Forest loss monitoring using multi-frequency radar and optical data

Keywords
deforestation monitoring, optical & radar remote sensing, SAR, time series, multi-frequency data, SAR interferometry, polarimetry, Bayesian approaches & machine learning

Background
The world's forests have undergone substantial changes in the last decades. In the tropics, 17% of moist forests disappeared between 1990 and 2019, through deforestation and forest degradation [6]. These changes contribute greatly to biodiversity loss through habitat destruction, soil erosion, terrestrial water cycle disturbances and anthropogenic CO2 emissions. Effective tools are thus urgently needed to survey forest disturbances.
Several forest disturbance detection systems have already been developed, mainly based on spaceborne optical remote sensing. Although radar images have a great potential for providing information over tropical areas, as electromagnetic waves are mostly insensitive to the presence of clouds, and despite the fact that Sentinel-1 radar images time series are now available to all at the global scale, few forest disturbances detection systems based on radar data have been developed so far. For notable exception, Marie Ballère (CNES-CESBIO Ph.D. defended in December 2021) improved the method previously developed at CESBIO by [1] and successfully applied it to French Guiana [2]. The system is now installed on the CNES high performing cluster and will allow to provide forest disturbances maps in the tropics [5], see Tropisco-Amazonia, Tropisco-2022.

Description
The work that is proposed here aims at improving the aforementioned Sentinel-1 based system developed by CESBIO/CNES:
1) The system shall be improved by using a diversity of images acquired from existing and future satellites missions, in addition to Sentinel-1 data. This task will require the selection of valuable data sets to be used in the frame of this work, in addition to handling and processing a large range of various data.
First, optical data from the openly available Sentinel-2 mission and from Planet mosaics shall be considered. Indeed, optical data allow to improve the spatial and temporal accuracy of the detection method, as shown in one of the few studies on the complementary features of radar and optical sensors for forest disturbance monitoring [3]. A variety of optical based forest detection methods, well developed so far and available in the literature, shall be tested.
L-band radar data shall be used too in the frame of multi-frequency radar data forest disturbances monitoring, in order to anticipate synergies between existing sensors and future L-band radar satellite missions such as NiSAR and Rose-L, and to prepare the launch of the upcoming P-band radar BIOMASS mission. For this purpose, L-band SAOCOM and ALOS-4 time series data over Brazil, made available at CESBIO by partners, can be used [4]. Due to the scarcity of the developed methods based on L-band data, new methods shall be developed.
Finally, some research is still needed to improve the detection method with Sentinel-1 data. In particular, the potential of coherent radar data will be investigated to derive new detection indicators, such as interferometric coherences or polarimetric indicators.

2) To ingest the optical and radar data described above, a fusion method shall be selected, that will use as inputs SAR data, or elaborated products, such as detected disturbances, to produce an improved detection system. To do so, several methods, including Bayesian approaches, will be investigated. However, the potential of machine learning-based approaches will be explored, as thousands of training samples, associated to forest disturbances in situ data have been gathered over French Guiana in the frame of Marie Ballère's Ph.D.
3) An important improvement of the existing detection method concerns the discrimination of very small objects, i.e., smaller than 0.2 hectare. This is important for forest degradation monitoring such as selective logging (which is currently a widely discussed topic), and also for tree mortality monitoring, which is also of interest for the ecology community. This topic will be supported by partnerships and collaborations within projects starting now, such as the ALT ANR project (led by Jérôme Chave, EDB). This topic represents a technical challenge as spatial speckle filtering should be avoided to preserve the spatial resolution of Sentinel-1 data.

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[2] Ballère, M., Bouvet, A., Mermoz, S., Le Toan, T., Koleck, T., Bedeau, C., ... & Lardeux, C. (2021). SAR data for tropical forest disturbance alerts in French Guiana: benefit over optical imagery. Remote Sensing of Environment, 252, 112159.
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[4] Mermoz, S., & Le Toan, T. (2016). Forest disturbances and regrowth assessment using ALOS PALSAR data from 2007 to 2010 in Vietnam, Cambodia and Lao PDR. Remote Sensing, 8(3), 217.
[5] Mermoz, S., Bouvet, A., Koleck, T., Ballère, M., & Le Toan, T. (2021). Continuous detection of forest loss in Vietnam, Laos and Cambodia using Sentinel-1 data. Accepted in Remote Sensing in October 2021.
[6] Vancutsem, C, Achard, F., Pekel, J.-F, Vieilledent, G, Carboni, S., Simonetti, D., Gallego P., Francisco J. , Aragão, L. & Nasi, R. (2021). Long-term (1990–2019) monitoring of forest cover changes in the humid tropics. Science Advances. 7. 10.1126/sciadv.abe1603.

Candidate Profile

The candidate should have a basic knowledge in at least two of the following domains, SAR remote sensing,EM wave propagation, signal processing, imaging, inverse problems, statistics and shall hold a Master degrees in remote sensing, signal processing, electronics, telecommunications, geophysics, imaging or statistics

Information

Dates: beginning October 2022, duration 3 years
Location: TeSA [link] & ISAE-SUPAERO/DEOS [link] labs, Toulouse
Funding : CNES & ISAE-SUPAERO
Supervision: L. Ferro-Famil (ISAE-SUPAERO), T. Koleck (CNES), A. Bouvet (CESBIO), S. Mermoz (GLOBEO)

To apply

Candidates shall send a detailed CV, motivation letter and the name and contact details of references to
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Deadline: March 31 2022