WATERAGRI

D 1.6 Workshop 3 report

February/2022

WP1: Farming Community Engagement

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Author(s)/Organisation(s)	Richard Hoffmann, Aashna Mittal
Contributor(s)	Harrie-Jan Hendricks-Franssen, Philip Brunner, Zoran Kapelan
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Abstract:	The WATERAGRI Workshop 3 was organized in Month 22 of the project to present physically-based models and the data assimilation framework and obtain feedback from internal and external stakeholders. This document presents the planning, execution and results of the workshop.

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1	LUNDS UNIVERSITET	ULUND	SE
2	EDEN MICROFLUIDICS	EDEN	FR
3	FORSCHUNGSZENTRUM JULICH GMBH	FZJ	DE
4	TEKNOLOGIAN TUTKIMUSKESKUS VTT Oy	VTT	FI
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14	UNIWERSYTET PRZYRODNICZY WE WROCLAWIU	UPWr	PL
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List of Abbreviations and Acronyms	
DEM	Digital Elevation Models
ESDAC	European Soil Data Center
EU	European Union
LAI	Leaf Area Index
NDVI	Normalized Difference Vegetation Index
PDAF	Parallel Data Assimilation Framework
TSMP	Terrestrial System Modeling Platform
WP	Work Package
WS 1/2/3	Workshop 1/2/3

Executive Summary

To cope with the challenges of climate change and the increase in demand for food, the WATERAGRI project aims to develop solutions that can lead to efficient management of agricultural water to enable sustainable food production. WATERAGRI consists of 10 pilot sites which are spread across three climate zones in Europe. New innovative solutions for climate and weather resilient agriculture will be tested and implemented. The solutions being developed as part of the project will help farmers to retain water and recycle nutrients in their agricultural fields. These solutions will be evaluated using physically-based models that simulate the hydrology cycle of selected test sites (e.g., Germany, Switzerland, Poland, Hungary, and Finland). Real-time measurements from online sensor networks installed at the German site, for example, are available remotely and sent to a database. Models will access the data stored in the database. The data can be then used in a data assimilation step for continuous model calibration and forecasting. In this way, simulations will be continuously corrected with actual measurements to provide real-time decision support to the end-users.

To obtain early feedback on the development of the physically-based models and the data assimilation framework, the third WATERAGRI stakeholder engagement workshop (i.e., WS3) was organized on 16th February 2022. The objectives of the workshop were to present and obtain feedback on the information products that can be made available with the current version of the cloud-based simulation and data assimilation system. This report presents the planning, execution, and results of WS3.

The planning of the WS3 was led by a steering committee consisting of representatives from various project partners: FZJ (workshop organizer), TU Delft (WP1 lead), AGRICOLUS, OULU, and INOSENS. WS3 was organized as a set of regional meetings followed by a plenary session. The motivation behind the regional meetings was to encourage in-depth interactions with local stakeholders across case studies in their respective regional languages. The plenary session was conducted to discuss the feedback collected during the regional meetings and translate them into actions for further development of the physically-based models and the data assimilation framework of WATERAGRI. Relevant stakeholders were invited to regional meetings and plenary session in consultation with the case study representatives and using the contacts in the stakeholder register prepared as part of previous WP1 activities. A total of 165 invitations were sent out for the regional meetings by the respective hosts and about 200 for the plenary session outlining the purpose of the meeting, the draft agenda and collecting the preference of the invitee to attend the workshop in a virtual, physical or hybrid format.

Five regional meetings were conducted in Hungary, Finland, Poland, Switzerland, and Germany between January 2022 to early February 2022. Although face-to-face meetings were preferred by the invitees, all regional meetings (except Switzerland) were hosted virtually owing to COVID-19 regulations. The regional meetings started with a brief introduction about the WATERAGRI project, and the aim of WS3 followed by a presentation of the cloud-based simulation and data assimilation system combining models and measurements. This presentation was prepared by FZJ and translated into the local language. Thereafter, feedback on three topics was discussed using guiding questions: (1) importance of irrigation systems in the agricultural sector (2) experience with data and tools (3) feedback on the proposed simulation system. The regional meetings ended with closing remarks from the local case study representatives.

Following the regional meetings, the plenary session was organized on 16th February 2022. This meeting was also switched to a virtual meeting due to COVID-19 regulations. The plenary session was divided into 2 parts. In the first part, the early version of the cloud-based simulation and data assimilation system was presented by FZJ followed by an open plenary discussion. In the second part, the outcomes of regional meetings were presented followed by a plenary discussion. Participants were also given the option to attend a technical discussion among internal project members to translate the outcomes of the regional meetings into specific actions that can be used to improve the data assimilation framework of WP7 and align them with the interests of the stakeholders.

The WATERAGRI WS3 was successfully conducted where 119 participants joined the regional meetings, and 33 participants attended the plenary session. Valuable insights and feedback were collected this way. Although the feedback on the physically-based models varied across case studies, some common concerns/needs emerged. Firstly, participants noted that spatial resolution of the models is more important to them in comparison to temporal resolution and efforts should be made to make a spatial resolution as high as possible. Secondly, participants indicated that they need information on the weather (rainfall patterns), soil water content, natural groundwater level, and quality of roads (to decide whether they can drive heavy machines on their fields) a long time ahead to better plan their activities. Lastly, participants preferred that this information is made available on mobile devices such as smartphones. The outcomes of the regional meetings were further discussed in the plenary session and translated into concrete actions that will be undertaken in the near future to implement the collected feedback. Three proposed actions/solutions for the further development of the physically-based models and the data assimilation framework were agreed upon:

1. Simulation of important fluxes and states will be made available for selected pilot sites and attempts will be made to keep the spatial resolution as high as technically possible and the forecast horizon long (at least > 10 days)
2. Model states and fluxes from existing real-time models will be made available to a smartphone or personal computer on the farm site on demand
3. Quantitative support in long-term decision making will be provided by simulating different scenarios defined by the end-user.

1 Introduction

Efficient management of agricultural water is critical to sustaining food production under the uncertainties of climate change impact. Within this context, the aim of the WATERAGRI project is to evaluate the water and nutrient needs of farming communities across 10 pilot sites in Europe (Finland-2, Sweden, Germany, France, Poland, Switzerland, Austria, Hungary, and Italy) and develop a set of water and nutrient retention technologies. The project is divided into 9 work packages (WP), each focused on a specific objective, while some developments of WP2 and WP7 were part of workshop #3 (WS3).

WP2 is concerned with the creation of a Geodatabase that will collect and manage data at the farm level from various sources and open-access databases. This data includes farm data (e.g., crop details and observations, soil, and water quality analysis, irrigation, and fertilization logs), meteorological data as well as hydraulic information such as groundwater levels, and soil moisture sensor data. In parallel, physically-based models will be developed in WP7 to assess later the efficiency of different WATERAGRI solutions (WP3 and WP6) by automatically loading in data stored in the Geodatabase. The development of the data assimilation framework is also part of WP7, which is also a major element of the WATERAGRI framework (Figure 1). Simulations will be combined with measurements in the data assimilation step to provide the best possible predictions of crop yield, crop status, groundwater level and soil moisture. Data assimilation allows to constrain model parameters and to update model states and fluxes in near real-time. The error between measurements and simulations will be successively minimized and uncertainty reduced. The WATERAGRI framework will further predict and indicate how a farmer's choice affects important parameters such as water levels and soil moisture and provide them with advice on different farm management activities such as pumping, drainage and irrigation.

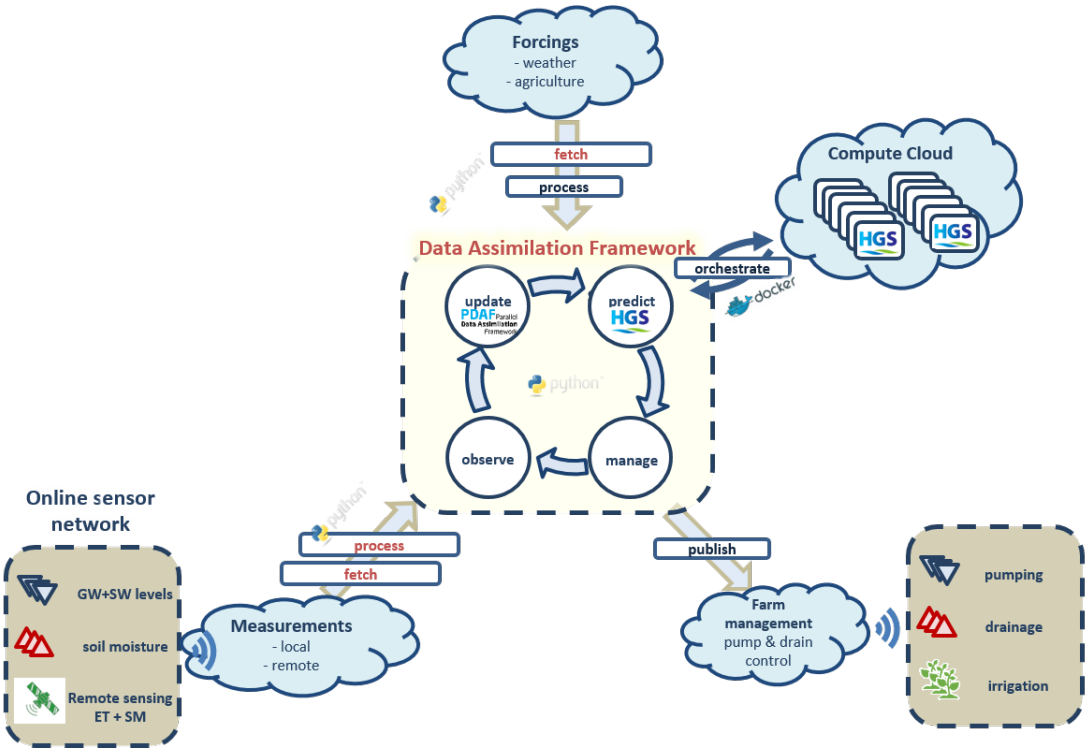

Figure 1: The proposed architecture of the WATERAGRI data assimilation framework

An important aspect of developing the data assimilation framework is co-design, where researchers and diverse stakeholders work together to co-develop knowledge and solutions. Thus, as part of WP1, the project aims to continuously engage stakeholders such as farmers, water associations/organization, policymakers, media, NGOs among others to discuss project developments and obtain their feedback.

The first two workshops were focused on identifying relevant stakeholders (see Mittal & Dahal, 2020) and obtaining feedback on the overall WATERAGRI framework, together with associated methods, metrics, and tools/solutions such as physically-based models (see Mittal et al., 2021). In continuation of the project's endeavour to present and discuss ongoing research with relevant stakeholders, the 3rd WATERAGRI stakeholder engagement workshop (hereafter referred to as WS3) was organized to present and receive feedback on an early version of the cloud-based simulation and data assimilation system. It is envisioned that the feedback received will be utilized by WP2 to WP4, to align them with the needs of the wide-ranging stakeholders' as much as possible and by developers in WP7 to adapt the WATERAGRI framework accordingly.

This report presents the planning, execution, and results of WS3 and consists of 5 sections. In section 1, we introduced the project background and the motivation to organize WS3. In section 2, we discuss the key features and concepts of the cloud-based simulation and data assimilation system. In section 3, the agenda and execution of the workshop are presented in detail. Section 4 presents the results of the workshop and Section 5 summarizes the key messages of the workshop along with lessons learned and future work.

2 Cloud-based simulation and Data assimilation system

2.1 Objectives

Integrated modelling is a key tool for evaluating the different solutions proposed in WATERAGRI and developed at the pilot sites. Water flow, land surface and plant processes at selected pilot sites are described by physically-based equations, which will be solved numerically using HydroGeoSphere (Therrien, 1992; Brunner & Simmons, 2012) or the Terrestrial System Modeling Platform (Shrestha et al., 2014; Kurtz et al. 2016). Examples of the latest information products for weather and climate resilient agriculture developed using the Terrestrial System Modeling Platform (TSMP) and its associated data assimilation tool were presented in WS3. TSMP simulates the exchange of water and energy between the land (soil and vegetation) and the atmosphere, water flow over the land, in the unsaturated zone (i.e., in soil), and in the saturated zone (i.e., in an aquifer) in 3D, incorporating spatially distributed input variables such as meteorological variables, land use, soil and aquifer properties. The best possible prediction of land and soil conditions such as soil moisture, groundwater level, crop condition, expected crop yield and river discharge are achieved if simulations by physically-based models (the topic of WS2) are combined with measured data (sensors in the field, remote sensing information) and weather forecasts (Kurtz et al., 2016) using data assimilation. Forecasts for the next few weeks include uncertainty quantification and can be made available online in the form of tables and graphs. This is intended to optimize the planning of agricultural activities, including the assessment of irrigation water demands.

2.2 Components

TSMP consists of three compartment models. COSMO is used to create convection-permitting atmospheric models (Baldauf et al., 2011). Terrestrial surface models can be created with CLM version 3.5 (CLM version 3.5, Oleson et al., 2008). CLM simulates the transfer and distribution of energy, momentum, water, carbon, and nitrogen fluxes between the atmosphere and the land surface (Oleson et al., 2008). Surface and subsurface flows are simulated with ParFlow version 3.2) (Ashby & Falgout, 1996; Kollet & Maxwell, 2006; Maxwell, 2013 and Figure 2). The 1-D kinematic wave approximation is used to calculate surface flow, and the Richards equation is solved in ParFlow to calculate variable saturated groundwater flow. Implicit time integration, a cell-centered finite difference scheme, and a terrain-following grid transformation with the possibility of variable vertical discretization are used (Ashby & Falgout, 1996; Kollet & Maxwell, 2006; Maxwell, 2013).

All compartment models of the modular earth system model TSMP are coupled by exchanging information on fluxes and state variables at the conceptual boundaries of the respective compartmental models (Shrestha et al., 2014). For example, CLM provides information on net infiltration values to ParFlow and ParFlow provides information on calculated subsurface pressure and saturation to CLM (Kurtz et al., 2016 and Figure 2).

a) b)

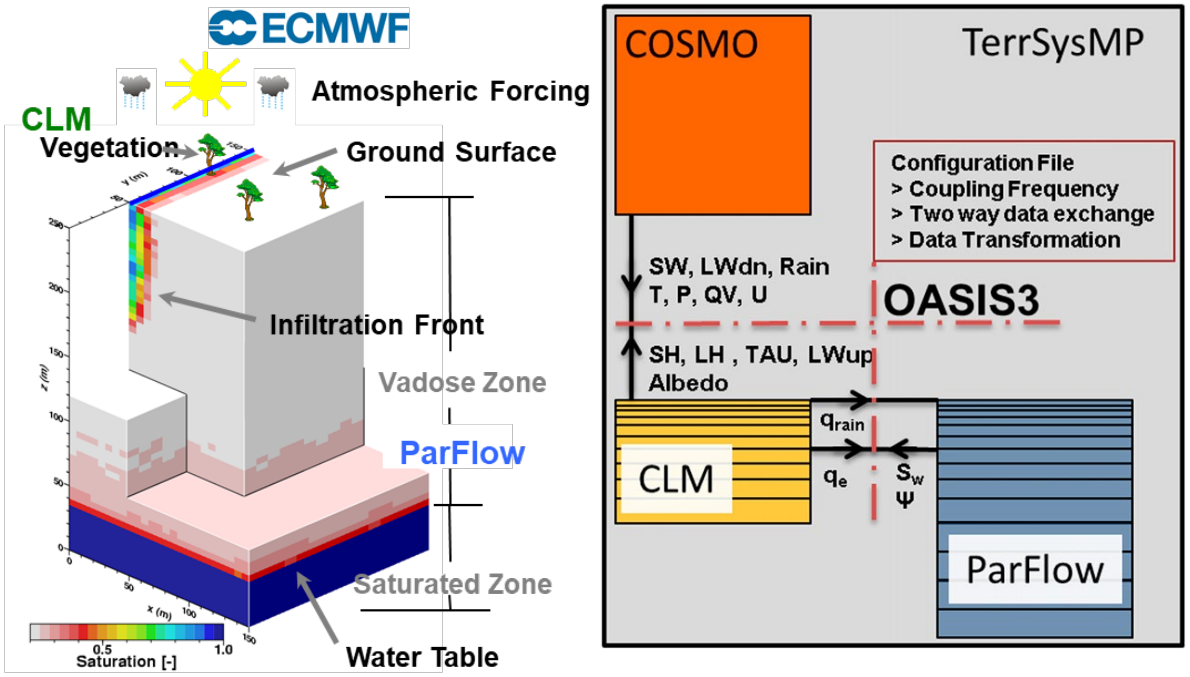

Figure 2: (a) The Terrestrial System Modeling Platform (TSMP) combines the compartment models COSMO, CLM and ParFlow. (b) The exchange of information about fluxes and states occurs at the conceptual boundaries (Shrestha et al., 2014).

The generic Parallel Data Assimilation Framework (PDAF) is used to quantify and reduce uncertainties associated with uncertain initial and boundary conditions, input parameters and their spatial distribution (Nerger & Hiller, 2013; Kurtz et al., 2016). PDAF is used to correct model simulations with measurements at specific time steps. This minimizes the error between the measurements and the model solution and constrains the initial conditions and parameters (Burgers et al., 1998; McLaughlin, 2002; Chen & Zhang, 2006; Hendricks Franssen & Kinzelbach, 2008; Reichle, 2008). For example, the ensemble Kalman filter (EnKF) is used (Evensen, 1994; Burgers et al., 1998; McLaughlin, 2002). TSMP-PDAF can thus be used to perform scale-consistent simulations of the Earth system at the catchment, regional, and continental scales using high-performance computing (HPC) resources at FZJ.

2.3 Model inputs and outputs

Models developed using TSMP-PDAF are generated using input topographic, geological, soil, vegetation and agricultural information and are forced by meteorological data (Shrestha et al., 2014). The surface topography is typically defined by digital elevation models (DEM). This is usually provided by national services (e.g., satellite programs) or obtained with unmanned airborne vehicles (e.g., Global Multiresolution Terrain Elevation Data 2010). Data obtained with e.g., drones can account for rapid changes in the topography of agricultural fields due to compaction and loss of soil.

The structure and hydraulic properties of the vadose zone are defined by soil profile databases and 2-D or 3-D soil maps (e.g., from the European Soil Data Center (ESDAC) or by using the FAO/UNESCO-Digital Soil Map of the World). Geological data such as 3-D geological models and/or 2-D maps of aquifer and aquitard surfaces, i.e., information about the saturated zone is used to define subsurface hydraulic parameters. Records of national surveys (e.g., long-term monitoring campaigns of groundwater level), local borehole information (e.g., geological models) or results from hydraulic tests (e.g., pumping, slug, and tracer tests) are used for this purpose.

Hydro(geo)logical data and meteorological data are used to define the initial model states and the boundary conditions or forcings that drive subsurface models (e.g., ParFlow) and land surface models (e.g., CLM). Relevant hydro(geo)logical data in this context are measurements of groundwater levels, river stages and soil moisture contents. Meteorological data for driving the model are air temperature, incoming shortwave and longwave radiation, air humidity, wind speed, air pressure and precipitation. The meteorological data can be obtained from existing governmental and proprietary measurement stations, national and international weather services (in particular reanalysis products like COSMO-REA6 or ERA5), hydro(geo)logical authorities and farming associations and/or (wireless) monitoring networks of observatories of the critical zone with remote access (e.g., https://www.tereno.net/). In parallel, meteorological short-, mid- and long-term forecasts can be used to define the transient behaviour of mode forcings in the near future. Some of these measurement data can be also used for model 'calibration' based on history matching, data assimilation or for consistency checks between measurements and simulations.

Remotely sensed data on vegetation such as leaf area index (LAI) and normalized difference vegetation index (NDVI), measured actual evapotranspiration by eddy covariance stations, and hydro(geo)logical data such as soil moisture content and groundwater levels can bring supplementary information and data to improve the model quality. Crop logs, vegetation information such as growth state and rooting depth, drainage and irrigation practices and schedules, i.e., agricultural data, can be used as supplementary information important as input for the land surface component of integrated terrestrial system models. These data are mainly collected by farmers, and farming associations (or WATERAGRI researchers on specific pilot sites).

The results obtained with TSMP-PDAF, such as forecasts of soil water content as a function of time can be presented in the form of tables and graphs for specific observation points or as large-scale maps. One of the latest information products developed by FZJ is the 'Water-monitor' (https://wasser-monitor.de/). The web application is free of charge and provides a 9-day forecast of soil water content for the upper 30 cm of soil in Germany. The current spatial resolution is 600 m x 600 m and one forecast per grid cell and per day can be provided (Figure 3).

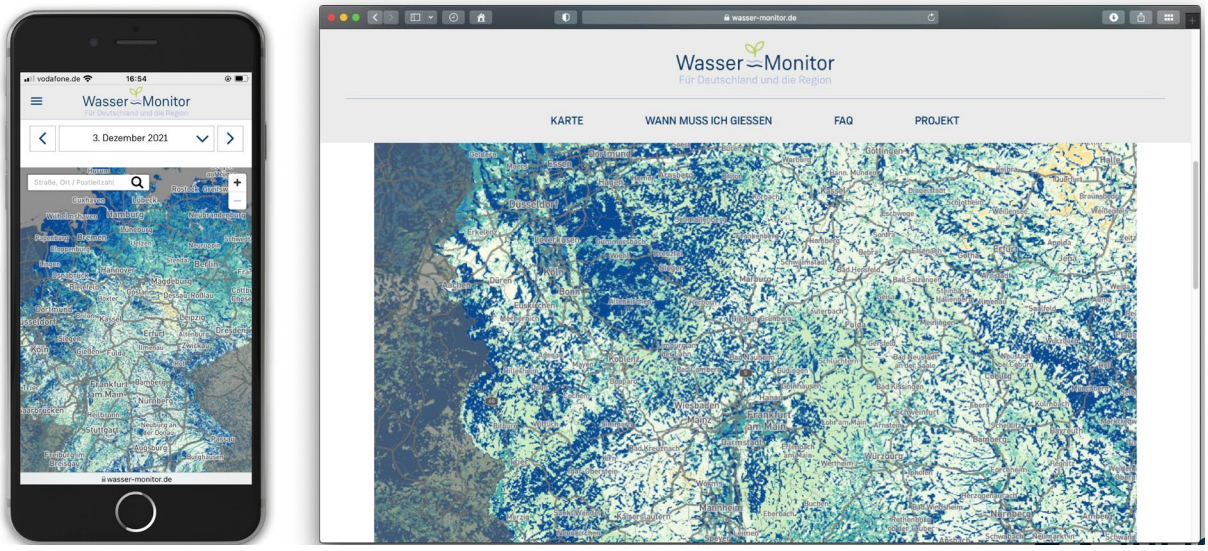

Figure 3: Screenshots of the web application 'water-monitor'(https://wasser-monitor.de/), which is free of charge.

3 Workshop

3.1 Workshop 3 agenda

The steering group organizing WS3 was composed of Richard Hoffmann (FZJ, Organizer), Harrie-Jan Hendricks-Franssen (FZJ, Organizer), Zoran Kapelan (TU Delft, WP1 Leader), Tamara Avéllan (Oulu University), Diego Guidotti (AGRICOLUS), Lisa Scholten (TU Delft) and Aashna Mittal (TU Delft). Unlike WS1 and WS2, WS3 was preceded by regional meetings in the respective national languages in Hungary, Finland, Poland, Switzerland, and Germany. WS3 itself was a 1-day plenary session (Figure 4).

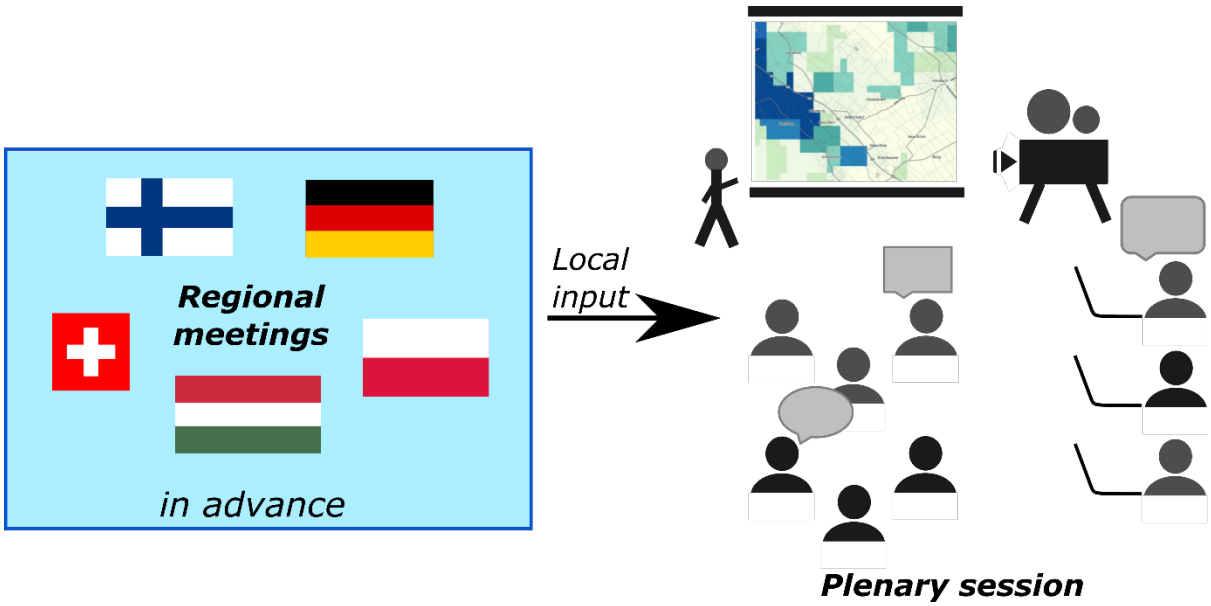

Figure 4: WS3 was a 1-day plenary session held online during the Covid-19 pandemic (February 16, 2022).

The motivation for regional meetings was to minimize language barriers when discussing interests in physically-based models and data assimilation, and thus to allow for intensive interactions between scientists working on the project and different stakeholders. The regional meetings consisted of:

1. the presentation of the cloud-based simulation and data assimilation system in non-technical language,
2. the presentation of the 'water-monitor' web application (https://wasser-monitor.de/) to exemplify the type of products that can currently be provided when using physically-based models at FZJ, and
3. the identification of stakeholders' needs for information products for the weather- and climate-resilient agriculture and their feedback on the demonstrated system.

The goal of the plenary session was to discuss feedback collected during the regional meetings among WATERAGRI consortium partners and participating stakeholders. Furthermore, the feedback should be translated into actions for the further development of the data assimilation framework (WP7).

A summary of the preparatory activities for the organization of WS3 can be found in Appendix A.1. FZJ started the planning activities in August 2021. The first steering group meeting to discuss the ideas of regional meetings was held in September 2021. The steering group decided to contact the WATERAGRI case study site owners in October 2021 and ask for their willingness to host a regional meeting with their respective stakeholders. The concept of the workshop and an approximate timeframe of the

plenary session were presented at the 4th general assembly of WATERAGRI in October 2021. Thereafter, case study site owners began to organize their respective regional meetings themselves with the help of FZJ (Chapter 4).

The date of the plenary session was determined based on a 'doodle' poll among WATERAGRI case study site owners, the executive committee, project leaders, work package leaders and internal stakeholders after the 4th general assembly in October 2021. Online events were clearly preferred by WATERAGRI consortium partners, as revealed by several discussions held during the Covid 19 pandemic in November 2021. Therefore, a save the date information for an online event was sent to the WATERAGRI consortium in mid-December 2021. The registration form for the plenary session was online at the beginning of January 2022. The final agenda was provided along with a reminder to register until the beginning of February 2022. Log-in details were first provided to registered users two days in advance. However, registration was possible until the beginning of the plenary session and log-in data was continuously provided.

Potential stakeholders for the regional meetings were selected and informed under the responsibility of local hosts. The informed target audience were associated water management and agricultural organizations at the regional/national level, (local) farmers or farmers associated to pilot sites of WATERAGRI, consultants and solution developers in the agricultural sector and persons from municipal, federal, and governmental institutions. The target audience informed about the plenary session was the WATERAGRI consortium (scientists, internal stakeholders, project partners), stakeholders from associated water management and agricultural organizations at the international level, farmers with international interests, persons listed in the WATERAGRI stakeholder register, and persons participating in one of the regional meetings. Also, other interested persons were welcomed to the regional meetings and the plenary session.

The local hosts announced their regional meeting/webinar two to eight weeks in advance via e-mail, personal correspondence (e.g., phone call) or national newsletters (e.g., from agricultural organizations). There was no specific registration form for the regional meetings. Stakeholders contacted were free to share the announcement and log-in information with colleagues, friends or any person interested in the regional meeting. However, interested participants were asked to provide brief feedback, for better planning of the content.

Selected participants for the plenary session were informed via email or personal contact. The partner InoSens helped with the dissemination and communication of the WS3. Everyone interested in the plenary session of WS3 had to fill out a registration form (Appendix A.4). This step is mandatory for this kind of events in Germany, especially if large numbers of participants (project externals) are expected or at least informed (more than 200 persons were informed here). Interested participants had to provide standard information such as Name, Surname, Organization/Institution and E-Mail address, and could provide their expectations for the WS3. All participants had to accept a disclaimer in accordance with German regulations, agreeing that feedback provided, and recordings would be synthesized and used for example for public reports. Participants could also indicate during registration whether they preferred to take part online or on site. This information was collected in case of short-term changes in the Covid-19 situation.

3.2 Setup and execution

The regional meetings took place in January and early February 2022 (Table 1). The plenary session was held on February 16, 2022. In total, 119 stakeholders participated in the regional meetings (Table 1) and 33 persons in the plenary session. All meetings, except the regional meeting in Switzerland, were held virtually. This was in accordance with the Covid-19 regulations in effect in the respective countries at the time. Each meeting had a specific agenda to also take the local interests and needs of the stakeholders into consideration (see sections 3.2.1 and 3.2.2). No regional meeting could be held in Sweden, Italy, Austria, and France. The willingness to participate in an event about physically-based models and data assimilation in irrigation was too low among the stakeholders in these countries.

Table 1: Overview of regional meetings held before the plenary meeting conducted on February 16, 2022.

Country	Date and time	Host	Invited participants	Actual participants	Format
Hungary	13/01/2022 13:00 to 15:00 CET	UNIDEB	30	13	online
Finland	26/01/2022 12:00 to 14:30 EET	OULU	17	15	online
Poland	08/02/2022 10:00 to 12:00 CET	UPWR	72	52	online
Switzerland	10/02/2022 16:00 to 18:00 CET	UNINE	8	6	At Ins (CH) (nearby Seeland site)
Germany	10/02/2022 17:00 to 19:30 CET	FZJ	38	33	online
		Sum	***165***	***119 (72 %)***	

Note that face to face events or at least hybrid events were clearly preferred by the organizers and local hosts (as it promised better interactivity). Efforts to arrange face-to-face meetings were negatively impacted by the increasingly strict Covid19 regulations due to the high Covid-19 incidences between August and December 2021. However, for example, FZJ retained the option of offering the plenary session as an ad-hoc hybrid meeting. A reservation of a separate room in a restaurant equipped with tools for a videoconference was kept until 7 days before the plenary session. It was finally cancelled, because the pandemic situation had not improved and only one participant was interested in attending the plenary session on site.

FZJ continuously supported the organization of all regional meetings. A set of presentation slides (Appendix C.1) and a two-pages summary of the cloud-based simulation and data assimilation system for personal use were provided by FZJ. Individual meetings were held with the hosts when more detailed explanations and support where needed. Local hosts translated the provided material into their local language. The translated slides were presented by the local hosts at the respective regional meeting. FZJ researchers attended all regional meetings, except the regional meeting in Switzerland that was organized by the WP7 leader. This allowed helping with questions about the system and the data assimilation part if necessary.

Three areas of discussion with a total of nine questions were defined for the regional meetings (Table 2). In parallel, a template was provided to report the stakeholders' feedback in all regional meetings in a structured way (Appendix A.6).

Table 2: Categories for the discussion part of the regional meetings and to deduce stakeholders' feedback.

Category 1: Importance of irrigation systems in the agricultural sector
To what extent and for which crops are irrigation systems already used?
What is the experience to date with common irrigation systems?
What are the limitations of common irrigation systems?
Category 2: Experiences with data and tools
Which data are demanded by e.g., farmers?
Which applications are offered for free, and which paid options are available?
What is the feedback on data available for free and for paid data?
Category 3: Feedback to the proposed simulation system
What do you think about the presented simulation system?
What temporal and spatial resolution would you like to have?
Other needs/criticism of the presented system?

The first area of discussion addressed the importance of irrigation to the participants in the regional meetings. The goal of the first point was to obtain information about the status quo for farmers in different areas of Europe and to identify potential problems for farmers related to irrigation, i.e., what are the expectations for physically-based models and what solutions are requested by stakeholders. The second area of discussion asked about stakeholders' experiences with data and tools. The goal was to obtain information on what products are used by farmers. It also asked about experiences with apps that are already being used in daily farming activities. The third area of discussion was about the feedback on the exemplary presented solution of the data assimilation framework (i.e., the web application 'Water-monitor'). The goal was to get information about what solutions are expected by stakeholders. Local hosts shared stakeholder feedback, i.e., responses to discussion points, with FZJ prior to the plenary session. The feedback from all regional meetings is summarized in Chapter 4.1 and was subsequently summarized by FZJ for presentation at the plenary session (Chapter 4.2).

3.2.1 Regional meetings

Hungary

The first regional meeting was held in Hungary on January 13, 2022, between 13:00 and 15:00 CET and was hosted by UNIDEB (Table 3). Main organizers were Attila Nagy, Erika Buday-Bódi and Zsolt Fehér. A total of 13 out of 30 informed stakeholders participated in the online event via the 'WebEx' tool. Two of the stakeholders were farmers with 50 ha and 500 ha of farming land.

Table 3: Agenda of the regional meeting in Hungary on January 13, 2022.

Time	Title/Topic	Moderator/Speaker
13:00 - 13:15	Welcome and introduction to the workshop and short presentation of the WATERAGRI project	Attila Nagy
13:15 - 13:35	Simulation system combining models and measurements	Attila Nagy
13:35 - 13:55	Sub-km interactive maps of plant-available water over Germany from daily ParFlow/CLM forecasts, interactive presentation on web-application on https://wasser-monitor.de/	Erika Buday-Bódi
Comfort break		
14:05 - 14:55	Discussion (feedbacks from the plenum)	Erika Buday-Bódi
14:55 - 15:00	Closing remarks	Attila Nagy

The goals of the WATERAGRI project and the global framework were presented by Attila Nagy after the opening of the regional meeting in Hungary. The presentation 'Simulation system combining models and measurements' was followed by the introduction of the web application from FZJ ('wasser-monitor.de') (Figure 5). Harrie-Jan Hendricks-Franssen and Richard Hoffmann (both from FZJ) were available to answer questions about the simulation and data assimilation system as well as the pilot site 'Selhausen' and its instrumentation. Questions and answers were translated by the local hosts. The round of questions was followed by a discussion between the local hosts and the participating stakeholders following the predefined structure from Table 2.

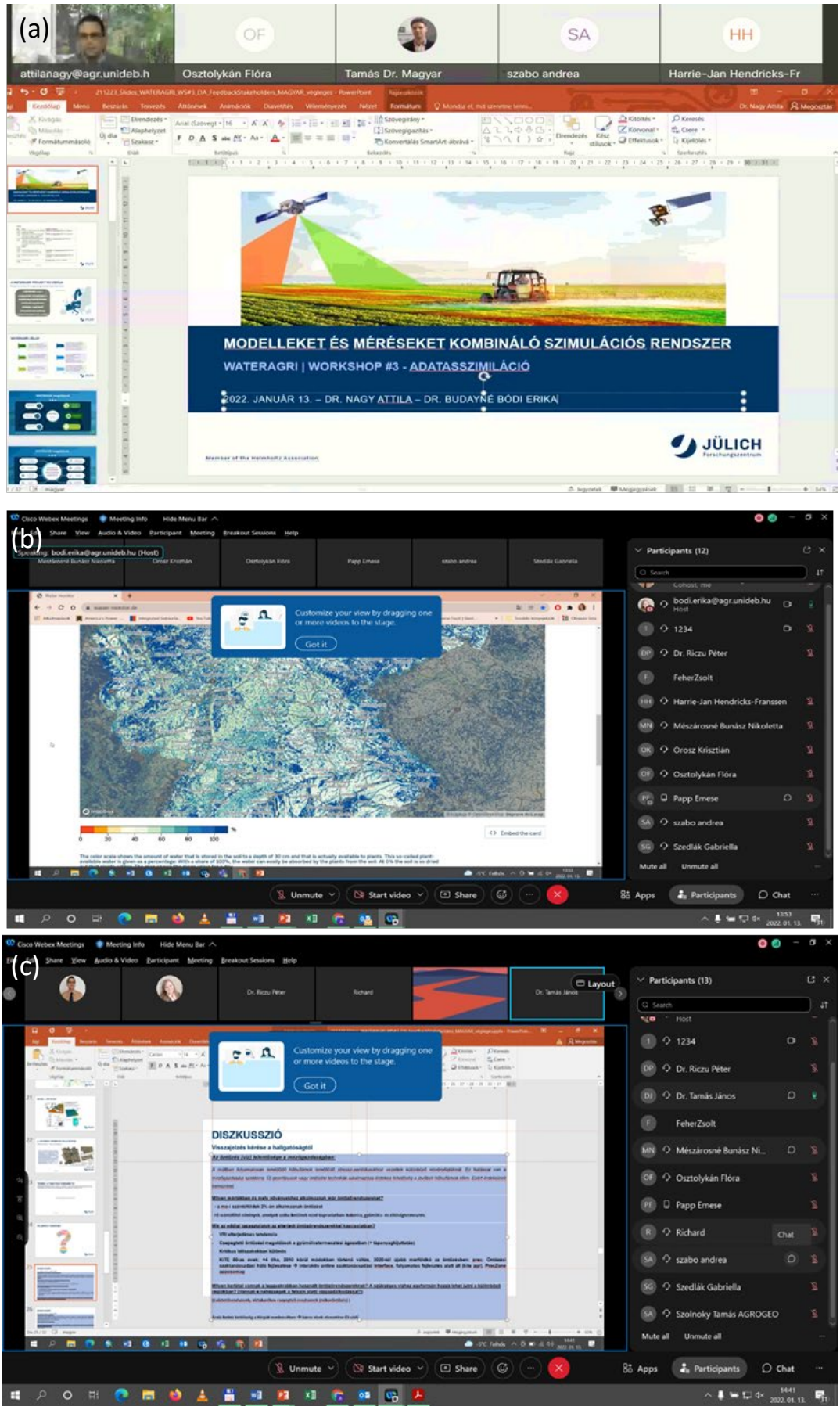

Figure 5: (a) Presentation of the cloud-based simulation and data assimilation system by Attila Nagy in Hungarian as representative of the FZJ researchers. (b) Presentation of the web application 'WATER-monitor' by Erika Buday-Bódi. (c) Plenary discussion on the 9 predefined discussion points.

Finland

The second regional meeting was held in Finland on January 26, 2022, between 12:00 to 14:30 EET and was hosted by OULU (Table 4). Main organizers were Björn Klöve, Tamara Avellán and Hannu Marttila. A total of 15 out of 17 informed stakeholders attended the online event using 'MS TEAMS'. The attendees were persons from advisory services and companies providing soil moisture and water management systems for agriculture. Three attendees were farmers.

Table 4: Agenda of regional meeting in Finland on January 26, 2022.

Time	*Title/Topic*	*Moderator/ Speaker*
12:00-12:10	Welcome	Björn Klöve
12:10-12:30	Presentation of participants and their experience on the topic	Björn Klöve
12:30-13:15	Presentation on research projects on controlled drainage	Björn Klöve
	- Measurement, modeling and assessment of water balance as part of the weather-compensated drainage of potato fields in Tyrnävä, 15 min	Björn Klöve
	- Ruuki Luke grassland experimental station and peatland studies - studies on hydrological research and greenhouse gas measurements, 15 min	Maarit Liimatainen
	- Studies and experience with the Sievi experimental field and the use of adjustable drainage, 15 min	Markus Sikkilä
Comfort break		
13:30-14:30	Presentation of simulation system combining models and measurements	Björn Klöve
	Presentation of the web-application 'water-monitor'	Richard Hoffmann
	Plenum discussion	Björn Klöve

The regional meeting started with a welcome and introduction by Björn Klöve. After that all participants introduced themselves. Two well-known stakeholders were actively involved in the development of the agenda. Based on discussions with these two stakeholders in advance of the meeting, the team organizing the regional meeting in Finland decided to include presentations of on-going activities in the regional meeting. So, the first part of the meeting had three presentations on controlled drainage and related water and soil moisture management predictions in Finland with a focus on WATERAGRI (Table 5). These are important research topics for stakeholders associated with the pilot sites in Finland. After a comfort break, Björn Klöve presented the simulation system and explained the combination of models with measurements by using the slides of FZJ. Slides were translated into Finish in advance. The web application by FZJ ('wasser-monitor.de') was presented to stakeholders by Richard Hoffmann (FZJ). After that a discussion followed according to the template provided. Local farmers participated actively in the discussion.

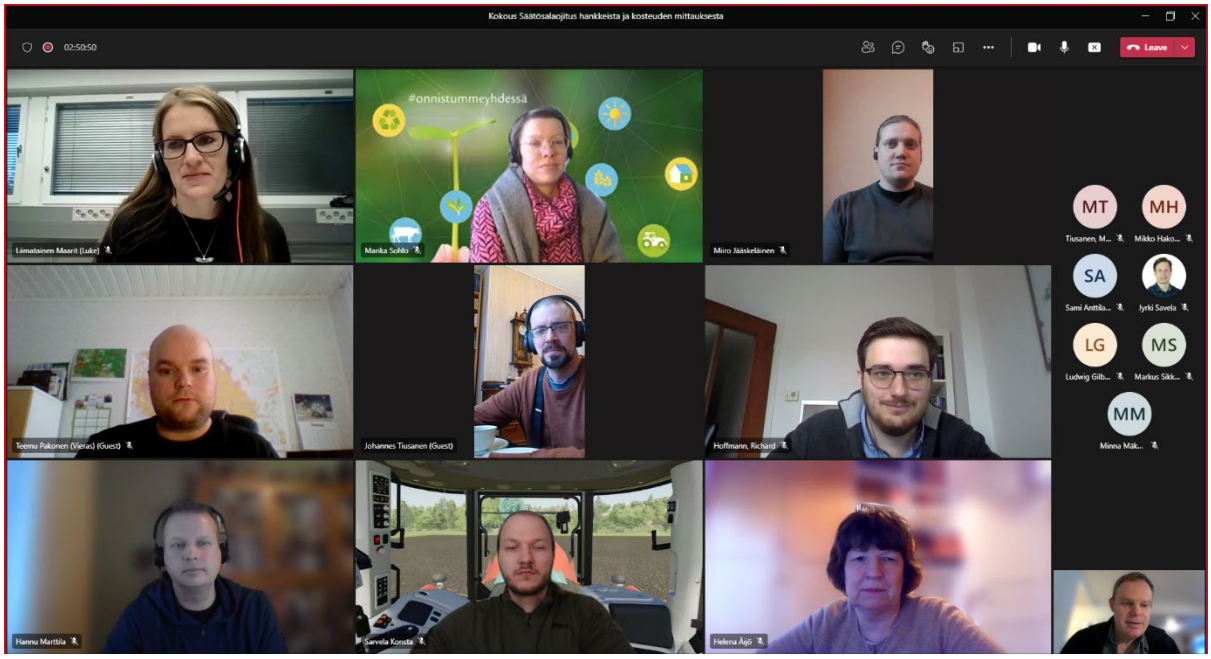

Figure 6: Impression of the regional meeting in Finland

Poland

The third regional meeting was held in Poland on February 8, 2022, between 09:45 to 13:00 CET and was hosted by UPWR (Table 5). Main organizers were Wiesław Fiałkiewicz and Arkadiusz Głogowski. A total of 52 out of 72 informed stakeholders participated in the online event using the 'google meet' video tool. Stakeholders were from water management agencies, consultants in agriculture and water services. Two of the stakeholders were farmers.

Table 5: Agenda of a regional meeting in Poland on February 08, 2022.

Time	Title/Topic	Moderator/Speaker
9:45-10:00	Connecting to the system. Please connect approximately 15 minutes before the start of the meeting to check the correct connection	
10:00-10:15	Welcome and presentation of the WATERAGRI project	Wiesław Fiałkiewicz
10:15-10:45	Good water management practices in projects implemented at CDR with examples	Marta Lubińska
10:45-11:15	Field measurement, calculation and forecasting systems: Forecasting in Lubnów Agricultural Farm	Arkadiusz Głogowski
11:15-11:45	Presentation of an early version of the cloud-based simulation and data assimilation system	Wiesław Fiałkiewicz
Comfort Break		
12:00-12:45	Plenum discussion of the presented system 1) Importance of irrigation and retention in agriculture 2) Availability of tools and data 3) Evaluation of the proposed simulation system 4) Cost and potential benefits to the farm	Arkadiusz Głogowski
12:45-13:00	Summary and closing	Wiesław Fiałkiewicz

Wiesław Fiałkiewicz welcomed the participants and introduced them to the regional meeting and presented the WATERAGRI project, its objectives, and its goals. A presentation on good water

management practices implemented at the agricultural advisory center (CDR) was given by Marta Lubińska. The presentation was animated with examples. Then, Arkadiusz Głogowski gave a presentation on field measurements, calculations and forecasting systems. It was presented for the Lubnów Agricultural Farm. This presentation also included parts of his PhD research and results. In parallel, UPWR developments in the context of WATERAGRI like the concept of physically-based models that are being developed with HydroGeoSphere for the pilot site in Poland were explained to stakeholders. The last presentation was given by Wiesław Fiałkiewicz about the early version of the cloud-based simulation and data assimilation system using the slides provided by FZJ. Slides were translated into Polish in advance. After the comfort break, the feedback was deduced by following the pregiven list of questions for discussion. Local farmers participated actively in the discussion.

Switzerland

The fourth regional meeting was held in Switzerland on February 10, 2022, between 16:00 to 18:00 CET and was hosted by UNINE (Table 6). Main organizers were Philip Brunner and Oliver Schilling who are also managing the WP7 of WATERAGRI and developing physically-based models for WATERAGRI with the code HydroGeoSphere (Therrien, 1992; Brunner & Simmons, 2012). A total of 6 out of 8 informed stakeholders attended the physical meeting in the city of Ins, which is located about 3 km away from the pilot site 'Seeland' in Switzerland. All stakeholders were related to the 'Seeland' region. Four of the stakeholders were farmers and one was a technician who controls for example manually a gate for filling a canal to provide water to farmers if they ask for it.

Table 6: Agenda of a regional meeting in Switzerland on February 10, 2022.

Time	Title/Topic	Moderator/Speaker
16:00-16:05	Welcome and Explanation of Goal of the WS3 (regional meeting)	Philip Brunner
16:05-16:15	Presentation of the current state of Data Assimilation and Field work	Philip Brunner
16:15-17:15	Open discussion / feedback	Philip Brunner + Oliver Schilling

Philip Brunner welcomed the attendees and explained the goals of the WS3 in the context of the WATERAGRI project. The WATERAGRI project was shortly introduced. Philip Brunner also explained how the new availability of measurement data and modeling techniques now allow data assimilation with physically-based models. Then the progress of the local modeling and data assimilation platform development (HydroGeoSphere + HydroGeoSphere and PDAF) were shown. The presentation part was followed by an open discussion round where the Stakeholders were asked about their wishes and potential use cases with respect to the presented real time modeling. Feedback to the predefined categories of discussion was reported using the template by FZJ.

Germany

The fifth regional meeting was held in Germany on February 10, 2022, between 17:00 to 19:30 CET and was hosted by FZJ (Table 7). Main organizers were Klaus Görgen, Alexandre Belleflamme, Patrizia Ney, Sebastian Bathiany, Richard Hoffmann and Harrie-Jan Hendricks-Franssen. A total of 33 out of 38 informed stakeholders attended a webinar using the meeting platform 'zoom'. Five stakeholders were farmers. The agenda of the regional meeting in Germany differed a bit as most of the contacted stakeholders are actively involved in the project ADAPTER (https://adapter-projekt.org/), led by FZJ colleagues. As part of ADPATER, webinars (and in-person events) keep stakeholders informed of new developments in information products for the weather- and climate-resilient agriculture. These

products are mainly developed using TSMP-PDAF. Some of the farmers are also testing on their plots new equipment developed for ADAPTER.

Table 7: Agenda of regional meeting in Germany on February 10, 2022.

Time	Title/Topic	Moderator/Speaker
17:00-17:10	Welcome and Introduction	Klaus Görgen
17:10-17:30	Climate change and agriculture - What lies ahead for Germany	Sebastian Bathiany
17:30-17:40	Observation of soil moisture and weather	Patrizia Ney
17:40-17:50	Forecast of the soil water content	Alexandre Belleflamme
17:50-18:00	Introduction to WATERAGRI – Assessment of demand for forecasts of water balance in the soil of agricultural lands	Richard Hoffmann
18:00-19:00	Open discussion / feedback including a life Demo	Klaus Görgen
19:00-19:30	Time for free exchange and contact exchange	Klaus Görgen

The stakeholders were first welcomed by Klaus Görgen and introduced to the webinar. This was followed by a series of presentations on climate change and agriculture in Germany, and on the methods and new developments in the ADAPTER project using TSMP-PDAF. ADAPTER products were presented to stakeholders, which included the presentation of the 'water-monitor' like in other regional meetings. The WATERAGRI project was then presented to the stakeholders, explaining its objective and structure, and briefly mentioning the pilot sites in Europe. The link between ADAPTER and WATERAGRI, i.e., the use of TSMP-PDAF to predict soil water content with high resolution was exemplarily explained by Richard Hoffmann for the WATERAGRI pilot site 'Selhausen'. The presented products and the objective of WATERAGRI were then discussed among the participants. In a relatively free discussion round, stakeholders' needs and expectations for the modeling systems were collected, as both projects benefit from the feedback. The discussion session covered largely the questions discussed in other regional meetings. Afterwards, participants were able to stay for additional 30 minutes for informal discussion and networking. It was used by four stakeholders.

3.2.2 Plenary session

The plenary session was held on February 16, 2022, between 10:00 and 15:00 CET. The main organizers were the Steering Committee, which organized WS3. The organizers informed about 200 persons using the stakeholder register of WATERAGRI and the consortium email list. A total of 33 out of 51 registered participants attended the plenary session, which was held as an online meeting via the meeting platform 'Zoom'. The exchange with stakeholders was achieved in the regional meetings, so the number of participants in the plenary session was obviously lower than in previous workshops without regional meetings. The plenary session was divided into a part with a presentation of the simulation system and a part with a presentation of the regional meetings, both times including discussions (Table 8).

Table 8: Agenda of a plenary session on February 16, 2022.

Time	*Title/Topic*	*Moderator/Speaker*
10:00-10:10	Welcome and introduction to WS3 On behalf of the project: M. Scholz, Lund University On behalf of WP1: Z. Kapelan, TU Delft	Zoran Kapelan (TU Delft) /FZJ
10:10-11:00	Presentation of an early version of the cloud-based simulation and data assimilation system	Harrie-Jan Hendricks-Franssen and Richard Hoffmann (both FZ Juelich)
	Slideshow + Presentation of web-application	
11:00-11:30	Plenary discussion about the presented system	Harrie-Jan Hendricks-Franssen (FZ Juelich)
Comfort break		
12:00-12:30	Presentation of the outcome of regional meetings	Richard Hoffmann (FZ Juelich) (+ UNINE)
12:30-13:00	Plenary discussion about outcomes of regional meetings	Richard Hoffmann (FZ Juelich) (+ UNINE)
13:00-13:05	Closure of the non-technical part	Z. Kapelan (TU Delft) / FZJ
13:05-14:00	Technical discussion to turn feedback into specific "actions" (open to anyone interested, but it will be held in technical language)	Richard Hoffmann (FZ Juelich) (+ UNINE)

Registered people could enter the virtual meeting room 15 minutes before. The organizers checked at that time the list of registrations, as only people who accepted the disclaimer (i.e., filled in the registration form) could attend the meeting (See chapter 3.1). The meeting officially started with a welcome and introduction by Miklas Scholz on behalf of the project and by Zoran Kapelan on behalf of WP1. The agenda of the plenary session was structured to attract participants who could not attend a regional meeting, as well as consortium partners interested in the modeling system and who were not involved in the regional meetings.

After that, Harrie-Jan Hendricks-Franssen presented the early version of the cloud-based simulation and data assimilation system in non-technical language and comparable to the presentation in the regional meetings given by local hosts (Figure 7). Some web applications such as the 'Water-monitor' were also demonstrated to motivate the plenary discussion afterwards. Time was also offered for questions and feedback on the system. Figure 8 shows participants captured before the comfort break.

After the break, Richard Hoffmann presented the outcomes of regional meetings and the collected stakeholder feedback as additional input for a final discussion (Appendix C.2). Local hosts and stakeholders who attended one of the regional meetings first had the opportunity to comment on the regional meeting presentation. This was followed by a free-form discussion among participants. After that, the non-technical part of the plenary session was closed. A technical discussion followed to translate the feedback into concrete "actions" for WP7. This part was open to all interested participants, but the language was more technical. The number of participants in the last meeting decreased accordingly.

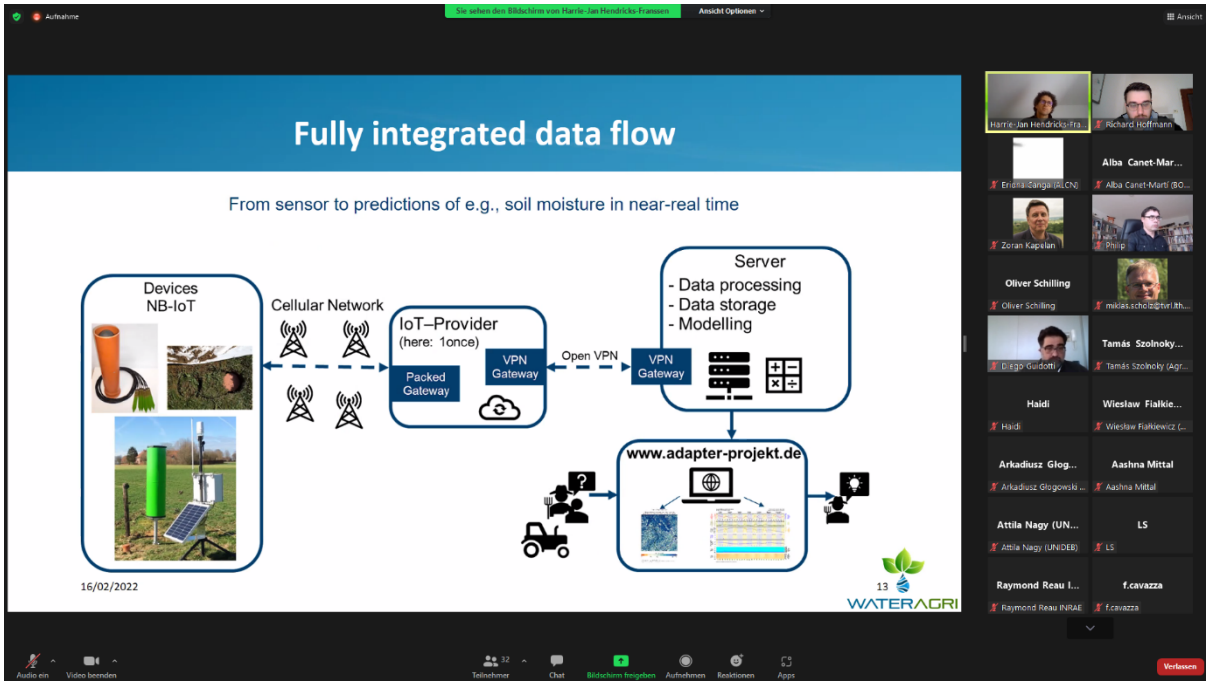

Figure 7: Impression of presentation of cloud-based simulation and data assimilation system in non-technical language.

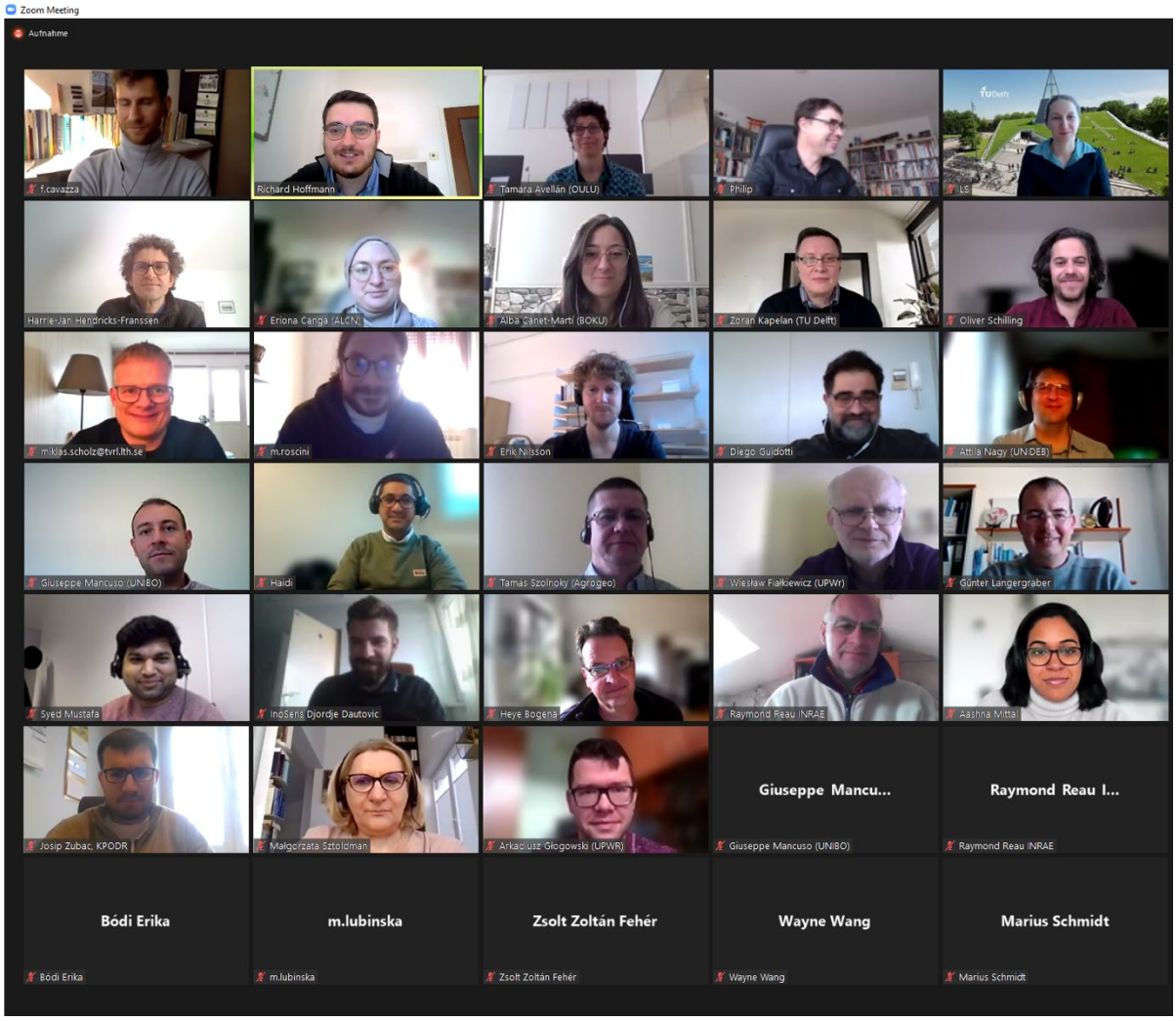

Figure 8: Screenshot of participants before the comfort break.

4 Results and Discussion

4.1 Regional meetings results

The key results from the regional meetings are summarized in the following. The entire feedback, i.e., the reports, are provided in Appendix B.

Hungary

During the discussion at the Hungarian regional meeting, some attendees said that certain agricultural service companies offer packages containing sensors for general hydro-meteorological monitoring providing data but farmers value consulting services. Attendees agreed that in everyday work simplified data instead of complex indicators are more helpful. Attendees from water management agencies highlighted typical Hungarian problems related to irrigation, for example suboptimal control of shallow groundwater exploitation, and lack of registration of wells and production rates. Besides the importance of knowing soil moisture content, also the interest in soil water quality was highlighted, while another attendee mentioned that not only water, but nutrition content information is interesting for agricultural producers.

The attendees discussed that the current practice in dynamic water supply modeling would be preferred instead of static water supply models. Some stakeholders also doubt that a model with one-hour temporal resolution is necessarily justified for every case. The spatial resolution seems more important for stakeholders than the temporal resolution and one forecast per day seems sufficient. In summary, attended stakeholders/participants agreed that the exemplary shown simulation system ('water monitor') is very impressive and already useful in its current version as it provides some regional information. However, solutions for the plot scale were requested. In parallel, attendees who had not attended WATERAGRI workshops before were interested in the WATERAGRI project goals and framework and were interested in the follow-up of the WATERAGRI project results.

Finland

Attendees in the Finland meeting explained that irrigation is carried out on some valuable crops such as potatoes, onions, carrots, and strawberries which cover only a small percentage of the Finnish agricultural fields. However, irrigation is becoming increasingly important due to recent droughts and uncertainties related to future climate change. Subsurface irrigation systems are used on about 70000 ha of agricultural land in Finland. Surface irrigation is used only on a small percentage of the fields. There is an interest in irrigation and controlled drainage. At some locations water availability restricts irrigation. Also, knowledge level and detailed data seem to be restricting. Information is needed for drainage control (to retain water but not cause waterlogging). Also, information is needed for irrigation scheduling. Weather stations have been used to some extent, but they have been perceived as more harmful than useful.

In this context, the stakeholders mentioned that the spatial resolution and the accuracy of modeling systems are important markers for them. The audience demanded for example estimates of the accuracy of the presented system based on observed and predicted values to better evaluate the reliability of the system. The stakeholders agreed that the presented modeling and data assimilation system could be useful for large farms. However, it was doubted that the current spatial resolution and the different resolutions of the input data used, provide forecasts of equal quality for all regions in Finland. It was questioned whether forecasts for areas with less dense data and monitoring networks are reliable enough for farming activities. A forecast once a day seems appropriate to

stakeholders, although it seems worthwhile to consider a higher frequency if it does not affect the accuracy of the forecasts. In parallel, the stakeholders motivated that the forecast model should consider soil composition and water management. Farmers clearly ask for example for the water balance at the field (and plot) scale. Finally, the products of such a forecast system must be very easy to use in the growing season because farmers will then be very busy.

Poland

During the Polish discussion it was stated that the large-scale irrigation of cereal crops is not profitable in Poland. Irrigation is mostly used for potatoes and for vegetables in greenhouses (precise irrigation). The farmers are aware of the irrigation need, but they underlined that there are many barriers preventing them from applying irrigation, these include long and complex administrative procedures, expensive equipment, access to sufficient water resources, and uncertainty about the future of the leased land. The most useful information for farmers is the forecast of rainfall for at least 7 days in advance. There is a need for precise information and accurate predictions and free of charge applications are preferred. The use of other hydro-meteorological data like soil water content could also be useful but would need additional training. The developed application should include all relevant information to avoid using many different platforms/tools to obtain a full overview of the local environment. The presented simulation system, i.e., the application 'water-monitor', was appraised as very promising and useful but at the same time there was expressed anxiety about what will happen with the system including the WATERAGRI improvements when the WATERAGRI project is finished. There was also a question of when the system would be available for the whole country (Poland).

Switzerland

The feedback related to the Seeland (Switzerland) case study site model (HydroGeoSphere + Data Assimilation) showed that tools must allow the assessment of the distributed status quo (groundwater levels + soil moisture) and should provide forecasts of the short-term development. The ideal forecast horizon for better planning of dewatering and irrigation would be one week ahead. In parallel, stakeholders desire a tool that is interactive and allows management options to be evaluated, e.g., "what happens if I now pump with flow rate 'Q' for 't' hours here, does that achieve my goal of lowering the ground water level 'z' cm within reasonable time and costs?". It would also be helpful to assess new infrastructure options like installation of a new drainage network based on a model that optimally reflects the status quo. However, any information provided by models needs to be accessible in the field via App. Such an app must be an easy tool, with predictions of depth to groundwater level and soil moisture distribution at different depths.

Overall, stakeholders were very interested in the product and had many questions about how they could use it and what it would allow them to do. They even asked about the future of the product, whether it would be maintained and extended to include the entire region. The region is a former lakebed, so the area has shallow groundwater levels, with the need for a large management model. They would like to see prototypes to do the first tests as soon as possible, but we can only deliver something good in 6-12 months due to the requirement to first develop a future proof data assimilation platform for HydroGeoSphere (i.e., HydroGeoSphere-PDAF).

Germany

Stakeholders in the German meeting mentioned that irrigation has started to become important in Germany since high yield and financial losses were experienced in the droughts in 2018 and 2020. Irrigation varies strongly between regions, as it competes with the management of the groundwater compartment that is used for drinking water supply. Where irrigation is possible, crops are largely irrigated with mobile systems and not with stationary systems. The mobile systems are expensive, and it is often not so clear where to place the machines in the fields. There are commercial apps available to optimize the positioning and driving of the irrigation machines as well as the irrigation volume and rates. However, the required sensors for the apps are often too expensive or too complex to use. Thus, farmers are often doing 'preventive' irrigation, i.e., irrigating for multiple days, without being fully aware of the required water amounts. At the same time, the applications available or mentioned in the meeting seem to lack scientific validation.

Farmers ask for weather data, the water balance including soil water content information, the degree of soil compaction on their fields and data relevant for fertilization. Stakeholders asked for depth-related information on hydrological states and fluxes as well as temperature. They clearly ask for an 'all in one' tool providing site specific information. A high spatial resolution of tens of meters and long forecast horizons (> 14 days) is desired.

In this context, one attending farmer had described a 'perfect' information product for him as a product that will present the current states and fluxes for his fields in the morning and the afternoon. The system should provide also forecasts of hydrological states at minimum 10 days ahead. The best visualization for him would be a map highlighting zones which are already (too) dry as well as zones which will become (too) dry in the next 10 days. Clear management options should be provided along with forecasts. Inputs for requesting management options should be kept simple so that requests can be made quickly. The farmer could clearly imagine that such a product, either as web-application in the office or as an app, would allow him to better plan the shifts of his workers and the positioning of the irrigation machines.

Summary

The regional meetings indicated that stakeholders would like information on the weather (mainly rainfall), soil water content, groundwater levels (if groundwater is close to the surface), and driving/'road' quality (i.e., to decide if they can drive on their fields with heavy machinery). The importance of this information differs locally. For example, stakeholders in Switzerland ask with high priority for information on the groundwater levels at the site while stakeholders in Germany are asking for more local weather forecasts. Other not model related expectations include cost-effective technical improvements to irrigation systems and clearer policy regulations. This is certainly of interest to WATERAGRI but it is beyond the scope of WS3 to deal with models combined with measurements and their output format for stakeholders.

Stakeholders clearly prefer that the information provided be easy to use and made available on mobile devices such as smartphones. Web applications could only be helpful to stakeholders if they allow full control of farming activities from the office. This seems to be more interesting for large farms. Any tool, whether an app or web application, should combine multiple hydro-meteorological information sources and should reflect the current situation on farms. Optimally, the information is provided several days in advance and along with management strategies.

4.2 Plenary meeting results

The discussion following the presentation of the cloud-based simulation and data assimilation system in the plenary session focused on a useful format of an information tool for weather and climate data and on stakeholder expectations for the presented system. The extent to which costs can be reduced by using the outputs of the system was discussed, although this is quite open at this time as the presented 'products' are prototypes. It was questioned whether the current spatial resolution of the FZJ products is sufficient.

The feedback from the regional meetings (Chapter 4.1) was presented in the second part of the plenary session as a start for discussion among the consortium partners. Scientific details of the models are not as important to stakeholders as their reliability. Both simple models and complex physically-based models seem appropriate to stakeholders as long as the predictions are reliable enough for them. Consortium partners mentioned that it can be too time consuming for farmers to regularly provide data (e.g., as input in apps) and that it is not always clear to farmers how to use the information from physically-based models or provided by consultants and agriculture services. It was mentioned that many commercial apps collect a large amount of data for different agricultural areas. When farmers then request advice for their land in these apps, the collected data is often just provided unprocessed. This is not helpful to farmers who expect local forecasts and management options for their land. This is consistent with feedback from Germany that many commercially distributed apps, while providing a lot of data, could have better scientific validation and more appealing visualization options. This is also consistent with feedback from all regional meetings indicating that stakeholders are clearly asking for management strategies that can be easily implemented in daily practice. Stakeholders have the interest in comparing the potential impact of different scenarios and want to see at a glance which management strategy could be most efficient given the current states, fluxes, and situation on their plots/farms.

The goal of the last part of the plenary session, i.e., the more technical part, was to identify activities for further development of the data assimilation framework in WP7. Key discussion points were how to add new information to the models in near real time, where the models will run, and how to make the asked information available to end users. It was noted that stakeholder expectations for forecast horizons partly contrast with the current technical status quo. Stakeholder asked about seasonal weather forecasts and forecast time frames, e.g., for soil moisture predictions of several weeks. Uncertainty increases for forecasts in the farther future. Weather forecasts are reliable for the next 5 days and are informative about a general trend for 10 days in the future. However, predictions concerning soil moisture, groundwater levels and plant states are more constrained by past conditions and can be made for longer periods in the future.

In addition, high spatial resolution (i.e., a local 'farm' model) was suggested. Forecasts for a single point and high-resolution maps showing the spatial distribution of a variable of interest like soil water content as a function of time are extremely data intensive and require, for example, plot-specific soil and plant data that are often not available. However, the highly instrumented WATERAGRI pilot sites can be used at the beginning and for demonstration purposes. In contrast, two forecasts per day, as asked in many regional meetings, are feasible, as this is also consistent with measurement frequency.

The feedback collected in WS3 is valuable and made clear that three 'solutions' for the data assimilation framework (WP7) are required (Table 9). Firstly, continuous simulations of typical fluxes and states for selected pilot sites should be made available. Farmers should be able to provide specific information about their farm and current observations, which should then be included in the next

simulations. The spatial resolution will be chosen in dependence on the available information and computer resources. The forecast horizon should be as long as reliable forecasts are available and the uncertainty is still not too high. Secondly, 'models on demand' would be interesting. Simple information will be extracted on demand and made available directly on the smartphone in the field. Hydro-meteorological information on demand could be useful, for example, to make quick decisions based on groundwater levels, and to decide on an open or closed channel providing water to farmers or not. One difficulty to be solved here is ensuring smartphone accessibility to WATERAGRI partner computing/cloud resources and how to extract the data in near real-time. However, it is realistic to test the procedure manually. Thirdly, it would be interesting to provide scenario-based models. Typical scenarios for farmers could be defined and then several models can be run in parallel. For demonstration, the models simulating different scenarios could be started manually by an expert. The results in the form of management strategies could then also be provided by an expert, e.g., a scientist associated with a pilot site. Management options could be also ranked.

Table 9: Potential information products that consider the feedback mentioned by stakeholders on physically-based models combined with measurements (Data Assimilation framework) in WS3.

	Real-time models and forecasts	Models on demand	Scenario models
What will be done	Continuous real-time simulations and forecasts of typical hydro(geo)logical fluxes and states of the test site considering the latest data available Farmers can provide information about their farm and plots for updating the simulations of the next day	Extraction of model states and fluxes from existent management or real-time model on demand Quick information will come directly on the smartphone onsite	Multiple models will run in parallel simulating different scenarios defined by the end-user (irrigation on/off) Models will be manually started by an expert, later with an automatic routine
Update frequency	Once per day	On demand	Individual
Expected product	Maps of depth to groundwater	Provide local information, such as groundwater level information to decide for example on adjusting the water level in a canal	Quantitative support in long-term decision making

5 Conclusion

5.1 Summary of key messages

WATERAGRI WS3 was organized to present and obtain feedback from project stakeholders on an early version of the cloud-based simulation and data assimilation system. The workshop was conducted as a series of regional meetings held prior to the plenary session. The feedback from regional meetings was discussed further in the plenary sessions and converted into 'next steps' for the development and improvement of the aforementioned cloud-based system.

The regional meetings had a high turnout with 119 participants attending across 5 pilot sites in an equal number of countries. In these meetings, participants discussed the importance of irrigation systems in the agricultural sectors, shared their experiences with data and tools, and provided feedback to the proposed simulation system as part of the WATERAGRI framework. The collected feedback in the regional meetings is fairly general as it also applies to other WATERAGRI solutions. With regard to the simulation and data assimilation system, stakeholders clearly seek different levels of information (from simple to complex) and they expect this information to be made available in a way that is easy to use. They also expect this information to help them combine different hydro-meteorological information sources, e.g., through an interactive and easy to use application on smartphones. Furthermore, stakeholders expect that they are provided with interpretations of the models results in the form of clear management strategies that can be easily implemented on their farm. Finally, they are also interested in comparing the impact of different decisions across multiple scenarios.

The plenary session of WS3 was focused on presenting the feedback from individual regional meetings and discussing further how the issues raised can be tackled in the further development of the cloud-based simulation and data assimilation system. This meeting was attended by 33 participants. Based on the inputs of the regional meetings, three solutions for the data assimilation framework were identified. Firstly, continuous simulations of typical fluxes and states for pilot sites will be made available with a high spatial resolution and a long, but reliable forecast horizon. Secondly, 'models on demand' will be explored where simple information can be extracted and made directly available to a farmer's smartphone on demand. Lastly, multiple scenarios of relevance to farmers will be developed, and the models will be run for these scenarios.

5.2 Limitations and lessons learnt

Several important lessons were learned while planning and executing the workshop that must be considered in the subsequent WATERAGRI workshops or similar transdisciplinary research projects:

1. The organization of regional meetings in the local language was a success as it enabled participants to interact in their local language. In comparison to the breakout sessions in previous workshops, we witnessed more attendance from participants in WS3. However, this approach came with the trade-off of time and effort as the presentation material needed to be translated into the local language and support was required from local project representatives to translate the questions and feedback to the presenters in real-time.
2. Our attempts to engage higher level stakeholders (e.g., with international commitment) were also constrained by their long response times (> 2 months) and limited availability. In contrast, webinars, and face-to-face meetings with local and regional stakeholders, as well as those

involved in other projects, were successfully organized within 2 to 4 months. Attendance rates were over 70 % when sufficient notice was given.

3. To ensure continuous stakeholder engagement, it is critical to think about providing "feedback on the feedback", i.e., communicating to the participants how their feedback will be used during future project activities. For WS3, we attempted to do this by holding a 'technical' session immediately after the plenary session where the participants' feedback was translated into concrete actions. Ideally, the results of the workshop should be communicated back to the participants through follow-up regional meetings, but to avoid stakeholder fatigue, we aim to provide feedback to the feedback through the means of this report.

5.3 Future work

Based on the feedback provided by participants and the follow-up discussions that ensued, future work on the data assimilation tool and the web-based visualisations as part of the WATERAGRI framework, will clearly be concerned with improving the spatial resolution of the simulation results. The goal is to provide reliable predictions not only at the regional or pan-European level but also at the individual farm level. Improving spatial resolution will significantly increase computational resources and will require additional high-resolution measurements for individual plots (e.g., drone data). The scale of the WATERAGRI pilot sites is therefore a good starting point for testing different strategies to improve the spatial resolution of physically-based models. Furthermore, attempts will be made to provide longer forecast horizons with low uncertainty/high reliability, although this is a highly technical challenge given the current state of the art and the remaining project duration.

Based on the planning and outcomes of WS3, a few recommendations can also be made for future project activities:

1. Conducting regional meetings prior to the plenary workshop led to an increase in participant turnout and enabled in-depth discussion in local language. Attempts should be made to involve local stakeholders through such meetings, keeping in mind the time and effort required to support translation activities.
2. Workshop participants showed interest in knowing how the results of the WATERAGRI project will be used after its completion and whether long-term collaborations with industry or spin-offs will be funded. These questions must be addressed as part of Task 1.4 of WP1 ("Ensuring engagement beyond the project end").

6 References

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7 Appendices

Appendix A: Workshop preparation

A.1 Preparatory steps for the organization of WS3

Date	Participant	Main activity
23/08/2021	FZJ	Start of activities
14/09/2021	FZJ with the steering group	*Kick off session for starting workshop organization:* - The decision to go for regional meetings preceding a plenary session - Plenary session as a hybrid event
15/09/2021-06/10/2021	FZJ with the steering group	Preparation of outlay of WS3
20/09/2021	FZJ	WATERAGRI case study site owners were informed of the concept
08/10/2021	FZJ, steering group, interested WATERAGRI case study site owners	*Points of discussion were:* - Willingness to host a regional meeting - definition of time frame and needs for material provided by FZJ - regional meeting preferably to be planned as face-to-face events
27/10/2021	FZJ + steering group	Workshop concept presented at 4th general assembly of WATERAGRI
10/11/2021-17/11/2021	FZJ + WATERAGRI consortium	Poll for defining a date for the plenary session
10/11/2021-10/12/2021	FZJ	Search for a venue for a hybrid event (plenary session)
17/11/2021-17/12/2021	FZJ + steering group	Material preparation for regional meetings (Presentation slides, information material, feedback templates)
01/11/2021-10/02/2022	Interested case study site owners	*Willing case study site owners:* - Organized their regional meetings with support from FZJ - Contacted/informed interested participants
01/11/2021-10/02/2022	FZJ, WATERAGRI case study site owners	Individual discussions and support
01/12/2021-10/12/2021	FZJ	Several polls and individual discussion clearly showed that an online event is preferred for the plenary session in times of a pandemic.
15/12/2021	FZJ with the steering group	The decision for hosting the plenary session virtually due to increased covid-19 measures
17/12/2021	Steering group	Save-the-date information
21/12/2021-10/01/2022	FZJ	Clarification of privacy policy and installation of a registration form for the plenary session conform with the regulations in Germany (disclaimer)
23/12/2021	FZJ	Material for regional meetings provided (Presentation slides, 2-page summary, questionnaire for farmers and 9 points of discussion)
11/01/2022-16/02/2022	Steering group	Registration form for plenary session activated
18/01/2022	FZJ with InoSens	Exchange with InoSens on dissemination and communication
01/02/2022	FZJ with the steering group and InoSens	*Key points:* - Definition of final agenda of the plenary session
11/02/2022	FZJ with the steering group and InoSens	Final discussion before the plenary session
14/02/2022	FZJ	Final discussion on presentation slides and technical aspects

A.2 Abstract for WS3, and updated agenda sent to participants in February 2022

WATERAGRI | Workshop #3

Presentation of an early version of a cloud-based simulation and Data Assimilation system

February 16, 2022 – 10:00 to 14:00 CET (Online Event)

Agenda:

Time	*Topic*	*Moderator/Speaker*
10:00 – 10:10	*Welcome and introduction to Workshop #3* On behalf of project: M. Scholz, Lund University On behalf of WP1: Z. Kapelan, TU Delft	Zoran Kapelan (TU Delft) / FZJ
10:10 - 11:00	*Presentation of an early version of the cloud-based simulation and data assimilation system* Slideshow + Presentation of web-application	Harrie Jan Hendricks-Franssen and Richard Hoffmann (both FZ Juelich)
11:00 – 11:30	*Plenary discussion about the presented system*	Harrie Jan Hendricks-Franssen (FZ Juelich)
11:30 – 12:00	*Comfort break*	
12:00 – 12:30	*Presentation of outcome of regional meetings*	Richard Hoffmann (FZ Juelich) (+ UNINE)
12:30 – 13:00	*Plenary discussion about outcomes of regional meetings*	Richard Hoffmann (FZ Juelich) (+ UNINE)
13:00 – 13:05	*Closure of the non-technical part*	Z. Kapelan (TU Delft) / FZJ
13:05 – 14:00	*Technical discussion to turn feedback into specific "actions" (open to anyone interested, but it will be held in technical language)*	Richard Hoffmann (FZ Juelich) (+ UNINE)

The European project 'WATERAGRI' develops innovative sustainable solutions for water retention and nutrient recycling to enable agricultural production that can sustain growing populations and cope with present and future climate change challenges. The project engages researchers and stakeholders to collaboratively develop new knowledge and innovative solutions. Ten case studies are spread across three climate zones in Europe and some of the developed solutions will be evaluated by physically based hydrological models.

Workshop #3 provides the opportunity for intensive interaction between scientists working in the project and stakeholders and is preceded by regional meetings. These meetings will be held in the respective national languages in Hungary, Poland, Finland, Switzerland and Germany between December 2021 and January 2022. The workshop itself is a plenary session scheduled for February 16, 2022 (10:00 to 14:00 CET). It will be an online Event.

An early version of a cloud-based simulation and data assimilation system will be presented at the workshop. This system will allow for the best possible predictions of conditions on the land and in the soil, like soil moisture contents, groundwater levels, crop status and expected yield, amongst others. The best possible prediction is achieved by combining physically based models (already topic of workshop #2) with measurement data (sensors in the field, remote sensing information) and weather predictions. These predictions for the next weeks can be made available online in tables and graphs and can be a good basis for planning for example farm activities.

The goal of Workshop #3 is to obtain feedback on the proposed cloud-based simulation and data assimilation system by different stakeholders, including their needs and expectations, also ensuring their continuous engagement. The outcomes of different regional meetings will be synthesized for the plenary session of Workshop #3. For that purpose, specific and predefined questions will be discussed in all regional meetings in the respective language.

We kindly ask that participants interested in attending the plenary session of Workshop #3 complete the registration form: https://www.fz-juelich.de/ibg/ibg-3/EN/News/Workshop/_node.html

The log-in details will send only to those registered to the event.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 858735.

A.3 Abstract for WS3 and tentative Agenda sent to participants in January 2022.

WATERAGRI | Workshop #3

Presentation of an early version of a cloud-based simulation and Data Assimilation system

The European project 'WATERAGRI' develops innovative sustainable solutions for water retention and nutrient recycling to enable agricultural production that can sustain growing populations and cope with present and future climate change challenges. The project engages researchers and stakeholders to collaboratively develop new knowledge and innovative solutions. Ten case studies are spread across three climate zones in Europe and some of the developed solutions will be evaluated by physically based hydrological models.

Workshop #3 provides the opportunity for intensive interaction between scientists working in the project and stakeholders and is preceded by regional meetings. These meetings will be held in the respective national languages in Hungary, Poland, Sweden, Finland, Switzerland and Germany between December 2021 and January 2022. The workshop itself is a plenary session scheduled for February 16, 2022 (10:00 to 15:00 CET). The plenary session is currently only offered as an online-only event due to the current developments of the Covid-19 pandemic. The plenary session will only be held as a hybrid event with 2G, tests and masks in Cologne (Germany) if a certain number of participants is interested in attending on site and this is permissible considering the pandemic situation.

An early version of a cloud-based simulation and data assimilation system will be presented at the workshop. This system will allow for the best possible predictions of conditions on the land and in the soil, like soil moisture contents, groundwater levels, crop status and expected yield, amongst others. The best possible prediction is achieved by combining physically based models (already topic of workshop #2) with measurement data (sensors in the field, remote sensing information) and weather predictions. These predictions for the next weeks can be made available online in tables and graphs and can be a good basis for planning for example farm activities.

The goal of Workshop #3 is to obtain feedback on the proposed cloud-based simulation and data assimilation system by different stakeholders, including their needs and expectations, also ensuring their continuous engagement. The outcomes of different regional meetings will be synthesized for the plenary session of Workshop #3. For that purpose, specific and predefined questions will be discussed in all regional meetings in the respective language.

We kindly ask that participants interested in attending the plenary session of Workshop #3 complete the registration form no later than January 31, 2022: https://www.fz-juelich.de/ibg/ibg-3/EN/News/Workshop/_node.html

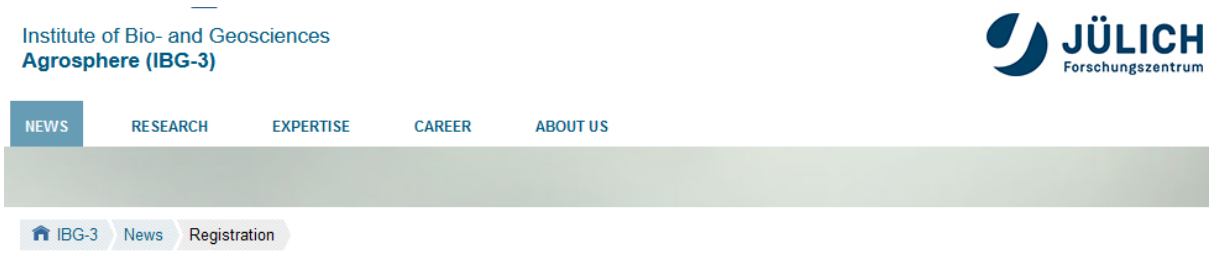
Please find a tentative agenda below. A final agenda and the log-in details will send only to those registered to the event.

Tentative agenda:

Time	*Topic*
10:00 – 10:10	*Welcome*
10:10 - 10:20	*Introduction to workshop #3 of WATERAGRI project*
10:20 – 11:00	*Session 1: Introduction to physical modeling and Data Assimilation*
11:00 – 12:00	*Session 2: Presentation of an early version of the cloud-based simulation and data assimilation system (Use, costs, benefits)*
12:00 – 13:00	*Lunch Break*
13:00 – 14:00	*Session 3: Feedback from regional meetings*
14:00 – 14:45	*Session 4: Cross-country plenary discussion*
14:45 – 15:00	*Summary and closing*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 858735.

A.4 Registration form for participants interested in attending the plenary session of WS3



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Workshop #3

Please find below the registration form for the plenary session of WATERAGRI Workshop #3. This will be an online event scheduled on February 16, 2022, from 10:00 to 15:00 CET. We kindly ask you to complete the registration form below by January 31, 2022. The details of the plenary session (e.g., link to the virtual meeting room) will be communicated to you along with the final agenda at the beginning of February 2022.

In addition, we would like to provide the possibility of on-site participation in Cologne, Germany (2G+ and masks), as this offers an even better exchange. However, we learned in the last weeks that the possibilities and perhaps the willingness to travel abroad for business purposes could be limited. Thus, we would like to kindly ask you to indicate your intention to participate on-site below. Details on a possibility to join on-site will follow February 2022.

Thank you very much.
Stay safe.

Your team organizing workshop #3

Title *
○ Ms. ○ Mr. ○ Dr. ○ Prof.

Last name *

First name *

Email *

Institution/Organization *

How do you prefer to participate in the plenary session of Workshop 3? *
○ I prefer to attend in person
○ I prefer to attend online
○ Not sure

What are your expectations for the workshop?

I have read and understood the privacy policy, which is part of this registration (see below). I agree to the processing of my data for the stated purposes for the implementation of the event. *
☐ yes

Data protection

Reset Send

WATERAGRI

A.5 WS3 invitation letter

To

Name and Surname

Company Name

Address

Your Name and Surname

Contact
Name and Surname
Company Name
Address

Email address

Website

04 Mar. 22

Invitation to the 3rd WATERAGRI Consultation Workshop

Dear NAME,

We herewith cordially invite you to the plenary session of the 3rd WATERAGRI Consultation Workshop on February 16, 2022. The plenary session is a follow-up to regional meetings held between December 2021 and January 2022 in the WATERAGRI consortium countries. The plenary meeting will be a hybrid meeting hosted by Forschungszentrum Jülich GmbH, Germany.

WATERAGRI aims to re-introduce and enhance sustainable solutions for water retention and nutrient recycling to enable agricultural production that can sustain growing populations and cope with present and future climate change challenges. Solutions designed by WATERAGRI to improve water and nutrient retention will be tested in ten case studies spread across three climate zones in Europe. The potential impacts of the developed solutions will be quantified by integrating them into physically based models of the surface and subsurface.

The goal of workshop #3 is to obtain feedback on the presentation of an early version of a cloud-based simulation and data assimilation system and to solicit needs and expectations for real-time simulation systems. A modeling system that uses plant data, soil parameters, information from drainage and irrigation systems, and current weather information for local predictions of hydraulic state variables was presented at the regional meetings in the local language and discussed with local stakeholders. The outcomes of the regional meetings will be synthesies as input for the plenary session, allowing a cross-country discussion of the WATERAGRI framework.

We look forward to meeting you.

Team organizing Workshop #3

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 858735.

A.6 Feedback template for willing WATERAGRI case study site owners to report on their regional meeting and the received feedback

Report 1 | Key information of the regional meeting for WATERAGRI workshop #3

Table 1: Key facts of the regional meeting.

Country:	
Host organization:	
Reporting person with email address (can be the case study site owner):	
Names of people who will facilitate the regional meeting (we recommend having two dedicated persons – one person to facilitate the meeting and one person to document the participant responses):	
Preferred language for delivering the presentation on cloud-based simulation:	
Do you want that FZJ attend your regional meeting for answering possible questions? If yes, please involve FZJ, when defining the day and time of your regional meeting. Thanks.	
Proposed day and time slot	
Planned type of meeting (physical/hybrid/online)	
Any other inputs or support required from the workshop organizers?	

Table 2: Possible list of invited persons.

Name	*Organization/Company/Institution*	*Already confirmed participation?*

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Report 2 | Summary of regional meeting for WATERAGRI workshop #3

Table 1: Summary of the regional meeting.

Country:	
Host organization:	
Day, time, and place ('online' for videoconference):	
Reporting person with email address (can be the case study site owner):	
Number of invited persons	
Number of actual participants	

Table 2: Agenda of the regional meeting (you can copy your agenda shared with your stakeholders).

Time	*Topic/Session*	*Moderator/Speaker*

Table 3: Summary of regional meeting discussions and feedback.

Please summarize/report shortly the main topics and points of discussion of your regional meeting, including the key feedback from the participating stakeholders (e.g., stakeholders were interested/not interested because…). Max. 300 words. This is also input for the Deliverable 1.6, Report on workshop #3. Thanks a lot.

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Please also add pictures/ a screenshot from your regional meeting. If the regional meeting is an online event, please make a screenshot. It will be needed for the Report (Deliverable) afterwards, so please ask for agreement to publish it. Thanks.

On the next pages you will find Table 5, which lists points for a plenary discussion. These points are also copied to the PowerPoint Presentation. We would like you to translate Table 5/the presentation slides and discuss these points with your participating stakeholders after the presentation of the cloud-based simulation system. Please record the responses. We are aware that you may not receive answers to all questions as it strongly depends on the type, the number and the motivation of the stakeholders who will participate. So, please fill it out the best possible. We are very grateful for your help.

If farmers are attending your regional meeting, please let them provide individual feedback. We have prepared a Google form for this purpose, as well as copied all the questions at the end of this document in case the regional meeting will be a physical meeting (Appendix 1, just after Table 5). Please translate either the online form or the print version also into your language if farmers will participate.

Google Form: *https://docs.google.com/forms/d/1LWqzHPHn4KdX1v--JiYoxTjlffFFB_QG5q6xQypyDk0/edit*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 858735.

Table 4: Points for a plenum discussion.

Importance of irrigation systems (water) in the agriculture sector:
Continuously recurring heat waves in the past have led to repeated periods of stress for various crop types. This has implications for the agriculture sector. Thus, seed switching to a more robust seed, or the use of irrigation techniques are interesting options to counter future heat waves. We are therefore interested in:
To what extent and for which crops are irrigation systems already used?
What is the experience to date with common irrigation systems?
What are the limitations of common irrigation systems? Can the water needed be accessed equally in different regions? (Are there complications with groundwater management?)
The use of tools and data:
Irrigation cannot always be used everywhere. In addition, water demand and the environmental impact must be critically evaluated. Therefore, other tools and data are needed to optimize agricultural activities as well. In particular, we are interested in the use of (web) applications such as weather forecasts in day-to-day operations.
Which data are demanded (by e.g., farmers)?

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Which applications are offered for free (e.g., weather app?) and which paid options (e.g., Farm consultancy, digital farming) are available? Applications for free: Applications to pay for:
What is the feedback on data available for free and for paid data? Which are more useful in daily field work? For free data: For paid data: More useful are:
Feedback to the proposed cloud-based simulation system:
Weather apps are mostly regional and therefore have lower resolution than needed for daily agricultural work. Weather or rain forecasts are usually only displayed for the whole county but not specifically for the own crop field. Recently, rain radars can predict cloud movement much more accurately. Nevertheless, uncertainties remain regarding the actual soil moisture on different fields. Today, we presented a cloud-based simulation system that can make high-resolution predictions of the spatial distribution of soil moisture for the next 14 days. We would like to kindly ask for feedback for further development.
What do you think about the cloud-based simulation system?

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Do you think such forecast maps as presented would be useful in periods without sufficient rain? E.g., to optimize the locations of irrigation systems?
What temporal resolution would you like to have? 1 information per week, day, hour, minute?
Other needs/criticism on the presented system?

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 858735.

Appendix B: Summary of feedback from regional meetings

B.1. A detailed summary of feedback on the extent and use of irrigation systems

Point of discussion: To what extent and for which crops are irrigation systems already used?	
Hungary	In Hungary, the use of irrigation systems is very low, only 2 % of the arable lands are irrigated in Hungary. However, an ascending tendency has been observed in the last few years: farmers are interested in VRI (Variable Irrigation Rate) solutions the most. Mainly maize, fruits and vegetables are irrigated under the climatic conditions of Hungary.
Finland	In Finland, irrigation is carried out mainly for some (valuable) crops such as potatoes, onions, carrots, and strawberries. Irrigation includes surface and subsurface irrigation systems. Irrigation is becoming increasingly important due to recent droughts (e.g., 2018) and uncertainties related to future change. There is already a need for irrigation more than it is used. Farmers use about 70 000 ha subsurface irrigation and irrigation in general on some percentage of the fields. There is an interest in it and controlled drainage.
Poland	Irrigation systems for cereals and energetic corps are considered unprofitable. Costs of amortization, time consumption, and equipment overrun benefits. For potatoes farmers are using reel irrigation and for vegetables precise irrigation (greenhouses)
Switzerland	Seeland is the vegetable garden of Switzerland. Irrigation is thus used for vegetables, including but not limited to, vegetables (tomatoes, pumpkin, cabbage and related etc.), potatoes, corn. Irrigation is achieved by controlling water levels in the former lakebed region via closure/opening of weirs & redistribution of water via pumps in a dense network of canals. Irrigation is furthermore used in classical ways by irrigating vegetable fields in case of dry conditions. Irrigation is used for: (i) increasing productivity during main growth by providing optimal soil moisture conditions, (ii) creating humid conditions for germination in the top cm after planting, & (iii) cooling fields during hot periods.
Germany	Irrigation is not used at the 'pilot site' Selhausen but in neighbouring regions. Which crops are allowed to irrigate and how to irrigate them across Germany? However, irrigation is largely carried for potatoes, corn, rye, and special crops. Latter must be irrigated accurately to the day. Thus, if allowed, farmers do "preventive" irrigation for multiple weeks.

B.2. A detailed summary of feedback on experience with common irrigation systems

Point of discussion: What is the experience to date with common irrigation systems?	
Hungary	VRI solutions seem to be popular among farmers nowadays, and there are certain companies aiming to fulfil this need with not only machinery but also consultancy and data management services. In irrigation of fruit orchards drip irrigation is applied, combined with nutrition supply solutions. There is special importance of adequate water and nutrition supply, which is mainly in the first half of the vegetation periods and within this first half, timing is crucial. There is a new era in irrigation in Hungary: a consultancy network has been being built from 2020 by one of the greatest agricultural service companies, KITE Ltd.
Finland	For some sites, irrigation is provided as much as possible during dry periods. There is a lot of uncertainty about surface-irrigation. The challenge of irrigation is especially the variation in soil composition within the block. One point in the block can be very water-permeable and the other point retains water efficiently. Vertical profiling of water can vary sharply. In sub-irrigation, sandy soils, in particular, face challenges in achieving sufficient impact on soil humidity. Sub-irrigation is especially used in potato growing. Adjustment drainage systems are enthusiastically installed and renewed, and the use of irrigation is increasing.
Poland	Present conditions (annoying administrative procedures, not so damaging climate changes) make irrigation systems not economical for some types of corps. Farmers do not exclude investment in irrigation systems in more favorable conditions.
Switzerland	Irrigation works and is used but is expensive due to electricity cost. The desire for a cheaper option, i.e., controlling GW depth via SW levels in channel network, but a better understanding of reaction speed and connections needed. Irrigation is not centrally managed or planned. The premise of water managers in the region: First comes drainage, irrigation comes second (because GW is typically too close to the surface). Thus, the need for drainage limits the possibilities of using SW level management as an irrigation option.
Germany	Irrigation was not needed in Germany for many years, but it became more important since the draughts in 2018 and 2020 have caused high yield and financial losses. Crops are largely irrigated in Germany with mobile systems and not with stationary systems. The mobile systems are expensive, and it is often not clear where to place the machines on the fields. There are some optionally sensors available to optimize the placement and driving of the irrigation machines, however, these sensors are often too expensive or too complex to use. If allowed, farmers will do 'preventive' irrigation, and the possibility of driving with heavy machines on the fields is limited.

B.3 Detailed summary of feedback on (1) limitations of common irrigation systems (2) access to water in different regions and (3) complications with groundwater management

Point of discussion: What are the limitations of common irrigation systems? Can the water need be accessed equally in different regions? Are there complications with groundwater management?	
Hungary	In the Pannonian Basin (or Carpathian Basin), there is a strong limitation factor which is the duality of drought and inland water. The financial side of building up irrigation systems was also mentioned as a limiting factor. Limitation effects may occur in the installation and operation of irrigation systems, these are so-called practical limitation factors: sizes and structure of arable lands, topographic factors, water demand problems, etc. There is a great consideration about the total dissolved solid concentration properties of water supplies (salt content), too. It can be harmful both for the plants, soils, and irrigation machinery.
Finland	Transfer of water, water availability and practical pumping issues is a challenges. Damming of main channels is required for pumping to allow for sufficient depth. If too much water is pumped (more than 100 m3/d), a permit is needed which is not always granted. The use of irrigation is particularly limited by cost issues. Where water is really needed, the quantities are large, and water may not always be available or restricted by the authority. Reaching a compromise between the climate and crop impact of irrigation is challenging.
Poland	Main limitations involve administration permits. In Poland farmers without project documentation can apply only to build small reservoirs (<1 ha). All irrigation/draining structures need special permits that require documentation, which without support very often is impossible to proceed for farmers. Even when they decide to build an irrigation system a legal use of water, they are retaining in their own reservoirs still require permission to use this water. Another restriction is caused by local development plans. Some farmers who lease the land from the state have doubts about investing in the land and infrastructure because they are not sure whether the land will be still used for agricultural production due to changes in the local development plans.
Switzerland	The Seeland is highly abundant in water and water for irrigation is available everywhere. The problem lies in the high costs for electricity and infrastructure, which may in fact not be needed if GW levels (and SW levels in the canals) were managed with a better tool and if there is more understanding of the reaction speed of the system (stakeholder feedback!)
Germany	The management of the groundwater compartment, e.g., for drinking water, competes with irrigation. In groundwater sensible regions, irrigation is not permitted. This means that Groundwater cannot be used everywhere for irrigation. Then irrigation becomes very expensive. In regions, where groundwater can theoretically be used, the number of wells is sometimes limited. In parallel, the administrative process to use groundwater for irrigation is very challenging and strict.

B.4 Detailed summary of reported feedback given by stakeholders on data demands

Point of discussion: Which data are demanded (by e.g., farmers)?	
Hungary	DEM, aspect, micro-relief, micro-climatic characteristics, erosion hazard water quality and quantity information nutrition and water content of the soil of the land, soil physical and chemical properties special meteorological parameters e.g., ET, plant health monitoring, yield-forecasts
Finland	Observations on soil moisture are needed on different plots due to spatial variation. Observation of soil moisture is typically demanded 3 times per hour per field (plot). Information is needed on when to close the drainage control (to retain water but not cause waterlogging). Also, information is needed on when to start the irrigation. Farmers need systems for measuring intra-block moisture profiling. Weather stations have been used to some extent, but they have been perceived as more harmful than useful. In heavy rain, precipitation ranges from 50% per 500m, which makes it a challenge to use the data generated by weather forecasts and weather stations.
Poland	The most demanded information is about when and how much it will be raining. The presence of rain is crucial to planning agricultural treatments, sowing, fertilization, harvesting etc. The data developed in our project are not common for the community. It is hard for them to specify how beneficial it can be and how much they need it.
Switzerland	Farmers need a better understanding of behavior of GW levels, the connection of GW levels in the field to the SW level in the canal, and the soil moisture in the upper soil layers. Farmers and infrastructure managers, therefore, need data on these aspects, for example prediction maps of GW levels and soil moisture. But they also would like to have outcomes of scenario simulations that were generated by playing with infrastructure/management options.
Germany	Farmers clearly ask for weather data, the water balance including soil water content information, the degree of soil compaction on their fields and data required for fertilization.

B.5 Detailed summary of feedback on free applications (e.g., weather app?) and paid options (e.g., Farm consultancy, digital farming)

Point of discussion: Which applications are offered for free (e.g., weather app?) and which paid options (e.g., Farm consultancy, digital farming) are available?	
Applications for free:	
Hungary	"met.hu" (OMSZ: National Meteorological Service), http://aszalymonitoring.vizugy.hu/index.php?view=custommap (General Directorate of Water Management in Hungary)
Finland	Both "Yr.no" and "Foreca.fi" web-based web sites are used for weather info
Poland	In general people are opting for simple and free of charge apps. A very common weather app in Poland is METEO that is developed by Warsaw University. In addition, the agricultural advisory centre (CDR) provides consultations for free https://www.meteo.pl , https://esusza.pl or other weather apps, farm consultancy
Switzerland	Not discussed
Germany	German weather service (DWD) for warning information (e.g., heavy rain, thunderstorms, windstorms) as well as multiple weather apps for the public (wetter.com, rain radar/monitoring) Web pages and web services of German authorities are consulted via computer but also via web browsers on the smart phone
Applications to pay for:	
Hungary	Apps of agricultural service companied e.g., KITE Ltd.
Finland	None mentioned. Some have their own systems such as those provided by soil scout
Poland	Our audience doesn't use pay applications but there are some developers offering applications and services for farmers e.g., https://www.365farmnet.com/pl/ or https://eagronom.com/pl
Switzerland	Not discussed
Germany	'Raindancer': Sector controlled movement of mobile irrigation equipment including automatization of irrigation systems 'Dacom.nl'/de: App of consultant companies providing management strategies for farming activities and for optimizing the seeding and growth of crops Apps from chemical concerns providing fertilizers

B.6 Detailed summary of feedback on data available for free and at a cost and their usefulness in daily field work

Point of discussion: What is the feedback on data available for free and for paid data? Which are more useful in daily field work?	
For free data:	
Hungary	such data is not available adequately for engineers and experts for their planning works, which is a problem.
Finland	The public weather forecast is the most useful and most used by far.
Poland	Some farmers say that the qualifications of the advisors are not useful and very often farmers go away without any solution or even suggestion. On the other hand, the largest group of attendees were agricultural advisors who probably didn't know any sources of data available for farmers. weather apps, weather predictions The most useful data are about rain events and rainfall amount. Farmers are checking different weather apps to find the most accurate predictions for their regions. However, all available apps do not provide local (small scale) predictions
Switzerland	Not discussed
Germany	The public weather forecast is the most useful and most used by far. Applications on the smartphone are clearly preferred as these provide information on-site and during the agricultural activities of farmers. These apps help for example to decide if it is still possible to drive on the field with heavy machines or if it would be better to wait some time till the rain period is finished.
For paid data:	
Hungary	an increasing need for paid data is observed.
Finland	There seems to be none. The is no info provided despite the fact that we asked for it.
Poland	No one from the audience used paid data
Switzerland	Not discussed
Germany	Experiences tend to be good, however, the scientific validation of these commercial products is not always clear. Such apps often need sensors, that are costly. Farmers seem to be skeptical about such products as they seem to question the reliability of the provided information and sometimes farmers feel "alone" with the large amount of data collected by these apps. Farmers prefer to rely on their decision based on their own experiences or simple and easy to understand free information provided by public institutions in relation to the scientific sector

B.7 Detailed summary of feedback on the presented simulation system

Point of discussion: What do you think about the presented simulation system	
Hungary	The attendees found the simulation system very impressive and useful.
Finland	It could be useful on large farms. The forecast model should consider soil composition and water management. We should get to the water balance at the field (and plot) scale.
Poland	People that were present in our workshops considered the proposed system very promising and useful. Agricultural advisors from different regions of Poland have shown a willingness to cooperate and disseminate knowledge about the system.
Switzerland	The simulation system is a good tool. Predictions will be very helpful IF they can be accessed in the field when management decisions are made (by farmers or regional water managers). The simulation system should allow scenario testing (e.g., what happens if I install a new drain here in X cm depth, does it allow draining this spot on the field?) and provide management options (e.g., what happens if I now lower or rise the SW levels in the canals by 0.5m?) The simulation system should be available soon for testing and elaboration.
Germany	Stakeholders had different opinions on the system. The tendency is that the current version of the system is not so useful for typical problems/challenges farmers are confronted with. But Stakeholders also explained that such information can be useful for some general impression of the new states in their regions.

B.8 Detailed summary of feedback on the usefulness of forecast maps

Point of discussion: Do you think such forecast maps as presented would be useful in periods without sufficient rain? E.g., to optimize the locations of irrigation systems?	
Hungary	Yes, such forecast models and maps can be definitely useful
Finland	It could be useful on large farms. The forecast model should consider soil composition and water management. We should get to the water balance at the field (and plot) scale.
Poland	Presented forecast maps can be useful but lack of knowledge about the proper location of irrigation system, present administrative obstructions and high cost of equipment is not encouraging.
Switzerland	As in Table 16, a forecast system would be great if it allows planning SW levels ahead for GW level management, but also for irrigation water demand calculation & placement of irrigation devices
Germany	A stakeholder mentioned that the current version is not practical enough. There is not enough local specific information, and the prediction horizon of 14 days is not enough for the planning of activities.

B.9 Detailed summary of feedback on temporal and spatial resolution needs

Point of discussion: What temporal and spatial resolution would you like to have? 1 information per week, day, hour, minute and per point/location or as a map?	
Hungary	The attendees found that the minute and hour scale temporal resolution maps may be less useful, but 3-hours, or half day forecasts can be. Data with very high temporal resolution can be interesting and useful for scientists but not really for farmers.
Finland	The tried and tested observation interval "soilscout" soil moisture measurement system is 20 min. When measuring less often, the moisture peaks caused by the rainfall are easily left undetected. In the forecast system, the update interval was considered, the forecast could come once a day or more frequently if it has no impact on the accuracy of the forecast.
Poland	Temporal resolution depends very much on what needs to be done on the farm as well as on the size of the farm. The audience agreed that it would be useful to get comprehensive information about all conditions at least once per week. It was proposed that in the period of sowing the perfect scenario would be even to have 14 days of prediction to plan all necessary activities in the field. During the vegetation period these predictions can be shorter.
Switzerland	After some discussion, stakeholders and we concluded that the ideal output would be maps of depth-to-GW and soil moisture at multiple depths with a ruler that allows scrolling forwards and backwards through time for the next week, ideally with hourly resolution at least for the first few days. It would be good to also have crop water demand maps or water deficit maps. The spatial resolution which captures primary variation in fields is needed, which is probably on the order of 10m-20m in the Seeland.
Germany	Stakeholder clearly asks for a higher spatial resolution, i.e., for site specific information (local models). Spatial resolutions of 10 to 50 m are asked. One or two updates of the now state per day would be enough. However, prediction horizons should be long. The best would be a seasonal forecast of rain periods to allow the planning of seeding. Forecasts of the water balance should provide information for the next week to have a better planning of irrigation activities. Information on hydrological states and fluxes as well as temperature is demanded with depth. It would be good to have warning maps where dry zones will appear in the next few days. However, probabilistic information can be also useful and understandable for farmers.

B.10 Detailed summary of feedback on the presented system

Point of discussion: Other needs/criticism on the presented system?	
Hungary	The input data are very diverse, and the attendees are interested in the error level/uncertainties of the model. What cons does it have?
Finland	The system must be very easy to use in the growing season because farmers will then be very busy. The audience demanded estimates of the system accuracy (based on observed and forecasted values).
Poland	In Poland there are many monitoring systems for drought, weather, and soil. However, they provide analysis of measurements at a national scale which is too coarse (resolution) for practical application and often completely unsynchronized. As a result, a user needs to utilize many different tools to get the overall picture of the situation which is not comfortable for them. The audience also showed concern that after the project is finished all that interesting work will not be supported anymore.
Switzerland	For the system to be useful, outputs must be accessible on an easy app which does not have lots of switches so that it can be used for assessment directly in the field with dirty hands. Both from regional water managers (that control the SW levels in the channel network) and the farmers (who control irrigation and drainage by pumping). Model should encompass the entire Seeland region, not just the pilot fields, as the entire region is intertwined by the network of SW canals. So, for optimal water management, the entire region should be covered. In principle, there is interest in a larger regional management tool that is maintained and provided as a service. A dedicated company to do this would be welcomed. It was asked that the tool and plans should be aligned with local farmer associations' political plans for water management…
Germany	The information provided must be clear and easy to understand. It should not be too time consuming to understand them or to get them. Management strategies should also be provided, or at least it should be clear what might be an appropriate action given the information. Farmers can imagine providing a handful of information in the morning and then getting quick information, in other words, being told what to do. Stakeholders think it is good that WATERAGRI wants to address such issues and seek further, practical developments.

Appendix C: Presentations

C.1 Presentation slides provided to the willing WATERAGRI case study site owners for compiling their slide show for regional meetings

SIMULATION SYSTEM COMBINING MODELS AND MEASUREMENTS

WATERAGRI | WORKSHOP #3 – DATA ASSIMILATION

Member of the Helmholtz Association

JÜLICH Forschungszentrum

AGENDA

PLEASE ADD YOUR AGENDA FOR THE REGIONAL MEETING HERE

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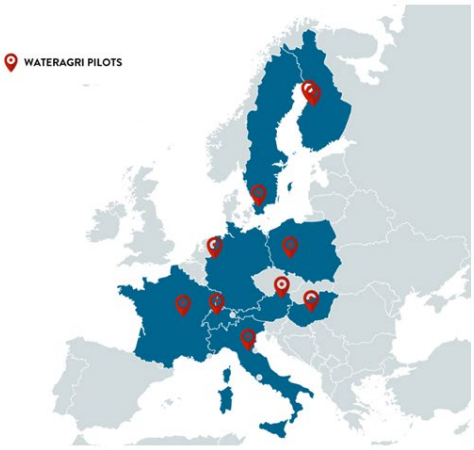
WATERAGRI PROJECT AND VISION

European consortium with 10 agricultural pilot sites

The **WATERAGRI** vision is to solve *agricultural water management* and *soil fertilisation challenges* in a *sustainable manner* to secure *affordable food production* in Europe for the 21st century.



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WATERAGRI OBJECTIVES

- Co-develop the links between agricultural land and soil-sediment-water management
- Identify, develop and test affordable and easy-to-implement technical and operational farm solutions
- Undertake technical and sustainability assessments of proposed measures
- Assess the proposed techniques for their potential regarding adaptation to climate change
- Develop a cloud-based simulation and data assimilation system
- Disseminate the implemented innovation to farmers, advisory services and decision-makers

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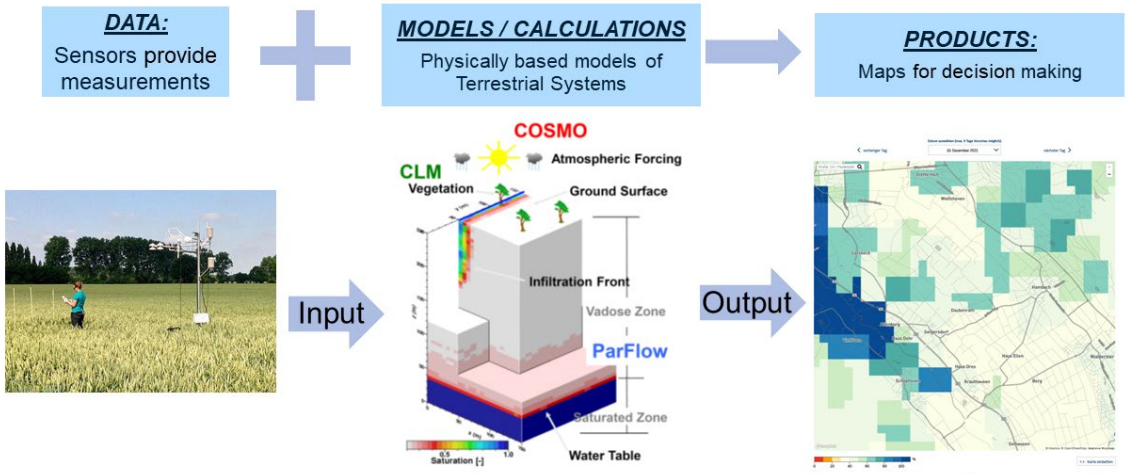
CONTENT OF WORKSHOP



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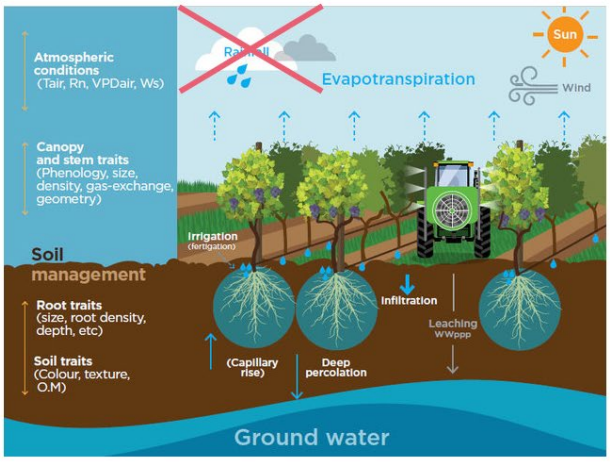
IMPACT OF CROP STRESS



Less precipitation → Irrigation ?

Does buying irrigation systems pay off?

Costa et al. (2020), Ciência Téc. Vitiv. 35(1) 1-15.

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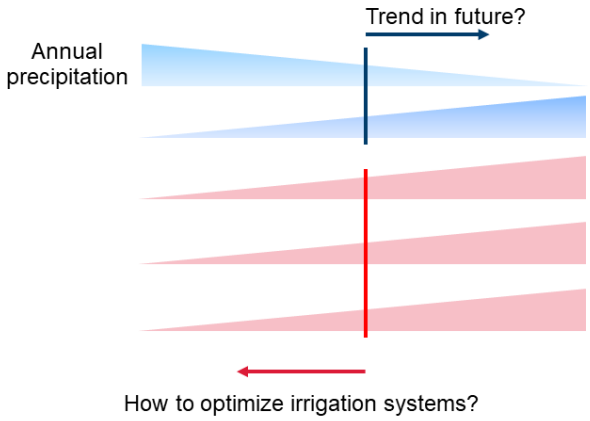
WATERAGRI

IRRIGATION SYSTEM?

On costs, benefits and issues of irrigation systems



Our goal: *Optimizing irrigation systems and minimizing costs by using predictions produced with physical based models*

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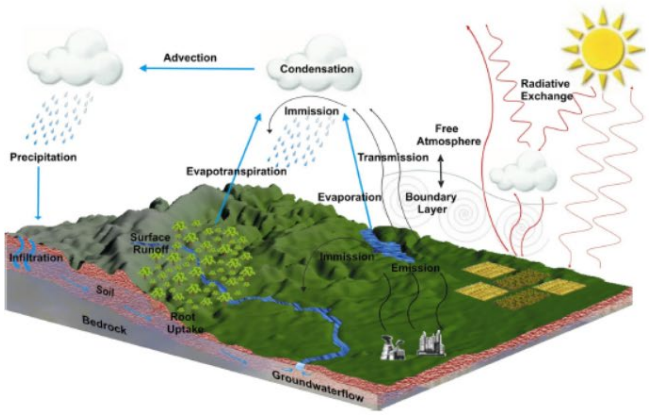
INTEGRATE MODELING OF TERRESTRIAL SYSTEMS

Our focus: Terrestrial water cycle and groundwater-to-atmosphere interactions and feedbacks



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DATA: REAL TIME MEASUREMENTS

Hydro-meteorological measurement system

1: All-in-one weather station (ATMOS-41)

2: Cosmic Ray Neutron Sensor
Neutrons → soil moisture
Area (radius of ~250 m)

3: Soil moisture and temperature sensors

Data is freely available in near real-time (meteograms) and for download (spreadsheets)

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DATA: REAL TIME MEASUREMENTS

Soil moisture measurement at one location and in different depths

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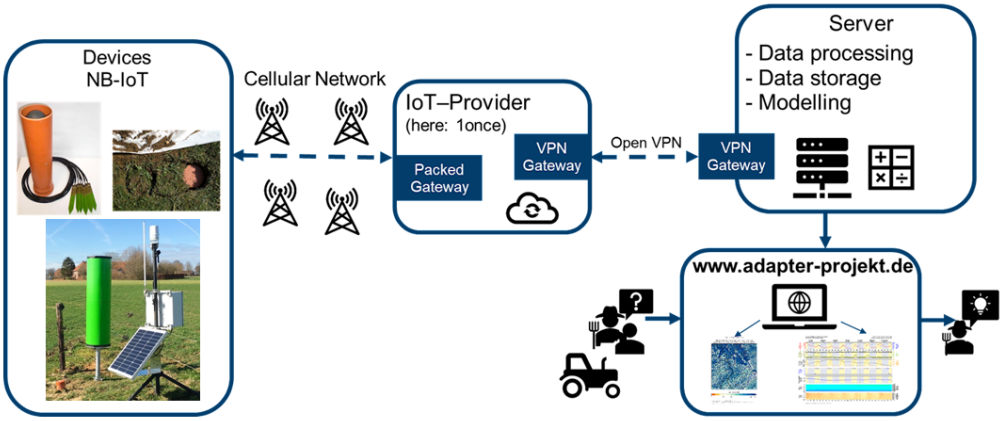
DATA: FULLY INTEGRATED DATA FLOW

Soil moisture: from sensor to forecast



Models directly access new measurements

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TERRESTRIAL SYSTEM MODELLING PLATFORM (TSMP)

Physically-based models representing soil water

1. Conceptualization ("sketch") e.g., the Water cycle

Transfer, into Software/Codes

2. Numerical model ("Representation"), allowing calculations

Simulations, ***address uncertainties***

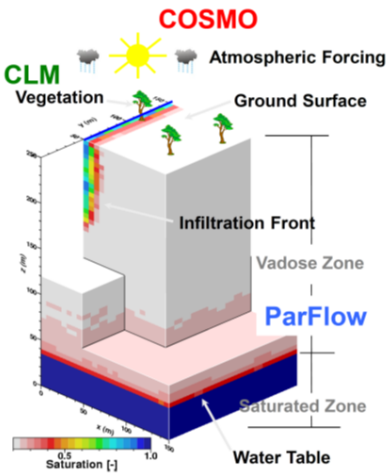
No, then optimize

3. Observations consistent with measurements?

Yes

Informations can be provided for the next day

Predictions can be made available online in tables/graphs



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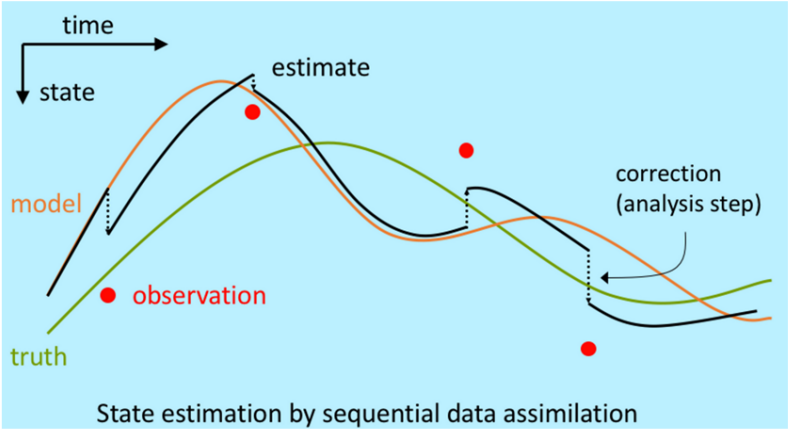
MODEL: PRINCIPLE OF DATA ASSIMILATION (PDAF)

To address uncertainty, i.e., to get results consistent with reality, we are continuously updating our simulations with real observations, e.g., with measurements of soil water content



Taken from ESM Project: Data Assimilation with the Parallel Data Assimilation Framework: A short course at EGU19

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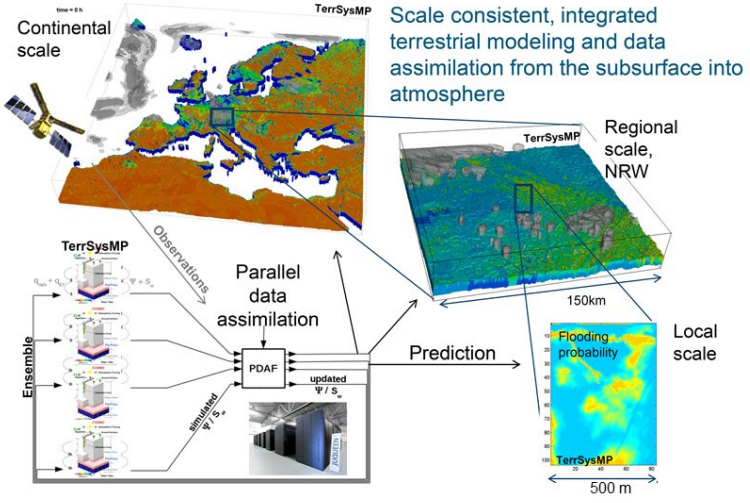
MODEL: SCALES



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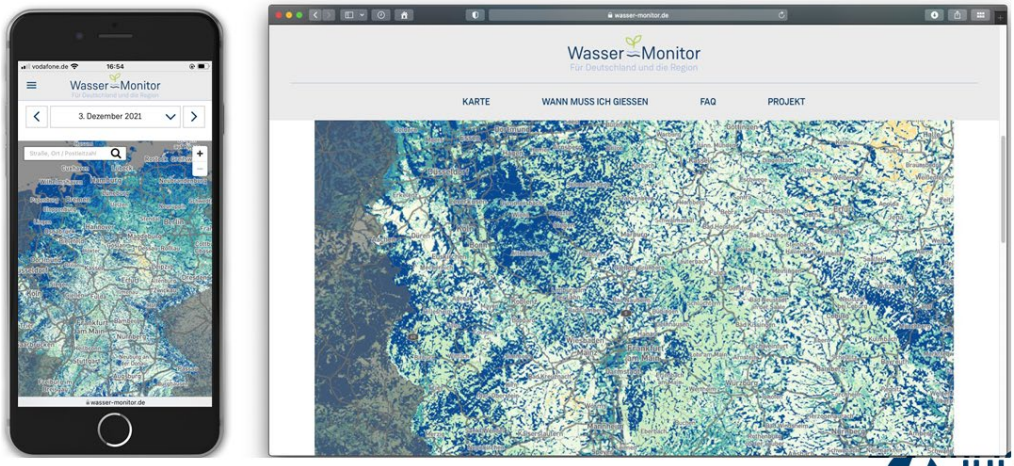
PRODUCT: THE OUTCOME OF TSMP-PDAF

www.wasser-monitor.de - developed in partner project ADAPTER



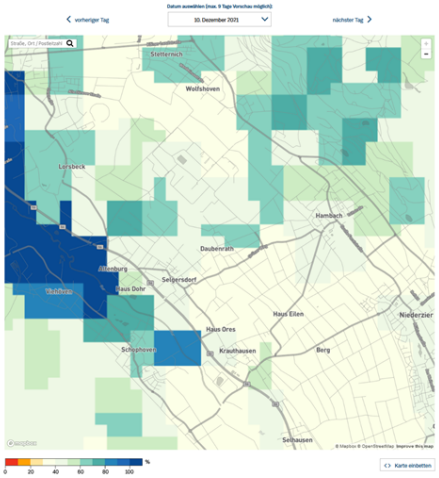
PRODUCT: THE OUTCOME OF TSMP-PDAF

Sub-km interactive maps of plant-available water over Germany from daily ParFlow/CLM forecasts

Spatial resolution: 600 x 600 m

Time resolution: 1 day

Already useful for large scale applications but not for practioneers working on one field



www.wasser-monitor.de

PRODUCT: OUTCOME OF TSMP-PDAF

Sub-km interactive maps of plant-available water over Germany from daily ParFlow/CLM forecasts

Show the web-application on https://wasser-monitor.de/

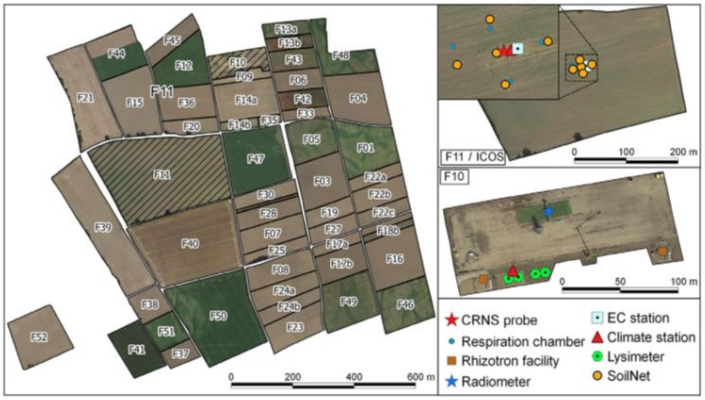
FUTURE PRODUCTS CO-DEVELOPED

Improvement of the resolution => Provide similar information for individual fields

We are currently developing a surface-subsurface model for the prediction of soil water content with

Spatial resolution: 100 m x 100 m

Time resolution: 1 hours



Bogena et al. 2018

QUESTIONAIRE

Asking farmers for feedback

- EDITABLE VERSIONS to be translated for Hungarian stakeholders: https://docs.google.com/forms/d/1LWqzHPHn4KdX1v--JiYoxTjlffFFB_QG5q6xQypyDk0/edit

DISCUSSIONS

Asking for feedback in the plenum

Importance of irrigation systems (water) in the agricultural sector:
Continuously recurring heat waves in the past have led to repeated periods of stress for various crop types. This has implications for the agricultural sector. Thus, seed switching to a more robust seed, or the use of irrigation techniques are interesting options to counter future heat waves. We are therefore interested in:
To what extent and for which crops are irrigation systems already used?
What is the experience to date with common irrigation systems?
What are the limitations of common irrigation systems? Can the water needed be accessed equally in different regions? (Are there complications with groundwater management?)

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DISCUSSIONS

Asking for feedback in the plenum

The use of tools and data:

Irrigation cannot always be used everywhere. In addition, water demand and the environmental impact must be critically evaluated. Therefore, other tools and data are needed to optimize agricultural activities as well. In particular, we are interested in the use of (web) applications such as weather forecasts in day-to-day operations.

Which data are demanded (by e.g., farmers)?

Which applications are offered for free (e.g., weather app?) and which paid options (e.g., Farm consultancy, digital farming) are available?

Applications for free:

Applications to pay for:

What is the feedback on data available for free and for paid data? Which are more useful in daily field work?

For free data:

For paid data:

More useful are:

DISCUSSIONS

Asking for feedback in the plenum

Feedback to the proposed simulation system:

Weather apps are mostly regional and therefore have lower resolution than needed for daily agricultural work. Weather or rain forecasts are usually only displayed for the whole county but not specifically for the own crop field. Recently, rain radars can predict cloud movement much more accurately. Nevertheless, uncertainties remain regarding the actual soil moisture on different fields. Today, we presented a simulation system that can make high-resolution predictions of the spatial distribution of soil moisture for the next 14 days. We would like to kindly ask for feedback for further development.

What do you think about the simulation system?

Do you think such forecast maps as presented would be useful in periods without sufficient rain? E.g., to optimize the locations of irrigation systems?

DISCUSSIONS

Asking for feedback in the plenum

What temporal and spatial resolution would you like to have? 1 information per week, day, hour, minute and per point/location or as map?
Other needs/criticism on the presented system?

CLOSING

THANK YOU VERY MUCH FOR YOUR ATTENTION

Contact: Dr. Richard Hoffmann · Institute of Bio- and Geosciences | Agrosphere (IBG-3)
Forschungszentrum Jülich GmbH · 52425 Jülich | Germany

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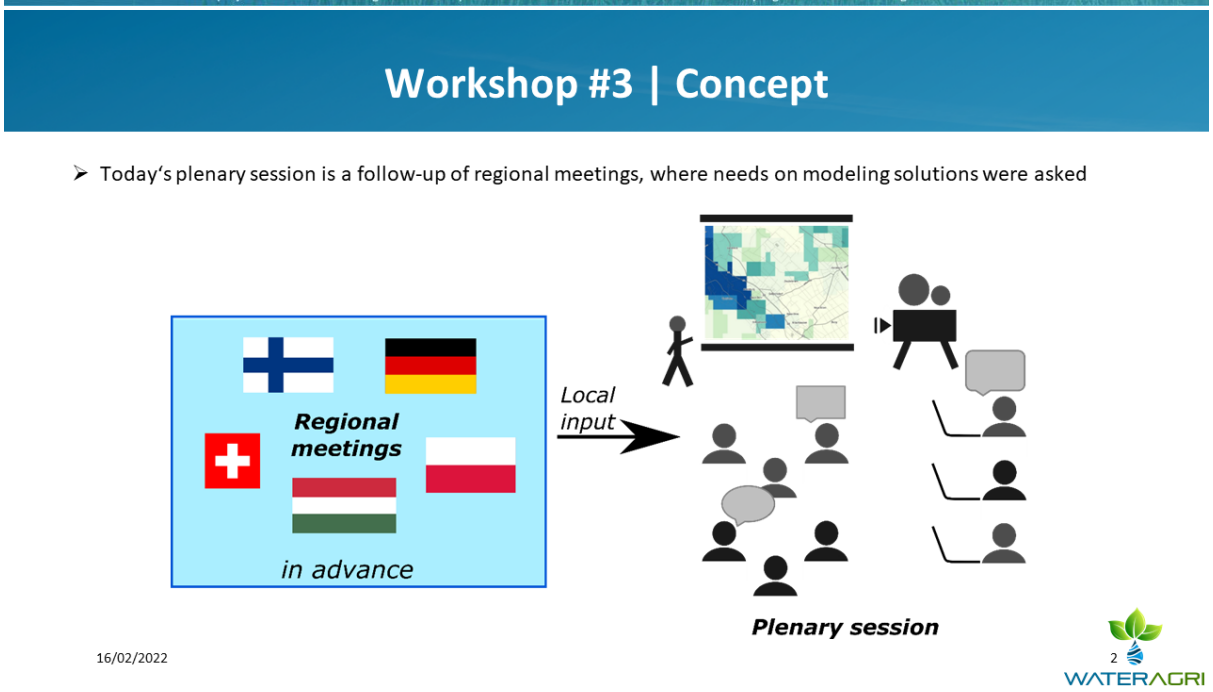
C.2 Presentation slides for the second part of the plenary session: Feedback from regional meetings including a discussion



Workshop #3 | Agenda of regional meetings

- *The basic agenda was proposed by the Organization committee to all WATERAGRI case study site owners:*
  - Presentation of slide show and information about the simulation system in non-technical language
    - Willing regional hosts presented that in the national language
    - Included a demo of a "prototype" developed at FZJ
  - Discussion on predefined questions to *deduce feedback on the simulation system in a structured way*
  - *Local hosts could add additional content of interest for their local stakeholders*

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Workshop #3 | Selection of Invitees

- *Local hosts selected participants by:*
  - discussing with close related Stakeholders/ "friends"
  - contacting federal agencies and consultancy companies
  - using the stakeholder register (WP1)
  - inviting stakeholders known from previous webinars in other scientific projects

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Workshop #3 | Overview Regional Meetings

Country	Date and time	Host	Invited participants	Actual participants	Format
Hungary	13/01/2022 13:00 to 15:00 CET	UNIDEB	30	13	online
Finland	26/01/2022 12:00 to 14:30 EET	OULU	25	15	online
Poland	08/02/2022 10:00 to 12:00 CET	UPWR	72	52	online
Switzerland	10/02/2022 16:00 to 18:00 CET	UNINE	8	6	Ins (Seeland, CH)
Germany	10/02/2022 17:00 to 19:00 CET	FZJ	38	33	online
		Sum	***165***	***119 (72%)***	

No regional meeting in Sweden, Austria, Italy and France

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Workshop #3 | Overview Regional Meetings

- *Participants were:*
  - Farmers (minority, but 1 to 5 per regional meeting)
  - Consultants working in the agricultural sector
  - Persons from municipal, federal and governmental institutions

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Workshop #3 | Feedback categories (9 questions)

1) Importance of irrigation systems in the agricultural sector
To what extent and for which crops are irrigation systems already used?
What is the experience to date with common irrigation systems?
What are the limitations of common irrigation systems?

2) Experiences with tools and data
Which data are demanded by e.g., farmers?
Which applications are offered for free, and which paid options are available?
What is the feedback on data available for free and for paid data?

3) Feedback to the proposed simulation system
What do you think about the presented simulation system?
What temporal and spatial resolution would you like to have?
Other needs/criticism on the presented system?

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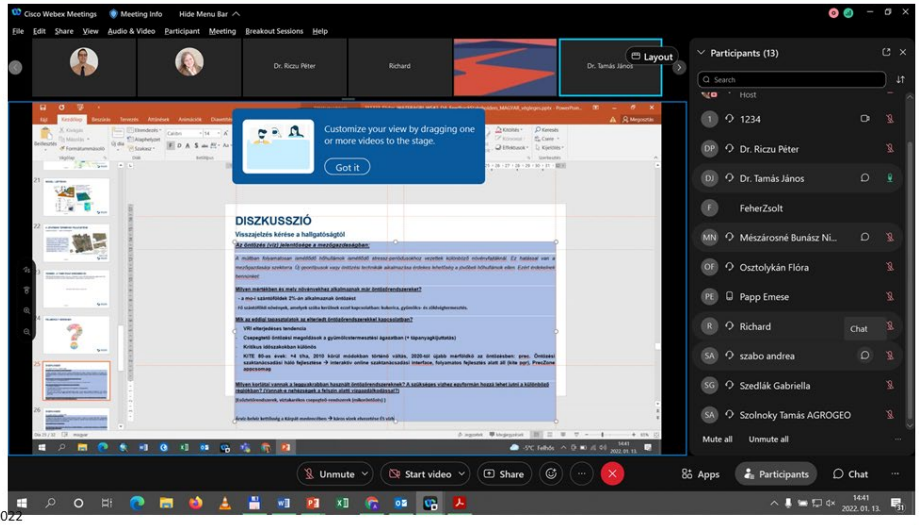
Workshop #3 | Impressions – Open Discussion



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Workshop #3 | Feedback - Importance of irrigation systems

Irrigation is largely used for "valuable" crops (since 2018)	Irrigation systems are costly
Mobile irrigation systems and "preventive" irrigation are commonly used	Sensors for optimizing irrigation times are very costly
Groundwater interactions problematic + no information	Regulations are often not clear / not consistent
"First comes drainage, second irrigation" (When Groundwater is close to surface)	Irrigation can be time consuming and not worthwhile

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Workshop #3 | Feedback - Importance of irrigation systems

Irrigation is largely used for "valuable" crops	Irrigation systems are costly
Mobile irrigation system and preventive irrigation are commonly used	Sensors for optimizing irrigation times are very costly
Groundwater interactions problematic	Regulations are often not clear
"First comes drainage, Second irrigation" (When Groundwater is close to surface)	Irrigation can be time consuming and not worthwhile

Expectations on physically based models

Information with the following priorities:
1) Rainfall (when and how much?)
2) Soil moisture (where is it low on my fields?)
3) Passability (drive on fields)

Support on:
1) Placement of irrigation machines
2) Defining irrigation flow rates
3) Planning drainage systems
4) Groundwater level information

Expectations beyond models

Cost-efficient technical innovations for irrigation systems asked

Clear regulations by governments

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Workshop #3 | Feedback – Experiences with tools and data

Newspapers/Journals

1) Useful for in-depth information or political decisions
2) But information are often not useful for daily business

Usefulness: ✖

Web-applications

1) Can be very useful, but sometimes too difficult to find on the internet
2) Understanding of information may require additional training if unconventional data is shown
3) Not always available on site, difficult to relate information to actions

Smartphone apps

1) Providing information fast and on site - very useful for actions
2) Commercial apps may need sensors (costly)
3) "Scientific validation of some products can be unclear"

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Workshop #3 | Feedback - Experiences with tools and data

Expectations

Expectations

- Free of charge	- Free of charge and one app for all services
- Organization of farming activities from office	- Easy to add new data, e.g., irrigation rates on site
- More visibility required + support bring it into actions: Information must be easy to find, to understand and to use, as there is no time for "complex" interpretation => goal: Actions ("Translations")	- For quick information - 2 to 3 entry options and then, - show surface-groundwater distance - tell placement of irrigation system - comparison of management strategies

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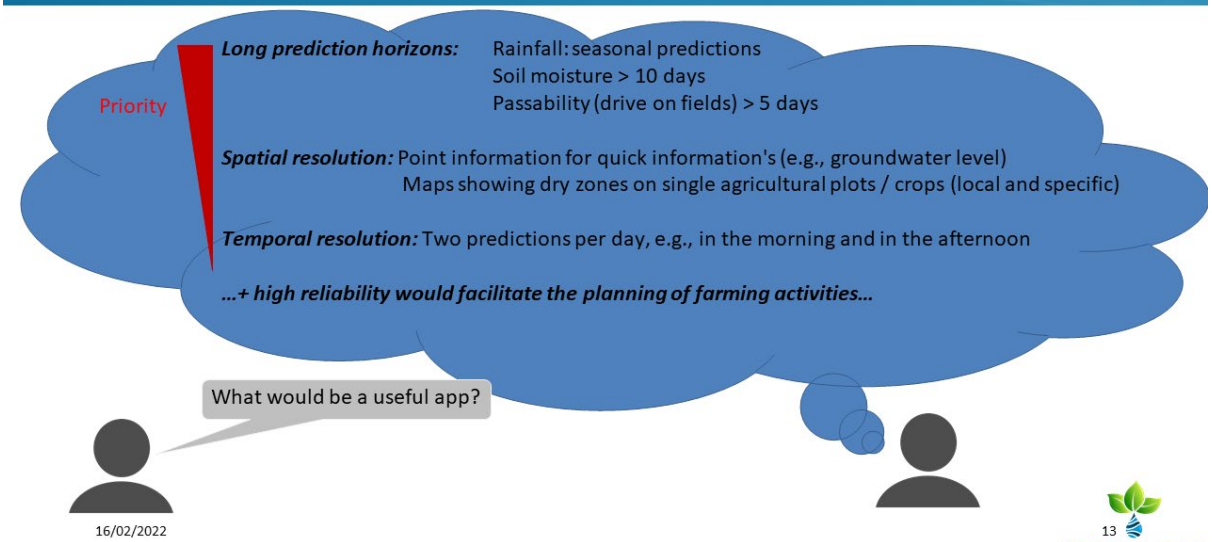
Workshop #3 | Needs for Modeling solutions ("Wishes")



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Workshop #3 | Additional remarks

- *Additional impressions from the reports of all regional meetings:*
  - The presented web-application is impressive/ useful, but spatial resolution and comprehension is criticized
  - Still some interest in scientific validation
  - *Stakeholder are interested what happens next and what will happen with the products at the end of WATERAGRI*
  - *Will the prototype developed in WATERAGRI, be maintained afterwards?*
  - *Will the prototype only cover single pilot sites or countries or Europe?*

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Workshop #3 | Conclusion of Feedback

- Information on rainfall, soil moisture, passability and groundwater level are asked
- Long prediction horizons (more days than technically possible)
- Predictions for specific agricultural plots
- Predictions on a daily basis seems to be enough
- Mobile available products (apps) are preferred
- "Products" must quickly provide a comparison of management strategies and which strategy is the best

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Plenum discussion on Stakeholders Feedback

Suggestion:

1) regional hosts and stakeholders who participated in the regional meetings are welcomed to add comments and/or provide their impression

2) Open discussion of the presented material by the plenum

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