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An artificial neural network technique for downscaling GCM outputs to RCM spatial scale

网格分辨率1.89度　网格间距25km

本文基于ANN中的MLP方法，针对欧洲地区进行降尺度。
时间：1960-2100
空间：entire European region
变量：Temperature and Rainfall(T and R)
输入：GCM　　输出：RCM

方法：

1. T和R在ANNs中分别进行训练；
2. ANN训练得到的实际值与真实值之差成为error（误差E），通过调整ANN权重以求得E的最小值，采用back-propagation algorithm；
3. 为了防止过拟合的出现，将时间片段再细分成训练集和测试集两种。在一次训练完成后，如果E在训练集持续下降但实在测试集中持续上升，则被诊断为过拟合并停止此次训练过程；
4. 由于GCM和RCM的网格尺度在空间上并不完全一一对应，并且RCM具有较高的空间分辨率，因此，对于任意一个RCM网格点，其周围的4个GCM网格点都被当作输入——NE/NW/SW/SE (Sooooo important!)；
5. 为了提高ANN训练的有效性，将所有输入变量进行标准化

结果：

In this case, the interest was in establishing the relation- ship between GCM and RCM output parameter fields, specifically temperature and rainfall (T and R).

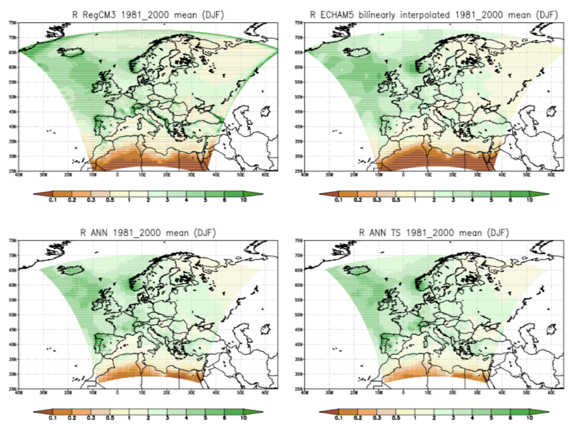

Fig. 2. DJF climatological mean R (mm day^{-1}) for Europe, 1981–2000. From RCM, GCM bilinearly interpolated to RCM scale, EurANN (ANN trained over the full European domain), and EurANNTS (Time-slice ANN trained over the full European domain).

The ANN R field does represent several features of the RCM field better than the GCM, such as the high precipitation over North-West Spain and Portugal. However some of the more detailed features such as enhanced rainfall over the mountainous coast of Croatia, and the extent of enhanced rainfall over the Alps, are not captured by the ANN.

因此，作如下改进：

It then remains to be seen whether the ANN can correctly reproduce the climate-change (CC) signal shown by the RCM over Europe.

结论：

As the ANN is capable of reproducing the RCM 1981– 2000 mean fields reasonably accurately and consistently, this failure to consistently reproduce the CC signal must be due to an inability to correctly reproduce the 2081–2100 fields. The ANN was trained with data from 1960–1980, and the successful application of the ANN to other time periods re- lies on the relationship between input and output data remaining constant with time and changing climate. This assumption appears to hold for the validation period of 1981–2000, which is close to the training period, but may break down for time periods further in the future such as 2081– 2100.

	Europe			Med		
	EurANN	EurANNTS	Lapse-rate/GCM	MedANN	MedANNTS	GCM
R Bias (mm day^{-1})						
DJF	−0.247	0.068	0.023	0.316	−0.023	−0.037
MAM	−0.255	0.065	0.035	0.071	0.087	0.131
JJA	−0.358	−0.055	−0.073	−0.319	−0.105	−0.053
SON	−0.300	−0.005	−0.016	0.278	0.599	0.517
R RMSE (mm day^{-1})						
DJF	0.292	0.161	0.169	0.417	0.187	0.152
MAM	0.286	0.162	0.163	0.245	0.173	0.207
JJA	0.367	0.149	0.169	0.320	0.124	0.091
SON	0.328	0.147	0.173	0.287	0.231	0.247
R Corr						
DJF	0.750	0.887	0.803	0.395	0.696	0.831
MAM	0.793	0.889	0.850	−0.072	0.562	0.207
JJA	0.728	0.764	0.654	0.561	0.636	0.567
SON	0.556	0.756	0.622	0.278	0.599	0.517