Final Publishable summary report

Monitoring forest change using terrestrial LIDAR and satellite images: Strucchange

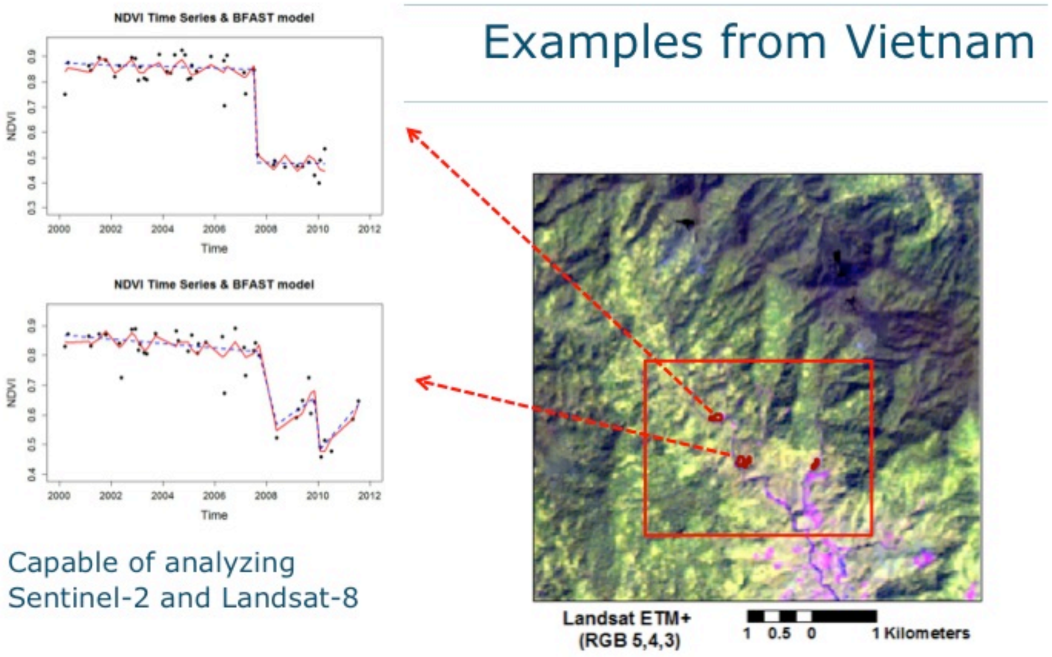
Natural resource managers, policy makers and researchers demand knowledge of deforestation and forest degradation over increasingly large spatial and temporal extents for addressing many pressing issues such as climate change mitigation and adaptation, carbon dynamics, biodiversity, and food security. The scientific community is witnessing a significant increase in the availability of different global satellite derived biophysical data sets (e.g. biomass and surface photosynthesis). However, the use of such data is not supported by accurate in-situ biophysical measurements (e.g. canopy structure) for the monitoring of forest and land dynamics. Consequently, there is an urgent need for methods to measure in-situ canopy structure accurately and better integrate with improved and innovative remote sensing approaches.

The research performed within the MC IRG has addressed this need by solving three core challenges. Main outcomes are published in peer-reviewed publications. Firstly, methods are developed to retrieve forest canopy structure attributes and biomass using a novel type of ground-based upward-looking laser scanner (Calders et al. 2013). Secondly, a physical modeling approach is used which provides a more rigorous framework than prior methods, which largely used regression relationships, to study relationship between the retrieved canopy attributes and satellite data (Calders et al. 2012 and 2013). Finally, these accurate satellite-derived biophysical data sets enable assessment deforestation and forest degradation (De Jong et al. 2012, 2013, De Sy et al. 2012, Reiche et al. 2013, Verbesselt et al. 2012,). However, existing methods to detect changes in satellite data are not able account for seasonal climatic variations. A new approach is therefore proposed to account for seasonality while detecting changes in forest ecosystems (Verbesselt et al. 2011, 2012) (Fig. 1). The research efforts are part of a coordinated research activity among groups in Europe, Australia, and USA.

A summary of main research outcome during the Marie Curie IRG (publications, figures) can be found here on (1) the project website (change monitoring), (2) terrestrial LIDAR website and (3) Open source code and functions are published and made available via : http://bfast.r-forge.r-project.org/. A full and complete overview of all relevant publications and their impact factors can be found via research candidate's publication profile.

The three core challenges were combined within a study where a longest global record of satellite image (1982-2011) was analyzed to analyzed impact of a more extreme climate and increasing human population on vegetation activity. Especially, information on timing and type of such trend shifts was lacking at global scale. In this summarizing study (De Jong & Verbesselt, 2013), we detected major shifts in vegetation activity trends and their associated type (either interruptions or reversals) and timing. It appeared that the biospheric trend shifts have, over time, increased in frequency, confirming recent findings of increased turnover rates in vegetated areas. Signs of greening-to-browning reversals around the millennium transition were found in many regions (Patagonia, the Sahel, northern Kazakhstan, among others), as well as negative interruptions—"setbacks"—in greening trends (southern Africa, India, Asia Minor, among others). A minority (26%) of all significant trends appeared monotonic (Fig. 2, 3).

In conclusion, the Strucchange project facilitated by the Marie Curie (MC) IRG grant is a success story for three main reasons. Firstly, Jan Verbesselt is currently continuing his academic career, on a tenure track towards a full professor position at the Remote Sensing group of Wageningen University. Secondly, high quality peer-review papers were published (see publication overview) thanks to intense collaboration with the Wageningen research team and other groups internationally (Belgium, Australia, Austria, US). Thirdly, based on peer-reviewed papers, open-source software was published via the Strucchange project website called BFAST (http://bfast.r-forge.r-project.org/). This open-source code platform led to a high impact and resulted in new scientific projects and collaboration with companies (i.e. Google) who are currently implementing the Strucchange algorithms for "Global near real-time deforestation Monitoring" using the Google Earth Engine Deforestation project. An extra research grant for operational implementation of change monitoring code was awarded to the BFAST coding project. Fig. 4 and 5 illustrate the socio-economic impact of the Strucchange – BFAST code project globally via reported statistics of visitors of the project website.



Examples from Vietnam

Capable of analyzing Sentinel-2 and Landsat-8

Fig. 1. Deforestation monitoring using satellite data in Vietnam using BFAST – Strucchange Marie Curie research developments.

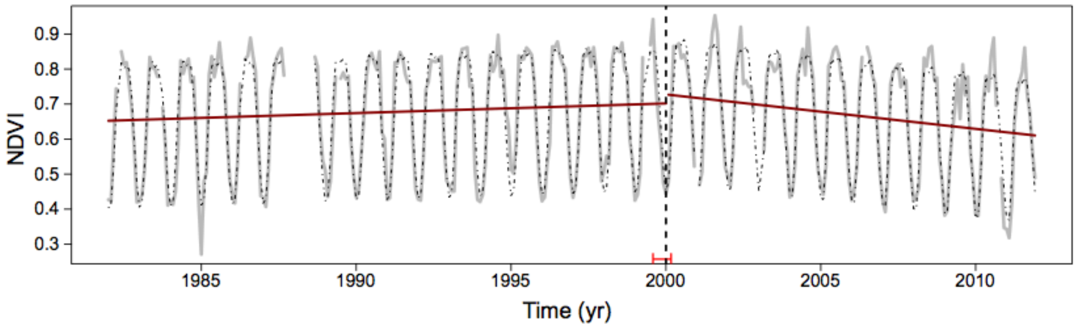


Fig. 2. Detecting one major trend shift within an NDVI time series. A season-trend model (dashed black line) was fitted to the NDVI time series (gray). The vertical dashed line depicts the detected trend shift, together with the confidence interval of its timing (red). This particular shift was detected in 2000, yielding separate trend segments (dark red) before and after. Data gaps due to non-zero quality flags (e.g., in 1988) do not influence the season-trend model parameter estimation (De Jong et al. 2013).

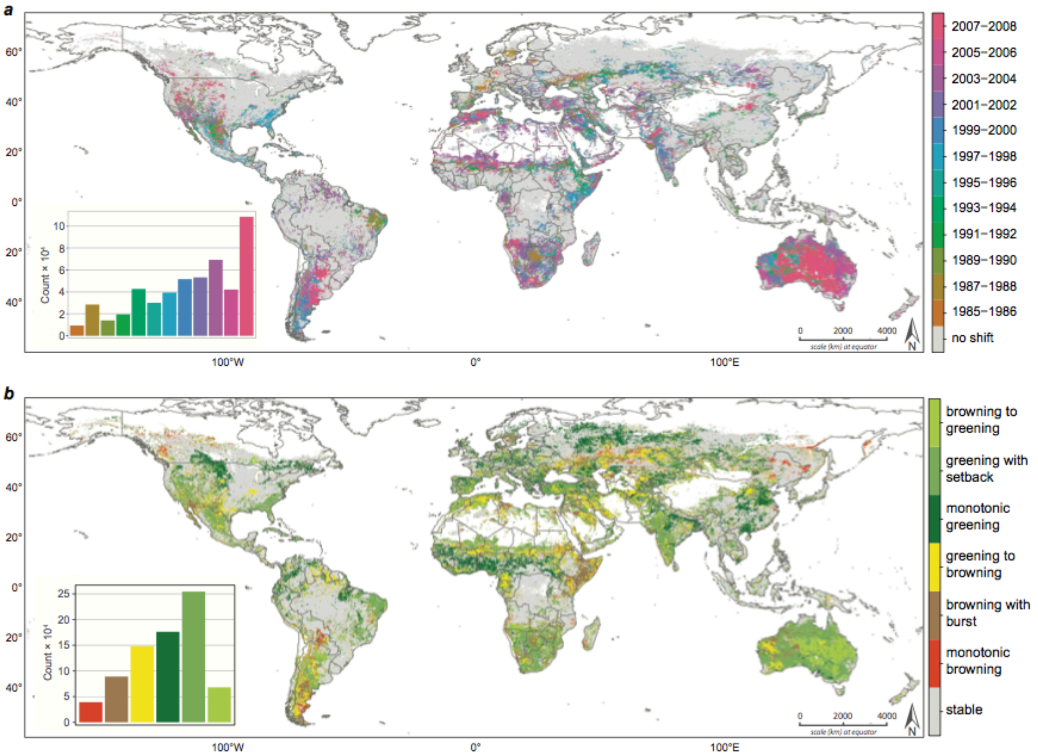


Fig. 3 (a) Spatial distribution of the timing of the shifts in the global greening and browning regime. The detected change points were binned into 2-yearly classes. The inset depicts the number of 0.083◦ grid cells per bin; (b) Spatial distribution of types of vegetation activity trends as defined in Figure 2. The inset depicts the number of 0.083◦ cells per trend type. In both maps, terrestrial areas that appear white were masked based on the quality flags or median NDVI criterion (De Jong et al. 2013).

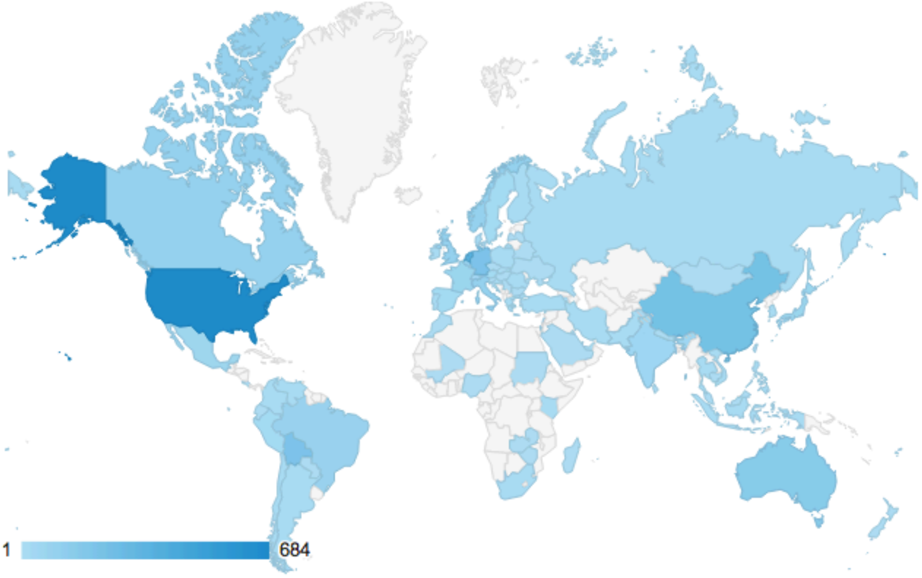
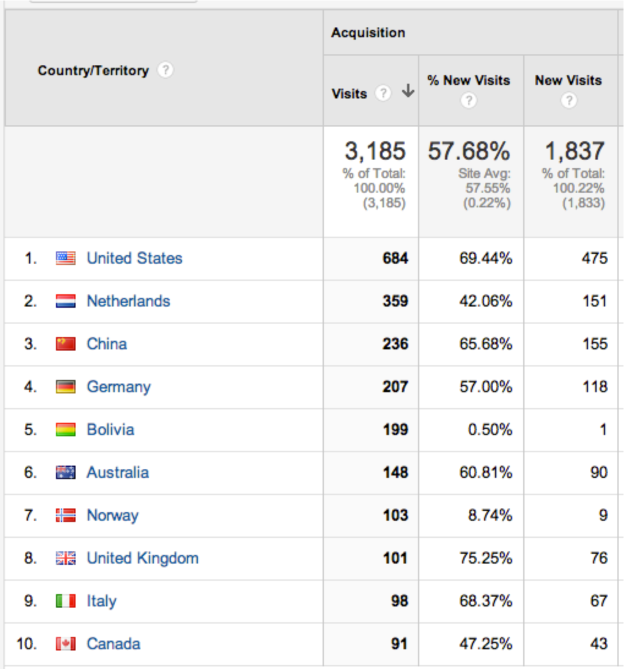


Fig. 4 Unique Download and visitor statistics of the open-source BFAST Strucchange Project illustrating international use and impact.



Country/Territory	Acquisition		
	Visits	% New Visits	New Visits
	3,185 % of Total: 100.00% (3,185)	57.68% Site Avg: 57.55% (0.22%)	1,837 % of Total: 100.22% (1,833)
1. United States	684	69.44%	475
2. Netherlands	359	42.06%	151
3. China	236	65.68%	155
4. Germany	207	57.00%	118
5. Bolivia	199	0.50%	1
6. Australia	148	60.81%	90
7. Norway	103	8.74%	9
8. United Kingdom	101	75.25%	76
9. Italy	98	68.37%	67
10. Canada	91	47.25%	43

Fig. 5 User statistics of the Strucchange-BFAST website (http://bfast.r-forge.r-project.org).

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