LaTeX TEMPLATE FOR IGARSS 2025 ARTICLES (WITH BibTeX)

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***Abstract*—Full waveform inversion (FWI) aims to reconstruct subsurface properties from observed seismic data. Since FWI is an ill-posed inverse problem, appropriate regularizations or constraints are effective approaches to achieve accurate reconstruction. The total variation (TV) -type regularization or constraint is widely known as a powerful prior that models the piecewise smoothness of subsurface properties. However, the optimization problem of the TV-type regularized or constrained FWI is difficult to solve due to the nonlinearity of the observation process and the non-smoothness of the TV-type regularization or constraint. Conventional approaches to solve the FWI problem rely on inner loops and/or approximations, resulting in high computational cost and/or inappropriate solutions. In this paper, we develop an efficient algorithm with neither inner loops nor approximations to solve the FWI problem based on a primal-dual splitting method. We also demonstrate the effectiveness of the proposed method through experiments using the SEG/EAGE Salt and Overthrust Models.**

***Index Terms*—IGARSS 2025, LaTeX, reproducibility, template.**

I. INTRODUCTION

This template is aligned with the good practices stated by Frery [1], which are a step towards a reproducible article [2]. We used the official IEEE Conference Proceedings template available here https://www.ieee.org/conferences/publishing/templates.html to produce this simplified version for IGARSS 2025. This template uses BibTeX, a convenient way of managing references that simplifies the formatting and automatically selects the bibliographic entries cited in the text.

A basic knowledge of LaTeX and BibTeX is required.

II. DOCUMENT STRUCTURE

Conceptually, a scientific document should have four elements:

- Introduction: your scientific question, the review of the literature, an outline of the steps you took to answer, a summary of what you observed, and a brief statement of how those observations changed the state-of-the-art (that was outlined in the review of the literature).
- Methodology: describe what you did so other researchers can replicate your study.
- Results: the core observations you collected, usually summarized in tables, figures, and images.
- Discussion: this is the essential part of your work. Do not summarize your results. Tell the reader how they answer (or not) your scientific question and how they change the state-of-the-art.

This structure is known as "IMRaD," and was consolidated by over a century of scientific practice. Fig. 1 shows a quote from the book by Day [3] about this structure, and this piece of code shows how to include a figure in your article. The file is in PNG format; reserve this format for matrix-like graphical elements. Use PDF for plots, as in Fig. 2.

> Human beings have been able to communicate for thousands of years. Yet scientific communication as we know it today is relatively new. The first journals were published only 300 years ago, and the IMRAD (Introduction, Methods, Results, and Discussion) organization of scientific papers has developed within the past 100 years.

Fig. 1. A screenshot from Day [3] about the structure of a scientific article.

The main textual components are controlled by the commands `\section`, `\subsection`, and `\subsubsection`.

A. *This is a subsection*

Text components are automatically numbered.

1) This is a subsection inside a subsection: This is the innermost text component you should use in your document. It appears as a paragraph with a title.

2) Nice tables: Citing Habib [4]:

> Tables are best suited for looking up precise values, comparing individual values or presenting values involving multiple units of measure. Graphs, on the other hand, are better for detecting trends, anomalies or relations. In other words, graphs show the forest while tables show the trees.

Once you have designed your table, type it using commands from `booktabs`, as in Table I. Notice that the second column type was stipulated with commands from the `siunitx` package. It switches to mathematical mode and aligns the figures by their decimal point, promoting an immediate visual comparison.

Tables and algorithms captions are usually at the top, while figures captions are at the bottom.

Identify applicable funding agency here. If none, delete this.

TABLE I
TRUE AND ESTIMATED CLASSES, WITH THE SAMPLE MEAN.

True LULC	Mean	Estimated LULC
Sand	1.32	Open sea
Forest	7.93	Forest
Open sea	-5	Open sea
Bare soil	100.41	Bare soil

B. Another subsection

Your document should have at least two components for each level, i.e., do not use a single `\subsubsection`, but at least two.

One of LaTeX's strongest abilities is producing high-quality equations:

$$i\hbar\frac{\partial}{\partial t}\Psi(\boldsymbol{r},t) = \widehat{H}\Psi(\boldsymbol{r},t), \tag{1}$$

where $i=\sqrt{-1}$ is the imaginary unit, $\hbar$ is the reduced Plank's constant, $\partial/\partial t$ is the partial derivative operator with respect to time, $\Psi(\boldsymbol{r},t)$ is the wave equation that depends on the position $\boldsymbol{r}$ and time t, and $\widehat{H}$ is the Hamiltonian operator. Always detail every component of each equation.

Use `amsmath`'s mathematical environments:

$$f_{\text{tr}A}(x) = \left|\frac{x\beta}{2}\Sigma^{-1}\right|^a \frac{e^{-z}}{x\Gamma(ma)} {}_1F_x^{(2a)}\Big(a; ma; zI_m - \frac{x\beta}{2}\Sigma^{-1}\Big), \tag{2}$$

in which we have followed the notation defined by Drensky et al. [5]. The package offers several options to align equations. Often, an equation is wider than a column; in that case, use the `\begin{multline} ... \end{multline}` environment.

$$\Pr\big(\text{tr}A \leq (x)\big) = \left|\frac{x\beta}{2}\Sigma^{-1}\right|^a \frac{1}{\Gamma(ma+1)} \\ {}_1F_x^{(2a)}\Big(a; ma+1; -\frac{x\beta}{2}\Sigma^{-1}\Big). \tag{3}$$

C. Algorithms

Algorithms summarize, in readable form, the steps that comprise a computational procedure. Algorithm 1 shows an example using the `algorithm2e` package. This pseudocode spans two columns.

D. Units

It is mandatory to state the measurement units. The `siunitx` provides commands that implement some of the best ways to do it. For instance, you type `\SI{10}{\mega\hertz}` and produce 10 MHz. You type `\qtyproduct{2x5}{\meter}` and produce $2\,\text{m} \times 5\,\text{m}$, e.g., for stating the spatial resolution of an image.

III. FIGURES

Fig. 2 shows a PDF figure. Notice that the font size is readable in the final version.

Making reproducible plots and storing the code that produced them is more than advisable. The plot displayed in

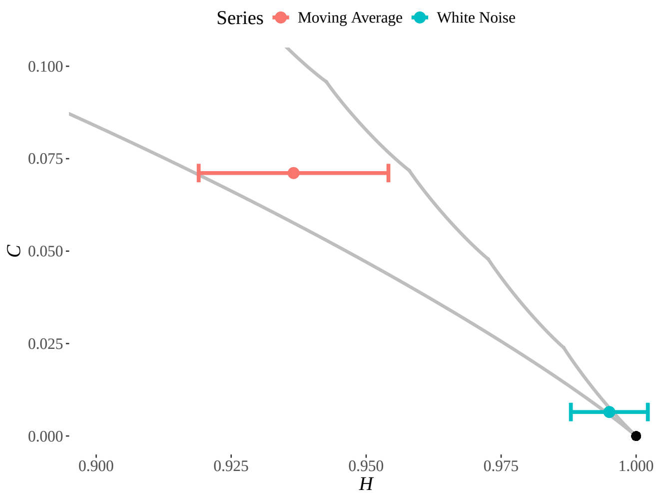

Fig. 2. Two time series mapped onto their Shannon Entropy (H) and Statistical Complexity (C) points along with 95 % confidence intervals for the entropy using $D=4$ embedding dimension; cf. Rey et al. [6].

Fig. 2 was created with R [7], and the code is in the `Code` folder accompanying this template. It requires a few packages: `ggplot2` [8], `ggthemes` [9], and `StatOrdPattHxC` [6].

Notice that I used `theme_tufte()` to obtain a minimalistic yet informative plot. I recommend the books by E. Tufte [10–13] are my preferred reference for communicating with graphics.

IV. REFERENCES USING BIBTEX

This template shows how to use BIBTEX. The `natbib` package allows several types of citations. Notice the convenience of using `\citet`, as in the book by Brockwell and Davis [14]. There is also the `\citep` option, where the reference is inserted between parenthesis [15]. The `references.bib` file provides examples of a journal article [2], a technical report [16], a conference article [15], a book [14], a manual [17], and a website [4].

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Algorithm 1: Quasi U-Statistics

Data: The list of folders $\mathcal{L}$
Data: The number of groups G.
Data: The sample size per group $n_1, n_2, \ldots, n_G$.
Data: The data per group $\boldsymbol{X}_1, \ldots, \boldsymbol{X}_{n_1}, \boldsymbol{X}_{n_1+1}, \ldots, \boldsymbol{X}_{n-n_G+1}, \ldots, \boldsymbol{X}_{n_G}$.
Data: The number of bootstrap replications B (we used 200).
Compute: Choose the kernel ϕ of degree two from

$$\begin{aligned}\phi_1(x,y) &= |x-y|^p,\\ \phi_2(x,y) &= \mathbb{1}\left\{|x-y| > \eta\right\}.\end{aligned}$$

Compute: Select p for ϕ_1, or η for ϕ_2, e.g., with a data-drive optimization method.
Define: Define T as

$$T = \sum \eta_{nij}\phi(\boldsymbol{X}_i, \boldsymbol{X}_j),$$

where the weights are given by:

$$\eta_{nij} = \begin{cases} 1 & \text{if } i \text{ and } j \text{ belong to different groups,}\\ -\frac{(n-n_g)}{(n_g-1)} & \text{if } i \text{ and } j \text{ belong to group } g, \text{ for each } 1 \le g \le G.\end{cases}$$

while *$\mathcal{L}$ has elements* **do**
  Read the following element ℓ in the list $\mathcal{L}$
  if *ℓ is empty* **then**
    Skip to the next element
  else
    Compute: Compute T on the sample $\boldsymbol{X}_1, \ldots, \boldsymbol{X}_{n_1}, \boldsymbol{X}_{n_1+1}, \ldots, \boldsymbol{X}_{n-n_G+1}, \ldots, \boldsymbol{X}_{n_G}$ and store it in T_{obs}
    for $1 \le b \le B$ **do**
      Build the bootstrap sample $\boldsymbol{X}^{(b)} = \left(\boldsymbol{X}_1^{(b)}, \ldots, \boldsymbol{X}_{n_1}^{(b)}, \ldots, \boldsymbol{X}_{n-n_G+1}^{(b)}, \ldots, \boldsymbol{X}_{n_G}^{(b)}\right)$
      Compute $T^{(b)}$ with $\boldsymbol{X}^{(b)}$
    Compute q_α, the upper α quantile of $T^{(1)}, T^{(2)}, \ldots, T^{(B)}$
    Output: Decision: reject H_0 if $T_{\text{obs}} > q_\alpha$.
    Remove the current set from the list $\mathcal{L}$

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