Hydrosat

Responses of Hydrosat to Questions for RFP Responders

Thank you for reviewing our proposal and for the opportunity to provide additional information. Please find below our responses to your follow-up questions.

1. **QA/QC** What processes are in play for quality assurance and quality control for data?

Our scientists are making sure that the models and algorithms we're using meet the state-of-the-art of surface energy balance & environmental monitoring.

On the data QA/QC, following the integration of IrriWatch with Hydrosat, we have implemented new procedures including performing routine quality checks of our input satellite data using the provided QC layers of the satellite data providers.
For data processing and model outputs, we're closely monitoring the availability of all of our model's input data in real-time. We also monitor consistent model output and potential data drifts using regression tests and real-time monitoring dashboards. At the technical level, our codebase is sufficiently covered with unit and integration tests.

2. **Data Security** How do you make sure that your data is securely shared and stored?

Our data pipelines and application run on AWS, and we follow industry best practices for data security. This includes encryption for data both at rest and in transit, strict access controls, and regular security audits. All data is securely stored within AWS infrastructure behind a firewall. Access is restricted to a subset of Hydrosat's engineering team and authorized Madera users with valid credentials.

On the other hand, regarding client data, we are fully committed to upholding the highest standards of data protection in accordance with the General Data Protection Regulation (GDPR). We want to assure you that:

- Your data will be handled lawfully, fairly, and transparently.
- We only collect and process data that is necessary for the agreed purposes.
- All personal data is stored securely, and access is strictly controlled.
- We do not share your data with third parties without your explicit consent, unless required by law.
- You have full rights over your data, including access, correction, deletion, and the ability to restrict or object to processing.

We also implement appropriate technical and organizational measures to ensure a level of security appropriate to the risk, including encryption, access controls, and regular audits.

If you have any specific concerns or would like more details about our data protection practices, we would be happy to provide further information or documentation.

3. **Mobile Apps** Does your product have a mobile applications or interface?

Yes, Hydrosat's product IrriWatch does have both a mobile app and a web portal. Our web portal is tailored to host water allocation budget at parcel level, farm unit level and account level. Madera County GSA and its growers have been using our portal the last couple of years. During 2024, a new portal was launched and made the user interface more user friendly.

The portal allows data access for the County GSA team to see and monitor all the fields, while also allowing individual growers or companies to have access to their own farm units, parcels and fields.

The standard IrriWatch portal (irriwatch@hydrosat.com) is geared towards irrigation scheduling, soil moisture and crop monitoring. However, for water allocation monitoring, specifically for Madera County, we have tailored our portal to provide more insights into the actual evapotranspiration from applied water (ETAW) vs Allocations and monitor the remaining allocations. For this budget tables are presented for each farm unit, each sub-basin etc. At the same time, monthly reports are generated at parcel level, farm unit level and master account level allowing maximum flexibility and visibility about data.

In addition to our web portal, data is also delivered via an API, excel downloads, PDF reports and Mobile App. Note that the Mobile App does not show ETAW or budget table, but rather a simple interface to check on field statuses, irrigation requirements, adding scouting notes and monitoring fields. The Mobile App is available via App Store https://apps.apple.com/us/app/irriwatch/id6738511023 and Google Play https://play.google.com/store/apps/details?id=com.hydrosat.irriwatch&pcampaignid=web_share
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4. **Use by Other GSAs** Please list any other Groundwater Sustainability Agencies (GSAs) using your products.

At present, only Madera County GSA is using our product.

We are currently exploring other proposals and expansion options to other GSAs.

5. **NOAA** Are any of your satellites/data collection capabilities affected by the loss of weather prediction in NOAA data?

The NOAA program that was entirely shut down is the Defense Meteorological Satellite Program (DMSP; https://www.theguardian.com/us-news/2025/jun/28/noaa-cuts-hurricane-forecasting-climate).
We acknowledge though that the DMSP program data was used in many NOAA provided data services and forecasts and its loss constitutes a major setback for the world's meteorological data landscape.

However, for weather prediction, IrriWatch product of Hydrosat uses the WeatherAPI and WeatherStack as main sources of climatic data. For Madera County GSA(s), we additionally use rainfall data from NWS. The DMSP has generally defense satellites primarily used for Hurricane monitoring and other rapid response applications and it is not affecting our weather data prediction sources. It is important to note firstly that neither WeatherAPI nor Weatherstack are American companies, so they do not have direct access to the data in the first place. Secondly, because most weather data providers rely on model output from the major climatic models such as GFS or IFS, combined with some proprietary ensembling methods.

As compared to that, NWS is (heavily) affected by the budget cuts. However, NWS rainfall dataset is not directly using DMSP data, hence it isn't impacted by the shut down of the program.

More generally, budget cuts due to the current administration pose a risk to the quality of the dataset though. Hydrosat will keep monitoring the weather prediction for data quality and will evaluate alternative weather providers as needed.

6. **Crops** Is there a list of crops covered by either the ET data collection or platform service? If so, can the public see it?

Hydrosat has been using its Surface Energy Balance Modeling SEBAL (4.0) for over 130 crops globally. The current crop list covered is attached to the response email.

7. **Grower Accessible Platform**:

- **Does the platform have the ability to aggregate ET data over unique geospatial polygons provided by the GSA (fields)?**

Yes, for the budget tables and ETAW calculations, our platform aggregates the parcel-fields into parcels. Each parcel can then have its own budget and report every month.

- **Does the platform have the ability for growers and /or the GSA to combine field polygons into larger management groups (farm units)?**

Yes, the IrriWatch platform has the ability to combine multiple parcels into a management group or farm unit. Each farm unit will also have its own budget and downloadable report. It also aggregates the Farm Unit to the Grower account level (Master Account) and has the possibility of downloading Account reports every month (*new feature introduced in Jul 2025*).

- **Does the platform have the ability to display and compare groundwater allocation amounts to current groundwater use (budgets) by farm unit or grower account?**

Yes, the IrriWatch platform has the ability to compare groundwater allocations amounts to current groundwater use (ETAW) at several levels: parcel level and farm unit level. These comparison and data is available in budget tables for both the parcels and farm units. In addition, for each parcel we also display the graph of ETAW compare to the allocation that is updated on daily basis so that the grower can monitor and follow how close their parcels are getting to the allocations and can take management decisions accordingly.

- **Does the platform have the ability to incorporate allocation adjustments provided by the GSA (recharge credits, surface water credits, carryover)?**

Yes, the platform have the ability to incorporate allocation adjustments provided by the GSA in terms of carryover, recharge or any adjustments. Generally these adjustments are updated once a month, and smaller adjustments like ownership changes, crop changes, etc. are updated on weekly basis (as soon as they are shared with us).

Our Software engineering team has also substantially grown over the past year allowing us for quick actions if any specific changes are required for the budget tables or other features.

- **Does the platform have the hold grower-uploaded, geotagged photos?**

In February 2025, after the launch of our new mobile App, we have enabled the possibility of adding geotagged photos via the mobile App. While this is more intended to work as Scouting notes for the farmers, field representatives etc. it can also be used to upload any pictures, for example flowmeter readings or other photos.

The geotagged photos will show on the mobile app as well as on the web portal.

- **Explain why your platform is the best.**

Our IrriWatch platform provides remotely sensed ET measurements stemming from 30+ years of global experience with different crops in more than 50 countries. A solid scientific knowledge is

behind our models along with continuous validation and improvement work. Despite all these years of experience, it is always challenging to have one universal model that works for all conditions. That is why Hydrosat has focused in the past year on building a strong science team that continue work on R&D and validation of our models in different conditions.

Any measurement method has its own level on inaccuracies, we believe measuring ET from remote sensing is the way forward, and with the advancement of technology and science, more accuracy will be achieved in the near-future due to higher spatial and temporal resolution of thermal imagery. That is why Hydrosat's vision is to invest more into building more thermal satellites that can help measure the precious resource, water.

So far, IrriWatch models have access to our privately owned satellite data from our satellites (Vanzyl-1 and Vanzyl-2) https://hydrosat.com/satellite-technology/ which allows us to reach more level of accuracy with our ET measurements.

In addition to the data, Hydrosat has invested into tailoring the portal to Madera County's GSA requirements to help them and their growers monitor their water allocation in near real-time. At the same time, it provides them the possibility of receiving daily irrigation advisory and crop monitoring features via the portal and mobile App.

8. **ET Data** :

- **Does your service calculate for ET? ETAW? If so, how does the calculation work (and why do you think it's the best). If not, where does the data come from?**

Hydrosat uses the latest generation of the surface energy balance algorithm for remote sensing (SEBAL 4.0, a proprietary version) to calculate ET from remote sensing every day. We use publicly available thermal (and multispectral) satellites along it own satellite constellation data (Vanzyl-1 and soon Vanzyl-2 data).

In addition to actual ET from SEBAL, we use the IDC model (a California DWR recommended model) to split ET into ETAW (ET from Applied Water) and ETPR (ET from precipitation P):

$ETAW = ET - ETPR$

and where $ETPR = \alpha P$

The ET is based on executing the propriety SEBAL model from Hydrosat. The source of P is the NWS weather grid. The empirical coefficient α is based on the IDC model from the California Department of Water Resources. The IDC model uses the P data as a source of input and then

computes storages available for ET based on P as being the single source of water resources. After a certain amount of days after the rainy season, this storage is vanished and α=0.

The IDC model was chosen because it was the official tool being available from the Department of Water Resources.

- **Can your firm's ET data be integrated into a groundwater accounting platform?**

Our data output are generated as geotiffs and field averages on daily basis and avaialble the next day. A sub-set of the data is available on our web portal; the full output are available via API in near-real time. Every morning the results until "yesterday" for every parcel-field, parcel and farm units will be available on the web portal as well as in the API.

- **Does your firm have the capability of providing ET data through an automated method (such as an API) to an accounting platform and at what frequency and with what delay factor?**

Our ET and ETAW data is available via API in near-real time. Every morning the results until "yesterday" of ET and ETAW for every parcel-field, parcel and farm units will be available on the web portal as well as in the API.

- **What is the expected accuracy of your calculation of ETAW, including its margin of error? Explain how the accuracy figure is calculated. Feel free to discuss "absolute accuracy" and accuracy relative to others. Quantify the improved accuracy.**

The accuracy of ET varies with:

· Different temporal integration

· Different spatial integration

· Different parameters involved (ET, P, α, ETAW)

ETAW = ET – ETPR and ETPR = α P

As mentioned previously, the ET is based on executing the propriety SEBAL model from Hydrosat. The source of P is the NWS weather grid. The empirical coefficient α is based on the IDC model from the California Department of Water Resources. The IDC model uses the P data as a source of input and then computes storages available for ET based on P as being the single source of water resources. After a certain amount of days after the rainy season, this storage is vanished and α=0.

The reason for selecting NWS weather grid was the erratic data series of CIMIS weather stations at the start of the project in 2020. The IDC model was chosen because it was the official tool being available from the Department of Water Resources.

The basis for accuracy assessment of ETAW is:

- Assess accuracy ET
- Assess accuracy P
- Assess accuracy α
- Combined error estimate

Field Measurement Technology	Location	Crop	Seasonal ET Deviation (%)
Water balance	Imperial Valley, CA	Alfalfa/Vegetables	1.0
Bowen ratio	Palo Verde, CA	Alfalfa	1.6
Lysimeter	Fresno (Parlier), CA	Peach Trees	6.9
Lysimeter	Bear River, ID	Forage grass	4.0
Lysimeter	Kimberly, ID	Sugarbeet	1.2
Soil water balance	Fresno, CA	Almonds	0.6
Surface renewal	Sac-San Joaquin Delta	Rice	5.1

Field Measurement Technology	Country	Land Use	Seasonal ET Deviation (%)
Catchment water balance	Sri Lanka	Mixed	1
Catchment water balance	Pakistan	Mixed	5
Catchment water balance	Australia	Mixed	1
Soil water balance	Philipines	Rice	10.5
Scintillometer	Sri Lanka	Coconut & rice	0.9
Scintillometer	Turkey	Grapes	5
Soil water balance	South Africa	Grapes	10.4
Eddy covariance	South Africa	Grapes	12
Surface renewal	South Africa	Sugarcane	5
Catchment water balance	South Sudan	Wetlands	1.5
Eddy covariance	Brazil	Mango & grapes	1
Catchment water balance	China	Mixed	5.6

P. Karimi and W. G. M. Bastiaanssen: Spatial evapotranspiration, rainfall and land use data – Part 1

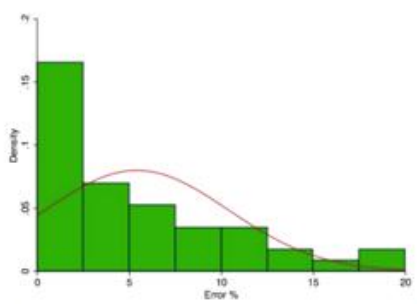

Figure 1. Probability density function of the reported mean absolute percentage error in remotely sensed ET estimates. A season or longer period was considered.

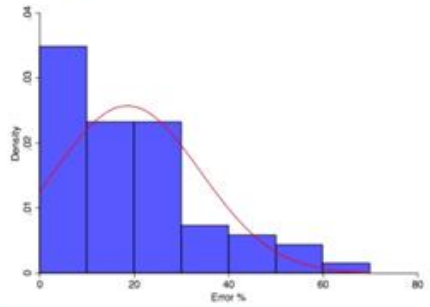

Figure 2. Probability density function of the reported mean absolute percentage error in rainfall estimates from remote sensing. A season or longer period is considered.

Water compliance monitoring should encompass longer periods of time. Growers will be evaluated on whether their seasonal total ETAW allocation is surpassed. Daily ET values have always more uncertainty, but this short time period can be disregarded. It is all about the accuracy of the accumulated ETAW across the season.

Field validations have demonstrate seasonal ET to have an uncertainty of 1 to 20%, but in most cases it is 5 or 6% (see tables and graphs above). The absolute ET value of the irrigated crops in Madera is approximately 900 mm/yr. This is confirmed from various type of ET field measurements executed in California including eddy covariance, lysimeter and surface renewal. It is also in line with various international ET validation studies. Again, in fact exceptions on ET accuracy can occur from a probability point of view, but for the majority of the cases, the relative error is 5% (being equivalent to an absolute error 45 mm/yr)

The accuracy of the gridded rainfall product is believed to have a substantial relative error (30%). Because the overall rainfall in Madera County is low (±200 mm/yr), the absolute rainfall values may have an error of 60 mm/yr, thus exceed the errors related to ET.

The conversion factor α from P to ETPR is believed to lay between 0.5 to 0.8 depending on the methodology chosen (USDA, USBR, CDWR). An average coefficient of 0.65 can be used. The IDC model may reach a good accuracy if it is calibrated and validated for rainfed cropping conditions. This was not accomplished for Madera County. We assume a relative error for α of 15%. For an annual rainfall of 200 mm/yr, this will be 30 mm/yr.

Hence, we have the following situation for irrigated crops in Madera:

- Average error ET ±45 mm/yr
- Average error ETPR ±30 mm/yr

These numbers representing an indication of the maximum boundaries of uncertainty. In reality these errors are much smaller because of the randomness of the errors of individual terms. A Monte Carlo simulation is needed to make assessment of the probability of these errors. It is expected that the average error of ETAW to be 5 to 10%.

- **What details can be shared on how the data is validated?**

We have added in the question above some references from publications about the validation of SEBAL model. Also several references were mentioned in our proposal. In addition to the published validation work, Hydrosat continues to work on validation with our current clients. We attach to this response a couple of our published validation books.

During the past year, following the merger of Hydrosat and IrriWatch, we have focused on growing our Science team that is focusing on R&D and validation. We currently have six dedicated scientists working on the SEBAL model validations and improvement. Part of this work is funded by the European Satellite Agency (ESA) and the Luxembourg Government especially under the Project HyWater. For this project, we started this year validations work in 3 sites where measurements of ET (using Eddy covariance towers), soil moisture, flowmeters etc. are taken. in 2026, the validation sites will increase to 10. Unfortunately, under this project, we cannot have Madera as a potential validation site however, we have validation site with similar climatic conditions and the results will be used for model continuous improvements.

Madera County has also published during the past couple years the results of the verification program https://www.maderacountywater.com/wp-content/uploads/2025/01/250127_VPP_Grower_Workshop.pdf.

Below are some additional links about our validations:

http://www.waterwatch.nl/en/tools0/sebal/validation.html
https://doi.org/10.1016/j.scitotenv.2025.178530
http://www.waterwatch.nl/tools0/sebal/sebal-a-scientific-description.html
https://doi.org/10.1016/j.rse.2018.12.033
https://doi.org/10.4060/cc8150en
Wageningen University Validation: https://edepot.wur.nl/564720

Kind Regards,
Hydrosat Team