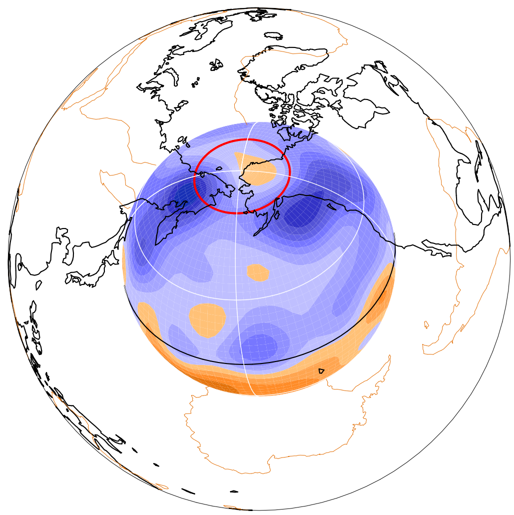
LEOPACK



rsvfg

Random **S**olution **V**ector **F**ile **G**enerator

Steven J. Gibbons, Oslo

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1 rsvfg

Random **S**olution **V**ector **F**ile **G**enerator

Generates a 'random' solution vector in standard format (i.e. `.ints`, `.vecs` and `.xarr` files) which satisfies the requested characteristics. Uses the subroutine **SHVECF** to fill in radial functions with **VERY** arbitrary functions which satisfy the appropriate boundary conditions. (Setting the parameter `FAC = 0.0d0` ofcourse outputs a zero vector.)

The input file must have the following format

```
* input file for rsvfg
root                                        : File-name stem
 35     4                                   : nr  iformf
 0.6666666666    1.6666666666  2  0.01 : ri   ro   insf  fac
 16     1     0     2     2     6       : lhv isv lhm ism minc mmax
 2           1                          : ivelbc ithebc
```

Any line in the input file beginning with an asterisk, `*`, is ignored by the program and can thus be used to enter comments and notes.

The arguments are as follows

- `filename stem`: First characters in output files to be generated by current run. Running `rsvfg` with the above input file will create the files `root.ints`, `root.vecs` and `root.xarr`.
- `nr`: number of radial grid nodes requested.
- `iformf`: Flag which chooses the order in which elements in the solution vector are stored. `iformf` can take the values `3` or `4`
- `ri`: Radius of the inner boundary, $r_{\rm i}$.
- `ro`: Radius of the outer boundary, $r_{\rm o}$.
- `insf`: Radial grid node spacings flag.
  `insf = 1` forces evenly spaced grid nodes from `ESNAAS` and `insf = 2` forces Chebyshev zero spaced nodes from `ZCPAAS`
- `fac`: Scales the random initial solution. It is probably best to begin with "numerical noise" and hence a low value of `fac`.
- `lhv`: Highest spherical harmonic degree, l requested for velocity and temperature

- `isv`: Symmetry flag for velocity.
  1. Velocity is equatorially symmetric (ES)
  2. Velocity is equatorially anti-symmetric (EA)
  3. Velocity contains both ES and EA parts
- `lhv`: Highest spherical harmonic degree, l requested for magnetic field
- `isv`: Symmetry flag for velocity.
  1. Magnetic field is equatorially symmetric (ES)
  2. Magnetic field is equatorially anti-symmetric (EA)
  3. Magnetic field contains both ES and EA parts
- `minc`: Increment of wavenumber.
- `mmax`: Maximum wavenumber. For example, `minc = 2` and `mmax = 6` will include the wavenumbers $\{0, 2, 4, 6\}$.
- `ivelbc`: Velocity boundary condition:
  1. Rigid (no-slip) boundary condition
  2. Stress-free (free-slip) boundary condition
- `ithebc`: Temperature boundary condition:
  1. Fixed temperature at inner and outer boundaries
  2. Fixed temperature at inner boundary and fixed heat-flux at outer boundary
  3. Fixed heat-flux at inner boundary and fixed temperature at outer boundary

1.1 Subprograms required for rsvfg

SUBS subroutines

```
esnaas.f zcpaas.f hminda.f shvecf.f hmfwt.f xarrwt.f
svfwt.f fopen.f fclose.f smitsl.f pmfabf.f fnamer.f
mnewtr.f
```

SUBS double precision function

```
pvnsrf.f tvsfrf.f pvsfrf.f pmfirf.f chorch.f chorcf.f
chorsf.f pmfsef.f
```

SUBS integer function

`indfun.f`

BLAS integer function

`idamax.f`

BLAS subroutines

`dgemm.f dtrsm.f dger.f  dscal.f dswap.f`

LAPACK subroutines

`dgetrf.f dgetrs.f dgetf2.f dlaswp.f xerbla.f`

LAPACK integer function

`ilaenv.f`

LAPACK logical function

`lsame.f`

1.2 Run-time limitations

Several parameters are set at the outset which limit the physical size of the problem.

```
 INTEGER NRMAX, NHMAX, LHMAX, NDCS, ISVMAX
 PARAMETER ( NRMAX = 300, NHMAX = 6000, LHMAX = 64,
1            NDCS  = LHMAX + 6, ISVMAX = NRMAX*NHMAX )
```

If the values are insufficient, then change them and recompile.

- `NRMAX` is the maximum number of radial grid nodes allowed.
- `NHMAX` is the maximum number of spherical harmonic radial functions allowed.
- `LHMAX` is the highest permitted spherical harmonic degree, l.

1.3 Outputs from RSVFG

If the filename stem "root" was specified in the input file, the files `root.ints`, `root.vecs` and `root.xarr` will all be created.

1.4 Sample runs of rsvfg

The directory

`$LEOPACK_DIR/SAMPLERUNS/RSVFG`

contains example input files and model output. Do not under any circumstances edit these files, as these examples should serve as a control for the correct working of the code. After compiling the program, copy the `.input` files to another directory, run the code and confirm that the output agrees with that in the directory.

1.4.1 Example a

The program **sbrlinonsd** calculates the critical Rayleigh number for the onset of convection in a spherical shell. In addition it solves for which drifting frame of reference is necessary for the solution to be stationary. In particular, it was used to reproduce some results from the paper [ZB87].

sbrlinonsd finds the critical Rayleigh number for $E = 10^{-3}$, $P = 1$, radius ratio 0.4, stress-free boundaries and fixed temperature to be 1.32×10^4 with a critical wavenumber of 6.

We would like to calculate a non-linear solution for a supercritical Rayleigh number for this case. We therefore need an initial solution. Firstly, given that the critical wavenumber is 6, we will concentrate on solutions which obey a six-fold symmetry in ϕ and so set `minc = 6`. We see that the critical Rayleigh number is converged very well for `LH = 26` and `NR = 50`.

We will then try our input file as follows for a non-magnetic initial condition:

```
* example file for rsvfg
example_aOUTPUT                          : File-name stem
 50     4                                : nr  iformf
 0.6666666666    1.6666666666  2  0.001  : ri   ro   insf   fac
 26     1     0     2     6     24       : lhv isv lhm ism minc mmax
 2           1                           : ivelbc ithebc
```

References

[ZB87] K. Zhang and F. H. Busse. On the onset of convection in rotating spherical shells. *Geophys. Astrophys. Fluid Dyn.*, 39:119–147, 1987.