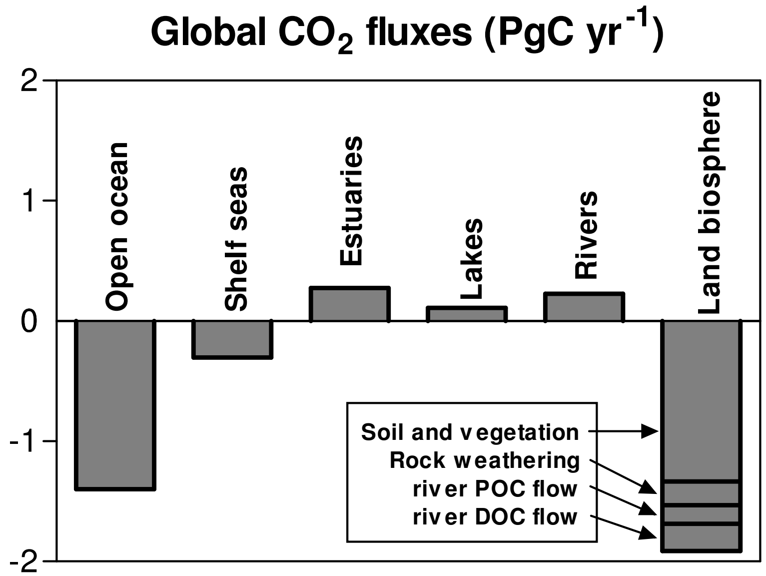
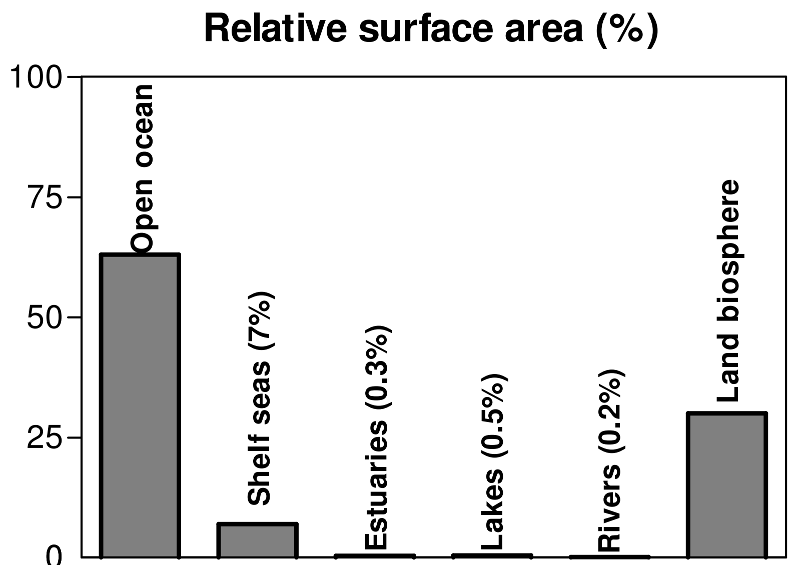
Estimating pCO_2 from remote sensing in the Belgian Coastal Zone

Alberto V. Borges *
Kevin Ruddick **
Jérôme Harlay *

* University of Liège
** Management Unit of the North Sea Mathematical Models

Introduction





Borges and Abril (2011) *In* Treatise on Estuarine and Coastal Science

Introduction

There is a paucity of data on CO_2 fluxes in most coastal environments to :

- adequately describe the spatial and seasonal variations
- capture inter-annual variations
- capture long-term changes

Can be achieved by a combination of :

- sustained observations
- numerical modelling
- interpolation/extrapolation with remote sensing

Introduction

Air-sea CO_2 flux (F) is computed according to :

$$F = k\,\alpha\,(pCO_{2sea} - pCO_{2air})$$

where α is the CO_2 solubility coefficient
that is mainly a function of SST
that can easily be derived from RS

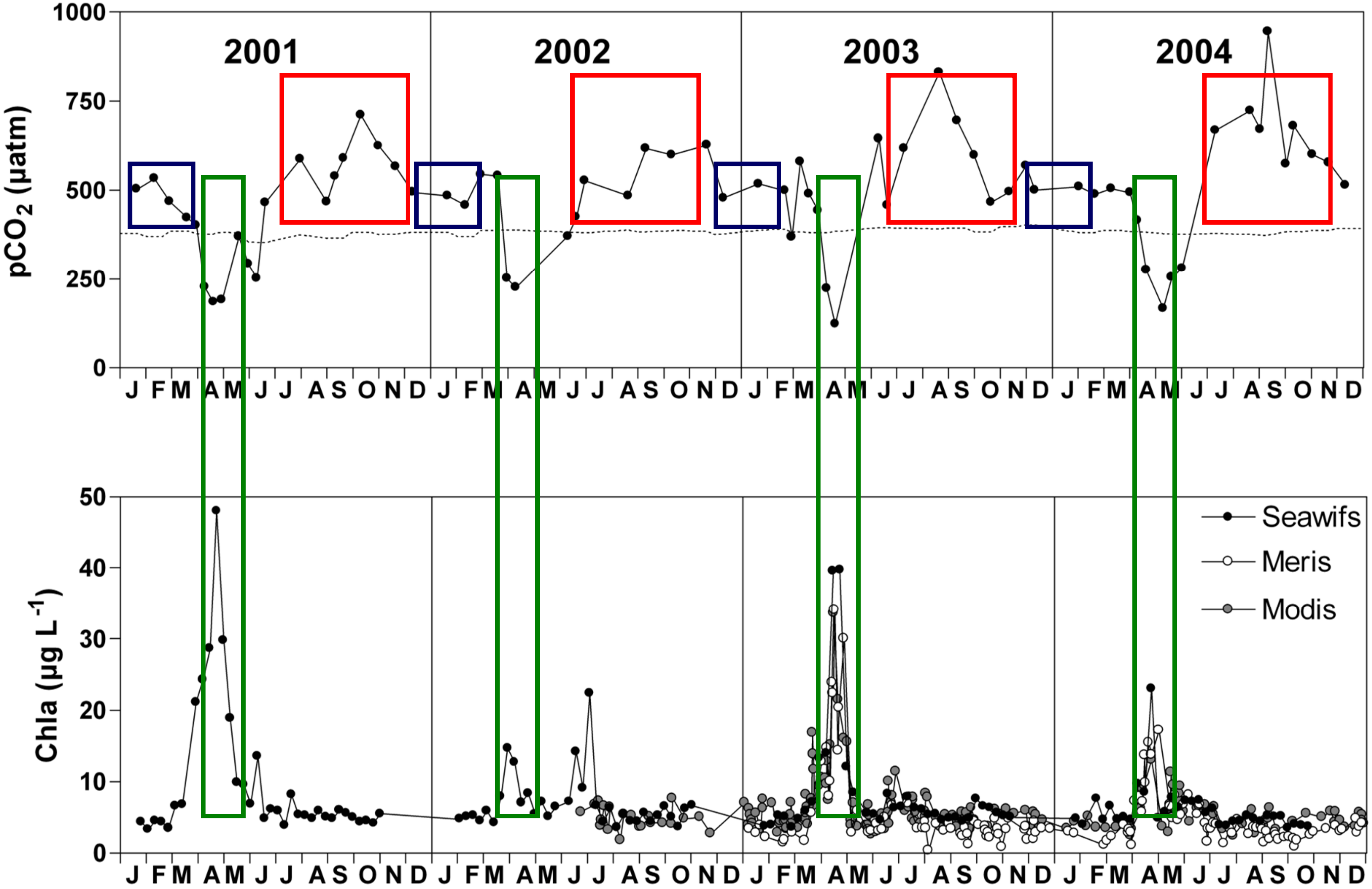
where k is the gas transfer velocity
that is parameterized as a function of wind speed
that can easily be derived from RS (Quickscat) or from reanalysis products (ECMWF or NCEP)

where pCO_{2air} is the partial pressure of CO_2 in the atmosphere
that changes much less than the pCO_{2sea}
that can be derived from monitoring stations

where pCO_{2sea} is the partial pressure of CO_2 in the sea
that is the tricky bit

Introduction

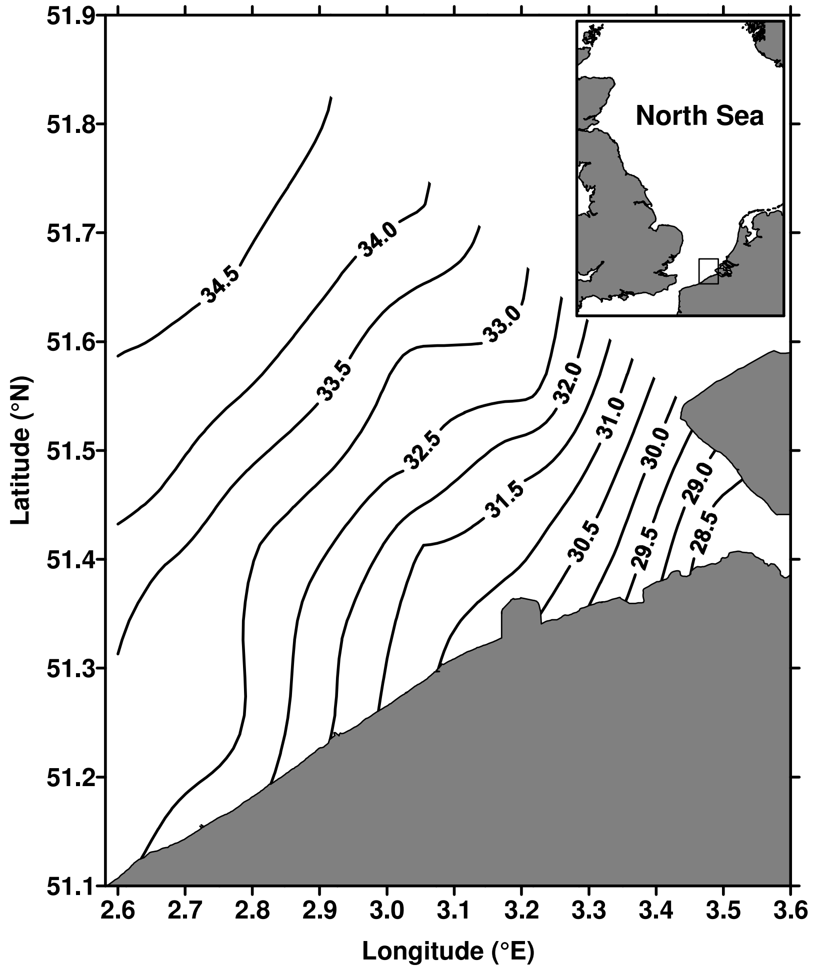
Seasonal variability of pCO_2 in the Belgian Coastal Zone



Borges et al. (2008) BMC Ecology, 8:15, doi:10.1186/1472-6785-8-15

Introduction

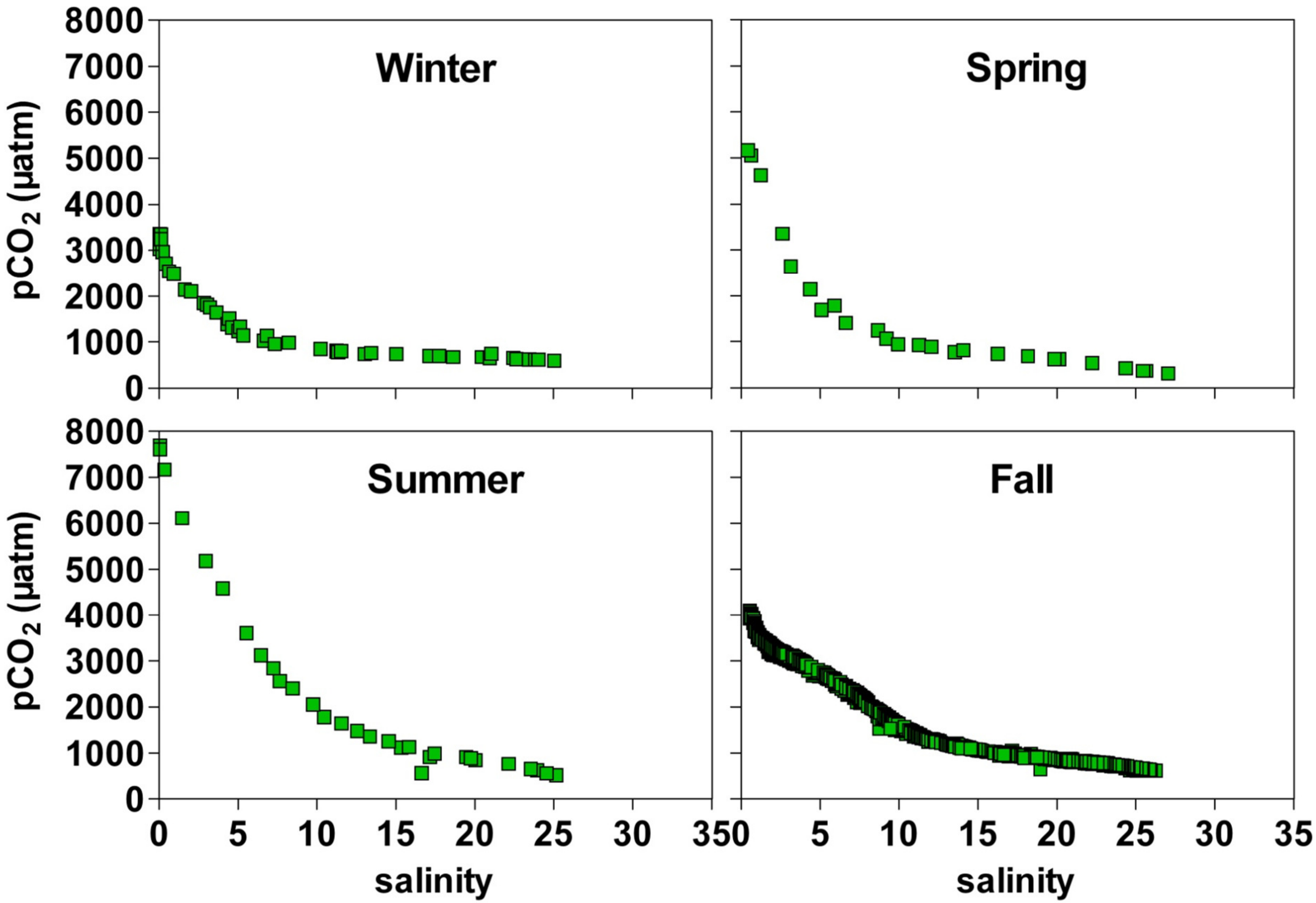
Strong influence by river inputs => strong salinity gradients
Strong tidal currents => permanently well mixed



Borges et al. (2008) BMC Ecology, 8:15, doi:10.1186/1472-6785-8-15

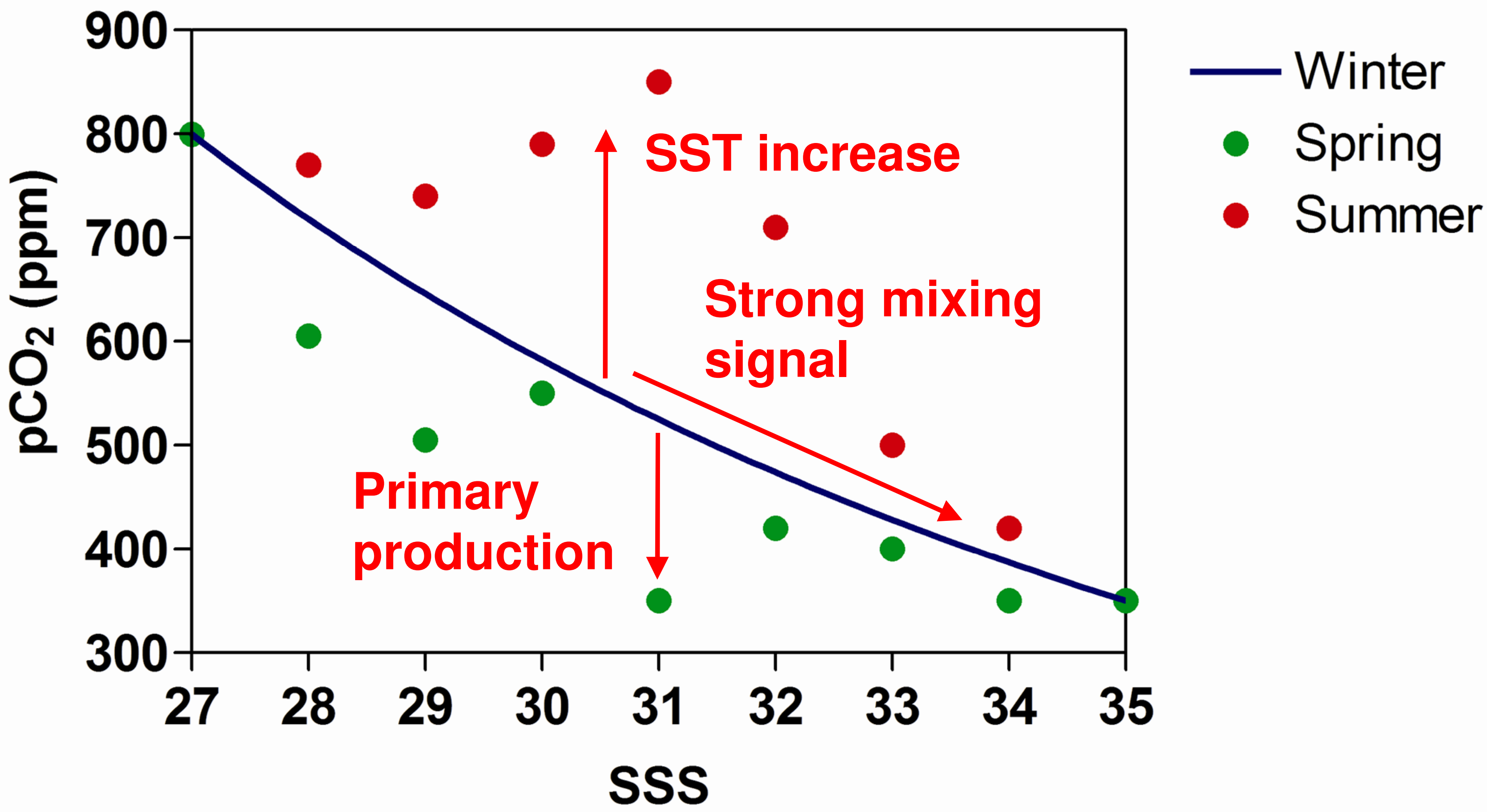
Introduction

Seasonal variability of pCO_2 in the Scheldt



Introduction

Seasonal and spatial variability of pCO_2 in the BCZ



RS algorithm

Development of RS algorithms :

pCO_2 = f(SSS, Chla)

- **SSS is essential but cannot be remote sensed at required resolution**

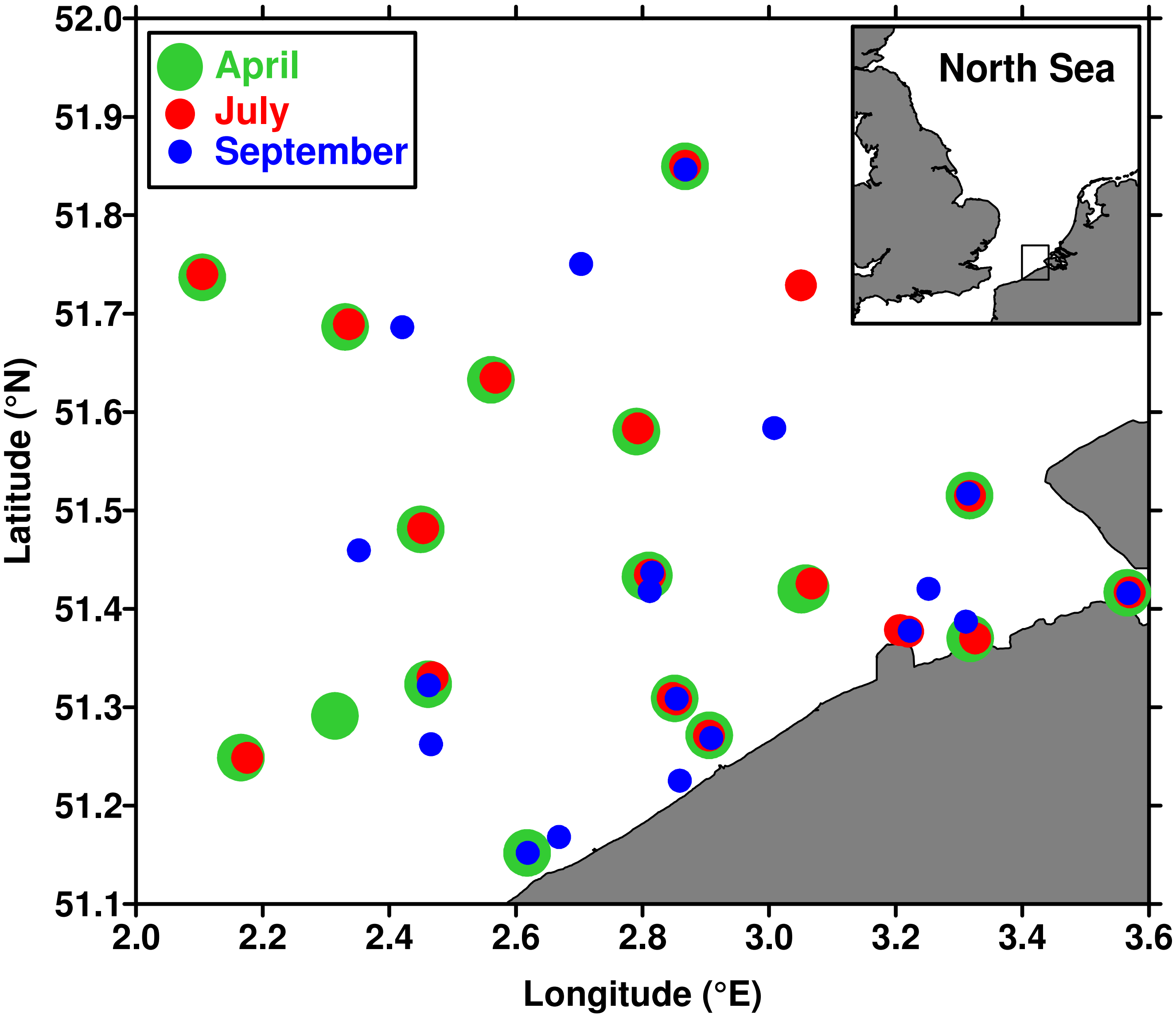
- **To remove source of variability of SST on solubility, pCO_2 was normalized at a constant temperature : pCO_2@10°C**

- **SST is not to be an useful variable in the algorithms**

- **Due to the non-linear nature of relationships we used Multiple Polynomial Regressions (MPR)**

Field data

Overview of field data



Field data

Overview of field data

		SSS		Chla (µg L^{-1})		pCO_2@10°C (ppm)	
2007							
	April	27.2	35.0	0.6	110.3	90	479
	July	28.5	35.0	1.0	10.0	284	479
	September	27.9	34.8	1.3	6.8	303	520
2008							
	April	28.0	35.2	1.7	69.6	103	517
	July	28.2	35.1	1.0	7.7	297	468
	September	31.4	34.8	0.2	6.1	284	554
2009							
	April	29.0	34.9	0.5	8.6	191	461
	July	24.6	35.0	0.3	15.0	265	400
	September	29.2	35.0	1.0	6.9	298	504

RS algorithm

2007 pCO_2 algorithms

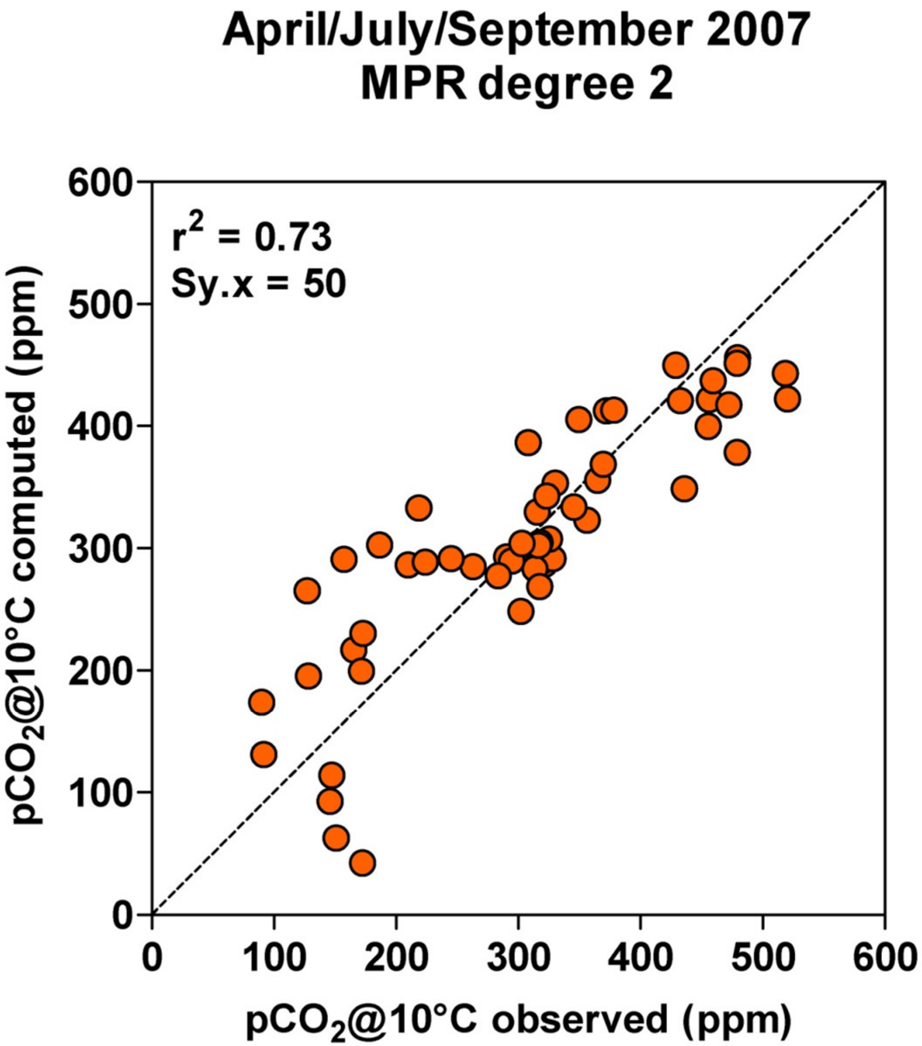
2007 Chla, SSS

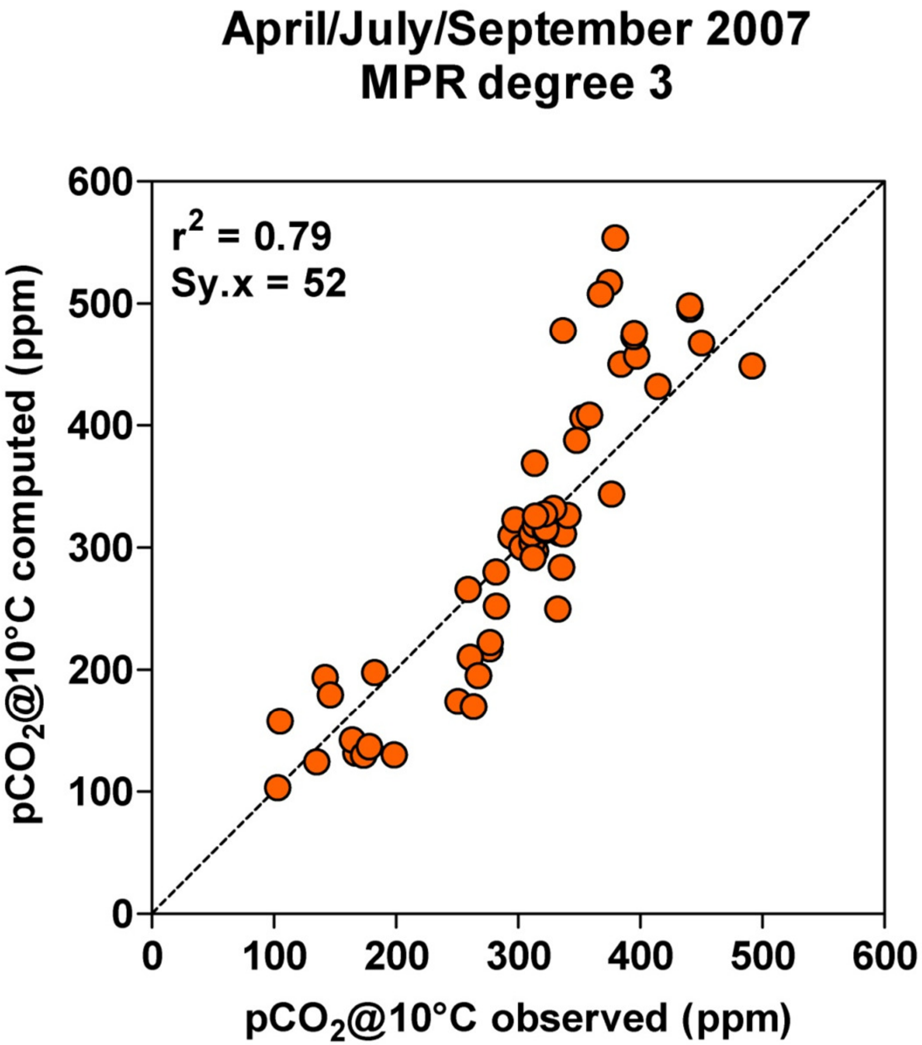
Computed pCO_2

versus

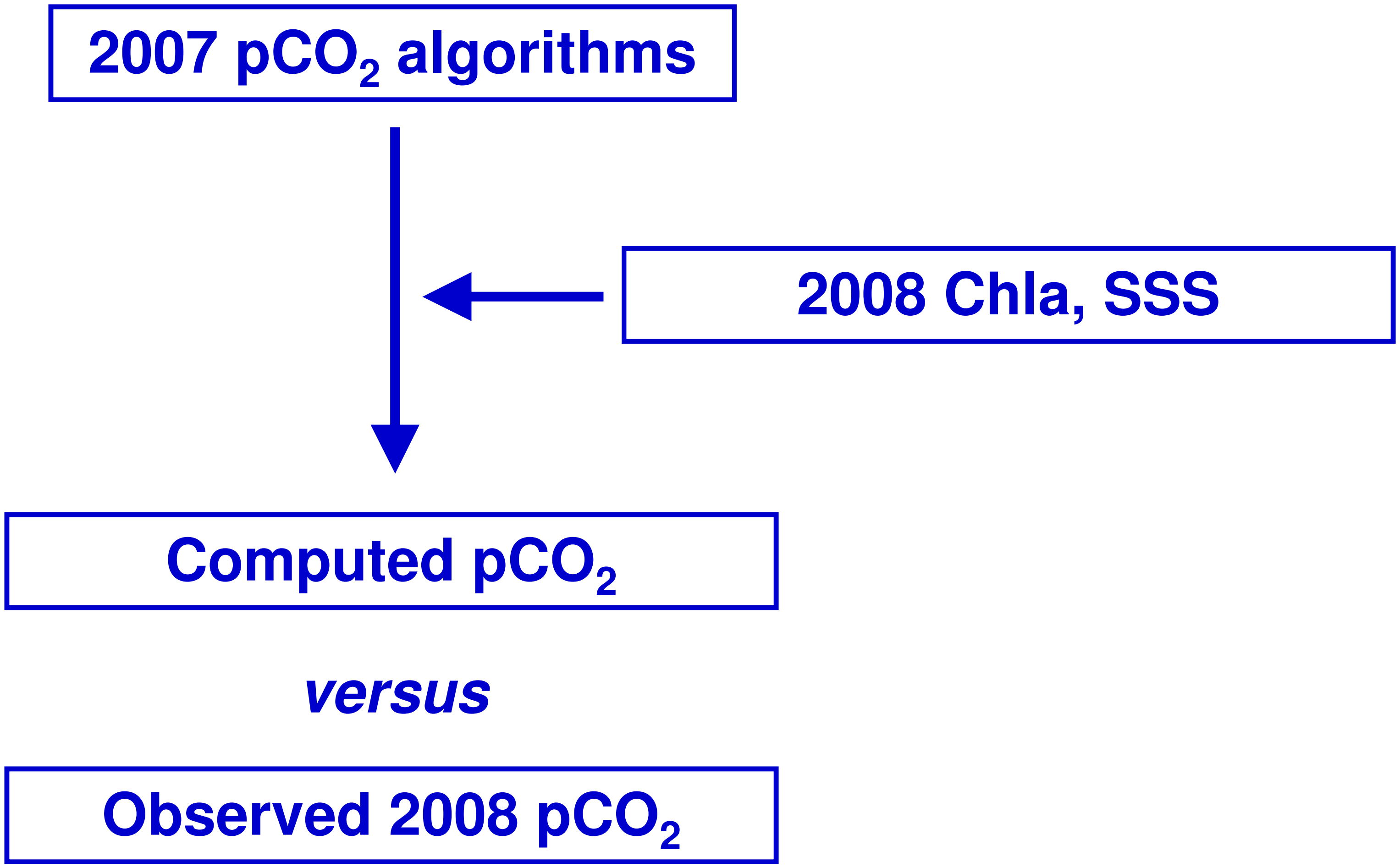
Observed 2007 pCO_2

RS algorithm

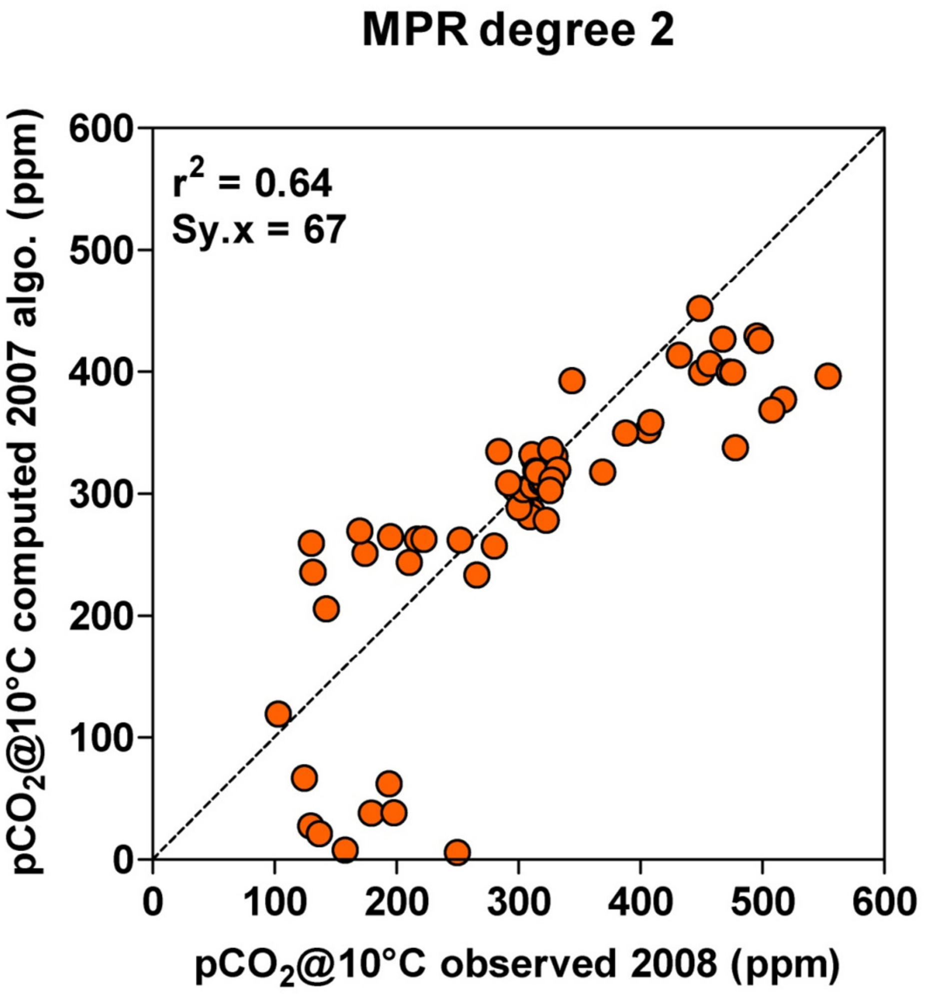


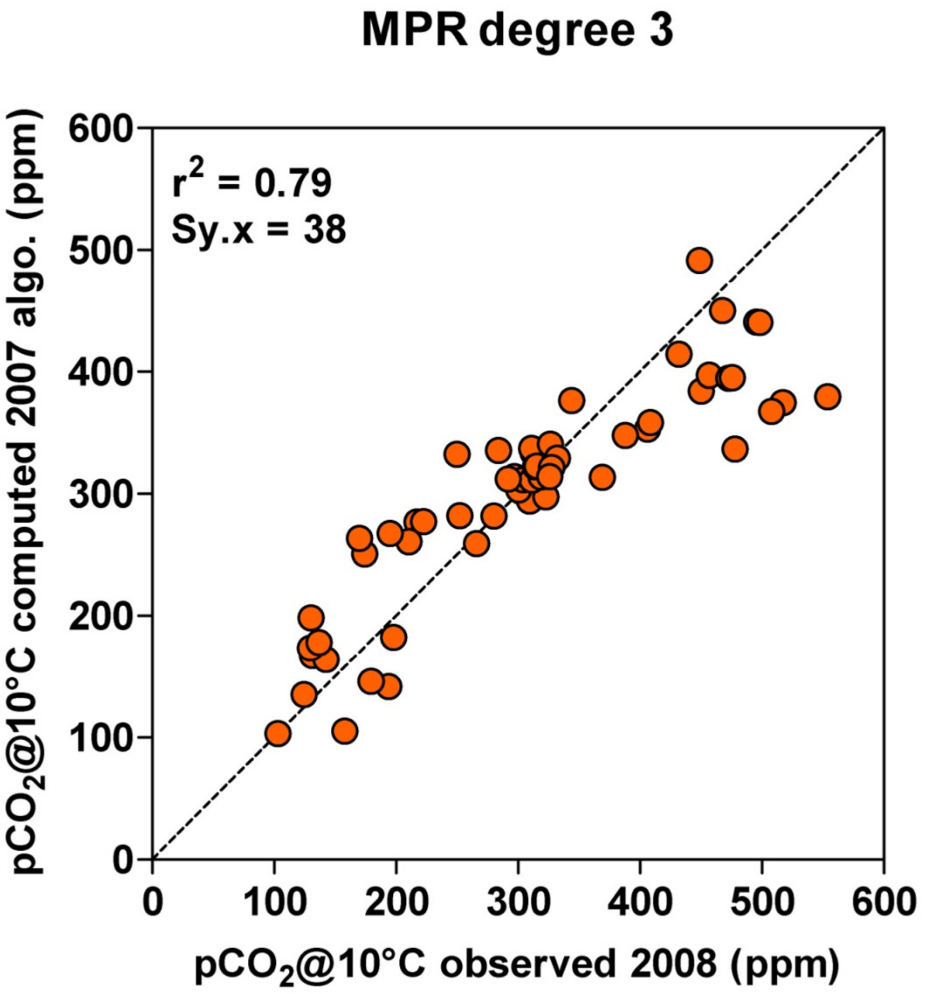


RS algorithm



RS algorithm





Aplication to 2007 situation

- Chl *a* from MERIS algal2 product
  - MEGS 7.1
  - QCed with Product Confidence Flag
  - Using best image of week during in situ campaigns (April/July/Sept 2007)

- SSS from COHERENS-3D hydrodynamic model
  - Southern North Sea model
  - Operational run for 2007
  - Using average output for week of in situ campaigns (April/July/Sept 2007)

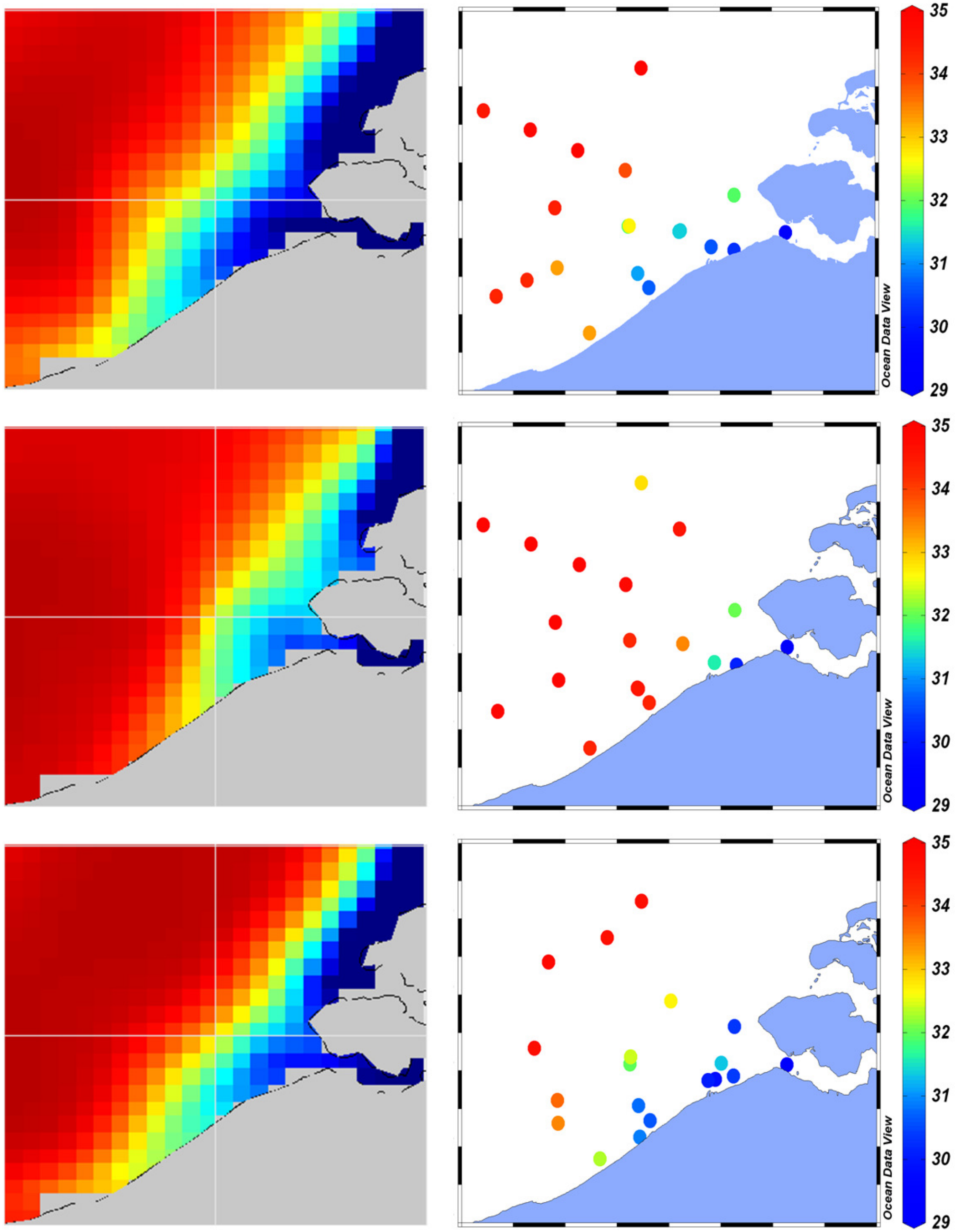
Aplication to 2007 situation

Model SSS | **In-situ SSS**

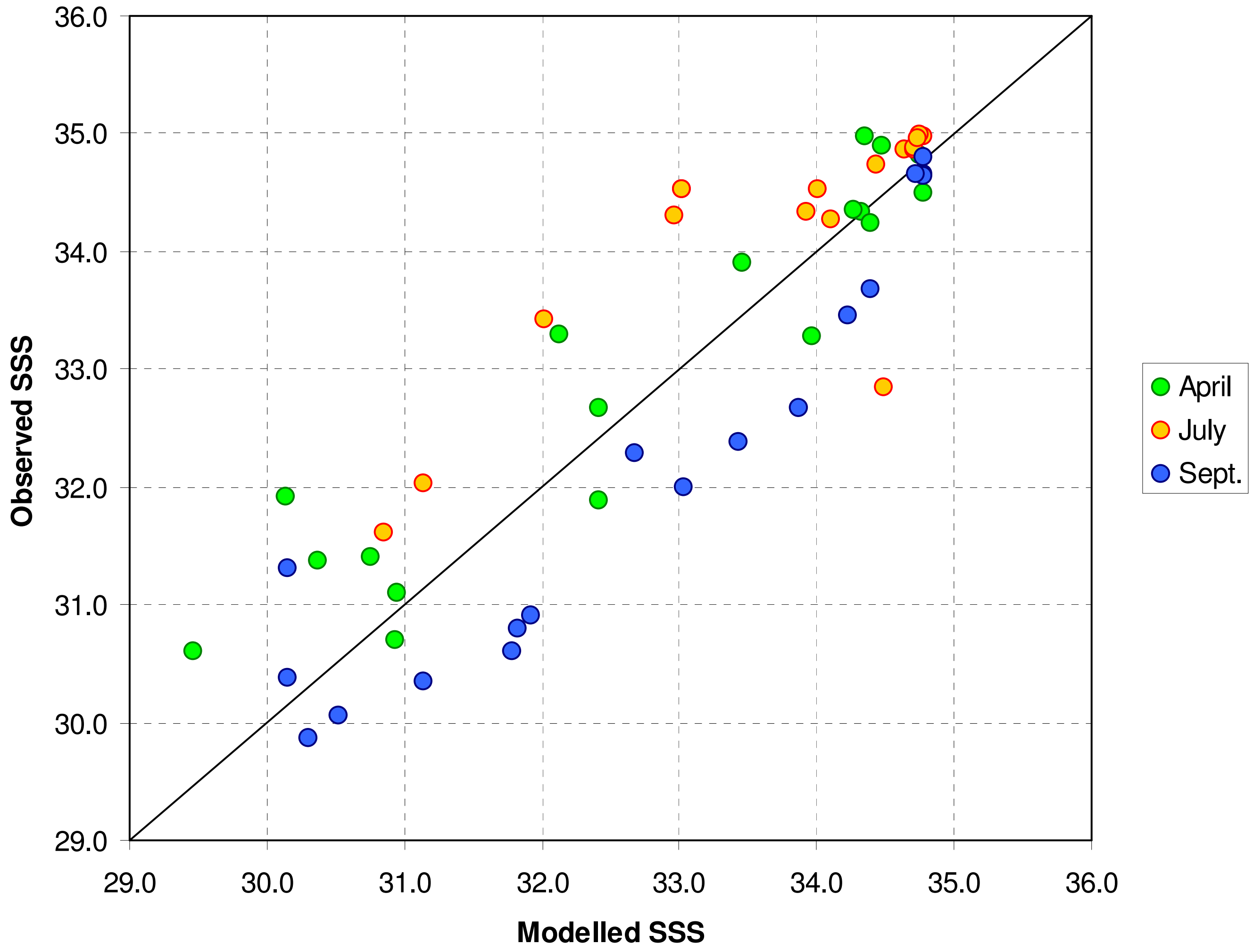
April 2007

July 2007

Sept 2007



Aplication to 2007 situation



Aplication to 2007 situation

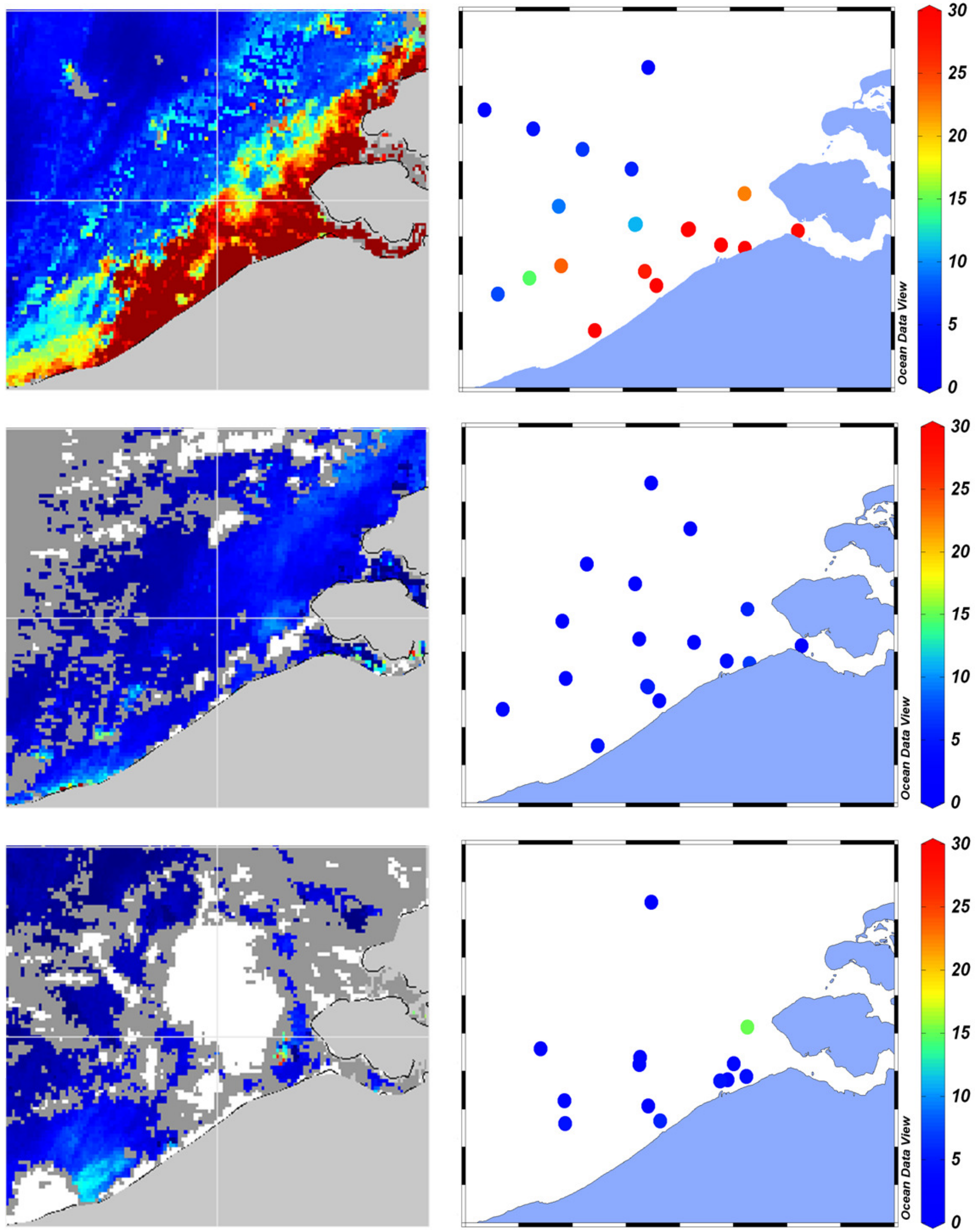
Meris Chl-a

In-situ Chl-a

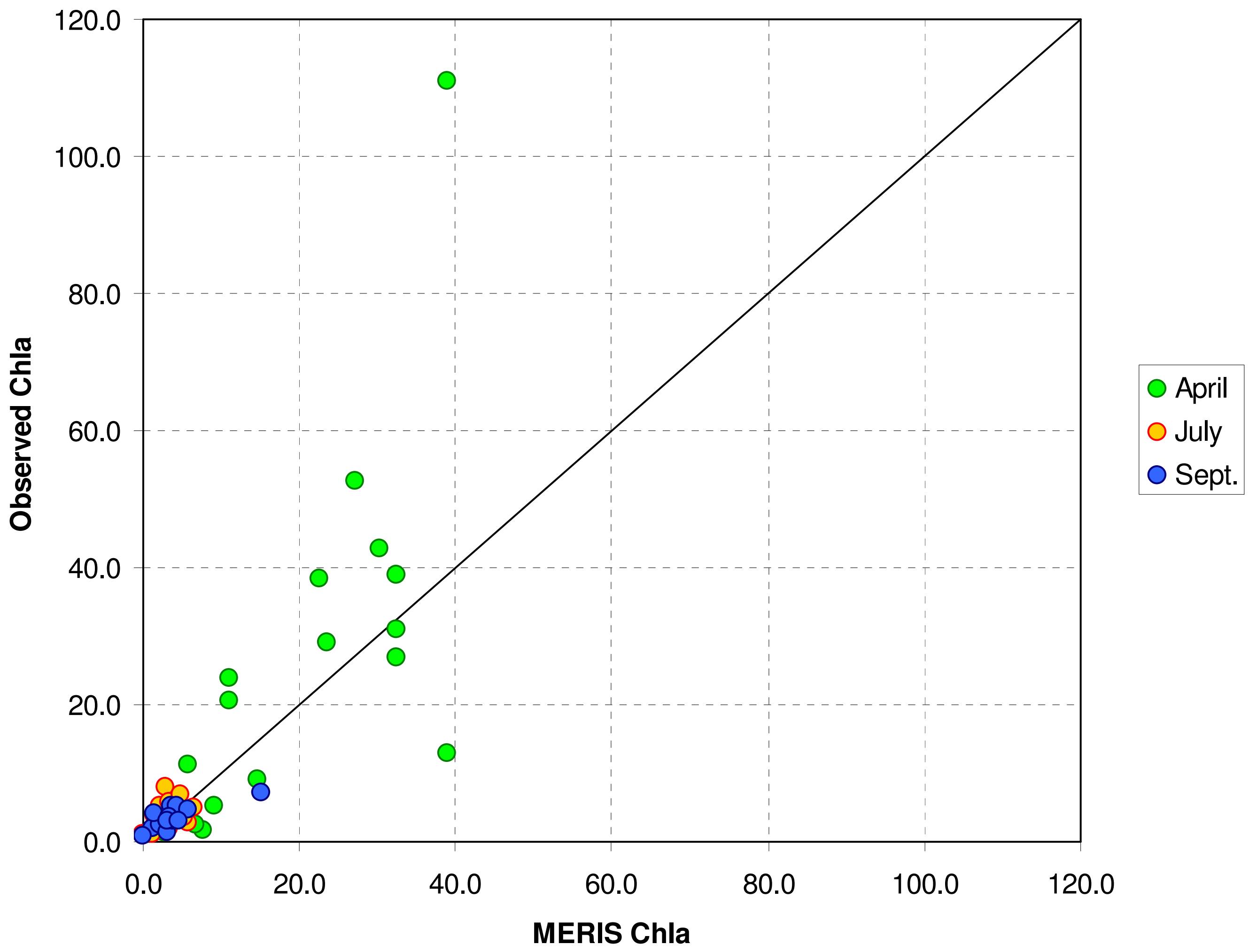
April 2007

July 2007

Sept 2007



Aplication to 2007 situation



Aplication to 2007 situation

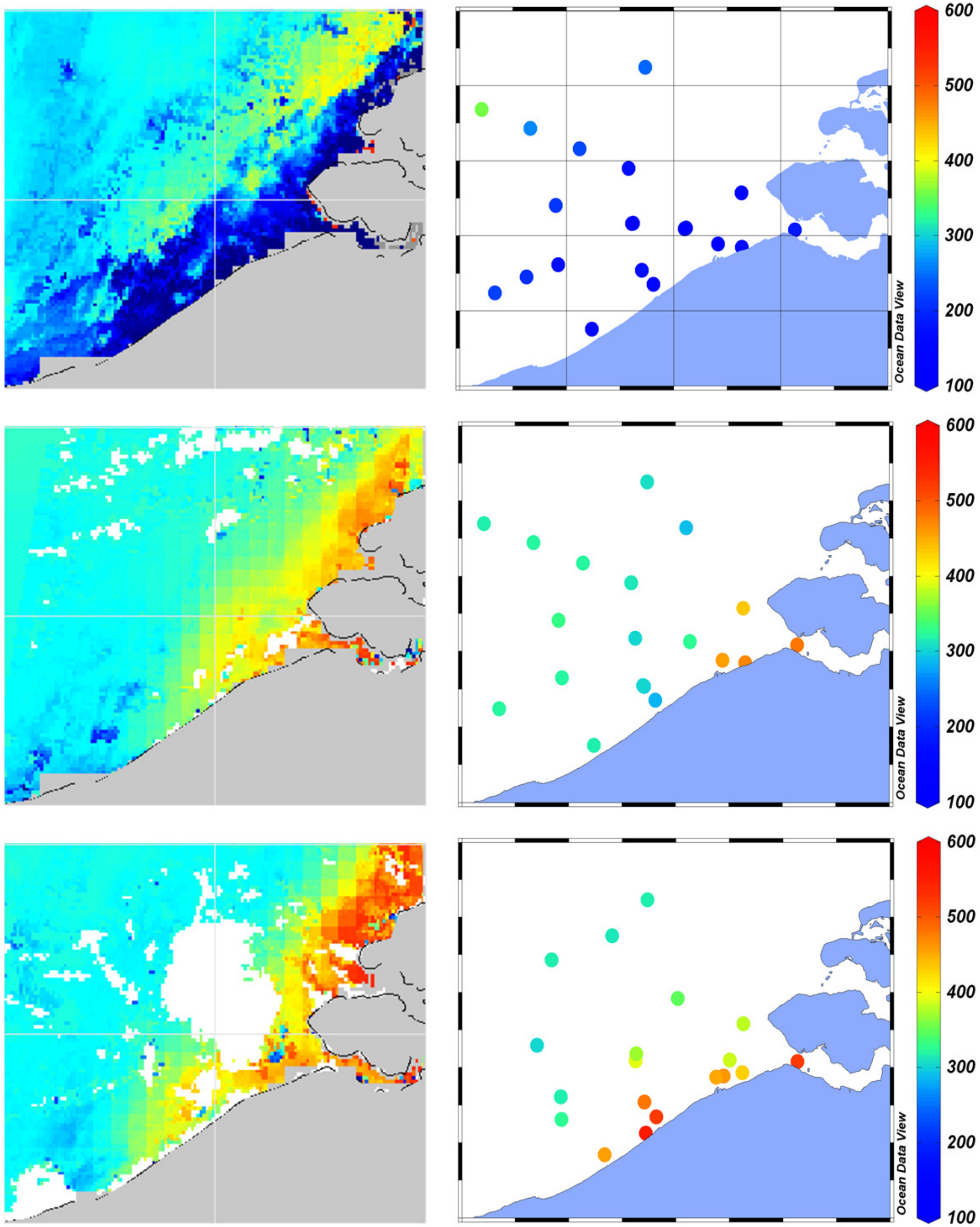
derived pCO_2

In-situ pCO_2

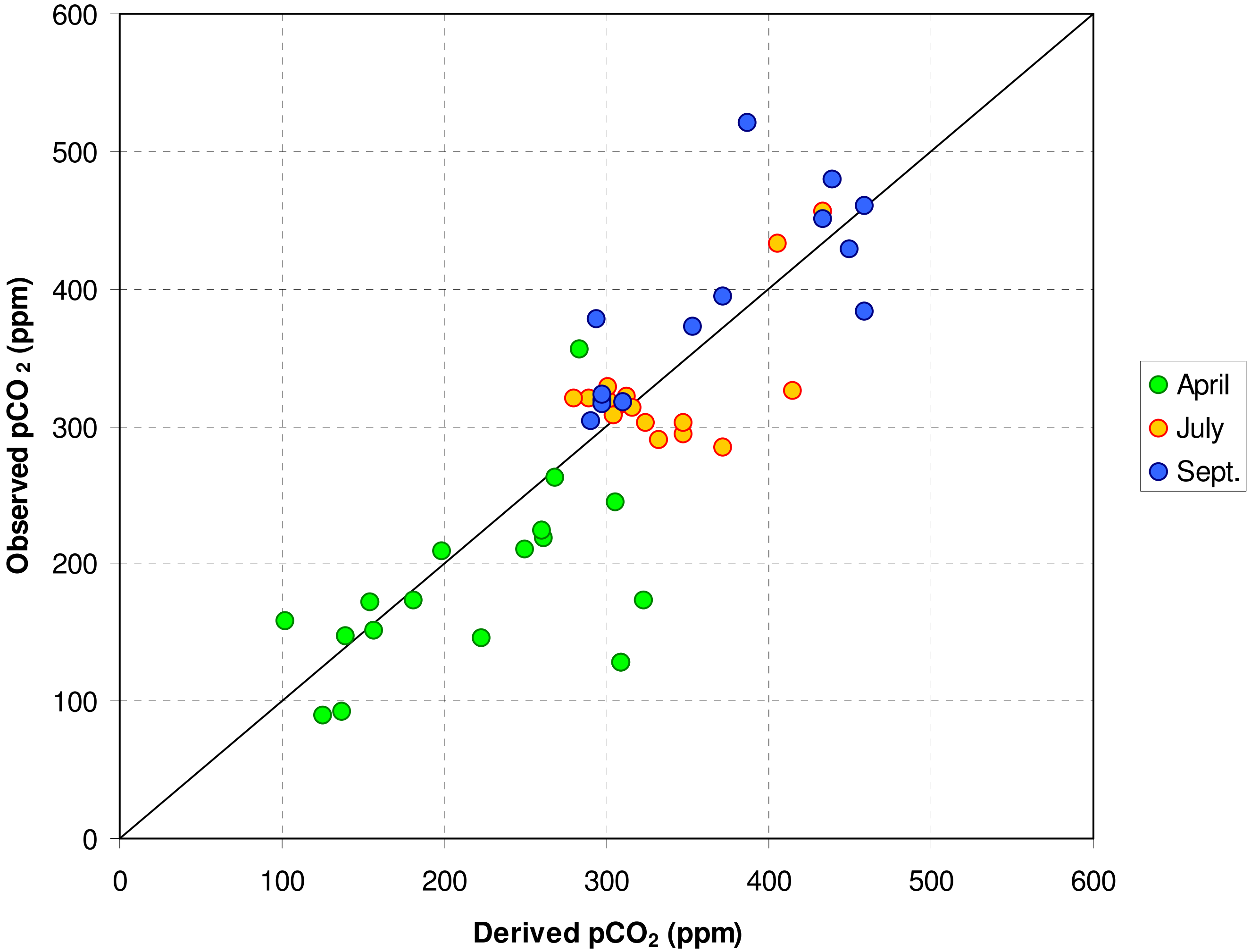
April 2007

July 2007

Sept 2007

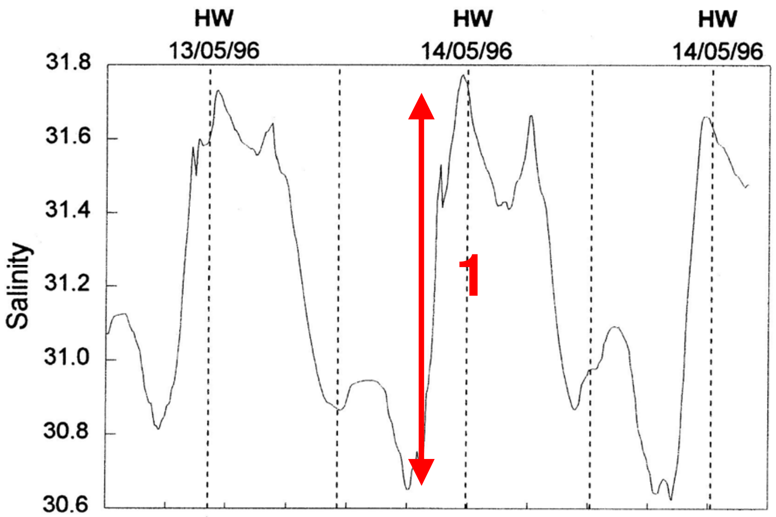


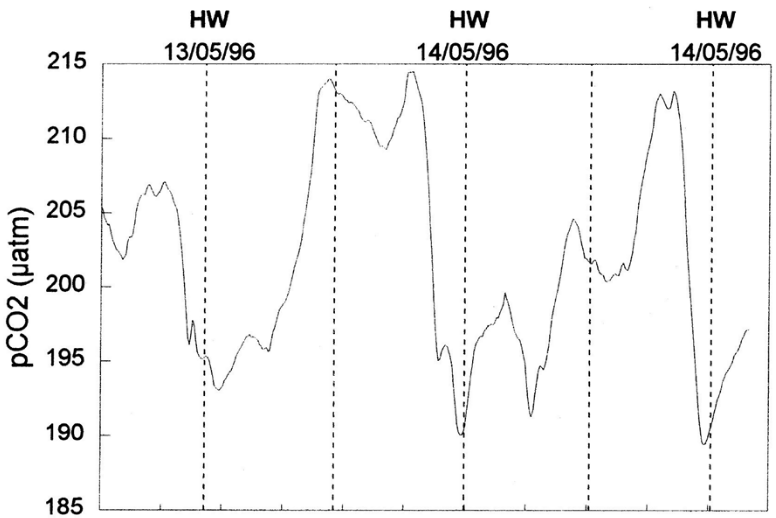
Aplication to 2007 situation

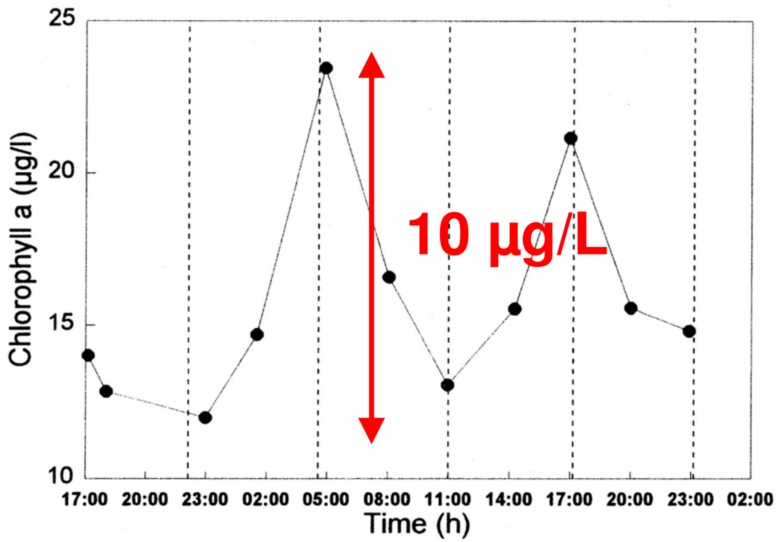


Aplication to 2007 situation

32 h cycle at a fixed station near Zeebrugge (May 1996)

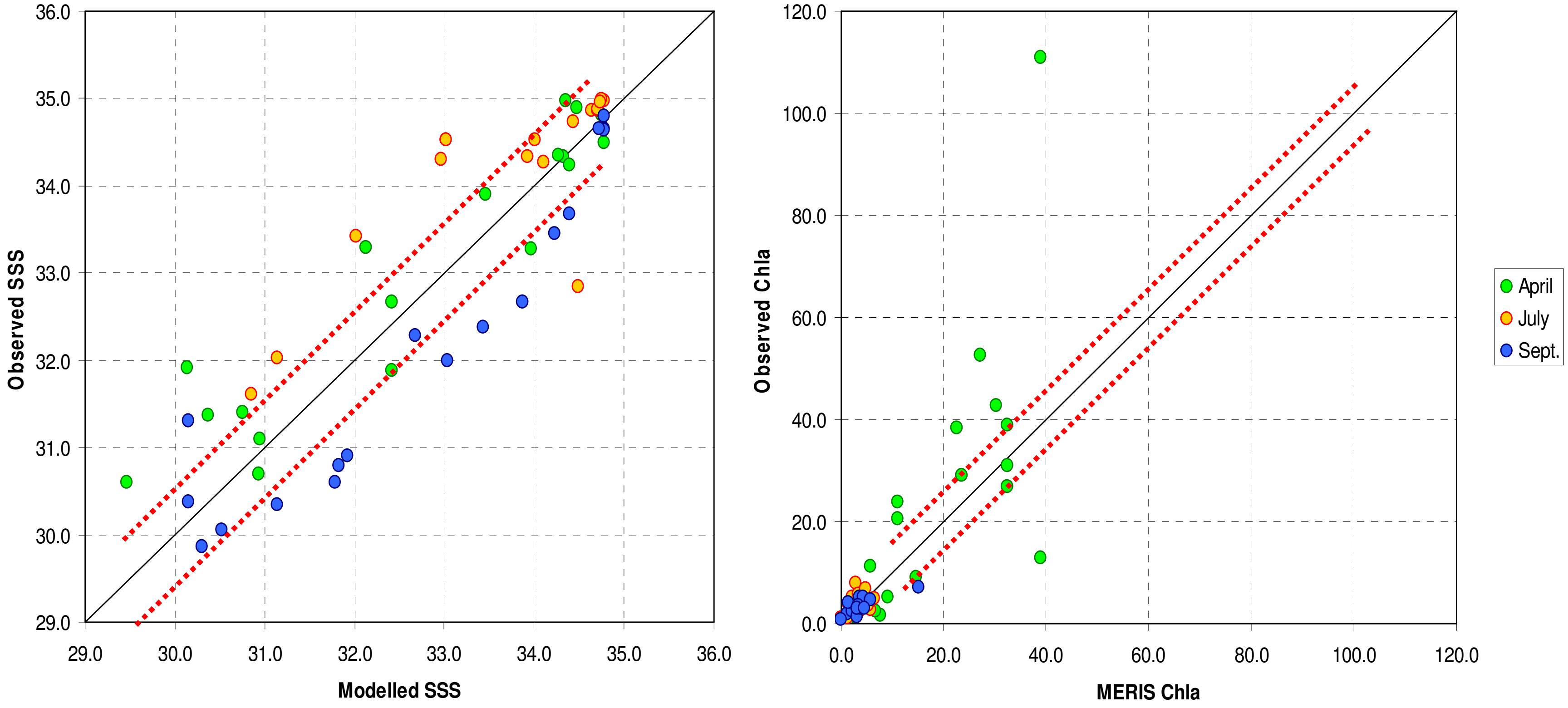






Borges and Frankignoulle (1999) JMS, 19(4): 251-266

Aplication to 2007 situation



Conclusions

- MPR algorithms were developed and tested to derive pCO_2 from SSS and Chla.

- SSS was modelled within ± 1 psu

- MERIS Chla reproduces well spatial patterns and seasonal variations, but possible under-estimates values at high values

- First attempt to derive pCO_2 was encouraging in these very challenging Case-II waters.

- Some of the scatter in comparison of SSS and Chl-a could be due to tidal effects