

Current status of mercury monitoring in India, research methods and knowledge gaps

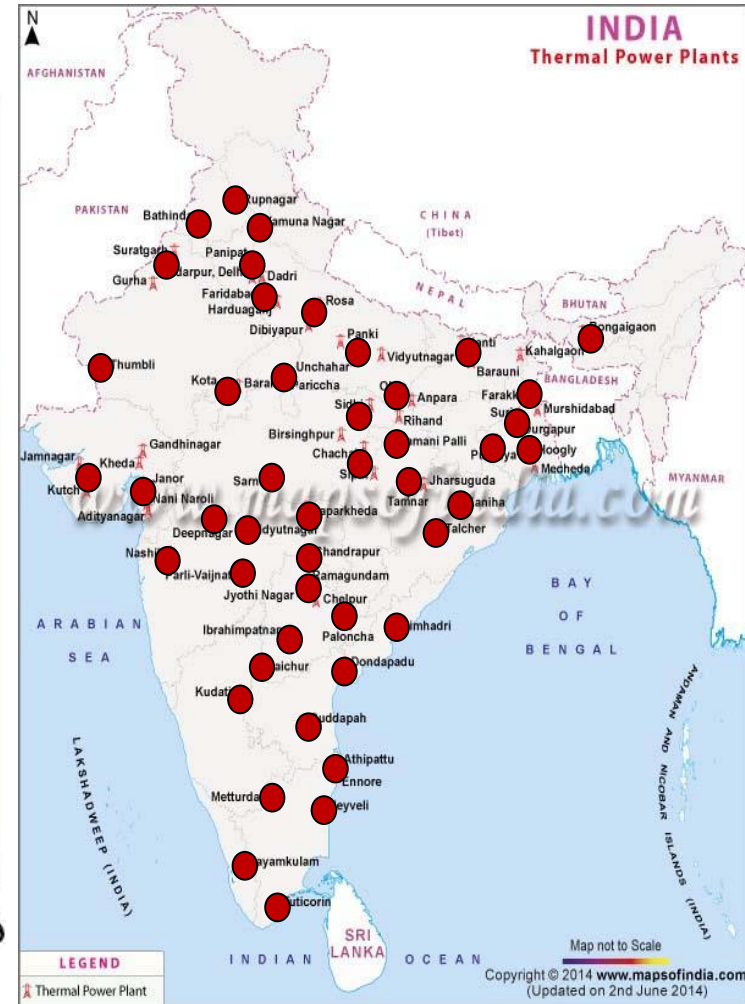
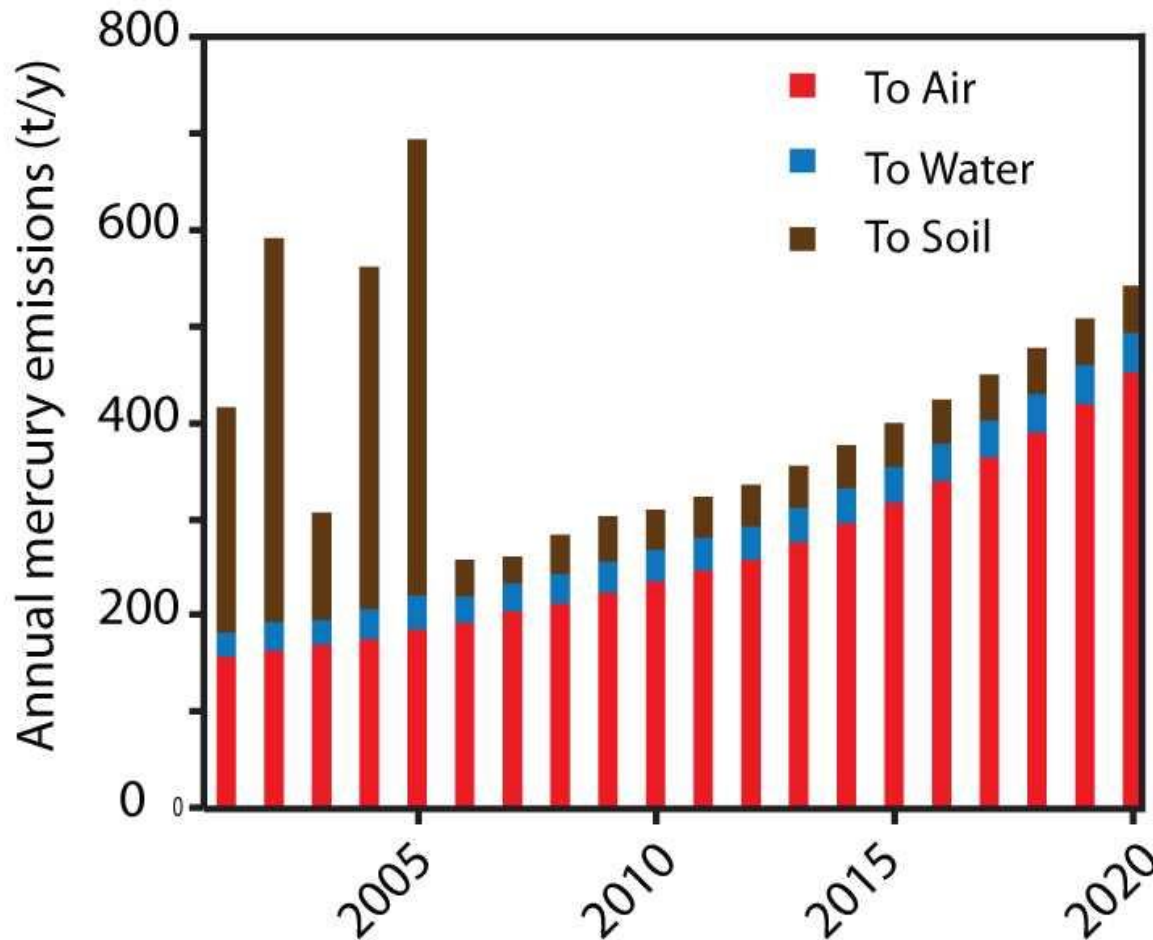
June 14, 2016

Asif Qureshi



IIT Hyderabad

Emissions projections¹



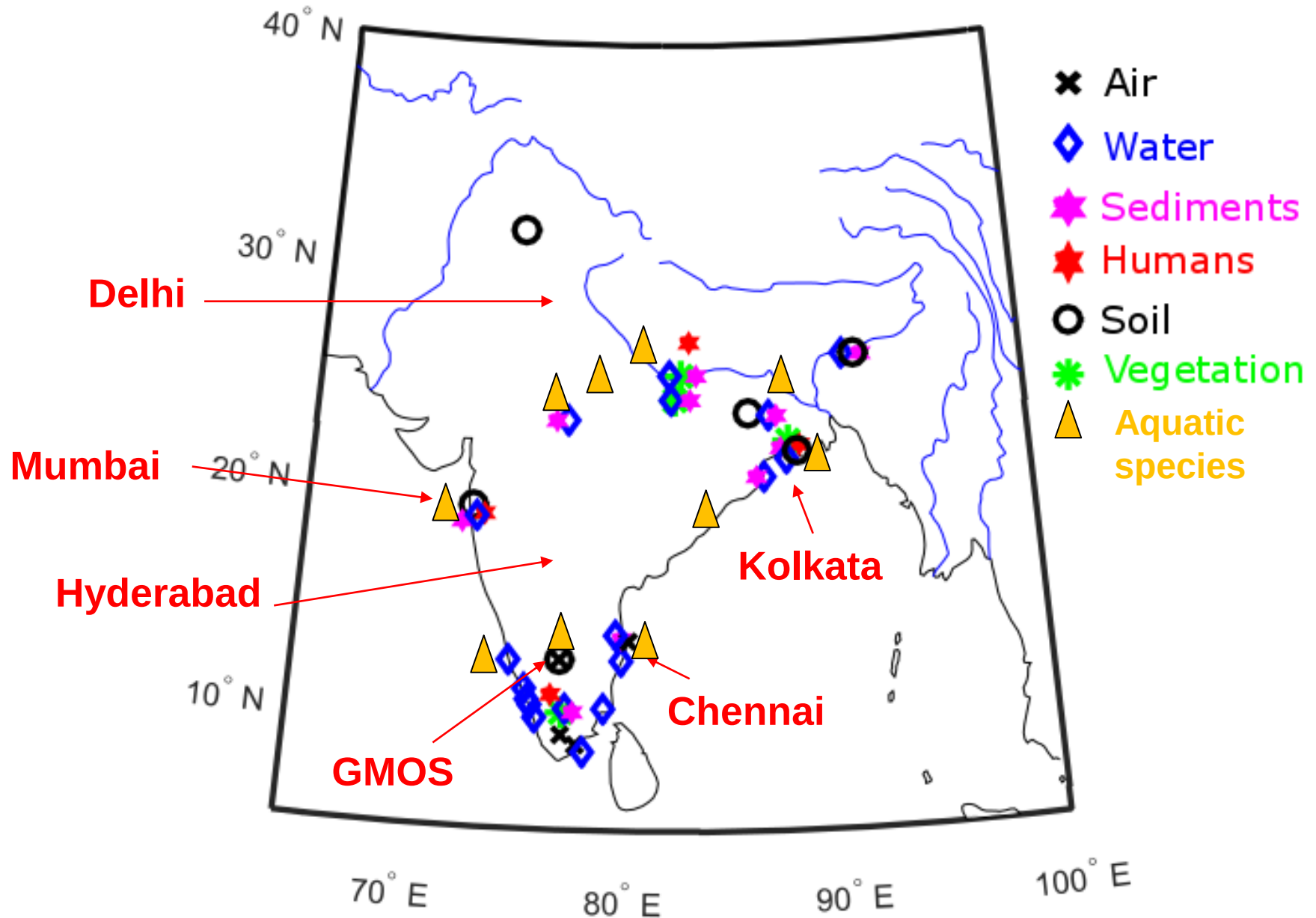
<http://www.mapsofindia.com/maps/india/thermalpowerplants.htm>

1: Chakraborty et al. (2013) *Environ. Sci. Technol.*, 47, 8105-8113.

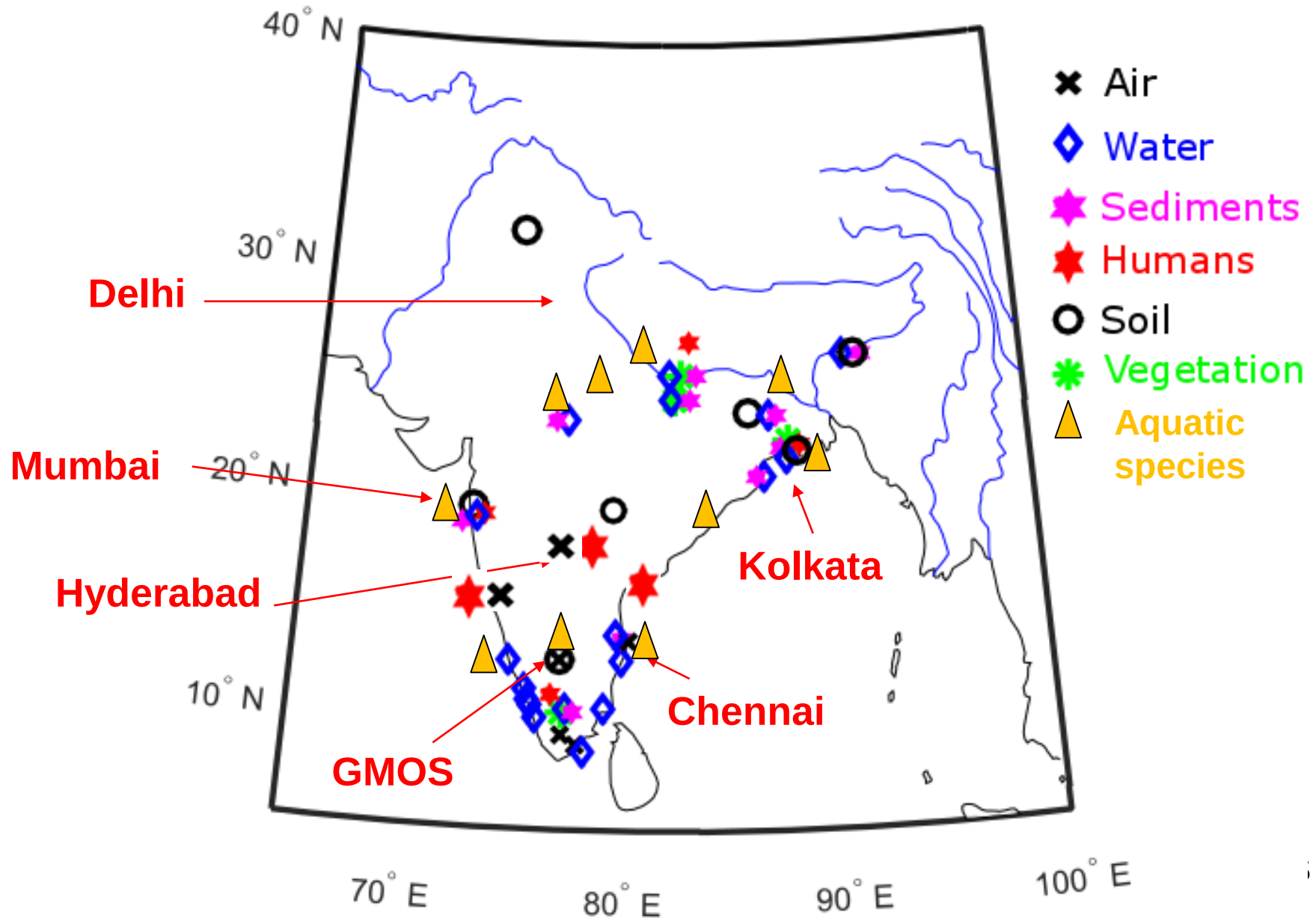
Review

- Literature in the period 1995 – 2015 (55 studies)
 - Air: 4 studies
 - Water: 17
 - Sediments: 27
 - Humans: 4
 - Aquatic biota: 19
 - Soil: 7; vegetation: 6

Reviewed locations



Reviewed locations + our work

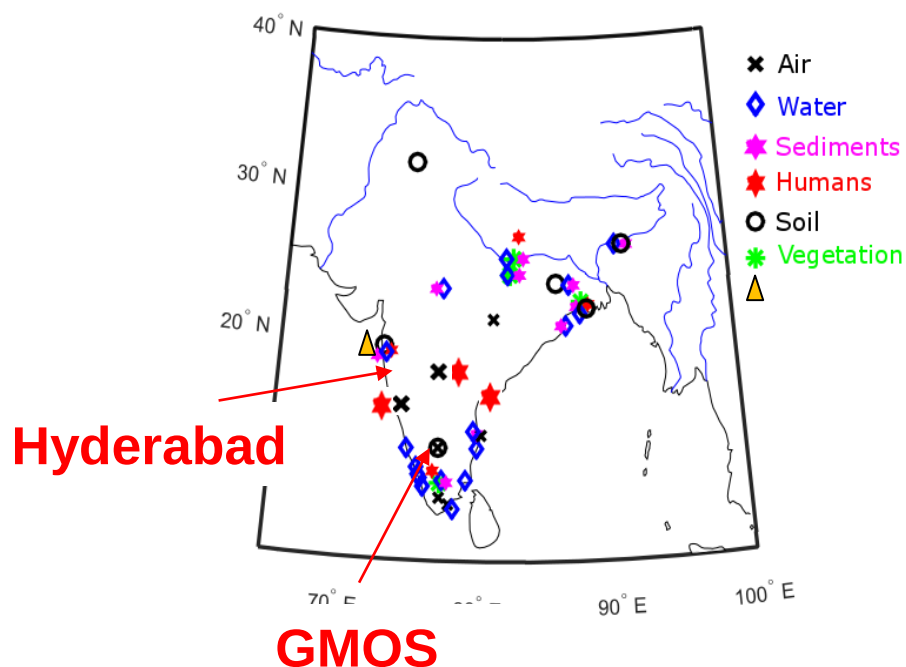


Methods used in reviewed studies

- Analysis method
 - CVAFS: 2; CVAAS: 24; AAS: 16; ICP-MS: 2; ICP-AES: 4; Rest: Unclear
- Sampling
 - Water – Polyethene/propylene bottles: 6; glass: 3; teflon: 1; Unclear: 6
 - Sediments and biota: Glass; zip-lock bags
 - Air: Tekran (GMOS), Gardis (ours), Activated charcoal trap: 1; Gas impingers: 1
 - Particulate matter: Glass microfilter: 1; respirable dust sampler: 1

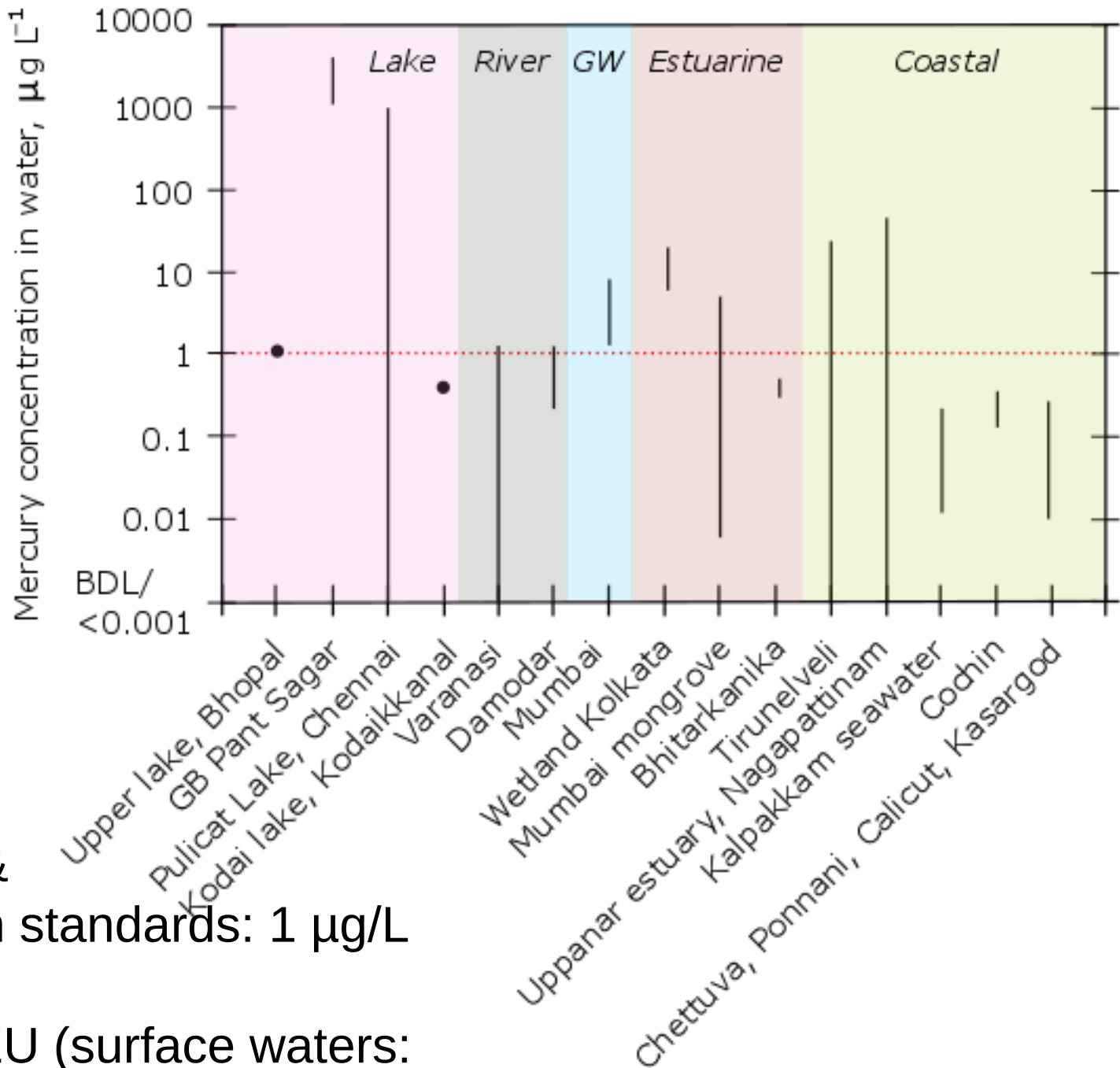
Air

Station	GEM (ng/m ³)	Time	Remarks
GMOS ¹	1.54 ± 0.26	2013-14	Other sites Tropics: 0.99 – 1.22 (ave) NH: 1.11 – 2.04 (ave)
Hyderabad	2.3 ± 1.2 3.3 ± 1.1	Oct 14; Nov15	Shanghai ² : 2.7 ± 1.5 Chicago ³ : 2.5 ± 1.5 Seoul ⁴ : 3.6 ± 1.4
Vasco (Goa)	2.5 ± 0.6	Oct 2014	



1: Sprovieriet al (2016), *Atmos. Chem. Phys. Dis.*, 10.5194/acp-2016-466; 2: Friedli et al (2011) *Atmos. Chem. Phys.*, 11, 3781-3788; 3: Gratz et al (2013) *Sci. Total Environ.*, 448, 84-95; 4: Kim & Kim (2001) *Atmos. Environ.*, 35, 49-59.

Water



Drinking water:

Heath Canada &

Bureau of Indian standards: $1 \mu\text{g/L}$

USEPA: $2 \mu\text{g/L}$

WHO: $6 \mu\text{g/L}$; EU (surface waters:

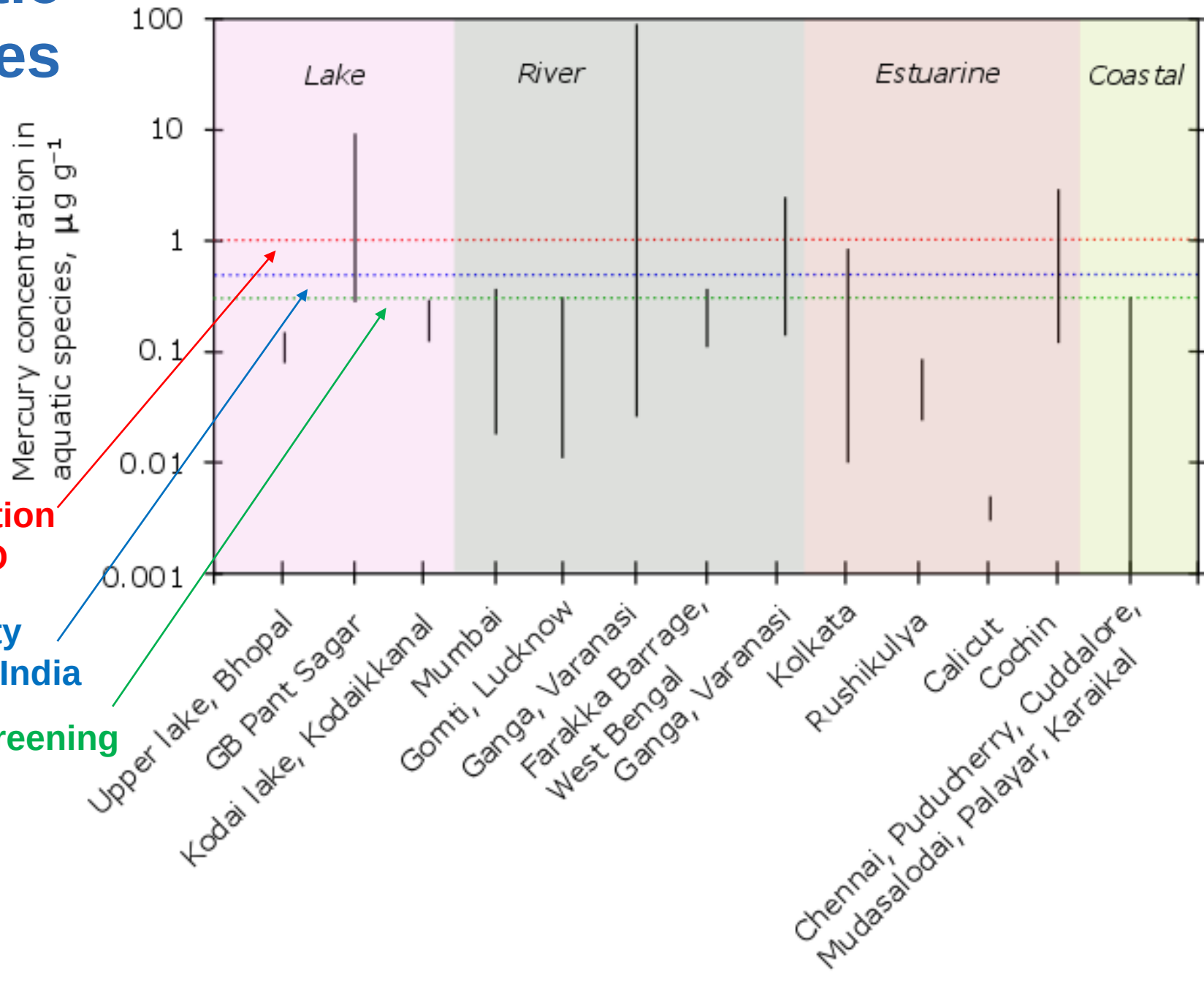
$0.07 \mu\text{g/L}$

Aquatic species

USFDA action level; WHO

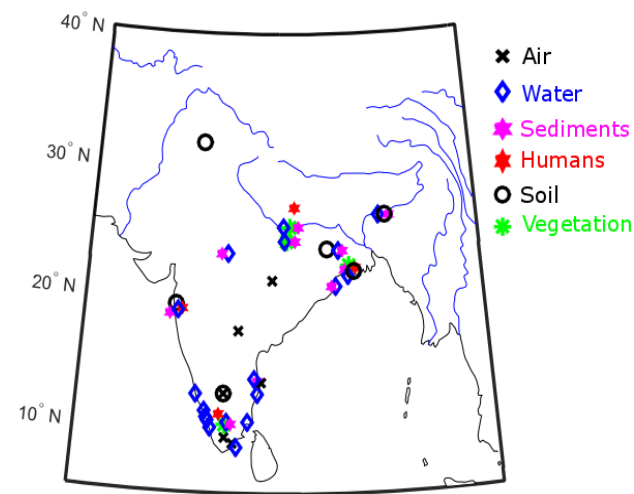
Food safety Std. Auth. India

USEPA screening level



Humans

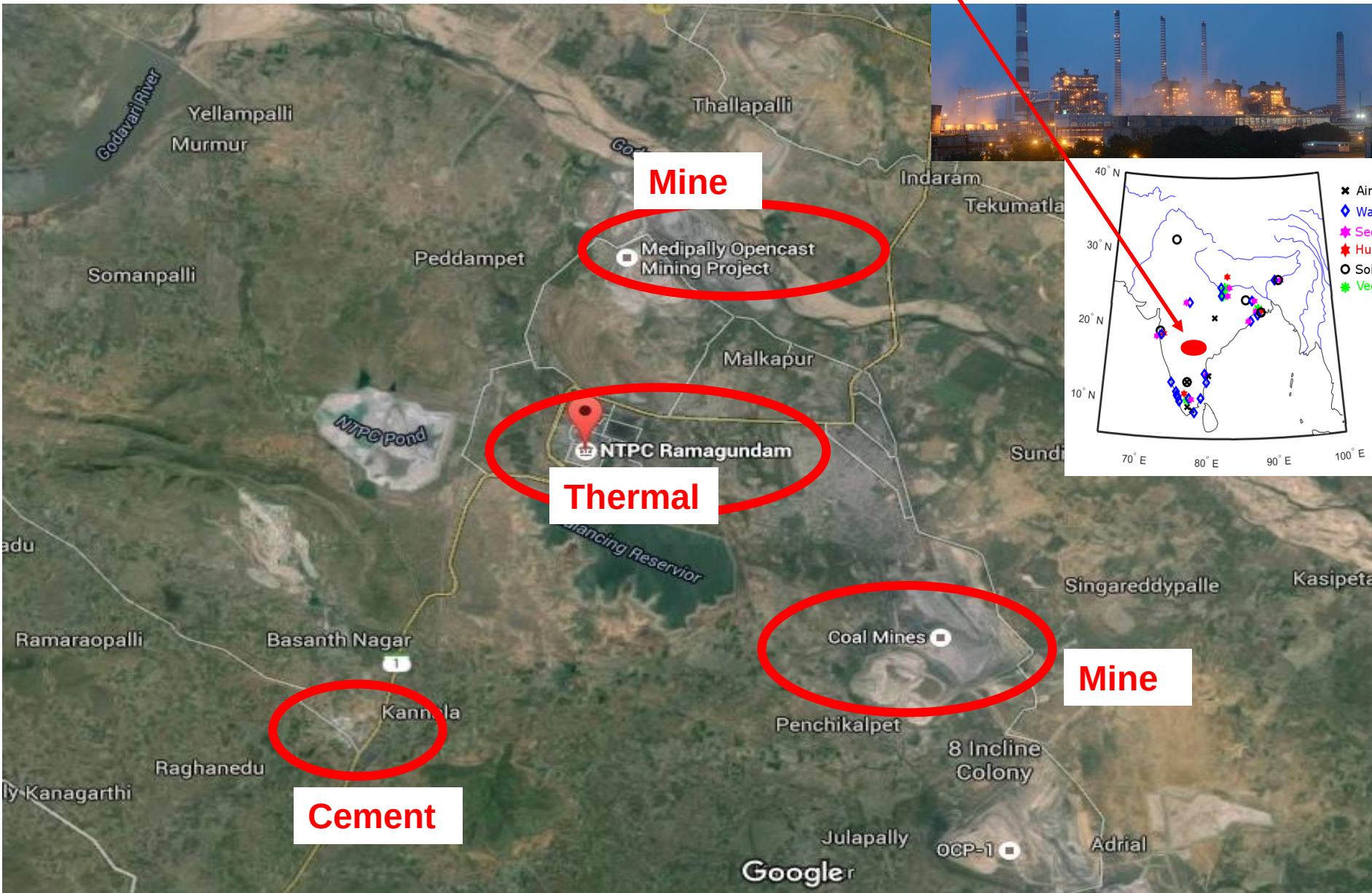
Values corresponding to Rfd ~
1 µg/g in hair; 5 µg/L in blood



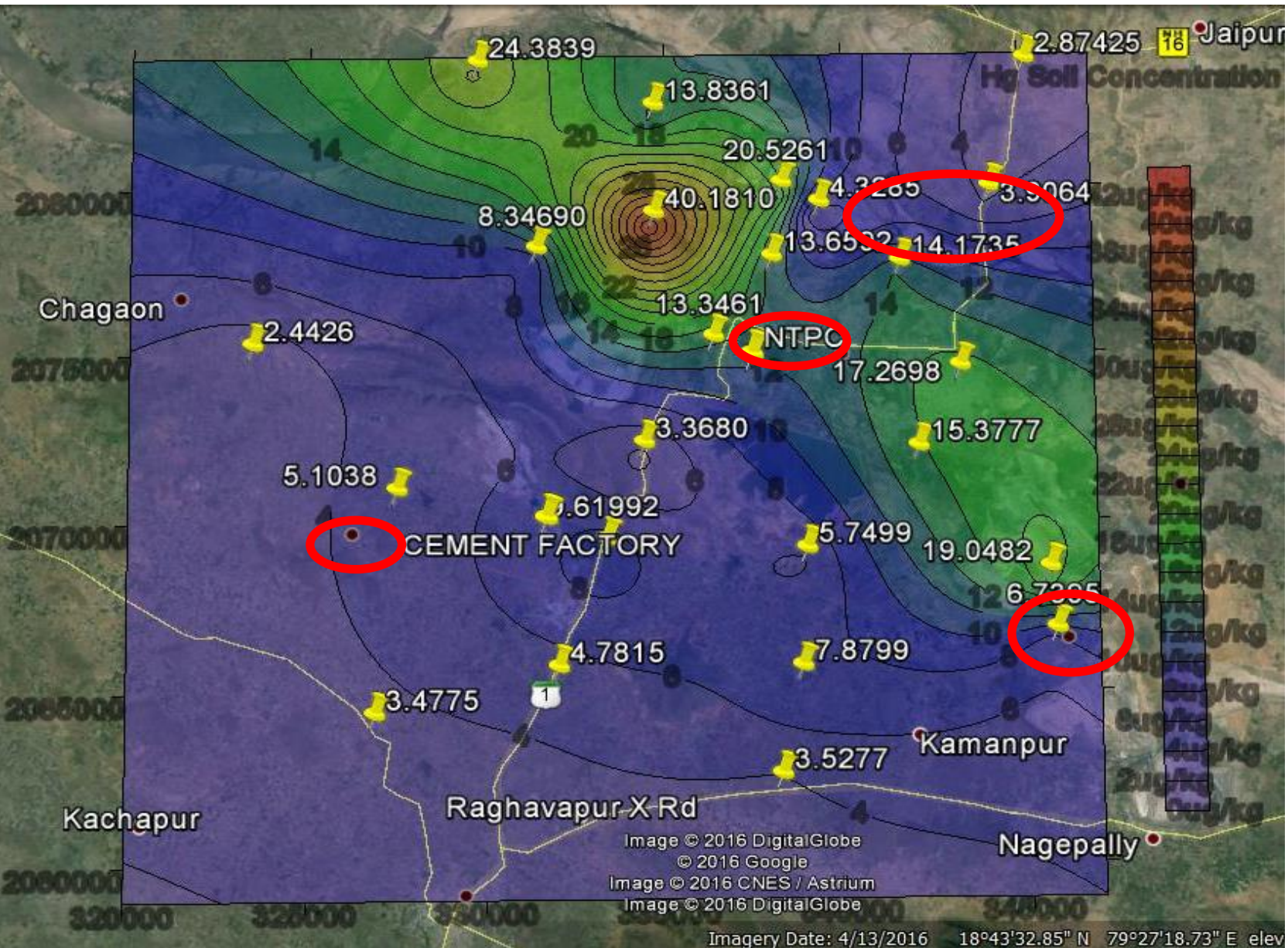
Location	Year of analysis	Gender	Media (hair, blood)	Hg concentration Hair (µg/g) Blood (µg/L)	Remarks
Mumbai	Mar-Aug 2006	Male Female Children	Hair	0.5 – 20.3 1.0 – 31.0 < 0.1 – 5.5	Estuary. Industrial discharge, fish consumers
Gorakhpur	Feb 2013	Male Female	Hair	0.16 0.12	Common people, Fish consumers
Sunderban Estuary	?	Male Female	Hair	0.6 (0.25 – 1.23) 0.6 (0.35 – 1.09)	Villagers, fish consumers
Coimbatore	2006-2007	Male	Blood	79.1 (41 – 117)	Goldsmiths
South India	Sep 14 – July 15	All	Hair	0.05 (0.05 – 0.06) 0.5 (0.3 – 0.8)	Vegetarians Fish: two times a day

Mercury distribution around power plant

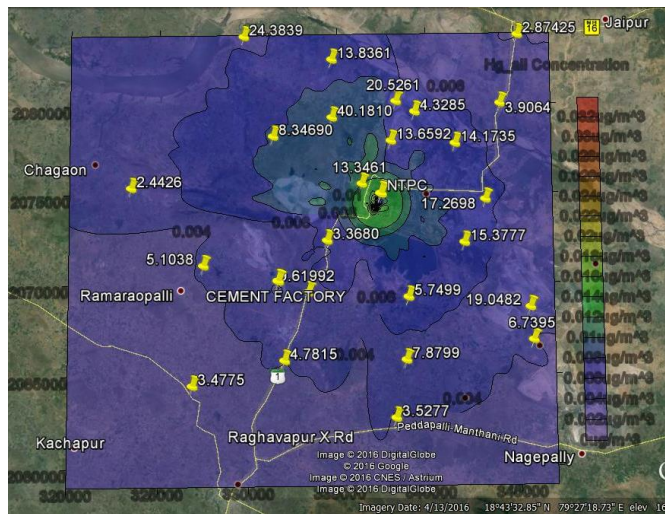
2600 MW
ntpc.co.in



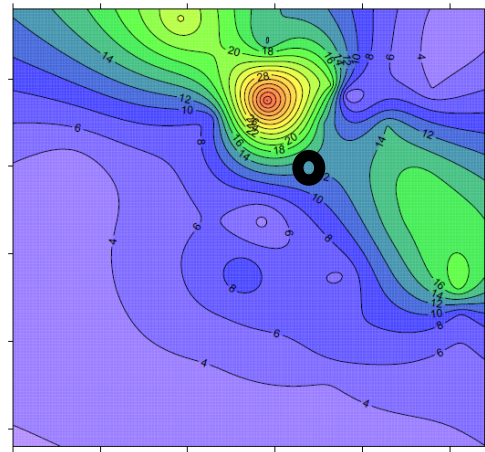
Field data (soil Hg conc, $\mu\text{g}/\text{kg}$)



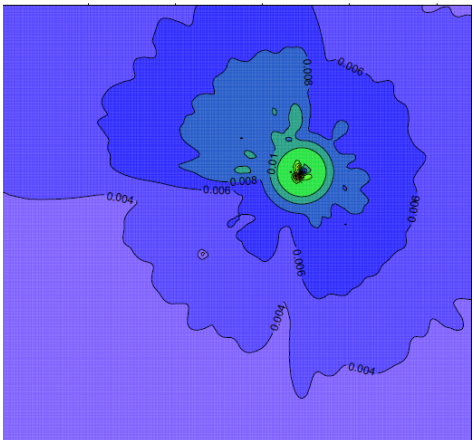
Model: Hg conc in air.
(AERMOD) - With only power
and cement plant as source



Field (soil Hg)



Model (conc. in air)



Air Hg
($\mu\text{g}/\text{m}^3$)
model

**Correlation: model
vs field data**

**Next trial: include
mines as sources**

0.01

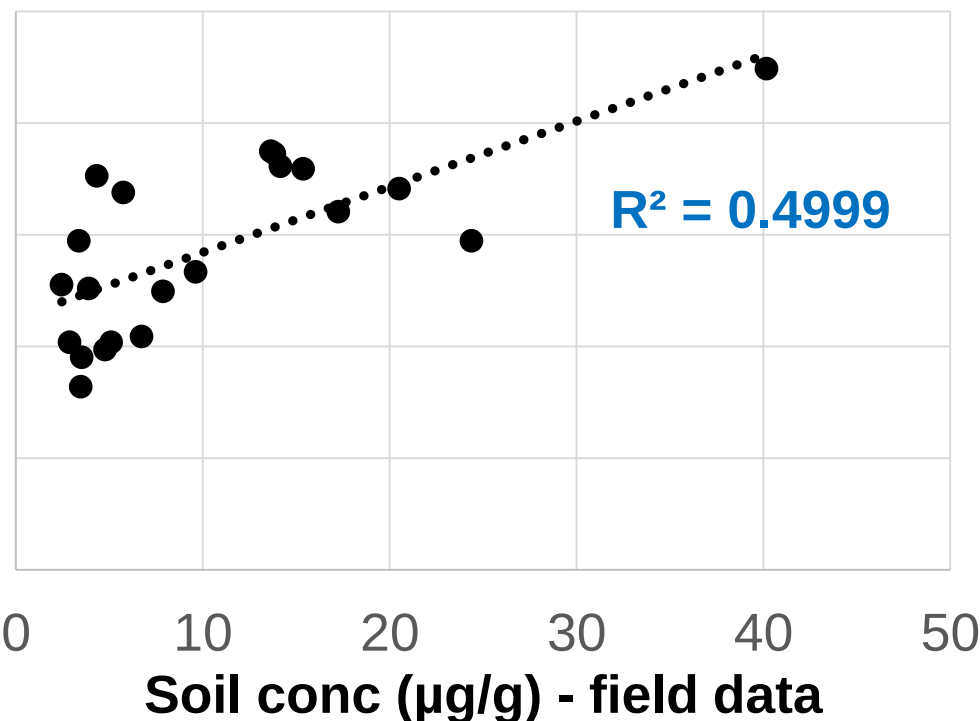
0.008

0.006

0.004

0.002

0



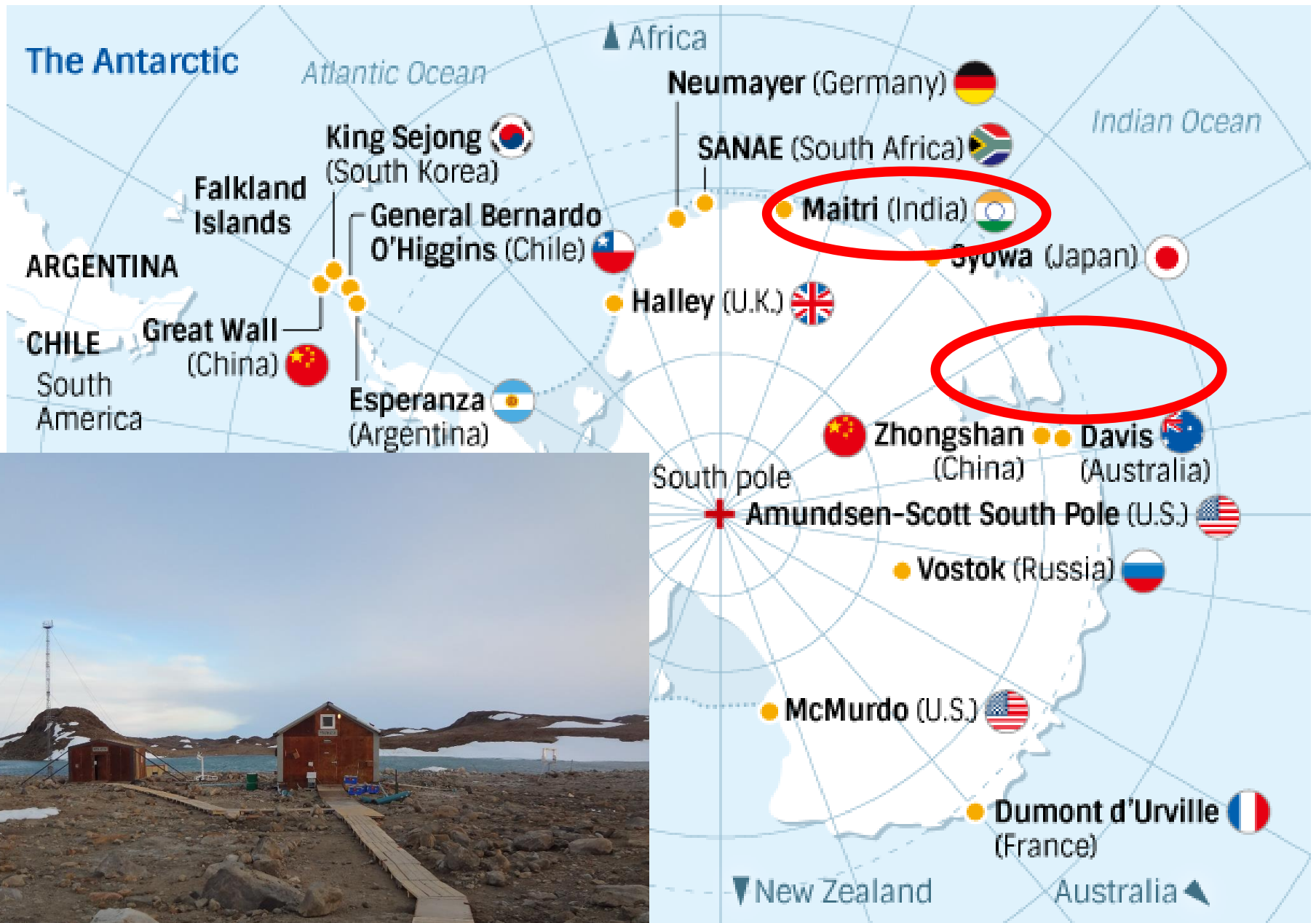
Summary & outstanding questions

- Many studies → levels close to reference/screening
- Huge spatial gaps with data needs
- High numbers localized, or a nationwide pattern?
- Exposure status of wider population?
- When government action is taken, how will we recognize effectiveness?

Recommendations

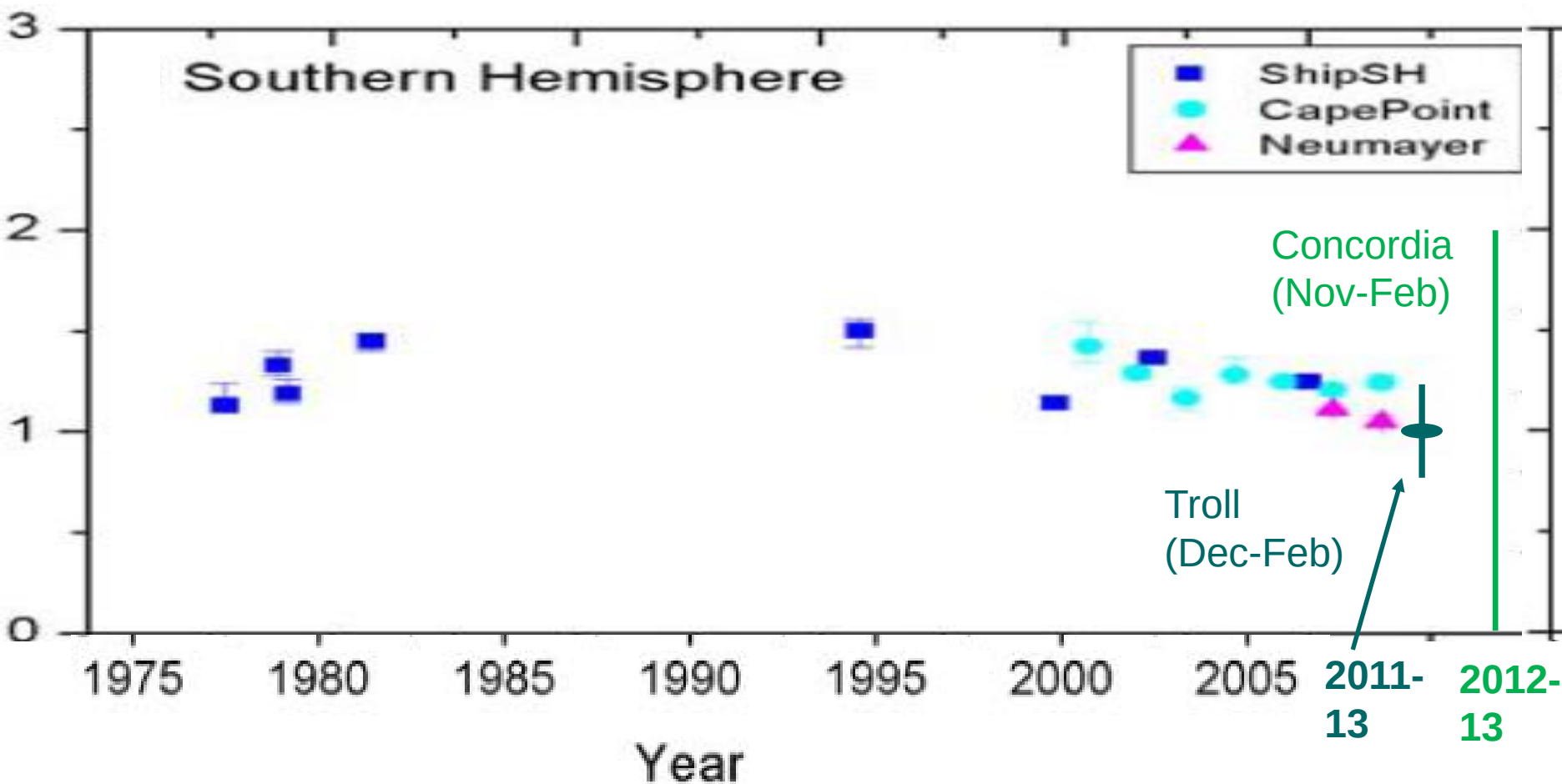
- Routine monitoring needed → air, flagship biota
- Bottom-up gridded emission inventory
- Modeling at local, regional and national scales
- Human exposure
 - Spatial comparisons
 - Critical groups (infants and pregnant women)
- Work seems to be picking up in last 2-3 years
 - **BUT much more is needed**

Antarctic work



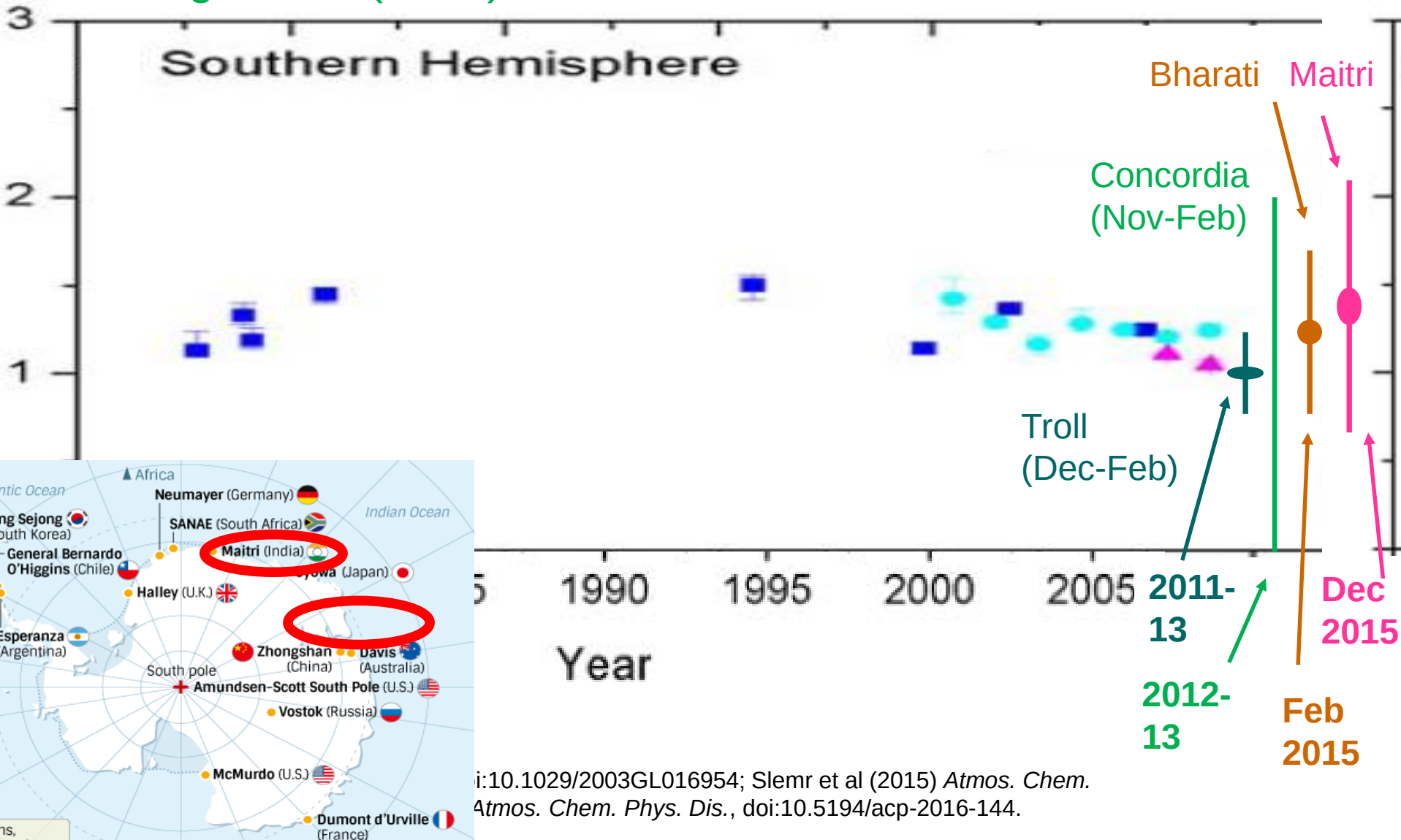
Atmospheric mercury data

Slemr et al (2003), Slemr et al (2015), Angot et al (2016)



Atmospheric mercury data

Our Data overlaid on Slemr et al (2003), Slemr et al (2015) and Angot et al (2016)

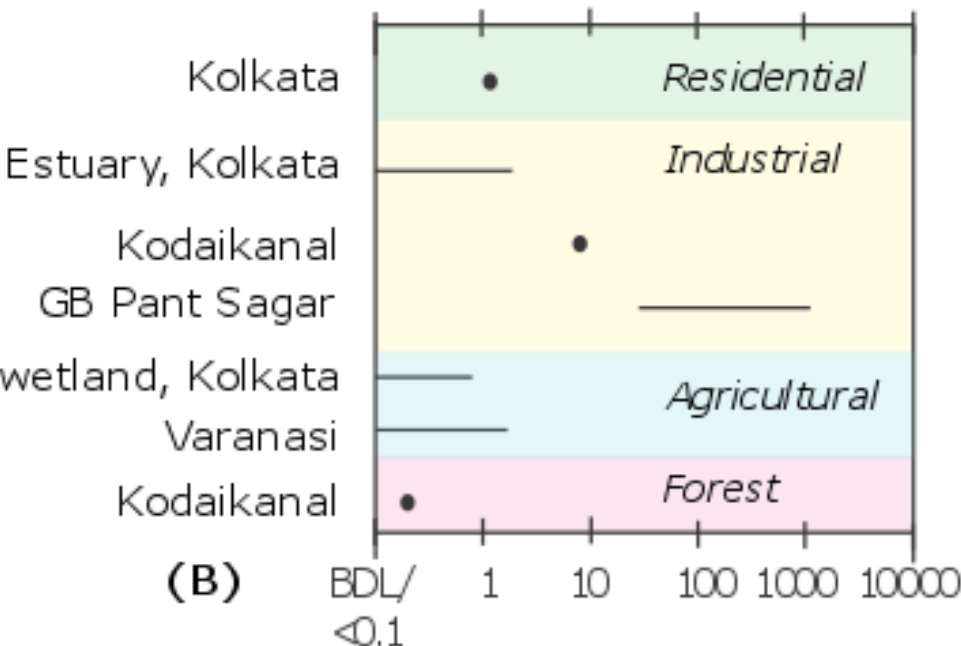
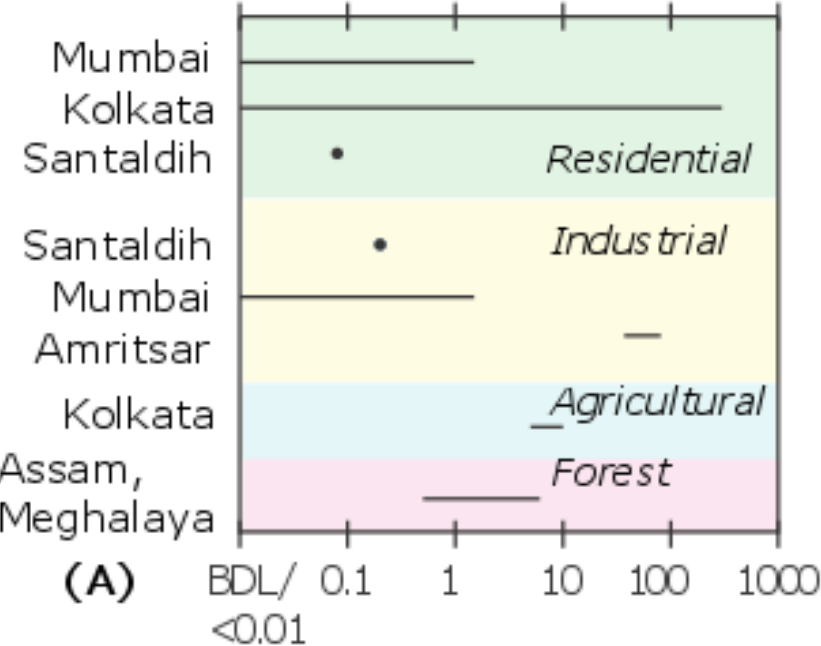


Thank you

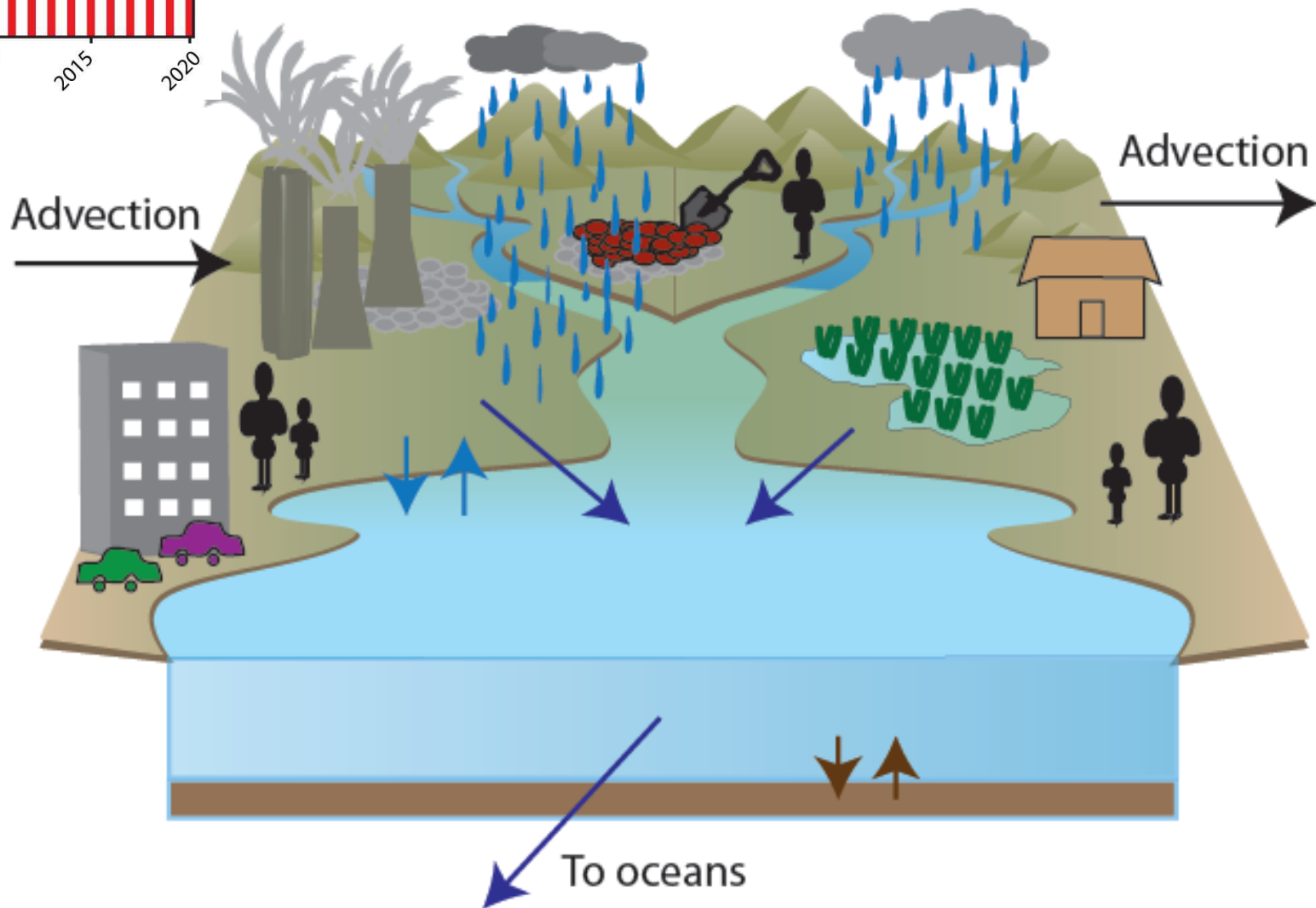
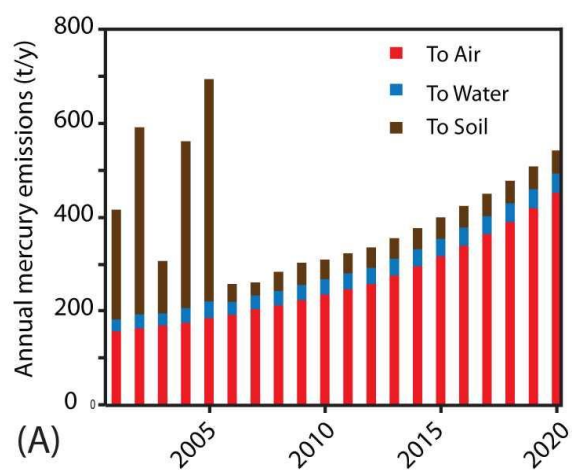
Summary

- Limited data
 - Air values similar to other urban regions elsewhere
 - Water runoff values high – but mostly from contaminated sites
 - Same as water for sediments
- Model results suggest that flue gas desulfurization may be the most efficient way to go.

Soil and vegetation



Mercury concentration in (A) soil and (B) vegetation, $\mu\text{g g}^{-1}$



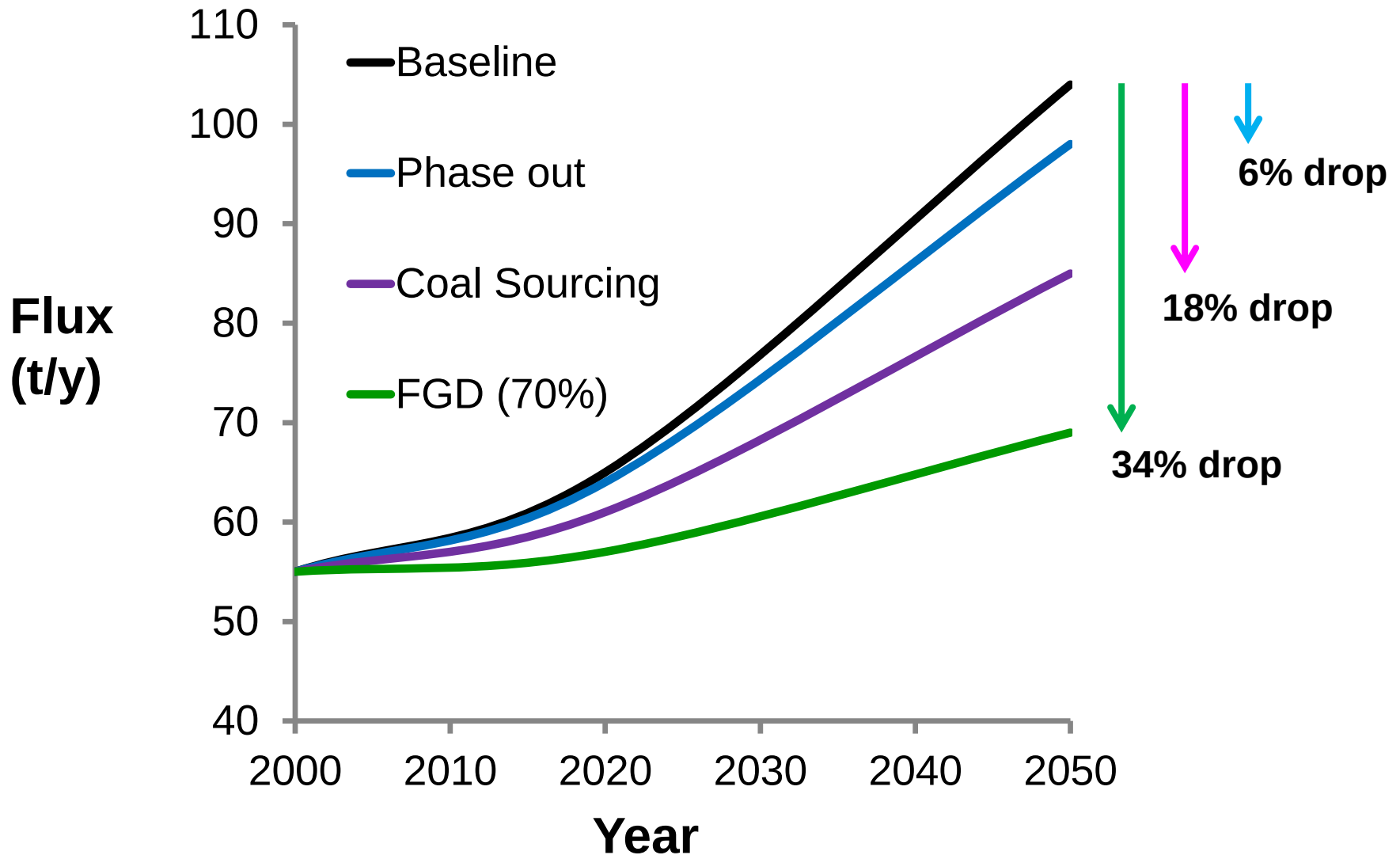
Comparison with observations

	Model	Observations (<i>min – max</i>)
Air (ng/m ³)	1.43	1.9 ± 0.6 ; 2.7 ± 0.5
Dissolved Water (pM)	13.6	1.15 ± 2.4 ($0 - 19$)*
Sediments (μg/g)	0.017	0.07 ± 0.09 ($0.01 - 0.3$)*

* *Uncontaminated/ Less contaminated region*

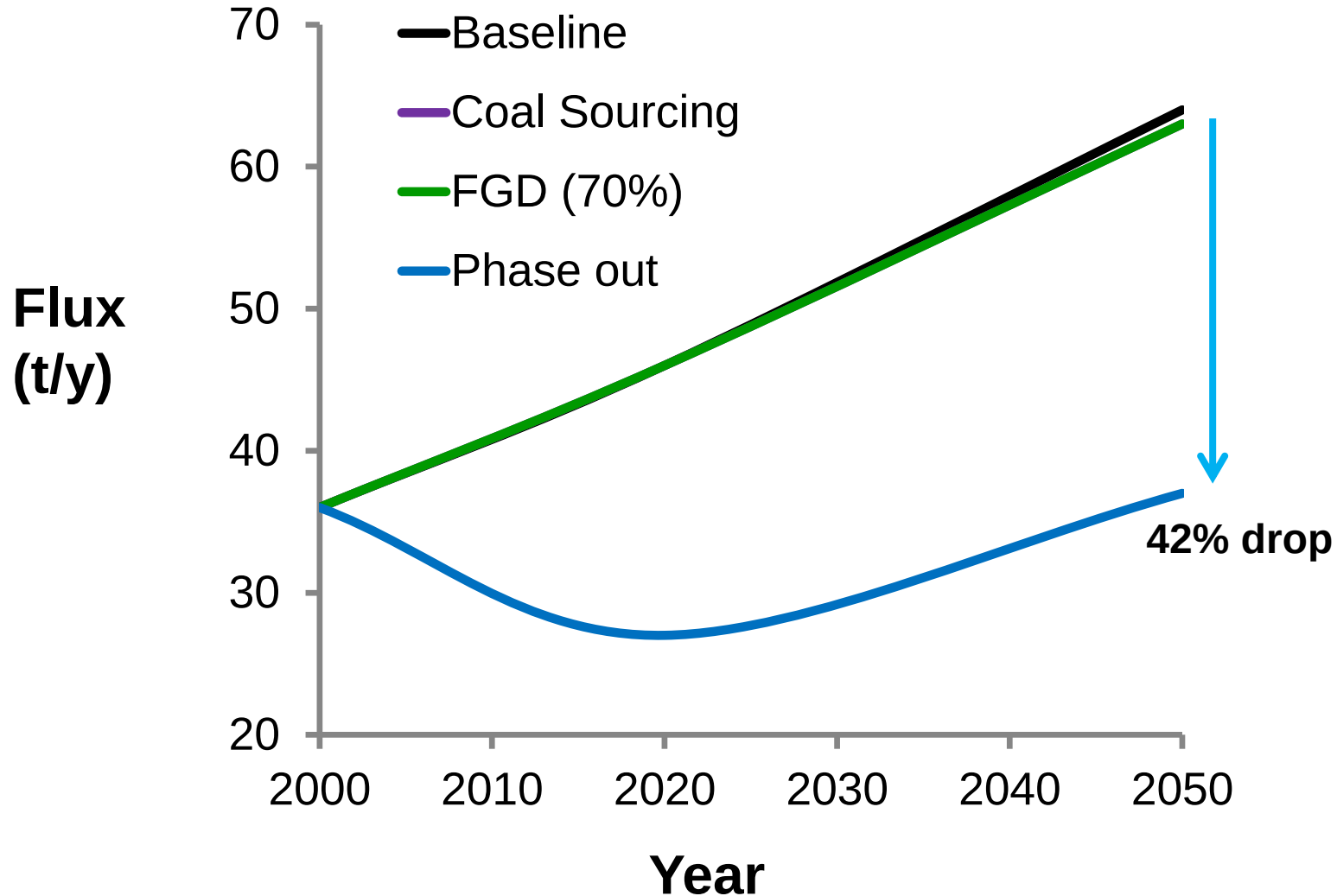
Reduction scenarios & 2000–2050 trends

Total Hg deposition to Land (t/y)



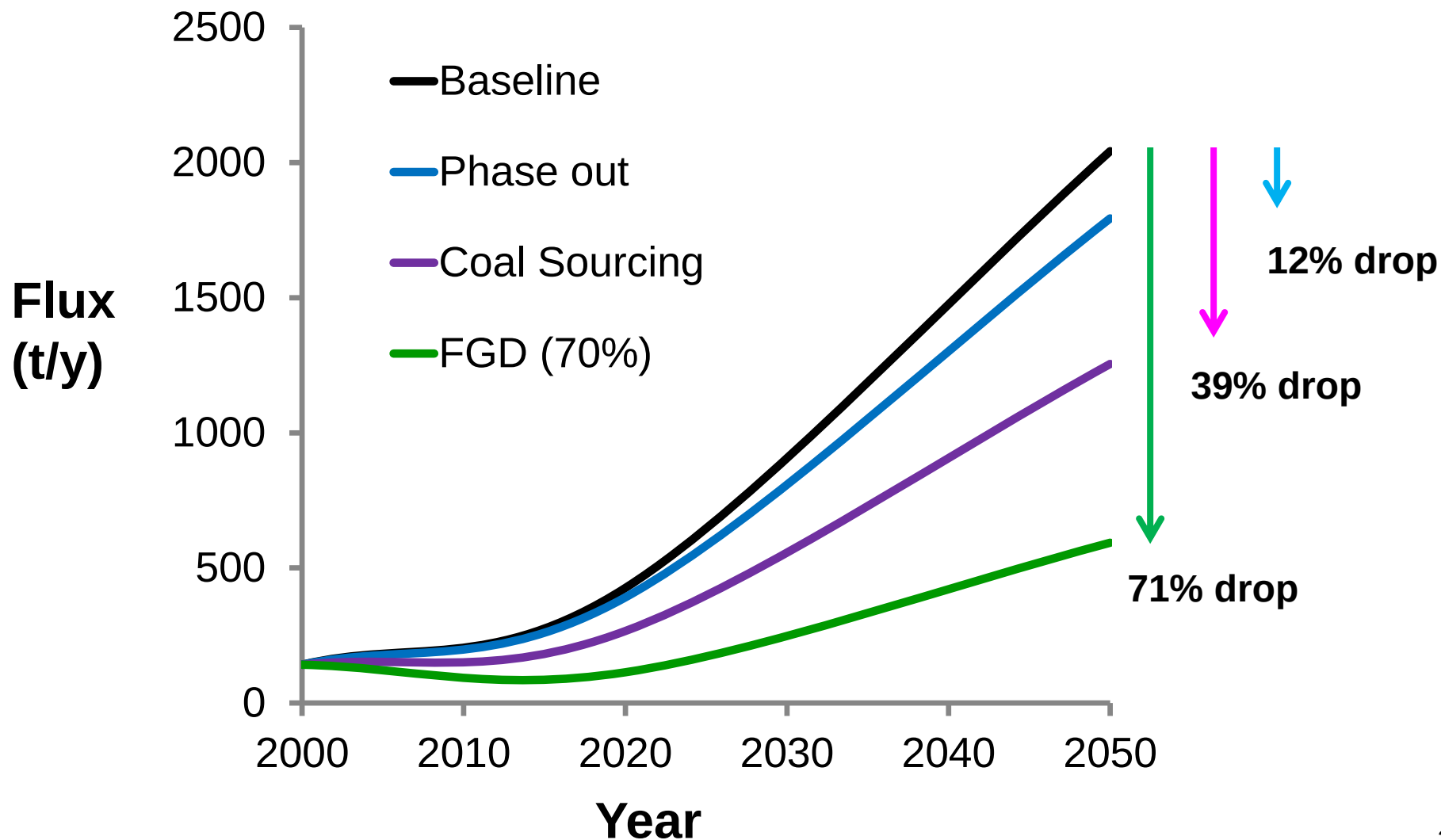
Reduction scenarios & 2000–2050 trends

Runoff to oceans (t/y)



Reduction scenarios & 2000–2050 trends

Net Hg out from air (t/y)



Trends over time

Fluxes and % increase	2000 (t/y)	% Increase in flux		
		2010	2020	2050
Deposition to land	55	10% 60.5	18% 64.9	89% 104
Net Atmospheric transport out of region (outflow – inflow)	142	56% 221.5	200% 426	2042 Very high
River runoff to oceans	36	11% 39.96	28% 46.08	78% 64.08

* Likely lower bound estimates for land & rivers
Upper bound for atmospheric transport

Trend over time*

Fluxes and % increase	2000 (t/y)	% Increase in flux		
		2010	2020	2050
Emissions to air ¹	160	60%	205%	High!
Emissions to water ¹	31	13%	29%	84%
Deposition to land	55	10%	18%	89%
Net Atmospheric transport out of region (outflow – inflow)	142	56%	200%	Very high
River runoff to oceans	36	11%	28%	78%

* *Likely lower bound estimates for land & rivers*
Upper bound for atmospheric transport

Emission Reduction Scenarios

Coal sourcing (-38% to air)¹

% benefits in Fluxes	2020	2050
Deposition to land	-7% 60.7	84.8
Atmospheric transport out of region (outflow – inflow)	-40% 267	1255
River runoff to oceans	0% 46	63.4

1: Chakraborty, Qureshi et al. (2013) *Environ. Sci. Technol.*,47,8105-8113.

Emission Reduction Scenarios

FDG (-70% to air)¹

% benefits in Fluxes	2020	2050
Deposition to land	57	68.7
Atmospheric transport out of region (outflow – inflow)	114	593
River runoff to oceans	46	63.1

1: Chakraborty, Qureshi et al. (2013) *Environ. Sci. Technol.*,47,8105-8113.

Emission Reduction Scenarios

Mercury phase-out. (-12% to air, -49% to water, +)¹

% benefits in Fluxes	2020	2050
Deposition to land	63.8	97.9
Atmospheric transport out of region (outflow – inflow)	391	1793
River runoff to oceans	26.6	36.7