Modeling Arctic Contamination by Persistent Organic Pollutants: Informing Governance in the Context of Global Change

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A-10
Abstract 1365266

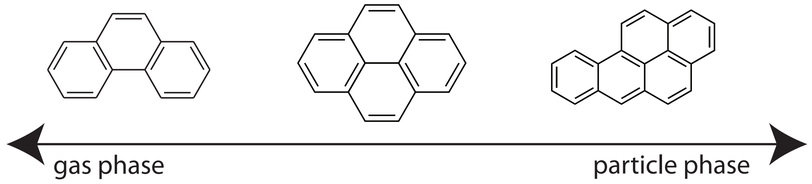
- Persistent organic pollutants (POPs) are chemicals that travel long distances in the atmosphere and deposit to the Arctic environment, where they pose human and environmental risks.
- POPs are regulated internationally under two treaties: the regional Convention on Long-Range Transboundary Air Pollution (CLRTAP), and the global Stockholm Convention.
- We use global atmospheric modeling to inform Arctic governance of POPs risks in the context of global change, focusing on polycyclic aromatic hydrocarbons (PAHs).

1. Introduction: PAHs and the Arctic

PAHs, toxic byproducts of combustion, have been identified as emerging Arctic contaminants. While other POPs are declining in Arctic marine organisms, PAHs are increasing (1). PAHs are currently regulated by CLRTAP but not by the Stockholm Convention.

We investigate the transport and fate of three PAHs with a range of chemical behavior:

Phenanthrene (PHE) Pyrene (PYR) Benzo(a)pyrene (BaP)



2. Methods: GEOS-Chem POPs Simulation

We develop and use a new global 3-D atmospheric simulation for PAHs using the GEOS-Chem chemical transport model to investigate transport to the Arctic. Our model is the first to use global meteorological data as a driver of chemical transport, enabling simulation of episodic pollution events. Simulations were conducted at 4° longitude by 5° latitude with 47 vertical levels. Global PAH emissions are from Zhang and Tao (2).

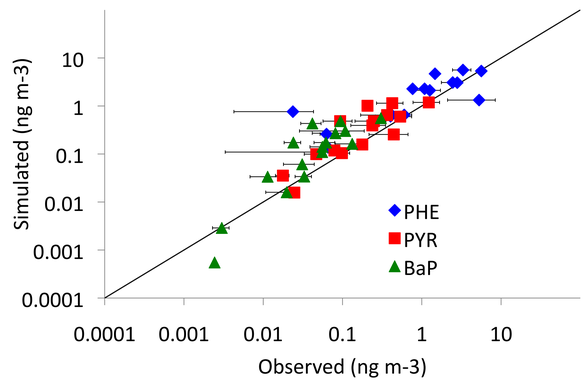


Figure 1. Annual average (2005-2009) simulated total concentrations of PHE, PYR, and BaP in surface air versus observed concentrations at nonurban locations. r=0.64 for PHE, 0.72 for PYR, and 0.74 for BaP.

3. How do PAHs reach the Arctic? Where do they come from?

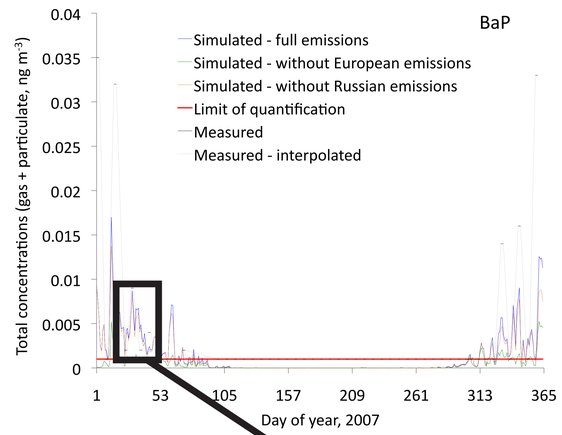
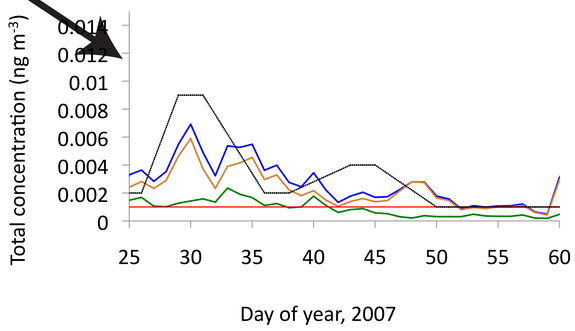


Figure 2. Total concentrations of BaP at Spitsbergen, Norway, an Arctic measurement station, for the year 2007. Correlation coefficients for PAHs at Spitsbergen ranged from 0.40 to 0.74 for individual years between 2005-2009.

Model results show that most high-PAH episodes at Spitsbergen result from emissions in Europe and Russia.



4. Do international screening thresholds for POPs long-range transport adequately protect the Arctic?

Both CLRTAP and the Stockholm Convention select POPs for regulation by applying scientific criteria. To assess long-range transport, both agreements use a **2-day atmospheric half-life threshold.** In our model, **all three PAHs have atmospheric half-lives well below two days**.

PAH	Simulated Atmospheric Half-Life (Days)
PHE	0.45
PYR	0.36
BaP	0.49

This suggests that screening chemicals for potential long-range transport using a 2-day atmospheric half-life threshold may fail to identify potential future contaminants.

5. How will global climate change affect PAH transport?

Global change could alter transport patterns and thus modify future Arctic contaminant pathways. We assess future PAH transport to the Arctic using a future climate simulation, and compare to present-day conditions.

		Change in lifetime due to climate		
PAH	Phase	Oxidation	Wet deposition	Dry deposition
PHE	Gas	↑	↑	None
	Particle	NA	None	None
PYR	Gas	↑	↑	↓
	Particle	NA	↓	None
BaP	Gas	None	↓	↓
	Particle	NA	↓	↓

Future climate increases wet deposition of particle phase PAHs globally. In the Arctic, this results in a lower mean BaP concentration, fewer BaP high pollution days, with a minimal impact on PHE and PYR.

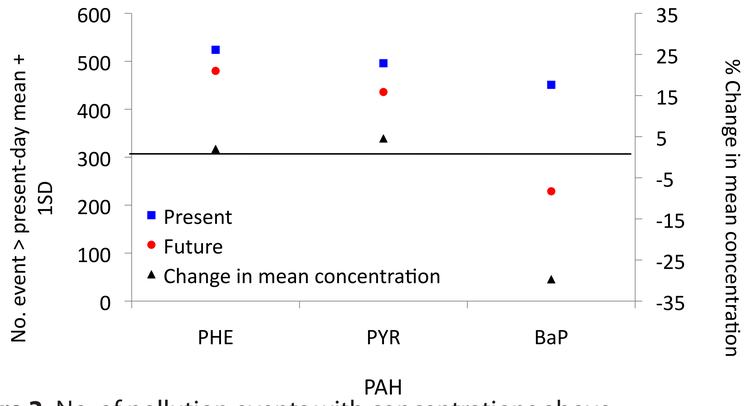


Figure 3. No. of pollution events with concentrations above present-day mean + one standard deviation under present (1997-2005) and future climate (2047-2055) at Stpitsbergen. Also shown is % change in mean concentration.

6. References

(1) De Laender, F.; Hammer, J.; Hendriks, A.J.; Soetaert, K.; Janssen, C.R. 2011. *Environ. Sci. Technol.*, 45:9024-9029.
(2) Zhang, Y.; Tao, S. 2009. *Atmos. Environ.*, 43:812-819.

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