

# Phenological Metrics Extraction for Agricultural Land-use

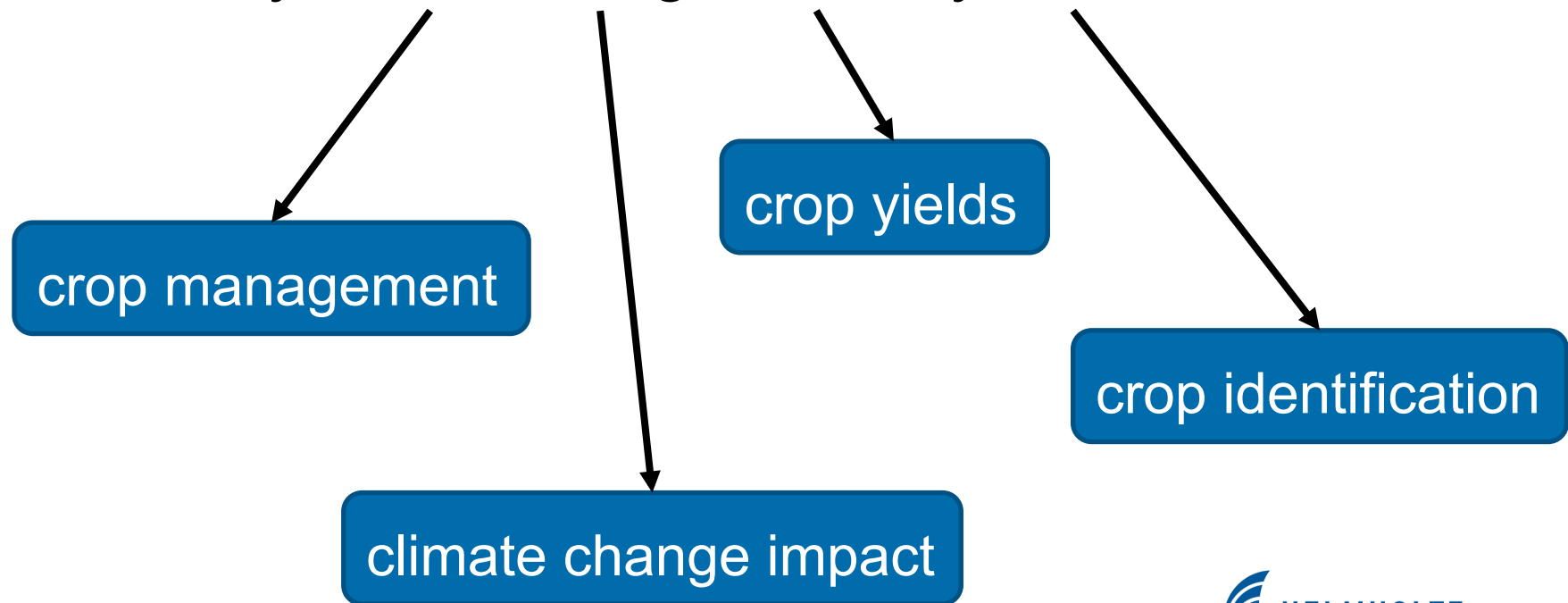
## Types Using RapidEye and MODIS

Xingmei Xu, Daniel Doktor

Anncy, 24.07.2015

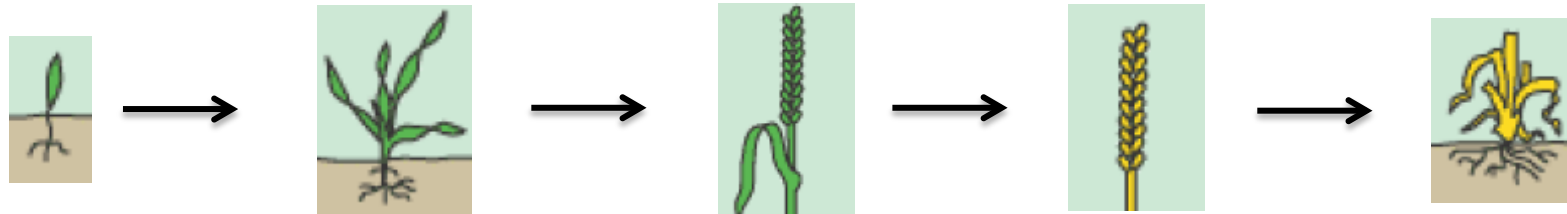
# 1. Introduction

**Crop phenology:** the study of the phases of the life cycle or the activities of agricultural species as they occur throughout the year



# 1.1. Measurements of phenology

- **Census and ground surveying**



emergence

tillering

heading

fruit ripening

senescence

- **Remote sensing:**

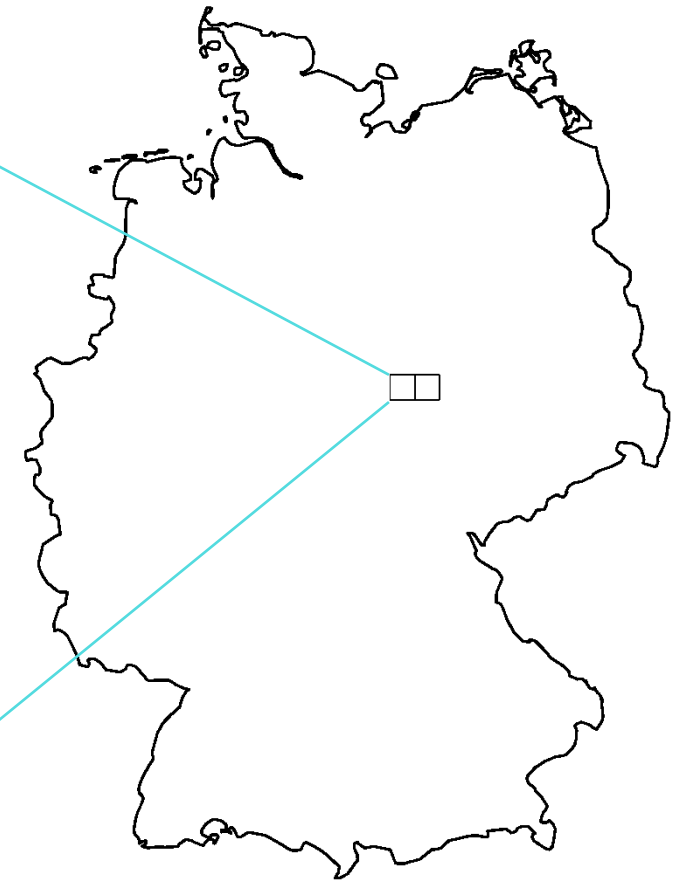
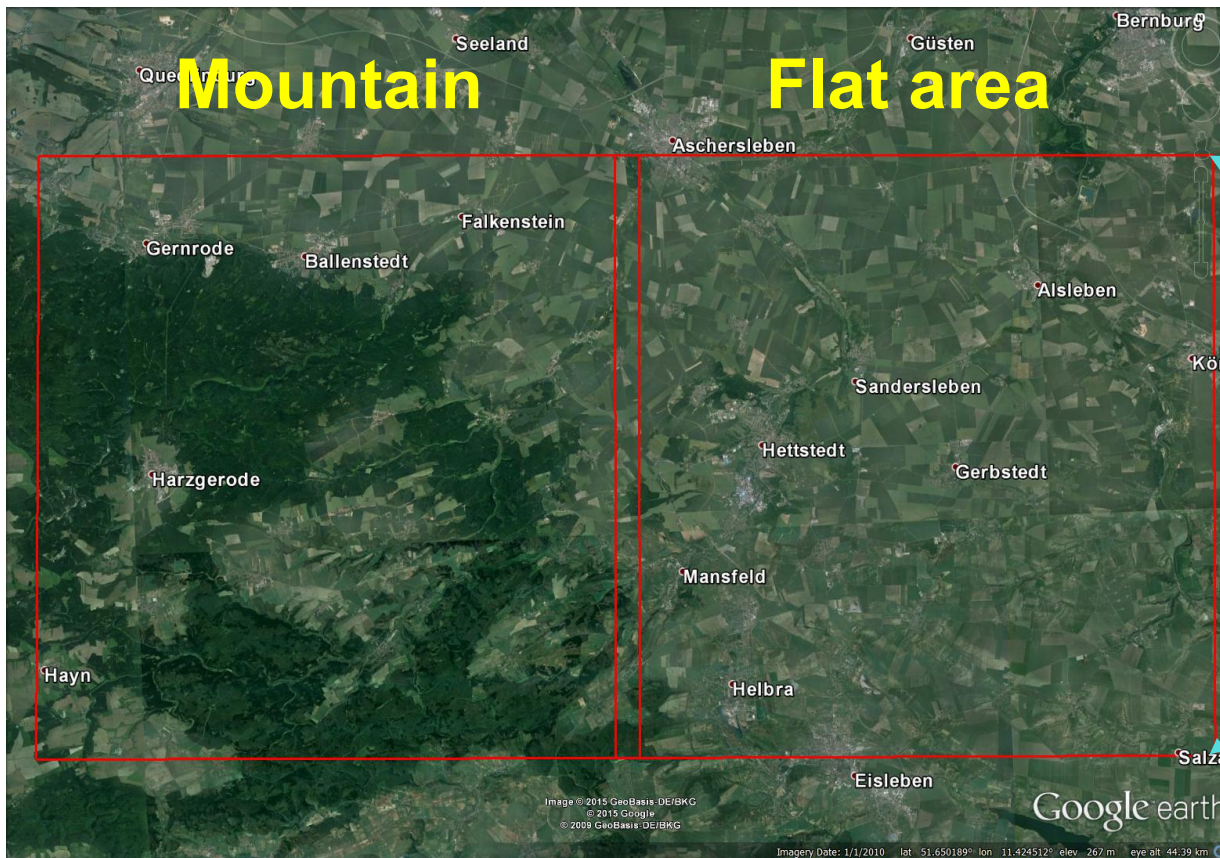
- ❖ **global** coverage: multi-spectral reflectance
- ❖ different **spatial** and **temporal** resolutions
- ❖ time-series → phenology

## 1.2. Outline

1. Extract phenological metrics (phenometrics) from RapidEye and MODIS NDVI time-series for agricultural species, which are calibrated using field data
2. Test RapidEye phenometrics performance comparing with MODIS phenometrics of homogenous pixels

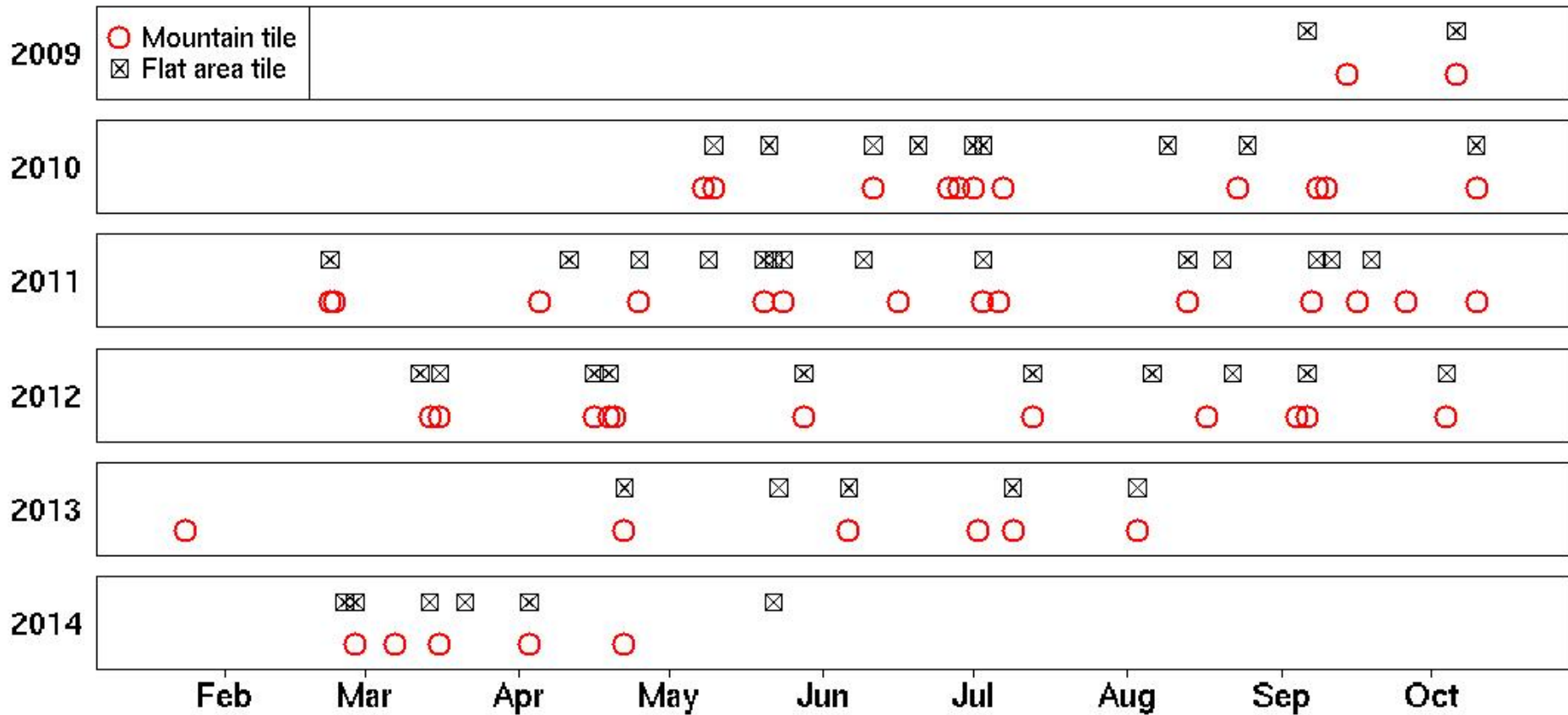
# 2. Data

## 2.1. Research area

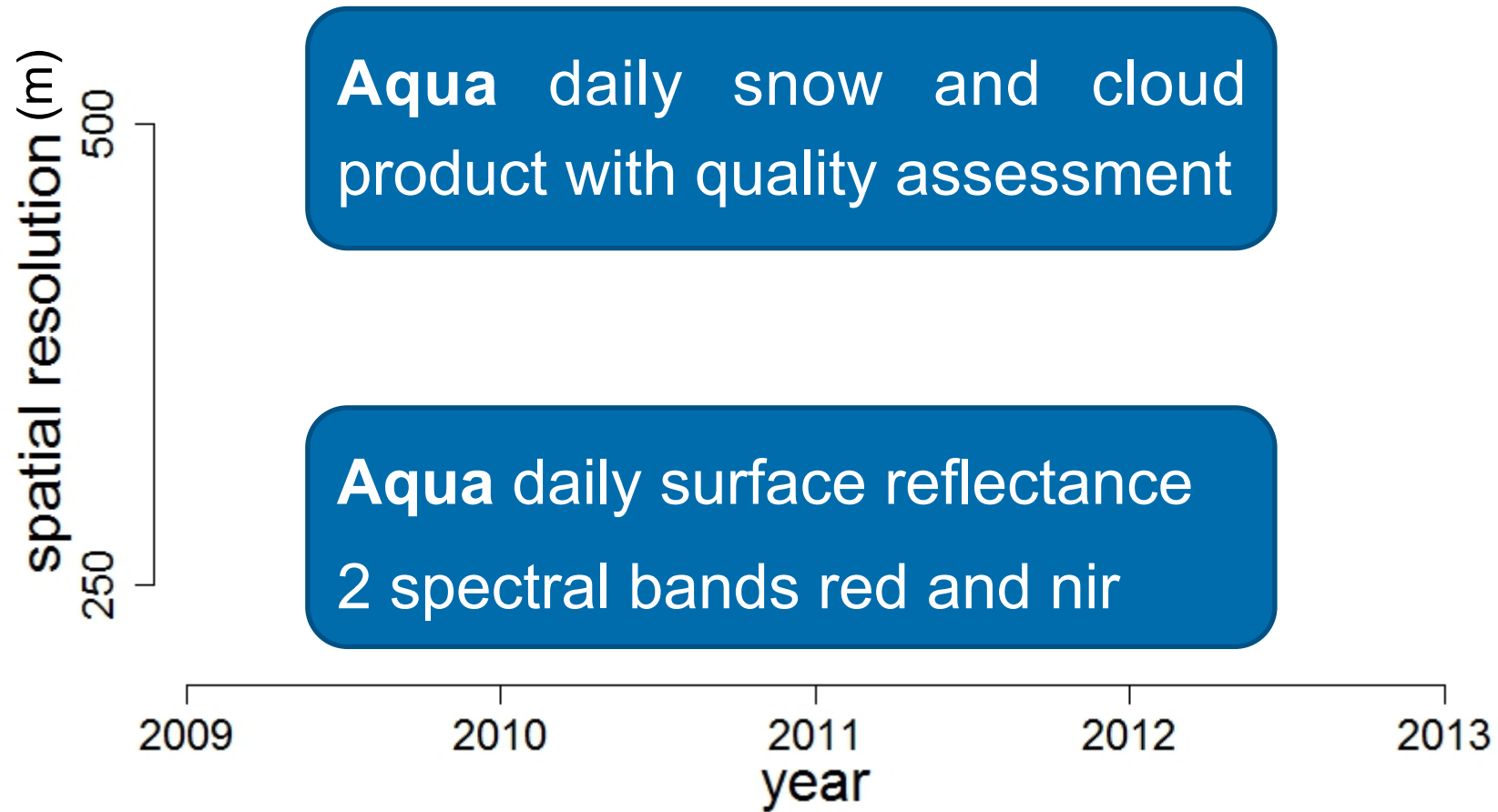


## 2.2. RapidEye level 3A products

- ❖ 5m spatial resolution
- ❖ 5 spectral bands in blue, green, red, red edge, nir



## 2.3. MODIS



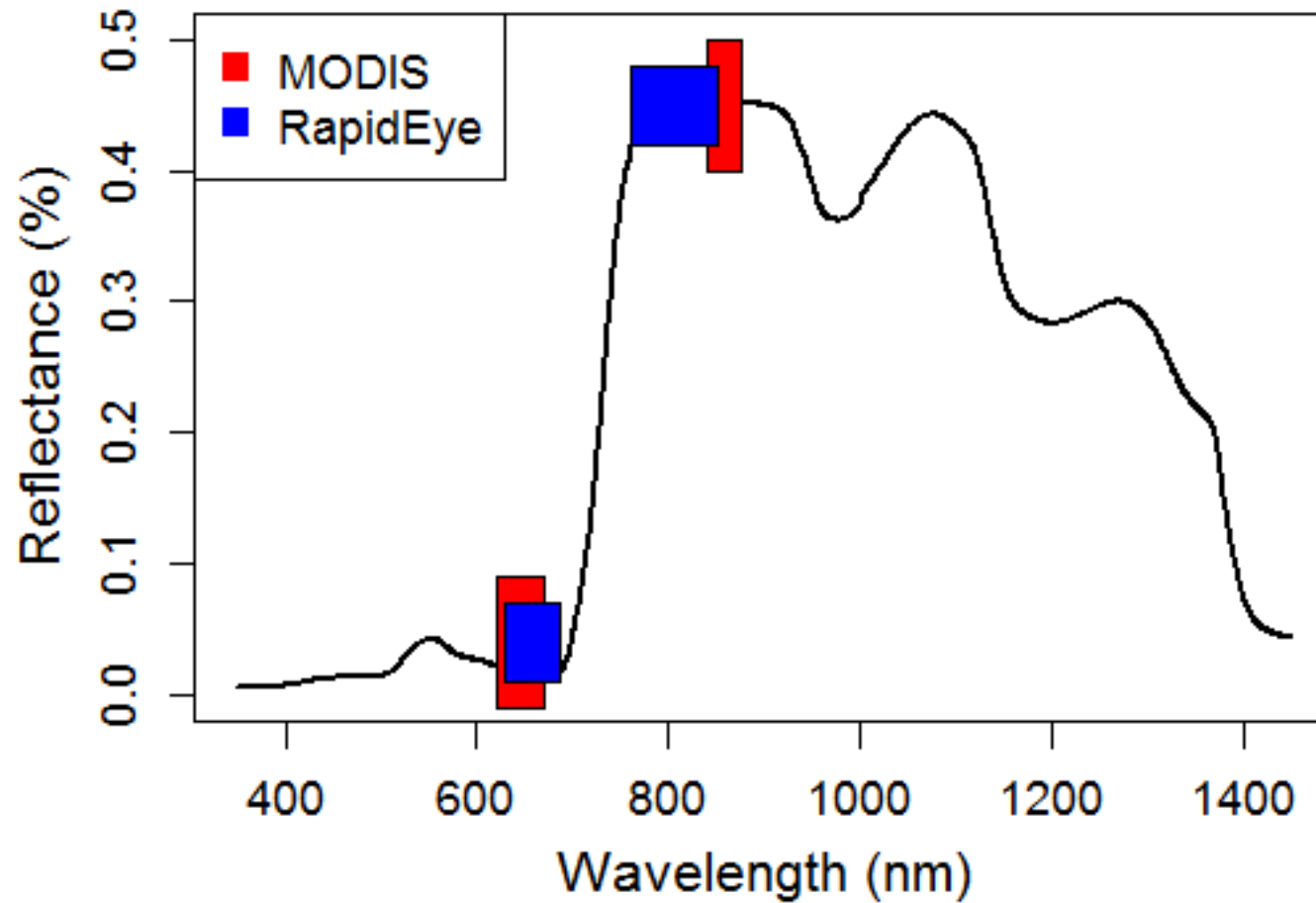
## 2.4. Field observations

- ❖ Maximum 5 available (German Weather Service) DWD stations for phenology observations 2010-2013 on:
  - 1) winter wheat
  - 2) winter barley
  - 3) winter oilseed rape
  - 4) sugar beet
- ❖ Phenology observations in 2014
- ❖ Crop classification map 2010-2014

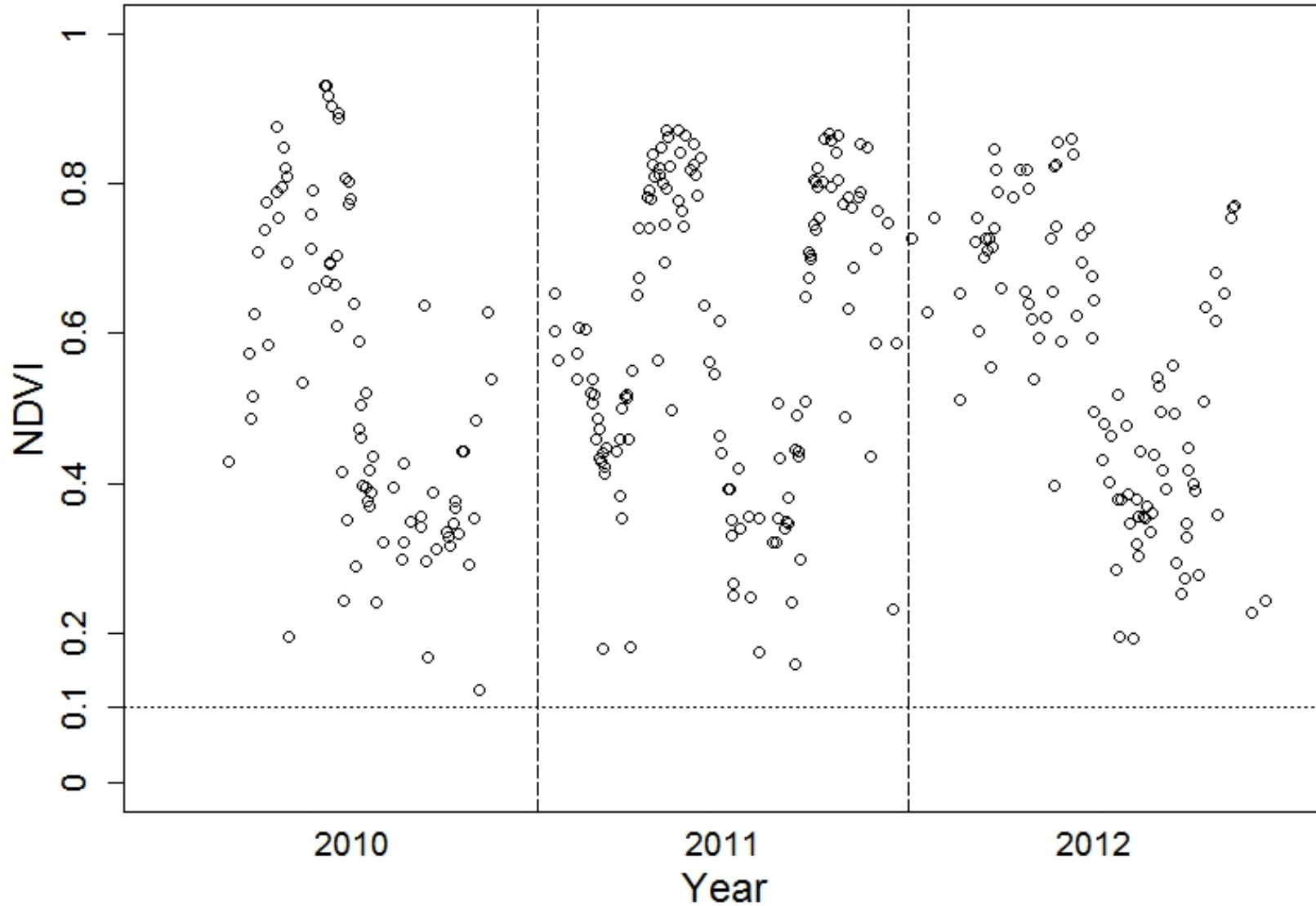


# 3. Method

## 3.1. $NDVI = (NIR - R) / (NIR + R)$

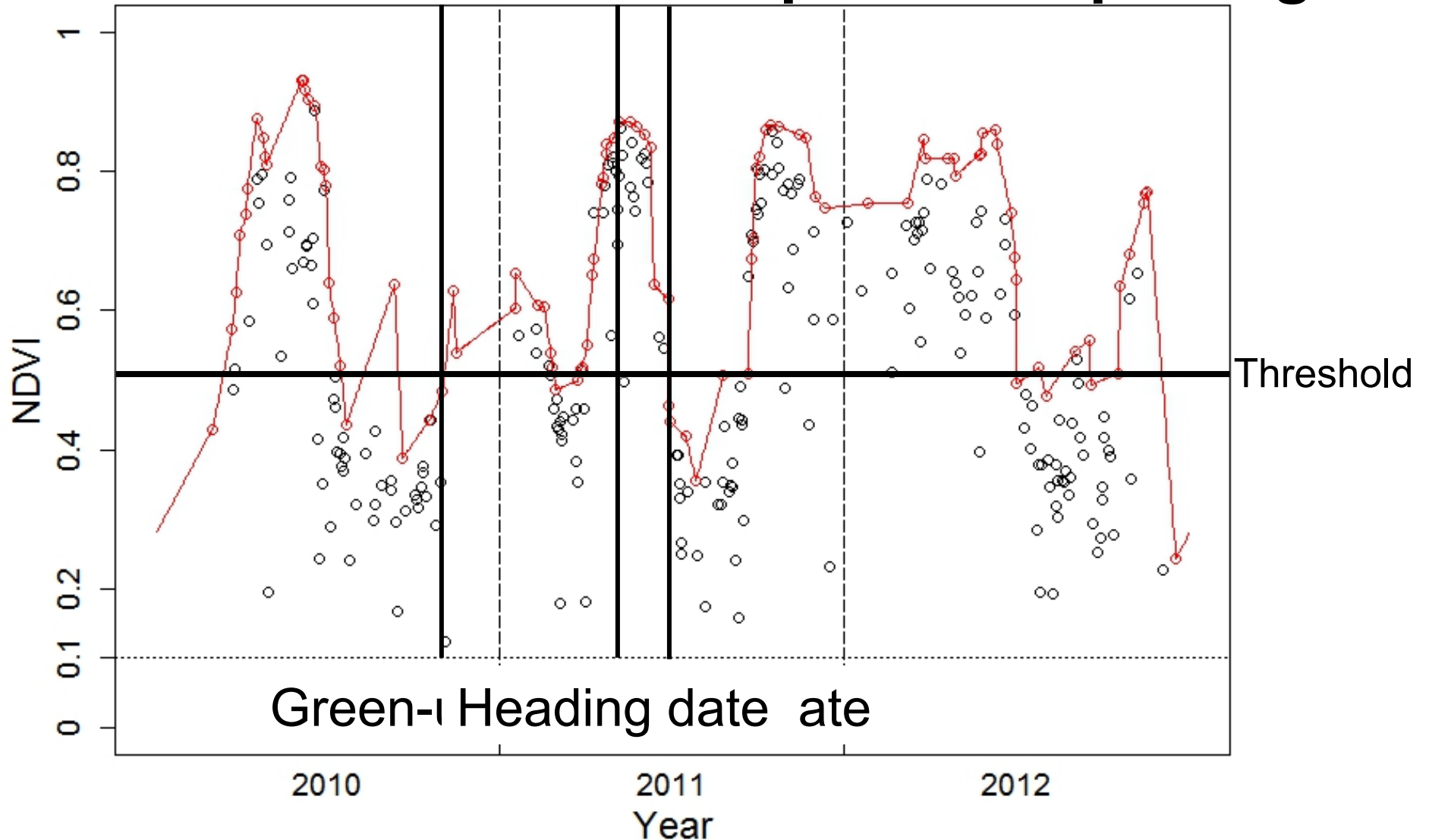


# 3.1. MODIS data processing



# Best Index Slope Extraction (BISE)

--phenex R package



## 3.2. RapidEye data processing

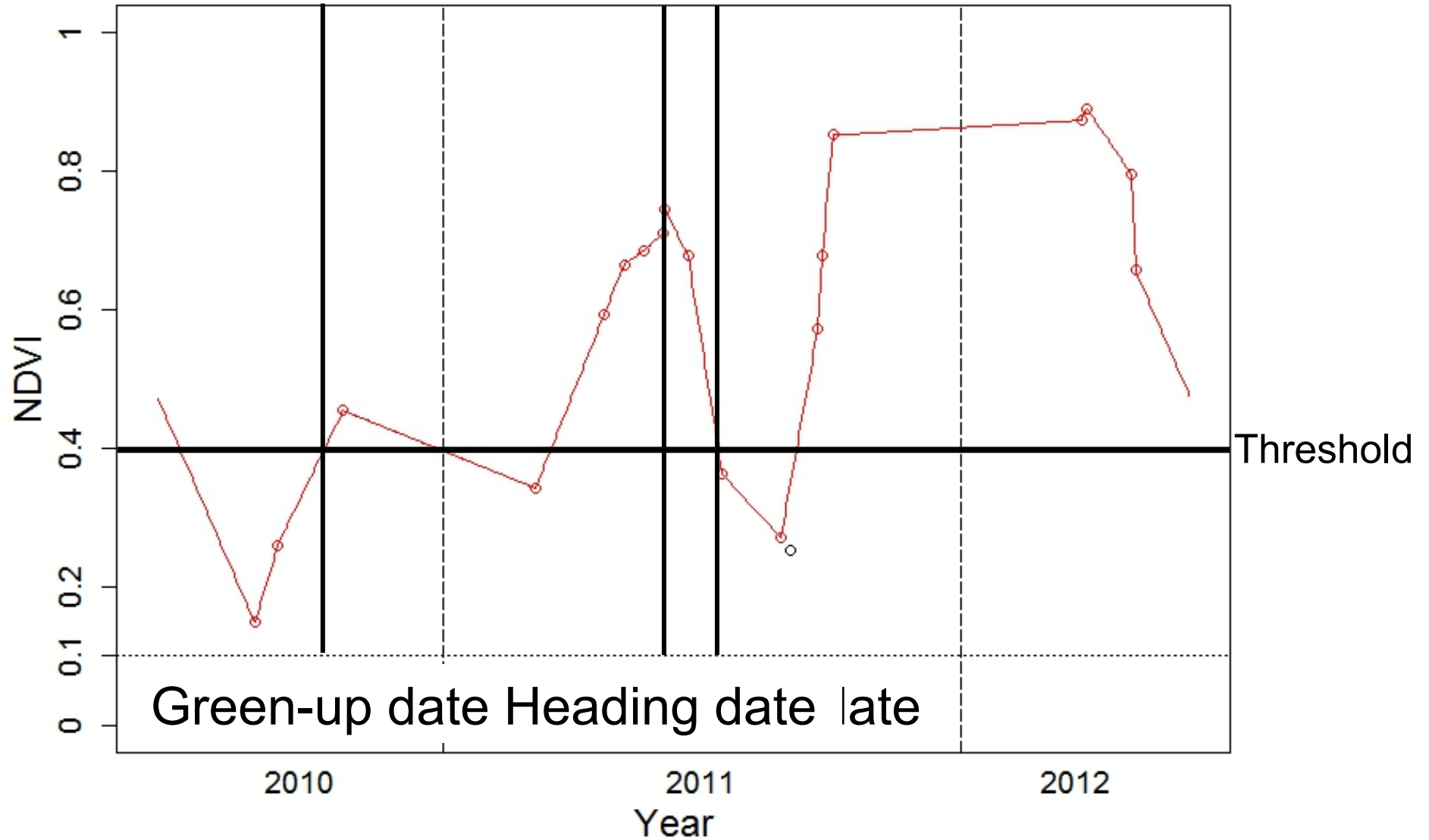
- ❖ Atmospheric correction(ATCOR 2/3)  
shadow and haze removal
- ❖ yearly **NDVI** time-series

| Tile      | Year |      |      |      |
|-----------|------|------|------|------|
|           | 2010 | 2011 | 2012 | 2013 |
| Mountain  | 19   | 28   | 21   | 16   |
| Flat area | 18   | 25   | 19   | 16   |

Number of  
images in NDVI  
time-series each  
year



## 3.2. RapidEye data processing



### 3.3. Phenological metrics

❖ Green-up and senescence dates

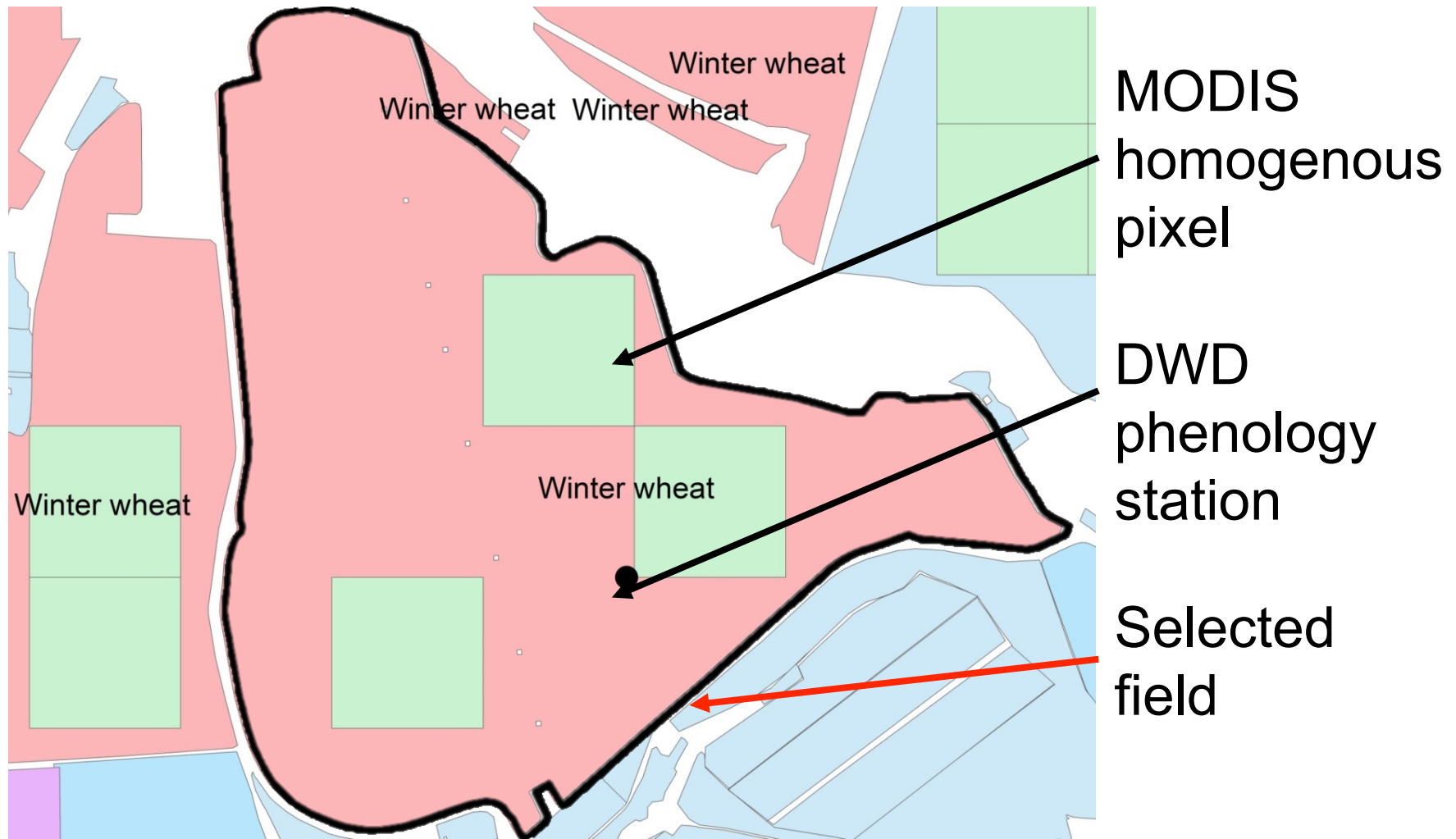
❖ Dates of the year with maximum NDVI and Emergence in Winter cereals

Winter rapeseed

Winter cereals



### 3.4. Sliding period and threshold optimization for MODIS and RapidEye



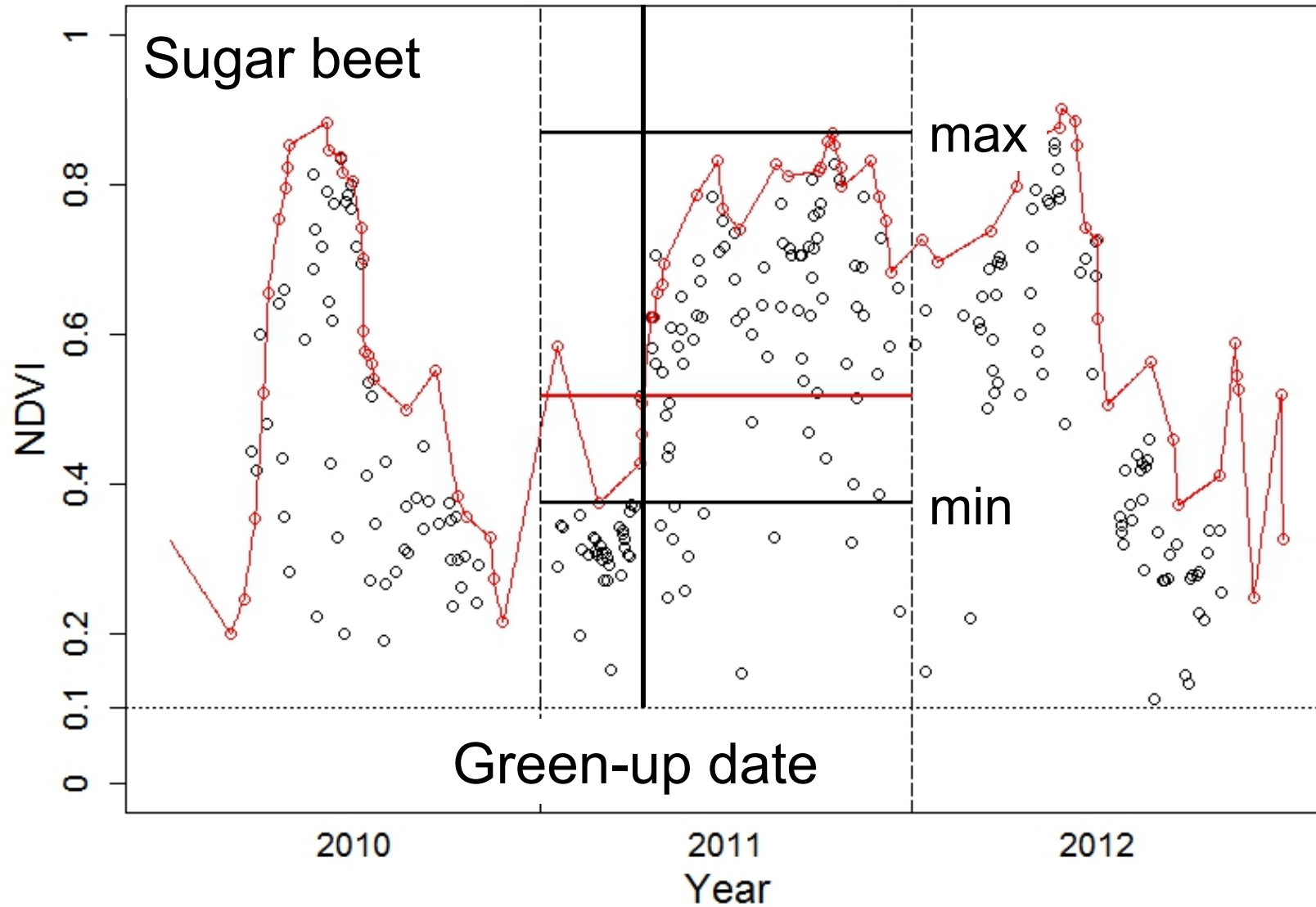
### 3.4. Sliding period and threshold optimization for MODIS and RapidEye

|                     | Crop type       | Nr. selected fields by year |      |      |      | Total |
|---------------------|-----------------|-----------------------------|------|------|------|-------|
|                     |                 | 2010                        | 2011 | 2012 | 2013 |       |
| MODIS<br>within 3km | Winter wheat    | 5                           | 4    | 4    | 5    | 18    |
|                     | Winter barley   | 3                           | 4    | 2    | 2    | 11    |
|                     | Winter rapeseed | 3                           | 4    | 4    | 2    | 13    |
|                     | Sugar beets     | 3                           | 2    | 1    | 1    | 7     |

|                        | Crop type       | Nr. selected fields by year |      |      |      | Total |
|------------------------|-----------------|-----------------------------|------|------|------|-------|
|                        |                 | 2010                        | 2011 | 2012 | 2013 |       |
| RapidEye<br>within 2km | Winter wheat    | 5                           | 5    | 5    | 5    | 20    |
|                        | Winter barley   | 3                           | 3    | 4    | 2    | 13    |
|                        | Winter rapeseed | 5                           | 3    | 4    | 4    | 16    |
|                        | Sugar beets     | 3                           | 2    | 3    | 2    | 10    |



## ➤ Local threshold



## 3.4. Sliding period and threshold optimization for MODIS and RapidEye

❖ Sliding period:

MODIS—23

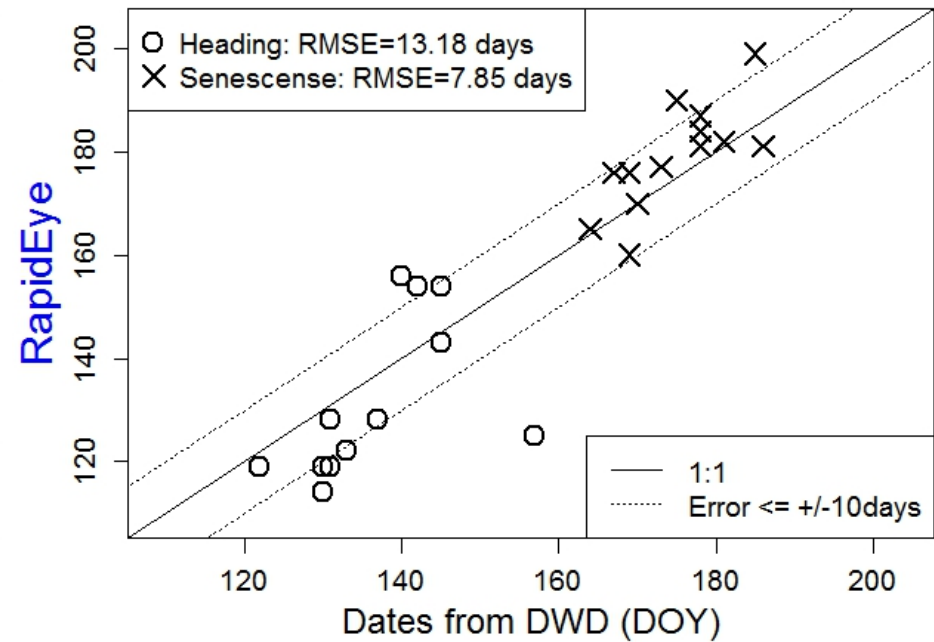
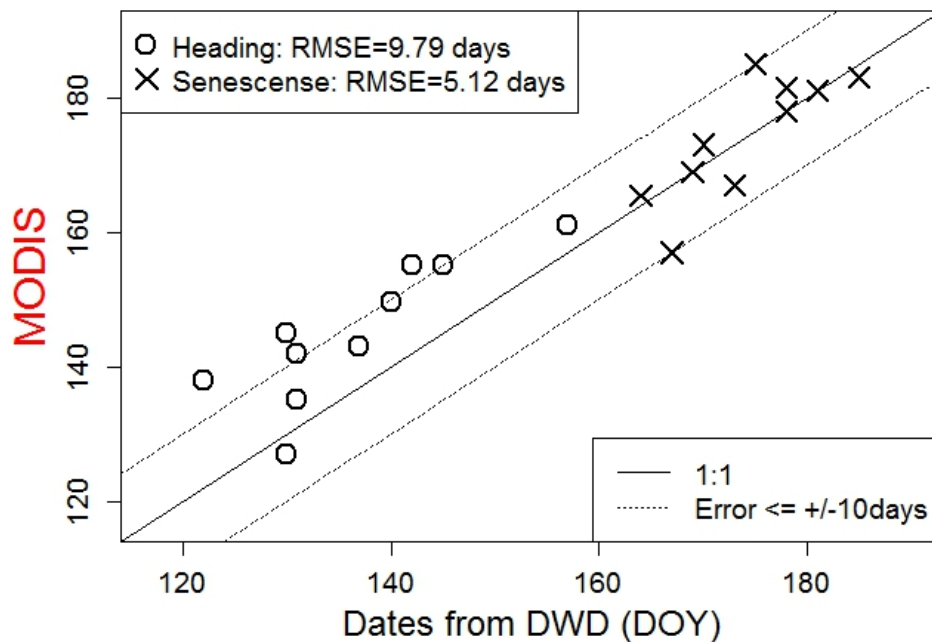
RapidEye—20

❖ 3 different thresholds for senescence, green-up dates of winter and summer crops for each satellite in 4 years

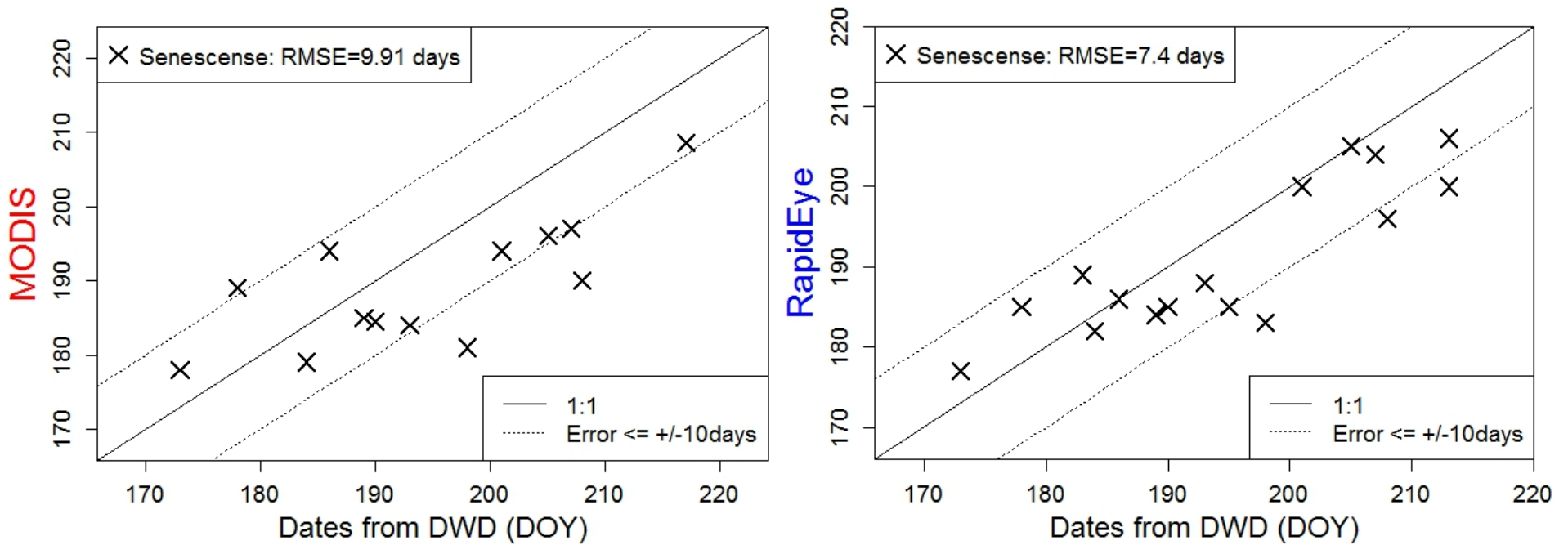
# 4. Results

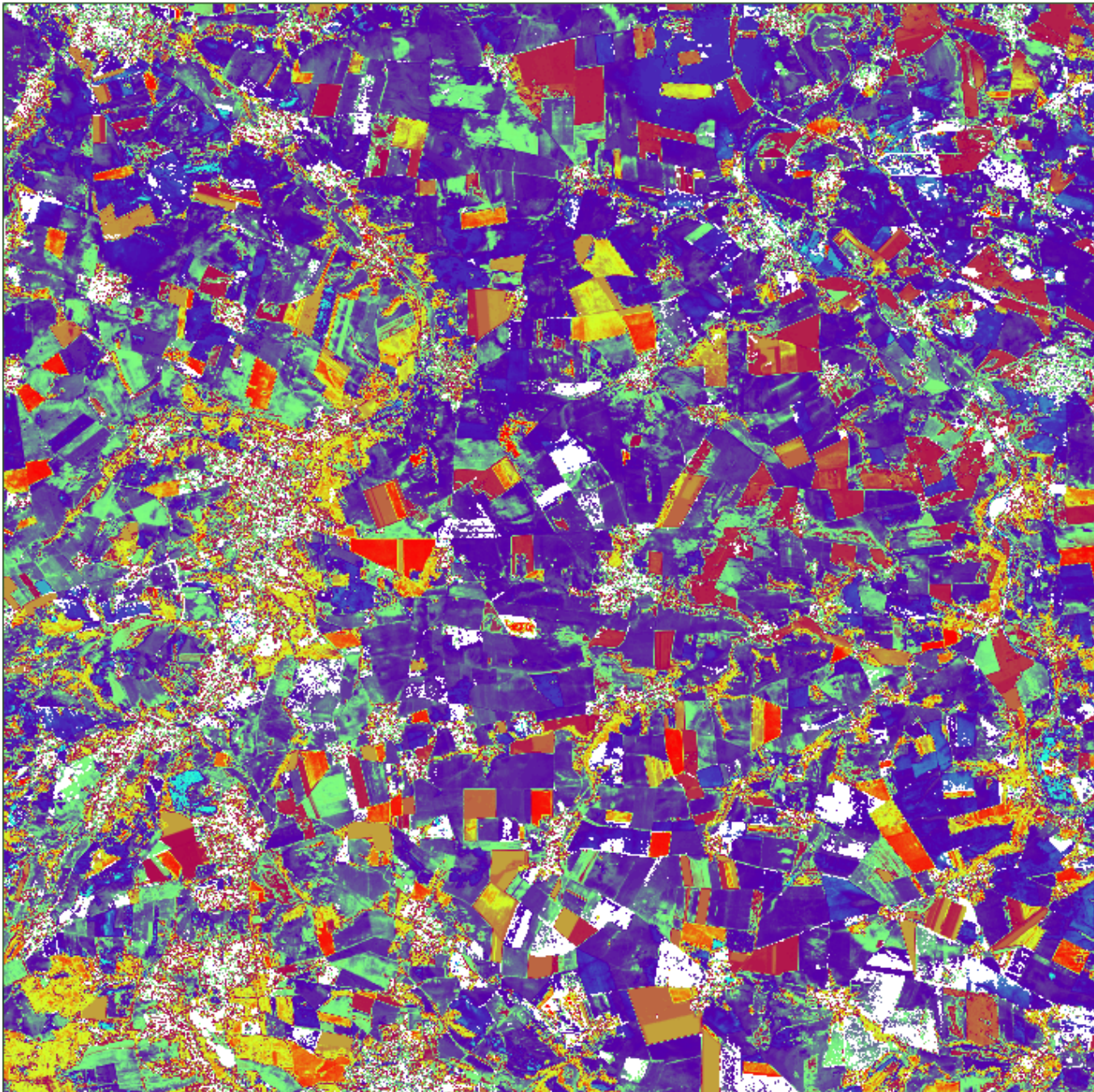
## 4.1. Calibration results using remote sensing and field data from 2010 to 2013

Winter barley phenological dates 2010-2013



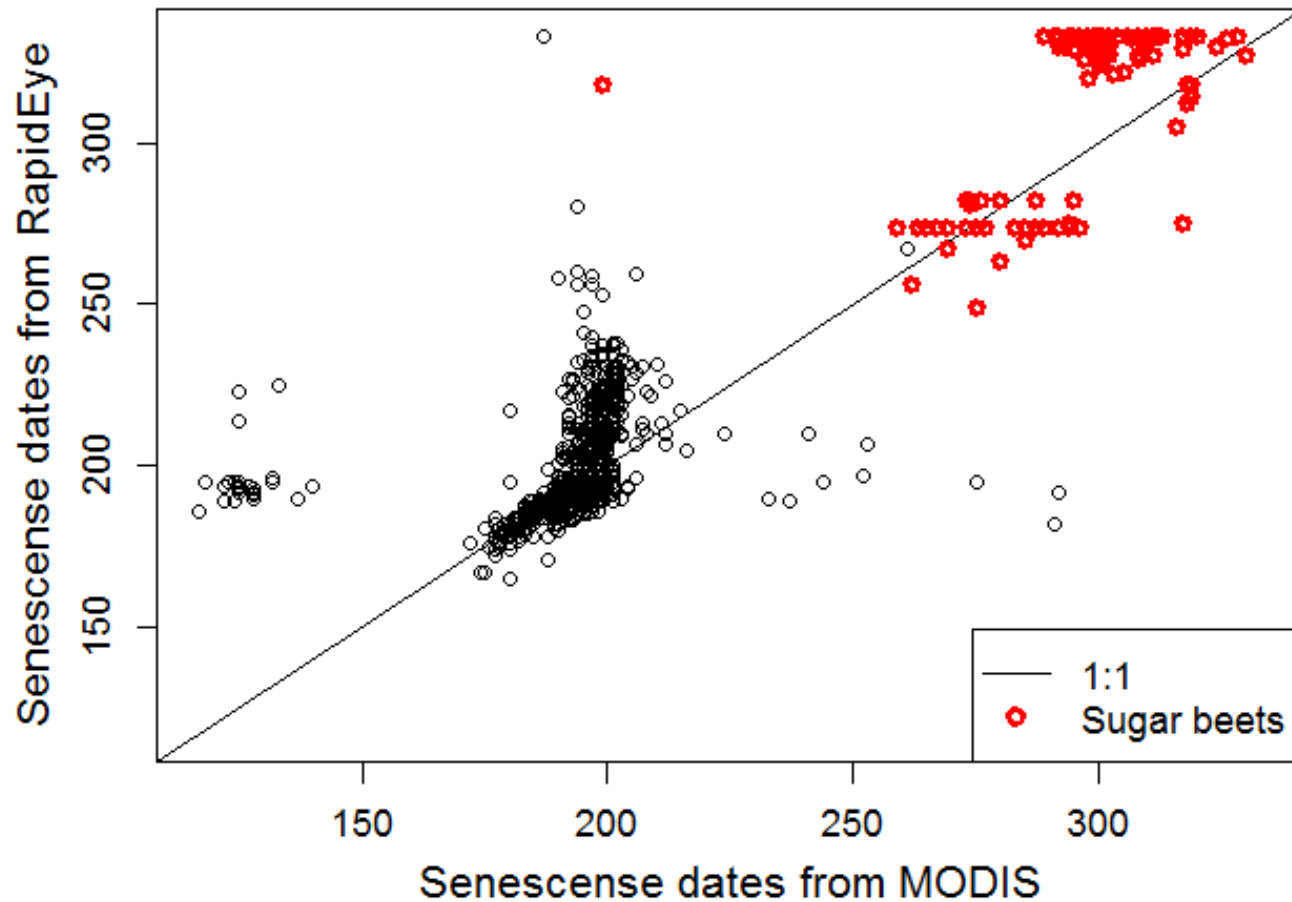
# Winter rape phenological dates 2010-2013





**RapidEye**  
**Year 2011**  
**Senescence**  
**Flat area**





Senescence dates calculated using MODIS homogenous pixels and RapidEye in year 2010, 1331 pixels in total for major crop types

## 4.2. Summary

### **Calibrated phenometrics of MODIS and RapidEye,**

- 1) senescence and heading dates could be very well calibrated using field observations
- 2) RMSEs of 4 years are around 2 weeks for green up dates of both winter and summer crops

### **Comparing phenometrics of MODIS and RapidEye,**

- 1) both yield similar senescence dates, with average  $R^2$  of 0.67 in 4 years
- 2) there is better agreements for winter barley than other winter crops

## 5. Outlook

1. Test whether current parameters suitable for observations in 2014
2. Curve fitting and smoothing algorithm to extract phenometrics should be tested
3. Temporal analysis to find optimal window of detecting phenology
4. Detect phenological variability within fields using RapidEye
5. Crop type classification



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**Thank you for your attention**