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Listen to the ocean

Data assimilation of chlorophyll in the North-West European Shelf

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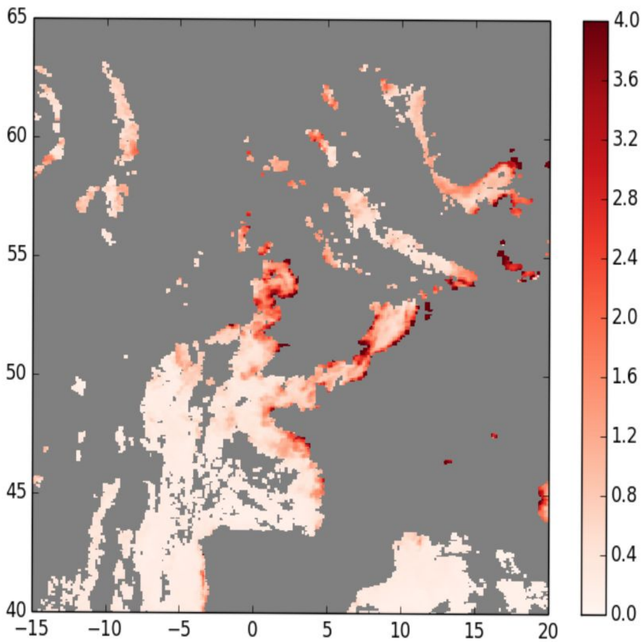
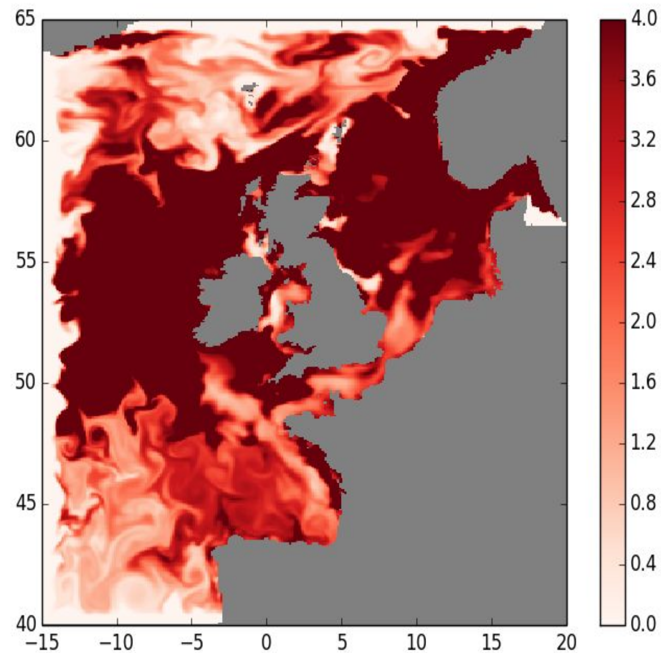
What is Data assimilation?



EO data – chlorophyll

(incomplete data, errors)



model – chlorophyll

(model approximations/errors)

What is the true chlorophyll?

Come up with a suggestion that the truth is something particular and data assimilation tells you how likely it is that you are right. Consequently data assimilation can find the description of the reality that represents the truth with the highest likelihood.

- **Bayes theorem:**

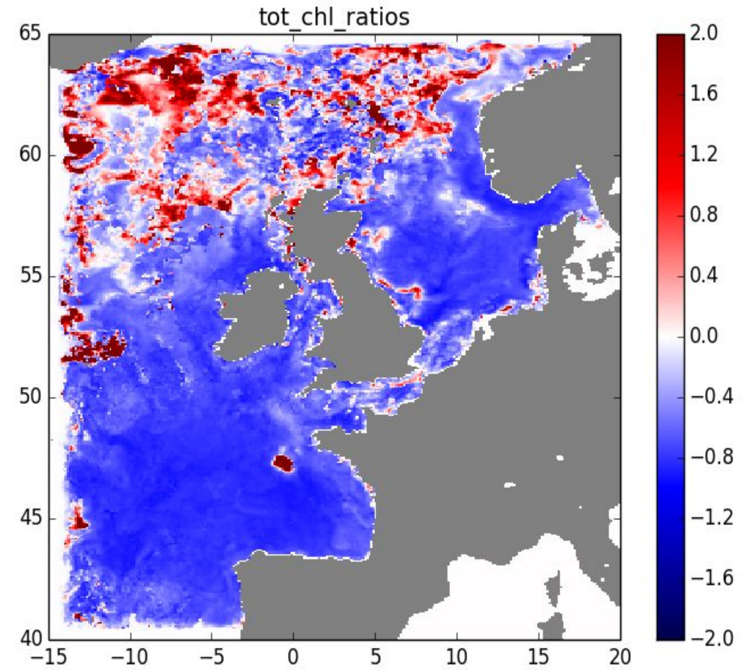
$$P(A \mid B) \sim P(B \mid A) \,.\, P(A)$$

where A | B is a real state A given the observation B, B | A vice versa, and P(A) is probability of the real state, A. Key idea: If we link P(A) to past observations propagating them in time using our models, we get (using Bayes theorem) a good estimate of what is the real state of the world (in the sense of Bayes probability), given our new observations.

- **One key issue with data assimilation:** *what often looks mathematically very simple on the black board, might not be computationally simple at all... For example, if we are interested in describing the ocean, the reasonable description of the ocean state (the truth) might be given by a number of variables of the order of 10 000 000 (multiple different physics and chemistry variables at a large number of spatial grid points)... This poses a huge problem with computational cost and efficiency... Therefore Bayes theorem (a trivial identity) needs to be resolved with a lot of thinking about approximations and suitable algorithms.*

- Data assimilation has a long tradition in the atmospheric science / meteorology and also in the assimilation of physical ocean fields. We are applying data assimilation to biogeochemistry in the North-West European shelf.
- The idea is to assimilate chlorophyll data-sets (total chlorophyll as well as the functional types), derived from satellite optical measurements, to improve the coupled NEMO -ERSEM model.

  - *The results for the total chlorophyll are shown in the next Figure: It shows relative difference in root-mean square error (with respect to the EO data) between the assimilated and the free run. It is a May monthly-average in the 3-month (March-May) test run.*

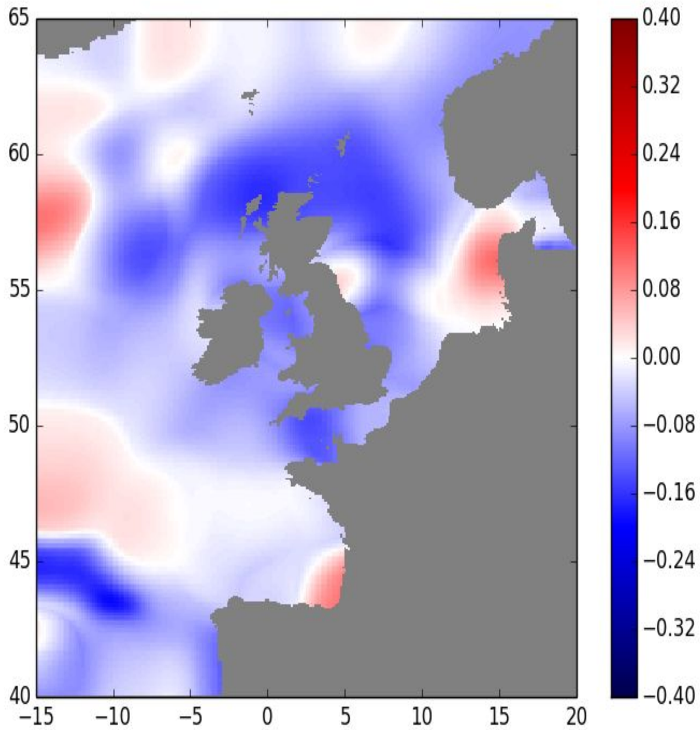


The improvement of chlorophyll should not be too surprising, but what about the nutrients?

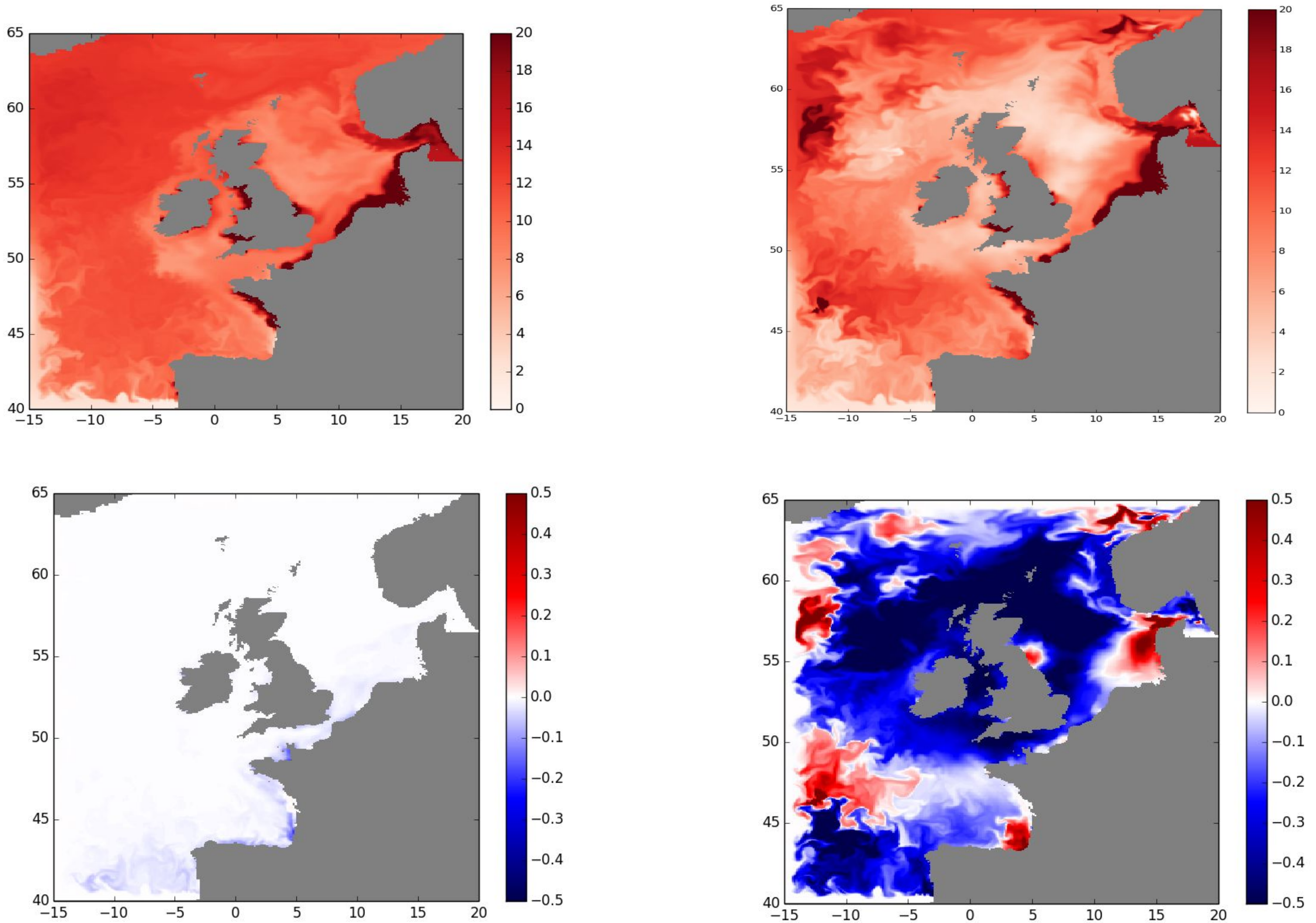
- The changes to chlorophyll need to be ``balanced out'' by the changes to the nutrients. A decadal 100-ensamble Kalman filter run was used to analyse the monthly climatological cross-covariances between nutrients and chlorophyll, as well as chlorophyll (functional types) variance.

- If we assume a simple (linear) proportionality between the increments of nutrients and chlorophyll:
  $\Delta_N = C.\ \Delta_{chl}$,
  then it is easy to calculate that:
  $C = cc_{N,Chl} / var_{Chl}$, with *cc* being cross-covariance and *var* variance.

  The next Figure shows the proportionality constant C values for nitrate.



Some very preliminary results: The images show nitrate – 1. free run, 2. balanced assimilated run, 3. relative difference between assimilated run without balancing and free run, 4. relative difference between balanced assimilated run and assimilated run without balancing.



Thank you for your attention!