Part II:
The application of a neural network to the length record of the Mer de Glace

Summary

A new suitable statistical approach to simulating glacier variations is the application of a neural network model, especially in combination with high-resolution climate data. In the present study, a non-linear back-propagation neural network model is successfully applied to simulate glacier variations of the Mer de Glace (Mont Blanc area, France), using multi-proxy reconstructions of seasonal temperature and precipitation back to 1500.

The neural network model is trained with high-resolution climate data (input data) and glacier length variations of the Mer de Glace (output data; cf. Part I of this issue). In the absence of glacier length data before 1570, the application of a neural network model yields plausible qualitative reconstructions of glacier fluctuations for the 16th century (glacier maximum around 1565, minima around 1552 and 1575).

In addition, future glacier length variations of the Mer de Glace are simulated using two climate scenarios. The first scenario assumes no changes in mean climate, the second scenario embodies higher temperature and changing precipitation values. Confronting current climate change, the more likely scenario 2 shows a continuous and remarkable retreat of the Mer de Glace until the end of the simulation period in 2042. The prediction for scenario 1 indicates a glacier front position in 2042 around that of the present-day. For both scenarios, the simulation period ranges from 1900 to 2042, showing a very good accordance between the simulated curve and the measured glacier front values for the 20th century. The glacier responses significantly distinguish between the two scenarios, showing the key role of glaciers for the detection of climate changes.

Moreover, the utilization of the neural network model as a sensitivity analysis tool suggests that the Mer de Glace is more influenced by temperature than precipitation, in contrast to the Unterer Grindelwaldgletscher (Bernese Alps, Switzerland). Finally, this non-linear neural network approach is a new contribution to the various investigations of the complex glacier-climate system, which allows finding explanations for several glacier advances and retreats. Even though the relationship between glacier length and climate parameters is not easy to determine, clear statements concerning glacier reaction to climate variables are possible.