FerryBox
EuroGOOS Task Team

Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

Seasonal and Spatial Variability of pCO2 and Total Alkalinity in the North Sea – Observations from Continuous FerryBox Measurements

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FerryBoxes in the North Sea operated by Helmholtz-Zentrum Geesthacht (HZG)

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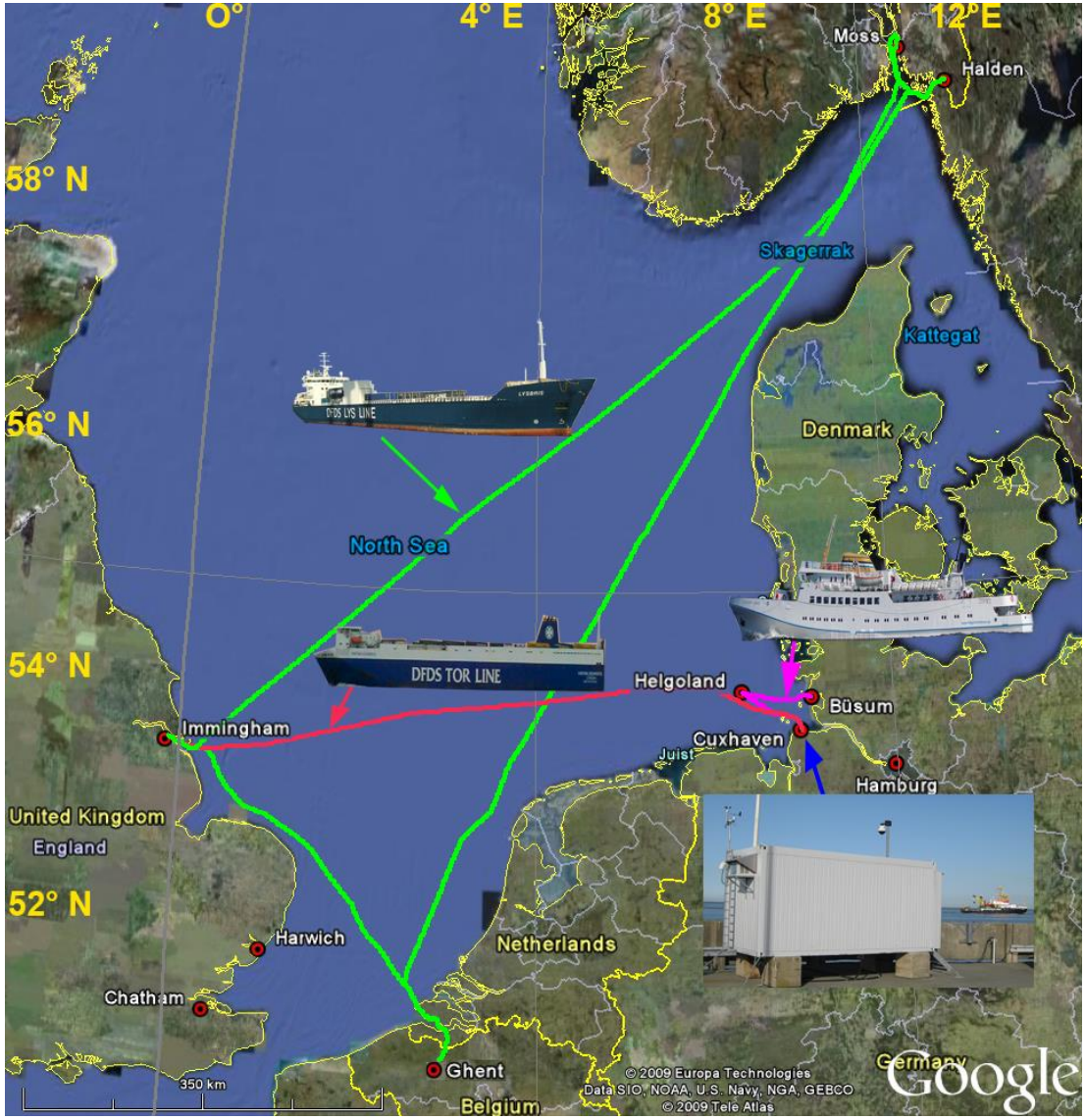

until end of 2018

Route M/V Lysbris since January 2019

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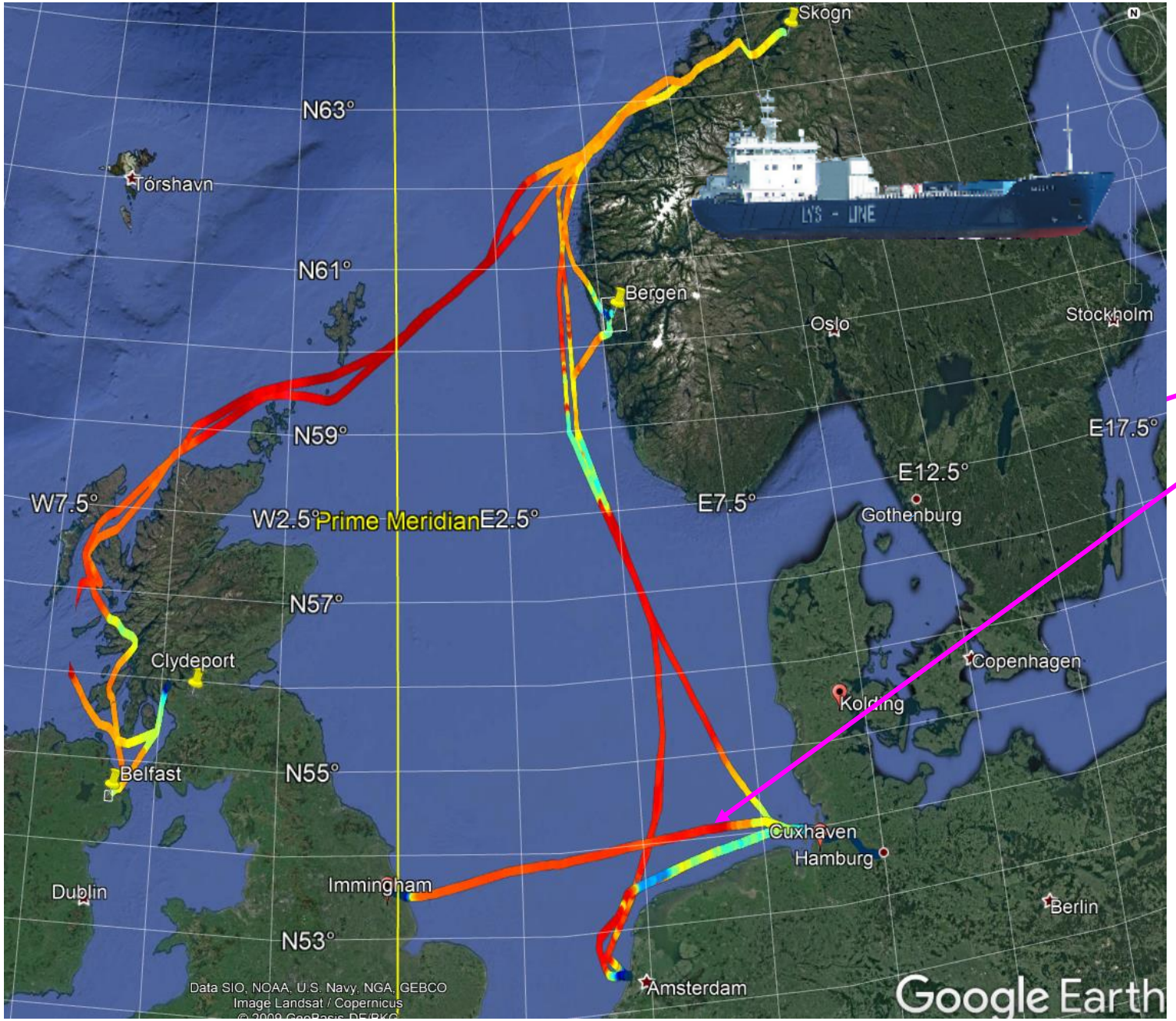

Magnolia Seaways
Later in 2019

Carbonate System Instruments

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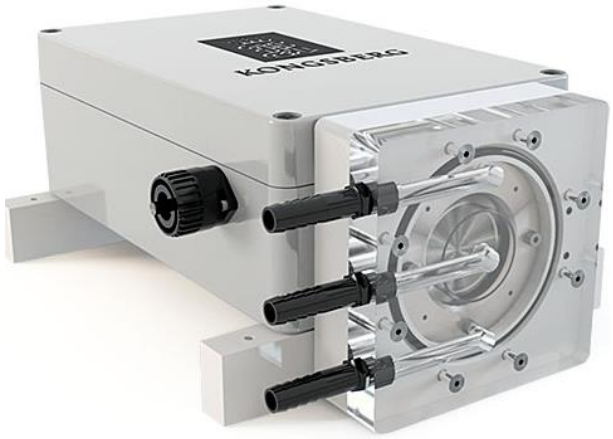
pCO_2 Sensor:
CONTROS HydroC CO_2-FT



Principle and Specifications:

- Membrane based system
- Detector: optical analyzing NDIR system
- Measuring range: 200 – 1000 µatm
- Resolution: < 1 µatm
- Initial accuracy: ± 0.5 % of reading
- Calibration: manufacturer (yearly)
- Using calibration gases not possible
- Zero drift control: regular zero measurements (~6h)

TA Analyser:
CONTROS HydroC CO_2-FT

Principle and Specifications:

- Acidification of seawater by injection of hydrochloric acid (HCl)
- CO2 removal by a degassing unit (open-cell titration)
- Subsequent pH determination by VIS absorption spectrometry (indicator dye Bromocresol green)
- Calculation of TA using T & S from sample water
- Dynamic range 400 µmol/kg
- Accuracy: ±25 µmol kg-1
- Precision: ±5 µmol kg-1
- Measuring cycle ~10 min

Carbon exchanges between a shelf sea (North Sea) and its intertidal coastal region (Wadden Sea)

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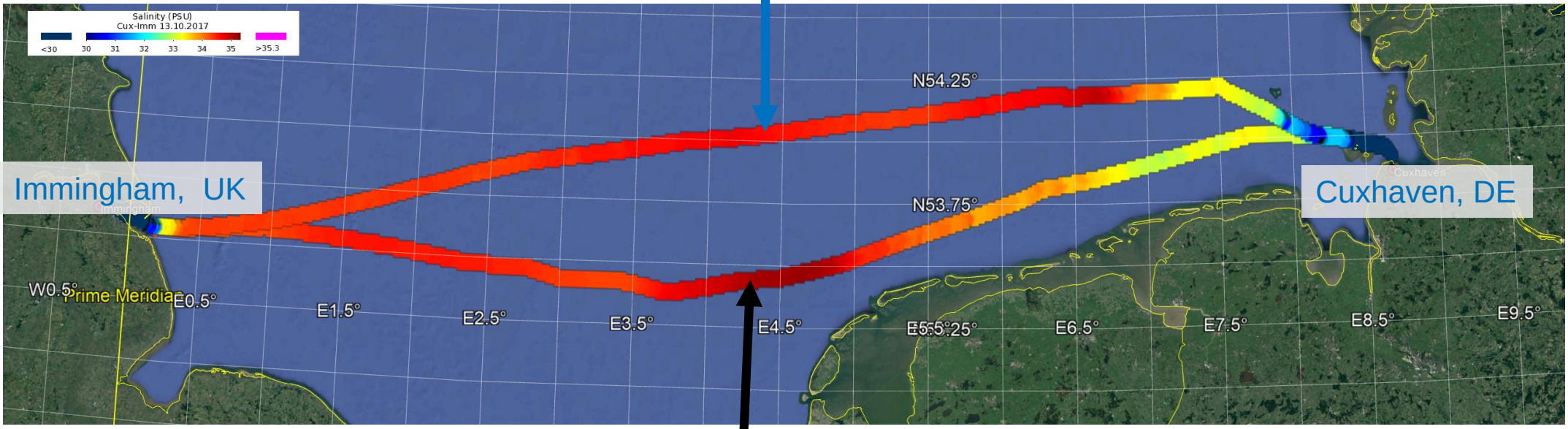
CONTROS HydroFIA TA
Total Alkalinity Analyser

Northern Route



Southern Route

Voynova et al., Limnol. Oceanogr. 2018

Seasonal and regional variability

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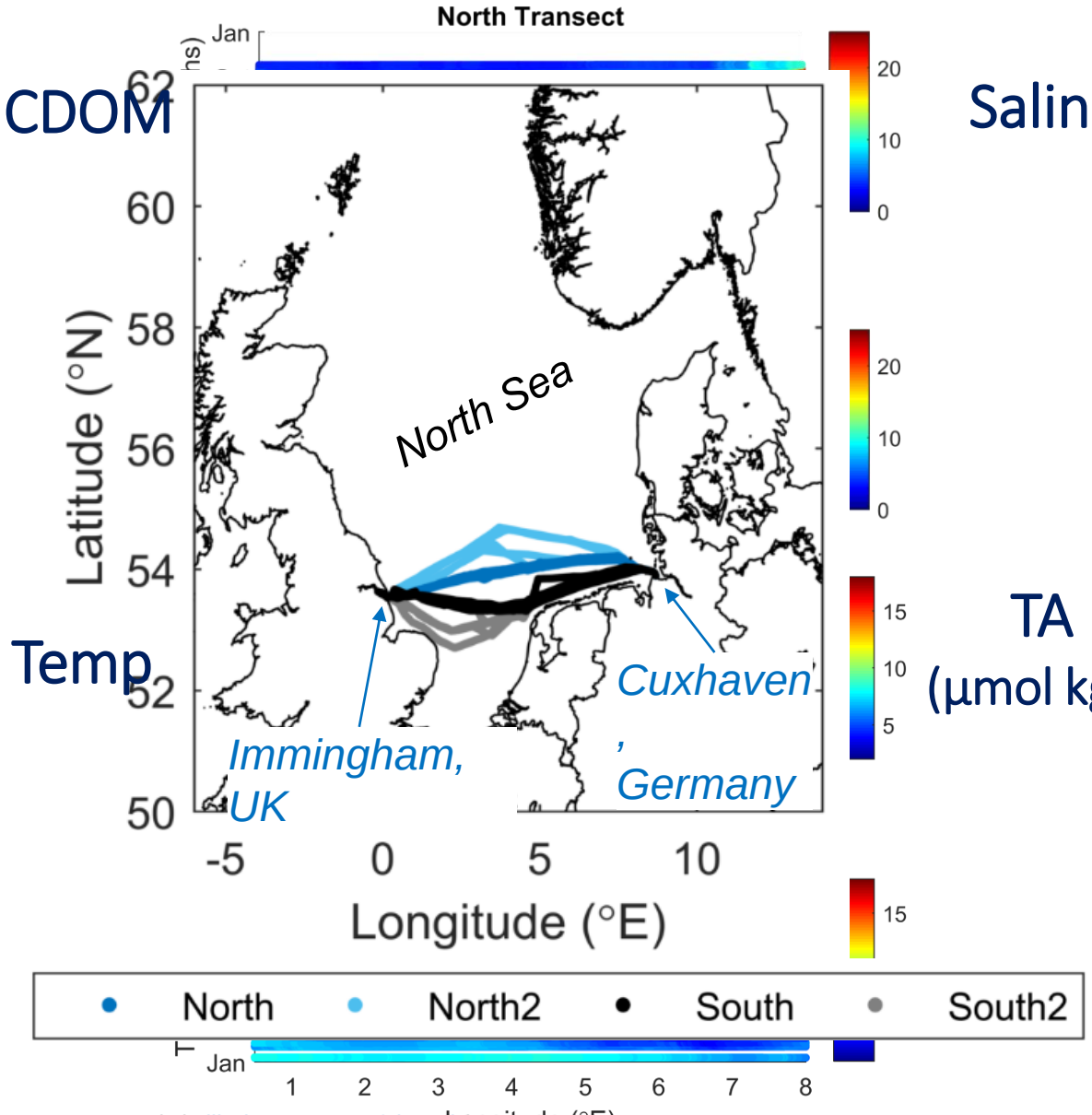
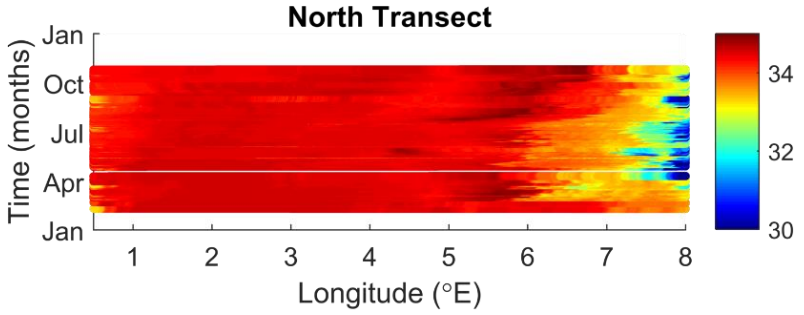
CDOM

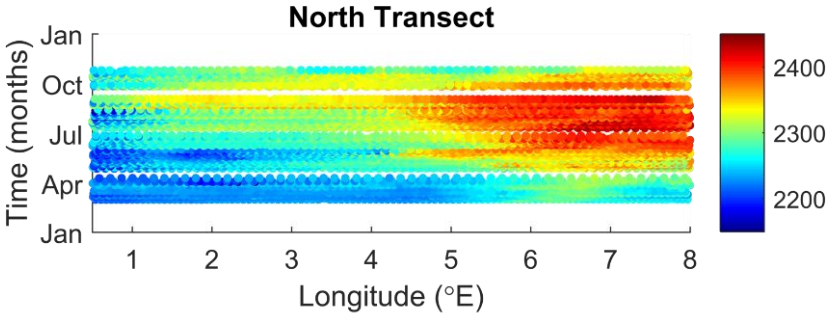
Temp



Salinity



TA ($\mu mol\ kg^{-1}$)



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Seasonal and regional variability

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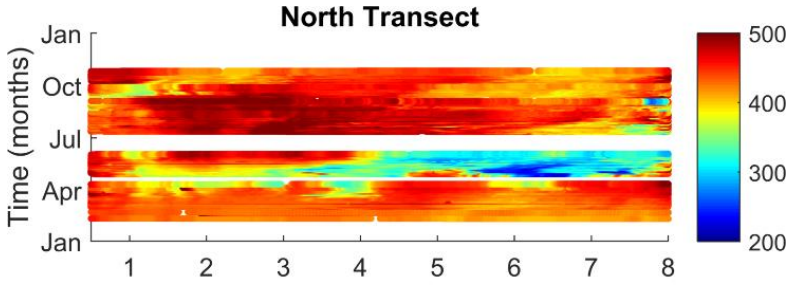
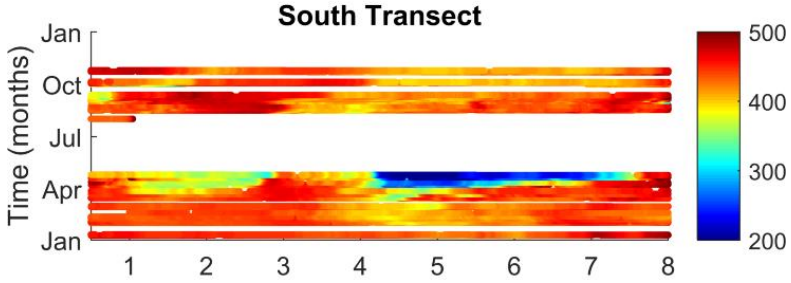
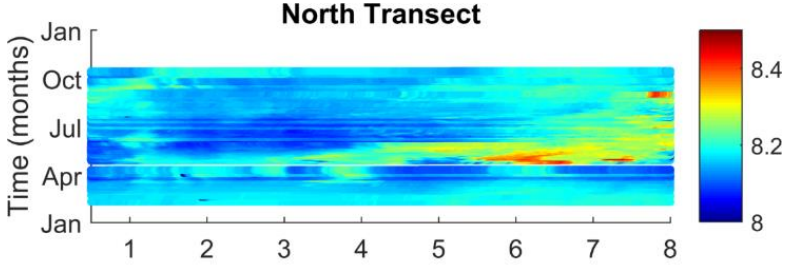
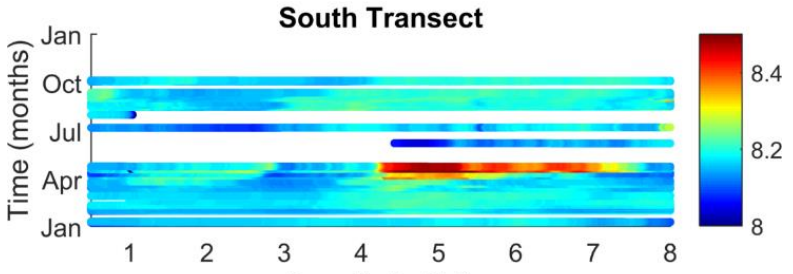
pCO_2 (µatm)



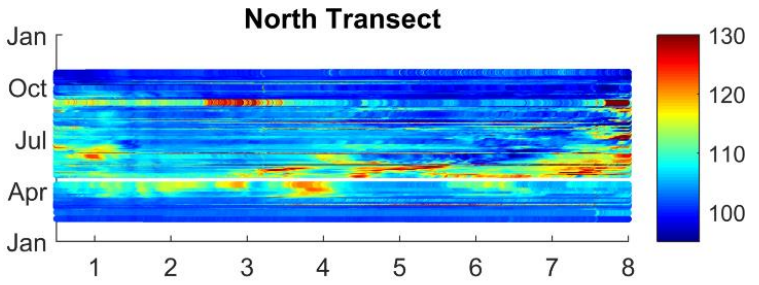


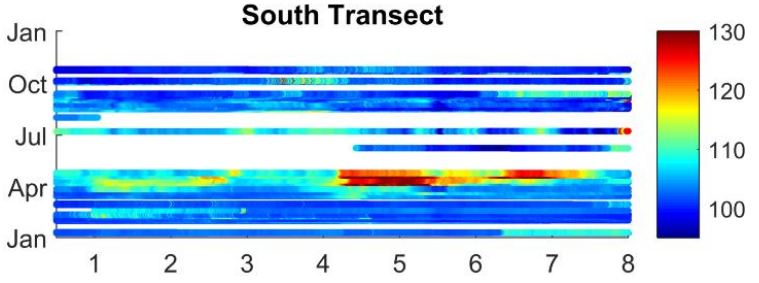
pH



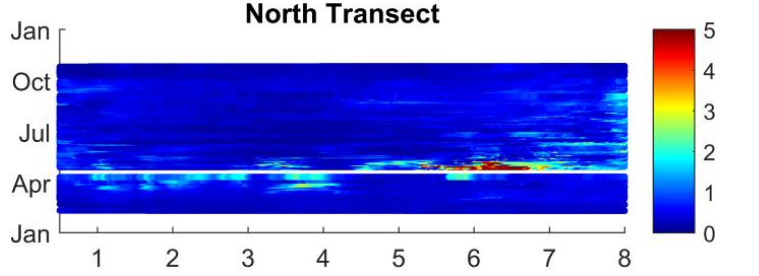


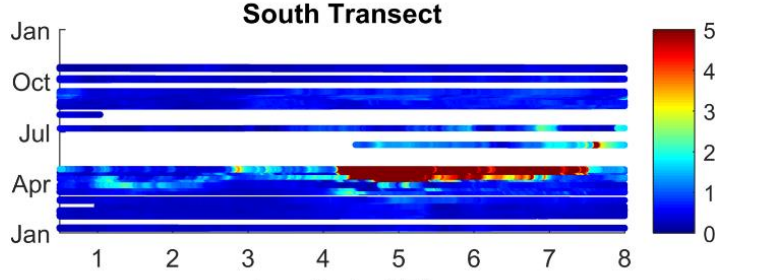
DO (% Sat)





Chl Fluor





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Near-shore to Coastal Gradient

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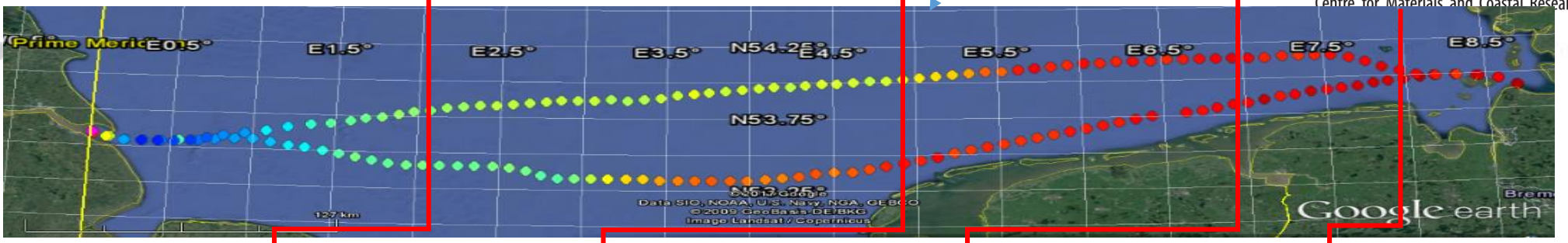

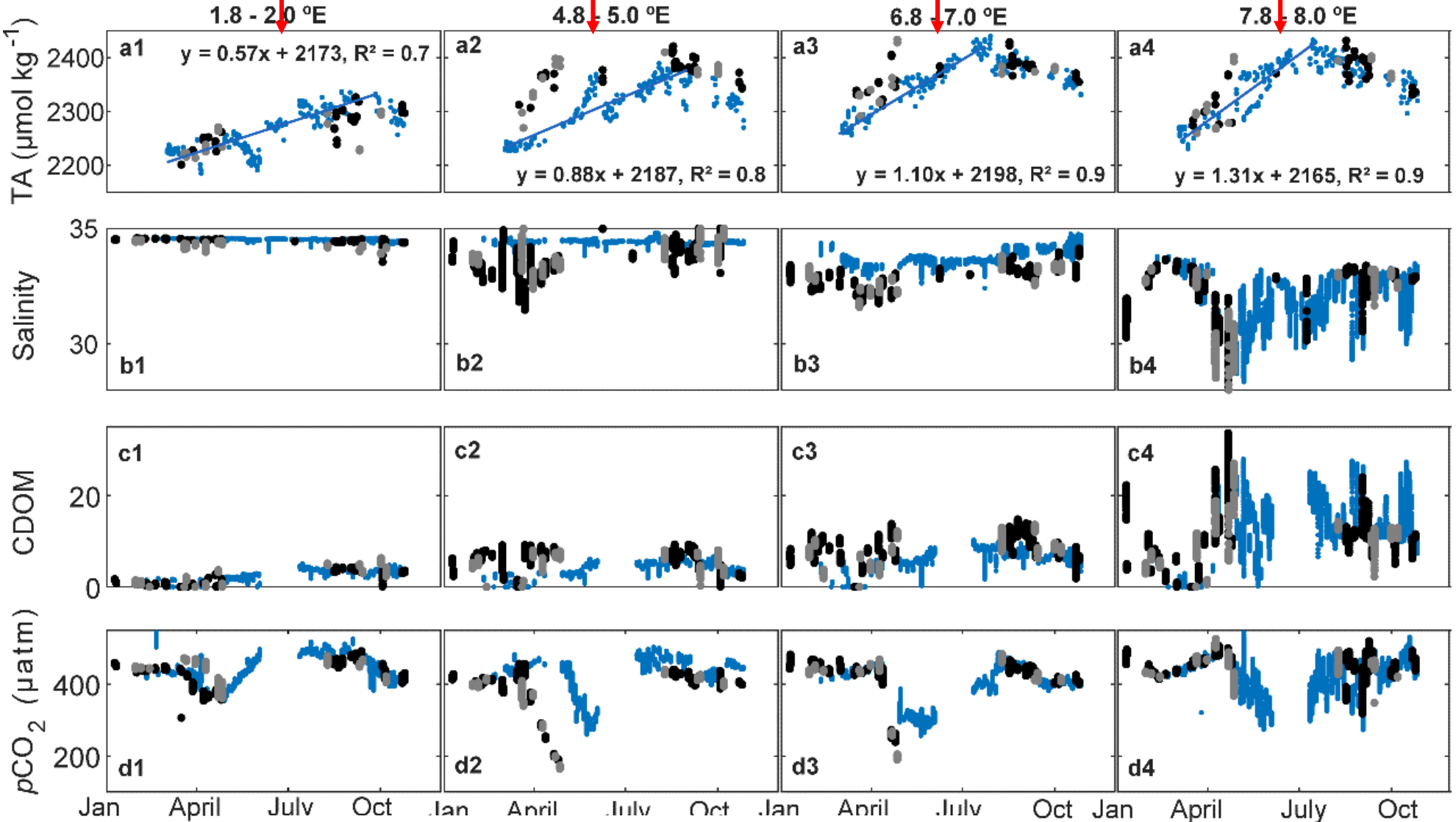

Estimated TA Fluxes

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Longitude (°E)	Intercept (μmol kg^{-1})	Slope (μmol kg^{-1} d^{-1})	Depth (m)	Temperature (°C)	Density (kg m^{-3})	TA flux (mmol m^{-2} d^{-1})
1.8–2.0	2172.8 ± 5.1	0.57 ± 0.03	20	15	1028	11.7 ± 0.6
4.8–5.0	2174.0 ± 6.6	0.88 ± 0.05	20	15	1027	18.0 ± 1.0
6.8–7.0	2198.4 ± 4.2	1.10 ± 0.03	20	15	1026	22.7 ± 0.6
7.8–8.0	2165.3 ± 5.9	1.31 ± 0.04	20	15	1024	26.8 ± 0.9

Voynova et al., Limnol. Oceanogr. 2018

Conclusions TA Measurements

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- HydroFIA TA was successfully operated with a FerryBox
- Total alkalinity (TA) did not follow salinity pattern
  - Seasonal increase of 100-200 µmol kg-1, spring to summer-fall
  - Influence from the Wadden Sea, mediated by tidal flow
- Further studies required to quantify the role of the Wadden Sea and the potential for net TA production

Time Series of pCO2 Measurements in the Southern and Central North Sea

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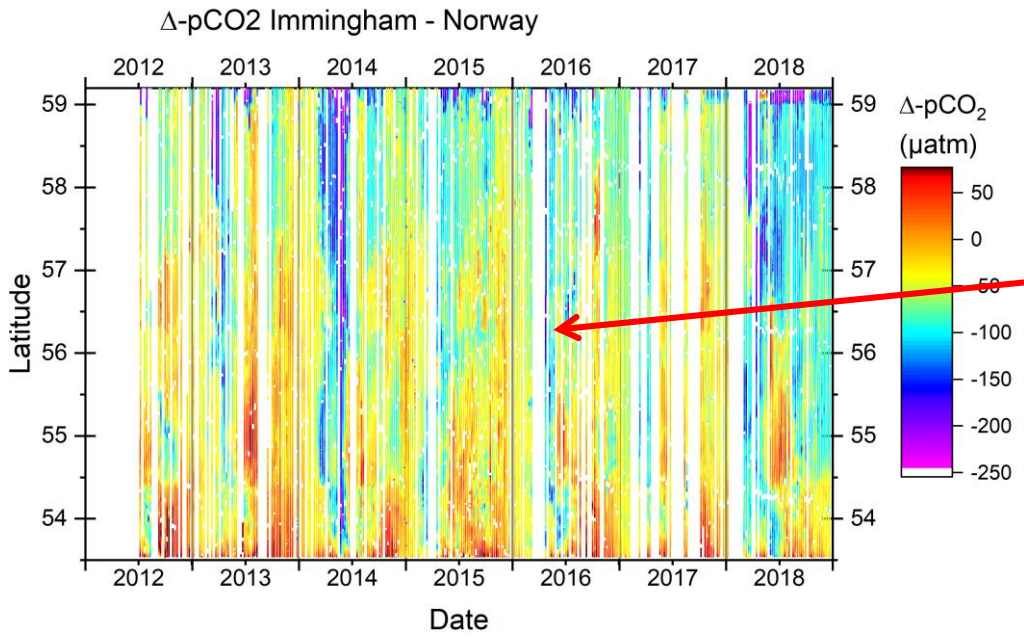
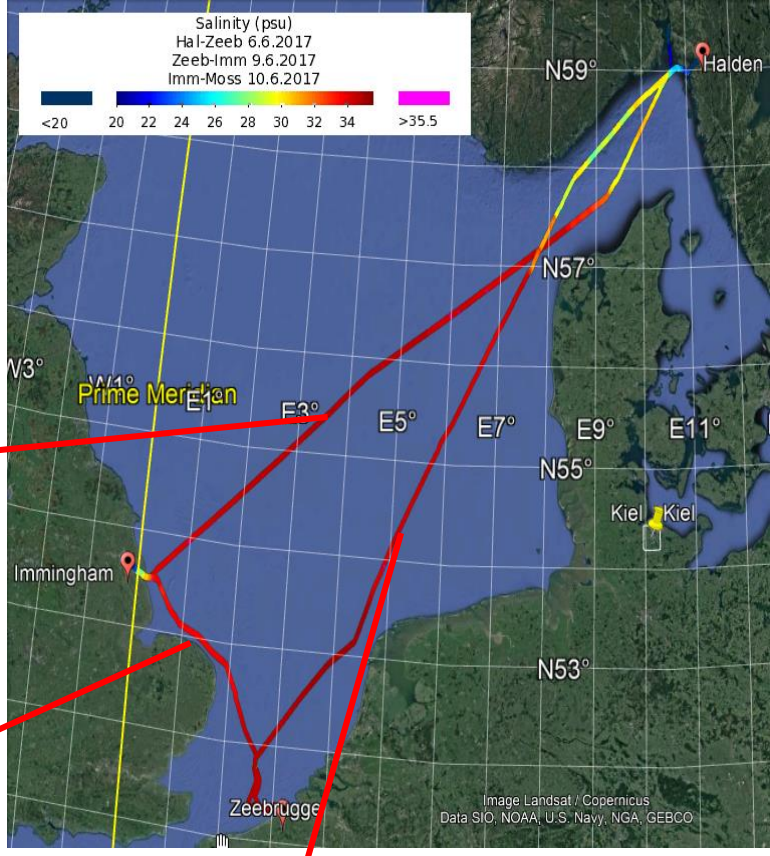
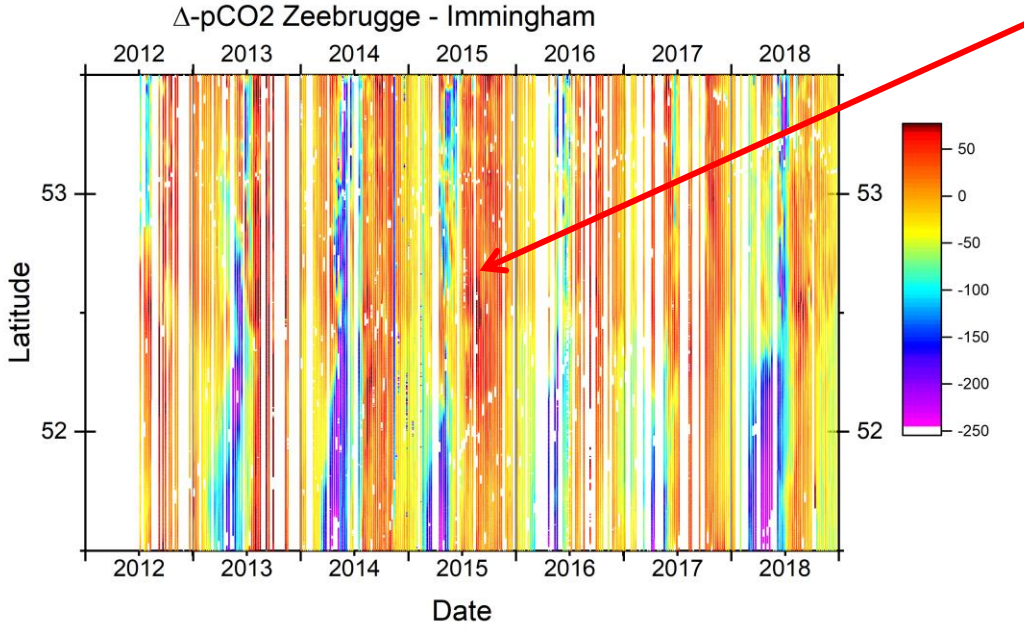
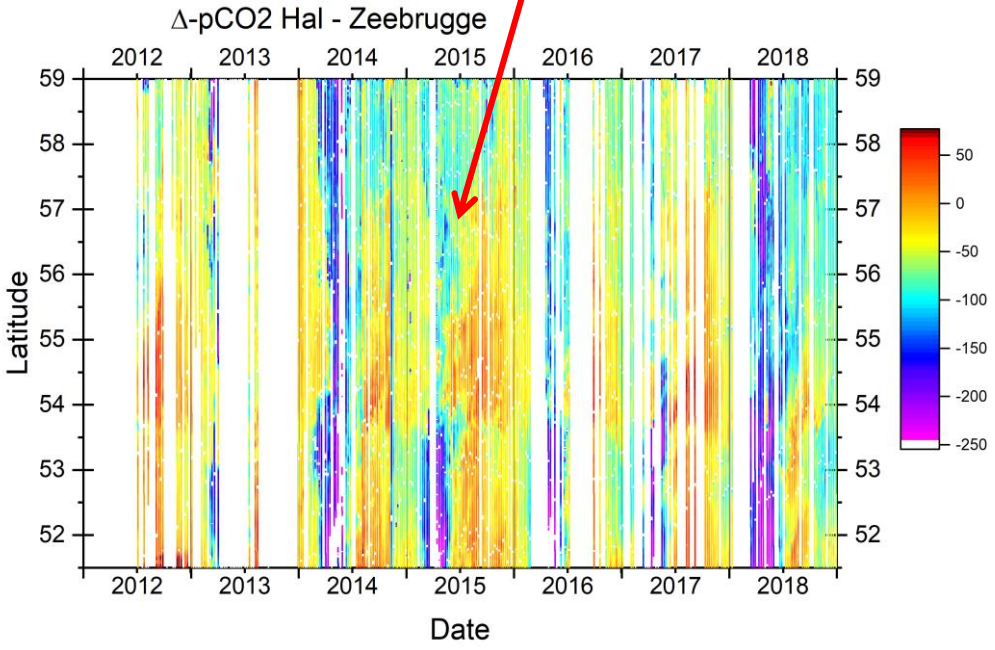
Seasonal and Spatial Differences of pCO2









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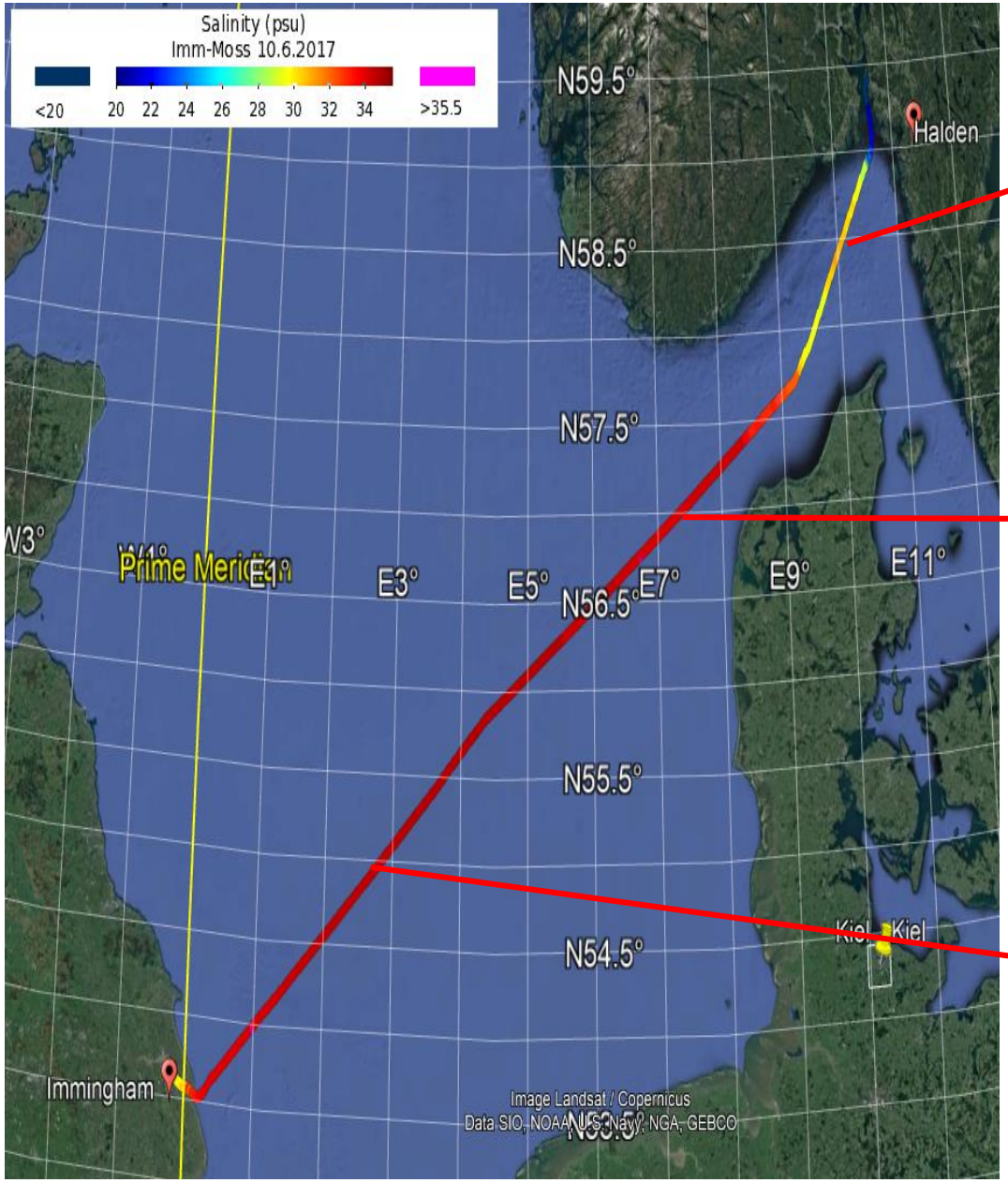
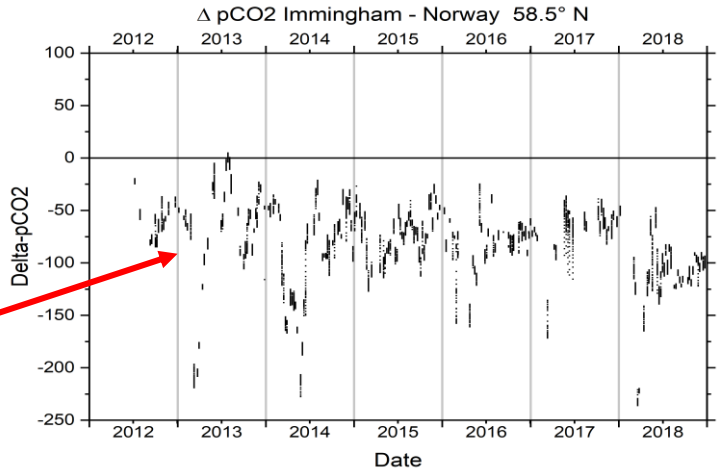
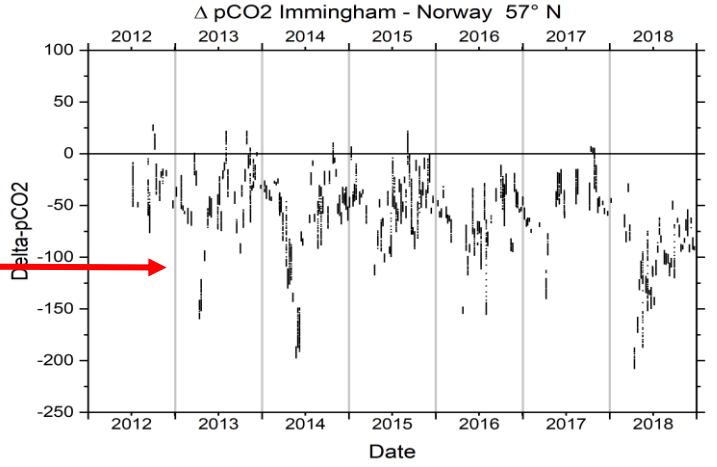
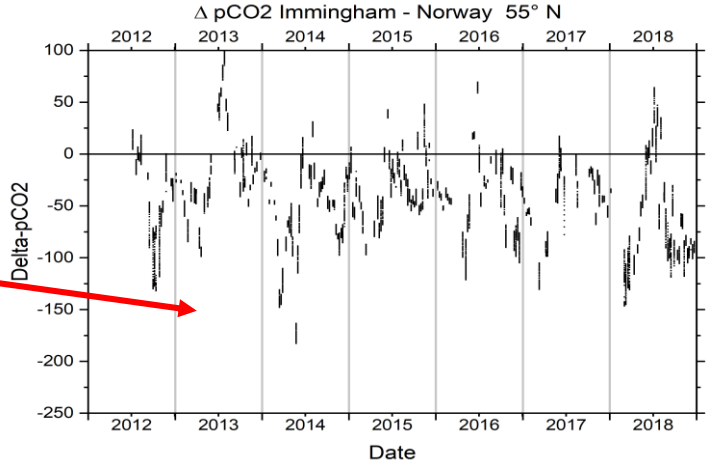
Time series at certain positions









Δ-pCO2 at Different Seasons

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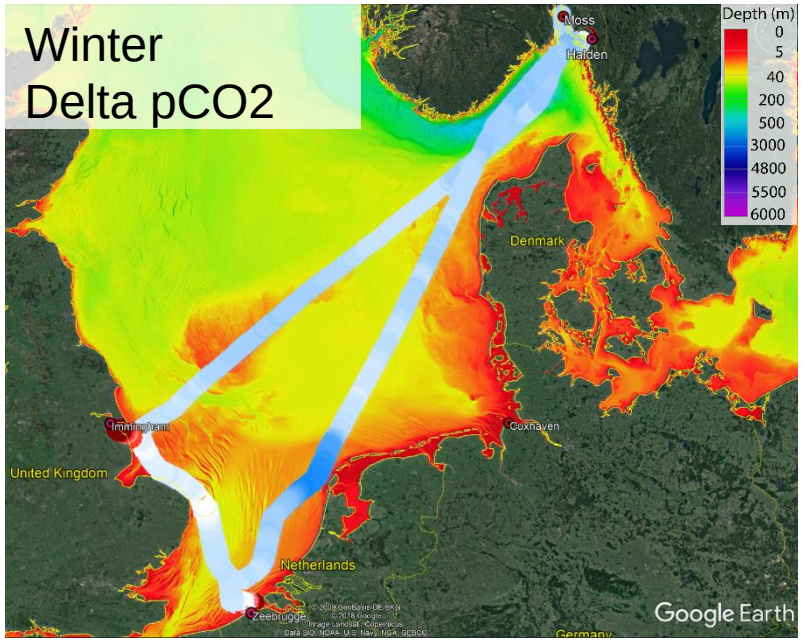

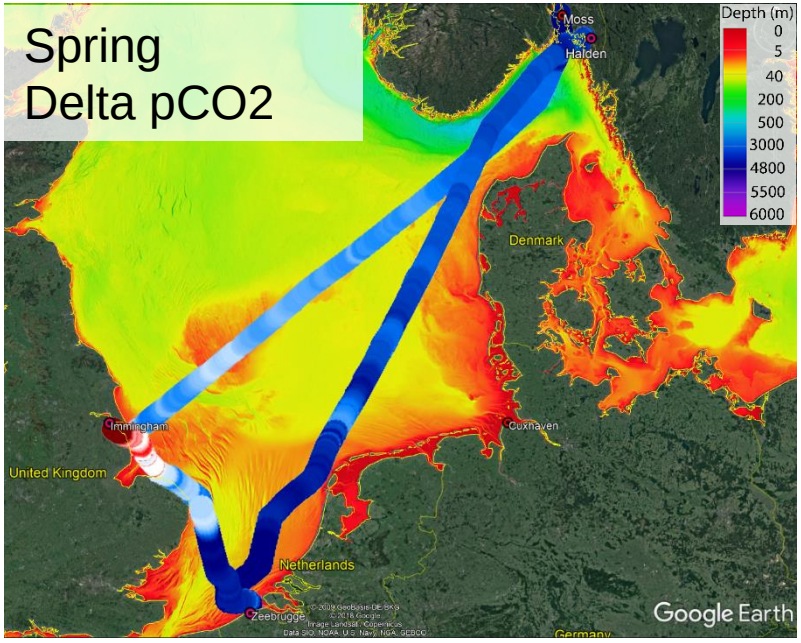

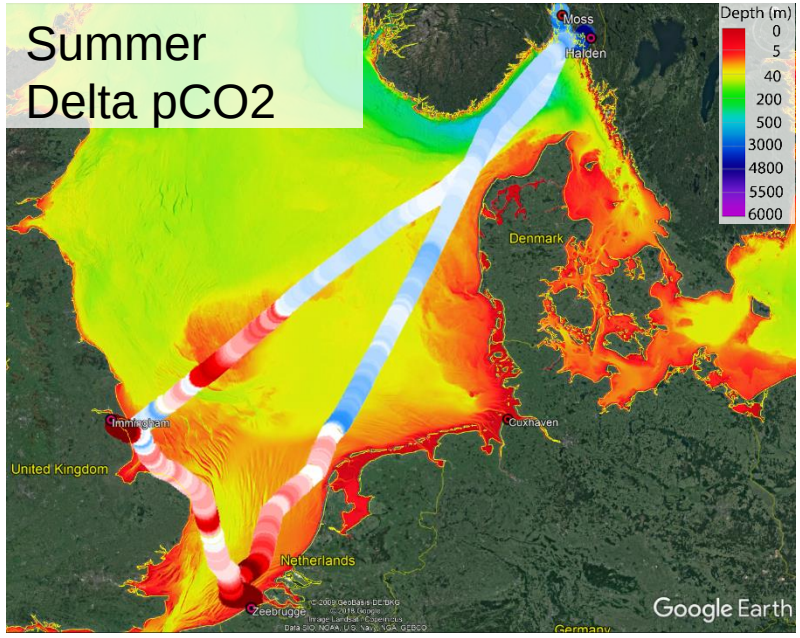

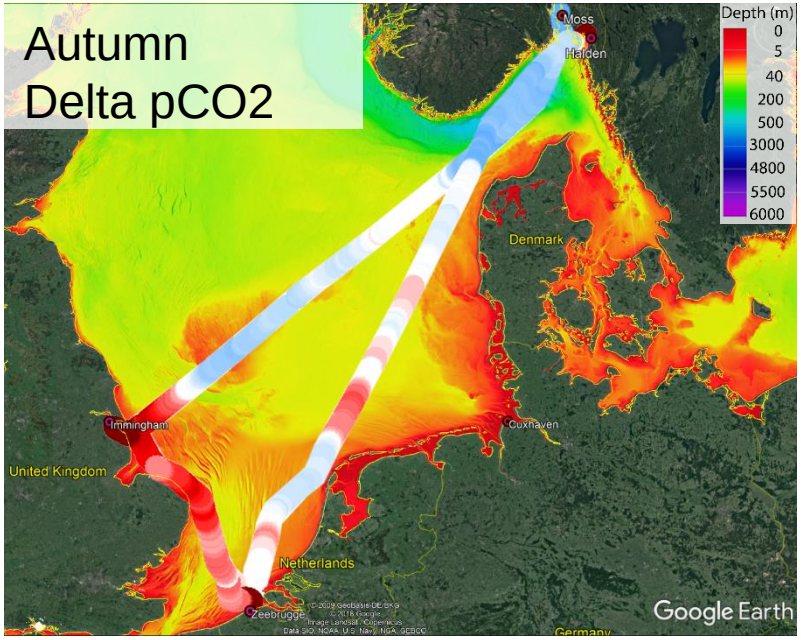

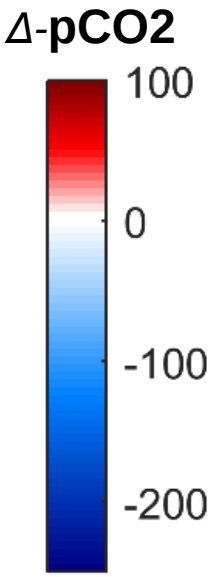

Conclusions pCO2 Measurements in the North Sea

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- FerryBox systems are a mature tool to continuously measure carbon related parameters like pH and pCO_2 along large sections of the southern and central North Sea.
- Data sets provide a detailed picture of the carbon dynamics in surface waters in different regions, in different years and at different seasons.
- Difference of pCO_2 between the atmosphere and the sea surface (ΔpCO_2) reveals a distinct behavior of shallow well mixed regions and deeper, stratified areas in the summer:
  - pCO_2 is undersaturated
    - during spring along all routes
    - in autumn in the region of the DoggerBank
  - pCO_2 is supersaturated
    - in summer in the English Chanel region and Dogger Bank
    - in autumn in Southern Central North Sea
- Different years depict different behavior. In 2018 and partly 2014 were extraordinary years with stronger and longer lasting negative gradients
- The measurement of pCO_2 can be combined with dissolved oxygen measurements to potentially derive a time series of productivity estimates along these transects.
- Carbon system measurements will be continued & complemented by a combination of high precision spectrophotometric pH sensor + Isfet Sensor

Thanks for your attention!

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JERICO-NEXT:

www.jerico-fp7.eu/

NEXOS:

www.nexosproject.eu

European FerryBox database:

http://ferrydata.hzg.de

Recent Total Alkalinity Data (Feb&Mar 2019) (M/V Lysbris)

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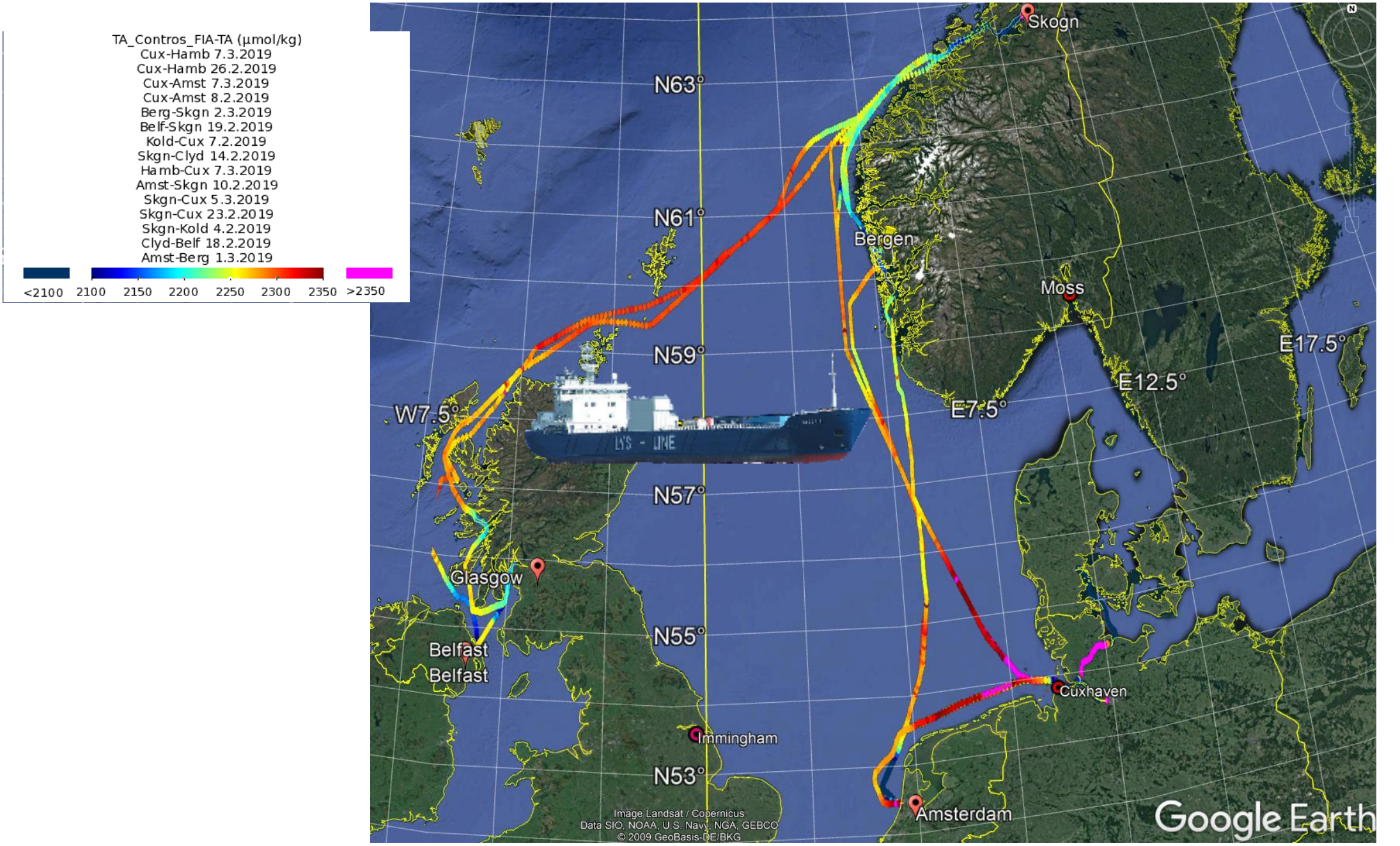

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Seasonal Behaviour of pCO2 and Oxygen Saturation

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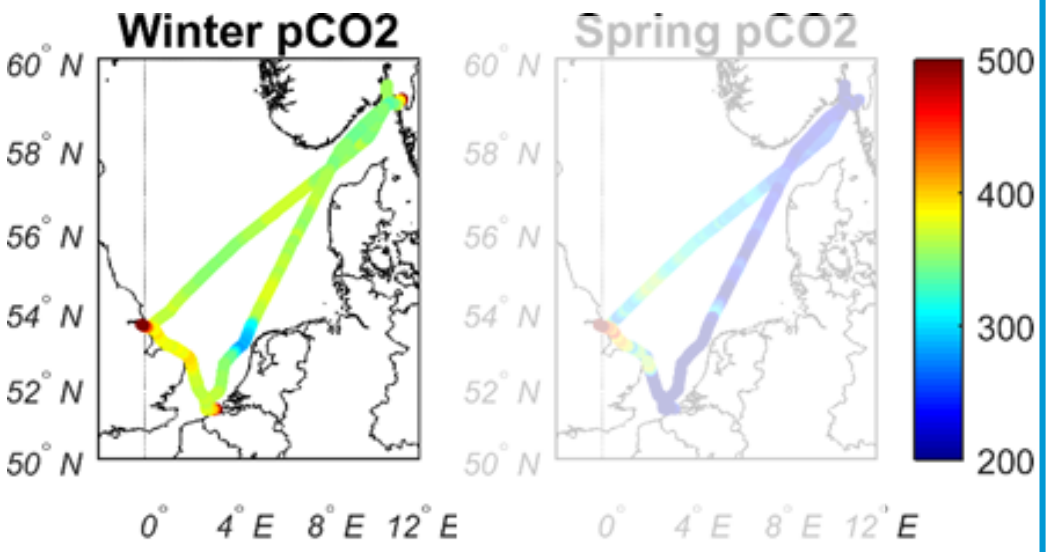

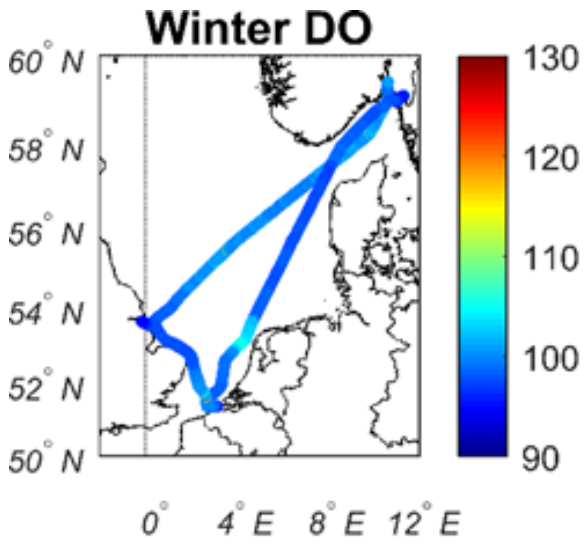

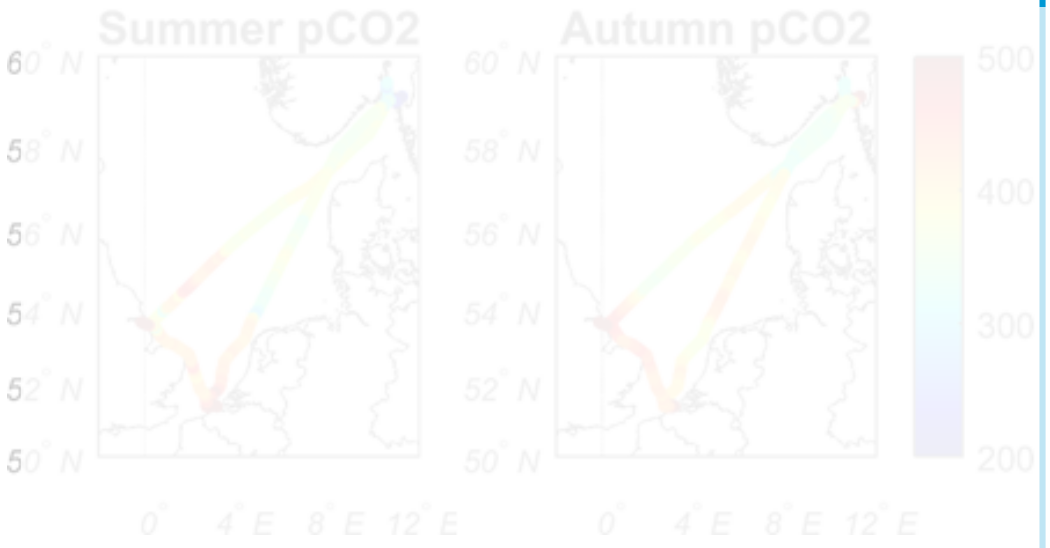

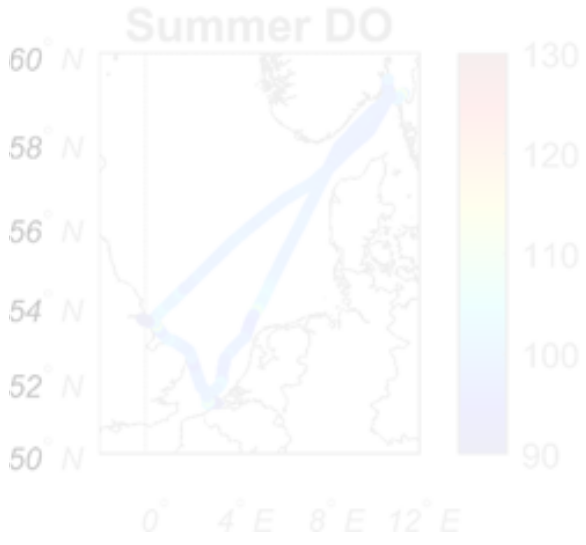

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Comparison of Seasonal Behaviour of pCO2 and Oxygen Saturation

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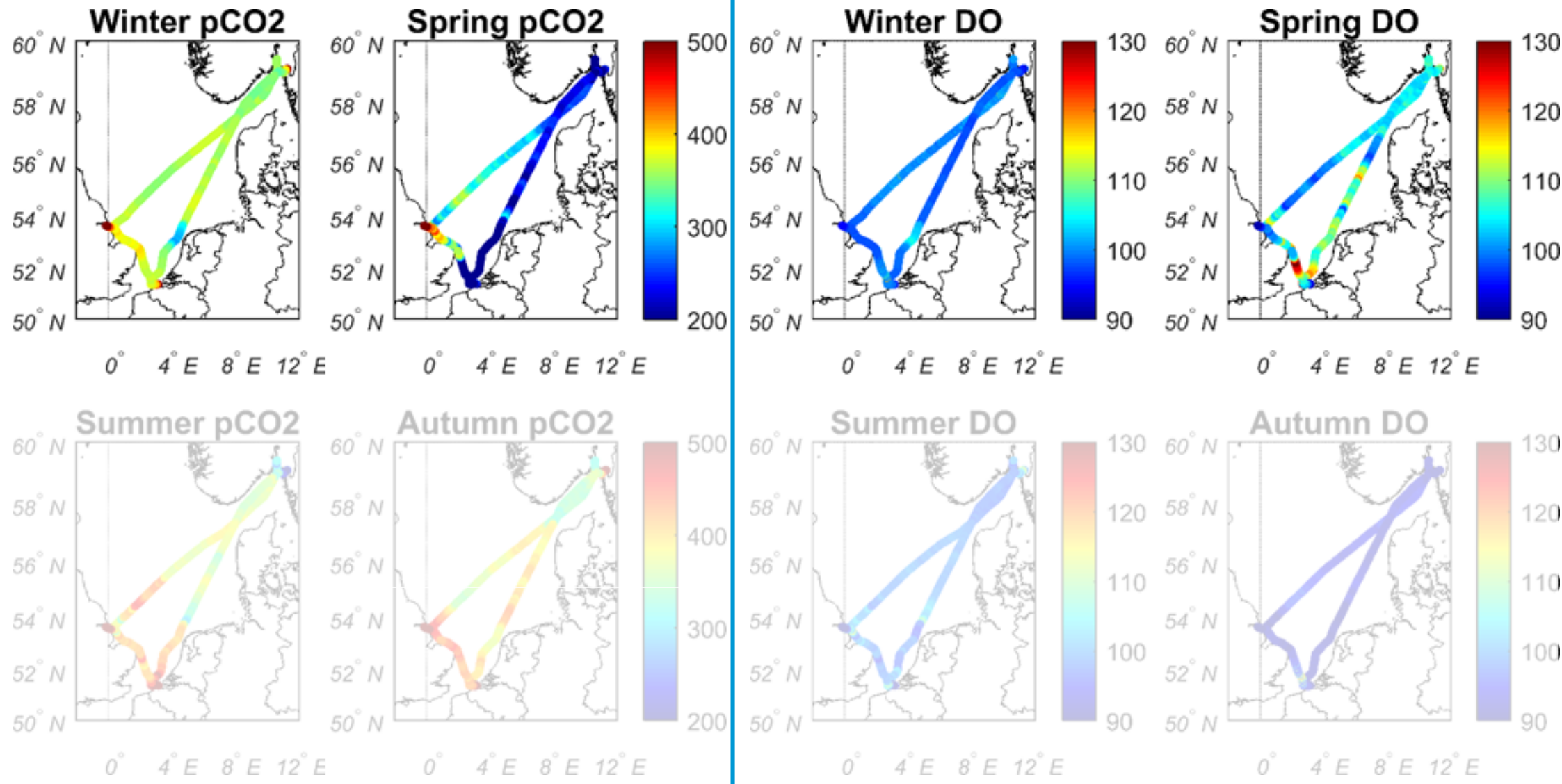

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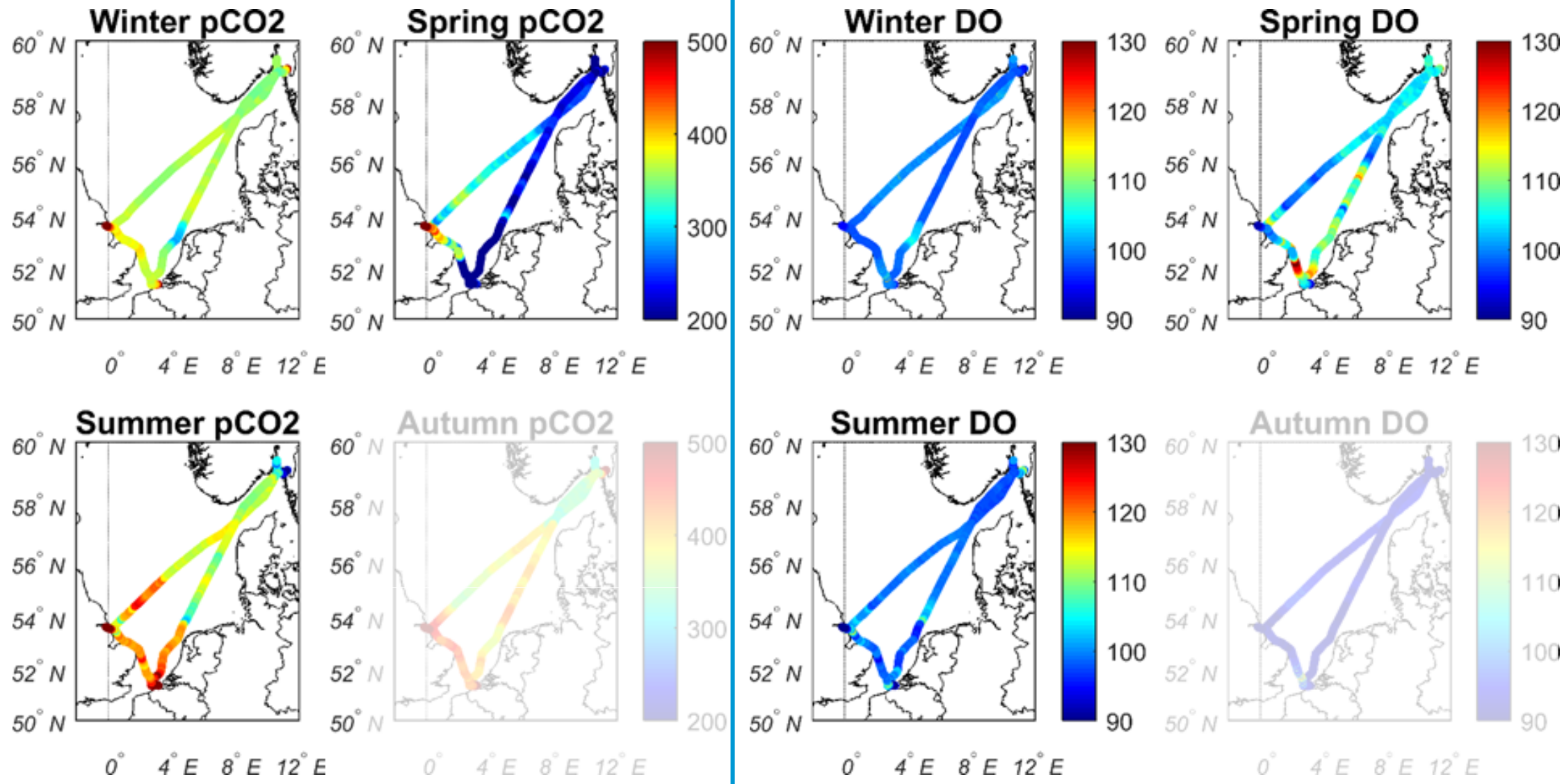

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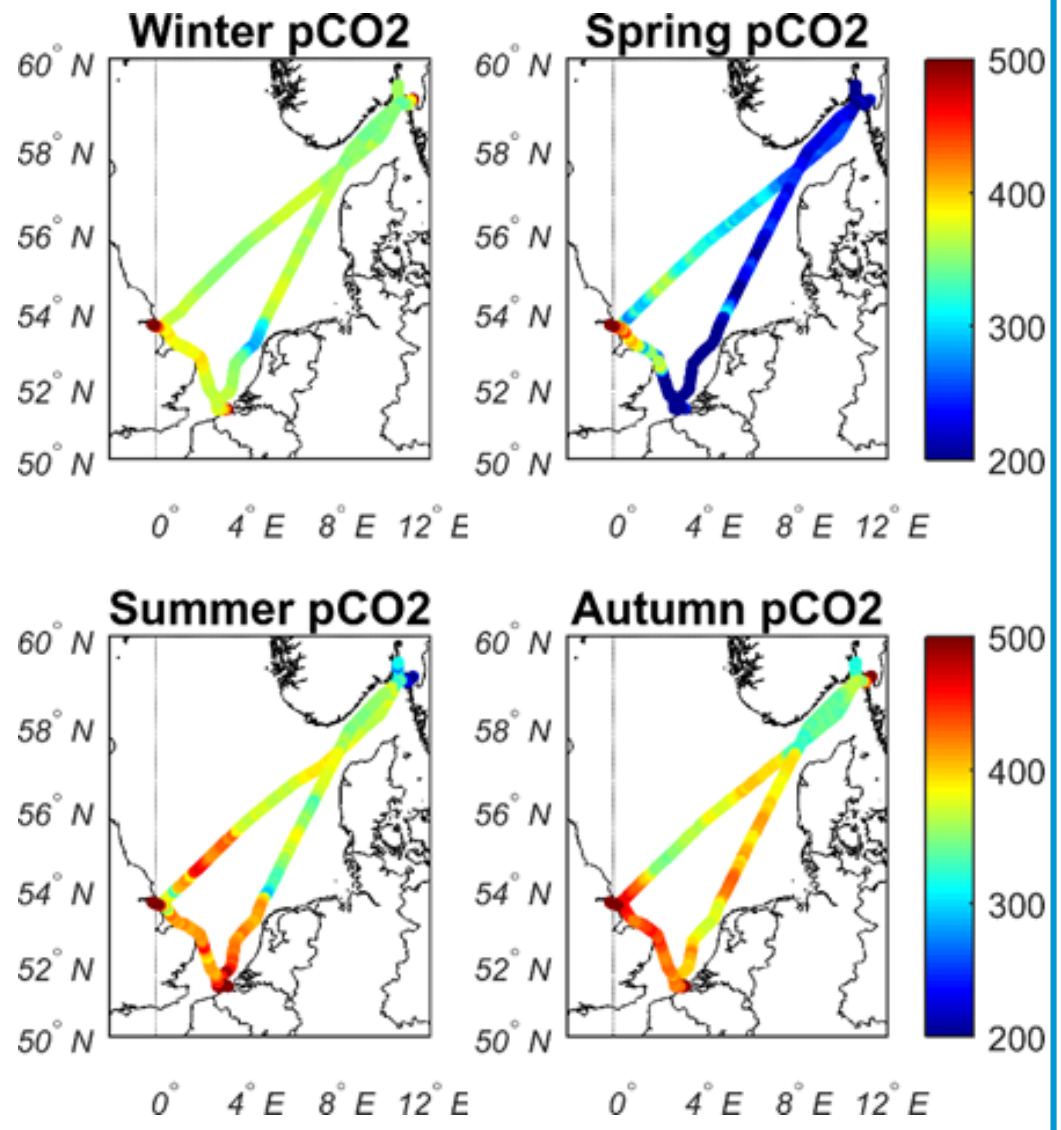

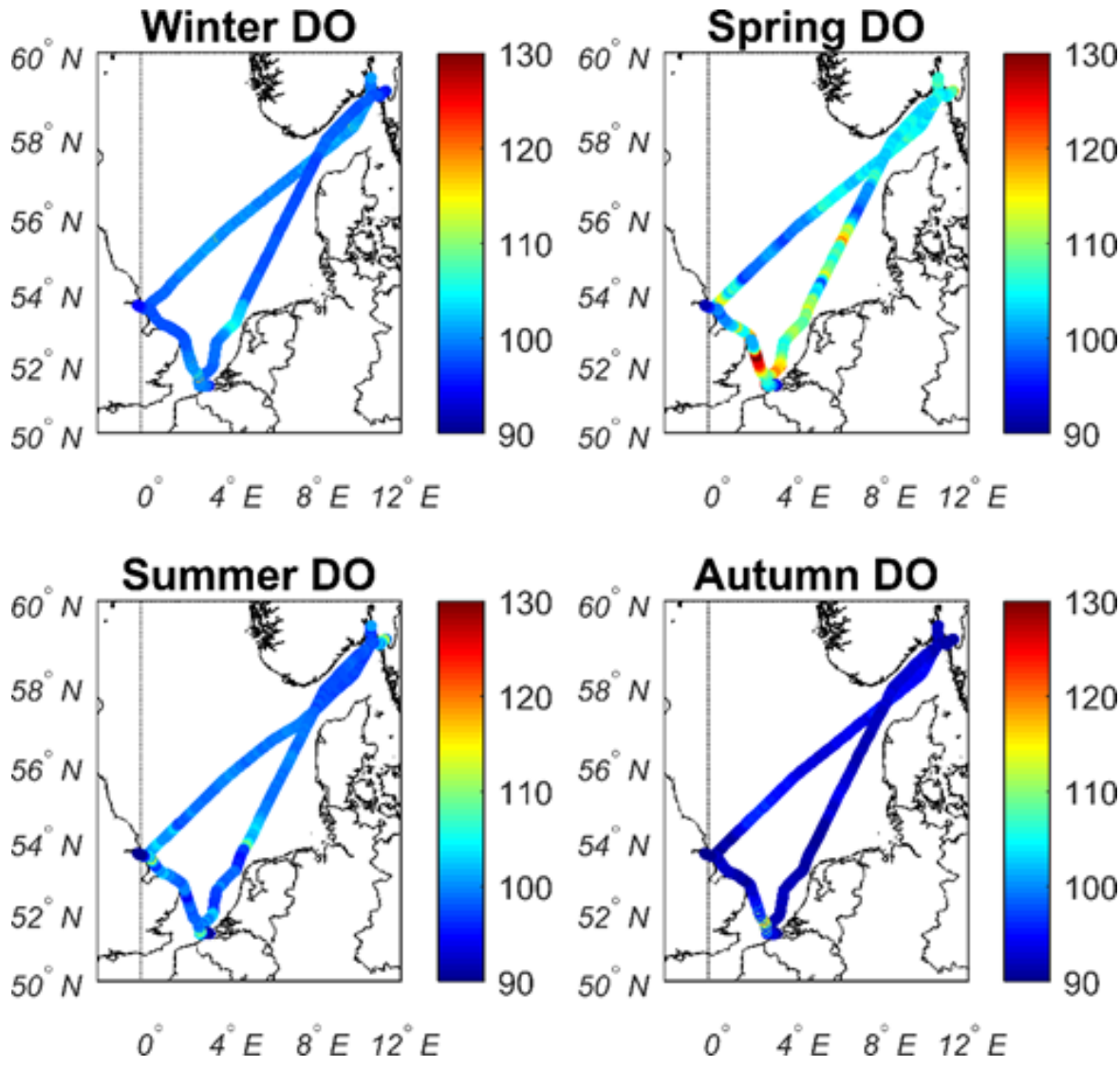

Introduction

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- Voynova et al., May 30, 2018, HZG