WaterSENSE

Making SENSE of the water value chain in Australia

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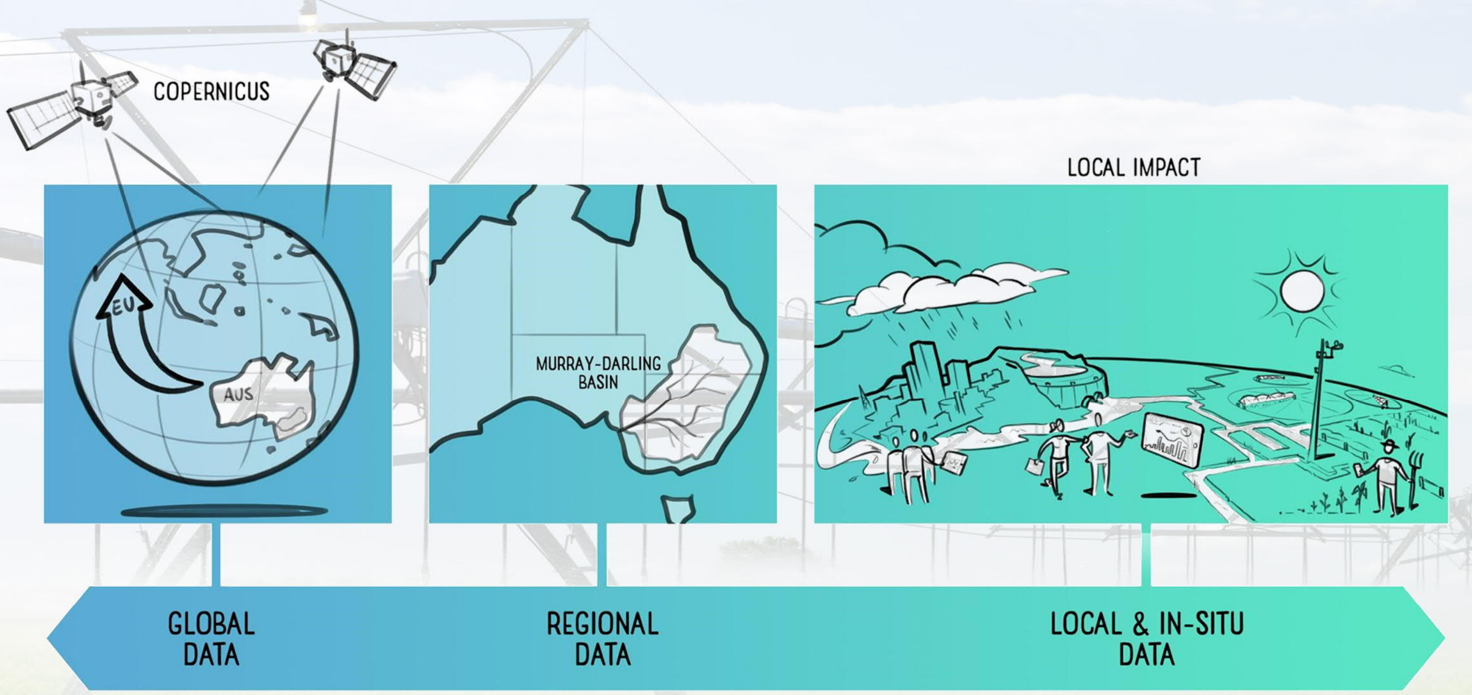
#MakingWaterSENSE

Newsletter 5 - September 2022



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This project has received funding from the Horizon 2020 research and innovation programme grant agreement No 870344

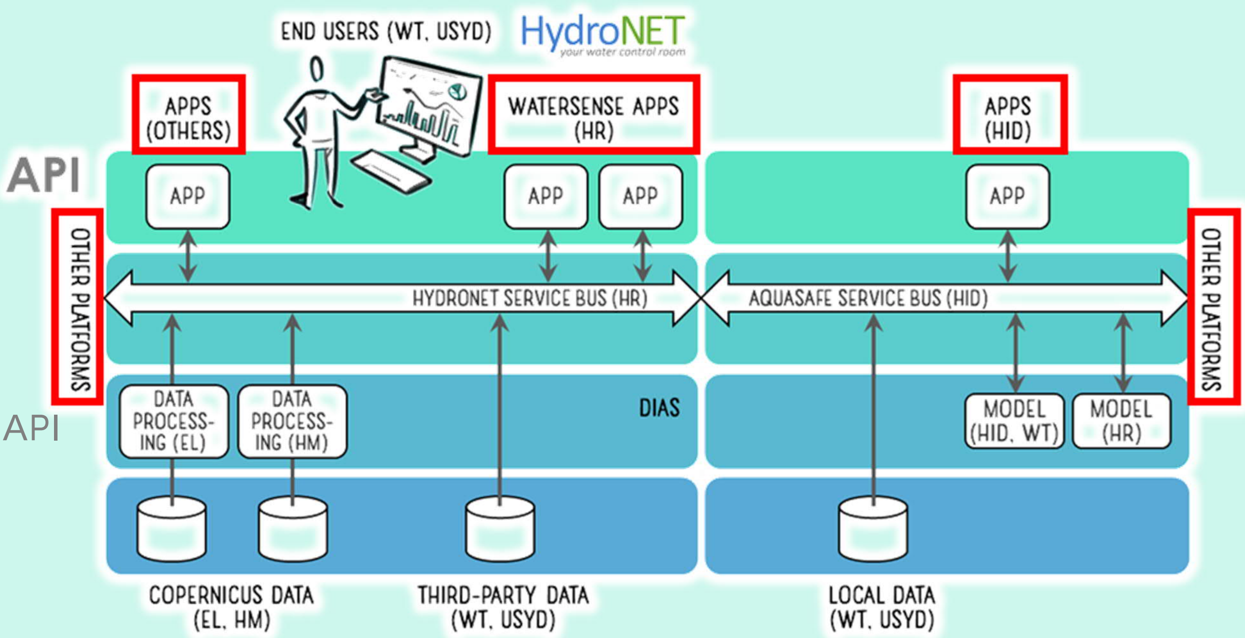
WaterSENSE

WaterSENSE Project Objectives

WaterSENSE is a research in action project under EU Grant agreement No.870344 within the DT-SPACE-06-EO-2019 call.

The WaterSENSE project aims to set up a water monitoring system and toolbox, as bulleted below, to provide water availability and mapping services and hassle free access to the information needed to support decisions, cooperate, share, collaborate and report for any place in the world at a different time and spatial resolutions, based on earth observation data, hydrological models and local field data. The toolbox concept of WaterSENSE is:

- Water Monitoring System: Modular, operational, water monitoring system: Integrates Copernicus EO data, ground radar, models, in-situ data, and novel research.
- Water Management Toolbox: Makes data, algorithms and services available to users. Various Apps provide reliable, actionable Information.
- Flexible Service Subscription models.
- Flexible Front Ends.



- Open Algorithms
- Independent
- Value Added Services
- Scalable data (sub field to Global)
- Scalable processing
- Operational (automated processing facility)
- Supported and maintained

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WaterSENSE consortium members

WaterSENSE is a collaborative solution between the consortium partners connecting platforms through service buses using open standards. The WaterSENSE consortium consists of 7 partners: eLEAF BV (Netherlands), Hydrologic Research (Netherlands), Water Technology (Australia), Hidromod (Portugal), hydro & meteo (Germany), the University of Sydney (Australia) and HCP International (Netherlands).

Consortium visit to Australia

Figure 1: WaterSENSE Consoprtium workshop with NSW DPI at the offices of the Australian Cotton Research Institute in Narrabri.

After a long wait, representatives of the European partners from the WaterSENSE consortium visited Australia. It was a fantastic opportunity for the consortium members to meet face to face rather than via digital platforms. Even better was the opportunity to sit down with many of our demonstration partners and receive feedback on the progress we have made in research and service development. These meetings also offered the opportunity to meet other interested parties from the water and agriculture sector. Presentations of WaterSense research and data products were combined with live demonstrations of the HydroNET platform through which the service will be made available. We were

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encouraged by the enthusiasm of many of the people we met; and we received some very constructive and positive feedback on the products and the research.

For the European representatives, it was also a great opportunity to experience the scale and complexity of the Australian landscape. In addition, several of our demonstration partners organised field visits that showcased the innovations they are working on and gave insight how WaterSENSE products can fit into the management and decision making. Overall, the WaterSENSE consortium believes we are on track, but also look forward to continuing the discussions with the demonstration partners and other interested parties to further develop the products.

Figure 2: WaterSENSE Consoprtium visit to the cotton fields of AFF near Narrabri.

Apart from the work visits, there was also time for the European partners to experience some of the quintessential Australian past-times: going to the beach, footy, having dinner in a country pub, seeing Emus on the farm.

Research and Services Updates

Updated Workflow for ETLook and HSP Algorithms

eLEAF has published their irrigation quantification algorithms in the Agricultural Water Management journal earlier this year. Despite the proven potential of the published models, some issues still needed to be addressed to improve scalability. eLEAF has been working on these improvements over the last couple of months.

Previous workflow Limitations:

The previous workflow relied heavily on static third-party land cover maps to distinguish natural vegetation from irrigated agriculture. The static nature of these maps hampered the scalability, because agricultural systems are not stable over time in terms of crop type selection and irrigation practices.

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In addition, because we only calculated the water use for areas which were classified as irrigated agriculture by the land cover map, irrigation at sites which were not recorded by the land cover map were missed. This proved to be a critical issue for (governmental) clients since they are also interested in the detection of potential illegal irrigation practices.

New Workflow

Therefore, instead of only calculating the water use for irrigated agriculture classes, all agricultural classes are now processed. This results in a ten times larger potential delivery area, as shown in Fig 3 below.

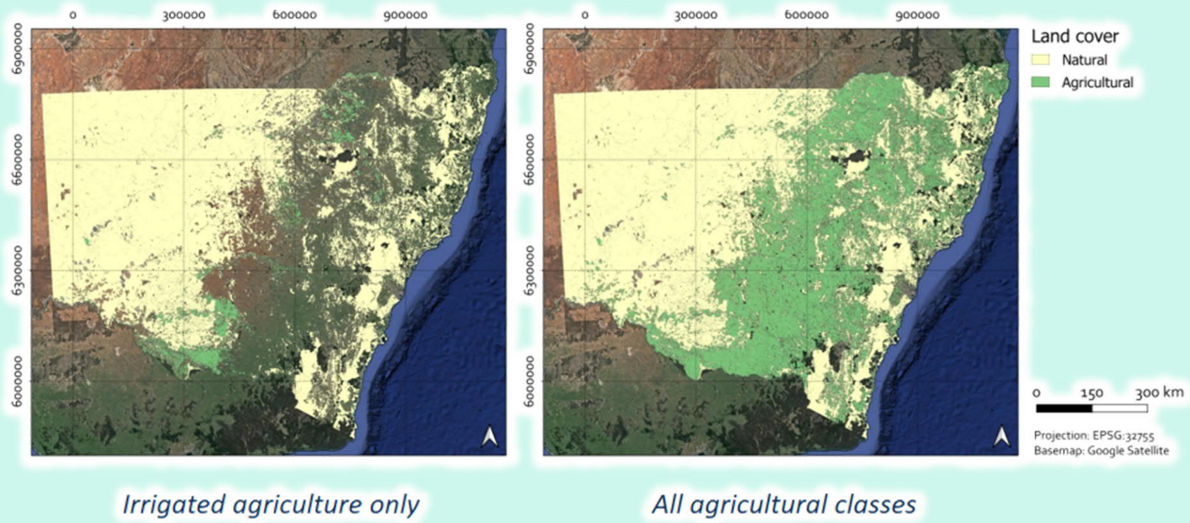

Figure 3: Significantly larger area for which irrigated water use can be estimated in the new ETLook and HSP workflow

This had a negative effect on the processing time of the algorithm. To increase the computational efficiency of the model, natural pixels are no longer compared at their native resolution, but are now segmented into blocks of multiple pixels. For these blocks the average values of all the period and static inputs are calculated and fed into the HSP algorithm. This way, the algorithm only needs to check the mean attributes of the blocks for similarity. This segmentation did not only increase the computational performance of the model, but also enabled a drastic increase in the search area, therefore making the model more stable and less vulnerable to local extremes.

ETinc and Automated Irrigated Area Detection

With these adaptations of the HSP model above in place, eLEAF has started testing its capabilities for detecting irrigated areas. As a test case, we selected multiple training points of fields that were and were not being irrigated in the 2020-2021 season. Since the output of the model is an estimate of the irrigated water use, one year of outputs was deemed to be sufficient to generate accurate irrigated area maps for areas with multiple crop types and growing seasons.

For these sample points some simple statistical metrics were calculated based upon the water use estimates (ETinc[1]). These metrics were the mean, maximum, minimum, and standard deviation of the incremental evapotranspiration (ETinc), the duration of a positive incremental evapotranspiration, and

[1] ETinc is the estimated ET due to irrigation only, and it is calculated using eLEAF's ETLook and HSP Algorithms. It is calculated by subtracting the weighted $ET_{act,nat}$ from the $ET_{act,irr}$ using the HSP algorithm. $ET_{act,nat}$ is the actual ET from surrounding natural vegetation and $ET_{act,irr}$ is the actual ET from the irrigated pixel. ET_{act} is calculated with the ETLook algorithm, while the weighted $ET_{act,nat}$ and ETinc are calculated with the HSP algorithm.

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the timing of the maximum incremental evapotranspiration. With these metrics a simple random forest model was trained. The feature importance of each of these metrics was then evaluated and finally, the trained model was used to compute annual irrigated area maps for different years (2017-2020). The feature importance metrics showed that, for this trained model, the standard deviation and maximum of ETinc explained 62.4% and 30.5% of the outputs, indicating that the data itself is able to accurately estimate the irrigated area without adding any auxiliary dataset, such as the more general satellite based indices such as NDVI and NDWI for example. Figures 4 to 6 illustrate this by comparing the training locations for the random forest model to NDVI, ETact and eLEAF's ETinc respectively. Figure 4 clearly shows that NDVI is poorly suited to differentiating irrigation from rainfed lands. Figure 5 shows that ETact is also poorly suited, as it does not cater very well for arid vs wet regions. Figure 6 demonstrates that ETinc is significantly more appropriate for detecting irrigated lands.

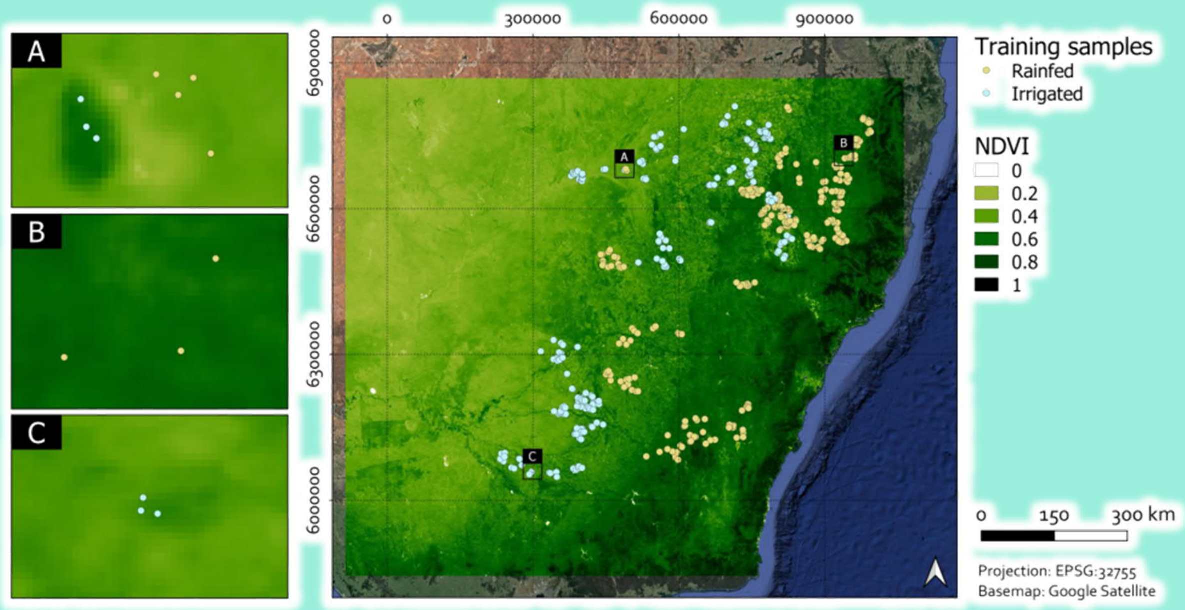

Figure 4: Training samples vs NDVI. Sites A and B show similar NDVI for training samples that are irrigated and rainfed.

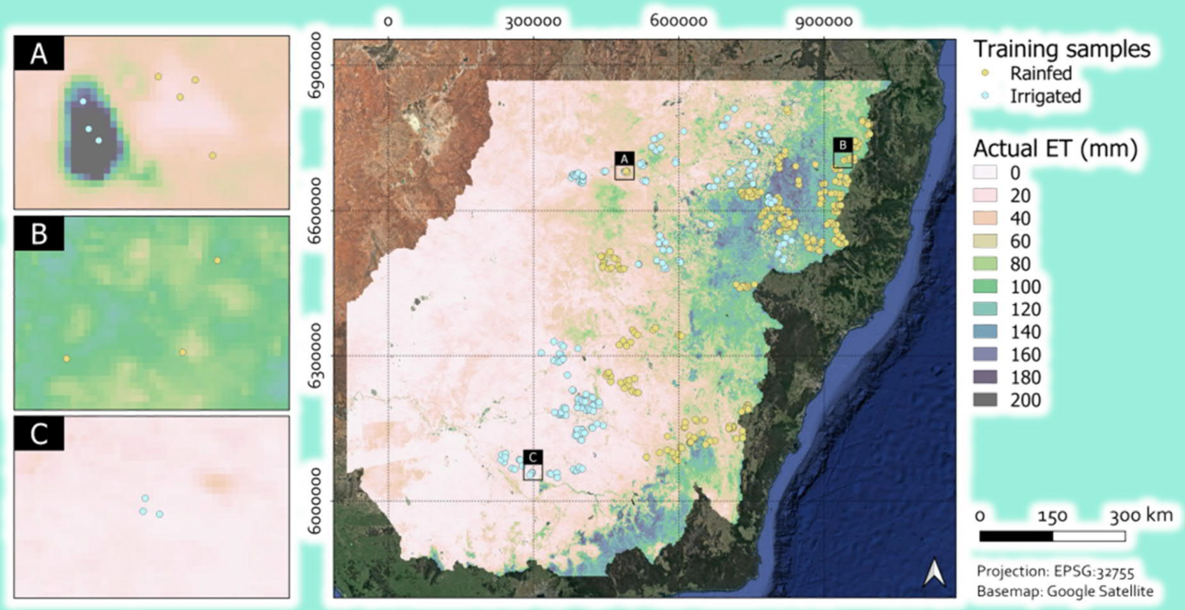

Figure 5: Training samples vs ETact. Site B shows significantly higher ET for rainfed training samples compared to site C, where the samples are for irrigated lands. Etact does not cater for arid vs wet region differentiation.

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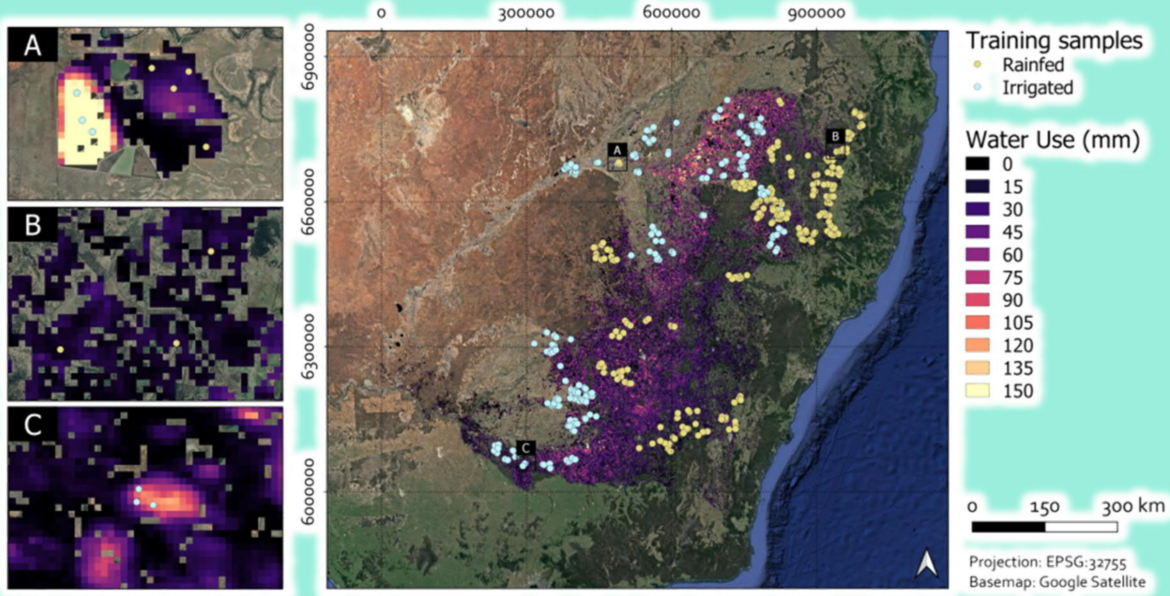

Figure 6: Training samples vs ETinc. ETinc is able to discern irrigated training samples from rainfed training samples across all sites.

The initial model results showed an F1-score and overall accuracy of 0.935 and 0.938, respectively, which is excellent.

True Positive (TP) 91 56.7%	False Negative (FN) 2 1.3%
False Positive (FP) 8 5.0%	True Negative (TN) 59 36.9%

Figure 7 below shows some initial irrigated area results:

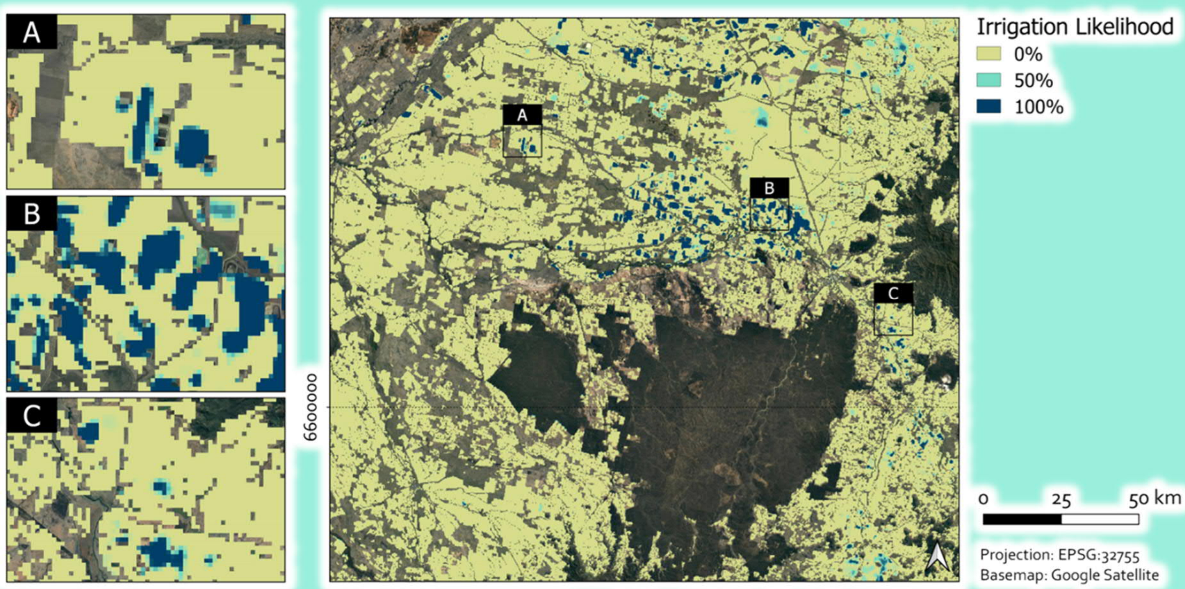

Figure 7: Irrigated area classification for the 2019-2020 season based upon a simple random forest model trained on the 2020-2021 season, using remote sensing based irrigated water use estimates only.

Applying this model to the seasons from 2017-18 up to 2019-20 has revealed some interesting information. Firstly, significantly less irrigation was detected compared to the training season (2020-

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2021). Secondly, different fields were irrigated throughout the 3 year period, showing variability of irrigation over time. Few fields are being constantly irrigated.

This demonstrates that static irrigated land cover maps are quickly outdated, and the need for dynamic irrigated area maps.

Significant irrigation was detected outside properties with authorised water use, highlighting possible unauthorised irrigation?

Lastly, low resolution irrigated area maps (250 m) from this model could be used for generating high resolution (10 m) water use estimates, as shown in fig 8 below.

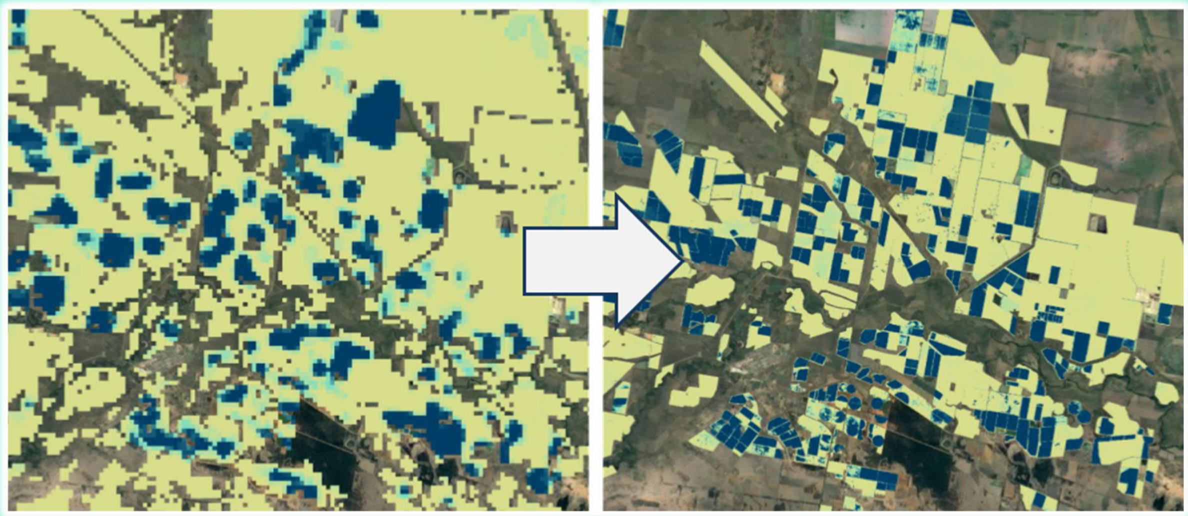

Figure8: low resulotion irrigated area maps could be used for generating high resolution water use estimates.

More training/validation data is necessary to derive more accurate decision trees for standardised irrigated area mapping.

Webinar

We have presented these efforts during the 5th WaterSENSE webinar (https://lnkd.in/epbhvxKp).

Open Water Detection and "growing" detected pixels under the trees

An extension of the open water detection algorithm for wetlands and riverine areas is currently being developed. In particular, the algorithm development focuses on solving identified problems with clouds, vegetation and coloured water interference in the open water detection (Fig 9) as well as the detection of surface water under vegetation (Fig 10).

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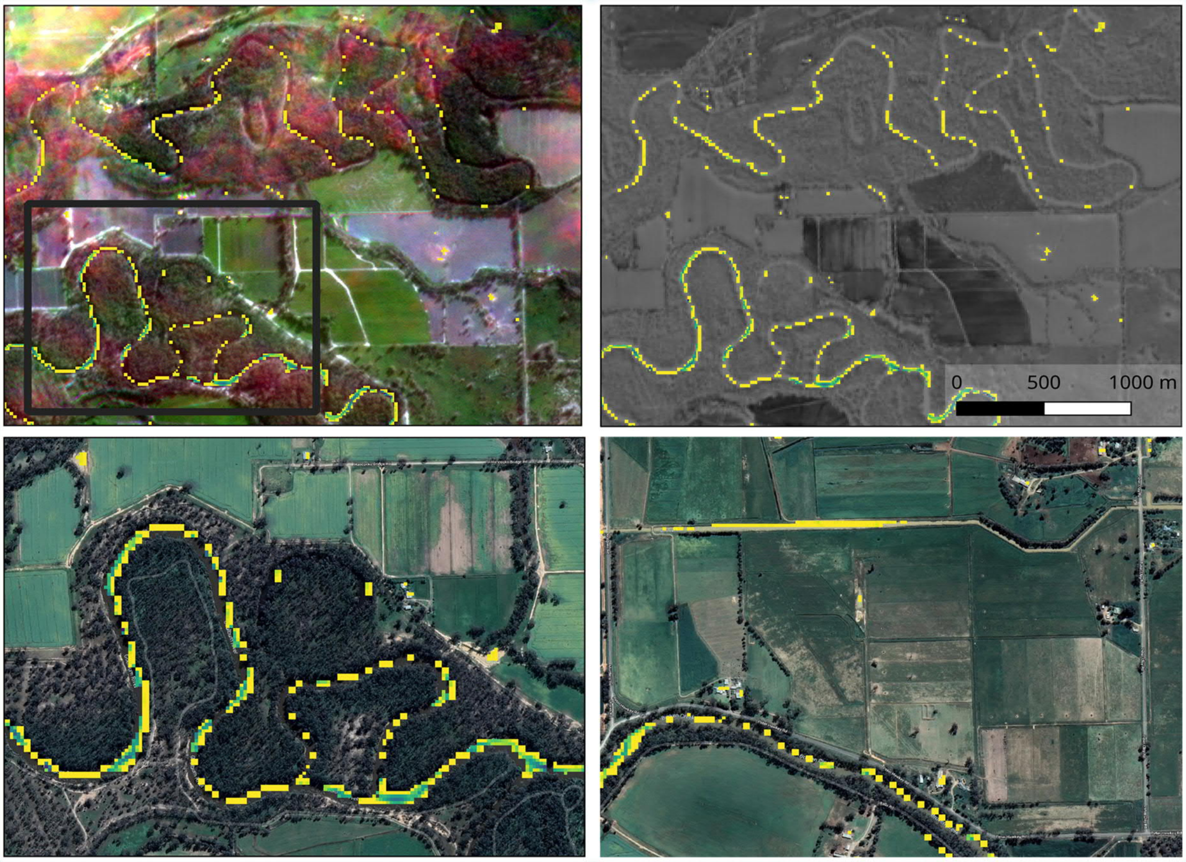

Figure 9: Identified problems with clouds, vegetation and coloured water interference.

The novel algorithm uses the digital elevation model to "grow" satellite-identified water patches to be hydrologically sensible and connected (Fig 10). This work was recently presented by the USYD WaterSENSE partner at the international Environmental Modelling and Software Society meeting in Brussels (July 2022). This algorithm will be further verified and completed by December 2022.

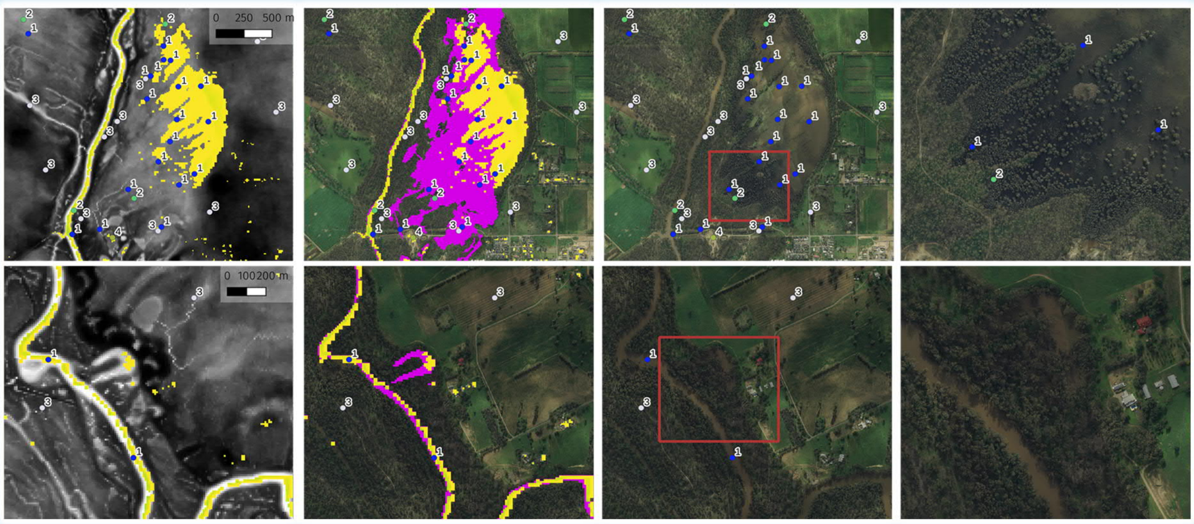

Figure 10: Satellite-identified wateralgorithm output in yellow. Gemorphib approach to "grow these pixels to hydrologically sensible and connected areas in violet.

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Vegetation Condition Parameters

To ecologically and sustainably manage wetlands, we aim to provide timely information from remote sensing data and algorithms on the extent, health and water-use of wetland vegetation to stakeholders involved.

One of the parameters we are exploring is the Biomass Production Condition (BPC) Score. This indicator tells us how the biomass production of an individual pixel is changing over time. It answers the questions below:

- How the vegetation condition of each pixel is changing independent of its performance in relation to other pixels in the AOI.
- What are the areas most affected by droughts, flow reduction or other human activities, over a longer period.

Figure 8 below shows some initial results in the Barmah Forest, Australia. It highlights how rapidly vegetation condition has changed from very high in October 2017 (in green) to very low in October 2021 (in red). The average biomass condition deteriorated from 82% in 2017 to 29% in 2021. How much flora and fauna would have been affected or lost? Can we prevent further deterioration? Can we mitigate the significant impact the drought has had through alternative management practices? Under the WaterSENSE project, together with Goulburn Broken Catchment Management Authority, we will explore this further.

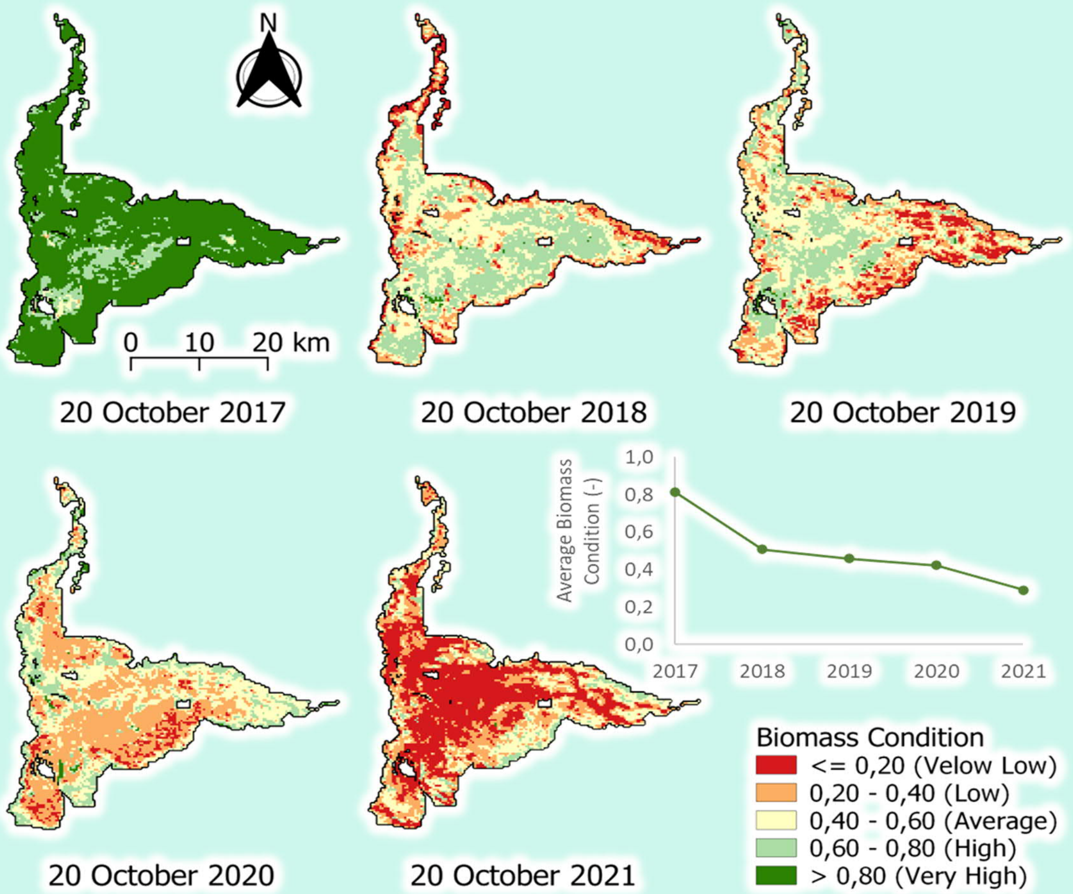

Figure 8: Biomass condition maps and graph show the deterioration of the vegetation condition from 2017 to 2021. Legend Explanation: Biomass condition represents a measure of plant production at a scale from 0 'the lowest' to 1.0 'the highest' in relation to reference (optimal) plant production.

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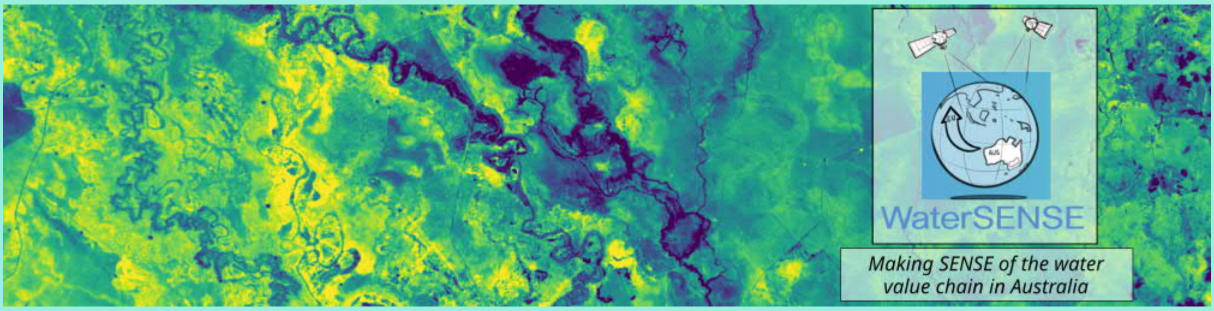
2nd WaterSENSE Summer School



What was planned

The second WaterSENSE Summer School was held online and at the University of Sydney from 23 to 25 February 2022. We advertised the workshop via Twitter and LinkedIn and through the University of Sydney and Water Technology networks.

WaterSense Summer School Program:

Day	Session		Activity	Who
1	Morning	9:00-10:00 10:00- 12:00	Introduction to the summer school and the partners Small start-up exercises using available data sets and platforms + set up	WaterSENSE consortium The University of Sydney
	Afternoon	2:00 – 3:30 3:30- 5:00	Rainfall advection correction of precipitation using Scout View Accessing data: Hydronet API to access rainfall fields.	Hydro & Meteo GmbH Water Technology Ltd / Hydrologic
2	Morning	9:00-10:30 10:30-12:00	Irrigation water use Worked Example with the Water Use Monitoring and Auditing Service (WUMAS)	eLEAF Water Technology Ltd
	Afternoon	2:00 – 3:30 3:30- 5:00	Flood mapping in wetlands (ODC/Digital Earth Australia) Irrigated area detection / Automated irrigated land use detection	The University of Sydney eLEAF
3	Morning	9:00-10:30 10:30-12:00	Crop type detection Farm dams: Water depth & volume in reservoirs	HIDROMOD The University of Sydney
	Afternoon	2:00 – 3:30	Wrap-up	WaterSENSE consortium

During the summer school, we covered the following WaterSENSE research topics with real world data:

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- Rainfall advection correction of precipitation using Scout View
- Accessing data: Hydronet API to access rainfall fields
- Irrigation water use estimation from RS data
- The WaterSENSE Water Use Monitoring and Auditing Service (WUMAS)
- Automated irrigated land use detection
- Crop type detection
- Flood mapping in wetlands
- Farm dams: Water depth & volume in reservoirs

We worked with an application platform that can be used for climate smart water management: a) Introduction into the HydroNET platform for data management; b) Remote sensing information via different platforms, such as Digital Earth Australia, Google Earth Engine (GEE) and the Hydronet API and platform; c) scripting and associated tools for collaboration with Jupiter Notebooks.

We asked all applicants to fill in an expression of interest we asked for a short CV and a rationale why they wanted to attend the summer school.

How it went

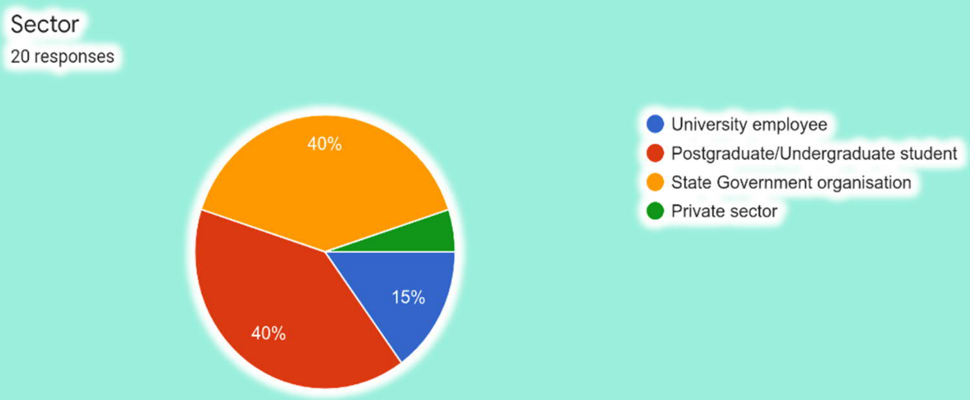

Figure 9: Overview of the backgrounds of the summer school attendees

We had 20 expressions of interests. Most of the participants were from a professional background, with the majority being employed by the state government (See figure 9 below), and mostly associated with the water sector. The skillset of attended is indicated in Figure 10.

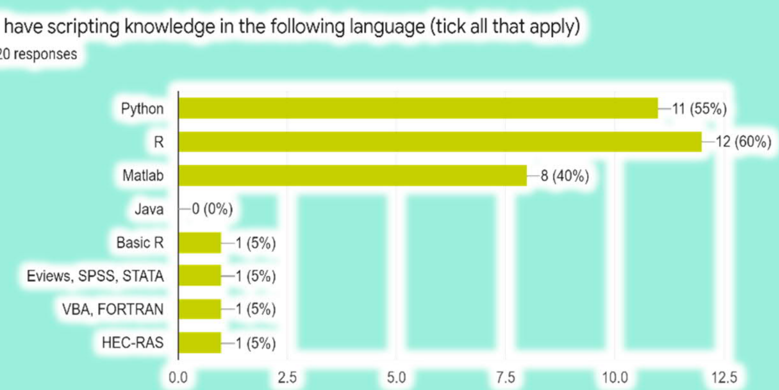

Figure 10: overview of the attendees previous scripting knowledge.

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During the workshop (see attached program), a combination of 'show and tell' and hands-on activities were presented by consortium members: WaterTechnology Pty Ltd, Hydrologic BV, eLeaf BV, HidroMOD and the University of Sydney.

Most of the attendees had scripting knowledge so they could follow and participate in the hands-on activities.

What went better than expected

Overall, the Summer School was a greater success than we expected. We received good feedback and participants were generally happy with the overall structure and delivery. It all worked very well and much better than expected. This is also a tribute to the amount of work put in by the individuals who delivered the teaching from WT, HL, eLEAF. Hidromod and the University of Sydney.

Verbal feedback was that all students liked the course and learned a lot. The variety of topics offered helped in moving the course along and gave nice hands-on experience.

Technology wise the delivery went very well

1. All on-line presenters connected and interacted easily and we had no connection issues
2. Google colabs, and Jupyter notebooks worked well, as well as the API query software. There were no problems with software installation or access to data and notebooks
3. Sound and vision worked well, and we had sufficient interactions with students

Research Update

List of Publications

Please find a list of published papers from WaterSENSE below:

- Ignacio Fuentes, Richard Scalzo, R. Willem Vervoort. Volume and uncertainty estimates of on-farm reservoirs using surface reflectance and LiDAR data. Environmental Modelling & Software, Volume 143, 2021, 105095. ISSN 1364-8152. https://doi.org/10.1016/j.envsoft.2021.105095. (https://www.sciencedirect.com/science/article/pii/S1364815221001389)
- Strehz, Alexander, and Thomas Einfalt. 2021. "Precipitation Data Retrieval and Quality Assurance from Different Data Sources for the Namoi Catchment in Australia" Geomatics 1, no. 4: 417-428. https://doi.org/10.3390/geomatics1040024T. Download here.
- Einfalt, P. Chambel Leitão, R. Dost, B. Jackson, A. Lobbrecht, M. Noort & R. W. Verwoort. Precipitation Data in Real-Time for Multiple Scale Applications in Australia. 15th International Conference on Urban Drainage, Melbourne, September 2020. YouTube Video.
- R. Willem Vervoort, Ignacio Fuentes, Joost Brombacher, Jelle Degen, Pedro Chambel-Leitão, and Flávio Santos. Progress in detailed water productivity analysis at global locations.
- Ignacio Fuentes, Jos´e Padarian, R. Willem Vervoort. Towards near real-time national-scale soil water content monitoring using 2 data fusion as a downscaling alternative.

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- Brombacher, J., Silva, I., Degen, J., Pelgrum, H., 2022. A Novel Evapotranspiration Based Irrigation Quantification Method Using the Hydrological Similar Pixels Algorithm. Submitted to Agricultural Water Management

Other relevant papers by consortium members:

- Fuentes, Ignacio & Padarian, José & Van Ogtrop, Floris & Vervoort, Rutger Willem. (2019). Spatiotemporal evaluation of inundated areas using MODIS imagery at a catchment scale. Journal of Hydrology. 573. 10.1016/j.jhydrol.2019.03.103.
- HydroNET SCOUT:
  - Jasper-Tönnies, A., Hellmers, S., Einfalt, T., Strehz, A., Fröhle, P. (2018) Ensembles of radar nowcasts and COSMO-DE-EPS for urban flood management, Water Science and Technology, DOI: 10.2166/wst.2018.079
  - Einfalt, T., Lürs, S., Grottker, M., Schäfers, B., Schlauss, S., Frerk, I. (2015): Flash flood warning for emergency management. 10th International Workshop on Precipitation in Urban Areas, 1-5 December 2015, Pontresina.
  - Einfalt, T., Lobbrecht, A., Leung, K., Lempio, G. (2013) Preparation and evaluation of a Dutch-German radar composite to enhance precipitation information in border areas, Journal of Hydrologic Engineering – ASCE, DOI:10.1061/(ASCE)HE.1943-5584.0000649.
  - Lobbrecht, A., Einfalt, T., Reichard, L., Poortinga, I. (2012) Decision support for urban drainage using radar data of HydroNET-SCOUT. IAHS Publ. 351, p.626 - 631.

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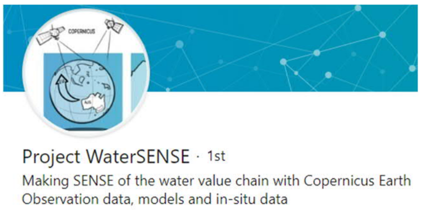

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