WeeklyNote

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張慕琪

Spatial Interpolation of Surface Air Temperatures Using Artificial Neural Networks: Evaluating Their Use for Downscaling GCMs

SETH E. SNELL

Department of Geography, University of New Mexico, Albuquerque, New Mexico

SUCHARITA GOPAL AND ROBERT K. KAUFMANN

Department of Geography, Boston University, Boston, Massachusetts

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Introduction

如今GCMs的精度范围为2.5* 2.5～8*10(lat and long)。

仍有几个因素主导了GCMs进行降尺度的难度：一些气象要素例如温度和降水会随着地形而改变；大多数的变量在空间中并非是一阶或者二阶稳定的；大多数气象变量会受到其他气象条件的影响，例如湿度、压力场和锋面边界。

因此，对GCMs进行传统的空间插值方法效果较差。

Methods

1. 研究地区：美国中部地区的11个台站
2. 研究时间：1931-1993（63-yr）
3. 数据来源：National Oceanic and Atmospheric Association(NOAA) ground weather stations(NCDC 1994)
4. 研究变量：Tmax
5. 使用模型：多层前反馈后向传播ANN(multilayer feedforward backpropagaiton ANN)

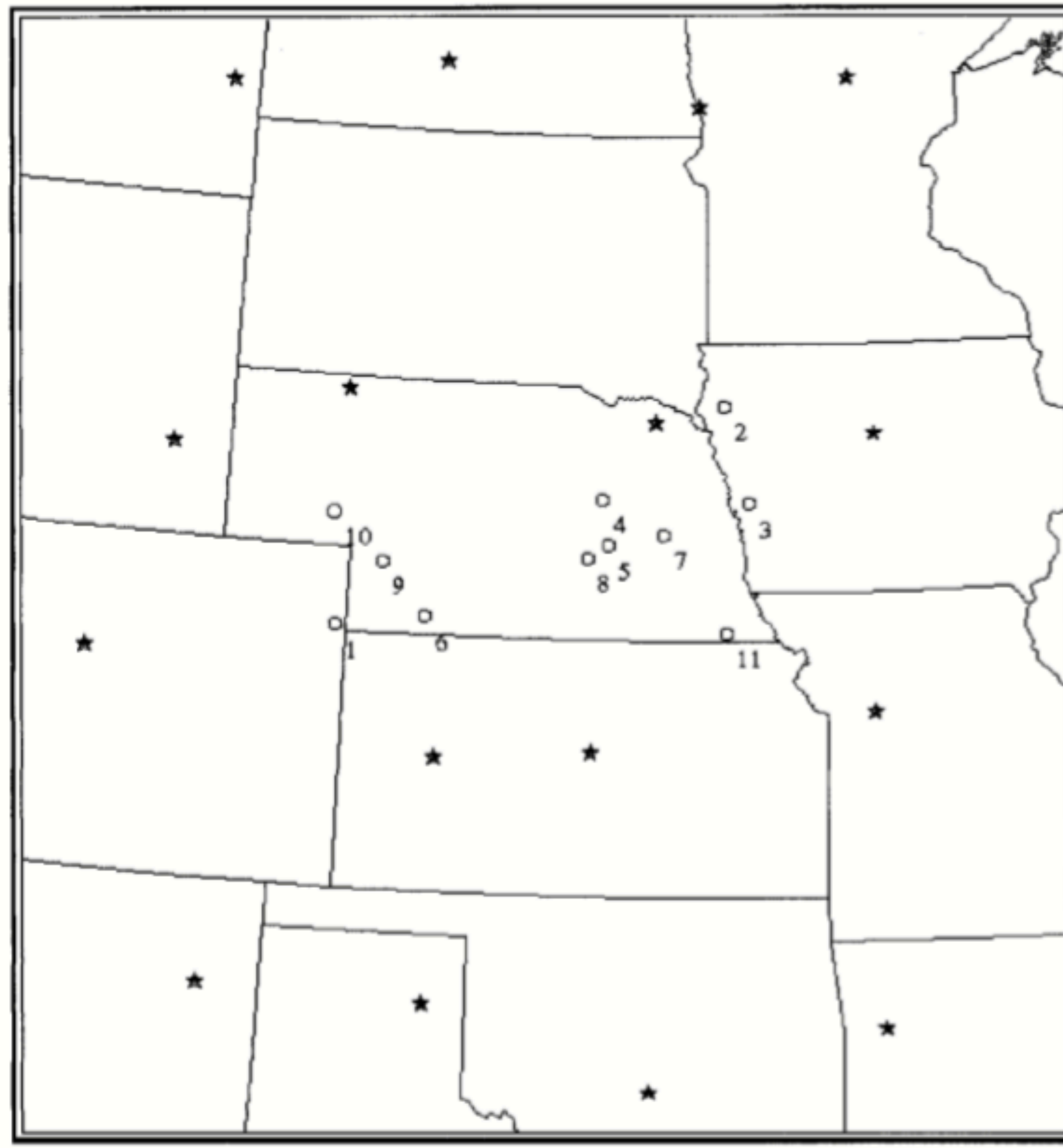

FIG. 1. Map of the study area. Stars depict grid of input NOAA weather stations. Open circles are 11 NOAA weather stations within the grid at which estimates are made.

Methods

1. 独立的两个网络（4—>1, 16—>1）
2. 激活函数使用sigmoid；
3. 隐藏层设置：4-point ANN有30个节点，16-point ANN有54和隐藏节点；
4. 数据划分：80%(14624 days)训练集+20%(2924 days)验证集，随即产生，共运行5次。

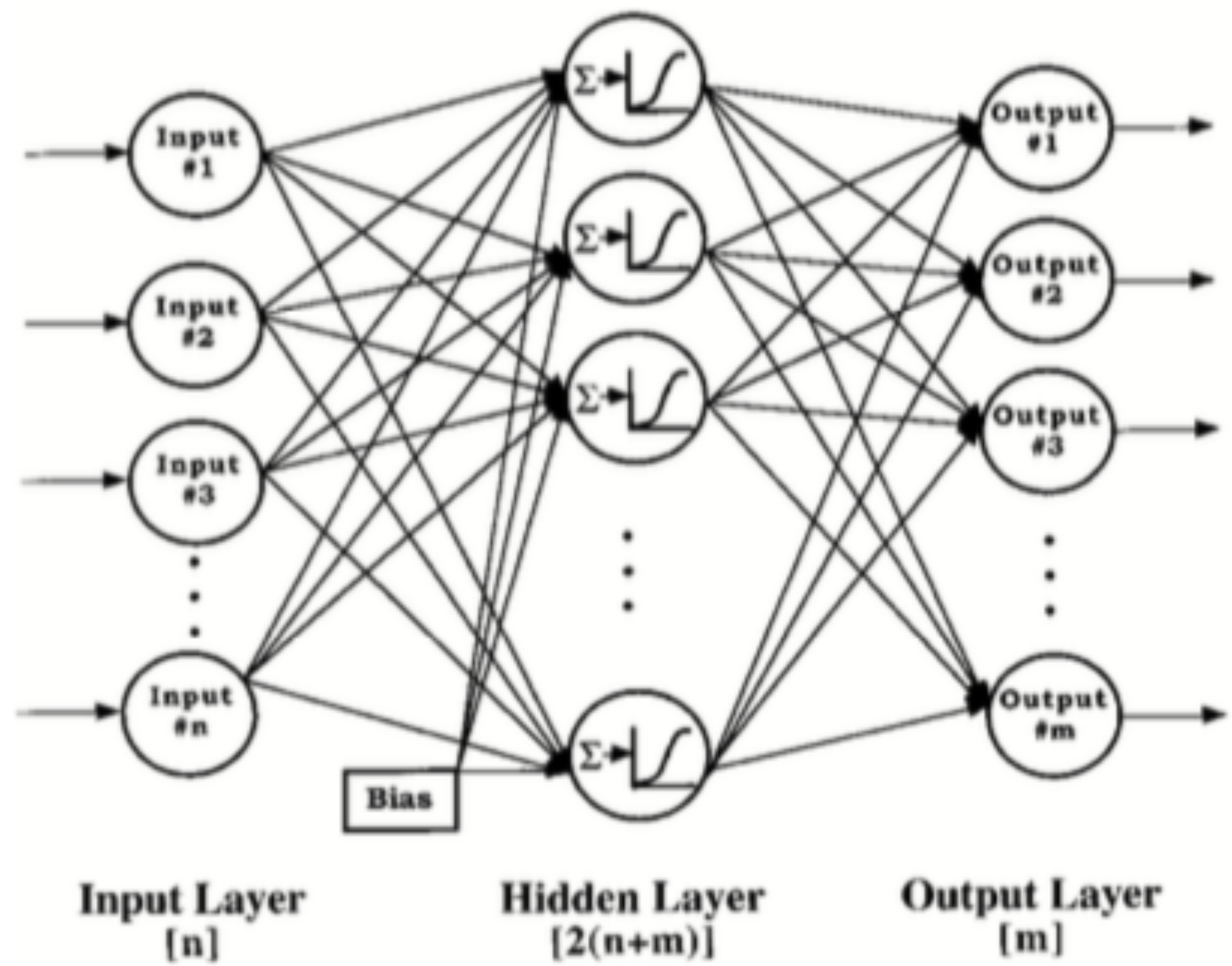

FIG. 2. ANN architecture used to interpolate maximum daily surface air temperature.

Results

在训练的前期，ANNs表现较差（RMSE较大且不稳定），这表明此时的ANNs还没有学习到输入变量和输出变量间的关系；

4-point的RMSE在第50000次时间间隔时达到最小值，16-point的RMSE在第75000次时间间隔时达到最小值；

超过这个时间节点后，即使再继续训练也不会再改变RMSE的表现，这说明较长时间的时间间隔并不会提升模型的水平。

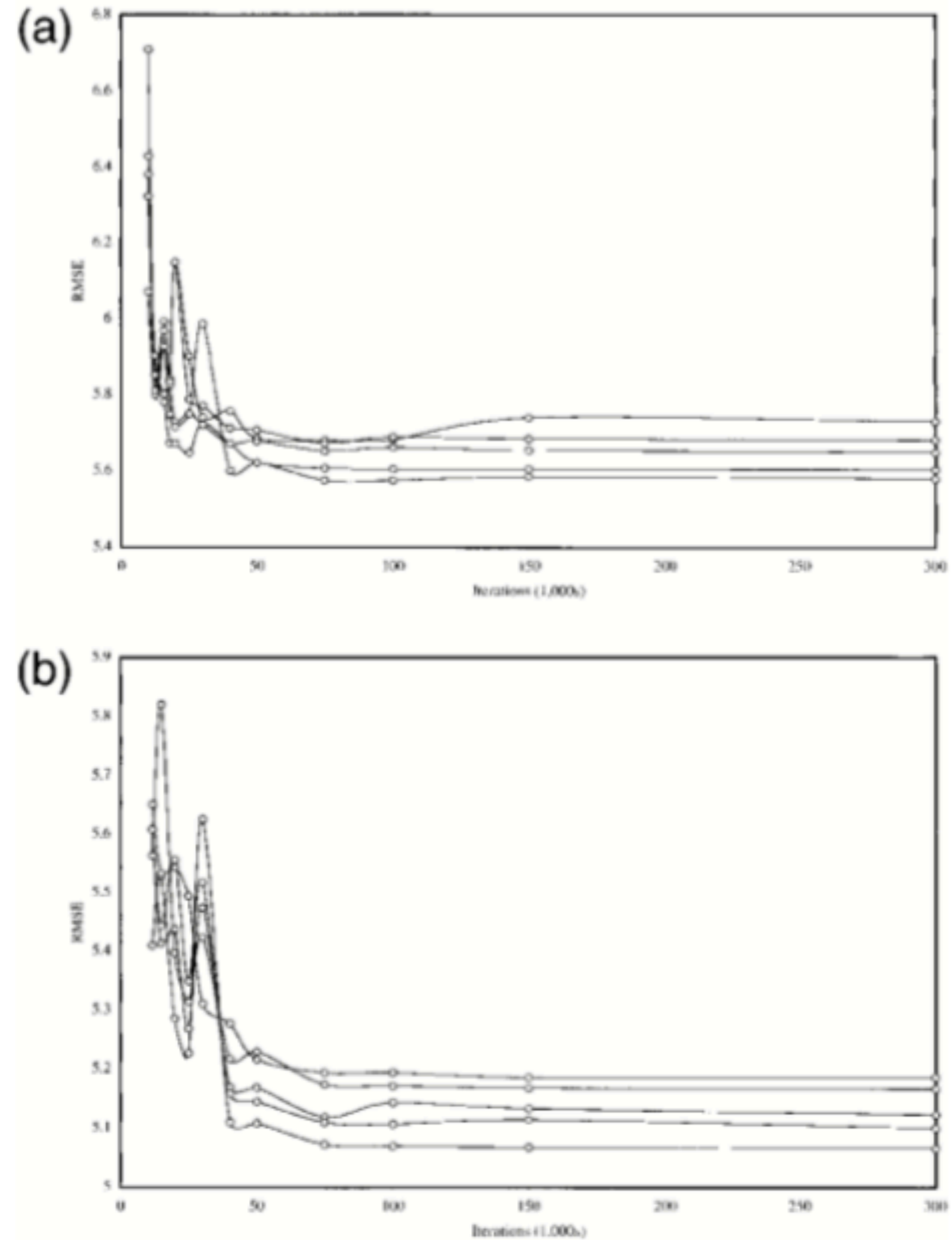

FIG. 3. (a) Rmse on test data at various training intervals for the 4-point ANN for five random divisions of the testing and training datasets. (b) Rmse on test data at various training intervals for the 16-point ANN for five random divisions of the testing and training datasets.

Results

16-point在station 6表现最差，而在station 2的表现最佳；
RMSE的表现和R^2大体一致；
4-point对于station 6的表现也最差。

TABLE 1. Overall performance measures. RMSE and R^2 for test dataset using the 4-point and 16-point ANNs by station and on average across stations.

	4-point ANN		16-point ANN	
	rmse	R^2	rmse	R^2
Station 1	6.123	0.916	5.889	0.922
Station 2	5.230	0.954	4.131	0.971
Station 3	5.409	0.947	4.125	0.969
Station 4	6.741	0.917	6.036	0.934
Station 5	4.905	0.956	4.664	0.960
Station 6	6.929	0.905	6.697	0.911
Station 7	6.158	0.932	5.340	0.949
Station 8	5.313	0.949	5.110	0.953
Station 9	4.994	0.951	4.761	0.955
Station 10	5.566	0.932	5.064	0.944
Station 11	5.268	0.946	4.488	0.961
Average	5.694	0.937	5.119	0.948
Minimum	4.905	0.905	4.125	0.911
Maximum	6.929	0.956	6.697	0.971

Results

TABLE 2. Test results for systematic bias. Regression coefficients from Eq. (1) for each station for the predicted output from the 4-point and 16-point ANNs. Bracketed values are p values for t statistics testing significant differences for α and β from 0 and 1, respectively. Values significant at $p < 0.05$ are in boldface.

	4-point ANN		16-point ANN	
	α	β	α	β
Station 1	0.464 [0.243]	0.992 [0.156]	0.693 [0.068]	0.989 **[0.043]**
Station 2	−1.380 **[0.000]**	1.007 [0.100]	−0.163 [0.434]	1.004 [0.261]
Station 3	−0.514 [0.076]	0.993 [0.123]	0.273 [0.213]	0.999 [0.819]
Station 4	−0.504 [0.166]	0.988 **[0.029]**	0.211 [0.518]	0.997 [0.564]
Station 5	−1.735 **[0.000]**	1.003 [0.459]	−0.148 [0.566]	1.001 [0.811]
Station 6	0.091 [0.828]	0.991 [0.151]	−0.063 [0.876]	0.998 [0.750]
Station 7	−0.343 [0.296]	0.986 **[0.004]**	0.554 [0.052]	0.993 [0.110]
Station 8	−0.805 **[0.005]**	0.999 [0.746]	0.351 [0.205]	0.996 [0.307]
Station 9	−0.299 [0.313]	1.001 [0.726]	0.242 [0.388]	0.996 [0.329]
Station 10	−0.080 [0.814]	0.994 [0.193]	0.477 [0.119]	0.992 [0.087]
Station 11	−1.069 **[0.001]**	1.002 [0.694]	−0.137 [0.602]	1.005 [0.144]

$$T\max_{it} = \alpha + \beta\hat{T}\max_{it} + \mu_{ij},$$

对于16-point，仅有一个未通过t-test；而4-point ANN有很明显的bias，截距在station2，5，8和11远小于零，斜率在station4和7明显小于1；因此16-point要明显优于4-point。

Conclusions

1. 采用16-point ANN的网络要比4-point的网络表现更好;
2. 这也可以表明使用ANNs对于GCMs的表面温度进行降尺度是一个叫有效的方法，ANNs可以抓住非线性系统中的复杂联系并学习空间中的相关之处。

谢谢