

# *GEWEX Hydroclimate Panel (GHP)*

## *Cross-cut on "Determining EvapoTranspiration" (CC-dET)*

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Following the concept of other GEWEX cross-cut science projects, we propose an initiative related to methods allowing to determine evapotranspiration (ET), experimentally, through remote sensing methods or via models, at different spatial and temporal scales.

This initiative is thought to fit in with the requirements for a crosscut, as it addresses a science concept common to most regions, with results obtained in one region of very likely interest for other regions. With this CC we also intend to synthesise the obtained knowledge from a global perspective. This CC-dET involves scientists from various disciplines and areas of interest; it requires a collaborative interdisciplinary effort to make this CC a success.

### **History and present situation**

This cross-cut initiative arises from the scientific community that formed to address the challenges concerning ET: in the 2018 GEWEX Science conference in Canmore and the two workshops that followed (Sydney October 2019, and Wageningen/online February 2021). The LIAISE campaign on ET and water management in semi-arid conditions (a HyMeX follow-up) was selected as a common working ground for most of the active participants in the second workshop. Following the successful field campaign in the summer of 2021, a third workshop (jointly with the LIAISE team) is planned for November 2022.

Scientific communities involved in LIAISE are based in France (Météo-France, CNRS, LMD), the UK (Met Office), Spain (IRTA, SMC, UIB, UB), The Netherlands (WUR, UU), Germany (JFZ, TH-OWL), and the USA (NASA), while there has been additional participation in the CC-dET workshops from scientists based in other countries in Europe, North and South America, Oceania and Asia.

The initiative is proposed to be managed by a board of scientists, Oscar Hartogensis (Wageningen University, NL), Aaron Boone (Centre National de Recherches Scientifiques, FR), Anne Verhoef (University of Reading, UK) and Joan Cuxart (University of the Balearic Islands, SP).

While the kick-off meeting at Canmore resulted in a paper in GEWEX News stating four main challenges related to ET (definition/understanding, in-situ measuring, parameterisation, remote sensing and catchment scale), the first workshop in Sydney preliminarily grouped the participants in 5 working groups (open water, landscape-scale, interception, transpiration, soil evaporation), with the emphasis on how to best model, and verify the different terrestrial ET components. In the second workshop, in Wageningen, an in-depth discussion (including polls, and 'quizzes' for stock-taking exercises) by a highly interdisciplinary community took place about the contributions to ET of vegetation, soil and inland open-water, as well as the role of surface heterogeneity, anthropic water management and the interaction between scales, from leaf to landscape and catchment. Based on the discussions at these workshops, four preliminary WG are proposed which are listed below.

## Motivation

Evapotranspiration is a principal term in the Earth's budgets of water and energy, and it is inextricably linked with the carbon budget as water vapour is lost from the stomata as the vegetation takes in CO<sub>2</sub> from the atmosphere, during the process of photosynthesis.

The determination of ET is still a challenge, as its reliable and accurate in-situ measurement needs costly equipment, using methods that may differ depending on the circumstances and conditions. ET estimates derived using vertical gradients of humidity are often not good when compared to direct observations using the eddy covariance method, especially over surfaces where water supply is limited. Furthermore, 'point measurement' using flux towers are often not representative of a larger area, since the landscape is usually heterogeneous in terms of soil and vegetation cover. Areal estimations as provided by remote-sensing methods or numerical models need input parameters (on soil, vegetation, land use, water management and use) that most closely represent the corresponding pixel or grid element. In addition, it is worth mentioning that, historically, parameterisations of ET have been developed for vegetated and well-watered terrains which, when applied to different conditions, such as for semi-arid areas, need modification or even a different approach, both ways still not completed successfully..

The study of ET has been undertaken from very different perspectives, ranging from a focus on process understanding and prediction by Earth System modellers, to quantification at a range of spatio-temporal scales for hydrological or agricultural applications such as reservoir dam regulation or crop irrigation. This Cross-cut aims to bring together experts from diverse disciplines to discuss key questions and methods to allow the community to communicate in an efficient manner, and to advance ET-related science.

In the frame of the Cross-cut science projects, CC-dET is expected:

- To contribute to the GEWEX Science Goals, in particular on the flux exchanges in the prediction of the Earth's water cycle (Goal 1), in the ABL representation and Land-Atmospheric Interactions in the quantification of Earth's energy, water and carbon cycles (Goal 2), and to the water variability, trends and water management influences (Goal 3).
- To test and evaluate the application of knowledge produced within RHPs, in particular those in areas with arid, semi-arid climates or those threatened to become drier in the future.
- To keep completed RHPs involved, such as HyMeX, as well as being a gateway for prospective RHPs such as ANDEX, TPE-WS, US-RHP, or networks like PannEx.
- To be a tool for collaboration between GEWEX panels, GHP, GLASS and GASS, with close relationship with GDAP, especially in satellite data use. Also, to provide information to the activities of the recently created EMSO of WCRP.
- To generate interactions between RHPs.
- To broaden the science community involved with GEWEX, as diverse disciplines will meet within this initiative (remote sensing, numerical modelling, atmospheric physics, soil science, plant physiology, water management for agronomical and hydrological applications)
- To contribute significantly to the WCRP Light House Activity "Explaining and predicting Earth system change" in particular to WG1 "Observing and modeling Earth system change" through the analysis of data gathered in campaigns and the development of updated parameterisations of ET.

The expected developments of CC-dET after its initial tentative steps end 2019 are described below. The proposition is for an initial period of 3 years (2022-2025), which may be extended if felt necessary in the most suitable organisational form at the end of the period.

## **Principal research questions to be addressed**

In the frame of the interdisciplinary approach, with the principal aim of producing meaningful values of ET from direct measurements, remote sensing methods and numerical models in a way that they can contribute to produce better surface budgets of energy, water and carbon, the Cross-cut is preliminarily organised in four main working groups:

WG1. Measuring ET and its role in the Surface Budgets and their coupling (energy, water, carbon)

WG2. Models and parameterisations of ET (including their use in numerical models and remote sensing methods), validation and networks

WG3. The partitioning of ET over the different elements of the terrestrial hydro- and biosphere: soil, vegetation (transpiration and interception), open-water (reservoirs & lakes, rivers will be less straightforward)

WG4. Heterogeneity, irrigation, varying spatial and temporal scales, extreme events.

It is expected that the working groups will be finally established after revision at the end of the November 2022 workshop.

## **Data requirements**

As agreed at the end of the second workshop, the LIAISE campaign was chosen to bring together many participants in this Cross-cut and be able to design the experiment and analyse in a synergetic approach the available data from multiple perspectives. Participants in LIAISE ranged from earth scientists dealing with ABL and land-surface interactions, from the experimental and the modeling points of view, plant physiologists and other biologists, engineering agronomists, remote sensing specialists and hydrologists. The LIAISE database is currently being constructed and the data will be shared amongst all participants.

On the other hand, it is clear that this effort must go beyond the analysis for a particular area during a couple of weeks (as is the case for LIAISE). Good quality ET data for all kinds of conditions are already being provided by long-term networks such as Fluxnet, Tereno, ICOS or Ameriflux. The proposed GLAFOs by the GLASS panel activity of the same name, also fits in very well with this effort. It is therefore a specific aim of this CC initiative to establish a good collaboration with these networks in order to interact with them and expand the CC activities for as many types of climate as possible. The inter-mediation of RHPs in this context might be of critical importance.

Additionally, the data-related activities of the CC-dET also include the generation of land surface maps including soil characteristics, dynamic vegetation and land uses, and rain and irrigation water inputs. These are necessary inputs in relation to the high spatio-temporal variability of land surface processes, including ET. These efforts also fit very well with the very high-resolution modelling being studied under a number of GEWEX panels and LHAs.

## Project methodology

Summarizing the information provided above, the CrossCut will organise itself as follows:

1. The four provisional WG will broadly assembly ABL/soil/veg experimentalists and data analysts (WG1), numerical modelers and remote sensing scientists (WG2) land-surface scientists and ecophysiologicalists (WG3) and climate scientists and hydrologists (WG4)
2. Data from the LIAISE experiment will be the subject of the first common effort of the CC-dET.
3. Communication with the major experimental networks will be established to obtain supplementary data for the widest possible representation of different climate conditions.
4. Workshops every 12-18 months will take place and joint publications in special issues will be encouraged.
5. Outreach will take place at the scientific level in specialized conferences or workshops, at open conferences such as GEWEX science meetings, and at the general level by knowledge transfer to interested parties, such as meteorological services, water management bodies or agronomic authorities.

## Collaboration Mechanisms

Many scientists participating in the CC-dET are already active in other GEWEX and WCRP activities, and we hope that information will flow although this has not yet been fully explored.

The CC-dET will have a website. The websites of previous activities have been hosted by the general GEWEX site. There is an e-mail list, managed by the IGPO, with roughly 120 members.

The main interaction events take place in workshops (the third to take place end 2022). Currently, there are also three working groups in LIAISE with a broader view (Atmosphere, Surface Processes and Hydrology).

All the activities conducted so far have been reported extensively in the GEWEX News Quarterly and also in the different GEWEX meetings, such as the GHP, GLASS and the SSG annual meetings.