Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)
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AAS004-03 Room: 101 Time: May 28 09:30-09:45

Reconstruction of Near-Global Precipitation Variations Based on Gauges and Correlations with SST and SLP

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Over the last 15 years a number of methods were developed for reconstructing near-global temperature and surface pressure variations using historical data and reconstruction statistics. Reconstruction statistics are based on the more dense modern data, and satellite data are especially valuable because of their more nearly complete sampling. Those reconstructions help to more clearly show climate variations over more than a hundred years. Reconstructions are especially valuable over the oceans where data are limited, and both sea-surface temperature (SST) and sea-level pressure (SLP) variations have been reconstructed using mostly for historical ship observations. Oceanic precipitation is another important climate variable, and a reconstruction of that would also be of value. However, historical oceanic precipitation data are limited because historical ship reports are typically only qualitative if they exist at all. In addition, individual precipitation events have smaller time and space scales than SST or SLP, making the available ocean-area records less representative of large-scale monthly or longer-term variations.

Using satellite-based precipitation estimates for reconstruction statistics, several groups have attempted to reconstruct monthly-average historical precipitation over oceans from land and island gauge variations. Those studies use the largest land-sea spatial modes to estimate ocean-area variations associated with the modes. A weighted sum of the modes is formed using the land and island historical gauge data to determine the best weights for the modes. This method works best for precipitation associated with large-scale modes accounting for large parts of the variance, such as ENSO or NAO. In our experiments we first tested this gauge-based method, making improvements where possible. We found that this method can resolve much of the oceanic interannual precipitation variation. For multi-decadal variations we found this method to be less reliable. Those variations account for less overall variance than interannual modes like ENSO, and may need more sampling to be reliably reconstructed. Therefore we developed a second reconstruction method that indirectly estimates precipitation from SST and SLP. This indirect method does not use the gauge data, but it is able to reconstruct large-scale land variations where gauges are available. Over the oceans the indirect method shows increasing interannual variations, consistent with theoretical estimates for a warming world. These two reconstructions, one direct from land and island gauges and the other indirect for correlations with SST and SLP, are combined to form a monthly reconstruction of historical precipitation beginning 1900.