Documentation for LMDZ, Planets version

The upper boundary sponge layer

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1 Theoretical aspects

Because of the inevitable numerical boundary at the top of the model, upward travelling waves are found to non-physically reflect down into the atmosphere. A common remedy to this unwanted behaviour is to apply a sponge layer near the top of the model in order to quench these waves and avoid significant reflection thereof. In practice such quenching is done by adding a dissipative term which forces a relaxation of potential temperature and/or winds of the form:

$$A(t) = A_m + A_0 \exp(-\lambda t)$$

Where A_m is the value towards which A is to asymptotically relax, and λ is the inverse of the characteristic relaxation time scale. As there is no obvious value of A_m towards which to relax, in practice it is often chosen to be either the zonal average of A (evaluated at time t, i.e. conveniently ignoring that A_m then is in fact not time-independent), or zero (at least for winds, since this would have little physical meaning for potential temperature).

2 Pratical aspects in the code

The tendencies for the upper boundary sponge layer are computed separately in the top_bound.F routine (called from leapfrog.F) and added in place. The resulting sponge tendency dutop, in m/s, is also given as an output for diagnostics.

Three parameters may be adjusted in the gcm.def file:

- iflag_top_bound: selects the affected layers.
  - 1: only the top 4 layers are affected. In this case, the damping rate is divided by 2 in the second layer, 4 in the third and 8 in the fourth.
  - 2: layers with pressure lower than 100 times the top pressure. In this case, the damping rate depends linearly on the pressure.
- mode_top_bound: selects how the fields are affected.
  - 0: No sponge layer is applied.
  - 1: Zonal and meridional winds are damped to zero.
  - 2: Zonal and meridional winds are damped to their zonally averaged value.
  - 3: Temperature, zonal and meridional winds are damped to their zonally averaged value.
- tau_top_bound: damping rate (λ in equation above, expressed in Hz) in the topmost layer.