WP1100

Consolidation of evapotranspiration scientific requirements

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1 Introduction

Land surface heat fluxes are essential components of the water and energy cycles and govern the interactions between the Earth surface and the atmosphere. Variables such as cloud cover, precipitation, surface radiation, and air temperature and humidity, strongly influence these fluxes. In turn, the energy balance at the surface and its partitioning between the turbulent sensible and latent heat fluxes also affect the atmosphere, determining the development of the atmospheric boundary layer. There has historically been a lack of consistent long-term and reliable estimates for the land surface heat fluxes. On the one hand, energy balance and flux partitioning are complex mechanisms with strong variability in both space and time, across climates and ecosystems. On the other hand, heat fluxes produce neither absorption nor emission of electromagnetic signals, which precludes a direct estimation by remote sensing techniques. Therefore global observations related to atmospheric and surface parameters have to be combined with an interpretive model to derive these fluxes at global scale.

This project aims to advance towards the development of evapotranspiration (ET) estimates at global and regional scales, having as main objectives to develop a Reference Input Data Set to derive and validate ET estimates, and to perform a cross-comparison, error characterization, and validation exercise of a group of selected ET algorithms driven by the Reference Input Data Set.

In this document, the technical and user requirements for the development of the targeted ET benchmark products will be evaluated. These requirements will also be driving the requirements for the Reference Input Data Set used to derive the ET products. Two user communities will be addressed: climate research, as well as operational water management and agriculture. The definition of the user requirements of the two communities will be based on a literature review, and on the consultation of selected users and experts within these communities. However, one should keep in mind that even within a user community, the requirements might differ from application to application. E.g., in the case of agriculture, the needs for an individual farmer or for a multinational agricultural company will never be the same, as they act on different temporal and spatial scales. Thus, the project team will likely need to find a compromise between possible different requirements within a user community and the given limits of available input data sets for the derivation of the targeted ET benchmark products.

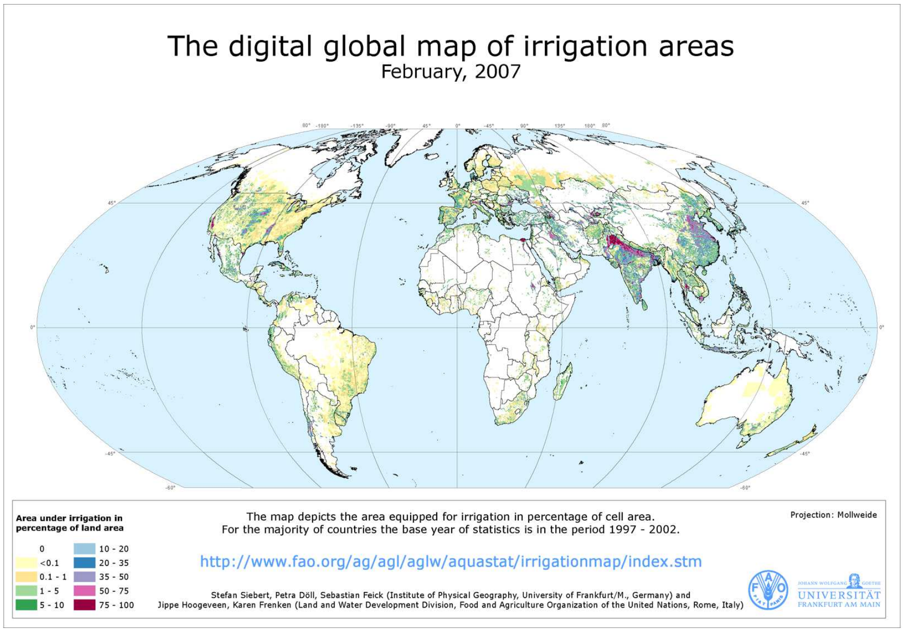

Figure 1: Global irrigation

2 Methods

We seek to evaluate the requirements on a targeted ET dataset. Besides inquiring general requirements on existing or new ET data, we include specifically the technical aspects.

Evapotranspiration data are important for several applications. ET is a crucial variable in the hydrological cycle and is linked to the atmosphere. Its relevance has therefore been recognized by climate scientists, which are the first user community for the targeted ET dataset. ET is the second largest water flux after precipitation on land (Trenberth et al., 2007) and determines the water available on the land surface, for example for plant growth or irrigation. Irrigation plays an important role in many areas in the world (see Fig. 1). The regions with the largest irrigated areas are Eastern China, India, Southern Europe and the central U.S.. Thus, the second type of users are the water management and agriculture community.

Many of the requirements of both user communities are determined in non-scientific and scientific literature. In order to have a more direct contact to the users, and to be able to also inquire the technical requirements, we did not only do a literature research, but also gathered information with an online questionnaire. This is a crucial step for the evaluation of user requirements for the water management and agriculture community.

The questionnaire was partly built upon the results from the literature research. It can be devided in two parts: Nine more general questions and nine specific or technical questions. We were, for example, interested in what the ET data will be used for, whether the requirements were already satisfied with current datasets, whether the users would need near-real time estimates or which time period and temporal resolution was necessary. A full list of the questions can be found in the Appendix. Some of the main aims were to derive the current needs and gaps in ET products for climate studies and for water management and agricultural applications.

We have chosen a web-based survey which could be easily sent to the potential users. The survey can still be accessed on `https://services.iac.ethz.ch/survey/index.php?sid=72382\&lang=en`. The chosen software provides convenient tools to analyze the data (statistics), but also to look at individual answers. The survey consists mostly of questions which have to be answered in full text, which allows the potential users to report their opinions and provide useful insight into shortcomings of current and hopes for future datasets.

Moreover, as part of this WP, existing activities carried out in the context of GEWEX are consulted (e.g., the work is built upon the experience with ET products gained in the Landflux-EVAL project). Based on the response of the users and experts, and based on the literature review, the requirements for the targeted ET benchmark products are translated into the technical specifications of the ET products and into the requirements for the reference input datasets.

3 Requirements

3.1 Climate science

ET is not only a main component of the land water cycle, but also an important energy flux: The energy required for evaporating a given mass (e.g. 1 g) of liquid water corresponds to approximately 600 times the energy required to increase its temperature by 1 K, and to 2400 times the energy required to increase the temperature of a corresponding mass of air by 1 K. Consequently, land ET also uses up more than half of the total solar energy absorbed by land surfaces (Trenberth et al., 2009).

Being a common component in the water and energy cycles, ET plays a key role in the land energy and water balance and provides a link between the land surface and the atmosphere (e.g., Seneviratne et al., 2010). As such, ET is directly coupled to soil moisture, and the impacts of soil moisture for the climate system are induced through ET, in particular in regions with soil moisture-limited ET regimes (e.g., Koster et al., 2004; Seneviratne et al., 2006, 2010; Hirschi et al., 2011; Mueller and Seneviratne, 2012).

In current climate models, ET is simulated by the employed land surface models (LSMs). These describe the dependency of ET on soil moisture in varying degrees of complexity (e.g., Sellers et al., 1997; Arora, 2002; Pitman, 2003). In order to validate climate models and the employed LSMs, (ground) observations are essential and can help to evaluate and improve the representation of relationships between the land surface and the atmosphere. Besides model evaluation, global-scale estimates of ET are critical for better understanding the climate system and hydrological cycle. In the investigation of soil moisture-climate interactions, ET is a key variable for three reasons (see Seneviratne et al., 2010): 1) In the terrestrial water balance, soil moisture and ET are the two main unknowns, and thus measurements of one of these two quantities can allow to derive estimates in the other (with rainfall and runoff measurements); 2) Concomitant ET and soil moisture measurements are crucial to derive soil moisture-ET relationships; 3) In some instances, inferences regarding soil moisture control on ET can be derived from ET measurements alone (e.g. during dry-downs).

Knowledge of the long-term evolution of ET fluxes (i.e., over the past decades) may give insights in changes of the global water cycle due to human influences such as land use change and large-scale irrigation. Agriculture has already led to a redistribution of the spatial patterns of ET globally, decreasing it in areas of large-scale deforestation and increasing it in many irrigated areas (Gordon et al., 2010). For such trend analyses, climate research strongly relies on long-term (i.e., 30 years and more) ET data derived as consistently as possible over the years in order to avoid spurious shifts. However, observational datasets of ET are scarce and limited in space and time. Also, there is a lack of long-term ET data, and the available products show considerable differences (Jiménez et al., 2011; Mueller et al., 2011).

ET can be measured by a variety of techniques, depending on the scale of the observations (e.g., Kalma et al., 2008). A standard approach to measure actual ET on the ground is to use weighing lysimeters. Due to their costs, there are, however, only few instruments worldwide with long-term measurement records. Some exceptions are for instance the sites of Rietholzbach[1] (in operation since 1976; Seneviratne et al., 2012), and Rheindahlen[2] (since 1982).

Another well investigated and now common approach is to estimate ET using eddy-covariance flux measurements, as is done as part of the FLUXNET network (e.g., Baldocchi et al., 2001). The present FLUXNET[3] network includes more than 500 sites worldwide, with excellent coverage in Europe and North America. However, one should note some issues with these measurements: 1) The turbulent fluxes are often underestimated (e.g., Foken, 2008); 2) The measurements are point-scale (small footprint area) and their interpretation for larger-scale areas is non-trivial; 3) The footprint area of which the measurements are representative depends on weather conditions and can thus vary in time; 4) Due to limitations of the approach, the measurements are generally performed in rather homogeneous flat terrain, and thus are not representative of all types of surface conditions (e.g. Rotach et al., 2004). Another approach to estimate ET is to use atmospheric water-balance estimates with atmospheric re-analyses data and measured precipitation (e.g., Yeh et al., 1998; Yeh and Famiglietti, 2008; Hirschi et al., 2007). However, these estimates can not be used for the investigation of long-term trends, due to the known artificial trends induced by the re-analyses data assimilation systems.

While above ET estimates are mostly restricted to the point scale (except for the atmospheric water balance estimates), land surface models can be used for the estimation of ET on a global grid, for instance as part of the GLDAS (Rodell et al., 2004) and GSWP-2 (Dirmeyer et al., 2006) products. Similarly, modelling algorithms can also be applied for the derivation of ET estimates from remote sensing data (e.g. Mu et al., 2007; Su et al., 2007; Fisher et al., 2008; Miralles et al., 2011; Anderson et al., 2011), which will be the topic of the current project.

Each available validation dataset for ET covers distinct spatial and temporal scales. Fig. 2 summarizes the spatial and temporal characteristics of existing validation datasets for specific measurement/estimation approaches (Seneviratne et al., 2010), by displaying the spatial and temporal scales that they can respectively resolve or cover (in the case of pointscale observations, the scales correspond to the most extended network using such observations, e.g. AmeriFlux for the eddy-covariance flux measurements). The shading of the different areas corresponds to the spatial continuity of coverage (scattered point observations vs. globally valid observations).

In Section 3.3, the climate science user requirements will be further specified based on the user survey.

[1] `www.iac.ethz.ch/research/rietholzbach`

[2] `www.niederrheinwasser.de`

[3] `www.fluxnet.ornl.gov/fluxnet/index.cfm`

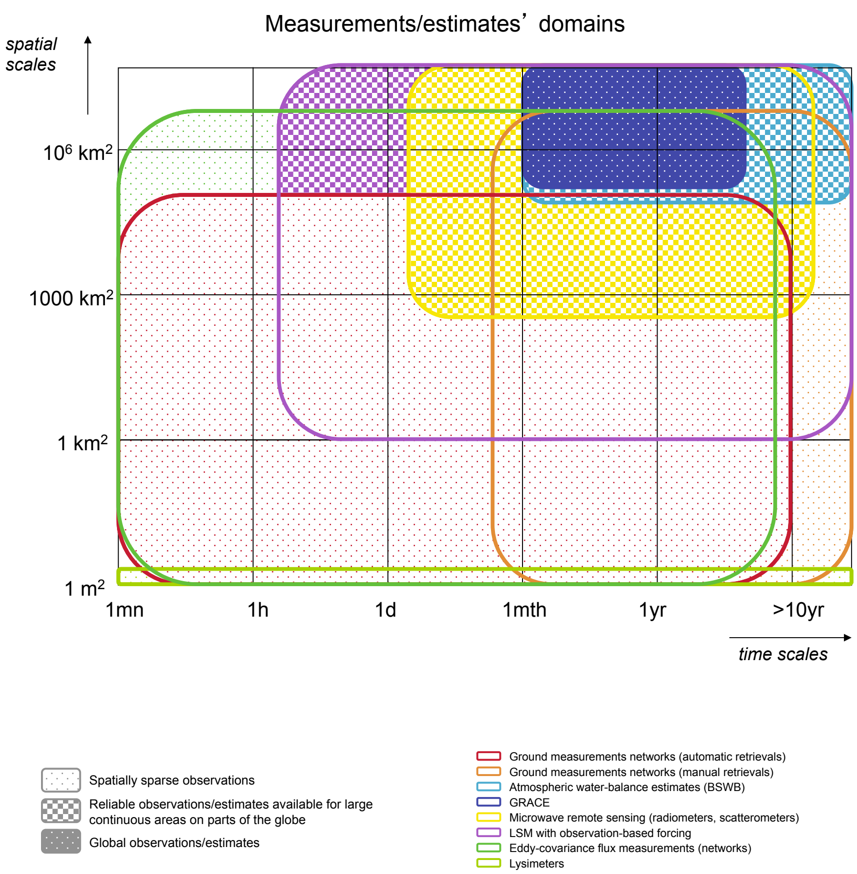

Figure 2: Spatial and temporal scales of measurements/estimates for soil moisture (ground measurements, microwave remote sensing, and LSMs' estimates), terrestrial water storage (atmospheric water balances/BSWB and GRACE), and ET (LSMs' estimates, atmospheric water balances/BSWBS, eddy-covariance flux measurements and lysimeters) (from Seneviratne et al., 2010)

3.2 Agriculture and water resources management

Evapotranspiration is a major component of the continental water cycle, returning as much as 60% of the whole land precipitation back to the atmosphere (Oki and Kanae, 2006). ET has high regional and seasonal variations and can aggrevate the developpment of droughts. Soil moisture and evaporation are directly linked, i.e. high evaporation decreases soil moisture or water availability, and in transitional climate regions, the evaporation rate is limited by soil moisture availability (see Seneviratne et al., 2010).

For agriculture, a water shortage implies a significant decrease in productivity. ET can dry out the soil and decrease infiltration. If the evaporation rate is known, the water demand of the crops and the amount of water needed for irrigation can be estimated. Good irrigation practice replaces the water lost by the plant through ET and the water content in the root zone is maintained (for more information on irrigation practice, see e.g. Kisekka et al., 2009). Currently, ET is mostly estimated by the Penman-Monteith equation (Allen et al., 1998) for such applications. However, the accuracy of ET estimates can be crucial for water management.

In recent years, droughts and water shortages have become more frequent, and climate models predict that this trend will continue into the future (IPCC, 2011). A recent study with newly available soil moisture estimates from satellite remote sensing has shown a drying trend over most parts of the world (Dorigo et al., 2012). Furthermore, a negative trend in ET has been found between 1998 and 2008 (Jung et al., 2010). Althought trend analysis from these newly developed datasets should be approached with caution, they seem to support a drying of the global land surface. Water scarcity for drinking water supply as well as irrigation of farms and crops is becoming problematic in more and more regions in the world, and increasing the efficiency of water utilisation to overcome the impact of water shortages an important goal.

From the user survey (see Section 3.3), it became clear that the requirements towards an ET dataset are different between the two user communities. As compared to the climate science community, the time span of ET data is not so important for the agricultural community, which preferes as much updates as possible. For agriculture and irrigation, real-time or near real-time availability is crucial for the benefit of the dataset. Some irrigation practicioners stated that a delay of a few days (up to 5) is possible, but best would be to have even a 7 day forecast of potential evaporation. For climate scientists, a longer delay of data availability is accepted (see Section 3.3). Important for irrigation scheduling is also a high resolution of ET data: 30 to 100 meters is necessary. The choice for resolution is possibly linked to the size of the users plots, which can range from very parceled fields to quite large fields for monoculture practices. Concerning temporal resolution, daily data are sufficent for agricultural applications.

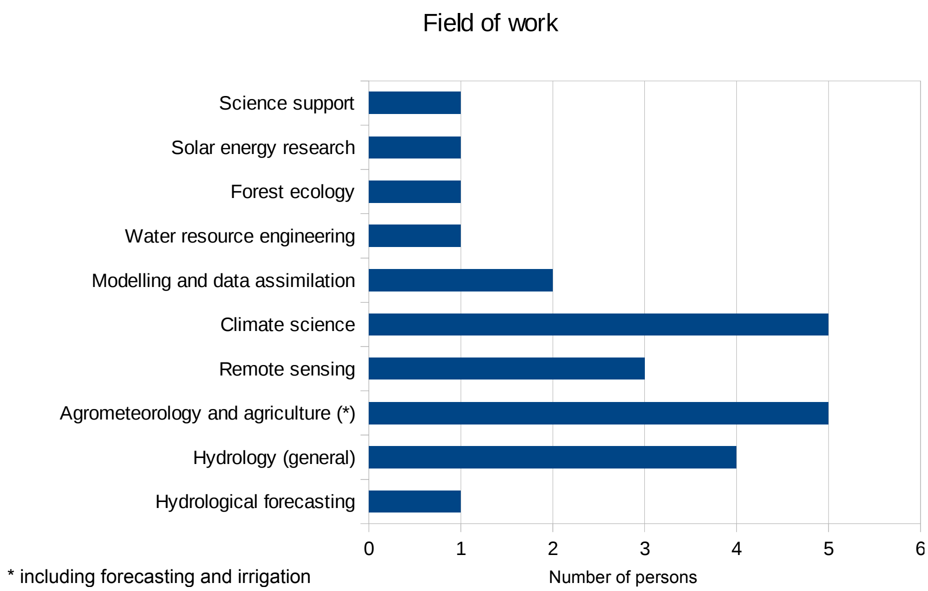

Figure 3: Information on user, field of work.

3.3 User requirements survey: results

3.3.1 Potential users of the targeted ET dataset

The questionnaire has been filled out completely from 25 potential users. The ET dataset users from the two communities that the questionnaire was sent to came from the following fields of work (see Figure 3). The climate scientist and the water resource management or agriculture community was well balanced within the potential users addressed. Notice that in some figures the results have been clustered in two classes associated with these two communities, which are loosely referred to as "Climate" and "Agriculture" in the plots.

A large fraction of the users are interested in the ET dataset to estimate, monitor or forecast soil moisture, drought, runoff or water resources and water use in general (10, of which three are interested in estimates for a field, see also Section 3.3.4). These applications are directly related to agriculture.

Many users will use the ET dataset for the evaluation of their own ET dataset or model (11), which could be either for agriculture or purely scientific purpose. Two users are going to use the ET dataset directly to study climate or climate extremes. Three users would like to assimilate the ET dataset into a model. Some of the users are also interested in several of the above mentioned purposes.

3.3.2 Currently used datasets, requirements and shortcomings

Twenty-four users answered the question whether their requirements for ET data were already satisfied with 'no'. Most of the users could either not find error estimates for their currently used dataset or else needed a higher resolution/better coverage. Only one user stated that most of the needs are covered by estimations which use standard climate variables. Nevertheless, this user believes that a new ET dataset would enable him to improve estimations of soil moisture and runoff generation thanks to their assimilation in a hydrological model.

Most of the potential users currently use model output of ET, some use satellite based ET and a few field measurements (local measurements, FLUXNET, water-balance data). The users mentioned different shortcomings of the current datasets. These answers reflect also the requirements that they have towards a future ET dataset. The shortcomings are:

- Lack of global data coverage, spatial and temporal coverage too small (needs to be extended into the future)
- assured data continuity missing (important for water forecasting), not routinely available
- data less reliable in arid regions and the tropics
- problems with own dataset generation (amplitude, seasonal cycle, variability)
- missing error estimates, large uncertainties
- spatial and temporal resolutions too coarse
- no gridded data sets available
- site data (FLUXNET) needs to be scaled up to regional/global
- missing ET components (interception).

3.3.3 Use of the targeted ET dataset

For more than 70% of the users, the targeted ET dataset will be used additionally to other datasets of the hydrological cycle (see Figure 4). The users are interested in different aspects of ET, such as absolute values, temporal variations and spatial patterns. Some are also interested in trends (Figure 5).

The dataset will be used in the regions listed below (Table 1). Note that the answers from this table do not necessarily reflect regions where ET data is most needed or most important, but might be dependent on the selection of the users.

The ET dataset users are mostly interested in bare soil evaporation and transpiration. Eighteen of the 25 users answered that they would be interested

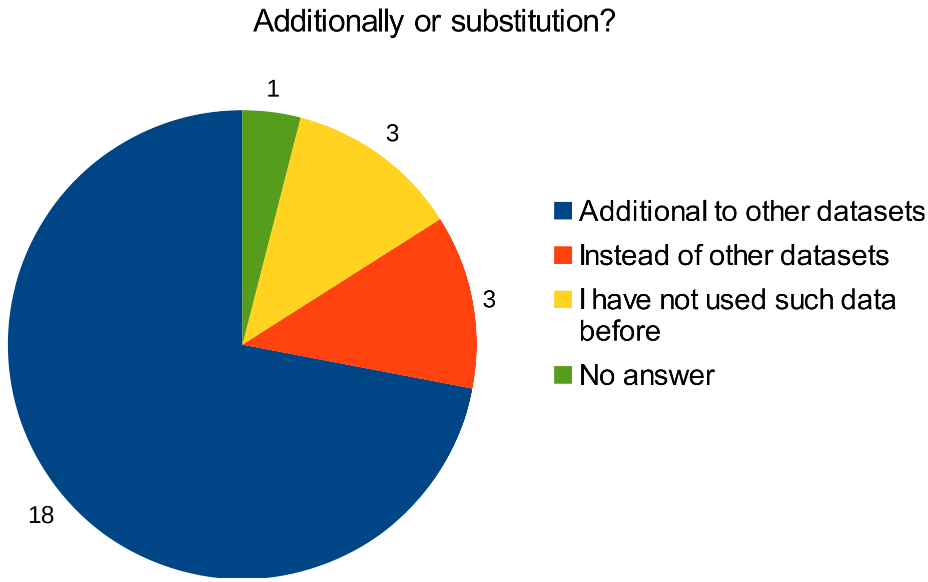

Figure 4: Would the ET dataset be an addition to precipitation or soil moisture data that you already use or does it substitute other datasets?

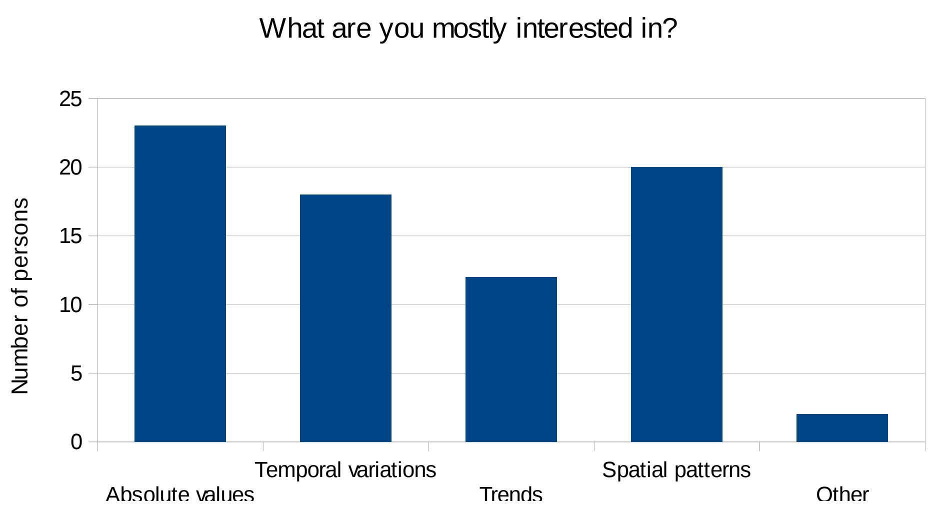

Figure 5: What are you mostly interested in?

Table 1: Which regions are you interested in?

Which regions are relevant for you?	Characteristics	Does irrigation play a role?	Hits
Global	Dry and wet	sometimes	6
Agricultural/crop regions	Dry and wet	in some regions yes	2
France	Dry and wet	yes	1
Europe	Dry and wet	intermediate	7
Australia	Dry and wet	yes	5
Switzerland	Dry and wet	yes	2
Africa	Dry and wet	yes	1
Midlatitudes, semi-arid regions	Wet, transitional	no	1
Semi-arid, tropical	Dry and wet	no	1
SE Asian region	Wet	yes	1
State of Idaho	Dry	yes	1
Western U.S.	Dry	yes	1
no specific regions	no response	no response	1

to obtain all types of ET data separately (i.e. transpiration, open water evaporation, bare soil evaporation and interception). The statistics are shown in Figure 6).

3.3.4 Technical requirements

Most people (72%) are not interested in real-time availability of ET data. They state that the maximum acceptable temporal delay of the data is 2 years (1 person), 1 year (7 persons), 6 months (2), 3 months (1), or 5-7 days (2). One person was unsure. For the other 28% of the users, real-time or near real-time availability is crucial. These users are all interested in ET data for water management purposes (see also Section 3.2).

The chosen spatial resolutions for the region of interest is shown in Figure 7. Three of the five users who chose 'other' for spatial resolution wish a resolution of 30 meters. Nevertheless, 1 km is the resolution chosen for most users in the 0-1 km resolution range. Most users (80%) are interested in daily values of ET, followed by monthly (see Figure 8).

The users provided the maximum uncertainty that would be acceptable for their purpose. All users provided numbers between 5 and 30% (5% (1 person), 10% (10), 15% (1), 20% (6), 25%(1) and 30% (5)).

The majority of users require ET data for the time period from the 1970ies or 80ies to present (12 persons). Only 4 persons request longer time periods, i.e. back to the 50ies or as long as possible. Three persons are satisfied with 2000-present, and one person would like to have data for future time periods and one for the irrigation season.

Nineteen of 25 users wish to receive the data in NetCDF. Other options that were mentioned from several users are GRIB and ASCII. Geo TIF, Excel

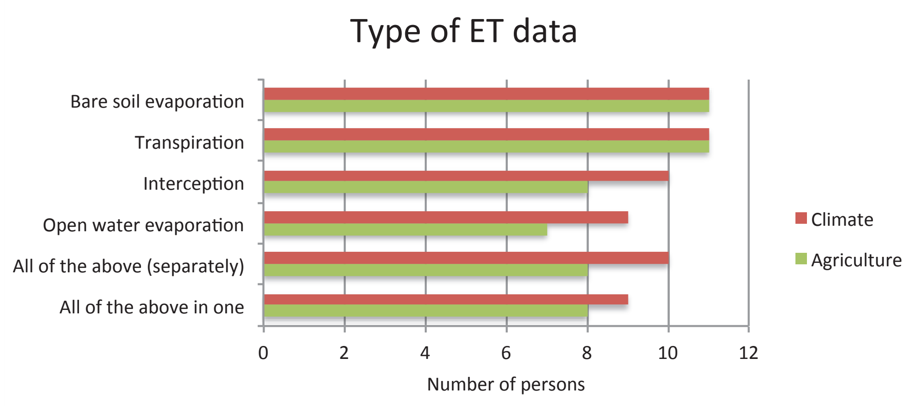

Figure 6: What type of ET data are you interested in?

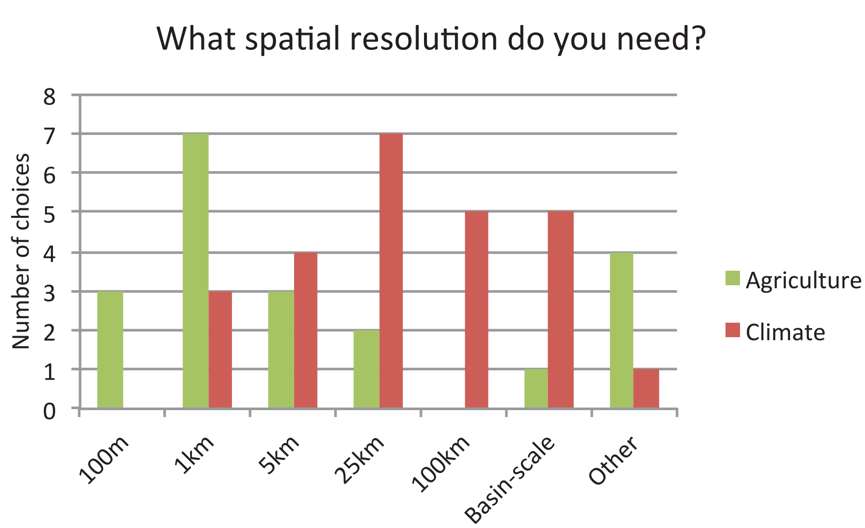

Figure 7: Choices of spatial resolution.

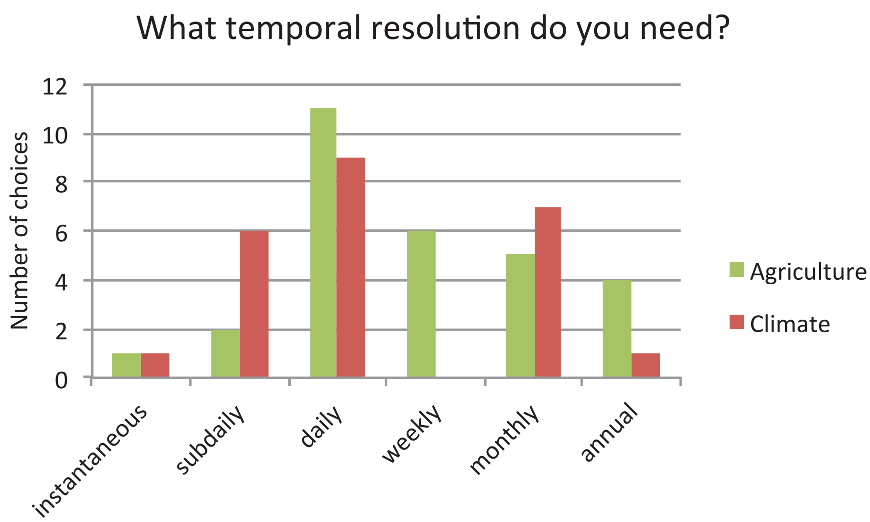

Figure 8: Choices of temporal resolution.

and ArcInfo were each mentioned only once. The users would like to receive a regular grid (20) or do not care (4). Only one user would like to receive an image.

Metadata information seems to be an important point for the potential users. Metadata that were mentioned to be necessary are listed in Table 2.

Nearly all of the users need an accuracy estimation. Some users point out that the uncertainty estimates need to be understandable and clearly defined.

The mostly chosen delivery method of the ET data were internet download (20 times) and ftp download (15 times). Two persons would like to receive a DVD or CD with the data.

Table 2: Necessary metadata information

Land use, soil type or soil texture	Model, method or measurement method
Land cover data (type)	Processing code version and details on tunable parameters
Date and time	Assumptions
Data type	Assimilated data streams/ input data
Elevation of gridded domain	How input data changes over time
Location and area/ geo-referencing info	Actual satellite images that contribute per pixel, incl. dates
Pixel size/ resolution	Who generated the data
Uncertainty per pixel	Processing date
Quality information (flags)	Geometric control
Information on gap-filling (if any)	Validation results
Projection metadata	

4 Scientific strategy

The scientific strategy to perform the required ET algorithm inter-comparison and product validation exercise is derived from: (1) the requirements for this project, (b) the knowledge of the project team members concerning methodologies and existing Earth observation datasets, (c) the results of the literature review and user questionnaires described in Section 3.3, and (d) the willingness of product PIs to share their algorith for our purposes.

First ET algorithms for the production of the benchmark product will be chosen based on a discussion of methodologies and adequacy to the Earth observation datasets availabe for this project. A representative approach for different types of algorithms will be selected and presented to ESA for approval. The will include representatives from:

- Energy balance closure approaches
- Empirical approaches
- Penman-Monteith approaches
- Priestley and Taylor approaches

Discussion with the modellers will be engaged during this phase as an optimal implementation, adaptation of the algorithms to the available forcing datasets, and discussion of the produced estimates requires also the modellers expertise.

In a following step, the reference input data set has to be specified. The ideal temporal and spatial resolution for ET data is different for the two user communities addressed with this project. For agricultural and water management purposes, near real-time or future prediction of ET and a spatial resolution ranging from 30 m to 1 km are preferred (see Section 3.3.4). For climate research, a much coarser resolution and a time-lag of weeks to years are acceptable. Current input datasets at the scales targeted by the project are not available on a resolution higher than around 1km and with no time-lag. The selected input data resolution will therefore cover the requirements from the climate research community completely, while the agriculture and water management requirements will only be partly full filled: A low resolution (10-25km) as well as a medium resolution (approx. 1km) dataset are targeted. Since 80% of the users which answered the questionnaire wished a daily temporal resolution, both medium and low resolution datasets will be provided at least in daily values. However, it is quite likely that providing sub-daily values will also be considered in order to contribute to the developments of the GEWEX LandFlux initiative, which is aiming at 3-hourly data sets of turbulent fluxes.

Most of the potential users from the climate science community wished a dataset covering the last 20 to 30 years. However, this project is especified as as demonstration of ET estimation and is not intended to produce long climatological records. The period 2005-2007 will be submitted to ESA for approval. Three years are judged enough and compatible with the resources allocated to the project, and a continuous time period common to all sites is judged more comprehensive than scattered and/or different years for each site, as a well defined observation period can facilitate the use of the Reference Input Data Set by third parties. The selection of these specific years is based on a compromise between data availability for driving the ET algorithms and for validating the produced estimates. The 2007 year is fixed by (1) the temporal coverage of one of the key in situ data sets for ET evaluation (the FLUXNET La Thuille Synthesis Dataset, `www.fluxdata.org`), and (2) the temporal coverage of one of the most used products for radiation data (SRB, (Stackhouse et al., 2004)).

Table 3 shows the major inputs required by the more recent algorithms deriving ET at the global scale. A possible approach is to select the "best" product for each category [see e.g., Vinukollu et al., 2011]. The problem is that lack of consistency between these products related to using different sensors, different auxlilary information, etc, can have an impact on the produced ET estimates. Therefore, we will develop our own products for some of the critical inputs to the models, assuring consistency between these estimates. The developed products will form a consistent data set of albedo, vegetation fAPAR, LAI, and land surface temperature. For the other products, the choice will be based on percieved quality and consistency with the rest of the developed products.

Once the Reference Input DataSet methodology is specified and the methodology developed, it needs to be produced for selected geographical regions and the agreed period of time. This will be followed by running the selected ET algoritms to estimate ET over the same regions. The geographical coverage mentioned mostly in the user requirement survey are global, Europe and Australia (see Table 1). Besides the imposed Europe and Australia, Africa and North America will be proposed to complete the 4 required regions at continental scale. Africa is proposed because it covers different hydrological regimes (from very dry areas in the northern deserts to the very humid rainforests around the Equator) and because it is a challenging region for ET estimation (possibly due to difficulties of the ET algorithms originally developed/tuned over other hydrologically better characterized regions to adapt to the particularities of this region). North America is chosen because of its variety of landscapes (from the arid regions in the Great Basin, to large agricultural regions in the Great Plains, and to the large northern forested areas), and because of its relatively large wealth of in situ data (compared with other regions).

For each of the large sites mentioned above, a specific regional site has been identified for production and evaluation of ET estimates at a finer resolution. However, the final selection will be revised during the course of the project based on the availability of input data sets to run the models at fine resolution and the project findings concerning the evaluation of the ET models. Concerning the rationale for the pre-selection, it has been based on (1) covering different climate/land-use conditions, (2) existence of relevant data for evaluation, (3) local knowledge of the area by the consortium members to facilitate data adquisition and interpretation of results, and (4) possible links to other projects. A

Table 3: The major type of products required by the more recent algorithms deriving ET at the global scale, and references to some of the existing choices.

Forcings	**Products**
Radiation and Albedo	NASA/GEWEX SRB, ISCCP FD-SRB, GOES-based products, MERRA
Surface Temperature	LPRM, ISCCP, GOES-based products
Air Temperature	CRU, ISCCP-TV, CIMSS CRAS, NCEP-NCAR, AIRS
Water Vapor Pressure	CRU, ISCCP-TV, MERRA
Wind Speed	NCEP-NCAR, HR Princenton
Soil Moisture	LPRM
Precipitation	GPCP, CMORPH, CPC-Unified
Land Cover and Soil Properties	MODIS IGBP, ISLSCP-II Land mask, UMD Land Cover, AVHRR Tree Cover Data, FAO soil database
Vegetation Properties	AVHRR GIMMS NDVI/LAI, AVHRR Boston Uni LAI LPRM veg. optical depth, MODIS NDVI/LAI/fAPAR

summary of the intended sites to be proposed to ESA for approval are given in Table 4. The site in Europe corresponds to a pre-alpine region with pasture and conniferous forest, and includes a well studied sub-catchment managed by one of the consortium members. The site in Africa is one of the savanna mesoscale sites of the African Monsoon Multidisciplinary Analysis (AMMA) Land Model Intercomparison Project Phase 2 (ALMIP-2), a GEWEX Global Land Atmosphere System Study (GLASS) initiative, with a climate dominated by the West-Africa monsoon, and it will allow to inter-compare estimates and forcings for both projects. In south-east Australia a cool temperate forested area around a well studied FLUXNET site is selected to represent tall stand forests. Finally, a cultivated area around the Atmospheric Radiation Measurement (ARM) Southern Great Plains site is selected in North America to have an example of ET estimation over parceled fields. The final size of the areas modeled at each of these sites will be decided during the study, but we envisage areas ranging from 1000 to 10000 km^2.

Table 4: Selected large scale and regional sites for the study.

Large site	**Regional site**	**Climate**	**Vegetation**	**Other**
Europe	Rietholzbach Catchment [Switzerland]	pre-alpine	pasture land, conniferous forest	+30 years studied catchment
Australia	Tumbarumba Forest [N.S. Wales]	cool temperate	sclerophyll forest	OzFlux carbon and flux site
Africa	Niamey [Niger]	semi-arid tropical	millet, fallow, tiger bush	AMMA mesoscales super-site
North America	Southern Great Plains [Oklahoma]	continental	wheat fields	ARM radiation site

Relevant for the development of the targeted ET dataset (both regarding the reference input data as well as the ET algorithms) is the importance of metadata information for the potential users (see Table 2), which requires a detailed description of, among other things, what data has been used, which version, processing date and person, and uncertainty. One major shortcoming of current ET datasets mentioned from the users (Section 3.3) was that error estimates or uncertainty information of the data are usually missing. The project intends to use the systematic inter-comparison between the different algorithms as the basis to provide some relevant information that help the user judge the uncertainty in the produced estimates. Comparison with in situ measurements will also be performed.

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Appendix: User requirements questionnaire

User requirements of a targeted evapotranspiration (ET) dataset

Questionnaire for the consolidation of scientific and user requirements of a targeted evapotranspiration (ET) dataset

Greetings.

We are working on a European Space Agency funded project to develop a preliminary global evapotranspiration data set from Earth observing satellite systems. One of the project objectives is to identify and then seek to address the data needs and requirements of the agricultural and water resource management community. To this end, we are requesting your input to aid in the development of this product. It would be greatly appreciated if you could take a few minutes of your time to answer the following brief questions to assist us in producing a dataset of relevance to a wide range of users in the Earth science community.

Best wishes!

Brigitte Mueller, Martin Hirschi, Carlos Jimenez, Matt McCabe, Sonia Seneviratne, Catherine Prigent and Diego Miralles

There are 19 questions in this survey

Information on user

1 [User]Name and institution *

Please write your answer(s) here:

First name	
Last name	
Institution	
Departement	
Field of work	

Please provide your first and last name, institution and position/department in the fields.

Current evapotranspiration datasets

2 [Purpose]

What is or could be (in case you do not yet use any ET data) the main purpose of a global or regional ET dataset for you?
*****

Please write your answer here:

3 [CurrentSatisf]

Are your requirements for ET data already satisfied currently?
*****

Please choose **only one** of the following:

- ◯ yes
- ◯ no

Make a comment on your choice here:

4 [Dataset]

In case you already use ET data, what data set do you use?

Please write your answer here:

5 [Shortcomings]

What are the shortcomings of the dataset you currently use?

Please write your answer here:

6 [Addition]

Would the ET dataset be an addition to precipitation or soil moisture data that you already use or does it substitute other datasets?

Please choose **only one** of the following:

- ○ Additional to other datasets (please specify)
- ○ Instead of other datasets
- ○ I have not used such data before

Make a comment on your choice here:

General requirements

7 [Variation]

What are you mostly interested in?
*

Please choose **all** that apply:

- ☐ Absolute values of ET
- ☐ Temporal variations of ET
- ☐ Trends
- ☐ Spatial patterns
- ☐ Other: ____________

8 [Regions] Regions that you are interested in: *

Please write your answer(s) here:

Which regions are relevant for you?	
Are these regions rather dry or wet?	
Does irrigation play a role in the region of interest?	

9 [type] What type of ET data are you interested in? *

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Bare soil evaporation	○	○	○
Transpiration	○	○	○
Interception	○	○	○
Open water evaporation	○	○	○
All of the above (separately)	○	○	○
All of the above in one (evapotranspiration)	○	○	○

Multiple answers possible

Technical requirements

10 [real-time]

Do you need the data in real-time?
*

Please choose **only one** of the following:

- ○ Yes
- ○ No

Make a comment on your choice here:

11 [real_time_no]How long is the maximum temporal delay of the data availability?

Only answer this question if the following conditions are met:
° ((real-time.NAOK == "A2"))

Please write your answer here:

12 [Resolution]

What spatial resolution do you need for the region of interest?
*

Please choose **all** that apply:

- ☐ 100m
- ☐ 1km
- ☐ 5km
- ☐ 25km
- ☐ 100km
- ☐ basin-scale
- ☐ Other:

If you wish to have several products, please chose all resolutions or add a comment.

13 [tempres]

What temporal resolution do you need?
*

Please choose **all** that apply:

- ☐ instantaneous
- ☐ subdaily (e.g. 3hourly)
- ☐ daily
- ☐ weekly
- ☐ monthly
- ☐ annual
- ☐ Other: ______

14 [Uncert]

How large is the maximum uncertainty in the data that is acceptable for your purpose (for the temporal resolution chosen above)?
*

Please write your answer here:

______

Please provide a value in %. For example, if we have an evaporation flux of 2 mm/day and the uncertainty is 50%, we do not know where between 1.0 mm/day and 3.0 mm/day the real value is.

15 [time span]For which time period do you need the data?

Please write your answer here:

______

Enter the time span, if appropriate (e.g. 1970-2010)

Data format and uncertainty

16 [format]What format suits you best? *

Please write your answer(s) here:

Preferred data format (text-file, excel table, NetCDF. GRIB...)	
Grid (regular grid, gaussian grid)	

17 [metadata]What metadata information is necessary?

Please write your answer here:

18 [uncertain]Do you want an uncertainty / accuracy estimation for the data? *

Please choose **only one** of the following:

- ○ Yes
- ○ No
- ○ Maybe

Make a comment on your choice here:

19 [download]How would you like to access / receive the data? *

Please choose **all** that apply:

- ☐ internet download
- ☐ ftp download
- ☐ delivered on DVD/CD
- ☐ Other: ____________

Thank you very much for your contribution to this survey!

If you have any questions or further comments, please contact

brigitte.mueller@env.ethz.ch

01.01.1970 – 01:00

Submit your survey.
Thank you for completing this survey.