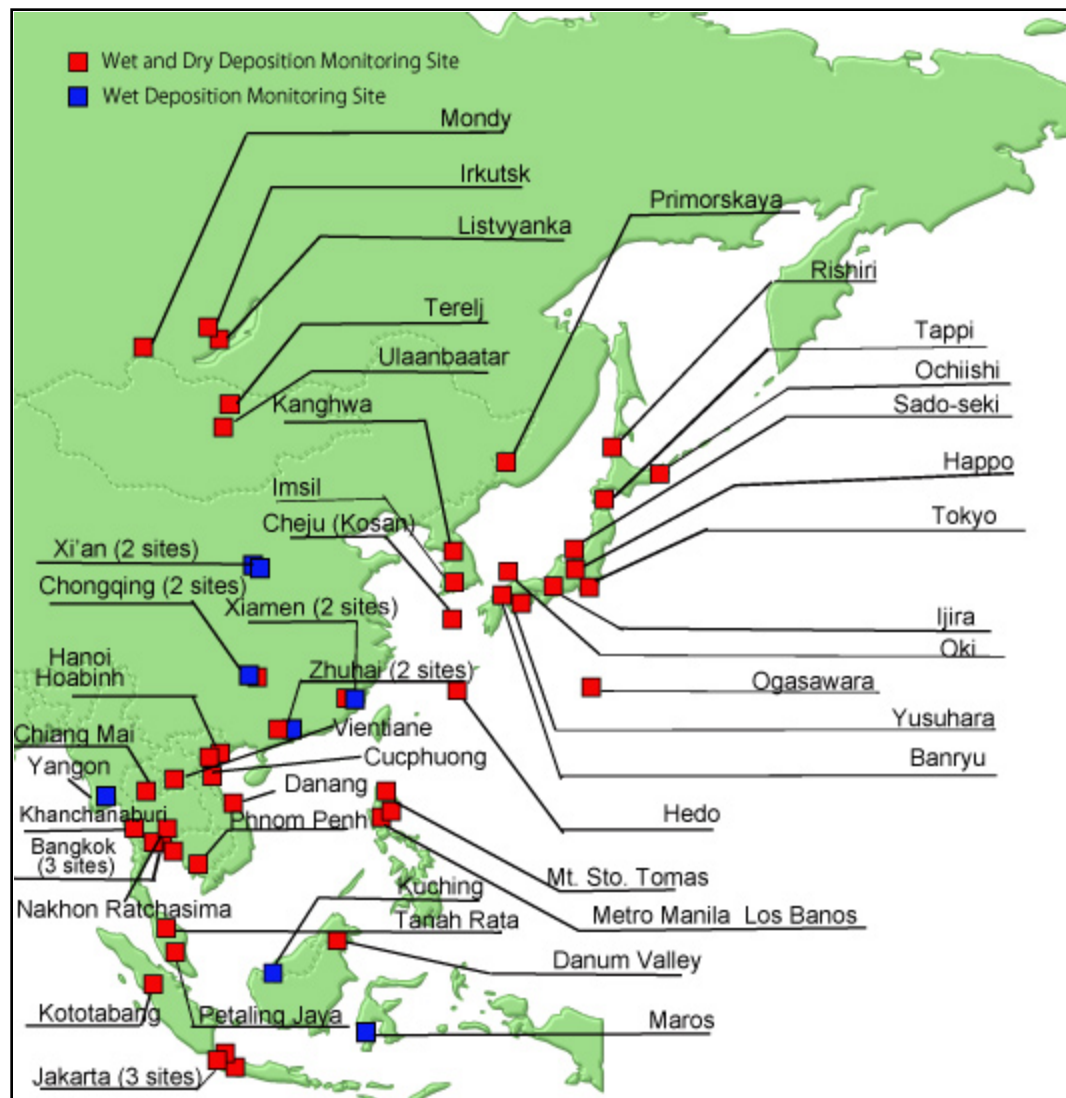
Domain 2



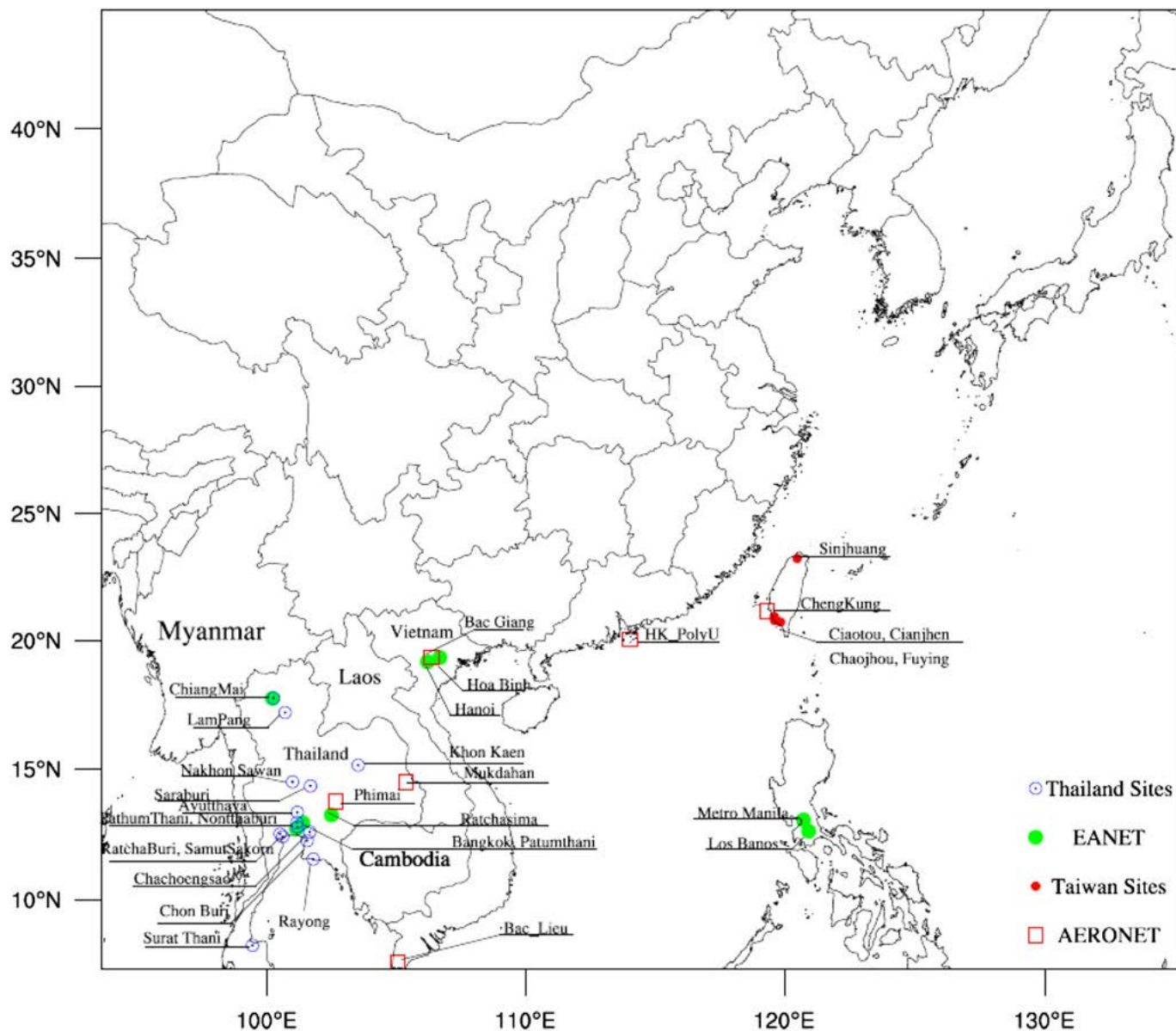
Domain 3



EANET (Acid Deposition Monitoring Network in East Asia)



Other Monitoring Sites in East Asia)



DOE's Arctic Black Carbon Transport Study

- Russia Black Carbon Inventory -

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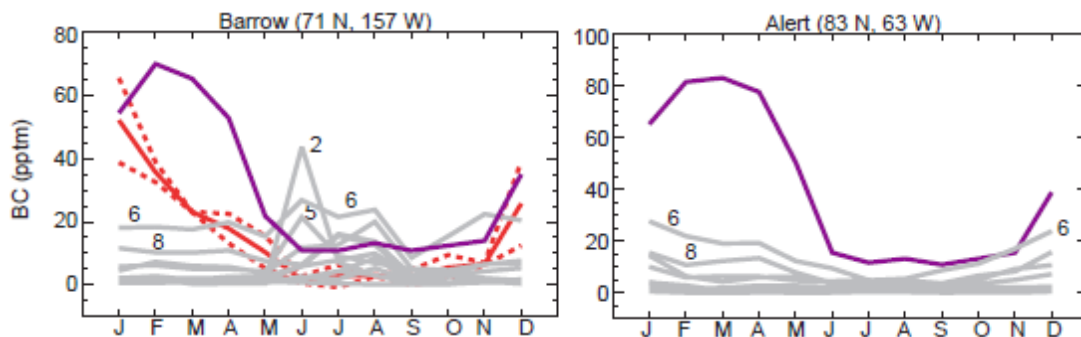
Motivations

Arctic black carbon simulation questions:

- ❖ Large diversity of modeling BC from different models (Shindell et al., 2008)
- ❖ Strong underestimation of BC in Arctic (Shindell et al., 2008; Koch et al., 2009)
- ❖ Improper wet scavenging parameterizations (Bourgeois et al., 2011)

Model	Gas-phase	Aerosols	Prescribed lifetime	Horizontal Resolution
1. CAMCHEM	NO _x , CO	SO ₂ , BC	Y	1.9
2. ECHAM5-HAMMOZ		SO ₂ , BC		2.8
3. EMEP	NO _x , CO	SO ₂		1.0
4. FRSGC/UCI	NO _x , CO		Y	2.8
5. GEOSChem	NO _x	SO ₂ , BC		2.0
6. GISS-PUCCINI	NO _x , CO	SO ₂ , BC	Y	4.0
7. GMI	NO _x , CO	SO ₂ , BC	Y	2.0
8. GOCART-2		SO ₂ , BC		2.0
9. LMDz4-INCA		SO ₂ , BC		2.5
10. LLNL-IMPACT	NO _x , CO	SO ₂ , BC		2.0
11. MOZARTGFDL	NO _x , CO	SO ₂ , BC	Y	1.9
12. MOZECH	NO _x , CO		Y	2.8
13. SPRINTARS		SO ₂ , BC		1.1
14. STOCHEM-HadGEM1	NO _x , CO			3.8
15. STOCHEM-HadAM3	NO _x , CO	SO ₂	Y	5.0
16. TM5-JRC	NO _x	SO ₂ , BC		1.0
17. UM-CAM	NO _x , CO		Y	2.5

Shindell et al., 2008



Motivations

On December 17, 2009, in Copenhagen, the US Government committed to international cooperation to reduce black carbon (BC) emissions in and around the Arctic.

Arctic Black Carbon (BC) Initiative: A project funded by U.S. DOE

❖ Activity #1:

Arctic BC Identification: Receptor modeling: Potential Source Contribution Function (PSCF) (*ORNL*)

❖ Activity #2:

Establish BC Emissions Inventory of Russia (base year : 2010): Improve estimates of BC emissions in Russia and verification by model simulation (*UTK*)

Tasks: BC emissions from gas flaring, transportation, residential, power plants and Industries

❖ Activity #3:

Demonstration of BC Emissions Reduction Technologies:

Demonstrate the best-available emissions reduction technologies for a subset of the identified sources in Russia. (*ORNL*)

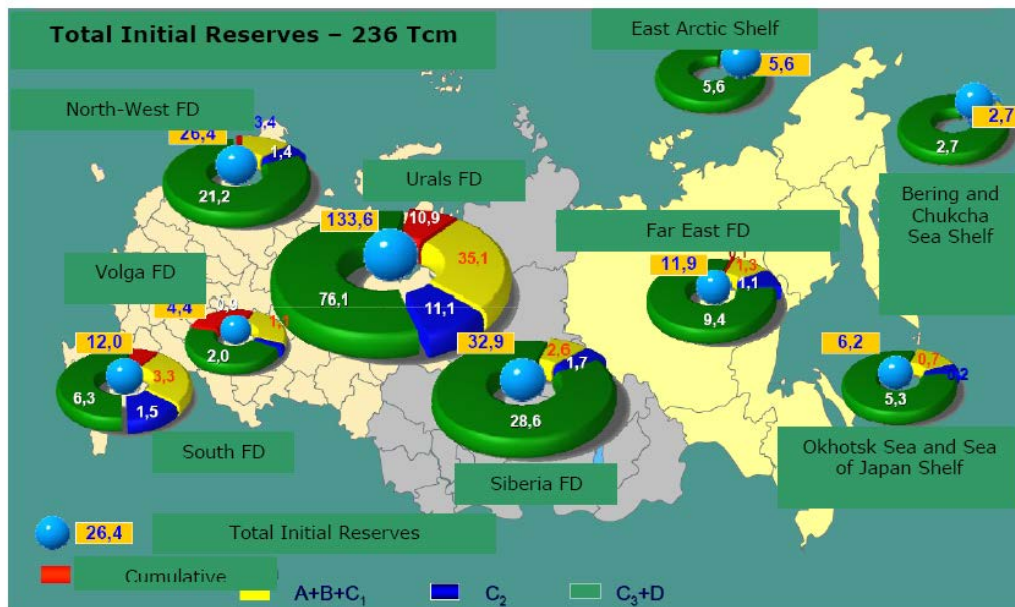
Sources

Summary of Russian BC emissions: Local source data

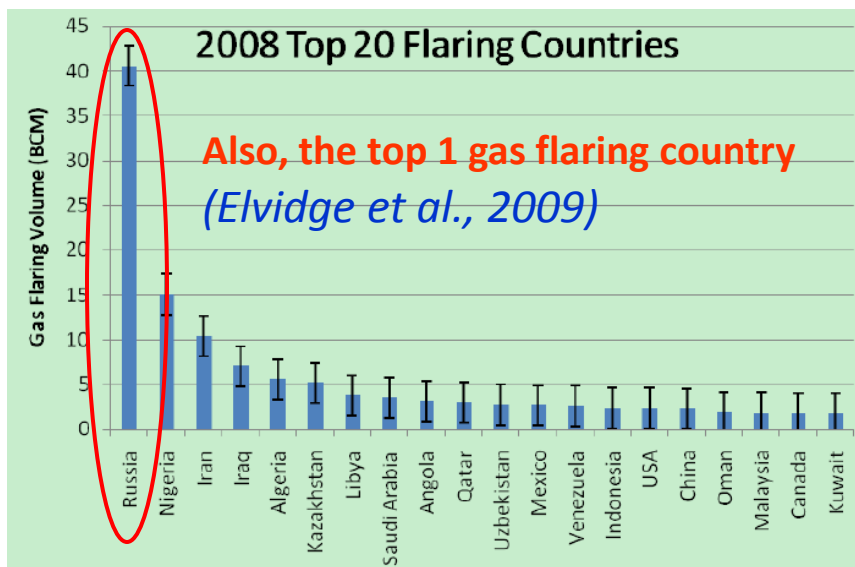
Emission sector	Local (Russia) data source
Gas Flaring	Laboratory experiments incorporated with local associated gas composition (1)
Transportation	Local emission factors (on-road and idling) dependent on vehicles, emission standards and driving conditions (6)
Residential	Local activity data and monthly temporal profile (2)
Power plants	Raw PM emission data from Russian federal authorities (1)
Industry	Raw PM emission data (various industrial sub-sectors) from Russian federal authorities (2)

** Red number indicates the number of Russian documents used*

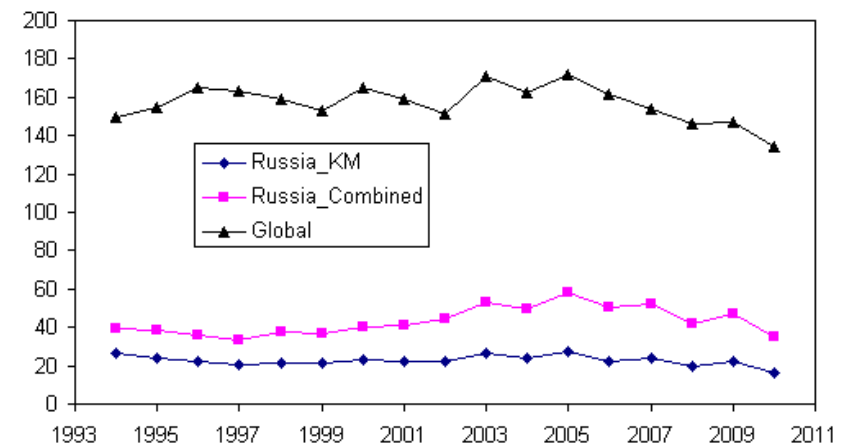
I. Gas flaring: a missing BC source



Russia possess the largest natural gas reserves of 24% in the world as of 2009. (*Dmitry Volkov, 2008*)



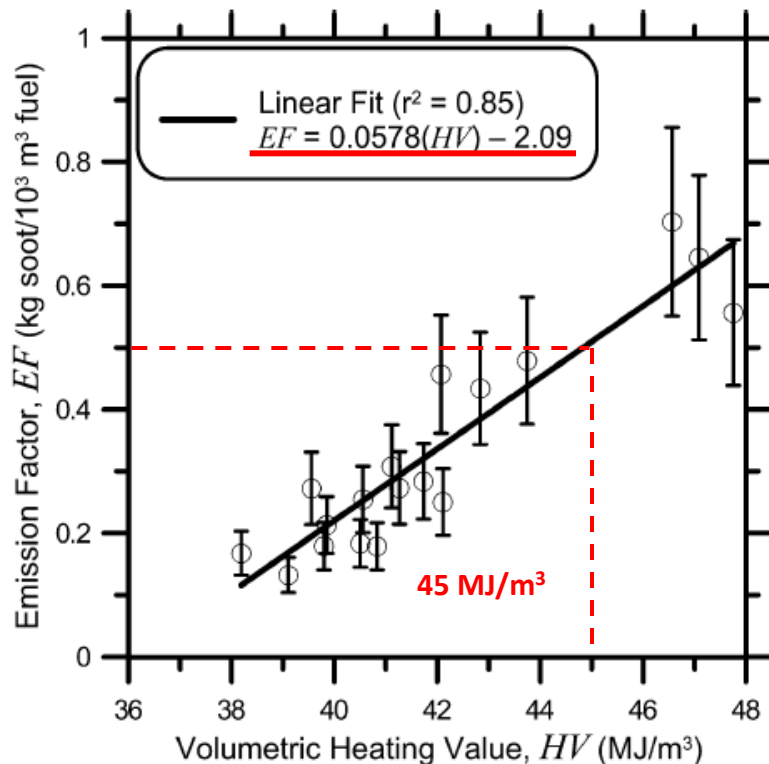
Annual gas flare volume in the global scale and in Russia



Estimation of gas flaring EF and emission in Russia

No field measurement available

Only laboratory test (*McEwen and Johnson, 2012*)



Composition of the associated gas in Russia

Associated Gas Composition		Percentage (%)	Heating Value (MJ/m ³)
Methane	CH ₄	61.7452	39.9012
Ethane	C ₂ H ₆	7.7166	69.9213
Propane	C ₃ H ₈	17.5915	101.3231
i-Butane	i-C ₄ H ₁₀	3.7653	133.1190
n-Butane	n-C ₄ H ₁₀	4.8729	134.0610
i-Pentanes	i-C ₅ H ₁₂	0.9822	148.4913
n-Pentane	n-C ₅ H ₁₂	0.9173	141.1918
i-Hexane	i-C ₆ H ₁₄	0.5266	176.8591
n-Hexane	n-C ₆ H ₁₄	0.2403	177.1907
i-Heptane	i-C ₇ H ₁₆	0.0274	205.0068
Benzene	C ₆ H ₆	0.0017	147.3980
n-Heptane	n-C ₇ H ₁₆	0.1014	205.0068
i-Octane	i-C ₈ H ₁₈	0.0256	232.8155
Toluene	C ₇ H ₈	0.0688	373.0365
n-Octane	n-C ₈ H ₁₈	0.0017	232.8155
i-Nonane	i-C ₉ H ₂₀	0.0006	260.6688
n-Nonane	n-C ₉ H ₂₀	0.0015	260.6688
i-Decane	i-C ₁₀ H ₂₂	0.0131	288.4775
n-Decane	n-C ₁₀ H ₂₂	0.0191	288.4775
Carbon dioxide	CO ₂	0.0382	-
Nitrogen	N ₂	1.343	-
Hydrogen sulfide	H ₂ S	0	-

1.62 g/m³

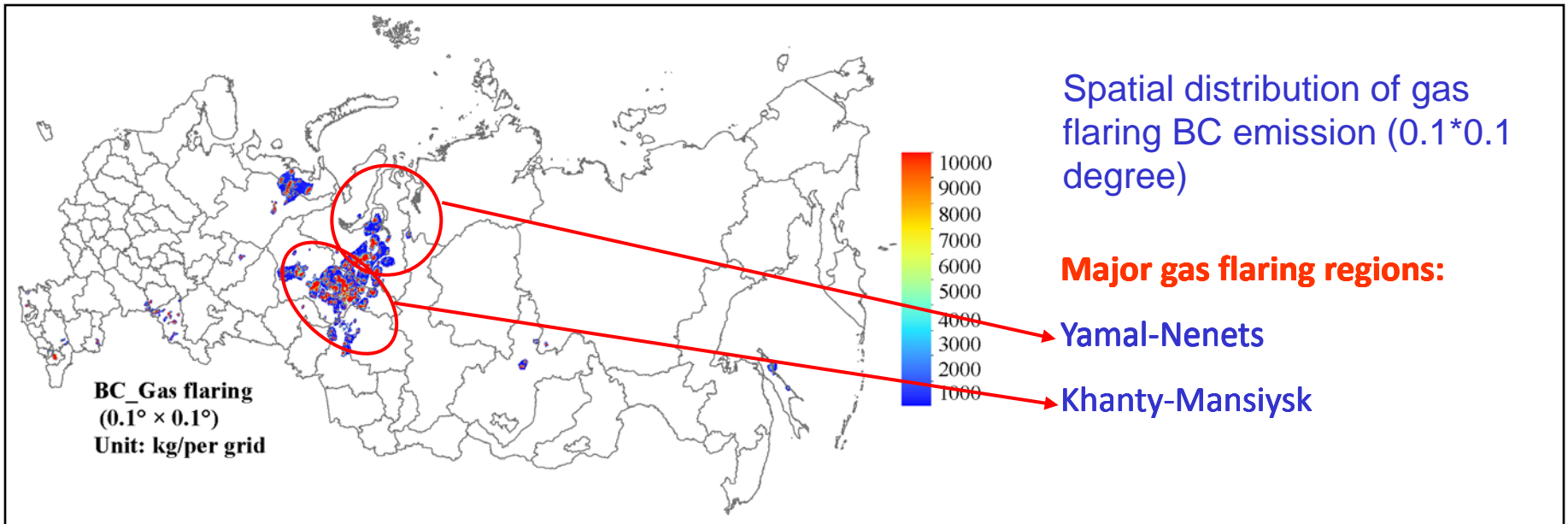
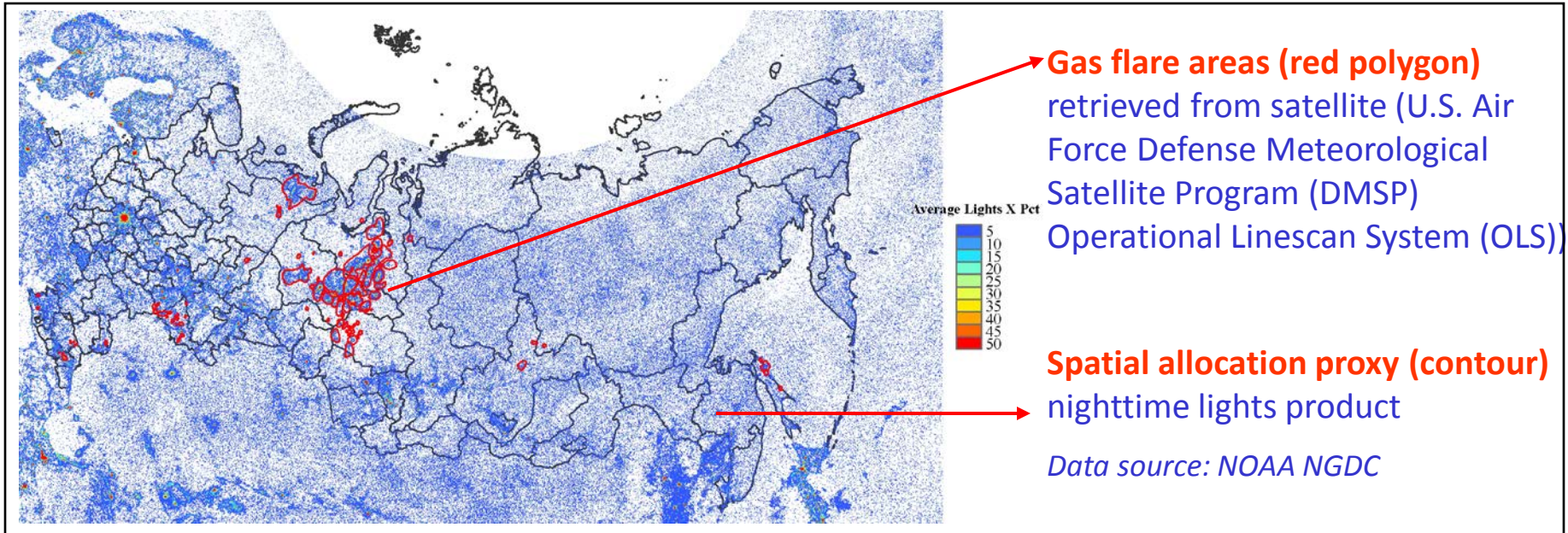
64.14 MJ/m³

$$BC_{\text{flaring}} = \text{Volume} * \text{Soot}_{\text{EF}}$$

Volume : Gas flaring volume of Russia in 2010 was **35.6 BCM** (billion cubic meters)

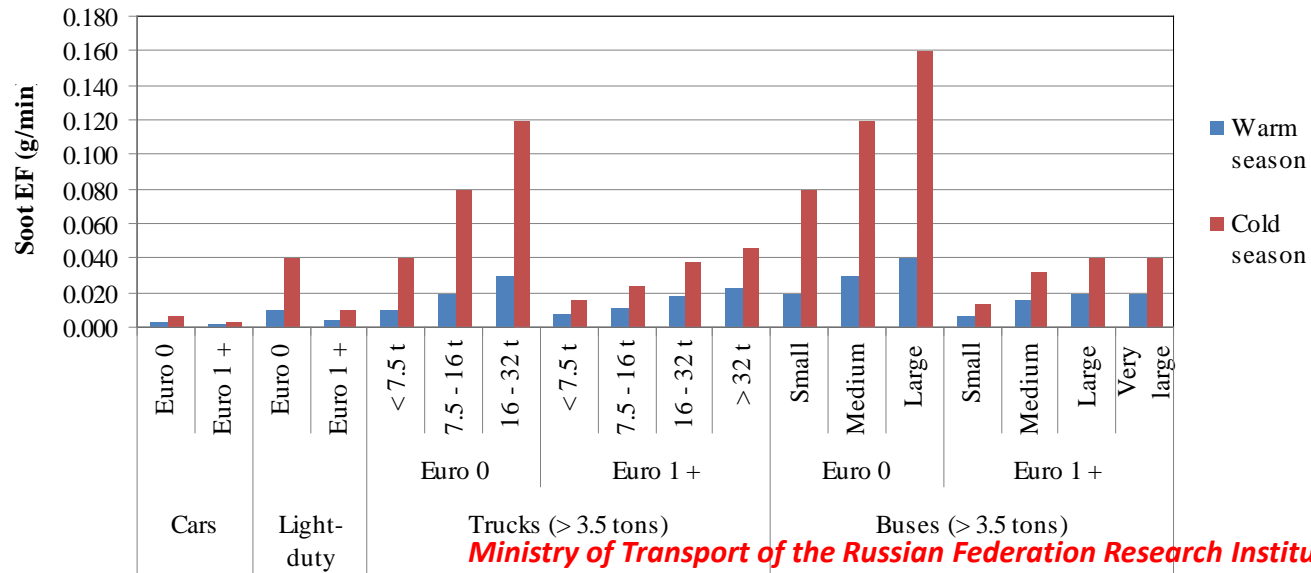
The BC emission from Russia's gas flaring in 2010 is estimated to be **57.6 Gg**.

Spatial distribution of gas flaring BC emission

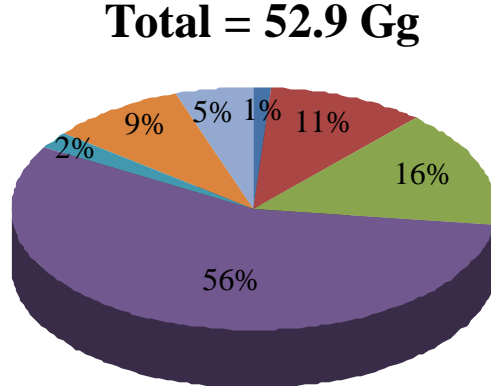


II. Transportation BC emission

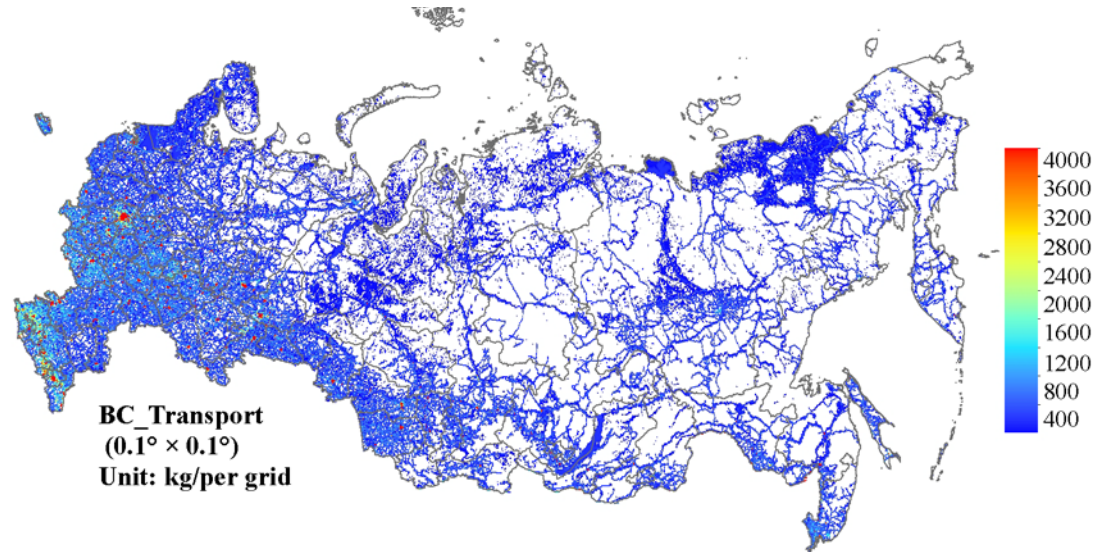
Soot emission factors (g/min) during warm-up (cold start)



Total = 52.9 Gg

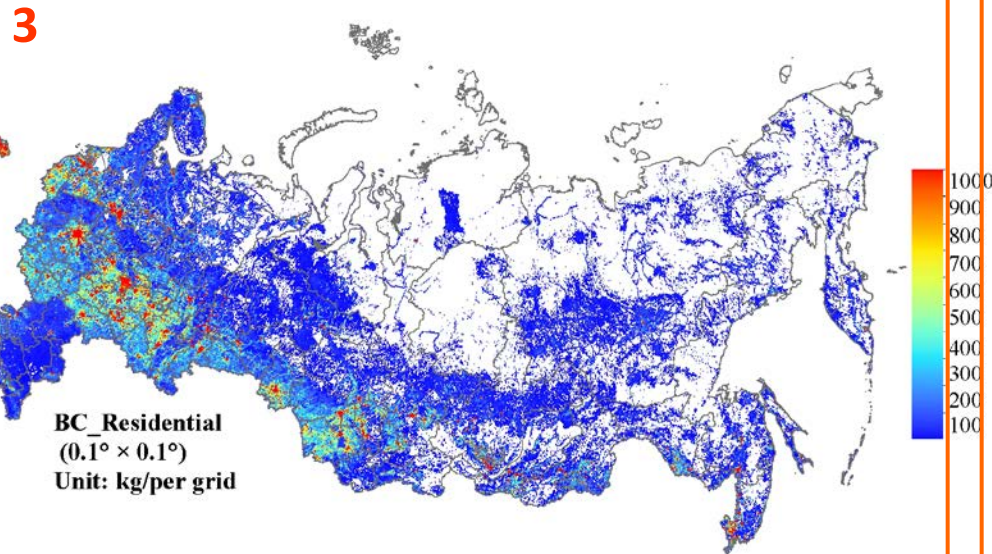
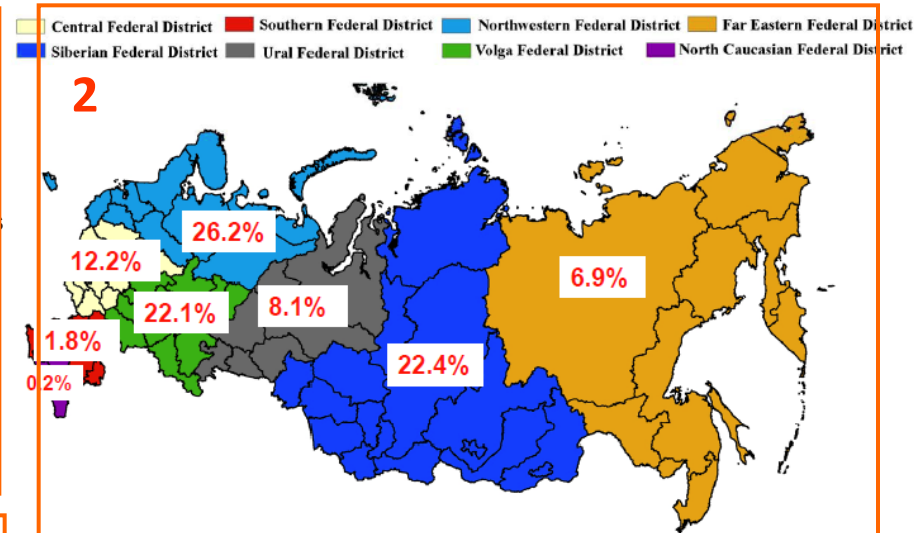
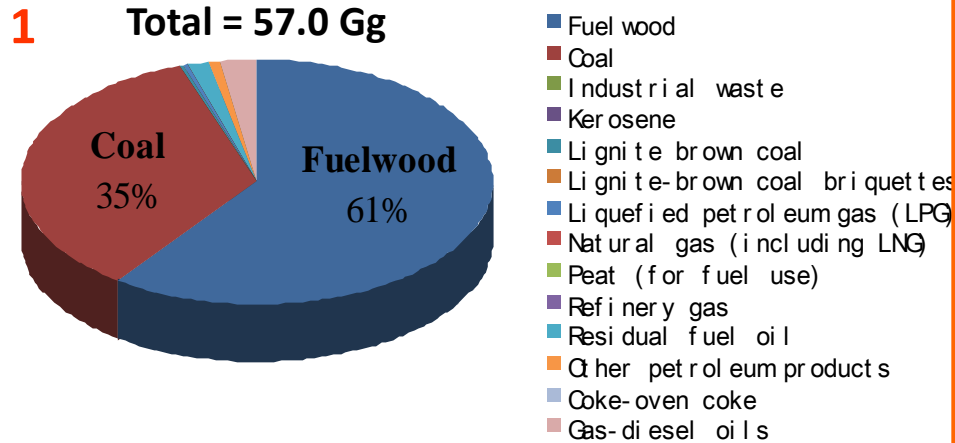


- Public buses
- Private buses
- Cars
- Trucks
- Warm-up
- Rail
- Non-road



III. Residential BC emission

Residential BC emissions in Russia are based on fuel consumption data and EFs.

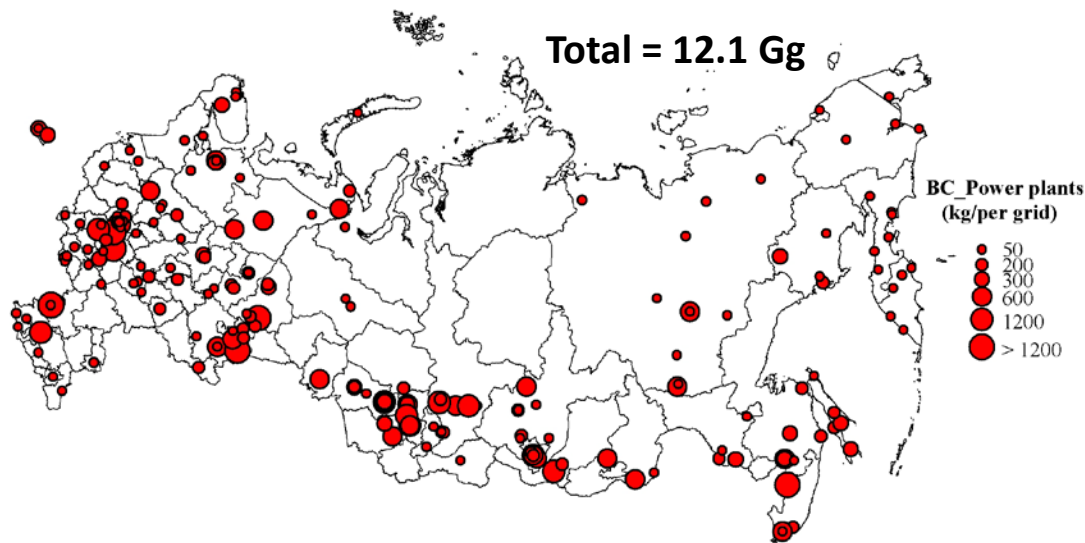


National BC -> Federal District level based on residential firewood consumption from *Russia's FSSS (Federal State Statistics Service)*

District BC -> grid cell population density within each district (*ORNL's LandScan dataset*)

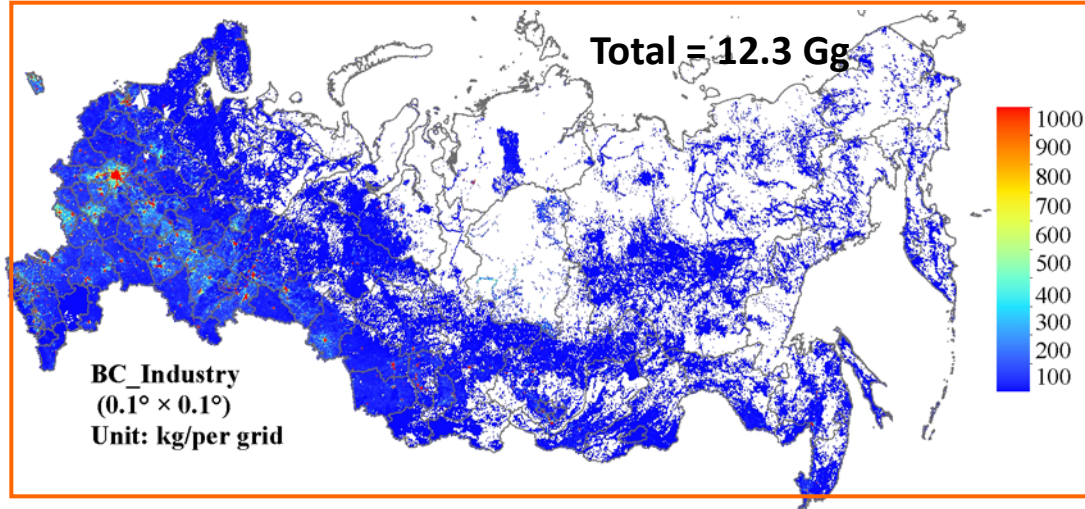
IV. Power plants & V. Industrial BC emission

BC emissions from power plants and industries in Russia are based on PM (particulate matter) data from Russian official figures and scaling factors (BC/PM_{2.5} ratio) from the U.S. EPA SPECIATE database.



National BC -> grid level

CARMA (Carbon Monitoring for Action):
power plant location, energy capacity and
CO₂ emission.



National BC -> Provincial level

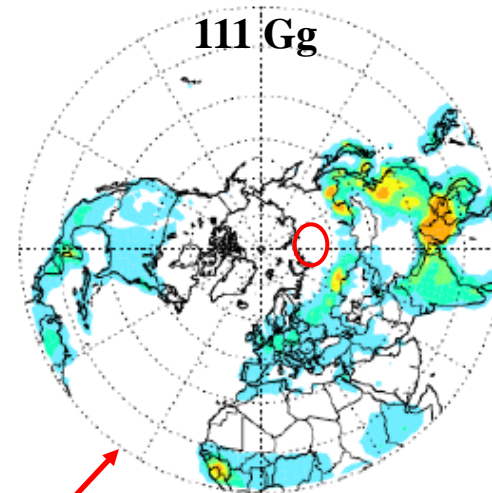
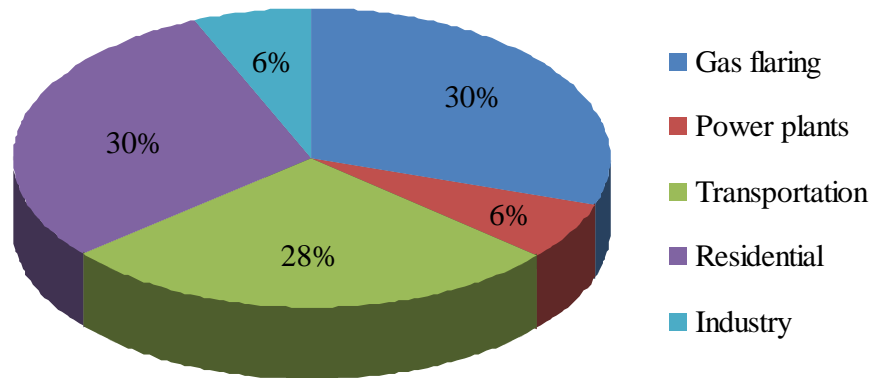
based on provincial industrial revenues
from *Russia's FSSS (Federal State Statistics Service)*

Provincial BC -> grid cell

population density within each district
(*ORNL's LandScan dataset*)

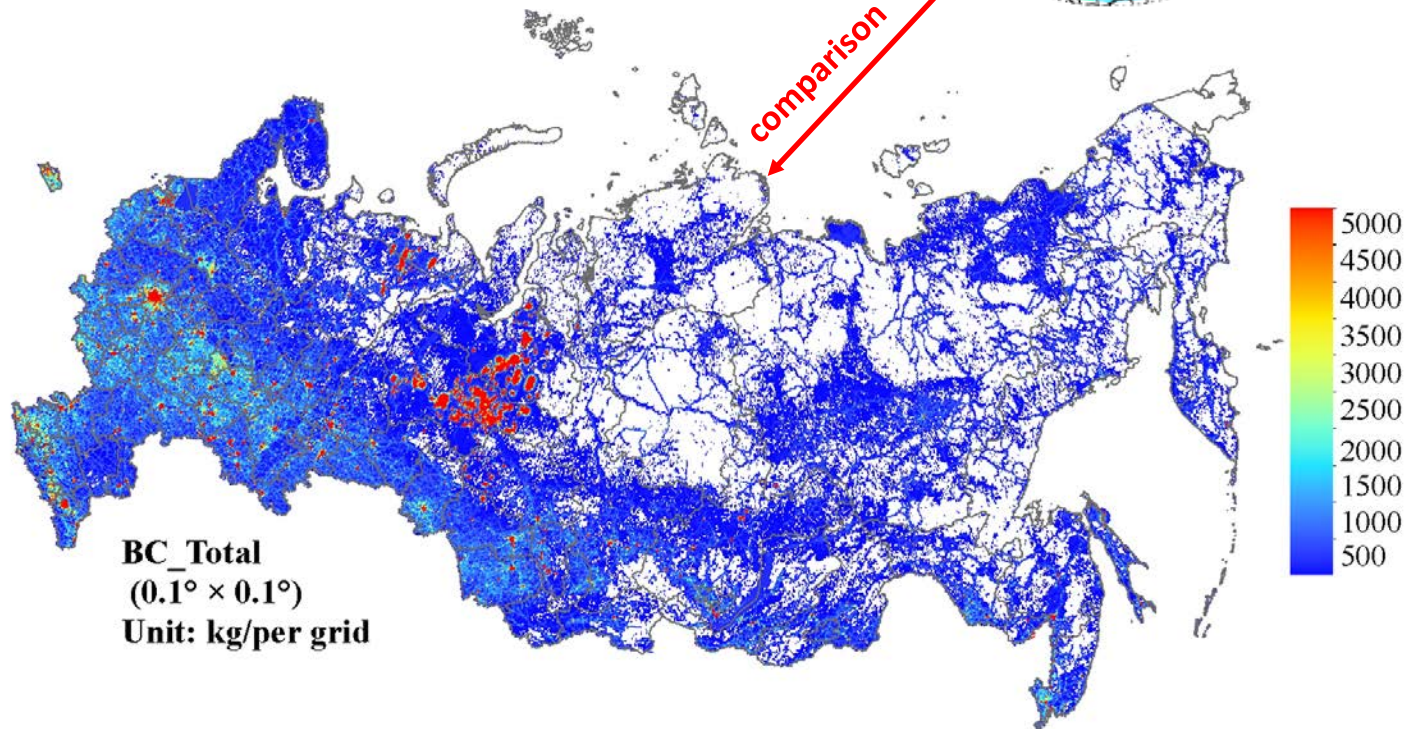
Sectoral contributions to Russian anthropogenic BC emissions

Russia total BC = 191.8 Gg

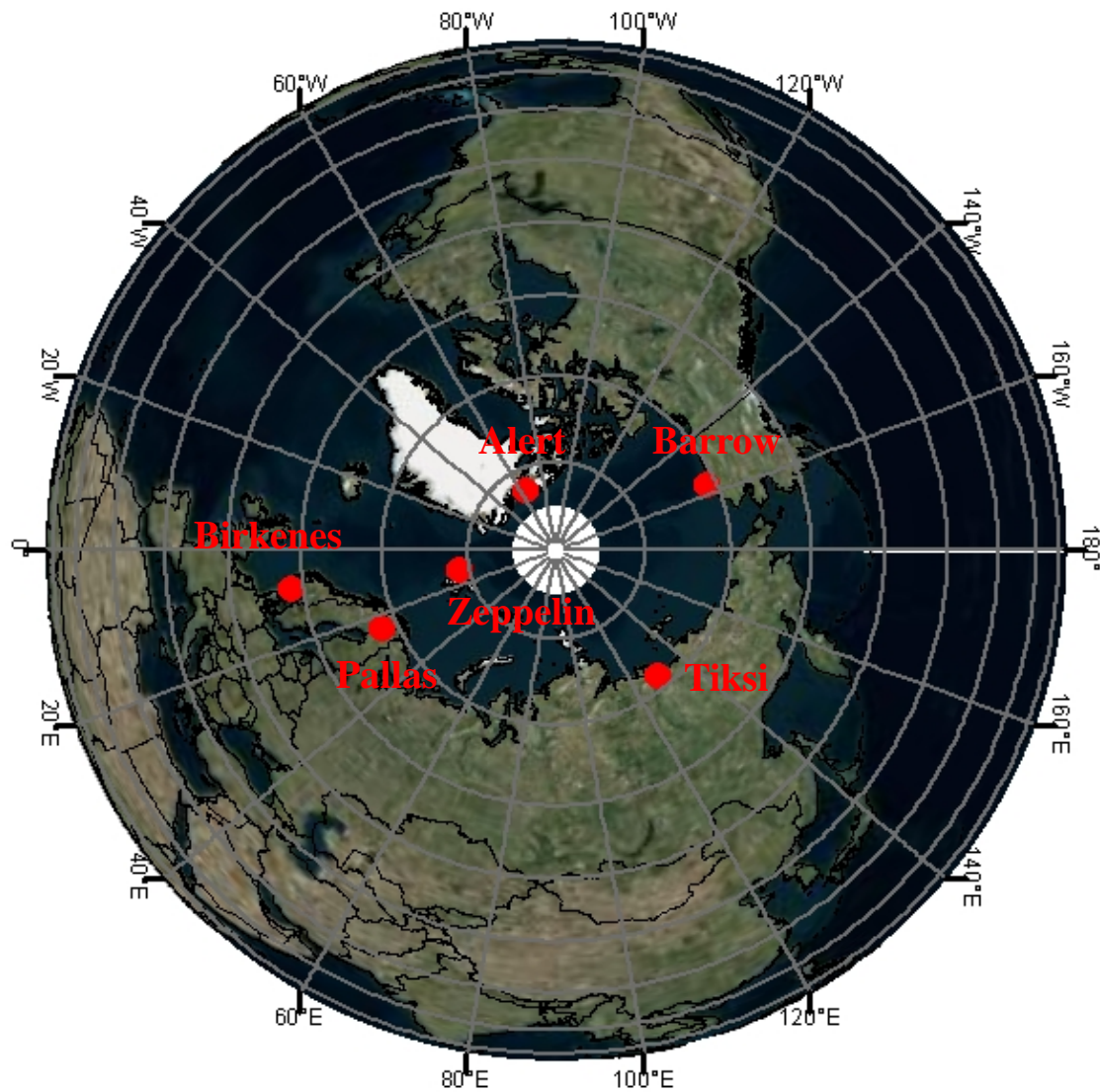


*BC emission
prepared for
ARCTAS*

Wang et al., 2011



Surface BC (or absorption coefficient) observation sites in the Arctic

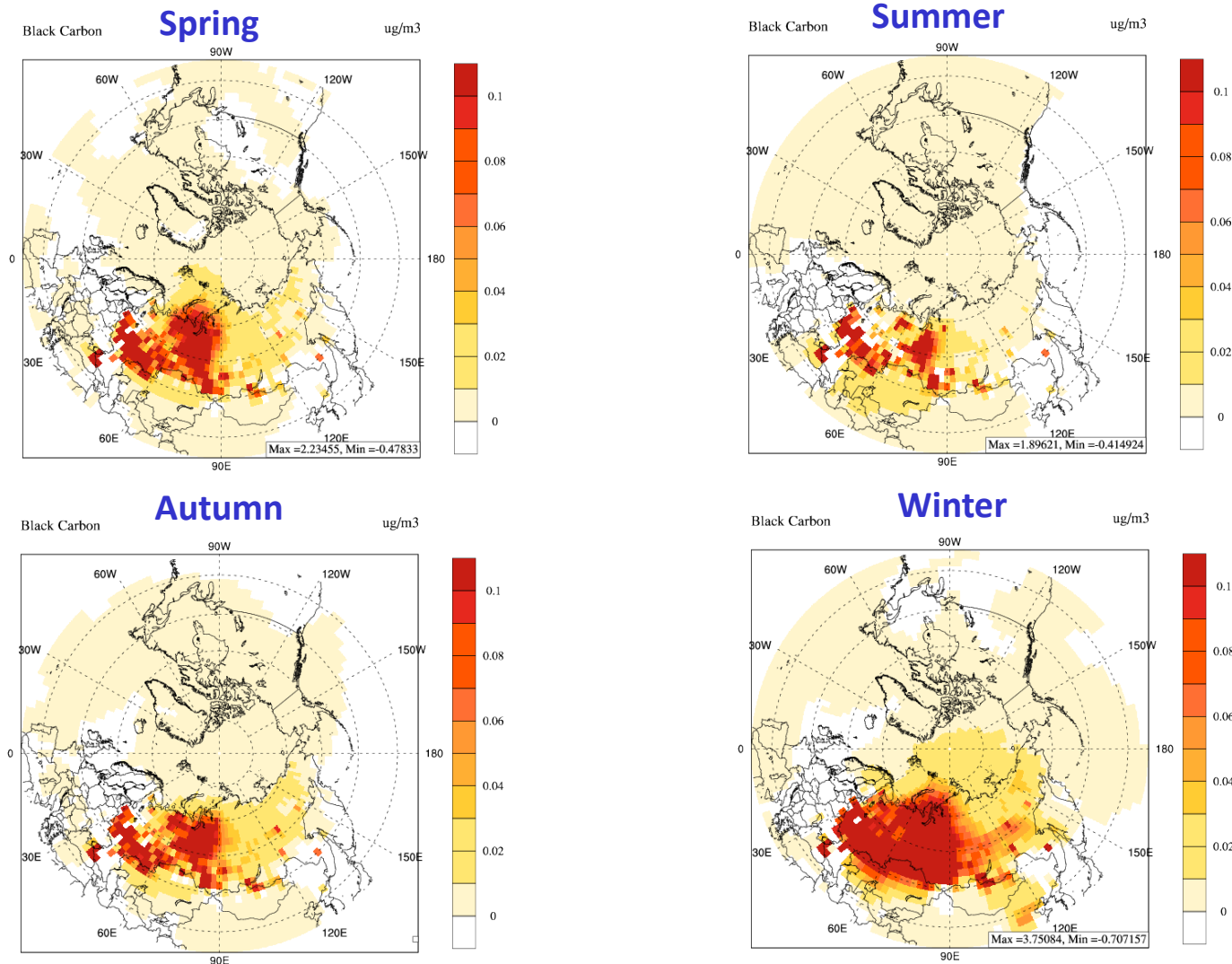


GEOS-Chem Simulation vs. Observations



Impact from increased BC emission

Surface BC from the difference between simulation with new emission and the base case



The impact of the new emission on the increased surface BC concentration could reach over **2 $\mu\text{g}/\text{m}^3$** in Russia and over **20 ng/m^3** over the Arctic Circle.

Thanks!