A BIOGENIC MARINE SOURCE OF ORGANIC AEROSOLS:

FROM FIELD MEASUREMENTS IN THE AUSTRAL OCEAN

TO MODEL ESTIMATES OF ITS CONTRIBUTION AT A GLOBAL SCALE

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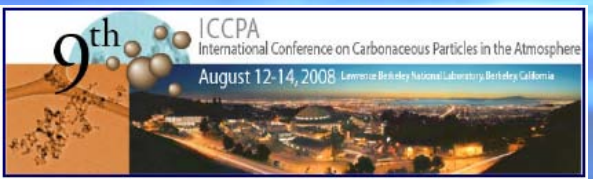
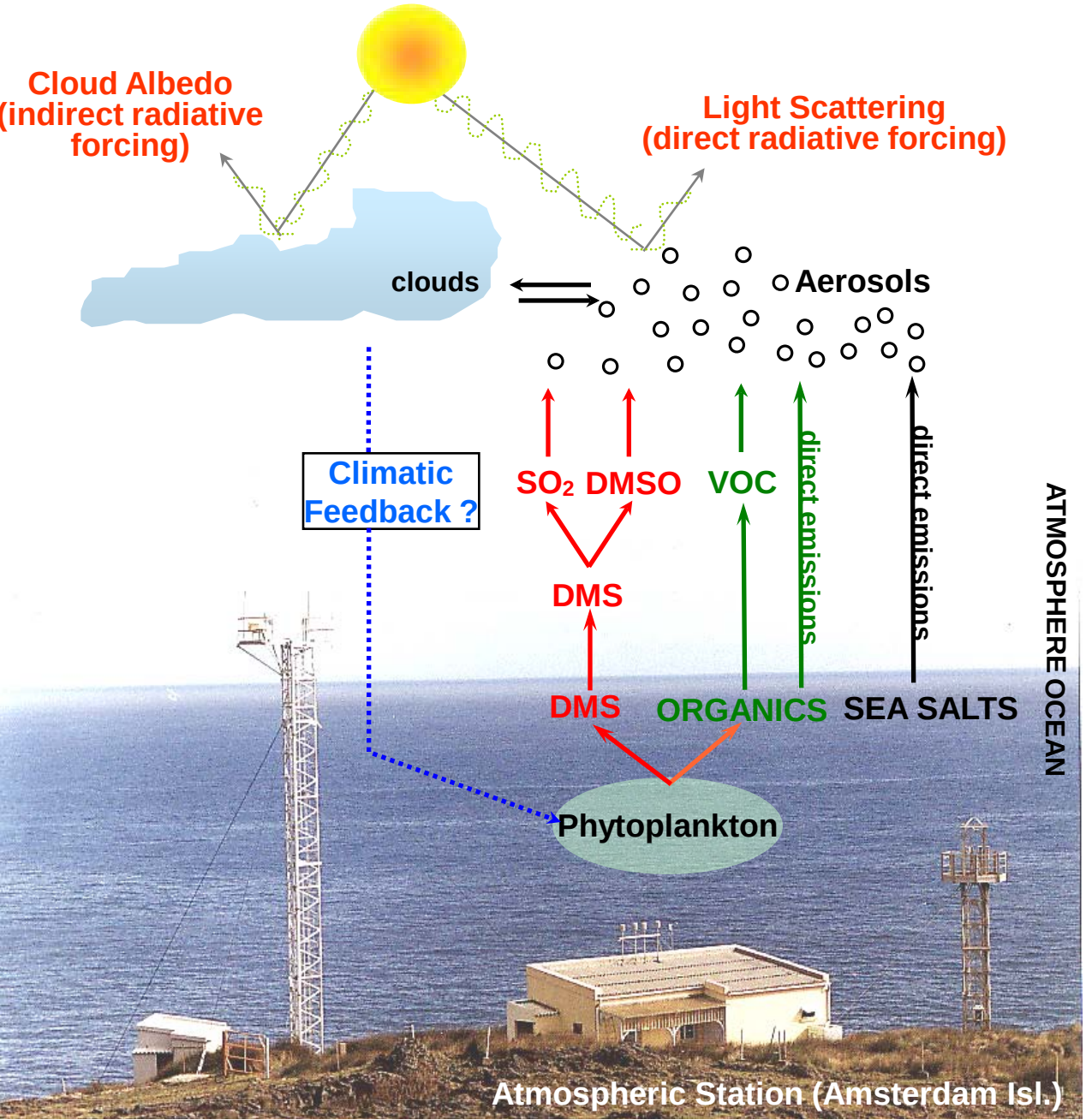


DIRECT & INDIRECT radiative forcing of marine Aerosols - State-of-the-art



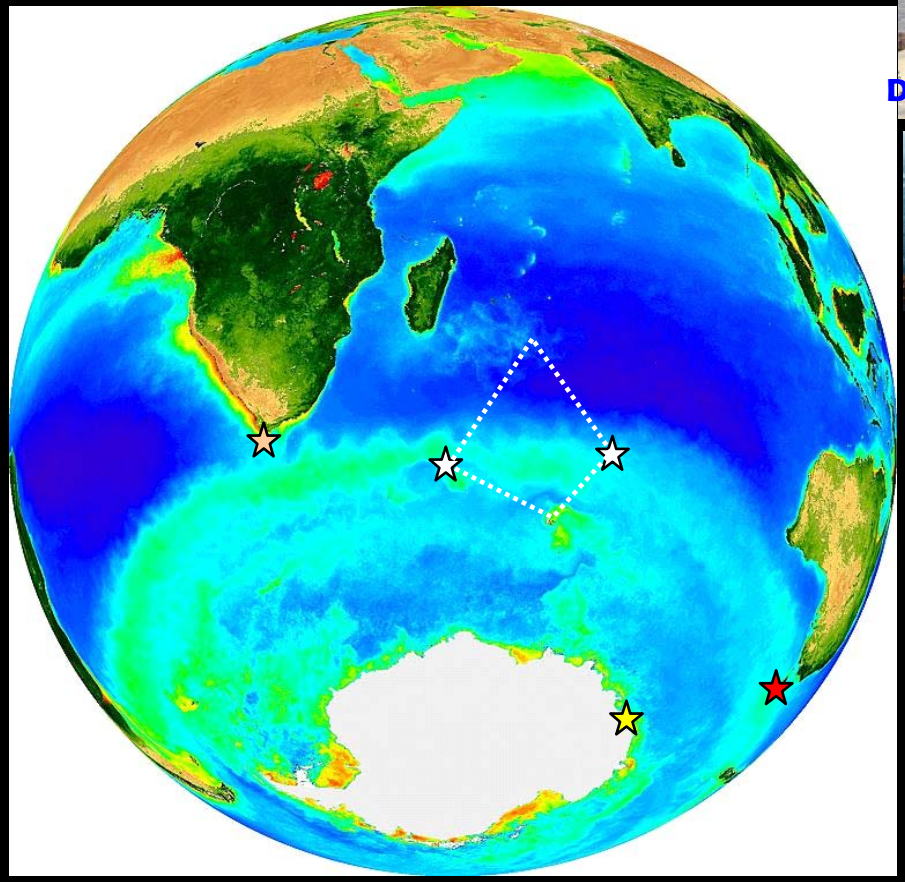
Motivations

Contribution of each of these 3 sources

(sea salt, S-biogenic, C-biogenic)

to CCN number & properties in the marine atmosphere

AEROSOL monitoring activities
Austral Ocean (Indian Ocean sector)



★ operated by LSCE (France)
★ operated by CSIRO (Australia)
★ co-operated by LSCE (France) and SAWS (S. Africa)
★ operated by LGGE (France)

National – International programs / networks

IPEV - AEROTR ACE
(Amsterdam + Crozet)

GAW – Global Station
(Amsterdam + Cape Point)
GAW – Regional Station
(Crozet)

ORE - AERONET
(Amsterdam + Crozet)
http://aeronet.gsfc.nasa.gov/

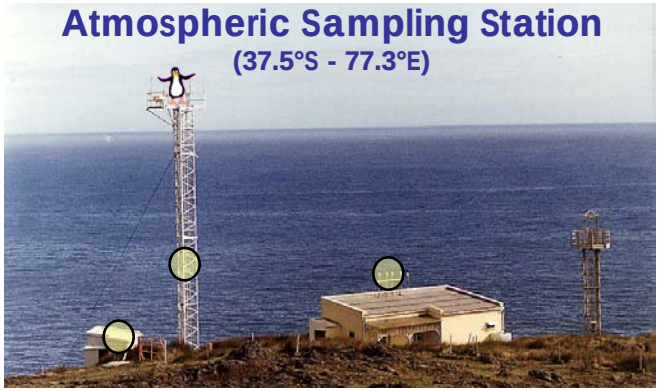
IPEV - ORE CESOA
(Amsterdam + Crozet)
http://cesoa.ore.fr/plan.php3

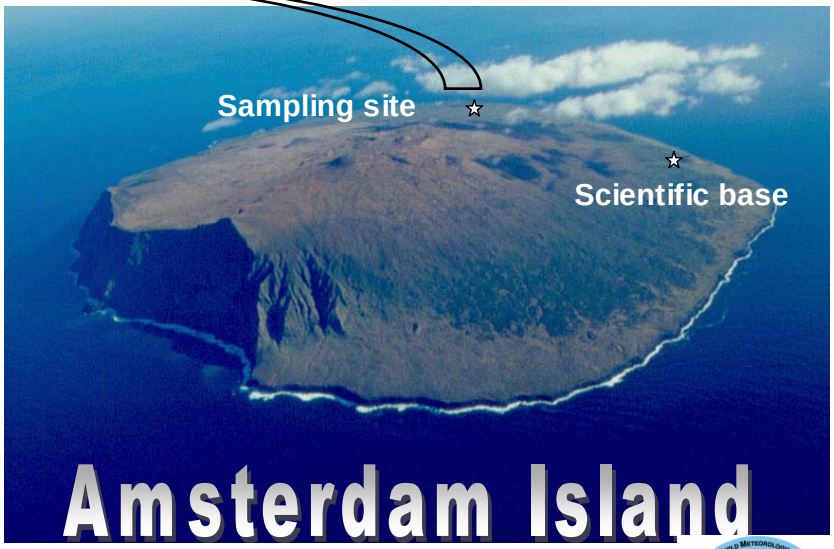
SOLAS – AEROTR ACE
(Amsterdam + Crozet)
http://www.uea.ac.uk/env/solas/

EL CID (2001-2003)
(Amsterdam + Crozet)

OOMPH (2005-2008)
(Amsterdam + Crozet)
http://www.atmosphere.mpg.de/enid/OOMPH

Experimental / Aerosol chemical composition measurements





Global fixed station in WMO RA I - Africa

1 x 11-stage MOUDI Impactor
(since 2006)
(OC, WSOC, ions)

Aethalometer Magee Scientific AE8
(1991-2002)
(EBC)

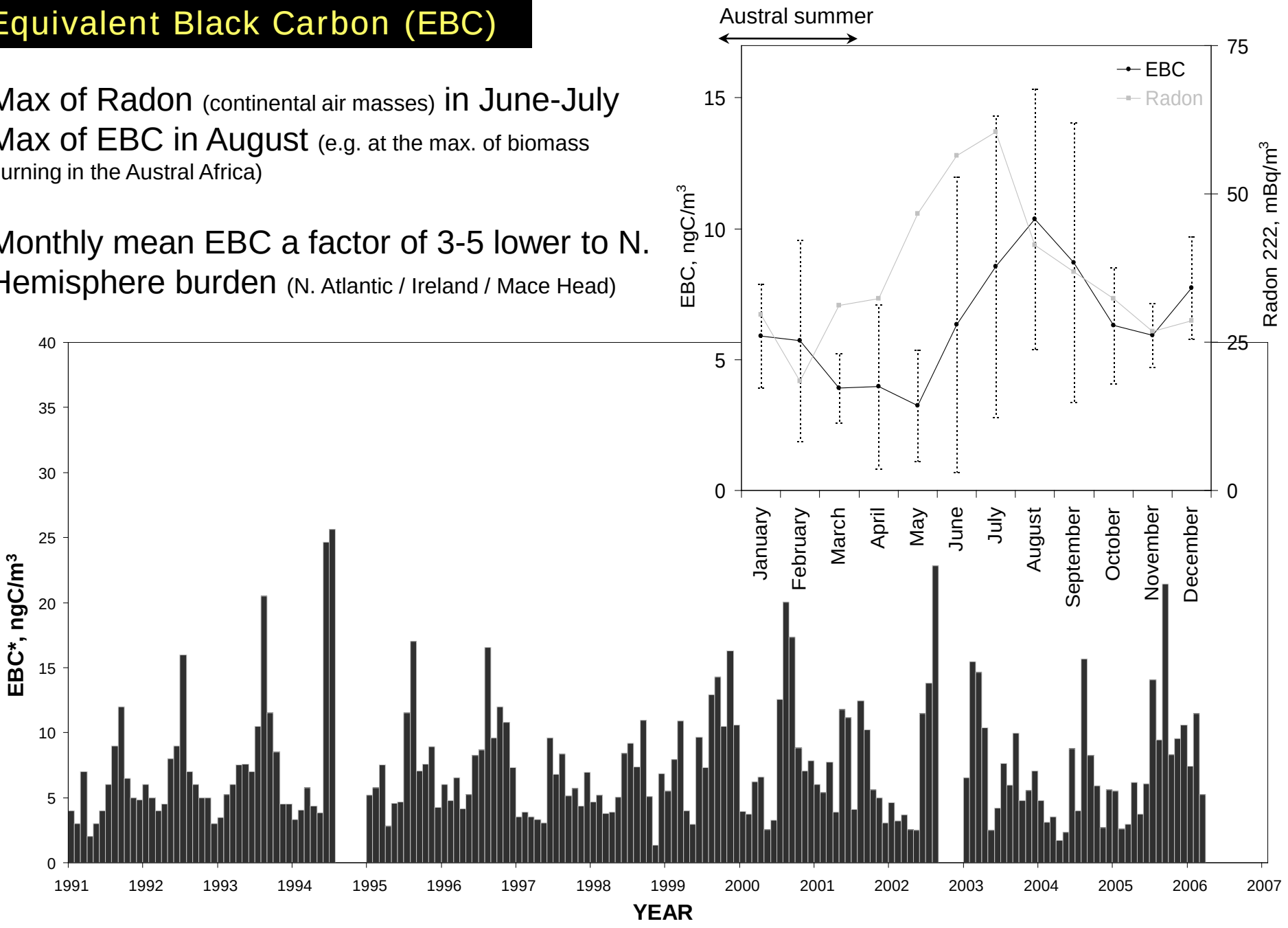
2 x Bulk filter sampling
(since 2003)
(EBC, OC, WSOC, ions)

2 x 4-stage DEKATI Impactor
(PM_1, $PM_{2.5}$, PM_{10}, TSP)
(since 2003)
(EBC, OC, WSOC, ions)

Equivalent Black Carbon (EBC)

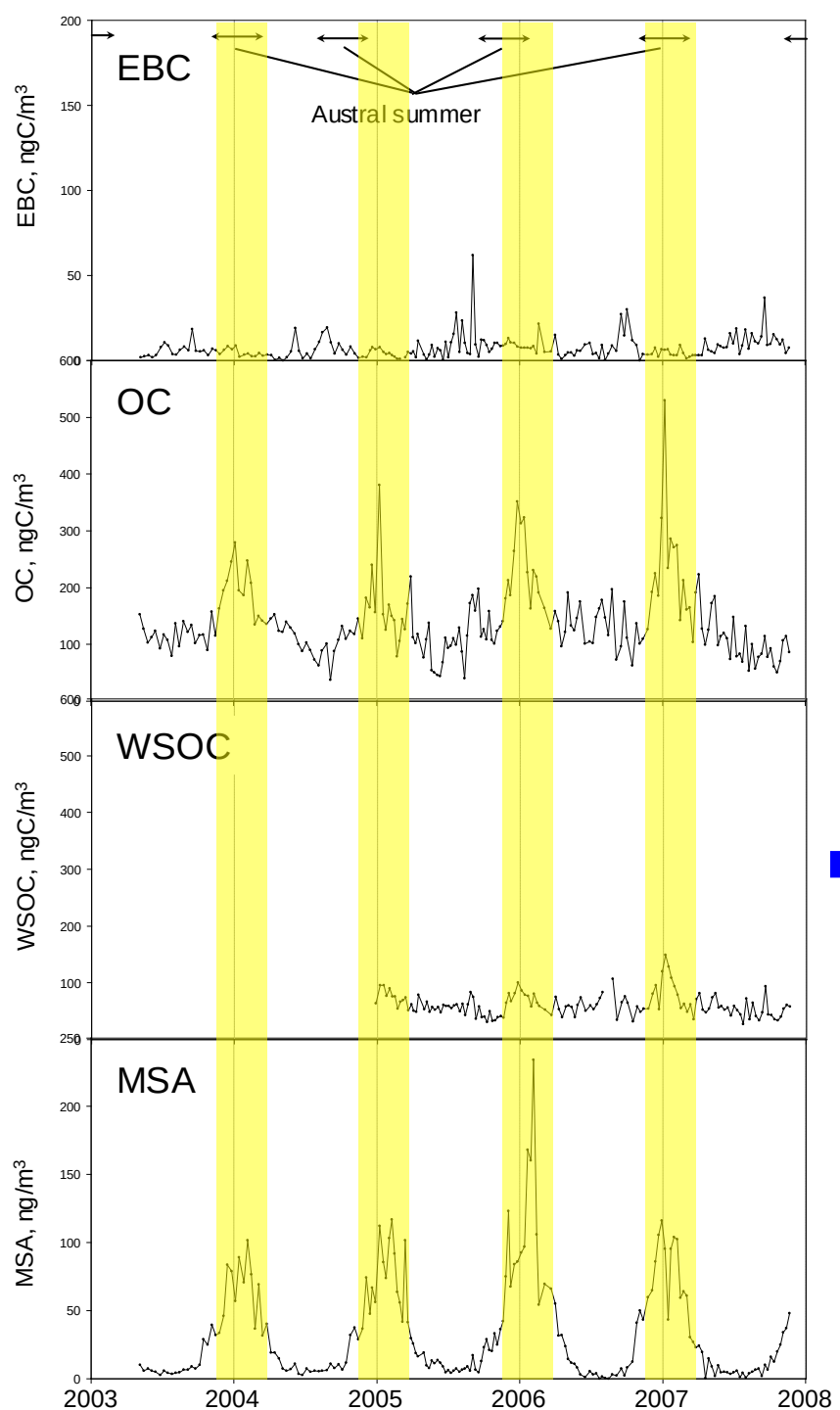
Max of Radon (continental air masses) in June-July
Max of EBC in August (e.g. at the max. of biomass burning in the Austral Africa)

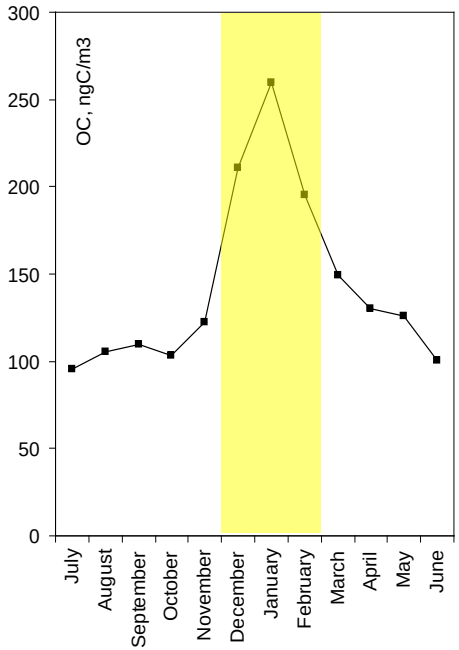
Monthly mean EBC a factor of 3-5 lower to N. Hemisphere burden (N. Atlantic / Ireland / Mace Head)



* Calculated using a Mass Attenuation efficiency of 19m²/g given by the constructor (Magee Scientific)

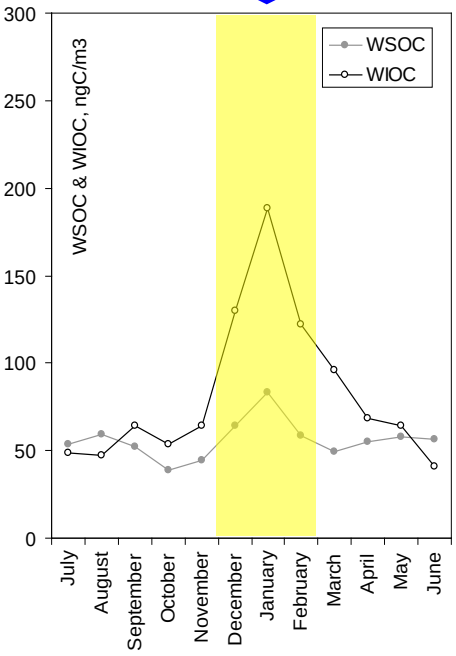
C-AEROSOLS





Summer max. of OC (at 250ngC/m³)

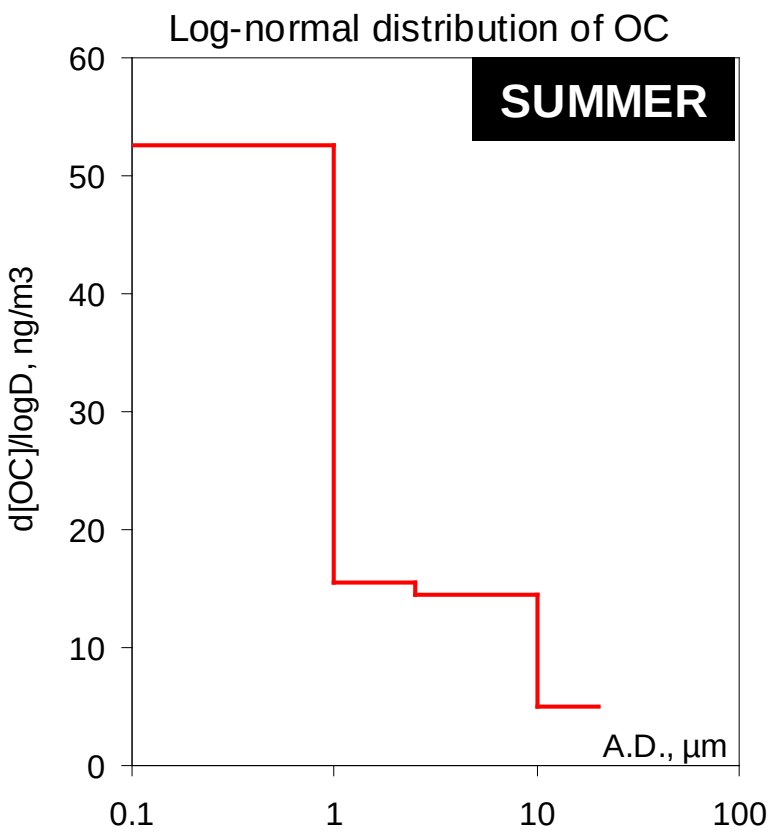
Background levels (~ 100ngC/m³)

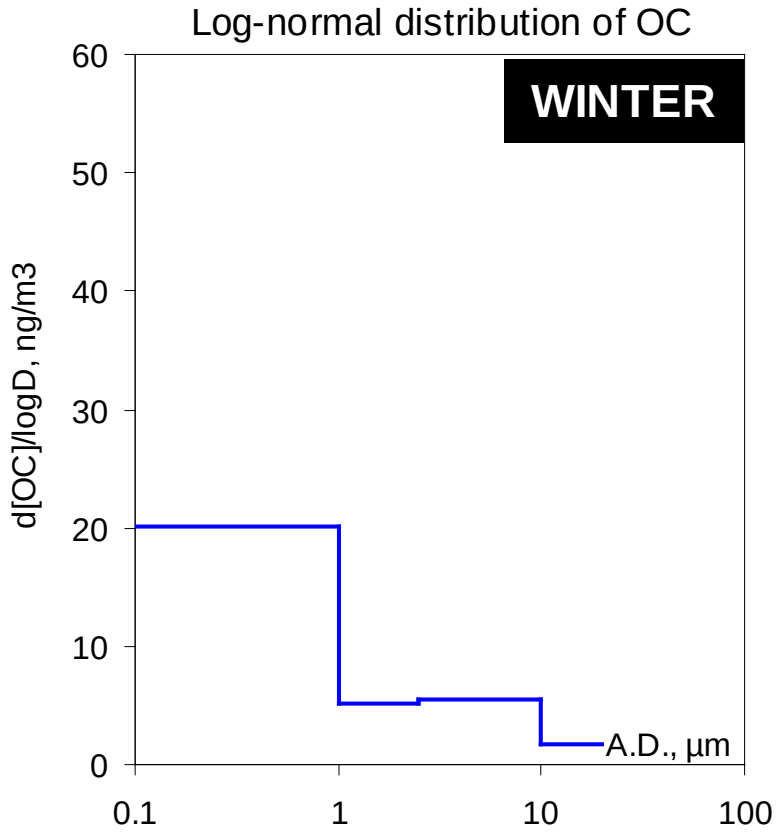


Summer max. mainly related in WIOC

(with summer/winter Amplitude of 4)

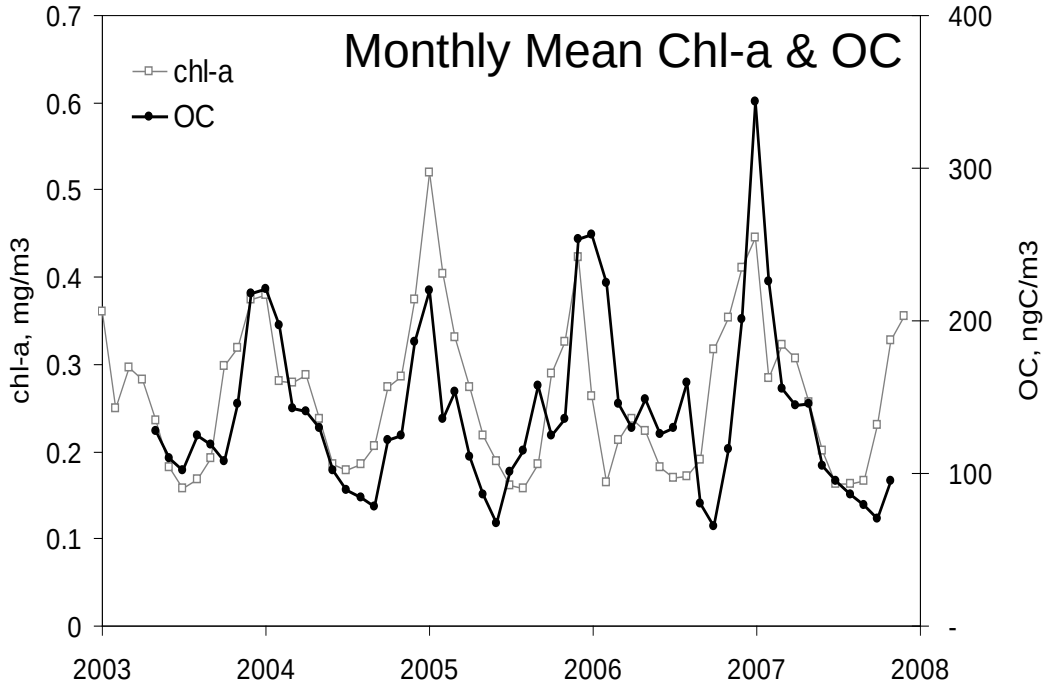
Size distribution of C-AEROSOLS

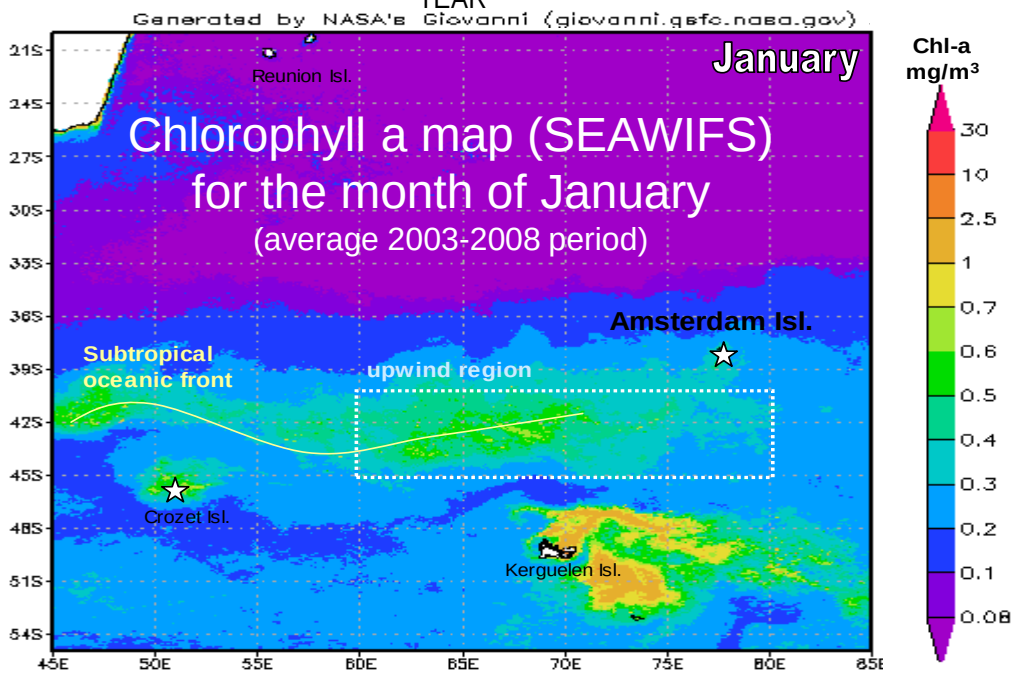




Most of organic aerosols are located
in the submicron size range

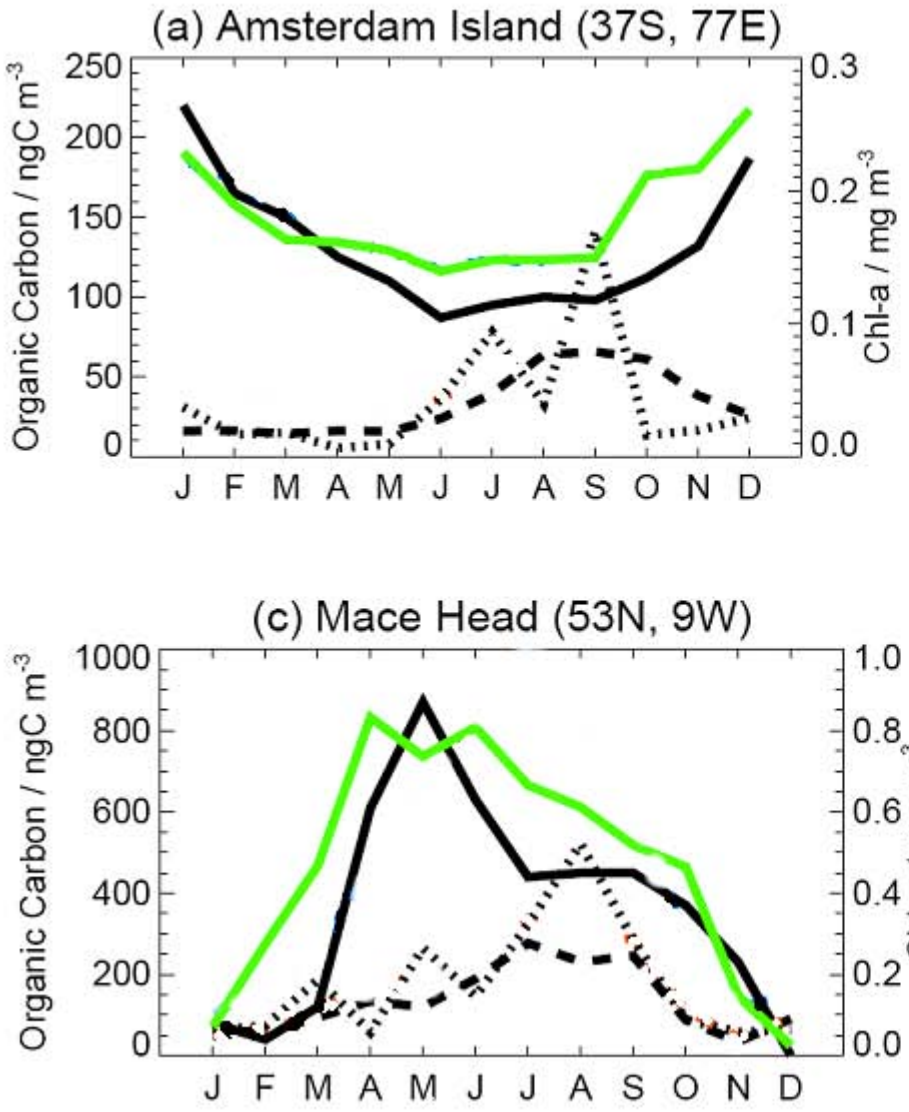
OC vs CHLa

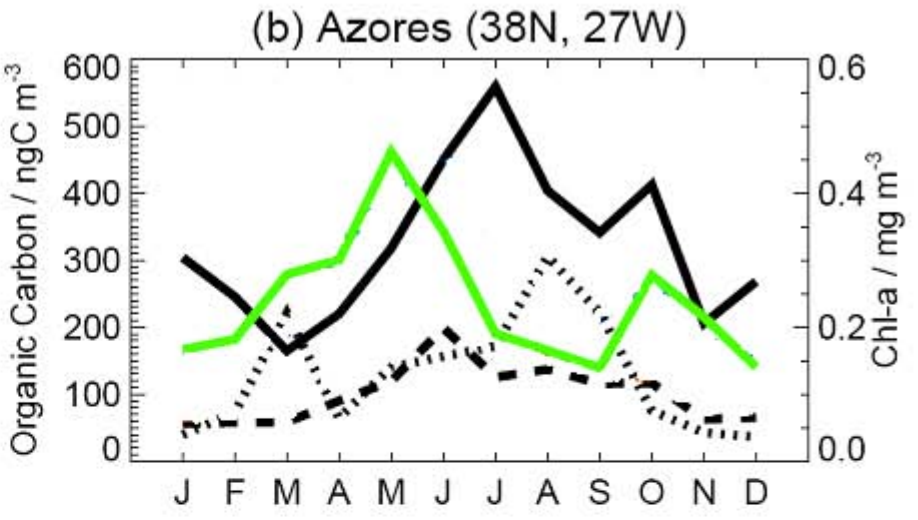


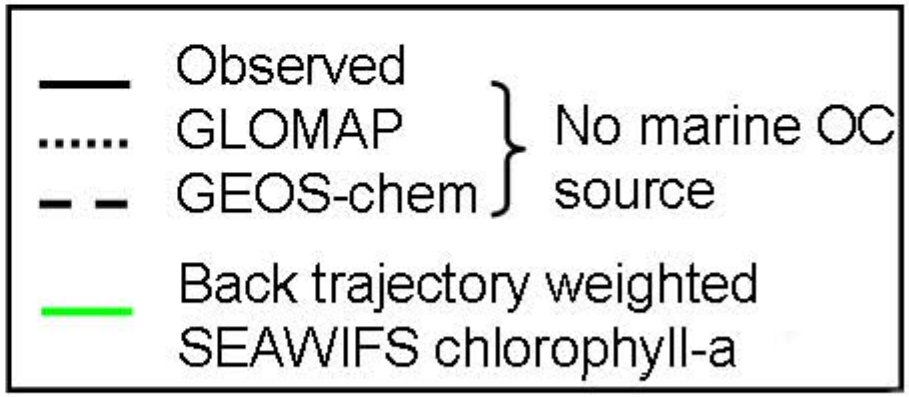


Importance of « long-range » transport of biogenic marine organic aerosols

Seasonal cycle of OC at remote marine sites







Back trajectory chlorophyll-a correlates well with observed OC at Mace Head and Amsterdam Island. Models under-predict OC by factor of 5-20 at all three sites.

Derive oceanic OC emissions driven by oceanic chlorophyll-a

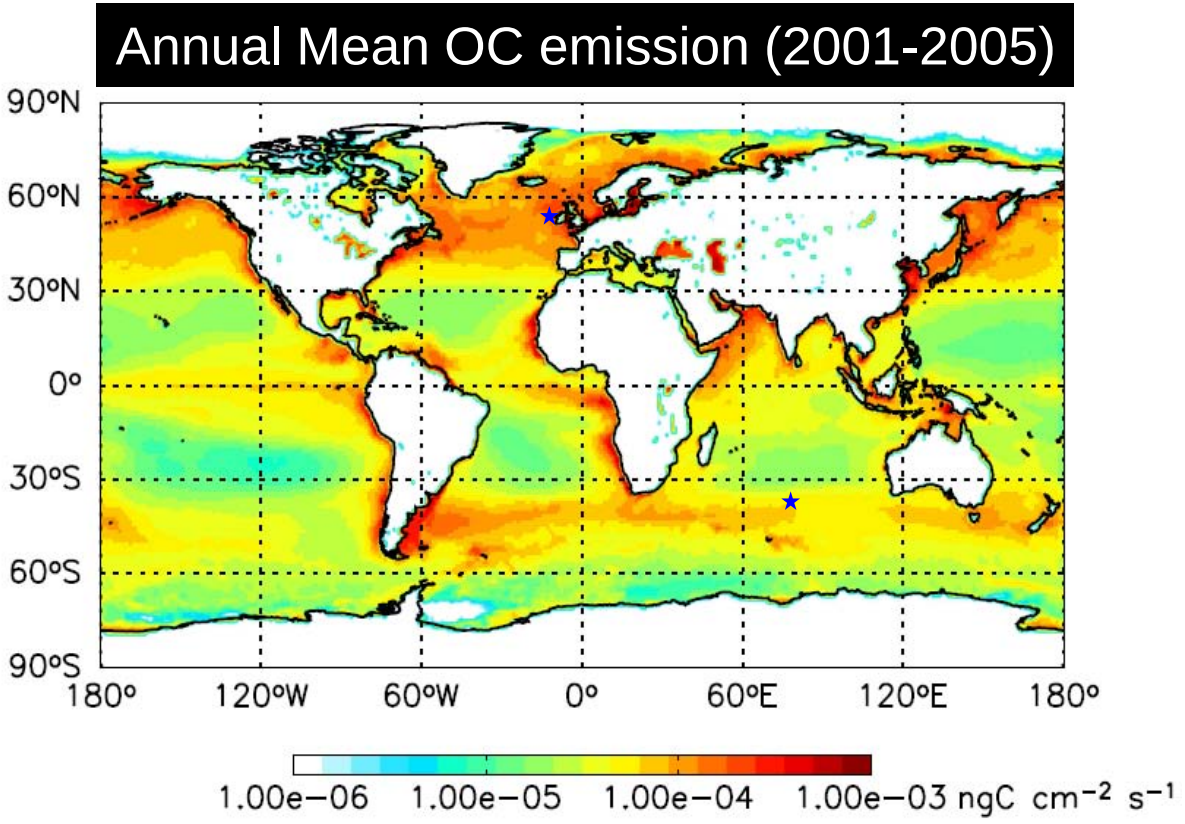
Correlation between observed OC and remote sensed chlorophyll-a suggests an oceanic source driven by biological activity.
We scale chlorophyll-a to produce OC emissions.

Emission factor

$$OC_{emis} = A. [Chl\text{-}a]$$

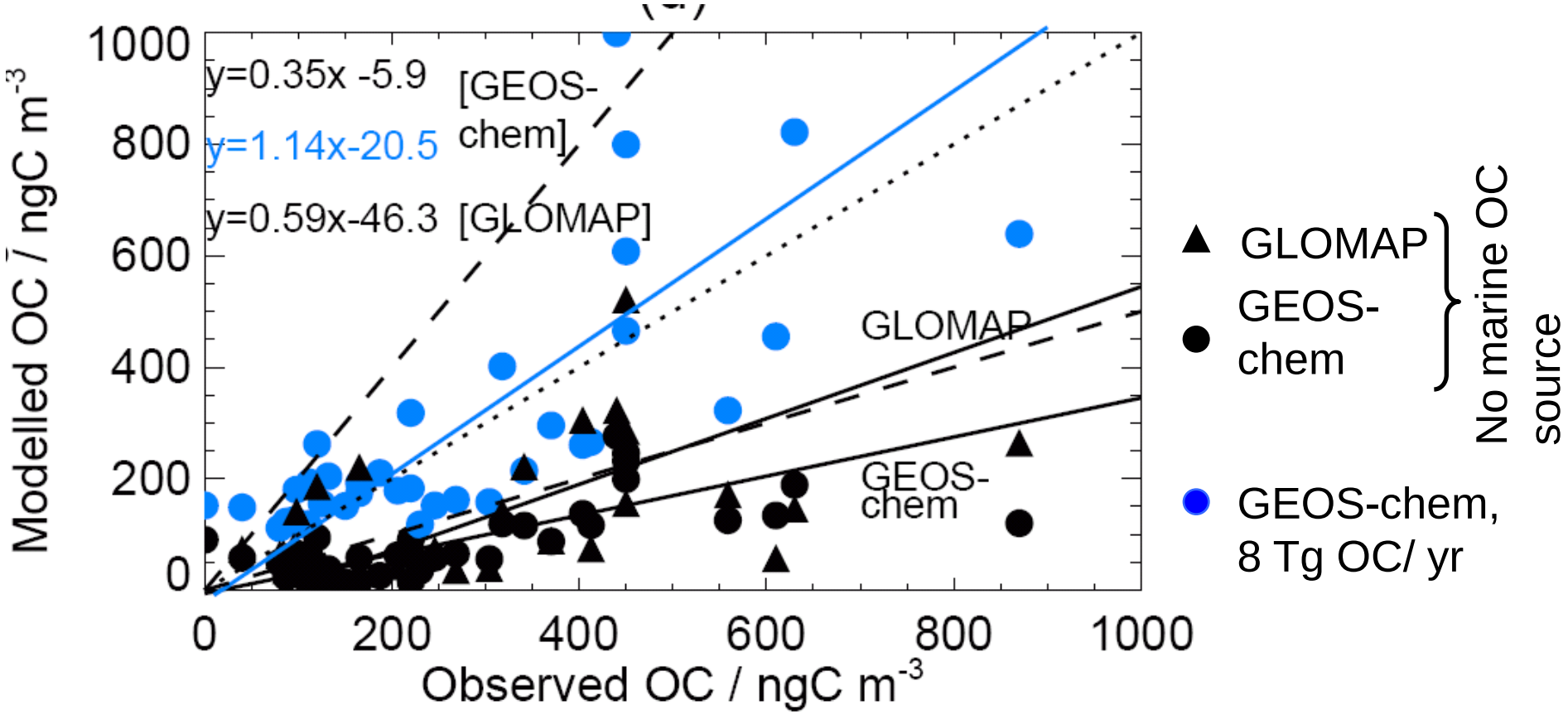
Oceanic OC emission

SeaWiFS chlorophyll-a



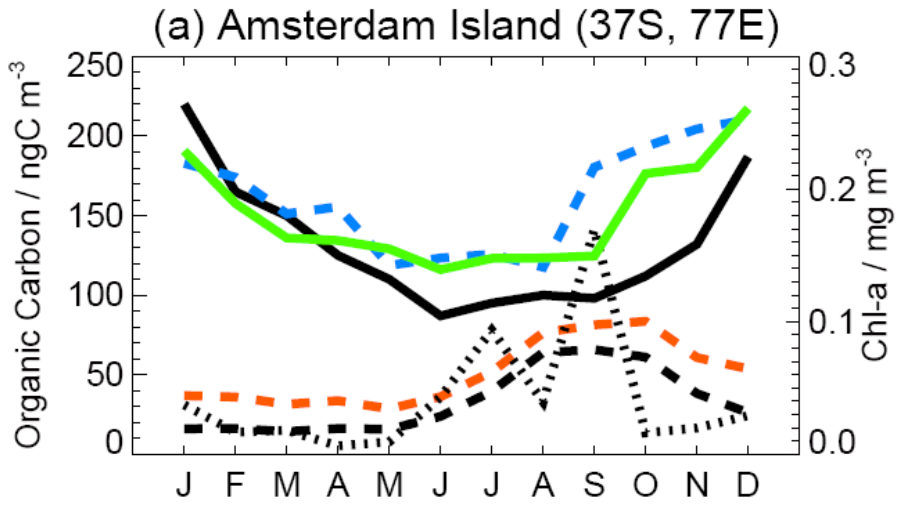
Biologically driven oceanic OC emissions reduce low model bias

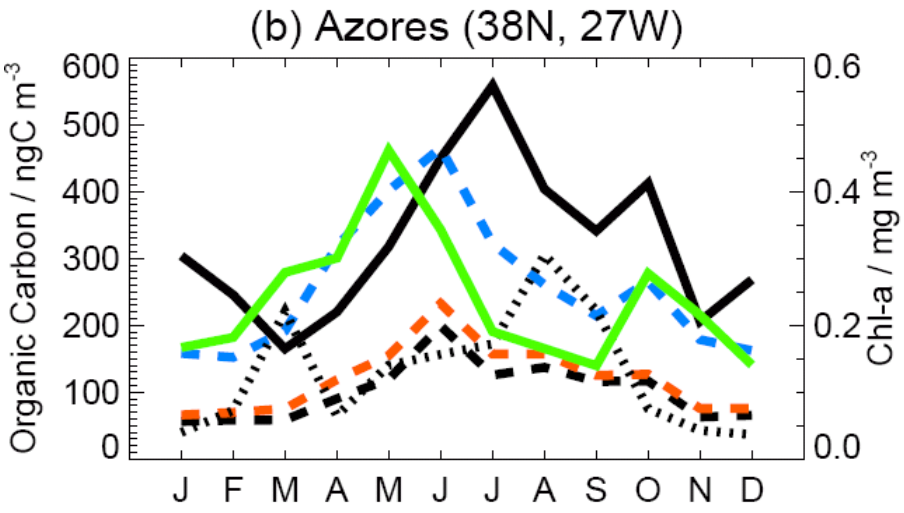
We implement these biologically driven OC emissions in the GEOS-chem model. We modify emission factor 'A' to find the best match between observed and simulated OC.

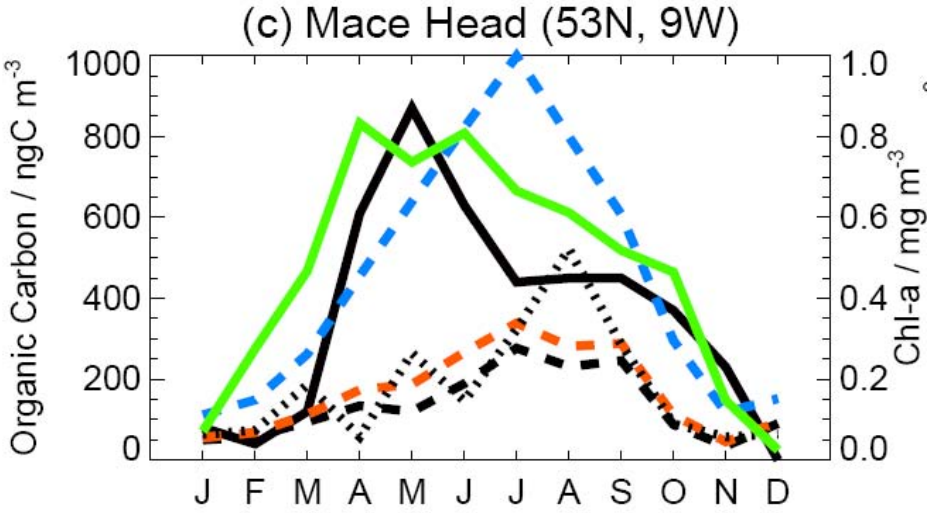


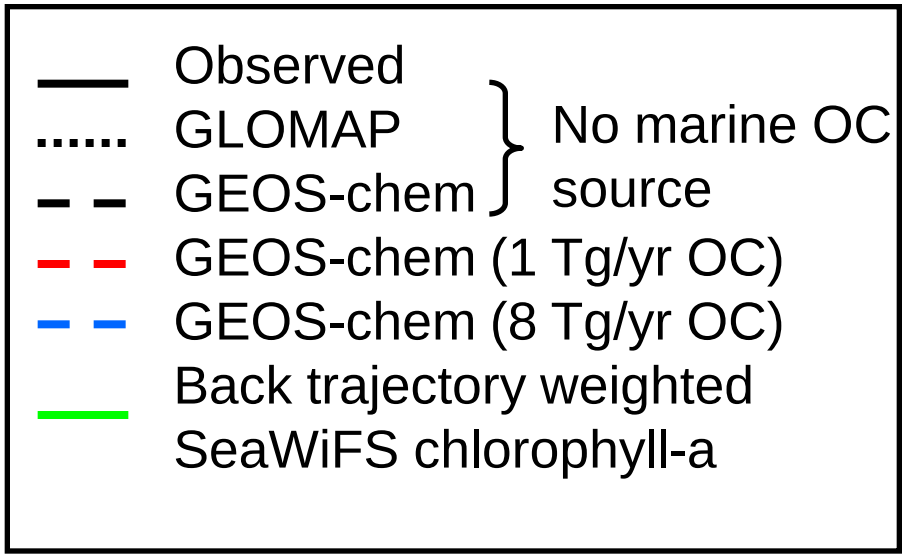
A biological oceanic OC source of 8 Tg / yr is required to match observed OC

Seasonal cycle of OC at remote marine sites

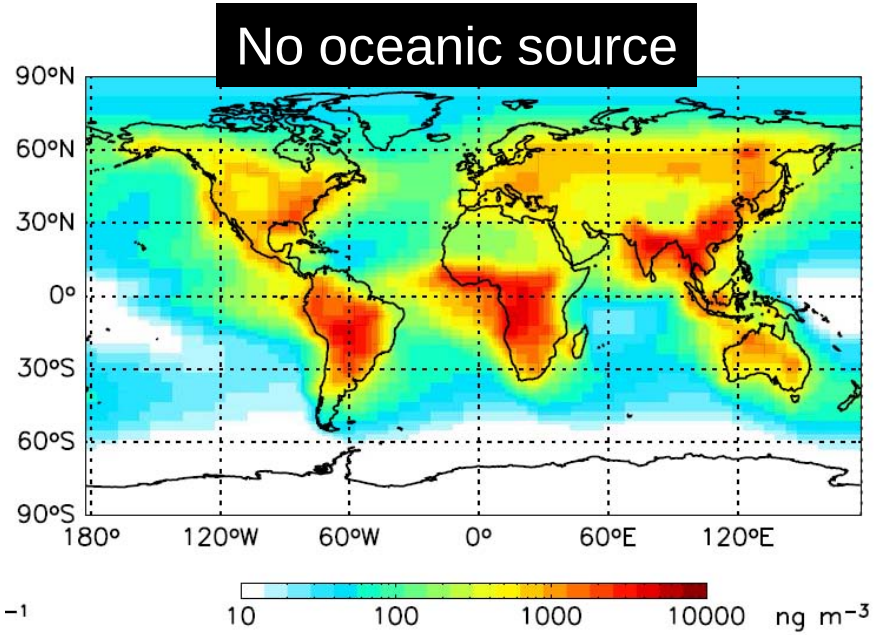


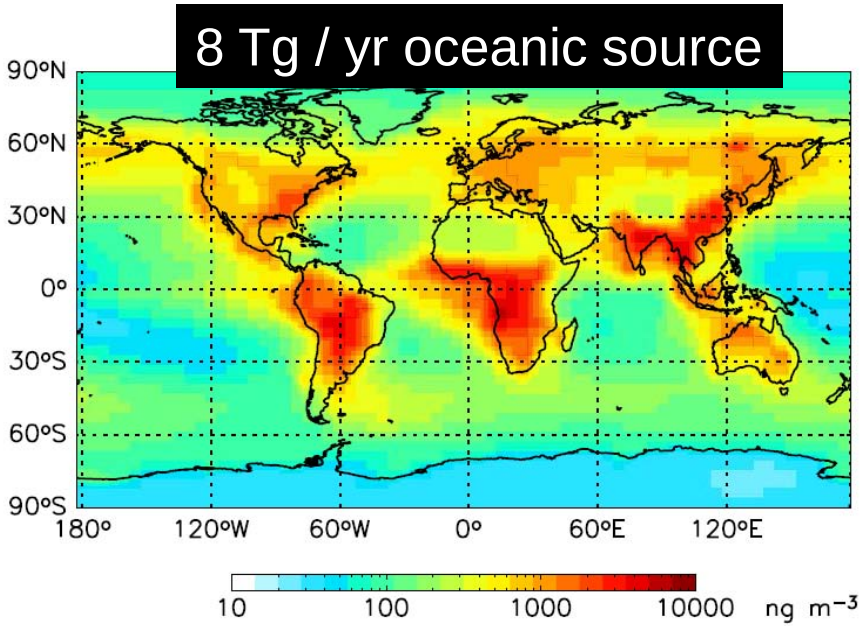


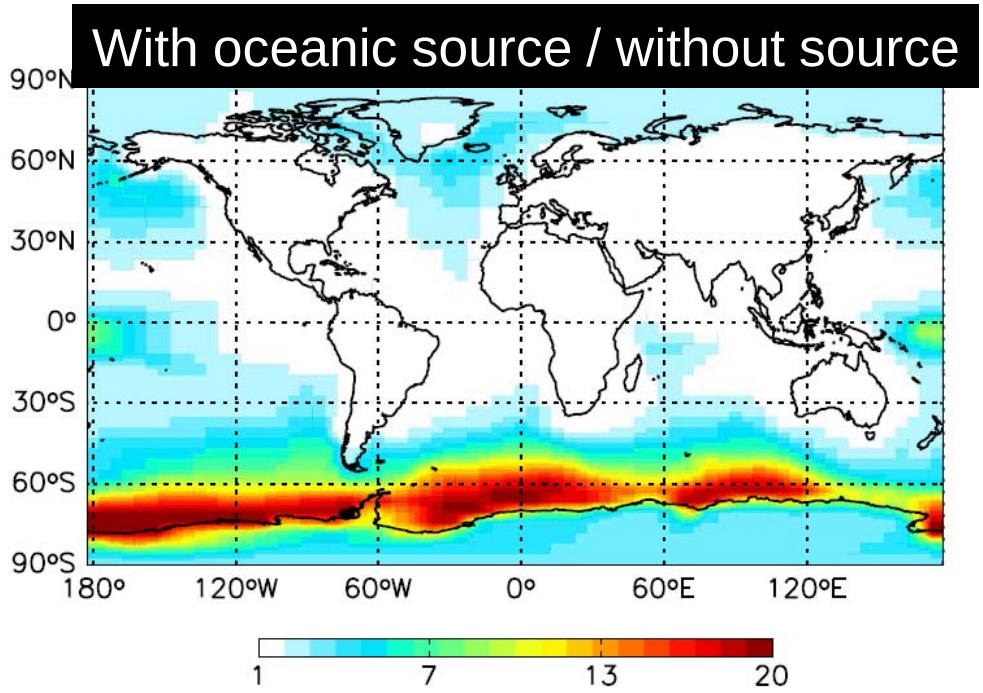




Simulated 2001-2005 surface OC concentrations



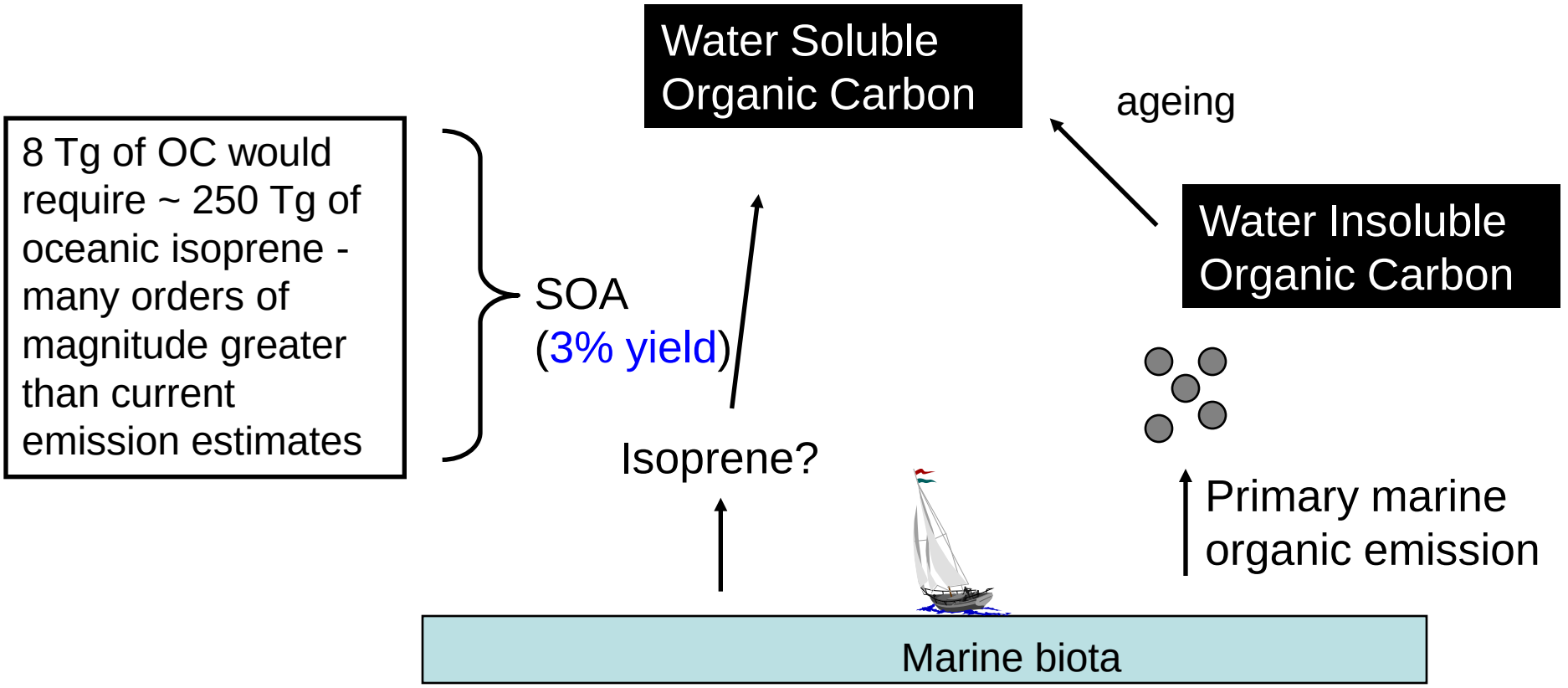




Oceanic OC source leads to large increases in simulated OC in the Southern Ocean.

Mechanism of oceanic carbon emission

Our method does not allow us to evaluate the mechanism for the OC emission. Can use observed water insoluble OC (WIOC) to water soluble OC ratios to give information about the likely source mechanism.



Observed OC at all 3 sites is ~80% WIOC suggesting a predominately primary ocean source.

Sources of Organic Carbon (OC) aerosol

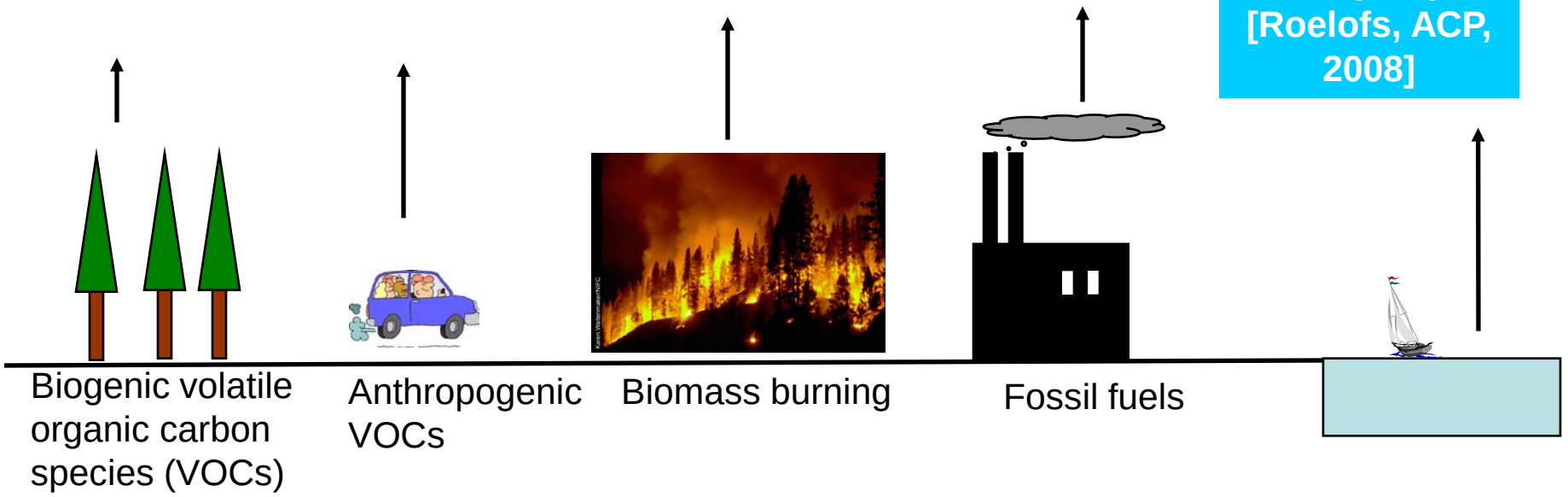
Secondary organic aerosol **Primary emission**

Secondary organic aerosol
10-100 Tg C / yr ??

Biomass burning
45-80 Tg C / yr

Fossil fuels
5-30 Tg C / yr

Oceanic organics
8 (this work) - 75 Tg C /yr [Roelofs, ACP, 2008]



Global OC budget is very uncertain. Our inferred oceanic OC source is significant compared to other known sources.

Conclusions

Evidence of an important source of biogenic marine organic aerosols in the Austral Ocean

- Submicron size range & mainly water insoluble (suggesting a primary origin for these organics).

- A global emission of ~8 Tg C / year, scaled with chlorophyll-a gives best model prediction.

- Further work needed 1) to better characterize (experimentally) this organic source, 2) to quantify the implications of this significant global source of organic aerosol.

Dominick V. Spracklen, Steve R. Arnold and Kenneth S. Carslaw, J. Sciare, and C. Pio, Globally significant oceanic source of organic carbon aerosol, Geophys. Res. Lett., in press, ***2008***

Thanks
for your attention