Value of satellite EO-enhanced models for policy and decision making

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History of Changes

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List of Acronyms

ACube4Floods	Flood Event Monitoring and Documentation enabled by the Austrian Sentinel Data Cube
ADCP	Acoustic Doppler Current Profiler
AIS	Automatic Identification System
APA	Portuguese Environment Agency
ARERA	Italian Regulatory Authority for Energy, Networks and Environment
ARCOS	Arctic Observatory for Copernicus SEA
BEYOND	Centre of EO Research and Satellite Remote Sensing
BSH	British Federal Maritime and Hydrographic Agency
CDR	Climate Data Record
CGLS	Copernicus Global Land Service
CEMS	Copernicus Emergency Management Service
CENIA	The Czech Environmental Information Agency
CLMS	Copernicus Land Monitoring Service
CNES	French Space Agency
CNRS	Centre National de la Recherche Scientifique
C3S	Climate change service
DEM	Digital Elevation Model

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DEMARINE-2	German Nationales Forum Fernerkundung und Copernicus
DGT	Portugese Direção-Geral do Território
DINOloket	Portal for subsurface data in the Netherlands (for groundwater)
DMI	Danish Meteorological Institute
DREAL	Regional authorities (Directions Régionales de l'Environnement, de l'Aménagement et du Logement)
DRMKC	European Disaster Risk Management Knowledge Centre
DWD	German Weather Service
ECMWF	European Centre for Medium-Range Weather Forecasts
ECVs	Essential Climatic Variables
EDO	European Drought Observatory
EEA	European Environmental Agency
EELIS	Estonian Nature Information System
EFAS	European Flood Awareness System
EnSAG Phase II	German Centre for Natural Ecosystems and Ecosystem Transitions
ELY Centres	Finland Centre for Economic Development, Transport and the Environment

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EmissionSEA	Emission assessment, reduction and avoidance of ships by evaluating AIS signals
EMOWAF	Project EO and Monitoring for better Water Management and Flood Prevention in Bulgaria
EMS	Emergency management Service
EnMAP	Environmental Monitoring and Analysis Programme
EO	Copernicus Earth Observation
EOP-Danube	Earth Observation Platform for the Greater Danube Region
EPAMA	The Public Entity for the Management of the River Meuse and its Tributaries
EPA	Environment Protection Agency
ERA-5	fifth generation ECMWF reanalysis for the global climate and weather for the past 4 to 7 decades
ESA	European Space Agency
ESOTC	European State of the Climate
ESTHub	National Satellite Data Centre
EU-DEM	EU- Digital Elevation Mopdel
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FAO	Food and Agriculture Organization

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FCUP	Framework for Copernicus User Uptake
FD	Flood Directive
FRM	Flood Risk Management
FRMP	New geodata to improve water
GeoWAM	German project on Ensuring safety on seaways with remote sensing
GEUS	Geological Survey of Denmark and Greenland
GHG	Green House Gassess
GIS	Geographic Information System
GLDAS	Global Land Data Assimilation System
GMTED 2010	Global Multi-resolution Terrain Elevation Data
GPCP	Global Precipitation Climatology Project
GRDC	Global Data Runoff Center
GRUMO	National Groundwater Monitoring Network
HIMIOFOTS	Hellenic Integrated Marine Inland Water Observing Forecasting and Offshore Technology System
HOBE	Danish Hydrological research laboratory
IGiK	Institute of Geodesy and Cartography
IO PAS	Polish Academy of Sciences
IPMA	Portuguese Institute for Sea and Atmosphere
IDAs	Inter-communal Development Associations
ISPRA	Italian Institute for Environmental Protection and Research

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IMGW-PIB	Polish Institute of Meteorology and Water Management - National Research Institute
INRAE	France's new National Research Institute for Agriculture, Food and Environment,
JRC	Joint Research Centre
KelpMap 2.0	Atmosphere correction for scientific use of EnMAP and Sentinel-2 data in turbid coastal waters
KCEO	Knowledge Centre on Earth Observation
LAKESAT	Lake surface temperature satellite data
LAWA	German Federal/state working group on water
LEGMC	Latvian Environment, Geology and Meteorology Centre
LGS	Lithuanian Geological Survey
LHS	Lithuanian Hydrometeorological Service
LOOP	Agricultural Catchment Monitoring Program
LSWT	Lake Surface Water Temperature
LU/LC	Land Use Land Cover
MODIS	Moderate Resolution Imaging Spectroradiometer
MICKA	Czech environmental information portal
NARW	National Administration Romanian Waters
NASA	National Aeronautics and Space Administration

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NCW	National Council for Water
NEPA	National Environment Protection Agency
NEREUS	Network of European Regions Using Space Technologies
NIHWM	National Institute of Hydrology and Water Management
NIRD	National Institute for Research and Development
NOA	National Observatory of Athens
NOVANA	National Monitoring Program for Aquatic Environment and Nature
OPW	Office of Public Works
OVF	General Directorate of Water Management
RBM	River Basin Management
RBMP	River Basin management Plan
ROSA	Romanian Space Agency
Rrs	Remote Sensing Reflectances
RS	Remote Sensing
RSS Hydro	Luxembourg Institute of Science and Technology
SAR	Synthetic-aperture radar
SDFE	Danish Agency for Data Supply and Infrastructure
SDGs	Sustainable Development Goals

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Sentinels4Marine	Plastic Waste - Pollution of aquatic ecosystems with plastic waste: Global and local monitoring using satellite-supported methods
ShipTac	Integrative use of X- and C-band SAR data for tactical ship route planning in arctic waters
SNIG	National Spatial Data Infrastructure
SOS	Satellite-based Operational Planning
SSW	Special Secretariat for Water
SWAT	Soil & Water Assessment Tool
SWOT	Surface Water and Ocean Topography
SYKE	Finish Environmental Institute
Tarkka	Finish Satellite images services
TanDEM-Ice	Glacier monitoring in high Asia using TanDEM-X InSAR and other earth observation sensors
UBA	German Environment Agency
UNOSA	United States Office for Space Affairs
UoMs	Units of Management
VESI	Inter-agency water portal
WP	Work Package
WALOUS	Wallonia Land use and land cover mapping for flood risk management
Water JPI	European Water Joint Programming Initiative

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WEO	Water Earth Observation
WFD	Water Framework Directive
WISA	Water Information System Austria
WRI	Water Research Institute

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Table of Contents

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

Executive Summary

The Horizon2020 project Water scenarios For Copernicus Exploitation (Water-ForCE) will develop a Roadmap for Copernicus Inland Water Services. The Roadmap will assess the current state of water related services provided by six existing Copernicus Services and will provide an optimal way forward for satisfying different user and stakeholder communities.

The current report provides the current state of the art in modelling using remote sensing (RS) services and data for water quantity and quality for decision support and policy. The report gives special attention to Copernicus services, in order to better formulate recommendations for the Water-ForCE final roadmap.

The analysis carried out in preparing this report focussed on three main pillars: EU institutions and their policies; the specific approaches by national policies in all EU countries and approaches at international level. The analysis presented in this deliverable is based on previous deliverables of WaterForCE, such as D3.3., and D1.4 and D1.6, looking at how the Copernicus data can be more effectively used in developing and delivering the next versions of the directives.

Present deliverable summarized the efforts of different countries, Eu agencies and International agencies to integrate EO data in policies, through modelling for more effective use of current and future Copernicus data.

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The analysis pointed out that the reasons for slow uptake of RS in general and/or Copernicus data in water management are primarily in the characteristics of the sector. Water is critical resource for so many different socio-economic activities, there are many different water management aspects: water resources assessment, planning development and protection (both surface water and groundwater), public water supply, waste water treatment and disposal, management of water-related disasters such as floods and droughts, agricultural water use (irrigation and drainage), water for energy production, inland navigation, water-related ecosystem services, tourism and recreation (including bathing waters), etc. This situation has resulted in distribution of water management across different organizations, agencies and actors, at different government level (national, regional, municipal), with complex inter-relationships, which sometimes hamper collaboration and use of integrated approaches. Because of this necessarily distributed management model, introduction of RS / Copernicus data in the diverse water management activities is still challenging.

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1. Introduction

1.1. Water-ForCE

Remote Sensing methodologies have seen major improvements over the last decade, but their uptake is still limited, owing to a lack of skills within the water sector regarding RS; sometimes limited confidence and overall lack of concerted effort to support their validation and integration. In EU the Copernicus programme was initiated to fill spatial and temporal gaps in availability of environmental data for management and decision making.

In this context the Horizon 2020 project Water-ForCE (Water scenarios for Copernicus Exploitation) is developing a Roadmap to better integrate the entire water cycle within the Copernicus services, thereby addressing needs and requirements from the user community, the current disconnection between Remote Sensing / in-situ observations and upgrade of the modelling algorithms.

The Roadmap will contain:

- Analysis of user communities' landscape
- Analysis on how Copernicus water services can support policy development and monitoring of their implementation
- Gap analysis of the Copernicus water-related service portfolio
- Identification of future higher-level biogeochemical products
- Technical requirements for future Copernicus sensors to improve the water-related service portfolio

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- Proposal for organising in situ measurement networks to validate Copernicus Remote Sensing and modelling products and to provide complementary data not collected by Remote Sensing
- Proposal on how to define relationships between Core Services and Downstream services
- Recommendation on the evolution of a water service (via the creation of a new service, or the improvement of water services under current Copernicus services, or through a better integration of water-related products)

The Water-ForCE project is coordinated by the University of Tartu (Estonia) with 20 participating organisations from all over Europe. It connects experts in water quality and quantity, in policy, research, engineering and service sectors. The project is divided into eight work packages (WP), each of them focusing on a specific problem and/or target of the Copernicus services. The project started on 1st of January 2021 with a duration of three years.

This report is part of Work Package 5 (WP5) “Modelling and data assimilation” which overall objective is to build on the knowledge acquired in WP1 to WP4 to identify the potential for future use of different satellite EO data in modelling of water resources for support of decision makers towards adaptive management of water resources and policy implementation. In particular Available satellite EO data were evaluated

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within D5.1, followed by a guide on how models should be adapted to use existing Copernicus data, including the use of Artificial Intelligence (AI), reported in D5.2. The findings were integrated in the present report showing the value of satellite EO-enhanced models for policy and decision making.

1.2. Purpose of this document

The current report provides the overview on how satellite EO and modelling aspects are used for providing better decision support and operational management, including their use in policy implementation at EU level and internationally.

The report gives special attention to Copernicus services, in order to better formulate recommendations for the Water-ForCE final roadmap. A series of challenges, to which solutions might be found through the roadmap, are stated in section 3.3 of this report.

1.3. Content of the Report

This document starts with an introduction presenting the scope of WaterForCE project, followed by an overview of the policies implementation at the EU level, based on three available Copernicus services for inland water. Three main EU institutions (EEA, JRC and European Civil Protection) are presented along with the directives they are improving through their work, analysis and implementation. Third

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section of the report presents what is the situation of using Copernicus data at national level. Fourth chapter presents overall use of RS at international level and the efforts in use of RS in policies.

The report ends with the conclusion section followed by references. Due to high number of links to sites where policies and national implementation of them is presented, along with use of RS, a special section with all links is provided after References.

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2. EU institutions use of RS in modelling for policies

This chapter of the report provides insights on how Copernicus satellite data are used by European institutions in their policy-making process, first introducing the relevant data and services used, and then giving detailed use cases per institution. In the context of this paragraph, European institutions are considered the Directorate General departments, executive agencies, and services who are using Copernicus Earth Observation (EO) data to develop policies for inland water, from a quantitative point of view. It is important to mention that only the Copernicus services and products relevant for water quantity policies are presented, discarding those datasets or services that are not related to the scope of this report (i.e. Copernicus Atmosphere, Marine, Security, European Forest Fire Information System).

2.1. Overview of Copernicus services used for inland waters

The considered Copernicus services in this present analysis of policies for inland waters, along with the EU institutions supporting these services are presented below.

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2.1.1. Copernicus Land Monitoring Service (CLMS)

The CLMS is jointly coordinated by the Joint Research Centre (JRC) and the European Environmental Agency (EEA) and it provides geographical information on land cover based on satellite imagery for several environmental applications, including applications in the fields of water management and climate change. CLMS products are used by many national and international agencies for a wide variety of purposes. The principal user among the European institutions is the EEA, which uses the data provided by CLMS to monitor the general status of water at the European level to check whether new policies are needed. The satellite-based datasets used by the EEA are:

- Urban Atlas, which provides Land Use Land Cover (LULC) information in urban environments and it is used to assess the extents of floods;
- Riparian Zones, providing information on the transitional areas occurring between land and freshwater ecosystems, which are adopted to define potential flood management measures;
- Water and Wetness, which shows the occurrence of water and wet surfaces from 2009 to 2018 and it is employed to assess the morphology of large rivers.
- Other satellite-based products such as Corine Land Cover, developed by CLMS, are employed by other Copernicus

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services for hydrological modelling (which are detailed in this report in the section on the Emergency and the Climate Change services). Moreover, details on how the EEA uses CLMS data are given in section 2.2 related to European institutions.

2.1.2. Copernicus Emergency Management Service (CEMS)

The aim of the CEMS is to provide valuable information to support stakeholders in making decisions during natural or manmade disasters (e.g. floods, droughts, fires), by constantly monitoring Europe and forecasting the occurrence of such events. In case a disaster is forecasted, the CEMS alerts the national authorities interested, which in turns can ask CEMS for specific additional information to support their decision making. CEMS data and products are also used in non-emergency situations by the European Disaster Risk Management Knowledge Centre (DRMKC). Detailed information on DRMKC is given later in this report in section 2.2, where JRC is presented. The DRMCK uses the information to observe and understand disasters genesis and evolution, and then use the information gained to develop new policies to prevent and reduce disaster risks.

The emergency management service has two main components, the on-demand mapping and the early warning and monitoring service, each with a different scope.

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2.1.2.1. Early warning and monitoring monitors European ongoing situation both in terms of floods and droughts, through the developed European Flood Awareness System (EFAS) and the European Drought Observatory (EDO), respectively. Both services are developed by the JRC.

EFAS is a European operational service developed to monitor and forecast flood events, mainly in large-scale and transboundary river basins. It is based on their LISFLOOD spatially distributed hydrological model developed by JRC. A series of applications of this model for policies are presented at JRC site. Although the primary focus of EFAS is in forecasting floods in real time, LISFLOOD model is also used in a monitoring context, using observations as meteorological forcing input, and to assess climate change effects, using climate projections as meteorological forcing. The output of the model, mainly flows and soil moisture, are used to monitor droughts (more details in the EDO description), and to monitor the general state of the climate (see the Climate Change Service section). Moreover, LISFLOOD hydrological model is also used by JRC to produce studies in anticipation and evaluation of European policies.

EDO uses both in-situ and satellite observations to compute a set of indicators for detecting drought events of different nature (meteorological, hydrological, agricultural) and drought impacts on soil, water and vegetation. In addition, EDO provides reports with the analysis of extreme drought events in Europe, based on the indicators computed. This information is used by the European Civil Protection and Humanitarian

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Aid Operations and the Disaster Risk Management Knowledge Centre (DRMKC) to develop policies aimed at preventing and reducing disaster risks, by EEA to monitor the status of water resources. The satellite-based datasets used in EDO are the MODIS Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), used to compute anomaly of vegetation condition (agricultural drought), and Corine Land Cover, Imperviousness layer, EU-DEM all employed to run LISFLOOD hydrological model and compute the low flow index and soil moisture anomaly (hydrological and agricultural drought respectively). Important to mention that though Sentinel has its own FAPAR data, EDO uses MODIS which is not a Copernicus product.

2.1.2.2 On-demand mapping provides maps of the disaster upon request of a stakeholder (usually a national government) to gather more information on the severity and extension of the event. The mapping can be done both during and after a disaster occurred. In the former case, satellites are pre-tasked to acquire new images in a specific area where a disaster has been forecasted. Pre-tasking needs are related to major challenges in using satellite data and are detailed in EFAS pre-tasking website, as it is for example the case of large-scale floods are forecasted by EFAS. Users can request to map the territory through satellite images before and after the disaster occurred and to make retrospective analysis, to help risk preparedness and the development of recovery plans. The users of the on-demand service are both national governments and EU institutions,

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which need to acquire pre and post-disaster satellite images to understand the evolution of the event and use the information learnt to develop European policies for increasing preparedness and disaster risk reduction.

2.1.3. Climate change service (C3S)

C3S was established to provide constant and reliable information related to climate change to the European Union, in order to support the European development of climate change mitigation and adaptation policies. This task is fulfilled by both analysing future climate projections and monitoring the past and present climate, using observational data. In the latter case, C3S produces, in collaboration with ECMWF and on behalf of the European Commission, monthly climate bulletins and annual reports on the European State of the Climate (ESOTC). The annual reports are focused on Europe and the Arctic and provide an overview of the climate both at the seasonal and annual scales, also giving updates on the current situation and on a set of long-term key climate indicators. The satellite datasets used to produce annual reports on ESOTC are: Corine Land Cover, Imperviousness layer, EU-DEM all employed to run LISFLOOD hydrological model and compute river discharges; C3S soil moisture v202012 dataset based on the PASSIVE data record, used to estimate soil moisture during floods, droughts and heatwaves; Global Precipitation Climatology Project (GPCP), which formally is not developed by C3S, however available as a C3S service, to monitor precipitation; Level-4 Sea

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Surface Temperature, used for the analysis of extreme precipitation events; various satellite products used to produce the ERA-5 reanalysis dataset.

2.2 European institutions and policies

2.2.1 European Civil Protection

European Civil Protection (ECP) is part of the Directorate General department of Civil Protection and Humanitarian Aid Operations. It aims at aiding countries affected by disasters and/or humanitarian emergencies, providing help during or after disasters occur.

The European Civil Protection supports the development of European policies focused at preventing and reducing disaster risks (e.g. floods and droughts) and their impacts on society by regularly producing overviews of natural and manmade disaster risks that are challenging the European territory. In this task, the Civil Protection is helped by specific working groups and by the DRMKC, which carry out multi-disciplinary research to monitor the evolution of disaster risk, identify its major drivers and assess the priority areas for policy development (ECHO, 2021) Those activities are achieved through the use of the Copernicus Emergency Service products, both for early warning and monitoring (EDO, EFAS) and for on demand mapping.

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2.2.2. Joint Research Centre (JRC)

JRC is the science and knowledge service of the European Commission and its main scope is to carry out independent scientific research to support the development of European policies, promoting an evidence-informed policy making process. Among its activities, JRC is the developer and coordinator of products and services such as EDO, CLMS and LISFLOOD model, which are used by JRC itself and also by other European institutions to monitor the current status of water resources and climate.

The LISFLOOD hydrological model is used by JRC to produce studies that support the policy making process both in the formulation and in evaluation phases. Examples of usage of LISFLOOD in formulation of policies are: the assessment study of the impacts of climate change, land use, and water usage on Europe's water resources (Bisselink et al, 2018), which was accompanying the document "Proposal for a Regulation of the European Parliament and of the Council: on minimum requirements for water reuse"; a study to assess the impacts of the policy "A Blueprint to safeguard Europe's waters" before it was released by the Directorate General Environment department (DG NEV) (JRC et al, 2012). An example on the usage of LISFLOOD for evaluation of policies is the study on the assessment of four policy measures related to water savings on European water resources (EC et al., 2020)

In order to inform policy makers at different levels, including the European one, and to provide them with necessary tools throughout the whole policy making process, JRC created several Knowledge and Competences

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Centres to analyse and review the current state of play on specific matters, such as disaster risk management and EO. Among the knowledge centres, the most relevant for inland water related policies are the Disaster Risk Management Knowledge Centre (DRMKC) and Knowledge Centre on Earth Observation (KCEO). DRMKC employs data and products from the Emergency Service and the Land Monitoring Service (EDO, EFAS, European Soil Database & soil properties, Corine Land Cover) to produce risk analysis maps both for flood and drought risks. This knowledge centre works in close collaboration with the European Civil Protection to develop policies aimed at preventing and reducing disaster risks. KCEO primarily aims at promoting the usage of EO products by policy makers, by assessing and translating the needs of European policies into technical requirements for EO, but also showcasing how remote sensing data are or could be applied in support of existing policies.

2.2.3. European Environment Agency (EEA)

The EEA is an agency of the European Union which aims at providing reliable information to be used by policy makers to develop, implement and evaluate environmental policies. The description on how EEA implments policies using Copernicus services can be found here. The main clients of EEA are some of the European Union institutions, such as the European Commission, the European Parliament, the Council, Economic and Social Committee and the Committee of the Regions, but

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also the national governments of the EU members and the cooperating countries.

Among its activities, the EEA coordinates the CLMS together with JRC and monitors the status of the European environment and the implementation of European environmental directives at national level, both by using information provided by the EU members and by checking new data sources, including Copernicus satellite observations and citizen science. The Agency employs the information collected to produce reports, briefings and to organise informal meetings to inform the European Commission and Parliament. These institutions employ the reports and briefings as tools to monitor the progresses of member states, the reaching of climate targets and to decide whether to intervene with additional policies.

Copernicus satellite-based datasets are used by EEA in different environment-related topics. For instance, the EEA monitors the evolution of drought events and water scarcity by using the data developed and provided by EDO. In the field of climate change, the EEA uses the Urban Atlas dataset to assess river, urban and coastal floods in the present and future conditions (Olesen, 2012), in order to show Europe's vulnerability to climate change and support the European Adaptation Strategy. Finally, to monitor the inland water, the EEA uses the Copernicus dataset of Riparian Zones, to estimate the potential of green infrastructure (EEA, et ala, 2017), such as wetlands restoration, as a measure of flood management, in support of multiple European policies (the Water

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Framework Directive, EU Biodiversity Strategy, Habitats and Birds Directive). Moreover, to assess the morphology of large rivers (Bechter,2018), in support of the Water Framework Directive, the Agency employs the Water and Wetness, which shows the occurrence of water and wet surfaces from 2009 to 2018.

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3. Use of RS for water-related policy and decision making at EU national level

3.1. Introduction to water management in EU member states in relation to Remote Sensing / Copernicus data and services

Previous deliverable reports of WaterForCE already indicated the value of remote sensing, and in particular Copernicus data for different aspects of water management. In particular, deliverable D1.6 indicated the values of Copernicus data for addressing achievement of the SDGs, many of which are water-related, as well as the relevance of Copernicus data for dealing with the climate change challenges (impact assessment, adaption, mitigation), via the provision of relevant data regarding the Essential Climatic Variables (ECVs). Furthermore, deliverable D5.1, presented the needs assessment for Copernicus data regarding modelling of water quantity and quality so that useful information can be provided for decision makers, and D5.2 presented the value of available Copernicus services for water systems modelling. A number of recommendations have been provided for improved uptake and use of Copernicus data in water modelling and decision making.

The information presented in these previous documents addressed the role of Copernicus data and services when dealing with global challenges

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and the needs of water modellers. This section presents actual water management in EU member states and the potential role of remote sensing and Copernicus (RS/Copernicus) data for water policy and decision making in that context. As it will be shown, use of RS/Copernicus data is extremely limited in regular water management activities in EU member states, due to different reasons.

Water policy in all member states is based on the relevant EU Directives, most important of which are the Water Framework Directive (WFD) and the Flood Directive (FD). These have been translated into corresponding national legislation, and have led to development of River Basin Management (FRM) and Flood Risk Management (FRM) plans. Other relevant directives include the Drinking Water Directive, Urban Wastewater Treatment Directive, Bathing Water Directive and additional EU water-related policy documents. Implementation of these directives, in particular the development of RBM and FRM plans have involved extensive modelling of the water systems, mostly with data from existing in-situ monitoring networks. Some recent initiatives for demonstrating the usefulness of Copernicus data in monitoring and assessing progress with implementation of WFD (so called 'downstream services' from Copernicus point of view - see examples in Estonia and Finland). However, such examples come from research centres and actors actively engaged in Copernicus uptake, and expansion to regular water management activities is yet to be realised.

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Reasons for slow uptake of RS / Copernicus data in water management are primarily in the characteristics of the sector. First, as water is critical resource for so many different socio-economic activities, there are many different water management aspects (many covering aspects beyond those of the EU Directives) : water resources assessment, planning development and protection (both surface water and groundwater), public water supply, waste water treatment and disposal, management of water-related disasters such as floods and droughts, agricultural water use (irrigation and drainage), water for energy production, inland navigation, water-related ecosystem services, tourism and recreation (including bathing waters), etc. This situation has resulted in distribution of water management across different organizations, agencies and actors, at different government level (national, regional, municipal), with complex inter-relationships, which sometimes hamper collaboration and use of integrated approaches. Because of this necessarily distributed management model, introduction of RS / Copernicus data in the diverse water management activities is quite challenging.

Perhaps even more importantly, many water management activities are critical for public and ecosystem health, and, consequently, are carried out within a strict regulatory framework, in particular for water monitoring. These conditions have contributed to the fact that the water management sector is rather ‘traditional’ and ‘conservative’, leaving exploration of advanced technologies and data (such as RS/Copernicus) to research

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organization, and adopting them only after clearly demonstrated proofs of their usefulness. Often, such technologies and data are used only if they are mandated by legislation. A clear example for this is drinking water quality, where sampling, testing and reporting is strictly regulated in all EU member states by responsible agencies.

Finally, many water management activities are necessarily local, and reliance on locally available data from in-situ monitoring networks is established and reliable, and RS/Copernicus data and services are not considered because they are yet to be developed with comparative quality (accuracy, required spatial and temporal resolution, etc.).

In this situation the primary responsibility for promotion the use of RS/Copernicus in water management comes from different actors and agencies, not the water management organizations themselves. Primary 'promoters' are the EU organizations involved in space exploration and research, such as the European Space Agency (ESA) and the Copernicus programme itself with its services. EU Research Programmes, such as the current Horizon Europe, are also having an important role, as use of RS/Copernicus data is promoted in a number of research calls where water plays an important role. In many EU member states there are also national active space agencies, mostly associated with research and innovation activities that also play an important role in promoting the use of RS / Copernicus in different sectors, including water management. Finally, a very important role of promotion and introduction of these data

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and technologies is taken up by the business sector involved in remote sensing and geo-spatial information services development and provision. Many companies in different countries are actively developing and demonstrating the usefulness of RS / Copernicus data in water-related applications.

Following this introduction, we will present in sub-section 3.2 a brief overview of water management characteristic of each EU member state, and relation to usage of RS Copernicus data and services, including research and innovation activities in this area. It will be demonstrated that such data are practically not used in regular water management, but that in many countries research and innovation actions are becoming more and more relevant and 'closer' to regular water management activities. After this presentation, in sub-section 3.3 we will provide some reflections and conclusions regarding opportunities and challenges for further introduction of RS / Remote Sensing in regular water management activities in EU member states.

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3.2. Water policy and management and the use of RS / Copernicus data and services in EU member states

Austria

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Agriculture, Forestry, Regions and Water Management: • Implementation of water policy (including WFD, FD) • Assessment and monitoring of water resources (surface and groundwater) • Enforcing regulation • Overall coordination, national and international (via international river commissions for Elbe, Danube, Rhine) • Water data portals via Water Information System Austria (WISA), all using in-situ monitoring data, without any reference to RS/Copernicus data Ministry of Health: • Drinking water quality standards	R&D promoted and supported nationally via: Austria-in-space: Part of open4innovation portal for publicly funded research in Austria. The portal lists a number of successful past and recent RS projects implemented in the filed of water management, some of which have continued to provide services after the research projects finished. Examples: • Earth observations for water resources management - Provision of agricultural and meteo data for smart farming • ACube4Floods - Flood Event Monitoring and Documentation enabled by the Austrian Sentinel Data Cube

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Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology • Environment Agency of Austria: expert laboratories, analyses, inspection bodies and advice on environmental issues, including water-related Regional: Provinces: • Flood management, including warning • Standards for waste water treatment • Water supply and wastewater management Local: Municipalities: • Implementation of water supply and wastewater collection ad treatment • Drinking water quality monitoring • Compliance with national and regional regulations and laws	• EOP-Danube - Earth Observation Platform for the Greater Danube Region EU-funded research contributions example: • Lake Neusiedl: monitoring water quality with satellite imagery Although Copernicus user uptake does not report any example from Austria, there are a number of research projects and RS companies in Austria that actively pursue development of RS / Copernicus-based applications, including in the water domain. An important example area is snow monitoring (for hydropower and for tourism). Austria is also a host of International organizations active in the area, such as the United Nations Office for Outer Space Affairs (UNOSA), which hosts the space4water portal.
Conclusion: Active R&D in RS / Copernicus data for water, but with very limited implementations in regular water management	

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Belgium

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Agency for Health, Food Chain Safety and the Environment: • Coordination of regional / provincial agencies • Managing coastal waters Regional: Brussels environment; Environment of Wallonia, Flemish Environment Agency • Assessment and monitoring of water resources (surface and groundwater) • Water-related legislation • Implementation of EU Directives (WFD, FD) • water services, such as water supply, sewerage and waste water treatment (via regionally owned companies, or in collaboration with local companies) • Coordination with neighbouring countries on shared river basins	R&D promoted and supported at provincial level Example projects and applications: • Watermonitor: Monitoring water quality of water bodies • WALOUS - Land use and land cover mapping in support of flood risk management in Wallonia Again, Copernicus user uptake does not report any example from Belgium, but a number of research projects and RS companies in Belgium are developing RS / Copernicus-based applications, either directly relevant for water management, or in areas related to it (agricultural applications, land use land cover monitoring, etc.). An interesting project has been initiated recently in Flanders, named Internet of Water - Flanders, for improved monitoring

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• Water data portals via respective sites; no reference to RS / Copernicus in regular monitoring / management activities Local: Municipalities: • Management of small non-navigable water bodies • Drinking water quality monitoring • Compliance with national and regional regulations and laws	of water quality and quantity, currently completely focused on integration of multiple in-situ sensors in one network for obtaining real-time data to be used in models and applications. Such projects could benefit from further integration of RS / Copernicus data, which hopefully would be planned in future.
Conclusion: Active R&D in RS / Copernicus data for water, no implementations in regular water management	

Bulgaria

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Environment and Water: • Implementation of water policy (including WFD, FD) • Assessment and monitoring of water resources (surface and groundwater) • Water permits • Enforcing regulation	R&D promoted at nationally by the Risk Space Transfer - Technology Transfer Office - part of Bulgarian Academy of Sciences. Example projects have been reported in Aleksieva-Petrova et al. (2022): • EMOWAF (EO Monitoring for better Water Management and Flood Prevention in Bulgaria),

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National Institute of Meteorology and Hydrology: • Water monitoring and reporting: Some data available via their web portal (in Bulgarian), but only from in-situ monitoring networks; there is no mentioning of RS / Copernicus data sources. More data available only on demand. Executive Environmental Agency: • Environmental monitoring and reporting (some relations to water issues). Data mostly available on demand. Copernicus Programme is introduced and their web site and some national projects regarding LULC mapping are reported. Regional: No separate responsibilities, but the Ministry of Water and Environment organises water management in four separate Basin Directorates. Local: Municipalities: • Local policy and management of drinking water supply, sewerage and waste water treatment	funded by the Government of Bulgaria through ESA. • Smart Crop Production, with components related to use of RS data Other example projects identified: • Danube River Basin Directorate: satellite information for risk assessment, contributing to development of Flood Risk Management Plan • Integrated Approach to Pluvial Flood Management There are no water-related projects reported in Bulgaria in Copernicus user uptake, but there are several that promote Copernicus activities and collaborations.
Conclusion: Initiated R&D in RS/Copernicus data for water; no implementation in regular water management	

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Croatia

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Hrvatske vode (Croatian waters) - main national water management agency • Implementation of water policy, including WFD, FD and other EU water-related directives • Water resources assessments • Planning, design and implementation of water resources projects and infrastructure • Drought and flood risk management • Irrigation and agricultural water use management. • Regulation and management of commercial use of water Data portals available with limited availability. All data are from in-situ networks, no RS / Copernicus data mentioned. Most data available only on demand Croatian Meteorological and Hydrological Service: Further hydrological data available in portals from in-situ networks, but, again, mostly on demand (no RS / Copernicus data)	R&D activities in Croatia with RS / Copernicus data and services are just beginning. Main promoter is the Ministry of science and education through its pillar on Digitization, industry and space (in Croatian). Another relevant organization is Adriatic Aerospace Association (A3). There are no identified water-related projects. Opportunities are in water quality observation projects and applications (including coastal waters), given the country's high reliance on tourism.

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Regional: Regions • Protection of drinking water sources in collaboration with 'Hrvatske vode' and municipalities Local: Municipalities: • Local management of drinking water supply, sewerage and waste water treatment • Implementation of local measures for RBM and FRM	There are no projects reported in Croatia in Copernicus user uptake
Conclusion: R&D in RS/Copernicus data needs to be initiated; no implementation in regular water management	

Cyprus

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Water Development Department of the Ministry of Agriculture, Natural Resources and the Environment • Planning, construction and operation of waterworks such as dams, reservoirs, water conveyance projects, irrigation and water supply networks and water treatment plants. • Desalination plants and contracts. • Managing and supplying water from Government Waterworks for various uses.	R&D promoted by organizations such as The Cyprus Institute, Cyprus Space Exploring Organization, Cyprus Remote Sensing Society. Example water-related R&D projects identified: • The Challenge of Irrigation Management

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• Water monitoring, assessment and reporting (groundwater and surface water) via web site • Implementation of European water-related directives • Drought and flood risk management • Development of awareness for rational water use and water saving Main focus on desalination, water saving, rational water usage and reuse of treated wastewater in agriculture: Water data for management from in-situ networks (no RS / Copernicus) Regional: Districts • Flood protection • Regional storm water management Local: Municipalities: • Local management of drinking water supply, sewerage and waste water treatment	in Cyprus using Copernicus • Cyprus Audit Office: EO to support beach inspections, improve coastal management, and prevent environmental damage Given that the main issue is water scarcity, agricultural water use could be the focus of future projects and applications with RS / Copernicus data and services No examples from Cyprus reported in Copernicus user uptake.
Conclusion: Initial R&D in RS/Copernicus data needs to be extended in water domain; no implementation in regular water management	

Czech Republic

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of the Environment	R&D promoted at nationally by the Geoinformatics

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• conservation of quantity and quality of surface water and groundwater, • flood prevention, • water planning at the national and international levels • international co-operation in water protection, • economic, financial and administrative instruments in water protection, • drafting of legislation and standards in water protection Czech Hydrometeorological Institute: • Water monitoring and reporting • Flood forecasting • Rich data portals including real-time data, but all from in-situ monitoring stations, no reference to RS/Copernicus data Water management information portal VODA (in Czech language) - a multi-agency portal for water data and information, presenting geospatial and other data from multiple sources, regarding water quantity and quality (surface and groundwater); again, using only in-situ data (no RS / Copernicus) Regional: Regions • Implementation of measures from RBM and FRM plans • Emergency situations management	department of CENIA - the Czech Environmental Information Agency. Many Copernicus-related activities but no examples of truly water-related R&D projects. However, CENIA runs a separate environmental information portal MICKA, where some Copernicus data (land monitoring, soil moisture) are included. Such information could be merged with existing water portals in future (e.g. VODA). There are also no water-related projects reported in the Czech Republic in Copernicus user uptake, but there are several that promote Copernicus activities and collaborations.

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Local: Municipalities: • Local management of drinking water supply, sewerage and waste water treatment	
Conclusion: Active R&D in RS/Copernicus data that needs to be extended in water; no implementation in regular water management	

Denmark

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Environmental Protection Agency, of the Ministry of Environment • Policy formulation • Monitoring and assessment of groundwater and surface water resources, • Permitting, enforcing regulations, • Preparation and implementation of RBM and FRM plans, according to EU directives • International cooperation, • Overseeing water supply and waste water management. Danish Meteorological Institute (DMI) (for Denmark and Greenland): • Monitoring and reporting water-related meteo data (precipitation, temperature etc.)	Use of RS/Copernicus data carried out nationally by the Danish Agency for Data Supply and Infrastructure (SDFE). They report a number of uses of RS data, but not in the domain of water directly. Further R&D is coordinated and funded by the Danish Ministry for Higher Education and Science, with many active research organizations.

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• Water levels monitoring and reporting • Sea ice data • Radar data • Forecasting data • Climate data Data portals include a number of free data sources, some are only available on demand. Regular data are provided from in situ observation network, but DMI is very active in merging RS data in its research, analysis and forecasts. They are active consumer of satellite data and contributor to the Danish Space Strategy, mainly in the domains of climate and Arctic research. Their web site cites a number of initiatives and research actions with Copernicus data.	A recent report coordinated by SDFE presents 50 Copernicus user stories in Denmark by different research organizations, with several water-related applications (e.g. assessing waterlogged agricultural fields, flood mapping, measuring water depth in shallow water bodies)
Geological Survey of Denmark and Greenland (GEUS) • Monitoring and mapping of water resources • Monitoring and analysis of water quality • Modelling of water quantity and quality • Monitoring of groundwater As practically all water for public water supply comes from groundwater the activities of GEUS on groundwater monitoring are of special importance. They maintain the data centre for the National Groundwater Monitoring Network (GRUMO), which is part of the National Monitoring Program for Aquatic Environment and Nature (NOVANA). NOVANA includes other related monitoring programmes, such as the Agricultural Catchment Monitoring Program (LOOP). Their GEUS Jupiter data	Additional examples identified is in the area of Land subsidence observations for utilities (land subsidence is an important concern in the whole country due to groundwater abstraction). Two examples are listed from Denmark in Copernicus user uptake, one of which is the SDFE's development of best practice catalogue

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portal provide access to groundwater, drinking water data and other related information (from existing in situ observation networks). No RS/Copernicus data for regular water management, but some research, particularly for Greenland and Arctic climate research. They also participate in the multi-agency Hydrological research laboratory (HOBE), where research is being carried out in experimental catchments where in-situ data are considered together with RS/Copernicus data (e.g. soil moisture) Local: Municipalities: • Development and implementation of local action plans regarding water management, based on the RBM and FRM plans • Operate own water supply and waste water treatment companies (other water service providers are private)	for use of Copernicus in the public sector in Denmark.
Conclusion: Very Active R&D in RS/Copernicus data that has already a number of water-related applications; implementation in regular water management could be next step.	

Estonia

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Environment the Water Department	Estonia is very active in R&D and use of RS/Copernicus data. Lead agencies are the Estonian

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• Overseeing preparation and implementation the RBM and FRM plans • Enforcement of regulations, • Economic analysis, • Coordination of WFD implementation. Estonian Environment Agency: • Hydrological monitoring (surface and groundwater) • Hydrological forecasting • Maintenance of hydrological information system • Data provided to national weather service portal • Monitoring and reporting of water use via the VEKA portal, as part of the Estonian Nature Information System (EELIS) • Administrating water-related databases, some of which provided via the Portal of the Environment Agency The above mentioned portals provide data from in situ observation network, with no reference to RS/Copernicus data for regular water management Further water-relevant data are provided by the Estonian Land Board, via its Geoportal, where Copernicus data and other RS data are provided, including those from the National Satellite Data	Space Office, Tartu Observatory at University of Tartu, which has water remote sensing group that focuses on monitoring lakes and water bodies with the aim of contributing to unified WFD implementation in Europe. The remote sensing website contains data and projects information from many collaborating research organizations. Water-related applications have also been reported in the Estonian Space Technologies Phonebook 2020 on following topics of water mapping from EO data, ocean monitoring and sea ice mapping with EO data. Five examples are listed from Estonia in Copernicus user uptake, most relevant of which is the one on unified approach to WFD implementation in Europe, based on RS data, already mentioned above.

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Centre ESTHub. Such data are yet to be integrated in regular water management. Local: Municipalities: • Organization of public supply of water and sewerage, • Control / restrict industrial water use related to drinking water quality, • Use of local natural resources, including bodies of water.	
Conclusion: Active R&D in RS/Copernicus data that has already a number of water-related applications; implementation in regular water management could be next step.	

Finland

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of the Environment • Overseeing preparation and implementation the RBM and FRM plans • Enforcement of regulations • Assessment of water bodies status • International cooperation Ministry of Agriculture and Forestry • Legislation relating to the water economy	Finland is advanced in using RS/Copernicus services and data including in regular water management by agencies such as: Finish Environmental Institute (SYKE) Finish Meteorological Institute

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• Legislation on water supply and services, dam safety and basic drainage • Transboundary watercourses agreements Finish Environmental Institute (SYKE) • Monitoring of waters; Portals: WaterMap (in Finish) ecological and chemical status of waters Tarkka: Satellite images services, including Copernicus Water data discoverable via their metadata portal Finish Meteorological Institute • Monitoring of weather, including water relevant data Inter-agency water portal: VESI (in Finish) • Water data from different agencies presented in one portal. • Map services that combine in-situ and RS data including RS/Copernicus, time series data of water variables from in situ observation networks. • Summary information provision Centre for Economic Development, Transport and the Environment (ELY Centres) • Support in preparing RBMPs and FRMPs • Supervision of adherence to water permits • Flood protection and prevention • Dam safety • Support municipalities in development of water services and sewerage and supervision of water supply Regional Councils:	RS/Copernicus data already included in their data portals and used in water management activities. Example activities and projects: • EO for Water Framework Directive and Marine Strategy Framework Directive monitoring (SYKE) • Water quality management in Finland • Copernicus Assisted Lake Water Quality Emergency Monitoring Service Finish agencies are also active in multinational consortia focused on RS/Copernicus services

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• Elaborate and implement local development plans • Organizing regional land use planning and leading flood working groups Municipalities: • Environmental permits and protection • Water services and sewerage • Monitoring quality of drinking and bathing water • Taking part in river basin management planning and flood working groups.	and data, some of which are relevant for water, for example: • ARCOS (Arctic Observatory for Copernicus SEA) • BalticSatApps – project and marketplace for speeding up Copernicus-based innovation in Baltic Sea Region
Conclusion: Active R&D in RS/Copernicus data that has already a number of water-related applications; further implementation in regular water management can be expanded	

France

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • Ministry for the Ecological and Inclusive Transition (*Ministère de la Transition Ecologique et Solidaire)*	There are two national organizations involved in RS activities: Centre National d'Etudes Spatiales - CNES (cnes.fr) :

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• Comite National de l'eau (Comité National de l'Eau) The central government is responsible for: • the development and implementation of water legislation, • developing national water policy and addressing common issues across river basins, • coordination of cooperation on water management with neighbouring countries and at international level Regional • Regional councils Regional councils are represented on the river basin committees (*comités de bassin*), which set river basin objectives, adopt the RBMPs and FRMPs and provide coordination among elected bodies and stakeholders. • Regional authorities (Directions Régionales de l'Environnement, de l'Aménagement et du Logement - DREAL) • Prefect Coordinators (Préfets Coordonnateurs de bassin) The prefect coordinators of the river basins give final approval to the RBMPs adopted by the river basin committees. They coordinate water	• Promotion of Copernicus Data and Services • Education / Training • Event on Copernicus • Development of Services NASA and CNES (French Space Agency) are collaborating to make the first global survey of Earth's surface fresh water and study fine-scale ocean currents with a new mission called SWOT, or Surface Water and Ocean Topography. SWOT will collect data on the height of Earth's salt and fresh water - including oceans, lakes, and rivers - enabling researchers to track the location of water over time, which will help measure the effects of climate change. SWOT is expected to launch from Vandenberg Space Force Base in central California in November 2022. SWOT is a collaboration between NASA and the French space agency Centre National d'Etudes Spatial (CNES), with

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management in their river basins, including enforcement of water regulations.

The Regional directorates for the environment, planning and housing (DREAL) support the authorities on water management, including monitoring of water bodies.

- Water Agencies (Agences de l'eau)

The water agencies provide technical and scientific support at river-basin level, including for the preparation of RBMPs. Moreover, they provide financial resources for implementing the Programmes of Measures.

The European Environmental Agency reports that here is no national programme for monitoring lake water quality in France.

- River Basin Committees (Comités de Bassin)

A national hydrological data for 4000 basins of France is hosted in the INRAE database (https://webgr.inrae.fr/activites/base-de-donnees/).

Local

- Municipalities (Municipalités)

Municipalities are responsible for:

- local implementation of water policies and plans, including local water management projects,
- managing drinking water supply, municipal sewerage and waste water treatment (either

contributions from the Canadian Space Agency (CSA) and United Kingdom Space Agency (UK Space Agency).

Centre National de la Recherche Scientifique - CNRS (www.cnrs.fr/), the main scientific organization in the country.

CNRS main interests in FCUP activities lay in:

- research activities based on the use of Copernicus data and services
- developement of research tools using Copenricus data and services
- training and dissemination activities to students/private sector

In the Copernicus user uptake, a large project is reported, using RS Copernicus data for inland water quality monitoring for France and across the globe. This data is hosted in THIEA (https://www.theia-land.fr/), part of Data Terra data center.

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directly via municipally owned companies or delegated to private operators), • local water protection and flood prevention measures. Municipalities can join together in inter-municipal unions (*Syndicat intercommunaux des eaux*) to manage common water services or undertake other water management activities. Municipalities and inter-municipal unions are represented on the river basin committees. Municipalities participate in Local Water Commissions (*Commission locale de l'eau*) together with water users and stakeholders. These Commissions develop local water plans, (*Schéma d'Aménagement et de Gestion des Eaux*). Municipalities and inter-municipality groups participate in river contracts that implement measures for the RBMPs, FRMPs and lower-level plans. • Local Water Commissions	RS data is used by EPAMA (the Public Entity for the Management of the River Meuse and its Tributaries) in the Meuse basin for a better management of flood risks.
Conclusion: very active in RS /Copernicus in research and academia and industry sector, but more in the coastal/transitional/marine areas than inland waters. implementation in regular water management could be next step.	

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Germany

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Federal/state working group on water (LAWA) Collaborative body on water issues, developing harmonized water policies regarding: • water law • hydrology • Water and marine protection • ecology • flood and coastal protection • groundwater • water supply • water supply and waste water • water pollution • technical coordination with EU German Environment Agency (UBA): • Environmental monitoring (including water) • Implementing environmental law • Research and international cooperation Water data available via portal on environmental data	A number of German agencies are active in RS/Copernicus data and services: • German Aerospace Center • German Environment Agency (UBA) • German Weather Service (DWD) • Helmholtz Centre Potsdam - German Research Centre for Geosciences • Federal Office of Civil Protection and Disaster Assistance R&D activities in the field of water exist, in regular water management are being initiated. Examples (where water data play a role) include: • Agrometeorological Modelling Based on Copernicus Regional Reanalysis Data • Downstream Service/Application Development for Monitoring of Environmental Indicators (Europe) • Monitoring sea pollution on German coasts using satellite information • Water quality management - lakes and water bodies

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Data available from in-situ monitoring networks; use of some RS data mentioned in some environmental reports German Weather Service (DWD) • Monitoring of water related weather data WaWIS portal - Water Management Weather Information System, only for registered users DWD services, also provides some water management relevant data and a limited number of RS data German Federal Institute of hydrology: they provide some water level and water quality data. They also host the Global Data Runoff Center (GRDC) with global in situ river discharge data. Regional: States (Länder Ministries, Länder Environmental Agencies): • coordination of water management at lower levels • preparing the RBMP and the FRMP	Like in other countries there are also applications in other domains relevant for water management (e.g. land use change monitoring, coastal monitoring etc.) There are a number of projects from the related Copernicus Marine Environment Monitoring Service in Germany, such as: • SOS - Satellite-based Operational Planning in Lake Surveying; Federal Maritime and Hydrographic Agency (BSH) • DEMARINE-2 • EisKlass31 - Improvement of sea ice situation information for shipping in polar waters by combining sea ice classification with optical data from the Sentinel-3 and SAR data from the Sentinel-1 satellite series • EmissionSEA - Emission assessment, reduction and avoidance of ships by evaluating AIS signals; • EnSAG Phase II: Coastal and inland waters; • GeoWAM - New geodata to improve water management in tidal coastal areas • KelpMap 2.0 - Development of an atmosphere correction for scientific use of

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• licencing polluting industry • reporting and measurement stations Regional - Counties: • water resource planning • household waste collection and disposal • permitting • monitoring of rivers Local: Municipalities: • drinking water supply. • sewerage and waste water treatment • monitoring of (smaller) water bodies and discharges Other institutions: BadenWürttemberg State Institute for the Environment monitors the quality of water in lakes through throughout their region using Sentinel 2 and 3 data.	EnMAP and Sentinel-2 data in turbid coastal waters • Consistent atmosphere correction and derivation of geophysical parameters from EnMAP and Sentinel-3 data for inland and coastal waters • LAKESAT - Synergetic use of spatially high- and medium-resolution satellite data for the operationalization of the analysis of inland waters • MERAMO - Support of the authorities involved in the implementation of the EU Marine Strategy Framework Directive using an assimilative ecosystem model • Sentinels4Marine Plastic Waste - Pollution of aquatic ecosystems with plastic waste: Global and local monitoring using satellite-supported methods • ShipTac - Integrative use of X- and C-band SAR data for tactical ship route planning in arctic waters • TanDEM-Ice - Glacier monitoring in high Asia using TanDEM-X InSAR and other earth observation sensors
Conclusion: Very active R&D in RS/Copernicus, as well as in the industry sector. Some data is already used in regular water management at national level.	

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Greece

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • Ministry of Environment and Energy (Υπουργείο Περιβάλλοντος και Ενεργειας) • Special Secretariat for Water (Ειδική Γραμματεία Υδάτων) The Special Secretariat for Water (SSW) under the Ministry of Environment and Energy are responsible for: • coordinating water management issues, • implementing the WFD, • monitoring the quality and quantity of water, • overseeing and regulating waste water and reuse and flood management, • engaging the public, • approving all regional RBMPs and FRMPs. The National Council for Water (NCW) is responsible for: • developing the national strategy on the management and protection of Greek waters • approving the national RBMP and FRMP prepared by the SSW *Regional* • Regional Water Departments (Περιφερειακές Διευθύνσεις Υδάτων)	• From the Copernicus user uptake, NOA (National Observatory of Athens), through its BEYOND Centre of EO Research and Satellite Remote Sensing and PRAXI Network/FORTH are leading efforts in Greece in:advocating the use of RS in Greece and the Balkans; • informing stakeholders - researchers, public

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• Regional environmental departments They are responsible for: • licensing discharges of industrial waste water and municipal waste water from treatment plants. The Regional Water Departments are responsible for: • overseeing or preparing the preparation the RBMPs and the FRMPs in their Region. The Regional Water Departments can transfer that competence to the Special Secretariat for Water, which was the case in the previous cycle of implementation for all but two Regions, • engaging the public in the preparation of the RBMP and FRMP. *Local:* Municipalities (Δήμοι) • participating in public consultations for the preparation of the RBMPs and FRMPs, • protecting and managing water resources from extensive fisheries and pollution, • constructing, maintaining and managing local water supply, irrigation, and sewage systems. The Hydrologic Observatory of Athens provides data on hydrology (water depth, water level and water quality), in the region of Attica. A national initiative is HIMIOFOTS, Hellenic Integrated Marine Inland Water Observing Forecasting and Offshore Technology System. It is coordinated by Hellenic Centre for Marine Research, with the participation of 7 universities of Greece. It contains a web platform for inland waters and a network of water quality monitoring stations.	and private sector, general public; • mapping needs and organizing training seminar for various applications (land use, forestry, wild fires, agriculture, geohazards) .Applications for water managements comprise: impacts of climate change, floods and soil moisture. BEYOND Centre of EO Research and Satellite Remote Sensing, part of NOA, has a hub dedicated to floods - management at basin scale, monitoring, mapping. Their projects also address water quality and climate change effects, but mostly in the marine

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Geoadata.gov.gr provides open geospatial data and services for Greece on: rivers, drainage basins, groundwater, transitional and coastal waters, foreshore.	domain. Several other research institutions and public companies (e.g. Planetek) are involved in projects that use RS data for water quality, coastal management and water management for agricultural activities.
Conclusion: Active in RS /Copernicus in research and academia and industry sector; implementation in regular water management could be next step.	

Hungary

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: The General Directorate of Water Management (OVF) (http://www.ovf.hu/en/) is a central government body under the direction and supervision of the Ministry of Interior. It supervises, coordinates and controls the activities of the water directorates. Regional: • Regional Water Directorates • Counties (*megyék*)	There are no examples from Hungary in the Copernicus user uptake. At national level, Hungary is very active in the R&D sector in RS. Two universities are listed as best in the country for RS - Eotvos Lorand University and

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Regional authorities are responsible for: • The implementation of measures as specified in a national level (especially concerning floods), • The monitoring and assessment of the status of the waters, including pressure and impacts analysis, • Participation in the preparation of the RBMP and FRMP and the development of the relevant measures, • Support for the engagement of the public, • Enforcement of regulations at regional level. Local authorities: • Drinking water supply and infrastructure as well as sewerage for and treatment of municipal waste water (these services are directly managed by publicly owned companies under contract to the municipalities), • Preventing flood damage. The Hungarian Hydrological Forecasting Service operates within the General Directorate of Water Management (OVF), providing data on hydrology (e.g. river discharge and water level), hydrological forecasting (e.g. flood alert), snow and river ice, meteorological data. The National Hydrographic Monitoring Network (http://www.ovf.hu/en/) contains data on surface water and groundwater, as well as precipitations, snow cover and soil moisture. Hydrogeological data is stored by the Department of Hydrogeology of Hungarian Mining and Geological Service (https://www.mbfsz.gov.hu/en/hydrogeological-data-store).	Budapest University of Technology and Economics. Hungary also has an Institute of Geodesy, Cartography and Remote Sensing. Most of the applications are thematic land mapping (Remetey-Fülöpp, 2013). One Hungarian company, Debrecen Innova, is part of the NEREUS (Network of European Regions Using Space Technologies) consortium. There is also a Hungarian Association for Geo-Information, with members form academia, R&D, private and public sector. In water management, their projects address water quality in large lakes, impacts of climate change, flood management (especially along the Danube River),

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The National Meteorological Service of Hungary (https://www.met.hu/en/idojaras/) provides data and forecasts for three large lakes: Balaton, Tisza, Velence, on storm warnings and wave height. The Balaton Limnological Institute (https://www.blki.hu/en/node/14854) performs research in the area of Balaton, the largest lake of Central Europe, which includes water quality and hydrology.	monitoring water facilities.
Conclusion: active in RS /Copernicus in R&D; implementation in regular water management could be next step.	

Ireland

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: *Central:* National government: • environmental legislation including freshwater and marine legislation. The Department of Housing, Planning and Local Government: • drafting the overall water policy, including the River Basin Management and Flood Risk Management Plans. The office of Public Works:	There are several examples in Copernicus user uptake, involving Ireland. The R&D in RS in Ireland addresses: land use changes and GHG emissions, agriculture and forestry. Maynooth University launched the Copernicus Academy & Relay in Ireland this year. Its main objectives are to: • foster user uptake of Copernicus Open

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• coordinates the implementation regarding the Flood Risk Management, • works with Environmental Protection Agency (EPA) and local authorities. Environmental Protection Agency • prepares river basin management plan templates • gathers information on programme measures and input from local authorities. • provides reports on key indicators on health of waters. EPA runs several projects that report the use of RS Copernicus data for the environmental assessment of lakes and coastal waters, especially on water quality. Irish Water, accountable to the EPA and the Commission for Energy Regulation • manages water and wastewater services. Regional Regional assemblies • coordinate the implementation of legislation at regional and local levels with the technical support of Environment Protection Agency (EPA) and the Local Authority Waters Programme *Local and national* The Local Authority Waters Programme • brings together local authorities and state agencies to implement RBMPs, promoting	Satellite data at a local, regional and national level • engage with new and existing Copernicus users to build capacity and skills in Earth Observation • share resources and help to build strategic networks across public and private sectors in Ireland • support public and private sectors in Ireland to harness funding opportunities for building real-world EO applications and services • showcase a range of real-world Use Cases from across Europe and Internationally with particular reference to agriculture, maritime and climate sectors • host a series of webinar & seminars aimed at deepening strategic

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the implementation of mitigation measures, providing scientific assessments of water bodies and encouraging citizen engagement at local level. In Ireland the OPW (Office of Public Works) provides, through www.waterlevel.ie, real time water level data recorded at hydrometric gauging stations at over 380 river, lake and tidal locations nationwide. The OPW also coordinates a national programme for flood studies (https://www.gov.ie/en/collection/34529d-flood-studies-update-fsu-programme/), using mostly in-situ measured data. Lan-cover data is used, as part of the models.	partnerships between interested stakeholders and developing EO based services that address real-world challenges The academy has several projects addressing: water quality in inland waters, soil moisture and management of coastal areas and their resources. The Copernicus Emergency Management Service was used by the Irish authorities to manage the greatest floods in their history, after several major storms, in the winter of 2015-2016.
Conclusion: Active R&D in RS / Copernicus data for water, some implementations in regular water management.	

Italy

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: *Central:* • Ministry of Environment, Land and Sea	On the Copernicus user uptake website, there are several examples from

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• Italian Institute for Environmental Protection and Research (ISPRA) • Italian Regulatory Authority for Energy, Networks and Environment (ARERA) - supervises water services The central government is responsible for: • national water legislation, including acts to transpose and implement the Water Framework Directive (WFD), Floods Directive and other EU water legislation, • coordination of the implementation of the WFD, Floods Directive and other EU water legislation, • development of methods for setting water tariffs and overseeing tariffs in place. *Regional* Regional authorities and the autonomous provinces of Trento and Bolzano/Bozen: • are represented on the board (*Conferenza istituzionale permanente*) of the river basin district (RBD) authorities of RBDs spanning more than one region, • prepare regional Water Protection Plans (*Piani di tutela delle acque*) to support and implement RBMPs, • undertake monitoring of groundwater and surface water, • enforce water legislation, • contribute to the RBMPs (prepared by the RBD authorities),	Italy, on the use of Copernicus data for geohazards, aquaculture, land use/land cover, forestry, cultural heritage. Water applications refer to aquaculture, soil moisture and management of bathing waters. The national partner is ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale). Public authorities use RS data for river basin management in the Alps, where the hydrogeological data is essential for mapping and mitigating land-slides. The R&D community in Italy is very active in many projects that use RS data for basin management, in inland waters, transitional and coastal waters for several applications, including water quality and quantity. They contribute

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• lead the preparation of FRMPs for Units of Management managed at regional level (often under the coordination of RBD authorities), • contribute to the preparation of FRMPs for interregional Units of Management (UoMs), • implement RBMP and FRMP measures at regional level, • identify and oversee water service areas (*Ambiti territoriali omogenei*), whose agencies in turn oversee water service companies and approve their tariffs. <u>*Local*</u> • Local authorities/Provinces • Roles vary by region and are delegated by the regions. Municipalities • Ownership of water service companies that manage drinking water supply, sewerage and waste water treatment (ownership structures vary across the country), • Management of local water issues, • Implementation of RBMP and FRMP measures at local level, • Participate in river contracts (*contratti di fiume*) for local, participatory management of water bodies. Data on lake water, derived from RS Copernicus imagery is hosted in https://dahiti.dgfi.tum.de/en/ database, developed by Deutsches Geodätisches Forschungsinstitut	towards improving algorithms in inland and transitional waters for retrieving parameters like climate variables - temperature, water level and water extent, ice cover, water quality parameters - chlorophyll-a, Total Suspended Matter, dissolved organic matter, etc. This data feeds and improves the results of mathematical models. Some examples listed in the C3S include: • A prototype service developed by the *Euro-Mediterranean Center on Climate Change* to provide users with decadal predictions of precipitation aggregated over three river catchments for the following 10 years

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der Technischen Universität München. The data set contains: altimetry water level, Surface Area Time Series from Optical Imagery, Time Series of Volume Variations, Bathymetry, Land-Water Masks, Time Series of River Discharge.	• The assessment of a climate-proof river water balance in the Po river basin.
Conclusion: Active R&D in RS / Copernicus data for water, the implementations in regular water management could be the next step.	

Latvia

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Environmental Protection and Regional Development: • enforcement of water regulations • coordination of public participation • implementation of measures and coordination of bodies involved in their implementation • support for the monitoring of surface water and groundwater, pressure and impact analysis, support for the preparation of the plans and Programmes of Measures • oversight of the Regional Environmental Boards (responsible for water use permits) • implementation and supervision of drinking water and sanitation improvement projects	There are no examples from Latvia in the Copernicus user uptake. R&D promoted at nationally by the IES (Institute for Environmental Solutions) is a leading research institution in Latvia in the field of Earth Observation and a service provider to the European Space Agency. IES Encouraging the use and uptake of Copernicus data and services through training, development of new EO

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Latvian Environment, Geology and Meteorology Centre (LEGMC): • monitoring and assessment of groundwater and surface water quality and quantity, economic analysis, pressure and impact analysis, • preparation of the FRMPs, RBMPs and Programmes of Measures and implementation of measures, • support for public participation, • support for River Basin management, • support for the assessment of flood risks Latvian Institute of Aquatic Ecology: • monitoring of surface waters • supporting the assessment of status of surface waters and pressure and impact analysis Local: Municipalities: • supervision and management of water use, drinking water supply, sewerage and waste water treatment • local water protection implementation of specific RBMP and FRMP measures	solutions for natural resource management and environmental monitoring. University of Latvia develop Copernicus User Uptake Activities such as: user consultations on Copernicus, dissemination of latest information on Copernicus programme and its products, linking the industry with research, attracting student researchers to opportunities of Copernicus. Copernicus EMS Rapid Mapping Activated for Floods in Latvia in 2018 (data are available on the EMS website) - monitors the Impact of Flooding in Central and Eastern Latvia.
Conclusion: Active R&D in RS / Copernicus data for water, no implementations in regular water management.	

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Lithuania

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Environment • legislation and regulation for water management • coordination and administration of the River Basin Districts • development and approval of RBMPs and FRMPs and their measures • regulation of drinking water and implementation of the EU Drinking Water Directive • water permit Environmental Protection Agency (EPA) • State monitoring of rivers, lakes and ponds • Water management on the principle of river basin districts • Flood risk management • Cadastre of rivers, lakes and ponds • Implementation of the Urban Wastewater Treatment Directive • Wastewater management accounting data Lithuanian Hydrometeorological Service (LHS)	Example of projects identified: Klaipeda University - Tracking algal blooms on the Curonian lagoon - Satellite data are leading to better water management, water quality assessment and cyanobacterial bloom tracking (funded by the Government of Lithuania through ESA) There are no examples from Lithuania in the Copernicus user uptake.

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• formulates and implements national policy in the field of hydrometeorology • performs hydrometeorological observations and participates in the state environmental monitoring programme • provides information on hydrological regime of surface water Lithuanian Geological Survey (LGS) • groundwater monitoring of economic entities Regional: • Ministry of Environment organises water management in four River Basin Districts. • Regional Environmental Protection Departments (REPDs) Local: Municipalities: • water management at a local level, supply of drinking water and monitoring of sewerage systems	
Conclusion: Active R&D in RS / Copernicus data for water, no implementations in regular water management.	

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Luxemburg

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry of Environment, Climate and Sustainable Development • water policy • enforcement of water regulations • coordination of the implementation of measures from RBMP and FRMP • establishment of administrative entities for water management • coordination of protection of water resources • national drinking water supply policy, including pricing and drinking water protection zones Water management agency: • monitoring and assessment of groundwater and surface waters • conducting pressure and impact analyses • preparation of RBMPs and FRMPs, Water data available via dedicated geoportal: all water data from in-situ networks, some background RS data are provided.	In Luxembourg RS/Copernicus R&D activities are led by the Luxembourg Space Agency. They provide data via their LSA Data Center. However, no clear water-related R&D activities / applications with RS/Copernicus data and services have been identified, although companies and research organizations are

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Further data regarding water management via the open data platform of Luxembourg Some RS data are available such as soil moisture and LULC data. Some information is also provided with the Environmental portal and the portal of the Luxembourg Met Office. Local: Municipalities: • implementation of government policies at local level • local water management and protection • implementation of drinking water supply, sewerage and waste water treatment services • issuing of abstraction and discharge permits	present in the domain, for example: Water Earth Observation (WEO); RSS-Hydro; Luxembourg Institute of Science and Technology.
Conclusion: Active R&D in RS/Copernicus data, but hardly any clear water-related applications; R&D capacity is present, needs to expand in water domain, and eventually in water management.	

Malta

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Ministry for Energy and Water Management	One example in the Copernicus user uptake refers to marine waters.

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• development of Water Policy and Energy and Water Services Energy and Water Agency and the Environmental and Resources Authority: • formulation and implementation of the Government's national policies in the energy and water sectors (Energy and Water Agency) • monitoring and assessment of status of groundwater (Energy and Water Agency) and surface water (Environment and Resources Authority) • pressure and impact analysis, economic analysis • preparation of the River Basin Management Plan (RBMP, which includes also flood risk management) and Programme of Measures • implementation of measures and coordination of implementation • enforcement of regulation (Environment and Resources Authority) Regulator for Energy and Water Services is responsible for regulating water services including: • the regulation of the national utilities (e.g. Water Services Corporation) and service providers for water • implementation of grant schemes and licences Water Services Corporation	University of Malta - Oil spill drift monitoring in the Maltese waters - forecasting tool to assist decision makers and stakeholders in the event of an oil spill around the Malta Island. Malta Copernicus Marine Service Platform - Web Service Platform for Maltese waters - serve local users with online access to dedicated products and services derived from the Copernicus Marine data. The Environmental and Resources Authority has a project for monitoring sea

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• complete drinking and waste water cycle from production and distribution of water, to the collection and treatment of wastewater Regional: No competencies identified at the local level concerning water management Local: Municipalities: No competencies identified at the local level concerning water management	grass using Copernicus data. No projects for inland waters were identified.
Conclusion: : Active R&D in RS / Copernicus data for water, no implementations in regular water management.	

Netherlands

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Government (multiple ministries) develop National water plan, also in accordance with EU directives Ministry of Infrastructure and Water management (Rijkswaterstaat) • management of the major waters, such as the sea and main rivers. • Flood warning and alerting for major floods • Maintenance of dykes, dams, weirs, and storm surge barriers.	Water management in the Netherlands is developed to a sophisticated level. All involved agencies collect, maintain and share data, but mostly from in situ monitoring networks, which are

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• Coastal protection and 'room for the rivers' projects Water data portals: Rijkswaterstaat data register; Many water related data from in-situ networks, no reference to RS/Copernicus. Data also available via the Rijkswaterstaat geoportal and Rijkswaterstaat Waterinfo portal; Netherlands Hydrology Instrumentarium (NHI) (provided by consortium of porganizations); rich source of data and models for groundwater and surface water. Data on national and regional scale available via their data portal. All from in-situ data, some RS data mentioned with their potential. Informatiehuis Water (Information house Water), a collaborative body of Rijkswaterstaat the provinces and Water boards maintains data portals on: Water quality, Water safety (flood), Droughts portal. They have also developed the Aquo-standard for interagency exchange of water data. DINOloket - portal for subsurface data in the Netherlands (for groundwater) Regional: District Water Boards: 21 regional water boards, organized on catchment level, joint in the Union of Dutch Water Boards for cooperation. • responsible for regional waters, such as canals and polder waterways.	dense and provide high quality data. Water managers mainly trust these data and the value of RS/Copernicus data is yet to be confirmed. There is active research on future use of RS for water management, with focus on variables such as evapotranspiration and soil moisture. The Netherlands Space office is active in sharing RS/Copernicus data via their Satellite Data Portal, where data from Sentinel / Copernicus and other sources are shared (without specific focus on water).

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• water quality in regional surface waters • flood protections • provision of water for agriculture • waste water purification Water Bords maintain own water data portals, for example from Delfland Water Board and from Rijnland Water Board Regional: Provinces • translating national water policy into regional measures • management of groundwater quality • bathing water quality Provinces maintain own data portals with environmental (including water) information, for example Climate adaptation in the Province of Noord Brabant, or joint (national) bathing water data information portal. Local: Municipalities: • groundwater in urban areas • drinking water supply and urban drainage (wastewater and rainwater)	Other (past) examples applications include: • Water Board De Stichtse Rijnlanden: integrated water management using satellite information • VOF School Jansen: "more crop per drop" thanks to satellite information • Improving coastal ecosystem benefits under increasing pressure (the Wadden Sea)
Conclusion: Active R&D in RS/Copernicus data for water applications; Expansion in regular water management is actively being explored.	

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Poland

Water management characteristics and data	*RS / Copernicus data in water management*

Responsible organizations:
National
National Water Agency (Gospodarstwo Wody Polskie)
• supervising:
  • National Board for Water Management in Warsaw,
  • Regional Water Management Boards,
  • water basin management boards,
  • water supervisory boards.
• holding ownership rights over state-owned waters,
• establishing and collects water use fees and taxes,
• supervising preparation and implementation of River Basin Management Plans and the Flood Risk Management Plans and the National Programme for Urban Wastewater treatment.
The Ministry of Environment is responsible for:
• adopting the National Environmental Policy,
• overseeing several institutions with relevance for water issues, including the Chief Inspectorate Of Environmental Protection (Główny Inspektorat Ochrony Środowiska) which monitors the state of environment including the quality of water and the National Fund of Environmental Protection and Water Management (Narodowy Fundusz Ochrony
	Examples in the Copernicus user uptake includes training workshops for various economical applications and the use of RS for land use changes, environmental assessment and agriculture and forestry.
	Thera re no examples about inland waters.
	
	The Institute of Geodesy and Cartography runs several R&D and support projects. The Remote Sensing Centre, within the Institute

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Środowiska i Gospodarki Wodnej) which provides funding for environmental investments, including in the water sector. Ministry of Maritime Economy and Inland Navigation (Ministerstwo Gospodarki Morskiej i Żeglugi Śródlądowej) deals with maritime issues, fishing and inland navigation. Hydroportal is a public mapping portal gathering information on water management for the territory of Poland - flood risk, the hydrographic network, water facilities and structures or water management plans, where information on surface and groundwater bodies can be found. Institute of Meteorology and Water Management - National Research Institute (IMGW-PIB). • regular hydrological measurements and observations, • acquisition, archiving, processing and making available, hydrological measurement and observational materials, • development and exploitation of hydrological mathematical models, Their data portals include marine meteorological observations, oceanographic measurements, hydrological and hydrochemical data, chlorophyll a, marine radioactivity, sea water salinity, sea water temperature, sea water level, ADCP data for the southern Baltic Sea. Institute of Hydro-Engineering of Polish Academy of Sciences does research in: Hydraulics of Rivers, Reservoirs and Estuaries, on: • dispersion of pollutants • thermal regime of inland waters	of Geodesy and Cartography, has many years of experience in R&D in the field of using aerial and satellite images to obtain information about objects, phenomena and processes taking place on the Earth's surface Currently, the Remote Sensing Centre carries out various research topics using optical data (visible, thermal) and radar data, we use the latest satellite imagery from the COPERNICUS Program. They include: • swamp areas (Natura 2000):

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• sediment transport and local erosion • hydraulic modelling Their data portals include bathymetry, shoreline monitoring, hydrodynamic, sea state, temperature data sets and a wind and wave parameters data set from the south Baltic sea (1995). Institute of Oceanology, Polish Academy of Sciences (IO PAS) does research on marine and atmospheric optics, remote sensing, and marine acoustics., numerical hydrodynamics and modelling, among other topics. Data portals include oxygen, sea water salinity, sea water temperature data sets, according to EEA Standard Report for Marine Environment Monitoring Component, 2021. Institute of Geodesy and Cartography (IGiK) • research and applied works in the field of surveying and mapping and related disciplines • research and applied works in the field of basic geodetic measurements • application of aerial and satellite remote sensing in agriculture, environmental protection, regional planning and public statistics	energy and water balance, carbon cycle, soil moisture • natural threats: droughts, floods, fires, landslides; Available data and services - Web Map Service - Copernicus high resolution layers are: wetness and water, imperviousness, tree cover density, dominant leaf type, grasslands.
Conclusion: Active R&D in RS / Copernicus data for several applications, including for water, no implementations in regular water management.	

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Portugal

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • Portuguese Environment Agency (Agência Portuguesa do Ambiente, APA) • River Basin District Administrations (RBDAs) • Águas de Portugal (co-owner of water services, supporting municipal governments) • Entidade Reguladora de Serviços de Águas e Resíduos Central authorities: • manage freshwater and coastal zones (as well as marine waters), • prepare and approve FRMPs and RBMPs, • implement water management in river basins via River Basin District Administrations (which are bodies of the Portuguese Environment Agency at regional level), • supervise the quality of both drinking water and waste water services, • regulate waste water treatment, discharge control and protection of water resources, by setting environmental standards, and the licensing/control. Regional authorities: • River Basin District Councils (multi-stakeholder forums)	**Examples in the Copernicus user uptake include** Copernicus Events for Business Innovation in Portugal - use of Copernicus data and tools by different end-users acting in fields of: Ocean Monitoring (Azores) Coastal Communities (Azores) Forest Fires (outside Lisbon)

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• advise and offer technical assistance during the development of RBMPs. The autonomous regions of Azores and Madeira have additional powers, including: • prepare and approve RBMPs and FRMPs, • responsibility for water supply (Azores). <u>Local:</u> Municipalities: • contribute to the drafting of the FRMPs and RBMPs, • take responsibility for water supply and sewerage, including via municipally owned companies and multi-municipal systems, • take responsibility for storm water drainage. Multi-municipal systems, jointly owned by Águas de Portugal (a national holding company) and the municipalities in their areas, are responsible for: • the abstraction, treatment and main regional distribution systems of drinking water, • regional sewerage and waste water treatment. <u>Local:</u> Municipalities: • promote adaptation measures to climate change • design and validation of strategies and action plans for local climate adaptation. <u>Direção-Geral do Território</u> (DGT) - responsible for: • pursuing public policies on spatial planning, land use, territorial and urban development, and geographic information (GI) • in charge of the National Geodetic Network	Agriculture (outside Lisbon) Smart Cities (Lisbon) Energy (Lisbon) There are no examples of RS uses for inland waters. The R&D activities, however, there are several institutions (universities, research centres) involved in projects on water quality of inland and transitional waters, hydrology, coastal management, etc.

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• production of topographic and thematic cartography and Cadastre • coordination of the National Spatial Data Infrastructure (SNIG). has an R&D department for the development of innovative methodologies to acquire, produce and explore geographic information. The Portuguese Institute for Sea and Atmosphere (IPMA) • Climate change • Remote sensing • Risk evaluation Tsunami early warning system • Assessment and prediction of environmental status • Fisheries science and management • Knowledge and innovative technologies for aquaculture development • Support to high added-value activities • Development and exploration of new products and technologies Data portals include daily and monthly climate data sets, waves, currents, sea level, sea temperature, air temperature, evapotranspiration, soil moisture.	
Conclusion: : Active R&D in RS / Copernicus data for several applications, including for water, no implementations in regular water management.	

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Romania

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • National Administration Romanian Waters • Ministry of the Environment, Waters and Forests • National Environment Protection Agency National Administration Romanian Waters (NARW), including the River Basin Administrations: • monitors and assesses status of groundwater and surface water, economic analysis, pressure and impact analysis, • prepares the RBMP and the PoM as well as the FRMPs, • carries out public participation activities, • implements measures in the PoM and the FRMPs, • administers the dam and reservoir situated at the border between Romania and Moldova. The Ministry of the Environment, Waters and Forests: • drafts and enforces regulations, • supervises the NARW. The National Environment Protection Agency (NEPA) is responsible for regulation in the area of environmental protection including permitting. Regional:	In the Copernicus user uptake, several examples are listed, that involve the Romanian Space Agency (ROSA), for: • Snow monitoring • Soil moisture • Agriculture • Forest studies, including one success story of identifying illegal deforestation • Identify places in the existing national legislation where

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• No specific water competencies were identified at regional level. Local: Counties and municipalities • Inter-communal Development Associations (IDAs) The Municipalities, Towns and rural Communes are responsible for: • water supply, • sewerage and treatment of wastewater and pluvial waters, • collective ownership of commercial Regional Operating Companies providing water services. National Institute of Hydrology and Water Management (NIHWM) • conception and policy issues within the area of hydrology hydrogeology and integrated management of water • short, medium, and long range hydrologic forecasts • warnings of dangerous hydrologic events for prevention and management of crisis situations (floods, droughts) • mathematical modelling of surface and groundwater resources, hydrological and hydrogeological synthetic parameters • water resources management, eco hydrology, flood and drought risk management, impact of human activity and of the climate changes on the hydrological regime • hydrological and hydrogeological data base development, GIS hydrological applications	Copernicus products and services can further improve policy making processes In the R&D sector, apart from ROSA, there are numerous universities (e.g. University of Bucharest, University of Timisoara, etc) and national institutes (NIRD GeoEcoMar, NIRD Grigore Antipa, NIRD Danube Delta), as well as companies (e.g. Terasigna) involved in projects using RS data for water quality, flood management, management of wetlands, including the Danube Delta, developing or improving algorithms

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• coordination of hydrologic and hydro geologic activity at a national level, providing the technical and scientific guidance and assistance of the hydrologic network and for the implementation of modernization programs of the national hydrological system Data portals include daily hydrological characterization for Danube and main rivers, short and medium term prognosis for the Danube and main rivers. National Meteorological Administration: • weather forecast • climatological studies and scenarios • climatological components within various impact and environmental balance studies Data portals include meteorological data - air temperature, wind speed and direction, air humidity, pressure, precipitation, cloud cover, sunshine duration	for water parameters, using RS in numerical modelling, coastal management, etc In these projects, a part of the effort consists in showcasing the use of RS/Copernicus data for water management to public authorities and municipalities.
Conclusion: : Very active R&D in RS/ Copernicus data for several applications, including for water, implementations in regular water management would be the next step.	

Slovakia

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: Central:	There is an example from Slovakia in the

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• Ministry of Environment, • Ministry of Agriculture and Rural Development, • Slovakian Environmental Inspection • Water Research Institute (WRI) • Regions with delegated competences The Ministry of Environment is responsible for: • preparing and coordinating the implementation of the RBMPs, PoMs and FRMPs, • managing River Basin Districts, • identifying water planning tasks, • enforcing regulations, • carrying out analyses of sub-basin characteristics and assessing the effects of human activities on surface water status and groundwater status, • creating and implementing monitoring programmes for surface waters, groundwater and protected areas, • ensuring public participation in the implementation of the Floods Directive and the WFD, • issuing permits and plans for water abstraction and water use, • monitoring and assessment of status of surface waters and groundwater, • monitoring wastewater discharges and their impacts on the recipient bodies (through the Slovak Environment Inspectorate), • overseeing water services (drinking water and waste water, including storm water), • coordinating international cooperation on the management of transboundary RBDs.	Copernicus user uptake on forests monitoring . There are reported R&D activities in Slovakia in the field - e.g. the activities of the Slovak Hydrometeorological Institute (SHMI) are oriented towards satellite information applications for flood forecasting, "nowcasting" (short-range weather forecasting) and monitoring support.

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Other ministries include: • Ministry of Agriculture: oversees water for irrigation, • Ministry of Economy: responsible for hydropower facilities, • Ministry of Health: monitors drinking water and bathing water quality. District offices of the state administration are responsible for: • giving consent and opinions in administrative proceedings and in matters concerning transboundary waters, • supervising water protection within the scope of their competence. Regional: Self-governing regions do not have significant water management competencies. Local: Municipalities: • grant permits for the abstraction of surface water and groundwater and their use to households and construction projects, • are responsible for drinking water supply, public sewers and waste water treatment (via municipally owned companies), • perform state water protection supervision within the scope of its competence and imposes measures to remedy the identified deficiencies, • regulate the use of small watercourses and other water bodies.	

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Water Research Institute: • Water sampling and Analysis for clients • Pesticides - Assessment for authorization of plant protection agents in SR • Flow Meter calibration • Maps/ Map services • Water monitoring • Identification of mixing zones • Primary advisement of new infrastructural project • Integrated monitoring of pollution sources **Slovak Hydrometeorological Institute (SHMU)** • Monitoring of quantitative and qualitative parameters, characterizing air and water conditions on the territory of the Slovak Republic, including air pollution, water quality and environmental radioactivity • Collection, validation, evaluation, archiving and interpretation of data on state and regime of air and water conditions • Provision of operational and non-operational data and information on conditions and regime of air and water including weather and hydrological forecasts and warnings to customers • Description and study of atmospheric and hydrological phenomena.	
Conclusion: Active R&D in RS / Copernicus data for several applications, including for water, no implementations in regular water management.	

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Slovenia

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • Ministry of the Environment and Spatial Planning The Ministry of Environment and Spatial Planning of Slovenia is responsible for: • monitoring of the status of groundwater and surface water, • enforcement of regulations, • pressure and impact analysis and economic analysis, • preparation of RBMPs and PoM, • coordination of public participation, • implementation of measures, • co-ordination of implementation Slovenian Environment Agency • Preserving natural resources, biodiversity and sustainable development; • Observing, analysing and forecasting natural phenomena and processes in the environment; • Reducing impact of natural hazards; • Ensuring legal protection and professional assistance to participants in environmental encroachment procedures;	There are no examples from Slovenia in the Copernicus user uptake. The Copernicus Emergency Management Service was accessed by Slovenia in 2014 for flood mapping. The country was hit by severe flooding after heavy snow.. RS data is used in R&D

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• Contribute to building national values system in relation to the environment as well as influencing the value criteria for environmental encroachments; • Ensuring high-quality environmental data for all target groups; • Raising the awareness of people and institutions about the environment and environmental issues. Data portals include surface water data - water level, discharge and temperature. Local: • Municipalities (občine) Local authorities are responsible for: • protection of drinking water sources, in cooperation with the regional water authorities, • implementation of specific measures set out in the RBMP and FRMP, • drinking water supply and the collection and treatment of urban waste water (including supervision of service providers, often municipally owned companies).	and by SMEs in Slovenia.
Conclusion: Active R&D in RS / Copernicus data for several applications, including for water, no implementations in regular water management.	

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Spain

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: Competencies on freshwater management are highly decentralized, managed by River Basin Authorities for inter-regional river basins and by regional authorities for intra-regional river basins. • Ministry for the Ecologic Transition • National Council on Water State authorities: • take responsibility for decision-making on fresh water, through consultation with the National Council on Water, • approve RBMPs and FRMPs prepared by either regional or river basin authorities, • manage conflicts between River Basin Authorities and other national-level issues (such as water transfers, flood management) detailed in the National Hydrologic Plan, • take responsibility for large-scale civil protection strategies and for coastal areas vulnerable to flood risk, • undertake international cooperation, with Portugal (under the Convention of Albufeira) and with France,	There are some examples in the Copernicus user uptake from Spain, on land monitoring and climate change studies. There are many workshops and training sessions organized for scientists working or studying at universities or research centres; professionals of

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• undertake public participation at national level. Regional: • River Basin authorities • Canary Islands water authority • Balearic Islands RB authority River Basin Authorities are responsible for inter-regional River Basins: • manage river basins and prepare and implement RBMPs and FRMPs for inter-regional River Basins (determining objectives, managing resources, risk assessment, public consultation, monitoring), • manage large-scale water users, such as agriculture or power generation, • plan and build infrastructure according to requests from the central government, • assist municipalities in implementing water-related projects. The governing boards of these River Basin Authorities include representatives of the central government and of the regions within their territories. Regional authorities are responsible for intra-regional River Basins: • manage river basins and prepare and implement RBMPs and FRMPs for intra-regional river basins (determining objectives, managing resources, risk assessment, public consultation, monitoring), • manage land and freshwater resources, civil protection. Local: • Different local authorities (in charge of water supply and wastewater treatment)	public organisms in charge of the management of natural and agricultural resources, the industry sector, Opportunities for economic development are presented. The R&D activities, that use RS data are focused on water sufficiency (drought being a major problem in Spain), basin management, lake monitoring (level, extent, e.g. Morales et al., 2021), water quality in inland,

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• Water Court of the plain of Valencia • Council of Wise Men of the plain of Murcia • Association of private or semi-public companies on water management Municipalities: • manage urban water supply and wastewater treatment (occasionally in collaboration with regional authorities), • define the regulation and price to be paid for water users, • manage water supply and wastewater treatment infrastructure and if applicable contract day to day management to private or semi-public enterprises, • undertake urban planning and civil protection plans related to flood risk Communities of users bring together local stakeholders (in particular, agriculture) to resolve conflicts related to water use. Some of these bodies have deep historical roots, such as the Court of Water of the plains of Valencia (dating to the 10th century) and the Council of Wise Men of the plain of Murcia. **Instituto de Hidráulica Ambiental de Cantabria (IHCantabria)** • climate change and climate services • marine energies and offshore engineering • environmental management and planning • coastal hydrodynamics and infrastructures • coastal engineering and management • port engineering and management National Institute for Aerospace Technology (INTA)	transitional and coastal waters, groundwater management. These activities also imply developing or improving algorithms and numerical models.

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• technological **research** and **development** in aerospace, aeronautics, and hydrodynamics, and in security and defence technologies • performing all types of tests to check, approve and certify materials, components equipment items, subsystems and systems • providing technical assessment and services to official entities and agencies, and also to industrial or technological companies	
Conclusion: Very active R&D in RS / Copernicus data for several applications, including for water, steps for implementations in regular water management. have been taken.	

Sweden

Water management characteristics and data	*RS / Copernicus data in water management*
Responsible organizations: National: • Havs- och vattenmyndigheten (Swedish Agency for Marine and Water Management, SwAM) • Environmental Protection Agency (Naturvårdsverket) • Geological Survey of Sweden (Sveriges Geologiska Undersökning) • Myndigheten för Samhällsskydd och Beredskap (Swedish Civil Contingencies Agency) Central authorities:	The examples from Sweden in the Copernicus user uptake show mostly coastal studies and forest management. Sweden is active in R&D and use of RS/Copernicus data. - Swedish National

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• preserve and ensure the sustainable development of Swedish lakes and waterways, prepare national guidance, enforce regulations, • act as competent authorities under the WFD and Floods Directive, • coordinate the five water authorities, • issue regulations regarding the implementation of measures and coordination of WFD measures, • implement certain WFD measures and coordinate implementation of others, • finance and carry out monitoring and financing of monitoring, • coordinate the production of regional FRPMs. • cooperation with neighbouring countries. Regional: • County boards (regionstyrelser), five of which are Water District Authority for a RBD. Sweden is divided into five water districts, which in turn cover 10 river basin districts (RBDs) reported under the WFD. One county administrative board in each water district is appointed as the authority for the water district. Counties and municipalities can belong to more than one water district. The Water Authorities: • prepare the RBMP and the programme of measures, • monitor groundwater and surface water, • coordinate implementation, • coordinate public participation, • set environmental quality standards. All county Administrative Boards:	Space Agency (SNSA). Piloting downstream applications and services of relevance to Coastal Management at local and regional level - to raise the awareness and use of Copernicus data and services for municipalities at local level as well as regional authorities; a novel Artificial Intelligence (AI) method based on Sentinel-2 data was developed to identify physical changes along the Swedish coast, especially physical constructions such as piers and jetties; to support marine and terrestrial planning regarding the dynamics of the coastal zone.

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• enforce regulations, • assess ground and surface water (including several monitoring programmes), • conduct analysis on pressures and impacts, • coordinates with other CABs, • prepare the FRMPs (at APSFR level), • coordinate public participation. Swedish Agency for Marine and Water Management, SwAM • environmental monitoring efforts of marine and freshwater bodies • aquatic biodiversity of Swedish waters and alien species • regulations and the control of commercial fishing • marine spatial planning - shipping, energy production, and other sectors, taking into account biodiversity and other environmental interests. Local authorities: local municipalities (kommuner) and stakeholder Water Councils • provide water supply, sewerage and waste water treatment, either directly or via municipally owned water companies • take responsibility for permits and enforcement relating to the WFD • support public participation • coordinate with regional representatives on water coordination policy Swedish Meteorological and Hydrological Institute	Other agencies that use TS / Copernicus adata: Swedish Forest Agency (SFA) - uses, among other things, earth observation data to monitor forest harvesting. Swedish Maritime Administration (SMA) - optimizes icebreaking and ensures maritime accessibility. Swedish Civil Contingencies Agency (MSB) - benefits from Copernicus for monitoring forest fires and floods. Some examples from Sweden are found in the C3S on: river hydrology, water quality of lakes in a

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• daily forecasts to the general public and issues warnings when faced with severe weather and water events • risk analyses for water catchment areas • calculations of emission and dispersion into the air • forecasts and scenarios on how accidental releases disperse in water	changing climate, urban flooding. R&D activities on water research using RS are very well developed, and they include studies on water quality of inland and coastal waters (see also Philipson et al. 2016; Kratzer et al. 2019) , hydrology - flood studies (Mourad et al. 2022), snow hydrology, effects of climate change, catchment management. These projects involve public authorities and companies.
Conclusion: Very active R&D in RS / Copernicus data for several applications, including for water, steps for implementations in regular water management. have been taken.	

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3.3. Opportunities and challenges for further use of RS/Copernicus data and services in water management at national level in EU

As the overview from the previous section shows, in most EU countries, use of RS/Copernicus data in regular water policy and management activities is still rather limited. With few exceptions (e.g. Finland) the potential of using such data is still only being explored in R&D activities. There are also large differences regarding advancement of these R&D activities across different countries. In these conditions it is worthwhile to address opportunities and challenges for further research, promotion and eventual use of RS/Copernicus data in national water policy and management.

Opportunities for introduction of RS/Copernicus data in national water management

1. Existing and initiated R&D activities on use of RS/Copernicus data in water-related applications. Most countries have developed ecosystem of research organizations and SMEs that are active in this kind of research, supported by national and European space and remote-sensing agencies. These actors are of vital importance for demonstrating the value of RS/Copernicus data in water management applications.
2. R&D and demonstration activities regarding use of RS/Copernicus data should be focused on current global challenges where water

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systems have a major role, such as climate change analysis and adaptation, achievement and monitoring of SDGs. These are not 'regular' water management activities, but given their importance, water agencies are requested to address them in their planning and policy development. At the same time, they require holistic and interdisciplinary approaches that combine different data sources coming from many different sectors. Through such activities, the value of RS/Copernicus data can be revealed and gradually introduced in mainstream water management as well.

3. Implementation and monitoring of progress with the EU water-related directives is a similar opportunity. Here, the water agencies are clearly mandated to carry out these tasks, and in some countries RS/Copernicus data are already used for these purposes (specifically for checking water quality status – related to WFD and for flood hazard and flood risk maps development and validation – related to FD). Such example uses should be continued, shared and replicated in other countries.
4. Some Copernicus services are naturally closer to inland water management activities. Examples are the Emergency Management Service (CEMS) (for managing floods and droughts), the Land Monitoring Service (CLMS) (e.g. for managing water resources, irrigation and agricultural use), or the Climate Change Service (CCCS) (for analysis of future climate). For their own operations they often need to collaborate with national water agencies. One

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clear example is the collaboration of the Emergency service with national hydrological agencies for obtaining in-situ measured discharge data. These data are used for calibration and validation of the CEMS flood models, used for their mapping and forecasting activities. Such relations are very valuable and need to be developed further for bringing Copernicus services to the local water management.

5. In relation to the previous point, an important condition for further introduction of RS/Copernicus data in national water management is the demonstration of the value of such data on *local* water management issues and problems. Copernicus services are naturally oriented at European and global scales and contexts. However, water management activities are often much more local in nature, and demonstrations on how these data and services can be used locally would be helpful. Some initial examples of these approaches are already provided in the water management sector of CCCS, where some demonstrator and showcase projects are developed in partnerships with national water management organizations and show results on local scales.
6. physical and biogeochemical processes in river basins, groundwater, lakes, estuaries, near coastal and ocean zones; it is a scalable technique across bodies of water, regions and applications

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Challenges to the introduction of RS/Copernicus data in national water management

1. Further improvements of RS/Copernicus data in terms of types of variables, spatial and temporal resolutions, accuracy and reliability are needed, as already reported in WoterForCE deliverables D1.4, D1.6, D3.1, D3.4., D 5.1, D5.2. These improvements will make such data more attractive to water managers for their regular activities.
2. Demonstrator applications with *merged data* from in-situ networks and RS/Copernicus sources are needed. Examples from countries where these approaches have been applied (Finland) need to be shared and replicated.
3. Investments in capacity development in water agencies for use of RS/Copernicus data are needed. This is a rather critical challenge. Many national water agencies lack skilled workforce that can explore and recognize the advantages of using RS/Copernicus data. Most current capacity development efforts are initiated by and delivered to actors active in the RS / space domain. Expanding these to the water management actors is both a financial and institutional challenge. One possible avenue is inclusion of water agencies in R&D projects and innovations specifically oriented to usage of RS/Copernicus data. However, moving beyond research activities towards capacity development for usage of RS/Copernicus in regular water management activities is also required.

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4. Closer cooperation between RS/ Copernicus services and national water monitoring organizations. Such cooperative activities need to go beyond concerns related to the importance of in-situ water monitoring networks for calibration and validation of satellite-based products. Joint engagement in local water management (in research and in operations), where usage of merged data will bring value is needed (see point 1), bringing in the advantages of both approaches.
5. As mentioned in the introductory sub-section 2.1, water management is a rather 'conservative' sector, which is often guided by regulations. Introducing usage of RS/Copernicus data as mandatory in water-related regulations is still far away, but initial explorations of such possibilities are needed. Again, this could start in areas of the European and global challenges mentioned above (WFD implementation and monitoring, SDGs, climate change analysis and adaptations), with demonstrations how RS/Copernicus data can lead to generalized and unified approaches (e.g. example research in Estonia).

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4. International use of RS

4.1 International initiatives to streamline the use of EO

There are multiple inter-governmental initiatives with exclusive mandates on streamlining the use of Earth Observation in solving global challenges including sustainable development. One of the major initiatives in this regard is Group on Earth Observations (GEO) which is a partnership of more than 100 national governments and organizations with major objective being main streaming Earth observation data for decisions and actions for the benefit of humankind by coordinated, comprehensive and sustained activities (url: www.earthobservations.org). GEO initiated the development of Global Earth Observation System of Systems (GEOSS) with the Committee on Earth Observation Satellites (CEOS) contributing to the technical side of the development. CEOS was established to provide coordination of the Earth observations provided by satellite missions, recognising that no single programme, agency or nation can satisfy all of the observational requirements that are necessary for improved understanding of the Earth system. Currently CEOS has 32 space agency members. CEOS provides a broad framework for international coordination on space-borne EO missions. The main objective of the GEOSS is to better integrate observing systems and share data by connecting existing infrastructures using common standards. There are more than 400 million open data resources in GEOSS (url: www.geoportal.org/) from more than 150 national and regional providers such as NASA and ESA; international organizations such as WMO and from the private sector. Together these

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efforts are expected to reap larger societal benefits in different application areas including weather, water, agriculture, health, disaster management, biodiversity etc.

The EO from space is internationally regulated by the Outer Space Treaty (OST),1967; the UN Resolution on Principles relating to Remote Sensing of the Earth from OuterSpace, 1986; and the World Meteorological Organisation (WMO) Resolution 40 adopted in 1995. In addition, many countries have their own policies developed on EO regulations and the use of remote sensing in emerging global topics. Here the role of GEO is to bring together these policies in such a way that it will promote data sharing to combat global challenges including water resource management and monitoring.

The open data policies adopted by NASA, the French space agency, Centre National d'Etudes Spatiales (CNES), the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Indian Department of Space Research Organisation (ISRO) has resulted in the availability of enormous amount of EO data in the public domain. Under the Copernicus programme, ESA provides free access to their satellite data and the derived products. For last three decades, EO data has been used extensively as a reliable source for informed decisions, for example in weather, climate, crop monitoring and early warning systems. Examples are the U.S. Agency for International Development's Famine Early Warning

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Systems Network–FEWS NET (Funk et al. 2019), and the Centre régional de formation et d'application en agrométéorologie et hydrologie opérationnelle (AGRHYMET - http://www.agrhymet.ne/) of the Permanent Interstates Committee for Drought Control in the Sahel (CILSS). Some African countries have also invested in developing nano/cube-satellites, such as Algeria (AlSat), Nigeria (NigeriaSat) and South Africa (SumbandilaSat, SUNSAT, ZACube-2) (Ifejika Speranza et.al, 2022). Most recently United Arab Emirates also entered into Earth observation satellites by deploying their own satellites (Khalifasat, Dubaisat etc).

4.2 Available RS data for water quantity and water quality modelling

In this sub-section the RS data availability to key inputs for water quantity and water quality models are explored. Data provided by Copernicus services are not focused here as they are explained in other deliverables. Here the focus is given to other global datasets from providers outside Europe. In the water quantity modelling, data are required from the following domains - topography, climate, soil, land cover, water level, discharge and flood extent. The use of remote sensing data can be broadly divided into two: (1) use of remote-sensing data to create some of the spatially distributed input parameter sets for a model, and (2) constraining of models during calibration by spatially distributed data derived from remote sensing (Brunner et.al, 2007).

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For topography, satellite derived Digital Elevation Models (DEM) are widely used. DEM's are available at global scale from multiple sources like NASA Shuttle Radar Topography Mission (SRTM) at 90 m, ALOS World 3D at 30 m from JAXA, Copernicus DEM GLO-30 and GLO-90 at 30 and 90 m respectively. There are domain specific derived DEM's like HydroSHEDS Hydrologically Conditioned DEM at 90 m exclusively developed for hydrological applications like water resource modelling (Lehner et.al, 2008). Within the climatic variables, the most important variable derived directly from satellite data is precipitation. Most important products are Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) and Global Precipitation Measurement (GPM) (collaborative mission between space agencies). Both CHIRPS and GPM offers 35 + years of precipitation data at daily scale, however the spatial resolution is coarse approximately 5 Km. There are no specific satellite derived products available for soil from the international agencies. For land cover land use, which is one of the major components while performing water use assessments and water accounting, there are multiple products available namely, MODIS Land cover product at 250 m which is available annually, Copernicus land cover product at 100m annually available since 2015 (upto 2019) (url: https://lcviewer.vito.be/) to high resolution global land cover products like ESA land cover at 10m available for 2020 and 2021 developed from Sentinel 2 data (url: https://esa-worldcover.org/en). Most recent high-resolution product released was from Google called Dynamic world based on deep learning models at 20 m resolution based on both Landsat and

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sentinel data. Water level data are available from Copernicus global land service and Database for Hydrological Time Series of Inland Waters (DAHITI), both very sparse. Water discharge data is very difficult to find and there are no sources available from Remote sensing. Determining the flood area is often done on a demand basis. Though this is of high interest there is no centralised platform providing near real time flood inundation maps using Synthetic Aperture Radar (SAR) data. In this aspect the synthetic aperture data is widely and efficiently used to map the water-logged area. Hence it is very important to have the SAR data sets available near real time from multiple sources to be able to use by agencies to map out the flood extent soon after the disaster strikes. Most useful ones are sentinel 1 from ESA, ALOS PALSAR from JAXA (recently made available in public domain etc. In order to quantify the water use by different sectors the most useful data is spatially distributed Actual Evapotranspiration (ETa) normally derived from the thermal bands. The open datasets for ETa are Operational Simplified Surface Energy Balance (SSEBop) based on MODIS data (~1km spatial resolution) (url: https://earlywarning.usgs.gov/ssebop/modis), MOD16 ETa product (8 day, monthly at 500 m spatial resolution) (url: https://modis.gsfc.nasa.gov/data/dataprod/mod16.php)and WaPOR ETa (Dekadal and monthly at 250 m for Africa and Near East countries) (url: https://wapor.apps.fao.org/). Recently a provisional high resolution on-demand ETa product at 30 m was introduced by USGS based on Landsat

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data (url: https://www.usgs.gov/landsat-missions/landsat-collection-1-provisional-actual-evapotranspiration-product).

Water quality parameters globally are available from NASA OceanColor Web database (url: https://oceancolor.gsfc.nasa.gov/) where daily data on Chlorophyll-a, Particulate Organic Carbon, Photosynthetically Active Radiation, Reflectances are provided. The data provided from OceanColor web are primarily aimed for oceans, though major inland water bodies are also covered in the database. The spatial resolution is 1 – 4 Km and the data is derived from SeaWiFS, MODIS and Sentinel 3 OLCI sensors. Another important source is the Copernicus Global land service (CGLS) (url: https://land.copernicus.eu/global/products/lwq) where water quality parameters for inland water bodies are provided. The variable provided are Chlorophyll-a, Trophic State Index (TSI) and Turbidity. The products are derived from Sentinel 3 OLCI and Envisat MERIS sensors at 300m resolution.

For physical properties of inland water bodies like surface area, water level and surface water temperature there are multiple project-based initiatives developing global databases. The Database for Hydrological Time Series of Inland Waters (DAHITI) was developed by the Deutsches Geodätisches Forschungsinstitut der Technischen Universität München (DGFI-TUM) in 2013 to provide water level time series of inland waters (url: https://dahiti.dgfi.tum.de/). DAIHITI provides remote sensing altimetry

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based water level data (historical to near real time) for 10042 inland water bodies all over the world. CGLS also provides alitimetry based water level data for many lakes and rivers around the world (url: https://land.copernicus.eu/global/products/wl).

Lake Surface Water Temperature (LSWT) is another physical property which is derived from the thermal bands of satellite data. There are multiple databases available which offers LSWT data of multiple inland waterbodies around the world. CGLS provided ongoing archive LSWT derived from Sentinel 3 SLSTR and Envisat AATSR at 1 km spatial resolution. The data is provided near real time within 3-5 days of latency. There are other project based databases like ArcLakes and GloboLakes which provides historical data of LSWT for hundreds of lakes globally (url: http://www.laketemp.net/home/).
More details on water quality parameters which can measured using EO and available products are covered in WP 2 deliverables.

4.3 Global Initiatives to disseminate Earth Observation data/products for water challenges

In this section several examples on thematic remote sensing based initiatives globally related to water are explained. Traditionally RS based Rainfall and ETa data have been used successfully in water balance studies all over the world. In recent years, there were lot of interest in

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developing the concept of Water accounting which aims at quantifying the water availability per sector usually in a basin. Water Accounting requires systematic acquisition, analysis and communication of data and information related to stocks and fluxes of water in natural, disturbed or heavily engineered environments within a geographical area such as an irrigation system, a river basin or a country. In this context remote sensing based spatial observations play key role in implementing water accounting analysis around the world. Three major RS data products are being used in the water accounting analysis, i) Land cover maps, ii) Actual EvapoTranspiration iii) Rainfall and iv) Net Primary Production (NPP). These data are usually obtained from the RS based data sources as explained in the above section 4.2. The Water Accounting Plus framework is developed by a partnership consisting of IHE Delft Institute for Water Education, the International Water Management Institute and the Food and Agricultural of the UN (url: www.wateraccounting.org).

Remote Sensing based products are also used extensively in modelling floods and droughts which are essentially quantifying the water availability over an area for a given time period. Time series of precipitation data available from micro wave remote sensing sensors and DEM data (see Section 4.2) are used as an input to hydrodynamic and hydrological models for the prediction of flood dynamics. With the availability of high-resolution Synthetic Aperture Radar (SAR) data, flood inundated areas are accurately mapped post disaster. Below several data dissemination

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platforms are introduced which also contributes to these applications worldwide.

FAO's portal to monitor Water Productivity through Open-access of Remotely sensed derived data (WaPOR) uses satellite data to help countries monitor agricultural water productivity, identify water productivity gaps and find solutions (url: https://wapor.apps.fao.org/). The portal offers RS derived products on ETa, ETp and NPP over Africa and Near East countries near real time. The data is available at three different spatial resolutions, 250 m (entire area), 100 m (Selected countries) and 30 m (few selected areas) at different temporal aggregations (decadal, monthly) since 2009.

SERVIR is a joint initiative of the NASA and United States Agency for International Development (USAID), and leading geospatial organizations in Asia, Africa, and Latin America. SERVIR partners with countries and organizations in these regions to address critical challenges in climate change, food security, water and related disasters, land use, and air quality. Using satellite data and geospatial technology, SERVIR co-develops innovative solutions through a network of regional hubs to improve resilience and sustainable resource management at local, national and regional scales. SERVIR also provides RS derived data for selected areas on flood prone areas, water quality parameters etc (url: https://www.servirglobal.net/).

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World Resource Institute's Aqueduct is a data platform providing global outlook on water stress and flood prone areas among many other variables available in the platform (url: https://www.wri.org/aqueduct/tools). Though the products are not directly derived from RS, there are many RS based inputs which drives the models behind the products provided by Aqueduct.

Global surface water explorer developed by EU Joint Research Centre (JRC) provides temporal dynamics of surface water globally at high resolution of 30 m (url: https://global-surface-water.appspot.com/). The product is developed from the historical Landsat images (1984 - 2021) and provide derived spatial layers on water occurance, seasonality, recurrence, transitions and maximum water extent in the last 4 decades.

The Freshwater Ecosystems Explorer primarily focusing on SDG indicator 6.6.1 (Change in the extent of water-related ecosystems over time) is an open data platform which provides high-resolution geospatial data depicting the extent freshwater ecosystems change over time (url: https://www.sdg661.app/). The data is intended to drive action to protect and restore freshwater ecosystems and enable countries to track progress towards the achievement of Sustainable Development Goal Target 6.6. Data can be visualized and downloaded at national, sub-national and basin levels. Data is available on permanent and seasonal surface waters, reservoirs, wetlands, mangroves, water quality.

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Digital Earth (DE) Africa platform is developed in collaboration with the partners in the Africa continent to leverage the use of Earth observations to address key challenges of the continent including water and food security (url: https://www.digitalearthafrica.org/). The platform enables African governments, industry and decision makers to track changes across the continent in different themes. This provides valuable insights for better decision making across many areas, including flooding, drought, soil and coastal erosion, agriculture, forest cover, land use and land cover change, water availability and quality, and changes to human settlements. For example DE Africa offers a continental wide service called Water observations from Sapce (WOfS) which covers the following layers, water and non-water classification, the ratio of wet to clear observations per calendar year and the ratio of wet to clear observations over longer time period.

The Worldview platform from NASA's Earth Observing System Data and Information System (EOSDIS) provides interactive browse of thousands of satellite images and products primarily from NASA satellites. The major advantage of the platform is that the data is updated within three hours after acquisition. The user can also preview, search and download from the platform. The real time snapshots of the data are critical especially for quick monitoring after any disaster.

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4.4 Integration of EO in water quantity and quality modelling at policy level

GEO is working with the member countries to increase the uptake of EO data in their monitoring and reporting systems. However, other than the global examples mentioned in the section 4.3 and isolated consortium projects a systematic national level system for periodic monitoring of water resources contributing to the reporting is still rare to find. There is still a large gap between the availability of data and how this data is being used for operational monitoring at national/country scale. Few countries now have data regulations in place related to Earth observations. Following the efforts of GEO it can be expected that more countries will adopt legislation in the near future: over 40 countries now have Earth observation systems and the trends toward commercialization and privatization have gained momentum in recent years (Harris & Boumann, 2021).

Key challenges in integrating the use of EO data for monitoring and assessing water resources at policy level are the lack of capacity, lack of trust in this data among the decision makers, un reliable temporal revisits especially for using in disaster responses. The acceptance of this technology in the operational use varies between countries, some being in the forefront while others still in very beginning stage. While there is plethora of digital platforms available, the uptake of these platforms in real use cases are still missing which results in less usage than expected.

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Hence raising awareness on the usability of the EO data in water resource management and capacity development is key to ensure adaptation of this technique by the governments.

5. Conclusions

Present report made an extensive overview of the use of Copernicus Services to support water related policies in Europe, both at European level and at country level. After the thorough analysis at country level, the report looks at RS in general and EO, in international context.

At EU level water policy in all member states is based on the relevant EU Directives, most important of which are the Water Framework Directive (WFD) and the Flood Directive (FD). These have been translated into corresponding national legislation, and have led to development of River Basin Management (FRM) and Flood Risk Management (FRM) plans. Implementation of these directives, in particular the development of RBM and FRM plans have involved extensive modelling of the water systems, mostly with data from existing in-situ monitoring networks. Some recent initiatives for demonstrating the usefulness of Copernicus data in monitoring and assessing progress with implementation of WFD. However, such examples come from research centres and actors actively engaged in Copernicus uptake, and expansion to regular water management activities is yet to be realised. This report makes an extensive overview of the use of Copernicus data at national levels

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References

A) Citations

- Aleksieva-Petrova, A.; Mladenova, I.; Dimitrova, K.; Iliev, K.; Georgiev, A.; Dyankova, A. Earth-Observation-Based Services for National Reporting of the Sustainable Development Goal Indicators–Three Showcases in Bulgaria. *Remote Sens.* 2022, 14, 2597. DOI:10.3390/rs14112597
- Bisselink, B., Bernhard, J., Gelati, E., Adamovic, M., Guenther, S., Mentaschi, L. and De Roo, A., (2018) Impact of a changing climate, land use, and water usage on Europe's water resources: A model simulation study, EUR 29130 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-80288-1, doi:10.2760/09027, JRC110927.
- D1.4 Report with end-user needs and requirements, (2022) (Water-ForCE deliverable, leading partner: ICCS)
- D1.6 Report with analysis for business opportunities, validated by industry, 2022 (Water-ForCE deliverable, leading partner: dotSPACE)
- D2.2 Recommendations on Copernicus products - Water Quality, 2021 (Water-ForCE deliverable, leading partners: FvB/IGB)
- D3.2 Review document on Copernicus products related to the hydrological water balance (Water-ForCE deliverable, leading partners: Vrije Universiteit Brussel and Antea Belgium)
- European Commission, Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO), (2021), Overview of natural and man-made disaster risks the European Union may face : 2020 edition, Publications Office, 2021, Doi: 10.2795/1521
- European Commission, Joint Research Centre, De Roo, A., Bisselink, B., Guenther, S., et al., Assessing the effects of water saving measures on Europe's water resources : BLUE2 project : freshwater quantity, Publications Office, 2020, https://data.europa.eu/doi/10.2760/739798

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- European Environment Agency, Ferreira, A., Kolaszewska, D., Adriaenssens, V., et al., Green infrastructure and flood management: promoting cost-efficient flood risk reduction via green infrastructure solutions, Publications Office, 2017,
- Funk, J., Merino, F., Schaks, M. et al. A barbed end interference mechanism reveals how capping protein promotes nucleation in branched actin networks. Nat Commun 12, 5329 (2021). https://doi.org/10.1038/s41467-021-25682-5
- Joint Research Centre, Institute for Environment and Sustainability, Vandecasteele, I., Baranzelli, C., De Roo, A., et al., Evaluation of the effectiveness of natural water retention measures: support to the EU blueprint to safeguard Europe's waters, Publications Office, 2012, https://data.europa.eu/doi/10.2788/5528
- Kratzer S, Kyryliuk D, Edman M, Philipson P, Lyon SW. Synergy of Satellite, In Situ and Modelled Data for Addressing the Scarcity of Water Quality Information for Eutrophication Assessment and Monitoring of Swedish Coastal Waters. Remote Sensing. 2019; 11(17):2051. https://doi.org/10.3390/rs11172051
- Morales, S.; Ruiz, M.; Soria, J. Water Level Fluctuations in Gallocanta Lake (Spain) Using Sentinel-2 Remote Sensing. Preprints 2020, 2020090100 (doi: 10.20944/preprints202009.0100.v1)
- Mourad K.A., Nordin L., Andersson-Sköld Y. (2022) Assessing flooding and possible adaptation measures using remote sensing data and hydrological modeling in Sweden, *Climate Risk Management*, Volume 38, 2022,- 100464, ISSN 2212-0963, https://doi.org/10.1016/j.crm.2022.100464
- Olesen, J E. Climate change, impacts and vulnerability in Europe 2012: An indicator-based report. Vol. 12 European Environment Agency - EEA, 2012. p. 158-171.
- Philipson, P., Kratzer, S., Ben Mustapha S., Strömbeck, N. & Stelzer K. (2016) Satellite-based water quality monitoring in Lake Vänern, Sweden, International Journal of Remote Sensing, 37:16, 3938-3960, DOI: 10.1080/01431161.2016.1204480

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- Remetey-Fülöpp G. (2013) Remote sensing and GIS in Hungary, Geocarto International, 28:1, 1-2, DOI: 10.1080/10106049.2013.766427SEI. 2016, WEAP Tutorial; Stockholm Environment Institute: Stockholm, Sweden

B) Links to websites mentioned in deliverable

Remarks: All sites were last visited on 20 December 2022

- http://www.waterlevel.ie/
- http://www.wateraccounting.org/
- http://www.cnrs.fr/)
- http://www.cadc-albufeira.eu/es/
- https://boe.es/buscar/doc.php?id=BOE-A-2003-19570
- https://boe.es/buscar/doc.php?id=BOE-A-2012-11464
- https://www.dwd.de/DE/leistungen/wawis/wawis.html
- https://remotesensing.vito.be/case/watermonitor
- https://kosmos.ut.ee/en/remote-sensing-water
- http://paikkatieto.ymparisto.fi/vesikarttaviewers/Html5Viewer_2_11_2/Index.html?configBase=http://paikkatieto.ymparisto.fi/Geocortex/Essentials/REST/sites/VesikarttaKansa/viewers/VesikarttaHTML525/virtualdirectory/Resources/Config/Default&locale=fi-FI
- https://climate.copernicus.eu/water-management
- https://www.copernicus.eu/en/use-cases/web-service-platform-maltese-waters
- https://waterveiligheidsportaal.nl/
- https://earsc.org/sebs/all-cases/water-quality-management-in-germany/
- https://earsc.org/sebs/water-quality-in-finland/
- https://www.waterkwaliteitsportaal.nl/
- https://voda.gov.cz/?page=Home
- https://eau.gouvernement.lu/fr.html
- https://info.bml.gv.at/en/topics/water/water-and-data-wisa.html
- https://www.weo-water.com/
- http://www.moa.gov.cy/moa/wdd/wdd.nsf/index_en/index_en?opendocument
- https://map.geoportail.lu/theme/eau?bgLayer=basemap_2015_global&version=3&zoom=9&X=667917&Y=6394482&lang=fr&rotation=0&layers=&opacities=

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- https://www.eurisy.eu/stories/water-board-de-stichtse-rijnlanden-integrated-water-management-using-satellite-information_58/
- http://www.lesagencesdeleau.fr/
- https://www.eurisy.eu/wp-content/uploads/2022/09/Wallonia_Monitoring-and-preventing-floods.pdf
- https://www.eurisy.eu/stories/vof-school-jansen-more-crop-per-drop-thanks-to-satellite-information_61/
- https://voda.gov.cz/?page=Home
- https://veka.eelis.ee/veka.aspx
- https://www.um.edu.mt/
- https://www.lu.lv/en/
- https://dutchwaterauthorities.com/
- https://opw.ie/en/
- https://www.cyi.ac.cy/
- https://www.copernicus.eu/sites/default/files/2018-10/copernicus4regions.pdf
- https://kosmos.ut.ee/en
- http://wwwi4.ymparisto.fi/i4/eng/tarkka/index.html?type=RGB&date=2019-12-16&datespan=1&name=AUTUMN&lang=en&zoom=5&lat=64.00373&lon=26.99417
- http://wfdver.ypeka.gr/el/home-gr/
- https://www.space4water.org/
- http://rst-tto.com/rsttakt/index.php/newsroom/news-releases/50-nrp-scp
- https://www.spaceoffice.nl/en/satellite-data-portal/
- https://rss-hydro.lu/
- https://www.stowa.nl/sites/default/files/assets/PUBLICATIES/Publicaties 2020/STOWA 2020-27 Remote Sensing.pdf
- http://rst-tto.com/rsttakt/
- https://rijnland.maps.arcgis.com/home/item.html?id=e772a5876dae4ad686d728e821ae5dfc
- https://waterinfo.rws.nl/
- https://maps.rijkswaterstaat.nl/GeoWebPortaal/
- https://maps.rijkswaterstaat.nl/dataregister/srv/dut/catalog.search
- https://kaugseire.ee/
- https://www.rews.org.mt/
- https://www.umweltbundesamt.de/daten/datensuche/?s=score&d=desc&t=Wasser&l=de

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- https://keskkonnaportaal.ee/et/teemad/vesi
- https://www.copernicus-user-uptake.eu/user-uptake?tx_news_pi1%5BoverwriteDemand%5D%5Bcategories%5D=62&cHash=fcf2196f9c8a09e4303ea173edf483ac
- https://open4innovation.at/en/
- https://data.public.lu/en/organizations/administration-de-la-gestion-de-leau/
- https://www.nhi.nu/
- https://www.ilmateenistus.ee/siseveed/hudroloogiline-prognoos/?lang=en
- https://www.helpdeskwater.nl/onderwerpen/wetgeving-beleid/nationaal/nationaal-water-programma-2022-2027/
- https://ehdatahub.maaamet.ee/dhus/
- http://www.hydro.bg/indexen.html
- https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/planificacion-hidrologica/plan-hidrologico-nacional/
- https://www.zwemwater.nl/
- https://www.nfosigw.gov.pl/en/
- https://www.eurisy.eu/stories/the-central-command-for-maritime-emergencies-uses-satellite-information-to-monitor-sea-pollution-on-german-coastal-states_7/
- https://www.rijkswaterstaat.nl/en
- https://envir.ee/en/water-forest-resources/water
- https://www.varam.gov.lv/en
- https://www.minambiente.it/aree/acqua
- https://mecdd.gouvernement.lu/en/service.html
- http://ypeka.gr/
- https://energy.gov.mt/en/Pages/default.aspx
- https://mmm.fi/en/frontpage
- https://www.gov.pl/web/gospodarkamorska/podstawowe-informacje
- https://micka.cenia.cz/en/
- https://space-agency.public.lu/en.html/
- https://www.meteolux.lu/?lang=fr
- https://www.collgs.lu/
- http://watersandcommunities.ie/about/
- http://www.meteo.lt/en
- https://www.lgt.lt/index.php/en/
- https://www.lhei.lv/en/

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- https://videscentrs.lvgmc.lv/
- https://www.eurisy.eu/stories/municipality-of-lemvig-denmark-managing-pipelines-and-wastepipes-with-the-support-of-satellite-data_238/
- https://www.eurisy.eu/stories/lake-neusiedl-monitoring-water-quality-with-satellite-imagery_8/
- https://www.ku.lt/en/
- https://www.internetofwater.be/
- https://www.vesi.fi/
- https://www.arera.it/it/inglese/index.htm
- http://www.isprambiente.gov.it/en/topics/Inland-and-coastal-marine-waters/index
- https://www.water.ie/
- https://www.copernicus.eu/sites/default/files/2018-10/copernicus4regions.pdf
- https://www.ihw.nl/home
- http://www.hobe.dk/
- https://www.hydroinfo.hu/
- https://www.vri.lv/en/how-we-work/copernicus/
- https://www.usgs.gov/landsat-missions/landsat-collection-1-provisional-actual-evapotranspiration-product
- https://www.theia-land.fr/
- https://www.tandfonline.com/doi/full/10.1080/10106049.2013.766427?scroll=top&needAccess=true&role=tab
- https://www.tandfonline.com/doi/full/10.1080/01431161.2016.1204480?cookieSet=1
- https://www.smhi.se/en/q/Stockholm/2673730
- https://www.servirglobal.net/
- http://www.ovf.hu/en/
- https://www.met.hu/en/idojaras/
- https://www.sciencedirect.com/science/article/pii/S2212096322000717
- https://earsc.org/sebs/aquifer-management-in-spain/
- https://www.preprints.org/manuscript/202009.0100/v1
- https://www.mdpi.com/2072-4292/11/17/2051
- https://www.mbfsz.gov.hu/en/hydrogeological-data-store
- http://www.laketemp.net/home/
- http://www.inhga.ro/en/web/guest/rivers-forecast
- http://www.igik.edu.pl/en/Services

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- http://www.igik.edu.pl/en/research-areas
- http://www.ibwpan.gda.pl/en
- https://www.himiofots.gr/en/the-project)
- https://www.globalsecurity.org/space/world/slovakia/earth.htm
- https://www.eeagrants.gov.pt/en/programmes/environment/agenda/
- https://www.eea.europa.eu/publications/92-9167-001-4/page008.html
- https://www.digitalearthafrica.org/
- https://www.d-copernicus.de/daten/beispiele-und-anwendungen/meeresumwelt-und-kuestengewaesser/
- https://www.copernicus.eu/en/slovenian-sme-boosts-copernicus-data-access-citizens-free-visualisation-tools
- http://www.brockmann-geomatics.se/aquatic-projects/water-quality-monitoring/
- https://www.blki.hu/en/node/14854
- https://webgr.inrae.fr/activites/base-de-donnees/
- https://web.jrc.ec.europa.eu/policy-model-inventory/explore/models/model-lisflood
- https://wapor.apps.fao.org/
- https://oceancolor.gsfc.nasa.gov/
- https://modis.gsfc.nasa.gov/data/dataprod/mod16.php
- https://lcviewer.vito.be/
- https://land.copernicus.eu/global/products/wl
- https://land.copernicus.eu/global/products/lwq
- https://global-surface-water.appspot.com/
- https://eurogoos.eu/member/slovenian-environment-agency/
- https://esa-worldcover.org/en
- https://emergency.copernicus.eu/mapping/list-of-components/EMSR070
- http://emergency.copernicus.eu/EMSR268
- https://edurank.org/engineering/remote-sensing/hu/
- https://edmo.seadatanet.org/report/193
- https://earlywarning.usgs.gov/ssebop/modis
- https://dl.acm.org/doi/10.5555/3028366.3028386
- https://dahiti.dgfi.tum.de/en/
- https://climate.copernicus.eu/taxonomy/term/141
- https://climate.copernicus.eu/climate-proof-river-water-balance
- https://voda.hr/en
- http://www.gios.gov.pl/en/

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- https://www.wody.gov.pl/
- https://www.bafg.de/GRDC/EN/Home/homepage_node.html
- https://data.geus.dk/geusmap/
- https://www.umweltbundesamt.de/en/topics/water/drinking-water
- https://www.lawa.de/
- https://www.dwd.de/DE/leistungen/wawis/wawis.html
- https://www.bafg.de/EN/06_Info_Service/info_service_node.html
- https://www.umweltbundesamt.de/en
- https://www.copernicus-user-uptake.eu/partner/partner-details?tx_hwtaddress_address%5Baddress%5D=12&cHash=c356cb5b271457d1955bce64d1573db6
- https://geoportaal.maaamet.ee/eng/Spatial-Data/National-Satellite-Data-Centre-ESTHub-p654.html
- https://eng.geus.dk/water-resources
- https://www.cenia.cz/geoinformatics/
- https://en.vmm.be/water
- https://earsc.org/sebs/wp-content/uploads/2019/03/Flood-management-Ireland-Full-case.pdf
- https://www.copernicus-user-uptake.eu/user-uptake/details/eo-for-water-framework-directive-and-marine-strategy-framework-directive-monitoring-36
- https://en.ilmatieteenlaitos.fi/precipitation-in-finland
- https://www.syke.fi/en-US
- https://www.lawa.de/
- https://www.copernicus-user-uptake.eu/partner/partner-details?tx_hwtaddress_address%5Baddress%5D=8&cHash=f8580c9372997228965a82652a296e7c
- https://eea.government.bg/en
- http://www.cmcc.it/
- https://ec.europa.eu/environment/water/index_en.htm
- https://issuu.com/eas-estonia/docs/estonian_space_technologies_phone_book_2020
- https://eas.ee/en/estonian-space-office/
- https://keskkonnaagentuur.ee/water

Water-ForCE is a CSA that has received funding form the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101004186.

- https://www.copernicus-user-uptake.eu/user-uptake/details/downstream-service-application-development-for-supporting-implementation-of-eu-water-framework-directive-in-estonia-194
- https://eng.mst.dk/nature-water/aquatic-environment/
- https://environnement.public.lu/fr.html
- http://environnement.wallonie.be/
- https://era.org.mt/
- https://www.umweltbundesamt.at/en/
- https://energywateragency.gov.mt/
- http://i.emowaf.eu/
- https://austria-in-space.at/en/projects/2015/eop-danube.php
- https://www.copernicus-user-uptake.eu/user-uptake/details/eo-for-water-framework-directive-and-marine-strategy-framework-directive-monitoring-36
- https://eo4water.com/
- https://www.dwd.de/DE/leistungen/_functions/Suche/Suche_Formular.html?nn=781246
- https://droogteportaal.nl/droogteportaal/web/
- https://www.copernicus-user-uptake.eu/user-uptake/details/downstream-service-application-development-for-monitoring-of-environmental-indicators-europe-171
- https://www.dinoloket.nl/en
- https://www.obzoreuropa.hr/structure-second-pillars/index/4
- https://www.housing.gov.ie/
- https://geohub-delfland-1-hhdelfland.hub.arcgis.com/
- https://data.nhi.nu/
- https://www.eurisy.eu/stories/danube-river-basin-directorate-satellite-information-for-risk-assessment_57/
- https://ufm.dk/en?set_language=en&cl=en
- https://www.dmi.dk/
- https://eng.sdfi.dk/
- http://www.spaceexploration.org.cy/
- http://www.cyprusremotesensing.com/
- https://www.eurisy.eu/stories/cyprus-audit-office-eo-to-support-beach-inspections-improve-coastal-management-and-prevent-environmental-damage/
- https://hydro.chmi.cz/index.php?lng=ENG
- https://meteo.hr/index_en.php

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- https://www.copernicus-user-uptake.eu/
- https://www.copernicus-user-uptake.eu/
- https://www.copernicus.eu/en/copernicus-services
- https://wqems.eu/
- https://www.copernicus-user-uptake.eu/user-uptake/details/launch-of-copernicus-academy-relay-in-ireland-1-415
- https://en.wikipedia.org/wiki/Commission_for_Energy_Regulation
- https://www.ecologique-solidaire.gouv.fr/gestion-leau-en-france
- https://www.klimaatadaptatiebrabant.nl/
- https://www.ely-keskus.fi/en/web/ely-en/environment
- https://edurank.org/uni/budapest-university-of-technology-and-economics/
- https://environment.brussels/
- https://balticsatapps.eu/
- https://austria-in-space.at/en/
- https://arcos-project.eu/dashboard
- https://www.eurisy.eu/stories/arno-river-basin-authority-using-satellite-maps-to-improve-monitoring-of-hydrogeological-phenomena_27/
- https://www.copernicus-user-uptake.eu/user-uptake/details/agrometeorological-modelling-based-on-copernicus-regional-reanalysis-data-451
- https://austria-in-space.at/en/projects/2019/acube4floods.php
- https://www.eea.europa.eu/about-us/who/key-partners
- https://www.eea.europa.eu/articles/eea-25-years-of-growing
- https://www.eea.europa.eu/about-us/who/copernicus-1
- https://www.eea.europa.eu/about-us/who
- https://www.copernicus.eu/sites/default/files/2021-01/Copernicus_ENG_digital.pdf

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