Mapping and modeling Earth Science Data

Some notes on typesetting

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Type setting: Graphics embedding: always use EPS or PDF files

- Adobe PS, EPS, or PDF files are moderately portable
- EPS & PDF can be included into (pdf)latex and Word (*e.g.* as **convert**ed png), *and* easily further edited
- EPS and PDF can be used for publications
- use Adobe Illustrator for EPS/PDF editing and making posters (this is the only non-LINUX, non-freeware software I am using)

Type setting: Some notes on type setting, publishing, and layout

- Alternatives (rest of the world) use office software: Word, Excel, Powerpoint
  - the free alternatives from OpenOffice (Mac, Windows, LINUX) are quite good now
  - this is good for small text projects without many equations, or presentations
- Latex (by D. Knuth) is much better for larger projects (*e.g.* thesis), and if using a lot of equations (this might change, Word Latex capabilities)
- Latex is bizarre.

Typesetting: Latex

```
$\lim_{n \to \infty}
\sum_{k=1}^n \frac{1}{k^2}
= \frac{\pi^2}{6}$
```

$\lim_{n \to \infty} \sum_{k=1}^n \frac{1}{k^2} = \frac{\pi^2}{6}$

```
\begin{displaymath}
\lim_{n \to \infty}
\sum_{k=1}^n \frac{1}{k^2}
= \frac{\pi^2}{6}
\end{displaymath}
```

$$\lim_{n \to \infty} \sum_{k=1}^n \frac{1}{k^2} = \frac{\pi^2}{6}$$

- typesetting program, not WYSIWYG
  - But there are tools like LyX and other Latex editors
- takes time to learn
- results look beautiful and are book quality
- produces DVI, PS or PDF files
- use **bibtex** for citing references
- good short reference:
  Short introduction to Latex in 120 minutes

Equations

- $$, \begin{equation}, \begin{eqnarray}

```
We use:
\begin{equation}
  \label{eq:vep}
  \dot\epsilon_{ij} = \frac{1}{2\eta}\tau_{ij}
  +\frac{1}{2G}\frac{D\tau_{ij}}{Dt}
  +\lambda\frac{\partial Q}{\partial\sigma_{ij}}
\end{equation}
```

We use:

$$\dot{\epsilon}_{ij} = \frac{1}{2\eta}\tau_{ij} + \frac{1}{2G}\frac{D\tau_{ij}}{Dt} + \lambda\frac{\partial Q}{\partial\sigma_{ij}} \qquad (8)$$

Symbols

α	\alpha	θ	\theta	o	o	τ	\tau
β	\beta	ϑ	\vartheta	π	\pi	υ	\upsilon
γ	\gamma	ι	\iota	ϖ	\varpi	ϕ	\phi
δ	\delta	κ	\kappa	ρ	\rho	φ	\varphi
ϵ	\epsilon	λ	\lambda	ϱ	\varrho	χ	\chi
ε	\varepsilon	μ	\mu	σ	\sigma	ψ	\psi
ζ	\zeta	ν	\nu	ς	\varsigma	ω	\omega
η	\eta	ξ	\xi				
Γ	\Gamma	Λ	\Lambda	Σ	\Sigma	Ψ	\Psi
Δ	\Delta	Ξ	\Xi	Υ	\Upsilon	Ω	\Omega
Θ	\Theta	Π	\Pi	Φ	\Phi		

Structure of a tex file

- Headers (documentclass, usepackage, \def...).
- Title, authors, author address, running title, bibliography style.
- Abstract, intro, sections, conclusion, acknowledgments, bibliography

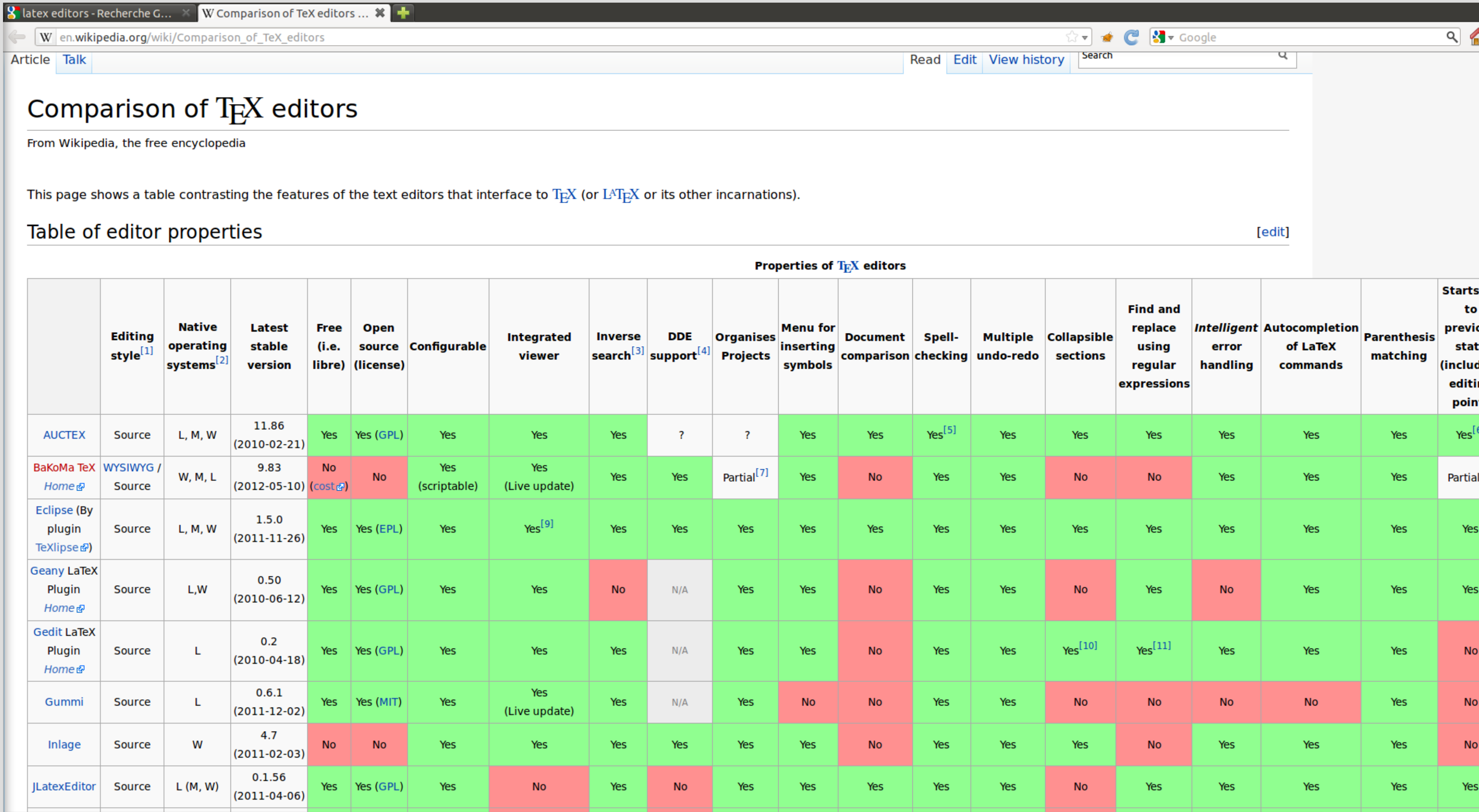
Example

```latex
\documentclass[draft,gc]{agutex}
\usepackage{graphicx}
\usepackage{amsmath}
\usepackage{amssymb}
\usepackage{color}
\authorrunninghead{My Name}
\titlerunninghead{Short title}
\authoraddr{My name,
  $^1$Your department address}
\begin{document}
\title{Long title}
\authors{My Name\altaffilmark{1},}
\altaffiltext{1}{Your department address}
\bibliographystyle{agufull08}

\begin{abstract}
\end{abstract}

\begin{article}

\section{Introduction}
\label{sec:intro}

\section{Setup}
\label{sec:setup}
\subsection{Important stuff}
\subsubsection{Detail of the important stuff}
\paragraph{By the way}

\begin{acknowledgments}
  Thanks!
\end{acknowledgments}

\bibliography{ref}
\end{article}
\end{document}
```

Figures, tables

```
\begin{figure}
  \centering
  \includegraphics[width=20pc,clip=true]{Images/figure_name}
  \caption{I explain the figure.}
  \label{fig:stuff}
\end{figure}
I show in figure \ref{fig:stuff} that...


\begin{table}
  \caption{Choice of parameters}
  \label{tab:par_conv_piezo}
  \begin{center}
    \begin{tabular}{llll}
      \hline
      Parameter & Value & Unit & Description\\
      \hline
      $\kappa$ & $10^{-6}$ & m$^2$ s$^{-1}$ & Thermal diffusivity\\
      $\alpha$ & $3\;10^{-5}$ & K$^{-1}$ & Thermal expansivity\\
      $\rho$ & $5000$ & kg m$^{-3}$& Density\\
      $g$ & $10$ & m s$^{-2}$ & Gravity\\
      $h$ & $2900$ & km & Domain depth\\
      \hline
    \end{tabular}
  \end{center}
\end{table}
```

Latex Editors



latex editors - Recherche G... | Comparison of TeX editors ...

en.wikipedia.org/wiki/Comparison_of_TeX_editors

Article Talk | Read Edit View history | Search

Comparison of TeX editors

From Wikipedia, the free encyclopedia

This page shows a table contrasting the features of the text editors that interface to TeX (or LaTeX or its other incarnations).

Table of editor properties

[edit]

Properties of TeX editors

	Editing style[1]	Native operating systems[2]	Latest stable version	Free (i.e. libre)	Open source (license)	Configurable	Integrated viewer	Inverse search[3]	DDE support[4]	Organises Projects	Menu for inserting symbols	Document comparison	Spell-checking	Multiple undo-redo	Collapsible sections	Find and replace using regular expressions	*Intelligent* error handling	Autocompletion of LaTeX commands	Parenthesis matching	Starts to previo state (includ editin point
AUCTEX	Source	L, M, W	11.86 (2010-02-21)	Yes	Yes (GPL)	Yes	Yes	Yes	?	?	Yes	Yes	Yes[5]	Yes	Yes	Yes	Yes	Yes	Yes	Yes[6
BaKoMa TeX Home	WYSIWYG / Source	W, M, L	9.83 (2012-05-10)	No (cost)	No	Yes (scriptable)	Yes (Live update)	Yes	Yes	Partial[7]	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Partial[
Eclipse (By plugin TeXlipse)	Source	L, M, W	1.5.0 (2011-11-26)	Yes	Yes (EPL)	Yes	Yes[9]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geany LaTeX Plugin Home	Source	L,W	0.50 (2010-06-12)	Yes	Yes (GPL)	Yes	Yes	No	N/A	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	Yes	Yes
Gedit LaTeX Plugin Home	Source	L	0.2 (2010-04-18)	Yes	Yes (GPL)	Yes	Yes	Yes	N/A	Yes	Yes	No	Yes	Yes	Yes[10]	Yes[11]	Yes	Yes	Yes	No
Gummi	Source	L	0.6.1 (2011-12-02)	Yes	Yes (MIT)	Yes	Yes (Live update)	Yes	N/A	Yes	No	No	Yes	Yes	No	No	No	No	Yes	No
Inlage	Source	W	4.7 (2011-02-03)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
JLatexEditor	Source	L (M, W)	0.1.56 (2011-04-06)	Yes	Yes (GPL)	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

Latex Editors

- Most of them are open source
- You will find source type and WYSIWYG
- Source: Emacs/Auctex, Texstudio, Texmaker...
- WYSIWYG: Lyx, Gnu Texmacs...

How does Latex work

- Create a .tex file
- Create an “Image” folder
- Compile your .tex file with latex, pdflatex etc.
- Compile with bibtex (for references)
- Recompile with latex

All that is usually done in your tex editor, not in command line, though it might be useful for automatic generation of reports

Bibliography

- Bibtex file .bib countains the references
- Call with \cite{articlelabel} in the .tex file
- You can also use \citet{} and \citep{}
- Example:

In the .tex file

\citep{bombadil1964}

In the .pdf file

ics, *6*(1), 23–74.
Bombadil, T., and S. Trahald (1964), Numerical simulation of relativistic mordor tectonics, *Advanced in Mordor Tectonics*, *21*(3), 43–78.
Brandebouque, M., and B. Baggins (1970), Where the hell would

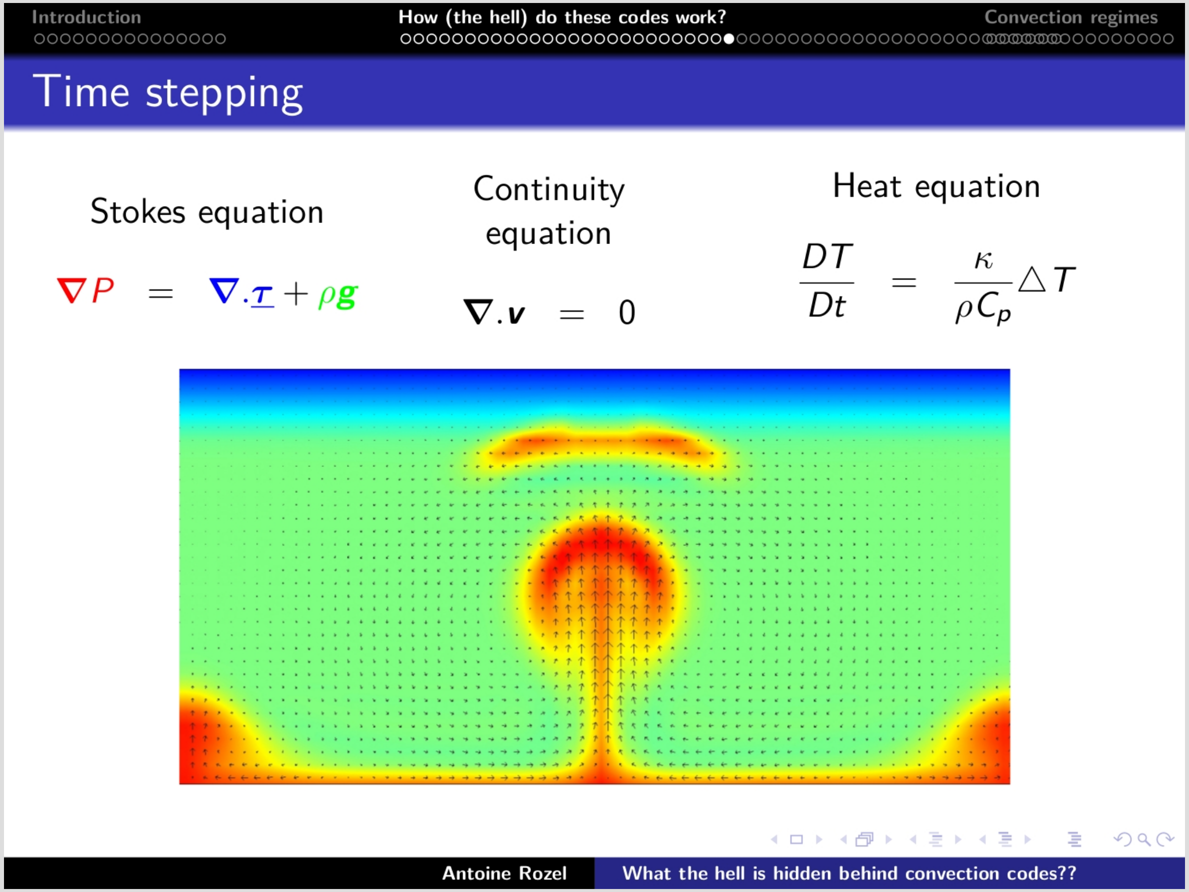
In the .bib file

```
@ARTICLE{bombadil1964,
AUTHOR = {T. Bombadil and S. Trahald},
TITLE = {Numerical simulation of
         relativistic Mordor Tectonics},
JOURNAL = {Advanced in Mordor Tectonics},
YEAR = 1964,
VOLUME = 21,
PAGES = {43--78},
NUMBER = 3}
```

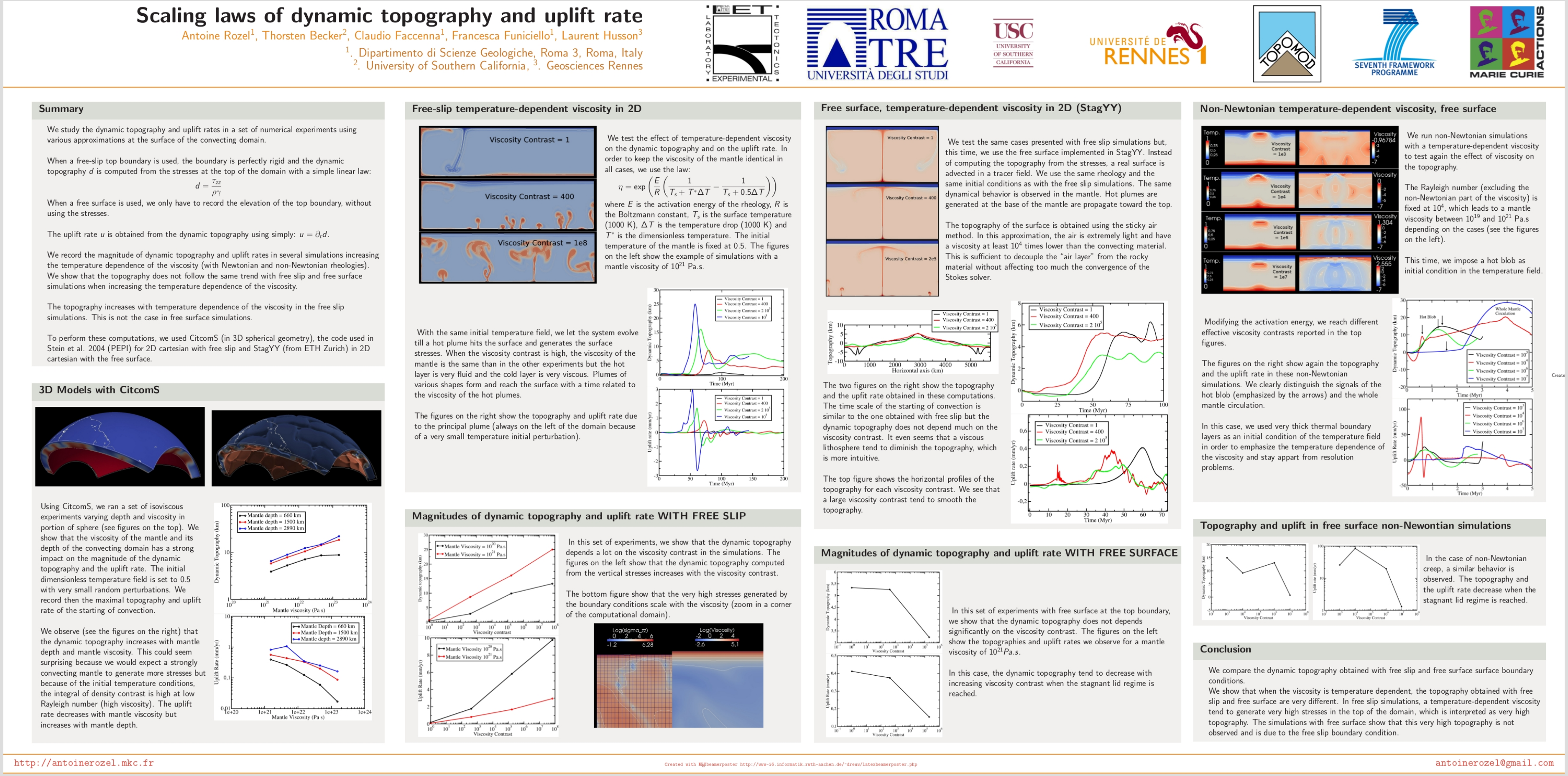
Beamer

- “PowerPoint” presentation with latex
- Several templates available on internet

```
\begin{frame}
\frametitle{Plate tectonics of the Earth}
 \begin{columns}
  \begin{column}{4cm}
   \begin{center}
    Deformation localized\\
    \vskip 0.5cm
    at plate boundaries
   \end{center}
  \end{column}
  \begin{column}{8cm}
   \begin{figure}
    \includegraphics[width=8cm]
    {images/plaques_Terre.jpg}\\
    \hskip 0.5cm
    \tiny{Wessel \& Muller 2007}
   \end{figure}
  \end{column}
 \end{columns}
\end{frame}
```



Posters



Scaling laws of dynamic topography and uplift rate

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Summary

We study the dynamic topography and uplift rates in a set of numerical experiments using various approximations at the surface of the convecting domain.

When a free-slip top boundary is used, the boundary is perfectly rigid and the dynamic topography d is computed from the stresses at the top of the domain with a simple linear law:

$$d = \frac{\tau_{zz}}{\rho\gamma}$$

When a free surface is used, we only have to record the elevation of the top boundary, without using the stresses.

The uplift rate u is obtained from the dynamic topography using simply: $u = \partial_t d$.

We record the magnitude of dynamic topography and uplift rates in several simulations increasing the temperature dependence of the viscosity (with Newtonian and non-Newtonian rheologies). We show that the topography does not follow the same trend with free slip and free surface simulations when increasing the temperature dependence of the viscosity.

The topography increases with temperature dependence of the viscosity in the free slip simulations. This is not the case in free surface simulations.

To perform these computations, we used CitcomS (in 3D spherical geometry), the code used in Stein et al. 2004 (PEPI) for 2D cartesian with free slip and StagYY (from ETH Zurich) in 2D cartesian with the free surface.

3D Models with CitcomS

Using CitcomS, we ran a set of isoviscous experiments varying depth and viscosity in portion of sphere (see figures on the top). We show that the viscosity of the mantle and its depth of the convecting domain has a strong impact on the magnitude of the dynamic topography and the uplift rate. The initial dimensionless temperature field is set to 0.5 with very small random perturbations. We record then the maximal topography and uplift rate of the starting of convection.

We observe (see the figures on the right) that the dynamic topography increases with mantle depth and mantle viscosity. This could seem surprising because we would expect a strongly convecting mantle to generate more stresses but because of the initial temperature conditions, the integral of density contrast is high at low Rayleigh number (high viscosity). The uplift rate decreases with mantle viscosity but increases with mantle depth.

Free-slip temperature-dependent viscosity in 2D

We test the effect of temperature-dependent viscosity on the dynamic topography and on the uplift rate. In order to keep the viscosity of the mantle identical in all cases, we use the law:

$$\eta = \exp\left(\frac{E}{R}\left(\frac{1}{T_s + T^*\Delta T} - \frac{1}{T_s + 0.5\Delta T}\right)\right)$$

where E is the activation energy of the rheology, R is the Boltzmann constant, T_s is the surface temperature (1000 K), ΔT is the temperature drop (1000 K) and T^* is the dimensionless temperature. The initial temperature of the mantle is fixed at 0.5. The figures on the left show the example of simulations with a mantle viscosity of 10^{21} Pa.s.

With the same initial temperature field, we let the system evolve till a hot plume hits the surface and generates the surface stresses. When the viscosity contrast is high, the viscosity of the mantle is the same than in the other experiments but the hot layer is very fluid and the cold layer is very viscous. Plumes of various shapes form and reach the surface with a time related to the viscosity of the hot plumes.

The figures on the right show the topography and uplift rate due to the principal plume (always on the left of the domain because of a very small temperature initial perturbation).

Magnitudes of dynamic topography and uplift rate WITH FREE SLIP

In this set of experiments, we show that the dynamic topography depends a lot on the viscosity contrast in the simulations. The figures on the left show that the dynamic topography computed from the vertical stresses increases with the viscosity contrast.

The bottom figure show that the very high stresses generated by the boundary conditions scale with the viscosity (zoom in a corner of the computational domain).

Free surface, temperature-dependent viscosity in 2D (StagYY)

We test the same cases presented with free slip simulations but, this time, we use the free surface implemented in StagYY. Instead of computing the topography from the stresses, a real surface is advected in a tracer field. We use the same rheology and the same initial conditions as with the free slip simulations. The same dynamical behavior is observed in the mantle. Hot plumes are generated at the base of the mantle are propagate toward the top.

The topography of the surface is obtained using the sticky air method. In this approximation, the air is extremely light and have a viscosity at least 10^4 times lower than the convecting material. This is sufficient to decouple the "air layer" from the rocky material without affecting too much the convergence of the Stokes solver.

The two figures on the right show the topography and the upfit rate obtained in these computations. The time scale of the starting of convection is similar to the one obtained with free slip but the dynamic topography does not depend much on the viscosity contrast. It even seems that a viscous lithosphere tend to diminish the topography, which is more intuitive.

The top figure shows the horizontal profiles of the topography for each viscosity contrast. We see that a large viscosity contrast tend to smooth the topography.

Magnitudes of dynamic topography and uplift rate WITH FREE SURFACE

In this set of experiments with free surface at the top boundary, we show that the dynamic topography does not depends significantly on the viscosity contrast. The figures on the left show the topographies and uplift rates we observe for a mantle viscosity of $10^{21} Pa.s$.

In this case, the dynamic topography tend to decrease with increasing viscosity contrast when the stagnant lid regime is reached.

Non-Newtonian temperature-dependent viscosity, free surface

We run non-Newtonian simulations with a temperature-dependent viscosity to test again the effect of viscosity on the topography.

The Rayleigh number (excluding the non-Newtonian part of the viscosity) is fixed at 10^4, which leads to a mantle viscosity between 10^{19} and 10^{21} Pa.s depending on the cases (see the figures on the left).

This time, we impose a hot blob as initial condition in the temperature field.

Modifying the activation energy, we reach different effective viscosity contrasts reported in the top figures.

The figures on the right show again the topography and the uplift rate in these non-Newtonian simulations. We clearly distinguish the signals of the hot blob (emphasized by the arrows) and the whole mantle circulation.

In this case, we used very thick thermal boundary layers as an initial condition of the temperature field in order to emphasize the temperature dependence of the viscosity and stay appart from resolution problems.

Topography and uplift in free surface non-Newontian simulations

In the case of non-Newtonian creep, a similar behavior is observed. The topography and the uplift rate decrease when the stagnant lid regime is reached.

Conclusion

We compare the dynamic topography obtained with free slip and free surface surface boundary conditions.
We show that when the viscosity is temperature dependent, the topography obtained with free slip and free surface are very different. In free slip simulations, a temperature-dependent viscosity tend to generate very high stresses in the top of the domain, which is interpreted as very high topography. The simulations with free surface show that this very high topography is not observed and is due to the free slip boundary condition.

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