Asia – Experience of APHRODITE daily gridded precipitation analyses

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Outline of the Talk

1. APHRODITE project
2. Algorithm
3. Extreme Analyses
4. Further developments for hydrological applications
5. Summary
   (Recommendation and requests)
Asian Precipitation -- Highly Resolved Observational Data Integration Towards Evaluation of the Water Resources (APHRODITE’s Water Resources)

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May 2005 - March 2011
Regional impact of climate changes (global warming) are widely concerned, and simulations are made by high resolution climate models.

- For model validation: High spatial resolution, quantitative accuracy
- For statistical downscaling: Long-term data is required
- Evaluation of water resources: Gridded precipitation data

- Analysis of extreme phenomena: High resolution (spatial & temporal) • Accuracy • Long-term data
- Water resource in the mountains: precipitation grid data, estimate of snow, temperature

Do we have enough data?
## Available grid precipitation data

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Source</th>
<th>Domain</th>
<th>Time Res.</th>
<th>Horizontal Res.</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legates and Willmott</td>
<td>Raingauge</td>
<td>Global Land</td>
<td>Climatology</td>
<td>0.5 deg</td>
<td>1921-1980</td>
</tr>
<tr>
<td>GPCP CMAP</td>
<td>Merged (GTS raingauge, IR, MW)</td>
<td>Global</td>
<td>monthly</td>
<td>2.5 deg</td>
<td>1979-</td>
</tr>
<tr>
<td>GPCP_pen CMAP_pen</td>
<td>Merged</td>
<td>Global</td>
<td>5-day</td>
<td>2.5 deg.</td>
<td>1979-</td>
</tr>
<tr>
<td>GPCP1DD</td>
<td>IR</td>
<td>Global</td>
<td>Daily</td>
<td>1 deg.</td>
<td>1997-</td>
</tr>
<tr>
<td>CRU PREC/L</td>
<td>Raingauge</td>
<td>Global Land</td>
<td>Month</td>
<td>0.5 deg.</td>
<td>1900-1998, 1948-2001</td>
</tr>
<tr>
<td>TRMM</td>
<td>PR,TMI,VIRS</td>
<td>37N-37S, 50N-50S</td>
<td>Path 3-hr</td>
<td>4.3km(PR), 0.25 deg.</td>
<td>1997.12-1998</td>
</tr>
<tr>
<td>CMORPH</td>
<td>MW+IR(cloud m.)</td>
<td>60N-60S</td>
<td>30 min.</td>
<td>0.25 deg.</td>
<td>2002-</td>
</tr>
<tr>
<td>GSMaP_TMI</td>
<td>TRMM/TMI</td>
<td>40N-40S</td>
<td>Daily</td>
<td>0.25deg.</td>
<td>1998-2005</td>
</tr>
<tr>
<td>GSMaP_MVK</td>
<td>MW+IR</td>
<td>60N-60S</td>
<td>Hrly</td>
<td>0.1 deg.</td>
<td>2005.7</td>
</tr>
<tr>
<td>APHRODITE</td>
<td>Raingauge</td>
<td>Regional</td>
<td>Daily</td>
<td>0.5 deg.</td>
<td>1978-2003.7, 1961-2003 (Cina)</td>
</tr>
<tr>
<td>East Asia</td>
<td>Regional</td>
<td>Asia</td>
<td>Daily</td>
<td>0.25/0.5 deg</td>
<td>1951-2007</td>
</tr>
<tr>
<td>India</td>
<td>Regional</td>
<td>Regional</td>
<td>Daily</td>
<td>1 deg.</td>
<td>1951-2004</td>
</tr>
<tr>
<td>Reanalyses</td>
<td>ECMWF JRA NCEP</td>
<td>Atmospheric observation + 4DDA (model)</td>
<td>Global</td>
<td>6 hrly</td>
<td>0.5~2.5 deg.</td>
</tr>
</tbody>
</table>
Can we use satellite-based daily precipitation data to study extreme events?

Satellite-based “observation” underestimates heavy precipitation compared to rain-gauge-based observation (Radar-AMeDAS)

Satellite-based rainfall estimation is not sufficient to validate extreme precipitation events simulated by high-resolution models
Input of rain gauges

EA_V0409 (Xie et al. 2007)  V0804 (Aphrodite product)

Number of Gauges  Number of Gauges (0.5° grid)

GTS 920 station  V0409 1400 stations

A case in 23 July, 1998  V0804 6030 stations
APHRODITE: Constructing a Long-term Daily Gridded Precipitation Dataset for Asia Based on a Dense Network of Rain Gauges (Yatagai et al., 2012, BAMS)

http://www.chikyu.ac.jp/precip/
(44803 access)
More than 3000 users.
APHRODITE algorithm

Data collection (daily)
  Reformat
  Quality Control: QC
    Daily QC
    Lookup Table
  Monthly mean
  Interpolation
    0.05-deg analysis
    regridding
    Validation and release of daily grid precipitation product
      0.5-deg analysis
      0.25-deg analysis

Data collection (monthly)
  Reformat
  Monthly QC
  Lookup Table

Yatagai et al. (2009, 2012)
Strategy to Define Analysis of Daily Precipitation

Step 1: Define daily climatology;

Step 2: Analysis of ratio to daily climatology;  
(Orographic effect)

Step 3: Define daily grid precipitation by multiplying the Climatology and the Ratio;

• APHRODITE Interpolation: Shepard (1968), Willmott et al. (1985)
• Xie et al. (2007, JHM) Interpolation: OI
Example: Annual precipitation in 1995 at Kathmandu AP.

GTS base real-time data

Publically available GTS-based datasets are 1/10 of our data. ⇒ Error information by QC should be exchanged. (We do not want to blame anybody.) Feedback from local meteorologists and data developers are important.
Quality Control

(a) Station data (10 months)

Values of 1.3 mm/day are repeated for 10 months

(b) Station data (2 months)

Same record in July and August

(c) APHRO_MA 0.05° analysis

suspect station

No large precipitation was observed at nearby stations

Station data (1 month)

>600 mm/day

Temporally (and spatially) isolated, extremely large precipitation
Quality Control

However, mm <-> inch, missing (0mm) are not completely repaired.

Hamada et al. (2011)
Number of Input data for APHRO V1003R1 & V1101.

We used about 2.3 times to 5.5 times data compared to GTS network.
Trade-off Issues

• We used all data that passed our QC, because we decided to use the same scheme (including QC) throughout the period (even we got off-line data, we still used GTS-based data)

• GTS sometimes reports as “0 mm” for missing value, that is a cause of underestimation.

• 1-day shift is seen between two data sources. That affects smoothed PDF, but total value is OK.
  (our algorithm is first designed for quantified daily data for hydro/agricultural purposes)

• A country used different 24-hr accumulation time (end-of-a-day) for synoptic network and climatological network. That makes extreme analyses difficult. => We may contribute to WMO observation guideline.
Figure 6: (a)-(c) June to September precipitation around the Himalayas (mm/4months). (a) APHRO_V1101, (b) GPCC full ver.4, and (c) simple interpolation result of GTS data by Shepard (1968). (d) Red: areal average (82-92E, 26-28N) of APHRO_V1101 daily precipitation, and Black: the same with Red but for interpolation of GTS data. Rectangles in (a) and (c) represent the domain to calculate the areal mean precipitation for (d).
Figure 3: Effectiveness of new interpolation algorithm in Nepal (upper) and Kalimantan Is. (lower). Shown are topography (left) and mean daily precipitation without (middle) and with (right) considering local topography.

Yatagai et al. (2012, BAMS)
Figure 7: Mean annual precipitation for 1990–2007 (18 years). (a) 0.25°APHRO_V1003R1; (b) GTS data analysis employing an interpolation method similar to that used for (a). (c) Difference between (b) and (a).

Yatagai et al. (2012, BAMS)
Comparison with Satellite Products

The areal average precipitation datasets (Land; June, July and August)

Area averaged mean Prec. : JJA

Rain-gauges
Daily
Monthly

Satellites

Rain-gauges + Satellites

Error-bar shows amplitude of interannual variability

Arakawa et al. (2011), Yatagai et al. (2012)
Release of APHRO Data

We released V1101 last year, and released temperature products (MA).
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Intercomparison with other data

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Comparison between APHRO_EA and Radar AMeDAS in Japan

• RA shows larger values than that of EA for most part, except for the Northeastern part of Hokkaido prefecture.
• RA shows 16.6% larger value of EA in average
• EA shows closer distribution to JMA Mesh climatology than RA

We developed 1km mesh data over Japan (APHRO_JP)

Kamiguchi et al. (2010)
We constructed historical (1900-) high-resolution (0.05x0.05 degree) daily precipitation data over Japanese land area.

The product can be used for statistical analysis of heavy precipitation up to about 150 mm/day, over a long term period (≥ 100 years). APHRO_JP enables diverse research, including validation of meso-scale models and analysis of the long-term extreme precipitation trend in Japan.
60 stable stations/1000 AMeDAS stations

Figure 1. Location of rain gauge and JMA-Radar sites (blue square). Black dots are AMeDAS rain gauges deployed after 1977, whereas red dots show JMA surface observatory rain gauge which have existed since 1900.

Figure 3. Mean monthly precipitation over Japanese land area (mm/day).

Kamiguchi et al. (2010)
Figure 4. Annual mean precipitation (mm/day) from 1989 to 2007.

PDF of daily precipitation (JJA)

Figure 5. Probability distribution function of daily precipitation.
Figure 2. Historical changes in the number of available rain gauges (bottom), annual mean and maximum daily precipitation (middle), and the ratio of annual maximum daily precipitation to annual mean daily precipitation (top).

Kamiguchi et al. (2010)
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Middle East version and model validation

Rain gauge-based climatology (upper)
TRMM/PR composite (lower)
For December

Yatagai, Xie and Alpert (2008)
Kitoh, Yatagai and Alpert (2008)

Yatagai, Kimura, Kitoh, Watanabe (2006)
Proceedings for International Symposium on Water and Land Management for Sustainable Irrigated Agriculture, Turkey
Improving climatology over the Himalayas

Hijimann et al. (2001)

APHRO (Yatagai et al., 2012)

(Yatagai and Kawamoto, 2008)
Further analysis for station network density

• Spatial Correlation (network density) – study
  – Following Xie et al. (2007), a cross validation of the interpolation technique used in APHRODITE daily precipitation was conducted.
    – 1) China
    – 2) Monsoon Asia

This strategy may answer the old WMO technical report statistics like.. “How many station data is necessary to make 5x5 degree monthly precipitation?”

Zhao and Yatagai (2013)
Recommendations & requests

• Make a network of exchange QC information
• We collect user’s email information (by GCOS guideline), but recently security issues happened.
• Clarify the strategy of this community
  – Station extreme?
    (if you want to use APHRODITE for this purpose please contact me!)
  – Hydrological extreme?
Recommendation & requests

<For users>

• Pay attention to NOG or RSTN
  – For trend analysis
  – For satellite comparison (error estimation!)
⇒ Only use grid boxes with raingauges

<For WMO/CCI or others>

• Clarify 24-hr accumulation time
• Educate for reporting “missing values”
• Let’s renew idealized observation network density for extreme events! (at least daily precipitation)
  -- that can be possible for data holders and researchers with enough analysis techniques.
Thank You


