Testing COSMO-CLM LBCs with Baroclinic Wave Test Case

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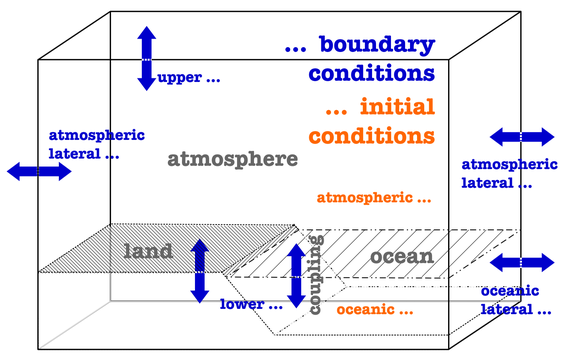
1 - Motivation

- Restricting conditions of regional climate system modelling: atmospheric **lower boundary conditions** (coupled ocean), atmospheric **upper boundary conditions**, **initial conditions** and **lateral boundary conditions** (**LBC**s)



→ Initial boundary value problem (IBVP), here focus on atmospheric LBCs.

- LBCs in regional climate models (RCMs) can lead to errors in simulations [1] due to different reasons (lack of spatio-temporal high-resolution driving data, model inaccuracies due to boundary coupling scheme, etc.).

- LBCs should be **adequate** (form well posed IBVP) and **transparent** (signals entering/ leaving the limited domain through lateral boundaries without being modified/ inducing reflections).

2 - Lateral Boundary Schemes

Davies Relaxation [2]

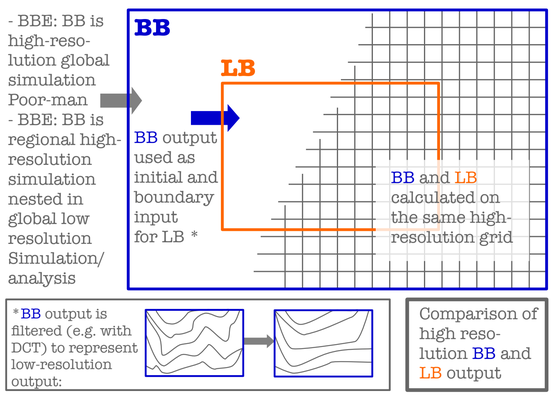
- all variables are fixed at all lateral boundaries
  → overspecification
- damping zone of ca. 8 grid points (blending of LBC values and interior solution)

Mesinger Eta-Model scheme [3]

- all variables but one fixed at all lateral boundaries
- extrapolation of tangential velocity at outflow boundary

3 - Experiments

- Use the **Big-Brother Experiment** protocol [4].



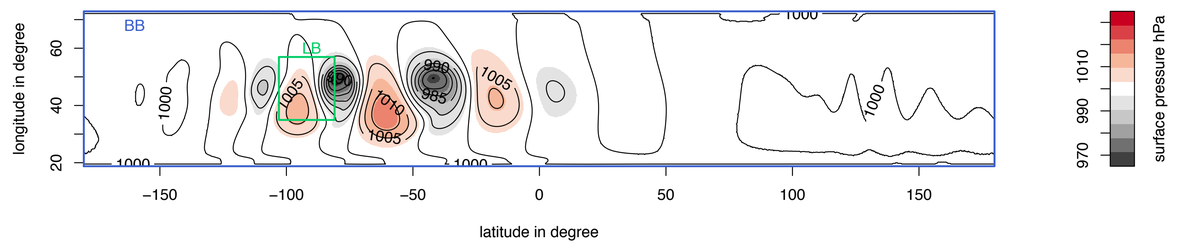
- The "Big Brother" (BB) is an "Idealised test case" [5] simulation of the baroclinc wave test case [6] on an f-plane which drives the "Little Brother" (LB).
- Differences between LB and BB can be attributed to LBCs.

- Model versions: `int2lm_131101_2.0_clm4`; `cosmo_131108_5.0_clm7` (including newly implemented [3] LBC scheme + [6] initial conditions)
- 17 forecast days; physics switched off; dry atmosphere; BB: zonal periodicity; 42 vertical levels

- Experiment modifications:
  - LBC scheme: standard Davies Relaxation (DR) or new scheme based on Mesinger Eta-model (ME)
  - Boundary input time increment: every (1 / 6 / 12) model time step (2.5min / 15min / 30min) or 1-/ 3-/ 6-/ 12- hourly
  - Resolution jump: BB 0.22°→LB 0.22° or BB 0.11°→LB 0.11° (J1); BB 0.33°→LB 0.11° (J3); BB 0.66°→LB 0.11° (J6);

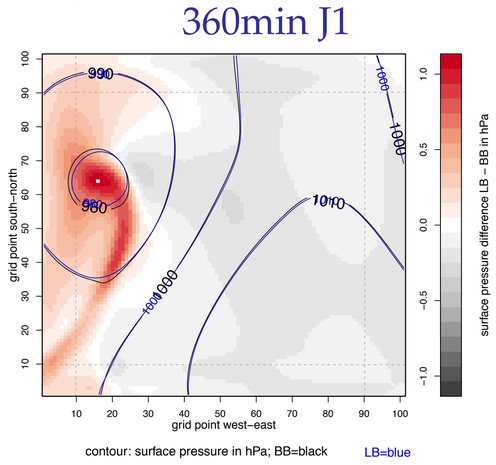
4 - Results

- Surface pressure of BB 0.22°; BB and LB domains, snapshot after 13 forecast days:

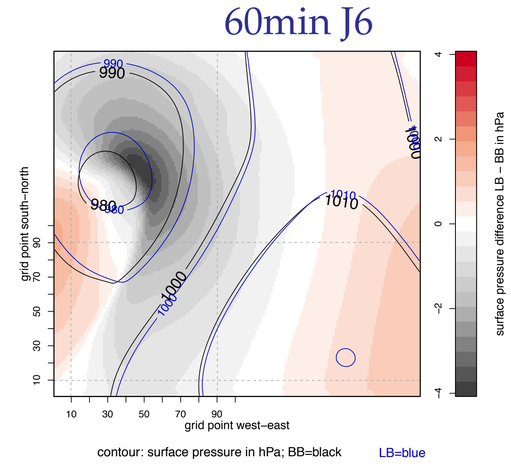


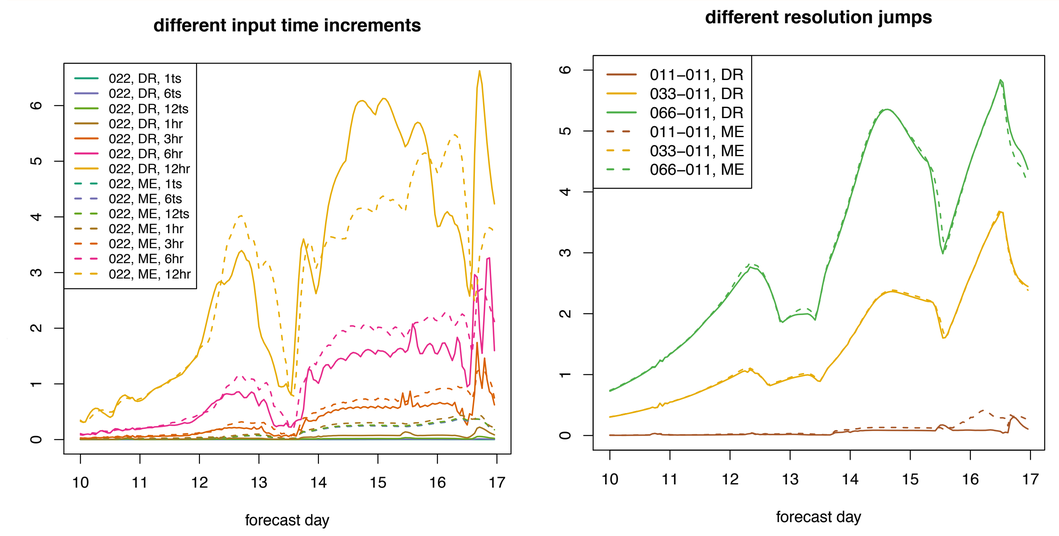
Snapshots at day 14 hour 2 of surface pressure LB-BB; both DR

360min J1



60min J6





Domain maximum of absolute LB-BB P_{sfc} difference in hPa;
top: time series;
bottom: time mean over last 7 forecast days DR and ME:

$\Delta\varphi/\lambda$ / Δt	0.22-0.22 (J1)	0.11-0.11 (J1)	0.33-0.11 (J3)	0.66-0.11 (J6)
2.5 min	0.0006 0.1336	-	-	-
15 min	0.0116 0.1353	-	-	-
30 min	0.0441 0.1408	-	-	-
1hr	0.0441 0.1646	0.0516 0.0971	1.4861 1.4973	3.0977 3.1130
3hr	0.3354 0.4292	-	1.5178 1.5150	3.0895 3.1030
6hr	0.9457 1.1742	-	1.6623 1.6378	3.0970 3.0849
12 hr	3.0337 2.8238	-	-	-

5 - Conclusions and Outlook

- Same order of magnitude in errors due to resolution jump and input timestep; However different characteristics of these errors.
- No large differences between the two LBC schemes.

→ Further study the two LBC schemes in this test case
→ Study the two LBC schemes in realistic simulations.

References

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[2] H.C. Davies (1976): A lateral boundary formulation for multi-level prediction models. *Q. J. Roy. Meteor. Soc.* 102(432), 405-418

[3] F. Mesinger et al. (2013): Limited area NWP and regional climate modeling: A test of the relaxation vs Eta lateral boundary conditions *Meteorology and Atmospheric Physics* 119, 1-16

[4] B. Denis et al. (2002): Downscaling ability of one-way nested regional climate models: the Big-Brother Experiment *Clim. Dynam.* 18, 627-646

[5] U. Blahak (2015) Simulating idealized cases with the COSMO-model (draft version)

[6] P.A. Ullrich et al. (2015) Analytical initial conditions and an analysis of baroclinic instability waves in f- and β-plane 3D channel models *Q. J. Roy. Meteor. Soc.* 141, 2972-2988