

Monitoring climate change

Professor Bob Su explains why augmenting existing data on climate change with newly available information from multiple sources is vital to understanding the potential implications for our planet and its population



Could you describe the context from which the CORE-CLIMAX project emerged?

In response to environmental and societal challenges associated with climate changes, the Copernicus Climate Change Service is helping to support climate adaptation and mitigation measures by providing access to several climate indicators (eg. temperature increase, sea level rise, ice sheet melting and ocean warming) and climate indices (eg. based on records of temperature, precipitation and drought event) for both the identified climate drivers and the expected climate impacts. In conjunction with the Global Climate Observing System (GCOS), EU climate change related projects, and ESA Climate Change Initiative projects, CORE-CLIMAX was proposed to coordinate the identification of available physical measurements that can be reconciled with previously existing data records to form long-term climate data records.

What are the key objectives of CORE-CLIMAX and how were these decided?

By establishing the extent to which observations complement existing climate

data records (CDRs), the project will help to substantiate how Copernicus observations and products (from both *in situ* and Space components) can contribute to climate change analyses. We are identifying gaps in ongoing climate and climate change activities, and this will contribute to the formulation of the Copernicus Climate Change Service. Dialogue mechanisms will be set up between climate and climate change researchers, modellers and policy makers at the national level in Europe, as well as globally. The team is also establishing a forum for providers of Earth Observation (EO) data and climate researchers to assess the status of available observational records, integrate Space data with *in situ* records and establish the foundations for a validated base of EO data for climate research.

It is expected that this repository of validated Space-based observational data (together with *in situ* data) will substantially support (in combination with reanalyses and model predictions) climate change impact and adaptation action assessments, policy development and monitoring for national, European and global users. It will also be an important asset for the development of downstream sector-specific, regional and local climate application services.

Why is it important to compare the results of different reanalysis techniques from a diverse range of products?

Via reanalysis, variations in weather and climate can be tracked globally at various temporal and spatial scales, covering decades and the entire globe, from the Earth's surface to the stratosphere. Reanalysis products are used extensively in climate services and climate change research, providing an important resource for climate monitoring.

To improve the quality of essential climate variables (ECVs) and quality of all downstream applications, coupling of

the models is beneficial. The Copernicus Climate Change Service has established a long-term target to develop a coupled Atmosphere-Ocean-Land-Ice/Snow-Hydrological Cycle-Dynamical Vegetation model within the reanalysis model. However, the large uncertainty in the feedbacks between the terrestrial, oceanic and atmospheric components and climate change projections is among the biggest concerns at the moment. Furthermore, different reanalyses centres use diverse techniques and synthesis information in their use of satellite information. The purpose of the intercomparison of results of reanalysis techniques is to survey the differences between the available reanalyses and how these differences may point to necessary improvements in monitoring ECVs.

Your final work package (WP6) is dedicated to dissemination, outreach and capacity building. How do you aim to ensure effective coordination with European and international stakeholders, and to organise your dissemination and outreach activities?

A digital forum has been established to serve this purpose. The information will be organised by ECV and Fundamental Climate Data Records (FCDRs). Such a deliverable could outlive the project and ultimately form part of the Copernicus Climate Change Service. Three areas will be developed: Central Copernicus CDR forum, Central CDR/ECV validation forum and Central Reanalysis forum. Whenever possible, coordination will be sought with existing digital forums (eg. www.reanalyses.org) to avoid dilution of efforts and to maximise audience reach. These fora will provide the CORE-CLIMAX participants with easy exchange and documentations of results and information, and act as a central site from which the Commission and other users can follow project progress and provide timely user feedback.

Coordinating Earth observation data validation

Leading international research institutions are currently assessing and redefining approaches to monitoring climate change under the auspices of **CORE-CLIMAX**. The group is investigating approaches to monitoring these changes in order to aid strategies to effectively managing their impacts

EARTH'S CLIMATE DIRECTLY affects humankind's ability to live and thrive as a species. This was one of the central facts highlighted by the *Report of the High-Level Taskforce* for the World Meteorological Organization (WMO) Global Framework for Climate Services (GFCS) in 2011. Extreme climate changes cause loss of lives and livelihoods all over the world, but this is overwhelmingly concentrated in developing countries. As such, accurately forecasting and preparing for future changes is vital to the wellbeing of millions and will significantly influence our future lifestyles.

WMO identified that needs-based climate services are extremely effective at helping communities, businesses, organisations and governments manage the risks associated with climate change, and also take advantage of potentially beneficial changes. The Report also revealed a large gap between the need for climate services, and their current provision.

In 2011, an EC report on Copernicus (formerly Global Monitoring of Environment and Security) articulated the EU's ambition that the Copernicus Climate Change Service would provide a suite of high-quality products and services relating to climate. These products will meet the first three goals of the Global Climate Observing System (GCOS): monitoring the climate system; detecting and attributing climate change; assessing impacts of, and supporting adaptation to, climate variability and change.

CLIMATE DATA RECORDS

The COordinating Earth observation data validation for RE-analysis for CLIMate ServiceS (CORE-CLIMAX) project is vital to supporting the Copernicus Climate Change Service in developing effective products. The project aims to coordinate the identification of available physical measurements, which can be reconciled with previously existing data records, to form long-term time series. These data will help monitoring, assessing, and ultimately understanding key indicators of climate variability and change.

Using methods of analysis and reanalysis, the impact of climate change on society, human health and ecosystems can be better understood, leading to the identification of those European countries most at risk. As well as the negative impacts, the potentially positive effects of climate change will also be recognised, and can therefore be utilised to benefit respective Member States.

The project's efforts primarily revolve around climate data records (CDR), which are time series of observations measuring variables believed to be associated with climate variation and change. The creation of CDRs is an exhaustive process, beginning with the availability of observations. These are calibrated, geo-located and intercalibrated in order to create calibrated Level 1 data – known as a fundamental climate data record (FCDR).

Following the establishment of an FCDR, it is then converted to geophysical/bio-geophysical parameters by means of inversion, and the converted result is termed a thematic climate data record (TCDR). A TCDR may form a complete or partial essential climate variable (ECV), which is a geophysical variable that is associated with climate variation and change as well as the impact of climate change on Earth. Once FCDRs and TCDRs have been established, they are then archived, along with relevant information including the results of peer review, validation and user feedback. This information is collectively referred to as CDR.

CORE-CLIMAX participants currently assess the European capability to provide GCOS ECV data records, prepare a structured process for delivering ECVs through the stepped and quality controlled elaboration of CDR, coordinate a harmonised approach for validating each ECV/CDR, identify the integration of ECVs into the reanalysis chain, and formulate a process to compare the results of different reanalysis techniques. As such, CORE-CLIMAX will provide procedures that are internationally coordinated and useful across all existing and future activities for CDR generation and maintenance.

EARLY PROGRESS

Tools and datasets have been developed for assessing the European capability to provide GCOS ECV data records. The international community has been invited to test the developed tools. The identification of datasets to be used as test cases has already been achieved for assessing ECV CDR quality via comparison with existing reanalysis and by assimilation into reanalysis. The work is still at an early stage as the consortium only kicked-off at the start of 2013. Nevertheless, the project is already identifying the potential of ongoing activities and in this way is contributing to the formulation of the Copernicus Climate Change Service's work by laying the foundations for future service activities.





The implications of a changing climate

EU policy briefs provide research insights at a glance, allowing decision makers to more easily discover thought-provoking results and comparisons in Europe. **CORE-CLIMAX** is utilising this medium to increase the impact of its work in a structured way

THE CORE-CLIMAX CONSORTIUM is comprised of several international research institutions, each responsible for measuring, monitoring and disseminating various aspects of climate change related to their particular areas of expertise. Specifically, the participants consist of seven European institutions and two international cooperation partner countries (ICPCs).

The consortium aims to provide coordination for producing and validating essential climate variables (ECVs) with the objective of reanalysing existing data to develop a clearer picture of global climate change and its implications. The project is coordinated by the University of Twente. Together with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) coordination will be made with European Space Agency's Climate Change Initiative through several key national ECV producers and climate change service providers – along with the major reanalysis centre in Europe (ECMWF), and satellite data processing and validation centres. In addition, the two ICPC participants are tasked with maintaining all of the activities at the major climate observations stations situated on the Tibetan Plateau (also known as the Third Pole). As such these participants provide an essential role in

coordinating the validation of ECVs and reanalysis results. Furthermore, these participants are also responsible for monitoring climate variations at the Tibetan Plateau in central and Southeast Asia. With such a wide range of expertise spread throughout key geographical locations, it is anticipated that CORE-CLIMAX will be able to implement an internationally recognised mechanism for the coordination of ECV climate data records (CDR) generation. The varying geographical locations of the consortium's participants will also facilitate links with Space nations holding satellite data repositories.

On 15-16 May 2013, the CORE-CLIMAX researchers organised a collocation meeting at the Research Executive Agency in Brussels. The aim of the meeting was to provide a better understanding of the gaps between Global Climate Observing System (GCOS) ECVs and user needs in climate change and mitigation. This would be facilitated by taking an inventory and bringing together knowledge and practices relating to the generating, validating and updating of GCOS ECVs and the downstream applications. This, in turn, would provide the necessary information for informed policy and decision making regarding climate change.

PREPARING FOR CLIMATE CHANGE

The first key point of the collocation meeting was the essential need for societies to prepare adaptation strategies for projected climate change. Despite uncertainties (rooted in existing observational products and projections) regarding future climate changes and their potential impact, the risk and needs of different societies need to be adequately addressed via climate change 'proofing'. Continued monitoring and research must be conducted to improve the climate change impact indicators. Datasets, graphs, maps, tools and platforms for sharing 'best practices' should all be made available to policy and decision makers via sites such as Climate-ADAPT. Dissemination of indicator reports and guidance documents from various relevant projects should also be facilitated through these platforms. Quality control of this information can ultimately be better monitored by the expert guidance of the climate and climate change community if made available through these proposed channels.

GENERATING ECVS AND DATA VALIDATION

The need to assess the European capacity for generating GCOS ECV has been highlighted as an

important objective of the consortium. Suitable tools need to be developed to assess whether data record generation follows best practice. These tools should also provide guidance on the use of data records for specific applications. Suggested tools that could be used for this purpose are the proposed System Maturity Matrix and the Application Performance Matrix. These tools should be used in conjunction with the ECV inventory list. At the upcoming CORE-CLIMAX capacity assessment workshop to be held 21-23 January 2014 at the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the consortium intends to implement these proposed tools to generate the first European capacity database. As such, CORE-CLIMAX is encouraging members of the climate and climate change community to attend the workshop to provide their views and input.

The importance of establishing detailed documentation regarding the validation of the GCOS ECV data records was also highlighted at the meeting. This kind of validation documentation is essential for the development of a useful ongoing evaluation strategy. It was also recommended that an independent review mechanism on validation results should be developed, and that validations should be regularly updated. Factors that result in uncertainty in GCOS ECV data records – such as inconsistency, representation and homogeneity – should also be analysed in order to provide essential reliable information about climate change.

ESTABLISHING ECV CONSISTENCY

Assessment of ECV consistency cannot be achieved through analysis of single ECV data records alone. It was thus proposed at the meeting that reanalysis data derived by assimilating data into models (both short- and long-term, *in situ* and satellite data) could provide an alternative

source for GCOS ECVs. By evaluating ECV data against processes embedded in established models, a greater consistency of data can be achieved. It was also highlighted that data rescue activities from old observation records can provide important information when analysing climate change. The observation feedback mechanism of reanalysis has already been prototyped, and the usage of the Observation Feedback Archive (OFA) will be developed further and promoted by CORE-CLIMAX.

ONGOING CHALLENGES

Detailed analysis of both long-term climate data records and data records close to real-time are not presently available. This analysis must be conducted to allow effective mitigation of the effects caused by extreme climate events. Sound scientific information can then be produced regarding extreme weather conditions and how these are linked with climate change. This information can then be disseminated through the aforementioned user-friendly channels and platforms in order to assist policy and decision makers in following the best practices and making informed decisions.

A new challenge for data providers is the need to place witnessed extreme events into the context of climate change to ensure adaptation measures can be developed if changes in frequency or intensity are expected. It was suggested that the delivery of this data could be planned in the framework of the Copernicus Climate Change Service. Cooperation and interaction amongst the various institutions involved with ongoing and upcoming Copernicus climate related projects is essential in order for the project to grow and develop. The promotion of CORE-CLIMAX as primary coordinators for these projects also needs to continue.

INTELLIGENCE

CORE-CLIMAX

COORDINATING EARTH OBSERVATION DATA VALIDATION FOR RE-ANALYSIS FOR CLIMATE SERVICES

OBJECTIVES

- To coordinate with Copernicus ongoing activities and contribute to the formulation of the Copernicus Climate Change Service theme
- To propose a structured process for delivering essential climate variables (ECVs) through the stepped and quality controlled elaboration of climate data records (CDR)
- To propose a validation process aiming at qualifying the accuracy of the climate variables
- To propose a feedback mechanism ensuring that the results of the reanalysis process get appropriately reflected into updates of the CDR
- To propose a process to compare reanalyses

PARTNERS

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FUNDING

EU Seventh Framework Programme (FP7-SPACE) – project reference no. 313085

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COPERNICUS AT A GLANCE

The wellbeing and security of future generations are more than ever dependent on everyone's actions and on the decisions being made today on environmental policies. To take the right actions, decision makers, businesses and citizens must be provided with reliable and up-to-date information on how our planet and its climate are changing: Copernicus, previously known as GMES (Global Monitoring for Environment and Security) provides this information.

As the European programme for the establishment of a European capacity for Earth observation, Copernicus consists of a complex set of systems which collect data from multiple sources: earth observation satellites and *in situ* sensors such as ground stations, airborne and sea-borne sensors. It processes these datasets and provides users with reliable and up-to-date information through a set of services related to environmental and security issues.

The services address six thematic areas: land, marine, atmosphere, climate change, emergency management and security. They support a wide range of applications, including environment protection, management of urban areas, regional and local planning, agriculture, forestry, fisheries, health, transport, climate change, sustainable development, civil protection and tourism.

The main users of Copernicus services are policy makers and public authorities who need the information to develop environmental legislation and policies or to take critical decisions in the event of an emergency, such as a natural disaster or a humanitarian crisis.

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