Assimilating Various Fields from Historical Documents: Idealized Experiments

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1. Introduction

It is important to understand the historical climate because the information from historical climate indicate previous states of the Earth in the past and the changes that have undergone. This information is helpful to better predict the future climate. However, observation instruments were not available in the past before the modern technology. Thus climate proxies are used as an alternative to estimate the historical climate. There are various type of proxies such as tree ring data, coral data, isotope data, ice core data and historical document data. However, most of these proxies are limited to annual or decadal temporal resolution. In this research, we focus on daily scale reconstruction in 18th and 19th centuries. Hence, historical documents such as personal diaries which have daily written information about whether can be used. These diaries consist of a small description of whether such as ‘sunny day’ and ‘rainy day’ (Minoru Yoshimura, 1993). Even though this information is quite uncertain, previous idealized experiments have shown that there is a potential to extract useful information from such kind of data (Toride and Yoshimura, 2014) In this study, we further carry on idealized experiments using Japan MeteoRological Agency (JMA) data after adding a mock error to represent the uncertainties of the diaries. Further on we have carried out sensitivity experiments with these data to check the possibility of assimilating different fields such as solar radiation or precipitation. More details are given under the next section.

2. Data and Methodology

The Global Spectral model (GSM) of National Centres for Environmental Prediction (NCEP) was used as the climate model with the Local Ensemble Transform Kalman filter (LETKF) (Harlim and Hunt, 2005) as the data assimilation scheme. This model was setup similar to Yoshimura et al. (2014). Japan MeteoroLological agency observation (JMA) data was used to mock the actual historical data. To consider the uncertainty and the availability of data, 17 stations were used while adding a random error to represent the uncertainty. The model was spun up for one year from 2005 to 2006 and then the model is initialized with 20 ensembles with a different date. The experiments were carried out for a period of two months from January to March while assimilating the daily average variables at a single time step during each day.

Fig. 1: Improvements to cumulative cloud cover content (%) by assimilating other variables, (a) solar radiation (b) zero precipitation events and cumulative cloud cover
3. Results

Fig. 1 shows assimilation of one variable affect other variables. The resulting cloud cover is different from only cloud assimilation and the sensitivity depends on the accuracy and the relationship of the variables. Daily assimilation of solar radiation has a strong effect on clouds while the assimilation of no rainy days helps to reduce unrealistic precipitation events. The direct impact on the assimilated variables are very clear according to results at a random observation point as on Fig. 2 and Fig 3. The zero precipitation assimilation mitigates the non-realistic precipitation events reducing the RMSE from 12.4 to 10.0 mm/day while the solar radiation assimilation improves the model's the solar addition considerably by reducing RMSE from 68.3 to 19.1 W/mm².

4. Summary

Idealized experiments show that it is possible to improve the other fields by assimilating of different variables. Even though the amount of precipitation cannot be retrieved from diary data, information such as no rainy days can be used to remove unrealistic precipitation events. Further experiments with different variable combinations and uncertainties have to be conducted to achieve optimum results.

Acknowledgement

The author Panduka Neluwala was supported by a scholarship from Ministry of Education, Culture, Sports, Science and Technology of Japan during the study.

References


Keywords:

Historical Climate Reconstruction, Historical Documents, Data Assimilation