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Regional detection of canopy nitrogen in Mediterranean forests using spaceborne MTCI

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Background

Nitrogen (N) is an essential nutrient for plant growth. Leaf nitrogen content is linked to photosynthesis capacity, leaf chlorophyll content and Rubisco. **Canopy N concentration (g.100g^{-1})**, which is the leaf N concentration averaged over a forest stand, is linked to forest productivity (1) and canopy-level photosynthetic capacity (2). For these reasons, it is crucial to find efficient ways to detect canopy N concentration.

Relevance

Remote sensing (RS) has already been used to estimate canopy nitrogen concentration at local scales (2). However, few studies to date have explored canopy N concentration detection in **Mediterranean forests** at regional scale using a spaceborne remote sensing product.

Research challenge

We investigated the opportunity to detect **canopy nitrogen concentration** in Mediterranean forests at regional scale using the **MERIS Terrestrial Chlorophyll Index** (**MTCI**) from ESA Envisat satellite, a readily available remote sensing product.

Study area

- Catalonia region, NE Spain
- 1075 forest plots
- Deciduous Broadleaf (DBF), Evergreen Broadleaf (EBF) and Evergreen Needleleaf (ENF) tree species

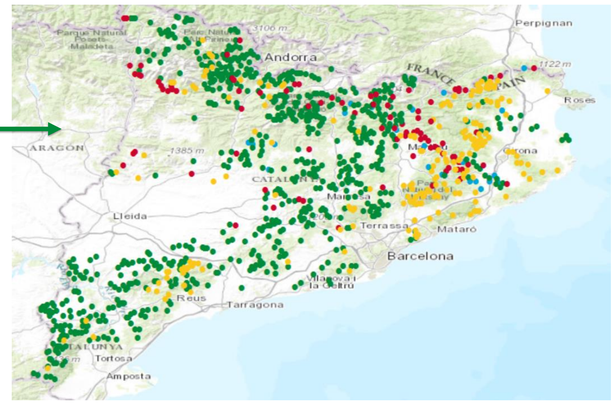

Fig 1. Forest plots map in the region of Catalonia, NE Spain. Red = Deciduous Broadleaf; Orange= Evergreen Broadleaf; Green = Evergreen Needleleaf; Blue = mixed

Remote sensing analysis

MTCI is a remote sensing product globally available from MERIS, aboard ESA Envisat satellite. It is a ratio of three spectral bands (681, 709 and 754 nm) located around the **red-edge region** of the spectrum (Eq. 1).

The spatial resolution is 1km.

Fig 2. Envisat satellite
(source: ioccg.org)

$$MTCI = \frac{R_{band10} - R_{band9}}{R_{band9} - R_{band8}} = \frac{R_{753.75} - R_{708.75}}{R_{708.75} - R_{681.25}} \quad (1)$$

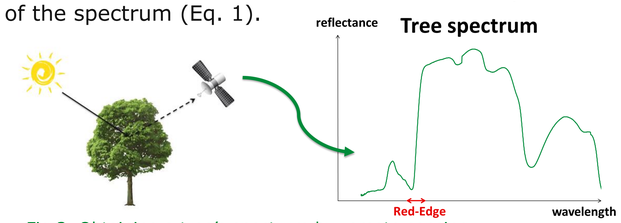

Fig 3. Obtaining a tree's spectrum by remote sensing

Results

- The relationship between canopy N concentration and MTCI (Fig 4.) is significant (R^2 = 0.28)
- A higher proportion of the variance is explained for DBF and mixed plots (R^2 = 0.33 and R^2 = 0.31) compared to EBF and ENF plots (R^2 = 0.02 and R^2 = 0.08)
- There is a relationship between canopy N concentration and MTCI for two individual DBF species: *Fagus sylvatica* and *Quercus cerrioides* (Fig 5.)

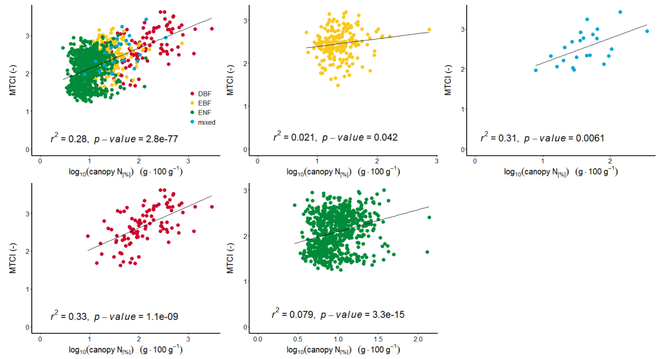

Fig 4. Relationship between canopy N concentration (canopy $N_{[\%]}$, g.100g^{-1}) and the MERIS Terrestrial Chlorophyll Index (MTCI) for the overall dataset (n=1075) and by plant functional type. DBF = Deciduous Broadleaf (n=96); EBF = Evergreen Broadleaf (n=199); ENF = Evergreen Needleleaf (n=757);

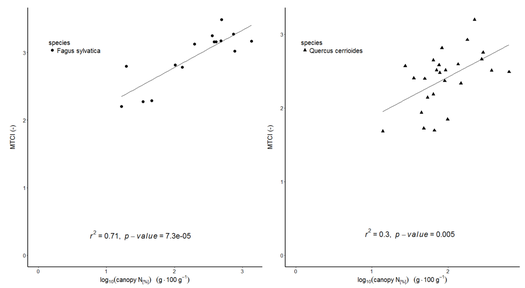

Fig 5. Relationship between canopy N concentration (g.100g^{-1}) and the MERIS Terrestrial Chlorophyll Index (MTCI) for two Deciduous Broadleaf species: *Fagus sylvatica* (n=15) and *Quercus cerrioides* (n=25).

Conclusions and perspective

- **The relationship between canopy N and MTCI is significant**
- It is influenced by the **plant functional type**: higher correlation for **broadleaf deciduous plots**
- A relationship between the variables is also found **at the species scale**
- Given the availability of MTCI data, this method could be applied at a broader, even **continental scale**

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NWO
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