Introduction to datasets and tools to support climate adaptation

Alfredo Reder

Fondazione CMCC

22/09/2021

cmcc
Centro Euro-Mediterraneo
sui Cambiamenti Climatici

Welcome and scope of the workshop

Outlook:

- Introduction to datasets and tools to support climate adaptation
- Heatwave, Urban Heat Island and microclimate assessment
- Extreme rainfall and pluvial flooding in urban areas

The project "participatory LAB" is funded by Green Fund in the framework of the action "Innovative actions with citizens" of the financing program Natural environment & Innovative actions 2020".

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About the speakers

Alfredo Reder

Carmela Apreda

Roberta Padulano

Welcome and scope of the workshop

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Menti Session

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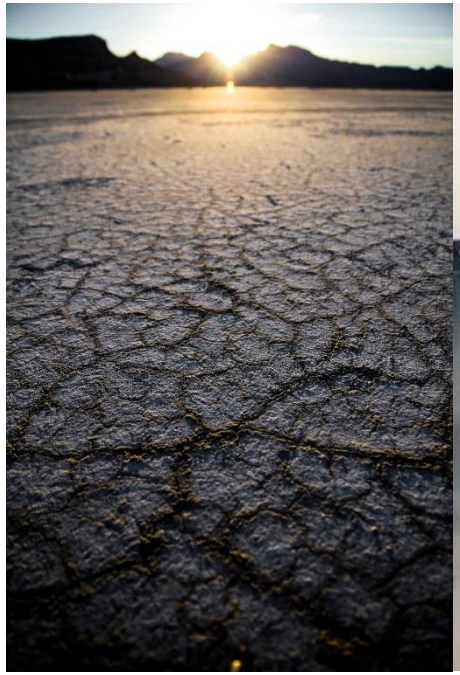
Impacts and economic losses due to climate change

- For three out of four European citizens climate change is a very serious problem
- Observed changes in climate are already having far-reaching repercussions on ecosystems, economic sectors, human health and well-being in Europe
- Overall, the economic losses in Europe over the period 1980-2016 caused by weather and climate-related extreme events exceeded EUR 436 billion.



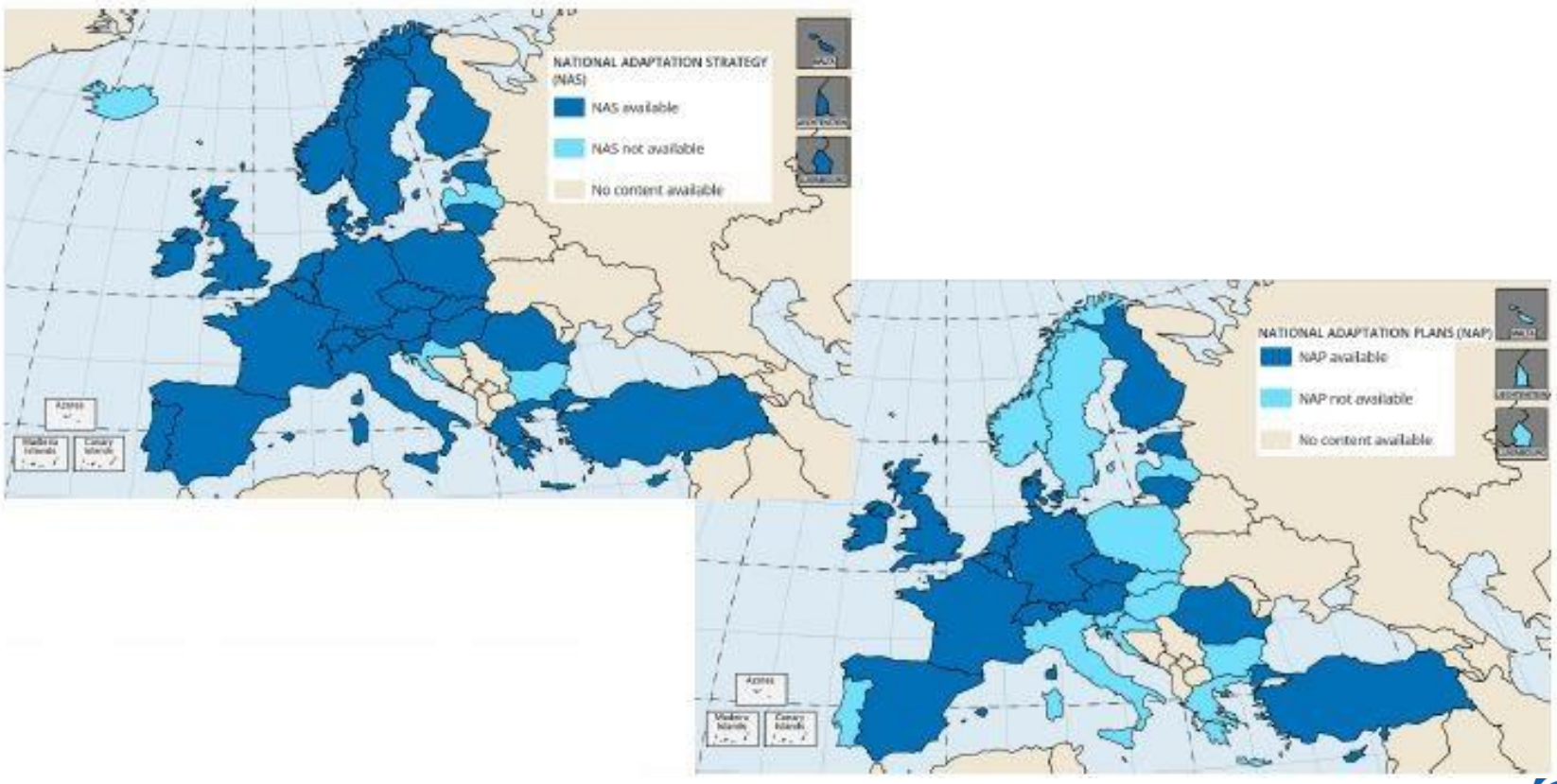
Climate Change Adaptation

- Adaptation means anticipating the negative effects of climate change and taking appropriate measures to prevent or minimise the damage it may cause or exploiting the opportunities that may arise. Well-planned and timely adaptation action has been shown to save lives and money.

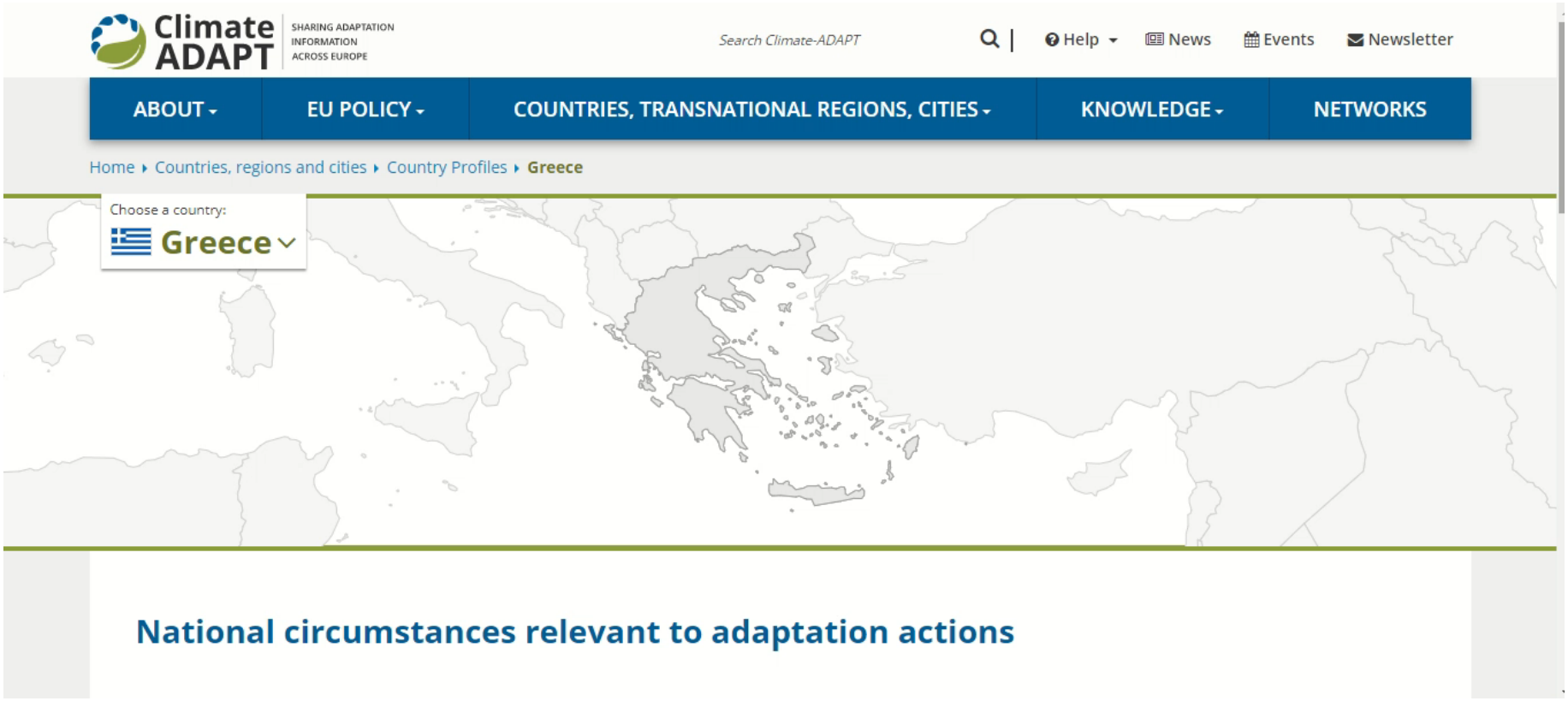
- Examples of adaptation measures are:
  - using water resources more efficiently
  - adapting building regulations to future climate conditions and extreme weather events
  - building flood defences and raising dam levels
  - developing drought-resistant crops
  - choosing tree species and forestry practices that are less vulnerable to storms and fires
  - establishing land corridors to help species migrate.

The road to the adaptation

- In 2005, the European Commission began to consider the need to adapt to climate change in Europe; a White Book was adopted in 2009, followed by an Adaptation Strategy in 2013.

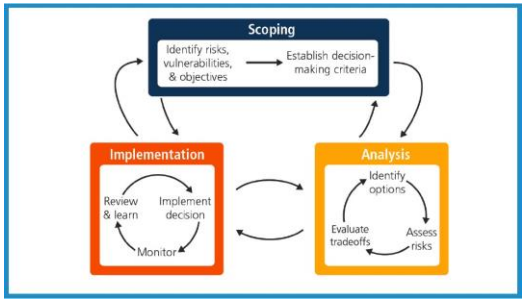


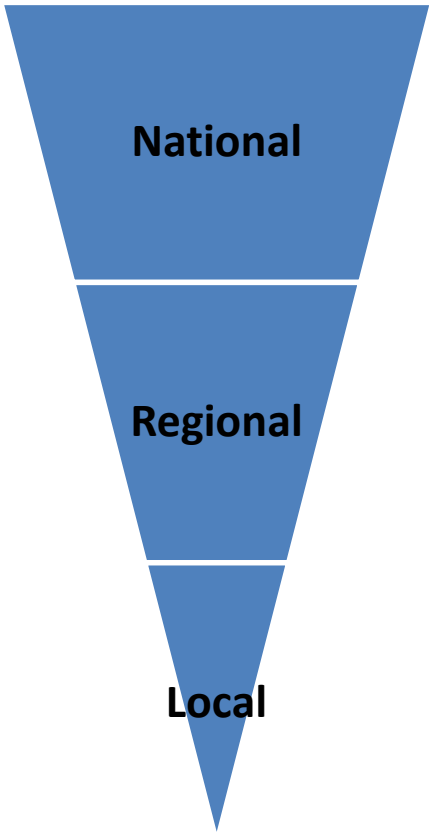
The road to the adaptation in Greece



https://climate-adapt.eea.europa.eu/countries-regions/countries/greece

Adaptation levels



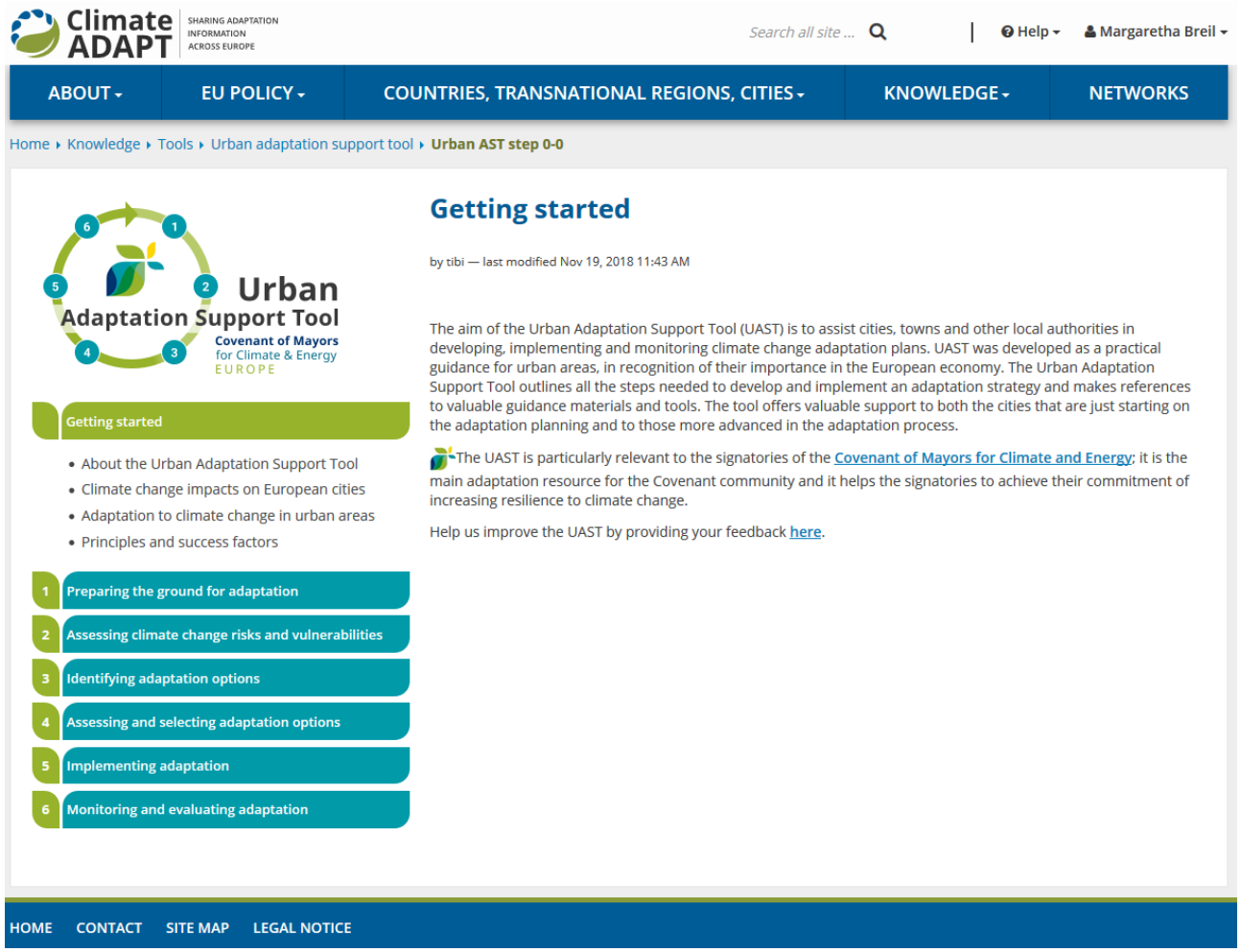


- Adaptation strategies are needed at all levels of administration: local, regional, national, EU and international.
- Due to the different severity and nature of climate impacts across Europe's regions, most adaptation initiatives need to be implemented at regional or local level.
- The ability to cope and adapt also varies between populations, economic sectors and regions within Europe.

Protagonists and actors

- Policy makers (civil protection/local government)
- Stakeholders representing users (international agencies)
- Private companies
- Consulting companies
- Scientific world
- Insurance sector (insurers and reinsurers, investors)

Urban Adaptation Support Tool



Methods used for adaptation planning are mostly based on step by step approaches; presented in different contexts.

The Urban Adaptation Support Tool (UAST) has been definded jointly by the Covenant of Mayors and the EEA.

https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast

Urban Adaptation Support Tool

1) Preparing the ground
2) Assessing risks and vulnerabilities
3) Identifying adaptation options
4) Assessing and selecting adaptation options
5) Implementing Adaptation
6) Monitoring Adaptation

Revising adaptation plans

Based on the knowledge from monitoring and new evidence (experiences with impacts, new climate projections), the existing plan can be revised or a new plan set up, restarting the process from **step 1**

https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast

The role of the science

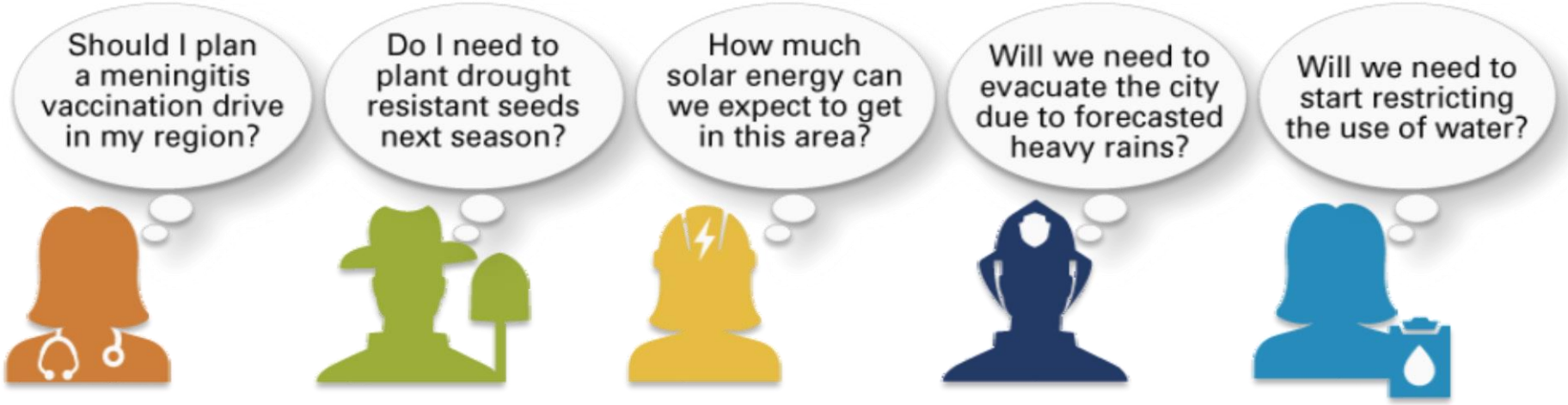
- For an efficient risk management, the availability of weather and climate data is increasingly assuming a central and essential role, both to locally assess risks based on past events and observations, and to predict and reduce the impact of extreme events over different time horizons.

- With climate change, historical averages are beginning to lose their effectiveness, while continuous updating of climate data is becoming increasingly indispensable. This aims to make the relationship between climate science and different actors as effective as possible in driving adaptation actions.

Climate Services

What are climate services?

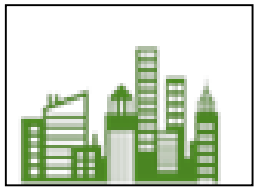
Climate services provide and process climate data to improve decision-making processes.
Climate services must be responsive to user needs, rely on high level scientific information and expertise, and require a continuous exchange between users and providers.



Climate Services

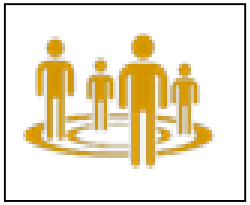
What do climate services do?

Climate services turn climate data from various national and international databases into customized products.



POLICY-MAKERS

COMPANIES



RESEARCHERS

INSURANCES

… to support several priority sectors

Agriculture and Food

Disaster Risk Reduction

Energy

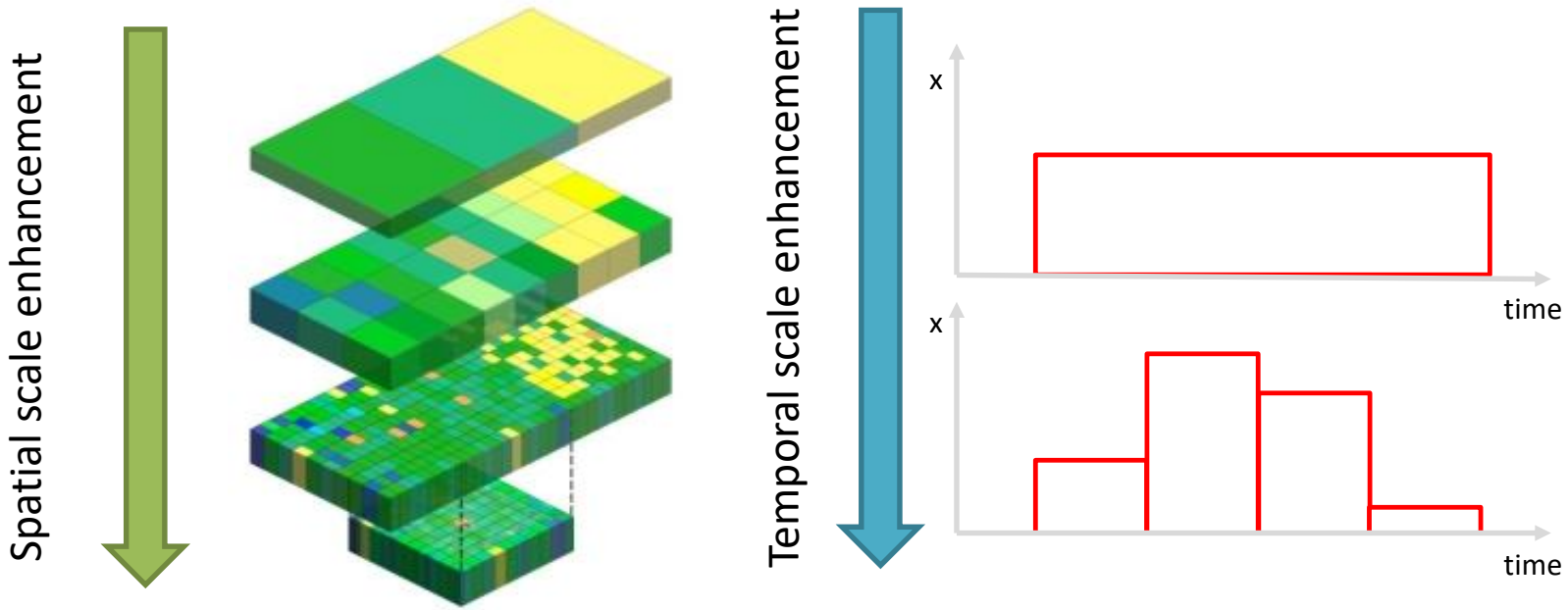
Health

Management of Water Resources

For further details see Global Framework for Climate Services (http://www.wmo.int/gfcs/)

Climate datasets at different spatial and temporal scales

Over the past two decades, several studies has produced excellent insights in the field of climate models at different temporal and spatial scales, including investigations on the extent to which human action is affecting climate change.

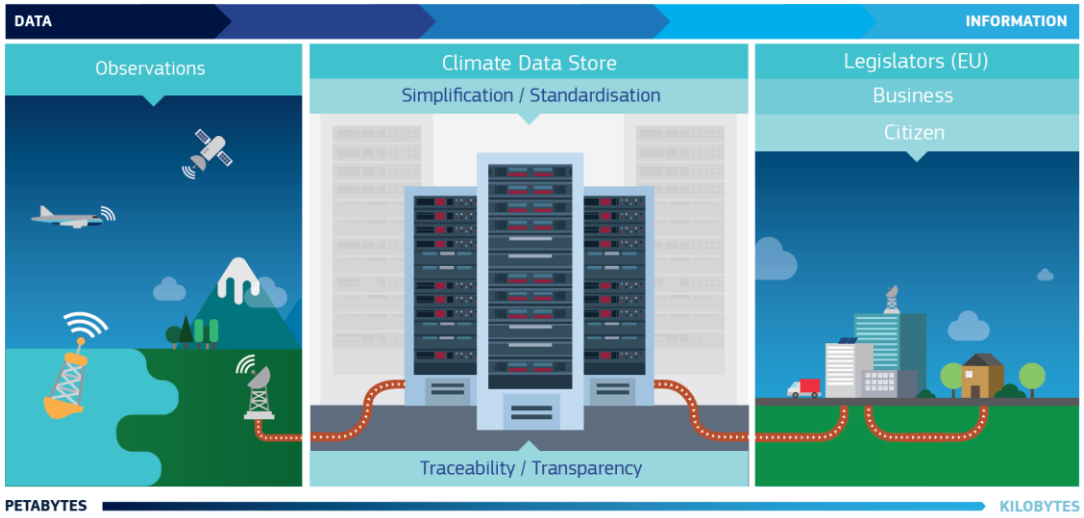


Copernicus Programme

IMPLEMENTED BY ECMWF

Copernicus Climate Change Service (C3S)

The Copernicus Climate Change Service (C3S) provides authoritative information about the past, present and future climate, as well as tools to enable climate change mitigation and adaptation strategies by policy makers and businesses.



- Provide consistent and authoritative climate information
- Exploit existing capacities and infrastructures (national, European and global)
- Stimulating the market for climate services in Europe

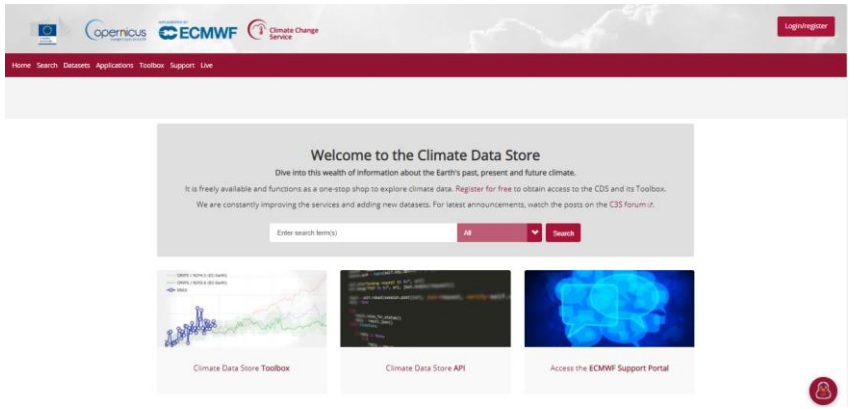
Climate Change Service
climate.copernicus.eu

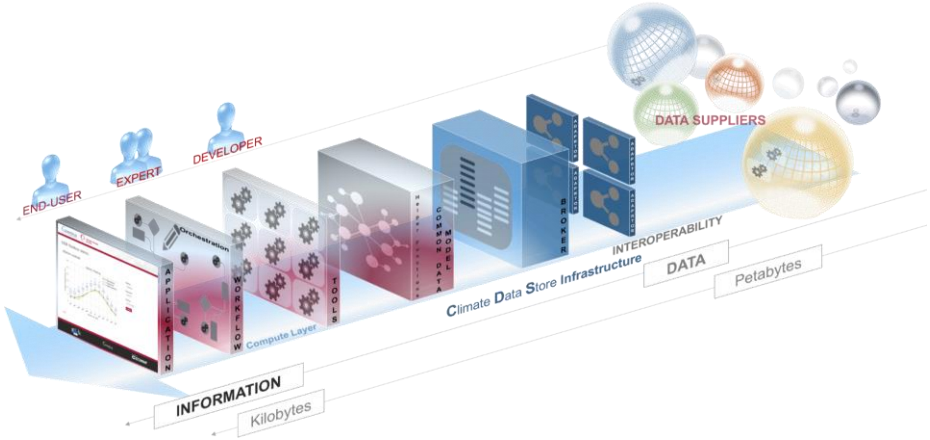
IMPLEMENTED BY ECMWF

https://cds.climate.copernicus.eu/about-c3s

C3S Climate Data Store (CDS)

- The C3S Climate Data Store (CDS) is a one-stop place for information on past, present and future climate.
- It provides easy access to a wide range of climate datasets such as Essential Climate Variables (ECVs), climate analyses, projections and indicators at temporal and spatial scales to support adaptation and mitigation strategies in different sectors.
- An online toolbox is available that allows users to build workflows and applications tailored to their needs.





https://cds.climate.copernicus.eu/#!/home

Examples of datasets currently available within CDS

1

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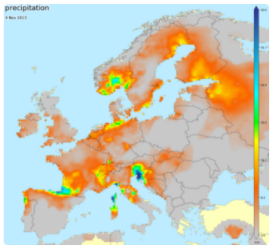
E-OBS daily gridded meteorological data for Europe from 1950 to present derived from in-situ observations

Overview | Download data | Quality assessment | Documentation

E-OBS is a daily gridded land-only observational dataset over Europe. The blended time series from the station network of the European Climate Assessment & Dataset (ECA&D) project form the basis for the E-OBS gridded dataset. All station data are sourced directly from the European National Meteorological and Hydrological Services (NMHSs) or other data holding institutions. For a considerable number of countries the number of stations used is the complete national network and therefore much more dense than the station network that is routinely shared among NMHSs (which is the basis of other gridded datasets). The density of stations gradually increases through collaborations with NMHSs within European research contracts.

Initially, in 2008, this gridded dataset was developed to provide validation for the suite of Europe-wide climate model simulations produced as part of the European Union ENSEMBLES project. While E-OBS remains an important dataset for model validation, it is also used more generally for monitoring the climate across Europe, particularly with regard to the assessment of the magnitude and frequency of daily extremes.

The position of E-OBS is unique in Europe because of the relatively high spatial horizontal



Contact

ECMWF Support Portal

Licence

E-OBS product licence

Publication date

2020-02-15

Resource updated

2021-07-25

References

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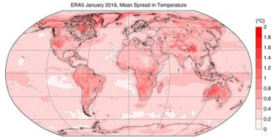
ERA5 hourly data on single levels from 1979 to present

WARNING 2021-06-25: Variable "Orography" is now named "Geopotential". No change in the data themselves. Previous API requests asking for "Orography" will fail now. To download the corresponding data the API request should ask for "Geopotential".

Overview | Download data | Quality assessment | Documentation

ERA5 is the fifth generation ECMWF reanalysis for the global climate and weather for the past 4 to 7 decades. Currently data is available from 1950, split into Climate Data Store entries for 1950-1978 (preliminary back extension) and from 1979 onwards (final release plus timely updates, this page). ERA5 replaces the ERA-Interim reanalysis.



Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset using the laws of physics. This principle, called data assimilation, is based on the method used by numerical weather prediction centres, where every so many hours (12 hours at ECMWF) a previous forecast is combined with newly available observations in an optimal way to produce a new best estimate of the state of the atmosphere, called analysis, from which an updated, improved forecast is issued. Reanalysis works in the same way, but at reduced resolution to allow for the provision of a dataset spanning back several decades. Reanalysis does not have the constraint of issuing timely forecasts, so there is more time to collect observations, and when going further back in time, to allow for the ingestion of improved versions of the

3

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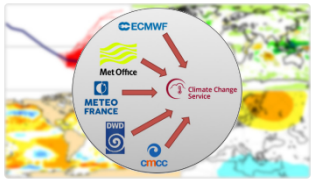
Seasonal forecast daily and subdaily data on single levels

Overview | Download data | Quality assessment | Documentation

This entry covers **single-level data** at the **original time resolution** (once a day, or once every 6 hours, depending on the variable).



Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the system. For example, ocean temperatures typically vary slowly, on timescales of weeks or months; as the ocean has an impact on the overlaying atmosphere, the variability of its properties (e.g. temperature) can modify both local and remote atmospheric conditions. Such modifications of the 'usual' atmospheric conditions are the essence of all long-range (e.g. seasonal) forecasts. This is different from a weather forecast, which gives a lot more precise detail - both in time and space - of the evolution of the state of the atmosphere over a few days into the future. Beyond a few days, the chaotic nature of the atmosphere limits the possibility to

https://cds.climate.copernicus.eu/cdsapp#!/home

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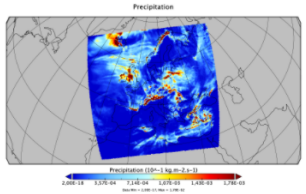
CORDEX regional climate model data on single levels

Overview | Download data | Quality assessment | Documentation

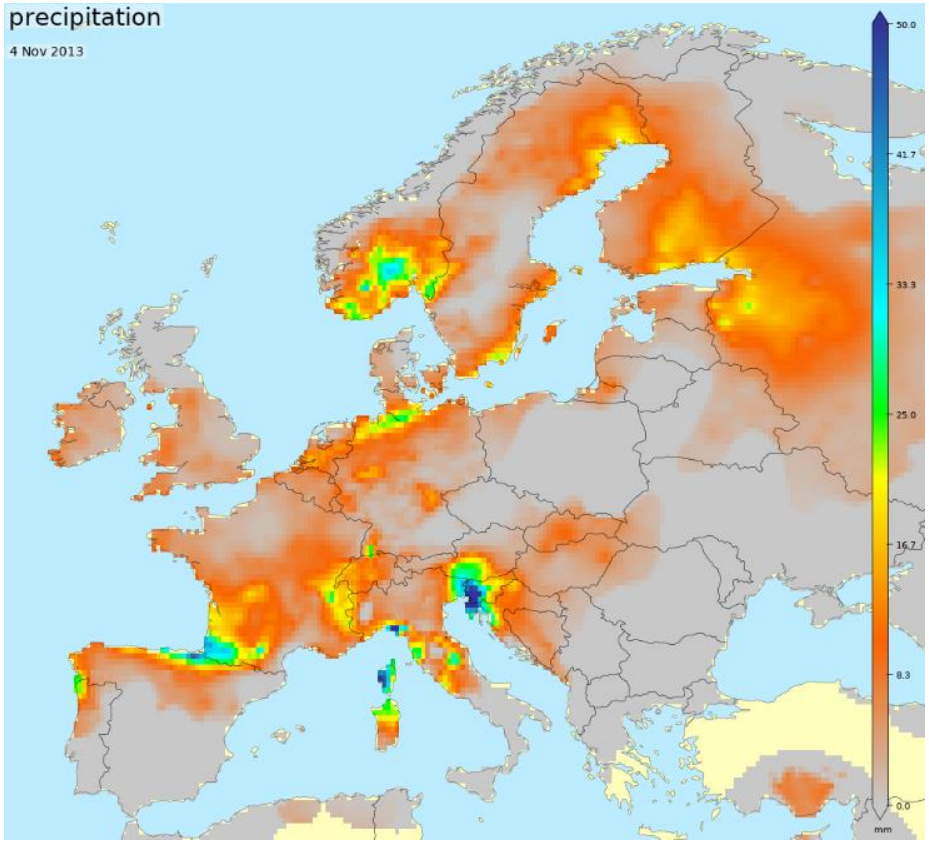
This catalogue entry provides Regional Climate Model (RCM) data on single levels from a number of experiments, models, domains, resolutions, ensemble members, time frequencies and periods computed over several regional domains all over the World in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX). The term "single levels" is used to express that the variables are 2D-matrices computed on one vertical level which can be surface (or a level close to the surface) or a dedicated pressure level in the atmosphere. Multiple vertical levels are excluded from this catalogue entry.



High-resolution Regional Climate Models (RCMs) can provide climate change information on regional and local scales in relatively fine detail, which cannot be obtained from coarse scale Global Climate Models (GCMs). This is manifested in better description of small-scale regional climate characteristics and also in more accurate representation of extreme events. Consequently, outputs of such RCMs are indispensable in supporting regional and local climate impact studies and adaptation decisions.

Examples of datasets currently available within CDS (1): E-OBS daily gridded data from in-situ observations

- The E-OBS dataset (Cornes et al., 2018) is a daily gridded land-only observational dataset over Europe available at a horizontal resolution of ~ 11 km relying on the 'blended' time series from the station network of the European Climate Assessment & Dataset (ECA&D) project.
- It contains data for precipitation amount, mean/maximum/minimum temperature, sea level pressure, and surface shortwave downwelling radiation.
- Its latest version (v.23) delivered by Copernicus Climate Data Store covers the period 1950-2021.

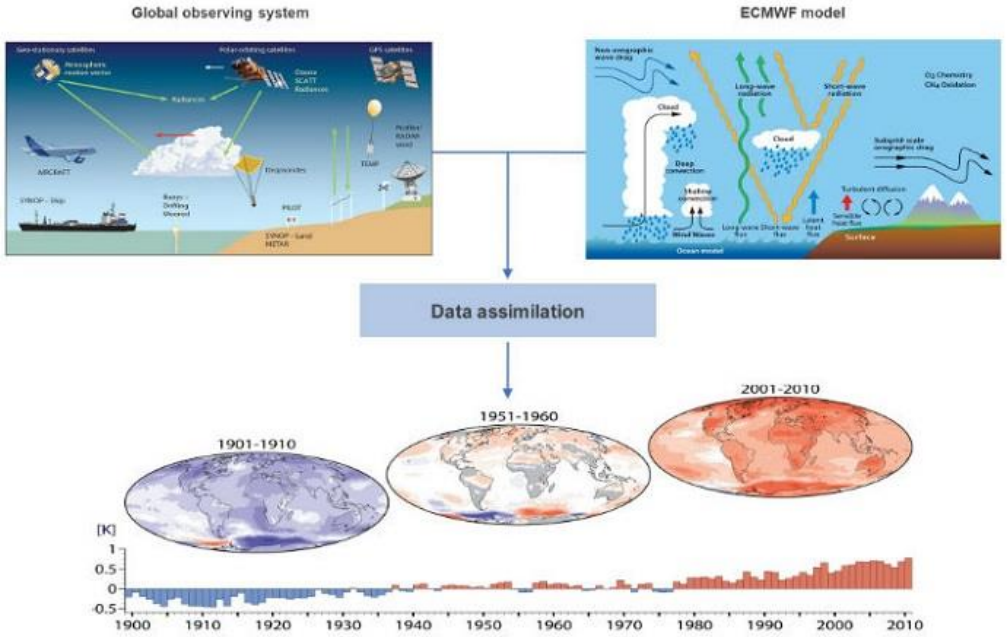


https://cds.climate.copernicus.eu/cdsapp#!/dataset/insitu-gridded-observations-europe?tab=overview

Examples of datasets currently available within CDS (2): ERA5 Reanalysis

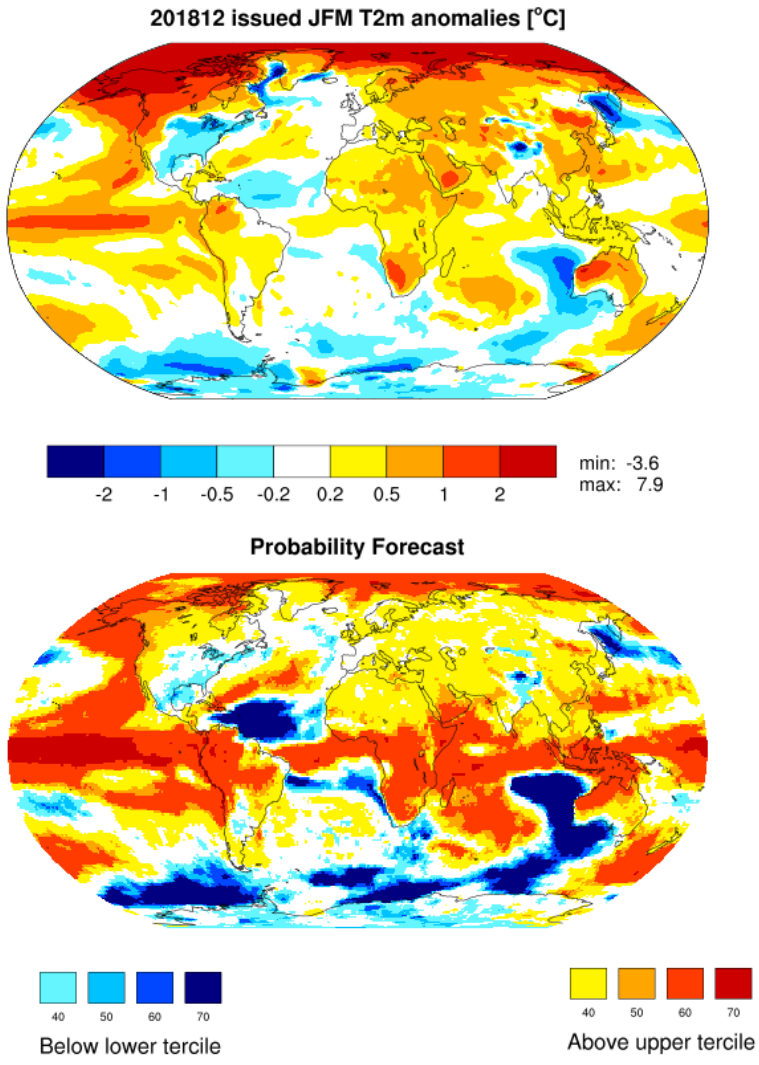
- ERA5 (Hersbach et al., 2020) represents the fifth global reanalysis produced by ECMWF with a horizontal resolution of ~ 31 km.
- A reanalysis combines numerical modelling with observations into a comprehensive global data set consistent with the laws of physics (data assimilation) that provides a picture of the current climate.
- At the present, it provides in operation data from 1979 to the present day at hourly resolution. There is also an extension to 1950 still in the validation phase.

https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview



Examples of datasets currently available within CDS (3): Seasonal Forecast

- This service provides a multi-system seasonal forecast service, where data produced by state-of-the-art seasonal forecast systems developed, implemented and operated at forecast centres in several European countries is collected, processed and combined to enable user-relevant applications.
- Seasonal forecasts provide a long-range outlook of changes in the Earth system over periods of a few weeks or months, as a result of predictable changes in some of the slow-varying components of the system.

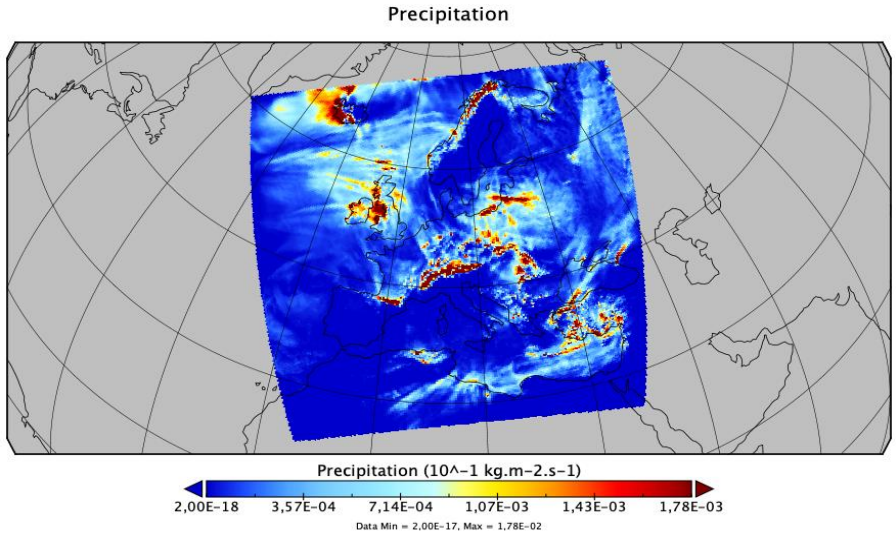


https://cds.climate.copernicus.eu/cdsapp#!/dataset/seasonal-original-single-levels?tab=overview

Examples of datasets currently available within CDS (4): CORDEX Regional Climate Model data

- It provides Regional Climate Model (RCM) data from a number of experiments, models, domains, resolutions, ensemble members, time frequencies and periods computed over several regional domains all over the World in the framework of the Coordinated Regional Climate Downscaling Experiment (CORDEX).
- The CORDEX experiments consist of RCM simulations up to 2100 representing different future socio-economic scenarios (forcings), different combinations of Global Circulation Models (GCMs) and RCMs and different ensemble members of the same GCM-RCM combinations.

https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cordex-domains-single-levels?tab=overview



Examples of applications currently available within CDS

1

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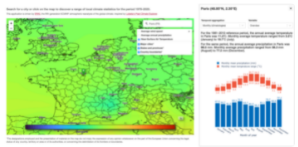
ERA5 explorer

Overview | Application | Documentation | Source code

This application provides visualisations of historical climate statistics for any location around the world. Click anywhere on the interactive map or search for a city to explore the typical monthly climate and discover how the climate has changed over the past forty years.



This application is driven by ERA5, the fifth generation ECMWF atmospheric reanalysis of the global climate. ERA5 describes the global history of the atmosphere for the period 1979-2020, using a combination of forecast models and data assimilation systems to 'reanalyse' past observations. As such, the information presented by this application for specific locations are not site-specific observations but rather based on the nearest grid point (nearest 1 degree) to the given location in the ERA5 reanalysis.

User-selectable parameters

- City: the city for which to generate location-specific climate statistics. The performance of the application is maximised for the most populous cities in Europe, along with all European capitals. For lower population and/or non-European cities, you might need to wait up to a

2

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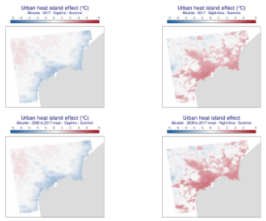
Urban heat island intensity for European cities from 2008 to 2017 derived from reanalysis

Overview | Application | Documentation | Source code

This application presents visualisations of Urban Heat Island (UHI) effect over the ten year period of 2008-2017. Users can select from 100 European cities for each year from 2008-2017, for both Summer (June, July August) and Winter (December, January, February) seasons. UHI maps are provided for the annual mean daytime and night-time UHI for the selected year, and the mean daytime and night-time UHI for the 10 year period 2008 to 2017.



The urban environment experiences higher temperatures than rural areas for many reasons, including the higher amount of paved surfaces and higher anthropogenic heat. The so-called Urban Heat Island (UHI) is the difference between the temperature at a location and the average temperature in the surrounding rural areas, and can range from a few degrees up to more than 10°C.

The input data comes from the UrbClim model, which utilises ERA 5 variables, namely air temperature, specific humidity, relative humidity and wind speed. The UrbClim model provides 100m resolution data for urban scale applications, specifically addressing the phenomena of urban heat isalnds.

3

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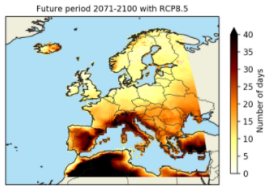
The number of heat wave days for European countries derived from climate projections

Overview | Application | Documentation | Source code

The application delivers the number of heat wave days experienced in Europe for both the historical period 1976-2005, and the projected 30-year periods 2031-2060 and 2071-2100 using different future climate change scenarios. A heat wave is a prolonged period of extremely high temperature for a particular region though multiple qualifying definitions are used in the climate and health communities. This application makes use of two European-wide definitions: the Climatological EURO-CORDEX and Euroheat project definitions, and one set of nation specific definitions which are available for a limited number of European countries.



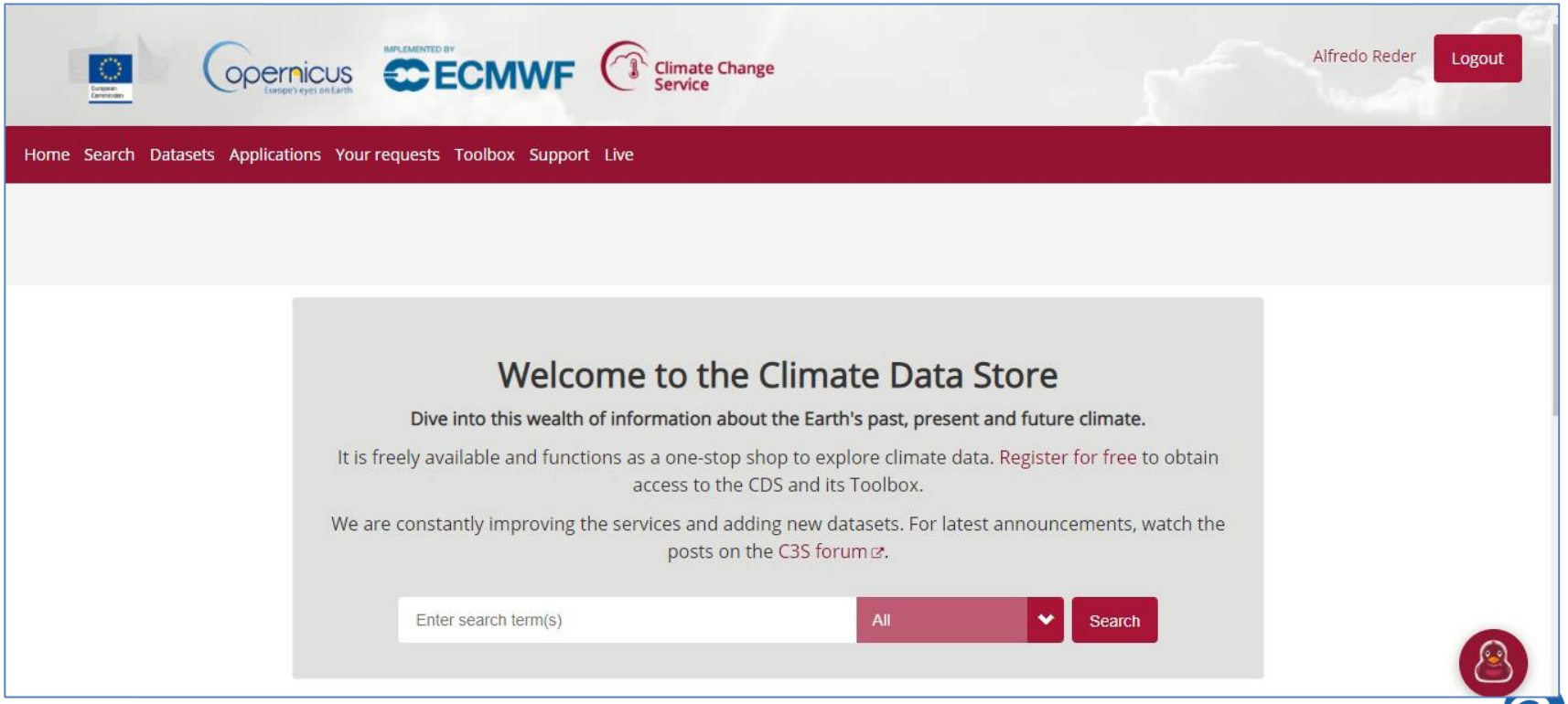
User-selectable parameters

Heat waves days are defined as follows:

- Climatological EURO-CORDEX - a period of at least three consecutive days on which the daily maximal temperature exceeds the 99th percentile of the daily maximal temperatures of the May to September months for the control period of 1971 to 2000.

Examples of applications currently available within CDS (1): ERA5 Explorer

It provides visualisations of historical climate statistics for any location around the world. Click anywhere on the interactive map or search for a city to explore the typical monthly climate and discover how the climate has changed over the past forty years. This application is driven by ERA5, the fifth generation ECMWF atmospheric reanalysis of the global climate.

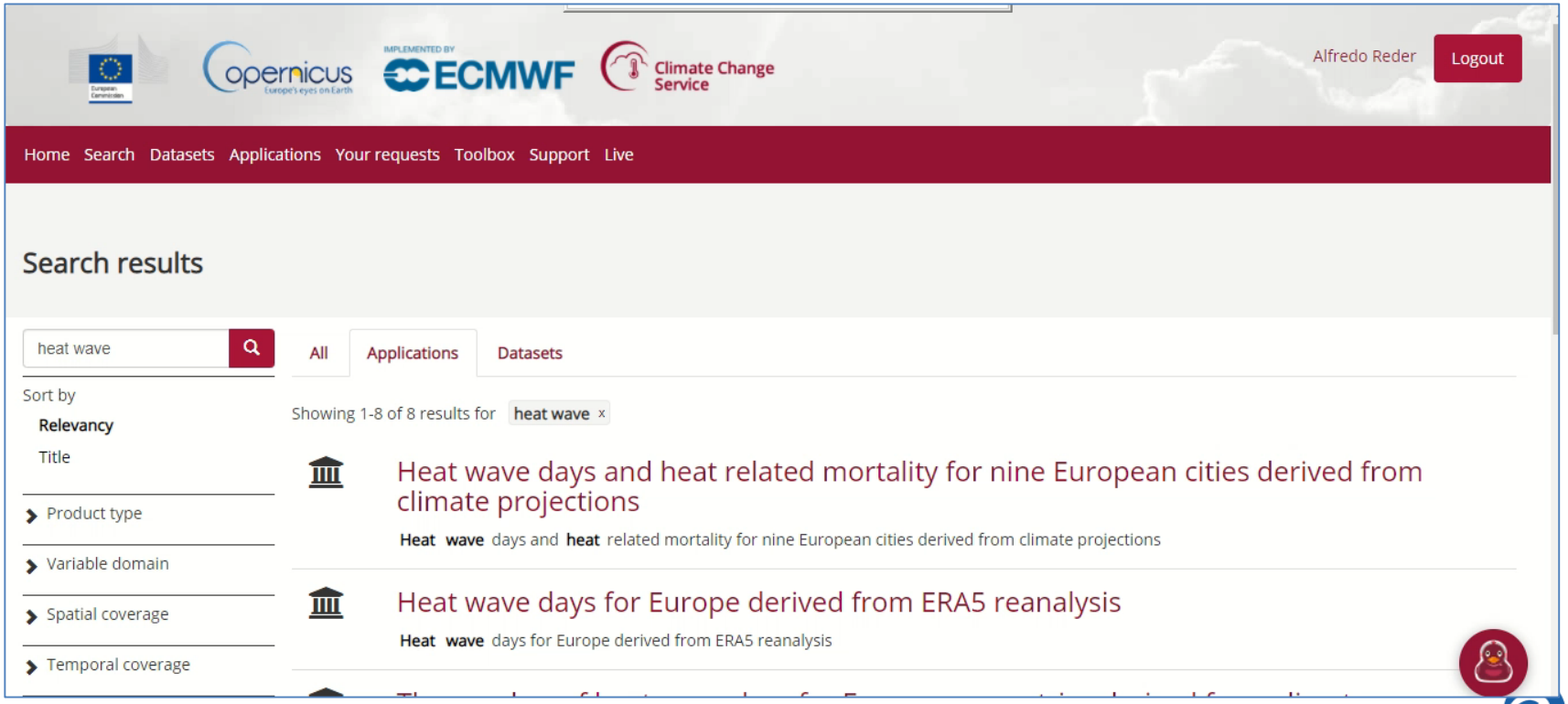


Examples of applications currently available within CDS (2): Urban heat island intensity for European cities

It presents visualisations of Urban Heat Island (UHI) effect over a 10-year period (2008-2017). The urban environment experiences higher temperatures than rural areas for many reasons (e.g., the higher amount of paved surfaces and higher anthropogenic heat). The difference between the temperature at a location and the average temperature in the surrounding rural areas represents the UHI.

Examples of applications currently available within CDS (3): Number of heat wave days derived from climate projections

It delivers the number of heat wave days experienced in Europe for both the historical period 1976-2005, and the projected 30-year periods 2031-2060 and 2071-2100 using different future climate change scenarios. A heat wave is a prolonged period of extremely high temperature for a particular region though multiple qualifying definitions are used in the climate and health communities.



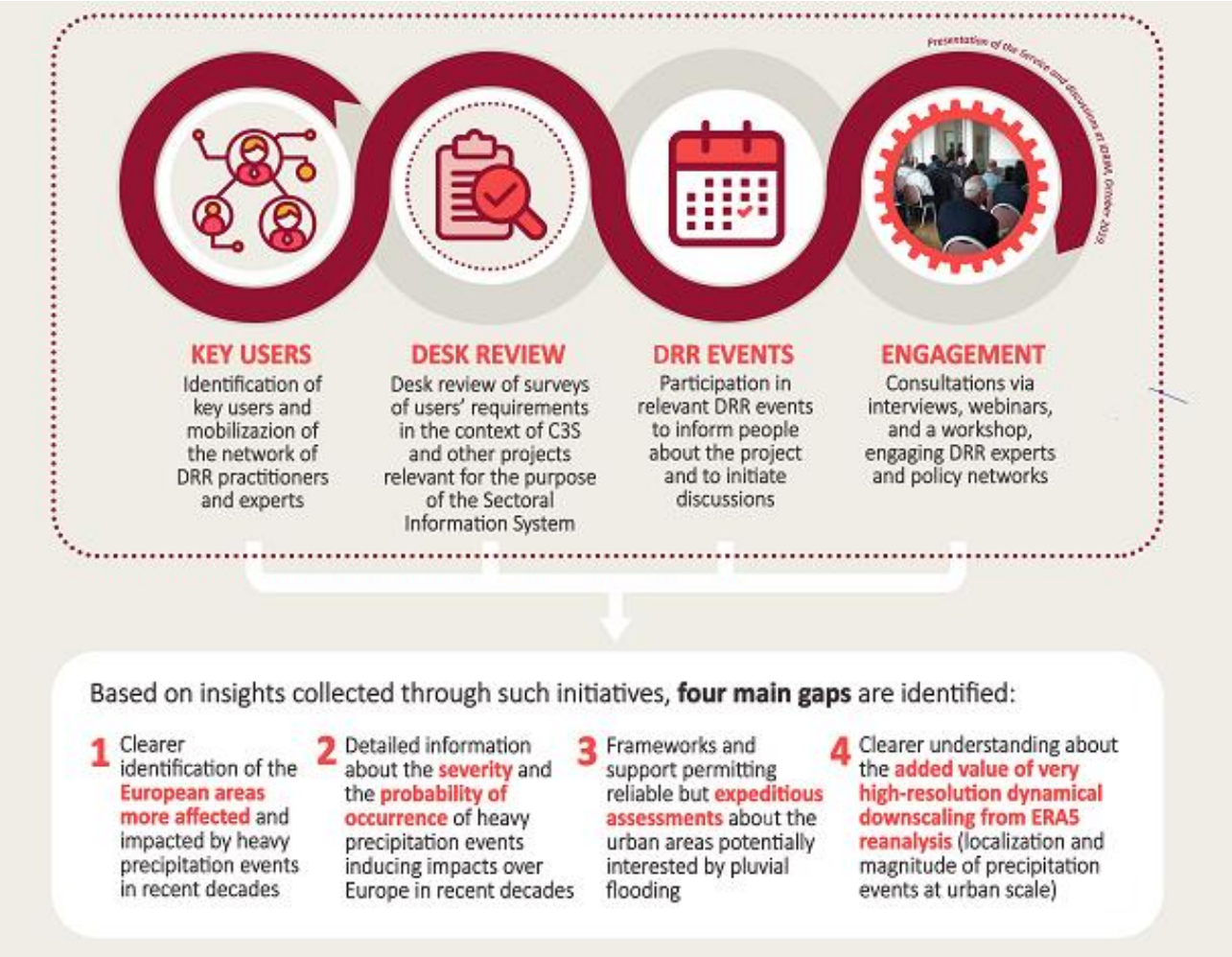
C3S Sectoral Information System on Disaster Risk Reduction

The Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC), in collaboration with the Koninklijk Nederlands Meteorologisch Instituut (KNMI), Wageningen Environmental Research (WENR) and GecoSistema s.r.l., were contracted by ECMWF to support "Sectoral Information System to support Disaster Risk Reduction".

The main target is a suite of tools capable of addressing these requirements to assess risks associated to extreme rainfall events in Europe with a specific focus on cities.

https://climate.copernicus.eu/pluvial-flood-risk-assessment-urban-areas

A Service relying on users' needs



Target groups

- Public administration & city councils; ICLEI, Covenant of Mayors
- Civil protection and risk management actors
- Insurers and financial organisations
- Business companies
- High-level policy organisations (EFDRR, DRMKC, EEA, ..)
- Copernicus EMS

A new portfolio of Datasets and Applications

Extreme precipitation statistics over Europe

Characterisation of extreme precipitation regimes through indicators and statistical approaches

Catalogue of extreme precipitation events over Europe

Affected areas, severity of the events, induced damages and losses

Pluvial flood hazard and risk assessment for 20 European pilot cities (case studies)

Affected areas, water depths, exposure to pluvial flooding and expected damages

End-users will browse through a **pan-European explorer** for profiling past precipitation characteristics and a **pan-European interactive catalogue of past extreme precipitation events** to detect and rank them in terms of affected area, magnitude, and severity (empirical damage and loss records from public repositories).

For 20 European cities, end-users will have access to a dedicated **pluvial flooding hazard and risk product** to detect the spatial distribution of water depth and direct damages at meters resolution for hourly precipitation maxima at different probability of occurrence.

ERA5-2km: Dynamical downscaling of ERA5 reanalysis at 2 km

ERA5-2km represents an additional hourly dataset at horizontal resolution of 0.02° (~ 2.2 km) for a pool of 20 user-selected cities over 1989-2018.

Regional Climate Model	Resolution	Period	Nesting Strategy
COSMO-CLM v 5.00 clm9 with urban parametrization TERRA-URB 2.3.1	0.02°, ~2.2 km	1989-2018 (spin-up 1988)	ERA5 (31km) → ERA5@2km (~2.2 km)

- It is developed by dynamically downscaling ERA5 with the regional climate model COSMO-CLM (Rockel et al., 2008) switching on the module TERRA-URB for accounting the urban parameterizations (Wouters et al., 2016).
- The downscaling activity relies on a one-step nesting strategy, in which the simulation at 2.2km is directly "one-way nested" in ERA5 (1:15 resolution jump).
- In ERA5-2km, no spectral nudging is adopted but observations are indirectly accounted through the atmospheric forcing of ERA5.

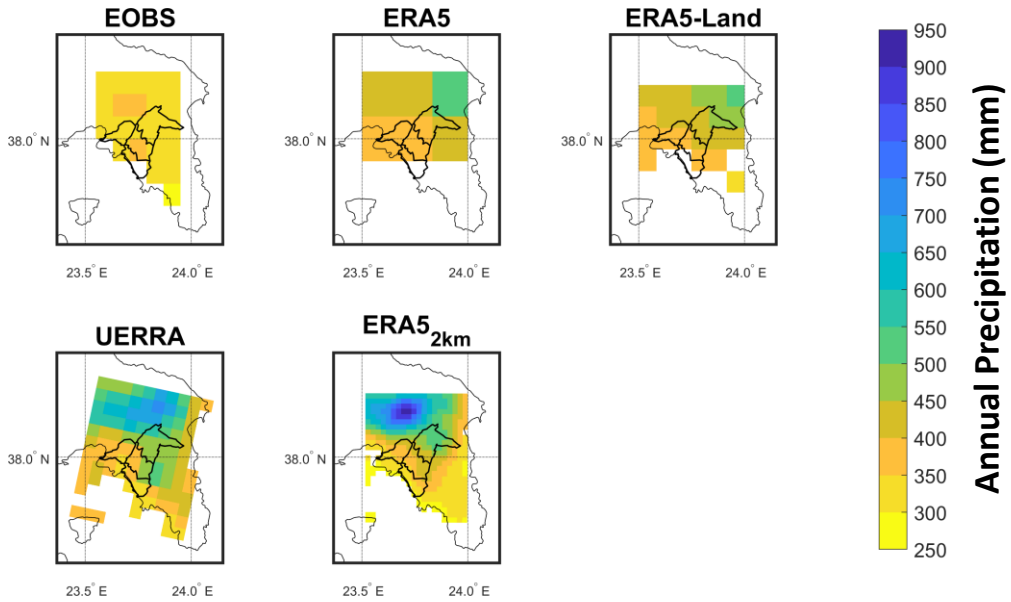
Raffa et al., doi: 10.3390/atmos12020260 *Raffa et al., doi: 10.3390/data6080088* *Reder et al., under review*

See webinar on CMCC YouTube Channel https://www.youtube.com/watch?v=B0lCuEX6sUs

Characterization of precipitation features over Athens with the new very high-resolution climate simulation ERA5@2km

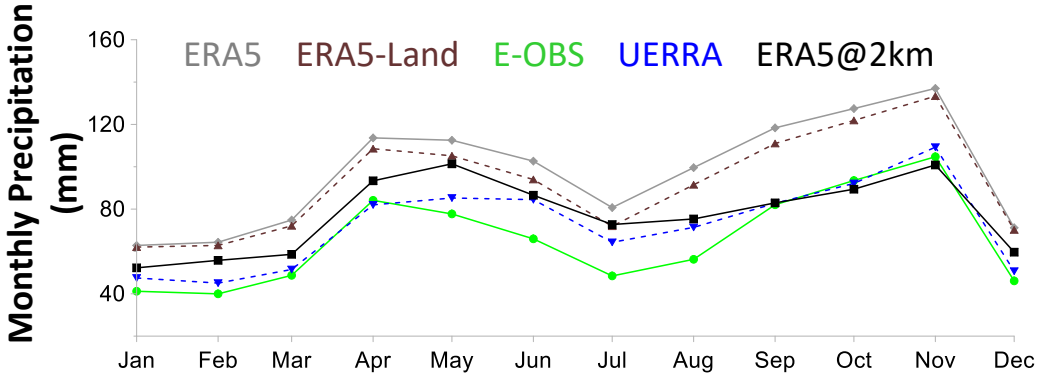
1

Average annual precipitation (1989-2018)



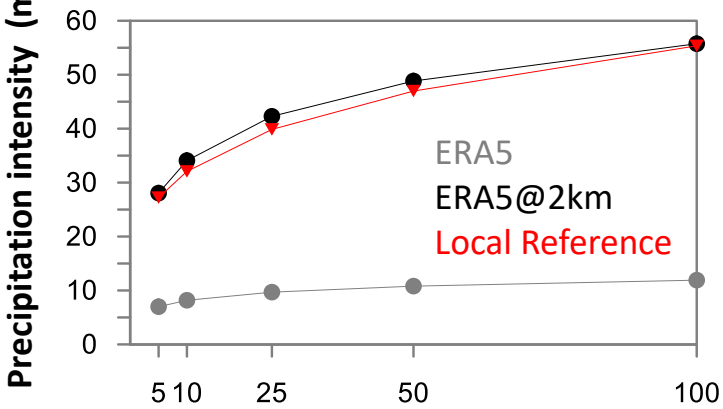
2

Annual cycle of monthly precipitation (1989-2018)



3

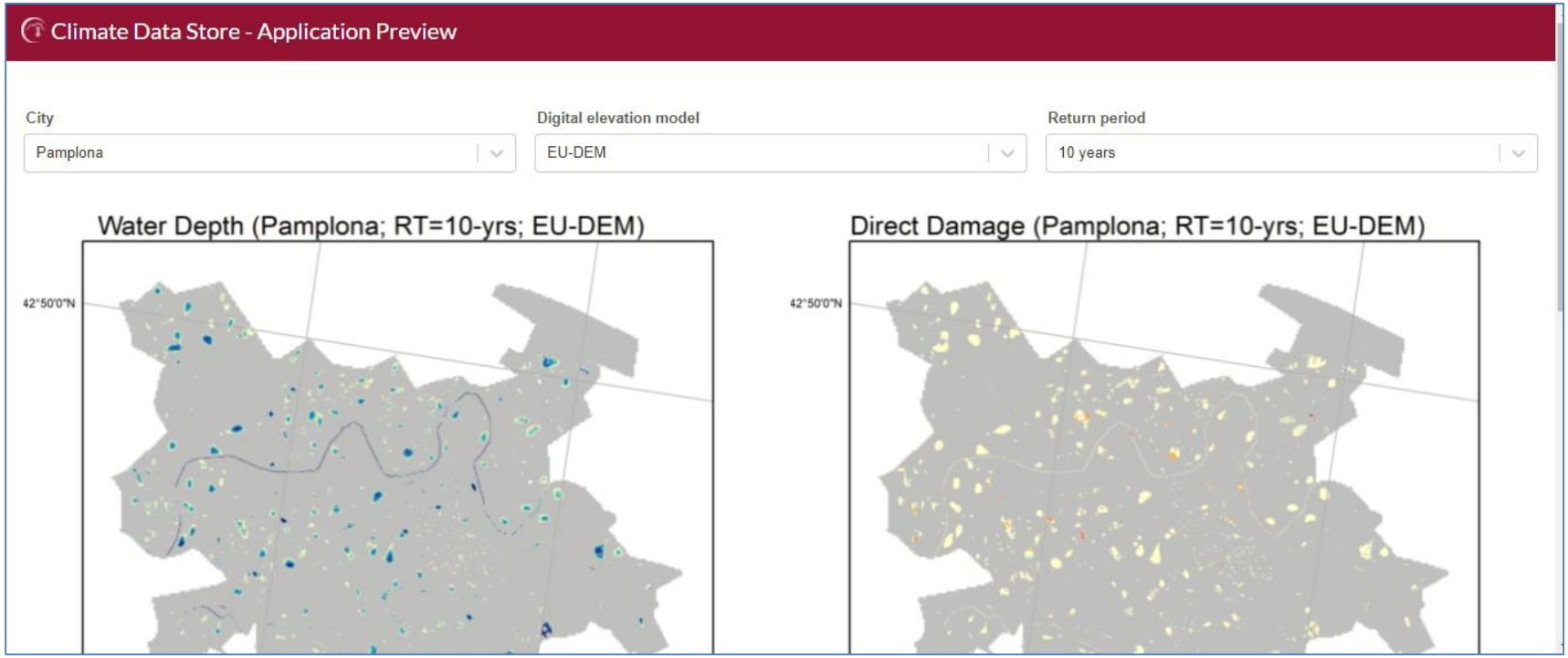
1-hr annual maxima for different return periods



Intensity-Duration-Frequency curve are usually used for the assessment of urban-scale impacts of heavy rainfall and the design of hydraulic infrastructures

Urban pluvial flood risk analysis

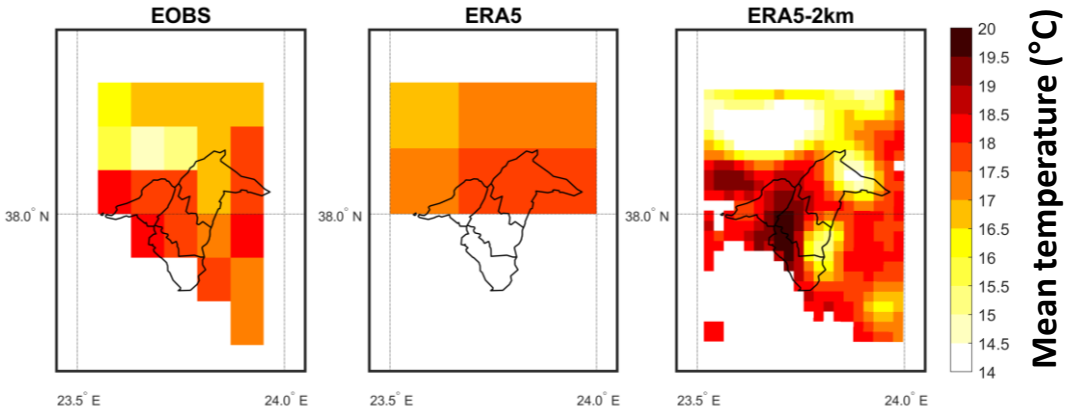
For 20 European cities, end-users will have access to a dedicated **pluvial flooding hazard and risk product** to detect the spatial distribution of water depth and direct damages at meters resolution for hourly precipitation maxima at different probability of occurrence.



Characterization of temperature features over Athens with the new very high-resolution climate simulation ERA5@2km

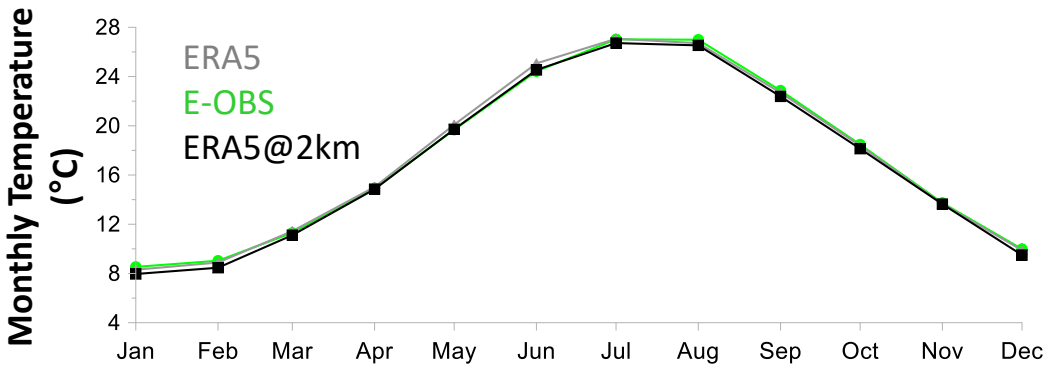
1

Average annual mean temperature (1989-2018)



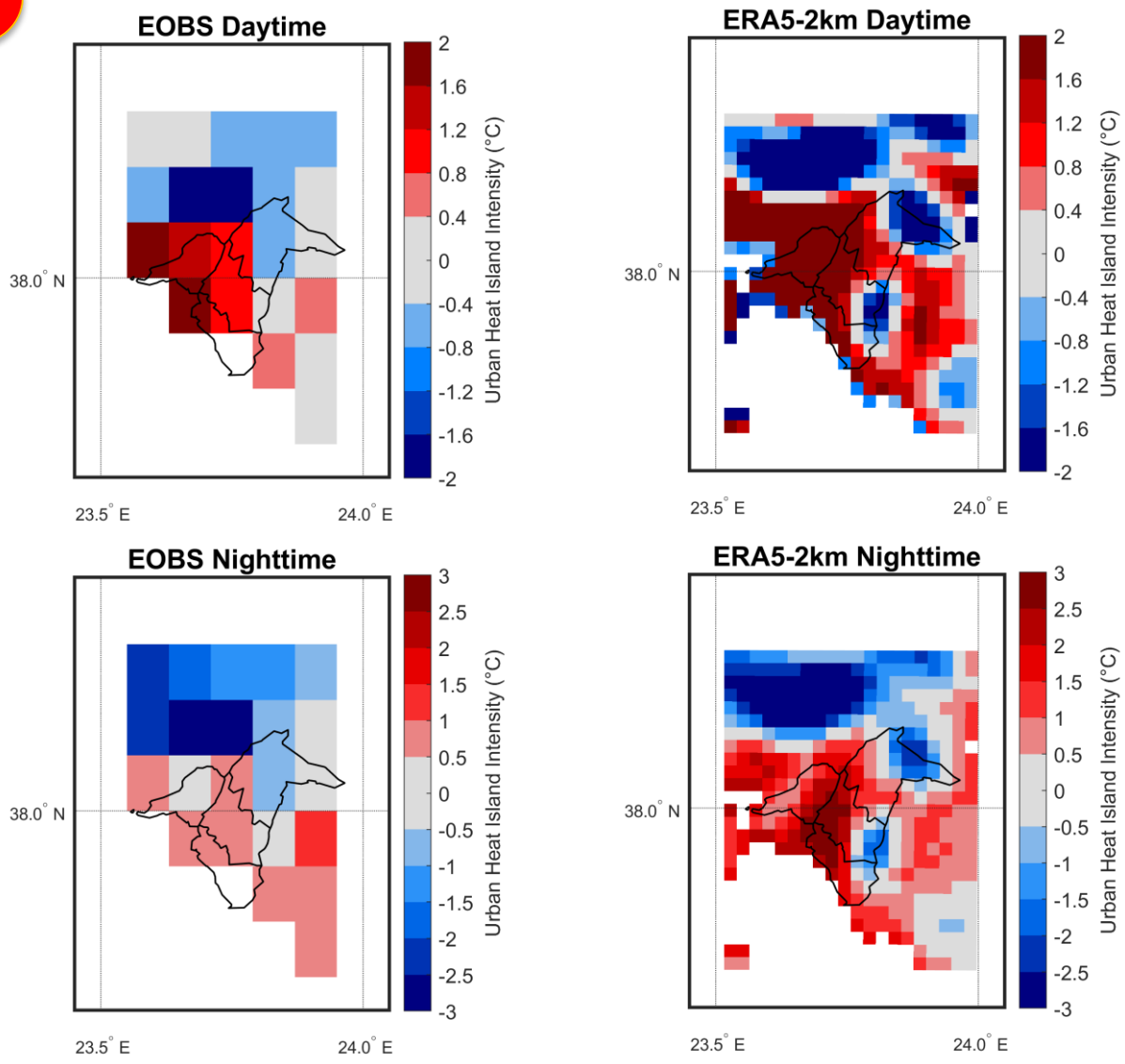
2

Annual cycle of mean temperature (1989-2018)



Characterization of temperature features over Athens with the new very high-resolution climate simulation ERA5@2km

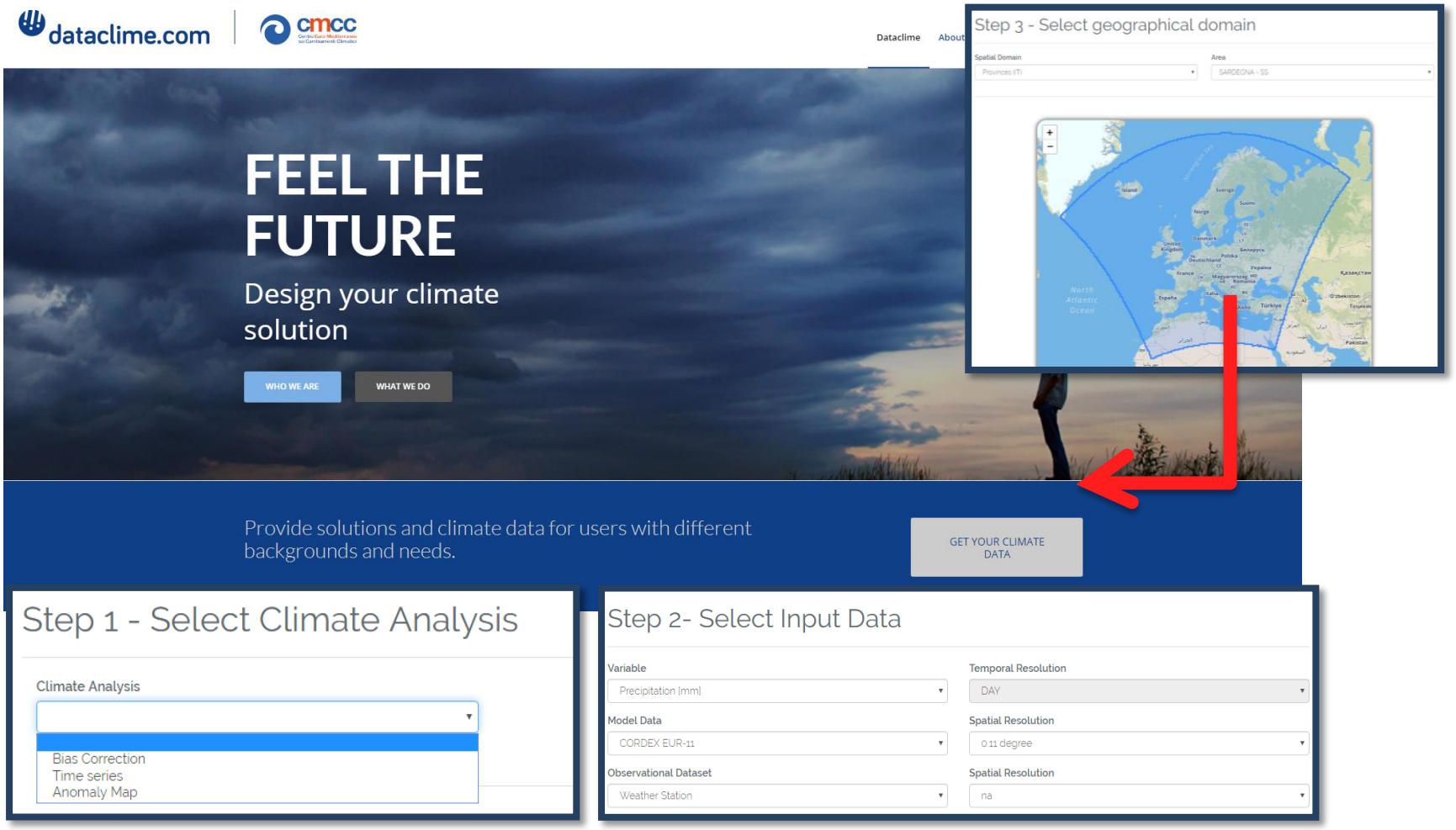
3



Urban Heat Island Intensity is evaluated as difference between temperature in urban areas and the mean values assessed in the rural ones

$$UHII = T_{urban} - T_{rural}$$

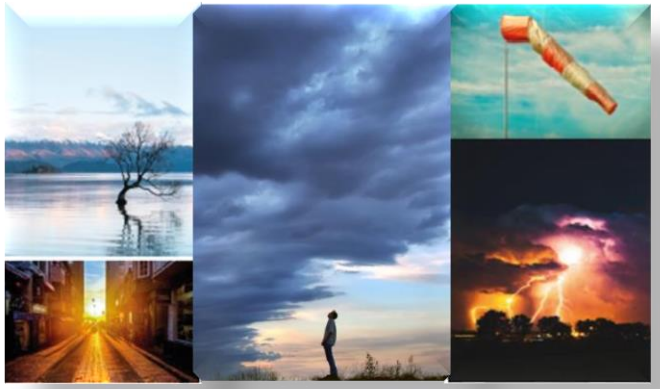
DATACLIME climate service: a CMCC web platform for specialised climate services



https://www.dataclime.com/

What is DATACLIME service?

- DATACLIME is a climate service developed by REMHI division of CMCC, to provide climate data and solutions to many different users with different skills and needs.
- DATACLIME service is able to take care of the whole information production chain: from the climate data collection/storage to their processing and analising according to user needs.



dataclime.com