

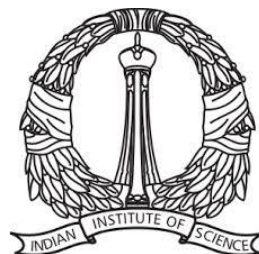
# Quantifying the uncertainty in the estimation of multilayered soil hydraulic properties at catchment scale

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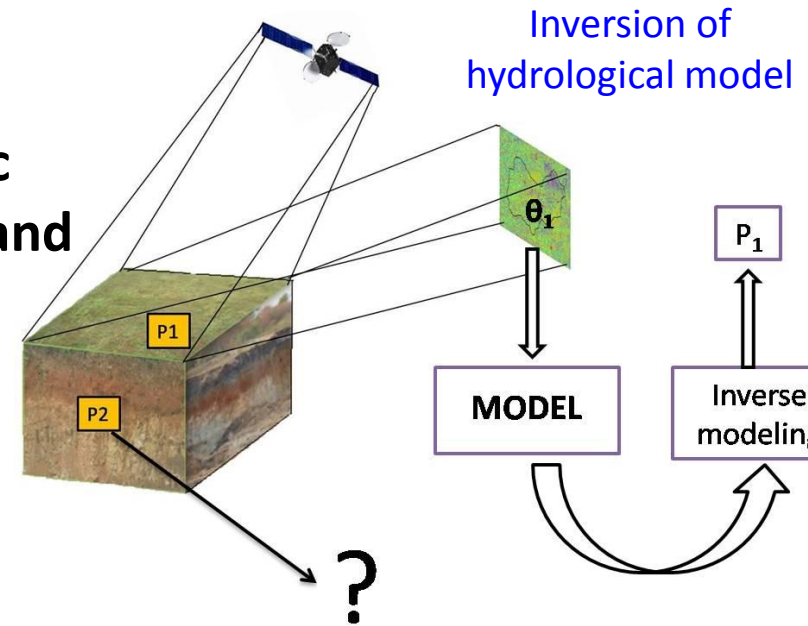
# Overview

- Introduction
- Inversion method and preliminary results
  - Synthetic Experiments
- Impact of model error and sensitivity of the observations on the estimation
- Soil Hydraulic Properties at catchment scale
  - Estimation of LAI and Soil moisture from SAR data
  - Uncertainty in the non-estimated parameters - application at the catchment scale

# Introduction

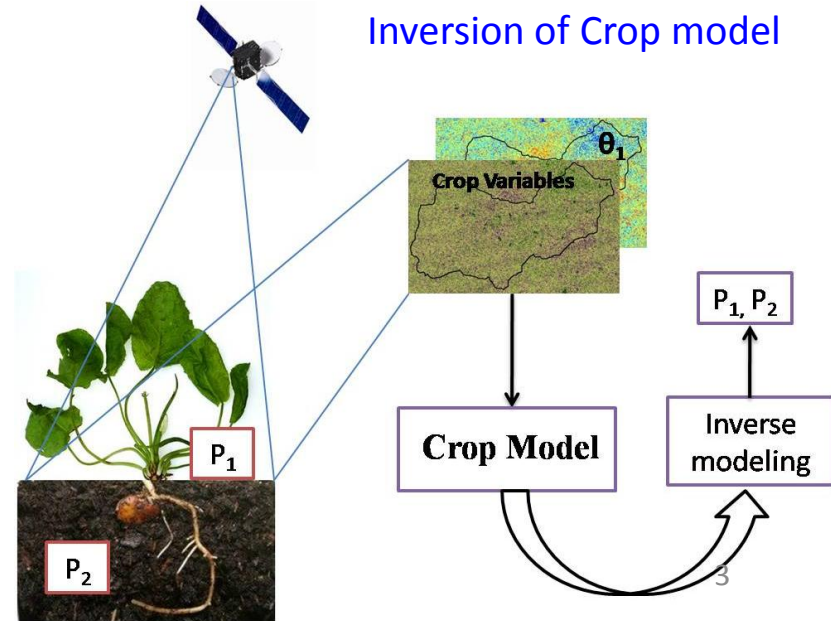
## ❖ Objectives

- Estimation of multilayered soil hydraulic parameters from crop model inversion and remote sensing observations.
- Quantification of uncertainty in the estimation of parameters at catchment scale



## Inversion of Crop Model:

- **Variable:** Surface Soil moisture, Crop variables (Leaf Area Index (LAI) and Biomass)
- Parameters:** Field Capacity, Wilting point and soil depth.
- Good estimation of both surface and **root zone** soil properties.
- Potential to estimate soil properties at **large scale**.



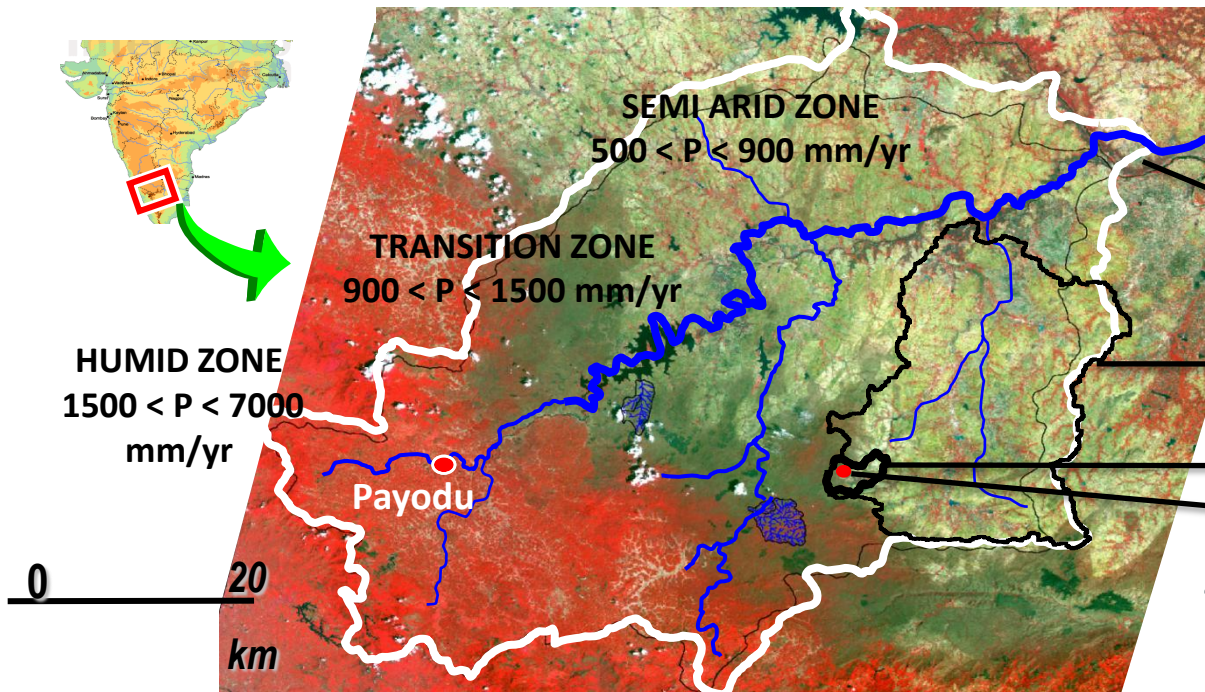
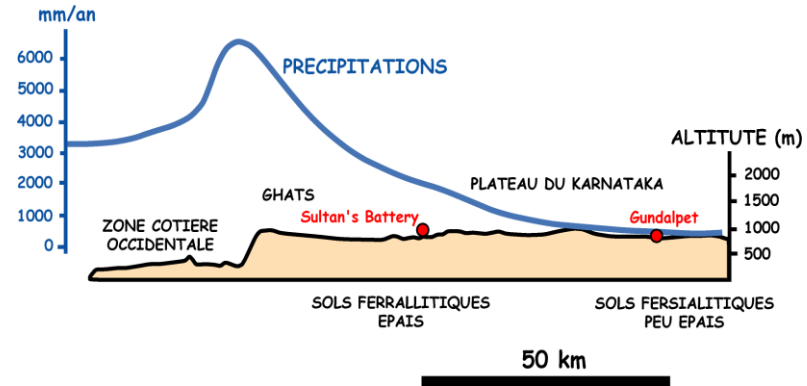
# Introduction

**AMBHAS RESEARCH OBSERVATORY** [www.ambhas.com](http://www.ambhas.com)  
 Indo-French network of observatories ORE BVET  
 Member of the RBV Network (<http://rnbv.ipgp.fr/>)



Geochemistry, weathering (Braun et al., 2009, GCA)  
 Hydrology / forest interactions (Ruiz et al., 2010, JoH)  
 Soil parameters/ Scale effect (Sat Kumar et al., 2010, HP)  
 Agrohydrology (Sreelash, Sekhar et al., 2012, JoH)  
 Satellite hydrology (Eswar et al., 2013, JGR-Atmos.)

## A strong climatic gradient



## NESTED WATERSHEDS Processes at different scales

The Kabini basin. 7000 km<sup>2</sup>

Gundal (900 km<sup>2</sup>)

Berambadi (84 km<sup>2</sup>)

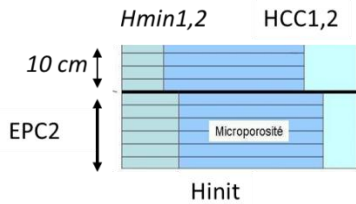
Maddur (7 km<sup>2</sup>)





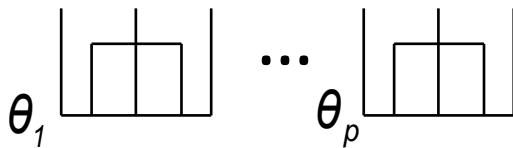
# The inversion method - GLUE

(Beven and Binley, 1992)



Soil parameters

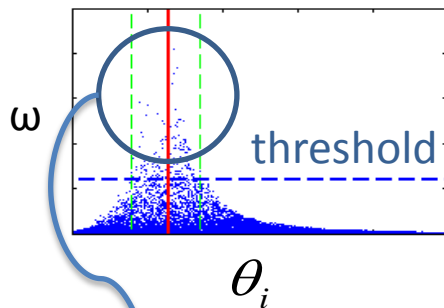
A priori distribution of parameters to estimate



Random sampling



Simulated values of observed variables

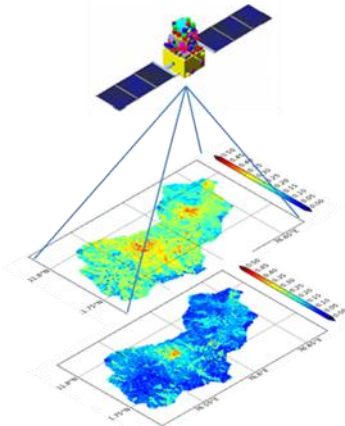


Likelihood function  $\omega$

Observations

$$\hat{\theta}_i = \text{mean}(\text{acceptable } \theta_i^j)$$

$$\sigma(\theta_i) \text{ (Uncertainty)}$$



Ground data  
Remote sensing data

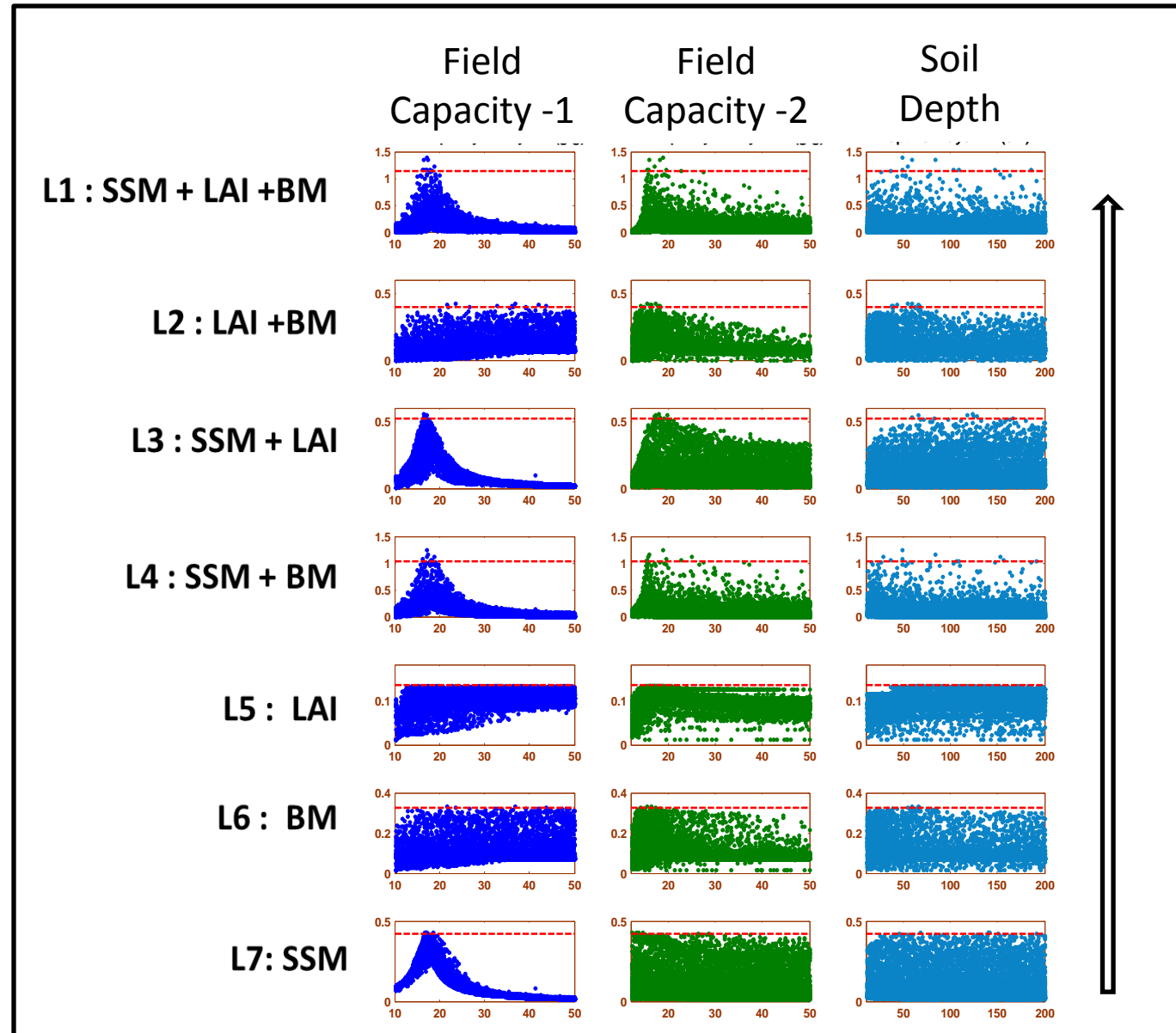
# Effect of type of observation set on parameter estimability

## Synthetic Experiment



- ❖ 15 soil types
- ❖ Maize crop
- ❖ Observations :
  - Surface soil moisture SSM
  - LAI, Biomass BM

(freq. of obs. = 10 days)

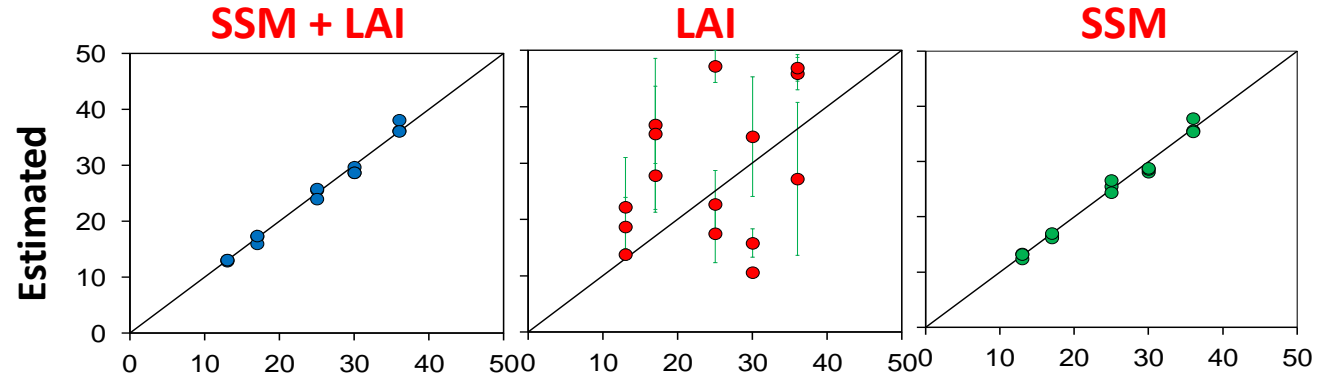


# Effect of type of observation set on parameter estimability

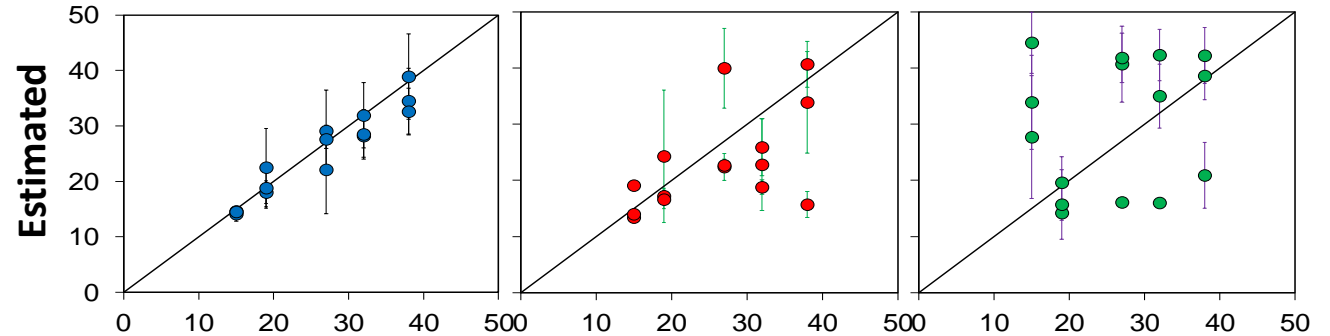


## Synthetic Experiment

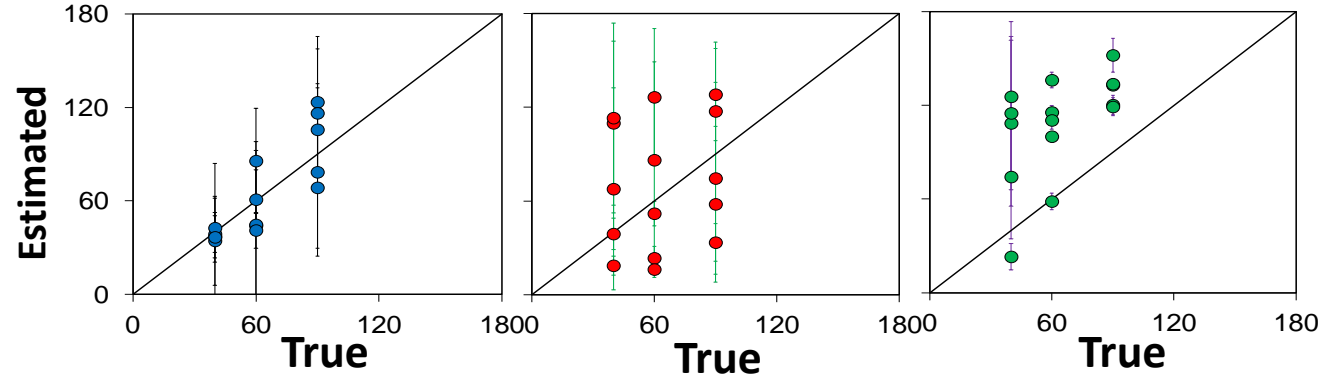
Field Capacity  
Layer-1



Field Capacity  
Layer-2



Thickness of  
Layer-2 (cm)



# Effect of type of observation set on parameter estimability

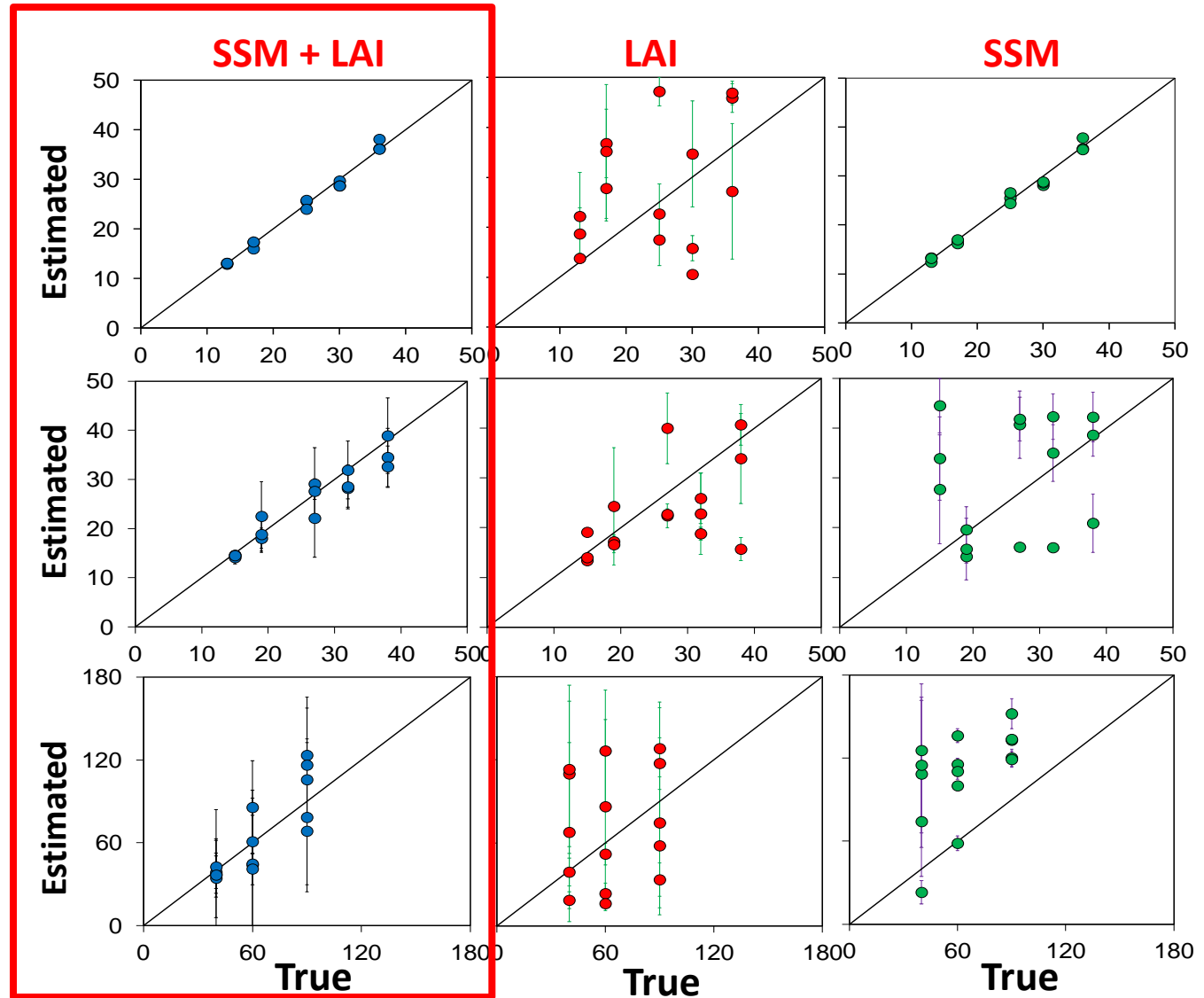


## Synthetic Experiment

Field Capacity  
Layer-1

Field Capacity  
Layer-2

Thickness of  
Layer-2 (cm)



# **Error analysis in the estimation of parameters**

## **Factors affecting the estimation of parameters**

- **Model error.**

  - **Model's ability to simulate the inversion variable**

- **Sensitivity of the observations.**

  - **Parameter sensitivity to observations over time.**

- **Compensation between parameters.**

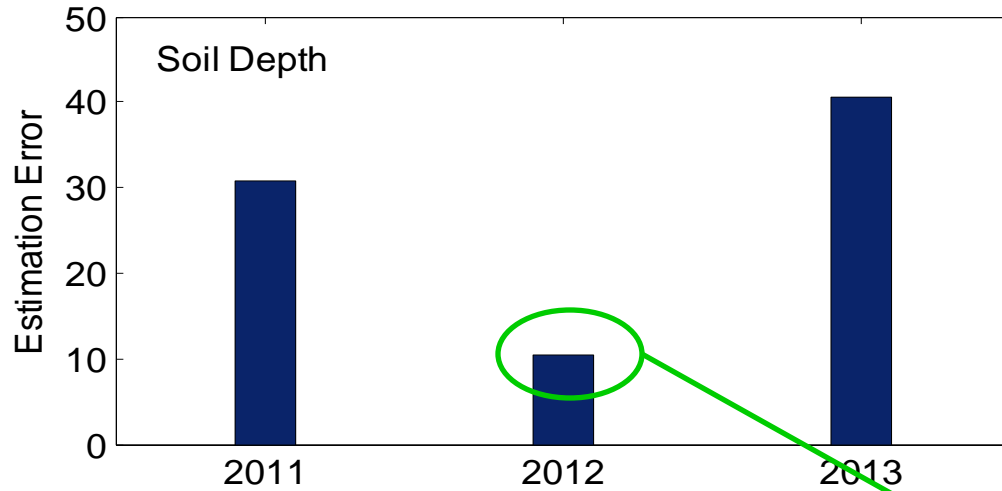
  - **Correlation between parameters in model.**



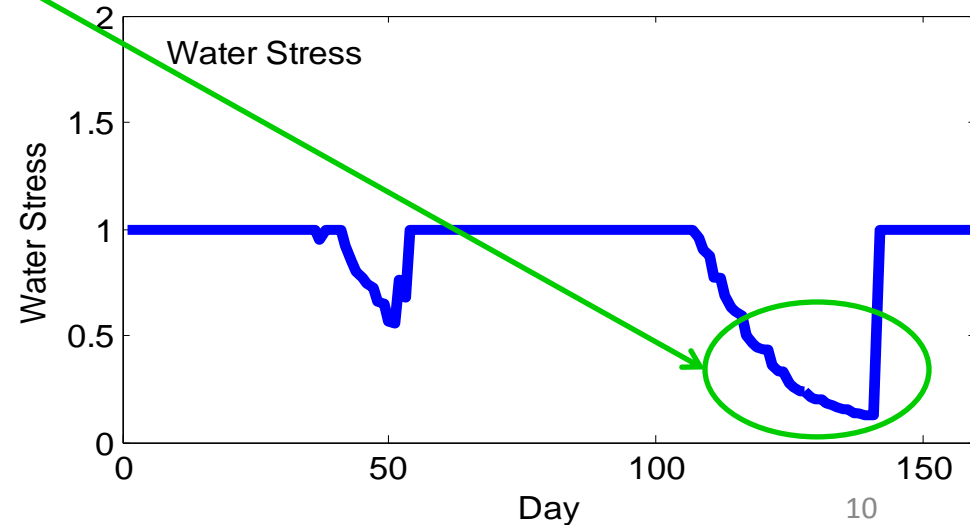
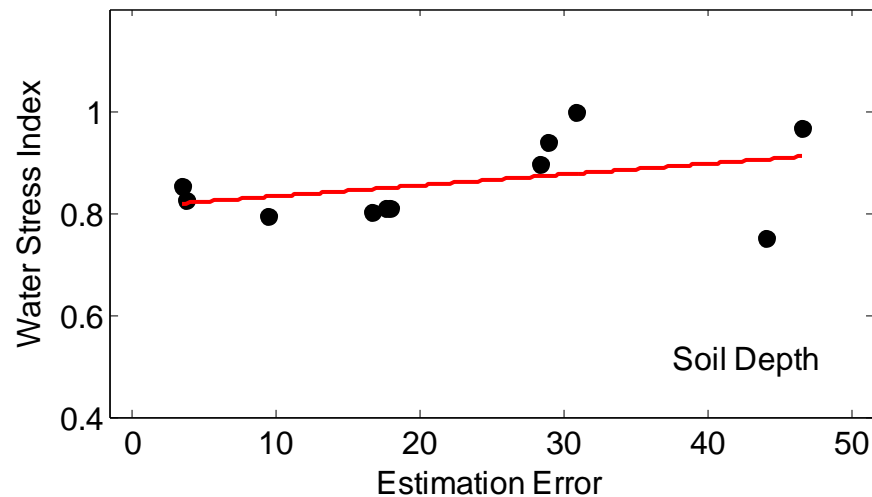
# Effect of Model Error and Crop condition

**Experiment :** Same experimental plot in three different years.

**Results :** Estimation quality is affected by



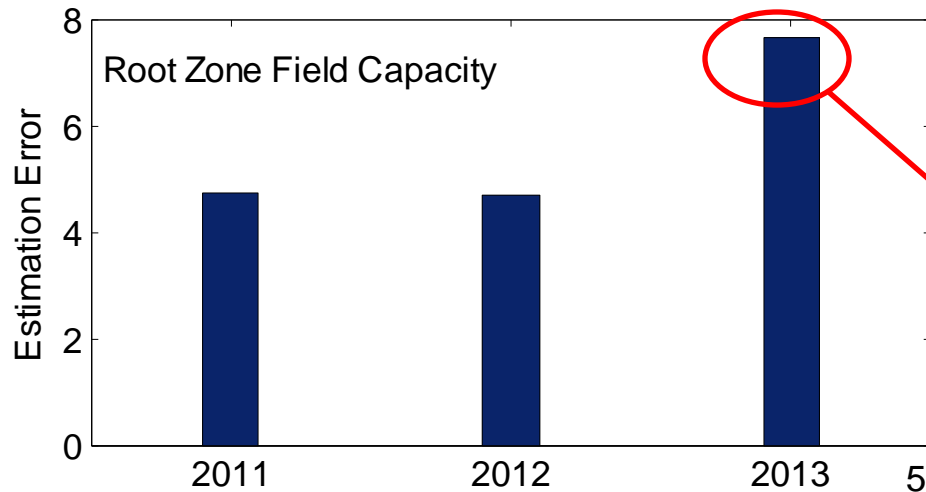
**(1) Crop condition :Water stress**



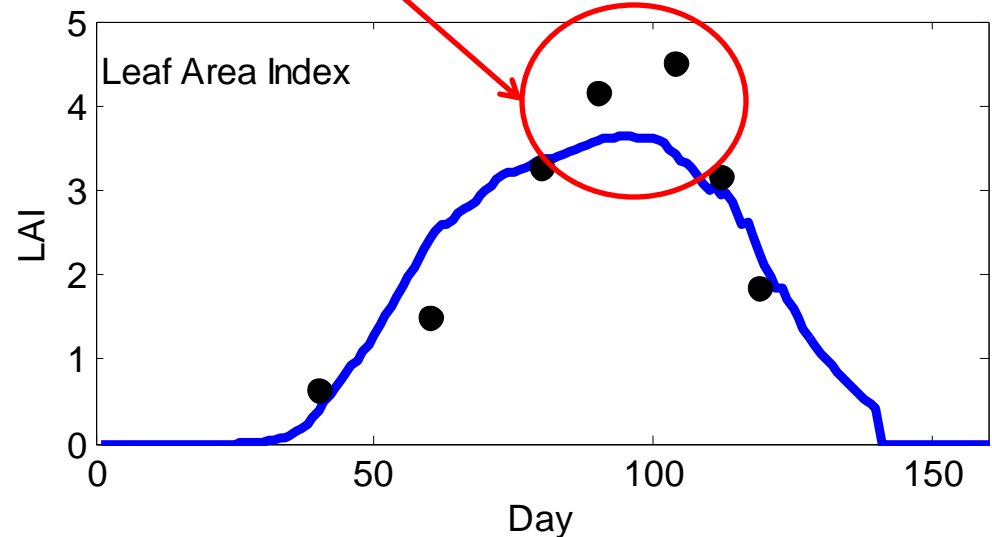
# Effect of Model Error and Crop condition

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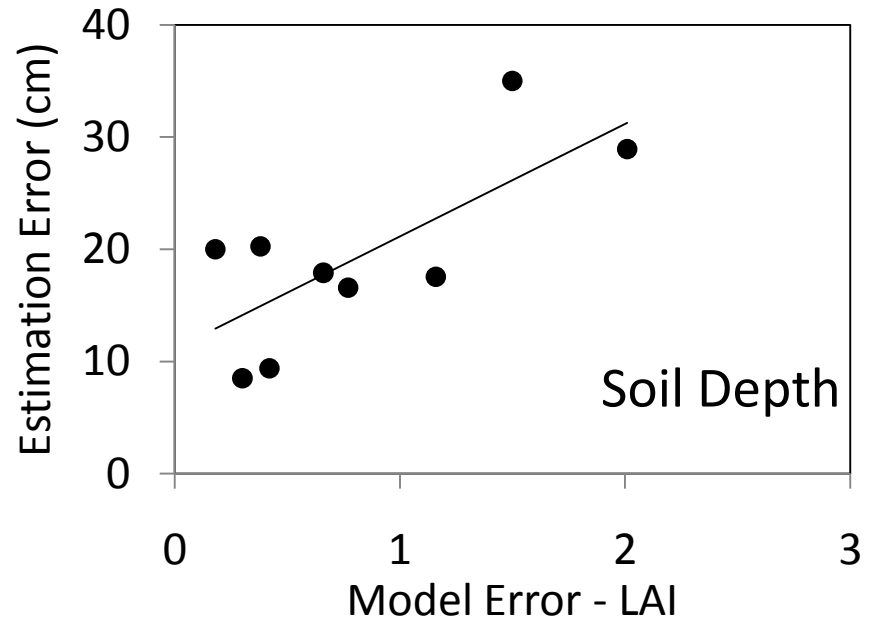
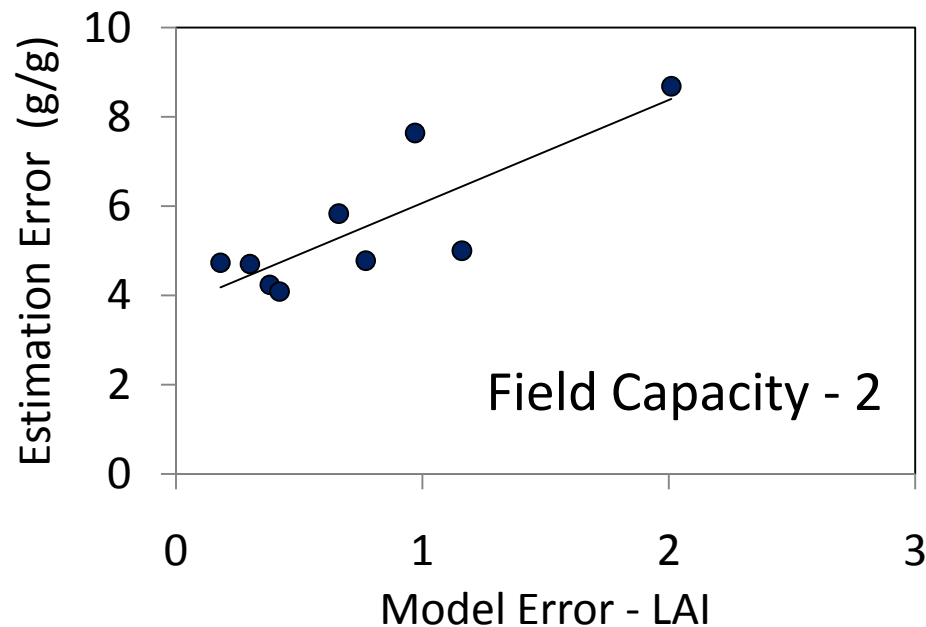
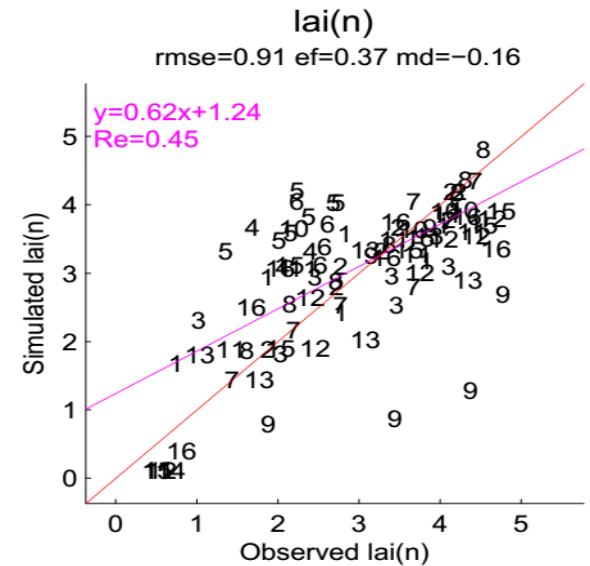
**(2) Model Errors**



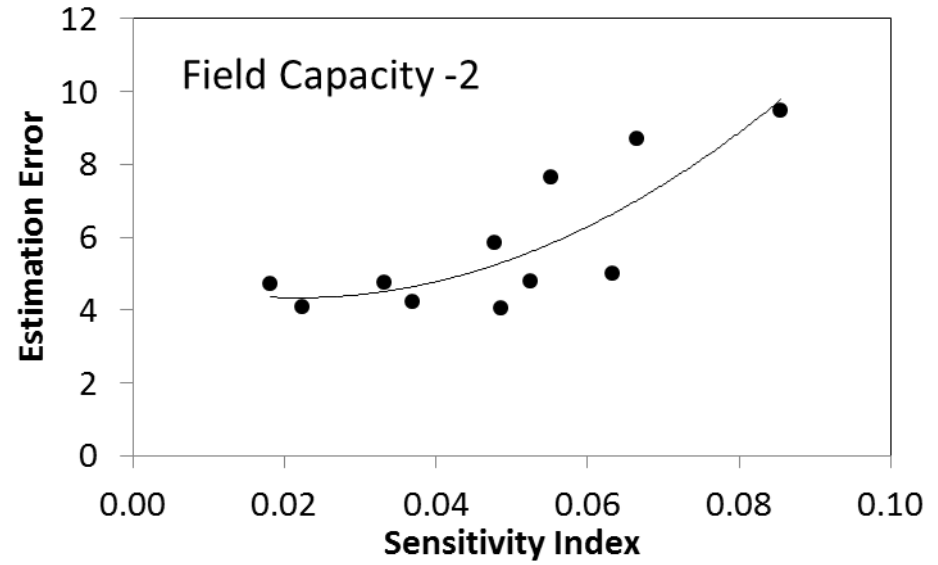
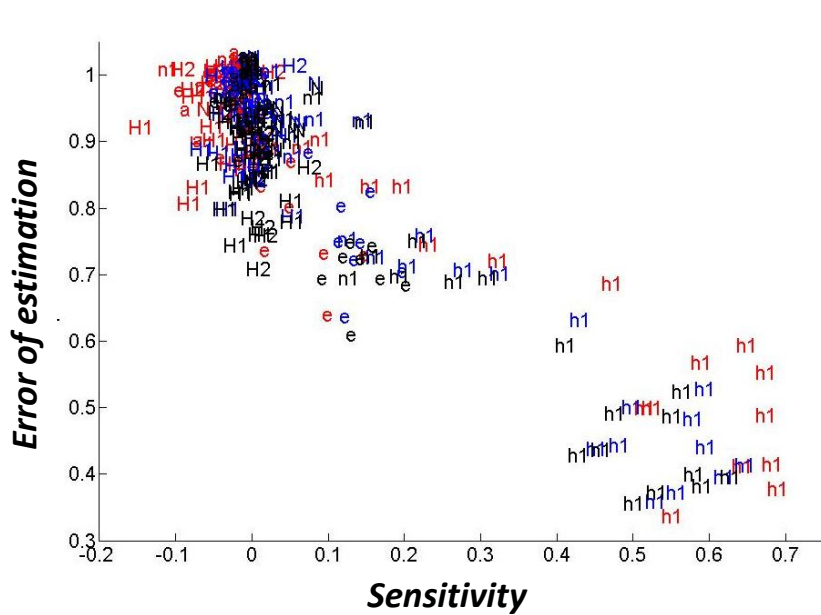
# Effect of Model Error on the quality of estimation

Model Error quantified w.r.t to SSM and LAI.

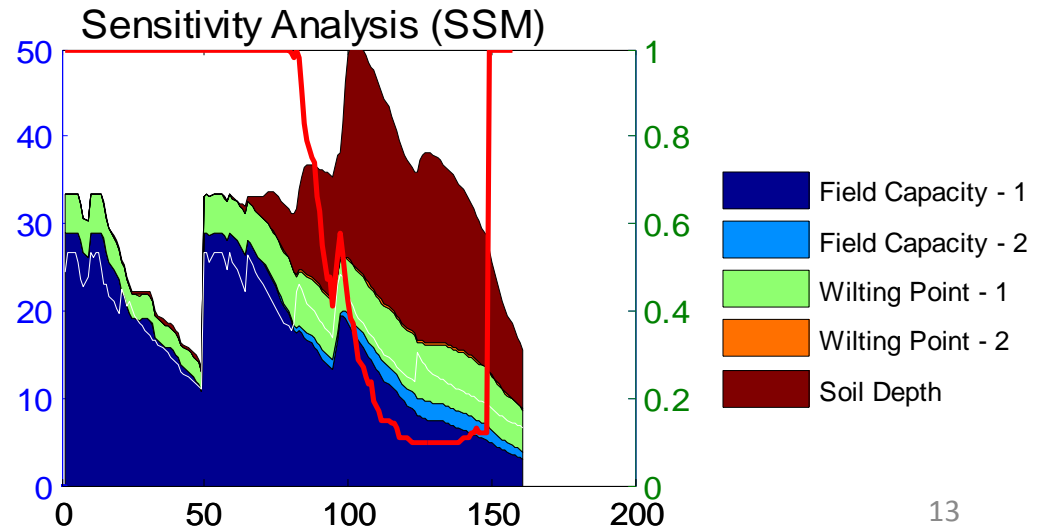
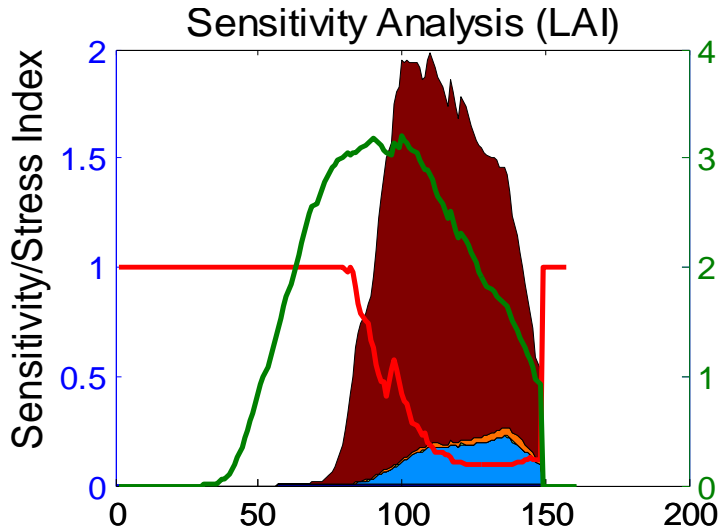
12 experimental sites used for study.  
Experiments with Maize crop.



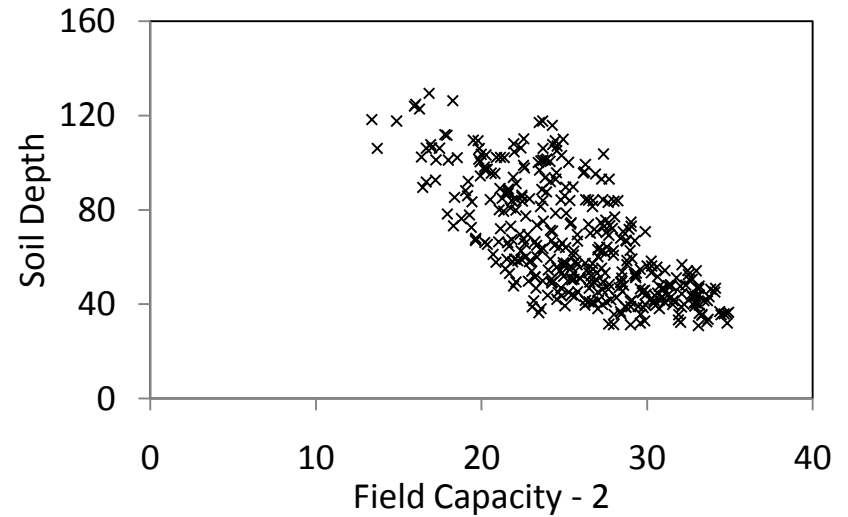
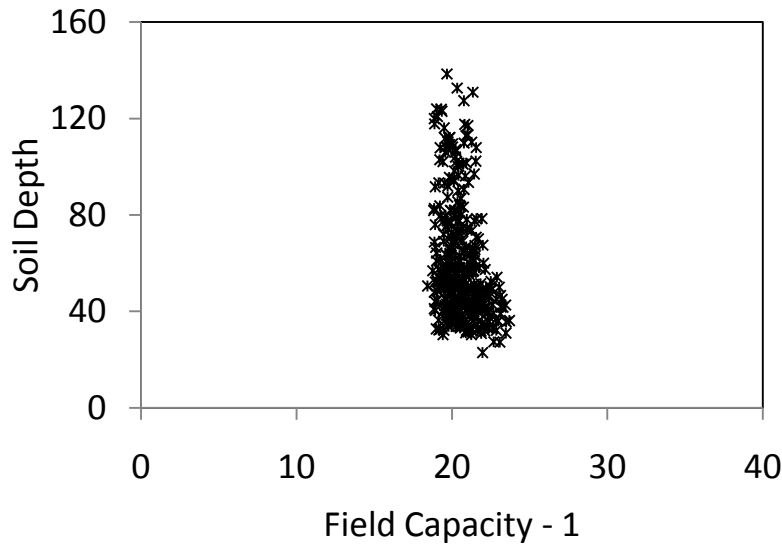
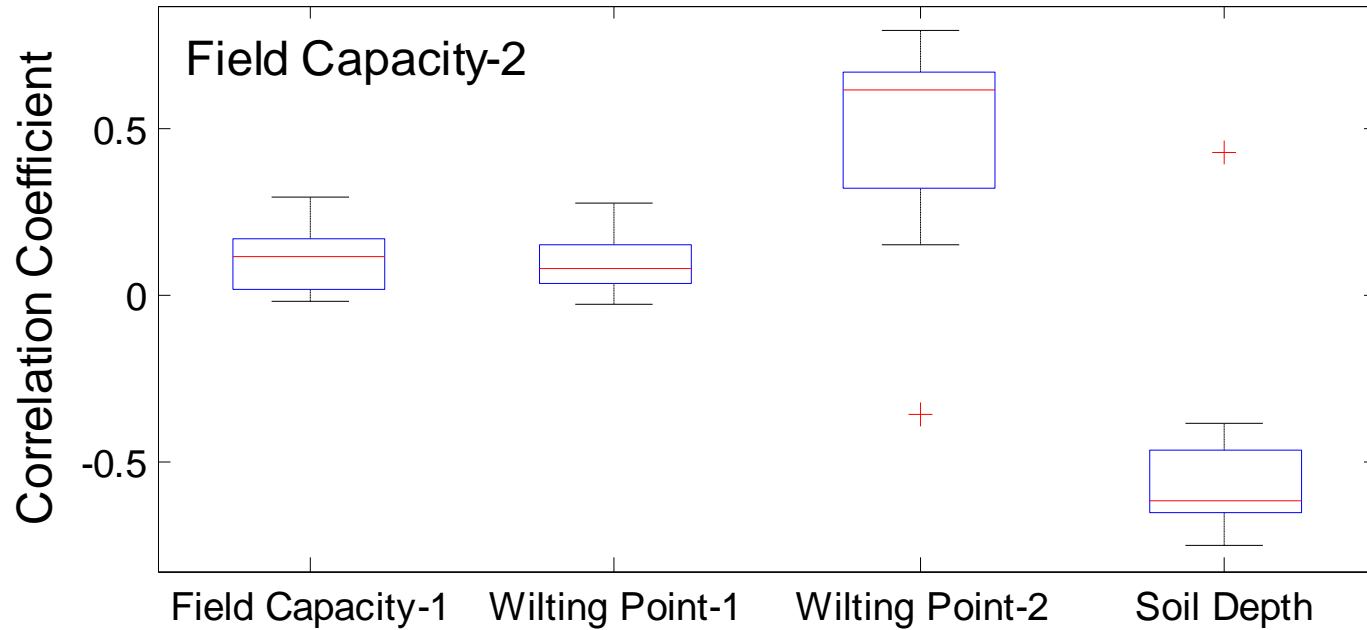
# Link between quantity of information in observations and water stress



Varela, H, Guérif, M, Buis, S, 2010. *Environmental Modelling & Software*. 25 (2010) 310–319.



# Compensation between estimated parameters

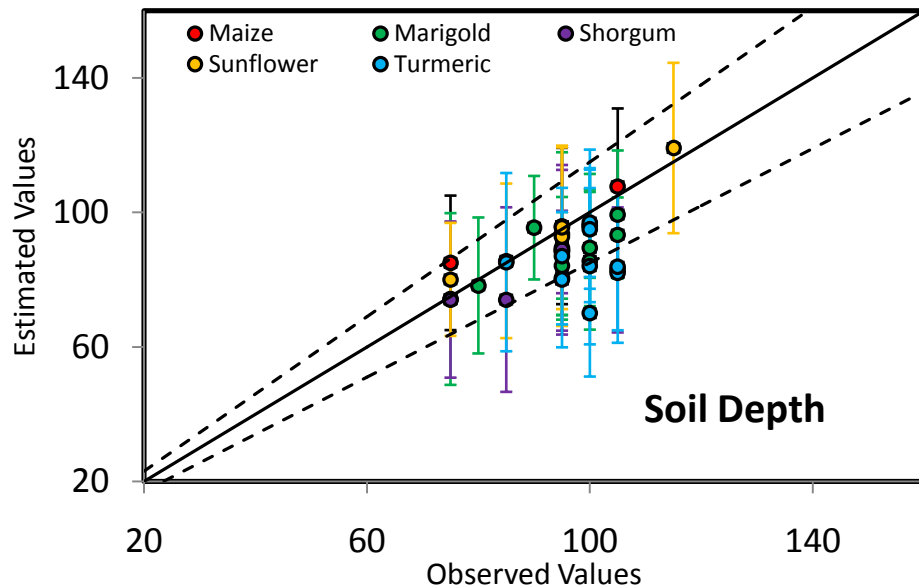
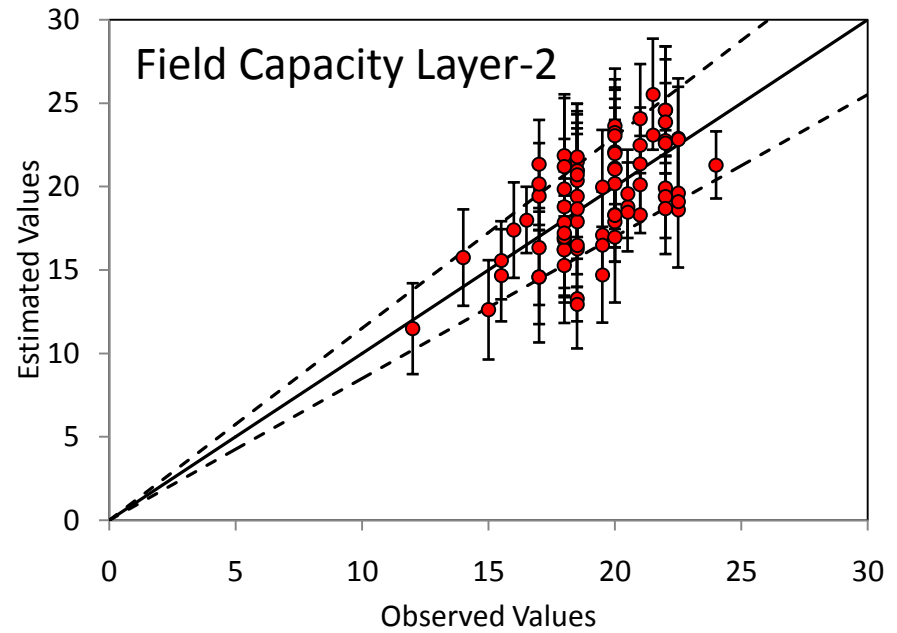
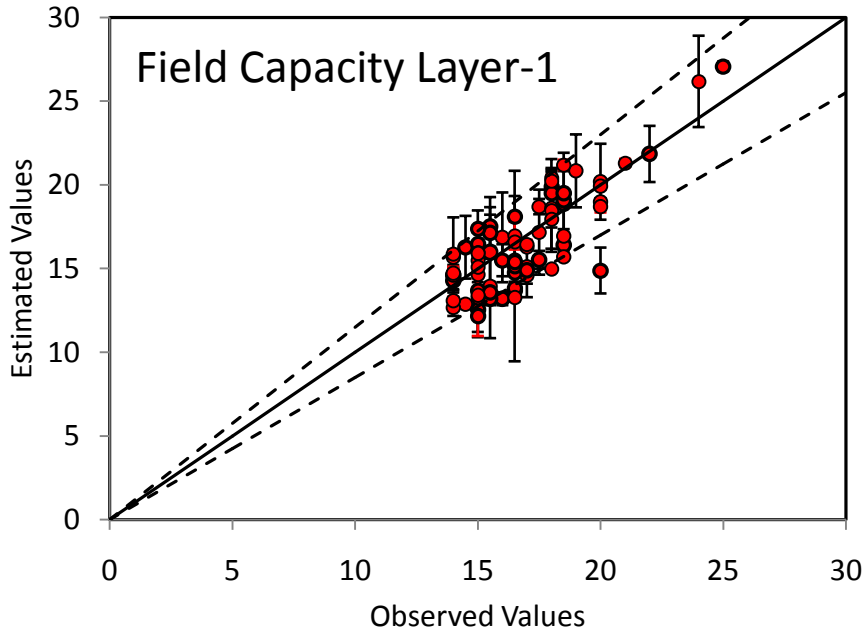




# Summary: Error analysis

- **Parameter estimation affected by model error, sensitivity of parameters to observations and parameter correlations.**
- **Model error can be reduced using locally calibrated model.**
- **Use of quality prior information essential to constrain some parameters and to minimize the parameter compensations.**
- **Model conditions (water stress in this case) also contributes to better/poor estimation of parameters.**
- **Parameters show varying sensitivity to the variables at different period of simulations.**

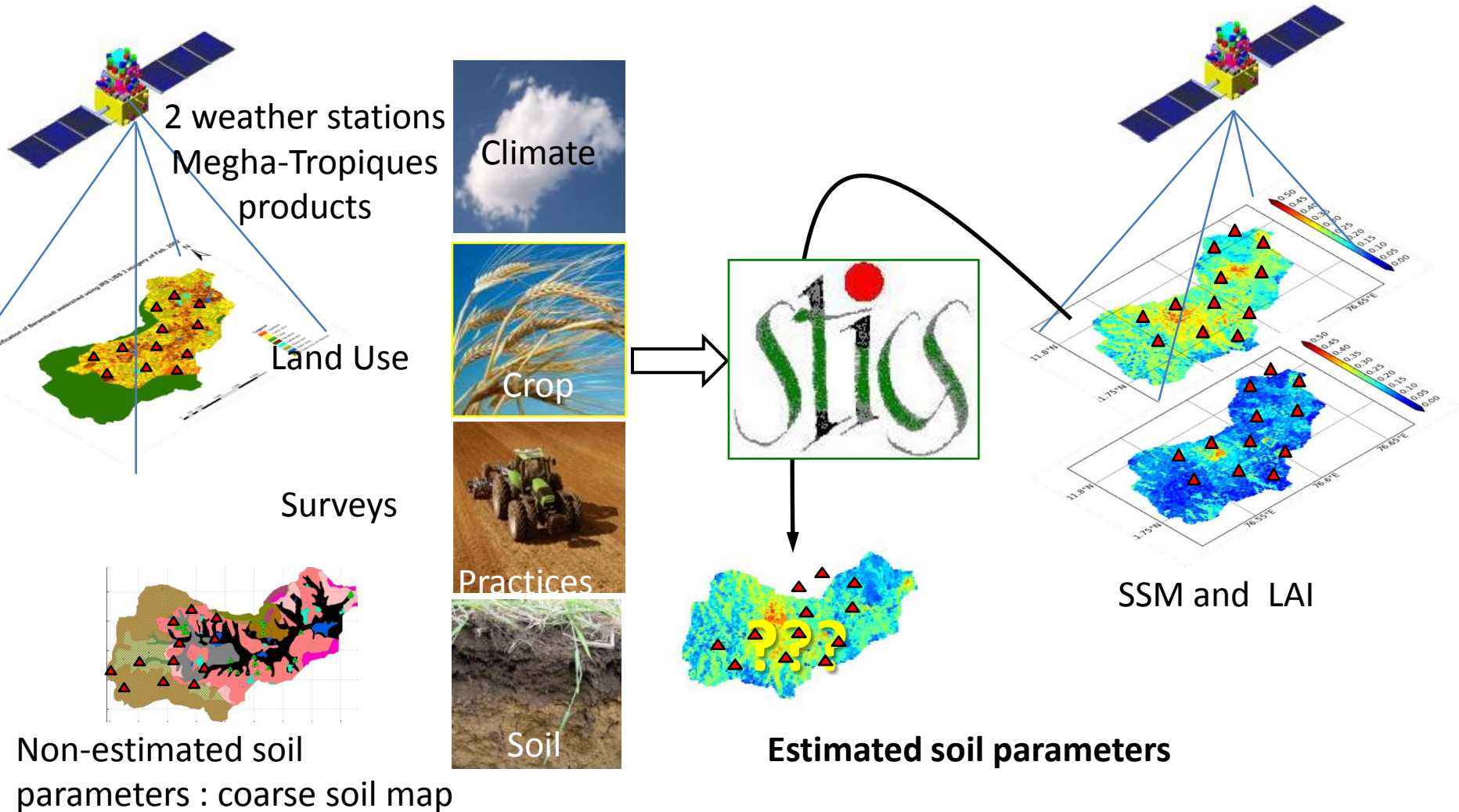
# Estimation of Soil Hydraulic Properties



Turmeric and Marigold provided relatively poor estimates of soil depth, this is because of the shallow rooting system of these crops (30 to 50 cm),

Deep rooted maize, sunflower and sorghum provided good estimates of soil depth.

# Soil Hydraulic Property Estimation at the catchment scale



# Retrieval of surface soil moisture from RADARSAT-2 data

## Data:

L-Band (Fully polarimetric radar data)

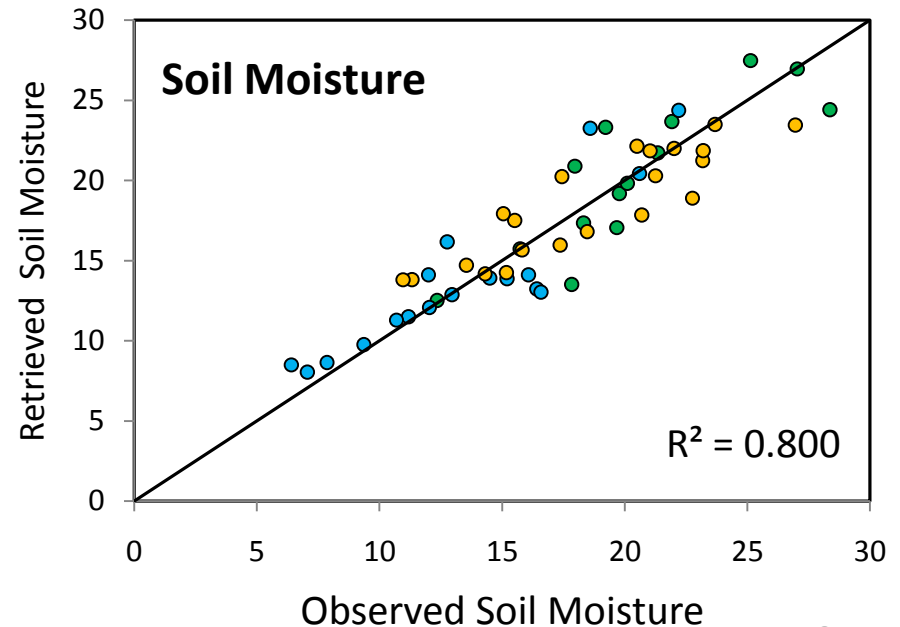
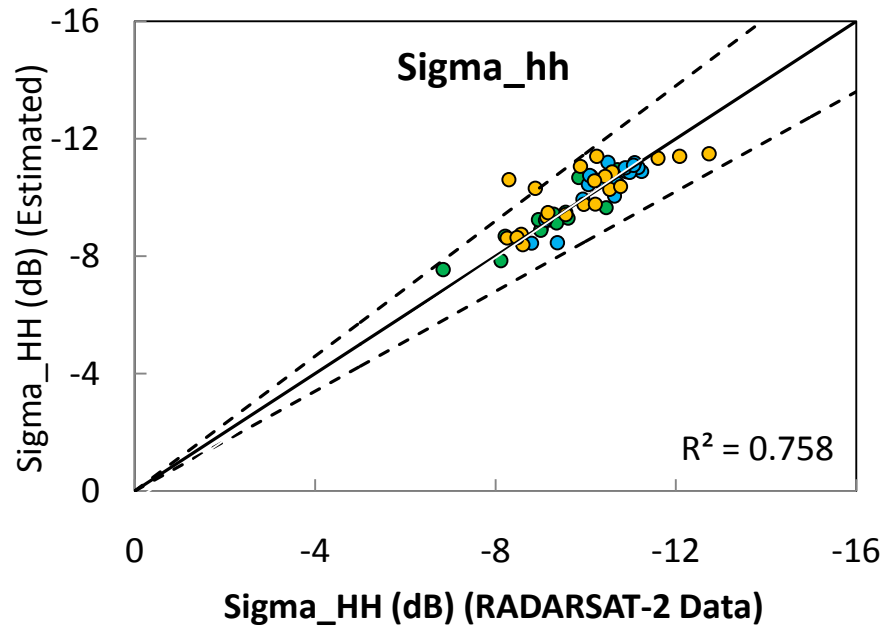
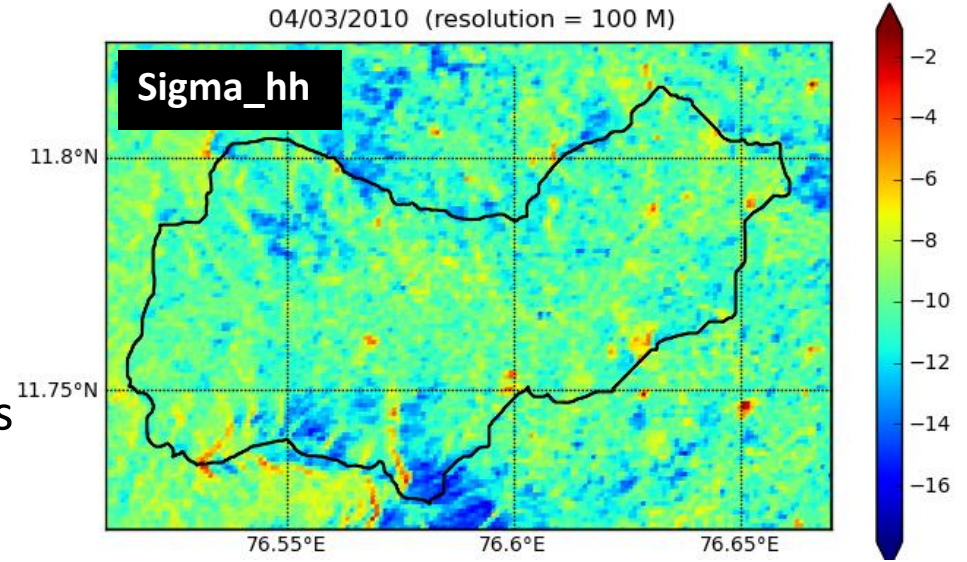
Spatial Resolution: 15.6 m

Incidence angle: 23 degrees.

## Method:

Water Cloud Model for vegetated areas

Calibrated for several crops



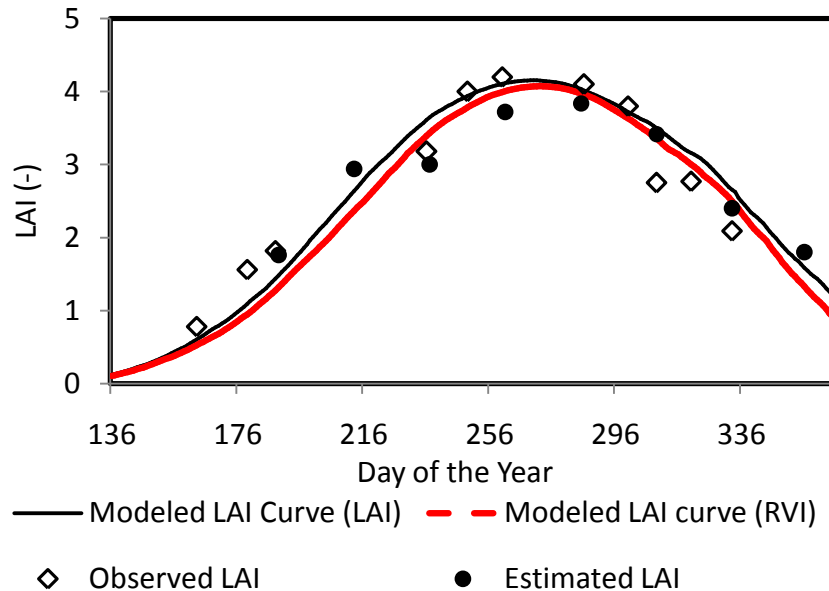
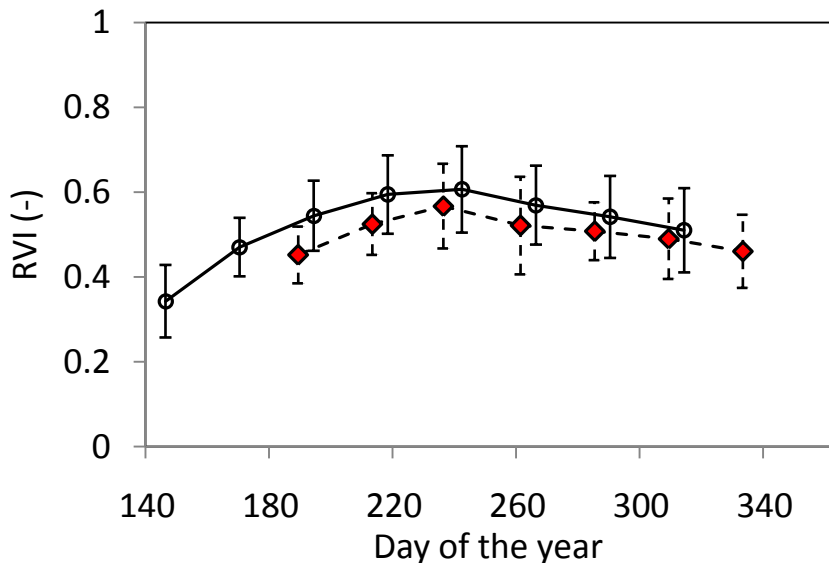
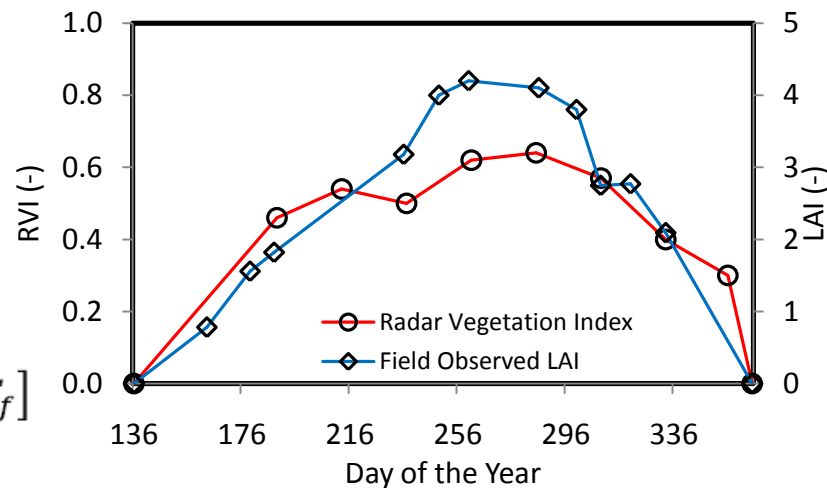
# Retrieval of LAI from RADARSAT-2 data

**Radar Vegetation Index** (Kim and Van Zyl, 2000)

$$RVI = \frac{8\sigma^o_{HV}}{\sigma^o_{HH} + \sigma^o_{VV} + 2\sigma^o_{HV}}$$

**Parametric LAI growth Curve** (F.Baret, 1996)

$$LAI(d) = K \left[ \frac{1}{1 + \exp(-b(T(d) - T_i))} - \exp(a * T(d) - T_f) \right]$$





# Uncertainty in the Non-Estimated Parameters

## Non- Estimated Parameters

### 1) Soil Parameters

- Soil Physical and
- Chemical properties
- Runoff Coefficient

### 2) Crop Parameters

- Sowing
- Fertilization
- Irrigation

## Data Sources

Field Experiments

Soil Map  
Farmer Survey

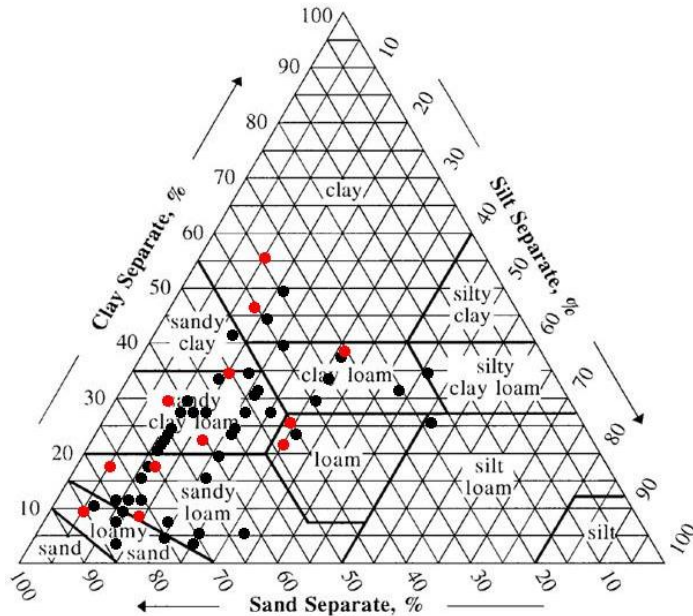
Standard references  
Decision Rules  
Remote Sensing proxies

## Level of Precision

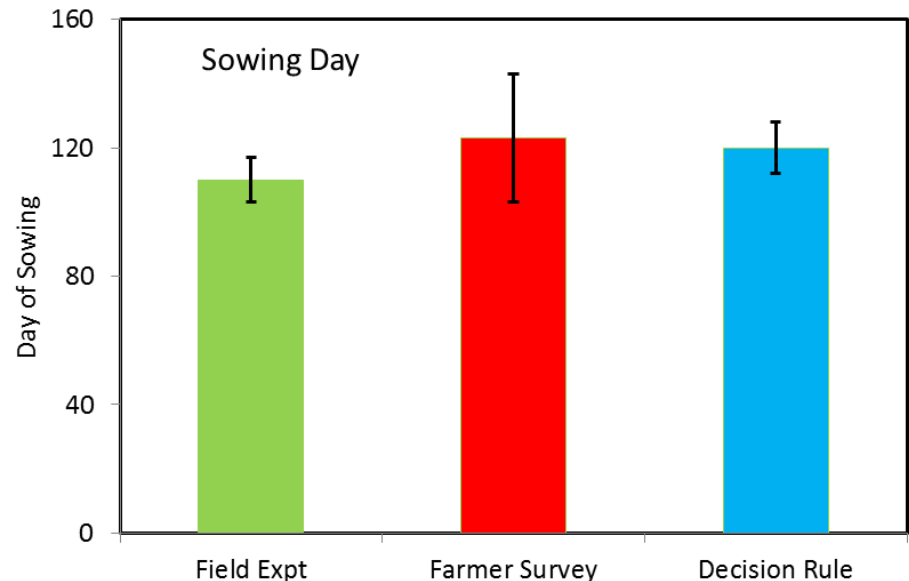
Good Precision (lesser uncertainty)

Low Precision (Larger uncertainty)

Medium Precision (Medium uncertainty)



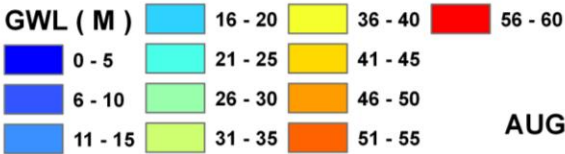
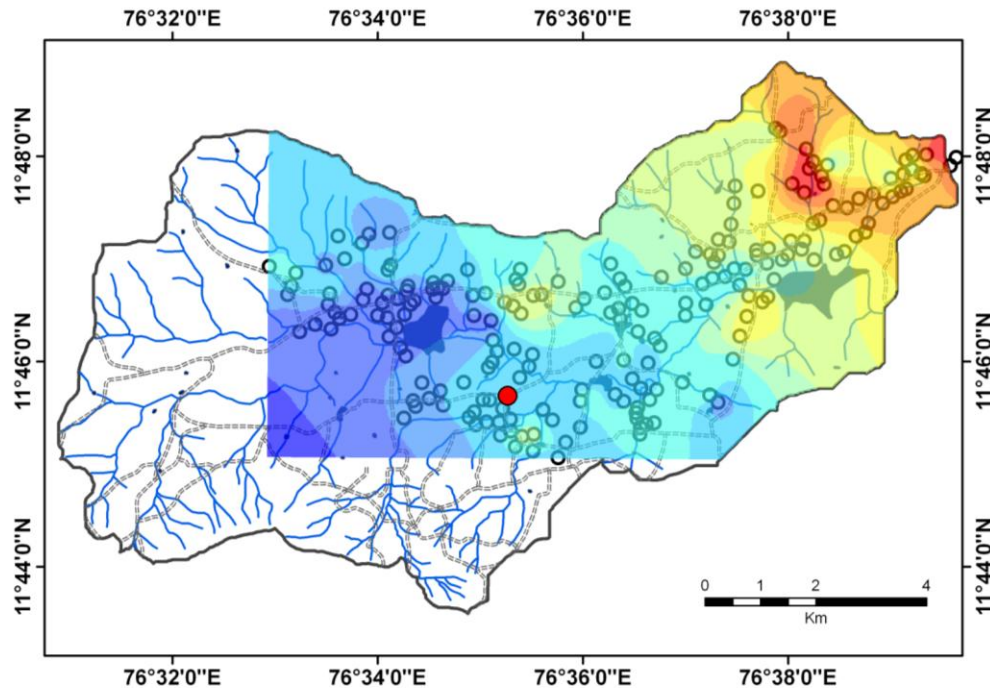
● Map Points ● Field Points



# Conclusions

- Estimation of multilayered soil hydraulic properties by inversion of a crop model : **Promising Approach.**
- Parameter estimation **affected by model error, sensitivity of parameters to observations and parameter correlations.**
- Uncertainty in **the non-estimated parameters** needs to be quantified for spatializing the approach.

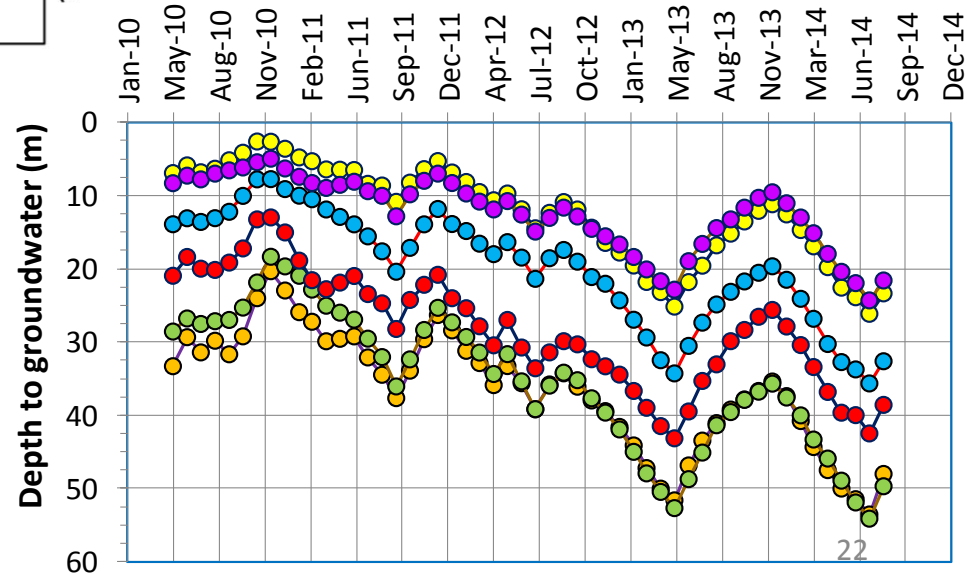
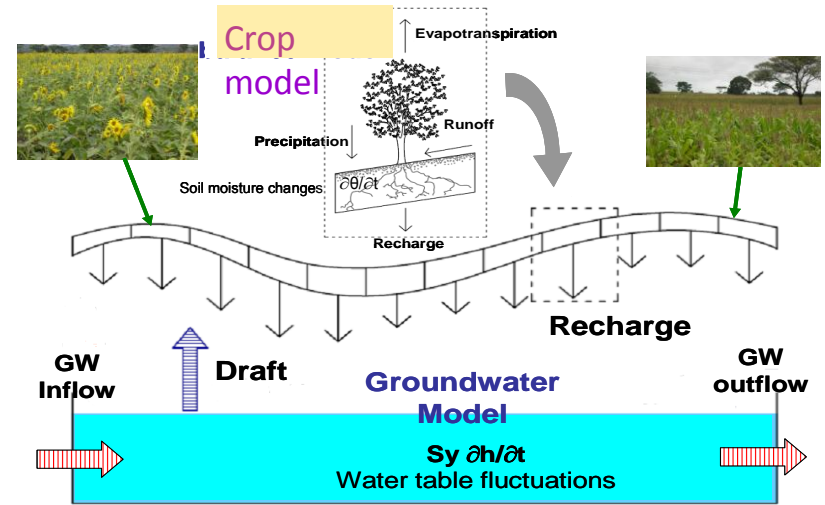
# Perspective – Next step : validation of potential recharge estimates using groundwater level measurements



AUGUST 2014

220 monitoring wells Since 2010

Large spatial and temporal contrasts



Thank you