

Monitoring of Plastic input in the ocean

What data could/should be added to the Integrated Marine Debris Observing System?

Maria Kanakidou

University of Crete, mariak@uoc.gr



surface.ocean



lower.atmosphere.study

Observing Air-Sea Interactions Strategy



IMDOS, Nov 18, 2021

Atmospheric plastics – size, shape, properties

Y. Zhang, et al.

Earth-Science Reviews 203 (2020) 103118

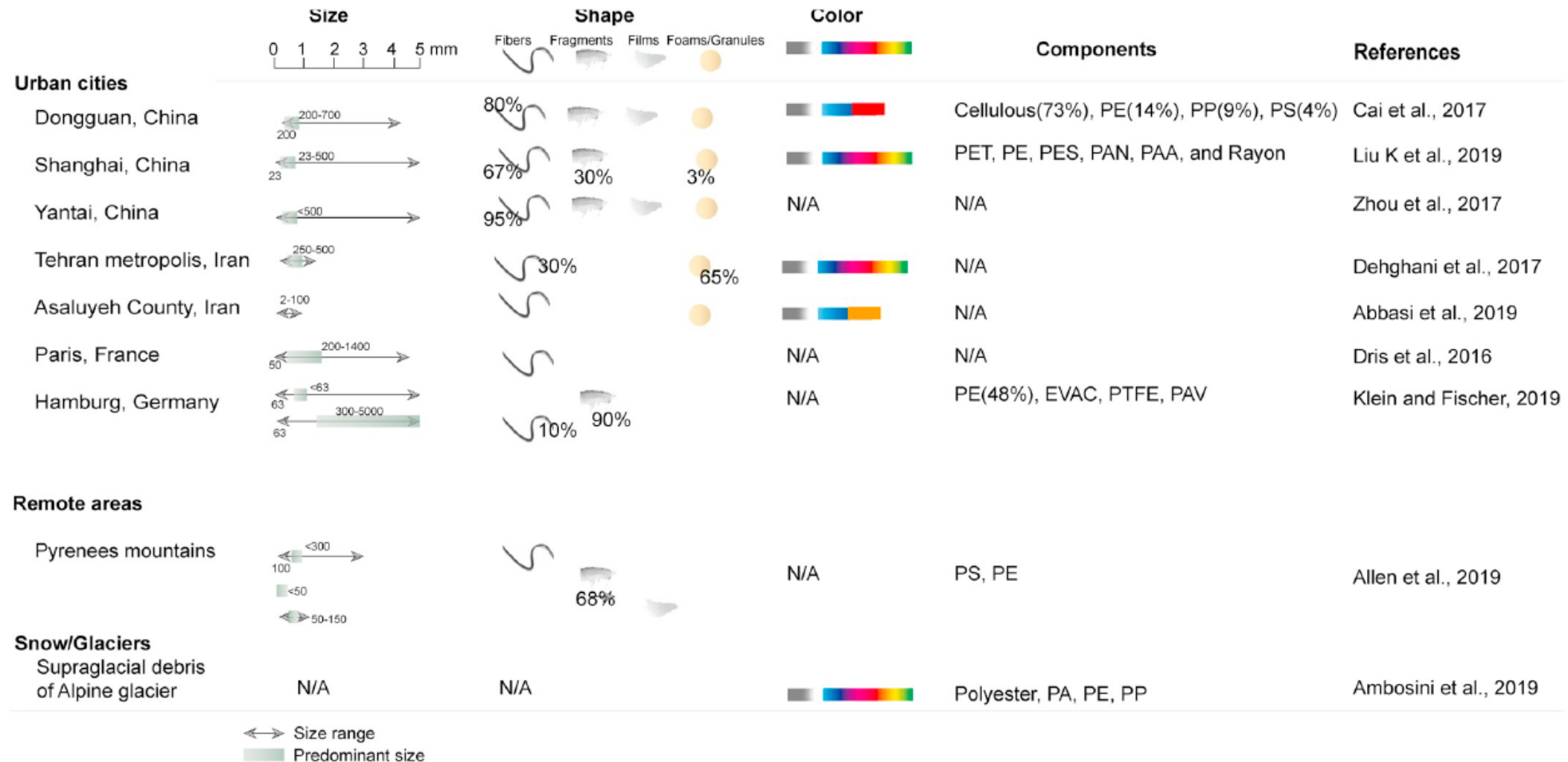
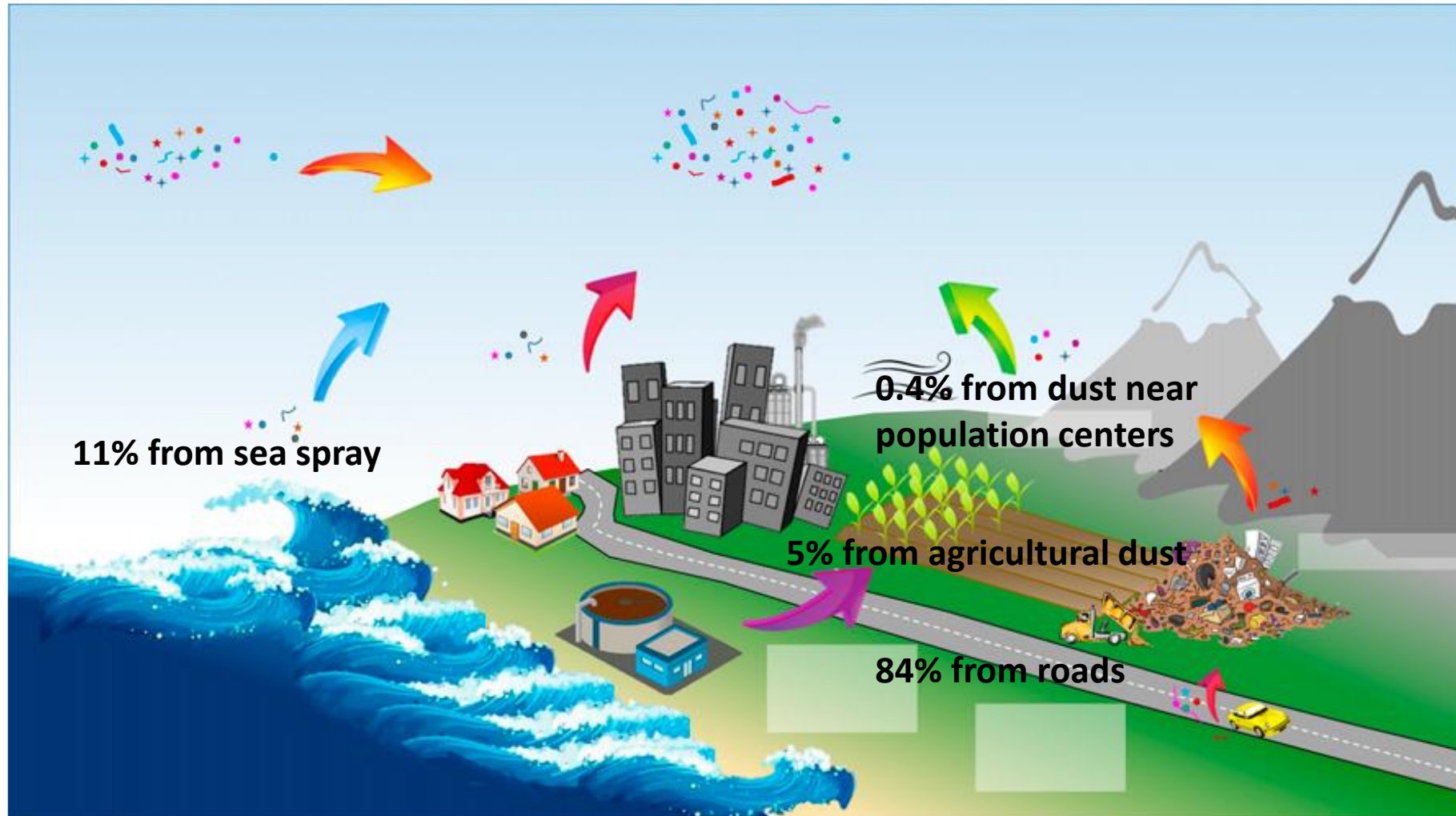


Fig. 2. A summary of characteristics of atmospheric microplastics from the literatures.

* It is acknowledged that not all sampled collected in the research represent atmospheric deposition or atmospheric microplastic pollution.

Plastic deposition to the terrestrial environment over the western United States

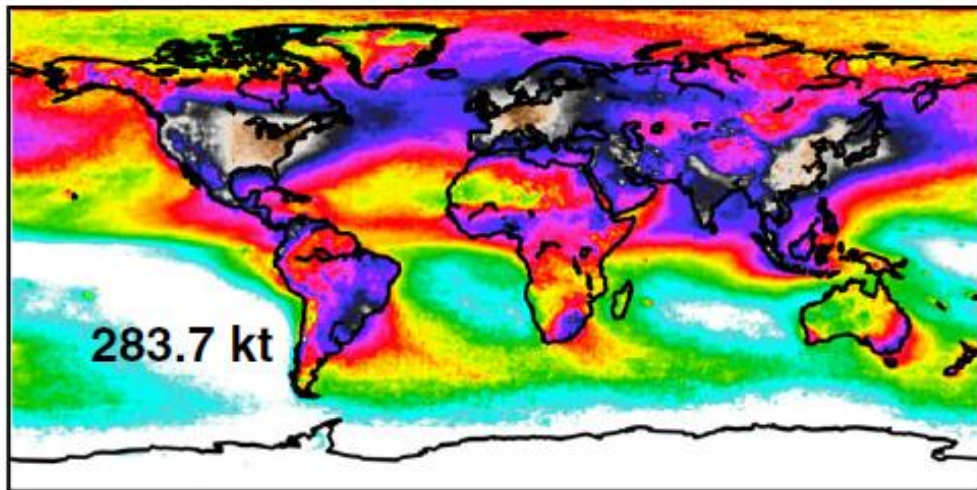


Representation of the major sources of microplastics to the atmosphere and their relative contributions to **deposition to the terrestrial environment over the western United States** (30 to 50°N, 120 to 100°W). Over this region, the deposition of microplastics is **84% from roads, 11% from sea spray, 5% from agricultural dust, and 0.4% from dust near population centers**. The atmospheric burden above this region is 1 Gg (0.001 Mt).

Brahney et al. PNAS 2021
<https://doi.org/10.1073/pnas.2020719118>

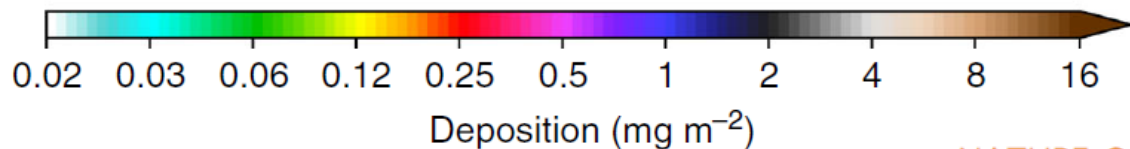
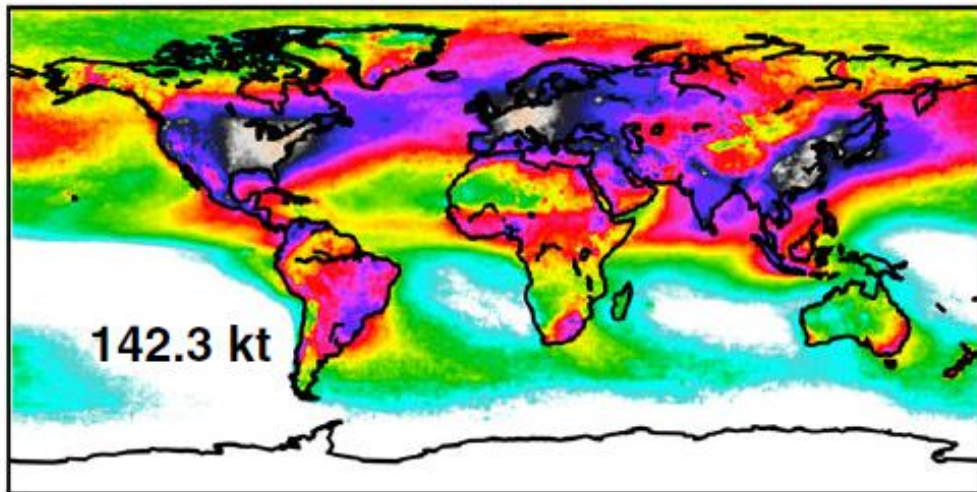
b

PM10 TWP



d

PM10 BWP



First global modeling:

Annual wet and dry atmospheric deposition of road microplastics

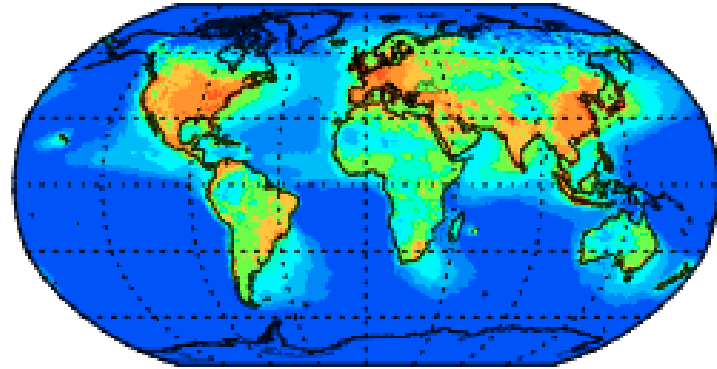
(tires & brakes wear)

Evangeliou et al., Nature Communications, 2020

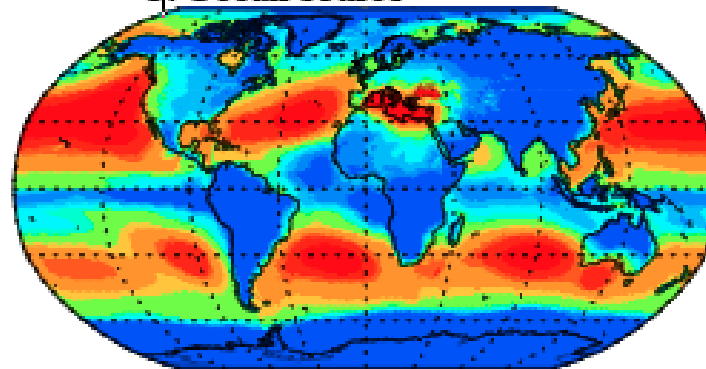
Sources of atmospheric plastics – deposition - globally

The contribution of plastic deposition from each source (model results)

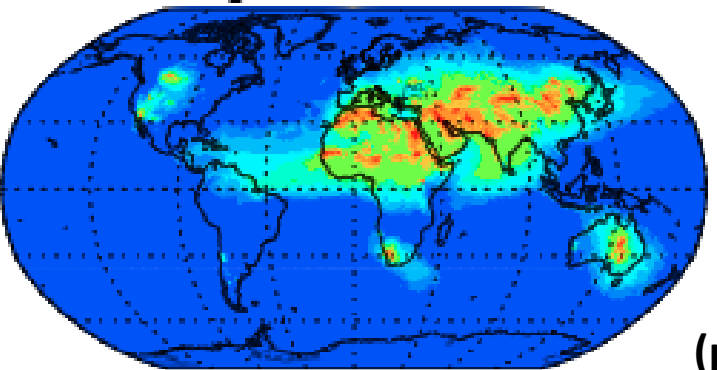
a. Roads



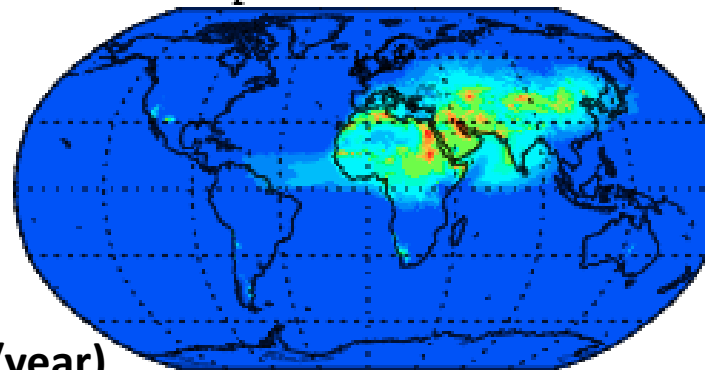
b. Ocean source



c. Agricultural dust



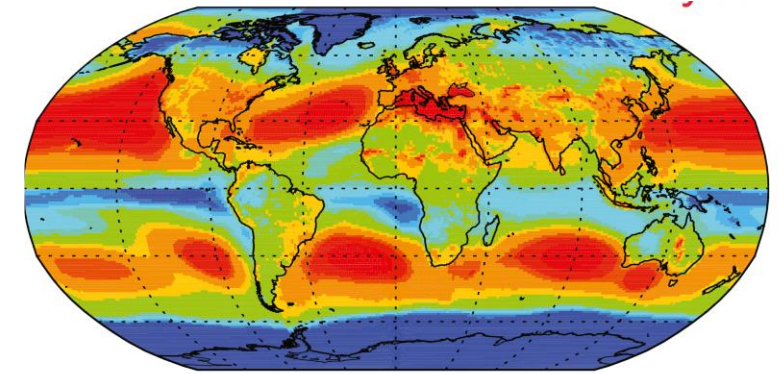
d. Population dust



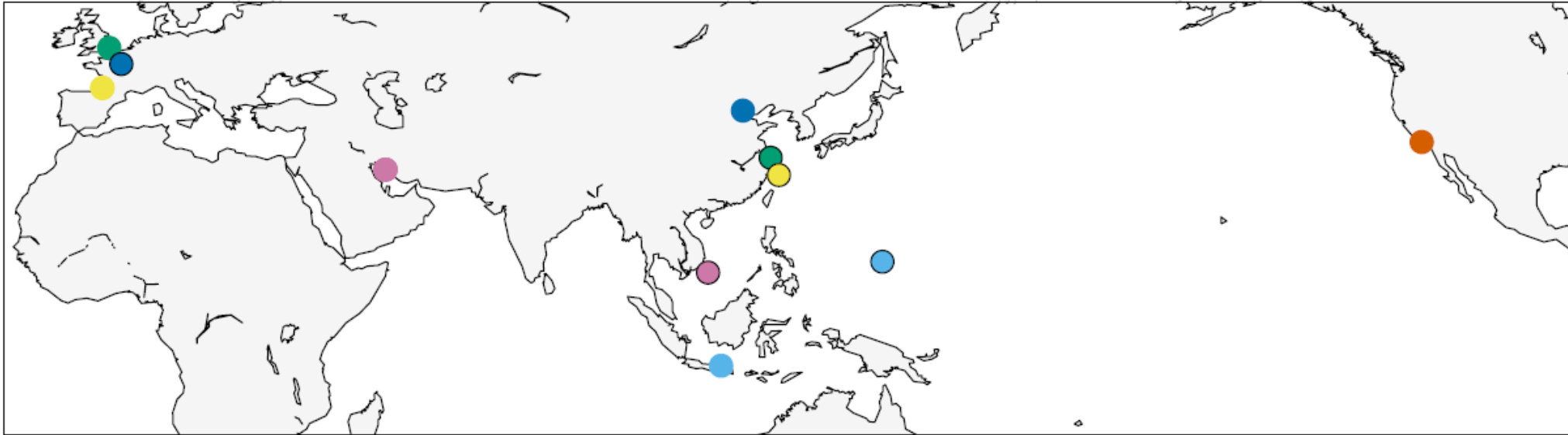
($\mu\text{g}/\text{m}^2/\text{year}$)



Total modeled microplastic deposition ($\mu\text{g}/\text{m}^2/\text{year}$)



Atmospheric observations of microplastics



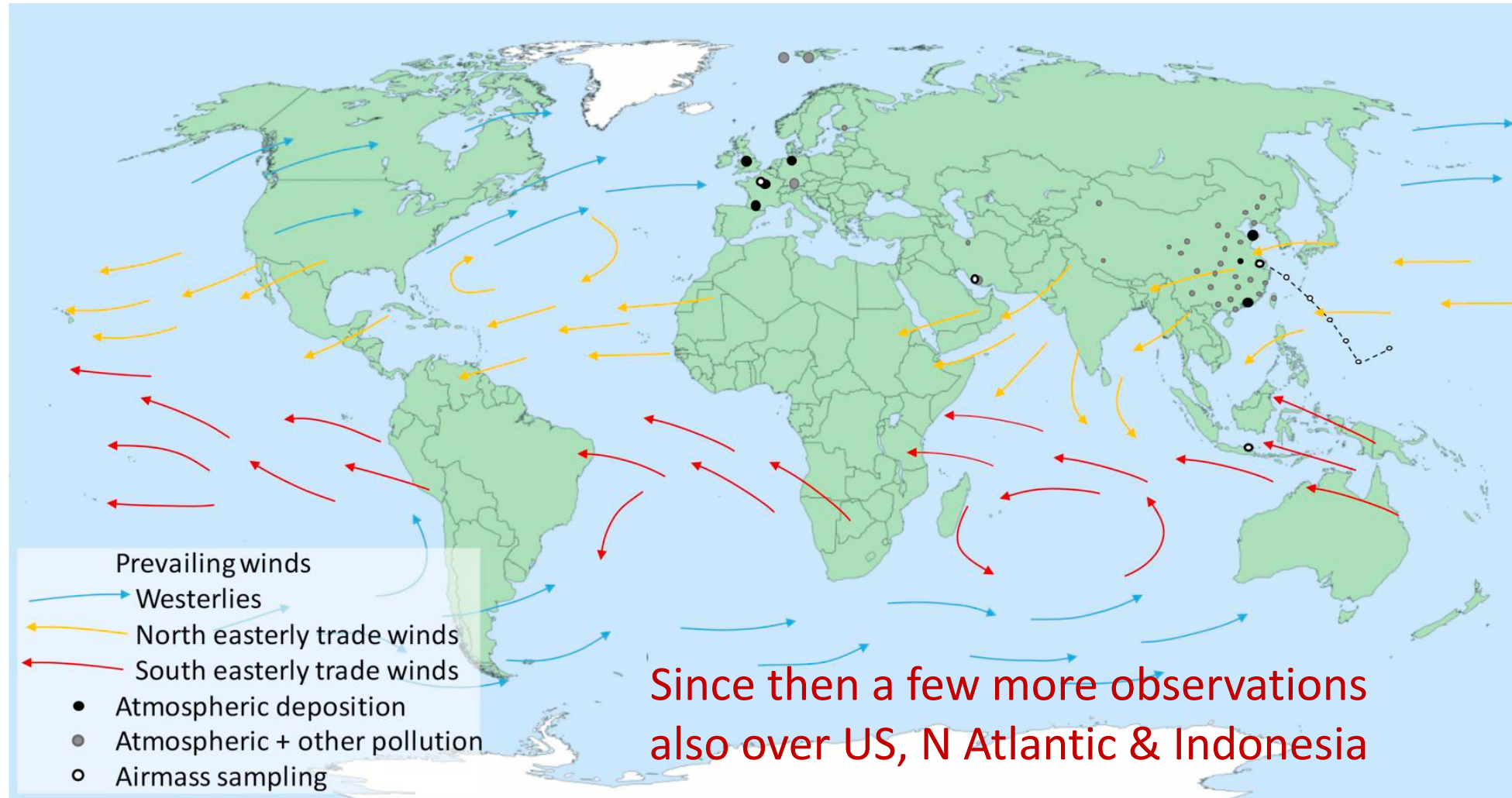
Location	Concentration (MP m ⁻³)	Analytical method
● Beijing, China ¹³	5,650	SEM-EDX
● London, United Kingdom ¹²	2,502	Raman spectral imaging
● Surabaya, Indonesia ²⁰	109	FTIR
● Bushehr Port, Iran (dusty days) ¹	10.3	μRaman
● French Atlantic Coast (offshore wind) ³	9.6	μRaman
● Southern California ⁹	6.2	μRaman and μFTIR
● French Atlantic Coast (onshore wind) ³	2.9	μRaman
● Bushehr Port, Iran (normal days) ¹	2.1	μRaman
● Shanghai, China ¹⁴	1.42	μFTIR
● Paris, France ⁸	0.9	μFTIR
● East China Sea ¹⁵	0.13	μFTIR
● South China Sea and West Pacific Ocean ¹⁷	0.11	μFTIR
● West Pacific Ocean ¹⁵	0.01	μFTIR

Direct radiative effects of airborne microplastics

<https://doi.org/10.1038/s41586-021-03864-x> Laura E. Revell¹, Peter Kuma^{1,3}, Eric C. Le Ru², Walter R. C. Somerville² & Sally Gaw¹

462 | Nature | Vol 598 | 21 October 2021

Global atmospheric observations of microplastics

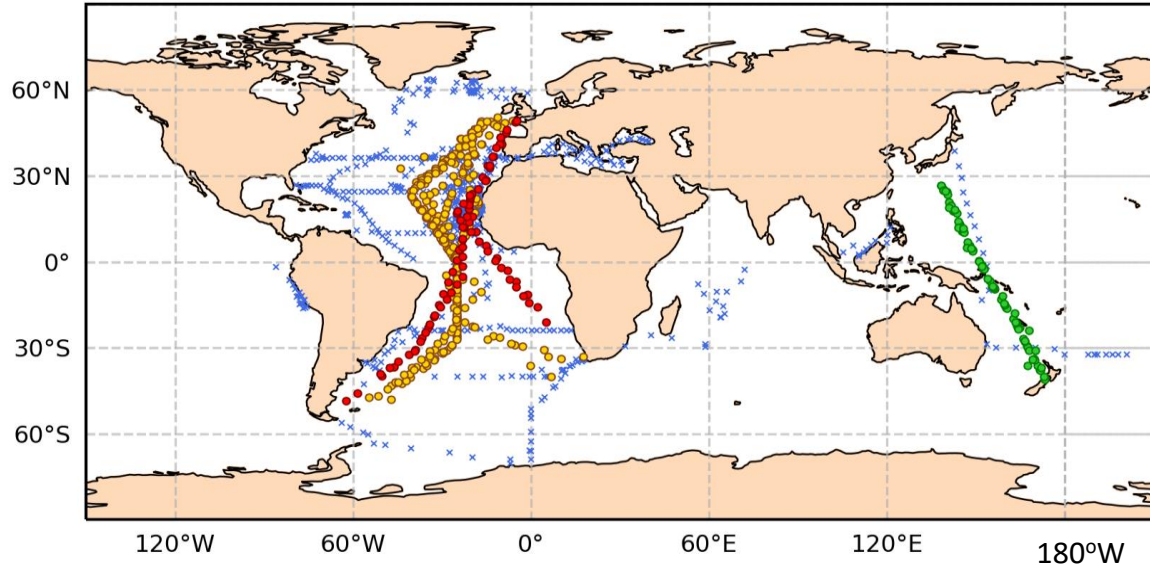


Zhang et al., Earth-Science Reviews, 2020

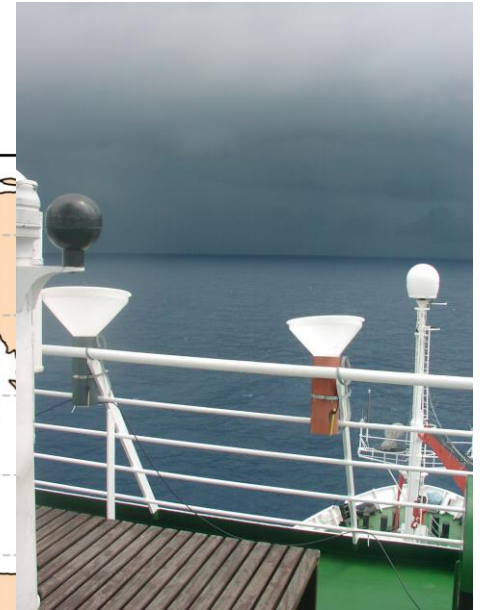
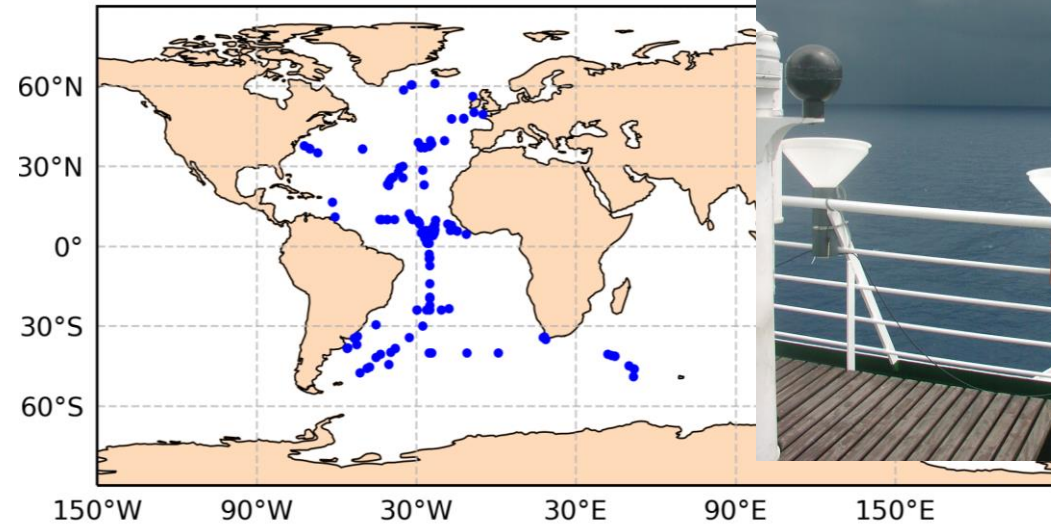
Representative coverage of the global atmosphere is missing

Ship-borne observations

UEA Repeat cruises



UEA Rain samples



Aerosol samples collected from UK, French, German, Dutch, New Zealand, Australian and Japanese ships and analysed at UEA from 2000 to 2019 (n = ~1750)

Atlantic Meridional Transect cruises

Polarstern inter-hemispheric transfers & Arctic campaigns

Transfuture5 voyages

Courtesy Alex Baker, UEA



Platform Type	Advantages	Disadvantages
<u>Ships</u>	<ul style="list-style-type: none"> Unlimited marine locations Can have trained personnel and appropriate technical capacity (i.e. clean labs) Potential of ocean-atmosphere exchange sampling Long-term monitoring through repeated visitation of selected offshore stations over multiple years (e.g. GEOTRACES program) 	<ul style="list-style-type: none"> Short-term (days or weeks to several months) temporal snapshots Very dirty environment May travel at speeds resulting in spatially ranging sample representation
<u>Sailing vessels</u>	<ul style="list-style-type: none"> Unlimited marine locations Can accommodate trained personnel Functional in mild to moderate weather conditions Slow passage speed supporting effective spatial sampling Potential for ocean-atmosphere exchange sampling Relatively low cost 	<ul style="list-style-type: none"> Short to moderate temporal snapshots Fewer personnel accommodated than ships Limited on-board analysis
<u>Island/coastal sites</u> <i>WMO/GAW permanent sites</i>	<ul style="list-style-type: none"> Synoptic, seasonal and annual variability Trained personnel Supporting chemical/meteorological measurements Multiple elevations 	<ul style="list-style-type: none"> Limited geographical locations
<u>Island/coastal sites</u> <i>Other permanent sites</i>	<ul style="list-style-type: none"> Synoptic, seasonal and annual variability Possible supporting chemical/meteorological measurements 	<ul style="list-style-type: none"> Limited trained personnel Limited geographical locations
<u>Island/coastal sites</u> <i>Non-permanent sites</i>	<ul style="list-style-type: none"> Synoptic and possibly seasonal scale variability Possible supporting chemical/meteorological measurements (in some cases) 	<ul style="list-style-type: none"> Limited/untrained personnel Limited geographical locations
<u>Aircraft</u>	<ul style="list-style-type: none"> Unlimited marine locations Trained personnel Multiple elevations 	<ul style="list-style-type: none"> Very short-term temporal snapshots Limited sampling intervals Very expensive
<u>Drones & UAVs</u>	<ul style="list-style-type: none"> Multiple elevations Relatively Low cost 	<ul style="list-style-type: none"> Limited marine locations unless launched from ships Very short-term temporal snapshots Limited sampling intervals
		<ul style="list-style-type: none"> Limited power availability and payload
<u>Tethered or remotely controlled balloons</u>	<ul style="list-style-type: none"> Full range of elevation (surface-PBL-troposphere) Generally limited to terrestrial release but potentially possible from ships 	<ul style="list-style-type: none"> Limited access due to expense, licensing Snapshot sampling rather than continuous Potential for constraints in spatial control Limited sampling equipment payload (when considering multiple elevation sampling)
<u>Buoys</u>	<ul style="list-style-type: none"> Synoptic, seasonal and annual variability Possible wide geographical coverage 	<ul style="list-style-type: none"> Difficult to service Possible limited power Excessive sea spray

Selection of a sampling platform in a particular region, 2 important questions :

Do we need a snapshot of near-instantaneous conditions, or do we need synoptic to seasonal to annual to decadal concentration information?

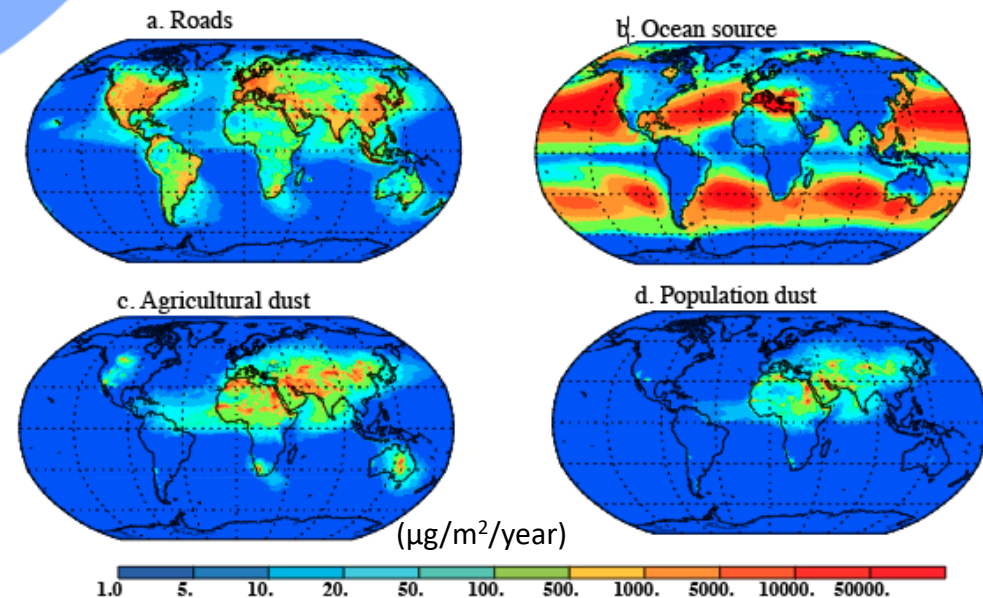
Can we be certain there are trained personnel who can minimize contamination during sample collection and processing?

Duce et al., 2021

A selection among GAW/WMO and EMEP/ACTRIS stations for long-term atmospheric micro(nano)plastic survey is been proposed by GESAMP/WMO

Building a Marine Network of Atmospheric Observations needs to consider:

- Areas with high deposition fluxes
- Existing stations with
 - extensive database
 - key for plastic variability analysis
 - trained personnel



Brahney et al. PNAS 2021

<https://doi.org/10.1073/pnas.2020719118>

Monitoring of Plastic input in the ocean

What data could/should be added to the Integrated Marine Debris Observing System?

Maria Kanakidou

University of Crete, mariak@uoc.gr



surface.ocean



lower.atmosphere.study



GESAMP

Joint Group of Experts on the
Scientific Aspects of Marine
Environmental Protection

Observing Air-Sea Interactions Strategy