

“Dynamics » and « Physics » tendencies

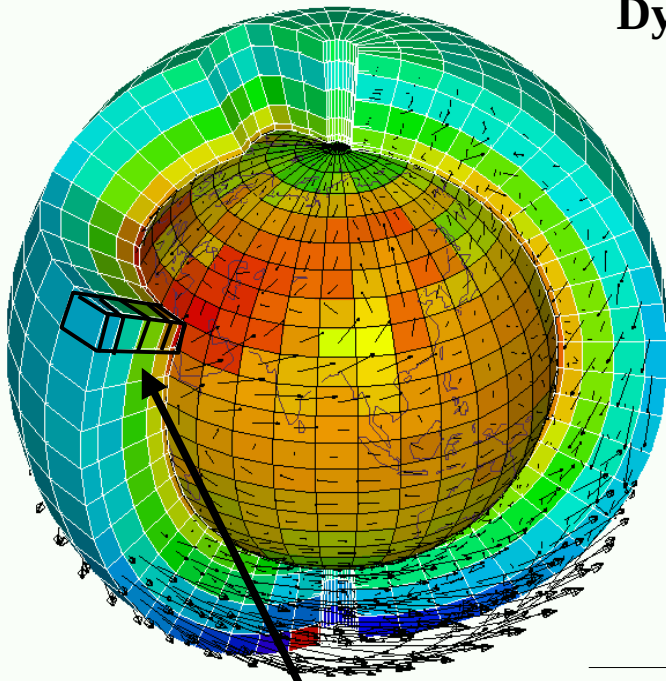
LMDZ team

Laboratoire de Météorology Dynamique / IPSL / CNRS /SU

LMDZ training, December 2024

During tutorial #1

Dynamical core : primitive equations discretized on the sphere



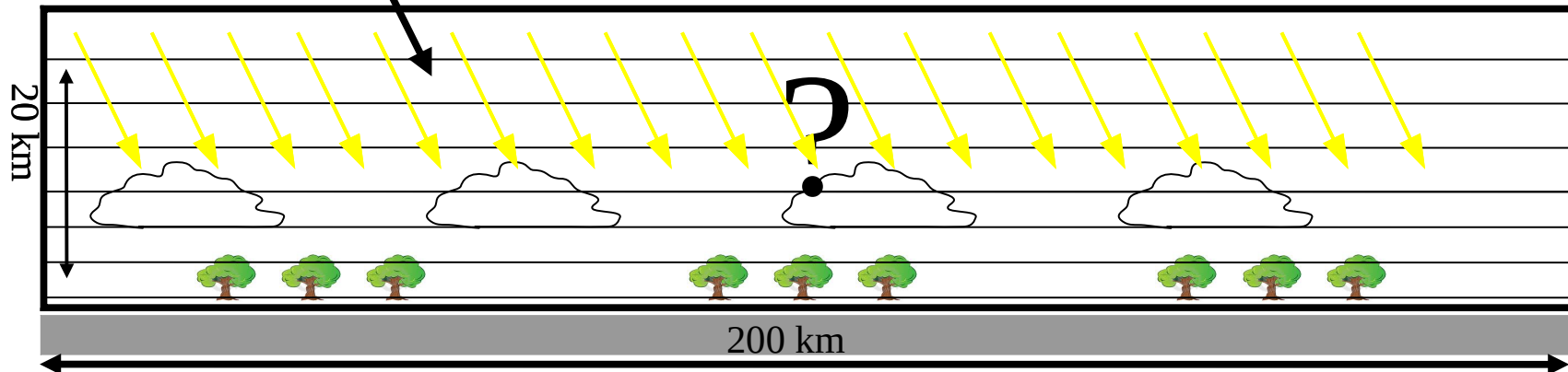
- Mass conservation

$$D\rho/Dt + \rho \operatorname{div}\underline{U} = 0$$
- Potential temperature conservation

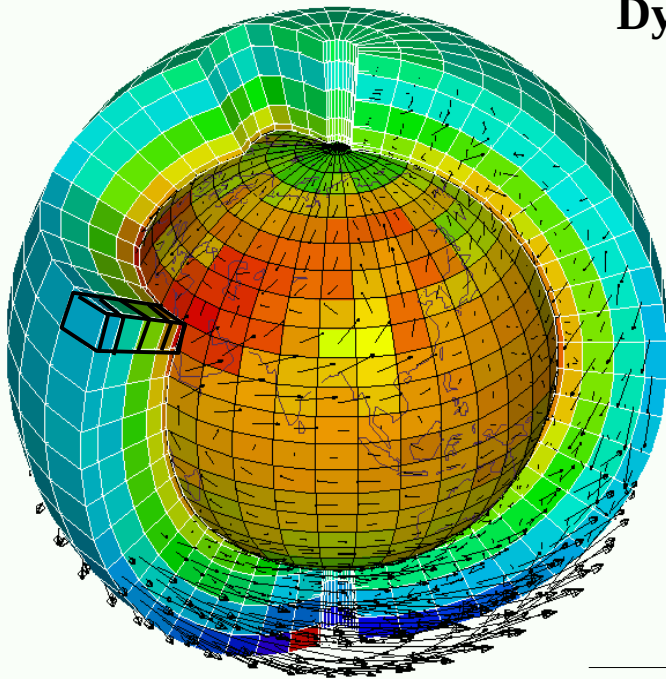
$$D\theta / Dt = Q / C_p (p_0/p)^\kappa$$
- Momentum conservation

$$D\underline{U}/Dt + (1/\rho) \operatorname{grad} p - g + 2 \underline{\Omega} \wedge \underline{U} = \underline{F}$$
- Secondary components conservation

$$Dq/Dt = Sq$$



Dynamical core : primitive equations discretized on the sphere



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 $D\rho/Dt + \rho \operatorname{div}\underline{U} = 0$
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- Momentum conservation
 $D\underline{U}/Dt + (1/\rho) \operatorname{grad} p - g + 2 \underline{\Omega} \wedge \underline{U} = \underline{E}$
- Secondary components conservation
 $Dq/Dt = Sq$

Parameterizations purpose : account for the effect of processes non resolved by the dynamical core

→ **Traditional « source » terms in the equations**

- Q : Heating by radiative exchanges, thermal conduction (neglected), condensation, sublimation, **subgrid-scale motions (turbulence, clouds, convection)**
- E : Molecular viscosity (neglected), **subgrid-scale motions (turbulence, clouds, convection)**
- Sq : condensation/sublimation (q = water vapor or condensed), chemical reactions, photo-dissociation (ozone, chemical species), micro physics and scavenging (pollution aerosols, dust, ...), **subgrid-scale motions (turbulence, clouds, convection)**

Model tendencies

The integration of a given prognostic variable X ($T, \vec{v}(u, v, w), p, \rho, q_{vap}$) can be written as :

$$X_{t+\Delta t} = X_t + \left(\frac{\partial X}{\partial t} \right)_{\text{dyn}} \Delta t \text{ (dynamical core)} \quad (1)$$

$$+ \left(\frac{\partial X}{\partial t} \right)_{\text{param}} \Delta t \text{ (parameterizations)} \quad (2)$$

From model outputs

temp(t+dtphys)-temp(t)=dtdyn+dtphy

ovap(t+dtphys)-ovap(t)=dqdyn+dqphy

vit[u/v](t+dtphys)-vit[u/v](t)=dudyn+duphy

Physics time-step :

dtphys=daysec*iphysic/(day_step) , day_sec=86400

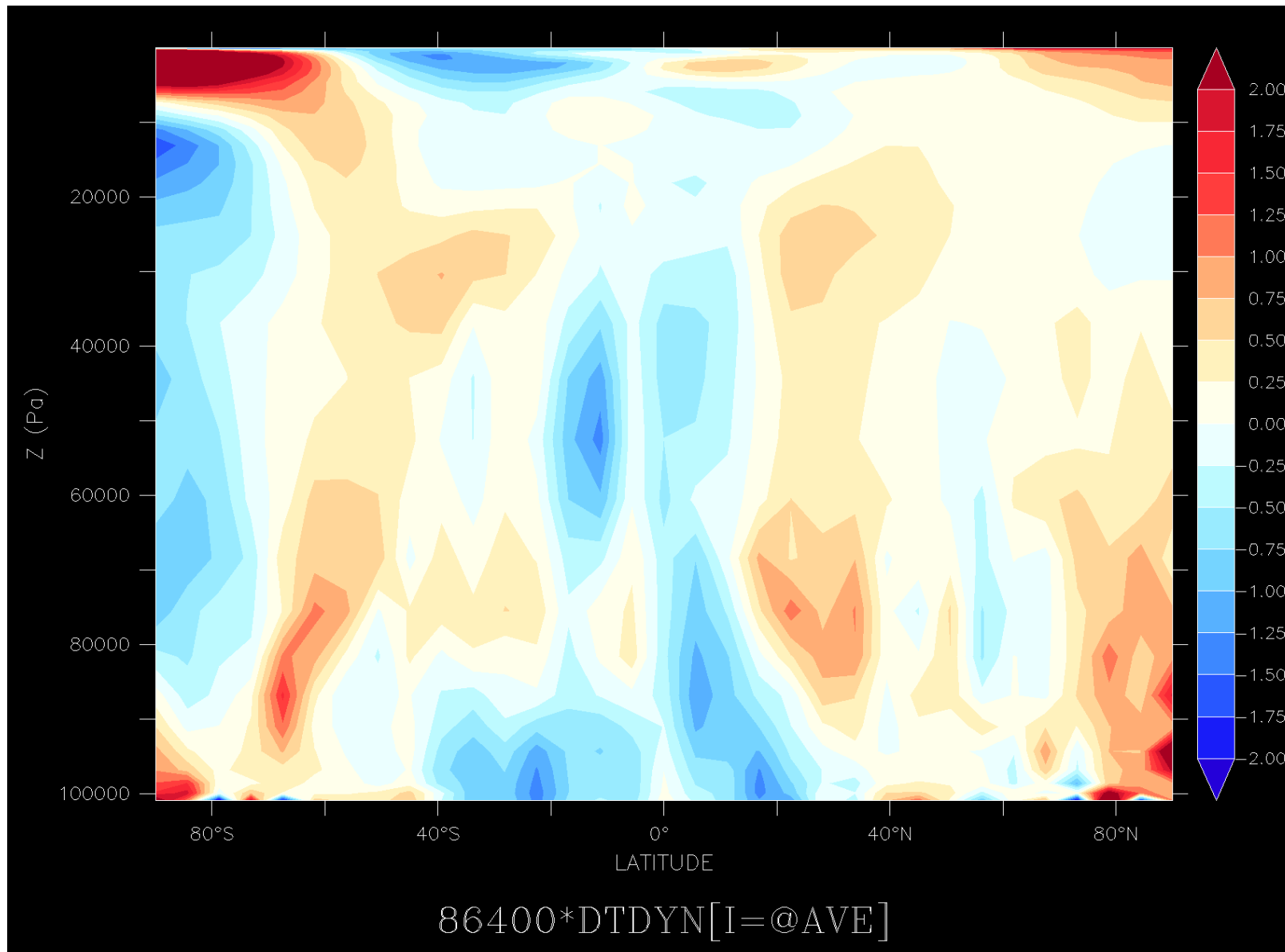
Zonal mean heating by large scale dynamics (K/day)

use histday.nc

reg/l=3

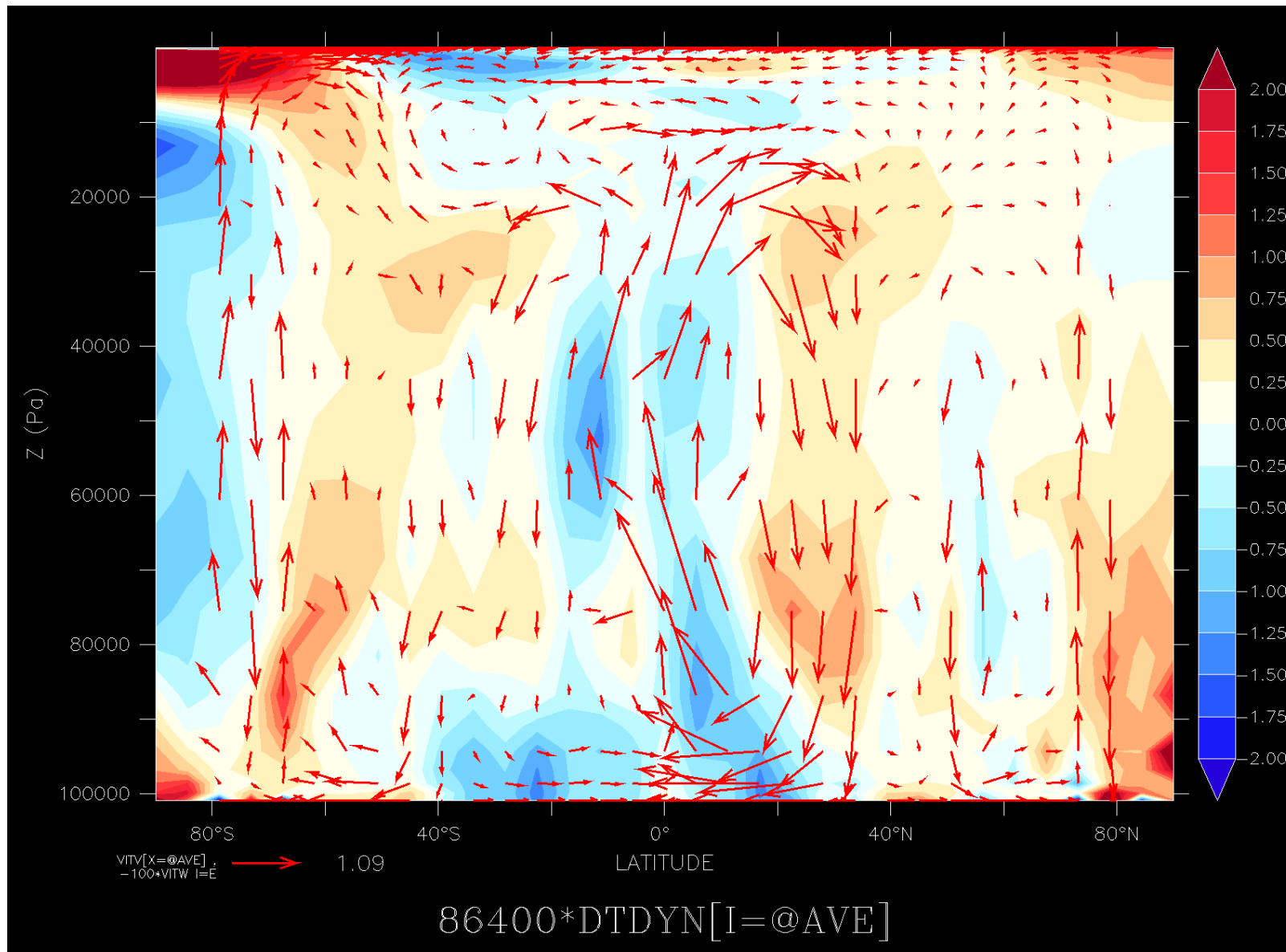
fill/lev=(-Inf)(-2,2,0.25)(inf)/pal=blue_darkred 86400*dtdyn[i=@ave]

(prendre le temps d'expliquer la commande)



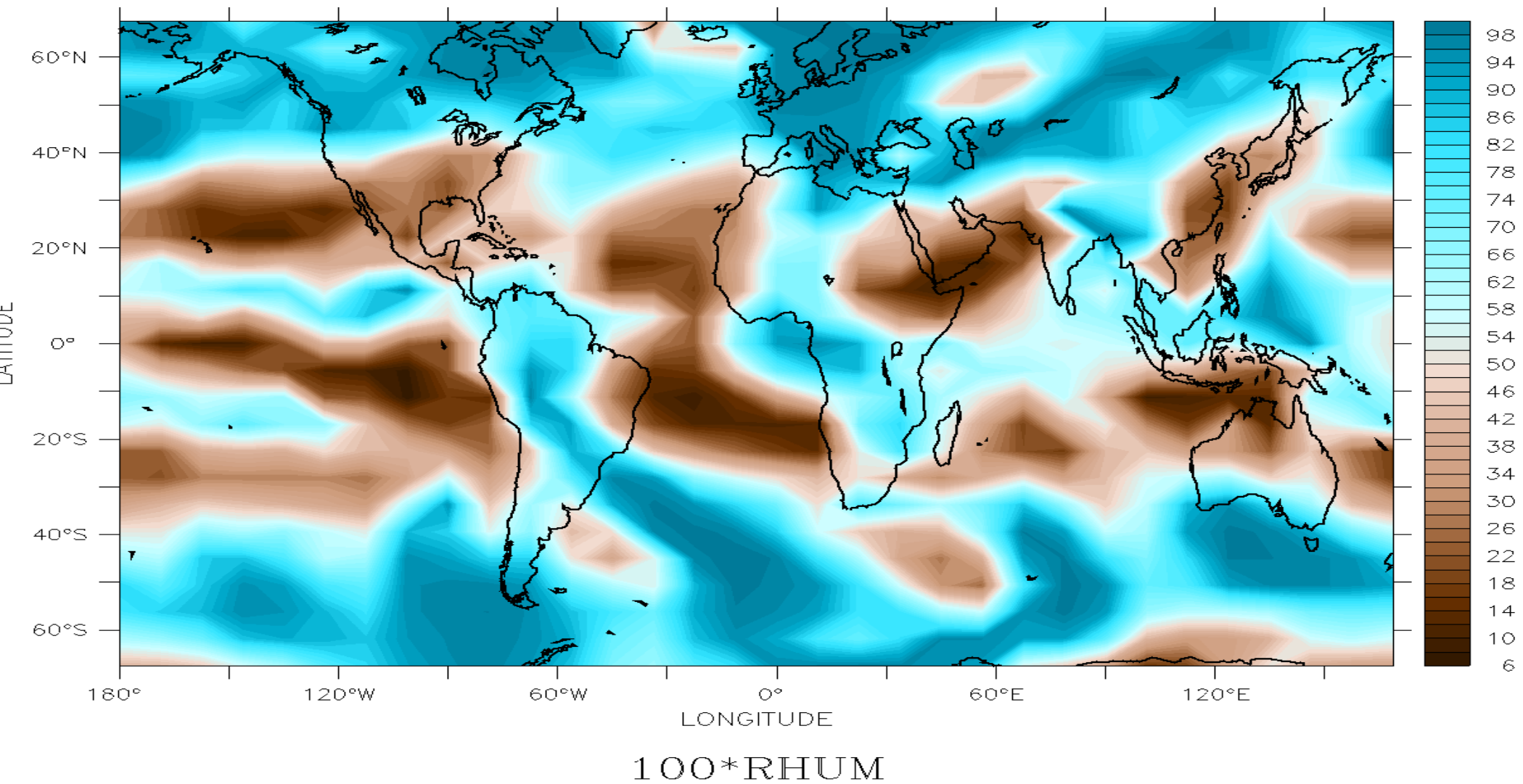
Mean meridional circulation

vector/o/l=3/col=14/y=-80:80 **vitv[i=@ave],-100*vitw[i=@ave]**



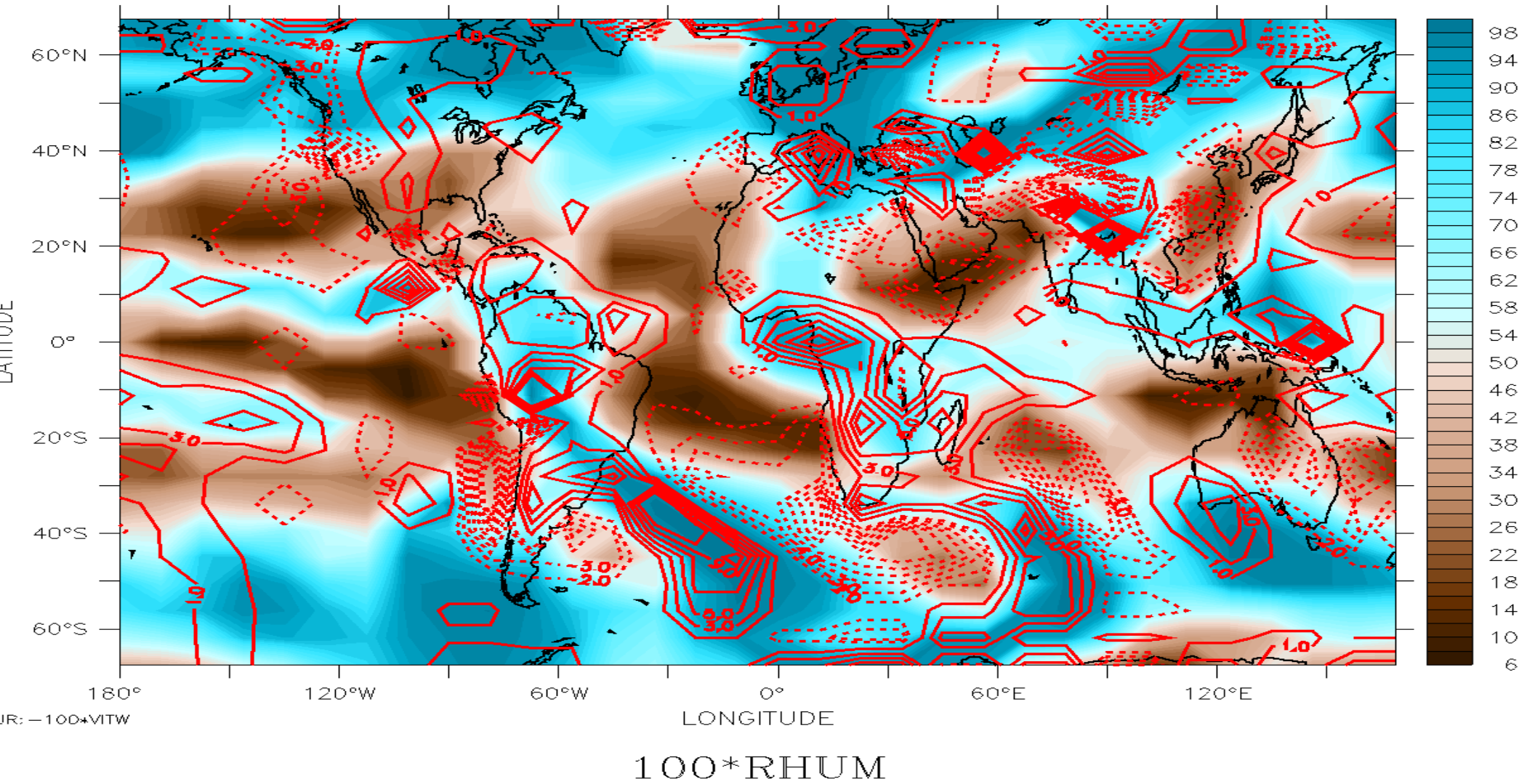
Tropospheric relative humidity at 500 hPa (~5 km)

fill/z=50000/y=-70:70/pal=brown_blue 100*rhum ; go land thick



Vertical velocity

contour/z=50000/lev=(-10,-2,1)(1,10,2)/col=14/o **-100*vitw**



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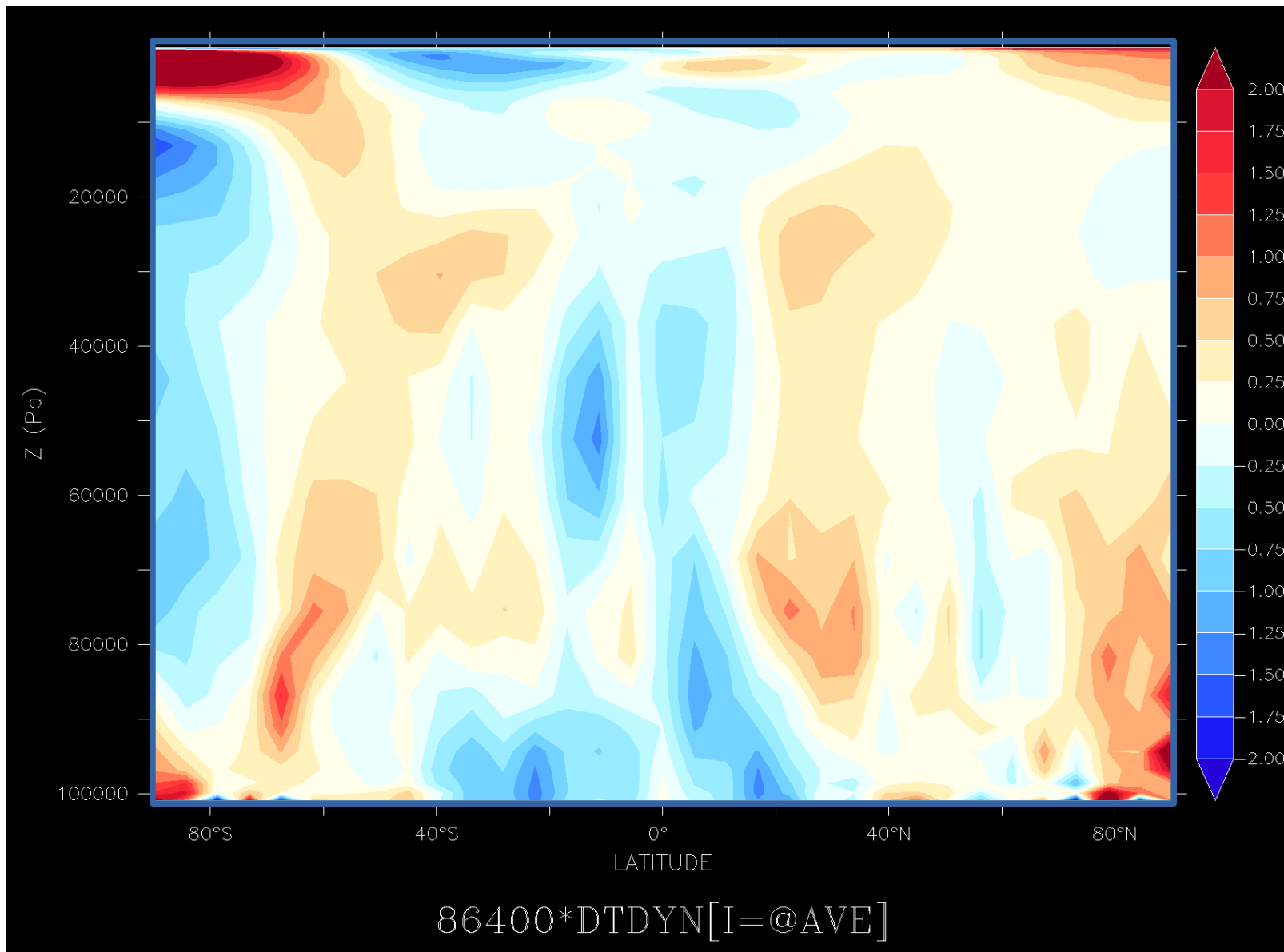
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