3MT in ARPEGE

Description of the code and namelist changes

APLPAR

We keep the call of cloud scheme routines ACNEBCOND, ACCDEV, due to 3MT cascade and also existing logical switches (this would need to be harmonized later).

Changes in APLPAR are then mainly due to changes in the interface of ACNEBCOND, ACNEBN, ACCDEV and APLMPHYS (adding needed dummy arguments).

There is a piece of computation to obtain cloud water for radiation corresponding to convective proportion of cloudiness:

```
    DO JLEV=KTDIA,KLEV
      DO JLON=KIDIA,KFDIA
        ZNEBT=ZNEBS0(JLON,JLEV)&
       &+ZUNEBH(JLON,JLEV)-ZNEBS0(JLON,JLEV)*ZUNEBH(JLON,JLEV)

ZQLIS0(JLON,JLEV)=((ZQI(JLON,JLEV)+ZQL(JLON,JLEV))*ZUNEBH(JLON,JLEV)+&
       & ZQLIS0(JLON,JLEV)*(1._JPRB-ZUNEBH(JLON,JLEV))*ZNEBS0(JLON,JLEV))/&
       & MAX(ZEPS0,ZNEBT)
      ENDDO
    ENDDO
```

Another small change is to add cloud water of shallow convection and take into account shallow convection cloudiness for the thermodynamic adjustment at the end of ACCDEV and not in APLPAR (the equivalent computation for the input to cloudiness for radiation –in ACNEBN- is however kept in APLPAR):

```
  IF (LCVPPKF) THEN
    DO JLEV=KTDIA,KLEV
      DO JLON=KIDIA,KFDIA
        ZQLIS0(JLON,JLEV)=ZQLIS0(JLON,JLEV)+ZQC_CVPP(JLON,JLEV)
        ZNEBS0(JLON,JLEV)=MAX(ZNEBS0(JLON,JLEV),ZNEB_CVPP(JLON,JLEV))
        IF(.NOT.L3MT) THEN
          ZQLIS (JLON,JLEV)=ZQLIS (JLON,JLEV)+ZQC_CVPP(JLON,JLEV)
          ZNEBS (JLON,JLEV)=MAX(ZNEBS (JLON,JLEV),ZNEB_CVPP(JLON,JLEV))
        ENDIF
      ENDDO
    ENDDO
  ENDIF
```

ACNEBCOND

Here we essentially added a new computation block (provisionally under the key LLSMITH):

```
LLSMITH=.TRUE.
ZEPS1=1.E-12_JPRB
ZEPS2=8.E-02_JPRB
ZEPS3=1.E-10_JPRB
……..
IF(LLSMITH) THEN
!*
!     ------------------------------------------------------------------
-
!     IVd - CALCUL DE LA NEBULOSITE (FORMULE SMITH-ARPEGE).

!           CLOUDINESS DIAGNOSED BY SMITH SCHEME.

  ZFACT0=(RETAMIN*(RETAMIN-1.0_JPRB))**2
  ZFACTA=(2.0_JPRB*RETAMIN-1.0_JPRB)
  ZFACTB=(1.0_JPRB-3._JPRB*RETAMIN**2)
  ZFACTC=(3._JPRB*RETAMIN-2.0_JPRB)*RETAMIN
  ZDCRI=(RHCRIT2-RHCRIT1)/ZFACT0

  DO JLON=KIDIA,KFDIA
    ZFACT=ZDCRI*(1.0_JPRB-GRHCMOD * EXP(-1.0_JPRB/(TEQH*PGM(JLON))))
    ZA(JLON)=ZFACTA*ZFACT
    ZB(JLON)=ZFACTB*ZFACT
    ZC(JLON)=ZFACTC*ZFACT
  ENDDO

  DO JLEV=KTDIA,KLEV
    ZVETAF(JLEV) = MAX(PVETAF(JLEV),RETAMIN)
  ENDDO

  DO JLEV=1,KLEV
    DO JLON=KIDIA,KFDIA
      PHCRICS(JLON,JLEV)=RHCRIT2+ZVETAF(JLEV)*(ZC(JLON)+ZVETAF(JLEV) &
                         & *(ZB(JLON)+ZVETAF(JLEV)*ZA(JLON)))
    ENDDO
  ENDDO

  IF (RQCRNS /= 0.0_JPRB) THEN
    DO JLEV=KTDIA,KLEV
      ZSURF(JLEV) = 1.0_JPRB-EXP(-(1.0_JPRB-PVETAF(JLEV))/RQCRNS)
    ENDDO
  ELSE
    DO JLEV=KTDIA,KLEV
      ZSURF(JLEV) = 1.0_JPRB
    ENDDO
  ENDIF

  DO JLEV=KTDIA,KLEV
    DO JLON=KIDIA,KFDIA

      ZQCST=PQI(JLON,JLEV)+PQL(JLON,JLEV)
      ZRHC=PHCRICS(JLON,JLEV)
```

```
      ZLV = FOLH(PT(JLON,JLEV),0.0_JPRB)
      ZLS = FOLH(PT(JLON,JLEV),1.0_JPRB)

      ZLEFF = ZLV * (1.0_JPRB-PRMF(JLON,JLEV)) + ZLS * PRMF(JLON,JLEV)
      ZTLIQ=PT(JLON,JLEV)-
(ZLV*PQL(JLON,JLEV)+ZLS*PQI(JLON,JLEV))/PCP(JLON,JLEV)

      ZESAT = FOEW(ZTLIQ,0.0_JPRB) * (1.0_JPRB-PRMF(JLON,JLEV)) &
       &    + FOEW(ZTLIQ,1.0_JPRB) *           PRMF(JLON,JLEV)
      ZESP = ZESAT / PAPRSF(JLON,JLEV)
      ZQSAT = FOQS(ZESP)
      PQSATS(JLON,JLEV) = ZQSAT

      ZSIGS=(1.0_JPRB-ZRHC) * ZQSAT/&
       &    (ZSQRT6 * (1.0_JPRB + (ZLEFF * ZLEFF * ZQSAT * ZRDSRV)/&
       &    (PR(JLON,JLEV) * ZTLIQ * ZTLIQ * PCP(JLON,JLEV))) )

      ZRATQ = (PQ(JLON,JLEV)+ZQCST)/PQSATS(JLON,JLEV)
      ZZRHC=MIN(ZRHC,1.0_JPRB-ZEPS1)
      ZRATQ=MAX(ZZRHC,MIN(2.0_JPRB-ZZRHC,ZRATQ))
      ZRAT2=(ZRATQ-1.0_JPRB)/(1.0_JPRB-ZZRHC)

      ZTEST=MAX(0.0_JPRB,SIGN(1.0_JPRB,ZRATQ-1.0_JPRB))

      PNEBCOND(JLON,JLEV)=ZTEST*(1.0_JPRB-0.5_JPRB*(1.0_JPRB-
ZRAT2)**2)+&
        &(1.0_JPRB-ZTEST)*(0.5_JPRB*(1.0_JPRB+ZRAT2)**2)

      ZQC(JLON,JLEV)=(ZTEST*(6.0_JPRB*ZRAT2+(1.0_JPRB-ZRAT2)**3)+&
        &(1.0_JPRB-ZTEST)*(1.0_JPRB+ZRAT2)**3)/ZSQRT6

      ZQC(JLON,JLEV)=ZQC(JLON,JLEV)*ZSIGS

! Where there is condensate impose a minimum of cloudiness.

      PNEBCOND(JLON,JLEV)=MAX(PNEBCOND(JLON,JLEV),ZEPS2*&
        &MAX(0.0_JPRB,SIGN(1.0_JPRB,ZQCST-ZEPS3)))

! Cloud cover reduction to avoid excessive values.


      PNEBCOND(JLON,JLEV) = PNEBCOND(JLON,JLEV)/(1.0_JPRB+&
        &(PAPHI(JLON,JLEV-1)-PAPHI(JLON,JLEV))/RDPHIC)



      PQCS0(JLON,JLEV)=ZQC(JLON,JLEV)
      PNEBS0(JLON,JLEV)=MIN(1.0_JPRB-
ZEPS1,MAX(PNEBCOND(JLON,JLEV),ZEPS1))

      PRHOUT(JLON,JLEV)=PQ(JLON,JLEV)/PQSATS(JLON,JLEV)


    ENDDO
  ENDDO


ENDIF ! LLSMITH
```

ACCDEV

Here as well the “Smith-Arpege” block was added under key LLSMITH:

```
LLSMITH=.TRUE.

…..

IF(LLSMITH) THEN

!     ------------------------------------------------------------------
-
!     IIId - SCHEMA SMITH-ARPEGE.

!            SMITH SCHEME.

  IF (RQCRNS /= 0.0_JPRB) THEN
    DO JLEV=KTDIA,KLEV
      ZSURF(JLEV) = 1.0_JPRB-EXP(-(1.0_JPRB-PVETAF(JLEV))/RQCRNS)
    ENDDO
  ELSE
    DO JLEV=KTDIA,KLEV
      ZSURF(JLEV) = 1.0_JPRB
    ENDDO
  ENDIF

  DO JLEV=KTDIA,KLEV
    DO JLON=KIDIA,KFDIA

      ZQCST=PQI(JLON,JLEV)+PQL(JLON,JLEV)
      ZRHC=PHCRICS(JLON,JLEV)

      ZLEFF = ZLHV(JLON,JLEV)*(1.0_JPRB-PRMF(JLON,JLEV))+&
       & ZLHS(JLON,JLEV)*PRMF(JLON,JLEV)
      ZTLIQ=PT(JLON,JLEV)-(ZLHV(JLON,JLEV)*PQL(JLON,JLEV)+&
       & ZLHS(JLON,JLEV)*PQI(JLON,JLEV))/PCP(JLON,JLEV)

      ZQSAT=PQSATS(JLON,JLEV)

      ZSIGS=(1.0_JPRB-ZRHC) *ZQSAT/&
       &    (ZSQRT6 * (1.0_JPRB + (ZLEFF * ZLEFF * ZQSAT * ZRDSRV)/&
       &    (PR(JLON,JLEV) * ZTLIQ * ZTLIQ * PCP(JLON,JLEV))) )

      ZRATQ = (PQ(JLON,JLEV)+ZQCST)/ZQSAT
      ZZRHC=MIN(ZRHC,1.0_JPRB-ZEPS1)
      ZRATQ=MAX(ZZRHC,MIN(2.0_JPRB-ZZRHC,ZRATQ))
      ZRAT2=(ZRATQ-1.0_JPRB)/(1.0_JPRB-ZZRHC)

      ZTEST=MAX(0.0_JPRB,SIGN(1.0_JPRB,ZRATQ-1.0_JPRB))

      ZQC=(ZTEST*(6.0_JPRB*ZRAT2+(1.0_JPRB-ZRAT2)**3)+&
        &(1.0_JPRB-ZTEST)*(1.0_JPRB+ZRAT2)**3)/ZSQRT6

      ZQC=ZSURF(JLEV) *ZQC*ZSIGS
```

```
! protection of convective condensate, using changed distribution

      ZNEBT=PNEBCOND(JLON,JLEV)&
       &+PNCV(JLON,JLEV)-PNEBCOND(JLON,JLEV)*PNCV(JLON,JLEV)
      ZZ=MAX(0.0_JPRB,SIGN(1.0_JPRB, ZNEBT-ZEPS1))
      ZFRACON=ZZ*PNCV(JLON,JLEV)/(ZNEBT+(1.0_JPRB-ZZ))

      ZQC=(ZQC**2+(ZQCST*ZFRACON)**2)/MAX(ZEPS1,(ZQC+ZQCST*ZFRACON))

! contribution of shallow convection

      IF (LCVPPKF) THEN
        ZQC=ZQC+PQC_CVPP(JLON,JLEV)

PNEBCOND(JLON,JLEV)=MAX(PNEBCOND(JLON,JLEV),PNEB_CVPP(JLON,JLEV))
      ENDIF

! repartition by FONICE

      ZQL=(1.0_JPRB-PRMF(JLON,JLEV))*ZQC
      ZQI=ZQC-ZQL

!-----------------------------------------------------
! COMPUTE LARGE-SCALE CONDENSATION/EVAPORATION FLUX.
!-----------------------------------------------------

      ZDQL=ZQL - PQL(JLON,JLEV)
      ZDQI=ZQI - PQI(JLON,JLEV)

! Stratiform fluxes:

      ZFCSQL(JLON,JLEV) = ZFCSQL(JLON,JLEV-1)+ ZPOID(JLON,JLEV)*ZDQL
      ZFCSQN(JLON,JLEV) = ZFCSQN(JLON,JLEV-1)+ ZPOID(JLON,JLEV)*ZDQI

! Update in case we call microphysics (LSTRAPRO):

      ZQLTMP(JLON,JLEV)=MAX(0.0_JPRB,PQL(JLON,JLEV)+ZDQL)
      ZQITMP(JLON,JLEV)=MAX(0.0_JPRB,PQI(JLON,JLEV)+ZDQI)
      ZQTMP(JLON,JLEV)=MAX(0.0_JPRB,PQ(JLON,JLEV)-ZDQL-ZDQI)
      ZDQ(JLON,JLEV)=MAX(0.0_JPRB,PQW(JLON,JLEV)-ZQTMP(JLON,JLEV))

    ENDDO
  ENDDO

ENDIF ! LLSMITH
```

There is also here the change of interface due to PDIFTQL, PDIFTQI fluxes entering APLMPHYS (called in case of LSTRAPRO=.T., an option without use for 3MT in ARPEGE).

ACNEBN

Here everything relies on prognostic values. We should still perhaps comsider the influence of the LRNUMX key as in ARPEGE. For the time being, the 3MT logic of cloud cover combination was transversally privileged, hence here as well.

```
LLSMITH=.TRUE.

….

IF (LLSMITH) THEN
  DO JLEV=KTDIA,KLEV
    DO JLON=KIDIA,KFDIA
      PNEBC(JLON,JLEV)=MAX(ZEPSNEB,MIN(1.0_JPRB-ZEPSNEB,&
       & PUNEBH(JLON,JLEV)))
      ZNEBS=PNEBS(JLON,JLEV)
      PNEB(JLON,JLEV)=ZNEBS+(1.0_JPRB-ZNEBS)*PNEBC(JLON,JLEV)
      PNEB(JLON,JLEV)=MAX(ZEPSNEB,MIN(1.0_JPRB-
ZEPSNEB,PNEB(JLON,JLEV)))
      ZPLS=FONICE(PT(JLON,JLEV))
      PQLI(JLON,JLEV)=PQLIS(JLON,JLEV)*(1.0_JPRB-ZPLS)
      PQICE(JLON,JLEV)=PQLIS(JLON,JLEV)*ZPLS
    ENDDO
  ENDDO
ENDIF
```

APLMPHYS

Switches for the ARPEGE version were activated.

```
289,292c289,292
< LLSTASED=.FALSE.
< LLLAGSED=.TRUE.
< LLFSVAR=.FALSE.
< LLFSFIX=.TRUE.
---
> LLSTASED=.TRUE.
> LLLAGSED=.FALSE.
> LLFSVAR=.TRUE.
> LLFSFIX=.FALSE.
294c294
< LLPSGRP=.FALSE.
---
> LLPSGRP=.TRUE.
```

We also added sedimentation of cloud liquid and solid water, with the following speeds:

```
ZFVL=0.02_JPRB
ZFVI=0.08_JPRB
```

ACACON

Switches for the ARPEGE version were activated.

```
157,158c157,158
< LLA0MPS=.FALSE.
< LLARPSC=.TRUE.
---
> LLA0MPS=.TRUE.
> LLARPSC=.FALSE.
```

ACCOLL

Switches for the ARPEGE version were activated.

```
153,154c153,154
< LLA0MPS=.FALSE.
< LLARPSC=.TRUE.
---
> LLA0MPS=.TRUE.
> LLARPSC=.FALSE.
```

ACEVMEL

Switches for the ARPEGE version were activated.

```
177,178c177,178
< LLA0MPS=.FALSE.
< LLARPSC=.TRUE.
---
> LLA0MPS=.TRUE.
> LLARPSC=.FALSE.
```

And freezing was introduced in symmetry with melting:

```
PFONT(JLON)=ZDELT/PLSCP(JLON)
```

NAMELIST

	ARPEGE	ALARO	3MT-ARPEGE
NAERAD/LRRTM	.TRUE.	.FALSE.	.TRUE.
LSRTM	.F.	Default	.F.
NRADFR	-3	Default	-1
NSW	6	Default	6
RLWINHF	0.9	default	0.9

NAMCVMNH		unused	
OTADJS	10800.		10800.
XCDEPTH	1.		1.
XCDEPTH_D	4000.		4000.
XDTPERT	0.3		0.3
XENTR	0.013		0.013
NAMDYN			
RDAMPT	5.	1.	5.
RDAMPVOR	5.	1.	5.
RDAMPDIVS	default	10.	default
RDAMPVORS	default	10.	default
RDAMPQ	5.	0.	5.
REXPDH	4.	2.	4.
SLEVDH	1.	0.1	1.
SLEVDHS	default	1.	default
ZSLHDP1	default	1.7	default
SLHDA0	default	0.25	default
SLHDB	default	4.	default
SLHDD00	default	6.5E-05	default
ZSLHDP3	default	0.6	default
SDRED	default	1.	default
NITMP	3	2	3
LQMHW	.TRUE.	.FALSE.	.TRUE.
LQMHT	.TRUE.	.FALSE.	.TRUE.
LQMP	.TRUE.	.FALSE.	.TRUE.
SITR	350.	300.	350.

	ARPEGE	ALARO	3MT-ARPEGE
NAMDYNA	default	SLHD setup	default
NAMGFL			
SLHD (Q, TKE, QL, QI)	.FALSE.	.TRUE.	.FALSE.
LQM (Q, TKE, QL, QI, QR, QS)	.TRUE.	.FALSE.	.TRUE.
UDOM,UDAL, DDOM, DDAL, UNEBH	none	Set with LQM=.FALSE.	Set with LQM=.TRUE.
NAMPHY			
L3MT (3mt)	.FALSE.	.TRUE.	.TRUE.
LCVRA	.TRUE.	.FALSE.	.FALSE.
LCVPRO (3mt)	.FALSE. (default)	.TRUE.	.TRUE.
LCDDPRO (3mt)	.FALSE. (default)	.TRUE.	.TRUE.
LNEBCV (3mt)	.FALSE. (default)	.TRUE.	.TRUE.
NIMELIT (3mt)	default	2	2
LSCMF (3mt)	default	.TRUE.	.TRUE.
LDIFCONS	.TRUE.	.TRUE.	.TRUE.
LCONDWT	.TRUE.	.TRUE.	.TRUE.
LXRCDEV (cloud)	.FALSE.	.TRUE.	.FALSE.

LPROCLD (cloud et micro)	.TRUE.	.FALSE.	.FALSE. (LLSMITH)
LSSD (sed neb)	.TRUE.	unused	(unused, ensured in APLMPHYS)
LRAY	.FALSE.	.TRUE.	.FALSE.
LRAYLU	.TRUE.	.FALSE.	.TRUE.
LRAYFM	.TRUE.	.FALSE.	.TRUE.
LPHSPSH (3mt)	.FALSE. (default)	.TRUE.	.TRUE.
LFLUSO	.TRUE.	.FALSE.	.TRUE.
LNEWD	.TRUE.	.TRUE.	.TRUE.
LGLT	.FALSE. (default)	.TRUE.	.FALSE. (default)
LRRGUST	.FALSE. (default)	.TRUE.	.FALSE. (default)
LVGSN	.TRUE.	.TRUE.	.TRUE.
LAERO* (all four)	.TRUE.	.TRUE.	.TRUE.
LO3ABC	.TRUE.	.TRUE.	.TRUE.
LCVPPKF	.TRUE.	default (lptke)	.TRUE.
LECDEEP	.TRUE.	default	.TRUE.
LECSHAL	.TRUE.	default	.TRUE.
LECT	.TRUE.	default	.TRUE.
LNEBECT	.FALSE.	default	.FALSE.
LNSMLIS	.FALSE.	default	.FALSE.
LO3FL	.TRUE.	default	.TRUE.
LECTFL	.TRUE.	default	.TRUE.
LZ0HSREL	.TRUE.	default	.TRUE.
LACPANMX	.FALSE.	.TRUE.	.FALSE.

	ARPEGE	ALARO	3MT-ARPEGE
NAMPHY0			
RAUTEFR	1.E-03	2.E-03	2.E-03
RAUTEFS	1.E-03	2.E-03	2.E-03
RQLCR	2.E-04	3.E-04	3.E-04
RQICRMIN	2.E-07	8.E-07	8.E-07
RQICRMAX	5.E-04	5.E-05	5.E-05
RFACNSM	1.2	unused	1.
RDPHIC	Unused	1.E+04 (Luc-Smith)	1.E+05
‘ZEPS2’	Unused	1.E-02 (Luc-Smith)	8.E-02
RCIN	0.	1.	1.
GCOMOD	1.	0.	0.
TENTR	2.5E-06	5.E-06	5.E-06
TENTRX	0.8E-04	1.6E-04	1.6E-04
TUDGP	0.6	0.8	0.8
TDDGP	0.6	0.8	0.8
GCVHMIN	0.3E+05	unused	unused
GCVALFA	4.5E-05	5.E-05	4.5E-05
GCVNU	5.E-05	1.E-05	1.E-05
GWDLT	0. (default)	1.	0. (default)

RDTFAC (FONICE)	0.5	1.	0.5
GCISMIN	0.67E-04	0.55E-03	0.67E-04 (default)