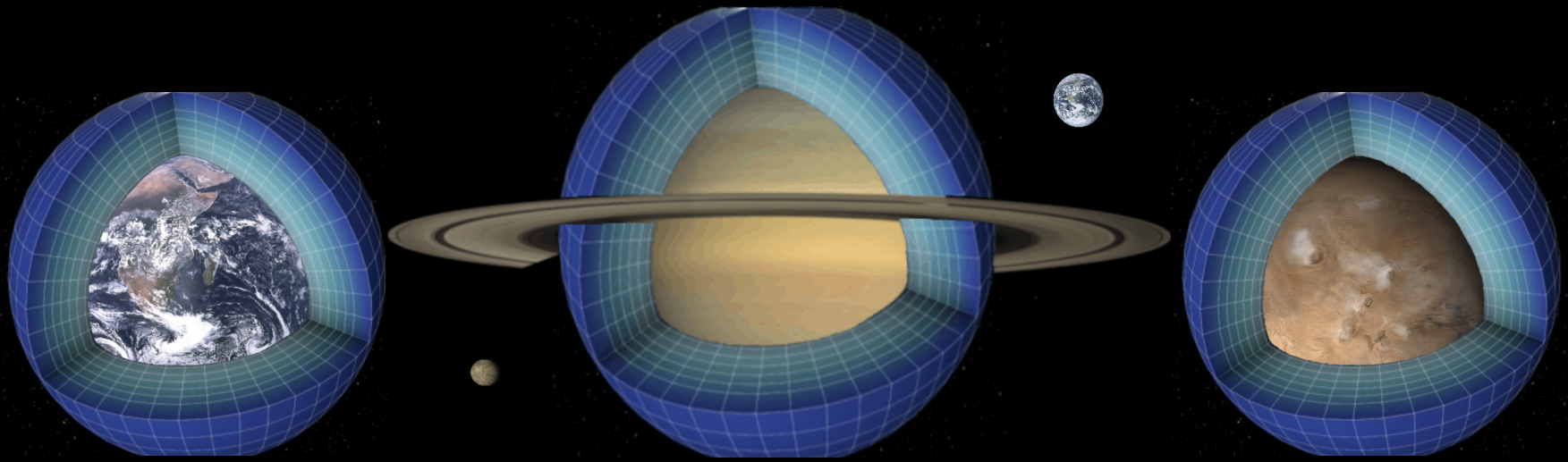
Energy spectra and dissipation



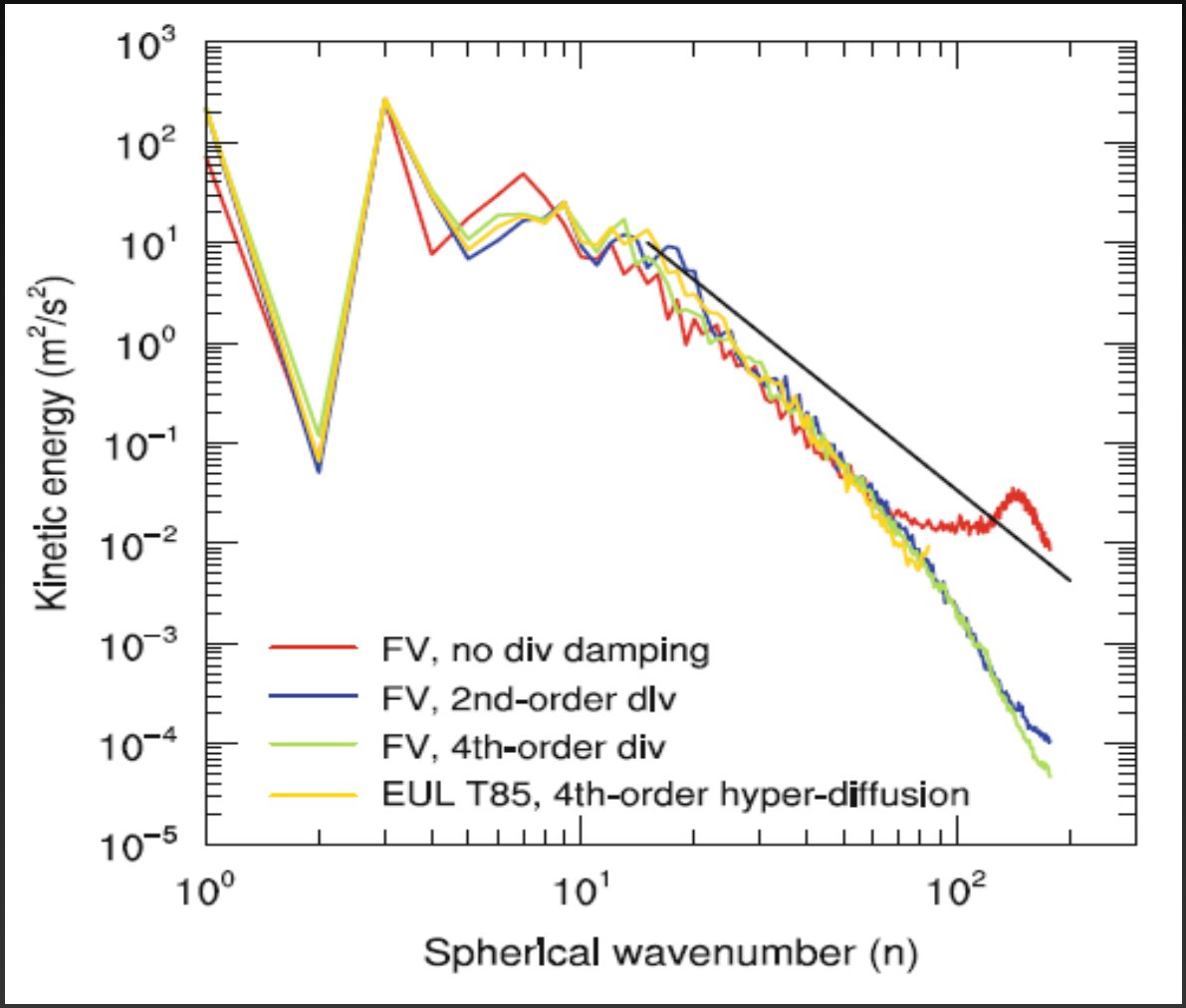
LMDZ.EARTH **LMDZ.GENERIC** **LMDZ.MARS**

Mikel Indurain, Equipe Planéto
LMD

Dissipation : introduction

Energy transfer from large scales to small scales.

Problem : energy accumulation if dissipative structures are not resolved



Jablonowski, 2011

Dissipation : introduction

Energy transfer from large scales to small scales.

Problem : energy accumulation if dissipative structures are not resolved

$\Rightarrow$ dissipation operator : $\boxed{F_\psi = (-1)^{q+1} K_\psi \nabla^{2q} \psi}$

K_ψ : diffusion coefficient

$2q$: diffusion order

$$\frac{\partial \psi}{\partial t} = \mathrm{Dyn}(\psi) + \mathrm{Phy}(\psi) + F_\psi$$

Energy spectra

To study dissipation effect, we compute the spectra of specific kinetic energy :

$$KE = \frac{1}{2}\vec{V}.\vec{V}$$

For $1 \leq n \leq N$, spatial mean of specific kinetic energy :

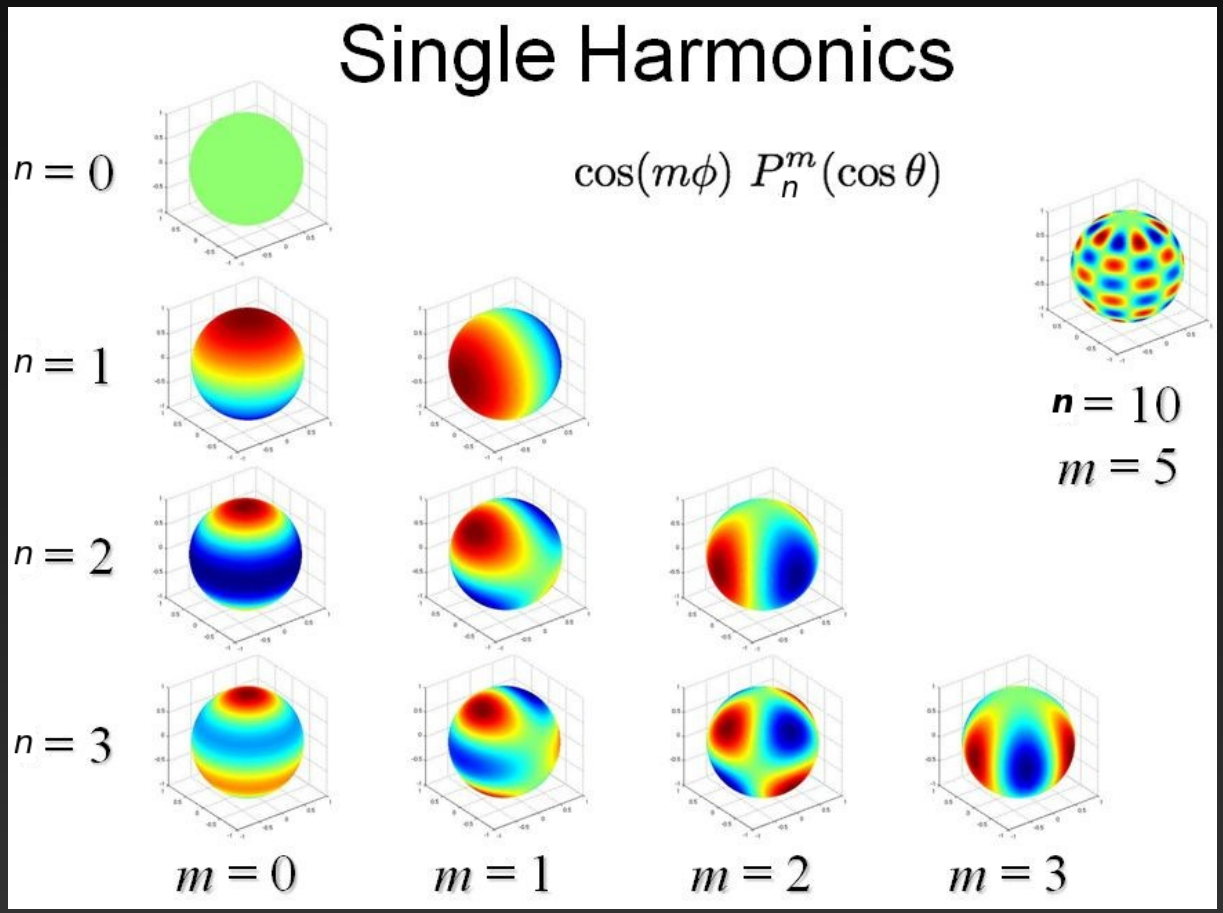
$$\overline{KE}_n = \xi_n^0(\xi_n^0)^* + \delta_n^0(\delta_n^0)^* + 2\sum_{m=1}^{n}[\xi_n^m(\xi_n^m)^* + \delta_n^m(\delta_n^m)^*]$$

where ξ_n^m : spectral coefficient of vorticity
δ_n^m : spectral coefficientdivergence

Spherical harmonics

Spherical harmonics form a basis for functions on the sphere :

$$f(\theta,\phi) = \sum_{n=0}^{N} \sum_{m=-n}^{n} c_n^m Y_n^m(\theta,\phi)$$



Truncation at :

$$N = \max(N_{lat}, \frac{N_{long}}{2})$$

Dissipation in LMDZ.EARTH

$$F_\psi = (-1)^{q+1} K_\psi \nabla^{2q} \psi$$

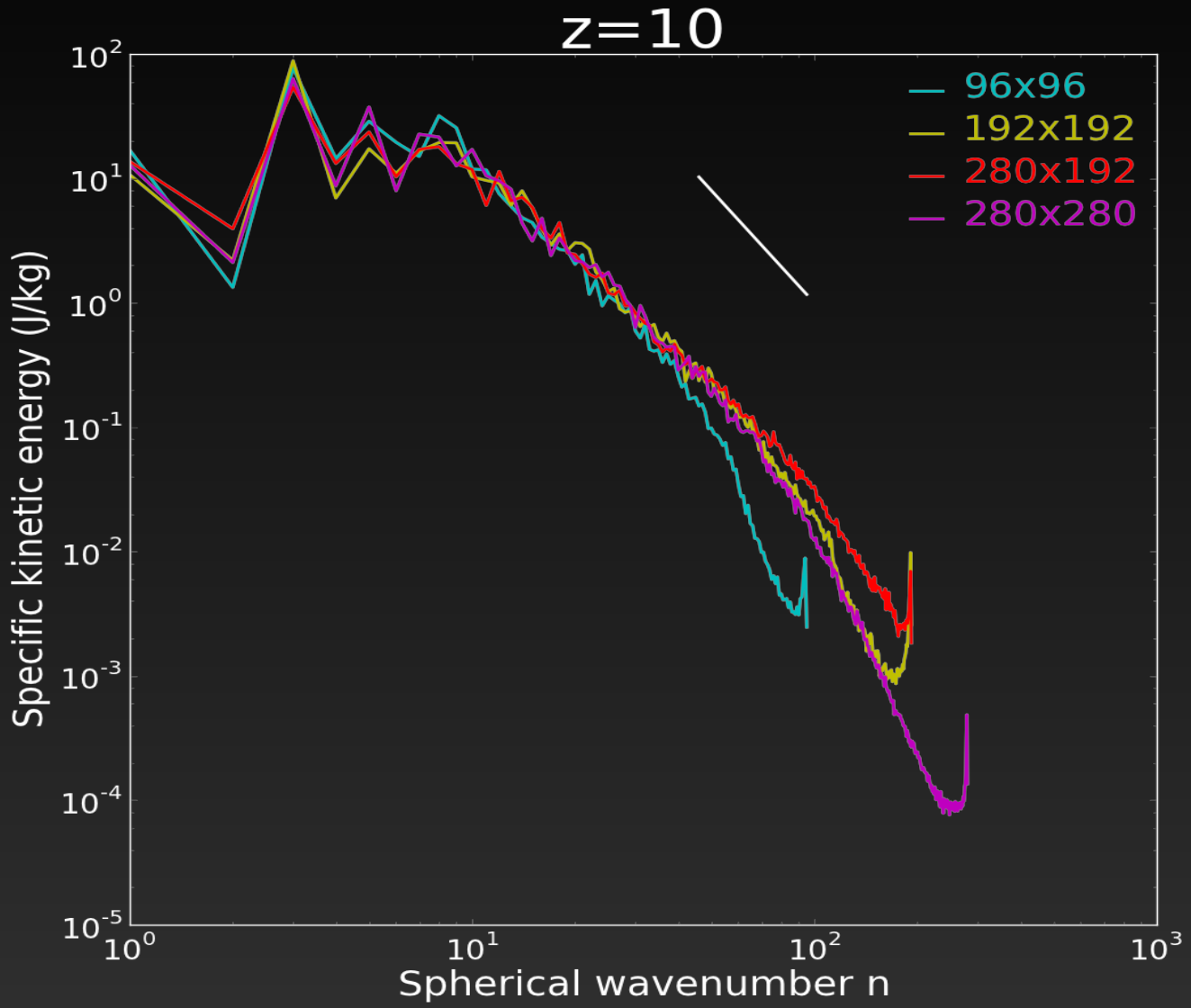
Dissipation operator is applied to :
- horizontal velocity
- potential temperature

Diffusion coefficient $K_\psi \propto \frac{1}{\text{tetagdiv}}$ or $\propto \frac{1}{\text{tetagrot}}$ or $\propto \frac{1}{\text{tetatemp}}$

Vertical variation of K_ψ with vert_prof_dissip = True
Dissipation coefficients increase with altitude

Diffusion order $2q$: nitergdiv (=1) or nitergrot (=2) or niterh (=2)

Energy spectra : Earth



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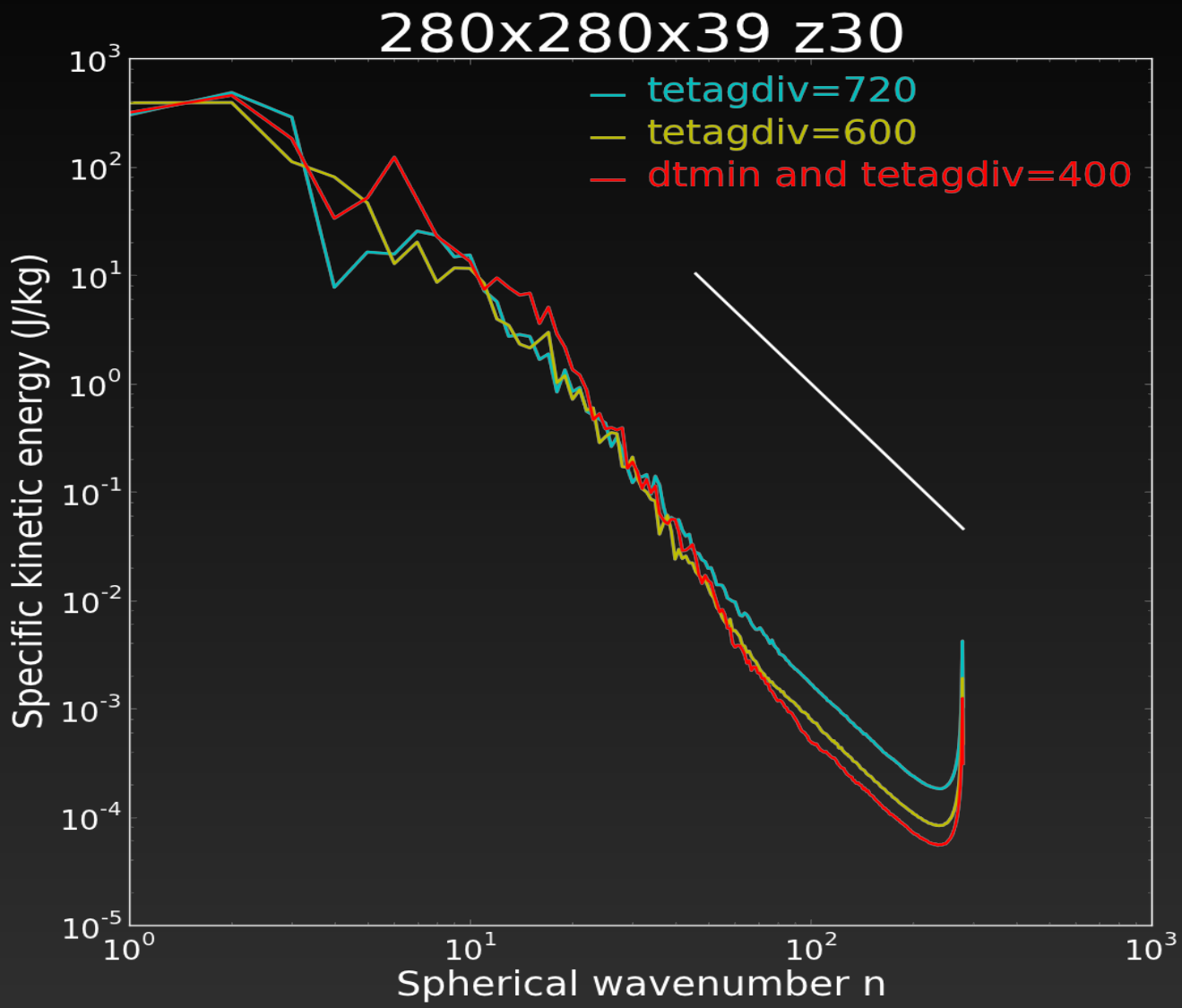
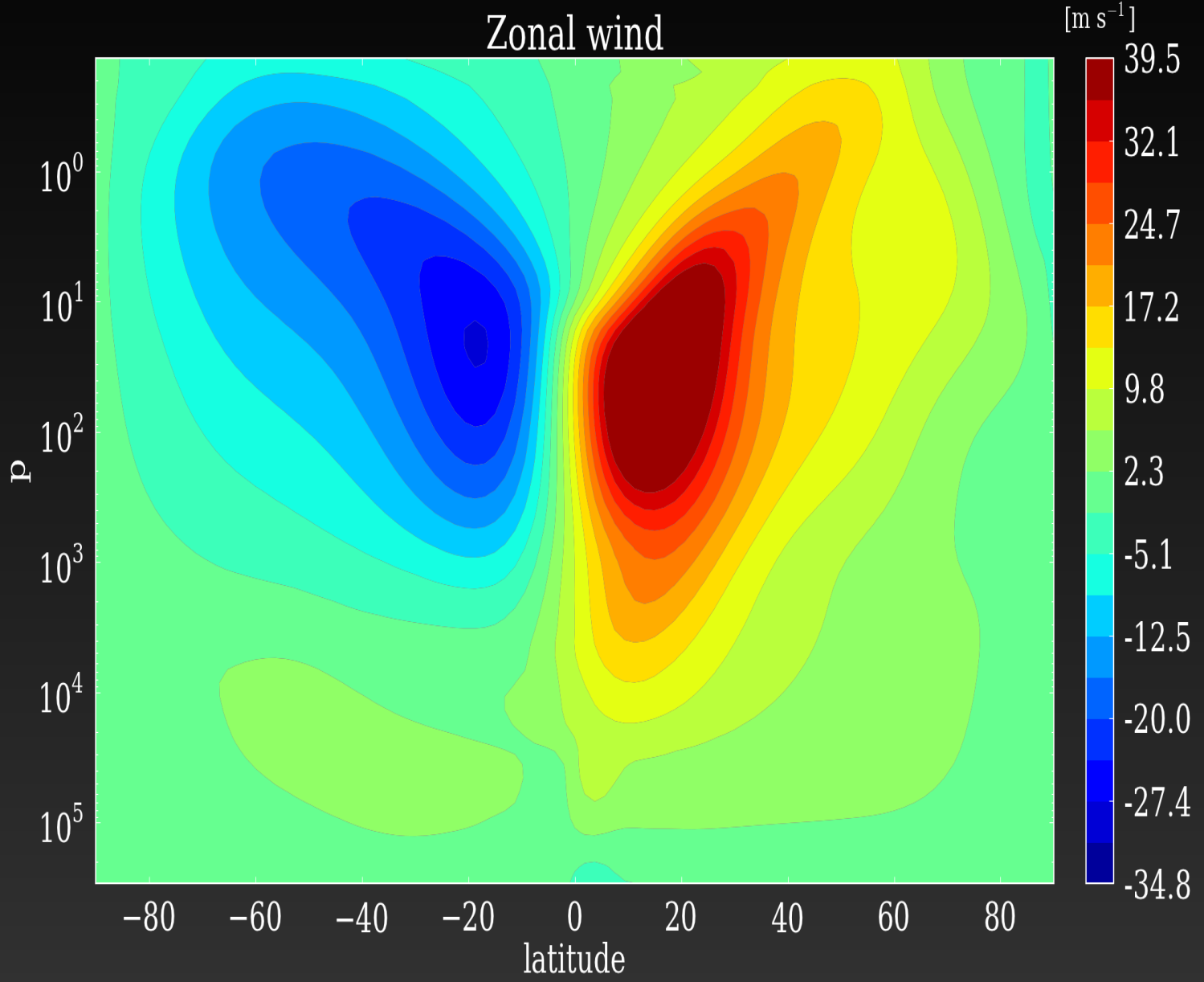


Energy spectra : Saturn's stratosphere



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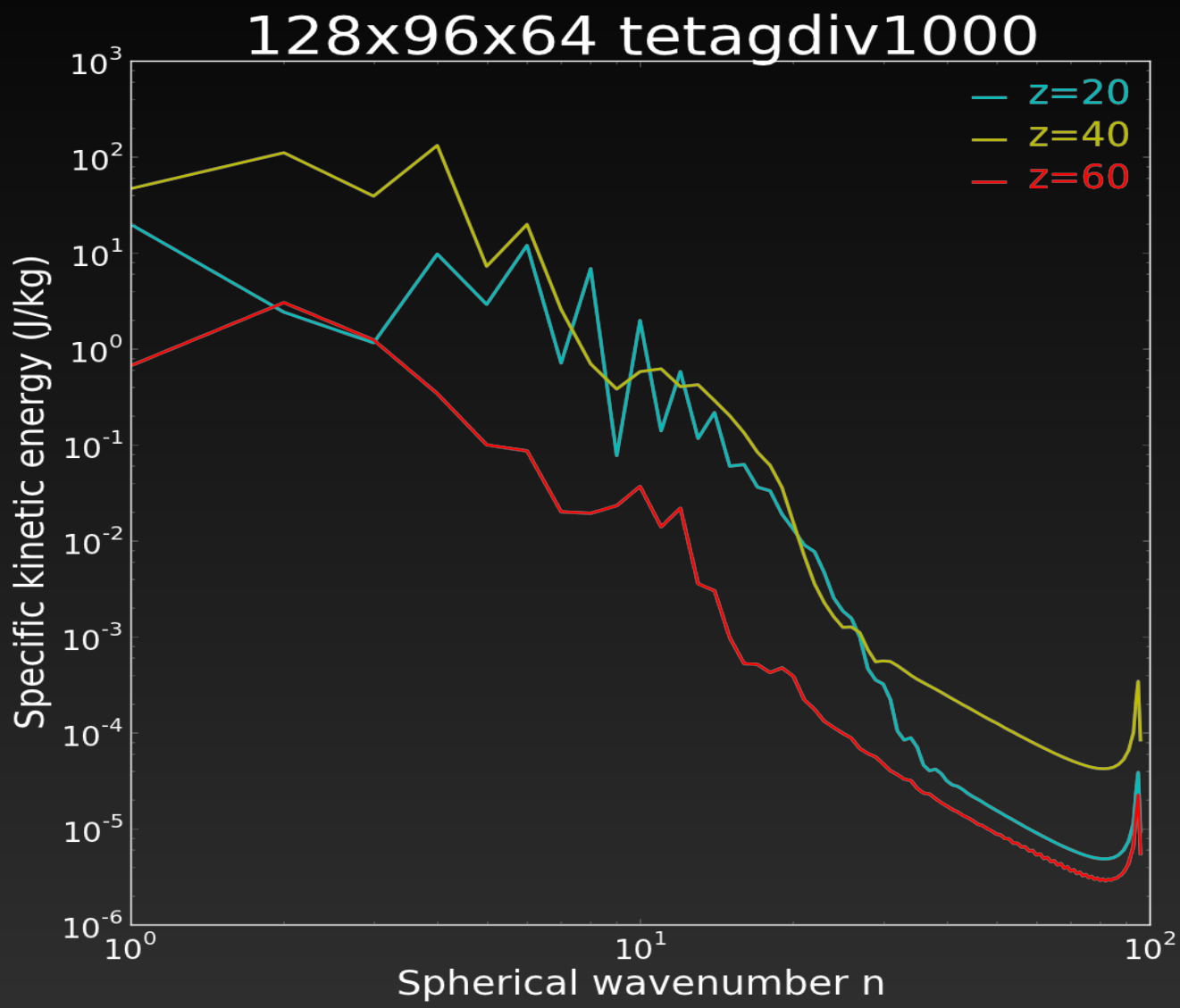
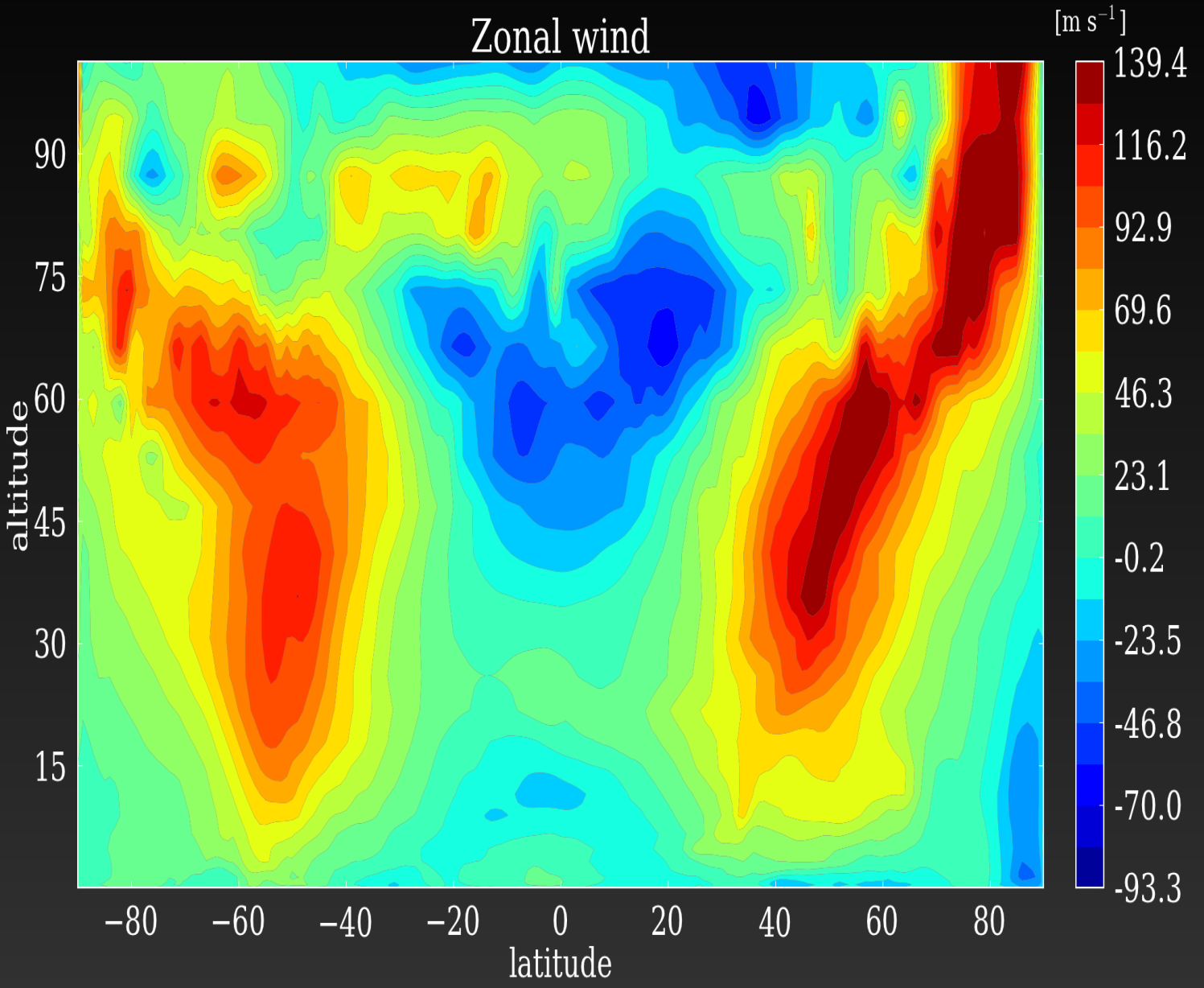
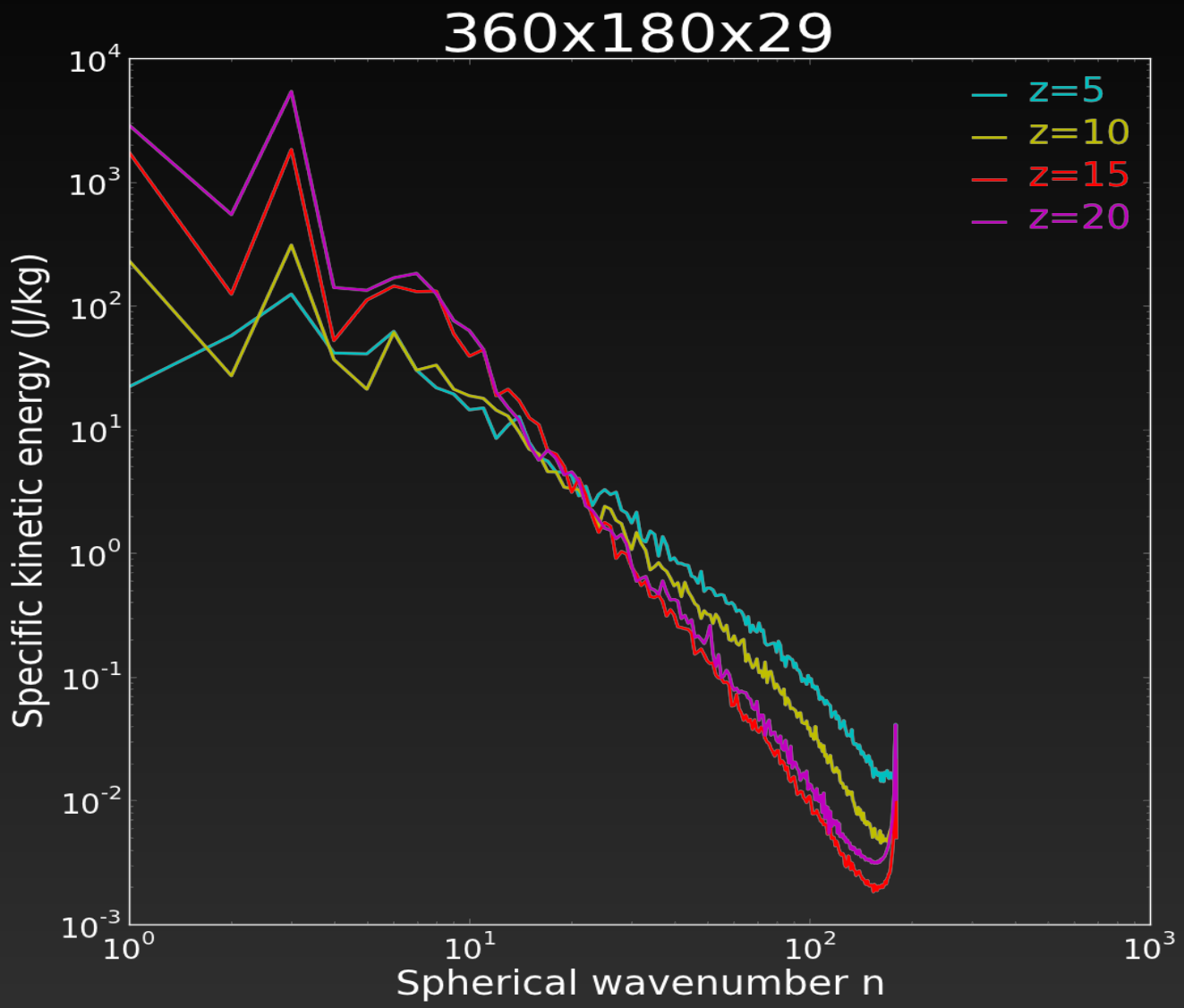


Energy spectra : Mars

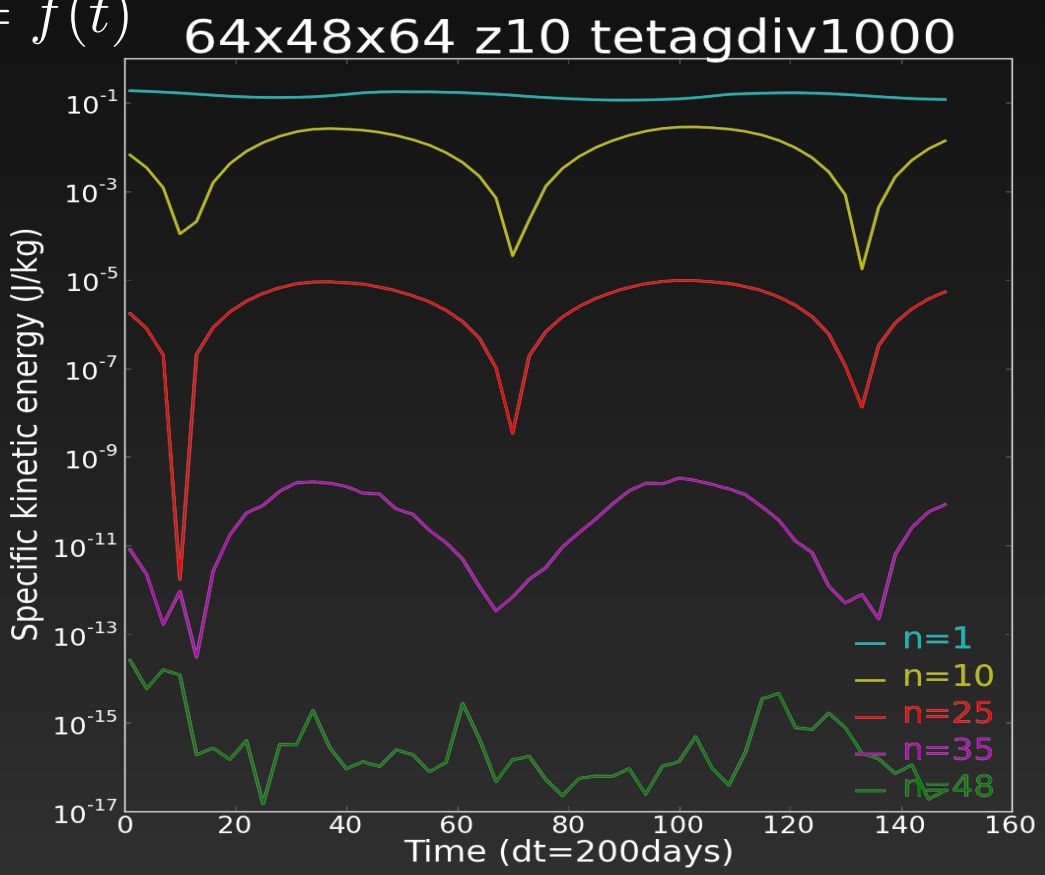


Energy spectra : Mars



Questions

- Number of truncation for harmonic basis
- Higher dissipation order (now : 1 or 2)
- Dissipation coefficient as a function of resolution
- $\overline{KE_n} = f(t)$



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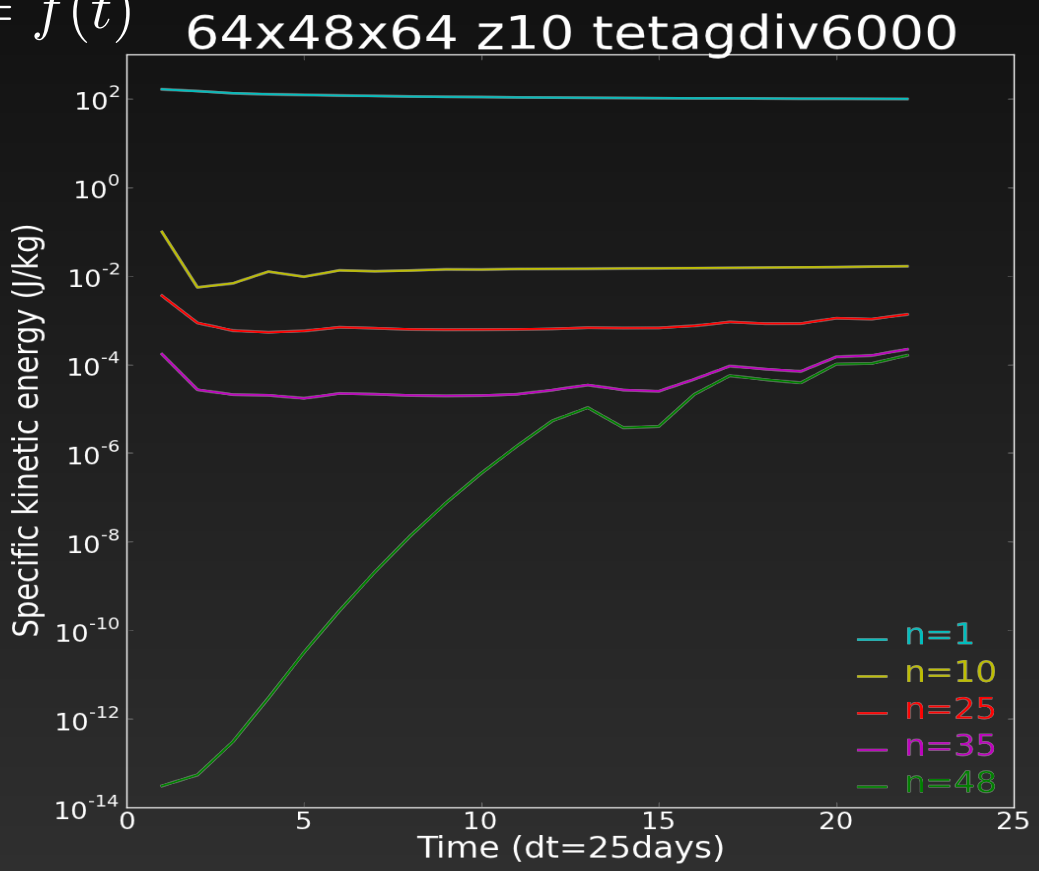

Thanks for your attention !