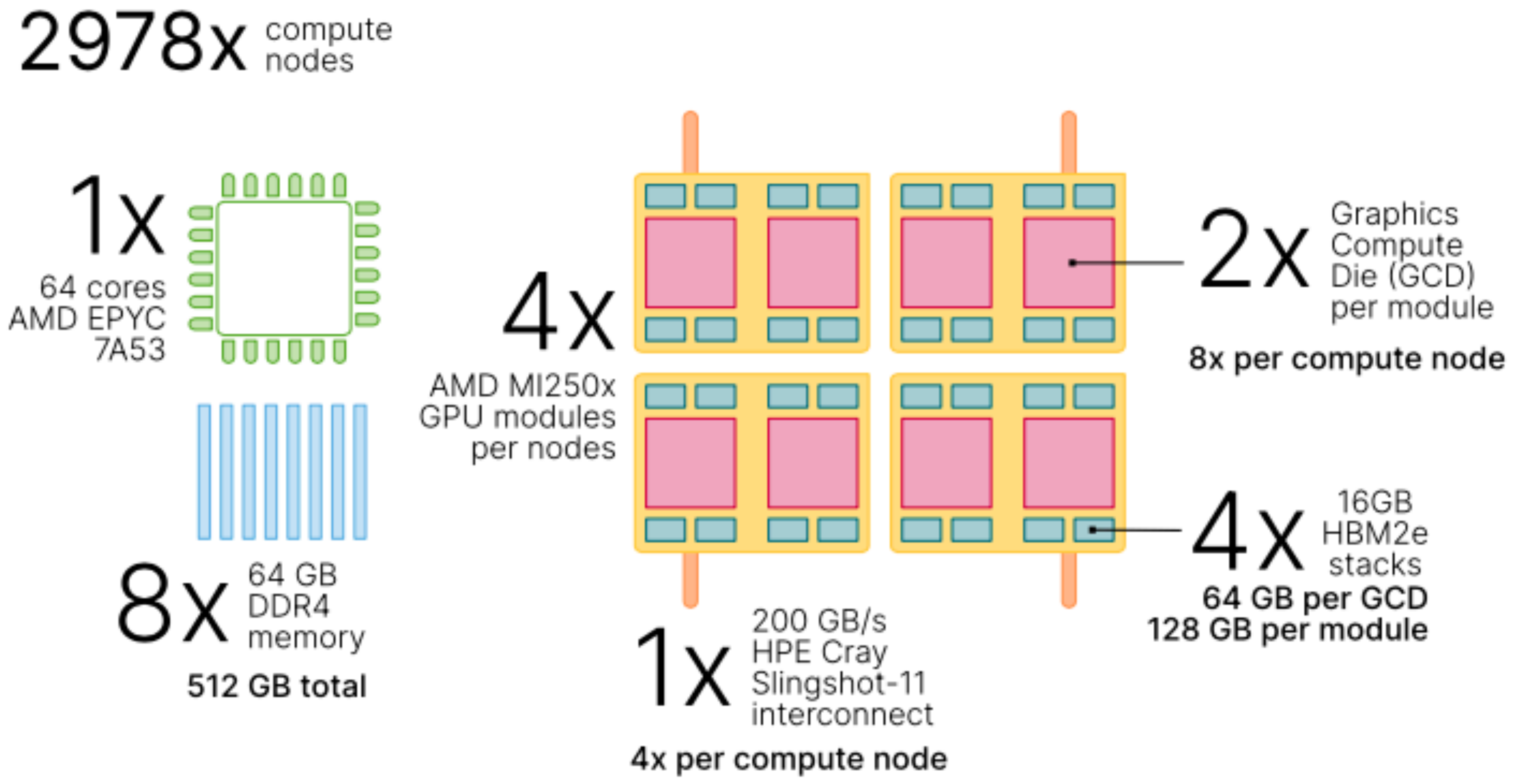
LUMI

Feedback from the use of the largest supercomputer in Europe

Geoff Lesur

What is LUMI?

- 2978 nodes with
  - 4 AMD MI250x GPUs
  - a single 64 cores AMD EPYC "Trento" CPU.
- The aggregated HPL Linpack performance of LUMI-G is 379.70 PFlop/s.



2978x compute nodes
1x 64 cores AMD EPYC 7A53
8x 64 GB DDR4 memory
512 GB total
4x AMD MI250x GPU modules per nodes
2x Graphics Compute Die (GCD) per module
8x per compute node
4x 16GB HBM2e stacks
64 GB per GCD
128 GB per module
1x 200 GB/s HPE Cray Slingshot-11 interconnect
4x per compute node

Overview of a LUMI-G compute node

~ 9x Adastra GPU @ CINES

Accessing LUMI

eurohpc-ju.europa.eu

The European High Performance Computing Joint Undertaking (EuroHPC JU)

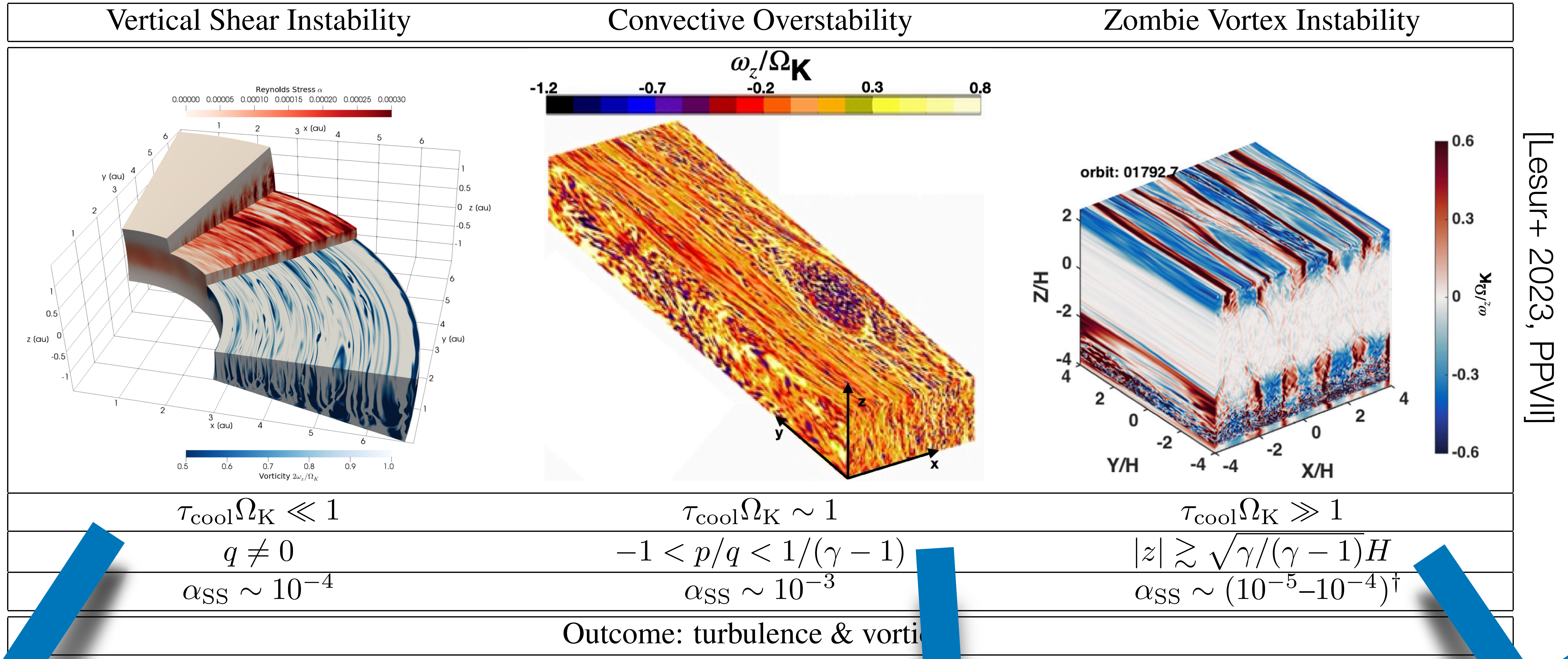
Home > Access to Our Supercomputers > EuroHPC Access Calls

EuroHPC Access Calls

- Granted an allocation for the « extreme scale access mode »
- 3,484,000 GPU h allocated on 1 year

The project « turbulent disks »

In collaboration with H. Latter (Univ. of Cambridge, UK)



Reynolds Stress α
0.00000 0.00005 0.00010 0.00015 0.00020 0.00025 0.00030
x (au)
y (au)
z (au)
Vorticity $2\omega_z/\Omega_K$
0.5 0.6 0.7 0.8 0.9 1.0
ω_z/Ω_K
-1.2 -0.7 -0.2 0.3 0.8
x
y
z
orbit: 01792.7
Z/H
Y/H
X/H
0.6 0.3 0 -0.3 -0.6
ω_z/Ω_K

Vertical Shear Instability	Convective Overstability	Zombie Vortex Instability
$\tau_{\rm cool}\Omega_{\rm K} \ll 1$	$\tau_{\rm cool}\Omega_{\rm K} \sim 1$	$\tau_{\rm cool}\Omega_{\rm K} \gg 1$
$q \neq 0$	$-1 < p/q < 1/(\gamma-1)$	$\lvert z\rvert \gtrsim \sqrt{\gamma/(\gamma-1)}H$
$\alpha_{\rm SS} \sim 10^{-4}$	$\alpha_{\rm SS} \sim 10^{-3}$	$\alpha_{\rm SS} \sim (10^{-5}\text{–}10^{-4})^{\dagger}$
Outcome: turbulence & vorti		

[Lesur+ 2023, PPVII]

- Full disk?
- Survival of corrugation modes?
- Dust settling?
- Vortices?

- Full disk?
- Impact of vertical stratification?
- Competition with VSI?

- Compressibility effects?
- Survival with curvature?
- Propagation to the midplane?

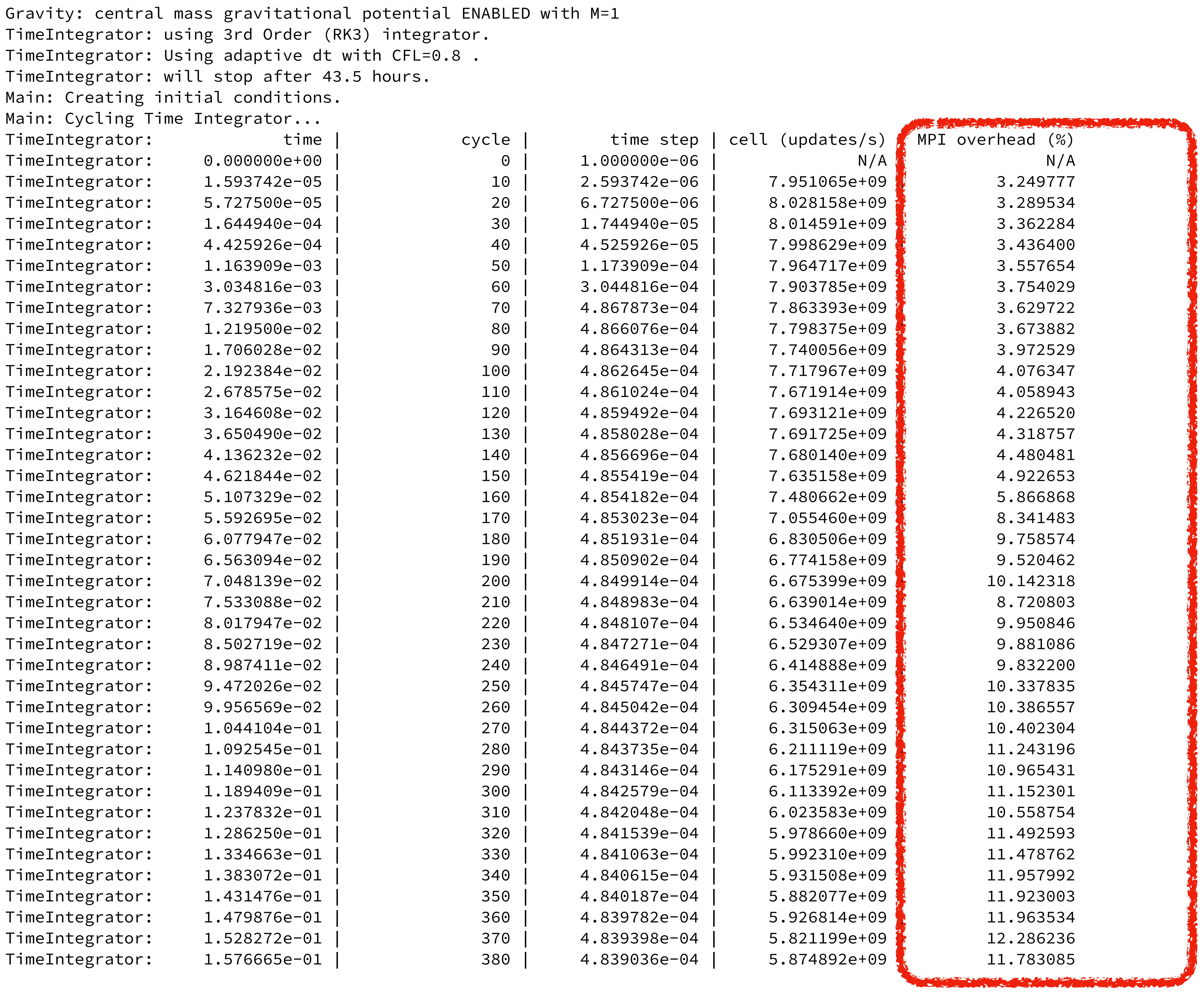
The challenge

#1: system stability

```
Gravity: central mass gravitational potential ENABLED with M=1
TimeIntegrator: using 3rd Order (RK3) integrator.
TimeIntegrator: Using adaptive dt with CFL=0.8 .
TimeIntegrator: will stop after 43.5 hours.
Main: Creating initial conditions.
Main: Cycling Time Integrator...
TimeIntegrator:             time |            cycle |        time step | cell (updates/s)   MPI overhead (%)
TimeIntegrator:     0.000000e+00 |                0 |     1.000000e-06 |              N/A                N/A
TimeIntegrator:     1.593742e-05 |               10 |     2.593742e-06 |     1.228411e+11           6.229152
TimeIntegrator:     5.727500e-05 |               20 |     6.727500e-06 |     1.263376e+11           6.696973
TimeIntegrator:     1.644940e-04 |               30 |     1.744940e-05 |     1.260329e+11           6.868502
TimeIntegrator:     4.425926e-04 |               40 |     4.525926e-05 |     1.260741e+11           6.713010
TimeIntegrator:     1.163909e-03 |               50 |     1.173909e-04 |     1.258320e+11           6.739630
TimeIntegrator:     3.034816e-03 |               60 |     3.044816e-04 |     1.251714e+11           6.986361
TimeIntegrator:     6.519082e-03 |               70 |     3.555275e-04 |     1.245450e+11           7.566431
TimeIntegrator:     1.007368e-02 |               80 |     3.553797e-04 |     1.238352e+11           8.051875
TimeIntegrator:     1.362683e-02 |               90 |     3.552368e-04 |     1.236095e+11           8.408736
TimeIntegrator:     1.717857e-02 |              100 |     3.550985e-04 |     1.230930e+11           8.999555
TimeIntegrator:     2.072898e-02 |              110 |     3.549738e-04 |     1.191618e+11          10.278076
...
TimeIntegrator:     6.680007e-02 |              240 |     3.539673e-04 |     8.560018e+10          31.998791
TimeIntegrator:     7.033955e-02 |              250 |     3.539236e-04 |     8.455433e+10          32.354674
TimeIntegrator:     7.387860e-02 |              260 |     3.538831e-04 |     8.536546e+10          31.871857
TimeIntegrator:     7.741726e-02 |              270 |     3.538455e-04 |     8.451818e+10          32.560332
...
TimeIntegrator:     3.213042e-01 |              960 |     3.533728e-04 |     7.226361e+10          39.876328
TimeIntegrator:     3.248379e-01 |              970 |     3.533726e-04 |     7.318458e+10          39.556451
TimeIntegrator:     3.283717e-01 |              980 |     3.533725e-04 |     7.281833e+10          39.854619
TimeIntegrator:     3.319054e-01 |              990 |     3.533724e-04 |     7.167976e+10          40.422609
Main: Reached maximum number of integration cycles.
Main: Reached t=0.335439
Main: Completed in 10 minutes 53 seconds and 1000 cycles
Main: Perfs are 8.174090e+10 cell updates/second
MPI overhead represents 34% of total run time.
```

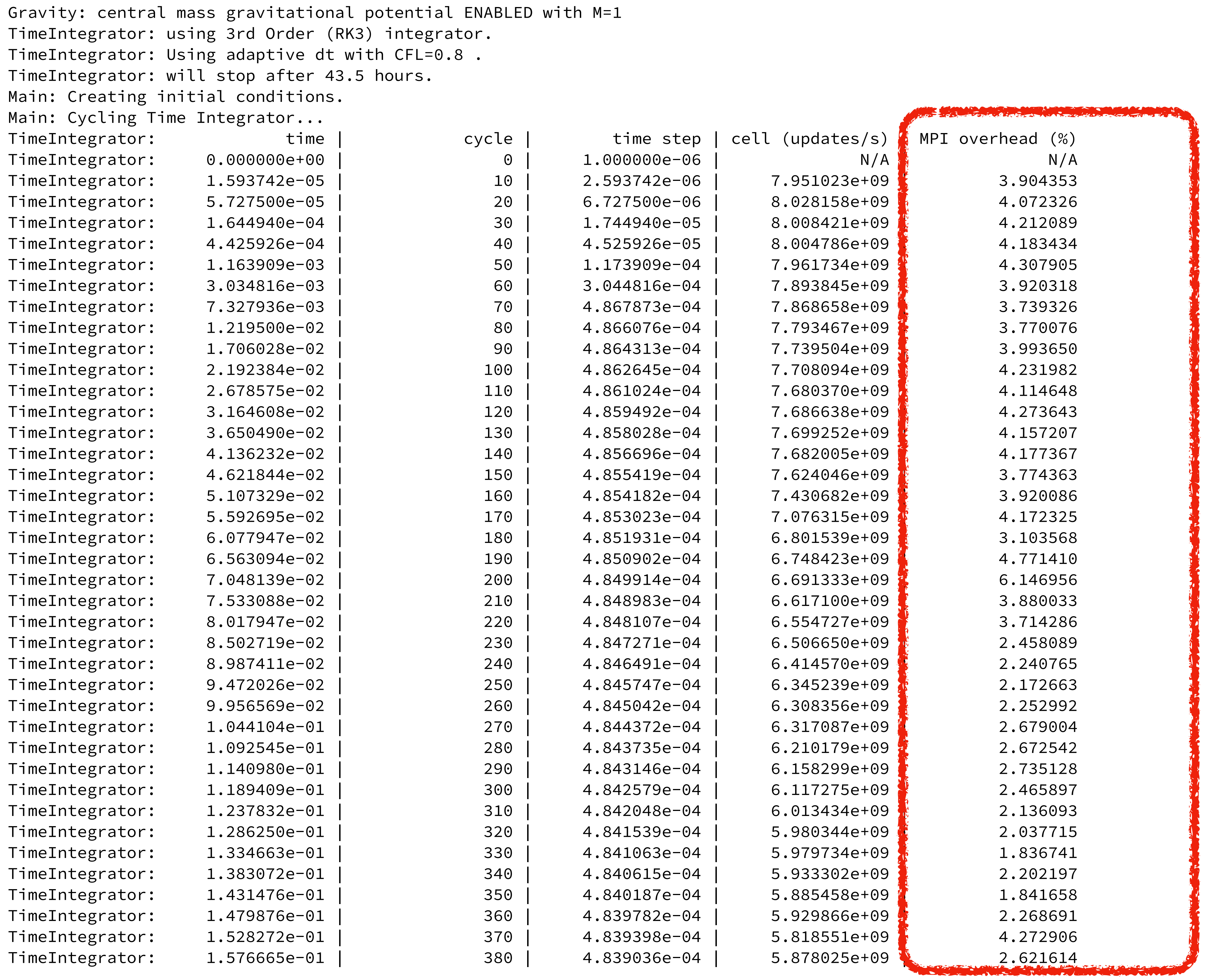
#1: system stability (cont’d)

process #1



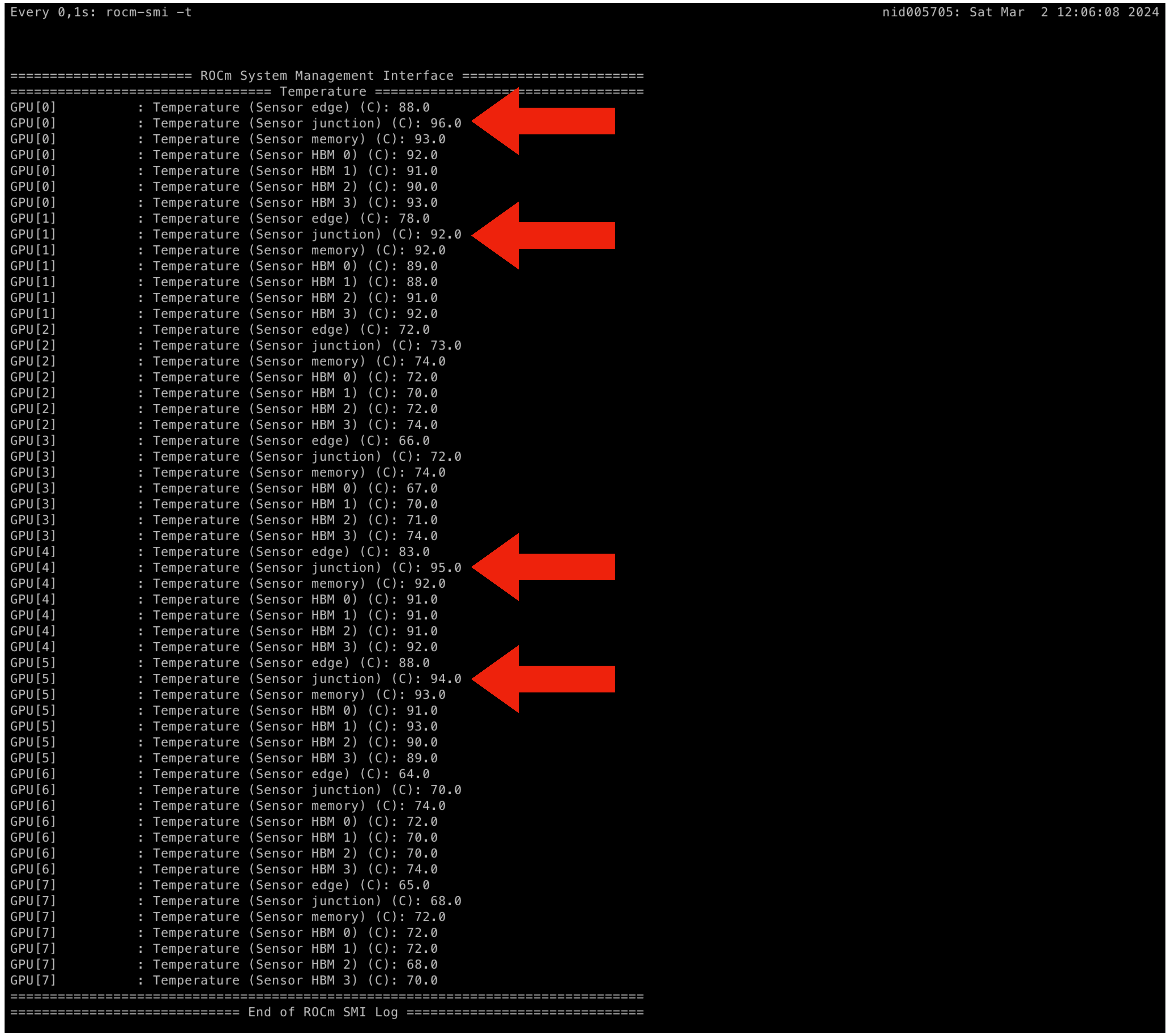
```
Gravity: central mass gravitational potential ENABLED with M=1
TimeIntegrator: using 3rd Order (RK3) integrator.
TimeIntegrator: Using adaptive dt with CFL=0.8 .
TimeIntegrator: will stop after 43.5 hours.
Main: Creating initial conditions.
Main: Cycling Time Integrator...
TimeIntegrator:             time |            cycle |      time step | cell (updates/s) | MPI overhead (%)
TimeIntegrator:     0.000000e+00 |                0 |   1.000000e-06 |              N/A |              N/A
TimeIntegrator:     1.593742e-05 |               10 |   2.593742e-06 |     7.951065e+09 |         3.249777
TimeIntegrator:     5.727500e-05 |               20 |   6.727500e-06 |     8.028158e+09 |         3.289534
TimeIntegrator:     1.644940e-04 |               30 |   1.744940e-05 |     8.014591e+09 |         3.362284
TimeIntegrator:     4.425926e-04 |               40 |   4.525926e-05 |     7.998629e+09 |         3.436400
TimeIntegrator:     1.163909e-03 |               50 |   1.173909e-04 |     7.964717e+09 |         3.557654
TimeIntegrator:     3.034816e-03 |               60 |   3.044816e-04 |     7.903785e+09 |         3.754029
TimeIntegrator:     7.327936e-03 |               70 |   4.867873e-04 |     7.863393e+09 |         3.629722
TimeIntegrator:     1.219500e-02 |               80 |   4.866076e-04 |     7.798375e+09 |         3.673882
TimeIntegrator:     1.706028e-02 |               90 |   4.864313e-04 |     7.740056e+09 |         3.972529
TimeIntegrator:     2.192384e-02 |              100 |   4.862645e-04 |     7.717967e+09 |         4.076347
TimeIntegrator:     2.678575e-02 |              110 |   4.861024e-04 |     7.671914e+09 |         4.058943
TimeIntegrator:     3.164608e-02 |              120 |   4.859492e-04 |     7.693121e+09 |         4.226520
TimeIntegrator:     3.650490e-02 |              130 |   4.858028e-04 |     7.691725e+09 |         4.318757
TimeIntegrator:     4.136232e-02 |              140 |   4.856696e-04 |     7.680140e+09 |         4.480481
TimeIntegrator:     4.621844e-02 |              150 |   4.855419e-04 |     7.635158e+09 |         4.922653
TimeIntegrator:     5.107329e-02 |              160 |   4.854182e-04 |     7.480662e+09 |         5.866868
TimeIntegrator:     5.592695e-02 |              170 |   4.853023e-04 |     7.055460e+09 |         8.341483
TimeIntegrator:     6.077947e-02 |              180 |   4.851931e-04 |     6.830506e+09 |         9.758574
TimeIntegrator:     6.563094e-02 |              190 |   4.850902e-04 |     6.774158e+09 |         9.520462
TimeIntegrator:     7.048139e-02 |              200 |   4.849914e-04 |     6.675399e+09 |        10.142318
TimeIntegrator:     7.533088e-02 |              210 |   4.848983e-04 |     6.639014e+09 |         8.720803
TimeIntegrator:     8.017947e-02 |              220 |   4.848107e-04 |     6.534640e+09 |         9.950846
TimeIntegrator:     8.502719e-02 |              230 |   4.847271e-04 |     6.529307e+09 |         9.881086
TimeIntegrator:     8.987411e-02 |              240 |   4.846491e-04 |     6.414888e+09 |         9.832200
TimeIntegrator:     9.472026e-02 |              250 |   4.845747e-04 |     6.354311e+09 |        10.337835
TimeIntegrator:     9.956569e-02 |              260 |   4.845042e-04 |     6.309454e+09 |        10.386557
TimeIntegrator:     1.044104e-01 |              270 |   4.844372e-04 |     6.315063e+09 |        10.402304
TimeIntegrator:     1.092545e-01 |              280 |   4.843735e-04 |     6.211119e+09 |        11.243196
TimeIntegrator:     1.140980e-01 |              290 |   4.843146e-04 |     6.175291e+09 |        10.965431
TimeIntegrator:     1.189409e-01 |              300 |   4.842579e-04 |     6.113392e+09 |        11.152301
TimeIntegrator:     1.237832e-01 |              310 |   4.842048e-04 |     6.023583e+09 |        10.558754
TimeIntegrator:     1.286250e-01 |              320 |   4.841539e-04 |     5.978660e+09 |        11.492593
TimeIntegrator:     1.334663e-01 |              330 |   4.841063e-04 |     5.992310e+09 |        11.478762
TimeIntegrator:     1.383072e-01 |              340 |   4.840615e-04 |     5.931508e+09 |        11.957992
TimeIntegrator:     1.431476e-01 |              350 |   4.840187e-04 |     5.882077e+09 |        11.923003
TimeIntegrator:     1.479876e-01 |              360 |   4.839782e-04 |     5.926814e+09 |        11.963534
TimeIntegrator:     1.528272e-01 |              370 |   4.839398e-04 |     5.821199e+09 |        12.286236
TimeIntegrator:     1.576665e-01 |              380 |   4.839036e-04 |     5.874892e+09 |        11.783085
```

process #24



```
Gravity: central mass gravitational potential ENABLED with M=1
TimeIntegrator: using 3rd Order (RK3) integrator.
TimeIntegrator: Using adaptive dt with CFL=0.8 .
TimeIntegrator: will stop after 43.5 hours.
Main: Creating initial conditions.
Main: Cycling Time Integrator...
TimeIntegrator:             time |            cycle |      time step | cell (updates/s) | MPI overhead (%)
TimeIntegrator:     0.000000e+00 |                0 |   1.000000e-06 |              N/A |              N/A
TimeIntegrator:     1.593742e-05 |               10 |   2.593742e-06 |     7.951023e+09 |         3.904353
TimeIntegrator:     5.727500e-05 |               20 |   6.727500e-06 |     8.028158e+09 |         4.072326
TimeIntegrator:     1.644940e-04 |               30 |   1.744940e-05 |     8.008421e+09 |         4.212089
TimeIntegrator:     4.425926e-04 |               40 |   4.525926e-05 |     8.004786e+09 |         4.183434
TimeIntegrator:     1.163909e-03 |               50 |   1.173909e-04 |     7.961734e+09 |         4.307905
TimeIntegrator:     3.034816e-03 |               60 |   3.044816e-04 |     7.893845e+09 |         3.920318
TimeIntegrator:     7.327936e-03 |               70 |   4.867873e-04 |     7.868658e+09 |         3.739326
TimeIntegrator:     1.219500e-02 |               80 |   4.866076e-04 |     7.793467e+09 |         3.770076
TimeIntegrator:     1.706028e-02 |               90 |   4.864313e-04 |     7.739504e+09 |         3.993650
TimeIntegrator:     2.192384e-02 |              100 |   4.862645e-04 |     7.708094e+09 |         4.231982
TimeIntegrator:     2.678575e-02 |              110 |   4.861024e-04 |     7.680370e+09 |         4.114648
TimeIntegrator:     3.164608e-02 |              120 |   4.859492e-04 |     7.686638e+09 |         4.273643
TimeIntegrator:     3.650490e-02 |              130 |   4.858028e-04 |     7.699252e+09 |         4.157207
TimeIntegrator:     4.136232e-02 |              140 |   4.856696e-04 |     7.682005e+09 |         4.177367
TimeIntegrator:     4.621844e-02 |              150 |   4.855419e-04 |     7.624046e+09 |         3.774363
TimeIntegrator:     5.107329e-02 |              160 |   4.854182e-04 |     7.430682e+09 |         3.920086
TimeIntegrator:     5.592695e-02 |              170 |   4.853023e-04 |     7.076315e+09 |         4.172325
TimeIntegrator:     6.077947e-02 |              180 |   4.851931e-04 |     6.801539e+09 |         3.103568
TimeIntegrator:     6.563094e-02 |              190 |   4.850902e-04 |     6.748423e+09 |         4.771410
TimeIntegrator:     7.048139e-02 |              200 |   4.849914e-04 |     6.691333e+09 |         6.146956
TimeIntegrator:     7.533088e-02 |              210 |   4.848983e-04 |     6.617100e+09 |         3.880033
TimeIntegrator:     8.017947e-02 |              220 |   4.848107e-04 |     6.554727e+09 |         3.714286
TimeIntegrator:     8.502719e-02 |              230 |   4.847271e-04 |     6.506650e+09 |         2.458089
TimeIntegrator:     8.987411e-02 |              240 |   4.846491e-04 |     6.414570e+09 |         2.240765
TimeIntegrator:     9.472026e-02 |              250 |   4.845747e-04 |     6.345239e+09 |         2.172663
TimeIntegrator:     9.956569e-02 |              260 |   4.845042e-04 |     6.308356e+09 |         2.252992
TimeIntegrator:     1.044104e-01 |              270 |   4.844372e-04 |     6.317087e+09 |         2.679004
TimeIntegrator:     1.092545e-01 |              280 |   4.843735e-04 |     6.210179e+09 |         2.672542
TimeIntegrator:     1.140980e-01 |              290 |   4.843146e-04 |     6.158299e+09 |         2.735128
TimeIntegrator:     1.189409e-01 |              300 |   4.842579e-04 |     6.117275e+09 |         2.465897
TimeIntegrator:     1.237832e-01 |              310 |   4.842048e-04 |     6.013434e+09 |         2.136093
TimeIntegrator:     1.286250e-01 |              320 |   4.841539e-04 |     5.980344e+09 |         2.037715
TimeIntegrator:     1.334663e-01 |              330 |   4.841063e-04 |     5.979734e+09 |         1.836741
TimeIntegrator:     1.383072e-01 |              340 |   4.840615e-04 |     5.933302e+09 |         2.202197
TimeIntegrator:     1.431476e-01 |              350 |   4.840187e-04 |     5.885458e+09 |         1.841658
TimeIntegrator:     1.479876e-01 |              360 |   4.839782e-04 |     5.929866e+09 |         2.268691
TimeIntegrator:     1.528272e-01 |              370 |   4.839398e-04 |     5.818551e+09 |         4.272906
TimeIntegrator:     1.576665e-01 |              380 |   4.839036e-04 |     5.878025e+09 |         2.621614
```

#1: system stability (cont'd)



```
Every 0,1s: rocm-smi -t                                                                                     nid005705: Sat Mar  2 12:06:08 2024



======================= ROCm System Management Interface =======================
================================ Temperature =================================
GPU[0]          : Temperature (Sensor edge) (C): 88.0
GPU[0]          : Temperature (Sensor junction) (C): 96.0
GPU[0]          : Temperature (Sensor memory) (C): 93.0
GPU[0]          : Temperature (Sensor HBM 0) (C): 92.0
GPU[0]          : Temperature (Sensor HBM 1) (C): 91.0
GPU[0]          : Temperature (Sensor HBM 2) (C): 90.0
GPU[0]          : Temperature (Sensor HBM 3) (C): 93.0
GPU[1]          : Temperature (Sensor edge) (C): 78.0
GPU[1]          : Temperature (Sensor junction) (C): 92.0
GPU[1]          : Temperature (Sensor memory) (C): 92.0
GPU[1]          : Temperature (Sensor HBM 0) (C): 89.0
GPU[1]          : Temperature (Sensor HBM 1) (C): 88.0
GPU[1]          : Temperature (Sensor HBM 2) (C): 91.0
GPU[1]          : Temperature (Sensor HBM 3) (C): 92.0
GPU[2]          : Temperature (Sensor edge) (C): 72.0
GPU[2]          : Temperature (Sensor junction) (C): 73.0
GPU[2]          : Temperature (Sensor memory) (C): 74.0
GPU[2]          : Temperature (Sensor HBM 0) (C): 72.0
GPU[2]          : Temperature (Sensor HBM 1) (C): 70.0
GPU[2]          : Temperature (Sensor HBM 2) (C): 72.0
GPU[2]          : Temperature (Sensor HBM 3) (C): 74.0
GPU[3]          : Temperature (Sensor edge) (C): 66.0
GPU[3]          : Temperature (Sensor junction) (C): 72.0
GPU[3]          : Temperature (Sensor memory) (C): 74.0
GPU[3]          : Temperature (Sensor HBM 0) (C): 67.0
GPU[3]          : Temperature (Sensor HBM 1) (C): 70.0
GPU[3]          : Temperature (Sensor HBM 2) (C): 71.0
GPU[3]          : Temperature (Sensor HBM 3) (C): 74.0
GPU[4]          : Temperature (Sensor edge) (C): 83.0
GPU[4]          : Temperature (Sensor junction) (C): 95.0
GPU[4]          : Temperature (Sensor memory) (C): 92.0
GPU[4]          : Temperature (Sensor HBM 0) (C): 91.0
GPU[4]          : Temperature (Sensor HBM 1) (C): 91.0
GPU[4]          : Temperature (Sensor HBM 2) (C): 91.0
GPU[4]          : Temperature (Sensor HBM 3) (C): 92.0
GPU[5]          : Temperature (Sensor edge) (C): 88.0
GPU[5]          : Temperature (Sensor junction) (C): 94.0
GPU[5]          : Temperature (Sensor memory) (C): 93.0
GPU[5]          : Temperature (Sensor HBM 0) (C): 91.0
GPU[5]          : Temperature (Sensor HBM 1) (C): 93.0
GPU[5]          : Temperature (Sensor HBM 2) (C): 90.0
GPU[5]          : Temperature (Sensor HBM 3) (C): 89.0
GPU[6]          : Temperature (Sensor edge) (C): 64.0
GPU[6]          : Temperature (Sensor junction) (C): 70.0
GPU[6]          : Temperature (Sensor memory) (C): 74.0
GPU[6]          : Temperature (Sensor HBM 0) (C): 72.0
GPU[6]          : Temperature (Sensor HBM 1) (C): 70.0
GPU[6]          : Temperature (Sensor HBM 2) (C): 70.0
GPU[6]          : Temperature (Sensor HBM 3) (C): 74.0
GPU[7]          : Temperature (Sensor edge) (C): 65.0
GPU[7]          : Temperature (Sensor junction) (C): 68.0
GPU[7]          : Temperature (Sensor memory) (C): 72.0
GPU[7]          : Temperature (Sensor HBM 0) (C): 72.0
GPU[7]          : Temperature (Sensor HBM 1) (C): 72.0
GPU[7]          : Temperature (Sensor HBM 2) (C): 68.0
GPU[7]          : Temperature (Sensor HBM 3) (C): 70.0
================================================================================
============================= End of ROCm SMI Log ==============================
```

#1: system stability (end)

- On some GPUs, the cooling was inefficient (growth of « biology » in the pipes = algae)
- To avoid overheating, these GPUs were slowed down automatically by the system.
- The MPI processes running on those « hot » GPUs were always lagging behind
- All the other processes had to wait for the hot one to finish their task

➡ MPI overhead was increasing on every processes but the hot ones

Addition of an MPI balance diagnostic in Idefix, to quickly identify these problems.

#2 file size

```
-rw-rw---- 1 lesurg l-ipag 2.2T Mar 29 22:13 data.0017.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T Apr  6 00:10 data.0018.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T Apr 23 04:52 data.0019.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T Apr 25 17:49 data.0020.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T May  4 22:06 data.0021.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T May 11 23:29 data.0022.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T May 29 17:21 data.0023.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T Jun 11 06:51 data.0024.vtk
-rw-rw---- 1 lesurg l-ipag 2.2T Jun 23 06:52 data.0025.vtk
```

- VTK files are typically above 1TB
  (NB: idefix is efficient: ~320s to write one of the above VTK file)

- How to open such a large file? (Paraview won't, unless with a lot or RAM)

- We don't have the ressources to directly load these files…

Solution: on-the-fly VTK slices (i.e. 2D slices of the 3D domain). See this afternoon

#3 node failure

```
MPICH ERROR [Rank 3284] [job id 6471201.0] [Mon Mar 25 16:22:20 2024] [nid006342] - Abort(1009397903) (rank 3284 in comm
error in PMPI_Waitall: Other MPI error, error stack:
PMPI_Waitall(378)..............: MPI_Waitall(count=2, req_array=0x14bf148, status_array=0x7ffe3211d520) failed
MPIR_Waitall(167)..............:
MPIR_Waitall_impl(51)..........:
MPID_Progress_wait(201)........:
MPIDI_Progress_test(97)........:
MPIDI_OFI_handle_cq_error(1067): OFI poll failed (ofi_events.c:1069:MPIDI_OFI_handle_cq_error:Input/output error - UNDELI
...
srun: error: Node failure on nid005989
srun: Force Terminated StepId=6471201.0
slurmstepd: error: *** JOB 6471201 ON nid005280 CANCELLED AT 2024-03-25T16:29:07 DUE TO NODE FAILURE, SEE SLURMCTLD LOG F
***
```

… this happens **a lot**

#3 node failure (cont’d)

After 2 months of intense exchange with LUMI support:

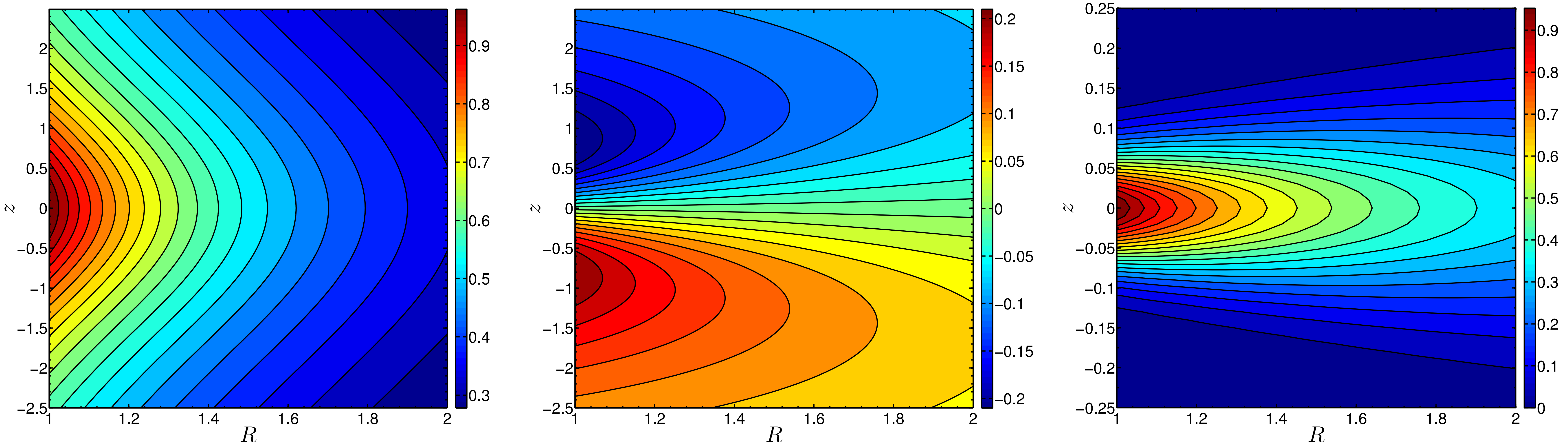
> *I have been discussing failure rate with the SysAdmins team and it is approximately 3 random GPU node failures per day observed (there are almost 3000 GPU nodes in total). This rough statistics gives at least some understanding of expected level of reliability or mean time to failure. I have been also again instructed these failures do not share any common characteristics. In other words, current diagnosis is "bad luck".*

In other words, a job running on 1000 GPUs for 24h *is expected to fail*

Solution(s):
- self-erasing dump files (but not satisfactory: significant I/O overheads)
- Idefix should rely on a resilience library (e.g. kokkos resilience): is it enough?

VSI

VSI=vertical shear instability



(a) Ω (b) $\partial_z(R\Omega)$ (c) ρ

Figure 1. Basic state for the locally isothermal disc with $q = -1$, $p = -1.5$ and $c_0 = 0.05$. The left-hand panel shows a contour plot of Ω on the (R, z) plane. The middle panel is a similar contour plot, but this shows the magnitude of the vertical shear $\partial_z(R\Omega)$, which has a maximum at $|z| \sim 1$ (whereas the scaleheight at the inner radial boundary is 0.05). The right-hand panel shows the density ρ.

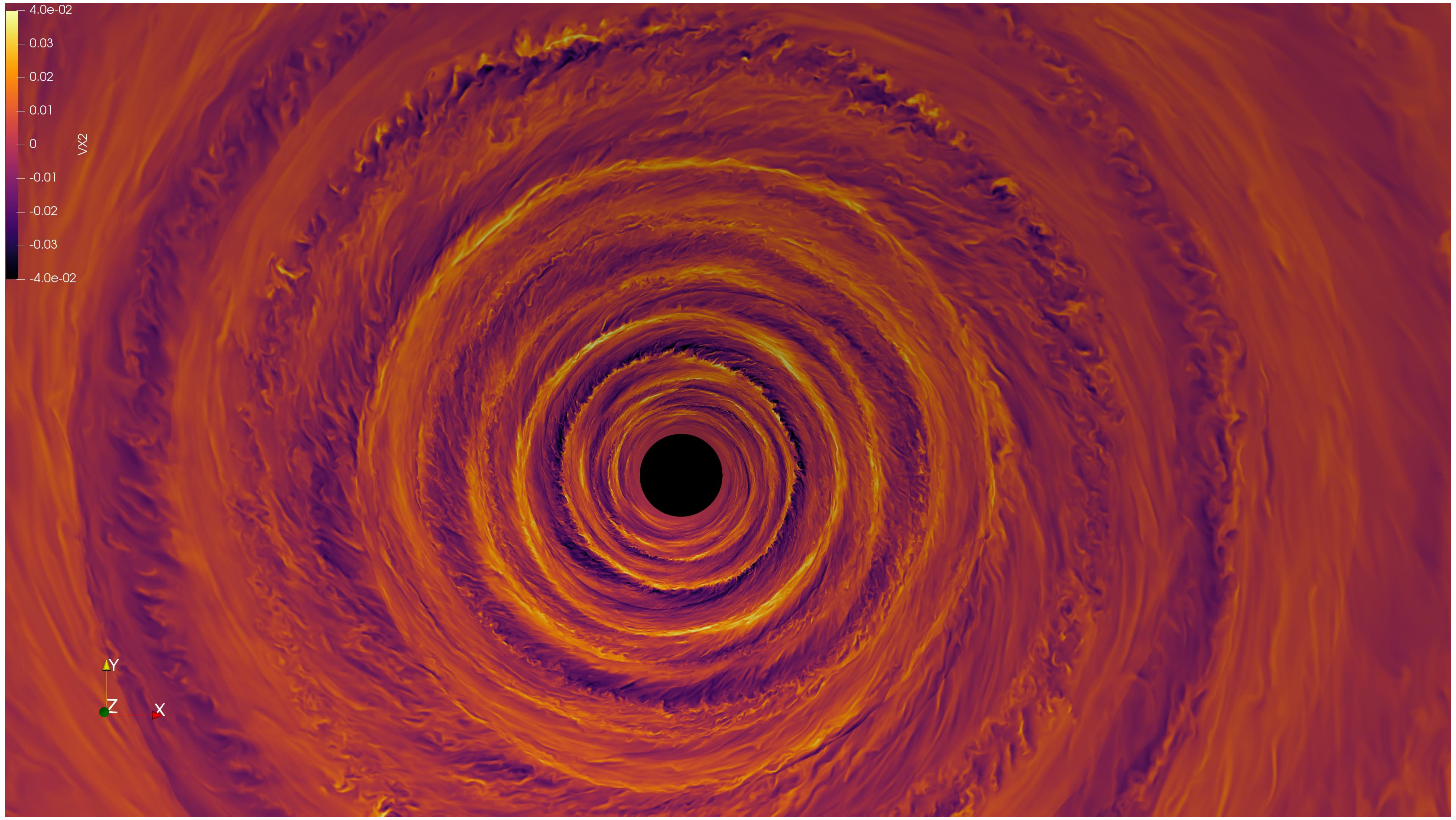
[Barker & Latter 2015]

$T \propto R^{-q}$

linear growth rate: $\sigma \approx |\partial_z(R\Omega)| \sim \epsilon|q|\Omega,$

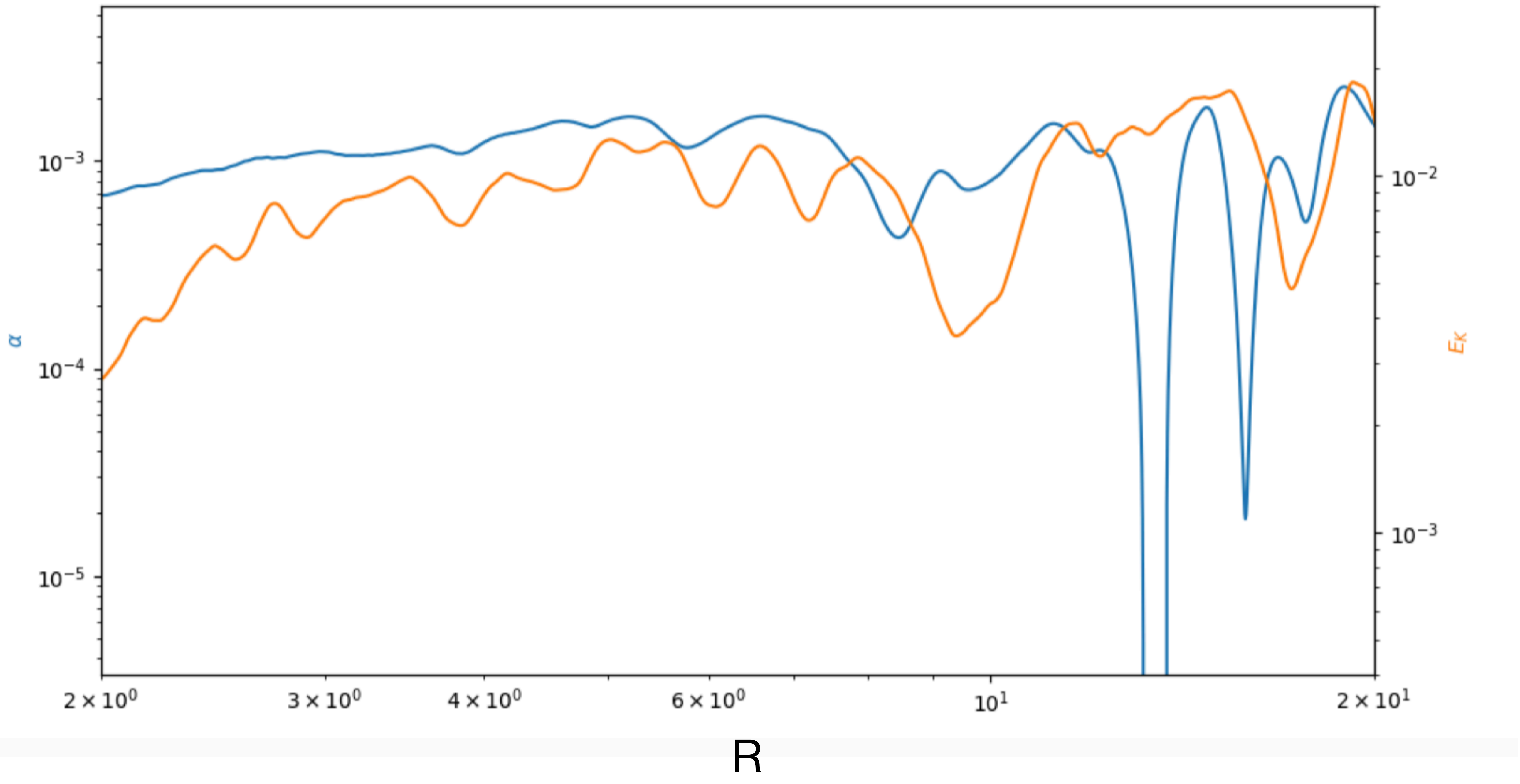
A high resolution VSI run

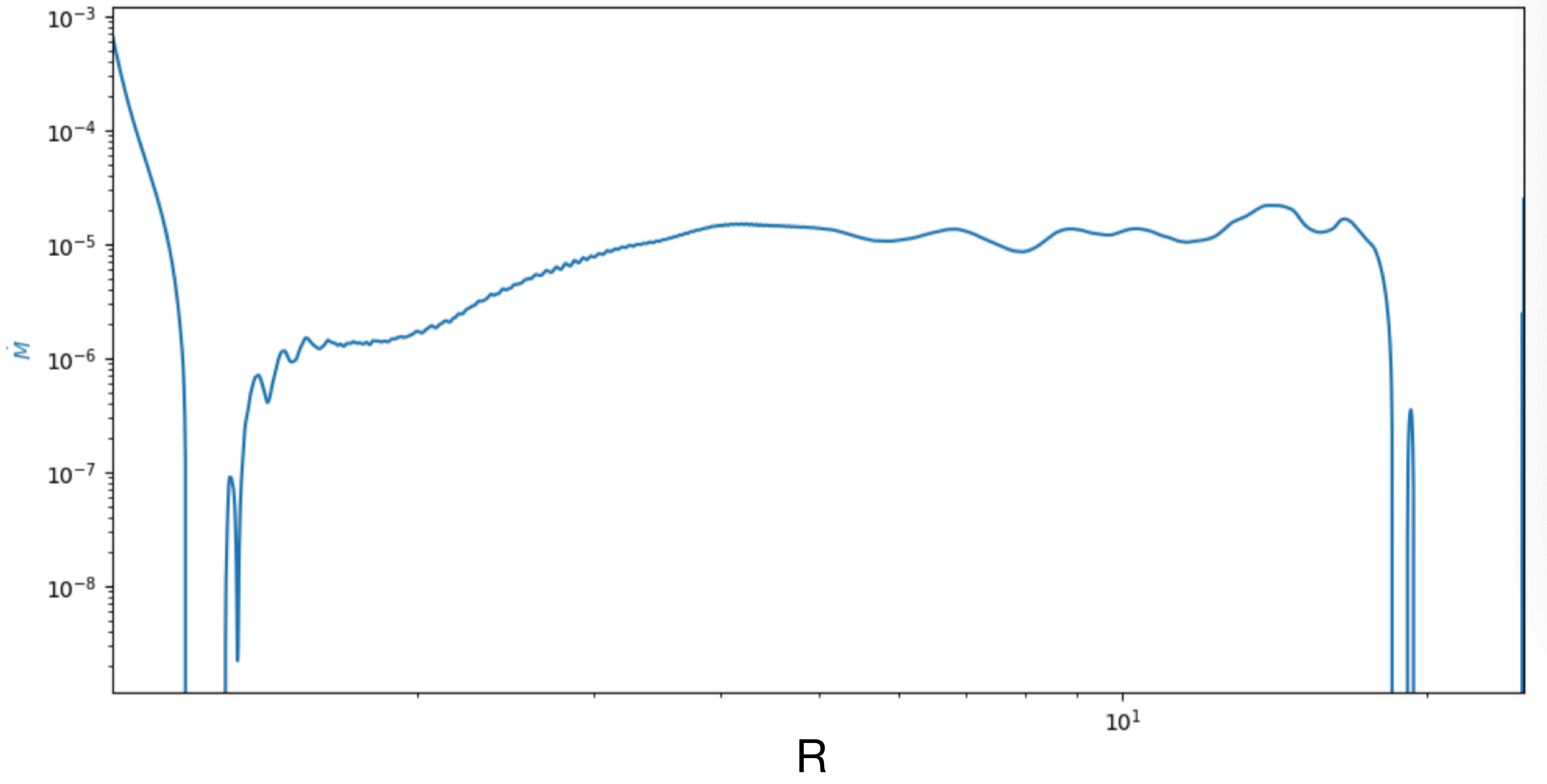
- Idefix code on AMD Mi250 GPUs (LUMI, Finland)
- 70pts/H, 3 directions
- High order reconstruction (LimO3)
- Fargo scheme
- Large aspect ratio ($R_{\mathrm{out}}/R_{\mathrm{in}}$=25)
- 4 dust size (pressure less fluid)



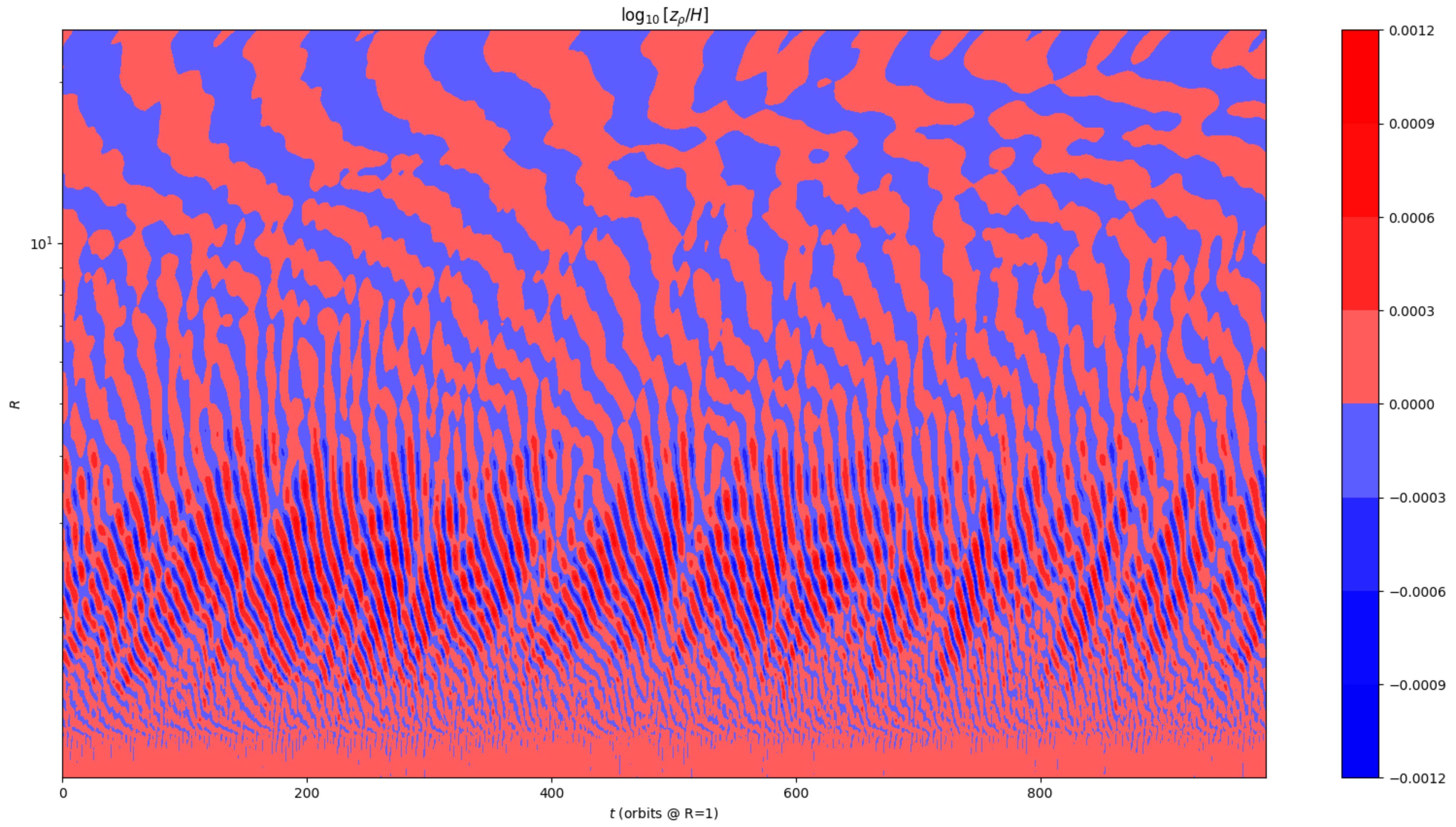
Time=4869.5693
4.0e-02
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03
-0.035
-4.0e-02
Vz

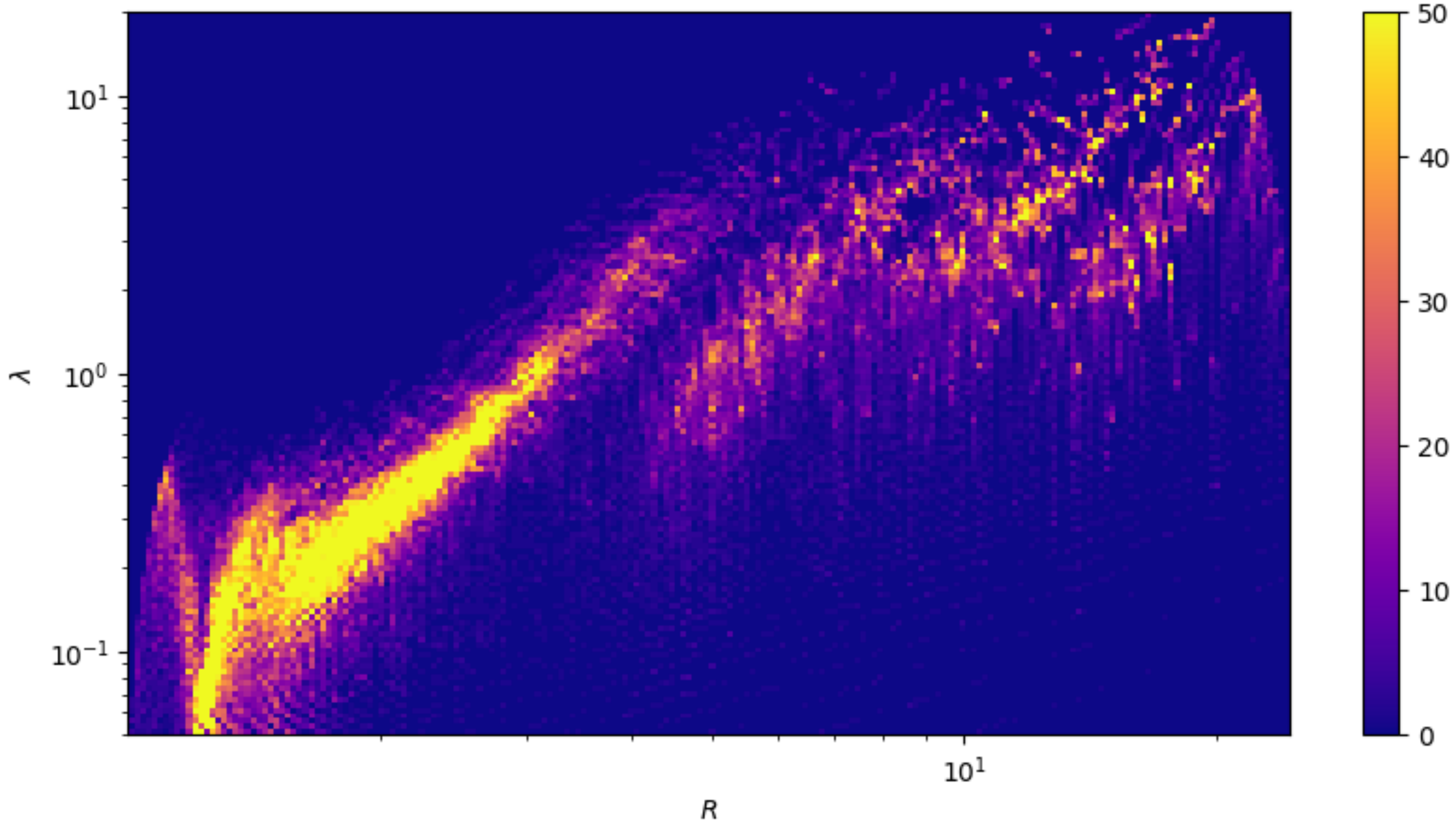
Average properties


α and kinetic energy


Accretion rate

Wave pattern

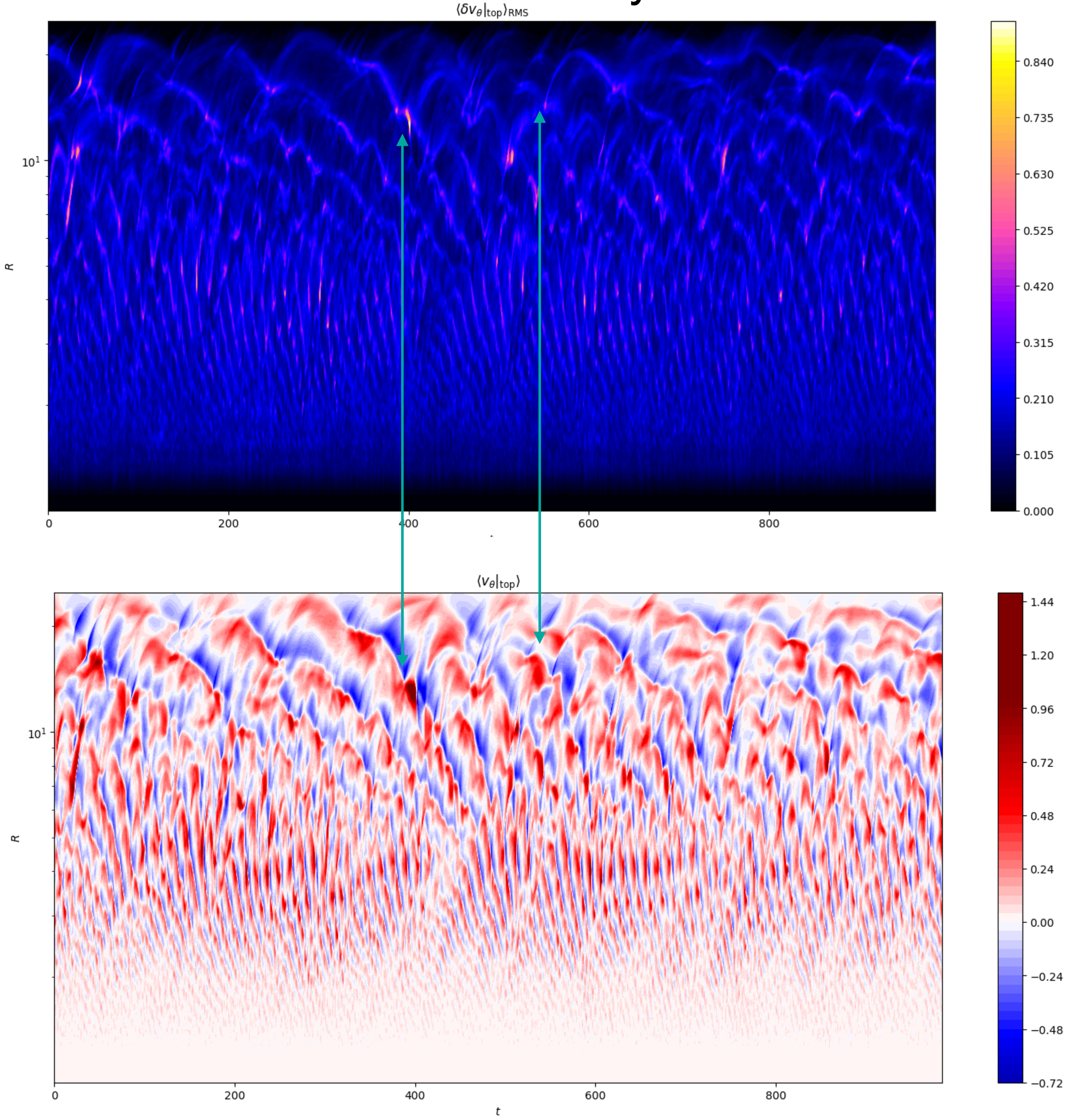




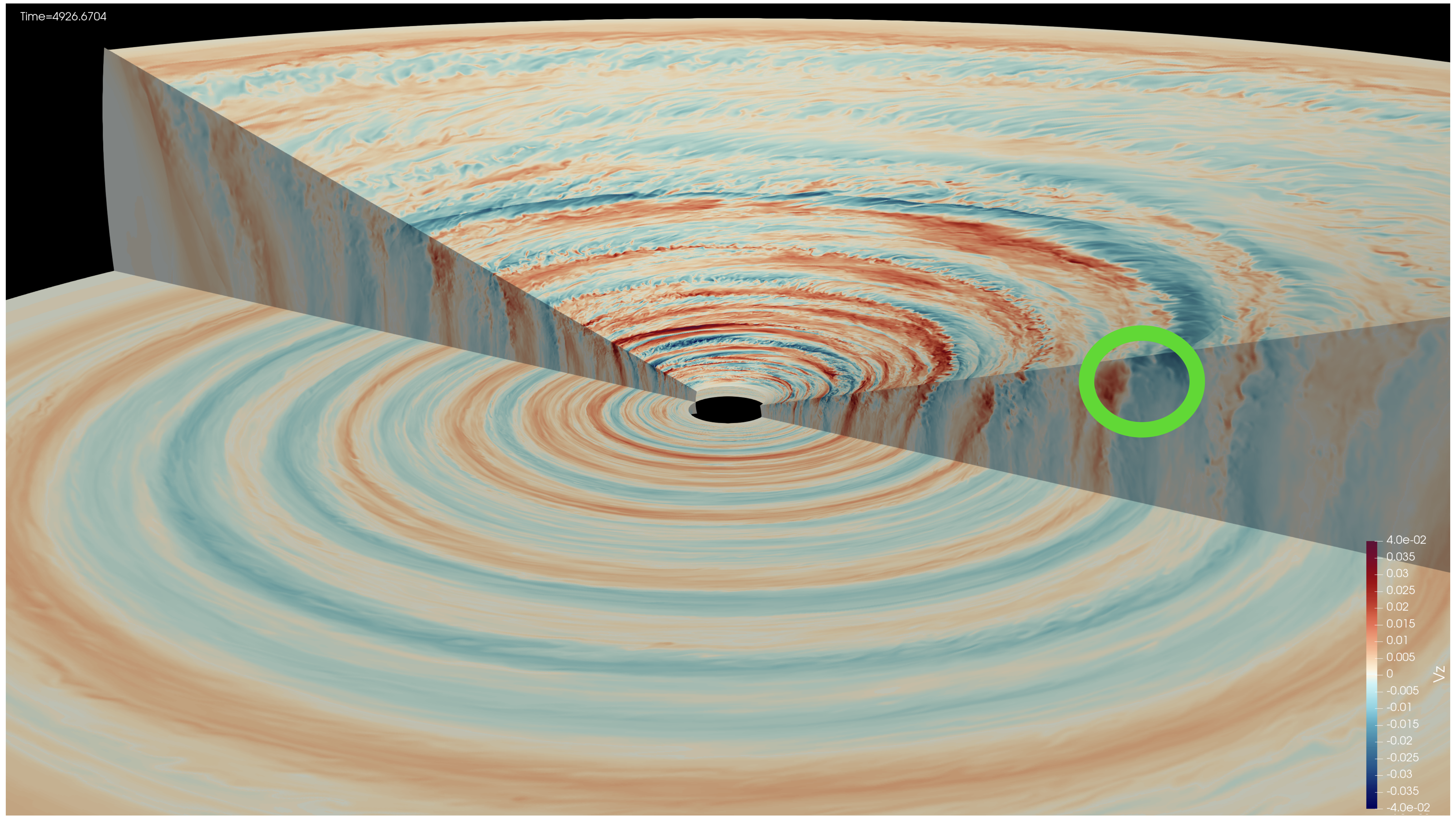
- We recover large-scale mean corrugation pattern seen in 2D!

Turbulence

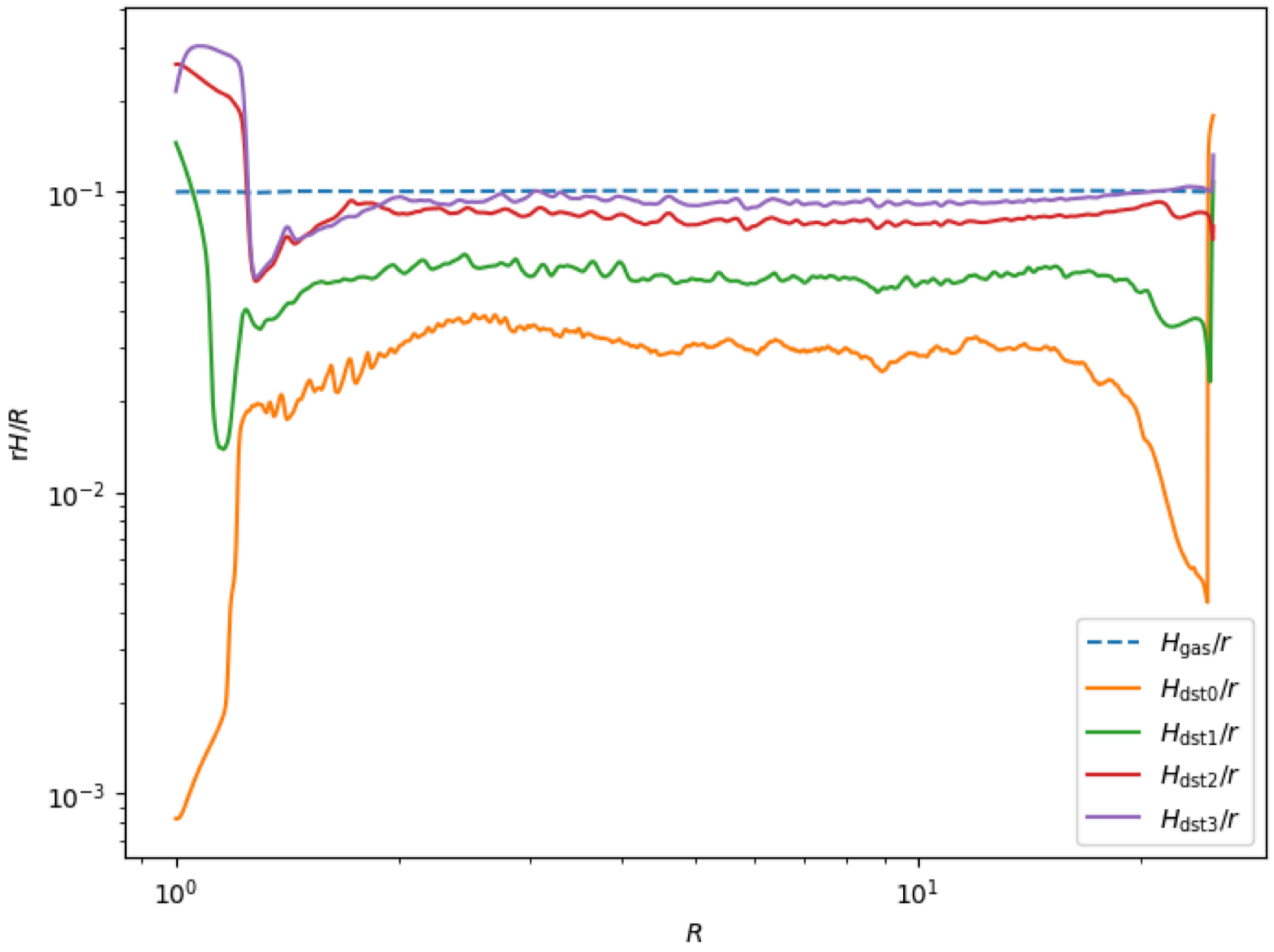
RMS turbulent velocity @ 3H



Mean vertical velocity @3H



Dust settling



Settling under-estimated in the innermost regions.

No radial dependence?

Conclusion

- Idefix runs efficiently on pre-exascale European machines. However:
  - These machines are very sensitive to heating problems, leading to reduced performances and imbalanced computations
  - The failure rate is high, impacting significantly the runs when using more than 100 nodes (+1000GPUs)
  - File size is huge
- But eventually, it works :-)