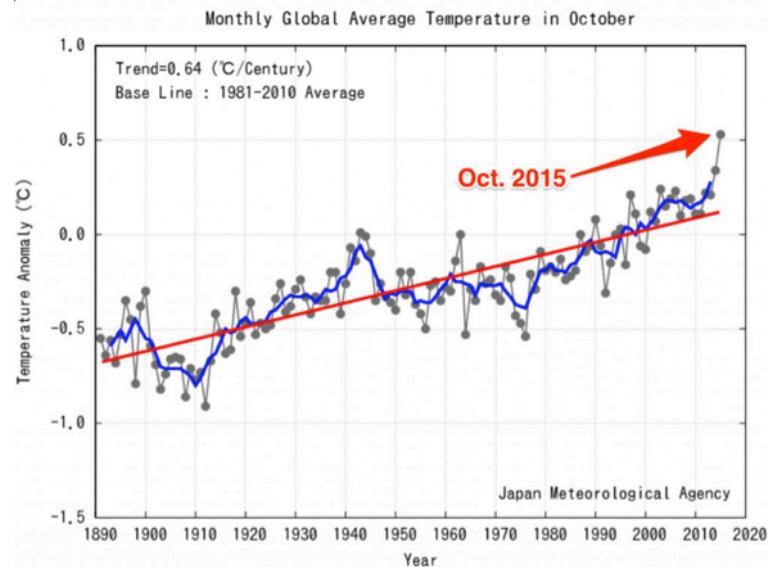
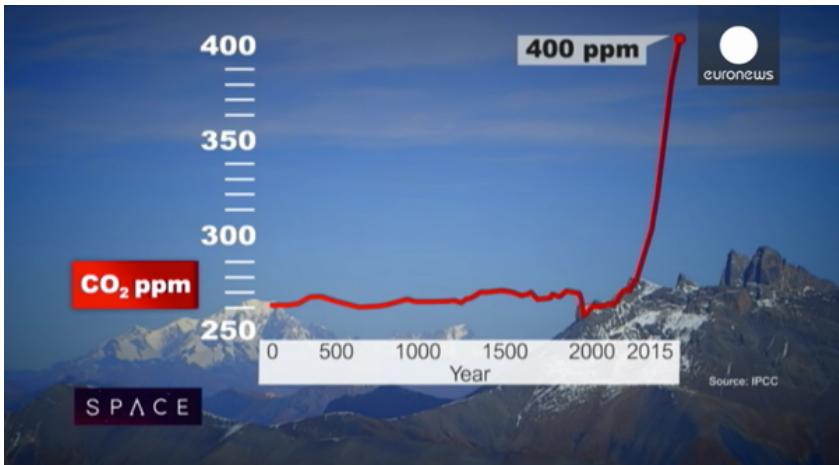




Monitoring tropical forest dynamics using satellite time series (optical, RADAR) and community-based data

Jan Verbesselt, Ben DeVries, Eliakim Hamunyela, Meng Lu,
Johannes Reiche, Loïc Dutrieux, Arun Pratihast, Mathieu Decuyper,
Martin Herold

Laboratory of Geo-Information Science and Remote Sensing,
Wageningen University, The Netherlands



SCIENCE, NEW YORK, ENVIRONMENT, NY NEWS

Deforestation Should Be at Heart of Climate Discussion, Says NGO Panel

By Arleen Richards, Epoch Times | September 23, 2015

Last Updated: September 24, 2015 8:53 pm

ENVIRONMENT

Fewer Rain Forests Mean Less Energy for Developing Nations, Study Finds

BBC

NEWS

By FELICITY BARRINGER MAY 13, 2013

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Science & Environment

Gold rush threat to tropical forests

By Helen Briggs
Environment correspondent, BBC News

© 14 January 2015 | Science & Environment

By MICHAEL CASEY / CBS NEWS / February 26, 2015, 11:03 AM

Tropical deforestation on the rise, contrary to reports





Paris climate summit

COP21: A TURNING POINT?

26 November, 2015



REDD+ Action

@REDDAction

REDD+ programs, projects, and practices ~~ helping communities achieve sustainable livelihoods

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In the Face of Climate Ch
Forests Promises to Strengthen
Supply Resilience in Tequendama



Global Landscapes Forum

Landscapes for a new climate and development agenda

FOOD, WATER & ENERGY

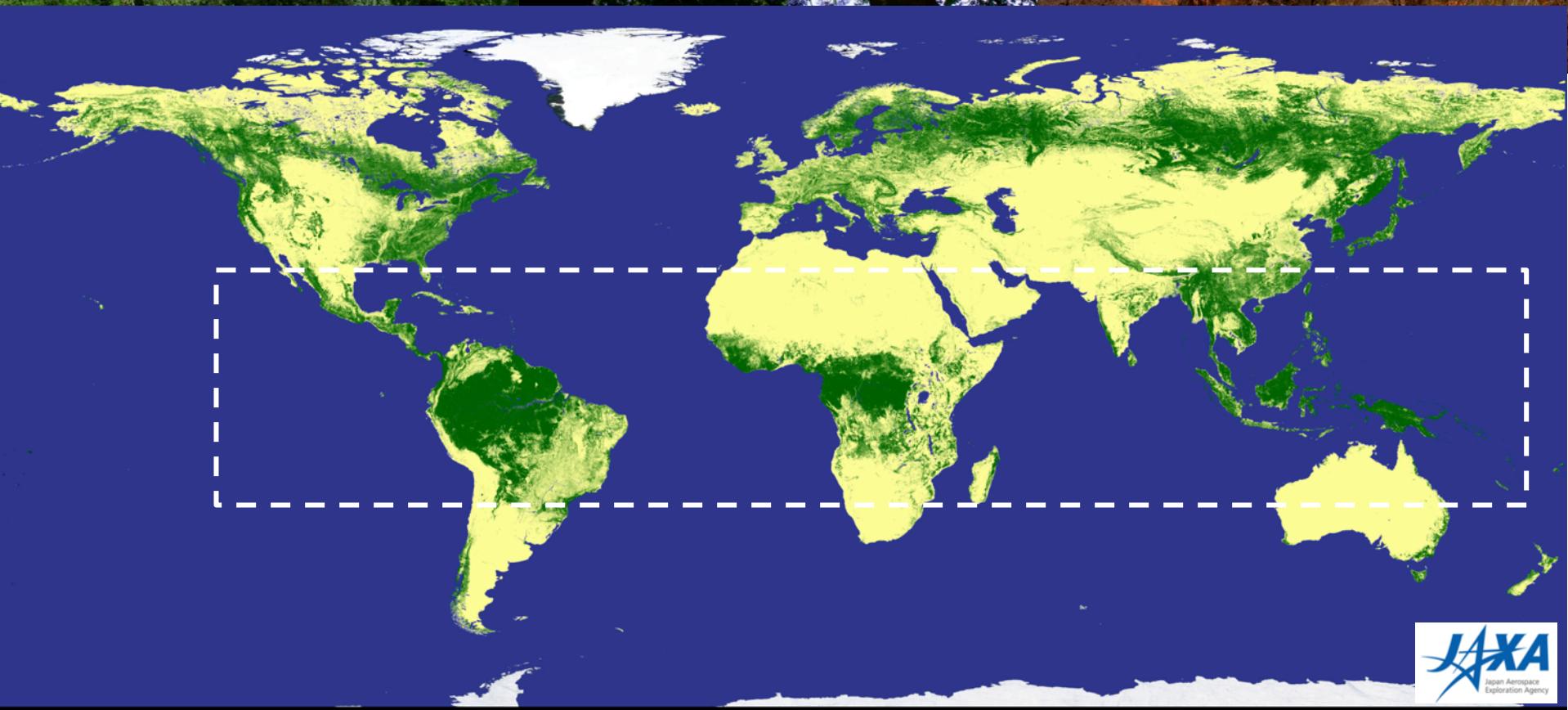
CLIMATE CHANGE

GREEN ECONOMY

SUSTAINABLE DEVELOPMENT



UNEP: changing fiscal policies to grow more food without cutting forests





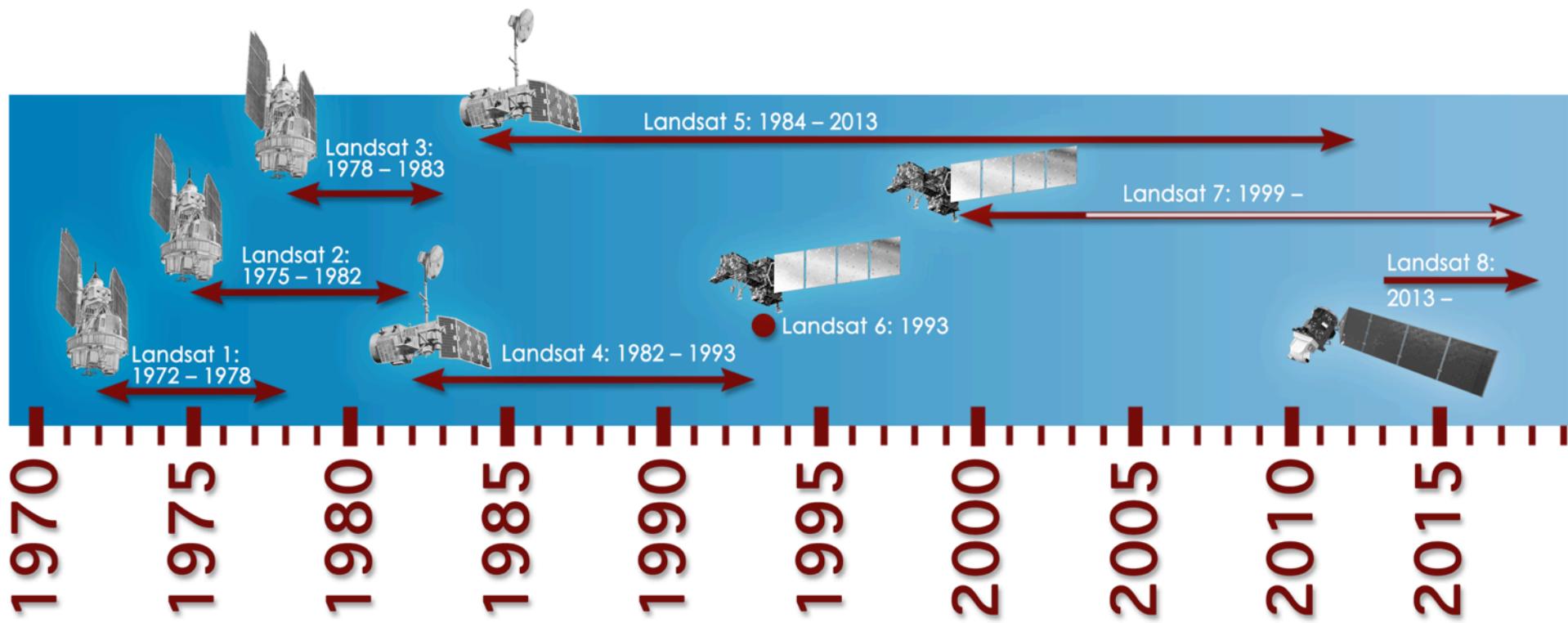








The Landsat Legacy

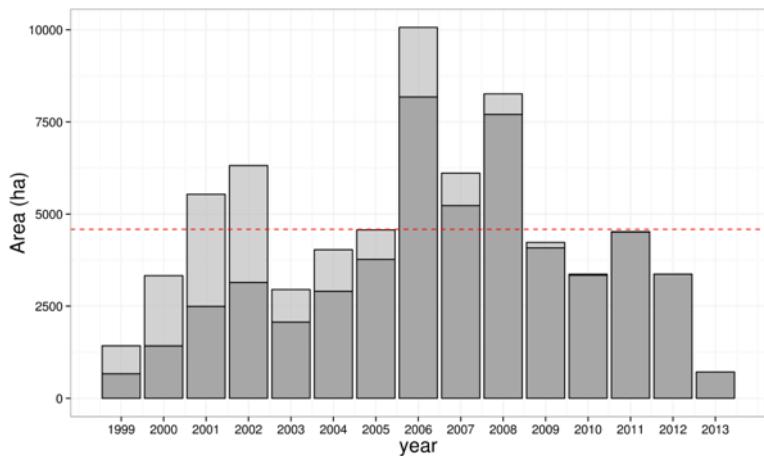
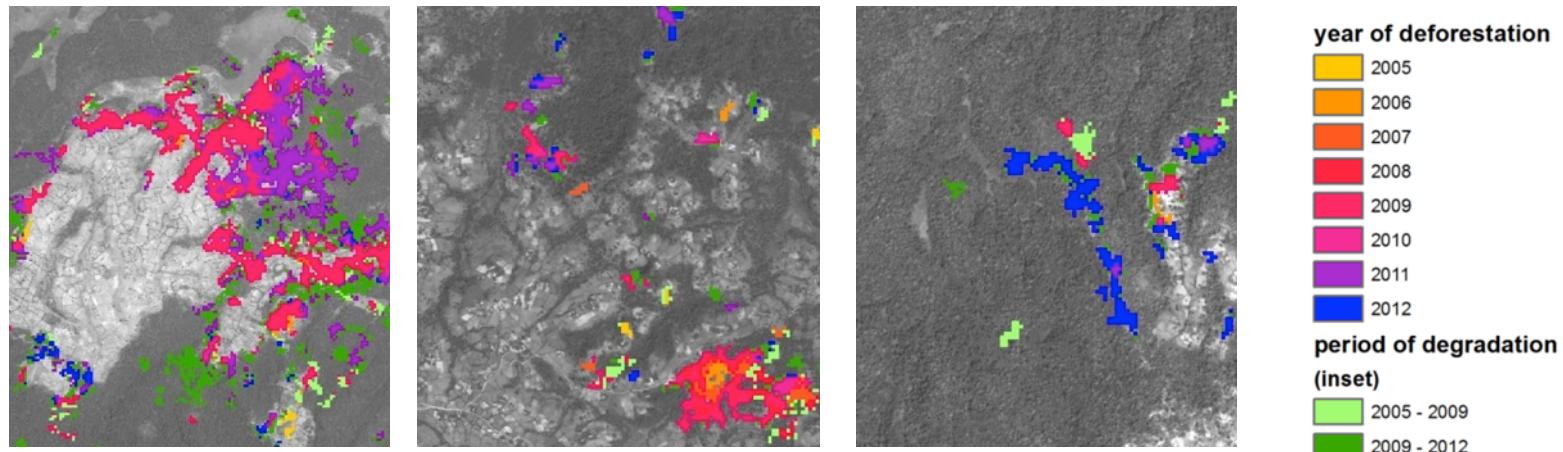




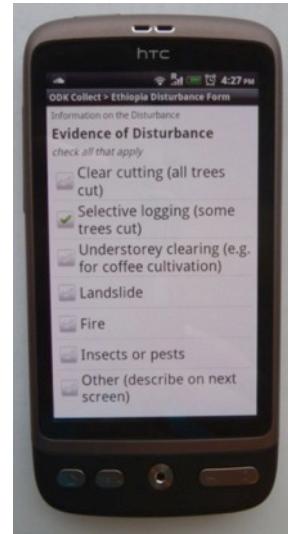
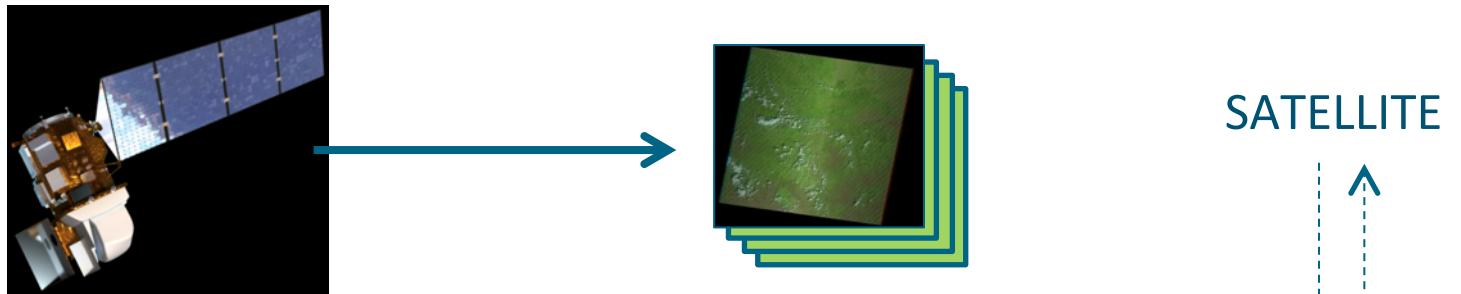
2010



2018



INFORMATION





Community-based observations for NRT forest monitoring



Key publications

Pratihast, A.K. et al.. Combining Satellite Data and Community-Based Observations for Forest Monitoring. *Forests* 2014, 5, 2464-2489.

Pratihast, A.K. et al. . Mobile Devices for Community-Based REDD+ Monitoring: A Case Study for Central Vietnam. *Sensors* , 2013, 13, 21-38.

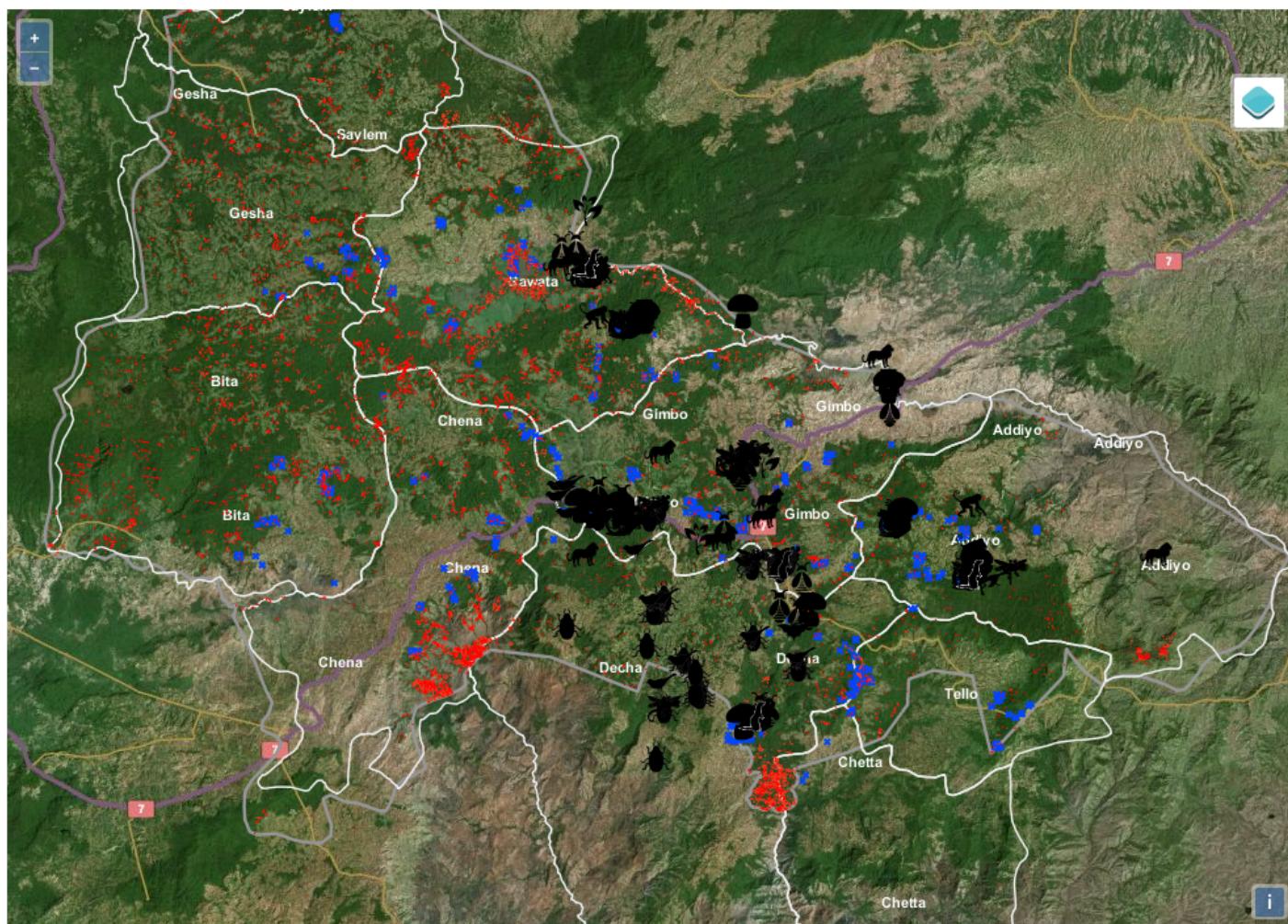
A screenshot of a Facebook group page. The group photo shows a diverse group of approximately 20 people, mostly young men, sitting and standing together outdoors. In the top right corner of the photo, there is a button labeled "Change Group Photo". Below the photo, the group name "Near Real-Time Disturbance Mon..." is visible, followed by "Secret Group". At the bottom of the screen, there are several action buttons: "Joined ▾", "Message", "Notifications", and three vertical dots for more options.

Near Real-Time Disturbance Mon...

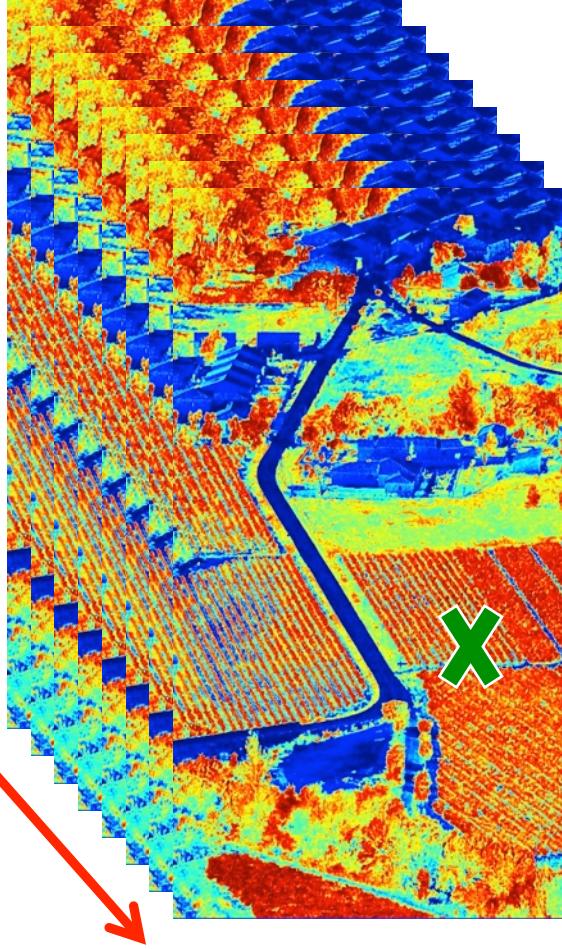
Secret Group

Joined ▾ Message Notifications ...

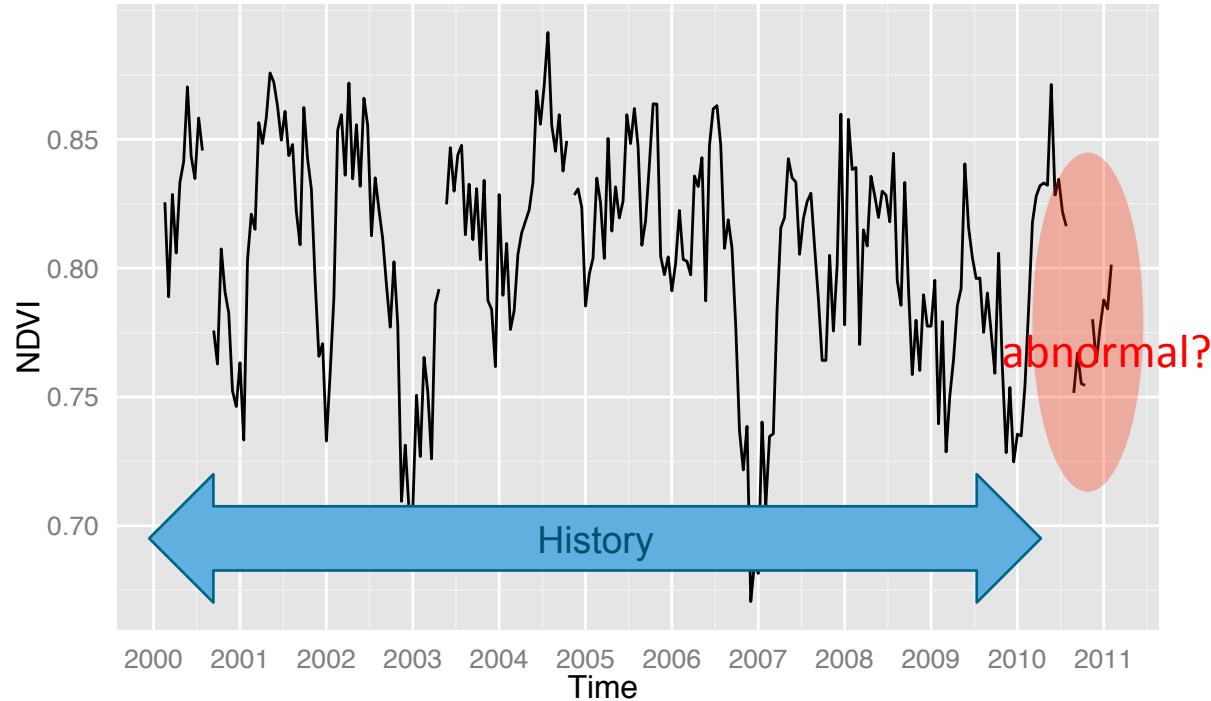




Forest change tracking?



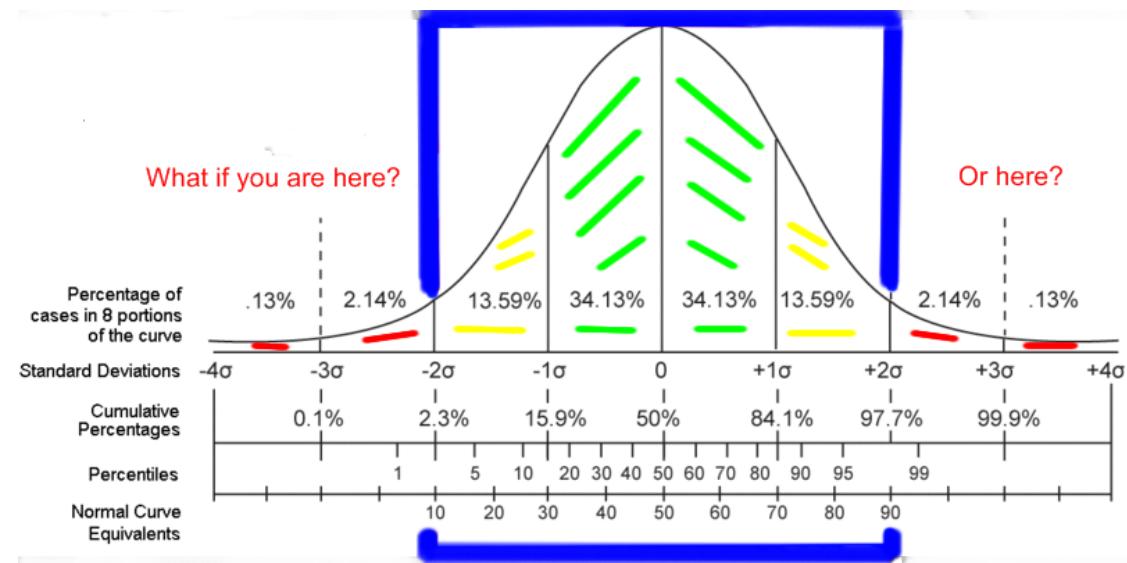
Near real-time forest change monitoring



- Is there a change at the end of the time series?

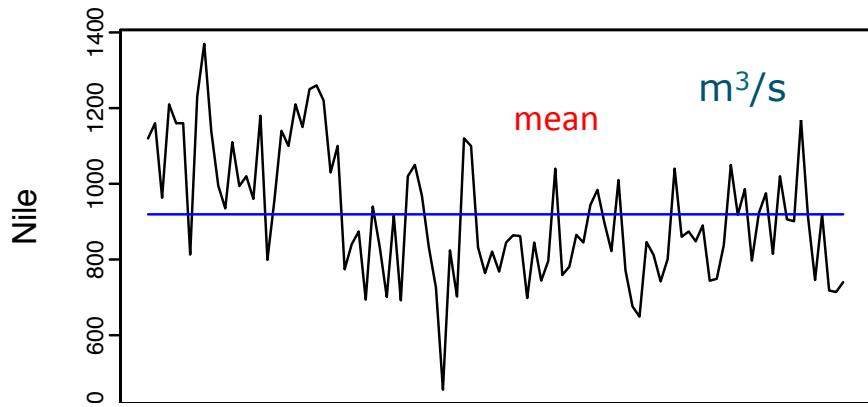
Near real-time forest change monitoring

- How do we know something is abnormal?
 - What is normal?
- From a statistical perspective...



Structural change tests

- Econometrics



- Test whether annual flow remains constant over the years?
- CUSUM – Cumulative SUM

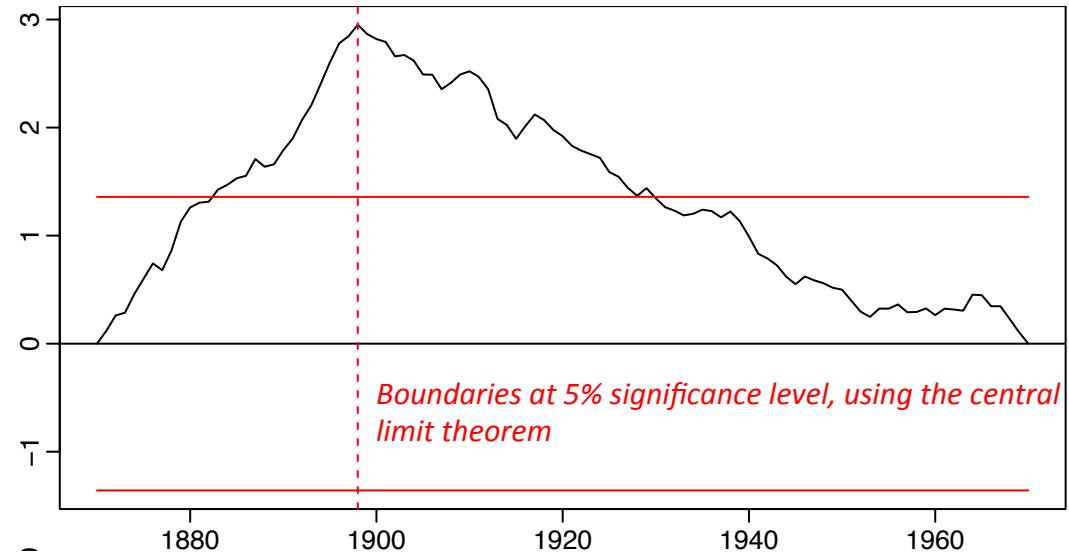
Annual discharge at Aswan dam, Egypt

Structural change tests

■ CUSUM

$$\frac{\sum_{i=1}^{zn} (y_i - \hat{y}_i)}{\hat{\sigma} \sqrt{n}}$$

Nile - mean

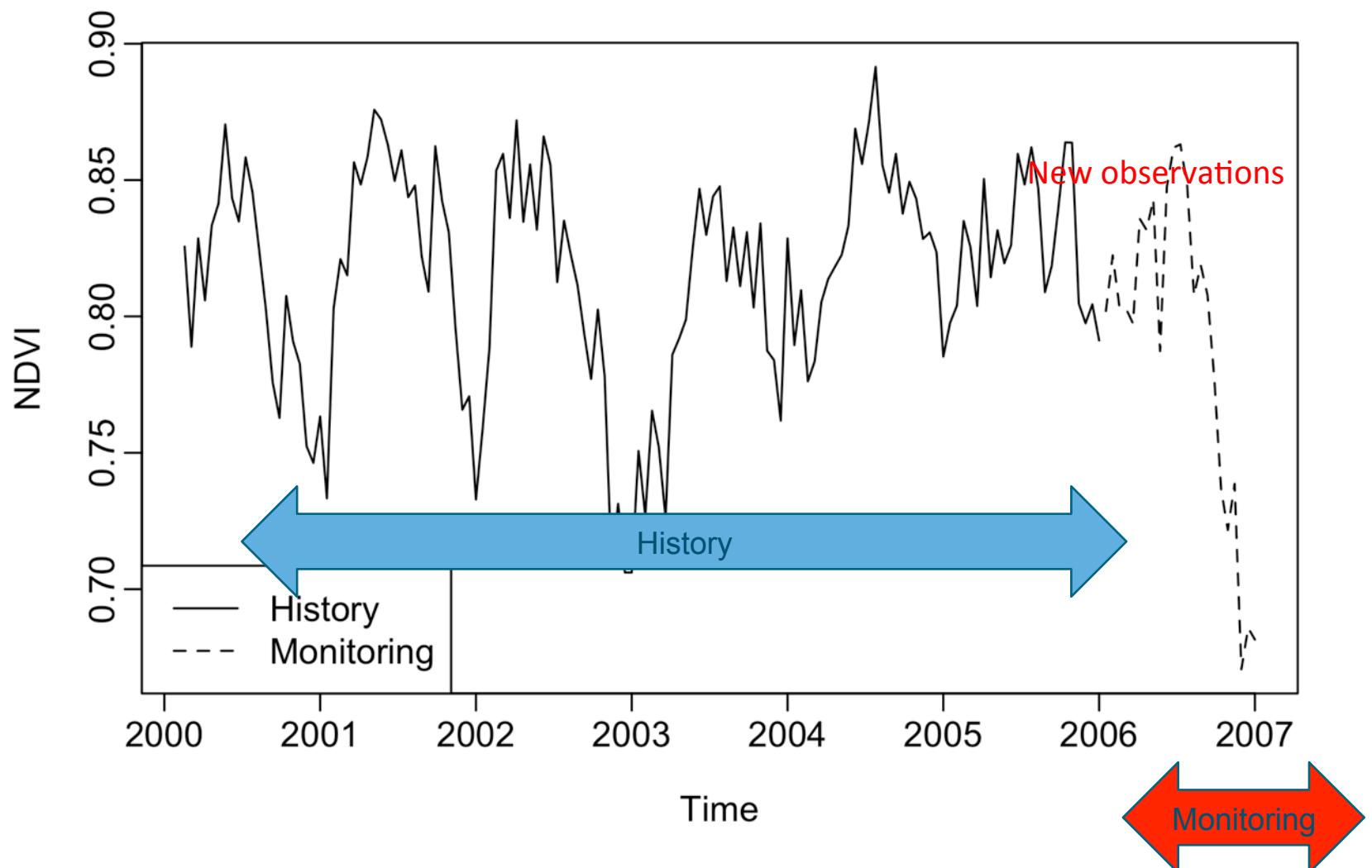


- Normalized by sample size (n) and estimated deviance from fitted history model

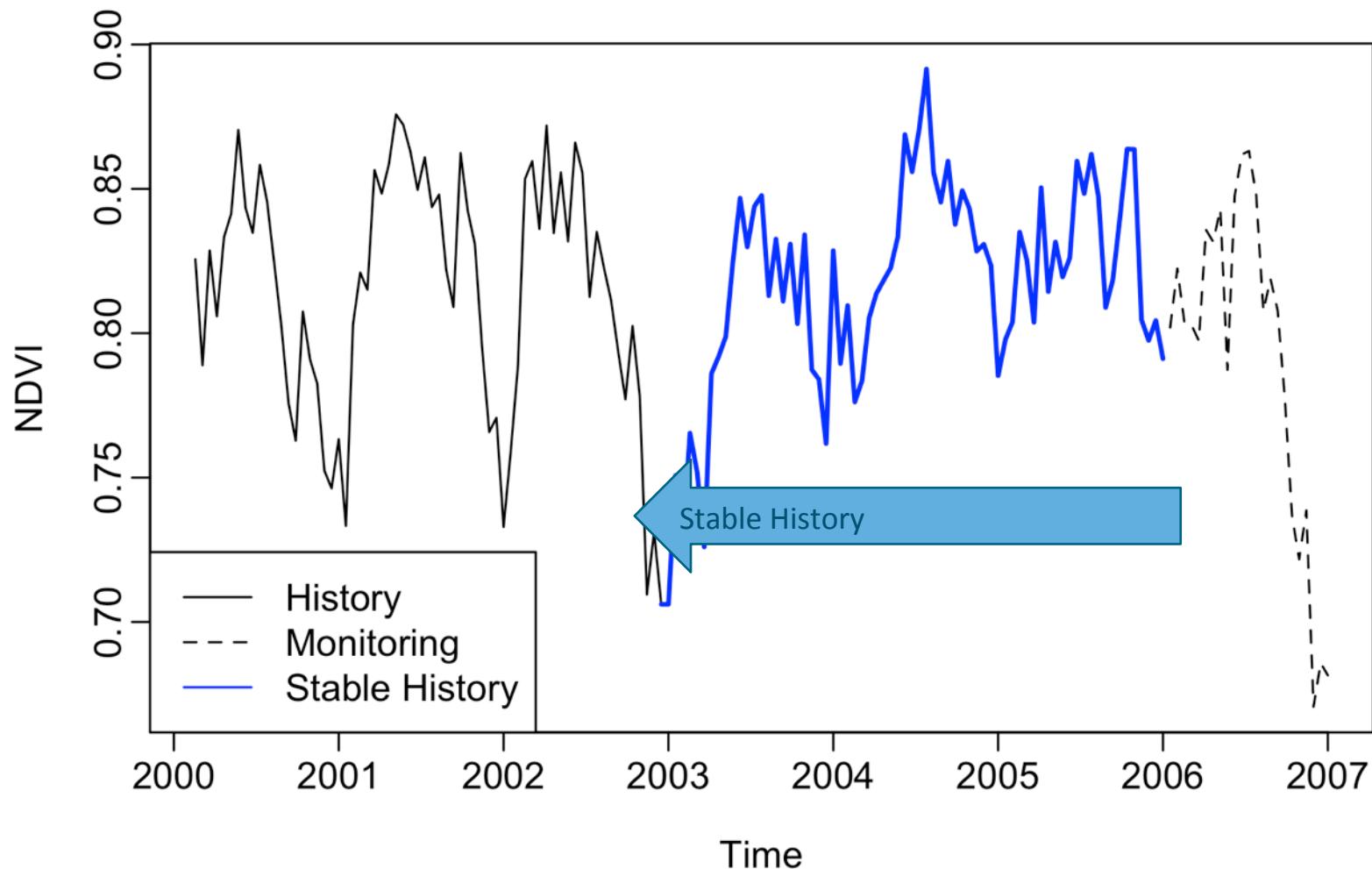
Forest change monitoring

- BFASTmonitor
 - Break detection for Seasonal Time series
 - Verbesselt, et al., Near Real-Time Disturbance Detection using satellite Image Time Series, 2012, RSE
- 3 steps for near real-time disturbance monitoring:
 - Identify a stable history period
 - Model the stable history period
 - Do new observations fit the model?

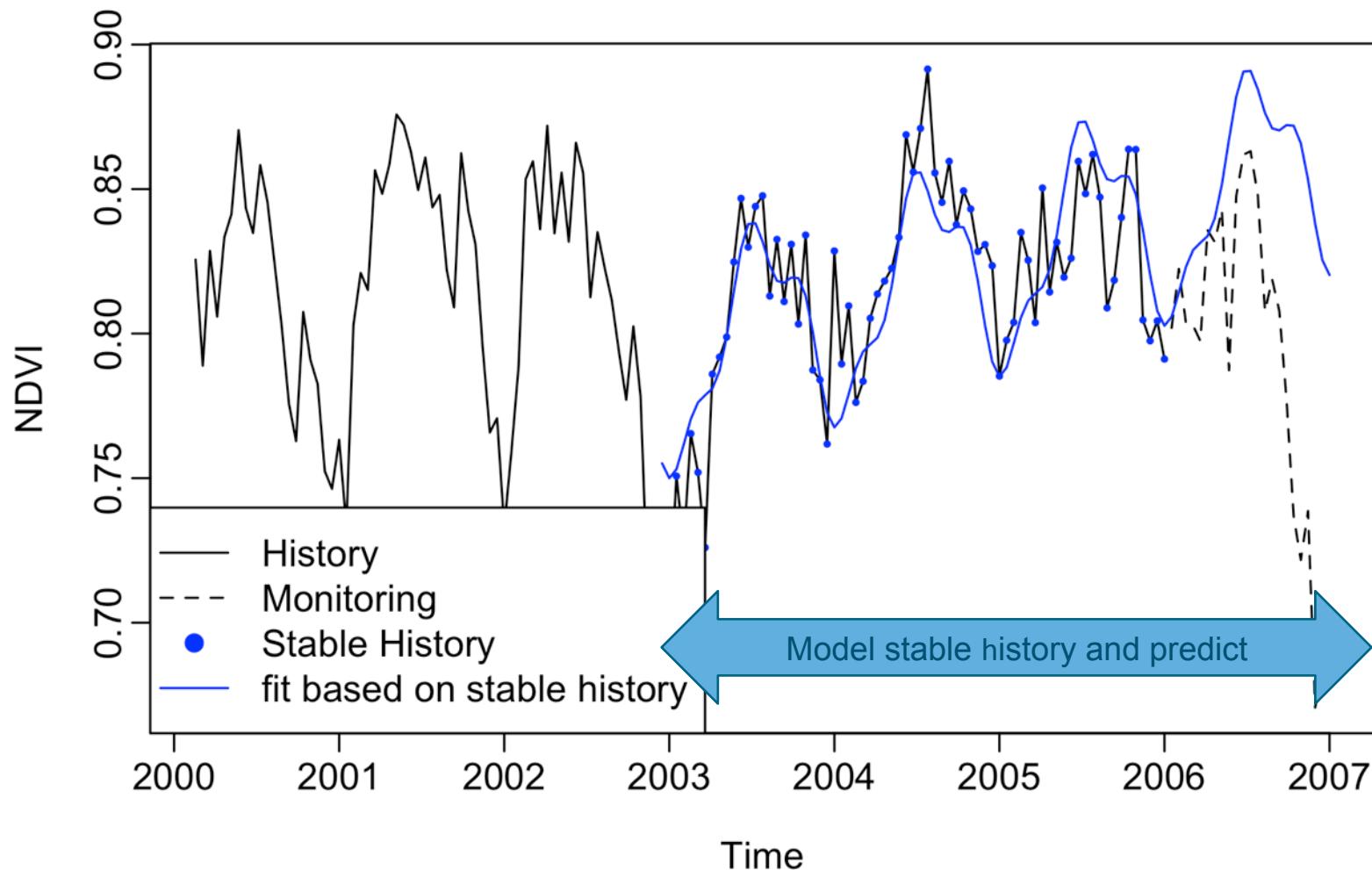
Forest change monitoring



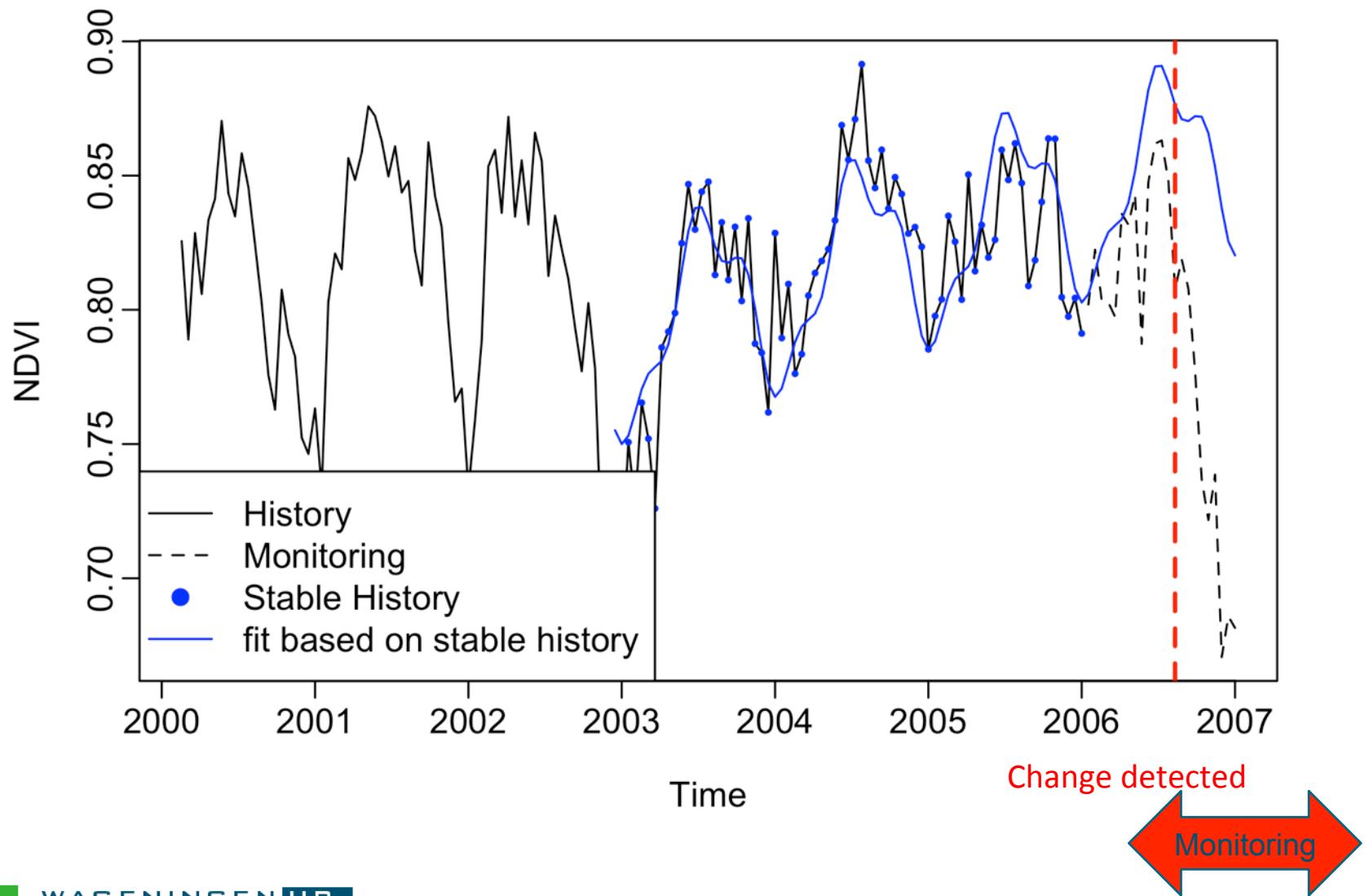
Forest change monitoring



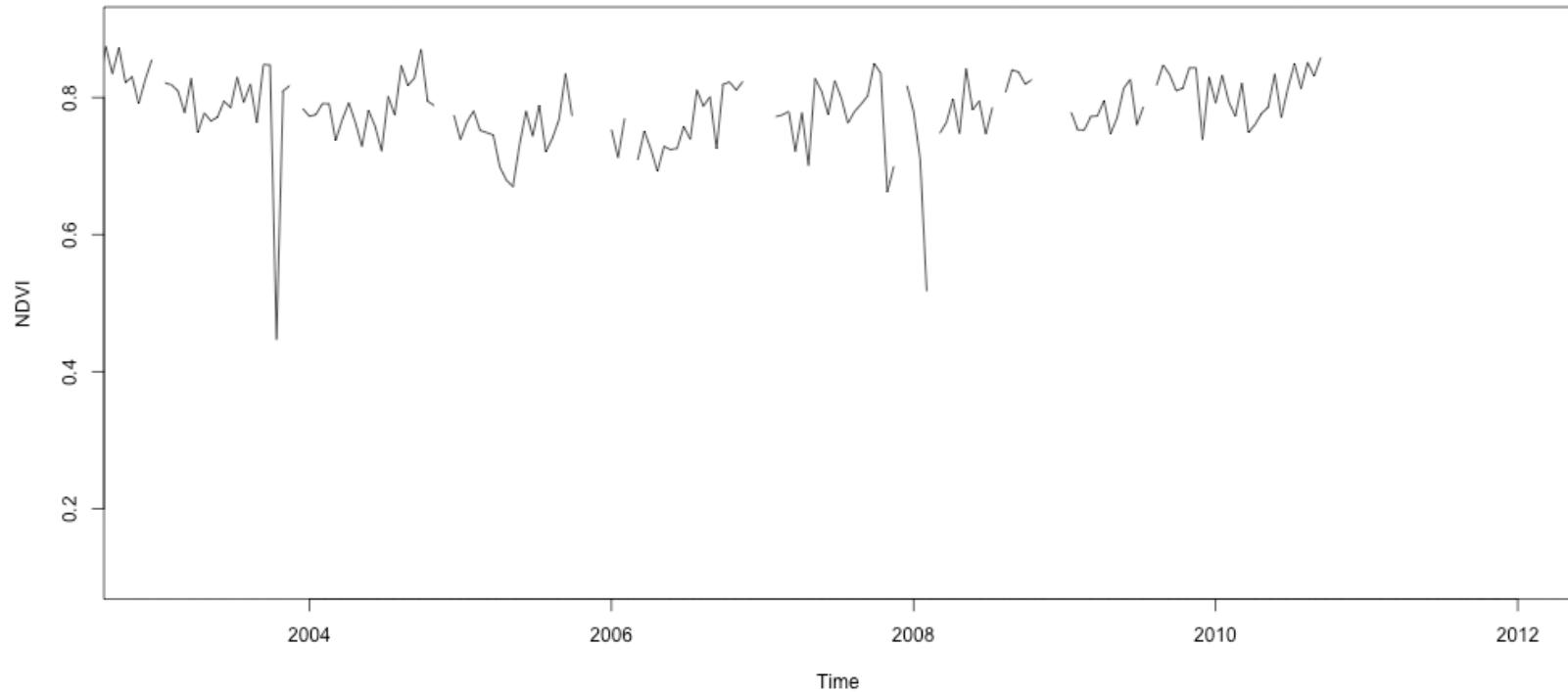
Forest change monitoring



Forest change monitoring

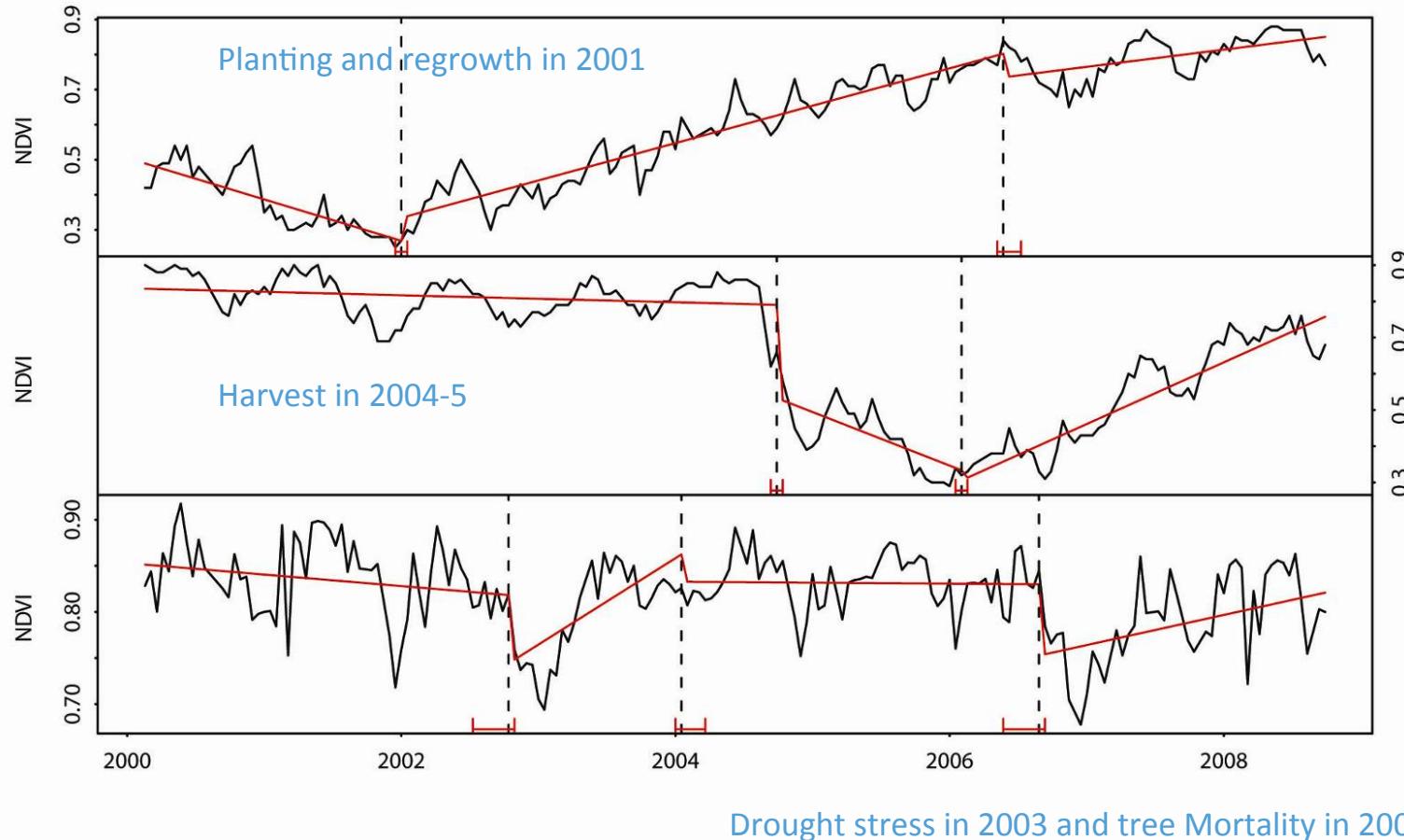


Forest change monitoring



- **BFASTmonitor:** <http://bfast.r-forge.r-project.org>
- Verbesselt, et al., Near Real-Time Disturbance Detection using satellite Image Time Series (2012), RSE

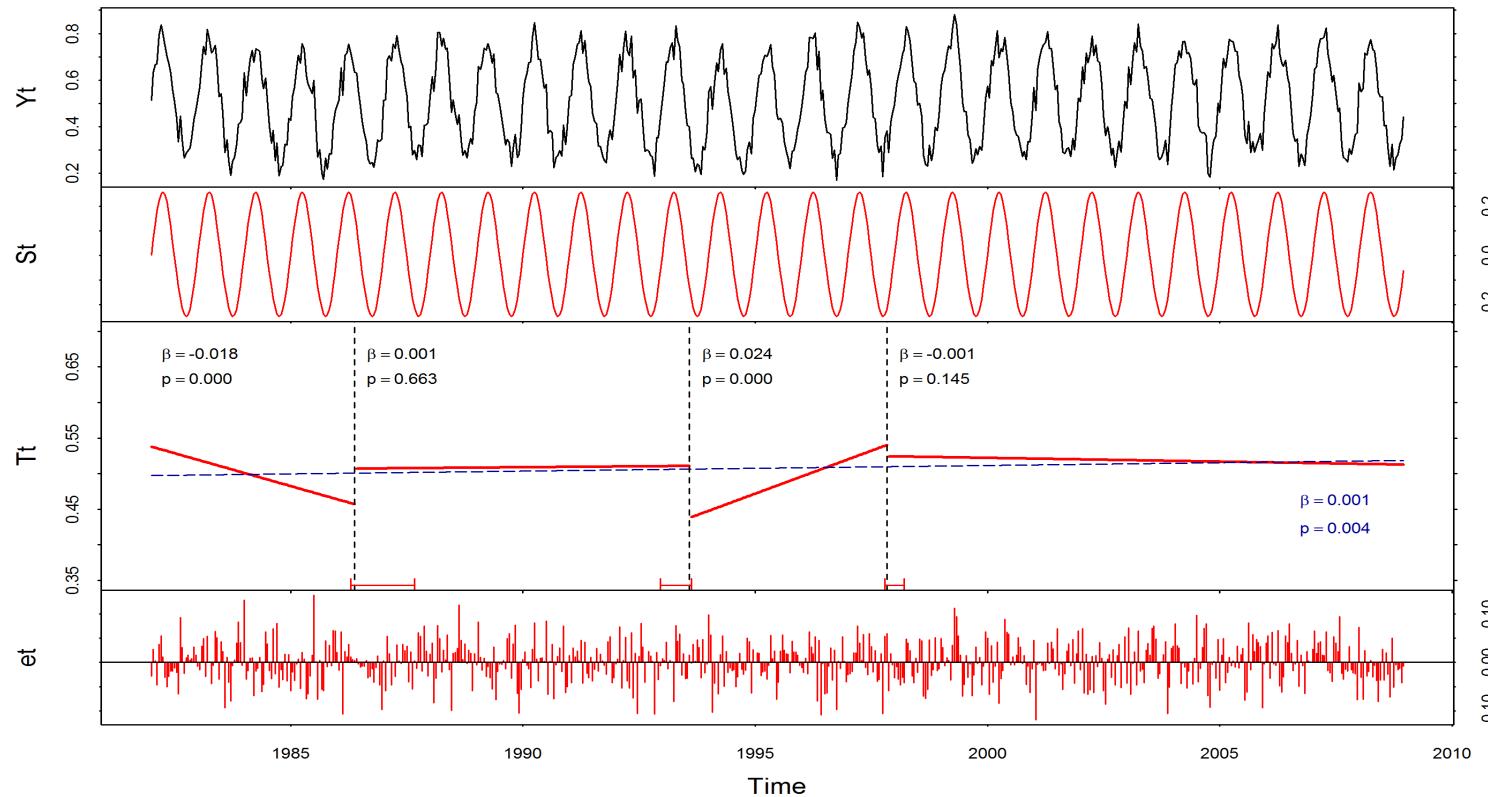
BFAST



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*.

BFAST



Jong, R., Verbesselt, J., Schaepman, M. E. & Bruun, S. Trend changes in global greening and browning: contribution of short-term trends to longer-term change. *Global Change Biol* 18, 642–655 (2011).

Deforestation, forest degradation, regrowth monitoring



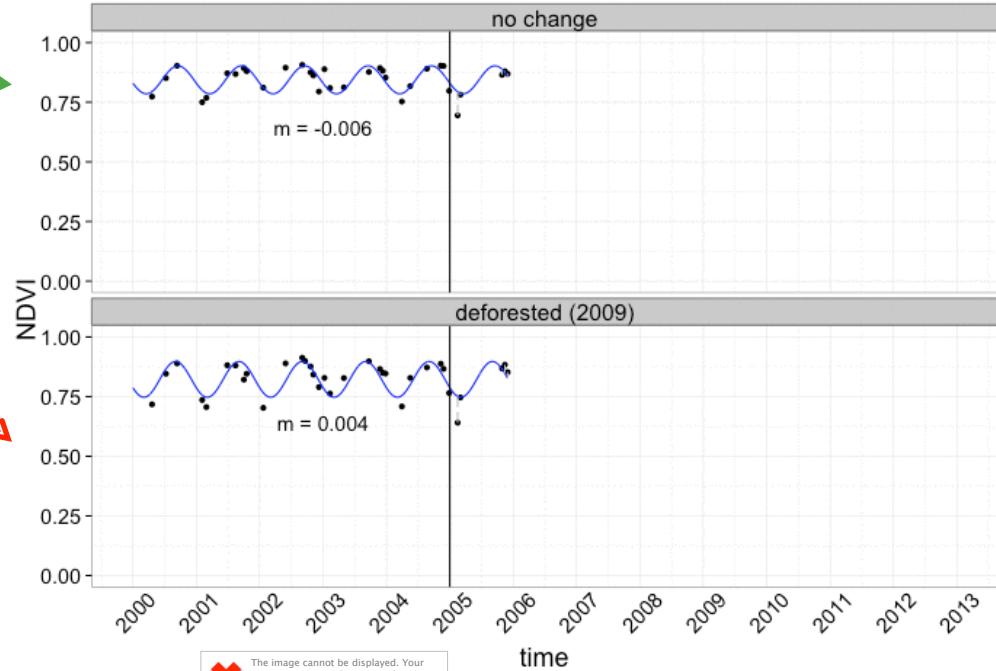
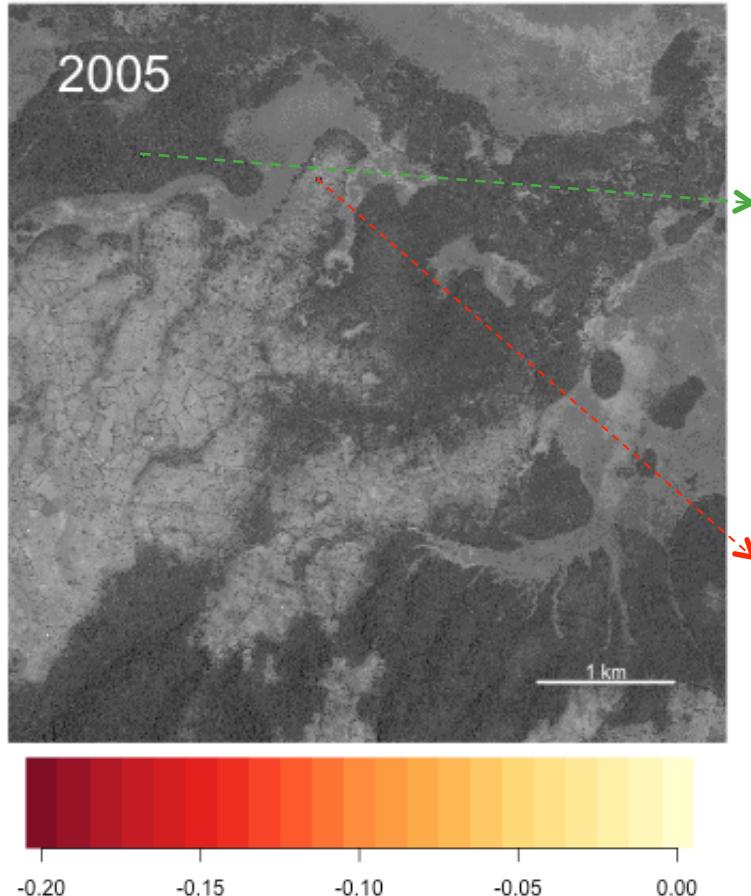
■ Ben DeVries:

- DeVries, B., et al. 2015. Robust monitoring of small-scale disturbances in a tropical montane forest. *RSE*.
- DeVries, B., et al. 2015. Tracking Forest Disturbance-Regrowth Dynamics in Tropical Forests using Landsat Time Series. *RSE*. In Review.

Small-scale disturbances: Kafa, Ethiopia

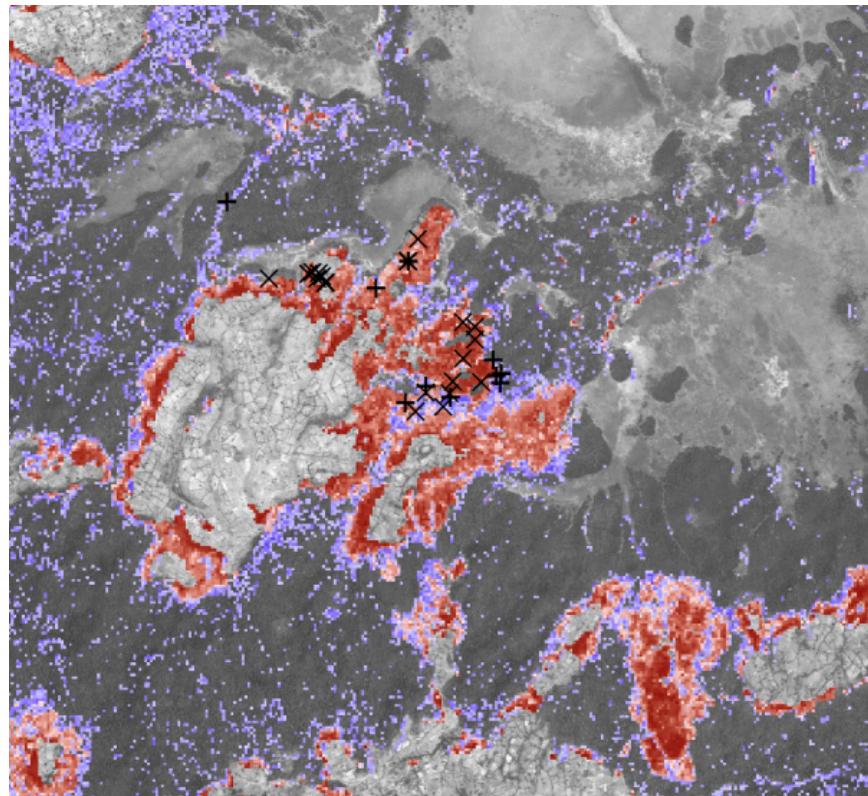


SPOT5: Feb 2011 (2.5m)

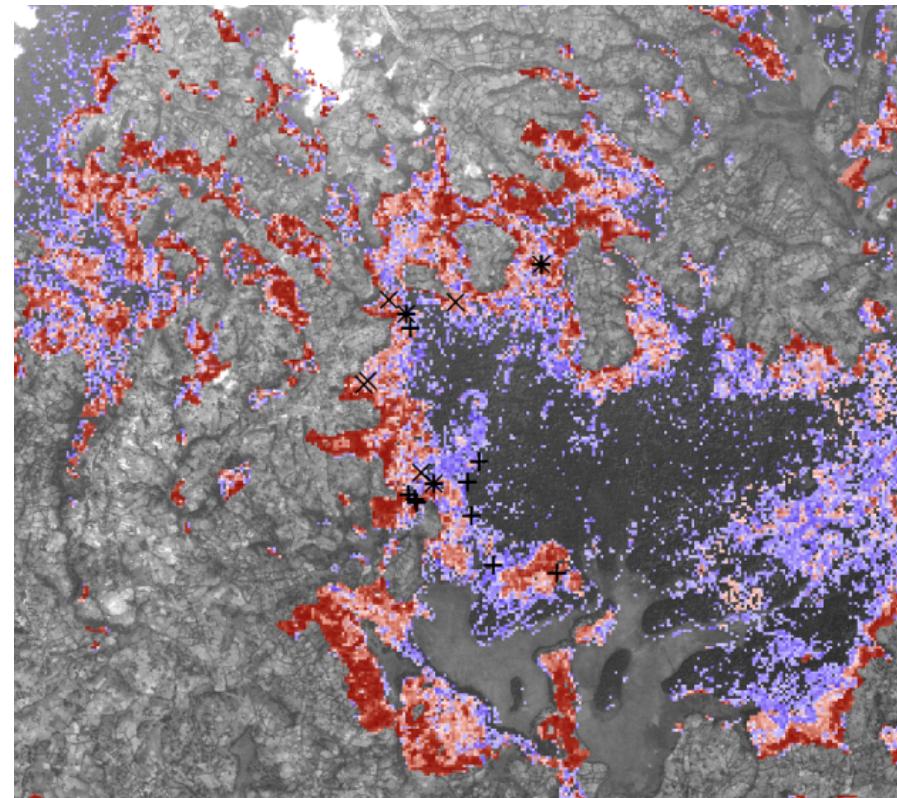


The image cannot be displayed. Your computer may not have enough memory to open the image, or the image may have been damaged. Restart your computer, and then open the file again. If the red x still appears, you may have to delete the image and then insert it again.

Forest degradation, Kafa, Ethiopia



X deforestation observations
+ degradation observations



Likelihood of deforestation (red)
Likelihood of degradation (blue)

Forest regrowth



- Test ability of structural change monitoring methods to detect follow-up regrowth using Landsat Time Series

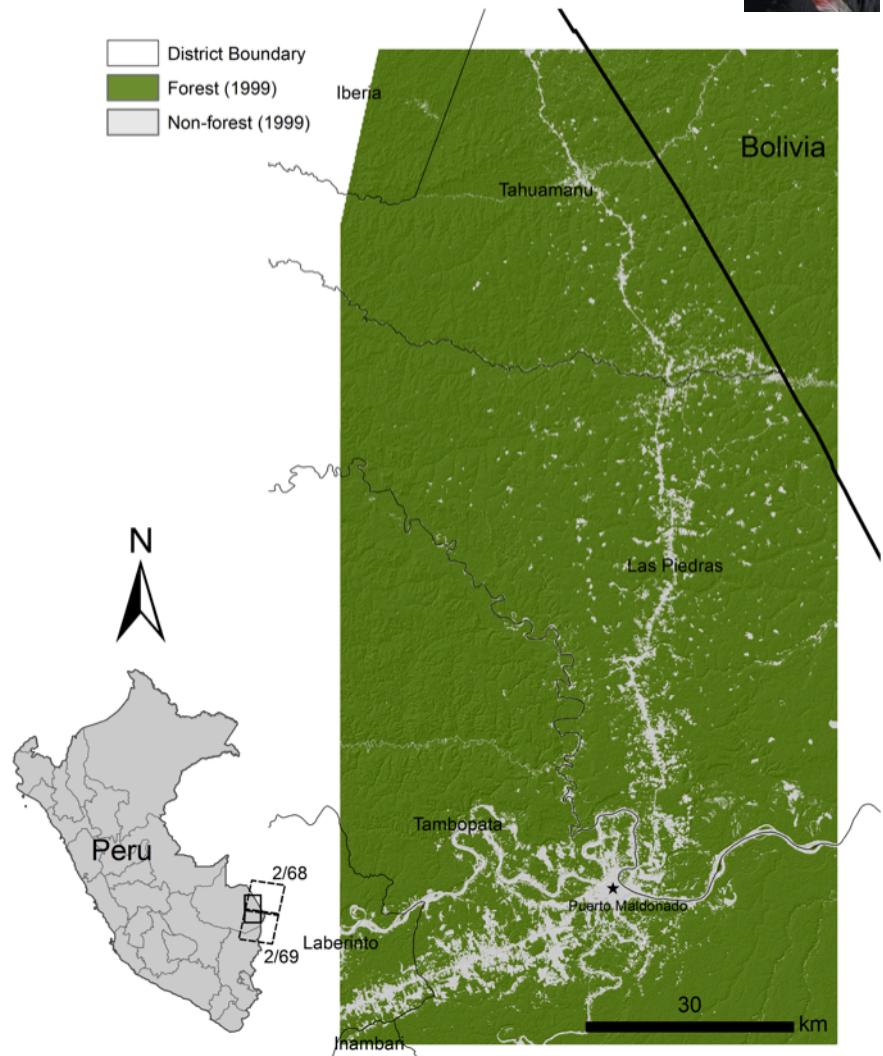


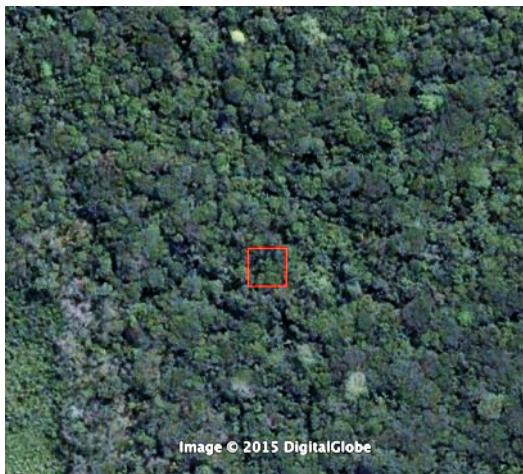
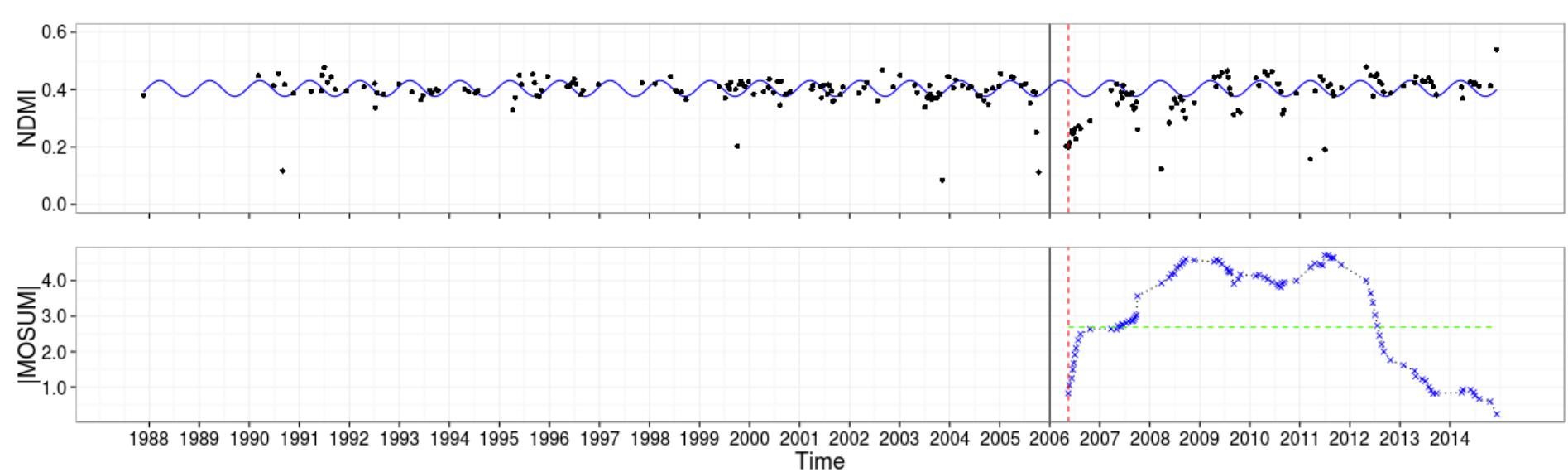
Forest regrowth



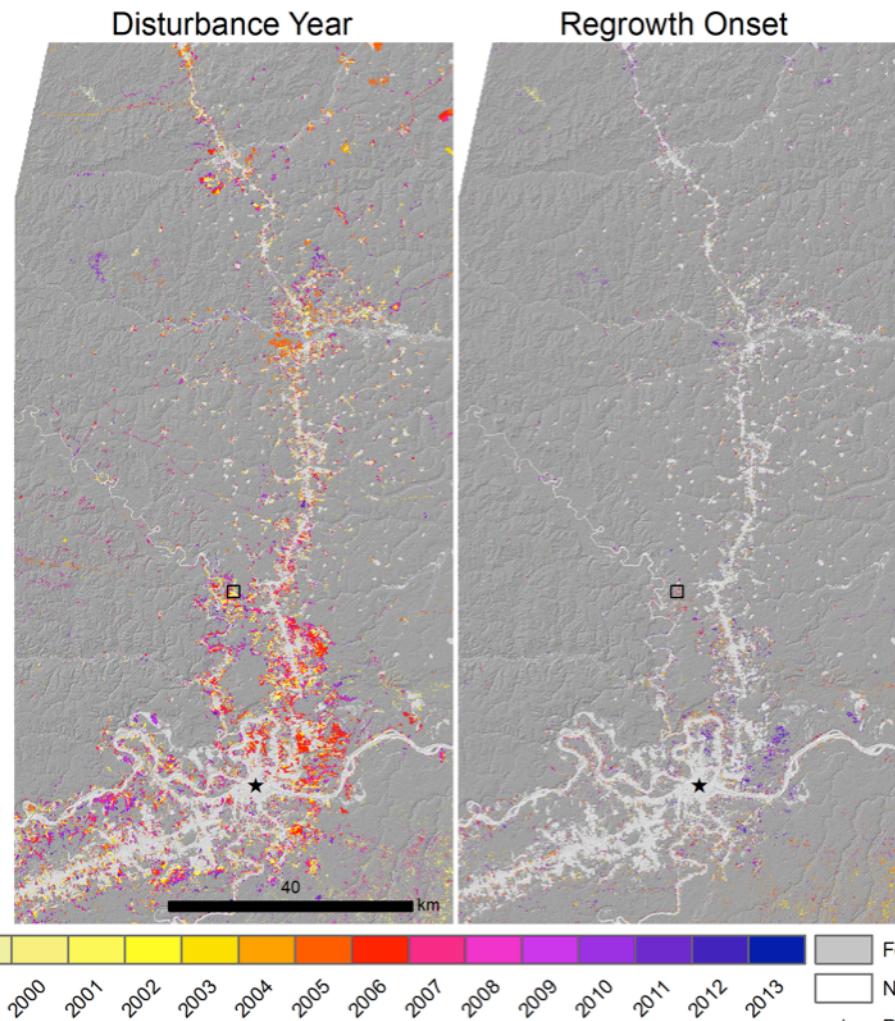
- Madre de Dios,
Southeastern Peru
- Deforestation driven by
pasture and cropland
expansion, and artisanal
gold mining

District Boundary
Forest (1999)
Non-forest (1999)





Forest regrowth



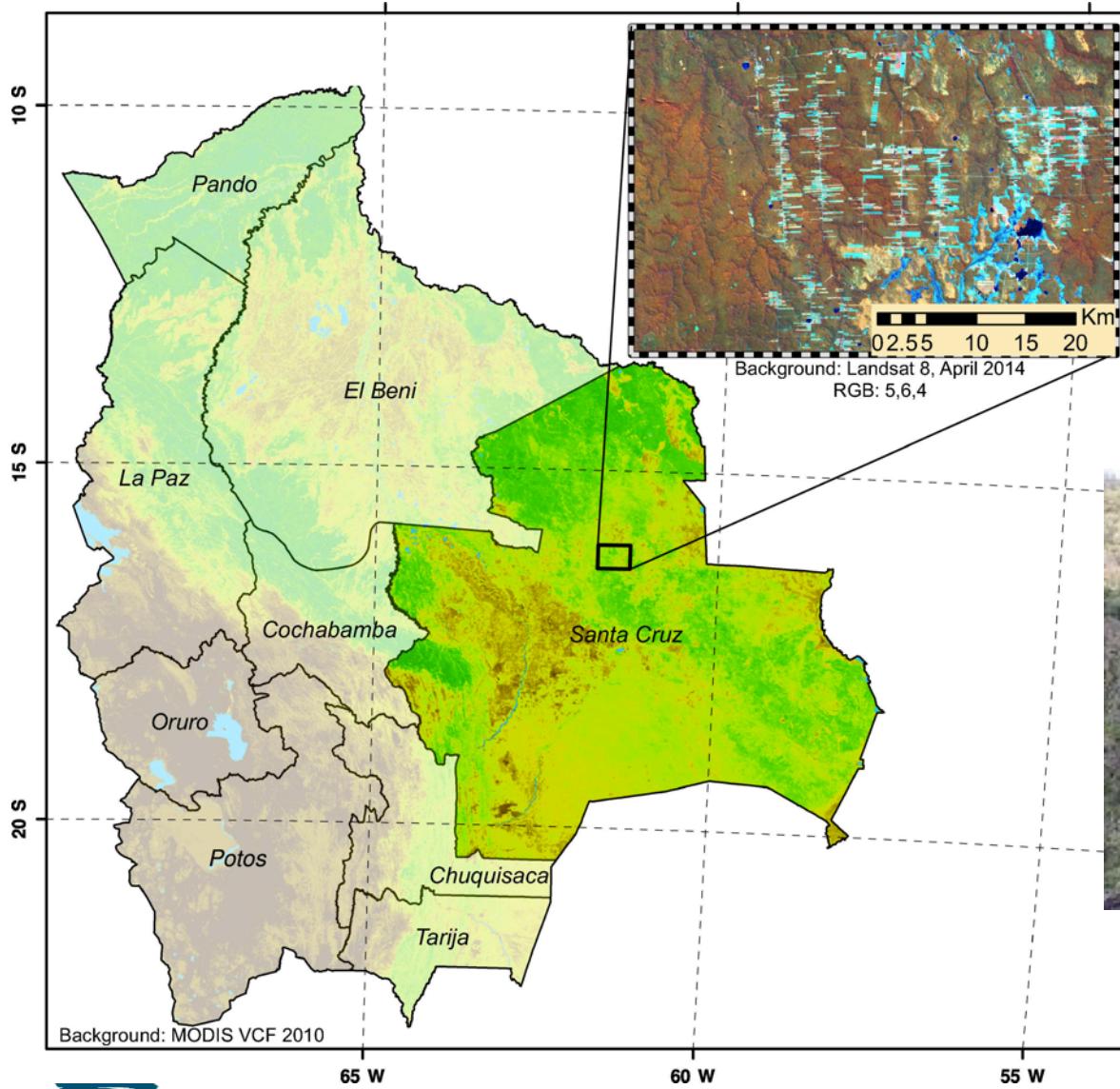
Multi-sensor forest change tracking

- Combining Landsat + MODIS

- Bolivia, Dry Forests
- Dutrieux et al., (2015): Monitoring forest cover loss using multiple data streams, a case study of a tropical dry forest in Bolivia. ISPRS.



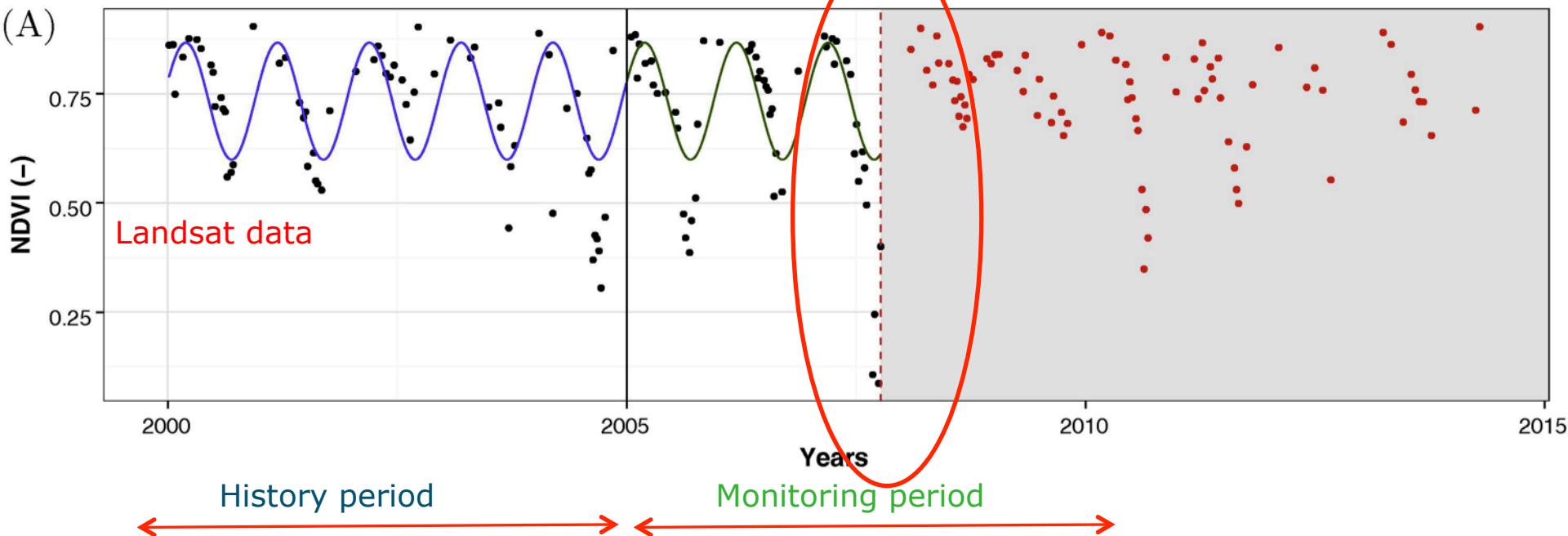
Bolivia: dry tropical forests



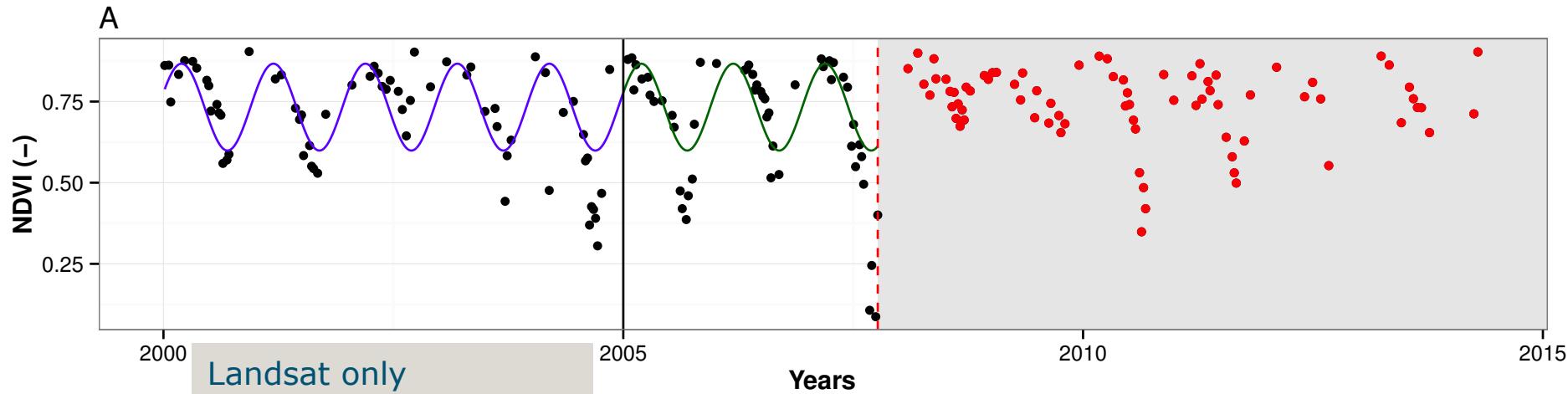
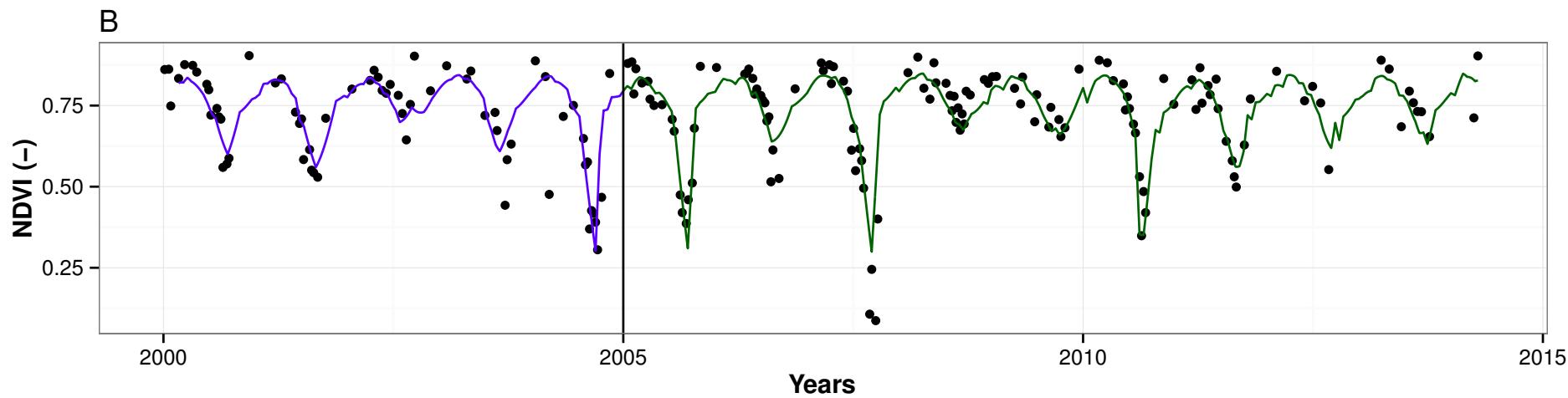
Dry tropical forests



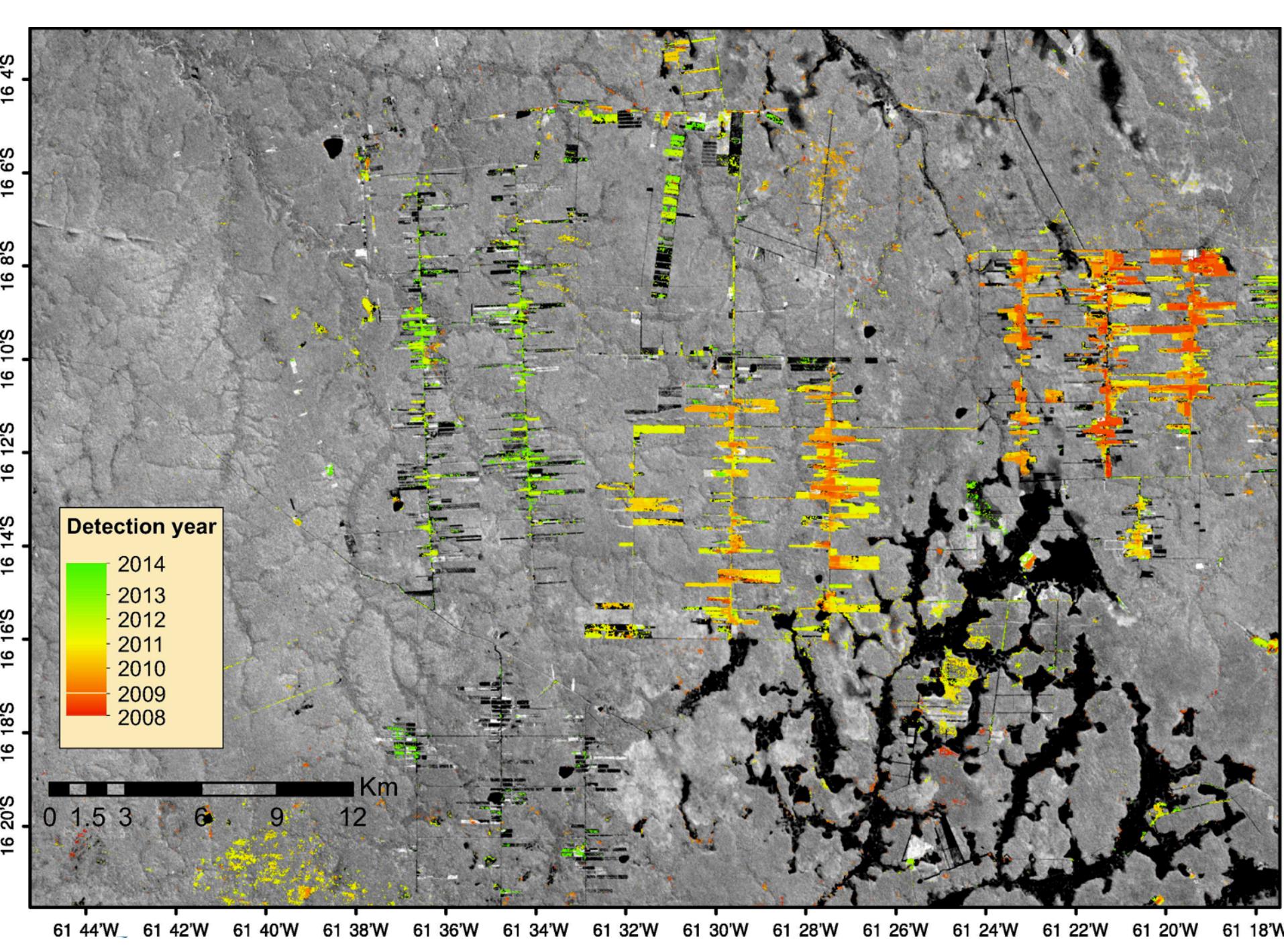
- BFASSTmonitor
 - Landsat time series



Dutriex et al., (2015): Monitoring forest cover loss using multiple data streams, a case study of a tropical dry forest in Bolivia. ISPRS.

A**B**

MODIS and Landsat NDVI used to model and predict



Free R toolkit: BFASTspatial

- Change detection using Landsat and MODIS data
 - Loïc Dutrieux, Ben DeVries, Jan Verbesselt
- <http://github.com/dutri001/bfastSpatial>
- Fully documented with tutorial and presentation
- FAO - OpenForis – Forest Monitoring
 - <http://www.openforis.org/>
 - SEPAL – FAO cloud



SAR + Landsat forest change monitoring



- Combining Landsat + SAR data

- Fiji, dense cloud cover
- Plantation forest

- MuTiFuse package for R

- <http://github.com/jreiche/multifuse>

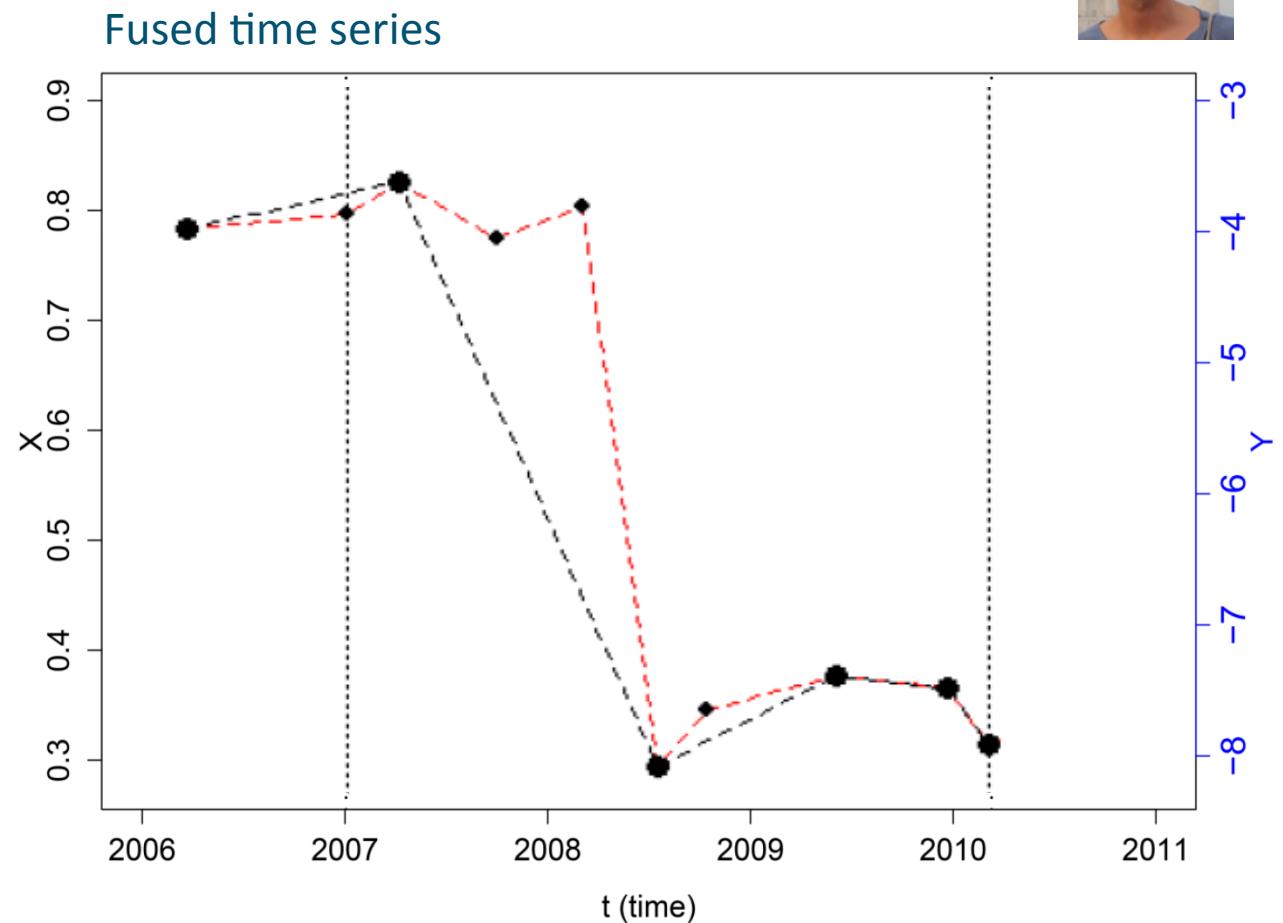
Reiche et al. (2015): Fusing Landsat and SAR time series to detect deforestation in the tropics. RSE.

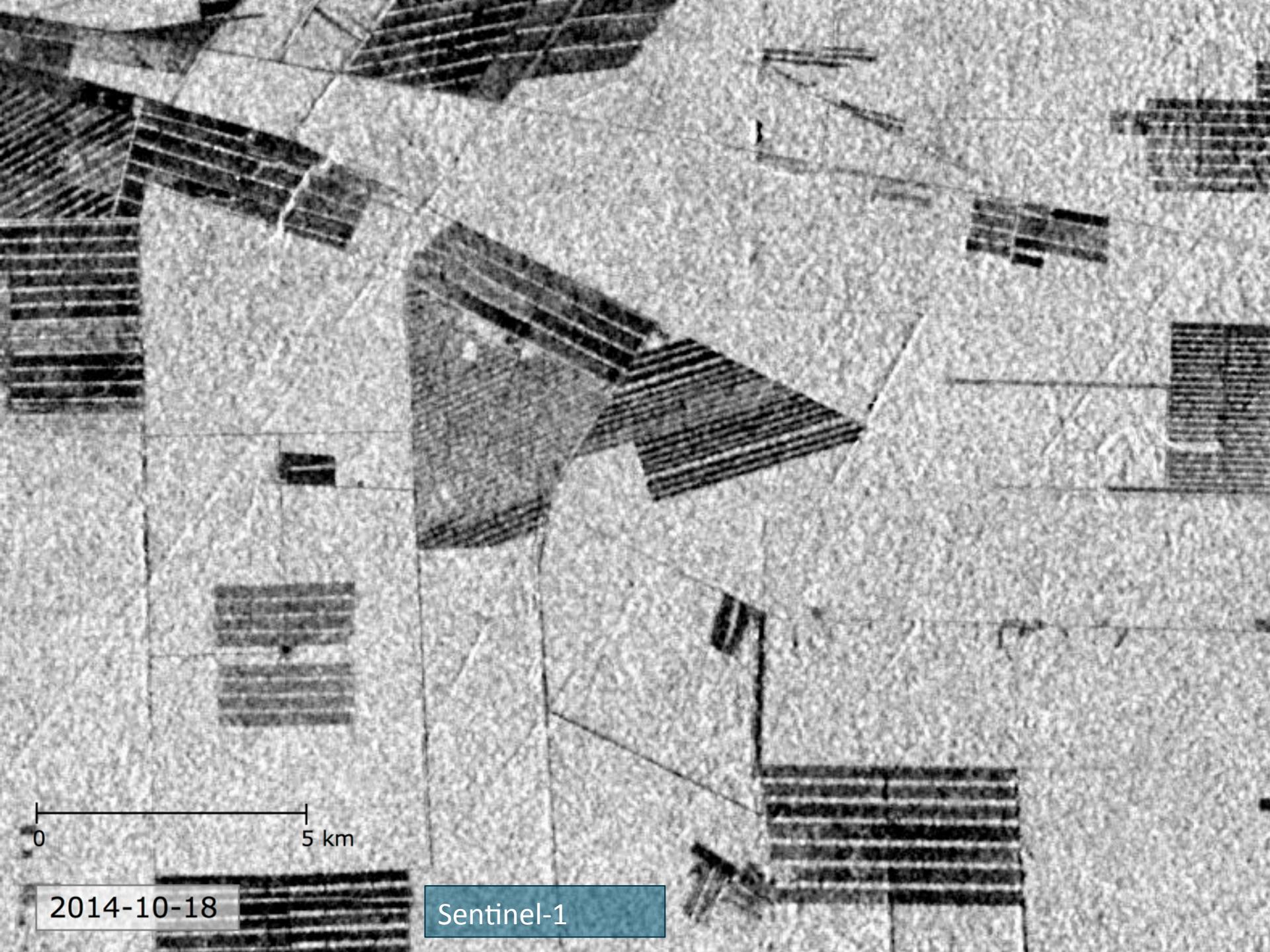
Reiche, J., et al. (2015). A Bayesian Approach to Combine Landsat and ALOS PALSAR Time Series for Near Real-Time Deforestation Detection. *Remote Sensing*.

SAR + Landsat forest change monitoring



(X) Landsat NDVI TS
(Y) PALSAR HVHH TS

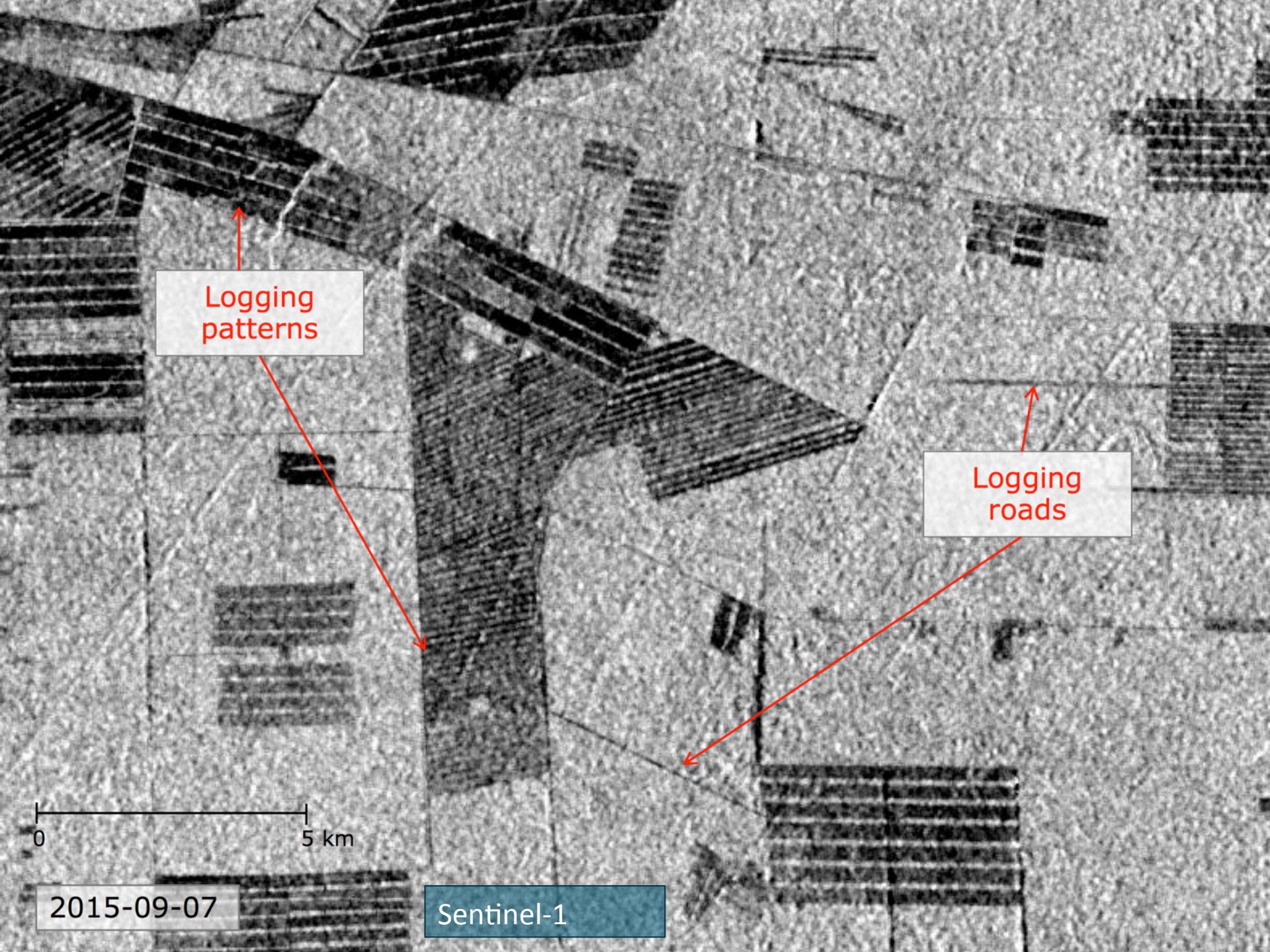




0 5 km

2014-10-18

Sentinel-1



Logging
patterns

Logging
roads

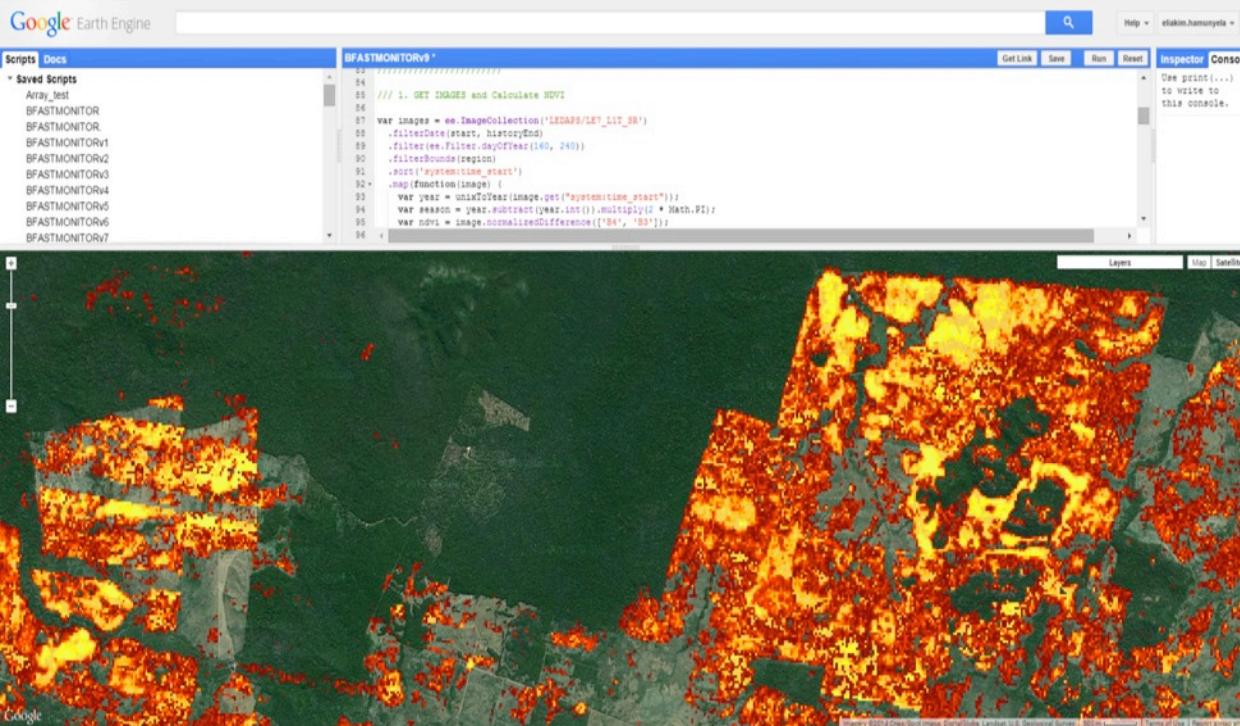
0 5 km

2015-09-07

Sentinel-1

Near real-time deforestation monitoring in the Google Earth Engine

■ Eliakim Hamunyela

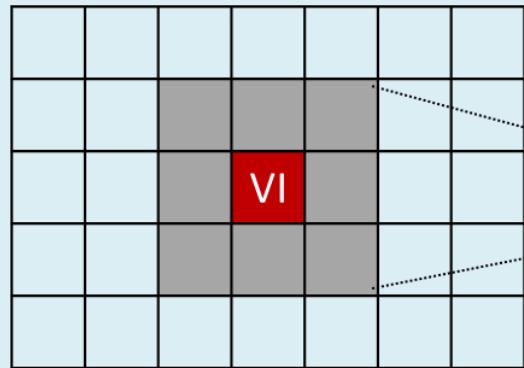


Hamunyela, E., Verbesselt, J. and Herold M. (2015) Using spatial context to improve early detection of deforestation from Landsat time series. RSE.

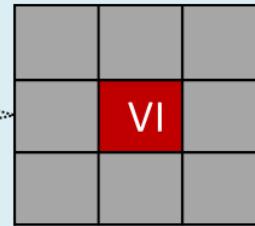
Using spatial context – the concept



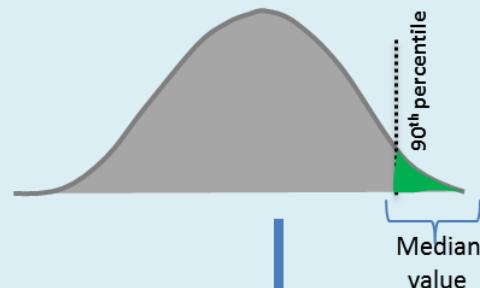
Vegetation index image (e.g., NDVI)



Spatial moving window

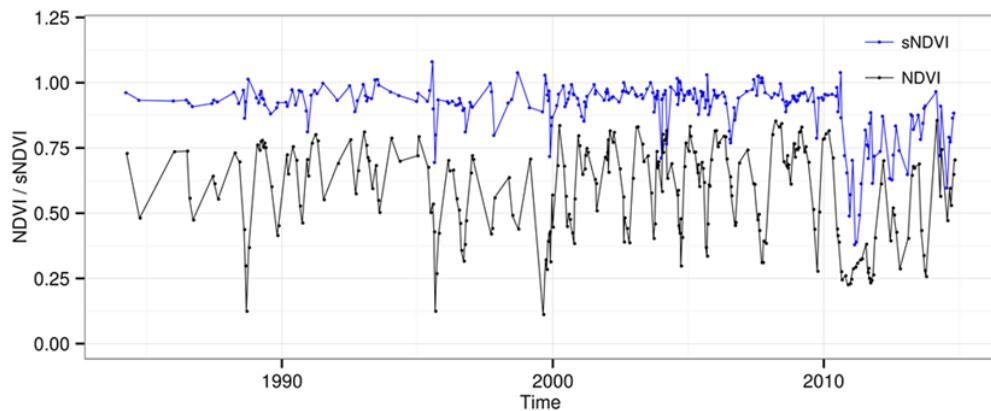


Distribution of values in the spatial window



Apply change
detection
method

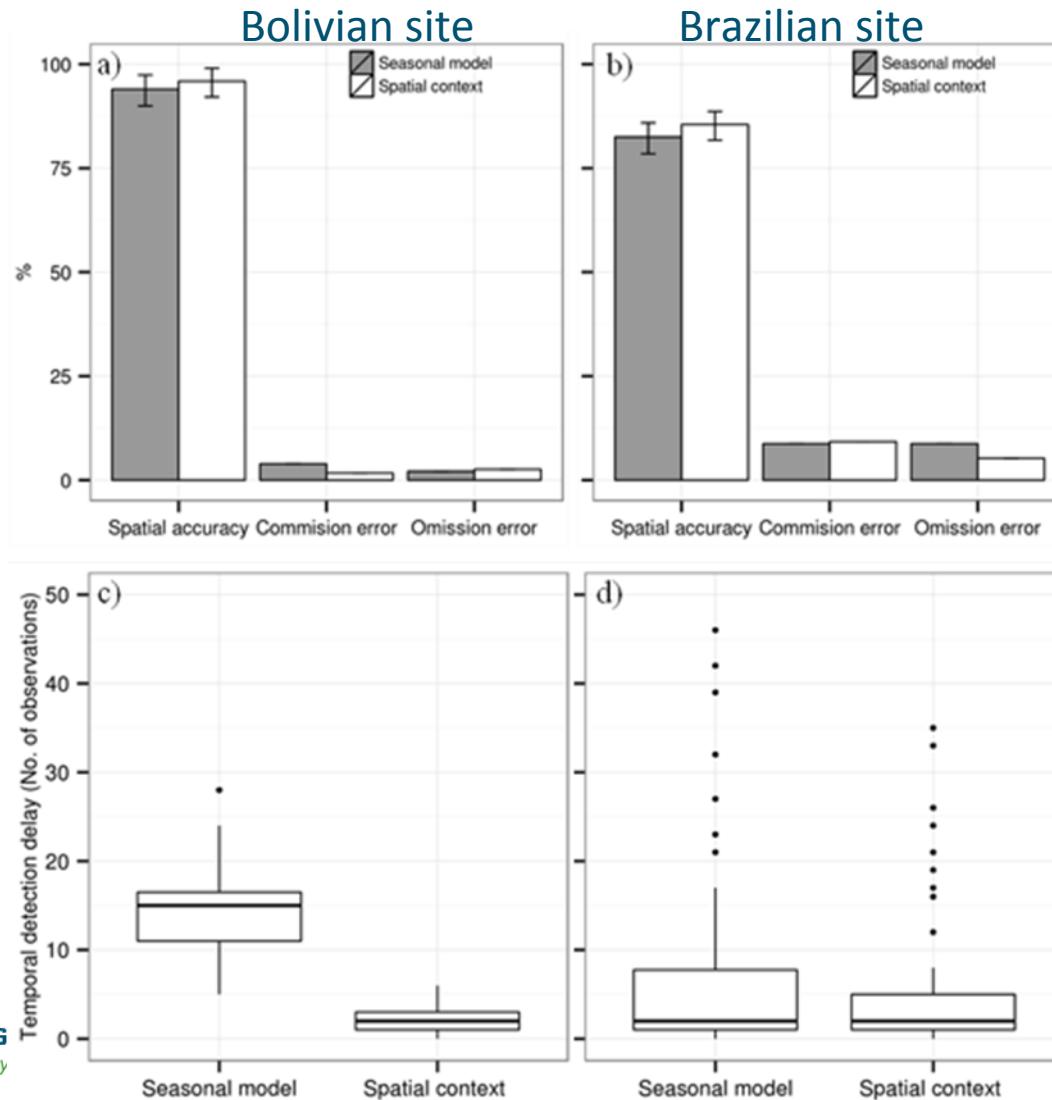
e.g. NDVI time series before and after spatially normalisation



Normalisation at each time step

$$sVI = VI / \text{Median value}$$

Spatial and temporal accuracy



Some summarizing thoughts



Outlook?!



2005



Outlook?!

NATURE | COMMENT



Satellites: Make Earth observations open access

Michael A. Wulder & Nicholas C. Coops

02 September 2014

Freely available satellite imagery will improve science and environmental-monitoring products, say Michael A. Wulder and Nicholas C. Coops.



PDF



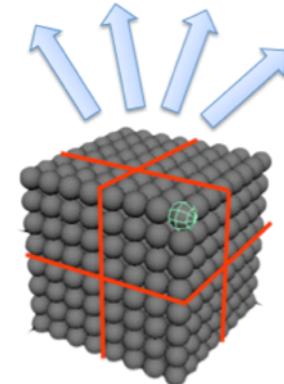
Rights & Permissions

Subject terms: Environmental sciences · Policy



Outlook?!

- Machine learning and data mining
- Structural change tests



NATURE | PERSPECTIVES[日本語要約](#)

The case for open computer programs

Darrel C. Ince, Leslie Hatton & John Graham-Cumming[Affiliations](#) | [Contributions](#) | [Corresponding author](#)*Nature* 482, 485–488 (23 February 2012) | doi:10.1038/nature10836

Received 09 May 2011 | Accepted 05 January 2012 | Published online 22 February 2012

Nature Editorial: If you want reproducible science, the software needs to be open source

According to an editorial in *Nature*, all scientific code should be released ...

by Kyle Niemeyer - Feb 26, 2012 9:00pm CET

[Share](#) [Tweet](#)

76

**NATURE | TOOLBOX**

Interactive notebooks: Sharing the code

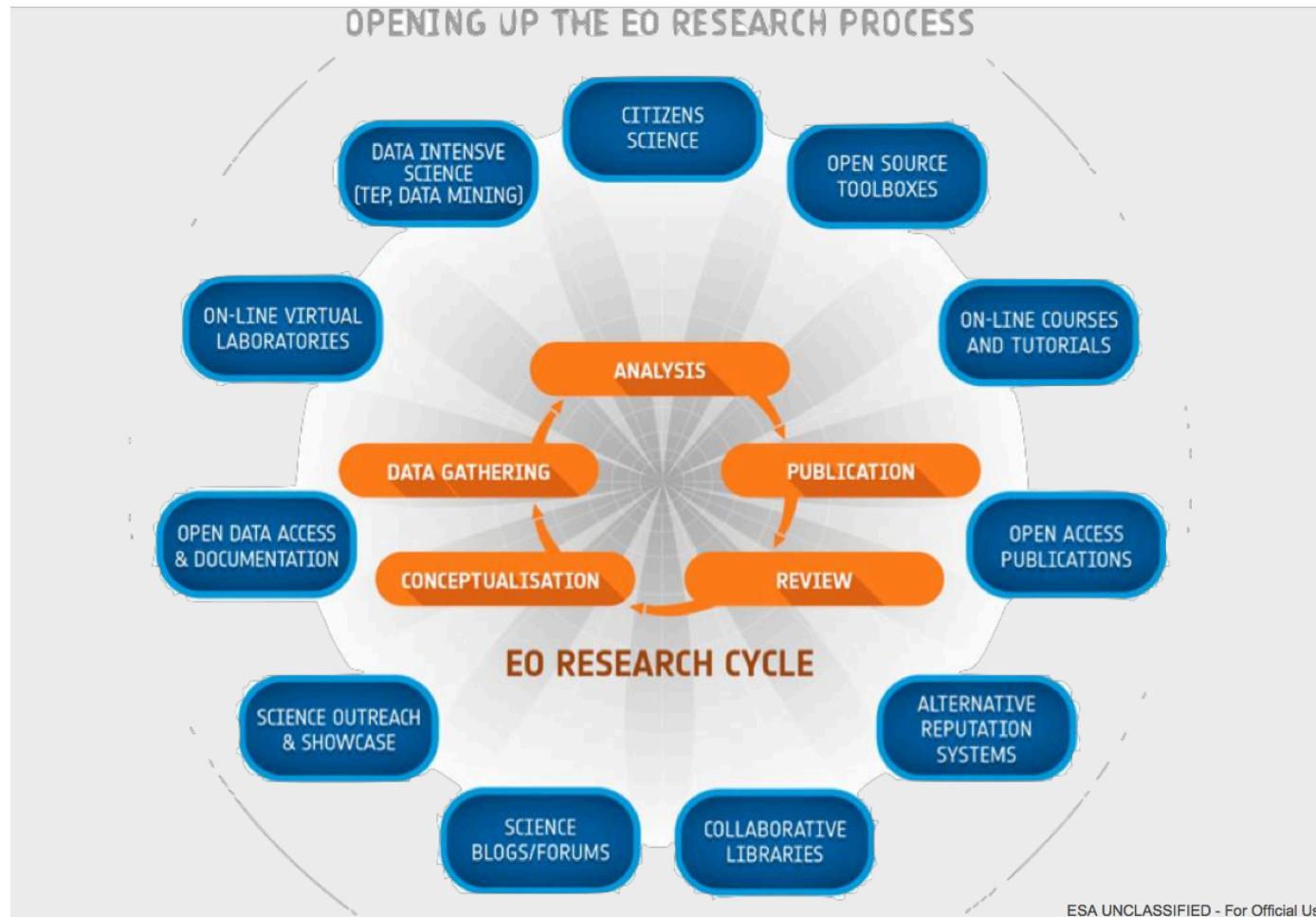
The free IPython notebook makes data analysis easier to record, understand and reproduce.

Helen Shen

05 November 2014

[Rights & Permissions](#)

Outlook?!





Thanks for your attention!

bfastSpatial for R: <http://github.com/dutri001/bfastSpatial>

timeSyncR package for R: <http://github.com/bendv/timeSyncR>

The timeSyncR package is based on the TimeSync method (Cohen et al., 2010, Remote Sensing of Environment).

MulTiFuse package for R: <http://github.com/jreiche/multifuse>

The MulTiFuse (Multi-sensor Time series Fusion) package provides functions to fuse optical and SAR time series (Reiche et al. 2015).

Jan Verbesselt
Laboratory of Geo-Information Science and Remote
Sensing, Wageningen University
<http://wageningenur.nl/changemonitor>

Tutorial session

- bfastSpatial
 - Intro:
 - <http://dutri001.github.io/bfastSpatial/quickStart#/>
 - Tutorial:
 - <https://dutri001.github.io/bfastSpatial/>
- Interactive application of change monitoring:
 - <https://loicdutrieux.shinyapps.io/bfmApp/>
- Community based monitoring
 - www.cbm.wur.nl

More info, extra talk and tutorial

- <http://www.loicdutrieux.com/talks/SCERIN-2015-change-detection/#/>
- <http://www.loicdutrieux.com/talks/SCERIN-2015-bfastSpatial/#/>
- <https://github.com/dutri001/bfastSpatial>