README document for the APHRODITE V1901 product

& its difference from the previous products (V1101_EX and V1801R1)

1. Introduction

A suite of precipitation products has been constructed by the Asian Precipitation -- Highly-Resolved Observational Data Integration Towards Evaluation of the Extreme Events (APHRODITE-2) project during June 2016 to March 2019. The aim of APHRODITE-2 is to refine APHRODITE algorithm (Yatagai et al., 2009; 2012) to evaluate extreme events and to contribute meteorological analyses including improving forecasts. To achieve the goal, we have improved our algorithm for the three points;

1) improving quality control,
2) careful treatment of “end of the day (EOD)” difference, and
3) modify interpolation algorithm to represent “extreme” values.

We are creating APHRODITE-2 product in collaboration with many friendly researchers and cooperative institutions. We had several workshops and shared our method to the participants. However, not all source codes as well as necessary files were opened. We know that “ratio” interpolation gives much better results especially for the data sparse and/or mountainous regions. Hence, we will release a 0.05 degree precipitation climatology data, as we released 0.05 degree temperature climatology data along with V1808 temperature data.

The three improved points are described in Section 2, and difference of V1901 from the previous products are shown in Section 3. This README also explains the structure of the product in Section 4.

2. Improvements

1) Quality Control (QC)

We are using automatic quality control program (Hamada et al., 2011) and put flags for the suspicious value. If a large value exceeds "country record" of the country, the data was automatically neglected. However, we have sometimes record-breaking heavy rainfall, and sometimes "country record" information of historical maximum is not available. In order to distinguish the real extremes with errors, we compared the large amount values with satellite estimates. Then we put specific errors to "black list" and real extremes to "white list". For V1801 and V1901, we used two satellite products (CMORPH, TRM3B42) to check large precipitation values and isolated extreme values, and to judge whether they are really extreme or not. Then, we rescued real extremes to the white list. During APHRODITE-2, we incorporate making a database (DB) in the analysis flow of making APHRODITE daily grid precipitation database for the fulfillment of the quality control of both original and gridded data (Yatagai et al., 2009a).

2) End of the Day (EOD)

In some countries, precipitation is observed hourly or 10 minutes, and in other countries, precipitation is measured in the morning or at regulated time manually. For example, in India, "daily precipitation" is observed in the morning (8:30 local time, LT), and stamped on that day. 8:30LT corresponds to 03 UTC (universal time). Hence, if station data shows 10 mm/day on August 31st, then, 10 mm rainfall is observed from 03 UTC of August 30th to 03 UTC of August 31st. We call this record as "EOD = 03 UTC". In V1101 and V1801 products, daily grid precipitation data over India ends at 03 UTC of recorded time.

In Japan, we have AMeDAS network based on 10 minutes automatic measurements, and we can accumulate hourly and/or daily values at any interval from 10 minutes observation. In APHRO_JP, we made grid precipitation according Japan standard time (JST), which is from 15 UTC of previous day to 15 UTC of the stamped date. In this case, EOD=15. Further, Japan Meteorological Agency (JMA) sends either 6-hrly, 12-hrly or 24-hrly precipitation to GTS network according to the WMO's regulation. (e.g. Synoptic stations (relatively big station) must send previous 24-hr rainfall at 00 UTC). This leads different EOD data are archived at GSOD database, although it contains flags of their processing. In previous version (V1101), we use only AMeDAS for APHRO_JP, but we used both AMeDAS and GTS based data for APHRO_MA_V1101. So, in V1801, we check EOD of each data file and we carefully select data to use. We decide not to use different EOD data in a domain for V1801. So, the number of data we used in V1801 is sometimes less than that of V1101.

To overcome this, APHRODITE-2 used a satellite (CMORPH) product to judge EOD time, and then we adjusted EOD to 00-24 UTC so that we can use this to validate satellite/model estimates. The number of stations does not decrease.

3) Station Value Conservation

When we interpolate station values (or ratio of the station value to climatology), we take several to several decadal number of station data around the target grid into consideration. Hence, if extremely heavy and localized precipitation occurs at or very near to the grid, using surrounding many station data may cause underestimate of the target grid. In V1801, after interpolation of ratio to climatology and after getting grid precipitation values by multiplying ratio to climatology, we put the original station value to the 0.05 degree grid box, if the grid box has a station. That means, station value is conserved (SVC) at each 0.05 grid box. If there are two or more stations in a grid box, we average them and put the averaged value into the grid box. Same way, if the grid has no rainfall, but if surrounding stations have rainfall, V1101 showed some precipitation. But V1801 and V1901 conserve the station value at 0.05 degree (intermediate) file, we can get statistics of "0 mm" at the grid. For the publicly released data, we regrid 0.05 grid to 0.25/0.5 degree, and station value is no more conserved (see Figures 1 and 2 of V1801R1 readme, http://aphrodite.st.hirosaki-u.ac.jp/product_readme/V1801R1_readme.pdf).

4) New climatology

APHRODITE product is calculated by RATIO (Obs/Clim) interpolation. Climatology of previous products are based on monthly analysis (Yatagai et al., 2012). Now that our project has collected dense observation data, new daily climatology is developed from APHRODITE daily precipitation product.

First, 30 year (1981-2010) daily precipitation product is calculated using previous climatology (WorldClim + Monthly station observation), without SVC. EOD adjustment is not applied, but unmixed EOD source is used for each country. 21-day running mean of daily average for 30 years is defined as new climatology. Data on February 29th of non-leap year is prepared by the average of February 28th and March 1st and 30-year average is carried out for that day.

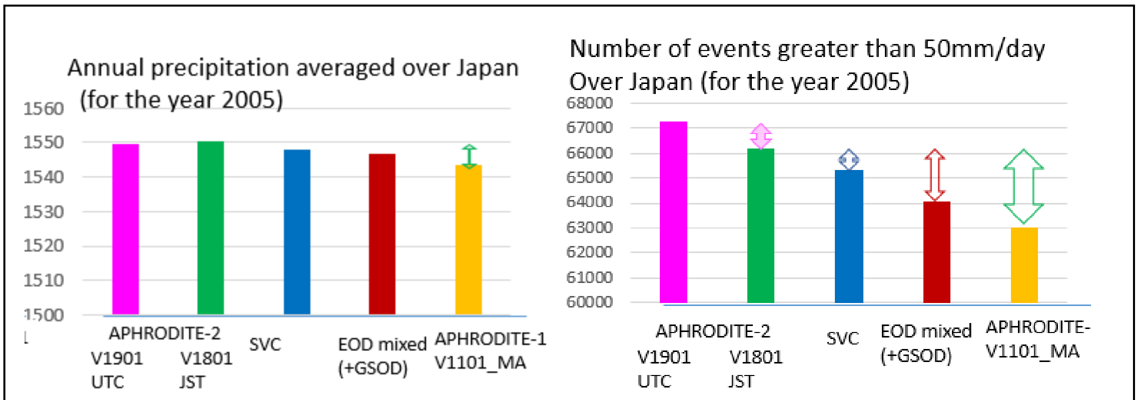

Figure 1. Left: Annual precipitation averaged over Japan; Right: Number of events (day, grid) counted on 0.05 degree grids over Japan for the year 2005. Both parameters increased from V1101 to V1801, and further to V1901. Yellow: V1101, Red: impact test of mixed EOD data, Blue: impact test of station value conservation (SVC), Green: V1801 (Japanese standard time, 15UTC- 15UTC), and Pink: V1901 (Universal time, 00UTC- 24UTC).

3. Difference from the previous products

We tested the relative impacts of 2) EOD and 3) SVC over China and Japan. For China, we mixed 12-hr different EOD time series (Yatagai et al., 2019b), and found 2) was much larger than that of 3) to reproduce extreme precipitation. For Japan, we mixed global summary of day precipitation to AMeDAS stations (Yatagai et al., 2019c). As shown in Figure 1, with reference to V1801 precipitation (Japan standard time, 15 UTC – 15UTC), the previous APHRO_MA over Japan (V1101) which mixed GSOD (GTS based) precipitation has significantly underestimated (4.9%) extreme events (number of events greater than 50 mm/day), in which SVC affects 1.3% and EOD mixed affects 3.5%. For V1901, as we describe below, we sum-up hourly precipitation to the universal time (00-24 UTC) for Japan. The difference between UTC based statistics (EOD=15JST, namely, it accumulates daily precipitation from 3PM to 3PM) and JST stems from heavy precipitation events in the mid-night separated into the two days when we use JST based statistics.

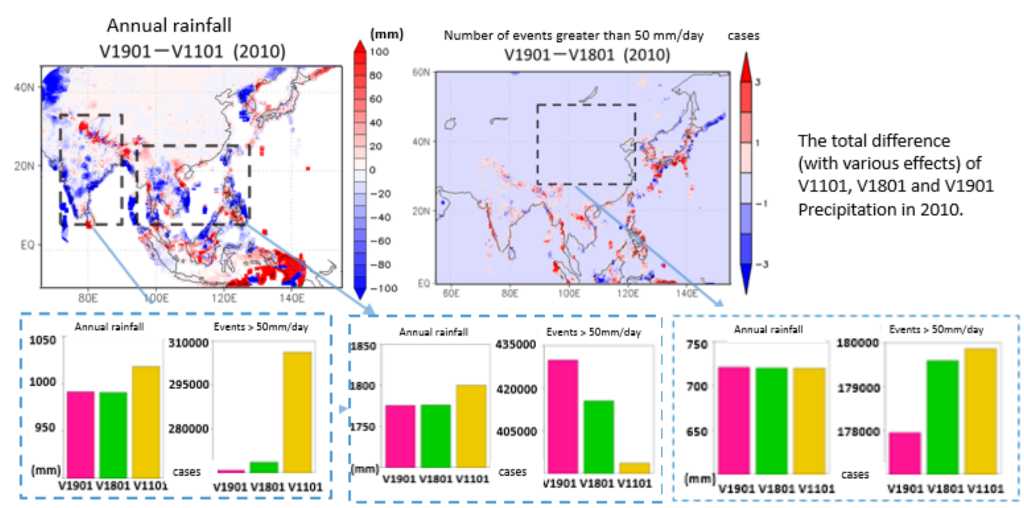

Figure 2 Total difference of annual rainfall and number of events greater than 50 mm/day (extremes) for V1101, V1801 and V1901. Top left shows difference of annual precipitation in 2010 from V1901 and V1101. Top right shows difference in the appearance of extremes between V1901 and V1801 for the year 2010.

Each bar shows area averaged annual precipitation and extremes for V1101 (Yellow), V1801 (Green) and V1901 (Pink).

Since we applied the three improvements and numbers of data used among the three products (V1101, V1801 and V1901) were different. As a total, we compare the two statistics, namely, averaged precipitation and number of extreme events (count events (day

& grid) of more than 50 mm/day, Figure 2). For EOD adjustment by using CMORPH v1.0 product (from V1801 to V1901), total precipitation amount does not change. However, there are regions of both showing increasing extreme events and decreasing extreme events. We are now investigating the reason and statistics.

4. V1901 Product structure

4.1 Period

V1901 is given for 1998-2015, and temporal resolution is "daily."
This "daily" means 24 hour accumulated precipitation through 00UTC-24UTC.

4.2 Region

We use the same domain with that of V1101 and V1801. For monsoon Asia, MA: 60.0E - 150.0E, 15.0S - 55.0N.

4.3. File Name/parameters

Name: APHRO_MA_V1901.yyyy
(yyyy: year)
The product is stored in one file per year.

Parameters: precipitation (mm/day)
RSTN (ratio of 0.05 grid box containing stations (%)

Missing Code: precipitation: -99.9

NetCDF data is also available.

4.4 Structure of Data Files

Each file contains daily fields for 365 (366 for leap years) days. These daily fields are arranged according to the Julian calendar. Daily fields (data arrays) contain information on the precipitation amount and number of ratio of the 0.05-degree cells to each grid (0.25 or 0.5 degree). If one rain-gauge is available at 0.25 degree grid box, rstn = 1/25, and if it is available at 0.5 degree grid box, rstn = 1/100.

Regarding the array with longitude by latitude dimensions of the elements, see GrADS control file.

[Note for plain binary format]

The data files are written in PLAIN DIRECT ACCESS BINARY. In each daily field, the array for precipitation comes first, followed by information on the rain gauge. Each element (both precipitation and rain gauge information) is written as a 4-byte floating-point number in little endian byte order. Users should swap the byte order to big endian if necessary. There are no 'space', 'end of record', or 'end of file' marks in between.

4.5 Sample Fortran 90 Program

A sample program written in Fortran 90 (read_V1901.f) is available at the site.
Note that the little-endian byte order is assumed in this program. You may change recl=nx*ny to recl=nx*ny*4 according to your machine environment.

5. Reference paper (tentative)

We have not written the exact algorithm explanation of this version.
If you need to present/publish your results by using this version data, please specify the version number, so that everybody can recognize this as EOD adjusted version.
Example: …. End-of-the-day adjusted version of APHRODITE (V1901, Yatagai et al. 2012).

<APHRO_V1101 reference>

Yatagai, A., K. Kamiguchi, O. Arakawa, A. Hamada, N. Yasutomi and A. Kitoh, 2012: APHRODITE: constracting a long-term daukt gridded precipitation dataset for Asia based on a dense network of rain gauges, BAMS, doi:10.1175/BAMS-D-11-00122.1

○QC and Data release system

Yatagai, A., Imai, M., Maeda, M. and Ishida, S. (2019a): Quality control by making a database (DB) of station precipitation data for APHRODITE and product release via the Web-Site, IPSJ Tohoku Branch SIG Technical Report, 2018-9-A2-3.
(It will be available at http://www.topic.ad.jp/ipsj-tohoku/doku.php?id=report)

○Impact of EOD and SVC for China

Yatagai, A., Maeda, M., Masuda M., Suetou, N., Yasutomi, N., Khadgarai, S. (2019b): Asian Precipitation – Highly Resolved Observational Data Integration Towards Evaluation of Extreme Events (APHRODITE-2), IPSJ Tohoku Branch SIG Technical Report, 2018-9-A2-2.
(It will be available at http://www.topic.ad.jp/ipsj-tohoku/doku.php?id=report)

○**Impact of EOD and SVC for Japan**

Yatagai, A., Yasutomi, N., Maeda, M., Khadgarai, S., Masuda, M. and Suetou, N. (2019c): Impact of separate End-of-the Day (EOD) and station value conservation (SVC) on the representation of extreme precipitation in APHRODITE algorithm, SOLA (submitted).

6. Contacts

Please contact APHRODITE-2 project (led by Dr. Akiyo Yatagai of Hirosaki University) for further questions regarding this product.

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