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REPORT

ASSEMBLING AND VALIDATION OF NEW PROGNOSTIC ACPLUIE SCHEME

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1.INTRODUCTION

A new prognostic version of ACPLUIE scheme was constructed. The routine treats three different sources of (liquid and solid) precipitation: coming from the layer above, already available in the layer from previous time step and precipitation generated in the layer during the current time step.
The aim of this work was to implement the new ACPLUIE_PROG scheme in operational ALADIN cycle 29 and validate it in respect to the old ACPLUIE.

2. ASSEMBLING

First part of the assignment was to implement the modified versions of CPTEND and CPUTQY to be able to run the new ACPLUIE_PROG routine, and to update the data flow upwards in the forerunning routines (APLPAR, MF_PHYS and CPG).

For that purpose, routines obtained from Bart Catry were implemented and tested. Some typos and inconsistencies were found and corrected in the ACPLUIE_PROG, and required changes in the environmental routines and corresponding interfaces were made.

Changes in the original ACPLUIE_PROG.F90 obtained by Bart Catry:

7, 429 (451) and 430 (452)   PFCSL, PFCSM → PFCSQL, PFCSQN

- typo corrected, fluxes named in consistency with previous/other routines

146 – 151   PFCSQL (KLON, KLEV) → PFCSQL (KLON, 0: KLEV) *etc*

- dimensioning problem, vertical dimension of all the fluxes should be KLEV+1

157 KIND=JPRB) :: ZDELTA, ZDQL, ZDQN, ZDQ, ZEPS1, ZEPS2, ZEVA, ZFON,&
158   &ZIPB, ZIPH, ZRME, ZFPSL, ZFPSN, ZFCSL, ZFCSN, ZFESL,&
159 &ZFESN, ZFASL, ZFASN, ZPL1, ZPL2, ZPL3, ZR, ZRHO, ~~ZDELTA&~~
160 &ZPN1, ZPN2, ZPN3, ZPROBL1, ZPROBN1, ZPROBL2, ZPROBN2, ZPROBL3,&
161 &ZPROBN3, ZTENDL1, ZTENDL2, ZTENDL3, ZTENDN1, ZTENDN2, ZTENDN3,&
162 &ZZL, ZZN, ZTAUL, ZTAUN, ZC, ZOMEGA, ZGDTI

- ZDELTA defined twice, latter one removed

191 – 198   PFESL=0._JPRB *etc*

- new lines added after constants definitions, all the real fluxes initialized to 0

243 (251) ZFALLL (JLON) =0.5_JPRB*RG*TSPHY → ZFALLL (JLON) =0.5_JPRB*RG

- initialized fall velocities should be independent of the time step

292 (306) ZFCSL=-ZDQL*ZPOID(JLON,JLEV) → ZFCSL=-MIN(0._JPRB,ZDQL)*ZPOID(JLON,JLEV)
293 (307) ZFCSN=-ZDQN*ZPOID(JLON,JLEV) → ZFCSN=-MIN(0._JPRB,ZDQN)*ZPOID(JLON,JLEV)

- condensation fluxes ZFCSL/N can only be condensation fluxes when saturation condition (ZDQL/N < 0) is fulfilled

297 (311) – 300 (314)   ZFASL=-(...   →   ZFASL=(...

- minus removed in the computation of auto-conversion fluxes ZFASL and ZFASN

367 (388) – 384 (406)   ZPL1 → MAX(ZPL1,0.0_JPRB) *etc*

- three sources of precipitation (liquid and solid) ZPL1, ZPL2, ZPL3, ZPN1, ZPN2, ZPN3 all conditioned to be positive to enable computing square roots in the evaporation tendencies calculations

318 (339)   ZPROBL3=1.0_JPRB/(2.0_JPRB*ZZL) &
319 (340)   &-(EXP(-ZZL)*(ZZL+1.0_JPRB))/(ZZL**3+4.0_JPRB*ZZL**2+2.0_JPRB*ZZL)
320 (341)   ZPROBN3=1.0_JPRB/(2.0_JPRB*ZZN) &

321 (342) & -(EXP(-ZZN)*(ZZN+1.0_JPRB))/(ZZN**3+4.0_JPRB*ZZN**2+2.0_JPRB*ZZN)
-missing division sign added

327 (348), 332 (353), 337 (358) and 342 (363) PDELP(JLON,JLEV) → ZPOID(JLON,JLEV)
- mistake in multiplication with dp instead of dp/gdt

330 (351), 335 (356) ZLP3 → ZPL3
- typo corrected

326 (349) - 345 (366) 1_JPRB, 5_JPRB, 5 → 1._JPRB, 5._JPRB, 5.
- in the computation of tendencies for collection of cloud water and ice division of integers resulted with zero instead of decimal number giving the extremely big values of tendencies and consequently the corresponding pseudo fluxes

349 (370), 350 (371) ZFALS, ZFANS → ZFASL, ZFASN
- typos corrected

367 (388) - 384 (405) 1_JPRB, 2_JPRB → 1._JPRB, 2._JPRB
- in computation of evaporation of precipitation, similar mistake as in computation of tendencies for collection above

427 (449) - 432 (454) PFASL(JLON,JLEV)= <u>PFASL(JLON,JLEV-1)</u>+ZFASL *etc*
- real fluxes from the layer above added

Changes in CPTEND and CPUTQY with respect to the original cy29:

The new versions of CPTEND and CPUTQY are supposed to be able to treat the new species rain (PQR) and snow (PQS).

In CPUTQY snow (PQST1) was added and its evolution is computed with the new corresponding tendency (PTENDQS).

In CPTEND some new assumptions were made and following changes were implemented:
* NDPSFI=.FALSE. (delta_m=0)
* LPROCLD=.FALSE. (no Lopez scheme)
* LCONDWT=.TRUE. (PQL and PQI are available)
* also PQR and PQS are available
* the pseudo-fluxes between the species (',″,‴) all have a stratiform component, only condensation has a convective component
* CPFHPFS is integrated in this routine and is not called anymore

Calculation of total enthalpy flux (ZJTOT), suspended liquid and ice water, rain and snow water (QL, QI, QR and QS) and corresponding tendencies is done according to the microphysical scheme described in *Catry, B., J.-F. Geleyn, M. Tudor and A. Trojakova (2005): Flux-conservative thermodynamic equations in a mass-weighted framework.*

Changes in the namelist with respect to the operational cy29:

The new version of the namelist has the additional moisture variables included (LADVAMV=.TRUE. in NAMDYN).

Furthermore, new GFL arrays (specific humidity YQ_NL, ice water YI_NL, liquid water YL_NL, snow YS_NL and rain YR_NL) are added in NAMGFL.

3. DDH, VALIDATION

Source was obtained from Jean Marcel Piriou.
Computation was tuned in the namelist:
→ to run the model on very fine time resolution, time steps were chosen instead of hours, the model was run for 24 hours and every second one was written out
→ LINC=.F. in NAMOPH and NHISTS(0)=97, NHISTS(1)=0, NHISTS(2)=2, *etc*. NHISTS(96)=192 in NAMCT0
→ to produce and write out the DDH files, following switches were added
→ NFRDHFG=1,NDHFGTS(0)=97, NDHFGTS(1)=0, ... NDHFGTS(96)=192, similar as above (in NAMCT0)
→ for DDH itself, for global domain, for files to be written out, for enthalpy and mass budget to be computed, following switches were added in NAMDDH:
LHDGLB=.TRUE.,
LHDEFG=.TRUE.,
LHDENT=.TRUE.,
LHDHKS=.TRUE.,
Visualization is done in gnuplot.
DDH scripts and binary are placed on tuba in:

/home/jcedilnik/ddh/

Tests were made to confirm that the DDH output is not processor dependant, in other words, that there is no need to run the model on only one processor. Results are kept in following directories:

/mnt/scratch/dunja/2005111612/ddh/ref>
/mnt/scratch/dunja/2005111612/ddh_1PROC>

4. DIAGNOSTICS AND DISCUSSION

The new routine was corrected and implemented and the environment was adjusted accordingly. Tests were made for four different cases with (mainly stratiform) precipitation 16, 23 and 25 November and 01 December 2005. Model was run for 192 time steps with operational time step dt=450.0s.

List of performed tests can be found in the Appendix1.

The new scheme appears to be extremely unstable, with only one case running for 24 hours and the other three exploding in 50th, 56th (around 6 hours of integration) and 142nd time step (18 hours of integration). DDH results for temperature budget are shown on plots ***_tBilan_*.png** .While most parameters remain unchanged (proving there's no influence on e.g. radiation), there is a slight change in turbulence impact and quite a distinguished difference in the impact of precipitation in lower troposphere. Cooling in the layer between 900 and 700 hPa due to precipitation is highly reduced.

Further tests (exp2 and exp3) were performed on 16 Nov case to check the sensitivity of the scheme to the time step. In exp2 time step was set to half and in exp3 to fourth of the reference and experiment time step, 225 and 112.5s respectively. The model blew up around the same time proving the instability of the scheme. Plots **2005111612_06_ref.ps** , **2005111612_06_exp.ps, 2005111612_06_exp2.ps, 2005111612_06_exp3.ps** show that in the experiment(s) the amount of precipitation is reduced, and furthermore that there is no significant influence of the time step to the amount or spatial distribution of precipitation. Plots **Prec_cumul_2005111612.ps, Prec_mean_2005111612.ps** and **Total_Prec_mean_2005112300.ps** affirm the former conclusions (latter one also showing that the amount of convective precipitation is less than 10% of the total amount).

Tests 7-13 were performed to check the sensitivity of the scheme to the changes of the autoconversion rate. Autoconversion constants for liquid and solid precipitation were reduced in different proportions to enhance autoconversion respectively. Plots **tBilan_EXP_01.ps, tBilan_REF_01.ps, tBilan_EXP_ZTAUL_01.ps, tBilan_EXP_ZTAUL2_01.ps, tBilan_EXP_ZTAUN_01.ps, tBilan_EXP_ZTAULN_01.ps and tBilan_EXP_ZTAULN2_01.ps** show the only impact of changes in autoconversion rate can be seen in total tendency in lower layers. Changes of tau (ZTAUL and ZTAUN in the code) do not change the impact of precipitation on the enthalpy. Plots **Prec_solid_ztauln2_exp_2005112300.ps** and **Prec_mean_exp_2005112300.ps** show there is almost no impact on accumulated precipitation amount when autoconversion for liquid precipitation is enhanced 10 or 12.5 times (ztaul and ztaul4). In the experiment in which autoconversion is enhanced 20 times (ztaul3) the accumulated amount of precipitation would approach the reference model but it grows so rapidly that the model explodes. This is even more enhanced in the ztaul2 experiment. Similar conclusions can be drawn out of the plot for solid precipitation changes in respect to variations of solid precipitation autoconversion constant (ztaun, ztauln, ztauln2).

Further tests (14-17) were made to examine the changes caused by switching off collection and enlargement of the initial fall speed. Plots **tBilan_EXP_collection_01.ps, tBilan_EXP_collection2_01.ps and tBilan_EXP_coll_ztaunl_zfall_01.ps** show there is no change in impact of precipitation on temperature budget when either collection or fall speed is changed. Plots **Prec_liquid_mean_exp_2005112300.ps and Prec_solid_mean_exp_2005112300.ps** confirm those results showing that, apart from the instability of the scheme, there is no change when there is no collection (experiment collection) or when the initial fall speed is enhanced 10 (experiment coll_ztauln_zfall) or 100 times (experiment coll_ztauln_zfall2). The only change is again caused by the enhanced autoconversion (both experiments coll_ztauln_zfall and coll_ztauln_zfall2) where liquid and solid accumulated stratiform precipitation in the first steps of the integration increase rapidly causing the explosion of the model.

Taking all of the above into account, the main conclusion of this work is that the routine is unstable and further investigation needs to be performed.

5. APPENDIX1: TESTS

✓ **TEST 1**

→ experiment: case 2005111612 with time-step 450.0, integration for 192 steps
→ crashes in time step 50 with convective precipitations and fluxes (SURFPREC.EAU.CON, SURFPREC.NEI.CON, SURFFL.EAU.CON, SURFFL.NEI.CON) becoming NaN
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp31373>**
→ results saved in **/mnt/scratch/dunja/2005111612/e001/exp>**

✓ **TEST 2**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ ok, runs for 24 hours
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp22712>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp>**

✓ **TEST 3**

→ experiment: case 2005112512 with time-step 450.0, integration for 192 steps
→ crashes in time step 56 with some surface parameters (SURFNEBUL.TOTALE, SURFNEBUL.CONVEC , SURFNEBUL.BASSE, SURFCAPE.MOD.XFU, SURFTENS.TURB.ZO, SURFTENS.TURB.ME, SURFPREC.EAU.CON, SURFFL.COND.L.CO , SURFPREC.NEI.CON, SURFFL.COND.N.CO, SOMMFLU.RAY.THER, SURFFLU.RAY.THER, SURFFLU.LAT.MEVA, SURFFLU.LAT.MSUB, SURFFLU.MEVAP.EA, SURFFLU.MSUBL.NE and SURFTIME.PREC.TO) becoming NaN
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp24881>**
→ results saved in **/mnt/scratch/dunja/2005112512/e001/exp>**

✓ **TEST 4:**

→ experiment: case 2005120100 with time-step 450.0, integration for 192 steps
→ in 142nd step almost everything becomes NaN and crashes
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp22690>**
→ results saved in **/mnt/scratch/dunja/2005120100/e001/exp>**

✓ **TEST 5: exp2**

→ experiment: case 2005111612 with time-step 225.0, integration for 192 steps
→ in 100th step (which corresponds to step 50 of TEST1) many parameters become NaN and crashes
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp18782>**
→ results saved in **/mnt/scratch/dunja/2005111612/e001/exp2>**

✓ **TEST 6: exp3**

→ experiment: case 2005111612 with time-step 112.5, integration for 384 steps
→ in 193rd step (which corresponds to step 50 of TEST1 and step 100 of TEST5) wind becomes too strong and it crashes
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp1892>**
→ results saved in **/mnt/scratch/dunja/2005111612/e001/exp3>**

→ DDH analysis of temperature budget done for four cases
→ script saved in **/home/dunja/runddh>**
→ results saved in **/mnt/scratch/dunja/2005111612/ddh/ref>**
/mnt/scratch/dunja/2005111612/ddh/exp>
/mnt/scratch/dunja/2005112300/ddh/ref>
/mnt/scratch/dunja/2005112300/ddh/exp> ***etc***

→ rain and snow plotted for 2005111612 case for ref, exp, exp2 and exp3 where exp2 is the experiment with the new scheme and dt=dt/2 and exp3 experiment with the new scheme and dt=dt/4
→ data files and gnuplot scripts saved in
/mnt/scratch/dunja/2005111612/e001/ref> ***etc***
→ plots saved in **/mnt/scratch/dunja/2005111612/e001/prec_plots>**

→ mean and cumulative precipitation calculated for 2005111612 and 2005112300 case
→ script saved in **/mnt/scratch/dunja/2005111612/e001>**
/mnt/scratch/dunja/2005112300/e001>
→ plots saved in **/mnt/scratch/dunja/2005111612/e001/tmp22921>**
/mnt/scratch/dunja/2005112300/e001/tmp28074>
→ mean stratiform and convective precipitation calculated for 2005112300 case
→ script saved in **/mnt/scratch/dunja/2005112300/e001>**
→ plots saved in **/mnt/scratch/dunja/2005112300/e001/tmp8449>**

✓ **TEST 7: ztaul**
→ experiment: (the most stable) case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant reduced to 10%, autoconversion enhanced 10 times (ZTAUL=0.1)
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp21485>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaul>**

✓ **TEST 8: ztaul2**
→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant for liquid precipitation reduced to 1%, autoconversion enhanced 100 times (ZTAUL=0.01)
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp8327>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaul2>**

✓ **TEST 9: ztaul3**
→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant reduced to 5%, autoconversion enhanced 20 times(ZTAUL=0.05)
→ explosion in time step 24
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp?>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaul3>**

✓ **TEST 10: ztaun**
→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant for liquid precipitation kept the same as in exp, for solid precipitation reduced to 10%, autoconversion enhanced 10 times (ZTAUL=1.0, ZTAUN=0.1)
→ explosion in time step 36
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp1516>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaun>**

✓ **TEST 11: ztaul4**
→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant for liquid precipitation reduced to 8%, autoconversion enhanced 12.5 times (ZTAUL=0.08)
→ explosion in time step 162
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp?>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaul4>**

✓ **TEST 12: ztauln**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant for liquid and solid precipitation reduced to 10%, autoconversion enhanced 10 times (ZTAUL=0.1, ZTAUN=0.1)
→ explosion in time step 38
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp4617>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztaun>**

✓ **TEST 13: ztauln2**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ autoconversion constant for liquid and solid precipitation reduced to 50%, autoconversion enhanced 2 times (ZTAUL=0.5, ZTAUN=0.5)
→ explosion in time step 174
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp1283>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_ztauln2>**

✓ **TEST 14: collection**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ collection put to zero, with other parameters unchanged (ZTAUL=1.0, ZTAUN=0.1)
→ explosion in time step 14
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp14195>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_collection>**

✓ **TEST 15: collection2**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ collection put to zero, autoconversion constants for liquid and solid precipitation reduced to 10%, autoconversion enhanced 10 times (ZTAUL=0.1, ZTAUN=0.1)
→ explosion in time step 10
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp12321>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_collection2>**

✓ **TEST 16: coll_ztaunl_zfall**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ collection put to zero, autoconversion constant for liquid precipitation kept the same as in exp, for solid precipitation reduced to 10%, autoconversion enhanced 10 times (ZTAUL=1.0, ZTAUN=0.1), fall speed enhanced 10 times (ZFALLL=5.*RG)
→ explosion in time step 10
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp20236>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_coll_ztauln_zfall>**

✓ **TEST 17: coll_ztaunl_zfall2**

→ experiment: case 2005112300 with time-step 450.0, integration for 192 steps
→ collection put to zero, autoconversion constant for liquid precipitation kept the same as in exp, for solid precipitation reduced to 10%, autoconversion enhanced 10 times (ZTAUL=1.0, ZTAUN=0.1), fall speed enhanced 100 times (ZFALLL=50.*RG)
→ explosion in time step 6
→ namelist and NODEs saved in **/home/dunja/rundir001/tmp30527>**
→ results saved in **/mnt/scratch/dunja/2005112300/e001/exp_coll_ztauln_zfall2>**

6.APPENDIX2: List of used files

- all the assembling work was done on tuba, in home directories of Jure Cedilnik and Dunja Drvar
- new routines and source are stored in:

/home/dunja/aldpacks/cy29t2_export.03.IA32_intel90.x.pack/pack_acpluie_prog>

- new binary:
  LAM-acpluie_prog.score
- new namelist:
  /home/dunja/aladin_test/rundir001/namelist/fort.4.exp
- all the plots are kept locally, on meosars.arso.sigov.si in
  /home/dunja/RESULTS/

7. APPENDIX3: SCRIPTS

home/dunja/aladin_test/rundir927/script> 927.sh
home/dunja/aladin_test/rundir927/namelist> fort.4.ee927
home/dunja/aladin_test/rundir001/script> 001.sh and 001-exp.sh
home/dunja/aladin_test/rundir001/namelist> fort.4 and fort.4.exp
home/dunja/aladin_test/rundddh> ddh.sh and ddh-exp.sh

8. APPENDIX4: Plots attached

- **2005111612_tBilan_EXP.png, 2005111612_tBilan_REF.png, 2005112300_tBilan_REF.png, 2005112300_tBilan_EXP.png, 2005112512_tBilan_REF.png, 2005112512_tBilan_EXP.png, 2005120100_tBilan_REF.png, 2005120100_tBilan_EXP.png**:
  DDH results for Temperature budget for four different cases, experiment vs. reference
- **2005111612_06_ref.ps , 2005111612_06_exp.ps, 2005111612_06_exp2.ps, 2005111612_06_exp3.ps:** precipitation amounts for 1h integration for case 2005111612 for reference, experiment, experiment with half operational time step and experiment with fourth of the operational time step
- **Prec_cumul_2005111612.ps** and **Prec_mean_2005111612.ps:** mean and cumulative stratiform precipitation accumulated during 6 hours of integration for case 2005111612
- **Total_Prec_mean_2005112300.ps:** liquid and solid convective and stratiform precipitation accumulated during 24 hours of integration for case 2005112300
- **tBilan_EXP_01.ps, tBilan_REF_01.ps, tBilan_EXP_ZTAUL_01.ps, tBilan_EXP_ZTAUL2_01.ps, tBilan_EXP_ZTAUN_01.ps, tBilan_EXP_ZTAULN_01.ps and tBilan_EXP_ZTAULN2_01.ps:** DDH results for Temperature budget for the 2005112300 case
- **Prec_solid_ztauln2_exp_2005112300.ps and Prec_mean_exp_2005112300.ps:** liquid and solid stratiform mean precipitation accumulated durring 24 hours of integration in different autoconversion experiments for the 2005112300 cases
- **tBilan_EXP_collection_01.ps, tBilan_EXP_collection2_01.ps and tBilan_EXP_coll_ztaunl_zfall_01.ps:** DDH results for Temperature budget for experiments with no collection with 10 times bigger autoconversion and 10 times bigger initial fall speed
- **Prec_liquid_mean_exp_2005112300.ps and Prec_solid_mean_exp_2005112300.ps:** liquid and solid stratiform mean precipitation accumulated durring 24 hours of integration in different collection experiments for the 2005112300 case