

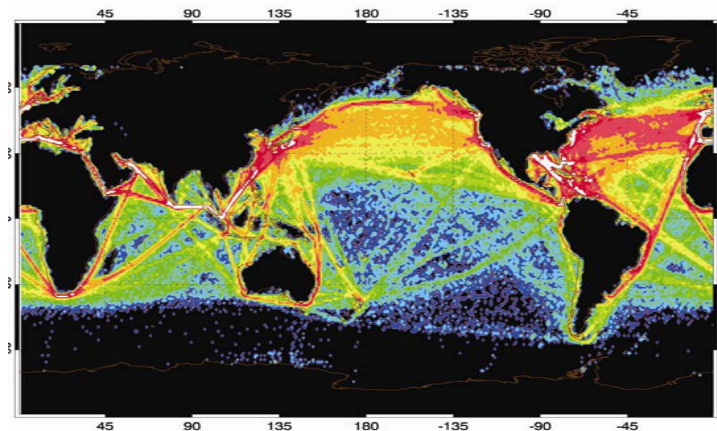
Ship emissions impacts on climate and air quality

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Why global shipping matters

- Worldwide fleet: >100,000 vessels (Lloyd's, 2010) significant emissions source, especially in NH
- Powered by large diesel engines (up to 80 MW) emissions of CO₂; NO_x; SO₂; particulates
- Impacts of global resource need global solution, but impacts are also regional and local



Global ship traffic density

What CSD has done to investigate impacts of ship emissions

- TexAQS 2006 – compiled the most comprehensive data set on in-use ship emission factors
 - included all important gaseous species and many aerosol parameters (a first for some!)
- CalNex 2010 – extensive data set on ship emission factors in an emissions-controlled region
 - conducted a coordinated ship and aircraft based experiment to investigate fuel switching



Benefits from CSD ship emissions research

Emission factors from in-use vessels provide:

- emissions inventory improvement
- informs regulatory agencies on compliance
- informs industry on environmental impacts

FOCUS - Sulfur Dioxide Emissions from Ships

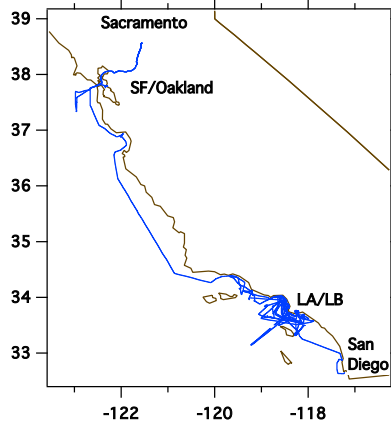
BACKGROUND

- International Maritime Organization (IMO) implements Emission Control Areas (ECA) for SO₂ in Baltic and North Seas (2006)
- California Air Resources Board (CARB) requires low-S fuels within 24 nautical miles (nm) of coasts and inland waters (2009)
- **CARB asks NOAA for information on effects of regulations (2010)**

CalNex study May-Jun 2010

- Led by NOAA and CARB
- R/V Atlantis: NOAA/OAR chartered
- **Marine vessel emissions a CSD focus**

R/V Atlantis cruise track and ports



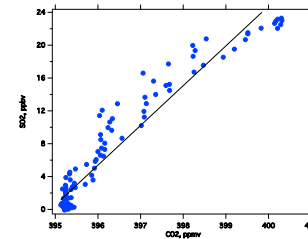
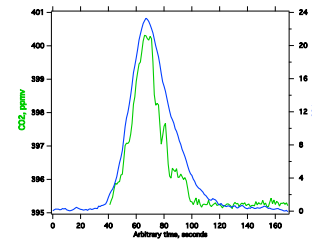
Data into information: mass-based emission factors

MEASUREMENTS

- Correlated CO₂ and SO₂
- CO₂ is measure of fuel burned
- SO₂ only from fuel-S content

ANALYSIS

- Calculate slope of SO₂ vs CO₂
- Slope * 4.6 = Emission factor
- Emission factor/20 = % fuel-S



Emission factors are key inputs for emission inventories

Key ship SO₂ emission results from CSD observations

- emissions from >100 ships measured
- data show full compliance with 1.5% fuel-S limit
- >80% compliance with 0.5% fuel-S limit
- scientific findings provided to CARB

"[NOAA's] scientific findings clearly demonstrate that ships off our coast now emit significantly less sulfur pollution than in the past... This is good news for California and for the nation. When the federal regulations kick in for ships to use low-sulfur fuel, communities throughout America that live near shipping lanes and next to ports will see clean air benefits."

-- California Air Resources Board Chairman Mary D. Nichols

FOCUS – Regulatory Impacts on Ship Emissions

BACKGROUND

- CARB low-S rule drops SO₂ emissions within 24 nm
- Vessel Speed Reduction (VSR) lowers other emissions
- less than 12 knots within 20 nm of ports

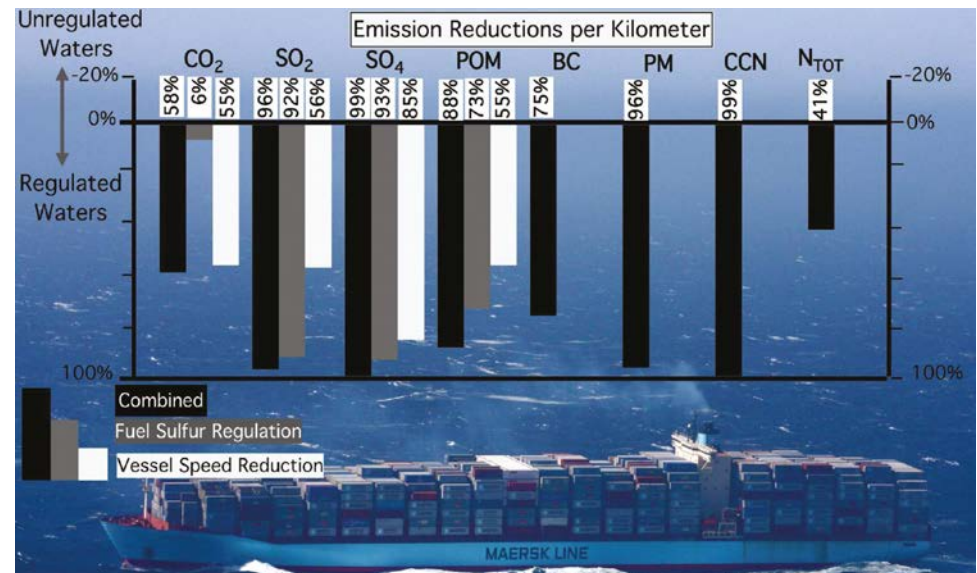
CalNex study May-Jun 2010

- CSD collaborates with Maersk Shipping Line to study emissions effects of fuel quality and vessel speed

Experiment results

- Substantial benefits from fuel switching and VSR
- Emission factors (EF) of SO₂, PM, sulfate, and cloud condensation nuclei reduced by >90%
- Particulate organic material EF reduced by 70%
- Black carbon (BC) EF reduced by 40%

Effect of fuel switching on ship emissions



Lack, D., Cappa, C., et al. (2011). Impact of Fuel Quality Regulation and Speed Reductions on Shipping Emissions: Implications for Climate and Air Quality, *Environ. Sci. Technol.*, 45, 9052-9060.

Findings from CSD-led ship fuel switching experiment

- CARB regulations are effective in reducing most emissions from commercial vessels
- Intended target was AQ improvement in ports and coastal areas, but benefits for climate (lower CO₂ emissions) are also realized

Impacts of CSD Ship Emissions Research

- **IMO Marine Environment Protection Committee (MEPC) has cited CSD publications as scientific basis for additional regulations**
- **Dan Lack (formerly at CSD) has been active in advising IMO/MEPC on BC**
Recent result - scientific definition of BC has been accepted
 - first step in limiting BC emissions from ships
 - recent BC assessment (D. Fahey co-author) was key
- **Consultations with other agencies continue**
US EPA has requested information/advice from CSD and GMD on obtaining emissions data from in-use vessels (compliance)

The poster has much more information and detail!

