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Towards ready-to-use, open-source automated geodynamic diagnostics and fair representation of numerical models

Collecting geodynamic diagnostics, automating them in a robust manner to be applied to the multitude of different geodynamic models and codes, and providing them back to the community can foster additional progress within the modelling community.

Why do we need automated post-processing?

What do we already have?

StagLab's geodynamic diagnostics

StagLab's scientific visualisation

What do we still need?

References

Click on it!

Do not print!

EGU2020-18384 | D1576

The Centre for Earth Evolution and Dynamics

Scientific Colour Maps

Go back

Why do we need automated post-processing?

Click on it!

- **Time efficiency**
  - Calculating diagnostics every time step vs. **Post-processing when needed**
  - Coding a plume tracking algorithm over 4 weeks vs. **Clicking one button**
  - Coding → forgetting vs. **Coding → extending**
- **Storage efficiency**
  - GBs of unused output data vs. **Post-processing when needed**
- **Flexibility**
  - Only one saved output for this model vs. **Post-processing tool output at any time**
- **Objective post-processing**
  - Picking subjective features vs. **Peer-reviewed objective algorithm**
- **Testability**
  - „We see that…“ vs. **„The diagnostics of StagLab v5.0 indicate that …“**
- **Reproducibility**
  - „Available“ by author request vs. **doi:10.5281/zenodo.1199037**
  - A code from a friend of a friend vs. **A code of fully acknowledged developers**

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What do we already have?

Forward-compatible parfiles

File overwrite prevention

Automated figure size

Automated error logging

✔ Automated Geodynamic diagnostics
✔ Clear and focussed plot design
✔ Scientific colour maps
✔ Light & Dark Mode
✔ Publication-ready figures & movies
✔ Easily extendable code design

User friendliness

Automated annotation

Automated dimensionalisation

Intelligent file finder

Intelligent error prevention

Analysis & Publication mode

Automated installation

Quick mode

Automated subplot layout

Various output file formats

Magnifier panels

www.fabiocrameri.ch/StagLab

2-D mode for 3-D data

Automated plot simplification

Verbose mode

Flipping and shifting datasets

Discretising colour maps

Figure background transparency

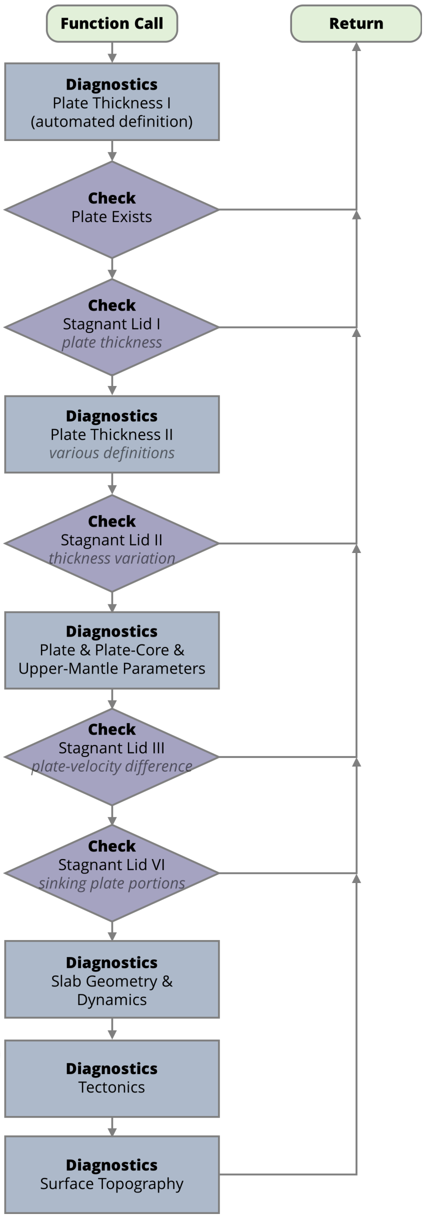
Looping existing files

Crameri, F. (2017), StagLab 3.0. **http://doi.org/10.5281/zenodo.1199037**

Crameri, F. (2018), Geodynamic diagnostics, scientific visualisation and StagLab 3.0, Geosci. Model Dev., 11, 2541-2562, **doi:10.5194/gmd-11-2541-2018**

StagLab’s geodynamic diagnostics

50+ individual diagnostics



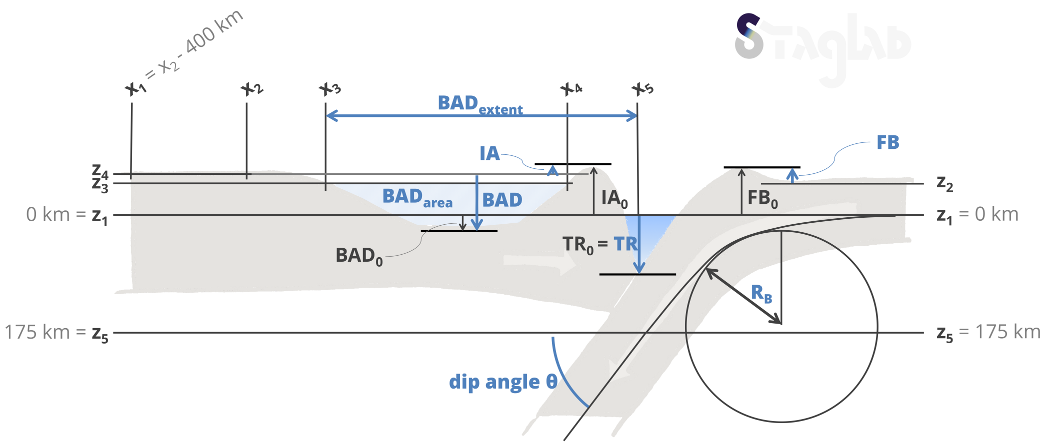
Diagnostics	Availability[a] 2-D Cartesian	2-D cylindrical	3-D Cartesian (2-D mode[b])
Topography			
Regional characteristics	✓	✓	✓
Isostatic topography component	✓	✓	✓
Residual topography component	✓	✓	✓
Plate			
Convergent-boundary tracking	✓	✓	✓
Divergent-boundary tracking	✓	✓	✓
Plate thickness	✓	✓	✓
Plate-core stress	✓	✓	✓
Plate-core strain rate	✓	✓	✓
Max. depth of plastic failure	✓	✓	✓
Subduction kinematics	✓	✓	✓
Subduction polarity	✓	✓	✓
Subducting plate age at trench	✓	✓	✓
Subducting plate bending	✓	✓	✓
Subduction flow rate	✓	✓	✓
Plate bending dissipation	✓	✓	✓
Overriding plate tilt	✓	✓	✓
Spreading kinematics	✓	✓	✓
Slab			
Slab viscosity	✓	✓	✓
Slab–mantle viscosity contrast	✓	✓	✓
Slab-tip depth	✓	✓	✓
Shallow-depth slab dip angle	✓	✓	✓
Slab-sinking velocity	✓	✓	✓
Slab water retention	✓	✓	✓
Mantle			
Mantle transit time	✓	✓	✓
Upper-mantle viscosity	✓	✓	✓
Mantle-plume tracking	✓	✓	✓
Active vs. passive upwelling–downwelling	✓	✓	✓
Total upwelling–downwelling volume	✓	✓	✓

[a] At the time of submission. [b] Diagnostics performed on a vertical cross section through a Cartesian 3-D model.

Table S1: StagLab’s diagnostic output parameters for 2-D model data[a]

Parameter	Symbol	Unit[b]
Time	t	*variable*
Time Seconds	t_s	s
Time Years	t_{yr}	yr
Mantle-Transit Time	t_{MT}	#MT
Trench Position	x_{Trench}	*variable*
Subduction Polarity	Pol_{Sub}	’-1’: left, ’1’: right, ’0’: unknown
Trench Velocity	v_{Trench}	$\mathrm{cm\,a^{-1}}$
Theoretic Trench Velocity	$v_{TrenchTheoretic}$	$\mathrm{cm\,a^{-1}}$
Upper-Plate Velocity	v_{UP}	$\mathrm{cm\,a^{-1}}$
Lower-Plate Velocity	v_{LP}	$\mathrm{cm\,a^{-1}}$
Convergence Velocity	$v_{Convergence}$	$\mathrm{cm\,a^{-1}}$
Slab Sinking Velocity	$v_{SlabSinking}$	$\mathrm{cm\,a^{-1}}$
Max. Plate Velocity	$v_{PlateMax}$	$\mathrm{cm\,a^{-1}}$
RMS Plate Velocity	$v_{PlateRMS}$	$\mathrm{cm\,a^{-1}}$
Slab Angle	θ_{Slab}	°
Slab-Tip Horiz. Position	$x_{SlabTip}$	*variable*
Slab-Tip Depth	$z_{SlabTip}$	*variable*
Slab Viscosity	η_{Slab}	Pa s
Slab Density	ρ_{Slab}	$\mathrm{kg\,m^{-3}}$
Upper-Mantle Viscosity	η_{UM}	Pa s
Upper-Mantle Density	ρ_{UM}	$\mathrm{kg\,m^{-3}}$
Max. Upper-Mantle Velocity	$v_{UM,Max}$	$\mathrm{cm\,a^{-1}}$
Slab-Mantle Visc.Contrast	$\Delta\eta_{Slab-Mantle}$	-
Left-Plate Thickness	d_{leftP}	*variable*
Right-Plate Thickness	d_{rightP}	*variable*
Lower-Plate Thickness	d_{LP}	*variable*
Upper-Plate Thickness	d_{UP}	*variable*
Plate Bending Radius	R_B	*variable*
Bending Dissipation	ϕ_L^{vd}	$\mathrm{N\,s^{-1}}$
Rel. Bending Dissipation	$\phi_{L,norm}^{vd}$	-
Viscous Plate Dissipation	ϕ_{Plate}^{vd}	$\mathrm{N\,s^{-1}}$
Max. Plate-Core Viscosity	$\eta_{PlateCore}$	Pa s
Min. Plate-Core Strainrate	$\dot{\epsilon}_{PlateCore,Min}$	$\mathrm{s^{-1}}$
Max. Plate-Core Strainrate	$\dot{\epsilon}_{PlateCore,Max}$	$\mathrm{s^{-1}}$
Max. Plate-Core Stress	$\sigma_{PlateCore,Max}$	MPa
Max. Plate Stress	$\sigma_{Plate,Max}$	MPa
LAB Depth	z_{LAB}	*variable*
Max. Yield Depth	$z_{yield,max}$	*variable*
Max. Yield Depth Fraction	$z_{yield,max,frac}$	fraction of mean plate thickness
Trench Depth	z_{Trench}	*variable*
Upper-Plate Tilt	θ_{UP}	°
Subduction Flow-Rate	d_{UP}	$\mathrm{m^2}\,s^{-1}$

[a] At time of submission. [b] In StagLab’s dimensional mode.



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StagLab's scientific visualisation

New in version 5.0

Automated journal-style plot design

Annotation

Capital lettre annotation?

Lower case annotation?

Annotation/dimensions

Parentheses?

Brackets?

Nothing?

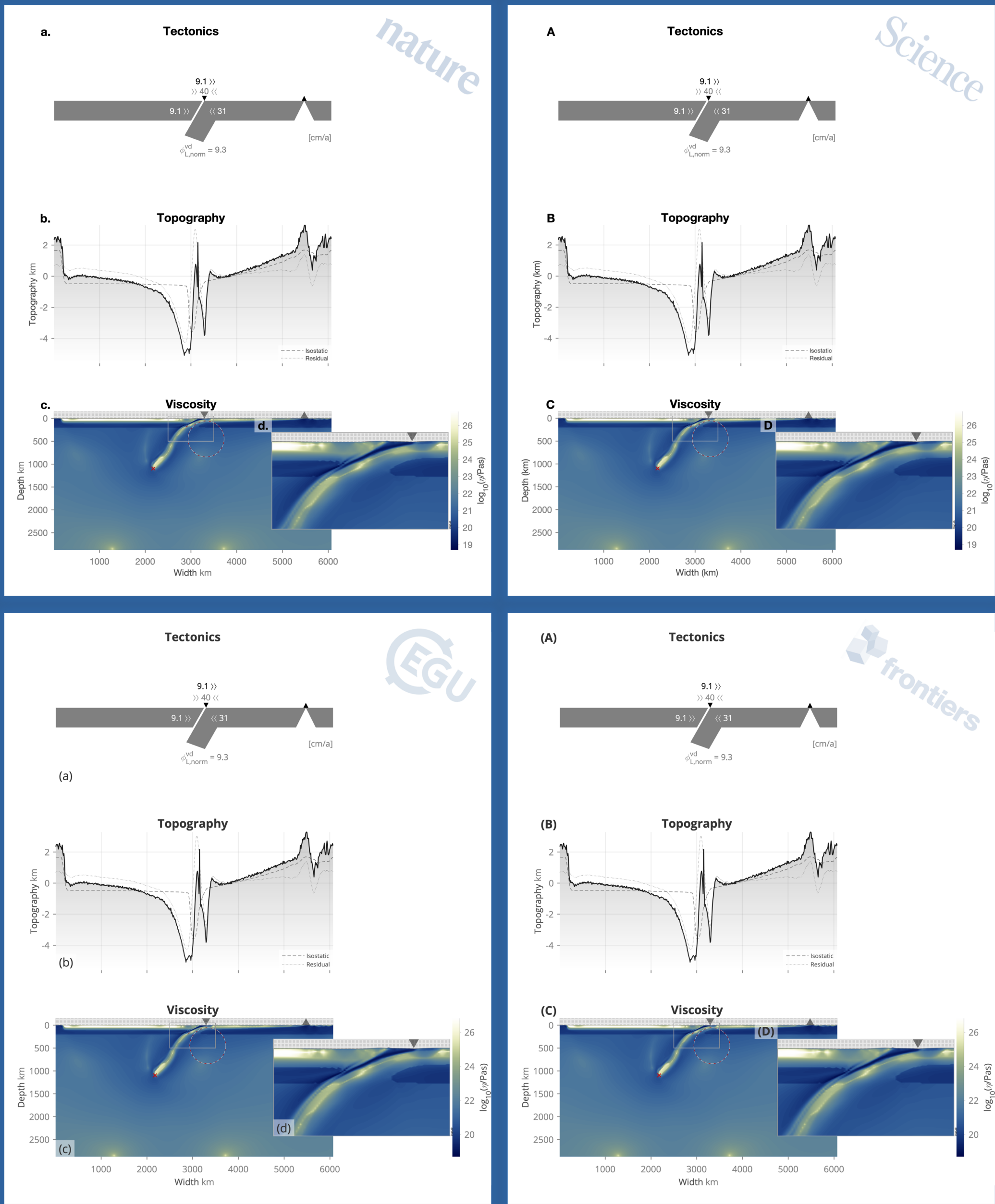
Font

Helvetica?

Arial?

Times New Roman?

~~Comic Sans?~~



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What do we still need?

- **Machine readable/understandable output from geodynamic codes**
  - ➡ Developers should provide detailed information of their code's output structure
  - ➡ Output structure should neither depend on number of computational cores used, nor model geometry, nor any other specific model setup

- **More sustainable geodynamic post-processing**
  - ➡ Software extensions instead of constant re-development
  - ➡ Covering more programming languages
  - ➡ Community-wide sharing and testing of tools and codes
  - ➡ Universal reproducibility

Help me!

References

Crameri, F. (2017), StagLab 3.0, *Zenodo*. **doi:10.5281/zenodo.1199037**

Crameri, F. (2018), Geodynamic diagnostics, scientific visualisation and StagLab 3.0, *Geosci. Model Dev.*, 11, 2541-2562, **doi:10.5194/gmd-11-2541-2018**

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