The Swedish National Report on Systematic Observations for Climate for 2008:

National Activities with Respect to the Global Climate Observing System (GCOS) Implementation Plan

Prepared for Submission to the United Nations Framework Convention on Climate Change (UNFCCC)

Compiled by the

Swedish Meteorological and Hydrological Institute

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Report on Global Climate Change Observing Systems 2008

Sweden

Summary

This report provides a brief description of current status and activities as regards Global Climate Change Observing Systems in Sweden 2008. Sweden reported in detail 2005 and this report, 2008, provides some update but less details.

The process to automize earlier manual stations has continued resulting in harmonization problems between old and new data series and loss of visual characterisation of weather. On the other side automation supports more frequent observations and denser networks.

In Sweden as in many countries there are ongoing efforts to have enhanced access to climate data. New archives are under development with meta-data, portals and networks with international links.

The contribution from Sweden in the field of capacity-building in the third world is not focussed towards direct observations and ECVs. One important objective as regards capacity-building is to increase the knowledge about climate change and its consequences. An aim in the Swedish work is also to provide methods for identification of vulnerable sectors in society. This in turn creates requirements on climate change observing systems.

An essential objective in the work with Global Climate Change Observing Systems and the ECVs is that data is included in holistic concepts, that observations more than prepared and archived according to international specifications also are processed and integrated in systems creating high level decision-making-material. The multipurpose observations, even temporary networks, will contribute more and more to the Global Climate Change Observing Systems and in parallel the value of sustained and quality controlled ECVs will increase, in dataassimilation in models as well as for validation purposes.

The evolution of GMES and GEOSS can make a considerable contribution to the European part and the whole GCOS network as these programmes are multipurpose ones, involve a whole production chain and have the challenging combination land, ocean and atmosphere.

CONTENT

1 Common Issues

The text in this chapter provides a brief description on Swedish activities and strategies as regards GCOS. It is also important to see GCOS and a Global Climate Change Observing Systems in a broader perspective, the possibilities to have common European strategies and possibilities to see the GCOS and ECV priorities in a context where observations are serving a multitude of objectives and at the same time to realize that a manifold of observations not primarily aimed at climate change monitoring indirectly can contribute to a more complete picture of the climate system, its variability, change and sensibility to anthropogenic sources. A short discussion is included in Chapter 5.

1.1 National coordination

Monitoring of global change is high on the political agenda in Sweden with the recent publication of the IPCC reports and the regular address of this issue at several high level meetings around the world. The Global Climate Observing System (GCOS) with the mission to ensure the availability of global climate observations for monitoring the climate system is essential and its importance will grow as a result of increased ability to make data in archive accessible and the enhanced methods to make reanalyses of the combined climate system.

GCOS has established GCOS Climate Monitoring Principles (GCMP), towards the delivery of global, long-term, high-quality, sustained and reliable climate products and has identified the list of the Essential Climate Variables (ECVs) that are both currently feasible for global implementation and have a high impact on the requirements of the UNFCCC. The GCOS Implementation Plan, expressing clear needs, including those for space observations in support to Climate Monitoring is in Sweden a document that guides the planning.

In **Sweden** a large number of monitoring activities and systematic observations are taking place with relevance for GCOS to characterise climate and to detect climate changes. The responsibility to develop, implement and maintain these systems is divided between several agencies and organisations, with different objectives and tasks. However, a significant advantage in Sweden as regards the coordination for observing, archiving and analysing the national contribution of observations of the ECVs is that the principal part of the activities are organised within one institute, the Swedish Meteorological and Hydrological Institute (SMHI).

SMHI (http://www.smhi.se) is a primary supplier to society of meteorological, hydrological and oceanographic data. SMHI is responsible for national meteorological, hydrological and oceanographic forecasts and warnings as well as preparedness for catastrophes where actual and prognostic information on weather and water conditions is required. The responsibility also includes production of basic information for the general needs of society for research and observations as well as for rational decision-making. SMHI is also responsible for the development and maintenance of national data sets in meteorology, hydrology and oceanography. The institute provides expertise in the area of climate and climate change issues and the Government has assigned to the institute a more permanent role as regards Climate Change Projections.

SMHI has a strong co-operation with the Swedish Armed Forces as regards the meteorological infrastructure. The Armed Forces is responsible for an aerologic station, surface stations and weather radars – all parts of the Swedish meteorological infrastructure. There is also a strong co-operation between SMHI and the national environmental monitoring programmes operated by Naturvårdsverket on measurements with specific environmental importance. SMHI has furthermore cooperation with LFV (Luftfartsverket) and Vägverket (the Swedish Road Administration) as regards observations at airports and along roads.

SMHI is entrusted by the Swedish Government to represent Sweden in the World Meteorology Organisation (WMO), the European organisation for exploitation of meteorological satellites (EUMETSAT) and the European Centre for Medium-Range Weather Forecasts (ECMWF). Furthermore, as regards the Intergovernmental Oceanographic Commission (IOC) SMHI upholds the secretariat function.

1.2 Efforts undertaken to ensure high-quality climate data records

The principles for setting up and operating systematic observations depend on the purpose of the systematic observation. Some of the observations have been established to follow up a specific objective such as in environmental monitoring programmes. Others have been established to

obtain basic information of the climate and the environment and its development over time. The principles of the systematic monitoring set up by GCOS have often been applied directly or indirectly in Swedish systematic observations. Uninterrupted station operations and observing systems should be maintained. Due to practical reasons some stations at remote locations are transformed from manned stations to automatic ones. As regards the most important climate stations, Sweden is handling this automation with the utmost carefulness.

Sweden has as regards meteorological observations, realised a rapid change to more automatic techniques. The network of SYNOP-stations has been reduced from around 100 to 20 during the last decade. And currently there is a process to automize the remaining manual stations. This also includes the GSN stations. The radiosounding stations are modern autosond stations. Most of these developments satisfy the new climate monitoring needs.

In the current development of a modern observation system in Sweden, an important aspect is to create synergism between meteorological, hydrological, oceanographic, climate and environmental systems. This can reduce costs in early investments as well in maintenance. The old datasets are of very great importance for the deeper understanding of climate and its variability. The importance of these has grown as a result of improved methods to assimilate digitised data in new reanalysis schemes with the integration of different datasets representing a multitude of variables. SMHI has a continuous work with digitising older data sets. SMHI will continue to search for relevant information to be digitised.

Referring again to SMHI as primary contributor of climate data in Sweden; As a result of efforts on national (National Data Strategy), European (GMES, INSPIRE, EUMETNET, EuroGOOS) and global scale (World Climate Data and Monitoring Programme (WCDMP), GEO/GEOSS Web Portal and Clearinghouse) as regards data archives and access to data there are projects ongoing and planned in order to build new structures with new portals, improved set of meta data and enhanced way to provide access to climate data, site specific as well as gridded or other spatial data.

There are Swedish activities and plans to archive and provide enhanced access to climate data from research programmes (IPY included). From the wide variety of research data there will be assessment of quality and also an evaluation of research stations set up whether these can be included in sustained climate observation networks.

Sweden is furthermore planning a BSRN station. The main objective is to provide the necessary facility for high quality long-term radiation and energy balance measurements **above boreal forest**. The special equipments at the Svartberget Experimental Forest encourage exploring the radiation conditions above forest. The advanced instrumentation at the planned BSRN provides unique possibilities to perform highly important and combined ecological, meteorological and climatological research related to boreal forests.

1.3 Capacity-building in least developed countries, small islands developing States and countries with economies in transition

The contribution from Sweden in the field of capacity-building is very little focussed towards direct observations and ECV. Since 2006, the Department of Meteorological and Hydrological Services (DMS) and the Swedish Meteorological and Hydrological Institute (SMHI) have been working together to improve the capacity of DMS to provide national weather services in Botswana. Inventories and analyses of current operations and facilities, including technical infrastructure (including automatic weather stations) and routine, have been made.

Sweden is furthermore developed training programme that are concentrated on knowledge and services. One important objective as regards capacity-building in the third world is to increase the knowledge about climate change and its consequences. An aim is to provide methods for identification of vulnerable sectors in society, both in a national and an international perspective. Adjustment to the future climate by society and plans of actions to counteract climate changes is also an important part of course programmes. One programme contains a 4-week training course in Sweden and a follow-up seminar in Asia, Latin America or Africa. The Swedish view is that this is especially important politically and seen from society in the developing world, also implicitly in order to recognize observation in a holistic concept. Thus this form of training is thus a way to prepare for undertakings in GCOS and in regional and national climate observation strategies.

1.4 Report on initiatives undertaken to acquire palaeoclimate data

Sweden participates[1] in APEX - Arctic Palaeoclimate and its Extremes. This is a research programme aiming at understanding Arctic climatic changes beyond instrumental records. It is an interdisciplinary programme that integrates marine and terrestrial science and utilises modelling and field observations. APEX involves scientists from 15 European countries, Canada and USA and is one of the coordinating programmes for palaeoclimate research during the International Polar Year (IPY) 2007/2008. APEX is endorsed by the International Arctic Science Committee (IASC).

2 Atmospheric ECV

2.1 Atmospheric ECV - Surface

Sweden has six official GSN stations (Figure 1) that collectively should represent the temperature and precipitation variability of the country. In addition to these, eight stations are reported in the same way to the National Climate Data Centre (NCDC) in Asheville, USA.

There is today and will be during the coming decade a transition from manual stations to automatic stations. Recently Sweden has reported that two stations have been replaced, Gotska Sandön and Holmögadd that has been moved to Holmön. This transition is due to the fact that it is difficult or impossible to keep remote and isolated places manned when automatic techniques are available. The manual observations have often been carried out together with other duties at lighthouses or other now automated functions.

Five principle GSN stations and at least six additional should continue to operate through 2010. If a new automatic station is established, it is an ambition to have parallel data series and as equal environmental conditions as possible at the new station.

As regards the WWW/GOS stations the transition from manual to automatic weather stations has also resulted in a higher temporal resolution including the precipitation measurements. For national climate analyses there is the special climate network where stations are reporting more frequently in order to support hydrologic requirements. The weather radar network has a gradually more important role for the climate monitoring.

Of the totally 100 upper air stations around the globe dedicated for GUAN no Swedish station is included in this network. The number of soundings from the four aerologic stations has been somewhat reduced in parallel with the upgrading of the upper air measurements from AMDAR.

As regards Global Atmospheric Watch – GAW - data are reported from 14 stations to the World Radiation Data Centre (WRDC) in St. Petersburg under GAW. This network has been upgraded and the number of stations has increased from earlier 11.

Ozone data have been collected at Vindeln and Norrköping since 1991 and 1988 respectively. These stations are within the World Ozone Observing System under GAW. Data are reported regularly to World Ozone and UV-radiation Data Centre in Toronto.

[1] Stockholm University, Department of Geology and Geochemistry

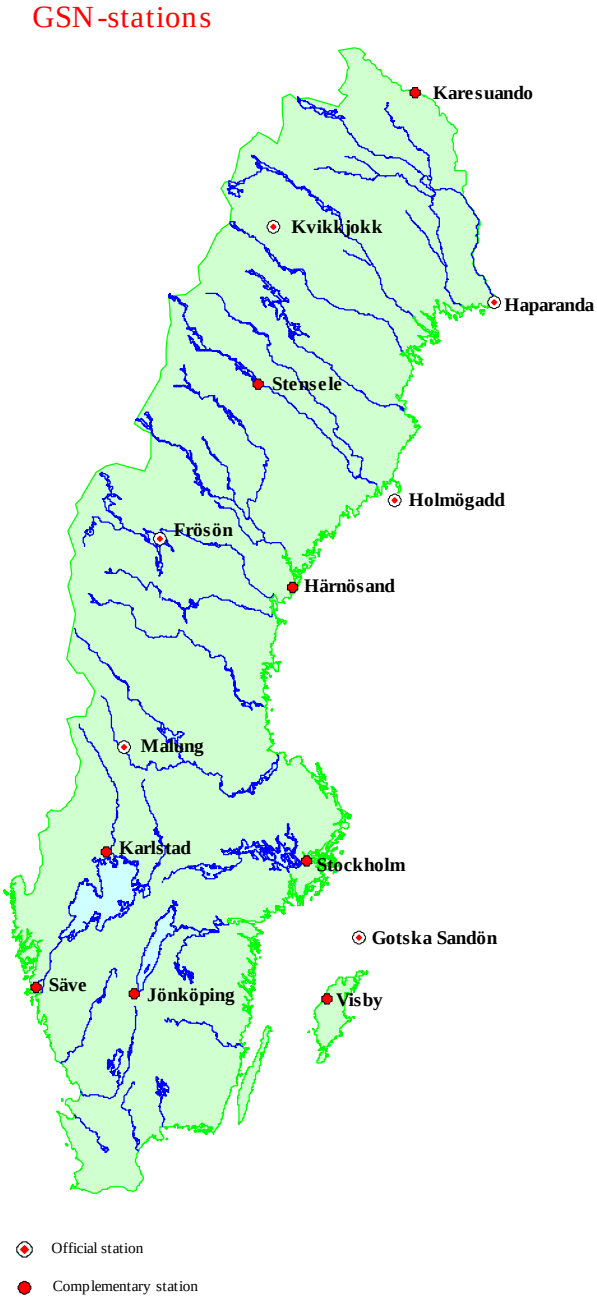

Figure1. Location of the Swedish GSN station, six official stations and eight complementary reported in the same way as the official ones. The station Holmögadd is now replaced by Holmön, an inhabited island just north of the Holmögadd lighthouse island.

Table 1a. National contributions to the surface-based atmospheric essential climate variables

Contributing networks specified in the GCOS implementation plan	ECVsa	Number of stations or platf-orms 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 internatio-nal data centres	Number of stations or platforms with complete historical record available in international data centres
GCOS Surface Network (GSN)	Air temperature	6 (14)	6 (14)	5 (11)	6 (14)	14
	Precipitation	6 (14)	6 (14)	5 (11)	6 (14)	14
Full World Weather Watch/Global Observing System (WWW/GOS) surface network	Air temperature, air pressure, wind speed and direction, water vapour	RBSN 45 + 151 =196	0[2]	200	196	Not known
	Precipitation	130	0	135	130	Not known
Baseline Surface Radiation Network (BSRN)	Surface radiation	0	0	1	0	0
Solar radiation and radiation balance data	Surface radiation	14 (global radiation) 5 (long wave r.)	14	14	12	0
Ocean drifting buoys	Air temperature, air pressure	0				
Moored buoys	Air temperature, air pressure					
Voluntary Observing Ship Climate Project (VOSClim)	Air temperature, air pressure, wind speed and direction, water vapour					
Ocean Reference Mooring Network and sites on small isolated islands	Air temperature, wind speed and direction, air pressure	1[3]				
	Precipitation	1				

[2] Although this network basically was built for real-time weather analyses it also at the same time contributes to climate monitoring. GCMPs are not fully satisfied for any of these stations.
[3] The GSN station Gotska Sandön

Table 1b. National contributions to the upper-air atmospheric essential climate variables

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-airtemperature, upper-air wind speed and direction, upper-air water vapour	0	0	0	0	0
Full WWW/GOS Upper Air Network	Upper-airtemperature, [4]upper-air wind speed and direction, upper-air water vapour	4	4	4	4	4

Table 1c. National contributions to the atmospheric composition

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 Atmosphere Watch (WMO/GAW) Global Atmospheric CO2 & CH4 Monitoring Network	Carbon dioxide	0	0	0	0	0
	Methane	0	0	0	0	0
	Other greenhouse gases	0	0	?	0	0
WMO/GAW ozone sonde networka	Ozone	0	0	0	0	0
WMO/GAW column ozone networkb	Ozone	2	2	2	2	2
WMO/GAW Aerosol Networkc	Aerosol optical depth	3	3	3	3	3
	Other aerosol properties	1	1	1	1	1

[4] Sweden has a very active contribution through EUMETNET programmes (EUCOS/E-AMDAR&E-ASAP, etc.)

2.2 Satellite observations as base for atmosphere related ECV observations

Sweden is member state in ECMWF, EUMETSAT and ESA. Especially through ECMWF and EUMETSAT Sweden takes functional part in activities related to the utilization of satellite data in analyses related to ECVs and climate monitoring. The table below is indicating **in blue** areas where the Swedish participation is more significant.

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 reanalysis	Passive microwave radiances and scatterometry
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, temperature analyses obtained from reanalyses	Passive microwave radiances, GPS radio occultation, high-spectral resolution IR radiances for use in reanalysis
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 6.7um band, microwave soundings in the 183 GHz band
Cloud properties Cloud radiative properties (initially key ISCCP products) **EUMETSAT CM SAF**[5]	VIS/IR imagery, IR and microwave soundings
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)
Earth radiation budget Top-of-atmosphere Earth radiation budget on a continuous basis **EUMETSAT CM SAF**[4]	Broadband radiances, spectrally-resolved solar irradiances, geostationary multi spectral imagery
Ozone Profiles and total column of ozone **Odin satellite programmes/projects**[6]	UV/VIS and IR microwave radiances
Aerosol properties Aerosol optical depth and other aerosol properties	VIS/NIR/SWIR radiances
Carbon dioxide, methane and other long-lived greenhouse gases Distribution of greenhouse gases, such as CO2 and CH4, of sufficient quality to estimate regional sources and sinks	NIR/IR radiances
Upper-air wind Upper-air wind analyses, particularly from reanalysis	VIS/IR imagery, Doppler wind lidar
Atmospheric reanalyses	Key FCDRs and products identified in this report, and other data of value to the analyses

[5] SMHI

[6] Sweden, Finland, France, ESA: In Sweden participation by the Swedish National Space Board, Chalmers University of Technology and Stockholm University; Meteorological Institution.

3 Oceanic ECV[7]

SMHI provides in Sweden the secretariat for the national involvement in the Intergovernmental Oceanographic Commission (IOC) and represents Sweden in the World Meteorological Organisation (WMO) and as well in the JCOMM, the WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology. This is an intergovernmental body of experts, which provides the international, intergovernmental coordination, regulation and management mechanism for an operational oceanographic and marine meteorological observing, data management and services system.

SMHI has a responsibility for the National Oceanographic Data Centre within the IOC's International Oceanographic Data and Information Exchange (IODE) network. One of the main objectives is here to participate and contribute in questions related to the development of Global Ocean Observation System (GOOS). SMHI is also member of the European component of the Global Ocean Observing System, EuroGOOS[8] and its secretariat is located at SMHI, and the Baltic Operational Oceanographic System, BOOS and North West Shelf Operational Oceanographic System, NOOS, in order to work with similar and GOOS-related issues on a regional and a sub-regional/national scale.

Sweden (SMHI) has the latest years participated in several projects with objectives to better include oceanic observation system in requested international and sustained networks also with the aim to support the GCOS Implementation Plan and its ECVs. SEPRISE[9] is one example preparing for a European Marine Core Service, MCS, under GMES.

3.1 Oceanic ECV- Surface

Table 3a. National contributions to the oceanic essential climate variables – 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 5x5 degree resolution	Sea surface temperature, sea level pressure, position-change-based current	0	0	0	0	0
GLOSS Core Sea-level Network	Sea level	**Core 1** Real time19 Non real time 4	1 23	1 23	1 23	1 18-20
Voluntary observing ships (VOS)	All feasible surface ECVs	35[10]	30-40	25-30	All on GTS and from there harvested to archives	-
Ship of Opportunity Programme	All feasible surface ECVs	0	0	0	0	0

[7] More information on IOC: http://ioc.unesco.org/GOOS/MS/rpts/Sweden_GOOS_2004.doc

[8] http://www.eurogoos.org/

[9] SEPRIS: Sustained, Efficient Production of Required information Services (http://www.seprise.eu)

[10] The number has been up to 44. The ambition is to increase the number but the Swedish fleet is decreasing and partly put up for sale on an international market.

Table 3b. National contributions to the oceanic essential climate variables – 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	0				
Global tropical moored buoy network	All feasible surface and subsurface ECVs	0				
Argo network	Temperature, salinity, current	0				
Carbon inventory survey lines	Temperature, salinity, ocean tracers, biogeochemistry variables	0				

3.2 Satellite observations as base for oceanic ECV observations.

Sweden is member state in EUMETSAT and ESA. Especially through EUMETSAT Sweden takes functional part in activities related to the utilization of satellite data in analyses related to ECVs and climate monitoring (EUMETSAT O&SI SAF). The table below is indicating **in blue** areas where the Swedish participation is more significant.

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 **EUMETSAT O&SI SAF and national contribution for the Baltic Sea**[11]	Microwave and visible imagery
Sea Level Sea level and variability of its global mean **Sweden participates in the Jason 2 Optional Programme (EUMETSAT)**	Altimetry
Sea Surface Temperature Sea surface temperature	Single and multi-view IR and microwave imagery
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 measurement 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

[11] SMHI

4 Terrestrial ECV

The terrestrial observation system is not as well established as the atmospheric or the oceanographic one. The reason is that most of the terrestrial observations are not part of international observation routines with a regular/daily exchange of data.

Sweden is reporting to the Global Runoff Data Centre (GRDC), based at the Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology, BfG) in Koblenz, Germany, and operating under the auspices of the World Meteorological Organization (WMO) participates in GTN-H covering the variable river discharge. GTN-R is a GRDC contribution to the Implementation Plan for the Global Observing System for Climate and to GTN-H. Sweden is reporting 38 stations. An increase from 25 to 38 was decided 2005.

The Department of Physical Geography and Quaternary Geology at Stockholm University has monitored the glacier Storglaciären that is situated close to the highest Swedish peak Kebnekaise in northern Sweden. The monitoring has been performed annually since 1945 and includes glacial front, mass and energy balance and run off physical parameters. The purpose of the monitoring is a better understanding of the dynamics of glaciers typical for the Scandinavian mountain ranges and to understand the climate impact on glaciers.

Scandinavia was entirely covered under ice during the last ice age. Sweden has records of the extent of the glacier fronts with high accuracy from about 12,000 years ago to the present.

Riksskogstaxeringen (National Forest Inventory, NFI) is a national regularly recurring inventory of the Swedish forested areas. One of the aims of the inventory is to quantify growth (biomass change) of the Swedish forests. Presently there are about 25,000 areas that are revisited at regular intervals of about 10 years. The inventory programme started in 1923. Since 1983 a programme with fixed plots has been run to improve the homogeneity of the series. The Swedish NFI also to some extent covers the systems of Land cover and of Vegetation type. The Department of Forest Resource Management is currently developing inventory methods based on the use of satellite imagery and field data, combined in a cost efficient way. The use of satellite imagery in the Swedish NFI gives new opportunities for the presentation of the results for small regions. The aim is to make it possible to present certain results for considerably smaller regions than today and, in addition, in an area covering way. To start with, a method for estimating state attributes (growing stock, for example) will be introduced in the NFI.

Table 5. National contributions to the terrestrial domain essential climate variables

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	38	38	38	38	38
GCOS Baseline Lake Level/ Area/Temperature Network (GTN-L)	Lake level/area/ temperature					
WWW/GOS synoptic network	Snow cover					
Contributing networks specified in the GCOS	Glaciers mass balance and length, also					

implementation plan	ice sheet mass					
GCOS glacier monitoring network (GTN-G)	balance					
GCOS permafrost monitoring network (GTN-P)	Permafrost borehole-temperatures and activelayer thickness					

Table 6. Global products requiring satellite observations – terrestrial

Sweden is member state in ECMWF, EUMETSAT and ESA. Especially through ECMWF (satellite dataassimilation of soil moisture in global models) and EUMETSAT (Land Monitoring SAF, Hydrology SAF) Sweden takes functional part in activities related to the utilization of satellite data in analyses related to ECVs and climate monitoring. The table below is indicating **in blue** areas where the Swedish participation is more significant.

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, 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
Snow cover Snow areal extent	Moderate-resolution VIS/NIR/IR and passive microwave imagery
Albedo Directional hemispherical (black sky) albedo	Multispectral and broadband imagery
ECVs/ Global products requiring satellite observations	**Fundamental climate data records required for product generation (from past, current and future missions)**
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 multispectral VIS/NIR imagery, high-resolution multispectral VIS/NIR imagery
fAPAR Maps of fAPAR	VIS/NIR imagery
LAI Maps of LAI	VIS/NIR imagery
Biomass Research towards global, above ground forest biomass and forest biomass change **Work going on** [12]	L band/P band SAR, Laser altimetry
Fire disturbance Burnt area, supplemented by active fire maps and fire radiated power	VIS/NIR/SWIR/TIR moderate-resolution multispectral imagery
Soil moisture Research towards global near-surface soil moisture map (up to 10 cm soil depth)	Active and passive microwave

[12] Swedish Defence Research Agency (FOI), supported by Swedish University of Agricultural Sciences in Umeå (SLU) and Chalmers University.

5 Additional Information

Sweden provided to the UNFCCC 2005 a detailed report using the same format as the for the National Communication 2001. This report provides a much more detailed insight in Swedish activities as regards observations and archiving of climate variables, those of high quality and recognized as ECV and also climate variables that provide the full picture of extremes and spatial variations.

5.1 The completeness and the completing of GCOS

The GCOS is now about fifteen years old. We can not expect that the system should be complete and it will never be complete. However, the GCOS should ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users.

GCOS is intended to be a long-term, user-driven operational system. It should also be capable of providing the comprehensive observations required for monitoring the climate system, for detecting and attributing climate change, for assessing the impacts of climate variability and change, and for supporting research toward improved understanding, modelling and prediction of the climate system. It addresses the total climate system including physical, chemical and biological properties as well as atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes.

This means that GCOS objectives address goals at some level as geographic completeness, completeness in time and completeness in disciplines (physical, chemical and biological). These three dimensions are needed and an awareness of the needs in the whole chain of processes to provide diagnoses for IPCC and for other political and societal planning.

An obvious question that immediately could be raised is; Is the globe covered by relevant data? The answer is certainly - no. The result of the UNFCCC compilations and syntheses of national reports will certainly again and again inform that there are enormous global **in**-homogeneities.

Furthermore as regards downscaling into a European scale there are other needs then the global. There is a need to improve the understanding and see the variety on smaller scales (time, space, intensity) also reflecting the need to study societal impacts on the European scale and their coupling to climate variability. There are also national interests to see an even higher resolution, for impact studies and also in the broader concept, to understand the coupling between smaller and larger scales and through this understanding develop different aspects of parameterisation.

In the view of in-homogeneity in GCOS databases over the world, networked and potentially networked databases, we find it important to **develop criteria** for the expansion and the completing (and perhaps also deleting) of data sets. What are the criteria for the data selection to the global, the regional and the national GCOS-databases? Motivated criteria are also needed to provide justification for the national and international funding.

5.2 Re-analyses using consistent assimilation systems – a way to define the black holes in current and future GCOS

In the GCOS Implementation plan the word reanalysis is used 66 times. Data sets provided by reanalysis programmes are fundamental for the understanding of important couplings; in space, in time, between variables – within and between disciplines. The data sets from reanalyses provide trends and are furthermore fundamental for the validation of GCMs and RCMs. The reanalysis programme themselves stimulates the establishment of databases, networks and portals combining databases.

Decision makers of different kind as well as the research community - realizing that observations and measurements prove useful, are integrated in highly developed decision-making-systems based on reanalyses and climate models - have to realize the advantage of these systems and the added value provided by these in order to have the political incentive to support new national investments related to the GCOS, and seen from Europe, the motive for investments in other parts of the globe or investments in enhanced space technique.

The vision for the future, also the far future that has to be considered within GCOS, should be that models step be step will have an evolution into broader and more sophisticated couplings. These

couplings will incorporate more or less all variables that are steered by natural laws and anthropogenic sources thus addressing the total climate system including physical, chemical and biological processes.

With this view, an obvious criteria for the selection of GCOS data is the requests for the future advanced reanalysis programmes (global, regional, perhaps special for identified GWEX areas, the Arctic region, etc.). We have to go back and identify what is recorded in the past and put those data in a digestible form. Hitherto the reanalyses have encompassed mainly the atmosphere and ocean data, in other words archived WWW data including its satellite component and GOOS data while GTOS data are somewhat still outside the scope. It is the feeling in Sweden that the requirements on GTOS are the least identified. In this domain also a wide set of national authorities are involved with loose relations to the climate and the GCOS issue. With a strategic and also far-sighted reanalysis and model-thinking, taking into account advanced biological and terrestrial processes, the GTOS requirements as well as the whole set of GCOS ECVs could be even more prioritised nationally and internationally. The GMES and GEOSS concept and realisation could by a catalyst in that process, the reanalysis aspect in the GCOS Implementation Plan can be a reality and observations strategies could come into a holistic perception.

5.3 GMES and GEOSS

A detailed understanding of climate change and its impact, right down to the sub-regional scale, can only be achieved through coordinated action based on:

- **climate observation**, using both satellites and other methods, in order to establish or consolidate the series of climate data necessary for clearly revealing climate change in progress, in particular by characterising changes in extremes (which are crucial for analysing impacts, and also to provide scientists with the knowledge and data needed to enhance existing climate change models).

- **numerical simulations of climate change**, which will have to achieve resolutions of around one kilometre, both to reduce uncertainties surrounding certain extreme phenomena (such as hurricanes and flash floods) and to be capable of dealing with regional and sub-regional scales. This advance requires a computing capability that is not yet available to European climatologists;

- a **European system** which provides the scientific community with homogeneous series of climate observation data, and regional and sub-regional climate change simulations obtained in Europe. This system should also enable these to be fully exploited - in a scientifically-controlled framework such as the IPCC - so that impact assessments can be carried out on the safety of people and property, or on the economy and society.

In one of the developing GMES services, the Atmosphere Service (GAS or GMES Atmosphere Core Service, GACS) there are two major themes:

1. Climate forcing (CF);
2. Air quality (AQ);

The AQ and CF components of the GACS should be considered first priority, due to their relevance to many different kinds and types of users, their estimated uptake by downstream users (especially AQ) and the high relevance to policy and research (especially CF). To fulfil its role regarding the monitoring of atmospheric chemistry/composition, observational data (space & in situ) from the themes **AQ, CF and stratospheric ozone are essential**. For stratospheric O_3, current efforts of collecting relevant observations are quite substantial already (→ IGACO report[13]), but there is a risk of degradation of the existing infrastructure due to lack of sustainable funding.

The **provision of GCOS essential climate variables (ECVs)** should be regarded as a priority for the atmosphere service and thus a main driver for the **climate forcing** service theme to be provided. The current situation in Europe is as follows:

- Surface ECVs: Many centres already do this and meet user requirements, e.g. gridded monthly, seasonal and annual averages.
- Upper-air ECVs: Temperature, wind and radiation budget are already available from different providers. Access and user specification may need improvement.

[13] www.wmo.int/pages/prog/arep/gaw/documents/gaw159.pdf

- Composition ECVs: There is a clear user requirement to do more than currently exists, especially with regard to gridded information.

For environmental policies, the **establishment of trends** based on long-term data is extremely relevant: For this purpose, high precision data with regard to space and time over long periods of time (several decades) is needed. Whilst a number of databases with observational data already exist, their specific objectives and/or limited access show significant potential for the Core Service to add value. CS should ensure proper archiving and effective access to the core data/information as identified by users.

Besides its monitoring capabilities, the GAS CS should also have **forecasting and predictive** as well as **analysis capabilities.** The added value and the value for money should be in providing new common services and products with at least EU-wide coverage that support a range of policies across several sectors including climate change mitigation and adaptation.As regards the priorities, addressing gaps in the information on atmospheric chemistry/composition **should be regarded as an initial priority.** The joint, proficient use of satellite and in situ data should be put to good use to address this priority. Example of objectives are confirmation of anthropogenic emissions (based on inverse modelling and satellite data) in MS as well as at global level (rapidly evolving economies) as well as the identification of sinks and clarification of the contribution of emission sources (e.g. agriculture emissions of methane, NOx and N2O and forests emissions of VOCs, GHG, fires/sand-dust storms).

Some other remarks:
The theme CF should have an initial focus on **gridded data** for atmospheric composition, in addition to relevant observational data such as that derived through the in situ measurement infrastructure. The GACS evolution process may include a move from providing GCOS atmospheric ECVs on composition towards a provision of all GCOS ECVs, with contributions from the marine and land CS.

As regards reanalysis: A focus of going back further in time (up to 1930, 40 with CC data), achieving better resolution & **coupling upper air with ocean/land state parameters, using a multi-model approach with improved (and 4D) modelling capacities now available in order to provide better information** – as compared to existing efforts such as ERA-40 – is clearly useful to climate modelling, but also for air quality and related fields.

There are obvious advantages to including reanalysis work within a GACS and providing such an exercise at regular intervals, rather than depending on research funding outside of the operational service[14]. The often mentioned reanalysis in the GCOS Implementation Plan could be realized and be the drive in a realizing of the plan and its practical influence.

The GMES concept with its new incentives as regards observations from space and surface and enhanced services is intended to be one of the most important European contributions to GEO/GEOSS. The building up of new European services will create a mutual impact on global developments between GCOS and GEOSS. An enhanced focus on climate change within GMES will gradually strengthen the relation between the GEOSS 10-year Implementation Plan and the GCOS Implementation Plan[15].

References:

SMHI 2005: Report to the UNFCCC regarding Sweden's participation in Global Climate Observing Systems (GCOS) and on systematic observation in Sweden.

[14] Large-scale re-analysis for climate purposes may become part of the GACS Core Service. Alternatively, funding for such efforts needs to come from R&D framework programmes. Reanalysis may be even more important due to larger number of pollutants/measurement methods/siting criteria which provide further challenges in ensuring a coherent picture and establish reliable long-term trends.
[15] http://www.wmo.ch/pages/prog/gcos/index.php?name=geoss

Appendix 1

Essential climate variables

Table 7. Essential climate variables that can be feasibly measured globally and are highly relevant to the Convention

Domain	Essential climate variables
Atmospheric (over land, sea and ice)	**Surface**: Air temperature, precipitation, air pressure, surface radiation budget, wind speed and direction, water vapour **Upper-air**: Earth radiation budget (including solar irradiance), upper-air temperature (including MSU radiances), wind speed and direction, water vapour, cloud properties **Composition:** Carbon dioxide, methane, ozone, other long-lived greenhouse gases,a aerosol properties
Oceanic	**Surface:** Sea surface temperature, sea surface salinity, sea level, sea state, sea ice, current, ocean colour (for biological activity), carbon dioxide partial pressure **Sub-surface:** Temperature, salinity, current, nutrients, carbon, ocean tracers, phytoplankton
Terrestrialb	River discharge, water use, groundwater, lake levels, snow cover, glaciers and ice caps, permafrost and seasonally-frozen ground, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation (fAPAR), leaf area index (LAI), biomass, fire disturbance