RITS: A Toolbox for Assessing Complex Interventions via Interrupted Time Series Models

Maricela Francis Cruz (maricelafcruz55@gmail.com)
Kaiser Permanente Washington Health Research Institute https://orcid.org/0000-0003-1644-9913

Marco A. Pinto-Orellana
Metropolitan Oslo University

Daniel L. Gillen
University of California Irvine

Hernando Ombao
King Abdullah University of Science and Technology

Software

Keywords: change-point detection, complex interventions, interrupted time series, policy interventions, segmented regression, toolbox

Posted Date: March 22nd, 2021

DOI: https://doi.org/10.21203/rs.3.rs-322376/v1

Version of Record: A version of this preprint was published at BMC Medical Research Methodology on July 8th, 2021. See the published version at https://doi.org/10.1186/s12874-021-01322-w.

Abstract

Background: Various interacting and interdependent components comprise complex interventions. These components create difficulty in assessing the true impact of interventions designed to improve patient-centered outcomes. Interrupted time series (ITS) designs borrow from case-crossover designs and serve as quasi-experimental methodology able to retrospectively assess the impact of an intervention while accounting for temporal correlation. While ITS designs are aptly situated for studying the impacts of large-scale public health policies, existing ITS software implement rigid ITS methodology that often assume the pre- and post-intervention phases are fully differentiated (by a known change-point or set of time points) and do not allow for changes in both the mean functions and correlation structure.

Results: This article describes the Robust Interrupted Time Series (RITS) toolbox, a stand-alone user-friendly application researchers can use to implement flexible ITS models that estimate the lagged effect of an intervention on an outcome, level and trend changes, and post-intervention changes in the correlation structure, for single and multiple ITS. The RITS toolbox incorporates a formal test for the existence of a change in the outcome and estimates a change-point over a set of possible change-points defined by the researcher. In settings with multiple ITS, RITS provides a global over-all units change-point and allows for unit-specific changes in the mean functions and correlation structures.

Conclusions: The RITS toolbox is the first piece of software that allows researchers to use flexible ITS models that test for the existence of a change-point, estimate the change-point (if estimation is desired), and allow for changes in both the mean functions and correlation structures at the change point. RITS does not require any knowledge of a statistical (or otherwise) programming language, is freely available to the community, and may be downloaded and used on a local machine to ensure data protection.

Full Text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the latest manuscript can be downloaded and accessed as a PDF.

Figures

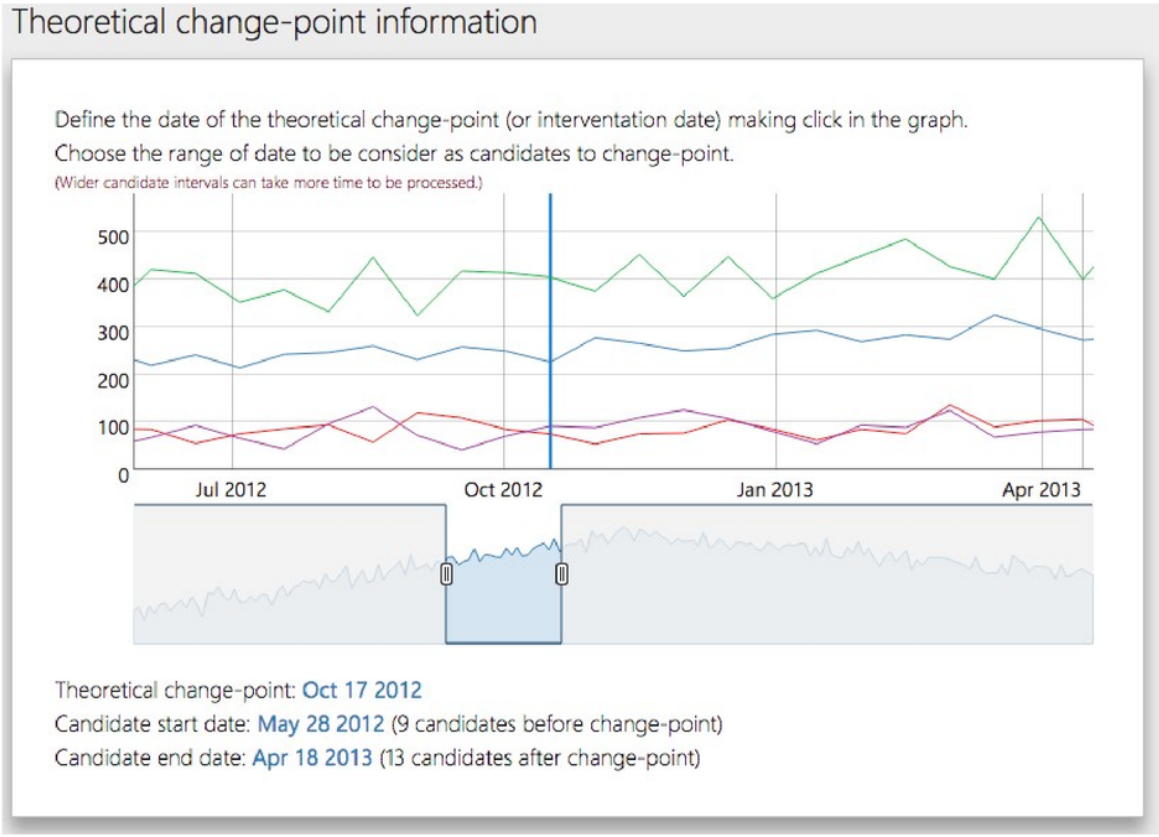


Figure 1

An example of an estimated mean function for sample data. Depicts: (1) the estimated mean function for the pre- and post-change-point phases, (2) the projection of the mean function at the change-point based on the pre-change-point regression, and (3) the change in level.

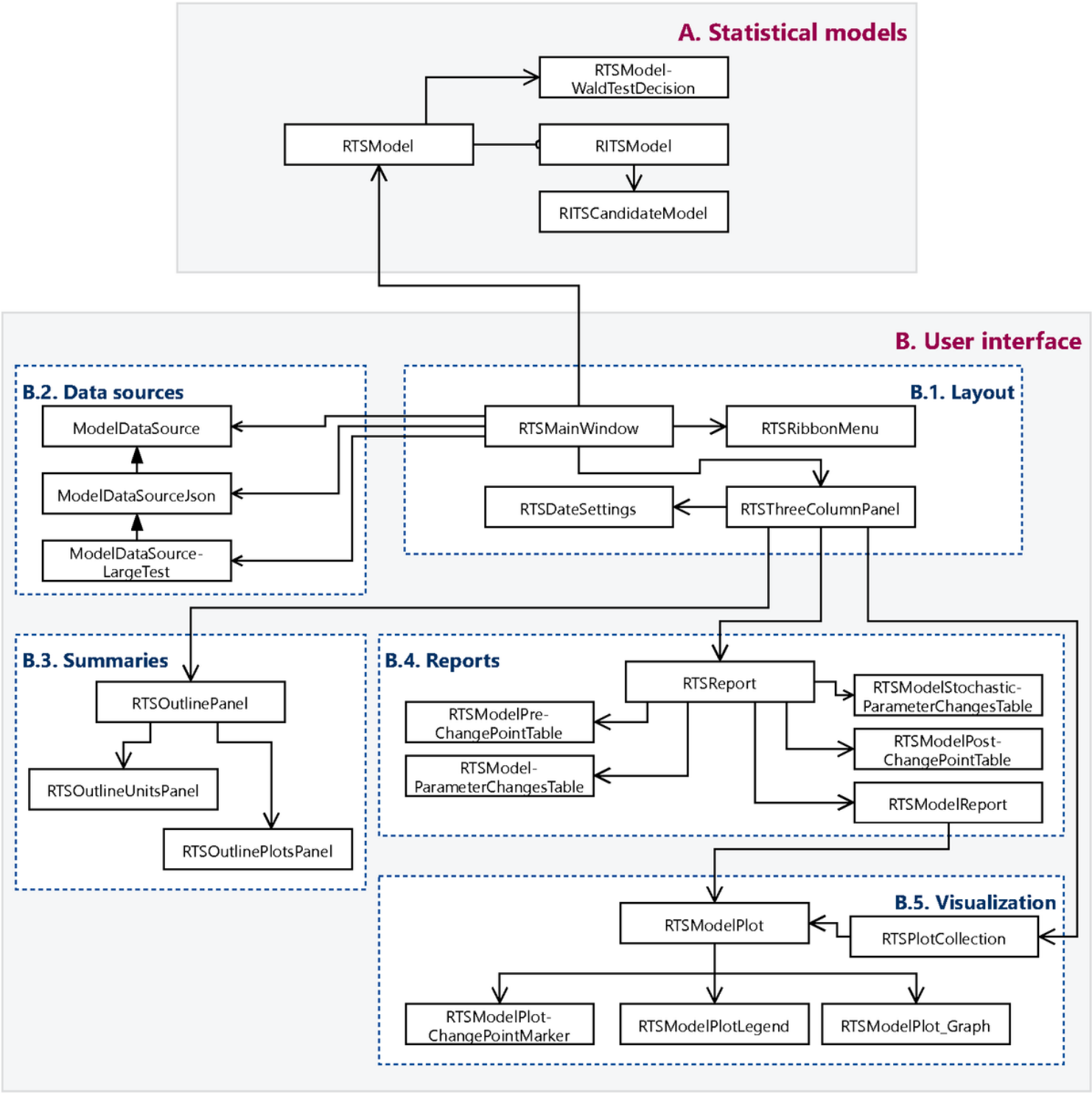


Figure 2

Abbreviated class diagram of the RITS toolbox with their respective subsystems: a) statistical model and b) user interface. Component packages part of the user interface subsystem are also marked with blue dotted boxes: b.1) layout controllers, b.2) data sources' management, b.3) summary panels' controllers, b.4) report panels' controllers, and b.5) visualization components.

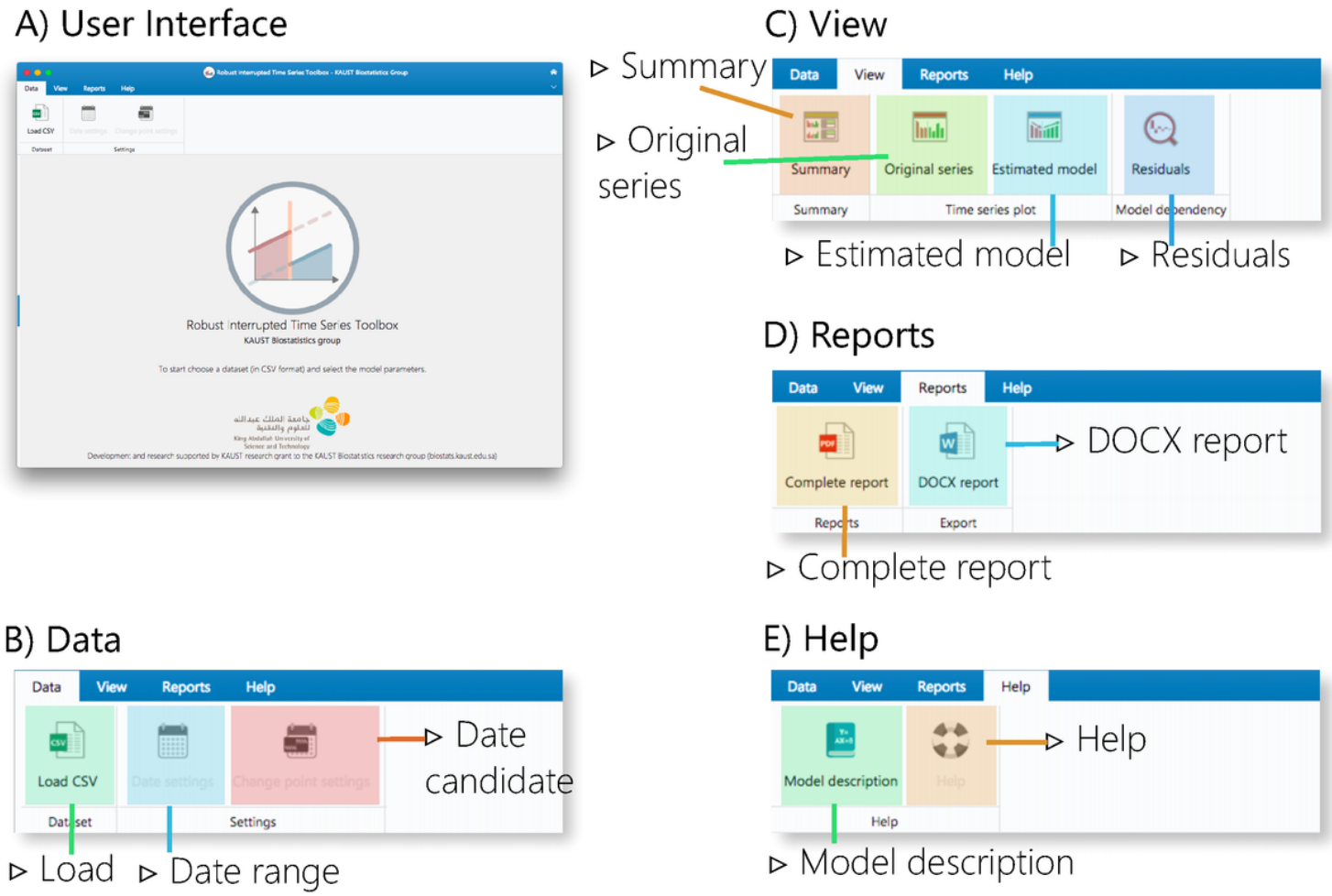


Figure 3

Overall user interface (a) of the RITS toolbox along with the menu options distributed in four main tabs: b) Data, c) Plots, d) Reports, and e) Help with their respective buttons.

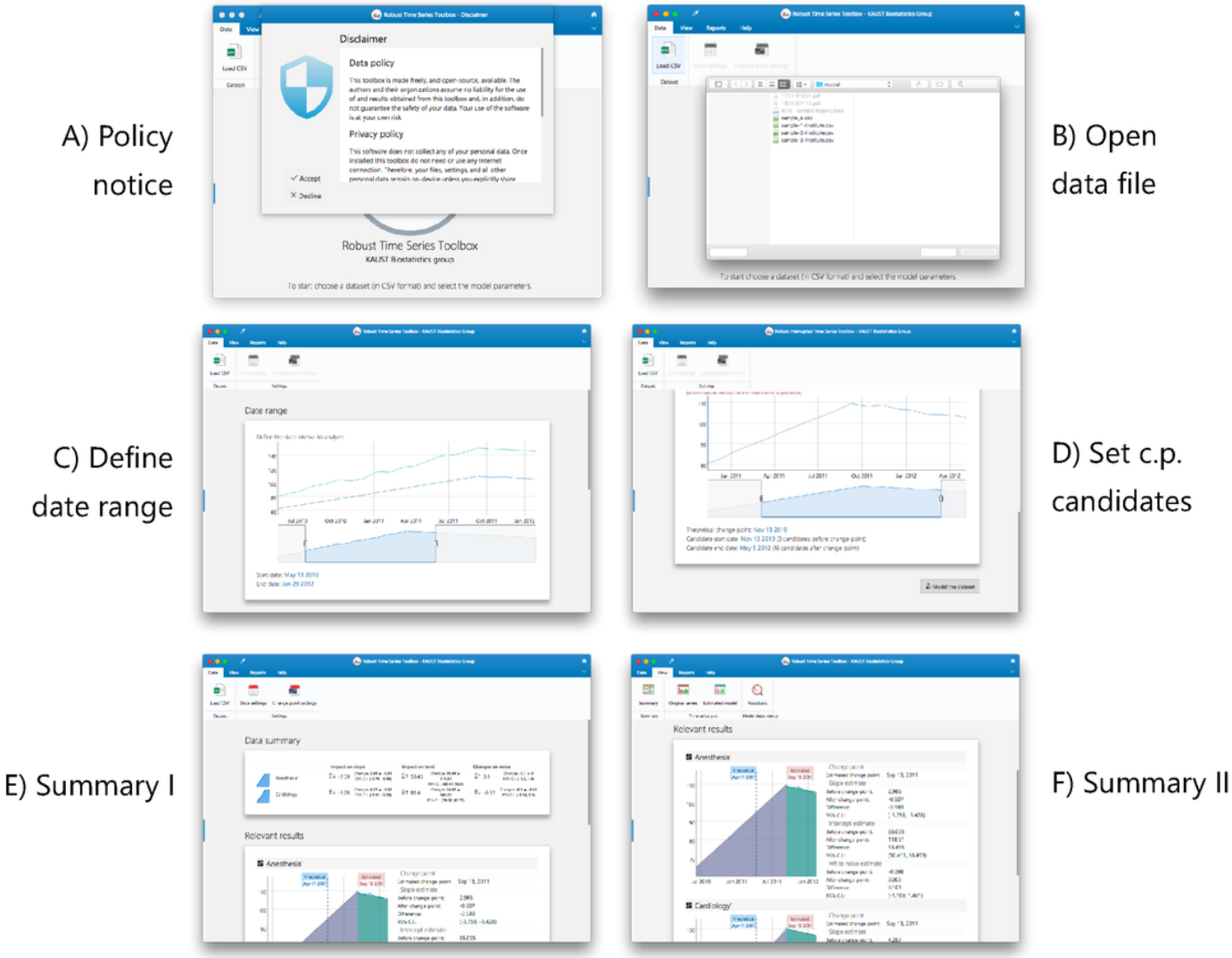


Figure 4

Screenshots of the RITS toolbox (I): A) data and security policy, B) loading open data file, C) defining time period analysis, D) setting change-point date candidates, E) data summary table, F) summary results per unit.

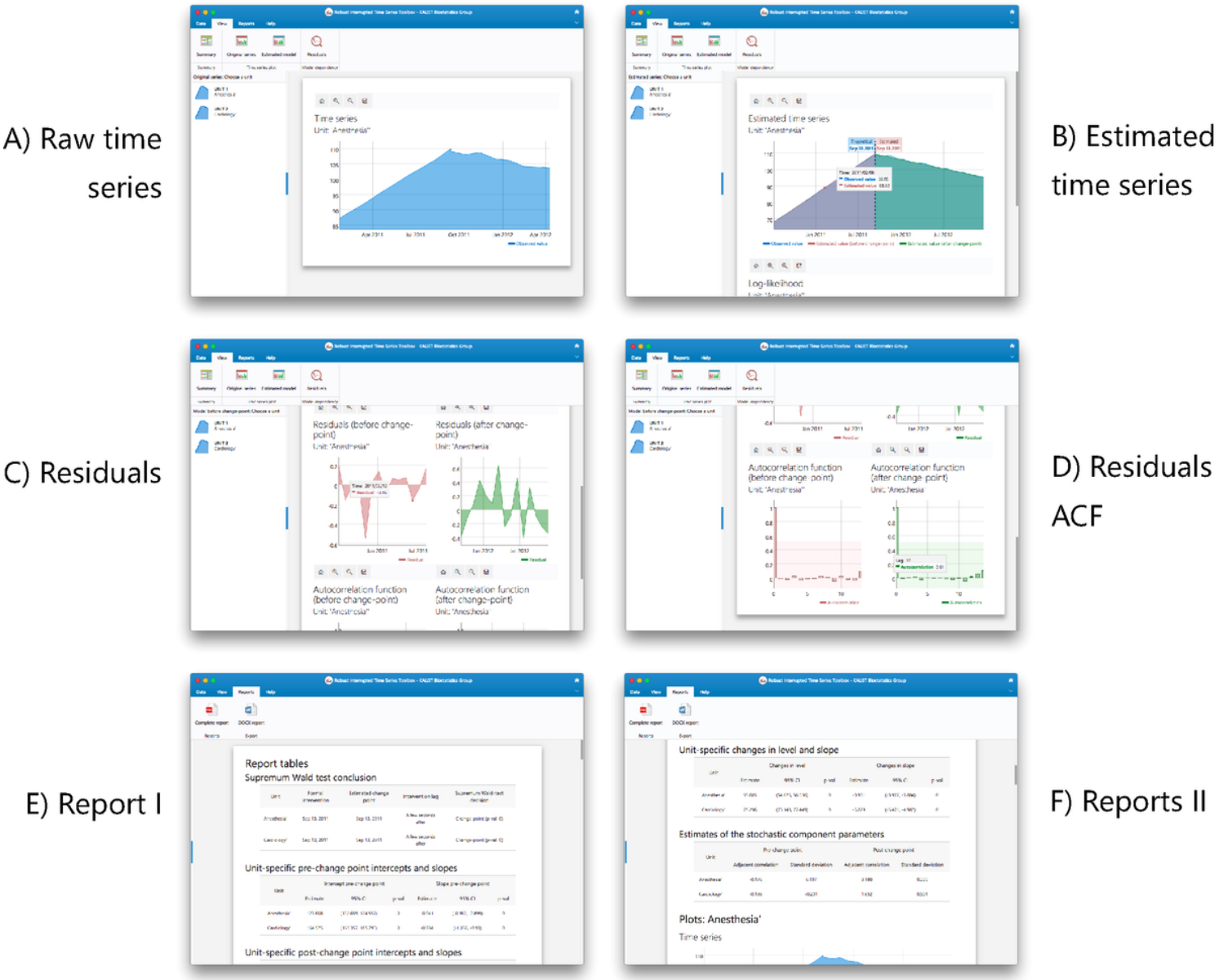


Figure 5

Screenshots of the RITS toolbox (II): A) raw time series plot, B) estimated model and change-point characteristics in the time series, C) residuals time-series, D) residuals auto-correlation function, E) reports I: supremum Wald test, F) reports II: intercept and slope changes pre- and post-change-point.

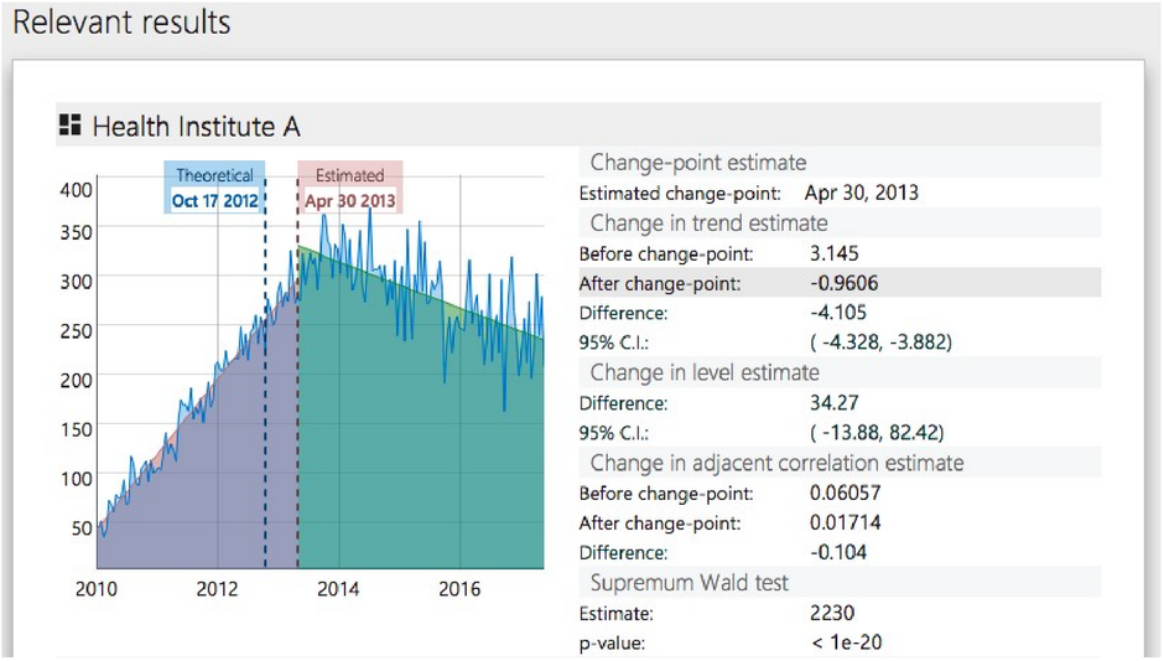


Figure 6

Plots the time series for each unit (or health institutes) and allows the user to select the time period of analyses. The first plot RITS provides.

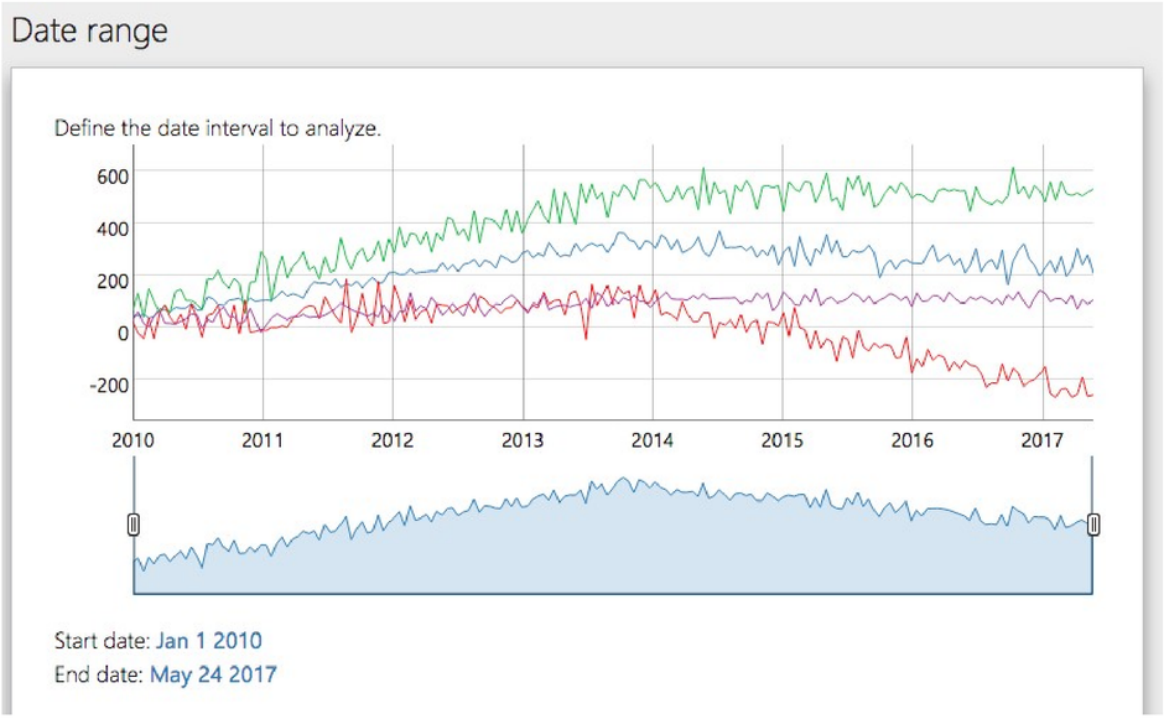
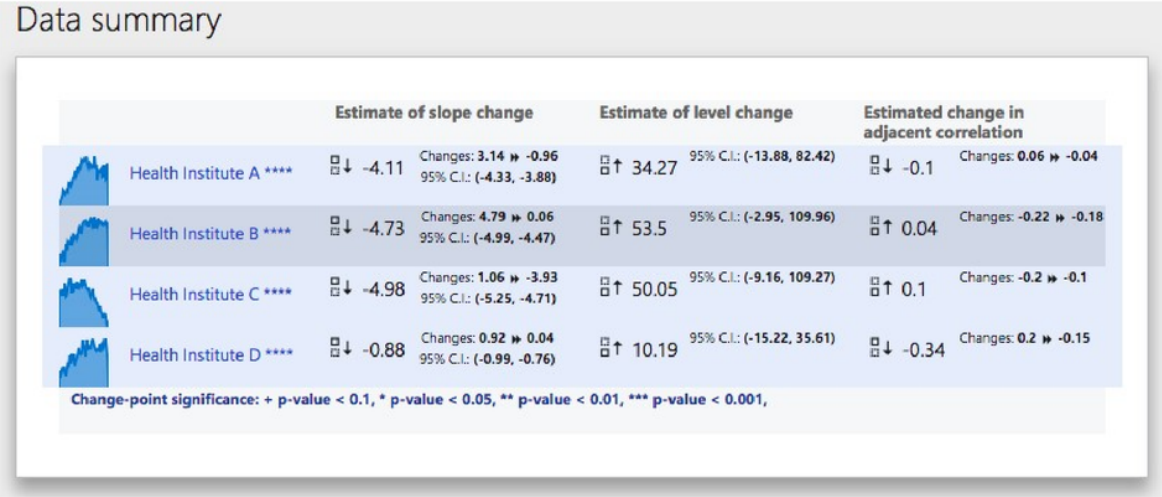


Figure 7

Plots and allows the user to select the set of possible change-points as well as the formal intervention or change-point, denoted as 'theoretical' in the plot. This is the second plot RITS produces.



Data summary

	Estimate of slope change		Estimate of level change		Estimated change in adjacent correlation	
Health Institute A ****	-4.11	Changes: **3.14 » -0.96** 95% C.I.: **(-4.33, -3.88)**	34.27	95% C.I.: **(-13.88, 82.42)**	-0.1	Changes: **0.06 » -0.04**
Health Institute B ****	-4.73	Changes: **4.79 » 0.06** 95% C.I.: **(-4.99, -4.47)**	53.5	95% C.I.: **(-2.95, 109.96)**	0.04	Changes: **-0.22 » -0.18**
Health Institute C ****	-4.98	Changes: **1.06 » -3.93** 95% C.I.: **(-5.25, -4.71)**	50.05	95% C.I.: **(-9.16, 109.27)**	0.1	Changes: **-0.2 » -0.1**
Health Institute D ****	-0.88	Changes: **0.92 » 0.04** 95% C.I.: **(-0.99, -0.76)**	10.19	95% C.I.: **(-15.22, 35.61)**	-0.34	Changes: **0.2 » -0.15**

Change-point significance: + p-value < 0.1, * p-value < 0.05, ** p-value < 0.01, *** p-value < 0.001,

Figure 8

Estimates of the trend change, level change, and change in adjacent correlation for the example data.

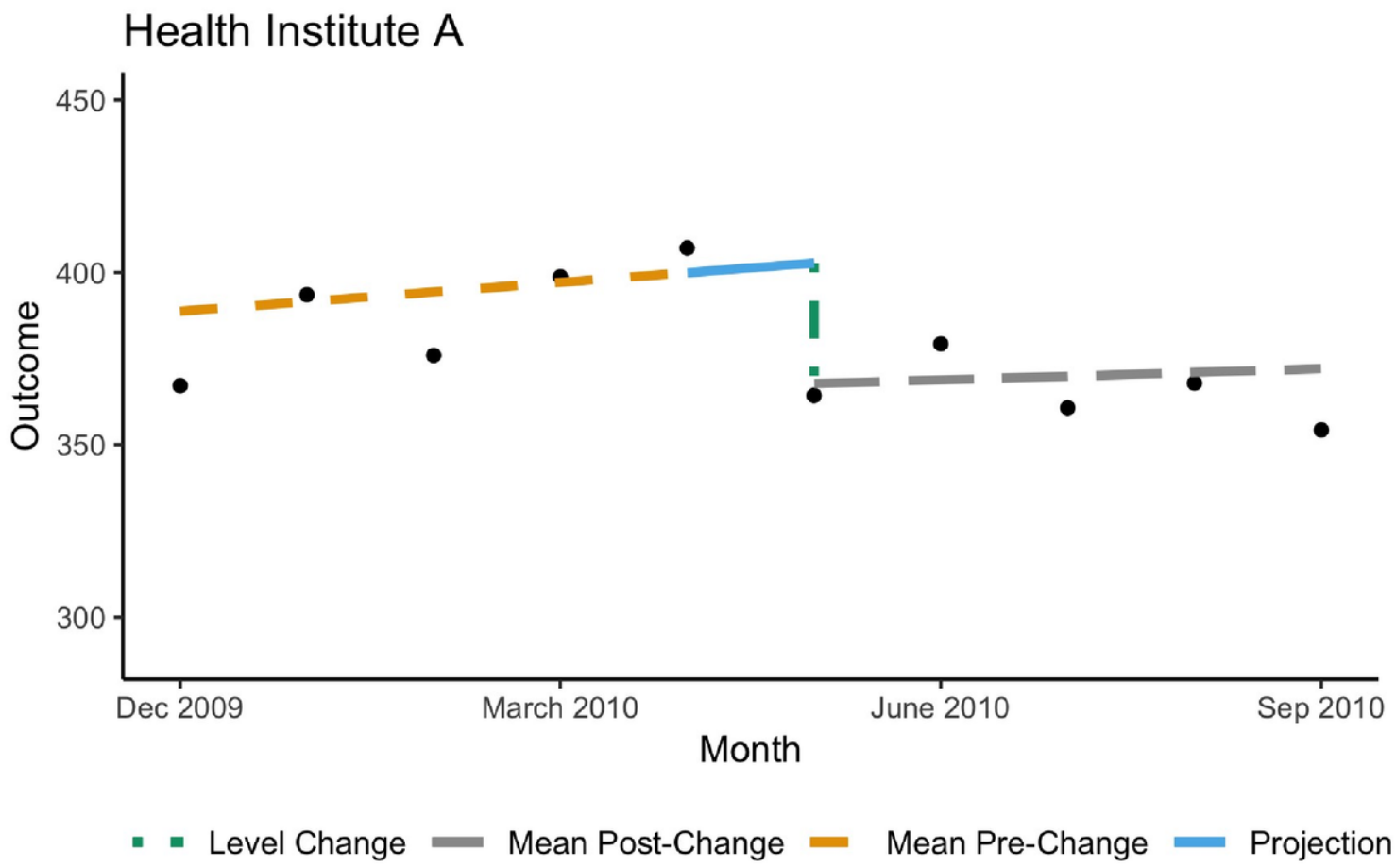


Figure 9

Estimates of model parameters for Health Institute A of our example data.

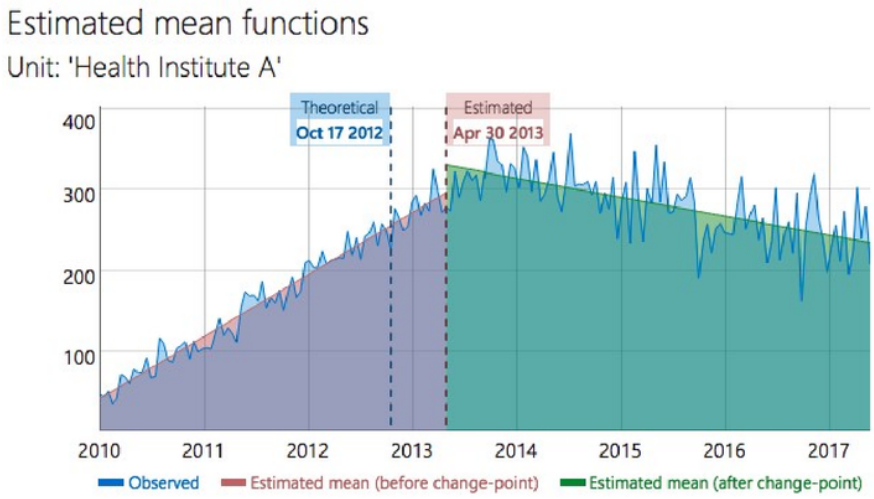


Figure 10

Estimated change-point and mean function for Health Institute A of our example data.

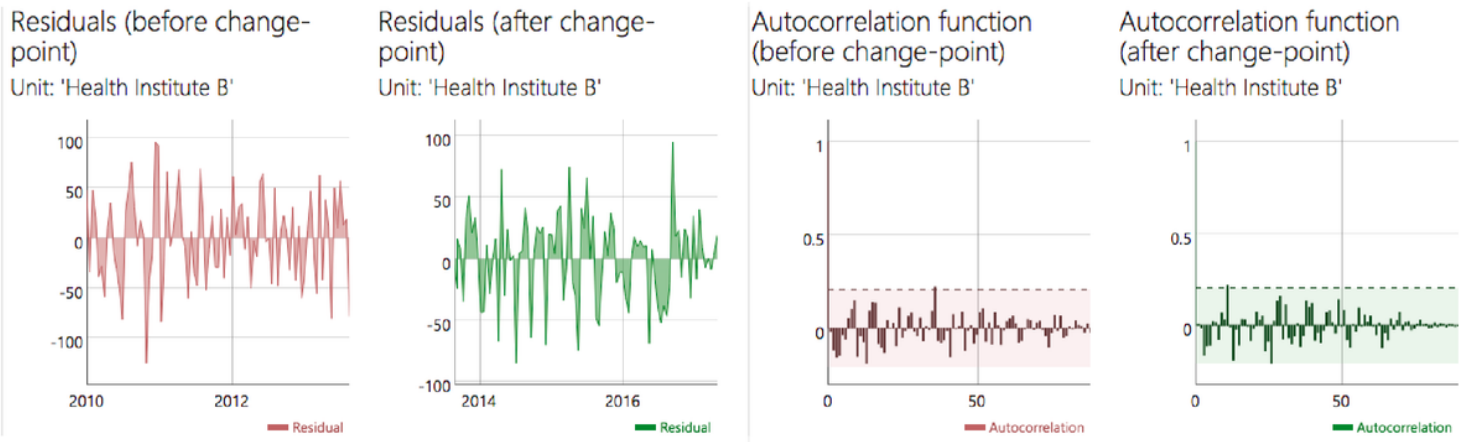


Figure 11

Residuals and autocorrelation function plots for Health Institute A of our example data.