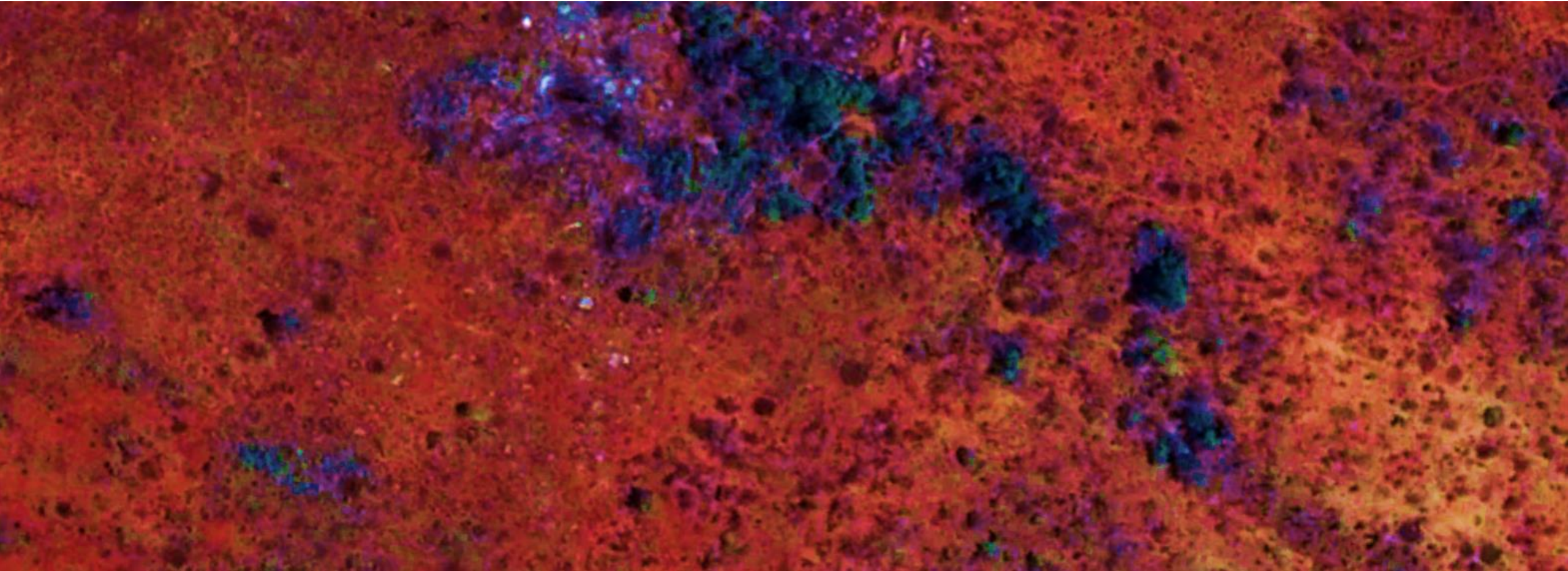


Detecting charcoal production sites using a combined remote sensing approach with Landsat-8, Sentinel-2 and VHR data



University of
Zurich ^{UZH}



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**EUROPEAN
SPACE
IMAGING[®]**



URPP
Global Change
and Biodiversity

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Advantages of using remote sensing to detect charcoal sites

Remote sensing allows us to acquire spatial information over large continuous areas



Monitoring and evaluation
of charcoal production

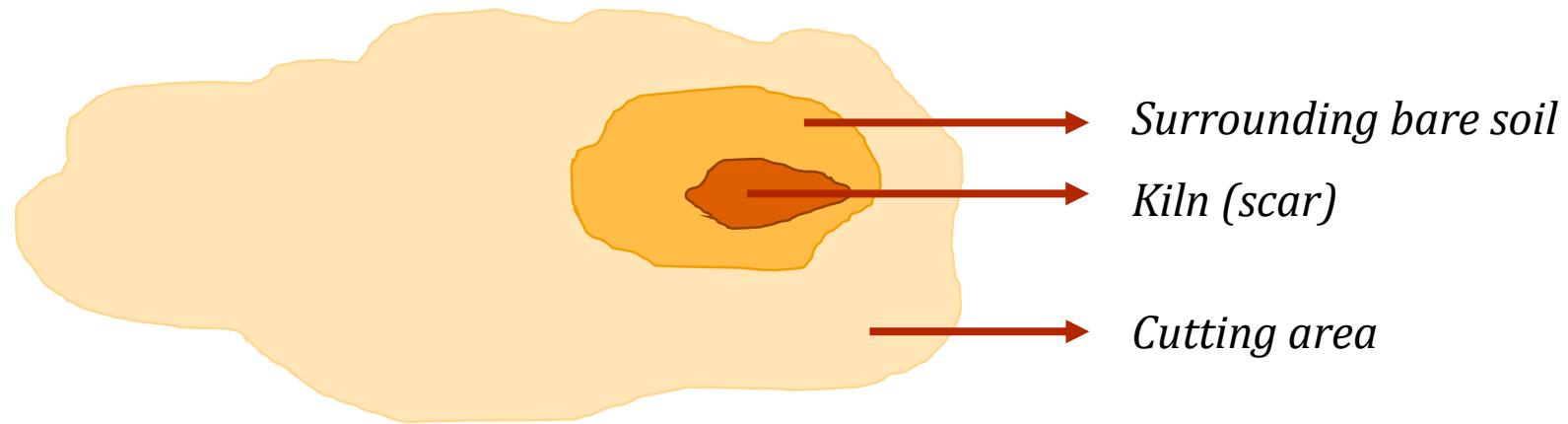


Understanding charcoal
producer behaviour
(drivers)



Forest regeneration and
biodiversity **impacts**

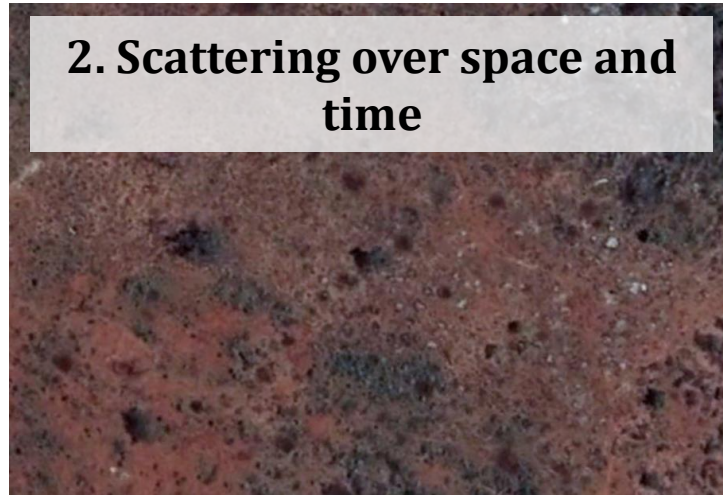
Challenges in charcoal site detection using remote sensing



1. Variations in cutting area and kiln size



2. Scattering over space and time

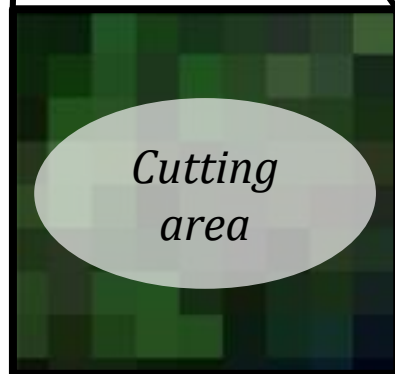


3. Canopy coverage of charcoal kiln (scar)

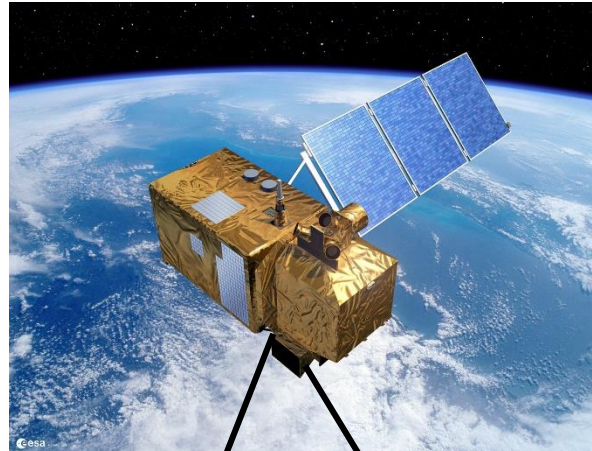


Different satellites produce images with different properties

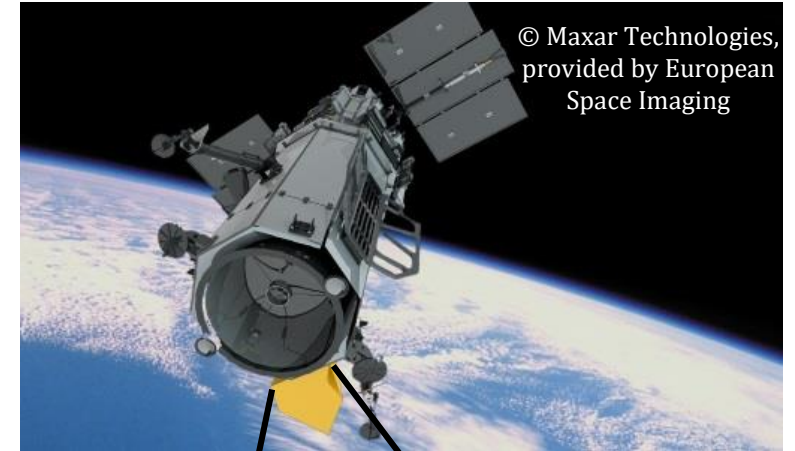
Landsat-8



Sentinel-2



Worldview-2/Planet (VHR)

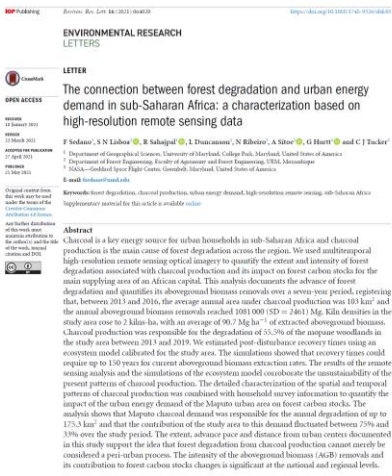


Need for automated approaches and uncertainty analyses

Multiple remote sensing approaches have been developed to differentiate charcoal production sites

Current needs

1. Understand the need for very-high resolution (VHR) imagery
2. Automated methods to reduce manpower and biases
3. Uncertainty analyses to better understand the robustness of remote sensing approaches



1. Introduction

Africa is experiencing a rapid urbanization process (Sutton 2016). While only 30% of the African population lived in urban centers in 2000, forecasts indicate that this figure will reach 60% in 2030 (UNEP 2014). This urbanization process is expected to have major implications for the natural environment within the growing sphere of influence of

the cities (Gutman et al. 2005), and it could potentially reshape our landscapes (Gutman et al. 2017). The connection between urban demand for food and forest and environmental degradation has been extensively documented (Defries et al. 2010; Satterthwaite et al. 2010; Lewis and Ramankutty 2015; Bender-Habib 2014). This urbanization process is expected to have major implications for the natural environment within the growing sphere of influence of

production by rural population (Muyanga et al. 2011). Estimates are consequently based on analysis of and projection models that use worldwide information of countries in similar socioeconomic and geographical situations, or by multiplying the country population by a per capita estimate based on a literature review carried out in 1980 (Vieira and Fonteneau, 1981; Wittmann et al., 2002). The distances of some of the estimates that are used as input in combination with the difficulty of data collection, makes that national charcoal production data are often at best "guesstimates" with limited accuracy (Muyanga et al., 2011). Levels of woodfuel harvesting may be in balance with the productive capacity of the woodlands, but overall fire loss occurs when the intensity of woodfuel production prevents regeneration and therefore sustainable production (Baker, 2005).

In Somalia, charcoal production is not only triggered by domestic consumption, which accounts for only a 40% of the total production and is the main source of energy in urban areas such as Mogadishu and Hargeisa, but mostly by foreign demand, which accounts for the remaining 60% (UNEP 2007). In fact, charcoal has developed into one of the main export products, and is commonly referred to as "black gold" (Shahin and Muddusa, 2006; UN Security Council 2013). UNEP (2007) estimated that 4.4 million tonnes of charcoal annually produce the 250,000 tonnes of charcoal that is exported every year from Somalia to South Africa, Yemen and the United Arab Emirates. While part of the charcoal exported from Somalia may originate from

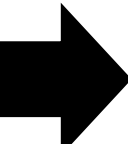
(Wurster, 2009; Bolognesi et al., 2015; Dons et al., 2015; Sedano et al., 2016; Nakalema, 2019; Sedano et al., 2020a,b; Sedano et al., 2021)

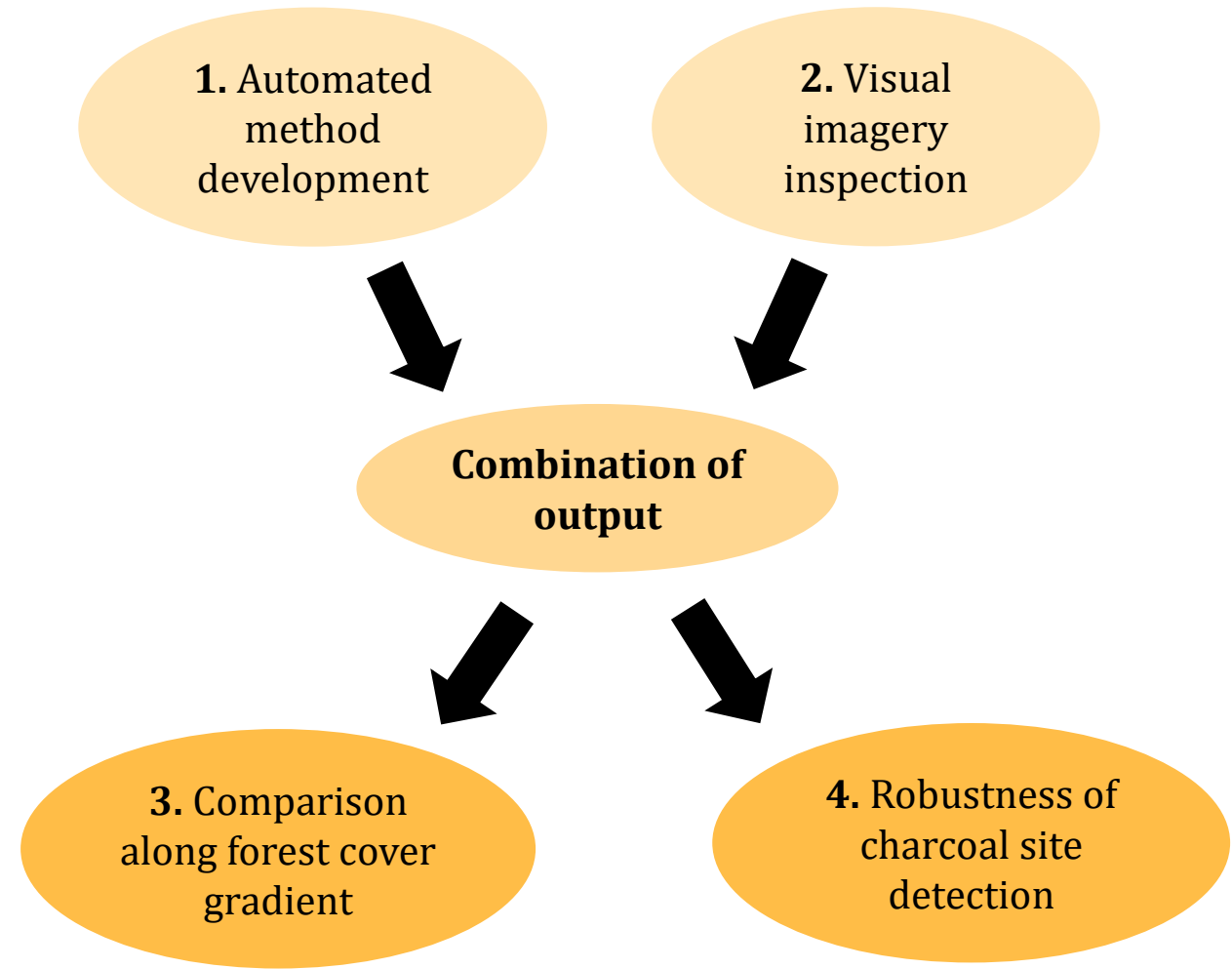
Research aims

1. Develop two automated classification methods using Landsat-8 and Sentinel-2 data

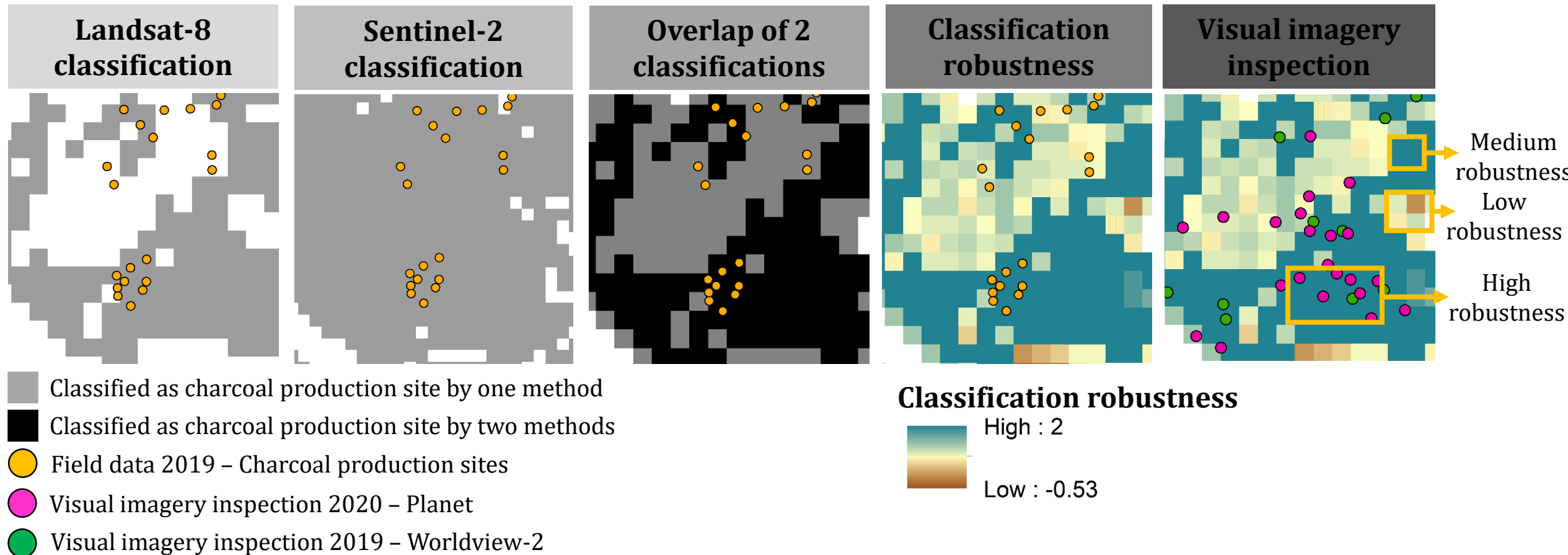
2. Use visual imagery inspection for charcoal kiln (scar) detection on VHR Worldview-2 and Planet imagery (Sedano et al. 2016)

3. Compare the performance of the methods along a gradient of forest cover

 **4.** Derive a metric to assess the robustness of charcoal production site detection



Combining output from automated classification methods



1. Charcoal site **classification Landsat-8**
2. Charcoal site **classification Sentinel-2**

3. **Overlap** classification Landsat-8 and Sentinel-2
4. Adjustment for **spatial uncertainty** in classification
5. Identifying areas with **different** levels of **robustness**

Summary and outlook

- A **combined approach** can improve charcoal production site detection
- A combined classification approach **reduces the need** for VHR imagery
- Robust charcoal production site recognition provides information on **monitoring and evaluation**



Thanks to all co-authors and collaborators

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Thank you!

