Tracking of mesoscale atmospheric phenomena in satellite mosaics using deep neural networks

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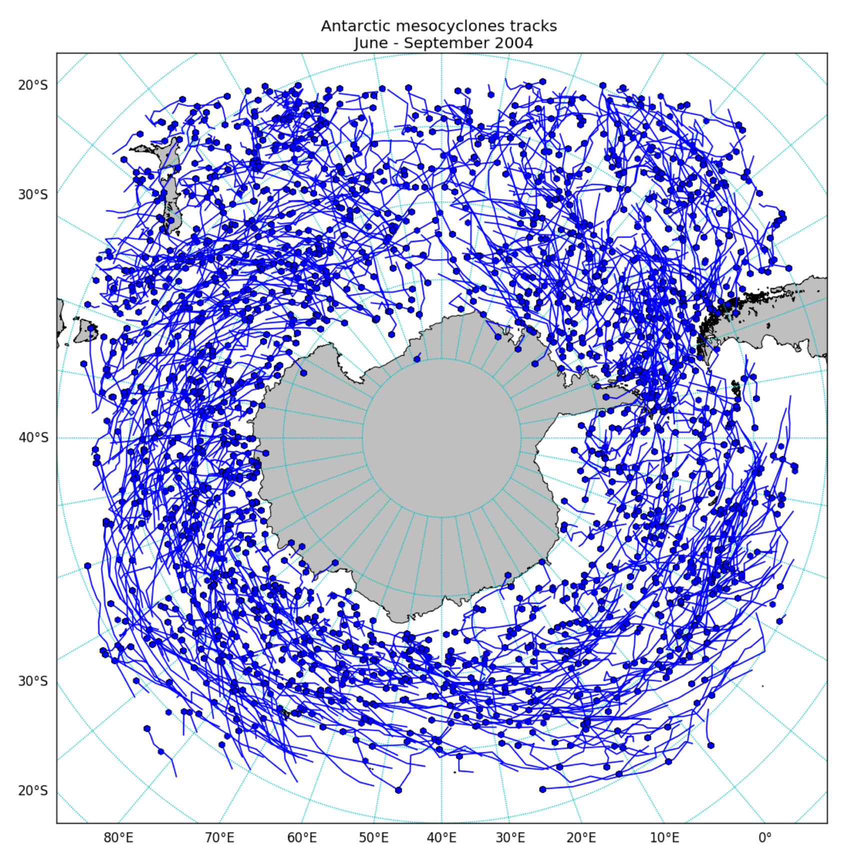
Motivation and previous works

Polar Lows (PLs) are intense atmospheric vortices that form mostly over the ocean. Due to their strong impact on the deep ocean convection and also on engineering infrastructure, their accurate detection and tracking is a very important task that is demanded by industrial end-users as well as academic researchers of various fields. While there are a few PL detection algorithms, there are no examples of successful automatic PL tracking methods that would be applicable to satellite mosaics or other data, which would as reliably represent PLs as remote sensing products. The only reliable way for the tracking of PLs at the moment is the manual tracking which is highly time-consuming and requires exhaustive examination of source data by an expert.

The recent advances in applications of Convolutional neural networks(CNNs) for solving problems in earth associated tasks* showed that CNNs could be helpful for improving the existing tracking results.

So this research aims to built a model based upon CNNs which is trained to perform an assignment task in which the initial problem of tracking would be reformulated.

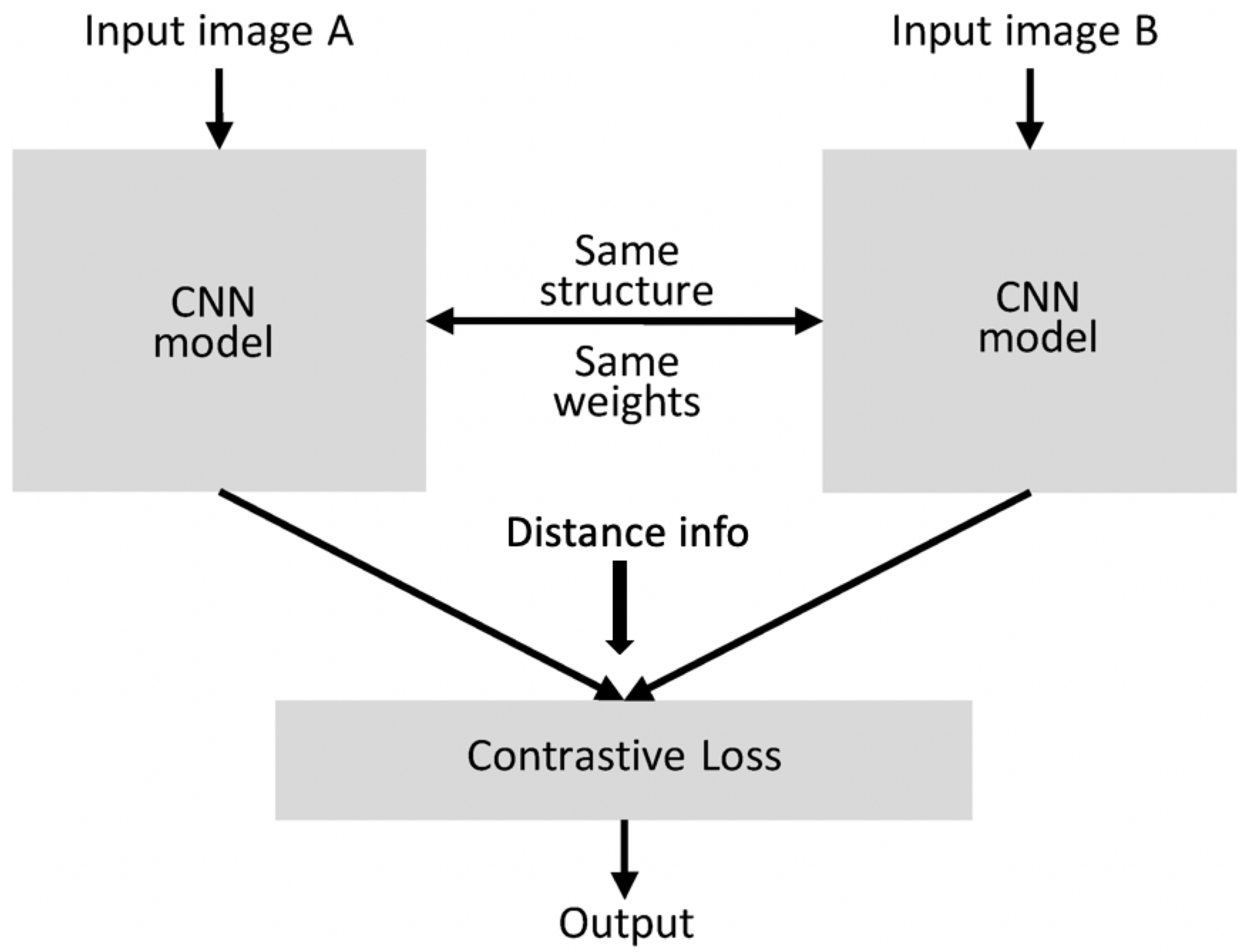


* M. Krinitskiy, P. Verezemskaya, K. Grashchenkov, N. Tilinina, S. Gulev, M. Lazzara "Deep Convolutional Neural Networks Capabilities for Binary Classification of Polar Mesocyclones in Satellite Mosaics" in *Atmosphere* **2018**, *9*, p. 426.

Data and methods

For the training of DCNNs, we use the MCs dataset for the Southern Ocean (SOMC*) consisting of 1735 MC trajectories, resulting in 9252 MC locations and associated estimates of MC sizes for the four-months period (June, July, August, September) of 2004. The dataset was developed by visual identification and tracking of MCs using 976 consecutive three-hourly satellite IR (10.3–11.3 micron) and WV (~6.7 microns) mosaics provided by the Antarctic Meteorological Research Center (AMRC) Antarctic Satellite Composite Imagery (AMRC ASCI).

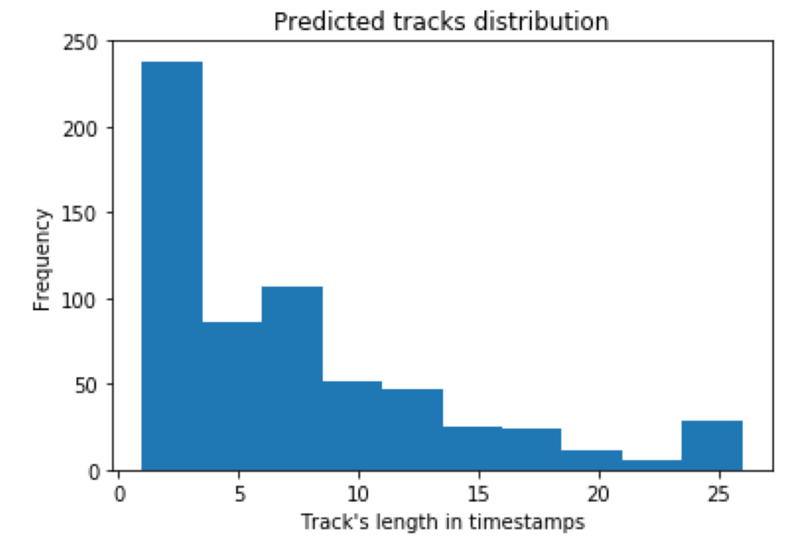
For solving an assignment task a special type of NN called Siamese network was used. This network learns metric in order to define how close given objects in a space. As input the model got two images with mesocyclones and information about distance between them and had to predict probability of the fact that mesocyclone on image B is continuation of A for a next timestamp.

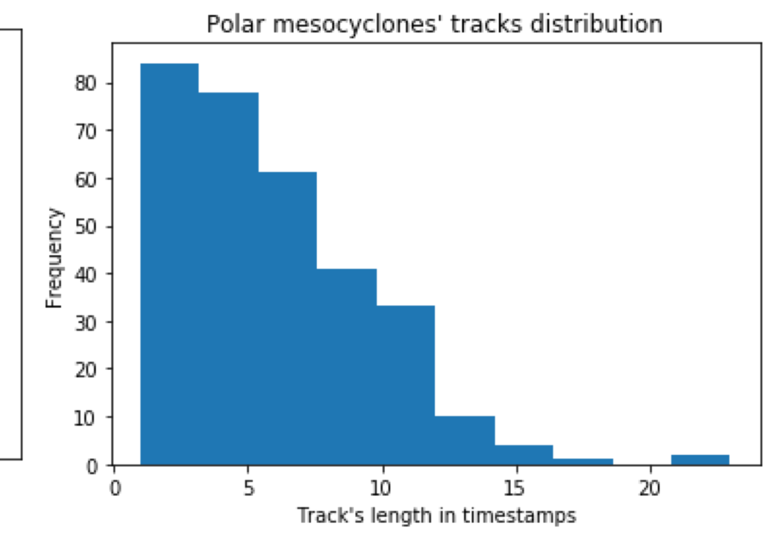


* Verezemskaya, P.; Tilinina, N.; Gulev, S.; Renfrew, I.A.; Lazzara, M. Southern Ocean mesocyclones and polar lows from manually tracked satellite mosaics. *Geophys. Res. Lett.* **2017**, *44*, 7985–7993.

Results and discussion

The built model was tested for the period of 1 month in order to track all existing mesocyclones during this season. As you can see from plots the distribution of predicted tracks is alike the distribution of tracks for all existing mesocyclones for the given period of time.





The model is able to reproduce tracks but has a drawback: while creating track the model decides include or not next point to an existing track but heavily relies on distance information between previous and next points. In order to handle this issue it's necessary to force the model to take into account visual information.