

Spatio-temporal dynamics of pCO₂ in the southern North Sea investigated by continuous FerryBox measurements

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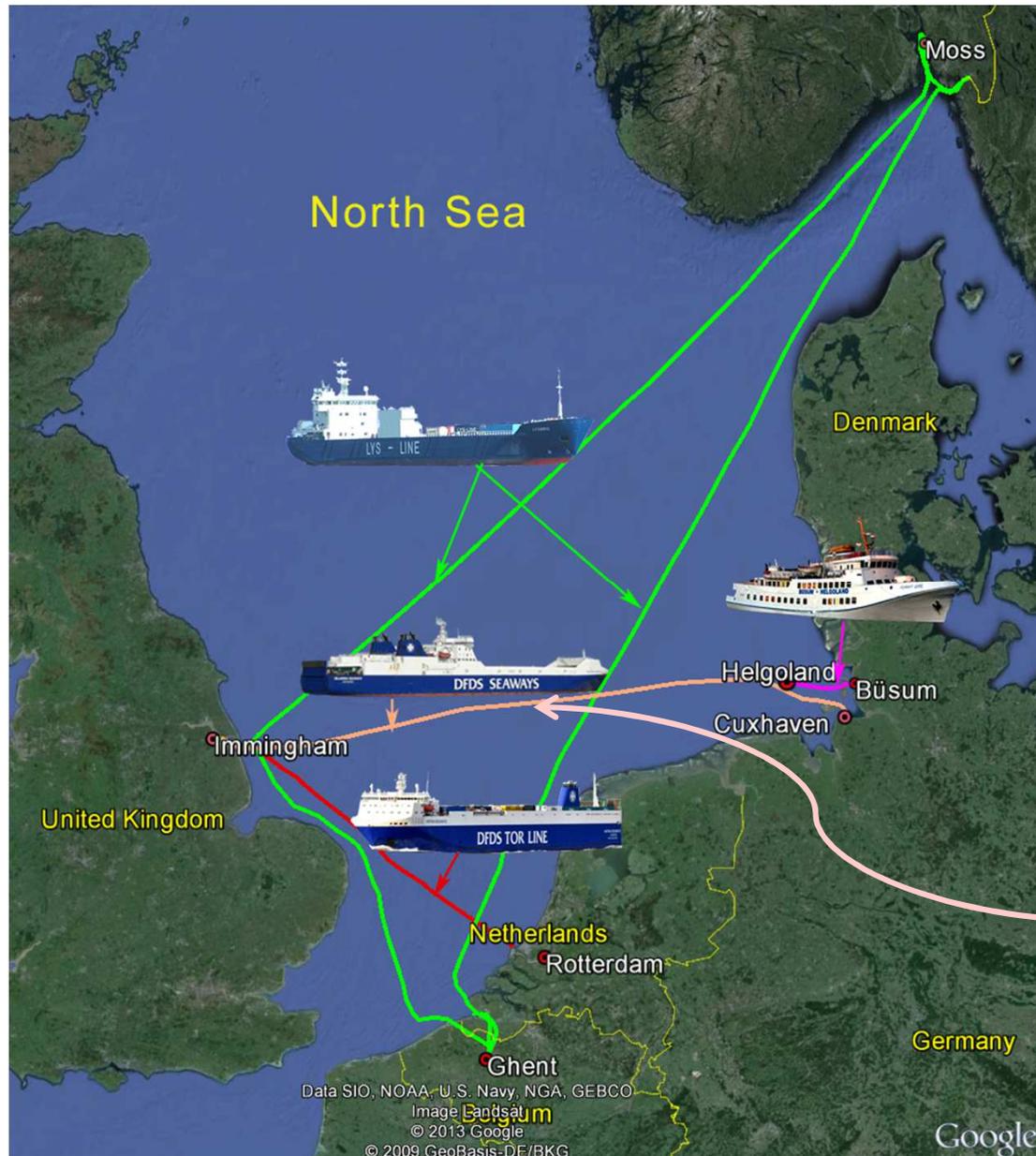
Outline:

- FerryBoxes activities at HZG in the North Sea
- Measurements of pCO₂ with FerryBox Systems
 - experiences with membrane based pCO₂ sensors
 - example data of pCO₂ and
- performance of pH sensors (glasselectrode vs. ISFET)
- Future plans for measuring the carbon cycle
- Summary

General Aims of FerryBox Activities at HZG

- provide basic measurements of oceanographic parameters (T, S, Turb, Chl-a, oxygen...)
- delivering data to European projects and activities (MyOcean, JERICO, EMODNet)
- application of physical parameters (T, S) in data assimilation schemes
- investigation of productivity along the transect from continuous oxygen data (+ wind fields)
- investigation of nutrient behaviour and algae dynamic along the transects
- investigation of the carbon cycle and the importance of different coastal areas as source or sink for atmospheric carbon (pCO₂, pH, TA)
(with newly developed instruments for continuous measurements of high precision pH and total alkalinity)
- optimization and validation of biogeochemical models with FerryBox data

FerryBox Routes operated by Helmholtz Zentrum Geesthacht (HZG)



currently not operated,
waiting for coming back in
autumn 2014

FerryBox Systems: Parameters

Basic parameter:

- water temperature
- salinity
- chlorophyll-a fluorescence
- turbidity
- dissolved oxygen
- pH (glass electrode)

Additional parameter:

- **CDOM** fluorescence (not all systems)
- **pCO₂** (Lysbris: Norway-Belgium-England, Hafnia: Rotterdam - Immingham)
- **algal groups** (algal-online-analyser (bbe))
- **nutrients** (nitrate, nitrite, o-phosphate, silicate, ammonium)
(devices from Systea (IT) only partly operated),

FerryBox Systems: Parameters (cont)

- **New developed sensors with focus on biogeochemistry:**
 - high precision pH & alkalinity (Steffen Aßmann, laboratory prototype, further development and test **EU project NEXOS**)
 - new **nutrient** analyzers based on SIA technique (Carsten Frank, laboratory prototype)
 - test of new nutrient analyzer from Systea (**µLFA, see talk from Enrico**)
 - PSICam (more reliable Chl-a & **turbidity, algal groups**)
Jochen Wollschläger, **EU project NEXOS**
 - BioSensor (detection of **algal species** and **HABs**) Co-operation AWI (Katja Metfies, **EU project EnviGuard**)

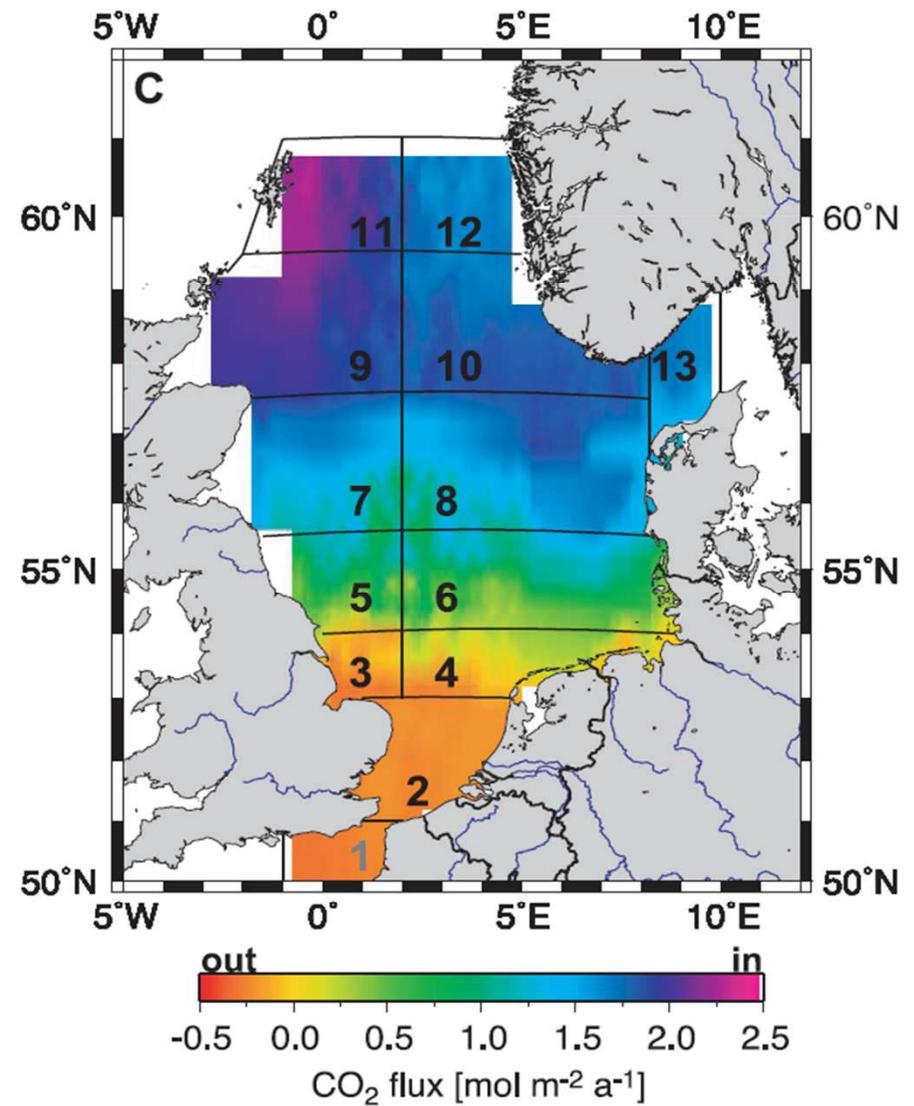
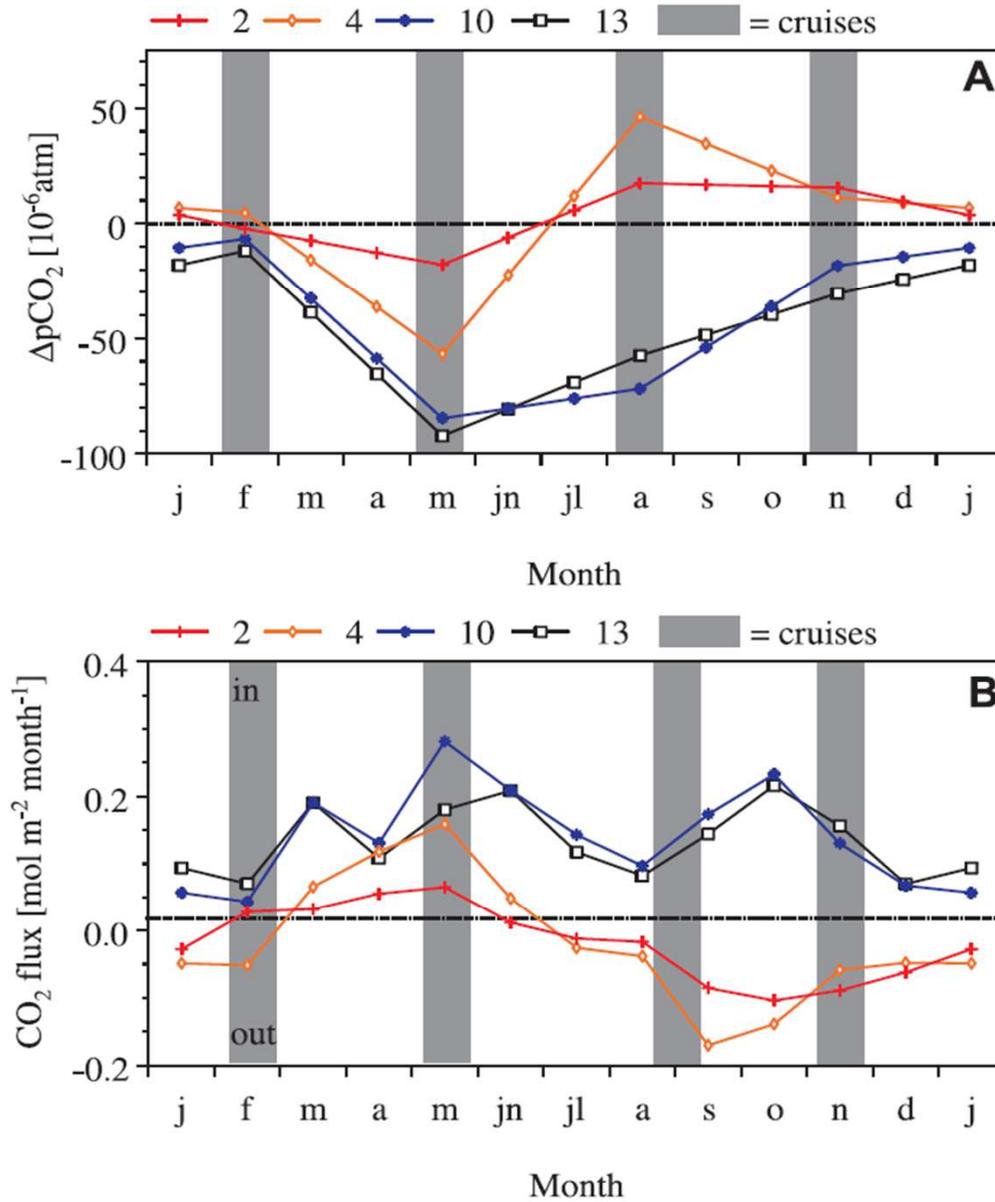
Coastal Seas: Sinks and sources of CO₂

Helmuth Thomas *et al.*
Science **304**, 1005 (2004);

Enhanced Open Ocean Storage of CO₂ from Shelf Sea Pumping

Helmuth Thomas,* Yann Bozec, Khalid Elkalay, Hein J. W. de Baar

Seasonal field observations show that the North Sea, a Northern European shelf sea, is highly efficient in pumping carbon dioxide from the atmosphere to the North Atlantic Ocean. The bottom topography–controlled stratification separates production and respiration processes in the North Sea, causing a carbon dioxide increase in the subsurface layer that is ultimately exported to the North Atlantic Ocean. Globally extrapolated, the net uptake of carbon dioxide by coastal and marginal seas is about 20% of the world ocean’s uptake of anthropogenic carbon dioxide, thus enhancing substantially the open ocean carbon dioxide storage.



Annual cycles of ΔCO_2 for selected areas in the North Sea

H. Thomas et al. Science (2004)

•Expected Results:

- Spatially and seasonally resolved sources and sinks of CO₂ along a certain transect
- Alkalinity transport from Land into the North Sea
- CO₂ air-sea fluxes
- ocean acidification
- quantification of production rates
 - comparison of productivity with estimates derived from other variables (DO, Chl-a, winter nutrient stocks....)
- phytoplankton dynamics (e.g. seasonality...)

Available pCO₂ Measurements:

- Immingham – Cuxhaven: 2011 – 2012 (TorDania)
- Halden – Zeebruegge – Immingham – Moss (LysBris): 2012 – 2014 (ongoing)
- Rotterdam – Immingham (Hafnia Seaways): 2013 – 2014 (ongoing)

ProOceanus pCO₂ sensor



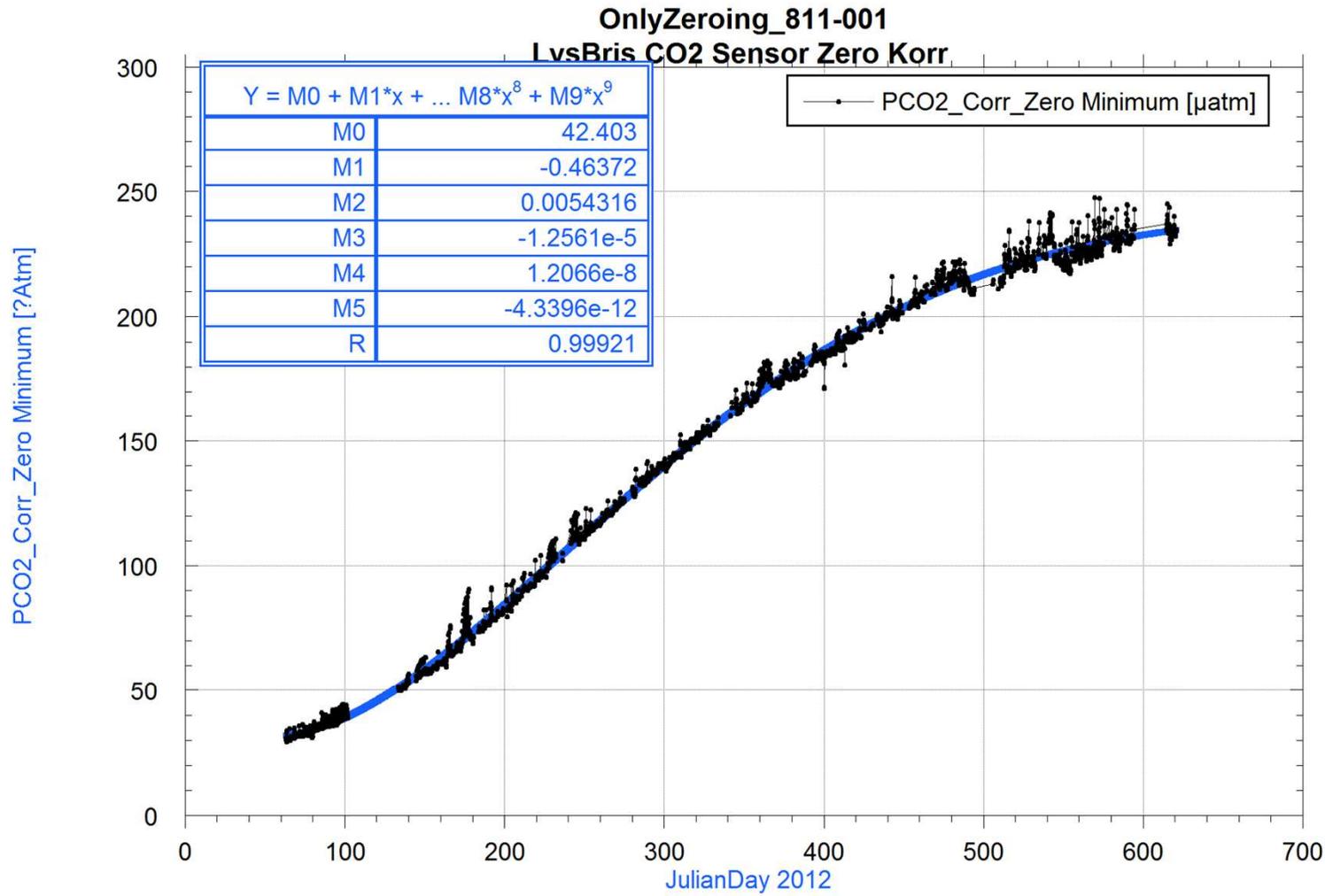
not suitable for long-term
unattend operation

Contros pCO₂ sensor

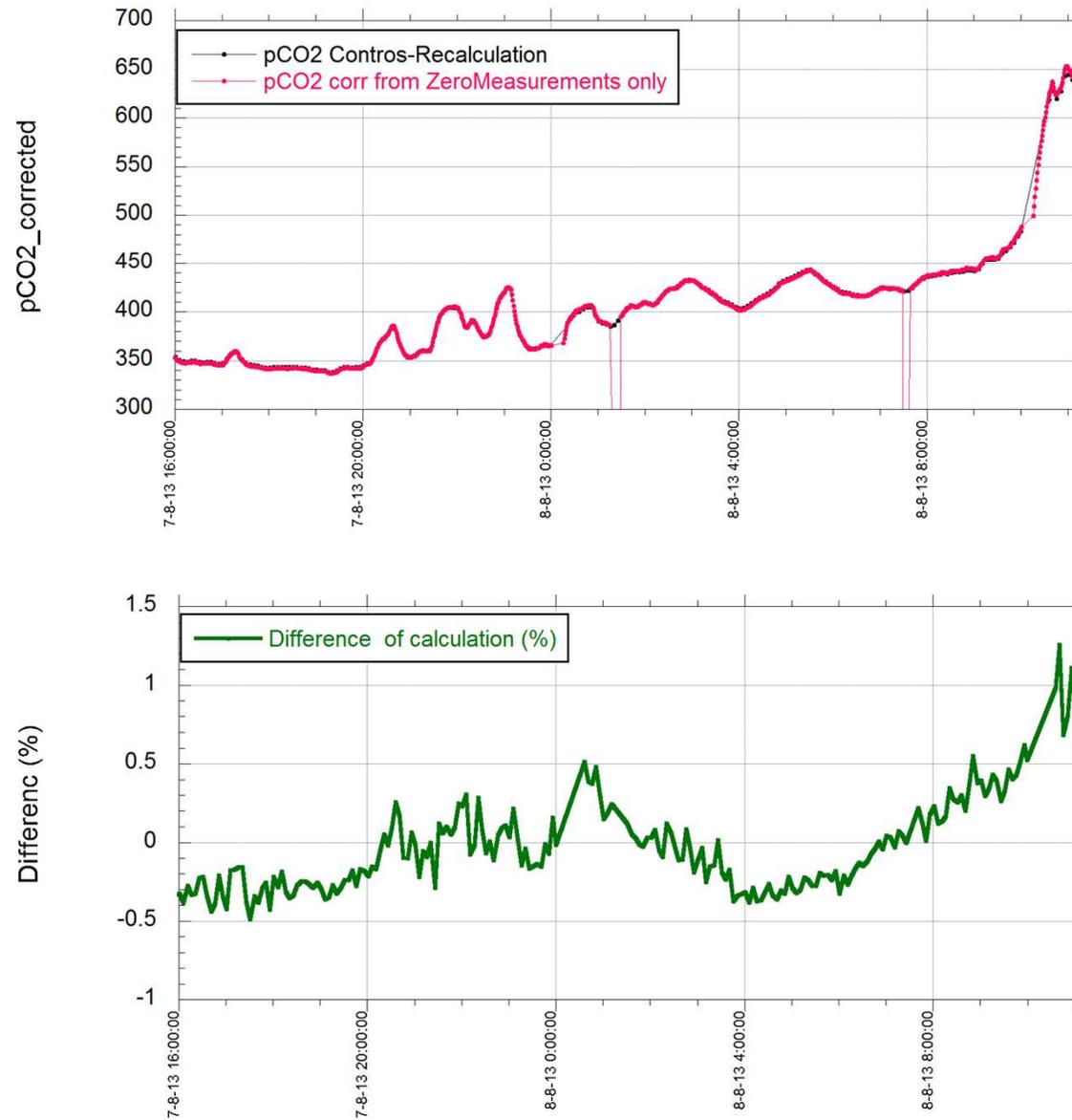


Problems of long-term Stability:

Zero Drift HydroC pCO₂ Analyzer During two Years of Operation at FerryBox (Lysbris)



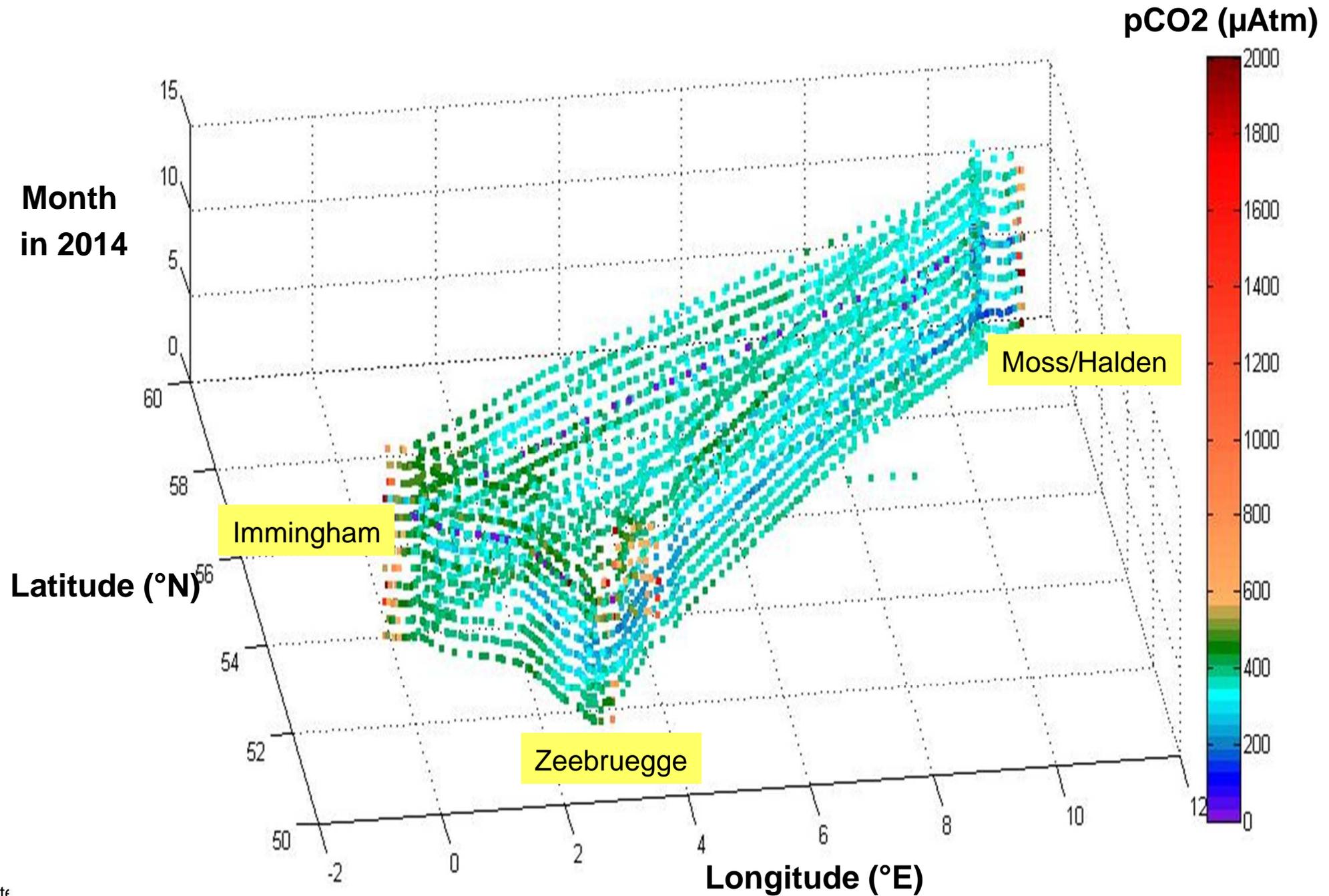
Performance of pCO₂ Sensor: Zero Drift Correction



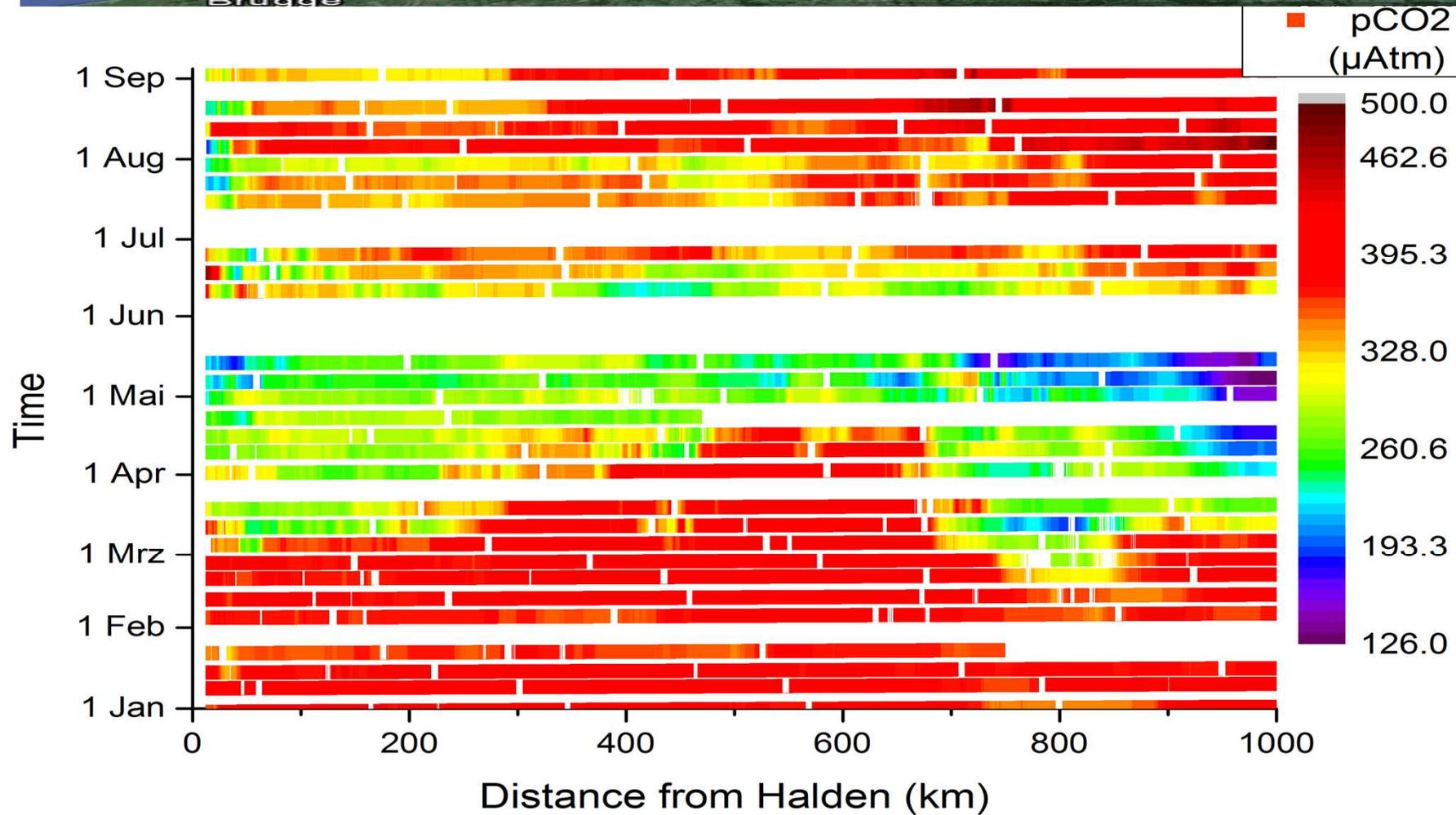
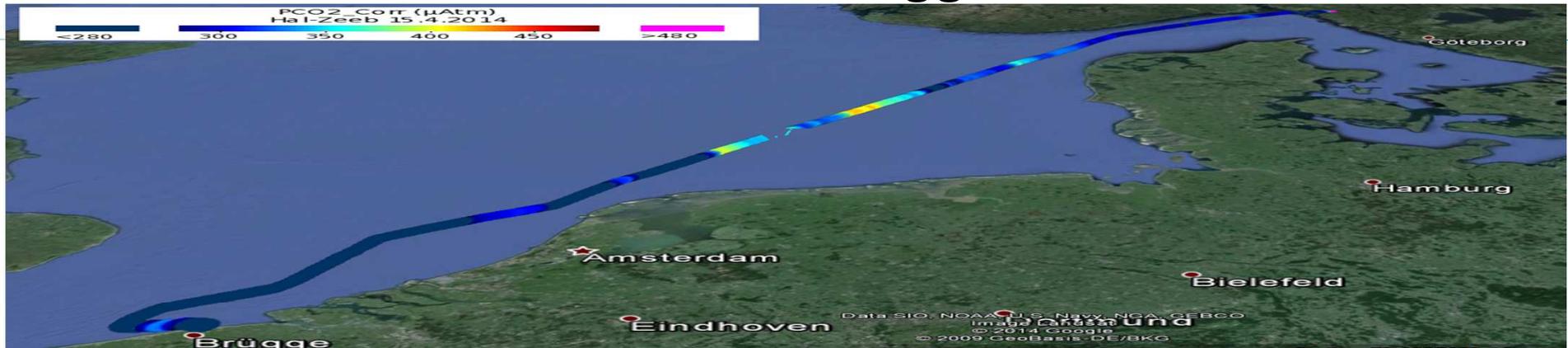
First Results of pCO₂ Measurements in the North Sea

pCO₂ Dataset

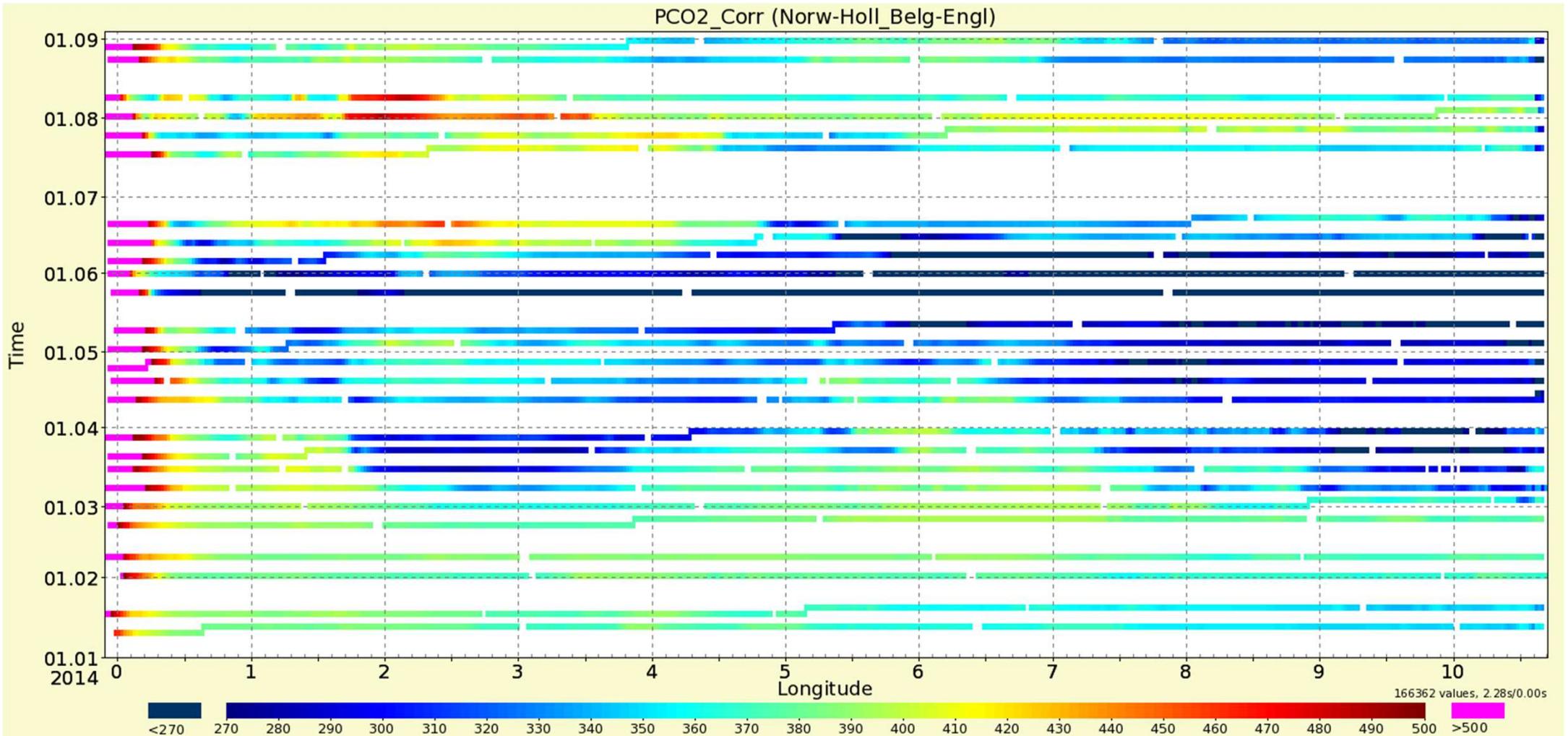
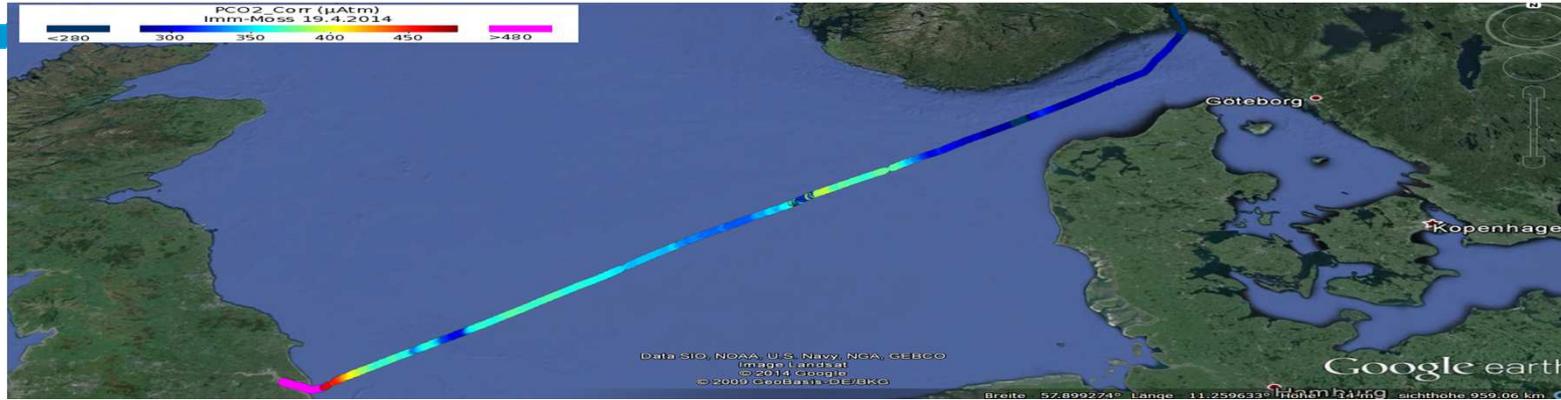
weekly transects from Lysbris in 2013



pCO₂ in 2013: Transect Halden – Zeebrügge



pCO₂ in 2014: North Sea (Immingham – Moss) :



Transect Apr 2014

Imm- Moss

