Using CHRIS PROBA Data for Forest Disturbance Mapping

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PROBA-1 End of Mission Workshop

SESSION 2: Results from Proba-1 CHRIS data usage

Marriott Hotel, Gent, Belgium

18-19 January 2024

Forest Disturbance Mapping and UN SDGs

- Forest disturbance mapping is related to SDG 15: Life on Land. The goal of SDG 15 is to protect, restore and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.
- The United Nations Strategic Plan for Forests 2030 and its six Global Forest Goals were created to strengthen the management of the world's forests and improve the lives of people who depend on these vital ecosystems.
- The Global Forest Goals Report 2021 provides a snapshot of actions being taken to implement the United Nations Strategic Plan for Forests 2030, and evaluates where the world stands in implementing it.

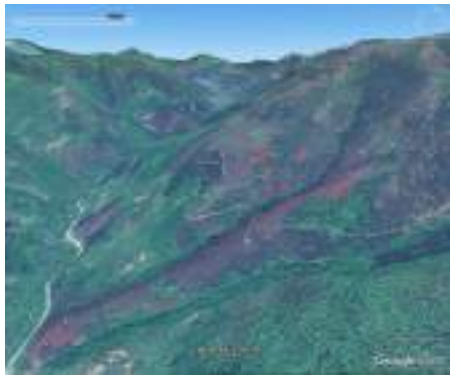
Natural Disturbances in Bulgarian Forests

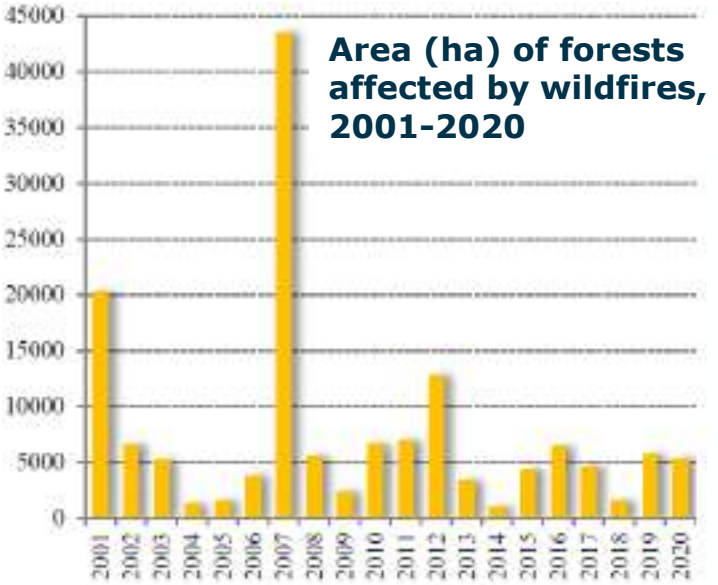
The scale of the problem

- In 2021 **disturbances** caused by different natural factors were observed in forests with area of **52 000 ha**
- Over **41 000 ha** pine plantations were affected by **bark beetle** between 2013 and 2019, with extremely large damages in 2017
- Over **51 000 ha** forest areas were affected by 4984 **wildfires** between 2011 и 2020

Information needs

- For planning (short-term) forestry operations (e.g. mitigation)
- **For long-term monitoring, analysis, modelling, etc.**





* Sources: http://www.iag.bg/data/docs/Prognoza2022.pdf , http://www.iag.bg/data/docs/Analiz_pogari_2021.pdf , Executive Forest Agency, Белилов и Георгиев. Наука за гората, 2020, 91-98

The scale of the problem

An infestation of European Spruce Bark Beetle (Ips typhographus L.) has been taking place since 2001 in the Norway spruce (Picea abies L.) forests of Bistrishko Branishte UNESCO Man and Biosphere (MAB) reserve

- The Bistrishko Branishte biosphere reserve is located in the upper part of Bistrica river basin in the Vitosha Mountain between 1430 and 2282 m a.s.l. It was enlisted in the UNESCO Man And Biosphere (MAB) Programme in 1977. The protected area is 1061.6 ha, of which 52% are forests, and the rest part is covered with sub-alpine meadows, rocks, and rock scree. The dominant tree species is Norway spruce (Picea abies L.), represented by 7 forms and varieties.
- Spruce forests affected by Ips typhographus L. experience **changes in leaf biochemistry and canopy structure**
- The combined spectral and angular data provided by CHRIS is hypothesized to **capture the extent and degree of the disturbance**.

A

B

A) The windthrow and the European Spruce Bark Beetle (Ips typhographus L.) infested trees in Bistrishko Branishte MAB reserve.
B) The European Spruce Bark Beetle Infestation in Bistrishko Branishte UNESCO MAB reserve.

Objectives

- To assess the impact of the infestation in Bistrishko Branishte UNESCO MAB Biosphere Reserve by comparing the pre- and post-fire CHRIS/PROBA Mode 1 narrow-band Vis;
- To estimate the fire-scar area using CHRIS-PROBA Mode 1 images;
- To study LU/LC change using simulated Sentinel-2 high-resolution satellite data.

Materials

Reference data collection and database compilation

Field data collection

- 4 test sites within the biosphere reserve: ASD field spectrometer data, expert evaluation of disturbance severity,

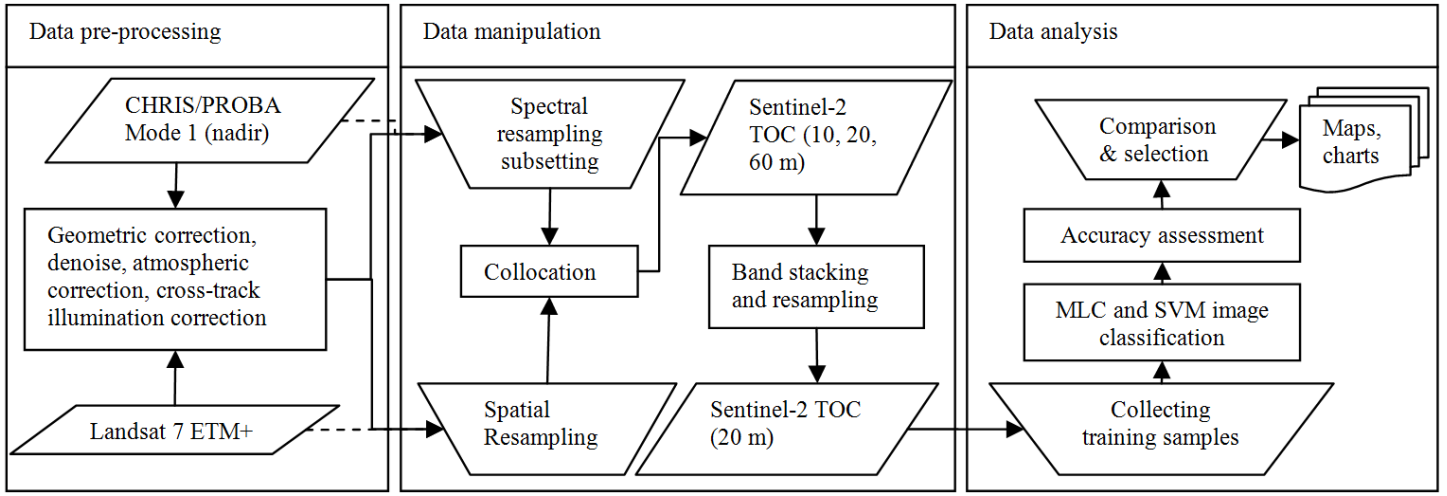
Other reference data

- CHRIS/PROBA scenes (RSAC/ESA), Landsat 7 ETM+ images from USGS LP DAAC online archive (for pansharpening of CHRIS data), a subset from ASTER GDEM V. 2 and a boundary (shape file) of the biosphere reserve (Vitosha Nature park authorities).

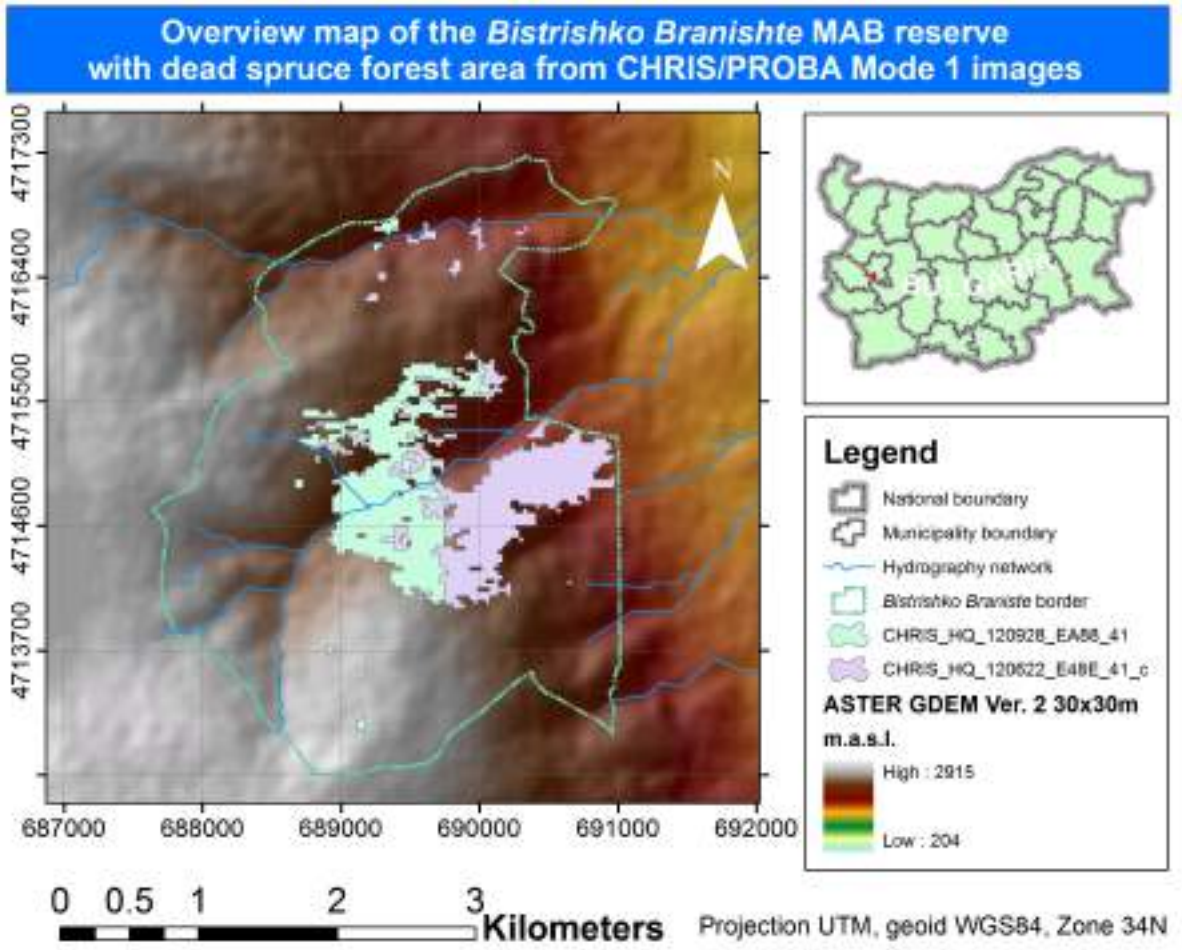
Software: BEAM VISAT (Brockmann Consult & ESA under free GNU license), ArcGIS/ArcInfo (ESRI Inc. under Academic License), ENVI (Exelis ITT VIS under Academic License).

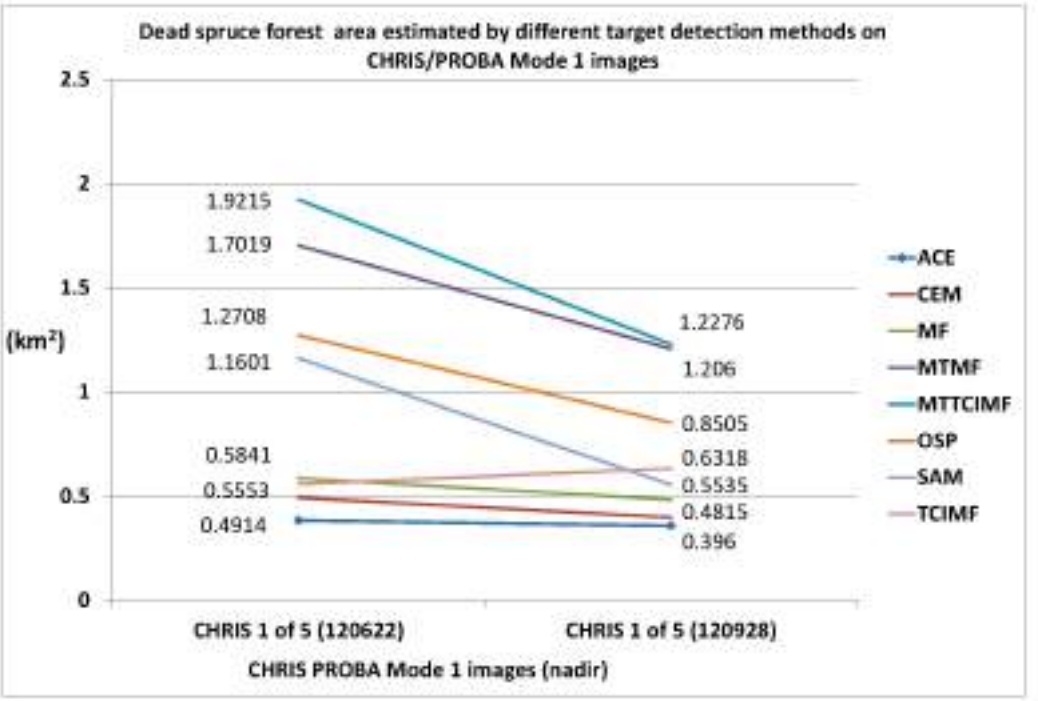
Methods

- **Data pre-processing and manipulation**: satellite data collection, noise correction, atmospheric and geometric correction, georeferencing, conversion to reflectance, cross-track illumination correction, Minnaert topography correction, spatial sub-setting, design of a geodatabase;
- **Data analysis**: Target Detection (TD), MLC, SVM, vegetation index (VI) - 19 VIs, zonal statistics, graphs, charts.



Summary of Main Achievements





Map of the spread of the European Bark Beetle (Ips typhographus L.) affected areas in Bistrishko Branishte UNESCO MAB reserve from CHRIS/PROBA Mode 1 pre- and post-fire images at nadir using CEM TD method.

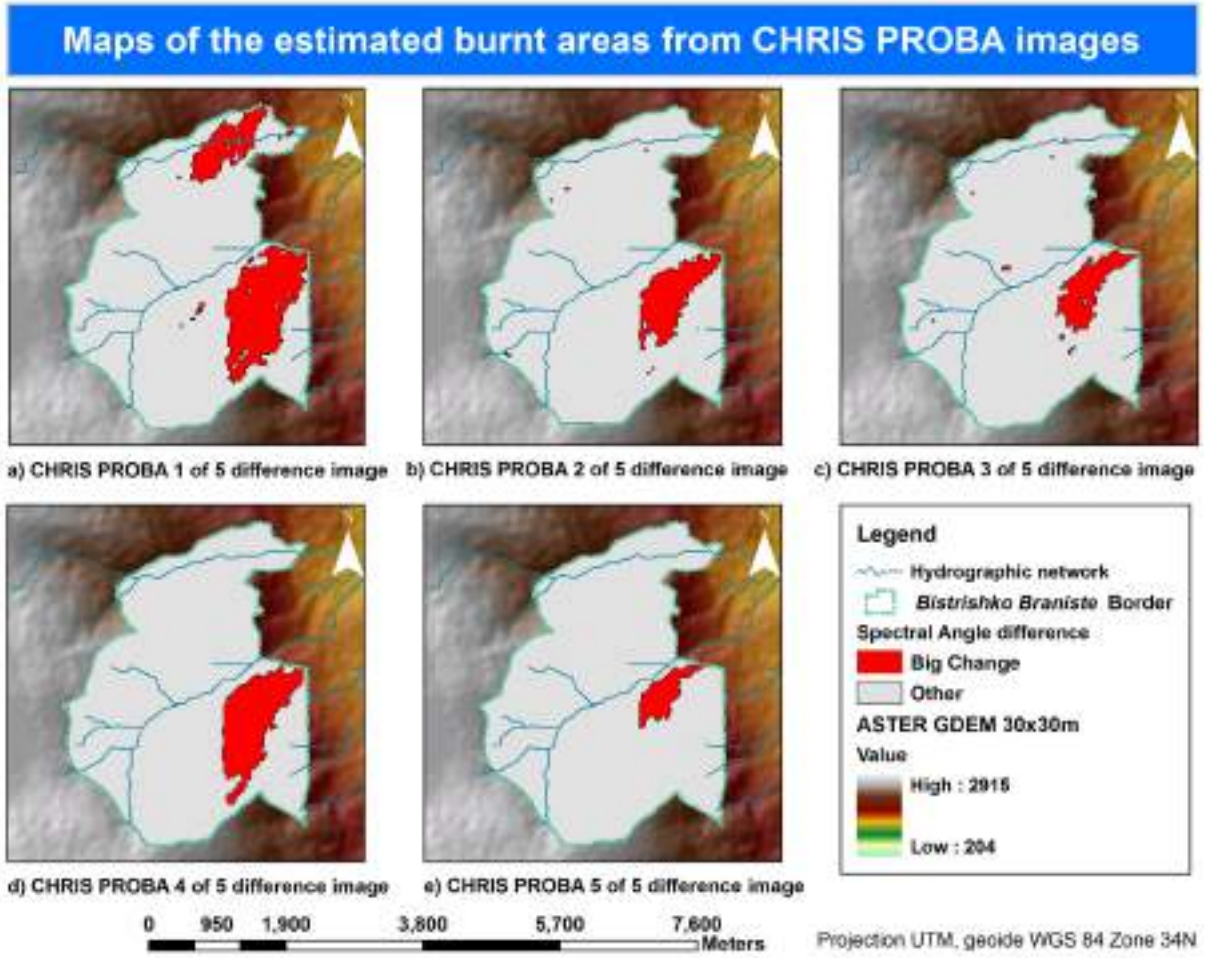
Results and Discussions

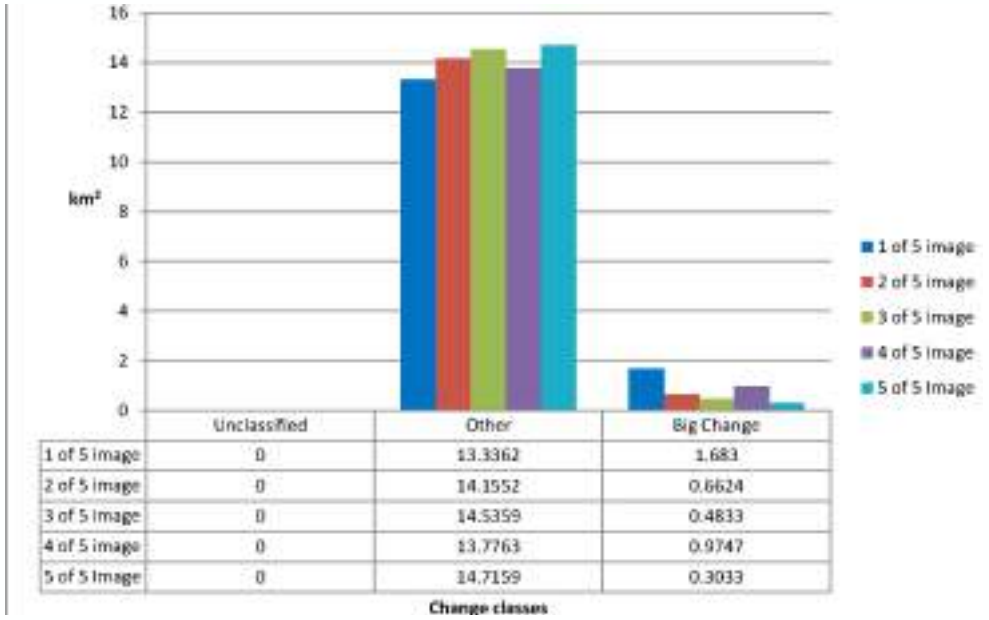
- *The highest accuracy amongst the eight target detection algorithms used in this study features the **OST algorithm (~90% thematic accuracy)** used as a basis for assessment of the changes before and after the forest fire.*

- *The results for pest-affected area estimation using different TD algorithms are **varying from 0.5-1.9 km^2 (pre-fire) to 0.4-1.2 km^2 (post-fire)**.*

- *Only RENDVI increases after the fire which suggests for a greening up of the pest-infected areas which is a seasonal change. The sudden decrease in CRI 2, ARI 1, and ARI 2 is attributed as well to seasonal changes.*

Results and Discussions





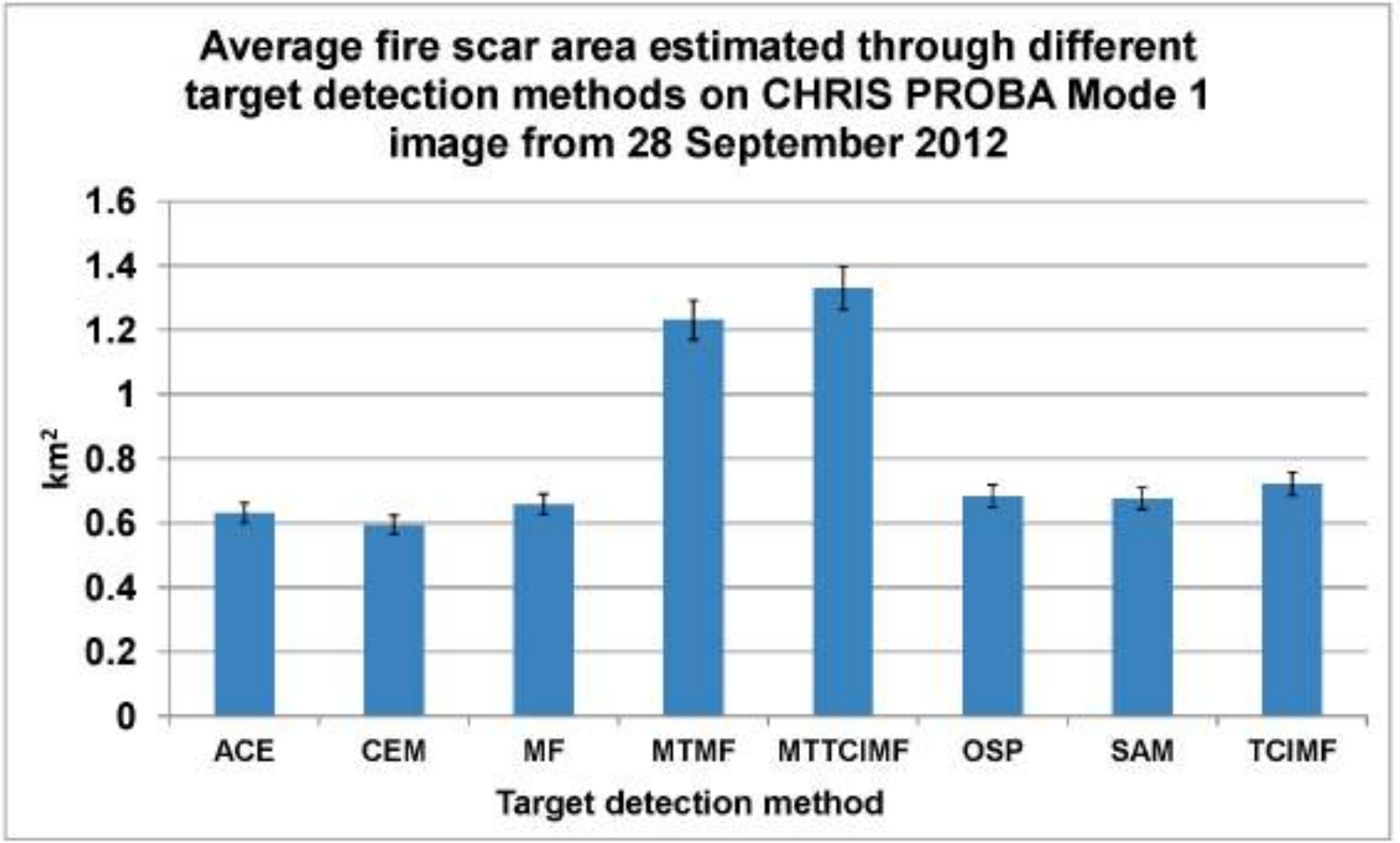
	Unclassified	Other	Big Change
1 of 5 image	0	13.3362	1.683
2 of 5 image	0	14.1552	0.6624
3 of 5 image	0	14.5359	0.4833
4 of 5 image	0	13.7763	0.9747
5 of 5 Image	0	14.7159	0.3033

Change classes

Chart of the areas of changed and unchanged (Other) territories estimated using SAD procedure on CHRIS/PROBA Mode 1 pair of images.

Maps of the estimated burnt areas in Bistrishko Branishte UNESCO MAB biosphere reserve using CHRIS PROBA Mode 1 five multi-angle images and SAD procedure.

Results and Discussions



Average fire scar area in Bistrishko Branishte UNESCO MAB reserve estimated on CHRIS/PROBA Mode 1 image from 28 September 2012.

- *The TD algorithms which do use the Minimum Noise Fraction (MNF) image which eliminates the detector's systematic noise perform equally well and give similar results, i.e. about 0.60 km2.*
-
- *Close to these results are those obtained by Landsat TM data.*
- *The big changes, detected using SAD, between each pair of the co-registered multi-angle CHRIS/PROBA images, vary significantly from nadir (image 1 of 5) to ±55 degrees.*

Results and Discussions

Sentinel-2 bands	Central wavelength λ (nm)	FWHM* (nm)
1	443	20
2	490	65
3	560	35
4	665	30
5	705	15
6	740	15
7	783	20
8	842	115
8b	865	20
9	945	20

Table 1. Spectral characteristics of Sentinel-2 simulated bands. After Law and Nichol, (2004) and Drusch et al. (2012) with modifications.

Results and Discussions

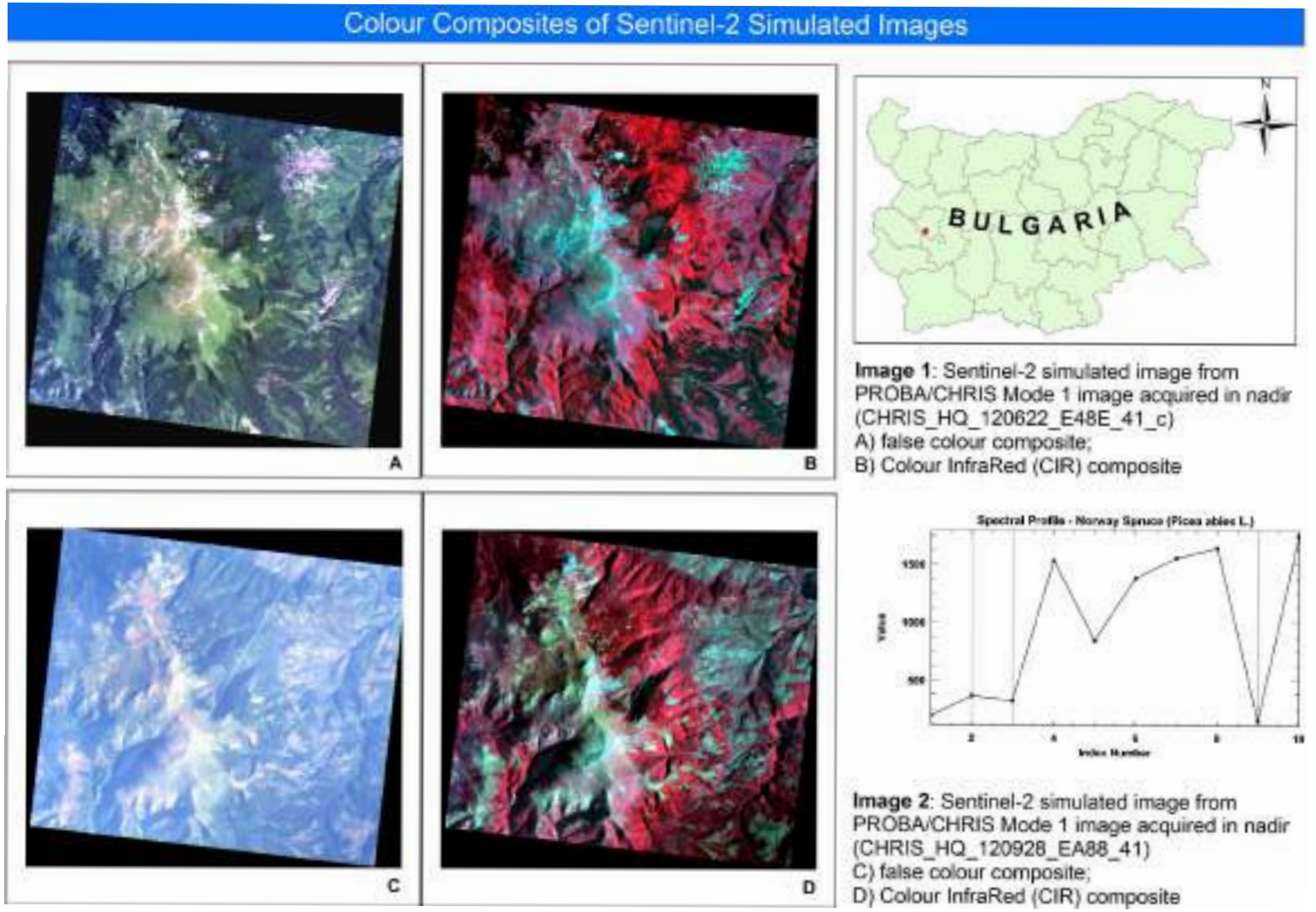
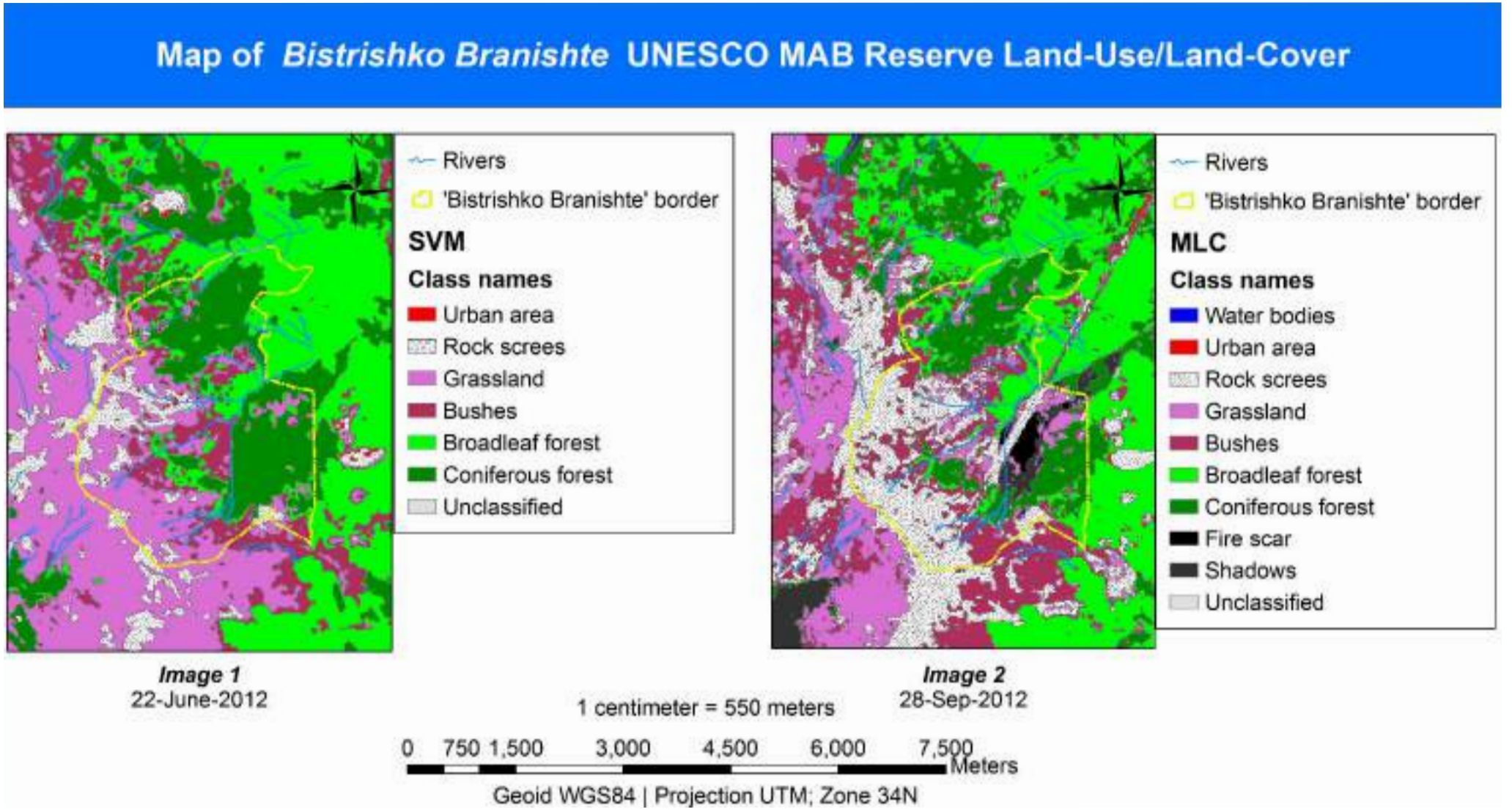


Image 1: Sentinel-2 simulated image from PROBA/CHRIS Mode 1 image acquired in nadir (CHRIS_HQ_120622_E48E_41_c)
A) false colour composite;
B) Colour InfraRed (CIR) composite

Image 2: Sentinel-2 simulated image from PROBA/CHRIS Mode 1 image acquired in nadir (CHRIS_HQ_120928_EA88_41)
C) false colour composite;
D) Colour InfraRed (CIR) composite

Results and Discussions



Results and Discussions

- *The overall accuracy of MLC is 76.98 %, which is well below for routine LU/LC mapping purposes (Kappa 0.7293).*

- *The simulated Sentinel-2 TOC data can serve for mapping and monitoring of coniferous, deciduous forests, and grasslands due to the achieved high-level of producer's and user's thematic accuracies, i.e. between 78 % and 98 %.*

- *Depending on the illumination conditions, throughout the seasons, the accuracy of specific LU/LC classes such as 'Bushes', 'Rock screes', and 'Urban area' vary significantly, due to the spectral similarity.*

Vision of the future

- For planning (short-term) forestry operations (e.g. mitigation); for long-term monitoring, analysis, modelling, etc.
- Enhancement of the models – better discrimination of forest disturbance types (e.g. by incorporating weather data), calibration of the disturbance severity measure with ground data.
- Development of new products – e.g. adding flexibility (on-demand products, shorter production interval)
- Field data sharing - most CHRIS data is acquired over protected areas or test sites with field data
- Addressing UN SDGs
- Need for a gap analysis, identifying potential users and or developing of use-cases (similar to SPOT 5/Take 5 initiative or the extended mission of EO-1/Hyperion)

Acnowledgements

CHRIS/PROBA images used in this study were acquired within the ESA Cat-1 Project No 8072 MODEL FOR ASSESSMENT OF CONIFEROUS VEGETATION STRESS USING MULTISPECTRAL AND HYPERSPECTRAL SATELLITE DATA, ESA, PI Dr. Lachezar Filchev.
The author is appreciated for the team of RSAC (UK) for the planning of the CHRIS PROBA acquisitions throughout the project implementation.

ASTER GDEM Version 2 data, is courtesy United States Geology Survey, Land Processes Distributed Active Archive Center (USGS LP DAAC), ERSDAC, National Aeronautics and Space Administration (NASA), and Ministry of Economy, Trade, and Industry (METI) of Japan and Digital Globe (8-Band Research Challenge).

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Thank you for your attention !

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