MONASH University
Engineering

Go Boldly.

Development of a "soil hydraulic property estimator"

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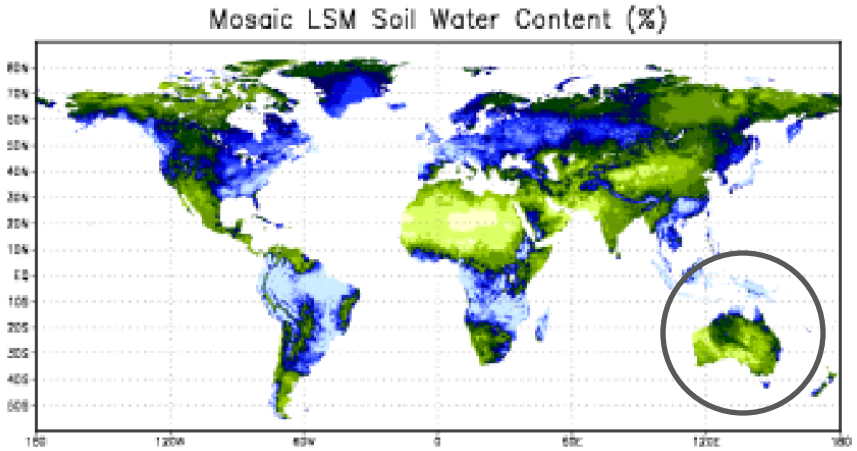
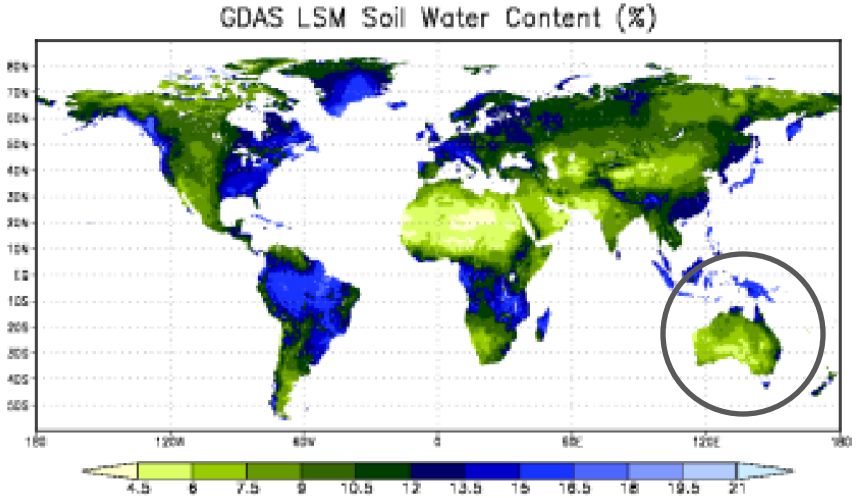
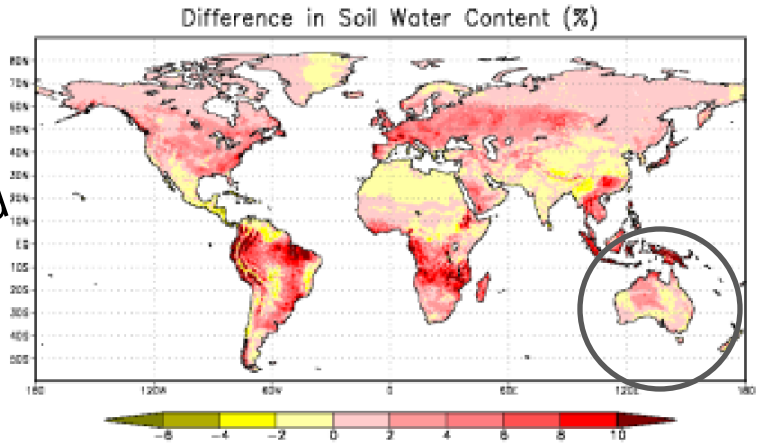
Ranmalee Bandara

Soil Moisture Prediction with Land Surface Models







Same forcing and initial conditions

(a) Errors in the model physics
(b) Errors in **model parameters on soil properties**

Source: Houser et al., GEWEX NEWS 2001

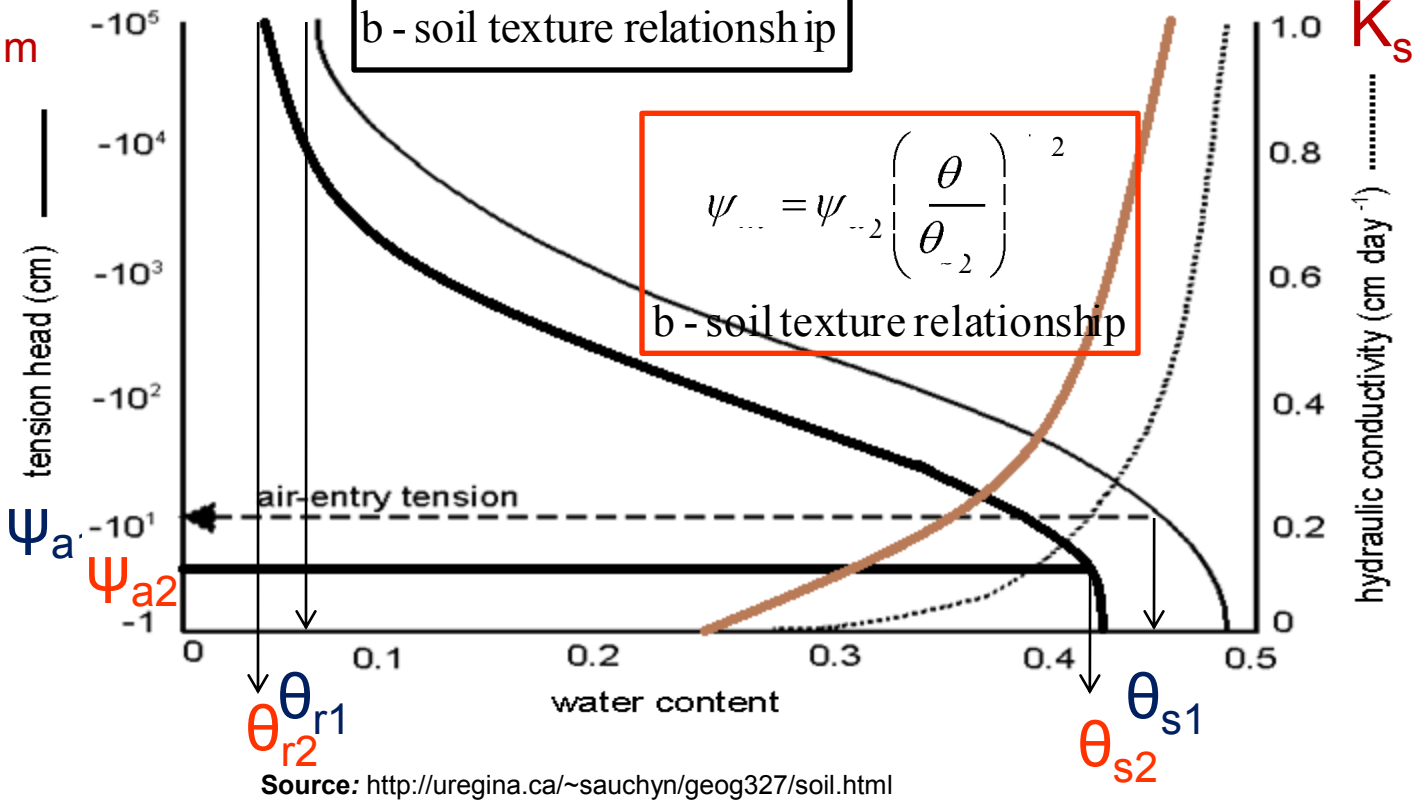
Key Soil Hydraulic Parameters

$$\psi_{...} = \psi_{...1}\left(\frac{\theta}{\theta_{...1}}\right)^{1}$$

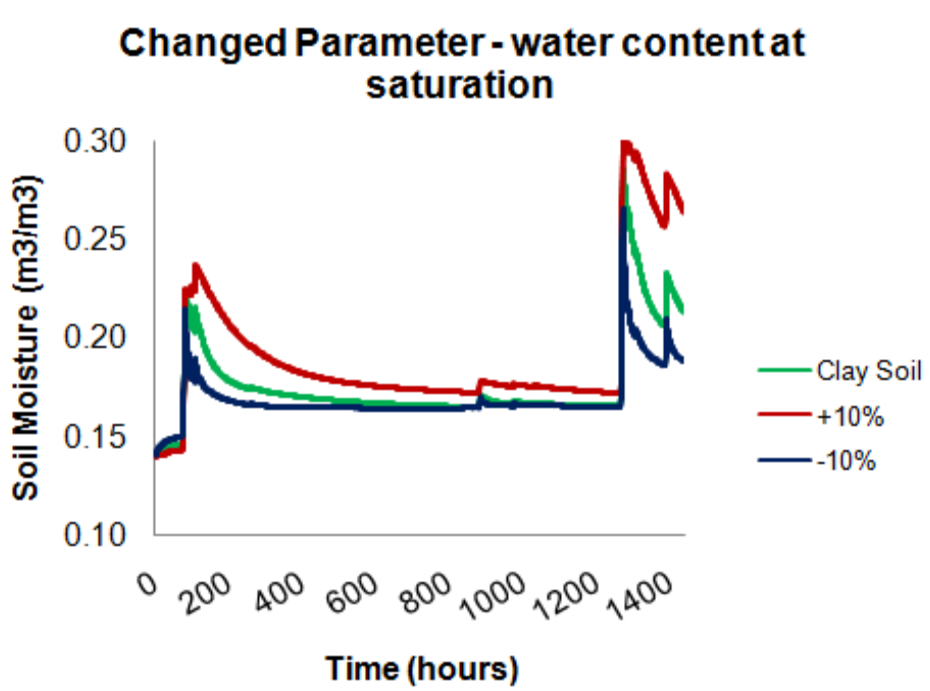
b - soil texture relationship

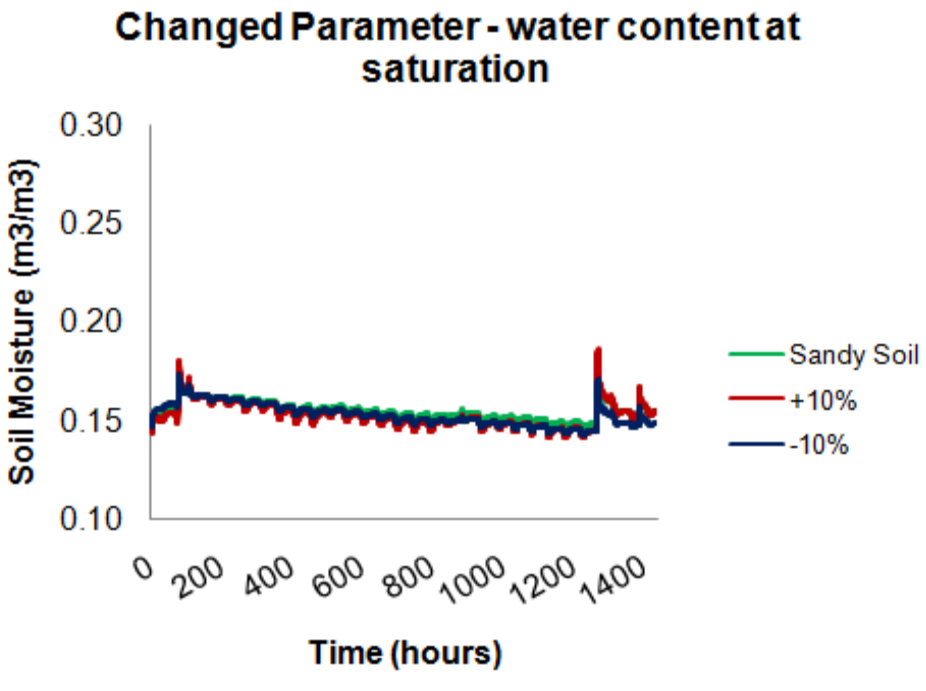
$$\psi_{...} = \psi_{...2}\left(\frac{\theta}{\theta_{...2}}\right)^{2}$$

b - soil texture relationship



Source: http://uregina.ca/~sauchyn/geog327/soil.html


Changed Parameter - water content at saturation
Soil Moisture (m3/m3)
0.30
0.25
0.20
0.15
0.10
0
200
400
600
800
1000
1200
1400
Time (hours)
Clay Soil
+10%
-10%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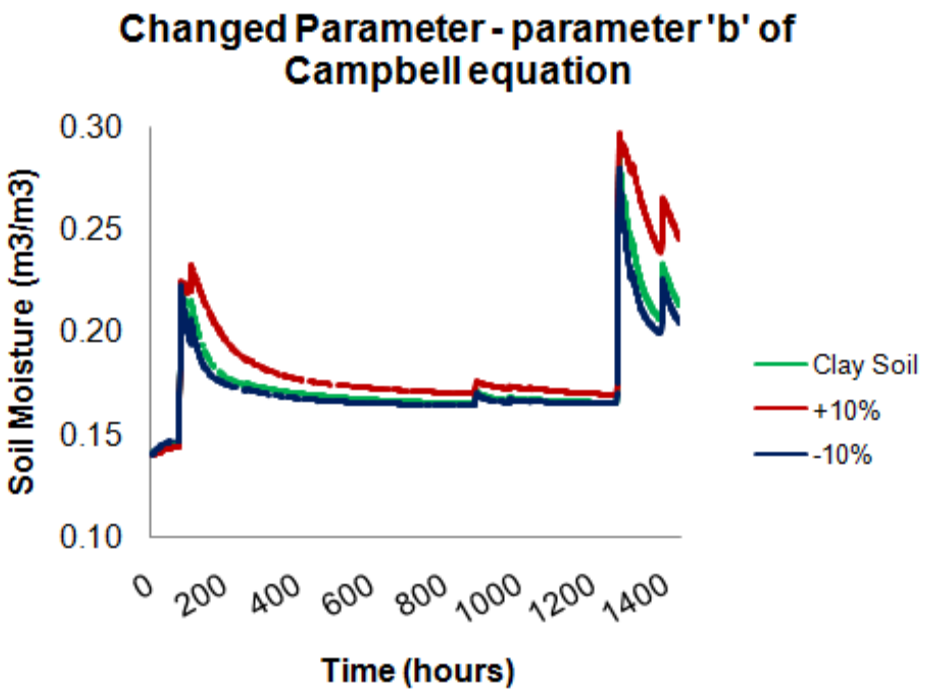
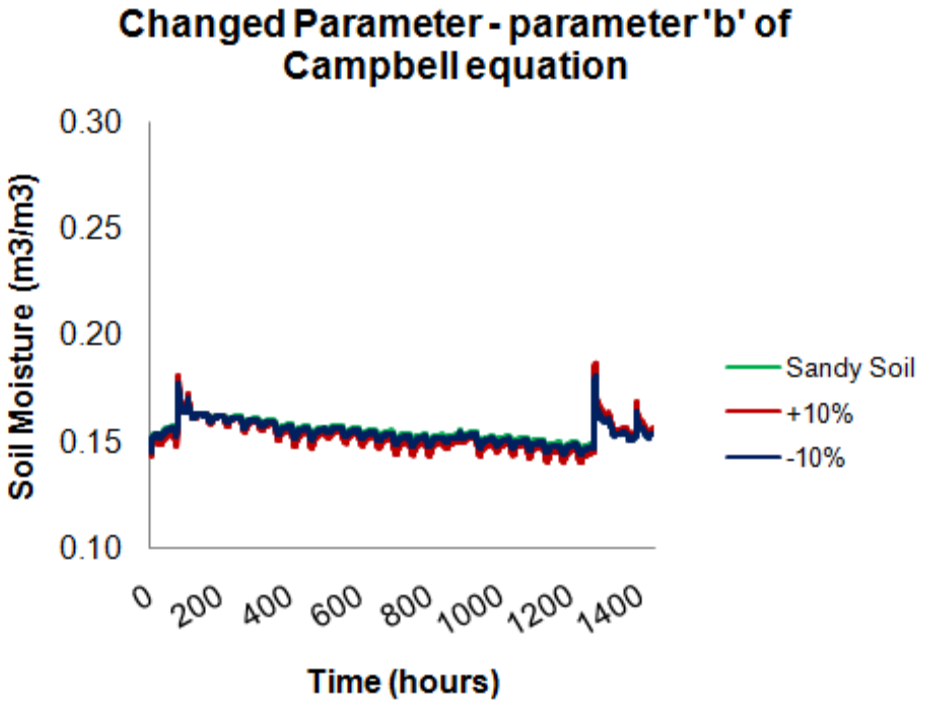
Soil Moisture (m3/m3)
0.30
0.25
0.20
0.15
0.10
0
200
400
600
800
1000
1200
1400
Time (hours)
Sandy Soil
+10%
-10%


Changed Parameter - parameter 'b' of Campbell equation
Soil Moisture (m3/m3)
0.30
0.25
0.20
0.15
0.10
0
200
400
600
800
1000
1200
1400
Time (hours)
Clay Soil
+10%
-10%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0.25
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600
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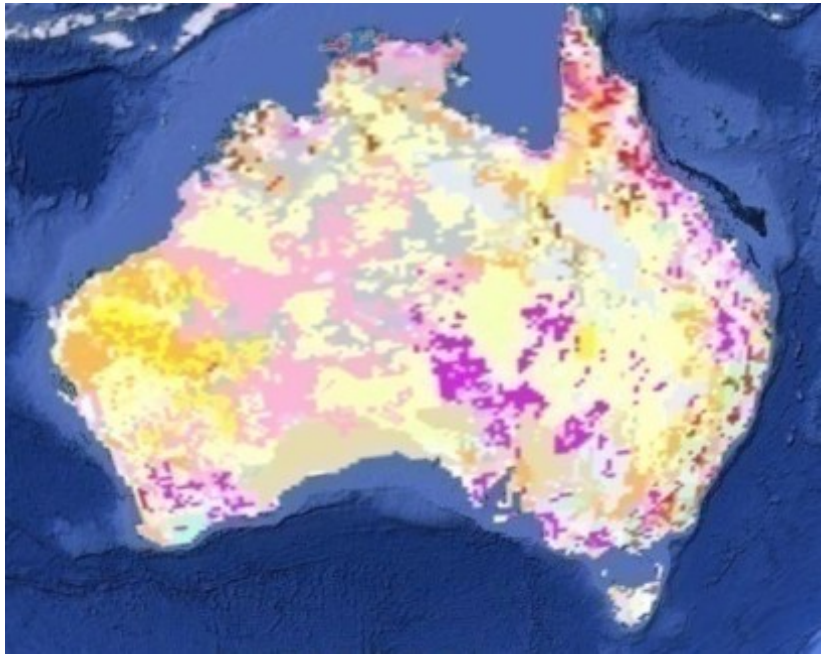
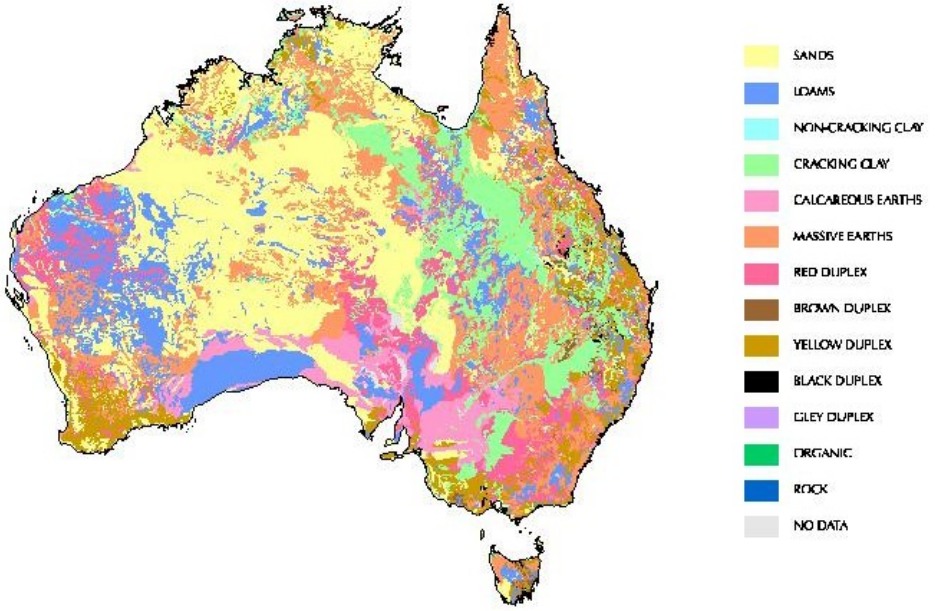
Time (hours)
Sandy Soil
+10%
-10%

GLOBAL – UNESCO Soil Map of the World



LOCAL – Atlas of Australian Soils



- Compiled from ~ 600 national soil maps and 11 000 ancillary maps (specific areas etc.)
- ~1/5 of the world soils have been surveyed

- Based on ~ 500 pits from South-Eastern Australia

(**Source**: http://adl.brs.gov.au/anrdl/metadata_files/pa_daaslr9abd_00111a01.xml)

Typical Values: Clapp & Hornberger

Soil Texture	Parameter 'b'	ψ_a (cm)	θ_s(cm^3/cm^3)	K_s (cm/minute)
Sand	4.05 (**1.78**)	-12.1 (**14.3**)	0.395 (**0.056**)	1.056
Silt Loam	5.30 (**1.96**)	-78.6 (**51.12**)	0.485 (**0.059**)	0.0432
Clay	11.4 (**3.70**)	-40.5 (**39.7**)	0.482 (**0.05**)	0.0077

Clapp and Hornberger, 1978

Objective

To develop a methodology for soil hydraulic property estimation using satellite observations of near surface soil moisture

- Vegetation Parameters
- Rain Fall
- Temperature
- Radiation
- Humidity
- Pressure
- $[CO_2]$

Vegetation Parameters

INPUT

Land Surface Model

SM ST

Microwave Model

T_{bH} T_{bV}

Optimization Model

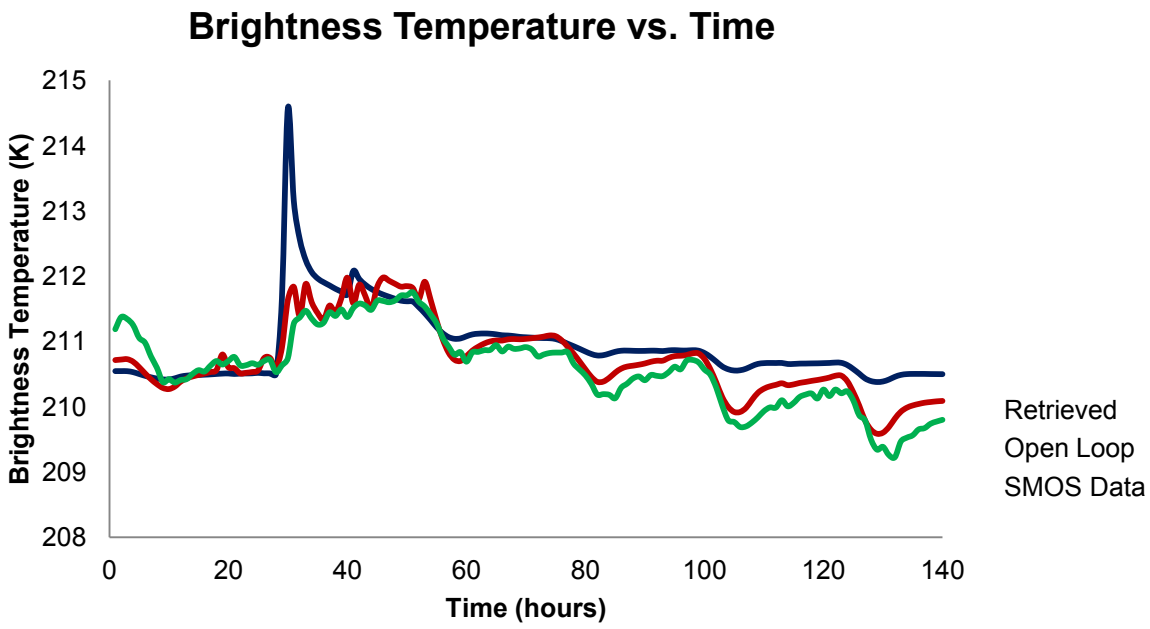
T_{bH} T_{bV}

SMOS Data

Soil Properties

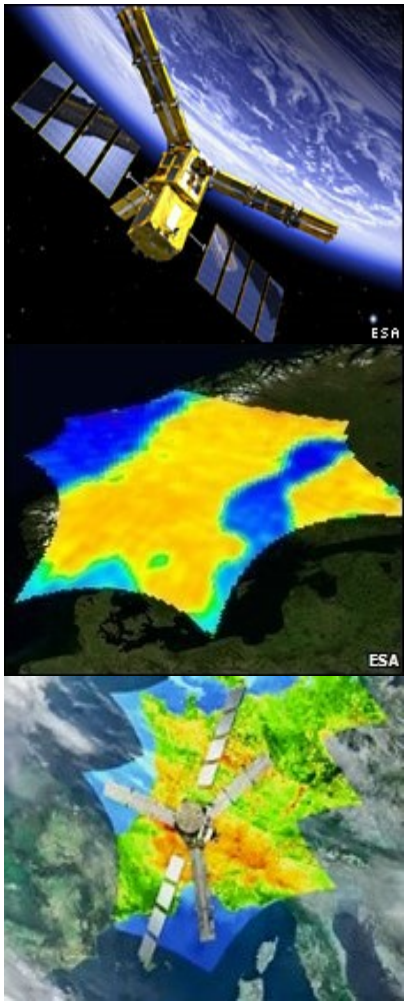
Validation

Ground-truth Data



SMOS – Soil Moisture & Ocean Salinity

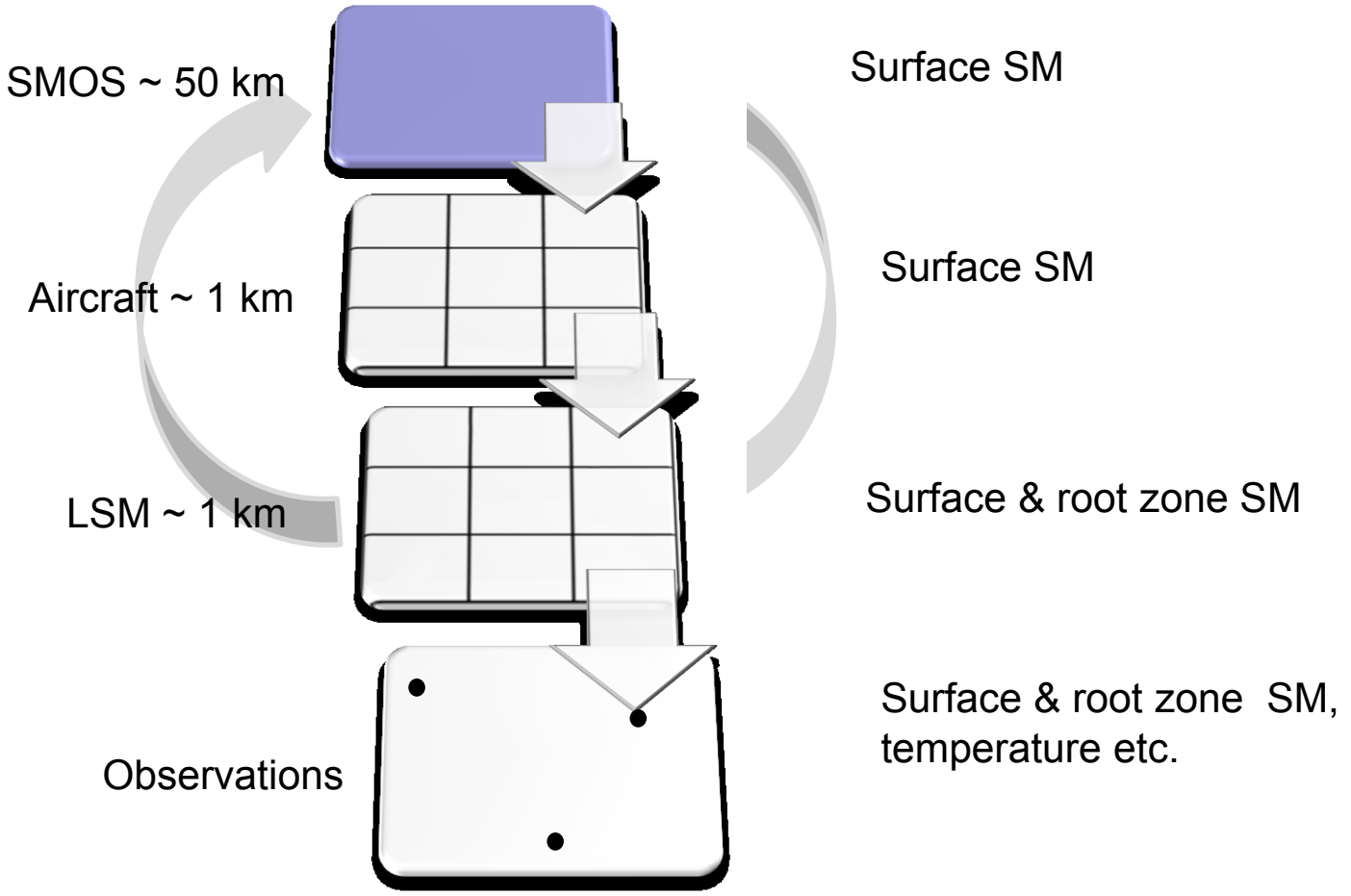
- November 2nd, 2009
- Ground resolution <= 50 km
- Revisit time ~ 3 days
- Target accuracy - **0.04 m^3/m^3**



(Kerr, 2000; Kerr, 2001; Kerr, 2010)

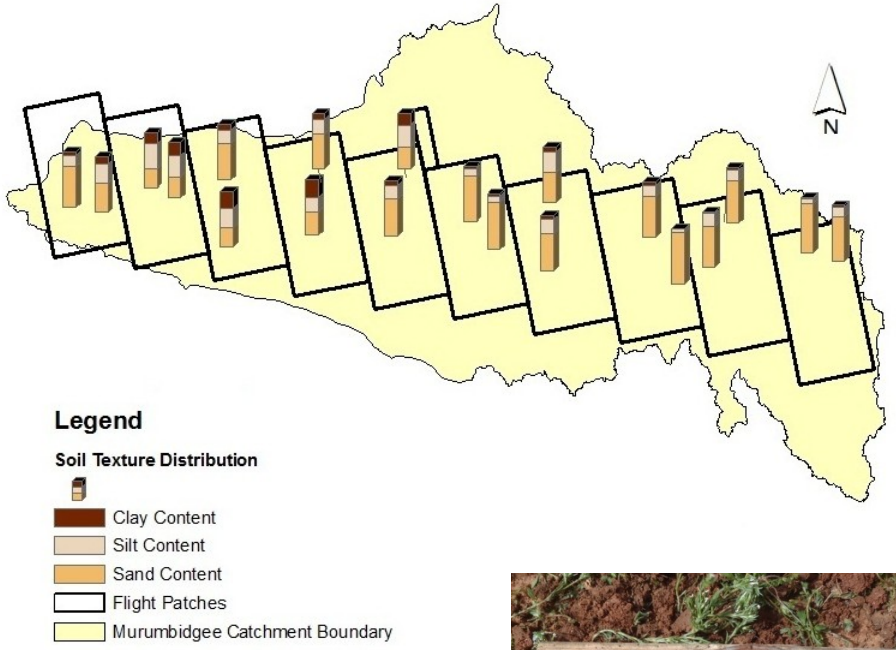
(**Source:** http://news.bbc.co.uk//2/hi/science/nature/8533265.stm)

Approach

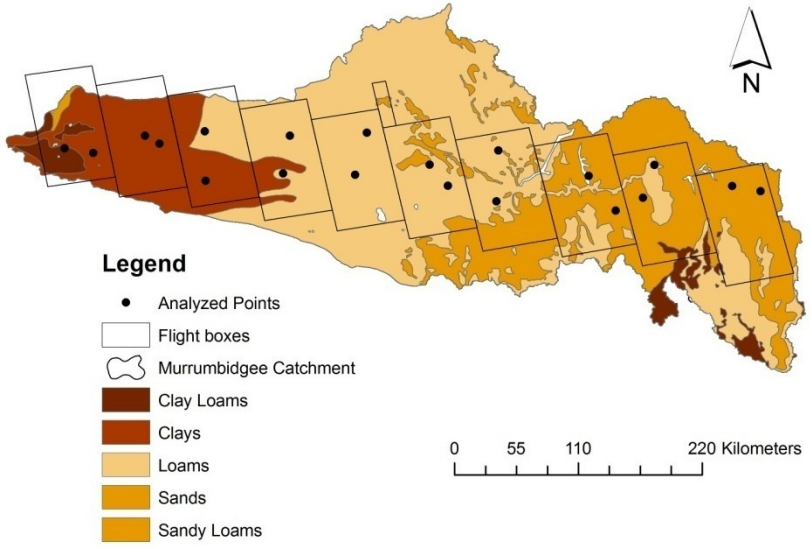

SMOS ~ 50 km
Aircraft ~ 1 km
LSM ~ 1 km
Observations
Surface SM
Surface SM
Surface & root zone SM
Surface & root zone SM, temperature etc.

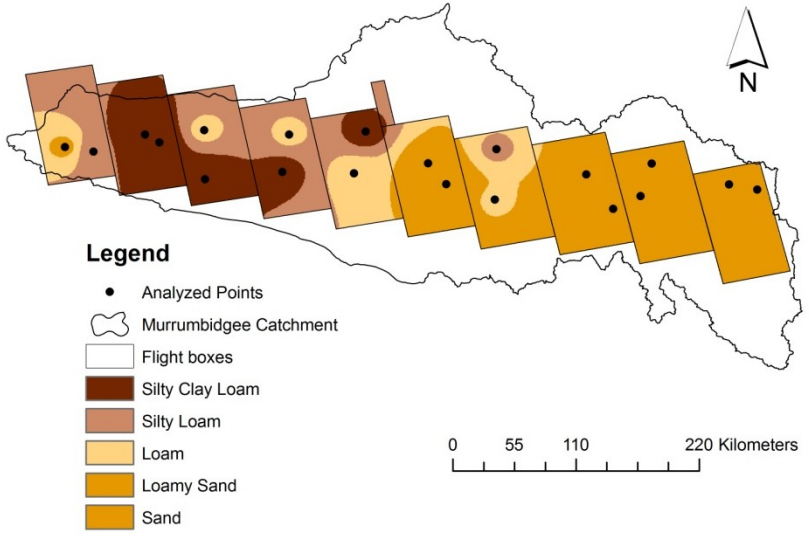
Ground Validation Data

Distribution of the sand, silt and clay contents



Undisturbed soil sample

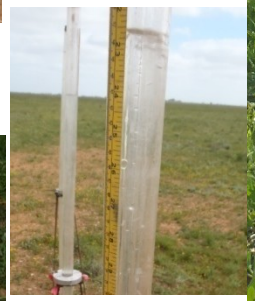




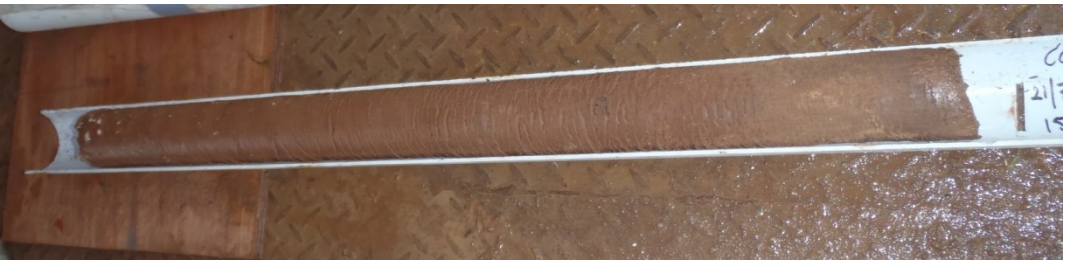
Green Machine

Soil Moisture measurement

Double-Ring Infiltrometer

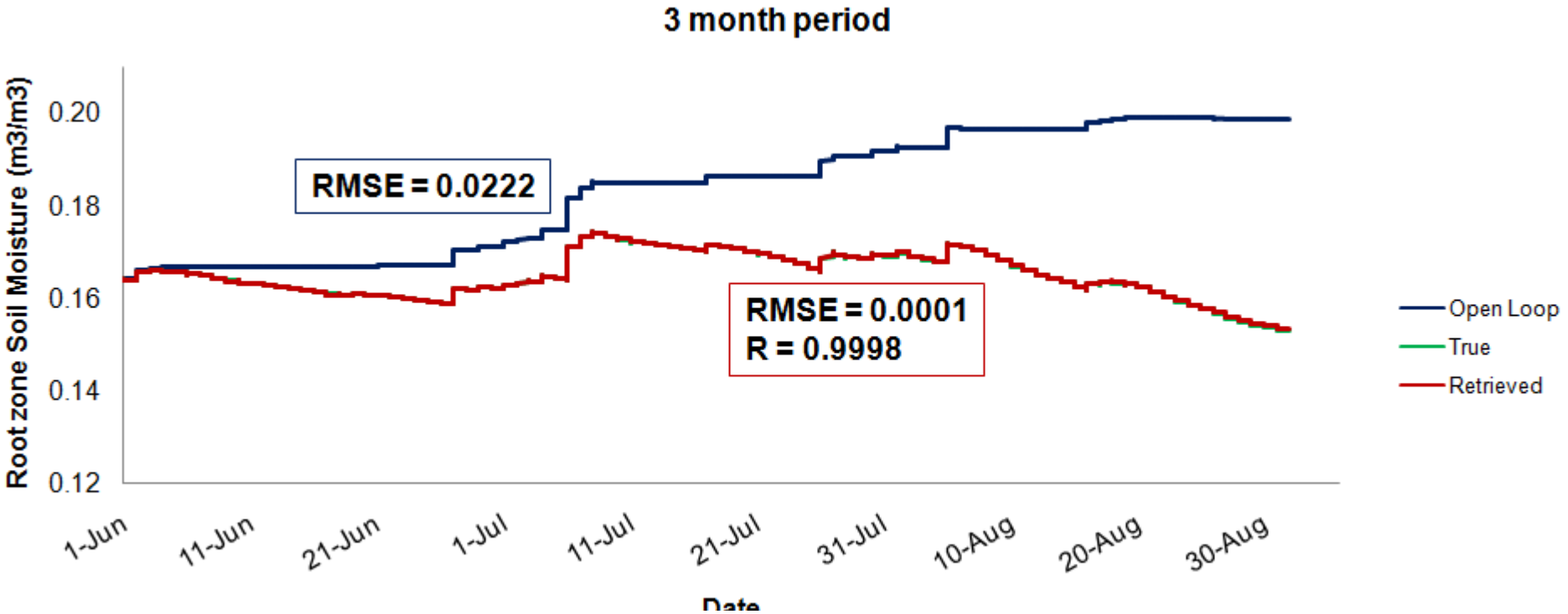


Well Permeameter



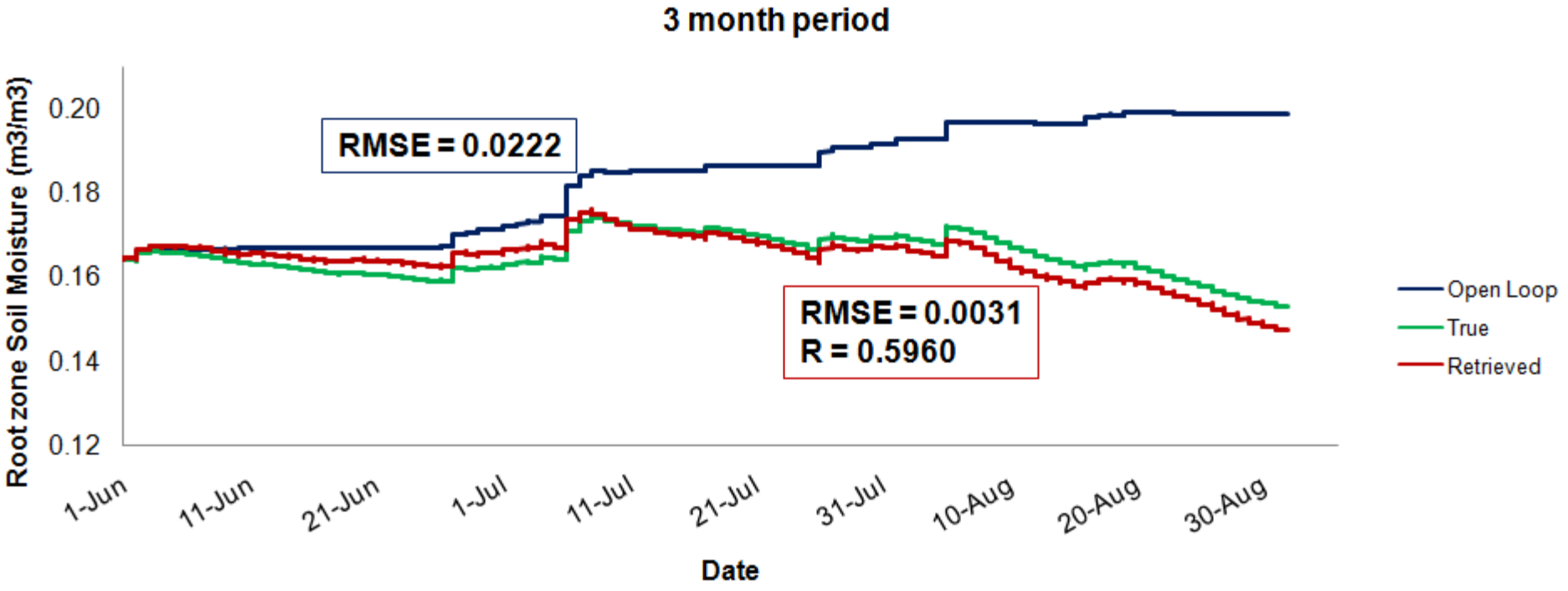
Undisturbed Soil Sample – 75 cm

Data used in the 'Retrieval' process – **Surface & root zone**

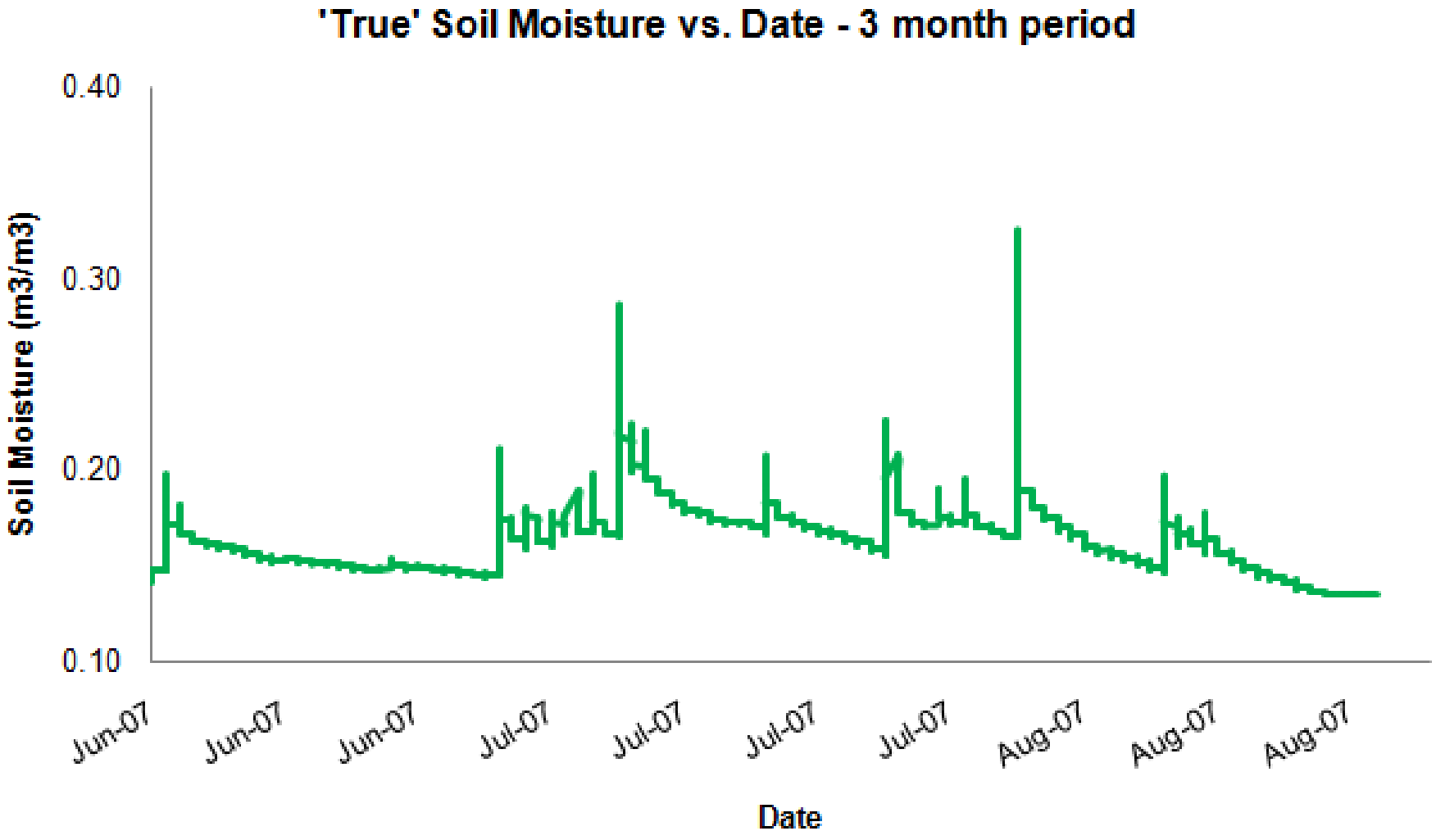


Parameter	3 month period			
	True Value	Open Loop Value	Retrieved Value	Standard Deviation
volume of water at wilting point (m3/m3)	0.135	0.283	0.135	0
volume of water at field capacity (m3/m3)	0.218	0.370	0.221	0.0001
volume of water at saturation (m3/m3)	0.443	0.482	0.379	0.0004
'b' in Campbell equation	5.15	10.40	5.93	0.249
saturated hydraulic conductivity (m/s)	0.000021	0.000001	0.000038	0
Air entry suction (m)	-0.348	-0.490	-0.104	0.0044

Data used in the 'Retrieval' process – **Surface data ONLY**



Parameter	3 month period			
	True Value	Open Loop Value	Retrieved Value	Standard Deviation
volume of water at wilting point (m3/m3)	0.135	0.283	0.142	0.0004
volume of water at field capacity (m3/m3)	0.218	0.370	0.183	0.0010
volume of water at saturation (m3/m3)	0.443	0.482	0.471	0.0227
'b' in Campbell equation	5.15	10.40	5.37	14.716
saturated hydraulic conductivity (m/s)	0.000021	0.000001	0.000114	0.000052
Air entry suction (m)	-0.348	-0.490	-0.103	0.2821


'True' Soil Moisture vs. Date - 3 month period
Soil Moisture (m3/m3)
0.40
0.30
0.20
0.10
Jun-07
Jun-07
Jun-07
Jul-07
Jul-07
Jul-07
Jul-07
Aug-07
Aug-07
Aug-07
Date

Thank You