DELIVERABLE 3.3.1

Report on the existing and future data exchange mechanisms over the Adriatic region

Let's be reSEAlient!

Project key facts

Priority:	2. Safety and resilience
Specific objective:	2.1 Improve the climate change monitoring and planning of adaptation measures tackling specific effects in the cooperation area
Acronym:	**RESPONSe**
Title:	**Strategies to adapt to climate change in Adriatic regions**
ID request:	10175714
Lead Partner:	INFORMEST
Duration:	01.01.2019 31.12.2021

Deliverable information

WP 3	Harmonization of the climate change analysis and monitoring systems
A 3	Analysis, enhancement and integration of existing climate and oceanographic monitoring systems
Issued by:	**Partner n°6 – DHMZ**
Reviewed by:	**All project partners**
Partners involved:	**Institute of oceanography and fisheries, Croatian meteorological and hydrological service, Regional agency for environmental protection and prevention of Veneto, University polytechnic of Marche**
Status:	v1.0
Distribution:	Internal
Date:	23.12.2021.

Document history

Version	Date	Author	Description of changes
V 0.1	25.06.2021.	DHMZ	Table of Content defined.
V 0.5	27.10.2021.	DHMZ	Main content drafted, contributions from other partners included.
V 0.9	30.11.2021.	DHMZ	Text revised, ready for the internal review.
V 1.0	23.12.2021.	DHMZ	Corrections by the partners included. Reference to D3.3.2 given.

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Introduction

The only method to reliably assess the condition and changes in our environment (e.g., atmosphere, hydrosphere, biosphere, and even earth's crust) is to observe/monitor and collect data. Monitoring is the foundation for weather forecasting, climate change detection, and various risks assessments and mitigation, and is thus beneficial for a wide range of human activities.

Both the Republic of Italy and the Republic of Croatia are full members of the World Meteorological Organization (WMO), an intergovernmental organization with 193 member states and territories, with Italy joining in 1951 and Croatia joining in 1992. WMO was established on March 23, 1950, when the WMO Convention was ratified, and it became the United Nations' specialized organization for meteorology (weather and climate), operational hydrology, and, a year later, related geophysical sciences.

Recognizing that members should work together to coordinate, standardize, improve, and encourage efficiencies in the exchange of meteorological, climatological, hydrological, and related information in support of human activities, the WMO convention[1], just after the text on the organization's establishment in Article I, states the organization's purpose, which is (among other things) to *"facilitate worldwide cooperation in the establishment of networks of stations for the making of meteorological observations and* ***to promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information*** *just as to promote standardization of meteorological and related observations and to ensure the uniform publication of observations and statistics"*.

[1] https://library.wmo.int/doc_num.php?explnum_id=10076

Croatian and Italian NWS

Croatian Meteorological and Hydrological Service (DHMZ)[2] is the country's National Weather Service (NWS). Despite the fact that there are a few state-owned companies and a number of professional private companies, non-professional societies, and individuals dealing with the environment, which includes some observations, DHMZ, as a government body in Croatia, has the responsibility to manage the meteorological, hydrological, air quality, and other relevant data monitoring infrastructure, as well as the national archives of meteorological, hydrological, air quality, and other relevant data, all in accordance with WMO guidelines.

Italy is one of the few European countries that has no a civil national weather/meteorological service, and the role of NWS is fulfilled by the Italian Air Force Meteorological Service, while, at the same time, other public regional structures (Civil Protection Department (DPC), The network of Agencies for Environmental Protection (SNPA), Inter-university consortium and the largest Italian supercomputing centre (CINECA), private companies, number of non-professional societies and individuals) are in charge of various meteorology-related tasks. Since December 2017, the National Agency for Meteorology and Climatology (ItaliaMeteo) has been established which is currently taking its first steps and will have the role of national meteorological service, in particular it will be a coordination structure of all the entities that moves of meteorology at local and national level. Meteorological Service by the Italian Air Force produces forecasts of weather and oceanic conditions at **national scale** and produces meteorological information for civil and military aviation and represents Italy in international institutions (e.g. WMO, ECMWF). Real-time monitoring and forecasting of hazardous meteorological and hydrological conditions are the responsibility of the Civil Protection Department. Early warnings are issued to local authorities, and direct support is provided during high-impact events. The Agencies for Environmental Protection (SNPA) build and manage the bulk of the meteorological observational networks, including both standard weather stations and sites with more sophisticated remote sensing capabilities (e.g. meteorological radar). They also produce weather forecasts at **regional scale**, and in most cases host the Civil Protection 'Functional Centre' for their region.

[2] Državni hidrometeorološki zavod (DHMZ), official website: https://meteo.hr/

The need of data exchange

The underlying basis of any National Meteorological and Hydrological Services (NMHS) or National Weather Service (NWS) operation, as well as the worldwide systems coordinated by WMO, is meteorological and related data and products. It is critical that data are measured according to specific standard criteria that are common to all stations in order to compare observations between different networks or countries. Nationally, to obtain data and offer services, and internationally, for NMHSs to exchange and share data and products for the benefit of all, effective and dependable information systems are required.

Until very recently, WMO policy on the international exchange of meteorological and hydrological data was determined to a large extent by two resolutions (Resolution 40[3] and Resolution 25[4]). These resolutions commit to *"broadening and enhancing the free and unrestricted international exchange"* of meteorological, hydrological and related data and products as a fundamental WMO principle[5]. NMHSs have developed and operate telecommunications networks that together form the WMO Global Telecommunication System (GTS), which enables NMHSs around the world to meet their national and international objectives by facilitating the rapid exchange of observations, data, and products.

The GTS serves as the foundation for the design and delivery of the World Meteorological Organization's (WMO) Information System (WIS). WIS is a one-of-a-kind worldwide infrastructure and telecommunications system that uses pre-defined automated protocols to exchange weather, climate, and water monitoring data across international borders. This system combines terrestrial and satellite communications to provide for continuous data and product interchange between state meteorological and hydrological services and users[6]. Each country must collect its own meteorological observation data for transmission via the GTS's telecommunication network.

[3]Resolution 40 (Cg-XII) – WMO policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities

[4] Resolution 25 (Cg-XIII) – Exchange of hydrological data and products

[5] Abridged Final Report with Resolutions of the Twelfth World Meteorological Congress (WMO-No. 827))

[6] e.g. https://narodne-novine.nn.hr/clanci/sluzbeni/2019_07_66_1287.html

The Member States of the EU have also to comply with the INSPIRE Directive (2007/2/EC). INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications including meteorological data. More information is available at https://inspire.ec.europa.eu/inspire-directive/2.

Examples of existing data exchange mechanisms over the Adriatic region

CROATIA

As a state meteorological, climate and hydrological centre, in accordance with international obligations, DHMZ:

- ensures the connection between the Republic of Croatia and international communication and information systems
- performs operational exchange of meteorological, hydrological and related data and products to the WIS
- participates in international meteorological, hydrological and related research and development programs
- performs international exchange of data and information on meteorological and hydrological disasters in cooperation with the legal entity for water management

Information based on meteorological and hydrological measurements and observations is one of DHMZ's key deliverables. A database of meteorological, hydrological, and related data is generated based on data observation, collection, processing, and quality control. DHMZ staff and external users can utilize the database's data for their own purposes. The DHMZ website provides free access to various data, products, and services while some products can be required per request[7].

Basic meteorological data for the last 24 hours can be viewed and downloaded in .xml format from the DHMZ website (https://meteo.hr). Also included is a map of all different meteorological stations, as well as basic station information. On request, archive data can be acquired in a strictly readable format. On the Hydrology Sector's pages, users can find information on available series / quantities of available measurements for water level and data flow in daily data for the selected year, as well as a map of stations and basic station information. On request, data in a readable format is

[7] https://klima.hr/razno/katalog_i_cjenikDHMZ.pdf

provided. In addition, results of the regional climate model's simulations are freely available through https://repozitorij.meteo.hr/ under the CC BY 4.0 licence[8].

DHMZ participates in the international exchange of monitoring data at ground and altitude meteorological stations, as stated previously (together with ship meteorological service data, radar data, hydrological data and air quality data). SYNOP reports contain meteorological data from ground measurements, while TEMP reports contain height measurements. The WMO specifies the format of telecommunication bulletins in which SYNOP and TEMP reports are sent for worldwide exchange. The Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organization (WMO) defines the format for conveying ship meteorological data. There are two types of data that are exchanged internationally: basic and additional. Users can get basic information for free, and there are possible costs additional information.

ITALY

At the national level in Italy, observational and prediction data are collected by a variety of government agencies and stored in a variety of tiny, diverse, and sometimes non-interoperable repositories, each with its own set of licenses, may restrict the data's usability for external users. The Italian synoptic network, which contributes to the international Global Telecommunication System (GTS), is managed by the Italian Air Force's Meteorological Service. These stations have extensive time series and adhere to WMO instrumentation and data distribution criteria, but their number is relatively small (about 100 stations nationwide).

The ARPA-managed networks are far more extensive (several thousand stations in total) and, as previously stated, provide the vast majority of real-time data needed by Civil Protection to monitor dangerous weather conditions. Several additional public and commercial companies operate their own weather stations, and high-quality observations are becoming more affordable and accessible to non-professionals. All of these networks are created and operated for distinct reasons, and there are significant technological differences between them, including equipment type and placement,

[8] https://creativecommons.org/licenses/by/4.0/

measurement frequency, data format and transmission. Data is stored in several repositories that are sometimes inaccessible to other users.

Most ARPAs already provide open access to their real-time and historical data, but the methods for acquiring it vary and are not always simple. Licensing restrictions and terms of use vary, and they aren't always obvious. ARPAs communicate data to both the Higher Institute for Environmental Protection and Research (ISPRA) as the coordination body of all the ARPAs network (SNPA) as well as to the Civil Protection Department (DPC) and the network of 'Functional Centres,' however this approach is primarily focused on precipitation and hydrology. Furthermore, the pooled database cannot be redistributed, and ARPAs can only use it for civil protection purposes. The ARPAs of Northern Italy began building the Climatological Archive for Northern Italy (ARCIS) in 2008, a climatological database containing daily precipitation and temperature data collected on a common platform and used for the production of climate products used both to respond to the signatory bodies' institutional tasks and to disseminate information on the climatic situation (https://www.arcis.it/wp/). An example of climate data collection at national level is the National system for the collection, processing and dissemination of climate data (SCIA), managed by the Higher Institute for Environmental Protection and Research (ISPRA). It is the system that collects, processes and disseminates the climate data mainly from national and regional monitoring networks managed by Italian Air Force and ARPAs. All the collected data are homogenized following the WMO's guidelines and used to produce climate indices describing the climate trend throughout Italy (http://www.scia.isprambiente.it/wwwrootscia/Home_new.html).

Under the direction of DPC, ARPAs and Functional Centres produce radar observations that span practically the whole country. DPC is also in charge of data collection and merging. On the DPC and ARPA websites (http://www.protezionecivile.gov.it/radar-dpc/), real-time maps are provided, but numerical products and historical data are not. Despite the fact that a number of numerical and graphical products are already freely available, no standard open data strategy has been established.

SYNOP

Coded messages are used for the international transmission of meteorological data, which includes observational data from the World Weather Watch (WWW) Global Observing System and processed data from the WWW Global Data-processing and Forecasting System. Coded messages are also utilized for the international sharing of observed and processed data necessary in specific meteorology applications to diverse human activities, as well as for meteorology-related information exchanges[9].

A set of code forms and binary codes made up of symbolic letters (or groups of letters) representing meteorological or other geophysical elements form the codes. These symbolic letters (or clusters of letters) are transcribed into figures in messages, representing the value or state of the described elements. The WMO Technical Regulations specify the rules for selecting code forms to be exchanged for international purposes, as well as the symbolic words, figure groups, and letters to be used[10].

In terms of DHMZ's SYNOP requirement, DHMZ determines which stations broadcast particular groupings of data and in what formats, based on practical demands. There are 16 stations that provide SYNOP data to the Split collection center, and 56 stations that send SYNOP data to the Zagreb collection center, according to the DHMZ's list. 12 of the 16 stations in the first group and 14 of the 56 stations in the second group are located along the Croatian coast. In Italy, the Regional Telecommunications Pole (RTH) for the VI region - Europe (COMET / RESIA-GSIM in Pratica di Mare, Rome) collects data from just over 100 SYNOP stations across the country and receives data from Malta, Greece, Turkey, and Lebanon for subsequent retransmissions, as well as centralizing all data from the European area (http://www.meteoam.it/international_activities/data_collection).

[9] https://library.wmo.int/doc_num.php?explnum_id=10235
[10] https://library.wmo.int/?lvl=notice_display&id=14073#.YaYimpHMKV4

ECA&D - European Climate Assessment and Dataset

Since 2010, ECA&D has served as the backbone of the Regional Climate Centre (RCC) for WMO Region VI's climate data node (Europe and the Middle East). The information and data products contribute to the Global Framework for Climate Services (GFCS). For assessing observed changes in climate extremes in Europe, ECA&D (https://www.ecad.eu/) provides science-based operational services. These services rely on the participants' provision of high-quality observational datasets. It was started by GIE-EUMETNET's Climate Support Network and is coordinated by the Royal Netherlands Meteorological Institute (KNMI).

ECA&D services comprise[11]:

- *"data gathering (long-term high quality daily observational series from meteorological stations)*
- *archiving and storage in a centralized relational database*
- *quality control and homogeneity checks*
- *analysis (calculation of indices (station-based and gridded) particularly related to climate extremes)"*

ECA&D products include[12]:

- *"meta information on station and time series homogeneity*
- *maps and plots for changes in extremes in the form of trends, anomalies, climatologies and return values for 75 indices*
- *E-OBS daily gridded observational dataset of precipitation, temperature and sea level pressure,*
- *monthly updates of stations and gridded datasets"*

ECA&D is receiving data from 81 participants for 65 countries and the ECA dataset contains 70877 series of observations for 13 elements (maximum temperature, minimum temperature, mean temperature, sunshine, snow depth, precipitation amount, global radiation, sea level pressure, humidity, wind gust, wind speed, wind direction, cloud cover) at 20506 meteorological stations throughout Europe and the Mediterranean (statistics as of November 2021; https://www.ecad.eu/). Croatia participates with 20 stations[13] (Zagreb-Grič, Crikvenica, Split-Marjan, Split (Lesina), Lastovo, Rijeka, Gospić, Osijek, Hvar,

[11] https://www.idare-portal.org/content/dare-datasets
[12] https://www.ecad.eu/documents/ECAD_flyer.pdf
[13] https://knmi-ecad-assets-prd.s3.amazonaws.com/download/stations.txt

Zavižan, Knin, Varaždin, Zadar, Ogulin, Dubrovnik, Križevci, Puntijarka, Parg, Zagreb/Horvatovac, Zagreb/Maksimir) governed by DHMZ, while there are 1551 Italian stations, governed by nine Italian institutions (ARPA-SIMC – Bologna, Arpa Valle d'Aosta - Saint Christophe, Agenzia Regionale per la Protezione delI'Ambiente della Sardegna – Sassari, Joint Research Centre – Ispra, Servizio Meteorologico dell' Aeronautica – Rome, ARPA Calabria – Catanzaro, Università degli Studi di Milano – Milano, ARPA Lombardia – Milan, Italian National Institute for Environmental Protection and Research - Rome).

Based on ECA&D information, observational dataset for precipitation, temperature, sea level pressure, relative humidity, wind speed and global radiation in Europe are used to create daily gridded via E-OBS. The full dataset covers the period 1950-01-01 to present. Currently it is maintained and elaborated as part of the Copernicus Climate Change Services[14].

"As a fundamental principle..., WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products," according to WMO Resolution 40 on the free exchange of data produced by NMHSs, so anyone maintaining daily station data is welcome to participate in ECA&D. In practice, there are still significant barriers to data availability at the European level. Even with legal mechanisms in place for international data interchange, data in international repositories is still scarce. Currently, 75% of daily series can be downloaded for free from the ECA&D website for non-commercial research and education projects only.

[14] https://cds.climate.copernicus.eu/cdsapp#!/dataset/insitu-gridded-observations-europe?tab=overview

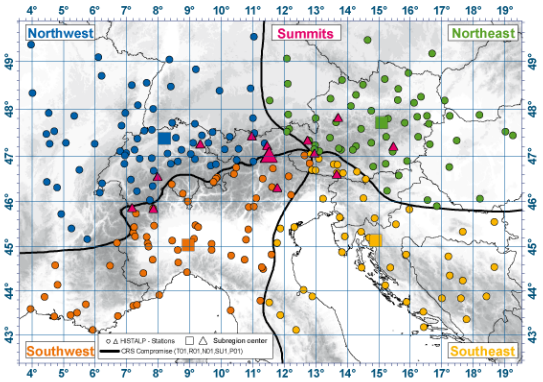
HISTALP

Historical instrumental climatological surface time series of the greater alpine area (HISTALP)[15] is an acronym for Historical instrumental climatological surface time series of the greater alpine region. It is a database that contains monthly homogenised records of temperature, pressure, precipitation, sunshine, and cloudiness for the 'Greater Alpine Region,' which includes the European Alps and its adjacent areas (approximately 724.000 km^2). It includes all of Switzerland, Liechtenstein, Austria, Slovenia, and Croatia, as well as portions of France, Germany, Italy, the Czech Republic, Slovakia, Hungary, and Bosnia and Herzegovina. This diverse climate and climate variability features, as well as a unique long-term instrumental climate data potential - the longest temperature and air pressure series date back to 1760, precipitation to 1800, cloudiness to the 1840s, and sunshine to the 1880s - are all found in a relatively small region.

The goal of creating this database, which was based on the ALOCLIM[16] project's experience, was to reduce the effects of national borders and sub-national administrative structures in the region as much as possible, and to establish systematic homogenisation of climate series, which was mostly done at the national weather service level. As a result, HISTALP maintains smooth climate data exchange within the region (at a higher spatial density than the already existing WMO-based CLIMAT-exchange mechanism), multi-parameter climate data collection, adequate spatial resolution in terms of the spatial de-correlation distances of each climate element at a given time resolution, best possible extension back to the early instrumental period (data recovery and rescue from non-electronic sources), and best possible extension back to the early instrumental period (data recovery and homogeneity breaks, outliers, gaps).

[15] https://www.zamg.ac.at/histalp/

[16] About ALOCLIM (Austrian Longterm Climate), a multiple instrumental climate time series from Central Europe (http://www.zamg.ac.at/docs/wir_ueber_uns/cv/boehm_reinhard/2001-Auer-etal-OEBMG-aloclim.pdf)



Austria: ZAMG, Lebensministerium
Bosnia and Herzegovina: Federal Hydrometeorological Institute
Czech Republic: Czech Hydrometeorological Institute
Croatia: Meteorological and Hydrological Service
France: Meteo France
Germany: Deutsche Wetterdienst DWD
Hungary: Hungarian Meteorological Service
Republika Srpska: Republic Hydrometeorological Service of Republika Srpska
Romania: National Administration of Meteorology Romania
Serbia: Republic Hydrometeorological Service of Serbia
Slovakia: Slovensky Hydrometeorological Service
Slovenia: Environmental Agency of the Republic of Slovenia
Switzerland: MeteoSwiss
Italy: Nimbus, ISAC, ISMAR, DSI University Milano, Hydrographisches Amt Bozen, ISMAA, SISSA University Trieste, AF FVG, CNMCA, DIFA University of Bologna , ARPAE, Settore Idrologico Regionale (S.I.R.) Della regione Toscana , A Lombardia
NOAA: Global Historical Climatology Network

FIGURE 1 HISTALP station map and list of recent data providers (source: https://www.zamg.ac.at/histalp/project/maps/station_map.php)

The climate element has a significant impact on the density of the station network and the length of a single station. All of the stations were divided into regions with similar climate variations. The majority of the homogenised data can be found on the HISTALP website (https://www.zamg.ac.at/histalp/datasets.php), where datasets are divided into two groups: station mode data, which contains incomplete data due to restrictions imposed by the original data providers, and gridded files, which contain all available data. It should be emphasized that HISTALP has focused solely on monthly data, giving it the advantage of advanced homogeneity testing and adjustment capabilities. In the spring of 2005, the HISTALP database reached its current state[17].

[17] https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.1377

Additional examples of good practice in international cooperation and data exchange

SAVA GIS

Through the International Sava River Basin Commission (ISRBC), the four riparian countries of the Sava River Basin (Croatia, Bosnia and Herzegovina, Slovenia, and Serbia) have been collaborating under the Framework Agreement on the Sava River Basin (FASRB). FASRB aims to achieve transboundary cooperation among governments, institutions, and individuals in order to establish an international navigation regime on the Sava River and its navigable tributaries, as well as to prevent or limit hazards such as floods, ice, droughts, and accidents involving substances hazardous to water, as well as to reduce or eliminate related negative consequences and to ensure the Sava River Basin's long-term sustainability. In this regard, one of the ISRBC's coordinated activities is the creation of integrated systems for the Sava River Basin (GIS, flood forecasting and warning system, etc.). The efficient handling of information was recognized as a cross-cutting issue that is required for the implementation of integrated systems. In the Strategy on Implementation of FASRB, which ISRBC adopted in 2011., ISRBC implemented core functionalities of Sava GIS platform[18].

Between ISRBC member nations, Sava GIS provides a shared platform for exchanging and disseminating information and expertise on water resource protection and management operations. It allows ISRBC member countries, stakeholders, and the general public to share, integrate, and utilise geographic data more easily. Sava Geoportal (https://www.savagis.org/map) provides secure access to ISRBC's geographic information and services. Users interact with spatial layers stored in geodatabases via a web-GIS-based portal that allows for content searching and spatial information discovery related to integrated water resource management.

As part of the Sava GIS Geoportal, a web-application for 'near real-time' hydrological and meteorological data has been developed with the goal of providing an effective common channel for

18 http://www.savacommission.org/dms/docs/dokumenti/documents_publications/publications/other_publications/savagis_booklet_.pdf

exchanging, viewing, filtering, and analyzing hydrological and meteorological data and information in normal and emergency situations, particularly those related to flood events.

CARPATCLIM

The CARPATCLIM project was started in response to the possibility of discrepancies in measuring networks, instruments, data management technologies, and data quality control procedures, which could contribute to inhomogeneities in climatological fields and possible bias in the results. The project's goal was to develop the Carpathian Region's climate database and use unified approaches to examine the fine temporal and spatial organization of the climate in the Carpathian Mountains and the Carpathian basin. As a result, a free, high-resolution gridded database for the Greater Carpathian Region has been created (LCR).

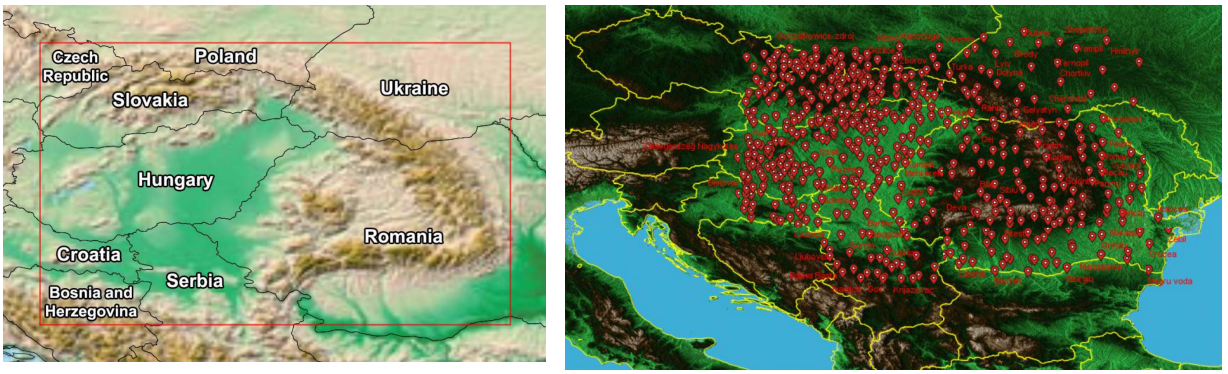


Figure 2 The area of interest with country names (except Bosnia and Herzegovina) and the map with the stations included (sources: http://www.carpatclim-eu.org/docs/deliverables/D3_6.pdf and http://www.carpatclim-eu.org/pages/atlas/)

Participants:

- Hungarian Meteorological Service (leading organisation)
- Szent Istvan University, Hungary
- Central Institute for Meteorology and Geodynamics, Austria
- Croatian Meteorological and Hydrological Service
- Czech Hydrometeorological Institute
- Institute of Meteorology and Water Management - National Research Institute, Poland
- National Institute for Research and Development in Environmental Protection of Romania

- Republic Hydrometeorological Service of Serbia
- Slovak Hydrometeorological Institute
- Ukrainian Research Hydrometeorological Institute.

With a spatial resolution of 0.1 x 0.1 and a temporal resolution of 1 day, the complete data sets provide total coverage of the CARPATCLIM interest region (between latitudes 44°N and 50°N, and longitudes 17°E and 27°E) during the period 1961 to 2010. At least 13 meteorological variables were studied for a total of 18262[19] days (mean daily air temperature, minimum air temperature, maximum air temperature, accumulated total precipitation, 10 m wind direction, 10 m horizontal wind speed, sunshine duration, cloud cover, global radiation, relative humidity, surface vapour pressure, surface air pressure, snow depth).

Users can acquire a specific grid (gridded data for a given variable/period/country) by using the CARPATCLIM Web portal interface, which stores all gridded data sets in a PostgreSQL database. For data download, users have two basic options:

- single grid download – gridded data for a specific set of selected options (variable, period, country, altitudes).
- bulk download – complete gridded data sets for the period 1961-2010.

Copernicus Climate Data Store

Copernicus Climate Data Store (CDS; https://cds.climate.copernicus.eu/) is a relatively recent portal developed through the Copernicus Climate Change (https://climate.copernicus.eu/). As of November 2021, CDS consists of several types of climate products and applications. Climate products include:

- Climate indices (4 products),
- Climate projections (28 products),
- External services (1 product),
- In-situ observations (6 products),
- Reanalysis (34 products),
- Satellite observations (31 products),

[19] http://www.carpatclim-eu.org/docs/deliverables/D2_8.pdf

- Seasonal forecasts (8 products).

From the data exchange perspective, the most relevant product is “E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations”, based on the ECA&D station data. The E-OBS consists of spatially interpolated fields at the 0.1 deg × 0.1 deg and 0.25 deg × 0.25 deg grids, and includes the following lists of the daily parameters:

- daily maximum air temperature,
- daily mean air temperature,
- daily minimum air temperature,
- daily total precipitation amount,
- daily mean relative humidity,
- daily mean sea level pressure,
- surface shortwave downwelling radiation.

The underlying station data that are the basis for the E-OBS product is based on the ECA&D programme. In addition, unique capability of Climate Data Store is the existence of the Toolbox (https://cds.climate.copernicus.eu/cdsapp#!/toolbox) which allows cloud based data processing, without the need for the large data transfer to the local systems.

Future data exchange mechanisms over the Adriatic region

The aggregation of meteorological forecasts and observations on a single platform has been proved to help institutions and citizens better anticipate and respond to the threat of extreme, high-impact weather and climate events.

Analysis of the current state of the meteorological observation network in Croatia and technical, information and organizational systems that support it (today in Croatia, under the jurisdiction of DHMZ, there are 40 main meteorological stations (+6 under the jurisdiction of the Croatian Air Navigation Services), 104 climatological and 341 rain gauge stations, two radio sounding stations and 8 radar stations)[20] confirmed that there is a great need to increase the availability of measured data on climatological variables and analysis of climate conditions for various industries and public activities[21].

The ongoing METMONIC (Modernisation of the National Weather Observation Network in Croatia – METMONIC) project, whose goal is to establish a modern and high-quality system of automatic surface meteorological stations, meteorological-oceanographic buoys, and remote measurement systems, including meteorological radars, is expected to make significant progress in this regard. 450 sophisticated automatic meteorological systems will be deployed by the completion of the project (June 2023). This will give traceable, dependable, high-quality, and timely information on the state of the atmosphere and the sea across the Republic of Croatia's territory. This will also allow for continuous weather, climate, and climate change monitoring, as well as improved early-warning of hazardous weather in order to support climate change and natural disaster adaptation systems, thereby directly supporting sustainable development, increasing security, and preserving human lives and property.

All data generated by the METMONIC project (current and archived) will be made publicly available on the DHMZ website, benefiting academic institutions, non-governmental organizations, and interested users, particularly in climate change research and its impact on vulnerable sectors. More details about the availability of new observations within the RESPONSe pilot areas are given in the Deliverable 3.3.2 *Inclusion of the new observational weather and climate stations into regional and national networks.*

[20] https://klima.hr/razno/publikacije/160_god_met_motrenjaHR.pdf
[21] https://meteo.hr/istrazivanje.php?section=projekti&param=projekti_u_tijeku&el=metmonic

The MISTRAL project aims to create a national meteorological open data portal that will preserve, share, process, and encourage reuse of meteorological datasets (ground stations, meteorological radars, and numerical forecasts) at a national scale, as well as provide added-value services using high-performance computing (HPC) resources, resulting in new business opportunities. It has been a technical and sociological challenge to make access to observed and forecast meteorological data easier. Interoperability and harmonization of data, infrastructures, and services are clearly needed on a technical level, while open data rules must be implemented on a social level. MISTRAL (Meteo Italian Supercomputing PoRtAL) is the first Italian meteorological open data portal, with the goal of encouraging the reuse of meteorological data sets with national coverage[22].

The MISTRAL portal provides and archives meteorological data from various public and private observation networks, as well as forecast data generated and post-processed using high-performance computing (HPC) facilities under the Consortium for Small-scale Modeling-Limited Area Model Italia (COSMO-LAMI) agreement. The Italy Flash Flood use case, developed in collaboration with the European Centre for Medium-Range Weather Forecasts (ECMWF), takes advantage of cutting-edge advances in HPC-based post-processing of ensemble precipitation forecasts for various model resolutions and applies them to produce novel blended-resolution forecasts tailored to Italy. Finally, MISTRAL provides an interactive system for viewing forecast data of various resolutions as superimposed multi-layer maps, in addition to systems for the collecting and display of observational data.

In addition to observed data, forecast data (COSMO-5M and COSMO-2I) created under the Consortium for Small-scale Modeling-Limited Area Model Italia (COSMO-LAMI) agreement are available. MISTRAL's goal is to become a national reference point for meteorological datasets not yet included in the portal, as well as to serve as a platform for a future Italian National Weather Service (NWS).

ADRIACLIM, a strategic project of the Italy-Croatia INTERREG programme, will develop a geoportal for uniform data collection and visualization for the whole Adriatic sea. ADRIACLIM will deliver such a system by mid 2023. Synergies with the MISTRAL project are explored.

[22] https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/met.2004

Finally, recent decisions of the World Meteorological Organization (WMO) set a new long-term framework for the data exchange practice in general, including the Adriatic region. In October 2021 WMO approved so called Unified Data Policy[23] or in its full name "WMO Unified Policy for the International Exchange of Earth System Data"[24]. It replaces earlier resolutions: Resolution 40 (Cg-XII), Resolution 25 (Cg-XIII), Resolution 60 (Cg-17), and Resolution 56 (Cg-18) which separately addressed data exchange practices in sharing weather, climate and hydrological variables. Unified Data Policy is followed by the four Annexes:

Annex 1: Discipline and Domain-Specific Practice for Core and Recommended Data

Annex 2: Guidelines to Members on Application of WMO Data Policy

Annex 3: Guidelines on the Application of Data Policy in Public-Private Engagement

Annex 4: Terms and Definitions

where Annex 1 defines seven domains of the Earth system data covered by the new resolution:

1. Weather
2. Climate
3. Hydrology
4. Atmospheric Composition
5. Cryosphere
6. Oceans
7. Space Weather.

While the implementation of the Unified Data Policy will be developed in the following years in parallel by WMO technical groups and independently in each WMO country, the main aspect of the resolution is definition of the core and recommended data that are defined as:

[23] https://public.wmo.int/en/our-mandate/what-we-do/observations/Unified-WMO-Data-Policy-Resolution

[24] https://ane4bf-datap1.s3-eu-west-1.amazonaws.com/wmocms/s3fs-public/ckeditor/files/Cg-Ext2021-d04-1-WMO-UNIFIED-POLICY-FOR-THE-INTERNATIONAL-approved_en_0.pdf?4pv38FtU6R4fDNtwqOxjBCndLIfntWeR

core data: Members shall exchange on a free and unrestricted basis to underpin the services they provide for the protection of life and property and for the well-being of all nations.

recommended data: should also be exchanged by Members to support Earth system monitoring and prediction efforts.

Also, by building relationships between national hydrometeorological services and other data providers such as research communities, private companies and citizens, the Unified Data Policy is hoped to facilitate data exchanges in future societies, with the aim to support and strengthen all activities related to improving and securing lives and infrastructure. In this sense, we can expect more actions and projects dedicated to data sharing over the Adriatic and Mediterranean regions which are continuously under various environmental pressures including the climate change issues explored in the RESPONSe project.