

RAYLEIGH TUTORIAL

MODULE 5: DIAGNOSTIC OUTPUTS



COMPUTATIONAL
INFRASTRUCTURE
for GEODYNAMICS

BEFORE WE BEGIN:

- Create a directory named module5
- Copy c2001_case0_input to module5/main_input
- DELETE benchmark_mode = 1
- TURN Magnetism ON and magnetic_init_type = 7
- Set to run for 50 time steps
- Set n_theta = 48
- Softlink rayleigh to module5 directory

IN THIS MODULE:

- Overview of Diagnostic Mechanics
- Diagnostic Types
- Diagnostic Quantities & Menu System

NOTE: We cover plotting/analysis in Module 5

RAYLEIGH DIAGNOSTICS: OVERVIEW

- Rayleigh performs a number of in-situ diagnostics
- Reduces disk usage and post-processing
- In-situ diagnostics represent varying degrees of slicing and averaging
- Controlled via the output namelist
- Each diagnostic stored in dedicated directory
- All outputs respect 2-D domain decomposition
- Many use MPI-IO

RAYLEIGH DIAGNOSTICS: MECHANICS

- Examine the output_namelist in main_input
- The prefix indicates the diagnostic TYPE
- This is a particular TYPE of analysis that MAY be performed

```
&output_namelist  
XXXX_values = 1, 2, 3, 64  
XXXX_frequency = 100  
XXXX_nrec = 10
```


RAYLEIGH DIAGNOSTICS: MECHANICS

- VALUES indicates WHAT should be analyzed in THIS fashion
- Numbers are code for physical quantities selected from menu
- In this example, we are analyzing the three velocity components (1,2,3) and temperature or entropy (64)

```
&output_namelist  
XXXX_values = 1, 2, 3, 64  
XXXX_frequency = 100  
XXXX_nrec = 10
```

RAYLEIGH DIAGNOSTICS: MECHANICS

- FREQUENCY indicates HOW OFTEN we perform THIS analysis
- Units are in time steps
- In this example, we perform our analysis of velocity and temperature once every 100 time steps

```
&output_namelist  
XXXX_values = 1, 2, 3, 64  
XXXX_frequency = 100  
XXXX_nrec = 10
```

RAYLEIGH DIAGNOSTICS: MECHANICS

- NREC indicates HOW MANY analyses are saved to one file
- In this example, 10 analyses are saved within each file.
- We generate a new file every 1000 time steps ($nrec * freq$)

```
&output_namelist  
XXXX_values = 1, 2, 3, 64  
XXXX_frequency = 100  
XXXX_nrec = 10
```


EXERCISE:

- Before we go any further, let's try this out
- Modify these portions (only) of main_input
- Run your code

```
&output_namelist  
  globalavg_frequency = 2  
  globalavg_nrec = 10  
  
  shellavg_frequency = 5  
  shellavg_nrec = 5
```

- Globalavg diagnostics are stored in G_Avgs
- Examine the contents of that directory
- Recall that
 - We output every 2nd time step
 - We stored 10 records per file

00000020 contains time steps:
2, 4, 6, 8, 10, 12, 14, 16, 18, 20

```
nick@nick-VirtualBox ~/Desktop/Rayleigh_Tutorial/module5 $ ls -lh G_Avgs/
total 12K
-rw-r--r-- 1 nick nick 472 Jun 17 14:57 00000020
-rw-r--r-- 1 nick nick 472 Jun 17 14:57 00000040
-rw-r--r-- 1 nick nick 252 Jun 17 14:57 00000060
```

00000060 contains time steps: 52, 54, 56, 58, 60

- Shellavg diagnostics are stored in Shell_Avgs
- Examine the contents of that directory
- Recall that
 - We output every 5th time step
 - We stored 5 records per file

00000025 contains time steps:
5, 10, 15, 20, 25

```
nick@nick-VirtualBox ~/Desktop/Rayleigh_Tutorial/module5 $ ls -lh Shell_Avgs/  
total 208K  
-rw-r--r-- 1 nick nick 101K Jun 17 14:57 00000025  
-rw-r--r-- 1 nick nick 101K Jun 17 14:57 00000050
```

00000050 contains time steps: 30, 35, 40, 45, 50

DIAGNOSTIC TYPES:

| Prefix | Directory | Description |
|--------------|---------------|---|
| globalavg | G_Avgs | Full-Volume Averages: $f = \frac{1}{V} \int_V g(r, \theta, \phi) dV$ |
| shellavg | Shell_Avgs | Averages over spherical surfaces: $f(r) = \frac{1}{4\pi} \int_0^{2\pi} \int_0^\pi g(r, \theta, \phi) \sin\theta d\theta d\phi$ |
| azavg | AZ_Avgs | Averages in longitude: $f(r, \theta) = \frac{1}{2\pi} \int_0^{2\pi} g(r, \theta, \phi) d\phi$ |
| shellslice | Shell_Slices | Spherical Surfaces: $f(r, \theta, \phi)$ |
| shellspectra | Shell_Spectra | Spherical harmonic spectra on surfaces |

SHELL SLICES AND SHELL SPECTRA

- Shell Slices and Shell Spectra have an additional line that needs to be specified:

```
&output_namelist  
  shellslice_levels   = 3,16,32,48,62  
  shellspectra_levels = 16,32,48
```

- This line specifies the INDICES of radii at which spherical surfaces or spectra are taken
- Index 1 corresponds to the upper boundary
- In our example, index 64 corresponds to the lower boundary

DIAGNOSTIC MENU CODES:

- Documentation in prep, but for now, examine:
rayleigh/physics/Diagnostics_Base.F90
- This is the code menu system. How do we read it?

```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!  Pressure, Entropy or Temperature, and Their Derivatives
!  Note:  In Boussinesq Mode, Temperature is Output
Integer, Parameter :: pt_off = voffset+63 ! = 63

!----- Fields -----!
Integer, Parameter :: entropy    = pt_off+1 ! Full
Integer, Parameter :: pressure   = pt_off+2

      : entropy_p  = pt_off+3 ! Fluctuating
      : pressure_p = pt_off+4

      : entropy_m  = pt_off+5 ! Mean
      : pressure_m = pt_off+6
```

Pressure code:
pressure = pt_off + 2
pt_off = 63
pressure = 65

Entropy code:
entropy = pt_off + 1
pt_off = 63
pressure = 64

See input examples for guidance!

Useful Menu Codes

| Quantity | Code |
|----------------------------|------|
| V_r | 1 |
| V_θ | 2 |
| V_ϕ | 3 |
| Radial Mass Flux | 55 |
| θ -Mass Flux | 56 |
| Temperature/Entropy | 64 |
| Pressure | 65 |
| Kinetic Energy | 125 |
| Axisymmetric V_ϕ - KE | 132 |
| B_r | 401 |
| B_θ | 402 |
| B_ϕ | 403 |
| Magnetic Energy | 475 |
| Axisymmetric B_ϕ - ME | 482 |

Final Thoughts

- Many possible outputs ...
- Only specified quantities are calculated
- Different diagnostics types can be used with different code combinations
- Try to sync your outputs so that infrequent outputs are written at same time as frequent outputs...

Useful Menu Codes

| Quantity | Code |
|----------------------------|------|
| V_r | 1 |
| V_θ | 2 |
| V_ϕ | 3 |
| Radial Mass Flux | 55 |
| θ -Mass Flux | 56 |
| Temperature/Entropy | 64 |
| Pressure | 65 |
| Kinetic Energy | 125 |
| Axisymmetric V_ϕ - KE | 132 |
| B_r | 401 |
| B_θ | 402 |
| B_ϕ | 403 |
| Magnetic Energy | 475 |
| Axisymmetric B_ϕ - ME | 482 |

Exercise

- Modify global averages:
 - Include magnetic energy
- Modify shell averages:
 - Include magnetic energy
- Modify shell slices:
 - Include B-field
 - Add additional radial levels
 - Output every 25th timestep
 - 2 records per file
- Run the code