

# Sea ice Freeboard or Thickness? Design Choices in the Context of Data Assimilation in the Coupled Seasonal Prediction System EC-Earth3 for Seasonal Arctic Sea ice Prediction

**François Massonnet**

Sara Fleury, Florent Garnier, Ed Blockley, Pablo Ortega Montilla, Juan C. Acosta Navarro, Leandro Ponsoni, and François Klein



Contact: francois.massonnet@uclouvain.be

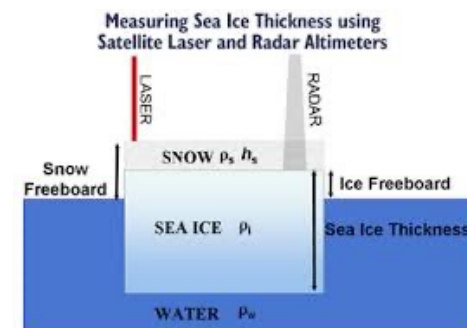
*American Meteorological Society's 16th Conference on Polar Meteorology and Oceanography 2021 (remotely)*

## The problem and the scientific questions

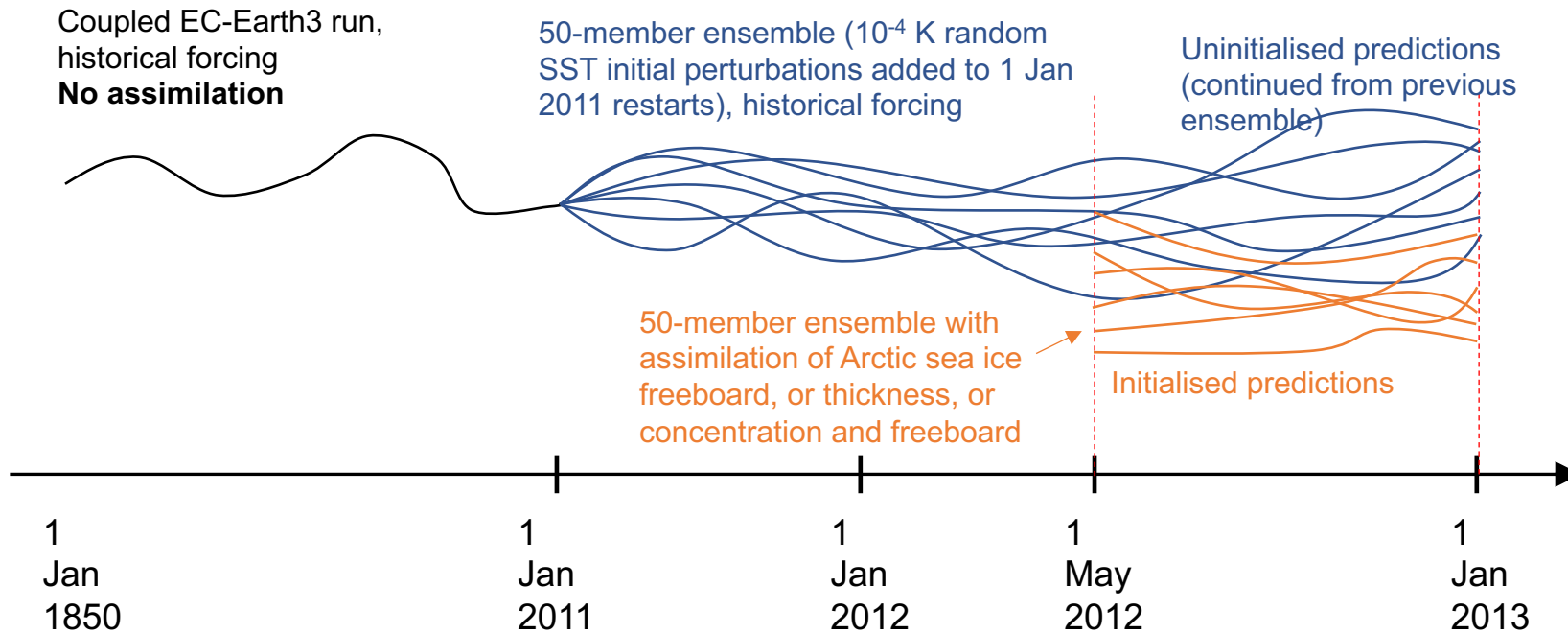
Predictability studies indicate that September sea ice concentration anomalies are in part **governed by spring sea ice thickness anomalies**

However, sea ice freeboard (not thickness) is the variable that is observed from space, although sea ice thickness products are distributed as level-4 products – assuming known snow depth.

Does it make a significant difference to initialize a dynamical coupled sea ice prediction system (a) with sea ice freeboard instead of nothing? (b) with sea ice thickness instead of sea ice freeboard? (c) with sea ice concentration instead of sea ice freeboard alone?



# The approach



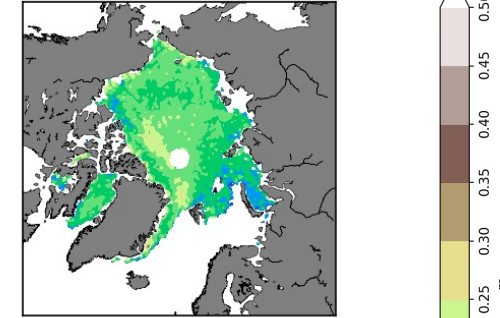
Assimilation method: Deterministic Ensemble Kalman Filter (DEnKF, Sakov et al. 2008), NERSC implementation adapted to EC-Earth3. See Massonnet et al. 2015

## Key ideas of EnKF:

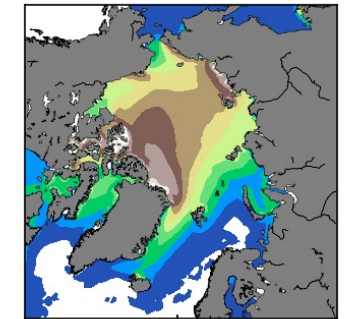
- The filter updates the fields that are not observed, incl. ocean ones, by exploiting covariances in the model forecast ensemble. However, here, atmospheric fields are not updated
- Under assumptions (unbiasedness, gaussianity of errors), the analyzed ensemble has lower bias compared to observations, and lower variance, than the forecast ensemble

Freeboard on May 1, 2012

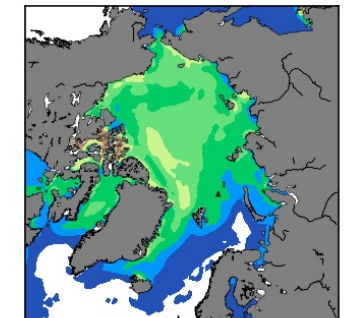
Observations, CryoSat-2 (CS2)



Model, nothing assimilated



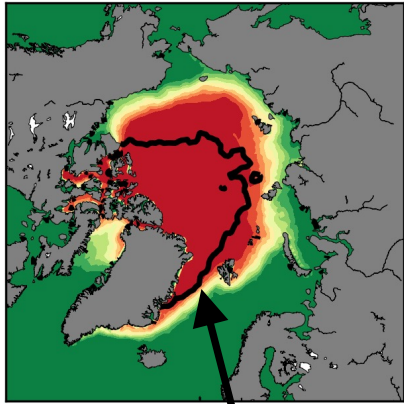
Model, CS2 freeboard assimilated



The uninitialised ensemble is biased high for sea ice concentration. The ensemble overstates the probability of finding ice in many parts of the basin

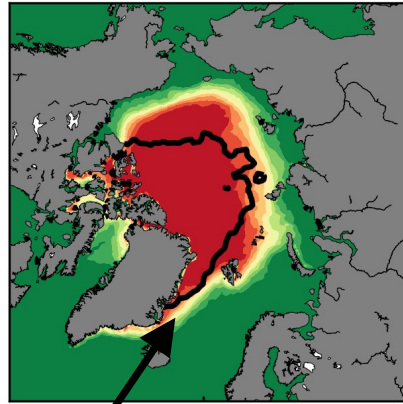


Uninitialised

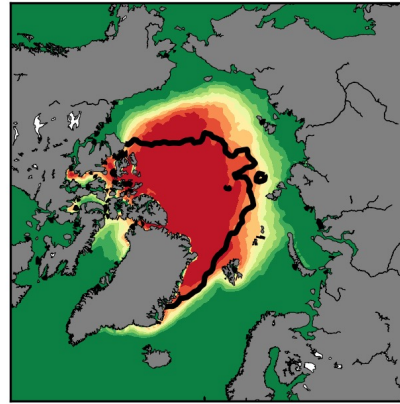


Observed ice edge

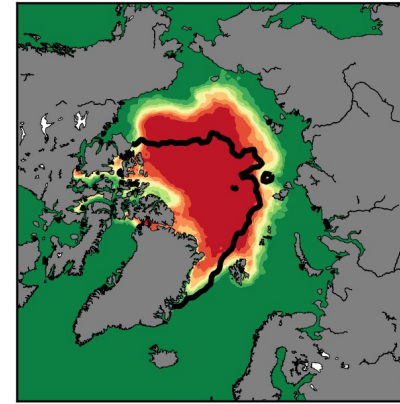
Freeboard



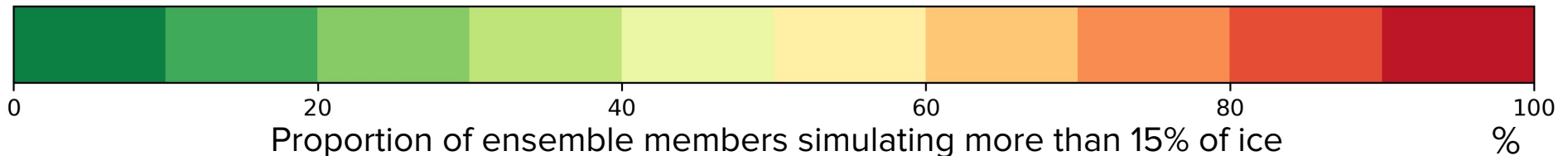
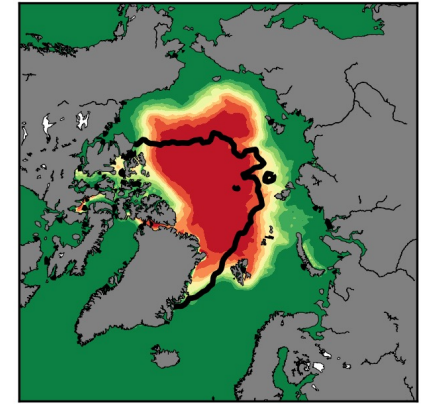
Thickness



Concentration



Freeboard + Concentration



Assimilation reduces, but does not eliminate, the biases in the Chukchi-Beaufort-East Siberian Seas by prescribing thinner ice (see previous slide).

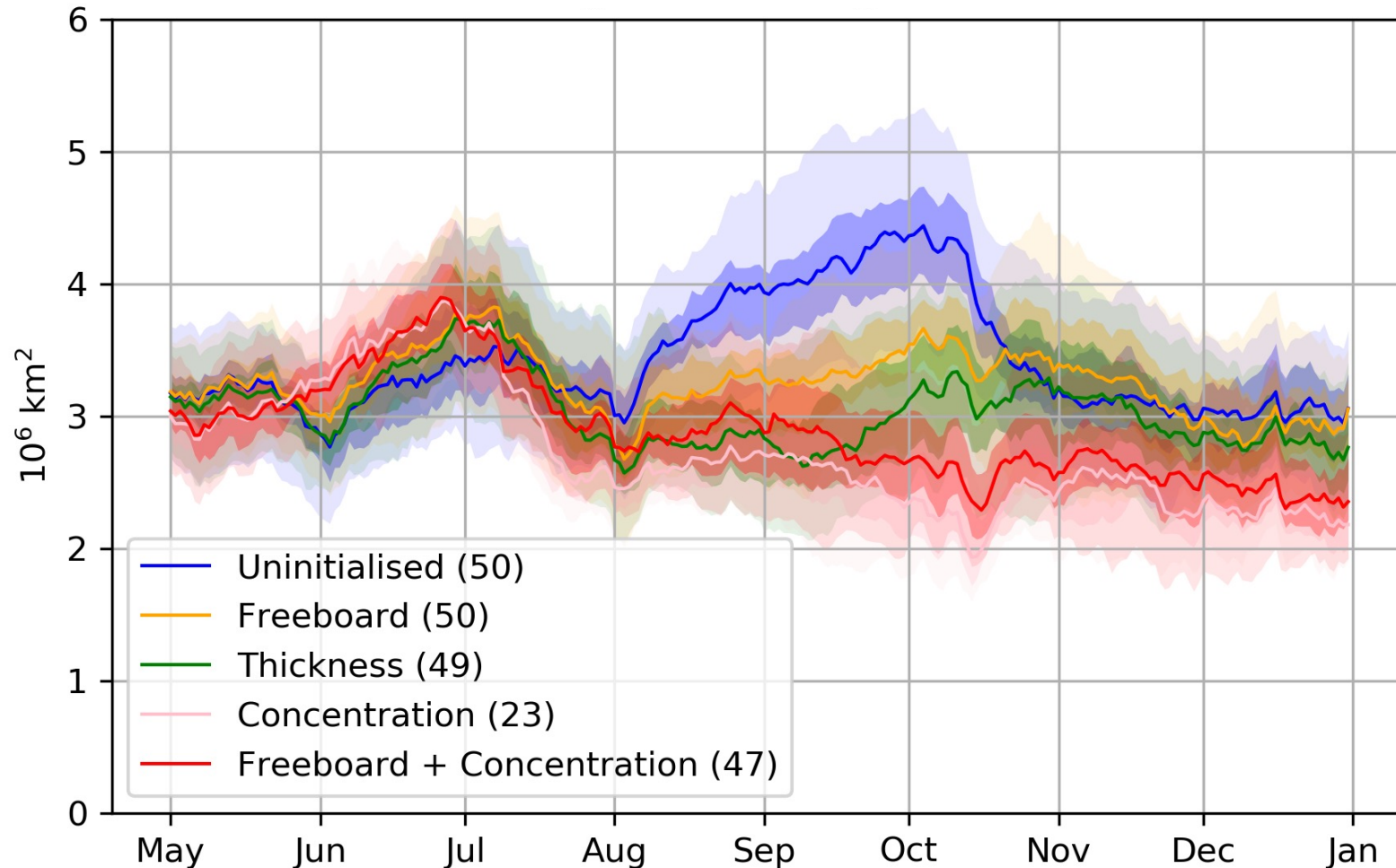
Interestingly, the constraint on concentration alone seems to be as efficient as the constraint on freeboard/thickness alone



Probability of sea ice presence on 2012-09-15

Note: the observed 2012 September sea ice conditions were affected by the « great » cyclone of early August 2012. The occurrence of this event is not predictable, but an ensemble of forecasts should be such that the observed ice edge lies in between the 0 and 100 % sea ice probability presence contours derived from the forecast ensemble

Integrated Ice Edge Error: cumulative area of grid cells where the forecasts and the verification data disagree on the event « sea ice concentration is above 15% »



Results so far suggest:

- That assimilation is always beneficial for summer sea ice prediction
- That assimilation of thickness yields slightly better results compared to assimilation of freeboard
- That assimilation of concentration yields good skill throughout the summer season → evidence for spring-to-fall reemergence of sea ice area anomalies?