Neural network based reconstruction of global surface ocean pCO_2 from 2001 to 2013

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GMMC 2017, BREST, IFREMER

Motivation of study:

provide update of the global ocean anthropogenic CO_2 sink based on observations

=> yearly assessment of global Carbon budget

provide estimate of inter-annual variability of source and sink regions across Atlantic ocean

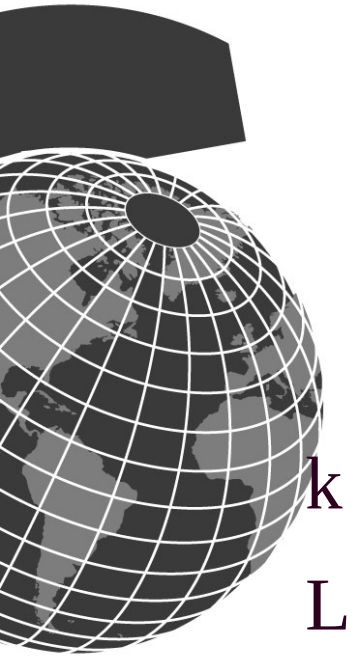
contribute to definition of next generation observing systems

Objective:

definition of an observing system enabling the release of carbon system estimates at the scale of the Atlantic basin at monthly, respectively seasonal frequencies

Carbon system estimates : pCO_2

Spatial scope : global, but focus on Atlantic basin



Air-sea flux

$$f_{CO2} = k\,\rho\,L\,(pCO_{2,ocean} - pCO_{2,atm})$$

k – gas transfer coefficient (function of wind speed)

L – solubility of CO_2 (function of SSS, SST, pressure)

ρ – water density

$pCO_{2,atm} = P_{dry} * xCO_2$ – *atmospheric partial pressure*

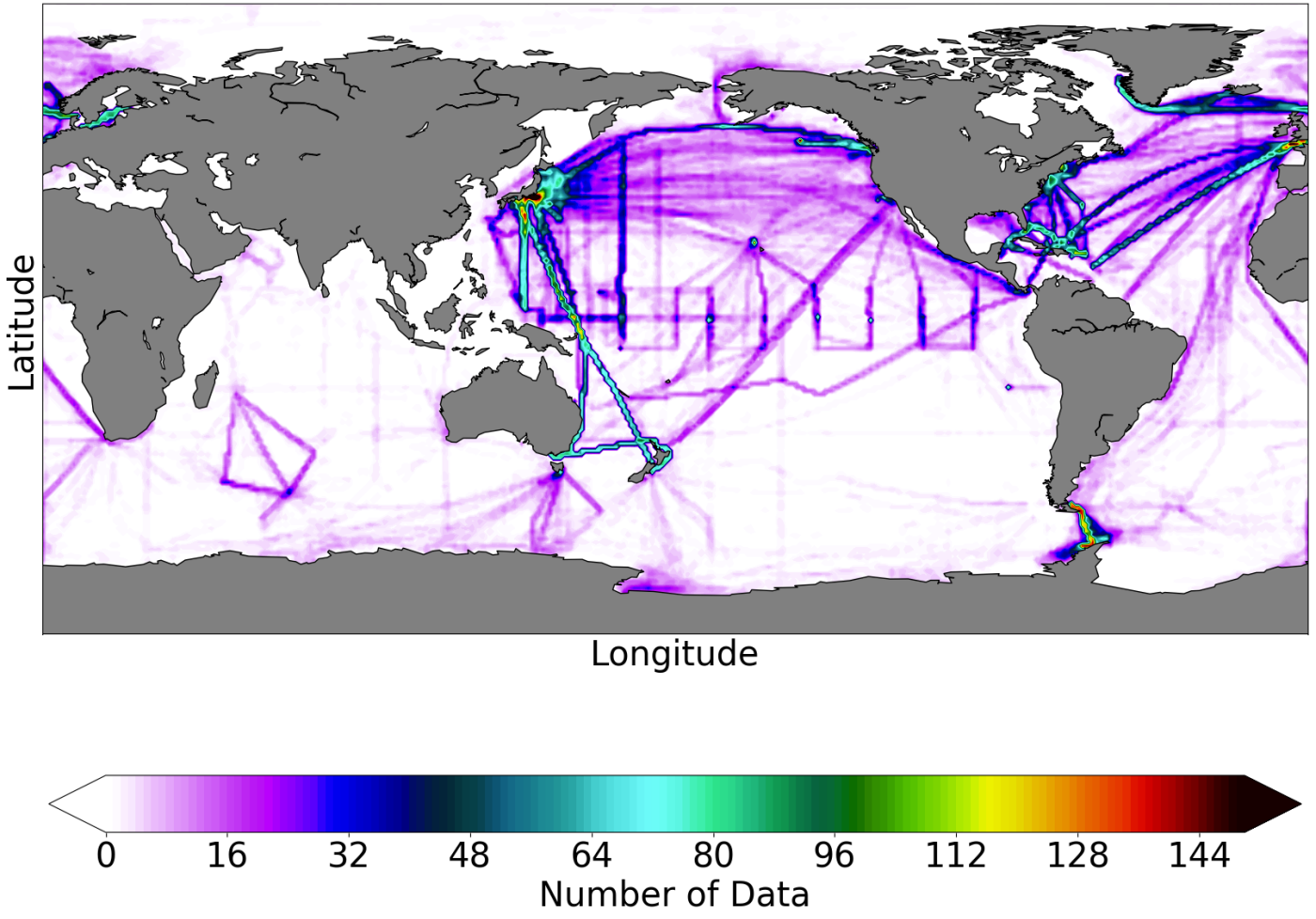
$pCO_{2,ocean}$ (seawater partial pressure) - ?

$pCO_{2,ocean}$

Observation data: SOCAT v4 – ship traces for period

Jan 1970-Dec 2015 (Bakker et al., 2016)

Monthly data on $1^{o}x1^{o}$

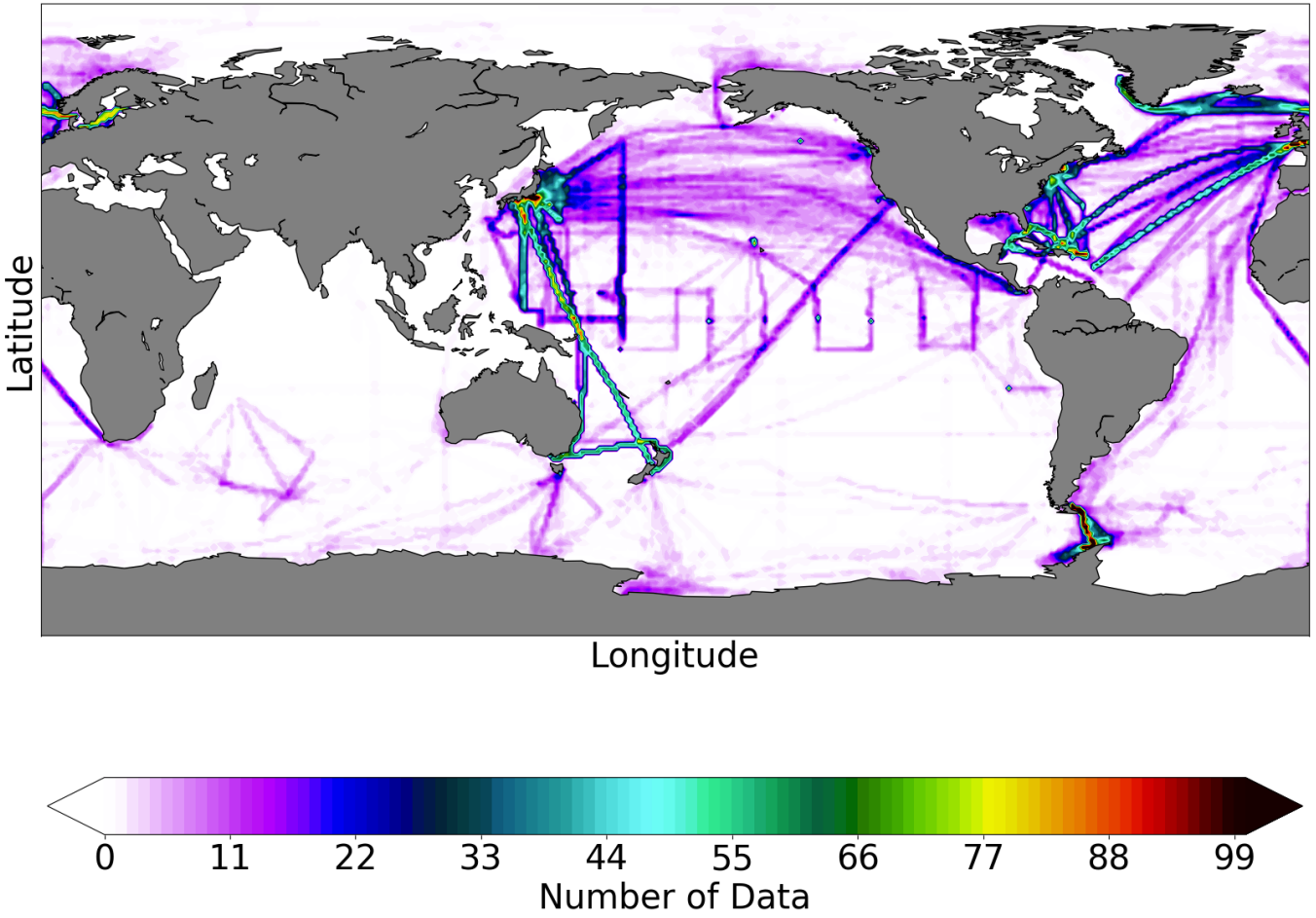


$pCO_{2,ocean}$

Observation data: SOCAT v4 – ship traces for period

Jan 1970-Dec 2015

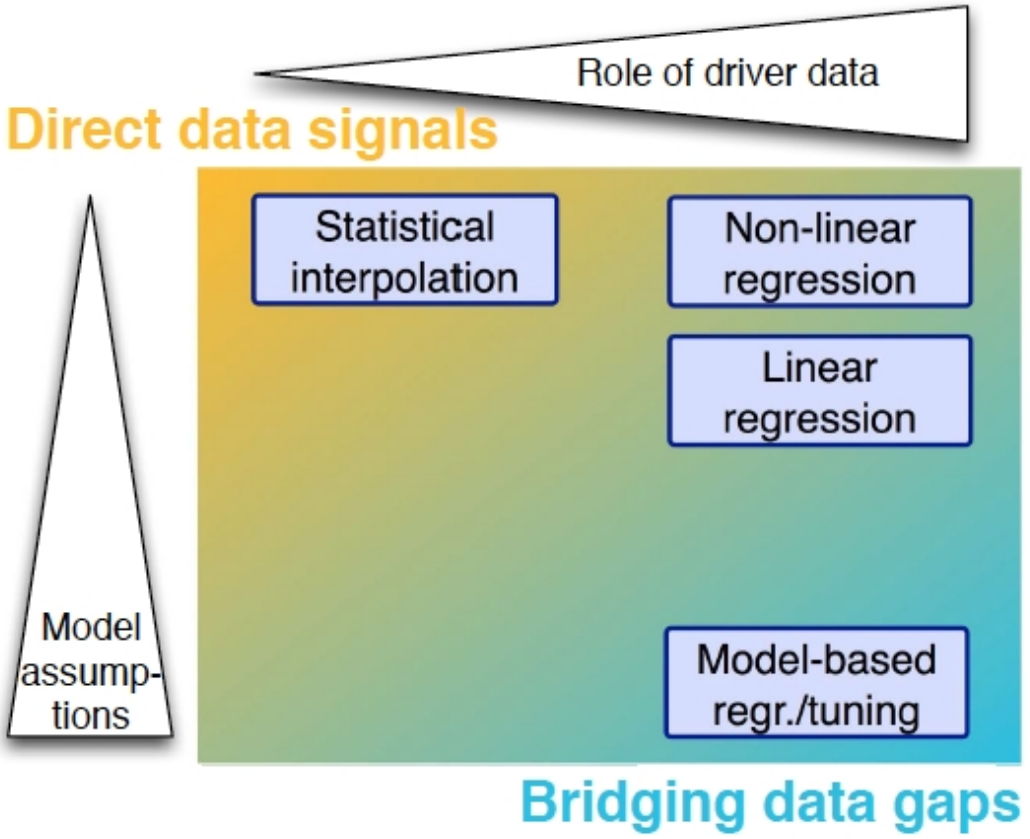
Chosen period: 2001-2013



Mapping of pCO_2

Rödenbeck et al. 2015

Comparison of 14 different mapping methods



Neural network model

1 st. $pCO_{2\,Clim} = f(SSS,SST,SSH,MLD,Chl,lon,lat)$

2 st. $pCO_{2\,Anom} = pCO_2 - pCO_{2\,Clim}$

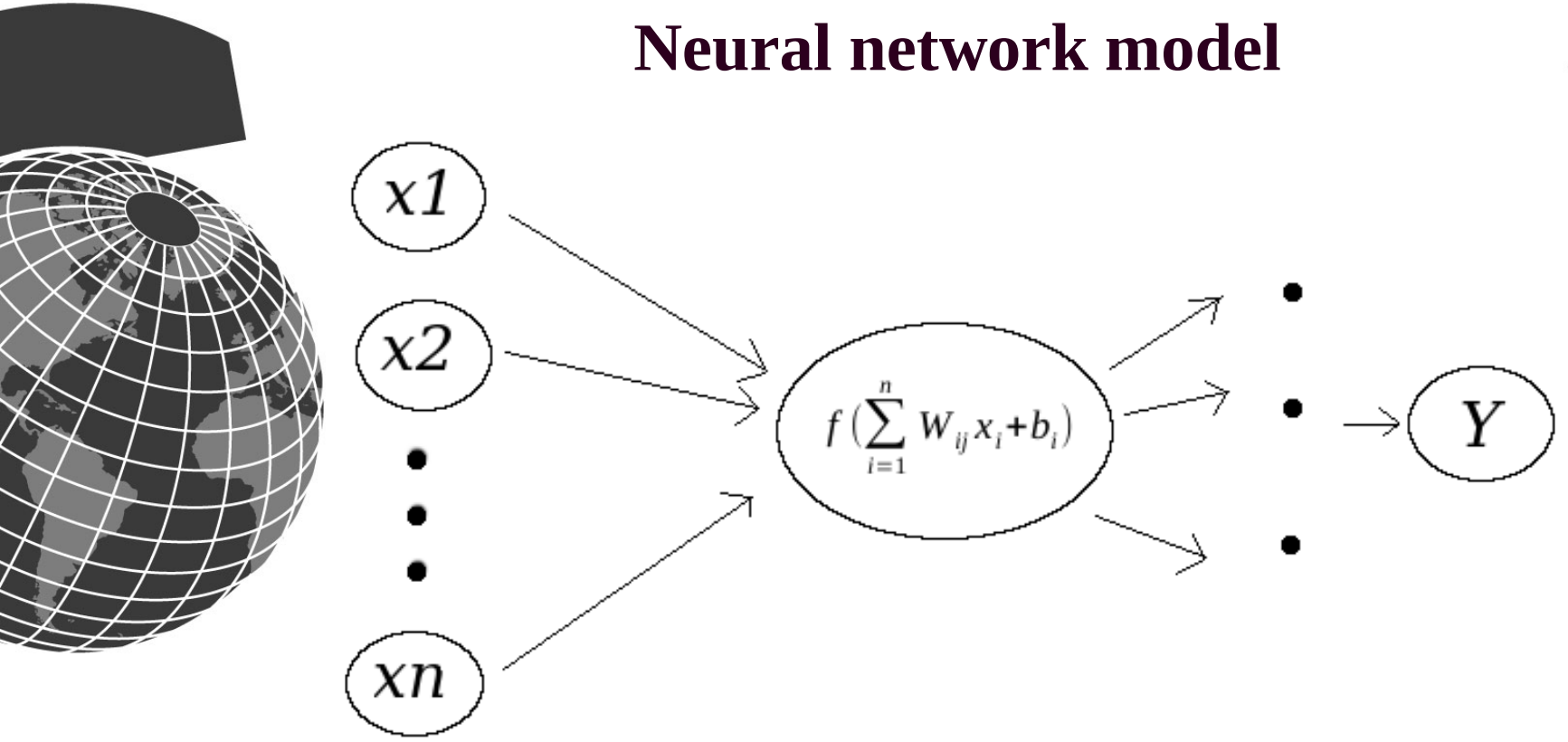
$$pCO_{2\,Anom} = g(SSS,SST,SSH,MLD,Chl,pCO_{2,Atm},lon,lat,SSS_{Anom},SST_{Anom},SSH_{Anom},MLD_{Anom},Chl_{Anom},pCO_{2,Atm\,Anom})$$

Copernicus: Global Ocean Obervation-based Reprocessed Products: SSS, SST, SSH

CMEMS products: Chl

ECMWF, CAMS Greenhouse Gases Flux Inversions: $pCO_{2,atm}$

Neural network model



For each month

1 st. 5 layers, activation - tanh, last level linear

1856 parameters, ~17238 training grid points

2 st. 4 layers, activation - tanh, last level linear

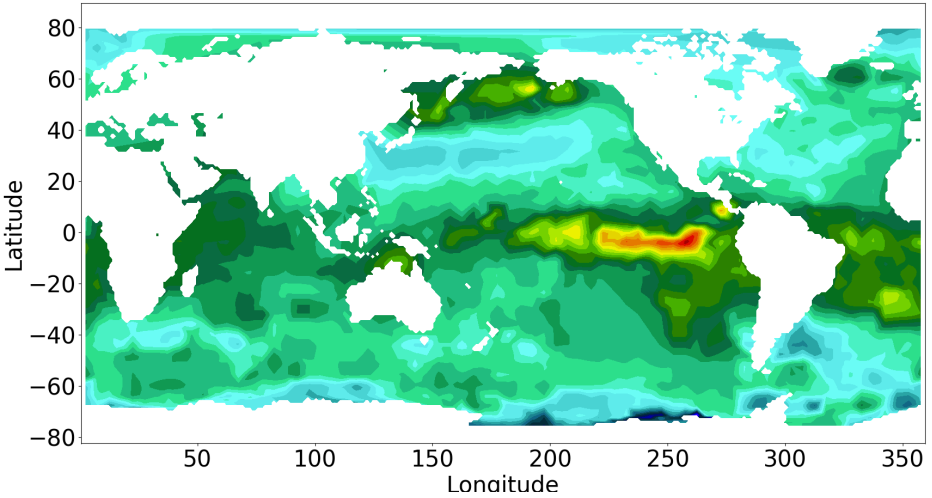
~1796 parameters, 16832 training grid points (over 3 months)

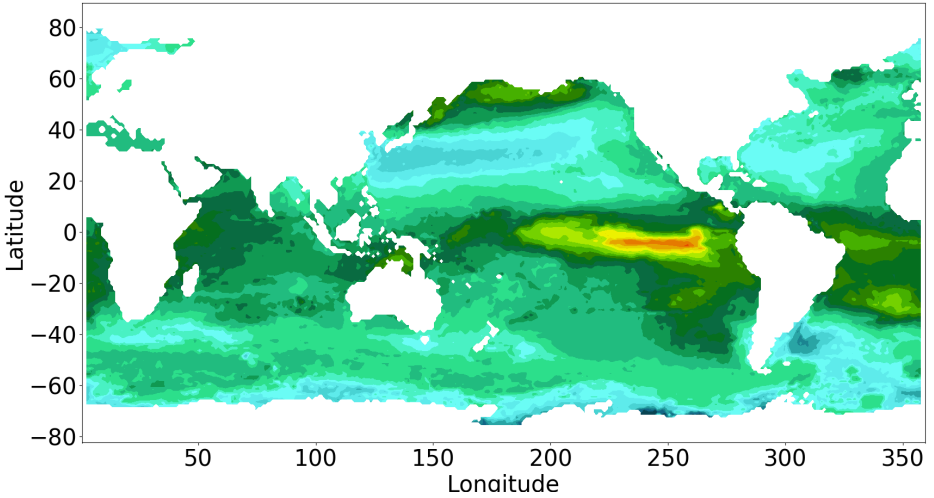
pCO_2 Climatology

Takahashi et al., 2014

Neural network model

Feb





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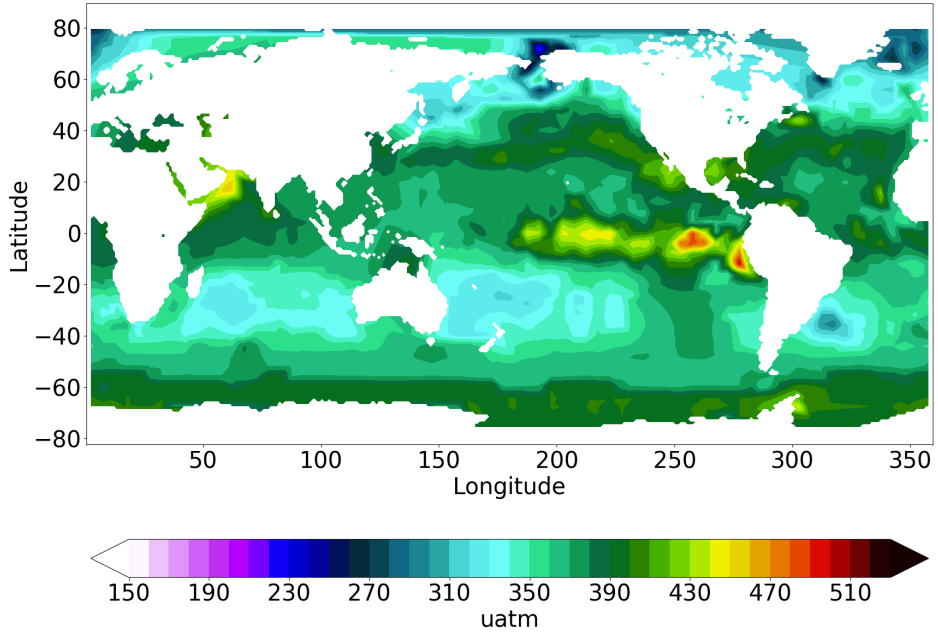
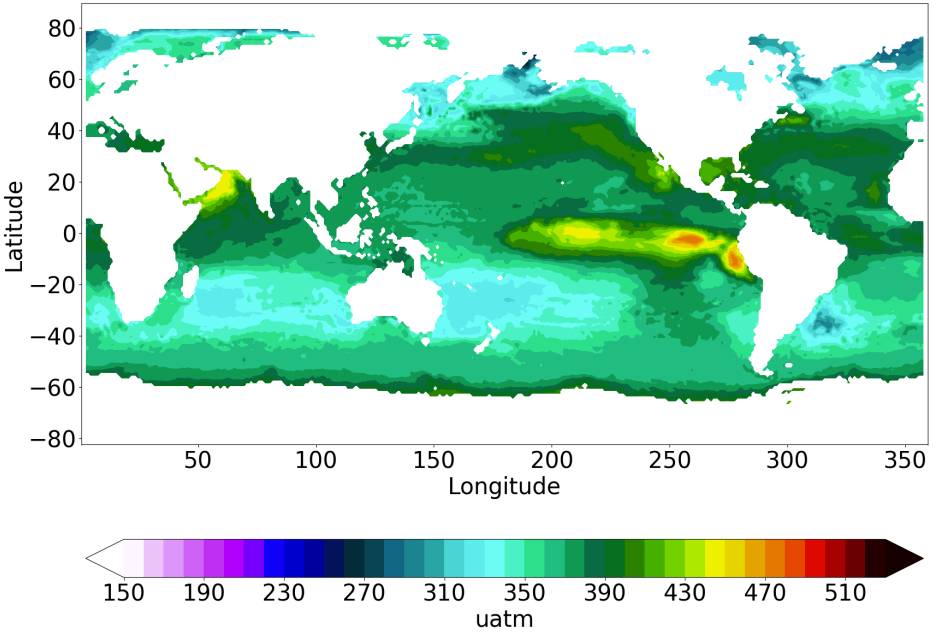




pCO_2 Climatology

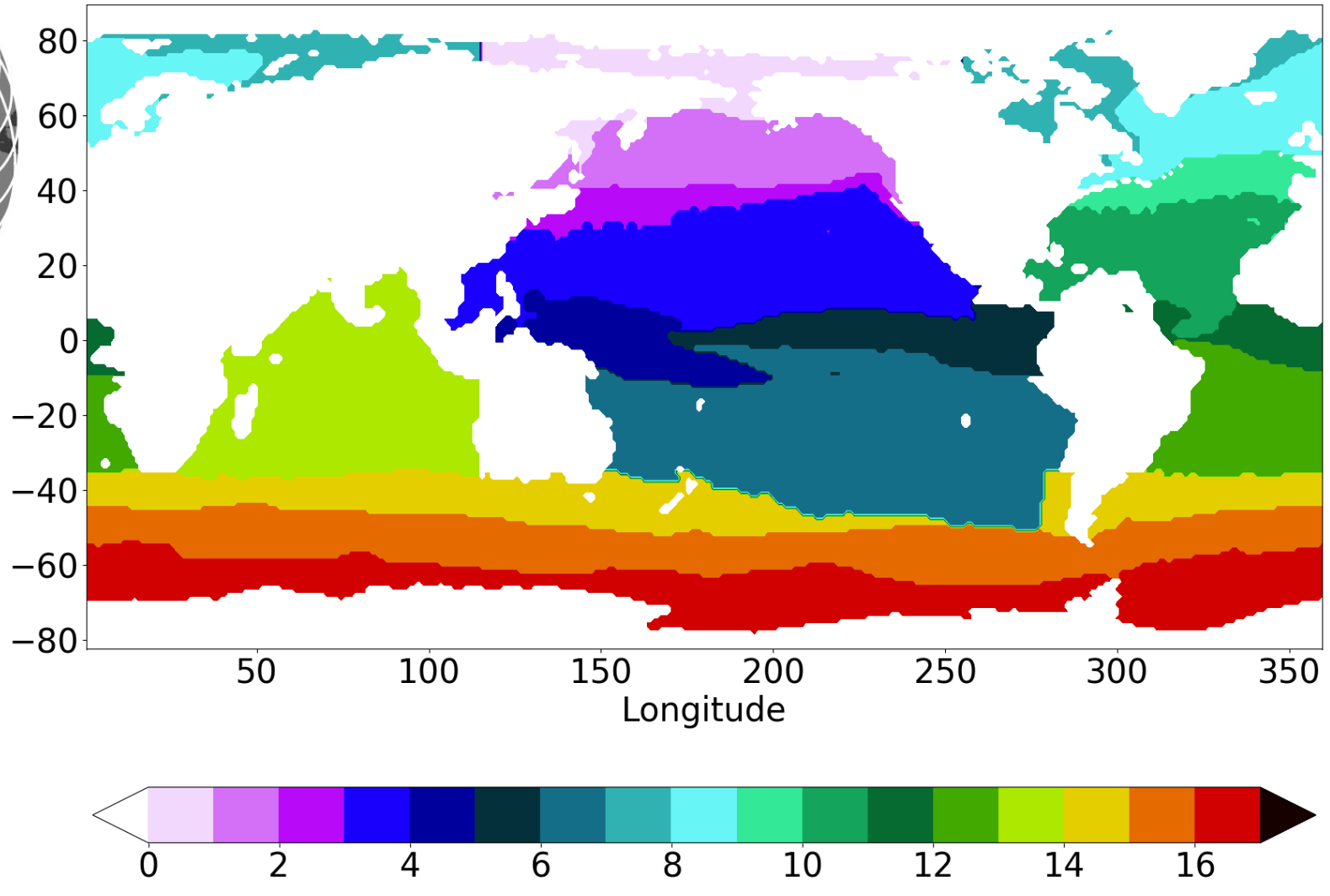
	Validation	SOCAT	SOCAT vs.Taka
RMSd	0.26	12.7	
R2	0.93	0.9	
Bias	-0.01	-0.83	
Spatial correlation		0.44	0.43

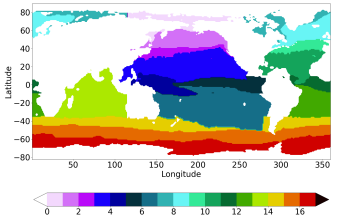
Reconstructed pCO_2

	Validation	SOCAT	Climatology vs.Taka
RMSd	19.04	19.1	17.28
R2	0.73	0.75	0.64
Bias	-0.22	0.78	0.85

Map of biomes used for pCO_2 reconstruction

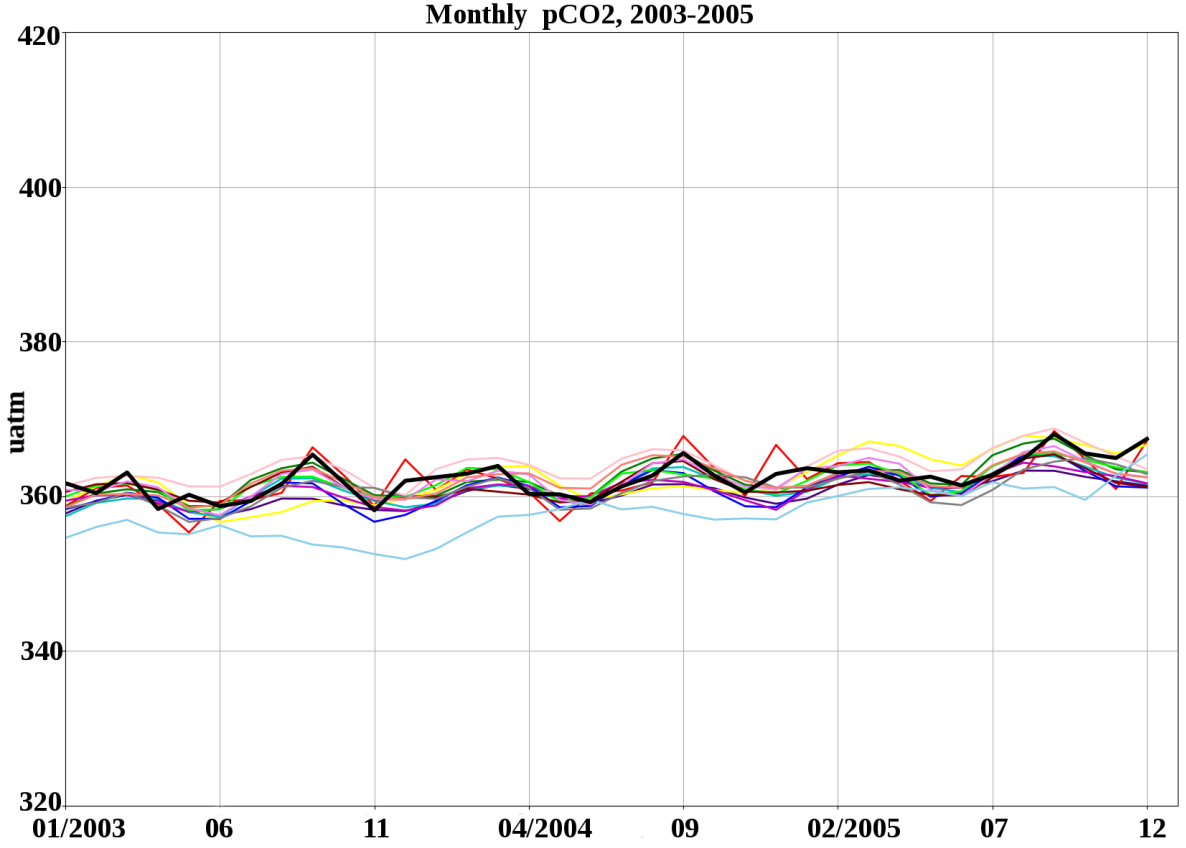
Rödenbeck et al. 2015 (Fay and McKinley 2014)

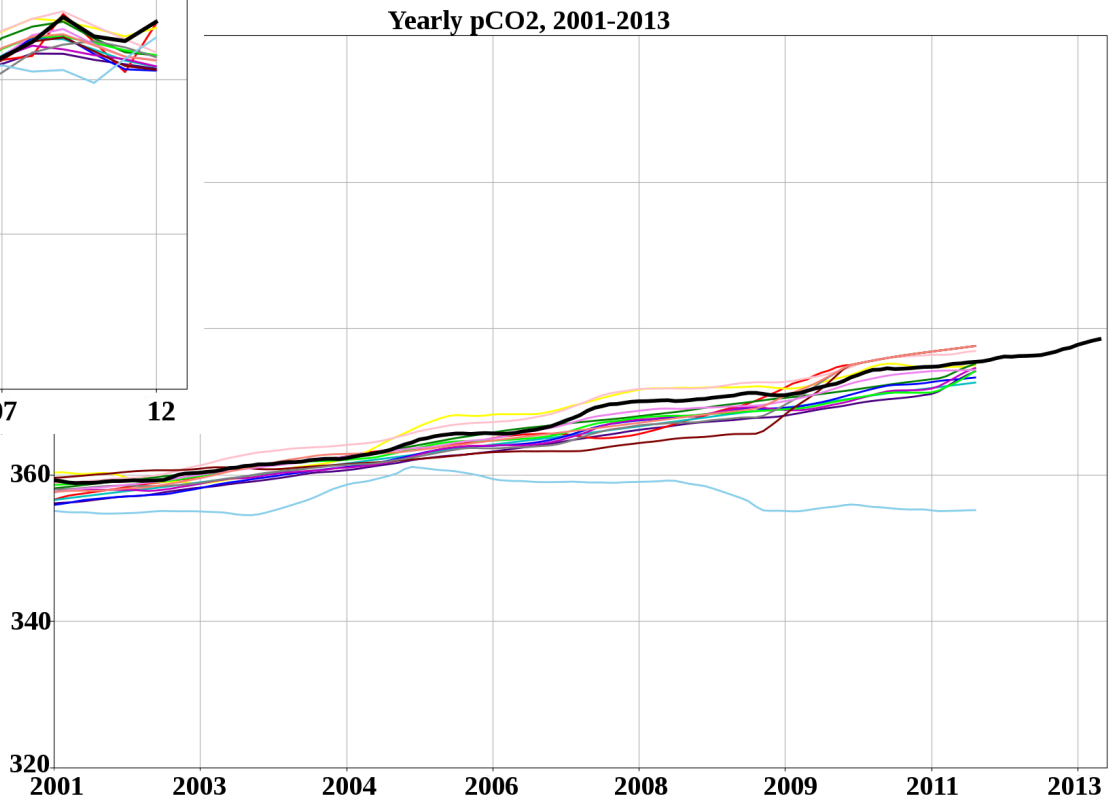


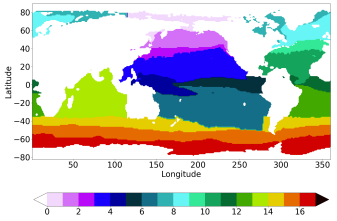


Global comparison of reconstructed pCO_2

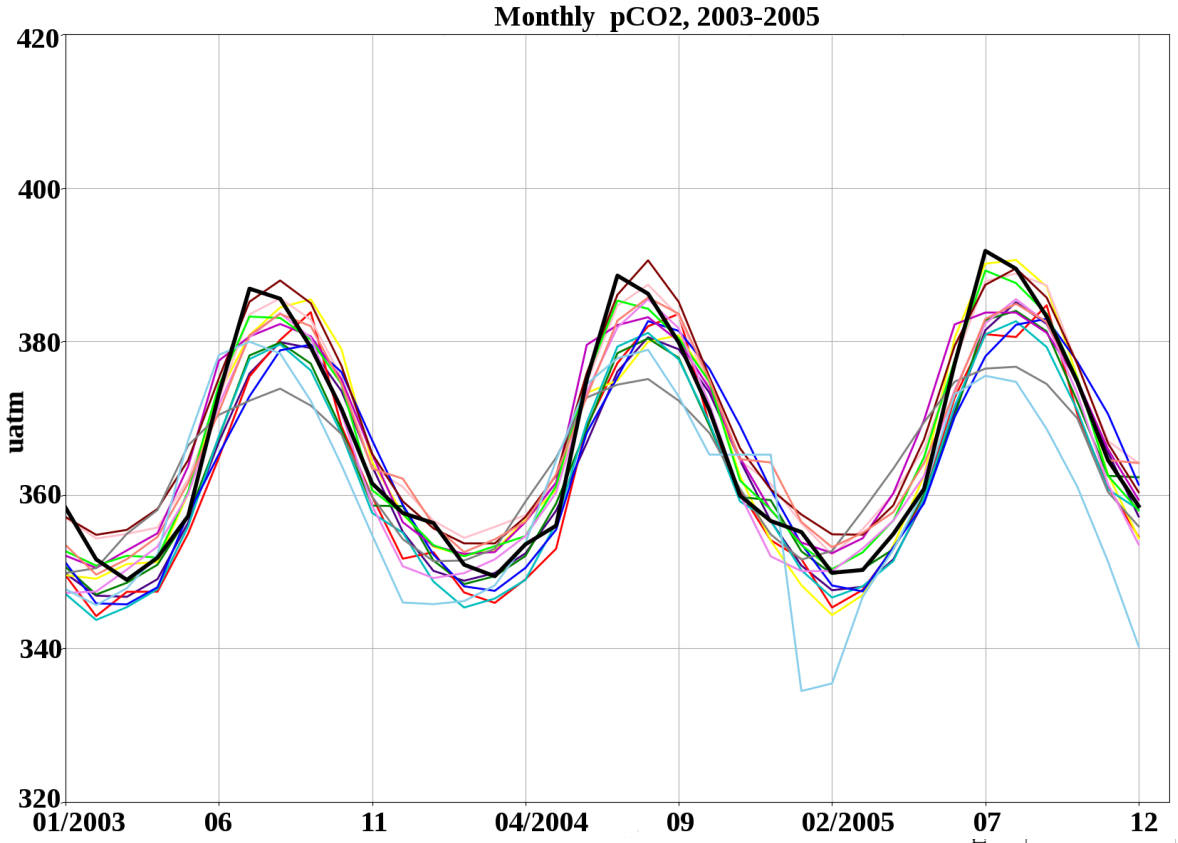
FNN pCO_2 is comparable with other mapping methods



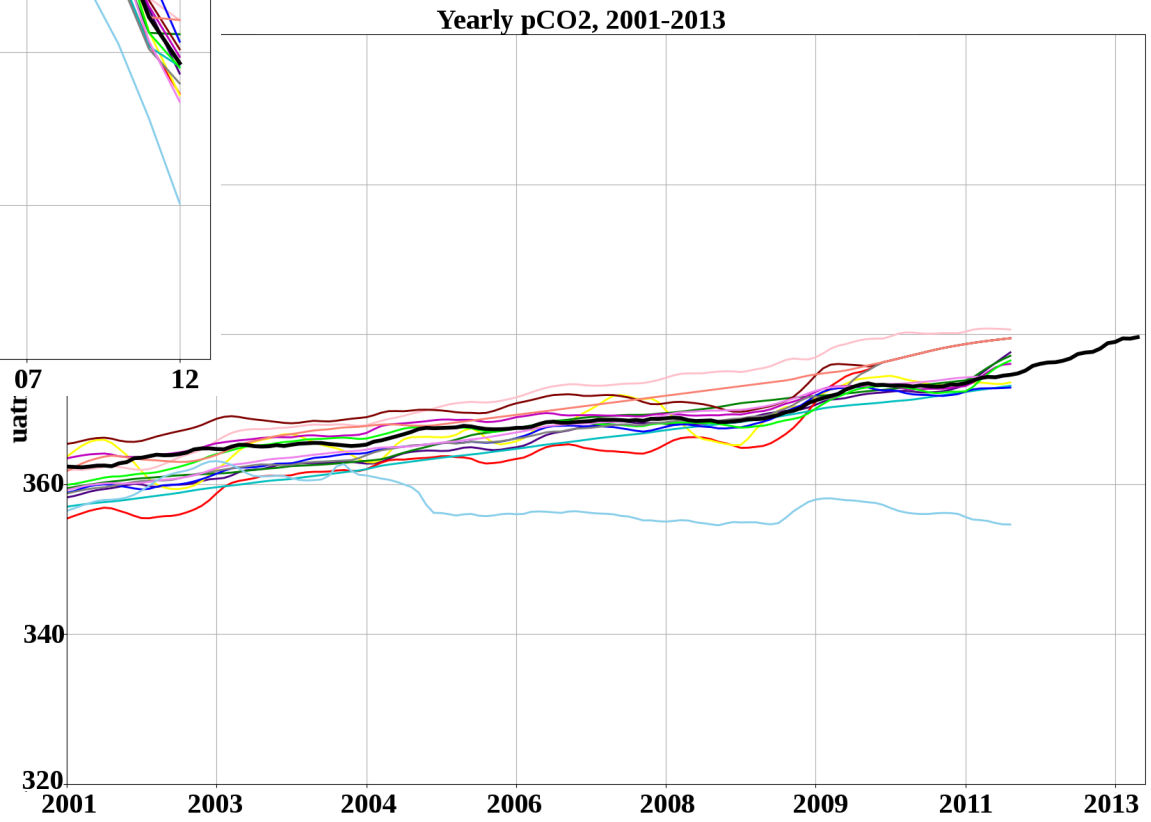


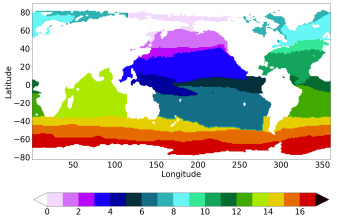


Regional comparison of reconstructed pCO_2 : North Atlantic (green region)



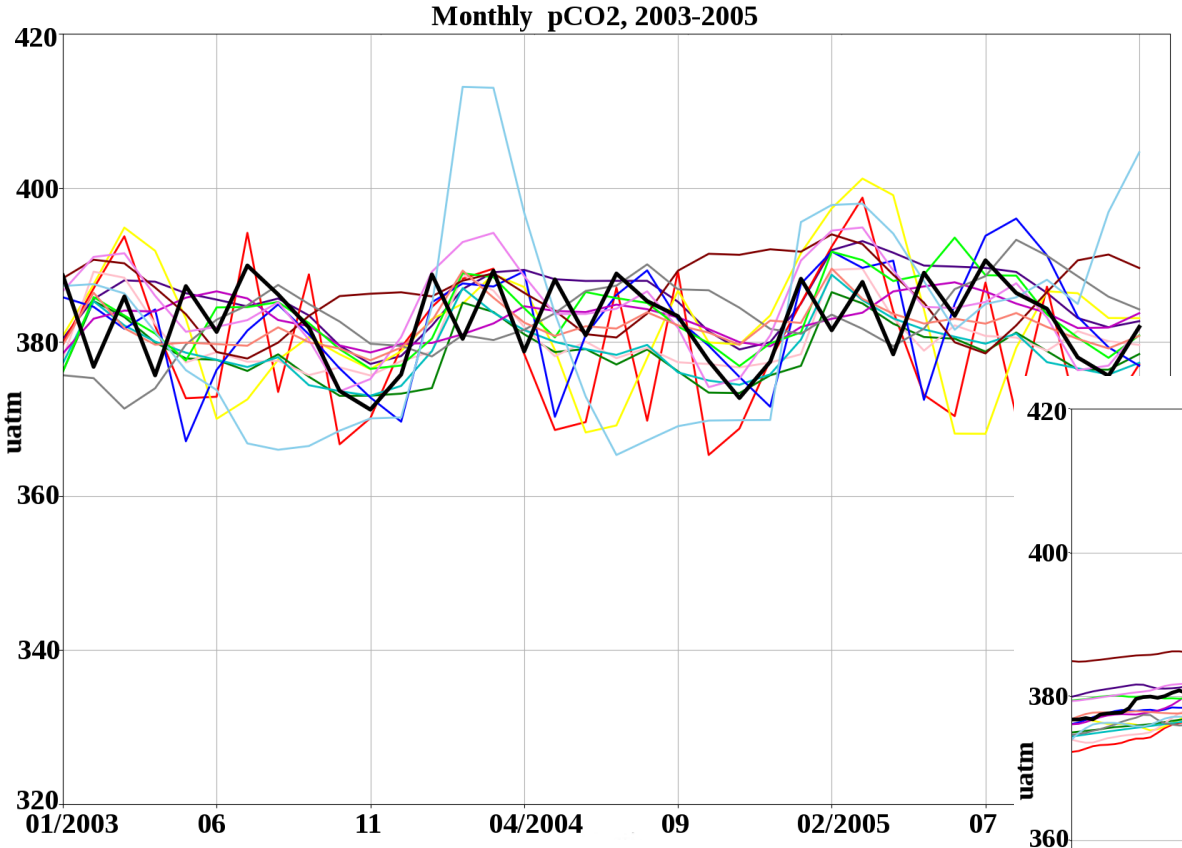
FNN pCO_2 is in good agreement with SOCOM mapping methods in regions with high concentration of observations.

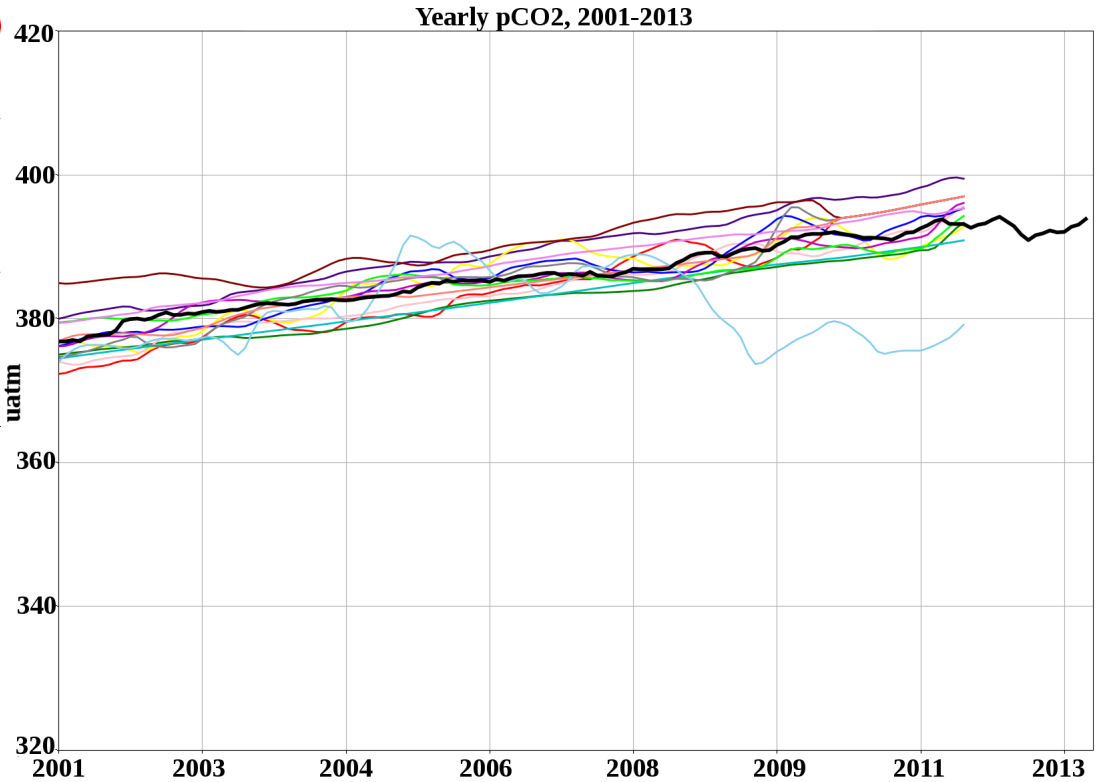




pCO_2 reconstructed. Atlantic Equatorial

In regions with small number of observation data it is hard to interpret the outputs from different mapping methods





Conclusion

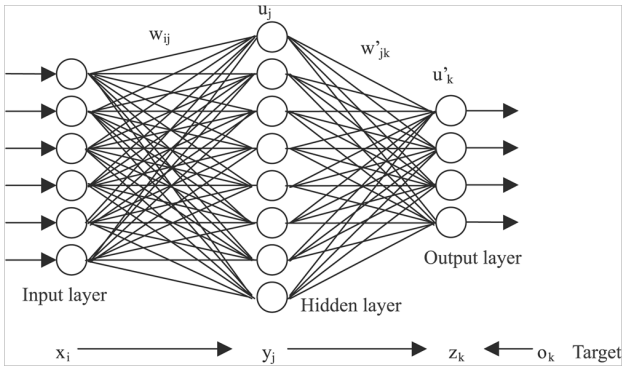
1. We are able to reconstruct pCO_2 over the global ocean with a good accuracy: RMSds are ~ 19 uatm, r2 is about 0.73.
2. We are able to represent interannual variability.
3. Our results are in the agreement with other mapping methods.
4. However, there is room for improvement especially in regions with limited data coverage => we propose to assess the impact of novel data in these regions through a model-based approach.

Perspectives

Use of NEMO PISCES Model:

1. Subsampling of model along ship tracks and application of chosen neural network model => provides best estimate of model performance given available information.
2. Expanding existing network by a series of Network design studies to identify optimal future observing systems.

   => Will be done over the next few months.



Thank for your attention!

for any information contact:

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