# Data Assimilation of P-band Microwaves to Improve Root Zone Soil Moisture Prediction and Monitoring

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## 1. Introduction

An accurate knowledge of the deeper soil moisture profile potentially allows for greater revegetation efficiency during mine rehabilitation. Observations of soil moisture are limited to indirect measurements, from either meteorological stations or remote sensing. Current satellite soil moisture observations only provide information on the top 5cm layer from passive microwave sensors operating at L-band [1]. By using P-band microwaves, which have a longer wavelength, moisture information up to 15-30cm into the soil can be retrieved. The hypothesis is there will be an improvement in soil moisture estimation when using P-band compared to existing L-band technology. This may be useful for water management in mine rehabilitation.

**This study aims to assess how assimilating 30cm of synthetic P-band soil moisture may improve root zone soil moisture prediction.**

## 2. Study Site and Method

- The site is at 'S2' on UON's SASMAS experimental catchment located in the Upper Hunter region near Merriwa, NSW [2]. Shown in Figure 1.
- In-situ soil moisture data is collected at intervals of 0-5cm, 0-30cm, 30-60cm and 60-90cm by monitoring devices as shown in Figure 2.
- Modeling is performed using the CSIRO's Community Atmosphere Biosphere Land Exchange (CABLE) land surface model running daily during 2007.
- A synthetic soil moisture data set created from in-situ measurements is assimilated into CABLE via an Ensemble Kalman Filter (EnKF) every two days.
- Model soil moisture outputs have been compared against in-situ values via Nash Sutcliffe Efficiencies (NSE) and Root Mean Square Errors (RMSE).

Figure 2. Soil moisture monitoring device on the SAMAS catchment

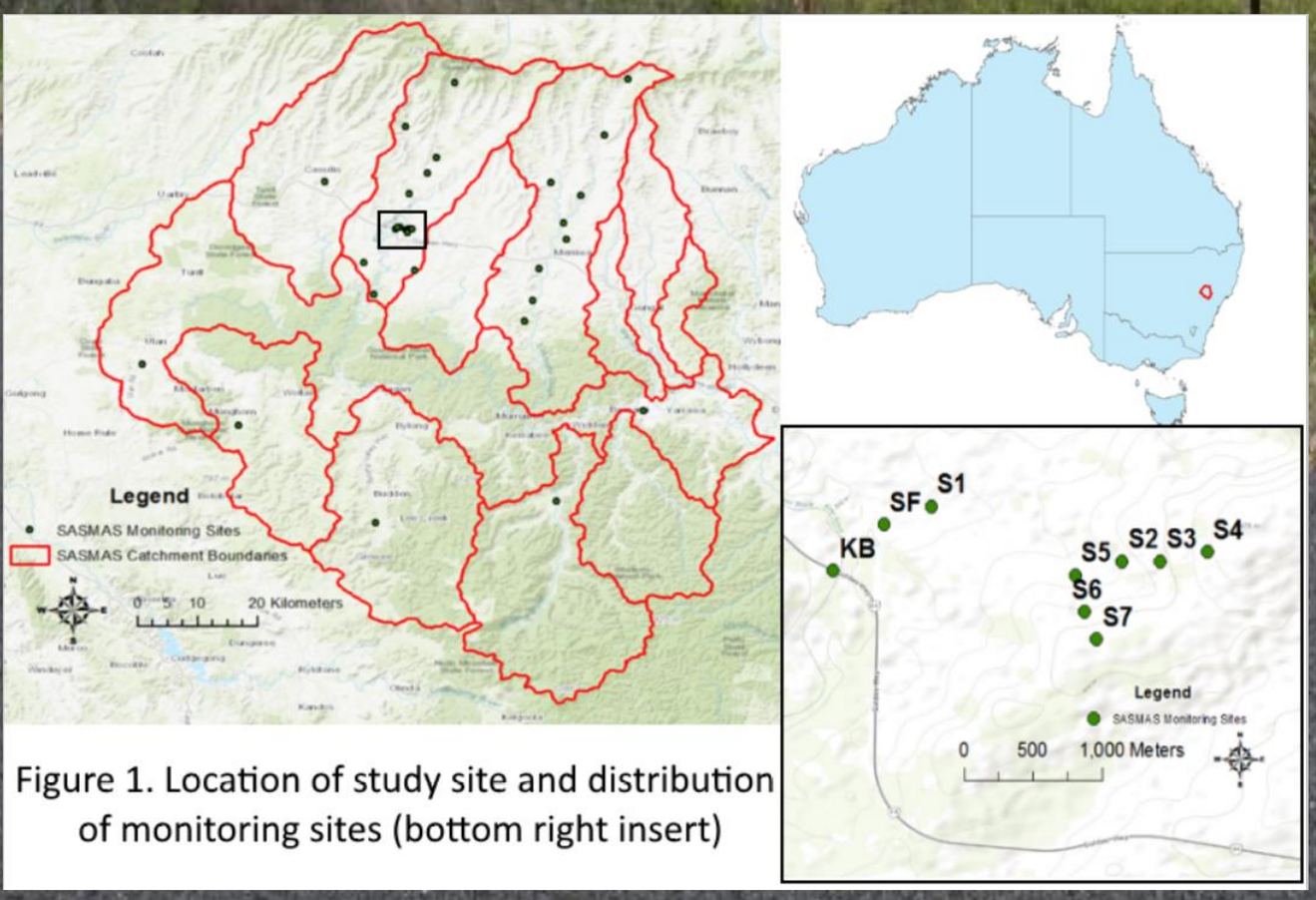


Figure 1. Location of study site and distribution of monitoring sites (bottom right insert)

## 3. Modelling Results

- The NSE and RMSE values indicate that CABLE is performing well without data assimilation (**Open EnKF**). CABLE with assimilated synthetic P-band microwaves improved the top soil and the root zone soil moisture predictions.
- The EnKF was set up so the number of ensembles were kept at 50 (n=50) and the introduced synthetic error kept at 10% (R=0.1).
- The magnitude of the perturbed meteorological variables have been altered by 1%, 5%, 10% and 20% for each model run (**indicated by p=0.01, 0.05, 0.1, 0.2**) .
- The results are shown in Table 1 and time series graphs for the three layers over 2007 are shown below.

Table 1. NSE and RMSE results from synthetic P-band assimilation

| | Depth (cm) | Open EnKF | p=0.01 | p=0.05 | p=0.1 | p=0.2 |
|---|---|---|---|---|---|---|
| NSE | 0-30 | 0.721 | 0.727 | 0.853 | 0.853 | 0.832 |
| | 30-60 | 0.422 | 0.474 | 0.249 | 0.120 | -0.194 |
| | 60-90 | 0.239 | 0.128 | 0.471 | 0.329 | 0.446 |
| | Average | 0.461 | 0.443 | 0.524 | 0.434 | 0.361 |
| | **Depth (cm)** | **Open EnKF** | **p=0.01** | **p=0.05** | **p=0.1** | **p=0.2** |
| RMSE ($m^3/m^3$) | 0-30 | 0.058 | 0.058 | 0.042 | 0.042 | 0.042 |
| | 30-60 | 0.075 | 0.071 | 0.085 | 0.092 | 0.092 |
| | 60-90 | 0.072 | 0.077 | 0.060 | 0.067 | 0.067 |
| | Average | 0.068 | 0.069 | 0.062 | 0.067 | 0.067 |


## 4. Discussion and Conclusion

This study demonstrates the potential use of P-band microwaves for measuring soil moisture by remote sensing. Future work includes comparing these results against L-band assimilation results. The improvement seen shows a potential use for monitoring and estimating root zone soil moisture to aid in scheduling revegetation work and potential irrigation events.

**References**

*[1] De Lannoy, G. J. M., et al. (2015). Handbook of Hydrometeorological Ensemble Forecasting. Soil Moisture Data Assimilation. Berlin, Springer-Verlag: 1-43.*
*[2] Rüdiger, C., et al. (2007). "Goulburn River experimental catchment data set." Water Resources Research **43**(10).*
Photos courtesy of Greg Hancock.