

# Mapping Cropping Intensity of Smallholder Farms in South Asia

## A Comparison of MODIS, Landsat, and Mixture Model Techniques

Meha Jain<sup>1</sup>, Pinki Mondal<sup>1</sup>, Christopher Small<sup>2</sup>, Gillian L. Galford<sup>3</sup>, and Ruth S. DeFries<sup>1</sup>  
<sup>1</sup>Columbia University, <sup>2</sup>Lamont-Doherty Earth Observatory, <sup>3</sup>Marine Biological Laboratory, Woods Hole

### Main Question

What is the most accurate method to map cropping intensity of smallholder farms using readily-available satellite data (i.e. Landsat, MODIS)?

### Motivation

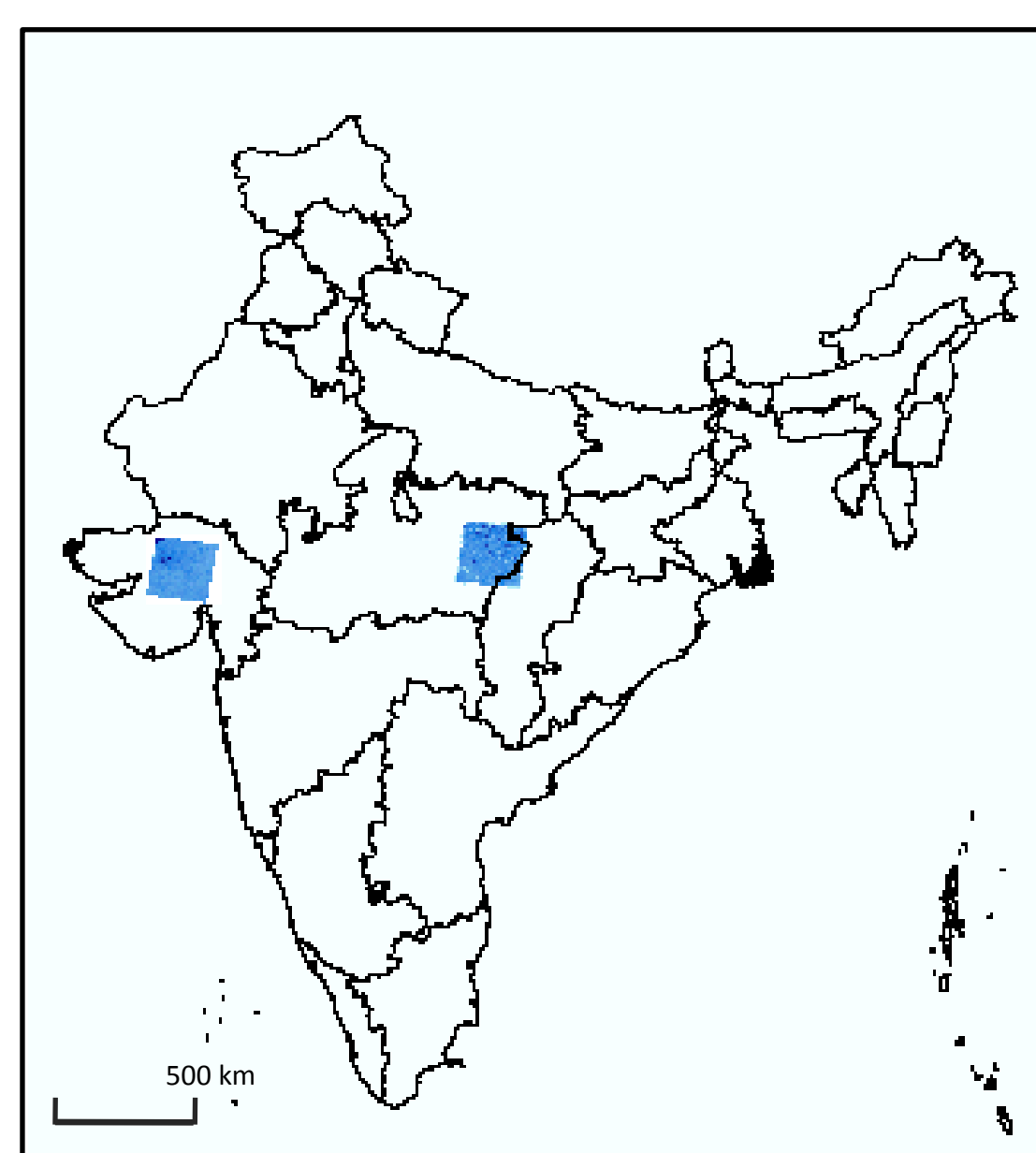
- ❖ Current techniques may not accurately map cropping intensity of smallholder farms because the size of one farm is smaller than the spatial resolution of readily-available imagery
- ❖ Smallholder farms are the most vulnerable to global environmental change (Morton, 2007)
- ❖ The number of crops per year (cropping intensity) is a crucial factor for livelihoods of smallholder farmers

### Study Goal

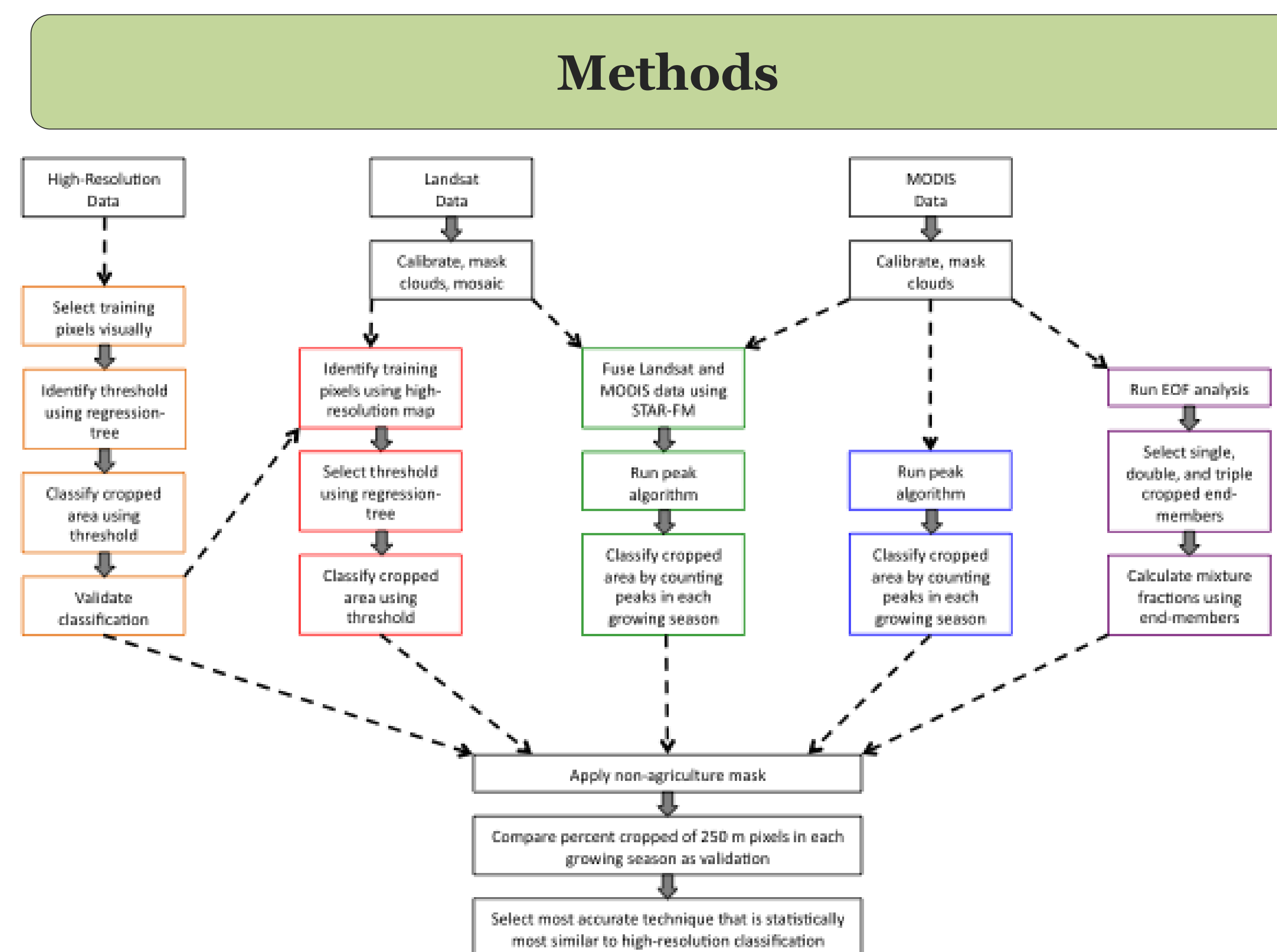
- ❖ We compare 4 techniques to identify the most accurate method to map cropping intensity in winter 2009 for smallholder farms in India:
  - + Landsat threshold
  - + MODIS peak
  - + Empirical Orthogonal Fractions (EOF) (Small, in prep.)
  - + Star-FM MODIS-Landsat fusion (Gao et al., 2006)

### Study Area

- ❖ Analyses were conducted in 2 regions (Fig. 1) in India to represent a range in precipitation levels, soil type, crop type, and market access

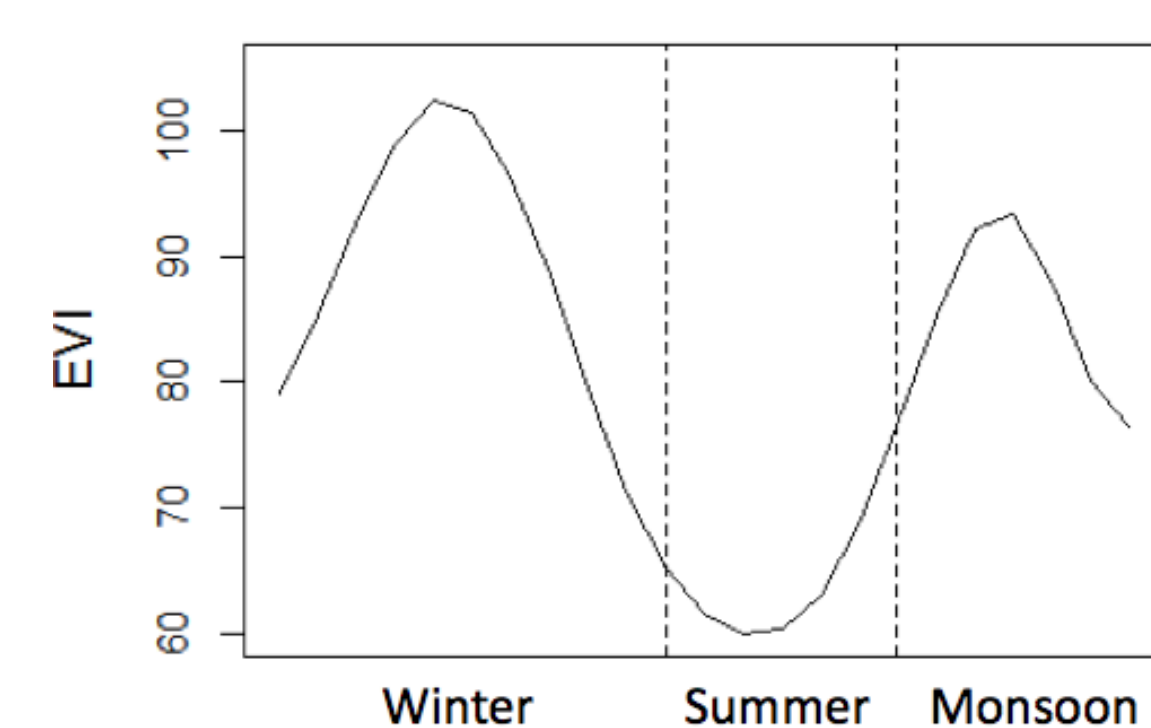


**Figure 1.** Study regions (central Gujarat and eastern Madhya Pradesh) are in blue



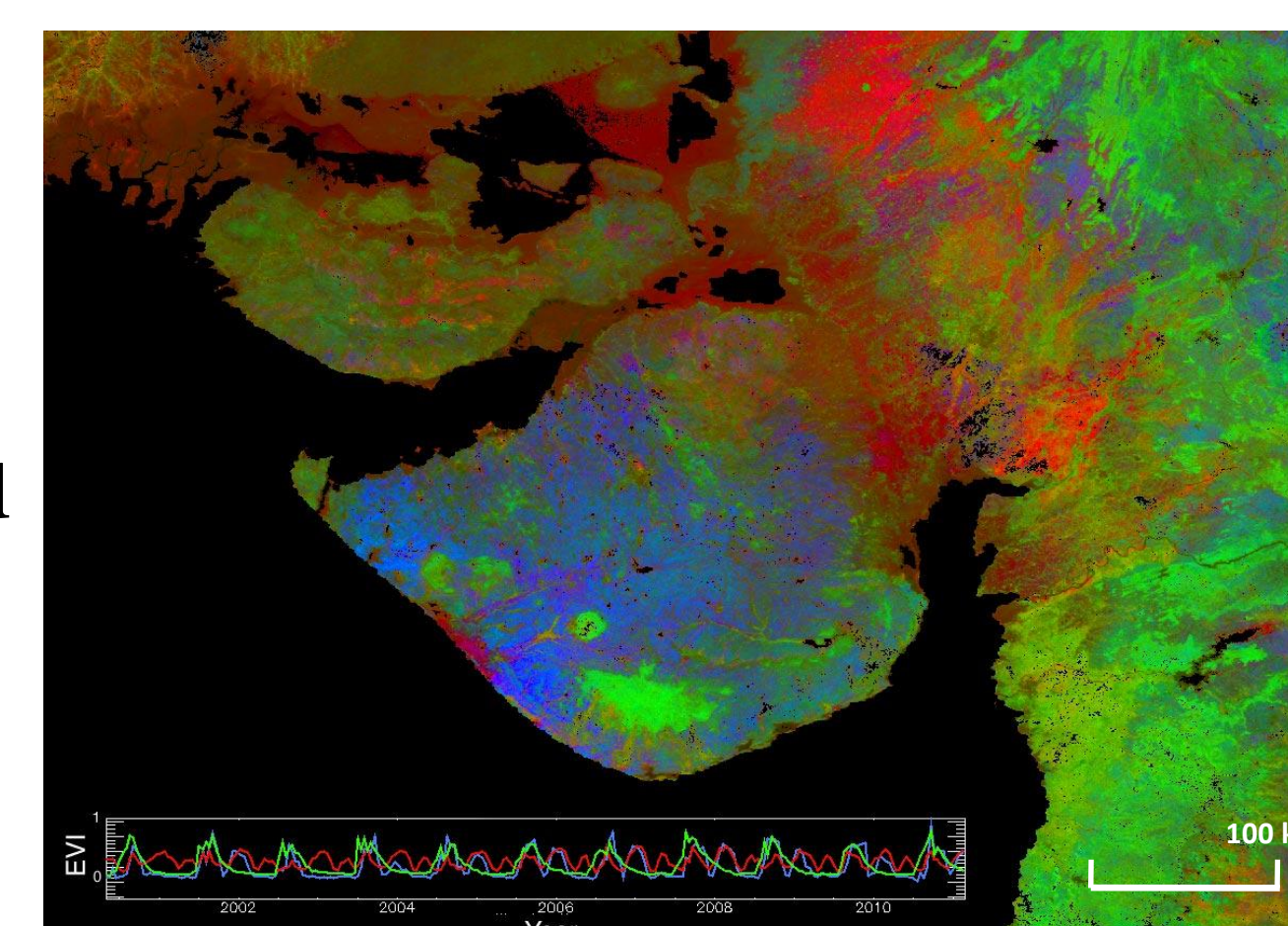
**Figure 2.** Work-flow diagram for each of the four methods used in our analyses. Each method is highlighted in a different color, which is coded in the Methods section below. All final cropped area maps are validated using high-resolution imagery. The most accurate technique is the one that is statistically most similar to the high-resolution cropped map.

- ❖ Landsat method (Fig. 2) identifies an NDVI threshold to classify cropped pixels (30 m)
- ❖ MODIS peak method (Fig. 2) classifies cropped pixels as those with a peak in EVI phenology (Fig. 3) during the growing season (250 m)
- ❖ EOF technique (Fig. 2) classifies the percent of a MODIS pixel that is cropped using a temporal mixture model (Fig. 4) (< 250 m)
- ❖ Star-FM peak technique (Fig. 2) fuses MODIS and Landsat imagery and uses the peak method (Fig. 3) to classify cropped area (30 m)
- ❖ Model results are validated using visual analysis of high-resolution Quickbird and WorldView-2 imagery (Fig. 2)

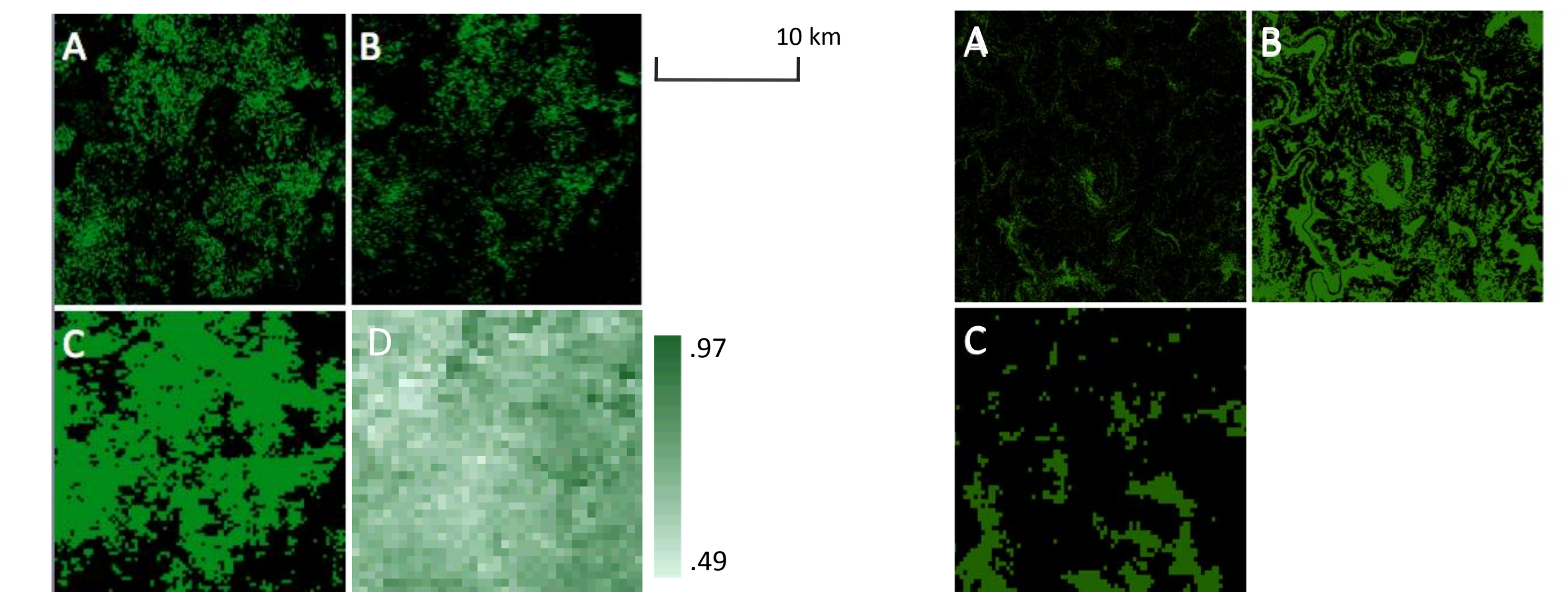


**Figure 3.** Cropped areas are defined as those that have a peak in the EVI phenology during the winter growing season. Data were smoothed using a B-spline curve.

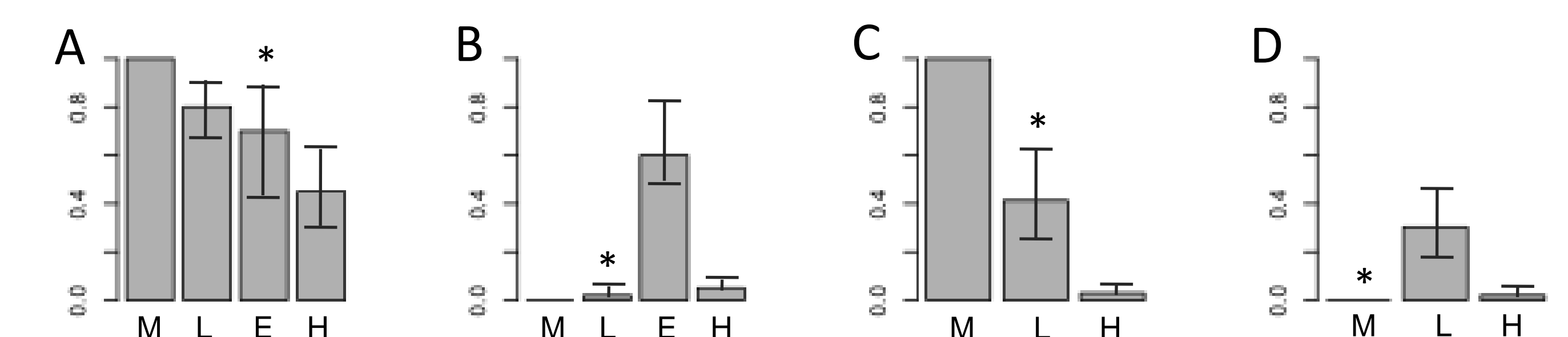
**Figure 4.** Temporal end-members of EOF analysis; end-members represent single, double, and triple cropped areas. Double and triple cropped areas are considered to be cropped in the winter of 2009 for the purposes of this analysis.



### Results



**Figure 5.** Cropped area (green) versus uncropped area (black) for high-resolution imagery (A), the Landsat threshold method (B), the MODIS peak method (C), and the EOF analysis (D). Images on the left (A-D) are from central Gujarat and images on the right (A-C) are from eastern Madhya Pradesh. All Star-FM analyses and the EOF analysis from Madhya Pradesh are currently in progress.



**Figure 6.** Percent cropped area under MODIS-peak (M), Landsat-threshold (L), and EOF (E) techniques compared to high-resolution (H) imagery for cropped MODIS pixels (A, C) and uncropped MODIS pixels (B, D). The most accurate methods for Gujarat (A, B) and Madhya Pradesh (C, D) are highlighted with an asterisk

### Discussion and Conclusion

- ❖ The most accurate method overall in both study regions is the Landsat threshold method. Future analyses will determine whether Star-FM outperforms this method.
- ❖ We believe that the Landsat threshold method can be applied to a variety of agro-ecological zones to map cropped areas
- ❖ Future studies will use the most accurate method from our analysis to assess inter-annual variability in cropping intensity across India

### Main Conclusion

The Landsat threshold method most accurately maps smallholder cropping intensity

### Acknowledgements and References

- ❖ This work was funded by the NASA LCLUC grant # 522363 and the NSF GRFP awarded to M. Jain
- ❖ J. Morton (2007). The impact of climate change on smallholder and subsistence agriculture. *PNAS*. 104 (50): 19680 – 19685
- ❖ F. Gao et al. (2006). On the Blending of the Landsat and MODIS Surface Reflectance: Predicting Daily Landsat Surface Reflectance. *IEEE Geosci. Remote Sens. Lett.* 44 (8): 2207 – 2218.