Modeling a seasonal variability of biogeochemical components at the sediment-water boundary in Baltic Sea

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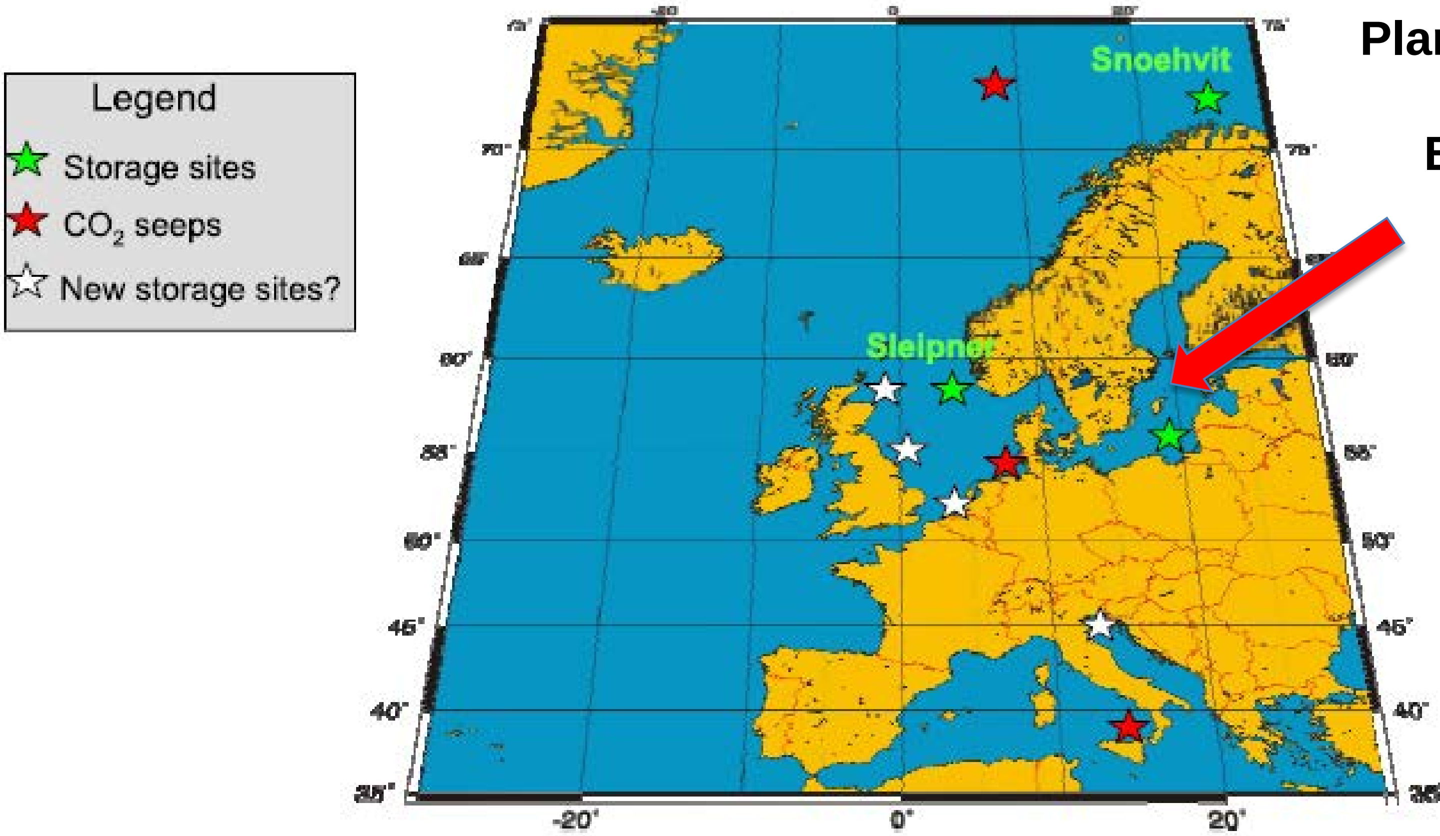
Study site

ECO

ECO_2 Study Sites



Planned CCS site at B3 field

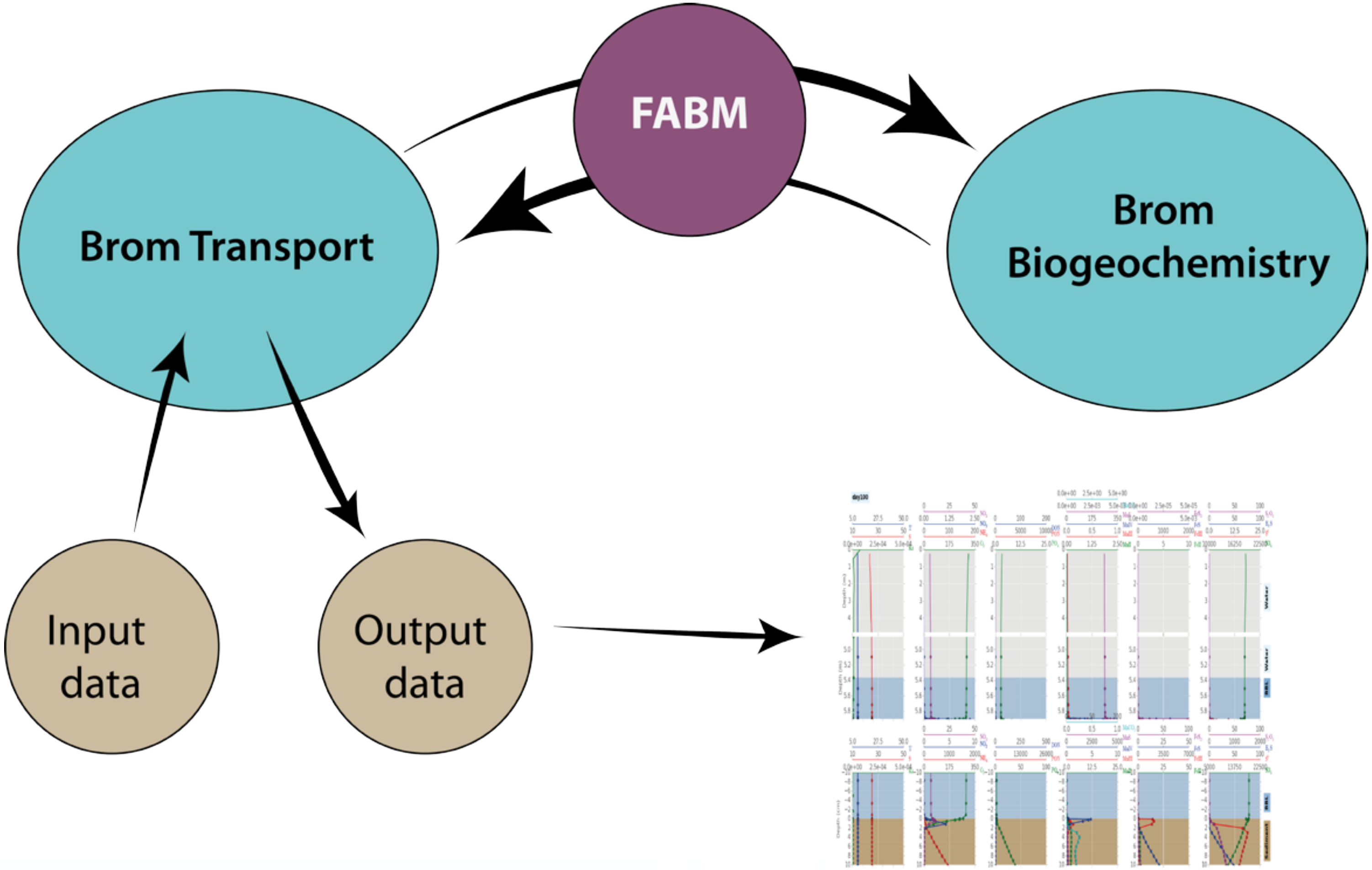
+ potential storage sites off Australia and natural CO_2 seeps off Japan

Goal:

To study the influence of gas leakages from B3 CCS site.

Objectives:

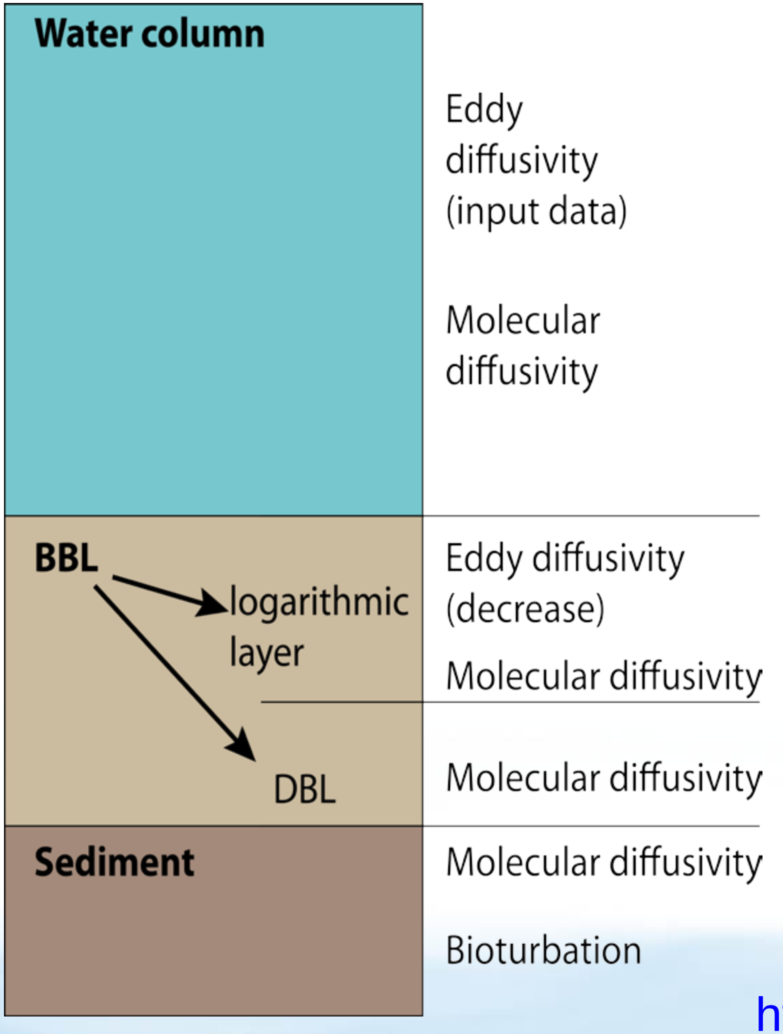
- Apply 1D biogeochemical model BROM to the area close to B3 oil field
- To determine consequences of the different scale leakages in the distributions and fluxes of matter in the BBL on the base of the numerical experiments
- To predict distribution and fluxes of different chemical species across the sediment-seawater interface for different CO_2 levels, using 1-dimensional vertical transport-reaction model



Bruggeman, J. and Bolding, K.: A general framework for aquatic biogeochemical models, Environ. Model. Softw., doi:10.1016/j.envsoft.2014.04.002, 2014.

BROM (Bottom RedOx Model)

1. Transport module

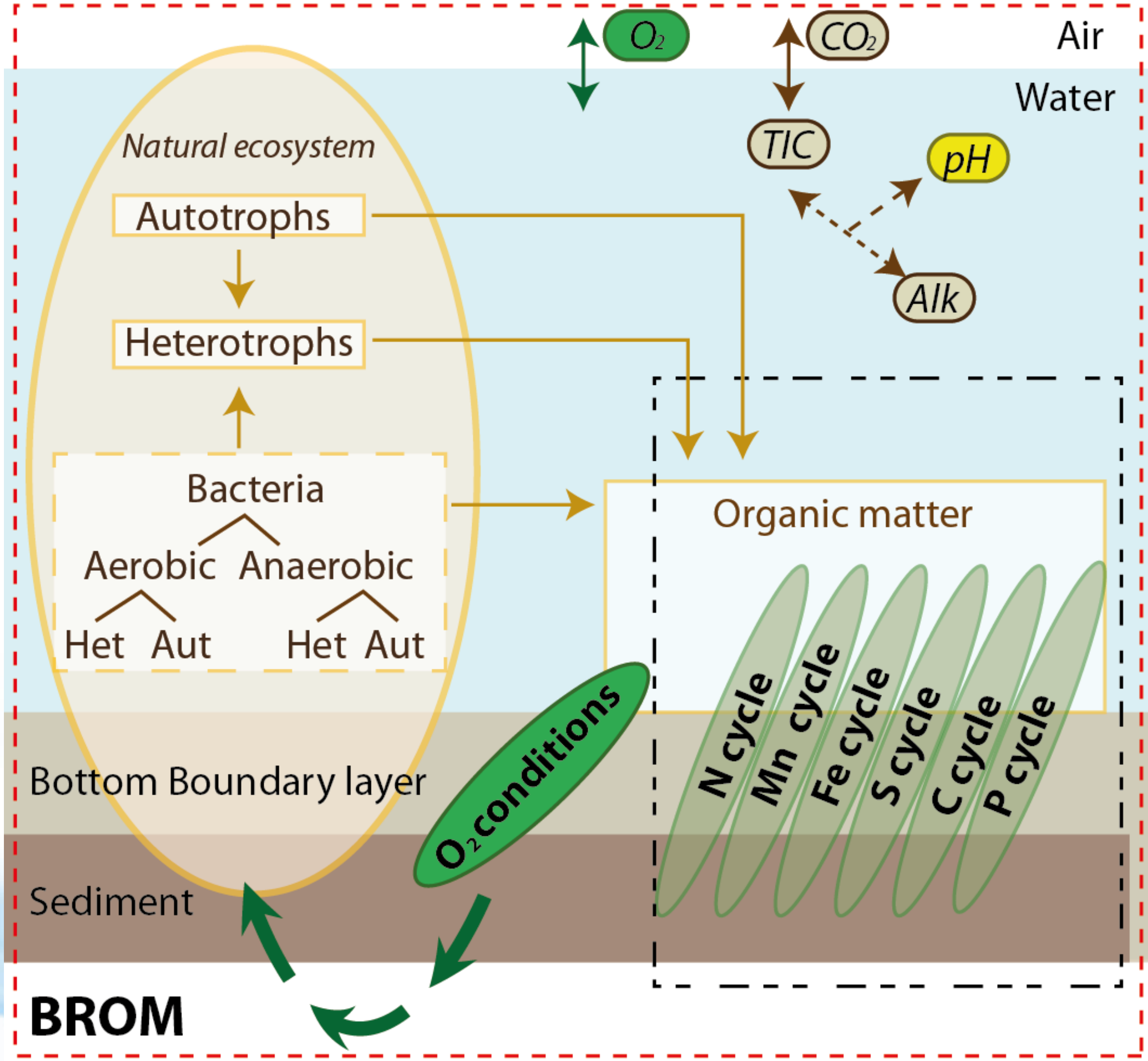


Benthic-Pelagic coupled model Bottom RedOx Model

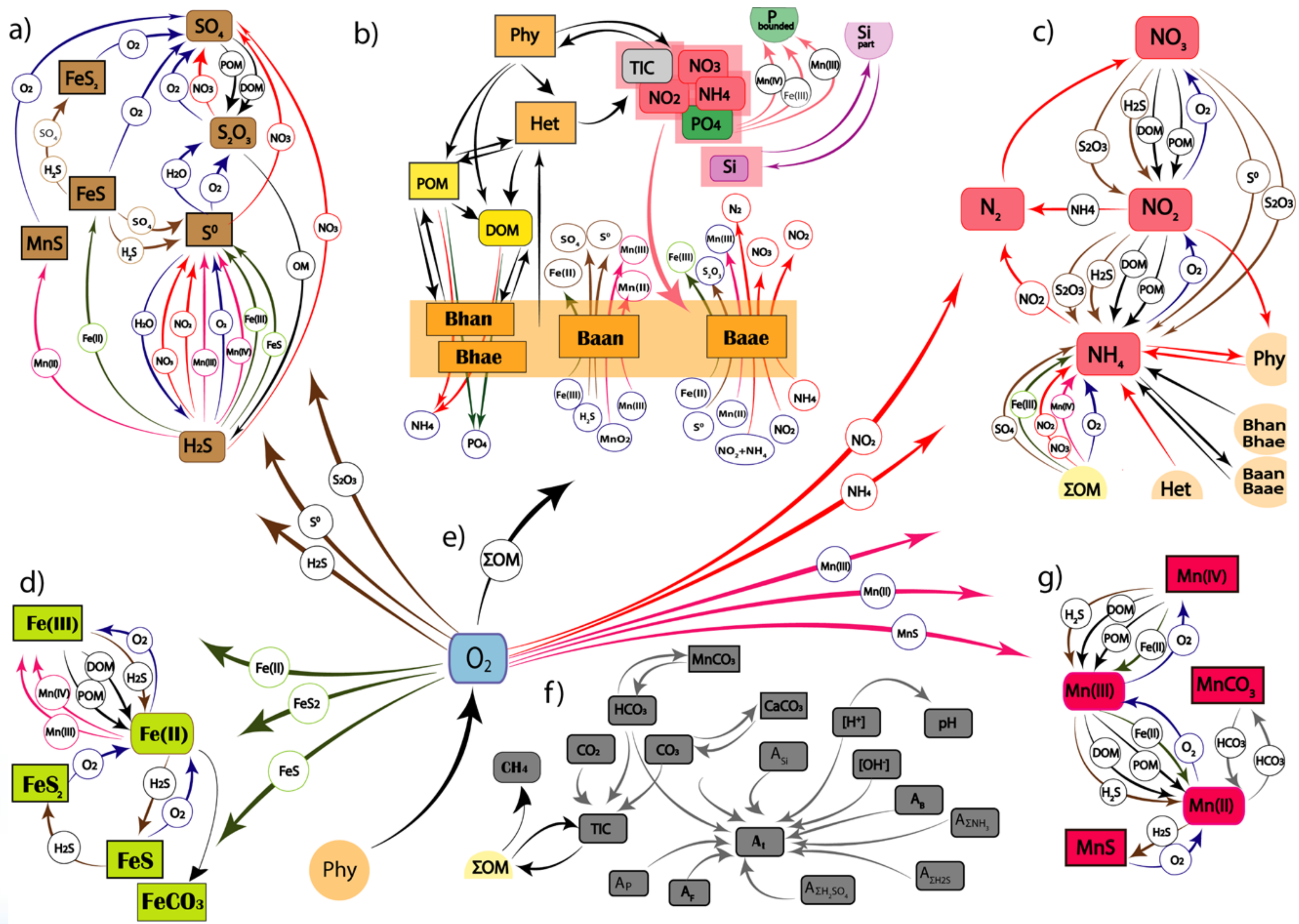
https://github.com/BottomRedoxModel/brom-git

BROM (Bottom RedOx Model)

2. Biogeochemical module



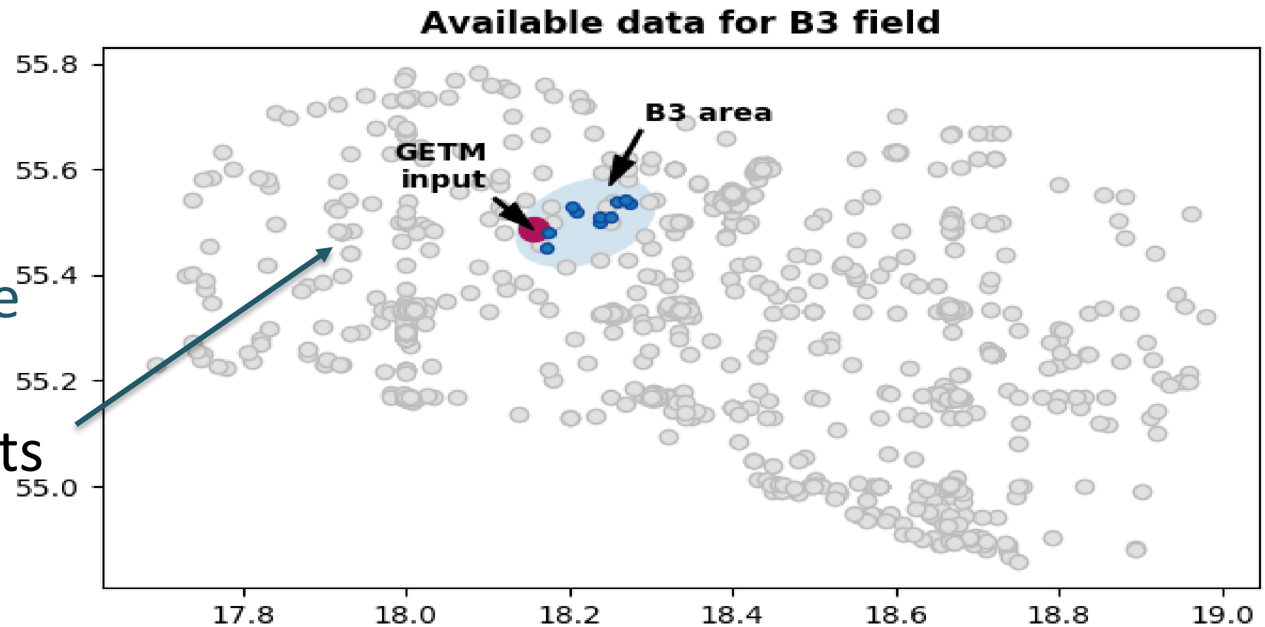
https://github.com/BottomRedoxModel/brom_niva_module.git



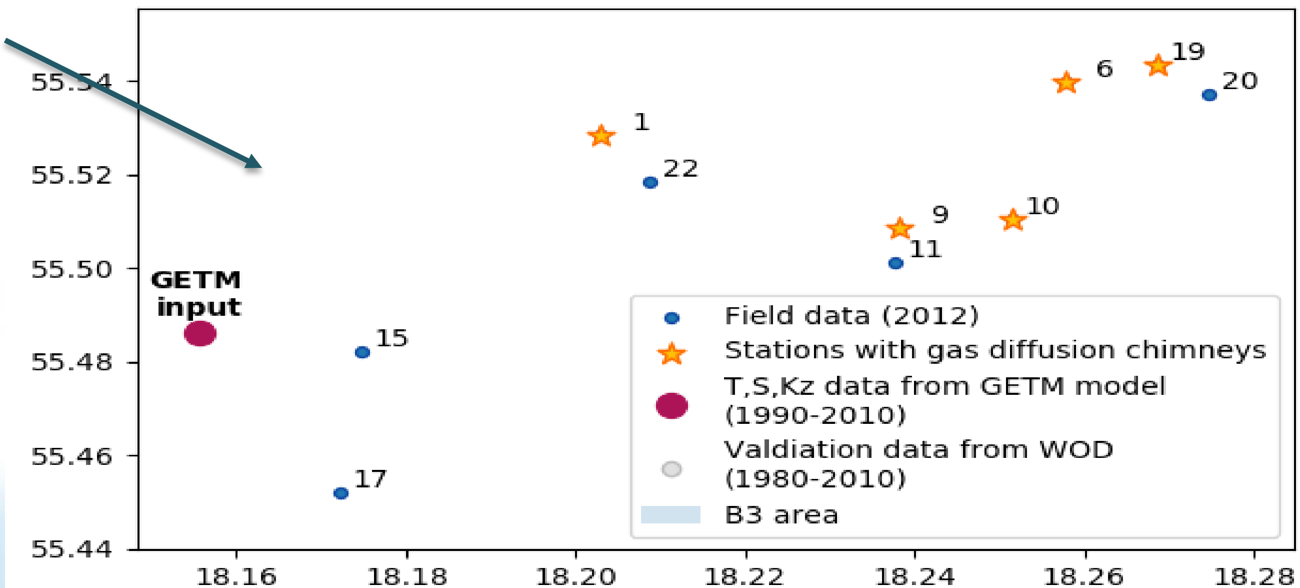
Flow-chat schemes of transfomarion of S (a), P (b), N (C), Fe (d), O (e), C (f), Mn (g) and ecosystem processes (b)

Model calibration

World Ocean Database 1980-2010 boundary Conditions for nutrients in water column



(T,S) – GETM output for 1993 y.



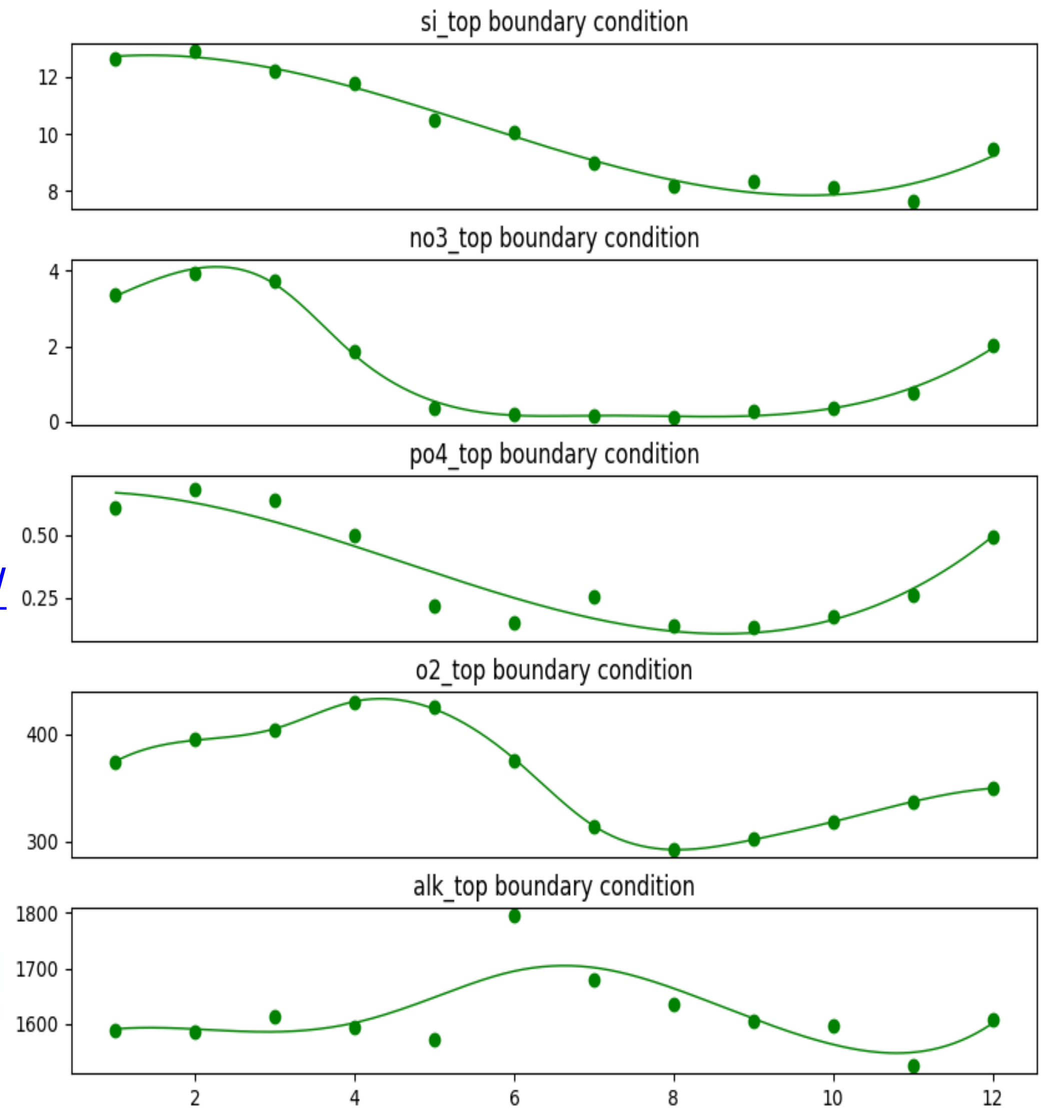
Porewater concentrations – field data

NIVA

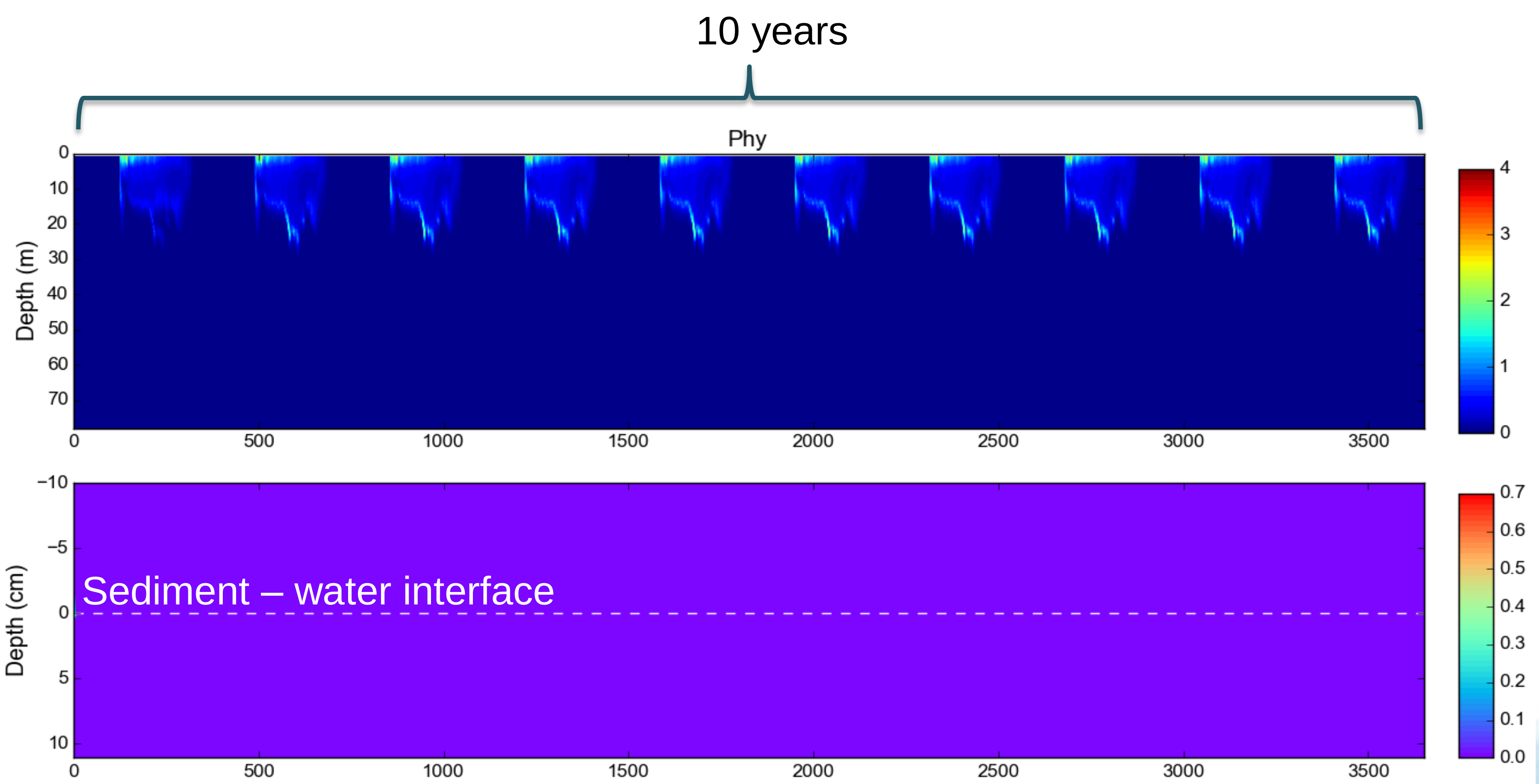
(WOD data 1980-2010) were created the typical seasonal distributions of several parameters. Monthly averages from all available data from this time period, not the same as for TS.

The script used for creating these distributions can be found here https://github.com/lisapro/co2marine/blob/master/create_relax_files.py

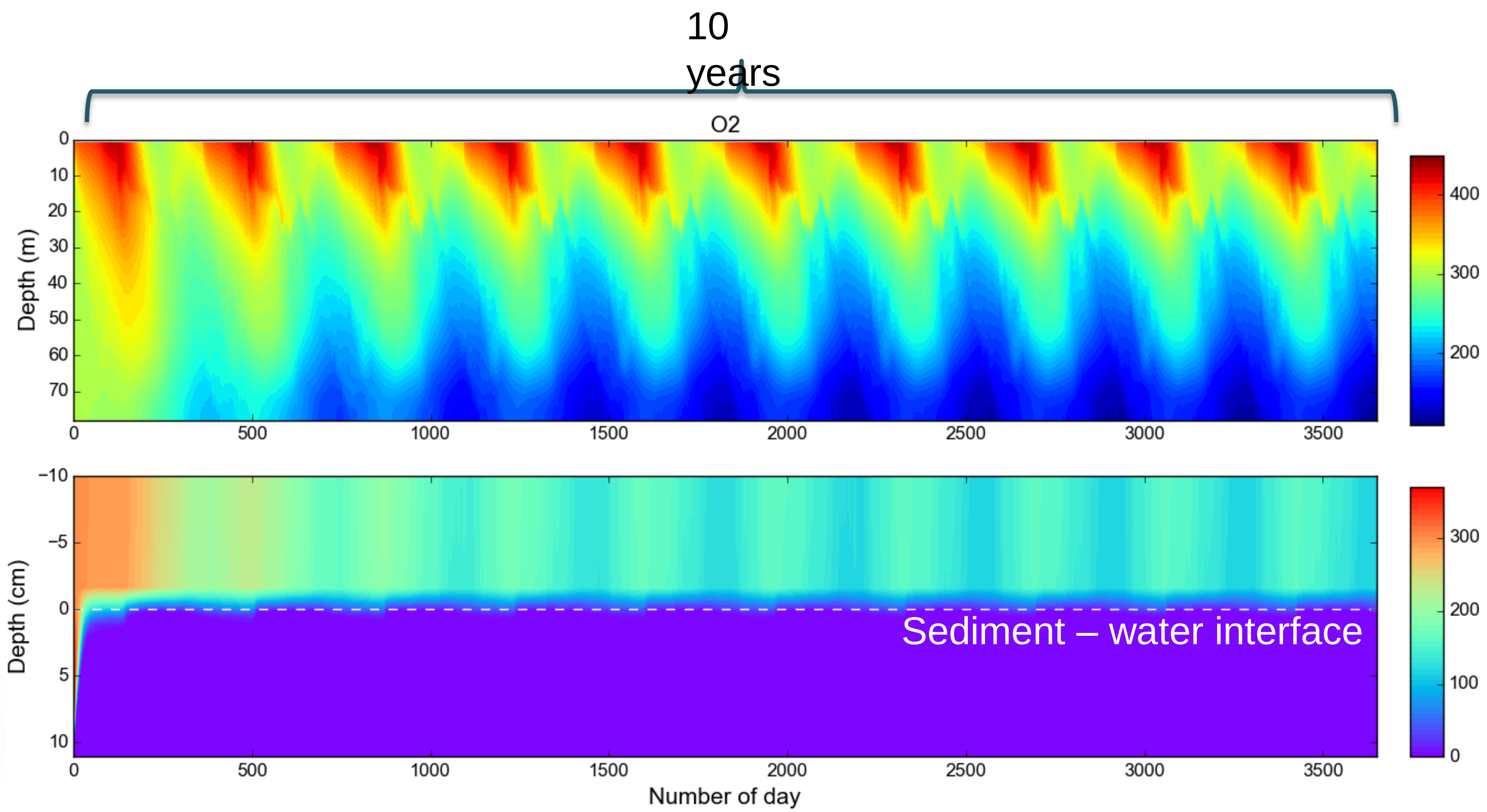
The top layer data of these distributions was interpolated and was used for top boundary condition for Si, NO3, PO4, O2, Alk



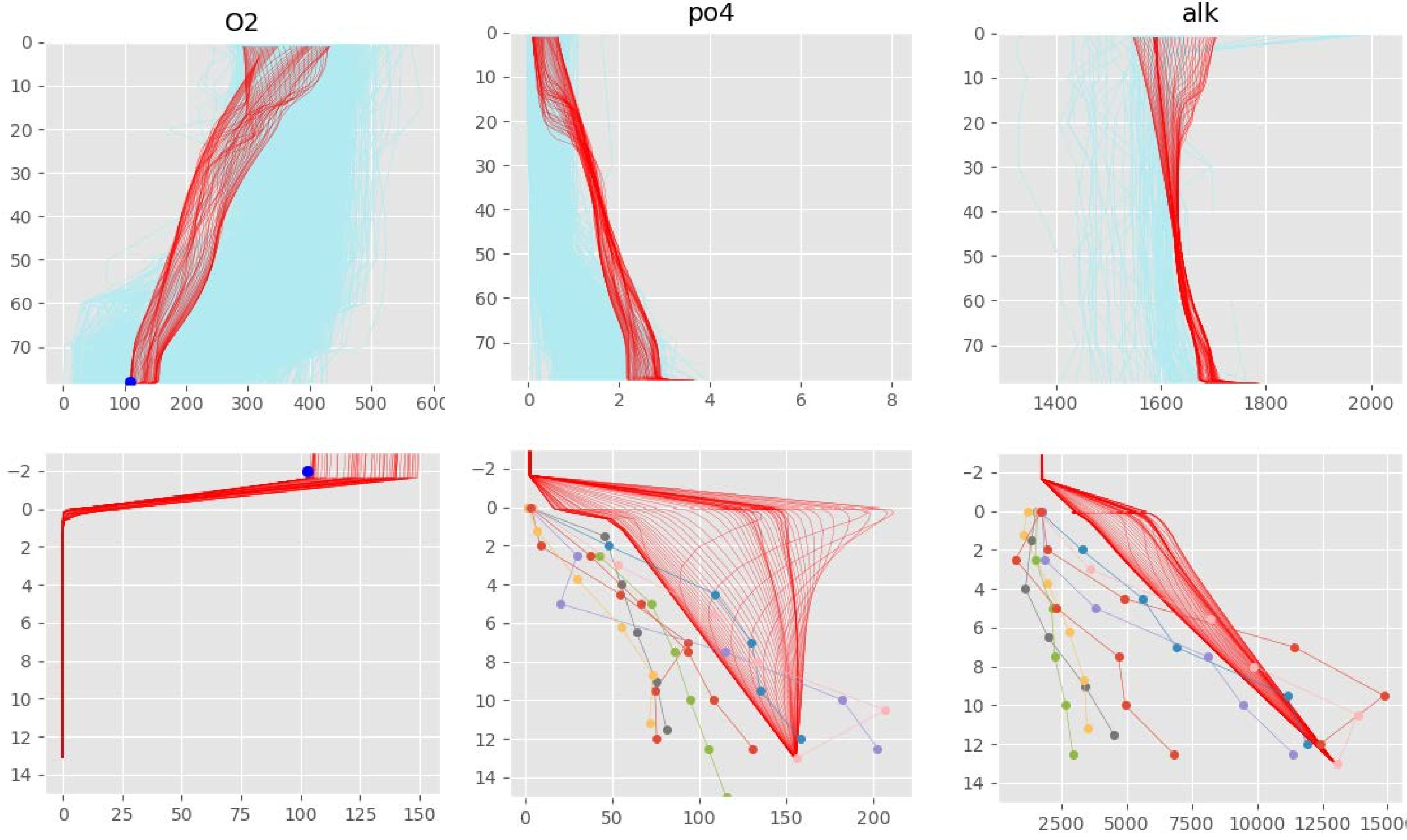
Calculation of baseline state



Calculation of baseline state



Model validation



Experiment

DIC was injected to SWI interface imitating the leakage through a crack or chimney.

Provided numerical experiment of gas leakage for 4 scenarios:

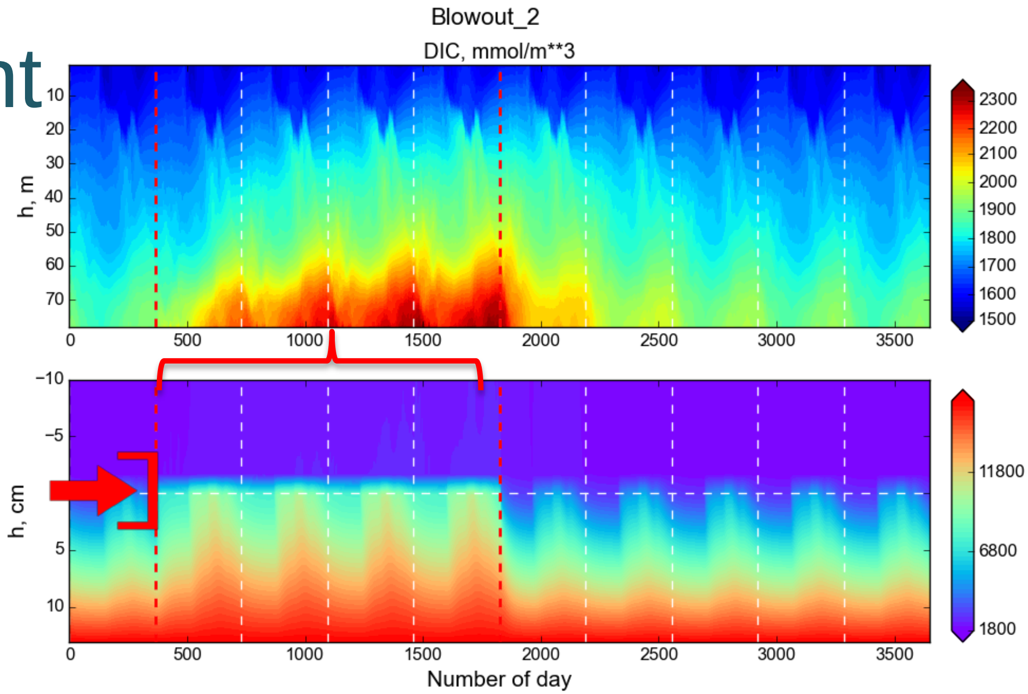
- 1. Blowout 1 : 26.8 mmolC/sec , 1 year
- 2. Blowout 2 26.8 mmolC/sec , 4 years
- 3. Chimney reactivation 0.2 mmolC/sec, 1 year
- 4. Leaky well 0.045 mmolC/sec , 1 year

Scenarios were adopted from ones elaborated within ECO2 project

Experiment

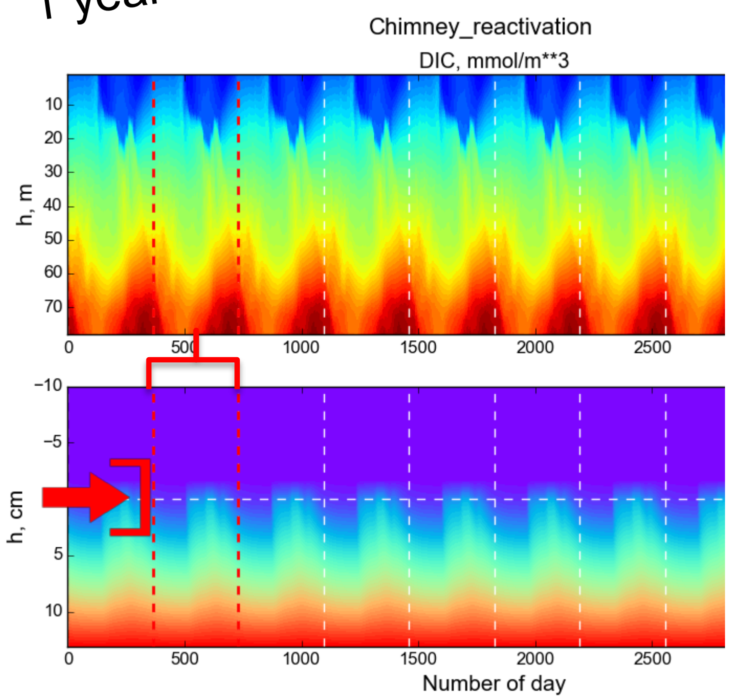
DIC

26.8 mmolC/sec
4 years

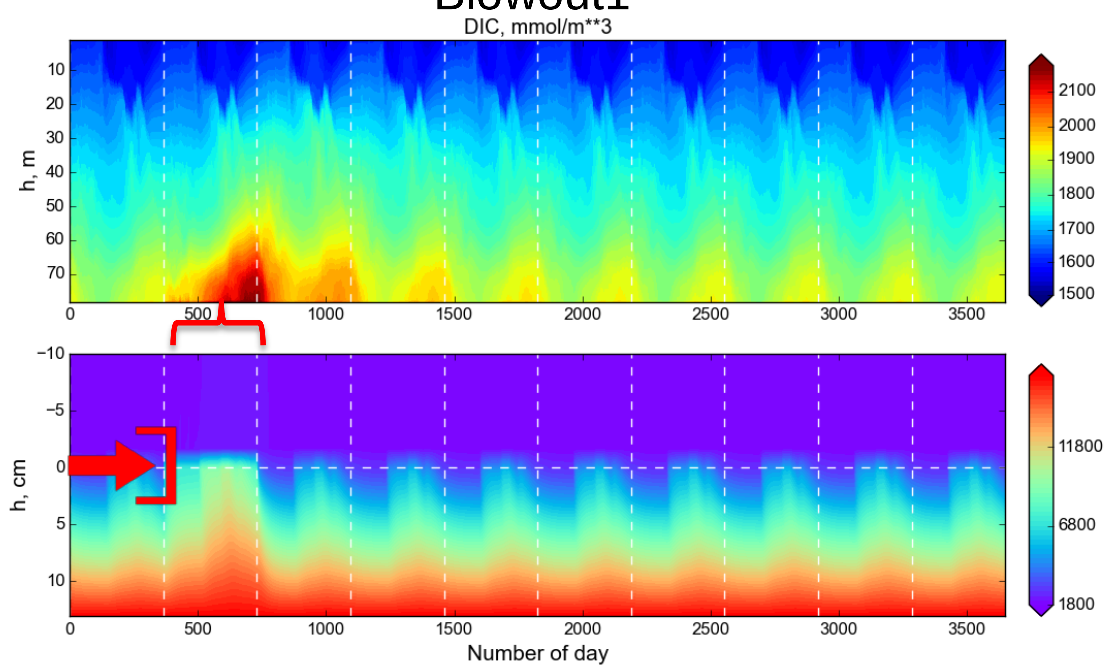


0.2
mmolC/sec
1 year

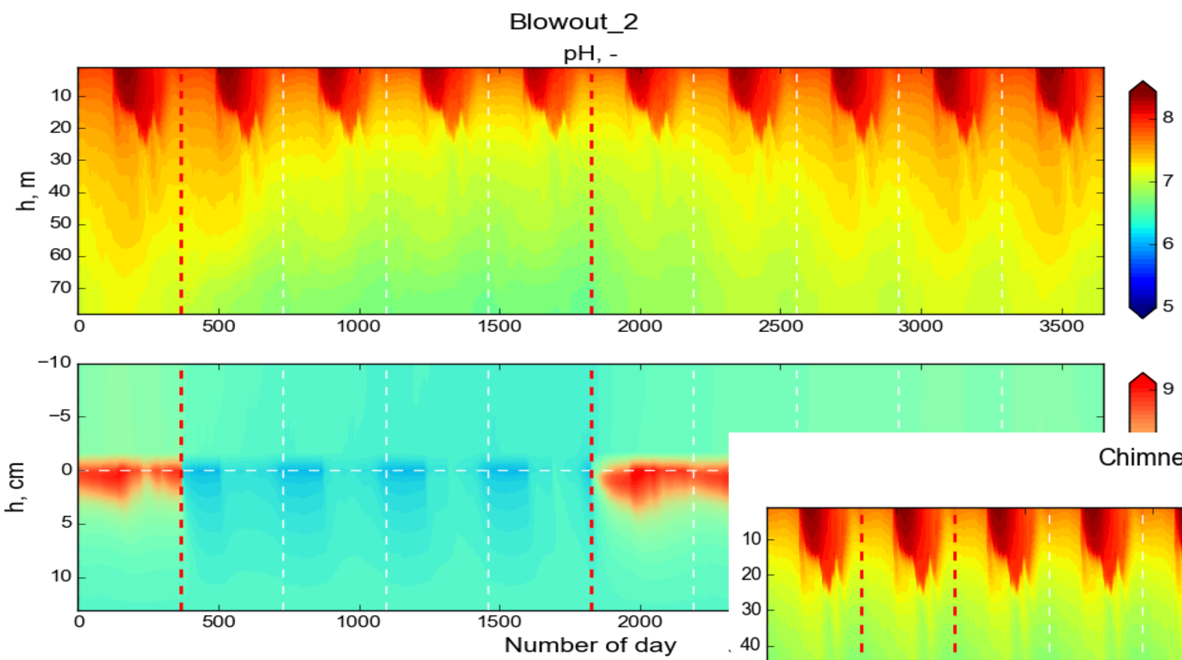
26.8
mmolC/sec
1 year

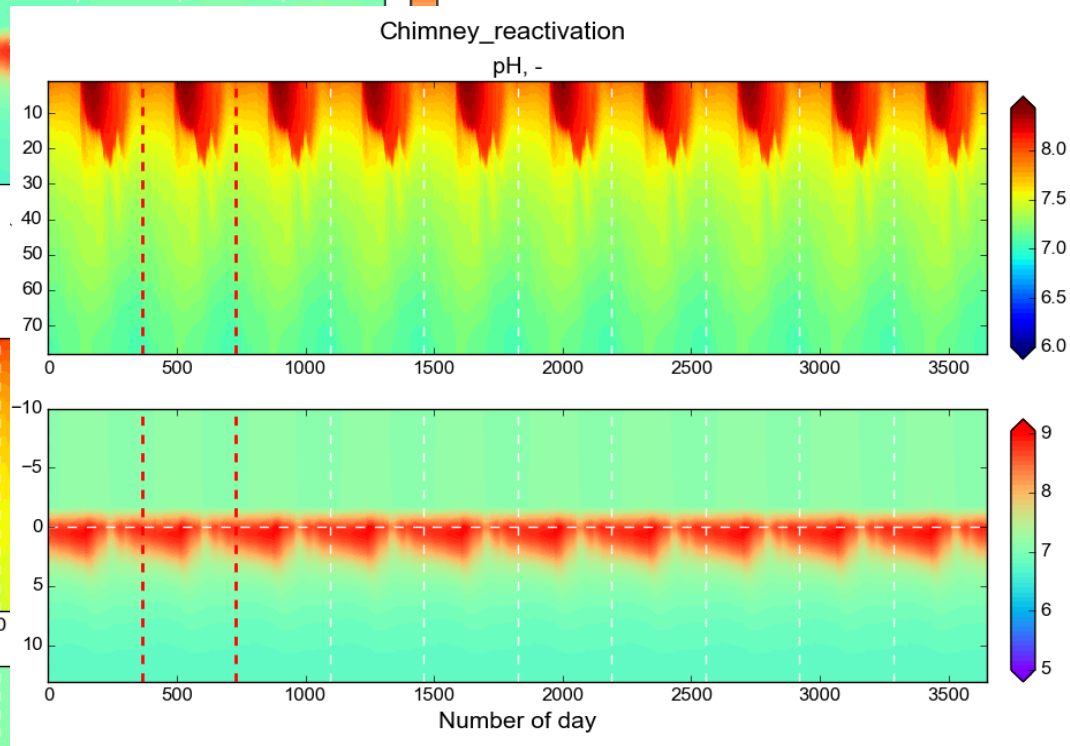


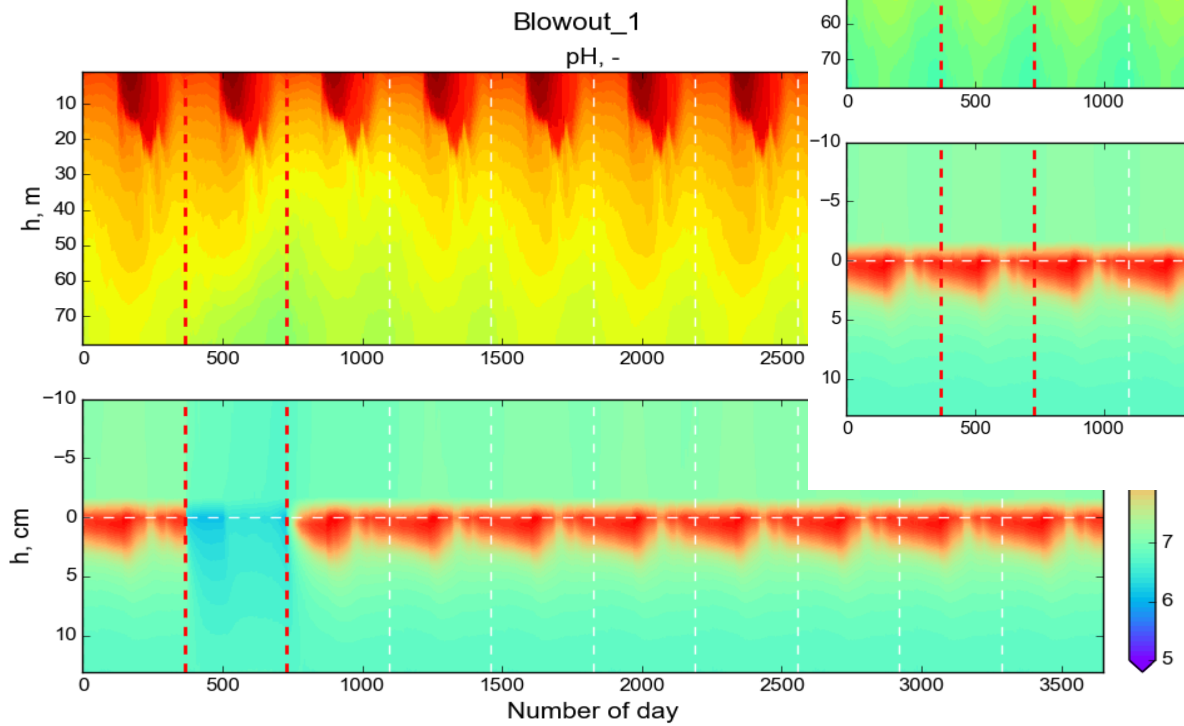
Blowout1



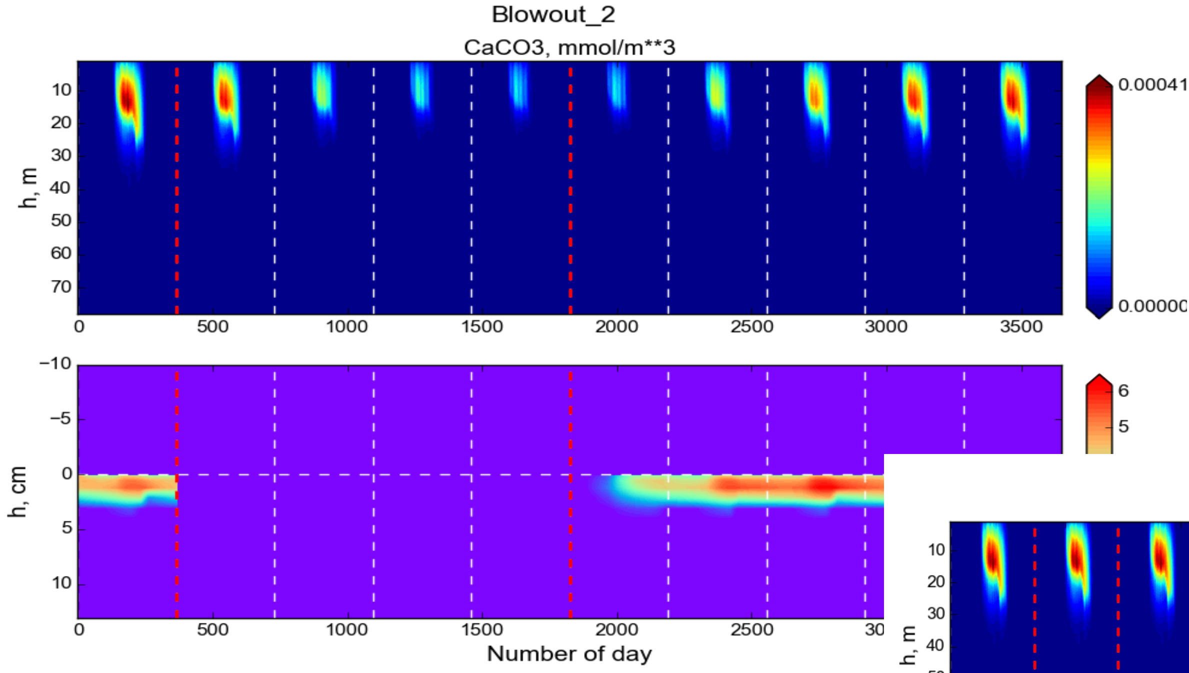
pH

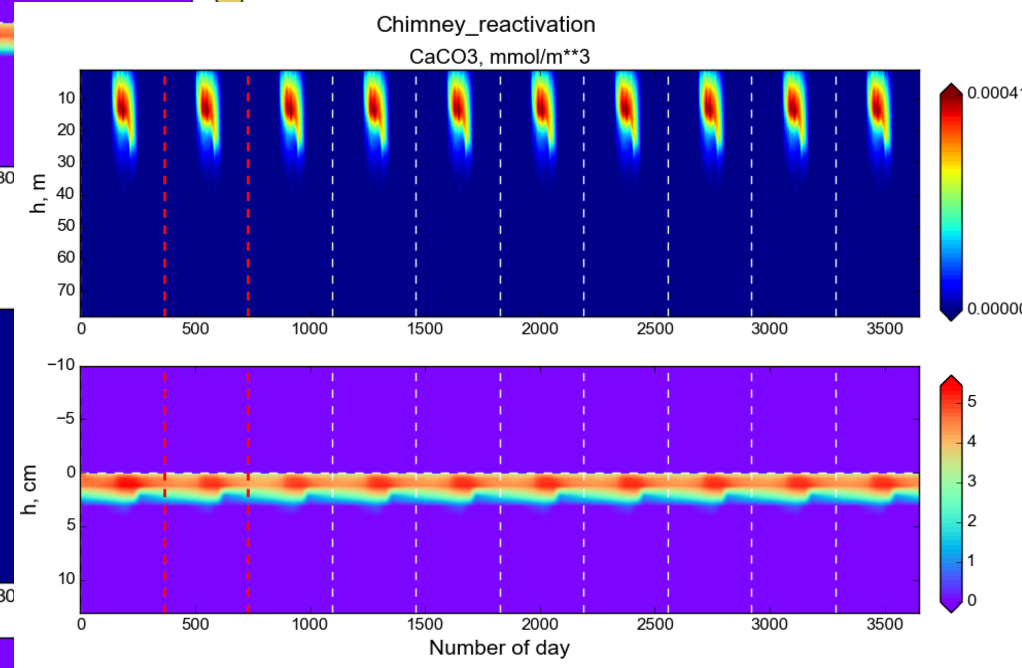

Blowout_2
pH, -
h, m
h, cm
Number of day

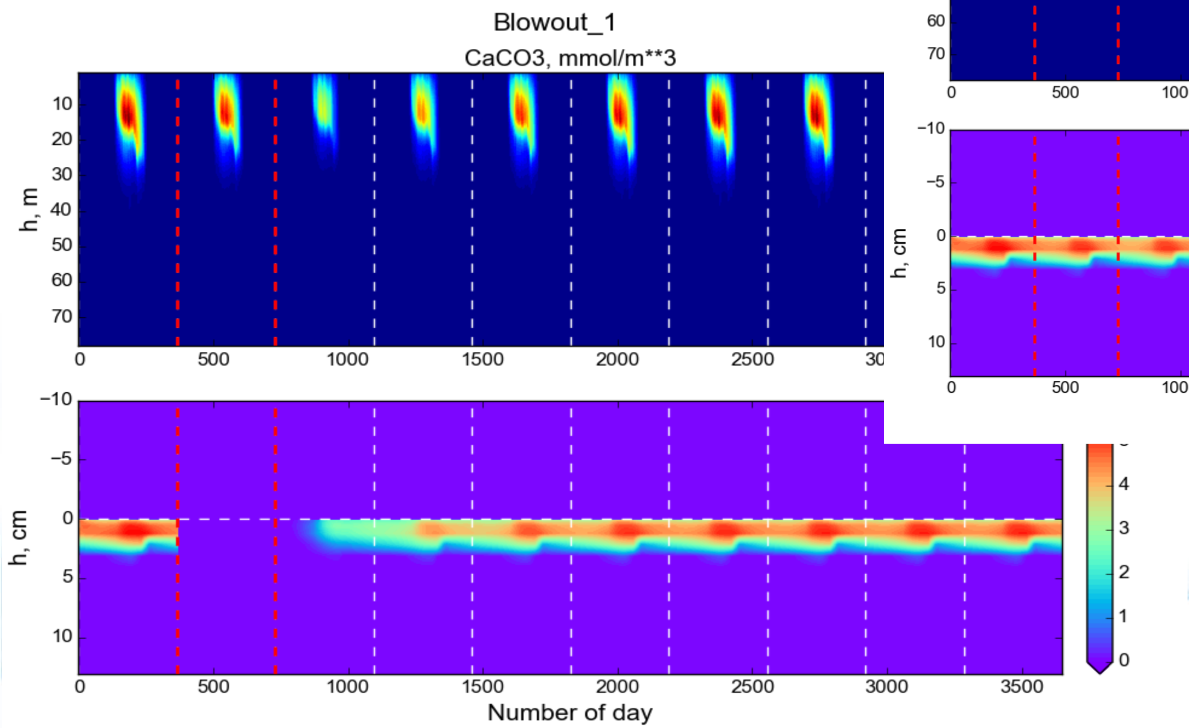

Chimney_reactivation
pH, -
Number of day


Blowout_1
pH, -
h, m
h, cm
Number of day

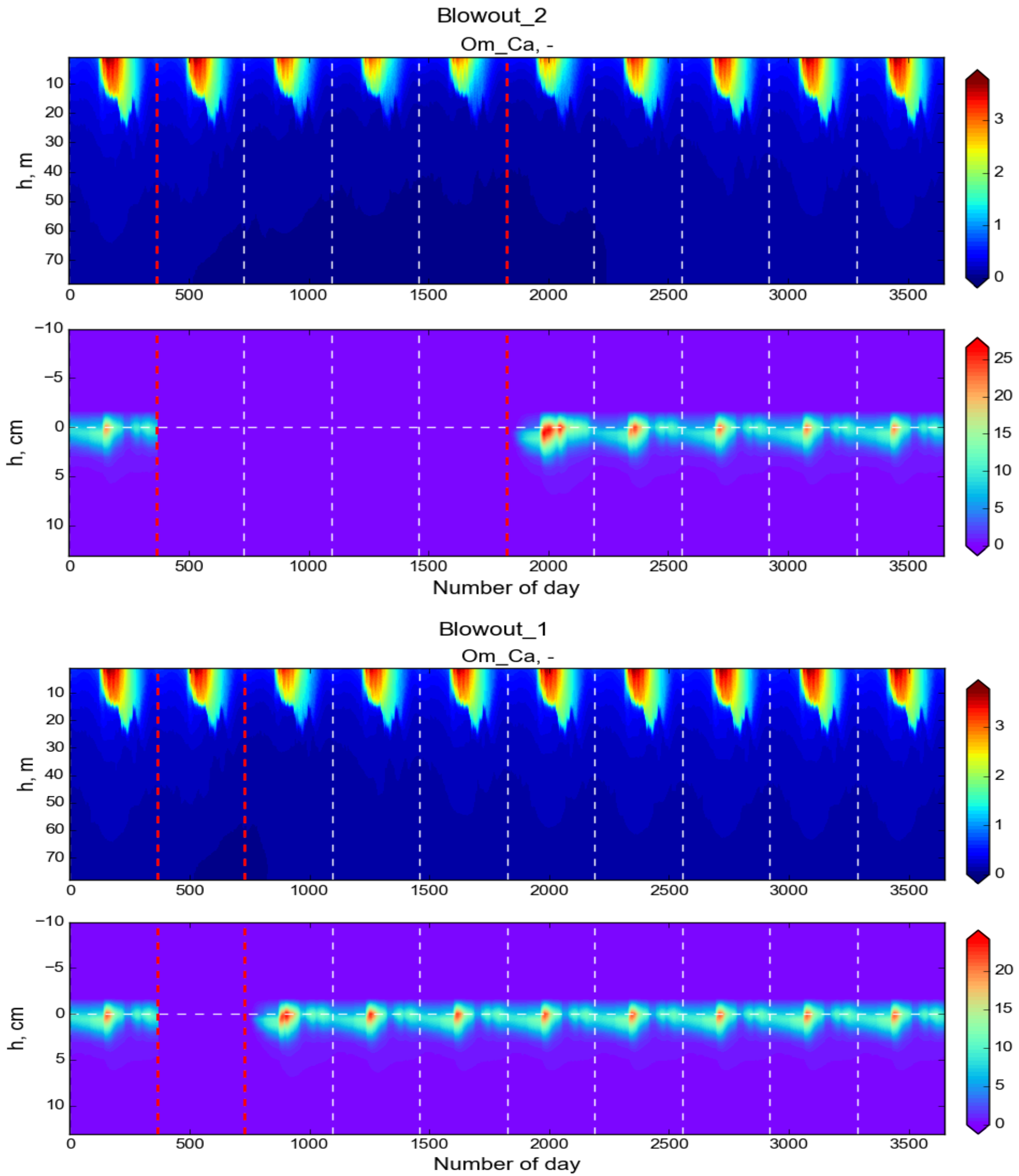
CaCO3


Blowout_2
CaCO3, mmol/m**3
h, m
0.00041
0.00000
h, cm
6
5
Number of day


Chimney_reactivation
CaCO3, mmol/m**3
h, m
0.00041
0.00000
h, cm
Number of day


Blowout_1
CaCO3, mmol/m**3
h, m
h, cm
Number of day

Om_ Ca


Blowout_2
Om_Ca, -
h, m
h, cm
Number of day
Blowout_1
Om_Ca, -
h, m
h, cm
Number of day

Discussion

- Model represents natural seasonal variability at the area close to B3 field in Baltic Sea
- Provided numerical experiment of gas leakage , scenario Chimney reactivation

Results:

- For B3 area such leakages does not have significant influence for scenarios 3 and 4.
- During leakages for scenarios 1 and 2 pH drops to 6, om_Calcite and om_Aragonite may become critical during the leakage and reveal negative effects to ecosystem.
- Calculated scenario could be further analyzed by detailed ecosystem model (for ex. ERSEM, ERGOM)

Thank you for you attention!

Code available at: https://github.com/BottomRedoxModel
scripts used in this work: https://github.com/lisapro/co2marine.git

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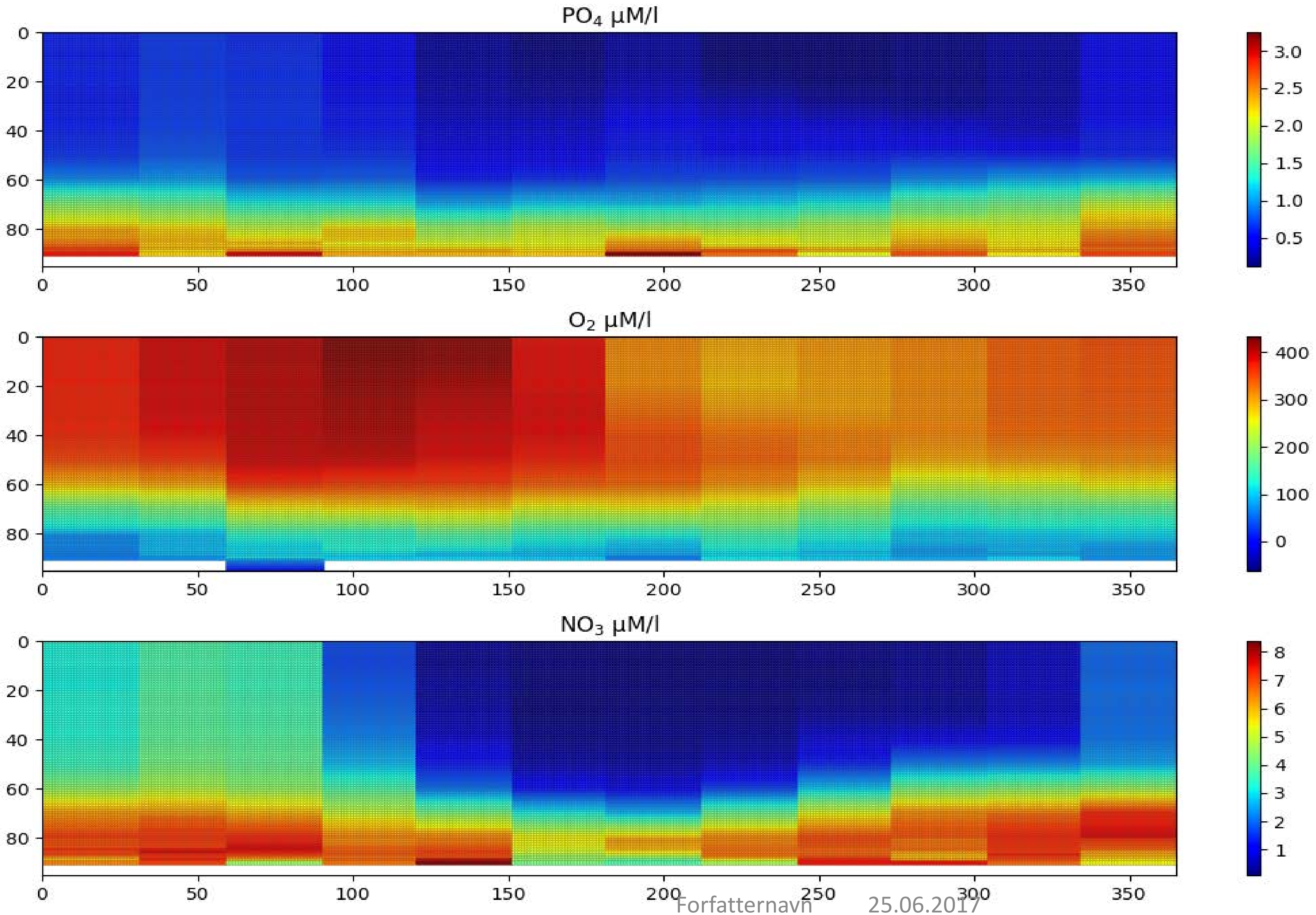
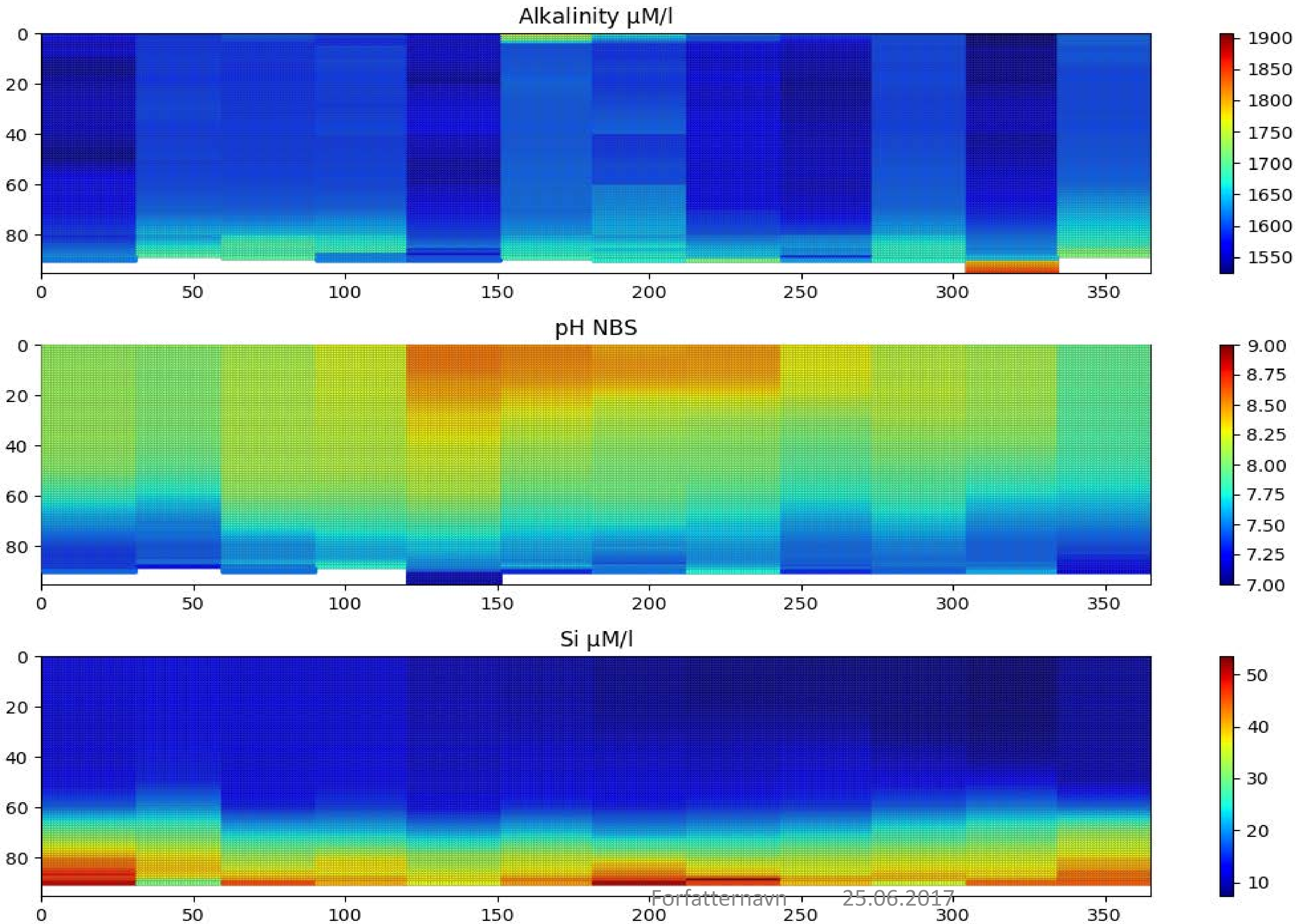
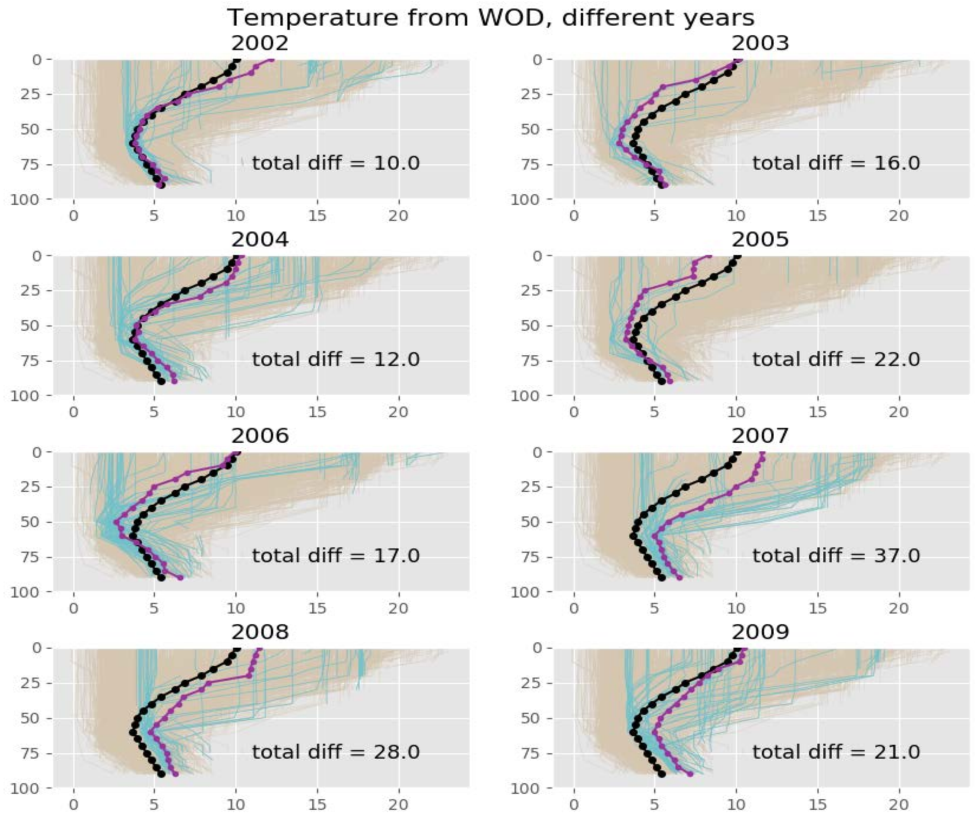
Special thanks to Gennagy Lessin (PML) for GETM data and
colleagues from IO PAS for the observation data

seasonal distributions



seasonal distributions





- To reveal the year with the most “typical” physical forcing, we calculated the mean temperature profile for all chosen period and for each year we calculated the total difference (sum of absolute values of differences for all standard levels). Doing so, we found out that the years 1993 and 1998 fit best to long-term average of temperature distributions. We decided to use input forcing from 1993.