A general methodology for beached oil spill hazard mapping and its application to the Atlantic basin coasts

Nadia Pinardi (1), A.A.Sepp-Neves (1), F.Trotta(1) and A.Navarra(2)

(1) Department of Physcis and Astronomy, University of Bologna and

(2) Foundation EuroMediterranean Center on Climate Change

Outline

1

Understand uncertainties in oil spill model simulations and use ensemble method

2

The nexus of a general hazard mapping methodology

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A general Beached oil distribution for the hazard:

The Weibull distribution

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Conclusions and outlook

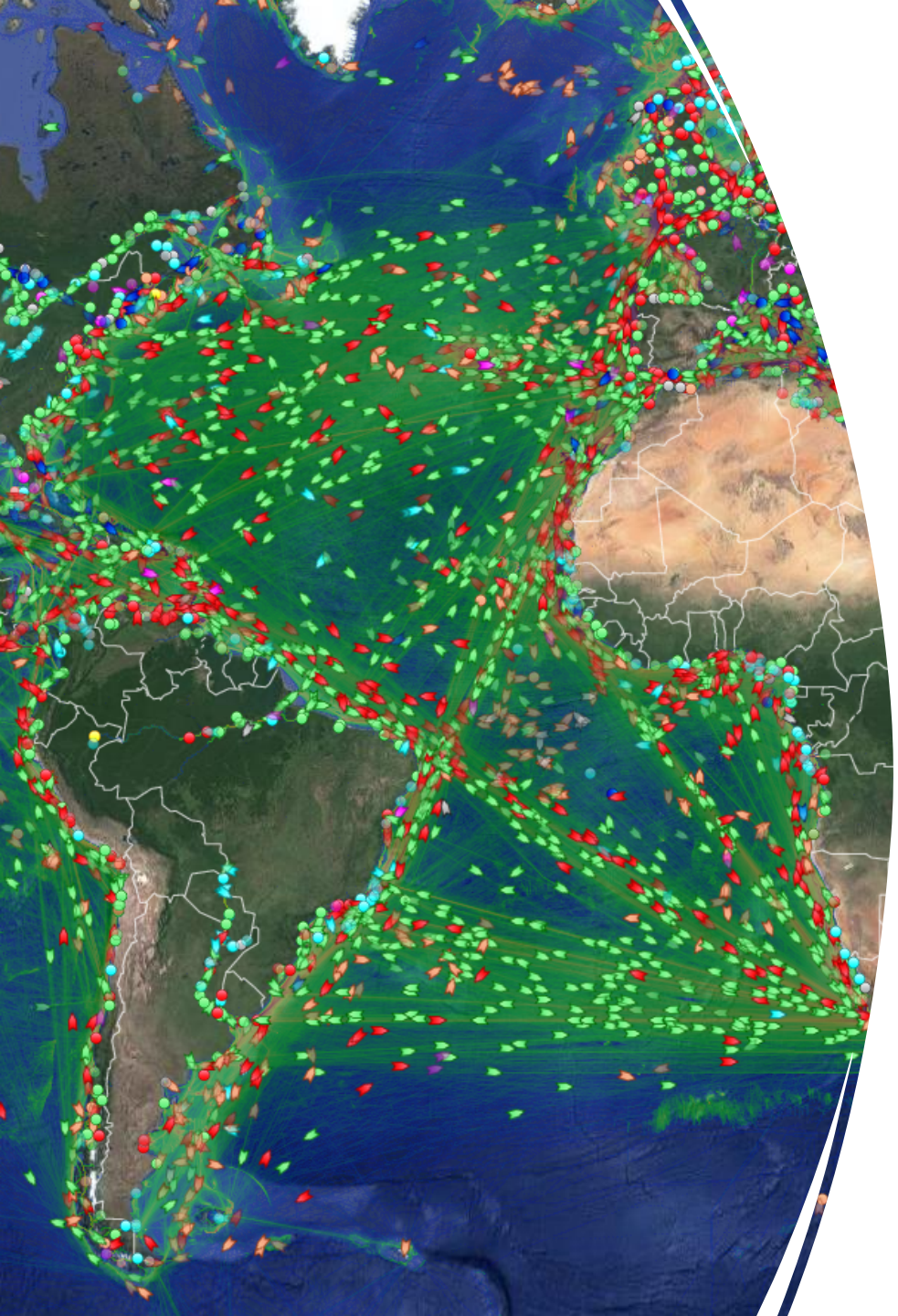
The Challenges of Sustainable development

- The first target for SDG 14 is:

14.1: By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution

- So we need to establish replicable and reproducible estimates of pollution hazard. We started with oil pollution

Goal 14: Life Below Water

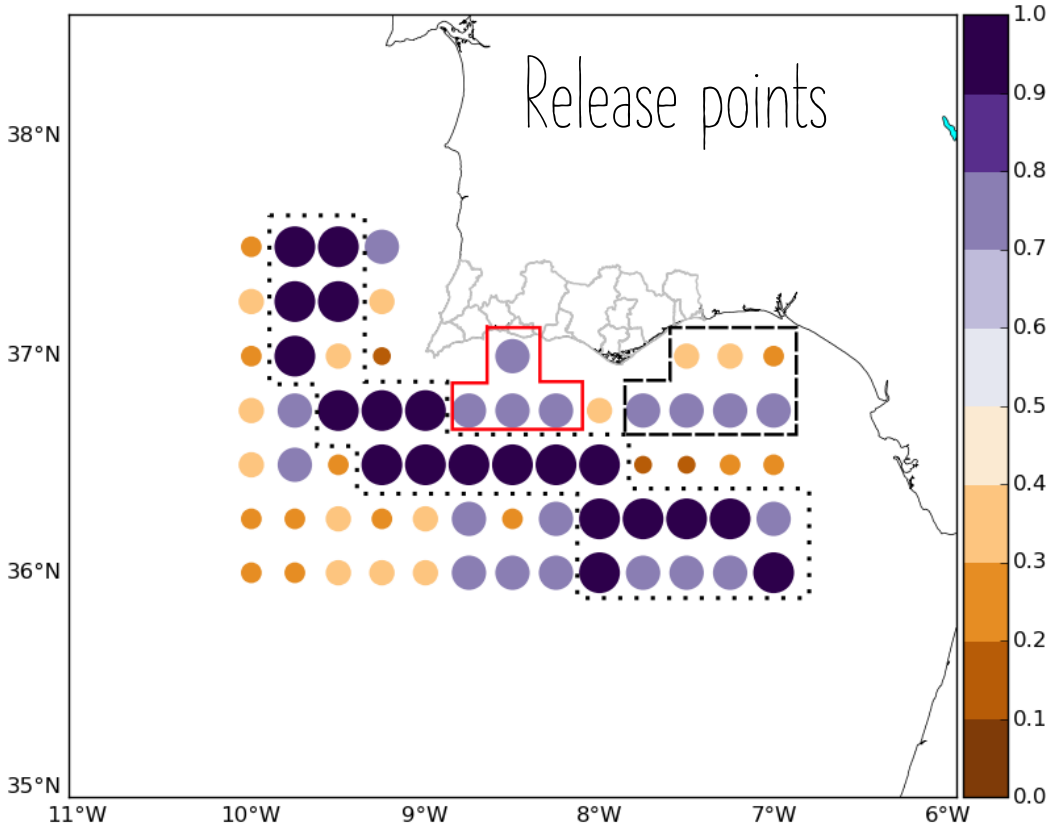


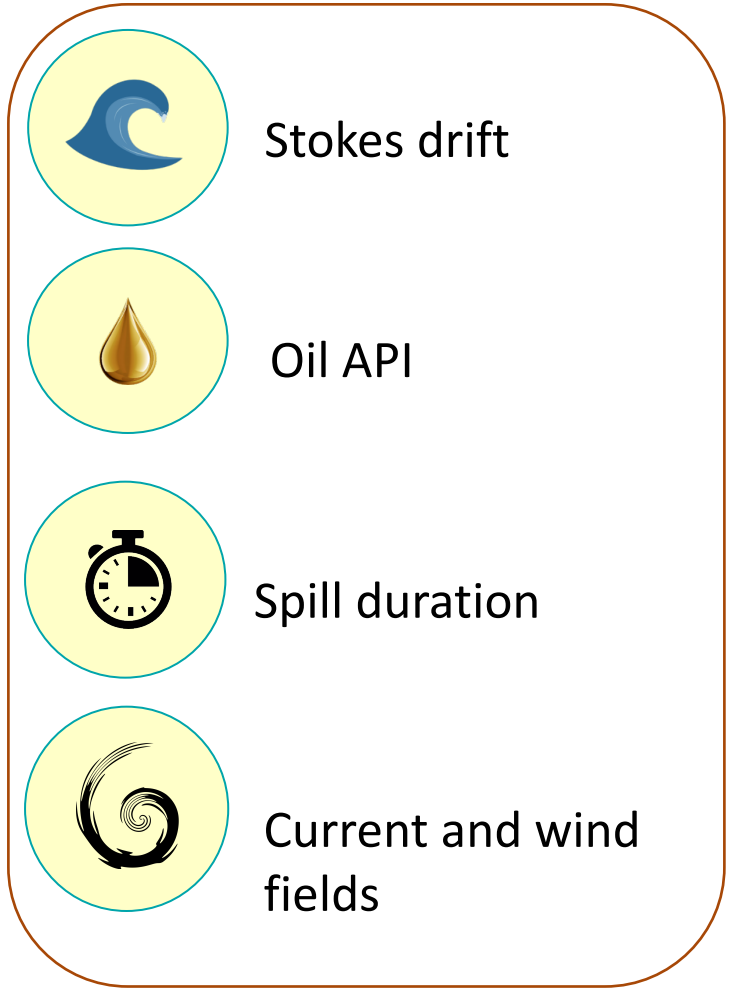
Why oil pollution?

- Millions of tonnes of oil transported by vessels
- Over 600,000 tonnes end up in the marine environment
- Almost 50% are due to operational spills and we ignore their impacts on the our coasts

What are the uncertainties connected to oil spill hazard modelling?

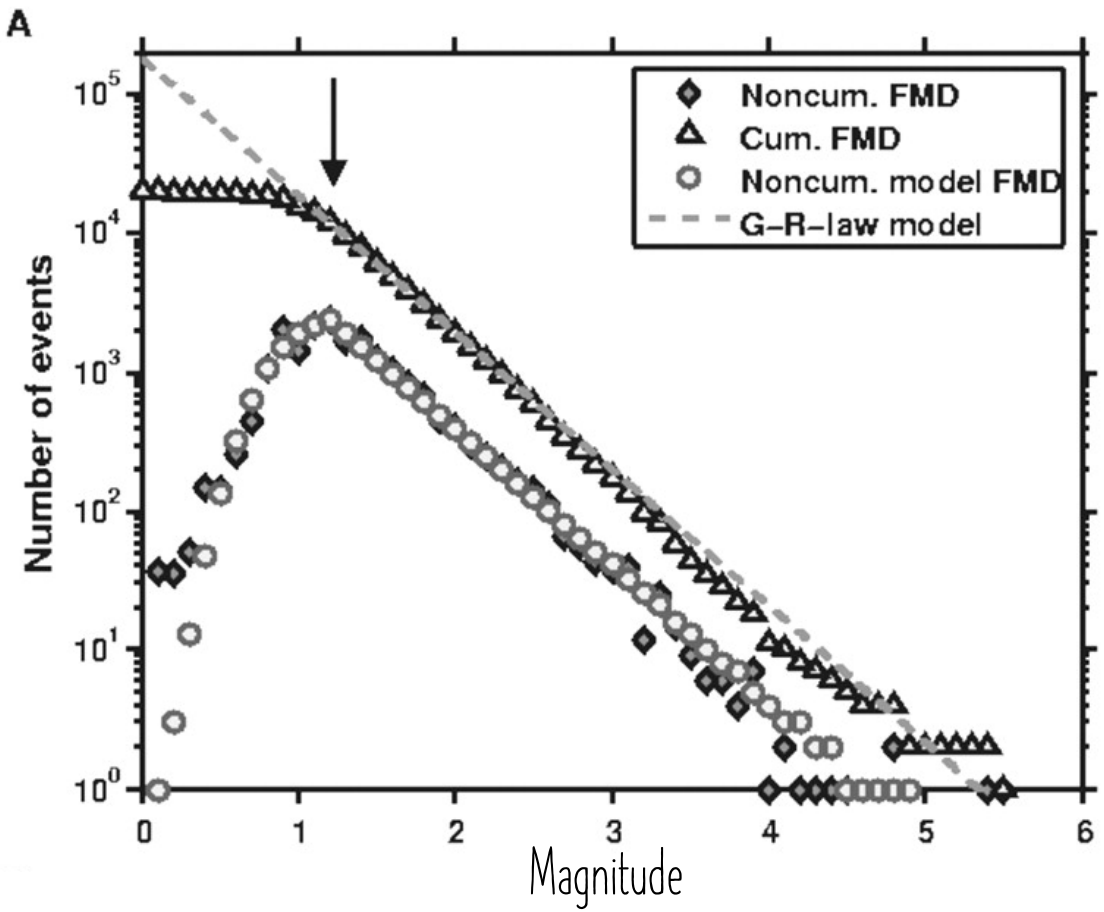
- Sepp-Neves, Pinardi and Martins, 2016. IT-OSRA: applying ensemble simulations to estimate the oil spill risk associated to operational and accidental oil spills, Climate dynamics, 66:939-954, doi: 10.1007/s10236-016-0960-0





The nexus of oil hazard mapping

- How do we synthetize the oil spill information considering the uncertainties?
- Can we construct a probability distribution of the beached oil on the coasts that will be equal for all the coasts so that we can compare distribution parameters?
- Do other examples of such methodology exists? Yes, for example in earthquake hazard mapping.



Earthquakes, Woessner and Wiemer 2005

Sepp Neves AA, Pinardi N, Navarra A and Trotta F (2020) A General Methodology for Beached Oil Spill Hazard Mapping. Front. Mar. Sci. 7:65. doi: 10.3389/fmars.2020.00065

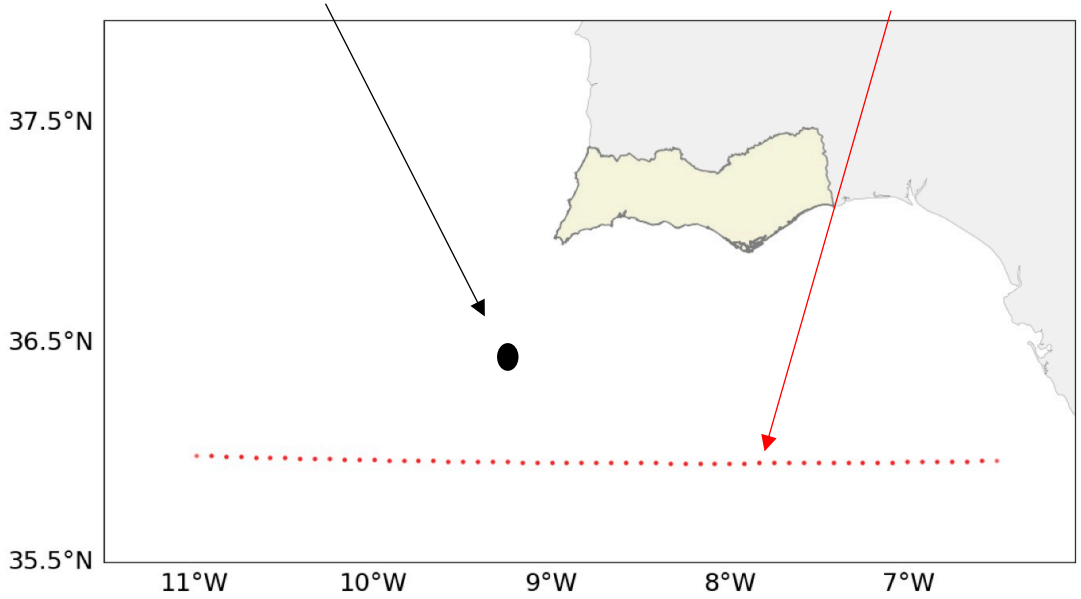
Need to construct the probability distribution for many different coastal areas

Changing currents	Use ensemble simulations to map beached oil due to changing ocean and atmosphere conditions and different release points
Realistic oil model	Use a realistic model for fate and transport of oil and oil beaching processes
Different coasts	Compare areas with very different coastal segments and in particular ocean current regimes
Beached oil distributions	Study the statistical distribution of concentration at the coasts and extract a general relationship

First let's do a gedanchen-experiment (thought-experiment)

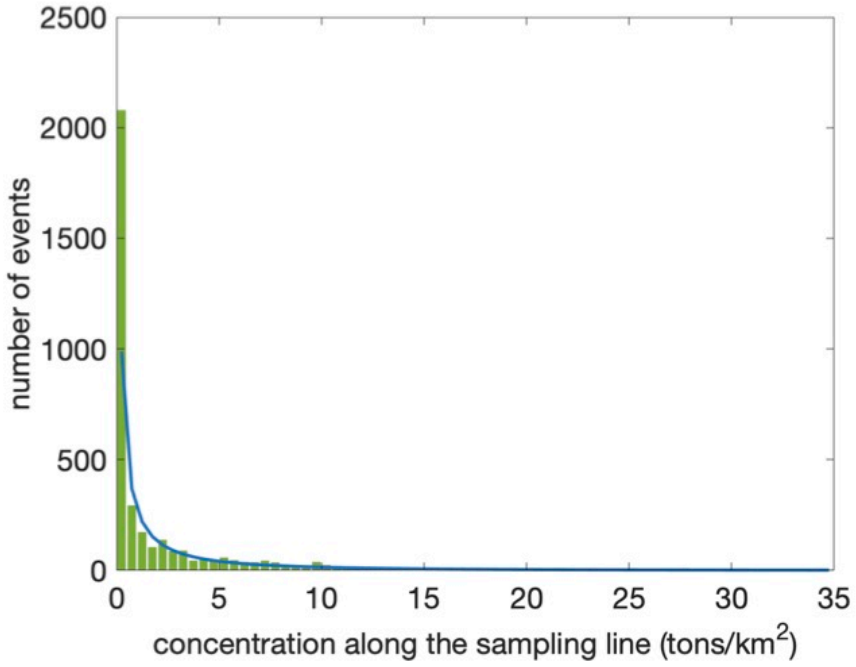
Analysis of the oil concentration crossing the red line for variable ocean currents

Only one release point



The oil oncentration distribution along the red line:

A Weibull (1950) distribution !



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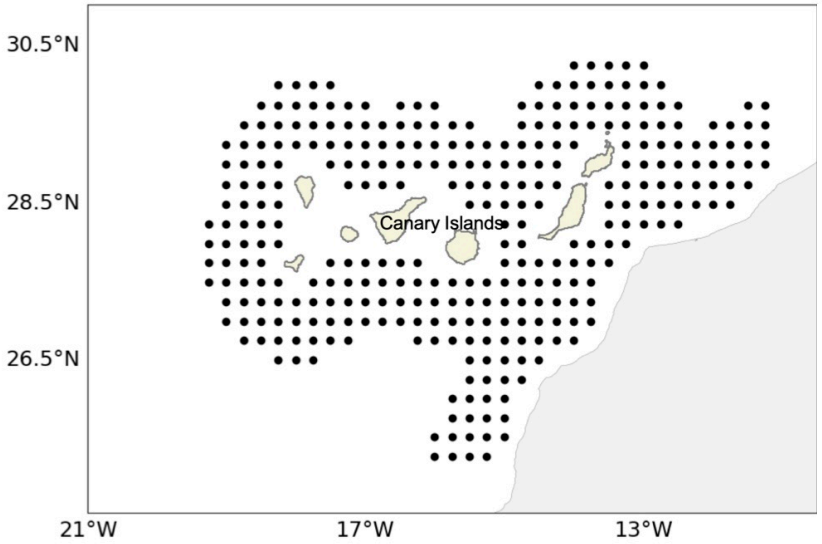
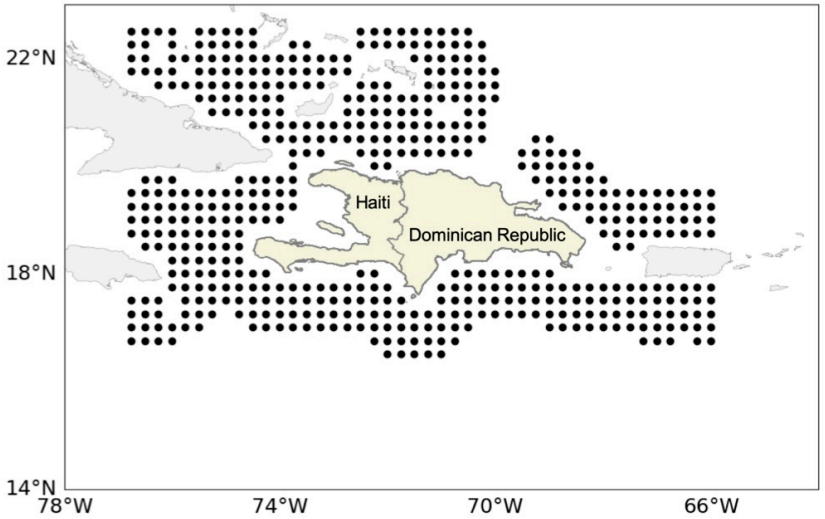
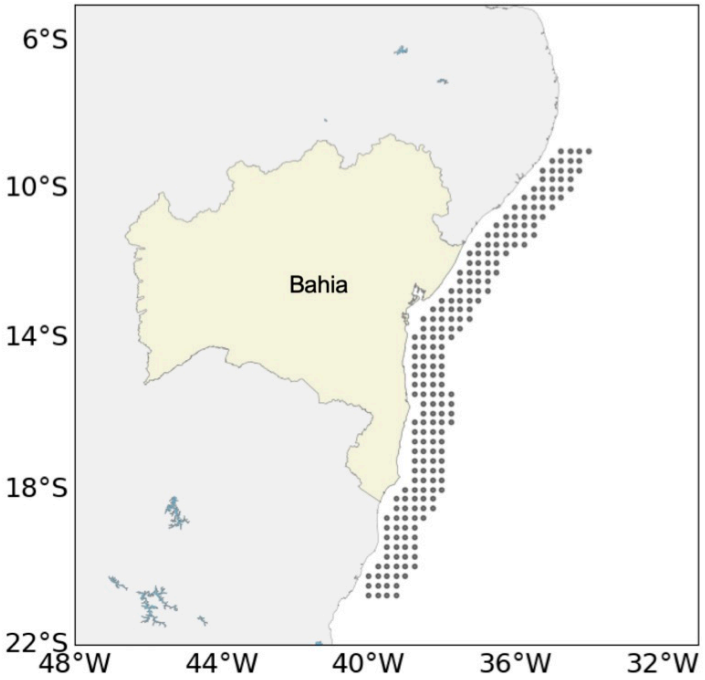
Now let's do realistic coastlines and many release points

Eastern Atlantic Archipelago



Western Atlantic Island





South Brazil coasts

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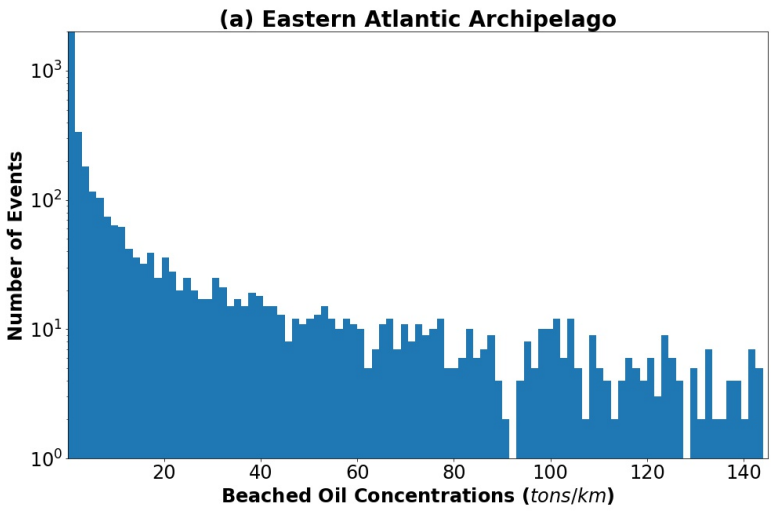
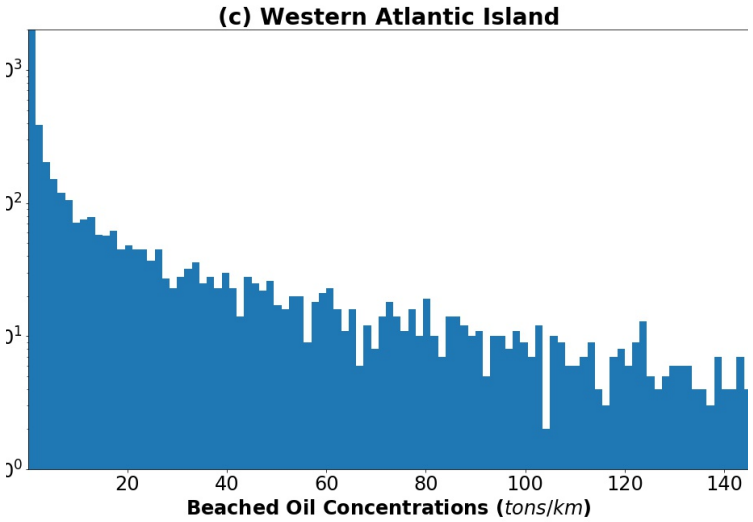
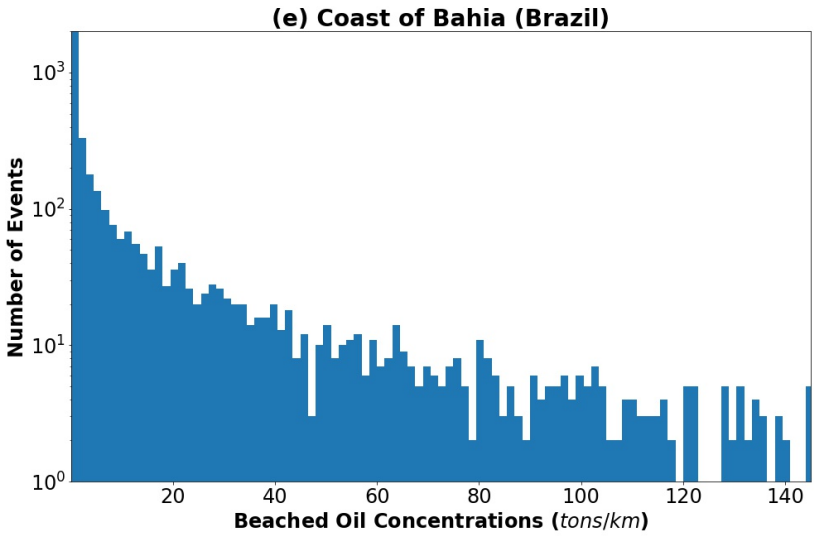
The distibution is the same but with different distribution parameters







The Weibull distribution is:

$$W(x;\beta,\eta) = \frac{\beta}{\eta}\left(\frac{x}{\eta}\right)^{\beta-1}\exp\left(-\frac{x}{\eta}\right)^{\beta}$$

β Shape parameter

η Scale parameter

What do we do now with the distribution: the beached Oil Hazard Index

- The Weibull distribution is a fat-tail distribution and it informs us that all coastal areas have the possibility of large concentration of oil deposited after operational releases.
- We can define the Weibull tail distribution H to assess the hazard and intercompare the diffferent areas

$$H = 1 - F(x_{cut}) = e^{-(\frac{x_{cut}}{\eta})^{\beta}}$$

  - Where x_{cut} is a threshold oil concentration here chosen to be $25\,\mathrm{tons/km}$

H is the beached Oil Hazard Index that is reproducible and replicable

The hazard is larger in the Western Atlantic Island

Area	Beached oil Hazard Index
East Atlantic Archipelago	0.16 ± 0.01
Western Atlantic island	0.18 ± 0.01
Bahia (Brazil)	0.14 ± 0.01

Weibull Parameters	Eastern Atlantic Archipelago	Western Atlantic Island	Bahia (Brazil)
scale (η)	5.1 ± 0.6 tons/km	5.86 ± 0.75 tons/km	4.2 ± 0.5 tons/km
shape (β)	0.362 ± 0.008	0.377 ± 0.009	0.377 ± 0.008
mean (μ)	23 tons/km	23 tons/km	17 tons/km
standard deviation (σ)	85 tons/km	80 tons/km	58 tons/km

Conclusions and outlook

- We have demonstrated a straightforward and objective method to quantify the coastal oil spill hazard based on ensemble oil spill experiments which sample the uncertainties associated with oil spill accidental releases.
- Both oil in the open ocean and beached oil concentrations are successfully described by the **Weibull distribution.** The large beach oil concentrations are contained in a **"fat tail"** which characterizes this distribution.
- We propose a new **hazard index** for beached oil which allows **to intercompare different world ocean areas and their different hazards.**
- Future work will consider an in-depth study of the ocean flow field parameters and how they modulate the coastal oil spill hazard.

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