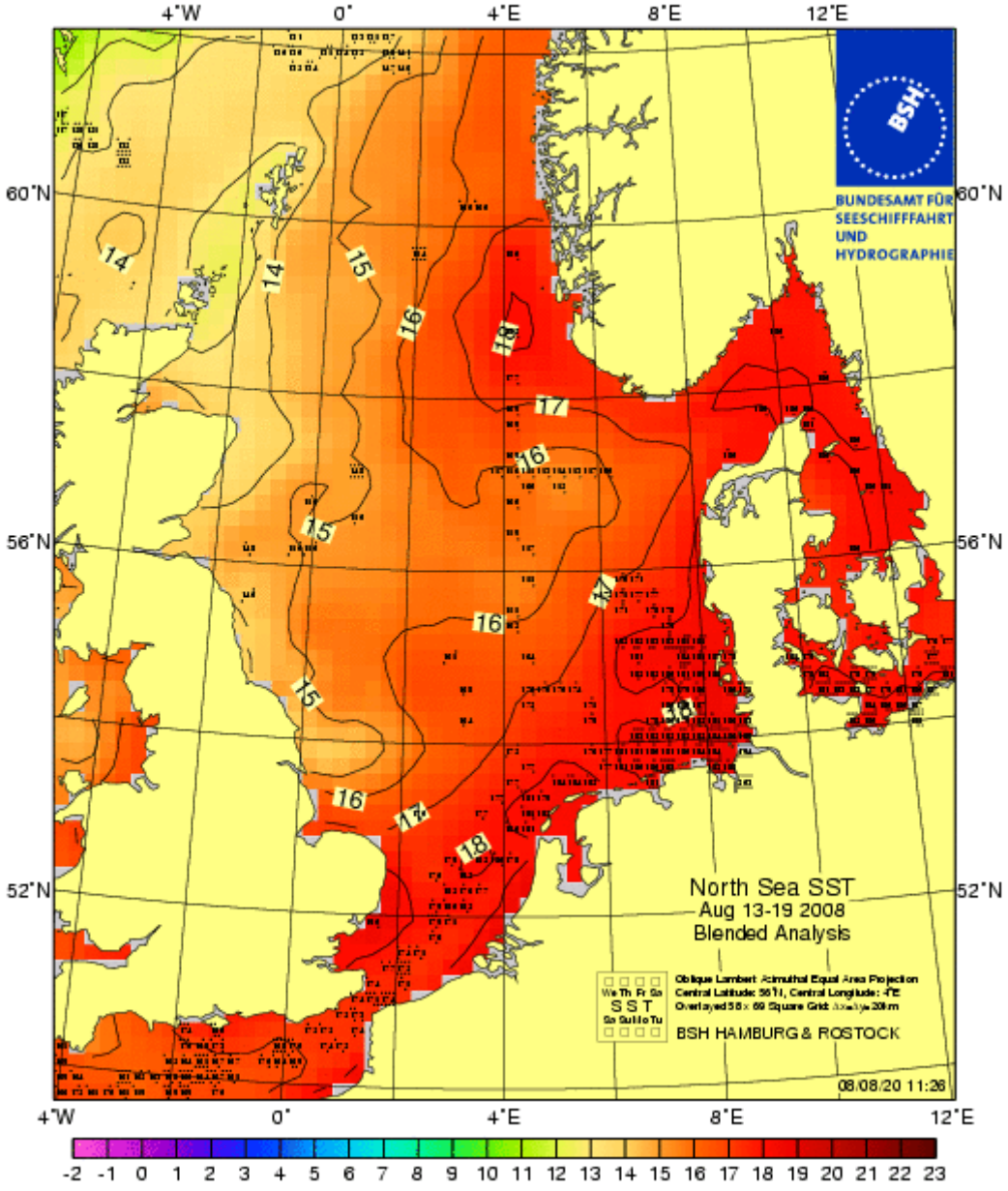
Germany's report on global observing systems for climate

- Informal report to provide input into GCOS' report at SBSTA- 30 -



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1 Common issues

The present report is the first report based on the reporting guidelines contained in decision 11/CP.13, focussing on Essential Climate Variables. More detailed information is contained in the Second Report of the Government of the Federal Republic of Germany on Systematic Climate Observation in Germany provided as part of Germany's 4th National Communication in 2006.

The purpose of this report is to provide to the Global Climate Observing System (GCOS) Secretariat additional information at national level for its detailed progress report on the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC, short GCOS IP, (GCOS-92) to be given at SBSTA-30 in June 2009. GCOS, being itself a system of systems, is also part of the Global Earth Observing System of Systems (GEOSS) implemented by the Group on Earth Observations (GEO). Many German institutions contribute to the GEO Work Plan, and thereby indirectly in many cases are also supporting the GCOS Implementation Plan.

An updated official version of this report will be provided together with Germany's 5th National Communication.

In Germany, competences for systematic long-term observation of the various variables describing the climate system are distributed among a number of different Federal Ministries. These are the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) and its subordinate authorities German Meteorological Service (DWD) and German Maritime and Hydrographic Agency (BSH) as well as the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and its subordinate authorities Federal Environmental Agency (UBA) and the Federal Agency for Nature Conservation (BfN). Research institutions also play an important role.
Moreover, Germany delivers significant contributions to European satellite observation systems developed and operated by the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) aiming at the detection of global climate changes.

In order to improve usability and accessibility of geographical data and information at Federal, Laender and Community levels a German Geodata Infrastructure (GDI-DE) was established. GDI-DE is also linked with the European INSPIRE and the Global Spatial Data Initiative. At Federal level an inter-ministerial committee (IMAGI) has been established as early as 1998. Progress is on the way in gradually completing a national Geo Portal[1] on the Internet.

In fall 1993, a national GCOS Secretariat was established at the DWD in Offenbach to coordinate the co-operation among the institutions involved on a national level in climate observing systems. Today the GCOS German Coordinator is a contribution by the DWD.
The BSH serves as national point of contact for the Global Ocean Observing System (GOOS).

IMAGI, GDI-DE, GCOS-, and GOOS Coordinator are also interlinked with the German GEO Experts Group (D-GEO).

[1] www.geoportal.bund.de

1.1 German contributions to capacity building

In Germany the overall responsibility for technical cooperation is with the Federal Ministry for Economic Cooperation and Development (BMZ).
Germany's contributions to the World Meteorological Organisations (WMO's) Voluntary Co-operation Programme come from several governmental organizations, but only few support climate related activities. The German Agency for Technical Co-operation (GTZ) works worldwide in the field of development cooperation. It inter alia supports the Focal point of Mali with the United Nations Framework Convention on Climate Change (UNFCCC) and provides for training and capacity building to digitize and distribute Malis climate data. DWD supported a satellite training workshop in Croatia and for training activities in the WMO Climate Information and Prediction Services (CLIPS) workshop in Tunisia. The Global Atmosphere Watch (GAW) Training & Education Centre (GAWTEC) since 2001 provides scientific guidance and instructions to GAW station personnel from worldwide global and regional stations. GAWTEC, operated through funds from the UBA and the Bavarian State Ministry for Environment, Health and Consumer Protection, is based at the Environmental Research Station "Umweltforschungsstation Schneefernerhaus" (UFS), which accommodates the high-alpine platform of the GAW Global Station "Zugspitze/ Hohenpeissenberg". GAWTEC is part of Quality Assurance / Science Assessment Centre (QA/SAC) Germany and responsible for training and education of station personnel from global and regional GAW stations by teaching measurement techniques and data analysis. Teaching (introductory courses and advanced training) is done by experts from UBA, the Swiss materials science and technology research institution EMPA and the DWD. Special topics are covered by experts from universities and other research facilities. The 15th GAWTEC course will be held in November 2008. The DWD has no own budget for technical cooperation and only limited financial resources to support the GCOS cooperation mechanism. This governmental support will be continued and hopefully can be extended.

1.2 Atmospheric observations

Systematic and long term observation of meteorological variables in Germany is the responsibility of the DWD, the national meteorological service of Germany. Some observations of atmospheric composition and aerosol properties are also the responsibility of the DWD, but most of the atmospheric composition and aerosol properties' observations are the responsibility of the UBA and the Laender. In addition the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven (AWI) is contributing observations in the Antarctic.

1.2.1 The Global Precipitation Climatology Centre (GPCC)

The Global Precipitation Climatology Centre (GPCC) provides global precipitation analyses for monitoring and research of the earth's climate. The GPCC provides free access to its monthly gridded precipitation data sets for climate monitoring purposes and related research. The centre is operated by the DWD and is a German contribution to the World Climate Research Programme (WCRP) and to the Global Climate Observing System (GCOS).

1.2.2 The CBS Lead Centre for GCOS Data – Europe

The CBS Lead Centre for GCOS Data for WMO Regional Association Europe (WMO RA VI) is also operated by the DWD. The World Meteorological Organization (WMO) Commission has designated a regional network of nine CBS Lead Centres for GCOS. They are responsible for collecting and providing the Essential Climate Variables (ECVs) in their regions and to support any follow-up action.

1.2.3 The World Radiation Monitoring Centre (WRMC)

The Baseline Surface Radiation Network (BSRN) is a project of the World Climate Research Programme (WCRP), the Global Energy and Water Experiment (GEWEX) and the GCOS. It is aimed to detect important changes in the Earth's radiation field at the Earth's surface which may be related to climate changes. To fulfil these objectives a central BSRN data archive is essential. This archive - called World Radiation Monitoring Centre (WRMC) – was established in 1991 under the leadership of Prof. Atsumu Ohmura at the Division of Climate Sciences at the Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland[2]. After 16 years of nearly continuous operation at ETH, the WRMC is currently going through a transition that resulted in the re-establishment of the archive at the AWI, Germany.

The WRMC at AWI[3] is based on the Publishing Network for Geoscientific & Environmental Data PANGAEA. At the moment data from more than 4000 station-month provided from more than 40 stations are available. A Google-like interface is used for searching and distributing BSRN-data via web. Each dataset is identified, shared and published by a persistent Digital Object Identifier (DOI). The WRMC at AWI offers output formats separated into radiation data, upper air sounding data and synoptic observations readable for a variety of widely-used software. The datasets always include all necessary metadata and citation information. Additional, links to the ftp-server[4], containing the original station-to-archive-files, are available.

1.3 Oceanographic observations

Oceanographic observations are mainly the responsibility of the BSH and several research agencies such as the Leibnitz Institute of Marine Science (IfM-Geomar), the Institute of Environmental Physics (IUP-Bremen) and others.

1.4 Terrestrial observations

Depending on the terrestrial variable different government and research institutions at the Federal and Laender level are responsible. Observation of some terrestrial variables is impossible within Germany. Thus observing sites for such variables are also funded in foreign countries.

1.4.1 The Global Runoff Data Centre (GRDC)

The Global Runoff Data Centre (GRDC) was established in 1988 at the Federal Institute of Hydrology (BfG) under the auspices of the WMO. It is a contribution of Germany to the World Climate Programme Water (WCP-Water) of the WMO. WMO mandates and directly supports GRDC through its Resolution 21 (Cg XII, 1995: Request to the member states to provide GRDC with river discharge data) and Resolution 25 (Cg XIII, 1999: Free and unrestricted exchange of hydrological data). The main objective of the GRDC is the world-wide acquisition, storage and dissemination of historical and near real-time river discharge data in support of the predominantly water and climate related programmes and projects of the United Nations (UN), their specialised agencies and the scientific research community.
The provision of hydrological data by National Hydrological Services to the GRDC is for the majority of the countries only happening sporadically, despite WMO resolutions. The GRDC

[2] http://bsrn.ethz.ch/
[3] http://www.bsrn.awi.de/
[4] ftp://ftp.bsrn.awi.de

is seeking to improve and operationalise the provision of data for the benefit of the research community.

1.5 Space-based observations

For the identification and assessment of changes in the climate system, satellites offer unique advantages: they provide continuous, seamless and timely data for regions where there are no or only sparse other observation data available; the data relating to various regions come from one and the same observing system; some information, such as the radiation budget at the top of the atmosphere, can only be determined by means of a satellite system.

1.5.1 Participation to relevant European Satellite Programmes

Germany is the largest contributor to all climate monitoring relevant European satellite programmes of ESA, EUMETSAT and the EU.

Of particular relevance for the investigation of the processes within the climate system are the experimental (the Earth Explorers) and pre-operational (such as ENVISAT with its multitude of land, atmosphere and ocean sensors) ESA Earth observation programmes. ESA also envisages to launch a major new programme dedicated explicitly to the generation of a number of ECVs, according to the GCOS IP.

Due to the longevity needed, operational satellites play a major role in the detection of variations or changes in the climate system. The operation of meteorological satellites and the planning of appropriate successor systems are in the responsibility of EUMETSAT with its headquarters in Darmstadt, Germany. EUMETSAT operates the geostationary METEOSAT satellites and the European polar-orbiting meteorological satellite MetOp (complementary with the US NOAA satellites), both developed by ESA. The first data transmitted from a METEOSAT satellite dates from 1977. METEOSAT has been operating since 1977 above Europe, Africa and the Atlantic and over the Indian Ocean since 2005. Since 2002 the METEOSAT Second Generation (MSG) is the primary service, with altogether 4 MSG satellites being secured. It is delivering considerably improved data with planned continuity at least until 2019. The development of the METEOSAT Third Generation (MTG) with again improved payload is already in preparation. MTG will secure data continuity and many new observations from 2016 through to 2030. Furthermore, in mid 2008 EUMETSAT became partner in the Franco-US JASON satellite altimetry programme, being responsible for operationally providing data to European users.

With the joint ESA/EU Global Monitoring for Environment and Security (GMES) initiative, Europe will secure long-term continuity for many of the required climate related satellite observations of oceans, atmospheric chemistry, land surfaces, that have been initiated particularly by ESA's ERS and ENVISAT, but also other European programmes. Germany is the largest contributor to GMES.

1.5.2 EUMETSAT Satellite Application Facility (SAF) on Climate Monitoring (CM-SAF):

Within the so-called Satellite Application Facilities (SAF) operated by EUMETSAT, the DWD has assumed to function as the lead institution for the tasks of deriving climate-relevant parameters from data transmitted by the MSG and EPS/MetOp satellites and of establishing, operating and further developing the 'SAF on Climate Monitoring'. Under the responsibility of EUMETSAT, the SAFs form a European network of specialised centres for the exploitation of

satellite data. The Satellite Application Facility on Climate Monitoring (CM-SAF) is one of presently 8 such competence centres. Early 2005, the CM-SAF started the pre-operational production of climatologies for radiation, clouds and humidity issues on the basis of satellite data.

In March 2007 the CM-SAF, hosted by the DWD, started its Continuous Development and Operations Phase (CDOP). CM-SAF will continue to provide products (cloud parameters, radiation at surface and top of atmosphere, humidity) in support to climate monitoring and analysis on a routine basis. In addition, during the CDOP phase the CM-SAF will provide data sets suitable for climate analysis on longer time scales (table for envisaged list of data-sets: can be found in GCOS SC-XV, Doc. 32: National GCOS Activities in Germany).

1.5.3 Contributions of the German Aerospace Centre (DLR)

DLR is Germany's national research centre for aeronautics and space. As Germany's Space Agency, DLR is also responsible for the planning and implementation of the German space programme as well as international representation of Germany's space interests.

DLR is involved in various activities related to the provision of ECVs in the atmospheric, oceanic and terrestrial domains. Main activities include:

- Data systems as part of EO mission ground segments
- The World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT)
- algorithm development for the retrieval of ECV related parameters from EO data
- contributions to CEOS Implementation Plan for Climate actions
- participation in GEO Work Plan tasks

1.5.3.1 Data systems at DLR

As part of the operational ground segments of relevant EO missions operated by ESA and EUMETSAT, DLR is responsible for the generation, archiving and dissemination of specific products:

- D-PAF for ERS-1 and ERS-2
- D-PAC for ENVISAT
- O3 Monitoring SAF for MetOp-1

D-PAF and D-PAC are hosted by DLR’s Applied Remote Sensing Cluster, formed by the Remote Sensing Technology Institute (IMF) and the Remote Sensing Data Centre (DFD). In the consortium for the O3 Monitoring SAF the Applied Remote Sensing Cluster is responsible for some of the specified ozone products. In addition EO data from other missions, acquired by national and international stations, are analyzed to yield climate related information. ECV related parameters retrieved comprise:

- GOME on ERS-2: total columns of O3 and NO2, cloud information
- SCIAMACHY on ENVISAT: O3 vertical columns and profiles, NO2 vertical columns and profiles, cloud information
- GOME-2 on MetOp-1: vertical columns of O3, NO2 and SO2, tropospheric columns of NO2, cloud information
- MERIS: regional Value Added information concerning clouds and aerosol
- TerraSAR-X: high resolution maps of ice coverage (related to IPY)
- NOAA AVHRR: regional Sea Surface Temperature

Whenever applicable, the acquired datasets are subject to reprocessing aiming at applying the most up-to-date retrieval algorithms. Example is e.g. the reprocessing of the complete SCIAMACHY measurement dataset obtained since the start of routine operations in August 2002.

Users can access these data using either DLR's EOWEB interface or the corresponding tools of other mission providers.

1.5.3.2 WDC-RSAT

WDC-RSAT is hosted by DLR-DFD and provides a wide collection of continuously generated geophysical parameters from the atmospheric and Earth's surface domain. These are either copies of data products listed under 'Data systems' or are the results of value adding processes.

1.5.3.3 Retrieval algorithm development

A major effort is required to develop retrieval and data analysis algorithms. This is not only true for new methodologies but also for existing code which has to be continuously adapted to reflect recent progress. Initial prototype algorithms are usually developed by DLR facilities in cooperation with scientific institutes and further on transferred to operational processor systems. The goal is to provide for a timely delivery of high quality data products even in missions generating permanently high data volumes.

1.6 Participation in CEOS Implementation Plan for Climate actions

The CEOS Implementation Plan for Climate in response to the GCOS implementation plan is comprised of 59 actions addressing space-based observations. They cover the atmospheric (12 actions), oceanic (19) and terrestrial (6) domains and are supplemented by 22 cross-cutting actions. For each action a Climate Action Team was established, with one or two persons acting as lead and a group of others as contributors. Each CEOS space agency was expected to nominate individuals. At DLR a point of contact was established, coordinating a team of experts participating in 15 climate actions.

2 Atmospheric Essential Climate Variables

2.1 General information

Meteorological observations have a long tradition in Europe. State-owned weather services in Germany started collecting climate data at the end of the 19th century, but only after the reunification of Germany in 1990 the data have been recorded and processed according to unified standards. With the use of automated stations, the frequency of measurements considerably increased with the result that today these stations record and store the data in intervals of one to 10 minutes. In addition, about 300 automated secondary weather stations with voluntary observations also measure and store climate relevant data in intervals of 1 to 10 minutes. About 500 automated precipitation stations have the same measured intervals. Further more, there is still a large number (>1000) of conventional precipitation stations, which record meteorological parameters once a day by voluntary observers.

Relevant climatological requirements – for example, relative to the networks operated by the German Meteorological Service (DWD) – have always been given careful attention, since both real-time and climate applications benefit from the precision required for climatological purposes. For this reason, the DWD recognizes and respects the GCOS Climate Monitoring Principles (GCMP see decision UNFCCC 11/CP.13) for its primary weather stations and with some restrictions also for its secondary weather stations.
Twelve National Reference Stations (Aachen, Brocken, Fichtelberg, Frankfurt/Main, Görlitz, Helgoland, Hamburg-Fuhlsbüttel, Hohenpeissenberg, Konstanz, Lindenberg, Potsdam and Schleswig) are being established in the national network. At these sites, conventional and new automatic measuring devices are operated in parallel. All measured data have been and are subjected to thorough quality checks and are stored in digital form.

2.2 Contributions to the GCOS Networks from international relevant stations

2.2.1 Contributions to the GCOS Surface Network (GSN)

In Germany four stations have been selected for the GCOS Surface Network i.e. three DWD stations and one station (Neumayer) is operated by the Alfred Wegener Institute (AWI) in the Antarctic.

- Hamburg-Fuhlsbüttel (WMO-Nr. 10147)
- Lindenberg (WMO-Nr. 10393)
- Hohenpeissenberg (WMO-Nr. 10962)
- Neumayer (WMO-Nr. 89002)

The three DWD stations all belong to the network of National Reference Stations.

Recently, DWD offered a new GSN station (Frankfurt/Main; WMO-Nr. 10637) to the WMO.

Hamburg-Fuhlsbüttel:
The Hamburg-Fuhlsbüttel station is an aeronautical meteorological office that was established in 1891 as an observatory. In 1955, it was moved about 270 m to the west, and it is now located on the grounds of Hamburg Airport. In 1995, the station was moved again – this time, about 700 m to the south-west. In that same year, a transition was made to semiautomatic operation, and since then the station has automatically recorded air temperature (at heights of 2 m and 5 cm), ground temperature, humidity, air pressure, wind direction and

wind speed, as well as precipitation and sunshine duration. This year the instrumentation and data collection system on this station has been changed to a modern and homogeneous system, now generally used throughout Germany.
Due to its long term data records and its representativness for the northern part of Germany Hamburg-Fuhlsbüttel has been selected as a National Reference Station in May 2008.

Lindenberg:
The Lindenberg Meteorological Observatory - Richard Assmann Observatory (MOL-RAO) was established in 1905 by Richard Assmann, the discoverer of the stratosphere, and it began taking measurements in the same year. In the years 1956 and 1971, the observation/measurement site has consecutively moved by around 200 m. Semi-automatic operation began already in 1992. Like the Hamburg-Fuhlsbüttel station, this station automatically measures air temperature at heights of 2 m and 5 cm, along with ground temperature, humidity, air pressure, wind direction and wind speed, precipitation and sunshine duration.
Due to its long term data records and its representativness for the eastern part of Germany Lindenberg has been selected as a National Reference Station in May 2008.

Hohenpeissenberg:
Measurements at the Hohenpeissenberg Meteorological Observatory started in 1781, within the framework of the Societas Meteorologica Palatina. This station has undergone the transition to semi-automatic operation in 1993. Since then, the station has automatically recorded air temperature at heights of 2 m and 5 cm, along with ground temperature, humidity, air pressure, wind direction and wind speed, precipitation and sunshine duration.
Due to its long term data records and its representation to the low mountain range of Germany Hohenpeissenberg has been selected as a National Reference Station in May 2008.

Neumayer:
Since March 1981 a meteorological observatory programme is carried out continuously at Neumayer Station (GvN, 70°37'S, 8°22'W). On March 16, 1992 the programme has been extended and transferred to the new Neumayer Station (NM II, 70°39'S, 8°15'W), in close proximity to the former one. The snow-covered Neumayer station is located on an ice shelf of 200 metres thickness which is almost completely flat. Today, the meteorological observatory of NM II is an integral part of many international networks, mostly associated with the World Meteorological Organization (WMO). The next station Neumayer III (70°40,8'S , 8°16,2'W) is currently built approximately 5 km south of the actual location.

As far as possible, all stations within DWD and AWI network comply with the GCMPs. The effects of introducing new measuring systems and of changing existing systems are checked by DWD via parallel measurements at selected stations.

Continued operation of GSN and GUAN stations is guaranteed by virtue of their status as aeronautical meteorological office or meteorological observatory within the network of National Reference Stations.

2.2.2 Contributions to the GCOS Upper Air Network (GUAN)

One DWD station in Germany and one AWI-operated station in the Antarctic have been selected to contribute to the GCOS Upper Air Network (GUAN):

- Lindenberg (10393) and
- Neumayer (89002).

Lindenberg:
At Lindenberg station, radiosonds are launched at 00, 06, 12, and 18 UTC, which also include upper tropospheric and lower stratosphere wind measurements. Radiosounding in Lin-

denberg started in 1957, and since July 2004 they have been updated to GPS navigation. In February 2004, Lindenberg has replaced Stuttgart-Schnarrenberg (10739) as the GUAN station of Germany. The MOL-RAO focuses in a unique manner on calibrating humidity measuring instruments on a routine basis by means of radiosondes. The aim is to achieve highest quality standards for humidity profile measurements from radiosondes (with the accuracy being better than an uncertainty of 1 % in relative humidity). Due to the synergy of the high-temporal-resolution measurements (e.g. GEWEX / GvaP water vapour measurements) at the MOL-RAO, the radiosounding assumes even more importance as it also allows for cross-calibrations between the existing measuring systems.

Neumayer:
Three-hourly synoptic observations and daily upper air soundings (12 UTC) including weekly ozone profiling are the main part of the measurements at Neumayer station.

2.2.3 Contributions to Global Atmosphere Watch (GAW)

Germany contributes to the Global Atmosphere Watch (GAW) with the following 4 stations:

- GAW Global Station at Zugspitze/Hohenpeissenberg,
- GAW Global Station at Neumayer (Antarctic, operated by AWI),
- GAW Regional Stations at Schauinsland and Neuglobsow.

Zugspitze/Hohenpeissenberg
The Zugspitze/Hohenpeissenberg GAW station consists of 2 platforms: one is based within the Zugspitze environmental research station and one is situated at the Hohenpeissenberg Meteorological Observatory of DWD.

The Hohenpeissenberg Meteorological Observatory has a long tradition of taking meteorological and atmospheric chemistry measurements. The beginning of its series of uninterrupted meteorological observations dates back to 1781. 1967 saw the start of the ozone measurement programme that has now developed into a vast and extensive programme. In 1994, the installation of the GAW station started, and the Observatory's measurement programme was considerably expanded. Pursuant to the GAW requirements for Global Stations, measured quantities include reactive trace gases, physical and chemical properties of aerosols, substances contained in precipitation and a range of auxiliary data needed to interpret atmospheric chemistry data.

The Global Station at the Zugspitze is operated jointly by the UBA and DWD. Starting in 1999, UBA established the platform Zugspitze at the site Schneefernerhaus, situated at 2656 m asl, approximately 300 m below the Zugspitze summit. The DWD measures meteorological components, aerosol concentrations and various radionuclides whereas the UBA deals with reactive (Ozone, CO, NO, NO2, NOx, NOy, PAN, VOCs, carbonyl samples) and trace gases relevant to climate (CO2, CH4, N2O, SF6, halogenated carbons), as well as aerosol related data, e.g., size distributions of fine and ultrafine particles in the range of 10-800 nm and precipitation chemistry.

The Zugspitze/Hohenpeissenberg Global Station co-ordinates its activities and co-operates closely with the observatories at the Hoher Sonnblick in Austria and the Jungfraujoch in Switzerland. Its neighbouring stations are situated to the East in Tibet, to the North at the Arctic Circle, to the West on the Irish Isles and to the South on the Canary Islands. What makes the GAW network so unique is the fact that the concentration measurements are made in the free troposphere above a densely populated and comparatively high industrialised area. The Zugspitze/Hohenpeissenberg GAW station largely fulfils the 10 GCMP.

Schauinsland: (regional station)
The air quality measuring site exists since the middle of the sixties. It was founded by the

German Research Foundation ('Deutsche Forschungsgemeinschaft', DFG) as part of a German monitoring network to investigate the composition of unpolluted air and background air pollution. In 1974 the network was integrated into the then newly established UBA. In the 1960s and early 1970s a lot of pioneering work concerning the development of methods to measure trace substances in air was necessary. Some measuring systems have been developed by the station staff themselves. Today, the site is one of seven stations of the German air monitoring network operated by the UBA. It serves for long-term monitoring of long-range transboundary air pollution within the scope of international programmes.

Over the years, the observational programme has changed according to new and emerging questions. While at the beginning sulphur dioxide was a main concern, its concentration in Germany today is very low. At the beginning of the nineties the tropospheric ozone became more important and a national ozone early warning system was installed. Recently one focus is on components having global effects, such as greenhouse gases.

Neuglobsow: (regional station)
From 1979 to 1991 the Stechlin Lake District station has been operated as a background site to monitor air pollutants and precipitation as well as their effects on ecosystems. In 1991 the monitoring site Neuglobsow was integrated into the German air monitoring network operated by the UBA.

The monitoring site Neuglobsow now serves as a regional GAW station as well as an EMEP site (European Monitoring and Evaluation Programme). In addition, Neuglobsow is one of two German Integrated Monitoring sites, the international cooperative programme of the Convention on Long-range Transboundary Air Pollution (CLRTAP) which investigates the effects of air pollutants on ecosystems.

2.3 Other networks for monitoring weather and atmospheric composition

2.3.1 DWD - National observing network

In addition to the stations in the global monitoring networks (GAW, GUAN, GSN), the DWD operates a national observing network that regularly collects meteorological data in Germany. The data is subject to quality assurance measures and then chronologically archived in a climatological database. Most of these time series begin in the 1940s, although some date back to the 19th and 18th centuries.

Since the mid-1970s, the DWD has regularly stored all meteorological data collected by its observing network on electronic media, checked the data for quality and then archived it on a routine basis. Furthermore, the data collected earlier in table form on paper or (since the 1950s) on punch cards, were registered, then archived in a standardised form on magnetic tape and later added to the climate database.

Data gathered by the Meteorological Service of the former German Democratic Republic (GDR), until 1990, has also been similarly processed (even though in some points in quite different ways) and compiled in a suitable data archive, the Standardised Meteorological Data-Storage Medium (EMDS). This data archive was integrated into the DWD climate database to the greatest possible extent with the work having been completed in 1992. Due to the different ways of data processing used in the old and new Federal Laender before 1990, the data sets differ in form and content.

Since 1997, new climate data has been stored within the DWD database application called MIRAKEL, which is based on a relational database system. The migration of the former data archive to the MIRAKEL database has largely been completed, with the result that the aforementioned climate data is now archived in a relational database system that greatly facilitates the use of the data.

The national observing network consists of (01.09.2008):

- **178** main meteorological watch offices and automatic weather stations, of which **51** are manned around the clock, **38** are manned part time and **89** are fully automatic weather stations;
- **34** surface weather stations run by the German Federal Armed Forces;
- **1859** voluntary weather stations carried out by non-professionals, of which **791** are automatic stations for 10-minute data (**33** stations measure only wind parameter and **465** only precipitation);
- **9** upper-air stations (**3** stations are auto launcher and **2** stations measure additionally ozone);
- **5** upper-air stations run by the German Federal Armed Forces.

DWD and the German Federal Armed Forces operate a combined network, the National Basic meteorological observing Network (NABAM). It consists of **178** main meteorological watch offices and automatic weather stations (DWD) and **19** surface weather stations operated by the German Federal Armed Forces.

The total network of the DWD and the German Federal Armed Forces thus comprises:

- **528** stations measuring temperature und humidity;
- **218** stations measuring air pressure;
- **2029** stations measuring precipitation;
- **296** stations measuring wind, of which **56** are part of the storm warning network;
- **306** stations measuring sunshine duration

At more than 550 stations two or more variables are measured. In addition the Laender are running their own observing networks. Presently DWD is receiving precipitation data from about 200 stations from Bavaria, Rhineland-Palatinate, and Baden-Württemberg. It is estimated that in total the Laender could contribute about 800 additional precipitation stations.

2.3.2 DWD - cooperation with other organizations

The DWD also participates in other global observing networks. Its MOL-RAO is part of the BSRN (Baseline Surface Radiation Network) and thereby contributes to the global monitoring of atmospheric radiation. Furthermore, the MOL-RAO acts as a regional radiation centre of WMO RA VI in the aim of guaranteeing highest standards of atmospheric radiation measurements in WMO RA VI Europe.

The MOL-RAO actively contributes to several sub-projects of the Global Energy and Water Cycle Project (GEWEX) being part of the World Climate Research Programme of WMO. This includes participation in the Coordinated Enhanced Observation Period (CEOP), GEWEX Atmospheric Boundary Layer Studies (GABLS) and GVaP projects.

2.3.3 AWI - cooperation with other organizations

The data from Neumayer station helps to close significant gaps in the global weather and climate observing networks. The station is part of the GCOS-, GAW-, the Network for the Detection of Atmospheric Composition Change (NDACC, the formerly Network for Detection of Stratospheric Change, NDSC) and the Baseline Surface Radiation Network (BSRN). Its data are also exchanged via WMO's Global Telecommunication System (GTS).

Another important station with global monitoring is the Koldewey station in Ny Ålesund on Spitsbergen.

2.3.4 UBA - cooperation with other organizations

The data from the GAW station 'Zugspitze' is also integrated in the UBA air quality network which contributes to EMEP. In addition, the GAW platform provides data for research activities of other scientific projects in the Environmental Research Station Schneefernerhaus.

The GAW regional station Schauinsland also contributes to the EMEP. In addition, the station serves as platform for research projects (e.g. CarboEurope-IP funded by EU) and is responsible for quality assurance of the greenhouse gases measurements within the total UBA-air monitoring network.

Neuglobsow also serves as well as an EMEP site. In addition, the station is one of two German Integrated Monitoring sites within the international cooperative programme of the CLRTAP which investigates the effects of air pollutants on ecosystems.

All in all there exist 21 regional GAW stations in Germany, one for example is Zingst. This station is included into Table 1c) in the next section.

2.4 National meteorological observations

The following tables (1a – 1c) give some detailed information on the contributions of the national observations.

General information for the historical data:
The National Climate Data Centre (Nationales Klimadatenzentrum, NKDZ) at the DWD provides historical and current climate data observed in Germany. The database contains the data generated by the surface and upper air observational networks of the DWD. The time resolution of the observations comprises minutes, hours, days and months: the number of observation stations differs according to observation time, time resolution and element. The length of time series may at some stations extend 100 years and more. The NKDZ provides products generated from the observational data like climate indices for months, seasons and years and produces grid fields with a 1-km-resolution as basis for more advanced products like time series of area means.
Not all records of climate data generated before 1969 are yet digitized and imported into the database of the NKDZ. So DWD is currently running a project for data rescue (KLIDADIGI) with the aim of saving and digitizing old, not yet digitized observation records and considerably enlarging the number of time series longer than 50 years.
The aim of the NKDZ is the archiving and documentation of the data, the establishment of quality control procedures to the historical data and the provision of access and distribution methods to make the data available for application and research. The current data of the NKDZ are distributed via the GTS. A web access to the historical database and a data catalogue according to ISO metadata standards is provided on the web. All precipitation data are provided to the GPCC (Global Precipitation Climatology Centre).

2.4.1 Surface-Based Atmospheric ECV's

The following gives some explanations for each row of Table 1a).

GCOS Surface Network (GSN):
see section 2.2.1

Full World Weather Watch / Global Observing System (WWW/GOS) surface network:
(see section 2.3.1)
The network of weather stations in Germany consists of:

- **197** main meteorological watch offices and automatic weather stations, including 19 surface weather stations run by the German Federal Armed Forces
- **15** surface weather stations run by the German Federal Armed Forces with temporarily measurements
- **1859** secondary weather and precipitation stations with voluntary observers, of which 791 are automatic stations for 10-minute data (33 stations measured only wind parameter and 465 only precipitation)

Baseline Surface Radiation Network (BSRN):
A total of three stations are involved in BSRN. The DWD station 'Lindenberg' and the two AWI stations Neumayer and Spitsbergen.

The WRMC with all BSRN measurements is now managed by the AWI.

Solar radiation and radiation balance data:
These parameters were measured at selected 93 stations. 29 stations are equipped with pyranometer (high level) and 64 stations with Scanning Pyrheliometer Pyranometer (SCAPPs, lower level).

Ocean drifting buoys:
Germany have no own drifting buoys.

Moored buoys:
The seven moored buoys currently consist of the following seven stations:

• 2 moored buoys	Nordseeboje II
	Nordseeboje III
• 1 navigation beacon	Bake Zulu
• 2 lightvessels	GW/EMS (TW Ems)
	G-Bight (Deutsche Bucht)
• 2 lighthouses	Alte Weser
	Leuchtturm Kiel

The four lightvessels and lighthouses are fully equipped with DWD standard sensors and therefore assigned to DWD's primary observing network (see table 1a).

In 2008 a third moored buoy Fehmarn Belt will be installed. Currently only the data from the lightvessels und the lighthouses are provided internationally. This will be changed during 2008, and then the data of all moored buys will be distributed internationally.

Voluntary Observing Ship Climate Project (VOSClim) ships
Germany currently operates 30 VOSClim ships having generated about 10.000 observations in 2007. It is part of 10 countries worldwide with recruited 251 VOSClim ships. As for the entire VOS fleet (refer chapter 3), the German Meteorological Service funds the meteorological equipment for the merchant ships and research vessels taking part in the VOSClim project.

Ocean reference Mooring Network and sites on small isolated islands:
Is not installed from Germany

Table 1a: National Contributions to the Surface-Based Atmospheric ECV's

Contributing Networks specified in the GCOS Implementation Plan	ECV's	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
GCOS Surface Network (GSN)	air temperature	**3 DWD** **1 AWI**	**3 DWD** **1 AWI**	**4 DWD** **1 AWI**	**3 DWD** **1 AWI**	**3 DWD** **1 AWI**
	precipitation	**3 DWD** **1 AWI**	**3 DWD** **1 AWI**	**4 DWD** **1 AWI**	**3 DWD** **1 AWI**	**3 DWD** **1 AWI**
Full World Weather Watch/Global Observing System (WWW/GOS) surface network	air temperature, air pressure, wind speed/ direction, water vapour	**178 primary DWD** **301 secondary DWD** (some wind only; no pressure) **34 BW[a]**	**178 DWD** **34 BW[a]**	**182 DWD**	**178 DWD** **19 BW[a]** **all NABAM[b] stations**	**178 DWD**
	precipitation	**178 primary DWD** **1859 secondary DWD (791 autom.)** **34 BW[a]**	**178 DWD** **34 BW[a]**	**182 DWD**	**178 DWD** **34 BW[a]**	**178 DWD**
Baseline Surface Radiation Network (BSRN)	surface radiation	**1 DWD** **2 AWI**	**1 DWD** **2 AWI**	**1 DWD** **2 AWI**	**1 DWD** **2 AWI**	**1 DWD** **2 AWI**
Solar radiation and radiation balance data	surface radiation	**93 DWD**	**29 DWD**	**100 DWD**	**8 DWD**	**8 DWD**
Ocean drifting buoys	air temperature, air pressure	**---**	**---**	**---**	**---**	**---**
Moored buoys	Air temperature, air pressure	**7 DWD**	**7 DWD**	**8 DWD**	**4 DWD**	**4 DWD**
Voluntary Observing Ship Climate Project (VOSClim) ships	Air temperature, air pressure, wind speed/ direction, water vapour	**30 DWD**	**30, as far as this is possible for a ship**	**40 DWD**	**30 DWD**	**---**

Contributing Networks specified in the GCOS Implementation Plan	ECV's	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
Ocean reference Mooring Network and sites on small isolated islands	Air temperature, wind speed/ direction, air pressure	---	---	---	---	---
	precipitation	---	---	---	---	---

[a] BW = Bundeswehr (German Federal Armed Forces)
[b] NABAM = National basic meteorological observing network (includes 178 primary weather stations and 19 surface weather stations run by the German Federal Armed Forces.

2.4.2 Upper-Air Atmospheric ECV's

The following gives some explanations for each row of Table 1b).

GCOS Upper Air Network (GUAN):
see section 2.2.2

Full WWW/GOS Upper-Air Network:
DWD has 9 operating systems (Emden, Schleswig, Greifswald, Lindenberg, Meiningen, Hohenpeissenberg, Essen [automated], Stuttgart [automated], München-Oberschleissheim [automated]) and the German Federal Armed Forces 5 stations (Bergen, Meppen, Idar-Oberstein, Kümmersbruck and Altenstadt). Three stations (Bergen, Idar-Oberstein and Kümmersbruck) are involved in the national basic meteorological observing network.
The Neumayer station operated by AWI is also involved in the WWW/ GOS upper-air network.

Table 1b: National Contributions to the Upper- Air Atmospheric ECVs

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
GCOS Upper Air Network (GUAN)	Upper-Air-Temperature, Upper-Air Wind Speed/ Direction, Upper-Air Water Vapour	**1 DWD** **1 AWI**	**1 DWD** **1 AWI**	**1 DWD** **1 AWI**	**1 DWD** **1 AWI**	**1 DWD** **1 AWI**
Full WWW/GOS Upper Air Network	Upper-Air-Temperature, Upper-Air Wind Speed/ Direction, Upper-Air Water Vapour	**9 primary DWD** **3 BW[a]** **1 AWI**	**9 DWD** **3 BW[a]** **1 AWI**	**9 DWD** **3 BW[a]** **1 AWI**	**9 DWD** **3 BW[a]**	**9 DWD** **3 BW[a]** **1 AWI**

[a]BW – German Federal Armed Forces (Bundeswehr)

2.4.3 Atmospheric Composition

The following gives some explanation for each row of Table 1c).

World Meteorological Organization / Global Atmospheric Watch (WMO / GAW) Global Atmospheric CO2 and CO4 Monitoring Network:
Generally there are four stations observing these variables: the two GAW regional stations Schauinsland and Neuglobsow, Neumayer (also part of GSN and GUAN networks) and the station Zugspitze/ Schneefernerhaus.
The GAW Regional Station Neuglobsow only measures CO2 and CO4 concentrations.

WMO / GAW ozone sonde network:
The stations Lindenberg, Hohenpeissenberg, Neumayer and Ny Ålesund/Koldevey measure ozone with ozone-sondes. At Hohenpeissenberg in addition an ozone-Lidar is used to detect ozone.

WMO / GAW column ozone network:
Lindenberg, Hohenpeissenberg, Neumayer and Ny Ålesund/Koldevey are involved in the WMO / GAW column ozone network.

WMO / GAW aerosol network:
The aerosol optical depth is detected at the four stations Lindenberg, Hohenpeissenberg, Zingst (a GAW regional station), and Zugspitze/ Schneefernerhaus.

Other aerosol properties are additionally measured at Schauinsland, Neuglobsow, Neumayer and Ny Ålesund/Koldevey. At Lindenberg only the optical depth is measured but no other components.

Table 1c: National contributions to the Atmospheric Composition

ECVs Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
World Meteorological Organization/ Global Atmospheric Watch (WMO/GAW) Global Atmospheric CO_2 & CH_4 Monitoring Network	Carbon Dioxide (CO_2)	**4**	**4**	**4**	**4**	**3**
	Methane (CH_4)	**4**	**4**	**4**	**4**	**3**
	Other greenhouse gases	**3**	**3**	**3**	**3**	**2**
WMO/GAW ozone sonde network[a]	Ozone	**4**	**4**	**4**	**4**	**2**
WMO/GAW column ozone network[b]	Ozone	**4**	**2**	**4**	**4**	**2**
WMO/GAW Aerosol Network[c]	Aerosol optical depth	**4**	**4**	**4**	**4**	**4**
	Other Aerosol Properties	**7**	**7**	**7**	**7**	**7**

[a] Including SHODOZ, NDACC, remote sensing and ozone sondes.
[b] Including filter, Dobson and Brewer stations.
[c] Including AERONET, SKYNET, BSRN and GAWPER.

2.5 Satellite observations

Satellite systems have become the major contribution to the global observing system for climate monitoring because of their global coverage, and uniform observing system for all parts of the globe Long-term continuity of many satellite missions in combination with reprocessing

of archived satellite data based on careful inter-sensor calibration, taking into account the GCOS systematic observing requirements for satellite-based products for climate (GCOS-107), facilitate the generation of ECV satellite products for climate monitoring purposes. The satellite systems have to be completed by in-situ measurements for calibration purposes and for the provision of ECVs which cannot be provided in sufficient quality from space data.

Like the other European meteorological services, DWD also coordinates its satellite matters via EUMETSAT, the European Organisation for the Exploitation of Meteorological Satellites. Therefore, all statements related to plans to ensure availability of past and future data and metadata records of satellite measurements for the atmospheric ECVs and associated global products contained in Table 2 are related to EUMETSAT. Some indications are directly introduced in Table 2 below. For more details it is recommended to visit the EUMETSAT home page[5] or the information provided by EUMETSAT via CEOS. DWD as a major Member State is strongly involved in the planning and decision processes of EUMETSAT. This concerns the current satellite systems of EUMETSAT, the planning of future programmes such as Meteosat Third Generation (MTG), Post-EPS and Jason-Follow-on as well as archiving aspects. The current satellite systems of EUMETSAT cover the period up to 2015 till 2020 and the future EUMETSAT satellite systems will cover the period roughly from 2015 till 2030.

The GCOS climate monitoring requirements for satellite based products (GCOS-107) are taken into account when the future satellite systems of EUMETSAT are planned. According to Article 2 of its convention one of the objectives of EUMETSAT is to contribute to the operational monitoring of the climate system and the detection of global climatic changes. In fulfilling its objectives EUMETSAT has also to take into account, as far as possible, the recommendations of the WMO, which are corresponding to GCOS requirements.

It should be noted that EUMETSAT has a decentralised network of Satellite Application Facilities (SAFs) for the generation of products from EUMETSAT satellite data. Of special relevance to GCOS is the Satellite Application Facility on Climate Monitoring (CM-SAF) which is hosted by the DWD. Detailed information on the CM-SAF can be retrieved from the Internet[6].

Table 2. Global products requiring satellite observations – atmospheric essential climate variables

ECVs/ Global Products requiring Satellite Observations	**Fundamental Climate Data Records required for Product Generation (from past, current and future missions)**
Surface Wind Speed and Direction Surface vector winds analyses, particularly from re-analysis	Passive microwave radiances and scatterometry Requirement is fulfilled: The METOP satellites of EUMETSAT have the ASCAT[7] instrument on board providing sea surface wind speed and direction; with all 3 METOP satellites data continuity can be expected until about 2018; resulting products are archived; see also the WebPages of the SAF on Ocean and Sea Ice.
Upper- Air Temperature Homogenized upper-air temperature analyses; Extended MSU-equivalent temperature record; New record for upper-troposphere and lower-stratosphere temperature using data from radio occultation;	Passive microwave radiances; GPS radio occultation; High-spectral resolution IR radiances for use in re-analysis Requirement is fulfilled: The METOP satellites have the IASI, AMSU[8]-A and GRAS[9] instruments on board;

[5] http://www.eumetsat.int
[6] http://www.cmsaf.eu
[7] Advanced Scatterometer
[8] Advanced Microwave Sounding Unit
[9] Global Navigation Satellite System Receiver for Atmospheric Sounding

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Temperature analyses obtained from reanalyses	with all 3 METOP satellites data continuity can be expected until about 2018; resulting data and products are archived.
Water Vapour Total column water vapour over the ocean and over land; Tropospheric and lower-stratospheric profiles of water vapour	Passive microwave radiances; UV/VIS radiances; IR imagery and soundings in the 6.7µm band; Microwave soundings in the 183 GHz band Requirement is fulfilled with Meteosat First and Second Generation (MSG) and METOP; with all 4 MSG and all 3 METOP satellites data and product continuity can be expected until about 2018 and longer; resulting products are archived.
Cloud Properties Cloud radiative properties (initially key ISCCP products)	VIS/IR imagery; IR and microwave soundings Requirement is fulfilled with Meteosat First and Second Generation and METOP; with all 4 MSG and all 3 METOP satellites data continuity can be expected until about 2018 and longer; resulting products are archived.
Precipitation Improved estimates of precipitation, both as derived from specific satellite instruments and as provided by composite products	Passive microwave radiances; High-frequency geostationary IR measurements; Active radar (for calibration) Requirement is fulfilled with Meteosat First and Second Generation and the MHS instrument on board of METOP; with all 4 MSG and all 3 METOP satellites product continuity can be expected until about 2018 and longer; resulting products are archived.
Earth Radiation Budget Top-of-atmosphere Earth radiation budget on a continuous basis	Broadband radiances; Spectrally-resolved solar irradiances; Geostationary multi-spectral imagery Requirement is fulfilled with GERB[10] on all 4 MSG satellites and the imaging instruments SEVIRI and AVHRR on board of MSG resp. METOP; with all 4 MSG and all 3 METOP satellites product continuity can be expected until about 2018 and longer; resulting products are archived.
Ozone Profiles and total column of ozone	UV/VIS and IR microwave radiances Requirement is fulfilled by GOME on ERS-2, SCIAMACHY on ENVISAT and GOME-2 and IASI on board of the METOP satellites; with all 3 METOP satellites product and data continuity can be expected until about 2018; resulting products are archived; see also the WebPages of the SAF on Ozone and Atmospheric Chemistry Monitoring.
Aerosol Properties Aerosol optical depth and other aerosol properties	VIS/NIR/SWIR radiances Requirement is fulfilled with MERIS providing regional value added information concerning clouds and aerosols and with Meteosat Second Generation and METOP; with all 4 MSG and all 3 METOP satellites product continuity can be expected until about 2018 and longer; resulting products are archived.
Carbon Dioxide, Methane and other GHG Distribution of greenhouse gases, such as CO_2 and CH_4,, of sufficient quality to estimate regional sources and sinks	NIR/IR radiances The IASI and GOME-2 instrument on board of METOP contribute to the monitoring of the listed trace gases.

[10] Geostationary Earth Radiation Budget

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Upper-air Wind Upper-air wind reanalyses, particularly from reanalysis	VIS/IR imagery; Doppler wind lidar Wind vectors are derived from data of Meteosat First and Second Generation; with MSG product continuity can be expected until about 2018 and longer; resulting products are archived; reanalysis is an issue to which EUMETSAT has to respond. Space-based Doppler wind lidar is an issue for the future, the relevant mission is not yet demonstrated and the expected data are probably not from the beginning on suitable for climate monitoring purposes.
Atmospheric Reanalyses	Key Fundamental Climate Data Records (FCDRs) and products identified in this report, and other data of value to the analyses The SAF on Climate Monitoring plans to perform reanalyses.

2.6 Responses to the actions recommended in the GCOS implementation plan

(a) Applying the GCMPs to all surface climate networks (A3);

To fulfil the GCMPs, DWD operates 12 Reference Stations throughout Germany. These are: Aachen, Brocken, Fichtelberg, Frankfurt am Main, Görlitz, Helgoland, Hamburg-Fuhlsbüttel, Hohenpeissenberg, Konstanz, Lindenberg, Potsdam and Schleswig. At these sites, conventional and new automatic measuring devices are operated in parallel. All measured data have been and are subjected to thorough quality checks and are stored in digital form (which also applies to all past records).

Before new instruments are installed and used operationally, they are tested at special test facilities (e.g. at Hamburg) to ensure that they comply with all requirements to replace the previous instrumentation (precicion, accuracy, availability, and so on).

With this, it is ensured that all primary weather stations (Wst I [meteorological watch office], Wst II [automatic weather office]) mostly comply with GCMPs and the secondary weather station which are operated by voluntary observers with some restrictions (Wst III [voluntary weather station], Nst(A) [automatic precipitation station] and Nst(k) [conventional precipitation station]).

(b) Incorporating atmospheric pressure sensors into drifting buoy programmes (A5)

Germany runs no own drifting buoys on its own, but contributes to EUCOS/E-SURFMAR.

(c) Ensuring availability of three-hourly mean sea level pressure and wind speed and direction data from GSN stations (A10)

The GSN stations are equipped with automatic sensors. These data (e.g. mean pressure at sea level, wind speed and direction) are hourly exchanged on the GTS.

(d) Implementing a reference network of high-altitude, high-quality radiosondes (A16)

In 2007, WMO assigned the Lead centre of the GCOS Reference Upper-air Network (GRUAN) to the MOL-RAO. DWD has employed three new staff for this obligation at Lindenberg. This was completed on 1 July 2008. Currently, the guidelines for running GRUAN reference observations are drafted. MOL-RAO will also be among the first reference stations in the frame of GRUAN. Currently, regular reference observation of water vapour in the upper troposphere and lower stratosphere using different type of sensors are conducted. This work is supported by systematic investigations of instrument performance in a climate chamber.

(e) Operating the WWW/GOS radiosonde network in full compliance with the GCMPs and coding conventions (A17)

Being a GUAN station, MOL-RAO complies with the GCMPs and coding conventions. All other measured with use routinely the same radio-sonde for at least two soundings a day (till 30 km).

(f) Submitting metadata records and inter-comparisons for radiosonde observations to the specified international data centres (A18)

Currently, a database is installed at MOL-RAO that will contain all metadata of GRUAN stations as well as the data from radiosonde (and other) inter-comparison campaigns.

(g) Developing a network of ground-based Global Positional System (GPS) receivers for measuring water vapour (A21)

Germany is operating a ground-based network of Global Positional System (GPS) receivers since 2000. The responsible and processing centre is located at the GeoForschung Zentrum (GFZ), Potsdam. At present the network consists of approximately 200 stations delivering measurements of integrated water vapour every 15 minutes and with an accuracy of circa 2 kg/m^2.

(h) Sustained measurements of the atmospheric composition ECVs, supplementary to those activities implicit in table 1c.

In Germany, the environmental agencies of the states all run monitoring programmes dedicated to characterizing aerosol mass concentrations (PM10, PM 2.5, soot, etc.) and ozone levels on regional scales. Thus, they contribute to “other aerosol parameters” and “other greenhouse gases”.

3 Oceanic Essential Climate Variables

3.1 Description of national contribution to oceanographic ECV

The German contribution to international networks and co-operation on climate research in the ocean is distributed over a wide range of centres of expertise at joint institutes, universities and operational agencies. Among the partners in this field are the Alfred-Wegener-Institute (AWI), the Centre for Marine and Atmospheric Sciences (ZMAW), the Federal Maritime and Hydrographic Agency (BSH), the German Meteorological Service (DWD), the Leibnitz Institute of Marine Science (IfM-Geomar), the Institute of Environmental Physics (IUP-Bremen) and others.

Suitable measuring instrumentation for field observations has been developed and used under German environmental research assistance measures. The measuring platforms available include aircrafts, research vessels (e.g. ‚Polarstern'), merchant vessels, drifting buoys, moorings and remotely operated vehicles (ROVs).

The BSH funds equipment for 2 merchant vessels conducting temperature measurements along 2 Atlantic XBT sections (AX03, AX11). These are part of the set of sections selected by the GCOS/WCRP Ocean Observations Panel for Climate (OOPC) and CLIVAR as Ship of Opportunity Programme (SOOP) lines to fulfil the upper ocean data requirements which have been established by GOOS and GCOS. The data are transmitted in near real-time to the Global Telecommunication network (GTS) of the World Meteorological Organization (WMO). The Federal Maritime Agency exchanges the data also to the Global Temperature and Salinity Profile Project (GTSPP). About 550 observations are generated by German SOOP ships each year.

The BSH also operates the German contribution to the international Array for real-time geostrophic oceanography (ARGO) network. Long-term funding will be provided by the Federal Ministry of Transport, Building and Urban Affairs (BMVBS) to deploy 50 ARGO floats each year. The focus of deployments will be the Atlantic Ocean, but if necessary other oceans could be selected to maintain the global array. Deployment of the instruments is achieved in co-operation with the research community using deployment opportunities during research cruises. Data are transmitted in real-time to the international data centre CORIOLIS[11]. The BSH provides quality control on the collected data according to the data management procedures developed in the ARGO programme and distributes the quality controlled data sets to the international data centres.

The BSH maintains a net of 9 autonomous observation platforms in the North Sea and Baltic Sea. The stations are regularly serviced and calibrated and data are transmitted in real-time to the BSH. The parameters measured at the stations include meteorological measurements, conducted by the DWD.

The German contribution to the global references mooring network is distributed over several research institutes. The AWI operates 24 individual long-term moorings which are part of the OceanSites project. The locations of the moorings are in the Greenland Sea (1), the Fram Strait (12), the Weddell Gyre along the Greenwich Meridian (5) and the Weddell Gyre proper (6). The IfM-Geomar operates 4 moorings in the Labrador and Irminger Sea and one near the Azores (K276) as part of the OceanSites project. Additional mooring activities of the IfM-Geomar are focused on the tropical Atlantic where 5 moorings are going to be deployed for a long-term period and 2 moorings further to the north. The IUP Bremen operates 4 integral moorings in the sub-polar North Atlantic to estimate the Gulf Stream transport. Data from these moorings will be available for climate research. A multidisciplinary mooring has been

[11] http://www.coriolis.eu.org/

established near the Cape Verde Islands and will contribute data to GEOSS. The ZMAW operates 3 moorings in the Nordic Seas as part of OceanSites.

Germany has played an important role in the World Ocean Circulation Experiment (WOCE) and has sampled several of the WOCE hydrographical sections. Although there is no special funding for these activities a repeated ship-based hydrographical network based on the formal WOCE lines is continued by the AWI and the IUP-Bremen. The AWI is repeating hydrographical surveys along SR03 and SR04 in the southern ocean and performs yearly measurements at Fram Strait and along 75°N. The IUP-Bremen is operating the A02 section every other year. Data are submitted to the WODC.

The AWI is also contributing to the global surface drifting buoy array with three buoys in the northern polar region. The ZMAW will start operation of 25 surface drifting buoys when the SMOS satellite mission is under way in 2009. The surface buoys are equipped with salinity sensors for satellite validation. Data will be reported to the international drifter data assembly centre.

The AWI is conducting underway pCO2 and TCO2 measurements in the water column from Polarstern along sections A13.5 and S04A in the southern ocean. The IfM-Geomar uses a VOS between Europe and North America to measure pCO2 and TCO2. Data are archived at the Carbon Dioxide Information Analysis Center (CDIAC).

There is only one official Global Sea Level Observing System (GLOSS) core sea level station which is operated by Germany. It‘s location is at Cuxhaven and it is serviced by the Federal Waterways Directorate North (WSD Nord23). Scientifically the data are looked after by the BfG. Hourly data are sent on a monthly basis to the data centre in Hawaii. In the research community additional activities are maintained to provide long-term sea level data. The AWI is providing 15 PIEs for validation of the Gravity Recovery And Climate Experiment (GRACE) mission, additional 4 PIEs are maintained by the IUP-Bremen for the same purpose.

The DWD funds the meteorological equipment for 857 merchant ships and research vessels within the framework of the WMO programme VOS (Voluntary Observing Ship). Most of the observations are transmitted in real-time to the GTS. The total amount of observations is stored to electronic data medium or manual diaries that are fetched by the PMO (Port Meteorological Officer) during their visits on board. Then, the data sets are transferred for climatological processing. About 250.000 observations are generated by German VOS worldwide each year. The VOSClim contribution is also managed by the DWD and reported under the meteorological section of this report.

3.2 Narrative of nominating national focal points and establishing partnerships between ocean research and operational communities

Due to the diversity of oceanic climate research in Germany contributions come from many different institutions. A high level national focal point for the oceanographic community is a member of the CLIVAR Steering committee (Prof. Visbeck, IfM-Geomar). The Argo programme has provided a good link between the ocean research and operational communities. The German contribution to Argo has been developed from a joint research project and float deployment and technical development are advanced in close collaboration with the scientific community.

Table 3a: National contributions to the Oceanic ECVs – Surface

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
Global surface drifting buoy array on 5×5 degree resolution	Sea – Surface Temperature, Sea-Level Pressure, Position-change-based Current	3	3	28	3	0
GLOSS Core Sea-level Network	Sea level	1	1	1	1	??
Voluntary Observing Ships (VOS)	All feasible surface ECVs	857	857	850	~600	None
Ship of Oppor. Programme	All feasible surface ECVs	2 ships	2 ships	2 ships	2 ships	2 ships

Table 3b: National contributions to the Oceanic ECVs – Water Column

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
Global reference mooring network	All feasible surface and subsurface ECVs	31	31	31	31	31

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
Global tropical moored buoy network	All feasible surface and subsurface ECVs	None	None	None	None	None
Argo network	Temperature, Salinity, Current	120	120	250	120	257
Sustained and repeated ship-based hydrography network	All feasible ECVs including those that depend on obtaining water samples	5 sections with 50 stations each	5 sections with 50 stations each	5 sections with 50 stations each	5 sections with 50 stations each	5 sections with 50 stations each
Carbon inventory survey lines	Temperature, Salinity, Ocean Tracers, Biogeochemistry variables	3 sections with 50 stations	3 sections with 50 stations	3 sections with 50 stations	3 sections with 50 stations	3 sections with 50 stations

3.3 Satellite observations

Table 4: Global Products requiring Satellite Observations – Oceans

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Sea Ice Sea –ice concentration	Microwave and visible imagery

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Sea Level Sea level and variability of its global mean	Altimetry
Sea Surface Temperature Sea surface temperature •	Single and multi-view IR and microwave imagery DLR: NOAA AVHRR: regional Sea Surface Temperature
Ocean Colour Ocean colour and oceanic chlorophyll-a concentration derived from ocean colour	Multi-spectral VIS imagery
Sea State Wave height and other measures of sea state (wave direction, wavelength, time period)	Altimetry
Ocean Salinity Research towards the measurements of changes in sea-surface salinity	Microwave radiances
Ocean Reanalyses Altimeter and ocean surface satellite measurements	Key FCDRs and products identified in this report, and other data of value to the analyses

3.4 Response to recommended actions on oceanic ECV

In this paragraph Parties are invited to report on specific actions.

(h) Conducting systematic global full-depth water column sampling along 30 sections repeated every 10 years

The sampling along 5 sections is operated by the AWI and the IUP-Bremen.

(i) Performing the 41 SOOP XBT/XCTD trans-oceanic sections

The BSH will continue to operate two of the Atlantic XBT sections along AX03 and AX11.

4 Terrestrial Essential Climate Variables

4.1 Global Terrestrial Network – Hydrology (GTN-H)

The GTN-H is a joint effort of the World Meteorological Organization / Climate and Water Department (WMO/CLW), the GCOS, and the Global Terrestrial Observing System (GTOS[12]), co-sponsored by WMO, UNESCO, ICSU, UNEP and FAO.
GTN-H represents the observational arm of the Group on Earth Observations / Integrated Global Water Cycle Observations Theme (GEO/IGWCO).
The following hydrological variables have been identified as essential for the GTN-H[13] network: precipitation, river discharge, groundwater, water vapour, lake level/ area, isotopic composition, soil moisture, water use, snow cover, glaciers and ice caps, evapotranspiration, water quality/ biogeochemical fluxes. For most of the variables a global network is defined and a contact established. The GPCC and the GRDC, both operational in Germany, are part of the GTN-H Panel and represent their respective networks on precipitation and river discharge.

4.2 Global Terrestrial Network for River Discharge (GTN-R)

The GRDC has been tasked with the implementation of the GTN-R to address the growing need for a global runoff network monitoring freshwater surface water fluxes. Only limited progress was achieved with this GCOS Baseline River Discharge Network during the reporting period. Currently near real-time hydrological data are received from 12 stations in 3 countries. 10 countries provided historical discharge data for 103 stations. The original objective was to include 380 stations from 81 countries, but only a quarter of the approached countries responded to the request to participate. A project proposal to boost the funding of the implementation of the GTN-R has been submitted to the European Union and currently the outcome is awaited before further action is taken.

4.3 Global Terrestrial Network – Lakes (GTN-L)

Lake level data are being observed by different agencies at Laender or community level. Though some of these observations are available in environmental information systems of the Laender on the Internet, there is no nation wide database established and it is therefore not known to which degree such data is made available to international data centres.

4.4 Global Terrestrial Network – Glacier (GTN-G)

The Commission for Glaciology of the Bavarian Academy of Sciences and Humanities runs a substantial recording programme in the catchment of the Vernagtferner, Oetztal, Austria. Maps of the glacier are available since 1889 and were repeated in 1912, 1938, 1954, 1969, 1979, 1982, 1990, 1999, and 2007. Mass balance is determined annually since 1964/65, including the separation into winter and summer series. Runoff, precipitation, all radiation components, temperature, humidity, air pressure, and wind are recorded since 1974 on an hourly basis. The permanent observations at Vernagtferner are complemented/ extended by

[12] http://www.fao.org/gtos/
[13] http://gtn-h.net/

mapping 15 glaciers in the Eastern Alps approx. every 10 years. Volume changes are derived from the maps of these 15 glaciers in the Eastern Alps, which include the five German glaciers: Nördlicher and Südlicher Schneeferner, Höllentalferner, Watzmanngletscher and Blaueis. The longest mapping series starts in 1889 (Vernagtferner and Guslarferner), next (1892) come the two Schneeferner on the Zugspitzplatt, the shortest series is provided for Watzmanngletscher (since 1959).

Data are regularly submitted to World Glacier Monitoring Service (WGMS[14]) and National Snow and Ice Data Center (NSIDC[15]), and analyses, results, and modelling approaches are presented in national and international Journals such as Zeitschrift für Gletscherkunde (Innsbruck), Journal of Glaciology, Annals of Glaciology (both: Cambridge), Geografiska Annaler (Stockholm), Climate Status Report 2007 of the DWD[16].

In addition, Germany contributes to and supports individual measurement campaigns in the Alps, in Central Asia, Greenland and Antarctica since many decades.

4.5 Global Terrestrial Network for Permafrost (GTN-P)

Soil or rock that is permanently frozen throughout the year is called permafrost. At high altitudes in the Alps, for example on the Zugspitze Mountain, permafrost occurs in the rock fissures. Global warming, however, would cause slow thawing. Consequences could be settlement, block fall or rock fall. The Zugspitze Mountain was chosen as a representative location in the northern Alps for monitoring changes in permafrost. In 2007 the mountaintop ridge was drilled through, commissioned by the Bavarian Environment Agency. Along a 44 m long borehole 25 temperature sensors were installed. These will collect temperature data for at least the next 15 years (planned up to 2022). The results contribute to a permafrost monitoring network for all of the Alps. This site is not included into the GTN-P but data will contribute to an alpine wide EU-PermaNet-project.

Table 5: National Contributions to the Terrestrial Domain ECVs

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
GCOS Baseline River Discharge Network (GTN-R)	River discharge	3	3	3	3 On request	3

[14] http://www.geo.unizh.ch/wgms/
[15] http://nsidc.org/index.html
[16] http://www.dwd.de

Contributing Networks specified in the GCOS Implementation Plan	ECVs	Number of Stations or Platforms currently operating	Number of Stations or Platforms operating in accordance with the GCMPs	Number of Stations or Platforms expected to be operating in 2010	Number of Stations or Platforms providing data to the International Data Centres	Number of Stations or Platforms with complete historical record available in International Data Centres
GCOS Baseline Lake Level/ Area/ Temperature Network (GTN-L)	Lake Level/ Area/ Temperature					
WWW/ GOS Synoptic Network	Snow Cover	911 (178 primary + 733 secondary DWD stations)	178 DWD	182 DWD	178 DWD	178 DWD
GCOS Glacier Monitoring Network (GTN-G)	Glaciers mass balance and length, also Ice sheet mass balance	1[a]	1	1	1	1
GCOS Permafrost Monitoring Network (GTN-P)	Permafrost borehole-temperatures and active - layer thickness	1[b]	?[b]	1[b]	(1)[b]	

[a] – Vernagtferner
[b] – Zugspitze established in 2007

4.6 Phenological monitoring network

A further important contribution to climatic change observations are the phenological observations which are also regularly conducted by the DWD at currently about 1339 sites in Germany (01.09.2008).

Phenology at the DWD deals with the periodically recurring growth and development phenomena of plants during the course of a year. The beginning of characteristic vegetation stages (phases) are observed and recorded. These are closely connected to the weather and climate and are thus suited for the most varied areas of application and for manifold scientific studies.

The phenological monitoring data of the DWD is not exchanged internationally, since there are no agreements in place for the exchange of such data between the Meteorological Services. In addition, such monitoring is carried out in only a few countries.

In 1957 a european network of International Phenological Gardens (IPGs) was established. This network was coached by DWD until 1995. Since then the responsibility is with the Humboldt-University in Berlin[17].

4.7 Satellite observations

Table 6: Global Products requiring Satellite Observations – Terrestrial

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Lakes Maps of lakes, lake levels, and surface temperatures of lakes in the Global Terrestrial network for Lakes	VIS/NIR imagery and radar imagery; Altimetry; High-resolution IR imagery
Glaciers and Ice Caps Maps of the areas covered by glaciers other than ice sheets Ice sheet elevation changes for mass balance determination	High-resolution VIS/NIR/SWIR optical imagery; Altimetry DLR: TerraSAR-X: high resolution maps of ice coverage (related to IPY)
Snow Cover Snow areal extent	Moderate-resolution VIS/NIR/IR and passive microwave imagery
Albedo Directional hemispherical (black sky) albedo	Multi-spectral and broadband imagery
Land Cover Moderate-resolution maps of land cover type; High-resolution maps of land cover type, for the detection of land cover change	Moderate-resolution multi-spectral VIS/NIR imagery; High-resolution multi-spectral VIS/NIR imagery GOFC-GOLD (University Jena): • Harmonization and Validation of existing 1 km data sets • GLOBCOVER 2005 • Participation in FAO Forest Resources Assessment 2010 • GEO task DA-07-02 • Technical support for “Reducing Emissions from Deforestation (REDD)
fAPAR Maps of fAPAR	VIS/NIR imagery
LAI Maps of LAI	VIS/NIR imagery

[17] http://www.agrar.hu-berlin.de/struktur/institute/pfb/struktur/agrarmet/phaenologie/ipg

ECVs/ Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)
Biomass Research towards global, above ground forest biomass and forest biomass change	L band/ P band SAR; Laser altimetry University Jena: • Regional biomass classification products in boreal areas (Siberia, China), derived from ERS interferometry and of hyper-temporal analysis of ENVISAT-ASAR time series
Fire Disturbance Burnt area, supplemented by active fire maps and fire radiated power	VIS/NIR/SWIR/TIR moderate-resolution multi-spectral imagery
Soil Moisture[a] Research towards global near-surface soil moisture map (up to 10cm soil depth)	Active and passive microwave

[a] Soil moisture is not listed as an ECV, but has been recognized in the GCOS implementation plan as an emerging ECV.

4.7.1 Contributions of the GOFC-GOLD land cover project office

The activities of Global Observation of Forest Cover and Land Dynamics (GOFC-GOLD[18]), a technical panel of the GTOS aim towards an operational terrestrial observation system with the key issues being the continuity and consistency in observations within an integrated framework, combining in situ measurements with fine and coarse resolution satellite data. These efforts go along with standardizing land cover characterization and validation, and end to end international coordination.

The GOFC-GOLD land cover project office hosted at the Friedrich Schiller University Jena, Germany[19] (funded by ESA) supports UNFCCC activities in different areas concerning forest and land cover observations:

- Technical input on reporting obligations in the Land Use, Land-Use Change and Forestry / Agriculture, Forestry and Other Land Use (LULUCF/AFOLU) section, i.e. on the use of satellite data (see GOFC-GOLD report 33[20])
- Supporting methodological discussions in the context of "Reducing Emissions from Deforestation and Forest Degradation" (see: GOFC-GOLD sourcebook[21])
- Implementation and input to observing terrestrial ECV's including land cover tasks in the GCOS IP and in defining reporting standards for land cover.

GOFC-GOLD is contributing to all of the Land Cover actions (T22-T27) noted in the GCOS IP. The actions are linked and built upon each other, e.g. the development of a standard land cover classification system (action T22) is to be parallelized with evolving common validation protocols (action T23). The availability of standards for land characterization (action T22) and validation (action T23), and the continuity of fine resolution observations (T24) are essential for implementing the other actions T25-27. Progress has been achieved in all actions.

[18] http://www.fao.org/gtos/gofc-gold/
[19] http://www.gofc-gold.uni-jena.de
[20] http://www.fao.org/gtos/gofc-gold/series.html
[21] http://www.gofc-gold.uni-jena.de/redd

5 List of abbreviations

ARGO	Array for real-time geostrophic oceanography
asl	Above sea level
AVHRR	Advanced Very High Resolution Radiometer
AWI	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung (Alfred Wegener Institute for Polar and Ocean Research)
BfG	Bundesanstalt für Gewässerkunde (German Federal Institute of Hydrology)
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety)
BMVBS	Bundesministerium für Verkehr, Bau und Stadtentwicklung (German Federal Ministry of Transport, Building and Urban Affairs)
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
BSH	Bundesamt für Seeschifffahrt und Hydrografie (Federal Maritime and Hydrographic Agency)
BSRN	Baseline Surface Radiation Network of the WCRP
CBS	WMO Commission for Basic Systems
CDOP	Continuous Development and Operations Phase (SAF)
CEOS	Committee on Earth Observation Satellites
CLIPS	Climate Information and Prediction Services (WMO)
CLIVAR	Climate Variability and Predictability
CLRTAP	UN/ECE Convention on Long-range Transboundary Air Pollution
CM-SAF	EUMETSAT Satellite Application Facility on Climate Monitoring
DFD	Deutsches Fernerkundungsdatenzentrum (Remote Sensing Data Centre)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V. (German Aerospace Center)
DWD	Deutscher Wetterdienst (German Meteorological Service)
ECV	Essential Climate Variable
EMDS	Einheitlicher Meteorologischer Datenspeicher (Standardised meteorological data memory system)
EMEP	European Monitoring and Evaluation Programme
ENVISAT	European Environmental Satellite (ESA)
EPS	EUMETSAT Polar System
ERS	European Earth Remote Sensing Satellite (ESA)
ESA	European Space Agency
E-SURFMAR	EUCOS Surface Marine programme
EU	European Union
EUCOS	EUMETNET Composite Observing System
EUMETNET	Network of European Meteorological Services
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization
FCDR	Fundamental Climate Data Record (from satellites)
GAW	Global Atmosphere Watch
GAWTEC	GAW Training and Education Centre
GCMP	GCOS Climate Monitoring Principles
GCOS	Global Climate Observing System (co-sponsored by WMO, UNEP,

	IOC and ICSU)
GDI-DE	Geodateninfrastruktur Deutschland
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water Cycle Experiment
GLOSS	Global Sea Level Observing System
GMES	Global Monitoring for Environment and Security
GOFC-GOLD	Global Observation of Forest Cover and Land Dynamics
GOME	Global Ozone Monitoring Experiment (instrument to measure ozone profiles, ERS-2 and EPS satellites)
GOOS	Global Ocean Observing System
GOS	WMO Global Observing System
GPCC	Global Precipitation Climatology Centre
GPS	Global Positioning System
GRDC	WMO Global Runoff Data Centre
GRUAN	GCOS Reference Upper-air Network
GSN	GCOS Surface Network
GTN-G	Global Terrestrial Network for Glaciers
GTN-H	Global Terrestrial Network for Hydrology
GTN-L	Global Terrestrial Network – Lakes
GTN-P	Global Terrestrial Network for Permafrost
GTN-R	Global Terrestrial Network for River Discharge
GTOS	Global Terrestrial Observing System (co-sponsored by WMO, UNESCO, ICSU, UNEP and FAO)
GTS	WMO Global Telecommunication System
GTZ	Gesellschaft für Technische Zusammenarbeit GmbH (German Agency for Technical Co-operation)
GUAN	GCOS Upper Air Network
GVaP	GEWEX Global water Vapor Project
IASI	Infrared Atmospheric Sounding Interferometer
ICSU	International Council for Science
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften (Leibniz Institute of Marine Sciences) at the University of Kiel
IMAGI	Interministerieller Ausschuss für Geoinformation (Interministerial Committee for Geoinformation)
ISO	International Organization for Standardization
MERIS	Medium Resolution Imaging Spectrometer
MetOp	EUMETSAT Meteorological Operational Satellite programme
MOL-RAO	Lindenberg Meteorological Observatory – Richard Assmann Observatory
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
NABAM	Nationales Basismessnetz (National Base Observing Network)
NASA	National Aeronautics and Space Administration
NDACC	Network for the Detection of Atmospheric Composition Change
NKDZ	Nationales Klimadatenzentrum (National Climate Data Centre)
NOAA	National Oceanic and Atmospheric Administration, USA
QA/SAC	Quality Assurance / Science Assessment Centre (within GAW)
RA	Regional Association (WMO)
SAF	EUMETSAT Satellite Application Facility
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography
SOOP	Ship of Opportunity Programme
TerraSAR	German radar satellite

UBA	Umweltbundesamt (Federal Environmental Agency)
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UTC	Coordinated Universal Time
VOS	Voluntary Observing Ships
VOSClim	Voluntary Observing Ship Climate Project
WCP	World Climate Programme (WMO)
WCRP	World Climate Research Programme
WDC-RSAT	ICSU World Data Centre for Remote Sensing of the Atmosphere
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment
WRMC	World Radiation Monitoring Centre
WWW	World Weather Watch (of WMO)
XBT	Expendable Bathythermograph
ZMAW	Zentrum für Marine und Atmosphärische Wissenschaften (Centre for Marine and Atmospheric Sciences), University of Hamburg