Turbulence in the presence of convection in ARPEGE-Climat

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Turbulence and convection in ARPEGE-Climat

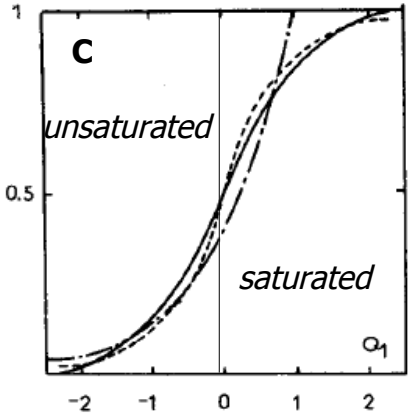
Turbulence is expressed in terms of the turbulent kinetic energy $\bar{e}$ computed following its time evolution equation

$$\frac{\partial \bar{e}}{\partial t} = [\,\text{Advect.}\,] + \text{Diff}_{\text{vert}} + P_{\text{dyn.}} + P_{\text{ther.}} - Diss \qquad P_{\text{dyn.}} = -\left[\overline{u'w'}\frac{\partial \bar{u}}{\partial z} + \overline{v'w'}\frac{\partial \bar{v}}{\partial z}\right] \qquad P_{\text{ther.}} = \beta\,\overline{w'\theta'_{vl}}$$

The convection scheme (PCMT, Guérémy and Piriou, 2018*) is providing the momentum and virtual temperature transport fluxes needed to get the convective dynamical and thermodynamical productions:

$\overline{\omega'\chi'} = -M\left(\chi_c - \bar{\chi}\right)$ with $M = -\alpha\sigma\omega_c$, thus $\overline{w'\chi'} = \frac{1}{\rho g}M\left(\chi_c - \bar{\chi}\right)$ for X=u, v et θ_{vl}.

---> These convective productions are added to their turbulent counterparts in the time evolution equation of $\bar{e}$.
Beyond the impact of convection on turbulence, there is another direct impact on cloudiness.
C=F(Q1), with Q1 being the departure of the mean state to saturation following Sommeria and Deardorff (1977), Q1=Δq/f(e) with f an increasing function:

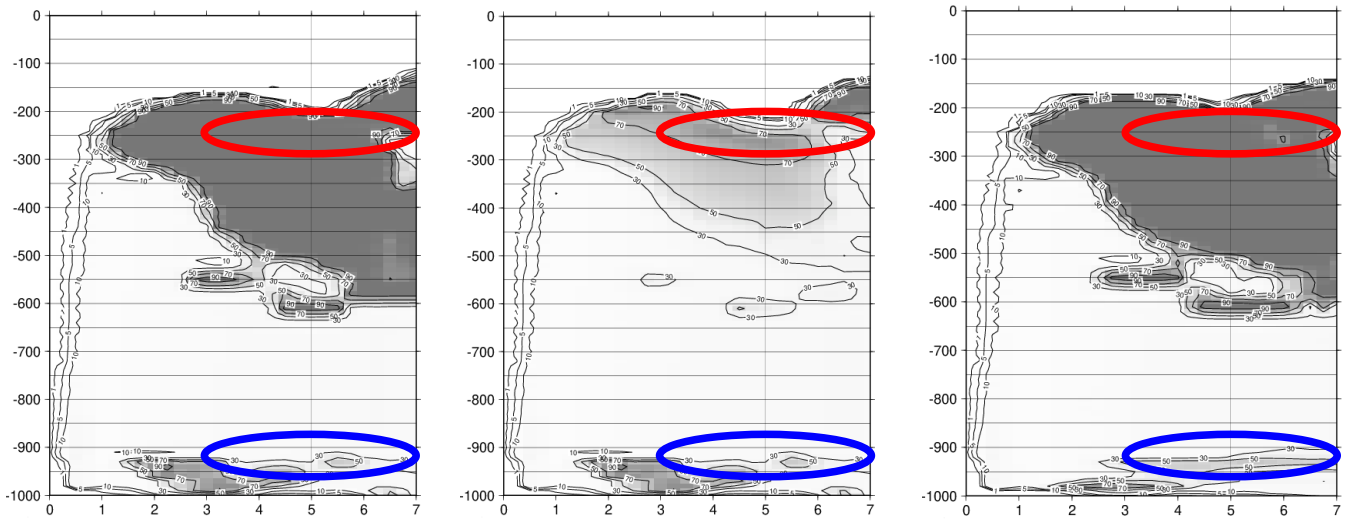


C=F(Q1), F solid line
(from Bougeault 1981)

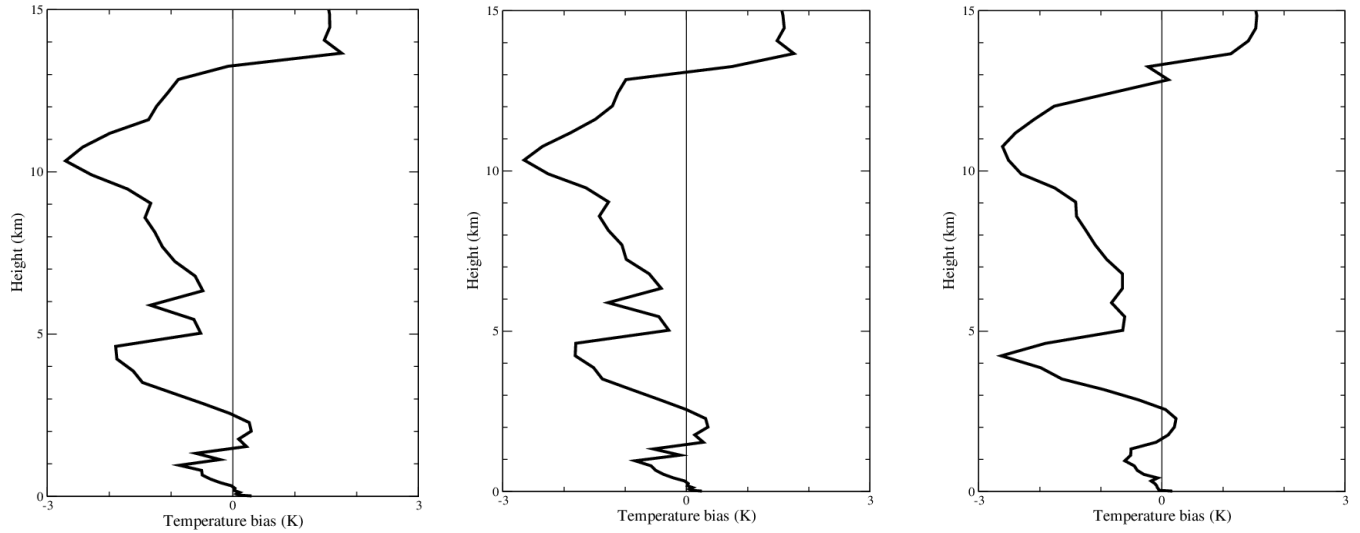
* (https://www.umr-cnrm.fr/spip.php?rubrique272)

1D Results TOGA case study (Bechtold et al., 2000)

Cloudiness time evolution



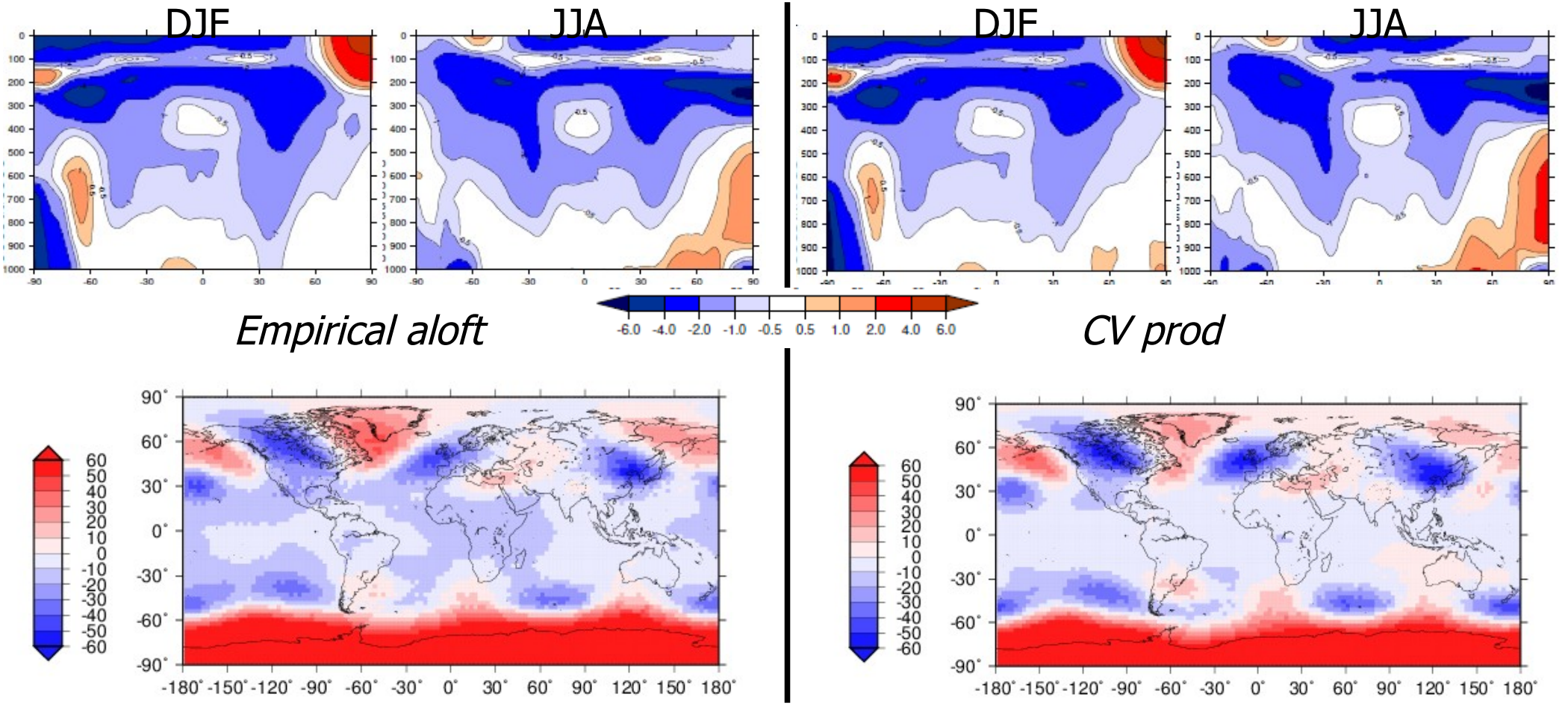
No CV prod *Empirical aloft* *CV prod*



Temperature bias at the end of the simulation (/ CRM)

3D Results

10 year coupled simulation Tl159(125km)l91-NEMO1°l75; IC ERA-I 01/79, o clim



DJF bias from seasonal re-forecast ensembles (15 members) starting 01/11 over the period 1993 to 2015
Tl359(55km)l91-NEMO1°l75