Climate change monitoring and atmospheric indices in Basque Country: experiences from URBANKLIMA2050 LIFE project

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Abstract

In this contribution we present some aspects related to the Climate change hub action, that take place in the context Urbanklima2050 Life project, led by the Basque Environmental Agency (IHOBE), in the Basque Autonomous Community (BAC).

In this particular action, different activities are developed by Tecnalia, AZTI, Neiker, IHOBE and other institutional agents (Naturklima, DAEM/Euskalmet,...) in order to establishing a Hub for observation and monitoring climate change at Basque Country level. Particularly, the weather and climate area of Tecnalia works in different project task in the atmospheric domain.

Among other topics we cover the identification of the main sources of instrumental information available in relation to the atmospheric characterization of the territory, including both those for which longer historical records are available and those of a more novel nature that may be useful in the future in an operational perspective. We also design and implement strategies for signals of change and trends detection of the most representative indices and indicators at different level of spatial and temporal aggregation.

In this paper, we share our experience in the development of this action, summarizing the key aspects and providing some conclusions in relation to the definition and implementation of the monitoring system for atmospheric-based indicators for the Basque Country. This system will be an essential part of the Basque HUB on climate change to be developed in UrbanKlima2050 project that has begin in 2020 and will end in 2025.

Life Urban Klima 2050
The Basque County's largest climate action project for de coming years

The Urban Klima 2050 project has been approved by the European Union within the integrated climate change mitigation and/or adaptation project area.

6	19,8	20	40
year plan until 2025	**million** direct investment	partner **entities**	concrete **actions**

UrbanKlima2050 (IHOBE 2022) is the most ambitious initiative led by the Basque Country which aims at ensuring the resilience of the territory from a multi-level governance, multi-stakeholder, and on-the-ground climate action approach. This largescale Life Integrated Project was launched at the end of 2019 thanks to a partnership of 20 organisations and an investment of EUR19,8 million. The project partners have set an ambitious target of delivering different actions during 6 years, impacting over 2 million people. The main aim of the project is to contribute to the full implementation of the Basque Climate Change Strategy 2050, developing a low-carbon and climate change resilient region by 2050.

Project actions are grouped in five major blocks:

- **Analyse**: to review the Basque KLIMA 2050 strategy through follow-ups and evaluations, with a continuous improvement approach;
- **Define**: how, where and when to act to reduce GHG emissions, increase absorption, and achieve territorial resilience;
- **Act**: to launch pilot projects at three levels of intervention: coast, river basins and urban/peri-urban areas, scalable to other areas of the Basque Country and to other regions;
- **Empower**: to promote climate awareness among the governmental institutions and the community and move them to action;
- **Manage**: to create structures to facilitate climate governance and climate change observation and monitoring and define new models for climate governance and launch the Hub for observing and monitoring of climate change in the Basque Country.

Tecnalia is participating on eleven actions (-), leading five (+):

- Action A.2. Extension of the climate risk analysis in the Basque country
+ Action C.1.2. Guidelines for integrating climate change in land use and urban planning
- Action C.1.3. Prioritisation of actions on climate change
+ Action C.2.1. Integration of the klima2050 strategy in land use planning
+ Action C.2.2. Evaluation of municipal emergency plans
+ Action C.3.2. Integration of climate change in energy policies
+ Action C.4.1. Natural solutions and their co-benefits
- Action C.6.1. Adaptation of the urban coast
- Action C.7.2. Citizen science platform
- Action C.8.3. Generation of tools and training for the town/city councils
- Action C.9.1. Climate change hub: observation and monitoring system

Action C.9.1. Climate change hub: observation and monitoring system

Action C9.1 belongs to action group C.9 for creation of structures to mobilize Basque society with regard to climate change.

Description: The objective of C.9.1. action is to aggregate existing and future knowledge regarding climate change in a single structure called the climate change HUB. The purpose of this hub will be to observe and monitor climate change in the Basque Country. In addition, it will have the function of disseminating information related to climate change in different formats depending on the target audience.

Responsible body and participants: Ihobe, Azti, Neiker, Naturklima and Tecnalia.

Duration of the action: dec 2019 - dec 2025

General activities structuration (see Fig 1):

- **C.9.1.1** "Execution of a current inventory map". The relevant indicators will be identified from the information available in the current data providers: Euskalmet (meteorological agency); emergency service of the Basque Government; coastal and marine observation network; infectious vectors and their associated pathogens, information related to soil and its carbon content; as well as the Gipuzkoa climate change observatory. The relevance of existing information and the quality of historical series will be reviewed.
- **C.9.1.2** "Definition and prioritization of new needs in the short, medium and long term". The overlaps and gaps of information will be analysed in order to synthesize the relevant information.
- **C.9.1.3** "Implementation of new systems and creation of the observatory". With the information gathered in previous tasks, information needs, information flows and the governance structure of climate information will be designed.
- **C.9.1.4** "Periodic review of actions taken and new needs".

Expected results: The main expected result of this action will be an improvement of information related to climate change, its impact and management of it. This expected result will be achieved by a creation of an information centralization platform (Basque CC HUB) and a report on climate change observation results.

Reasons why this action is necessary:

Climate action in the Basque Country is currently disseminated in the different areas of administration, at its various levels (municipalities, county councils, and regional government), and in its sectoral areas (emergencies, health, agriculture).

Both research on climate change and diagnosis (analysis of climate scenarios, droughts and diseases in the agricultural sector, monitoring of extreme events, infectious vectors, evolution and displacement in fishing areas, etc.), as well as control activities (flood warning alerts, wave tracking, tides and affection on the coast, etc.), and subsequent actions (planning actions, prevention plans, alert and emergency, dune regeneration, etc.) fall on different agents working independently under the guidelines of the different sectorial policies. The Klima 2050 climate change strategy aims to be the umbrella that protects all prevention policies in climate matters, and to increase the ambition of these policies with a view to the long term.
To achieve this, it establishes the creation of a meeting point, or HUB, that gather, all the existing information on climate change, and establishes the priorities and needs for knowledge and action.

Role of Techonological partners

NEIKER focus on land, AZTI focus on ocean and TECNALIA focus on atmosphere.

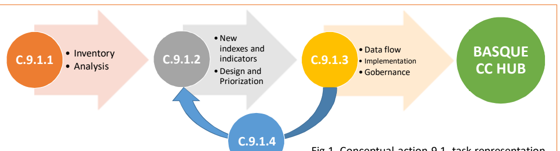

Fig 1. Conceptual action 9.1. task representation

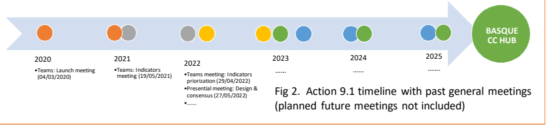
2020
•Teams: Launch meeting (04/03/2020)
2021
•Teams: Indicators meeting (19/05/2021)
2022
•Teams meeting: Indicators priorization (29/04/2022)
•Presential meeting: Design & consensus (27/05/2022)
•......
2023
......
2024
......
2025
......
BASQUE CC HUB

Fig 2. Action 9.1 timeline with past general meetings (planned future meetings not included)

Tecnalia´s Weather and Climate Area Tasks (2020-2022) : atmospheric domain

OBSERVATIONS & RAW DATA — **9.1.1** — INDICES /INDICATORS

- ☐ The main sources of instrumental information available in relation to the atmospheric characterisation of the territory have been analysed, including both those for which longer historical records are available and those of a novel nature that may be useful in the future (Gaztelumendi et al 2021). The different surface networks and remote sensing systems have been characterised, as well as the sources of reanalysis that can be used at different scales (e.g. Aranda 2018, Gaztelumendi et al 2006, 2008, 2017, 2018, Lopez et al 2011).
- ☐ Previous work carried out by different agencies that have defined climate indicators based on the daily information collected in the global observation network has been reviewed (Gaztelumendi et al 2021). These indicators are defined taking into account a set of criteria established by different groups of experts focusing mainly on global/regional climate and generally constructed on the basis of essential climate variables (ECVs) as defined by WMO.
- ☐ Working with time series of ECVs from the global climate observation network (GCOS) is a classical and widespread approach in global climate studies. Usually from these time series, sets of indices and indicators are established and classified according to their potential area of application.
- ☐ There are a multitude of tools (Python and R open source libraries, specific software, etc.) that facilitate the calculation of most widespread indices as well as for the monitoring and analysis of signals of change and trends (e.g. ClimInd, climpact, climdex.pcic). These libraries will be the basis for the local implementation of new indices, indicators and monitoring metrics.

SELECTION & NEW INDICES/ INDICATORS — **9.1.2** — PRIORIZATION SHORT, MEDIUM LONG TERM

- ☐ Although the apparent availability of information sources at the local level is overwhelming in many ways (typology, coverage, cadence, availability of data in real time, ...), in most cases it has not been designed, nor does it operate with a "climate" vision, but rather as a way of monitoring the current weather state. The necessary actions need to be taken (partly addressed in the current project) to incorporate the "climate" perspective. Particularly with regard to the availability of subdaily "climatic" series, based on the specific observation networks in the territory responsibility of Basque Institutions.
- ☐ There are hundreds of climate indices and metrics for the possible monitoring of change. A process is undertaken for the selection of indices/indicators and the implementation of methodologies and metrics that make it possible to adequately monitor meteo-climatic evolution at a local level (Gaztelumendi et al 2021, 2022). The sub-daily information available will be the basis for a large part of the new indicators (mainly focusing on extremes).
- ☐ Euskalmet has been routinely calculating and disseminating "official" statistics (Hernandez et al 2009, Gaztelumendi et al 2008) which are calculated and published on a monthly, seasonal and annual basis during last twenty years available online (https://www.euskalmet.euskadi.eus/clima). Operations should shift towards the calculation of indices and indicators on the climatic change perspective and ensure that the system is operational, based on the observation structure from the Basque Government, enhancing local and sub-daily detail. Euskalmet should also be the focal point for the distribution of clasical atmospheric indicators from other official sources at a supra-autonomous level.
- ☐ Based on the list of more than 180 indicators (Gaztelumendi et al 2021) plus the new (more than 100) atmospheric base indicators defined (Gaztelumendi et al 2022), a final set are priorised for the short, medium and long term operational development based on the needs of the CC HUB and Euskalmet estrategy.

DESIGN & CONTENT CONSENSUS — **9.1.3** — IMPLEMENTATION BASQUE CC HUB V.0.0

- ☐ A review of worldwide CC HUBs initiatives is carried out, focusing on environmental perspective, with the aim of contextualizing the content and relative contribution in the field of weather-climate and others domains dependent on atmospheric-based indicators.
- ☐ The need for multi-source (observational, reanalysis) and multi-scale (global, european, regional and local) indicators is established, so that each element is monitored locally but with a view of what is happening in the surroundings at different scales (Gaztelumendi et al 2021, 2022).
- ☐ For the weather and climate content, non-frozen free data repositories that are being updated at the appropriate rate will be used (Gaztelumendi et al 2021, 2022). From global climate observation networks (e.g. GCOS, ECA&D), local observation networks (e.g. Gaztelumendi et al 2018), local reanalyses (e.g. Klimatek) as well as global reanalyses (e.g. ECMWF ERA5) will be selected.
- ☐ A preliminary design of contents is established based on the prioritized information (average, high and low temperatures, heat waves, average, intense and scarce rainfall and droughts). In this design, priority is given to concreteness and simplicity both in graphic resources (x-t graphics and maps) and in textual content. This design is agreed between the different agents to guarantee, as far as possible, the homogeneity of the information present in the CC HUB, regardless of the agent responsible of the information.
- ☐ The first version of the atmospheric-based climate indicator monitoring system will be available pre-operationally at the end of 2022 as an essential part of the first version of the CC HUB of the Basque Country. Note that this HUB contains information from other areas by AZTI and NEIKER.
- ☐ The design and content will be revised and expanded in subsequent stages of the project until 2025, when the final operational governance of the system will be established.

Climate change monitoring and atmospheric indices

Different joint workshops have been carried out by Tecnalia's Weather and Climate area and the Basque Meteorology Agency (Euskalmet) with the aim to discuss about CC monitoring and to set procedures to maintain operational essential variables, climate indices and indicators at a national level. Here we list some general principles and key questions from those sessions:

Some general rules:

- As many "classical" meteo-climatic indices as required by the user community will be calculated and provided from publicly available repositories of essential climate variables.
- Given the potential volume of indices to be generated, a reduced set of essential ones have to be selected, based on different factors (feasibility, availability, comprehensibility, presence of change signal, robustness, continuity, length, quality, ...).
- We pay special attention to the local, but without forgetting the context (Iberian Peninsula, Europe, World). So that, where appropriate, the use and calculation of some indices, apparently of little sense in the BAC, is assumed for harmonisation.
- In defining the new indices, we must think in long term, not been limited by the current lack of long data series. We must focus on today monitorization but also think on future explotation of observational systems or medium and long term needs in CC business.
- The fixed thresholds involved in the calculations of some of the usual climate indices, are adapted to local thresholds based on the definitions of the Euskalmet style manual and to the severe weather thresholds. Severe weather operational protocols must be the basis for some new climatic extremes indicators (GV 2018, Gaztelumendi et al 2012, 2016, 2020, 2021, 2022).
- Spatial aggregations will be available at national, regional and county level, depending on granularity and type of variables, indices and indicators.

Some key aspects:

- **Precipitation**: Different sub-daily aggregation periods are included (12h, 6h, 3h, 1h, 30min and 10 min).
- **Wind**: Wind speed and wind direction are considered with special care about its spatial aggregation.
- **Cloud cover/insolation**: the complementarity of the pyranometer network and satellite sources must be considered.
- **Snow**. As no direct measures are available, it will be established indirectly.
- **Bio-climatic:** human perception of heat should be included (HI,WCI,AT,UTCI,...) .
- **Dryness/aridity**: should be included routinely (SPI and derived, Martonne, Pinna, Emberger, ...).
- **Fires**: climatic use of operational Basque meteorological risk system based on FWI must be considered.
- **Coastal-marine.** Risk indicators present in the marine warnings/alerts/alarms operational system should be included in "climatic" perspective.
- **Rivers**. Existing flow and level information should be used and agreed with URA (Basque Water Agency).
- **Other** sub-areas of application (tourism, etc...) will be calculated according to the needs expressed by different sectors.
- New temporal criteria will be established that do not restrict statistics to fixed 24-hour periods (e.g. real day and night). Thresholds are established according to the Euskalmet style manual and operational zoning.
- New synoptical and empirical indicators inspired by local operational meteorology (e.g. pressure difference between two points) need to be established

Remarks and Conclusions

- ✓ In addition to indicators specific to the territory, for reasons of consistency and comparability with other regions, indicators and indices used at European and global level by the major centres that monitor climate change should be included.
- ✓ The weather and environmental observation systems, maintain by different Basque institutions, are a essential source of local data, so that the climatic perspective should be incorporated as deeply as possible in their current management.
- ✓ It is essential that the major centres at European level maintained a real open-data policy not only in relation to raw data but also for homogenized series. The updating and availability of these data must be adequate for its operational use in monitoring CC.
- ✓ The country's strategy in relation to CC monitoring must be unique, the Basque CC HUB must have an essential role in environmental side, but others plataforms more specific from the weather and climate perspective must coexist. Meteo-climatic data and guidance must be provided by Euskalmet.
- ✓ Despite Environmental Agency objectives and culture and Meteorological Agency objectives and culture are quite different both must work together, and always thinking on users needs.
- ✓ A single, consensual institutional discourse must be constructed in relation to the observation of signs of change and trends in the current climate. This discourse must be established on the basis of consensual data at global, regional and local scales.
- ✓ Climate change indicators have to carry additional information on how to interpret it and which scope and utility are associated. Such details as geographic coverage, source, quality, date of production and update and others may conform the metadata repository in the CC Hub.
- ✓ Visualization and visual analytics techniques are needed for and heterogeneous number of indicators and results. Indicators are grouped according to climate impact drivers concept (IPCC AR6 2022). Work will be based on expertise of the partners and inspired by interesting iniciatives like Klina, Navarra's CC Roadmap, adapteCCa or Copernicus, EEA or EPA webs on CC monitoring.
- ✓ Euskalmet must provide as much hydro-ocean-meteo-climatic information as necessary and plausible to be used in "climatic" mode and update it under the terms established.
- ✓ The incremental project`s approach allows to laid a first version of the hub with a subset of indicators and indices that will be expanded in successive cycles. This is crucial in order to manage the possible excess of diagnostic information and move to action.
- ✓ This project led by IHOBE (environmental side) is in line with other projects and lines of action being carried out at Euskalmet (weather and climate side) in the field of climate monitoring. The presence of Tecnalia and Euskalmet in this project guarantees the operational continuity of the HUB in relation to atmospheric-based elements.
- ✓ The co-financing of the Directorate of Emergency Attention and Meteorology (Department of Security of the Basque Government) of the activities carried out by Tecnalia's Weather and Climate team is essential for the development of the tasks undertaken and for the fulfilment of the objectives set out in this action.
- ✓ Two years after launching the LIFE integrated Urban Klima 2050 project, it has been difficult to implement some of the planned initiatives due to the pandemic. However, alternative plans have been put in place and several of the first milestones have already been achieved.
- ✓ IHOBE's effective leadership, despite the pandemic, has made it possible to maintain involvement and coordination with stakeholders, to control the information overload and to discern what is important from what is incidental

Observed changes not projections | **Climate variables, índices and indicators** | **Multiple sources and temporal cover**
Including daily and subdaily variables | **Monthly, seasonal and annual** | **Including impact weather indicators**
Trends and change signals | **Key messages & operational** | **Visual data analytics capabilities**

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