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)

Akiyo Yatagai[1], Akio Kitoh[2], Kenji Kamiguchi[2], Osamu Arakawa[2] , Atsushi Hamada[1], Natsuko Yasutomi [1], Tsugihiro Watanabe[1], Jumpei Kubota[1], Makoto Taniguchi [1]

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2. **Meteorological Research Institute (MRI), Japan Meteorological Agency (JMA), Tsukuba, Japan**

May 2005 - March 2011

Background

In 2005

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 reqired
- 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

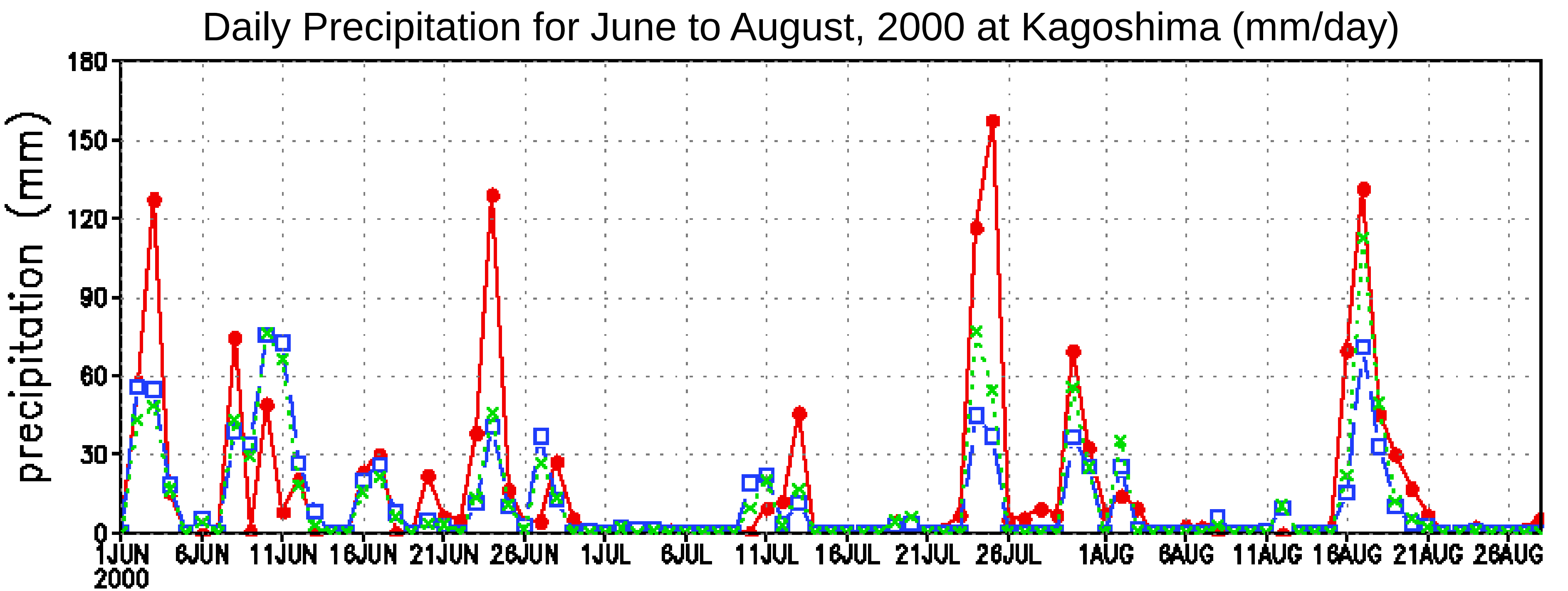
Do we have enough data?

Available grid precipitation data

Dataset		Source	Domain	Time Res.	Horizontal Res.	Period
Legates and Willmott		Raingauge	Global Land	Climatology	0.5 deg	1921-1980
GPCP CMAP		Merged (GTS raingauge, IR, MW)	Global	monthly	2.5 deg	1979-
GPCP_pen CMAP_pen		Merged	Global	5-day	2.5 deg.	1979-
GPCP1DD		IR	Global	Daily	1 deg.	1997-
CRU PREC/L		Raingauge	Global Land	Month	0.5 deg.	1900-1998 1948-2001
TRMM		PR,TMI,VIRS 3B42（Ver6)	37N-37S 50N-50S	Path 3-hr	4.3km(PR) 0.25 deg.	1997.12- 1998-
CMORPH		MW+IR(cloud m.)	60N-60S	30 min.	0.25 deg.	2002-
GSMaP_TMI GSMaP_MVK		TRMM/TMI MW+IR	40N-40S 60N-60S	Daily Hrly	0.25deg. 0.1 deg.	1998-2005 2005.7
Regio Prec Analysis	East Asia	Raingauge	Regional	Daily	0.5 deg.	1978-2003.7 （1961-2003Cina）
	India	Raingauges	Regional	Daily	1 deg.	1951-2004
Reanalyses	ECMWF JRA NCEP	Atmosheric observation + 4DDA (model)	Global	6 hrly	0.5～2.5 deg.	1957-2002 1979- 1948-

APHRODITE | Asia | 0.25/0.5 deg | 1951-2007

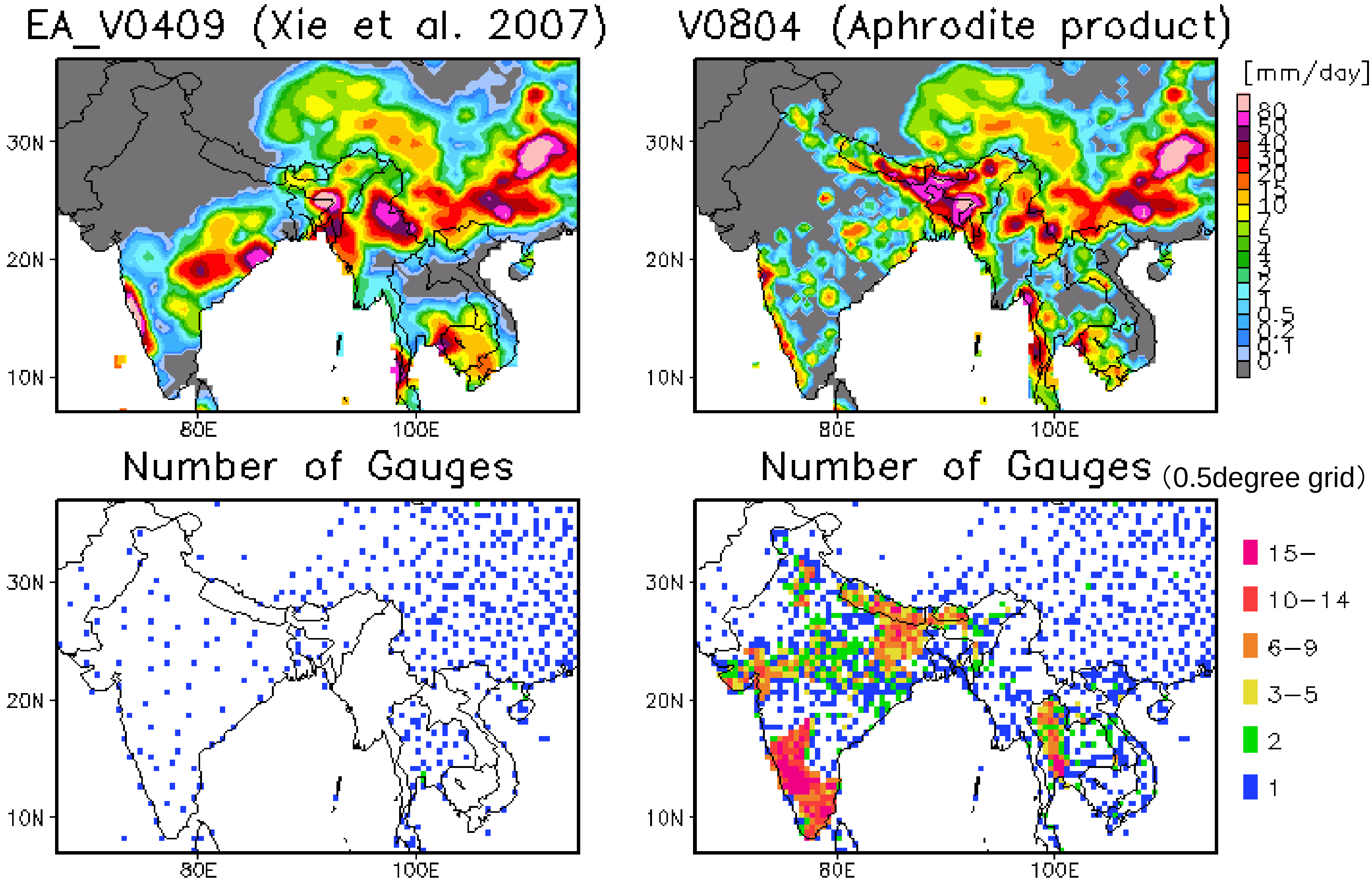
Can we use satellite-based daily precipitation data to study extreme events?



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



GTS
920 station

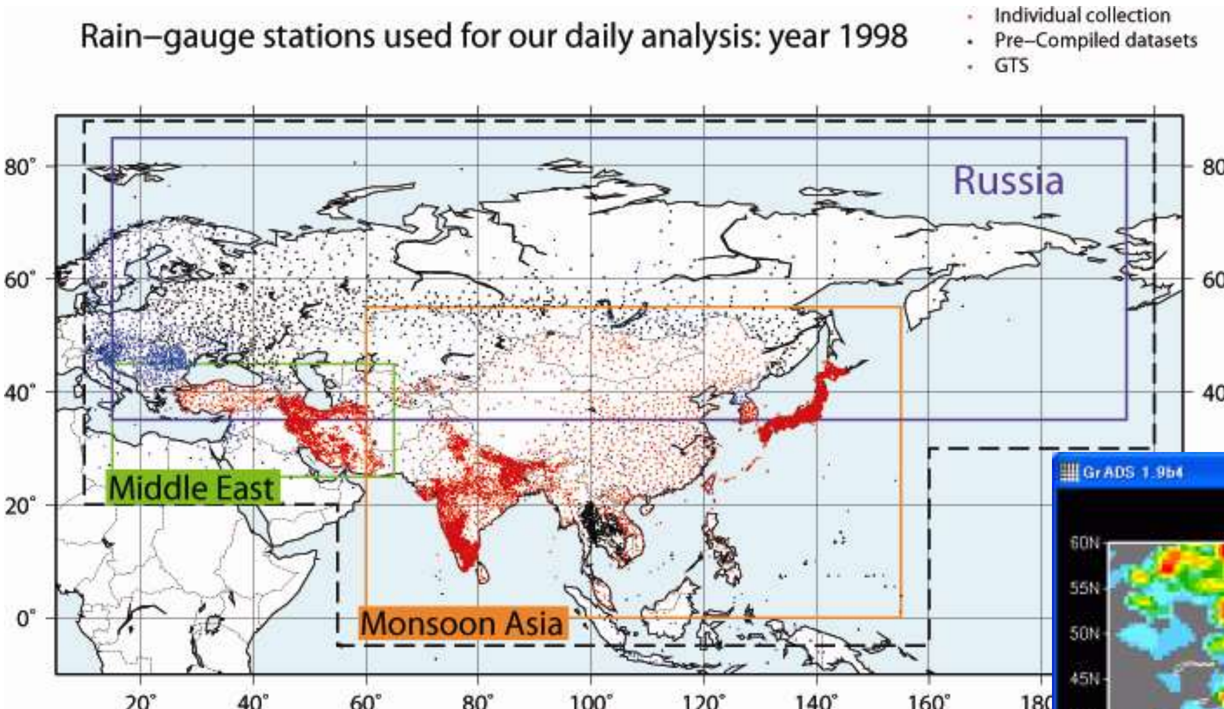
V0409
1400 stations

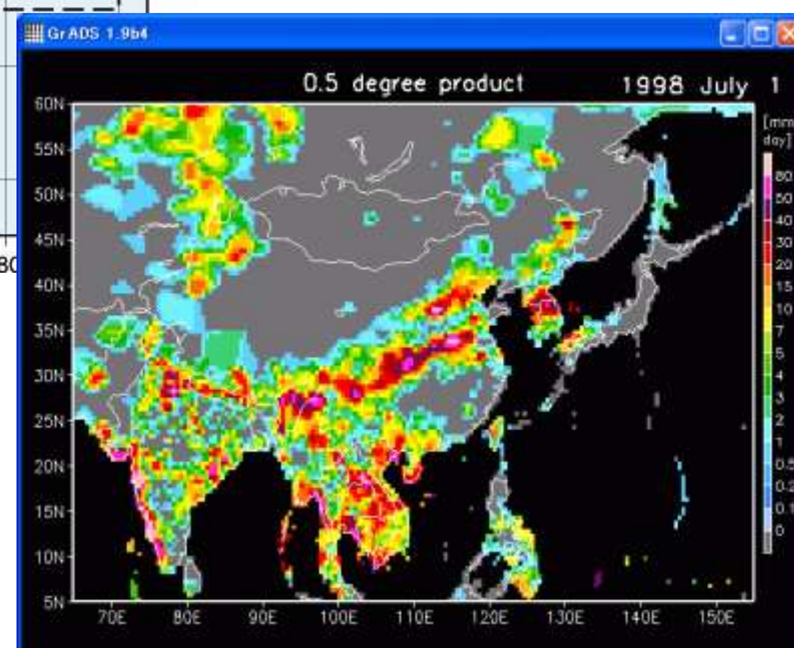
A case in
23 July, 1998

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)

ESI Hot 高被引用文献



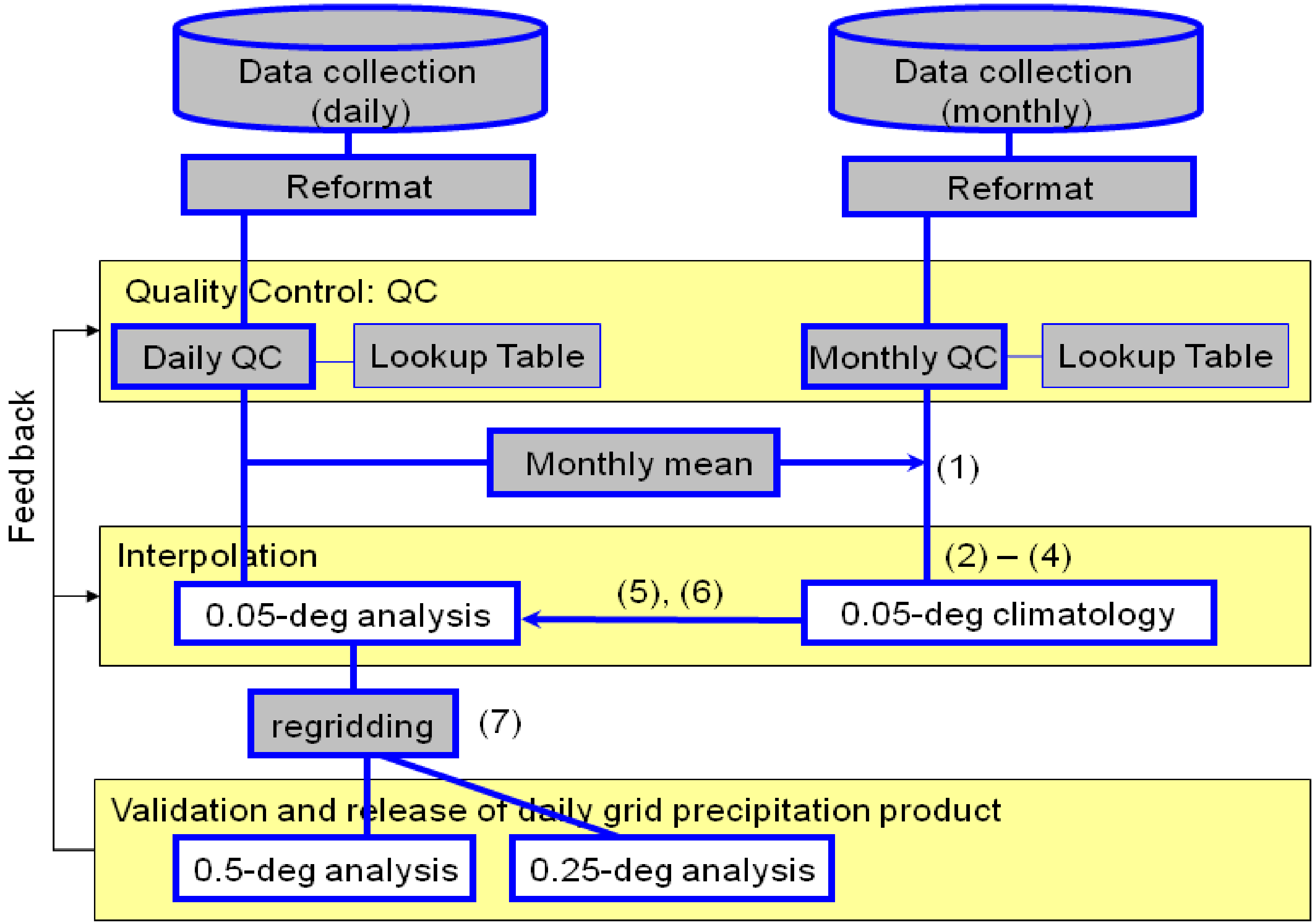


http://www.chikyu.ac.jp/precip/

(44803 access)

More than 3000 users.

APHRODITE algorithm



Yatagai et al. (2009, 2012)

Strategy to Define Analysis of Daily Precipitation

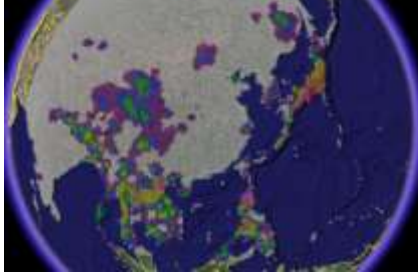
Step 1: Define daily climatology;

Step 2: Analysis of ratio to daily climatology；

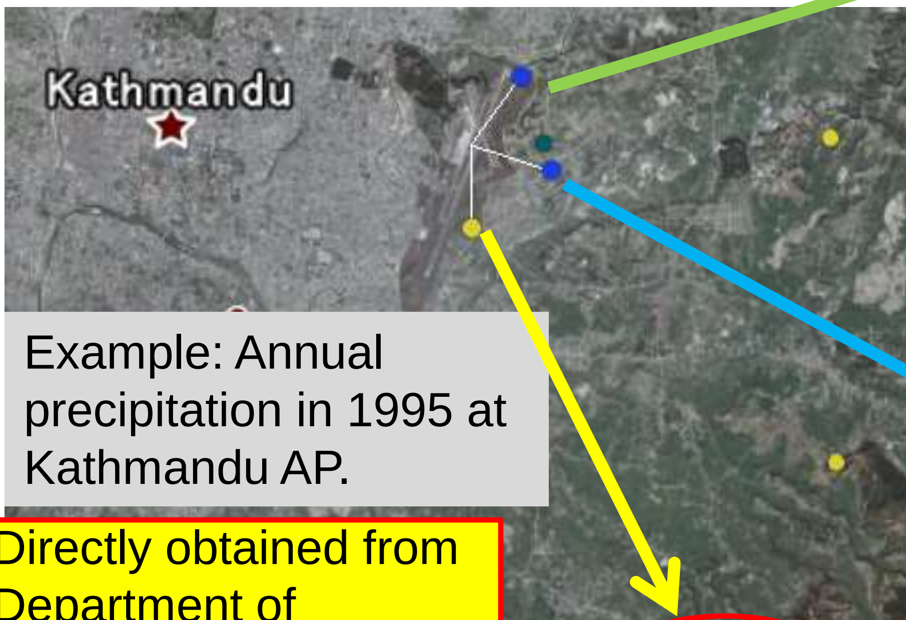
（Orographic effect）

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



QC tool with oogle Earth



Example: Annual precipitation in 1995 at Kathmandu AP.

Directly obtained from Department of Hydrometorology, Nepal

...m)	1673.80
...m/d)	73.50
Valid obs rate	1.0
Name	KATHMANDU AIRPORT
Station NO	1030
Data Source	NPL__12
Longitude	85.36
Latitude	27.70

A global dataset

Ann. Precip (mm)	167.40
Max. Precip (mm/d)	7.40
Valid obs rate	1.0
Name	KATHMANDU AIRPORT
Station NO	NP000444540
Data Source	_
Longitude	85.36
Latitude	27.70

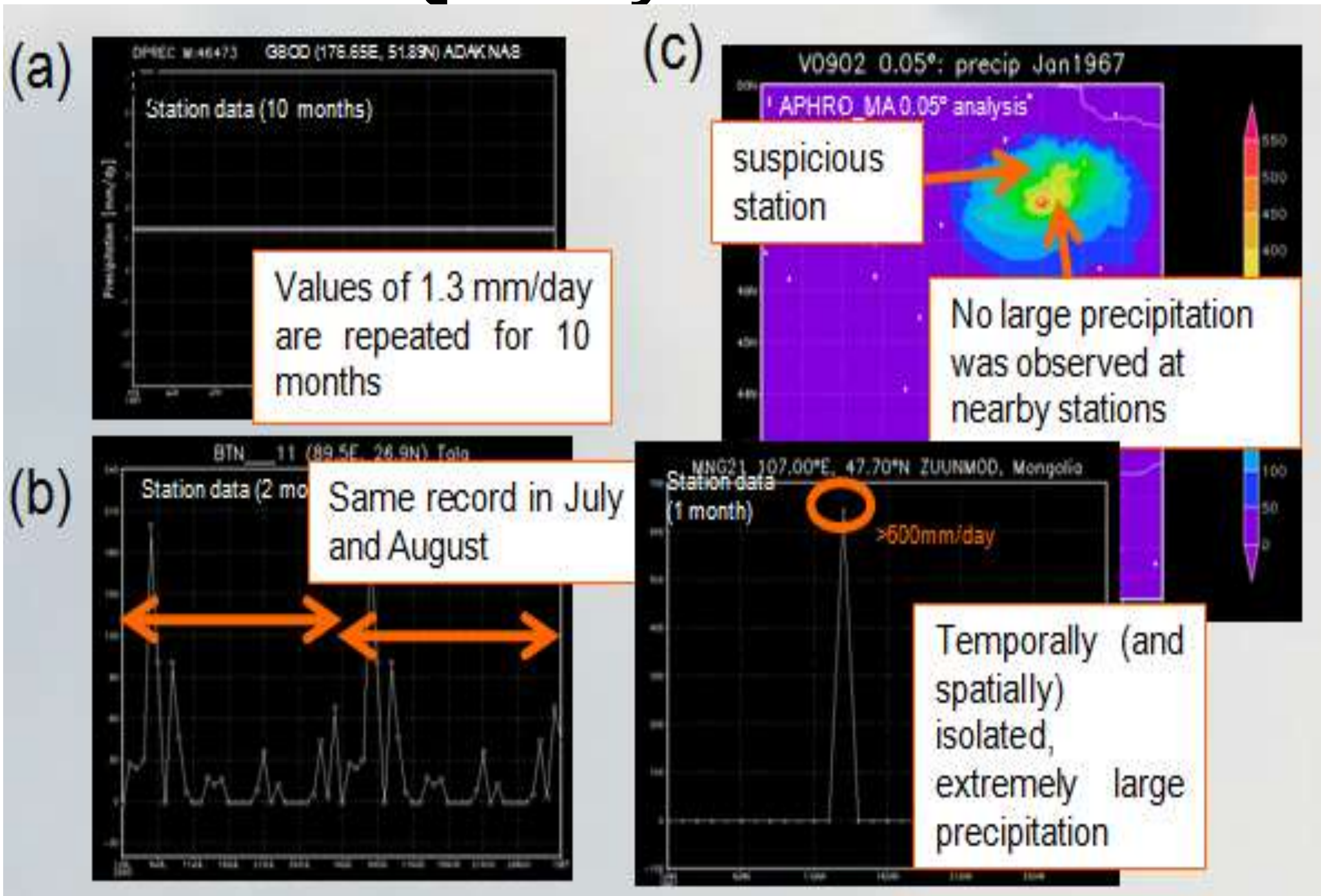
GTS base real-time data

Ann. Precip (mm)	153.40
Max. Precip (mm/d)	64.00
Valid obs rate	0.6

Publically available GTS-based datasets are 1/10 of our data.

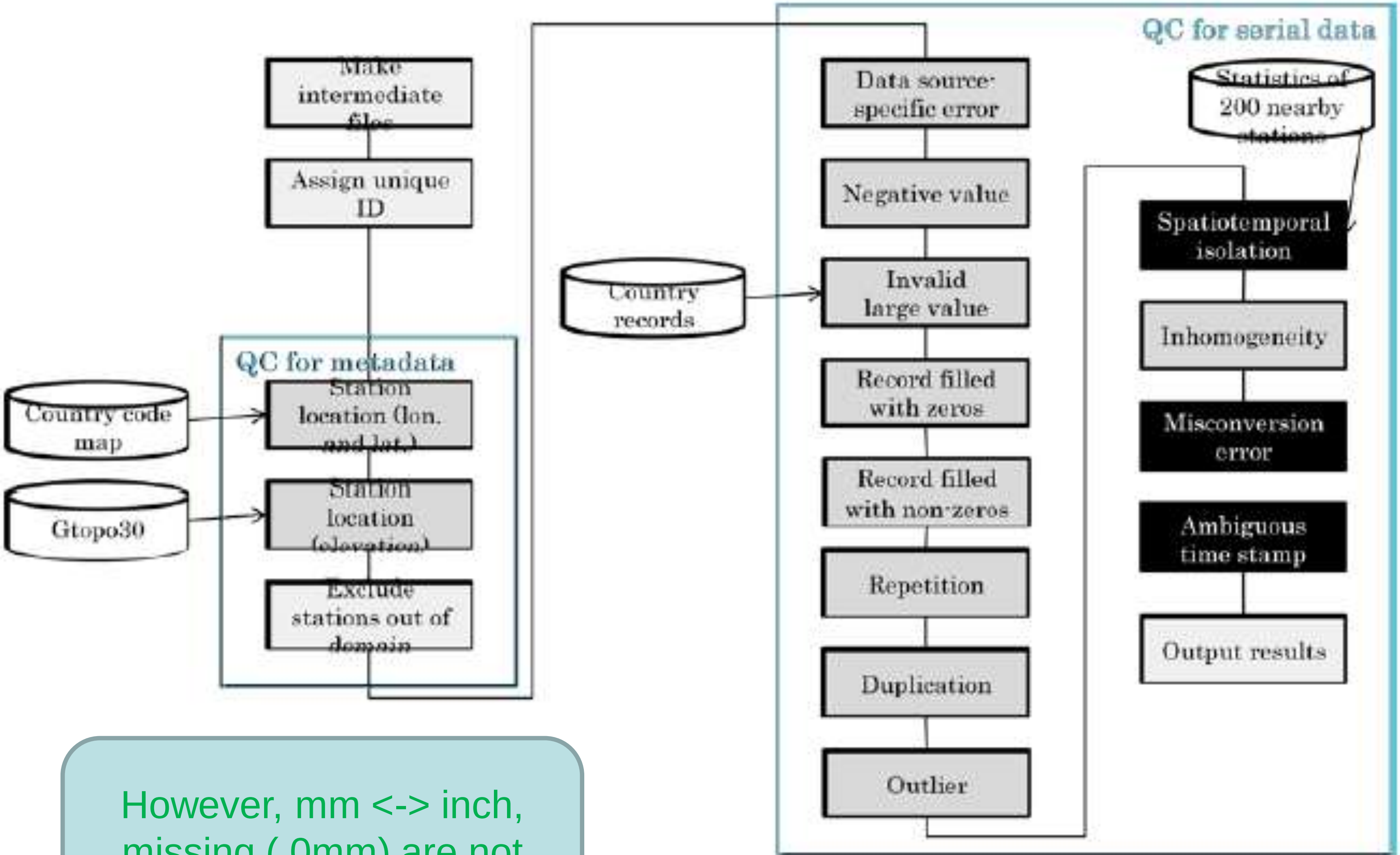
⇒Error information by QC should be exchanged. (We do not want to blame anybody.) Feedback from local meteorologists and data developers are important.

Quality Control



Quality Control

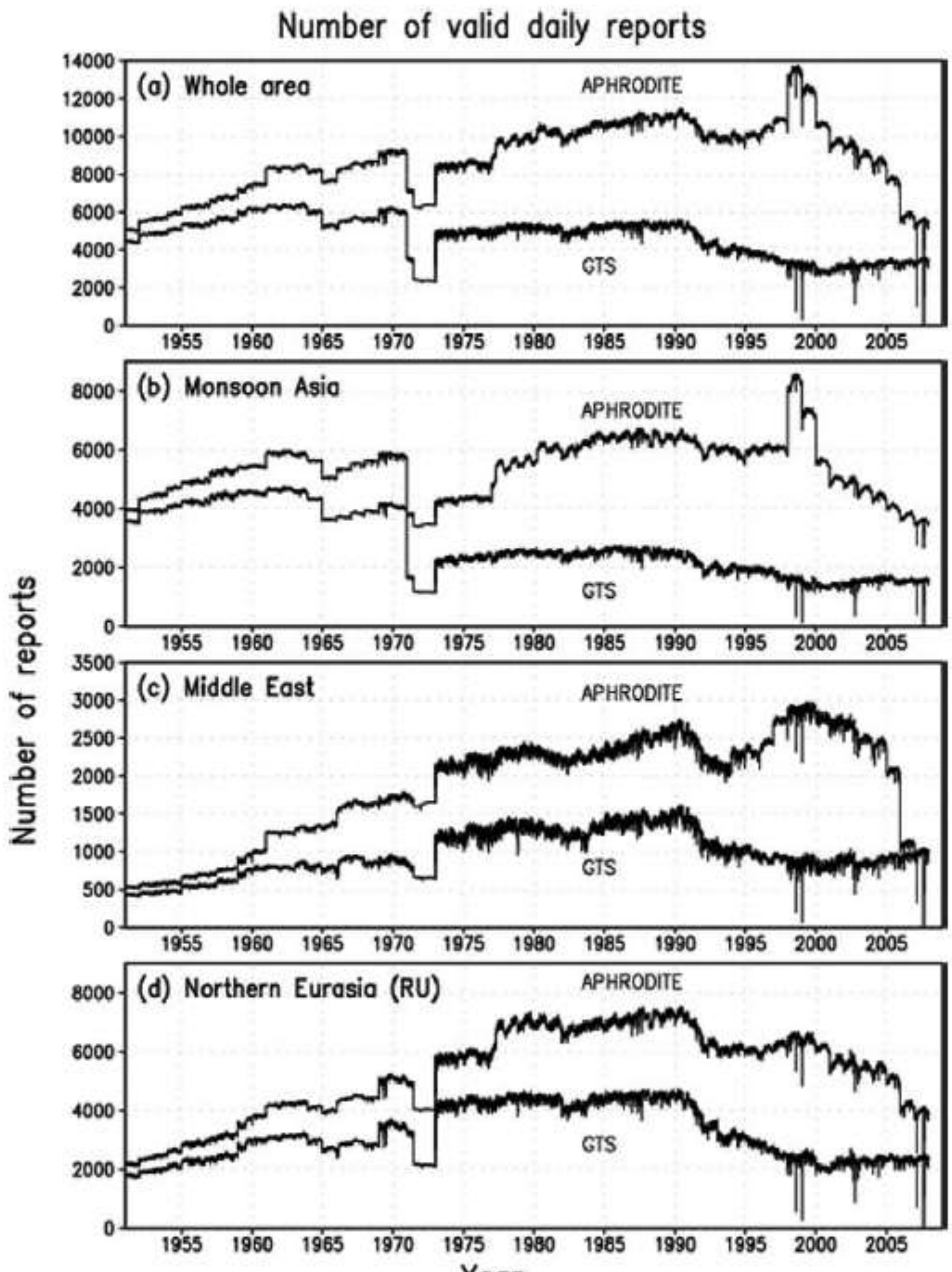
(b)



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.

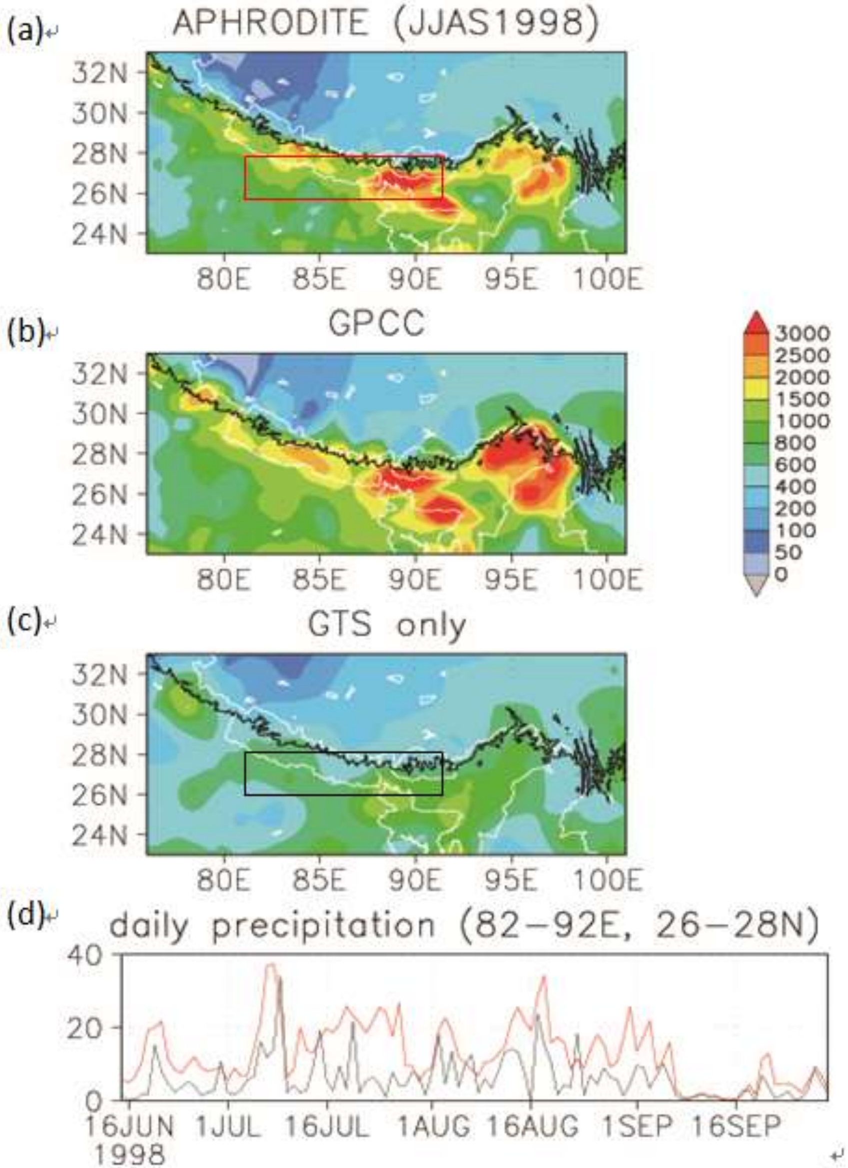
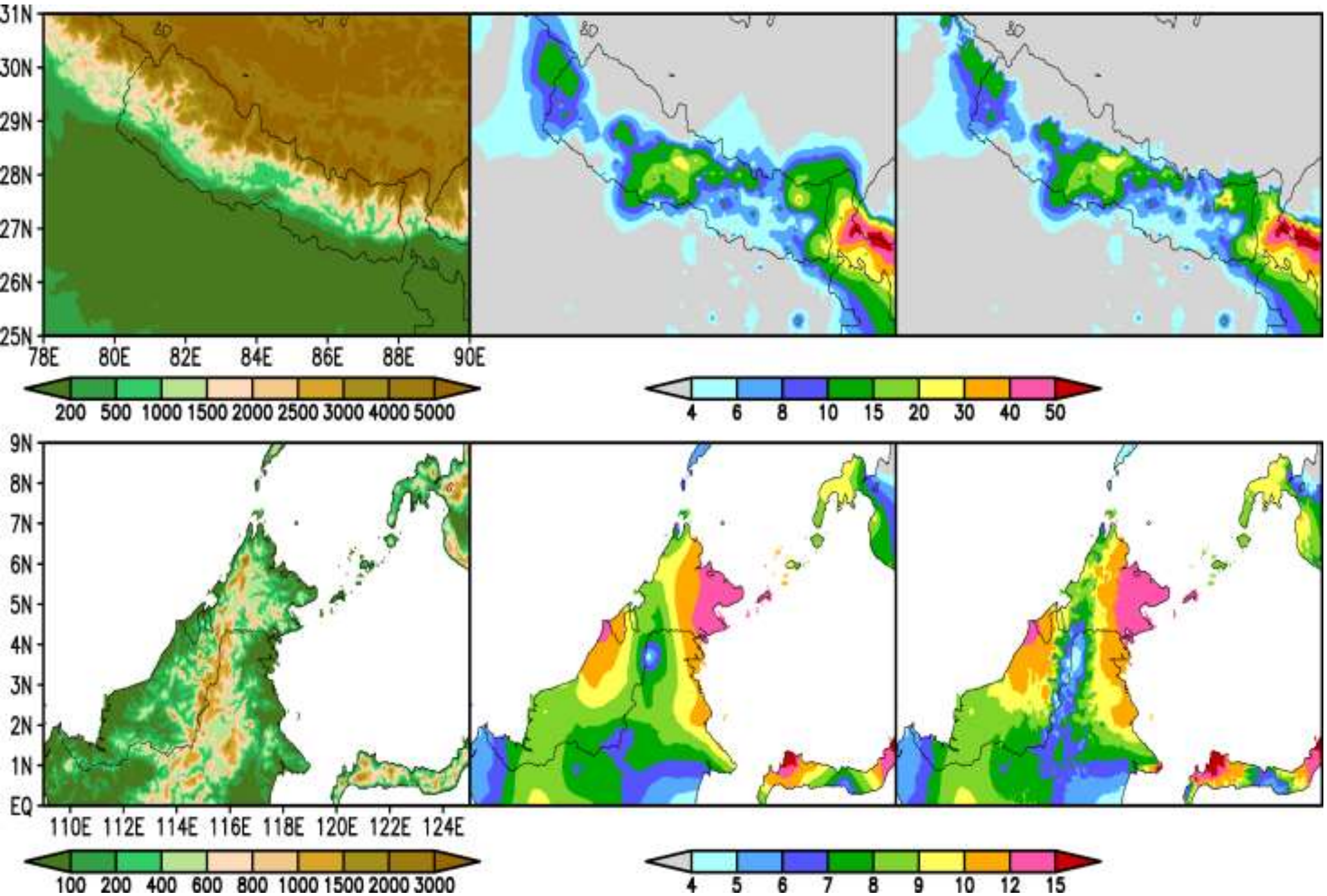


Figure 6: (a)-(c) June to September precipitation around the Himalayas (mm/4months). (a) APHRO_V1101, (b) GPCC full ver.4, and (c) simple interpolation result of GTS data by Shepard (1968). (d) Red: areal average (82-92E, 26-28N) of APHRO_V1101 daily precipitation, and Black: the same with Red but for interpolation of GTS data. Rectangles in (a) and (c) represent the domain to calculate the areal mean precipitation for (d).

Yatagai et al. (2012, BAMS)



Yatagai et al. (2012, BAMS)

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.

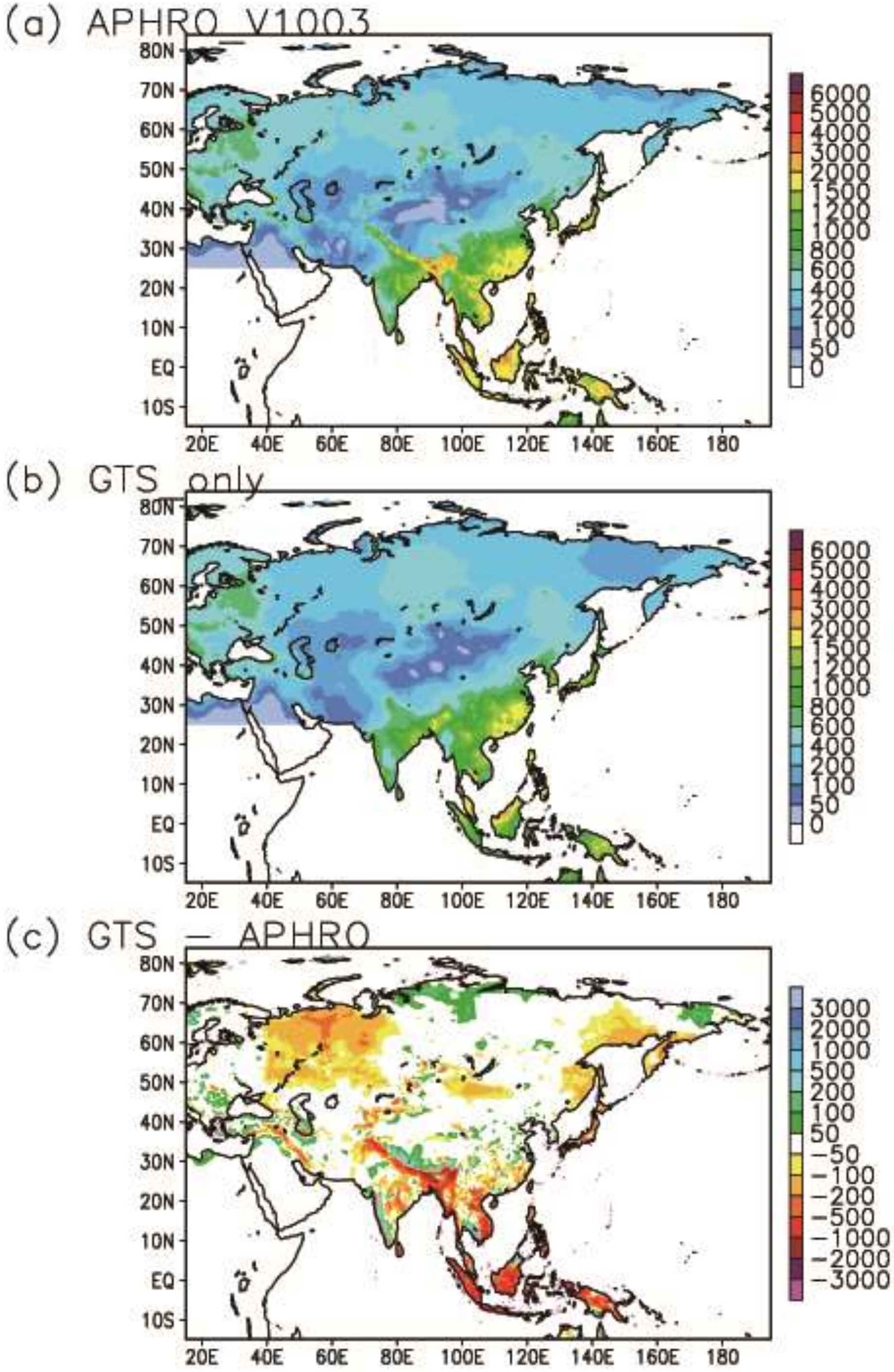


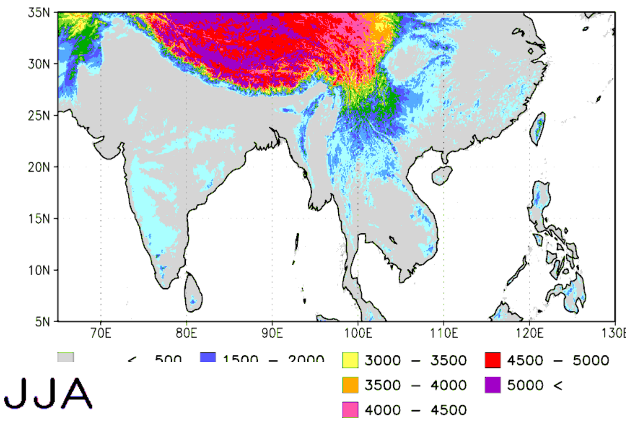
Figure 7: Mean annual precipitation for 1990–2007 (18 years). (a) 0.25°APHRO_V1003R1; (b) GTS data analysis employing an interpolation method similar to that used for (a). (c) Difference between (b) and (a).

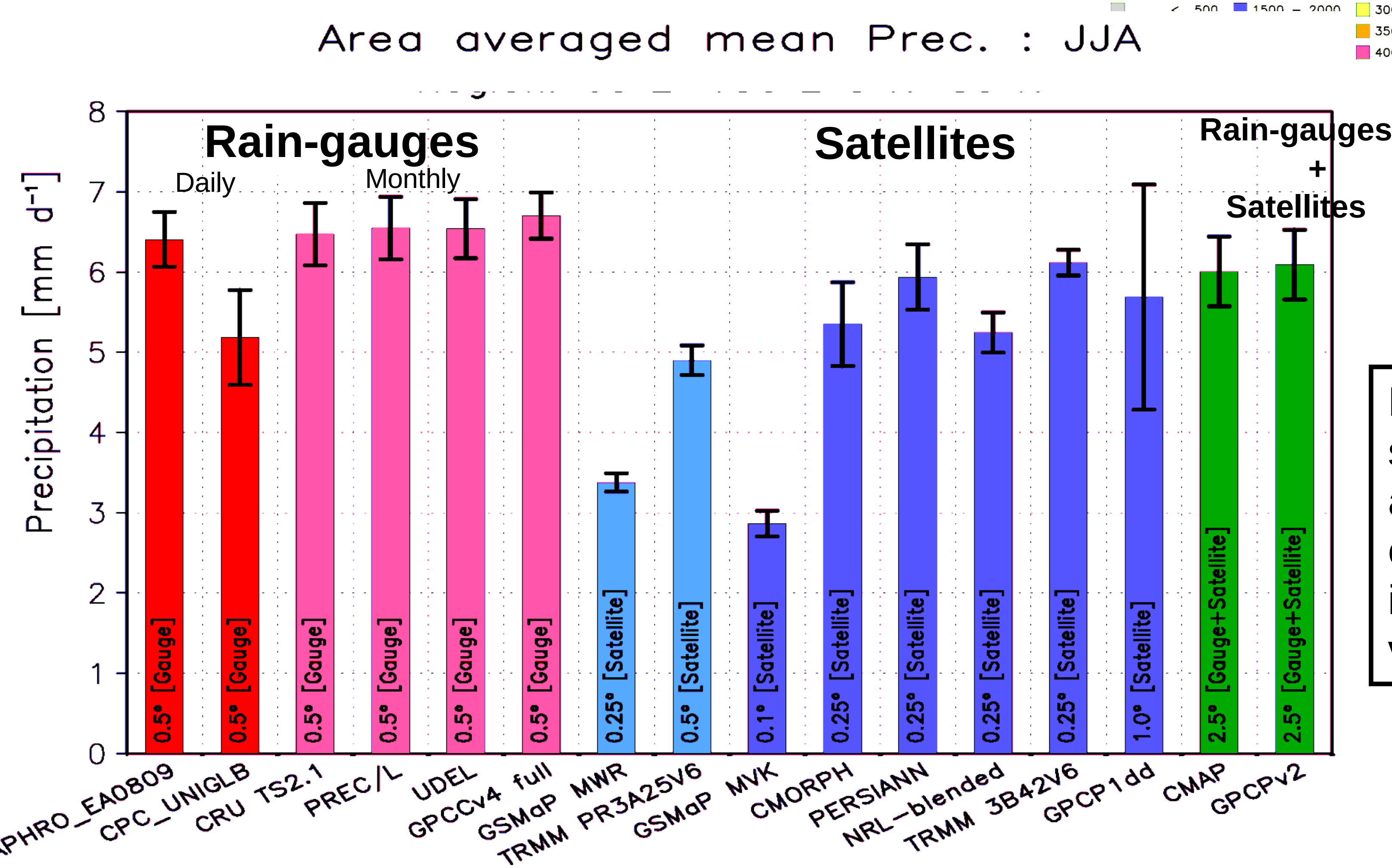
Yatagai et al. (2012, BAMS)

Comparison with Satellite Products

The areal average precipitation datasets

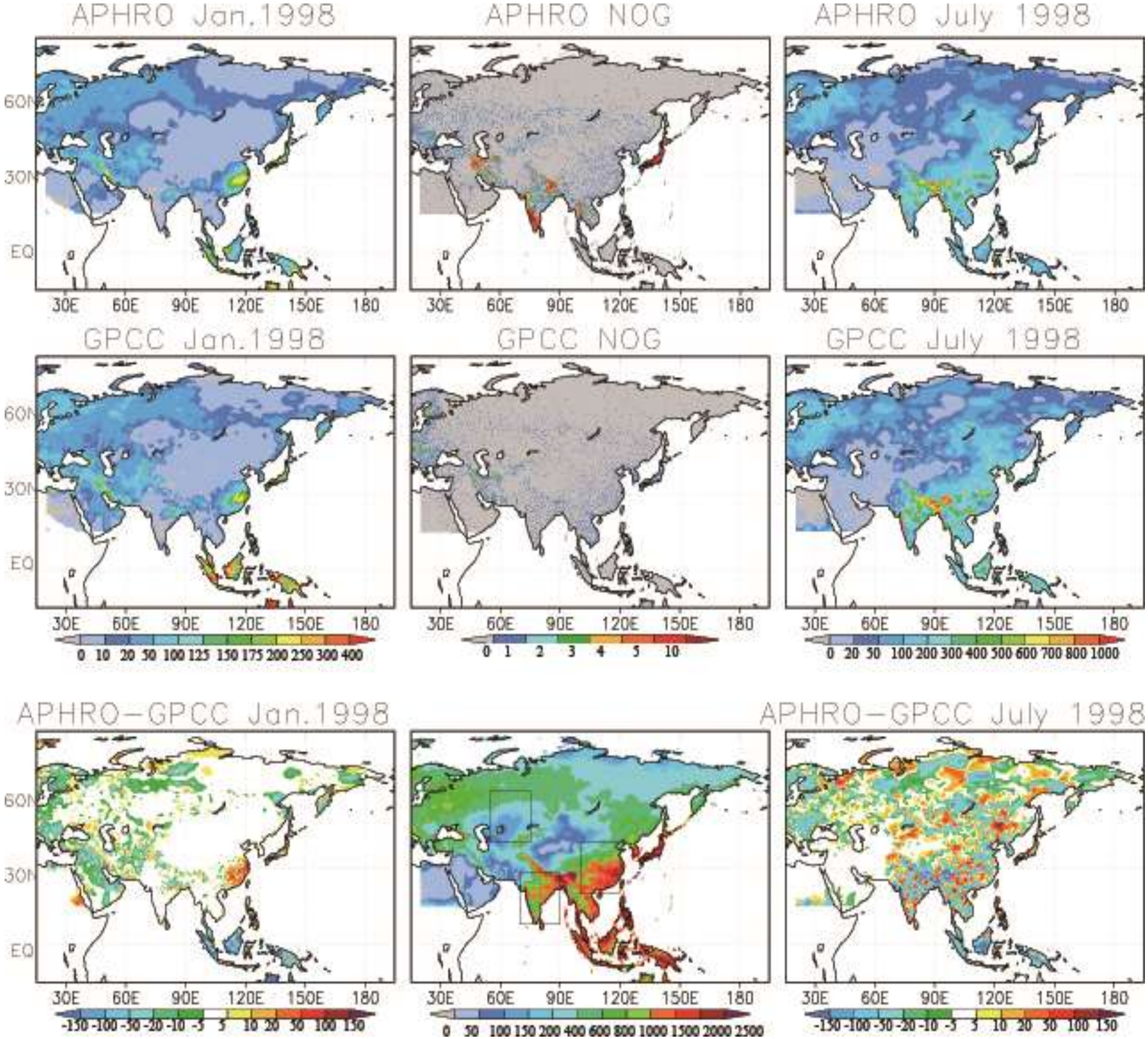
(Land;June,July and August)





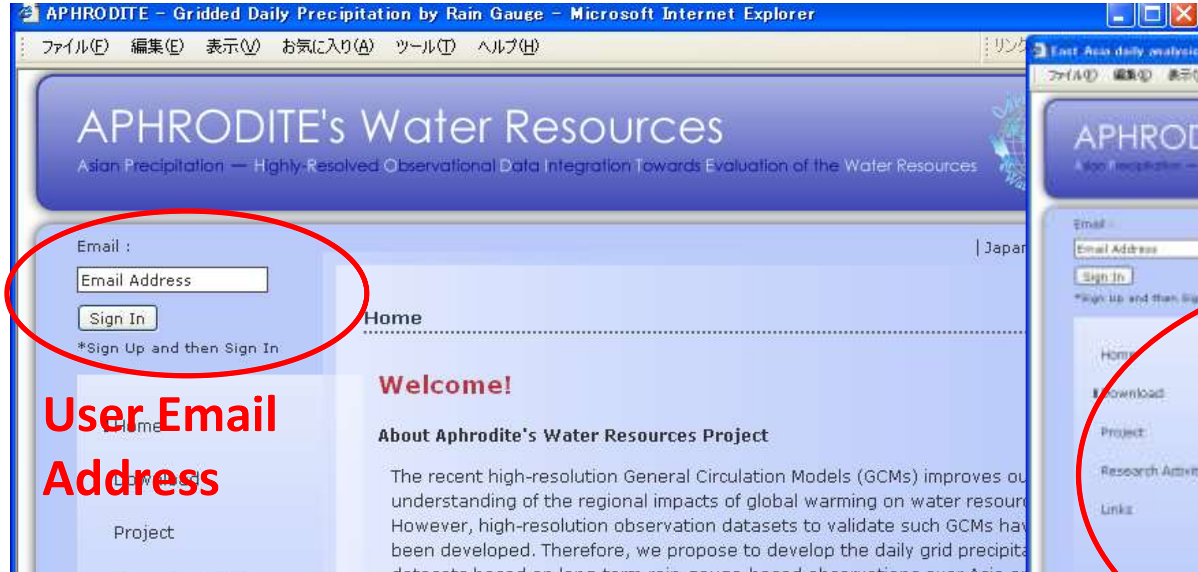
Error-bar shows amplitude of interannual variability

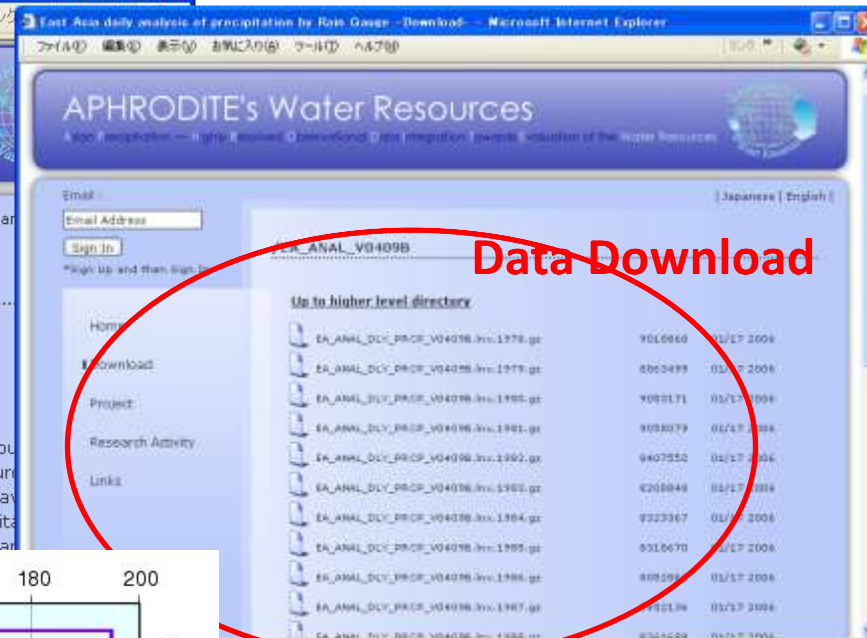
Arakawa et al. (2011), Yatagai et al. (2012)

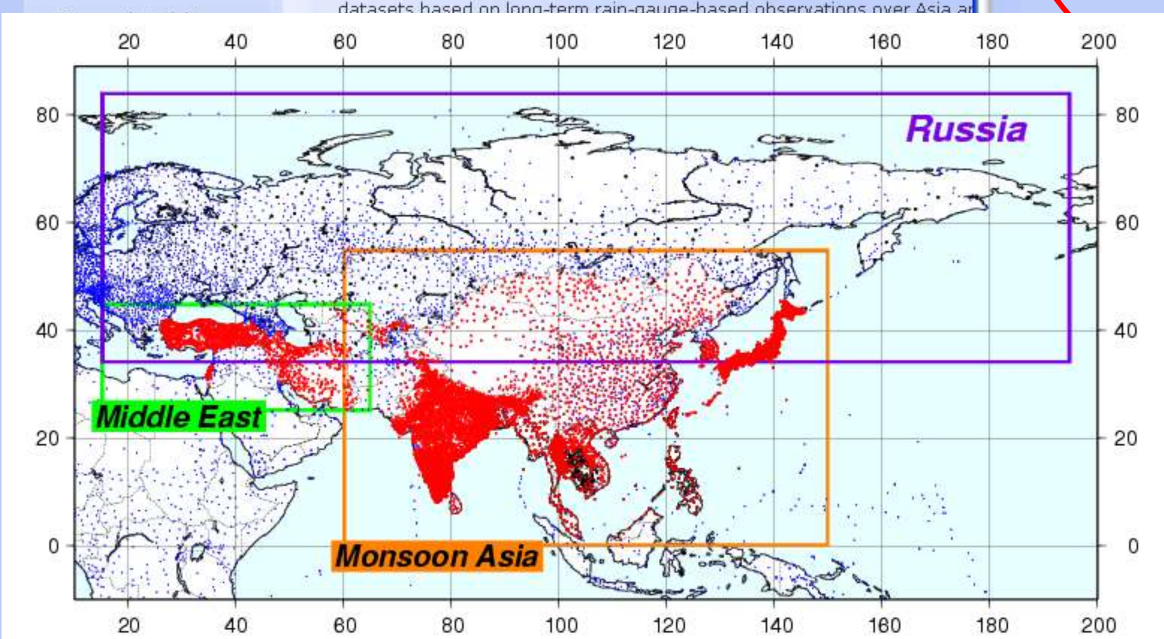


Yatagai et al. (2012, BAMS)

Release of APHRO Data







We released V1101 last year, and released temperature products (MA).

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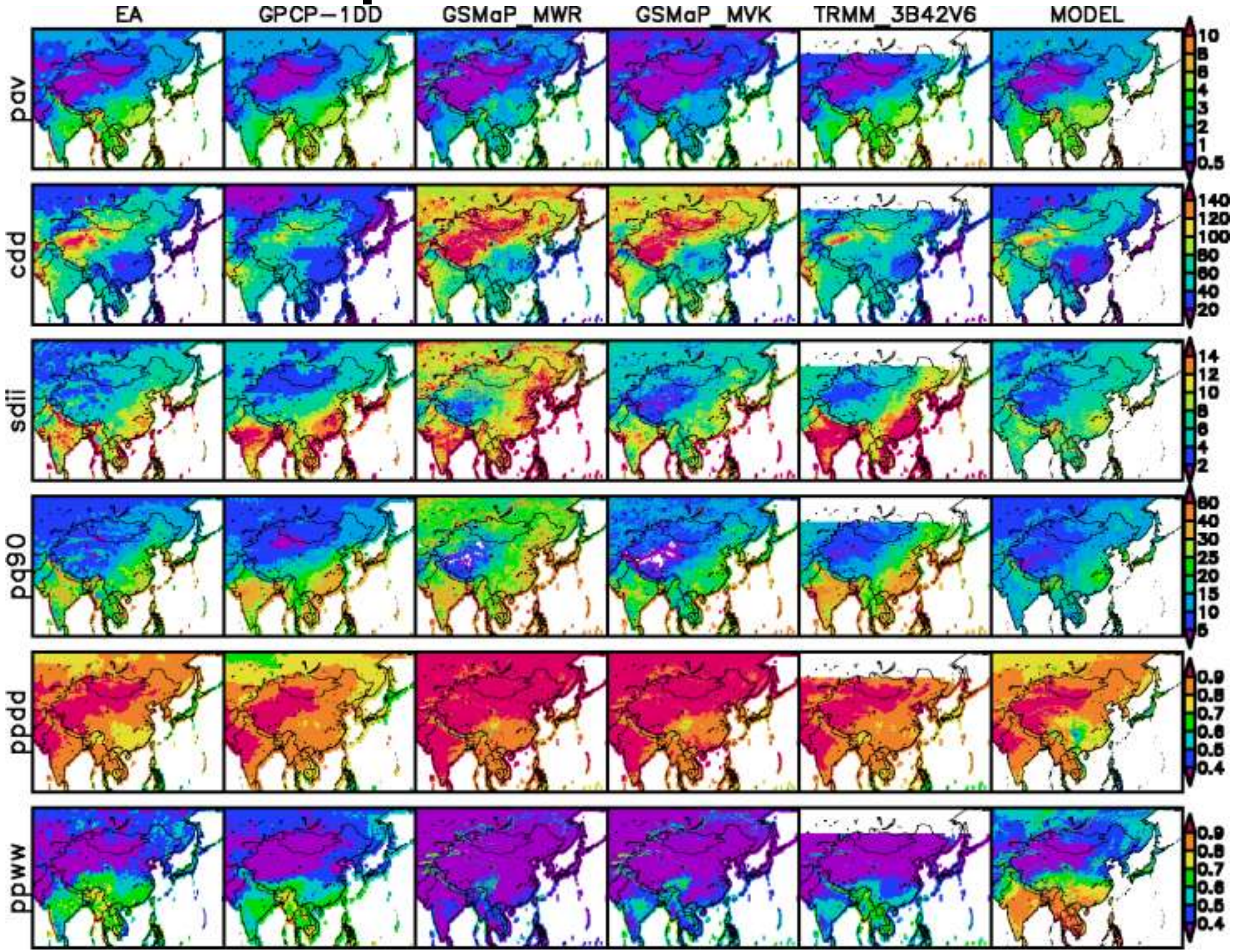
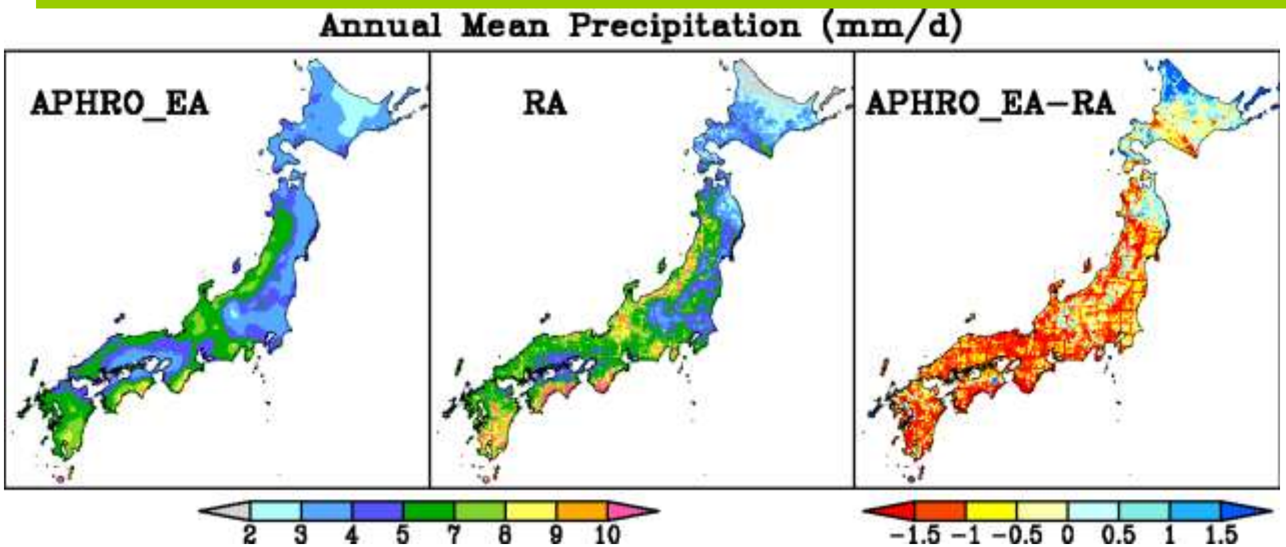
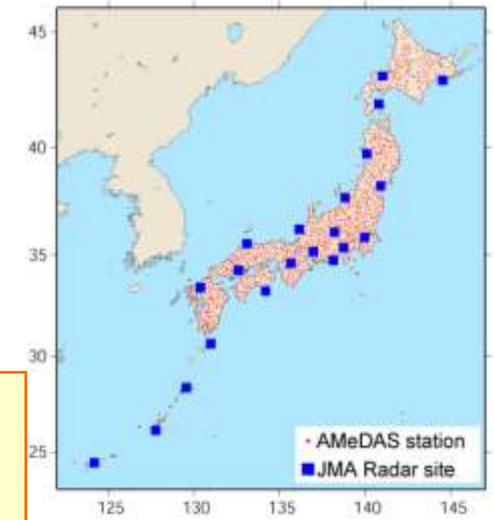
Intercomparison with other data



Comparison between APHRO_EA and Radar AMeDAS in Japan



AMeDAS rain stations and Radar stations



- 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

APHRO is better?

We developped 1km mesh data over Japan (APHRO_JP)

Kamiguchi et al. (2010)

Hydrological Research Letters, **4**, 60–64 (2010)
Published online in J-STAGE (www.jstage.jst.go.jp/browse/HRL). DOI: 10.3178/HRL.4.60

Development of APHRO_JP, the first Japanese high-resolution daily precipitation product for more than 100 years

Kenji Kamiguchi[1], Osamu Arakawa[1], Akio Kitoh[1], Akiyo Yatagai[2], Atsushi Hamada[2] and Natsuko Yasutomi[2]
[1] *Meteorological Research Institute, Ibaraki, Japan*
[2] *Research Institute for Humanity and Nature, Kyoto, Japan*

- 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 longterm extreme precipitation trend in Japan.

60 stable stations/1000 AMeDAS stations

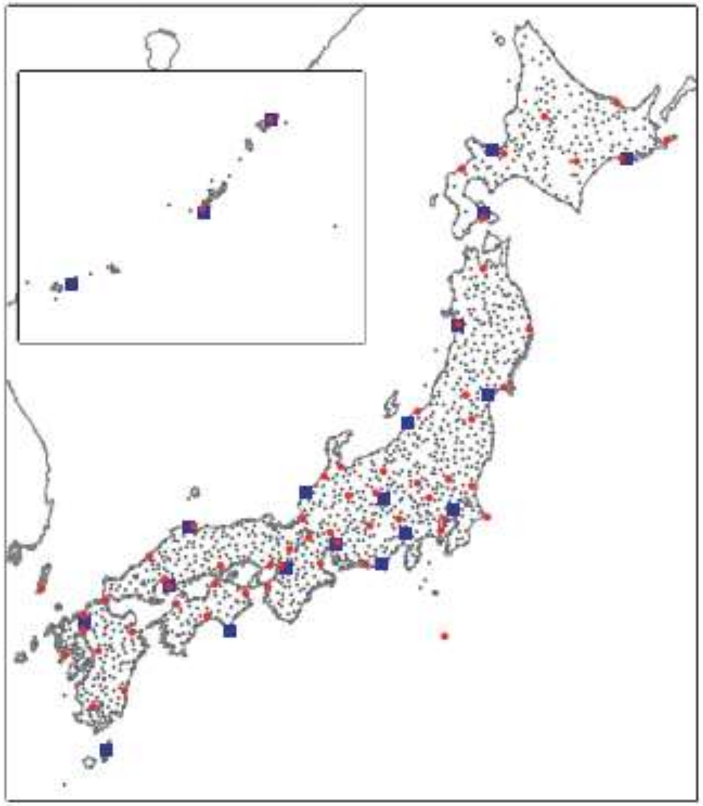


Figure 1. Location of rain gauge and JMA-Radar sites (blue square). Black dots are AMeDAS rain gauges deployed after 1977, whereas red dots show JMA surface observatory rain gauge which have existed since 1900.

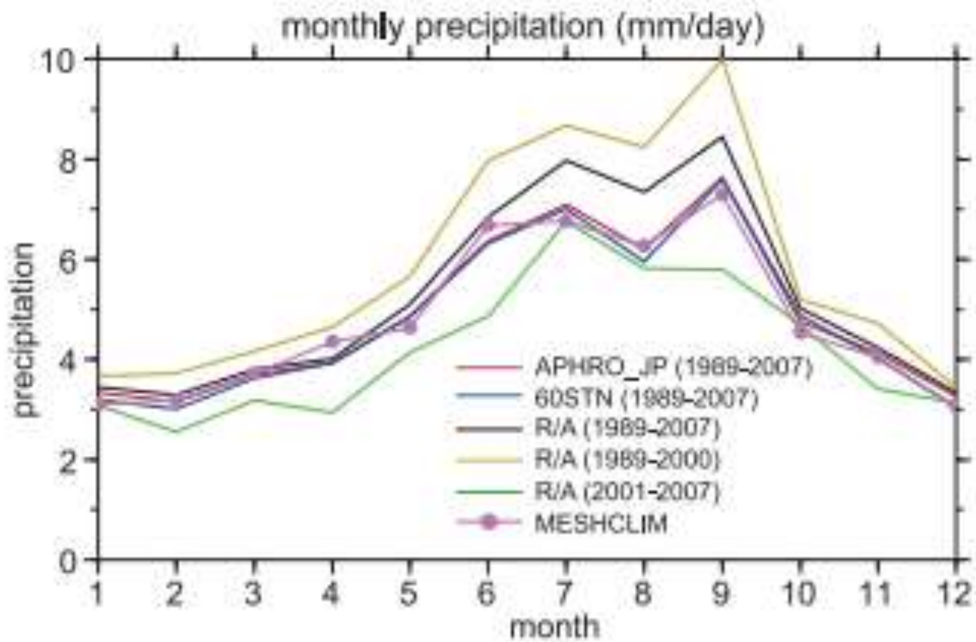


Figure 3. Mean monthly precipitation over Japanese land area (mm/day).

Kamiguchi et al. (2010)

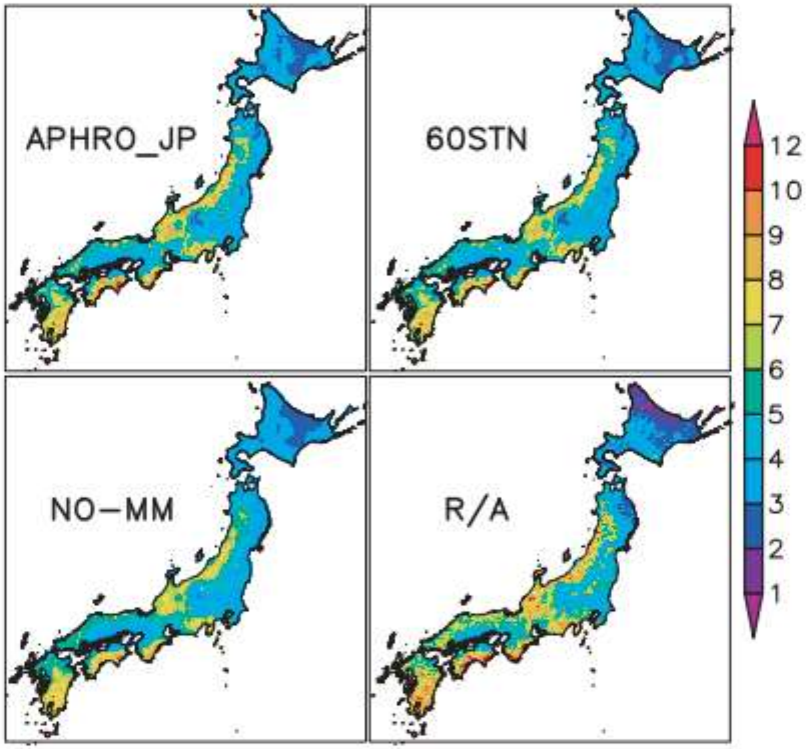


Figure 4. Annual mean precipitation (mm/day) from 1989 to 2007.

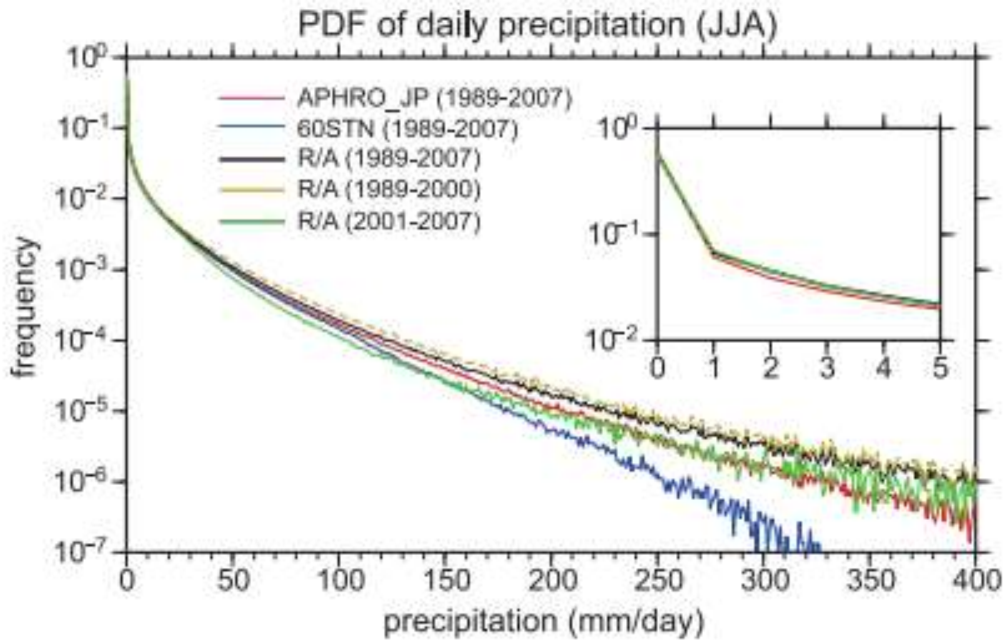


Figure 5. Probability distribution function of daily precipitation.

Kamiguchi et al. (2010)

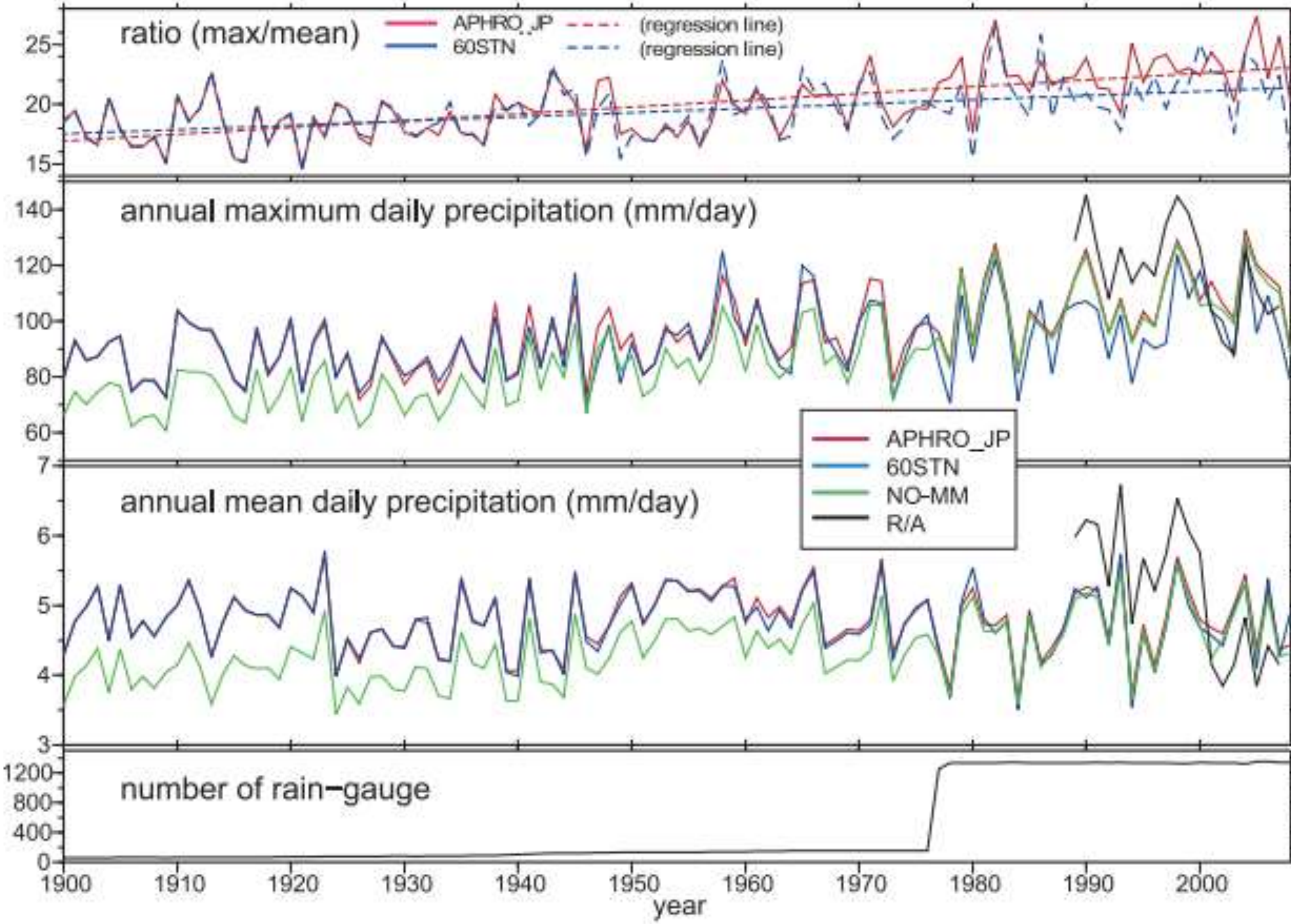


Figure 2. Historical changes in the number of available rain gauges (bottom), annual mean and maximum daily precipitation (middle), and the ratio of annual maximum daily precipitation to annual mean daily precipitation (top).

Kamiguchi et al. (2010)

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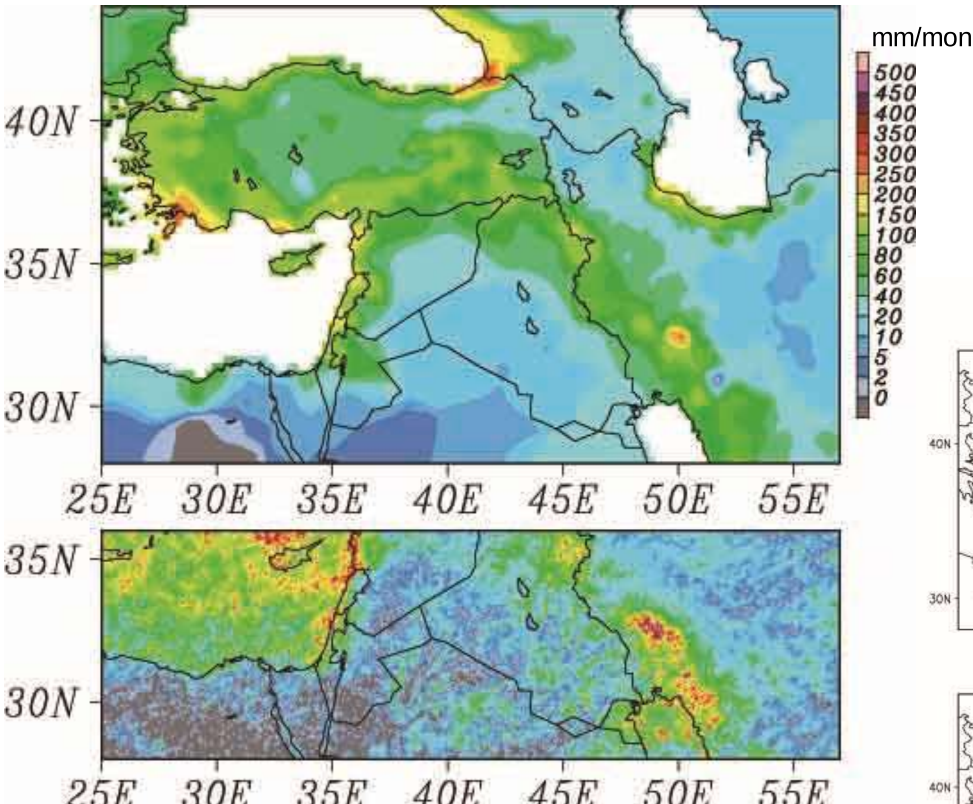
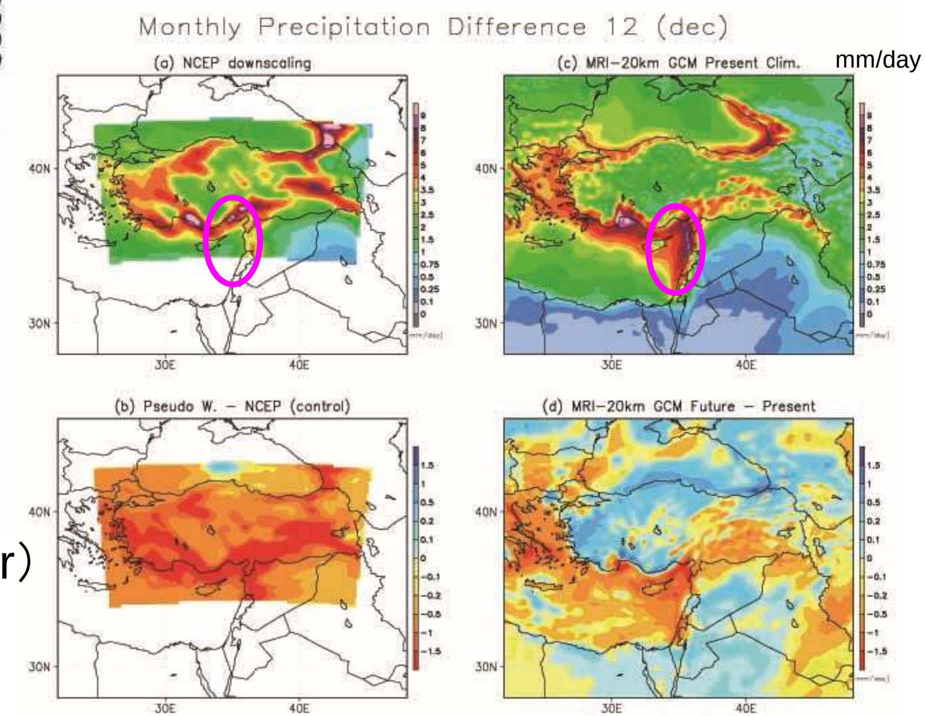
Middle East version and model validation



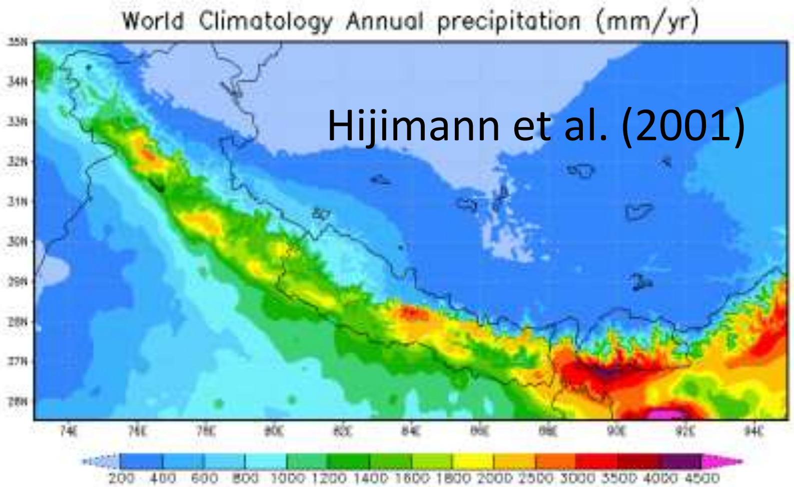
Rain gauge-based climatology(upper）
TRMM/PR composite（lower）
For December



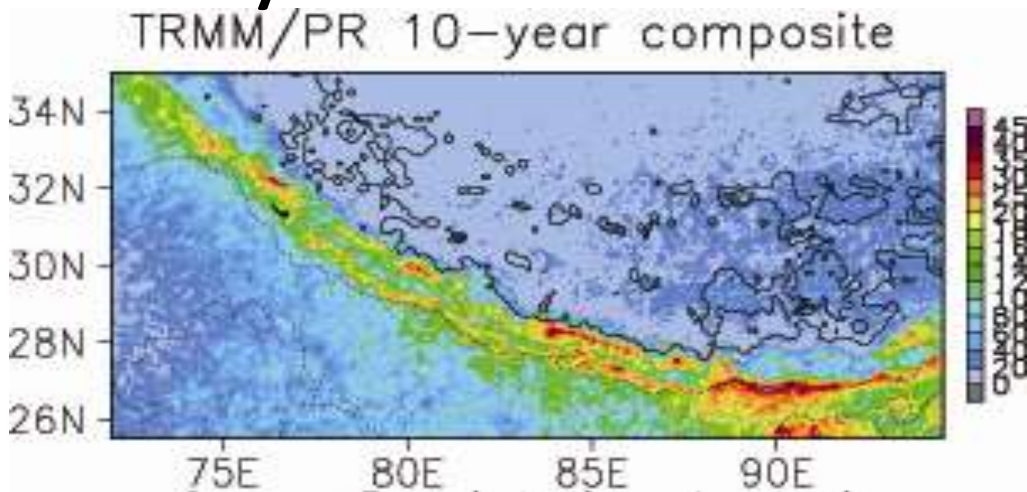
Yatagai, Kimura, Kitoh, Watanabe (2006)
Proceedings for International Symposium on Water and Land Management for Sustainable Irrigated Agriculture, Turkey

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

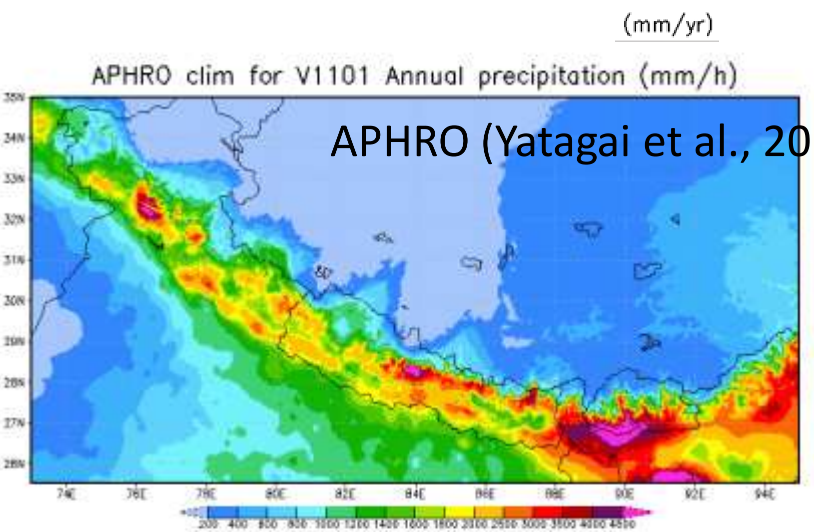
Improving climatology over the Himalayas



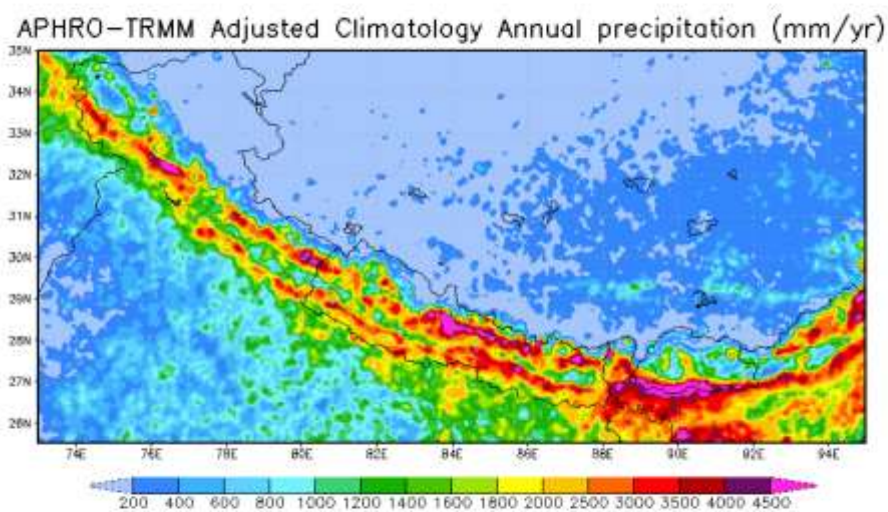
Hijimann et al. (2001)



(Yatagai and Kawamoto, 2008)



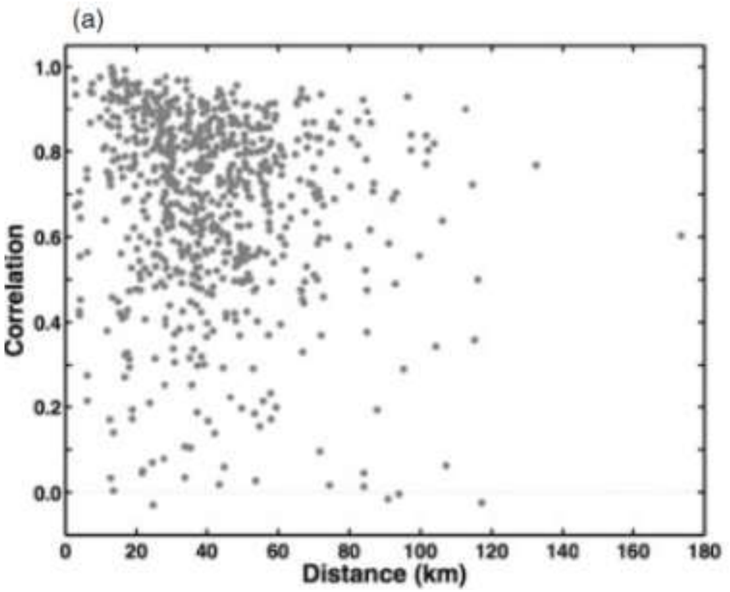
APHRO (Yatagai et al., 2012)



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/CCl 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

References

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- Zhao, T. and A. Yatagai (2013): Evaluation of TRMM 3B42 product using a new gauge-based analysis of daily precipitation over China, *Int. J. Climatol.* , DOI: 10.1002/joc.3872.