Indecis

Sectorial Climate Services

Integrated approach for the development across Europe of user oriented climate indicators for GFCS high-priority sectors: Agriculture, disaster risk reduction, energy, health, water and tourism

Work Package 7

Deliverable 7.1

Communication Strategy for Delivering Effective Climate Services

ASTERISC COMMUNICATION RESEARCH GROUP (URV)

Jordi Prades-Tena; Jordi Farré-Coma; Juan Luis Gonzalo-Iglesia

CENTRE FOR CLIMATE CHANGE, C3 (URV)

Joan Ramon Coll-Benages; Enric Aguilar-Anfrons

ERA4CS European Research Area for Climate Services

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Executive summary

Since the European Commission published the European Research and Innovation Roadmap for Climate Services (EC, 2015) hundreds of climate-related projects have been funded by the Horizon 2020 programme and other funding mechanisms under the Joint Programming Initiative "Connecting Climate Knowledge for Europe" (JPI Climate)[1] and the ERA-NET Consortium "European Research Area for Climate Services" (ERA4CS) and its Joint Call on Researching and Advancing Climate Services Development.[2] Previously, the European Union's Seventh Framework Programme developed an European Climate Services market.

Communication of Climate Services needs, as a first step, a clear definition of the "Climate Services" concept. The tendency today is to group under the "Climate Services label" all weather and climate products which can be communicated in a way that provide useful information and insights for decision making, mitigation and adaptation strategies. In the Climate Services market INDECIS project seeks to reach not only broad audiences but also strategic groups of key sectors (agriculture, disaster risk reduction, energy, health, water, tourism, transportation, housing, infrastructure, industry, trade, insurances, etc.) as possible customers interested in particular information, as well as policy-makers responsible for taking climate informed decisions to improve social well-being and sustainability.

This deliverable D7.1 aims to design a communication strategy for delivering effective Climate Services and provide a list of useful recommendations to allow Climate Services providers target intermediary users, end users and stakeholders. From the early steps of the project it is critical to understand the users' needs and the stakeholders' requirements. Decision making should be connected to science knowledge so relationships between scientists and official bodies, and between economic sectors and affected communities, are crucial to know what each group are waiting for under climate change conditions. Contextualization and guidance are requirements to turn data into useful and useable information to deliver effective Climate Services (Bessembinder et al, 2013).

In the last years there has been a turn from climate change information to Climate Services communication thanks to the Information and Communication Technologies (ICT). Huge progress have been made regarding Climate Science (data collection, modelling, risks assessment, etc.) but neither specific audiences nor the whole public perceive these advances as milestones toward a more fair and sustainable welfare society. To do so instrumental communication (e.g. developing communication skills) is not enough, but a culture of constitutive, organizational, internal communication (e.g. strategic communication) of climate-related bodies, whether they are governments, institutions, research groups and universities, companies, NGOs, and other stakeholders, should be strongly implemented. Accordingly, Atmospheric sciences, other Environmental sciences, Geography, Legal sciences, Politics, Economics, Sociology, Psychology, Humanities and Communication are called to work together to solve environmental problems in the age of the Anthropocene.

As Ballantyne argues, "defining communication as a social and cultural process that constitutes reality could lead to exploring 'meanings' of climate change as an ideological, cultural and sociological phenomenon. Key in this perspective is a conceptualization of communication participants, senders and receivers, as co-creators of meaning" (Ballantyne, 2016: 340). Communication is a research priority to advance Climate Services, specifically for connecting climate information to decision makers by means of understanding users' needs, contexts, and capacities; improving relationships between and among stakeholders; tailoring information, and facing uncertain information (Vaughan et al., 2016). According to these authors, a two-way model of communication between climate service providers and consumers "is essential given the overwhelming evidence that climate services are most useful when they are developed as part of an iterative process of 'co-discovery', 'co-development', and 'co-evaluation' involving the producers and users of climate information" (Vaughan et al., 2016: 66). In this regard Climate Services can be understood as a meaning making process in which participants

[1] http://www.jpi-climate.eu/joint-activities/fundedprojects
[2] http://www.jpi-climate.eu/ERA4CS.activities/jointcallprojects

intervene as producers and as users as well —"*produsers*"—, in the same way that ICT users are not only consumers but also producers of information, the so called "*prosumers*".

According to the World Meteorological Organization (WMO), value stories ("how climate data and information are already used" by different sectors) and benefit analysis ("building quantitative cases depicting the economic value" of Climate Services) "can enhance stakeholder engagement" and establish "intellectual capital concerning the economic consequences of climate variability and change, along with expertise in ascertaining the economic value of climate data and services" (WMO, 2014f: 22-23). INDECIS will contribute to valorise Climate Services and bring socio-economic value to the users of these services by a series of products developed throughout the project, e.g. **1)** Datasets; **2)** Software; **3)** Reports; and **4)** Graphical output (including maps).

Based upon the *Communicating EU research and innovation guidance for project participants* and the "DADDIE" model (Description; Analysis; Design; Development; Implementation; Evaluation) six steps have been identified to develop a communication strategy for delivering effective Climate Services:

1) Our situation in the public sphere and in the media arena was described from the comparison of the scientific, the social and the media cultures.

2) Audiences were analysed and segmented by sectors (agriculture, disaster risk reduction, energy, health, water and tourism), by nature (public, private, social), by level of action (global, regional, international, domestic, local); by power capacity (governments and official bodies, big companies and corporations, lobbyists); by expertise in climate-related fields (scholars, practitioners, advisors), and by influence capacity level (NGOs, environmental representatives and even famous and popular people). All these actors in the public sphere are potential audiences for receiving and sharing both climate information and data, and for creating awareness about climate change which results in a need for Climate Services and products. Also, two additional criteria were included regarding segmentation: first, what communication channels people use; secondly, how those who belongs to each segment can be identified as Climate Services intermediary users or end-users.

3) Messages contents to be spread to each segment of the audience, and to engage them and the stakeholders, are designed based in the "5 Ws and the H" (who?, what?, where?, when?, why? how?), and message structure are based in "the inverted pyramid". In face of communication challenges —climate change is complex, uncertain and variable; people learn and remember selectively; people pay attention to those who are like them, and audiences vary— (Needham et al, 2017), a "fresh approach to public engagement" and "a new visual language" (videos, images, popular science, scientific conferences, workshops, etc.) are highly encouraged.

4) In order to reach the targeted audiences special attention is paid to develop tailored messages for each communication channels, both classical and social media: One-way/two-way and one-to-one/mass communication offline and online models, as well as a SWOT analysis of social media have been presented. Properties, advantages, disadvantages, potential users and examples of each channel are detailed.

5) As for users and stakeholders engagement, three broad methods are discussed —websites and web-based tools, interactive group activities and focused relationships between providers and users— and a workshop organized by INDECIS in Spain is presented as a link between deliverable D7.1 and deliverable D7.2, and as an example of implementation to test further steps to be done to involve tourism stakeholders.

6) Available tools, methods and quantitative/qualitative indicators for monitoring communications and impacts serve to evaluate our communication strategy for delivering effective Climate Services.

Finally, as already said, a list of recommendations regarding Climate Services delivery, communication, dissemination and exploitation of the project' results concludes this work.

1.- Introduction and context

The Global Framework for Climate Services (GFCS) of WMO describes the Climate Services process by means of five pillars: the User Interface Platform (UIP); the Climate Services Information System (CSIS); the Observations and Monitoring (OM) network; the Research, Modelling and Prediction (RMP) area, and the cross cutting pillar Capacity Development (CD) component. Instead of a physical platform, UIP is a set of actions involving the concepts of feedback, dialogue, outreach and evaluation. For example, thanks to Climate Services a subsistence farmer can react to a three days frost warning by protecting the crops and the cattle; the local authorities can use this same information to deploy first-aid kits. Both can make use of a seasonal forecast explaining that the winter season will be colder than normal, the farmer by selecting seeds and planting in less exposed areas, the authorities by collecting and storing in advance the items that will be distributed when the emergency strikes. These same users can also make good use of climate projections: authorities need this information to plan ahead organization and infrastructures and the smallholders can understand the mid and long-term adaptations that will make their businesses survive, even thrive in the light of new opportunities.

End users of Climate Services have their own capacities, skills and information channels that are not necessarily those of climate scientists. Although this asseveration seems too obvious, it implies a not always well understood barrier that often becomes a usage barrier for Climate Services. For instance, a three days frost warning posted in a website will not reach the farmer living in an isolated area at 4,000 meters above sea level with limited or inexistent access to the internet; a temperature seasonal forecast expressed as probabilities of the terciles might not properly inform the local authorities on how to plan ahead an how to include the uncertainty associated with the forecast into include this planning. The process of lifting these and other barriers is the true "service" part in the "Climate Services" concept.

Therefore, we can define as Climate Service the whole process involved in providing weather and climate information in a way that helps end users to take weather and climate informed decisions and they take many different forms, such as "tools, products, websites, or bulletins" (Vaughan and Dessai, 2014: 588). Climate Services are "an activity rather than a product" (Klein, 2018). This has evident consequences from a communicative point of view because, like news in the digital age, Climate Services are also a process involving climate products, users and channels in a triangle of co-creation (**figure 1**).

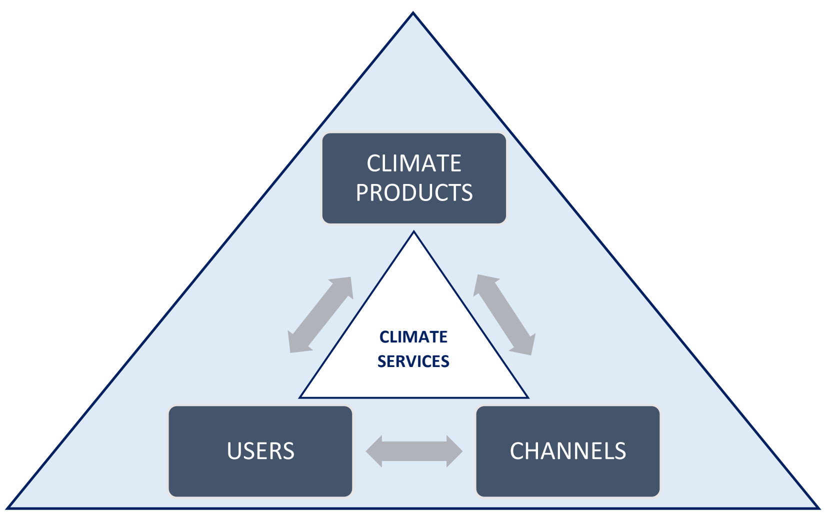

Figure 1. Triangle of co-creation of Climate Services. **Design:** Jordi Prades-Tena.

INDECIS develops climate-related products and provides Climate Services in the five GFCS' high-priority sectors —agriculture, disaster risk reduction, energy, health, water— plus tourism.

1.1- Agriculture, food security and food safety. According to the Food and Agricultural Organization (FAO), "a narrow definition of agriculture includes cultivation of crops and animal husbandry as well as forestry, fisheries, and the development of land and water resources" and "a broader definition of agriculture includes in addition agro-industries, manufacturing of agricultural inputs and machinery, regional and river development, and rural development". Weather and climate conditions, particularly variability and extremes determine agriculture-related activities and therefore food production, food security and food safety. In this context FAO and WMO strengthen cooperation on climate change, provide accessible agro-meteorological services, improve monitoring for early warning and response to high-impact events at global and regional level, etc. WMO's Commission for Agricultural Meteorology priorities are: "(**1**) developing enhanced services for the agricultural, livestock, forestry and fisheries communities and partner agencies, including climate services; (**2**) encouraging development of a knowledge sharing interface between forecasters/scientists and the agricultural decision-makers; and (**3**) supporting agrometeorological training at regional, national and local levels" (WMO, 2014a: 5). In terms of communication, the aim is "to establish a four-way communication between climate scientists, climate and agricultural researchers, agricultural extension services and the decision making community, to ensure that applied research is refined and expanded to meet community needs", and to "develop information channels that the farming community (including farmer associations, NGOs, village leaders, etc.) can easily understand and grow to trust" (WMO, 2014a: 28).

1.2- Disaster risk reduction. "Disaster risk reduction" is "the concept and practice of analysing and reducing the causal factors of disasters by decreasing exposure to hazards, lessening vulnerability of people and property, improving management of land and the environment, and enhancing preparedness for adverse events". It also includes financial protection, and planning, investment and financial mechanisms (WMO, 2014b: 3). The Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters and the GFCS aim to "develop and incorporate climate information and prediction into planning, policy and practice to build society's resilience in the face of disaster risk" (WMO, 2014b: 2). Climate Services can reduce the risk of disasters through risk assessment; Data on loss and damage; Early warning systems; Information on climate-sensitive sectors; Planning investment in reducing risk; and risk financing and transfer. An effective communication is needed to carry out the GFCS's proposed activities to enhance resilience capabilities and reduce damages in case of natural disasters (WMO, 2014b: 34). More recently the Sendai Framework for Disaster Risk Reduction 2015–2030 stresses the important role that information, communication activities, and telecommunications networks must play from global to local levels, and on the media (UNISDR, 2015: 16-24).

1.3- Energy. The energy sector is in transformation due to an increasing power demand, technological advances in renewables, and demanding global environmental requirements resulting from international agreements (COP 21) to reduce greenhouse gas emissions (GHG). As climate conditions affect both fossil fuel facilities (oil, coal, wood, gas, nuclear) and renewable power plants (wind, solar, water, biomass), Climate Services can foster changes in the energy system in a sustainable way, reducing waste and pollution and contributing to emission mitigation of GHG. Challenges to address in order to facilitate these changes are mainly related to climate resilience and adaptation across the energy sector; changes in precipitation patterns, droughts and floods that may impact hydropower generation and reduce water availability for cooling thermal and nuclear power plants; extreme weather events that can cut the supply of fuel, damage grid and power plants, reduce electrical production and impact the security of supply; and sea-level rise (WMO, 2014c: 15-16). Main requirements of the energy sectors related to climate services are historical, predicted and projected data; impact and risk assessment (on facilities, infrastructures and the environment as well), and information (for financing, siting selection, operation, maintenance and closure). Also energy integration, efficiency and market trading can benefit from Climate Services linked to each of the 5 GFCS pillars (WMO, 2014c: 20-21).

1.4- Health. "Climate informed health decisions are those that incorporate spatial and time-scale climate data with clinical and epidemiological data to prevent public health impact from climate-sensitive variables" (WMO, 2014d: 70). Although until recently climate change has been mainly faced just as an environmental issue, nowadays there is no discussion about the fact that it is a health concern too. Climate change and extreme climate events menace human health in many ways, either directly or indirectly, so the healthcare system can beneficiate from Climate Services provision. For instance, heat-health actions plans and warning systems should be implemented during heat waves under the supervision of both medical and meteorological authorities in order to reduce morbidity among the most vulnerable population. The same should be done by means of communication practices in case of extreme cold weather. Actually, "a global observational study found that more temperature-attributable deaths were due to cold than heat. Overall, an increase of mortality during heat-waves is expected to reach about 8.9–12.1%; the expected increase is 12.8% during cold spells" (WHO, 2017: 36). Successful examples of plans involving climate-, health- and communication science, and specific examples of health applications for climate products are listed in the Health Exemplar of WMO (2014d: 46-47).

1.5- Water. Management of aquatic ecosystems requires a holistic approach such as the Integrated Water Resources Management (IWRM) proposes at international level and the EU Water Framework Directive (2000/60/EC) decrees at regional level. "Water is not a commercial product like any other but, rather, a heritage which must be protected, defended and treated as such" (Directive 2000/60/EC). In short, access to both safe and clean drinking water and sanitation is worldwide recognized as a human right (A/RES/64/292). Energy is crucial to provide such right. The water-energy nexus needs a long-term broad vision, in the same way that water links to agriculture, disasters risk reduction, health and tourism claim for political, social, legal, economic and media dimensions being taken into account. Also, "the connection between the weather and climate and the terrestrial water cycle, including the freshwater-ocean interface, appears fundamental, and thus a high level of synergy should exist between the disciplines involved" (WMO, 2014e: 2). In the case of Climate Sciences, water management aspects depending on them are, among others: hydrological characterization, hydro-ecology and hydro-morphology; catchment/watershed planning; general water balance; flood frequency estimation, plain zoning, forecasting, warning, management and control; structures (dams, weirs, bridges, channels, conduits, etc.); coastal inundation; soil erosion; irrigation and drainage; salinity and sedimentation; navigation, canal systems and dredging; power generation (hydropower and cooling water); industrial processing, purification, quality control, demand scheduling and supply; pollution control; effluent disposal; treatment plants for water reuse; fisheries and conservation; tourism, amenity, and recreation (WMO, 2014e: 3).

1.6- Tourism. Tourism is one of the largest and fastest growing economic activities and is strongly affected by climate change, particularly in both coastal and mountain destinations. Also tourism contributes to climate change, mainly through greenhouse gas emission caused by transportation and accommodation activities. "Climate is also a crucial determinant of tourist decision-making. Seasonal climate fluctuations at tourism destinations and at major outbound markets are key drivers of tourism demand at global and regional scales. Weather is an intrinsic component of the travel experience and also influences tourist spending and holiday satisfaction" (WTO, 2009: 5). In sum, "climate information represents a double-edged sword for the tourism sector, for while accurate climate information can be invaluable to the tourism industry, inaccurate climate information that deters visitation is a lament heard often from the tourism industry" (Scott & Lemieux, 2009: iii). For that reason climate services tourism-driven can be one of the best allies of the sector. Tourism climate indices "are commonly used to describe the climate conditions suitable for tourism activities, from the planning, investment or daily operations perspectives" (Dubois et al., 2016: 1). Climate variability effects on tourism destinations and operators are evident in the definition of the length and quality of tourism seasons, especially in those regions where the climate is the basic resource upon the tourism industry is grounded. Climate affects tourism-related activities such as water quality, supply and uses; cooling and heating costs; pest management; exploitation capacity of environmental resources (wildlife in nature destinations); environmental conditions (weather and health-related), etc. (WTO, 2009: 5).

Having saw what is already done in each five GFCS high-priority sectors plus tourism, and what gaps still remain to fill in, now is time to look at how INDECIS can contribute to build bridges between climate and environmental scientists and Climate Services users, both through the development of climate products and the delivery of Climate Services (**section 2**) as well as through communication strategies (**section 3**) and practical recommendations (**section 4**).

2.- INDECIS products

INDECIS project is creating a series of products which are expected to become part of "climate services activities", as previously defined. These products are:

2.1) Datasets

INDECIS Core Datasets: Core Climate Datasets used in the INDECIS project will be constituted by the different versions of the European Climate Assessment & Dataset (ECA&D: https://www.ecad.eu/dailydata/index.php); raw, quality controlled and homogenized versions. Variables included in ECA&D at daily resolution are; maximum, minimum and mean temperature, precipitation, sea level pressure, humidity, wind speed, wind gust, wind direction, cloud cover, sunshine duration, global radiation and snow depth. A quality controlled and homogenized version of the ECA&D Dataset will be produced for all variables mentioned above at daily and monthly scale. For this purpose, the Quality Control Software Suite and the Homogenization Software Suite will be applied to the whole dataset. All dataset will be gridded using the E-OBS approach and machinery developed in the EU-FP7 UERRA project.

Tall Wind Mast Dataset: The Tall Tower Database is a unique archive containing meteorological observations from instrumented tall towers measuring winds at heights above 10 meters. A total of 311 potential sites have been identified. Almost 70% of these sites (214 tall towers) have been already processed and formatted so far. It is expected to enlarge this database by adding new observations, especially in the European continent (temperature, relative humidity and barometric pressure).

INDECIS Benchmark Datasets: INDECIS Benchmark Datasets are based on KNMI's Climate Regional Model and the series are sampled from the model grid points composing a network of 100 stations in South Sweden and 30 stations in Slovenia (named as Clean World) for maximum and minimum temperature, precipitation, sea level pressure, snow depth, wind speed, sunshine duration, relative humidity and cloud cover at daily scale (available at: http://www.indecis.eu/benchmarking.php). The main purpose of the benchmarking experiment is to identify the capabilities, strengths and weakness of the different quality control and homogenization approaches as well as the associated uncertainties. The INDECIS' Benchmark will be presented in various flavors for testing purposes. The final goal is to identify the best homogenization method for large datasets such as ECA&D.

INDECIS Indices Datasets: A set of sectorial relevant climate indices (available at: http://www.indecis.eu/indices.php) were defined and inventoried to determine the response and sensitivity of sectorial variables to the different climate indices. A list of 136 indices for temperature (42 indices), precipitation (22 indices), bioclimatic (21 indices), snow (13 indices), aridity/continentality (10 indices), drought (8 indices), cloud/radiation (6 indices), wind (5 indices), fire (5 indices) and 4 indices for tourism were identified. All climate indices will be computed by applying the INDECIS Software Suite for Indices calculation to the INDECIS-Quality-Controlled and Homogenised Dataset and also to the ERA5 reanalysis data to obtain the newly INDECIS Indices Datasets (station-based and gridded).

Sectorial data: In the framework of linking climatic indices with different sectorial data, INDECIS have collected non-climatic data that cover a wide array of sectorial data in Europe, mainly focusing on agriculture, human health, water resources, energy and tourism. These datasets include different statistics, spanning a broad range of specific sectorial information, such as forest fires, reservoir storages, landslides, mortality/morbidity, hydropower production, road accidents, crop yields, phenological indicators, economic and human losses, water availability, groundwater quality, tourism nights, among others. The overriding aim is to assess the response of these relevant sectors to different climate indices.

2.2) Software

INDECIS Quality Control Software Suite (INDECIS-QCSS): INDECIS are using two software suite to quality control the ECA&D Dataset; the INDECIS MetQC (main QC software available at: http://www.indecis.eu/software.php) and the INDECIS QC (INQC) (complementary QC software available at: https://github.com/INDECIS-Project/INQC).

The **MetQC** software suite is based on the ProClimDB software, but re-programmed into R language, for QC testing the variables included in the ECA&D Dataset (maximum, minimum and average temperature, precipitation, sea level pressure, relative humidity, wind speed, snow depth, cloud coverage and sunshine duration). The aim of this software is to process large datasets of daily (and sub-daily) values fully automatically without the intervention of the user.
The complementary software **INDECIS QC (INQC)** is an R-coded and open-source software suite with capabilities to quality control large datasets in ECA&D format. 19 QC routines were developed and tested for daily data of maximum, minimum and average temperature, precipitation, sea level pressure, relative humidity, wind speed, snow depth, cloud coverage and sunshine duration. INQC will be available in the INDECIS website and GitHub repository with sample data.

INDECIS Quality Control Software Suite for Tall Tower Data (INDECIS-QCSS4TT): INDECIS also developed a software suite to quality control tall tower data (available at: https://earth.bsc.es/gitlab/jramon/INDECIS-QCSS4TT/). In order to ensure a minimum quality of tall tower wind data, a set of sequential Quality Control (QC) tests were coded to be performed over wind speed and wind direction measurements. Three different categories were defined depending on whether an observation passes the test successfully (*Pass*); passes the test but could need further check (*Suspect*); or fails the test (*Fail*). These classification has been done by setting different threshold values based on WMO standards, manuals or scientific articles and after testing them over observations from more than 200 tall towers. 18 QC tests were provided within the INDECIS WP3 and were applied over the previously compiled tall tower wind data.

INDECIS Homogenization Software Suite (INDECIS-HSS): Open-source software, designed in R with capabilities to homogenise the INDECIS' climate datasets at the daily scale. Included variables are: Maximum, minimum and mean temperature, precipitation, snow depth, sea level pressure, relative humidity, wind direction, wind speed and wind gust, cloud cover, sunshine duration and global radiation.

INDECIS Software Suite for Indices Calculation (INDECIS-SSIC): Open-source software, stand-alone and designed in R with capabilities to compute the 134 indices defined in the INDECIS project. Each index corresponds to a single function with options to be calculated on different time scales: annual, monthly and seasonal. Some of the indices only show an annual functionality, but most of them can be calculated at the three different time scales. The functions can be adapted to any format of data inputs and they can be adapted to calculate iteratively the climate indices from large datasets (e.g. gridded netcdf files).

2.3) INDECIS Reports

The analysis of temporal evolution of the INDECIS-QCHDS and INDECIS-ISD datasets, including derived climate extremes, will be conducted in **WP5** to quantify the variability and change across time. Their link to atmospheric circulation patterns, which modulate and exacerbate climate impacts over sectors, will be also analysed. Special emphasis on understanding the physical processes shaping these relations is a priority. By understanding how climate indices have evolved in the past and the physical processes involved INDECIS aims to provide a solid scientific foundation for building policy-relevant information on why key climate indices vary over time and how they may alter in the future. The limits and strengths of selected gridded, reanalysed and modelled datasets, as alternative data sources to compute the indices in the absence of observations, will be examined in **WP6**. The inventory and catalogue of selected hindcasts of climate simulations, reanalysis products as well as gridded observational datasets will be conducted first. Next, a set of statistical measures, including the widely used Taylor diagram, for the inter-comparison of selected datasets will be defined. A datasets comparison software suite will be designed/adapted for this purpose, focusing on the comparison of newly developed, sectorial indices (**defined in WP4**). **Secondly**, the skills of the European Centre for Medium-Range Weather Forecast (ECMWF) system and the applicability of seasonal forecast outputs will be examined through five test cases targeting agriculture, energy and tourism sectors. **Finally**, sectorial climate change impact based on INDECIS-IDS will be explored in the context of the latest climate change scenarios (EUROCORDEX), in the near-future (2021-2050) and on long term (2070-2100). The obtained results could pave the way to use alternative data sources in areas with sparse observational coverage and they will also serve for designing basic semi-automated free climate services (e.g. monitors and watches).

2.4) INDECIS Graphical and monitoring products

After transforming the climate products developed in the project into user-friendly climate services, targeting a wide range of stakeholders, all datasets, indices and climate services will be delivered to the INDECIS Data Indices and Services Portal (IDISP). The core content of IDISP will be; climate services, indices, data, software and information. This includes effective creation and delivery of graphic output, GIS-based visualization functionalities and semi-automated free basic climate services, regularly updated, such as monitors and watches. This will be packaged into a software suite based in free open source language and front-ended with IDISP. It will also include into IDISP a system for the request of advanced climate services, to link potential users with the specialists in the consortium. It is expected to be an extension of the ECA&D dataset, thus information needs to be converted to ECA&D format. Other resolutions different to ECA&D are also expected. General idea is that daily station data will allocate to ECA&D and derived data will also be incorporated into ECA&D. In INDECIS website will be available an IDISP section, which will link to various sub-sections: data, software, indices and services. AEMET servers will store indices' data and future climate services due to AEMET has full control over their servers, thus, the IDISP functionalities are guaranteed. The web portal will be the single entry point for the discovery and manipulation of data and products available in INDECIS. It will allow users to browse and search for data and products, perform data retrievals and visualize or download results.

3.- Communicative strategy and related activities

In the last years there has been a turn from climate change information to Climate Services communication. In fact, although we are not often aware of this relationship, Climate Sciences and Communication Sciences are closely linked. Climate Science rapidly evolved in the knowledge/risk society thanks to the Information and Communication Technologies (ICT). Huge progress have been made regarding climate data collection, climate modelling, climate risks assessment etc., but neither specific audiences nor the whole public perceive these advances as milestones toward a fair and sustainable welfare society. At the end, the value of Climate Services depends on information, dissemination and other forms of communication which are crucial for their success:

> "Without good service delivery, the value enabled by all the technical and scientific resources of climatology can be completely lost", so "it is not only about technology" but "the social context, the beliefs, the culture and capacity of those recipients to act on the information" matter, and "experience is needed [...] "Excellent products do not guarantee appreciation and that the users will use them. We cannot take it for granted that they know what is our contribution to the benefit of society. If they does not 'get it', we often see this as evidence of deficits on their part and we often have a tendency to repeat the same message in the same way, only louder. We have to make our products and services visible, show our credibility, competency, reliability. Show that we are able to serve the users and the society" (Cegnar, 2018).

To do so developing communication skills is not enough, but a culture of strategic communication is needed:

> "Communications worthy of climate change will require sustained contributions from cross-disciplinary teams […] Such teams would include, at minimum, climate and other experts, decision scientists, social and communications specialists, and programme designers […] many climate scientists are understandably frustrated by the limited

response to what they see as the greatest threat facing our planet. One impulsive response to a seemingly recalcitrant public is a big advertising campaign. However, unless founded on sound social and decision science principles and accompanied by rigorous empirical evaluation, such efforts have little chance of sustained success. Moreover, each communication failure makes future success less likely, by eroding both the public's trust in the experts, who seem not to know their needs, and the experts' trust in the public, which seems unable to understand the issues. Given the gravity and the complexity of climate-related decisions, we need a new model of science communication, with new collaborations among the sciences" (Pidgeon and Fischhoff, 2011: 39-40).

Accordingly, Atmospheric Sciences, other Environmental Sciences, Geography, Legal Sciences, Politics, Economics, Sociology, Psychology, Humanities and Communication have to work together to solve environmental problems in the Anthropocene. From a communicative point of view Climate Services can be understood as a meaning making process in which participants intervene as producers and as users as well — "*produsers*"—, in the same way that ICT users are not only consumers but also producers of information, the so called "*prosumers*". **Figure 2** depicts relationships between and among actors' roles ("*producers*" and "*prosumers*"), channels, topics (5 GFCS high-priority sectors and other areas), and sources involved in these processes.[3]

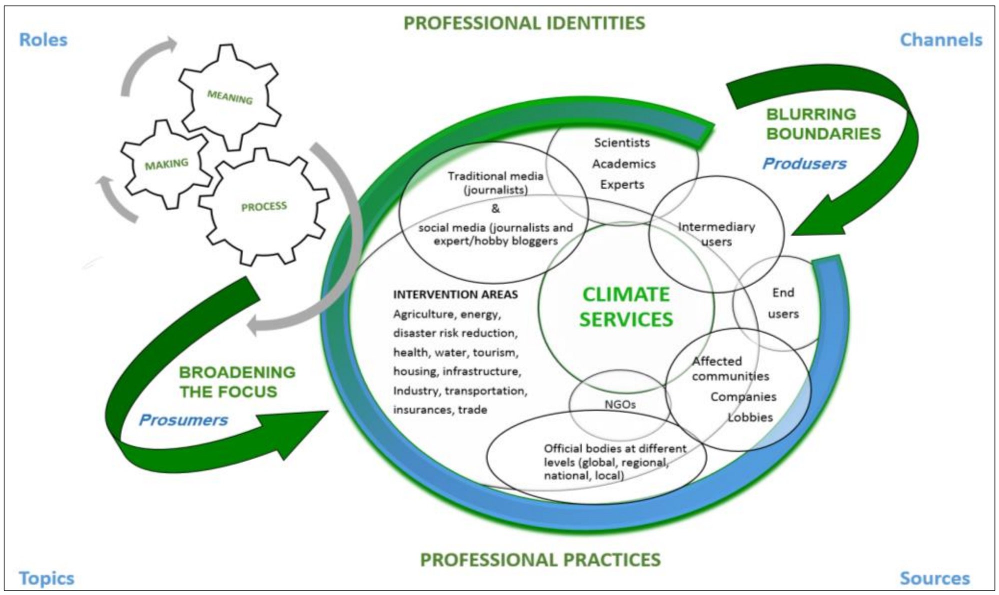

Figure 2. Climate services design, production and consumption as a meaning making process. **Design:** Jordi Prades-Tena.

Climate Services are an emerging field still in a building process "marked by contested definitions" (Vaughan et al., 2018: 391). In this context of uncertain dynamics, in which involved actors try to impose their points of view in order to gain public and media attention, and where Climate Services are a "developing paradigm" and a "voyage of discovery" (McNie, 2103: 23), we shall try to enlighten a useful and robust communication strategy for effective delivering these services based upon: **1)** value stories —how climate data is used by citing examples and applications to enhance stakeholder engagement— and **2)** socioeconomic benefit analysis —building

[3] "Roles are linked to channels as defining dimensions for professional identities in the 2.0 environment, whereas topics and sources define the professional identities of journalists in the traditional media. As core elements of journalism and communication, topics and sources are reflexive so they operate in parallel planes. They are therefore not only constitutive in the creation of discourse and meaning, but also in shaping roles and the identities of the actors. This two-dimensional approach lends itself to the analysis of the 2.0 environment, where roles and channels are located at the level of professional identity and where topics and sources operate at the level of professional practices" (Prades et al., 2014: 6).

quantitative cases depicting the economic value of climate data, products and services— (WMO, 2014f: 22-23). In line with these strategies Corner and Clarke (2017) call for "a fresh approach to public engagement".

INDECIS' communication strategy for delivering effective Climate Services is based on the following six steps: **3.1.-Evaluate your situation (where we are and how we are perceived in the media arena-public sphere?).** To evaluate our situation it is important to establish as starting point the differences between three main cultures that can be identified when communicating science and socioenvironmental issues like climate change: The scientific, the social and the media cultures. The limits of "the 'deficit model' of the public understanding of science, which assumes that simply teaching more science will bring lay behaviour into line with scientists' expectations", are well known; therefore "communication must explicitly adopt an alternative strategy if it is to respect audiences' values, feelings and need for dialogue and engagement" (Pidgeon and Fischhoff, 2011: 38). Indeed, "climate change is a scientific and environmental-related topic but it is also, fundamentally, a social issue" (Borràs, 2016: 97), so "there is a greater need to acknowledge the metaphorical character of tipping point warnings of climate change danger, as scientists and others strive to reshape climate change as a social policy problem" (Russill & Nyssa, 2009: 343). Actually, in the risk society "competition is not just over who gains advantaged access to the media and gets their voice heard, but who manages to successfully frame the issues […] media coverage, after all, is rarely an end in itself" (Anderson, 2015: 46). This brings us to the media culture because in the same way that scientific and social cultures collide, scientific and media cultures also do so. Either in the public sphere or in the media arena, media culture features (agenda setting, watchdog and gatekeeper functions, time and space conditions and limits, commercialization, cutbacks on science-reporting teams, job insecurity, false balance, editorial policies, etc.) influence environmental and climate-related journalism. In a reflective and mediated environment "intermediaries" or "climate knowledge brokers" play different roles such as receiving, tailoring and distributing climate information, so boundaries between users and providers are blurred (Wihbey and Ward, 2016: 8). At this point it is time to get back to the concepts of *prosumers* and *producers* to refer to audiences in terms of information production and consumption and in terms of Climate Services production and use, as the next section does.

3.2.-Understand your audience (what are their needs?). For an effective communication there is a need to understand our audience and tailoring our messages to them taking into account what current interests and previous knowledge they have on this topic: "Besides knowing what the users ask for, we should also have more information on the users themselves: what is the role of climate data in their decisions, what is their framing, what is their background knowledge, etc.?" (Bessembinder et al., 2013: 3). There are many ways to segment audiences, but, although compartmentalized classifications might be useful in terms of a marketing approach, these labels have limitations given the permeability of segments and the hybridization of roles, rules and spaces in the current media landscape. In that sense, especially for INDECIS project purpose, two criteria are key regarding segmentation: first, what communication channels people use; secondly, how those who belong to each segment can be identified as intermediary or end-users of Climate Services. **Table 1** summarizes what INDECIS products might be used by both intermediary and end users in the 5 CFGS high-priority sectors plus tourism. Furthermore, other potential users have been included.

3.3.-Create your message (what kind of messages should be spread to each segment of the audience?). WMO, the Sendai Framework for disaster risk reduction and the United Nation's Sustainable Development Goals (goal 13 is climate action) form an integrate framework for climate governance. From a strategic approach to communication they are in charge of sharing coherent and consistent messages and to spread them between both the specialized science community and the general public. In this regard some concerns arise: **1)** Uncertainty is inherent to climate but outside the scientific community it is perceived as a knowledge gap which may result in scepticism so, what information do we want to communicate? **2)** Overwhelming information might broaden rather than narrow uncertainty; more dispersion results in risk confusion and blurred messages. **3)** Should scientific rigour prevail at the expense of societal usefulness or should social understanding prevail bearing in mind that the aim is science socialization? Although here is not just an answer in binary terms some tips can be highlighted (**please see box 1: Content and structure of the messages**).

Table 1. Potential customers of INDECIS climate services by sectors and type of users. **Design:** Jordi Prades-Tena.

GFCS high-priority sectors plus tourism	Potential customers		Climate services and products	
	Intermediary users	End users	Intermediary users	End users
Agriculture	Public bodies and private agriculture organizations, rural developers, European food safety agencies	Farmers, breeders and cattle ranchers, irrigators, veterinarians, fishers, forest managers, food brokers, seedstock, agro-industry	Datasets, indices and reports	Reports and visualization tools
Disaster risk reduction	Insurance companies, emergency and land-planners, urban & risk maps developers, civil protection and defence agencies, disaster risk advisors, early warning systems developers, infrastructures managers	Banks, financial, security and compensation funds companies, real-estate agencies, civil protection and defence personnel, communities at risk, rescue teams and volunteers	Datasets, indices and reports	Reports and visualization tools
Energy	Hydro, wind, solar, thermal and nuclear power plants owners and companies, risk advisors, siting planners, scenarios for energy mixes designers	Power plants managers, self-power producers, energy marketers, trainers in the use of forecasts, electric technology and smart grids developers, grids maintenance firms	Datasets, indices and reports	Reports and visualization tools
Health	Medical associations, hospital managers, pharma companies, risk advisors, early warning system managers, health facilities siting and planning consultants, emergency planners	Health insurance companies, health personnel, drug marketers, chemists, experts fighters against transmission of epidemics and infectious diseases, post-disaster intervention teams, fumigators against pests	Datasets, indices and reports	Reports and visualization tools
Water	Hydrologists, geologists, basins and dams managers, hydro, thermal and nuclear power plants owners, risk advisors, land- planners, forecasters	Irrigators, hydro, thermal and nuclear power plant managers, shipping companies, water-related industries (purification, recycling, reusing, etc.).	Datasets, indices and reports	Reports and visualization tools

Tourism	Tourism companies and associations; managers of natural parks and protected areas, climate brands designers, destinations	Accommodation business, operators, sky and beach resorts, outdoor activities planners, low season closures calendars and schedules managers, tourists	Datasets, indices and reports	Reports and visualization tools
Other sectors				
Scientific community	Climatologists, climate services developers and providers, researchers, academics, experts	Met-man, climate advisors, climate appraisal experts, big data computer engineers and social scientists	Datasets, indices, software, reports, tools	Reports and visualization tools
Policy sector	Governments and ministries, policy-makers, decision-makers, authorities, public bodies at local, national, regional and international level	Public agencies, fire brigades, police and military forces, emergency teams,	Datasets, indices and reports	Reports and visualization tools
Media	Weather forecasters, environmental and science journalists, audiences researchers, disaster emergency and risk communication practitioners, experts in hazard-monitoring, creators of public educational and consultation campaigns	Media audiences, information channels developers, information trainers and communications advisors, climate image branding and marketing campaigns creators	Datasets, indices, reports and software	Reports and visualization tools
NGOs and civil society	Red Cross and Red Crescent, Doctors Without Borders, Engineers Without Borders, humanitarian NGOs at local level, managers for on-going risks and humanitarian response	Post-disaster recovery teams, safe management of mass gatherings and emergency teams, logistics managers, health-care equipment distribution, infrastructure repair workers, NGOs', volunteers associations, climate refugees, migrants	Datasets, indices and reports	Reports and visualization tools
Other areas	Transport (terrestrial, aerial, marine), housing, infrastructure, industry, trade, insurances, sports	Airlines, cargo ships and cruises crews, house rental & real-estate agencies, traffic authorities, construction companies, outdoor sports trainers, teams, and clubs	Datasets, indices and reports	Reports and visualization tools

Box 1. Content and structure of the messages. **Design:** Jordi Prades-Tena.

- Simple, understandable and relevant.
- Well-founded but concise and to the point.
- Catchy (seek for a hook in the headline) and newsworthy to draw media attention.
- Transparent, honest and humble.
- Innovative and interactive (include images, videos, games, exercises, etc.).
- Balanced: Be realistic and, when possible, optimistic and positive due that catastrophism and based-fear messages produce rejection, so the audience will avoid to listen to you.
- Take care of the style and tone, and personalize your message to reach the hearts rather than the brains.
- Be passionate when talking stories and promote action going from the storytelling to the "*story doing*".
- Choose the right words for any language. For instance, "prediction" and "prevision" are used in Spanish to refer to weather forecast, although these terms do not mean the same.
- Frame your message in your own interest. Talk about climate change (neutral/positive connotation) instead about global warming (negative connotation). Narratives matter.
- Avoid specialized terms. When jargon must to be used, choose standard definitions.
- Besides the content of the messages there is their structure. The inverted pyramid, based in the "5 Ws and the H", is a useful tool to organize the information.

In addition to these tips Corner and Clarke (2017) claim for "starting from the 'values-up' instead from the 'numbers-down'"; "telling new values-based stories to shift climate change from a scientific to a social reality"; "turning from 'nudge' to 'think' to build climate citizenship"; and "promoting new voices to reach beyond the so called 'usual suspects' [the environmentalists]". Also these authors advocate in their key research findings of the Climate Outreach project, led by Shaw et al. (2017), for: "show 'real people' not staged photo-ops; "tell new stories; show climate causes at scale"; "balance images of climate impacts"; "show local (but serious) climate impacts"; "be very careful with protest imagery"; and "understand the audience".

By way of advice Shaw et al. (2017) propose to create "a new visual language" on climate change from the analysis of the COP21 pictures published in several media and those that appear on the internet and in various social networks. As for the World Climate Research Programme communication strategy, its values are accountability, approachability, bottom-up, clarity, consistency, integration, legitimacy and transparency.

Finally in their turn, Needham et al. (2017) propose four strategies to deal with climate change communication challenges identified by Monroe et al. (2015): Climate change is complex, uncertain and variable; people learn and remember selectively; people pay attention to those who are like them; and audiences vary although individuals are not likely to shift between categories quickly.

3.4.-Media channels (what channels should be used?). In last decades the explosion of the ICT have radically altered the classic communication model in which the stream from a source to a receiver was linear, hierarchical (top-down), one-way and mediated by journalists. Today, the Internet and social media permits a non-linear, decentralized and multi-way / many-to-many model of communication. The Internet and its associated channels have gained relevance when it comes to communicating both scientific and social topics. Websites, online forums, blogs, video portals and social media compete with classical, mainstream media (printed publications, radio and TV) and their digital versions, e.g. editions through 2.0 channels. In addition to news and online media are books, museums, science-centres, talks and science-related events. Therefore there are a broad range of sources of information, media and channels to choose, and several actors playing different roles depending on the sources (official, companies, lobbyists, academics), media (public, private, social) and channels (analogical or digital) they are on. Media and channels can be classified differently according to varying criteria, such as **table 2** shows.

Table 2. Channels by communication model. **Design:** Jordi Prades-Tena.

Communication model					
One-way		Two-way			
One to one communication	Mass communication	One to one communication		Mass communication	
Offline	Online	Offline	Online	Offline	Online
Newspapers	Digital editions, websites	Telephone	e-mail	Workshops, Public hearings, audiences and consultations, Seminars, briefings	Facebook
Scientific journals, books	Digital editions, websites		WhatsApp		Twitter
Printed materials	Newsletters		Video conferences		Instagram
Bulletins boards, posters	Podcasts				LinkedIn
Radio	Online TV			Scientific conferences	ResearchGate
TV	YouTube			Science events	WhatsApp
	Wikis			Press conference	Webinars
	Widgets				Online forums
	Blogs				
	RSS				
	SMS				
	Mobile apps				

Research suggest that many climate institutions are still waiting for what others are doing in the social media environment in order to learn successes and mistakes, due that "for the institutions, the social media add new problems to the traditional communication of risk: they feel obliged to participate in the virtual environment, but at the same time they are afraid to lose control of both the message and legitimacy, and they don't know how to talk to users. Institutions still consider social media as an uncertain opportunity" (Farré et al., 2013: 384). For instance, the National Oceanic and Atmospheric Administration "utilizes social media to interact with publics" but "does not fully utilize the dialogic potential of social media, which could enhance both the public's science literacy and trust in science regarding climate change specifically" (Lee et al., 2018: 274).

Faced with situations like these, this section encourage for a proactive use of both classical and social media for climate services delivery. According to Schäfer et al. (2018: 17) "interest in science, scientific literacy, and actively searching for information about science correlates with more frequent science related information use", so in the current, changing media landscape "target audiences may differ and different aims, messages, and communicative channels need to be utilized" to reach fragmented publics both through classical and social media —A SWOT analysis of social media can be found in Farré et al. (2012: 384) and here. Some general rules that can be established regarding both traditional and social media are:

1) Traditional media based on the ideal principles of the good professional journalism are credible, impartial, neutral, fair, honest, free, independent, rapid, accurate, balanced, reflective, valid and reliable. Access traditional media is difficult because media routines, and advertising is expensive.

2) Social media are fast, interactive, amicable, user-friendly, popular, emotional, fast-evolving and proper to segmented audiences. Access social media is easy and cheap but maintaining a robust profile on the network is time consuming and needs hard and specialized staff effort. Social Media are for sharing rather than for showing.

Table 3 can be used as a template to fill in with other media and channels in order to evaluate which one should be used in each situation, both for each message and audience.

Table 3. Scientific journals and books. **Design:** Jordi Prades-Tena.

One-way one to one offline	Properties		Potential users	Examples
	Advantages	Disadvantages		
Scientific journals, magazines and books	-Double blind review -Credibility -Trustworthiness -Open Access available	-Limited to very specialized public -Restricted access (if not Open)	-Scholars & practitioners -Planners -Political advisors -Policy-makers	Climate Services Nature Climate Change WMO bulletin

3.5.-Public involvement (how to engage people?). Engagement refers to "[...] activities at the interface of those who develop and provide climate services with those who make use of climate services for decision-making. The activities include one-way engagement such as websites, seminars, and brochures; but tend to more commonly refer to interactive two- or multi-way engagement such as workshops, interviews, and the co-design and co-production of information or services" (Golding et al., 2017: 72). Three broad methods of user engagement have been identified for Hewitt and colleagues, as WMO Commission for Climatology' Expert Team on User Interface for Climate Services' members, in the *Guidance on Good Practices for Climate Services User Engagement* (WMO, 2018). These methods or categories are websites and web-based tools; interactive group activities; and focused relationships between providers and users. Further steps to build more effective interfaces between Climate Services providers and users include, among other activities, "elicit users' feedback"; "convene user-focused workshops ensuring a follow-up mechanism that results in ongoing interactions and activities"; "build capacity within user groups to understand, interpret and apply climate information within contextually relevant decision-making frameworks"; "Consider development of customer-focused relationships that identify the specific decision needs of users and especially key decision points"; and "Consider formalizing partnerships using memorandums of understanding or other suitable mechanisms" (WMO, 2018: 5).

3.6.-Monitor communications (what tools are available?). Social media allow to assess in detail the impact of each message both in real time and from the moment it was posted/tweeted to days, weeks and months afterwards. Twitter Analytics and Audience Insights, from Facebook, are free tools to do so in these respective social networks. The most appropriate metric tool for each channel used must be chosen, being aware that "simple statistical analysis of outreach is insufficient to gain proper insight; we need to understand also the semantics of messages so that we can better correlate social communication with environmental behaviour, i.e. not just whether people respond to a tweet, but *how* they responded" (Fernández et al., 2016: 86). **1)** Quantitative aspects are number of clicks, likes, shares, tags, video views, new followers, profile visits, engagement rates, cost per result, uses of hashtags and retweets and influence of the accounts that use it, etc. **2)** Qualitative aspects are "types of comments received, their tone, the number of people they reached, the types of followers, impressions, traffic data, ratings, word clouds, etc. They can also include new collaborations, product commercialisation, appreciation for research, as well as greater knowledge among specialists and the general public" (EC, 2018: 12). Looking at how "*produsers*" look for information should be another item to monitor because it combines quantitative and qualitative aspects and can offer valuable data about our website functionality, the interest of audiences about our posts and tweets, and social media use patterns. Again drawing a parallelism between climate and communication sciences: "Like climate systems, human systems involve the complex, uncertain interaction of many processes. As a result, even the best-designed communications, based on the strongest social and decision science, require rigorous implementation and empirical evaluation to determine how effective they are. […] The decision science approach takes an 'inside view', letting decision-makers' needs determine the content of communications, rather than just relaying the messages that scientists think are important (Pidgeon and Fischhoff, 2011: 39). Scientists are reliable sources of information but they do not should take for granted that people will pay attention to what they say by the mere fact of being an official source. Being an academic authority does not means being an opinion leader (Farré et al., 2012: 382). Nevertheless, monitoring and post research impacts can transform public perceptions of science.

4.- Concluding recommendations

Although this report is rather a guide to what should be done than a list of actions to carry out some advice can be given. Accordingly, ranging from the most general to the most concrete, the following recommendations are presented:

1.- Integrate communication into the organization chart of your project at high level to avoid misunderstandings, communication breakdowns or the recurrently so called "communication problems".

2.- Engage opinion leaders and experts (journalists and social media influencers, academics, social scientists) to your project, and involve them in it in order to build "a communicative community" of your project.

3.- Deploy communicative and public relations activities with the media, public institutions, companies, NGOs, etc. in order to present your climate products and services and their usefulness both for the society as a whole and stakeholders.

4.- Make a portfolio of what climate-related products —e.g. datasets, software, reports and graphical and monitoring tools— you can offer to Climate Services intermediary and end-users, and distribute it between your stakeholders and the whole public by means of tailored messages and targeted campaigns respectively.

5.- Detail what is your added value in front of other products and services, e.g. "the best homogenization method for large datasets"; "the unique archive containing meteorological observations form instrumented tall towers measuring winds at heights above 10 meters"; the "sectorial data" addressed to specific users, etc.

6.- Move from science-driven and user-informed research to demand-driven and science-informed practices. Post examples of how you approached and engaged stakeholders and users to fulfil their needs, and collect evidences about how your research outputs and operational methods can be applied beyond your project.

7.- Transform scientific data in facts-based stories focused on the applied profitableness of your climate products and services, and on the socioeconomic benefits of your research. Look for individuals and beneficiaries, participants in study cases, which can witness and corroborate specific claims with factual statements.

8.- Think carefully whether you want and why you want to be on social media to choose which ones are better for your project. Do not forget neither traditional media nor face-to-face dialogue: All forms of communication are complementary, not exclusive.

9.- Share your results with both the specialized audience and the general public in an appropriate channel, tone and manner: Open access journals for scholars; reports for authorities and decision makers; social media and popular science linked to action and to daily life for ordinary people.

10.- Leave the lab and tread the street! Talk to the people and listen to what people say. Be an exemplar to convince your audiences that you are not only acting just as a scientific but also as a committed citizen interested in stakeholders and people's concerns about climate change and the environment.

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