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Estimating crop emergence dates from satellite imagery fusion

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What was the problem?

- Models that required emergence date observations
- Hard to validate the accuracy of the data points
- Can it be done using public imagery datasets?
- How to avoid trade-offs between costs vs spatial & temporal resolution

Datasets

Imagery

- NASA L2G daily 250m^2 pixel MODIS images
- ESA L2A 4/5 day revisit 10m^2 Sentinel 2 (S2) images
- Processed into Enhanced Vegetation Index (EVI2) using Google Earth Engine (GEE)
- Default GEE cloud mask applied
- Cropped to paddock arable boundary's

Emergence observations

- 154 observations
  - 43 observations in 2023 season
  - 111 observations in 2022 season
- ‘Paddock level’
- Spread across WA wheatbelt

Processing steps for emergence estimates

Raw time series of pixel EVI values (default GEE cloud removal)

Smooth & interpolate the time series of pixel level EVI values

Calculate differences between S2 and 'Context feature'

Smooth the differences

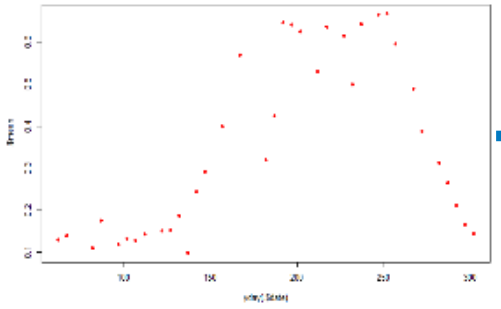
Recombine with Context feature to generate daily 10m^2 time series

Identify local minima point inflection (baseline removal)

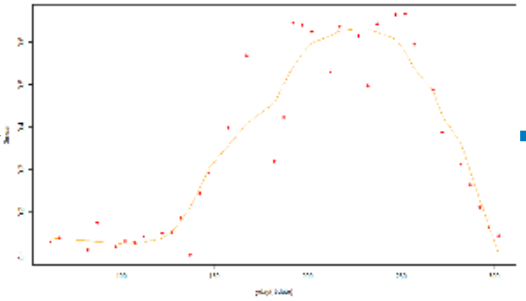
Fit double logistic curve to the time series

Estimate emergence based on a curve derivative threshold

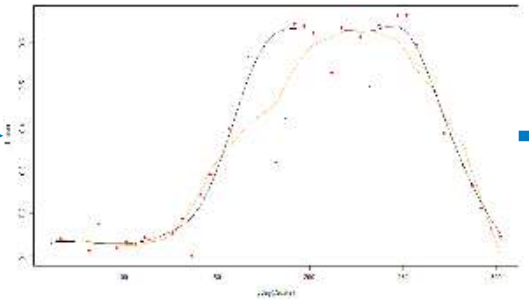
Raw EVI



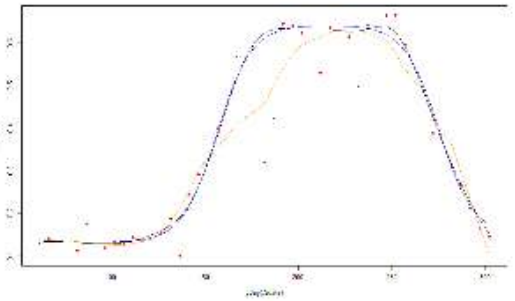
Smoothed EVI



Recombined EVI



Double logistic



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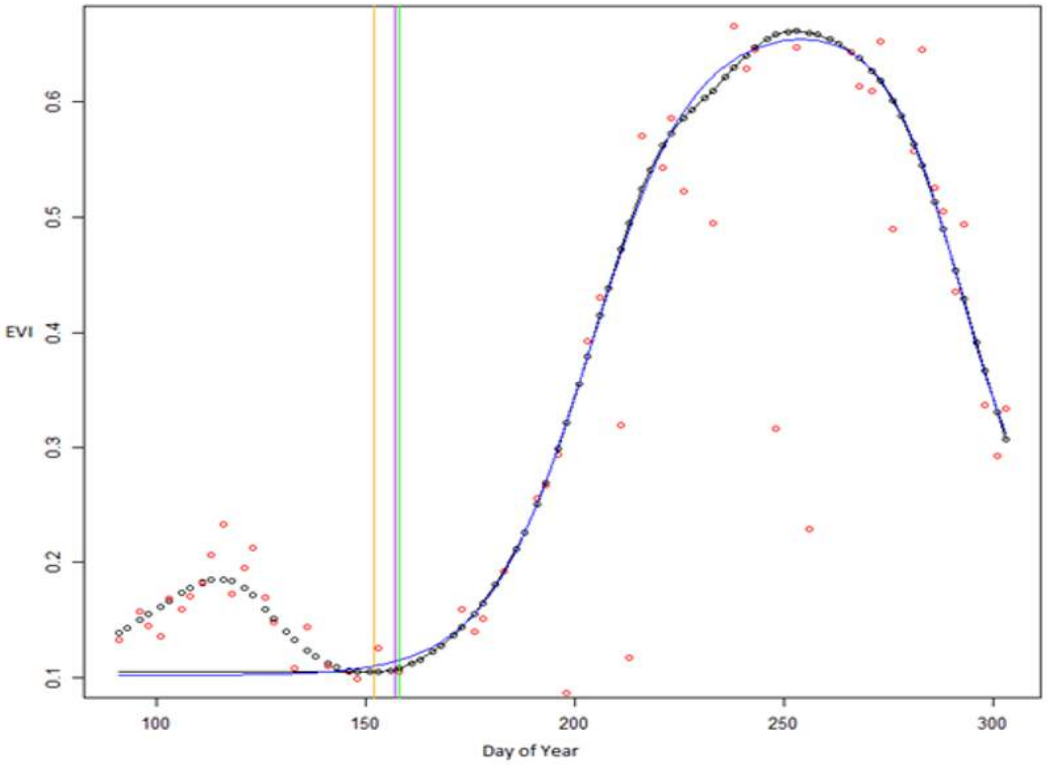
RESULTS – PADDOCK AVERAGE

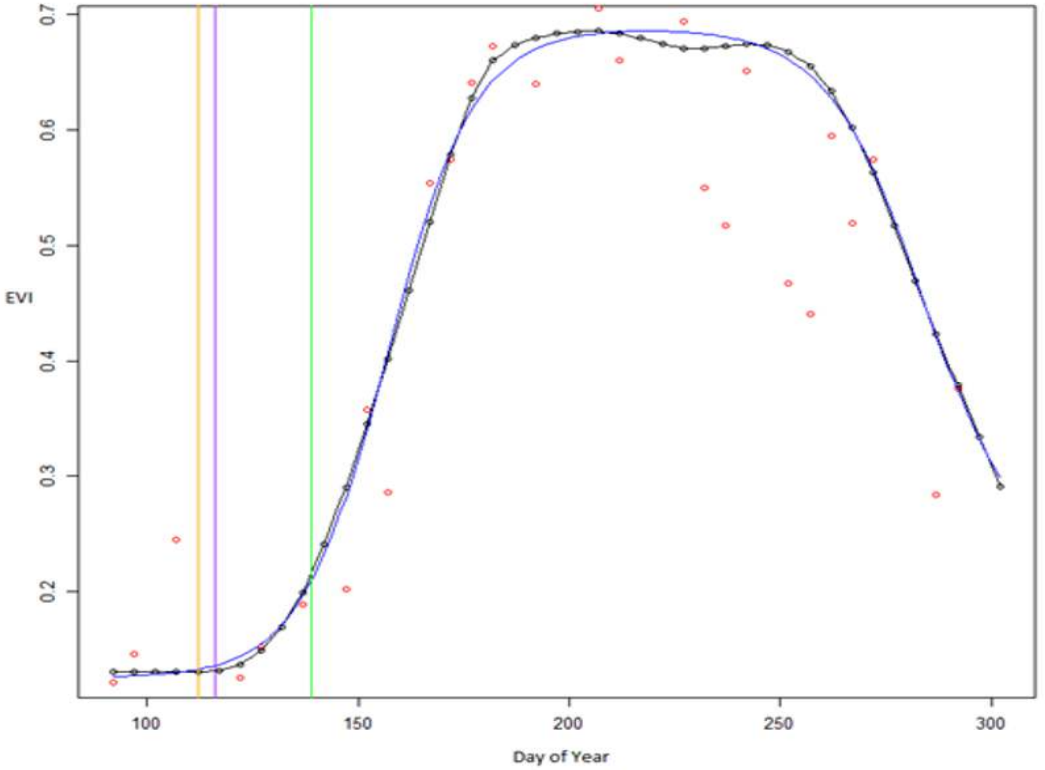
‘Good’ (left) vs ‘bad’ (right) emergence estimates

Dots: **Red** - raw Sentinel 2 time series; **Black** - smoothed Sentinel 2 time series

Lines: **Black** - smoothed Sentinel 2 with weed filtering; **Blue** - double logistic fit curve

Vertical line: **Orange** - weed inflection point; **Blue** - emergence estimate; **Green** - emergence ground truth.





EVALUATION

Paddock level accuracy

- Training set of 43 paddocks from 2023 season
- Testing set of 111 paddocks
- Record error as Mean Absolute Error
- Reverse order, repeat

$$\mathrm{MAE} = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n}$$

y_i = prediction

x_i = true value

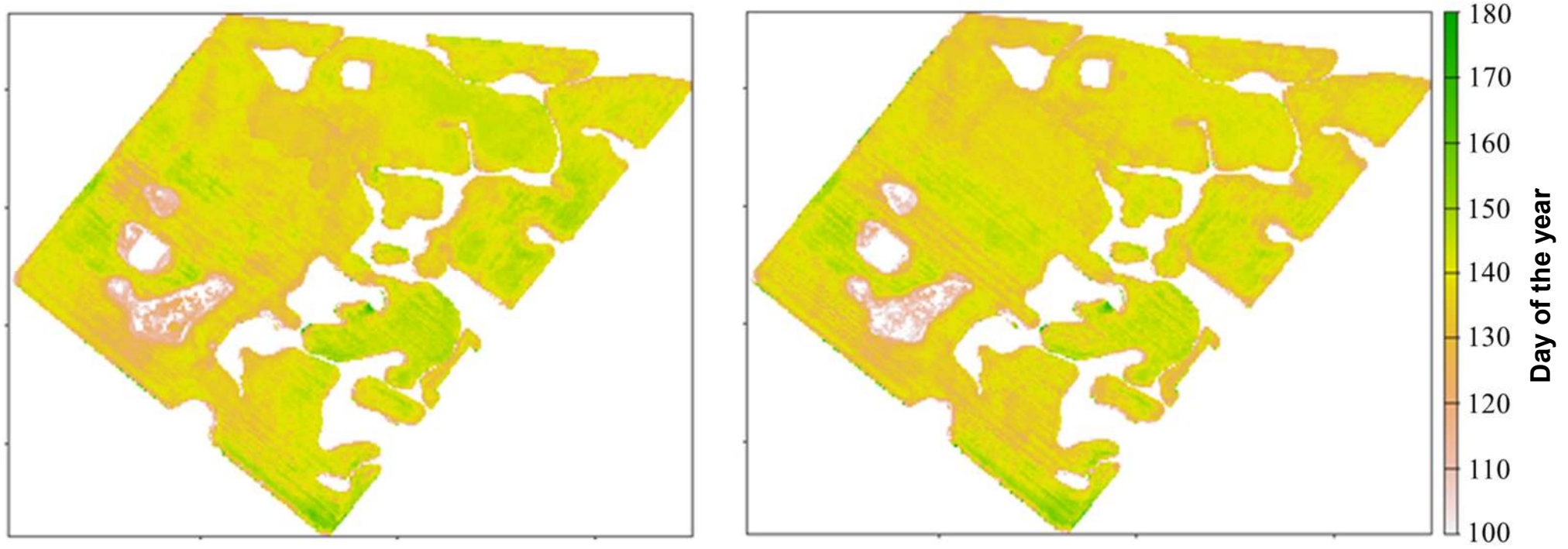
n = total number of data points

Year (test set)	**MAE (days)** S2 Only	**MAE (days)** MODIS Fused	**Within 14 days (%)** S2 Only	**Within 14 days (%)** MODIS Fused
2022	5.83	6.18	98%	98%
2023	9.43	9.02	77%	78%

RESULTS – SUB-PADDOCK ACCURACY

‘Artefacts’ in cloud removal smoothing

- Left – Sentinel 2 only smoothed with Paddock Average as a context feature
- Right – Sentinel 2 with MODIS as the context feature



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Discussion & conclusions

- Paddock level emergence estimates are similar
- Visual inspection on sub-paddock levels shows improvement with fusion images
- Shows potential for agronomic applications in modelling crop yields as well as crop monitoring
- Investigate time-frame for how quickly the information can be turned around

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Thanks for listening