REDD+ Monitoring, and MRV Workshop

April 18-22 2016, Bangkok, Thailand

Time series analysis for monitoring of activity data

P. Olofsson et al.

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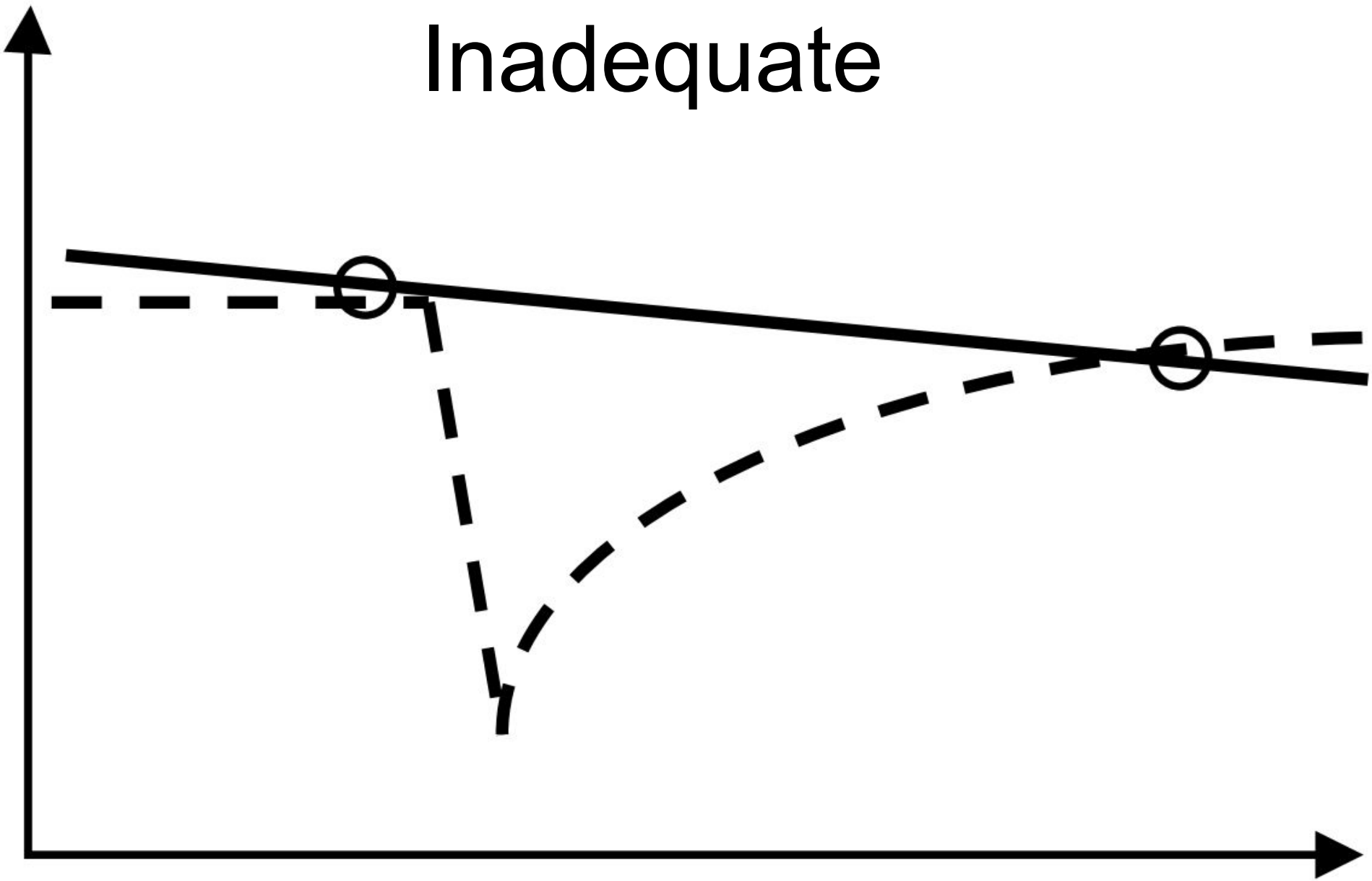
“What is a time series?”

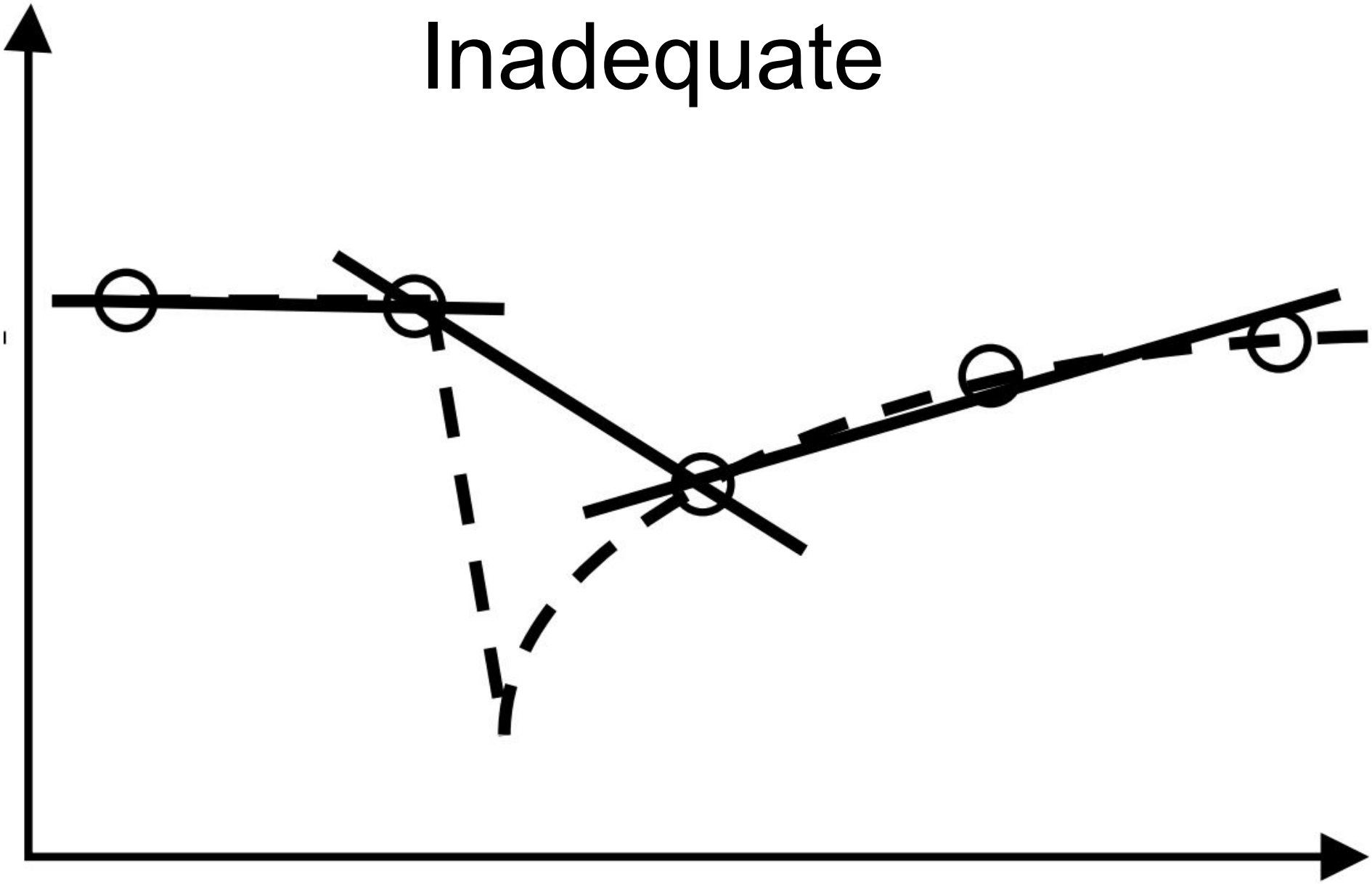
A time series is a sequence of observations taken sequentially in time. Adjacent observations are typically dependent and time series analysis is concerned with techniques for analysis of this dependency.

(Box & Jenkins, 1970)

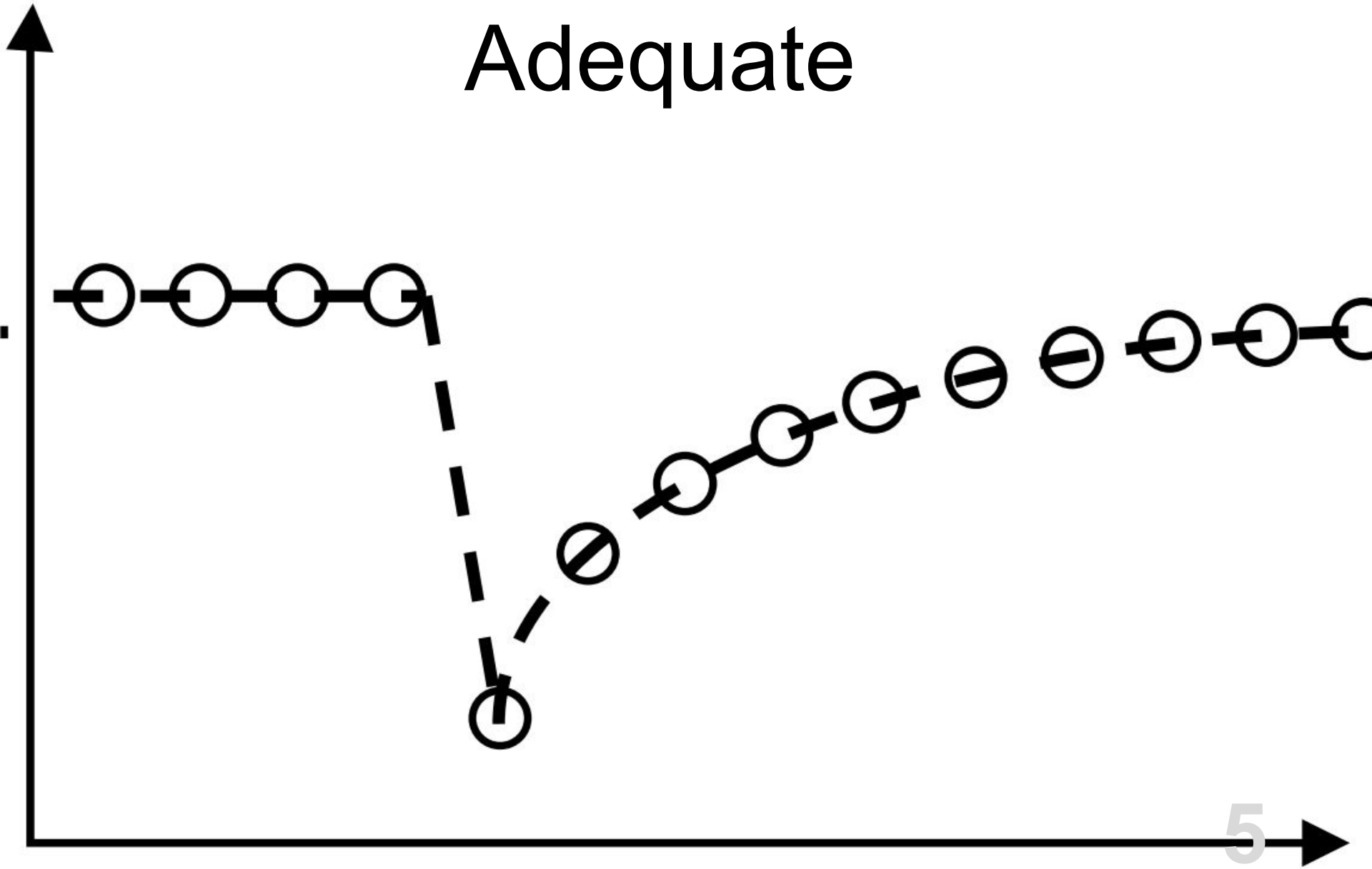
Inadequate

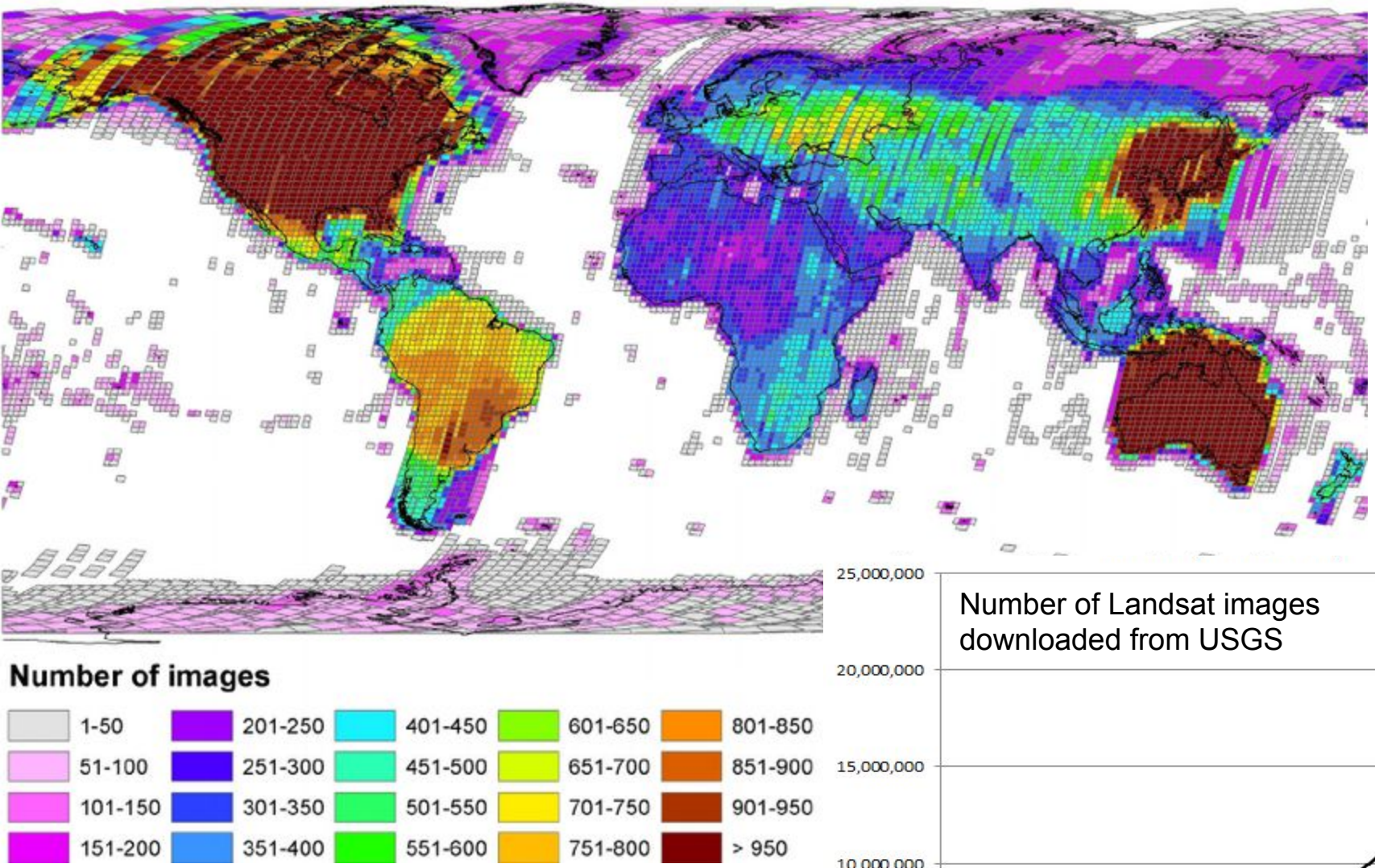


Inadequate

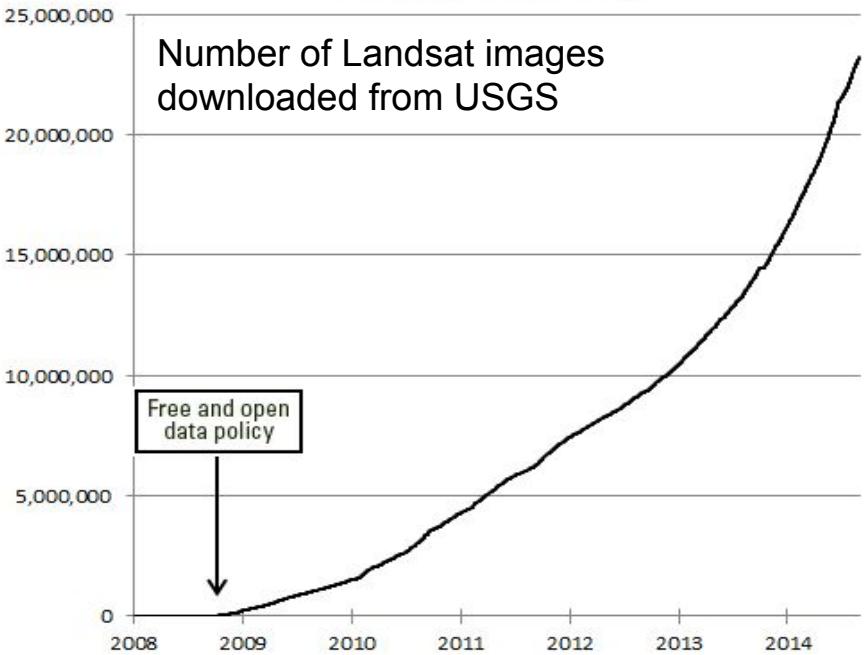


Adequate





From Wulder et al. (2015)



How to achieve this analysis?

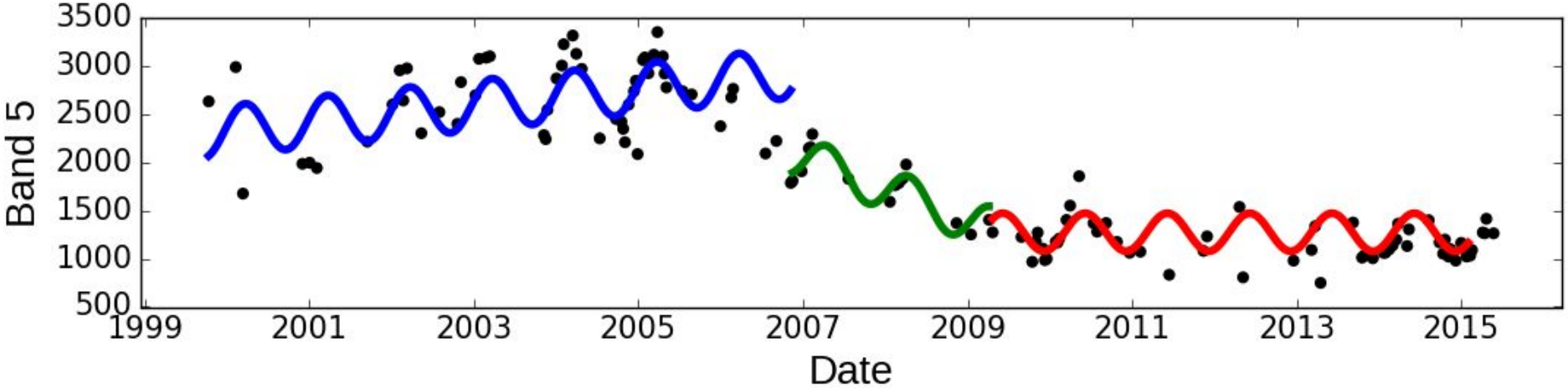
Three main approaches:

- *"Best images"* -- selects best image at fixed intervals -- global forest cover change every 5 years (GLS)
- *Compositing* -- selects best pixels in time series according to some criteria -- global forest cover change every year (GLAD, LandTrendr, VCT)
- *"All images"* -- ingests *all* observations -- allow for monitoring of land conversion and timing of activities (CCDC, BFAST)

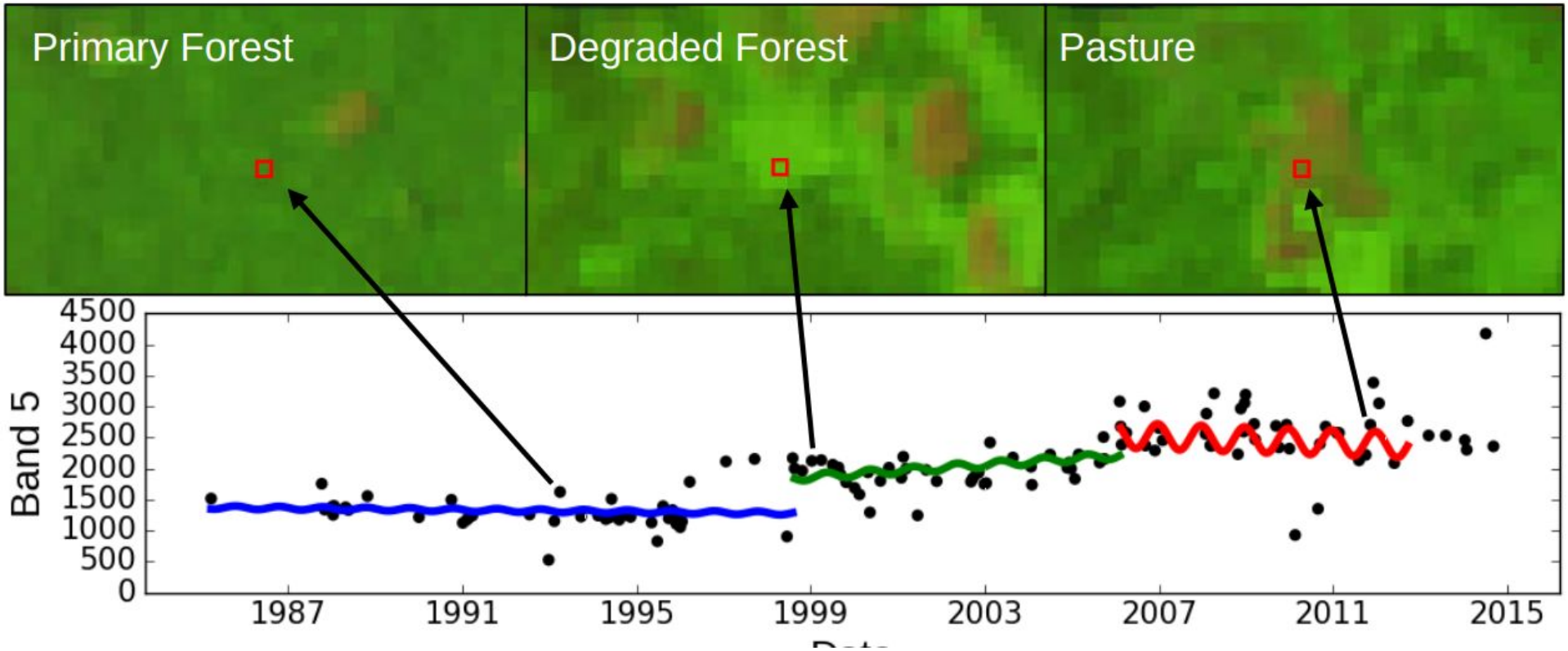
Name	Where	Inputs	Outputs
GLAD	University of Maryland	Yearly 'best' composite images	Deforestation map
LandTrendr	Oregon State University / US Forest Service	Yearly 'best' composite images	Change maps
bFast/ bFastMonitor	Wageningen University (Netherlands)	All available images, forest mask	Change map
Continuous Change Detection and Classification (CCDC/YATSM)	Boston University / United States Geological Survey	All available imagery, training data	Change maps, land cover classifications

Complexity

Example, CCDC/YATSM, Vietnam



Example, CCDC/YATSM, Colombia

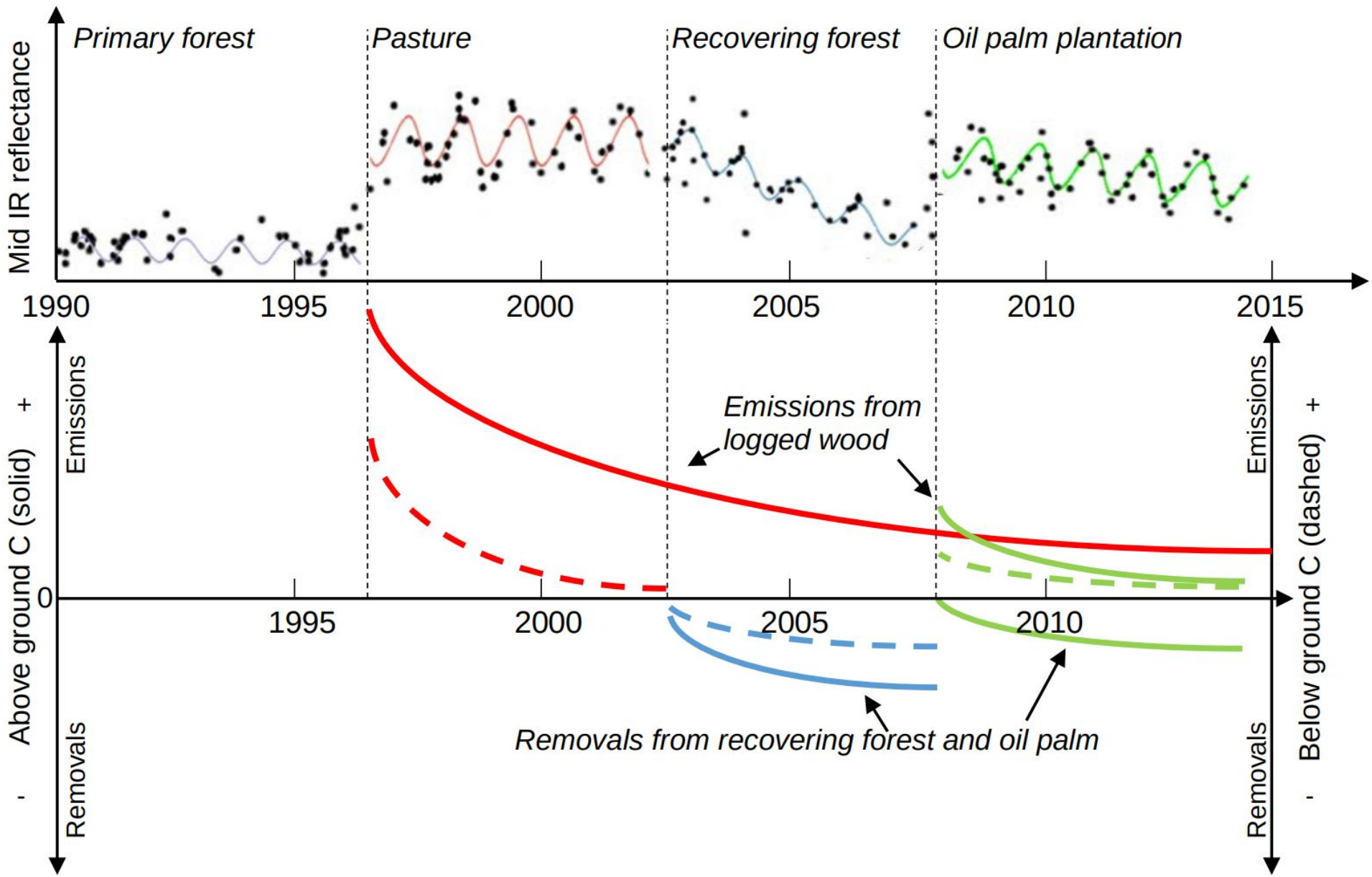


[Slides from Eric showing change detection in Brazil]

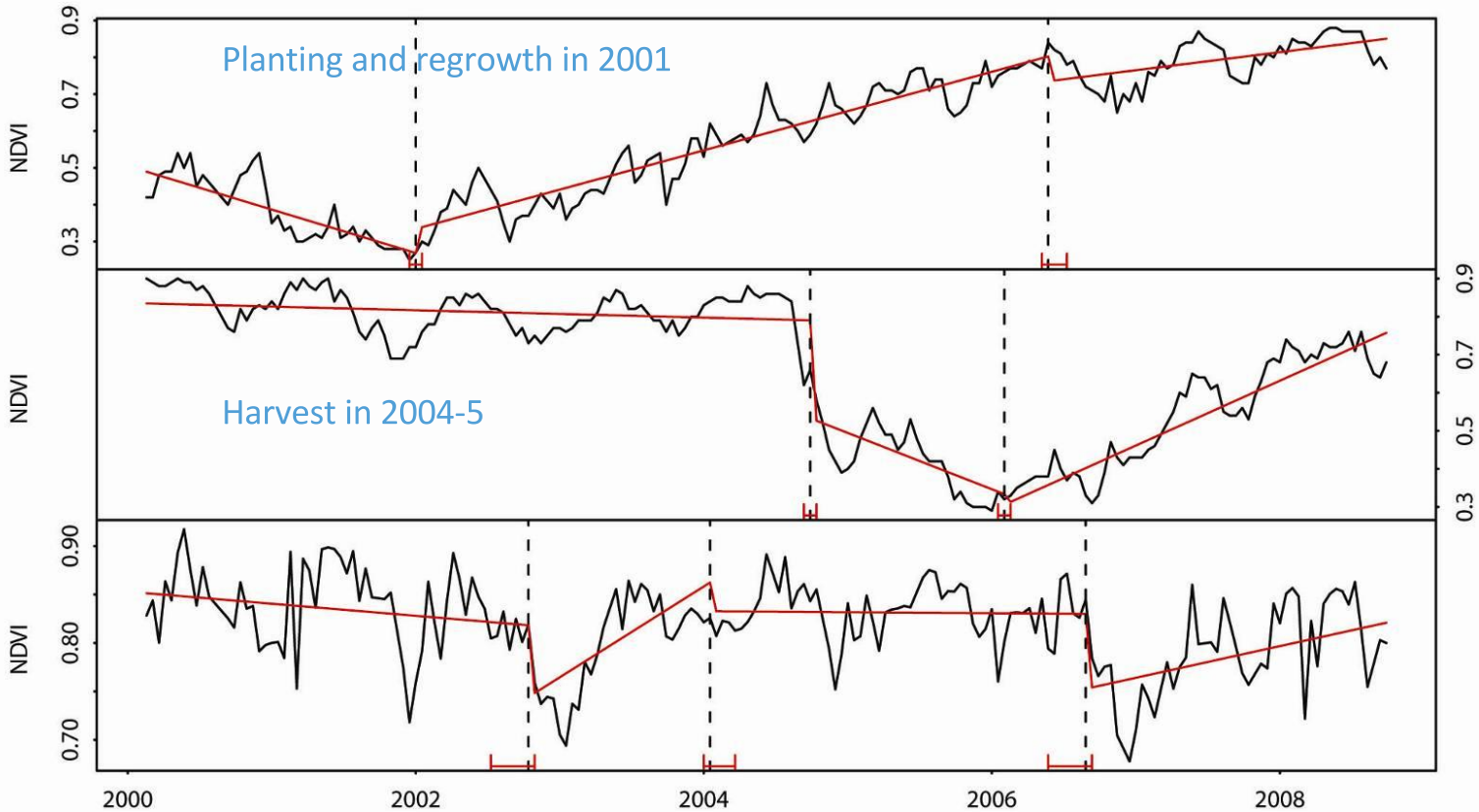
CCDC/YATSM

- Implementation across the U.S. (USGS/BU)
- Plan to extend effort to SilvaCarbon Partner Countries
- Implementation across Colombian Amazon for monitoring of transition between IPCC land categories (SilvaCarbon/BU)
- Plan to tag on pixel-level carbon bookkeeping model for temporally and spatially explicit carbon modeling framework (i.e. Tier 3 compliant estimation)
- Integration with other approaches, e.g. BFAST

Proposed research, Tier 3 C emissions/removals



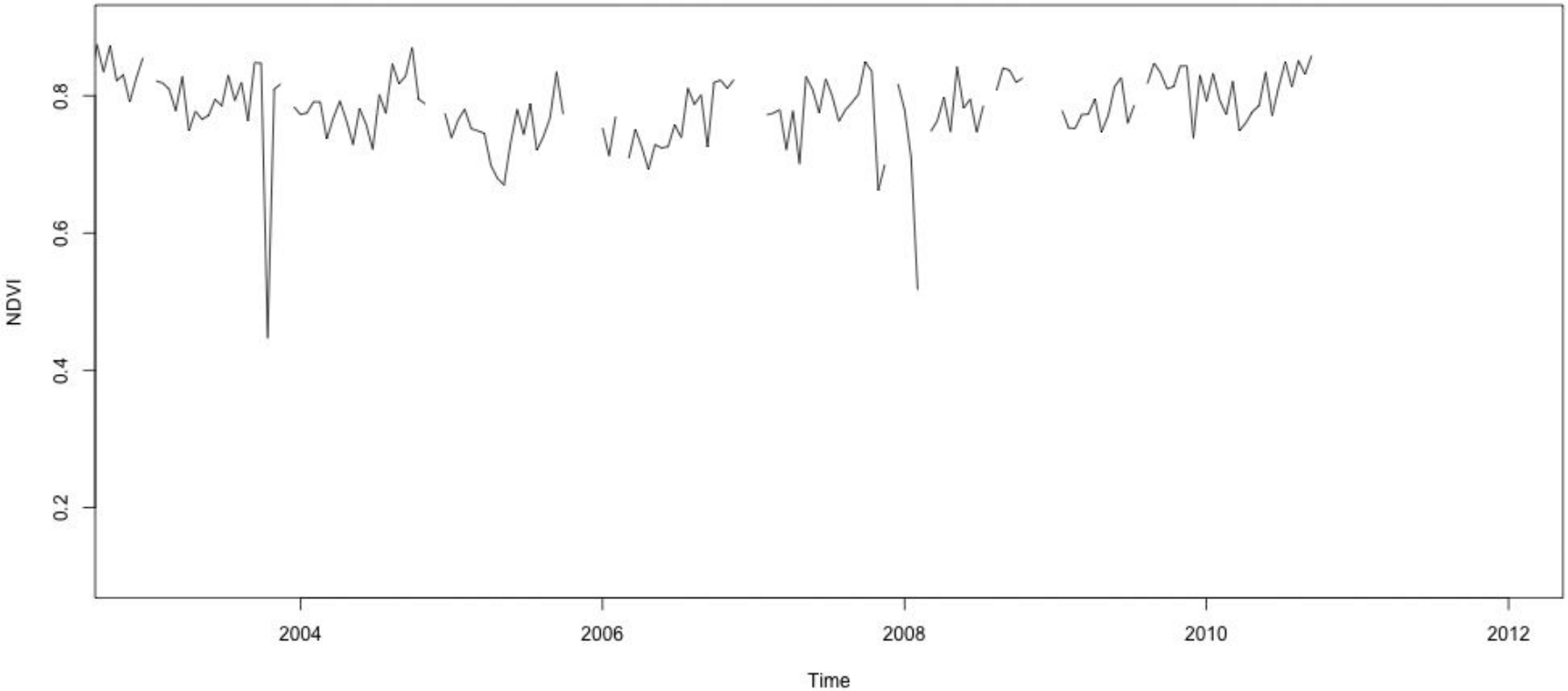
BFAST

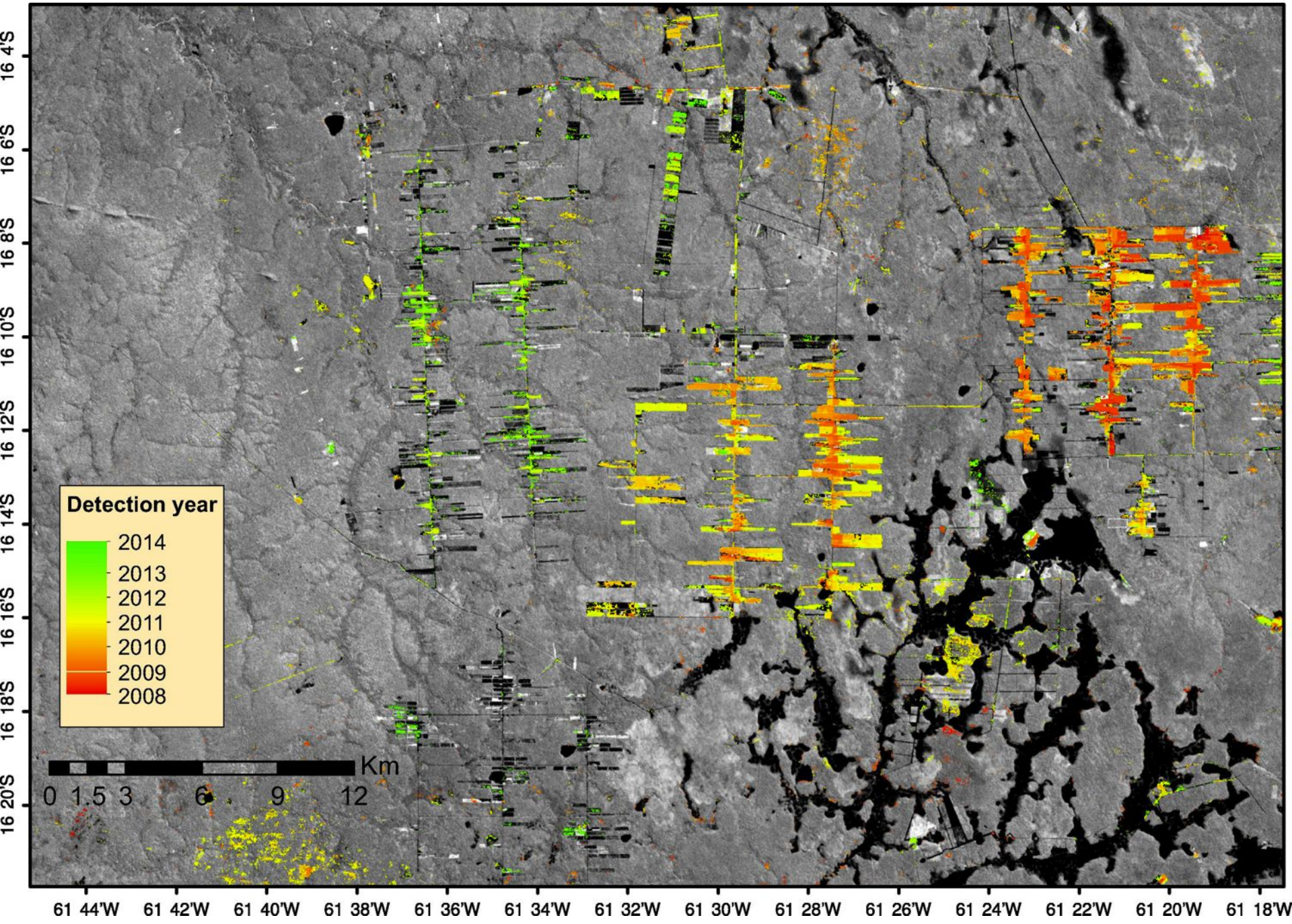


Drought stress in 2003 and tree Mortality in 2007

Verbesselt, J., Hyndman, R., Newnham, G., & Culvenor, D. (2010). Detecting trend and seasonal changes in satellite image time series. RSE.

NRT monitoring - BFAST



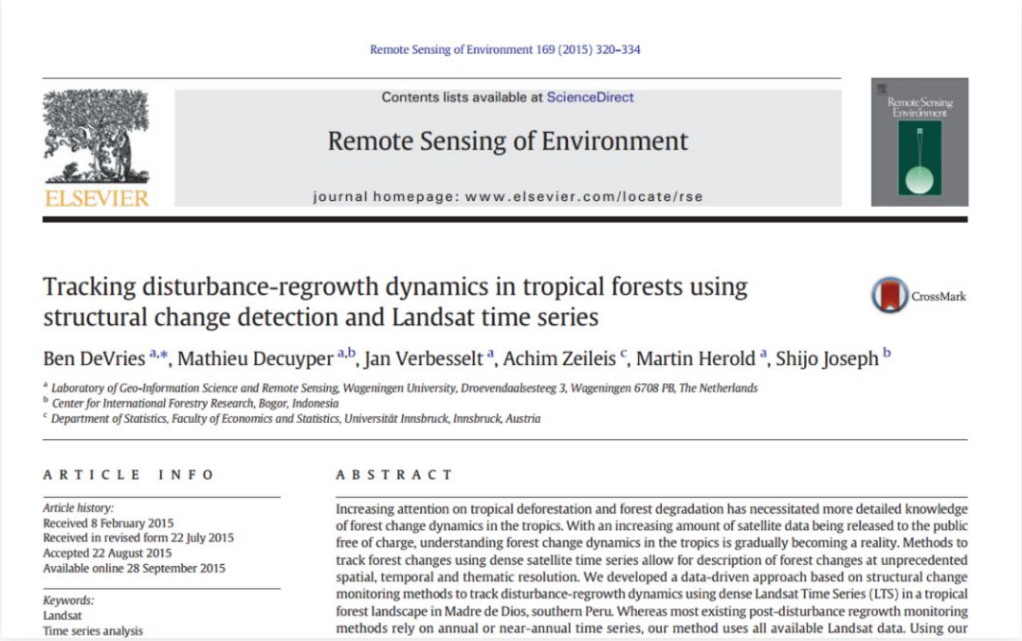

Detection year
2014
2013
2012
2011
2010
2009
2008
Km
0 1.5 3 6 9 12
16 4'S
16 6'S
16 8'S
16 10'S
16 12'S
16 14'S
16 16'S
16 18'S
16 20'S
61 44'W
61 42'W
61 40'W
61 38'W
61 36'W
61 34'W
61 32'W
61 30'W
61 28'W
61 26'W
61 24'W
61 22'W
61 20'W
61 18'W

POST-DISTURBANCE REGROWTH

What happens after a disturbance?

- Permanent land use change (forest → cropland)
- Secondary forest regrowth (forestry, shifting agriculture)

How well can we track post-disturbance regrowth with LTS?



Remote Sensing of Environment 169 (2015) 320–334

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

Tracking disturbance-regrowth dynamics in tropical forests using structural change detection and Landsat time series

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ARTICLE INFO

Article history:
Received 8 February 2015
Received in revised form 22 July 2015
Accepted 22 August 2015
Available online 28 September 2015

Keywords:
Landsat
Time series analysis

ABSTRACT

Increasing attention on tropical deforestation and forest degradation has necessitated more detailed knowledge of forest change dynamics in the tropics. With an increasing amount of satellite data being released to the public free of charge, understanding forest change dynamics in the tropics is gradually becoming a reality. Methods to track forest changes using dense satellite time series allow for description of forest changes at unprecedented spatial, temporal and thematic resolution. We developed a data-driven approach based on structural change monitoring methods to track disturbance-regrowth dynamics using dense Landsat Time Series (LTS) in a tropical forest landscape in Madre de Dios, southern Peru. Whereas most existing post-disturbance regrowth monitoring methods rely on annual or near-annual time series, our method uses all available Landsat data. Using our

CCDC/YATSM:
https://github.com/ceholden
https://github.com/prs021/ccdc

Open source code and tutorials @ Wageningen Uni:

- LTS change monitoring package and tutorial
  https://github.com/dutri001/bfastSpatial
- open-source scripting course
  https://geoscripting-wur.github.io
- Regrowth monitoring:
  https://github.com/bendv/rgrowth