THE SCIPPER PROJECT

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Shipping Contributions to Inland Pollution Push for the Enforcement of Regulations

Monitoring shipping emissions with various techniques towards ensuring compliance to the new regulations:

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Background

Emission Control Areas (ECAs) in EU waters

- Baltic Sea
- North Sea
- English Channel

Limits

- **1.1.2015:** 0.1% max FSC in ECAs
- **1.1.2020:** 0.5% max FSC globally outside ECAs
- **1.1.2021:** NO_x Tier III in ECAs

Developments

- **1.1.2025:** Med Sea becomes a SECA
- Voluntary use of LFO in the Arctic region

There is the need to monitor emissions during real sailing conditions to make sure vessels comply with environmental regulations.

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Objectives

Characterise the performance of different techniques for measuring vessel emission levels of SO_x and NO_x in actual field campaigns

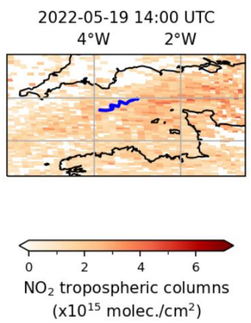
Identify current emission levels of vessels under real sailing conditions

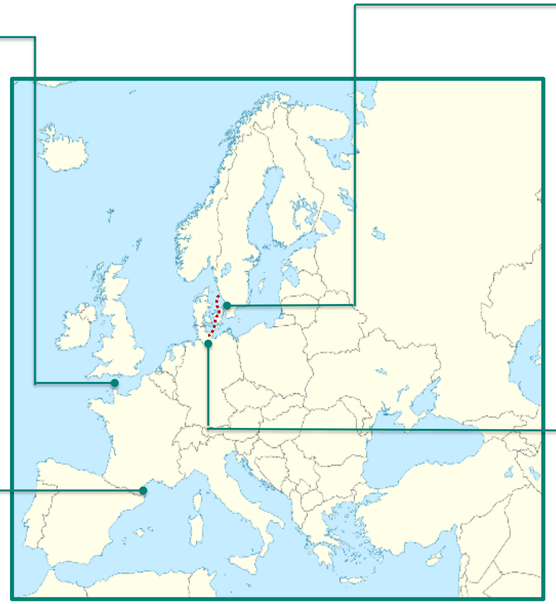
SCIPPER Campaigns & Techniques

Western English channel (GB)

Remote sniffers vs **SATELLITE**

40 plumes





Gothenburg (SE) to Kiel (DE)

On-board sensors assessment

7 days of operation,
> 30 sensor systems

Marseille (FR)

DRONES & **PATROL** vessels

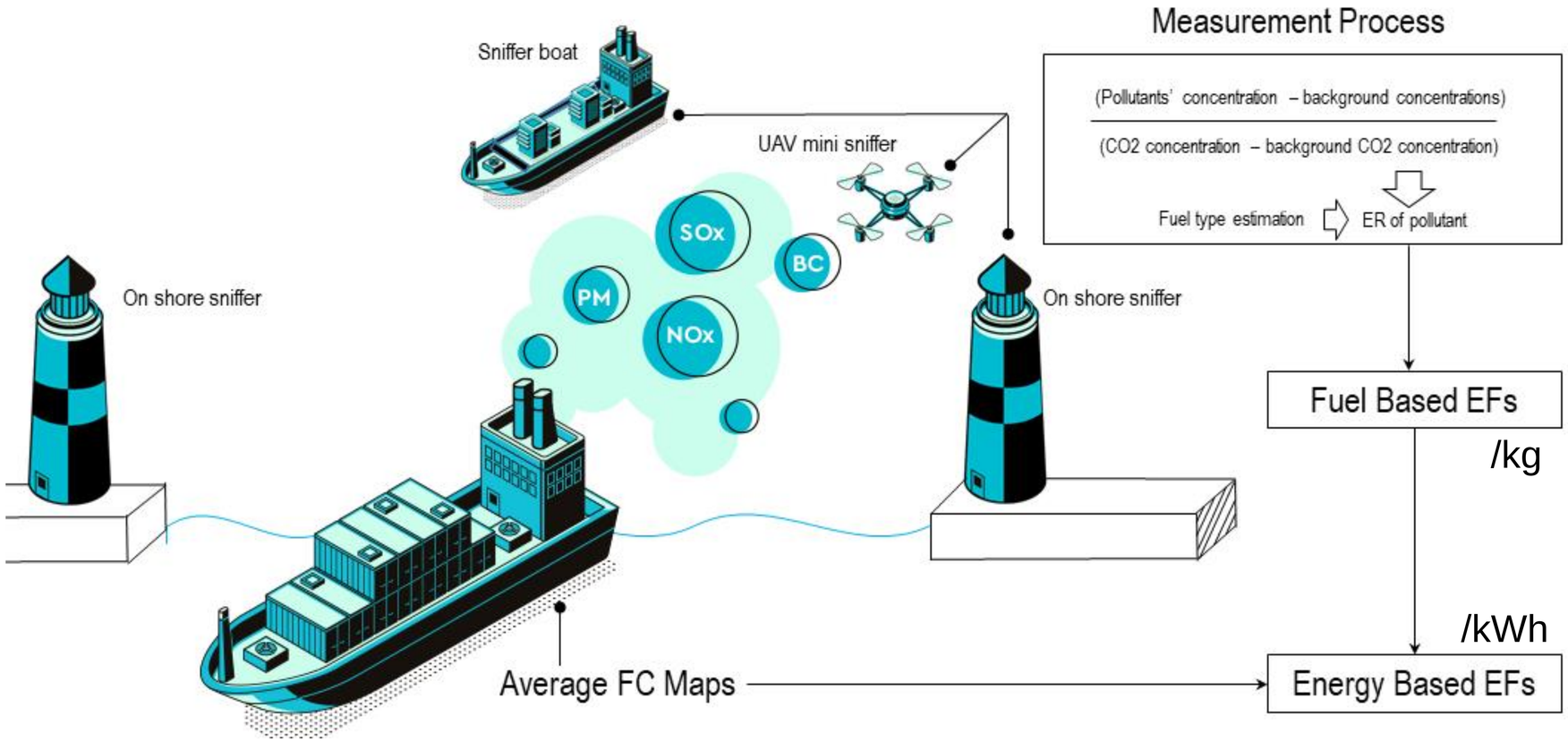
>150 plumes measured with sniffer boat and UAV

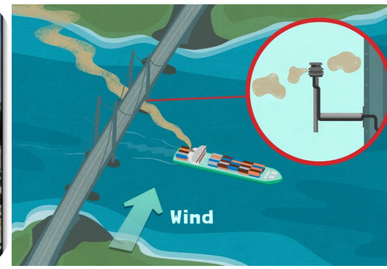
Hamburg - Wedel (DE)

SNIFFER intercomparison campaign

> 900 plumes, 55 fuel samples

‘Sniffer’ systems

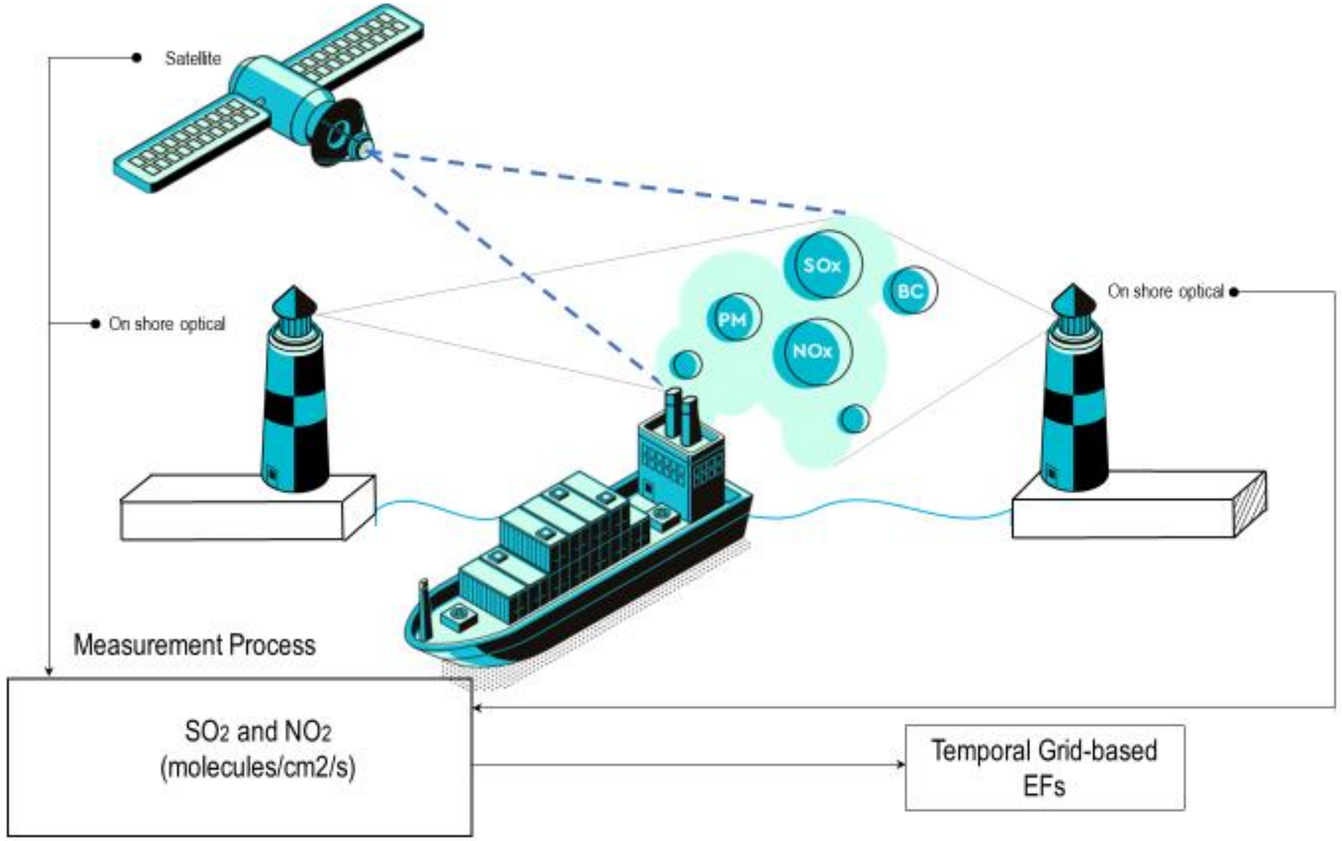




Remote sniffer

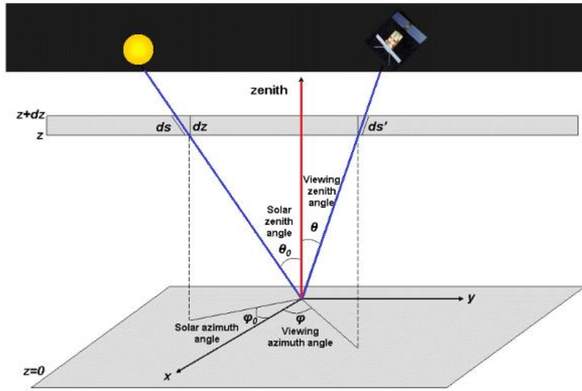
Sniffer on-board a UAV (Drone)

Remote optical detection (incl. satellite)



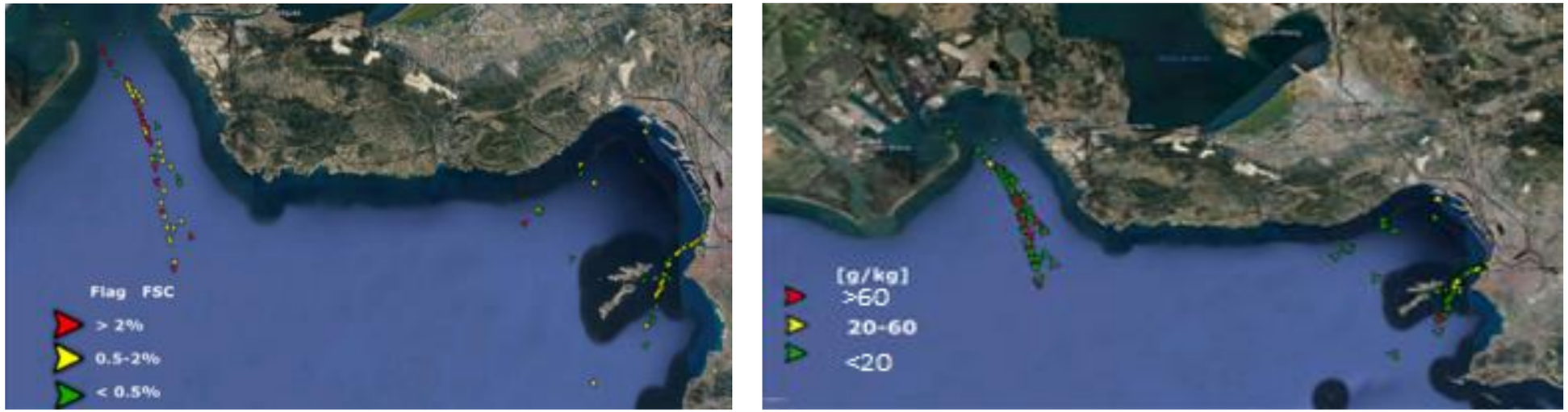
Zenith-sky
DOAS

Satellite DOAS
on Sentinel 5P
(TROPOMI)



Port of Marseille (2019)

Pre-global FSC campaign with remote techniques demonstration



First successful measurement of SOx and NOx emission levels using drones and patrol vessels

Very variable emission levels for different ship types

Port of Marseille (2021)

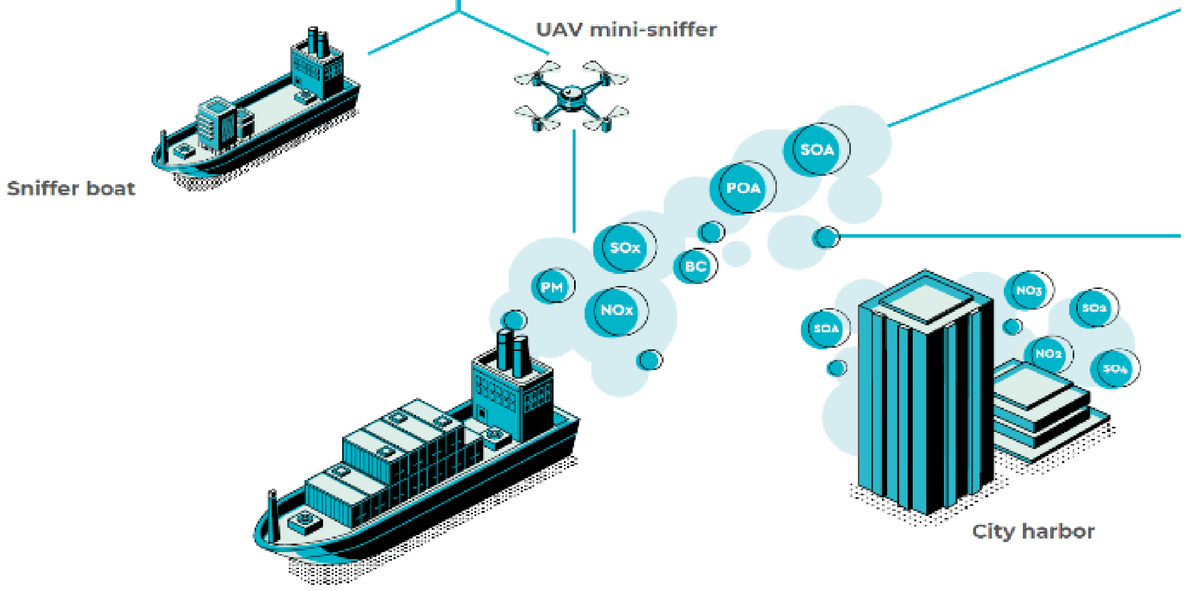
Post-global FSC campaign incl. remote techniques and plume ageing

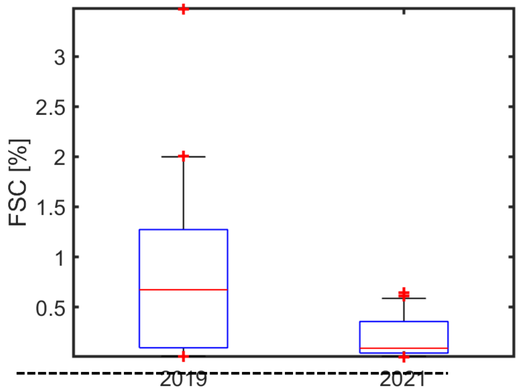
FSC detections after the 2020 cap enforcement. Comparison with the status before the regulation

Additional evidence on comparison of remote techniques

- **FSC regulation appears particularly effective, but violations continue**
- **Standard sniffer and drone mini-sniffer presented good agreement**

Campaign / date	Plumes measured	Plumes exceeded 0,5% FSC
Marseille (2019)	21	10 (48%)
Marseille (2021)	22	1 (4,5%)





In the Mediterranean Sea, there are still **violations** of FSC limits:

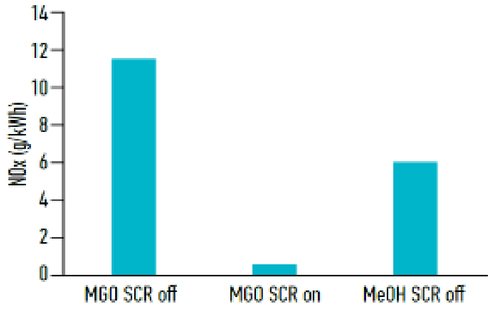
need for monitoring for SECA enforcement

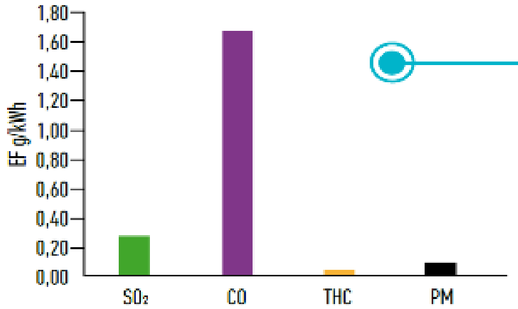
Ferry ship in a western Baltic sea route (2021)

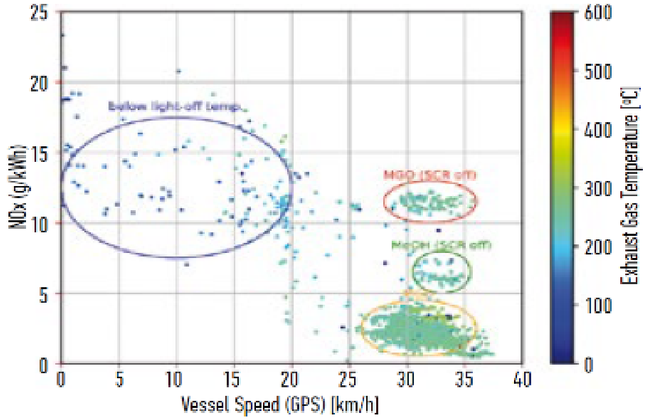
On-board campaign

Characterization of ship emissions with high-end equipment.
Results at the 70% engine load for MGO/Methanol use and SCR on/off

- **NOx emissions reduced by half with methanol combustion**
- **Almost 95% efficiency in NOx reduction is observed with SCR in MGO**
- **Emission values detected are rather typical of the engine technology that is found installed on such ferries**







NOx emission performance monitoring with low-cost sensor boxes

- **There is good potential for several sensor systems tested**
- **Clear identification of ship emission performance in various operating conditions**

On-board sensors can be used for monitoring ship emissions, durability remains a concern

Two observations:

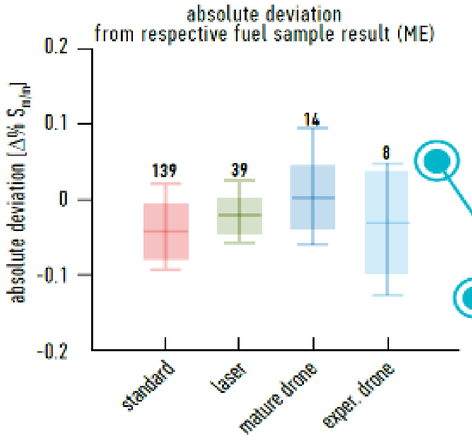
- MeOH can lead to significant NOx reductions evens w/o SCR
- SCR not operational for most operation conditions close and in the ports

Port of Wedel/Hamburg (2020)

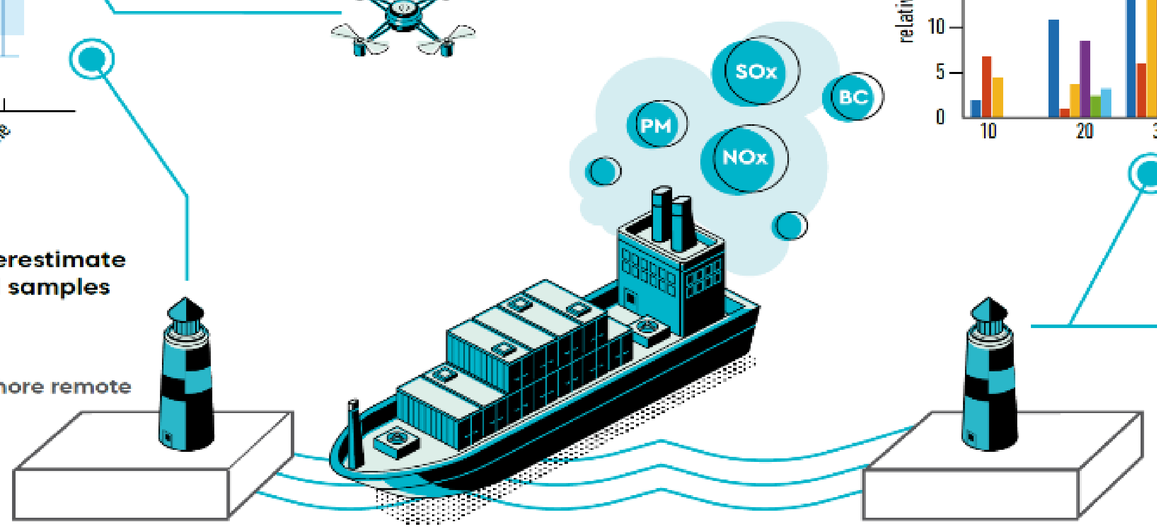
Sniffer intecomparison campaign

FSC identification by remote sensors, in relation to fuel sampling results

Sulphur content, as analyzed in samples, was found to comply with the new regulations

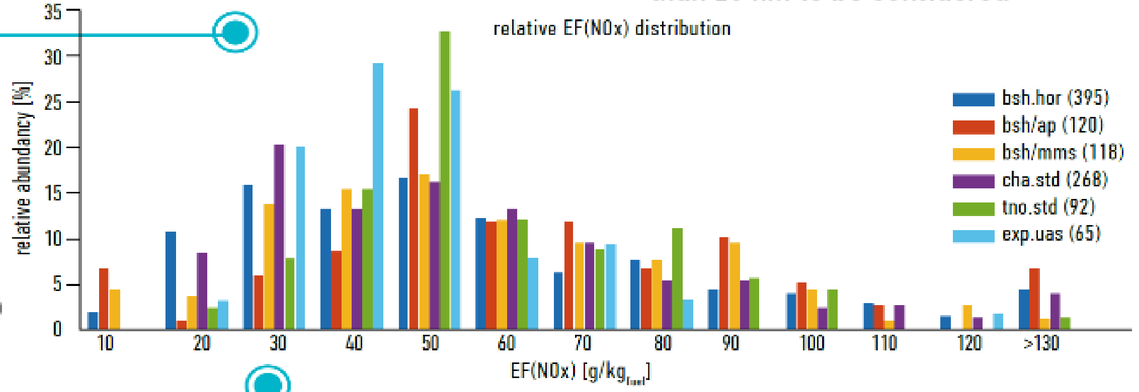


Remote techniques slightly underestimate the FSC, in reference to the fuel samples characterization



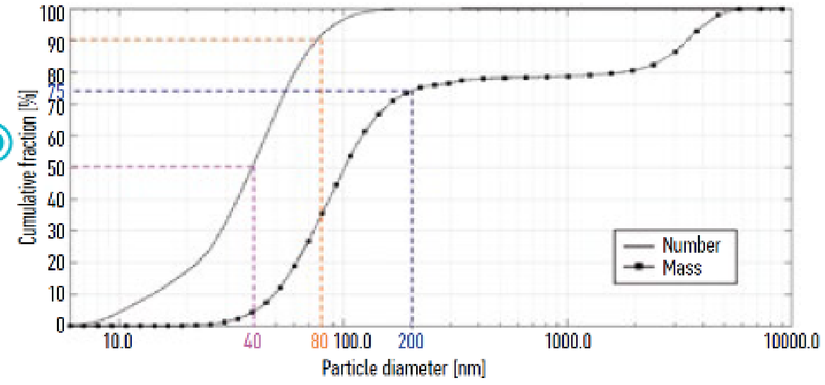
NOx EFs detection frequency with various remote instrumentation

Distribution of high, medium and low NOx emitters in an area can be sufficiently identified by all the remote instrumentation



Analysis for PM & PN

Effective mitigation of PM require regulation of particles larger than 50 nm. For PN, even smaller particles than 20 nm to be considered



Effectiveness of NOx Tier III

- SCR not operational at low load conditions due to low exhaust gas temperatures
- Performance of SCR questionable in real sailing conditions
- SCIPPER observed 2/3 of Tier III vessels violating expected Tier III NOx in the North and Baltic Seas
- Violations for 50% of the measurements were 2× to 5× of the emission limit

Evaluation of techniques

Technique		On-Board	Small UAV	Patrol-Vessel	Aircraft / Large UAV	Fixed Station	Fixed station	Optical - Satellite
Method		Sensors	Sniffers				Remote Optical	
Criteria	Most widespread detection techniques	SO_x (IR or DOAS) NO, NO_2 (Electrochem.) CO_2 (NDIR) BC/PN (various)	SO_2 (Electrochem., DOAS) NO, NO_2 (Electrochem.) CO_2 (NDIR), New concepts	SO_2 (UV Fluorescence) NO, NO_2 (CLD) PN (CPC) CO_2 (NDIR, CRDS)			SO_2 (DOAS, IR Iradiance) NO_2 (DOAS)	NO_2, SO_2 (DOAS)
	Experience	Yes, Scrubber vessels	DK, FI, EMSA	DE, FR, SE	EMSA, BE, FI, (SE)	DE, NL, SE, DK, FI	DE	FI, GR, NL
	Monitoring location flexibility	On-board	Yes (restrictions)	Yes (restrictions)	Yes (restrictions)	No	No	No (5.5×3.5 km^2, depends on pass)
	Open Sea surveillance	Yes	No	Yes	Yes	No	No	Yes
	Availability of results	Can be on-line	Immediately	Immediately	After landing	Immediately	Immediately	Post-processing
	Suitable sites	vessels	line of sight (smaller harbour, canal, …)	ports, busy lanes	coast and open sea	major shipping lane (harbour, canal, pole, bridge,…)		Away from other major sources
	Operation time	24/7 (automated)	daylight	24/7	daylight	24/7 (automated)	24/7 (automated)	daylight/weather
	Resources (cost, personnel) / vessel	High	Low-Medium	Medium	High	Low	Low	Medium (currently processing-tedious)
	Costs - NOT prices - (Equipment & monitoring)	500-7.500 €/ship	140-350 €/per ship pass	N/A	Manned Aircraft: 200-870 €/per ship pass Large drone: 400-1.000 €/per ship pass	20-770 €/per ship pass	N/A	100 €/per ship pass

Conclusions

- **On-board systems** are sensitive and provide real-time information but development is required to achieve long-term durability

- **Sniffers** are mature technology and are able to measure SOx and NOx with good accuracy and sensitivity

- Operational systems have decreased FSC **incompliance** to almost zero but incompliance is present in locations without monitoring

- Monitoring should be **extended to NOx** for Tier III compliance checking. NTE /kg could be adopted for fast screening NOx

Thank you

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