GPCC Annual Report for the year 2006

Development of the GPCC Data Base and Analysis Products

Summary

Data Base

During the year 2006 the GPCC observational climate data base has been further complemented with regard to spatial as well as temporal coverage. Monthly precipitation data from 41 WMO member countries have been received and processed into the GPCC Data Base. The GPCC highly appreciates the assistance by all the countries having supplied observed precipitation data. Additionally the integration of the historical precipitation databases of CRU, FAO and GHCN into the GPCC data base has been finished. GPCC has now the largest global monthly precipitation station database of the world (data from more than 60 000 different stations in more than 170 countries of the world).

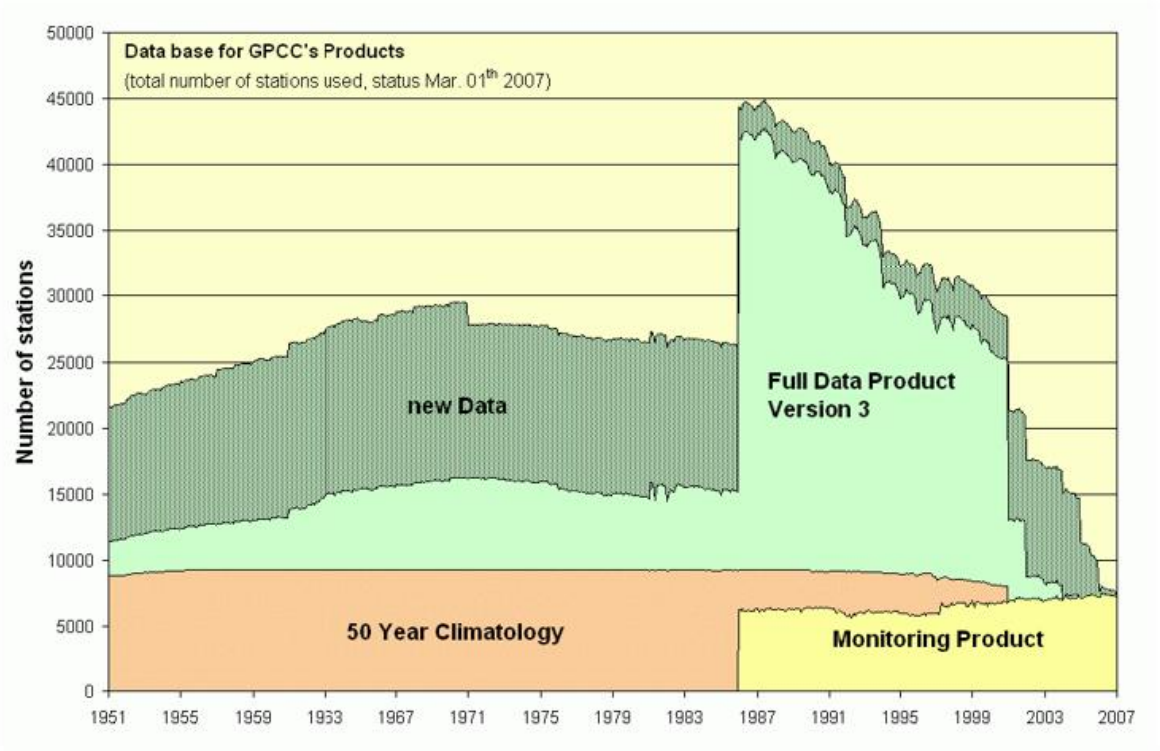
Monthly precipitation totals are routinely accumulated from SYNOP reports received via GTS at DWD and NOAA and obtained from CLIMAT reports received at DWD, JMA and UKMO from a total number of about 7.500 stations. These GTS data have been used for the GPCC near-realtime analyses in year 2006.

Analysis Products

As before, the GPCC continuously processed in year 2006 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 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 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, development of seasonal forecast systems.

The 2 non-realtime products, GPCC Full Data and GPCC VASClimO, have not been changed during 2006. The current product versions are: GPCC Full Data Version 3, available for the period 1951-2004, and GPCC VASClimO Version 1.1, available for the period 1951-2000. 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 VASClimO and GPCC Full Data have been input to the IPCC 4AR WG I report published in 2007.

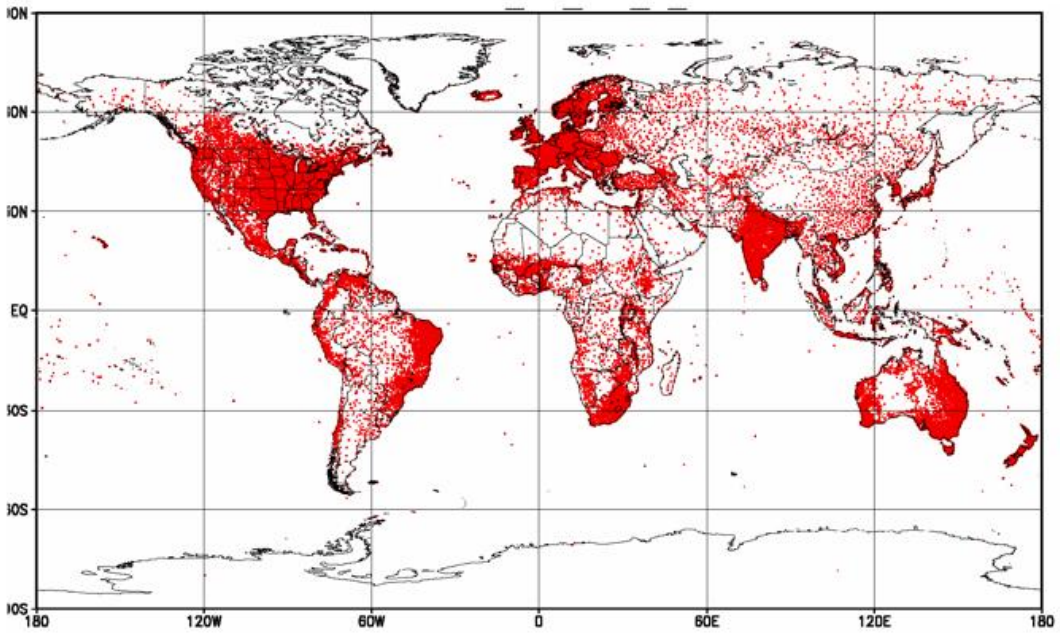
The original station data cannot be redistributed by the GPCC respecting the restrictions of the data owners. But the gridded GPCC products are freely accessible in the Internet for visualisation and download (http://gpcc.dwd.de). All global analysis products mentioned above are available as gridded 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).



The figure shows the 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 Reanalysis Version 3 (disseminated Feb. 2005) and for the VASClimO 50-Year Climatology Version 1.1 (released in August 2005), as well as the new data received and pre-processed in the course of the years 2005 and 2006. **The new data will be included in the Full Data Reanalysis Version 4 (planned to be ready by autumn 2007) and in an update of the VASClimO Climatology coming later in the year 2007.**

The significant enlargement of GPCC's monthly precipitation data base by inclusion of all major global precipitation databases enables the GPCC to produce a new mean precipitation climatology (period mainly 1961-1990) based on the largest monthly precipitation station data base of the world (more than 60.000 different stations). This new climatology, expected to be ready by summer 2007, will support to change the GPCC analysis method from analysing total precipitation amounts to the analysis of relative anomalies based on this new background climatology.

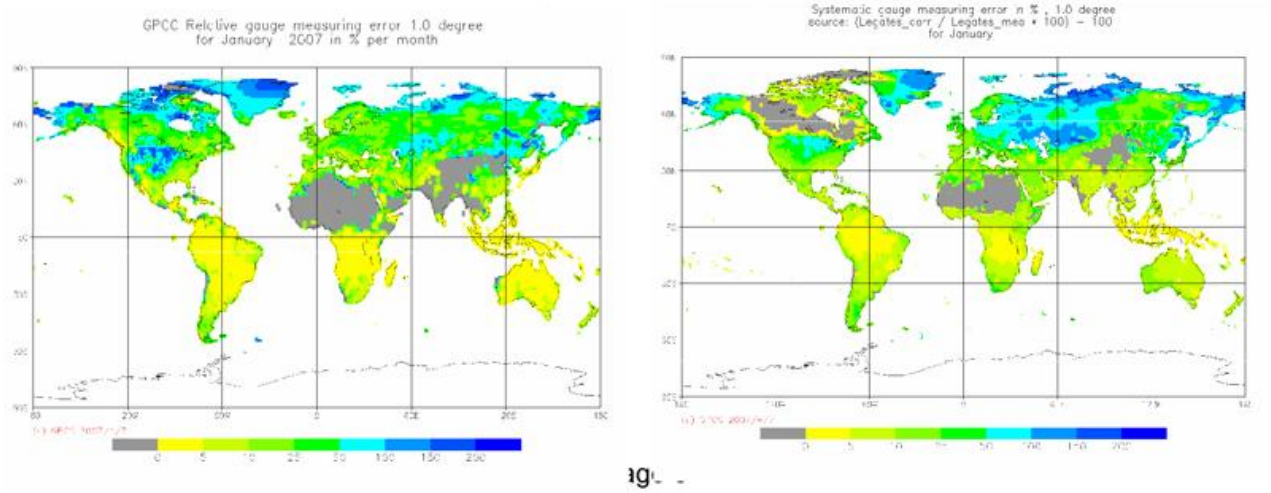
The quasi-operational products of GPCC (First Guess, Monitoring Product) and the Full Data Reanalysis are expected to be significantly improved by this change in the GPCC analysis method. Also an improvement of the VASClimO 50-Year Climatology will be backed by this activity since VASClimO was calculated as relative anomalies from a background climatology based on ca. 26,000 stations; the new climatology will be based on climatological normals from about 50.000 stations. Another positive side effect of the new climatology on the quality of the GPCC products will be a better representation of orographic rainfall effects. The high number of stations is expected to lead to a better station distribution in different altitudes. Interpolation methods to directly take into account the impact of station altitude and orientation related to orography were tested during 2006, however they did not show potential for operational applicability on a global scale by GPCC.



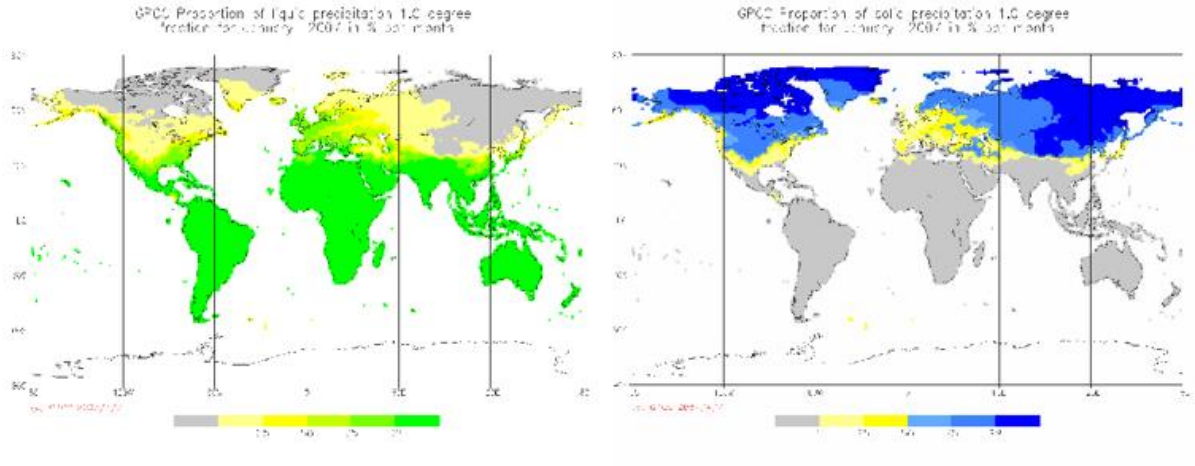
The figure shows the spatial distribution of the 50026 stations available for calculation of the new GPCC precipitation climatology

The new GPCC method enabling an improved estimation of the systematic gauge measuring error depending on the weather conditions during the analysis month, became operational since the GPCC Monitoring Analysis of January 2007. In addition to the syst. gauge measuring error also the monthly rate of the different precipitation types (liquid, solid, mixed) is routinely provided by GPCC from Jan. 2007 onwards. The basis for these products are the global synoptic data, which comprise 6h to 24 hour precipitation, air temperature, humidity, wind speed and classified weather information. The systematic error is calculated for the individual days of one month using formulas resulting from the WMO Instrument intercomparison studies (Goodison et al, 1998). The error is gridded with the interpolation method used for the GPCC precipitation products (SPHEREMAP). The new on event correction is expected to be more realistic than the bulk correction resulting from the Legates climatology. However, the corrections are still believed to be too large. The new error estimate is valid for the sites of 1st order weather stations which are mostly open for wind. Most of the climate or hydrometeorological stations are located in a more wind protected environment. The problem is that the rain gauge type used as well as the installation and siting of the stations are unknown for most of the 60,000 rainfall stations registered at the GPCC. A WMO activity to acquire these informations from all members could be very beneficial in this context.

The figures below show the relative systematic gauge measuring error in % for January 2007 (left: based on the new GPCC method; right: based on Legates' climatology)



The figures below show the fraction of liquid (left side) and of solid precipitation (right side) both in % for January 2007.



GPCC user advices:

- Users of raingauge-based precipitation products should carefully consider, which GPCC product they use for which application;
- Users should carefully take into account the number of stations used for calculation of grid values when interpreting GPCC products (The higher the product resolution, the higher the sampling error of analysis products);
- Correction factors reg. systematic gauge measuring errors might be applied to the GPCC precipitation products before using them for water balance studies.

GPCC activities/plans for 2007/2008:

- Production of a new global precipitation climatology;
- Change of the GPCC analysis method using the new climatology as background;
- Update of the GPCC Full Data Product;
- Update of the GPCC VASClimO Product;
- Continuous update of the GPCC near-realtime products;
- Continuous update and enlargement of the GPCC monthly precipitation station database;
- Contribution to a GPCP Re-Analysis;
- First steps towards the preparation of a global precipitation climatology based on a merger of GPCC (land) with HOAPS[1] (ocean).

[1] HOAPS: Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data, http://www.hoaps.org

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 2006 GPCC received additional monthly precipitation data from 41 countries.

Table 1: Data deliveries of individual countries to GPCC during year 2006

Country	Number of stations	Period	Remarks
Algeria	75	1936/01-2005/12	update
Austria	266	2005/01-2005/12	update
Belgium	27	2005/01-2005/12	update
Benin	6	1947/01-1980/12	supplement
Burkina Faso	146	1902/01-2000/12	supplement
Cameroon	1	1948/01-1949/12	supplement
Central Africa	14	1950/01-1980/12	new
Chad	11	1950/01-1978/12	new
Congo	12	1947/01-1980/12	new
Cote d'Ivoire	12	1940/01-1980/12	new
Croatia	40	2001/01-2001/12 and 2003/01-2005/12	update
Czech Rep.	70	2005/01-2005/12	update
Denmark/ Greenland	19	2005/12-2006/11	update
Ecuador	60	1901/01-2005/12	supplement
Finland	954	1961/01-2005/12	update
France	894	2005/01-2005/12	update
Gabon	14	1950/01-1980/12	new
Ghana	22	1944/01-2005/12	update
Guinea	8	1945/01-1958/12	supplement
Guinea-Bissau	29	1924/01-2005/12	new
Hong Kong	62	1947/01-2005/12	supplement
India	1000	1960/01-2000/12	supplement
Italy	33	2005/12-2006/11	update
Japan	168	1873/01-2005/12	update
Latvia	21	2005/01-2005/12	update
Mali	18	1940/01-1980/12	supplement
Mauretania	12	1940/01-1980/12	new
Mauritius	2	1971/01-2000/12	additional
Mexico	320	1902/01-2005/12	update
Nepal	261	1995/01-2004/12	update
Macedonia	12	2003/01-2003/12	update
Netherlands	98	2005/11-2006/10	update

New Zealand	10	1960/01-1980/12	update
Niger	10	1938/01-1080/12	supplement
Poland	140	2005/01-2005/12	update
Senegal	12	1854/01-1983/12	new
Slovakia	45	2005/07-2006/06	update
South Africa	800	1951/01-2005/12	update
Thailand	81	2005/01-2005/12	update
Togo	5	1945/01-1974/12	new
United Kingdom	460	2005/01-2005/12	update

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 and loading them into GPCC's RDBMS is a continuous GPCC activity. Additionally, the historical extension of the GPCC data base by integrating the precipitation data collections of CRU, FAO and GHCN has been completed during year 2006. Fig. 1 displays the number of monthly precipitation station data included in the GPCC data base from the different sources ("SYNOP": GTS-based synoptic weather observations analysed at DWD; „CLIMAT": GTS-based CLIMAT data; „All": Data from all sources; „CPC": GTS-based synoptic weather observations analysed at NOAA/CPC; „Reg": Regional data bases; „Nat": National data provided by WMO member countries; „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) for the period 1840-2006.

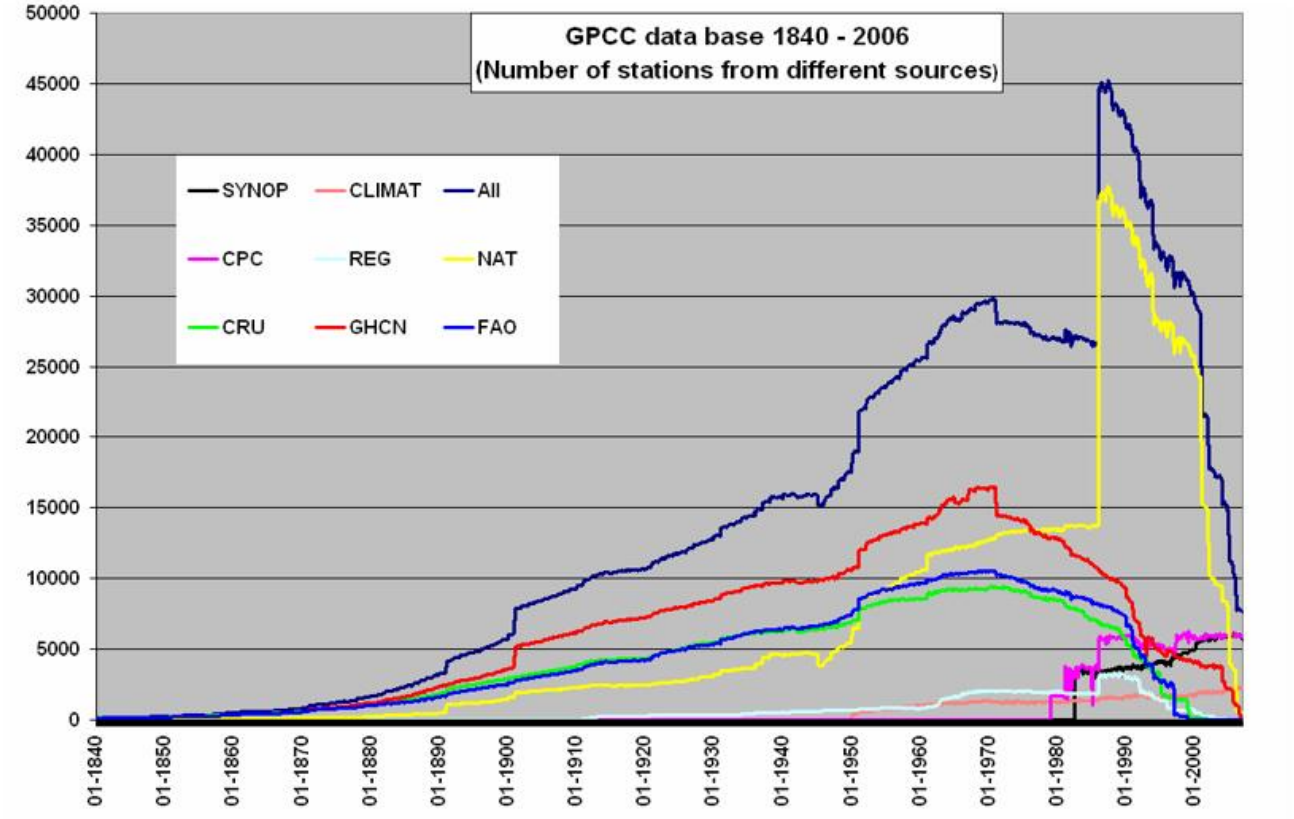


***Fig. 1**: Number of monthly precipitation data in the GPCC data base as a function of time for the different data sources in the GPCC database.*

Fig. 2a and 2b show the evolution of the GPCC Monthly Precipitation Database between January 2000 and December 2006. It can be seen in Fig. 2a, that the starting period of GPCC, 1986-2001, is still the period with the most station data. Fig. 2b indicates, that the extension of the GPCC data base concerning historical data before year 1986 started in 2003. The progress regarding the historical extension of the GPCC data base during the last 5 years is very visible in both figures.

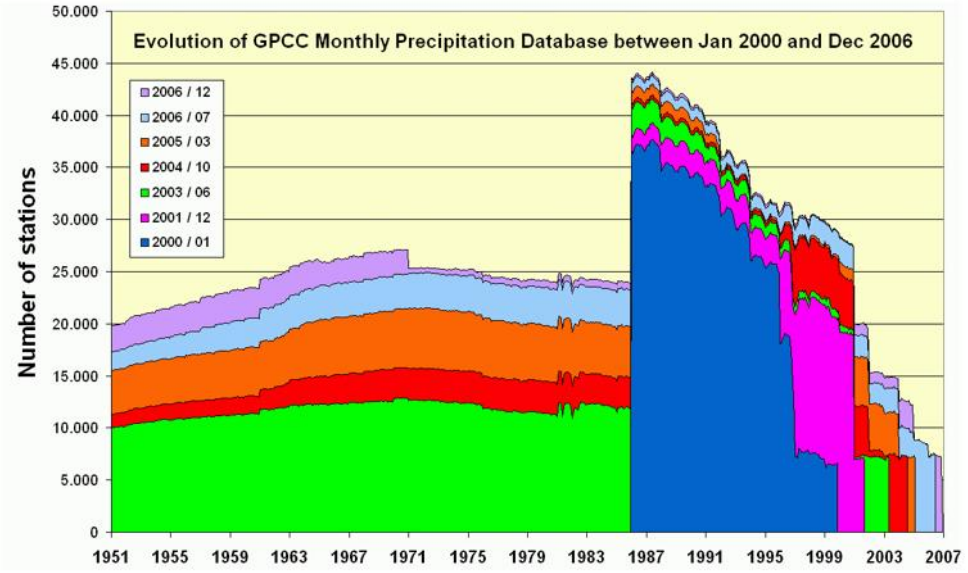


Fig. 2a *Evolution of the GPCC Monthly Precipitation Database between January 2000 and December 2006 (Number of stations per data year)*

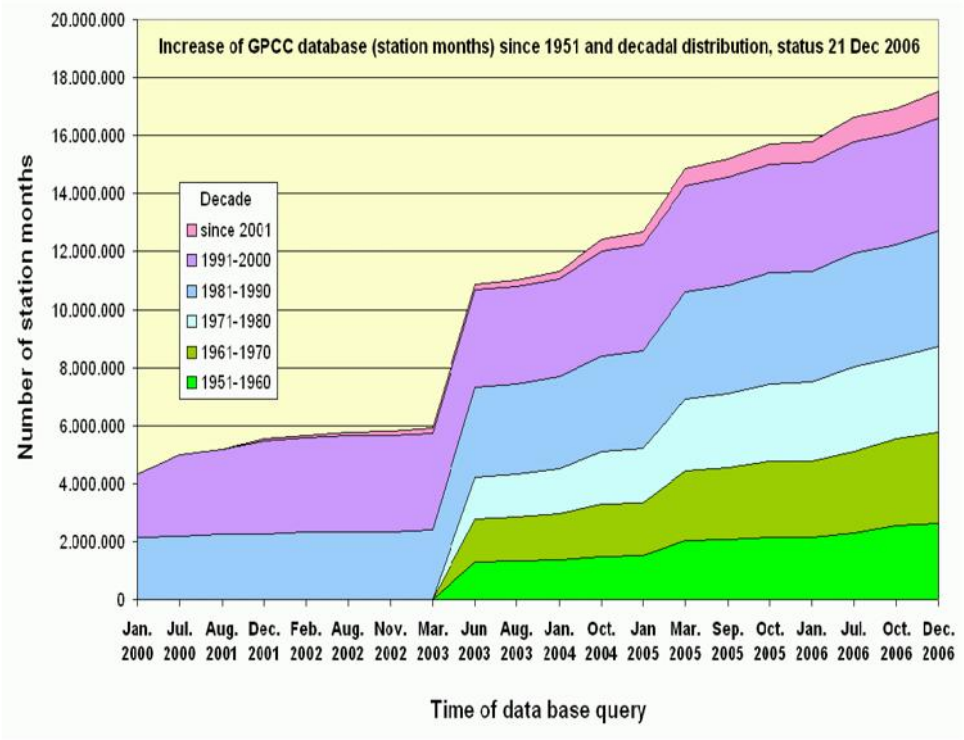


Fig. 2b *Evolution of the GPCC Monthly Precipitation Database between January 2000 and December 2006 (Number of station months per time of data base query)*

The figures 3 a-f on this page indicate the spatial coverage of the GPCC database after the inclusion of all historical global precipitation climatologies. The changes in temporal composition of the database are visualised by line "All Data" in Fig. 1.

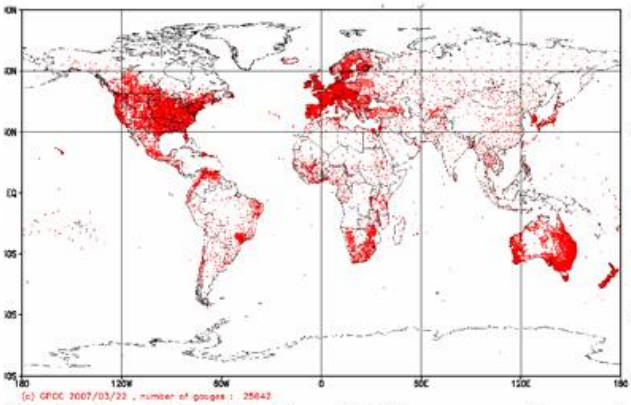


Fig. 3a *Spatial distribution of stations currently used at GPCC for calculation of precipitation normals and anomalies (Total number: 25642 stations)*

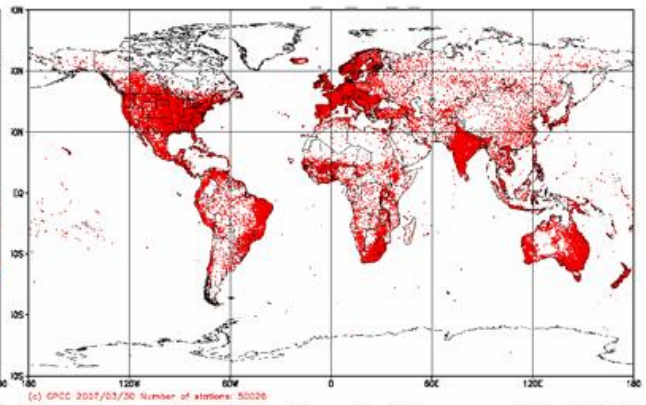


Fig. 3b *Spatial distribution of stations useful at GPCC for calculation of the new global precipitation climatology (Total number: 50026 stations)*

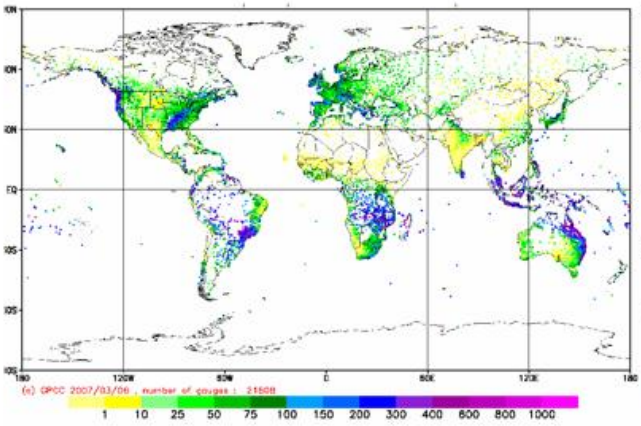


Fig. 3c *Spatial distribution of stations in GPCC data base for January 1951 (Total number: 21808 stations) Colors indicate precipitation in mm at station*

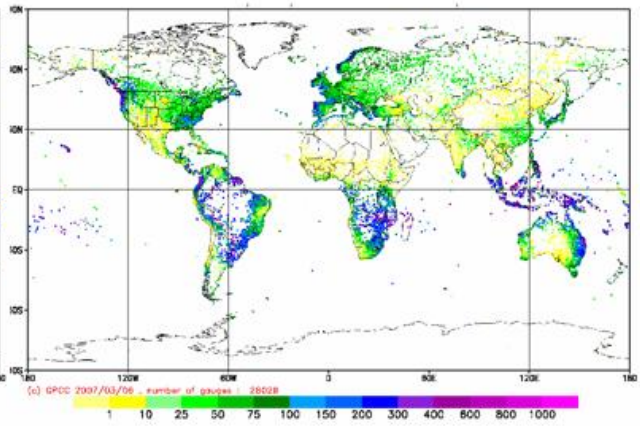


Fig. 3d *Spatial distribution of stations in GPCC data base for January 1971 (Total number: 28029 stations) Colors indicate total precipitation in mm at station*

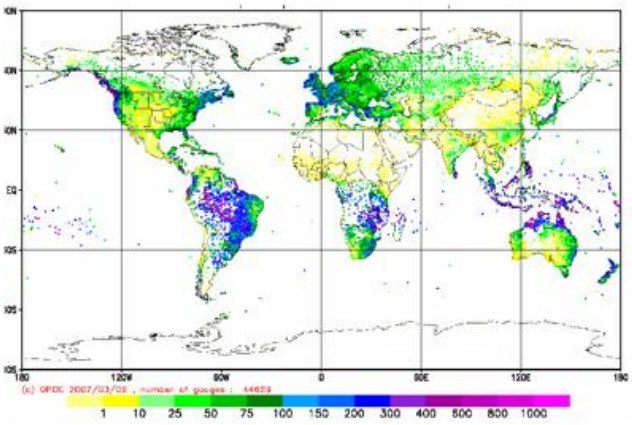


Fig. 3e *Spatial distribution of stations in GPCC data base for January 1986 (Total number: 44629 stations) Colors indicate precipitation in mm at station*

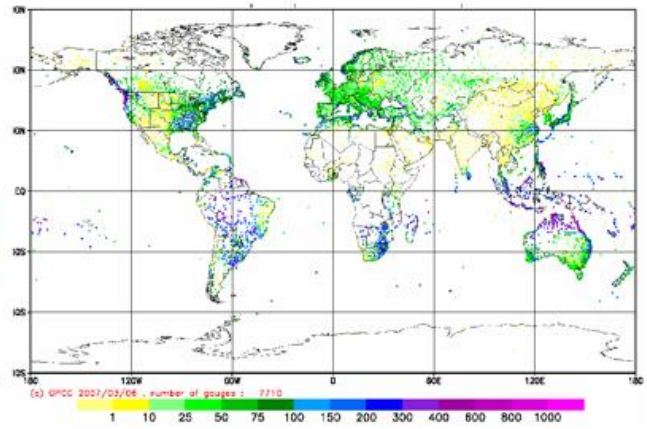


Fig. 3f *Spatial distribution of stations in GPCC data base for January 2006 (Total number: 7710 stations) Colors indicate total precipitation in mm at station*

2) GPCC Analysis Products

a) GPCC Monitoring Product

The monthly "GPCC Monitoring Product" is now available for all months since January 1986, i.e. 230 months. The GTS-based rain-gauge data used for the GPCC Monitoring Product analyses have been processed and analysed for all months of year 2006. All data were quality-controlled on a high level with automatic plus visual checks. The quality-control results for the year 2006 are summarized in Fig. 4. 6 - 10 % of the totally available stations (500-700 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).

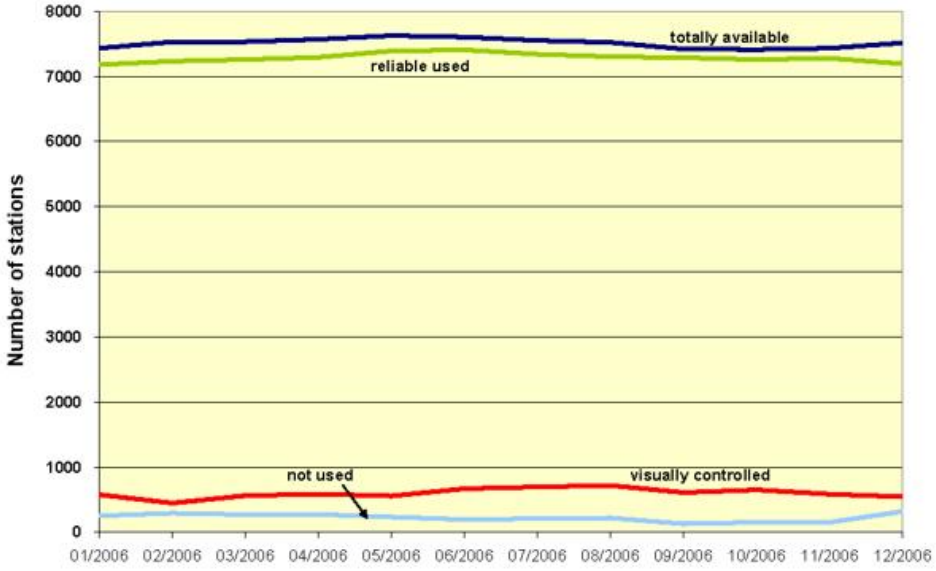


***Fig. 4** Quality-control results of data used for GPCC Monitoring product analyses during year 2006*

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 (see Fig. 5 below).

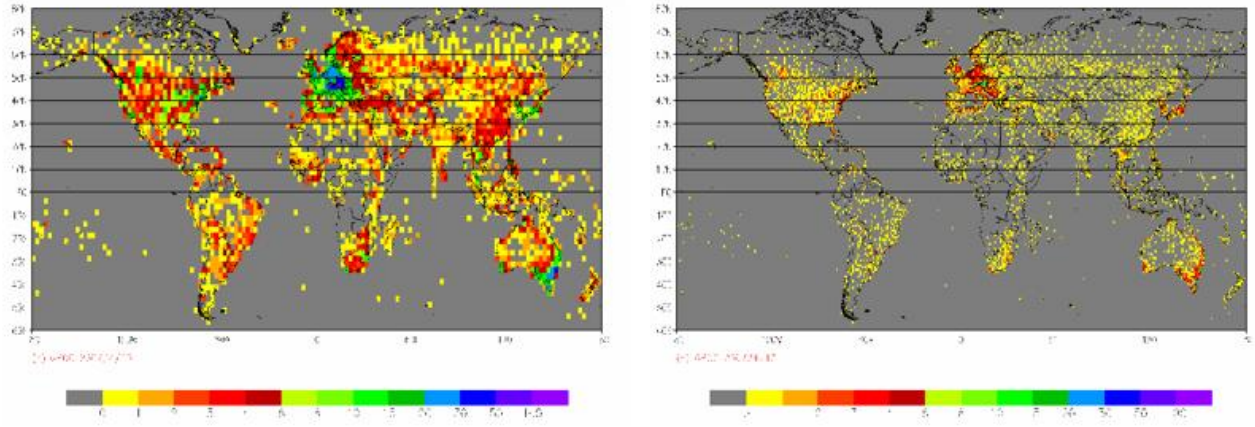


***Fig. 5** Number of stations used for each grid of GPCC Monitoring product analyses of December 2006 (Left: Grid resolution 2.5° x 2.5°; Right: Grid resolution 1.0° x 1.0°)*

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. 5,700 stations). The monthly precipitation totals undergo only an automatic pre-control, but no additional visual quality-control. The most recent analysis month is March 2007. Global precipitation anomalies based on the First-Guess Product are provided via Internet.

c) GPCC Full Data Product

The GPCC Full Data product Version 3 analyses based on the full GPCC database (near-realtime and non-realtime) of January 2005 are available for the period 1951 to 2004 on 0.5°, 1.0° and 2.5° grid resolutions. The GPCC Visualiser has been enlarged in year 2006 to display also the GPCC Full Data product in 0.5 x 0.5° grid resolution. A new version of the Full Data Product based on a significantly enlarged database will be available by autumn 2007.

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 winter 2007.

3) Other GPCC Matters

Global Precipitation Climatology Centre staff at DWD during year 2006

GPCC head: Dr. Bruno Rudolf (until 14 May 2006), Mr. T. Fuchs (from 15 May 2006 onwards)
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.
Scientists of research project 'Variability Analysis of Surface Climate Observations' (VASClimO):
Dr. Christoph Beck (until 30 Sept. 2006), Dr. Juergen Grieser (until 30 June 2006)
In addition, Dr. Bruno Rudolf guides the GPCC-activities

GPCC staff changes during year 2006:
On 15 May 2006 Mr. T. Fuchs became head of GPCC, replacing the previous GPCC head, Dr. B. Rudolf, who became head of DWD hydrometeorology division. The terms of the 2 project scientists Dr. C. Beck and Dr. J. Grieser, who developed the GPCC VASClimO Climatology during the last 5 years and contributed to a significant enlargement of the GPCC database, ended in autumn 2006.

Visitors at GPCC during year 2006

May 2006: Prof. S. Demuth (Director National Office of Germany for the UNESCO Int. Hydrological Programme IHP and the WMO Hydrology and Water Ressources Programme HWRP)

September 2006: Mr. B. Fekete and colleagues (University of New Hampshire, USA)

September/October 2006: Mr. Th. Greis (Trainee from University of Trier, Germany)

October 2006: Mr. F. A. Dide (Director of Benin Meteorological Service)

December 2006: Mr. R. Thigpen (WMO GCOS Secretariat)

GPCC related presentations in 2006

Oral presentation at event	*Date*	*Location*
4th National GCOS Meeting	13 June 2006	Langen (DE)
First Pan-GEWEX Meeting	10/11 Oct 2006	Frascati (IT)
3rd IPWG Workshop	23-27 Oct 2006	Melbourne (AU)
2nd National GEOSS Meeting	9 Nov 2006	Bonn (DE)

2 new posters have been compiled in year 2006:
- GPCC poster compiled for the 6th European Conference on Applied Climatology (ECAC), 4-8 Sep 2006, Ljubljana, Slovenia (see Fig. 7 on page 13);
- GPCC poster compiled for the 3rd Group on Earth Observation (GEO) plenary meeting (GEO-III), 28/29 Nov 2006 in Bonn, Germany (see Fig. 8 on page 14).

Publications by GPCC staff members during 2006

Beck, C. and J. Grieser (2006): Hydroclimatic variations in Europe since 1951 as reflected by shifts of Köppen Climate types. Geophysical Research Abstracts, Vol. 8, 07645, 2006.

Beck, C., J. Grieser (2006): Precipitation trends and shifts of rainfall regimes in Africa since 1951. In: Lozan, J. L., H. Graßl, P. Hupfer, L. Menzel, C.-D. Schönwiese (Hrsg.): Climate Change: Enough Water for all: 191-194.

Beck, C., J. Grieser (2006): Constructing a new set of gridded monthly precipitation data for the global land areas for the period 1951 to 2000. Journal Of Hydrometeorology, submitted.

Beck, C., J. Grieser, M. Kottek, F. Rubel and B. Rudolf (2006): Characterizing Global Climate Change by means of Köppen climate classification. Climate Status Report 2005, Deutscher Wetterdienst: 139-149

Beck, C., J. Jacobeit and P. D. Jones (2006): Frequency and within-type variations of large scale circulation types and their effects on low-frequency climate variability in Central Europe since 1780. International Journal Of Climatology, accepted.

Grieser, J. and C. Beck (2006): Analysis of observed Global Mean Land-Surface Precipitation for the Period 1951 to 2000. Geophysical Research Abstracts, Vol. 8, 08444, 2006.

Grieser, J. and. C. Beck (2006): Variability and Triggering Factors of Observed Global Mean Land Surface Precipitation since 1951. Climate Status Report 2005, Deutscher Wetterdienst: 131-138.

Grieser, J., C. Beck and B. Rudolf (2006): The Summer Flooding 2005 in Southern Bavaria – A Climatological Review. Climate Status Report 2005, Deutscher Wetterdienst: 168-173.

Kottek, M., J. Grieser, C. Beck, F. Rubel and B. Rudolf (2006): World map of the Köppen-Geiger climate classification updated. Met. Z. 15, 3: 259-263.

GPCC contact details

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Tel.: +49 - 69 - 8062 2872
Fax: +49 - 69 - 8062 3759
Web: http://gpcc.dwd.de/

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KU42 / Global Precipitation Climatology Centre
P.O. Box 10 04 65
63004 Offenbach am Main, Germany

GPCC internet and FTP contacts

Fig. 6a indicates, that the accesses to the GPCC Website have increased by factor 2 since Jan 2004 to more than 8000 hits nearly every month of year 2006. Between 1000 and 2000 visitors at the GPCC Visualiser and FTP download have been counted during each month of year 2006. Fig. 6b shows monthly access numbers to the different GPCC products: The most popular product in 2006 was the GPCC Monitoring Product in 1° x 1° grid.

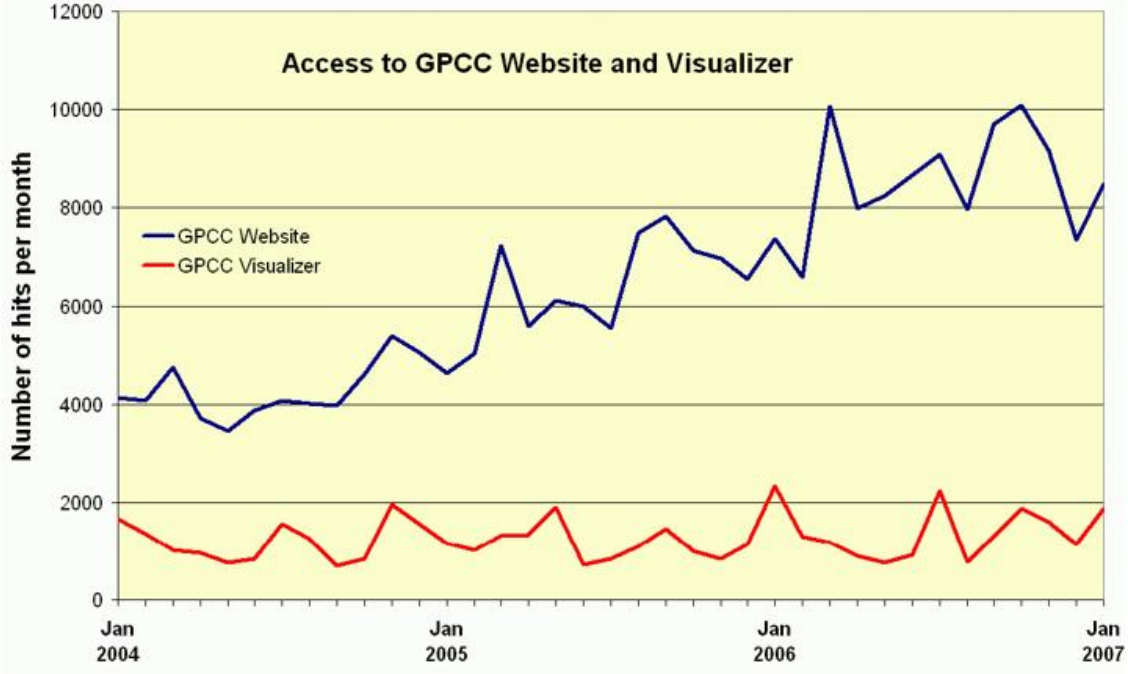


Fig. 6a *Number of GPCC Website and Visualizer accesses during 2004- 2006*

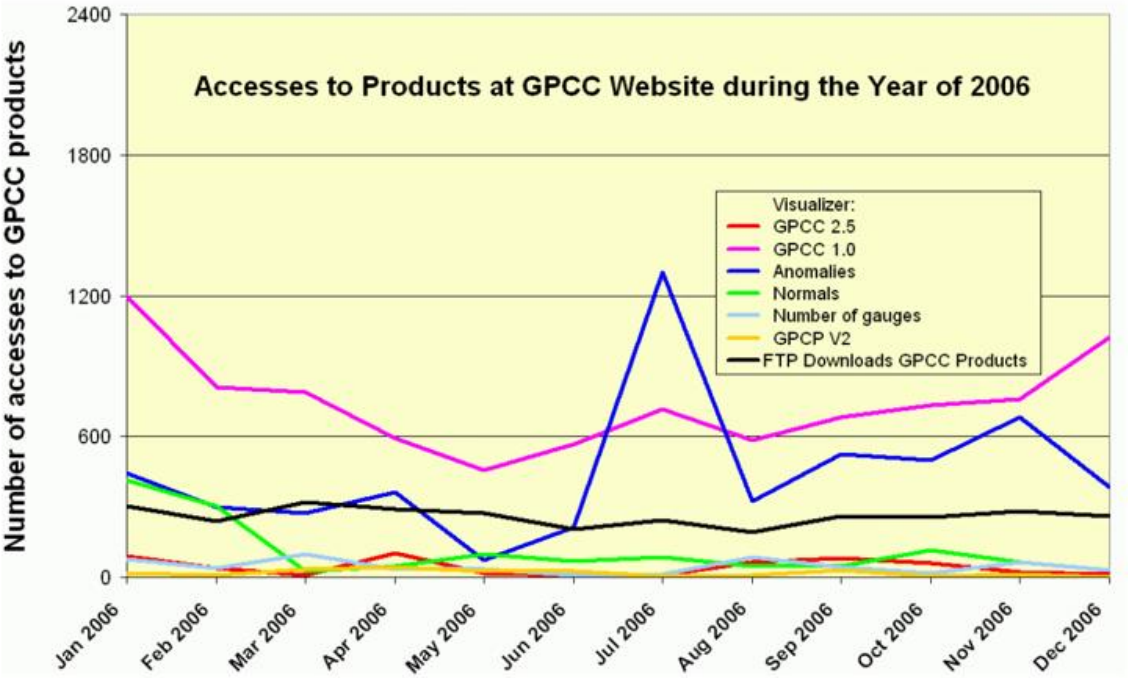


Fig. 6b *Number of accesses to products on the GPCC Website during 2006*

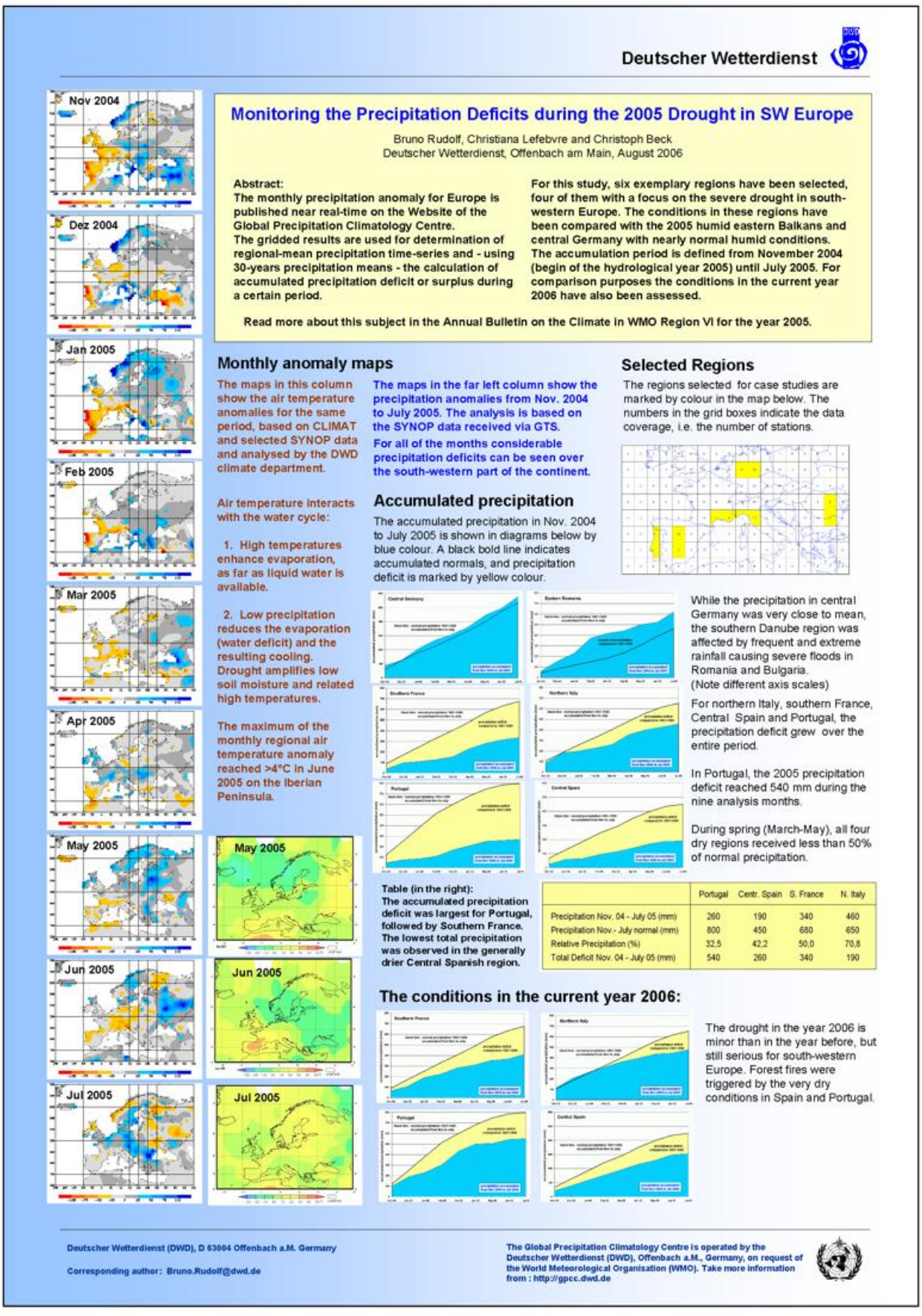


Fig. 7 GPCC poster compiled for the 6th European Conference on Applied Climatology (ECAC), 4-8 Sep 2006, Ljubljana, Slovenia

Global Precipitation Climatology Centre — Deutscher Wetterdienst

The GPCC – a German contribution to GEOSS

The GPCC task and functions

The Global Precipitation Climatology Centre (GPCC) has been implemented in year 1988 at the Deutscher Wetterdienst (DWD) as a German contribution to the World Climate Research Programme (WCRP) and to the Global Climate Observing System (GCOS). The general task of the GPCC is to analyse the spatial and temporal distribution of land-surface precipitation on a monthly time-scale. Analysis of precipitation variability and trends in context of climate change requires long time-series of data, which are only available from surface *in situ* EO rainfall networks.
GPCC provides global precipitation analyses for monitoring and research of the earth's climate. Its products are gridded data sets of monthly precipitation totals for the global land-surface based on *in situ* EO data. The GPCC products are freely available via internet.

The GPCC *in situ* EO rainfall data and their sources

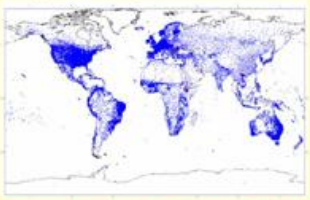
Near real-time data from the Global Telecommunication System (GTS) of the World Meteorological Organisation (WMO):

+

Non real-time data from international projects, historical data collections and (so far) 177 countries of the world:

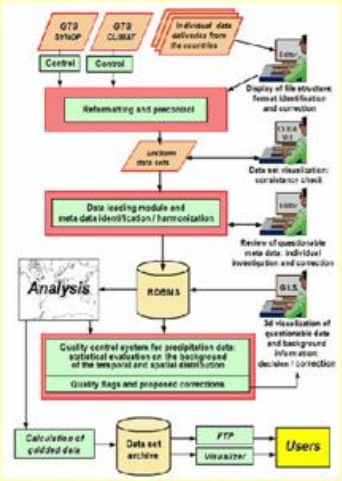
=>

Monthly in situ rainfall stations in the GPCC data base with at least 10 years of monthly precipitation data (Total number of stations in July 2006: 43028):



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

The GPCC data processing and data management system



Intensive automatic and manual data processing and data management procedures ensure high quality and easy accessibility of GPCC products

The GPCC monthly gridded precipitation products

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

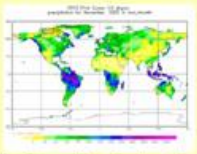
Monitoring Product (since January 1986)
- for near real-time climate monitoring and adjustment of satellite-based EO
- available 2 months after the observation month
- based on near real-time data from 7500 *in situ* stations
- High Level Quality Control of all data used

Full Data Reanalysis Product (1951-2004)
- for model verification and water cycle analysis
- use of the complete GPCC data base
- monthly data coverage varies from 10,000 to more than 40,000 *in situ* rainfall stations
- High level Quality Control/Assurance of all data used

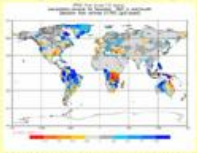
50 Year Climatology (1951-2000)
- for analysis of climate variability and trends
- High level quality and homogeneity control analysis based on climatic background
- based on 9343 *in situ* stations with nearly complete time-series

The GPCC standard product features

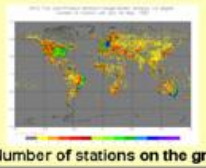
(Monthly data sets on 1.0x1.0° and 2.5°x 2.5° grid cells):



Total precipitation (mm)



Precipitation anomaly (mm and %)



Number of stations on the grid

The users of GPCC gridded data sets and their applications

GEWEX	Adjustment of satellite-based EO and analyses of hydrometeorol. processes
FAO, UNEP	Near real-time drought monitoring
GCOS	Global climate monitoring
CLIVAR, IPCC	Climate variability and trend analyses
UNESCO	Water resources assessment
HWRP, GTN-H	Runoff estimation (ungauged rivers)
ECMWF	Weather forecast model verification (Re-analysis, seasonal forecasts)
CLIC	Precipitation estimation in cryospheric regions
more than 2000 scientists	many different research activities

GPCC products are adjusted to the needs of different user communities and are suitable to contribute to applications in the GEOSS Societal Benefit Areas water, climate, weather, disasters, agriculture

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. 8 GPCC poster compiled for the GEO-III plenary meeting, 28/29 Sep 2006, Bonn, Germany