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Atmospheric Measurement Techniques Discussions

Interactive comment on "Characterisation of the artificial neural network CiPS for cirrus cloud remote sensing with MSG/SEVIRI" *by* Johan Strandgren et al.

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We thank the reviewer for taking the time to read and review our manuscript. Each comment from the reviewer (roman style) is listed below along with the corresponding reply from the authors (in italic font style) as well as possible changes in the manuscript (in blue italic font style).

General comments

1. (Section 3.2 or somewhere) IR measurements are sensitive to atmospheric temperature and humidity profiles, as well. CiPS uses surface temperature and latitude

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and DOY as input. Although they could provide some information about atmospheric profile, I believe it is better to include temperature and humidity profiles. Variability of humidity is particularly large, and I think that surface temperature and latitude and DOY are not enough to model that variability. If atmospheric profile is included in the input, cirrus detection and retrieval can be improved, and water vapor channels can become more important.

We agree with the reviewer that including vertical humidity and temperature profiles as input data would improve the performance of CiPS. This is also something that was addressed in our previous manuscript that was recently accepted for publication in AMT, where the development and validation of CiPS is presented (AMTD version available here: https://www.atmos-meas-tech-discuss.net/amt-2017-64/). We chose not to include any vertical profiles in order to keep the computational costs down. By including vertical profiles of temperature and humidity we would increase the number of input neurons and consequently the time required to train and use CiPS considerably. We have added some lines about this in the concluding section of this manuscript: "In general auxiliary data like surface type flags and day of the year are shown to have a comparably small relative importance and for future developments within this field, surface emissivities as well as vertical humidity and temperature profiles would probably prove more useful. Using vertical profiles as input data would increase the computational costs though."

2. For CTH, the percentage error is not very comprehensive. Error in CTH scale (unit in km) is more comprehensive.

The reviewer is right, probably it would be more reasonable to use a relative error measure (%) for IOT and IWP, but an absolute error (km) for the CTH. However, we would prefer to stick to the relative error for the CTH for consistency purposes, since this is also used in the first manuscript about CiPS (see above). We think that it would

be less confusing if we stick to the same error measure for the same variable in the two manuscripts.

3. ANN may output multiple variables. Why two ANNs are constructed to estimate CTH and IOT separately? I guess one reason is that by doing so, sensitivities to input can be investigated as shown in Fig. 1. Is there any reason concerning to retrieval accuracy?

In principle the retrieval accuracy should increase if the output variables are retrieved with separate ANNs. But our reason for doing so is related to the fact that the CTH can be retrieved by CALIOP (our training reference data source) for all cirrus/ice clouds independent of the thickness, whereas the IOT/IWP can only be retrieved for cirrus clouds with an optical thickness up to about 3 (usually less) due to the saturation of the laser beam. Consequently we can only train the IOT/IWP ANN with cirrus cloud retrievals where CALIOP could fully penetrate the cirrus cloud (transparent cirrus). The CTH ANN however, can be trained with all cirrus/ice cloud retrievals independent of transparency/opacity. To summarise, the reason to use two ANNs is that we use different training datasets. More details about this is available in the first manuscript about CiPS, referred to above.

Specific comments

Page 1, line 10, “thin”: How thin is it?

It refers to an optical thickness less than approx. 0.3. This information has been added in the revised manuscript.

Page 8, line 17: Results presented in Section 4.2 are interesting and useful. I am just wondering how the weights are normalized. Is variability of every input variable

normalized?

This part has been extended and clarified and it is now clearly written how the relative importance of the single input variables is obtained. This part now reads as follows: "The importance of an input variable can be estimated as the euclidean length of the vector holding all weights that connect that input neuron with the hidden neurons in the first hidden layer (LeCun et al., 1990). The importance (or total weight) of an input variable i is thus calculated as $W_i = \sqrt{w_{i,1}^2 + w_{i,2}^2 + \ldots + w_{i,N}^2}$, where $w_{i,1}$ to $w_{i,N}$ are the single weights connecting input variable i with the N neurons in the first hidden layer. Figure 1 shows the relative importance of the 18 input variables used by CiPS. The relative importance of all input variables is calculates as $W_i^* = 100\,\% \cdot W_i/(W_1 + W_2 + \ldots + W_{18})$ for the respective ANNs such that the sum of the relative importance across all input variables adds up to 100 % for each ANN."

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