



SEVENTH FRAMEWORK PROGRAMME  
FP7-SPACE-2010.1.1-04  
GA No. 262255  
**[Restricted]**

A collaborative project aimed at pre-validation of a GMES Global Water Scarcity Information Service

<b>Deliverable No.</b>	GLOWASIS D60.2
<b>Deliverable Title</b>	Final Report
<b>Dissemination level</b>	Restricted
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<b>Issue date</b>	29-May-2013

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## Executive summary

This final project report describes the FP7 project GLOWASIS ('A collaborative project aimed at pre-validation of a GMES Global Water Scarcity Information Service'), running from January 2012 until March 2013. It comprises a summary description of the project context and objectives, a description of the main S&T results, the potential impact (including the socio-economic impact of the project) and the main dissemination activities and exploitation of results. It also includes a plan for the use and dissemination of foreground, to spread awareness.

The GLOWASIS project has had a duration of two years and three months and has started in January 2011. The project has pre-validated a COPERNICUS/GMES Global Service for Water Scarcity Information. In European, African and global pilots we have combined societal water demand data with hydrological models, in-situ and satellite derived water cycle information to derive water scarcity data. The project has added value to JRC's European Drought Observatory seasonal forecasting skills and to JRC's reporting for the Blueprint on Safeguarding Europe's Water Resources. We have created historical time series and have made the first step in creating global operational water scarcity forecasts. The open data from the GLOWASIS project contains water cycle information from water demand, satellites and meteorological and hydrological models and can be used by river basin agencies to add value to their drought forecasting research. Besides its outstanding scientific results and firm links to GEO/GEOSS, the project also features a popular website, where awareness for the complexity of water scarcity is created by visualizing our data in animations, blogs by experts and a daily newspaper on water scarcity and drought.

The GLOWASIS service uses data from GMES Core Services LMCS Geoland2 and Marine Core Service MyOcean, agricultural and industrial water use and demand and additional water-cycle information from existing global satellite services. Also, data sources from GEWEX' initiatives (i.e. International Soil Moisture network) and GEOSS are promoted. In-depth interviews and advisory workshops with UN-WFP, UN-FAO, EEA and the Australian Bureau of Meteorology have taken place. GLOWASIS plays a role in the joint drought-flooding forecasting platform within the new Group on Earth Observation 2012 Work Plan, GEO task WA-01-C2: 'Information Systems for Hydro-Meteorological Extremes (Incl. Floods and Droughts)'. International advisors have acknowledged the added value of the project (e.g. "GLOWASIS results demonstrate that integrating water scarcity into COPERNICUS climate and land services is needed and feasible"). We hope to have created a user-scientist community to guide earth observation scientists to more efficient innovation for the specific purpose of water scarcity assessment and forecasting.

The most important scientific results of the project have been:

- Seasonal forecasts on water scarcity and drought with a better known uncertainty;
- Long-term (decade or more) time series of drought parameters observed by satellites or modeled (or combined);
- The use of additional satellite sources for drought and water scarcity assessment and forecasting;
- Setting the path towards drought warning indicators for decision makers;
- Open data dissemination of all our datasets;
- 20+ peer reviewed papers (a.o. Nature and Science).

The costs for exploitation of the project results in a GMES/Copernicus Service have been estimated at 817,802 EUR for a period over three years. Without this budget we cannot guarantee the operational exploitation of the open data GLOWASIS portal and data servers.

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# 1. Summary description of the project context and the main objectives

## 1.1 Information from the Annex I of Grant Agreement

Project title: A collaborative project aimed at pre-validation of a GMES Global Water Scarcity Information Service

Starting date: 01-Jan-2011

Duration in months: 24

Call identifier: FP7-SPACE-2010-1

Activity code: SPA.2010.1.1-04: Stimulating the development of GMES services in specific areas

## 1.2 General description of the GLOWASIS project, goals and activities

GLOWASIS has pre-validated a GMES Global Service for Water Scarcity Information. In European and global pilots it has combined hydrological models with in-situ and satellite derived water cycle information, as well as statistical water demand data. GLOWASIS is set up as an open data portal, where water scarcity model time series and relevant satellite derived. Water cycle parameters can be downloaded. Awareness for the complexity of water scarcity is created on a popular website. By creating a user-scientist community (by stakeholder consultation, linking with GEOSS and GEO community, blogs etc), GLOWASIS guides earth observation scientists to efficient innovation for the specific purpose of water scarcity assessment and forecasting. By linking water demand and supply in three pilot studies with existing platforms (a.o. European Drought Observatory and PCRGLOBWB) for seasonal forecasting in Europe, Africa and worldwide, GLOWASIS' information can contribute both in reporting for emerging drought events as well as in provision of climate change time series. By combining water cycle variables with water demand, GLOWASIS has streamlined the variety of water scarcity information. The GLOWASIS data portal is set up for dissemination of integrated data for open standard applications. By disseminating on a data portal as well as on a popular website, including a daily newspaper, more awareness for the complexity of water scarcity research has been raised. The service uses data from GMES Core Services LMCS Geoland2 and Marine Core Service MyOcean, agricultural and industrial water use and demand and additional water-cycle information from existing global satellite services. Also, data sources from GEWEX' initiatives (i.e. International Soil Moisture network) and GEOSS are promoted. In-depth interviews and advisory workshops with UN-WFP, EEA and the Australian Bureau

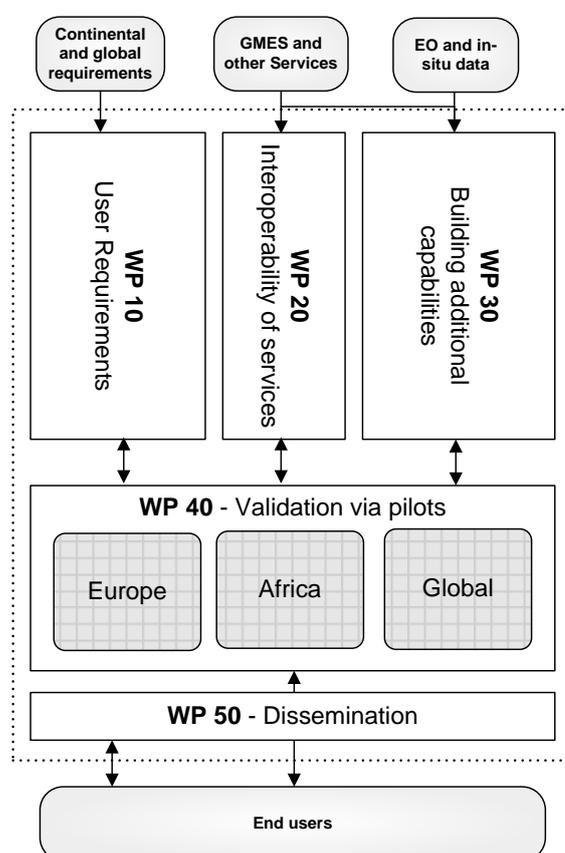


Figure 1-1 Work packages in the GLOWASIS project. WP60 – Management is not shown

of Meteorology have taken place. GLOWASIS plays a role in the joint drought-flooding forecasting platform within the new Group on Earth Observation 2012 Work Plan, GEO task WA-01-C2: 'Information Systems for Hydro-Meteorological Extremes (Incl. Floods and Droughts)'

The project consisted of nine work packages (see figure 1-1), of which seven are considered RTD activities:

WP 10 – User Requirements (RTD);  
WP 20 – Interoperability with Existing Services (RTD);  
WP 30 – Building additional capabilities (RTD);  
WP 41 – Pilot preparations and overview (RTD);  
WP 42 – European pilot (RTD);  
WP 43 – African pilot (RTD);  
WP 44 – Global pilot (RTD);  
WP 50 – Dissemination (OTHER);  
WP 60 – Project Management (MGT).

The project has run until March 2013 and with partners Deltares (coordinator), CNR-ISAC, ECWMF, JRC, NEO, University Utrecht, TU Wien, TNO, University of Santiago de Compostela, IMGW, and University of Kwazulu-Natal. The project is currently awaiting the status of a GMES/Copernicus Service.

## 1.3 Context and objectives

### 1.3.1 Context: why have we done this project?

Water scarcity is caused by economic development, but also has very large economic impacts on society due to crop loss, lower water quality, forest fires, and reduced hydropower generation. In many areas of the world water stress will be enhanced if climate change increases drought occurrence. The existing imbalance of water availability and water demand causes water scarcity to be one of the most pressing environmental issues in the world today. More intense droughts in the past decade, affecting an increasing number of people, have been linked to higher temperatures and decreased precipitation but are also frequently a consequence of the mismanagement of resources. The increased exposure to potential climate change hazards has led to more **awareness of water resources management**. The uneven distribution of water resources over time and space and the way human activity is affecting that distribution today are fundamental sources of water crises in many parts of the world.

Worldwide, water observation networks provide incomplete and incompatible data on water quantity and quality for properly managing water resources and predicting future needs – and these networks are in jeopardy of further decline. While new technologies based on **satellite remote sensing and modelling** present opportunities, their value is limited by our ability to **ground-truth** and validate the simulated information. Management of the world's water resources requires reliable information about the state of the resource and how it is changing in response to external drivers such as climate change and water and land use. There is little sharing of hydrologic data, largely due to limited physical access to data, policy and security issues, lack of agreed protocols for sharing and commercial considerations. This hampers regional and global projects that build on shared datasets for scientific and applications-oriented purposes, such as seasonal regional hydrologic outlooks, forecasting, disaster warning and prevention, and integrated water resources management in **transboundary**

basins. One of the greatest opportunities and challenges of the EC Water Framework Directive (WFD) is the obligation to manage waters across frontiers. To consider a river basin district as an entity requires transboundary, integrated assessment and management. Close interaction with INSPIRE is necessary to ensure harmonized European products for further use at all (global/national/local) levels. It is however recognised that **the amount of in-situ data will be insufficient** in the coming years. Most river basins lie in the territory of more than one Member State. Improving water resources management requires investments on a regional, continental and possible global scale in monitoring and more efficient use of existing data, including traditional ground-based observations and newer satellite-based data products. Most countries, developed and developing, need to give greater attention to monitoring of the status of water resources.

In both developed and developing countries, water protection can only be successful, if the public is informed and involved. Interest groups play a key role, since they represent the entire range of pressures on water bodies, no matter whether economic uses, nature protection or leisure are concerned. In the future, environment authorities will closer co-operate with users and environmentalists, as, today more than ever, it is important to let all water users participate in reflections and actions. Public participation in drafting management plans is obligatory from 2006 on. Today anybody can use the internet for information on the state of the water bodies in his/her immediate neighbourhood.

It was estimated that by 2007, at least 11 % of Europe's population and 17 % of its territory had been affected by water scarcity, putting the cost of droughts in Europe over the past thirty years at EUR 100 billion. The European Union expects further deterioration of the water situation in Europe if temperatures keep rising as a result of climate change. Water is no longer the problem of a few regions, but now concerns all 500 million Europeans. The main overall objective of EU water policy is to ensure access to good quality water in sufficient quantity for all Europeans, and to ensure the good status of all water bodies across Europe. Therefore, policies and actions are set up in order to prevent and to mitigate water scarcity and drought situations, with the priority to move towards a water-efficient and water-saving economy. The major challenge from water scarcity and droughts has been recognised in the Communication "Addressing the challenge of water scarcity and droughts" from the European Commission adopted in 2007. Implementation of the Communication is periodically assessed through annual Follow-up Reports. Finally, the European Commission's 'Blueprint to Safeguard Europe's Water Resources' was launched in November 2012 by DG Environment.

With varying opinions in technology and policies on climate, drought and water resource management it is complex to create a helicopter view of all ongoing activities for water resource management. When zooming in to technology involved in climate change with relation to drought, streamlining will also be complex as we live in a dynamic environment in which the actual status and importance of activities can not always be put in a logical order of importance and accuracy. In this dynamic environment, there is a structural need for understandable information for river catchment agencies, and governmental continental and global water resource organisations.

### **1.3.2 S&T objectives**

The main objective of the proposed project GLOWASIS has been to pre-validate a **GMES Global Service for Water Scarcity Information**. On a European and global scale on the scale of river catchments it has focused on building and validating a '**one-stop-shop**' portal in which existing water supply and water demand data services for water resource management

are combined. Awareness will be created for government and industry for the scientific complexity of the water scarcity problem. For scientists, it will be possible to promote innovative observational methods for water cycle parameters while matching these to user requirements. GLOWASIS will create the means of defining and promoting guidelines for combining different types of data (i.e. in-situ – satellite; statistical – physical; satellite – satellite, etc.).

R&D has focused on relating water demand information to water supply information in a water scarcity information service in three pilots, in an infrastructure in which the added value of in-situ and satellite data for the water resources management of river catchment authorities is obvious, as well as the need for innovations in this area. The overall R&D question can be compiled into one main question:

**How can the manager's countermeasures with respect to water scarcity be strengthened with the help of EO and in situ measurements?**

In more detail, R&D can be focused in three bullets:

- Creating awareness for the public, water managers and the scientific community. This 'socio-economic' part will translate scientific output for the water managers and convert user requirements to data requirements and accuracy of EO and in-situ data on a river catchment scale. Close and iterative collaboration with end-users worldwide in the pilot studies is foreseen, by research on
  - Defining existing methods, the countermeasures and obligations of water managers on a regional, continental and global scale;
  - Global and continental governmental structures (WWAP, WFD, IPCC, EEA water demand studies);
  - Possible solutions of EO for transboundary problems;
  - Translation of decision parameters to bandwidth in measured parameters;

The user requirements, resulting from end user needs, can be very different when looking at different managers. Three examples:

- 1) the European Drought Observatory needs NRT input of in-situ and satellite data to improve the forecast capability of drought parameters;
  - 2) The UN, European Environmental Agency and DG-ENV need more and better monitoring data for their (mostly annual) analyses on water resources. Also, they are in need of seasonal forecasts of drought as well as water scarcity for better water strategies;
  - 3) End user systems (a.o. Catchment agencies in Europe, Africa and Australia) need fit-to-purpose data for their water accounting studies, that are ranging from European satellite data to short-, medium-, and seasonal forecasts to better water demand statistical data.
- IT R&D on interoperability of existing EO Services, GMES Core Services and open standard water management platforms. Tasks are:
    - Standardization and implementation of meta-data standards following INSPIRE initiatives;
    - Interoperability and interconnection of management platforms with existing services;
    - Improved accessibility to and use of in-situ systems;
    - Guidelines for combining different types of data sources for water scarcity;
    - Creating an interface for interaction of governmental/management organisation and researchers in the WISE(-RTD) portal.

- Adding capabilities by EO and in-situ data in the water cycle on some issues:
  - Enhanced error characterisation of model and observed data combinations;
  - Enhancements in climatology;
  - Incorporation of global groundwater information;
  - Production of extended satellite rainfall and snow datasets;
  - Harmonisation of errors in data assimilation;
  - Incorporation of new and future satellite services (SMOS, CryoSAT-2 and Sentinel);
  - Improvement in soil moisture index products;

**In-situ data** is foreseen to include existing GRDC hydrological gauges and soil moisture sensor networks from GEWEX' International Soil Moisture Network, urban and industrial water-use, land-cover and land-use data, and possible other agricultural and geo(hydro)logical data.

**EO data** is foreseen to be used from existing Land Core Mapping Service (LandSAF products, Soil Moisture, Freeze Thaw, land use, soil sealing), Marine Core Service MyOcean (sea level), satellite precipitation products (TRMM, AMSU-B, SSM/I, SSMIS) and other predominantly European satellite sources ASCAT, SMOS, ASAR, MERIS, GRACE, AMSR-E, CryoSat-2, and MODIS.

## 2. Main S&T results / foregrounds

### 2.1 Overall

The GLOWASIS project has pre-validated a COPERNICUS/GMES Global Service for Water Scarcity Information. In European, African and global pilots we have combined societal water demand data with hydrological models, in-situ and satellite derived water cycle information to derive water scarcity data. The project has added value to JRC's European Drought Observatory seasonal forecasting skills and with JRC's reporting for the Blueprint on Water Scarcity. We have created historical time series and have made the first step in creating operational water scarcity forecasts. The open data from the GLOWASIS project contains water cycle information from water demand, satellites and meteorological and hydrological models and can be used by river basin agencies to add value to their drought forecasting research. Besides its outstanding scientific results and firm links to GEO/GEOSS, the project also features a popular website, where awareness for the complexity of water scarcity is created by visualizing our data in animations, and blogs by experts. By combining water cycle variables with water demand, GLOWASIS has streamlined the variety of water scarcity information. The GLOWASIS data portal is set up for open data dissemination of integrated data for open standard applications. By disseminating on a data portal as well as on a popular website, including a daily newspaper, more awareness for the complexity of water scarcity research has been raised. The service uses data from GMES Core Services LMCS Geoland2 and Marine Core Service MyOcean, agricultural and industrial water use and demand and additional water-cycle information from existing global satellite services. Also, data sources from GEWEX' initiatives (i.e. International Soil Moisture network) and GEOSS are promoted. In-depth interviews and advisory workshops with UN-WFP, UN-FAO, EEA and the Australian Bureau of Meteorology have taken place. GLOWASIS plays a role in the joint drought-flooding forecasting platform within the new Group on Earth Observation 2012 Work Plan, GEO task WA-01-C2: 'Information Systems for Hydro-Meteorological Extremes (Incl. Floods and Droughts)'. International advisors have mentioned the added value of the project as GLOWASIS results demonstrate that integrating water scarcity into COPERNICUS climate and land services is needed and feasible". We hope to have created a user-scientist community to guide earth observation scientists to more efficient innovation for the specific purpose of water scarcity assessment and forecasting.

The most important scientific results of the project have been:

- Seasonal forecasts on water scarcity and drought with a better known uncertainty;
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- The use of additional satellite sources for drought and water scarcity assessment and forecasting;
- Setting the path towards drought warning indicators for decision makers;
- Open data dissemination of all our datasets;
- 20+ peer reviewed papers (a.o. Nature and Science).

### 2.2 Main S&T results per work package

#### 2.2.1 User Requirements

In work package 10, in the first six months a first requirements document has been established, which has been iterative refined through user feedback from questionnaires, in-

depth interviews, case studies and the expert blogs. The resulting document can be downloaded from the project website on <http://glowasis.eu/results/>.

## 2.2.2 Data portal

In work package 20, the data portal has been built. All the datasets resulting from the GLOWASIS are open: they can be viewed and downloaded by everyone.

Data can be directly downloaded through the OPeNDAP framework through the GLOWASIS data core server at <https://glowasis.deltares.nl/thredds/catalog/opendap/opendap/catalog.html>. All datasets are available through this data core.

Data can be viewed on the GLOWASIS Data Portal (<http://portal.glowasis.eu>). The viewer in this portal connects to a data core server and creates visual maps in popular and commonly used formats, including a Google Earth plugin. These maps can be used by the public, media and policy makers. The GLOWASIS data portal acts as a demonstrator.



Figure 2-1 – Example visualization of the Data Portal.

Registration for the portal is recommended, but not mandatory. Registered users will be sent a manual on how to use the data, and a summarized description of the portal data, and will be notified in case of updates.

## 2.2.3 Satellite derived additional capabilities

The satellite derived hydrological products, which are available on the data core server, have been built and improved in work package 30. A description on these parameters, as well as

summarizing factsheets, are available from the GLOWASIS project website on <http://glowasis.eu/results/>.

These products have also (partly) been used in the case studies.

All project data is available on the GLOWASIS portal (more details on <http://glowasis.eu/getdata>). GLOWASIS has focused on the added value of satellite signals in the following units:

- Soil moisture
- Ground Water
- Precipitation
- Meteorological assessment and forecasting
- Hydrological assessment and forecasting

*Soil Moisture*

We have calculated a more consistent error characterisation of satellite soil moisture datasets which have combined satellites into a 32 year dataset (a.o. AMSR-E, ERS and EUMETSAT-ASCAT) in light of the WACMOS/ESA CCI project. These datasets can be used as an assessment tool and warning indicator for drought. An example is shown in Figure 2-2, where the anomaly related to the climatology is shown and an indication of unusual drought is shown.

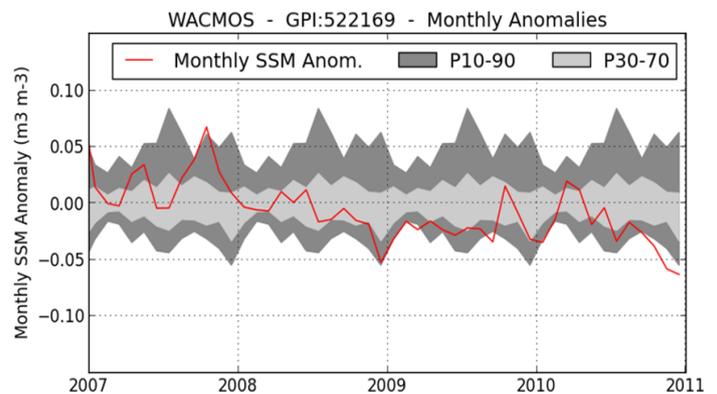


Fig.2-2 – relative surface soil moisture anomaly in the Horn of Africa from 2007 to 2011. The red line gives the anomaly compared to the climatology, shown in the 10-90 percentile and 30-70 percentile in grey.

*Groundwater*

GLOWASIS has improved a global water table. It gives the 'Equilibrium Water Table' (EWT): a climatological mean water table shown in figure 2-3. The calculations are based on satellite derived topography, 30 years of climate data coming from three Global Land Data Assimilation System (GLDAS) Data Products and soil texture from a global (FAO) database. The EWT has been published in Science Magazine in 2013.

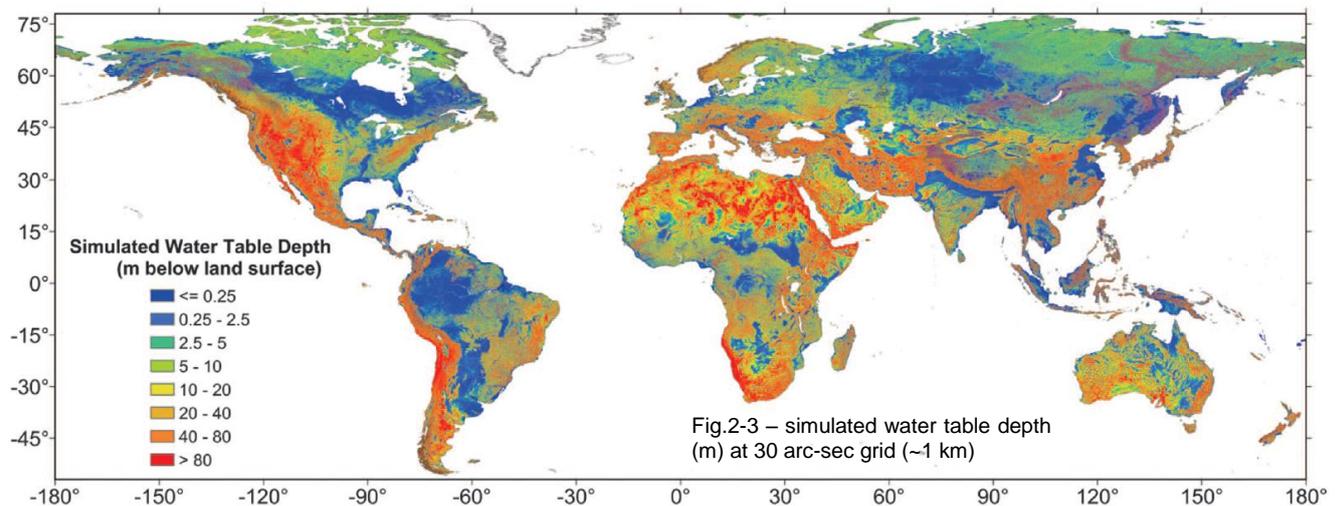
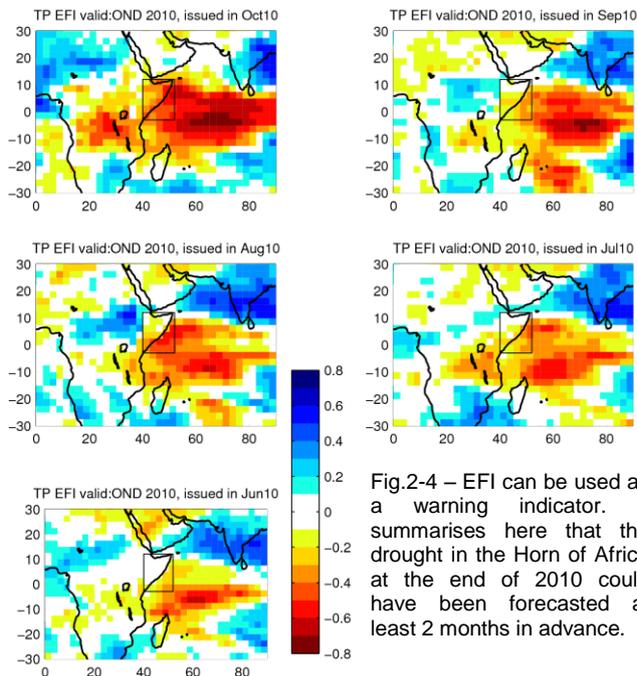


Fig.2-3 – simulated water table depth (m) at 30 arc-sec grid (~1 km)

### Precipitation and Snow

The GLOWASIS project has evaluated several precipitation and snow products. Satellite precipitation proves its value in places where the density of in-situ rain gauges is sparse. For example, in Europe increased model skill by adding satellite precipitation has not (yet) been proven, while it adds much skill to the model simulations in Africa. Several sources of satellite rainfall have been reformatted for optimal use in modelling and put on the data portal. Also, A satellite snowfall algorithm has been developed and applied. Concerning snow extent on the surface, after careful evaluation, a logical conclusion was that combined satellite optical and radar techniques are superior over the sole use of optical satellites. Combined data from the NSDIC, called IMS, has been reformatted and put on the data portal. These are daily snow cover and sea ice data for the Northern hemisphere. We recommend the foreseen findings of the FP7 Cryoland project (<http://cryoland.eu/>), where these combinations will be available and improved.



### Meteorological assessment and forecasting

We have developed the seasonal version of the Extreme Forecast Index (EFI), which for precipitation and temperature gives a summary of the proportion of 51-ensemble member forecast being over or under the climate average. This indicator can be used as a first indicator of an upcoming drought in areas where drought is governed by ‘teleconnections’ (like La Niña and El Niño). An example visualisation is shown in figure 2-4.

### 2.2.4 Case studies

The case studies were performed in work packages WP41-44. All project data on the hydrological outputs from the global case study are available on the GLOWASIS portal (more details on <http://glowasis.eu/getdata>).

Through European and African pilot studies, JRC’s LISFLOOD has been used for seasonal drought forecasting. LISFLOOD establishes the basis for the European Drought Observatory. A screen of the EDO website is shown in figure 5. In November 2012, the JRC has published two new assessments on the effects of combinations of measures on water availability and water quality to 2030. These assessments were carried out in support of the European Commission’s ‘Blueprint to Safeguard Europe’s Water Resources’, which was launched in November 2012 by DG Environment. While most of the work was funded from JRC’s core budget, parts of the work were

developed with funds from DG Environment and through the FP7 GLOWASIS project. The GLOWASIS project delivered water requirement data for non-EU countries, and some of the algorithms developed for GLOWASIS on the Water Exploitation Index were directly embedded in the Blueprint work.

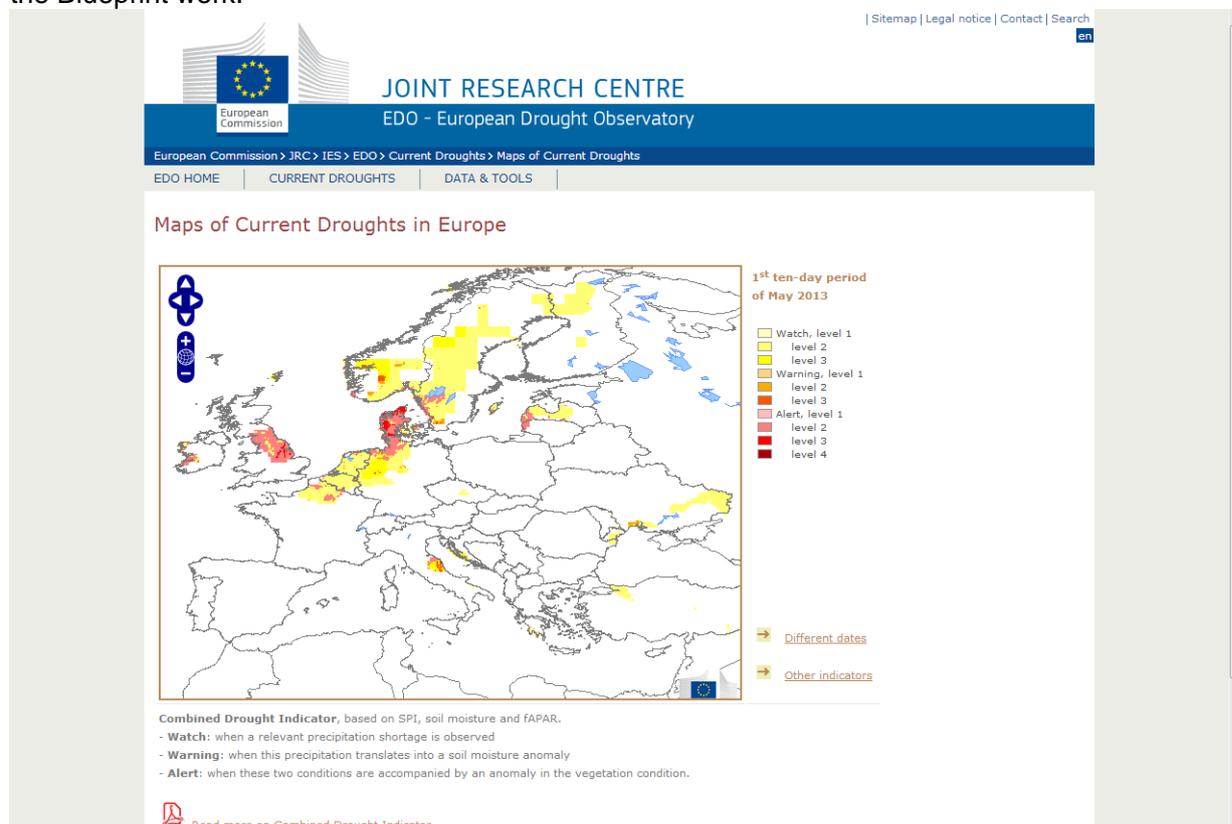


Fig. 2-5 – European Drought Observatory (source <http://edo.jrc.ec.europa.eu/edov2/php/index.php>)

With a global hydrological model and input from a range of satellite source derived precipitation we have made a long term assessments (50 years) of monthly water scarcity and terrestrial water cycle parameters using the PCRGLOBWB model, including water demand from all sectors (agriculture, domestic, industrial) at ~10km resolution. The same model has been evaluated for its skill to forecast on an operational scale, and the tests have been evaluated in the case studies. In general we concluded, that with the best data available we can forecast about 1-2 months in advance when a drought will occur. This lead time however is depending on the area in the world; it is sometimes more governed by meteorology and sometimes more to hydrology. GLOWASIS has resulted in clear visualisation of this dependency in so-called Critical Lead Time plots. Furthermore, the use of warning indicators has been used to take along the uncertainty of the forecast for decision making. Figure 2-7 shows that when taking along the uncertainty of the forecasts, warnings can be issued when most forecast ensembles are below the driest in the climatology (i.e. 30 years of climate data).

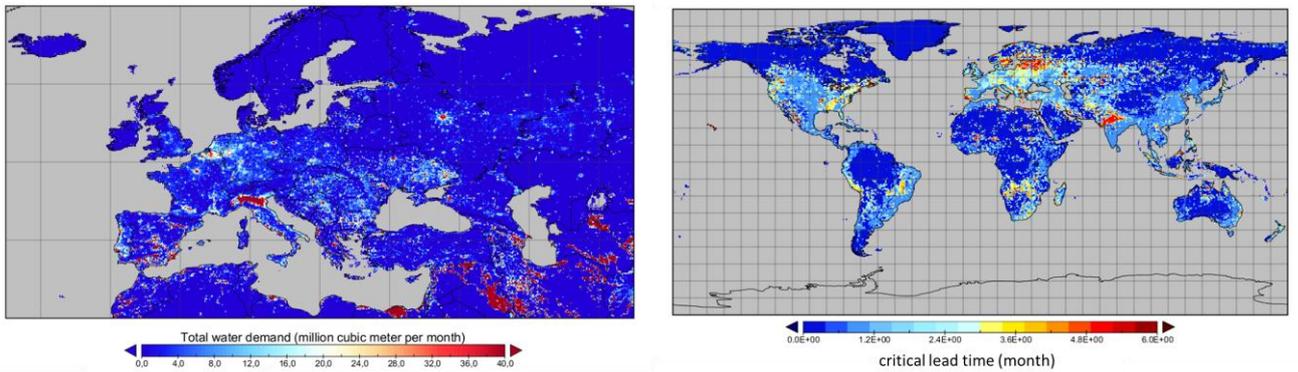


Fig.2-6 – *Left*: Total water demand in July 2003 with a resolution of ~10 km. *Right*: the critical lead time indicates whether forecasting is governed by meteorological or hydrological data

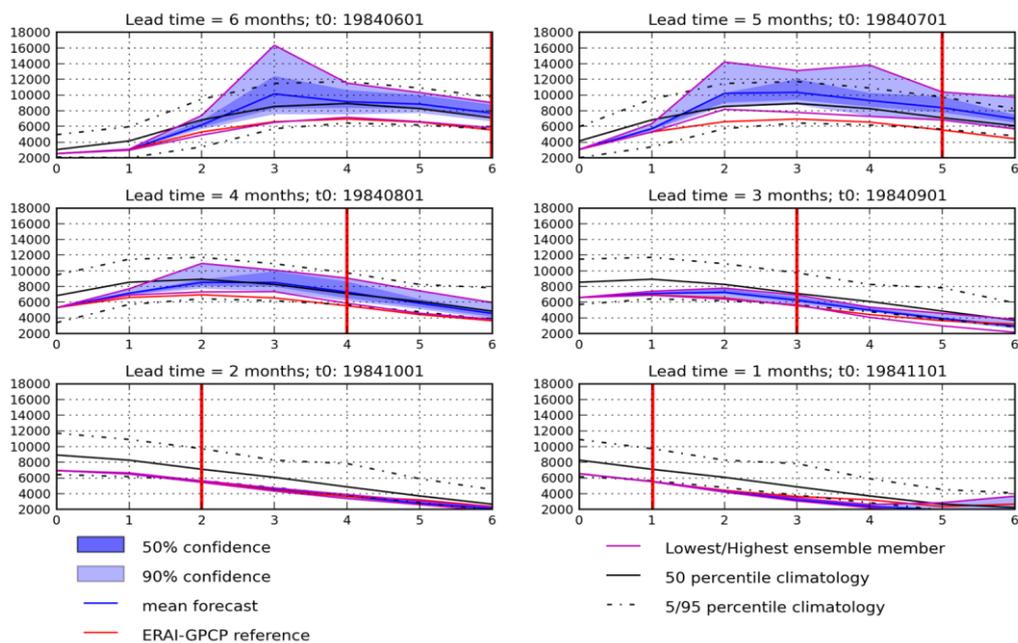


Fig 2-7: For historical cases (in this figure the 1984-85 Horn of Africa Drought), the forecast of water scarcity or other related drought parameters has been tested for its use in decision-making. In this case, 2 to 3 months before the December drought most forecasts were pointing to a drought within or even below the driest 5% of the 30 years climate average

### **3. Potential impact: the dissemination and exploitation of results**

*[The following chapter has been compiled and adapted from the Deliverable D50.5 – Exploitation Strategy.]*

#### **3.1 Benefits of the project**

##### **One-stop-shop for water scarcity information**

By linking existing European satellite services with user communities, government and public, GLOWASIS aims for a significant uptake of these services. By R&D and pilots on combination of data (validation, calibration or assimilation) the capabilities of existing water management tools are improved. The improved achievements of the operational systems in the user community are disseminated in a prototype service on the web. This 'one-stop-shop' portal on water scarcity data strengthens the decision maker's countermeasures with respect to water scarcity forthcoming from user requirements.

##### **Innovative infrastructure**

GLOWASIS establishes an innovative infrastructure. It creates public and governmental awareness and promotion for GMES, EO and in-situ data in a new service for the specific purpose for water scarcity information.

##### **Awareness for complexity**

Awareness is created for government and industry for the complexity of the water scarcity problem. For scientists, it is possible to promote innovative observational methods for water cycle parameters while matching these to user requirements. GLOWASIS creates the means of defining and promoting guidelines for combining different types of data (i.e. in-situ – satellite; statistical – physical; satellite – satellite, etc.).

##### **Promotion of integrated data products**

GLOWASIS aims for the global uptake of the use of GMES Core Service Information by public, government, and industry all over the world, each working with its own software and protocols and each interested in short-term and long-term impact of drought. It helps on-going activities (amongst others GEO, ESA, GEWEX) of combining observation and modelling techniques of the water cycle to be used for water resource management.

##### **Promotion of EO data**

GLOWASIS demonstrates the use of new and future European satellites SMOS, CryoSAT-2 and Sentinel. EO data used are from existing GMES Land Core Services GeoLand2, LandSAF products, Soil Moisture, Freeze Thaw, land use, soil sealing), GMES Marine Core Service MyOcean (sea surface temperature), satellite precipitation products (TRMM, AMSU-B, SSM/I, SSMIS) and other predominantly European satellite sources ASCAT, SMOS, ASAR, including U.S. AMSR-E, and MODIS.

#### **3.2 Target groups**

The dissemination and exploitation strategy focus on three main target groups. The language of communication is in all instances English. Each of these target groups needs a specific approach to ensure awareness and involvement. The GLOWASIS target groups are:

- Different level policy makers and policy advising organisations;
  - Research institutes and universities;
  - The public.
-

### **3.2.1 Policy makers and policy advising organisations**

The project generates scientific advice and expertise that can be used by policy makers as a secondary objective in the fields of environment, food safety and space. Policy makers are made aware of the GLOWASIS results through publications of all sorts, presence at congresses and workshops and direct communication. Policy makers are interested in the GLOWASIS data and maps on regional, national and international levels, since the most detailed level of the data is on the catchment level. Moreover, they require policy drafts which translate the scientific results to relevant applications for policy. For policy makers the focus is on easy access, quick-to-understand information and science translated to policy measures. However, policy advising companies may invest in getting to know scientific data and generate derived products to be used by policy makers.

### **3.2.2 Research institutes and universities**

Researchers are made aware of the GLOWASIS results through publications of all sorts, presence at congresses and workshops and direct communication. Some researchers might be served with the same functionality and information as policy makers depending on their research activities. However, a substantial part of the research community is interested in complete and open access to datasets, scientific articles and methodologies. This target group can invest time in understanding the methodologies and datasets and continue research from where GLOWASIS left of.

### **3.2.3 The public**

For the public the focus is on easy understanding and bringing across the urgency of water scarcity. The information GLOWASIS delivers needs to be straightforwardly accessible and does not need to be complete as long as the main water scarcity message comes across.

### **3.2.4 Associated partners**

The associated partners contribute to the project by steering the project results towards useful products. These products are not only useful and available to the associated partners but also to similar organizations.

#### Policy makers

- Food and Agriculture Organization of the United Nations (FAO), Agro-meteorology Group
- European Commission (EC)
  - Directorate-General Environment (DG-ENV), Water and Adaptation to Climate Change Group
  - Directorate-General Enterprise (DG-ENTR), Global Monitoring of Environment and Agriculture (GMES) Bureau
- Dutch Ministry of Infrastructure and the Environment, Rijkswaterstaat, Directorate Water
- Bureau of Meteorology - Australian Government Directory, Climate and Water Data Branch

#### Research Institutes

- United Nations Educational, Scientific and Cultural Organization (UNESCO), World Water Assessment Programme (WWAP)
- Global Energy and Water Cycle Experiment (GEWEX)
- European Commission (EC)

- European Environment Agency (EEA)
  - Water Group
  - Natural systems and vulnerability programme (NSV)
- Joint Research Centre (JRC), Institute for Environment and Sustainability (IES)
- Météo-France
- Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), Land and Water Group

### 3.3 Dissemination channels

The table below gives an overview of the channels used for dissemination and the target groups that correspond with these channels.

**Table 1. Overview of dissemination channels and its target groups**

Channel	Target group			
	EC	Other policy organisation	Research	Public
Website	X	X	X	X
Blogs	X	X	X	X
Online daily newsletter	X	X	X	X
Daily Twitter	X	X	X	X
Data portal	X	X	X	X
Public deliverables	X	X	X	X
Restricted deliverables	X			
Stakeholders workshops	X	X	X	
Congresses	X	X	X	
Posters, flyers, brochures	X	X	X	
OPeNDAP server		X	X	
Scientific publications			X	

#### 3.3.1 GLOWASIS identity

A suitable and attractive logo was created to firmly establish GLOWASIS's identity and visibility. The design resembles the water cycle and its caption clarifies what GLOWASIS is: a 'global water scarcity information service'.



*Figure 3-1 – The GLOWASIS logo*

This logo is consistently used in all dissemination products such as presentations, the website, the data portal, project reports and policy drafts.

### 3.3.2 GLOWASIS flyer

A one page flyer with a GLOWASIS project summary was disseminated and is available for downloading on the website (<http://glowasis.eu/results/>). This summary contains the project essentials, a list of the participating institutions and an abstract explaining the objectives, dissemination channels and links with other water scarcity initiatives.

### 3.3.3 GLOWASIS website

The GLOWASIS website is the primary entry point to get to know GLOWASIS. The following domain name has been registered since January 2011:

<http://glowasis.eu/>

The website is actively hosted (recovery within 8 hours) and has a memory capacity of 2.000 MB and a data traffic capacity of 200 GB. We will try to keep the website online and active for a minimum of 3 years after the project is finished.

The website has six pages, which will be explained below:

- Home;
- Blog;
- About;
- Results;
- Get data!;
- Contact.



Figure 3-1. Homepage of GLOWASIS website

#### Home

The homepage is the business card of the project. It serves all target groups on the most basic level of dissemination. This page consists of 3 main content sections.

- Tweets  
New content is added daily automatically on the homepage of the website and on Twitter (<http://twitter.com>) by the online content curation service paper.li (<http://paper.li>).
- Blogs

- There is a quick menu on the home page to the blog entries on the blog page.
- Viewer (figure 3-2)
  - This viewer is specifically created for the public target group to get acquainted with water scarcity. The viewer has a limited functionality, which makes it easy to use. Easy to interpret parameters are displayed on a global scale and give a general view of critical water scarcity regions.
  - Several hydrological parameters can be displayed;
  - The point of time to be displayed can be chosen;
  - For pre-set locations, where significant water scarcity has been measured, explanations are available;
  - Standard the viewer is displayed in 3D. However it is possible to change the 3D view to 2D view.

**Blog**

Since April 2012 blog entries have been posted on a monthly basis. These blogs were written by stakeholders and relevant players in the global water scarcity arena, some of whom are on the GLOWASIS advisory board as well.

**About**

This page gives an overview of the GLOWASIS project.

**Results**

The Results page lists the public deliverables with a short explanation and a link to the report. Moreover, there is a link to a 1 page project summary.

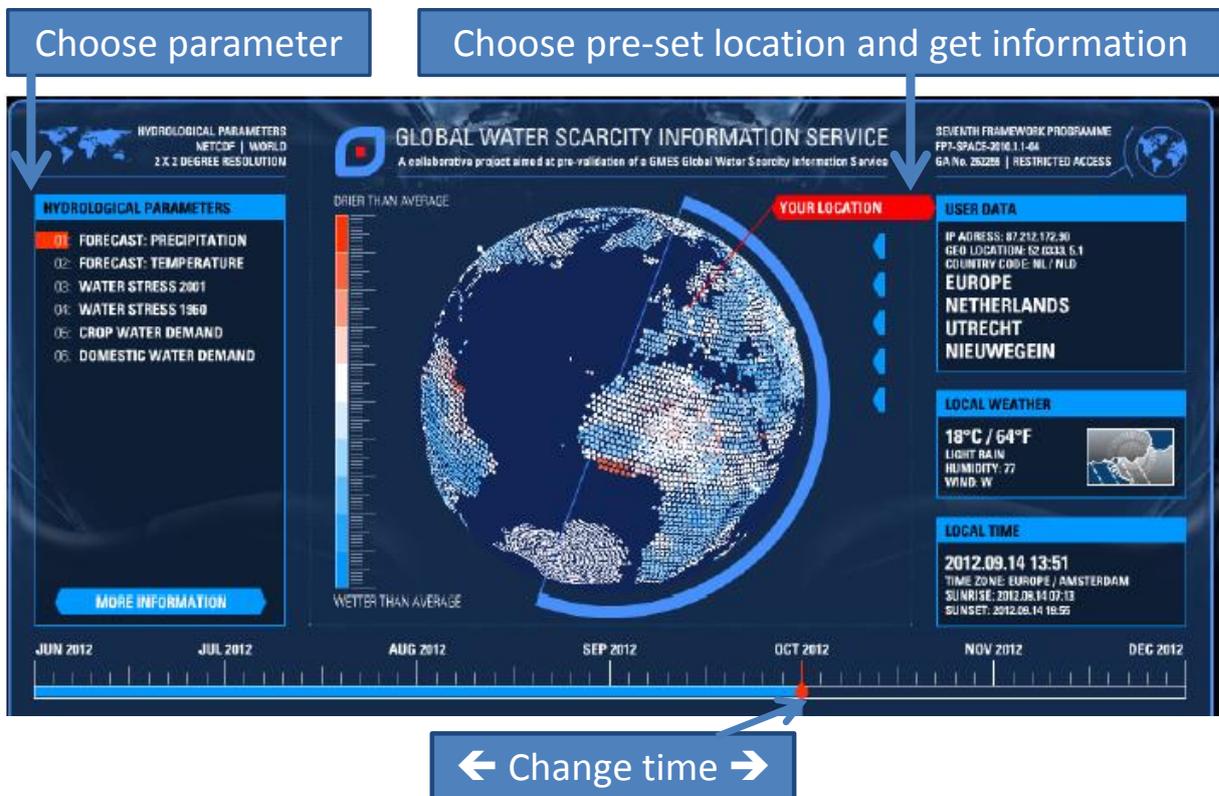


Figure3-2. Three possibilities for using the viewer

### **Get data!**

This page points to the **GLOWASIS DATA SERVERS** and is specifically meant for the target groups policy makers and researchers. For both policy makers and researchers the GLOWASIS data portal (section 3.3.4) is shortly explained and there is a link to this data portal where the GLOWASIS water scarcity parameters can be viewed and maps and data can be downloaded.

Specifically for the research user community there is a short explanation of the GLOWASIS data core server (where the actual data are) and there is link to a viewing server where parameter datasets can be sliced in space and time before downloading.

Moreover, on this page there is a short registration form to be filled in by visitors interested in getting data.

### **Contact**

The contact page lists the contact details of the project coordinator and renders the possibility to leave a comment or ask questions with an online contact form.

#### **3.3.4 GLOWASIS data portal**

The GLOWASIS data portal gives access to all datasets resulting from the GLOWASIS project. We will try to keep it online and functional for a minimum of 3 years after the project is finished.

In work package 20, the data portal has been built. All the datasets resulting from the GLOWASIS are open: they can be viewed and downloaded by everyone.

Data can be directly downloaded through the OPeNDAP framework through the GLOWASIS data core server at <https://glowasis.deltares.nl/thredds/catalog/opendap/opendap/catalog.html>. All datasets are available through this data core.

Data can be viewed on the GLOWASIS Data Viewing Portal (<http://portal.glowasis.eu>). The viewer in this portal only uses open source software and connects to a data core server and creates visual maps in popular and commonly used formats, including a Google Earth plugin. These maps can be used by the public, media and policy makers. The GLOWASIS data portal acts as a demonstrator.

## **3.4 Open data and Intellectual property management**

In the Consortium Agreement the ownership, dissemination and exploitation of background and foreground is specified.

As set out in the Consortium Agreement background will always remain the property of the partner that created this background and involved it in the project. Background that laid the foundation for foreground can be disseminated and used in this specific relation. For example, for the GLOWASIS project several pre-existing models were used to create the GLOWASIS hydrological parameter datasets. The methodology used to create these models is available in the form of scientific articles.

The foreground resulting from the project is owned by the partner that produced that specific foreground. In respect to dissemination and exploitation of foreground one of the key principles of the GLOWASIS consortium is the ambition to use as much open source data infrastructure

as possible. This facilitates not only free sharing of data between online data service points, but also makes all project results freely available for viewing and downloading to anyone who is interested.

The GLOWASIS open source data portal delivers open data on water scarcity, water demand and related satellite and model derived data. Most data are long term time series, such as 1960-2010, 1980-2010, or 2000-2010, as measured by satellites, as calculated by (statistical / hydrological / land-surface / atmospheric) models, or as a combination of measurements and model results.

All data offered on the portal is queried from the data core- <http://glowasis.deltares.nl/>, which is an open source data infrastructure. Information on the intellectual property rights is incorporated in the metadata of the online available data files, but there is also an overview for all parameters available in PDF format. If not mentioned or incomplete as described in the disclaimer of each data set, the license for the data is a Creative Commons Attribution-NonCommercial 3.0 Unported License:



For more information: <http://creativecommons.org/licenses/by-nc/3.0/>

### 3.5 Impacts on society

The GLOWASIS project is a major player in the scientific water scarcity community. It aids the politic and scientific community with improved seasonal forecasting methodologies and data and it creates public awareness of water scarcity and drought.

#### 3.5.1 Project Advisory Board

During the project, two Advisory Meetings have taken place, in which the following stakeholders were invited:

##### Policy makers

- Food and Agriculture Organization of the United Nations (FAO), Agro-meteorology Group
- European Commission (EC)
  - Directorate-General Environment (DG-ENV), Water and Adaptation to Climate Change Group
  - Directorate-General Enterprise (DG-ENTR), Global Monitoring of Environment and Agriculture (GMES) Bureau
- Dutch Ministry of Infrastructure and the Environment, Rijkswaterstaat, Directorate Water
- Bureau of Meteorology - Australian Government Directory, Climate and Water Data Branch

##### Research Institutes

- Global Energy and Water Cycle Experiment (GEWEX)
- European Commission (EC)
  - European Environment Agency (EEA)
    - Water Group
    - Natural systems and vulnerability programme (NSV)

- Joint Research Centre (JRC), Institute for Environment and Sustainability (IES)
- DG-ENV
- Météo-France

Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO), Land and Water Group

Through the project Advisory Stakeholder Meetings, the following was said about the GLOWASIS project results:

- “GLOWASIS results demonstrate that integrating water scarcity into COPERNICUS climate and land services is needed and feasible”;
- “Water scarcity & drought early warning forecasting up to seasonal scale is very promising”;
- “GLOWASIS has made an important step in helping the global community understand the complexity of drought and help us better prepare for future of droughts in a changing climate”;
- “Significant steps have been made towards improving our forecasting and predictive capabilities around drought occurrence”
- “Satellite soil moisture drought indication is sometimes more reliable than large-scale hydrometeorological model output”

### **3.5.2 Policy briefs**

Three GLOWASIS policy briefs were disseminated, one in June 2011 (in which several projects were presented at a GMES Meeting for water) and one in June 2012 (where the Project Officer presented several project at an EC meeting), to frame the research agenda on water scarcity for Horizon 2020. The final policy brief from March 2013 has focussed on the use of the GLOWASIS data for policy making and the added use of earth observation satellite signals for drought and water scarcity assessment and forecasting.

### **3.5.3 Contribution to ‘A Blueprint to Safeguard Europe’s Water Resources’**

The GLOWASIS project results aided DG-ENV of the EC in writing the ‘Blueprint to Safeguard Europe’s Water Resources’, which was published on 14 November 2012. The GLOWASIS project delivered water requirement data for non-EU countries, and some of the algorithms developed for GLOWASIS on the Water Exploitation Index were directly embedded in the Blueprint work. It can be downloaded here: [http://ec.europa.eu/environment/water/blueprint/index\\_en.htm](http://ec.europa.eu/environment/water/blueprint/index_en.htm)

### **3.5.4 Contribution to decision-making - river catchment and civil protection**

At the European Commission's JRC the LISFLOOD model is used to simulate and forecast water resources and water scarcity at pan-European and pan-African scale. At the global scale, the PCRGLOBWB model has done the simulations. Both models require remote sensing, as well as quasi-static GIS data as model input. In the context of model requirements GLOWASIS can be regarded as a platform to fill the gaps. Missing data (or missing data in appropriate quality) is therefore either produced by project partners or made available through existing products.

The value addition of GLOWASIS to forecast drought has been shown in the case studies, where for different drought parameters we have shown that forecasting drought and water scarcity parameters 1-2 months or more in advance is feasible.

### **3.5.5 Contribution to decision-making - climate change**

The contribution consists of three parts:

- An overview of long-range weather forecasts;
- Their capacity use for the prediction of water scarcity;
- The added value of satellite data to improve this capacity;
  - Long term historical simulations in which we prove that it is feasible to provide a bandwidth relating to the climate extremes (i.e. when is my drought forecast below the lowest of the last 30 years?)
  - A list of possible indicators useful for validating the medium- to long-range weather forecasts produced at ECMWF (like SPI Standardized precipitation index, SPEI Standardized Precipitation Evapotranspiration index, SRI Standardized runoff index, Soil Moisture, PDSI Palmer Drought Severity Index, etc)

### **3.5.6 Contribution to short and long term global water resource management**

While for short-term decision-making on basin scale auxiliary data may play an inferior role, long-term decision-making on global scale has to take several key factors into consideration, which are badly integrated and thus represented on that scale. Some examples include irrigated area, paddy rice area, percolation rates in paddy soils, overall irrigation efficiencies and precipitation. GLOWASIS contributes to increase data quality by provision, inter-comparison and validation of data from different sources to facilitate more accurate monitoring, as well as to increase the reliability of forecasts.

As long as these auxiliary data cannot be provided next to classical water scarcity products such as drought indices, operational and research organisations will keep lacking helpful information on water use. The user requirement questionnaires illustrated that water demand is a missing parameter in the water assessments of all three organisations. GLOWASIS provides in this missing parameter. The relation between water supply and water demand data is essential for water resource management.

The distributed hydrological model PCR-GLOBWB and the ECMWF forecast fields provide the opportunity for verification of forecasts of drought indicators.

### **3.5.7 Contribution to data presentation - governance and legal issues**

With respect to the European scale the WFD (2000/60/EC, Article 8) requires member states to develop monitoring "in order to establish a coherent and comprehensive overview of the water status within each River Basin District". These monitoring initiatives have to cover surface- and ground waters. Therefore, GLOWASIS:

- links the different data sources on water supply and demand in one portal;
- creates new products for monitoring and forecasting;
- supports the WFD common implementation strategy on water scarcity and droughts, which aims at contributions to the EDO and WISE, the definition of commonly accepted indicators, the link of policies to research, etc.

GLOWASIS also defines a framework for access rights and provide information on propagation of errors and uncertainty to INSPIRE.

Governance and legal issues determine properties of the portal with respect to data presentation and data exchange. These properties are:

- clear licensing of all data available through portal;
- using open and/or low-cost standards;
- providing uninterrupted operation of service;

- possibility of a clear and rapid application for administrative decision-making based on properties mentioned above.

## **3.6 Exploitable results**

In this section the exploitable results of the GLOWASIS project are described. The detailed descriptions of the products can be found on the factsheets on the website (<http://glowasis.eu/results>). The results are a pre-validated open source data portal and several datasets of improved hydrological parameters. For extensive descriptions of the GLOWASIS parameters other reports are recommended. The report on improved hydrological parameters version 2 (D30.4) reads as a factsheet of the GLOWASIS parameters. The report on improved hydrological parameters version 2 (D30.5) is a comprehensive report on the improvements made on the characterization of the identified hydrological parameters and their uncertainties. Both reports are available on the GLOWASIS website: <http://glowasis.eu/results>.

### **3.6.1 European and Global Seasonal Forecasting Service**

The European Drought Observatory has been improved by the addition of GLOWASIS project results, especially the addition of water demand data and algorithms.

On a global scale, the system that has been developed has been validated in the case studies and can be implemented to provide global seasonal forecasts on drought and water scarcity.

### **3.6.2 GLOWASIS Pre-validated open source data portal**

Water scarcity and drought concerns and interests the public as well as scientists and policy makers. The GLOWASIS consortium aims at bringing free information and services to these different types of stakeholders via freely accessible pathways. The data available from the portal are described in more detail in the Exploitation Strategy Report D50.5, but are summarised below, including the improvements that have been made in the G:PWASIS project:

- Global Water stress; improvement: data available from 1958-2010;
- Global Water demand; improvement: data available from 1958-2010;
- Extreme Forecast Index; improvements: seasonal, available with most up-to-date forecasts;
- Equilibrium Water Table; improvements made in validation.
- Surface and Profile Soil Moisture datasets; improvements in more consistent error characterisation;
- Precipitation; Improvements, a diverse range of satellite precipitation datasets available from 2000-2010 in a uniform format.

## **3.7 Operational exploitation**

The exploitability of each GLOWASIS dataset has been described in the project's Exploitation Strategy. The operational exploitation is summarised in this paragraph and amounts up to a total cost of 817,802 Euro for a period of three years.

### **3.7.1 ICT, servers and maintenance**

The operational stage describes the minimal exploitation scenario. The website, data portal and data core server are kept online and functional for the period of 3 years after project's end. No new datasets are added. The website remains available for the public. Registered organisations can directly plug the GLOWASIS data into their own data viewers using WMS or

WCS protocols. This type of exploitation serves solely as an overview of what the GLOWASIS research has resulted in and delivers the opportunity for other organisations to use the results for further research or policymaking. For the operational stage a couple of conditions need to be met. For the combined efforts the total estimated amount of 68,270 Euro is needed.

### **3.7.2 Political and scientific exploitation**

For political and scientific exploitation after project's end it is necessary to update the GLOWASIS datasets. For this exploitation scenario all the conditions of the operational stage are met, and in addition all temporal datasets are generated and updated online for the period of 3 years by the GLOWASIS partners. This will significantly improve the impact of the portal and data core server, which will offer users up-to-date backcasts, nowcasts and forecasts for 3 years after the end of the project. For the combined efforts for this stage the total estimated amount of 715,032 Euro is needed. This is based on continuation of all the datasets provided within the GLOWASIS research project.

### **3.7.3 Exploitation through program collaboration**

During the project phase, GLOWASIS has been part of the GEO Work Program. Mainly as part of the joint drought-flooding forecasting platform within the new Group on Earth Observation 2012 Work Plan, GEO task WA-01-C2: 'Information Systems for Hydro-Meteorological Extremes (Incl. Floods and Droughts)'. Also, GLOWASIS is part of the Integrated Global Water Cycle Observations (IGWCO) Community of Practice.

For preparation, travel and wrap-up of these activities the total yearly estimated amount of 11,500 Euro is needed, which is summed up to 34,500 Euro for a three year period.

## **3.8 Funding strategies**

For finding an optimal strategy, the GLOWASIS consortium has had discussions with the European Research Executive Agency (the project officer), JRC, EEA, DG-ENV during the project. Unfortunately, the DG-ENV people have been found to be hard to reach, resulting in two no-shows from DG-ENV at the GLOWASIS Stakeholder meetings and two visits to DG-ENV in Brussels in 2011 and 2012.

For the exploitation of the GLOWASIS foreground two main strategies could be used:

- Each GLOWASIS hydrological parameter is funded by a specific stakeholder and available through the most suitable GLOWASIS exploitation platform;
- Datasets are delivered to EDO and made available via their platform.

### **3.8.1 Datasets available at GLOWASIS exploitation platform**

Based on the overview of exploitability and the production costs funding can be requested from suitable parties. This funding can come from:

- Global organizations (UN), but these do not have too much funding for these prototype research products;
- DG-ENV or GMES/Copernicus, through an Inland Water Data Core Service. This is currently the most feasible option and appropriate actions are taken for this.in collaboration with the Project Officer.

### **3.8.2 Datasets available at EDO platform**

Some datasets could be made available on the EDO platform, but as there is also much discussion on the research funds of the EDO group within JRC (coming from DG-ENV), we have not reached a clear target on how to act on this.

### **3.8.3 Conclusive strategy**

Despite the efforts made, up to this moment we do not know where the funding for the operational, as well as political/scientific exploitation has not been found and therefore we cannot guarantee the operational exploitation of the open data GLOWASIS portal and data servers.