It’s raining PFAS

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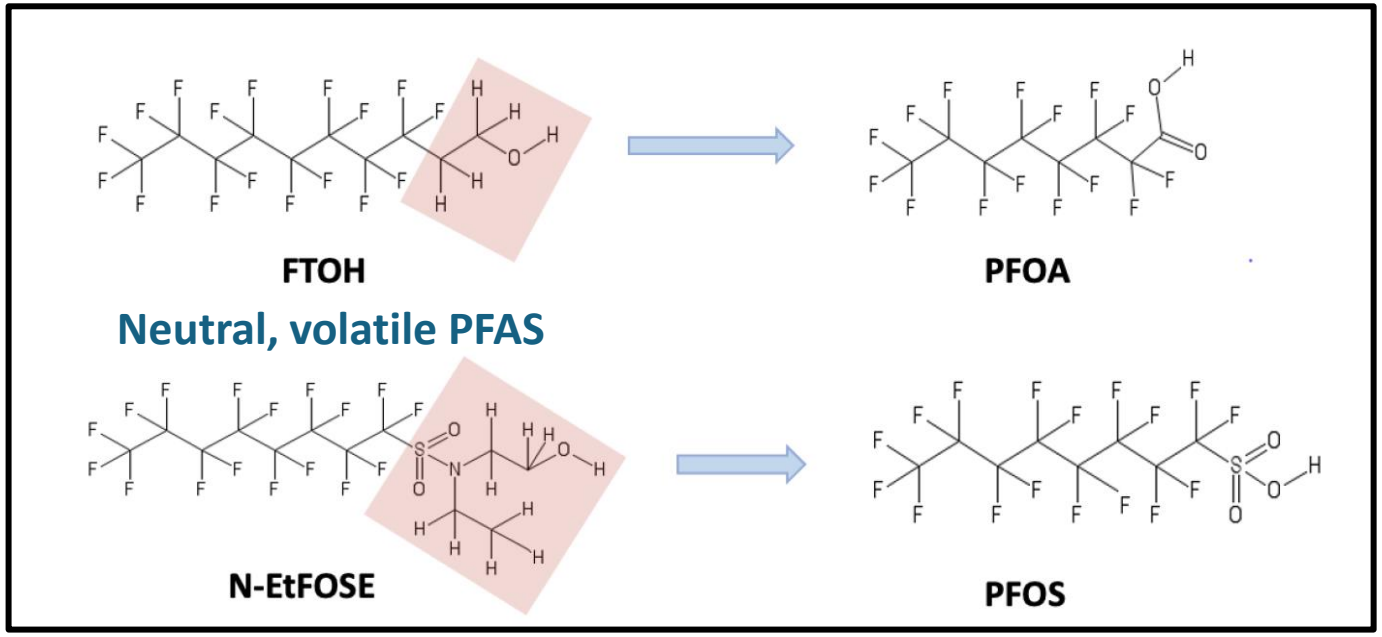
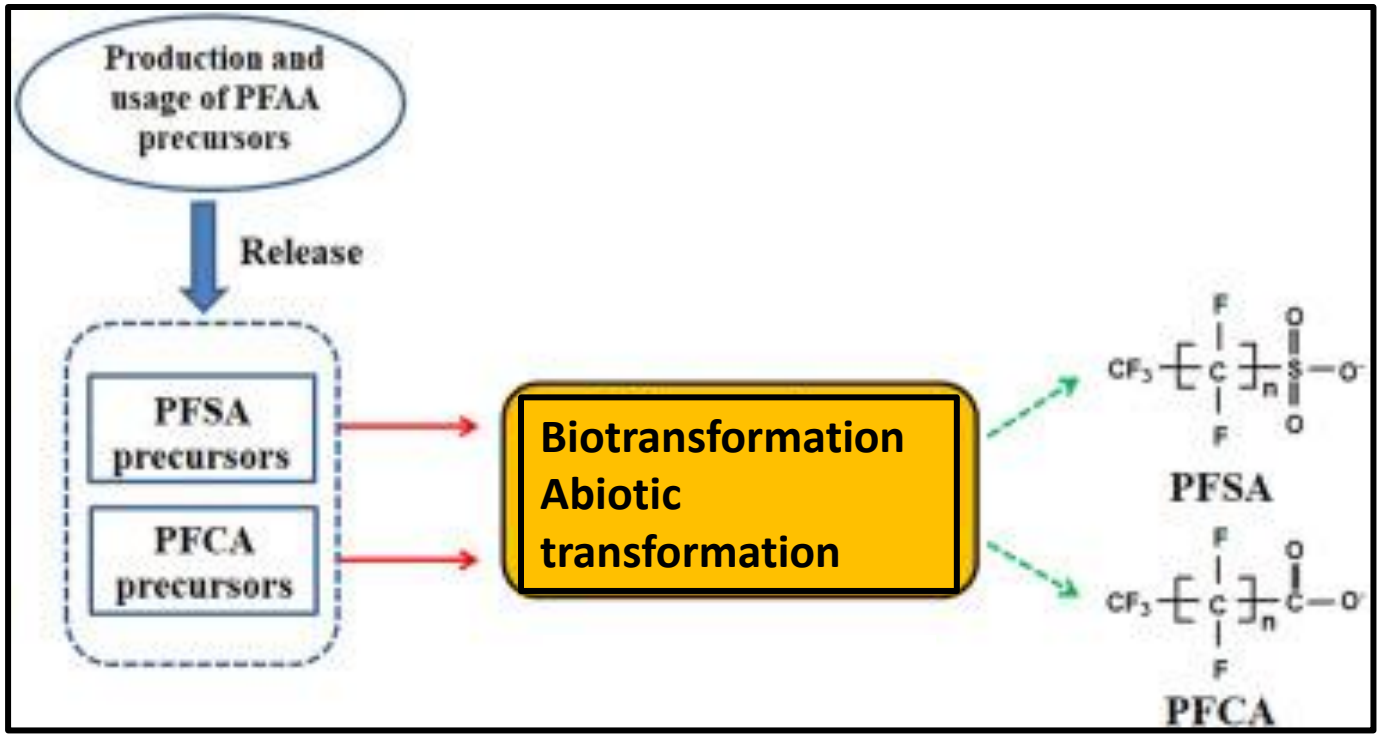
DISCLAIMER

The precipitation data used in this study were obtained from the U.S. EPA and is the only data set formally reviewed by the EPA. All TFA data were formally reviewed by the EPA. This presentation has not been formally reviewed by EPA and the views expressed in this document are solely those of the authors and do not necessarily reflect those of the Agency. EPA does not endorse any products or commercial services mentioned in this publication.

PFAS in air: indoor vs outdoor

Volatile PFAS as precursors of ionic PFAS





Images
Zhang et al., Env Pollut, 272, 2021
JRC Technical Reports

PFAS: from skies to shores

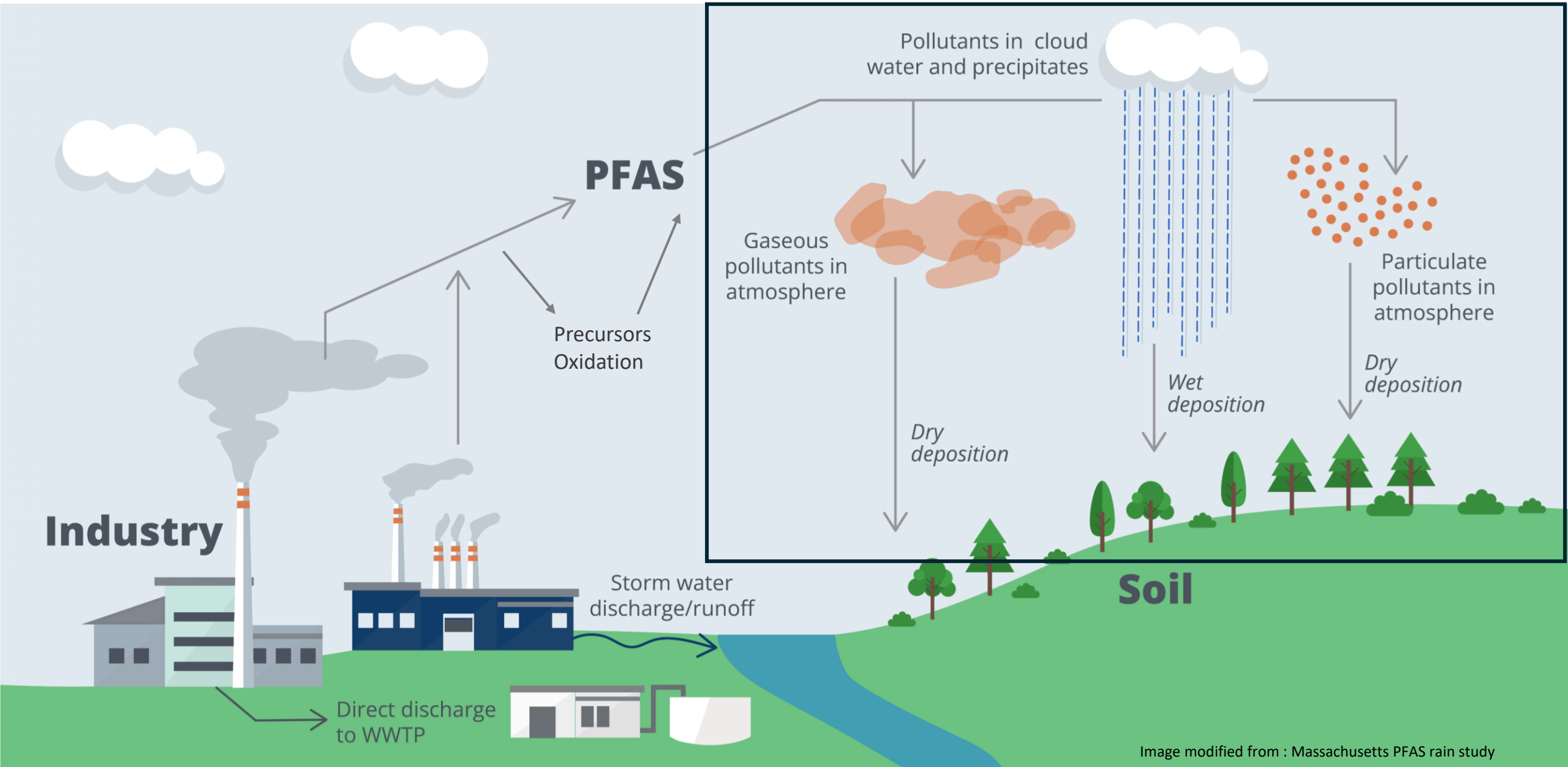
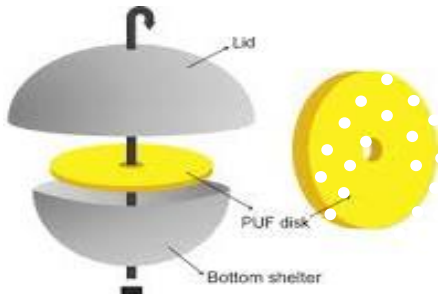


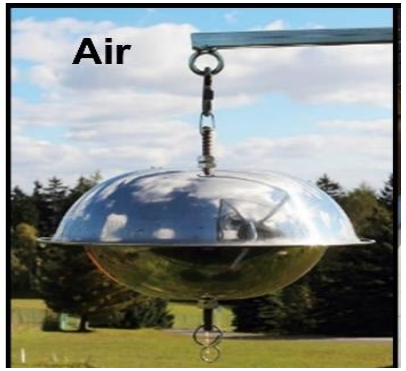
Image modified from : Massachusetts PFAS rain study

Measuring atmospheric deposition of PFAS

AIR - PASSIVE

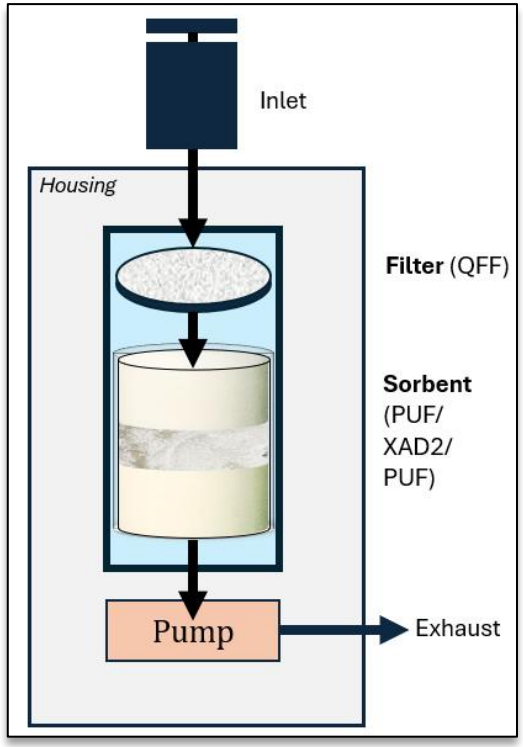


XAD-4 resin



Collects also particles
Deployed for 1 month
No power needed

AIR - ACTIVE



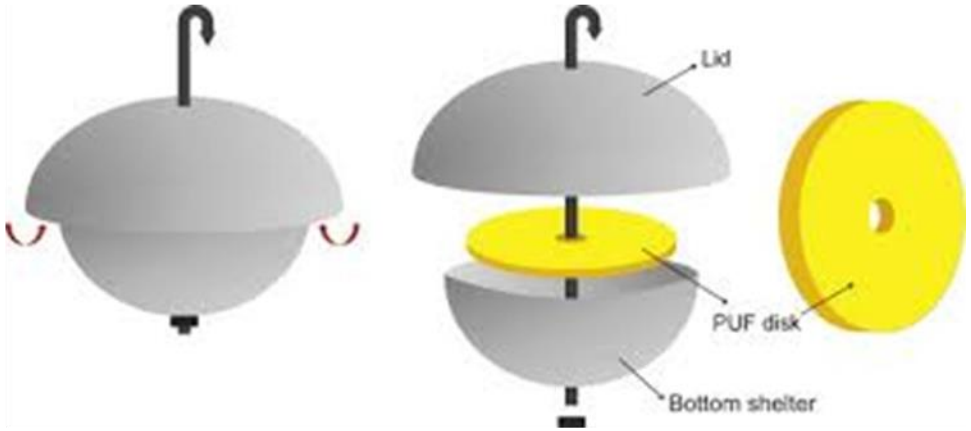
Separates gas from particles
Deployed for 24-48 hours
Needs power

PRECIPITATION

Collects wet + dry deposition
Deployed for 2 weeks/month,
Needs power

A note on atmospheric flows

$F_{atmo} = F_{wet} + \underline{F_{dry}} + F_{aw}$



$SIP = Gas + particles$

$$\Phi = \frac{C_p}{C_g + C_p}$$

Φ from Ahrens et. al. 2012

Φ

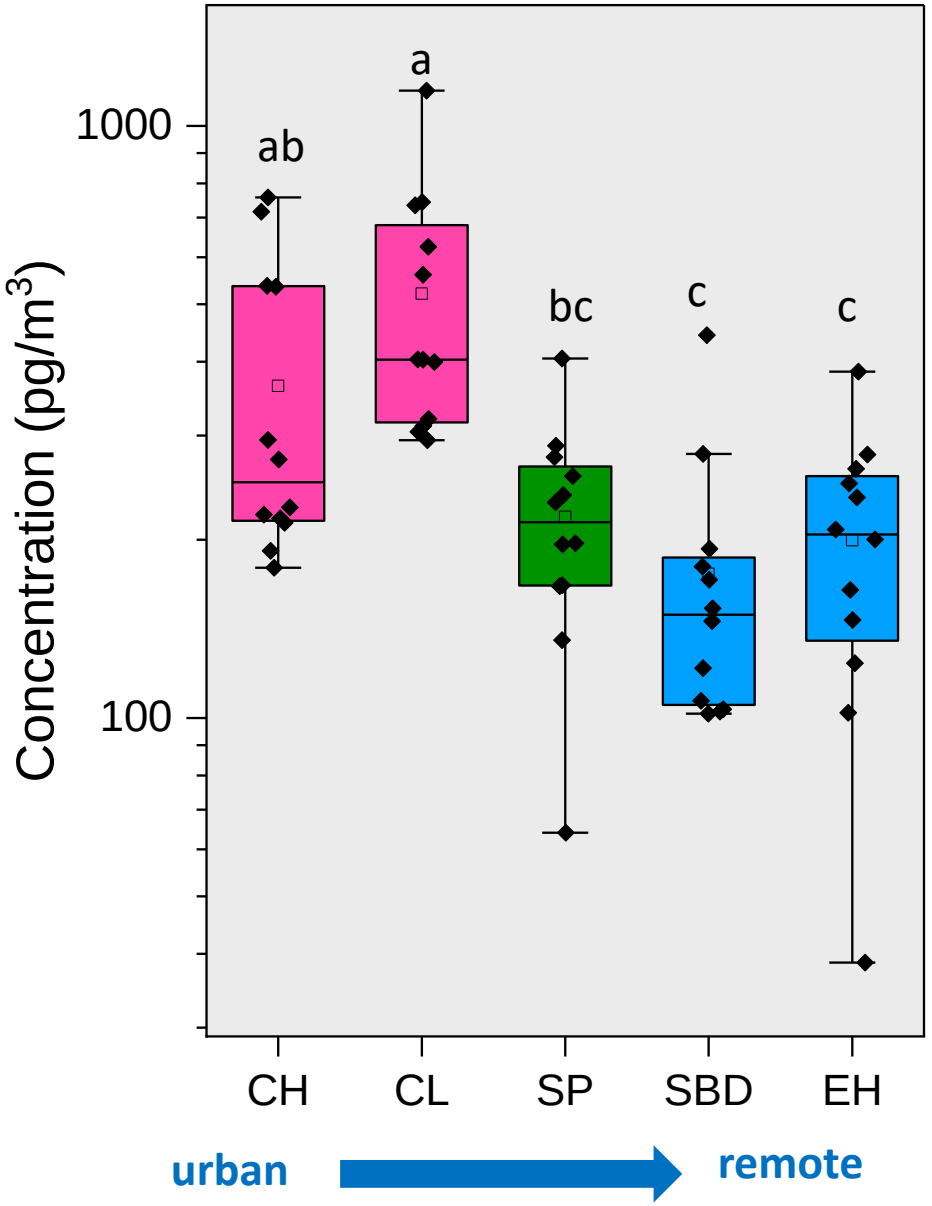
- 0: PFBA, PFPeA, PFHxA, PFHpA
- 0.06: PFOA
- 0.14: PFNA, PFDA
- 0.12: PFOS
- 0.61: PFTeDA
- 1: PFHxDA

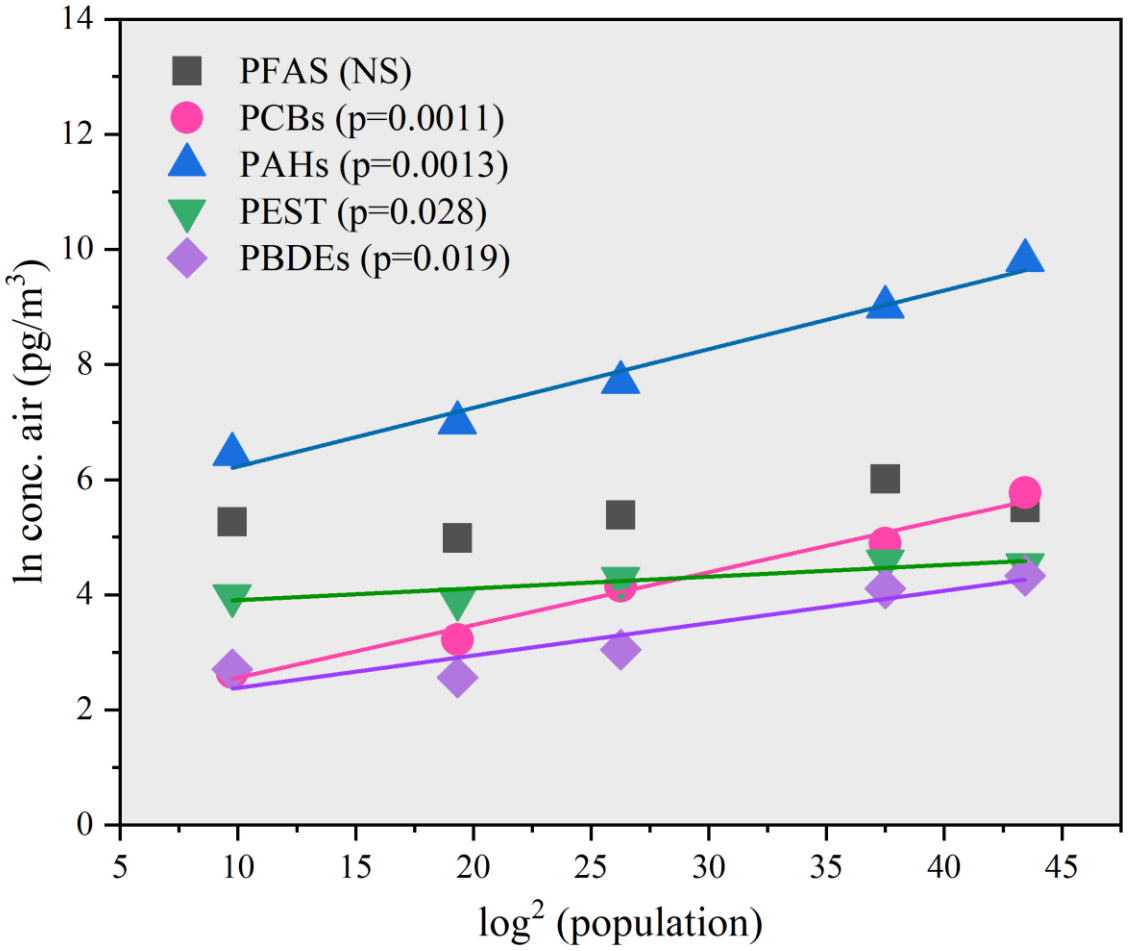
GAS

↓

PARTICLE

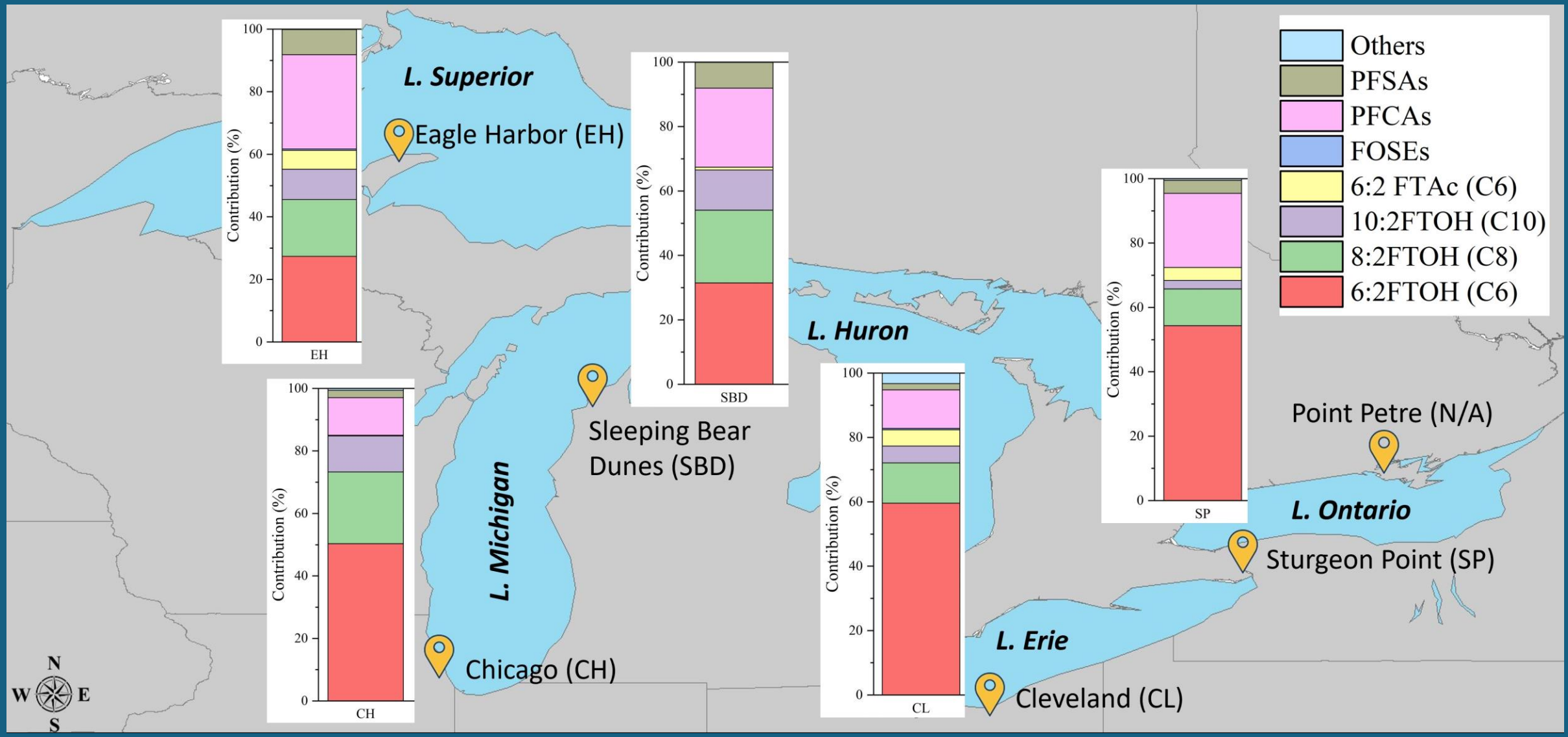
Total PFAS levels in air are highest at the urban sites



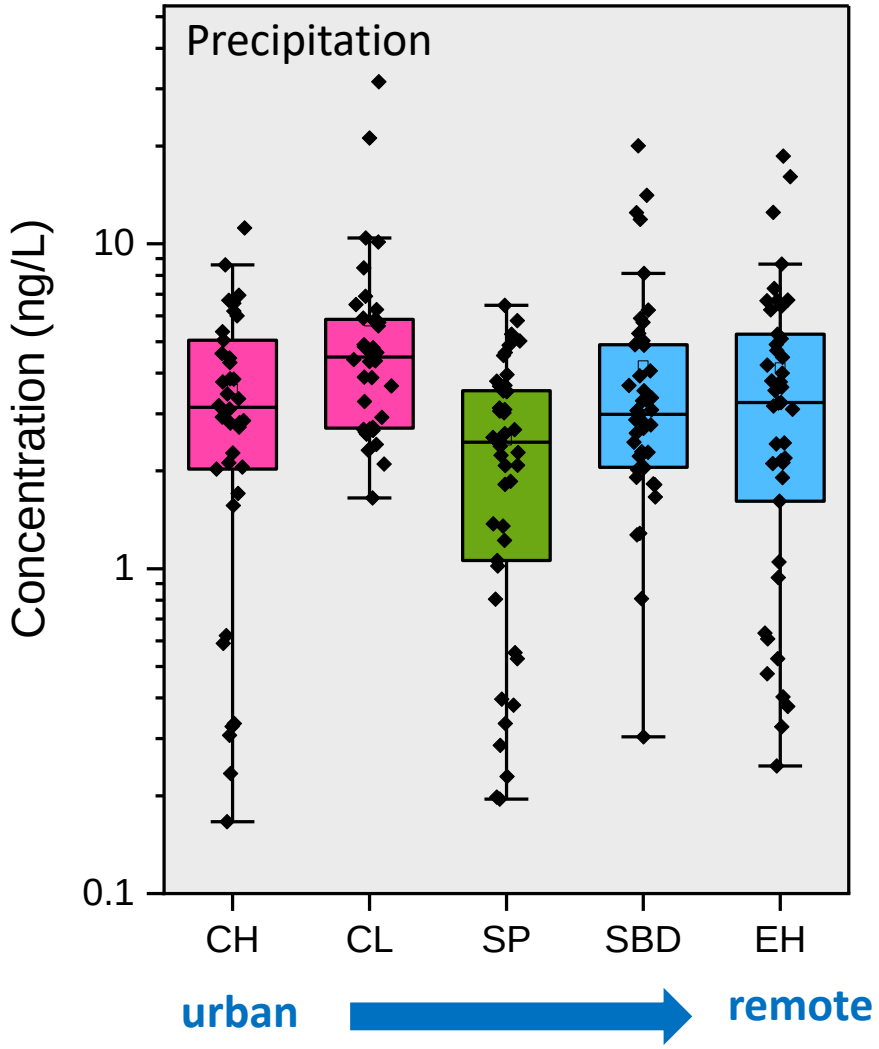


Xia et al., Environ Sci Technol, 2024, 58, 9303-13

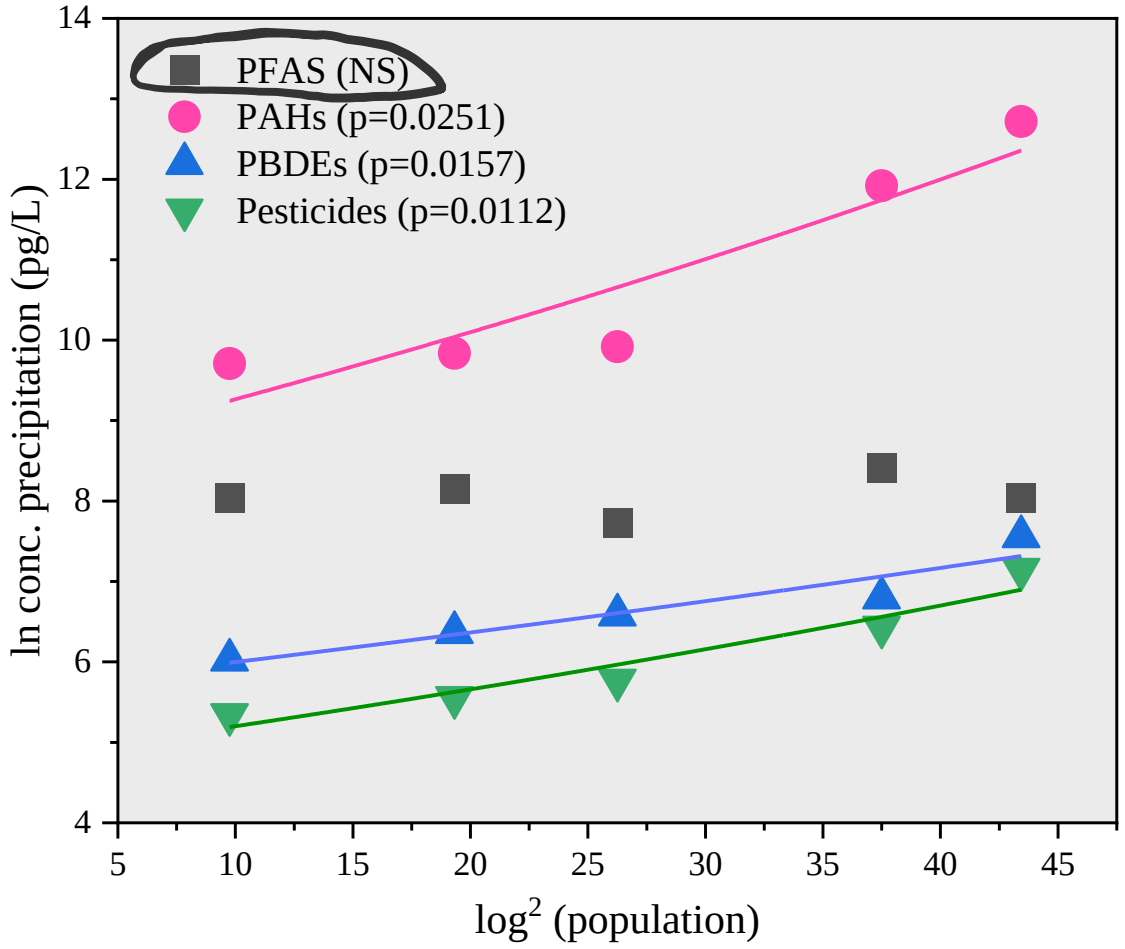
Air profiles are dominated by neutral PFAS



FROM SKIES TO SHORES: it's raining PFAS

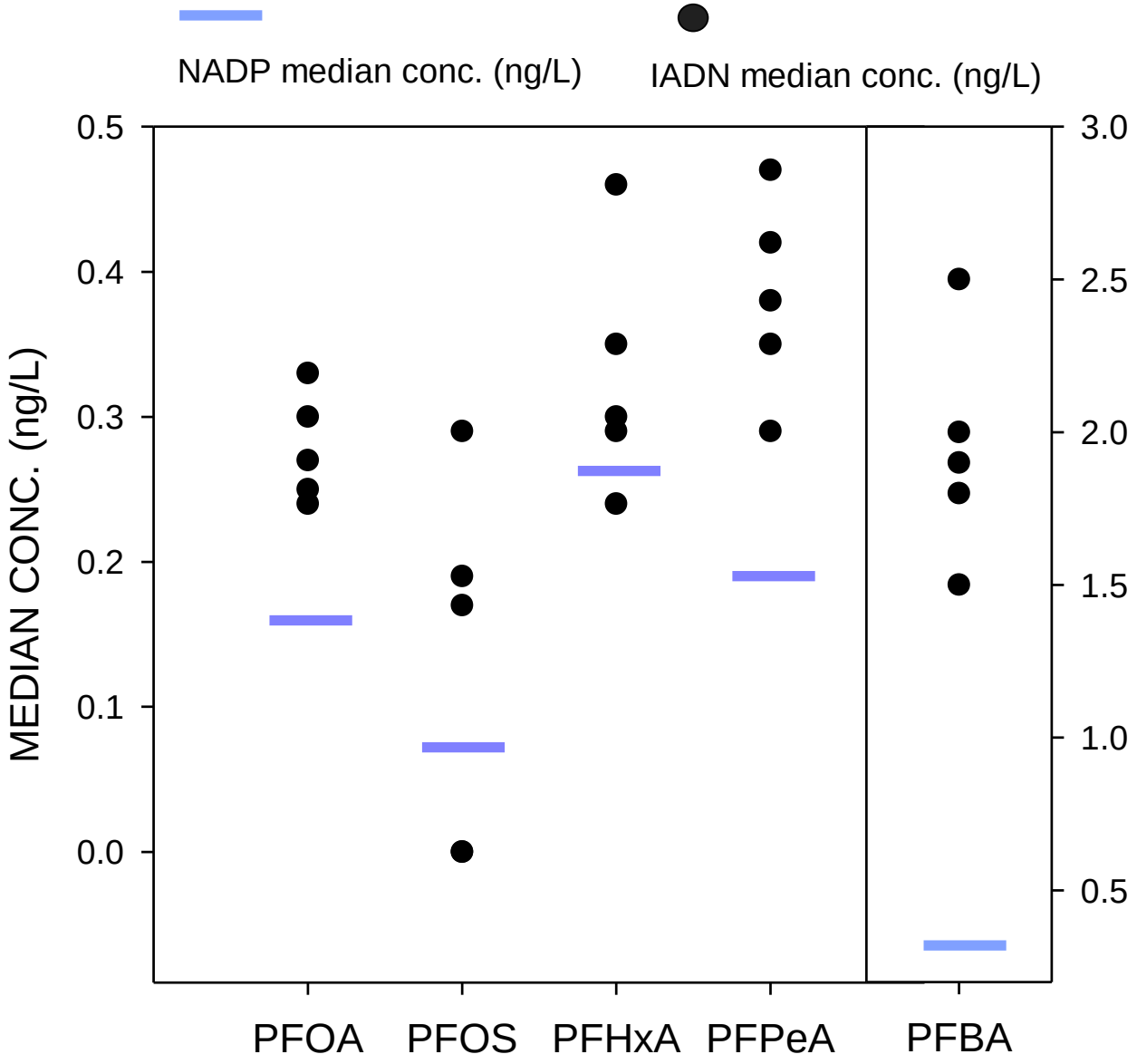


LEVELS SIMILAR ACROSS POPULATION SCALE



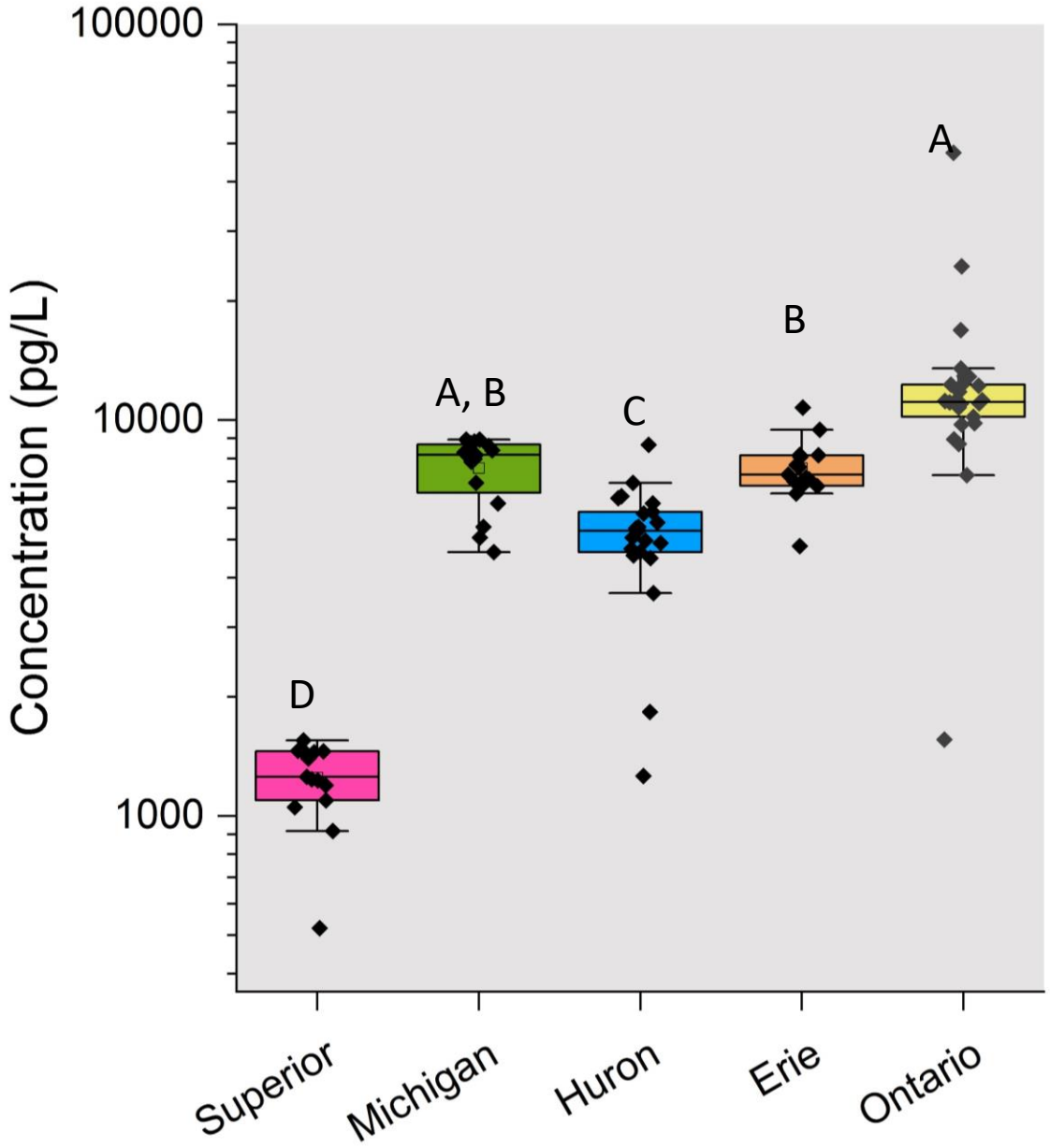
Xia et al., Environ Sci Technol, 2024, 58, 9303-13

Concentrations in rain are homogeneous in the basin

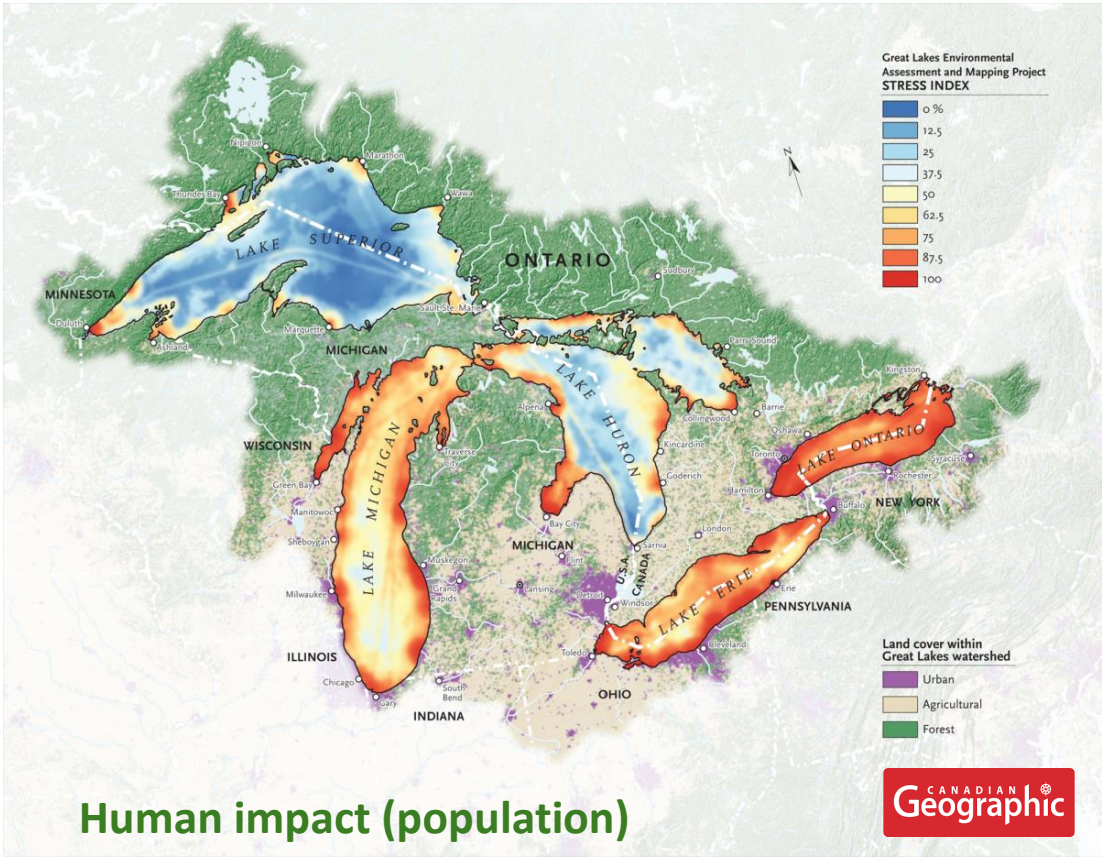


Pfotenhauer, et al, Atm Environ, 2022, 291

PFAS levels in lake water are highest in Lake Ontario

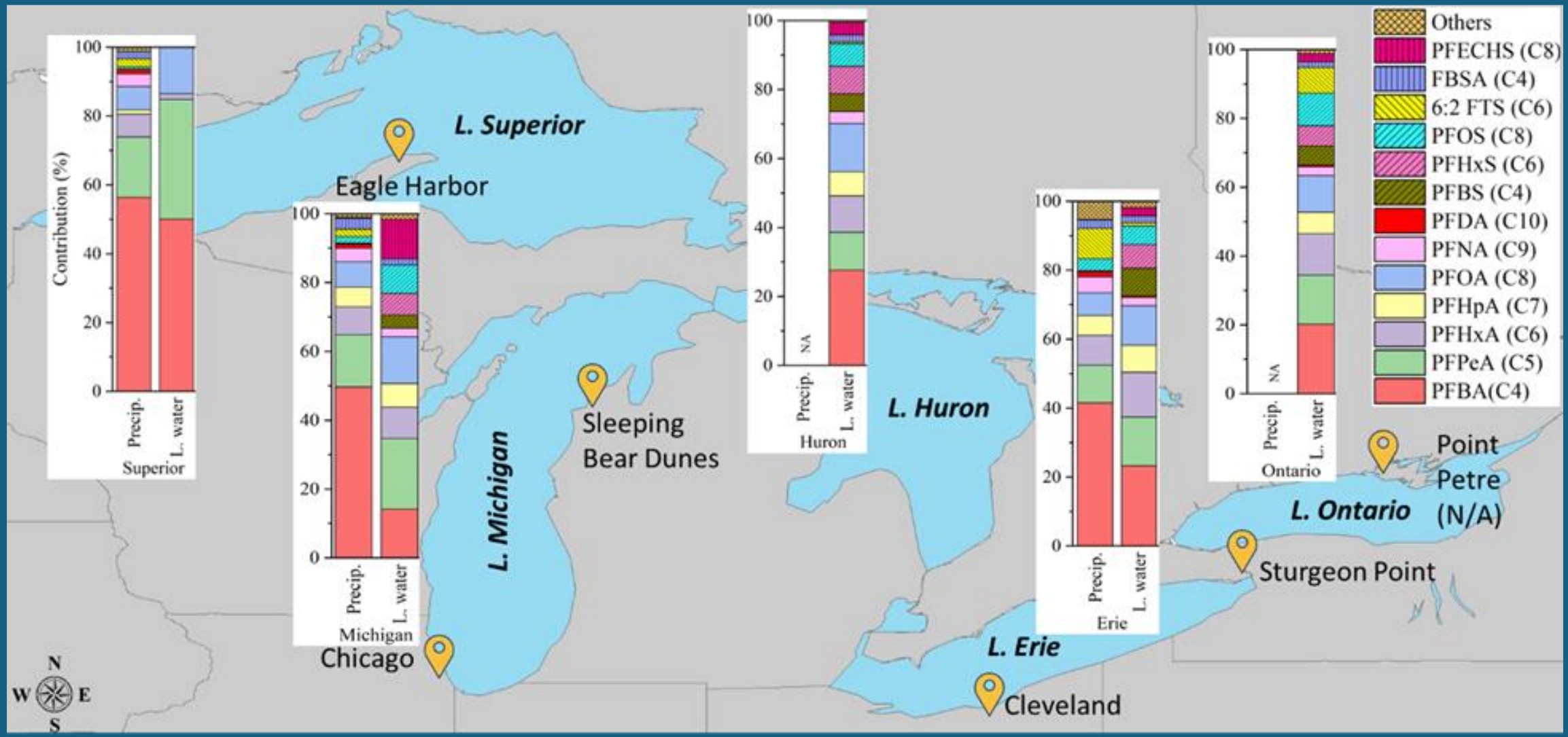


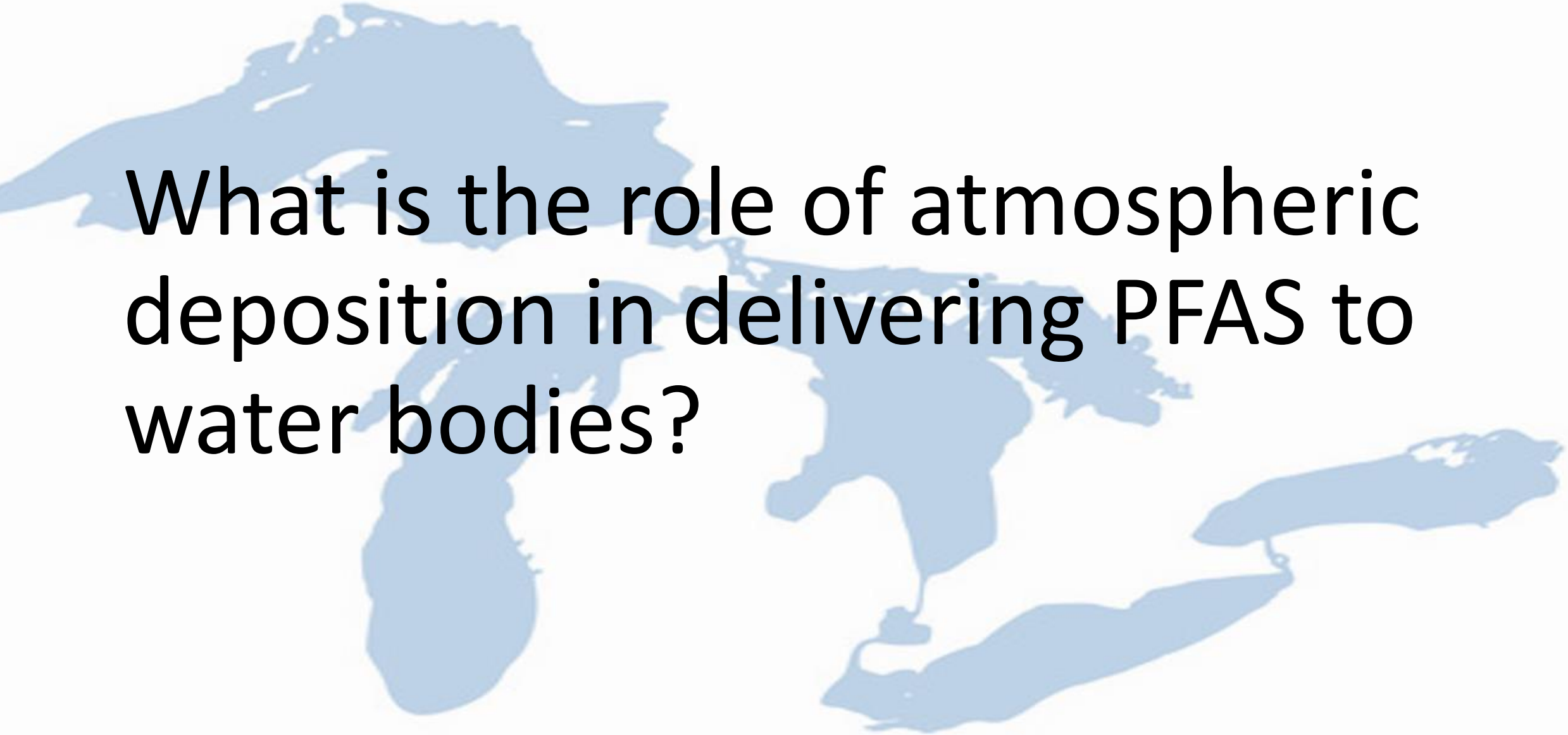
WEST → EAST



Xia et al., Environ Sci Technol, 2024, 58, 9303-13

Precipitation is dominated by carboxylic acids (PFCAs)

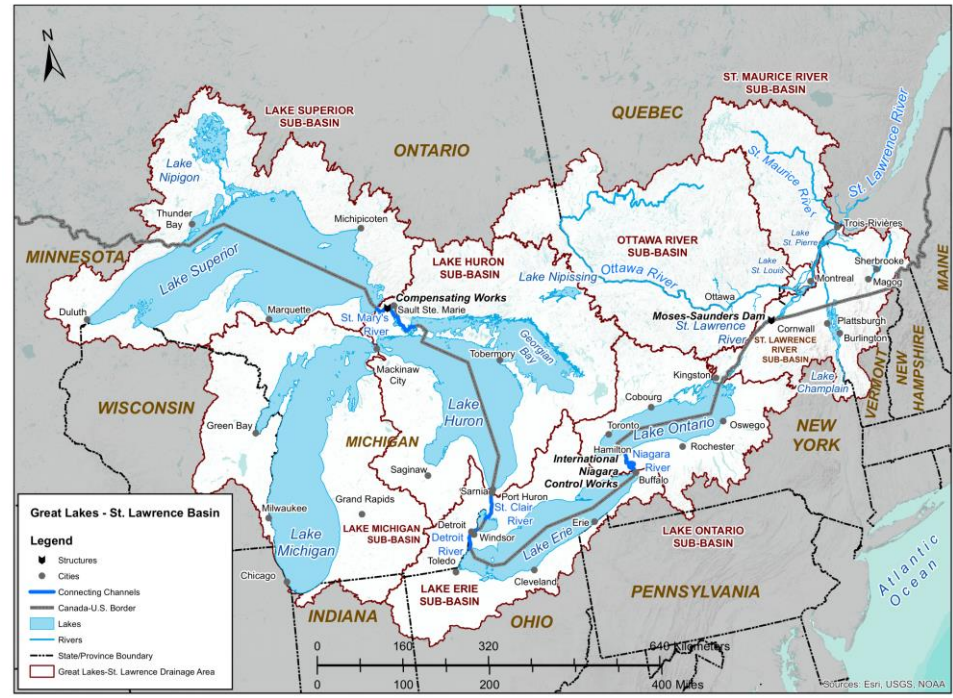




What is the role of atmospheric deposition in delivering PFAS to water bodies?

Calculating flows

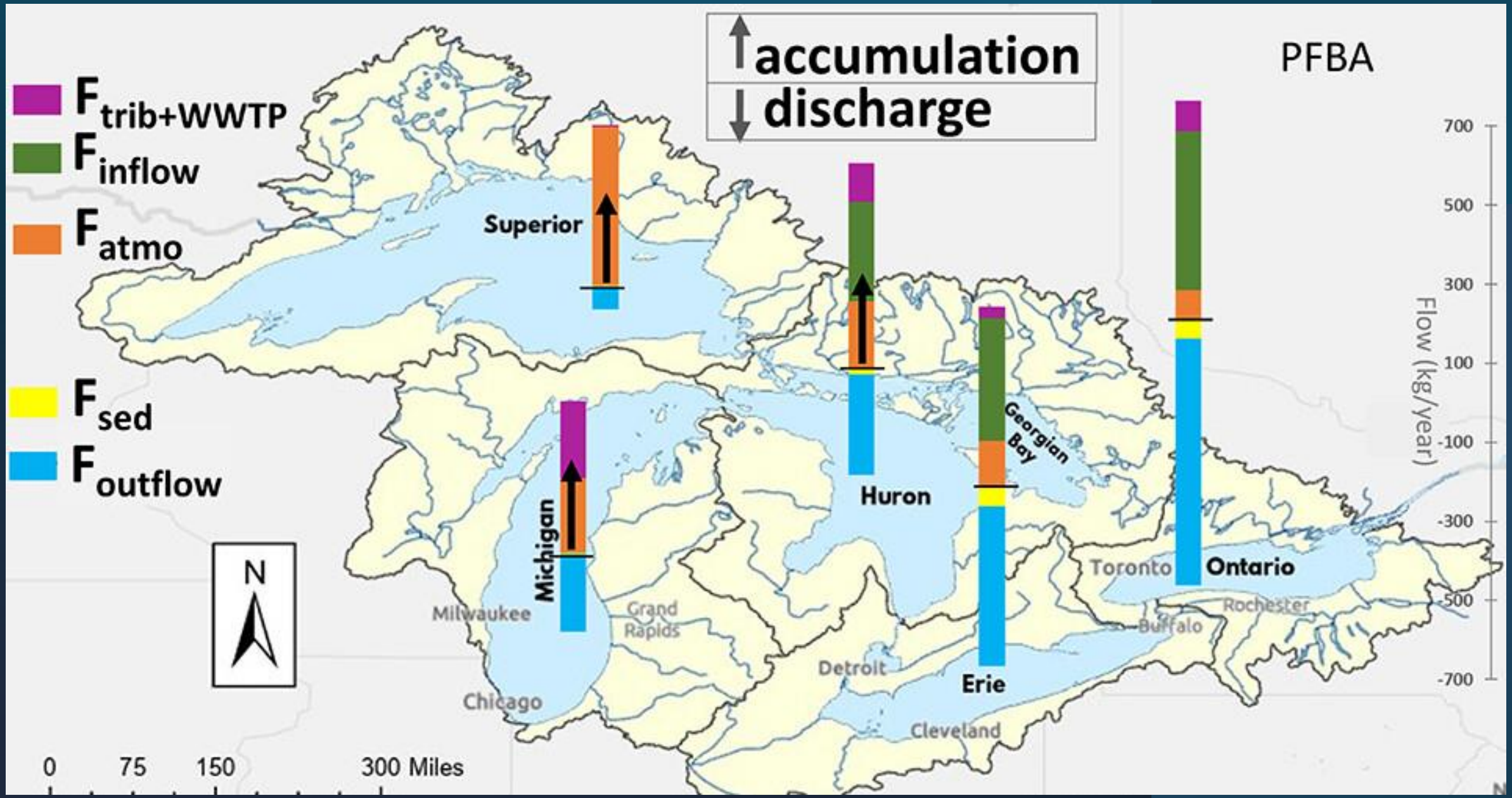
putting everything together (PFOS, PFOA, PFBS, PFBA)



$$F_{net} = \text{output} - \text{input}$$

$$= (F_{sed} + F_{outflow}) - (F_{atmo} + F_{inflow} + F_{trib.})$$

- F_{sed}: Sedimentation rate
- $F_{outflow}$: water leaving the lake
- F_{atmo}: wet + dry dep. air/water exch.
- F_{inflow}: water entering the lake
- $F_{trib.}$: tributaries + WWTPs


accumulation
discharge
PFBA
$F_{trib+WWTP}$
F_{inflow}
F_{atmo}
F_{sed}
$F_{outflow}$
Superior
Michigan
Huron
Georgian Bay
Erie
Ontario
Toronto
Rochester
Buffalo
Detroit
Cleveland
Chicago
Grand Rapids
Milwaukee
N
0 75 150 300 Miles
700
500
300
100
-100
-300
-500
-700
Flow (kg/year)

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