Centrifugal

Fredy Ramirez

Last Modified: January 2020

1 Mathematical Model

2 Centrifugal Force Only

2.1 Aspect Ratio = 0.1

The $E = 10^{-5}$ case may be under resolved. May need to increase gridpoint resolution.

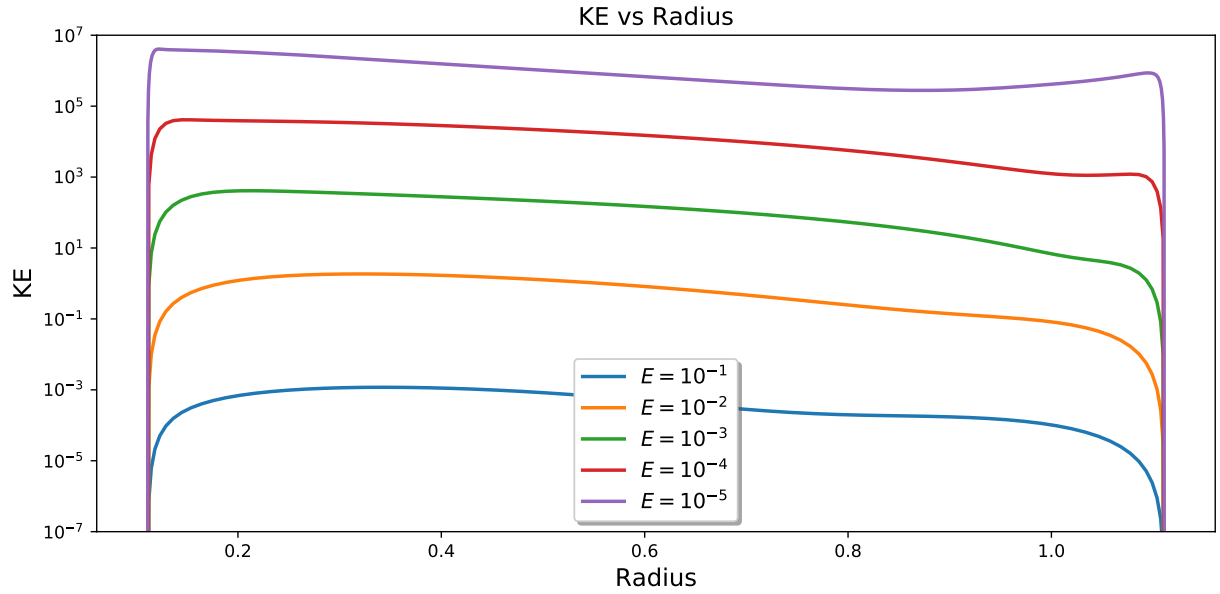

Figure 1: Kinetic energy shell average as a function of radius during equilibrated phase for a range of Ekman numbers.

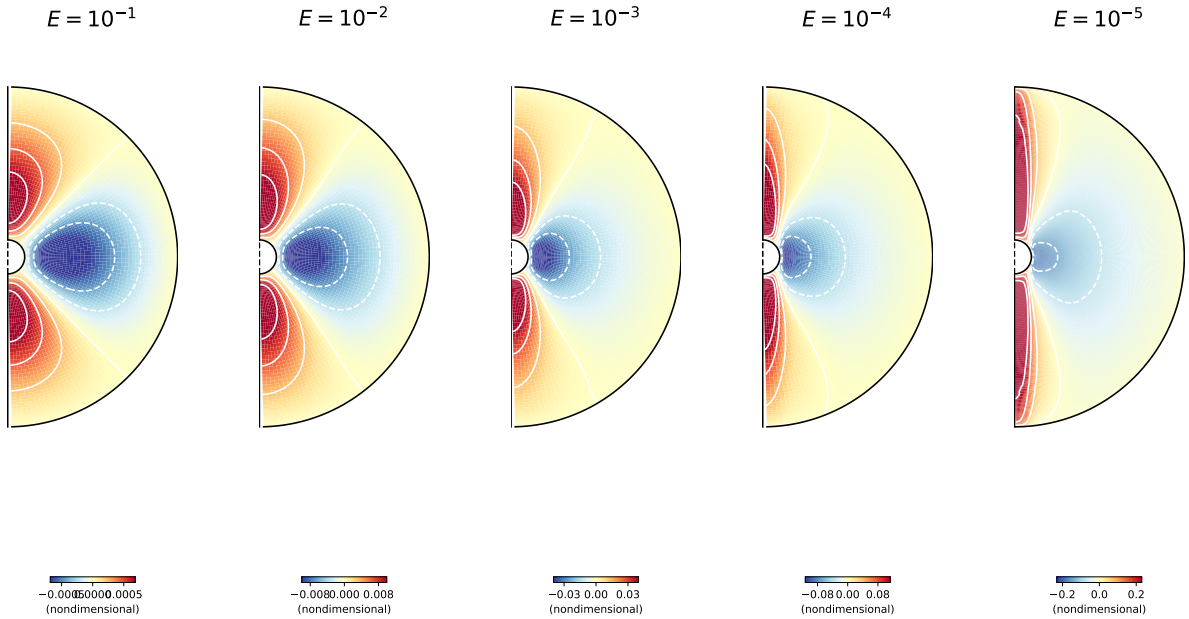

Figure 2: Temperature azimuthal average during equilibrated phase for a range of Ekman numbers.

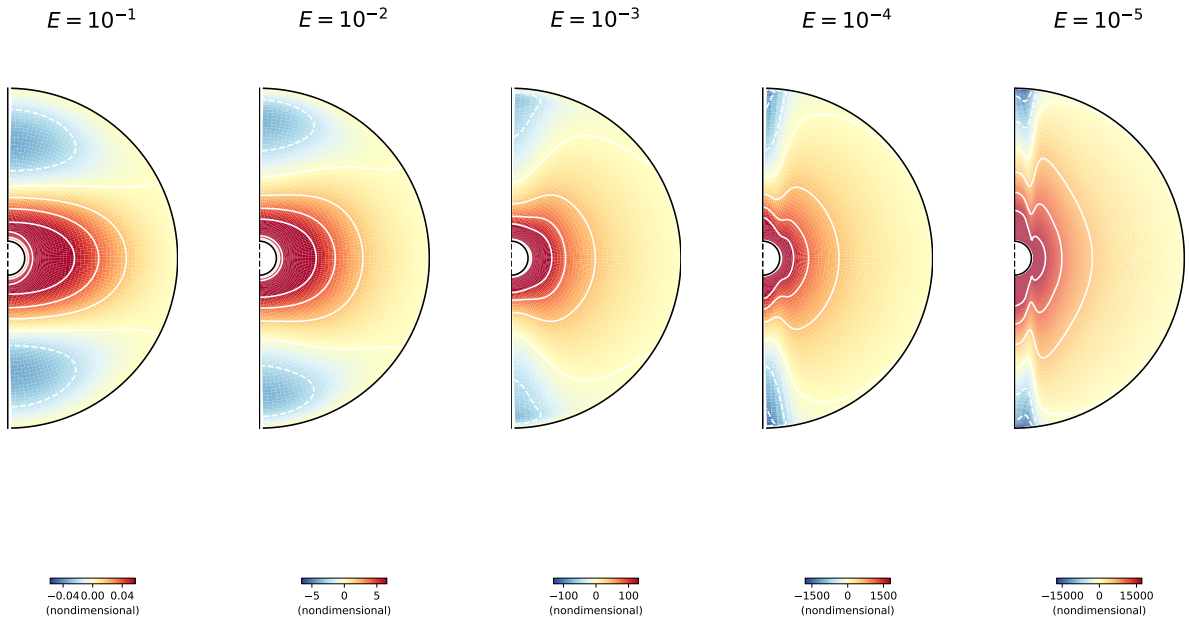

Figure 3: Angular velocity azimuthal average during equilibrated phase for a range of Ekman numbers.

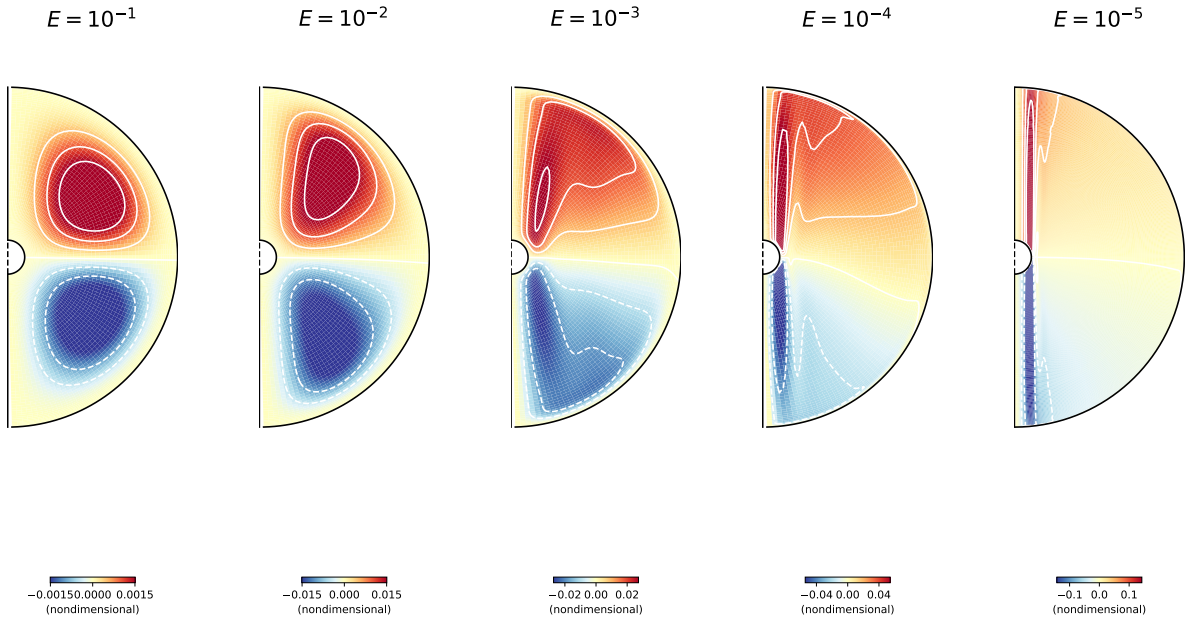

Figure 4: Mass flux azimuthal average during equilibrated phase for a range of Ekman numbers.

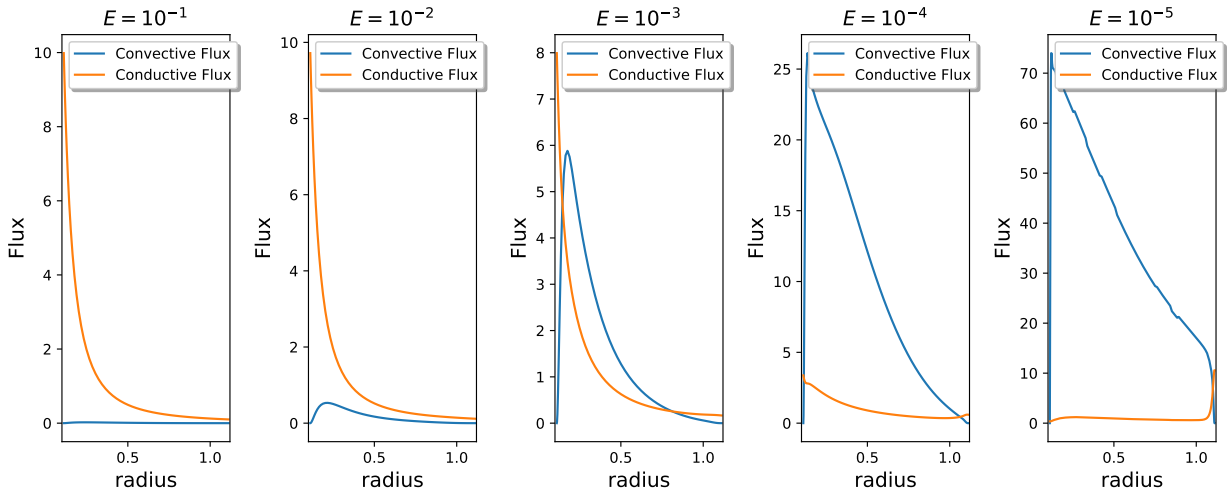

Figure 5: Azimuthal average of convective and conductive heat flux at the pole for a range of Ekman numbers.

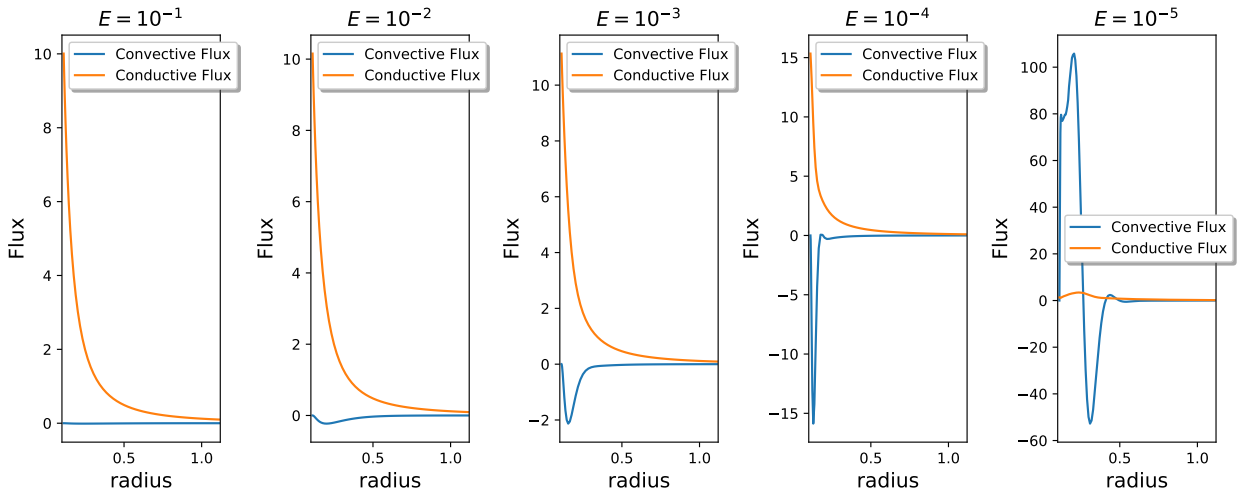

Figure 6: Azimuthal average of convective and conductive heat flux at the equator for a range of Ekman numbers.

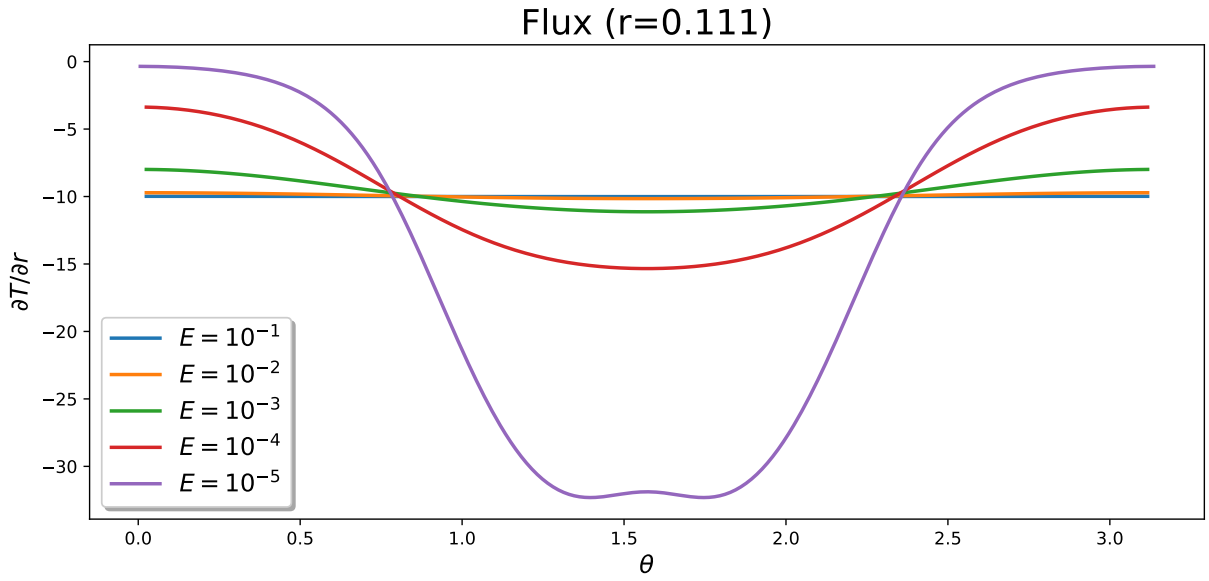

Figure 7: Conductive flux azimuthal average as a function of θ at the inner radius for a range of Ekman numbers.

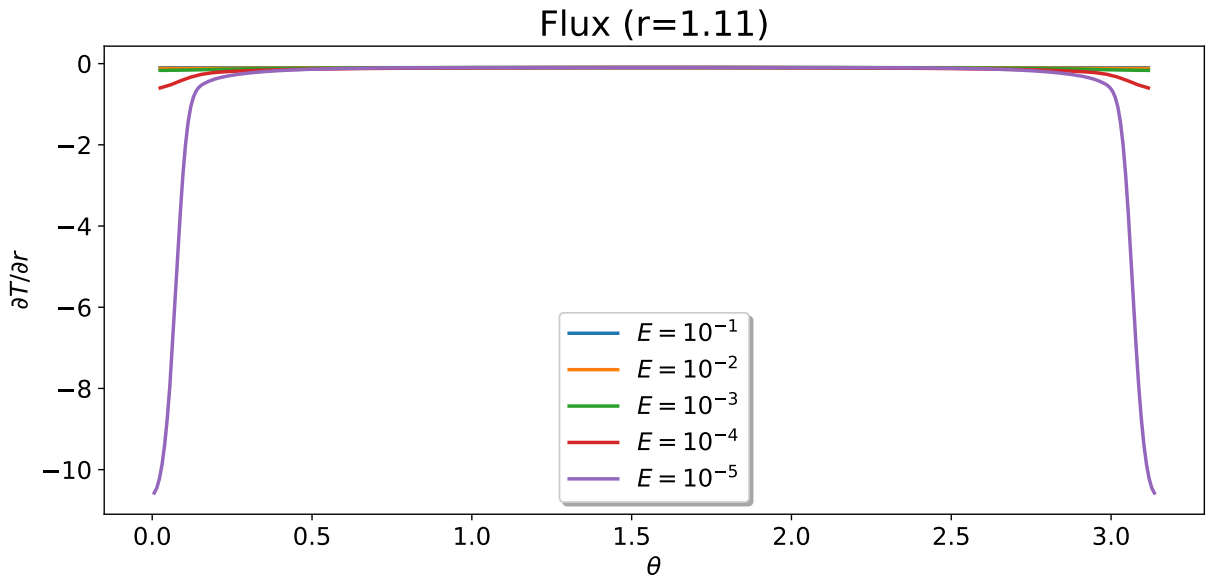

Figure 8: Conductive flux azimuthal average as a function of θ at the outer radius for a range of Ekman numbers.

Flux ratio values are not making any sense. The ratio is near 1 in some parts of the array, but for others it blows up especially at the outer and inner boundary. Need to ask Nick.

Aspect Ratio	E	Δt	N_r x N_θ x N_ϕ	KE	KE$_r$	KE$_\theta$	KE$_\phi$	Flux Ratio (r_i)	Flux Ratio (r_o)
0.1	10^{-1}	10^{-4}	64x96x192	2.72×10^{-4}	1.33×10^{-4}	9.82×10^{-5}	4.00×10^{-5}	6	4
0.1	10^{-2}	10^{-4}	64x96x192	3.71×10^{-1}	1.98×10^{-2}	1.08×10^{-2}	3.4×10^{-1}	6	4
0.1	10^{-3}	5×10^{-5}	64x96x192	67.23	2.12×10^{-1}	1.01×10^{-1}	66.92	6	4
0.1	10^{-4}	10^{-5}	64x96x192	9.77×10^{3}	3.511	2.016	9.76×10^{3}	6	4
0.1	10^{-5}	10^{-6}	128x384x768	9.59×10^{5}	85.2	251.36	9.76×10^{3}	6	4

Table 1: Details of numerical simulations performed for the incompressible model in this section. The following are specified, aspect ratio of the sphere, the Ekman number (E), the time-step size (Δt), the spatial resolution (N_r x N_θ x N_ϕ), kinetic energy and its components, and the flux ratio at the inner and outer boundary.

2.2 Aspect Ratio = 0.5

Working currently on getting $E = 10^{-4}$ to run on Summit. Attempt failed increased resolution and timestep and also started from $E = 10^{-3}$ case, but the simulation still requires a smaller time-step. May need to run on Pleadis. Leaving plots here as place holders.

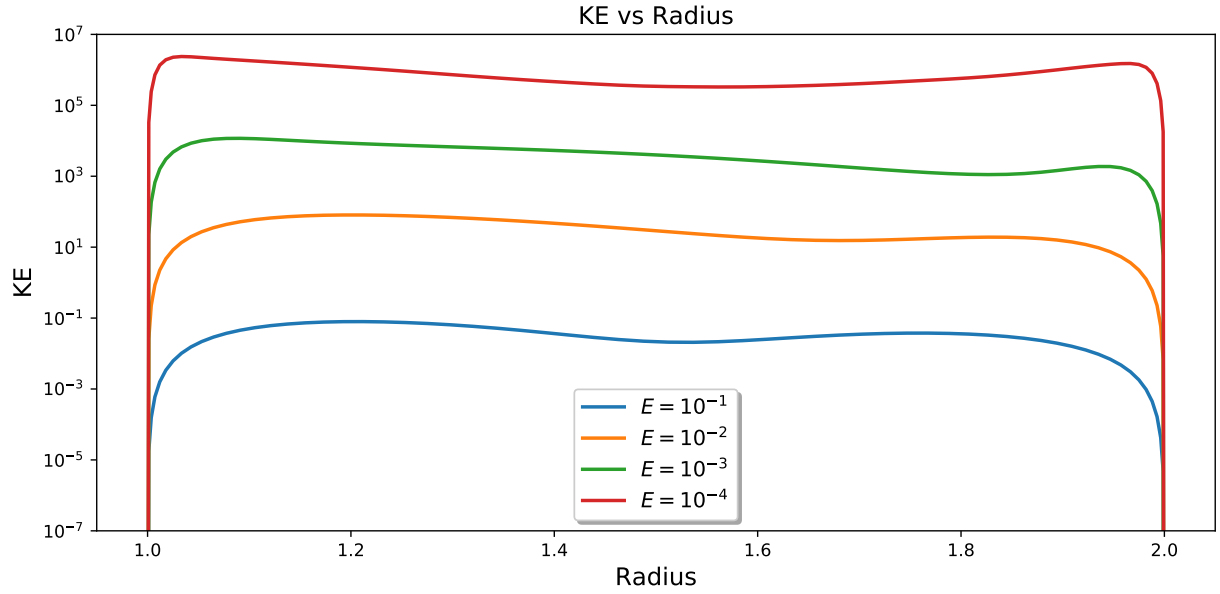

Figure 9: Kinetic energy shell average as a function of radius during equilibrated phase for a range of Ekman numbers with aspect ratio set to 0.5.

Aspect Ratio	E	Δt	N_r x N_θ x N_ϕ	KE	KE$_r$	KE$_\theta$	KE$_\phi$	Flux Ratio (r_i)	Flux Ratio (r_o)
0.5	10^{-1}	10^{-3}	64x96x192	3.22×10^{-2}	4.81×10^{-3}	2.07×10^{-2}	6.71×10^{-3}	6	4
0.5	10^{-2}	10^{-4}	64x96x192	28.3	1.98×10^{-2}	2.02	25.75	6	4
0.5	10^{-3}	5×10^{-5}	64x96x192	3.19×10^{3}	9.74	57.9	3.12×10^{3}	6	4
0.5	10^{-4}	10^{-5}	64x96x192	2.49×10^{big}	3.511	2.016	9.76×10^{3}	6	4

Table 2: Details of numerical simulations performed for the incompressible model in this section. The following are specified, aspect ratio of the sphere, the Ekman number (E), the time-step size (Δt), the spatial resolution (N_r x N_θ x N_ϕ), kinetic energy and its components, and the flux ratio at the inner and outer boundary.

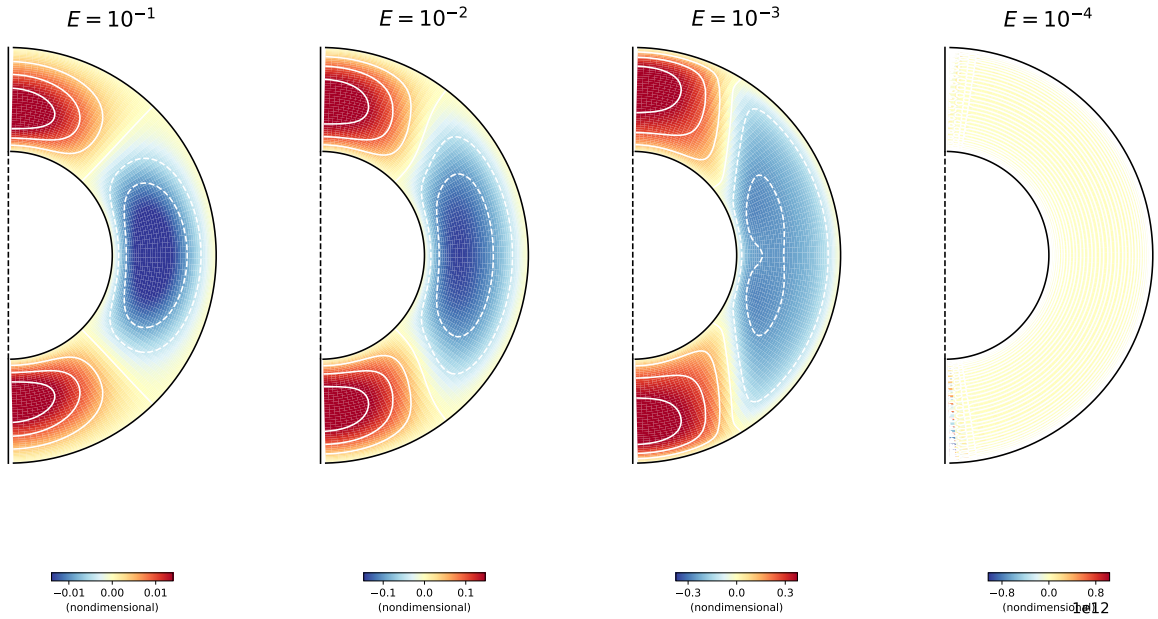

Figure 10: Temperature azimuthal average during equilibrated phase for a range of Ekman numbers.

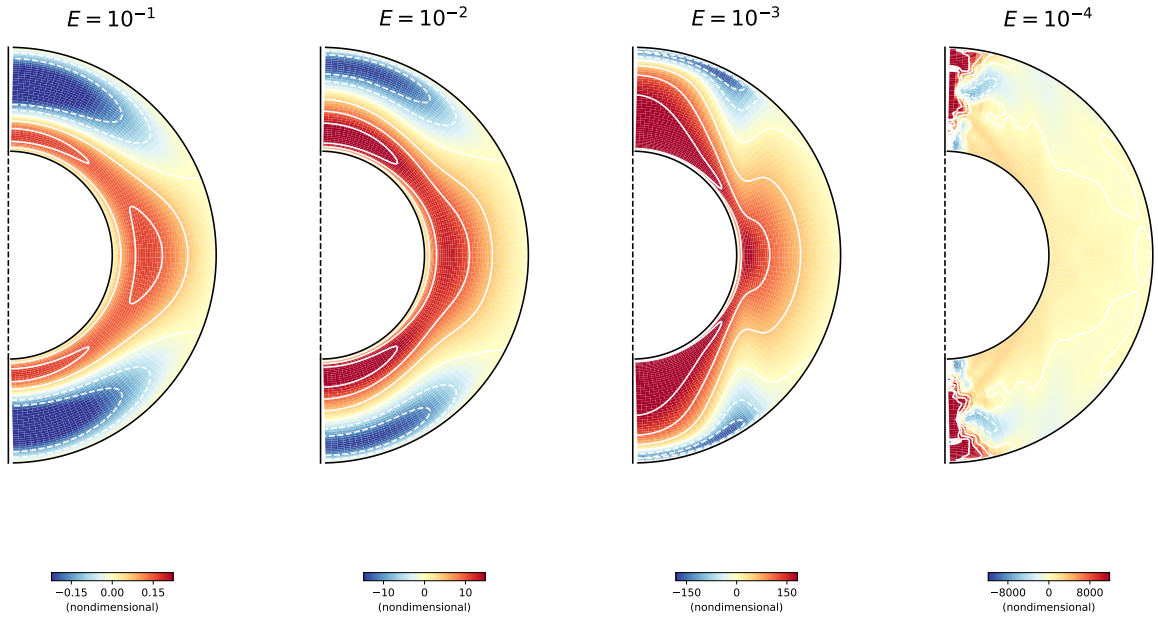

Figure 11: Angular velocity azimuthal average during equilibrated phase for a range of Ekman numbers.

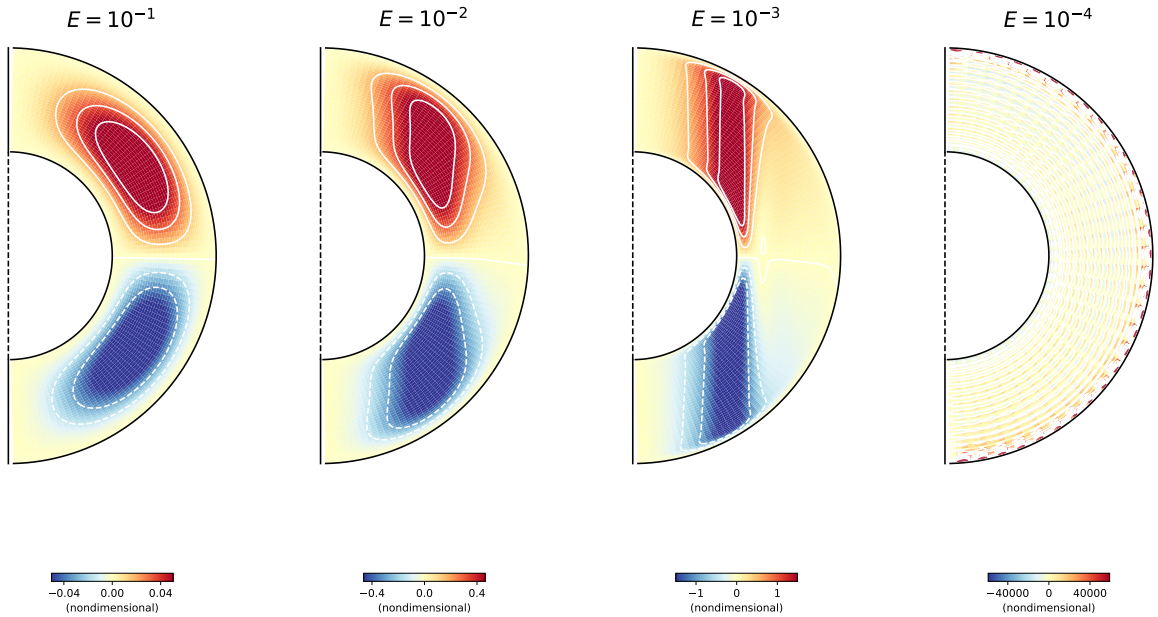

Figure 12: Mass flux azimuthal average during equilibrated phase for a range of Ekman numbers.