**Subject Editor (Dr. Michael Borregaard) Comments**

The package is purely geographical, and thus somewhat on the edge of what Ecography publishes, but given the widespread use of landsat data among ecologists it still seems useful. It does mean, however, that the quite complicated installation procedure becomes an issue. Very few of the readers of Ecography are likely to have rgee and google earth engine installed and have an active google earth account. They are not trivial to install, and the reviewer had multiple problems getting the install to work. These procedures should be spelt out much more clearly.

Author response:

* Add some further install instructions to GitHub and note this in the manuscript
* No matter where you want to download Landsat data, you’ll need an account.
* GEE accounts only take minutes to open and provides access to a wider variety of data

In extension of this, it is hard to see whether your lsatTS install actually works, as the running example in the paper requires 2 days to download the data! I would definitely like the example in the paper to be one that is immediately runnable, so that a reader can read the paper with a working R session next to them, and also use the example to troubleshoot that their install of the package actually works correctly. Maybe one approach is to split the data acquisition and analysis example into two bits, make

the data acquisition smaller and supply the data needed for the example within the package.

Author response: We agree the original example application was a poor choice that took too long to run and so now provide a different example application that more quickly and effectively demonstrates software functionality. The new example application focuses on long-term changes in vegetation greenness for 28 field sites where plant phenology is monitored as part of the International Tundra Experiment (ITEX; Prevey et al. 2021). Nevertheless, extracting Landsat data for these 28 field sites still takes about 10 hours when run as a single task on GEE. As suggested, to facilitate the example application, we therefore extracted these data and now include them within the package. To demonstrate data export from GEE, the example application randomly selects and exports data for three field sites, which takes about 30 minutes to complete. The revised example application more efficiently demonstrates functionality of *LandsatTS*. Lastly, we rather than delete the original example application focused on vegetation dynamics on Disko Island, we instead moved it to the Supplemental Material.

Much of the description in the paper is a point-by-point description of the functions, making this read less like an article and more like a printed manual page. It might make sense to leave the function descriptions in there, but I suggest having them a little later (maybe after the example) and focusing more on a description of the philosophy of the package, use case and workflow design. The readme of the github repository is useful and contains some good illustrations and could probably be reproduced in the supplementary materials.

Author response: We significantly restructured the manuscript to emphasize the philosophy, workflow, and use case of the package. This included fully restructuring the introduction, modifying the use case, and moving the function descriptions to end of the manuscript. This restructuring much improves the manuscript.

In general, Ecography prefers packages installable directly from CRAN. Are there strong technical reasons for not doing this?

Author response: While having written the code to a high standard and provided thorough documentation, we currently are not able to muster the further time and resources necessary to get this R package onto the CRAN. We did not originally plan to develop this package but rather did so opportunistically once it became apparent there was broader community interest in utilizing these tools. Developing this package has already taken time and resources that were considerably beyond the scope of our funded research projects. Besides resource limitations, there currently are a huge and growing number of R packages, many of which are available through GitHub. GitHub makes it possible to readily implement software changes and updates, as well as easily install the package from within R.

In general, the github repo and code is well organized and documented, with a good set of unit tests. As a small comment maybe activating continuous integration on repo pushes would secure long-term consistency of the code base.

Author response:

* Continuous integration makes sure they don’t mess up the code. Basically we’d stop working on the main branch and instead do development on a side branch that then get’s merged with the main branch.

Secondly, I do have another concern about the package that I'd like you to address. It seems that the workflow is fairly fixed (some functions are marked as "optional"), and I partly get the impression that this package, especially the analytical part, is intended for a very particular pre-determined workflow, leading to a defined set of analyses/results. It would be good to see discussed how much the package lends itself to a broader set of use cases and frameworks, and how much creativity they allow the researchers using the package.

Author response: We primarily developed this package for generating and analyzing multi-decadal time series of vegetation greenness using Landsat data and believe there is considerable interest among the ecological community in conducting similar analyses. That said, the package’s data extraction and processing tools also enable users to undertake other analyses that rely on carefully processed Landsat time series data for sample locations.

* Xcal function allows users to supply their own co-variates for cross calibration
* Drought impact monitoring, phenology
* Inventory and monitoring of local, state or provincial protected area monitoring
  + One metric of vegetation condition that complements field-based monitoring
* Facilitates comparisons among field sites (simple comparisons among sites)

In all these comments amount to quite a bit of restructuring, but I feel confident the authors should be able to meet the comments and submit a version that can eventually be accepted, so it's somewhere between a major and a minor revision.

Author response: We appreciate your feedback and have revised and restructured the manuscript as recommended.

As two small comments that I just mention for consideration:

1. would it be easier if the package was named LsatTS? This seems more consistent with the acronym

Author response: To improve clarity and discoverability, we changed the name of the package from *lsatTS* to *LandsatTS*.

2. It seems unnecessary to have all functions preceeded by `lsat\_`. Any user interested in such explicitness could always use `lsatTS::` instead.

Author response: We agree it is not entirely necessary for function names to be preceded by “lsat\_”, but conveniently groups package functions while adding little to the length of function names. Further, we already have a userbase that is using the current naming convention. Therefore, we have opted to maintain the current naming convention.

**Review 1 Comments**

The authors present a novel R package (lsatTS) that offers a range of functions for constructing, cleaning, and analyzing Landsat time series for phenology purposes. The integration with Google Earth Engine and related 3rd-party libraries (i.e., rgee) is a key feature. The authors have written a clear, well-organized overview of the package components and background rationale. There are only a few areas where I thought they could strengthen their description of their work, as described below, followed by comments regarding grammatical errors and minor edits.

Author response: We thank the reviewer for their positive, constructive feedback and have accordingly revised the manuscript and software.

The authors describe several existing R packages for processing Landsat data. However, they do not similarly review existing R packages for phenological analysis, such as “phenology”, “phenor”, and “phenofit”. Explaining how lsatTS complements those packages or provides additional functionality would highlight the novelty and utility of their effort.

Author response: We appreciate the reviewer’s suggestion and examined the packages they mentioned. The *phenology* package focuses on animal phenological count data, while *phenor* provides tools for evaluating plant phenology for set of datasets. Since the manuscript is already rather long, we chose not to review those two packages; however, we now highlight the new *phenofit* package given its particular relevance. Part of the introduction now reads:

… *LandsatTS* includes tools to estimate annual maximum vegetation greenness based on site-specific phenological modeling that iteratively fits flexible cubic splines to vegetation greenness time series. Users interested in other aspects of vegetation phenology could extract and process Landsat data using *LandsatTS*, but then capitalize on tools provided by other R packages. For instance, the new *phenofit* package provides state-of-the-art tools for fitting phenological models that can be used to estimate metrics such as the timing of spring onset and fall senescence (Kong et al. 2022). More broadly, while *LandsatTS* provides tools focused on generating high-quality vegetation greenness times series, it also enables users to undertake other analyses that rely on cleaned and cross-calibrated Landsat data.

I think the random forest cross-calibration option is intriguing but a little puzzling. What is the benefit of the site-specific process over applying fixed band/index transformations (e.g., those in Roy et al. 2016)? If users do not have enough samples to train random forest models, the authors already provide the option of pre-processed data, which seems like a similar approach. Can the authors make some statement about the advisability of performing the RF step?

Author response:

* The cross-calibration function that we present
* Roy et al. (2016)

Currently, the user is able to set a threshold deviation from the cubic spline curve for removing points (last\_fit\_phenological\_curves()). It would be helpful to have the option to specify thresholds that are distinguished by whether the point is above or below the curve, since typically a lower value is more suspect than a higher one.

Author response:

It might be prudent to present readers with a small, manageable process instead of one that takes ~2 days to export the files.

Author response: We fully agree that a smaller, more manageable example application is needed. Therefore, we developed a new example application that focuses on long-term changes in vegetation greenness at 26 field sites that are part of the International Tundra Experiment (ITEX) network. Running as a single task, it takes about 10 hours to export Landsat data for these 26 field sites; however, running the maximum of four task simultaneously would decrease export time to about 2.5 hours. We now stage this dataset (< 5 MB) within the *LandsatTS* package, so it is available for the example application. To demonstrate the data export function, we now randomly select three field sites and export data for those sites, which takes about 30 minutes. This example now effectively demonstrates the package’s functionality in a far more reasonable amount of time.

I recommend commenting out (or at least drawing attention to!) the rm(list=ls()) command in the code, and setting setwd to a generic folder (see <https://www.tidyverse.org/blog/2017/12/workflow-vs-script/>)

Author response: We appreciate the reviewer highlighting the workflow vs script distinction and have revised the scripts accordingly.

**Minor edits and typos:**

L78: Remove hyphen between “widely-used”. Not necessary in compound adjectives when the first word is an adverb that ends in -ly. Other instances throughout paper.

Author response: Fixed here and elsewhere throughout the manuscript.

L98: “…provides integrated, sample-based framework…” Insert “an” before “integrated”.

Author response: Done

L132: This is a trivial request but it would be useful for the packages to be listed alphabetically.

Author response: Done

L210: Italicize “last\_general\_prep()”

Author response: Done

L216: “Each…were”. Change to “was”.

Author response: Done

L244: The Landsat sensors are listed correctly on page 2 (L5 TM, L7 ETM+, L8 OLI), but here L7 and L8 are

incorrectly referred to as ETM and ETM+, respectively. See also L248, Table 3.

Author response: Fixed

L278, 280: “moving-windows” incorrectly hyphenated here.

Author response: Fixed

L298: Change “(4) and” to “and (4)”

Author response: Done

L311: Missing period at end of sentence.

Author response: Done

L340: “The function extracts site x years with at least…” I’m unclear whether “site x years” is something I’m misinterpreting (x years of data at a site?) or if it’s a typo. Either way, the meaning could be clearer.

Author response: That is the correct interpretation, but to improve clarity, we modified the sentence to now read, “For each site, the function extracts years with at least the user-specified number of growing season observations…”

L354: “remove” -> “removes”

Author response: Done

L383: “was” -> “were” (Landsat data)

Author response: Done

L402: “…observations in the between…” Remove “in the”.

Author response: Done

L488: Italicize “last”

Author response: Done

L544: “…where there were temporally overlaps measurements from pairs Landsat satellites”. Couple of typos in there.

Author response: Corrected to, “… where there were temporally overlapping measurements from pairs of Landsat satellites.”

L566: “estimate” -> “estimates”

Author response: Done

L573: “…prior TO the turn…”

Author response: Done

L610: “dried” -> “drier”

Author response: Done

L611: “with defoliation” -> “to defoliation”

Author response: Done

Figure 1: Is there any significance to the fact that only some functions are italicized?

Author response: No, that was an accident. For the figure, we remove italics from all text.

Figure 2: (b) appears to show the location of Disko Island rather than the study area per se. A different color scheme for the positive NDVImax values might provide more contrast to the green background of the image.

Author response: This figure no longer appears in the manuscript because we now use a different example application.

Figure 4: Remove decimal from right-hand column “count” legend

Author response: Done.

Figure 5:

- Mention the time frame of the example in the caption.

Author response: Done. We now mention observations were made between 1985 and 2021.

- It’s unclear whether the Observation (pts) and Curve legends are supposed to match temporally; the color ramps are identical, but the years are clearly at unequal spacing. Is the reader meant to visually match the color of the points with a similarly colored curve? Otherwise I’m not sure I understand the point of the color-coding.

Author response:

- I’m a little confused about some of the curve fitting. In samples like pixel \_1838 (top row, middle column) many of the lower-NDVI pre-200 DOY points appear to be ignored, while curves are seemingly well-matched to the higher-NDVI points. Is there a weighting function in the curve-fitting routine that promotes points with higher NDVI?

Author response:

- There seems to be quite a lot of low-NDVI points, which makes me wonder about the noise reduction function in the library.

Author response:

- Overall, I find this figure hard to follow. Personally, I think I would prefer to see a sequence of years with individual phenology curves rather than the kind of consolidated representation shown here. This opinion is not a request to revise the approach! But it would be helpful for the authors to explain their justification for the 11-year aggregation of data.

Author response:

Figure 7: Mention the number of sample locations. Please specify what “grouped by the concomitant temporal trends” means. Were the annual data for all sample locations with a particular trend (browning/greening/no-change) averaged?

Author response: