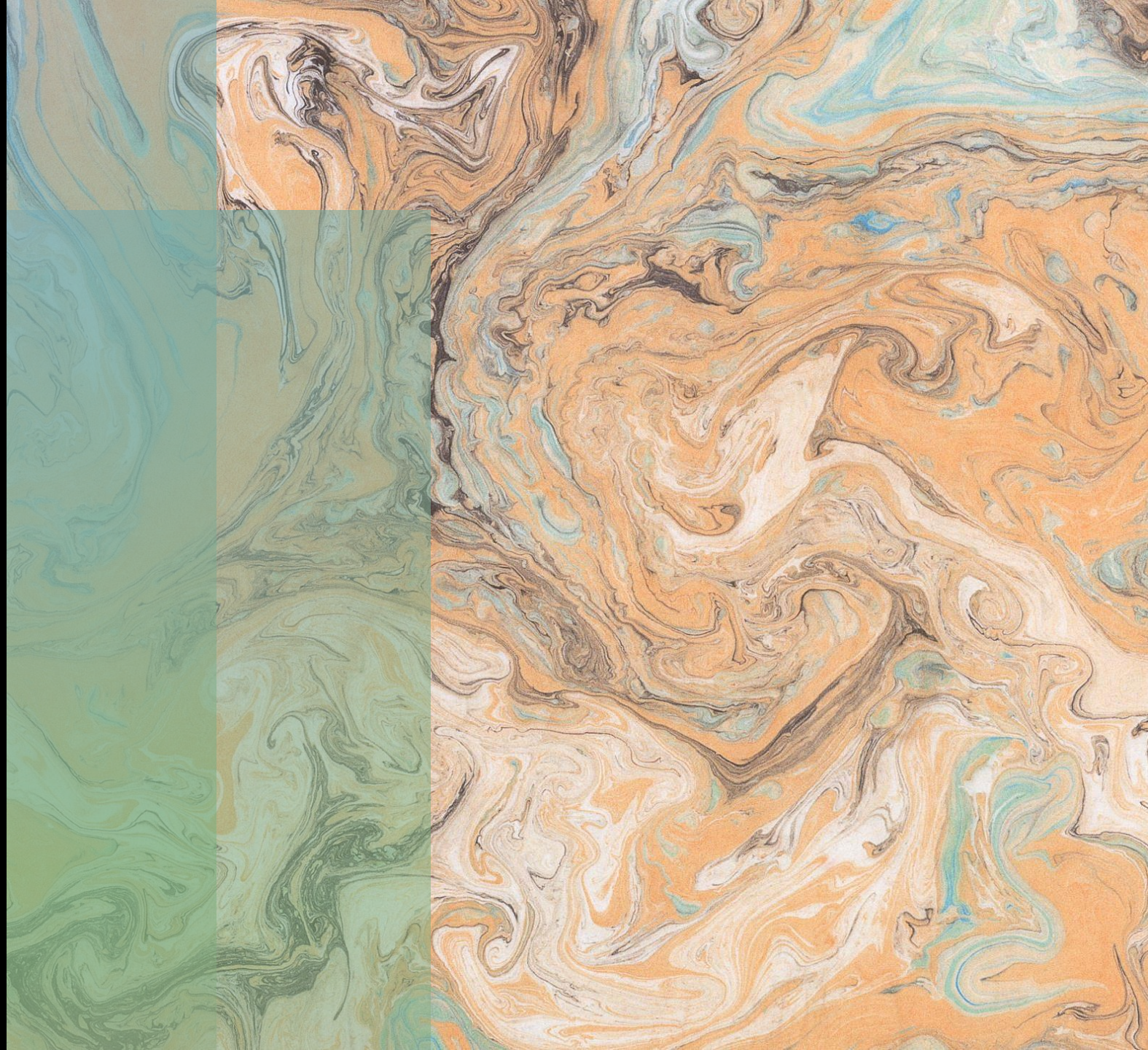
Recent development in acute marine pollution modelling: IMAROS and MANIFESTS

S. Legrand

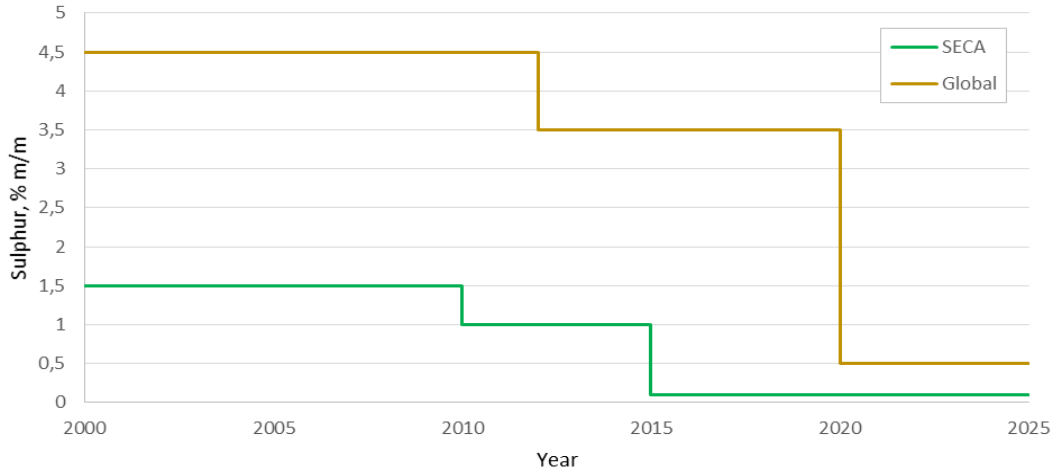
NOOS AM 2021



Very-low and Ultra-low Sulphur Fuel Oil

- Present changes in IMO regulations to reduce air emissions from ships have resulted in a *"new generation"* of fuel oils.
- Laboratory and basin testing so far revealed a substantial diversity of the fuel oils with regard to physical and chemical properties, as well as to toxicity.
- A ship incident involving this new generation fuel oil may challenge oil spill response operations, as it might be difficult to recover the oil with conventional oil spill response equipment and methods.
- Limited efficiency of oil spill response may in turn lead to adverse environmental impacts.

MARPOL Annex VI:



Limits on the sulphur content of fuel to be used inside and outside SOx Emission Control Areas (SECA). Alternatively, approved abatement methods must be applied.

IMAROS website

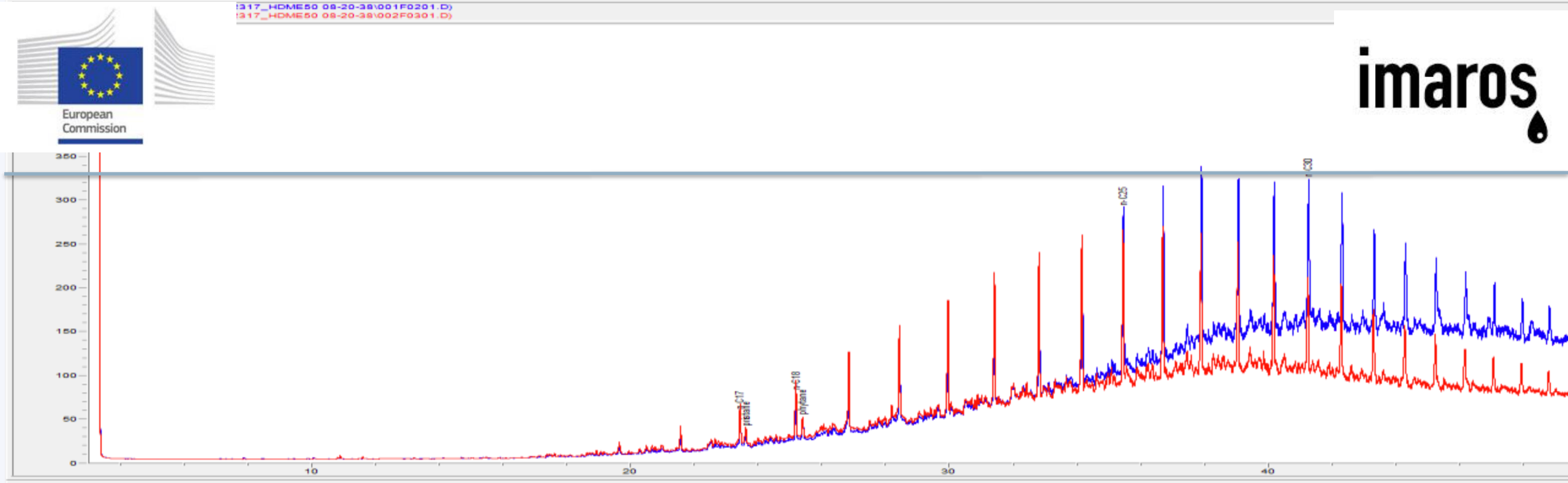
Project partners

Number	Role	Name	Short name	Country
1	COO	Norwegian Coastal Administration	NCA	Norway
2	BEN	Swedish Coast Guard	KBV	Sweden
3	BEN	Institut Royal des Sciences Naturelles de Belgique	RBINS	Belgium
4	BEN	Royal Danish Navy Command	RDNC	Denmark
5	BEN	CEDRE - Centre de Documentation de Recherches et d'Experimentation sur les Pollutions accidentelles des Eaux Association	CEDRE	France
6	BEN	Transport Malta	TM	Malta

Overall objectives

- The overall aim is to develop recommendations for oil spill response to the new generation of fuel oils
- Identify best methods for response at sea as well as on shorelines
- Increase knowledge to understand potential environmental impacts from an accidental spill

Photo: Kustbevakningen



Project management

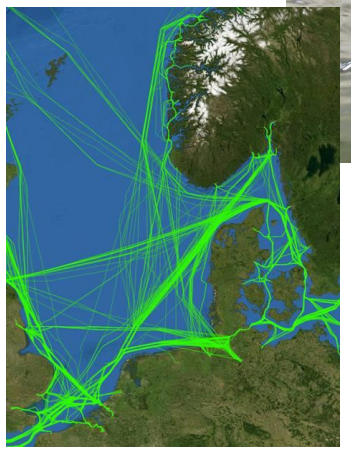
Compilation of knowledge

WP 3

Chemical characterisation

WP 4

Response options



Photos: SINTEF, Kystverket

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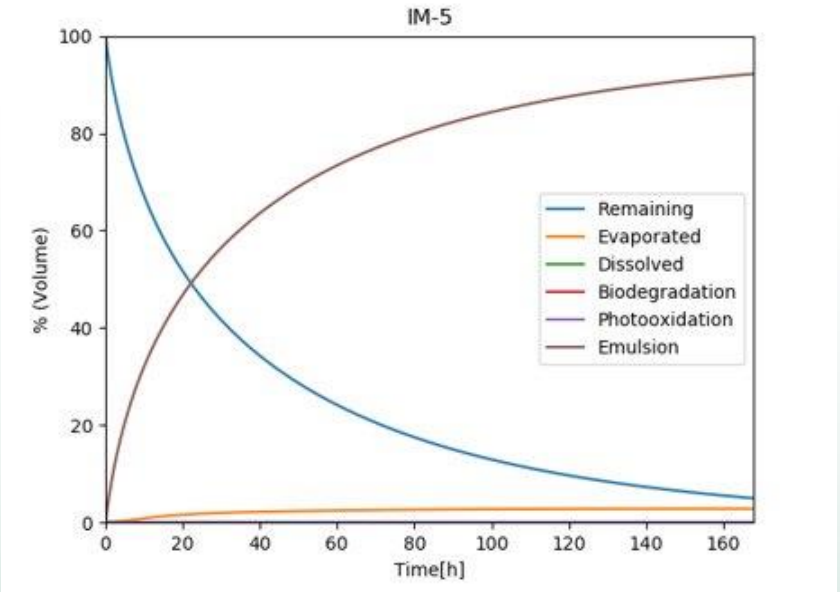
imaros

Assessment efficiency of the existing parametrisation to simulate ULSFO and VLSFO weathering

Implementing a 0D "toy model" for the weathering of oil (and other chemical) spill at sea, in python, with the following processes:

- Evaporation
- Emulsion
- Dissolution
- Volatilization
- Degradation (photoxidation + biodegradation)

} Multiple parametrization available



Oil weathering : physical and chemical change occurring in the oil while in the environment.

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The model use a pseudo component approach

Oil properties

Global properties:
- Viscosity
- Density
- ...

Pseudo components:

- Pseudo component 1
- Pseudo component 2
- Pseudo component 3

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Composition (% weight)
C_1-C_4 (dissolved gas)
C_5-saturates (n-/iso-/cyclo)
C_6- saturates (n-/iso-/cyclo)
C_7- saturates (n-/iso-/cyclo)
C_8- saturates (n-/iso-/cyclo)
C_9- saturates (n-/iso-/cyclo)
Benzene
C_1-Benzene
C_2-Benzenes
C_3-Benzenes
C_4 & C_5-Benzenes
C_{10}- saturates (n-/iso-/cyclo)
C_{11}-C_{12} (total saturates + aromatics)
C_{13}-C_{14} (total saturates + aromatics)
C_{15}-C_{16} (total saturates + aromatics)
C_{17}-C_{18} (total saturates + aromatics)
C_{19}-C_{20} (total saturates + aromatics)
C_{21}-C_{25} (total saturates + aromatics)
C_{25}+ (total)
Naphthalenes 1 (C_0-C_1 alkylated)
Naphthalenes 2 (C_2-C_3 alkylated)
PAHs 1 (medium solubility)
PAHs 2 (low solubility)
Phenols (C_0-C_4)

Properties:
- Vapor pressure
- Density
- ...

Properties:
- Vapor pressure
- Density
- ...

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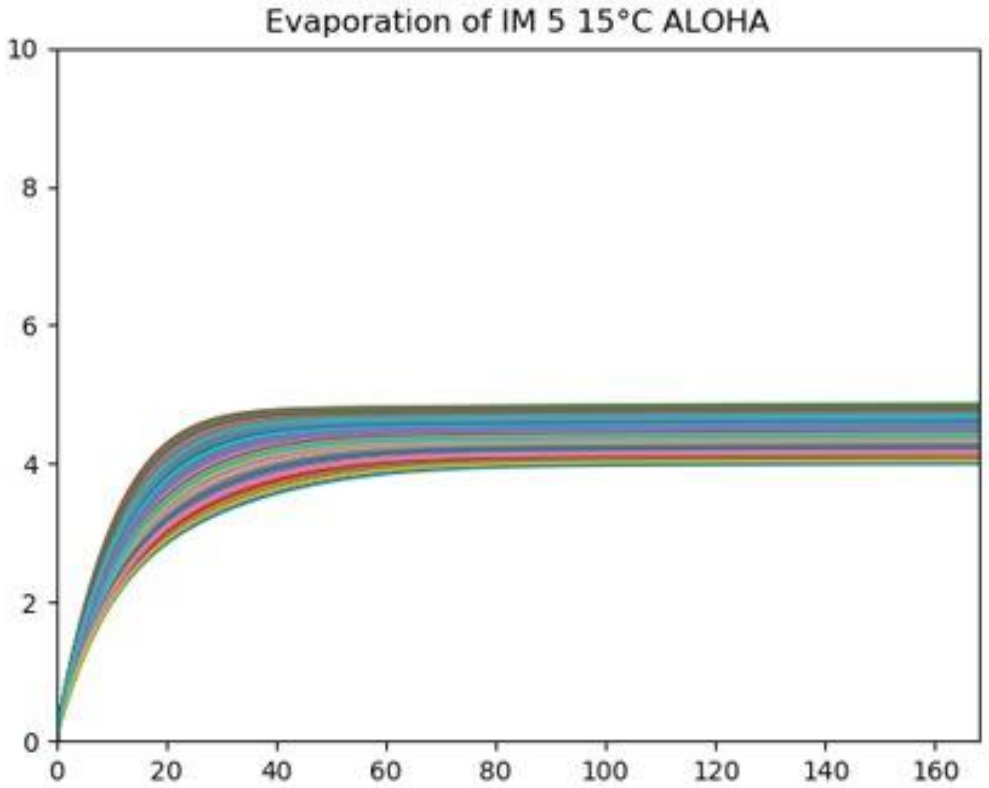

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Oil can be transposed using distillation curve, and other chemical using their properties

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Model validation with polludrome experiments

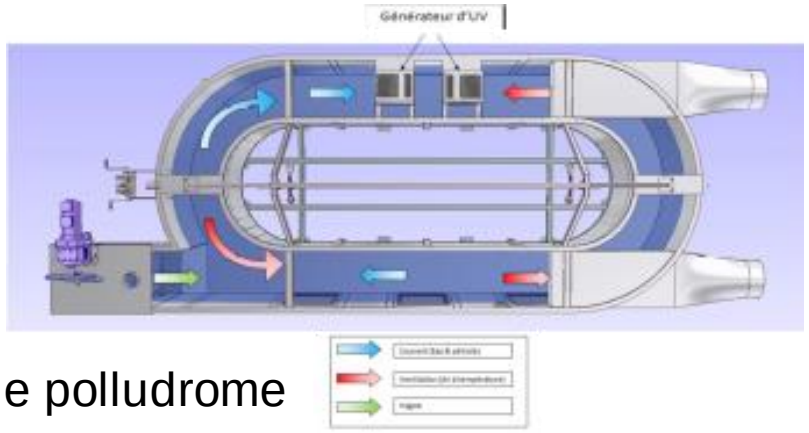
The polludrome is model and 13 samples from previous accidents or from the industry will be tested

- Trying to be as close as possible to the polludrome of CEDRE
  - Wind of 5 m/s
  - Depth of 0.9 m
  - Volume of water of 7 m³
  - Surface of 7.78 m²
  - Current speed of 0.4 m/s
  - Wave height of 0.75 m
  - Volume of oil spill of 0.02 m³ (20l)
  - Temperature of 5 or 15 ° C
  - Pasquill stability class "C"

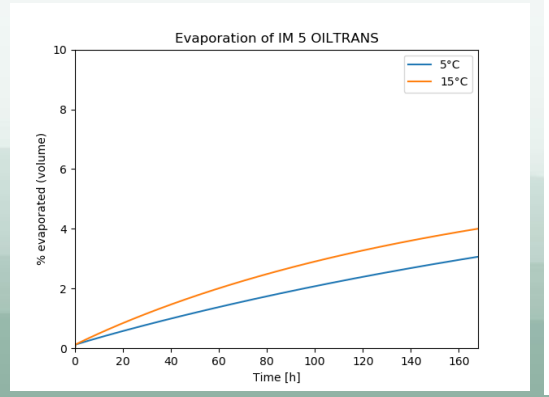
Using the IM5 (wakashio oil)

The oil is represented as a linear sum of the OSCAR fractions in it

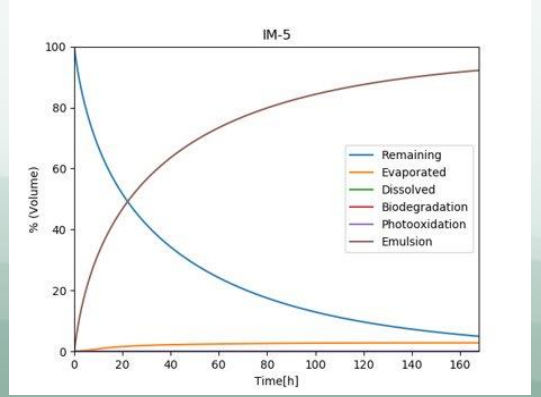
The viscosity is described for the entire oil (but not used for the moment)



The polludrome



Without emulsification



With emulsification

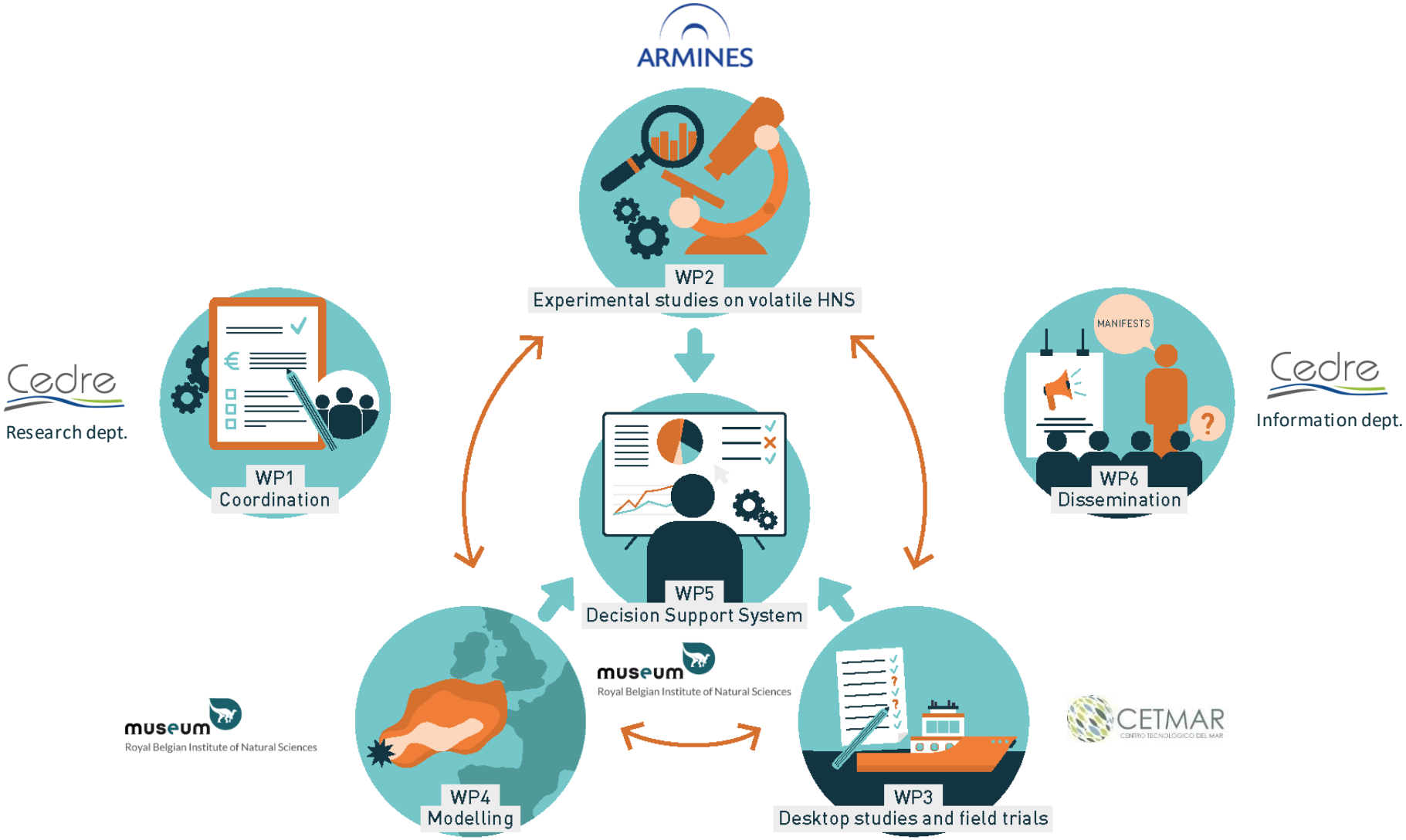
- The characterization have been already provided and implemented
- Next step => comparison with the results (when available)
- Investigating for a viscoelastic modelling approach for the slick spreading

https://manifests-project.eu/

MANaging risks and Impacts From Evaporating and gaseous Substances To population Safety

MANIFESTS is a project co-funded by the European Union Civil Protection – DG-ECHO, developed in cooperation with RBINS, CETMAR, ARMINES, INTECMAR, MET.NO, IST, PHE and DG-ENV and coordinated by Cedre.

WP structure



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WP4 – Improving Modelling Tools

Sébastien Legrand
Knut-Frode Dagestad, Ligia Pinto, Vincent Gouriou, Laurent Aprin, Ludovic Lepers

WP4 Objectives

Improving modelling tools for evaporating and gaseous HNS

- Developing a module to quickly assess risks of fire and explosion (WP2)
- Developing or improving modelling capacities to simulate atmospheric dispersion processes

Understanding our models' strengths and weaknesses:

- Performing inter-model comparison
- Validating models against data collected in Lab (WP2) and during the field trials (WP3)

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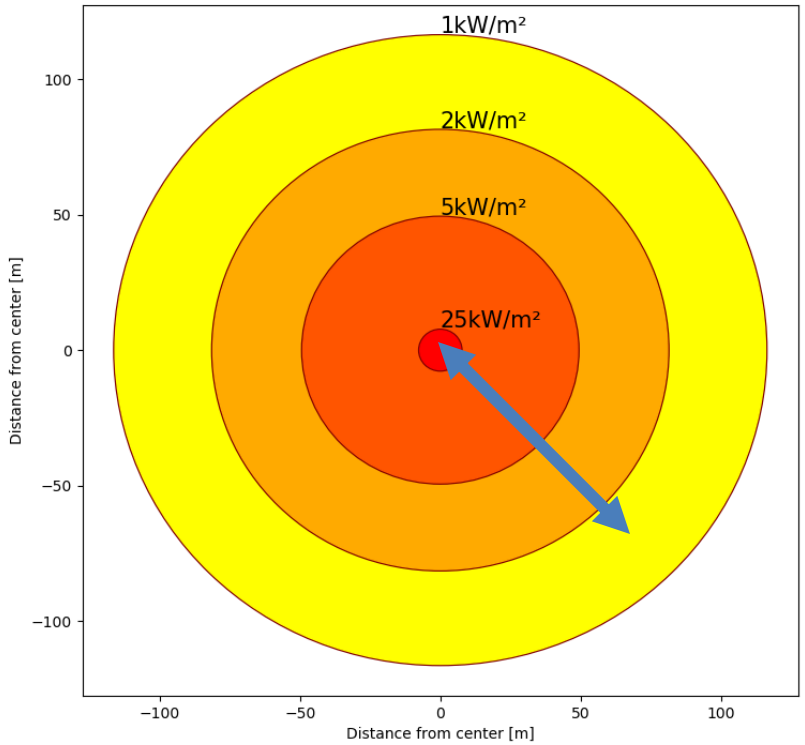
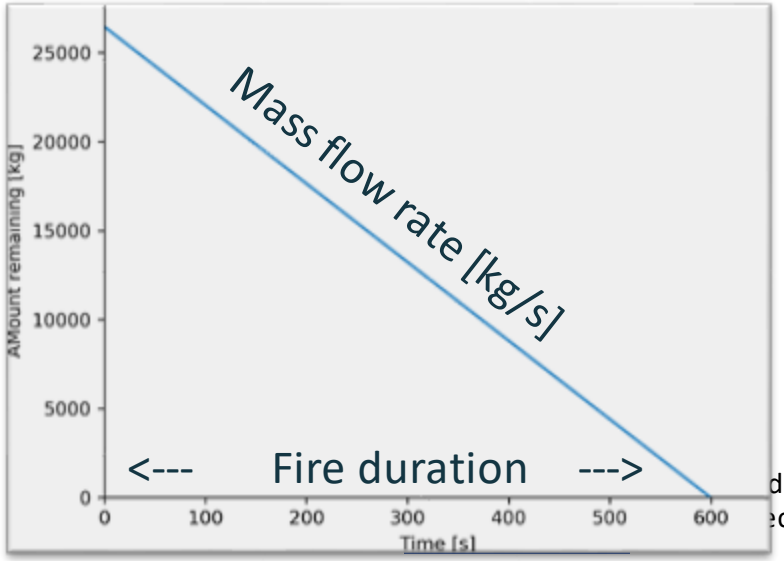
Objectives of fire risk module

1. Compute the **thermal energy flux** as a function of the **distance from the fire source**



2. Compute mass flow rate -> **estimate fire duration**



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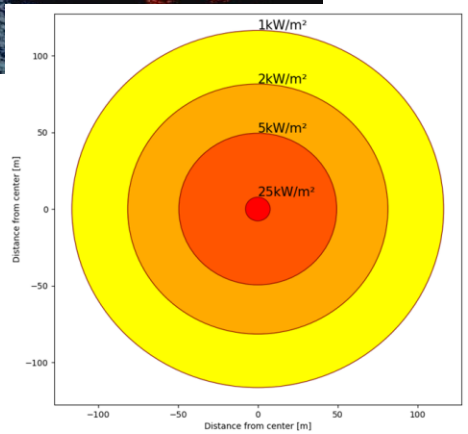
Fire module: How it works

Flux = initial_flux*view_factor *transmisivity

- Initial flux : compute the flux at the fire source, multiple parametrization are available
  - Air temperature
  - Product properties
  - Slick size
  - Windspeed (for the flame height)

- View_factor : model the fire as a cylinder
  - Windspeed
  - Flame height (computed for the initial_flux)
  - Slick size
  - Distance to the source



- Transmisivity : model the energy absorbed by the air
  - Relative humidity
  - Distance to the source

Ref: Heskestad, Thomas, TNO "Yellow book", Mudan and Croce, Brzustowski and Sommer, IT89

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Explosion generate a shockwave

Explosion ≃ Combustion but with an oxidizer well mixed with the fuel (gas cloud, TNT, Ammonium nitrate...)

Explosion in the port of Beyrouth in 2020

Shockwave : rapid change in pressure propagating in the fluid

Rapid release of energy cause a shockwave

Can have disastrous consequences...

Overpressure [bar]	Effect
0.05	Irreversible harm
0.14	Death possible
0.2	Death likely
0.3	High structure impact

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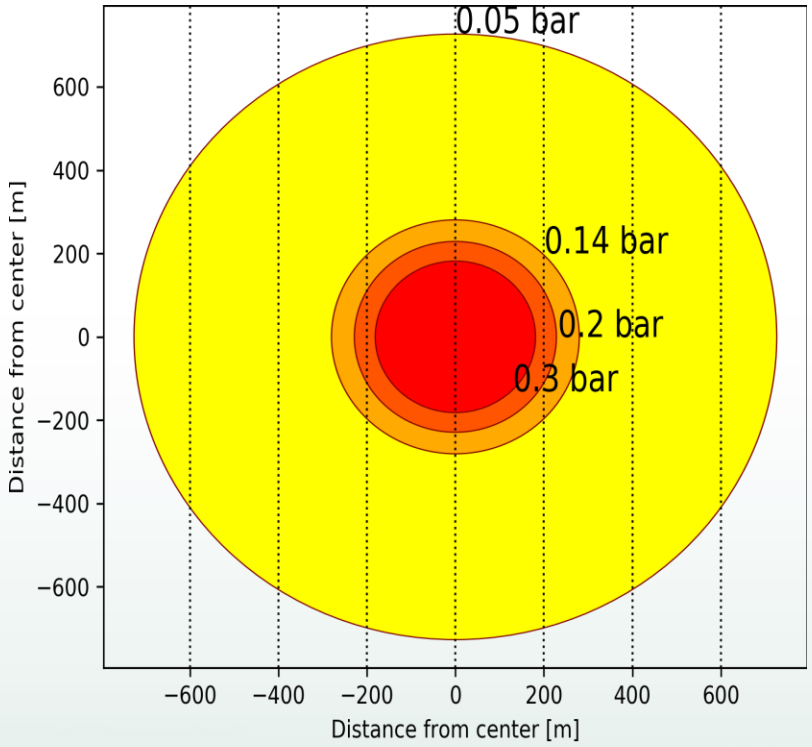
Explosion module

The shockwave strength depend on the energy release and distance of the source

Using TNT equivalent

- Computing the energy release (combustion with a yield)
- Converting this to a distance for a pressure given

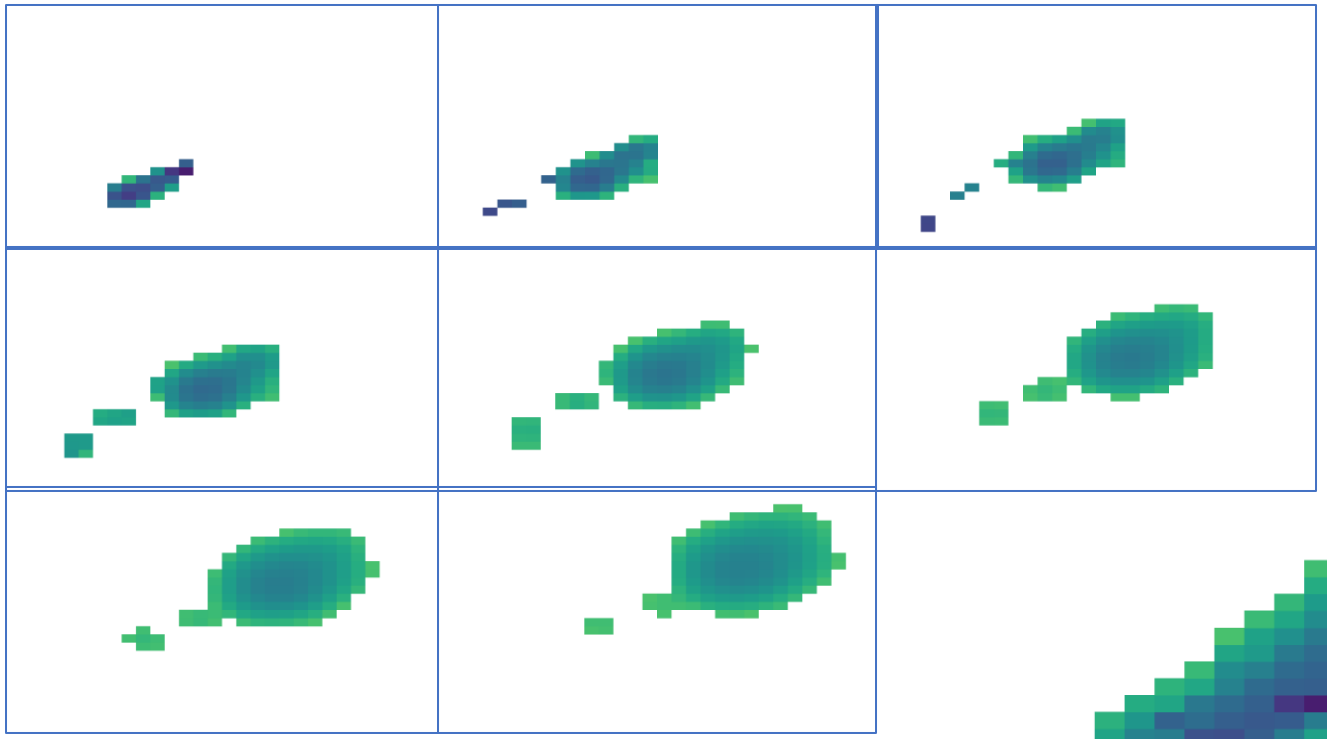
Overpressure [bar]	Distance [m]	Effect
0.05	722	Irreversible harm
0.14	276	Death possible
0.2	224	Death likely
0.3	177	High structure impact



For open area (sea...)

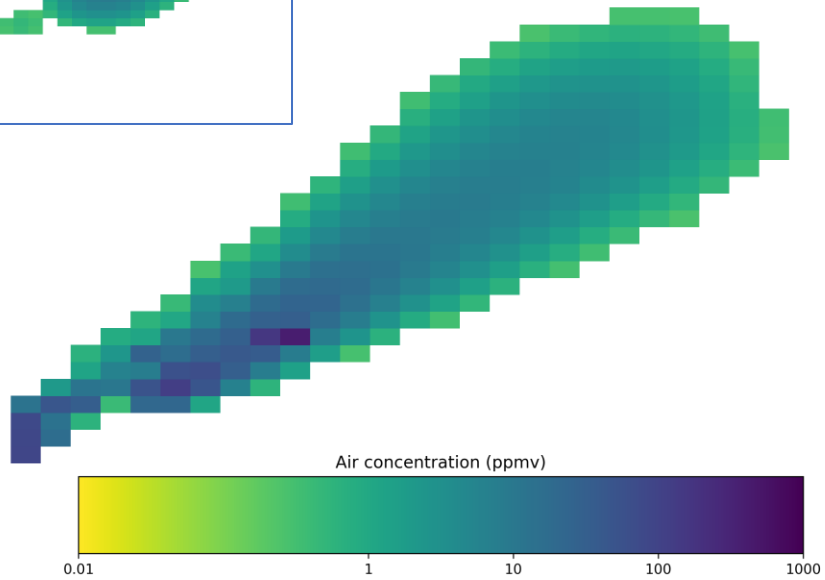
OSERIT atmospheric dispersion module

- advection by displacement of Lagrangian particles ;
- dispersion based on a gaussian distributions centred at each particle



Plot every 6 hours, interval between plot can be modified, such as the resolution

Maximum value at each cell of the grid for the entire simulation



Concentration plot with AEGLs value possible
Close-up view only on the released area possible
Several altitude possible

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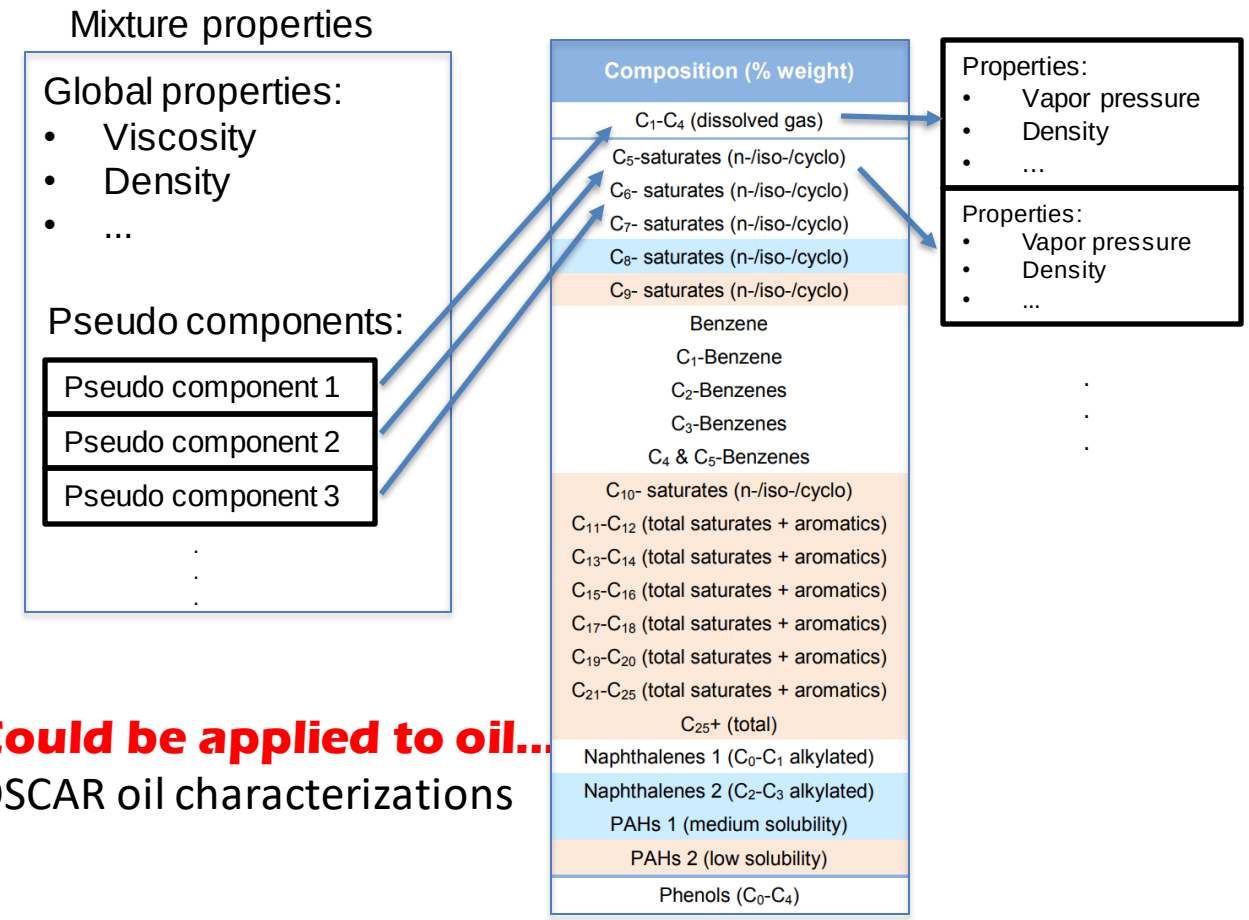
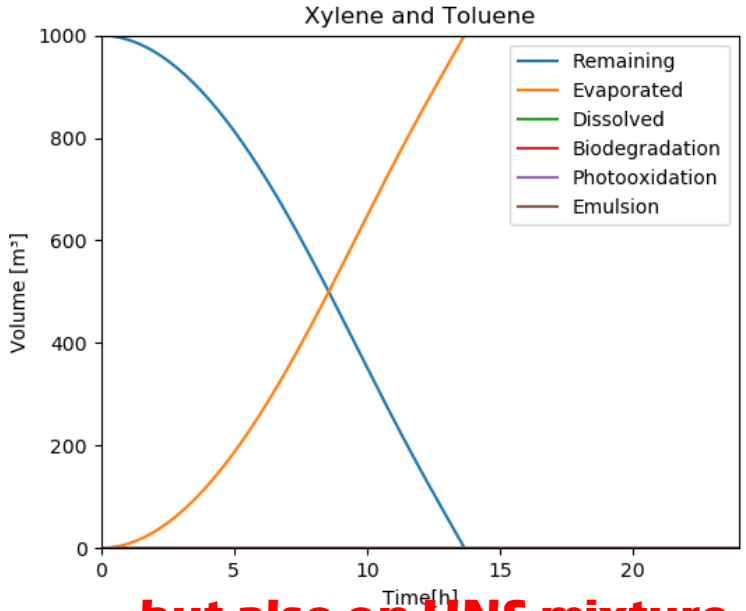
The IMAROS pseudo component approach to simulate chemical mixture



Could be applied to oil...
OSCAR oil characterizations

Assumption : components do not interact with each other!



... but also on HNS mixture

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More model intercomparison and validation in 2022

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WP5 – MANIFESTS Decision Support Systems

Sébastien Legrand

Pedro Montero, Ligia Pinto, Samuël Orsi

MANIFESTS

T5.2 Data base

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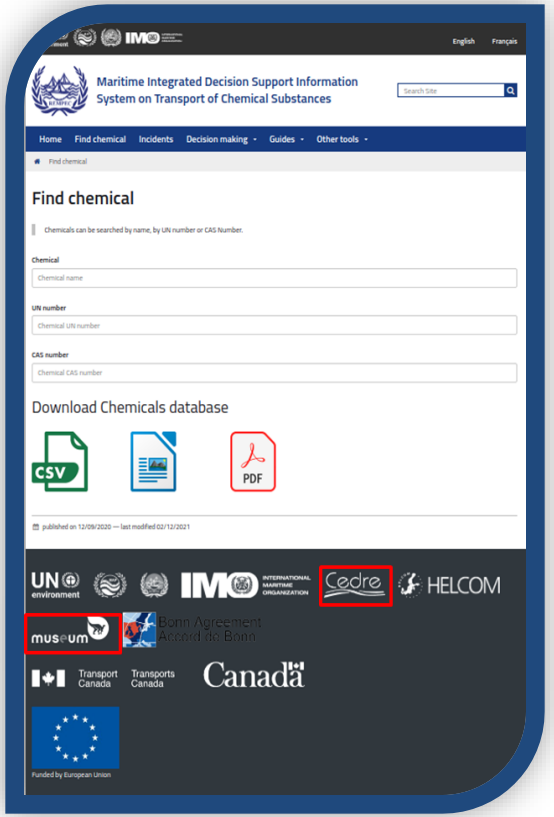
Agreement on principle to merge HNS-MS data base with MIDSIS-TROCS 4.0



Cooperation with WP2

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T5.3 Development of model web applications

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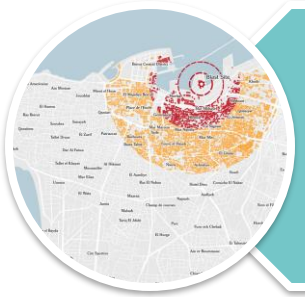

Explosion risk app
(pressure blast and over-pressure contour)

Fire risk app
(thermal heat flux contour, timeseries of remaining HNS volume, etc.)

Linked with models developped in T4.1

HNS drift, behaviour & fate app
(trajectories, mass balance, concentration maps, AEGL contour levels, PNEC contour level, exposure times, etc.)

Must be interfaced with national model (out of the scope of the task)

MANIFESTS

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T5.1 Resource's Centre

What is?

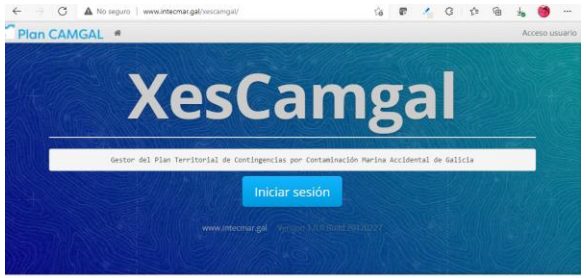
A tool that **collates** and **gives access** to all relevant **sources** of information and knowledge needed by a regional or national maritime authority in order to

- manage a maritime pollution event.
- assess risks and to plan.
- follow response activities.

Collecting **diverse** kind of sources:

- Contingency management information: **POLREP & SCAT.**
- **On-field information**: pictures, assets locations, etc.
- **Numerical forecasting**: meteorological, hydrodynamic, waves and HNS dispersion.
- **Former information**: coastline, protected areas, risk assessment, etc.

Resource's Center



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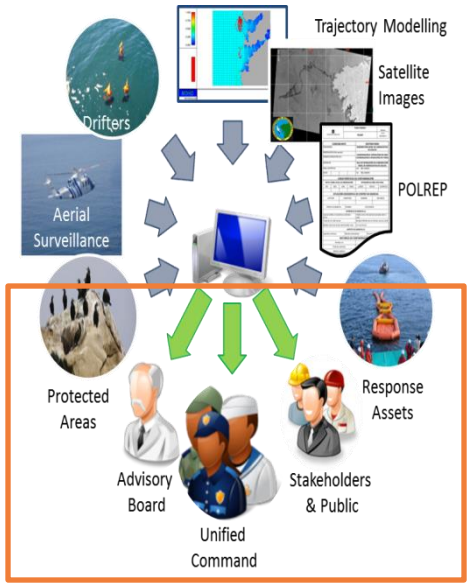
T5.4 Common Operational Picture

What is?

An information system allowing a 2-way same **information exchange** between the crisis committee and the response teams.

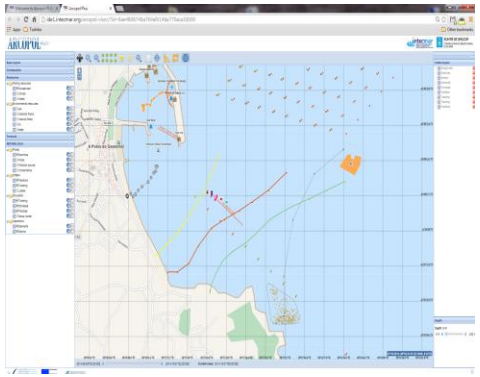
- Providing an interface to **fill and submit standard reports**, pictures, short videos.
- Allowing every **COP user to read the exchanged information** and eventually comment them.
- Synthetizing all the available information on a **dynamic map.**



Common Operational Picture

Requirements

- **User-friendly**, without user friction.
- Responsive application: for **mobile** and computers.
- **Transferable:** opensource, adaptability, documented, etc.



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