Guidance to support the identification and assessment of users' requirements

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We aim to include more experiences and examples from other countries and organizations. Therefore everyone is invited to:

- comment on the structure and content;
- add examples/figures/experiences/documents from other countries.

Feel free to distribute this document to anyone interested.

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1. Aims for identifying users' requirements

1.1 Background and aim of this document

This document is provided to support delivery of the Fast Track Activity (FTA) 2.1 "Mapping users' requirements", which is a contribution of Module 2 "Research for Climate Service Development" of JPI-Climate (http://www.jpi-climate.eu/). FTA 2.1 aims to collect and analyze information on users' requirements related to Climate Services (including similarities and differences between sectors and countries, and knowledge gaps plus suggestions for research) during the period summer 2012 to summer 2013, to inform the activities across the JPI Climate and the further development of the strategic research. Although national dialogues directed at identifying and understanding users' requirements in various European countries are not part of this FTA, this guidance, based on lessons learned through experience, is intended to support and encourage JPI Climate members (and non JPI Climate countries) to undertake national dialogues and prepare an inventory of users' requirements. The intention is that through these national dialogues additional data/information will become available to support the aims of this FTA.

Aim of this document:

- To provide examples based on lessons learned through experiences, background information and documents to support those wanting to identify and analyse users' requirements related to Climate Services.

The intention is that this guidance provides an opportunity for those less experienced to learn from the experience of others and thereby providing the means to more efficiently target their collection and analysis of users' requirements. Those that have experience in such matters may also find this guidance helpful for updates of users' requirements and to further support their collection and analysis of those requirements. To these ends, each chapter of this guidance contains some advice, based on experiences of the contributors to this document.

This document is considered to be a "living" document to which new information can be added over time. We welcome contributions (experiences and lessons learned (good and bad examples), relevant documents/figures, etc.). We also intend to update this document with the experiences and lessons learned from the national dialogues undertaken as contributions to FTA 2.1.

1.2 Why inventory of users' requirements?

Climate services include the development, provision and dissemination of climate data, information and knowledge to inform the public, researchers, decision makers (policy and practice) or other specific users. As such, climate services should involve strong partnerships among stakeholders[1] (engagement of users and providers of climate services that includes two-way communication) (http://www.wmo.int/pages/themes/climate/climate_services.php). The main aim of JPI-Climate is to develop more informative and relevant information and to improve the transfer of data, information and knowledge about climate and climate change, its impacts and adaptation options to society and within Europe[2]. Better dissemination and increased relevance require proper knowledge of users' requirements, which set the scope for the relevance of the data/information/knowledge. For this purpose, identifying

[1] The terms stakeholders and users are used both in this document. Users are almost always stakeholders, but not all stakeholders are direct users of climate data, information or knowledge. Impact/adaptation researchers are users and stakeholders, but e.g. policy makers may be the final stakeholders;

[2] JPI aims to coordinate national research funds in Europe. Therefore, the activities of JPI-Climate, at first instance, focus on Europe. However, later on activities could also include other continents.

users' requirements is needed, including an understanding of the scope and characteristics of the overlap and discrepancies (similarities and differences) in requirements (e.g., nature, extent, similarities and differences among the different users, sectors, uses of climate services and countries).

An understanding of users' requirements can also identify where there is a need for further research, including research that specifically supports the development and delivery of climate services. This understanding can also support the development of products and services, both standard[3] products (advice/information/data) that fit a broad spectrum of users' requirements and those where the requirements can best or should be met through the provision on demand of tailored advice, information and/or data. It should be noted that one advantage of providing standard products is that the intended users can draw on the same products, thereby providing the opportunity for comparability and consistency across the uses to which the products are directed.

1.3 Concept of Climate Services

Climate Services encompass a wide range of activities such as: the management of climatological and linked data collected; the further derivation of products from the data; the development of techniques in order to apply the data in a wide range of economic, social and environmental contexts; and the provision of information, analysis and advice to the general public and specialist users about the nature of climate in general. The intention in providing sound scientific and relevant knowledge, information and data is that those using it will be better informed and will make more informed choices as to how it is to be used, including making better informed risk-based decisions plans, strategies and actions. As the science and our scientific understanding develop, and users' requirements evolve, these climate services will also need to continue to evolve.

No single definition of Climate Services seems to capture the vast diversity of needs or applications. That is part of the problem in developing climate services and the associated infrastructure. Climate service means different things to different people, both from the perspective of different users and providers. From the local farmer wanting to know about drought conditions to the federal agency conducting climate change research, each application involves having access to specific knowledge, information and data on the state of Earth's climate. Each user is different, each application unique. In the most general sense, perhaps climate services are simply providing access to and helping people use appropriate climate knowledge, information and data. It involves developing and providing access to data, analyses, research, and knowledge relevant to a particular application and helping individuals apply it in their particular application. Thus, at the heart of climate services is the understanding of users' requirements and providing flexibility so that individual users can tailor in an informed manner the provided services to meet their own particular needs. A climate service is more than simply the provision of data. It also involves providing context and support that is the basis for turning data into useable and relevant information (Shafer, 2004).

Definitions used for Climate Services differ, including in the following aspects:

- Some use the term especially for services related to the current climate, others especially for services that are related to future climate change, and for others it includes both;
- Some include within climate services providing information on the impact of climate (change) and adaptation options, for others climate services include only the

[3] Products that were first developed as tailored products can sometimes evolve into standard products when they appear useful for a larger group of users. E.g. in The Netherlands climate change scenarios were first developed for policy making at the national level. Since 2006 generic climate change scenarios are developed for use by many sectors, and tailored information can be produced for specific sectors.

provision/dissemination of climate data/information (e.g. temperature, wind, water temperature);
- Some include only the provision of products (data and information), others also include services such as guidance in the process of adaptation.

The Global Framework on Climate Services gives the following (broad) definition of Climate Services in the Report of the High-Level Taskforce (WMO No. 1065, 2011) (http://www.wmo.int/hlt-gfcs/downloads/HLT_book_full.pdf):

"Climate services encompass a range of activities that deal with generating and providing information based on past, present and future climate and on its impacts on natural and human systems. Climate services include the use of simple information like historical climate data sets as well as more complex products such as predictions of weather elements on monthly, seasonal or decadal timescales, also making use of climate projections according to different greenhouse gas emission scenarios and time frames. Included as well are information and support that help the user choose the right product for the decision they need to make and that explain the uncertainty associated with the information offered while advising on how to best use it in the decision-making process."

Advice (for those who want to do an inventory)
- Identify who should be involved in identifying and understanding users' requirements (which stakeholders, including providers and users) and engage them early in the process;
- Engage the identified stakeholders in identifying the scope[4] of Climate Services to be considered in the context of identifying and understanding users' requirements. There is a risk that this definition may be very broad, therefore the effort of identifying and understanding users' requirements may also become broad or unfocused (and thus difficult to manage);
- Define the aims for identifying and understanding users' requirements: is it to get a broad overview of users' requirements or detailed information from one user group, to confirm whether users' requirements have changed over time, and/or to design new climate services or adapt existing ones? An important additional aim may also be to keep users involved in the design, development and delivery of climate services, including new climate scenarios. The aims may determine the most appropriate methods to be used, the level of detail required, etc. (see following chapter).

[4] The scope of the Climate Services that can be delivered by a provider may be limited by its expertise or legal mandate. A meteorological institute is often not an expert on impacts and adaptation options for e.g. ecosystems.

2. Who are the users?

Users of climate services (they may also be intermediary users (e.g. researchers and consultancy) and end-users) can be categorized in different ways. They can be divided according to sector(s) of interest, intended use (e.g., communication, research, decision/policy making) or capabilities all with their specific needs. For example, impact researchers often need time series of climate variables and indices as input for their impact models. Adaptation researchers requirements depend on what aspect of the assessment process they are considering (e.g., risk assessment, adaptation options assessment, implementation or evaluation of implemented measures). Decision makers needs vary considerably from more general information to information related to sensitivities and the chances that certain thresholds will be surpassed.

Researchers, particularly those with a climate science or impacts background generally have a relatively high level of knowledge about climate change and the possibilities and limitations of climate data. Politicians and others that might want to raise the profile of climate change on the political or public agenda may be more interested in information about extremes, maps or (photo) graphs that illustrate clearly climate trends and projected change, including information on recent extremes that have had large socio-economic impacts (to illustrate the vulnerability and to emphasize the need for action).

Different sectors may also require quite different data and information, as well different capacities to access and use the available information, knowledge and data (see Table 1). There may also be users that do not necessarily need climate variables. They may want to use story lines that are based on the different climate scenarios (e.g., qualitative information related to exceeding a particular threshold).

Table 1. Examples of differences in users' requirements between sectors (Bessembinder et al., 2011b).

	1 	2 	3 
	Energy	**Urban water management**	**Coastal protection**
Preferred climate data	Wind speed	Rainfall extremes	Sea level rise, wind extremes
Time resolution	Day-month-year	5-60 minutes	hours-year
Preferred time horizon	2015-2020	2050-2100	2050-2200

Sectors for which experiences suggest that they can have different requirements:

- Water management (e.g. rural and urban water management, water safety/defense against flooding);
- Agriculture (e.g. crop husbandry and animal husbandry, annual and perennial crops, etc.);
- Forestry;
- Fishery;
- Ecosystems (e.g. terrestrial or marine);
- Financial sector (e.g. insurance, banks);
- Transport (e.g. transport by air, roads, water);

- Energy (e.g. wind energy, solar energy, biofuels, energy production and distribution);
- Infrastructure/construction (e.g. housing, roads, bridges, etc.);
- Health (including air quality);
- Tourism and recreation (e.g. green spaces, winter sports, etc.);
- Spatial planning (e.g. urban or rural environments, regional or local planning);
- Industry and Business (Note that these sectors can be very diverse);
- Education;
- Civil protection (e.g. disaster risk reduction, emergency services).

Experience also suggests that in some cases some of the above sectors can be grouped or may need to be further subdivided. In fact, the relevant sectors (and subdivisions) may differ between countries and regions related to geography, social, cultural, political and economic circumstances. For example, coastal protection is not relevant for a country such as Austria, whereas for those with a vulnerable coastline such as the Netherlands, this sector would be of particular interest.

Type of user and its aim can also be a useful category by which to understand users' requirements. Some examples of types of users that can be considered are:
Research and education:
- Researchers working on impacts, adaptation and mitigation studies/assessments. These can be further subdivided if necessary by considering where the researcher is located (e.g., academic institution or within a private institution (e.g., NGO, private company) and their discipline. These considerations will help better understand the diversity of researchers needs and capabilities;
- Consultancy companies: varies from companies that do impact/adaptation studies, develop adaptation strategies, up to companies that give information on climate change and/or support to the process of adaptation/mitigation (these can be considered to be climate service providers too, sometimes also called "purveyors[5]");
- Teachers and those developing educational material and curriculum;

Policy makers/NGO/politicians:
- Policy makers: this may be a rather diverse group (see figure 4 about the various roles in the decision making process; consultancy companies may also have many of the roles of policy makers);
- Politicians and other stakeholders/interest groups (those that want to put or represent climate change within the political or public agenda), or skeptics that want the opposite;
- NGO's or other stakeholder/interest groups communicating information about climate and climate change (often also want to put climate change at the political and public agenda (or the opposite));

Practitioners:
- Practitioners (e.g. engineers, planners, investment portfolio managers) within local government, industry and business, including financial services providers: A diverse and evolving group of users that can use publically available information, but also are interested in bespoke climate services. Due to their diversity this is a difficult but essential group of users to engage in the development and delivery of climate services;

General public:
- General public and media (interested, but without specific aim).

[5] People that are users of climate services offered by providers may also be a climate service provider to other groups. E.g. a consultancy company can be a user of climate data/information from a meteorological institute or other provider. When this company translates/processes/transforms the information and or adds other data/information or services it is also acting as a provider of climate services (e.g. providing services to a government organization, industry and businesses). A research institute can also be a "purveyor": at the same time user and provider of climate services.

The same type of users (with or within the same sector) **may frame the effect of climate change differently** and therefore have different requirements. It is important to understand the motivation behind users requiring climate services (e.g., regulatory requirement, corporate social responsibility, meeting business requirements such as ISO accreditation or responding to real or perceived risks), their perceptions of the relative importance of climate change to other issues of concern (e.g., economics, business sustainability and political uncertainties) and their timeframes for action (when the services are needed and for which period of time).

Those involved in **decision making** can be further subdivided looking at the decisions to be:

- Requirements for knowledge, information and data vary based on the framing/context within which these services are used. Clearly understanding the framing will facilitate better targeting the services offered, as well as better inform the understanding of the level of support and guidance decision makers will require. It is also worth noting that users' awareness of the difference framing/contexts will improve their requests for services;
- The role climate information plays in decision making, can depend on whether a top-down or bottom-up approach/strategy is being used. When using a top-down approach, information on climate and its impacts is the starting point, whereas in a bottom-up approach the starting point is determining the vulnerability of a system and only in a later stage is climate information needed (e.g., to determine whether and when sensitivities are realised and/or thresholds will be surpassed due to climate change);
- When undertaking an adaptation assessment, depending whether the purpose is to identify and assess adaptation options or to evaluate implemented adaptation measures, the climate services required can be different. For example more information and data related to exceeding thresholds and sensitivities to extremes and variability (current and projected) and to impacts may be required during evaluation of implemented adaptation options.

Categorising users based on their **capabilities**. This should consider the capabilities of users to access and use climate services and recognise that capabilities can range from specialist users who can access and use detailed data and require little guidance to non-specialist users who have a limited capacity to access the available climate services, limited knowledge or experience in using such data and need guidance and support (Swart, 2011, Swart & Page, 2010; Themeßl et al., 2011). In Austria for example the following categories have been used:

- Climate and climate impact researchers;
- Professionals in environmental and conservation organizations, or in NGO's;
- Professionals in industry and business (consultants, spatial planners, architects, engineers, etc.);
- People in federal institutions;
- Politicians and policy makers.

However, the capabilities may be rather diverse in each of these groups. As categories also the following could be used:

- Able to access and use large volumes of data (e.g. climate and climate impact researchers often belong to this group);
- Able to use services with limited support and guidance;
- Limitations in ability to access services due to technical limitations;
- Limitations in ability to use services due to time/resource limitations;
- Limited understanding/experience in using services and requiring more support and guidance.

Advice

Several organizations in Europe have experience working with users and with identifying and understanding users' requirements. Below is offered some advice, based on that experience and lessons learned by these organizations/persons (see also Chapter 3):

- When you acquire a general overview of users' requirements, the range of users' and their requirements considered will determine the validity and representativeness of that overview. There is a need to understand what users should (or have been) considered and the degree to which they represent the range of users to be targeted (increase the likelihood that the resulting overview provides the desired breadth and balanced view). For example, have you included various types of users with different capabilities? Are the different sectors of interest represented?
- When engaging users and providers in identifying and understanding users' requirements, understanding the breadth of their respective communities those engaged represent is essential. This includes the degree to which they represent the range of capabilities and interests within their sector, user type, etc.;
- There are advantages to including consideration of both current and potential users. Understanding the requirements of current users can improve existing services and provide informed advices on the need for new or enhanced services, whereas potential users can offer different perspectives on requirements and provide an opportunity to address barriers;
- Users' requirements are very much influenced by the context in which the data/information/knowledge will be used, and by the framing of the users themselves. Therefore, understanding users' requirements should always include understanding this context and framing (or even start with it). When users express requirements/wishes, try to find out why they want these data/that information/etc.; what are the motivations behind that request; what are their capabilities in terms of accessing and using what they are requesting; how will it be used (the framing) and the timescales within which they are operating (when they require the requested services, as well as the timeframe to be covered). It is essential to work with the users to understand the nature and scope of their requirements (What are the "questions" behind their requests for climate data/information?);
- Climate information used by others (e.g., researchers, analysts and consultancies) is in many cases also intended to reach policy makers and decision makers, and sometimes/often (?) having been further analyzed, interpreted or transformed (value added). As such, it is also important to understand when considering these users' requirements how they expect their results (the value-added information) to be used by the intended audience(s) (researchers, policy makers, decision makers, etc.).

3. What information on users' requirements is needed as a basis for Climate Services?

Until now most inventories of users' requirements focused especially at what type of data or information is needed (see below under par. 3.2, first group of requirements). However, for users the form of presentation may also be important, or the availability of guidance, overview etc. Some efforts on identifying users' requirements paid attention to one or more of these aspects. To get a more comprehensive understanding (and to be able to provide better and more relevant services) information is needed on presentation and support, as well as on why and how the requested data/information is to be used (context, strategy, framing, etc.). These latter aspects have had relatively little attention (or at least little has been documented), possibly as this type of information is more difficult to get.

To understand users' requirements both information about the services that users require (what do users ask for/need?) and information to better understand the requests (why do users ask for these services, how will they use the data/information?, etc.) are required. In the paragraphs below we try to specify what type of information is required for both these categories.

When a user requests data/information, ideally climate service providers should first get information on the intended use, context, framing within which the data/information will be used before providing the requested data/information. It may be that users do not need the data/information that they requested at first. This only becomes clear when providers and users of climate services discuss the intended use and context of the requested data[6]. For this reason Par. 3.1. first deals with the information that providers need about users. Par. 3.2 than deals with what users ask for.

3.1. What do providers need to know about users?

How climate information fits into users' proposed use – how the requested information and data will be used and for what purpose:

- Some users have difficulty articulating their requirements and obtaining a better understanding of the intended use will inform their request and your response (including how it is presented and provided). For what type of problem is climate data/information required? In unstructured problems much more time has to be invested in articulation of and understanding the requests – interaction between users and providers, etc. (see Figure 1);
- Users often ask for a lot of information, whereas in the end they may only use a small part of the requested data/information. Information about the use (e.g., how it was communicated or introduced in the decision making process) may help in determining why and what they really need (e.g. may be only interested in certain threshold values);
- Information on the use of climate data/information from users may provide information on how they interpret (and possibly misinterpret) the delivered services and what they assume implicitly (e.g. about the quality or homogeneity of the data). This can help providers to understand the need for and type of guidance and other support required. In addition, since those requesting the climate services could also be disseminating the climate data/information or derived products to other users (in

[6]Based on experiences of contributors to this document (e.g. in the Netherlands spatial planners once asked for maps of various average climate variables in the Netherlands according to the KNMI'06 climate scenarios. The spatial differences in average temperature, precipitation, etc. do not influence spatial planning in the Netherlands; differences in the occurrence of extremes may. Although maps were requested for use in spatial planning it appeared after some time that they would be used especially for creating public awareness (including in the government organizations) related to spatial planning and climate change.

this case the initial users can be referred to as purveyors), it is important to understand the intended target for the users' outputs and what they will be communicating (e.g., content and messages regarding uncertainties[7]);

- The relative role of climate information and data (compared to other information, including current and future climate and their risk perception (see Figure 2). Is climate change considered an important issue or are other issues/drivers of change more important? Understanding these will help identify the type and level of detail that may be required (e.g., where climate is not an important driver of change, more general (or less detailed information may be all that is necessary);
- At what point in the decision making process is the climate data/information needed and in which form? In a linear and top-down approach climate data/information is usually needed at the start, whereas in a bottom-up approach information on climate change is used in a later stage (to determine when certain threshold may be passed (Dessai & Van de Sluijs, 2007; see Figure 3). In addition, different types of climate information are needed throughout the process (may require past and current climate to inform the vulnerability assessment prior to future climate projections);

	Agreement and values and objectives	**Disagreement and values and objectives**
Certainty and agreement on knowledge	Structured	Semi-structured
Uncertainty and disagreement on knowlegde	Semi-structured	Un-structured

	Outcome preferences certain	Outcome preferences uncertain
Cause-effect relations certain	Causation and outcome preferences are certain – data are voluminous **Computational strategy**	Uncertain due to - opposing preferences - external constraints **Compromise strategy**
Cause-effect relations uncertain	Uncertain due to - incomplete knowledge - inherent uncertainty - competition with rival decision-makers **Judgmental strategy**	Uncertain due to - a combination of reasons **Inspirational strategy**

Figure 1. Type of problem (top panel; after Hisschemöller, 1993) and related strategies to solve the problems (Source: Thompson, J.D. (1967/2003).

[7] E.g. only presenting one scenario does not give the message that the future is uncertain.

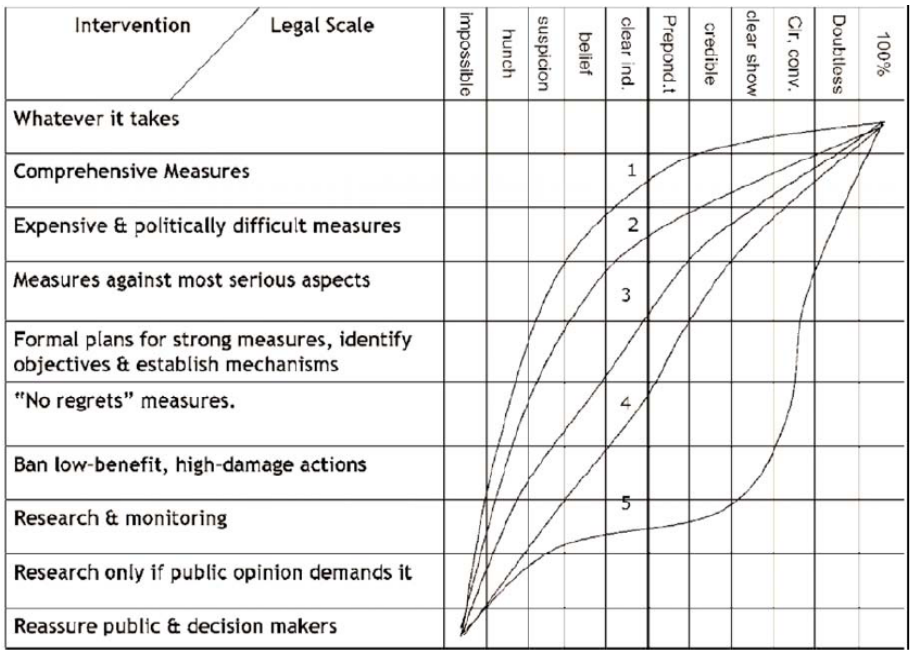


Figure 2. Effect of risk aversion on required scientific information: Justified levels of interventions (vertical axis) to address shared danger of severe and irreversible harm, as a function of the level of scientific evidence (horizontal axis) and degree of risk aversion (numbered curves) (Weiss, 2003 in Dessai & Van de Sluijs 2007).

- What is the organizational structure of the organization/company and how may this affect the manner in which the requested information/data will be used (e.g., decision making and further dissemination and communications within the organization/company, with shareholders and other stakeholders)?
- Where the information/data is being used to support the identification and assessment of adaptation options, providers should seek an understanding of the approach being used. For example, if an adaptive management approach is being used (Dessai & Van de Sluijs, 2007), observed climate information and data may be more important than that related to long term climate scenarios. This may also be the case for the evaluation of implemented adaptation measures for which the performance relative to coincident climate relative to objectives is important (as well as continued performance in the future);
- When is the information/data needed? Depending on this timing there may or may not be time for the development of targeted information/data. Does the timing of publication of new climate scenarios (or other data/information) make information more or less relevant? For example, decisions to be made or other end-products stemming from the use of climate information/data which are to be completed prior to the publishing of a forthcoming new set of climate scenarios or observed information and data.
    - What does this mean for the relevance of the decisions or other end products produced? Can this situation be mitigated through closer engagement between providers and users?
    - This also requires clear articulation of why the new information/data has been developed and how its use will improve/better inform the intended purpose;
    - This also leads to the need for an understanding and communicating that understanding as to the implications of new climate information/data (scenarios or updated observational) for the studies, assessments, strategies, communications or plans based on that previously available?
- What are the capabilities of the users? What is their background knowledge, do they need a lot of guidance in using, processing, interpretation, communicating climate data/information?

- In case of purveyors also: who are their intended clients? How did their networks evolve?
- If users have used climate services in the past, it would be useful to understand where, what and why they used those services and how have they searched for and identified those services. Has this got to do with credibility of the provider?

In a more general sense and in the context of better understanding how to improve the effectiveness/relevance and delivery of climate services, providers have also expressed an interest in better understanding:

- Users' decision spaces in the broader sense (sectors where needs are greater, where are vulnerabilities/risks high, drivers of concern, risk appetite and timeframes for decisions/ policies)
- Valuing of climate services from the perspective of users (purveyors and end-users) and their perspectives of the need and potential for establishing standards;
- Nature and scope of current and future users' needs (foresight) and users' current and changing technical capacity to ingest climate services;
- Capacity (including funds) and willingness to be engaged in developing and delivery of climate services and in climate services science;
- Breadth of users those engaged represent and how to engage better the spectrum of users. However, it may be difficult to engage them collectively, due to competition among them;
- Perspectives on the scope of services that users expect to be available free of charge and for which there is a 'willingness' to pay. These perspectives may differ considerably by country and user types, potentially related to the current structure and governance of climate services, current availability and the prices of climate services;
- How users value and judge credibility of climate services and providers of those services.

When is data/information useful/relevant?

Users require data, information, and knowledge that is both relevant and useful to the context in which they intend to use it. McNie (2007) defines useful data in science by salience, credibility and legitimacy. Useful data will account for these three points in a balanced way:

- Salient information/data are context sensitive and tailored to the users' requirements. For example, an urban administration is interested in very high spatial and temporal resolution precipitation data, such as that required to assess possible discharges for planning an urban sewerage system. For such users, climate scenarios from Global Circulation Models (GCMs) with only average changes are obviously insufficient for making appropriate decisions;
- Data users should consider the information/data they are working with credible. Credibility in the data may be achieved by various pathways ranging from scientific peer review processes, via strong communication between producers and users to the inclusion of users in the data production process. Jacobs (2005) stated ease of interpretation, clear communication of 'accuracy', or the possibility to assess the 'accuracy' of the provided data by themselves (e.g. by hands on training), to be essential. Furthermore, clear communications about the assumptions made, methodological shortcomings, validation methods as well as statements about uncertainties are important attributes that supports enhanced credibility (Maraun et al., 2010);
- Legitimacy means that the provided information/data have been generated free from political persuasion or bias and that the interests of the users have been considered in the generation process.

The above brings in the question of how to evaluate[8] the provided climate services. The general usefulness of data may be judged in various ways, but one should look especially for evidence of utility and relevance (i.e. success) from the users' perspectives.

Intermediaries or translators at the boundaries between producers and users may play a very important role in this framework (Jacobson et al., 2005 in Themeßl, 2011).

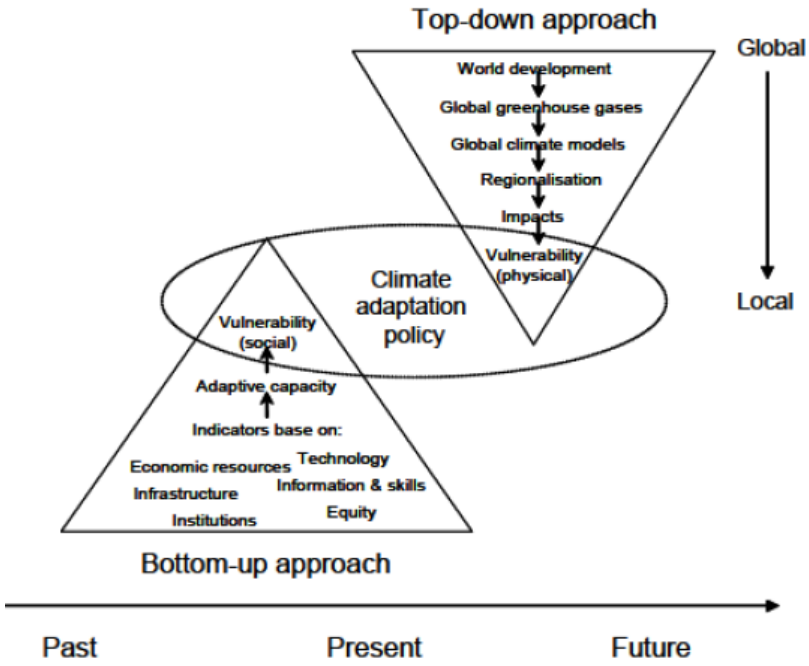


Figure 3. Approaches to climate adaptation (Dessai & Hulme, 2004).

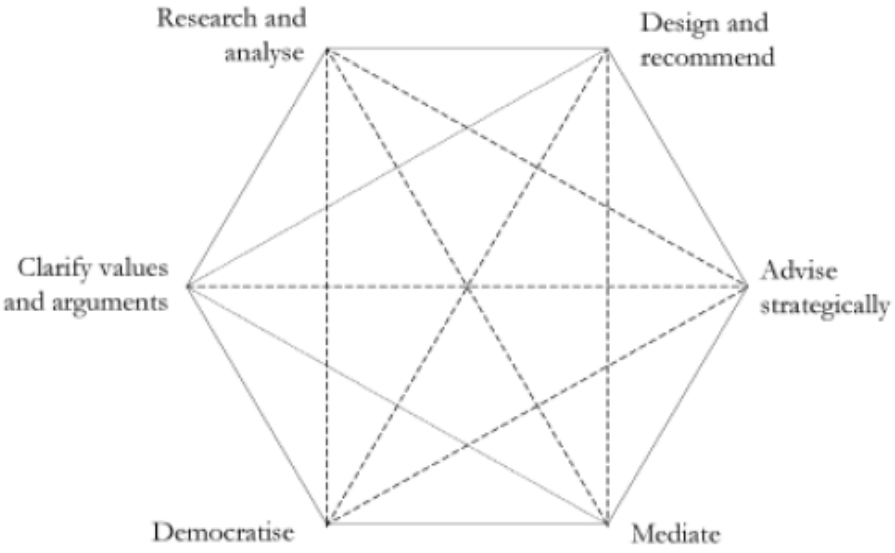


Figure 4. Overview of the six policy analysis styles (Mayer, Van Daalen et al. 2004).

Important for credibility is also the role that a climate service provider plays and that he can and/or is expected to play in society. Figure 4 shows various policy analysis styles. For example, scientific research institutes can play a useful role in decision support

[8] This document hardly gives information on how to evaluate climate services. However, this is an important questions. Contributions on this point are welcome.

through “research and analyse”, however, they often have to be careful when providing strategic advice or recommending the use of specific climate information/data[9] as the advice and recommendation may affect whether they are seen as objective or not.

3.2. What services do users need?

Data, information and knowledge needs

- Climate variables (maximum and minimum temperature, precipitation, extreme precipitation exceeded once in 10 years, cloud cover, etc.), time horizon (current climate, around 2020/2030, around 2050, etc.), spatial and temporal resolution, area-average or point data, etc. (for an example of the type of questions and information collected see annex 1), is a generic set of climate scenarios needed, or tailored/extreme climate scenarios, baseline/reference period (what period and using which set of observational data?
- Similar data/information for impacts such as hydrology, ecosystems, agriculture, health, and other sectors: changes in groundwater levels, production, presence of species; time horizon of interest, spatial and temporal resolution, etc.;
- Input for risk-analysis, e.g. probability or cost-loss estimates;
- Additional data such as land cover data, elevation, social-economic data, emissions (including scenarios for the future);
- Indices and other data related to known thresholds (e.g., heating/cooling/growing degree days, days without precipitation, days with temperature over/under a particular temperature, and special indices (e.g., aridity index, drought indices and those related to extremes such as the STARDEX indices[10]);
- Storylines related to climate trends and projected changes (more than the data) and can be a combination of impacts and adaptation measures related to climate trends and projections; and
- Adaptation options and supportive information (what they comprise and why they were introduced).

Users also require (and request):

- An overview of the available information/data and other available services;
- Consistency between information/data on climate and climate change and its impacts (same time horizon, same climate scenarios, same socio-economic scenarios, etc.);
- Information about uncertainty (e.g., types of uncertainty included, quantification of uncertainties and/or qualitative information, etc.), information on biases in the data and on robustness;
- Scientific and other publications related to the information/data available and its use (building credibility and legitimacy);
- Metadata for the information/data on offer (that required to support an understanding of precisely what it is and its lineage);
- Information related to the evolution of the information/data (e.g., how does current information/data relate to that previously available and expected updates, similarities and differences to allow users to interpret the implications for previous work);
- Tools to generate time series, derived data[11] such as indices, maps;
- Case studies of good/acceptable and bad examples of uses of the available services, including what and how the information/data was used and why. Users often find in easier, informative and reassuring to refer to examples of what others have done, especially if first time users or undertaking a new task;
- Information about the financing aspects of their needs.

Presentation and accessibility needs (and related interpretation):

[9] This may go beyond their scientific position and in that case should not be recommended.
[10] http://www.cru.uea.ac.uk/projects/stardex/reports/STARDEX_FINAL_REPORT.pdf, http://www.cru.uea.ac.uk/cru/research/stardex;
[11] An example of a website with such tools is the ECA&D website: http://eca.knmi.nl/.

There is a need to understand what makes presentation/accessibility (websites, brochures, etc.) user-friendly. This starts with understanding the capabilities of targeted users (ability to access and use information/data) and their specific needs. Considerations include:

- Language – appropriate for the intended users;
- Data formats (ASCII, xls, netCDF, GIS, etc.) preferences;
- Presentation of metadata, guidance and support information (accessible and can be interpreted relative to the intended use);
- Alternative presentations such as interpretations using tables, graphs, maps, including their specific formats, usability and accessibility;
- Preferences for presentation of uncertainties - to facilitate awareness, interpretation and use of the associated information;
- Preferences for the way information/data can be accessed: documents, brochures, website (navigation and readability of a website needs to be user-friendly, e.g., balance between efficient, self-explanatory, comprehensive and logical);

Decisions about presentation and the right level of user-friendliness should be taken with the intended users. These decisions should be based on personal contact/engagement with the intended users with reference to the need for professional data preparation and data accessibility, as well as consideration of whether the requirement is a customized service or can be pulled from standard products.

Guidance and other support

Evidence, based on experience and expressed requirements by both users and providers, means that provision and access to information/data should be supported with guidance and other support services, information and knowledge. These should include:

- Training (courses and on-line training either general or targeted to specific users or user groups), and on various aspects such as the use of climate data in general, statistics, processing of climate data, presentation of uncertainties, etc.);
- Guidance related to:
  - How to and how not to use climate information/data, including responses to individual questions/problems (e.g., Frequently Asked Questions);
  - How to deal with possible inconsistencies between the climate data/information that can be delivered for the current and future climate? For example, for the current climate statistics are available on extreme 5 minute precipitation, but this cannot be delivered for the future, since climate models don't provide output per 5 minutes, and even the hourly outputs from climate models are rarely validated (this means we do not know what is the reliability of these data);
- Access to means of seeking help or further assistance (e.g., e-mail, telephone and personal contact), potentially including reviewing of proposed outputs;
- Access to case studies providing examples of good/acceptable (and improper) uses of the information/data on offer are a useful and seen as essential by many users'.

Decision on what other support is needed should be taken with the engagement of both users and providers. Other support could include providing: links to sources of other data sources (e.g. land cover, elevation); guidance on interpreting metadata; and story lines behind the available information/data. Support could also include providing tools and guidance in support of adaptation assessments and communications or for specific uses such as determining critical thresholds for organizations, systems.

There may also be the need for guidance and other support related to identifying the need for tailored information/data.

Advice

Many users find it difficult to articulate their requirements. The following may help in articulating and understanding their requirements:

- Always ask how and for what purposes the data/information will be used, including who is the intended audience or end-users (e.g. what kind of decisions will be taken and by whom as a result of the data/information to be used). If those requesting the information have not previously used climate information on the future, explore with them how they have used information on the current climate, and try to understand the role and expectations of climate information within their intended use (e.g., its place within the decision-making process and how the climate information will be included in the dissemination);
- Ask people to provide their perspective of what constitute good/useful (and bad) examples of information/data and its presentation and accessibility. For many it is often easier to refer to examples of what has been useful data/information, than to formulate themselves what they need (for examples see Chapter 6);
- Sustained personal contact with specific users may be needed to get an informed insight into their needs and use of climate data/information. This can be achieved through sustained engagement such as working together to tailor specific projects, engagement throughout the development and delivery of climate services, and working sometime in the organization of the user/stakeholder (see also Chapter 5);
- Consider the background of the user when looking for information, since the practices may be different from country to country, the needs different and the ways to approach users different as well.

4. Methods for gathering and analyzing information on users' requirements

In all European countries some information is available on users' requirements, from practise or from targeted inventories. However, relatively little of this information is documented and the information is fragmented and scattered. Besides this, users' requirements can be very diverse (users are very diverse) and requirements may change over time.

Although information on users' requirements is preferably collected in a systematic way, this is not always possible because, among other reasons, users do not necessarily have the same experience or opportunities to articulate their requirements. As such, various methods are and can be used. It is suggested that where information on users' requirements is collected using one or a combination of methods, that information and the resulting analysis should be checked/verified with the representatives of the targeted users.

Possible ways to collect information on users' requirements:

- Questionnaire (web-based or through focus groups and personal interviews);
- Workshops/meetings with a group of representative users (can be organized for specific sectors or groups of users, or for broader groups of sectors and users). Care should be taken that a representative set of users participate (e.g., range of appropriate types of users, capabilities and sectors) and that methods employed within the workshop provide opportunities for all participants to express their views and perspectives regarding requirements);
- Personal contacts with users, either short contacts (requests for advice/information) or contacts in longer lasting projects (need to ensure that requirements are properly noted and recorded;
- Interviews with providers of climate services drawing on their experiences of working with different users: information about users' requirements can probably also be collected from questions (or frequently asked questions). National Meteorological and Hydrological Institutes (NM(H)I's), other providers of climate services also have some knowledge about users' requirements;
- Drawing on existing information on users' needs from other countries (or earlier compiled inventories in the same country). Care should be taken when interpreting users' requirements from other countries to ensure that circumstances (e.g., scope of users' requirements, including capabilities and areas of interest) are similar by verifying those results with users within your own country;
- Drawing on comments by users of existing climate information/data and supportive information (e.g., what they liked and did not like, and what was missing). Many users already access climate information/data from domestic and international sources for a wide variety of potential providers, including data , information in documents or web-based, and advice resulting from research and other projects;
- Information on users' requirements may also be collected in a two-step or iterative approach. In the first step, information related to the most important questions or issues related to the intended use (i.e. framing and context) and the information/data that could be used to address these is compiled by involving both users and providers. In a second step, this compilation and the resulting recommendation are considered by both users and providers as to whether the recommendations (including the identified information/data and supportive materials) is indeed fit for purpose;
- As part of the above methods, opportunities should also be sought to understand requirements and capabilities with respect to requirements related to the presentation and accessibility of information/data, supportive guidance and resources (i.e. what constitutes user-friendly to the different users).

When part of an overall, long-term engagement strategy and plan involving both users and providers the following may also provide useful information:

- To support the identification and analysis of users' requirements, a method comparable to the SCRUM method may be used (http://en.wikipedia.org/wiki/Scrum_(development)), in which regular feed-back of (potential) users on their requirements can be obtained. There is a need to take care that this is truly engagement and that the reasons behind the resulting positive and negative feedback is sought. In addition, responses to the feedback should be recorded and communicated to those participating (necessary to encourage and show the benefits of engagement);
- User Requirement Documents (URDs) for websites on climate (change) and data portals may also contain useful information, especially when they are developed together with users;
- Mapping of relations/information networks/issues/opinions may be useful to get insight in the decision processes and how climate information is used?

Meetings and workshops with users (and providers) may be one of the methods employed to understand users' requirements, but these can also be useful to support the overall development and delivery of climate services. Preferably, such meetings and workshops should not be limited to one as their continued and informed engagement is critical to both the development and delivery of climate services that are both relevant and critical. For example, engagement can improve understanding by both users and providers of users' requirements and the potential for meeting those needs (including potential enhancements to existing services), but also provide opportunities to articulate and understand changing requirements and supply of information/data. As such, regular engagement of users and providers can also improve credibility, relevance of the services and salience.
This engagement can also play a role in enhancing users' awareness of their vulnerabilities to current and future changes in climate, including variability and extremes; the role and value of climate data/information in their research, assessment, decision-making and communication processes; and possible opportunities and constraints in the use of climate information/data. This type of engagement can also be used to provide information about where users should be obtaining their required information/data, what is the quality and robustness of that information/data, how do they determine/verify that quality and robustness, as well as providing providers with information of the value of information/data available and where there may be opportunities to enhance existing or to provide additional services. Users may also get a better understanding as to how robust is their use of climate information/data, whether the climate information/data used and the methods used reflect the associated importance/vulnerability/risks, etc.).

Advice

- What is the aim and available time and budget: look for methods that match these;
- Good insight into users' requirements cannot be achieved in a limited time and through limited consultations. As a provider, try to build up a relation with the users of your climate services by regular contact and exchange of information. This sustained engagement can help you understand their requirements; including how and why their requirements are evolving, and it can provide users with information on the services that are available, including how and why the services available may also be evolving. Thusly informed there is a better understanding of what can and cannot (limits) be delivered and how that information can and should not be used;
- Seek appropriate expertise, guidance and training to support the methods you as a provider have decided to use. These include those related to planning and running productive workshops, stakeholder (users and providers) engagement, interviewing techniques, and developing, administrating and analyzing questionnaires and surveys.

5. Some experiences/lessons learned from other projects/countries

See also the advice at the end of the former Chapters.

1. Difficult to get into contact with representative users for specific sectors, because:

- The requirements of users within one sector may differ considerably. Those working on impacts or the more technical aspects don't always know (often don't know) what the policy makers in the same sectors need. Besides, there may be different "schools" within a sector (e.g. in the Netherlands there are water boards that use climatological time series for impact studies and do statistic calculations afterwards based on the results of hydrological models, However, there are also water boards that use the "stochastical method" is which the statistical calculations take place before the hydrological impact analysis).
- Those that may have an overview of the sector don't always know what are the exact/real requirements of the various user groups within a sector.

Advice:

- Use your contacts in projects where you are working together with users. They may help you give an overview of the various representatives within a sector (organizations and persons), whether there are various "schools", etc.)
- Get into contact with professional organizations that represent specific users in specific sectors;
- Understand the representativeness and reach of those you have engaged (i.e. the breadth of the users within a sector they represent)
- Look for representatives of the various user groups in the same sector;
- Do not expect to have a representative group/network within a short time;
- Realize that users' requirements may change, but also that the users within a given sector can change.

2. Be aware of differences between user groups.

Advice

- Some user groups have much more experience with using climate data and information, than others. Those with little or no experience often *have difficulty articulating their requirements and are often uncomfortable at voicing their needs* when in the presence of more sophisticated users. Ensure that these users are provided with opportunities to voice their needs;
- Some groups have much more experience with using future projections than others. Those that have little experience *often ask the same information for the future that they are also using for the current* (or past) climate. However, in several situations it is impossible to deliver exactly the same type of information for the future. For example, current climate statistics are available on extreme 5 minute precipitation, but this cannot be delivered for the future, since climate models do not provide output per 5 minutes, and even the output on hourly basis of climate models is rarely validated (this means we do not know the reliability of these data). Limitations and the rationale for them should be clearly articulated;
- Some user groups have much more background information/knowledge on climate and climate change than others. Those with little background knowledge often have *difficulty articulating what they require*, and also they have no or limited understanding of what is possible. It takes more time and effort/interaction to understand the requirements are of groups with little background knowledge and to explain what can and cannot be delivered.

3. Exploring with users their requirements may result in high expectations of what will be delivered later on.

Advice:

- As part of the process gathering information on users' requirement, feedback should be given on what is possible to deliver and what is not and why. In other words, an early focus on *expectation management* – check what users require and why, tell them what is possible and what is not and why, including the dilemmas (e.g. higher temporal resolution may result in less spatial resolution). This clarification can be beneficial when part of a longer term engagement process.

4. There may also be a discrepancy between what users desire and what is scientifically sound to deliver. For example, some impact researchers use as input into their models gridded data sets at a spatial resolution of 250 by 250 m. For climatological data no such high spatial resolution can be delivered, since the observational network does not cover all climatological differences at that scale. A gridded data set of 250 by 250 m can be prepared, in principle, however, the users should be aware of the limitations of such a dataset. The quality of information and the reliability of models constrain the type of information which we can provide the end-users, no matter how much they desire a specific type. Many end-users do not understand the assumptions made - they are rarely climate experts.

Advice:

- Be aware of how users may interpret data and information that you present. They often do not read information on assumptions and limitations that is supplied along with data sets, especially when it is longer than half a page (they will only start reading when things go wrong, unexpected results are obtained, etc.). However, you are not responsible for incorrect use, when you gave sufficient background/guidance information[12];
- Do not provide through a website that is publicly available data/information that need a lot of guidance to support its correct use and interpretation. Supply these data preferably after personal contact through "restricted areas", such that the presentation can be targeted to the needs and capabilities of specific users;
- Case studies (especially those conducted by peers) and information on how to use and not to use (or interpret) climate information can be very helpful to users;
- As part of the supplied metadata, information on the limitations of datasets should be provided. For example, when providing a gridded temperature dataset at a spatial resolution of 1*1 km or 10*10 km, the metadata should explicitly state that the spatial resolution is lower and interpretation of this data should recognize that the effect of spatial differences in surface characteristics on temperature is not modeled or observed at a resolution of 1*1 km or 10*10 km.

5. It may be difficult to get a good overview of users' requirements when you have little contact with them. Sometimes it happens that users initially come with a request for data/information and then after some time (months?) they return phrasing/articulating their requirements in a different way, and it appears that they need quite different information.

Advice:

[12] Legal liability may be different in each country. Try to make a reasonable effort to draw to the attention of users to the specific assumptions and limitations that may affect their intended use (possible when there is informed engagement with the users). Having done so and supplied the users with sufficient information and guidance does not necessarily prevent users from incorrectly using the data/information, but they have been advised.

- It is advisable to seek to understand users' requirements through regular contact/engagement, including in some cases by working together as they undertake their intended project(s). Generally, this level of engagement leads to both the users and yourself better understanding their requirements and how best to respond with climate data/information.

6. Difficulties in providing information to non-technical users.

Advice:

- Close the gap by "adapting" the information provided and the means of delivering it according to the capacity and background of the specific user;
- There is especially a need under these circumstances to ensure that both users and providers understand what the other is saying. As the language used may be different, this includes confirming with the user your understanding of their request and verifying with them the suitability of what is being provided.

7……. (experiences from other countries?)

Experiences from other countries and providers are welcome and may be included in later versions of this document. Please send your experiences and advices to bessembi@knmi.nl.

6. Examples from other countries that could be used during assembling an inventory of users' requirements

To provide inspiration, the following are examples of climate services provided and examples of questionnaires and questions that others have used when seeking to understand users' requirements.

The questions in Par. 6.2. focus on seeking to understand the purpose for which users need data/information, how it will be used, what is the context, who will use the results of his/her work, etc.? Experience has shown that not all users clearly understand nor can they clearly articulate what they need. It is for this reason that when trying to understand their requirements, examples should be sought, for example, as to:

- How they have previously dealt with climate information; and
- How they have previously dealt with uncertainties about the future (not necessarily related to climate information/data)?

Examples can be very illustrative. When the users have difficulties giving examples, providing examples of how others used climate data and dealt with uncertainties can be helpful. The reaction/opinion of the users to these examples may give useful information.

6.1. Examples on what services users need and what services are provided

See Annex 1 for examples of questions/aspects treated in earlier inventories. You can use the examples below from other countries and let users comment on: what is useful and why, what is not useful, what is user-friendly presentation, what are they missing, etc.

Websites and documents from other countries that can be used:

Austria

- **Climate scenarios**: Project reclip:century with a data download and visualization tool: http://sf5.arcs.ac.at/reclip_century/dl/explore.html
- **Climate data**: Austrian Met Service (ZAMG, http://www.zamg.ac.at/cms/de/klima/produkte-und-services, and hydrological service Austria; download portal: http://geoinfo.lfrz.at/eHYD/frames/index.php?PHPSESSID=d163ba897d9b6fe7af3c2a6b474392d3&146=true&gui_id=eHYD; small scale observational network Wegener Net: http://www.wegenernet.org/
- **Climate change impacts and adaptation:**
- **Uncertainties**: Project reclip:century, report: http://reclip.ait.ac.at/reclip_century/index.php?id=8
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

Belgium:

- **Climate scenarios**
- **Climate data**:
- **Climate change impacts and adaptation**:
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

Denmark

- **Climate scenarios**: http://www.klimatilpasning.dk/en-US/Service/Climate/DenmarksFutureClimate/Sider/Forside.aspx

- **Climate data** :
- **Climate change impacts and adaptation**: http://www.klimatilpasning.dk/en-us/Sider/ClimateChangeAdaptation.aspx;
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication**:

Finland:

- **Climate scenarios:** http://ilmasto-opas.fi/en/ilmastonmuutos/suomen-muuttuva-ilmasto/-/artikkeli/74b167fc-384b-44ae-84aa-c585ec218b41/ennustettu-ilmastonmuutos-suomessa.html
- **Climate data**: http://ilmasto-opas.fi/en/datat
- **Climate change impacts and adaptation**: changing climate zones (http://ilmasto-opas.fi/en/ilmastonmuutos/ilmio/-/artikkeli/962d9aa2-e7e3-4df5-89a2-9f1f653e0d4e/ilmastonmuutos-ilmiona.html); relevant impacts for Finland (http://ilmasto-opas.fi/en/ilmastonmuutos/vaikutukset); adaptation challenges in Finland (http://ilmasto-opas.fi/en/ilmastonmuutos/sopeutuminen/-/artikkeli/c6c4fc92-cf01-43c4-b9d6-866d4f2e00f1/sopeutumishaasteet-suomessa.html)
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication**: website (http://ilmasto-opas.fi/en/)

France

- **Climate scenarios**: http://www.drias-climat.fr/; Espace Accompagnement : users'guide and good practice
  Espace Découverte : information and exploration
  Espace Données et produits : data and products
- PRODIGUER database for CMIP5 and CORDEX
- **Climate data**: climate model data http://www.drias-climat.fr/commande
- **Climate change impacts and adaptation:** national programs: GICC from Ministry of Environment (http://www.gip-ecofor.org/gicc/), ANR programs (several under Environment), Paris Consortium "Climate-Environment-Society" (http://www.gisclimat.fr)
- **Uncertainties**: within projects, discussed at workshops
- **Case studies**: Practice oriented projects (http://www.gip-ecofor.org/gicc/?q=en
  Research program led by the Ministry in charge of the Environment (MEDDE) and the French Observatory of Climate Change effects (ONERC). Topics: climate evolution, impacts on ecosystems, human health, adaptation, etc. Objectives: development of scientific knowledge for public policies
- **Inventories of users' requirements:** SECIF for industry
- **Communication:** http://www.developpement-durable.gouv.fr/-Publications-sur-le-changement-.html ; see also : http://climat.meteofrance.com/

Germany

- **Climate scenarios**: Deutsche Wetter Dienst (http://www.dwd.de/bvbw/appmanager/bvbw/dwdwwwDesktop?_nfpb=true&_pageLabel=dwdwww_start&T998038271711963283542 69gsbDocumentPath=Navigation%2FOeffentlichkeit%2FHomepage%2FKlimawandel%2FKlimawandel__neu__Klimaszenarien__node.html%3F__nnn%3Dtrue); Climate Service Centre (http://www.climate-service-center.de/009940/index_0009940.html.en); Regionale Climaburo: http://www.regionaler-klimaatlas.de/klimaatlas/2071-2100/jahr/durchschnittliche-temperatur/deutschland.html
- **Climate change impacts and adaptation:** coastal defense (http://www.sturmfluten-klimawandel.de/ostsee.html)

- **Uncertainties**:
- **Case studies**: Practice oriented projects
- **Inventories of users' requirements:** Responses to enquiries
- **Communication:** Supporting interpretation of climate simulations; Consultations: Nord-Deutsches Klimaburo (http://www.norddeutsches-klimabuero.de/regionaler-klimabericht.html)

Italy

- **Climate scenarios:** Division at Euro Mediterranean Center on Climate Change on "Numerical Applications and Scenarios division -ANS –" (http://www.cmcc.it/research/research-units/ans/description-1/?searchterm=climate%20scenarios); Project CLIMADAPT, Climate Adaptation – Modelling water scenarios and sectoral impacts (http://www.cmcc.it/research/research-projects/concluded-projects/climate-adaptation-1/?searchterm=climate%20scenarios); climate change projections (http://www.cmcc.it/data-models/database/climate-change-projections)
- **Climate data**: Models and observations (http://www.cmcc.it/data-models); climatology (http://www.isac.cnr.it/~climstor/climate_news.html#long-term); Models and observations analysis, Multivariate Statistics,..eg: A Guide to Empirical Orthogonal Functions for Climate Data Analysis (http://www.cmcc.it/blog-en/a-guide-to-empirical-orthogonal-functions-for-climate-data-analysis-the-book-by-antonio-navarra-and-valeria-simoncini/?searchterm=%E2%80%A2Climate%20data); ODAS - Ocean Data Assimilation System (http://www.cmcc.it/data-models/database/oda-ans-ma2/?searchterm=%E2%80%A2Climate%20data); ClimateAdapt project (http://climate-adapt.eea.europa.eu/)
- **Climate change impacts and adaptation**: Italian initiatives on climate change (http://www.cmcc.it/ipcc-focal-point-1/italian-initiatives-on-climate-change; Water and energy balance, Impacts of climate on agriculture, economy, forest, oceans and coasts, Land capability and land sustainability analysis); Water and energy balance, Impacts of climate on agriculture, economy, forest, oceans and coasts, Land capability and land sustainability analysis. E.g. ETC-CCA - European Topic Centre on: Climate Change impacts, vulnerability and adaptation 2011-2013 (http://www.cmcc.it/research/research-projects/etc-cca-european-topic-centre-on-climate-change-impacts-vulnerability-and-adaptation-2011-2013/?searchterm=%E2%80%A2Climate%20change%20impacts%20and%20adaptation); Division at the Euro Mediterranean Center on Climate Change "CIP-Climate Change Impacts and Policy Division" (http://www.cmcc.it/research/research-units/cip/climate-change-impacts-and-policy-division-cip/?searchterm=%E2%80%A2Climate%20change%20impacts%20and%20adaptation)
- **Uncertainties**: Modelling Negotiated Decision Making: a Multilateral, Multiple Issues, Non-Cooperative Bargaining Model with Uncertainty (http://www.cmcc.it/publications-meetings/publications/research-papers/previous-series/working-papers/0012-cip-wp12/?searchterm=uncertainties)
- **Case studies**: CLIM-RUN-Local Climate Informations to Respond to Users Needs" project (http://www.cmcc.it/research/research-projects/clim-run-local-climate-informations-to-respond-to-users-needs)
- **Inventories of users' requirements:**
- **Communication**: http://clima.meteoam.it/; There will be a section on climate services in the near future on www.cmcc.it

Netherlands

- **Climate scenarios**: http://www.knmi.nl/climatescenarios/; for relation with socio-economic scenarios see: http://www.knmi.nl/climatescenarios/knmi06/ipcc.php;

variables for which changes are given in the KNMI'06 climate scenarios for 2050 and 2100: http://www.knmi.nl/klimaatscenarios/knmi06/samenvatting/index.html#Inhoud_2;

- **Climate data:** Climate explorer (database and downloading, visualization statistical processing tools: http://climexp.knmi.nl (EN)); Tool for producing time series for temperature and precipitation for the future (in Dutch): http://climexp.knmi.nl/Scenarios_monthly/; background document (in English): http://www.knmi.nl/bibliotheek/technischrapport.html…….
- **Climate change impacts and adaptation:** research programme "Knowledge for Climate" (http://knowledgeforclimate.climateresearchnetherlands.nl/); Climate impact guide (http://www.klimaatportaal.nl/pro1/general/start.asp?i=7&j=1&k=0&p=0&itemid=866&folder=Klimaat%20Effect%20Wijzer&title=Home%20Klimaat%20Effect%20Wijzer)
- **Uncertainties**: general description of uncertainties in weather/climate data (http://www.knmi.nl/klimaatmaatwerk/KEW/onzekerheden/index.html); High-end climate scenario (http://www.deltacommissie.com/en/advies); scientific report KNMI'06 climate scenarios (http://www.knmi.nl/climatescenarios/documents/WR23mei2006.pdf);
- **Case studies**: tailoring of climate data for various sectors (in Dutch, some documents in English): http://www.knmi.nl/klimaatscenarios/maatwerk/index.html; see e.g. the climate sketchbook with maps for the future climates: http://www.knmi.nl/klimaatscenarios/maatwerk/ro/Klimaatschetsboek.pdf;"Climate Impact Guide" with also information on impacts of climate change (in Dutch, some documents in English): http://www.klimaatportaal.nl/pro1/general/start.asp?i=8&j=1&k=0&p=0&itemid=866;
- **Inventories of users' requirements** (NL, with long summary in EN): http://www.knmi.nl/bibliotheek/technischrapport.html Technical report 317;
- **Communication:** Brochures on KNMI'06 climate scenarios: 2006 (http://www.knmi.nl/publications/fulltexts/knmi_eng_lr.pdf) and 2009 (http://www.knmi.nl/climatescenarios/documents/KNMI_2009_EN.pdf); Klimaatportaal (information from all scientific institutes in the Netherlands working on climate change, impacts and adaptation: www.klimaatportaal.nl).

Norway:

- **Climate scenarios:** http://noserc.met.no/ http://www.regjeringen.no/nb/dep/md/kampanjer/klimatilpasning-norge-2/temperatur--og-nedborendringer-2050-og-2.html?id=609105
- **Climate data**: arcticdata.met.no, yr.no, eklima.met.no, www.senorge.no, ftp://ftp.met.no/projects/klimagrid/
- **Climate change impacts and adaptation**: http://www.regjeringen.no/en/dep/md/kampanjer/engelsk-forside-for-klimatilpasning.html?id=539980
- **Uncertainties**: see under climate scenarios
- **Case studies**: see under climate scenarios
- **Inventories of users' requirements:**
- **Communication:** yr.no, http://www.cicero.uio.no/klima/, http://www.klimaloftet.no/

Portugal:

- **Climate scenarios**
- **Climate data**:
- **Climate change impacts and adaptation**:
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

Spain:

- **Climate scenarios**
- **Climate data**:
- **Climate change impacts and adaptation**:
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

Sweden:

- **Climate scenarios:**
- **Climate data**:
- **Climate change impacts and adaptation**:
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

Switzerland

- **Climate scenarios**: http://www.climate-change.ch/4DCGI/wetter_klima/detail_all?2110;
- **Climate data** : http://www.climate-change.ch/4DCGI/wetter_klima/daten_all.html
- **Climate change impacts and adaptation**:
- **Uncertainties**:
- **Case studies**:
- **Inventories of users' requirements:**
- **Communication:**

UK

- **Climate projections**: UKCP09 website and User Interface; UKCP09 Technical Notes and Reports (see http://ukclimateprojections.defra.gov.uk)
- **Climate data**: http://www.metoffice.gov.uk/climatechange/science/monitoring/ukcp09/download/index.html
- **Climate change impacts and adaptation: UKCIP (see http://www.ukcip.org.uk) and Environment Agency Climate Ready (seehttp://www.environment-agency.gov.uk/research/137557.aspx)**
- **Uncertainties**: UKCP09http://ukclimateprojections.defra.gov.ukUKCIP (http://www.ukcip.org.uk/risk/)
- **Case studies**http://ukclimateprojections.defra.gov.uk/23081
- **Inventories of users' requirements:** UKCIP http://www.ukcip.org.uk/resources/ukcp09/what-users-wanted/
- **Climate Service Science, including understanding users' and providers' needs**:http://www.ukcip.org.uk/essentials/adaptation/climate-services-science/
- **Communication**: Frequently asked Questions (see http://ukclimateprojections.defra.gov.uk/22543)

European

- **Climate scenarios**[13]: European projects (ENSEMBLES, COMBINE, IMPACT2C …), Access to CMIP5 and CORDEX data trough ENES infrastructure (http://enes.org, IS-ENES project)

[13] The term climate scenarios are used in different ways: for climate model runs with different emission scenarios, but also for climate scenarios that are derived from climate model simulations. Sometimes the term is also used for changes in individual climate variables (without considering consistency between various

- **Climate data**: ECA&D, European Climate Assessment & Dataset: http://eca.knmi.nl (EN);
- **Climate change impact and adaptation**: EEA (http://climate-adapt.eea.europa.eu/); Climate adaptation research agenda (http://www.circle-era.eu/np4/CARA); European InfoBase of Climate Adaptation (http://www.circle-era.eu/np4/10); agriculture (http://www.faccejpi.com/)
- **Uncertainties**: EEA (http://climate-adapt.eea.europa.eu/uncertainty-guidance)
- **Case studies**: Climate Services Partnership (http://www.climate-services.org/resource-type/case-studies); IS-ENES prototype portal for climate impact communities (http://enes.org to be delivered soon); CLIMRUN (http://www.climrun.eu/); ECLISE (http://www.eclise-project.eu/)
- **Inventories of users' requirements:** Proceedings from 2011 ISENES-Circle2-EEA workshop on data needs for the impact community (https://is.enes.org/events/is-enes-workshop-on-bridging-climate-research-data-and-the-needs-of-the-impact-community)
- **Communication:** European commission: adaptation to climate change (http://ec.europa.eu/clima/sites/change/); links for Europe and several countries (http://www.circle-era.eu/np4/11)

Other international examples

- **Climate scenarios**:
- **Climate data**: historical and projections for Africa and Asia (http://cip.csag.uct.ac.za/webclient/introduction); Climate explorer (http://climexp.knmi.nl/start.cgi?id=someone@somewhere)
- **Climate change impacts and adaptation:** CLIMAFRICA - Climate change predictions in Sub-Saharian Africa : impacts and adaptations (HYPERLINK "http://www.cmcc.it/research/research-projects/climafrica/?searchterm=%E2%80%A2Climate%20change%20impacts%20and%20adaptation" http://www.cmcc.it/research/research-projects/climafrica/?searchterm=%E2%80%A2Climate%20change%20impacts%20and%20adaptation);
- **Uncertainties**:
- **Case studies**: Climate Services Partnership (http://www.climate-services.org/resource-type/case-studies)
- **Inventories of users' requirements:** WCC3 (http://www.wmo.int/wcc3/documents/WCC-3_Statement_07-09-09_mods.pdf), UNEP Financial Initiative (http://www.unepfi.org/fileadmin/documents/advancing_adaptation.pdf)
- **Communication**:

6.2. Information about how climate data/information will be used

Generally this is the most difficult subject to get information on (users, but also providers of climate information/data, are not always aware of their framing, implicit assumptions/interpretations, etc.). However, for those providing climate services it is essential to understand the intended use of the requested climate data/information, as it will help inform what and how to respond to the request to enhance the relevance and utility of that data/information. Obtaining this understanding generally requires more time and sustained engagement with users. Below are some suggestions of the type of questions, examples, etc. that can be used to enhance your understanding of specific aspects related to the use of climate (change) information.

Questions to understand the background knowledge and capabilities of users:

climate variables). Therefore access to climate model simulations is sometimes mentioned under "Climate scenarios" and in other cases under "Climate data".

- What do they know about the current climate, climate change and the impacts of climate on their and related sectors?
- What is their definition of climate and climate change, climate scenarios?
- Where do they look to find this information?
- Where do they currently get their climate information/data?
- How regularly do they need information on climate?
- In their opinion has the climate changed considerably? If yes, how and since when? If no, why not?
- According to the users, what is the cause of climate change?
- What uncertainties exist about climate change and its impacts? What about these uncertainties, are they important from their perspective and why?
- Questions on their computational skills and data/information handling capabilities: Can they process data themselves? How much time do they have available to include climate information/data? Examples of data they have handled in the past.
- ….

Questions intended to understand the users' framing of climate and climate:

- According to the users, is climate an important issue? If so, what aspects are most important and why? If not, why and what are more important problems/issues and what is the relative role of climate information/data?
- What are important policy issues and sensitive subjects in the users' organizations or sector? Which one is most important?
- Should adaptation/mitigation measures be taken because of climate change and when? Why or why not?
- What is their risk perception and tolerance (use figure about risk aversion)?
- What is their view on the role of the precautionary principle in the context of climate change?
- What are their drivers for using climate data, information and knowledge (internal, external, regulatory, business, policy, etc.)?
- ….

Questions about the organizational structure and decision making process:

- Who decides which scenarios and time horizons you will take into account in your impact studies, decisions or policy making?
- Is there clear agreement in your organization about objectives and values related to addressing climate and climate change?
- Do you know whether your sector/organization is vulnerable to climate (change)? If so, do you know what are critical processes and thresholds?
- Why do you request climate information and why this climate information? Do you consider their sector/company/organization at risk, are there legal requirements to take climate (change) into account, are there other groups that ask about the impacts of climate change? Will you use the climate information/data for decision making about mitigation or adaptation, is it used to increase awareness, or to inform policy or practices?
- Have you identified specific climate-related thresholds or sensitivities? Are there different aspects/parts of your decisions, operations or policies that are more or less sensitive to climate?
- What kind of decision making approach is followed in your organization (see Dessai & Van de Sluijs, 2007)? Is it possible to include climate risks into these processes/methods?
- How do you (and your organization) deal with uncertainties in the information that you use (e.g., socio-economic information/data)? How would you expect to deal with uncertainties in climate information/data?
- What is your risk perception/aversion (see Figure 1)?
- What type(s) of decisions or policy analysis are you undertaking (see Figure 4)? Do these currently include climate information/data? If so, from where is this information/data obtained and why?

- Is it important that you have specific data/information? If so, why?
- Are your decision- or policy-making processes able to address new/updated data and information? What are the decision or policy making timeframes?
- Does your company/organization have a focal point (champion or working group) on the topic of climate or climate change and why?
- ….

Questions about how climate data/information is used:

- What type of information was used by the end-users in the past?
- How is data/information on the current climate used in models/policy making in your organization? From whom did you get this data/information?
- Have you previously used climate data/information about the future?
- Do you process climate data yourself?
- What will be the result of your study and what role does climate data play in the end-result?
- Are you especially interested in certain thresholds, because thresholds are used in decision making? What are critical situations in your sector in which weather/climate plays a role? Can you give examples of these critical situations?
- Have they used or are they capable of using figures/graphs/maps within their decision or policy making process? If so, how would they use them and what would they be trying to conclude?
- What constrains their use of climate data, information and knowledge in their decision and policy making (how and why). This could include information about uncertainty, likelihood, as well timing of availability, access, quality (real or perceived), ability to use (including utility and relevance), etc.
- ….

7. References

Bessembinder J., B. Overbeek & G. Verver, 2011a. Inventarisatie van gebruikerswensen voor klimaatinformatie [Inventarisation of user requirements for climate information]. De Bilt, KNMI. TR-317 (in Dutch, with summary in English; PDF). http://www.knmi.nl/klimaatscenarios/maatwerk/Rapport_gebruikers_april_2011.pdf.

Bessembinder, J. B. Overbeek, B. van den Hurk& A. Bakker, 2011b. Klimaatdienstverlening: Maatwerk [Climate Services: tailoring]. Synthesis report CS7, Climate changes Spatial Planning (in Dutch, with summary in English; PDF). http://www.knmi.nl/klimaatscenarios/maatwerk/index.html see under "Verder lezen/download"

Dessai, S. & J. Van de Sluijs, 2007. Uncertainty and climate change adaptation – a scoping study. University of Utrecht, Copernicus Institute, PBL, UEA Norwich, Tyndall Centre, 95 pp.

Dessai, S. & M. Hulme, 2004. Does climate adaptation policy need probabilities. *Climate Policy* 4(2): 107-128.

Dessai, S., X. Lu, et al. (2005). On the role of climate scenarios for adaptation planning. Global Environmental Change Part A 15(2): 87-97.

Gawith, M., R. Street, et al., 2009. Application of the UKCIP02 climate change scenarios: reflections and lessons learnt. *Global Environmental Change* 19(1): 113-121.

? Hisschemöller, 1993.

Hisschemöller, M. & R. Hoppe, 1995. Coping with intractable controversies: the case for problem structuring in policy design and analysis. *Knowledge, Technology & Policy* 8(4): 40-60.

Hulme, M. & S. Dessai, 2008. Negotiating future climates for public policy: a critical assessment of the development of climate scenarios for the UK. *Environmental science & policy* 11(1): 54-70.

Hulme, M. & S. Dessai, 2008. Predicting, deciding, learning: can one evaluate the 'success' of national climate scenarios? *Environmental Research Letters* 3: 045013.

? Jacobs, 2005.

Jacobs K, Garfin G, Lenart M. 2005. More than Just Talk…Connecting Science and decision making. *Environment* 47: 6–21.

? Jacobsen et al., 2005

Maraun D., Ireson A., Wetterhall F., Bachner S., Kendon E., Rust H.W., Venema V.K.C., Widmann M., Chandler R.E., Onof C.J., Osborn T.J., Sautner T., Themeßl M., Thiele-Eich I., 2010. Statistical downscaling and modelling of precipitation. Bridging the gap between dynamical models and the end users. *Reviews of Geophysics* 48,RG3003. doi: 10.1029/2009RG000314.

Mayer, I., C. Van Daalen, et al., 2004. Perspectives on policy analyses: a framework for understanding and design. *International Journal of Technology, Policy and Management* 4(2): 169-191.

McNie, E. C., 2007. Reconciling the Supply of Scientific Information with User Demands: An Analysis of the Problem and Review of the Literature. *Environmental Science & Policy*, Vol. 10, 17-38.

Shafer, M.A., 2004. Climate Services: Where Do We Go From Here? 14th Conference on Applied Climatology, American Meteorological Society, Seattle, WA.

Swart R., Pagé C., 2010. Defining climate modelling user needs: which data are actually required to support impact analysis and adaptation policy development. American Geophysical Union, Fall Meeting. abstract # GC31E-04.

Swart R., 2011. Bridging Climate Research Data and the Needs of the Impact Community. Discussion paper of the IS-ENES/EEA/CIRCLE workshop, 11-12 January 2012. Copenhagen.

Themeßl, M., 2011. Empirical-statistical downscaling and error correction of temperature, precipitation and derived extremes in Europe. (http://www.uni-graz.at/igam7www-report_45_mtheme_l_june11.pdf). PhD thesis.

Themeßl, M., A. Gobiet & H. Truhetz, 2011. Concept for an Austrian Climate Data Centre (KlimDatZ), WEGC Report to the ACRP Nr. 01/2011

Thompson, J.D. (1967/2003). Organizations in action: social science bases of administrative theory.

Van der Veeken, L.C.a., 2011. Technical and organizational aspects of climate scenarios. MSc thesis, TU Delft.103 pp.

Walker, W., S. Rahman, et al., 2001. Adaptive policies, policy analysis, and policy-making. *European Journal of Operational Research* 128(2): 282-289.

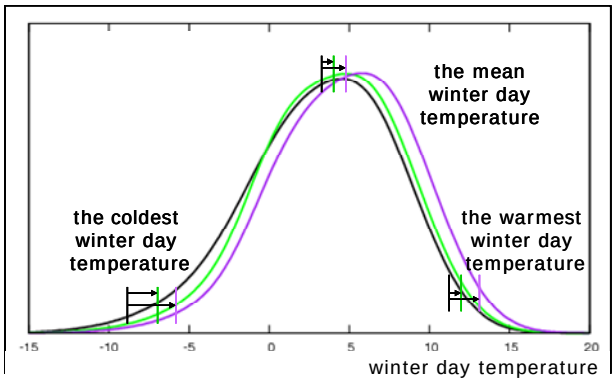
WMO, 2011. Climate Knowledge for Action: A Global Framework for Climate Services - empowering the most vulnerable. No. 1065.

ANNEX 1.

Scheme and questions used in the inventory in the Netherlands (Bessembinder et al., 2011a):

Table 1. Explanation of the tables about user demands per sector.

Variables	Which climate variables are required? For example: sea level, precipitation, extreme precipitation, temperature, wind, humidity? When it is not explicitly indicated whether means or extremes of climate variables are required, than the whole range is required (for example for wind: mean wind speed, but also extremes and the chance of extremes)
Time resolution	Which time resolution is requested per variable? Year, season, day, hour, minute?
Spatial resolution	Which spatial resolution is requested per variable? For example 10 * 10 km, 50 * 50 km, per province or for the Netherlands as a whole?
Time series needed?	Are time series requested? In this report we consider time series to be series of yearly-, daily- or hourly values of climate variables. For example a series with mean day temperature for the period January 1st 1976 until December 31st 2005
Priority in improving time series:	What should KNMI prioritize during the improvement of time series for the future?
- good day-to-day variation	- so a better estimation of, for example, the chance on heat waves or on a sequence of days with extreme precipitation can be given
- good variation within the year (seasons)	- the time series give information about changes in the differences between seasons
- good year-to-year variation	- a better estimation of, for example, the chance on two succeeding dry days can be given
- consistency between variables	- for example, for the estimation of crop yield, the change in temperature on a certain day should fit with the change in precipitation and potential evaporation on the same day
- reference year/ reference situation	- "example" (or reference) years/periods, time series of mean or extreme periods for use in impact analysis of different weather situations (1967 is often used as reference for the mean in hydrological studies, 2003 as example of a drought which can occur about once every 10 years)
Information about the probability of the changes? For which variable and period?	Is information about the probability of the changes needed? If so, which probability is needed? For example: the probability of an increase of the mean daily precipitation, the probability of occurrence of 50 mm precipitation on a day day, or the change on dry periods longer than two weeks?
Are "the most plausible" scenarios enough, or are also "extreme" scenarios required?	Is a set of climate scenarios such as the KNMI'06 scenarios (which together describe the range of most likely changes) sufficient, or are also more extreme scenarios needed (plausible scenarios with a low probability, for example the scenario of the Deltacommittee, which describes an extreme sea level scenario for the Netherlands)?
Is the probability of a scenario requested?	Is the probability of individual scenarios requested? For the KNMI'06 scenarios no information about the probability of individual scenarios

	is provided
Is the probability distribution (natural variation[14]) within a scenario requested?	Is more information about natural variation requested? For example, KNMI '06 gives information for temperature for three points on the probability distribution: the change of the mean, the coldest and warmest winter day temperature (the change is displayed in the figure below with arrows for two scenarios: purple and green). The question is whether these three points on the probability distribution are enough, or that the whole probability distribution is needed? (for example also information about the change in winter day temperature which occurs once every 10 years or 10 times a year). 
Is information about uncertainty in climate change presented in "probability density functions" such as those from UKCP, requested?	Is information per variable about *uncertainty* in climate change per scenario requested? For example: what is the median (50% percentile) of the change of the mean winter day temperature), and what are the 10% and 90% percentiles of the change of the mean winter day temperature? See for more information about types of uncertainty and causes of uncertainty: http://www.knmi.nl/klimaatmaatwerk/KEW/onzekerheden/index.html (Dutch) Example of UKCP: http://ukclimateprojections.defra.gov.uk/content/view/650/
Is a mitigation scenario requested?	Is there a need for a climate scenario with a direct relation with mitigation policy, for example the 2 °C goal?
What is the desired time horizon?	What is the desired time horizon for climate information? The KNMI '06 scenarios give information for the climate around 2050 and 2100. Is for example also information for 2030 and 2200 requested?

[14] Natural variation = in a climate without human influence there is also variation with respect to the "normals", caused by the chaotic character of the weather. This natural variation can be described with statistics, for example: on average once every 10 years an amount of 54 mm precipitation in 24 hours is exceeded in the current climate in De Bilt, the Netherlands.