Machine learning of cloud types for evaluation of climate models and constraining climate sensitivity

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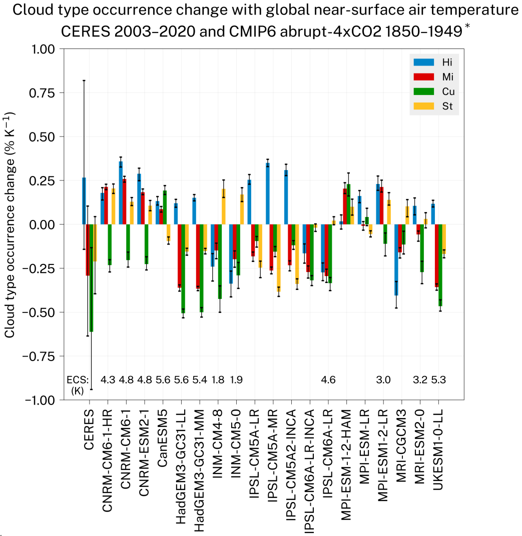
Introduction

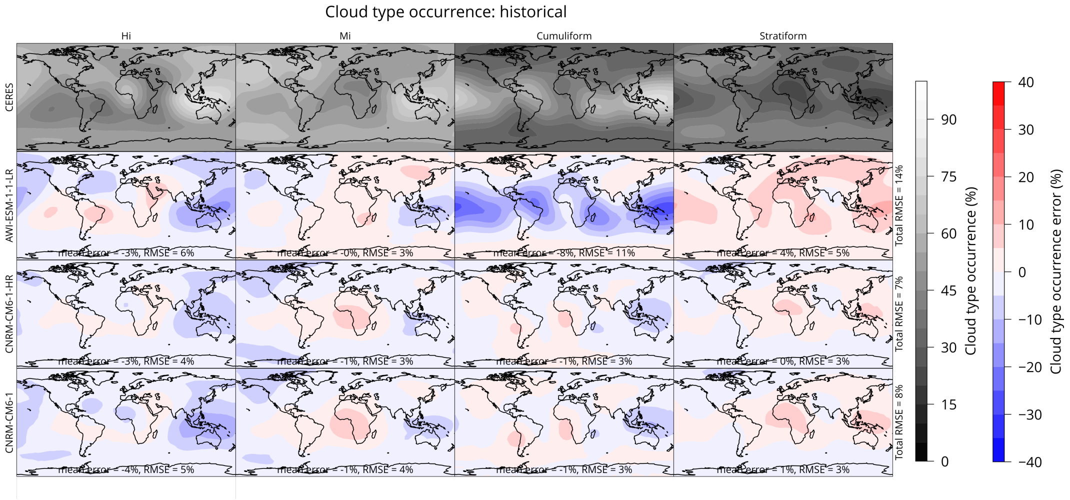
- Deep convolutional artificial neural network (TensorFlow) for determination of cloud types in low-resolution daily mean top-of-atmosphere shortwave and longwave radiation images, corresponding to the classical cloud types recorded by human observers in the Global Telecommunication System (GTS).
- Training phase: CERES top of atmosphere radiation.
- Samples: 4000×4000 km samples, 20 per day, centred at random geographical points.
- Labels: Cloud genera as reported by stations within a sample.
- Cloud classes grouped into four classes: cumuliform (Cu, Cb), stratiform (St, Sc), middle (As, Ac), high (Ci, Cs, Cc).
- Application phase: CERES and CMIP6 historical and aburpt-4xCO2 experiment to determine long-term change in cloud type occurrence in these models with increasing CO2 concentration.

Comparison of the CMIP abrupt-4xCO2 experiment with CERES



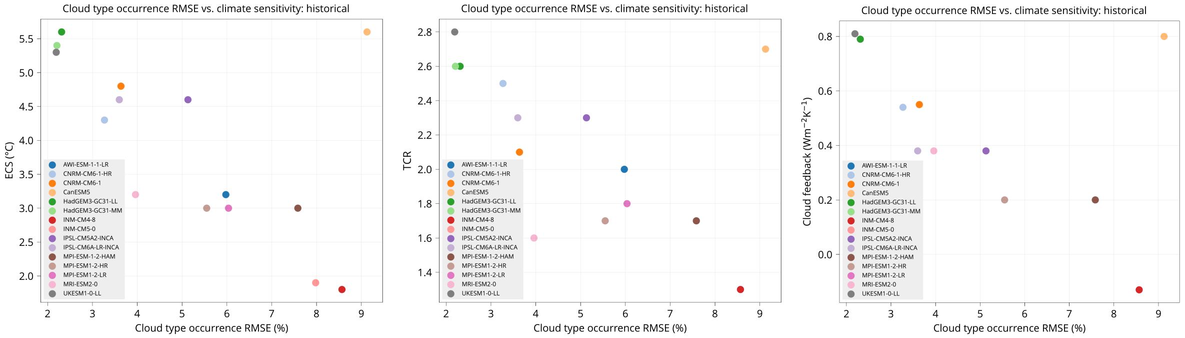
*68% error bars and confidence bands.

Comparison of the CMIP historical experiment with CERES



and more models (see our poster on Wednesday)...

Relationship between cloud biases and climate sensitivity



Conclusions

- We developed an artificial neural network (ANN) to identify the occurrence of cloud types in satellite and model data.
- The types correspond to WMO cloud genera, grouped into 4 groups: high, middle, cumuliform and stratiform.
- The training was based on WMO ground station reports and CERES.
- We find large differences between CMIP6 models in their cloud type occurrence relative to CERES.
- The root mean square error (RMSE) of a model correlates strongly with the model equilibrium climate sensitivity (ECS).
- Models with smaller error have greater ECS, transient climate response (TCR) and cloud feedback.