Understanding the Impact of Cruise Ship Emission in Urban Harbour Using CFD Modelling in CAPNAVIR Project

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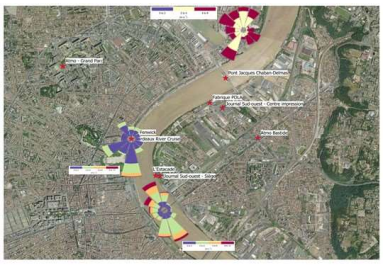
Project CAPNAVIR

Target: Improve the knowledge on emission factors from cruise ships

- Health in cities/harbours
- Background regulation and methodology (MARPOL - OMI) NOx (Tier III since 2016 / NECA), fuels for SOx (sulphur reduction/ SECA)
- Focus on pm10, pm2.5 and content on BC and Ultrafine particles UFP

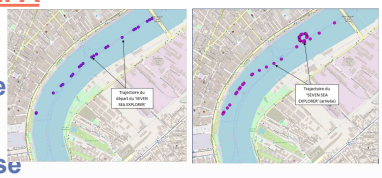


Phase	Navigation/Manœuvre			Mooring		
Mass rate (kg/s)	9.37			3.58		
Temperature(°C)	300			300		
Species	NOx	PM10	SO2	NOx	PM10	SO2
Mass fraction (%)	0.296	0.0269	0.0667	0.3994	0.0092	0.0133
Stack height(m)	40.5			40.5		
Speed (m/s)	10			10		

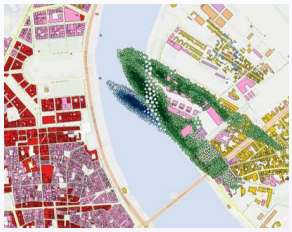
Preparation phase with CFD modelling and EMEP/EFA

- 3D setup – ship trajectories (AIS) and mooring position
- 1.A.3.dNavigation-shipping-GB2013 Tier 3 ship moveme and methodology
- Flow and transient dispersion for dominant weather case
- Selection of relevant locations for sensors systems

pm10 → pm2.5 → %BC (0.3) and % ufp



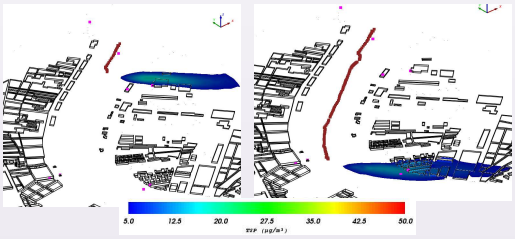
Moving source along AIS position

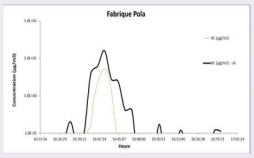


Steady source for two ship positions

Ship name	Jauge brute (tonne)	Main Engine power (kW)	Secondary engine power(kW)	Fuel	Type de motorisation
ARTANIA	44697	29160	7290	Diesel	Medium speed
AMERA	39051	21120	5280	Diesel	Medium speed
SEVEN SEAS SPLENDOR	56182	32000	8000	Diesel	Medium speed
WORLD VOYAGER	9934	5330	1332,5	Diesel	High speed
MARINA	66084	42000	10500	Diesel	Medium speed
SILVER SPIRIT	39444	26100	6525	Diesel	Medium speed
CRYSTAL ENDEAVOR	20449	12000	3000	Diesel	Medium speed

Artania Arrival





Campaign 09-10/21 - Model/data comparison

- 7 cruise ships – analysis for each individual ship and operation
  - arrival/departure phases: moving source ~30mn / 35% of nominal power
  - mooring phase: steady source >24h with 55% power for secondary engine
- Continuous measurements for SOx, BC, ufp particles at several location
- Focus on transient plume signature for model/data comparisons and emission re-assessment

Conclusions for emissions factors assessment

- Order of magnitude correct for Emep tier3 process with ad hoc data per ship (Nox, Sox, TSP)
- Conversion parameter (factor 0.3) to BC needs to be adapted per ship (w/wo scrubber)
- Ufp content needs to be revisited as far as secondary production of aerosols from VOC content contributes to distant measurements.