Radiative-Convective Equilibrium case : introduction and case setup

L.M.D./I.P.S.L., Paris ; France

Continental RCE case

The RCE case is intended to :

– **Characterize the workings of parametrizations** :

1. Vertical profiles of tendencies $\longrightarrow$ how parametrizations interact towards equilibrium
2. Time series of diabatic heating and drying and of precipitation $\longrightarrow$ diurnal cycle of model physics

– **Help parametrization development** by providing a large spectrum of situations where the model behaviour may be analysed.

– **Provide a simple instance of atmosphere-land surface coupling.**

The idea is to run the model physics isolated from all external interaction except the sun and the soil. In order to make the case simpler the soil is devoid of any hydrology. Instead, the ratio β of evaporation to potential evaporation is fixed. Then some temperature has to be fixed : We nudge the soil temperature at a depth such that the diurnal cycle is present.

In order to implement the case a Fortran subroutine (named "Surflandx") is provided which simulates the soil evolution and its coupling with the atmosphere.

Setup-1

- Initial profiles of temperature T and specific humidity q (although they are not expected to play any role).
- Latitude ; day of the year.
- Aridity coeficient β (between 0 and 1)
- Target temperature in the ground.
- Domain size (for scale aware parametrizations).

The target temperature and aridity coefficient are read from a file.

Setup-2

Subroutine "surflandx"simulates the dry soil evolution and its coupling with the atmosphere.

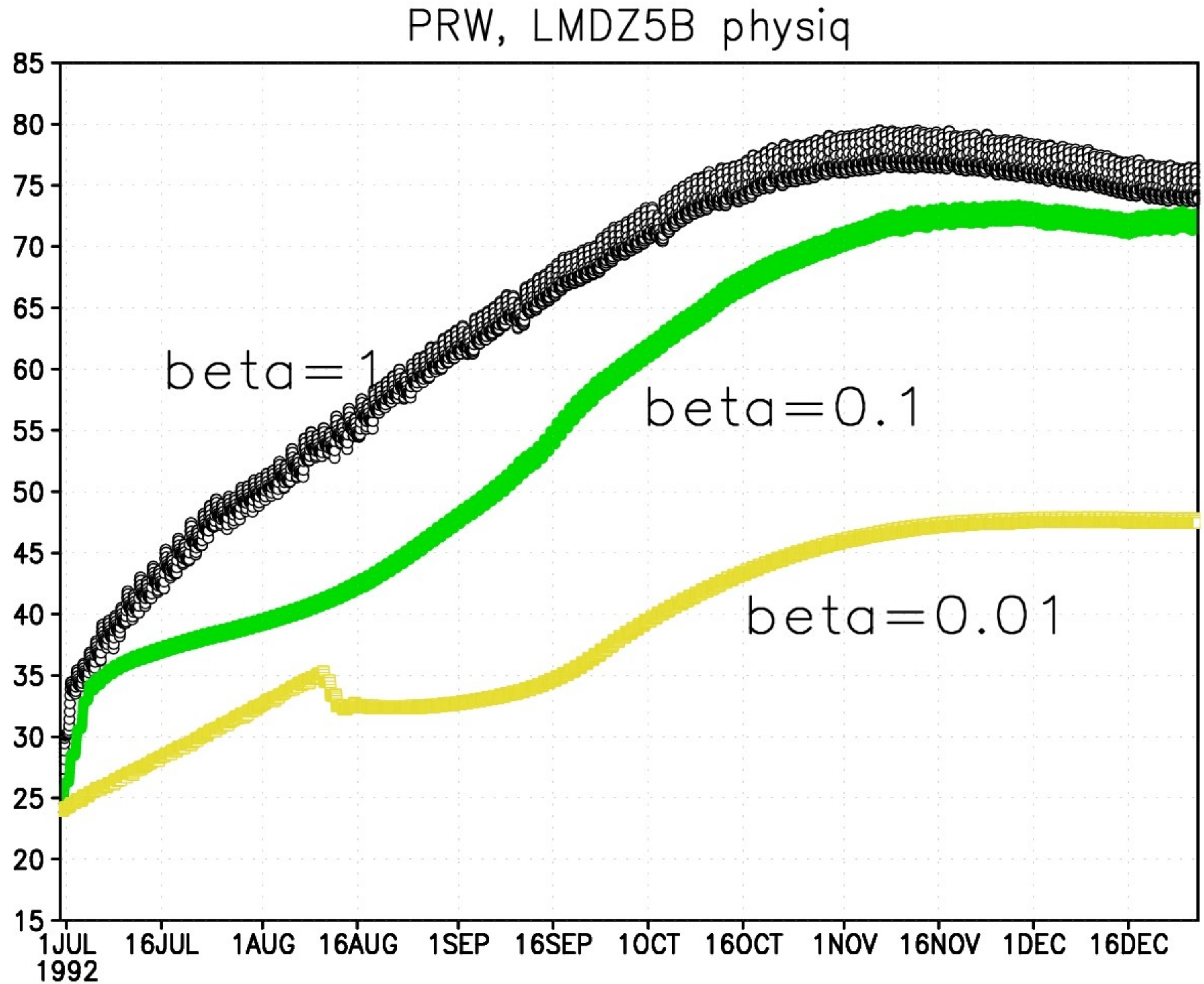
Input arguments =

1. variables at time $t - \delta t$:
   - δt = time step
   - p_1 = Pressure at first model level
   - T_1, q_1 = temperature and specific humidity at first level
   - (u_1 , v_1) = air velocity at first model level
   - p_{surf} = Surface pressure
   - SW_{net} and LW_{net} = shortwave and longwave net radiative fluxes at surface (positive downward)
   - T_{surf} = Surface temperature, assumed homogeneous
   - C_D = Drag coefficient to be used in the equation : $\phi_s = \rho C_D(1+\sqrt{u^2+v^2})(T_1 - T_s)$ (similar equation for humidity) (ρ = air density ;ϕ_s = sensible heat flux).
   - A_T and B_T = coefficients relating T_1 and the sensible flux ϕ_s : $C_p T_1 = A_T + B_T \phi_s \delta t$
   - A_q and B_q = coefficients relating q_1 and the evaporation E : $q_1 = A_q + B_q E \delta t$
2. and $T_{\text{soil}}(t - 2\delta t)$ = the soil temperature profile at $t - 2\delta t$.

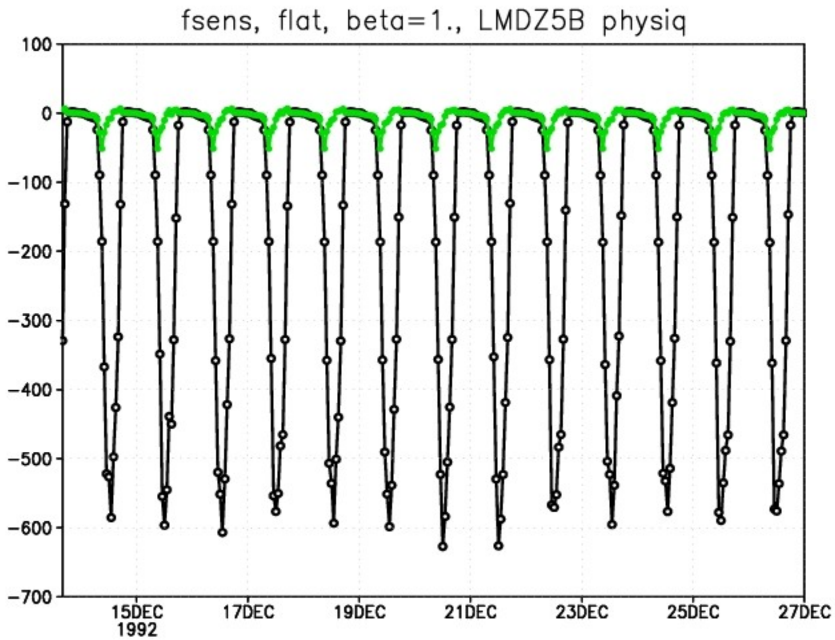
Setup-3

Output from subroutine surflandx =

1. variables at time t :
   - $E(t)$ = surface evaporation at time t (kg m^{-2} s^{-1}, positive upward)
   - $\phi_s(t)$ = surface sensible heat flux at time t (W m^{-2}, positive upward)
   - $\phi_l(t)$ = surface latent heat flux at time t (W m^{-2}, positive downward : $\phi_l = -L_v E$)
   - $T_{\text{surf}(t)}$ = Surface temperature at time t
   - $q_{\text{surf}(t)}$ = specific humidity above surface
2. and the updated soil temperature profile $T_{\text{soil}}(t - \delta t)$ at time $t - \delta t$.



PRW, LMDZ5B physiq
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
beta=1
beta=0.1
beta=0.01
1JUL 1992
16JUL
1AUG
16AUG
1SEP
16SEP
1OCT
16OCT
1NOV
16NOV
1DEC
16DEC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0
−100
−200
−300
−400
−500
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15DEC
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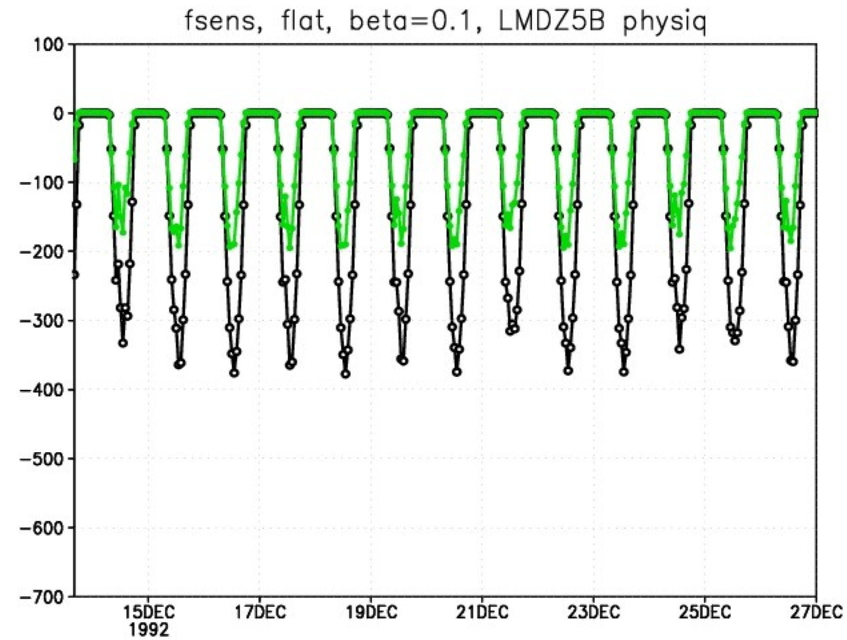
21DEC
23DEC
25DEC
27DEC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0
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21DEC
23DEC
25DEC
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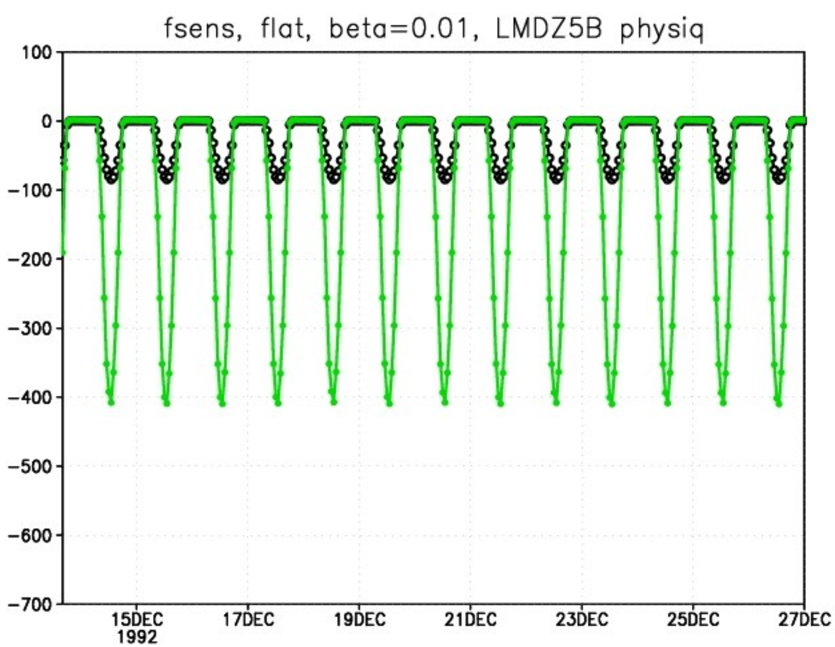
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100
0
−100
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−700
15DEC
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21DEC
23DEC
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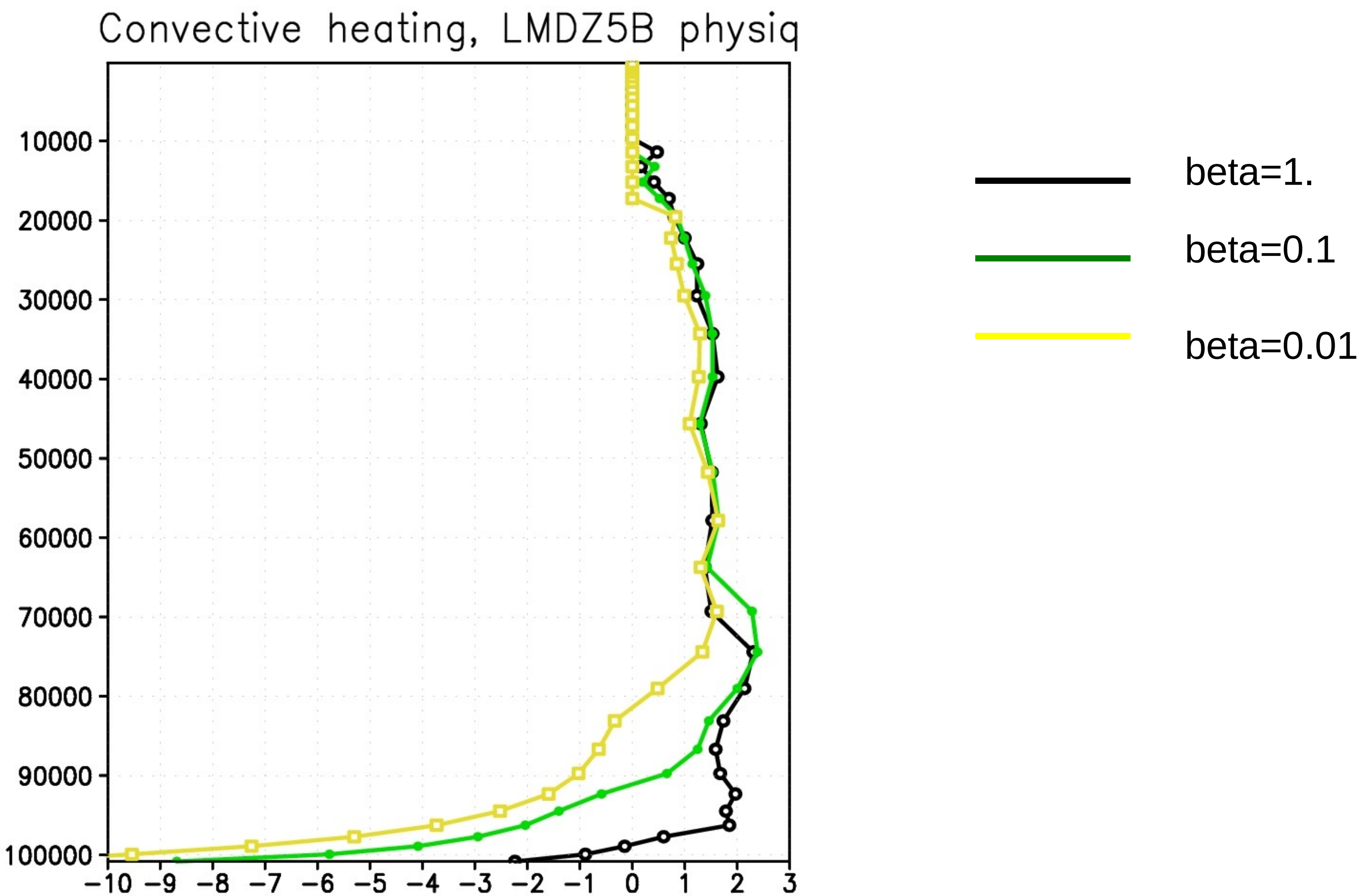
27DEC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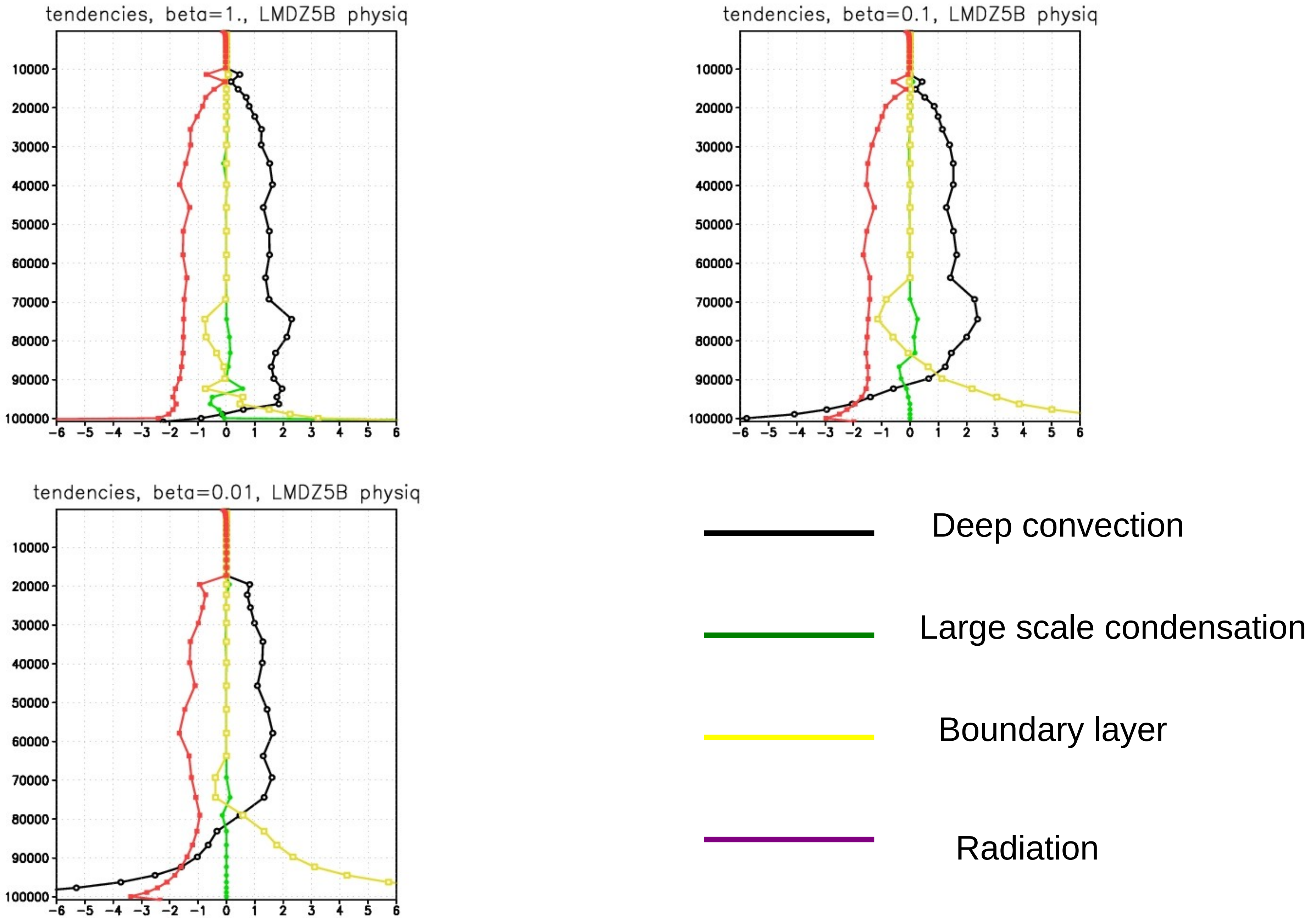
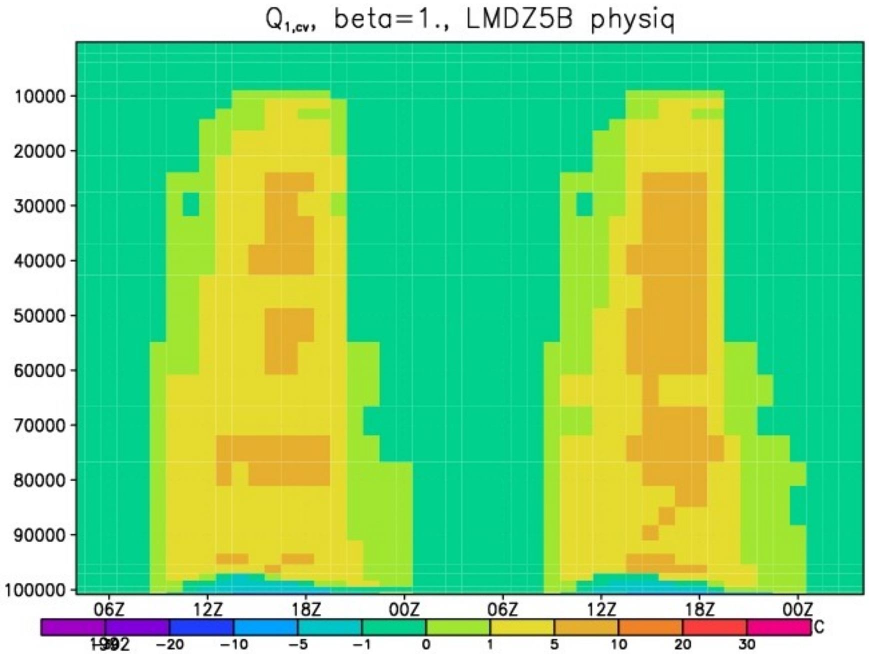
30000
40000
50000
60000
70000
80000
90000
100000
−10
−9
−8
−7
−6
−5
−4
−3
−2
−1
0
1
2
3
beta=1.
beta=0.1
beta=0.01



tendencies, beta=1., LMDZ5B physiq
tendencies, beta=0.1, LMDZ5B physiq
tendencies, beta=0.01, LMDZ5B physiq
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
−6 −5 −4 −3 −2 −1 0 1 2 3 4 5 6
Deep convection
Large scale condensation
Boundary layer
Radiation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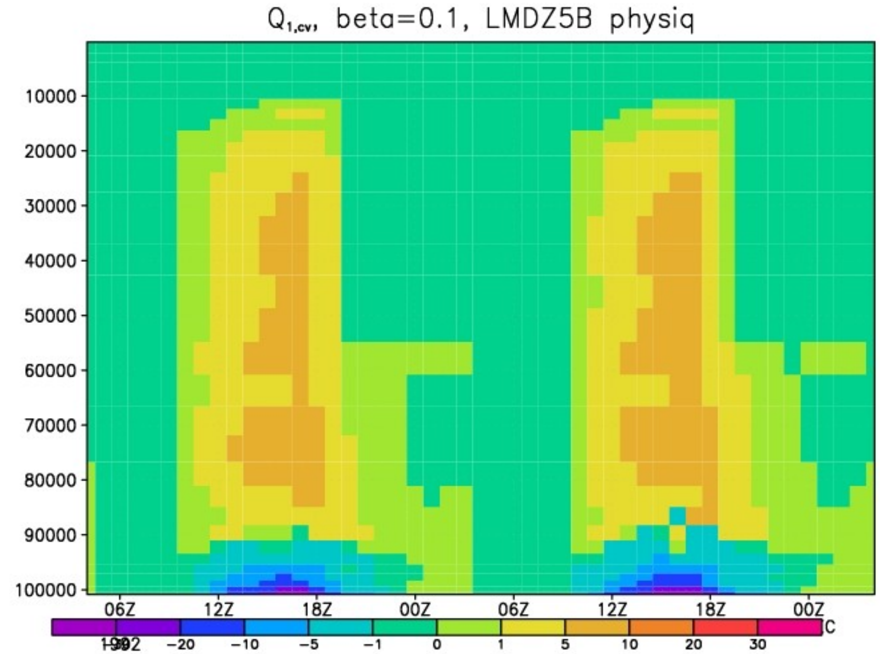
20000
30000
40000
50000
60000
70000
80000
90000
100000
06Z 12Z 18Z 00Z 06Z 12Z 18Z 00Z
1992
−20 −10 −5 −1 0 1 5 10 20 30
C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10000
20000
30000
40000
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60000
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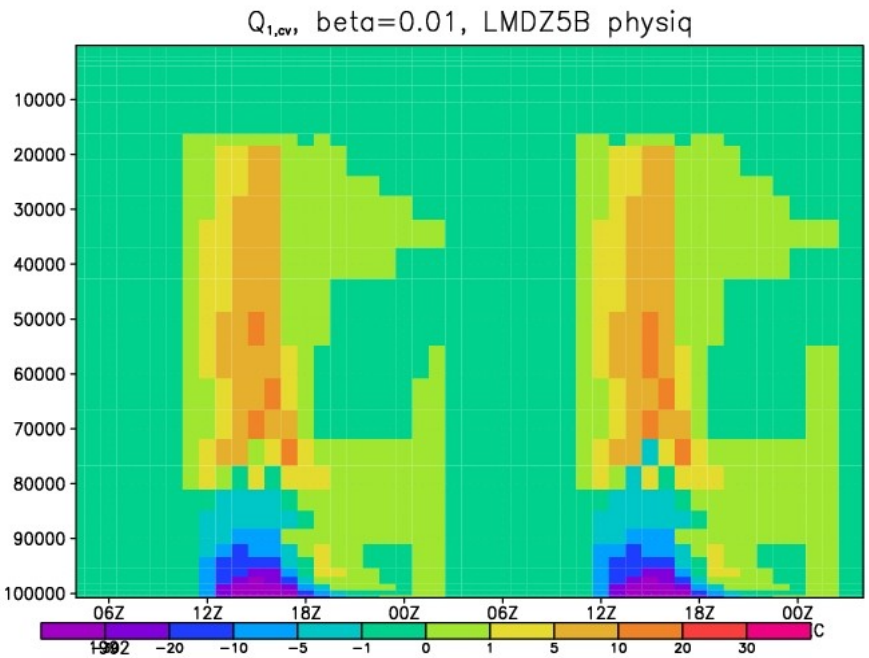
90000
100000
06Z 12Z 18Z 00Z 06Z 12Z 18Z 00Z
1992
−20 −10 −5 −1 0 1 5 10 20 30
C


Q1,cv, beta=0.01, LMDZ5B physiq
10000
20000
30000
40000
50000
60000
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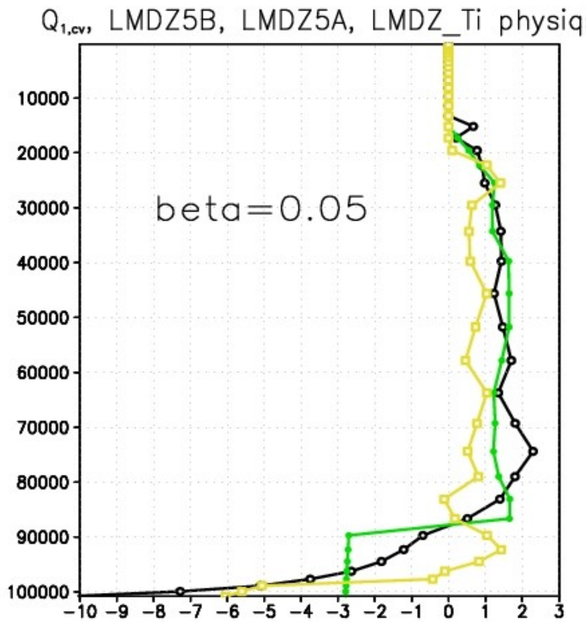
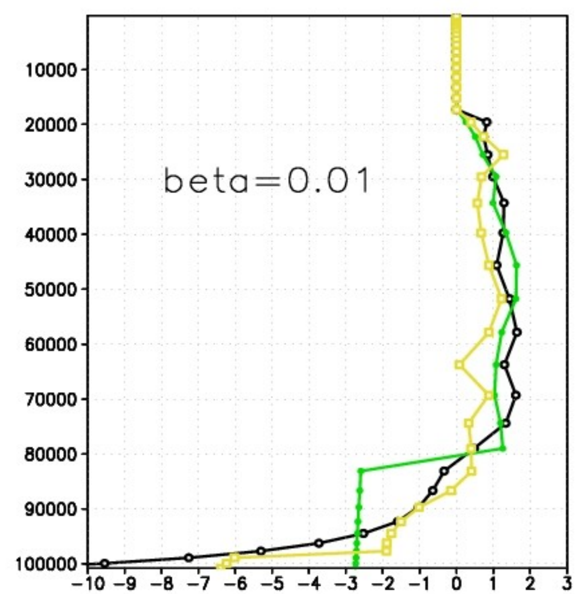
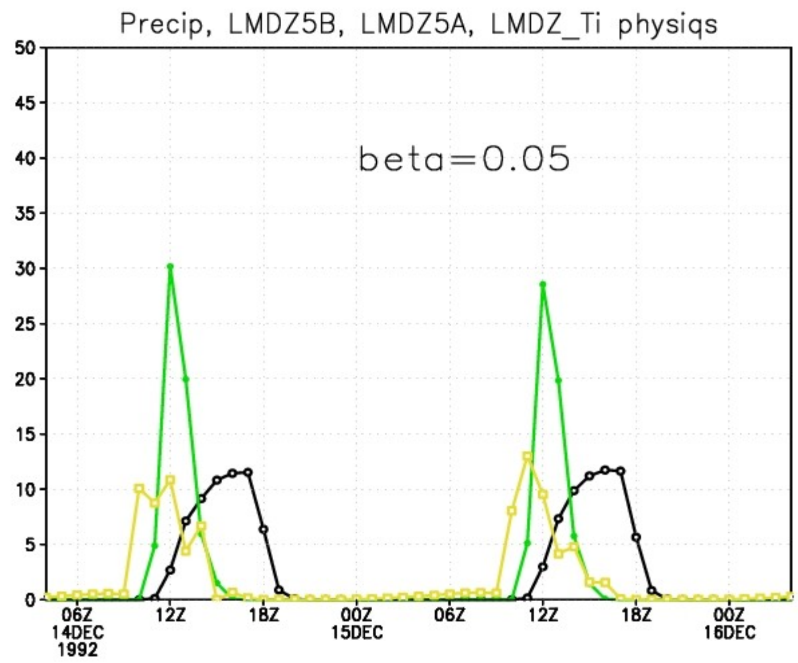
90000
100000
06Z 12Z 18Z 00Z 06Z 12Z 18Z 00Z
1992
−20 −10 −5 −1 0 1 5 10 20 30
C







B physics (Emanuel scheme coupled with thermals and wakes)

A physics (stand alone Emanuel scheme)

Tiedtke scheme