5th FerryBox workshop

Application of continuous FerryBox measurements to oxygen and carbon fluxes in the North Sea

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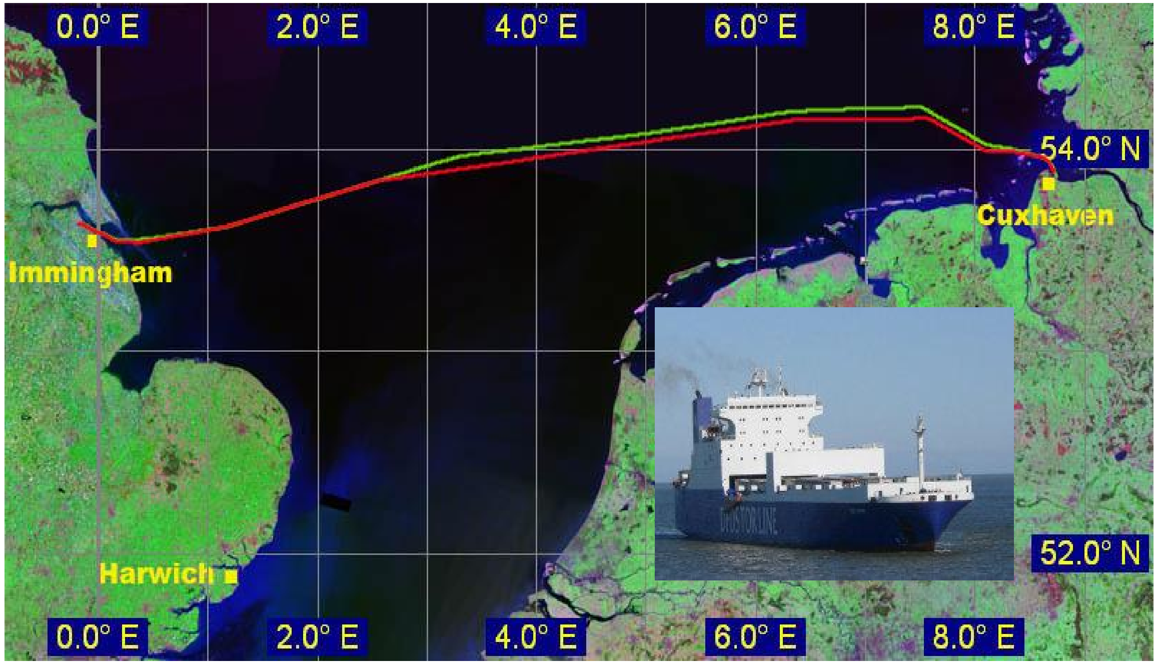
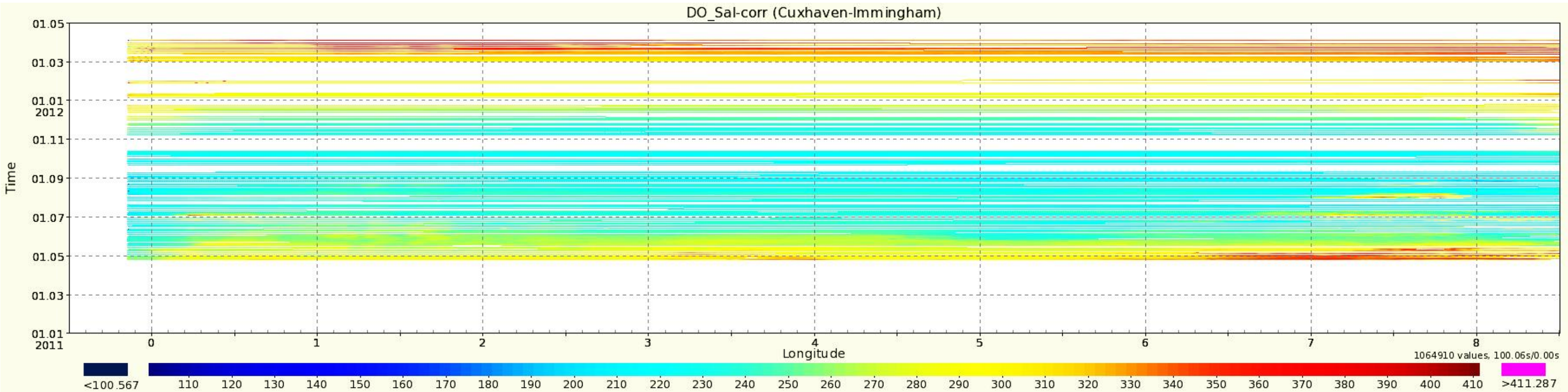
Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

Motivation

- CO_2 in the atmosphere → climate change
- to which extent it is dissolved in the ocean
  - → primary production
  - → acidification
- continuous O_2 measurements in FerryBox system
- O_2 serves as a proxy for primary production
  - quantification of carbon fluxes at air-sea interface





Calculation of fluxes

- Air-sea flux of oxygen expressed by gas concentration anomaly and gas exchange velocity:

$$F = k_w \cdot \Delta O_2$$

- Gas concentration anomaly is difference of observed concentration and saturation concentration

- k_w is parameterized by wind speed (in 10 meter height) and the dimensionless Schmidt number Sc.

$$Sc = \frac{\mu}{D} = A - bt + Ct^2 - Dt^3$$

μ is kinematic viscocity of water, D is diffusion coeffcient of the gas

- general parameterization term:

$$k_w = a \cdot Sc^n \cdot U^b$$

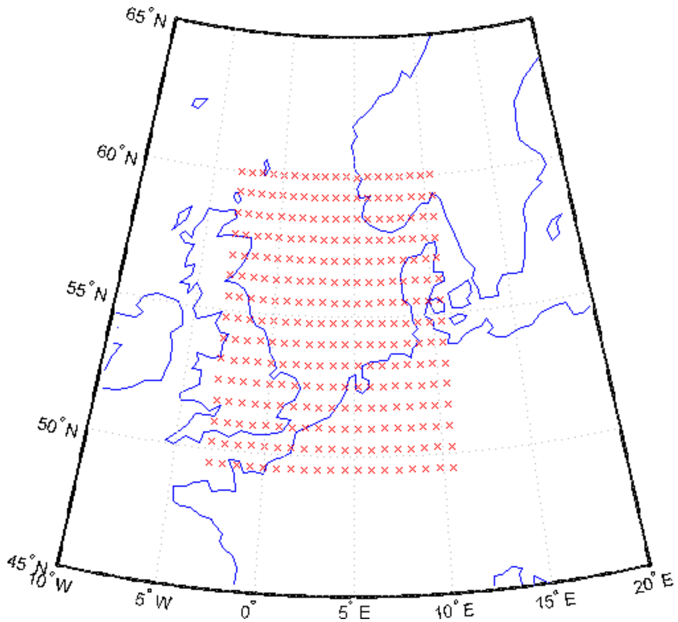
- f.e. Wanninkhof, 1992:

$$k_w = 0.31 \cdot \left({}^{Sc}/_{660}\right)^{-1/2} \cdot U^2$$

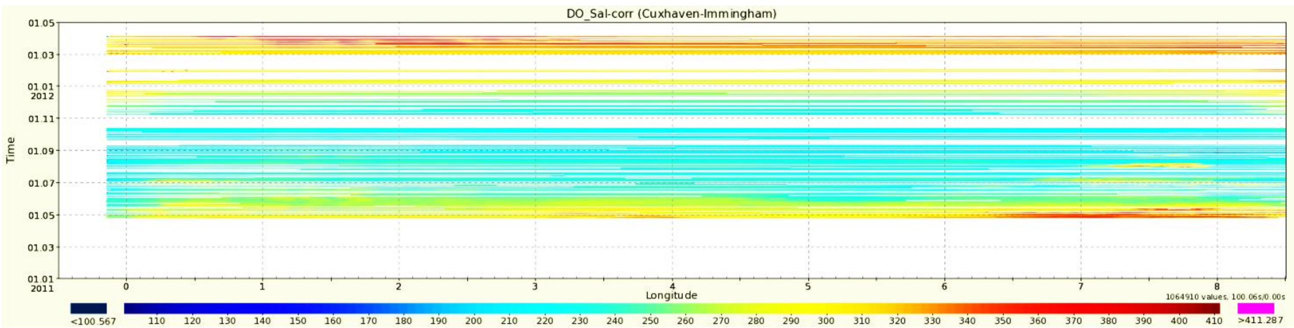
- Defining carbon flux rates via Redfield molar ratio of 0.77 (C:O)

Data

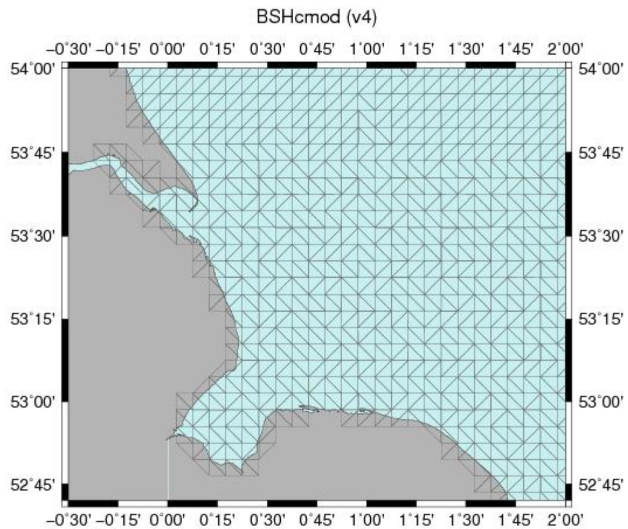
- FerryBox data of Tor Dania 04/2011-04/2012
  - Dissolved oxygen
  - Water temperature
  - Salinity
- ECMW ERA-Interim reanalysis data, 0.75° grid, 6-hourly
- BSH cmod model 0.02° grid, 1 hour time resolution



Part of ERA-Interim grid

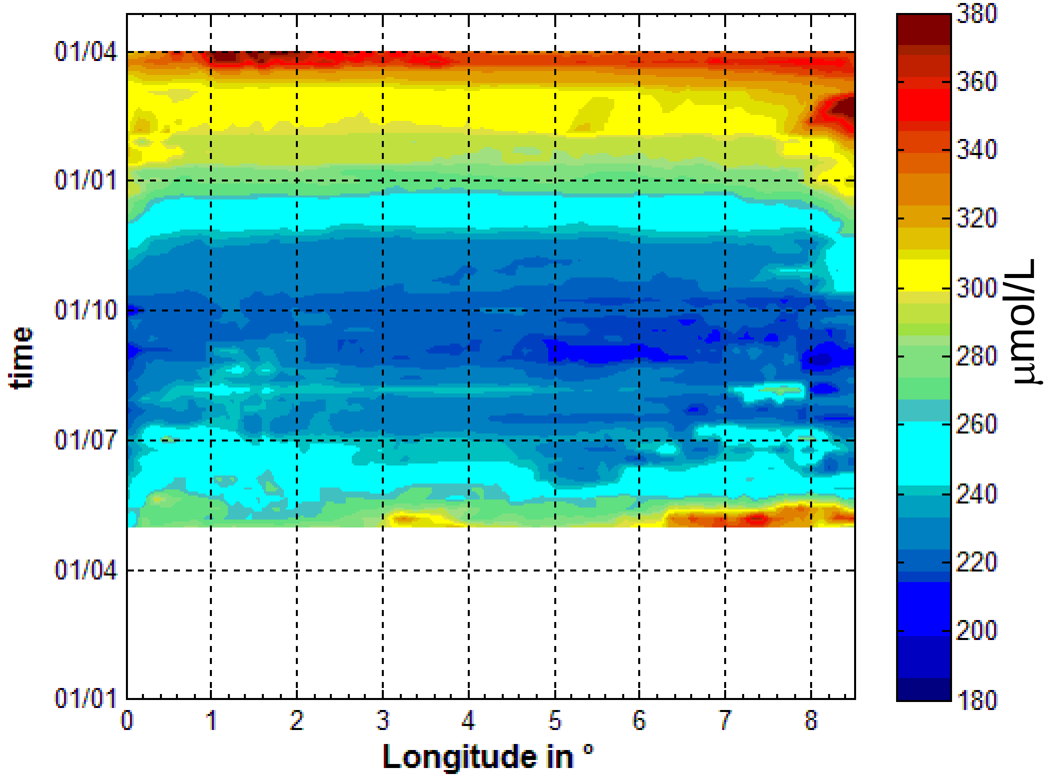


Ferrybox measurements of dissolved oxygen

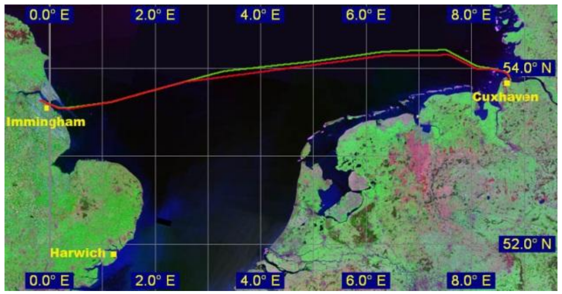


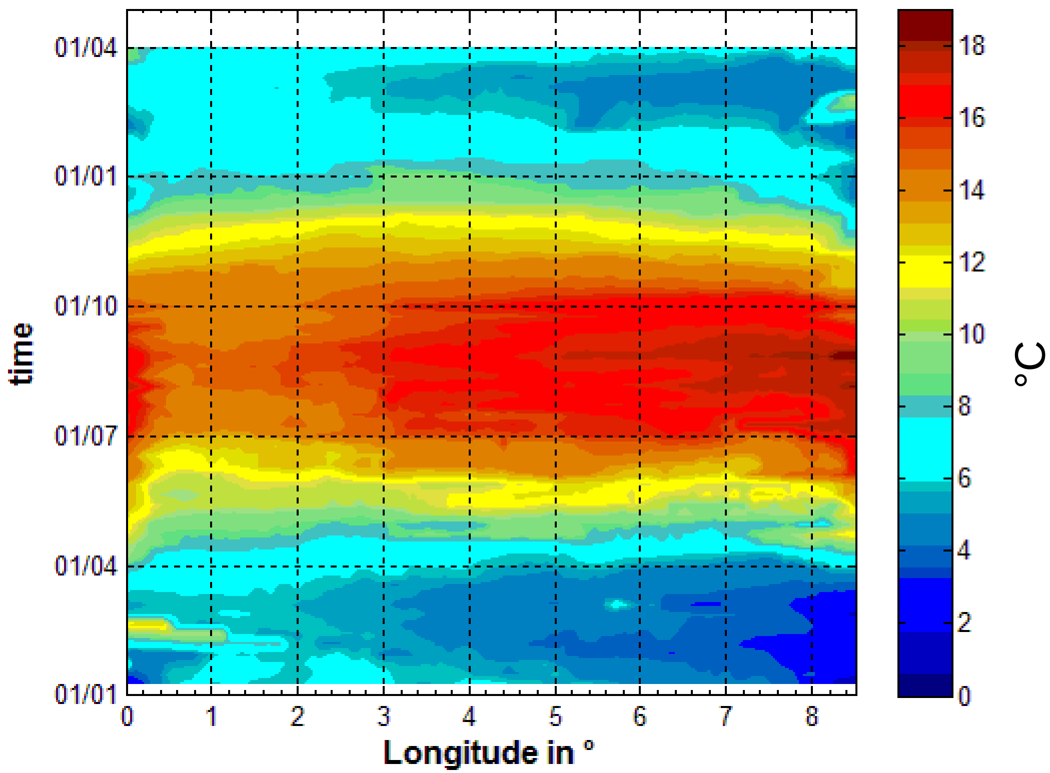
Part of BSHcmod grid

FerryBox measurements Tor Dania 2011-2012



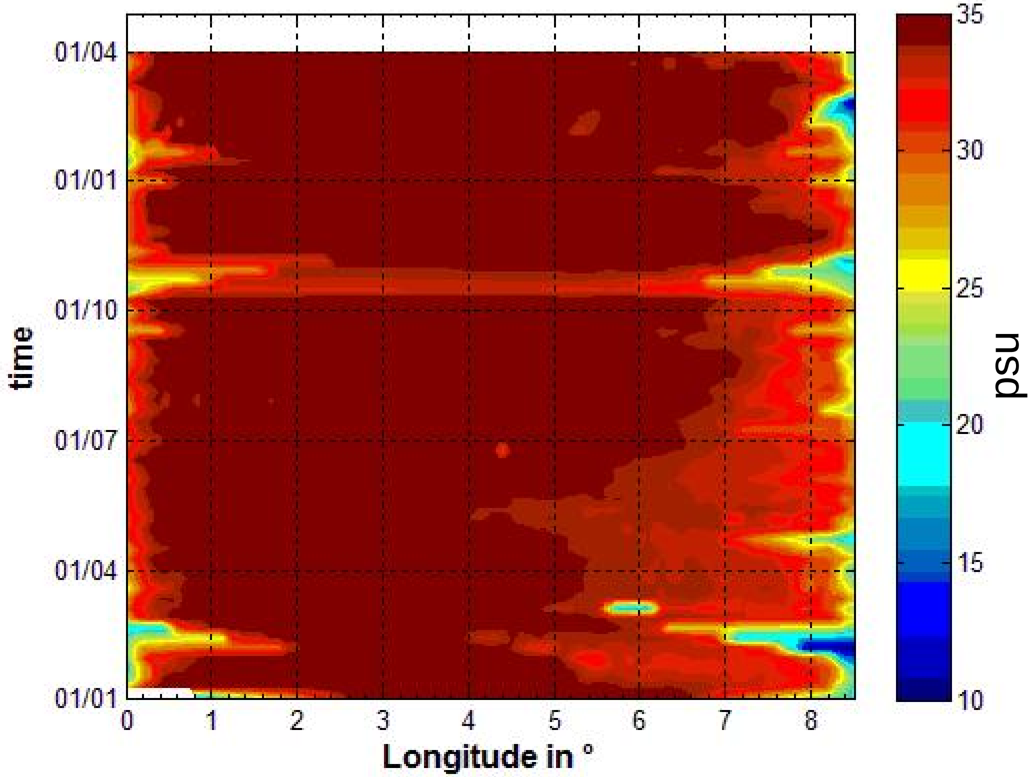
Dissolved oxygen



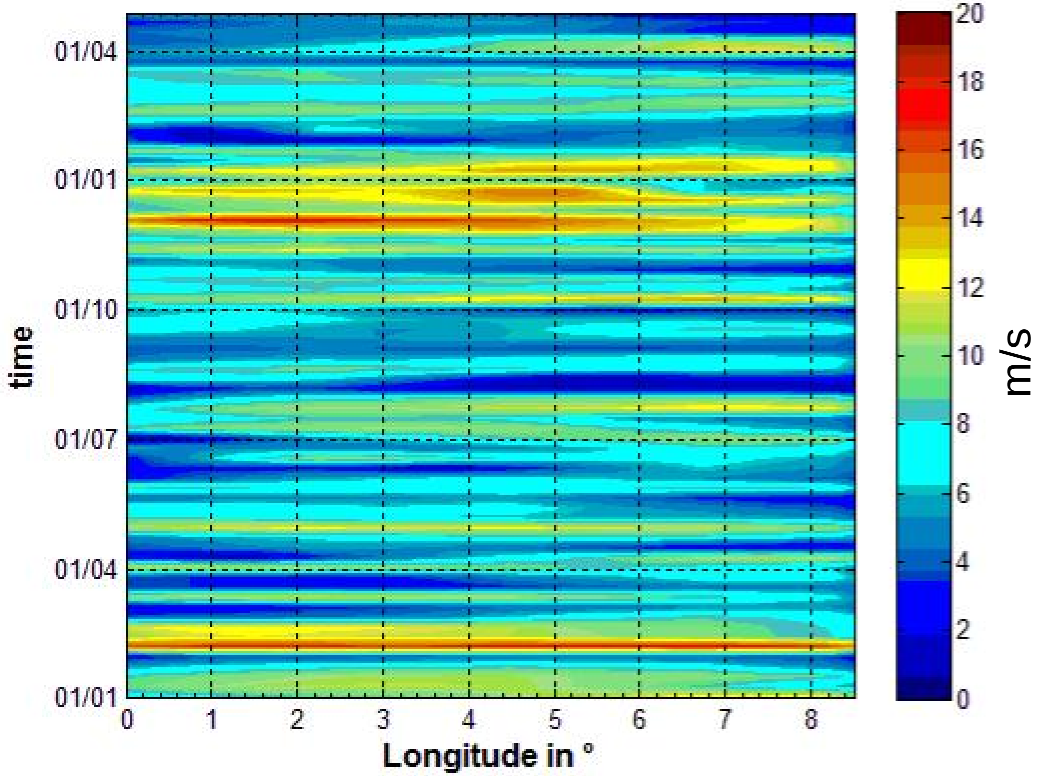


Water temperature

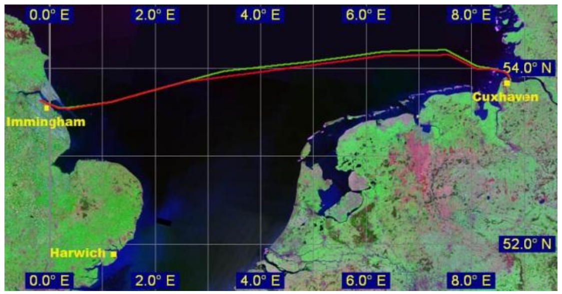
FerryBox measurements & model output



Salinity



ERA-Interim wind speed



Results

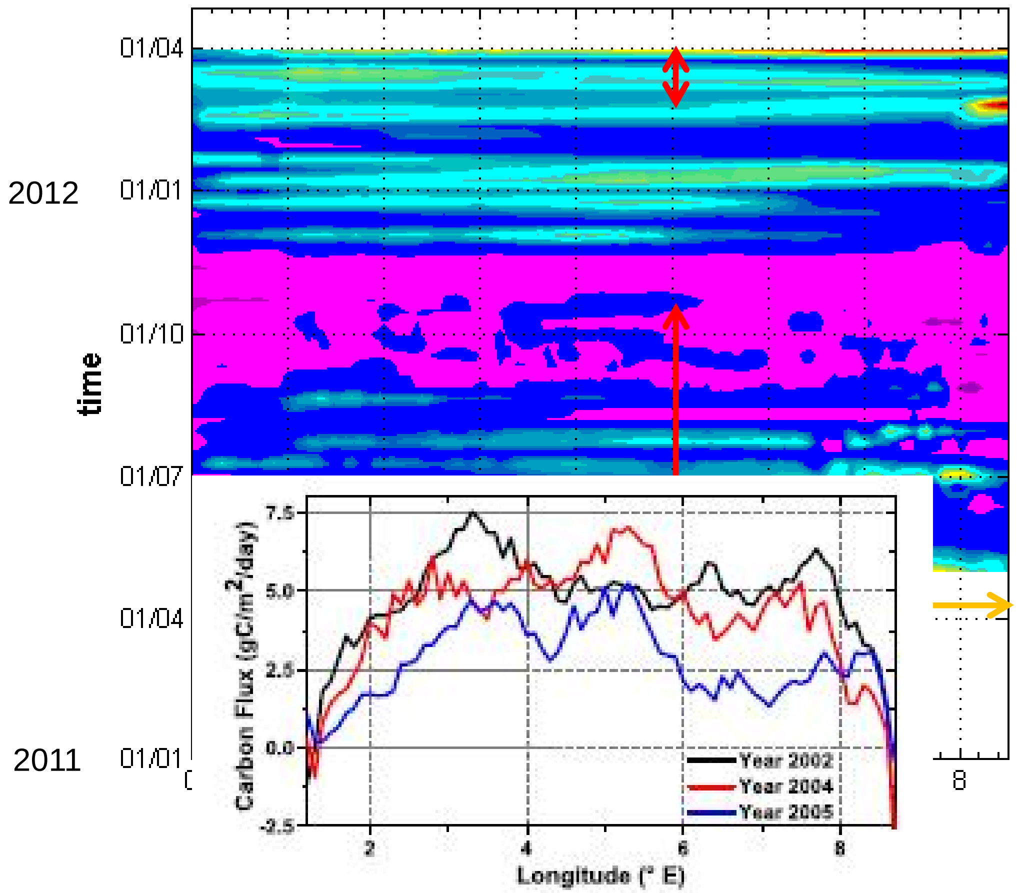
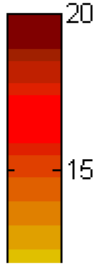
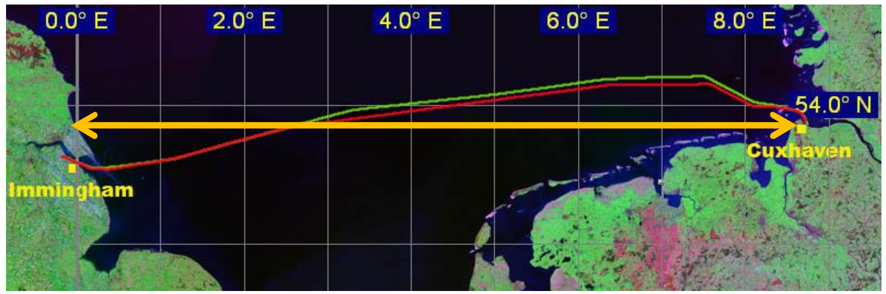
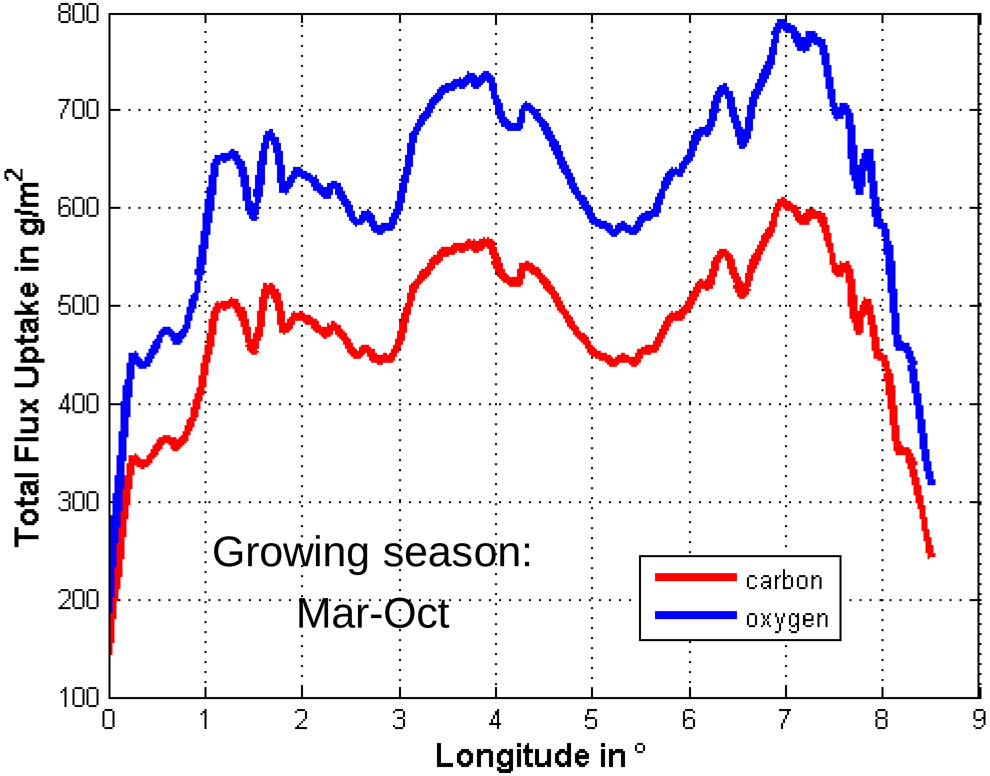


Fig. 11 Uptake of carbon during growing season (March to October) calculated from average oxygen fluxes measured along the transect Harwich-Cuxhaven in 2002, 2004 and 2005







Petersen et al., 2011

Parameter tests

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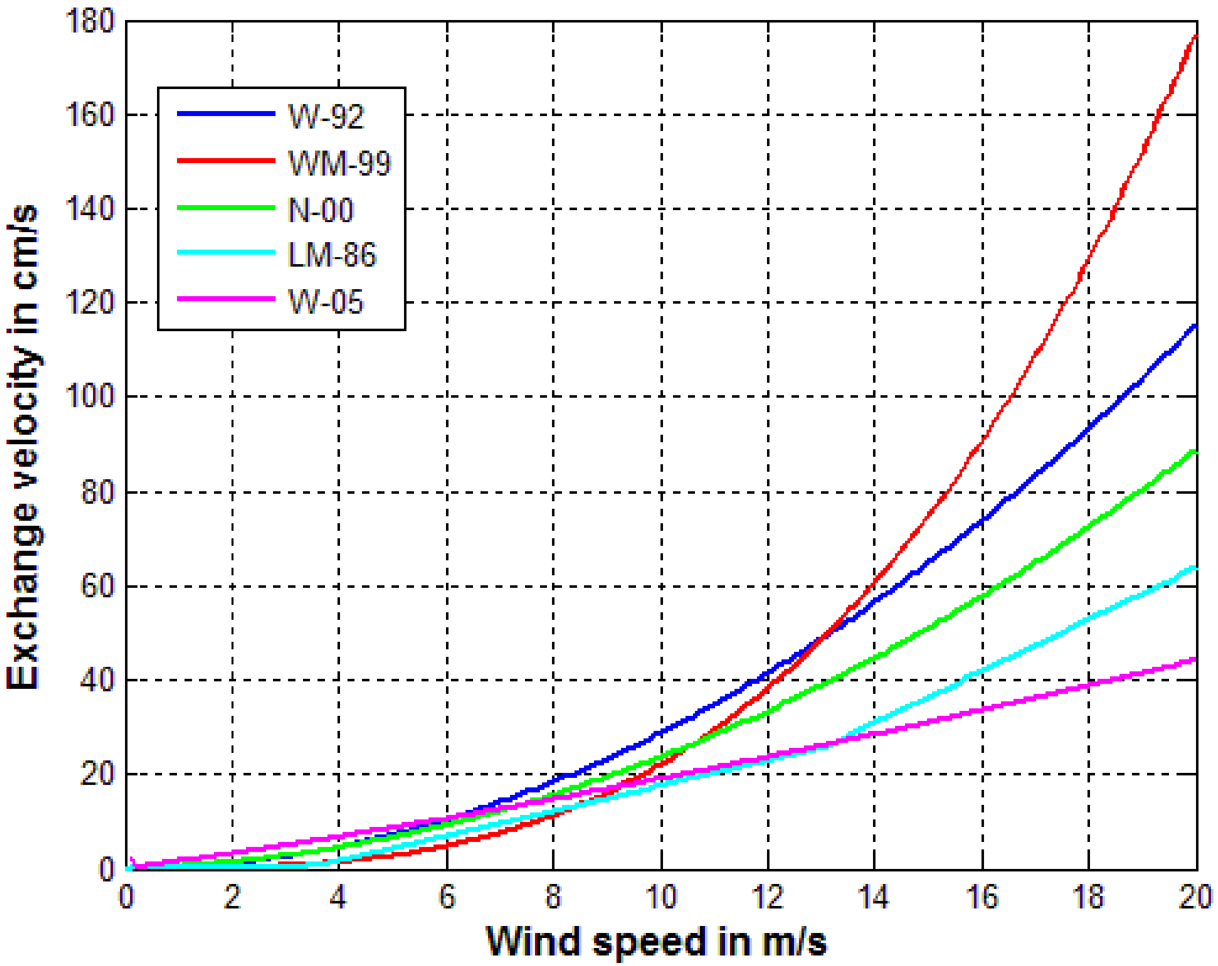
- Impact of choice of parameterization scheme
- Impact of high wind speeds, exclusion of winds > 12 m/s
- Wind speed: ERA-Interim vs BSH cmod model

Parameterization solutions



Parameterisation schemes for exchange velocity of air-sea flux of oxygen in dependance of wind speed U_{10}:

W-92: Wanninkhof, 1992:

$$k_w = 0.31 \cdot (Sc/660)^{-1/2} \cdot U^2$$

WM-99: Wanninkhof & McGillis, 1999:

$$k_w = 0.0283 \cdot u^3 \cdot \left(\frac{Sc}{660}\right)^{-1/2}$$

N-00: Nightingale, 2000:

$$k_w = (0.222u^2 + 0.333u)\left(\frac{Sc}{660}\right)^{-1/2}$$

LM-86: Liss & Merlivat, 1986:

$$k_w = 0.17u \cdot \left(\frac{Sc}{660}\right)^{-2/3}$$

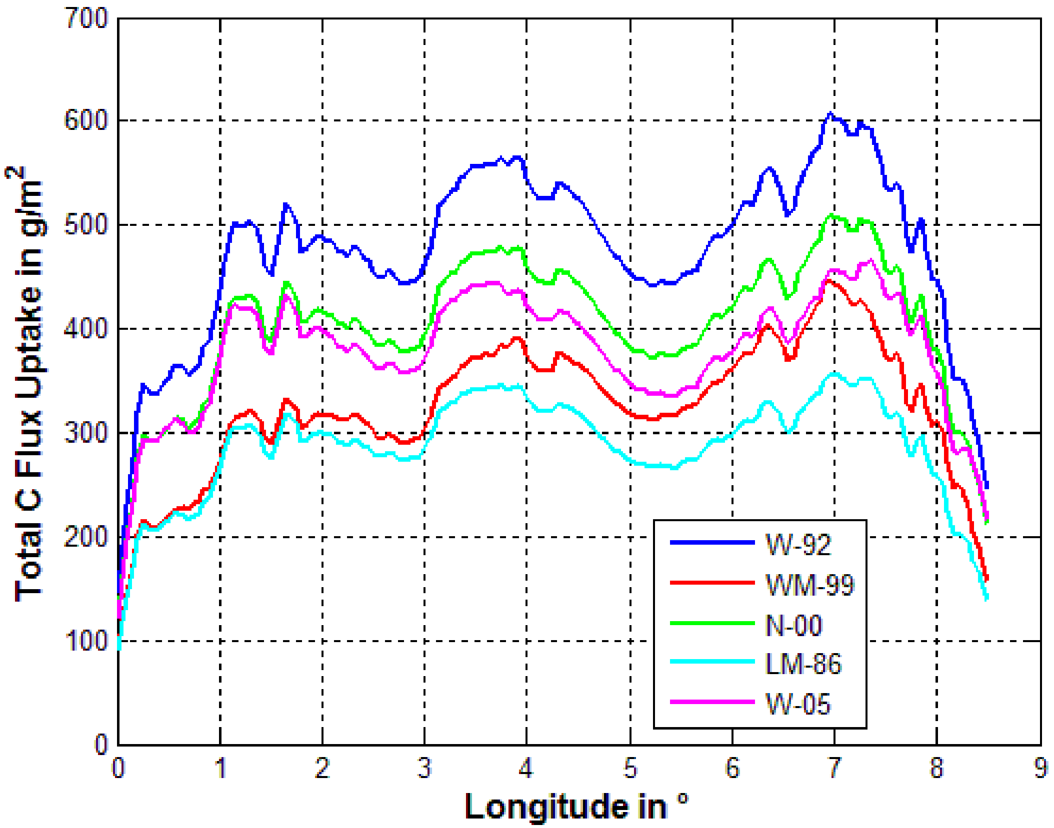
$$k_w = (2.85u - 9.65) \cdot \left(\frac{Sc}{660}\right)^{-1/2}$$

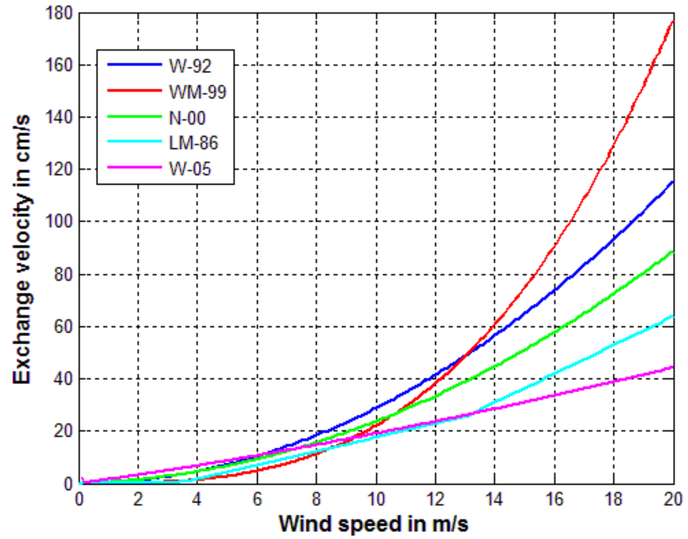
$$k_w = (5.9u - 49.3) \cdot \left(\frac{Sc}{660}\right)^{-1/2}$$

W-05: Woolf, 2005:

$$k_w = (56.52\sqrt{C_d}u + 2.5 \cdot 10^{-4}u^{4.04}) \cdot \left(\frac{Sc}{660}\right)^{-1/2}$$

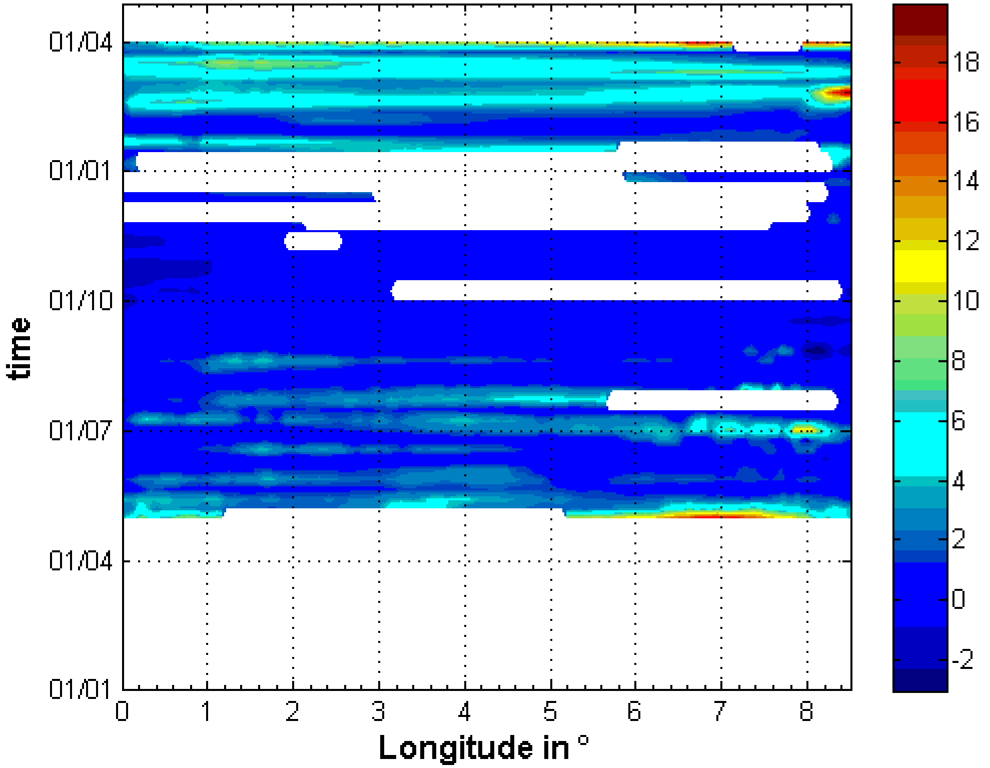
Parameterizations

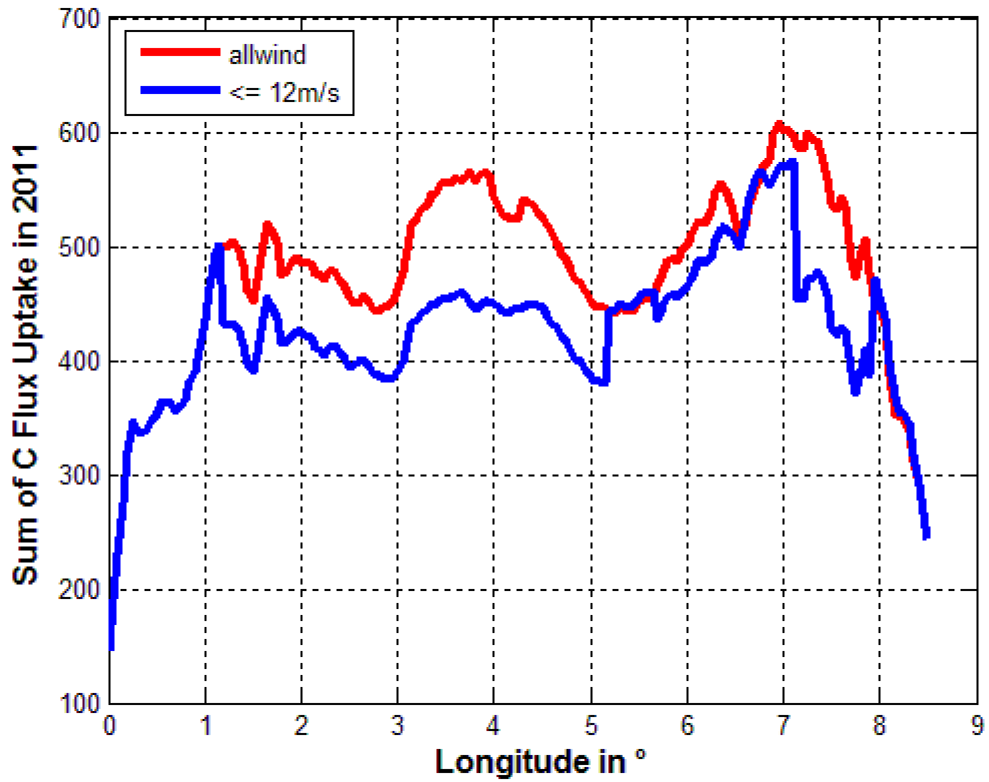




Wind forcing by ERA-Interim

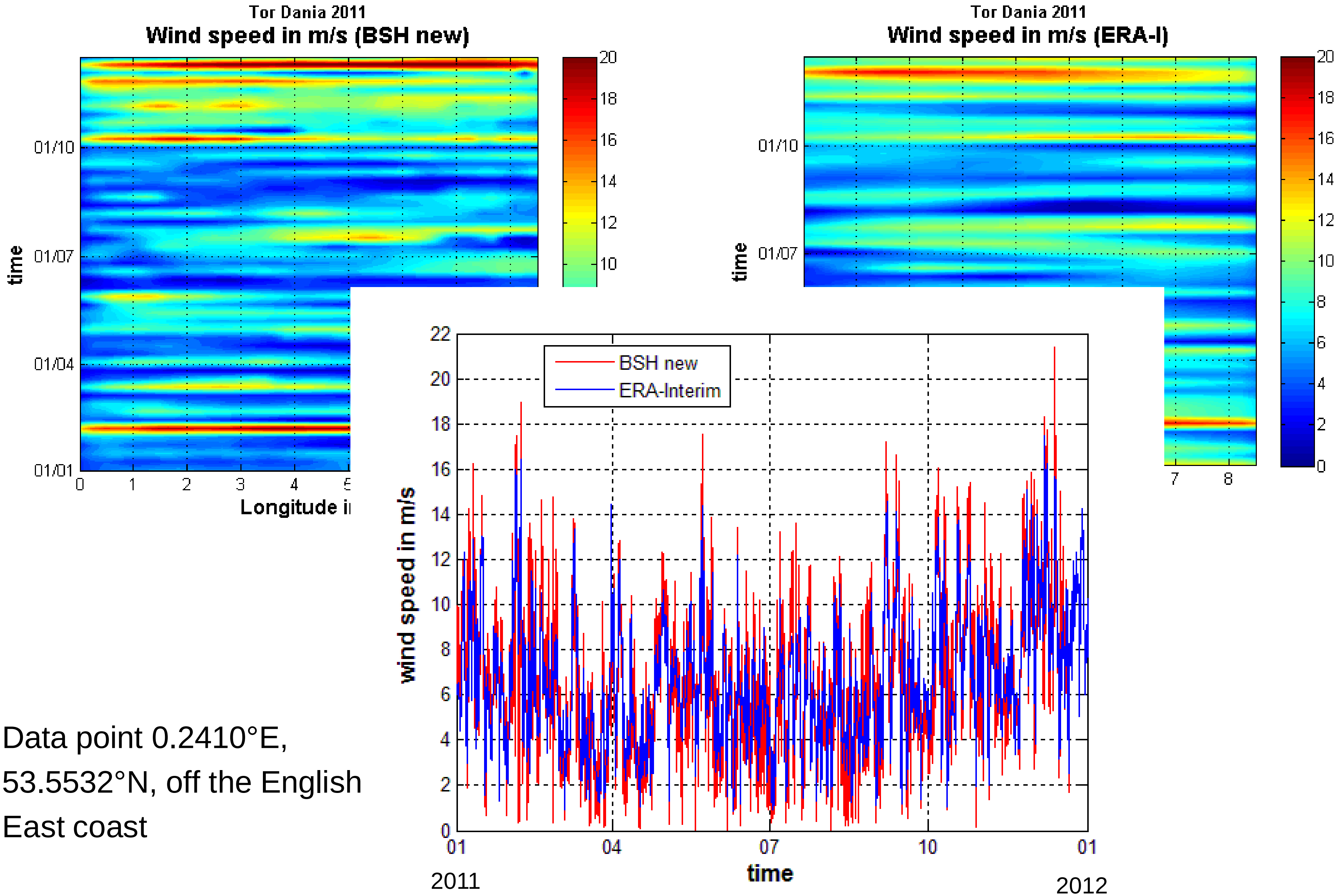
Exclusion of high winds





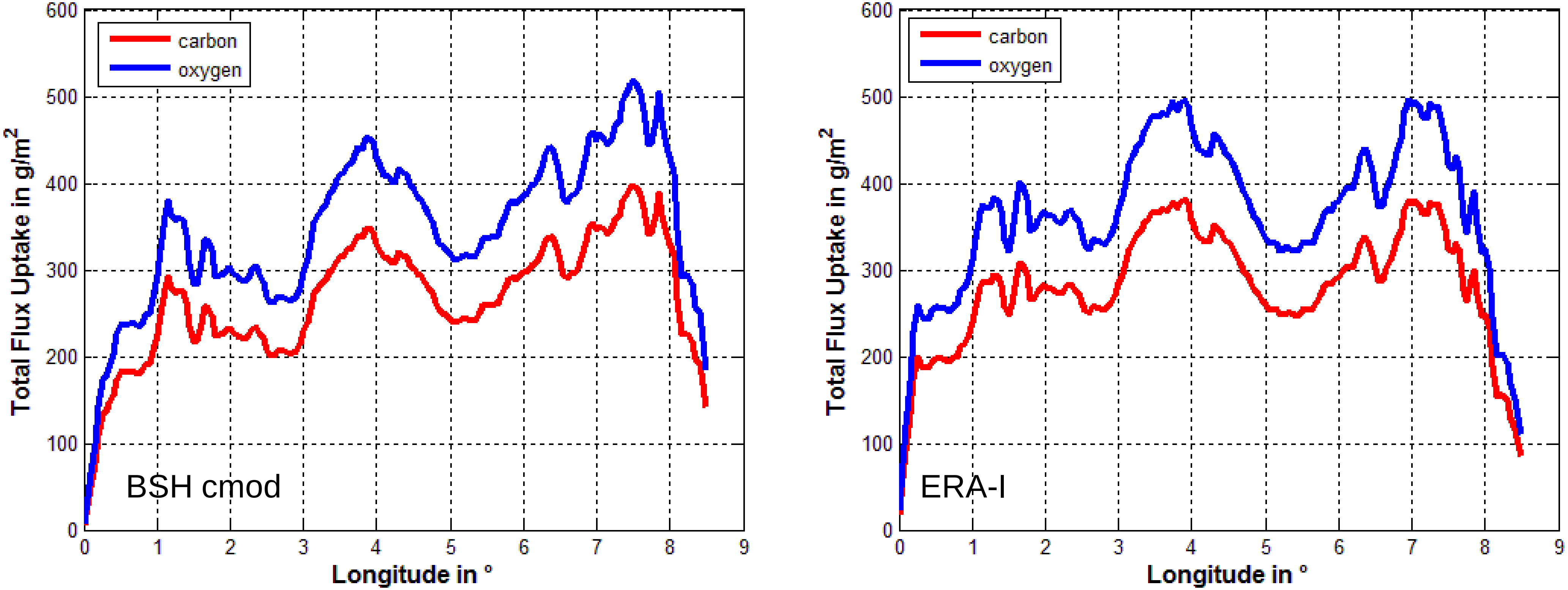
Wind forcing by ERA-I, Wanninkhof (1992) parameterization

Wind input BSHcmod vs ERA-I



Data point 0.2410°E, 53.5532°N, off the English East coast

Carbon fluxes: Wind input BSH cmod vs ERA-I



Conclusions

- Results of flux calculations for one annual cycle from Tor Dania dataset
- In general, southern North Sea is sink for carbon during growing season
- Carbon fluxes reach up to 600 gC/m^2 in one year, located in the German Bight
- Tests show
  - variation for different parameterizations of exchange velocity
  - High impact of high winds, although they occurr mainly in winter
  - Coarse ERA-I dataset affect lower carbon fluxes near the coast

what is still to do...

- dataset over longer timescale
  - more than one seasonal cycle → annual variability (Petersen et al., 2011)
- calculations for other ferrybox routes,
  - long timescales
  - continuous data sets
- Extent study of parameter reliability

Thank you!

Data processing…

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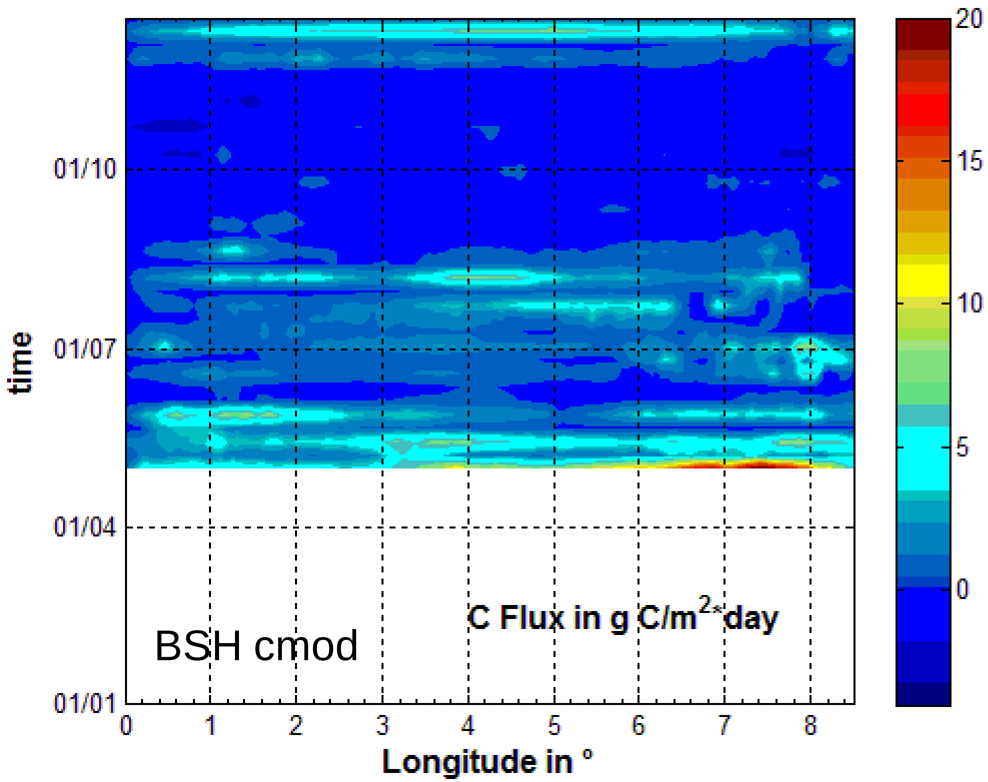
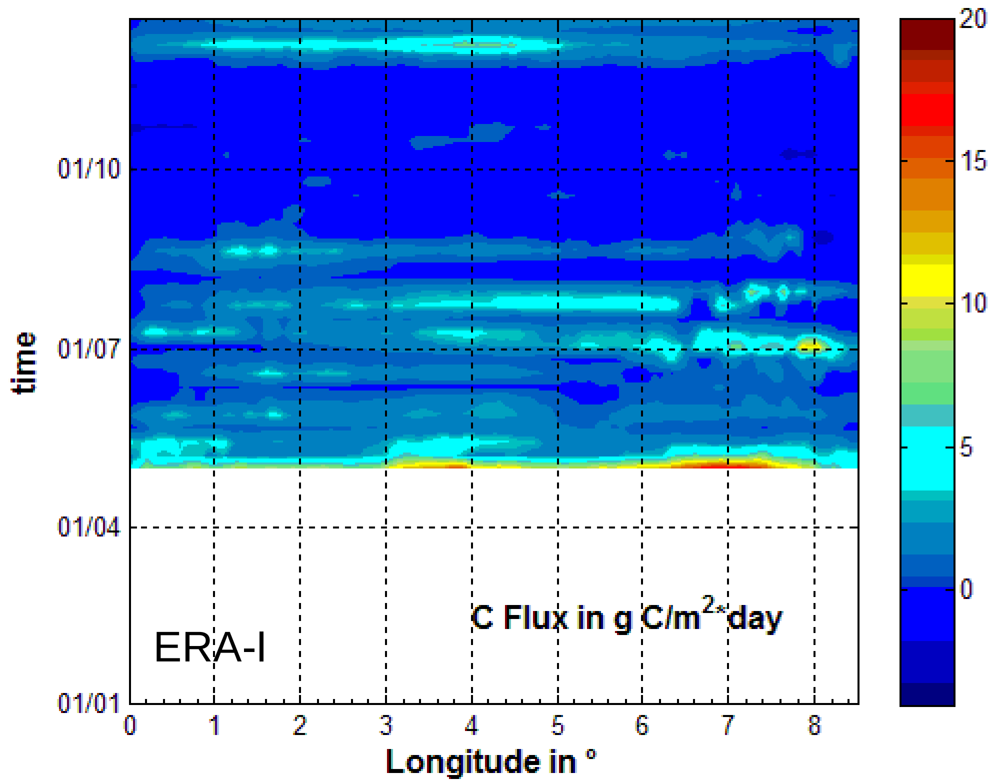
- Transect data of Tor Dania: every 2-3 days a data set at one point of the transect
- Create grid of 0.05°E (x-axis) x 7 days (y-axis)
- Interpolate model wind data on that grid

Carbon fluxes depending on wind forcing





- Wanninkhof (1992) parameterization
- BSH cmod data available until end of 2011