A brief report from the ASPECT Hackathon, College Station, TX, May 14-23, 2014

Introduction

The first ASPECT "hackathon" was held May 14-23, 2014 in College Station, TX. The format of a hackathon differs from that of a regular workshop in that the main objective is to jointly work, in the present, on code and *create* something, rather than to listen to what others have done in the past. A small amount of time is set aside to informal presentations on topics that help participants be productive and that are of general interest (see the "Program" section below for an overview of the topics discussed in plenary session).

The ASPECT hackathon brought together 14 participants from the United States, The Netherlands, Germany, and Australia. All had previously used ASPECT for their work and about half had indeed contributed code to ASPECT before. While the outcome of traditional workshops and conferences is typically measured in the number of talks given, the number of participants and, possible, concrete action plans, measuring the success of a hackathon can take two forms:

- Concrete metrics on the code that was developed. In the case of our hackathon, the participants committed some 400 patches to the ASPECT repository. This is clearly visible from the weekly statistics our code repository at github provides: https://github.com/geodynamics/aspect/graphs/commit-activity. This number has to be compared to the number of commits over the entire lifetime of ASPECT, which stood at around 2000 before the hackathon. (The numbers are not entirely comparable because we switched from *subversion* to using *git* immediately before the hackathon, and developers typically create more *git* commits than they would when using *subversion*; however, the overall picture is nevertheless correct.)
  These patches increased the number of lines of code in ASPECT from around 45,000 to around 52,000. Most patchsets came with testcases, increasing the number of tests in ASPECT from 53 to 102 with the 10-day time span. More importantly, however, is the fact that 8 of the 14 participants directly submitted code for inclusion (see https://github.com/geodynamics/aspect/graphs/contributors), with another 2 sending code to existing developers, and contributions anticipated from at least 2 more

participants.
As indicated by the results of the survey sent to participants after the end of the workshop (see the section at the end of this document), most participants found the hackathon to be very productive and intend to continue working with and contributing to ASPECT.

- Projects participants worked on: The ultimate metric for a scientific code is whether it can support its users scientific needs. Our impression is that ASPECT does this for the work participants want to do with it or are already doing. Each project, of course, has individual needs that often require adding code. In ASPECT, this is typically done by writing a new “plug-in” that is almost completely independent of the core code and we have integrated more than 20 such plugins for material models, heating sources, boundary conditions, and postprocessing solution contributed by participants during this meeting. At the same time, the “science” output of this work is more difficult to evaluate. To this end, we have asked all participants to both contribute to a section on “small projects necessary for my work” as well as a section on “the science I want to achieve”. These sections are reproduced below and allow readers of this report to judge the quality of the science that can be done with ASPECT today.

To the best of our knowledge, this was CIG’s first sponsored hackathon. We believe (and think that our participants share this belief) that it was an incredible success as far as the mission of CIG is concerned:

- A very significant amount of code was contributed during the hackathon. Importantly, this code was typically motivated by concrete applications, not abstract considerations.
- We built a community in which people felt that their contributions were respected and in which we believe that contributing patches to a common code base will be the norm, rather than an abstract goal whose reality never catches up to its promise.
- We were able to teach and practice relevant software development skills so that every single participant of the hackathon is now able to contribute to ASPECT in the future.
- We have seen an incredible amount of science being done with the model participants built.

We believe that this experience should be repeated in the future. Given the relatively small cost of running a workshop like this (in the range of $10-15k in travel support for 7 sponsored participants; some participants paid for their own travel expenses, and local support -- food, coffee, workshop rooms -- was contributed by W. Bangerth), we can envision it become a bigger event over time. The critical limiting factor is the number of senior developers able and willing to provide their time in advising participants in ways to implement approaches and then to review and revise patches. Although there was an incredible spirit of mutual support -- at any given time one could see small groups huddle and hatching ideas --, advising and code reviews proved to be an almost full-time job for the two senior developers (Bangerth and Heister), with practically no time to develop code on their own. While this is not a problem in itself -- providing expertise and reviewing results is far more productive than having to do it yourself -- this is a clear bottleneck that can only be addressed by growing a larger developer base. Separately, one might be able to stretch the time of these individuals by holding the workshop in a location where all participants are in the same place all the time and away from their home institutions (with correspondingly reduced local responsibilities). One could envision renting a large house in a remote location, instead of holding the workshop at a university and housing participants in local hotels.

Program

The following are organized events during the hackathon. There is free work and interaction with others during all non-scheduled times.

Wed 5/14 9:00 Introduction, meet&greet, discuss things to work on (SLIDES)
Wed 5/14 12:00 Lunch
Wed 5/14 2:00 Timo: Git tutorial (SLIDES)
Wed 5/14 6:00 Dinner at Wolfgang's

Thur 5/15 9:30 Juliane: talk about the latent heat implementation
Rene: talk about the GPlates model
Thur 5/15 2:00 Discussion about their recent ASPECT posters:
Menno: mediterranean slab subduction (2D)
Anne: various benchmarks with nonlinear rheologies
Cedric: 2d and 3d numerical benchmarks for subduction and slab detachment
Juliane: Modeling of thermochemical mantle plumes

Fri 5/16 10:30 Ian: free surface computations
Fri 5/16 2:00 Wolfgang: test suite

Mon 5/19 9:00 Set up GIT with those that have not done so yet?
Mon 5/19 2:00 Cedric: Writing a benchmarking paper

Tue 5/20 2:00 Cedric: Benchmarking paper
Wed 5/21 10:00 Wolfgang: Pressure boundary conditions

Participants

Name	Email	Things I would like to work on	I can talk about...
Timo Heister	heister@clemson.edu	- help others - direct solver - tutorial improvements	- git

		- bug fixes - merge free surface stuff	
Wolfgang Bangerth	bangerth@math.tamu.edu	- provide help - merge codes others have written	- unit tests
D. Sarah Stamps	dstamps@mit.edu	- define the region of interest on Earth with 4 coordinates and a depth (m) in the parameter file - read in crustal input file and define the crustal region. The file does not need to be the same resolution as the other files. - Incorporate dislocation creep for mantle lithosphere and diffusion creep for deeper mantle. - assign Coulomb friction law for crustal region - have default values for flow laws in source code with options to change them in the parameter file	
Jacky Austermann	jaustermann@fas.harvard.edu	- dynamic topography (surface and CMB) - implementing S40RTS as temperature initial condition	
Siqi Zhang	siqi.zhang@mq.edu.au	- Core dynamo and mantle flow coupling (time dependent temperature boundary conditions) - Treatment of magma in global scale models (history dependent magma generation) - Time dependent radioactive heating	
Katrina Arredondo	karredondo@ucdavis.edu	- Nonlinear solvers - Nonlinear rheology - Large viscosity range that can change quickly locally - Subduction models!! - Benchmark with CitcomS - Add multiple phase transitions (need latent heat) - Active tracers/fields that modify the viscosity and density fields - Move CitcomS models into ASPECT (longterm goal for thesis).	
Ian Rose	ian.rose@berkeley.edu	- free surface stuff - nonlinear rheology - active tracers - initial conditions - boundary layer refinement?	- free surface

		- stress boundary conditions	
Ryan Grove	rgrove@clemson.edu	- stabilization - help others - tutorial improvements - bug fixes	- stabilization - parameter handler
Juliane Dannberg	dannberg@gfz-potsdam.de	- melting postprocessor and material model (with latent heat) - testing & documentation of melting - vp/vs postprocessor using the PERPLEX material model - dynamic topography computation - open/stress boundary conditions??? - radiogenic heating in material model	- latent heat - mantle plumes
Rene Gassmoeller	rengas@gfz-potsdam.de	- DONE improve / document self-consistent material model with PERPLEX data - maybe do a scaling section in the manual - DONE anyone interested in a simple compressible material model for tutorial purpose? (I am interested -- Ian) - DONE radiogenic heating should be in material model right?	- GPlates velocity-boundary condition interface
Anne Glerum	A.C.Glerum@uu.nl	- provide the nonlinear viscoplastic material model (diff + disl + Mohr-Coulomb) - nonlinear solvers stopping criteria - stress boundary conditions - multiple compositional fields - monitor tracers (P,T,x,strain)? - elasticity? - coupling to our inhouse “geometry generator”? - tutorials	- nonlinear rheology benchmarks
Cedric Thieulot	c.thieulot@uu.nl	- free surface - coupling to gplates - nonlinear rheology	benchmarking/testing
Menno Fraters	menno.fraters@outlook.com	- subduction - free surface - custom shapes - nonlinear solvers	poster+custom shapes
Nan Zhang	nzhang@colorado.edu	-regional model embedded in the global model -magma migration in the mid-ocean ridge and subduction system	

Self-contained projects necessary to support science needs

Nonlinear solvers (Anne, Cedric, Katrina, Wolfgang, Menno)

The existing solvers need to be looked over and tested. Use different tolerances for pre-refinement steps. Come up with some simple nonlinear rheology tests. More elegant stopping criterion for nonlinear iterations.

Started. The criteria are implemented and tested. The default values we suggest seem to work, but more testing is needed.

Direct solvers (Timo)

Make it possible to solve the velocity/pressure system with a direct solver.

Done. The solver is slower than the iterative solver, though. We may want to look at using not just the old KLU solver of Trilinos, but one of the others provided by Amesos or Amesos2. Note that the PETSc version uses MUMPS, which seem to work a little better.

Improve the radiogenic heating handling (Rene & Siqi)

Make radiogenic heating a new set of plugins since it may be dependent on time and composition and is essentially quite independent from material model. Also generate tests and a set of possible plugins.

Done. Where previously there was only a (spatially, temporally, compositionally) constant internal heating rate, there is now a set of plugins where people can implement their own ways of describing internal heating. In particular, there are now 3 models that are already implements: a heating model with a constant heating rate, a model in which the heating rate is described by a spatially and temporally variable function, and a model in which one describes the initial concentrations of radioactive isotopes and their decay rates, and then computes the heating rate based on these concentrations, the time, and possibly a modification for the crust. Postprocess for internal heating rate is in place as well.

Create a lookup material model for arbitrary thermodynamics codes (Rene, Timo, and Ian)

There are several thermodynamic codes to produce material data (Perplex, Burnman, HeFesto). We want a material model that is easily adjustable to read in that data and use it.

There is now an improvement to the Steinberger model that uses some data from the Perplex code. More work in this area is necessary, but has been postponed to the CIDER meeting.

Time dependent temperature boundary conditions (Siqi, Wolfgang)

Make the temperature boundary conditions can access the time and heat flux, and make a dynamic core plugin.

Started. Temperature boundary conditions could previously only be constant in time (but spatially variable). This limitation has now been lifted, and a few bugs associated with handling this fixed. There is still work to do in generating boundary temperature models that create a boundary temperature computed through feedback from the solution, such as a dynamic core model.

An initial temperature plugin that starts as mantle solidus (Siqi)

A small plugin that used for early Mars that the model start close to mantle solidus with lithosphere.

Done. There is now a plugin that uses a mantle solidus temperature from a lookup table/file for initial conditions. A sample input file is provided that uses data for an early Mars model.

Custom shapes (Menno)

Implementing a way to define custom shapes within the material model, temperature, refinement and composition plugin. This should be done in a way that users can easily setup complex models without writing plugins, or can override the fields made by the plugins.

This is done but because there may not be wider appeal the work is currently in a private repository.

Create a material model and cookbook that implements and introduces reactions between compositional field (Juliane, Rene)

Previously, compositional fields were inert, but we would like to use them to describe phase transitions or melt models. In those cases, one needs to be able to have reactions and source terms between compositional fields.

Done. Material models can now describe reactions and sources. Furthermore, an approach has been implemented in which compositional fields are not identified by number only, but have a name attached to them so that one can more easily identify what each model represents.

Fix description of governing equations in the manual (Ian + others)

The Boussinesq approximation has implications for whether you include viscous heating. The manual currently includes this term in that section, do we want this?

Status: The Boussinesq approximation (BSQ) <u>does not</u> include viscous heating. Only the Extended Boussinesq approximation (EBA) has viscous heating, latent heating and adiabatic heating/cooling. This still needs to be clarified in the manual.

Embed the high resolution regional model into the global model (Nan)

Simply put a high resolution region into a low resolution global model. I am working on the source code part.

Some of this has been achieved by generalizing the plugin infrastructure of ASPECT so that one can tag individual cells for refinement. Making this particular for the region I'm interested in remains to be done.

Move subduction models from CitcomS into ASPECT (Katrina)

Create a simple subduction zone in ASPECT using the same parameters as in the CitcomS models.

Status: I fine-tuned my initial temperature condition, debugged my material model with nonlinear rheology and weak zone and got help setting up a kinematic velocity boundary condition. The model set-up is nearly completed and AMR tests are being run in preparation for running the model forward.

Write a benchmarking paper

We want to document the many benchmarks people have tested with, and complex models people already use with ASPECT. To this end, we will use Cedric's initial mockup of a paper and complete it. Work to be done:

- Add latent heat benchmark (Juliane -- add section, run computations, write up results)
- Numerical sandbox (Anne -- polish text)
- Crameri benchmark, both versions (Ian -- set up free surface input file, run, document results; Jacky/Juliane -- set up postprocessor input files, run , document results; Cedric/Jacky -- do sticky air)
- Sinking cube, 2d (Cedric -- send input files to Wolfgang; Wolfgang run & document; mention the falling sphere already discussed in the manual)
- Schmeling benchmark (Anne -- polish)
- van Keken benchmark in 2d (Cedric, Wolfgang -- polish text)
- "van Keken-like" benchmark in 3d, smooth interface (???)
- Sinking cube, 3d (???)

- Rhodri Davies benchmark (???)
- 3d slab detachment (Cedric)
- Polynomial 3d (???)

Applications:

- 2d subduction (Menno: setup model, run, document)

- 2d subduction compared to CitcomS (Katrina: setup simple model and compare run to identical copy in CitcomS, create cookbook for manual).
- 3d subduction (Anne: setup model, run, document)
- Regional model (Sarah: setup model, run, document)
- Thermochemical plumes (Juliane: document)
- 3d gplates (Rene: setup more realistic material model, run, document)

Status: Started. The goal is to have the paper finished by September and ultimately submitted by the end of the year.

Move plugins that are only necessary for benchmarking out of the Aspect code base (Timo)

Some models, such as the SolCx or SolKz models, are only necessary to run completely artificial benchmarks, but they are no use to anyone else. They should not live in the regular Aspect executable, given that the latter is already getting very large indeed. We should instead move these models into a shared library (or some other benchmark example) that can be linked in specifically for these benchmarks.
Done.

Davies-Benchmarks (Cedric & Wolfgang)

Work on the benchmark suite sent around a while ago by Rhodri Davies.
Started. Much work remains.

Cleanups (Wolfgang, Timo, …)

1. There are numerous places where we directly access the base elements of the global FE. An example is right at the top of temperature_statistics.cc. Clean these up by using introspection. This would also obviate the need for a number of really obscure assertions, like the one immediate preceding the place in temperature_statistics.cc.
   Done.
2. The compressible scheme is not in the manual (Timo).
   Done.
3. Add new aim to ASPECT: community (manual, website)
   Done
4. Can we use boundary indicator names instead of numbers?
5. Simple model: too complicated, what is the formula? Why clamp [1e-2,1e2]?
   The model is still too complicated, but at least the formulas there are now fully documented. A new model “simpler” has been implemented that does what “simple” was intended to be.
6. Need a test for the latent heat benchmark (Juliane)
   Done.

7. Put a try/catch around the Function Parsers so that the user will know which one triggered an exception (e.g. for invalid number of components) (suggested by Juliane)
   Done.
8. Move all the prm texts inside manual.tex into cookbooks/*prm files (Timo)
   Done.
9. Move all benchmark material models out of Aspect (Timo)
   Done.

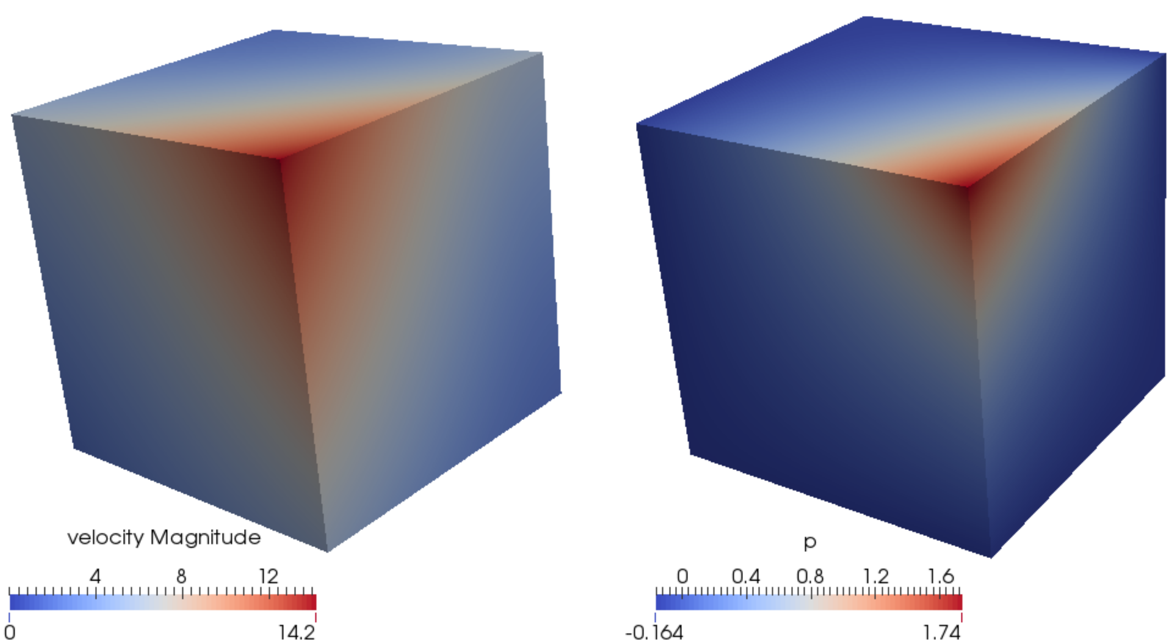
Cleanups we did not get to:

10. Why does convection-box.prm need temperature residual of 1e-15?
11. New material model that is completely driven by FunctionParser? Performance?
12. Should we always log everything into output/log.txt? (I think so… -Ian)
13. Convection-box: Why can I not change gravity/thermal cond. (keep same Ra) and get the same answer?
14. The computation of seismic anomalies in seismic_anomalies.cc is confusing and, currently, uses a fixed number of 50 depth slices. Document this better, make n_slices a parameter.
15. Determine the prm subsection name that a given plugin should put its parameters into, automatically, instead of having to write the same code over and over again with small variations (Timo)
16. Put an assertion/warning in the code that shear heating and adiabatic heating should be used together
17. Move the function such as ‘spherical_surface_coordinates’ in ‘initial_conditions/harmonic_perturbation’ and ‘velocity_boundary_conditon/gplate’ to somewhere else that we don’t need to write it inside different classes.
18. in parameters.tex, escape “<...>” automatically (Timo)
19. Simplify the following slow tests: spherical_velocity_statistics, velocity_boundary_statistics, refine_vel, multicomponent_max_composition, multicomponent_geometric, multicomponent_arithmetic, diffusion?
20. Postprocessor: all is a stupid default, now that we have so many of them. Some of them also don’t work with every material model.

Short reports on science projects we were working on

C. Thieulot

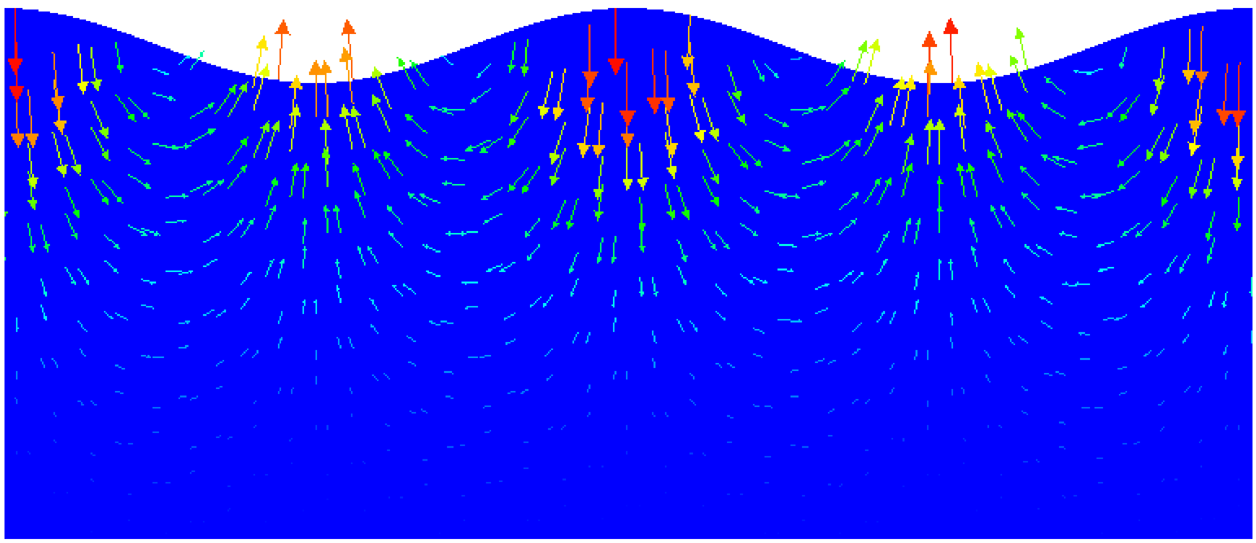
I mainly worked on the implementation of a variable viscosity analytical benchmark to be included in the code. User-defined polynomials representing the velocity field are prescribed on the boundaries, corresponding rhs values are implemented through a gravity model and a complex space-varying viscosity field is used.
L1 and L2-norms of pressure and velocity errors are computed. This benchmark will be converted into a test for the linear solver. The results were compared with those of Burstedde et al. and appear correct.



After more than a week of work, having merged all the participants' contributions and assessed their validity by running geodynamics benchmarks, it was decided to write a peer-reviewed article based on our work (see also above). This article will showcase the recent additions to the code (with respect to the first ASPECT article in GJI, 2012), such as the compositional fields, nonlinear rheologies, free surface implementation and other modifications, illustrate the correctness of the implementation(s) through a handful of carefully chosen benchmark and finally present a variety of applications ranging from subduction to plume evolution. A dozen authors will contribute to the manuscript and its completion is expected to occur in the fall.

Ian Rose

I mostly worked on implementing and merging a free surface implementation into Aspect using an arbitrary Lagrangian-Eulerian framework. The figure below shows an example where initial sinusoidal topography relaxes to zero. This has been benchmarked against other free surface computations in the literature, and we will be continuing this benchmarking effort by comparing the free surface results with those using "sticky air," as well as pseudo-topography calculated from normal stresses on the surface in free-slip models.

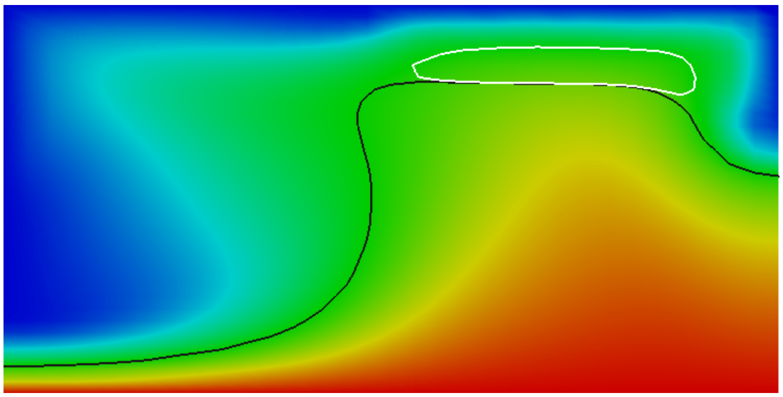


This tool will be useful for calculating dynamic topography due to tectonics and mantle convection, and may be an important boundary condition for various tectonic processes. The basic implementation of the free surface is now described in a new section in the Aspect manual, and there is a new cookbook which demonstrates how to use it. The implementation we provide in Aspect now moves the mesh, but with Juliane and Jacky, we also implemented a postprocessor that computes a dynamic topography simply as a function of the internal variables, without actually changing the domain in which flow is simulated. Both methods have also been compared.

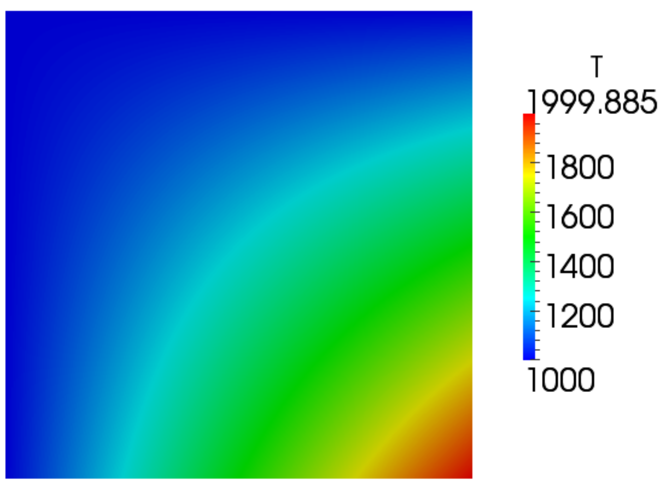
Additionally, I worked on improving the logic for removing nullspace modes from convection models with free-slip boundary conditions and provided a number of new unit tests for various functionalities.

Juliane Dannberg & Rene Gassmoeller

We have documented the possibility of ASPECT to have a reaction term between compositional fields that are converting into each other in dependence of temperature, pressure, composition or position. A cookbook now illustrates this possibility for new users and a supplied material model makes it easy for new users to modify this functionality. In the picture below, a compositional field 1 (black isoline) is converted to a compositional field 2 (white isoline) above a fixed depth.

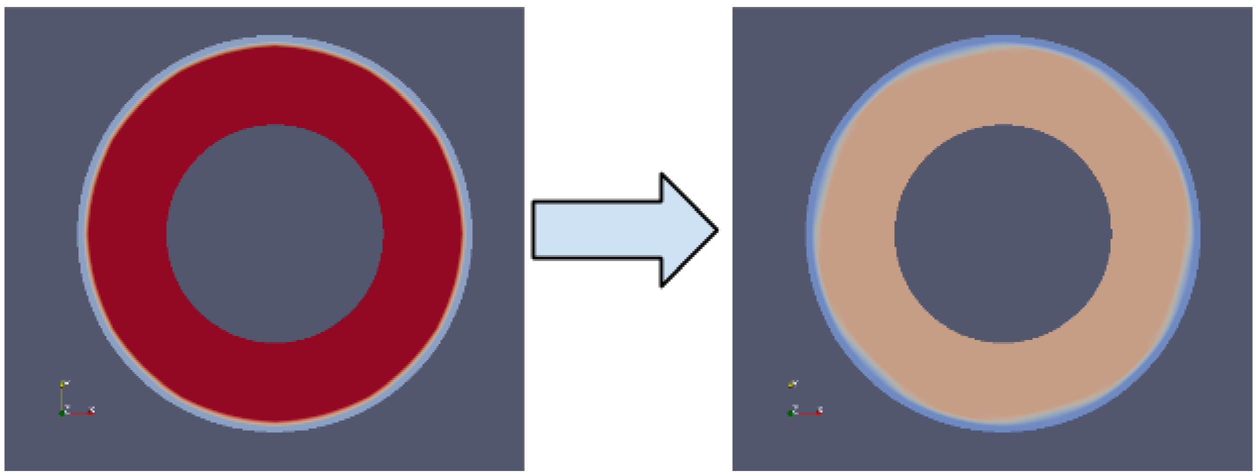


Siqi Zhang & Rene Gassmoeller



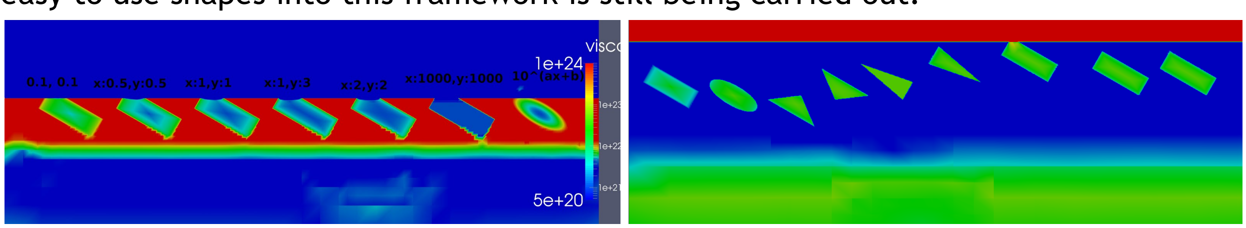
We have implemented a plugin architecture for user-defined heating models and related postprocessors. With this architecture users can easily define their own radiogenic heating models that depend on temperature, pressure, composition, position or time. We also added some easy and more complicated plugins that users are likely to use. The picture above shows a reference case in which the heating rate is linearly increasing in *x*-direction. The material flows in at the top with a constant temperature and flows out at the bottom with a linear temperature profile. The velocity is constant. The analytical solution to this test case predicts a temperature of 2000 K in the lower right corner, which is very closely reproduced.

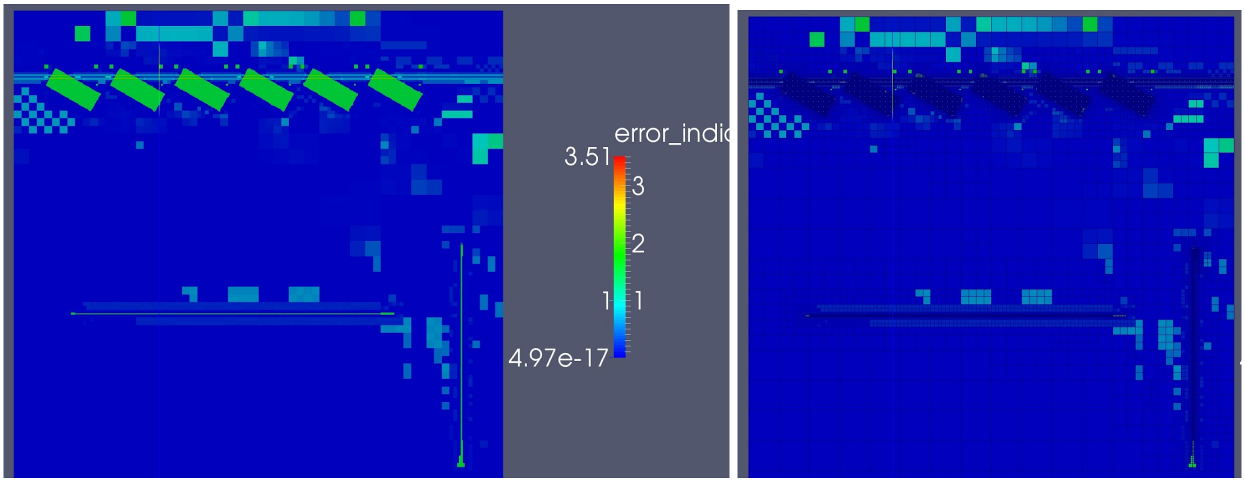
Another internal heating model based on the decay of radioactive isotopes is also in place which allow user to different isotopes and the concentration of isotopes in mantle and crust can be define differently which the crust can be defined by either depth or one of the compositional fields. Postprocessors were also be written to check the internal heating rate. The following figure shows internal heating rate change through time (radioactive heating elements in mantle and ‘crust’ have different concentrations and half life)



Menno Fraters

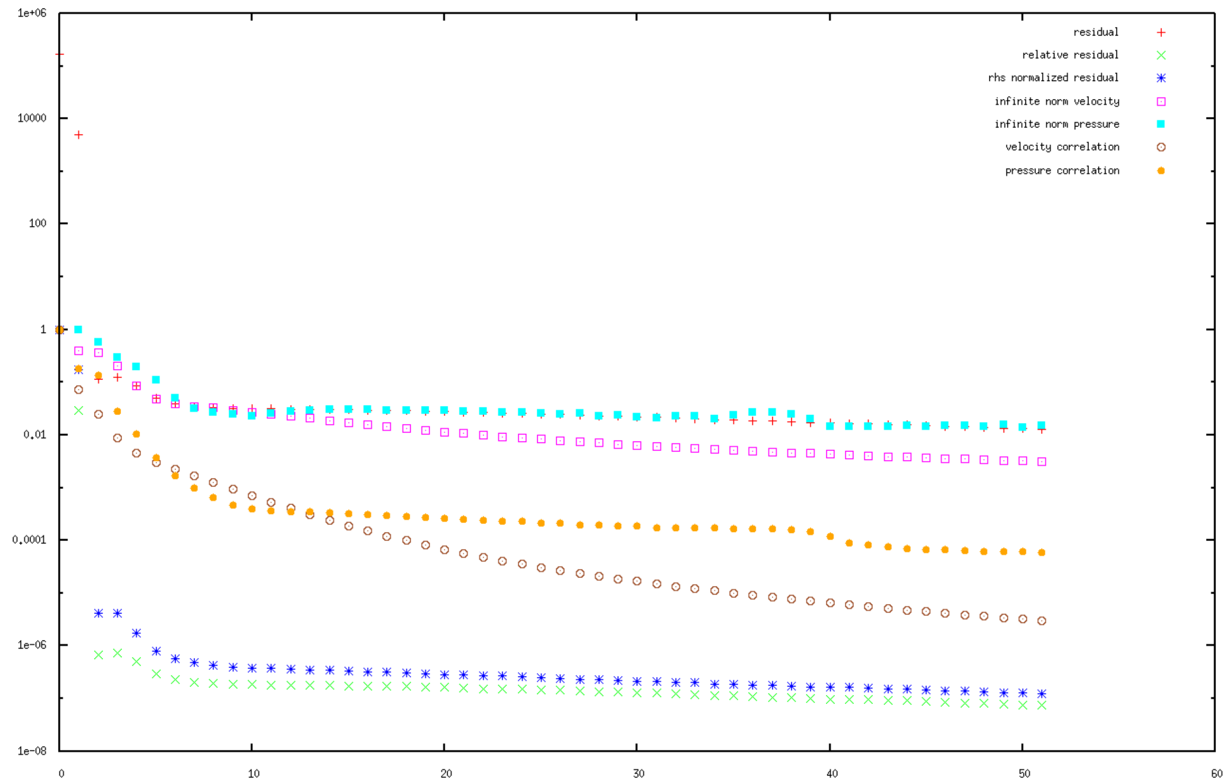
I mainly worked on making it possible to define your model largely through the input file instead of having to write separate plugins for all your models. To make this feasible, some adaptations had to be made within the core files, which were accepted in the mainline. The basic framework to easily add this function to every plugin has now also been created, and work on the actual implementation of several easy to use shapes into this framework is still being carried out.





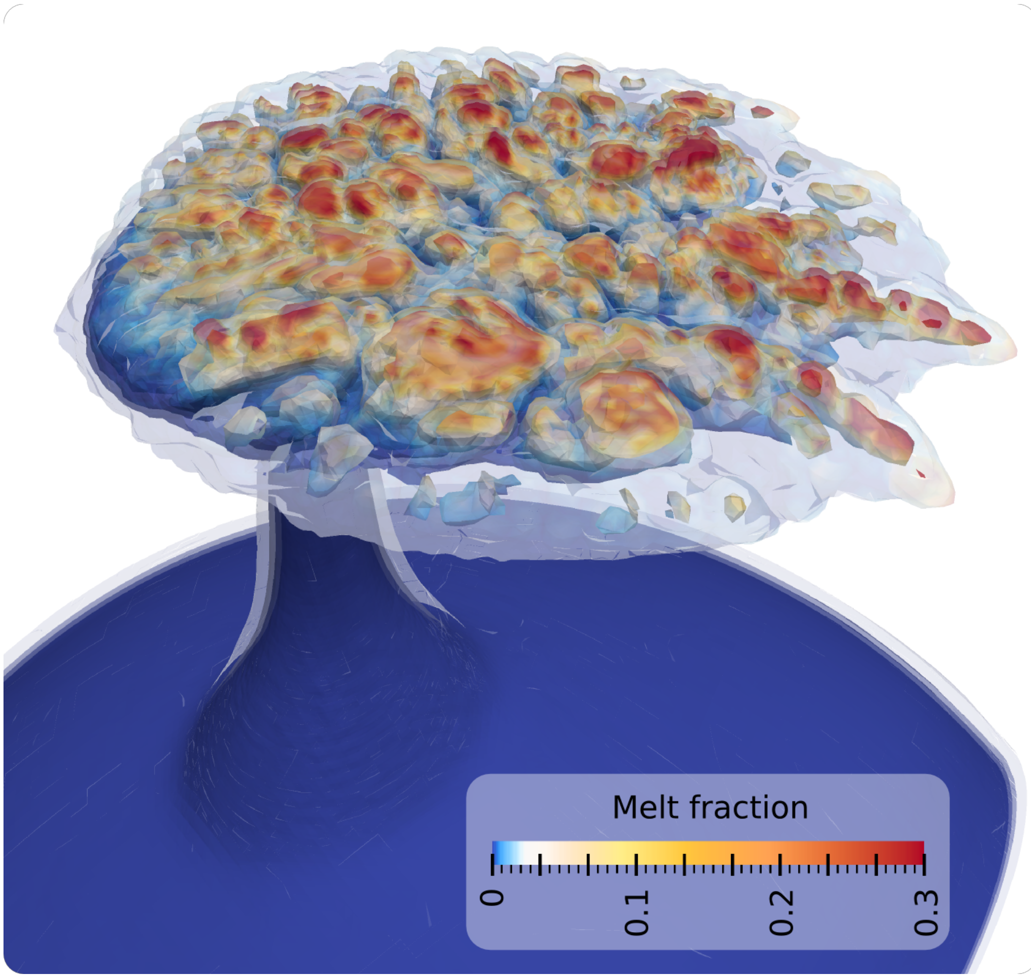
Anne Glerum & Cedric Thieulot

We worked on the implementation of different stopping criteria for the nonlinear iterations of the ‘iterated IMPES’, ‘iterates Stokes’ and ‘Stokes only’ nonlinear solvers. The different criteria include a residual normalized by the right-hand-side; a normalized infinite norm of the difference between the previous and current solution (velocity or pressure); and the correlation of the previous and current solution (velocity or pressure). For a rigid plastic punch problem, the pressure and velocity correlation criteria show a behaviour different from each other and from the relative residual (the current stopping criterion), as shown in the figure. We are currently investigating appropriate default values.



Anne Glerum
I worked on unifying the different nonlinear solvers and added some output information. Also, I wrote several simple postprocessors required for specific benchmarks (min/max velocity on the boundaries, radial and tangential RMS velocities and viscous dissipation).

Juliane Dannberg & Timo Heister
We mainly worked on the implementation of melting models and melt transport in Aspect. There is already a postprocessor that describes the melt fraction in dependence of temperature, pressure and composition, and I implemented and started to test a material model that also incorporates the effects of latent heat of melting. We already implemented the structures to add the additional variables and equation that are needed for melt transport, added an advection equation for an additional compositional field (the porosity field) and started to implement an additional equation for the compaction pressure.



Model of a mantle plume. Colors illustrate the melt fraction calculated using the melting postprocessor.

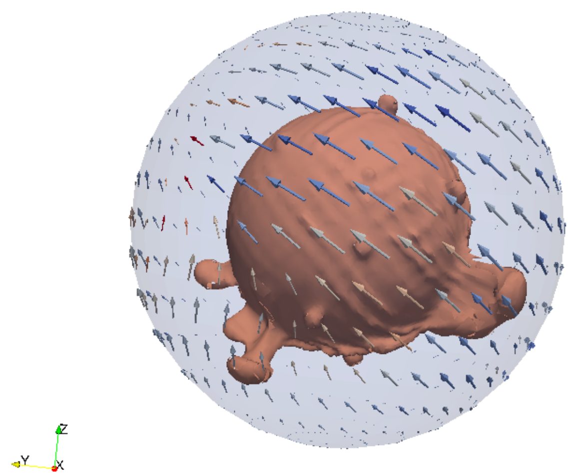
Wolfgang Bangerth

I worked on basically every part of the code, though maybe not in implementing any particular large feature. My main job during the hackathon was that of shepherd for the many many patches others wrote, both in terms of describing how to implement things, as well as commenting on patches and finally merging them. I also fixed a good number of bugs and corner cases that people ran into while implementing their own work, and developed infrastructure that was necessary to do what they wanted to do.

In addition, I implemented the foundations of what is necessary to have “open” boundary conditions. “Open” in the current context means that we impose tractions that are exclusively due to a pressure force, i.e., they are normal to the boundary. This requires adding boundary forces to the assembly of the Stokes right hand side, and is implemented in practice through a system of plugins (like almost everything else) that allows to provide a wide variety of different descriptions how these tractions should look like. As of writing this text, the implementation works but produces the wrong results.

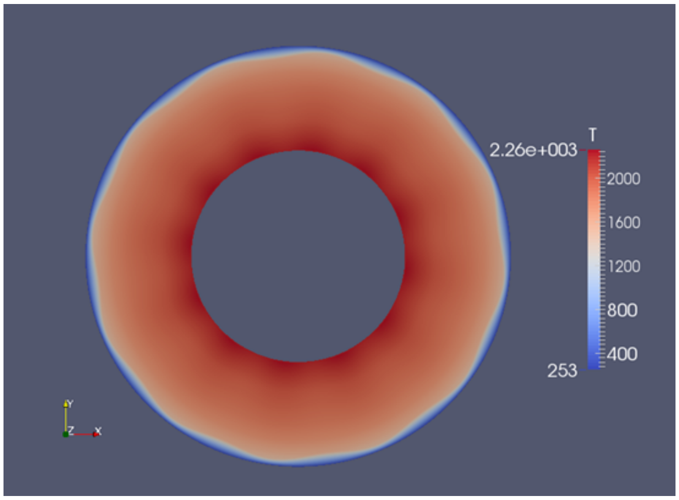
Nan Zhang

I am working on a general tool putting high resolution spherical caps in a low resolution global spherical shell. While Timo finished most part of this plug-in before me, I feel that I still have some details for add-in. Additionally, I learned to run time-dependent plate-motion driven model with ASPECT and compare it with CitcomS. An example of the kind of runs I have been doing is shown below.



Siqi Zhang

An initial temperature plugin was created to make the model start at a temperature close to solidus given by a data file, and with a lithosphere which its thickness can be defined by user, perturbation in temperature and lithosphere thickness are also included in this plugin. The following figure shows how this plugin works.

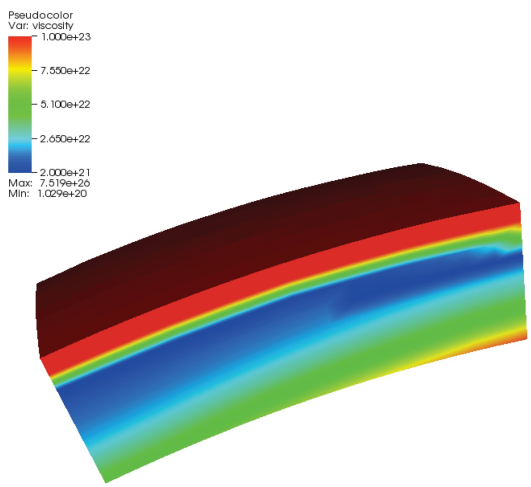


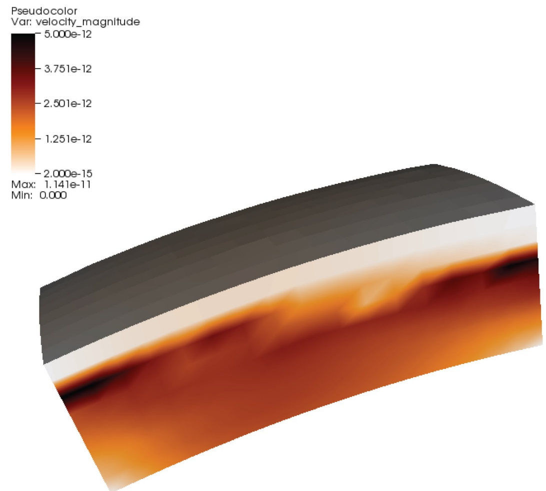
Wolfgang Bangerth & Siqi Zhang

The temperature boundary condition plugin has changed so that it now can be time dependent. A temperature boundary condition based on core energy balance that dynamically changes the core-mantle boundary temperature is to going be ported to this new interface.

D. Sarah Stamps

I updated several features of my regional, instantaneous, realistic Earth's curvature model that make it more flexible with respect to the region of interest on Earth to model, the input files, and the rheological flow laws. Now the region is defined with 4 coordinates and a chosen depth in the Geometry model subsection of the parameter file. Prior to the workshop this model used input files for topography and lithospheric thickness that needed to be the same resolution as ETOPO1. Now the input files can be any resolution provided it is uniform and high enough in resolution to resolve features of interest. During this workshop I added in the ability to define the crustal region such I can assign dislocation creep flow law below the crust to the base of the thermal lithosphere (user defined with an input file). The user can also define a different density for the crust now. Dislocation creep governs the mantle lithosphere region and diffusion creep governs the rheology of sub-lithospheric mantle. To use the dislocation creep flow law I tested iterative non-linear solvers to ensure the viscosity and velocity solutions are consistent. The figures below show a viscosity solution (left) and associated velocity magnitudes (right) for a 500 km deep lithosphere-mantle regional model. Viscosity magnitudes are lower beneath the lithosphere and increase with depth. Velocity magnitudes are relatively higher beneath the lithosphere and slowest at the surface.



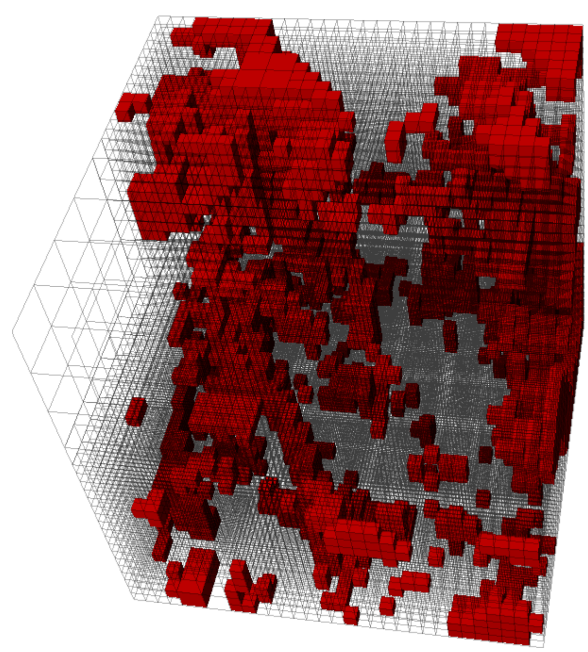


Katrina Arredondo

Setting up a simple subduction zone identical to those from Billen and Hirth, 2007 and from my upcoming paper. The initial temperature, material model (viscosity and rheology) and viscosity boundary condition were fine-tuned and nearly completed. Simple runs of the model were completed but more more work is required before the final cookbook for the manual can be completed.

Timo Heister

I spent most of my time jumping around, helping others, and reviewing contributions. I gave a lot of individual help on using git, creating pull requests, and how to use the test suite. With my help Ian was able to integrate the free surface branch into the main version. In between I worked on small code cleanup, improvements to the manual, and the unit tests.

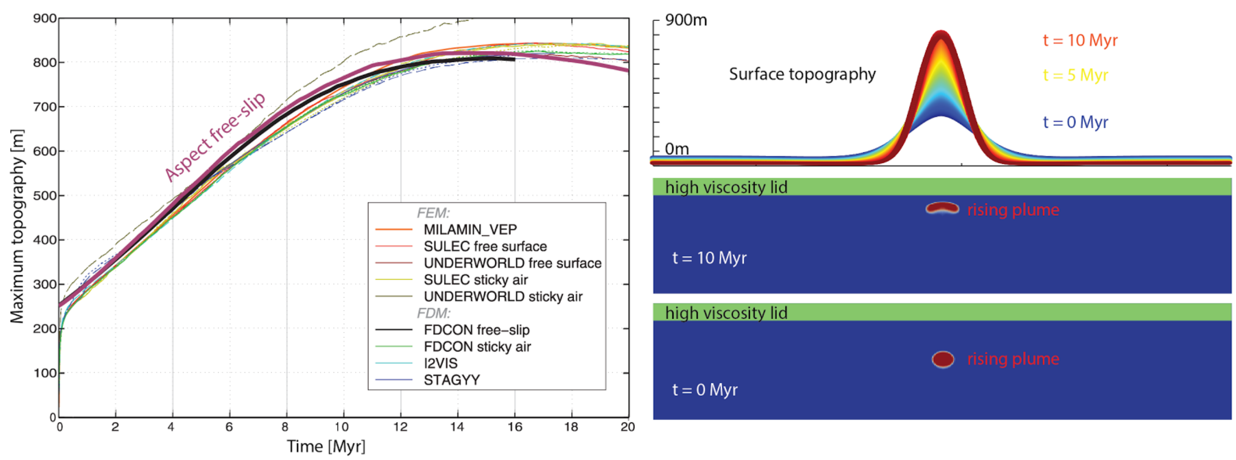


As a bigger project I was able to implement a direct solver for the Stokes system, which required some effort in modularizing the code base, which is helping us already for the integration of melt transport.

Finally, I started working on importing regular data like tomography data into Aspect. The goal is to create an adaptively refined mesh that resolves the input data with the smallest number of cells (homogeneous regions do not need small cells). This is still work in progress, but I have an example picture to show.

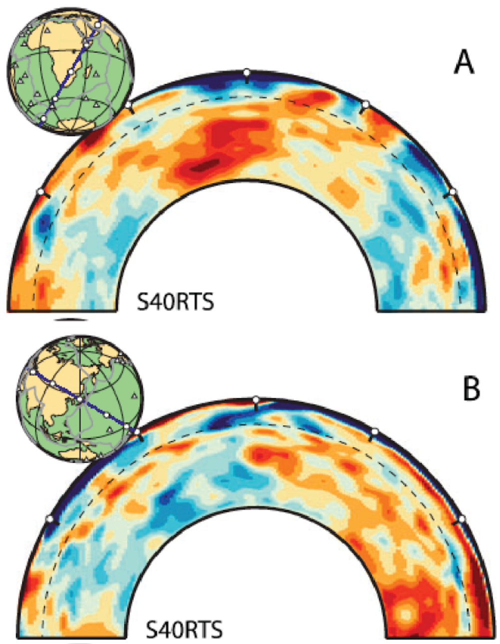
Jacky Austermann & Juliane Dannberg

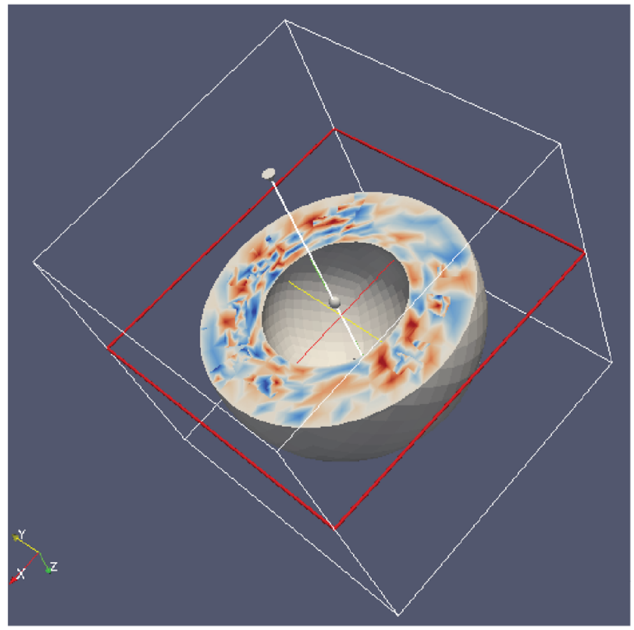
We have been working on calculating the deflection of the surface that is caused by viscous flow inside a domain, for example an upwelling plume or a subducting slab. The amount of deflection can be calculated from the radial stresses at the surface (without actually deforming the domain / remeshing). As an example, we computed the amount of surface topography that is caused by a rising plume. The lower right panels shows the model setup at two time steps (t = 0 Myr and t = 10 Myr). We included a rising plume and a highly viscous lid. The top right panel shows the surface deflection color-coded with time. As the plume rises the surface deflection increases until the plume stretches out underneath the lid. This calculation has been used for a community benchmark by Crameri et al. (2012). They compare the surface deflection that is caused by this setup using three different methods: sticky-air, free surface and free-slip - our method compares to the free-slip approach. The left panel shows the maximum height of the surface deflection over the time span 0 Myr - 20 Myr. Our free-slip topography is shown in pink, their free-slip calculation is shown in black. All other lines are model runs from sticky-air and free surface calculations. Ian has already worked on the free surface run with Aspect and Cedric is working on the sticky-air run with Aspect. We will compare our results from all these different runs and the results will be included in the benchmarking paper.



Jacky Austermann

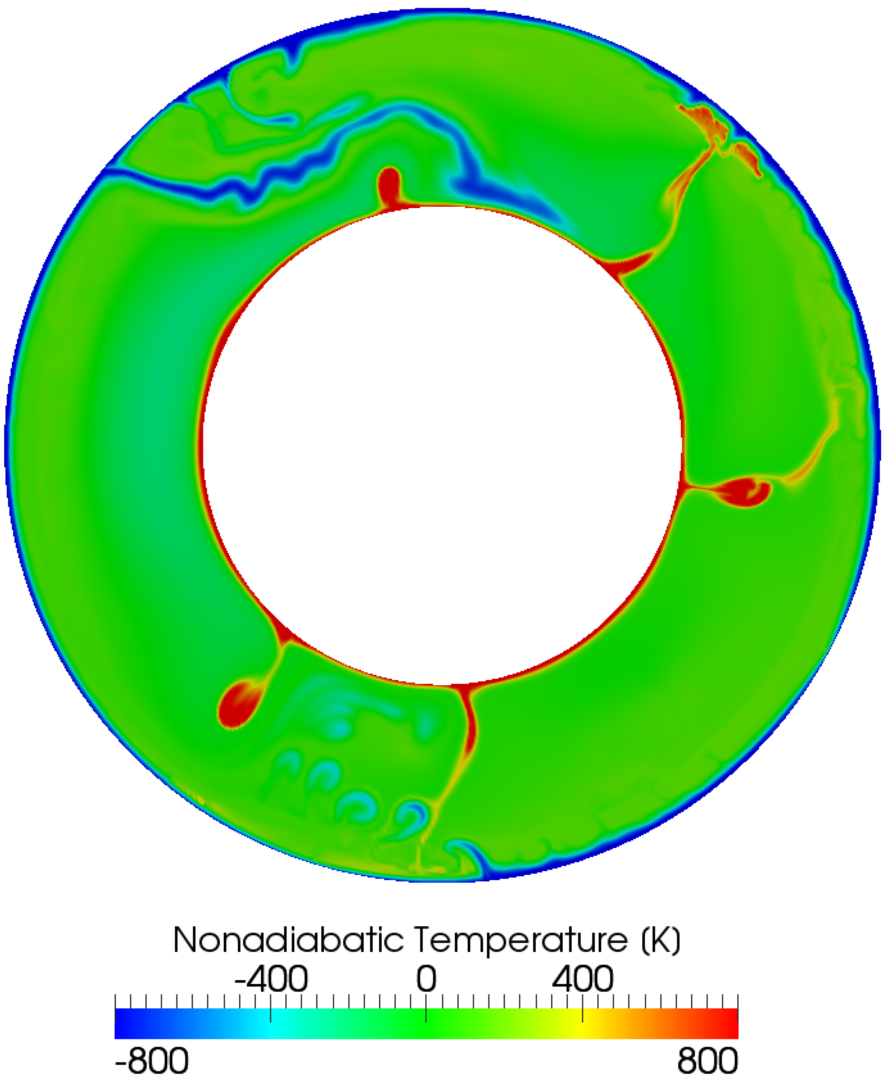
I've been working on implementing an initial condition that is prescribed by the tomography model S40RTS by Ritsema et al. (2011). S40RTS provides shear-wave perturbations that can be scaled to density perturbations and then to temperature perturbations. These are used as perturbations on the background temperature in the initial state of the model run. The figure below shows two exemplary slices through the S40RTS tomography model and the temperature perturbation that I can prescribe in Aspect so far. This is work in progress since I don’t yet correctly compute the perturbations. I will continue to work on this over the next couple of weeks.





Rene Gassmoeller

I have been working on the combination of highly temperature-dependent viscosity models with realistic prescribed velocity boundary conditions in compressible mantle convection models. The picture below shows the combination of the Steinberger material model plugin with the GPlates velocity boundary condition plugin, which are both included in Aspect.


Nonadiabatic Temperature (K)
-400
0
400
-800
800

Survey Results

General Questions

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree	Total	Average Rating
I learned new things on how to use ASPECT	0.00% 0	0.00% 0	8.33% 1	16.67% 2	75.00% 9	12	4.67
I learned how to contribute to ASPECT	0.00% 0	0.00% 0	0.00% 0	50.00% 6	50.00% 6	12	4.50
I made progress on my work during the hackathon or learned things that will help me with my work in the future.	0.00% 0	0.00% 0	0.00% 0	8.33% 1	91.67% 11	12	4.92
I learned other things useful for my work (version control, C++, etc.)	0.00% 0	0.00% 0	0.00% 0	25.00% 3	75.00% 9	12	4.75

Contribution

Answer Choices	Responses	
I contributed to ASPECT before the Hackathon	70.00%	7
I contributed to ASPECT during the Hackathon	90.00%	9
Total Respondents: 10		

Format

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree	Total	Average Rating
I am likely to contribute to ASPECT in the future.	0.00% 0	0.00% 0	0.00% 0	16.67% 2	83.33% 10	12	4.83
The Hackathon made it more likely that I will contribute in the future.	0.00% 0	0.00% 0	16.67% 2	16.67% 2	66.67% 8	12	4.50
The Hackathon was awesome!	0.00% 0	0.00% 0	0.00% 0	16.67% 2	83.33% 10	12	4.83
The Hackathon format was better than a typical workshop.	0.00% 0	0.00% 0	16.67% 2	16.67% 2	66.67% 8	12	4.50
This and future Hackathons are important for the development of ASPECT.	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 12	12	5.00
I am likely to participate in a future Hackathon (probably next year).	0.00% 0	0.00% 0	0.00% 0	0.00% 0	100.00% 12	12	5.00

Future Hackathons

	Fewer	Same	More	Total	Average Rating
the number of participants should be	0.00% 0	83.33% 10	16.67% 2	12	2.17
the number of days should be	25.00% 3	75.00% 9	0.00% 0	12	1.75

What suggestions do you have for improvements for a future Hackathon?

“I am pretty positive on the hackathon. It worked well, and I think we got some strong networking going. I would have liked to spend some more time identifying and working on small, significant improvements with others, but instead I spent most of the time working on my own stuff. That is as much my fault as anything else, though.”

“It might be nice to have a 2 slide intro from everyone at the beginning to know what people are working on / using aspect for.”

“blending lectures in the morning with programming/committing in the afternoon would give a bit more structure to the event in my opinion.”

“It was great the first time around.”

Do you have any other comments, questions, or concerns?

“Thanks for organizing!”

“Thanks for organizing the hackathon, it was awesome!”

“There should be a clear distinction between ASPECT tutorials and hackathons. Hackathons are intended for users already familiar with ASPECT, who would like to introduce certain features, ask for assistance with a special project, or want to contribute back to the community / learn about habits of development in the ASPECT community. A hackathon is not the best place for learning ASPECT.”

“a series of videos dedicated to ASPECT would be very nice for new users. They could reuse W's website videos partially. Certainly a video on git, ASPECT classes and algorithms would be useful.”

“Nice job keeping an atmosphere of mutual respect and support.”