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ASSIMILATION OF ICE PRODUCTS IN NWP

Summary and Purpose of Document

This document provides an overview of ice product assimilation into the NWP from the modellers' point of view. The most common sea ice assimilation to the NWP models is initializing the NWP model with gridded sea ice concentration. Ice models use more parameters such as ice thickness. In coupled air-sea models more sophisticated assimilation methods are used.

ACTION PROPOSED

The Team is invited to:

(a) Note and comment on the information provided as appropriate;

(b) Provide additional recommendations and suggestions for its future workplan as appropriate.

References: none

Appendices: none

DISCUSSION

1. The approach for this paper was from the user point of perspective; Instead of theoretical approach the document presents few Numerical Weather Prediction (NWP) modelers' info and opinions about sea ice product assimilation. In this paper the NWP models were not only restricted to the weather prediction models, but also to the sea/ocean circulation, wave and sea ice models. In the sophisticated prediction systems the sea and weather models are used together as a coupled model.

2. A short questionnaire was sent to various people who were involved with global and local weather models (European Center for Medium Range Forecasts ECMWF and Finnish Meteorological Institute FMI) and wave, sea ice and general circulation models (FMI). Also ice data producer (FMI) opinion was asked. This paper represents their opinion.

3. The ice products are used generally in NWP models. The NWP models that need the ice data are global or mid to high latitude weather, wave, sea ice and general ocean circulation models. As the ice conditions are changing from rapid ice drift (hours) to decade long trends, the static or climatological ice conditions cannot be used in accurate modeling.

Why assimilation?

4. With ice data assimilation the modeling of the sea, waves, currents and sea ice improved. This leads to improvement in the weather models which use ocean model results or have internal coupled ocean models.

5. The bad side is more complex system: the errors in assimilation can reduce the NWP model stability. Also more work is needed in implementation and maintenance. One general comment was that a lot of expert time has to be used in inputting the data.

How?

6. Most of the NWP model used sea ice products to initialize the sea ice field in the forecast. Secondly the products were used as boundary condition for example in wave model to not to calculate waves in ice field. In ECMWF research assimilation systems that have been developed using gridded sea ice concentration are a nonlinear nudging of the sea ice model towards observations and by using the NEMOVAR (3DVAR) assimilation system.

Ice assimilation parameters

7. *Concentration*: By far the most common ice data required from the NWP users was sea ice concentration in gridded data format. Nearly all answered that concentration was the only parameter they are using at the moment. The reason behind this is that the data is widely available. The sources for sea ice concentration products were satellite observations or satellites based products, manually analyzed conditions (ice charts) or the ice models. The concentration was used to initialize the models (most common use), used in forcing or nudging or as boundary condition. For example, wave model do not calculate waves if concentration exceeds 30%.

8. *Ice thickness:* The gridded thickness product generated from the ice chart was used in sea ice model. Some modelers were thinking of using observations or gridded thickness products in the near future.

9. Other parameters were seen as potentially important, but the assimilation was not yet implemented: Ice movement and ice type (fast ice, drift ice etc.) for the ice and wave models. Snow thickness on the ice for the weather and ice models and for the calculation of the ice

thickness from satellite altimetry.

10. The ice surface temperature, the temperature profiles inside the ice and the ice salinity were also mentioned as potential input products but not within the near future.

11. **Lake ice** concentration products are used in global weather models and are investigated if they should be used in the local weather models.

Temporal and spatial resolution

12. In the most of the cases the ice products were used to improve the initial ice conditions. Very many NWP models used the gridded ice concentration as a constant during the few days forecast. In most of the cases this is sufficient, but it was also well understood that in ideal case the input field would be also forecasted and would vary in time. This is of course not a problem to the coupled models with ice model included.

13. The product delivery should be as quickly after sensing (at least less than 24 hours). The NWP models that used manually analyzed sea ice information (nowcast ice chart) for defining the initial conditions got the products once a day, few of them requested more frequent delivery. If satellite based sea ice products were used in assimilation, the sensing time was important to know and NRT delivery was emphasized.

14. Spatial resolution for the gridded data was required to the same resolution than the NWP model. This varied from several nautical miles down to 0.2 nautical miles.

Ice product quality

15. The quality of ice data was seen important or very important. The input data should be checked and if possible flagged by the producer carefully. The quality information can be used to define the importance and therefore the weight factor for the data. Errors in the data cause difficult-to-handle problems in the automated assimilation processes. As FMI weather modeler said: Since the assimilation is fully automatic we prefer less data with no rubbish than vice versa.

16. Understanding the quality of satellite sensed sea ice products was seen a challenge due to the fact that the ground truth observations are limited.

17. From the ice data provider perspective it is important that the users understand what data are they using and how they should use it.

Coupled models

18. The trend in NWP is clearly towards the coupled air-sea models. Sea ice model becomes vital if the model domain is having large ice covered seas. An example would be air-wave-sea ice-model which runs each modules in turn before moving to next time step. The coupled model needs ice products in initializing the sea ice conditions and nudging and assimilation. The coupled models need several parameters; for example sea and lake ice concentration, ice thickness and snow cover thickness.

Data format

19. The preferred data format was gridded data, either in GRIB or NetCDF format. Also simple ASCII files were accepted to some models. Generally the models input and output formats are in GRIB and NetCDF, and it is convenient to treat all sources in same tool and libraries.

20. From the ice data producer point of view it is useful to provide the products in as fine spatial and temporal resolution as possible and import the data to a data base. From the data base the ice products can be easily exported in different grids and time steps to the NWP models or other users.

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