Revision Report

NTS: An R Package for Nonlinear Time Series Analysis

Response to the Editor

We thank you for your encouragement and comments. We have made a significant effort in this revision to address all comments and concerns raised by the referees. We thank them for their insightful suggestions, which led to significant improvements of the paper. We hope that you will find the revision satisfactory.

Response to the comments of Reviewer #1

We appreciate your insightful comments and advice, which help us to make significant improvement of the paper. In the following we report in detail our revision in response to your feedback.

- **Overview:** The article presents methods for non linear time series analysis. In particular, the authors provide formulations of the following models:
  - Threshold Autoregressive models.
  - Autoregressive conditional mean models.
  - Functional time series models.
  - The sequential Monte Carlo algorithm.

  Responses: Thanks for the comment. This is a very accurate summary of our paper.

- **Overview:** *This is an interesting package for the R the community. In particular, for those who work on time series analysis and prediction. Although the article handles nonlinear time series analysis, the term "nonlinear time series analysis" is very large, and the package focus only on just a part of it, as there are many modern nonlinear models that are not presented, e.g. model based on information theory and artificial neural networks, and many others.*

  Responses: Thanks for your valuable comment. There are indeed several R packages focusing on nonlinear time series. The **nonlinearTseries** package implements the methods based on information theory, the **NlinTS** package introduces functions for neural networks, and the **nlts** package emphasizes nonparametric autoregression and tests. **NTS** offers various computational tools with a wide range of applications, and it fills the gaps left by the existing R packages. **NTS**, providing computational tools for threshold autoregressive (TAR) models, autoregressive conditional mean models, convolutional functional autoregressive (CFAR) models, and non-Gaussian and nonlinear state-space models, consists of some of the missing pieces in the current coverage, hence making a more completed toolkit for nonlinear time series analysis in R. Other well-known modern methods for nonlinear data such as smoothing, deep learning and random forest that have been implemented in packages **sm**, **tree** and **randomForest** can be adopted for nonlinear time series analysis, even though they are mainly designed for independent data. Hence, they are not included in **NTS**. We wrote the above sentences in the second paragraph on page 1, explaining why these models are not incorporated in the package.

  We also added the following sentence in the first paragraph on page 1 in the revision:
  While **NTS** package does not intend to be comprehensive, it fills the important missing parts

of the existing packages, providing users valuable tools for analyzing dependent data with nonlinear dynamics.

In the abstract of this revision, we also emphasize that "The package fills the gaps of several outstanding R packages for nonlinear time series analysis."

- **Article:** *The article is well presented, and the mathematical background and the examples are sufficient.*

  Responses: Thanks for the comment.

- **Article:** *Authors should specify if the implemented functions have been already implemented in other R packages. In this case, it is recommended to make comparison showing if there are improvements of methods of NTS package compared to existing methods. For example, a discussion can be made with existing R packages concerning the following models:*
  Bayesian Modeling of Autoregressive Threshold Time Series Models (TAR Package)
  Sequential Monte Carlo (SMC) Algorithm (SMC Package)

  Responses: Thanks for your advise. We compare the existing R packages with ours in the second paragraph on page 1 in the revision. **NTS** allows the threshold variable in the model to be a lag variable or an exogenous variable, while the **TAR** package, using Markov Chain Monte Carlo and Bayesian methods aiming to deal with missing values, assumes that the threshold variable is exogenous. **NTS** provides easy access to sequential Monte Carlo methods with various options for statistical inference. It contains different R functions which can be easily implemented for filtering and smoothing and are much more user-friendly, while the **SMC** package only writes a generic function and requires more effort from users. Table 1 shows a list of comparisons between our package and others presented in the second paragraph on page 1[1]. The difference between **NTS** and others is also emphasized in corresponding sections in the revision, such as in the last paragraph on page 10 and in the paragraph above Table 3 on page 12.

- **Package:** *In terms of the package implementation, all the functions are written in one file. Therefore, it is very hard to see the code of all functions easily. Maybe it is better to regroup the functions by categories in multiple files to help the reader.*

  Responses: Thanks for your suggestion. We regroup the functions by models. The functions are written in four files, TAR.r, ACMx.r, CFAR.r, and SMC.r.

[1] In the older version of our manuscript, we also compared **NTS** with package **TSA**. However, **TSA** is not available in the latest R, so we do not discuss it in this revision.

Table 1: Comparisons Between **NTS** and Other Related Packages

Models/methods	**NTS**	Other packages
TAR model setting	Threshold variable can be a lag variable or an exogenous variable	**TAR**: Use the Markov Chain Monte Carlo and Bayesian approaches and assume that threshold variable is exogenous
TAR model estimation	More computational efficient	**tsDyn**: Taking longer time
TAR model tests	Specifically designed for self-exciting TAR models	**nonlinearTseries**: General nonlinearity tests
TAR model comparison	Out-of-sample forecast	**tsDyn**: AIC
ACMx model	Conditional distribution can be Poisson, double Poisson, and negative binomial	**tscount**: Conditional distribution can only be Poisson and negative binomiał
Functional time series	Irregular observation locations	**ftsa**: regular observation locations only
Sequential Monte Carlo	Various functions for filtering and smoothing, more user-friendly	**SMC**: One generic function and requiring more effort

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Response to the comments of Reviewer #2

We appreciate your insightful comments and suggestions which help us to make significant improvement of the paper. In the following we report in detail our revision in response to your comments.

- *The package provides capabilities for fitting some nonlinear time series models, which contributes to the field of applied nonlinear time series. On the other hand, the implementation and design of the package are not elegant, and the description of the methods are at times uneven.*

  Responses: Thanks for your valuable comment. We have revised our paper and package based on your specific suggestions accordingly, and the point-by-point response to your comments is written below.

- *The article introduces NTS, an R package on nonlinear time series analysis. The NTS package contains capabilities for estimation and prediction for several time series models including the univariate and multivariate threshold autoregressive models, the ACM for modeling time series of counts, convolutional functional autoregressive models and state-space models. These capabilities will be helpful for applied statisticians and scientists interested in fitting these four types of nonlinear time series models. However, the package does not seem to contain functions for model diagnostics.*

  Responses: Thank you for the important comment. The model diagnostics for nonlinear time series analysis can be conducted by residual analysis, which is similar to linear time series. Therefore, it is not discussed in the paper. In fact, several of the commands in NTS return standardized residuals, which can be used to perform model checking in R such as applying the Ljung-Box statistics to check residual serial correlation. If you think necessary, we could add more R functions for diagnostics, including some parametric bootstrap methods for model checking as in Tsay (1992, *Applied Statistics*, 41, 1-15).

- *The four nonlinear time series topics seem to be disjoint. The authors may want to explain why they focus on these topics in their package.*

  Responses: Thank you for the valuable suggestion. We added the following to the second paragraph on page 1 in the revision:

  NTS offers various computational tools with a wide range of applications, and it fills the gaps left by the existing R functions. There are several R packages focusing on nonlinear time series. The **nonlinearTseries** package implements the methods based on information theory, the **NlinTS** package introduces functions for neural networks, and the **nlts** package

emphasizes nonparametric autoregression and tests. **NTS**, providing computational tools for threshold autoregressive (TAR) models, autoregressive conditional mean models, convolutional functional autoregressive (CFAR) models, and non-Gaussian state-space models, consists of some of the missing pieces in the current coverage, hence making a more completed toolkit for nonlinear time series analysis in R. Other well-known modern methods for nonlinear data such as smoothing, deep learning and random forest that have been implemented in packages **sm**, **tree** and **randomForest** can be adopted for nonlinear time series analysis, even though they are mainly designed for independent data. Hence, they are not included in this package.

We also added the following sentence in the first paragraph on page 1 in the revision:
While **NTS** package does not intend to be comprehensive, it fills the important missing parts of the existing packages, providing users valuable tools for analyzing dependent data with nonlinear dynamics.

In the abstract of this revision, we emphasize that "The package fills the gaps of several outstanding R packages for nonlinear time series analysis."

- *The paper used simulated data for illustration. The example in the section on state-space modeling is the simplest signal plus noise model, which can be fitted by much more simpler methods. Some more interesting examples will better illustrate the needs of the sequential Monte Carlo approach for fitting the state-space models.*

  Responses: Thank you for the valuable comment. A more complicated example about bearing-only tracking problem which is highly nonlinear is used in the last paragraph on page 12 in the revision.

- *The package contains two separate R functions that implement two different approaches other than the method of least squares for fitting a SETAR model. A more elegant way is to have a single function that implements the different fitting methods. There is then no need to reproduce the R codes for executing the two R functions fitting the same simulated data. By the way, the outputs from these two R functions are of different formats, which should not be the case.*

  Responses: Thank you for the wonderful suggestion. In the new version, there is only one R function "uTAR" with an option "method". "method" could be "RLS"(recursive lease squares) or "NeSS"(nested sub-sample search). The default method is least squares. The outputs have the same format.