Model parameters adjustment using an EnKF in a 1-D numerical model of the North Sea CS station

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Overview

- Motivation for the study
- Description of the ensemble Kalman filter
- Description of the simulations
- Description of the sources of model error
- Effect of data assimilation on model variables
- Sensitivity of model variables to values of model parameters
- Effect of data assimilation on model parameters
- Simultaneous adjustment of model variables and model parameters
- Conclusions

Motivation

- Sources of model error:
  - initial conditions
  - resolution of physical processes generating T, S fronts
  - parameterization of the air-sea interactions
- Data assimilation: combination of the available observations and the dynamical model to estimate as accurately as possible the state of the ocean
- Approach:
  - model state + parameter estimation
  - state space augmentation

Description of the ensemble Kalman filter

- Developed by G. Evensen, 1994, 2003, 2005
- Sequential data assimilation method:
  - model updated when $t_{mod} = t_{obs}$
  - integration of the model restarted from the updated state (forecast step):

$$\psi^f_{t+1} = M\psi^a_t$$

- Based on the Kalman Filter (analysis step):

$$\psi^a = \psi^f + K(d - H\psi^f),$$

- To compute the Kalman gain: model and observations error covariance matrices must be known

EnKF - Estimation of the model error

- Initial model error statistics: gaussian
- Monte-Carlo method:
  - ensemble of N state vectors of the model:

$$\mathbf{A} = (\psi_1, \psi_2, \ldots, \psi_N),$$

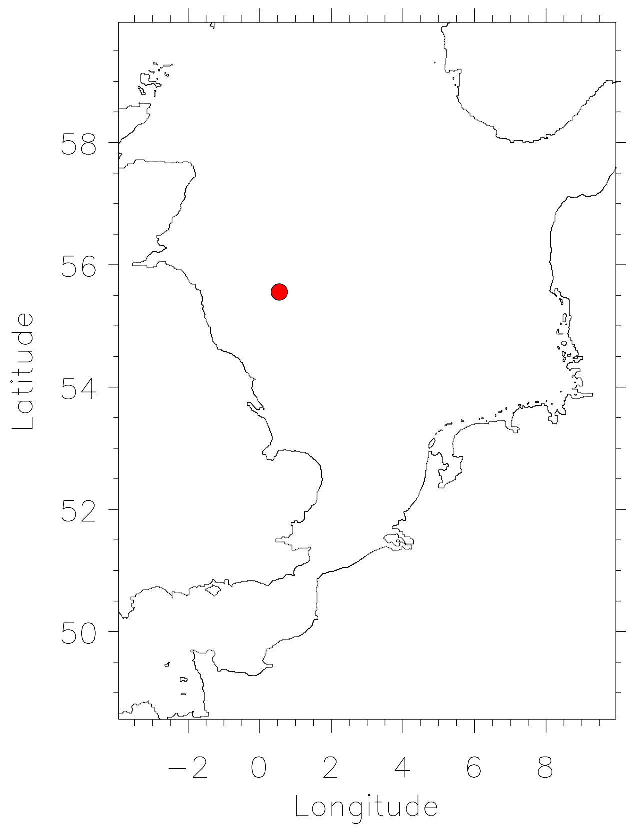
  - ensemble perturbations ÷ ensemble mean:

$$\mathbf{A}' = \mathbf{A} - \bar{\mathbf{A}},$$

- Model error covariance matrix:

$$\mathbf{P} = \frac{\mathbf{A}'(\mathbf{A}')^T}{N-1}.$$

The North Sea CS station



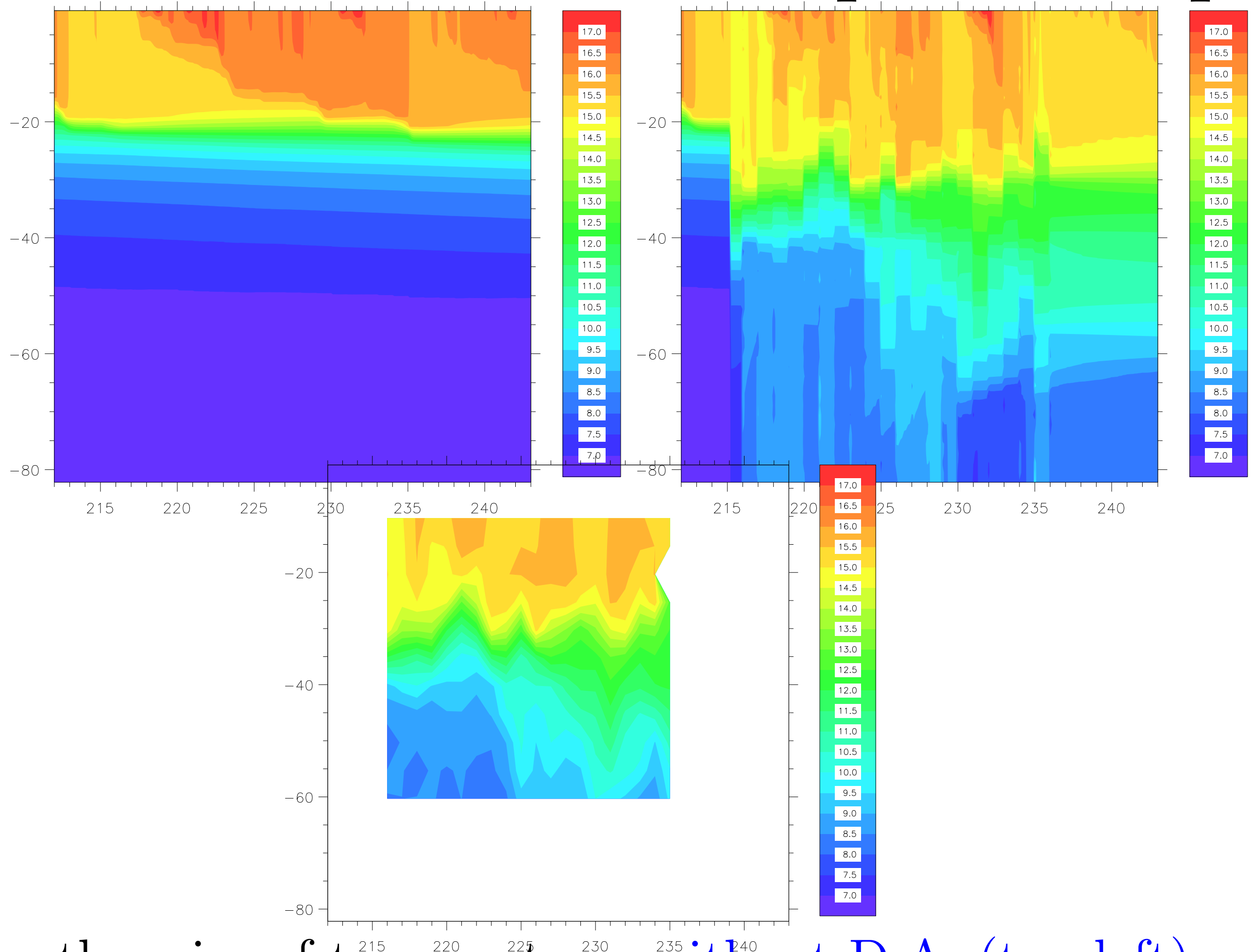
Description of the simulations

- CS station (55° 30' N, 0° 55' E)
- Realistic meteo data
- Physical model based on COHERENS 1-D implementation
- Assimilation of temperature profiles from the 'North Sea Project', 1989 (thermistor chain data)
- 3 months ensemble generation, assimilation in August 1989
- 50 ensemble members

Description of the sources of model error

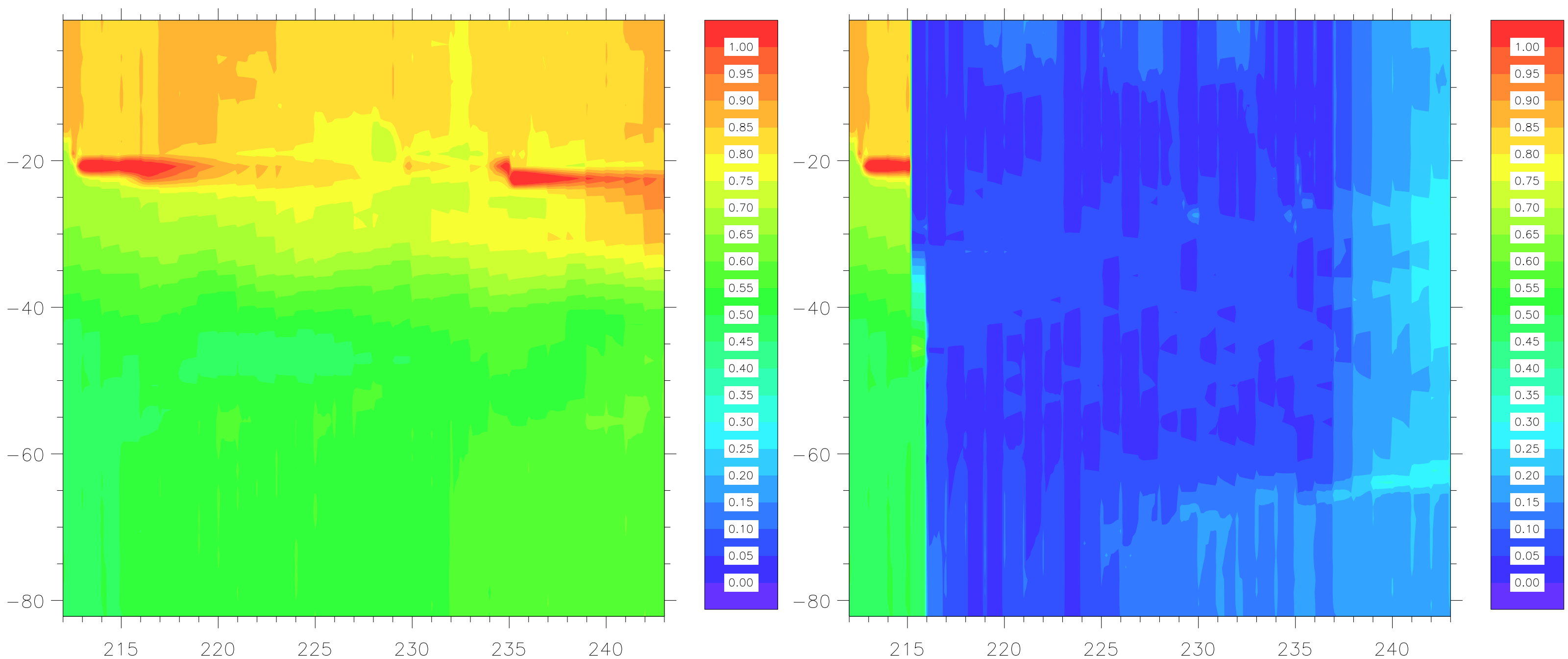
- Most important forcing mechanisms in the North Sea:
  - tides, wind
  - time scales: 1 hour to 1 day
- Dominant forcing on the temperature field in the central North Sea: surface seasonal cooling and heating
- Model error sampling:
  - reference simulation: (T)
  - augmented state vector: (T, K_{opt}), (T, C_{ds}), (T, K_{opt}, C_{ds})

Effect of D.A. on the temperature profile



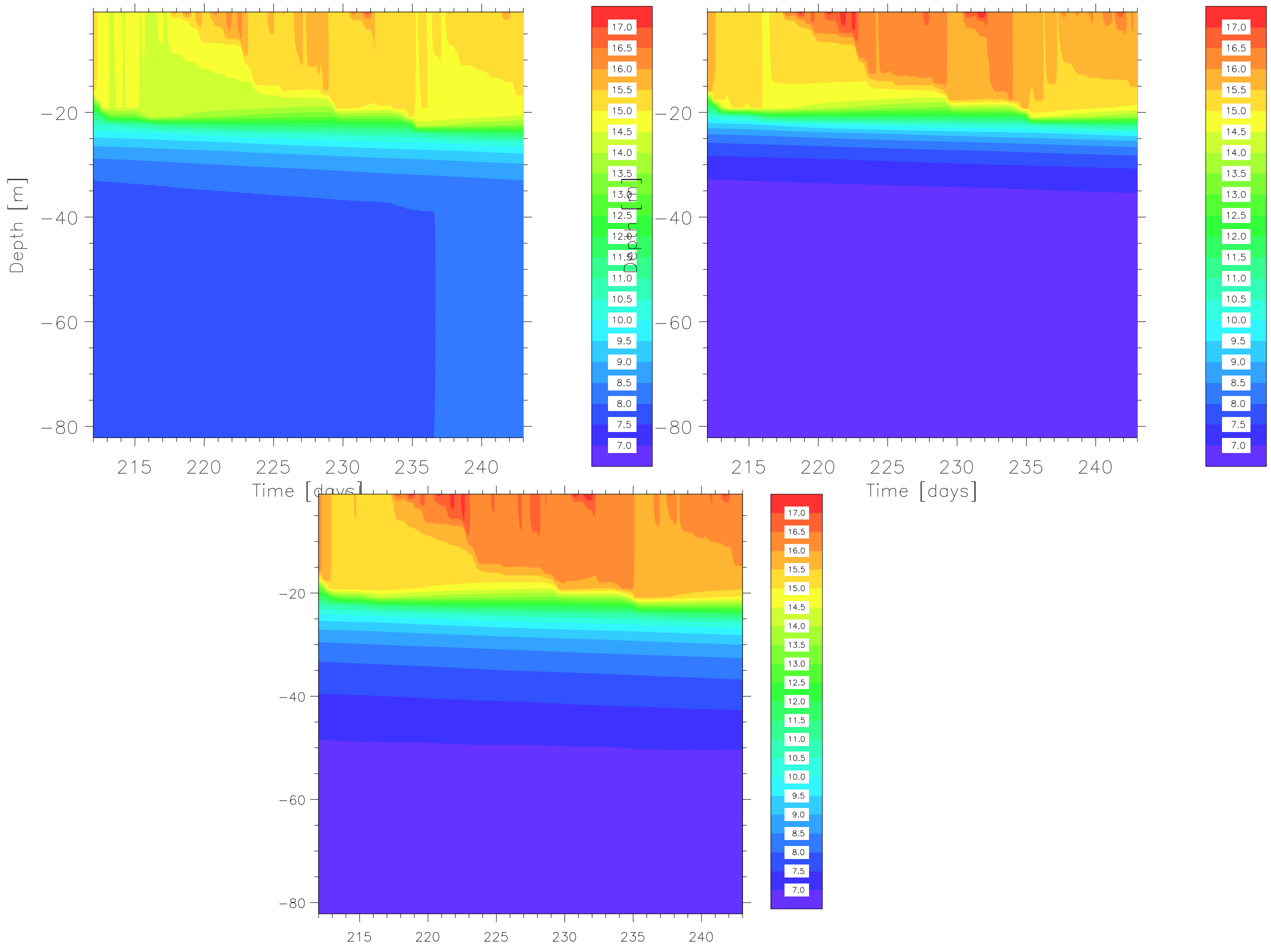
Time-depth series of temperature, without D.A. (top left), with D.A. (top right), observations (bottom)

Effect of D.A. on the mod. standard error



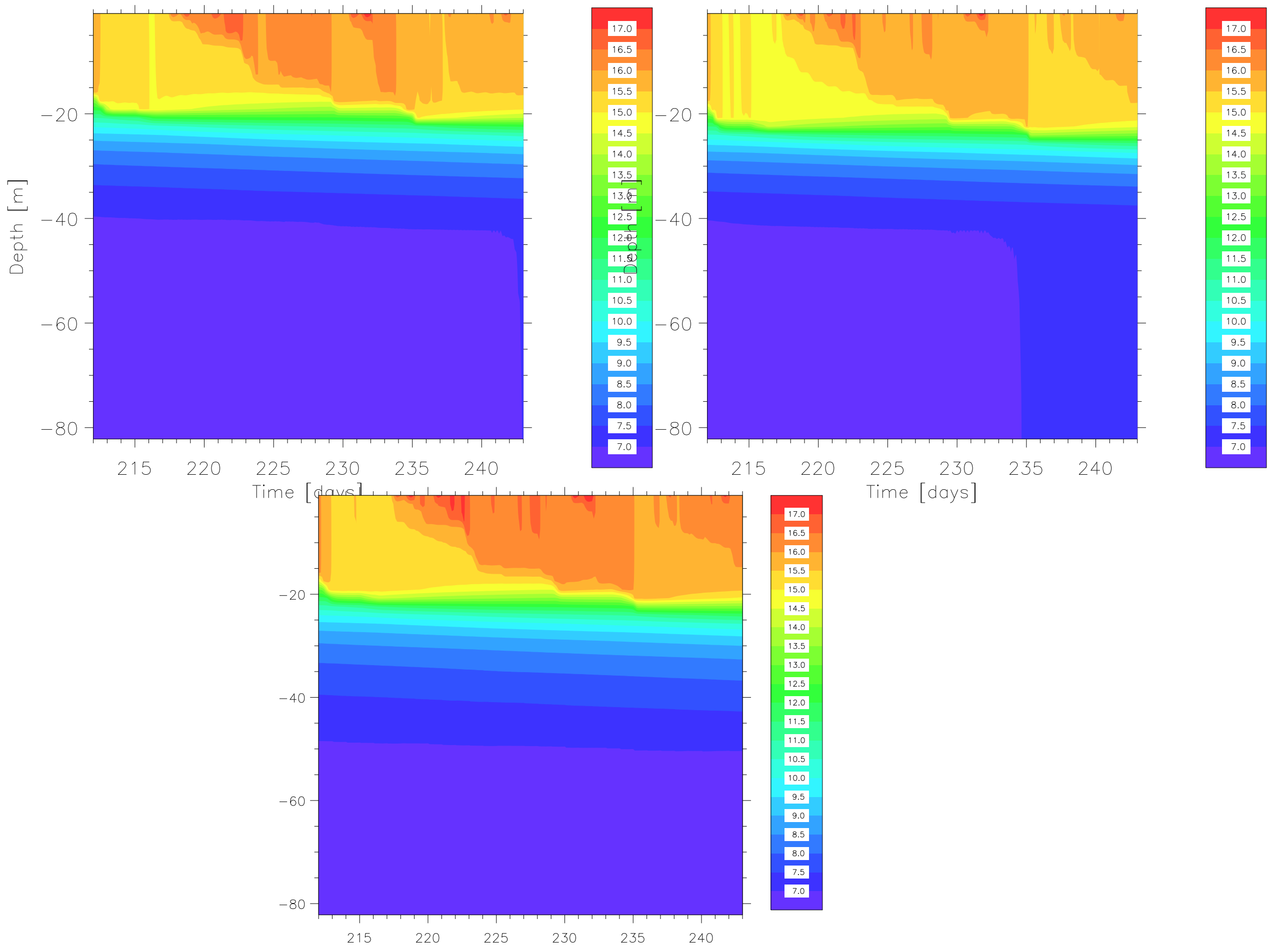
Time-depth series of temperature standard error, without (left) D.A., with (right) D.A.

Mod. temperature vs opt. att. coefficient



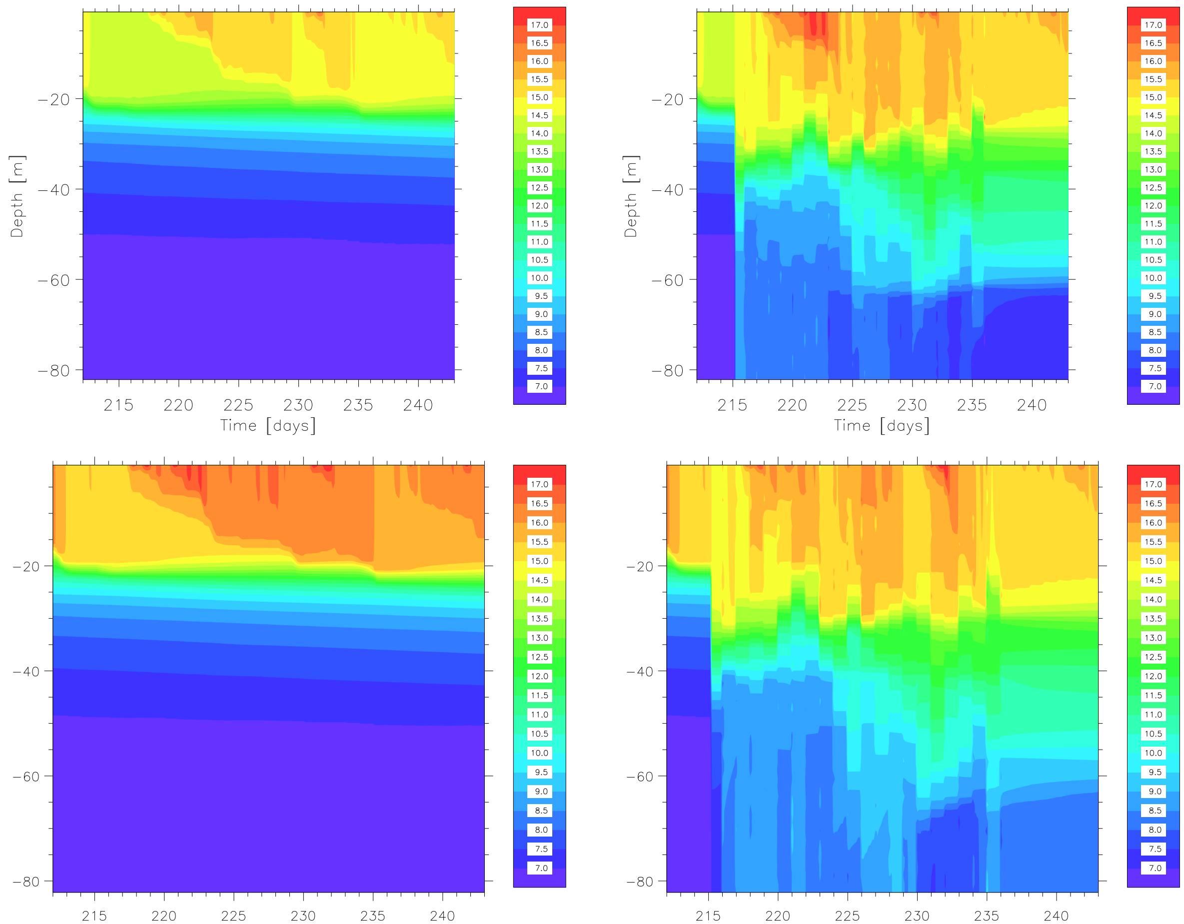
Time-depth series of temperature, with an optical attenuation coefficient of $1.99m^{-1}$ (top left), $2.26m^{-1}$ (top right), $2.06m^{-1}$ (bottom)

Mod. temperature vs sea sfce drag coef.



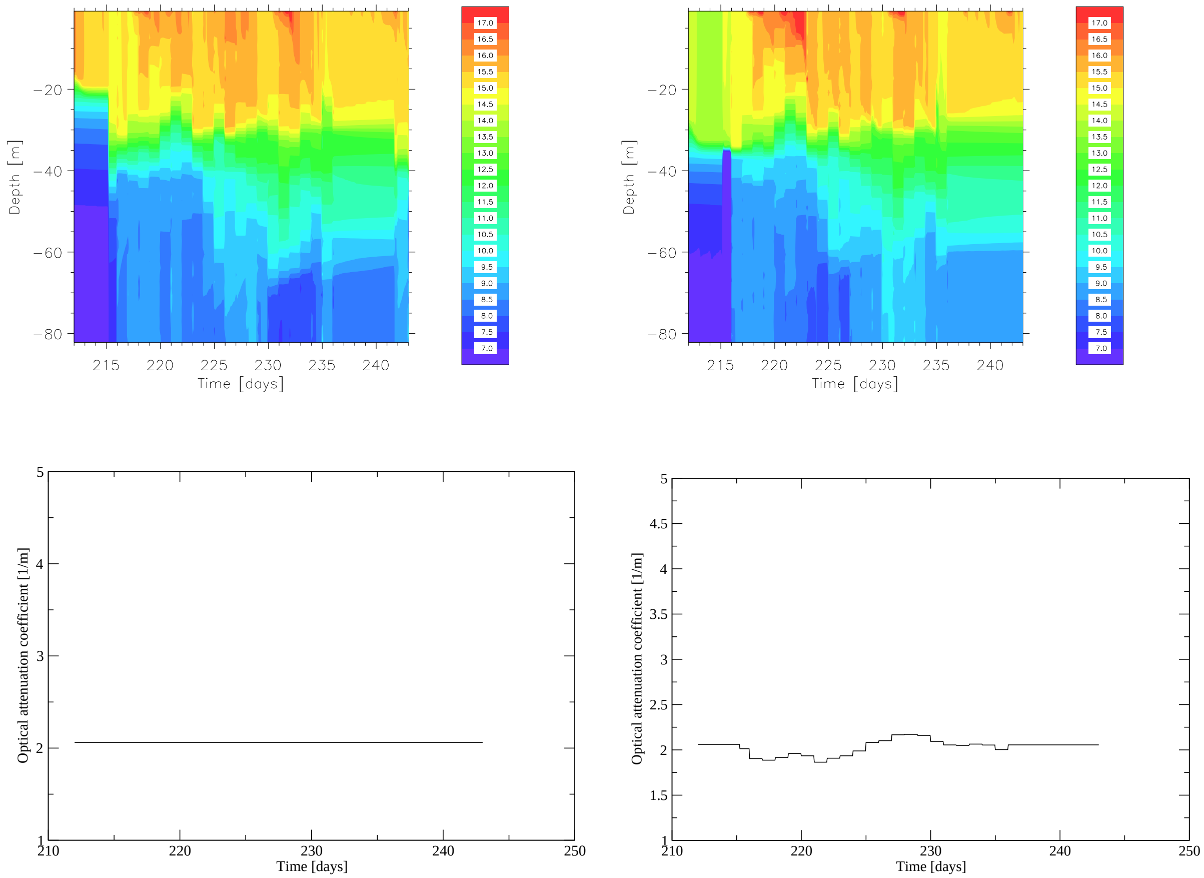
Time-depth series of temperature, with a sea surface drag coefficient of 90% (top left), 110 % (top right), reference value (bottom)

Working with an augmented state vector



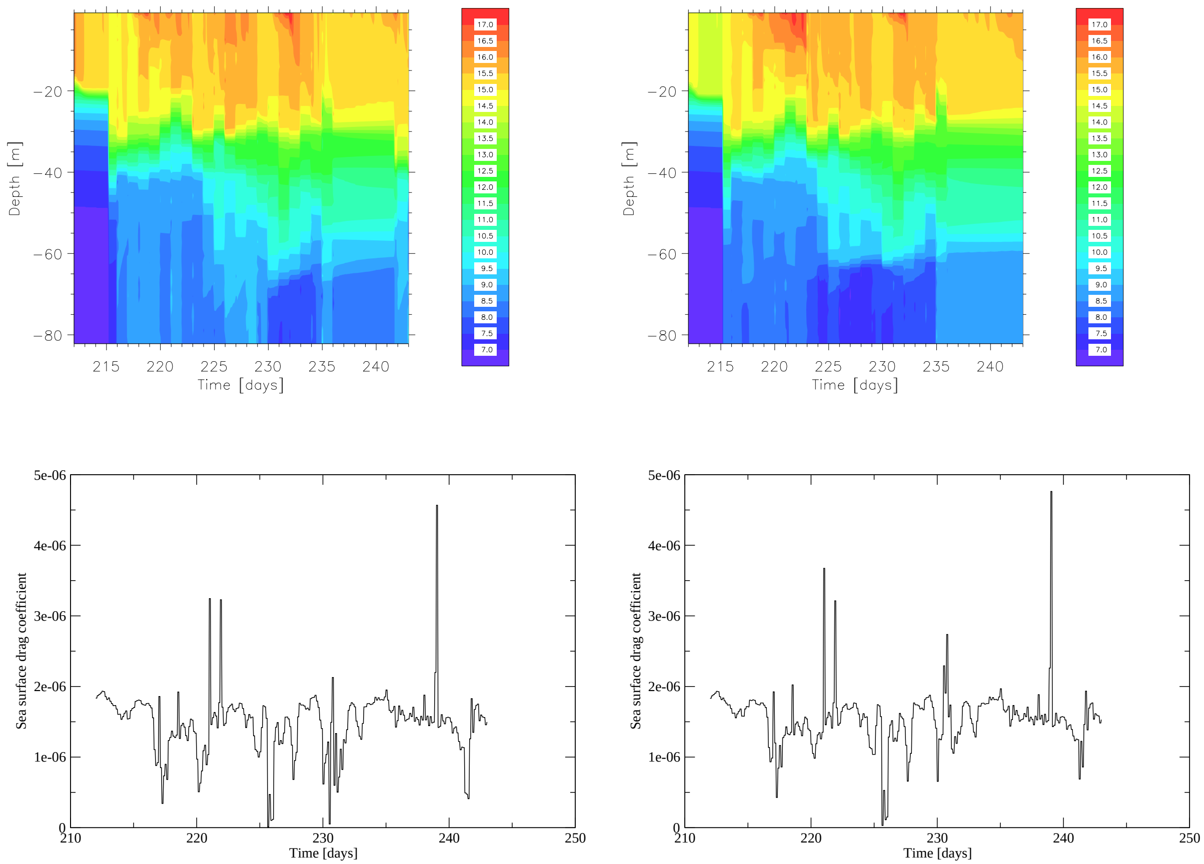
T-D of temp. mod. with an ASV without D.A. (top left), with D.A. (top right); ref. simul. without D.A. (bot. left), with D.A. (bot. right)

Simult. adj. temperature and opt. att.



T-D of temp., adj. (T)(top left), (T, K_{opt}) (top right)
Opt. att. coef. without adj. (bot. left), with adj. (bot. right)

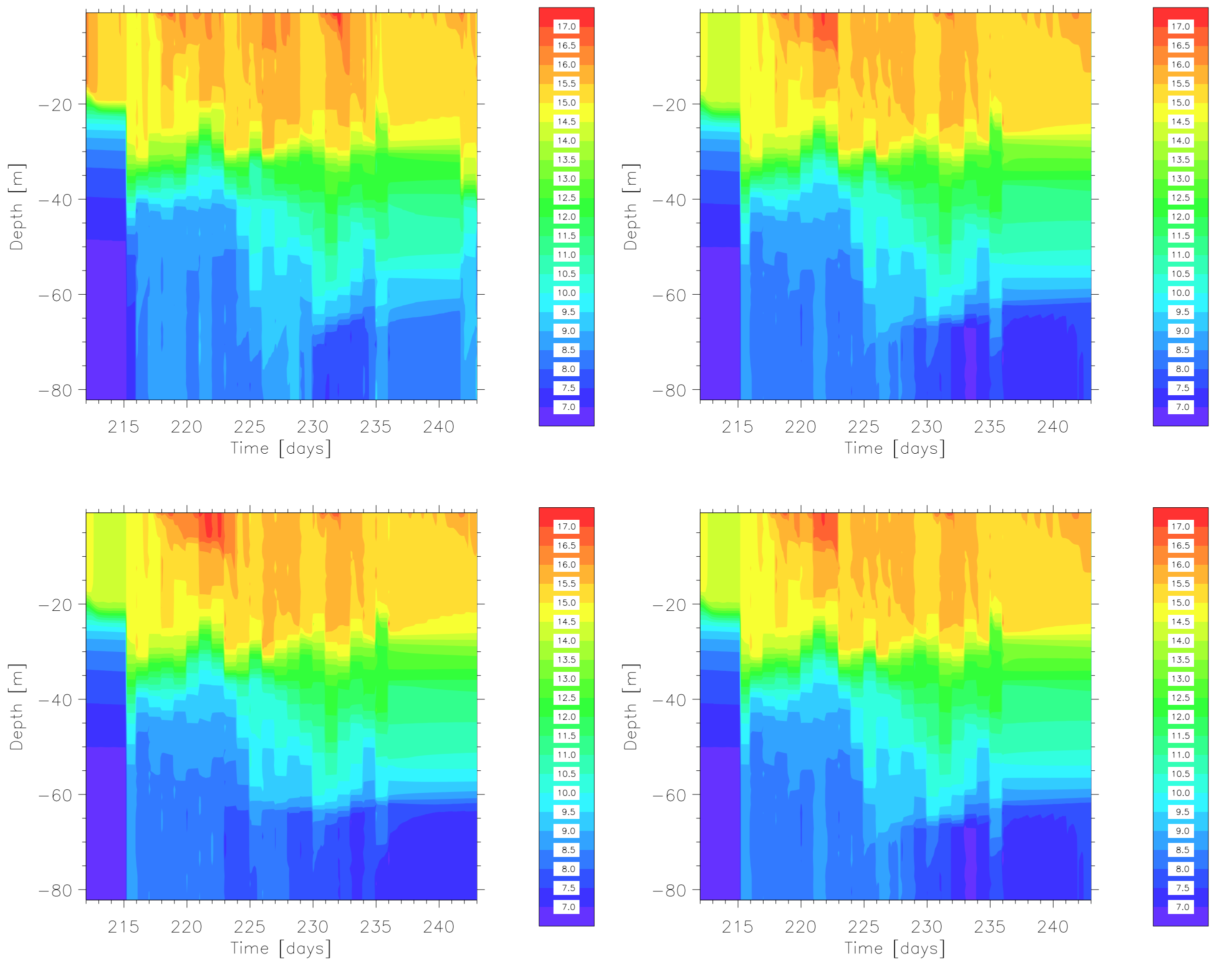
Simult. adj. temperature and sea sfce drag



T-D of temp., adj. (T)(top left), (T, C_{ds}) (top right)

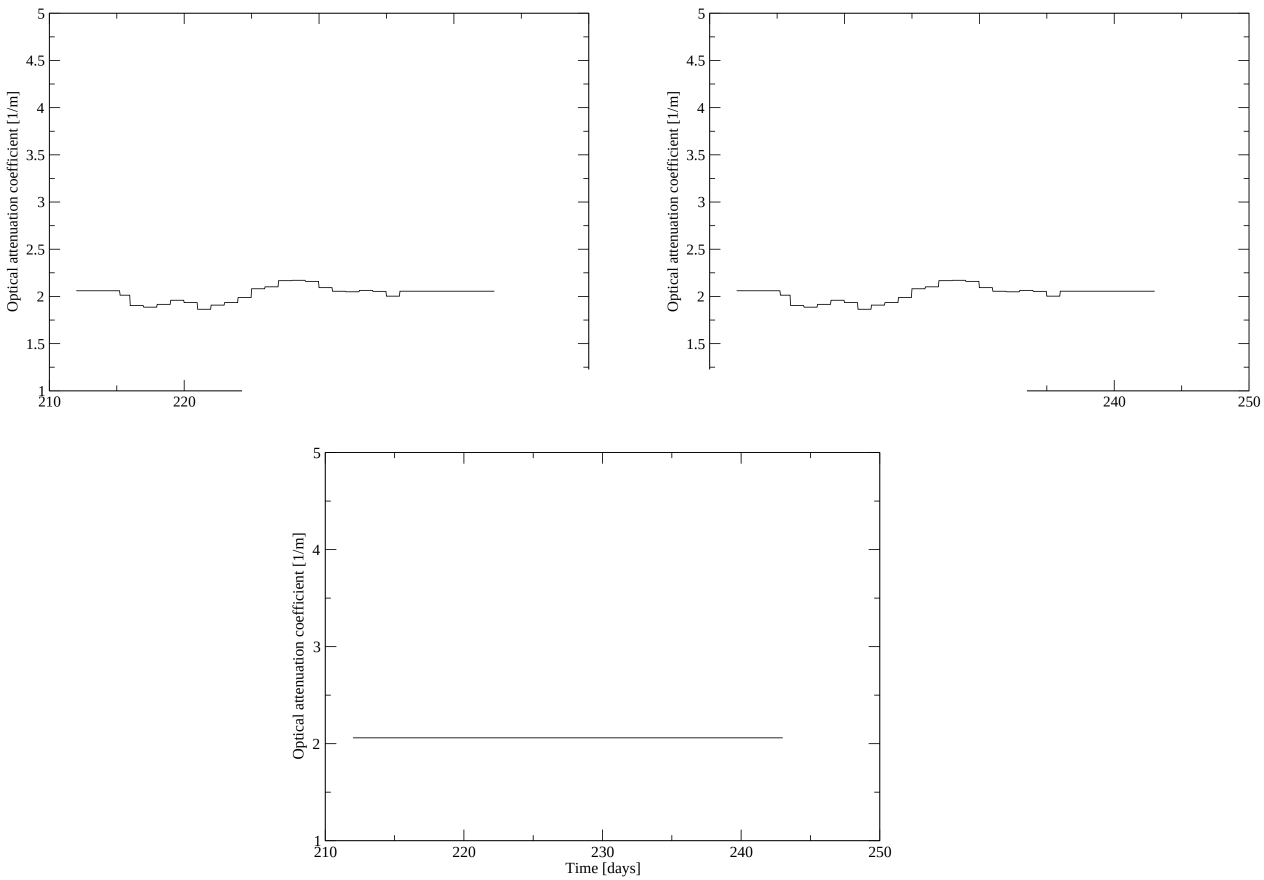
Sea sfce drag coef. without adj. (bot. left), with adj. (bot. right)

Temp., opt. att., sea sfce drag



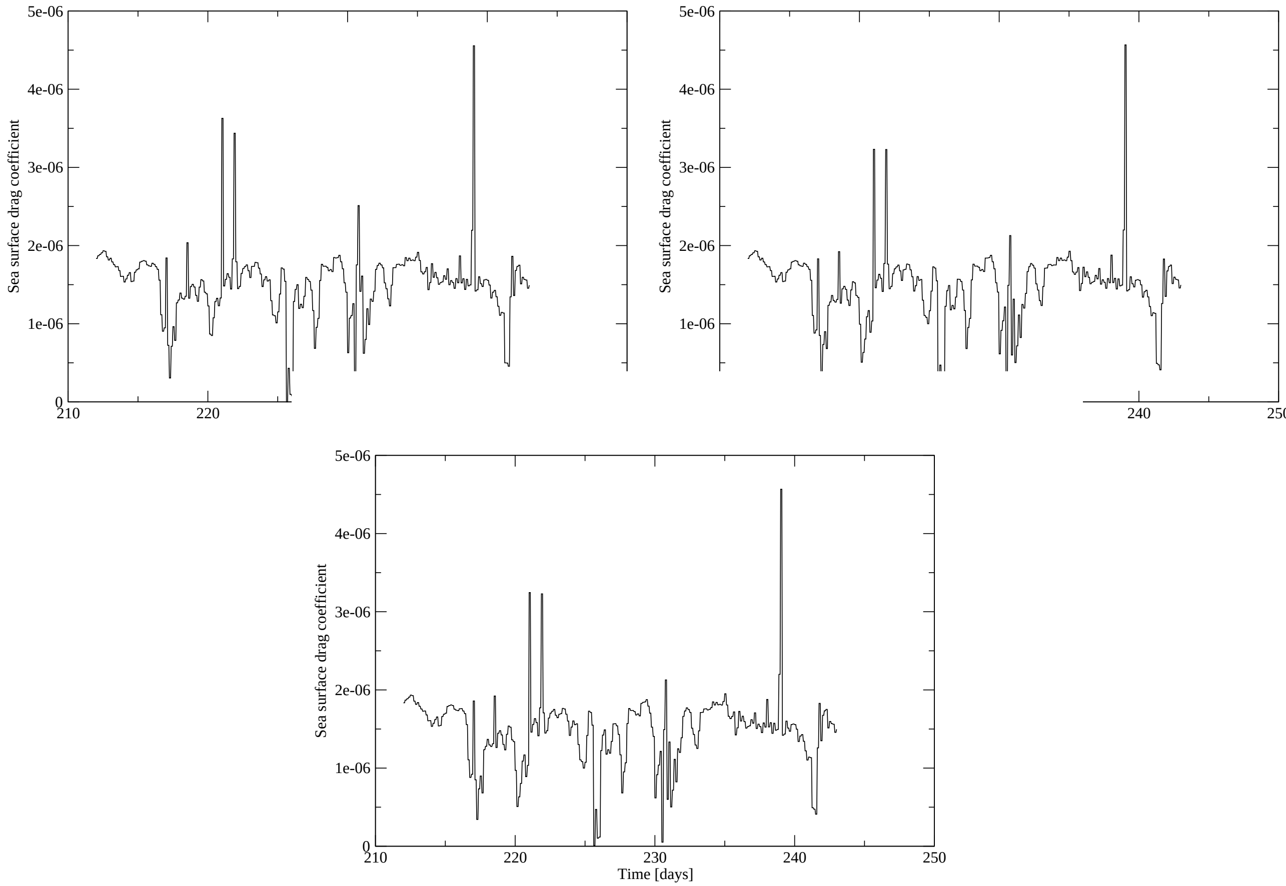
T-D of temp., adj. (T) (top left), (T, K_{opt}) (top right), (T, C_{ds}) (bottom left), (T, K_{opt}, C_{ds}) (bottom right)

Temp., opt. att., sea sfce drag



(T, K_{opt}) (top left), (T, K_{opt}, C_{ds}) (top right), without adj. (bottom)

Temp., opt. att., sea sfce drag



(T, K_{cds}) (top left), (T, K_{opt}, C_{ds}) (top right), without adj. (bottom)

Conclusions

- Adjustment of optical attenuation coefficient:
  - close to the reference value
  - no difference in adjustment using (T, K_{opt}), (T, K_{opt}, C_{ds})
- Adjustment of sea surface drag coefficient:
  - almost no effect
  - almost no difference in adjustment using (T, C_{ds}), (T, K_{opt}, C_{ds})
- Preliminary results before more realistic 3-D simulations