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ASPECT

MID-PROJECT UPDATE

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Prepared by:
Barcelona Supercomputing Center

ABOUT ASPECT

The need for climate information spanning across multiple timescales to support decision-making for adaptation to a changing climate is becoming increasingly evident. Such information must be robust, reliable and relevant to users in a wide range of sectors.

ASPECT is a four-year Horizon Europe project that explores the frontiers of seamless climate information at seasonal to decadal (S2D) timescales. By delivering continuous and coherent information for the next 30 years, ASPECT simplifies access to information, addressing the challenge of having to interpret multiple and often inconsistent climate products. Ultimately, this facilitates users' uptake of climate information across different timescales, enhancing the management of climate-related risks and enabling better-informed decisions.

The project lays the foundation to establish a seamless climate information system, linked with the Copernicus Climate Change Service. This system will close the gap between climate predictions and projections, delivering actionable, accessible, and user-centred information to support climate resilience across socio-economic sectors.

OUR VISION

The vision of ASPECT is to advance the provision of *seamless* climate information that covers the next months to 30 years, and to make this information usable and actionable for key sectors by working closely with users. The project ultimately strives to enhance decision-making and climate adaptation, and fosters a community of practice to ensure long-term impact and societal transformation.

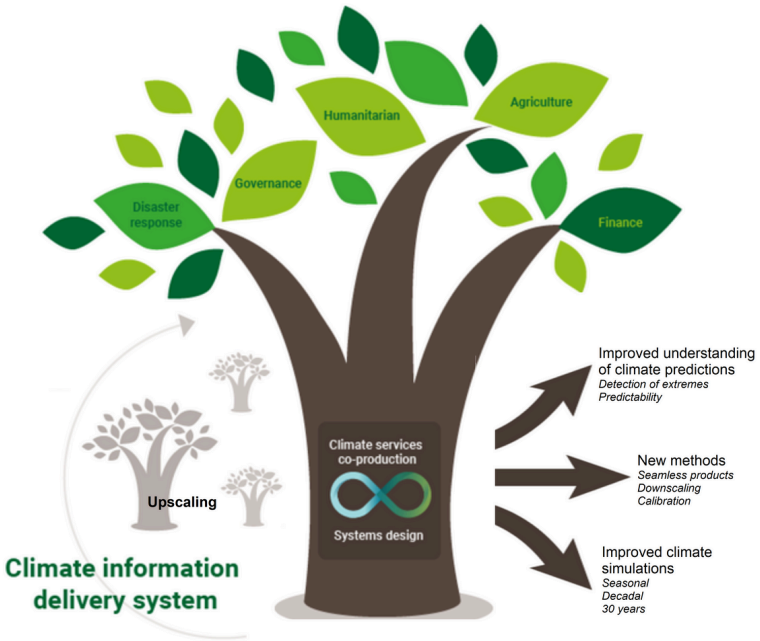
OUR MAIN OBJECTIVES

01.

Improve seasonal-to-decadal forecasts, targeting user-driven metrics and accounting for the signal-to-noise paradox and other model deficiencies

02.

Pioneer new extended initialised forecasts up to 30 years ahead and assess whether they can provide improved information for users



03.

Pioneer new approaches to join the best forecasts on seasonal, 1 to 5-year, and 5 to 30-year timescales, and apply them to user-relevant adaptation decisions

04.

Design and implement new ways to extract high-resolution information on extremes from seasonal to 30-year predictions

05.

Explore for the first time how users can get value from considering information on seasonal, 1 to 5-year, and 5 to 30-year timescales together to improve decision-making

06.

Design and implement a delivery system for the data and methods produced, enabling the scaling up of the use of climate risk information on the 1 to 30-year timescale beyond pilot studies

PROJECT RESEARCH

In ASPECT, various groups of researchers are working across different aspects of climate science and services. These different research lines (in the form of 'work packages') work closely together and share knowledge to ensure the production of user-driven climate information and to support adaptation and better informed decision-making.

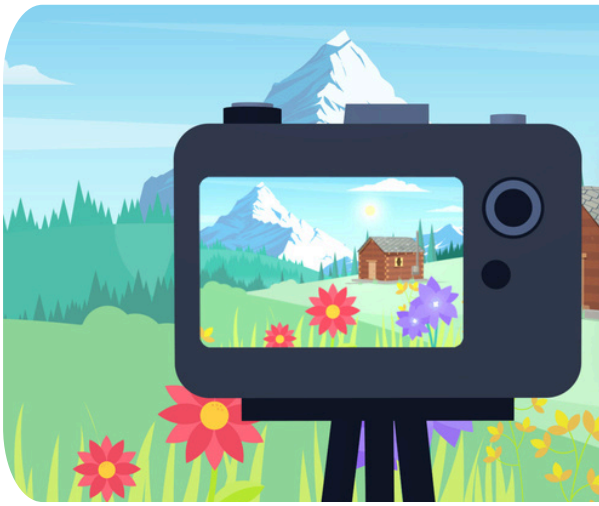
New technical developments, such as improvement of simulations and their quality, and the development of new methods in seamless climate predictions, are in response to a wide range of user needs, including those identified by working with the Super Users (WP1-3). In turn, these developments allow the **co-production of climate services**, considering both current and enhanced climate information, and assessment of the value of this information (WP4).

Engagement with a wider group of potential users through User Forums and other activities seeks to ensure the **scaling-up** of this information and its wider application (WP5). At the same time, the project works to deliver this information, workflows and guidance through a **climate information delivery system** (WP6), while increasing the **visibility of the research and building capacity** for users (WP7).

ASPECT TEAM

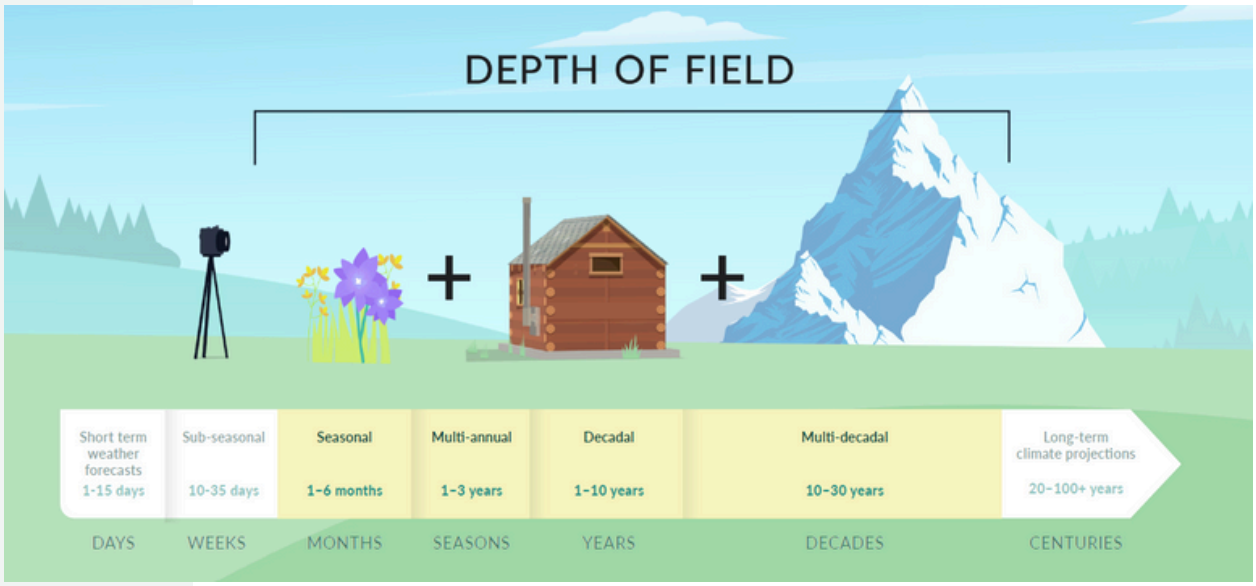
The project consortium consists of **11 partners**, including research centres, universities and end users. This diverse team brings in expertise in a broad spectrum of fields, including natural and social sciences, humanities, communication and economics.

SEAMLESS PREDICTIONS



ASPECT works to develop innovative ***seamless climate predictions*** that provide a single, coherent "image" of the future climate. Just as a camera's depth of field can be adjusted to bring into focus both nearby and distant objects, seamless climate predictions can connect predictions for the next months (seasonal) with longer-term ones for the next decades (multi-decadal).

This unified approach avoids fragmented or inconsistent information, similar to how adjusting the depth of field or changing lenses can make it harder to see the whole picture at once. By providing a continuous, well-aligned perspective across timescales, seamless predictions offer users a clearer and more complete picture of the climate, enabling better-informed decisions for the near and distant future.



USER-CENTRED APPROACH

BUILDING A COMMUNITY OF PRACTICE

ASPECT is building a community of practice in seamless climate predictions. By co-developing prototype services with Super Users and engaging with stakeholders, we work to build capacity for using climate information. This includes developing a community of practice, where users gain the skills to apply or to commission climate services using seasonal-to-decadal climate information. In addition, a wider community of interest is reached, where potential users learn about the benefits of climate information for decision making and are motivated to adopt such information.

Seamless climate information is co-produced through close collaboration with stakeholders (Super Users) from key societal sectors. This approach ensures their needs are understood and met, resulting in information that is scientifically robust, actionable, and tailored to real-world applications. As a result, stakeholders can make informed decisions for climate adaptation and resilience.

Super Users

These stakeholders from sectors like agriculture and finance work closely with ASPECT to co-produce tailored climate information to support their decision-making and adaptation needs.

User Forums

These annual forums bring together users and purveyors of climate data to share new insights on seamless predictions, and support future adaptation efforts.

Case studies

We assess the usability, socio-economic benefits and added value of seamless climate information, exploring its practical applications for adaptation.

Uptake & upscaling

We work to bring seamless climate information into the mainstream, increasing its adoption across users, sectors and regions, and ensuring its wider impact on climate resilience and adaptation efforts.

WP1

IMPROVING SEAMLESS PREDICTIONS

ASPECT works to produce **improved seasonal-to-decadal** (S2D) predictions, delivering seamless climate information that meets the user needs. **New forecast methodologies** are designed across different temporal and spatial scales, supporting operational modeling and monitoring activities, including the Copernicus Climate Change Service (C3S) and Destination Earth (DestinE) initiatives.

Achievements so far

'The first two years of the project have focused on consolidating the suggested improvements in consultation with users and establishing clear experimental protocols. The progress so far involves:

- A *questionnaire* was carried out to obtain feedback on the perceived needs for improvements in climate predictions. The results highlighted the need for increasing the model ensemble size and re-forecast period.
- *New experimental protocols* were defined for seasonal-to-decadal (S2D) and decadal-to-projections (D2P). The protocols have been agreed, while the first round of integrations was completed and communicated to the rest of the ASPECT team to begin with the data analysis and exploitation.

Want to know more?

Seasonal-to-decadal (S2D) predictions cover a period of 2-3 years, and can be seen as an extension of seasonal or a 'zoom' into decadal forecasts. These will be produced twice a year (starting in May and November), with a minimum re-forecast period of 1981-2022 and around 20 ensemble members or more, depending on available resources.

Decadal-to-projections (D2P) are initialised predictions up to 20 or 30 years ahead. These can be considered an extension of decadal forecasts, with less frequent re-forecast samples.

A sneak peek into the results

Improvements in initialisation techniques and in the skill of multi-decadal predictions beyond 10 years were achieved. In addition, work has been carried out to bridge seasonal and decadal predictions and obtain forecasts for up to 24-36 months ahead. Enhancements were also made to traditional systems, such as boosting the ensemble size. These advances can help better predict events such as El Niño or extremes, providing more reliable, actionable climate information for adaptation.

WP2

IMPROVING THE PREDICTION SKILL

ASPECT evaluates how well climate prediction systems can forecast impactful events and extremes (i.e. their **skill**) in Europe and beyond, to support their use in climate adaptation. The project also works to increase the confidence in these predictions by better understanding the climate dynamics behind them and addressing model shortcomings.

Achievements so far

In the past two years, the project worked to assess and advance the skill of climate predictions, and explore their applications. The progress so far:

- Assessed the skill for predicting extreme events, with significant skill seen for both multi-annual and decadal predictions
- Evaluated how *skilful S2D predictions* of the European climate and extremes can be used in climate services and adaptation strategies
- Explored how information on the forecast quality and sources of predictability can be *useful* to users in different case studies
- Examined the importance of *understanding the mechanisms* behind forecast skill
- Contributed to new prediction experiments, such as for bridging different timescales, and identified *new opportunities for skill assessment*

More about our research

- Predicting ***extreme events*** and their likelihood in the next decade is key for protecting the population and minimising damages. However, climate forecast assessment in the past has rarely focused on extreme events, since by definition they are rare. In ASPECT, using the available large ensembles of forecasts, we revisited the skill assessment for predicting weather and climate extremes, in particular high-impact events, providing more insights on their occurrence and underlying causes.
- **Skill scores** show how good the forecast performance is, but the origin of the skill can be hard to interpret. Also, current systems tend to underestimate the predictable climate variations. It is crucial to understand the mechanisms behind predictability and why the signal-to-noise ratio is low in order to correct forecast errors and reduce uncertainties in regional climate information. To this end, ASPECT explored such mechanisms, thus improving prediction skill and its practical use in different applications.
- The project also assessed whether 2024 could be the first year where global average temperatures exceed 1.5°C above pre-industrial levels. A temporary exceedance does not breach the Paris Agreement, but the world is approaching this threshold where 1.5°C could be exceeded regularly.
- New methods have been developed to account for and enhance weak predictable signals, resulting in improved forecasts.

WP3

SEAMLESS INFORMATION ACROSS SPACE AND TIME

Delivering **new, actionable climate data** to support climate adaptation efforts is another key focus of the project. These data have:

- higher spatial resolution, i.e. increased level of detail for specific locations, and
- temporally seamless presentation, i.e. covering different timescales.

Achievements so far

ASPECT has been working to:

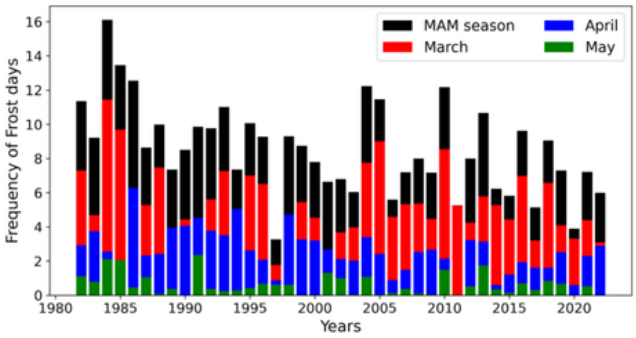
- develop a range of methodologies for *spatial downscaling* and *temporal merging*
- tailor climate prediction methods to real-world applications by adopting the work done with the project users to meet their needs
- provide high-resolution data on *extreme events* to support climate resilience planning
  - An event-based dynamical downscaling workflow was developed and applied to events in the Emilia-Romagna region (Italy), and urban heatwaves in Stockholm (Sweden).
- improve seasonal climate risk assessment
  - Statistical downscaling methods were applied to predict spring frost in vineyards in Catalonia (Spain).
- seamlessly merge seasonal, multi-annual and decadal climate forecasts, and improve the forecast skill.

Concepts behind the research

Spatial downscaling refers to making data relevant for local or regional-scale use. It involves refining global climate model data to provide high-resolution information for a specific region or area. In ASPECT, different downscaling methods are tested, and the most suitable one is determined depending on the variable and specific time frame.

Temporal or time merging refers to merging climate data to 'seamlessly' cover different timescales, i.e. with no interruptions in the information provided, despite the information developed through different models or methods. Several methods are explored in ASPECT to obtain seamless information:

- The *stitching* approach uses the most reliable predictions for as long as they have a good skill, and then replaces less skillful information with long-term projections.
- The *shadowing* approach selects specific trajectories from long-term projection ensembles that closely follow or are 'in the shadow' of a predefined target trajectory.



***Frequency of frost days in March-April-May (MAM) in Catalonia**. Frost days in spring can have catastrophic effects for grapes and wine production, particularly in MAM. ASPECT examined the past frequency of such days in the area of a vineyard based in Catalonia, Spain, aiming to predict these in the future (data: ERA5 1981-2022).*

WP4

CO-DEVELOPING INFORMATION WITH USERS

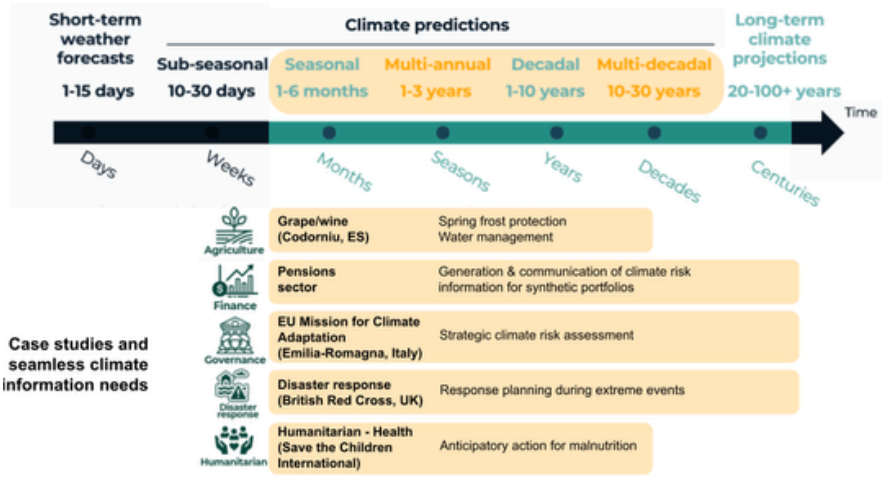
ASPECT aims to **co-develop several case studies** that explore a range of fit-for-purpose climate information to support the adaptation decisions of the project's Super Users over different timescales (covering the next months, seasons and years, up to 30 years ahead). The project is also co-developing the best options for the delivery of the climate services together with each Super User, and assessing their value.

Achievements so far

The project began working with five key Super Users from a range of sectors to understand their evolving needs and assess the risks they face related to the changing climate. The interactions (periodic bilateral meetings with Super Users) focused on understanding the users' decision-making context and identifying the information they require for time-scales ranging from the next season up to 30 years ahead. The project has been working on the development and provision of tailored indicators for decisions that Super Users need to take across different timescales.

Our Super Users

- **Agriculture / wine**: Codorniu winery in Catalonia, Spain. Wine production is highly dependent on weather and climate variations, such as frost days and water scarcity.
- **Governance**: Emilia-Romagna region in Italy, part of the EU Mission on Climate Adaptation. The region is vulnerable to climate change and actively working on climate adaptation strategies.
- **Finance**: Organisations across the pensions sector. Understanding climate change risks is key for existing and future investment decisions in this sector.
- **Disaster response**: British Red Cross is an NGO that supports individuals and communities to prepare for, respond to and recover from disasters.
- **Humanitarian**: Save the Children International is an NGO that aims to use climate information to anticipate and minimise the impact of climate change on the malnutrition of children and mothers in vulnerable areas.



WP5

INCREASING THE USABILITY OF CLIMATE INFORMATION

Enhancing the usability of climate information for adaptation is another integral part of ASPECT. We work to better understand how climate information and knowledge can help organisations prepare for and take action to reduce climate change risks, while facilitating the interactions between climate scientists and users of such information. In addition, we work to understand how to scale up what we learn to a broader set of users and practitioners to enable a climate resilient future.

Achievements so far

ASPECT has been working to better understand and promote climate information for adaptation:

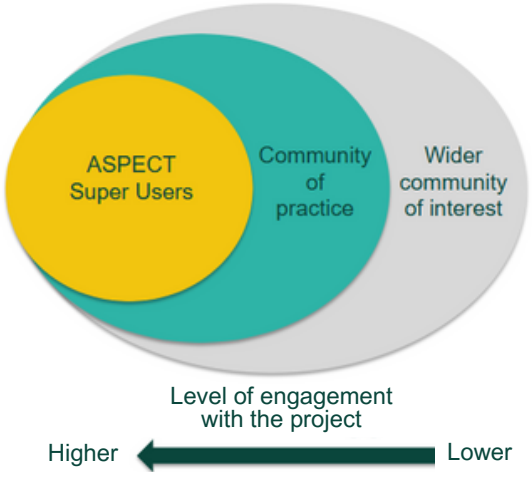
- A *comprehensive assessment* of climate information use and user needs across Europe was carried out, reviewing grey and peer-reviewed literature.
- Three *User Forums* were organised, serving as a platform for engaging users and purveyors of climate information.
- A *quantitative survey* with ~2,000 respondents was conducted, targeting risk analysts in climate-sensitive organisations across Europe to assess their current use of weather / climate information and identify unmet needs.
- *Two new Super Users* beyond the three original users were recruited through a competition. These represent the disaster response and humanitarian sectors.

Building a community

Annual, multi-sector **User Forums** are organised by ASPECT to facilitate the sharing of knowledge, experiences, and challenges related to climate predictions. They bring together researchers, users and providers of climate services, and other stakeholders who use or wish to utilise climate predictions more effectively.

The project communities include:

- ***Super Users***, working with researchers to co-develop prototype climate services of S2D predictions and projections.
- ***Community of practice***, including users of climate information, who are building their capacities for using S2D predictions.
- ***Wider community of interest***, including decision makers who are aware of and want to use S2D predictions directly or through partnership with climate service providers.



WP6

DATA IN ACTION

Supporting the practical use and operationalisation of climate predictions is another integral part of ASPECT. Alongside scientific innovation, the project works to transform the prediction data into information and applications that are useful and relevant to users. By providing access to improved knowledge and novel methodologies, ASPECT promotes user uptake and data literacy. The project also seeks to build strong links with the Copernicus Climate Change Service (C3S), to support the integration of its results into climate services and products.

Achievements so far

In order to put climate data into action, ASPECT has been working to:

- Prepare and implement a *data management plan*, defining how data is handled in the project
- Develop a *series of workflows* illustrating the usage of ASPECT and climate data
- Develop an *online catalogue (*shown in a Shiny application) of decadal prediction graphical products, as well as temporal merging products comparing the skill of seasonal, multi-annual and decadal predictions
- Develop *interactive web applications* to visualise climate data, in a user-friendly way suitable for both beginners and advanced users
- Prepare a web interface for accessing and downloading ASPECT data

Managing the project data

In ASPECT, a heterogeneous variety of datasets and data types are developed, as well as a large volume of data. Therefore, careful planning and management is crucial. For this, we have been working to develop solutions and strategies for storing, accessing and using data efficiently, including protocols, metadata definitions and documentation. Efforts have been made to produce data in accordance with the *FAIR principles*, ensuring their short and long-term preservation.

Furthermore, we have been working to collect and make the datasets developed in ASPECT easily accessible for all through our project website.

WP7

CONNECTING RESEARCH WITH SOCIETY

Communication and dissemination activities in ASPECT aim to bring visibility to the project, and ensure that its scientific advances reach those who can use and benefit from them. Connecting research with society is crucial to improve the understanding of the underlying science, build capacity, and enhance the uptake and application of the outputs, which leads to a lasting impact and supports climate adaptation across sectors. Some of the project activities and channels are shown below.

ASPECT website

A hub for the project research, news and material

Audiovisual material

Videos about the project and its research

Knowledge sharing

Explaining key concepts behind the research (infosheets), or summarising studies (briefings)

Engagement & Collaboration

Participating in events, engaging with national meteorological services, projects & initiatives *(e.g. dedicated workshops, joint sessions)*

Communication

Newsletters to >375 subscribers, posters, infographics and other material

Social media

Sharing project updates with a wider community on LinkedIn, BlueSky and X

EPILOGUE

To summarise, ASPECT researchers are working hard to advance climate prediction methodologies and produce seamless, high-resolution, and user-relevant climate information. These advances provide tangible benefits to stakeholders across a range of sectors and geographies, from agriculture to disaster response.

In the remaining two years of the project, we will strive to further advance the field of climate predictions to strengthen resilience and support seamless adaptation to climate change.

As we move forward, the challenge remains to translate scientific progress into meaningful impact, ensuring that decision-makers have access to the best possible climate information, that in turn allows them to make better decisions. This comparison between the outcome of real-world decisions using individual versus seamless climate predictions has not been done yet and remains as uncharted territory. Exciting research lies ahead!

To prepare for the challenges that climate change will bring, we need to adapt simultaneously at different timescales. Seamless climate predictions provide continuous information across timescales, giving a single, coherent picture of the future climate, which is essential to address the multifaceted nature of climate change. To be truly effective, adaptation must be seamless.

***Marta Terrado**, Barcelona Supercomputing Center, ASPECT coordinator*

Climate change is affecting our society in many different aspects, implying more extreme events, for instance, and it's affecting different sectors like agriculture, energy, city planning. The objective of ASPECT is to develop methods, and to develop the science to meet some specific requirements and improvements. Having a better understanding of the climate and its impact on different sectors is critical.

***Albert Soret,** Barcelona Supercomputing Center, ASPECT coordinator*

Many people threatened by changing climate extremes need better and more relevant information in order to become more resilient. ASPECT is producing a number of scientific advances to improve climate predictions and projections out to 30 years ahead. We are also working with a diverse range of users to tailor the information and make it easier to access.

***Jason Lowe,** Met Office, ASPECT scientific coordinator*

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