REVISION 1 - Anonymous Referee

Dear revisor, thank you for your valuable revision and insightful comments. We have carefully considered your feedback and tried our best to address each point accordingly.

On behalf of the authors,

Lorena Baglioni

This manuscript presents an ambitious and methodologically rich study on the upward dynamics of forestlines in Italian mountain ranges, using a 40-year Landsat time series and robust trend detection techniques. The authors propose a semi-automated workflow for delineating the uppermost forestlines and interpreting spectral greenness and wetness trends across canopy classes and topographic gradients.

The paper offers valuable insights into large-scale forest recolonisation processes and is grounded in a solid conceptual framework. However, a key aim listed in the abstract is the mapping of the current position of the uppermost Italian forestlines. This core claim is not supported by any form of spatial validation or uncertainty assessment. While statistical comparisons (e.g. Wilcoxon tests, GAMs) are used effectively to interpret spectral trend variability, they do not establish the accuracy or ecological credibility of the detected forestlines themselves. Given the reliance on an automated method to infer a critical ecological boundary, this omission undermines confidence in one of the study's central contributions.

The manuscript is generally well written, although there are scattered typographic and formatting issues. Figures would benefit from improved labelling and clarity, particularly in terms of geographical referencing and scalebar readability.

I recommend major revisions to address the validation gap and improve clarity for an international audience.

Specific Comments

- ***Forestline validation missing**: A core objective stated in the abstract is to "map the current position of the uppermost Italian forestlines." However, there is no spatial accuracy assessment of these delineated lines. The method's reliability is only indirectly supported through descriptive summaries (e.g. mean elevation), but not through comparison with independent references. I strongly recommend including a validation step - this could involve:*
  - *Visual comparison with high-resolution imagery or historical orthophotos,*
  - *Use of GEDI canopy height profiles,*
  - *Manual digitisation for a subset of sites,*
  - *Field plot data where available.*

  Including even a partial validation would significantly strengthen the credibility of the forestline mapping method.

Thank you for your suggestion, but a visual comparison with high-resolution imagery or historical orthophotos and a manual digitisation for a subset of sites would be subjective and time-consuming validations, limiting the replicability and automaticity of the method. Using field plot data is also not applicable to our scale of analysis, as the data collected may not refer to the same year of the Tree Cover Density (TCD) product and may relate to the position of the treeline and not of the closed forest limit (we considered TCD >10%). GEDI canopy height profiles has a worse spatial resolution (30 m) than the TCD (10 m) and therefore it is an unsuitable validating dataset.

We did not include this step in our research because, as we pointed out in the abstract and in the introduction, we aimed to develop an automated methodology for mapping the current position of the uppermost Italian forestlines, replicable in other geographic contexts. For this reason, we decided to use the TCD that is an official and validated large-scale forest cover map.

Referring to the TCD, we added in the manuscript (line 129) "*with a minimum thematic target producer and user accuracies of 90 % (EEA, 2025)*", as reported in the Product User Manual of the Copernicus Land Monitoring Service of the European Environment Agency (EEA).

In addition, we mapped only a subset of the whole forestlines, considering only those at the highest elevation according to a statistical criterion based on the 1st percentile of all the vertical distances. With manual verification or field data, we couldn't validate the relative elevation of each forestline into its GMBA mountain group limit.

For this reason, we underlined the importance of the input data quality on which the automated detection process is based. However, it must be considered that the first aim of the analysis is functional to the spectral analysis that is carried out in a buffer zone.

Nonetheless, thanks to your comment we had the chance to clarify this issue in the manuscript.

- ***Use of Landsat over Sentinel-2*** *(ll. 151–155): The authors should clearly justify the exclusive use of Landsat imagery, given that Sentinel-2 offers higher spatial resolution and comparable temporal coverage (since 2018). If the decision is based on the 40-year archive or data processing/infrastructure concerns, this should be explicitly stated.*

  Thank you for your suggestion. As you correctly reported, the decision is based on the longer time span covered by Landsat. At the lines 153 – 158, we modified the text as follow:

  "*Sentinel-2 provide images with higher spatial resolution (10 m) but a shorter time span (since 2018) than Landsat. Infact, Landsat images supply multispectral information at medium resolution (30 m pixel size) since 1984 and are commonly used in treeline studies (Arekhi et al., 2018, Bharti et al., 2012, Morley et al., 2019, Garbarino et al., 2024) as they give a good compromise between space and time resolution at regional scale (Hansson et al., 2020). We collected Landsat images acquired from June 1st to September 30th of each year in the period 1984 – 2023, to analyse forest vegetation dynamics during the growing season*"

- ***Line 60****: Remove placeholder Italian text: "Fare clic o toccare qui per immettere il testo...".*

  Amended.

- ***Lines 113–114****: The transition into peak selection is abrupt. Clarify why peaks were chosen before introducing the selection process, to improve narrative flow.*

  We modified the text as follows: "*Being the Italian forestline ecotones the targets of our study, we selected the highest peaks for each mountain group of the Alps and of the Apennines, as*

defined by the Global Mountain Biodiversity Assessment (GMBA) inventory (Snethlage et al., 2022a, 2022b).”

- ***Line 115**: Non-European readers may not be familiar with the Tinitaly DEM. Add a brief description including spatial resolution and accuracy compared to existing sources*

  We modified the text following your suggestion and describing that Tinitaly is a 10 m spatial resolution DEM obtained from the harmonisation of each regional Digital Terrain Models.

- ***Line 118**: Typo — "affetced" → "affected".*

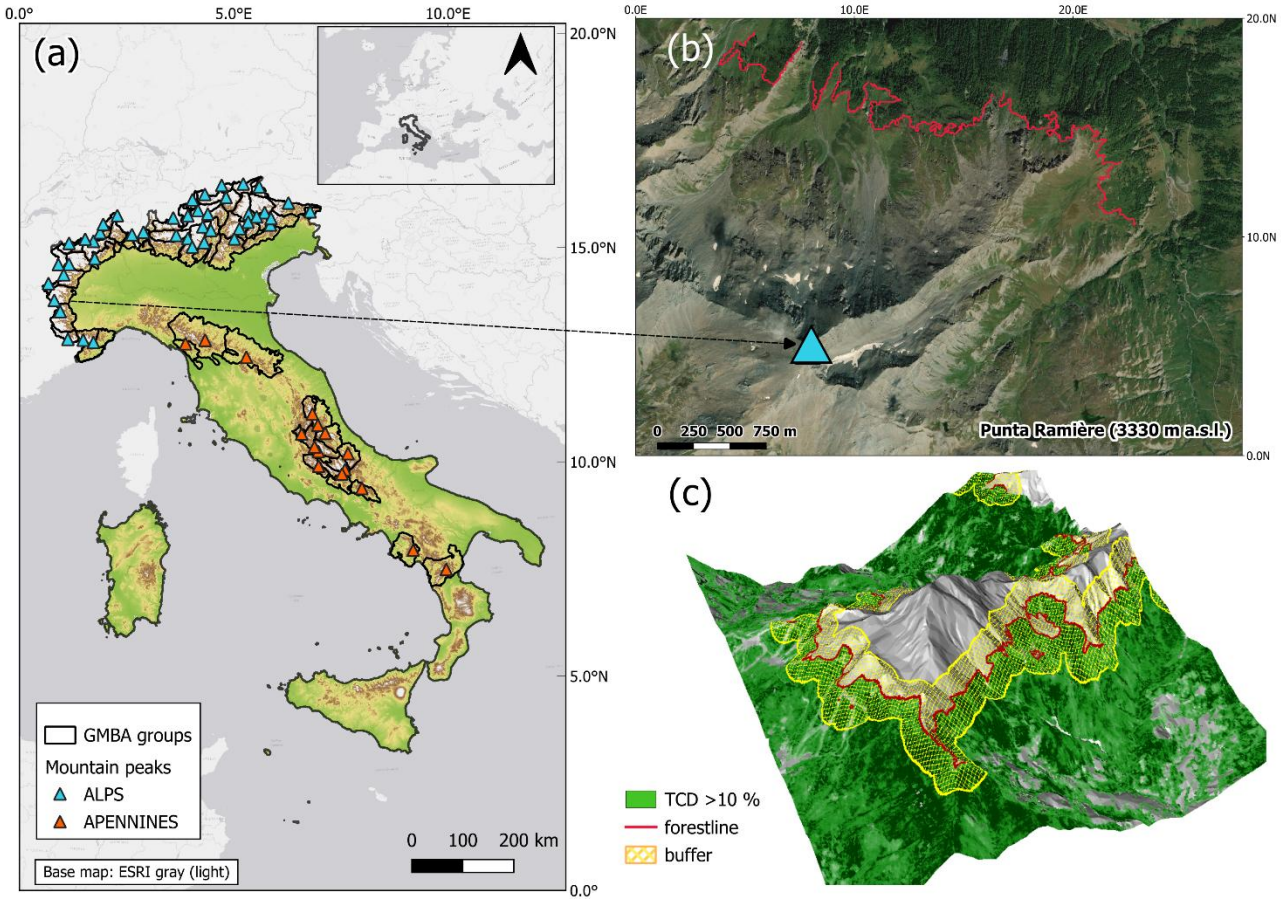
  Amended.

- ***Line 119**: Typo — "alpine bel" → "alpine belt".*

  Amended.

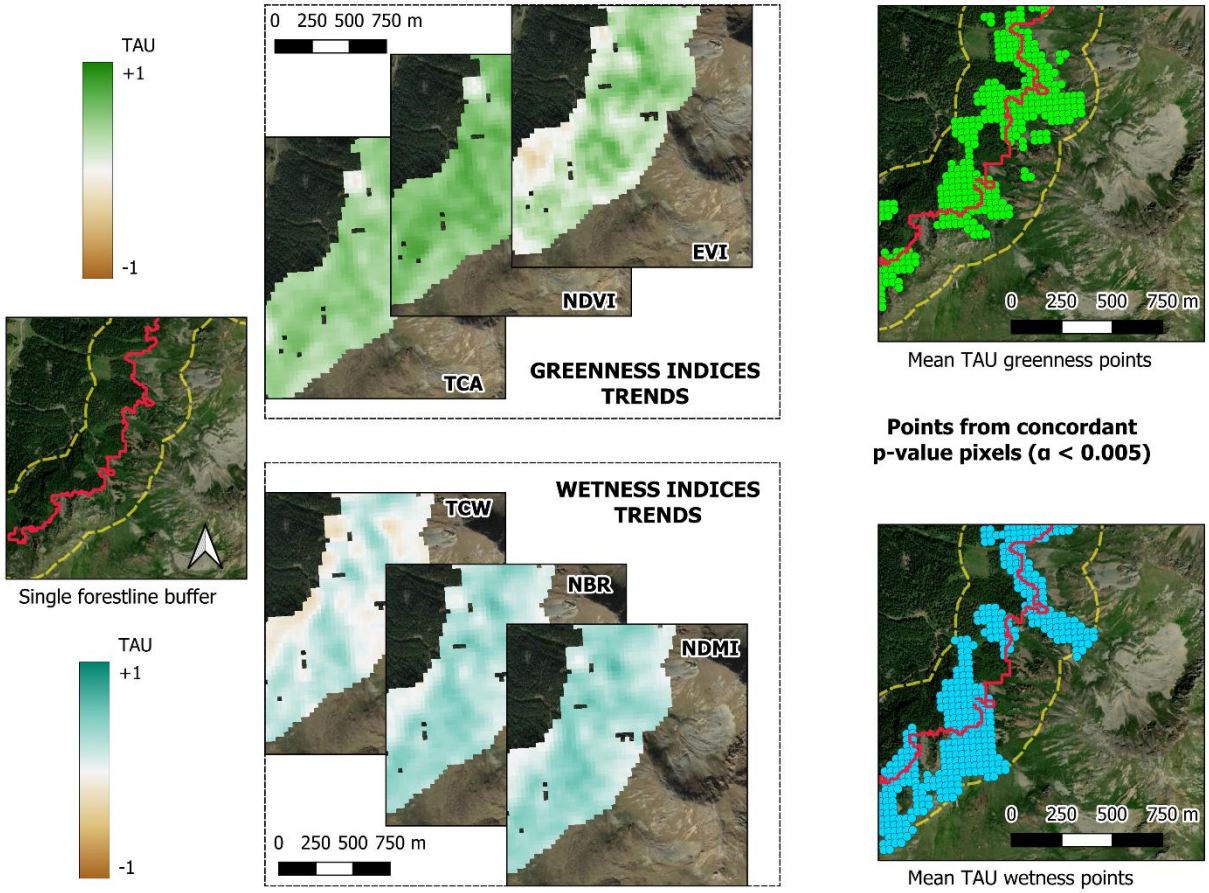
- ***Figure 1b**: Scalebar tick labels are not legible. Improve contrast and font size.*

  We modified the figure following your suggestions.



- ***Figure 2**: No need to highlight the exact location, but indicate whether the example is located in the Alps or Apennines. Add scalebar.*

  We modified the caption of the figure 2 specifying “*in the Alps*” and we added the scalebars.



- ***Figure 3****: Typo in caption header — "statistical analysis" should be corrected.*

  Amended.

Technical Corrections

- ***Typographic and formatting issues****: Address minor typos such as "affetced" (l. 118), "alpine bel" (l. 119) and inconsistent spelling of the indices (e.g. "grenness")*

  Amended.

- ***Figures****: All figures should include legible scalebars and clearer geographical context where relevant."*

  We improved all figures.