UPPSALA UNIVERSITET

RYMDSTYRELSEN Swedish National Space Board

Workshop

Oceanflux Greenhouse Gases

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Remote sensing algorithm for sea surface CO_2 in the Baltic Sea

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Context

- Problem for the quantification of the oceanic sink is thus the spatial and temporal distribution of available in-situ pCO_2 data
- Constrain the carbon fluxes in the Baltic sea remains particularly challenging
- Worldwide networks of measurements of surface water pCO_2 have been initiated in the 1990s (Poisson et al. 1993; Takahashi et al., 1993-2009 Jamet et al, 2007…).
- Data available can be use to this type of study in the Baltic Sea

Aims

- Swedish National Spaceboard project focusing the Baltic Sea :
  - ***Remote sensing algorithms for sea surface CO_2 and CO_2 flux***

    Anna Rutgersson, Tiit Kutser, Melissa Chierici, Gaëlle Parard, Sindu Parampil[1], Erik Sahlée, Maria Norman …

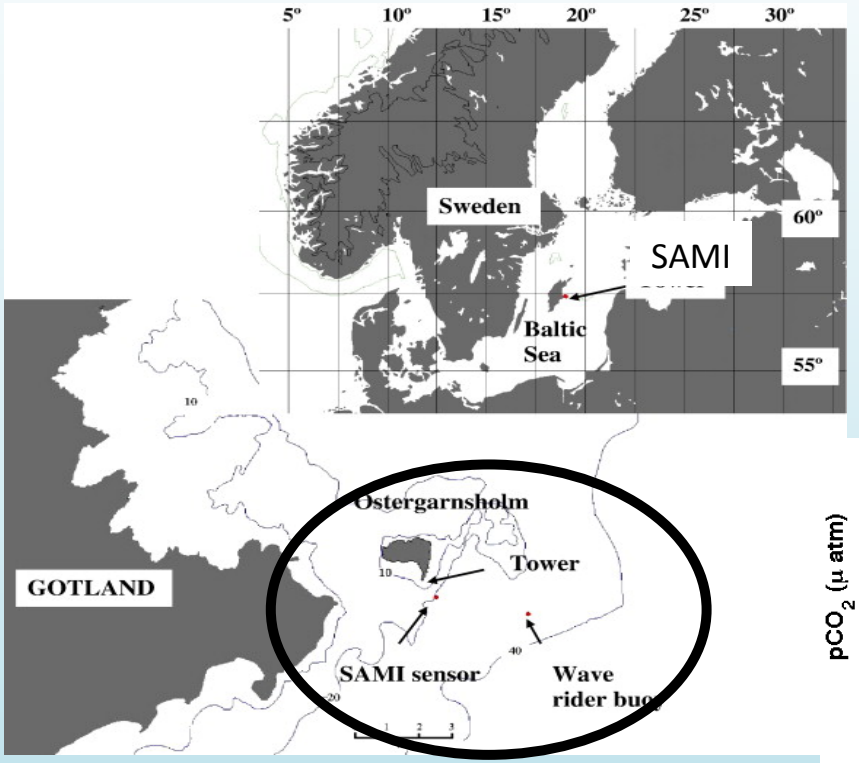
→Estimate pCO_2 variability in the global Baltic Sea with satellite data

→ Estimate the CO_2 fluxes in Baltic sea at several scale

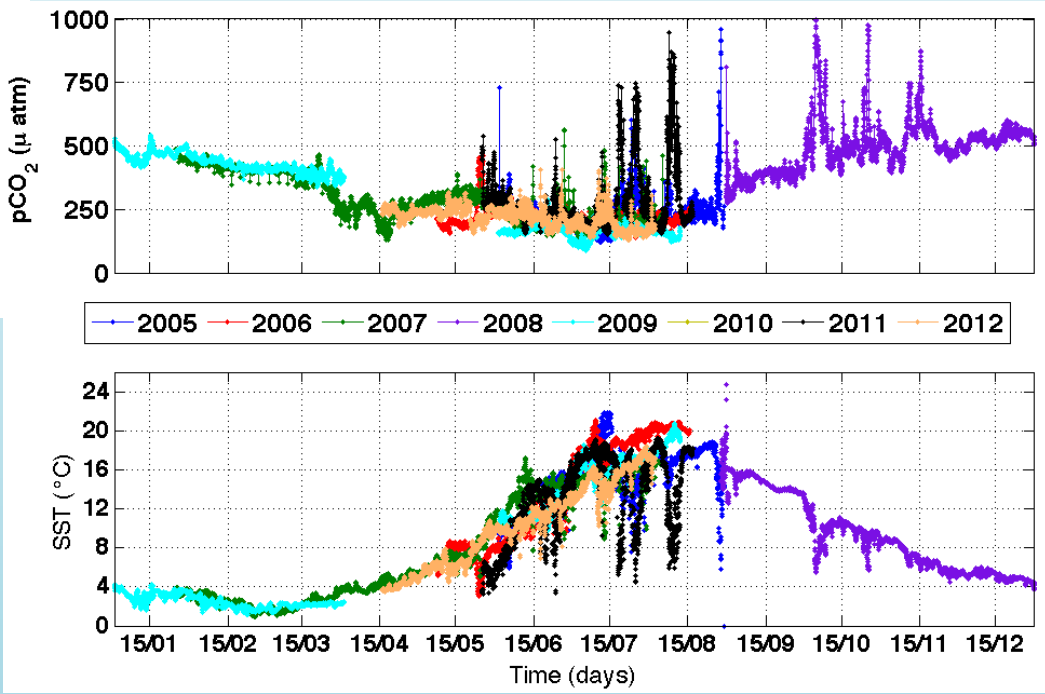
Content

- Data availability and validation
  - In situ data (Mooring, ship)
  - Satellite data
- Method : Self Organising Maps: Statistical Neuronal Approach
- First Results
- Conclusions and Perspectives

Data: Availability and Validation

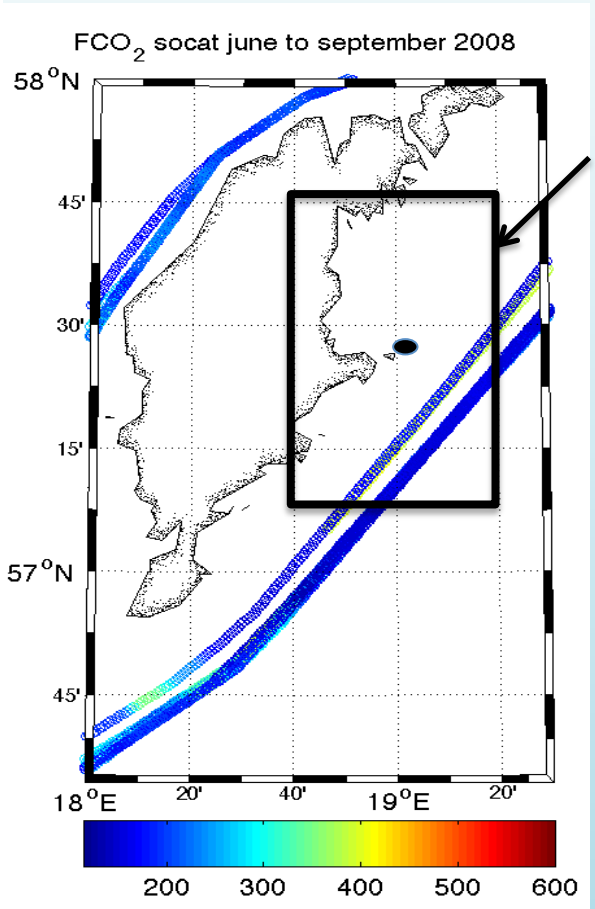


- Measurement of pCO_2 (SAMI sensor) and SST (4 m depth) at Östergarnsholm station since June 2005-July 2012
- Wave mooring (SST (0.5 m))



- Strong variation of SST and pCO_2 → upwelling events

In situ data : VOS and SMHI (Validation)

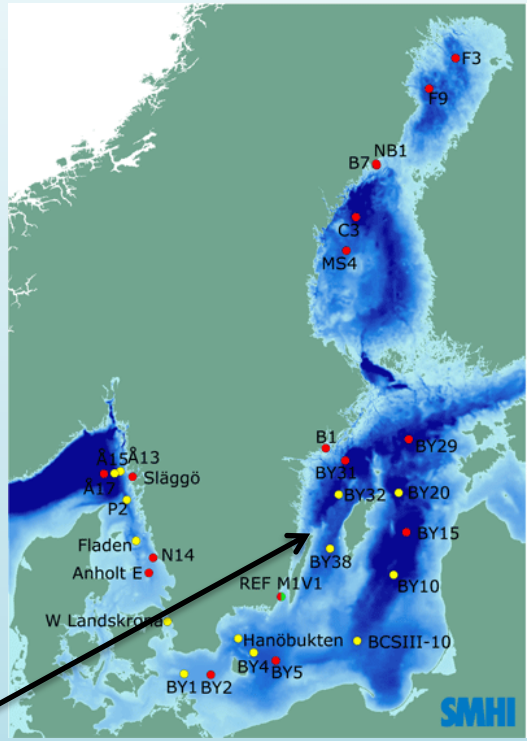


Ship measurements VOS comparison with the SAMI data (CDIAC+SOCAT database (Schneider et al,2006)

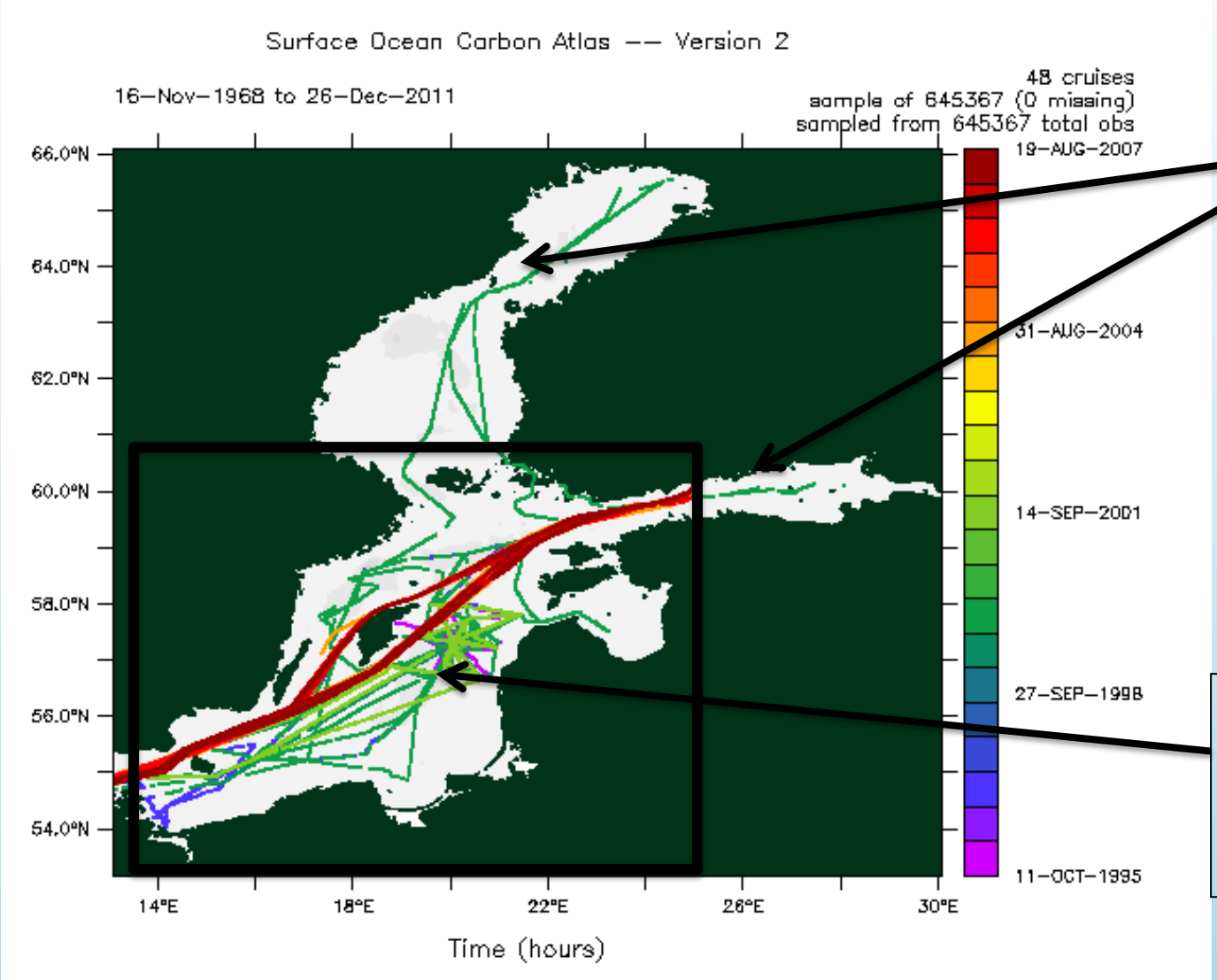
- Comparison (0.2° around the SAMI sensor (black square) & Time)
- Quite good correlation factor (0.98) and STD=9 µatm

SMHI mooring in Baltic sea compare to SAMI data (Not used yet)

- pCO_2 compute with carbonate relation (TA and pH)
- Quite good
- Need validation



In situ data: conclusion



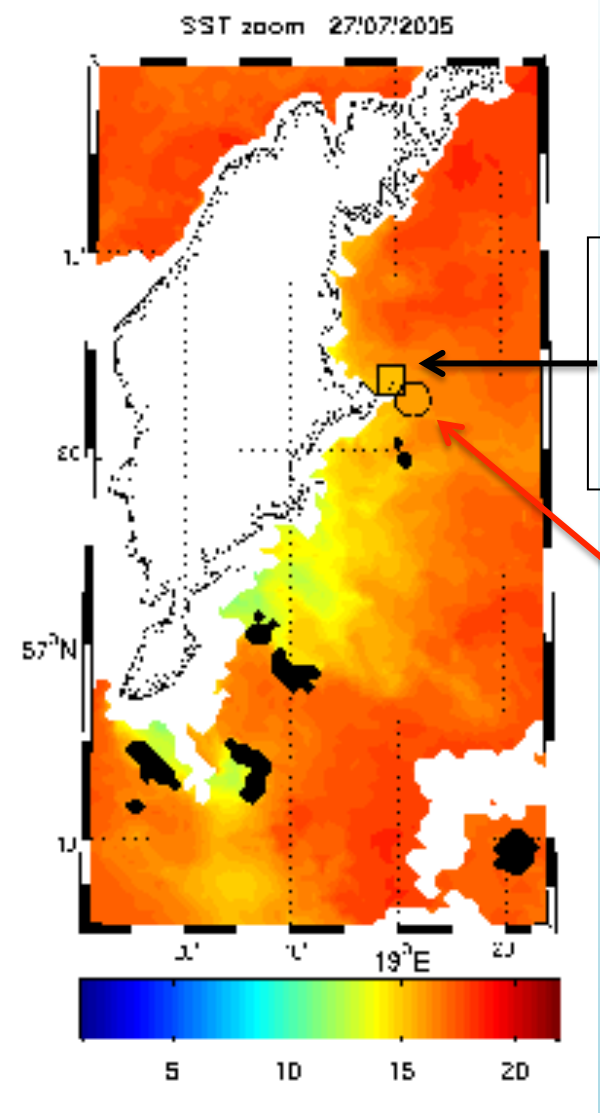
No data yet for this two basin between 2005 and 2011

VOS cruises + SAMI + SMHI estimation 2005-2011

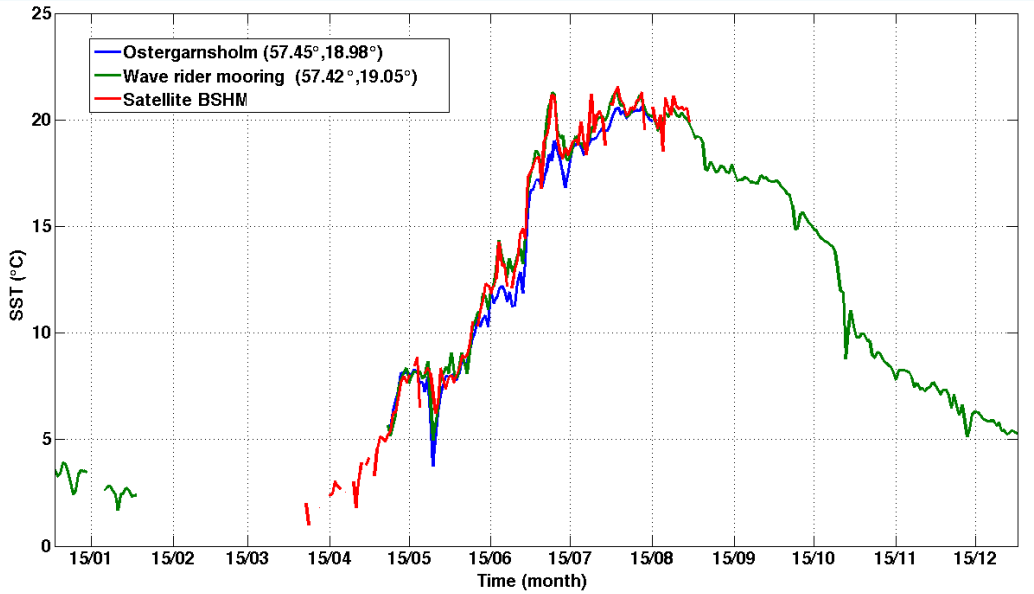
Satellite DATA

- Daily:
  - SST :
    - Federal Maritime and Hydrographic Agency (BSH) processing the data from AVHRR-NOAA . 2005-2012
    - GRHSST product for Baltic sea 2007-2011
  - Chlorophyll : JRC MERSEA Ocean Colour Products :
    - SeaWiFS: standard OC4-V4 algorithm, reprocessing 5.1 by the Goddard Space Flight Center (NASA) 2002-2011
    - MODIS-AQUA : reprocessing 1.1 by the Goddard Space Flight Center (NASA)
  - CDOM: Modis (need to validate)
- Monthly
  - Photosynthetically Active Radiation (PAR): Averages from:
    - SeaWiFS (Sept. 1997 - Dec. 2004) 4 km monthly
    - MODIS-Aqua (Jul. 2002 - Jun. 2011) 4 km monthly,
  - Primary Production: Source: http://oceancolor.gsfc.nasa.gov
    - SeaDAS 6.2
- NOT Satellite Data :
  - Mixed Layer Depth: hydrodynamic model General Estuarine Transport Model - www.getm.eu)

Comparison : SST satellite & SST mooring



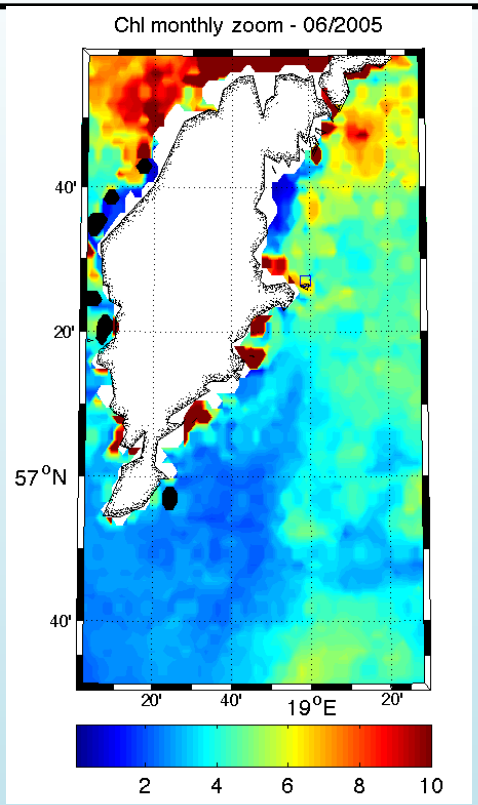
SAMI sensor (4 m depth)

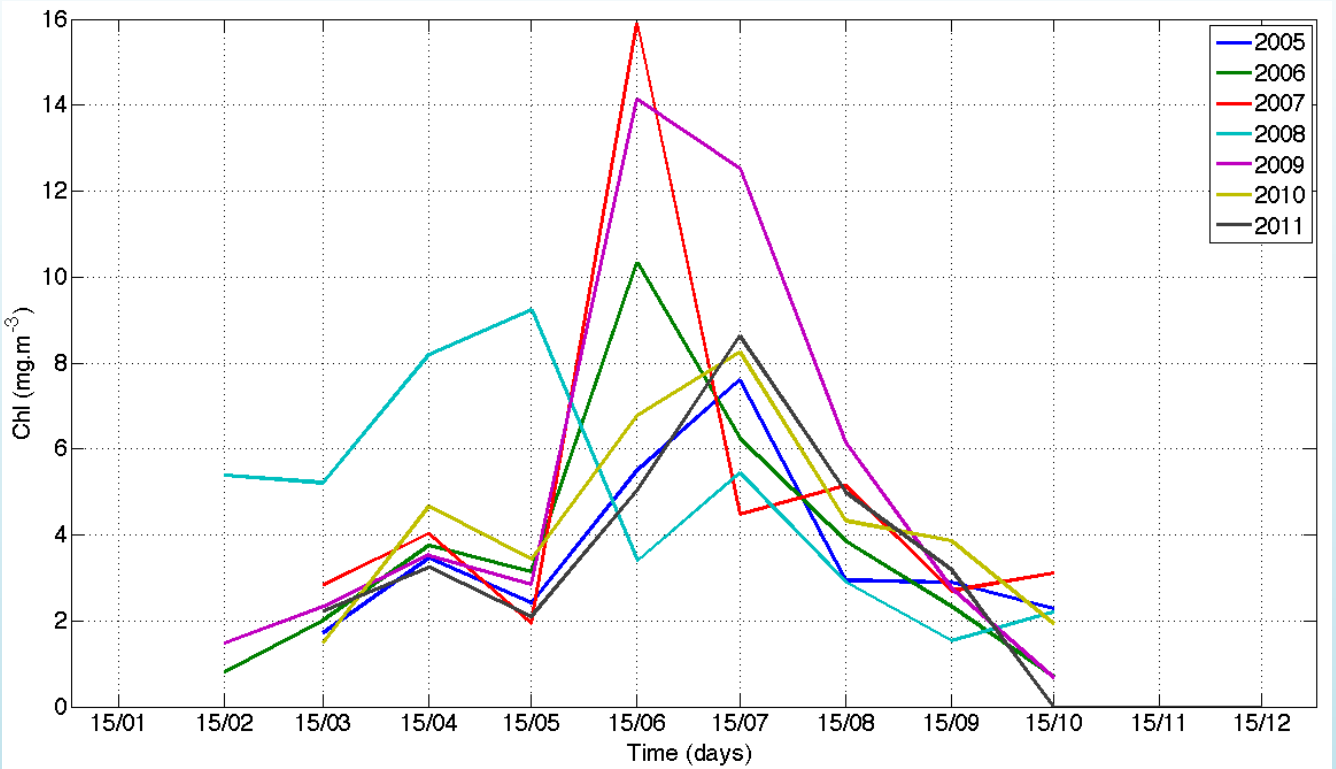


Wave mooring (1 m depth)

- Daily comparison for 2005 → Good correlation (0.95)
- Similar for all year
- But problem with strong variation during upwelling event
- Validation with VOS & SMHI data

Chlorophyll data

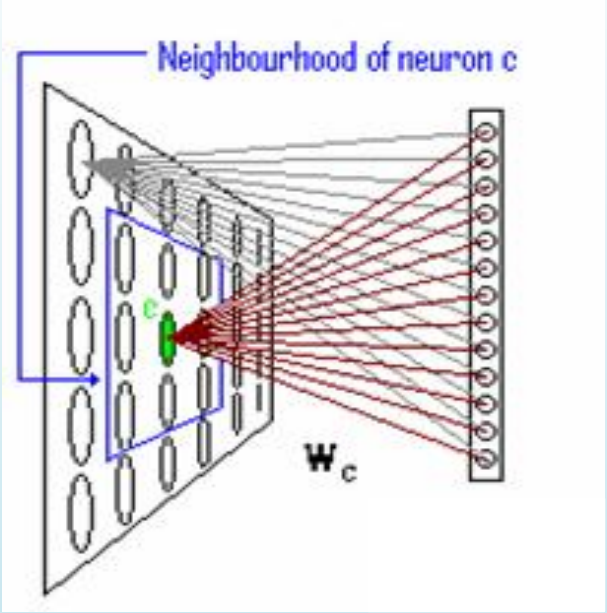




- Monthly spatial coverage quite good compare to the daily spatial coverage
- Interannual and seasonal high variation
- Validate chlorophyll daily and monthly product

Method : Self Organising Maps

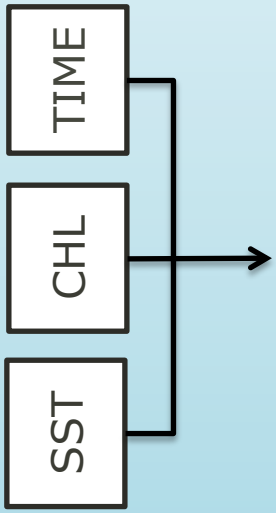
- Input: Multidimensional Data
- Output: A clusterization of the data through projection on a topologically organised 2D map, in a way that respects the underlying variability of the higher dimension.



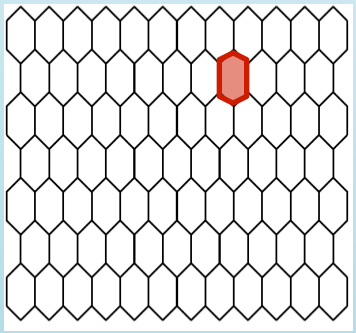
Observation

•Initially used for the training of the map

•New observations are compared with the elements of the map to classify them.



Self Organising Map:



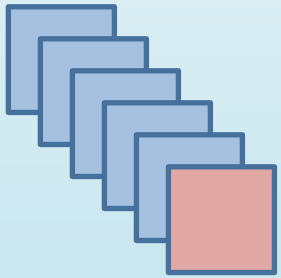
Classes:

- Arranged by similarity
- Correspond to:
  - an index number representing the position on the SOM
  - a referent vector

Reconstruction through SOM

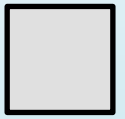
Compare the observable data with the corresponding values of all Referent Vectors of the SOM

Incomplete Vector



Referent Vector of the i-th Class

$(i \in [1,\ldots,N_{ref}])$

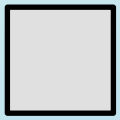


PCO2

Takes the value of the most similar referent vector.

PCO2

of the most similar class of the SOM



PCO2

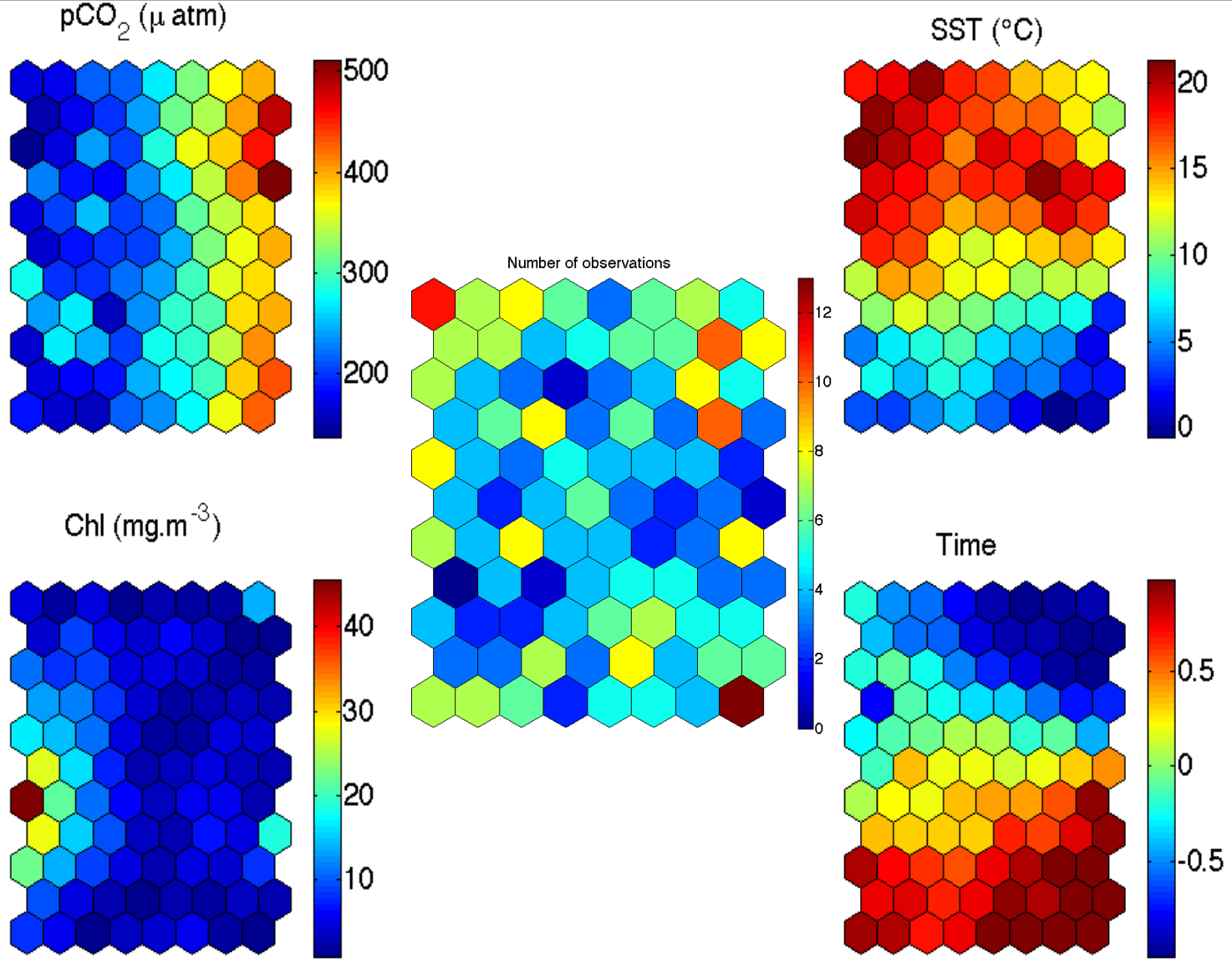
Observable data

First results: not enough data at monthly scale

- First test monthly scale : (pCO_2, SST, PAR, PP, Chl, MLD)
  - 2 data bases : Construct the Map/ Validate (≈10%)
  - Validation difficult : pCO_2± 20 µatm
  - → High error but not enough data to conclude

- Second test daily scale: (pCO_2,SST, Chl, time)
  - pCO_2 : SAMI sensor + VOS ship data
  - To represent the evolution in time : $time = \sin(\frac{Nbday \times 2\pi}{365})$
  - Principal component analysis :
    - 4 parameters stronger link :
      - » First mode explain 44 % of the variance of the phenomen
      - » First mode explain at 93% by SST strongly anti correlate by time
      - » Second mode by chlorophyll
    - All parameters significantly correlated to the first 3 axes.

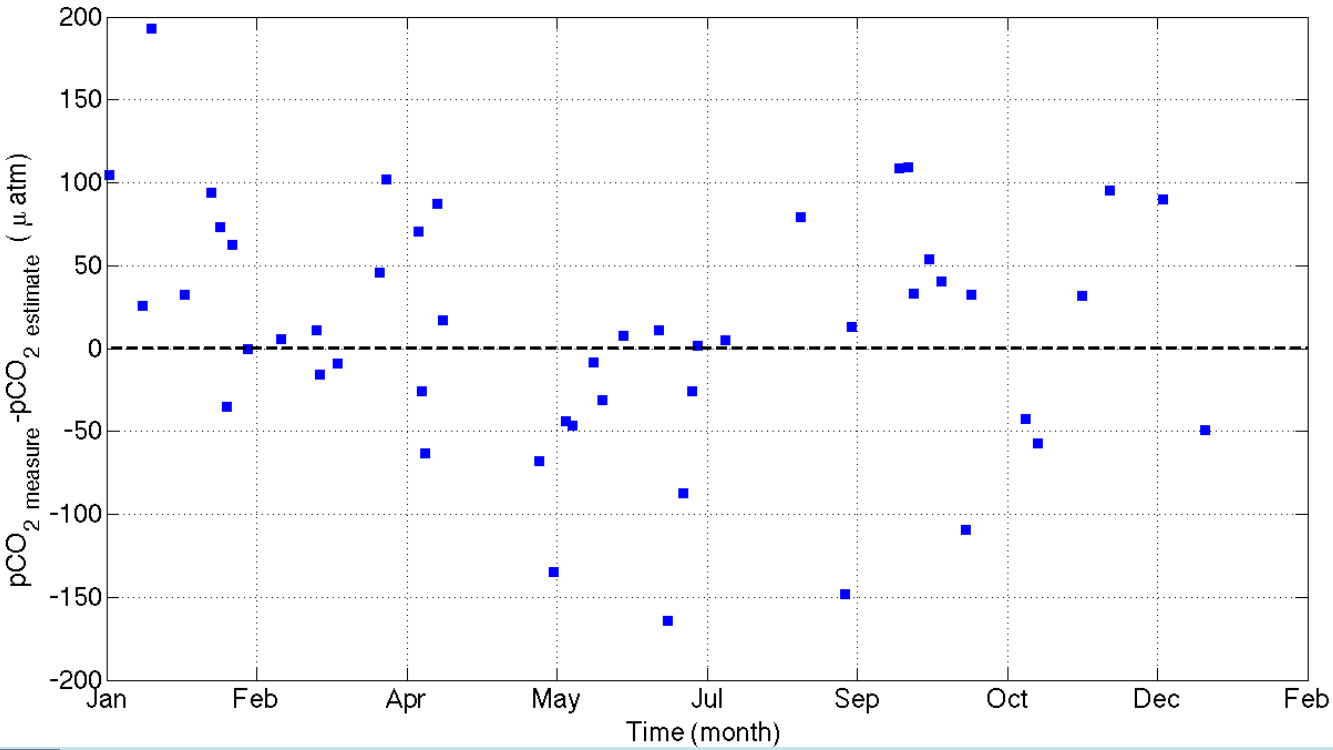
First results : Repartition



First Results : high error on pCO_2

- Difference pCO_2 high : 56 % less than 50 µatm
- 89 % less than 1 °C
- 86% less than 2 $mg.m^{-3}$
- Higher error on time

→ Outliners : ±2σ remove : winter time



	SST	CHL	pCO_2
R^2	0.99	0.97	0.71
ΔSTD	0.04	1.08	5
RMSE	0.85	1.8	73

→ Need other parameter like MLD and CDOM
→ Validate all the data used

Conclusion and Perspectives

- Data validation and availability:
  - SST and pCO_2 quite good compare to other data
  - → Need to verify in all Baltic Sea
  - Difficult to validate: Chlorophyll and CDOM data
- Daily scale much better
  - Distribution problem Vs number of data : use data before 2005
  - Have more pCO_2 data in all basin of the Baltic sea (Gulf of Bothnia and Gulf of Finland)
- Estimate the air-sea fluxes in Baltic sea with the pCO_2 estimation