TransformAr

Accelerating and upscaling transformational adaptation in Europe: demonstration of water-related innovation packages

Consolidated data framework

Deliverable 2.1

This project has received funding from the European Union's Horizon H2020 innovation action programme under grant agreement 101036683.

Deliverable Number and Name	D2.1 – Consolidated data framework
Work Package	WP2 – Integrated biophysical/socio-economic framework for modelling multi-sector dynamics
Dissemination Level	Public
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Date Due	30.09.2022
Date Submitted	30.09.2022
File Name	TransformAr_WP2_D2.1_Consolidated_Data_Framework _V2_30092022
Status	Final Version
Reviewed by (if applicable)	
Suggested citation	/

This document has been prepared in the framework of the European project TransformAr. This project has received funding from the European Union's Horizon 2020 innovation action programme under grant agreement no. 101036683.

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ABBREVIATIONS

Abbreviations	Description
CMIP	Coupled Model Intercomparison Project
GCM	General Circulation Model
GHG	GreenHouse Gas
IPCC	Intergovernmental Panel on Climate Change
ISIMIP	Inter-Sectoral Impact Model Intercomparison Project
RCP	Representative Concentration Pathway
SSP	Shared Socioeconomic Pathways
WP	Work Package
Participant acronym	**Description**
UA	University of Antwerp
CMCC	Euro-Mediterranean Center on Climate Change
ACTERRA	Acterra
E3M	E3-Modelling
PIK	Potsdam Institute for Climate Impact Research
VERHAERT	Verhaert
FEUGA	Fundación Empresa-Universidad Gallega
NCSRD	National Center for Scientific Research "Demokritos"
CZU	Czech University of Life Sciences Prague
LUT	LUT University
NTNU	Norwegian University of Science and Technology
UVIGO	University of Vigo
EPSILON	EPSILON
ADEME	ADEME Guadeloupe
WRT	Westcountry Rivers Trust
MEDSEA	Mediterranean Sea and Coast Foundation
CETMAR	Fundación CETMAR: Centro Tecnológico del Mar
LAPP	Lappeenranta Municipality
MOE	Egaleo Municipality
WE	Water Europe
EQY	Euroquality
MOG	Municipality of Gjøvik

AKNOWLEDGEMENT

This report forms part of the deliverables from the TransformAr project which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036683. The Community is not responsible for any use that might be made of the content of this publication.

TransformAr – Accelerating and upscaling transformational adaptation in Europe: demonstration of water-related innovation packages – is an H2020 project funded under the H2020 Programme, coordinated by the University of Antwerp (UA).

The TransformAr project, launched on October 1st 2021, precisely aims to develop and demonstrate products and services to launch and accelerate large-scale and disruptive adaptive process for transformational adaptation in vulnerable regions and communities across Europe.

The project, funded by the EU Research and Innovation Programme Horizon 2020 under Grant Agreement No 101036683, gathers 22 partnering organisations from 11 Member States. It has an overall budget of approximately €12 million and will run for 4 years, between October 2021 and September 2025.

EXECUTIVE SUMMARY

The TransformAr WP2 consolidated data framework aims at providing a portfolio of future biophysical data trends for each Demo region to characterize climatic, hydrological and environmental variables, in line with a set of selected IPCC scenarios, as combination of shared socioeconomic pathway (SSP) and representative concentration pathway (RCP) scenarios. This document aims at providing an initial overview of the climate and biophysical data that was consolidated in the first 12 months of the project and made available to facilitate project activities. The framework of macro data/general trends has been structured, listing significant available variables that can be generated under uniform methodology, assumptions and modelling across all Demo regions. The report gives an overview of the origin of the data, the model used, the RCP and SSP scenarios discussed, their purpose within the project, and the spatial and temporal scale at which this quantitative information can be provided. An inventory list of climate and biophysical data is formulated and some key variables presented to describe potential support for activity development for the different Demo regions. List of variables consolidated and available in the data framework will increase during the project lifetime, while data requests and project modelling activities are accomplished.

1. Introduction

Management tools evaluating climate risks and benefits from adaptation practices require scientific and up-to-date basis, which should rather be defined as a harmonized data structure with homogeneous modelling protocol and drivers in order to allow comparison of results across the demo regions. To this end, WP2 is developing consolidated projections at multi-decadal scale for historical baseline and future time frames up to 2100 under different recent emission scenarios (i.e. RCPs). A special relevance however is given to 2030-2050 for EU policy objectives. It mostly includes climate and biophysical processes characterizing natural hazards to relevant sectors for TransformAr. Climate data follow the latest CMIP6 generation of data (i.e. associated with the IPCC VI report) and include an extensive set of climate variables and indicators to encompass the wide range of hazards and processes relevant to TransformAr Demo regions. Biophysical data may integrate as well available and relevant modelling output for hydrological, marine, land use and land use changes, natural resources, ecosystem services.

Under this framework, extensive data acquisition for relevant thematic components takes place and is consolidated, and data structured and harmonized across EU and demonstrator sites to facilitate an effective and comparable implementation of each demonstrator-specific designed solution. Data consolidation exploit existing resources from inter-comparison modelling projects (e.g., ISI-MIP), EU operational services (Copernicus Climate Change Service, Emergency Management Service, Land Monitoring, etc.) and relevant EU projects. It does allow for a harmonized data structure to fulfil needs for other tasks of TranformAr project (e.g. T2.3; T2.4; engagement with SHs; evaluation of natural hazard and solution at demonstrators in WP3 and WP4; evaluation of natural risks and econometric analyses representing larger transformational pathways and upscaling in WP5 and WP6).

2. Climate and biophysical modelling

2.1 Modelling Climate Change

Numerical models or General Circulation Models (GCMs) are used and implemented to simulate and represent physical processes in great detail within and between the atmosphere, ocean, cryosphere and land surface systems. They normally depict climate using three dimensional grids over the globe, with horizontal resolution between 70 and 300 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. GCMs are very advanced tools currently available to understand how

the climate has changed in the past and may change in the future, for simulating and predicting the response of the planet climate system to increasing concentration of Green-House Gasses (GHGs). Still, GCMs are extremely demanding in processing time and require some of the largest computing facilities in order to generate their projections. The complexity, and high level of interactions involved to represent accurately the climate system, and processing limitations lead to still quite coarse resolution (70-100 km over land) for most impact assessments.

Thus, the known properties and extremes of many physical processes must be averaged over larger scale with such coarse pixel resolution. Moreover, many physical processes related to clouds formation and development also occur at smaller scale and cannot be modelled accurately with most current pixel resolution. Downscaling is an additional post-processing method widely used to increase resolution, to which processes may be simulated to better represent spatial variability, but often only to limited regions. Altogether, there are several sources of uncertainties in the use of GCMs to simulate climate processes for the future and especially in relation to extreme events. Different GCMs may articulate and simulate different responses under similar GHG and radiative forcing, simply due to the fact that different approaches are used to model processes and feedbacks. Thus, several sources of modelling errors and divergences among model outputs (i.e. uncertainties) are present, and it becomes essential to improve reliability and confidence of climate modelling outputs. Therefore, climate models are constantly updated and improved by different modelling groups around the world, both in terms of increased spatial resolution and more accurate parameterization and simulation of biophysical processes and biogeochemical cycles. A coordinated effort of these modelling groups is part of the Coupled Model Intercomparison Project (CMIP), aiming to improve climate models by cross-comparing different simulations and coordinate the update of the results around the schedule of the Intergovernmental Panel on Climate Change (IPCC) assessment reports. Thus, set of CMIP model results, known as runs, are released in the lead-up of IPCC reports: 2013 IPCC fifth assessment report (AR5) featured climate models from CMIP5, while the 2021 IPCC sixth assessment report (AR6) features new state-of-the-art CMIP6 models.

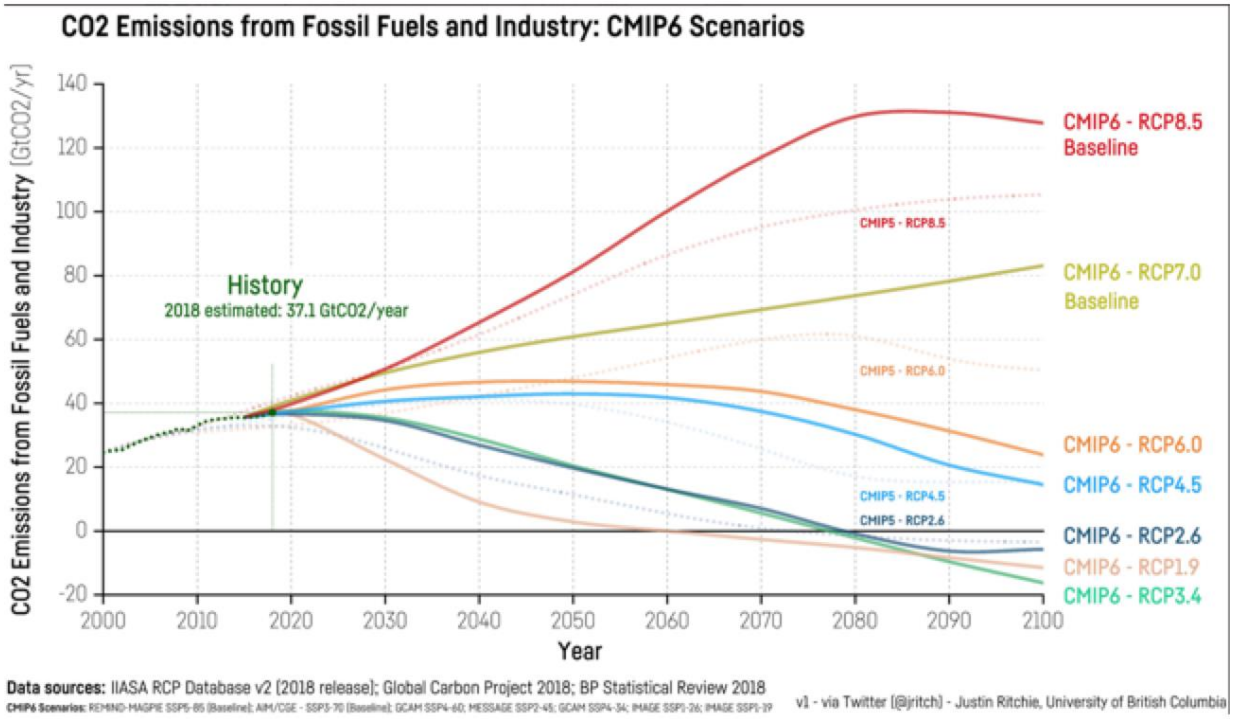
While comparing results from most CMIP6 model runs, it has become evident that they have a notably higher climate sensitivity than models in CMIP5, which contributes to projections of greater warming this century – around 0.4C warmer than similar scenarios run in CMIP5. Altogether, it is clear that data framework must include plenty of climate model projections to highlight and emphasize inherent climate model uncertainties and divergence across model projections, and possibly characterize the climate signal difference emerging from the latest climate model runs (i.e. CMIP6) over previous ones (i.e. CMIP3/6).

2.2 Scenarios

In order to understand how our climate may change in future, we need to predict also how it may behave through some consolidated scenarios. Representative Concentration Pathways (RCPs) include transient predictions under different assumptions of future emissions and concentrations of greenhouse gases (GHGs) and aerosols and chemically active gases, as well as trends representing dynamics of land use/land

cover. Each RCP provides a possible scenario, the trajectory over time extending up to 2100, defining specific radiative forcing characteristics. Several RCPs are produced and introduced from published literature, and used in Fifth and Sixth IPCC Assessment as a basis for the climate predictions and projections, each categorized by the peak radiative forcing in 2100, thus:

- RCP2.6 peaks at approximately 3 W m-2 before 2100 and then declines;
- RCP4.5 and RCP6.0 represent intermediate stabilisation pathways in which radiative forcing is stabilised at 4.5 W m-2 and 6.0 W m-2 after 2100;
- RCP 7.0 and RCP 8.5 high pathway for which radiative forcing reaches greater than 7 or 8.5 W m-2 by 2100 and continues to rise for some amount of time.



Furthermore, alternative socio-economic future development trajectories are defined and described by a collection of alternative shared socio-economic pathways (SSP). The combination of RCP climate projections and SSP socio-economic scenarios should provide an integrated framework useful to combine climate impact and policy analysis

2.3 The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP)

The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) is a community-driven climate-impacts modelling initiative aimed at contributing cross-sectoral quantitative synthesis of the differential impacts of climate change, including the associated uncertainties. The initiative thus provides a consistent framework with shared, coherent and consolidated drivers among across-scale modelling chain of the impacts of climate change. Results aim to consolidate a comprehensive and harmonized understanding that can be adopted to easily relate impacts results not only across sectors but also across different regions.

ISIMIP is organized into simulation rounds. For each round, a simulation protocol defines a set of common simulation scenarios (e.g. climate input data) and other global drivers. Recent ISIMIP simulation rounds have been mostly constructed in combination and based on the different CMIP simulation rounds. These implementations complete and create coherent impact modelling chains around CMIP simulation rounds for different sectors (Climate, Water, Agriculture, Forest, Biomes, terrestrial biodiversity, etc.), following common standard protocol and underlying climate forcing/scenarios.

All the underlying climate projections established from CMIP and used as climate input/drivers in ISIMIP are downscaled and bias corrected, and available at global scale with a spatial resolution of 0.5 degrees (i.e. 50-60 km). CMIP6 and CMIP5 climate projections for pre-industrial, historical, and future conditions have been downscaled in ISIMIP to 0.5 degrees and bias-corrected using corrected ERA5 observational data (W5E5), according to following methodology:

https://www.isimip.org/documents/16/Fact_Sheet_Bias_Correction.pdf

For ISIMIP 2b impacts on different sectors are already available at the global and regional scales for many sectors: water, fisheries and marine ecosystems, energy supply and demand, forests, biomes, agriculture, agro-economics, terrestrial biodiversity, permafrost, coastal systems, health and lakes. However, establishment of impact projections following most recent CMIP6 on different sectors is still under way. It is very likely that within the next few years most climate change sectorial impacts following CMIP6 will be available and streamlined in politically and scientifically-relevant climate-change scenarios assessments.

2. Projections for TransformAr DEMO Regions

A framework of macro data/general trends will be generated under uniform methodology, assumptions and modelling across demo regions to characterize both climatic and environmental conditions, expressed in quantitative terms as absolute values or relative changes to baseline period in line with a combination of selected IPCC future scenarios (SSP and RCP).

The key goal here is to establish the framework, as ground basis for different project outcomes, that can be also linked to comprehensive cross-sectoral understanding emerging from CMIP and ISIMIP communities, but ultimately with IPCC report outcomes. As mentioned, the ISIMIP is organized in simulation rounds: simulation round 2b is consolidated on CMIP5, while simulation round 3b is consolidated on CMIP6. Many project partners and database have been consolidated around CMIP5 in the last years, but it is extremely relevant to provide also new climate modelling outputs following CMIP6 results and their relative difference in climate signal and uncertainties compared to previous CMIP5 projections.

Thus, in order to be consistent with latest IPCC/CMIP elaboration, the TransformAr consolidated framework include the climate input data/forcing for phase 3b of the ISIMIP based on CMIP6 simulation runs, as starting point. These include projections for the following 5 climate models, based on combination of 3 RCP scenarios (RCP2.6, RCP7.0 and RCP8.5):

- GFDL-ESM4
- IPSL-CM6A-LR
- MPI-ESM1-2-HR
- MRI-ESM2-0
- UKESM1-0-LL

The frequency of the available climate and data ranges from daily to monthly to 30-yr mean temporal resolution depending on the variable. Data are available for the historical (1850-2014) and future (2015-2100) time period and under one or more climate scenarios e.g., RCP 2.6, RCP 7.0, RCP 8.5 (respectively ssp126, ssp370, ssp585, following SSP/RCP associations). A general screening of potentially available climate data for the demo regions has been established with extensive inventory list available on TransformAr team platform. The variable selected so far from the ISIMP database are:

- Total Precipitation (short_name pr) Total precipitation is expressed as kg m-2 s-1 or mm day-1 and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.
- Average Temperature (short_name tas) Near-Surface Air average Temperature is expressed as K° or C° and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.
- Maximum Temperature (short_name tasmax) Near-Surface Air Maximum Temperature is expressed as K° or C° and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Minimum Temperature (short_name tasmin) Near-Surface Air Minimum Temperature is expressed as K° or C° and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Snowfall (short_name prsn) Total snowfall is expressed as kg m-2 s-1 or mm day-1 and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Relative Humidity (short_name rhs) Near-Surface Average Relative Humidity is expressed as % and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Shortwave Radiation (short_name rsds) Surface Downwelling or Incoming Shortwave Radiation is expressed as W m-2 and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Longwave Radiation (short_name rsds) Surface Downwelling or Incoming Longwave Radiation is expressed as W m-2 and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Wind Speed (short_name wind) near surface wind speed (m s-1) is expressed as m s-1 and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

- Atmospheric pressure (short_name ps) Surface Air Pressure is expressed as Pa and is available at daily or monthly temporal resolution under RCP 2.6, RCP 7.0, RCP 8.5.

In addition, the framework consolidates and makes available climate extremes indices (e.g. WMO, Climdex) based on temperature and precipitation for the demo regions. These indices are annual or monthly, statistics based on the CMIP6 climate data, and reflect nature and intensity in relation to droughts, heatwaves, extreme rainfall events, etc.

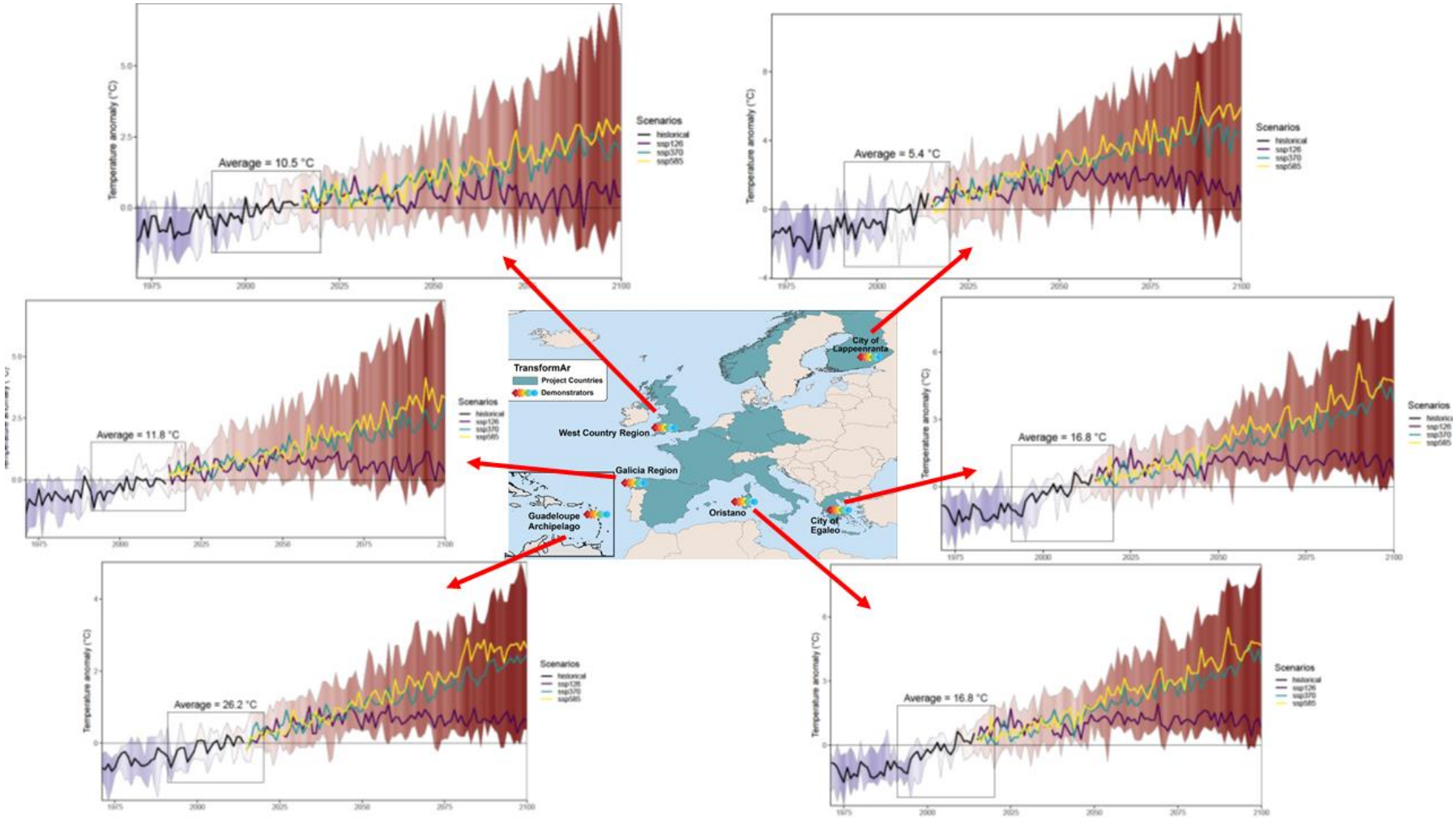


Figure 1.1 Relative change of annual temperature across TransformAr Demo regions over baseline period (1986-2005). Ensemble include endmembers from 5 climate modelling projections and 3 RCP scenarios (rcp26 in purple, rcp70 in cyan and rcp85 in yellow)

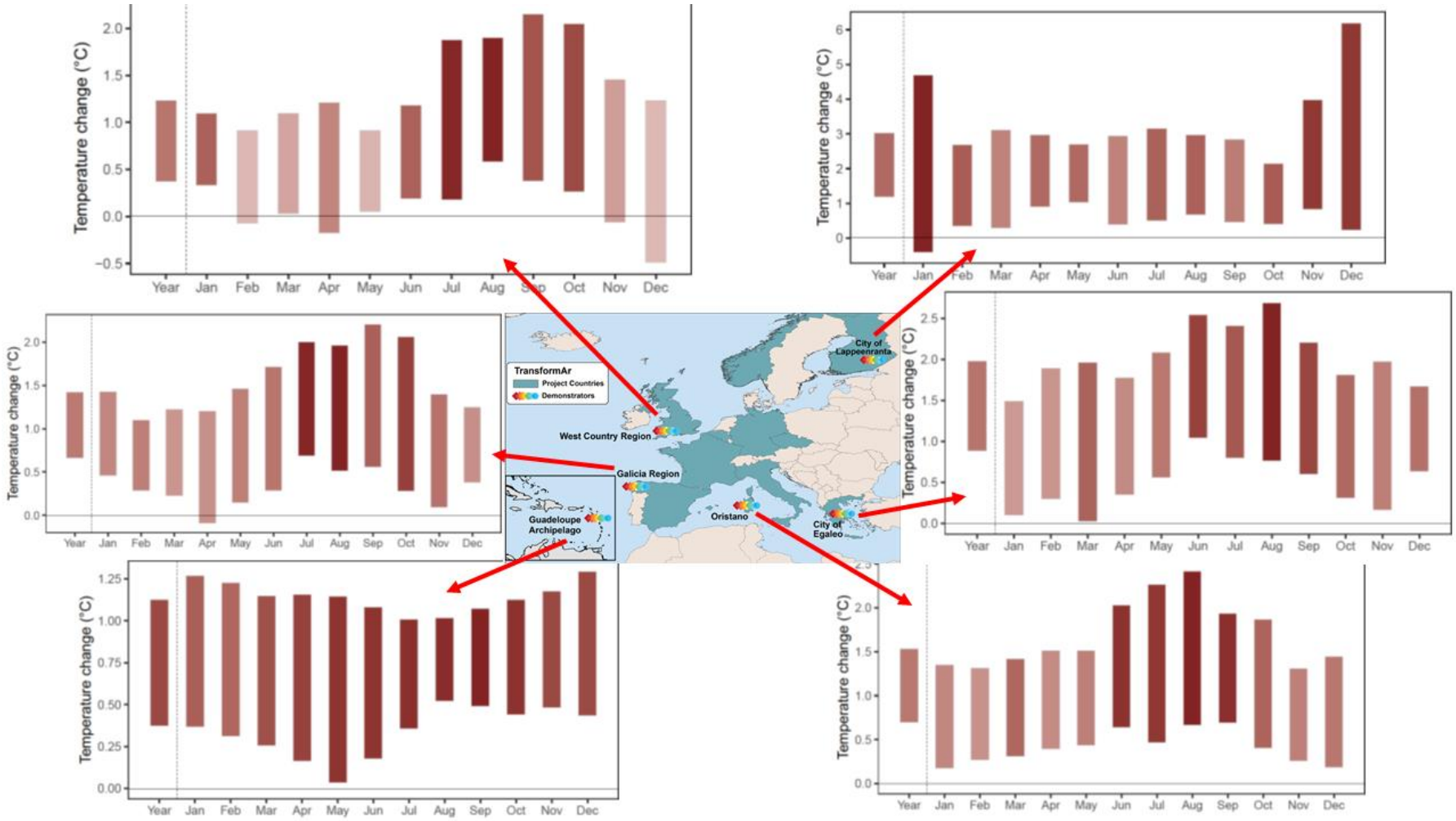


Figure 1.2 Relative change of monthly mean temperature across TransformAr Demo regions over baseline period (2050 vs 2000). Ensemble include endmembers from 5 climate modelling projections and 3 RCP scenarios (rcp26 in purple, rcp70 in cyan and rcp85 in yellow)

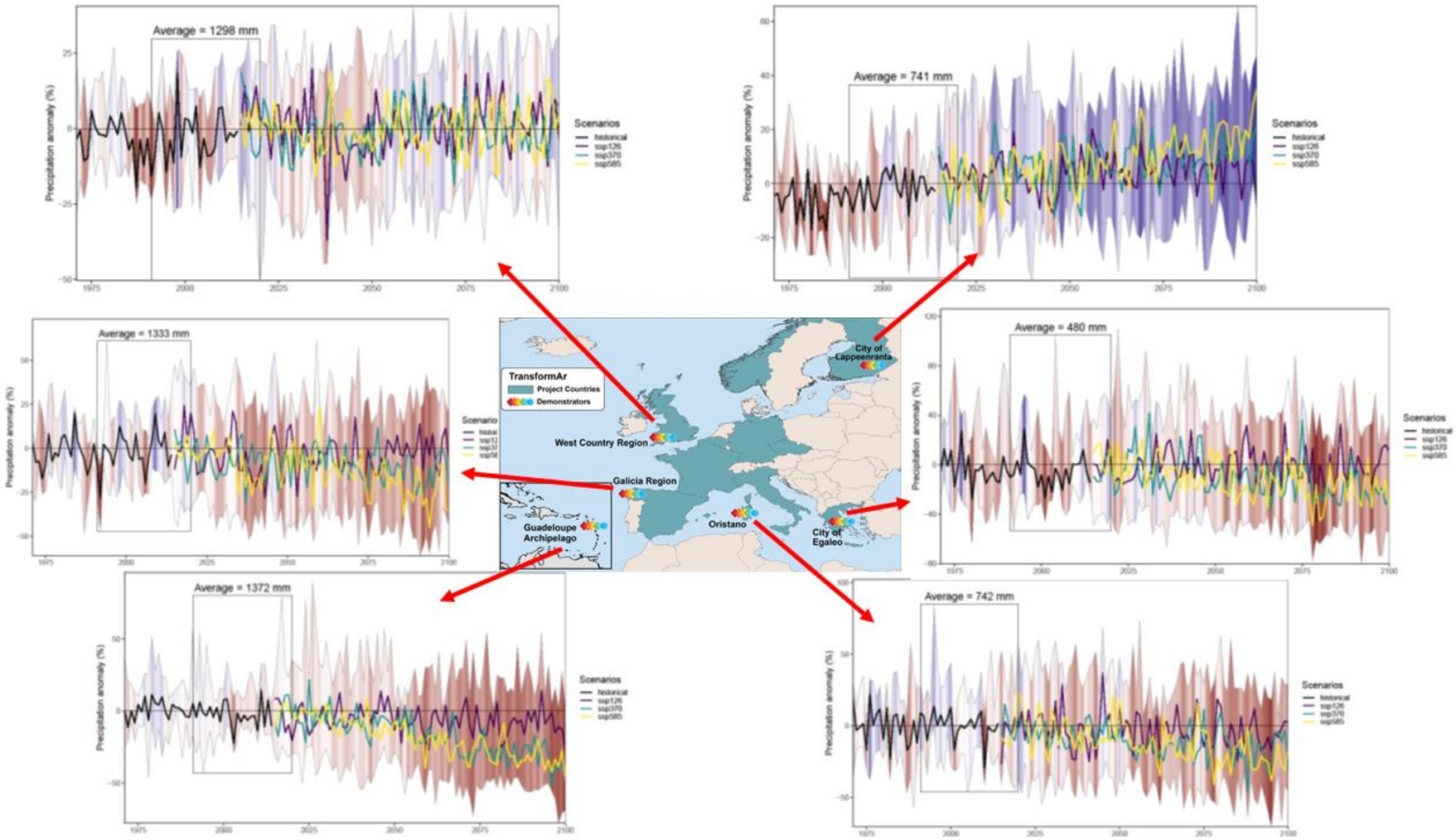


Figure 1.3 Relative change of annual precipitation across TransformAr Demo regions over baseline period (1986-2005). Ensemble include endmembers from 5 climate modelling projections and 3 RCP scenarios (rcp26 in purple, rcp70 in cyan and rcp85 in yellow)

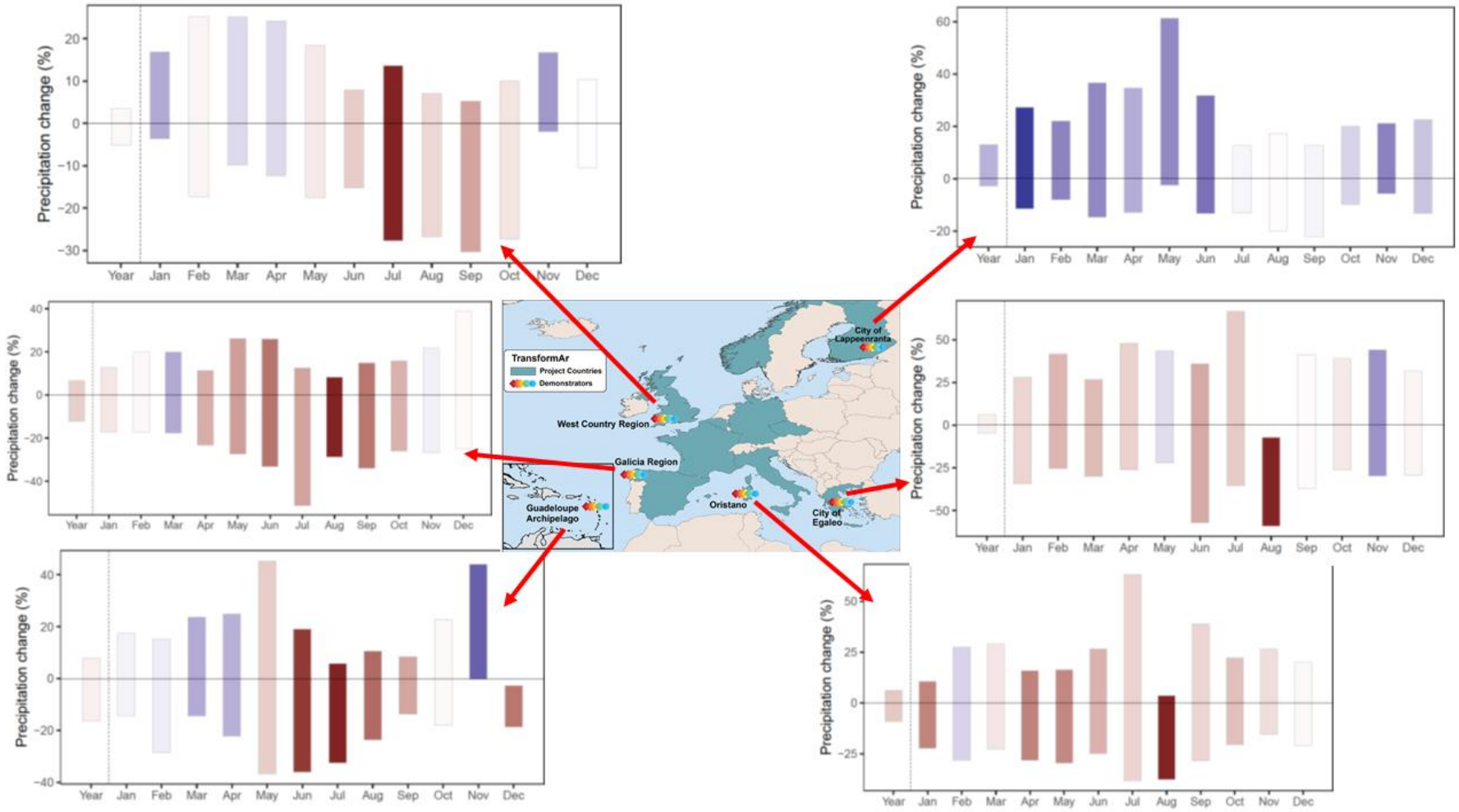


Figure 1.4 Relative change of monthly mean temperature across TransformAr Demo regions over baseline period (2050 vs 2000). Ensemble include endmembers from 5 climate modelling projections and 3 RCP scenarios (rcp26 in purple, rcp70 in cyan and rcp85 in yellow)

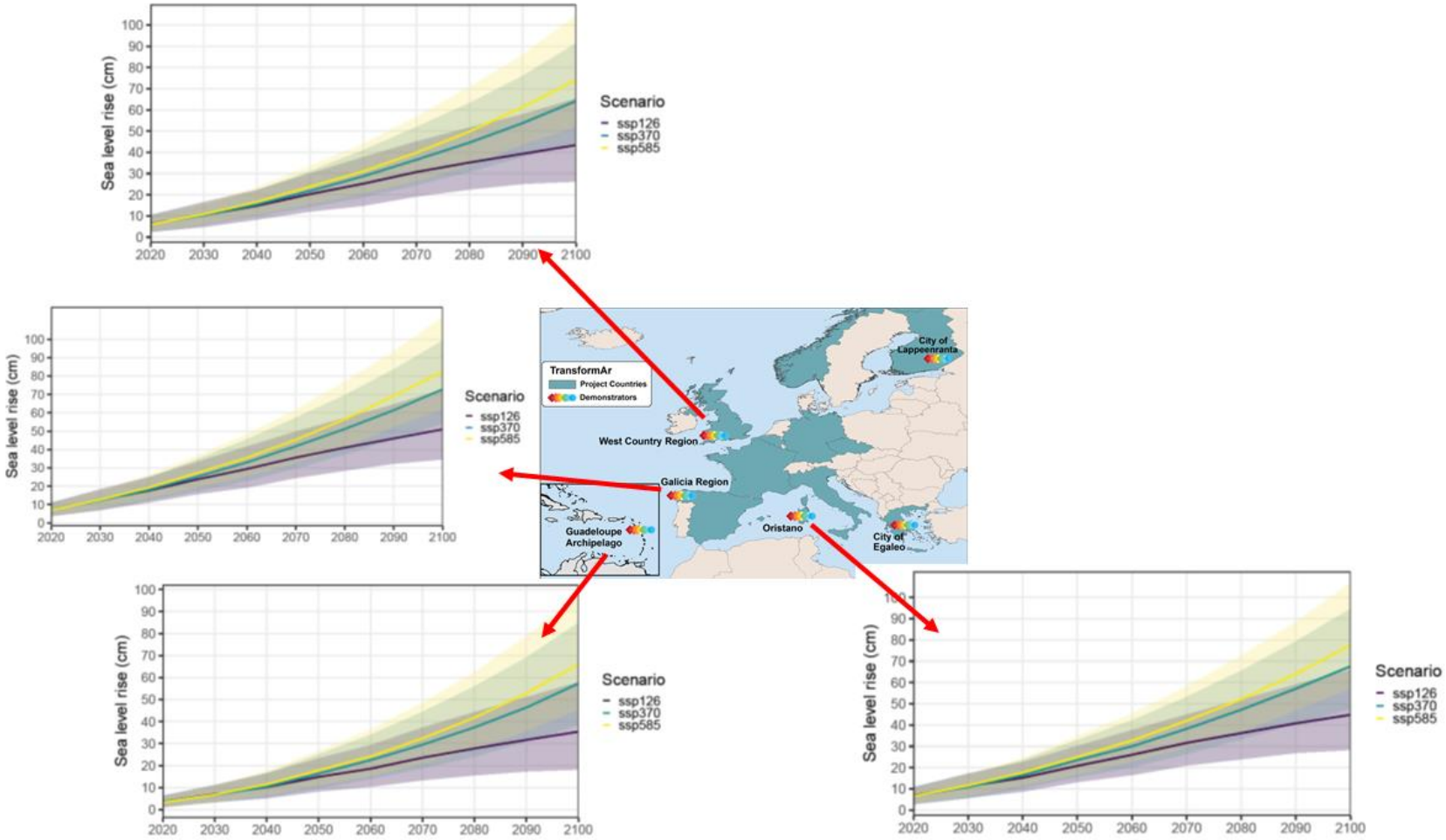


Figure 1.5 Relative change of annual sea level rise across TransformAr Demo regions over baseline period (1986-2005). Ensemble include endmembers from 5 climate modelling projections and 3 RCP scenarios (rcp26 in purple, rcp70 in cyan and rcp85 in yellow)

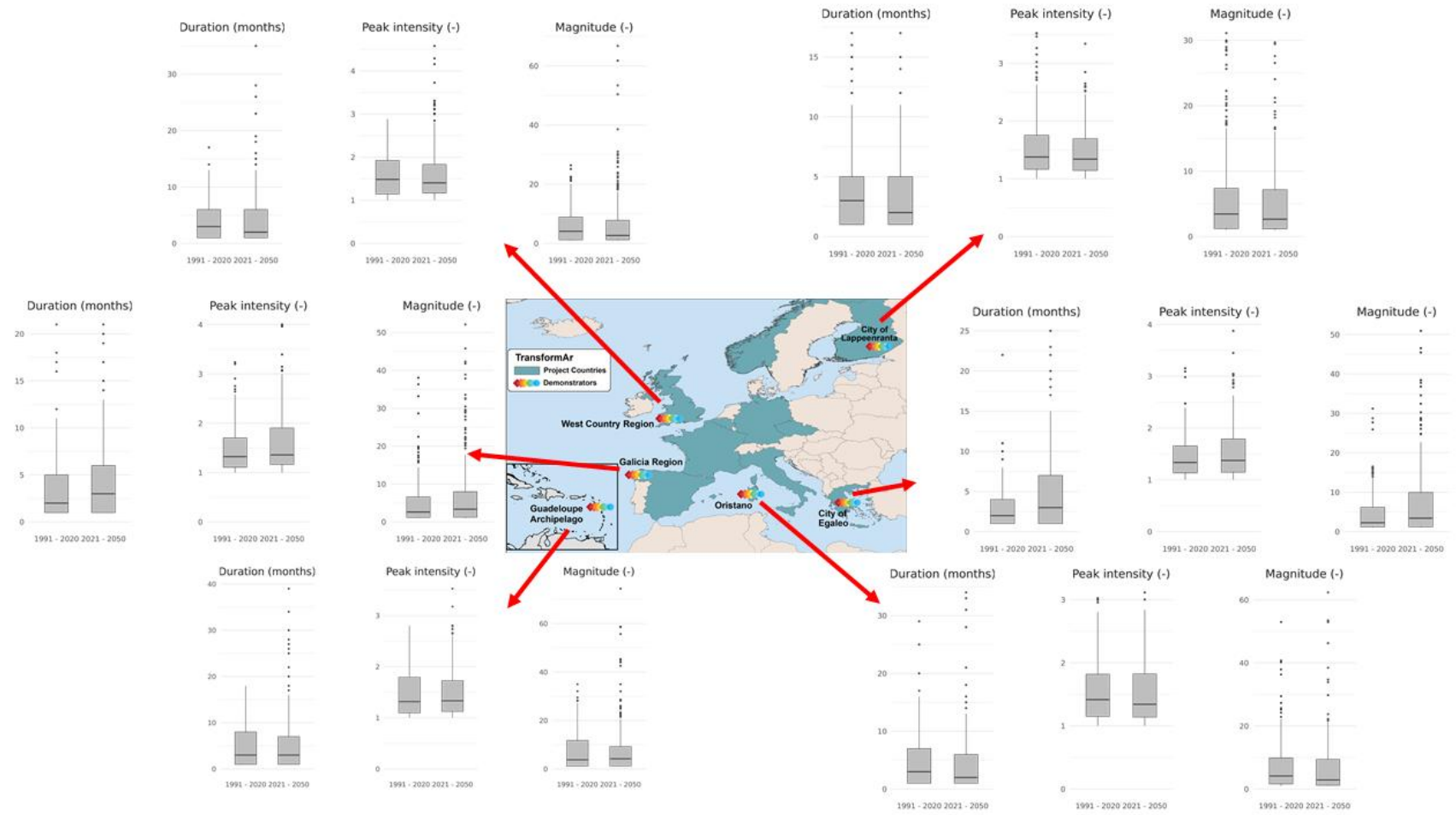


Figure 1.6 Relative changes through Standardized Precipitation Index (SPI) of Duration, Peak Intensity and Magnitude of drought between 1991-2020 and 2021-2050 periods. Ensemble include endmembers from 5 climate modelling projections and 3 RCP scen

3. Repository site

3.1 Repository Site

The data framework is currently available and established for most common and relevant variables and handled directly from WP2 partners to other project partners and demo regions based on the planned activities within the project. A repository site will be available both internally to project partners and externally for data dissemination to wider community, and linked to other major and relevant data portal (EU node data portal). The development and functioning of the data repository site will be defined and refined according the to the Data Management Plan and foreseen project needs.

The repository site is indicated as sustainable information infrastructure which provides long-term storage and access to research data that is the basis for research and tool development, planning, scholarly publication, communication and dissemination, etc.. It may include features as free visual data analytics tool for multi-dimensional data-sets.

3.2 Naming Convention

All the climate and biophysical data that will be collected will follow a specific ontology, i.e., naming convention to represent nexus components and variables. The data come with the description, the unit, and an already established long and short name provided by the specific data source (e.g., ISIMIP, C3S) which will be used to identify the specific variable. The use of the naming convention within the TransformAr project will be crucial to be able to avoid mistakes and/or misinterpretations of the variables that will be used in the development of the model output implementation for Demo regions. File names consist of a series of identifier, separated by underscores, which may be articulated according to specific sectors. Following few proposed conventions for specific sectors:

Climate

<climate-model>_<climate-scenario>_<variable>_<region>_<time-step>_<start-year>_<end-year>.nc

Water

<model>_<climate-forcing>_<climate-scenario>_<soc-scenario>_<sens-scenario>_<variable>(-<crop>-<irrigation>|-<pft>)-<region>_<time-step>_<start-year>_<end-year>.nc

Agriculture

<model>_<climate-forcing>_<climate-scenario>_<soc-scenario>_<sens-scenario>_<variable>-<crop>-<irrigation>_<region>_<time-step>_<start-year>_<end-year>.nc

Climate change impacts are here and now. The impacts on people, prosperity and planet are already pervasive but unevenly distributed, as stated in the new EU Blueprint strategy (European Commission-EC, 2019). To reduce climate-related risks, the EC and the IPCC agree that transformational adaptation is essential. The TranformAr project aims to develop and demonstrate products and services to launch and accelerate large-scale and disruptive adaptive process for transformational adaptation in vulnerable regions and communities across Europe.

The 6 TransformAr lighthouse demonstrators face a common challenge: water-related risks and impacts of climate change. Based on existing successful initiatives, the project will develop, test and demonstrate solutions and pathways, integrated in Innovation Packages, in 6 territories.

Transformational pathways, including an integrated risk assessment approach are co-developed by means of 9 Transformational Adaptive Blocks. A set of 22 tested actionable adaptive solutions are tested and demonstrated, ranging from nature-based solutions, innovative technologies, financing, insurance and governance models, awareness and behavioral change solutions.

TransformAr

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