

# Gerris examples

Version 1.2.0

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## 1 Introduction

This document is a collection of examples contributed by Gerris users and intended to illustrate the range of applications where Gerris is applicable. It should also serve as a useful starting point for customised applications.

The sections in this document are a rough classification of the various applications. In particular, an example appearing in a subsection usually indicates that this example is a relatively small incremental change over the parent example appearing in the section above it.

Gerris parameter files are commented and cross-linked with the Object Hierarchy<sup>1</sup> documentation. As a rule, the first examples in the document contain comments for most of the instructions in the parameter file. Latter examples only contain comments for the relevant new instructions or for more complex usage of already introduced instructions.

The indicative running times given are representative of the running time on an Intel 2.4 GHz processor.

The usefulness and quality of this document very much depend on the contributions of users. If you think you have used Gerris in an interesting way which is not already covered by the existing examples, you are very welcome to contribute. Have a look at section 5 for instructions on how to do so.

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<sup>1</sup>[http://gfs.sf.net/wiki/index.php/Object\\_hierarchy](http://gfs.sf.net/wiki/index.php/Object_hierarchy)

## 2 2D

### 2.1 Bénard–von Kármán Vortex Street for flow around a cylinder at $Re=160$

**Author** Stéphane Popinet

**Command** `gerris2D cylinder.gfs`

**Version** 1.1.0

**Required files** `cylinder.gfs` (view)<sup>2</sup> (download)<sup>3</sup>

**Running time** 32 minutes

An example of 2D viscous flow around a simple solid boundary. Fluid is injected to the left of a channel bounded by solid walls with a slip boundary condition. A passive tracer is injected in the bottom half of the inlet.

Adaptive refinement is used based on both the vorticity and the gradient of the passive tracer.

After an initial growth phase, a classical Bénard–von Kármán vortex street is formed.

The results are visualised using MPEG movies of the vorticity (Figure 1) and tracer concentration (Figure 2) generated on-the-fly.

Figure 1: MPEG movie of the vorticity field.

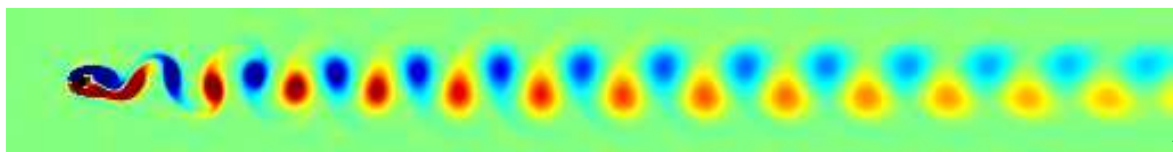
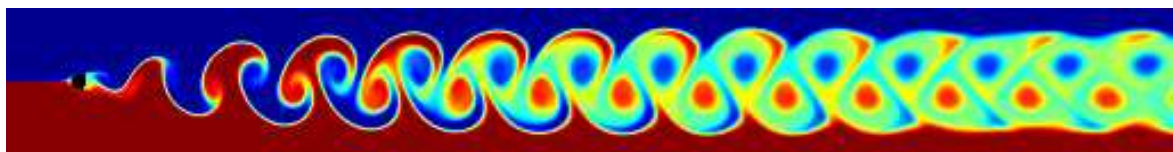


Figure 2: MPEG movie of the tracer field.



#### 2.1.1 Vortex street around a "heated" cylinder

**Author** Stéphane Popinet

**Command** `gerris2D heated.gfs`

**Version** 1.1.0

**Required files** `heated.gfs` (view)<sup>6</sup> (download)<sup>7</sup>

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<sup>2</sup>[cylinder/cylinder.gfs.html](#)

<sup>3</sup>[cylinder/cylinder.gfs](#)

<sup>6</sup>[cylinder/heated/heated.gfs.html](#)

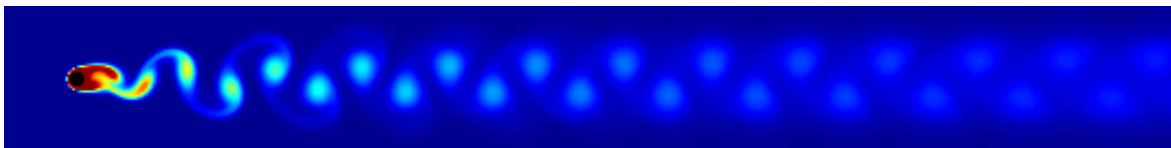
<sup>7</sup>[cylinder/heated/heated.gfs](#)

**Running time** 22 minutes

Same as the previous example but this time the tracer is "passive temperature" (i.e. the change in density due to heating is assumed to be negligible).

This is an example on how to solve an advection-diffusion equation for a tracer with Dirichlet boundary conditions on an immersed solid boundary.

Figure 3: MPEG movie of the tracer field.



## 2.2 Rayleigh-Taylor instability

**Author** Stéphane Popinet

**Command** `gerris2D rt.gfs | gfsview2D rt.gfv`

**Version** 1.1.0

**Required files** [rt.gfs \(view\)](#)<sup>9</sup> ([download](#))<sup>10</sup>  
[rt.gfv](#)<sup>11</sup>

**Running time** 12 minutes

A classical test case for the flow of two fluids of different densities. A sinusoidal interface separates the two fluids. The heavier fluid is on top. A mushroom-shaped instability develops in time as illustrated on Figure 4.

## 2.3 Boussinesq flow generated by a heated cylinder

**Author** Stéphane Popinet

**Command** `gerris2D boussinesq.gfs | gfsview2D boussinesq.gfv | ppm2mpeg > t.mpg`

**Version** 1.1.2

**Required files** [boussinesq.gfs \(view\)](#)<sup>14</sup> ([download](#))<sup>15</sup>  
[boussinesq.gfv](#)<sup>16</sup>

**Running time** 60 minutes

The classical Boussinesq approximation is applied to solve the flow generated by a heated cylinder. A source term proportional to a diffusive tracer is added to the vertical component of the velocity field.

Adaptivity is used to generate a "sponge" outflow condition on the top boundary.

The turbulent plume obtained is illustrated on Figure 6.

The movie is generated using the scripting mode of GfsView.

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<sup>9</sup>[rt/rt.gfs.html](#)

<sup>10</sup>[rt/rt.gfs](#)

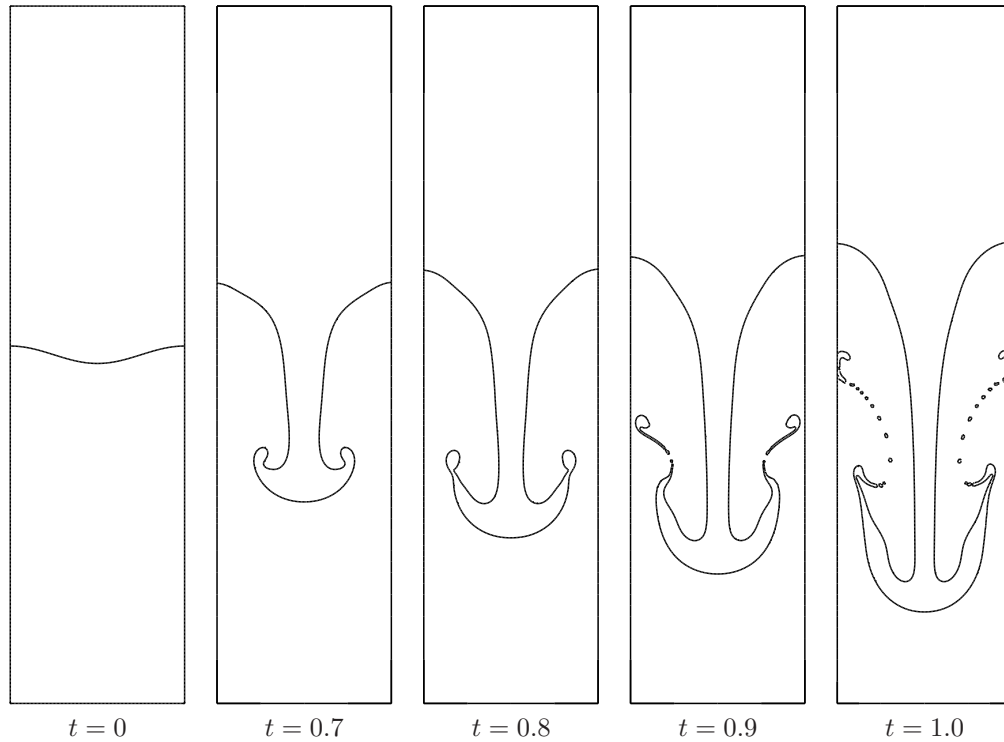
<sup>11</sup>[rt/rt.gfv](#)

<sup>14</sup>[boussinesq/boussinesq.gfs.html](#)

<sup>15</sup>[boussinesq/boussinesq.gfs](#)

<sup>16</sup>[boussinesq/boussinesq.gfv](#)

Figure 4: Evolution of the interface.



## 2.4 Coalescence of a pair of Gaussian vortices (Gerris logo)

**Author** Stéphane Popinet

**Command** `gerris2D logo.gfs | gfsview2D logo.gfv`

**Version** 1.0.0

**Required files** `logo.gfs` (view)<sup>18</sup> (download)<sup>19</sup>  
`logo.gfv`<sup>20</sup>

**Running time** 5 minutes

This example generates the Gerris desktop logo (Figure 7).

A pair of Gaussian vortices slowly merge. This is the primary mechanism controlling the evolution of two-dimensional turbulence and consequently has been studied in some detail.

## 3 3D

### 3.1 Turbulent air flow around RV Tangaroa

**Author** Stéphane Popinet

**Command** `gerris3D tangaroa.gfs | gfsview3D sections.gfv | ppm2mpeg -s 640x480 > sections.mpg`

**Version** 0.9.2

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<sup>18</sup>`logo/logo.gfs.html`

<sup>19</sup>`logo/logo.gfs`

<sup>20</sup>`logo/logo.gfv`

Figure 5: MPEG movies of the tracer and vorticity fields.

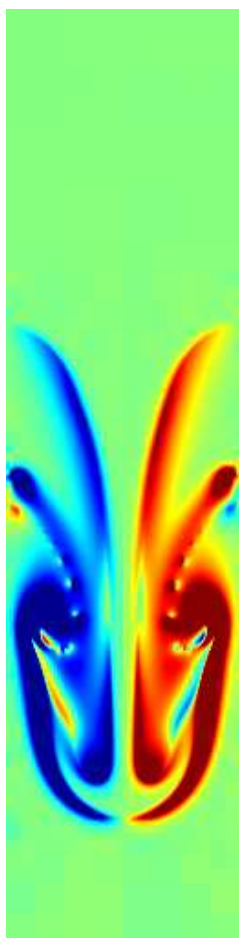
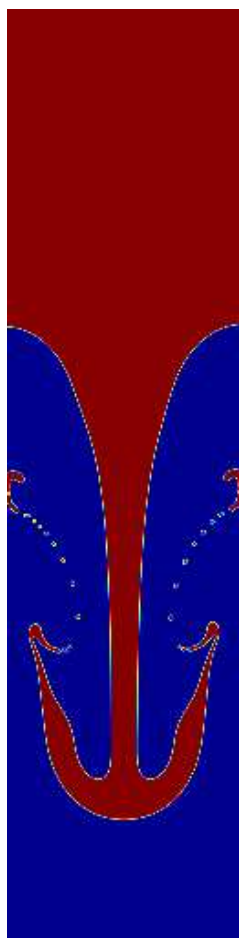


Figure 6: MPEG movie of the tracer field.

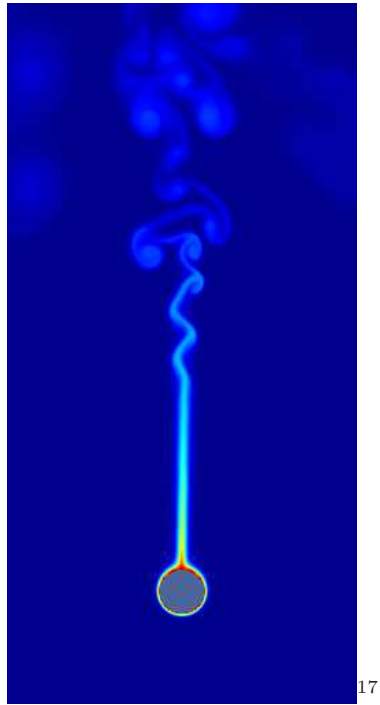
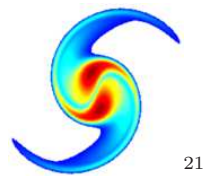


Figure 7: Gerris logo and animation.

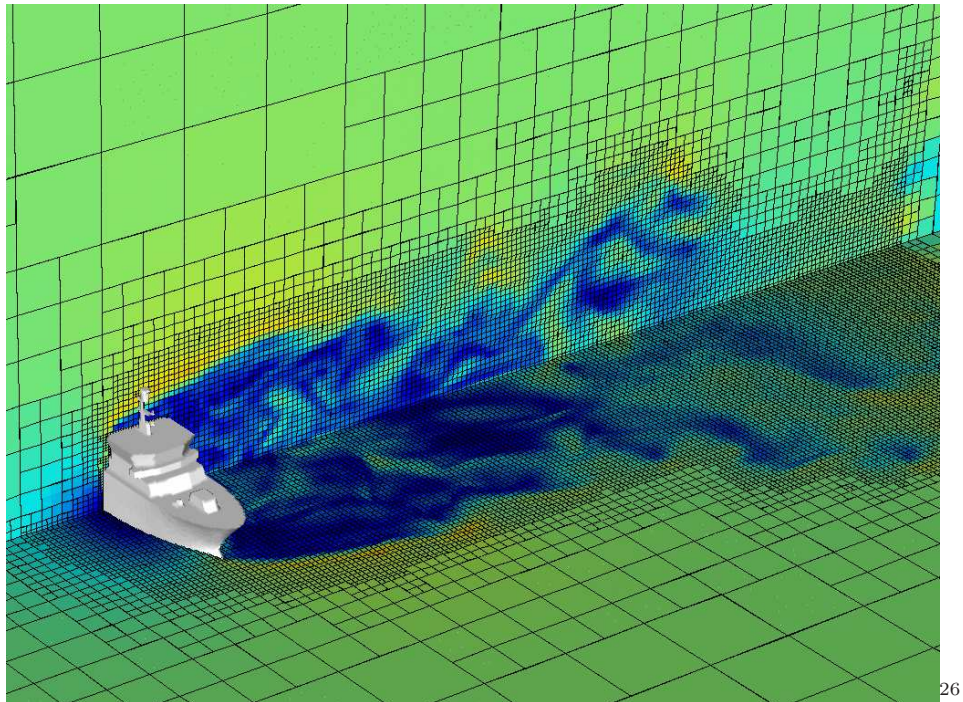


**Required files** [tangaroo.gfs \(view\)<sup>22</sup>](#) ([download](#))<sup>23</sup>  
[tangaroo.gts](#)<sup>24</sup> [sections.gfv](#)<sup>25</sup>

**Running time** 7 hours

An example of the simulations described in Popinet, Smith and Stevens (2004), *Journal of Atmospheric and Oceanic Technology*, 21.

Figure 8: MPEG movie of the adaptive mesh. The two cross-sections are coloured according to the norm of the velocity vector.



## 4 Shallow-water

### 4.1 Lunar tides in Cook Strait, New Zealand

**Author** Stéphane Popinet

**Command** `sh tides.sh`

**Version** 1.1.2

**Required files** [tides.gfs \(view\)<sup>27</sup>](#) ([download](#))<sup>28</sup>

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<sup>22</sup>[tangaroo/tangaroo.gfs.html](#)

<sup>23</sup>[tangaroo/tangaroo.gfs](#)

<sup>24</sup>[tangaroo/tangaroo.gts](#)

<sup>25</sup>[tangaroo/sections.gfv](#)

<sup>27</sup>[tides/tides.gfs.html](#)

<sup>28</sup>[tides/tides.gfs](#)

tides.sh<sup>29</sup> bathymetry<sup>30</sup> coefficients<sup>31</sup> amplitude.gfv<sup>32</sup> ellipses.gfv<sup>33</sup> phase.gfv<sup>34</sup> residual.gfv<sup>35</sup>  
tides.gfv<sup>36</sup>

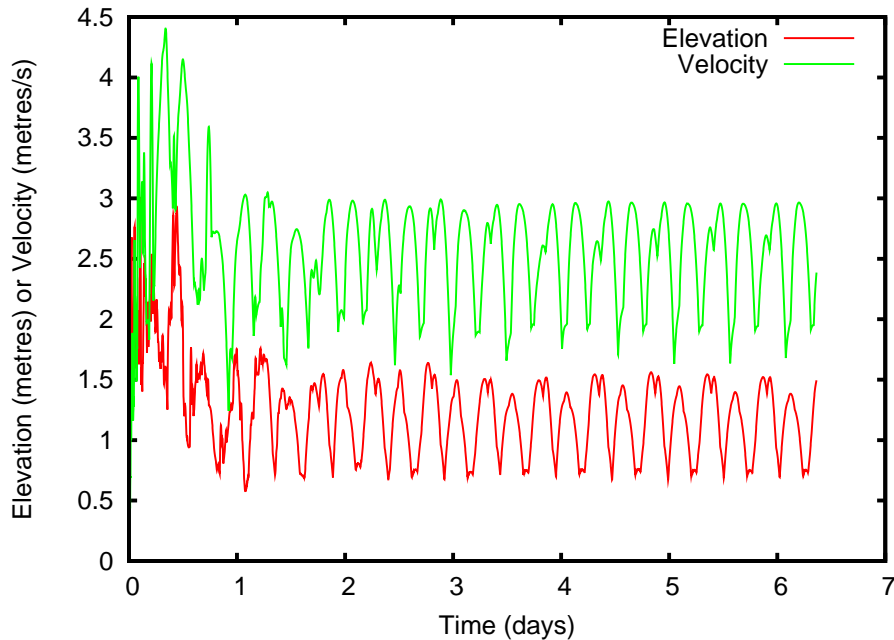
### Running time 2 hours

The shallow-water equations are solved using the "ocean" version of Gerris. The tidal elevations for the lunar (M2) component obtained from a larger-area tidal model are imposed as conditions on the boundaries of the domain.

The comments in the tides.sh<sup>37</sup> script describe how to generate the appropriate GTS files from the tidal elevation and bathymetry data.

After an initial transient ( $t < \approx 1$  day) due to relaxation of the model toward a state consistent with the mathematical model and with the imposed boundary conditions, the model reaches a periodic regime (Figure 9).

Figure 9: Evolution of the maximum velocity and elevation with time.



Online harmonic decomposition can then be used to extract the amplitudes and phases of the computed M2 tidal components. The simulation stops automatically when convergence of the harmonic decomposition is reached (Figure 10).

The final tidal amplitudes and phases are illustrated in Figures 11 and 12 respectively. The harmonic decomposition is also applied to the velocity field. The results can be represented as tidal ellipses (Figure 13) and residual currents (Figure 14).

Note that the results for this simulation will not be as good as these described in Rym Msadek's technical report<sup>38</sup> because iterative Flather conditions have not been applied. See the report for details.

<sup>29</sup>tides/tides.sh

<sup>30</sup>tides/bathymetry

<sup>31</sup>tides/coefficients

<sup>32</sup>tides/amplitude.gfv

<sup>33</sup>tides/ellipses.gfv

<sup>34</sup>tides/phase.gfv

<sup>35</sup>tides/residual.gfv

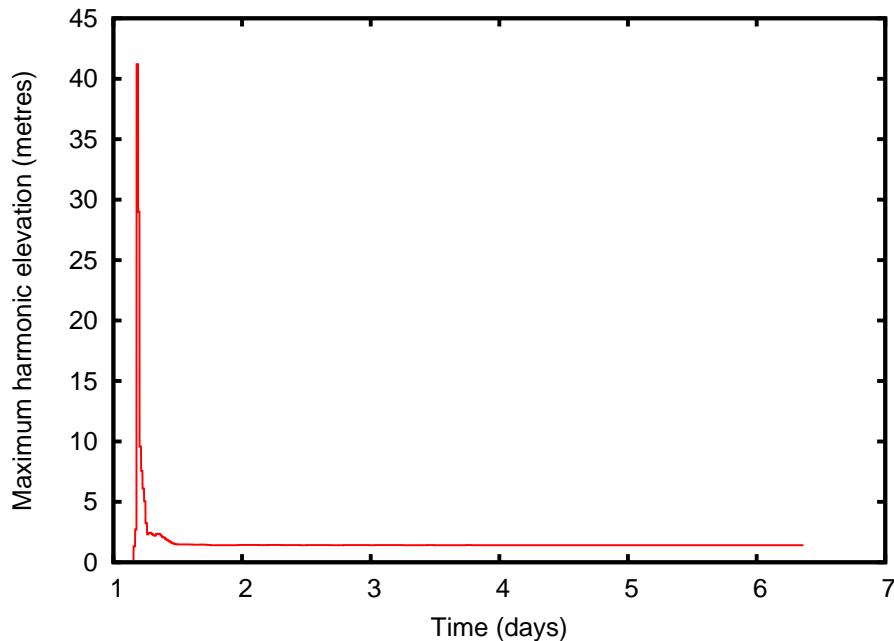
<sup>36</sup>tides/tides.gfv

<sup>37</sup>tides/tides.sh

<sup>38</sup><http://gfs.sf.net/tides.pdf>



Figure 10: Convergence of the maximum tidal amplitude (estimated from harmonic decomposition) with time.



## 5 How to write examples

This document is generated automatically using self-documenting Gerris parameter files. If you look at any<sup>39</sup> of the `.gfs` files in this document you will see that apart from comments on specific instructions, the top of the file contains fields which describe the simulation. They are:

**Title:** the title of the simulation.

**Description:** a Latex block of text describing the simulation. It can contain figures, tables, equations etc. . .

**Author:** you.

**Command:** the exact command needed to run the example.

**Version:** the version of Gerris you used (output of `gerris2D -V`).

**Required files:** any file (e.g. GTS files etc. . .) other than the Gerris simulation file required to run the simulation. Try to keep the total size of these files reasonable.

**Running time:** the approximate total running time of the simulation. This is of course machine-dependent but must be appropriately scaled to be representative of the running time on an Intel 2.4 GHz processor.

**Generated files:** any file (movies, images, curves etc. . .) generated by the simulation.

Apart from the “Description:” field all the fields must fit on a single line just after the field name.

Any extra data you need for the description (e.g. figures as EPS files) must be generated by the simulation. Have a look at other examples to see how this can be done.

Once you have an initial draft for your documented parameter file, you need to package it like this:

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<sup>39</sup>`cylinder/cylinder.gfs`

Figure 11: Tidal amplitude estimated from the harmonic decomposition. Dark red is 1.4 metres, dark blue is 0.

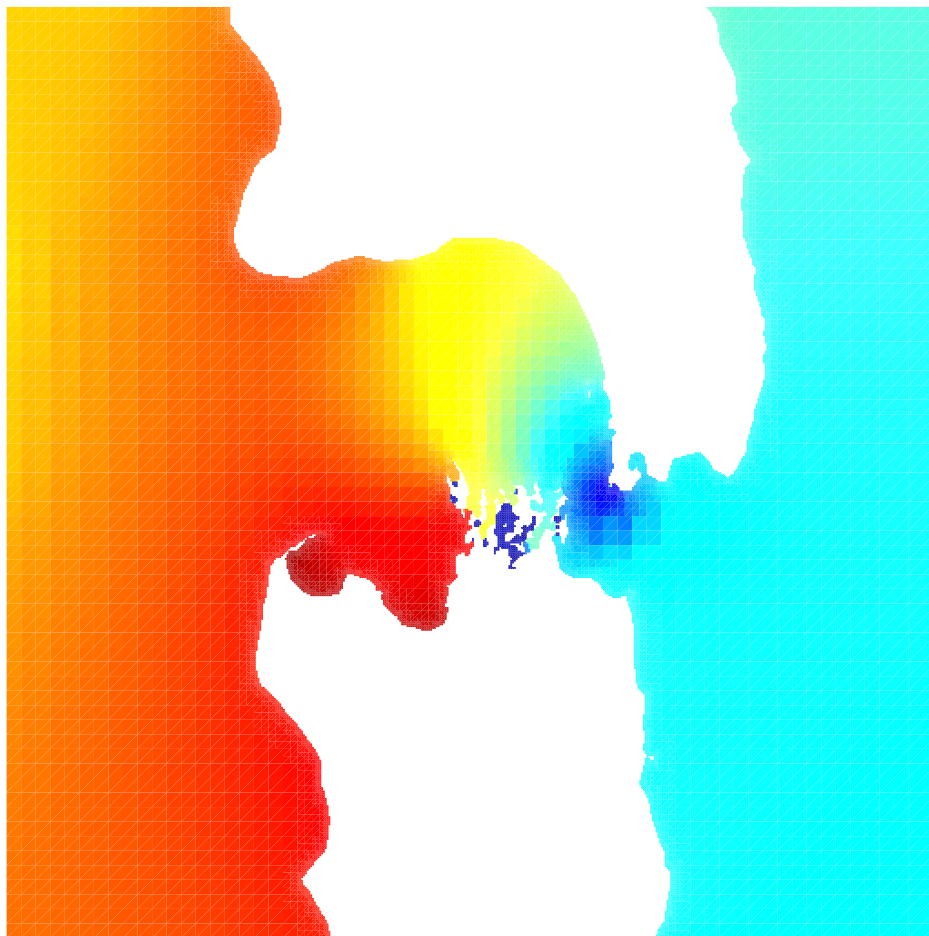


Figure 12: Tidal phase estimated from the harmonic decomposition. Dark red is 180 degrees, dark blue -180 degrees.

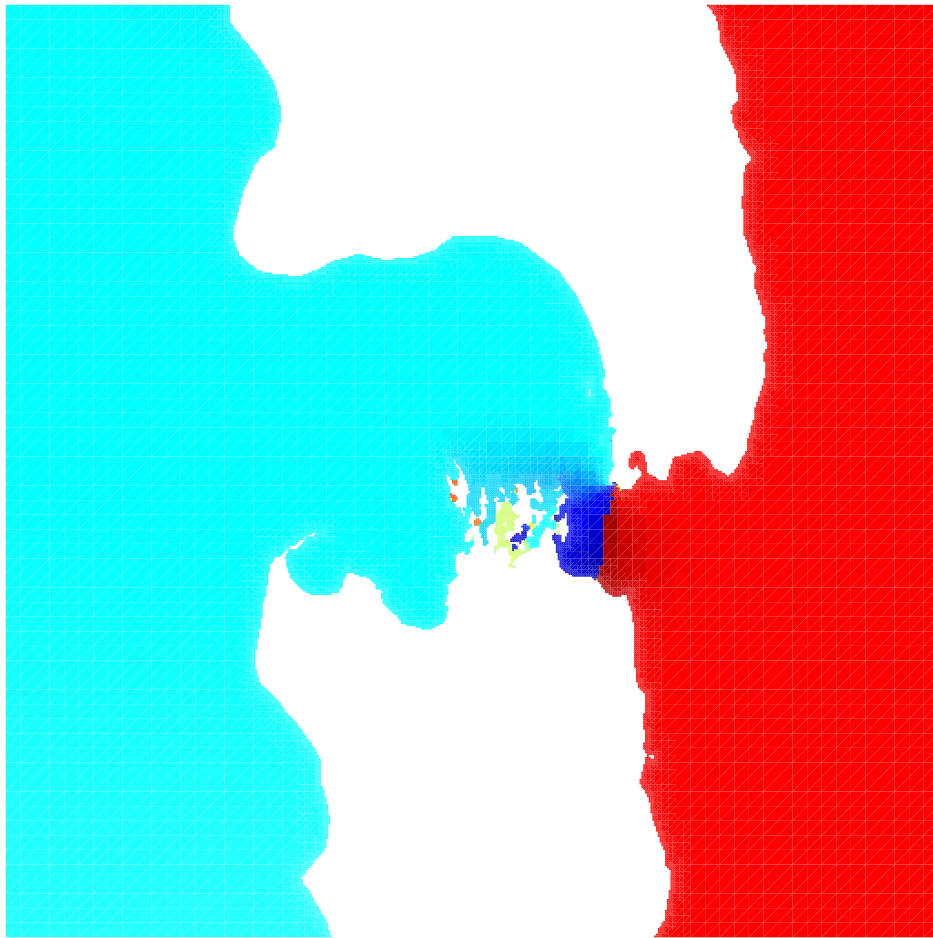


Figure 13: Detail of tidal ellipses estimated from the harmonic decomposition coloured according to maximum current speed. Dark red is 2 metres/sec, dark blue is zero.

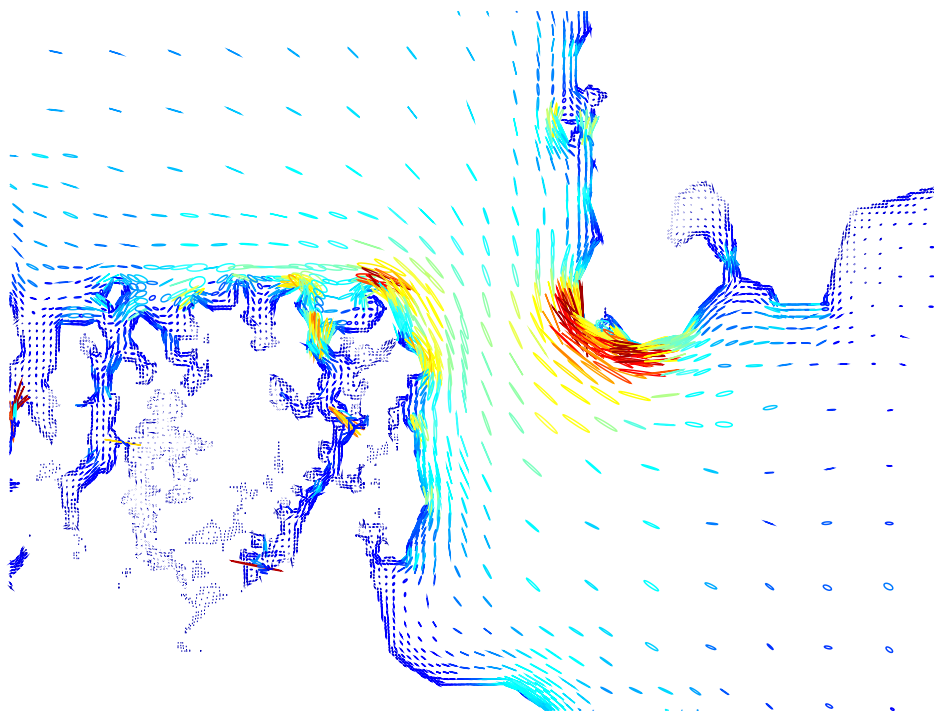
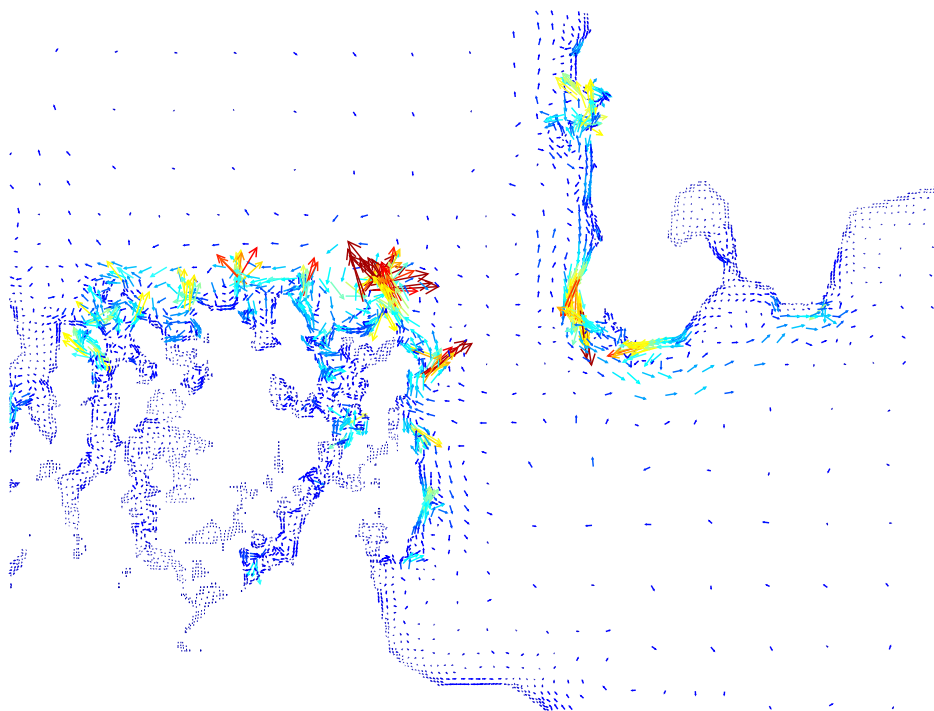


Figure 14: Detail of residual tidal currents estimated from the harmonic decomposition coloured according to residual current speed. Dark red is 0.6 metres/sec, dark blue is zero.



1. Choose a short name for your example. This short name should not already be used by any of the examples in this document. Let's say `myexample`.
2. Create a directory `myexample`.
3. Copy your parameter file in `myexample/myexample.gfs`. You must use the same name for the directory and the parameter file.
4. Copy any other file you need (as listed in the "Required files:" field) in `myexample`.
5. Cd to `myexample` and re-run the simulation (using the command listed in the "Command:" field) or alternatively copy the previously generated files listed in the "Generated files:" field into `myexample`.
6. Cd to `myexample/..`
7. Generate the HTML and PDF documentation for your example using:

```
% gfs2doc myexample
```

Note that this script requires `hevea`<sup>40</sup>.

8. Check that the `myexample.html/index.html` and `myexample.pdf` files are to your liking. If they are not, edit your parameter file and return to 7.
9. Send me (`s.popinet` at `niwa.cri.nz`) your example (`myexample.tgz` as an attachment). Tell me which section, subsection you think it would most naturally fit in (or request a new section). I will then review it and integrate it in this document.

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<sup>40</sup><http://pauillac.inria.fr/~maranget/hevea/index.html>