NEW WAYS TO USE REMOTE SENSING PHENOLOGY AND MACHINE LEARNING FOR PREDICTING IRRIGATED AND RAINFED AGRICULTURE IN AFRICA

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GRoW - GlobeDrought
Characterizing drought risk and impact

Bundesministerium für Bildung und Forschung

REMOTE SENSING SOLUTIONS GMBH

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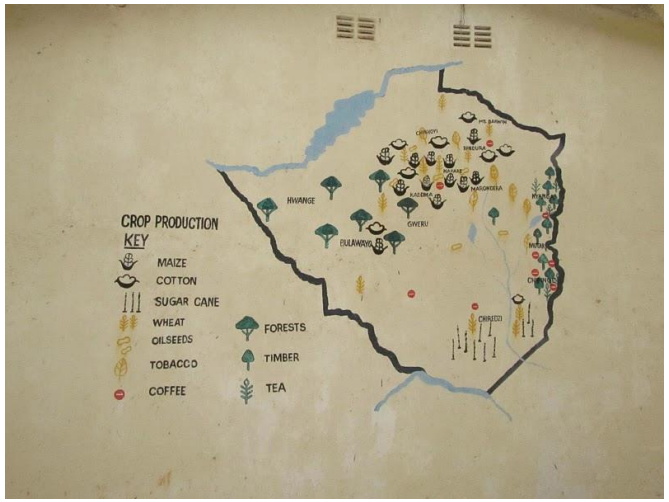
Background and rationale

- Exploit wealth of information from time-series data for enhanced land use mapping
- Time-series data still exhibits data gaps (i.e. clouds) and large data volumes a problem for many users in developing nations
- Information about the extent of rainfed and irrigated land are needed for drought impact and food production estimates and land policies,
  - But this information is still missing

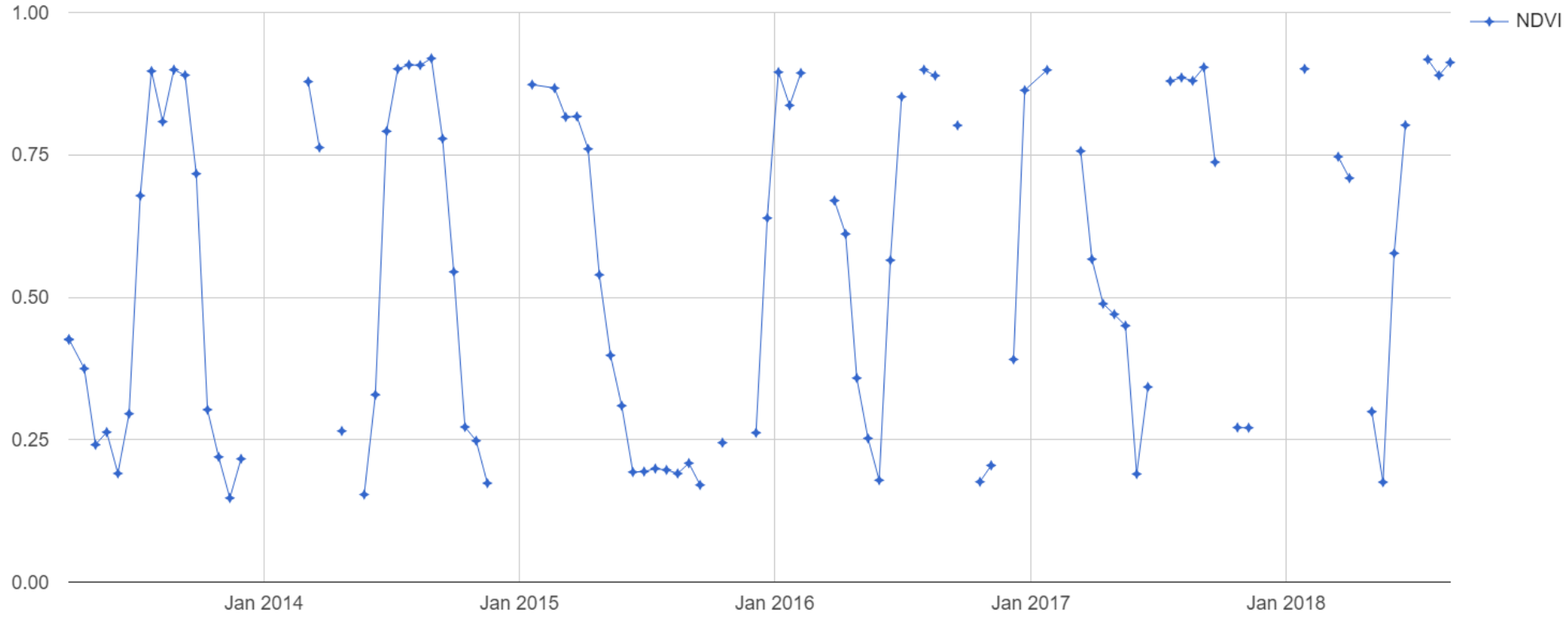


Objectives

- Optimize harmonics curve parameters (representing crop phenology) and machine learning classification from Landsat time series data (2013-2018), to map the spatial distribution of irrigated and rainfed agriculture in Zimbabwe
  - Help to gauge food supply
  - Understand resilience of the agro-ecological system to climate variability
  - Produce land use data that is critical to land management policies on drought and food security

Why harmonics?

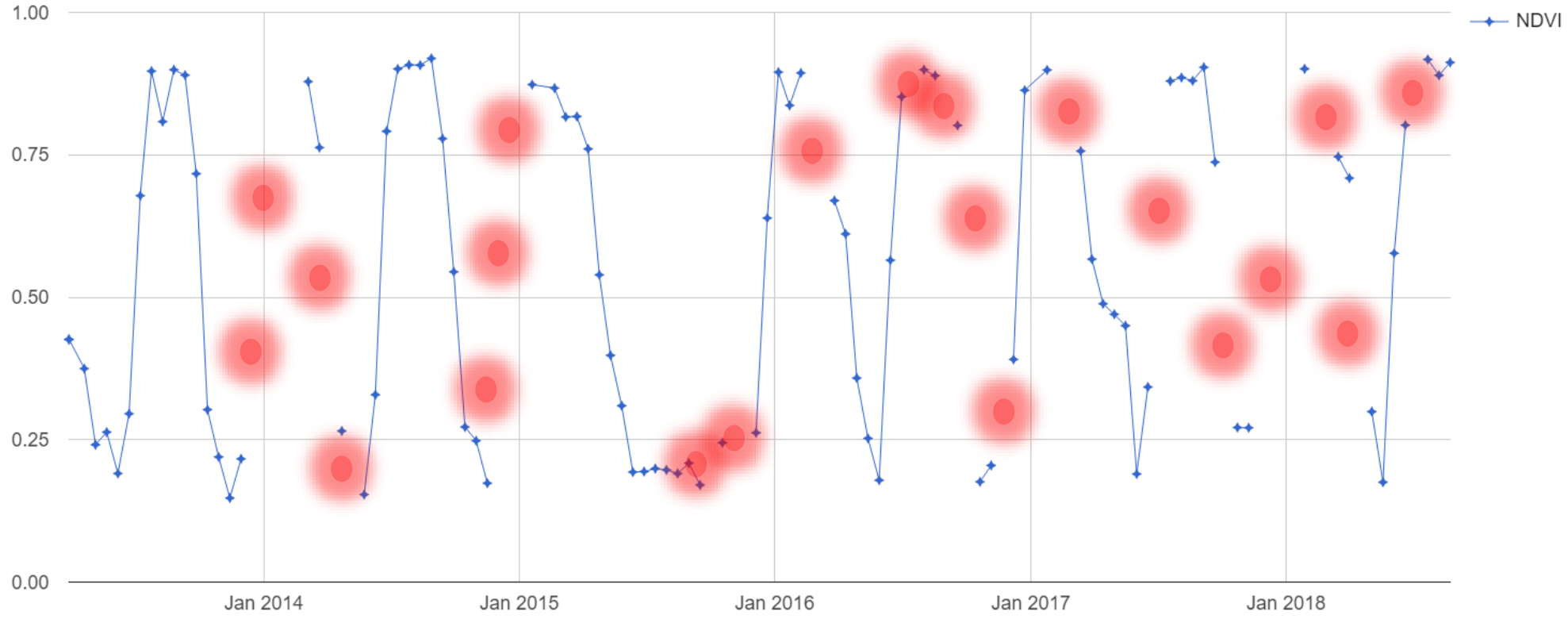
Landsat NDVI time series in Zimbabwe



Why harmonics?

Data Gaps

NDVI time series



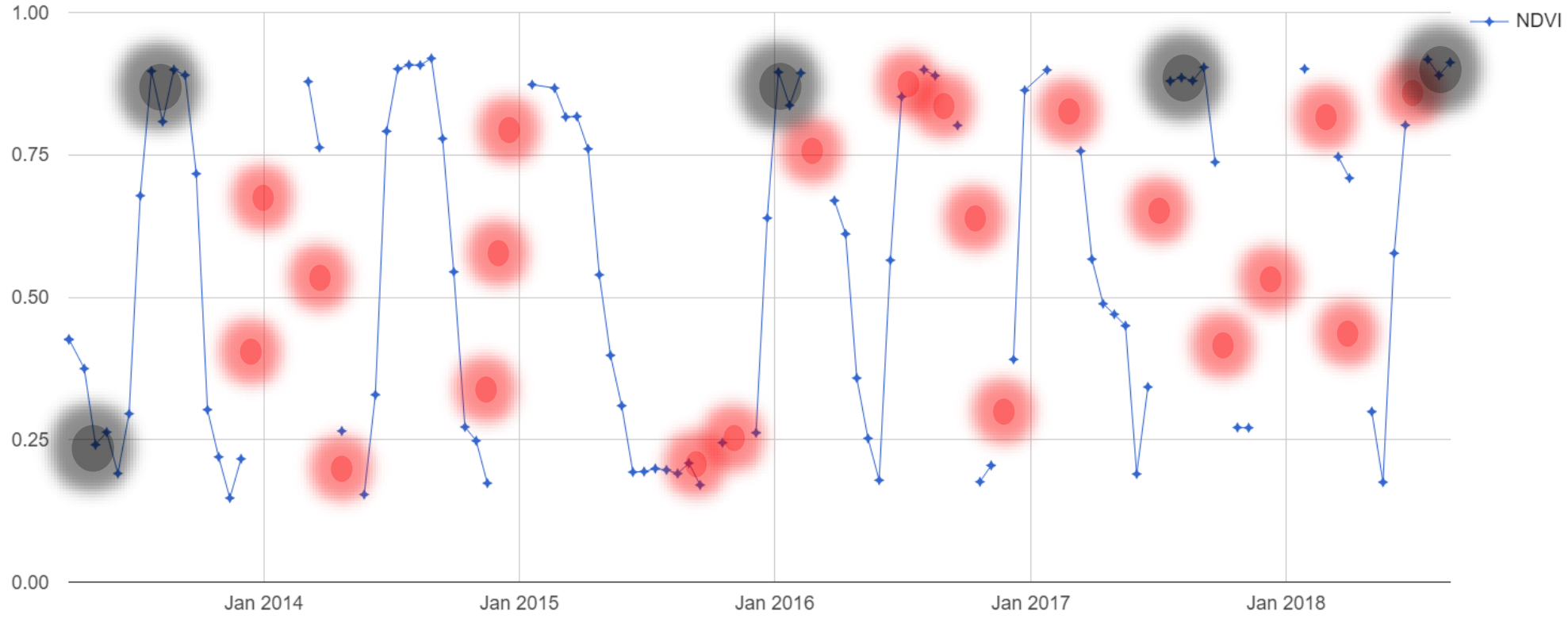
Why harmonics?

Data Gaps

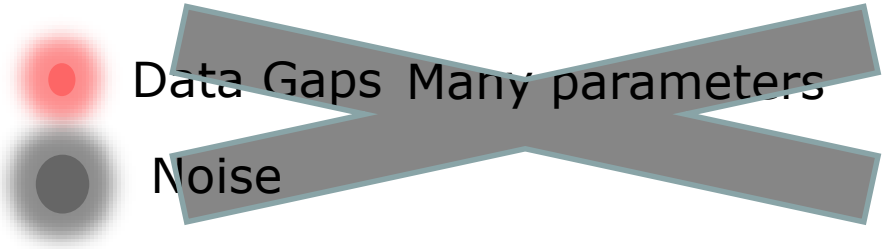
Many parameters

Noise

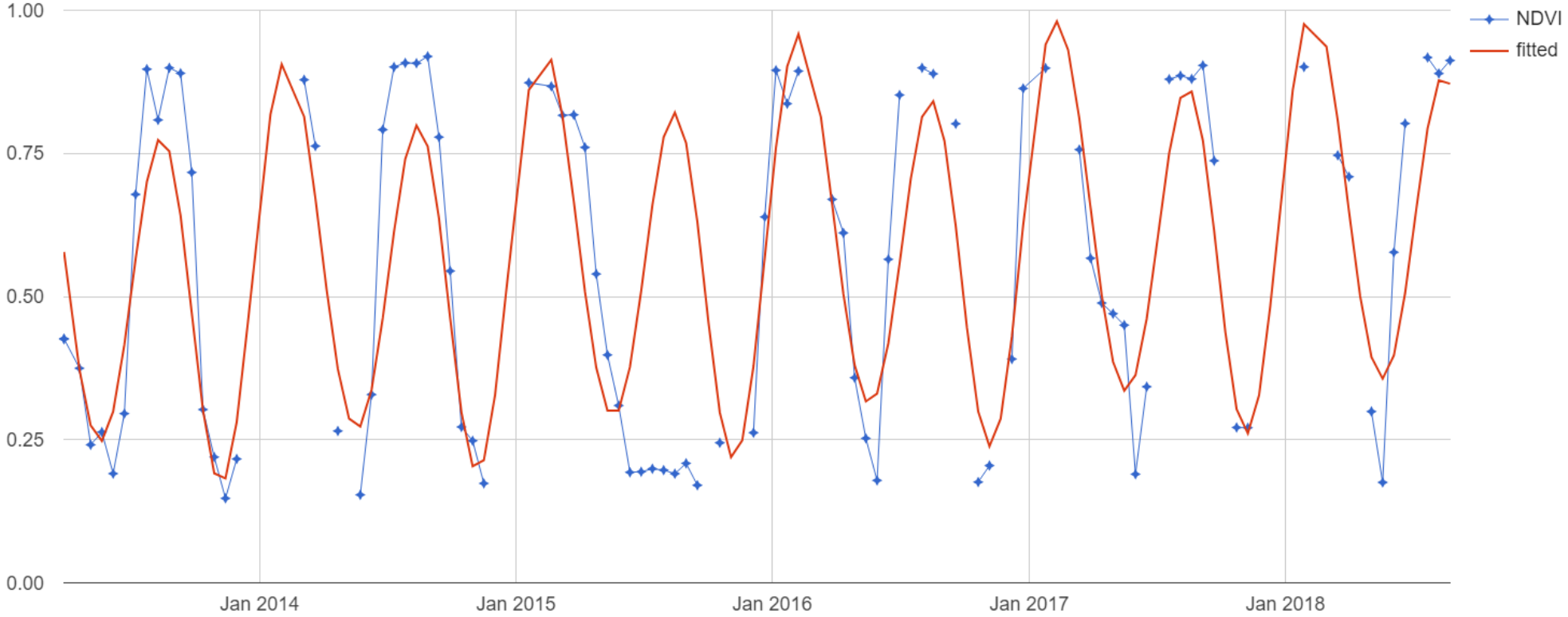
NDVI time series



Why harmonics?



NDVI time series with harmonic fitting



➡ Continuous data (no gaps) ➡ Less noise ➡ Few parameters

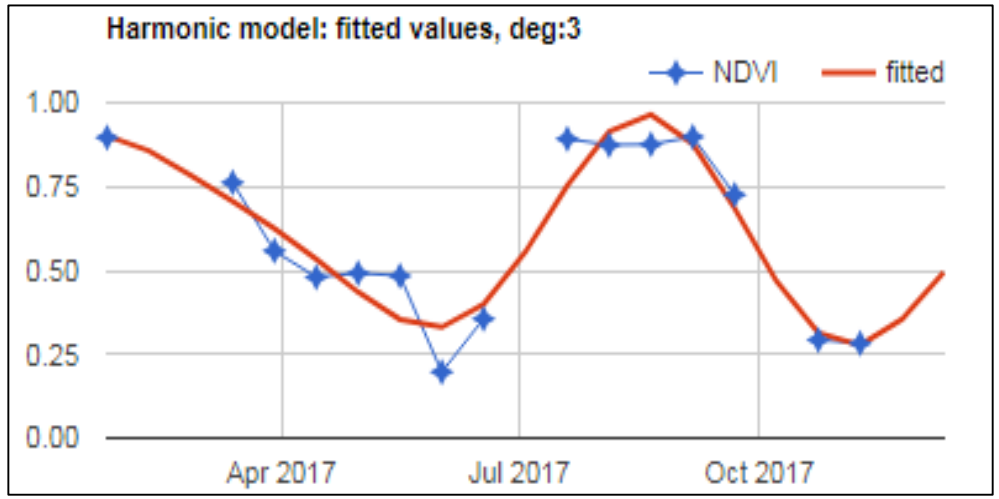
What are Harmonics?

Harmonic degree

$$f(t) = a_0 + b_0 \cdot t + \sum_{i=1}^{n} (a_i cos(i \cdot t| \quad |+b_i sin(i \cdot t))$$

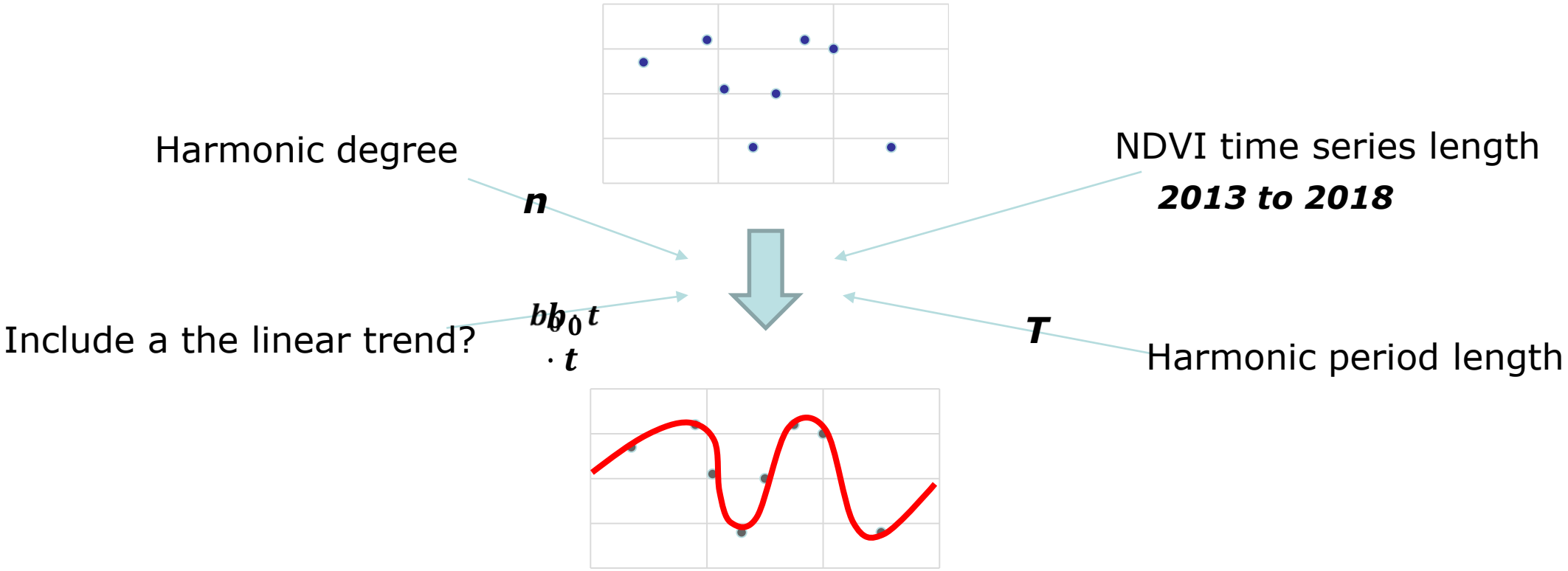
Independent parameters: , ….

➡ 2n + 2 independent parameters



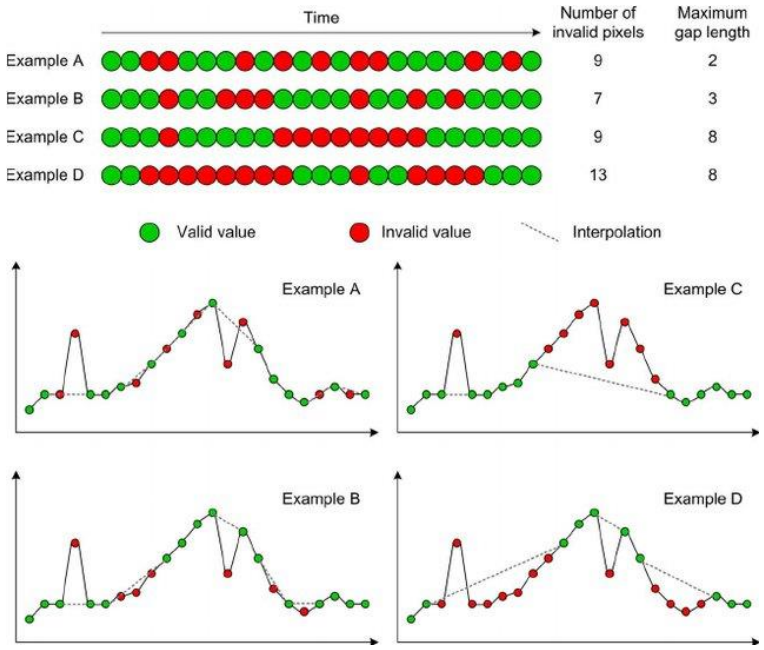
Optimizations & utility

- Can be optimized depending on: noise levels, data gaps, length of data series



Other pros and cons

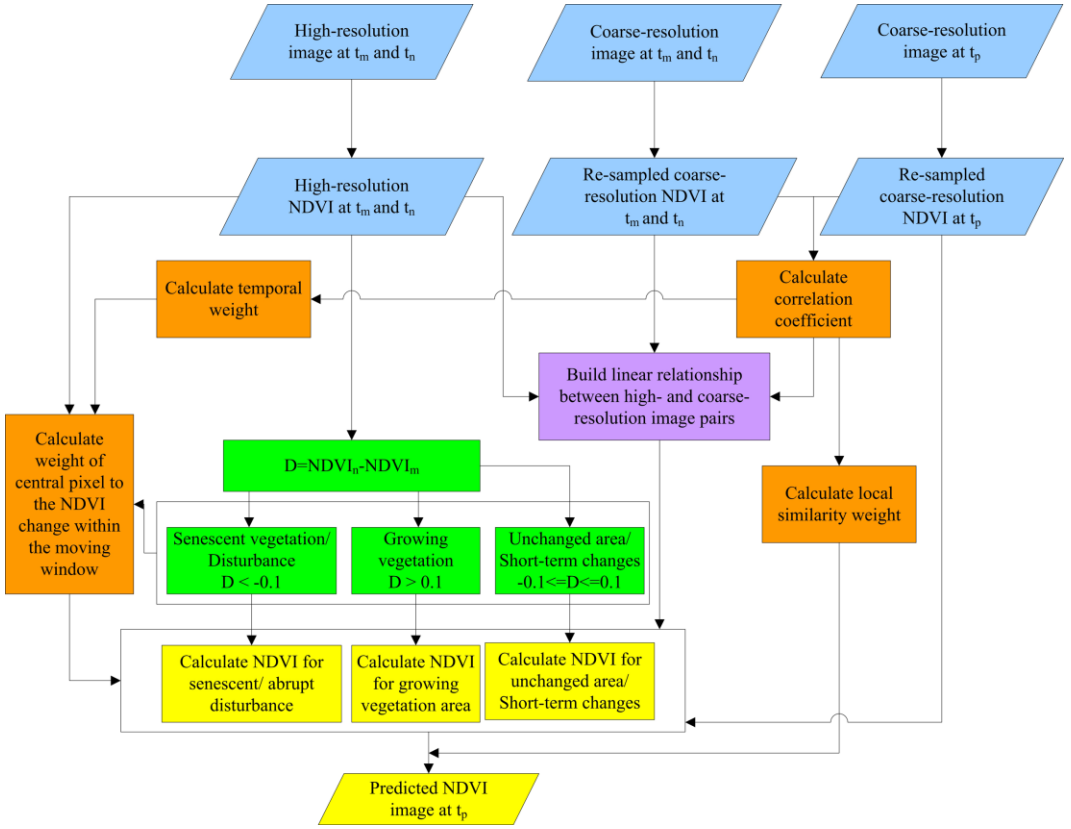
- **Pros:** Continuous curve, computationally effective, Shape and brightness, other filtering functions between extreme points may results in non-comparable phenology metrics (amplitude)
- **Cons:** noise over image invariant, outliers/gaps can result in **wild swings**, inter-annual dynamics difficult to handle (**needs stable seasonality**)



Colditz et al., 2008

For instance, compared to ‚State of Art' data fusion

- Characterized by regression coefficients, the computational and storage costs are far less than data stacks created by fusion algorithms



Liao et al., 2017

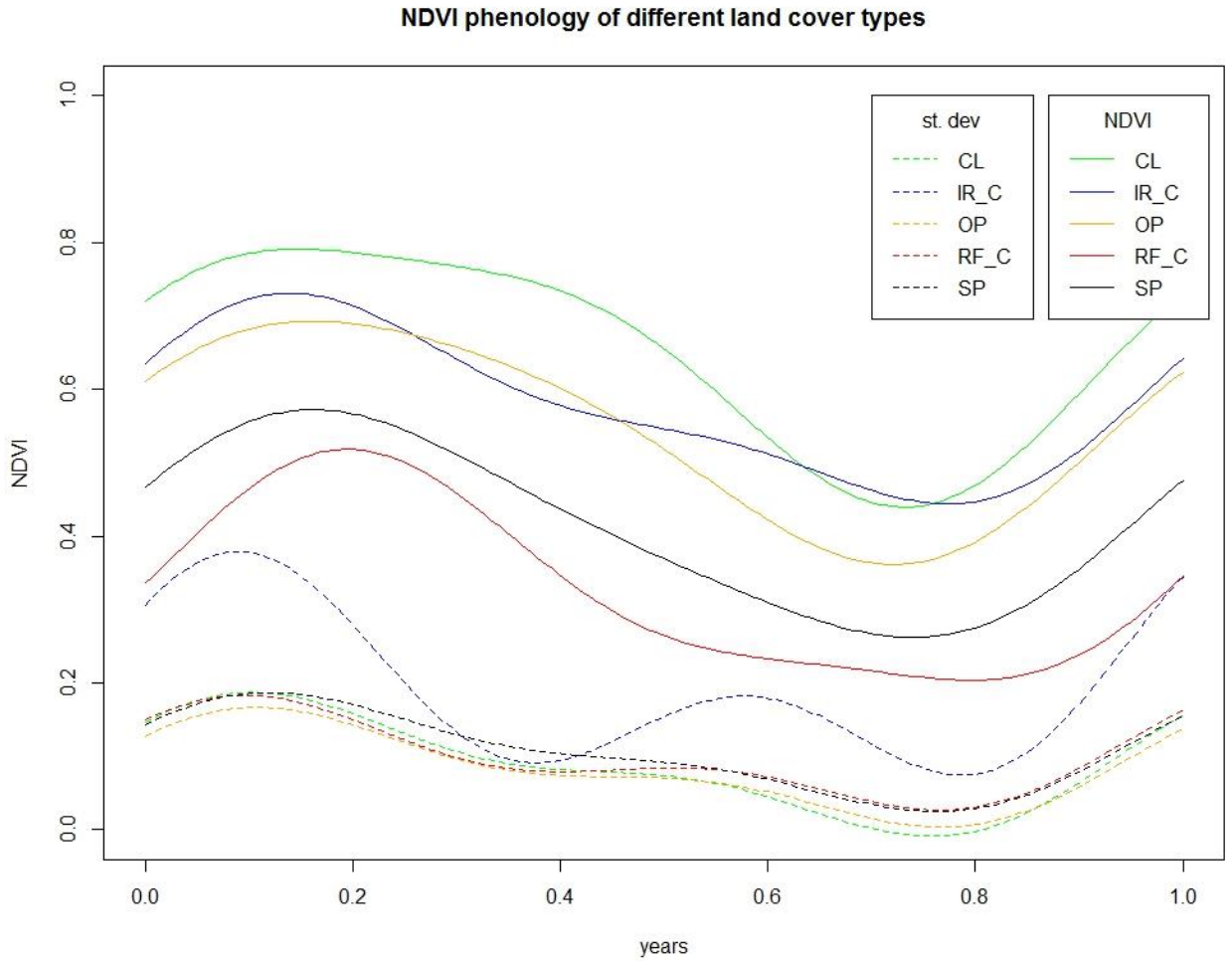
Sampling of test and model evaluation pixels

Rainfed Cropland

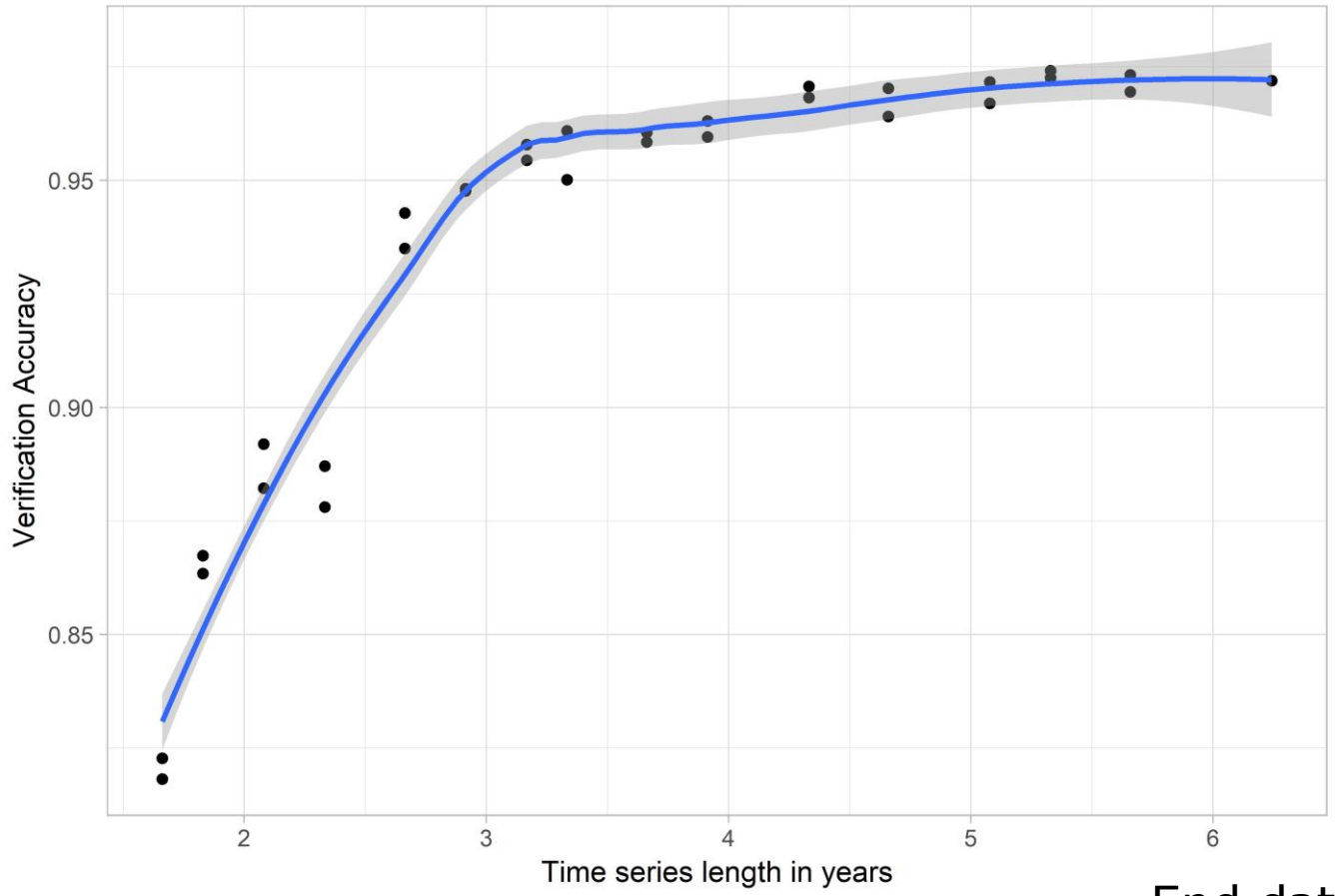
Irrigated Cropland

Rainfed Natural Vegetation

Mean Landsat NDVI harmonics for farm systems and natural vegetation in Zimbabwe



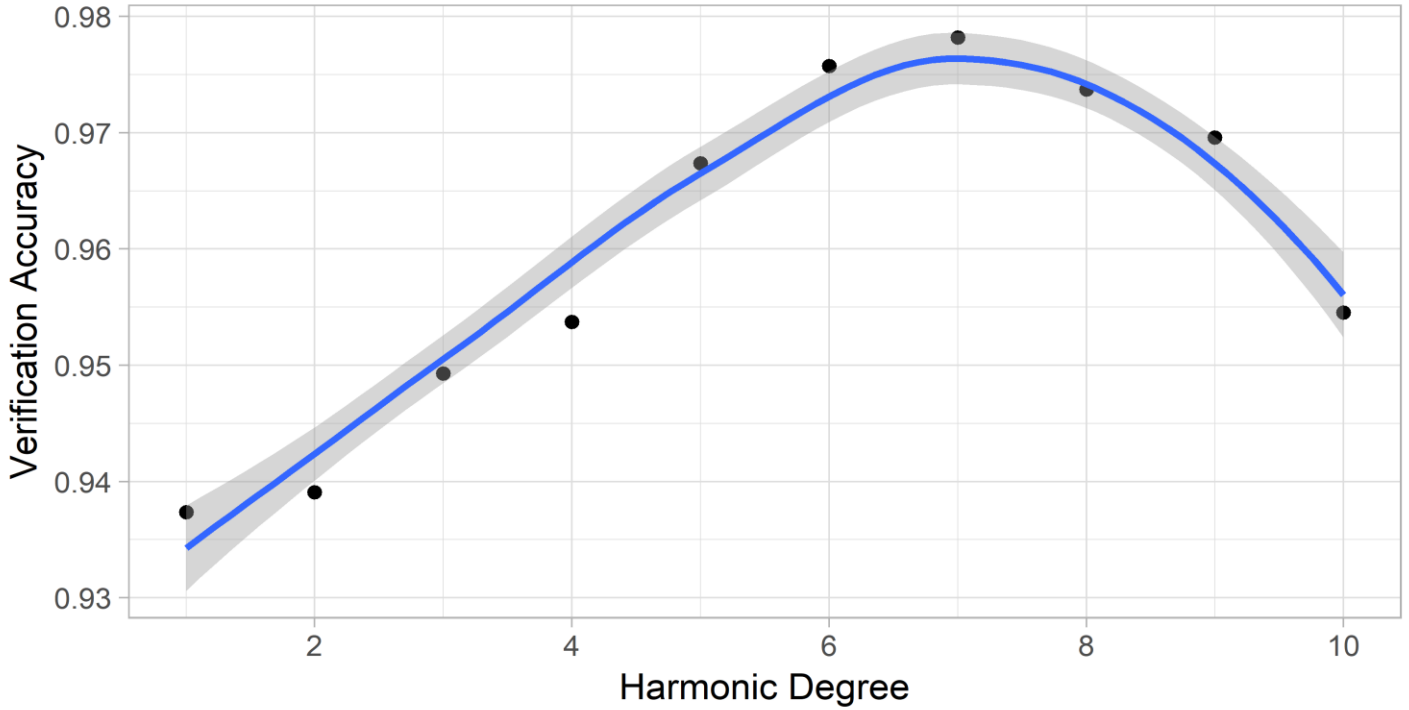
Results: Optimizing harmonics – length of time series



Longer time series perform superior

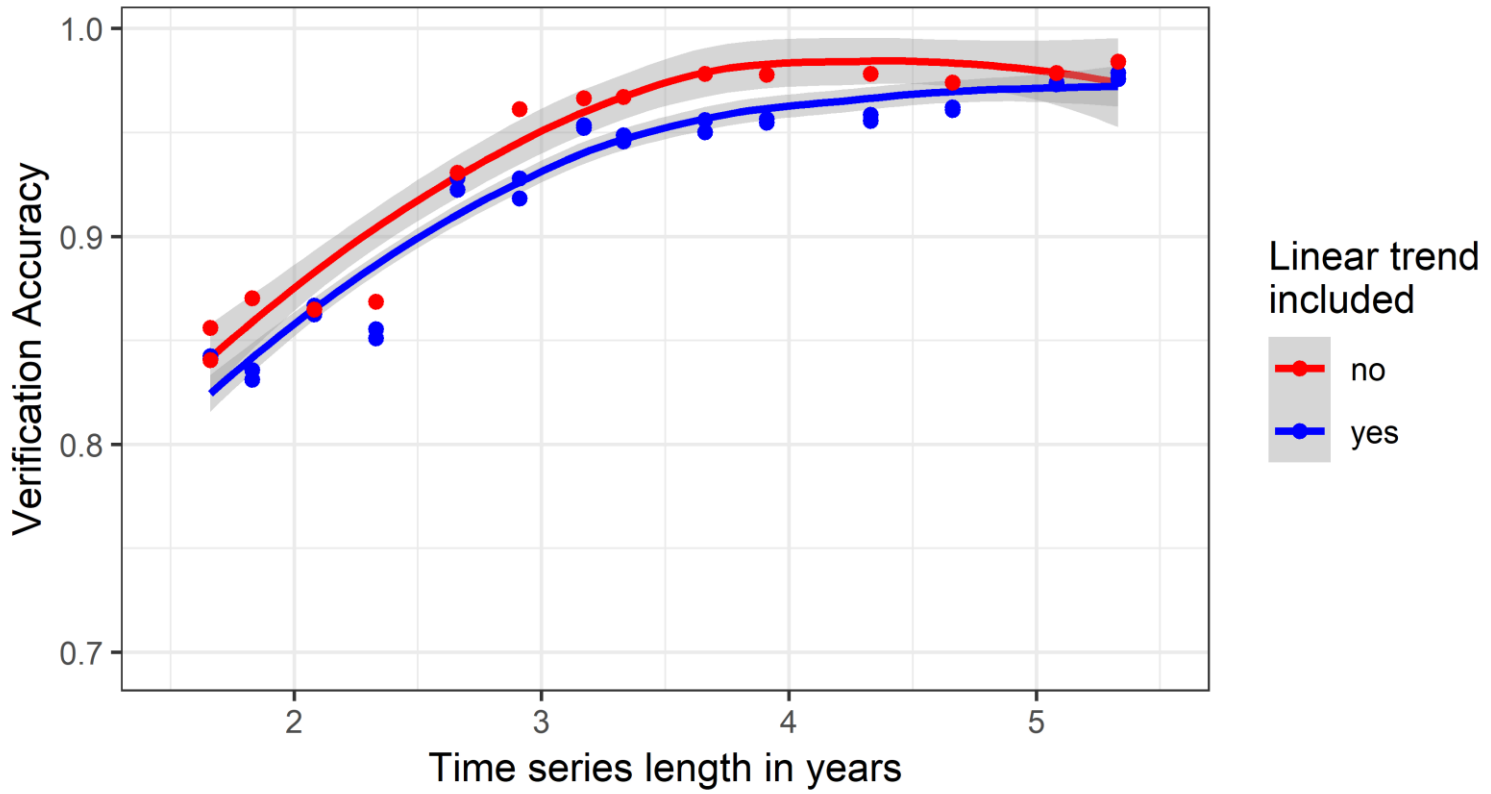
End date: 01.09.2018

Results: Optimizing harmonics – harmonic degree



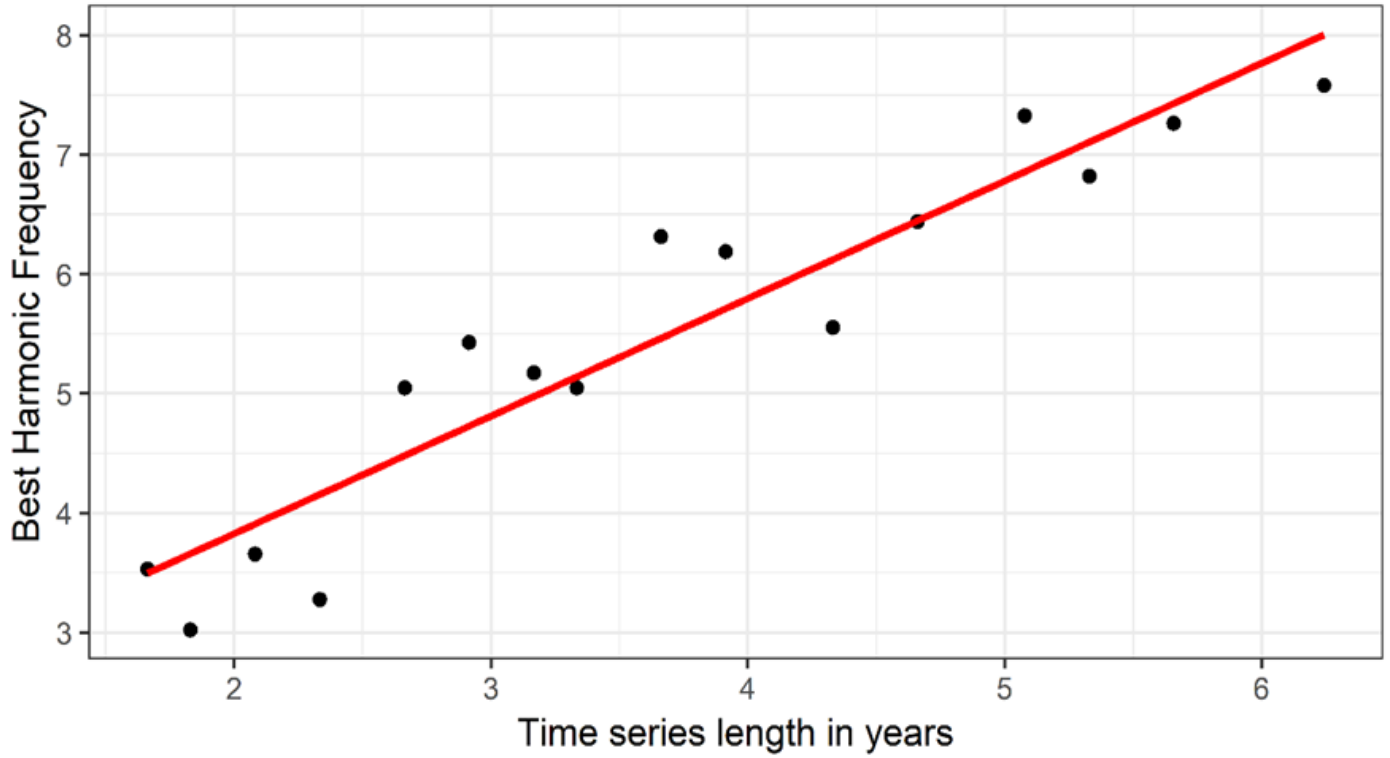
Best harmonic degree: 7

Results: Optimizing harmonics – linear trend



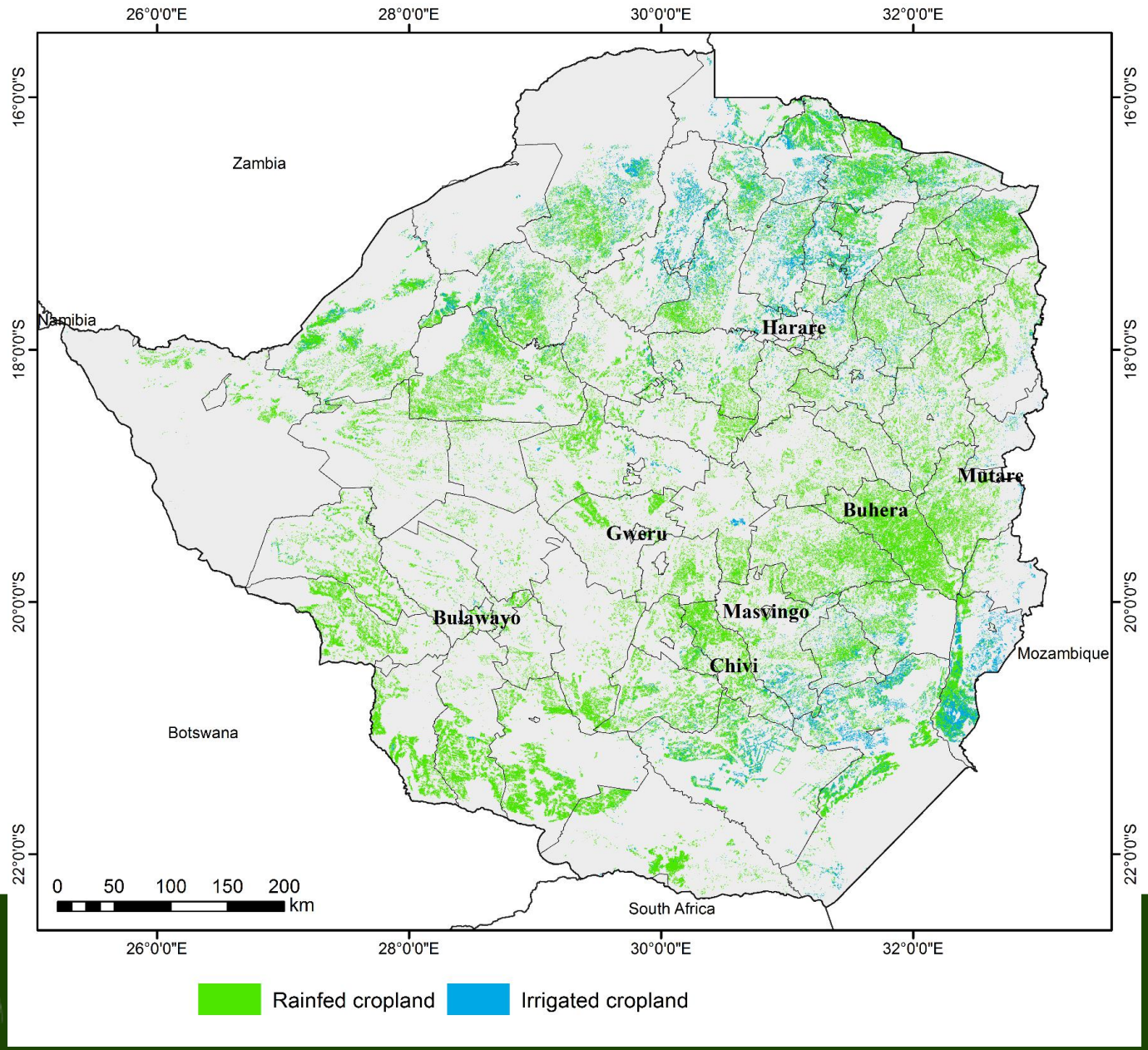
-Best to exclude trend variable!

Results: Optimizing harmonics - Best harmonic frequency (y) against time series length in years (x).

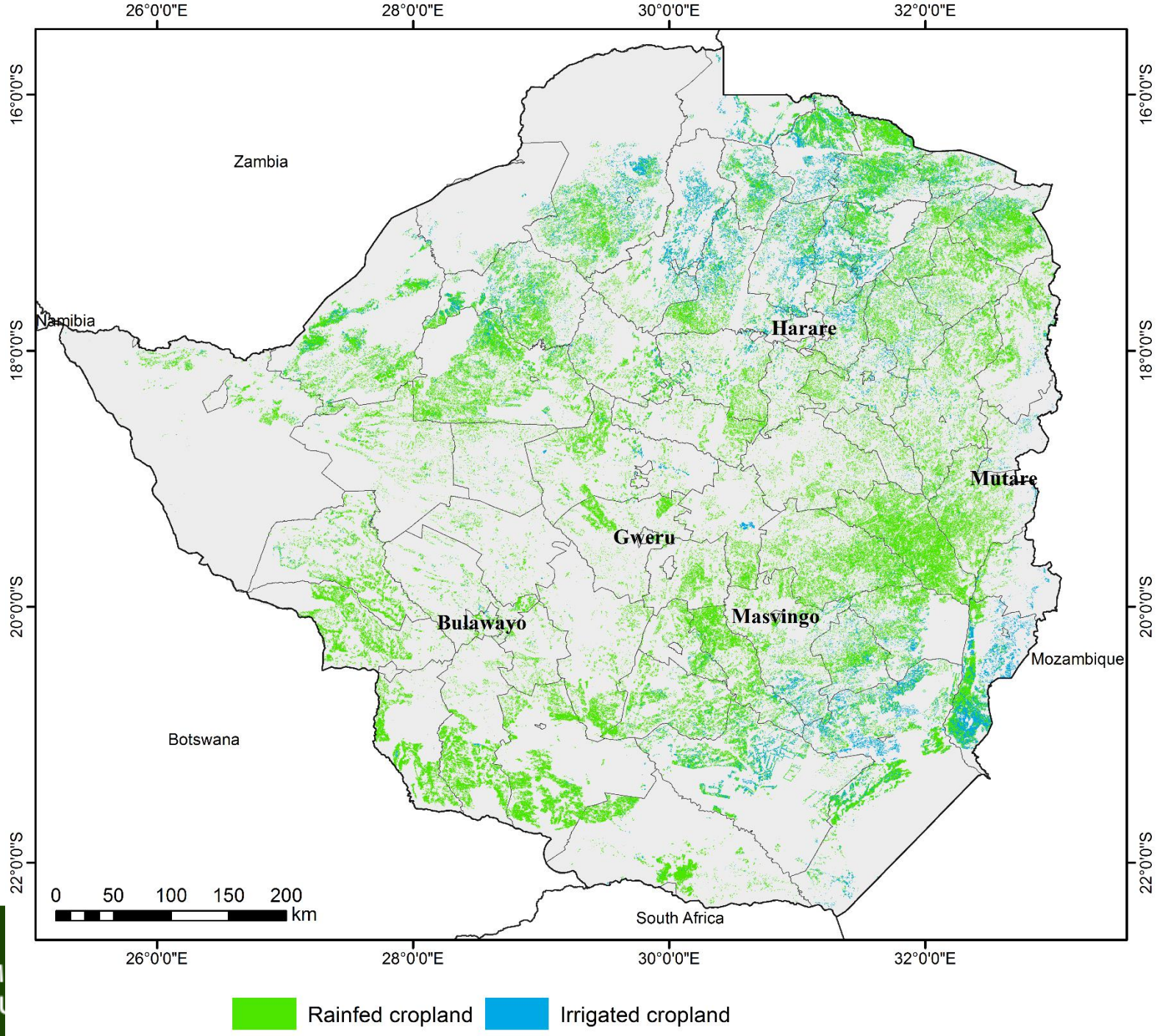


Harmonics frequency = 1.8598 + 0.9848 * length of time series (R^2=0.88)

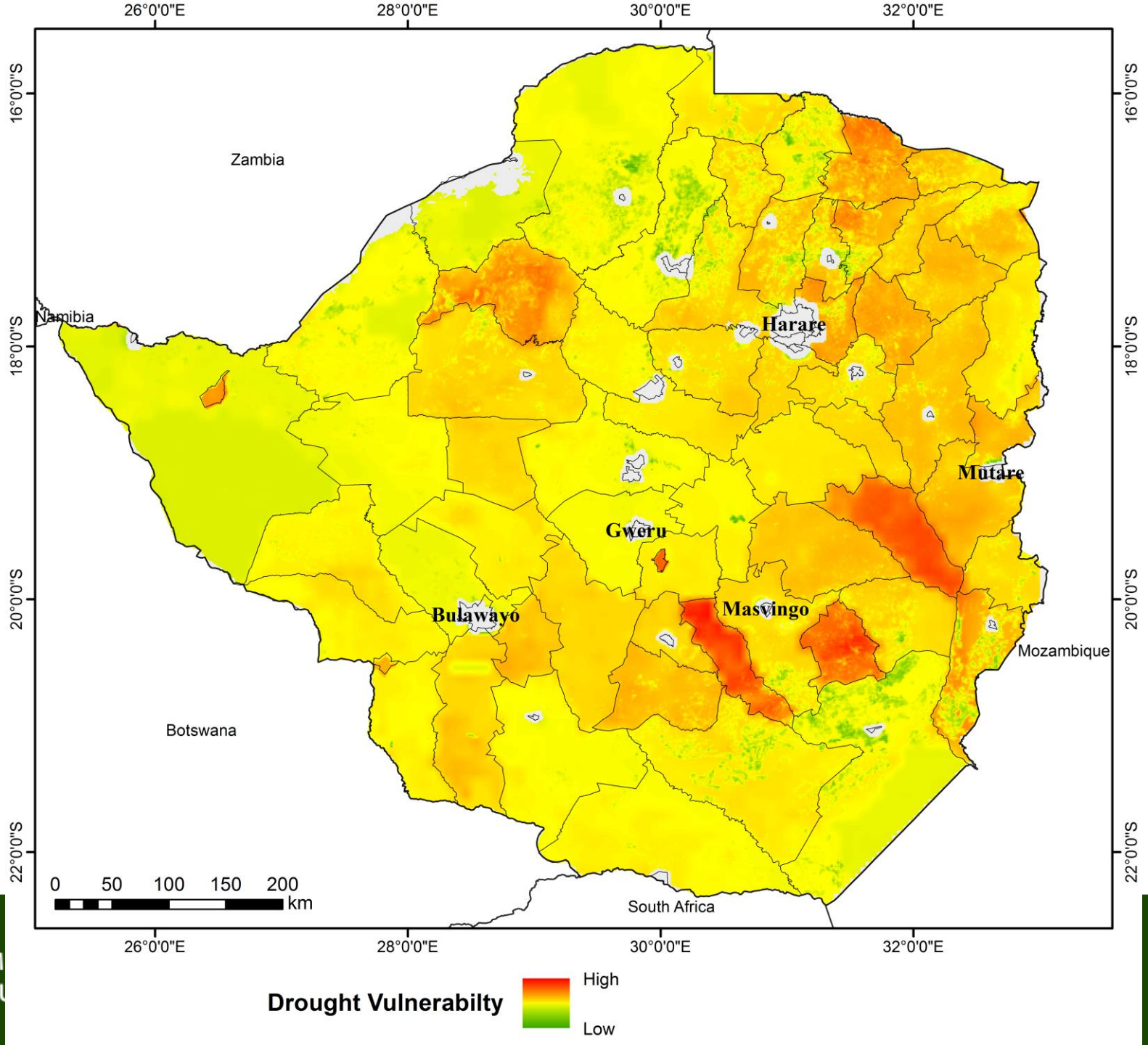
Result (97% accuracy)– using optimized LS harmonics & random forest



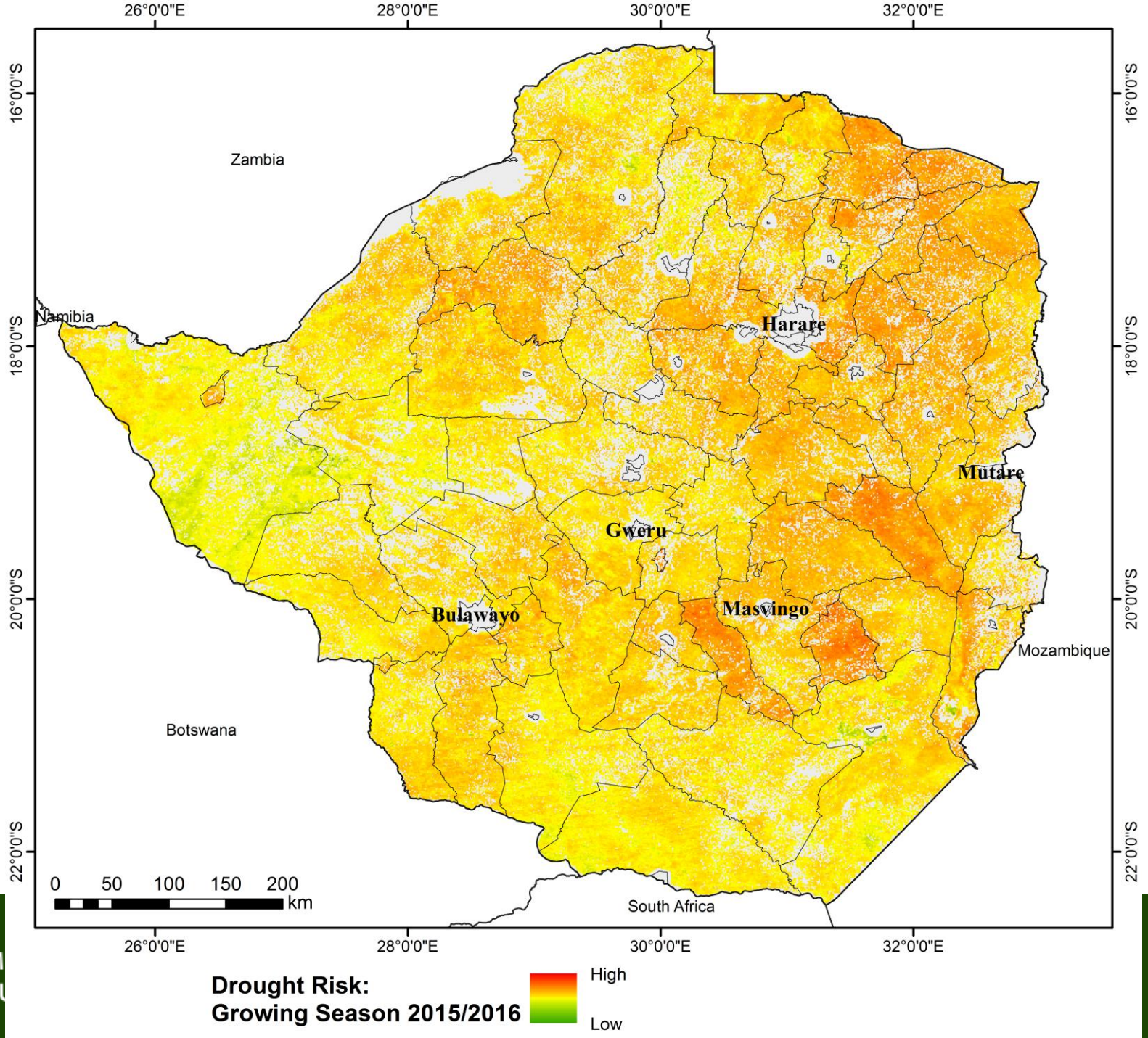
Rainfed and irrigated agriculture (as an important vulnerability aspect)

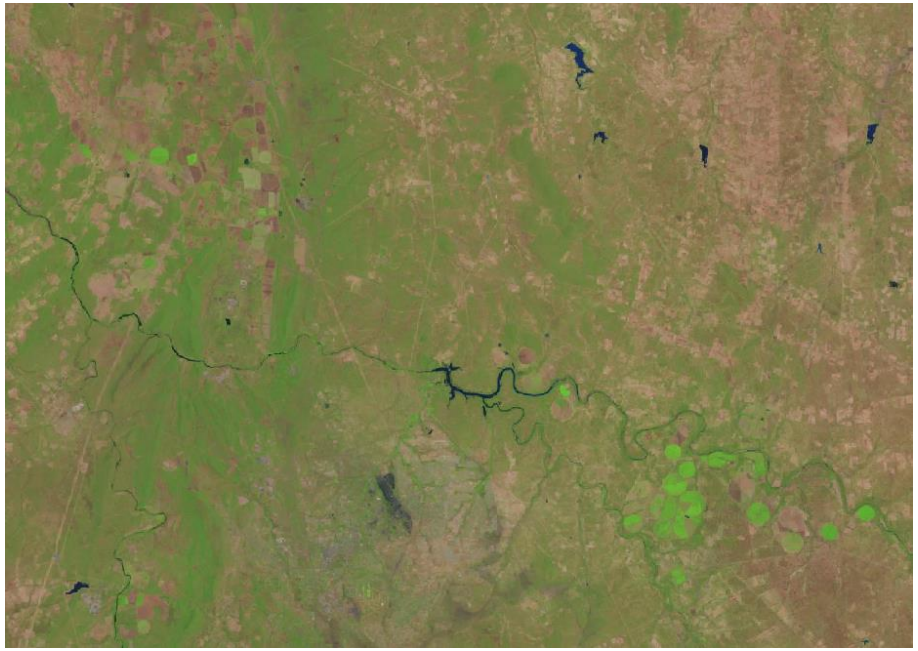


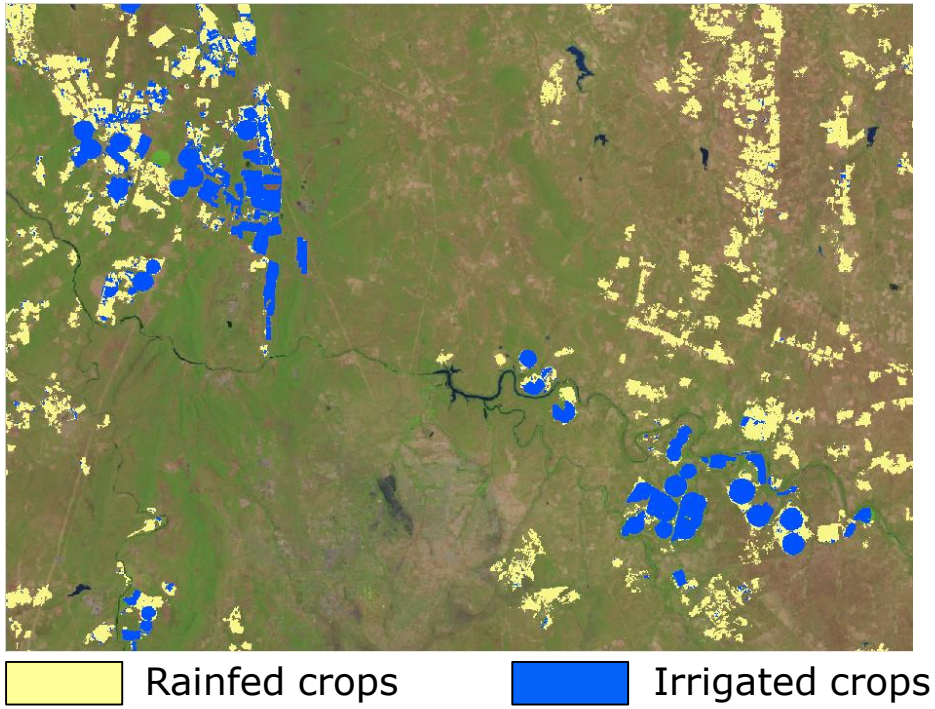
Drought vulnerability using animal density, GDP, farming systems



Drought risk using hazard and vulnerability

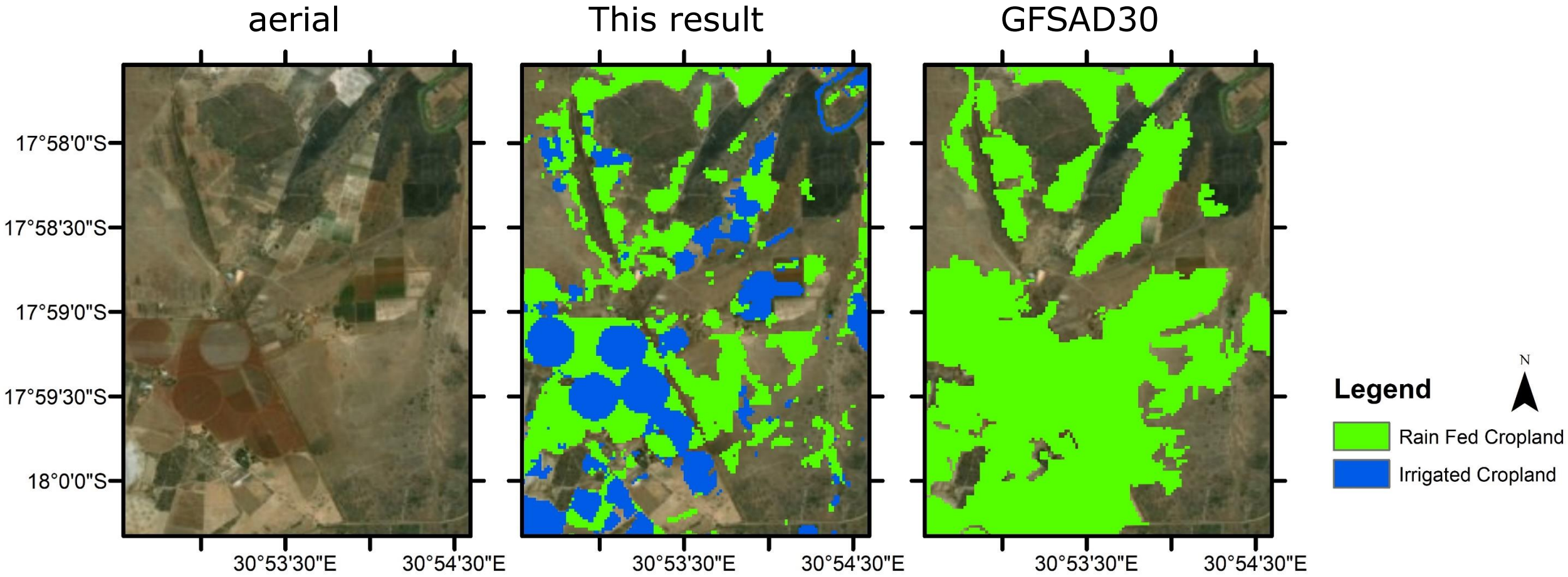




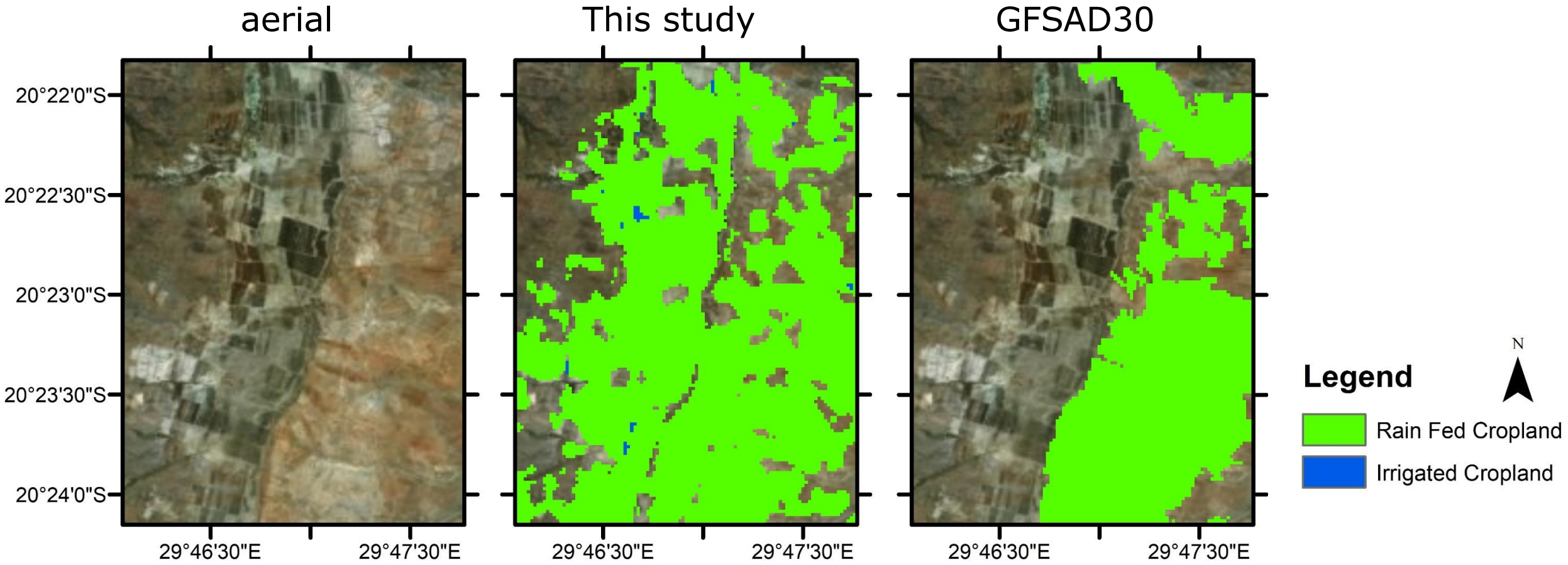


- Drought risk assessment for Southern Africa is constrained by the lack of basic information
- Global data sets are often not accurate enough for use in regional assessments

Results – comparison with state-of-art croplands map (GFSAD)



Results – comparison with state-of-art croplands map (GFSAD 30)



Conclusions

- Harmonics method has many advantages when aim is to effectively exploit the Landsat time-series over Africa for enhanced mapping
- Farm systems mapping; using optimizations, accuracies of over 97% and more thematic detail than state-of-art map
- Information about farming systems are important for land management policies pertaining to drought and food security

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Thank you for your attention!

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