RAYLEIGH TUTORIAL

MODULE 5: DIAGNOSTIC OUTPUTS

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 6

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: 42, 44, 46, 48, 50

- 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: $f(r_o,\theta,\phi)$
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 Der
!  Note:  In Boussinesq Mode, Temperature is Outpu
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
```

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
Vr	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
Br	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…

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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 25^{th} timestep
  - 2 records per file
- Run the code