Dynamo Good Practice

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   Ek, Ra, ..., boundary conditions, background state ...
   Not all parameter can be realistic!!
   Decide where you can afford to make compromises!!
   Remember: Parameter may have to be varied along a certain path in order to stay in the desired regime.

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4. Estimate computer resources and check what is available.
   Go back to step 3. if required.

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8. Compare with published results.
9. Start running at more demanding parameters. Go back to 7.
   Check parameter dependence. Derive scaling law.

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   Check parameter dependence. Derive scaling law.
10. Thoroughly analyse solution details.
11. Do the most extreme final runs.
12. Rescale the model to the real problem!

7. Check the Solution

1 Check you spatial resolutions (plots, spectra)!

2 Look at flow field and magnetic field!

3 Does the solution make sense?

4 Check that all required modes are excited!

5 Check that no undesired modes are excited!

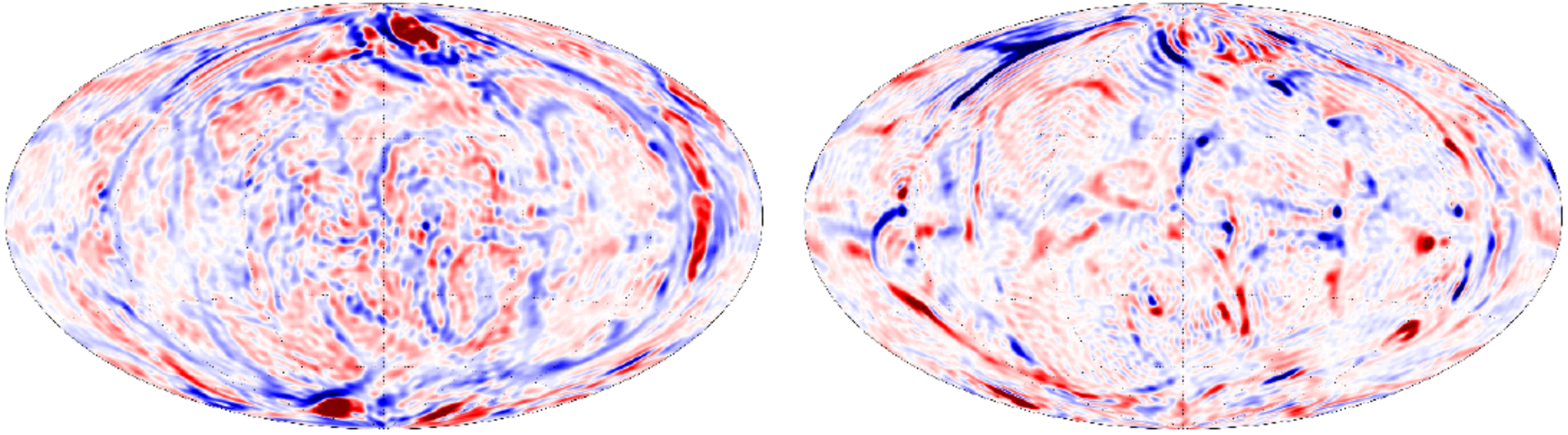
6 Integrate long enough in time!

7 Dismiss transients!

Mind the Resolution

- **Look at the solutions!** Usually: flows and magnetic field close to the surfaces are usually prone to under-resolution (boundary layers)

$u_r,\ r = 0.99\, r_o$ $B_r,\ r = 0.99\, r_o$



$E = 3 \times 10^{-4},\ Ra = 3 \times 10^{6}$

- **Obvious signatures of under-resolution**: small-scale structures of comparable size than the grid, "eyes", aliases (sudden localized changes of polarities)

10. Rescale the Model

- MagIC uses a dimensionless formulation.
- Since not all parameters are realistic, the rescaling may be complex.
- Rescaling time: The different time scales in the system are

$$\tau_\nu = d^2/\nu \ , \ \tau_u = d/u \ , \ \tau_\lambda = d^2/\lambda$$

The dimensionless numbers defined the time scale ratios:

$$\mathrm{Pm} = \tau_\lambda/\tau_\nu \ , \ \mathrm{Rm} = \tau_\lambda/\tau_u \ , \ \mathrm{E} = \tau_\Omega/\tau_\nu$$

We can thus rescale MagIC time, given in viscous diffusion time, $\tau_\nu = d^2/\nu$, to the 200 yr turnover time $\tau_u = d/u$ for Earth using:

$$t = \mathrm{Rm}\ \mathrm{Pm}^{-1}\ t_\nu \tau_u \approx (\mathrm{Rm}_{\mathrm{Earth}}\ \mathrm{Pm}^{-1}\ t_\nu)\ 200yr$$

- Rescaling of field strength and flow velocity required complex scaling laws.

Things Likely not Correct

- Small scale turbulence
- Small scale mixing
- Temperature gradients (lateral)
- Way of imposing stable layers.

Reasons for Numerical Problems

- Too coarse spatial grid.
  Check spectra and solution maps.
  Run may stop because of too small time step.
- Too large time step.
  Check for frequent change of time step in log-file. Decrease dtmax.
- Ra/Pm not adequate.
- Initial solution too far away from true solution.
  Run may stop because of too small time step.
- Spurious inertial modes excited (small E, stress free boundaries)

- **l_correct_AMe** (default `l_correct_AMe=.false.`) is a logical. This is used to correct the equatorial angular momentum.
- **l_correct_AMz** (default `l_correct_AMz=.false.`) is a logical. This is used to correct the axial angular momentum.