SEVENTH FRAMEWORK PROGRAMME

THEME 9 “SPACE”

Grant agreement for: Collaborative project
(small-medium scale focused research project)

Annex I – “Description of Work”

Project acronym: EURO4M

Project full title: European Reanalysis and Observations for Monitoring

Grant agreement no.: 242093

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List of Beneficiaries

No.	Name	Short name	Country	Enter project	Exit project
1	Royal Netherlands Meteorological Institute	KNMI	Netherlands	Month 1	Month 48
2	Met Office	MO	United Kingdom	Month 1	Month 48
3	University Rovira i Virgili	URV	Spain	Month 1	Month 48
4	National Meteorological Administration	NMA-RO	Romania	Month 1	Month 48
5	Meteo Swiss	MS	Switzerland	Month 1	Month 48
6	Deutscher Wetterdienst	DWD	Germany	Month 1	Month 48
7	Swedish Meteorological and Hydrological Institute	SMHI	Sweden	Month 1	Month 48
8	University of East Anglia (Climatic Research Unit)	UEA	United Kingdom	Month 1	Month 48
9	Météo France	MF	France	Month 1	Month 48

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B.1. Concept and objectives, progress beyond the state-of-the-art, S/T methodology and work plan

B.1.1 Concept and objective(s)

Concept

As the primary source of timely, targeted and reliable information about the state of the climate in Europe, the suggested collaborative project is an important building block for the Global Monitoring for Environment and Security (GMES) initiative. No other coordinated contribution for this area exists or is currently planned within GMES. The current GMES services, which have already entered into their pre-operational phase, are not designed to provide climate change monitoring information nor reports about high impact weather and climate extremes placed in an historical context. For example, the Atmosphere service is mainly directed towards air quality and focuses on the shorter time scales. Also, the *in situ* component of GMES at present does not fully address meteorological observations. The coordination action for *in situ* data indicated in the Work Programme (p30) alone will not result in comprehensive pan-European climate datasets at a useful level of aggregation and processing.

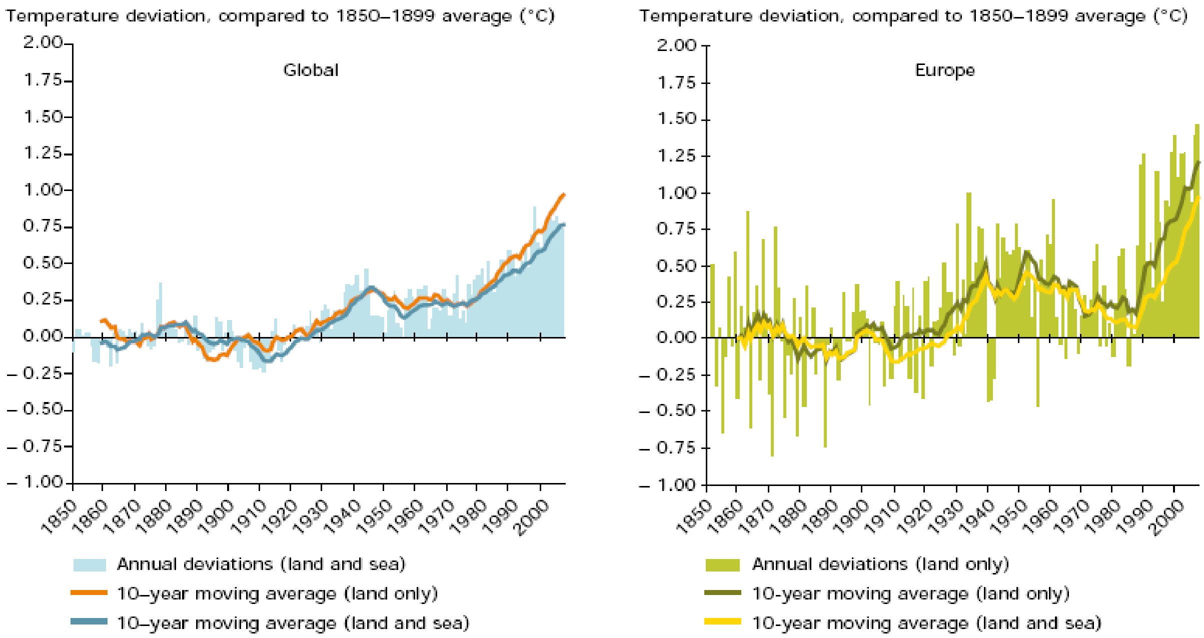

Figure B.1.1a. Observed global and European annual average temperature deviations, 1850-2007 (EEA-JRC-WHO, 2008; Figure B.5.2). The figure indicates that Europe warms more rapidly than the globe (+0.74°C over the last 100 years). The annual deviations are relative to the period 1850-1899 to better monitor the EU objective not to exceed 2 °C above pre-industrial values. Over Europe average annual temperatures during the real pre-industrial period (1750–1799) were very similar to those during 1850–1899. Source: UEA/Climate Research Unit (www.cru.uea.ac.uk/cru/data/temperature/).

Climate change is the societal benefit area of the Group on Earth Observations (GEO; see Appendix A for a list of acronyms) that lacks, and urgently needs, an integrated and coordinated approach with a focus, in particular, on climate information for the multi-decadal time scales that are most relevant for adaptation. The other societal benefit areas (water, natural and human-induced disasters, environment and health, energy, ecosystem services, agriculture and desertification, biodiversity) are already reasonably well covered in the existing data information systems, such as the European Environment Information and Observation NETwork (EIONET) and the Shared Environmental Information System (SEIS). Integrated long-term and high-quality datasets of climate change information (in particular extremes) in terms of atmospheric Essential Climate Variables (ECVs) are typically missing (see dataservice.eea.europa.eu).

This situation is limiting the response strategies to adapt to climate variability and change at the regional, sub-regional and national scales. In particular, information on changes in weather and climate extremes is crucial, especially as the driving force for the impact work in all GMES services and GEO areas. If the relevant climate change information is not made available, then these services and areas will not be able to be successful. Due to a lack of coherent information on weather and climate extremes many GMES services and GEO areas base their work on changes in mean climate only. However, it is generally accepted that the impacts of climate change are caused primarily by changes in variability and extremes, rather than changes in the mean climate. For adaptation strategies, the longer (multi-decadal) time scales are particularly relevant, because nearly all infrastructure design relies on assessment of probabilities of extremes with return periods of ≥ 50 years. These assessments should take into account that the climate is non stationary because of climate change. It is the longer time scale that is needed for governments to implement their climate change action plans.

The members of this project's consortium are currently the main source of climate change time series and monitoring information for governments, policy-makers and the general public across Europe. They are frequently approached by the European Environment Agency (EEA), Joint Research Centre (JRC), World Meteorological Organization (WMO) and World Health Organization (WHO) to contribute this information to environmental assessment reports. The EURO4M beneficiaries **MO** and **UEA** collectively provide information on European temperature change over the past decades based on their global datasets (Figure B.1.1a), which are also prime inputs to the reports of the Intergovernmental Panel on Climate Change (IPCC) and to the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). **KNMI** contributes up-to-date information about trends in extremes (Figure B.1.1b) by linking the historical data archives of more than 40 meteorological services and universities in Europe through the European Climate Assessment & Dataset project (ECA&D; a forthcoming WMO Regional Climate Centre). **DWD** operates the Global Precipitation Climatology Centre (GPCC), which provides global analysis of precipitation on the earth's land surface based on *in situ* rain gauge data.

All these activities have an *ad hoc* character and limited spatial (horizontal and vertical) resolution for the longer time scales. Also, the potential of data assimilation and reanalysis for climate change monitoring are not yet fully exploited. **MO**, **SMHI** and **MF** are at the forefront of data assimilation developments in Europe, but no regional reanalysis for Europe is currently available that improves on the existing global reanalyses (particularly ERA-40 at the European Centre for Medium-Range Weather Forecasts ECMWF). **URV**, **NMA-RO** and **MS** have contributed significantly to improved observational datasets for sub-regions, but these activities have not yet been integrated within the European context. **DWD** coordinates the Satellite Application Facility on Climate Monitoring (CM-SAF) of EUMETSAT, which aims at the provision of satellite-derived geophysical parameter datasets suitable for climate monitoring. These datasets need integration too.

In summary, for GMES to become a success, the situation of fragmentation and scarcity of long-term climate change monitoring information in Europe needs to change. There is the vast task of integrating national observing systems, existing global and European observation datasets, satellite-derived datasets and reanalyses into GMES (see Butler, 2007). This is needed to fill the gap for surface climatological data and information which, at present, is clearly visible in all environmental assessments. In the words of our third party participant EEA (see Section B.2.3): “Everybody is expecting that weather and climate data is simply available (according to their experience having weather forecasts for every location on every day), but for historical data on climate extremes this is clearly not the case”.

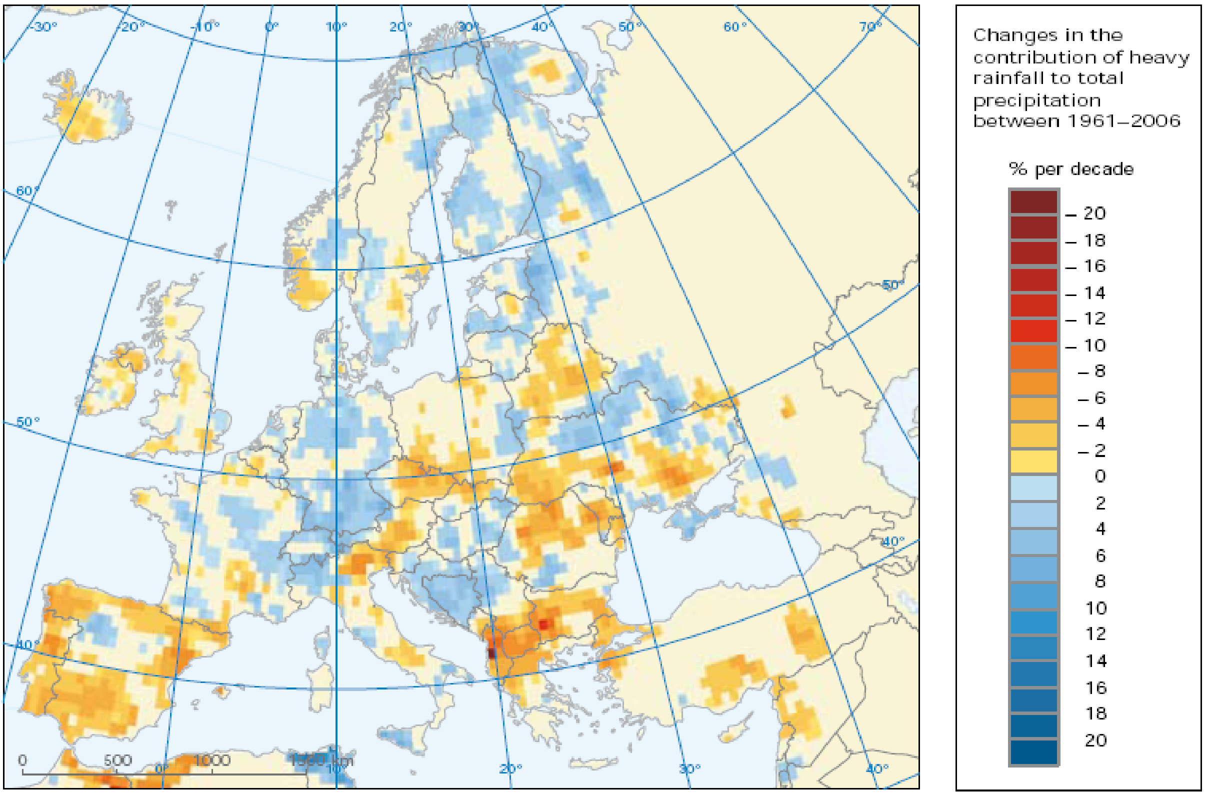

Figure B.1.1b. Changes in the contribution of heavy rainfall to total precipitation 1961-2006 (EEA-JRC-WHO, 2008; Map 5.9). The figure indicates that the proportion of rainfall from heavy falls increases over most areas. Source: The E-OBS dataset from the EU-FP6 project ENSEMBLES (www.ensembles-eu.org) and the data providers in the ECA&D project (eca.knmi.nl).

Objective(s)

The overall goal of EURO4M is to develop the capacity for, and deliver the best possible and most complete (gridded) climate change time series and monitoring services covering all of Europe. These will enable adequate descriptions of the status and evolution of the Earth system components.

Specifically, the objectives of EURO4M are to:

1. **generate time series of observation datasets and reanalyses of past observational data**;
   - build on and integrate existing European *in situ* and satellite datasets, bearing in mind global connectivity, interoperability and data sharing;
   - develop the capacity for climate quality dynamic reanalysis that optimally integrates the widest possible range of *in situ* and satellite data;
   - demonstrate the capability of regional reanalysis and multi-staged downscaling with increased levels of accuracy;
   - deliver demonstration regional reanalysis for parts of the past 20 years;
   - reduce gaps and deficiencies in European monitoring capacity through a better exploitation of existing atmospheric observations and data exchange;
   - build on the strong synergy the beneficiaries have with other major climate monitoring centres worldwide, in particular with centres involved in global reanalysis.
2. **produce innovative and integrated high-quality data products for research and applications sector users**;
   - produce multi-purpose products and information to assist climate change research to incorporate the monitored ECVs;
   - provide reliable, up-to-date scientific input (especially through the IPCC) for the implementation of European and international policies and strategies on the environment and society, including the EU climate adaptation strategy;
   - provide online reporting during emerging extreme events.
3. **reach out with data products and climate change services to the user community, stakeholders, policy-makers, and general public**;
   - demonstrate the climate change services to policy-makers, researchers, planners and citizens at European, national and local levels;
   - hold frequent dialogues and interactions with a wide range of end-users to achieve a better understanding of information needs and formats;
   - make the data and information readily accessible to users with full consideration of the appropriate level of aggregation and standardization.
4. **evolve into a future GMES service on climate change monitoring that is fully complimentary and supporting the existing core services**.
   - integrate and extend core GMES services activities on ECVs, specifically developing the capacity required for user-oriented multi-purpose products for monitoring of climate change;
   - link to existing GMES services, and especially those on marine, land and atmosphere monitoring, which include – or will include in the near future – a global component by design;
   - stimulate the GMES downstream sector;
   - demonstrate and strengthen the European leadership in long-term monitoring of climate change.

These objectives will be achieved over a 4 yr period in 4 major Work Packages (WPs) detailed in Section B.1.3. Together, they comprehensively address the scientific, technical and wider societal and policy objectives of the Sub-activity SPA.2009.1.1.02 "Monitoring of climate change issues (extending core service activities)".

Scope

Variables: EURO4M will focus on atmospheric surface climate (air temperature, sea surface temperature, precipitation, snow cover, air pressure, surface radiation budget, wind speed and direction, water vapour) and upper-air climate (earth radiation budget, upper-air temperature, wind speed and direction, water vapour, cloud properties). These are the majority of the ECVs for the atmosphere defined for the Global Climate Observing System (GCOS) and endorsed by GEO for their System of Systems GEOSS.

Area: EURO4M will cover Europe in its entirety. The extent of the datasets will include Region VI as defined by WMO and Europe as defined by EEA. As an illustration of the typical area that the regional datasets of EURO4M will cover, Figure B.1.1c presents the reanalysis domain of the North Atlantic & European Model (NAE). This includes the whole Mediterranean Sea.

Resolution: EURO4M will provide multi-decadal gridded datasets down to 25 km horizontal resolution (obtained by direct observations) or 3 km horizontal resolution (obtained by regional reanalysis and downscaling).

Period: EURO4M will include the past 20-150 years. The exact period will differ between the various data sources considered (up to 150 years for *in situ* data, 30 years for satellite data, and, at this stage, parts of the last 20 years for the regional reanalysis).

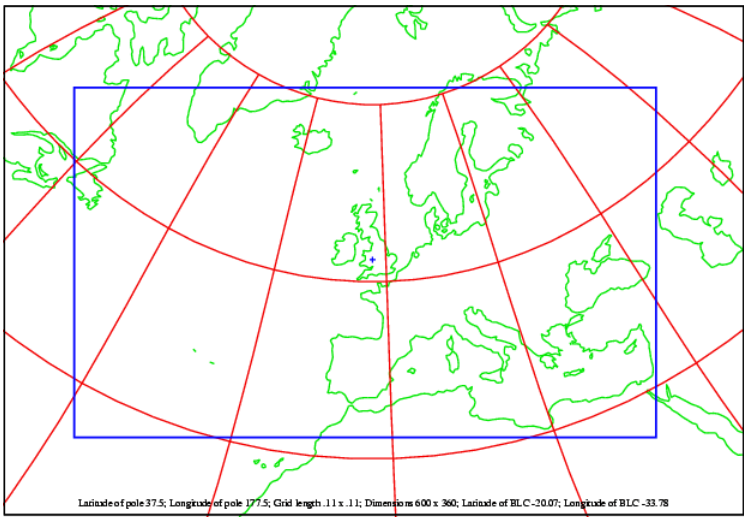

Figure B.1.1c. Domain of the Met Office operational North Atlantic & European (NAE) Model, which has a grid-length of 12km and 38 vertical levels with a top at 39km. In autumn 2009, it will move to 70 levels with a top at 80km.

This selection is a compromise between data availability, computer power, and resources dedicated to the project. It aims at finding the optimum given the current state-of-the-art and the user requirements. A more detailed overview of the variables, area, resolution and period is provided in Table B.1.1a for each individual dataset (referring to the forthcoming sections, in particular the list of deliverables in B.1.3.4 and the work packages descriptions in B.1.3.5).

In line with the GMES goals, EURO4M will not stop when the raw (observation and reanalysis) data have been made available. The project will also engage in developing the multi-purpose products and services at the appropriate level of aggregation and processing to respond to a wide range of users and downstream services. This is implemented through issuing the so-called Climate Indicator Bulletins and establishing the Climate Liaison Team (see below).

Key scientific question

The key scientific question EURO4M addresses is: "**How can we improve monitoring to help us better understand and predict climate change, extremes and weather related hazards, so that society can respond in the best possible way**?"

In order to place recent changes, fluctuations and extremes in their long-term perspective, optimal usage of all conventional (*in situ*) and satellite sources will be required. EURO4M will achieve this by seamless integration of data from the satellite era (back to the 1970s) with early instrumental observations (back to the mid-19th century). A vital approach to integrating these quantities is for EURO4M to explore the use of new regional reanalysis as well as existing global reanalyses, especially ERA-40 (Uppala *et al.*, 2005).

The focus on extremes and weather related hazards requires more detail than is strictly necessary for GCOS global climate monitoring, because as a potential future GMES service on climate change monitoring, we need to fully satisfy the information needs for sub-regional and local adaptation measures. It is at those scales where climate and weather impacts are most strongly experienced. High impact extreme events range from those of short duration (such as heavy rain and associated flooding, and windstorms) to those which extend over several days (heat waves, atmospheric pollution), several months or perhaps even years (drought). They also range from continental-to-local spatial scales.

The science included in EURO4M (in particular in WPs 1 and 2; see Section B.1.3) ensures that the overall goal of developing the capacity for, and delivering the best possible and most complete (gridded) climate change time series and monitoring services for Europe will be achieved at a high scientific level. We combine two different but complementary approaches: regional observation datasets of ECVs on the one hand and model based regional reanalysis on the other. Choosing direct observations alone would have left the potential of data assimilation unexplored; choosing reanalysis only would have run the risk of missing some important aspects in the observations and might have compromised the quality of the final monitoring products and services. We are convinced that integrated climate change monitoring products of state–of–the–art quality are needed, because most of the work in downstream GMES services and GEO areas will be based on this information.

Output datasets	Variables	Area	Spatial resolution	Period
Gridded daily high-resolution dataset (D1.1)	Precipitation	Alpine region	2-5 km	1971-present
GPCC gridded dataset (D1.3)	Precipitation	European window	0.5 degree	1901-2007
E-OBS gridded dataset (D1.4)	Precipitation, Temperature, Snow cover	Europe, incl N. Africa	25 km	1950-present
CRU gridded data products (D1.6)	Potential evapotranspir ation and PDSI	European window	0.5 degree	1901-present
Heliosat gridded dataset (D1.7) based on MVIRI instrument onboard MFG	Surface solar irradiance (SSI), albedo, radiation budget	European window	0.05 degree	1986-2006
Integrated HOAPS/GPCC gridded dataset (D1.8)	Precipitation	European window	0.5 degree	1986-2006
ATOVS gridded dataset (D1.9)	Water vapour	European window	90 km	2004-present
MSG based gridded datasets (D1.10)	Precipitation, SSI, Cloud properties	Europe, incl. N. Africa	5 km	2005-present
Updated and merged station based dataset (D1.12, D1.13)	Pressure, temperature, precipitation	All countries bordering the Mediterran ean Sea	Points	From 1850 onwards
4DVAR-based regional reanalysis (D2.1)	Complete set of variables	NAE-region	12/36 km	1-2 years
3DVAR-based regional reanalysis (D2.3)	Complete set of variables	HIRLAM region	25 km	Most of the past 20 yr period
Downscaled dataset (D2.4)	Set of variables	HIRLAM region	3-12 km	Most of the past 20 yr period

Table B.1.1a. Details of the scope for each data set. Note that the specified resolutions refer to the grid spacing; the effective resolution can be coarser. For the satellite, GPCC and CRU datasets, a European window will be extracted from the available global datasets. The extent of this window will be the same as for the ground based observations and the reanalyses datasets.

Role of reanalysis

A reanalysis of the past atmospheric state can be obtained by combining observational datasets with a comprehensive Numerical Weather Prediction (NWP) model. Using modern data assimilation methods, a complete estimate of the atmospheric state is computed that is both dynamically consistent and optimally close to the observations. The great benefit of a reanalysis is that it provides a complete picture of the atmosphere covering the whole of the three-dimensional domain, also for the ECVs and parameters which are not routinely monitored by observations.

In a reanalysis (or rather re-assimilation) also, the consistency in time is ensured through the forecast model used in the data assimilation cycles. It carries the information from cycle to cycle with dynamical changes in order to give a best background before the observations are analysed. This 4-dimensional dynamical consistency is strong both in 3D and 4D assimilation algorithms. In 4D variational assimilation (4D-VAR) the consistency is even stronger within each time window. The dynamical model trajectory is fitted as closely as possible (as given by model and observation statistics) to all the observations within the time window of 4D-VAR (6-12 hours). It means that also atmospheric tendencies are well assimilated and the resulting analysis fields provide better estimates of moist variables like precipitation rates and cloud cover compared with what 3D methods give.

The availability of forecast model fields in the assimilation cycles provides a whole range of diagnostic quantities like radiative fluxes and accumulated precipitation where there are no observations. The accuracy of these is of course limited by the quality of the forecast model, but by basing reanalysis systems on state-of-the-art operational NWP models, we benefit from past careful validation and model development in the operational centres. Experience from global reanalyses has shown that there is a potential in the use of such model-derived quantities.

The benefit of complete multi-decadal sets of ECV products motivates EEA to investigate the use of reanalysis for future assessment studies and explore possibilities for a regional analysis in Europe (the EURRA project). However, current reanalysis products are not yet reliable enough to satisfy user needs entirely, because the basic raw observations and measurements are not consistently of climate quality. Problems arise partly because the assimilating numerical model is inevitably biased to some degree in its representation of the climate system. If observations are abundant and unbiased, they can correct the biases in background forecasts when assimilated (Simmons *et al.*, 2004). In reality, however, observational coverage varies over time, observations are themselves prone to bias, either instrumental or through not being representative of their wider surroundings, and these observational biases can change over time. This introduces trends and low-frequency variations in analyses that are mixed with the true climatic signals (see Figure B.1.1d). Moreover, the limited spatial resolution of current models that are affordable for global reanalysis inhibits the applicability of products for the study of local climate change and extremes.

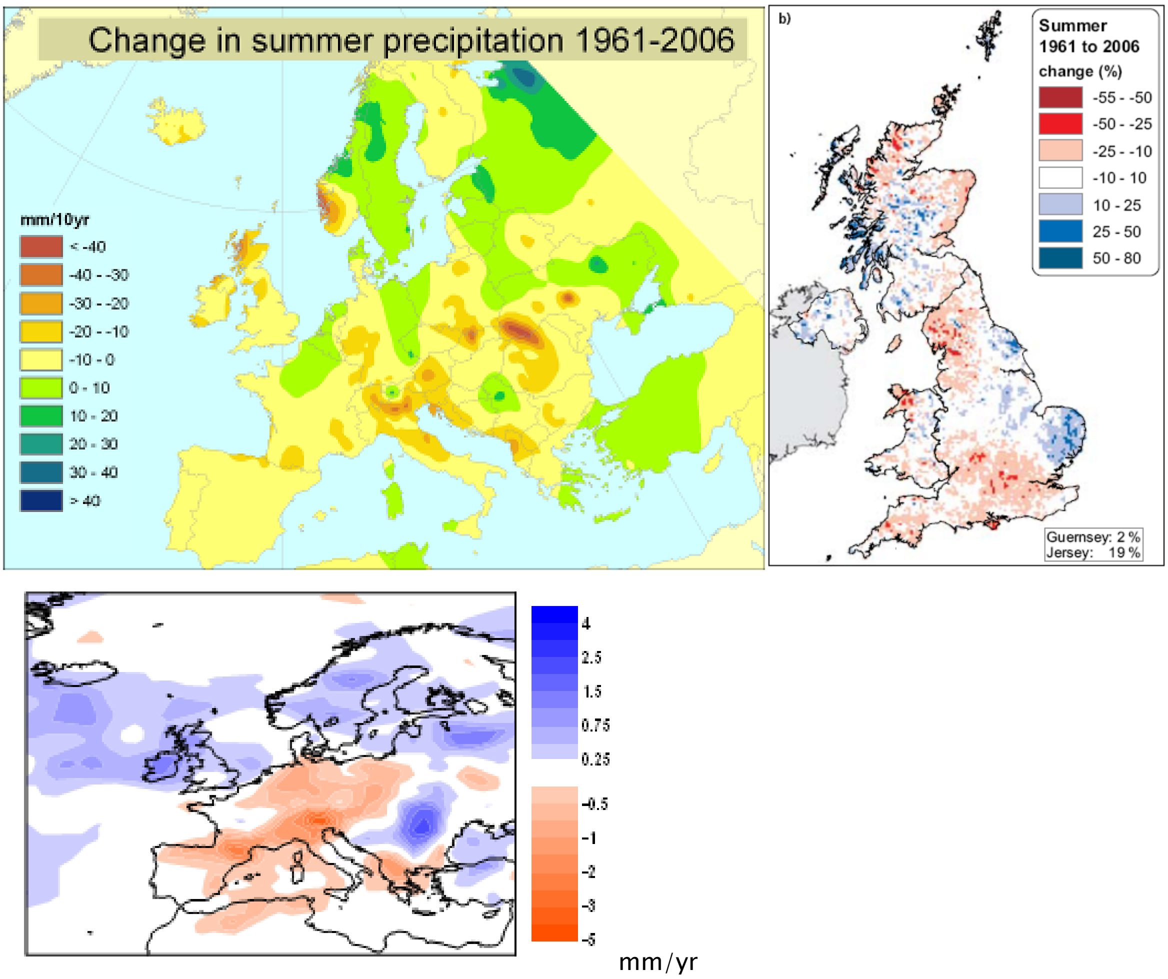

Figure B.1.1d. Changes in summer (JJA) rainfall since 1961 estimated from different sources:
a) the E-Obs dataset based on station observations (see Figure 1.1b);
b) UKCIP08 (Jenkins *et al.*, 2007);
c) ERA-40 reanalysis (ECMWF)
The difference in trends over the UK illustrates the biases in existing global reanalysis products.

Progress in the provision of reanalyses suitable for climate monitoring requires improvements in data assimilation systems, both in assimilating models and the analysis methods used to incorporate observational information, and improved recovery, quality control and bias correction (or homogenization) of past observations. Assessment of existing products through comparison either with high quality regional datasets or alternative global ECV products is a further important activity needed both to guide potential users as to the applicability of the products they are using and to guide where the emphasis needs to be placed for the improvement of the production systems.

EURO4M will enhance the quality of regional reanalysis methods and deliver different levels of advanced regional reanalysis datasets for Europe. Some of these datasets will cover most of the last 20 years, whereas other more advanced systems will be demonstrated for a few years. There will be improvement of data assimilation systems, in resolution, and in the use of precipitation and surface data. Selected products will be evaluated in detail, comparing also with existing products from global reanalyses.

In order to further enhance the horizontal resolution and detailed structures of the regional reanalyses, EURO4M will also perform 2-dimensional downscaling at a considerably higher resolution than is possible with the 3D (or 4D) methods. The 2D analysis methods still combine observations with background fields from the 3D regional system, but the analysis methods are relaxed from fulfilling all the 3-dimensional balance constraints that are required for NWP. In the 2D analyses one employs a lot of regional variation given by observational statistics and by physiographic factors (land-sea and orography, mainly). In this way it is possible to analyse fine scale structures given by observations and closer to the observations than the full 3D systems can do.

We will also prepare bias-adjusted observed data inputs to climate quality reanalyses in close cooperation with ECMWF. We will contribute to the improved capability for reanalysis needed to ensure that the next generation of longer-term global and regional reanalysis is as well prepared as possible to meet the needs of climate monitoring. Our third party participant ECMWF (see Section B.2.3) strongly supports this activity and will collaborate by providing the current ERA-Interim reanalysis, the raw observations and by exchanging ideas on the formats of observation files, monitoring techniques and any other possible commonalities between the regional reanalysis in EURO4M and the global reanalysis.

Role of satellite data and derived products

Satellite-derived products will supplement the reanalysis data and ground measurements. Over the oceans and sparsely populated areas satellite data are often the only data source. The quality of cloud information, the surface radiation budget, water vapour and precipitation can be significantly increased by use of satellite data within the integrated data products. The top of the atmosphere radiation budget can be only observed by satellites.

Satellite products (e.g. water vapour, cloud properties, sea ice and shortwave radiation) together with ground-based measurements will also be used to verify the reanalysis data. Biases in the radiances of satellite sensors, e.g. due to missing inter-calibration, lead to biases or breaks of homogeneity in reanalysis data as the models themselves cannot absolutely correct biases in grossly inhomogeneous input data. Satellite radiances are already assimilated into reanalysis datasets. In order to improve the homogeneity of reanalysis data, EURO4M will support satellite inter-calibration activities. The sensitivity of reanalysis ECVs for inhomogeneities and biases in satellite radiances will be evaluated.

Satellite data will be used together with reanalysis data to provide a long-term record of the surface radiation budget. Climate indices derived from satellite-based products are of value for monitoring of specific climate impacts (e.g. droughts in Wang and Qu, 2007). Additionally, the commercial solar energy market demonstrates the suitability of satellite data for climate applications. E.g. satellite-based solar irradiance data are used for the efficient planning and monitoring of solar energy systems (Hammer *et al.* 2003; Drews *et al.* 2008).

The product palette of the CM-SAF has been evaluated to be suitable for monitoring of climate change (Schultz *et al.*, 2008). However, **the overall capacity of satellite-derived data for climate monitoring has by no means been explored satisfactorily. EURO4M will integrate the EUMETSAT-SAF products and methods for climate monitoring**. In this respect, reprocessing of existing satellite products in order to derive homogeneous long-term datasets is an important effort. At the same time, there is scope for merging these products with shorter-term but possibly more advanced datasets.

Climate Indicator Bulletins and Climate Liaison Team

The output datasets from EURO4M (Table B.1.1.a) will be distributed mainly through existing systems, which can be accessed from a dedicated EURO4M web-based data portal. The scientific results will be distributed through peer-reviewed scientific and technical journals. In addition, **the EURO4M multi-purpose products will be disseminated through regularly issued Climate Indicator Bulletins (CIBs)**. These will focus on user groups (such as disaster prevention, health, energy, water resources, ecosystems, forestry agriculture, transport, tourism and biodiversity) at European, national and local levels. In general, these user groups do not have the required expertise and knowledge to access and process Terabytes of observation data or reanalysis data. CIBs will provide simple, effective and timely knowledge abstractions from EURO4M data and activities. The CIBs will be flexible and optimal products that will be responsive to current environmental and climatic events, extremes and also user needs.

The exact specifications for the CIBs will be developed as part of the project, with "proof of concept" undertaken for selected extreme events from the past, such as the heat wave of 2003. Apart from multi-purpose information on changes and significant anomalies for ECVs, user-oriented derived indices will also be included, such as heating degree days, number of high intensity precipitation events, etc. The CIBs will be based on the output datasets available at the time of CIB writing. This implies that the CIBs do not rely on the datasets that will be delivered late in the project. The CIBs will be published both as bulletins (electronic documents/newsletters) as well as being provided through a web-portal, including access to the associated data series, gridded datasets and editorial texts. The system for producing CIBs will be made configurable and flexible, and capable of reacting in near-real time to user needs.

Within EURO4M a Climate Liaison Team (CLT) will actively solicit user requirements and feedback. Through their mediation, the multi-purpose results of EURO4M will feedback directly into applications and impact assessments relevant to European societal and community needs. The Climate Liaison Team (CLT) will establish a communication process, which responds to information flow in both directions (providers > users and users > providers) and evolves through time, so that users can both obtain and influence the nature (user-driven data format, content and delivery style) of the information they need while understanding the strengths and limitations of the monitoring products. In doing so, the team will establish sustainable links between EURO4M and all GMES services and GEO societal benefit areas. The CLT will also train users in the handling of EURO4M products and services through workshops, e-learning modules, podcasts and user guides covering different skill levels. In this way, EURO4M will ensure stronger links between European applications studies and the outputs from traditional and advanced climate monitoring systems.

The existing core GMES services and the downstream GMES services, which are currently planned and positioned between the multi-purpose core services and the individual user clients, will be actively involved in the CLT. This will ensure that the end-users can and will take full benefit of the wide range of products and services EURO4M will develop. The CLT will build on existing national experience and related ERA-Net activities, such as the ERA-Net: Climate Impact Research Coordination within a Larger

Europe (CIRCLE; see Section B.3.1 and Kabat and Vellinga, 2005). The lessons learned from the process for establishing user needs that has been used for the selection of fast track and pilot services will be considered too. The CLT enables that, already in an early stage, users are involved in the decision-making process in a structured way. This is in line with the user-driven objective of GMES (EC, 2008).

B.1.2 Progress beyond the state-of-the-art

Innovation-related activities

Never before has the pan-European integration of atmospheric observations from ground-based sources, satellite sources and reanalysis been optimized in such a comprehensive way for long-term climate monitoring and adaptation policy support. Remotely sensed data from satellites deliver near-real time estimates of key parameters worldwide. However, they must be complemented by *in situ* data, even though these are often much more sparsely and irregularly distributed in time and space. The *in situ* data are indispensable for calibration and validation of satellite data. Also they give information representative of a finer spatial scale, often with higher precision, which complements satellite information which is coarser, but has wider coverage.

The problems with estimates of lower tropospheric temperatures from satellite-based Microwave Sounding Unit (MSU) radiances since 1978, and their subsequent comparisons with sonde-based and surface temperature data, indicate that datasets need to be considered together rather than in isolation. In contrast to satellite data, *in situ* measurements have often been acquired and handled by a wide variety of laboratories and institutions for the purposes of specific research programmes and are not managed in a unified way.

Climate quality reanalysis

The data assimilation and downscaling activities in EURO4M will progress the regional reanalysis science beyond the present state-of-the-art. The data assimilation systems are making rapid progress as they benefit from research in NWP, which has lead to much improved weather-forecast skill. Also, progress is made in the correction of biases and discontinuities of the observing system that obscure the detection of climate trends. Computing resources are growing with time, which will enable future reanalyses to be calculated at finer horizontal and vertical resolutions, with immediate effects on product quality and on the relevance of products for new applications.

An example of what can be achieved is provided by the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis (NARR). This long-term, consistent, high-resolution climate dataset for the North American domain is a major improvement upon the earlier global reanalysis datasets in both resolution and accuracy (Mesinger *et al.*, 2006). At 32 km horizontal resolution, NARR covers the 25-yr period 1979–2003 and is being continued in near–real time. In particular, NARR has successfully assimilated high-quality and detailed precipitation observations into the atmospheric analysis. Consequently, the forcing to the land-surface model component of the system is more accurate than in previous reanalyses, so that NARR provides a much-improved analysis of land hydrology and land–atmosphere interaction. The overall atmospheric circulation throughout the troposphere has been substantially improved as well.

Operational agencies responsible for reanalysis need to be kept abreast of advances in data recovery and rehabilitation, which will lead to improvements in datasets for assimilation in reanalysis. **In the long run, new "climate quality" dynamic reanalyses will then be able to provide the necessary ECVs**. This requires data from a network of radiosonde, surface-based, and satellite-based observations that are specifically pre-validated with respect to systematic biases. The models themselves cannot absolutely correct biases in grossly inhomogeneous input data. Incorrect or incomplete data with spatio-temporal inhomogeneities can be misleading in estimating climate change, in particular changes in extremes. Recovery of synoptic surface meteorological data and radiosonde upper-air data is needed to fill gaps in the observational records held by reanalysis centres. Major efforts are needed to bring together more of the available data into a coherent form suitable for climate quality reanalyses. For instance, existing reanalysis products did not use all corrected surface-based and radiosonde observations. For the early years, much better exploitation of existing and digitized high-resolution observational series can be made. EURO4M will therefore extend these data back well before 1958 (the start date of ERA-40) to serve future reanalysis prior to this time, e.g. the proposed next generation reanalysis that ECMWF plans to carry out, with "proof of concept" being undertaken by the global reanalysis proposal for FP7 should it be successful (see Section B.2.3). The project will also link with the ACRE-facilitated reanalyses to aid the development and testing of a 100+ year reanalysis using only surface observations (the 20th Century Reanalysis Project), and thus be positioned to work similarly with even longer historical climate quality reanalyses.

Essential Climate Variables (ECVs) state-of-the-art

The Second Adequacy Report of GCOS (GCOS, 2003) developed the concept of Essential Climate Variables (ECVs) encompassing the atmospheric, oceanic and terrestrial domains. The concept forms part of the GCOS Implementation Plan (GCOS, 2004), which for these three domains has been endorsed by GEO in its GEOSS work plan (GEO, 2007). The GCOS Implementation Plan has been updated with the help of EURO4M partners. The new report (GCOS, 2009) provides a comprehensive assessment on the status and trends in global observing systems for climate over the past five years, as well as on progress in related activities (research, infrastructure, organizational issues). GCOS named the ECVs in a somewhat *ad hoc* way. Some are very specific physical quantities, e.g. surface temperature and precipitation, while others are more vague and generic, e.g. cloud properties and minor greenhouse gases, encompassing a number of measurements. Some can be considered at point locations, while others only really have scientific relevance as global fields.

EURO4M will consider a selection of ECVs from the atmospheric domain, which comprises 6 surface level, 5 upper atmosphere ECVs, and only one ECV from each of the oceanic and terrestrial domains (see Table B.1.2a). Specific reasons for this selection of ECVs are justified in the assessment below. The general motivation is that **these ECVs form primary input to all GMES services and GEO societal benefit areas** and that most services and areas currently make suboptimal use of existing information. Often the changes in extremes that accompany the average warming are not taken into account. Also, most of the other ocean and terrestrial ECVs are part of other core GMES services. With several other projects underway that are fully dedicated to monitoring the atmospheric composition (such as CarboEurope and NitroEurope), these ECVs are not considered within EURO4M.

Domain	Essential Climate Variables (ECVs)	
Atmospheric (over land, sea an ice)	Surface:	**Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour**
	Upper-air:	**Earth radiation budget, Upper-air temperature, Wind speed and direction, Water vapour, Cloud properties**
	Composition:	Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases, Aerosol properties
Oceanic	Surface:	**Sea-surface temperature**, Sea-surface salinity, Sea level, Sea state, Sea ice, Currents, Ocean colour, CO2 partial pressure
	Sub-surface:	Temperature, Salinity, Currents, Nutrients, Carbon, Ocean tracers, Phytoplankton
Terrestrial	River discharge, Water use, Ground water, Lake levels, **Snow cover**, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Biomass, Fire disturbance.	

Table B.1.2a. GCOS ECVs: Those that will be part of EURO4M are shown in bold.

Baseline for each ECV:

ECV: Surface Temperature

The best-known product for monitoring surface temperature, using a combination of land station data and *in situ* sea surface temperature observations, has been developed by the Climatic Research Unit of UEA and the MO. The current version of the monthly dataset, which extends back to 1850, is HadCRUT3 (Brohan *et al.*, 2006) but its spatial and temporal resolutions of 5° by 5° latitude/longitude and monthly timescale are rather coarse. A higher resolution version, back to 1901 at 0.5° by 0.5° spatial resolution, is available for land areas only (Mitchell and Jones, 2005) but the temporal resolution is still monthly. Sea surface temperature data is well studied (as it is a vital input to Reanalyses) and datasets such as HadISST and HadSST2 (Rayner *et al.*, 2006) are readily available. National Meteorological and Hydrological Services (NMHSs) have collected most of the historical station temperature data, but only a few have digitized their entire daily to sub-daily holdings. Fewer still have homogenized their long series. Some additionally charge for accessing this type of data.

Recent EU projects EMULATE (European and North Atlantic daily to MULtidecadal climate variability), ENSEMBLES (ENSEMBLE-based Predictions of Climate Changes and their Impacts), STARDEX (Statistical and Regional dynamical Downscaling of Extremes for European regions), IMPROVE (Improved Understanding of past climatic variability from early daily European instrumental sources), CIRCE (Climate change and impact research: the Mediterranean environment) and ECA&D have assembled daily series of maximum and minimum temperature, all of which will be available to EURO4M. ENSEMBLES and STARDEX have emphasised high spatial density observations, but over relatively short periods from the 1950s. EMULATE, CIRCE and ECA&D concentrated on records that extended back to the 19th century, but their databases were limited to about 200 records, and spatial gaps continue to affect Europe. ENSEMBLES has produced a daily gridded dataset at a resolution of 25 by 25 km for statistical comparisons with Regional Climate Model output (Haylock *et al.*, 2008). Higher-resolution (3 hourly) data are also digitally available from the Integrated Surface Hourly (ISH) dataset. These are discussed under the surface humidity ECV, but Integrated Surface Hourly (ISH) temperatures will also be investigated in EURO4M.

In summary, temperature is the ECV for which most digitized data are readily available, and it is also the most widely analyzed variable. Some spatial limitations affect Europe in the daily series, and there are concerns about the long-term homogeneity of the records (Wijngaard *et al.*, 2003).

ECV: Precipitation

Gridded precipitation datasets are available at 0.5°, 1° and 2.5° resolution from the WMO Global Precipitation Climatology Centre (GPCC) operated by DWD. These are at the monthly timescale, extend back to 1951, have global coverage (land-surface), and use between 10,000 and 40,000 individual station series (Rudolf and Schneider, 2005, Beck *et al.*, 2005).

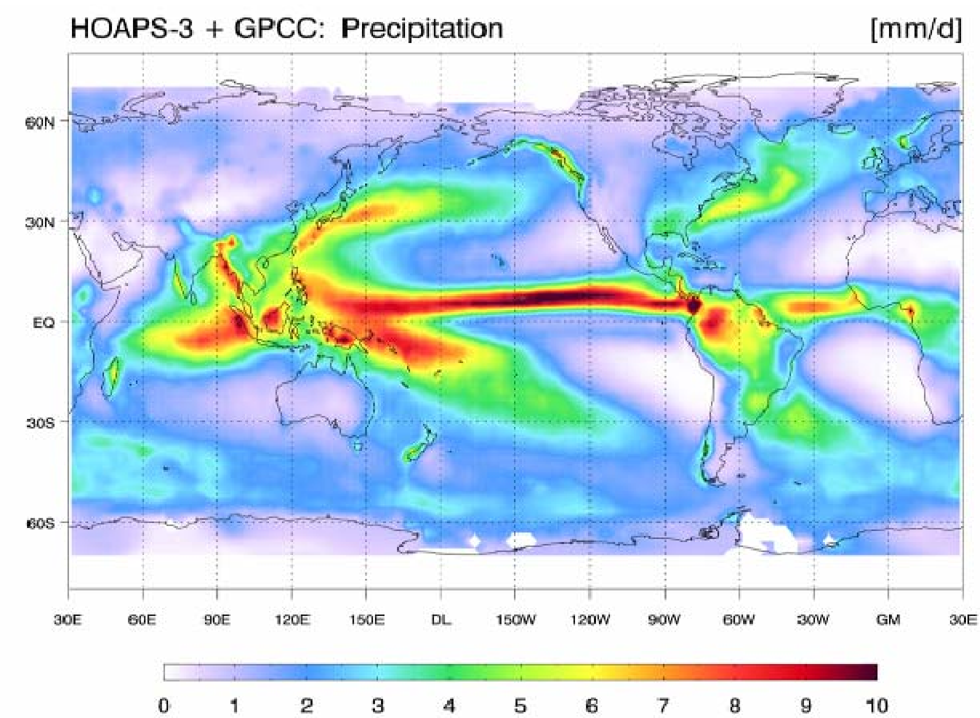

Figure B.1.2a: Annual average precipitation amount derived by blending GPCC with HOAPS-3. DWD will generate a blend of HOAPS-4 and GPCC, which will comprise 20y of global precipitation over land (GPCC) and ocean (HOAPS).

Since the late 1970s, it has been possible to incorporate satellite precipitation estimates, although these raise a myriad of issues regarding the types of satellite sensors used and the algorithms which convert sensor measurements into surface precipitation rates. Accordingly, global datasets of precipitation have been constructed by the Global Precipitation Climatology Project (GPCP) and NOAA's Climate Prediction Center Merged Analysis of Precipitation, both being available at 2.5° resolution. Blending of the ground-based GPCC precipitation dataset with the satellite-based HOAPS dataset (Hamburgs Ocean Atmosphere Parameters from Satellite; Grassl *et al.*, 2000; Bauer and Schluessel, 1993) lead to a global precipitation dataset covering both land surface and ocean (Figure B.1.2a).

Slightly more digitized daily records are available for precipitation than temperature across Europe, but given the much greater spatial variability of precipitation, a much greater density is essential. This is particularly the case for mountain regions (Frei and Schär 1998). ENSEMBLES has produced a daily gridded dataset at a resolution of 25 by 25 km for statistical comparisons with Regional Climate Model output (Haylock *et al.*, 2008). In specific regions and projects (e.g. the Alps, the Baltic Sea Experiment (BALTEX), the European Land Data Assimilation System to predict Floods and Droughts (ELDAS) and for many individual countries), much denser networks have been used in regional and national studies. Gridded versions of these data will be used to assess the accuracy of interpolation in ENSEMBLES (extending the initial work reported by Hofstra *et al.,* 2008). As for temperature, CIRCE aims at collecting, updating and homogenising daily precipitation station series from the larger Mediterranean area covering the last decades to 100 years. The WMO MEDARE initiative aims at pushing this limit even further back in time and recover additional series from this region.

In summary, precipitation data need to be more spatially extensive than temperature to achieve a given level of accuracy in regional-scale estimations. There are again limitations with the availability of digitized data across Europe, and although there are fewer concerns about homogeneity, this may be because the density of networks is inadequate to address this issue (Auer *et al.*, 2005). EURO4M will have access to daily station series as well as gridded products from GPCC, EMULATE, ENSEMBLES, CIRCE and MEDARE (see Section B.1.3).

ECV: Atmospheric Air Pressure

Most analyses of atmospheric circulation in the scientific literature during the last few years make use of reanalyses (ERA-40 or NCEP/NCAR). However, efforts to examine circulation patterns over longer time scales have focused on observational datasets of atmospheric pressure. Foremost amongst these, using both global terrestrial ISPD and marine ICOADS data at monthly timescales back to 1850 (and at 5° by 5° spatial resolution), is the Hadley Centre mean Sea Level Pressure dataset, Version 2 (HadSLP2) compiled by MO (Allan and Ansell, 2006). The same institution led the EMULATE project in its development of a daily (24 hour mean) mean sea level pressure (MSLP) product from 1850, also including both terrestrial and marine ICOADS data at the same resolution (EMSLP), but only for the North Atlantic-European region 25-70°N by 70°W-50°E (Ansell *et al.* 2006). EMULATE made extensive use of earlier EU-funded projects that digitized long daily pressure series, such as WASA (Waves and Storms in the North Atlantic) and IMPROVE. The basic terrestrial and island station pressure data in the ISPD and the marine measurements from ICOADS, that are the basis of the above gridded datasets, are being expanded and improved through the Atmospheric Circulation

Reconstructions over the Earth (ACRE) initiative (led by MO) and will be available for EURO4M. The importance of atmospheric air pressure for climate change monitoring is illustrated by Figure B.1.2b from IPCC-WGI-AR4. Here, SMHI have used station data to indicate evidence for changes in extratropical cyclone activity (storminess).

Efforts are underway at MO via the ACRE initiative and its links to the 20th Century Reanalysis Project of its US collaborators, to develop the combined ISPD and ICOADS global sub-daily MSLP databases for climate quality surface-observations-only reanalyses extending back to 1891. Additional ACRE-facilitated historical reanalyses using only surface observations are planned to extend these reconstructions back over the last 150 years globally and for the North Atlantic-European region to the mid-18th century. The development of the combined ISPD and ICOADS sub-daily MSLP dataset needed for such activities will be closely linked to EURO4M activities in WP1. All of these new MSLP data activities are structurally, but not financially, supported by GCOS through the AOPC/OOPC Surface Pressure Working Group.

Station pressure data are rarely analyzed in isolation (except for the WASA work with pressure triangles) and most studies derive MSLP fields. For Europe, these fields are generally adequate, but will be improved and extended back in time over both the land and oceans by the ACRE project. Improvements are required for sub-daily fields and in marine data in some parts of the world, and new surface-observations-only reanalyses should begin to address these deficiencies.

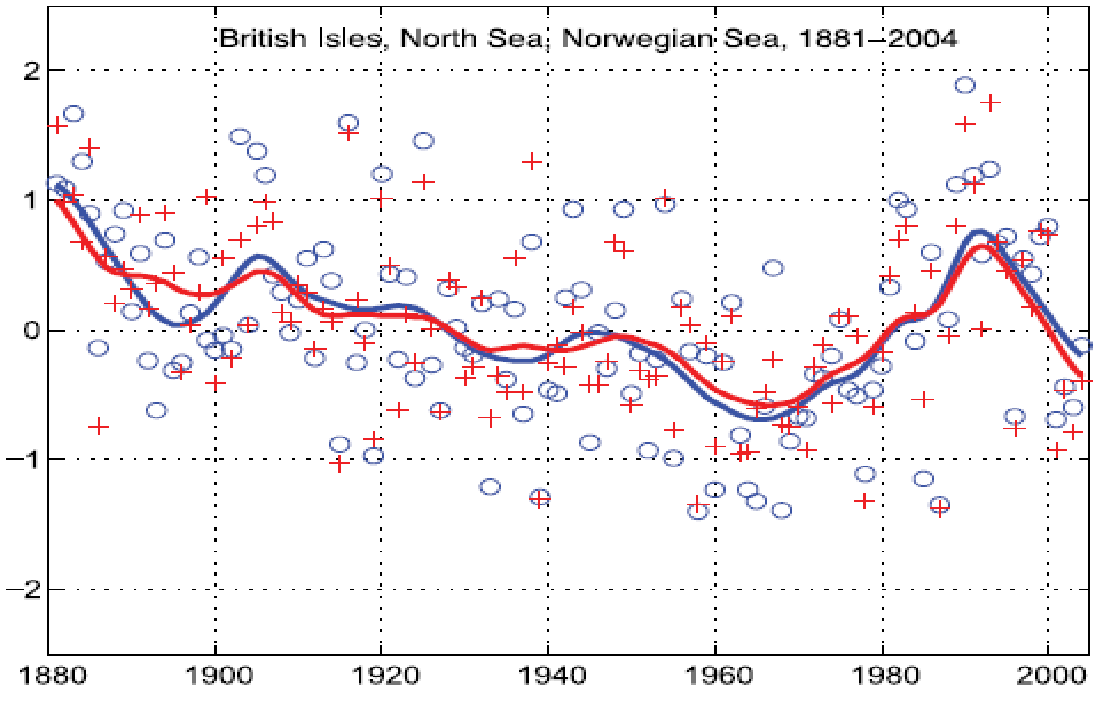

Figure B.1.2b: Storm index for the British Isles, North Sea and Norwegian Sea, 1881 to 2004. Blue circles are 95th percentiles and red crosses 99th percentiles of standardised geostrophic winds averaged over 10 sets of triangles of stations. The smoothed curves are a decadal filter (updated by SMHI from Alexandersson *et al.*, 2000; see Figure 3.41 in IPCC-WGI-AR4).

ECV: Surface and Earth Radiation

The surface radiation budget is a fundamental component of the surface energy budget that is crucial to nearly all aspects of climate. The Baseline Surface Radiation Network (BSRN) of the World Climate Research Programme (WCRP) has established the relevant measurement techniques and is now recognized as the GCOS baseline network for surface radiation. The BSRN provides high-quality but spatially limited measurements of radiation at the surface. The GCOS action to expand the BSRN network, increasing the number of land stations and using research ships and buoys over the ocean is an important step. However, additional data are needed to obtain a sufficient spatial coverage for climate monitoring. As with most GCOS actions and plans, the initiatives and financial resources must come from the scientific community, principally through the member states and their NMHSs.

Satellite data can be used to monitor clouds and surface solar radiation quite well. Hence BSRN stations in combination with satellites are a powerful option for an appropriate monitoring of the surface radiation with high accuracy and spatial coverage. The International Satellite Cloud Climatology Project (ISCCP), the Earth Radiation Budget Experiment (ERBE), as well as the CM-SAF Climate Data Records will be used within EURO4M. The potential of merging *in situ* data with satellite-derived data will be investigated in WP1.

In addition, reanalysis data has the potential to contribute to the appropriate monitoring of radiation ECVs. Trentmann *et al.* (2008) has recently evaluated the thermal flux densities at the surface of the ERA-Interim dataset and concludes that this has a high accuracy and can therefore be used in conjunction with satellite-based shortwave surface radiation fluxes in order to provide the surface radiation budget and its components in climate accuracy. Of course, monitoring the radiation budget at the top of the atmosphere cannot be based on surface data, but needs satellite data. WP2.4 will address the accuracy of reanalysis data by comparison with the radiation budget derived with GERB/CERES (Geostationary Earth Radiation Budget/Clouds and the Earth's Radiant Energy System) and ERBE data.

One of the radiation budget components, the surface solar radiation, is necessary for an efficient planning and monitoring of solar energy systems (Hammer *et al*, 2003; Drews *et al.*, 2008). Surface solar radiation is also important for the satellite-based estimation of drought and evaporation (Wang and Liang, 2008; Wang and Qu, 2007).

ECV: Wind Speed and Direction

This ECV is measured at many stations across Europe, but because of local effects, studies of longer-term changes in high wind speeds during storms generally make use of daily and sub-daily MSLP fields (from reanalyses or from the EMULATE and WASA projects) as these are generally more consistent through time.

Figure B.1.2c illustrates the use of reanalysis data for the reconstruction of past extreme wind storm events. The violent storms that swept Western and central Europe from 25 to 28 December 1999, left more than 60 dead.

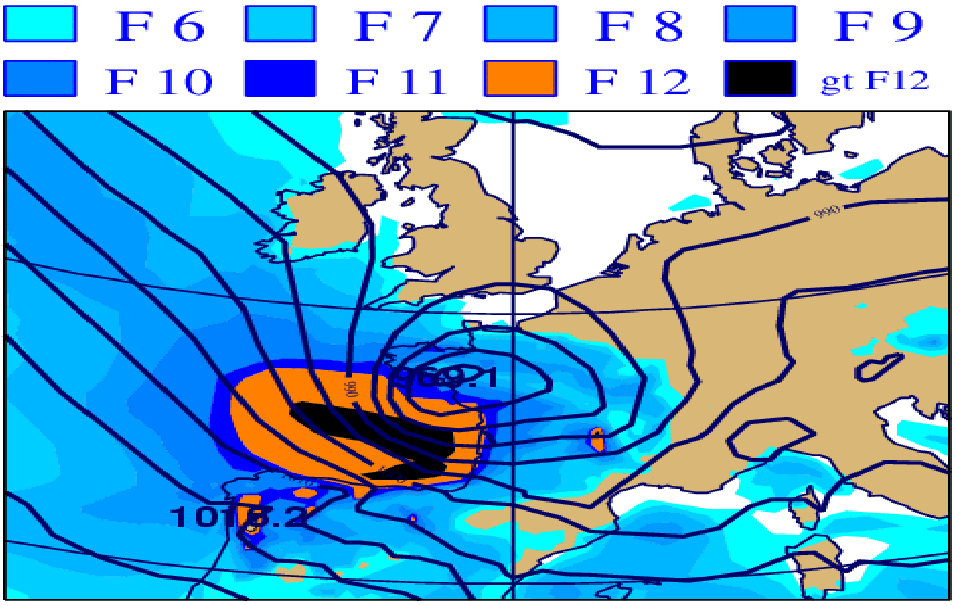

Figure B.1.2c: Reconstruction of the 1999 "Christmas" storms using ERA-40 reanalysis data. This example shows the wind field of 27 December 1999 at 00 UTC. Colours indicate wind speed in Beaufort scale F (source: ECMWF).

ECV: Surface Humidity

HadCRUH is a new dataset of monthly mean surface humidity anomalies at 5°×5° resolution, covering the period 1973–2003, with respect to the 1974–2003 climatology (available at www.hadobs.org ; see Willett *et al.*, 2007; 2008). It is nearly global in coverage, combining land data from observing stations and marine data from ships, buoys and observing platforms. The land data are sourced from version 2 of the integrated surface hourly (ISH) dataset, supplied by the National Climatic Data Center. The marine data are sourced from release 2.1 of ICOADS (International Comprehensive Ocean-Atmosphere Dataset) for 1973–1997 and from NCEP GTS data (Global Telecommunications System data made available through NOAA's National Centers for Environmental Prediction) for 1998–2003. HadCRUH is available in specific humidity and relative humidity forms. This dataset uses all available humidity observations (vapour pressure, relative humidity and dew point temperature). EURO4M will analyse the dataset for changes over the last 30 years. The GTS dataset will also be investigated for some of the other surface ECVs (e.g. temperature and pressure), as it will likely provide sub-daily resolution for the European domain.

ECVs: Upper Air Temperature/Upper Air Humidity/Wind Speed and Direction

Upper-air temperatures, humidities and wind speeds/directions from radiosondes are a cornerstone of the data input to most reanalyses. However, improvements in the response times and radiative shielding of instruments on the sondes mean that all upper-air temperatures and humidities are subject to major heterogeneities throughout the 50+ yr record. A significant change to ascent times took place in 1957, partly explaining why ERA-40 begins in 1958. Changes to the times of the sonde ascents can affect the long-term homogeneity of the derived series through changes in the effect of radiation on the sensors as well as through the true, though small, diurnal cycle of atmospheric temperature. Some important advances in radiosonde homogeneity have been made in recent years, e.g. Thorne *et al.* (2005a, b) and the MO gridded radiosonde temperature dataset (HadAT). At the National Climatic Data Center (NCDC, US), many of the original sonde ascents were collected or digitized in the Integrated Global Radiosonde Archive (IGRA; Durre *et al.*, 2006).

WP2 will benefit significantly from previous work using data from both HadAT (homogeneity adjustments, see Titchner *et al.*, 2008) and IGRA (additional pre-1979 ascents). Data homogenization by near neighbour-comparisons, and by reference to reanalysis feedback files (e.g. by Haimberger *et al.*, 2008), will be incorporated into improved analyses for the European-North Atlantic region.

ECV: Cloud Properties

Cloud feedback is considered to be the single most uncertain aspect of future climate projections and is responsible for much of the wide range of estimates of climate sensitivity in climate models. Therefore, it is vital to maintain long-term records of cloud properties. Satellite data, for example constructed by ISCCP, provide an appropriate basis for monitoring of cloud parameters. EURO4M will deliver a number of new cloud property datasets produced within the framework of the CM-SAF (including a 20+ yr cloud albedo dataset). Monitoring of developments within ISCCP and a liaison with AOPC will ensure that the most up-to-date information is used. A metric for evaluation of reanalysis cloud data will be developed using ISCCP, CM-SAF and cloud products derived in WP2.1.

ECV: Snow cover

This ECV is classed by GCOS as being in the terrestrial domain, but it has traditionally been measured by NMHSs. Thus across northern and high-elevation areas of Europe, there are long daily records of station-observed snow cover, many of which are digitally available. In addition to the *in situ* observations, satellites have measured snow cover since about 1966. Fields of snow cover have been quite deficient in previous reanalyses, and experiments with improved fields will be investigated within WP2. Data for this ECV will also be available through interactions between EURO4M and the EuroCryoClim project for high latitude Europe and the Arctic.

Performance / research indicators

The criteria for the project along which results, progress and impact of the project will be measured in later reviews and assessments are: timeliness of CIBs, datasets, reports and papers (see deliverables) and usage of this information by stakeholders.

B.1.3 S/T methodology and associated work plan

B.1.3.1 Overall strategy and general description

The scientific and technical approach of EURO4M has been designed to achieve the project goal and objectives (as stated in Section B.1.1) in a realistic, measurable and specific manner within **4 years**. EURO4M will combine an integrated European climate monitoring capacity (supply) with user needs (demand). Improved data coordination and analyses will help fill gaps in the atmospheric observation system, and contribute to advanced data assimilation and reanalyses. High quality integrated ECV datasets and aggregated climate change products and services (CIBs) form the major outputs of the project.

Graphical presentation of the components

As illustrated in Figure B.1.3c, the activities in the 4 WPs of EURO4M strongly interact. In order to enable EURO4M to accomplish its goal of developing the capacity for, and delivering the best possible and most complete (gridded) climate change time series and monitoring services for Europe a total of 4 WPs is required. WP1, 2 and 3 form the face of the project and fit together tightly. WP4 is overarching the project ensuring adequate project management (see Section B.2.1).

In summary, WP1 and WP2 produce the data that will feed into WP3. Many of the WP1 observations will also feed into the reanalysis activities in WP2. WP3 will produce the EURO4M multi-purpose products and services. For these to be state–of–the–art, we need improved regional observation datasets (WP1), as well as advanced regional data assimilation and reanalyses (WP2). WP3 also has prime responsibility for project outreach.

In detail, WP1.1 will provide high-quality gridded ground truth observations feeding the CIBs (WP3.1) and serving as input for the evaluation of the regional reanalyses (WP2.4). Moreover, these datasets constitute an indispensable basis for the calibration and application of 2D-mesoscale downscaling in WP2.3 and satellite retrieval algorithms in WP1.2. The satellite-based datasets of WP1.2 also feed into the CIBs and will be used for reanalysis evaluation too. The data coordination activities in WP1.3 make additional *in situ* datasets accessible to WP1.1 and interact with the *in situ* component of GMES.

WP2.1 guarantees that the possibilities of regional reanalysis as an optimal integration tool for ECVs are fully exploited and links to global reanalysis outside the project. The downscaling activities in this WP and in WP2.2 and 2.3 are jointly evaluated in WP2.4. This evaluation is partly based on the datasets developed in WP1.1 and WP1.2. It enables a rigorous quantification of the capabilities of regional reanalysis and an assessment of the various methodological options in downscaling techniques developed and implemented in WP2.1, WP2.2 and WP2.3. The results provide elementary guidance for the appropriate derivation and interpretation of the derived products in the Climate Indicator Bulletins (WP3.1). WP2.5 will provide additional capability for the work in WP2.1 and WP2.2 through improved input data for regional (and global) reanalysis.

The dataset production and evaluation activities in WP1 and WP2 complement each other. They are brought together in WP3.1, where the best possible multi-purpose products and services will be developed. WP3.1 makes the high quality spatial ECV data accessible at the required level of aggregation. In particular, the "optimum" results need to be based on different underlying ECV datasets. The added value given to the output datasets (Table B1.1a) by this WP should not be underestimated. The EURO4M integrated climate change products and services will be produced in the form of CIBs. Data products and services in the CIBs will evolve in response to feedback from the various users through user interaction in WP3.2. The Climate Liaison Team of WP3.2 will link user needs to the CIBs. The capabilities for meeting specific user requirements will ultimately depend on the quality of the raw data and hence a vivid exchange of information between WP1, WP2 and the CLT of WP3.2 is decisive. In doing this, WP3.2 will demonstrate that bridging the gap between the climate community and the user community is feasible.

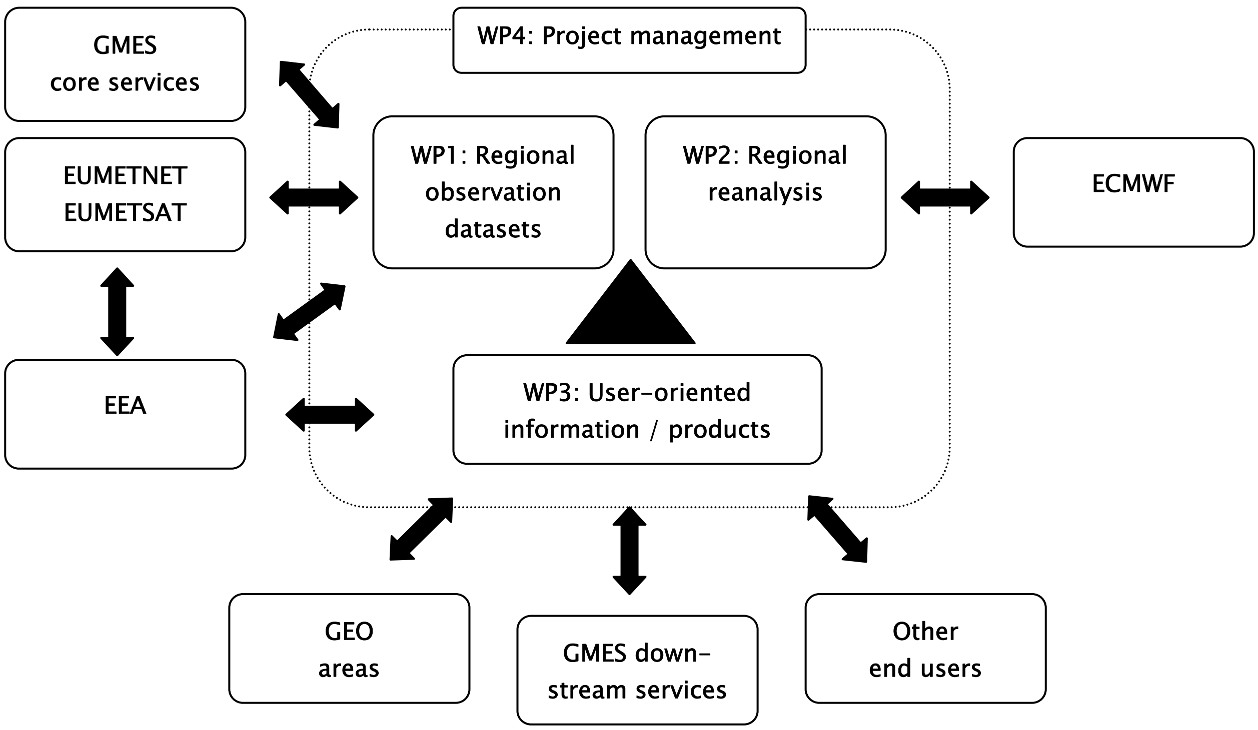

Figure B.1.3c. Interactions between the 4 WPs of EURO4M plus links to the outside world (see Section B.2.3).

Data exchange

Many NMHSs have been made to, or found it necessary to, charge for the acquisition of such data, especially daily to sub-daily weather records. This has put some NMHSs data outside of the budgetary realms of research institutes, organisations and agencies. It may also be one of the reasons that integrated datasets of climate change information (in particular extremes) are typically missing in the existing data information systems, such as EIONET and SEIS (see dataservice.eea.europa.eu). No uniform data policy for climatological data exists in Europe. The Network of European Meteorological Services

(EUMETNET) has struggled with this topic for many years now without reaching a solution. Large differences continue to exist between individual countries and there is no single European counter (or portal) for climatological data.

In EURO4M, we will respect the data policies of NMHSs and other data providing institutions. At the same time, we will also respect and try to work in the spirit of GMES and WMO:

- GMES services, according to the Commission (EC, 2008), should be fully and openly accessible, as long as EU and Member States security interests do not suggest otherwise. This will help to promote the widest possible use and sharing of Earth observation data and information in line with the proposed SEIS and in accordance with existing legislation such as the INfrastructure for SPatial InfoRmation in Europe (INSPIRE) Directive taking into account the Global Earth Observation System of Systems (GEOSS) principles.
- WMO Resolution 40 on free exchange of data (Res40Cg-XII WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities and its annex 4: definitions of terms in the practice and guidelines) states that: "As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted exchange of meteorological and related data and products".

Good examples of how this will work in practice are available from the ongoing daily station data collation for the ECA&D, the ENSEMBLES and the GPCC project, as well as the reanalysis data from ECMWF and the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR).

B.2.2 Beneficiaries

The sections below describe how each of the individual beneficiaries is well equipped to deliver her or his required part of the project. Special attention has been given to the responsible scientists involved (bold face).

Beneficiary no. 1: Royal Netherlands Meteorological Institute (KNMI), Netherlands

The Royal Netherlands Meteorological Institute (KNMI) is the national research and information centre for weather, climate and climate change in the Netherlands. KNMI has a long tradition in operational and scientific activities. Climate research at KNMI aims at observing, understanding and predicting changes in the climate system.

Dr. Albert Klein Tank, who has been working as a scientist for KNMI for almost 20 years now, will coordinate EURO4M. He is actively involved in observational research embedded in international projects and programmes. Albert Klein Tank leads the EUMETNET project ECA&D (eca.knmi.nl) that joins over 40 meteorological services in Europe and the Mediterranean. This project has proved to deliver high quality observational datasets and derived information on indices for studying extremes. He has been involved in the production of the IPCC-WGI-AR4 as a lead author of the chapter on observations. He is currently co-leading the CCl/CLIVAR/JCOMM Expert Team on Climate Change Detection and Indices. In the Netherlands, he is responsible for the national climate change scenario activities at KNMI. His experiences as a project leader and skills to mobilize scientists will be beneficial to managing EURO4M in a successful manner and will ensure an adequate dissemination of the project results. Albert Klein Tank is a member of the FP6 IP ENSEMBLES Management Board, which provides the necessary experience to successfully coordinate EURO4M.

Dr. Gerard van der Schrier also is a scientist at KNMI. Following a post-doctoral at the Climatic Research Unit, UEA, where Gerard van der Schrier worked on estimating thermohaline ocean-circulation influences on European climate and on quantification and analysis of European droughts for the 1900-2002 period with Prof. Phil Jones, he returned to KNMI. Working first on climate change from a modelling perspective, by applying a newly developed data assimilation method to model past climate changes, he now focuses on changes in climate extremes from the viewpoint of observations. Gerard van der Schrier's research is largely based on the station data from the ECA&D project for which he also maintains the database and website.

Dr. Jan Fokke Meirink holds a PhD in the field of air-sea interaction (2002). From 2001 until 2007 he has been working at KNMI and Utrecht University on the interpretation of satellite measurements of atmospheric trace gases using transport models, and the assimilation of these measurements in order to improve existing estimates of trace gas emissions. The main focus was on methane observations from SCIAMACHY. Since January 2008 he is working in the Climate Observations department at KNMI on retrieval, validation and evaluation of cloud physical properties from MSG-SEVIRI observations. This work is performed in the framework of the CM-SAF.

Dr. Ir. Rob A. Roebeling holds a PhD in Environmental Sciences (2008) from Wageningen University, on Cloud Properties Retrievals from Satellite Observations. In 1991 and 1992 he worked at the DLO-Staring Centrum in Wageningen (the Netherlands) on surface flux retrievals from satellite data. In the period 1993-1999 he worked at the Environmenal Analysis and Remote Sensing Ltd. as a consultant in the field of boundary layer meteorology and crop growth modelling. He has been project leader of several national and international projects. Rob Roebeling has been employed at KNMI since 2000, where he works as senior scientist on cloud properties retrievals from meteorological satellites. He is principle investigator for the cloud property retrievals within the CM-SAF. Furthermore, he is leading scientific projects in the fields of atmospheric radiative transfer and multi-sensor cloud remote sensing.

Beneficiary no. 2: Met Office (MO), United Kingdom

The Met Office in the UK (MO) is among the world leaders in both NWP and climate research, the latter being grouped in its Hadley Centre. Both use its Unified Model, facilitating projects like EURO4M which combine NWP data assimilation with climate studies. The Climate Monitoring and Attribution Group within the Hadley Centre has considerable expertise and experience in the development of high quality historical datasets and gridded products of ECVs for the purposes of climate studies, and their application to observational and model-based studies of climate variations. Several members have been instrumental in leading the development and evolution of key surface datasets that are internationally recognised and utilised (e.g. Central England Temperature, HadISST (Hadley Centre Sea Ice and Sea Surface Temperature dataset), HadCRUT3 (Hadley Centre and Climatic Research Unit's Air and Marine Temperature Anomalies Version 3 dataset)) for the assessment of climatic variability and change. MO beneficiaries have links to the ETCCDI and were also actively involved in the recent EMULATE project, and continue to play a prominent role in ENSEMBLES. The MO Hadley Centre is also a major partner in the international ACRE (Atmospheric Circulation Reconstructions over the Earth) initiative: it is part of the consortium behind ACRE, along with the Queensland Climate Change Centre of Excellence (QCCCE) in Australia, and the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory (ESRL) and Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado in the US.

Dr Rob Allan is a Climate Scientist at the MO Hadley Centre, where he led the development of surface pressure datasets and products such as HadSLP and EMSLP. Rob Allan is currently the Project Manager of the ACRE initiative and a Co-convenor of the GCOS AOPC/OOPC Working Group on Surface Pressure, with a EURO4M third party participant (see Section B.2.3) Dr Gil Compo from NOAA/ESRL/CIRES in the US. Dr Compo is leading a component of the ACRE initiative, in which the development of an International Surface Pressure Database (ISPD) is "fuelling" a series of surface-observations-only historical climate quality 3D reanalyses of global weather variables for climate variability and change research. ACRE is helping to facilitate these historical reanalyses through the data rescue of old high-resolution marine and terrestrial observations.

The production of oceanographic ECVs, in particular SST, in near-real time is one of the activities performed within the National Centre for Ocean Forecasting (NCOF) located in the MO. In addition, **Dr Nick Rayner** is the Managing Scientist responsible for Marine Data working in the Climate Monitoring and Attribution Group, especially the Hadley Centre Sea Ice and Sea Surface Temperature (HadISST).

The members of the Climatic Monitoring and Attribution Group within the **MO** have been involved in the development of UK and/or international climate products and outreach. These include the preparation of quarterly diagrams and information for DECC (UK), monthly graphics and text to update climate information and indices on the MO's Internet site, annual summaries for the UK Royal Meteorological Society's publication Weather, contributions to the EUMETNET-ECSN/WMO/DWD Annual Bulletin on the Climate in WMO Region 6, and input to the annual WMO press statement and *Bulletin of the American Meteorological Society* world climate summary. In the same group, Dr Lizzie Good has begun to develop techniques to blend satellite-sensed surface temperature and cloudiness with in-situ air temperature and sunshine duration respectively for climate monitoring.

Dale Barker is the Head of the Data Assimilation and Ensembles section of the Met Office's Forecasting Research and Development Programme. Dr. Barker is responsible for research and development for NWP data assimilation and ensemble forecasting. He has recently rejoined the Met Office following a decade in the US at the National Center for Atmospheric Research (NCAR) in Boulder Colorado. At NCAR, he led the Weather Research and Forecasting (WRF) model's data assimilation efforts, and was also initial PI on a new Arctic System Reanalysis project.

Dr Bruce Macpherson manages a team developing operational regional NWP data assimilation systems. He was chair (1999-2004) of working group 3 of the COST Action 717 on Use of Radar Observations in Hydrological and NWP Models. Currently he is chair of the SRNWP (Short-Range NWP Programme) Expert Team on Data Assimilation and Use of Observations, a group organised by collaborating European Meteorological Services.

Beneficiary no. 3: University Rovira i Virgili (URV), Spain

The new Centre on Climate Change (C3), set recently up by University Rovira i Virgili (URV) in support of the work carried out by the former URV's Climate Change Research Group (CCRG), is chaired by **Dr. Manola Brunet** and supported by **Drs. Enric Aguilar and Javier Sigró.** It has a research experience and scientific background in the fields of climate data archaeology, instrumental climate reconstruction and analysis of climate variability and change and its forcing factors. C3's experience, through the former CCRG, is based on either the development of high-quality and homogenised climate datasets (at different temporal and spatial scales: i.e. at the daily scale in Brunet *et al.*, 2006) and on the assessments of climate variability and change (both on the mean and extreme states of the climate: i.e. Brunet *et al.*, 2007a,b). Its expertise in the field of the development of high-quality climate datasets is also endorsed by the contribution of its members to both normative World Meteorological/World Climate Data Monitoring Programme (WMO/WCDMP) guides on quality control and homogeneity (Aguilar *et al.*, 2003) and on the development of daily adjusted temperature records (Brunet *et al.*, 2008). The C3's has also contributed to the development and analysis of high-quality controlled and homogeneous climate datasets for the Globe, Europe, America, Africa, Middle East and Spain, with which has contributed to document changes in the mean and extreme states of the climate at regional and global scales for the last two IPCC-WGI reports (i.e. Alexander *et al.*, 2006; Ansell *et al.*, 2006; Moberg *et al.*, 2006). URV has been leading and taking part in several European and national research projects, like EMULATE at the European scale. URV has strong links and active involvement with international bodies and their activities, such as WMO/CCL, UNFCCC and GCOS.

Manola Brunet is currently co-chairing WMO/CCl OPAG II: Monitoring and Analysis of Climatic Variability and Change, she is member of the CCL Implementation and Coordination Team and is also co-chairing the WMO-MEDARE Initiative (www.omm.urv.cat/MEDARE), which bring together climatologists from most of the GMR-NMHSs with scientists from universities, research centres and international bodies and projects with the main objective is being to develop, consolidate and progress climate data and metadata rescue activities across the GMR. She is also an UNFCCC/SBSTA international expert on data and observations in support of the Nairobi work programme on impacts, vulnerability and adaptation to climate change. Finally, Manola Brunet had an active role in the development of the GCOS Regional Action Plan for the Mediterranean Basin.

Two members of the C3, Enric Aguilar and Manola Brunet, have been actively involved in regional training activities addressed to the staff of NMHSs in RA I, II, III and IV organized by the Expert Team on Climate Change Detection and Indices (ETCCDI) for WMO Regions I, II, III and IV focused on analysis of climatic extremes (i.e. Aguilar *et al.*, 2005; Aguilar *et al.*, 2008; Peterson *et al.*, 2007; Zhang *et al.*, 2005).

Beneficiary no. 4: National Meteorological Administration (NMA–RO), Romania

The National Meteorological Administration (NMA-RO) represents the national authority in the field of meteorology in Romania acting within the Ministry of Environment and Sustainable Development. NMA-RO is the owner and unique administrator of the meteorological, climatological and aerological Romanian databases. NMA-RO coordinates the National Meteorological Observation Network, which consist of: 162 meteorological stations, 2 aerological stations, 8 radar centers, 60 agrometeorological stations and 8 actinometrical stations. Our research activity is focused on climate variability and change at the regional scale and climate predictability. The main research topics are: analysis of the main characteristics of climate variability over Romania using long-term observations (trends, shifts, extreme events), connection between Romanian climate and large-scale phenomena (e.g. the North Atlantic Oscillation, Atlantic Multidecadal Oscillation), projection of global climate change on local scale using statistical and dynamical downscaling models, validation of global/regional climate models on large-scale and regional scale.

Dr. Roxana Bojariu is leading the Climate Research Group at the NMA-RO. Her expertise is in the field of climate variability and change and associated impacts. She has been involved in European projects such as EuroGLOBEC (European global ocean ecosystem dynamics), FP6 DYNAMITE (Understanding the Dynamics of the Coupled System), FP6 IPY-CARE (Climate of the Arctic and its role for Europe – an European component of the International Polar Year), FP6 CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment), FP7 METAFOR (Common Metadata for Climate Modelling Digital Repositories) and in international ones (e.g. Small Pelagic Fishes and Climate Change). She was lead author of the chapter on observations in the IPCC-WGI-AR4 and Review Editor of the AR4 Synthesis Report.

Dr. Mihaela Caian, senior research scientist, is leading the Numerical Modeling group and has more than 15 yr experience in numerical modeling for meteorology. She started the regional climate modeling at NMA-RO and participated in the construction and development of ALADIN and RegCM model for Romania. She has been leading or was involved in several international projects for the NMA-RO such as LIFE ASSURE, LIFE AIRFORALL.

Dr. Sorin Cheval is the Deputy Head of the Department of Climatology of NMA-RO. His expertise focuses on urban climate, climatic hazards, and GIS and remote sensing applications in climatology. He is a member in the Management Committee of the COST Action HOME. Sorin Cheval was a Fulbright grantee at the Hazards Research Lab, University of South Carolina, USA (2001-2002), and he has been involved in several national and international research projects. He is conducting the research project "The Climatic Atlas of Romania" sponsored by the Romanian Ministry of Environment (2007-2009).

Beneficiary no. 5: Meteo Swiss (MS), Switzerland

The Federal Institute of Meteorology and Climatology MeteoSwiss (MS), is the governmental centre for information on weather and climate in Switzerland. It operates the national observation networks, issues weather forecasts and warnings, provides generic and tailor-made datasets for customers, and conducts research on themes from now-casting to climate prediction. Weather and climate in the Alpine region is one of its core competences. MeteoSwiss hosts the national GCOS office, it is currently presiding WMO RA VI Europe, and is national contact point to inter-national institutions (WMO, ECMWF, EUMETNET etc.). MeteoSwiss participates in the Swiss National Centre for Competence in Research on Climate (NCCR-Climate), in the EU FP6 project ENSEMBLES, in the CM-SAF and in several COST actions. In its research MeteoSwiss collaborates with academia (e.g. ETH Zurich), with other governmental offices (e.g. hydrology) and the private sector (e.g. reinsurance).

PD Dr. Christof Appenzeller, is head of the section Climate Services at MeteoSwiss (35 collaborators) and senior lecturer at ETH Zürich. He has long-standing research experience in the analysis and prediction of the atmosphere-ocean-cryosphere system and was PI of several research projects on climate variability and climate risk management. He is author of numerous papers, including Science and Nature, and is governmental representative in various commissions (ECSN, WMO and IPCC).

Dr. Mischa Croci-Maspoli, is head of the Climate Information Group. His research experience covers the dynamics of large-scale atmospheric flow and inter- and intraseasonal climate variability. He was a Co-PI of the ETH contribution to the Swiss NCCR-Climate project and is currently a member of the management committee of the COST ES0601 Action. In EURO4M he will collaborate with **Dr. Simon Scherrer**. Simon Scherrer's expertise encompasses climate variability and change, atmospheric predictability, dynamics and physics of the atmosphere and the hydrological cycle and data quality management in climate monitoring. He was a contributing author to the IPCC-AR4.

Dr. Mark A. Liniger, is head of the Climate Analysis Group, and as such responsible for several ongoing research projects on past, present and future climate. He has research experience in upper tropospheric and stratospheric transport, mid-latitude dynamics and intra-seasonal variability. His latest work focuses on the verification and application of dynamical seasonal forecasts, climate risk management and statistical data analysis. He is Co-PI of the MeteoSwiss contribution to the Swiss NCCR-Climate.

PD Dr. Christoph Frei, is senior scientist in the Climate Analysis Group. He has long-standing research experience in spatial climate analysis, evaluation of climate models, application of extreme value statistics in climatology, and climate change downscaling. He compiled a pan-Alpine rain-gauge dataset and derived widely used precipitation analyses. He was Co-PI in EU research projects (e.g. PRUDENCE, STARDEX), was a contributing author to IPCC-AR4, and is a lecturer at ETH Zürich. In EURO4M he will collaborate closely with **Dr. Reto Stöckli**, who is responsible for MeteoSwiss activities in CM-SAF. Reto Stöckli has many years of research experience in the analysis of satellite datasets, in land surface modelling and in radiation. He was also active in visualizing satellite data for public outreach and earth science education.

Beneficiary no. 6: Deutscher Wetterdienst (DWD), Germany

The CM-SAF, which is under the guidance of the German Weather Service (DWD), is dedicated to the high-quality long-term monitoring of the climate systems state and variability, partly on the regional level. It supports the analysis and diagnosis of climate parameters in order to detect and understand changes in the climate system. The SAF, furthermore, serves the modelling of the atmospheric system as well as planning and management purposes. Utilising specialist expertise from the Member States, SAFs are dedicated centres of excellence for processing satellite data and form an integral part of the distributed EUMETSAT Application Ground Segment. Each SAF is led by a consortium of organisations under the guidance of a National Meteorological Service. The research, data and services provided by the SAFs complement the standard meteorological products delivered by EUMETSATs central facilities in Darmstadt, Germany. EUMETSAT supervises and coordinates the overall activities of the SAF network and the integration of the SAFs into the various operations within the EUMETSAT Application Ground Segment.

Dr. Richard Müller is head of the radiation group of CM-SAF. Richard Müller has excellent expertises in different fields of atmospheric research, such as meso-scale modelling of wind fields, modelling, analysis and interpretation of stratospheric processes, radiative transfer modelling and development of radiation retrieval schemes. The main focus of his work within CM-SAF is the generation and analysis of radiation and cloud climatologies. He has published several articles in peer-reviewed journals. The expertise of Richard Müller is supplemented by other CM-SAF scientists, experts in climate monitoring and retrieval of atmospheric parameters. They have liaisons with GCOS and GEWEX, e.g. the scientific head of the CM-SAF. **Dr. Jörg Schulz** is member of the GEWEX radiation panel. In addition, Richard Müller studied pedagogics, with special focus on the adaptation of Paulo Freires concepts to “modern education” in natural sciences. Richard Müller has several years of training and teaching experience.

Dr. Tobias Fuchs, head of the WMO Global Precipitation Climatology Centre (GPCC) also participates in this project. The GPCC is operated by DWD. The Centre holds the world-wide largest global rain gauge database for monthly precipitation. Tobias Fuchs and the scientific staff members of GPCC are experienced in data processing, quality control, gridding and statistical analysis. The GPCC co-operates with NOAA and NASA within the GPCP on the merging of rain gauge and satellite-based observations. The Centre also co-operates with the Global Runoff Data Centre in water budget studies. Tobias Fuchs is Member of the GCOS Atmospheric Observation Panel for Climate (AOPC) and of the WMO Region VI Working Group for Hydrology.

Beneficiary no. 7: Swedish Meteorological and Hydrological Institute (SMHI), Sweden

The Swedish Meteorological and Hydrological Institute (SMHI), is a governmental institute under the auspices of the Swedish Ministry of the Environment. With expertise in meteorology, hydrology and oceanography, a well developed international network and access to advanced models, SMHI offers services and products to promote efficiency, safety and sustainable development in various areas of society. Vast quantities of data are gathered continuously in real time from land-based weather stations, balloons, ships, buoys, aircrafts, weather radars, satellites and lightning localisation systems. All information from SMHI's and other international observation systems is managed using powerful computers, and based on these observations highly advanced numerical models and statistical methods are used in real time to carry out analyses and forecasts which form the basis of further work. This includes air pollution forecasts and nuclear emergency preparedness on different scales. In addition, high-quality gridded analyses with high resolution in space and time are performed in non real time, covering Europe or parts of Europe and including meteorological, climate and environmental variables.

SMHI's products are presented and disseminated using state–of–the–art IT-technology, serving the differing needs and requirements of its large community of users from both the public and the commercial sector. SMHI's expertise is used in extensive analyses, climate studies and research. SMHI has approximately 550 employees. It has seven departments and its management system has been certified under the quality standards ISO 9001 and ISO 14001.

SMHI has a most keen interest on the European collaboration and participates enthusiastically in the ECMWF, HIRLAM and the EUMETNET activities. **Prof Nils Gustafsson** has been at the forefront of data assimilations since the early sixties. Within the HIRLAM consortium he has lead the development and implementation of not only the 3-dimensional variational analysis (3D-VAR) but also the full 4-dimensional version (4D-VAR). **Dr Magnus Lindskog** is the other SMHI expert on 3D-VAR and has been working closely with Nils Gustafsson and other colleagues in several of the HIRLAM countries. Magnus Lindskog has particular insight in the use and quality control of observations inside the variational assimilation. **Ulf Andrae** has a lot of modelling and actual reanalysis experience. During the first years of this century he developed and ran the BALTEX (Fortelius *et al.*, 2002) reanalysis for the areas around the Baltic catchment and made a lot of diagnostic computations of balances for the basin. **Per Undén** has extensive experience of data assimilation at ECMWF during earlier years and at SMHI he has 6 years of experience of leading and managing the HIRLAM-5 and HIRLAM-6 research programmes involving well over 50 scientists in 8 countries (Undén *et al.*, 2002). SMHI has played a strong role in the ECMWF reanalysis activities (**Dr Per Kållberg**) and presently leads the EUMETNET-ECSN Showcase EUROGRID (**Christer Persson**). SMHI continues investing heavily on the HIRLAM/ALADIN collaboration, not least on variational data assimilation. Furthermore, SMHI devotes considerable effort on the advanced mesoscale analysis system, MESAN, (**Dr Tomas Landelius and Anna Jansson**) both for Sweden and on the scale of Europe. **Assoc. Prof Lars Bärring**, formerly head of the Rossby Centre, the climate research and modelling unit of SMHI, has 20+ years experience in research on climate variability and experience from several European projects (e.g., ADVICE, WEELS, MICE, PRUDENCE, ESPON, ENSEMBLES).

Tomas Landelius, Nils Gustafsson, Per Kållberg, and Magnus Lindskog together with Per Undén, Ulf Andrae, Christer Persson and Anna Jansson will be key participants in WP2.

Beneficiary no. 8: Climatic Research Unit, University of East Anglia (UEA), United Kingdom

The Climatic Research Unit (CRU) at the University of East Anglia (UEA) has over 35 years of extensive experience in the analysis of climate data. CRU jointly produces the well-known datasets of global surface temperatures (HadCRUT3 and CRUTEM3 - see www.cru.uea.ac.uk/cru/data/temperature), as well as many other climatic variables (www.cru.uea.ac.uk/data). CRU has been involved in a number of studies on the analysis of long instrumental records with particular emphasis on extremes, as well as the development of long homogeneous series not only within Britain, but also in other parts of Europe. UEA were actively involved in the recent ALP-IMP and EMULATE projects and are involved in ENSEMBLES. The EMULATE daily pressure dataset (EMSLP) will be particularly useful for the analysis of changes in storminess and in storm tracks. CRU/UEA has also been involved in a recent assessment of radiosonde data and has experience of using the Integrated Surface Hourly (ISH) dataset. Both these datasets are likely to significantly improve the conventional input data used by the ERA-40 Reanalyses.

Prof. Phil Jones is Director of the Climatic Research Unit at UEA. He is also a member of the Atmospheric Observations Panel (AOPC) for GCOS and was one of the two coordinating lead authors on the Chapter on Atmospheric Observations of the 2007 IPCC report. Within the AOPC, he chairs the Advisory Group for the GCOS Upper Air and Surface Networks (the GUAN and GSN). This group assesses the performance of these two key networks and suggests improvements and changes to NMHSs as well as approving or not suggestions for network improvements made by NMHSs. He co-ordinated the EMULATE project and has been involved in numerous other EU projects including (IMPROVE, STARDEX, ALP-IMP) and is currently involved in ENSEMBLES, ECOCHANGE and CLARIS-LPB. He has over 30 yr of experience in the climate change field. He was awarded the Hans Oeschger medal from the European Geophysical Society in 2002 for work in paleoclimatology. Also in that year he was awarded the International Journal of Climatology prize of the Royal Meteorological Society for papers published in the past five years in the International Journal of Climatology. He is recognised as one of the top 0.5% of highly-cited researchers in the Geosciences field by the ISI (the institute in the US that maintains the Web of Science, where publications and citations are monitored). In 2007 he was awarded a fellowship by the American Meteorological Society. He has worked with most of the partners within the present proposal.

David Lister has been in CRU since the mid-1990s. He has worked on a number of EU-supported projects (including EMULATE and ENSEMBLES) as well as several for the Environment Agency in the UK as well as a number of consultancy type projects. He is adept at data handling, particularly when comparing observations with climate model output.

Ian Harris has been in CRU since the late-1990s. He has worked on a number of EU-supported projects (including HOLSMEER and one on the effects of climate change on historic building across Europe) as well as a number of NERC projects within the UK. He is currently working on updating the CRU High-resolution datasets. He is also adept at data handling, and will be well-suited to the software needed to read the NCEP/NCAR Reanalysis input as well as the ISH data.

Beneficiary no. 9: Météo France (MF), France

Météo France (MF) is the national research and information centre for weather and climate. The meteorological research is a major part of the activity of MF. With 250 researchers, MF plays a leading role in the international community, especially in the fields of climate research and atmospheric modelling. The NWP models, developed jointly with ECMWF for the global model ARPEGE-IFS and the ALADIN Group for a small scale numerical limited area model ALADIN and recently for the NH-model AROME. MF owns and maintains a climatological database which archives data acquired by more than 1300 automatic stations and over 3200 weather stations, some of which go back to 1850. This dense observation network allows statistical studies for research purposes and the elaboration of decision support tools for various sectors of the economy.

MF participates actively in several European collaborations, including HIRLAM, EUMETNET, GMES, and ENSEMBLES.

Eric Bazile is senior scientist at the research center of MF (CNRM-GAME) since 1991. He has several years of experience in the fields of surface data assimilation, surface and boundary layer parameterization for NWP. He has been involved and collaborates with both the HIRLAM and ALADIN consortia since 1993, in particular during the development and the operational implementation of the soil moisture assimilation and the ISBA scheme. He is member of the coordinating group in the NetFAM project (Nordic Network on Fine-scale Atmospheric Modelling).

Dr Jean-Francois Mahfouf is senior scientist. He worked at CNRM-GAME from 1988 to 1994 with main activities on land surface processes for NWP and climate modelling. From 1995 to 2002, he performed research at ECMWF on global variational data assimilation and on land surface analysis. He worked at Environment Canada from 2002 to 2006 on mesoscale data assimilation of soil and precipitations. In 2006, he moved back to CNRM with main activities on meso-scale data assimilation of soil and boundary layer observations. He is a Member of the Royal Meteorological Society since 2000.

Eric Martin is head of the CNRM-GAME team involved in atmosphere-surface-hydrology interactions research. This team has used and validated the SAFRAN analysis system at the scale of France. Eric Martin has a long experience in surface processes modelling, including snow cover modelling. He will be involved in the definition and the validation of the new analysis system by comparison to the present SAFRAN analysis. He will also assess the impact of the new analysis on the modelled surface fluxes.

Dr Fabienne Rousset-Regimbeau has worked at CNRM-GAME from 2003 to 2007, with activities on land surface processes, hydro-meteorological modelling and hydrological ensemble predictions (HEPEX experiment). Since 2007 she has been working in the team in charge of performing SAFRAN meteorological analyses, both in real-time operational and retrospective contexts. Since 2007, she has also been contributing to the H-SAF project (Satellite Application Facility on Support to Operational Hydrology and Water Management).

Laurent Franchisteguy has worked at CNRM from 1999 to 2004 with activities on land surface processes and particularly on retrieval of surface properties using remote sensing (contribution to both CYCLOPES FP5 and Land-SAF projects). From 2004, he has been working in the team in charge of performing SAFRAN meteorological analyses, both in real-time operational and retrospective contexts. Since 2005, he has also been contributing to the H-SAF project.

Marie-Hélène Théron is deputy-director of the Climate Data Management team at MF. She occupied various positions in the National Meteorological Service. She was namely involved in data monitoring and control. In her present affectation, Marie-Hélène Théron is in charge of the data collection, climatological control and validation. She is heavily involved in the French national coordination mechanisms in charge of data management.

Pierre Lassègues is senior engineer in the Climate Data Management team at MF. He occupied various positions in the National Meteorological Service. Since 1998, Pierre Lassègues is in charge of the data management and data bases, especially for model outputs. He is specialized in valorisation of different sources of climatological information, namely reanalysis.

B.3 Potential impact

B.3.1 Strategic impact

EURO4M will contribute to establishing a data archive of systematic observational data related to the climate system. The climate change time series will be based on the optimal combination of regional observation datasets of Essential Climate Variables (ECVs) and model based regional reanalysis. A continuous record of ECVs will be developed, coherent with UNFCCC requirements. EURO4M will contribute to the consistency of such a dataset, as well as to a sustainable and transparent access to such data for global climate scientific and operational communities. This paves the way for a sustainable provision compliant with the requirements of climate analysis communities.

The high costs and joint responsibilities of climate monitoring have always favoured international co-operation, which helps to avoid duplication and promotes sharing of information. The World Weather Watch (WWW) of the WMO is a very positive example of successful international co-operation. Unfortunately, many national climate monitoring systems still operate independently, exchanging little or no data or information. Significant temporal and spatial gaps exist and therefore European integration is necessary. By providing a complete and accurate picture of the history of our atmosphere throughout the period of quantitative human observation, the regional reanalysis activity eventually provides basic input material for a large variety of activities in the domains of science, policy and applications.

In addition, many potential users see little of the data produced and are not offered data, information, products and services tailored to their needs. For instance, decision makers and policy-makers need information summaries in the form of indicators and indices, which are presently neither readily available nor based on sound scientific understanding and indisputable evidence. As illustrated in Figure B.3.1a, aggregated solar energy maps are needed, rather than the underlying raw satellite data. Without these summaries it will be difficult to move into the sustainable path, where (according to the EU Sustainable Development Strategy) environmental protection goes hand in hand with economic prosperity and social cohesion.

Through the development of internationally recognised datasets, feedback and user interaction protocols, EURO4M will work to develop new high quality data products and services for the evaluation of severe climatic events that will aid both intermediate- and end-users, whether institutional, civil society organisations (e.g. the Red Cross/Red Crescent) or from the private sector (e.g. reinsurance). EURO4M will initiate and facilitate dialogues between scientists and end-users leading to a better understanding among scientists on the information needs of end-users and a better understanding of the end-users on how the available data-products can be understood. **The EURO4M system has the potential to evolve into a future GMES service on climate change monitoring that is fully complimentary and supporting the existing operational services**.

The results and outputs of EURO4M will also provide a new way to support climate-policy-related research at the national and local scale. National decision makers and local authorities will be able to utilise the state–of–the–art EURO4M data products and services for their country or region as input to climate change assessments, and the formulation of adaptation and mitigation strategies. It is the longer multi-decadal time scale addressed in EURO4M that is needed for governments to minimize and adapt to the societal and environmental impacts of climate variability and change. European countries can directly use the results of the proposed project for their "national communications on climate change policies" which are a written requirement for the Conference of the Parties of the UNFCCC and include national GCOS implementation activities.

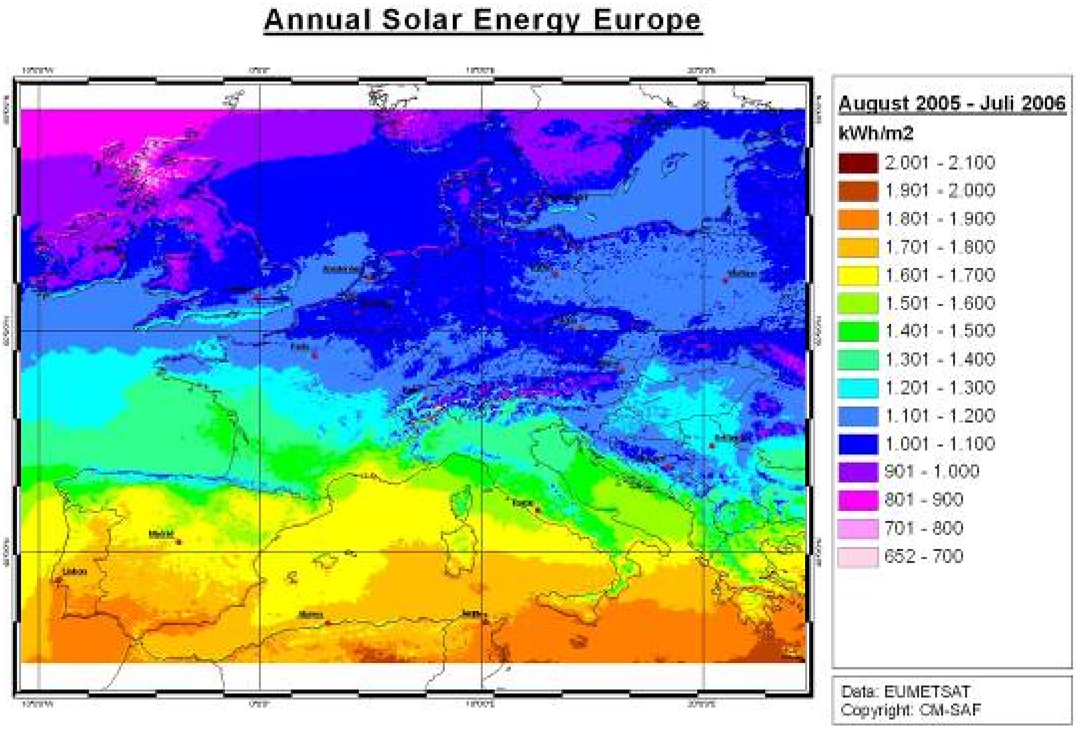

Figure B.3.1a. Map of calculated solar energy in a typical year.
Source: CM-SAF lead by DWD.

New research initiatives

High quality, high-resolution data products from EURO4M will provide the information basis for new generations of research initiatives (e.g. initialization and evaluation of Earth System Models, climate change detection and attribution studies) **and wider societal, industrial and environmental user applications** (e.g. climate risk, impact assessment, study of socio-economic effects of extreme climate events, reducing loss of life and property from disasters, managing the consequences of climate change, development of integrated management strategies).

EURO4M will provide a vital stimulus for the next generation of reanalyses, including those extending further back in time. Analyses of observations used in existing reanalysis products, and those that could have been used, will highlight what can be achieved if all available observations are improved and used where possible.

These new research initiatives fully comply with the recommendations for future EU integrated climate research resulting from the IPCC-AR4, which have been discussed at the international symposium "Future climate, impacts and responses" organised by the European Commission, Research Directorate-General in Brussels, 19-20 November 2007.

B.3.2 Plan for the use and dissemination of foreground

Dissemination and/or exploitation plans

EURO4M provides an exciting and unique opportunity to bring together existing meteorological services, universities, research institutions and programs in order to provide a seamless integration of climate change data and information flows and feedbacks. **The proposed Climate Indicator Bulletins (CIBs; see WP3.1) and Climate Liaison Team (CLT; see WP3.2) will provide a framework for a new generation of flexible products that foster better dialogue between data providers and data users, and integration of end-user requirements for environmental and societal applications**.

The effective dissemination strategy includes the identification of the target audience at regional and global levels by the CLT. An analysis of relevant interested stakeholders will be carried out and a list of all other relevant stakeholders will be produced. Then the most suitable communications programs and products (meetings, conferences, seminars, workshops, publications, brochures and leaflets) will be identified and a timeframe will be defined for their delivery, as specified in WP3. In particular, the CIBs will be used to demonstrate the project outcomes to all participating and interested stakeholders. All project activities, related documents and results, published materials (including training materials and reports) and events announcements will be regularly posted on the project website.

The knowledge and expertise developed in the project will be passed on to the young scientists and engineers in training through university professors involved who teach at their institutions and supervise PhD and graduate students. Chances will be provided for young scientists to be integrated into, and gain experience in, high level European research and international collaboration. National workshops will facilitate dialogue between the scientific institutes involved and representatives of operational sectors.

Specific communication activities, targeted at the general public, schools and the press, will be developed in order to stimulate interest in youth audiences, to attract future scientists in the broad fields of geo-sciences, and to increase public awareness about climate change and the risks of extreme weather events, leading to a better integration of these risks in the policies and programs of operational sectors. In addition, communication activities will also address educational outreach to the public with respect to basic knowledge about climate change.

Data storage and dissemination

A huge amount of observational and reanalysis data will be produced in WP1 and WP2. The output datasets from EURO4M (Table B.1.1.a) will be distributed mainly through existing systems, which can be accessed from a dedicated EURO4M web-based data portal. These data will be analysed within the project and used for the multi-purpose products developed in WP3. WP3 will make an inventory of raw data needs by users outside the project as part of the CLT activities. We anticipate the need for EURO4M data after the end of the project. Therefore, the main datasets (and the web-based data portal) will be secured for at least 5 yr after the project ends. This is possible with the allocated resources only by virtue of exploiting existing infrastructure to the full, and capitalising on the benefits associated with an adherence to standards and interoperability.

Educational links and capacity building

EURO4M will foster better integration of research laboratories and operational meteorological agencies in education programs. The project will catalyse a program of visiting scientists and postdoctoral positions through existing institutions. Emphasis will focus on fostering interactions between existing, new, Accession and Candidate EU States and neighbouring countries.

In order to promote common approaches and develop consensus best practice for climate data, a series of workshops will be organised, and specialised collaborations will be sponsored on specific topics of relevance to the project. The CM-SAF at DWD has already established a training group, which is operating in an international network in cooperation with EUMETSAT. The involvement of universities in the consortium means that the EURO4M approach and data products will be incorporated in existing earth system education programs. EURO4M funding will support Masters, PhD and post-doctoral fellowships at some of the participant institutions.

The consortium will also engender access to developing countries, which will be amongst the largest potential beneficiaries of international co-operation in earth observation. The latter will be done through liaising with the series of worldwide workshops (Peterson and Manton, 2008; see also Klein Tank *et al.*, 2006) organised by the joint Expert Team on Climate Change Detection and Indices (ETCCDI) of the CCL, CLIVAR and JCOMM (Peterson *et al.*, 2001). The EURO4M Coordinator is currently also co-chair of this Expert Team. This will complement the GMES activities in the field of capacity building as discussed at the Lisbon meeting in December 2007 and contributes to the Nairobi work programme on impacts, vulnerability and adaptation to climate change of the UNFCCC. In addition, outreach activities on data rescue, preservation, digitization and homogenization techniques and procedures programmed jointly with the WMO MEDARE Initiative will also contribute to capacity building on these subjects in developing countries and Least Developed Countries.

Contribution to standards

The formation of the EURO4M consortium responds directly to the Commission's recommendations to mobilise all European resources through coordinating and networking efforts in Research and Technical Development areas related to climate change and environmental monitoring.

EURO4M will link EU and international system outputs, capitalising on the benefits associated with an adherence to standards (e.g. Open GIS Consortium developments, ISO19100 series, Geographical Markup Language), interoperability (e.g. within INSPIRE and the WMO Information System (WIS)) and consolidation (see Section B.2.4).

Data sharing within EURO4M will follow a service-oriented approach adopting common standards on metadata, data models, and network services as described by INSPIRE and the GEOSS Architecture and Data Committee. **MO** leads the special group within EUMETNET called INSPIMET, which looks after the implementation rules of INSPIRE for meteorological and climatological data and services. Following these rules will ensure global connectivity and interoperability, also providing appropriate links to the WMO Information System (WIS). **The INSPIRE-compliant infrastructure will enable considerable data-sharing efficiencies to be realised between EURO4M and the various GMES services requiring access to climate-related data**. WP3 will describe the infrastructure that is used for the datasets produced in EURO4M.

Contribution to policy development

Long-term and reliable climate data are vital for detecting, understanding, predicting and responding to climate change and variability. The development of increasingly sophisticated climate models has reinforced the need for basic observations. However, as the demand for objective information grows, GEO and GCOS have indicated that our capacity to monitor climate and environmental changes and fluctuations is still largely inadequate.

Monitoring climate change and extremes at the multi-decadal and century time scale is currently not among the core GMES services. Ongoing activities in the GEO work plan also do not cover long-term climate observations and monitoring, even though GEO is a strong advocate for sustained and coordinated climate observing systems. EURO4M is positioned to form the implementation component of the atmospheric sections of GCOS and GEOSS. By taking on the climate section of the plan EURO4M will coordinate a monitoring framework essential for the success of GEOSS.

EURO4M is crucial for establishing the climate change component of GMES and thus for the European contribution to the development and integration of the GEOSS. A key system for climate change observations and information will be provided for the benefit of each of the nine societal benefit areas of GEO. The system integrates European climate change monitoring activities into the global picture. In this way, the project will contribute to forward European and international efforts in strategic policy areas, such as climate change and energy. Involvement of international partnerships will ensure proper know-how is taken into account, as well as avoiding duplication of efforts. This will enable Europe to play a pivotal role in the systematic monitoring of climate mandated by the UNFCCC.

EURO4M will form a core component of the European implementation of the atmospheric climate component of GCOS in support of the UNFCCC. The Implementation Plan for GCOS addresses the requirements identified in the Second Report on the Adequacy of the GCOS (GCOS, 2003), in particular the ECVs and associated climate products defined in the report. In summer 2009, Parties to the UNFCCC endorsed the main findings of the recently issued "Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008" (GCOS, 2009) in their conclusions at SBSTA 30, as well as in a draft decision, for consideration at COP 15 in Copenhagen in December 2009. This encourages Parties to strengthen their efforts to address the priorities identified.

Finally, within the context of the Kyoto Protocol, EURO4M will directly focus on the following Articles: 9.1) Provide the best available scientific information and assessment on climate change and its impacts; 10.c) Promote education and training, and increase public awareness of climate change; 10.d) Participate and co-operate in international scientific research programmes to reduce uncertainties related to the climate system and the adverse impacts of climate change.

Added-value in carrying out the work at a European level

EURO4M will only work when carried out at the European level, building on existing national monitoring capacity and atmospheric observation programs to form a truly European integrated system capable of providing CIBs on extreme events that threaten Europe, and its citizens and interests worldwide. The development of such a system requires an unprecedented level of collaboration and coordination of multidisciplinary research, enhancement of operational activities within the climate research and monitoring community.

Although elements of such a system presently exist, the state of their development in the different European countries is uneven. More critically, access to data, information, and products by users is in many cases inadequate and difficult.

A European-wide coordination will avoid unnecessary duplication and hence enable resources to be focussed more effectively. This will also result in more uniform, high quality and standardised products, which will be available to all European countries, reducing the geographical disparity between countries and regions for information and services available to intermediate- and end-users. It will encourage the development of scientific research and analysis at the national level as well as at the EU level, allowing countries to make the most of the collaboration both in terms of data resources and R&D expertise. As a side-effect, improved access to products and services will encourage smaller nations to make a greater contribution to existing observation networks.

The enlargement of the European Union in 2004 gives the opportunity to enlarge the scientific co-operation. In fact, co-operation with East and Southeast European countries is essential to tackle topics in environmental research with a wider regional dimension such as climatic change and variability. The European scale ensures that sufficient resources are mobilised to address the goal and objectives of the work program and maintain pre-eminence within the international community.

Account taken of other national or international research activities

EURO4M is designed to build on existing capacity. As described in Section B.1.1, the project fully benefits from ongoing national and international work on observational datasets and data assimilation. **EURO4M will link very strongly to the wider international community**. GMES cannot be successfully implemented without exchanging equivalent observational data through cooperation schemes, thereby sharing the cost of observation infrastructure with non-EU partners (EC, 2008).

EURO4M beneficiaries include members of the GEO Committees, GCOS Steering Committee, its Atmospheric Observation Panel for Climate (AOPC) and Oceanic Observation Panel for Climate (OOPC) specialist groups, WMO Open Programme Area Groups (OPAGs) and Expert Teams (some of them also lead by EURO4M beneficiaries), International research programme on Climate Variability and Predictability (CLIVAR) Expert Teams, the WCRP Observations and Assimilation Panel and the WCRP WG on Observational Data Sets for Reanalyses. EURO4M beneficiaries are also intimately involved in IPCC activities.

EURO4M will work with its international partners to collate and report on ECVs, including integrating existing data products and providing uncertainty estimates for each ECV. EURO4M will link with WMO programmes and improve the reporting of observations to international data centres. **EURO4M fits perfectly in the WCRP strategy for Coordinated Observation and Prediction of the Earth System (COPES; WMO, 2005).**

Links to ongoing FP projects

EURO4M links to ongoing FP6 and FP7 projects, including those developing prototype and pre-operational GMES services (such as GEOLAND2, MyOcean, MACC), and other related FP projects (such as ENSEMBLES, EURO-LIMPACS, CECILIA, CIRCE, etc.):

- EURO4M will complement GEOLAND2, which joins a range of previous GMES projects to deliver a range of geo-information services for the terrestrial sphere, and MyOcean, which will define and set up a concerted and integrated pan-European capacity for ocean monitoring and forecasting. EURO4M partners involved in GEOLAND2 and MyOcean will link the project results to these services.
  They both require the long-term climate change monitoring information that EURO4M will deliver (in particular on extremes) as an input.
- Strong ties also exist with the MACC consortium lead by ECMWF. MACC (Monitoring Atmospheric Composition and Climate) combines the earlier projects PROMOTE and GEMS, which provide prototype atmospheric services for GMES. PROMOTE (PROtocol MOniToring for the GMES Service Element: Atmosphere) focuses on stratospheric ozone depletion, surface UV exposure, air quality, whereas GEMS (Global and regional Earth-system Atmosphere Monitoring using Satellite and *in situ* data) focuses on global distributions of atmospheric constituents important for climate. **Although responsible for the pre-operational atmospheric services from 2009 onwards, MACC does not include the longer (multi-decadal) time scales and many of the ECVs required for climate change monitoring that EURO4M will address**.
- EURO4M will build on the high-resolution gridded observational datasets for Europe developed in ENSEMBLES and work towards getting these datasets into an operational status. Our user-oriented work will benefit from collaboration with the EURO-LIMPACS (Integrated project to evaluate impacts of global change on European freshwater ecosystems) team, designed to assess the effects of future global change on Europe's freshwater ecosystems, as well as from CIRCE and CECILIA for collection and homogenisation of long daily temperature and precipitation data for all the Mediterranean countries and Eastern Europe.
- The work on extremes in WP3 will be performed through strong connections with the EU projects ENSEMBLES, CIRCE and CLARIS-LPB (A Europe-South America Network for Climate Change Assessment and Impact Studies). The work on extremes will also build on the results of earlier EU FP5 projects, like STARDEX, MICE (Modelling the Impact of Climate Extremes), EMULATE and ALP-IMP (Multi-centennial climate variability in the Alps based on Instrumental data, Model simulations and Proxy data), plus recent global initiatives from IPCC which many EURO4M beneficiaries have been actively involved with.

A clear link also exists with the global reanalyses proposal to EU FP7 ENV, which is in preparation by a consortium led by ECMWF. EURO4M is designed to be complementary to global reanalysis efforts, by concentrating on aspects where it can add value, such as a higher horizontal resolution (the global reanalysis proposal will likely suggest a 40km resolution), the assimilation of surface precipitation data, and delivering integrated products at the required level of aggregation and processing to respond to a wide range of users and downstream services.

Links to other activities

In an effort to further harmonize European climate change information, EURO4M will connect to the European Co-operation in the field of Scientific and Technical Research (COST-) Action ES0601 (HOME) on comparisons of methods for homogenisation of long instrumental climate records. New quality control and homogeneity testing of early instrumental observations, particularly from EU Accession and Candidate States and neighbouring countries will build on the data products generated by EU-funded and other projects, such as ECA&D, NORDKLIM (Nordic co-operation within climate activities), EuroClim (European Climate Change Monitoring and Prediction System), MedCLIVAR (Mediterranean CLIVAR) and CLIWOC (Climate of the world's oceans), integrating these data with the holdings of a suite of international databases.

EURO4M will work with International Comprehensive Ocean-Atmosphere Dataset (ICOADS) initiatives to aid the digitisation of many millions of historical marine data in European archives being funded separately under projects such as ACRE. **EURO4M will link via ACRE to the 20th Century Reanalysis Project and other longer historical reanalyses.** With these reanalysis products, there are also the full linkages and "end-to-end" infrastructure which ACRE integrates in working with climate applications users.

EURO4M has already linked with the EUMETSAT-SAFs, in particular to assess user community needs and to contribute to the development of integrated products. The coordinator (at DWD) of the CM-SAF is participating in EURO4M.

EURO4M also links to MEDARE activities on data rescue and surface climate reconstruction for the GMR (under the umbrella of WMO; see Brunet and Kuglitsch, 2008), EUMETNET-ECSN for the remainder of Europe and EuroCryoClim for the Arctic. We will liaise with other recent initiatives for particular sub-regions such as the Alps and the Baltic Sea region. Examples are the project MOnitoring Climate variability and Change for an improved environmental and risk management in the Alpine space (MOCCA) and the Baltic Sea Experiment (BALTEX). The latter will seek to exploit and analyze the results of EURO4M to quantify the water and energy budgets over the Baltic Sea basin and evaluate and improve regional climate models. The good results in the spatialization tools for complex terrain achieved in the EUMETNET-ECSN HRT-GAR project constructing a High resolution Temperature Climatology for the Greater Alpine Region will also be taken into account. These kinds of products are useful to fill the existing gap between the present day observation datasets for Europe and what end users really need in terms of spatial resolution to support impact evaluation.

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Appendix A: Baseline input datasets

The baseline datasets which serve as inputs for EURO4M are detailed in the Table below, as well as whether they are classified as Earth Observation (satellite) data. For each dataset, the table also gives the respective source and the way the consortium has access to this source (including GMES core services and/or ESA data if applicable).

Input dataset	EO	Source	Access
E-OBS	No	ENSEMBLES	Available and maintained at KNMI
Station observation series	No	Met. Services	Through EUMETNET, but data policy issues may arise
ERA40 and ERA-Interim global analyses	No	ECMWF	Consortium members are members of ECMWF and have direct access to the MARS archives
Observations used in ERA40 and ERA-Interim (reanalysis input)	No	ECMWF	Consortium members are members of ECMWF and have direct access to the MARS archives
Operational fine scale atmospheric analyses	No	MF, SMHI, ECMWF	Consortium members are members of ECMWF and have direct access to the MARS archives
OSTIA	No	Met Office, UK	Available and maintained at MO. See http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html
HadISST	No	Met Office, UK	Available and maintained at MO. HadISST2 available October 2010.
IGRA radiosonde data	No	NOAA/NCDC	Available and maintained at NCDC. Working relations exist.
RAOBCORE/RICH radiosonde data	No	University of Vienna	Contact Leo Haimberger
ISD surface data	No	NOAA/NCDC	Through MO
ACRE-facilitated 20th Century Reanalysis 1891-2008	No	NOAA ESRL/CIRES University of Colorado	Via ACRE from Gil Compo
Spanish Daily Adjusted Temperature Series (SDATS) and Spanish Daily Adjusted Temperature	No	Centre on Climate Change (C3)	Available, maintained and updated by C3

Series (SDAPS)			
CM, NWC and Land-Satellite Application Facility products (cloud properties, albedo, surface solar irradiance)	Yes, but derived products	EUMETSAT	Available from SAF-websites
MSG-SEVIRI radiances	Yes, but derived products	EUMETSAT	Available at KNMI or from EUMETSAT's UMARF archive

Table. Baseline datasets used in EURO4M.

Appendix B: Acronym list

ACRE: Atmospheric Circulation Reconstructions over the Earth
AIREP: Air Report (aviation)
ALADIN: Limited-area NWP model
ALP-IMP: Multi-centennial climate variability in the Alps based on Instrumental data, Model simulations and Proxy data
AMDAR: Aircraft Meteorological Data Relay
AOPC: Atmospheric Observation Panel for Climate (part of GCOS)
AROME: High resolution model of Météo France
ARPEGE-IFS: atmospheric model developed jointly by Météo France and ECMWF
ATOVS: Advanced TIROS Operational Vertical Sounder
BALTEX: Baltic Sea Experiment
BSRN: Baseline Surface Radiation Network
CarboEurope: Assessment of the European Terrestrial Carbon Balance
CCl: Commission for Climatology (of WMO)
CECILIA: Central and Eastern Europe Climate Change Impact and Vulnerability Assessment (EU-project)
CIB: Climate Indicator Bulletin (part of EURO4M)
CIRCE: Climate change and impact research: the Mediterranean environment (EU-project)
CIRCLE: Climate Impact Research Coordination within a Larger Europe (EU ERA-Net activity)
CIRES: Cooperative Institute for Research in Environmental Sciences
CLARIS-LPB: A Europe-South America Network for Climate Change Assessment and Impact Studies
CLIVAR: International research programme on Climate Variability and Predictability
CLIWOC: Climate of the world's oceans (EU-project)
CLT: Climate Liaison Team (part of EURO4M)
CM-SAF: Satellite Application Facility on Climate Monitoring
COPES: Coordinated Observation and Prediction of the Earth System (WCRP strategy 2005-2015)
COST: European Co-operation in the field of Scientific and Technical Research
CPP: Cloud Physical Properties
CRUTEM3: Climatic Research Unit's Land Air Temperature database
DARE: Data Rescue (WMO initiative)
DWD: Deutscher Wetterdienst (German Weather Service)
DYNAMITE: Understanding the Dynamics of the Coupled Climate System (EU-project)
E-Obs: ENSEMBLES gridded daily dataset for Europe
ECA&D: European Climate Assessment & Dataset
ECMWF: European Centre for Medium-Range Weather Forecasts
ECOCHANGE: Biodiversity and ecosystem changes in Europe (FP-project)
ECVs: Essential Climate Variables (defined by GCOS)
EEA: European Environment Agency
EIONET: European Environment Information and Observation NETwork

ELDAS: Development of a European Land Data Assimilation System to predict Floods and Droughts (EU-project)

EMI: European Meteorological Infrastructure

EMSLP: EMULATE Mean Sea Level Pressure dataset

EMULATE: European and North Atlantic daily to MULtidecadal climATE variability (EU project)

ENSEMBLES: ENSEMBLE-based Predictions of Climate Changes and their Impacts (EU-project)

EQUAL II: A laboratory for new ideas to the European Employment Strategy and the Social inclusion process (EU initiative)

ERA-Interim: ECMWF reanalysis

ERA-40: ECMWF reanalysis for the period from September 1957 to August 2002

ERA-75: Proposed next generation ECMWF reanalysis

ERAMESAN: Meso-scale reanalysis by SMHI

ERA-Net: FP-scheme for the coordination and cooperation of national and regional programmes

ERBE: Earth Radiation Budget Experiment

ESA: European Space Agency

ESPON: European Spatial Planning Observation Network

ESRL: Earth System Research Laboratory (USA)

ETCCDI: Expert Team on Climate Change Detection and Indices

EUMETNET-ECSN: European Climate Support Network of the Network of European Meteorological Services

EUMETSAT: European Meteorological Satellite Organisation

EURO-LIMPACS: Integrated project to evaluate impacts of global change on European freshwater ecosystems (EU-project)

EURO4M: EUropean Reanalysis and Observations for Monitoring (this project)

EuroClim: European Climate Change Monitoring and Prediction System (EU-project)

EuroCryoClim: European Climate Change Monitoring and Prediction System

EUROGRID: European Gridding (EUMETNET-ECSN project)

EuroGLOBEC: European global ocean ecosystem dynamics

EURRA: European Regional Reanalysis

GAIA-network: Network for female earth scientists in the Netherlands

GAR: Greater Alpine Region

GAW: Global Atmospheric Watch

GCOS: Global Climate Observing System

GEMS: Global and regional Earth-system (Atmosphere) Monitoring using Satellite and *in situ* data

GEO: Group on Earth Observations

GEOLAND2: Integrated GMES Project On Land Cover and Vegetation (EU-project)

GEOSS: Global Earth Observations System of Systems

GERB/CERES: Geostationary Earth Radiation Budget/Clouds and the Earth's Radiant Energy System

GEWEX: Global Energy and Water Cycle Experiment

GIS: Geographical Information System

GMES: Global Monitoring for Environment and Security

GMR: Greater Mediterranean Region

GPCC: Global Precipitation Climatology Centre

GPCP: Global Precipitation Climatology Project

GSN: GCOS Surface Network
GTS: Global Telecommunications System
GUAN: GCOS Upper Air Network
HadAT: Hadley Centre gridded radiosonde temperature dataset
HadCRUH: Hadley Centre and Climatic Research Unit's monthly mean surface humidity dataset
HadCRUT3: Hadley Centre and Climatic Research Unit's Air and Marine Temperature Anomalies Version 3 dataset
HadISST2: Hadley Centre Sea Ice and Sea Surface Temperature dataset
HadSLP: Hadley Centre mean Sea Level Pressure dataset
HadSST2: Hadley Centre Sea Surface Temperature dataset
HIRLAM: High-Resolution Limited-Area Model
HOAPS: Hamburgs Ocean Atmosphere Parameters from Satellite dataset
HOLSMEER: Late holocene shallow marine environments of Europe (FP-project)
HOME: Advances in Homogenisation Methods of Climate Series: An Integrated Approach (COST-Action)
HRT-GAR: High resolution Temperature Climatology for the Greater Alpine Region
H-SAF: Satellite Application Facility on Support to Operational Hydrology and Water Management
IAPP: International ATOVS Processing Package
ICOADS: International Comprehensive Ocean-Atmosphere Dataset
IGRA: Integrated Global Radiosonde Archive (www.ncdc.noaa.gov/oa/cab/igra/index.php)
IMPROVE: Improved Understanding of past climatic variability from early daily European instrumental sources (EU-project)
INSPIMET: EUMETNET group that oversees the user requirements for the implementation rules of INSPIRE
INSPIRE: INfrastructure for SPatial InfoRmation in Europe
INTAS: International Association for the Promotion of Co-operation with Scientists from the New Independent States of the Former Soviet Union
IPCC: Intergovernmental Panel on Climate Change
IPCC-AR4: Fourth Assessment Report of the IPCC
IPCC-TAR: Third Assessment Report of the IPCC
IPY-CARE: Climate of the Arctic and its Role for Europe (CARE) - a European component of the International Polar Year (EU-project)
ISCCP: International Satellite Cloud Climatology Data
ISH: Integrated Surface Hourly dataset
ISOWG: GMES In Situ Observation Working Group
ISPD: International Surface Pressure Data Bank
JCOMM: Joint WMO/IOC Commission for Oceanography and Marine Meteorology
JRC: Joint Research Centre
KNMI: Royal Netherlands Meteorological Institute
Land-SAF: Land Surface Analysis Satellite Applications Facility
LIFE AIRFORALL: Air Pollution Forecasting, Alert and Monitoring System on Short Time Scale, at local and regional scale in unfavourable meteorological and topographic conditions
LIFE ASSURE: Assessment System for Urban Environment
MACC: Monitoring Atmospheric Composition and Climate
MEDARE: MEditerranean climate DAta REscue Initiative under the auspice of WMO

MedCLIVAR: Mediterranean CLIVAR
MESAN: Meso-scale analysis system by SMHI
METAFOR: Common Metadata for Climate Modelling Digital Repositories (EU-project)
METEOSAT: Meteorological Satellite of ESA and EUMETSAT
MF: Météo France
MICE: Modelling the Impact of Climate Extremes (EU-project)
MO: Met Office
MOCCA: MOnitoring Climate variability and Change for an improved environmental and risk management in the Alpine space
MOODLE: course management system (Open Source)
MS: Meteo Swiss
MSLP: Mean Sea Level Pressure
MSG: METEOSAT Second Generation
MSU: Microwave Sounding Unit
MVIRI (SEVIRI): satellite instrument on-board of MSG
MyOCEAN: GMES service for ocean monitoring and forecasting
NAE: North Atlantic and European (NWP configuration)
NARR: North American Regional Reanalysis
NCAR: National Center for Atmospheric Research (Boulder, Co, USA)
NCDC: National Climatic Data Center (Asheville, NC, USA)
NCEP: National Centers for Environmental Prediction (USA)
NERC: Natural Environmental Research Council (UK)
NetFAM: Nordic Network on Fine-scale Atmospheric Modelling
NitroEurope: Contribution of Nitrogen to the net greenhouse gas budgets of Europe
NMA: National Meteorological Administration
NMHS: National Meteorological and Hydrological Service
NOAA: National Oceanic & Atmospheric Administration (USA)
NORDKLIM: Nordic co-operation within climate activities
NWCSAF: Nowcasting Satellite Applications Facility
NWP: Numerical Weather Prediction
OOPC: Oceanic Observation Panel for Climate (part of GCOS)
OPAG: Open Programme Area Group (WMO/CCL body)
QC: Quality Control
QCCCE: Queensland Climate Change Centre of Excellence (Australia)
PDSI: Palmer Drought Severity Index
PET: Potential Evapotranspiration
PROMOTE: PROtocol MOniToring for the GMES Service Element: Atmosphere
PRUDENCE: Prediction of Regional scenarios and Uncertainties for Defining EuropeaN Climate change risks and Effects (FP-project)
SAF: Satellite Application Facility (EUMETSAT)
SAFRAN: Meteorological analysis system
SBSTA: Subsidiary Body for Scientific and Technological Advice
SCCONE: Snow Cover Changes over Northern Eurasia during the last century (INTAS-project)
SCIAMACHY: SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY
SDI: Spatial Data Infrastructure

SEIS: Shared Environmental Information System
SEVIRI: satellite instrument on-board of MSG
SIM: Hydrometeorological model
SMHI: Swedish Meteorological and Hydrological Institute
SST: Sea Surface Temperature
STARDEX: Statistical and Regional dynamical Downscaling of Extremes for European regions (EU project)
SYNOP: Synoptic observation
UEA: University of East Anglia (Climatic Research Unit)
UKCIP08: UK 21st Century Climate Scenarios
UNESCO-Bilko: United Nations Educational, Scientific and Cultural Organization project for training in coastal and marine remote sensing
UNFCCC: United Nations Framework Convention on Climate Change
URV: University Rovira i Virgili
WASA: Waves and Storms in the North Atlantic (FP-project)
WCDMP: World Climate Data Monitoring Programme
WCRP: World Climate Research Programme
WEELS: Wind Erosion on European Light Soils (FP-project)
WHO: World Health Organization
WIS: WMO Information System
WMO: World Meteorological Organization
WWW: World Weather Watch
3D-Var: Three-dimensional Variational (analysis or assimilation)
4D-Var: Four-dimensional Variational (analysis or assimilation)