New options ND4SYS=0 and LSPNHX=T implemented on top of Czech operational model version CY46t1as_op1

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The full modset based on CY46t1as_op1 may be found in Prague on lada1:
/local/mma130/CY46t1/CY46t1as_op1_spnhx

The modified routines are:
1) Introduction and dimensioning for LSPNHX:
  Ald/adiab/espchor.F90
  Ald/transform/etransdir_nhconv.F90
  Ald/transform/etransinv_mdl.F90
  Arp/adiab/cpg_gp.F90
  Arp/adiab/cpg_gp_nhee.F90
  Arp/adiab/gpinislb.F90
  Arp/adiab/spchor.F90
  Arp/dfi/dfi2.F90
  Arp/dia/sualdyn_ddh.F90
  Arp/module/gmv_subs_mod.F90
  Arp/module/iospeca_mod.F90
  Arp/module/yemlbc_fields.F90
  Arp/module/yemlbc_init.F90
  Arp/module/yemlbc_model.F90
  Arp/module/yomdyna.F90
  Arp/namelist/namdyna.nam.h
  Arp/parallel/trmtos.F90
  Arp/parallel/trstom.F90
  Arp/setup/sudyna.F90
  Arp/setup/suhdu.F90
  Arp/transform/transdir_nhconv.F90
  Arp/transform/transinv_mdl.F90
  Arp/utility/suspvariables.F90

2) ND4SYS=0:
  Arp/pp_obs/pos.F90
  Arp/adiab/cpglag.F90

3) small bug:
  Arp/module/field_gfl_wrapper.F90

To run the new code, one has to set
  ND4SYS=0
  LSPNHX=.F.
in namdyna.

Then under the option ND4SYS=0 the orographically induced X-term is being diagnosed at the beginning or at the end of the time step. In case LSPNHX=F, it happens at the beginning of the time step using values from the previous time step and at the end of the time step using new guesses of model variables. The X-term does not enter the spectral space in this case. In case LSPNHX=T, the X-term is being diagnosed at the end of the time step only, using new guesses of model variables. Then the X-term enters the spectral space and it is retrieved at the beginning of the next time step and used for further calculations.

The time evolution of the domain averaged spectral norms of model variables shows that the change of model variables in time is smoother with the option ND4SYS=0 then with the previously used ND4SYS=2. This is more visible in higher horizontal resolution and above steep terrain. With operational resolution of 2.325km the norms are very close. See Figure 1.
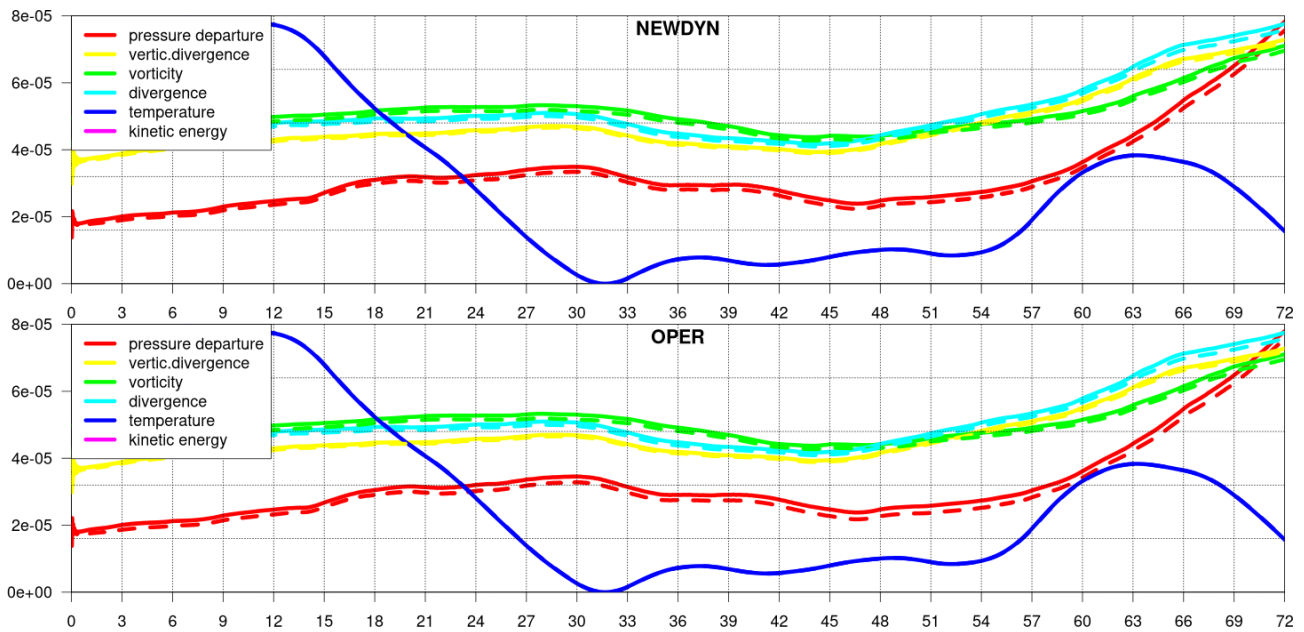

Figure 1: Time evolution of domain averaged spectral norms for the New dynamics options experiment (top) and the Operations (bottom).

See Table 1 for differences in domain averaged spectral norms of model variables for 17 Nov 2024 0UTC + 0072 hours.

Table 1: Domain averaged spectral norms at time +72 hours starting from 17 Nov 2024, 0UTC.

Variable	Operations	New dynamic options	Difference
VORTICITY	0.139177639704249E-03	0.139201295271402E-03	4th digit
DIVERGENCE	0.151613272621224E-03	0.151673923496907E-03	5th digit
TEMPERATURE	0.251123079069717E+03	0.251123089325386E+03	8th digit
HUMIDITY	0.187242049393601E-02	0.187243267102504E-02	6th digit
KIN.ENERGY	0.264554165619030E+03	0.264530537106224E+03	5th digit
LOG(PRE/PREHYD)	0.756139593925501E-04	0.757474123716386E-04	3rd digit
d4 = VERT.DIV + X	0.143820145777784E-03	0.143893018509883E-03	5th digit

The objective scores show that there is no significant change when comparing the forecast for the first 72 hours with ND4SYS=2 & LSPNHX=T (Operations) and similar experiment with ND4SYS=0 & LSPNHX=F (New dynamic options). See the example of wind characteristics for +72 hours in Figure 2.
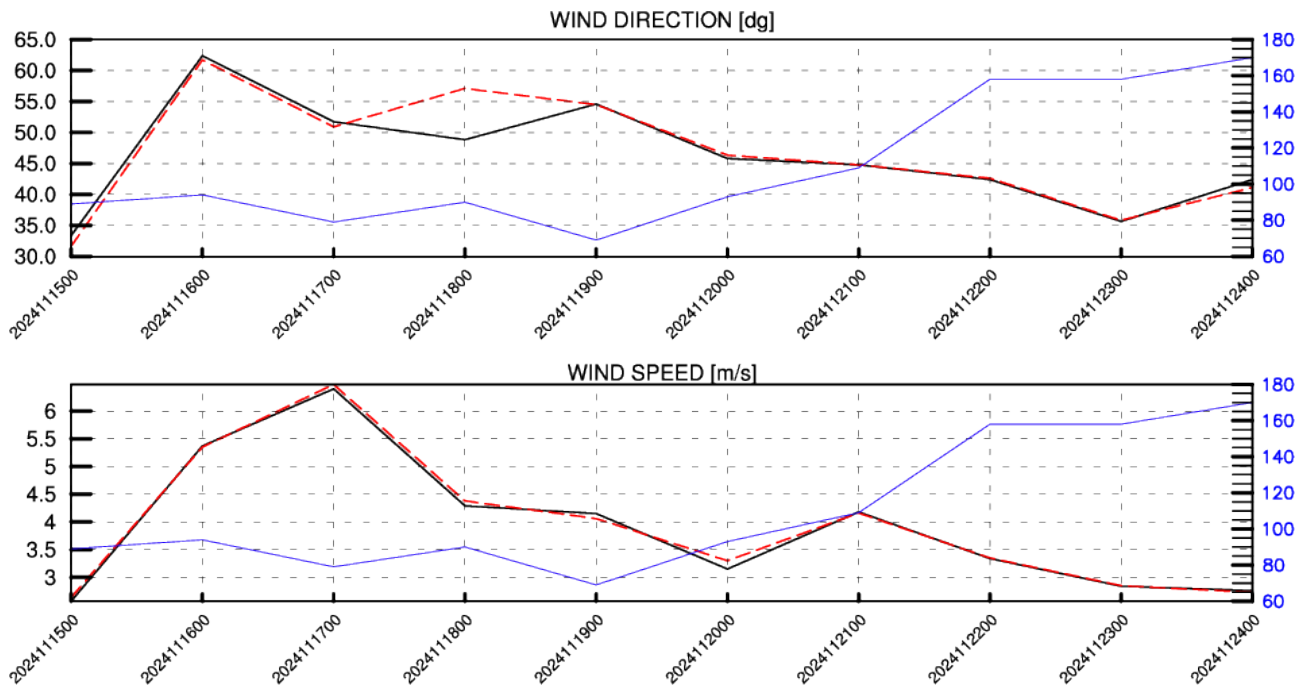

Figure 2: Evolution of RMSE for the wind direction and the wind speed for the forecast for 72 hours comparing Operations (red) and New dynamics options (black). The number of measurements is in blue.

The DDH characteristics are influenced by the change so that the surface part of the temperature budget differs in resid and dynam. Probably a residual part was diminished and the dynamical part has increased with the new dynamics options.
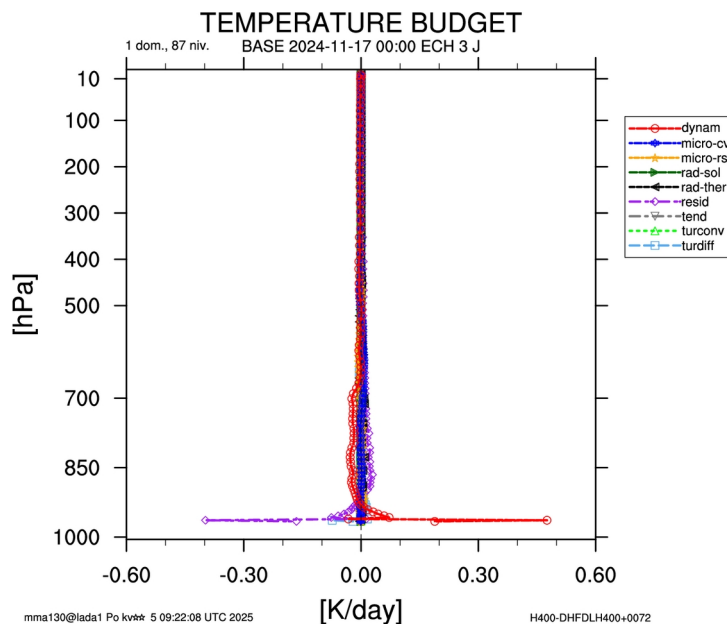

Figure 3: The difference in the temperature budget between the New dynamics options and Operations after 72 hours of forecast.

The CPU time savings are substantial on lada. See Table 2 and Figure 4 for the illustration.

Table 2: Overall Data of 128 Vector processes
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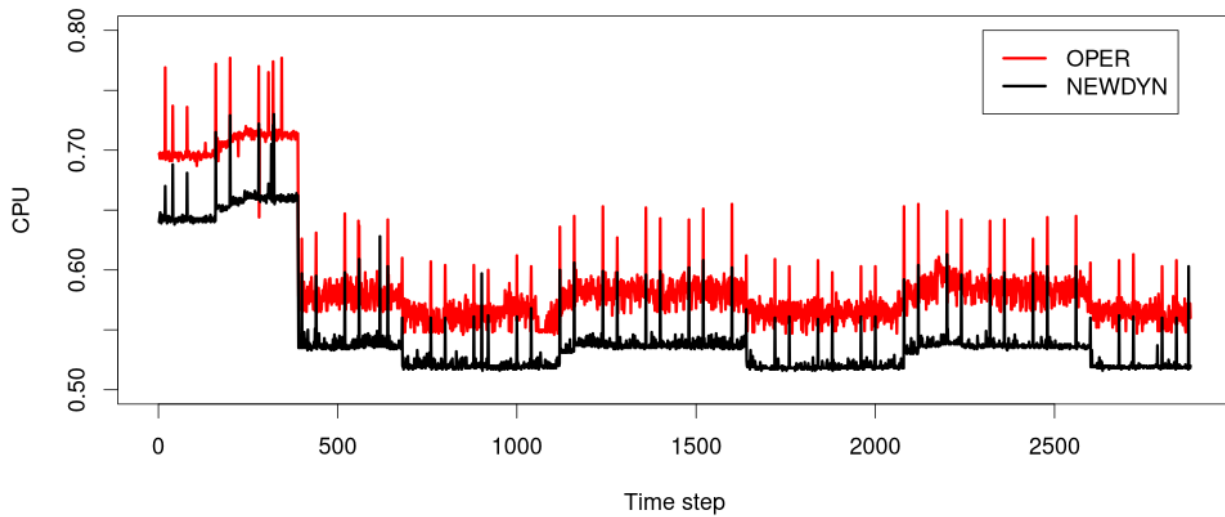| Time characteristic	Operations	New dynamic options	Difference
Real Time (sec)	3137.481	2566.882	18%
User Time (sec)	801650.624	654292.451	18%
Vector Time (sec)	290322.651	283956.940	2%

Figure 4: The CPU time needed for the individual time steps of the Operations (red) and the New dynamics option experiment (black). The average saving in CPU time per time step is 7.6%.