Review von ACP paper:

3D Radiative Heating of Tropical Upper Tropospheric Cloud Systems derived from Synergistic A-Train Observations and Machine Learning

The authors present a new method using ANN to expand narrow track CloudSat and CALIPSO data of heating rates using CRIS (Clouds from IR Sounders) and reanalyses data in order to generate a 3D heating rate data set for the inner tropics (15N to 15S). For the training of the ANN 4 years data collocated in space and time are used. The trained ANN are applied to a long term data yielding to a 15 year data set of 3D heating rates. This data set was discussed in the light of ENSO for different could type and cloud systems (e.g. MCS: mesoscale convective systems).

This principal approach using measurements collocated with 2 or 3D satellite data is not new and was applied for the generation of different products with higher resolution in space and time and expansion to longer data records more suitable for thorough analysis. The data sets used are described for some parts in too much detail while for the ANN part some details are missing. Some streamlining of the text would be good to improve the understanding by merging with the supplement part or move some parts of the detailed data set descriptions to the supplement including more text and description to the figures. The discussion of the results e.g. with ENSO index and PDO is mainly qualitatively, some quantitative measures should be added.

Major comments:

1. Section 2.1: This section should be shortened and only the key facts of the CRIS data set relevant for the interpretation of the results should be mentioned. The other part can be moved to the supplement part. Line 90: Is the information about AMSU relevant for CIRS, if yes, this yields to some restrictions for the application of the new ANN-based method.

2. Section 2.2: This section can also be shortened or some parts can be moved to the supplement. E.g. the ERA-Interim description, TIGR data set.

3. Section 2.3: This section can also be shortened or some parts can be moved to the supplement.

4. Line 223 ff: the absolute number of pattern (samples for training/test/validation) should be given. These values are important for the interpretation of the results in Tab. 2 as well as for Fig. S1 and S2. For the latter ones, it should be explained why the number of epochs is different for the different data sets and what was the stopping criteria for the training of the ANN.

5. Line 280 ff.: The different types of models should be given in a bullet list or table with corresponding labels given in Tab. 2 and streamlined with the labels in Fig. S1, S2.

6. Tab. 2 & 3: In these tables as well as in the discussion of it, relative error measures should be given, too. It would be good in order to judge the approximation and generalisation accuracy of the ANN it would be good to have the mean absolute percentage error (MAPE) in addition.

7. Fig 13 & 14: It is hard to compare the different panels of these figures and the usage e.g. for upcoming climate studies. It would be better to have only one panel of the total net HR. Furthermore in order to judge the influence of the ENSO index, PDO and surface temperature (see Fig. 12) to total

net HR over time in a more quantitative way, mean total net HR time series data for different pressure layers (e.g. low, middle, high) should be correlated to the time series data of Fig. 12.

Minor comments

1. Line 255 ff. There are techniques available to deal with partly missing values in the target vector. The target vector can be masked for valid/not valid training value in the target vector. Then only for the valid elements in the target vector, the error in backpropagated during training. For not valid elements (NaN) the error is set to zero. This is a proven concept for training of ANN with incomplete target vectors.

1. Line 423 & 424: ".. is 24% larger, larger than 21% found by Li … " needs some clarification

2. Line 578: data processed for 30N to 30S; but only results of latitude band 15N to 15S are shown (Fig. 10).

3. Fig. 7: the data sources should be mentioned in more detail.

4. The quality of some figures should be improved e.g. Fig. 6 (use of vector instead of raster graphics is highly recommended)

Recommendation:

The developed method to derive high resolution 3D HR in the inner tropics uses a lot of different model data: CRIS, ERA-interim, MOIDS AOD. Each of the models mentioned has its own errors and bias which are described well in paper. ANN can handle systematic model error of the input data well, but if one or more models will change over time (which is likely for such kind of long term data sets) the trained ANN model for the generation of 3D HR data will generate most likely biases. ANN are also not able to cope for random errors in the model input data.

This can be omitted if the original satellite data (in this case AIRS spectral radiance data) are used with full spectral resolution as input data. This makes the ANN HR model more applicable and more robust especially in order to transfer this approach to other IR sounder data (e.g. IASI) for further studies. For transfer of a trained ANN model on AIRS data e.g. transfer learning techniques can be used to adapt it for IASI.