Discover LaTeX

or how to start making beautiful documents

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Important dates

- **Donald Knuth (1977)** : scientific (computing/mathematics), created TEX, a text formatter designed to produce scientific documents, particularly suited to mathematical formalism. TEX comes the word $\tau\acute{\epsilon}\chi\nu\eta$ which means "Art".[1]
- **Leslie Lamport (1980)** : created LATEX from TEX increasing the level of abstraction and adding a separation of document form and content. Introduction of new features such as Table of contents, Index, labels, bibliography, figures, tables.

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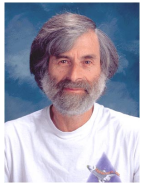
Important dates



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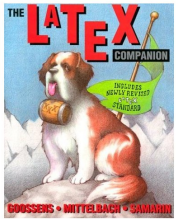
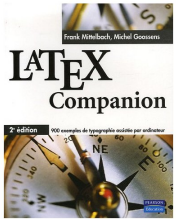
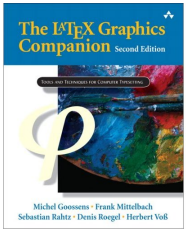
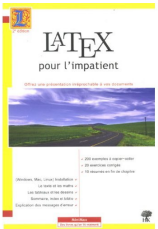
Few reference books









- The LaTeX Companion (1996) - M. Goossens, F. Mittelbach, A. Samarin.
- The LaTeX Companion 2nd Edition (2004) - M. Goossens, F. Mittelbach.
- The LaTeX Graphics Companion (2007) - M. Goossens, F. Mittelbach, S. Rahtz, D. Roegel, H. Voss.
- The LaTeX Web Companion: Integrating Tex, Html and Xml - M. Goossens, S. Rahtz, M. Goosens.
- LaTeX pour l'impatient (2007) - W. Appel, C. Chevalier, E. Cornet, S. Desreux.

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A few (partially) wrong point of views

- TEX (or LATEX) is a scientific word processor designed only for writing equations and abstruse mathematical symbols;
- LATEX is complicated;
- A LATEX source file is unreadable unless you have studied LATEX for several years.

What do you think of this source file?

```
\documentclass{article}
\usepackage[english]{babel}
\usepackage[utf8]{inputenc}
\begin{document}
Today we're going to discover a new way of creating scientific documents,
the one that produces the best results.
\end{document}
```

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Advantages of LaTeX

- The result is **beautiful**: consistent document layout, font resolution that far exceeds the perceptive capacity of the human eye with typical encoding length of 5.36×10^{-6} mm (extreme finesse);
- *open source*, various operating systems (windows, MacOS X, GNU/Linux), stable, free, active community;
- does not require extensive IT resources (ASCII source files, images are not included in the source files);
- flexible and efficient management of bibliographies, equations, graphs, tables and floating objects;
- the text written in a source file is directly reusable (with almost no modifications) in another document written with LaTeX (*e. g.* ex: books, reports, articles, web pages, posters, beamer)
- may add-ons in various domains: muscial scores, chemistry formula, cartoons and sketches (tikz)...

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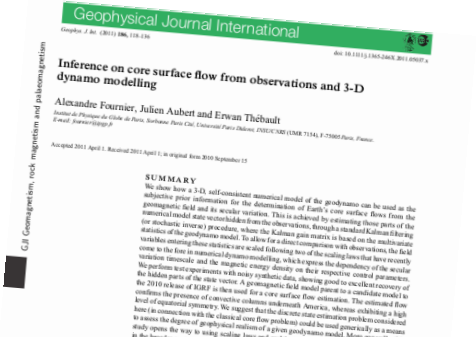
A few examples



Geophysical Journal International

Geophys. J. Int. (2011) 186, 118–136. doi: 10.1111/j.1365-246X.2011.05037.x

GJI Geomagnetism, rock magnetism and palaeomagnetism

Inference on core surface flow from observations and 3-D dynamo modelling

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SUMMARY

We show how a 3-D, self-consistent numerical model of the geodynamo can be used as the subjective prior information for the determination of Earth's core surface flows from the geomagnetic field and its secular variation. This is achieved by estimating those parts of the numerical model state vector/history from the observations, through a standard Kalman filtering (or stochastic inverse) procedure, where the Kalman gain matrix is based on the multivariate statistics of the geodynamo model. To allow for a direct comparison with observations, the field variables entering these statistics are scaled following two of the scaling laws that have recently come to the fore in numerical dynamo modelling, which express the dependency of the secular variation timescale and the magnetic energy density on their respective control parameters. We perform test experiments with noisy synthetic data, showing good to excellent recovery of the hidden parts of the state vector. A geomagnetic field model parent to a candidate model to the 2010 release of IGRF is then used for a core surface flow estimation. The estimated flow confirms the presence of convective cohesion underneath America, whereas exhibiting a high level of equatorial symmetry. We suggest that the discrete-state estimation problem considered here (in connection with the classical core flow problem) could be used generically as a means to assess the degree of geophysical realism of a given geodynamo model. More generally, this study opens the way to using scaling laws and multivariate statistics from numerical models in the broader context of geomagnetic data assimilation.

Key words: Inverse theory; Dynamo theories and simulations; Rapid time variations; Core, outer core and inner core.

1 INTRODUCTION

Assuming that we have knowledge of the radial component of the magnetic induction B_r and of its rate-of-change $\dot{A}_r B_r$ at the top of Earth's core, the so-called core flow problem consists of trying to estimate the flow $\mathbf{u}$ compatible with these observations, by using the radial component of the magnetic induction equation

$$\dot{A}_r B_r = -\nabla_\perp \cdot (\mathbf{u}_r B_r) + \lambda r^{-1} \partial_r^2 (r B_r), \tag{1}$$

in which $\nabla_\perp$ is the horizontal divergence operator, λ is the magnetic diffusivity of the fluid core, and $\mathbf{u}_r = (u_\theta, u_\phi)$, where u_θ and u_ϕ are the eastward and southward horizontal components of the flow near the surface of the core, respectively. (In the remainder of this paper, θ, ϕ, r will refer to the standard spherical coordinates.) This problem has been the focus of a long-standing interest for the past 45 yr (see the reviews by Bloxham & Jackson 1991; Holme 2007). It is of fundamental importance, for its solution throws light on the underlying geodynamo processes, while providing insight on important geophysical phenomena, such as the interannual to decadal changes in the length-of-day (see, e.g. Jault *et al.* 1988; Jackson *et al.* 1993; Gillet *et al.* 2010a). In their pioneering paper, Roberts & Scott (1965) proposed to neglect the effect of magnetic diffusion in eq. (1), on the account of its negligible contribution to the large-scale secular variation, leading to the popular frozen-flux approximation. Despite this important simplification, it was soon demonstrated by Backus (1968) that the problem is non-unique, and that further *a priori* hypotheses concerning the nature of the flow $\mathbf{u}$ are needed, along with regularization, for the inversion to yield a stable solution with a moderate level of spatial complexity. Hypotheses concerning the dynamics of the flow have included e.g. Gubbins (1982), Voorhies (1986), tangential geostrophy (see, e.g. Le Mouël [illegible]

A few examples

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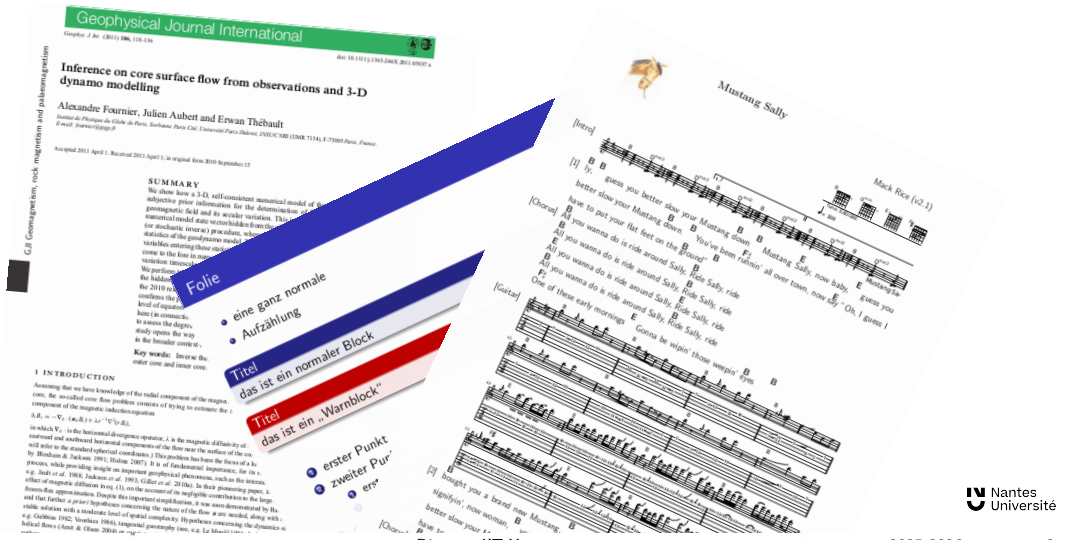
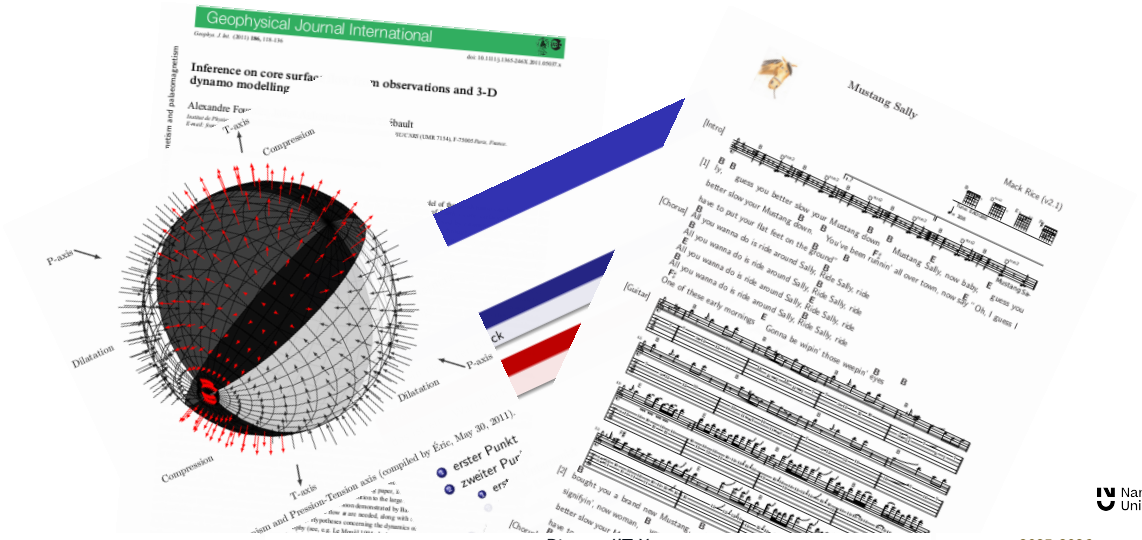
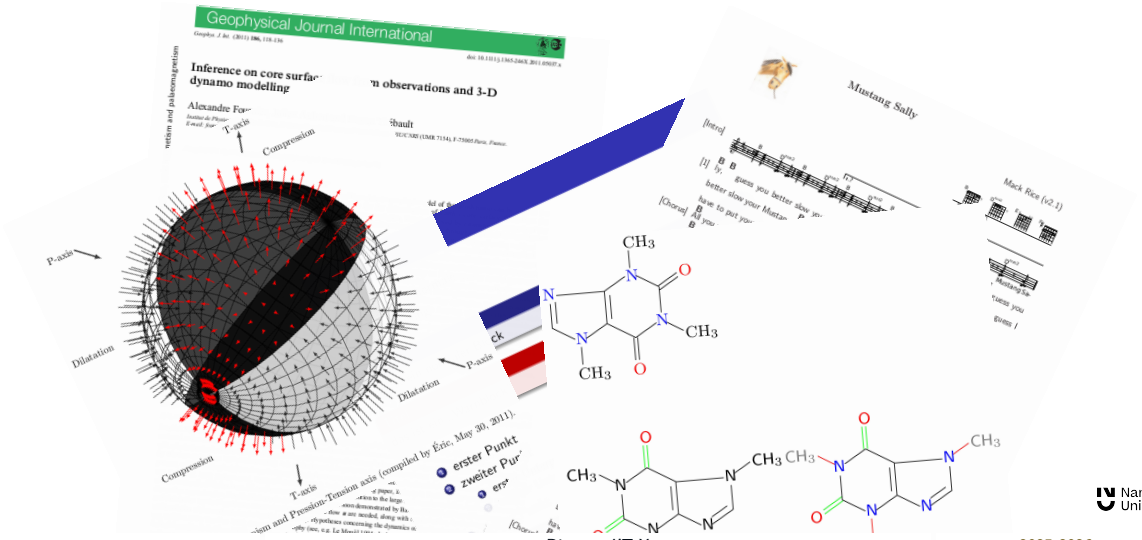


A few examples



A few examples



A few examples

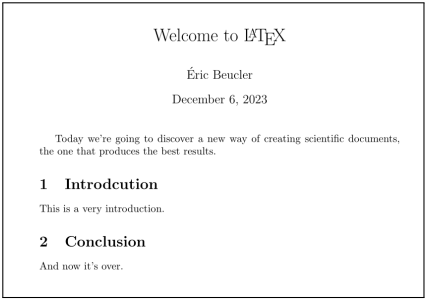
The main feature of LaTeX: compilation

Source file (`welcome.tex`)

```
\documentclass{article}
\usepackage[english]{babel}
\usepackage[utf8]{inputenc}
\title{Welcome to \LaTeX}
\author{Éric Beucler}
\date{December 6, 2023}
\begin{document}
\maketitle
Today we're going to discover a new way of creating scientific documents,
the one that produces the best results.
\section{Introdcution}
This is a very introduction.
\section{Conclusion}
And now it's over.
\end{document}
```

⟶ `pdflatex`

Result (`welcome.pdf`)



Welcome to LaTeX

Éric Beucler

December 6, 2023

Today we're going to discover a new way of creating scientific documents, the one that produces the best results.

1 Introdcution

This is a very introduction.

2 Conclusion

And now it's over.

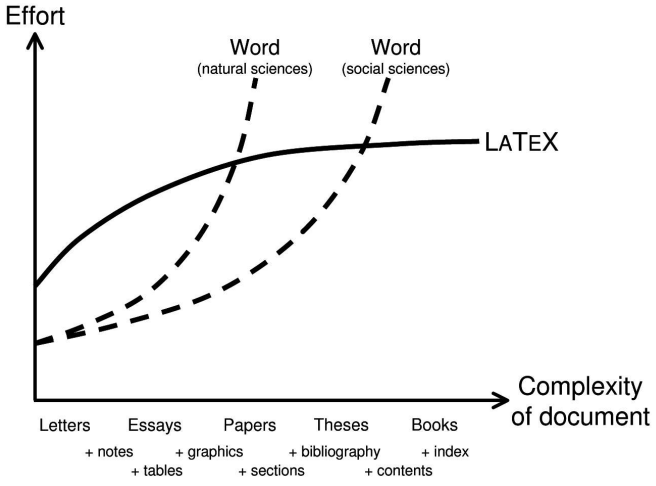
Unlike WYSIWYG[2] software, the result is not directly visible.

Advantage or disadvantage?

It's not as easy as using a traditional word processor intuitively (*Libreoffice* or *MSWord*), but it allows you to concentrate on the content rather than dwelling on formatting problems.

[2] What You See Is What You Get

Why use LaTeX rather than *MSWord*?



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A quick look on a LaTeX source file

Source file or .tex → needs a text editor (vi, emacs, gedit, notepad...)

Source file (document in French)

```
\documentclass[a4paper]{article}
\usepackage[french]{babel}
\usepackage[latin1]{inputenc}
% Main text
\begin{document}
Ici on va commencer à mettre le texte, les figures, les équations, et patati et patata
\end{document}
```

Compilation:

- latex → .dvi (then dvips old school)
- pdflatex → .pdf and more recently xetex → .pdf

Visualisation of the document (evince, acroread, okular, gv)

Try Overleaf

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Preamble (*header*)

The first command of a LaTeX source file must be:

```
\documentclass[]{}
```

Rule

Use { } for arguments of the command and [] for the options (which sometimes depend on the chosen arguments), for instance:

```
\documentclass[11pt]{article}
```

This command declares the class of the document:

- letter, article, book, report
- beamer
- *cls_maison* (fichier avec extension .cls)

Options for the *article* class:

`draft, 11pt, 12pt, leqno, reqno, a4paper, twocolumn`

Packages

Introduction of optional modules ou *packages* using:

```
\usepackage[opt1,opt2,...]{name-of-the-package}
\usepackage{package1, package2, ...}
```

Examples:

```
\usepackage[french]{babel}
\usepackage{graphicx}
\usepackage{chemistry,times}
\usepackage[square]{natbib}
...
```

Warning! Insert only necessary packages

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Commands & Environments

- Commands:

  `\name-of-the-command[opt1,opt2,...]{arg1}{arg2}...`

  ex: chapter, section, subsection, usepackage, includegraphics,... + any new ad-hoc new command with `\newcommand`, for instance:

  `\newcommand{\cityname}{Nantes}`

- Environments:

  ```
  \begin{name-of-the-environment}
    ...
  \end{name-of-the-environment}
  ```

  ex: table, tabular, figure, minipage, center...

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How to split a document

7 levels of depth for defining the document sections:

```
\part{}, \chapter{}, % report or book only (depend on \documentclass)
\section{}, \subsection{}, \subsubsection{}, \paragraph{}, \subparagraph{},
```

Use the short and long titles:

```
\split-type[short-title]{long-title}
```

[short-title] is useful for pages header/footer (*running head*) and Table of contents[3]

Example

```
\section{The discontinuity due to phase transition at $670$~km depth}
\section[670 Discontinuity]{The discontinuity due to phase transition at $670$~km depth}
```

[3] If no [short-title] then short-title = long-title

Some tips for entering text

- Separation between 2 paragraphs: one empty line (means 2×return) or `\par` → adjusted spaces between words in balanced paragraphs.
- **Warning** "`\\`" differs from "`\par`"
  - `\\` : carriage return only
  - `\par` is used to end a paragraph means carriage return + vertical skip (`\parskip`) + indentation using `\parindent` (including text balancing) - do not confuse with `\paragraph`
- `\parskip` influences the overall layout of the document: space between paragraphs, but also around headings, lists, table of contents...
  It can be modified at any place and to allow a flexibility:
  `\parskip 10pt plus 2pt minus 2pt`
- Use the tilde ("~") to insert a non-breaking space:
  - `$2$~km` → 2 km
  - `When looking around the points A and~B` → When looking around the points A and B

Highlighting some parts of the text

Changing the shape of the current font

Italic: `\textit{text1}` or `{\itshape text2}` or `{\it text3}` → *text1* or *text2* or *text3*
Slanted: `{\slshape text1}` `{\sl text2}` → *text1* or *text2*
Bold: `\textbf{text1}` or `{\bfseries text2}` or `{\bf text3}` → **text1** or **text2** or **text3**
Typewriter : `\texttt{text}` → `text`
Emphasise : `{\em text}` → *text*
Underlined: `\underline{text}` → <u>text</u>

Ten commands to modify the font size

`\tiny, \scriptsize, \footnotesize, \small, \normalsize, \large, \Large, \LARGE, \huge, \Huge`

`{\tiny minuscule}` → minuscule `{\normalsize normale}` → normale `{\Huge énorme}` → énorme

Colour

```
\usepackage{xcolor}
\textcolor{red}{Text in red}
```
→ Text in red

Inserting an equation/symbol in a sentence (do not emphasise)

Without number or line break - example 1

```
In order to simplify, the distance $x = \pi\sum_{i=1}^{n} y_i,$ becomes real and consequently
```

Result

In order to simplify, the distance $x = \pi \sum_{i=1}^{n} y_i$ becomes real and consequently...

Without number or line break - example 2 (Greek symbol and physical units)

```
in all experiments $\sigma=34$~N/m$^2$, which induces a mechanical forcing\dots
```

Result

in all experiments $\sigma = 34$ N/m^2, which induces a mechanical forcing...

Equation with enhanced presentation

Without number but with line break

```
In order to simplify, the distance
$$
x = \pi\sum_{i=1}^{n} y_i,
$$
becomes real and consequently\dots
```

Result

In order to simplify, the distance

$$x = \pi \sum_{i=1}^{n} y_i,$$

becomes real and consequently...

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Numbered equation

Line break, equation number and label declaration

```
In order to simplify, the distance
\begin{equation}
  x = \pi\sum_{i=1}^{n} y_i\label{eqn:xpiy}
\end{equation}
becomes real and consequently\dots
% elsewhere in the document %  using eq.~(\ref{eqn:xpiy}), it is thus possible to\dots
```

Résultat

In order to simplify, the distance

$$x = \pi \sum_{i=1}^{n} y_i \tag{1}$$

becomes real and consequently...
using eq. (1), it is thus possible to ...

Dynamic numbering management at each compilation

Initial situation

```
We assume here that $x$ can be defined
using the offset $u$,
\begin{equation}
  x = \int_{0}^{+\infty} 2u^2 du,
  \label{eqn:xpi}
\end{equation}
thus the depth of each sample is
\begin{equation}
  z(x) = 3\cos(2n\pi+\phi).
  \label{eqn:zdex}
\end{equation}
```

An equation is a sentence in its own right (think about punctuation).

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Dynamic numbering management at each compilation

Result

We assume here that x can be defined using the offset u,

$$x = \int_0^{+\infty} 2u^2 du, \tag{2}$$

thus the depth of each sample is

$$z(x) = 3\cos(2n\pi + \phi). \tag{3}$$

Dynamic numbering management at each compilation

Modified situation (insertion of a new equation at the beginning)

```
If we assume that the offset $u$ derives from~$P$, such as
\begin{equation}
  P(u) = \frac{3u}{2u+1}+2u^2,
  \label{eqn:poly}\end{equation}
between 0 and $+\infty$, then
\begin{equation}
  x = \int_{0}^{+\infty} 2u^2 du,
  \label{eqn:xpi}\end{equation}
thus the depth of each sample is
\begin{equation}
  z(x) = 3\cos(2n\pi+\phi).
  \label{eqn:zdex}\end{equation}
```

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Dynamic numbering management at each compilation

Result

If we assume that the offset u derives from P, such as

$$P(u) = \frac{3u}{2u+1} + 2u^2, \tag{2}$$

between 0 and $+\infty$, then

$$x = \int_0^{+\infty} 2u^2 du, \tag{3}$$

thus the depth of each sample is

$$z(x) = 3\cos(2n\pi + \phi). \tag{4}$$

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Document organisation

Floats

- Floats are containers for things in a document that cannot be broken over a page.
- Images, in a `figure` environment, and tables, in a `table` environment, are placed aesthetically by default and then in the output, they are not necessarily at the exact location they are inserted in the source file.
- Their location can be forced using option `[ht!]`

Automatic generation of lists using floats:

```
\tableofcontents
\listoffigures
\listoftables
```

The `figure` and `table` environments obey different aesthetic rules.

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Figures and images

Example

```
\begin{figure}
  \includegraphics[width=1.7cm]{./img/earth.png}
  \label{fig:earth-cartoon}
  \caption{The Earth centered on the Atlantic Ocean.}
\end{figure}
```

Result

Figure 1: *The Earth centered on the Atlantic Ocean.*

Figures and images

Do not forget to insert `\usepackage{graphicx}` in the preamble (see packages in the section 2.1)

Call in the text

```
Figure~\ref{fig:earth-cartoon} represents a well-known projection of our planet
```

Result

Figure 1 represents a well-known projection of our planet

Accepted image formats

- `pdflatex`: png, pdf, jpg
- `latex`: ps, eps

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Figures and images

Options of the command \includegraphics

```
\includegraphics[width=...]{./img/earth.png}
or the centered version
\centerline{\includegraphics[width=...]{./img/earth.png}}
```

Among the most used options:

- dimensions/deformations
  - in distance units [width=3cm, height=25pt];
  - or in % of the linewidth such as `[width=0.99\linewidth]`;
  - if only width OR height then autoscaling of the other dimension.
- draft mode [draft=true] ou [draft=false];
- rotation [angle=...].

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Figures and images

Draft option draft and width in %

```
\begin{figure}
  \includegraphics[draft=true,width=0.13\linewidth]{./img/earth.png}
  \label{fig:earth-cartoon}
  \caption{The Earth centered on the Atlantic Ocean.}
\end{figure}
```

Résultat

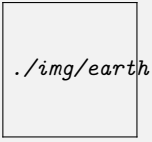

Figure 1: *The Earth centered on the Atlantic Ocean.*

Figures and images

Rotation and deformation

```
\begin{figure}
  \includegraphics[angle=45,width=3cm,height=1.5cm]{./img/earth.png}
  \label{fig:earth-cartoon}
  \caption{The Earth centered on the Atlantic Ocean (slighty rotated and distorted).}
\end{figure}
```

Result

Figure 1: *The Earth centered on the Atlantic Ocean (slighty rotated and distorted).*

Figures and images

Don't confuse the `figure` environment with the command `\includegraphics`

A figure can exist with no image

```
\begin{figure}
  \label{fig:earth-cartoon}
  \caption{The Earth centered on the Atlantic Ocean (no image).}
\end{figure}
```

Result

Figure 1: The Earth centered on the Atlantic Ocean (no image).

Table and tabular

Example

```
\begin{table}
  \begin{tabular}{|l|c||r|}
    line1 field1 & field2 & field3\\
                 & $\xi=4$ & \\\hline
    line3 $2x+1$ & field7 &
  \end{tabular}
  \caption{Measured values of \%Cu realised during the stage.}
\end{table}
```

Result

line1 field1	*field2* $\xi = 4$	*field3*
line3 $2x + 1$	*field7*	

Table 1: *Measured values of %Cu realised during the stage.*

Index

In the preamble:

- `\usepackage{imakeidx}`
- `\makeindex`

Somewhere in the body text, when you want to add words in the index table use the command `\index{}`:

Example

```
Apatite\index{Apatatite} is a generic name for hexagonal phosphates\index{Phosphates}.
```

At the end (or the beginning) of the document, the command `\printindex` creates the Index table (according to alphabetic order), it gathers all words referenced by `\index{}`

Possible options: `\makeindex[columns=2, title=Index]`

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Bibliography

Needs a database (`.bib` file) and a package (for instance `natbib`)

Example of a bibliography entry in the "articles.bib" file

```
@article{als1993,
author = "D. Alsina and R. Snieder and V. Maupin",
journal = "Geophys. Res. Lett.",
pages = "915--918",
title = "A test of the great circle approximation in the analysis of surface waves",
volume = 20,
year = 1993}
```

The bibliography is inserted in most cases at the end of the document with the command:

`\bibliography{./articles.bib}`

The style of the bibliography is defined with `\bibliographystyle{}`, for instance `\bibliographystyle{alpha}`

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Insert a bibliographic reference in the body text such as:

```
these assumptions are proposed by \citet{als1993}.
```

Result

"... these assumptions are proposed by [ASM93]"

at the end of the document (where the command `\bibliography{./articles.bib}` is inserted:

Bibliography

D. Alsina, R. Snieder, and V. Maupin.
A test of the great circle approximation in the analysis of surface waves.
Geophys. Res. Lett., 20:915–918, 1993.

Difference between `\citet{}`, `\citep{}`, `\citeauthor{}`, `\citeyear{}` (`\cite{}` is somewhat deprecated)
`\nocite{*}` to print all entries of a given `.bib` file.
To change the way references are cited, change the `.bst` file.

What else?

- Beware of the forums (and all advices about loading thousands of packages and other such good ideas) - *the simplest is the best*
- Spell checker under Linux: `aspell`
- For oral presentations: `beamer` class
- Vectorial graphics or modification of existing images: `tikz`
- Geneviève Moguilny's LaTeX web page (French reference): https://www.ipgp.fr/latex