→ BALTIC FROM SPACE WORKSHOP

29–31 March 2017 | Helsinki, Finland

Sea-air interactions (CO_2-fluxes)

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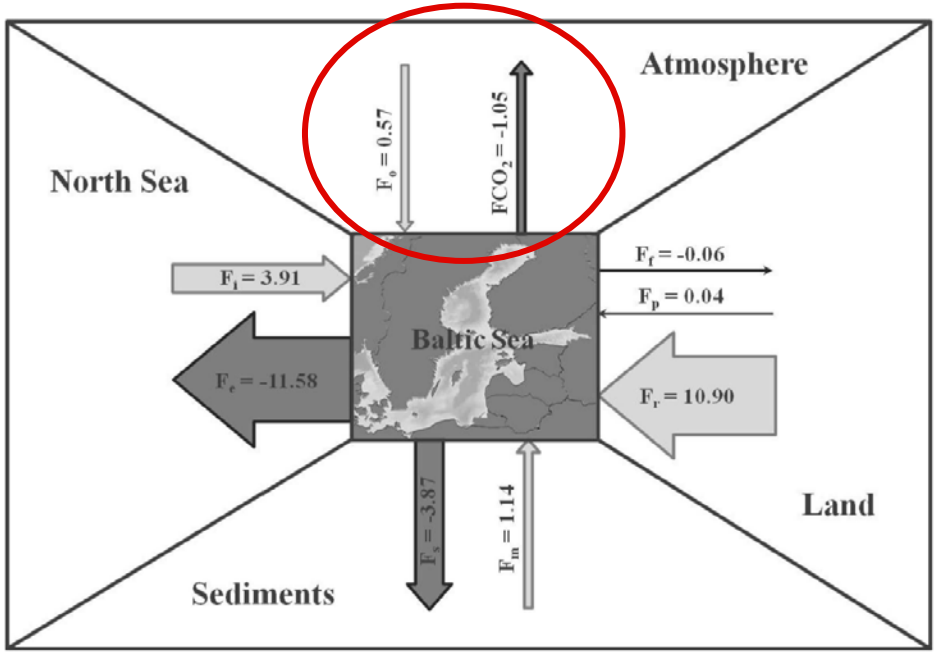
Carbon cycle of the Baltic Sea

All carbon fluxes are expressed in Tg yr−1 (Tg = 1012 g).

Baltic Sea sink or source of atmospheric CO_2?



Kulinski et al (2011)

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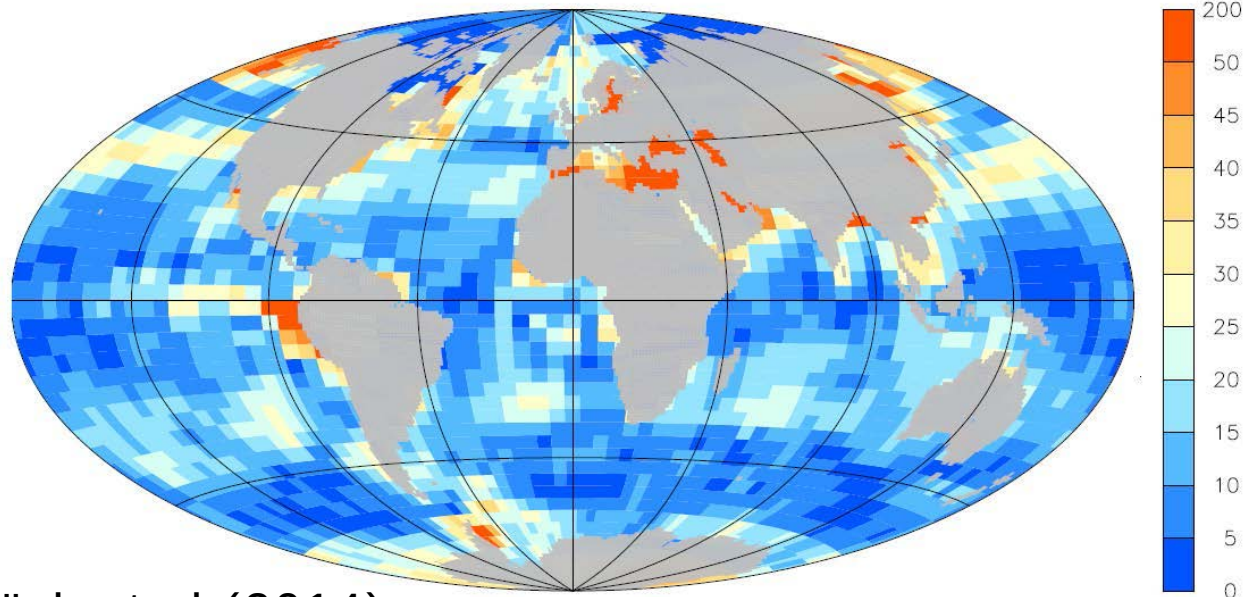
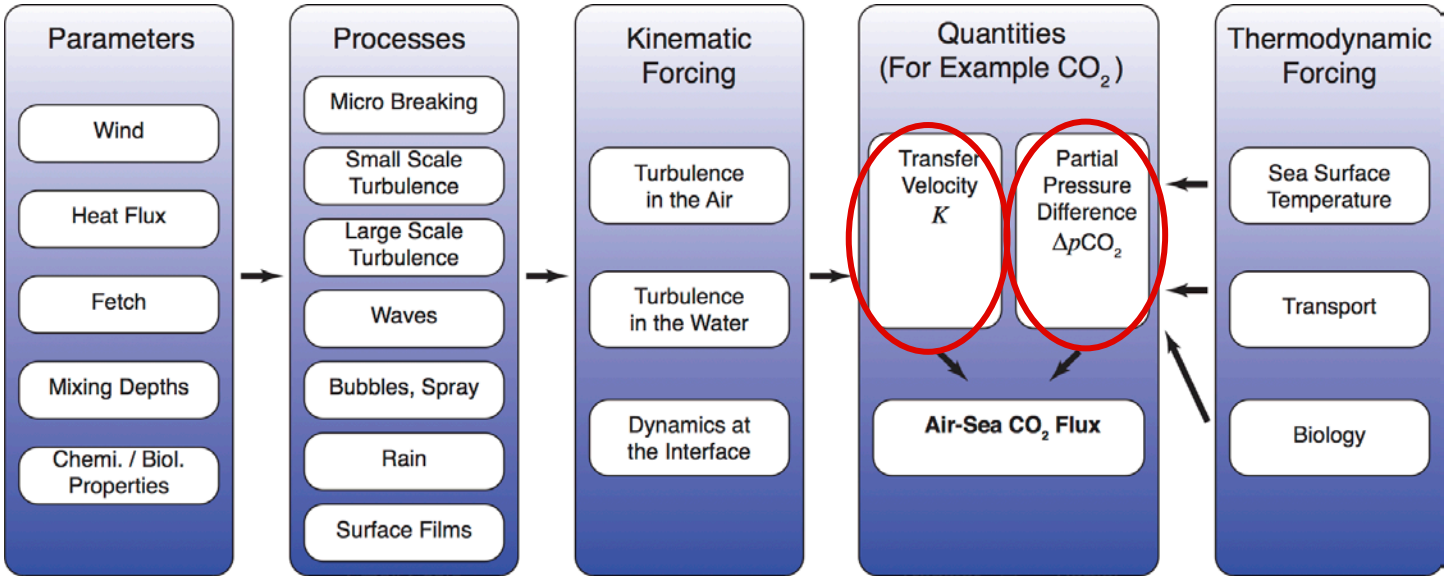
The role of marginals seas

Annual amplitude of pCO_2 (uatm)



Rödenbäck et al (2014)

What controls the flux at the surface?



COST735 book (Garbe and Rutgersson et al)

Controls of transfer velocities: types of water basins:

- Open ocean
  - Spray, bubbles
  - waves

  → Wind speed, Waves

- Marginal and coastal seas
  - Spray, bubbles, waves
  - buoyancy

  → Wind speed and waves, Surface heat flux

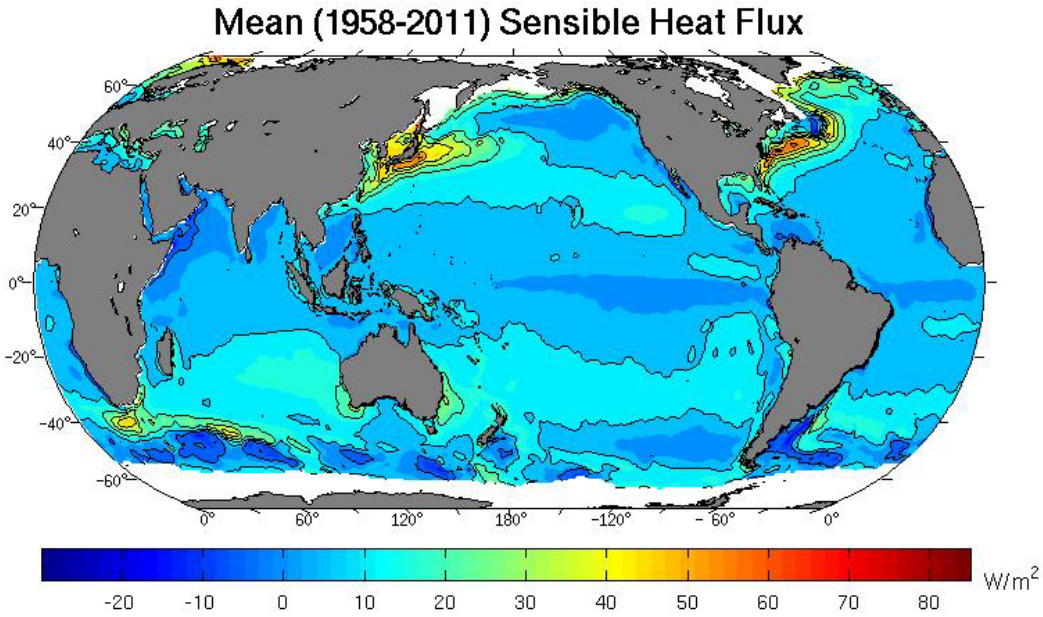
- Shore areas
  - Spray, bubbles, waves
  - buoyancy
  - surfactants

  → Wind speed and waves, Temperature difference, Chem/biol properties

- Lakes
  - buoyancy
  - Surfactants

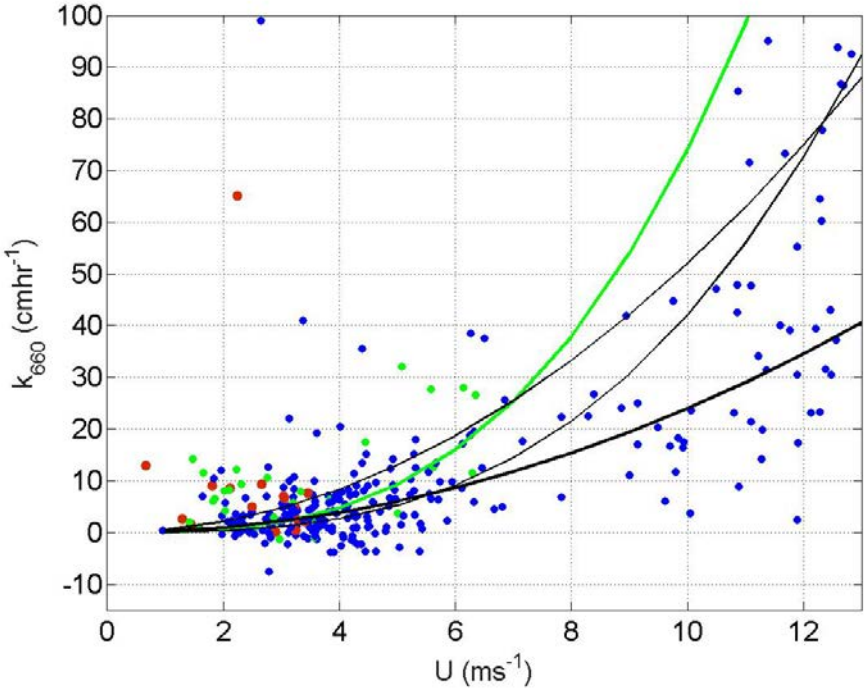
  → Temperature difference, Chem/biol properties, Wind speed?

Heat flux globally (indicates air-sea temeprature difference):



From WHOI OAflux

Dependence of wind speed for transfer velocity

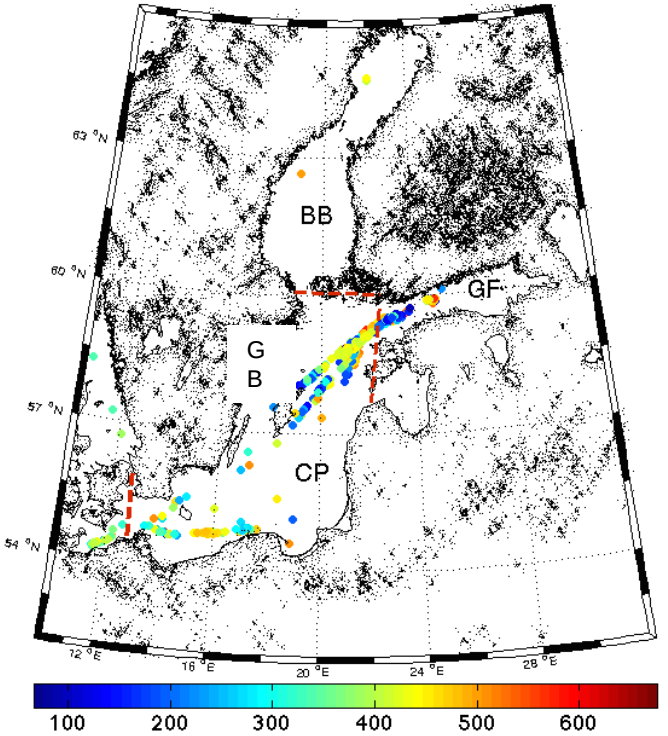


Can we use EO for air-sea gas exchange?

- Need pCO_{2w} (SST, MLD, CDOM, other parameters?)
- Need transfer velocity (high quality winds, wave information, buoyancy?).

Develop remote sensing algorithm for monthly maps

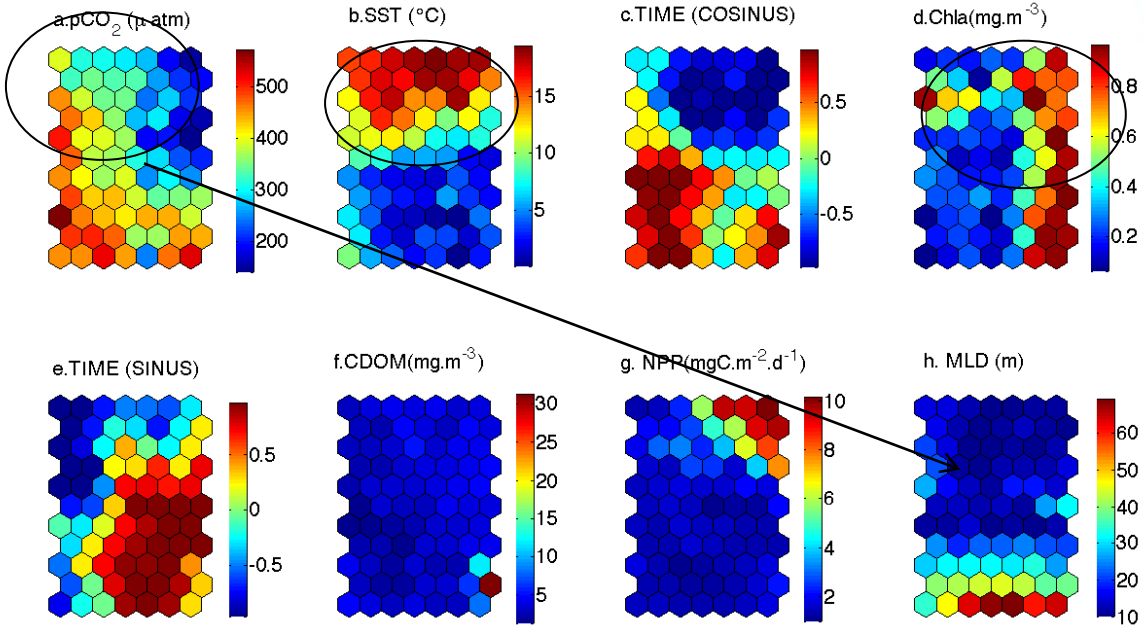
- Combined methods : Self Organizing Map and Multiple Linear regression (SOMLO from Sasse et al., 2013).
- Train algorithms using observations



Satellite DATA for the first try

- SST:
- Chlorophyll :
  - -SeaWiFS (Sept. 1998 - Dec. 2002) 4 km monthly
  - -MODIS-Aqua (Jul. 2002 - Jun. 2011) 4 km monthly
- CDOM :
  - -MODIS data 4km monthly average.
- Primary Production:
  - -EMIS: depth-integrated model (Lee et al., 2005). .
  - -Vertically Generalized Production Model (VGPM) (2009-2011). The VGPM is a "chlorophyll-based" model that estimate net primary production from chlorophyll.
- MLD
  - -Modelled
- Wind speed
  - -ASCAT/QSCAT satellite products
  - -Modelled wind speeds, SMHI

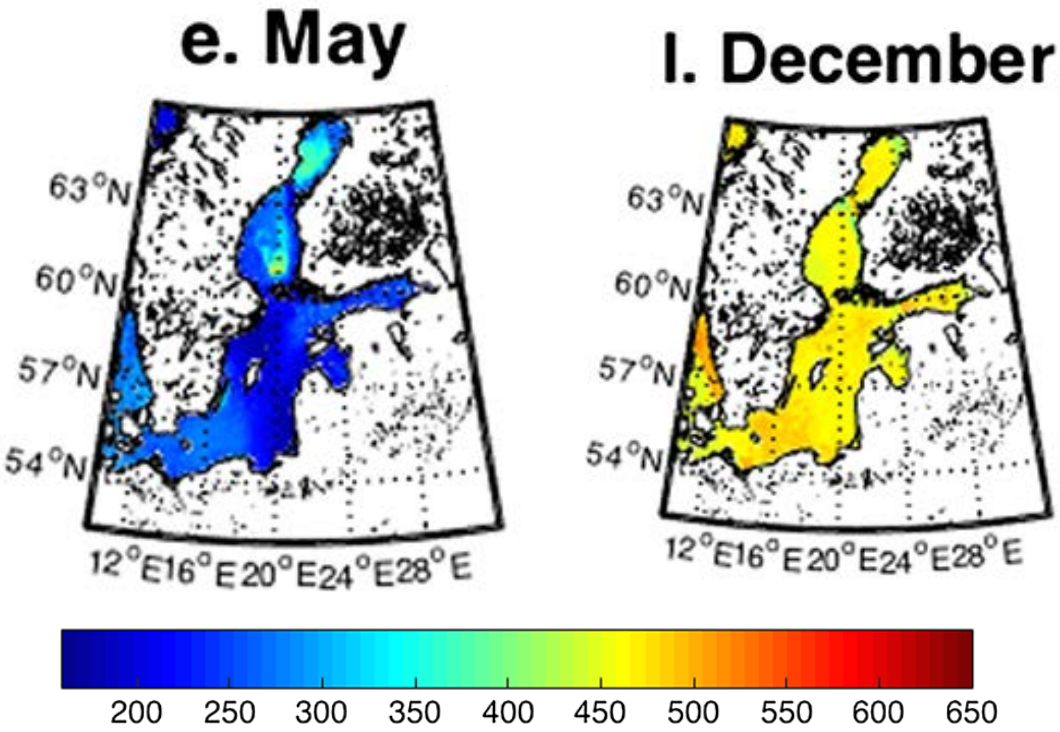
Distribution of parameters



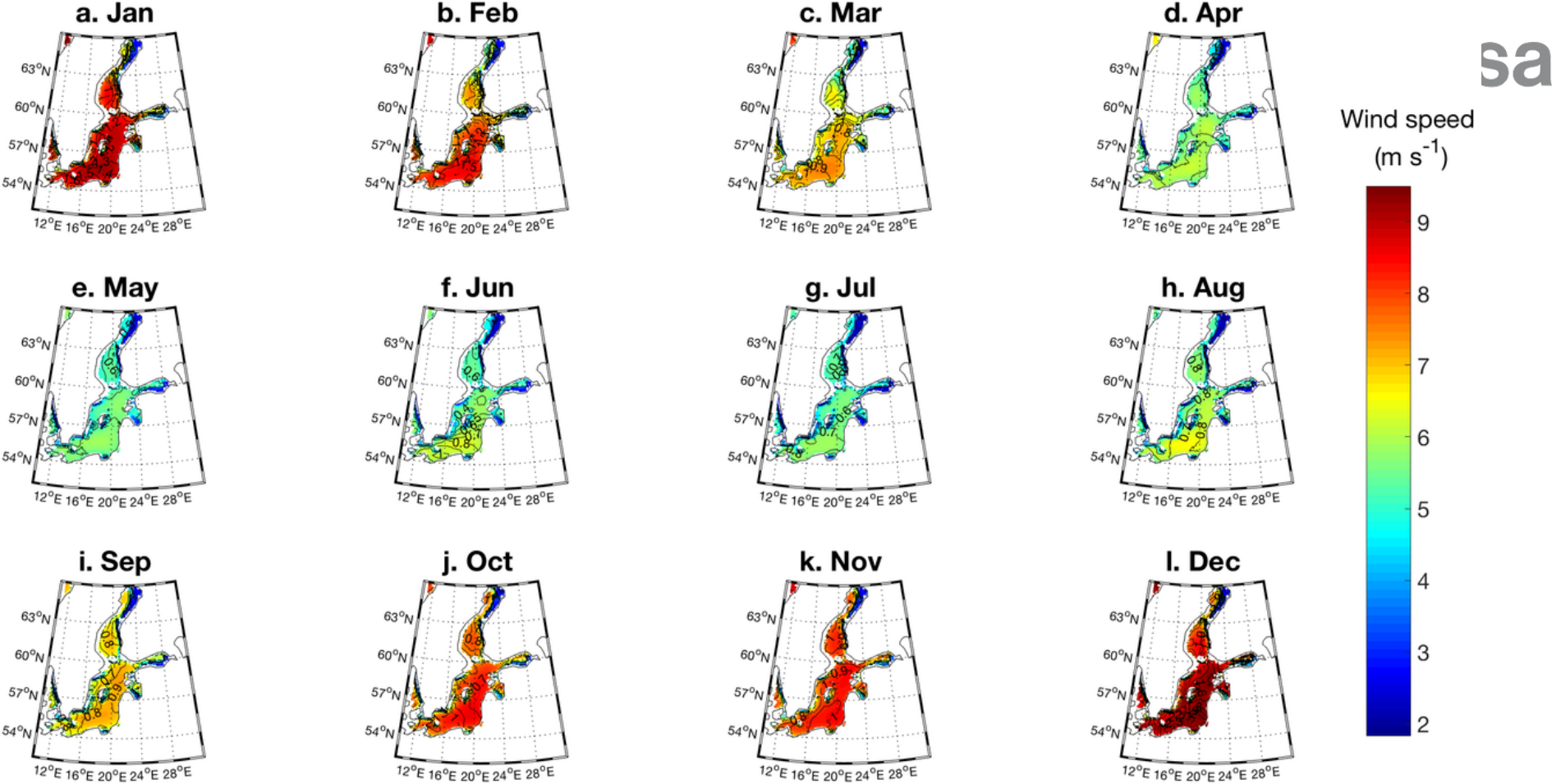
- Strongly dependent of SST and chlorophyll. MLD : Higher value during winter

Parard, G., A. A. Charantonis, and A. Rutgerson (2015), Remote sensing algorithm for sea surface CO2 in the Baltic Sea, *Biogeosci. Discuss.*, *11*, 12,255–12,294, doi:10.5194/bgd-11-12255-2014.

Monthly mean pCO_{2w} (uatm)



Parard, G., Charantonis, A., Rutgersson, A. (2016). Using Satellite Data to estimate partial pressure of CO_2 in the Baltic Sea. *J. Geophys. Res. Biogeosci.,*



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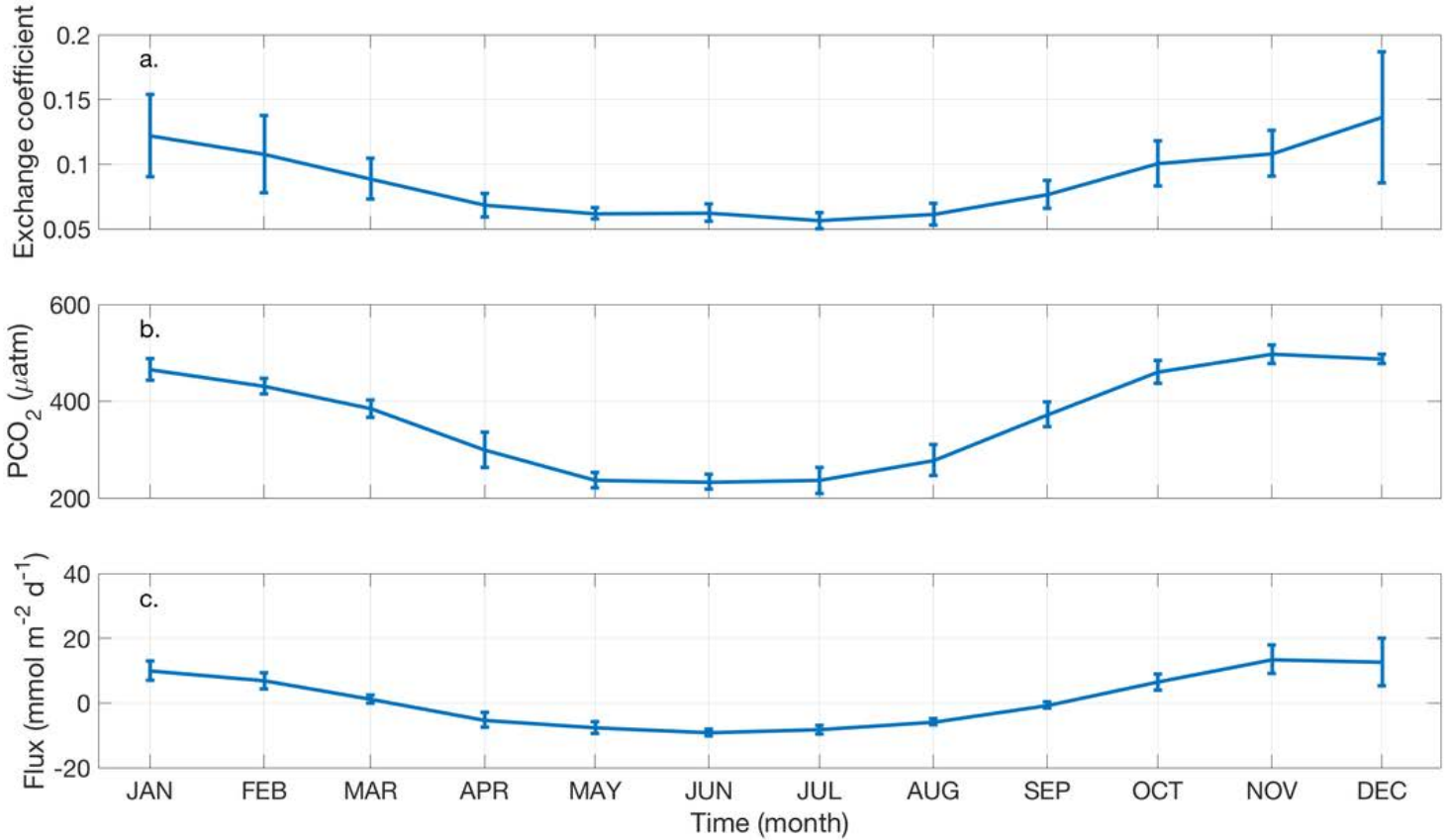
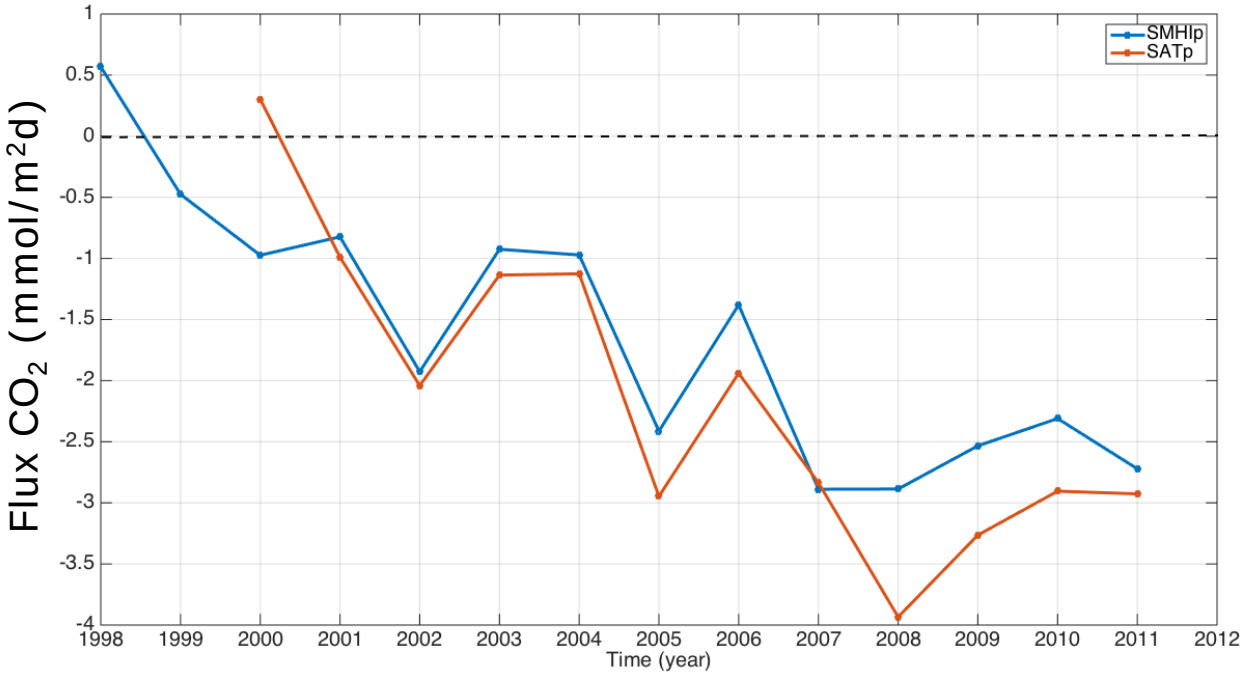
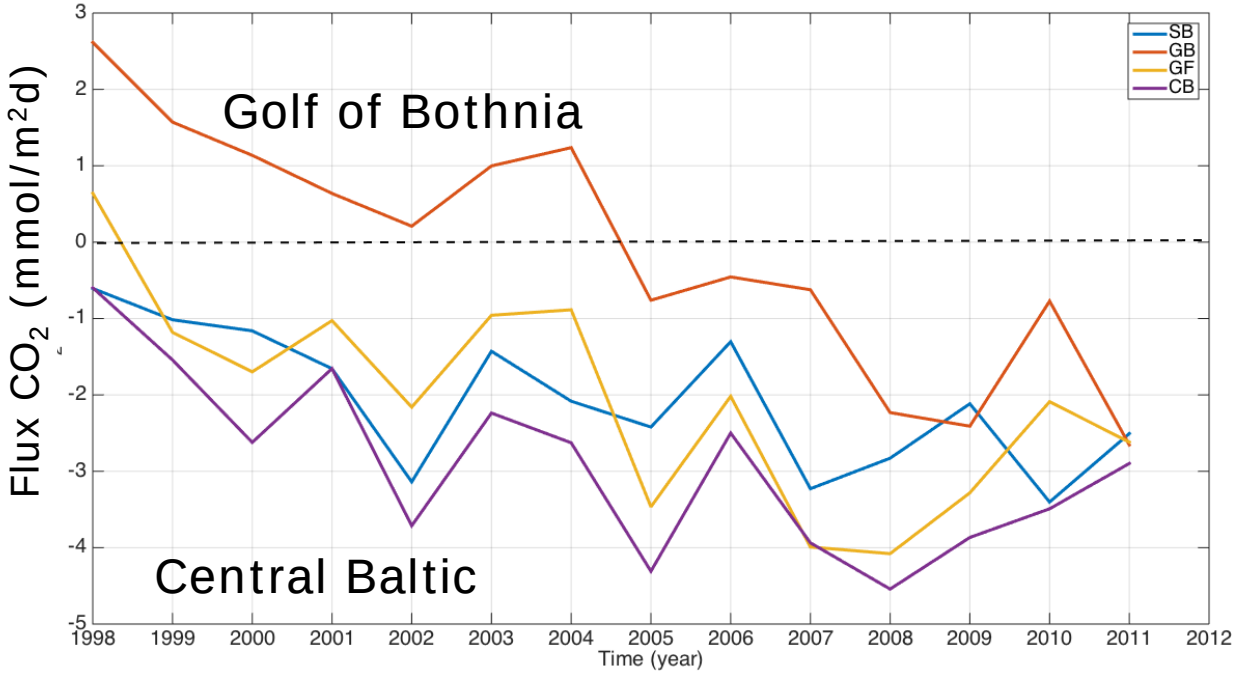

a.
Exchange coefficient
0.2
0.15
0.1
0.05
b.
PCO_2 (μatm)
600
400
200
c.
Flux (mmol m^{-2} d^{-1})
40
20
0
-20
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Time (month)

Baltic Sea total air-sea flux



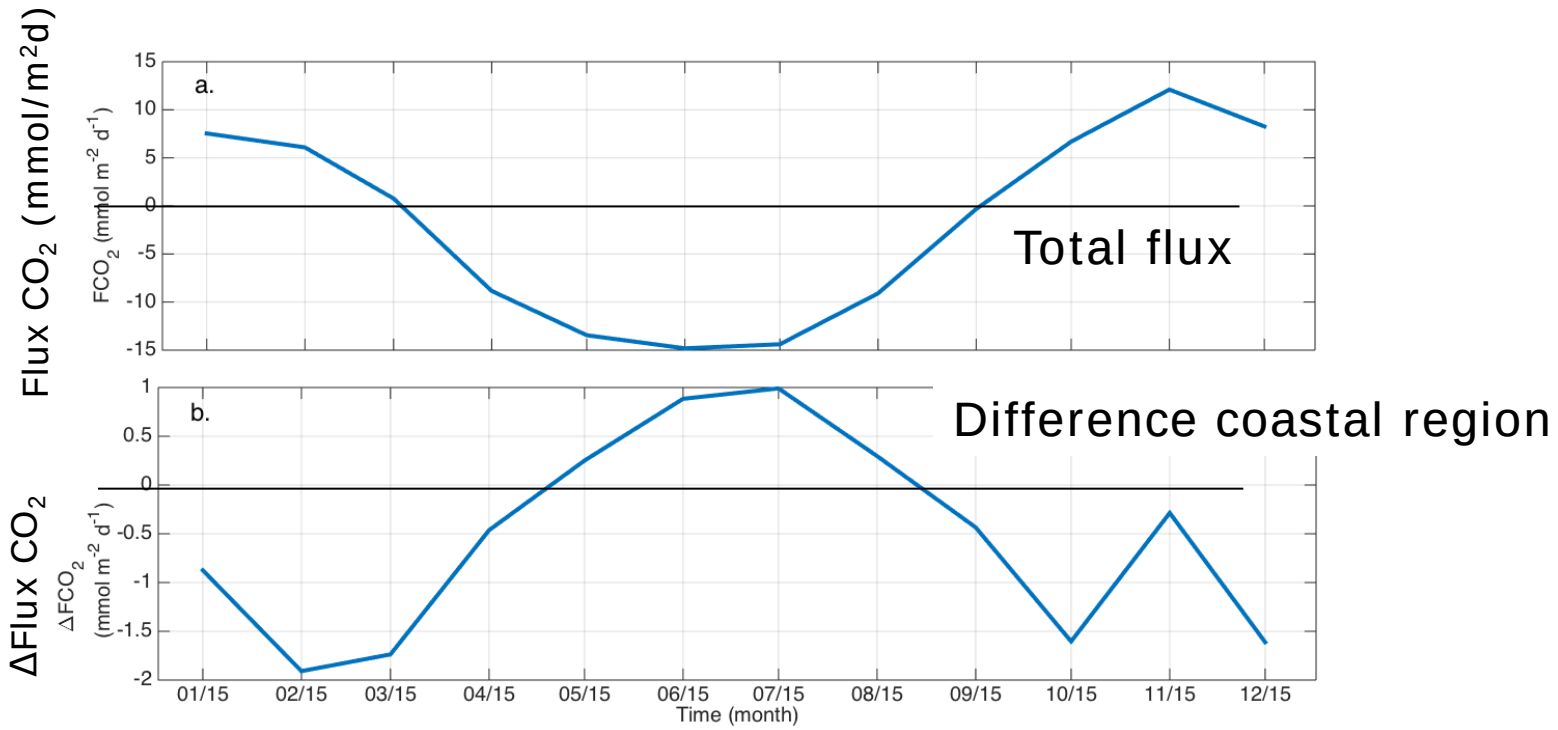
Parard et al (2016), In manuscript

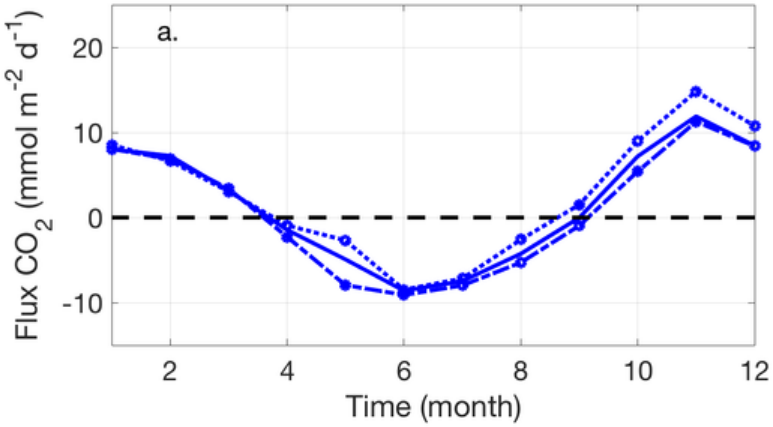
Baltic Sea air-sea flux for different basins

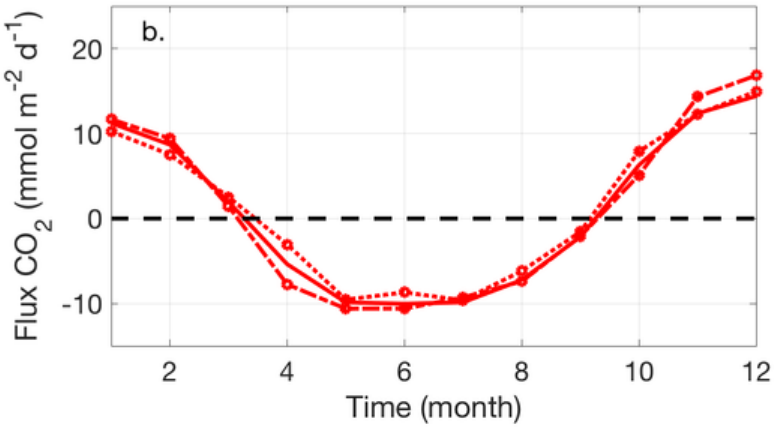


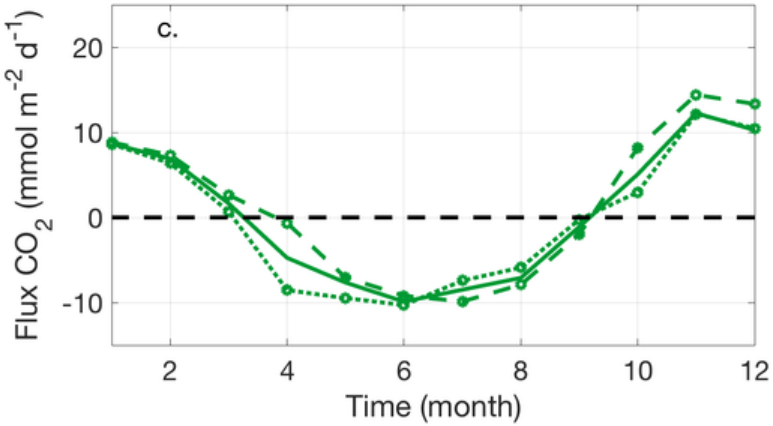
Parard et al (2015), In manuscript

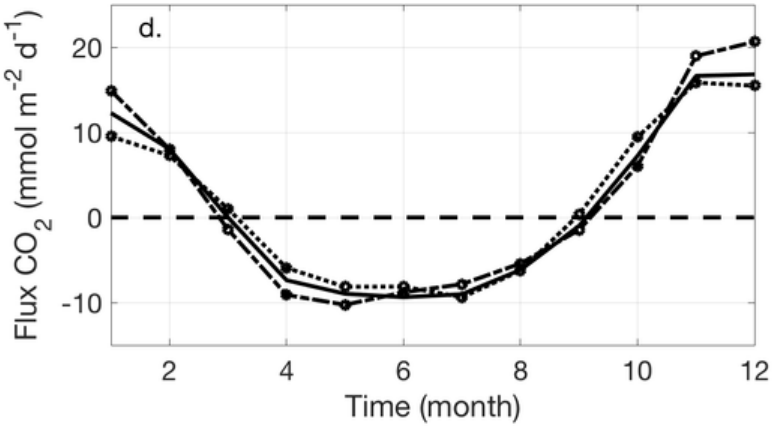
Baltic Sea air-sea flux, seasonal cycle




a.
Flux CO_2 (mmol m^{-2} d^{-1})
Time (month)


b.
Flux CO_2 (mmol m^{-2} d^{-1})
Time (month)


c.
Flux CO_2 (mmol m^{-2} d^{-1})
Time (month)


d.
Flux CO_2 (mmol m^{-2} d^{-1})
Time (month)

To conclude

- Sea surface pCO_2 and CO_2-flux estimated using available remote sensing products
- Remote sensing algorithm requres: SST, MLD, Chl-a, CDOM
- Net annual uptake
- The annual uptake increases over time.

Can we use this?

Missing knowledge:

- Monthly resolution too poor, many processes have a higher reolution (upwelling, coastal).
- Different algorithms for different basins – incitates limitation in method or missing input information (salinity?).
- Transfer coefficients needs improvement

Thank you!