GPCC Annual Report for year 2008

Development of the GPCC Data Base and Analysis Products

Summary

Data Base

During year 2008 monthly precipitation data from 36 WMO member countries have been received and processed into the GPCC database, which is continuously complemented with regard to spatial as well as temporal coverage. The GPCC highly appreciates the assistance by all the countries having supplied observed precipitation data. During the two decades since its origin in year 1988 the largest global monthly *in situ* observed precipitation station database of the world (data from about 78 000 different stations in around 180 countries of the world) has been compiled at GPCC. The database has been intensively quality controlled in context of the preparation of the new 2008 GPCC products: the Global monthly precipitation climatology and the Full Data Reanalysis Version 4 for the period 1901-2007.

Monthly precipitation totals are routinely accumulated from SYNOP reports received via GTS at DWD and NOAA and obtained from CLIMAT reports received at DWD, JMA and UKMO from a total number of 6.500 – 8.000 stations. These GTS data have been used as basis for the GPCC near-realtime precipitation monitoring product analyses in year 2008.

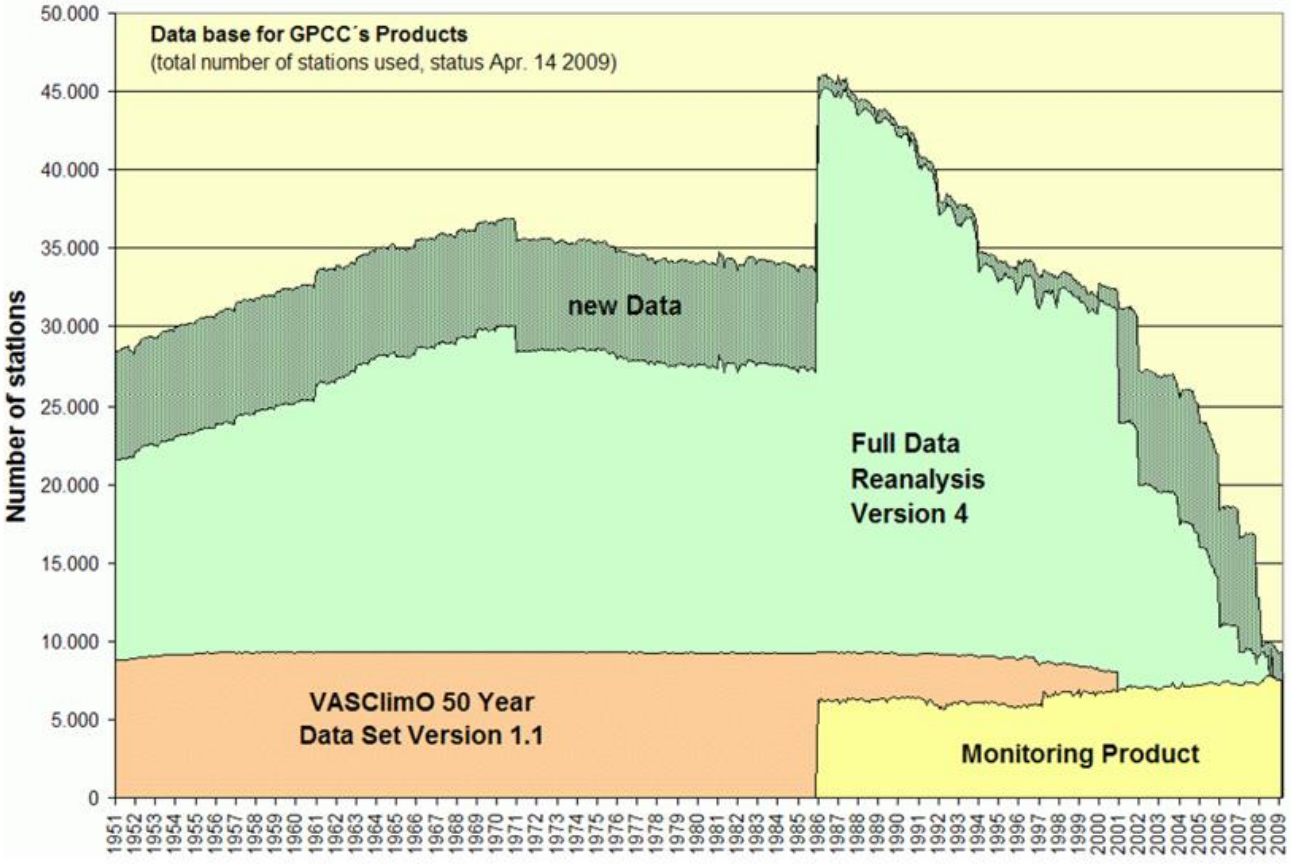

Figure 1: *Composition (number of stations) of the global precipitation station data base of GPCC used for the near real-time "Monitoring product", for the "Full Data Product Version 4" (new version 4 ready since Sep. 2008) and for the VASClimO "50-Year Climatology" Version 1.1 (released in August 2005), as well as "new Data" integrated since Sep. 2008.*

The original station data (see in Fig. 11 in page 13 the length and density of the station data contributions by WMO member countries to GPCC) cannot be redistributed by the GPCC respecting the requests of the data owners. But the gridded GPCC products are freely accessible via Internet for visualisation and download (http://gpcc.dwd.de). All global analysis products mentioned above are available as gridded area averaged data in geographical coordinates (grid box resolutions 0.5° latitude by 0.5° longitude and aggregated to 1.0° x 1.0° and 2.5° x 2.5° boxes).

Analysis Products

As before, the GPCC continuously processed in year 2008 its two near-realtime analysis products, the First Guess of the monthly global land-surface precipitation anomalies (available within 5 days after the end of the month, based on the globally disseminated synoptic weather reports SYNOP) and the traditional Monitoring Product (available about 2 months after the end of the month, based on the global synoptic reports and, in addition to that, the globally disseminated climate bulletins CLIMAT). Both products are early available but can be affected by typical real-time data deficiencies (sparse coverage, missing data, coding errors). The GPCC First Guess is used in the framework of drought monitoring by FAO and others. The GPCC Monitoring Product is requested by GEWEX/GPCP and is used as an early *in situ* reference for adjustment of satellite-based global precipitation estimates (e.g. Adler et al. 2003, Huffman et al. 1995, Xie and Arkin 1997). The satellite-gauge combined analyses of the GPCP cover the full globe (ocean and land surface) and are of use in many applications as global energy and water cycle studies, verification of global climate models, validation of numerical weather forecasts.

The significant enlargement of GPCC's monthly precipitation data base during the last years enabled the GPCC to produce a new high resolution gridded monthly precipitation climatology (reference periods preferably 1951-2000 and 1961-1990) based on climatological normals from ca. 50,650 stations (which is a doubling in the number of available stations compared to the previous GPCC precipitation climatology). The new climatology is available since May 2008 in 4 different spatial grid resolutions: 0.25°, 0.5°, 1.0° and 2.5°.

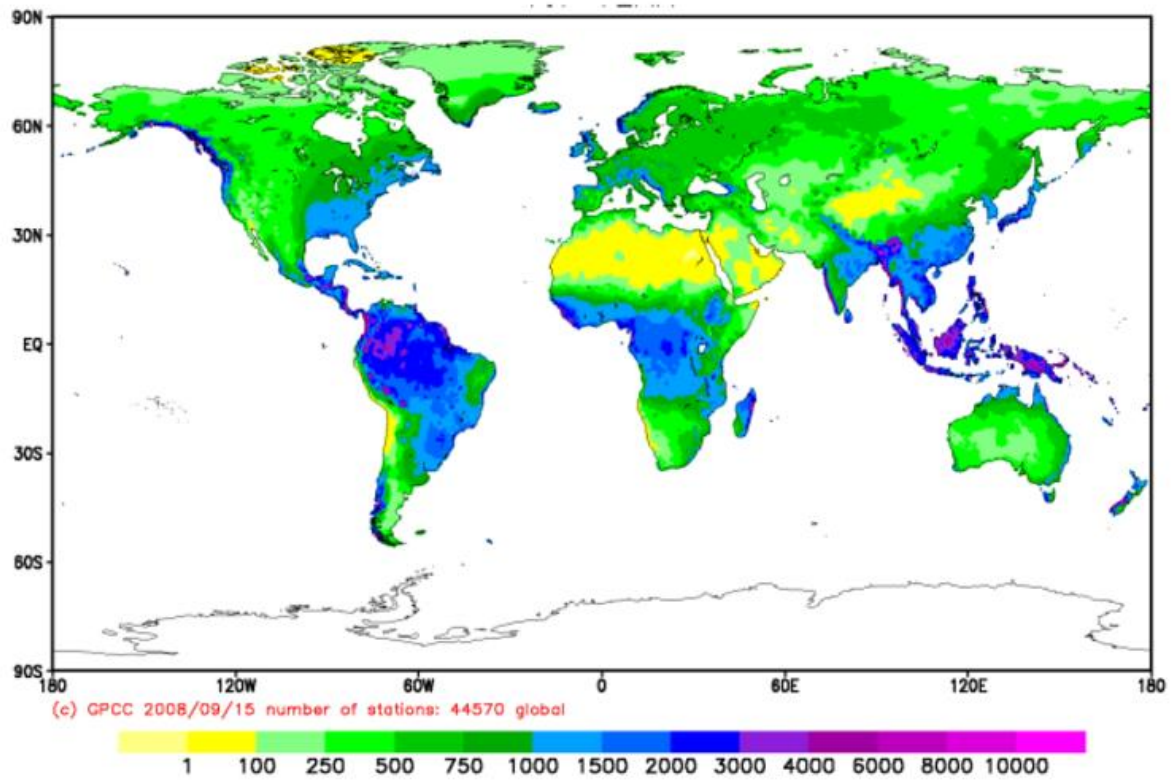

***Figure 2:** Example of the new GPCC precipitation climatology: Total mean annual precipitation in spatial resolution 0.25° x 0.25°.*

After finalisation of the new precipitation climatology the GPCC analysis method has been changed. Since autumn 2008 GPCC's monthly precipitation analysis products (except VASClimO data set V1.1) are based on anomalies from climatological normals at the stations or, where no station normal is available, from GPCC's high resolution gridded climatology. The anomalies are spatially interpolated by the analysis method SPHEREMAP and, for the Monitoring and Full Data Version 4 Reanalysis Products, the gridded anomaly analyses are then superimposed on GPCC's new background climatology. This change in analysis method is expected to further improve GPCC gridded analyses in data sparse areas, e.g. concerning a better representation of orographic rainfall effects.

Since September 2008 a new extended product version of the GPCC non real-time Full Data Reanalysis Product is available. This analysis product is based on all stations, near real-time and non real-time, in the GPCC data base supplying data for the individual month. The data coverage per month varies from less than 10,000 to more than 45,000 stations. The GPCC Full Data Reanalysis Product Version 4 has significantly been extended backwards in time compared to previous Full Database analyses. It covers the period from 1901 to 2007 and is available in 3 different spatial grid resolutions: 0.5°, 1.0° and 2.5°.

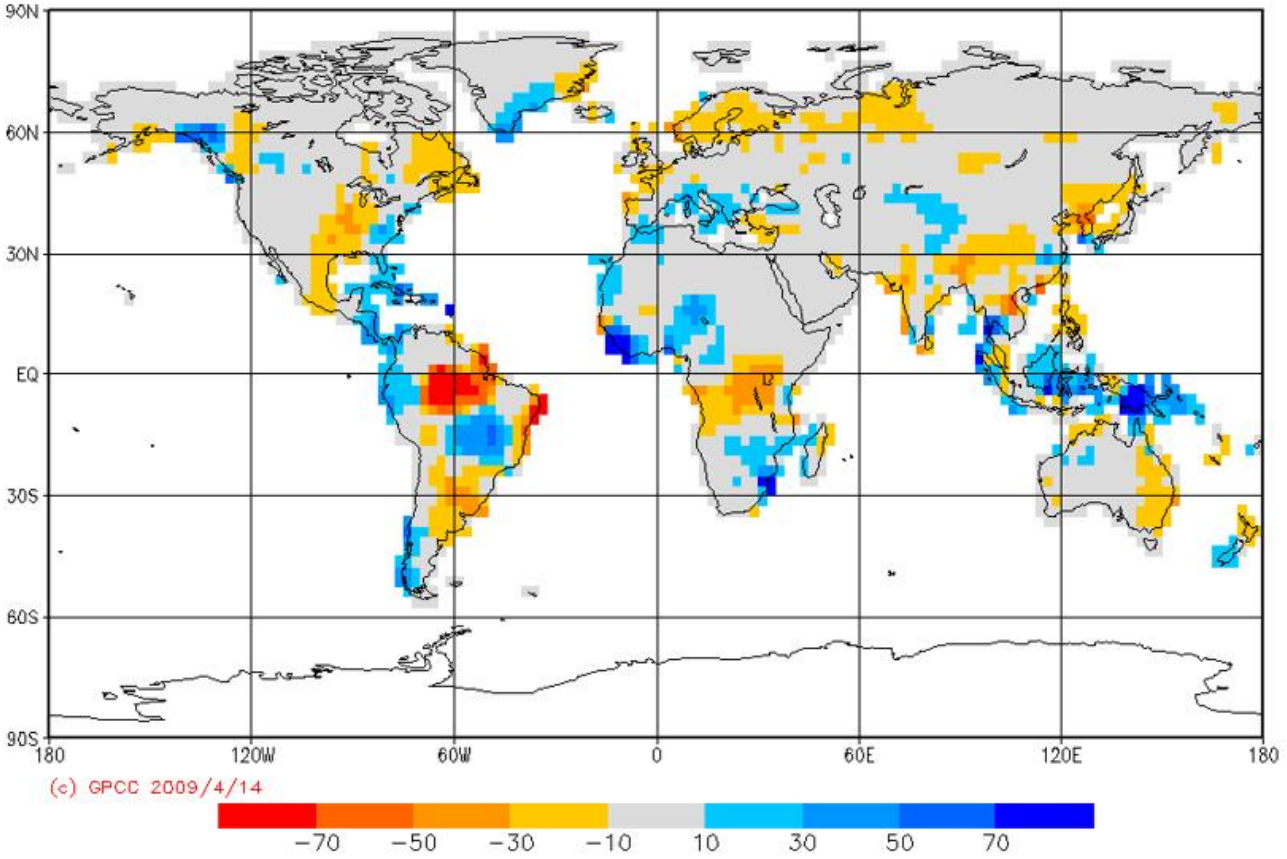

Figure 3: *Example of the new GPCC Full Data Version 4 analysis: Deviation (mm) of the total annual precipitation in year 1901 from the GPCC climatology, spatial grid resolution 2.5° x 2.5°.*

The non-realtime GPCC VASClimO product - Version 1.1, available for the period 1951-2000 – has not been changed during year 2008. It is currently being updated. The new GPCC VASClimO product Version 2 is planned to become available in summer 2009 and will cover the period 1951-2005.

While the Full Data Reanalysis Product provides the best spatial data coverage for each individual month, the VASClimO Climatology is optimized for completeness and homogeneity for the period 1951-2000. Application of the Full Data product is recommended for water budget studies, but the VASClimO Climatology should be preferred for analysis of temporal climate variability, in particular of the spatial distribution of climate change with respect to precipitation.

GPCC plans for 2009:

- **Continuous enlargement of the GPCC database esp. concerning the period before 1986. Already during the first quarter of 2009 some multi-annual data sets have been received e.g. from Belarus, Pakistan, Mongolia, Norway, Turkey.** These as well as additional datasets received in course of year 2009 will be integrated in the GPCC database;
- **Finalisation of new version 2 of the GPCC monthly non-realtime VASClimO Product (adjusted for climate variability and trend analyses) covering the time period: 1951-2005 in spatial resolutions: 0.5°, 1.0°, 2.5°. Planned to be ready until mid of year 2009;**
- **Finalisation of a GPCC reference publication introducing the GPCC analysis products;**
- **Update and enlargement of the functionalities of the "GPCC Visualiser";**
- **Contribution to a Re-Analysis of the monthly gauge-satellite combined products of the WCRP GEWEX Global Precipitation Climatology Project (GPCP);**
- **Preparation of first steps towards a daily GPCC near realtime precipitation monitoring product based on GTS based SYNOP data.**

Additional Information

1) Development of the GPCC monthly precipitation data base

a) Near real-time GTS Data Base

Monthly precipitation totals were routinely obtained from SYNOP and CLIMAT reports received via GTS at DWD from a total number of about 7.500 stations. These GTS data have been reformatted and loaded into GPCC's relational data base management system (RDBMS) and they were subsequently used for the monthly near-realtime GPCC Monitoring analyses.

b) GPCC Full Data Base

During year 2008 GPCC received additional monthly precipitation data from 36 countries.

Table 1: Data deliveries of individual countries to GPCC during year 2008

Country	*Number of Stations*	*Period with data YYYY/MM - YYYY/MM*
Argentina	114	1861/01 - 2008/06
Angola	180	1958/01 - 1974/12
Australia	~ 6000	1850/01 - 2008/04
Bhutan	25	1990/01 – 2007/12
Botswana	33-38	1981/01 – 1985/12, 2001/01 – 2006/12
Bulgaria	27	1951/01 - 1985/12, 2005/01 - 2006/12
Chile	162	1970/01 - 2007/12
Colombia	20	1953/01 – 1954/12
	163	1955/01 – 1985/12
Costa Rica	20	1951/01 – 2008/04
Cyprus	9	2007/01 – 2007/12
Czech Republic	70	2007/01 - 2007/12
Denmark	16	2007/12 – 2008/11
Egypt	30	1968/01 – 2007/12
France	5036	2007/01 – 2007/12
France (overseas departments)	~70	1953/01 – 2008/11
Iceland	363	1924/01 – 2007/12
Iran	1632	1957/01 – 2005/12
Israel	13	2005/01 – 2007/12
Italy	33	2007/12 – 2008/10
Kyrgyzstan	76	1889/01 – 2007/12
Latvia	21	2007/01 – 2007/12
Luxembourg	~20	2006/01 – 2006/12
Macedonia	12	2005/01 – 2007/12
Malaysia	37	2007/01 – 2007/12
Mauritius	2	1992/01 – 2008/09
Morocco	21	1920/01 – 2007/12
Mozambique	32	1951/01 – 2006/12
Netherlands	96	2007/11 – 2008/10
Oman	75	1894/01 – 1992/12
Panama	92	1955/01 – 2008/06
Poland	140	2007/01 - 2007/12
Slovakia	45	2007/01 – 2008/06

Country	*Number of Stations*	*Period with data YYYY/MM - YYYY/MM*
South Korea	82	1951/01 – 2008/05
Switzerland	428	2007/01 – 2007/12
USA.	~22000	1886/01- 2008/01
Uganda	17	2007/01 – 2007/12
Uzbekistan	71	2005/01 – 2007/12

Please note: GPCC is not able to distribute station-related observational data to others in order to respect the interests of the data suppliers.

Processing of the additionally delivered national/regional data sets (inl. quality control of metadata and observation data) and inserting them into GPCC's RDBMS is a continuous GPCC activity. Fig. 4 displays the temporal evolution of the number of monthly precipitation station data in the GPCC data base from the different sources during the time period 1840-2008 ("SYNOP": GTS-based synoptic weather observations analysed at DWD; „CLIMAT": GTS-based CLIMAT data; „CPC": GTS-based synoptic weather observations analysed at NOAA/CPC; „REG": Regional data bases; „NAT": National data provided by WMO members; „CRU": Database of the Climate Research Unit of University of East Anglia, UK; „GHCN": Database of the Global Historical Climatology Network, USA; „FAO": Database of the UN Food and Agricultural Organisation, Italy; „ALL": Total number of station data from all available sources).

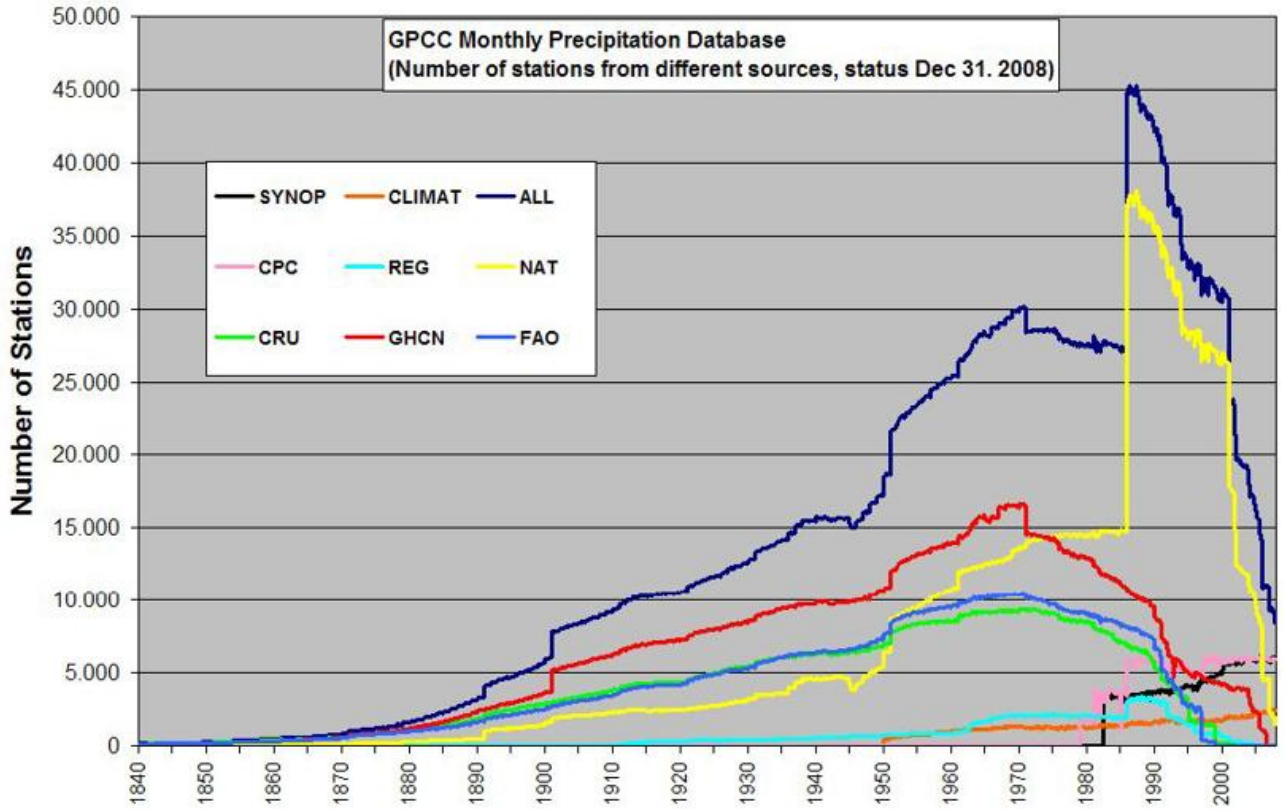

Figure 4: *Number of monthly precipitation data in the GPCC data base as a function of time for the different data sources in the GPCC database.*

Fig. 5a on the next page shows the evolution of the GPCC Monthly Precipitation Database (data period from 1951 onwards) between January 2000 and April 2009. It can be seen, that the starting period of GPCC, 1986-2001, is still the period with the highest number of station data. However a larger increase of the number of stations available for the period before 1986 and after 2001 is visible for the last few years when compared to the number of stations for 1986-2001.

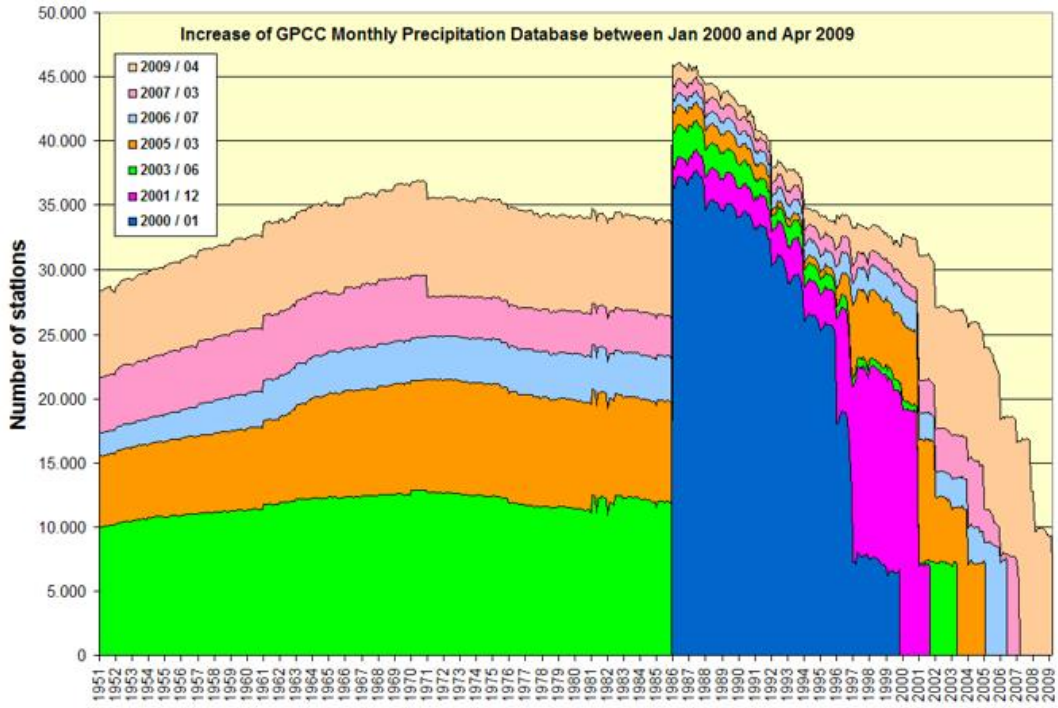

Figure 5a: *Evolution of the GPCC Monthly Precipitation Database between January 2000 and April 2008 (Number of stations per data year)*

Fig. 5b shows the evolution of the number of station months in the GPCC Monthly Precipitation Database (decades with data from 1951 onwards) during the period July 1997 until April 2009. It indicates, that the extension of the GPCC data base concerning historical data (data before year 1986) started in 2003. The historical extension of the GPCC data base during the last 6 years is very visible by looking at the decades with data before year 1981. Alltogether the number of station months almost increased by a factor of 6 during the last 12 years.

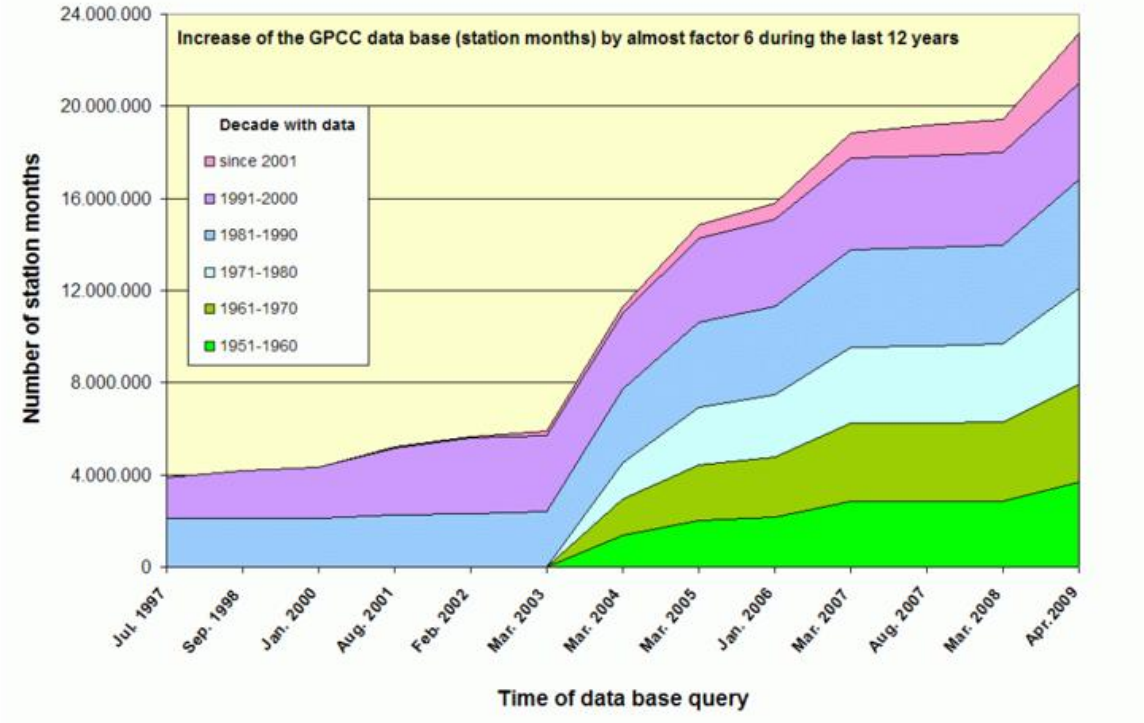

Figure 5b: *Evolution of the GPCC Monthly Precipitation Database between July 1997 and April 2009 (Number of station months per date of data base query)*

The figures 6 a-f show the temporal evolution of the spatial coverage of the GPCC database (indicated by the number of stations available for analyses in each 2.5° x 2.5° grid) used for GPCC Full Data Reanalysis Version 4 available since September 2008. Green and blue colours indicate grids with a sampling error of less than 10 % of the precipitation total on the grid.

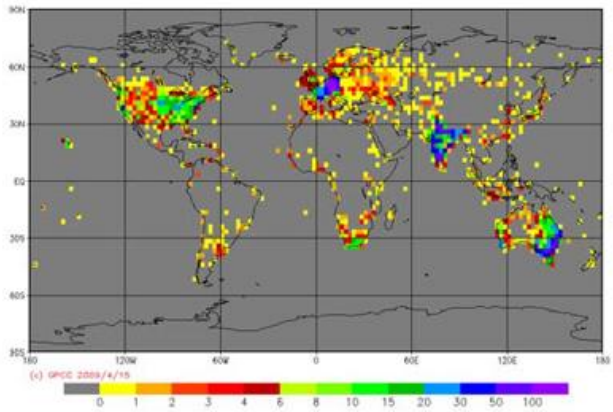

Fig. 6a *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 1901, Total number of stations: 7831*

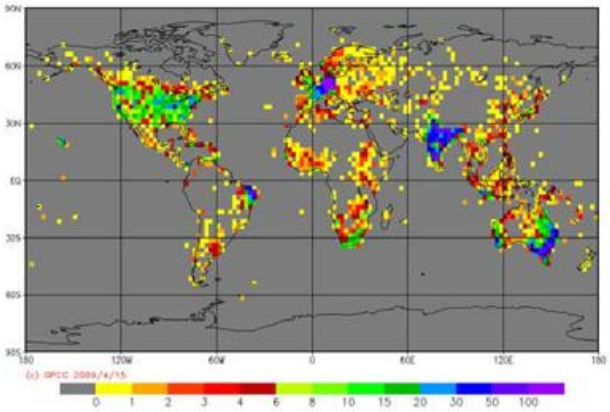

Fig. 6b *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 1921, Total number of stations: 10985*

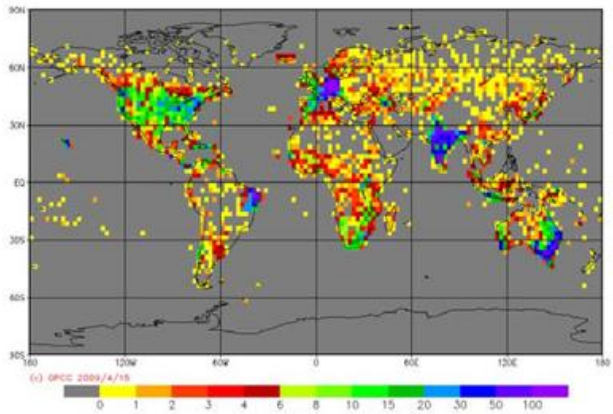

Fig. 6c *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 1941, Total number of stations: 15653*

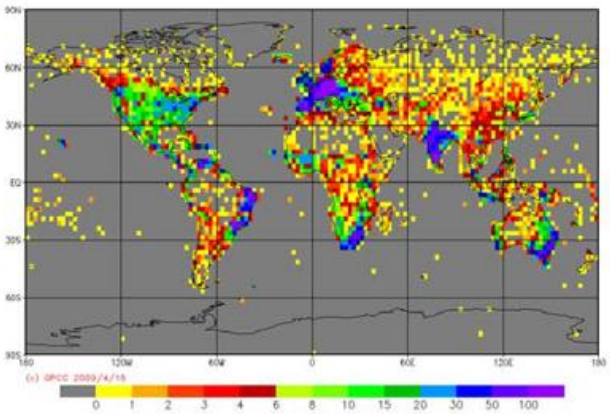

Fig. 6d *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 1961, Total number of stations: 26377*

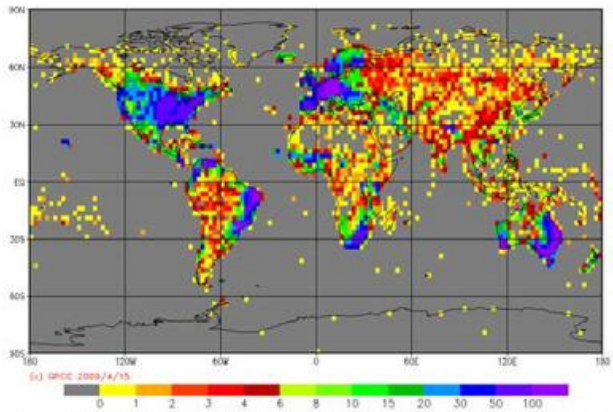

Fig. 6e *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 1986, Total number of stations: 45152*

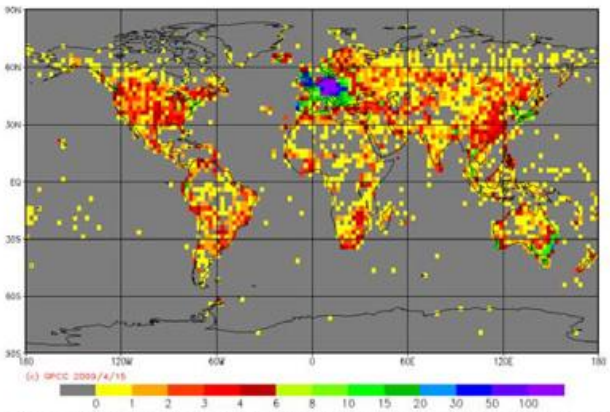

Fig. 6f *Spatial distribution of the number of stations used for the new GPCC Full Data Reanalysis Version 4 analysis with 2.5° x 2.5° grid resolution Month: July 2006, Total number of stations: 11015*

2) GPCC Analysis Products

a) GPCC Monitoring Product

The monthly "GPCC Monitoring Product" is now available for all months since January 1986, i.e. 276 months. The GTS-based rain-gauge data used for the GPCC Monitoring Product analyses have been processed and analysed for all months of year 2008. All data were quality-controlled on a high level with automatic plus visual checks. The quality-control results for the year 2008 are summarized in Fig. 7. 5 - 8 % of the totally available stations (450-650 stations every month) are flagged by the automatic GPCC procedures for visual control. Most of the flagged station data can be accepted or modified during manual control. About 2 - 4 % of the available GTS station data need to be rejected. A significant error source is the increasing automatisation of networks (e.g. many rejected stations are AWS in North America continuously reporting 0 mm precipitation).

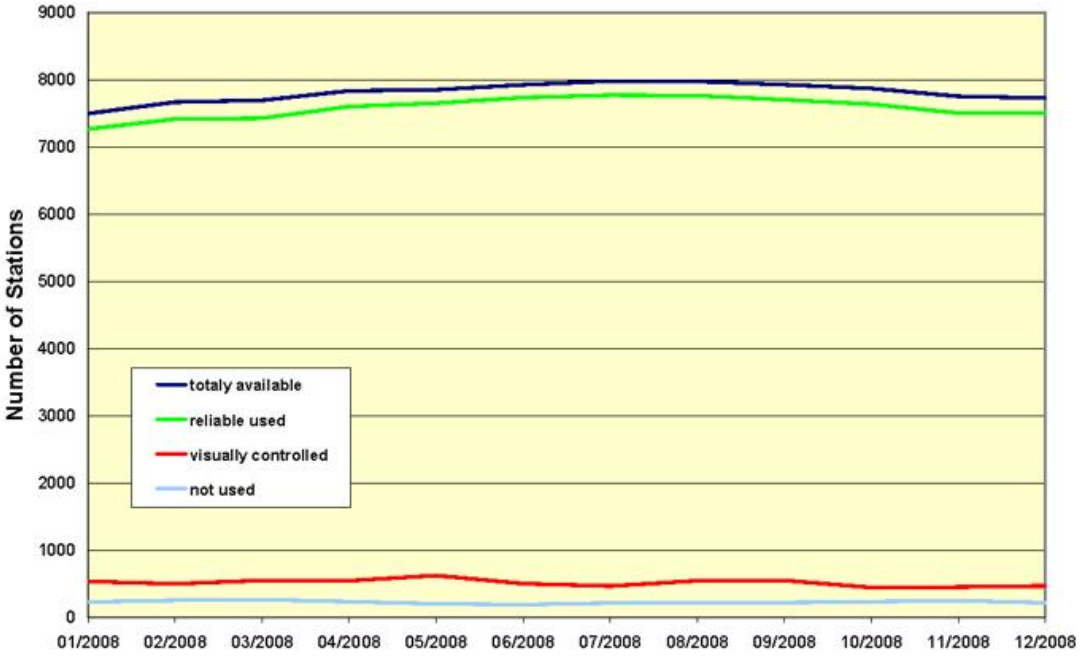

Fig. 7 Quality-control results of data used for GPCC Monitoring product analyses during year 2008

Users of gridded GPCC products are advised to take into account the grid size and related number of stations per grid when using and interpreting GPCC analyses. A high grid resolution relates to a low number of stations available for gridded analyses and thus to a higher sampling error. See Fig. 8 below, on which red colours indicate grids with at least 3 stations and green colours mark grids with at least 6 stations. It can be seen, that there are more as well as larger red and green areas on the left figure (grid resolution: 2.5°) compared to the right figure (grid resolution: 1.0°).

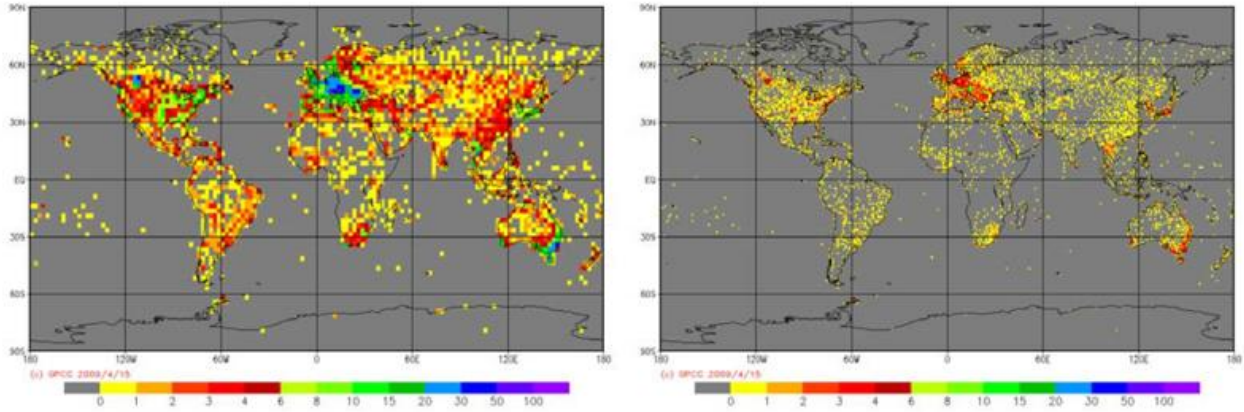

***Fig. 8** Number of stations used for each grid of GPCC Monitoring Product analyses of January 2009 (Left: Grid resolution 2.5° x 2.5°; Right: Grid resolution 1.0° x 1.0°)*

b) GPCC First-Guess Product

This product, which is available a few days after the end of the month, is based only on monthly precipitation totals calculated from SYNOP reports received at DWD (Offenbach) in near real-time (ca. 5,800 – 6,500 stations). The monthly precipitation totals undergo only an automatic pre-control, but no additional visual quality-control. The most recent analysis month is March 2009. Global precipitation anomalies based on the First-Guess Product are provided via Internet.

c) GPCC Full Data Product

The new GPCC Full Data product Version 4 analyses based on the full GPCC database (near-realtime and non-realtime) of September 2008 are available for the period 1901 to 2007 on 0.5°, 1.0° and 2.5° grid resolutions.

d) GPCC VASClimO Product

The GPCC VASClimO product Version 1.1 analyses based on nearly complete and homogenised time series extracted from the full GPCC database (near-realtime and non-realtime) of January 2005 are available for the period 1951 to 2000 on 0.5°, 1.0° and 2.5° grid resolutions. This product is optimised for climatological analyses of precipitation variability and trends. A new version of VASClimO based on a significantly enlarged database will be available by mid 2009.

3) Other GPCC Matters

Visitors at GPCC during year 2008

April 2008:	Delegation of the Italian Met Service, Rome, Italy
Sept. 2008:	Mrs. A. Kuhn, Junior Programme Officer at GCOS JPO, Geneva, CH
Dec. 2008:	Prof. P. Döll, Univ. of Frankfurt/Main, Germany

GPCC related outreach activities in 2008

Oral presentation at event	*Date*	*Location*
Atmospheric Observation Panel for Climate (AOPC)	21 – 25 April 2008	Geneva (CH)
UNESCO NE FRIEND Meeting	29 – 30 May 2008	Koblenz (DE)
German Meteorological Society Meeting	25 June 2008	Munich (DE)
WCRP GEWEX CEOP Meeting	15 – 17 Sept. 2008	Geneva (CH)
WCRP GEWEX GRP/WGDMA Meeting	22 - 24 Sept. 2008	Hongkong (CHN)
European Conference on Applied Climatology	30 Sept. - 03 Oct. 2008	Amsterdam (NL)
WMO WIGOS-WIS Expert Team on WIGOS	10 – 13 Nov. 2008	Geneva (CH)
Participation at event	*Date*	*Location*
National GEO Meeting	21 Jan – 22 Jan 2008	Frankfurt (DE)
National Committee on Disaster prevention	20 Nov. 2008	Offenbach (DE)

New GPCC posters have been compiled in year 2008 for:
- WMO RA VI conference "Hydrology in the Arctic Climate", June 2008, Spitsbergen, Norway
- WCRP GEWEX CEOP Meeting, Sept. 2008, Geneva, Switzerland
- Meeting of the International Precipitation Working Group, Nov. 2008, Beijing, China

A GPCC precipitation anomaly map for year 2008 has been provided to WMO and published in the WMO report on the status of the global Climate of year 2008.

Global Precipitation Climatology Centre staff at DWD during year 2008

GPCC head: Mr. T. Fuchs

Scientific staff members: Mr. Udo Schneider (deputy GPCC head), Mrs. Anja Meyer-Christoffer

Data administrator and programmer: Mr. Peter Finger

Technical assistants: Mr. Jan Nicolas Breidenbach, Mrs. Astrid Heller, Mr. Peter Stender.

In addition, the former GPCC head Dr. Bruno Rudolf guides the GPCC-activities

GPCC contact details

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Business Unit Climate and Environment
Division KU42
Global Precipitation Climatology Centre
P.O. Box 10 04 65
D-63004 Offenbach am Main, Germany

GPCC Homepage: http://gpcc.dwd.de/
The GPCC homepage has been newly designed and updated at the begin of year 2008.

***Fig. 9** New layout of the GPCC homepage*

GPCC Internet and FTP contacts

Fig. 10 shows, that between 1000 and 2000 visitors at the GPCC Visualiser have been counted during each month of year 2008. The monthly access numbers to the different GPCC Monitoring Product indicate: The most popular GPCC product in 2008 was the GPCC Monitoring Product in 1° x 1° grid resolution.

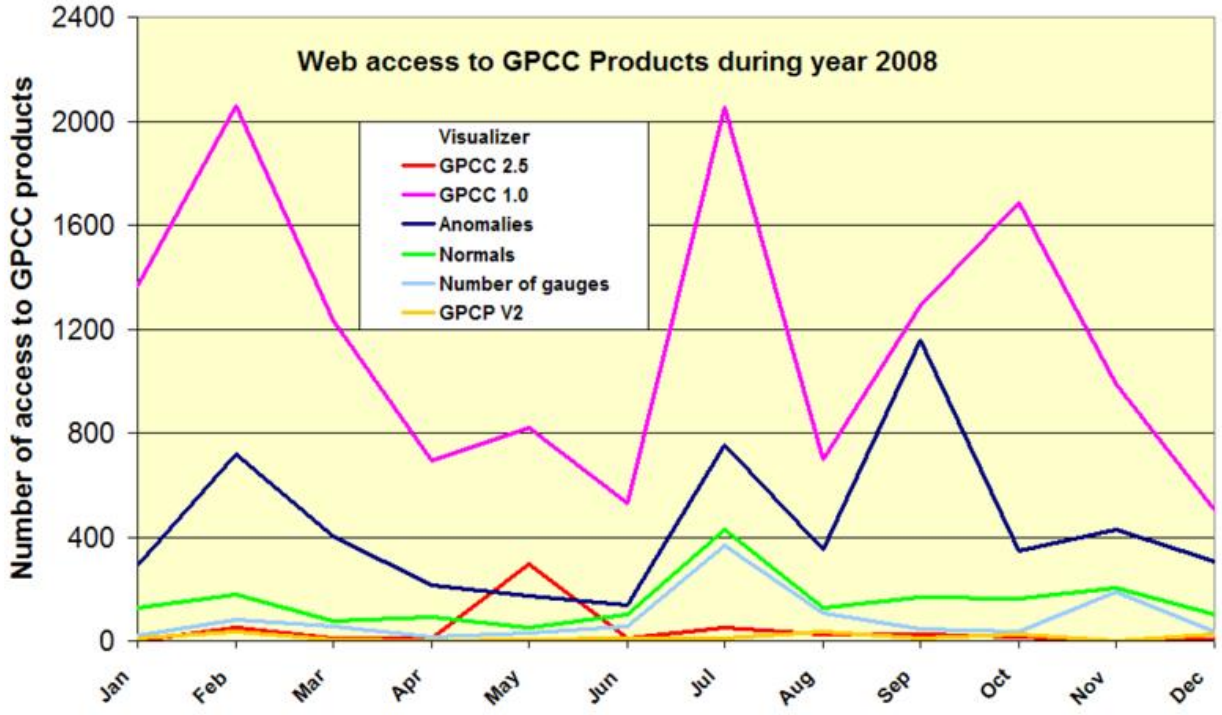


Fig. 10 *Number of accesses to products on the GPCC Website during 2008*

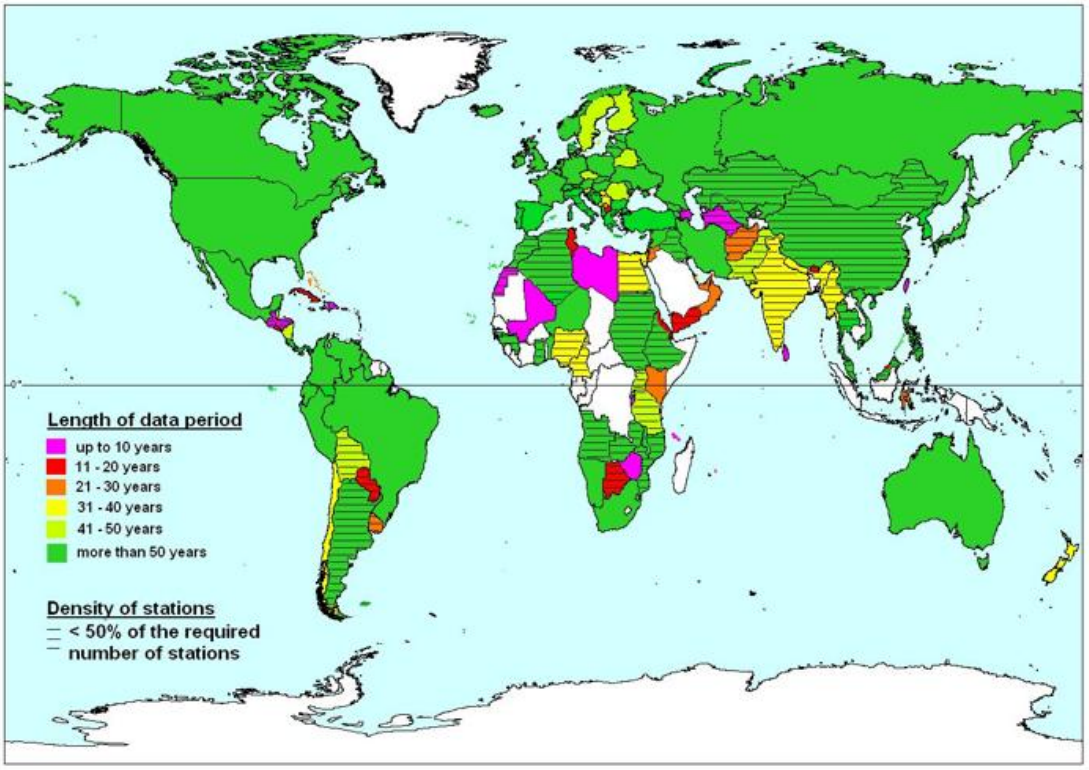


Fig. 11 *Contributions of precipitation data sets by WMO member countries to GPCC*

Global Precipitation Climatology Centre (GPCC) Deutscher Wetterdienst

The GPCC – A contribution to Climate Monitoring and Research in context of GCOS and WCRP

The GPCC task and functions

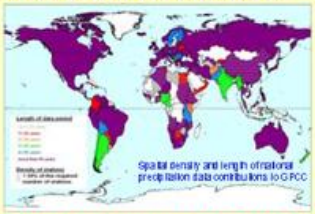
- Continuous operation by the Deutscher Wetterdienst (DWD) since 1989 under auspices of WMO;
- Integration as Global Data Center in GCOS and in WCRP GEWEX;
- Provision of global precipitation analysis products for monitoring and research of the Earth's climate (gridded data sets of monthly precipitation totals for the global land-surface based on in situ EO data);
- The GPCC analysis products are freely available via Internet (http://gpcc.dwd.de).

The GPCC *in situ* precipitation station data base

Near real-time data from the Global Telecommunication System (GTS) of the World Meteorological Organisation (WMO):

+

Non real-time data from international projects, historical data collections and more than 175 countries of the world:



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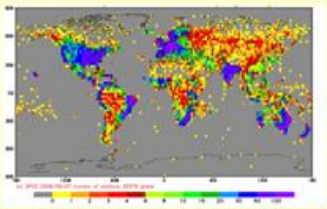
Total data base (number of stations per grid) used for calculation of the new GPCC global precipitation climatology in 2.5° x 2.5° grid resolution (Total number of stations: 50376)



GPCC contributes to *in situ* EO Network Monitoring activities of WMO WWW and GCOS; GPCC has the largest global monthly *in situ* EO rainfall data base

The current GPCC monthly gridded precipitation product suite

First Guess Analysis (since 2003)
- for early monitoring of precipitation anomalies
- available within 3-5 days after observation
- based on 6000 near real-time available stations
- automatic-only quality-control

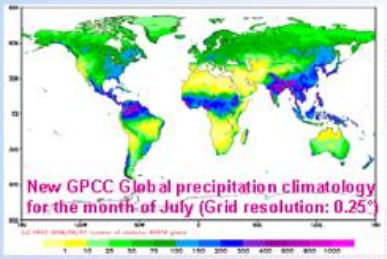
Monitoring Product (since January 1986)
- for near real-time climate monitoring and adjustment of satellite-based EO
- available 2 months after the observation month
- based on 7500 near real-time available stations
- High Level Quality Control of metadata and data

Full Data Reanalysis Product (1901-2007)
- for model verification and water cycle analysis
- use of the complete GPCC data base
- monthly data coverage varies from 8,000 to more than 47,000 *in situ* rainfall stations
- High level QC/QA of metadata and data

VASClimO 50 Year Data Set (1951-2000)
- for analysis of climate variability and trends
- High level quality and homogeneity control analysis based on climatic background
- based on 9343 *in situ* stations with nearly complete time-series

New GPCC Product versions (2008/2009)

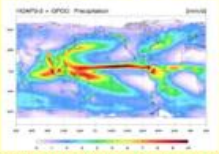
Monthly Global Precipitation Climatology (available since end of May 2008):
- -> based on more than 50,000 stations with at least 10 years of data;
- -> intensive QC/QA of metadata and data;
- -> spatial grid resolution: 0.25°, 0.5°, 1°, 2.5°



Version 4 of Full Data Reanalysis Product (available since end of September 2008)
- extended time period: 1901-2007;
- significantly enlarged database;

Version 2 of VASClimO Data Set (to be available until spring 2009)
- extended time period: 1951-2005;
- significantly enlarged database.

Outlook into potential future GPCC products



Daily near real-time global precipitation analyses based on combination of GPCC (land) and HOAPS http://www.hoaps.zmaw.de (ocean). Example above: HOAPS3 and GPCC combination for 1994-2004 (Source:S. Bakan, MPI-M Hamburg).

Hourly precipitation products for Central Europe in 1 x 1 km resolution based on weather radar QPE online adjusted with automatic raingauges.

The users of GPCC gridded data sets and their applications

GPCC products are adjusted to the needs of different user communities and are used by institutions worldwide, in particular in context of water- and climate-related research and monitoring activities

• WCRP GEWEX	Analyses of hydrometeorological processes and CalVal of satellite-based EO
• GEO	Contribution to GEOSS implementation
• GCOS	Global climate monitoring applications
• IPCC	Climate variability and trend analyses
• UNESCO IHP	Global and regional water resources assessments
• WMO HWRP	Runoff estimation (ungauged rivers) and contribution to GTN-H development
• ECMWF, UKMO	Weather forecast model verification (Re-analysis, seasonal forecasts)
• FAO	Water stress and drought monitoring

The Global Precipitation Climatology Centre (GPCC) is operated by the Deutscher Wetterdienst (DWD), Offenbach a.M., Germany, on request of the World Meteorological Organisation (WMO). For more information please visit the GPCC website http://gpcc.dwd.de

Fig. 12 GPCC poster compiled for the IPWG meeting, Beijing, China, 8-11 Nov 2008