1 Datasets

This study combines different datasets consisting of fields from the Arome Arctic forecasting product and ice charts created by the Tromsø division of MET Norway.

1.1 Sea Ice Charts

The Sea Ice charts is an operational Sea Ice Concentration product provided by MET Norway. The product is manually drawn by a Sea Ice Specialist, and is distributed every workday at 15:00 UTC. The Sea Ice specialist assesses available SAR data from Sentinel 1 and Radarsat 2. However, due to the spatial variability in daily SAR coverage, visual, infrared and low resolution passive microwave observations are supplied to achieve a consistent spatial coverage [1]. The Sea Ice charts are drawn in an ArcGIS production environment, and is as such intrinsically not projected onto a defined grid. Yet, the operational product available for download on Copernicus is provided as mean values on a 1km grid.

From the description of the Sea Ice charts given above, it is worth addressing the spatial inconsistency following the projection onto a uniformly sized grid. As the Sea Ice specialist draws polygons based on data from different satellite sources with a wide range of spatial resolution (80m from SAR, 1000m from visible / infrared and even lower resolution for passive microwave), the underlying uncertainty and detailed structures in the Sea Ice chart varies [1]. Furthermore, I was made aware by one of the Sea Ice Analysts that time constraints also limits the hours different sections of the Ice chart is alloted. Moreover, the Sea Ice charts is an operational product aimed at end users in industries such as fishing, tourism, shipping or other maritime operations. This influences the decision-making when creating the final operational product. . As a consequence, the Sea Ice analyst spends approximately half of the total time draw polygons around the Svalbard archipelago. ask Trond on email

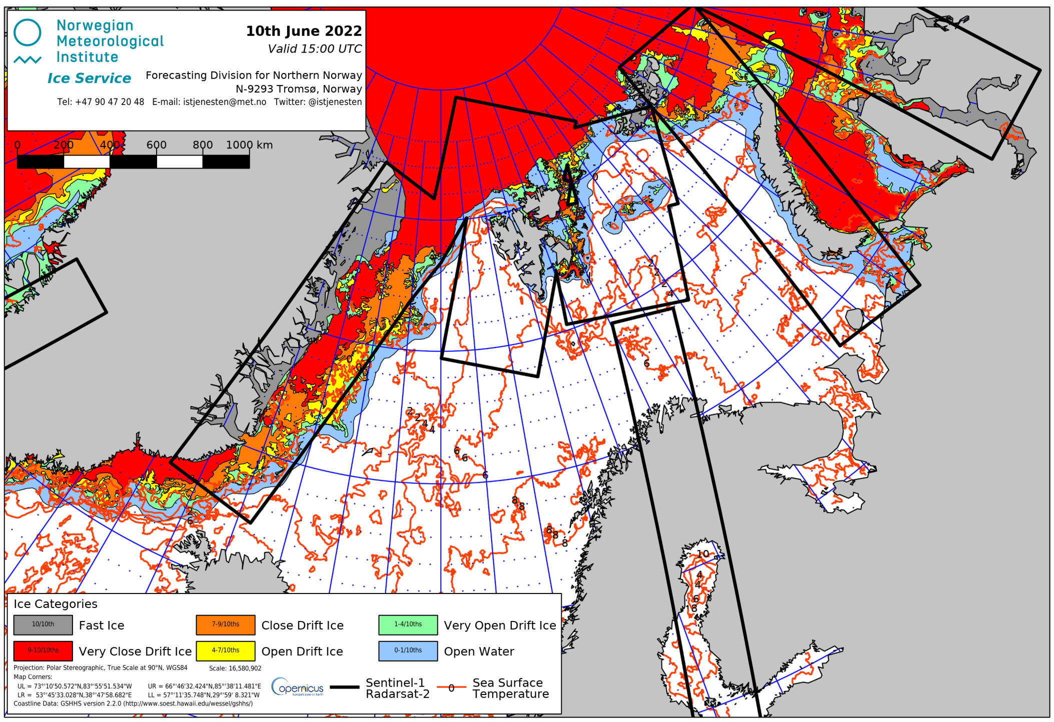
In conclusion, concerning the limited resources available both with regards to data availability as well as total hours available, the Sea Ice charts represents a dataset with a spatial uncertainty that is non-uniform across a single sample, and that changes in time. In spite of that, the involvement of a Sea Ice specialist which manually assures each Sea Ice charts, the temporal consistency as well as their high resolution has led us to believe that the Sea Ice charts is the overall best Sea Ice Concentration product available for the current study region.

2 Data pipeline

The main motivation for writing this section is to outline the production pipeline which collects and merges different sources of data into the finished data-generator used to train the Deep Learning model. Ideally, this section will be somewhat exhausting such that all steps taken are presented clearly with the intent of providing a source for the inspiration as well as the necessity of the step. However, source code will be presented sparingly.

Sea Ice Charts

The Sea Ice Charts used are a derived dataset of the Sea Ice Charts presented in a previous section . The present Ice Chart dataset has been postprocessed by Nick Hughes of the National Ice Service, label sections such that they are presented on a 1km Arome Arctic grid. Furthermore, the Ice Charts does not


Norwegian Meteorological Institute
Ice Service
10th June 2022
Valid 15:00 UTC
Forecasting Division for Northern Norway
N-9293 Tromsø, Norway
Tel: +47 90 47 20 48 E-mail: istjenesten@met.no Twitter: @istjenesten
0 200 400 600 800 1000 km
Ice Categories
10/10th Fast Ice
7-9/10ths Close Drift Ice
1-4/10ths Very Open Drift Ice
9-10/10ths Very Close Drift Ice
4-7/10ths Open Drift Ice
0-1/10ths Open Water
Projection: Polar Stereographic, True Scale at 90°N, WGS84
Scale: 16,580,902
Map Corners:
UL = 73°'10'50.572"N,83°'55'51.534"W
UR = 66°'46'32.424"N,85°'38'11.481"E
LR = 53°'45'33.028"N,38°'47'58.682"E
LL = 57°'11'35.748"N,29°'59' 8.321"W
Coastline Data: GSHHS version 2.2.0 (http://www.soest.hawaii.edu/wessel/gshhs/)
Sentinel-1
Radarsat-2
0
Sea Surface Temperature

feature a land-mask, which has been replaced with interpolated values resulting in a spatially consistent dataset where all values present are according to the WMO Sea Ice Concentration intervals [2].

3 Forecast verification metrics

A robust verification scheme is essential to gain insight into how the developed forecasting product performs. Both from the point of view of a developer which aim to increase the skill of the prediction but also from the user which may utilize the verification score to assess the quality of a given forecast [3]. In the context of Sea Ice forecasting, a spatial field of continuos or discrete sea ice concentration is predicted, the latter being the case for the current work. Given the uneven distribution intra sea ice concentration classes as well as sea ice compared to ice free open water, simply comparing pixels for correctness would be biased by the large portion of open water and result in difficult to interpret values devoid of physical reasoning. Furthermore, as the rate of maritime activity such as commercial shipping increases in the Arctic due to the sea ice decline [4], having user relevant metrics can aid and alleviate the risks surrounding Arctic navigation. As such, several studies have proposed calculating the position of the ice edge as a user relevant metric which also provides information of the distribution of the Sea Ice Concentration [5, 6, 7]. However, there is no agreement with how to best calculate the position of the Ice Edge, with the currently available metrics posing different advantages/disadvantages [8, 9]. For the purpose of this thesis, The ice edge position and length will be calculated according to [9, Melsom 2019 et.al], whereas the IIEE originally proposed by Goessling. H. [6] will also be utilized.

Syk udokumentert påstand, må modereres

3.1 Defining the Ice Edge

The ice edge for a given Sea Ice Concentration product is derived on a per pixel basis, and defined as the grid cells which meet the condition

$$c[i,j] \geq c_q \wedge \min(c[i-1,j], c[i+1,j], c[i,j-1], c[i,j+1]) < c_e \tag{1}$$

i.e. a pixel is marked as a ice edge pixel if the current pixel itself is larger than some given concentration threshold c_e and the minimum of the pixel's 4-neighbors is less than the same threshold. Moreover, the marked grid cells each contribute to the total length of the ice edge, with each pixel's length contribution determined based on the number neighbors also marked as an ice edge pixel. Consequently, a neighborless pixel is assumed to yield a contribution the length of the diagonal to the ice-edge ($l = \sqrt{2}s$) where s is the side length of the pixel. A pixel with one neighbor a contributes a mixed horizontal - diagonasl length $l = \frac{s+\sqrt{2}s}{2}$. Finally a pixel with two or more neighbors contributes with a pixel side-length $l = s$.

3.2 Integrated Ice Edge Error

The Integrated Ice Edge Length (IIEE) is an error metric which compares the forecast to some ground truth target [6]. The metric is defined as

$$\mathrm{IIEE} = \mathrm{O} + \mathrm{U} \tag{2}$$

where

$$O = \int_A \max(c_f - c_t, 0) dA \tag{3}$$

and

$$U = \int_A \max(c_t - c_f, 0) dA \tag{4}$$

with c_t and c_f being the target and forecast concentration respectively, attaining a value of 1 if the concentration for a given pixel i above a set threshold, and 0 elsewhere. From the definition of the metric, it can be seen that the IIEE is a sum of the forecast overshoot and undershoot compared to the ground truth target. For the current work, the IIEE is an easily interpreted metric as it quantifies the total forecast error and reports on the error spatially.

Furthermore, the IIEE can be combined with the length of the Ice Edge which was derived in the previous section 3.1. Thus, the metric is seasonally normalized, assuming that the IIEE and Ice Edge Length is seasonally correlated.

Add Figure showing IIEE and ice edge length seasonal correlation

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