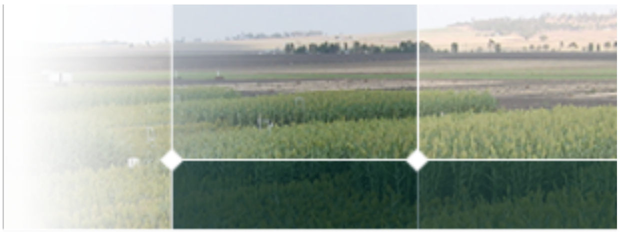


# 1 SoilWater

The SoilWater module is a cascading water balance model that owes much to its precursors in CERES (Jones and Kiniry, 1986) and PERFECT(Littleboy et al, 1992). The algorithms for redistribution of water throughout the soil profile have been inherited from the CERES family of models.

The water characteristics of the soil are specified in terms of the lower limit (ll15), drained upper limit(dul) and saturated(sat) volumetric water contents. Water movement is described using separate algorithms for saturated or unsaturated flow. It is notable that redistribution of solutes, such as nitrate- and urea-N, is carried out in this module.

Modifications adopted from PERFECT include:

* the effects of surface residues and crop cover on modifying runoff and reducing potential soil evaporation,
* small rainfall events are lost as first stage evaporation rather than by the slower process of second stage evaporation, and
* specification of the second stage evaporation coefficient(cona) as an input parameter, providing more flexibility for describing differences in long term soil drying due to soil texture and environmental effects.

The module is interfaced with SurfaceOrganicMatter and crop modules so that simulation of the soil water balance responds to change in the status of surface residues and crop cover(via tillage, decomposition and crop growth).

Enhancements beyond CERES and PERFECT include:

* the specification of swcon for each layer, being the proportion of soil water above dul that drains in one day
* isolation from the code of the coefficients determining diffusivity as a function of soil water (used in calculating unsaturated flow).Choice of diffusivity coefficients more appropriate for soil type have been found to improve model performance.
* unsaturated flow is permitted to move water between adjacent soil layers until some nominated gradient in soil water content is achieved, thereby accounting for the effect of gravity on the fully drained soil water profile.

SoilWater is called by APSIM on a daily basis, and typical of such models, the various processes are calculated consecutively. This contrasts with models such as SWIM that solve simultaneously a set of differential equations that describe the flow processes.

# 2 Evaporation

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
|---|---|
| ABlock_Residues | Cover (4) |

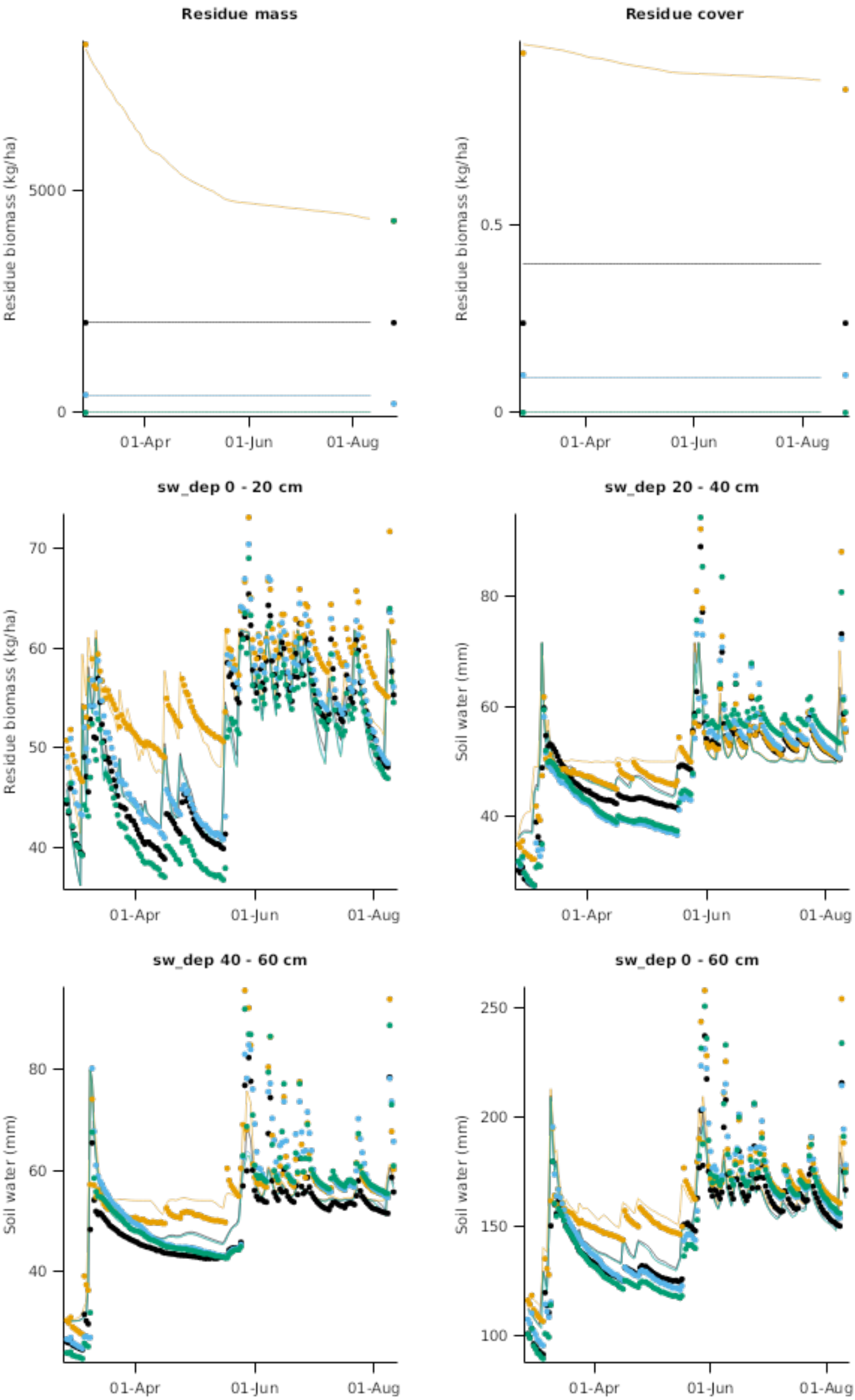
## 2.1 ABlock_Residues

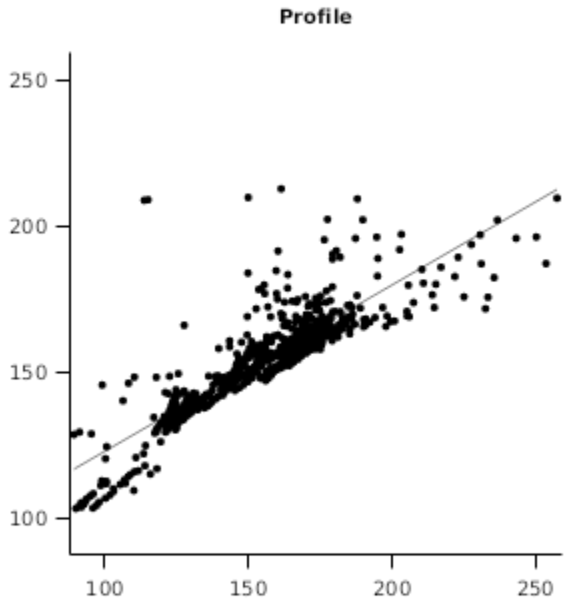
This experiment was conducted in Plant and Food Researches A Block field near Lincoln, New Zealand. A uniformly managed, unirrigated barley crop was grown and harvested prior to the estastablishment of this experiment. A randomised complete block was layed out with 5 x 15 m plots laid out to avoid harvester wheel tracks with 4 replicates of 4 treatments:

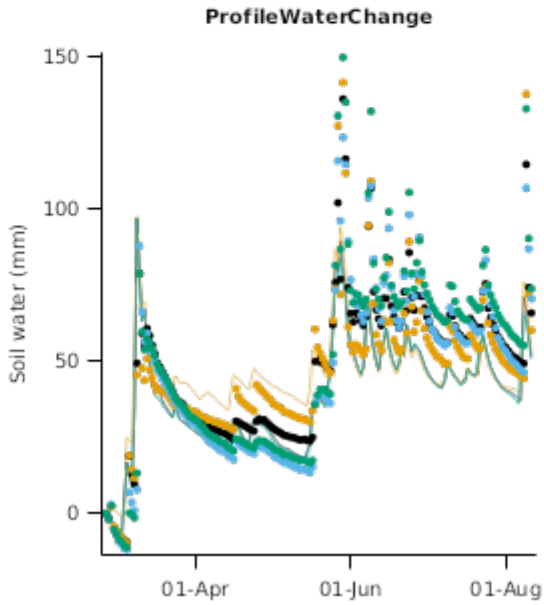
- <b>StandingStubble</b> where the stubble that was left by the combine harvester remained standing and any residue that
- <b>HarvesterWindrow</b> where the residue mown from the other two treatments was piled ontop of the standing stubble to simulate a harvester windrow with the residue from approximately 2 times the area applied
- <b>MownStubble</b> where stubble was mown at 5cm height and removed from the plots
- <b>BareSoil</b> where stubble was mown and removed and then plots were ploughed and cultivated to leave a bare soil.

Following the establishment of treatments CS616 soil moisture sensors were installed in each plot at 0-20, 20-40 and 40-60 cm depth and logged at 1 hourly intervals from establishment in Autumn through until the following spring.

### 2.1.1 Graphs


Residue mass
Residue biomass (kg/ha)
5000
0
01-Apr
01-Jun
01-Aug
Residue cover
Residue biomass (kg/ha)
0.5
0
01-Apr
01-Jun
01-Aug
sw_dep 0 - 20 cm
Residue biomass (kg/ha)
70
60
50
40
01-Apr
01-Jun
01-Aug
sw_dep 20 - 40 cm
Soil water (mm)
80
60
40
01-Apr
01-Jun
01-Aug
sw_dep 40 - 60 cm
Soil water (mm)
80
60
40
01-Apr
01-Jun
01-Aug
sw_dep 0 - 60 cm
Soil water (mm)
250
200
150
100
01-Apr
01-Jun
01-Aug



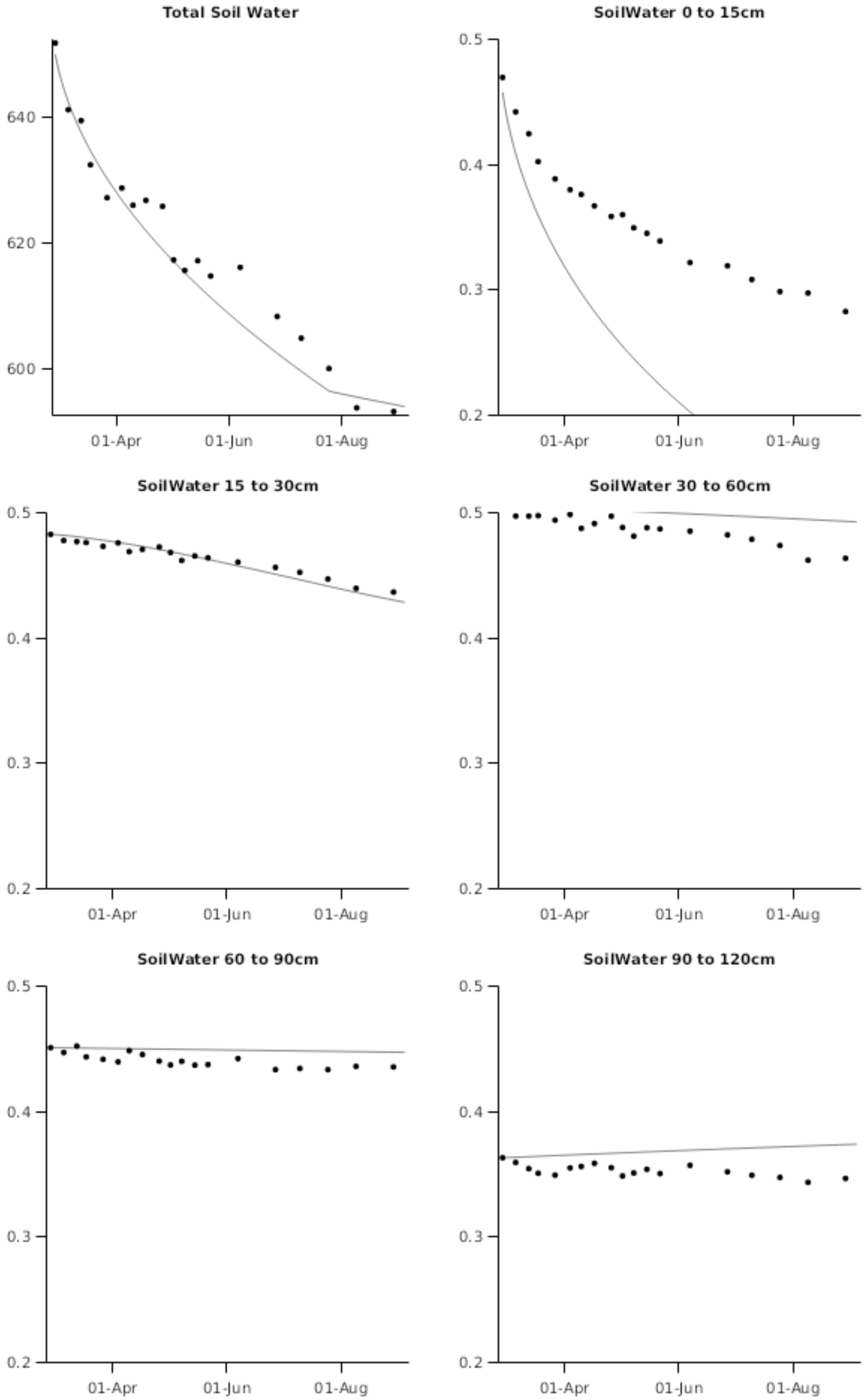




## 2.2 Wellcamp

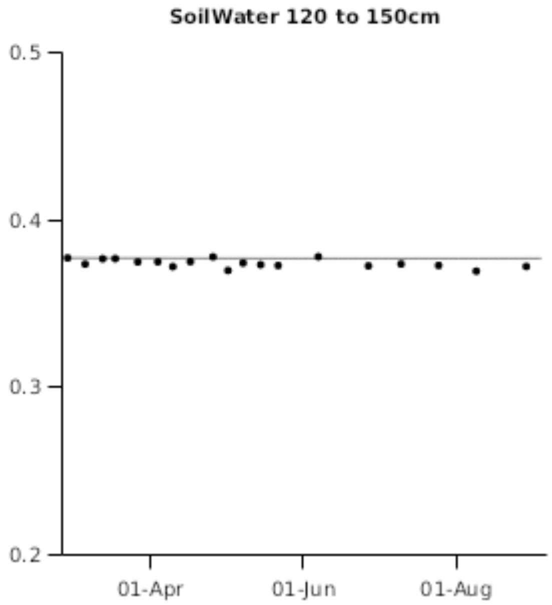
This dataset was developed as part of work by Huth et al., 2008. Evaporation from a Black Vertosol over a period of 6 months was measured using a Neutron Moisture Meter at Wellcamp, near Toowoomba in Queensland, Australia. Rainfall was excluded from the soil. Drainage was unlikely during the study period and so all changes in water content should be due to evaporation alone.

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
|---|---|
| WellCamp | Surface (1) |



Total Soil Water
640
620
600
01-Apr
01-Jun
01-Aug
SoilWater 0 to 15cm
0.5
0.4
0.3
0.2
SoilWater 15 to 30cm
SoilWater 30 to 60cm
SoilWater 60 to 90cm
SoilWater 90 to 120cm

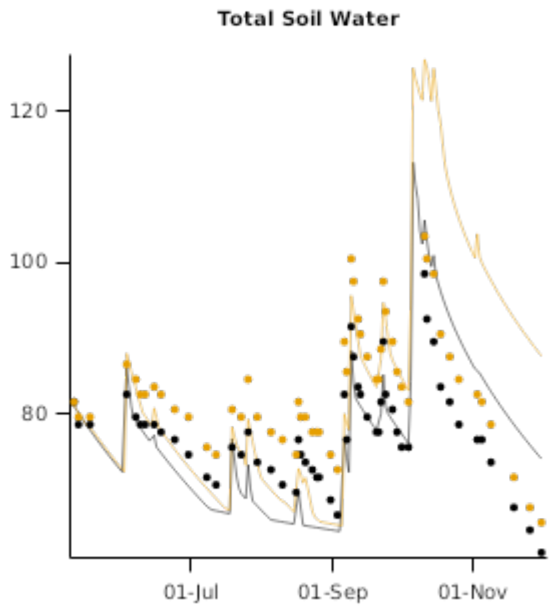


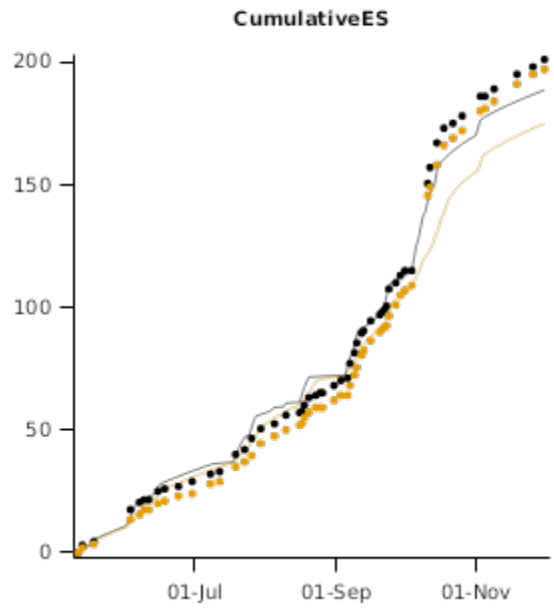

## 2.3 TorStreet

Evaporation from a Grey Vertosol over a period of 7 months was measured using weighing lysimeters in Toowoomba, Queensland, Australia.

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
|---|---|
| TorStreet | Surface (2) |



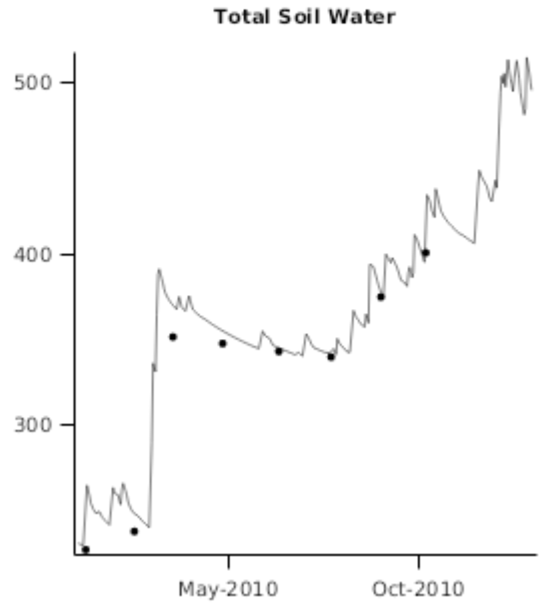




## 2.4 Norwin

This dataset was developed as part of work by Huth et al., 2008. Evaporation from a Black Vertosol over a period of 6 months was measured using a Neutron Moisture Meter at Wellcamp, near Toowoomba in Queensland, Australia. Rainfall was excluded from the soil. Drainage was unlikely during the study period and so all changes in water content should be due to evaporation alone.

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
|---|---|
| Norwin | Surface (1) |




Soil Temperature 0 to 10cm

Soil Temperature 10 to 20cm

Soil Temperature 20 to 30cm

Soil Temperature 50cm

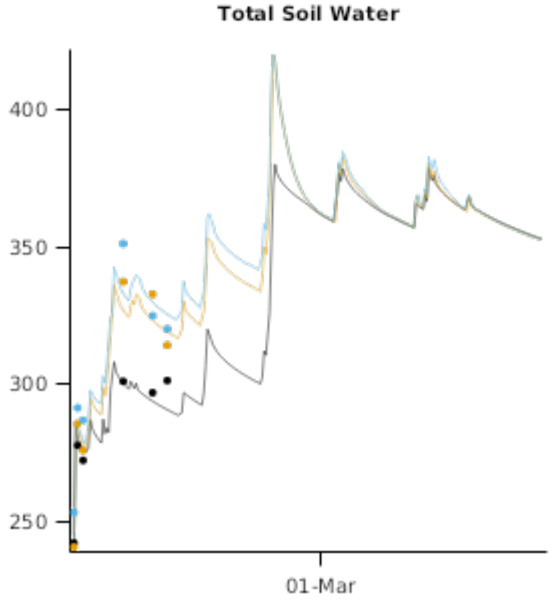
Soil Temperature

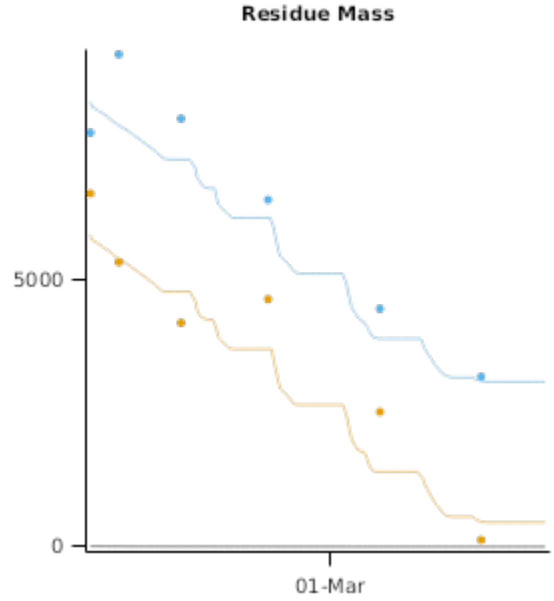
## 2.5 Gatton

Evaporation from a Grey Vertosol over a period of 7 months was measured using weighing lysimeters in Toowoomba, Queensland, Australia.

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
| --- | --- |
| Gatton | Surface (3) |



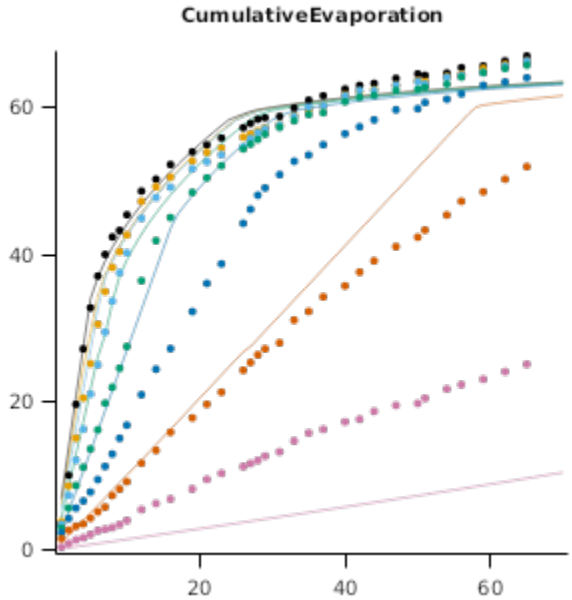



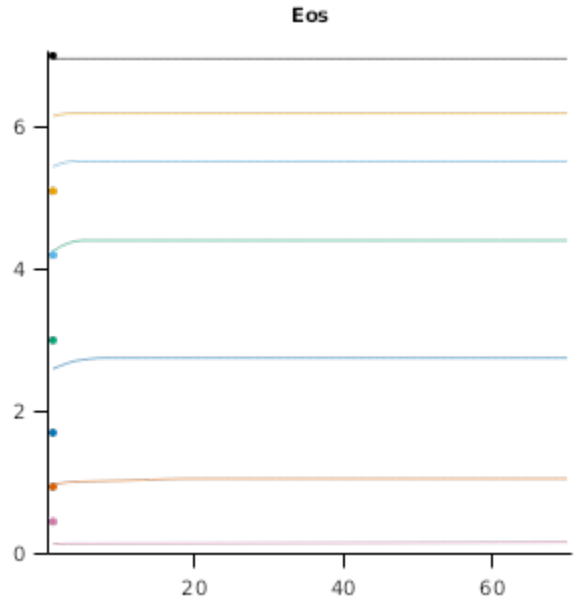

## 2.6 BondAndWillis

This dataset reproduces the evaporation experiment by Bond et al., 1970 in which microlysimeters were used to measure evaporation under varying residue levels and evaporative demands within controled environments. Note that evaporation parameters may be higher than under natural systems as evaporative conditions were maintained for 24 hours per day. The soil type was a fine sandy loam and the residue was clean bright wheat straw cut into 1.3 cm lengths.

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
| --- | --- |
| BondAndWillis | Residue (7) |



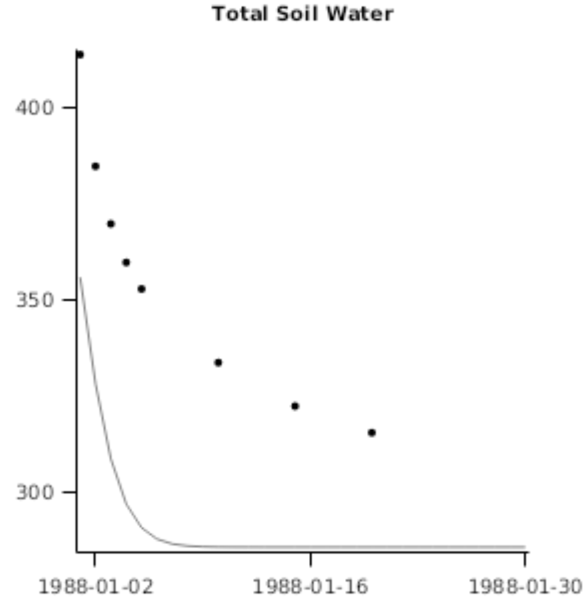

# 3 Drainage

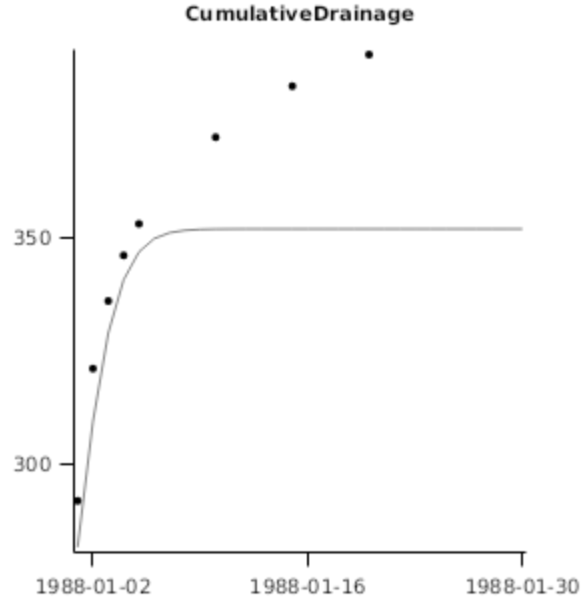
## 3.1 Libardi

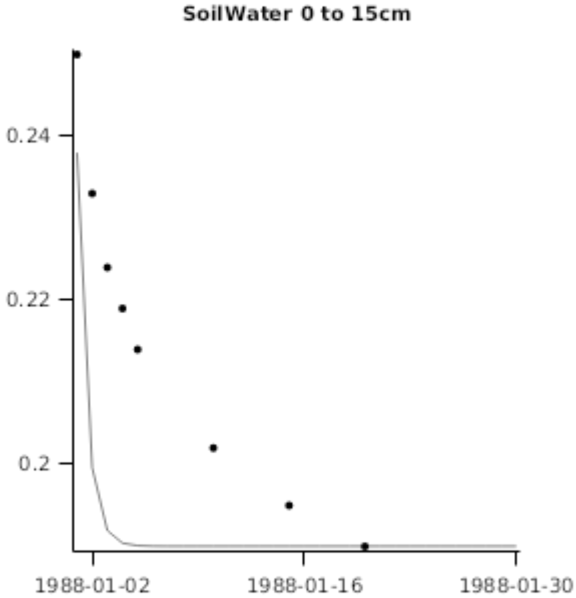
Data used here were collected during an internal drainage experimentLibardi et al., 2001, carried out on a sandy–loam Red Yellow Latosol (Typic Hapludox) near Piracicaba, SP, Brazil. The soil had a fairly homogeneous profile down to the depth of 2 m. Soil water content values were calculated from tensiometer readings, through the use of laboratory established soil water retention curves and of soil water potential heads, measured with the same mercury manometer tensiometers.

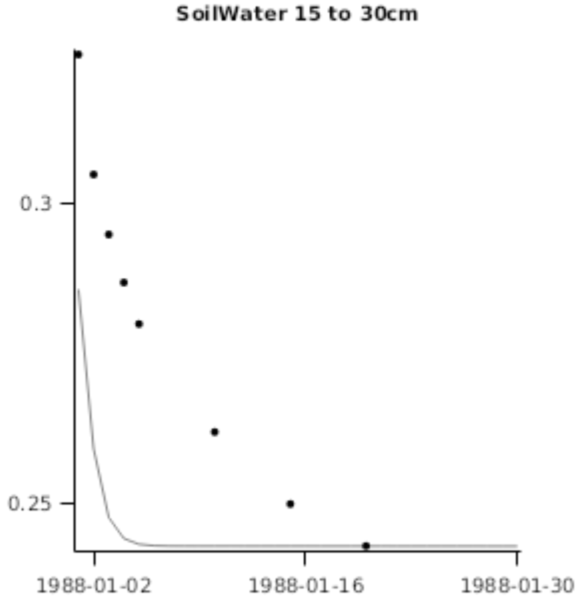
**List of experiments.**

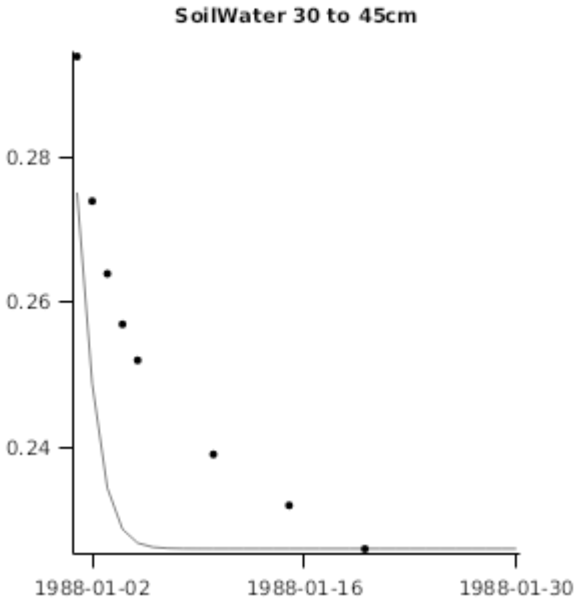
| Experiment Name | Design (Number of Treatments) |
|---|---|
| Libardi | Surface (1) |

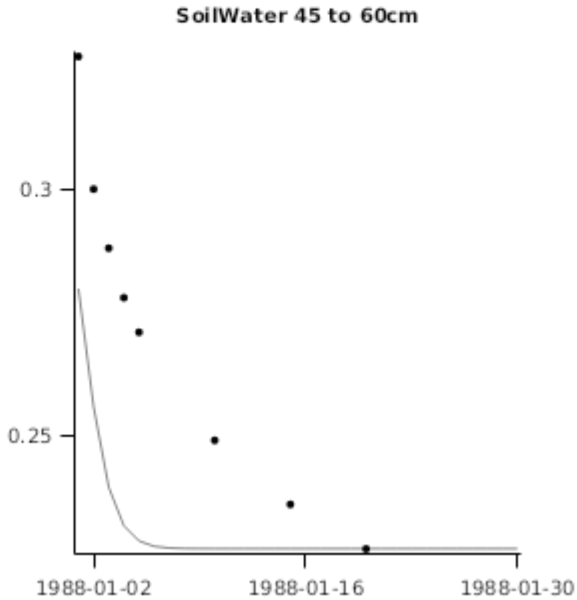


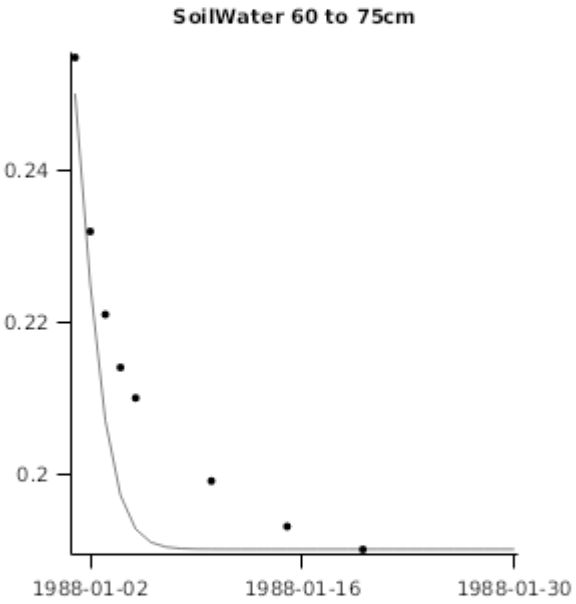



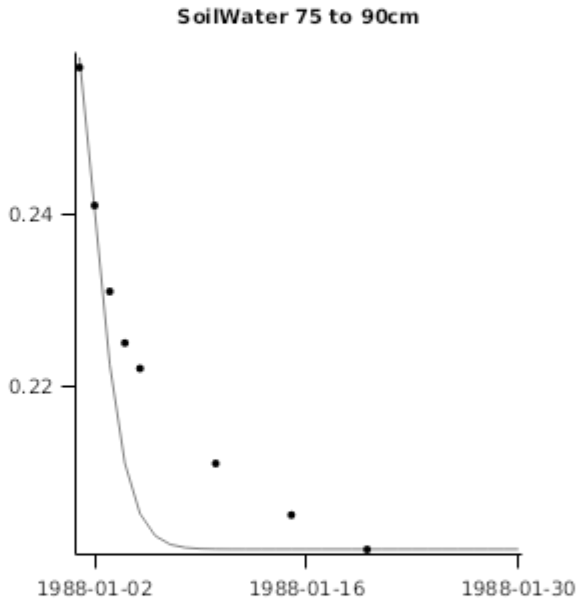

SoilWater 0 to 15cm
0.24
0.22
0.2
1988-01-02
1988-01-16
1988-01-30

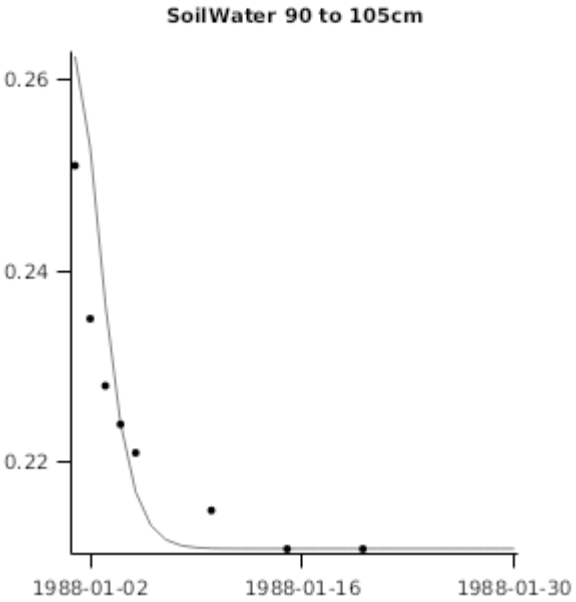

SoilWater 15 to 30cm
0.3
0.25
1988-01-02
1988-01-16
1988-01-30

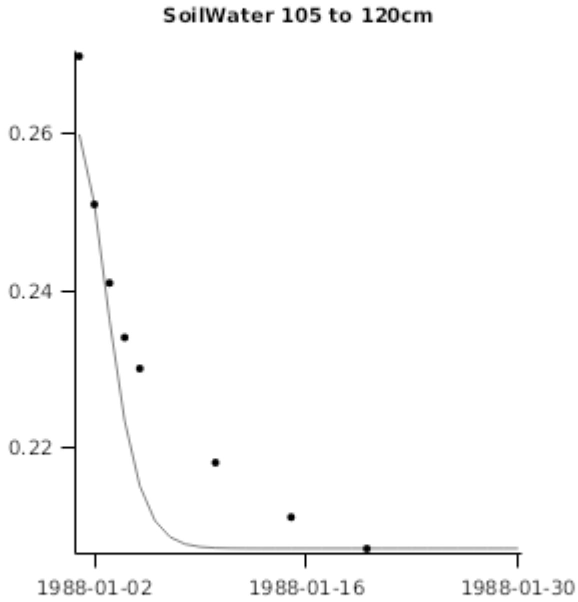

SoilWater 30 to 45cm
0.28
0.26
0.24
1988-01-02
1988-01-16
1988-01-30

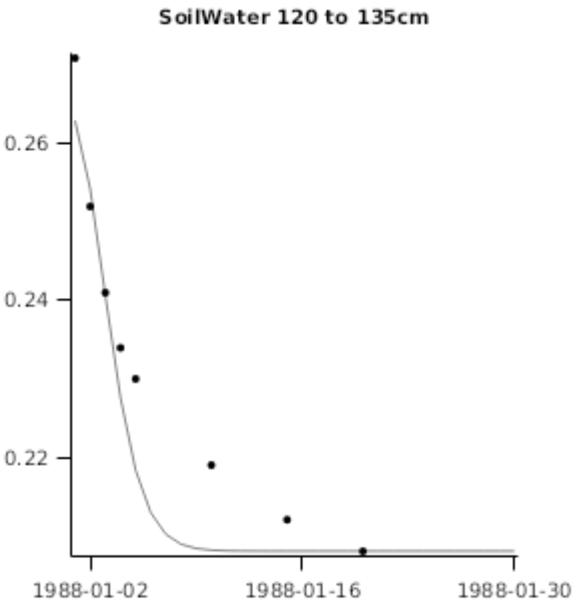

SoilWater 45 to 60cm
0.3
0.25
1988-01-02
1988-01-16
1988-01-30




# 4 WaterExtraction

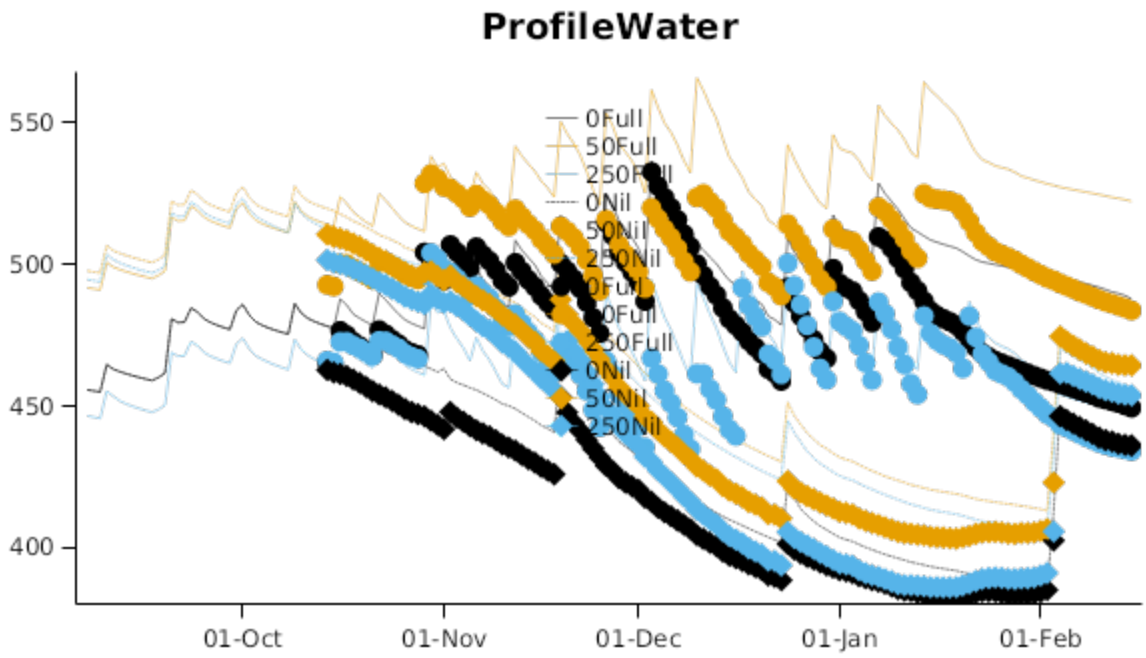
**List of experiments.**

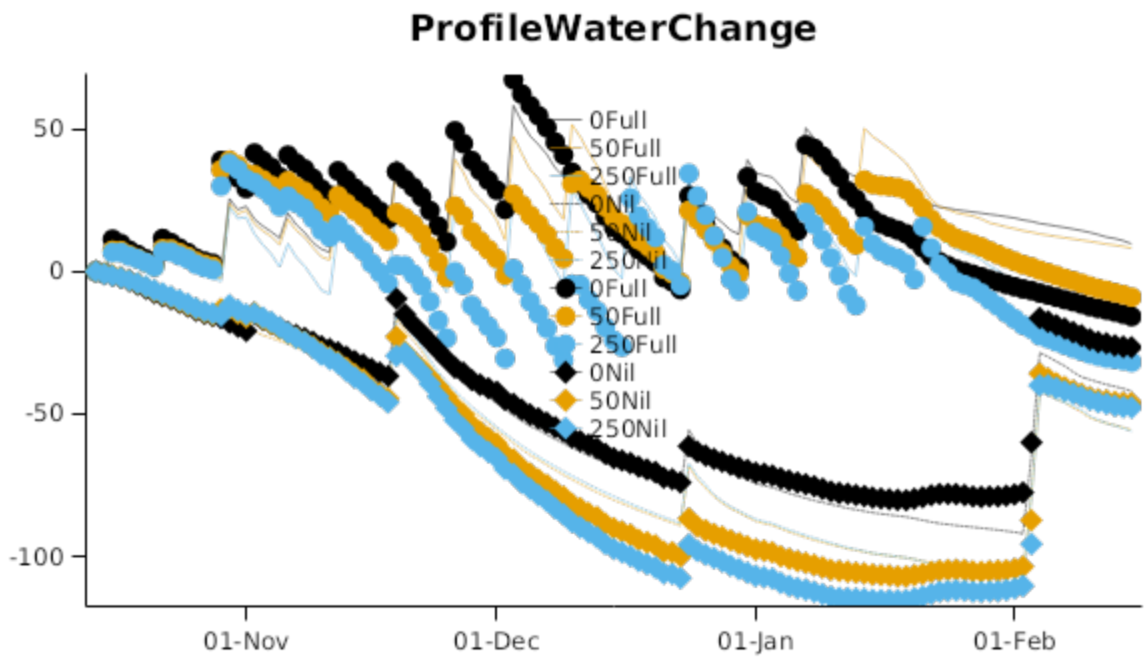
| Experiment Name | Design (Number of Treatments) |
|---|---|
| Lincoln2015 | Nit x Irr (6) |
| LandP | Irrigation x CoverType (8) |

## 4.1 Lincoln2015

### 4.1.1 Lincoln2015 (Rain-Shelter Trail)

This dataset demonstrates the impact of three N (0, 50 and 250 kg/ha N) and two water regimes (dryland and fully irrigated) using a rain-shelter structure at Lincoln, New Zealand. A crop of 'Discovery' wheat was sown in October and managed as a typical spring wheat crop. Soil water content was measured with CS650 soil moisture probes positioned at 7 depths in each plot (192 probes in total) and logged at 15 min intervals for the duration of the experiment. Total cover was measured using linear PAR sensors in each plot logged for the duration of the experiment and green cover was measured ever 3-4 days with NDVI and interpolated to daily values.
Slurp is used to represent the crop in this test so it can focus on soil water and not be blured by the performance of the crop model. To do this observed values for green and total cover, LAI, and Height were set in Slurp each day using a manager script.



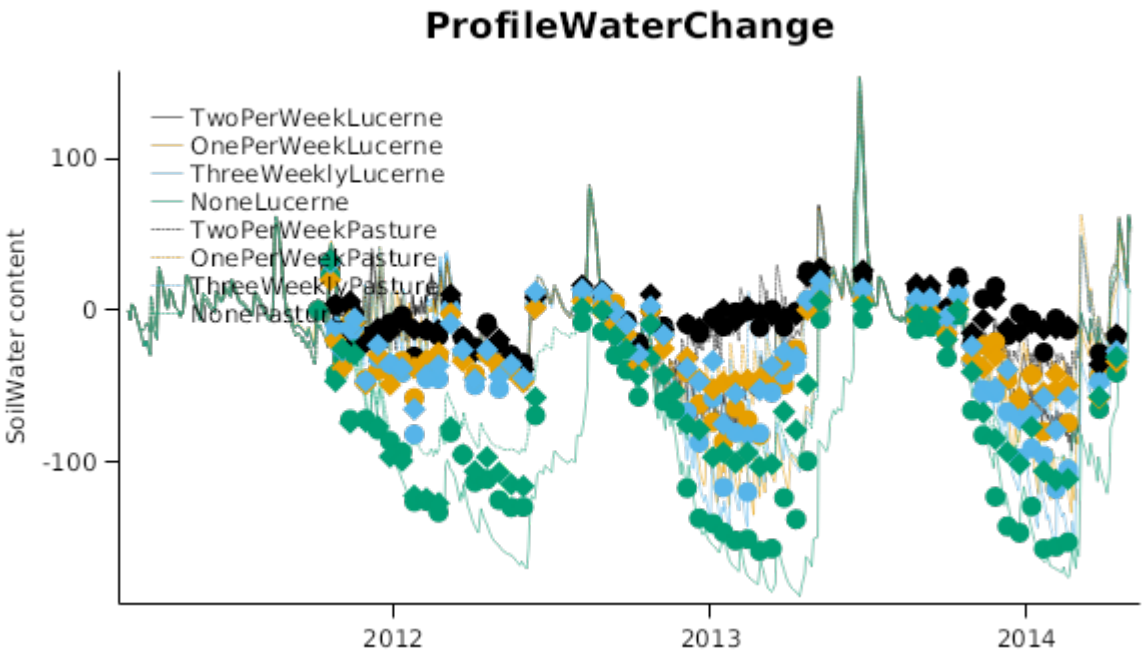




## 4.2 LandP

This experiment was run over 3 years in Lincoln, New Zealand on a shallow stony soil. Treatments of Lucerne and Pasture (Ryegrass) were established in the Autumn of 2011 and irrigtion treatments were installed in the spring of 2011 and applied for three years. Treatments were:

- None where no irrigation was applied
- TwoPerWeek where irrigation was applied twice per week during spring/summer/autumn to replace water use measured by neutron probe
- OnePerWeek where the same amout of irrigation was applied as the above treatment but at weekly frequency (i.e fewer, larger irrigations)
- ThreeWeekly where the same amount of irrigation was applied as abouve but at a 3 weekely frequency (i.e fewer, larger irrigations)

Lucerne and pasture were defoliated at differing frequiencies following best mananagment practice resulting in 8-10 regrowth period per year for pasture and 5-6 for lucerne. Neutron probes were installed to 1.6 m depth using a 20T digger with a pnumatic plate on its boom to drive and extract a pilot rod into the stony sub soil and then an aluminum access tube was installed into the resultant hole. Neutron probes measurements were tatken at 7 - 10 day intervals during the irrigation season. CS616 probes were also installed in the top soil at 0-15 and 15-30 cm depths in each plot and logged hourly. Slurp is used to represent the crop in this test so it can focus on soil water and not be blured by the performance of the crop model. To do this observed values for green cover, LAI, and Height were set in Slurp each day using a manager script.



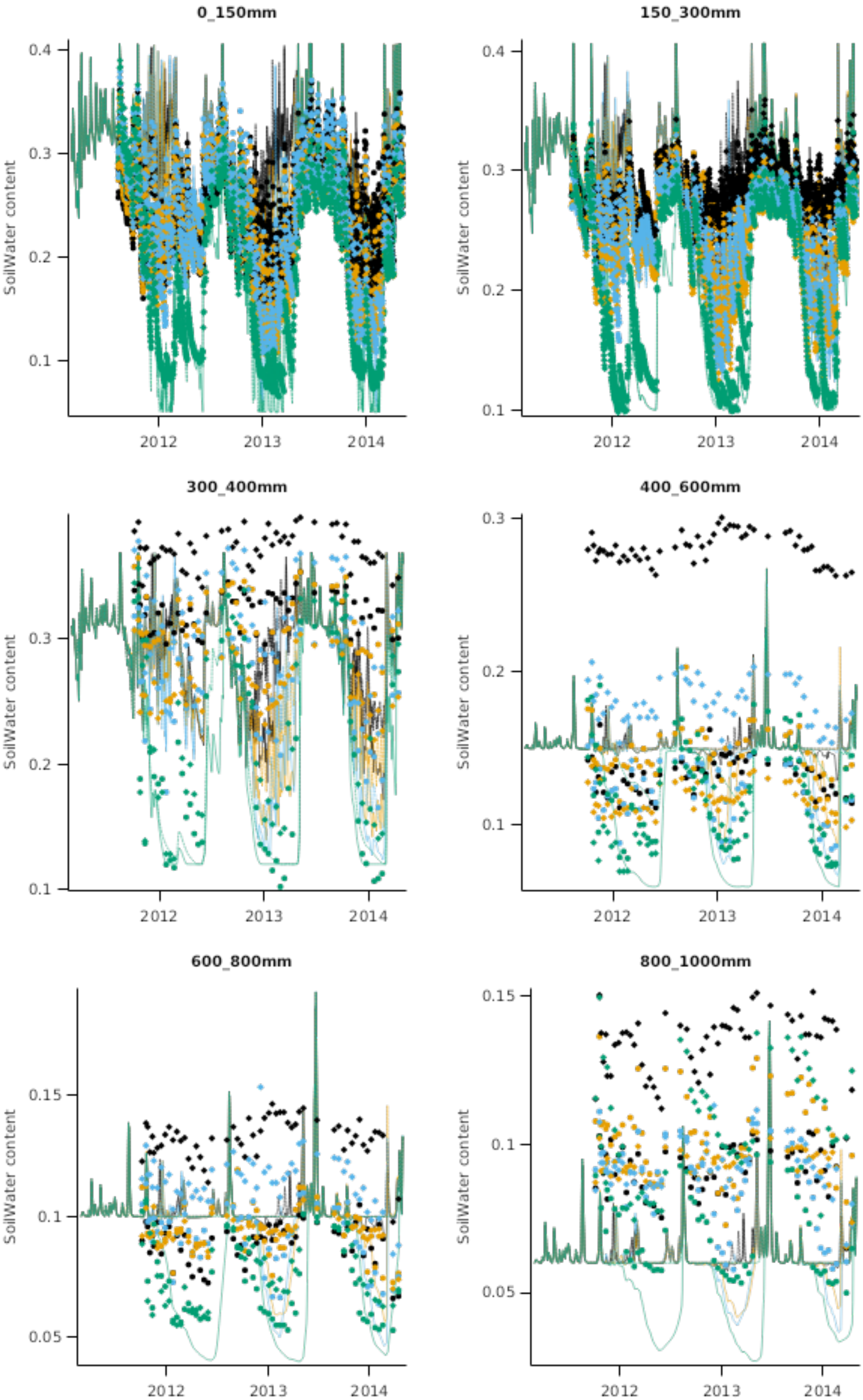

### 4.2.1 Crop Status

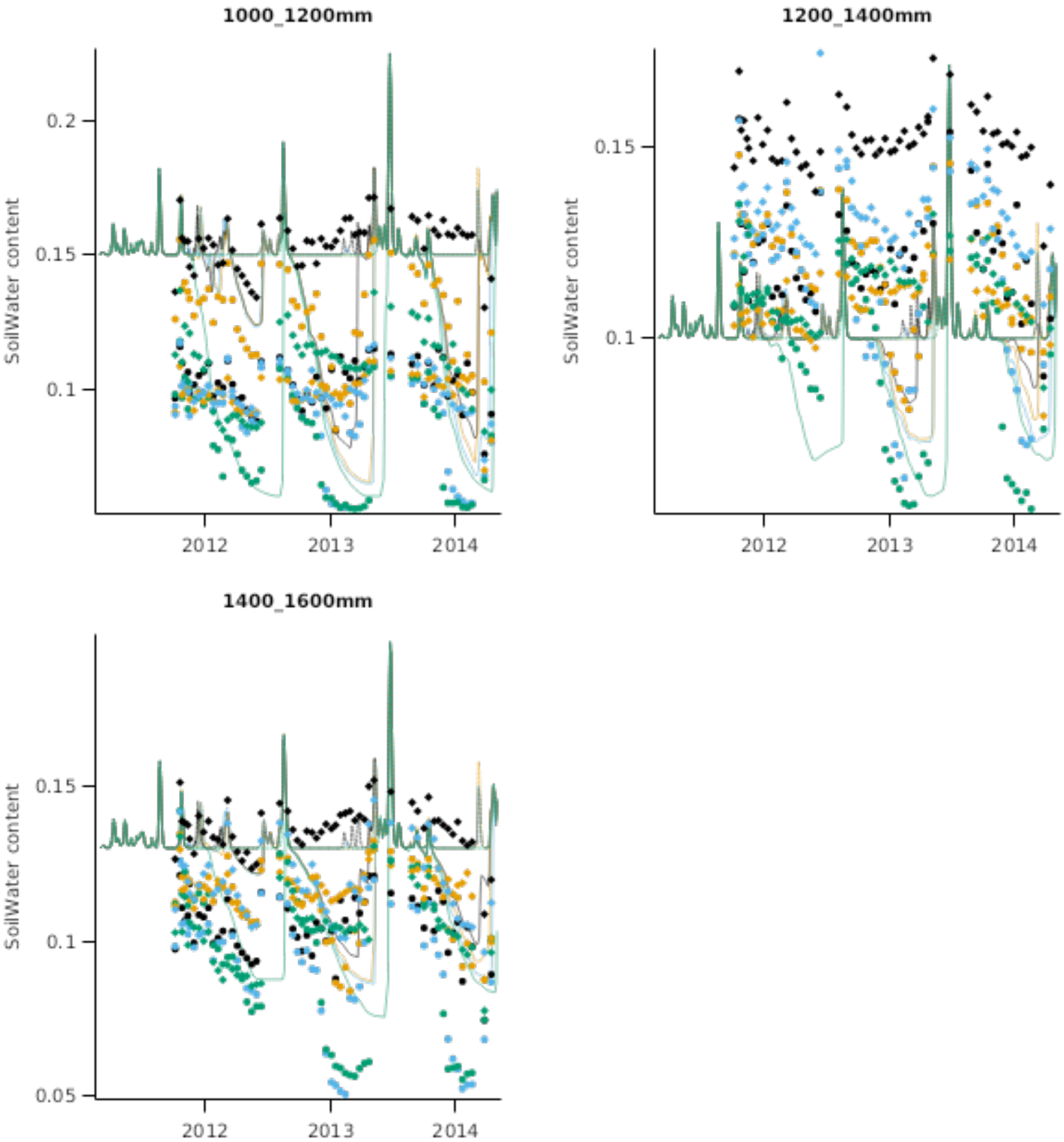
Height

RootDepth

Cover

### 4.2.2 Soil Water by layer


0_150mm
150_300mm
300_400mm
400_600mm
600_800mm
800_1000mm
SoilWater content
0.1
0.2
0.3
0.4
0.05
0.15
2012
2013
2014



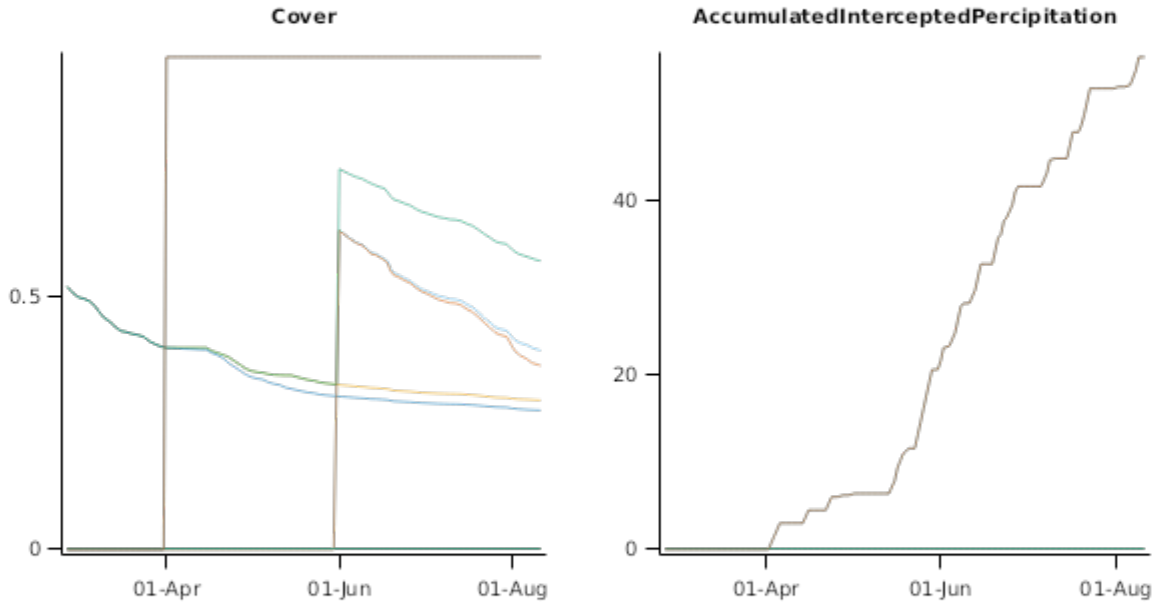

# 5 SensibilityTests

**List of experiments.**

| Experiment Name | Design (Number of Treatments) |
|---|---|
| ResidueEvaporationTest | Residue (6) |

## 5.1 ResidueEvaporationTest

### 5.1.1 Folder




# 6 References

Bond, JJ, Willis, WO, 1970. Soil Water Evaporation: First Stage Drying as Influenced by Surface Residue and Evaporation Potential. Soil Science Society of America Proceedings 34, 924-928.

Huth, N. I., Carberry, P. S., Cocks, B., Graham, S., McGinness, H. M., O'Connell, D. A., 2008. Managing drought risk in eucalypt seedling establishment: An analysis using experiment and model. Forest Ecology and Management 255 (8-9), 3307-3317.

Libardi, PL, Reichardt, Klaus, 2001. Libardi's method refinement for soil hydraulic conductivity measurement. Australian Journal of Soil Research 39, 851-860.