

# <sup>1</sup> Supplementary Information

## <sup>2</sup> 1 Approximations: Hyperdiffusivity and Axial Inertia

<sup>3</sup> In this section we first defend our use of hyperdiffusivity by demonstrating that one of  
<sup>4</sup> the standard references demonstrating that hyperdiffusivity can alter dynamo simulation  
<sup>5</sup> results does not apply to our study because of large differences in the employment. We then  
<sup>6</sup> compare our characteristic dipolar models from Table 1 in the main text with similar models  
<sup>7</sup> run with the mMoSST dynamo model [[Jiang and Kuang, 2008](#)] at the same parameters but  
<sup>8</sup> no hyperdiffusivity and full inertia.

### <sup>9</sup> 1.1 In defence of hyperdiffusivity

<sup>10</sup> [Grote et al. \[2000\]](#) find that the use of hyperdiffusivity can significantly affect the results of  
<sup>11</sup> dynamo simulations. However, the form of hyperdiffusivity in our study is much milder than  
<sup>12</sup> in [Grote et al. \[2000\]](#) and may therefore have much less effect on the model results. Here  
<sup>13</sup> we demonstrate the difference between our usage and theirs as well as that in [Kuang and](#)  
<sup>14</sup> [Bloxham \[1999\]](#). All hyperdiffusivities in these models can be written in the form:

$$\nu_t(l) = \nu_0 \left[ \frac{1 + a(l - l_0)^n}{1 + a(l_1 - l_0)^n} \right] \quad \text{for } l > l_0. \quad (1)$$

<sup>15</sup> This is equation 1 in [Grote et al. \[2000\]](#). The values for the parameters  $a, l_0, l_1$  and  $n$  for the  
<sup>16</sup> three studies are:

- <sup>17</sup> • [[Grote et al., 2000](#)]:  $a = 0.075, l_0 = 0, l_1 = 4, n = 3$
- <sup>18</sup> • [[Kuang and Bloxham, 1999](#)]:  $a = 0.05, l_0 = 0, l_1 = 0, n = 2$
- <sup>19</sup> • This study:  $a = 0.05, l_0 = 30, l_1 = 0, n = 2$

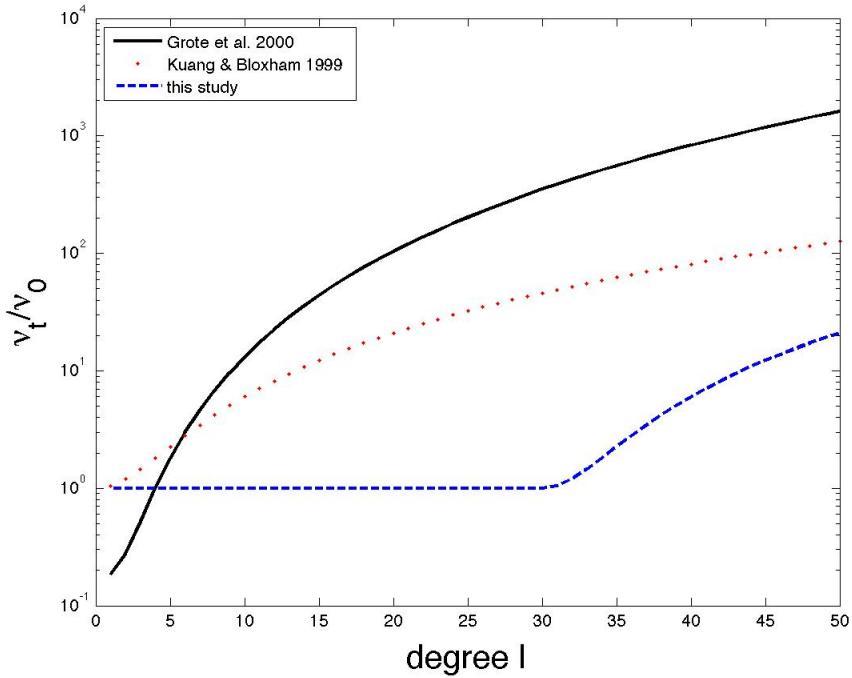


Figure 1: Viscosity as a function of spherical harmonic degree  $l$  for various hyperdiffusivity implementations in dynamo simulations. The viscosity is normalized by the value at  $l = 0$  for each degree.

The values of the viscosity as a function of degree  $l$  are plotted in Figure 1. It is clear that the [Kuang and Bloxham \[1999\]](#) study and this study have much weaker hyperdiffusivity than the [Grote et al. \[2000\]](#) study. For example, the ratio of the viscosity at degree  $l = 20$  to degree  $l = 1$  in the [Grote et al. \[2000\]](#) study is  $\sim 100$  whereas in this study, it is 1 (since hyperdiffusivity doesn't onset until at least  $l = 30$ ). Comparing at a higher degree where hyperdiffusivity is acting in both cases, the ratio at  $l = 50$  to  $l = 1$  in this study is 21 whereas in the [Grote et al. \[2000\]](#) study it is  $\sim 8700$ .

## 1.2 Comparing models with and without hyperdiffusivity

The mMoSST dynamo model [[Jiang and Kuang, 2008](#)] is a benchmarked version of the [Kuang and Bloxham \[1999\]](#) model that is used in this study. Updated numerics allow it to

30 be run without hyperdiffusivity at similar parameters to those used in this study. Table 3  
31 provides values for some of the diagnostic parameters given in Table 1 of the main text for  
32 the characteristic models.

33 The use of hyperdiffusivity has some effect on our model diagnostic parameters, as ex-  
34 pected, but does not alter any trends or conclusions in our paper. Most notably for our  
35 scaling laws, the Nusselt numbers are similar between the Table 1 and Suppl. Table 3 val-  
36 ues, differing at most by 20%. The Rossby and local Rossby numbers differ at most by  
37 50%. The kinetic energies are quite similar with the largest variation being  $\sim$ 30% for model  
38 FFSF. The magnetic energies are most different for the FFNS and FTSF models ( $\sim$ factor  
39 of 2 difference). The dipole fraction ( $f_{dip}$ ) is very similar between the Table 1 and Suppl.  
40 Table 3 values except for model FTSF-15. The model without hyperdiffusivity produces  
41 a multipolar dynamo. For this case, we believe we have the weak solution for a bistable  
42 model (as demonstrated in Figure 1 of the main text, bistable solutions are possible in this  
43 parameter regime).

44 From these comparisons, and the fact that our scaling laws in the main text compare  
45 favourably with those by other authors, we conclude that the use of hyperdiffusivity in our  
46 main text models does not alter our results or conclusions.

## 47 2 Axial vs. Full Inertia

48 The Kuang & Bloxham dynamo model approximates the momentum equation by only in-  
49 cluding the axial component of inertia. See [Kuang and Bloxham \[1999\]](#) for a justification  
50 of this approximation. The mMoSST model can be run with either full-inertia or axial-only  
51 inertia, allowing us to investigate the effect of this approximation.

52 In Suppl. Table 3, the diagnostics for the models with full inertia match those with axial-  
53 only inertia very well. The largest discrepancies are in the magnetic energies for FFSF-21

54 ( $\sim 15\%$  difference) and FTNS-24 ( $\sim 20\%$  difference). This discrepancy in the energy does  
55 not appear to affect the other diagnostic parameters significantly. For example, the kinetic  
56 energies are very similar, the dipole fractions differ by less than 5%, and the local Rossby  
57 numbers by  $\sim 10\%$ . The toroidal/poloidal energy ratios, the Rossby number and the Nusselt  
58 number match almost exactly. We are therefore confident that the axial-only approximation  
59 does not affect the results or conclusions of our study.

**Supplementary Table 1: Dynamo Model Results.** The column headings from left to right are: model ID, number of radial grid points in outer core ( $N_{r_o}$ ), Rayleigh number ( $Ra$ ), super criticality of Rayleigh number ( $\frac{Ra}{Ra_C}$ ), magnetic energy ( $E_B$ ), kinetic energy ( $E_k$ ), ratio of poloidal to toroidal magnetic energy ( $\frac{E_{B_P}}{E_{B_T}}$ ), relative dipole strength ( $f_{Dip}$ ), Rossby number ( $Ro$ ), local Rossby number ( $Ro_l$ ), Nusselt number ( $Nu$ ), Match Coefficient of the Lorentz to Coriolis force ( $M_{LC}$ ) and the Match Coefficient of  $\alpha$  and  $\omega$  effects ( $M_\alpha$  and  $M_\omega$ ) respectively. All models use hyperdiffusivity parameter  $l_0 = 30$  except for models whose model IDs are marked with the following symbols: \*:  $l_0 = 50$ , \*\*:  $l_0 = 40$ . All models were run for at least three magnetic dipole diffusion times and results are based on analysis after the system equilibrated.

Model	$N_{r_o}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{B_P}}{E_{B_T}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$
$E = 2.00\text{e-}05$ , $Ro_M = 2.00\text{e-}05$ and $q_k = 1$													
FFSF-01**	93	2.50e+03	6.98	2.6e-01	3.2e+05	3.5e-01	2.1e-01	1.1e-02	9.3e-03	1.62	0.17	0.39	0.41
FFSF-02**	93	5.00e+03	13.97	6.4e-01	3.8e+05	4.0e-01	3.1e-01	1.2e-02	1.6e-02	2.06	0.24	0.44	0.34
FFSF-03	64	5.00e+03	13.97	1.7e+00	8.6e+04	8.4e-01	9.5e-01	5.9e-03	2.3e-02	2.40	0.38	0.32	0.16
FFSF-04**	93	7.50e+03	20.95	2.4e+00	2.3e+05	9.7e-01	9.5e-01	9.6e-03	2.5e-02	2.81	0.39	0.30	0.28
FFSF-05**	93	1.00e+04	27.93	3.9e+00	2.3e+05	9.5e-01	9.5e-01	9.6e-03	3.3e-02	3.22	0.46	0.22	0.29
FFSF-06**	93	1.25e+04	34.92	4.9e+00	3.0e+05	7.6e-01	9.2e-01	1.1e-02	3.7e-02	3.64	0.41	0.24	0.34
FFSF-07	64	1.50e+04	41.90	5.9e+00	2.4e+05	8.6e-01	9.3e-01	9.9e-03	4.3e-02	4.01	0.44	0.30	0.26
FFNS-01	64	2.50e+03	9.03	7.5e-01	3.6e+04	1.0e+00	9.6e-01	3.8e-03	1.3e-02	1.96	0.32	0.33	0.21
FFNS-02	64	5.00e+03	18.05	2.9e+00	6.3e+04	7.9e-01	9.4e-01	5.0e-03	1.6e-02	2.73	0.42	0.37	0.22
FFNS-03	64	7.50e+03	27.08	5.0e+00	8.3e+04	8.5e-01	8.7e-01	5.8e-03	2.0e-02	3.39	0.49	0.27	0.27
FFNS-04	64	1.00e+04	36.10	6.3e+00	1.0e+05	8.8e-01	8.7e-01	6.5e-03	2.4e-02	3.84	0.49	0.27	0.35
FFNS-05	93	1.25e+04	45.13	6.9e+00	1.3e+05	8.9e-01	8.4e-01	7.2e-03	2.8e-02	4.23	0.48	0.34	0.27
FFNS-06	64	1.50e+04	54.15	6.8e+00	1.6e+05	8.7e-01	8.6e-01	8.0e-03	3.2e-02	4.58	0.48	0.40	0.23
FTSF-01	64	1.25e+03	2.71	8.1e-01	3.7e+04	1.1e+00	9.8e-01	3.8e-03	1.6e-02	1.91	0.36	0.33	0.23
FTSF-02	64	1.50e+03	3.25	1.1e+00	5.2e+04	1.1e+00	9.4e-01	4.6e-03	2.0e-02	2.13	0.28	0.32	0.10
FTSF-03	64	1.75e+03	3.79	1.4e+00	6.9e+04	1.0e+00	8.9e-01	5.2e-03	2.3e-02	2.30	0.34	0.36	0.12
FTSF-04	64	2.00e+03	4.33	1.7e+00	8.9e+04	9.2e-01	9.0e-01	5.9e-03	2.6e-02	2.51	0.30	0.41	0.13
FTSF-05	64	2.25e+03	4.87	1.8e+00	1.0e+05	1.1e+00	9.0e-01	6.3e-03	3.1e-02	2.69	0.32	0.38	0.20

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Table 1 – *Continued from previous page*

Model	$N_{ro}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{BP}}{E_{BT}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$
FTSF-06	64	2.50e+03	5.41	2.2e+00	1.2e+05	9.9e-01	9.1e-01	7.0e-03	3.3e-02	2.90	0.32	0.40	0.23
FTSF-07	64	5.00e+03	10.82	6.2e+00	3.7e+05	1.4e+00	9.4e-01	1.2e-02	7.0e-02	4.94	0.34	0.39	0.28
FTSF-08	64	7.50e+03	16.23	1.0e+01	7.5e+05	1.3e+00	9.3e-01	1.7e-02	9.8e-02	6.75	0.31	0.39	0.27
FTSF-09	93	1.00e+04	21.65	7.1e+00	2.7e+06	6.9e-01	1.9e-01	3.3e-02	1.2e-01	7.59	0.09	0.56	0.19
FTSF-10	93	1.25e+04	27.06	9.6e+00	4.1e+06	6.9e-01	2.3e-01	4.0e-02	1.4e-01	8.71	0.08	0.48	0.26
FTSF-11	93	1.50e+04	32.47	1.3e+01	5.4e+06	6.8e-01	2.5e-01	4.6e-02	1.5e-01	9.82	0.09	0.52	0.21
FTNS-01	64	1.25e+03	3.46	9.9e-01	3.2e+04	1.4e+00	9.2e-01	3.5e-03	1.5e-02	2.07	0.29	0.39	0.16
FTNS-02**	64	1.50e+03	4.16	2.8e+00	4.3e+04	1.8e+00	9.6e-01	4.1e-03	2.1e-02	2.89	0.32	0.55	0.18
FTNS-03**	64	1.75e+03	4.85	2.9e+00	4.1e+04	1.8e+00	9.4e-01	4.1e-03	1.9e-02	2.64	0.41	0.27	0.38
FTNS-04	64	1.75e+03	4.85	2.2e+00	4.8e+04	1.4e+00	8.6e-01	4.4e-03	1.8e-02	2.48	0.43	0.25	0.41
FTNS-05	64	2.00e+03	5.54	2.6e+00	5.7e+04	1.6e+00	8.8e-01	4.8e-03	2.1e-02	2.72	0.48	0.26	0.39
FTNS-06**	64	2.25e+03	6.23	3.7e+00	6.5e+04	1.8e+00	9.3e-01	5.1e-03	2.6e-02	3.05	0.46	0.21	0.42
FTNS-07	64	2.25e+03	6.23	2.9e+00	7.3e+04	1.8e+00	8.9e-01	5.4e-03	2.6e-02	3.04	0.43	0.31	0.31
FTNS-08**	93	2.50e+03	6.93	3.7e+00	7.8e+04	1.9e+00	9.3e-01	5.6e-03	2.9e-02	3.22	0.45	0.23	0.40
FTNS-09	64	2.50e+03	6.93	3.3e+00	8.5e+04	1.6e+00	8.9e-01	5.8e-03	2.8e-02	3.27	0.47	0.30	0.35
FTNS-10**	93	5.00e+03	13.85	5.9e+00	2.9e+05	1.3e+00	8.6e-01	1.1e-02	5.9e-02	5.18	0.32	0.45	0.25
FTNS-11	64	5.00e+03	13.85	7.3e+00	2.8e+05	1.5e+00	8.8e-01	1.1e-02	5.1e-02	5.22	0.42	0.41	0.26
FTNS-12	64	7.50e+03	20.78	9.6e+00	5.6e+05	1.3e+00	7.8e-01	1.5e-02	7.5e-02	6.94	0.33	0.51	0.21
FTNS-13	64	1.00e+04	27.70	5.7e+00	1.8e+06	7.7e-01	1.8e-01	2.7e-02	1.1e-01	8.45	-0.00	0.51	0.21
FTNS-14	93	1.25e+04	34.63	7.5e+00	2.6e+06	7.6e-01	1.4e-01	3.2e-02	1.4e-01	9.37	-0.02	0.38	0.26
FTNS-15	64	1.25e+04	34.63	7.5e+00	2.6e+06	7.5e-01	2.0e-01	3.2e-02	1.3e-01	9.33	0.02	0.50	0.20
FTNS-16	93	1.50e+04	41.55	9.8e+00	3.4e+06	7.5e-01	8.2e-02	3.7e-02	1.5e-01	10.21	-0.01	0.46	0.21

$E = 6.00\text{e-}05$ ,  $Ro_M = 2.00\text{e-}05$  and  $q_k = 1$

FFSF-08**	64	3.50e+03	12.24	8.4e-01	5.6e+04	7.6e-01	9.8e-01	4.7e-03	1.4e-02	2.18	0.33	0.30	0.17
FFSF-09*	64	5.00e+03	17.48	1.4e+00	7.1e+04	1.0e+00	9.7e-01	5.3e-03	1.8e-02	2.54	0.36	0.26	0.22
FFSF-10	64	5.00e+03	17.48	2.2e-01	1.2e+05	4.3e-01	2.0e-01	6.9e-03	1.7e-02	2.29	0.12	0.66	0.16
FFSF-11*	64	6.00e+03	20.98	1.9e+00	8.4e+04	9.7e-01	9.4e-01	5.8e-03	1.9e-02	2.70	0.41	0.21	0.22

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Table 1 – *Continued from previous page*

Model	$N_{ro}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{BP}}{E_{BT}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$
FFSF-12	64	6.00e+03	20.98	2.9e-01	1.8e+05	4.5e-01	1.5e-01	8.5e-03	1.9e-02	2.51	0.14	0.46	0.31
FFSF-13*	64	7.50e+03	26.22	3.1e+00	1.1e+05	8.2e-01	9.5e-01	6.6e-03	2.2e-02	2.98	0.45	0.29	0.20
FFSF-14*	64	7.50e+03	26.22	3.5e-01	2.2e+05	4.6e-01	1.8e-01	9.3e-03	2.3e-02	2.67	0.13	0.51	0.29
FFSF-15*	64	1.00e+04	34.97	4.0e+00	1.4e+05	8.1e-01	9.2e-01	7.5e-03	2.6e-02	3.46	0.49	0.29	0.17
FFSF-16	64	1.00e+04	34.97	3.6e-01	3.2e+05	4.2e-01	1.1e-01	1.1e-02	2.8e-02	2.93	0.11	0.57	0.26
FFSF-17	64	1.25e+04	43.71	4.2e+00	1.9e+05	9.2e-01	9.1e-01	8.6e-03	3.3e-02	3.83	0.42	0.34	0.27
FFSF-18	64	1.50e+04	52.45	6.0e+00	2.1e+05	8.0e-01	9.1e-01	9.2e-03	3.3e-02	4.15	0.49	0.30	0.22
FFSF-19*	64	1.50e+04	52.45	7.3e-01	5.4e+05	4.8e-01	2.6e-01	1.5e-02	3.8e-02	3.57	0.12	0.49	0.33
FFSF-20	64	2.00e+04	69.93	7.6e+00	2.6e+05	8.4e-01	8.6e-01	1.0e-02	4.0e-02	4.80	0.50	0.33	0.26
FFSF-21	64	2.50e+04	87.41	8.1e+00	3.2e+05	8.8e-01	8.3e-01	1.1e-02	4.6e-02	5.36	0.45	0.39	0.23
FFSF-22	64	3.00e+04	104.90	8.1e+00	3.9e+05	8.7e-01	8.0e-01	1.2e-02	5.2e-02	5.85	0.45	0.45	0.19
FFSF-23	64	3.50e+04	122.38	9.1e+00	4.2e+05	9.1e-01	8.0e-01	1.3e-02	5.6e-02	6.32	0.41	0.51	0.16
FFSF-24	64	5.00e+04	174.83	9.9e+00	6.6e+05	9.0e-01	7.8e-01	1.6e-02	7.2e-02	7.32	0.36	0.58	0.15
FFSF-25	64	7.50e+04	262.24	1.0e+01	1.0e+06	9.1e-01	7.9e-01	2.0e-02	9.0e-02	8.60	0.31	0.57	0.17
FFSF-26	64	7.50e+04	262.24	3.8e+00	2.6e+06	5.9e-01	3.8e-01	3.2e-02	9.1e-02	8.07	0.12	0.52	0.25
FFSF-27	64	8.00e+04	279.72	9.9e+00	1.1e+06	8.9e-01	7.7e-01	2.1e-02	9.4e-02	8.85	0.31	0.58	0.15
FFSF-28	64	9.50e+04	332.17	4.7e+00	3.1e+06	6.1e-01	2.3e-01	3.5e-02	1.0e-01	8.99	0.11	0.60	0.21
FFNS-07**	64	3.00e+03	12.45	5.3e-01	3.3e+04	8.7e-01	9.4e-01	3.6e-03	1.0e-02	2.27	0.25	0.38	0.29
FFNS-08	64	3.50e+03	14.52	1.4e+00	3.5e+04	8.7e-01	9.3e-01	3.8e-03	1.0e-02	2.48	0.34	0.14	0.51
FFNS-09	64	5.00e+03	20.75	2.2e+00	4.7e+04	7.6e-01	9.0e-01	4.3e-03	1.2e-02	2.89	0.47	0.19	0.42
FFNS-10	64	6.00e+03	24.90	2.7e+00	5.4e+04	8.7e-01	9.0e-01	4.6e-03	1.4e-02	3.15	0.42	0.33	0.31
FFNS-11	64	7.50e+03	31.12	3.4e+00	6.2e+04	8.1e-01	8.3e-01	5.0e-03	1.6e-02	3.52	0.46	0.28	0.38
FFNS-12	64	1.00e+04	41.49	4.4e+00	8.2e+04	8.2e-01	8.1e-01	5.7e-03	1.8e-02	3.94	0.49	0.28	0.40
FFNS-13	64	1.25e+04	51.87	4.8e+00	9.6e+04	9.7e-01	7.3e-01	6.2e-03	2.2e-02	4.38	0.45	0.42	0.27
FFNS-14	64	1.50e+04	62.24	4.8e+00	1.2e+05	8.7e-01	7.7e-01	7.0e-03	2.4e-02	4.57	0.46	0.44	0.23
FFNS-15	64	2.00e+04	82.99	4.5e+00	1.6e+05	1.0e+00	7.5e-01	8.1e-03	3.0e-02	5.21	0.42	0.52	0.17
FFNS-16	64	2.50e+04	103.73	5.1e+00	2.1e+05	1.0e+00	7.2e-01	9.1e-03	3.5e-02	5.59	0.39	0.45	0.23
FFNS-17	64	3.00e+04	124.48	5.3e+00	2.5e+05	9.6e-01	7.2e-01	1.0e-02	3.8e-02	5.93	0.36	0.52	0.21
FFNS-18	64	3.50e+04	145.23	5.5e+00	2.8e+05	1.0e+00	7.2e-01	1.1e-02	4.2e-02	6.29	0.34	0.50	0.22

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Table 1 – *Continued from previous page*

Model	$N_{ro}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{BP}}{E_{BT}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$	
$\infty$	FFNS-19	64	5.00e+04	207.47	5.9e+00	3.9e+05	1.0e+00	6.8e-01	1.2e-02	5.2e-02	7.15	0.29	0.60	0.14
	FFNS-20	64	7.50e+04	311.20	5.9e+00	6.0e+05	1.0e+00	6.3e-01	1.5e-02	6.6e-02	8.18	0.22	0.66	0.14
	FFNS-21	64	8.00e+04	331.95	3.9e+00	7.7e+05	8.6e-01	5.6e-01	1.8e-02	7.1e-02	8.38	0.11	0.69	0.11
	FFNS-22	64	9.50e+04	394.19	4.6e+00	8.4e+05	9.6e-01	5.6e-01	1.8e-02	7.8e-02	8.86	0.13	0.69	0.11
	FTSF-12	64	1.50e+03	4.35	1.0e+00	4.0e+04	1.4e+00	9.4e-01	4.0e-03	1.6e-02	2.32	0.36	0.35	0.09
	FTSF-13	64	2.00e+03	5.80	1.6e+00	6.3e+04	1.4e+00	9.2e-01	5.0e-03	2.2e-02	2.74	0.34	0.25	0.26
	FTSF-14	64	2.50e+03	7.25	6.4e-01	2.1e+05	6.3e-01	5.7e-01	9.2e-03	2.5e-02	3.11	0.19	0.34	0.41
	FTSF-15	64	5.00e+03	14.49	4.6e+00	3.1e+05	1.3e+00	9.3e-01	1.1e-02	5.5e-02	5.06	0.36	0.41	0.27
	FTSF-16	64	7.50e+03	21.74	7.0e+00	6.2e+05	1.2e+00	8.9e-01	1.6e-02	7.8e-02	6.70	0.32	0.54	0.20
	FTSF-17	64	1.00e+04	28.99	3.8e+00	1.6e+06	8.3e-01	3.1e-01	2.5e-02	9.6e-02	8.00	0.11	0.57	0.21
	FTSF-18	64	1.25e+04	36.23	5.6e+00	2.2e+06	8.4e-01	2.4e-01	3.0e-02	1.1e-01	9.11	0.13	0.56	0.22
	FTSF-19	64	1.50e+04	43.48	7.6e+00	2.9e+06	8.3e-01	1.8e-01	3.4e-02	1.3e-01	10.09	0.12	0.58	0.21
	FTSF-20	64	2.00e+04	57.97	1.2e+01	4.8e+06	8.1e-01	1.7e-01	4.4e-02	1.5e-01	11.74	0.09	0.60	0.19
	FTSF-21	64	2.50e+04	72.46	1.6e+01	6.8e+06	7.9e-01	1.4e-01	5.2e-02	1.8e-01	13.16	0.10	0.58	0.19
	FTNS-17	64	1.00e+03	3.61	4.1e-01	1.6e+04	2.0e+00	9.5e-01	2.5e-03	9.2e-03	1.96	0.25	0.46	0.11
	FTNS-18	64	1.50e+03	5.42	3.5e+00	2.2e+04	1.7e+00	9.6e-01	3.0e-03	9.5e-03	2.45	0.48	0.15	0.52
	FTNS-19	64	2.00e+03	7.22	4.5e+00	3.5e+04	1.8e+00	9.5e-01	3.7e-03	1.3e-02	2.93	0.50	0.20	0.52
	FTNS-20	64	2.50e+03	9.03	4.6e+00	5.6e+04	1.7e+00	9.2e-01	4.7e-03	1.8e-02	3.38	0.50	0.27	0.42
	FTNS-21*	64	3.00e+03	10.83	4.2e+00	8.0e+04	1.5e+00	8.9e-01	5.6e-03	2.2e-02	3.66	0.46	0.33	0.36
	FTNS-22	64	3.00e+03	10.83	5.4e+00	7.2e+04	1.4e+00	9.1e-01	5.4e-03	2.0e-02	3.61	0.48	0.33	0.35
	FTNS-23*	64	3.50e+03	12.64	4.8e+00	1.1e+05	1.5e+00	8.7e-01	6.5e-03	2.5e-02	4.05	0.44	0.31	0.38
	FTNS-24	64	5.00e+03	18.05	6.6e+00	1.7e+05	1.3e+00	8.1e-01	8.3e-03	3.4e-02	5.05	0.47	0.39	0.32
	FTNS-25	64	6.00e+03	21.66	6.1e+00	2.6e+05	1.3e+00	7.7e-01	1.0e-02	4.2e-02	5.59	0.42	0.52	0.24
	FTNS-26	64	7.50e+03	27.08	5.6e+00	3.9e+05	1.2e+00	7.2e-01	1.2e-02	5.3e-02	6.36	0.33	0.57	0.19
	FTNS-27	64	1.00e+04	36.10	5.5e+00	6.3e+05	1.1e+00	6.5e-01	1.6e-02	6.9e-02	7.47	0.21	0.63	0.15
	FTNS-28	64	1.25e+04	45.13	2.9e+00	1.1e+06	9.3e-01	2.3e-01	2.1e-02	9.1e-02	8.55	-0.08	0.63	0.17
	FTNS-29	64	1.50e+04	54.15	4.2e+00	1.4e+06	9.4e-01	1.1e-01	2.4e-02	9.9e-02	9.16	-0.04	0.64	0.15
	FTNS-30	64	1.50e+04	54.15	4.2e+00	1.4e+06	9.3e-01	1.6e-01	2.4e-02	1.0e-01	9.21	-0.04	0.60	0.18
	FTNS-31	64	2.00e+04	72.20	6.9e+00	2.0e+06	9.3e-01	1.1e-01	2.8e-02	1.2e-01	10.21	-0.04	0.60	0.17

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Table 1 – *Continued from previous page*

Model	$N_{ro}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{BP}}{E_{BT}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$
FTNS-32	64	2.50e+04	90.25	1.0e+01	2.4e+06	9.2e-01	1.4e-01	3.1e-02	1.3e-01	11.04	0.02	0.66	0.12
FTNS-33	64	3.00e+04	108.30	1.3e+01	3.3e+06	9.1e-01	9.7e-02	3.6e-02	1.4e-01	11.75	0.02	0.67	0.12
FTNS-34	64	3.50e+04	126.35	1.6e+01	3.9e+06	9.2e-01	1.2e-01	3.9e-02	1.5e-01	12.30	0.01	0.62	0.15
FTNS-35	64	4.00e+04	144.40	1.9e+01	4.5e+06	9.2e-01	1.0e-01	4.2e-02	1.6e-01	12.84	0.04	0.68	0.10
FTNS-36	64	5.00e+04	180.51	2.6e+01	5.9e+06	9.3e-01	9.8e-02	4.9e-02	1.8e-01	13.77	0.04	0.69	0.09
$E = 2.00\text{e-}04$ , $Ro_M = 1.00\text{e-}04$ and $q_k = 1$													
FFSF-29	64	7.50e+03	31.91	6.1e-01	2.6e+05	3.1e-01	1.6e-01	5.0e-02	6.9e-02	3.09	0.09	0.24	0.46
FFSF-30*	64	1.00e+04	42.55	6.1e-01	3.2e+05	3.3e-01	1.7e-01	5.7e-02	8.5e-02	3.45	0.06	0.40	0.39
FFSF-31	64	1.25e+04	53.19	6.9e-01	7.3e+05	2.9e-01	2.7e-01	8.4e-02	1.1e-01	3.63	0.09	0.42	0.40
FFSF-32	64	1.50e+04	63.83	1.3e+00	5.6e+05	3.4e-01	1.5e-01	7.5e-02	1.1e-01	4.20	0.09	0.31	0.47
FFSF-33	64	2.00e+04	85.11	2.4e+00	1.7e+06	1.6e-01	1.4e-01	1.3e-01	1.6e-01	4.59	0.02	0.36	0.47
FFSF-34	64	3.00e+04	127.66	3.7e+00	1.6e+06	2.8e-01	3.5e-01	1.3e-01	1.9e-01	5.73	0.07	0.29	0.46
FFSF-35	64	4.00e+04	170.21	6.0e+00	2.5e+06	3.0e-01	5.2e-01	1.6e-01	2.4e-01	6.59	0.09	0.37	0.38
FFSF-36	64	5.00e+04	212.77	6.8e+00	3.3e+06	2.6e-01	1.6e-01	1.8e-01	2.7e-01	7.25	0.04	0.29	0.48
FFSF-37	64	6.00e+04	255.32	8.1e+00	3.4e+06	2.9e-01	1.7e-01	1.8e-01	2.8e-01	7.78	0.04	0.39	0.40
FFSF-38	64	7.00e+04	297.87	7.6e+00	5.2e+06	3.1e-01	2.1e-01	2.3e-01	3.2e-01	8.19	0.02	0.33	0.43
FFNS-23	64	5.00e+04	241.55	7.4e-01	3.4e+05	6.9e-01	4.5e-01	5.9e-02	1.6e-01	6.13	-0.02	0.48	0.30
FFNS-24**	64	6.00e+04	289.86	3.9e-01	4.5e+05	7.1e-01	3.5e-01	6.7e-02	1.8e-01	6.43	-0.01	0.54	0.25
FFNS-25	64	7.00e+04	338.16	3.0e+00	5.2e+05	8.1e-01	1.5e-01	7.2e-02	1.8e-01	6.66	-0.02	0.65	0.15
FFNS-26	64	1.00e+05	483.09	2.5e+00	8.0e+05	7.8e-01	2.2e-01	8.9e-02	2.2e-01	7.25	-0.01	0.54	0.22
FFNS-27	64	1.50e+05	724.64	7.2e+00	1.3e+06	7.9e-01	1.3e-01	1.1e-01	2.4e-01	7.94	-0.02	0.55	0.20
FTSF-22**	93	2.50e+03	9.19	3.9e+00	5.5e+04	1.4e+00	9.6e-01	2.3e-02	7.3e-02	3.24	0.32	0.21	0.47
FTSF-23	64	2.50e+03	9.19	6.6e-01	2.2e+05	4.5e-01	1.2e-01	4.7e-02	6.1e-02	2.85	0.01	0.22	0.56
FTSF-24	64	3.00e+03	11.03	1.3e+00	3.1e+05	4.6e-01	9.1e-02	5.5e-02	7.3e-02	3.42	0.09	0.29	0.49
FTSF-25	64	5.00e+03	18.38	2.6e+00	8.4e+05	4.2e-01	1.8e-01	9.1e-02	1.2e-01	4.65	0.03	0.35	0.43
FTSF-26	64	7.50e+03	27.57	5.5e+00	1.6e+06	4.2e-01	1.5e-01	1.3e-01	1.6e-01	5.91	0.03	0.37	0.42
FTSF-27	64	1.00e+04	36.76	6.3e+00	2.4e+06	4.3e-01	1.3e-01	1.6e-01	2.3e-01	7.02	0.02	0.32	0.45

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Table 1 – *Continued from previous page*

Model	$N_{ro}$	$Ra$	$\frac{Ra}{Ra_C}$	$E_B$	$E_k$	$\frac{E_{BP}}{E_{BT}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$	$M_{LC}$	$M_\alpha$	$M_\omega$
FTSF-28	64	1.25e+04	45.96	6.0e+00	2.1e+06	6.7e-01	1.3e-01	1.4e-01	3.1e-01	7.44	0.03	0.42	0.32
FTSF-29	64	1.50e+04	55.15	8.5e+00	3.4e+06	5.6e-01	1.5e-01	1.8e-01	3.4e-01	8.20	0.01	0.30	0.44
FTSF-30	64	2.00e+04	73.53	1.4e+01	4.5e+06	6.2e-01	1.5e-01	2.1e-01	4.3e-01	9.37	0.02	0.40	0.33
FTNS-37**	93	2.50e+03	10.73	9.9e-01	4.5e+04	1.1e+00	8.2e-01	2.1e-02	5.8e-02	3.15	0.04	0.34	0.46
FTNS-38	64	2.50e+03	10.73	1.3e+00	4.6e+04	1.1e+00	8.2e-01	2.1e-02	5.7e-02	3.21	0.04	0.27	0.48
FTNS-39	64	3.00e+03	12.88	1.4e+00	6.2e+04	1.1e+00	8.0e-01	2.5e-02	6.6e-02	3.48	0.06	0.27	0.43
FTNS-40**	93	5.00e+03	21.46	2.8e-01	1.7e+05	6.7e-01	1.5e-01	4.1e-02	1.1e-01	4.33	-0.01	0.57	0.23
FTNS-41	64	5.00e+03	21.46	2.9e-01	1.7e+05	6.8e-01	2.5e-01	4.1e-02	1.1e-01	4.33	-0.01	0.53	0.25
FTNS-42**	93	7.50e+03	32.19	8.8e-01	3.0e+05	8.4e-01	9.6e-02	5.4e-02	1.4e-01	5.06	-0.01	0.55	0.24
FTNS-43	64	7.50e+03	32.19	7.0e-01	3.0e+05	8.4e-01	1.2e-01	5.5e-02	1.4e-01	5.15	-0.01	0.55	0.23
FTNS-44**	93	1.00e+04	42.92	1.1e+00	4.3e+05	8.9e-01	1.0e-01	6.5e-02	1.8e-01	5.91	-0.03	0.54	0.23
FTNS-45	64	1.00e+04	42.92	1.2e+00	4.3e+05	8.7e-01	1.4e-01	6.5e-02	1.8e-01	5.88	-0.04	0.52	0.27
FTNS-46**	93	1.25e+04	53.65	2.6e+00	5.4e+05	8.8e-01	1.1e-01	7.3e-02	2.0e-01	6.36	-0.04	0.56	0.21
FTNS-47	64	1.25e+04	53.65	1.7e+00	5.9e+05	8.4e-01	8.0e-02	7.7e-02	2.1e-01	6.39	-0.02	0.53	0.21
FTNS-48**	93	1.50e+04	64.38	3.8e+00	6.8e+05	8.8e-01	1.4e-01	8.3e-02	2.2e-01	6.81	-0.02	0.57	0.21
FTNS-49	93	1.50e+04	64.38	4.3e+00	6.8e+05	8.8e-01	1.4e-01	8.2e-02	2.2e-01	6.76	-0.04	0.57	0.21
FTNS-50	64	1.50e+04	64.38	4.2e+00	7.6e+05	8.4e-01	1.3e-01	8.7e-02	2.2e-01	6.73	-0.05	0.50	0.25
FTNS-51	64	2.00e+04	85.84	7.2e+00	1.0e+06	8.5e-01	9.6e-02	1.0e-01	2.5e-01	7.42	-0.06	0.52	0.22
FTNS-52	64	3.00e+04	128.76	1.6e+01	1.8e+06	8.3e-01	1.2e-01	1.4e-01	3.1e-01	8.37	-0.02	0.58	0.17
FTNS-53	64	4.00e+04	171.67	2.4e+01	3.1e+06	7.8e-01	1.2e-01	1.8e-01	3.6e-01	9.14	-0.02	0.55	0.16
FTNS-54	64	5.00e+04	214.59	2.9e+01	4.3e+06	7.7e-01	1.1e-01	2.1e-01	4.2e-01	9.83	-0.03	0.53	0.17

Table 2: **Results of Convection Models.** The boundary conditions are applied at both the inner and outer core boundaries. The column headings from left to right are: model ID, Rayleigh number ( $Ra$ ), ratio of Rayleigh number to its critical value ( $\frac{Ra}{Ra_C}$ ), kinetic energy ( $E_k$ ), Rossby number ( $Ro$ ), local Rossby number ( $Ro_l$ ) and the Nusselt number ( $Nu$ ).

Model	$Ra$	$\frac{Ra}{Ra_C}$	$E_k$	$Ro$	$Ro_l$	$Nu$
$E = 2.00\text{e-}05$ , $Ro_M = 2.00\text{e-}05$ and $q_k = 1$						
FFSF <sub>C</sub> -01	2.50e+03	6.98	3.4e+05	1.2e-02	1.1e-02	1.36
FFSF <sub>C</sub> -02	5.00e+03	13.97	2.0e+06	2.8e-02	2.3e-02	1.73
FFSF <sub>C</sub> -03	7.50e+03	20.95	4.4e+06	4.2e-02	3.4e-02	2.02
FFSF <sub>C</sub> -04	1.00e+04	27.93	7.6e+06	5.5e-02	4.6e-02	2.31
FFSF <sub>C</sub> -05	1.25e+04	34.92	1.4e+07	7.4e-02	6.1e-02	2.60
FFSF <sub>C</sub> -06	1.50e+04	41.90	2.1e+07	9.1e-02	7.6e-02	2.89
FFNS <sub>C</sub> -01	2.50e+03	9.03	4.4e+04	4.2e-03	1.7e-02	1.75
FFNS <sub>C</sub> -02	5.00e+03	18.05	1.3e+05	7.1e-03	2.7e-02	2.40
FFNS <sub>C</sub> -03	7.50e+03	27.08	2.2e+05	9.5e-03	3.5e-02	2.79
FFNS <sub>C</sub> -04	1.00e+04	36.10	3.3e+05	1.2e-02	4.0e-02	3.13
FFNS <sub>C</sub> -05	1.25e+04	45.13	5.1e+05	1.4e-02	4.4e-02	3.39
FFNS <sub>C</sub> -06	1.50e+04	54.15	7.0e+05	1.7e-02	4.8e-02	3.69
FTSF <sub>C</sub> -01	2.50e+03	5.41	1.1e+06	2.1e-02	1.7e-02	1.54
FTSF <sub>C</sub> -02	5.00e+03	10.82	8.8e+06	5.9e-02	4.9e-02	2.45
FTSF <sub>C</sub> -03	7.50e+03	16.23	2.1e+07	9.1e-02	1.3e-01	6.50
FTSF <sub>C</sub> -04	1.00e+04	21.65	3.5e+07	1.2e-01	1.7e-01	7.73
FTSF <sub>C</sub> -05	1.25e+04	27.06	5.2e+07	1.4e-01	2.3e-01	9.62
FTSF <sub>C</sub> -06	1.50e+04	32.47	7.6e+07	1.7e-01	2.6e-01	10.54
FTNS <sub>C</sub> -01	2.50e+03	6.93	1.7e+05	8.3e-03	3.9e-02	2.90
FTNS <sub>C</sub> -02	5.00e+03	13.85	7.7e+05	1.8e-02	6.6e-02	4.08
FTNS <sub>C</sub> -03	7.50e+03	20.78	2.0e+06	2.8e-02	1.0e-01	5.62
FTNS <sub>C</sub> -04	1.00e+04	27.70	4.1e+06	4.1e-02	1.4e-01	7.13
FTNS <sub>C</sub> -05	1.25e+04	34.63	7.5e+06	5.5e-02	1.8e-01	8.75
FTNS <sub>C</sub> -06	1.50e+04	41.55	1.2e+07	6.9e-02	2.2e-01	9.54
$E = 6.00\text{e-}05$ , $Ro_M = 2.00\text{e-}05$ and $q_k = 1$						
FFSF <sub>C</sub> -07	2.50e+03	8.74	8.0e+04	5.6e-03	1.0e-02	1.74
FFSF <sub>C</sub> -08	5.00e+03	17.48	3.0e+05	1.1e-02	1.5e-02	2.23
FFSF <sub>C</sub> -09	7.50e+03	26.22	5.7e+05	1.5e-02	2.1e-02	2.59

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Table 2 – *Continued from previous page*

Model	$Ra$	$\frac{Ra}{Ra_C}$	$E_k$	$Ro$	$Ro_l$	$Nu$
FFSF <sub>C</sub> -10	1.00e+04	34.97	7.1e+05	1.7e-02	2.7e-02	2.86
FFSF <sub>C</sub> -11	1.25e+04	43.71	1.1e+06	2.1e-02	2.8e-02	3.34
FFSF <sub>C</sub> -12	1.50e+04	52.45	1.4e+06	2.4e-02	3.5e-02	3.42
FFSF <sub>C</sub> -13	2.00e+04	69.93	2.6e+06	3.2e-02	4.3e-02	3.96
FFSF <sub>C</sub> -14	2.50e+04	87.41	4.9e+06	4.4e-02	5.5e-02	4.37
FFSF <sub>C</sub> -15	3.00e+04	104.90	1.1e+07	6.5e-02	7.5e-02	4.49
FFSF <sub>C</sub> -16	3.50e+04	122.38	1.5e+07	7.6e-02	8.6e-02	4.83
FFSF <sub>C</sub> -17	5.00e+04	174.83	3.2e+07	1.1e-01	1.2e-01	5.61
FFSF <sub>C</sub> -18	7.50e+04	262.24	7.1e+07	1.7e-01	1.7e-01	7.03
FFSF <sub>C</sub> -19	8.00e+04	279.72	8.1e+07	1.8e-01	1.9e-01	7.33
FFSF <sub>C</sub> -20	9.50e+04	332.17	1.1e+08	2.1e-01	2.1e-01	8.11
FFNS <sub>C</sub> -07	2.50e+03	10.37	2.8e+04	3.4e-03	9.8e-03	2.03
FFNS <sub>C</sub> -08	5.00e+03	20.75	7.2e+04	5.4e-03	1.6e-02	2.75
FFNS <sub>C</sub> -09	7.50e+03	31.12	1.3e+05	7.1e-03	2.0e-02	3.22
FFNS <sub>C</sub> -10	1.00e+04	41.49	2.0e+05	8.9e-03	2.3e-02	3.58
FFNS <sub>C</sub> -11	1.25e+04	51.87	2.7e+05	1.0e-02	2.6e-02	3.90
FFNS <sub>C</sub> -12	1.50e+04	62.24	3.4e+05	1.2e-02	2.8e-02	4.19
FFNS <sub>C</sub> -13	2.00e+04	82.99	4.4e+05	1.3e-02	3.3e-02	4.82
FFNS <sub>C</sub> -14	2.50e+04	103.73	5.9e+05	1.5e-02	3.7e-02	5.20
FFNS <sub>C</sub> -15	3.00e+04	124.48	7.5e+05	1.7e-02	4.1e-02	5.58
FFNS <sub>C</sub> -16	3.50e+04	145.23	8.6e+05	1.8e-02	4.4e-02	5.96
FFNS <sub>C</sub> -17	5.00e+04	207.47	1.3e+06	2.3e-02	5.4e-02	6.75
FFNS <sub>C</sub> -18	7.50e+04	311.20	1.7e+06	2.6e-02	7.1e-02	7.87
FFNS <sub>C</sub> -19	8.00e+04	331.95	1.9e+06	2.7e-02	7.2e-02	8.01
FFNS <sub>C</sub> -20	9.50e+04	394.19	2.0e+06	2.8e-02	8.1e-02	8.50
FTSF <sub>C</sub> -07	2.50e+03	7.25	4.5e+05	1.3e-02	1.7e-02	2.42
FTSF <sub>C</sub> -08	5.00e+03	14.49	3.2e+06	3.6e-02	3.5e-02	3.81
FTSF <sub>C</sub> -09	7.50e+03	21.74	6.5e+06	5.1e-02	5.4e-02	4.87
FTSF <sub>C</sub> -10	1.00e+04	28.99	1.5e+07	7.6e-02	7.6e-02	5.96
FTSF <sub>C</sub> -11	1.25e+04	36.23	2.9e+07	1.1e-01	1.0e-01	7.25
FTSF <sub>C</sub> -12	1.50e+04	43.48	4.4e+07	1.3e-01	1.4e-01	8.91
FTSF <sub>C</sub> -13	2.00e+04	57.97	6.2e+07	1.6e-01	2.1e-01	11.41
FTSF <sub>C</sub> -14	2.50e+04	72.46	8.9e+07	1.9e-01	2.4e-01	12.48
FTSF <sub>C</sub> -15	3.00e+04	86.96	1.1e+08	2.1e-01	2.8e-01	13.47
FTSF <sub>C</sub> -16	3.50e+04	101.45	1.3e+08	2.3e-01	3.2e-01	14.73
FTNS <sub>C</sub> -07	2.50e+03	9.03	1.1e+05	6.6e-03	2.7e-02	3.49
FTNS <sub>C</sub> -08	5.00e+03	18.05	4.2e+05	1.3e-02	4.1e-02	4.65
FTNS <sub>C</sub> -09	7.50e+03	27.08	9.4e+05	1.9e-02	5.6e-02	5.94
FTNS <sub>C</sub> -10	1.00e+04	36.10	1.4e+06	2.4e-02	7.6e-02	7.29
FTNS <sub>C</sub> -11	1.25e+04	45.13	2.0e+06	2.8e-02	9.0e-02	8.09

*Continued on next page*

Table 2 – *Continued from previous page*

Model	$Ra$	$\frac{Ra}{Ra_C}$	$E_k$	$Ro$	$Ro_l$	$Nu$
FTNS <sub>C</sub> -12	1.50e+04	54.15	2.4e+06	3.1e-02	1.1e-01	8.98
FTNS <sub>C</sub> -13	2.00e+04	72.20	4.0e+06	4.0e-02	1.4e-01	10.09
FTNS <sub>C</sub> -14	2.50e+04	90.25	6.6e+06	5.1e-02	1.6e-01	10.89
FTNS <sub>C</sub> -15	3.00e+04	108.30	1.0e+07	6.3e-02	1.8e-01	11.63
FTNS <sub>C</sub> -16	3.50e+04	126.35	1.4e+07	7.6e-02	2.0e-01	12.21

$E = 2.00\text{e-}04$ ,  $Ro_M = 1.00\text{e-}04$  and  $q_k = 1$

FFSF <sub>C</sub> -21	2.50e+03	10.64	1.1e+05	3.2e-02	1.5e-01	1.17
FFSF <sub>C</sub> -22	5.00e+03	21.28	2.1e+05	4.6e-02	5.3e-02	2.42
FFSF <sub>C</sub> -23	7.50e+03	31.91	3.7e+05	6.1e-02	7.3e-02	2.78
FFSF <sub>C</sub> -24	1.00e+04	42.55	6.3e+05	8.0e-02	9.2e-02	3.17
FFSF <sub>C</sub> -25	1.25e+04	53.19	1.1e+06	1.1e-01	1.3e-01	3.81
FFSF <sub>C</sub> -26	1.50e+04	63.83	1.8e+06	1.3e-01	1.6e-01	4.13
FFNS <sub>C</sub> -21	2.50e+03	12.08	1.7e+04	1.3e-02	2.6e-02	2.20
FFNS <sub>C</sub> -22	5.00e+03	24.15	3.8e+04	2.0e-02	4.2e-02	2.91
FFNS <sub>C</sub> -23	7.50e+03	36.23	5.8e+04	2.4e-02	5.5e-02	3.39
FFNS <sub>C</sub> -24	1.00e+04	48.31	7.4e+04	2.7e-02	6.6e-02	3.77
FFNS <sub>C</sub> -25	1.25e+04	60.39	9.0e+04	3.0e-02	7.4e-02	4.13
FFNS <sub>C</sub> -26	1.50e+04	72.46	1.1e+05	3.3e-02	8.2e-02	4.35
FTSF <sub>C</sub> -17	2.50e+03	9.19	3.8e+05	6.1e-02	5.9e-02	2.53
FTSF <sub>C</sub> -18	5.00e+03	18.38	2.3e+06	1.5e-01	1.2e-01	3.90
FTSF <sub>C</sub> -19	7.50e+03	27.57	2.9e+06	1.7e-01	2.4e-01	5.98
FTSF <sub>C</sub> -20	1.00e+04	36.76	4.3e+06	2.1e-01	3.1e-01	7.16
FTSF <sub>C</sub> -21	1.25e+04	45.96	6.0e+06	2.5e-01	3.8e-01	7.94
FTSF <sub>C</sub> -22	1.50e+04	55.15	6.8e+06	2.6e-01	4.5e-01	8.58
FTNS <sub>C</sub> -17	2.50e+03	10.73	5.3e+04	2.3e-02	6.2e-02	3.14
FTNS <sub>C</sub> -18	5.00e+03	21.46	1.7e+05	4.1e-02	1.1e-01	4.48
FTNS <sub>C</sub> -19	7.50e+03	32.19	3.1e+05	5.6e-02	1.5e-01	5.36
FTNS <sub>C</sub> -20	1.00e+04	42.92	5.1e+05	7.1e-02	1.9e-01	5.96
FTNS <sub>C</sub> -21	1.25e+04	53.65	7.6e+05	8.7e-02	2.2e-01	6.35
FTNS <sub>C</sub> -22	1.50e+04	64.38	1.1e+06	1.0e-01	2.5e-01	6.76

Table 3: **Models Without Hyperdiffusion.** The column headings are defined in the Table 2 header. Models are given the same names as Table 2 models with the same control parameters. The only differences are that models in this table are run without hyper diffusion. Subscript ‘ai’ implies the model contains only axial inertia (like the characteristic models), subscript ‘fi’ indicates models with full inertia.

Model	$E_B$	$E_k$	$\frac{E_{B_P}}{E_{B_T}}$	$f_{Dip}$	$Ro$	$Ro_l$	$Nu$
FFSF-21 <sub>ai</sub>	7.7e+00	2.3e+05	1.2e+00	9.2e-01	1.5e-02	6.0e-02	5.5e+00
FFSF-21 <sub>fi</sub>	6.6e+00	2.4e+05	1.1e+00	9.5e-01	1.5e-02	6.7e-02	5.5e+00
FFNS-15 <sub>ai</sub>	1.0e+01	1.6e+05	1.2e+00	7.3e-01	1.2e-02	4.4e-02	5.0e+00
FFNS-15 <sub>fi</sub>	1.0e+01	1.4e+05	1.1e+00	7.3e-01	1.2e-02	4.4e-02	5.0e+00
FTSF-15 <sub>ai</sub>	2.6e+00	3.5e+05	1.0e+00	1.7e-01	1.8e-02	7.1e-02	5.2e+00
FTSF-15 <sub>fi</sub>	2.2e+00	3.5e+05	1.0e+00	1.6e-01	1.8e-02	6.1e-02	5.2e+00
FTNS-24 <sub>ai</sub>	6.2e+00	1.8e+05	1.2e+00	8.1e-01	1.3e-02	5.8e-02	5.0e+00
FTNS-24 <sub>fi</sub>	5.0e+00	1.9e+05	1.2e+00	7.7e-01	1.3e-02	6.6e-02	5.0e+00

## References

- E. Grote, F. H. Busse, and A. Tilgner. Effects of hyperdiffusivities on dynamo simulations. *Geophys. Res. Lett.*, 27:2001 – 2004, 2000.
- W. Jiang and W. Kuang. An mpi-based mosst core dynamics model. *Phys. Earth Planet. Int.*, 170:46–51, 2008.
- W. Kuang and J. Bloxham. Numerical modeling of magnetohydrodynamic convection in a rapidly rotating spherical shell: Weak and strong field dynamo action. *J. Comp. Phys.*, 153:51–81, 1999.