

# Multi-temporal remote sensing for spatial estimation of Plant Available Water holding Capacity (PAWC)

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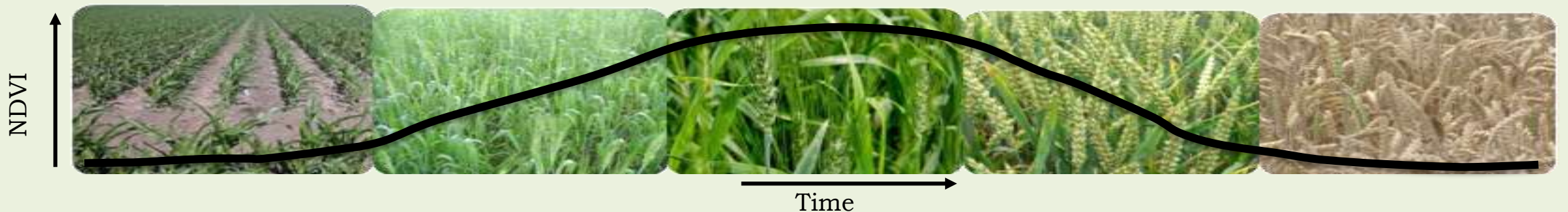
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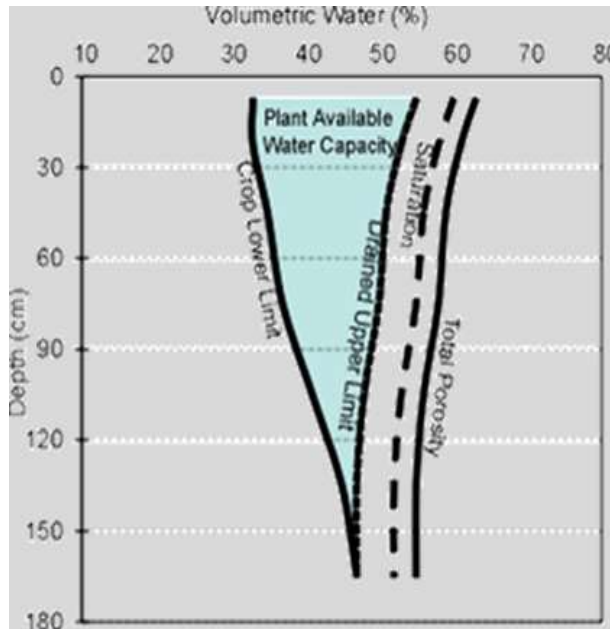
Spatial Information Group (SIG)

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# Background

## ➤ Plant Available Water Capacity (PAWC)-



- Bucket size of a soil
- Total amount of water available for crops that the soil can store
- Upper storage limit (saturation) - Lower limit (wilting Point).

# Background

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## ➤ Plant Available Water Capacity (PAWC)-



*Patchiness in crop due to variable soil water holding capacity*

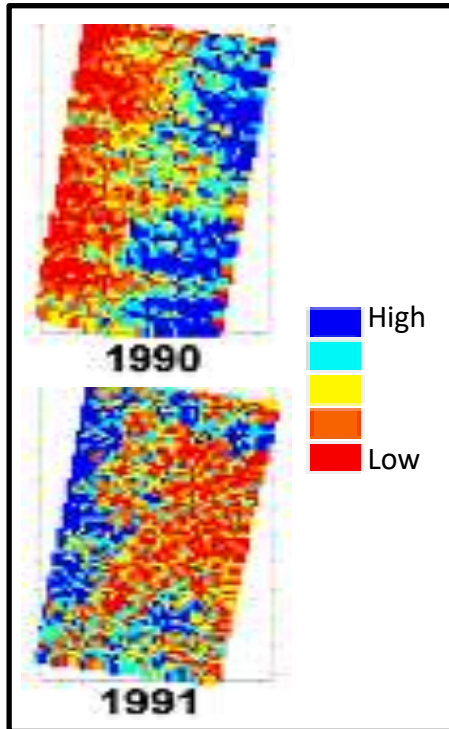
(Hall et al., 2009)

- Spatially – highly variable => high growth and yield variability
- In Mediterranean environment – differences in PAWC explained a large portion of crop yield variability

# Background

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## ➤ Plant Available Water Capacity (PAWC)-



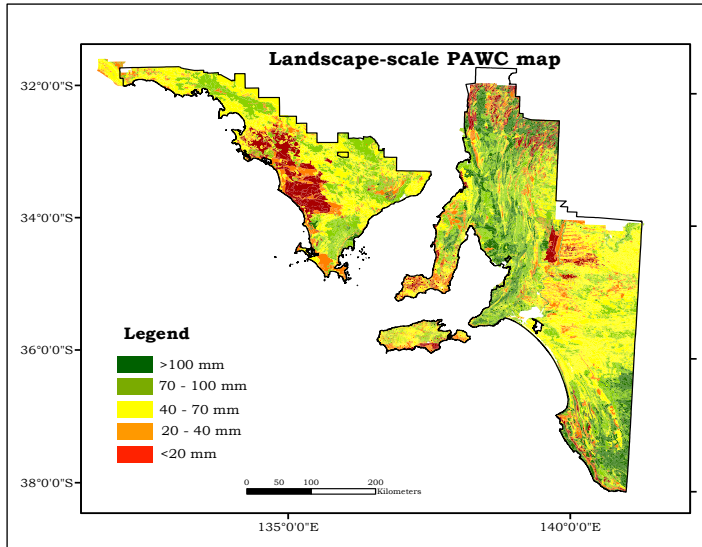
(Boydell et al., 2001)

- Temporally - strong interaction with climate => yield and growth pattern variability from year to year- “flip flop scenario”
- Interaction with rainfall amount and seasonality
- PAWC modulates the vegetation response to climatic variability

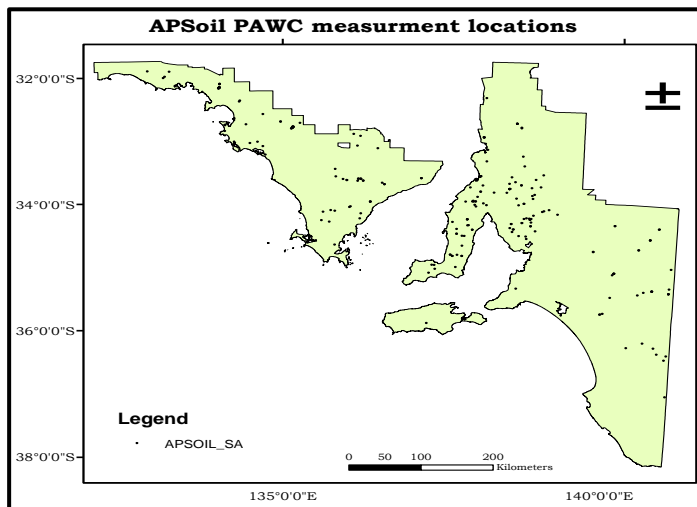


# Existing PAWC data in SA

- The two most used available PAWC data in South Australia:



- Soil landscape map of South Australia – 1:100,000 (Hall et al., 2009)



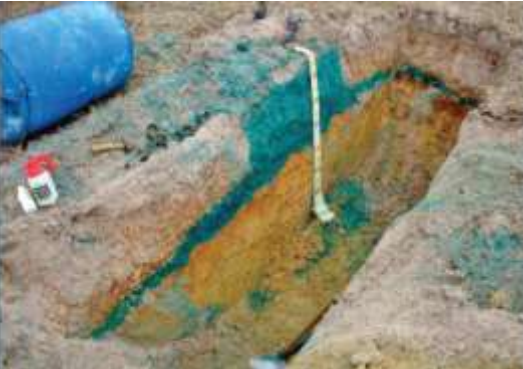
- APSoil database - Point based database of soil PAWC measurement (<http://www.asris.csiro.au>)

# Plant Available Water Capacity (PAWC)

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Source: <http://aciar.gov.au/>



Source: <http://www.soilquality.org.au/>

## ➤ Measurement

- Time consuming
- Relatively expensive
- Difficult to choose representative soil sampling locations

➤ So alternative approach is needed to be used as a surrogate

# Plant Available Water Capacity (PAWC)

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## ➤ Indicators

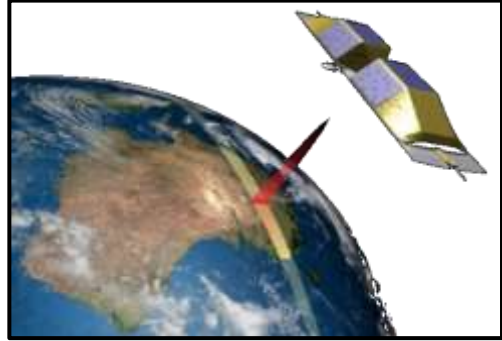
- Spatial growth variability or Patchiness
- Temporal variability



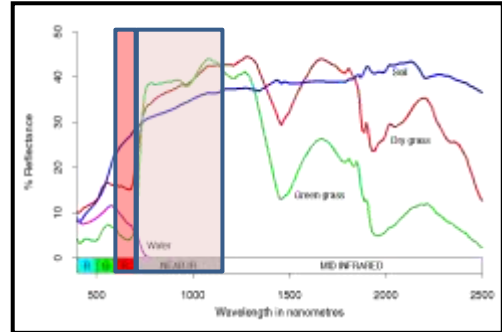
## ➤ So we need to observe

- Vegetation variability
- Regular temporal change – intra annual time scale

# Potential of Remote Sensing

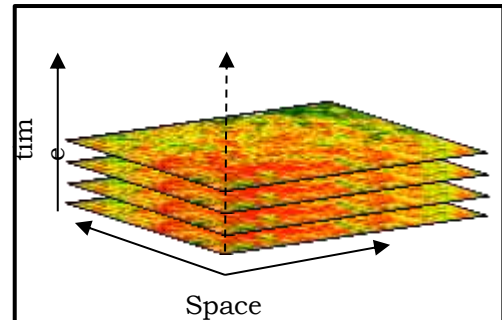


- **Quantify vegetation vigour** - Vegetation indices (eg. NDVI)



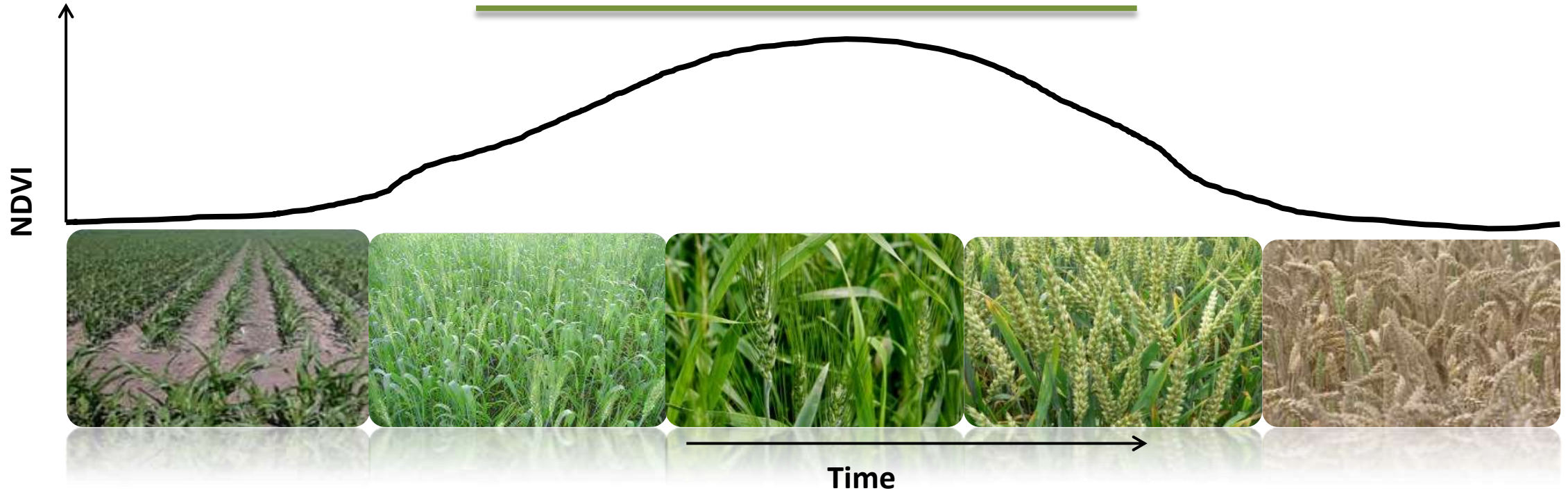
- **Regular revisiting time** – Multi- temporal observation

=> Vegetation growth dynamics



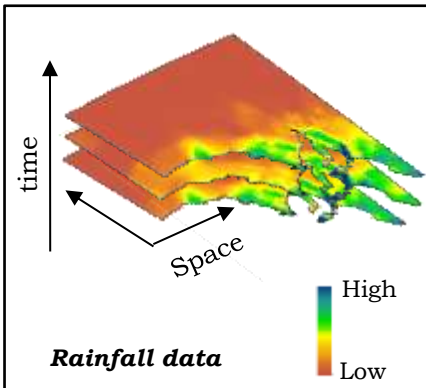
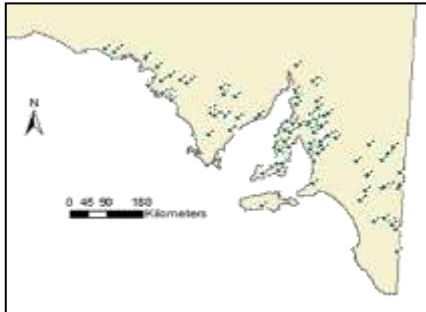
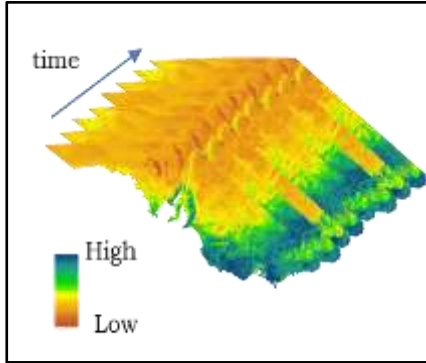


# Crop phenology from NDVI



- Crop growth dynamics - inform about the environment including water availability,
- Observations across different climatic conditions (many years) can provide a novel insight about the spatial variability of the underlying soil

# Materials and Methods



## ➤ MODIS NDVI - Phenological metrics

- Temporal - 16 days
- Spatial - 250m
- 2001 – 2015 (345 images)

## ➤ Measured Soil PAWC from APSoil (<http://www.asris.csiro.au>)

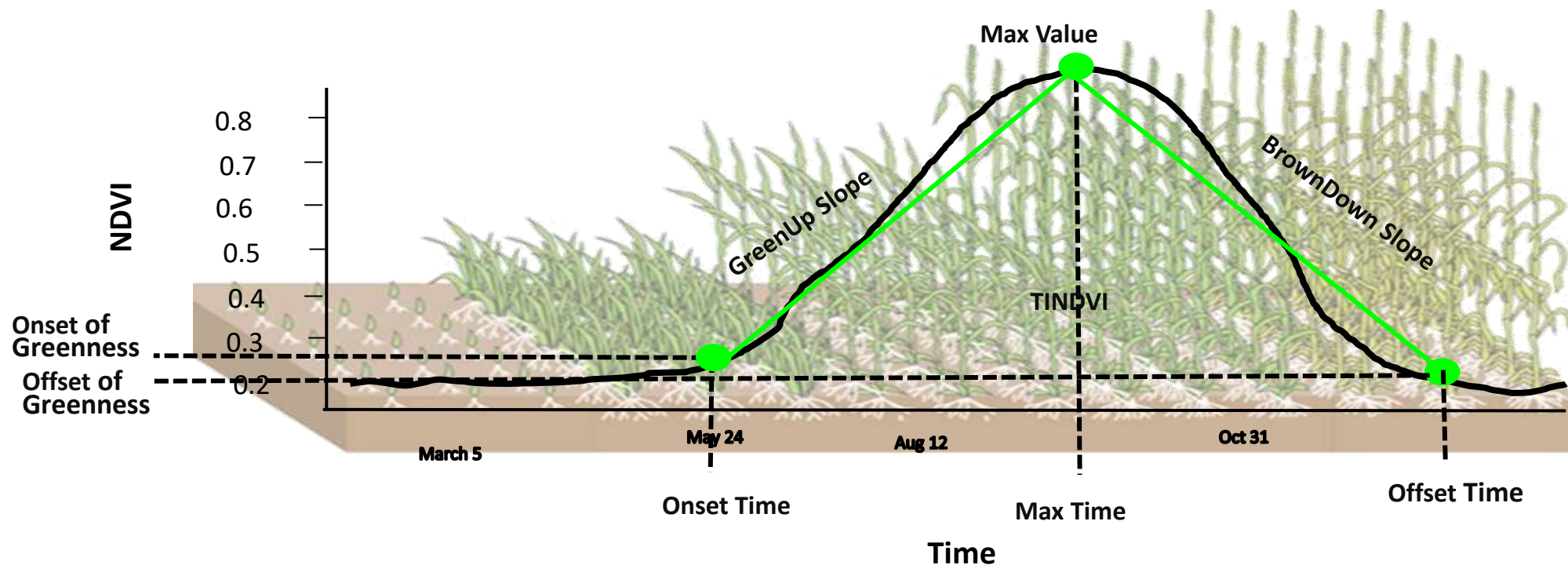
- 256 observation points across SA

## ➤ Rainfall data (<http://www.bom.gov.au/>)

- Spatial resolution of 5km



# Phenologic metrics



- A new software package – “CropPhenology package” in R software environment

(<https://github.com/SofanitAraya/CropPhenology/wiki/CropPhenology-Package>)

- 15 Metrics are defined

# Spatial Modelling

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- To assess the relationship between Phenological metrics and PAWC across different climatic conditions - A linear mixed effects model

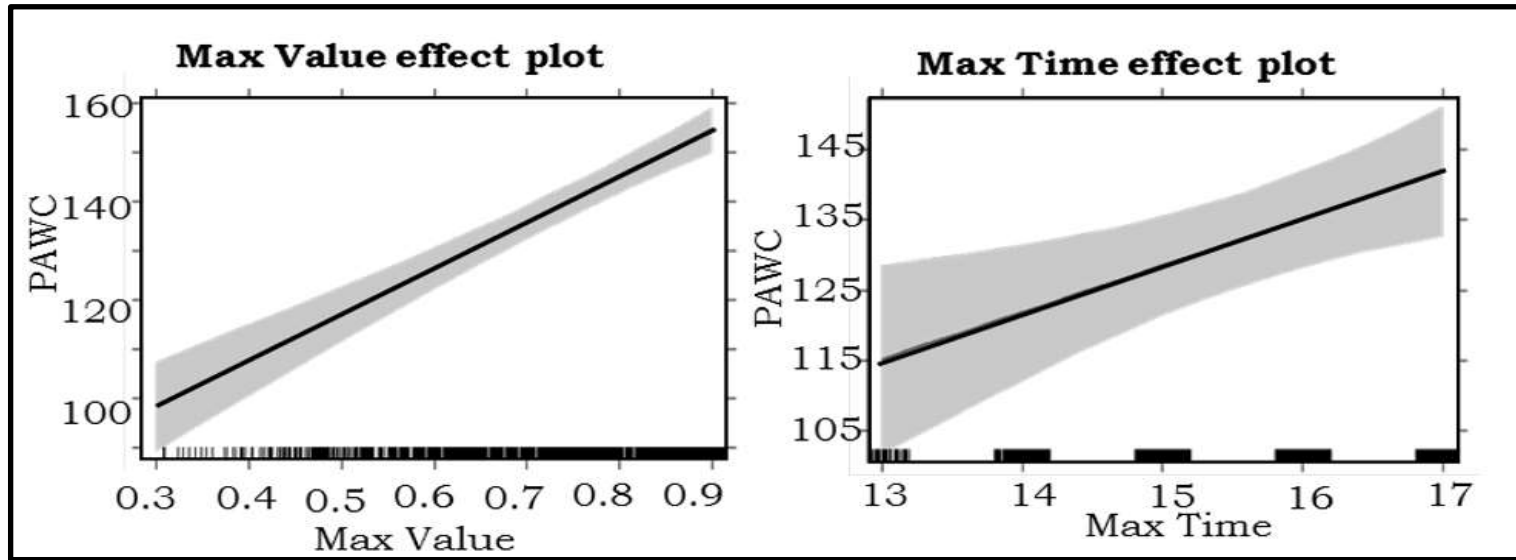
PAWC  $\Leftrightarrow$  (Phenologic Metrics, Growing season rainfall, Year, sub region, error )

$$PAWC_j^{\frac{1}{3}} = \beta_0 + \beta_1(Max Value_j)^3 + \beta_2(Max Time_j) + \beta_3(GSRF) + a_1(Year) + a_2(S) + \epsilon_j$$

Where :

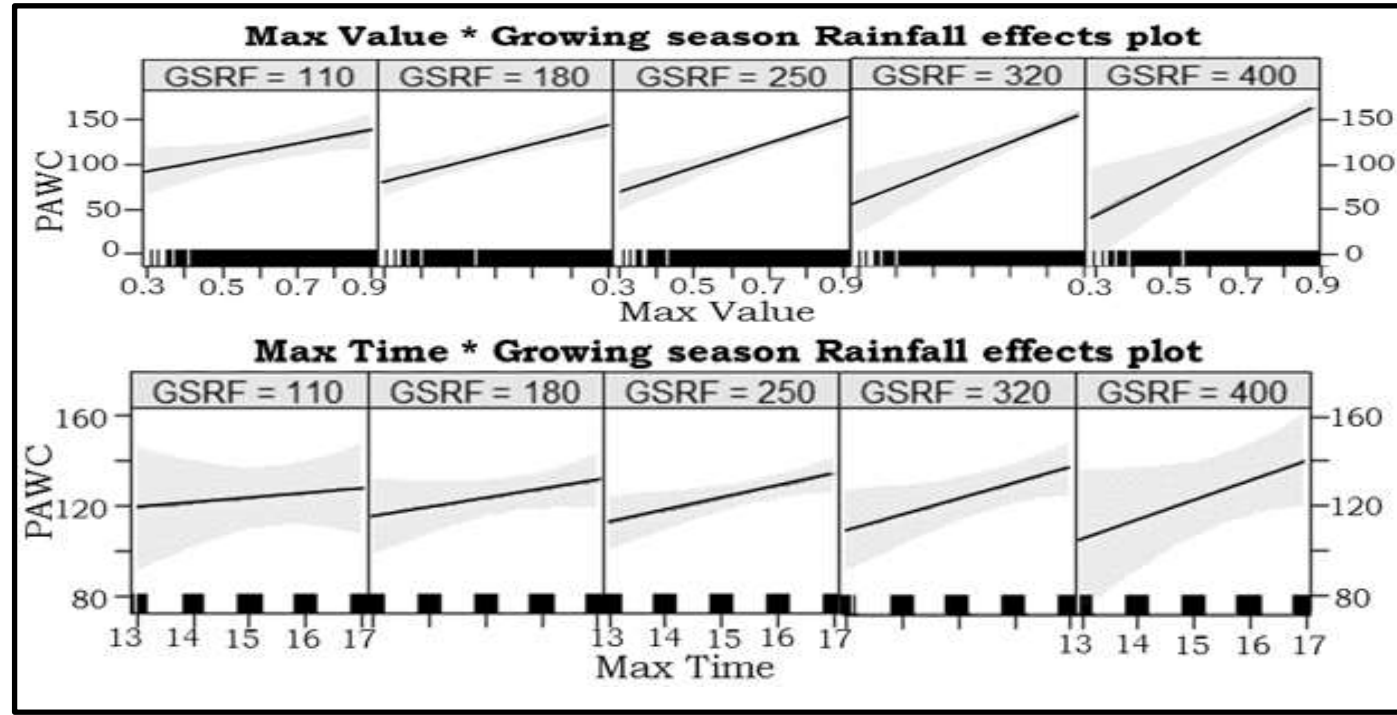
- **Max Value** and **Max Time** are phenological metrics,
- **GSRF**- growing season rainfall
- **Year** – the observation year and
- **S** – a dummy variable representing the subregion of the state
- $\epsilon$  - an error term

# Spatial Modelling



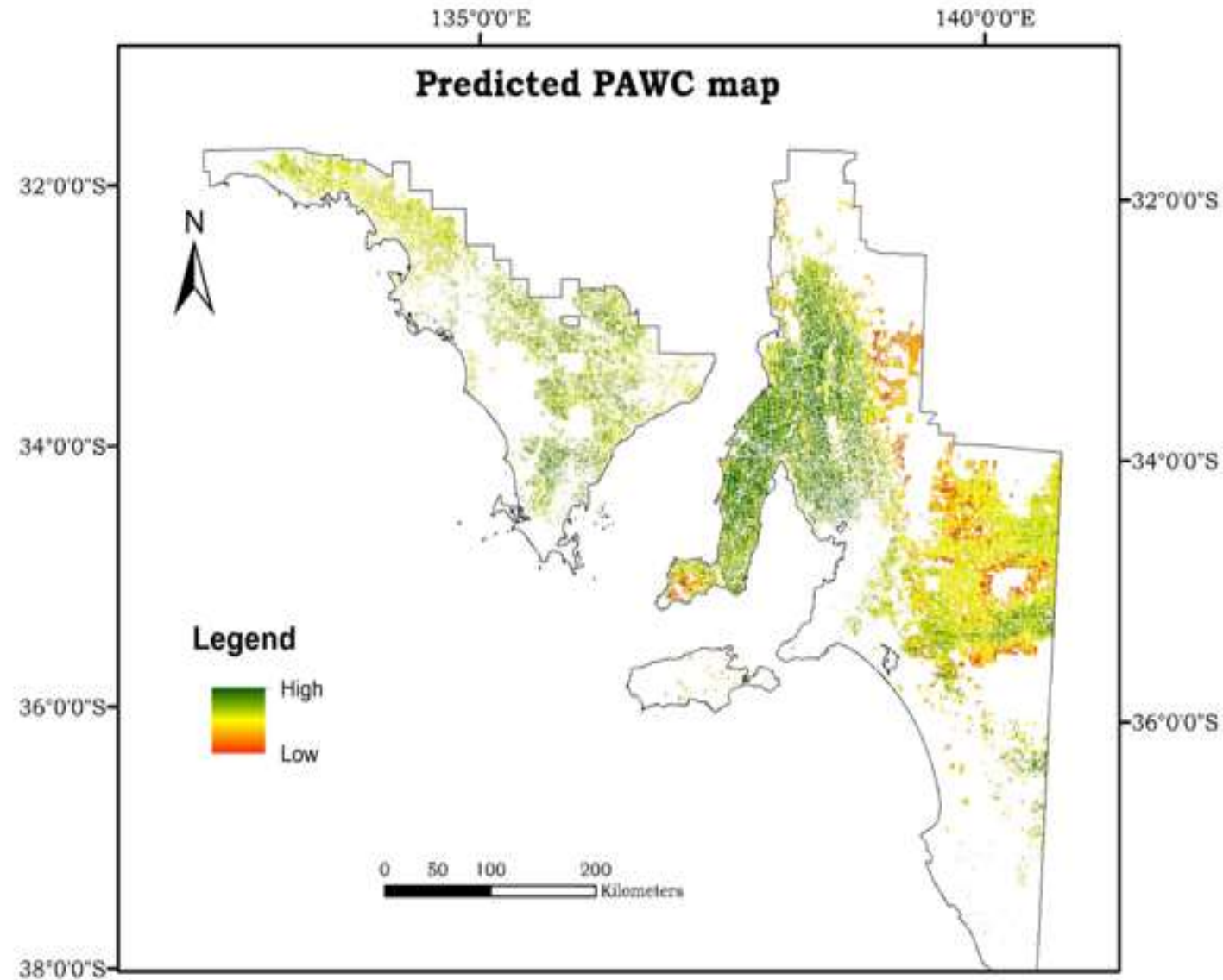
- Maximum NDVI and Time of Maximum NDVI - Positive correlation with PAWC
- The higher the PAWC the higher the maximum NDVI
  - High PAWC => more water => high greenness (NDVI)
- The higher the PAWC the later the maximum NDVI attained
  - Crop growth under water stress => faster growth rate

# Spatial Modelling



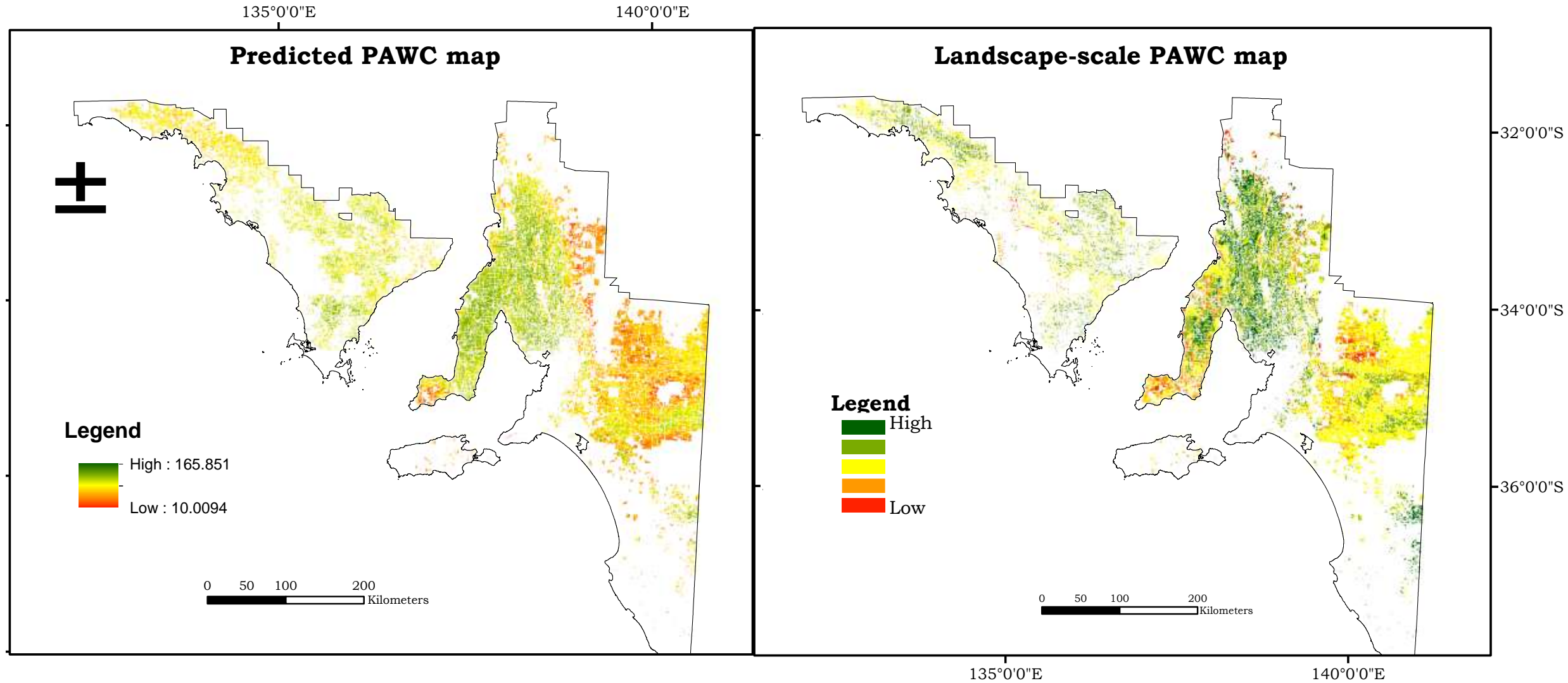
- Interactions with growing season rainfall indicate stronger relationship at higher rainfall seasons
- Coincides with previous observation that PAWC – Crop growth association is stronger in wet years than dry years.

# Spatial Estimation



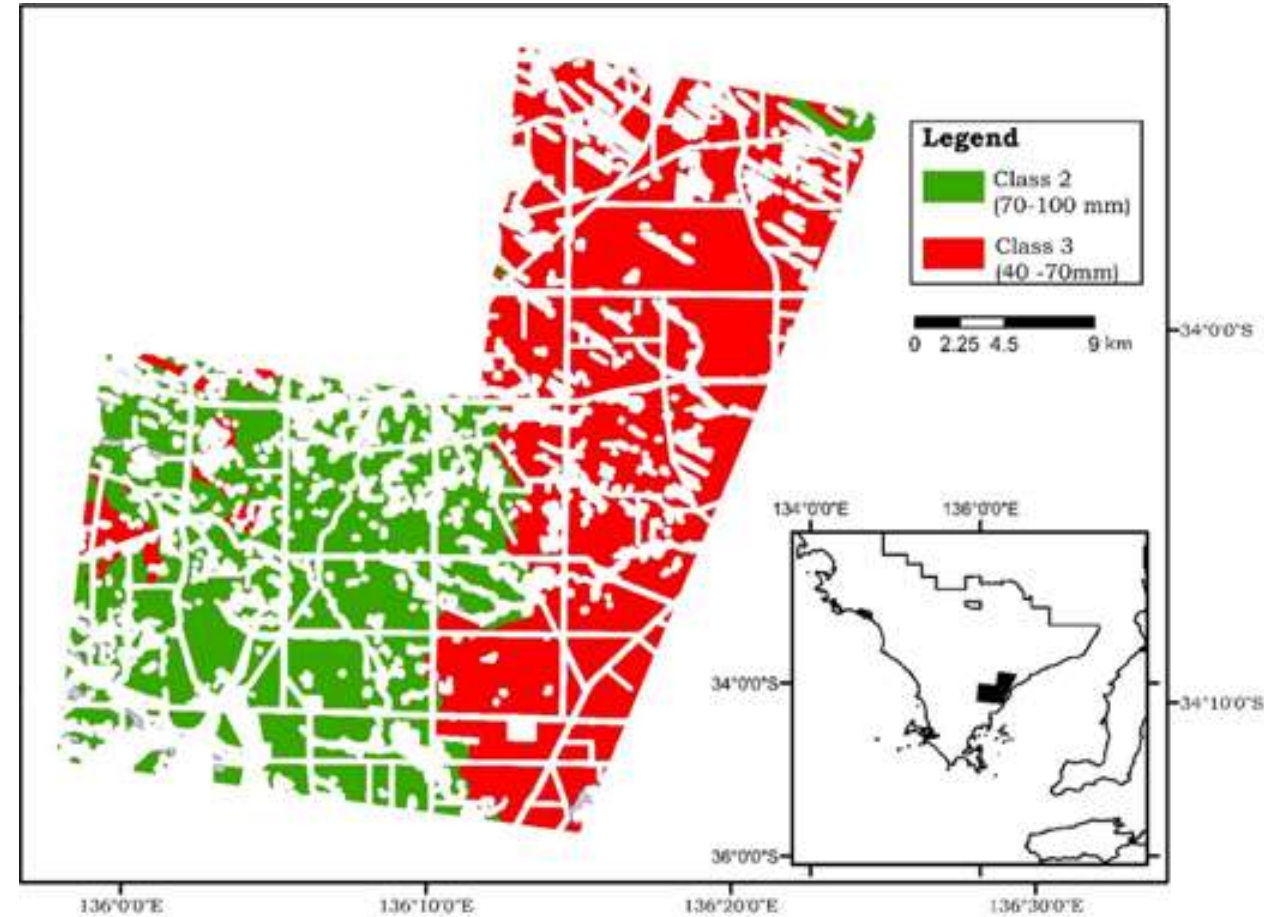
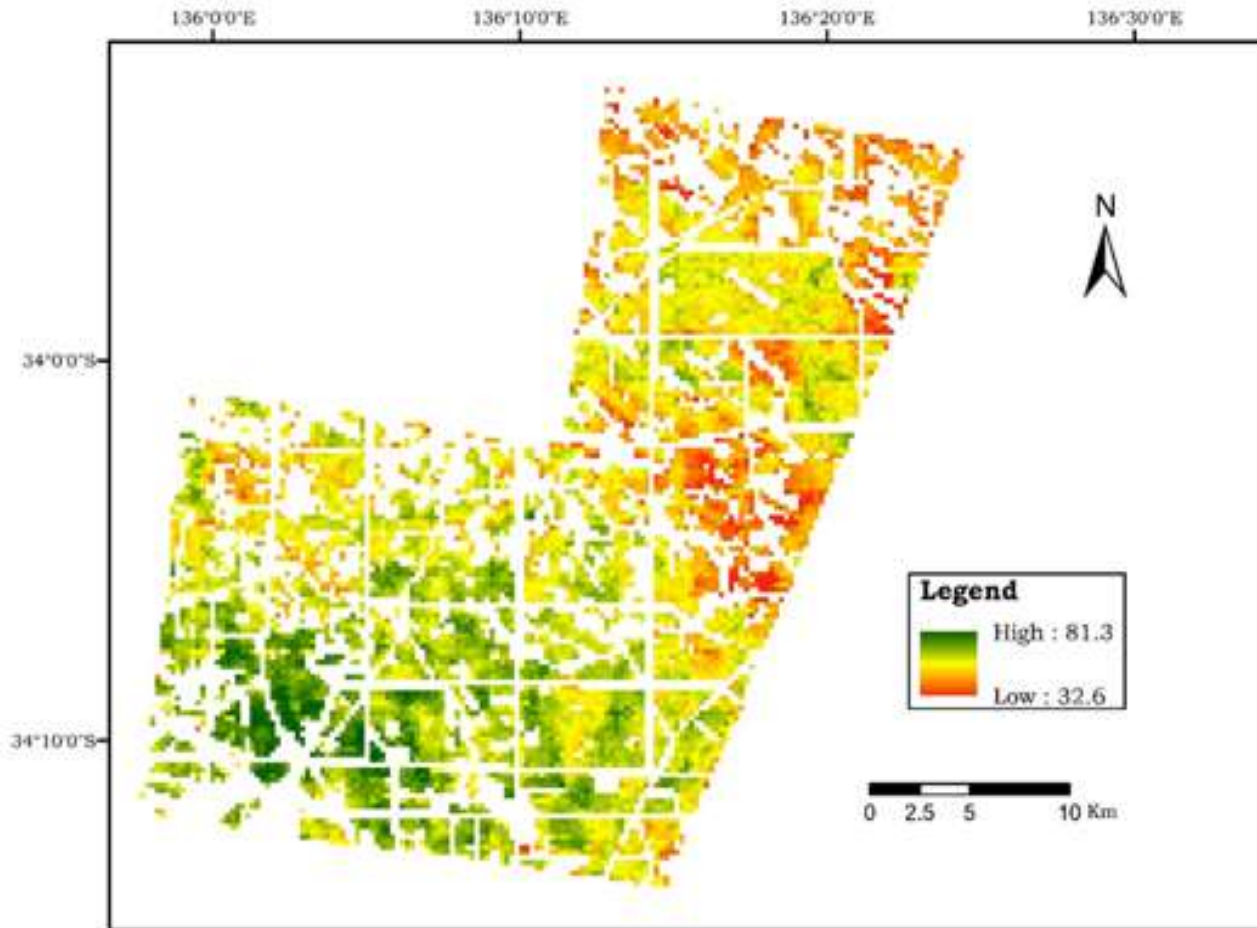


# Spatial Estimation





# Spatial Estimation



# Corroboration

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Challenging !

- Different method used for creation of these datasets –
  - Soil-Landscape map - local knowledge and experience using terrain and air photo interpretation
  - APSoil database - measurements were collected using field and laboratory analysis of soil samples

In spite of these difficulty

- 52% of the pixels were classified into similar categories, with 31% more probability than would have happened by chance.

# Conclusion

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- There is a consistent soil PAWC signal in the NDVI dynamics, which can be utilized in understanding of variability for agronomic management purpose .
- The results demonstrate a strong potential of remote sensing derived phenological metrics as indicators for soil PAWC, providing unprecedented spatial detail for digital soil mapping at broad spatial scales.
- Hence, the presented method can provide an alternative approach for the future broad scale high-resolution soil mapping with the promising advancement of image fusion techniques

# Thank You

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