An Analysis of Daily Precipitation over East Asia: Current Status and Future Improvements

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Abstract

A new gauge-based data set of daily precipitation has been created on a 0.5°lat/lon grid over the East Asia for a 20-year period from 1978 to 1997 for meteorological and hydrological applications.

Keyword: precipitation, daily, East Asia, gauge.

1. Introduction

As part of the Yellow River Project, a suite of daily precipitation analyses products are being constructed for potential applications in meteorological, hydrological and water resources research. The product suite, designed to best take advantage of the available information to meet the needs for various programs, is composed of three major components: i.e. 1) a gauge-based analysis on a 0.5°lat/lon grid over the East Asia (65°E-155°E; 5°N-60°N) for an extended period from 1978 to the present (the Base Product); 2) a gauge-based analysis on 0.1°lat/lon grid over the Yellow River Basin (the Derived Product); and 3) a satellite-gauge merged analysis on 0.25°lat/lon grid over the East Asia over both land and ocean for a recent period (The Merged Product).

The gauge-based analyses are the mainstay of the products, both for their extended temporal coverage and for their role in determining the magnitude of the precipitation fields in the merged analysis. As of October, 2004, the gauge-based analyses have been created for a 20-year period from 1978 to 1997 and the prototype algorithm for combining the satellite estimates and the gauge observations has been developed.

In this paper, we describe the construction of the gauge-based analyses and their quantitative accuracy.

2. Methodology

The overall strategy for constructing the gauge-based daily precipitation analyses is a modification of Chen et al. (2002), which was originally designed for interpolation of monthly precipitation over the global land areas.

The creation of the daily precipitation analysis is conducted in three steps. First, a gridded analysis of daily precipitation climatology is created for each of the 365 calendar days. For this purpose, daily precipitation climatology are defined for all stations with 90% or higher reporting rates by accumulating the first 6 harmonic components of the 365-day time series of the 20-year (1978-1997) mean values. Analyzed fields of daily precipitation climatology are then defined by interpolating the station climatology and by adjusting it against the PRISM (Daily et al. 1994) monthly climatology over China and Mongolia and against the PREC/L (Chen et al. 2002) elsewhere. The purpose of this adjustment is to better represent the orographic effects in precipitation that are not accounted for in the interpolation of the station climatology.

The second step of the algorithm involves the definition of an analyzed field of ratio of daily precipitation to daily climatology. This is done by interpolating the corresponding station values, defined as the ratio of daily observation at a station to the daily climatology at the grid box at the gauge location, using the Optimal Interpolation (OI) algorithm.

In the final step, the analysis of total daily precipitation is calculated by multiplying the analyzed daily climatology with the ratio.

In creating the products, the analysis is first produced on a 0.05°lat/lon grid over the entire East Asia domain. The Base Product and the Derived Product are then computed by averaging the values at the 0.05°lat/lon resolution. A gauge-based analysis on 0.25°lat/lon is also created for use as input to the Merged Product, ensuring quantitative consistency among the various products.

3. Gauge Data

Station observations of daily precipitation from three individual data sets are used to construct the gauge-based analyses over the East Asia. These are the Global Telecommunication System (GTS) daily summary files archived by the NOAA Climate Prediction Center (CPC) for a period from 1977 to the present; a personal collection of Chinese daily observations (CHN) at over 700 stations for a period from 1971 to the present; and the daily gauge data at over ~1000 hydrological stations from the Chinese Yellow River Commission (YRC) for a period from 1930S to 1997. Since most of the GTS stations are included in the CHN data set, only daily observations from CHN and YRC data sets are used inside China, while the GTS gauge data

are used over the regions outside China. Combined, observations of daily precipitation at over 3000 stations are available over the target domain. Fig.1 shows gauge locations from the individual and the combined data sets. Reasonable gauge coverage is available over most of the land areas of the East Asia domain, while network density is very high along the Yellow River, making it possible to create a high resolution precipitation analysis with reliable quality over the region.

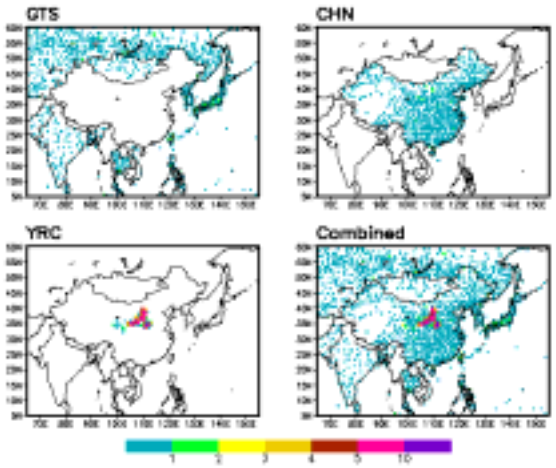

Fig.1: Number of gauges in each 0.5°lat/lon grid box from the individual and combined data sets.

4. Gauge-Based Analyses

As of October, 2004, the gauge-based analyses of daily precipitation have been generated for a 20-year period from 1978 to 1997. Presented in fig.2 is an animation of the daily precipitation maps for a 31-day period from July 1 – 31, 1997. Day-to-Day variations of precipitation are well captured in our gauge-based products.

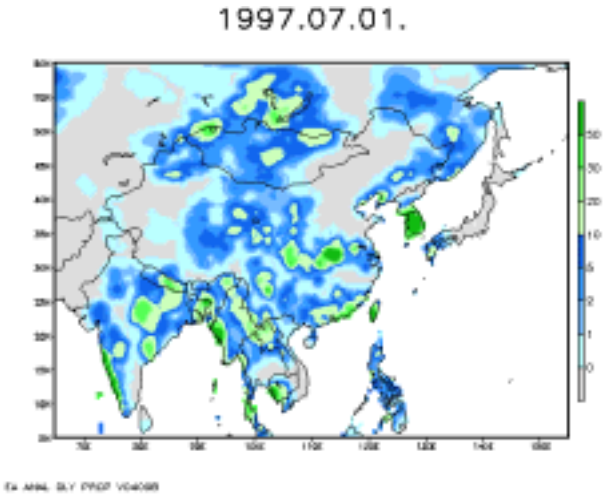

Fig.2: An animation of daily precipitation maps (mm/day) for a 31-day period from July 1 – 31, 1997. This animation is based on the Base Product on 0.5°lat/lon resolution.

5. Quantitative Accuracy of the Analyses

Cross-validation tests are conducted to examine the quantitative accuracy of the gauge-based analyses. For this purpose, daily precipitation observations at 10% randomly selected stations are withdrawn and the daily data over the remaining 90% stations are used to create the gauge-based analyses as described in section 2. This process is repeated for 10 times so that each station is withdrawn once. The withdrawn gauge observations are then compared with analyzed daily precipitation at the 0.05°lat/lon grid box where the gauge is located. Table 1 presents the comparison results for a 365-day period of 1997. The biases are very small for all stations, indicating that the daily analysis has very good overall magnitude agreements with the observations. The correlation between the analyzed daily precipitation and the withdrawn (independent) gauge observations is 0.504 for GTS stations which are sparsely distributed, while it reaches 0.860 for YRC stations that are very densely distributed. Overall, the correlation for all stations combined is 0.594, suggesting good performance of the analysis in representing variations of daily precipitation on a spatial scale of 0.05°lat/lon.

Table 1: Cross-Validation Results for 1997

Stations	Mean (mm)	Bias (mm)	RMSE (mm)	Corr.
ALL	1.972	0.036	7.194	0.594
GTS	2.590	0.086	10.122	0.504
CHN	2.211	-0.009	5.801	0.716
YRC	0.913	0.005	2.131	0.860

Dependence of the performance of the gauge-based analyses on gauge-network density can be further explored by comparing the statistics for grid boxes with various network densities. Fig.3 presents the scatter plots between the analysis – gauge observation correlation and the distance to the closest gauge location. It is very clear that the correlation, or the quality of the analysis, improves as the gauge network becomes denser.

One of the areas with relatively poor gauge coverage is the South East Asia. To further investigate how the current version of our gauge-based analysis may be improved by including more station observations, a variation of the analysis is constructed for the 365 days of 1998 using GTS, CHN and gauge observations at ~1000 additional stations collected by the GAME project. Fig.4 shows the maps of daily precipitation and gauge locations for products with and without the GAME gauge data. Derived from gauge observations of GTS and CHN stations, the current version of the analysis (right side) missed some important features of precipitation over Nepal, Myanmar and Thailand where the GTS gauge network is too sparse to represent the spatial distribution patterns of daily precipitation. Including additional gauge over the region greatly improves the quality of the analysis over the region.

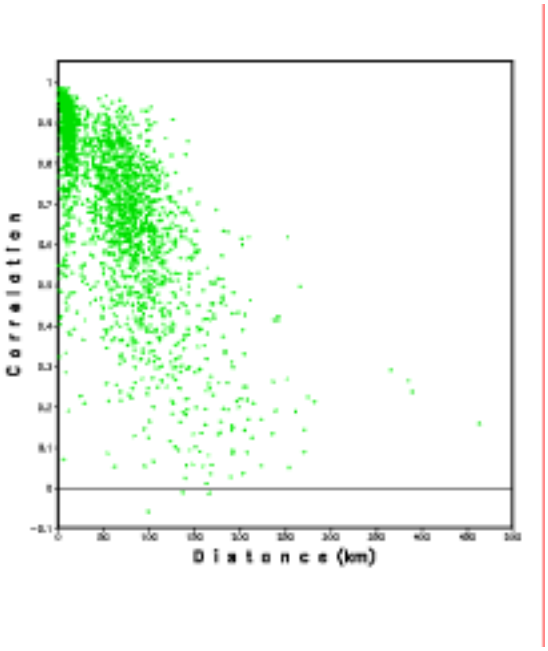

Fig 3: Scatter plots between the analysis – gauge observation correlation and the distance to the closest gauge.

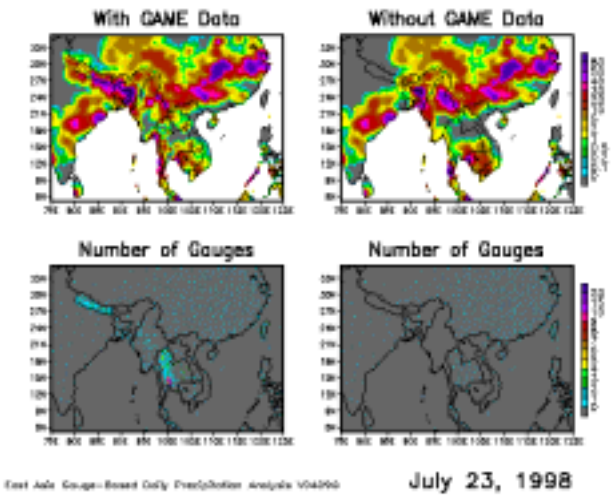

Fig.4: Maps of daily precipitation (top, mm/day) and number of gauges in a 0.5°lat/lon grid box (bottom) for the analyses with and without additional GAME gauge data.

6. Summary

An analysis of gauge-based analysis of daily precipitation has been constructed on a 0.5°lat/lon grid for a 20-year period from 1978 to 1997 by interpolating observations from over 3000 stations collected in three individual data sets.

The analysis is capable of representing precipitation variations with good quality over most of the regions and its quality depends primarily on the gauge-network density.

A variation of the analysis is created for 1998 using additional gauge data collected by the GAME project and the results showed that including more gauges in the data-sparse areas such as the Southeast Asia will greatly improve the quality of our gauge-based analysis.

The Base Product of daily precipitation described in this paper is available to all interested scientists. We welcome collaborations of any form in improving this analysis by refining the algorithm and including more gauge data.

References

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