Health status diagnosis of chestnut forest stands using Sentinel-2 images

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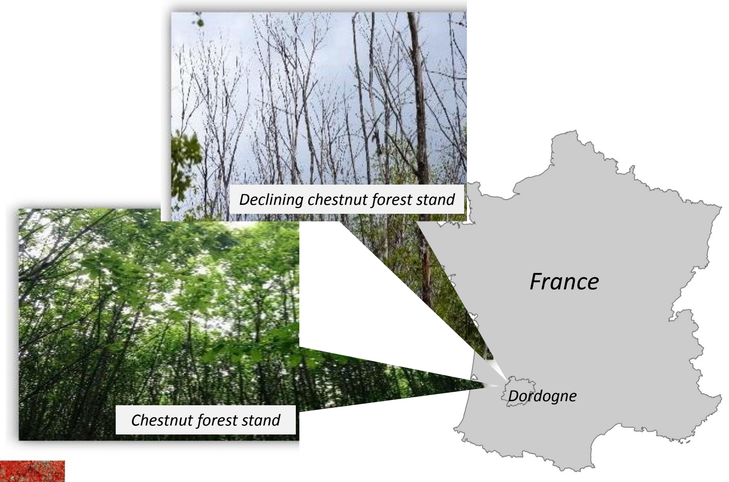
Context - Objectives

Health status diagnosis of chestnut forest stands is a crucial concern for forest managers. These stands are made vulnerable by numerous diseases and sometimes unadapted forestry practices. Moreover, since last years, they were submitted to several droughts. In Dordogne province (France), the economic stakes are important. For example, about 2/3 of the chestnut forest area are below the optimal production level, and most of this area shows forest stands with a high proportion of dry branches. The actual extent of chestnut forest decline remains still unknown. Sentinel-2 time series show an interesting potential to map declining stands over a wide area and to monitor their evolutions. This study aim to propose a method to discriminate healthy chestnut forest stands from the declining ones with several levels of withering intensity over the whole Dordogne province.



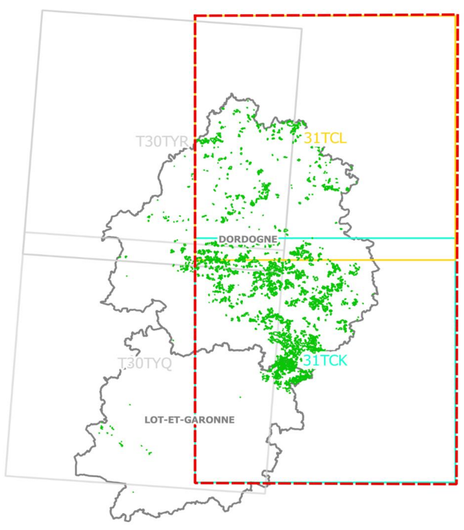
Data

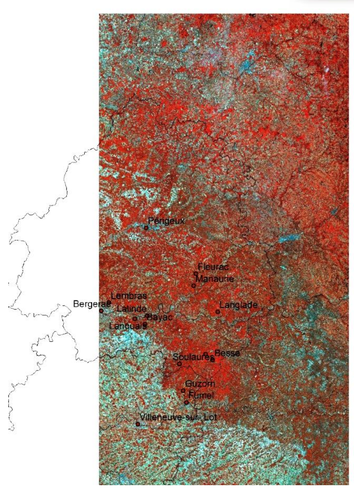
In this study, Sentinel-2 images (10 bands at 10 and 20 m spatial resolution) acquired during the growing season of 2016 have been processed. Due to insufficient data quality related to atmospheric conditions, only 2 cloud-free images could be analyzed (one in July and one in September).

2 dates images

- *30/07/2016*
- *28/09/2016*

Remark : Image to image registration shows up to 1.5 pixel error

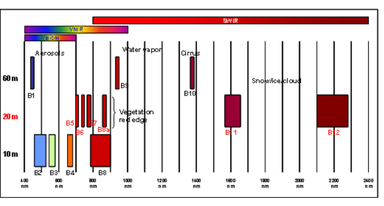




Method

The proposed method is the development of a statistical model integrating in a parsimonious manner several vegetation indices and biophysical parameters.
The statistical approach is based on an ordered polytomous regression to which are applied various technics of models' selection *(A. Agresti, 2003)*.

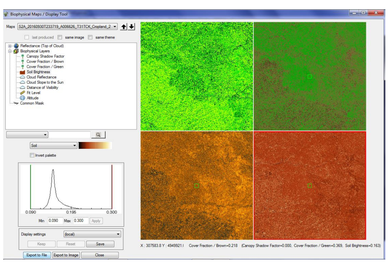
1- Remote sensing variables : About 36 vegetation indices were calculated from THEIA-MAJA L2A products and 5 biophysical parameters were processed from ESA level 1C product. These last parameters have been obtained with the Overland software (developed by Airbus DS Geo-Intelligence) by inverting a canopy reflectance model. This software couples the PROSPECT leaf model and the scattering by arbitrary inclined leaves (SAIL) canopy model.



SENTINEL-2 spectral bands (ESA)

Remote sensing variables

- 10 spectral bands (resampled at 10m spatial resolution)
  - B2, B3, B4, B5, B6, B7, B8, B8a, B11 et B12
- 36 vegetation indices
  - NDVI, EVI, NDII, $NDVI_{RedEdge}$, MCARI, DVI, Clgreen, CRI2, NBR, PSRI ….



Software Overland (Airbus DS)

- 5 Biophysical parameters
  - Blcv : Cover fraction of brown vegetation
  - Glcv : Cover fraction of green vegetation
  - Fapar : Fraction of Absorbed Photosynthetically Active Radiation
  - Glai : Gren Leaf Area Index
  - Wat : Leaf water content

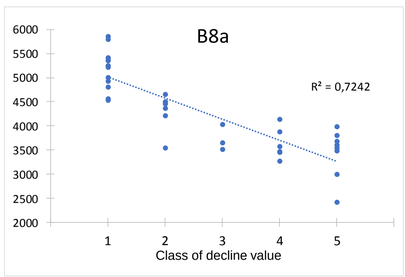
Decline value of forest plots

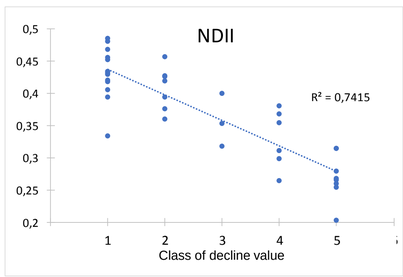
Chestnut forest health status (decline %)	*Class of decline value (5 levels)*	*Class of decline value (3 levels)*
0-10%	1	1
10%-30%	2	2
30%-50%	3	
50%-80%	4	3
80%-100%	5	

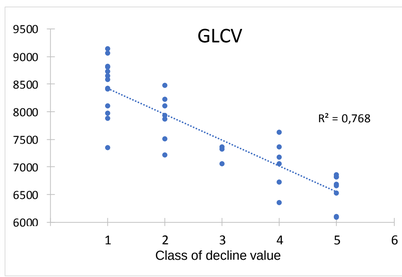
Plots area for expert Knowledge observations

Plots area for ARCHI observations (30 trees in 4 pixels)

Examples of significant correlations between remote sensing variables and class of decline value







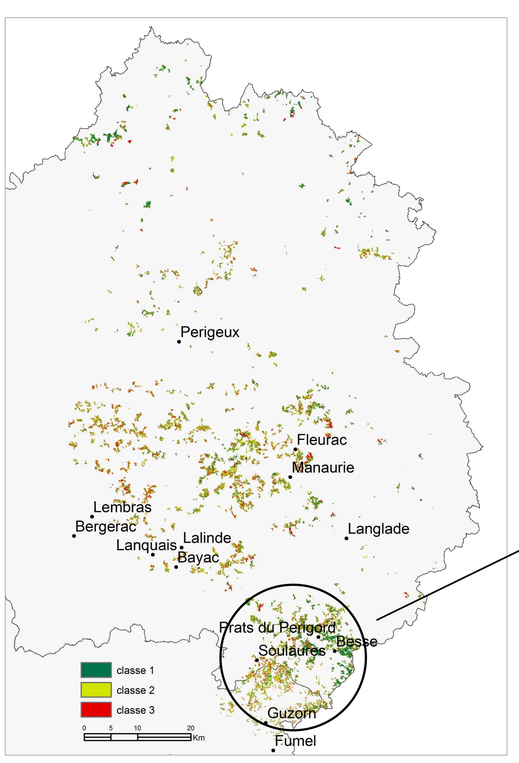
Results

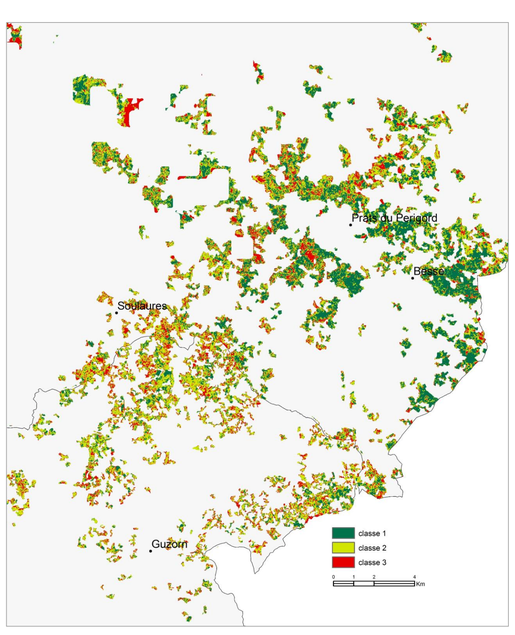
1- The best remote sensing variables according to AIC and cross validation :
- Vegetation Red Edge and NIR spectral bands : B8a, B7, B6, B8,
- Vegetation indices : NDII *(B8-B11/B8+B11)*, NDVIre2n *(B8a-B6/B8a+B6)*, DVI *(b7-b3)*, IRECI *((b6 – b3)*b5/b4),* NBR *(B8-B12/B8+B12)…*
- Biophysical parameters : GLAI and GLCV.

2- About 24 selected models using for 2 to 5 variables, and using single date images (July and Sept) or both combined

3- Maps from the 12 best models :
- Linear prediction maps,
- Maps of probability of belonging to a class of decline value,
- Expected classification maps.

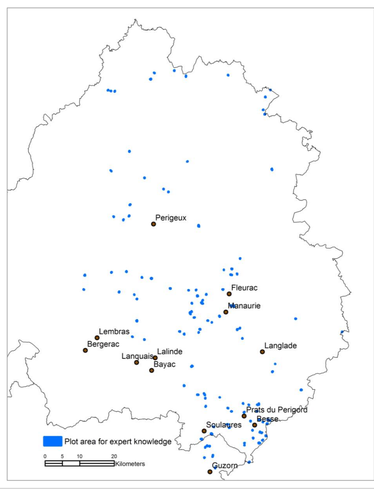
Example : linear prediction map





In progress :
- **Spatial analyses** of the 24 selected models

In progress :
- **Validation** of the selected models with additional plots of expert knowledge observations (spring 2018)



This study is funded by the network "Adaptation des forêts au Changement climatique" (AFORCE)