EGU General Assembly

14-19 Sep. 2024
EGU24-13495

Event-based groundwater recharge: drip observations reach new depths in mine tunnels

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- Australia's **National Groundwater Recharge Observing System,** established in 2022**,** provides the first dedicated sensor network for observing the recharge of groundwater at an event-scale across a wide range of geologies, environments, and climate types that represent a wide range of Australian hydroclimates (Fig. 1).
- Capturing recharge accurately is widely acknowledged to be a major challenge. It is of fundamental importance to understand when and why groundwater recharge occurs for the sustainable use of this essential freshwater resource for humans and ecosystems. The network of hydrological sensors can help measure groundwater recharge as it is occurring. This is possible by utilizing a sensor deployed in underground spaces located in the vadose zone (Figs. 2, 3). Through measurements of water percolating into these spaces from above, the potential groundwater recharge processes are observed.
- **Methods** - The use of automated sensors determines precisely when recharge occurs (e.g., event, month, or season, and the climate conditions). Combined with daily rainfall data, it is possible to quantify the 'rainfall recharge threshold', the amount of rainfall needed to generate groundwater recharge, and its temporal and spatial variability (Fig. 4, 5). ***Tunnels, mines, caves and other subsurface spaces*** located in the vadose zone house the sensors that effectively record 'deep drainage'- water that can move beyond the shallow subsurface and root zone to generate groundwater recharge. The network has the ***temporal resolution to capture individual recharge events***, with multiple sensors deployed at each site to constrain the heterogeneity of recharge between different flow paths, and to quantify (including uncertainty bounds) rainfall recharge thresholds.
- The data presented here is the ***first time that drip sensors have been used at more than 100 m below ground*** to monitor changes in inflow. Average annual rainfall for the two gold mines in South-east Australia varied from <500 mm at Stawell mine to >1200 mm per annum near Walhalla mine. At the Walhalla gold mine, distinct recharge pathways including fracture zones around quartzite intrusions were evident. At the Stawell mine, there were limited fracture zones evident in the roof of the tunnel where the sensors were deployed.

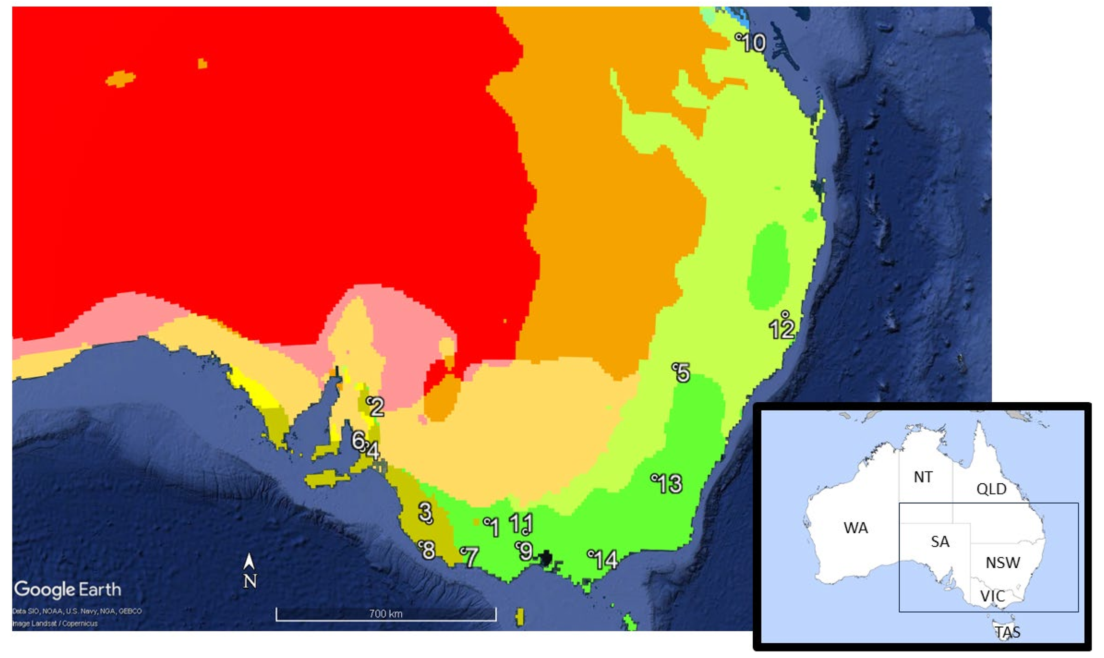


Fig. 1. The location of the initial sites for drip sensors in the NGROS network. Scan the QR code for more information about the sites.

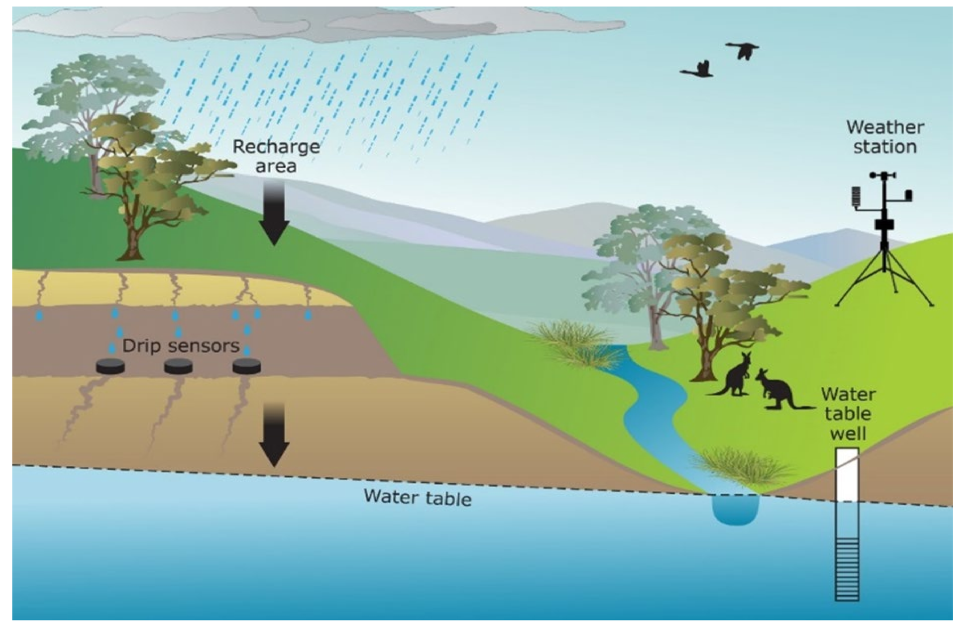


Fig. 2. We have placed these sensors in tunnels, mines and other subsurface spaces to measure recharge over time and space and utilise locally available rainfall data to calculate "event-based" recharge following rainfall.

Fig. 3. Photos of Walhalla gold mine emergency exit tunnel with drip sensors at regular intervals & overburden depth from <10 m to >70 m. The sensors (INSET) are on the floor recording water dripping from the mine roof.

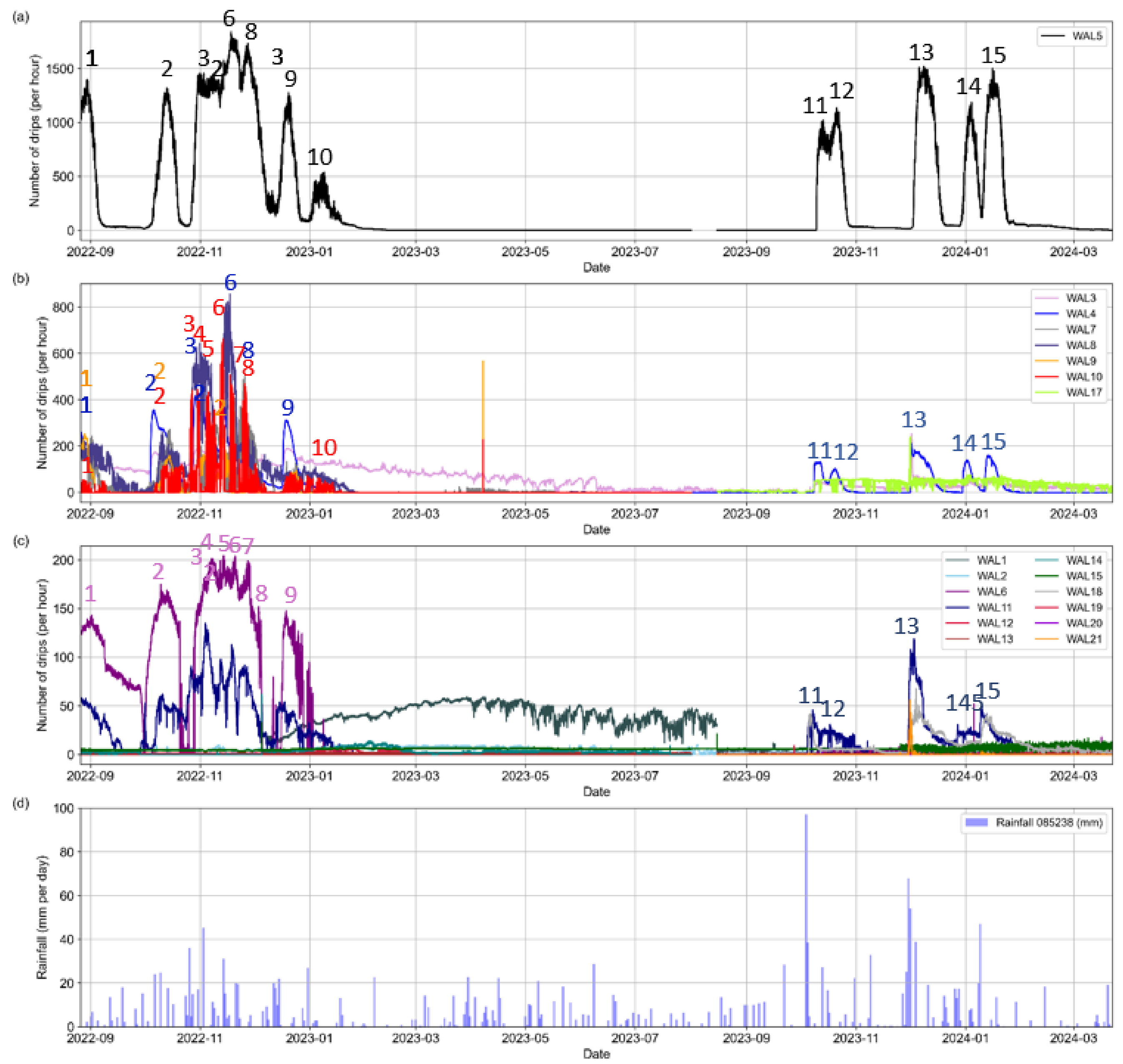


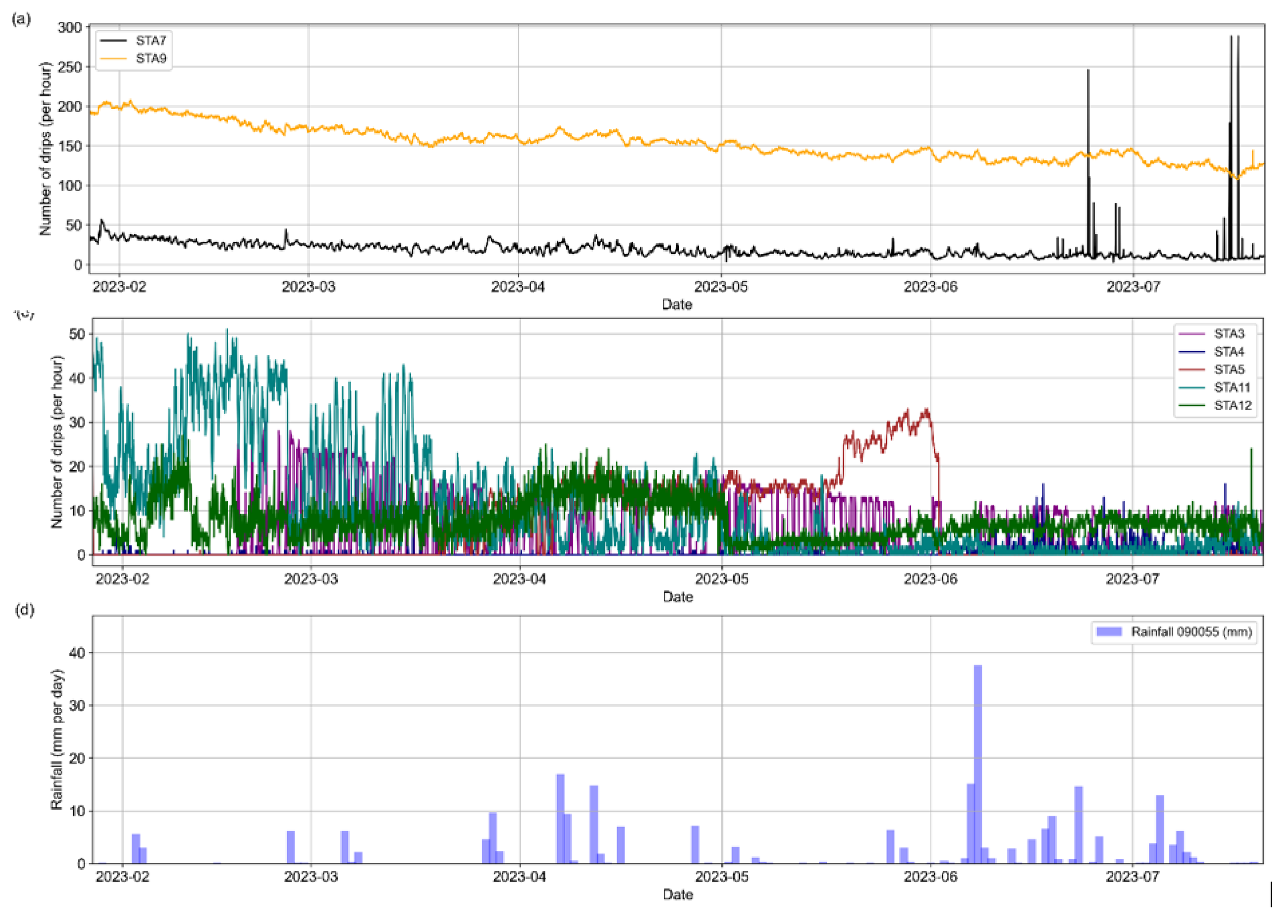
Fig. 4. Drip results at the Walhalla gold mine: fifteen (15) recharge events were observed between September 2022 to March 2024. Drip logger responses are highest for group a) at 1500 per hour and lowest for group c), correlating with daily rainfall shown in d).

Preferential flow/recharge after at least **5-10 mm in 48 hours of rainfall** was observed at some locations.

Following a dry summer (Event 11)

~40-50 mm in 96 hours of rainfall was required for recharge/ preferential flow.

Fig. 5. Drip results at the Stawell gold mine: at 115 m below ground the drip counts were relatively low (<300 per hour) from January to July 2023 and complex variability. Data analysis indicates confined conditions and dampened response to rainfall events.



We gratefully acknowledge support for data collection provided by: Sirjana Adhikari and Deakin University, Beth Askew and Stawell Gold Mine personnel, Rob Gaulton and Walhalla Long Tunnel Extended Gold Mine tour guides. Rainfall data was sourced from the Bureau of Meteorology.

Timms et al 2024. Abstract EGU24-13495 : https://meetingorganizer.copernicus.org/EGU24/EGU24-13495.html
Baker et al 2023. A pre-print is here: https://egusphere.copernicus.org/preprints/2023/egusphere-2023-2053