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The Cryosphere
Discussions

Interactive comment on “Melt ponds on Arctic sea ice determined from MODIS satellite data using an artificial neural network” *by* A. Rösel et al.

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Dear Marc,

thank you for your helpful comments and remarks.

1) The system of linear equations (2) is overdetermined, that means, we have 3 unknowns and 4 equations. That means in fact, there are only approximate solutions. Thus, we consider the linear equations (2) together with equation (4) as an optimization problem that we solve in a least-squares sense.

The equations (2) can be described as matrix equation of the form Ax=d, where A is an 4×3 matrix, containing the input values for melt ponds [0.22,0.16,0.07,1], snow/ice [0.95,0.95,0.87,1] and water [0.08,0.08,0.08,1]. The input variables for melt ponds

[0.22,0.16,0.07,1] and water [0.08,0.08,0.08,1], are highly correlated (r=0.98), that means they are almost linearly dependent, therefore the set of linear equations (2) is not well-conditioned.

The reduction of the amount of surface types is useful, since it enhances the condition of the equations. With 3 surface types the number of condition (cond(A3)= 29) is better than with 4 surface types (ponds, open water, snow, and bare ice) (cond(A4)= 117).

To comply with the physical principles, it is necessary to constrain the interval of the solution between zero and one for each class. This is done by a sigmoid function (eq 4). On the one hand, the implementation of of the cost function constrains the range of solutions and enhances the condition of the equation system, but on the other hand, this limitation causes higher computational costs as compared to the solution of the linear equations (2) alone. This is the reason for using the fast neural network approach.

2) To determine, if the result or the output of the ANN is reasonable, we calculate some predefined datasets twice: the first time with the trained ANN, the second time we apply eq (2) and (4). Then we compare the results of both procedures. The first test we made, was to recalculate the data set we used for the training. Here the difference between both results was (as expected) very low (0.1 %). The mean difference of eight further tests was around 1 %. But maybe we should express it with a correlation of Rˆ2=0.977 for the class of the melt pond fraction. That means that the ANN delivers nearly the same results than eq (2) + (4) do - but much more faster. The high accuracy of the ANN shows, that the ANN learns the solutions of eq (2)+(4), but it says nothing about the overall accuracy, if there are melt ponds or not.

3) For the melt pond product we use only the cloud information from the MOD09 product - due to to large amount of data, we have not checked the single tiles individually. But we found, especially in the 500 m resolution pre-product some single pixel with a very high melt pond signatures, especially at the edges of the cloudmask (see Figure

1). We assume, that these pixel are a misclassified cloud signal.

In cloudy regions it can be possible, that only a few pixel incorporate into the coarse 12.5 km grid – if these pixel are "faulty", they can highly influence the results – see Figure 1. For our further analysis we did with the data, we calculated the amount of pixel used for creating the mean value in the 12.5 km-gridding routine. This product can be used to mask the relative melt pond fraction 12.5 km-product for further analysis and can be used as a kind of "indicator" how trustful is the result of the coarse grid. A high amount of valid observations indicates a high data quality. To enhance data quality for further studies, a data mask with a defined threshold of incorporating pixel can be applied after the gridding routine. This data mask minimizes the influence of the misclassified single pixel (Figure 1), because grid cells with a low data quality are eliminated. However, the existing problem of cloudy pixel in the initial dataset can impact the melt pond fraction and should be considered. As an example, we created a data mask and used 50 % as threshold - that means we use only gridcells which contain in their mean value at least 313 incoming values. The attached Figure 2 displays the difference between a unmasked and a masked dataset.

Interactive comment on The Cryosphere Discuss., 5, 2991, 2011.

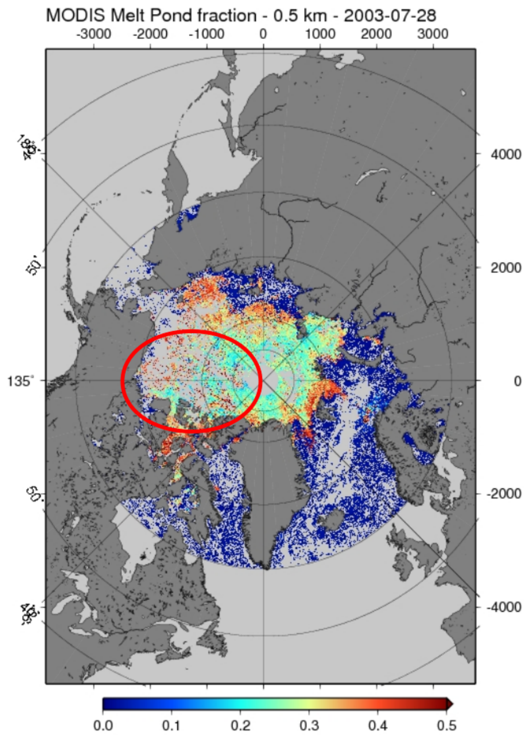

Fig. 1. 500 m resolution pre-product from MODIS data: In the red cycle single pixel with high melt pond signatures occur.

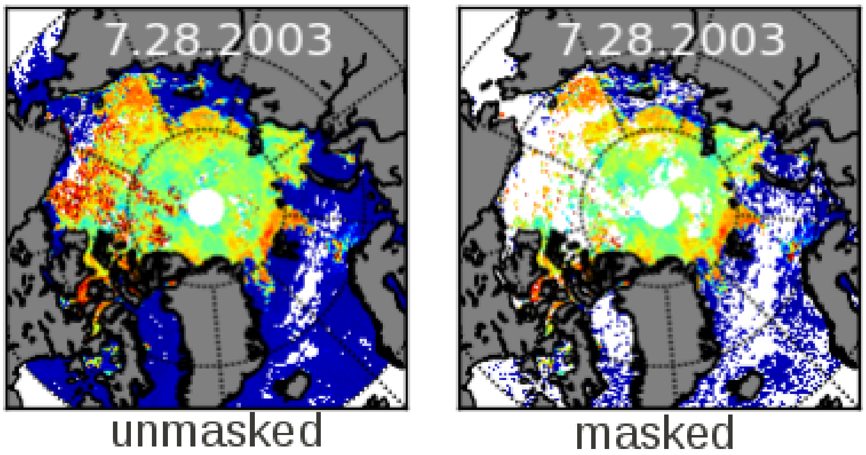

Fig. 2. Difference between a unmasked (left) and a masked (right) data set.