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c
cc D. Posselt 10/01/2008
cc Modified this to be called as a column model from an external driver
cc Stripped out unneccessary common blocks and statistics
c
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc

      subroutine saticerh (dt,dpt,dqv,qcl,qrn,qci,qcs,qcg,ww1,
     1                     rho,rrho,ta1,qa1,pi,p0,fv,improve)
      include 'dimensions.h'
c     (r&h)  compute ice phase microphysics and saturation processes
c     parameter (nx=66,ny=10,nz=34,nm=nx,nt=2880)

c D.Posselt input variable declarations
      real dt, d2t, d22t
      real dpt(nx,ny,nz), dqv(nx,ny,nz)
      real qcl(nx,ny,nz), qrn(nx,ny,nz)
      real qci(nx,ny,nz), qcs(nx,ny,nz), qcg(nx,ny,nz)
      real rho(nz), rrho(nz)
      real ta1(nz), qa1(nz)
      real p0(nz), pi(nz), fv(nz)
      real ww1(nx,ny,nz)

c D.Posselt variable declarations
      integer kles
      integer ijkadv, id
      integer new_ice_sat
      real    rijl2

      parameter (nm=nx,nz2=2*nz,nz3=3*nz,nz4=4*nz,nm2=2*nm)
!     parameter (nxy=nx*ny,nb=nx*ny*(nz-29),nb2=nx*ny*(nz-25),nt2=2*nt)
      parameter (nxy=nx*ny,nb=nx*ny*(nz-29),nb2=nx*ny*(nz-25))
      parameter (nb3=nz+nx,nb5=nx*ny*(nz-29))
!       parameter (nb3=nz+nx,nb4=5*nt,nb5=nx*ny*(nz-29))
!       common/mpi_parameter/imax,iles1,iles,il2,jmax,jles1,jles,jl2,
!      1    kmax,kles,kl2
!       common/bxyz/ n,isec,nran,kt1,kt2
!       common/option/ lipps,ijkadv,istatmin,iwater,itoga,imlifting,lin,
!      1   irf,iadvh,irfg,ismg,id
!       common/timestat/ ndt_stat,idq
!       common/iice/ new_ice_sat
      common/icemass/ ami50,ami40
!       common/bt/ dt,d2t,rijl2,dts,f5,rd1,rd2,bound,al,cp,ra,ck,ce,eps,
!      1    psfc,fcor,sec,aminut,rdt
      common/cont/ c38,c358,c610,c149,c879,c172,c409,c76,c218,c580,c141
      common/b3cs/ ag,bg,as,bs,aw,bw,bgh,bgq,bsh,bsq,bwh,bwq
      common/size/ tnw,tns,tng,roqs,roqg,roqr
      common/rterv/ zrc,zgc,zsc,vr0,vr1,vr2,vr3,vgc,vsc
      common/rsnw/ alv,alf,als,t0,t00,avc,afc,asc,rn1,rn2,bnd2,rn3,rn4,
     1  rn5,rn50,rn51,rn52,rn53,rn6,rn60,rn61,rn62,rn63,rn7,rn8,rn9,
     2  rn10,rn101,rn102,rn10a,rn10b,rn10c,rn11,rn12,rn12a(31),
     3  rn12b(31),rn13(31),rn14,rn15,rn15a,rn16,rn171,rn172,rn17a,rn17b,
     4  rn17c,rn18,rn18a,rn19,rn191,rn192,rn19a,rn20,rn20a,rn20b,rn30,
     5  rn30a,rn21,bnd21,rn22,rn23,rn231,rn232,rn25,rn25a(31),rn31,beta,
     6  rn32,rn33,rn331,rn332,rn34,rn35

      common /BergCon/BergCon1(31),BergCon2(31)
     1               ,BergCon3(31),BergCon4(31)

c
!       common/b1tq/ dpt(nx,ny,nz),dqv(nx,ny,nz)
!       common/b1cr/ qcl(nx,ny,nz),qrn(nx,ny,nz)
!       common/b1ig/ qci(nx,ny,nz),qcg(nx,ny,nz)
!       common/b2tq/ dpt1(nx,ny,nz),dqv1(nx,ny,nz)
!       common/b2cr/ qcl1(nx,ny,nz),qrn1(nx,ny,nz)
!       common/b2ig/ qci1(nx,ny,nz),qcg1(nx,ny,nz)
!       common/b1s/ qcs(nx,ny,nz)
!       common/b2s/ qcs1(nx,ny,nz)
!       common/b4wp/ ww1(nx,ny,nz)
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```
!       common/slwave/ rsw(nx,ny,nz),rlw(nx,ny,nz)
c
c      common/bw/ trahx(nx,ny,nz),trahy(nx,ny,nz),trav(nx,ny,nz)
c
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
      common/bsat1/ pt(nx,ny),qv(nx,ny),qc(nx,ny),qr(nx,ny),qi(nx,ny),
     1 qs(nx,ny),qg(nx,ny),tair(nx,ny),tairc(nx,ny),rtair(nx,ny),
     2 dep(nx,ny),dd(nx,ny),dd1(nx,ny),qvs(nx,ny),dm(nx,ny),
     3 rq(nx,ny),rsub1(nx,ny),col(nx,ny),cnd(nx,ny),ern(nx,ny),
     4 dlt1(nx,ny),dlt2(nx,ny),dlt3(nx,ny),dlt4(nx,ny),zr(nx,ny),
     5 vr(nx,ny),zs(nx,ny),vs(nx,ny),dbz(nx,ny),dda(nb)
      common/badv/ vg(nx,ny),zg(nx,ny),ps(nx,ny),pg(nx,ny),prn(nx,ny),
     1 psn(nx,ny),pwacs(nx,ny),wgacr(nx,ny),pidep(nx,ny),pint(nx,ny),
     2 qsi(nx,ny),ssi(nx,ny),esi(nx,ny),esw(nx,ny),qsw(nx,ny),
     3 pr(nx,ny),ssw(nx,ny),pihom(nx,ny),pidw(nx,ny),pimlt(nx,ny),
     4 psaut(nx,ny),qracs(nx,ny),psaci(nx,ny),psacw(nx,ny),
     5 qsacw(nx,ny),praci(nx,ny),pmlts(nx,ny),pmltg(nx,ny),
     6 asss(nx,ny),dde(nb5)
      common/bsat/ praut(nx,ny),pracw(nx,ny),psfw(nx,ny),psfi(nx,ny),
     1 dgacs(nx,ny),dgacw(nx,ny),dgaci(nx,ny),dgacr(nx,ny),
     2 pgacs(nx,ny),wgacs(nx,ny),qgacw(nx,ny),wgaci(nx,ny),
     3 qgacr(nx,ny),pgwet(nx,ny),pgaut(nx,ny),pracs(nx,ny),
     4 psacr(nx,ny),qsacr(nx,ny),pgfr(nx,ny),psmlt(nx,ny),
     5 pgmlt(nx,ny),psdep(nx,ny),pgdep(nx,ny),piacr(nx,ny),y5(nx,ny),
     6 ddb(nb2)
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
!       common/b5/ tb(nz),qb(nz),rho1(nz),rho(nz),ta(nz),qa(nz),ta1(nz),
!      1  qa1(nz),zx(nz4),am(nz),zq(nz3),wb(nz),zw(nz2),rrho(nz),wbx(nb3)
!       common/b6/ fd(nz),fe(nz),p0(nz),pi(nz),f0(nz),st(nz),sv(nz),
!      1   sq(nz),sc(nz),se(nz),sqa(nz)
      common/b66b/ s_dep(nz),s_sub(nz),s_qrs(nz),s_qrl(nz),s_mel(nz),
     1   s_frz(nz)
      common/brh1/ srro(nz),qrro(nz),sqc(nz),sqr(nz),sqi(nz),sqs(nz),
     1   sqg(nz),stqc(nz),stqr(nz),stqi(nz),stqs(nz),stqg(nz)
!      1   sqg(nz),stqc(nz),stqr(nz),stqi(nz),stqs(nz),stqg(nz),tttd(nb4)
      common/bsts/ thom(nz,4,7),tdw(nz,4,7),tmlt(nz,4,7),saut(nz,4,7),
     1 saci(nz,4,7),sacw(nz,4,7),raci(nz,4,7),tacr(nz,4,7),raut(nz,4,7),
     2 racw(nz,4,7),sfw(nz,4,7),sfi(nz,4,7),gacs(nz,4,7),gacw(nz,4,7),
     3 gaci(nz,4,7),gacr(nz,4,7),gwet(nz,4,7),gaut(nz,4,7),racs(nz,4,7),
     4 sacr(nz,4,7),gfr(nz,4,7),smlt(nz,4,7),gmlt(nz,4,7),sdep(nz,4,7),
     5 ssub(nz,4,7),gsub(nz,4,7),pern(nz,4,7),d3ri(nz,4,7),d3ir(nz,4,7),
     6 d2sr(nz,4,7),d2rs(nz,4,7),gdry(nz,4,7),coc(nz,4,7),coe(nz,4,7),
     7 smf0(nz,4,7),qc0(nz,4,7),qr0(nz,4,7),qi0(nz,4,7),qs0(nz,4,7),
     8 qg0(nz,4,7),sqc0(nz,4,7),sqr0(nz,4,7),sqi0(nz,4,7),sqs0(nz,4,7),
     9 sqg0(nz,4,7),erns(nz,4,7),wgrs(nz,4,7),qsws(nz,4,7),tb00(nz,4),
     1 qb00(nz,4)
      common/bsts1/ tut1(nz,4,7),tut2(nz,4,7),tvt1(nz,4,7),tvt2(nz,4,7),
     1 tstf(nz,4,7),tstf1(nz,4,7),tstf2(nz,4,7),tsqf(nz,4,7),
     2 qqq(nz,4,7),tsqf1(nz,4,7),tsqf2(nz,4,7),tsqq(nz,4,7),
     3 tsqq1(nz,4,7)
      common/bsts3/ qv0(nz,4,7),tt0(nz,4,7),sqv0(nz,4,7),stt0(nz,4,7),
     1 sgpt(nz,4,7),ssgpt(nz,4,7),snqhd(nz,4,7),snqvd(nz,4,7),
     2 q1t(nz,4,7),snhdh(nz,4,7),sqhdt(nz,4,7),sqvdt(nz,4,7)
      common/bsts4/ srsw(nz,4,7),srlw(nz,4,7),sqtdt(nz,4,7),sqhl(nz,4,7)
      common/bsts7/ pim(nz,4,7),cfr(nz,4,7)

      common/bsts40/ fcld(nz,4,7)

      common/bcs/cf1(61,nz),cf2(61,nz),cf3(61,nz),cf4(61,nz),cf5(61,nz),
     1   cf6(61,nz),cf7(61,nz),cf8(61,nz),cf9(61,nz),cf10(61,nz),
     2   cf11(61,nz),cf12(61,nz),cfnum(61,nz),cfs1(61,nz),cfs2(61,nz),
     3   cfs3(61,nz),cfs4(61,nz),cfs5(61,nz),cfs6(61,nz),cfs7(61,nz),
     4   cfs8(61,nz),cfs9(61,nz),cfs10(61,nz),cfs11(61,nz),cfs12(61,nz),
     5   cfsnum(61,nz),cfz(41,nz),cfw(61,nz),scu1(nz),sed1(nz)

!       common/bsts5/ aco5,aco15,aan5,aan15,anv(nt2),cnv(nt2),spn(nt2)
      common/bsts6/ lconv5,lanvl5,lnspt5,ivv(nx,ny),ics5(nx,ny,4),
     1  ibz(nx,ny,4)
      common/bi/ it(nx,ny),ics(nx,ny,4)
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      common/rstat/ csttt(nx,ny),cstt(nx,ny)
      common/bls/ y0(nx,ny),ts0new(nx,ny),qss0new(nx,ny)
      common /micro/physc(nx,ny,nz),physe(nx,ny,nz),physd(nx,ny,nz),
     1              physs(nx,ny,nz),physm(nx,ny,nz),physf(nx,ny,nz)

      dimension y1(nx,ny),y2(nx,ny),y3(nx,ny),y4(nx,ny),
     1               b1(nz),b2(nz)
c     1  y7(nm),b0(nm),b1(nm),b2(nm),y6(nm)
c hmhj modified above

      dimension dda0(nx,ny), ddb0(nx,ny) ! cccshie 7/1/02

c     q budget for each point

c_tao
c     common/q_bugt/ q1_g_h(nx,ny,nz),q1_g_v(nx,ny,nz),
c    1               q1a_g_h(nx,ny,nz),q1a_g_v(nx,ny,nz),
c    2               q1_d_h(nx,ny,nz),q1_d_v(nx,ny,nz),
c    3               q1a_d_h(nx,ny,nz),q1a_d_v(nx,ny,nz),
c    4               q2_g_h(nx,ny,nz),q2_g_v(nx,ny,nz),
c    5               q2a_g_h(nx,ny,nz),q2a_g_v(nx,ny,nz),
c    6               q2_d_h(nx,ny,nz),q2_d_v(nx,ny,nz),
c    7               q2a_d_h(nx,ny,nz),q2a_d_v(nx,ny,nz),
c    8               q1_hyd(nxy,nz),q2_hyd(nxy,nz),
c    9               q1a_hyd(nxy,nz),q2a_hyd(nxy,nz),
c    9               q1_rad(nx,ny,nz),q1a_rad(nx,ny,nz),
c    9               ibudsec,rbud

c_tao


      integer itaobraun
      real tairccri, cn0

ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
!       dimension fv(1),rby(7),aa1(31),aa2(31)
      dimension rby(7),aa1(31),aa2(31)
      DIMENSION tairN(nx,ny),tairI(nx,ny),tns_funT(nx,ny)
      DIMENSION pihms(nx,ny),pihmg(nx,ny),pssub(nx,ny),pgsub(nx,ny)
      DIMENSION pimm(nx,ny),pcfr(nx,ny)
c     real tttbud(nxy),qqqbud(nxy)
      data aa1/.7939e-7,.7841e-6,.3369e-5,.4336e-5,.5285e-5,.3728e-5,
     1   .1852e-5,.2991e-6,.4248e-6,.7434e-6,.1812e-5,.4394e-5,.9145e-5,
     2   .1725e-4,.3348e-4,.1725e-4,.9175e-5,.4412e-5,.2252e-5,.9115e-6,
     3   .4876e-6,.3473e-6,.4758e-6,.6306e-6,.8573e-6,.7868e-6,.7192e-6,
     4   .6513e-6,.5956e-6,.5333e-6,.4834e-6/
      data aa2/.4006,.4831,.5320,.5307,.5319,.5249,.4888,.3894,.4047,
     1   .4318,.4771,.5183,.5463,.5651,.5813,.5655,.5478,.5203,.4906,
     2   .4447,.4126,.3960,.4149,.4320,.4506,.4483,.4460,.4433,.4413,
     3   .4382,.4361/
      data rby/2.,1.,0.,0.,0.,-.5,-1./
      real, allocatable :: tmpd(:,:,:),sumd(:)
      save

      allocate(tmpd(nx,ny,55))
      allocate(sumd(55))

c D.Posselt: Set values of parameters for column model
      kles = nz-1
      ndt_stat = dt
      id = 1
      ijkadv = 1
      d22t = dt + dt
      rijl2 = 1.
      do k=1,nz
!         fv(k)   = sqrt(rho(2) * rrho(k))
        srro(k) = 1. / sqrt(rho(k))
        qrro(k) = sqrt ( srro(k) )
      enddo
```



```
c. D. Posselt: Check input data
!       print '(a)','Input to saticerh'
!       print '(a)','dpt, ta, dqv, qa, qcl, qrn, qci, qcs, qcg'
!       do k=1,nz
!         print '(i5,9(2x,e10.5))',
!      1        k,dpt(1,1,k),ta1(k),dqv(1,1,k),qa1(k),
!      2        qcl(1,1,k),qrn(1,1,k),qci(1,1,k),qcs(1,1,k),qcg(1,1,k)
!       enddo

cc    ***   three classes of ice-phase   ******************************


!       d22t=d2t

      if(ijkadv .eq. 1) then
            d2t=dt
      else
            d2t=d2t
      endif
ctao
          rd2t=1./d2t

!       print*,'dt, d2t, rd2t', dt,d2t,rd2t
ctao
c
c      ijles=nx*(ny-1)-1
c      istart=nx+2
c
c      ijles=max(nx*(ny-1), ny*(nx-1))-1
c      istart=min(nx, ny)+2
c
ctao
      do k=1,nz
      do j=1,1
      do i=1,1
        physc(i,j,k)=0.
        physe(i,j,k)=0.
        physd(i,j,k)=0.
        physs(i,j,k)=0.
        physm(i,j,k)=0.
        physf(i,j,k)=0.
      enddo
      enddo
      enddo
ctao


      cmin=1.e-40
      cmin1=1.e-20
      cmin2=1.e-40
c      cmax2=1.e20
      ucor=3071.29/tnw**.75
      ucos=687.97*roqs**.25/tns**.75
      ucog=687.97*roqg**.25/tng**.75
      uwet=4.464**.95

!       print*,'tnw,tns,tng,roqs,roqg,ucor,ucos,ucog,uwet: ',
!      1        tnw,tns,tng,roqs,roqg,ucor,ucos,ucog,uwet

C  HALLET-MOSSOP RIME SPLINTERING parameters
      if(improve.ge.3) ihalmos=1
      xnsplnt=350.      ! peak # splinters per milligram of rime
      xmsplnt=4.4e-8    ! mass of a splinter (from Ferrier 1994)
      hmtemp1=-2.
      hmtemp2=-4.
      hmtemp3=-6.
      hmtemp4=-8.


      ft=dt/d2t
```

```
      rft=rijl2*ft
!       a0=.5*istatmin*rijl2
ctao
!         a200=ndt_stat*rijl2
ctao
c$doacross local(i,j)
      do j=1,1
c hmhj modified
c     do i=1,ny
      do i=1,1
           it(i,j)=1
ctao
!          asss(i,j)=csttt(i,j)*a200
ctao
      enddo
      enddo

      rt0=1./(t0-t00)
      bs3=bs+3.
      bg3=bg+3.
      bsh5=2.5+bsh
      bgh5=2.5+bgh
      bs6=6.+bs
      betah=.5*beta
      rdt=1./d2t
      r10t=rn10*d2t
      r11t=rn11*d2t
      r19t=rn19*d2t
      r19at=rn19a*d2t
      r20t=rn20*d2t
      r23t=rn23*d2t
          r25a=rn25
      r30t=rn30*d2t
      r33t=rn33*d2t

!       print*,'rt0,bs3,bg3,bsh5,bgh5,bs6,betah,rdt ',
!      1        rt0,bs3,bg3,bsh5,bgh5,bs6,betah,rdt
!       print*,'r10t,r11t,r19t,r19at,r20t,r23t,r25a,r30t,r33t ',
!      1        r10t,r11t,r19t,r19at,r20t,r23t,r25a,r30t,r33t
!       print*
!       print*
cccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
ccc    rh-type ice scheme

      do 1000 k=2,kles
c          if (ijkadv .eq. 1) then
c            tb0=ta(k)
c            qb0=qa(k)
c          else
          tb0=ta1(k)
          qb0=qa1(k)
c          endif
c          p00=p0(k)
          rp0=3.799052e3/p0(k)
          pi0=pi(k)
          pir=1./(pi(k))
crh        pr0=1./p0(k)
          r00=rho(k)
c          r0s=sqrt(rho(k))
          rr0=rrho(k)
          rrs=srro(k)
          rrq=qrro(k)
          fv0=fv(k)
          fvs=sqrt(fv(k))
          cp409=c409*pi0
          cv409=c409*avc
          cp580=c580*pi0
          cs580=c580*asc
crh        alvr=r00*alv
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```
          afcp=afc*pir
          avcp=avc*pir
          ascp=asc*pir
          zrr=1.e5*zrc*rrq
          zsr=1.e5*zsc*rrq
          zgr=1.e5*zgc*rrq
          vscf=vsc*fv0
          vgcf=vgc*fv0
cs         vgcf=vgc*rrs
c         r1r=rn1*rr0
          r3f=rn3*fv0
          r4f=rn4*fv0
          r5f=rn5*fv0
          r6f=rn6*fv0
          r7rf=rn7*rr0*fv0
          r8rf=rn8*rr0*fv0
          r9rf=rn9*rr0*fv0
          r101r=rn101*rr0
          r102rf=rn102*rrs*fvs
          r12r=rn12*r00
          r14f=rn14*fv0
          r15f=rn15*fv0
          r16rf=rn16*rr0*fv0
          r18r=rn18*rr0
          r191r=rn191*rr0
          r192rf=rn192*rrs*fvs
          r22f=rn22*fv0
          r231r=rn231*rr0
          r232rf=rn232*rrs*fvs
          r25rt=rn25*rr0*d2t
          r31r=rn31*rr0
          r32rt=rn32*d2t*rrs
          r331r=rn331*rr0
          r332rf=rn332*rrs*fvs
          r34f=rn34*fv0
          scc=0.
          see=0.

c$doacross local(j,i)
          do 150 j=1,1
c hmhj
c       do i=1,1
        do i=1,1

c             tttbud(i,j)=dpt(i,j,k)
c             qqqbud(i,j)=dqv(i,j,k)

             pt(i,j)=dpt(i,j,k)
             qv(i,j)=dqv(i,j,k)
             qc(i,j)=qcl(i,j,k)
             qr(i,j)=qrn(i,j,k)
             qi(i,j)=qci(i,j,k)
             qs(i,j)=qcs(i,j,k)
             qg(i,j)=qcg(i,j,k)
c             if (qv(i,j)+qb0 .le. 0.) qv(i,j)=-qb0
             if (qc(i,j) .le. cmin) qc(i,j)=0.0
             if (qr(i,j) .le. cmin) qr(i,j)=0.0
             if (qi(i,j) .le. cmin) qi(i,j)=0.0
             if (qs(i,j) .le. cmin) qs(i,j)=0.0
             if (qg(i,j) .le. cmin) qg(i,j)=0.0
c             xx0(i,j)=pt(i,j)
c             xx00(i,j)=qv(i,j)
             tair(i,j)=(pt(i,j)+tb0)*pi0
             tairc(i,j)=tair(i,j)-t0
             zr(i,j)=zrr
             vr(i,j)=0.0
             zs(i,j)=zsr
             vs(i,j)=0.0
             zg(i,j)=zgr
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```
            vg(i,j)=0.0

            if (qr(i,j) .gt. cmin) then
               dd(i,j)=r00*qr(i,j)
               y1(i,j)=sqrt(dd(i,j))
               y2(i,j)=sqrt(y1(i,j))
               zr(i,j)=zrc/y2(i,j)
               vr(i,j)=fv0*(vr0+vr1*y2(i,j)+vr2*y1(i,j)+
     1                    vr3*y1(i,j)*y2(i,j))
               vr(i,j)=max(vr(i,j), 0.0)
            endif

            if (qs(i,j) .gt. cmin) then
               dd(i,j)=r00*qs(i,j)
               y1(i,j)=dd(i,j)**.25
               tns_funT(i,j)=1.
               if(improve.ge.3)then
                y3(i,j)=min(0.,max(-50.,tair(i,j)-t0))                  !2007b
                tns_funT(i,j)=exp(-0.060000*y3(i,j)*0.25)               !2007b
               endif
               ZS(I,J)=ZSC/Y1(I,J)* tns_funT(i,j)
               if(improve.ge.3)then
                y3(i,j)=min(0.,max(-50.,tair(i,j)-t0))                  !2007b
                tns_funT(i,j)=exp(0.060000*y3(i,j)*0.25*bs)             !2007b
               endif
               VS(I,J)=MAX(VSCF*DD(I,J)**BSQ * tns_funT(i,j), 0.)
            endif

            if (qg(i,j) .gt. cmin) then
               dd(i,j)=r00*qg(i,j)
               y1(i,j)=dd(i,j)**.25
               zg(i,j)=zgc/y1(i,j)
               vg(i,j)=max(vgcf*dd(i,j)**bgq, 0.0)
            endif

            if (qr(i,j) .le. cmin1) vr(i,j)=0.0
            if (qs(i,j) .le. cmin1) vs(i,j)=0.0
            if (qg(i,j) .le. cmin1) vg(i,j)=0.0
c
c*  1 * psaut : autoconversion of qi to qs                          ***1**
c*  3 * psaci : accretion of qi to qs                               ***3**
c*  4 * psacw : accretion of qc by qs (riming) (qsacw for psmlt)    ***4**
c* 34 * pwacs : collection of qs by qc                              **34**
c*  5 * praci : accretion of qi by qr                               ***5**
c*  6 * piacr : accretion of qr or qg by qi                         ***6**

          psaut(i,j)=0.0
          psaci(i,j)=0.0
          praci(i,j)=0.0
          piacr(i,j)=0.0
          psacw(i,j)=0.0
          pwacs(i,j)=0.0
          qsacw(i,j)=0.0
          if(tair(i,j).lt.t0) then
c            y1(i,j)=rdt*(qi(i,j)-r1r*exp(beta*tairc(i,j)))
c           psaut(i,j)=max(y1(i,j),0.0)
              rn1=1.e-3
              bnd1=6.e-4
              esi(i,j)=exp(.025*tairc(i,j))
              if(improve.ge.3) esi(i,j)=0.15
             psaut(i,j)=max(rn1*esi(i,j)*(qi(i,j)-bnd1*fv0*fv0) ,0.0)
          endif

          if(tair(i,j).lt.t0) then
           tns_funT(i,j)=1.
          if(improve.ge.3) tns_funT(i,j)=min(20.,exp(-0.060000*tairc(i,j)))  !Lang
et al. 2007b
           esi(i,j)=1.
           if(improve.ge.3) esi(i,j)=0.15
```



```
          psaci(i,j)=r3f*qi(i,j)/zs(i,j)**bs3 *tns_funT(i,j) * esi(i,j)    !Lang e
t al. 2007b
          psacw(i,j)=r4f*qc(i,j)/zs(i,j)**bs3 *tns_funT(i,j)
          if(ihalmos.eq.1)then                                             !Lang e
t al. 2007b
            y2(i,j)=0.
            if((tairc(i,j).le.hmtemp1).and.(tairc(i,j).ge.hmtemp4))
     1                                                          y2(i,j)=0.5
            if((tairc(i,j).ge.hmtemp2).and.(tairc(i,j).le.hmtemp3))
     1                                                          y2(i,j)=1.
            pihms(i,j)=psacw(i,j)*y2(i,j)*xnsplnt*1000.*xmsplnt
            psacw(i,j)=psacw(i,j)-pihms(i,j)
          endif
          pwacs(i,j)=r34f*qc(i,j)/zs(i,j)**bs6 *tns_funT(i,j)
           y1(i,j)=1./zr(i,j)
           y2(i,j)=y1(i,j)*y1(i,j)
           y3(i,j)=y1(i,j)*y2(i,j)
           dd(i,j)=r5f*qi(i,j)*y3(i,j)*(rn50+rn51*y1(i,j)+rn52*y2(i,j)
     1                                +rn53*y3(i,j))
          praci(i,j)=max(dd(i,j),0.0)
             y4(i,j)=y3(i,j)*y3(i,j)
           dd1(i,j)=r6f*qi(i,j)*y4(i,j)*(rn60+rn61*y1(i,j)+rn62*y2(i,j)
     1                               +rn63*y3(i,j))
          piacr(i,j)=max(dd1(i,j),0.0)
         else
          qsacw(i,j)=r4f*qc(i,j)/zs(i,j)**bs3 *tns_funT(i,j)
         endif

c* 21 * praut   autoconversion of qc to qr                          **21**
c* 22 * pracw : accretion of qc by qr                              **22**
           praut(i,j)=max(rn21*(qc(i,j)-bnd21),0.0)
           y1(i,j)=1./zr(i,j)
           y2(i,j)=y1(i,j)*y1(i,j)
           y3(i,j)=y1(i,j)*y2(i,j)
           y4(i,j)=r22f*qc(i,j)*y3(i,j)*(rn50+rn51*y1(i,j)+rn52*y2(i,j)
     1                                +rn53*y3(i,j))
          pracw(i,j)=max(y4(i,j),0.0)
c* 12 * psfw : bergeron processes for qs (koening, 1971)          **12**
c* 13 * psfi : bergeron processes for qs                          **13**

            psfw(i,j)=0.0
            psfi(i,j)=0.0
             if(tair(i,j).lt.t0) then
               y1(i,j)=max( min(tairc(i,j), -1.), -31.)
               it(i,j)=int(abs(y1(i,j)))
               y1(i,j)=rn12a(it(i,j))
               y2(i,j)=rn12b(it(i,j))
               y3(i,j)=rn13(it(i,j))
              psfw(i,j)=max(d2t*y1(i,j)*(y2(i,j)+r12r*qc(i,j))*qi(i,j),0.0)
              psfi(i,j)=y3(i,j)*qi(i,j)

              if(improve.eq.-1)then                                    !xp
                tmp=BergCon1(it(i,j))*qi(i,j)
     1           +BergCon2(it(i,j))*rrho(k)*rn25*exp(beta*(tair(i,j)-t0))
                psfi(i,j)=max(tmp*d2t,0.0)
              endif

              if(improve.ge.2)then                                 !Lang et al. 2007b
               y4(i,j)=1./(tair(i,j)-c358)
               y5(i,j)=1./(tair(i,j)-c76)
               qsw(i,j)=rp0*exp(c172-c409*y4(i,j))
               qsi(i,j)=rp0*exp(c218-c580*y5(i,j))
               hfact=(qv(i,j)+qb0-qsi(i,j))/(qsw(i,j)-qsi(i,j))
               if(hfact.gt.1.) hfact=1.
clang          if(qc(i,j).le.cmin) hfact=0.
               sfact=1.
               if(improve.ge.3)then
                SSI(i,j)=(qv(i,j)+qb0)/qsi(i,j)-1.
                xssi=min(ssi(i,j), 0.20)                           !cap at 20% su
```

```
per wrt ice
              r_nci=min(1.e-3*exp(-.639+12.96*xssi),1.)           !meyers et al.
 1992
              dd(i,j)=min((r00*qi(i,j)/r_nci),ami40)              !mean cloud ic
e mass
              yy1=1.-aa2(it(i,j))
              sfact=(AMI50**YY1-AMI40**YY1)/(AMI50**YY1-dd(i,j)**YY1)
             endif
             if(hfact.gt.0.)then
               psfi(i,j)=psfi(i,j)*hfact*sfact
             else
               psfi(i,j)=0.
             endif
            endif
           endif
cttt***** qg=qg+min(pgdry,pgwet)
c*  9 * pgacs : accretion of qs by qg (dgacs,wgacs: dry and wet)  ***9**
c* 14 * dgacw : accretion of qc by qg (qgacw for pgmlt)           **14**
c* 15 * dgaci : accretion of qi by qg (wgaci for wet growth)      **15**
c* 16 * dgacr : accretion of qr to qg (qgacr for pgmlt)           **16**
          y1(i,j)=abs( vg(i,j)-vs(i,j) )
          y2(i,j)=zs(i,j)*zg(i,j)
          y3(i,j)=5./y2(i,j)
          y4(i,j)=.08*y3(i,j)*y3(i,j)
          y5(i,j)=.05*y3(i,j)*y4(i,j)
          y2(i,j)=y1(i,j)*(y3(i,j)/zs(i,j)**5+y4(i,j)/zs(i,j)**3+y5(i,j)
     1                    /zs(i,j))

         pgacs(i,j)=r9rf*y2(i,j) *tns_funT(i,j)
         dgacs(i,j)=pgacs(i,j)
         if(improve.ge.1) dgacs(i,j)=0.0
crh      wgacs(i,j)=10.*r9rf*y2(i,j)
         wgacs(i,j)=0.0
          y1(i,j)=1./zg(i,j)**bg3
         dgacw(i,j)=r14f*qc(i,j)*y1(i,j)
         if(ihalmos.eq.1)then                                    !Lang et al. 200
7b
           y2(i,j)=0.
           if((tairc(i,j).le.hmtemp1).and.(tairc(i,j).ge.hmtemp4))
     1                                                        y2(i,j)=0.5
           if((tairc(i,j).ge.hmtemp2).and.(tairc(i,j).le.hmtemp3))
     1                                                      y2(i,j)=1.
           pihmg(i,j)=dgacw(i,j)*y2(i,j)*xnsplnt*1000.*xmsplnt
           dgacw(i,j)=dgacw(i,j)-pihmg(i,j)
         endif
         qgacw(i,j)=dgacw(i,j)
         dgaci(i,j)=r15f*qi(i,j)*y1(i,j)
         if(improve.ge.1) dgaci(i,j)=0.0
crh      wgaci(i,j)=r15af*qi(i,j)*y1(i,j)
         wgaci(i,j)=0.0

          y1(i,j)=abs( vg(i,j)-vr(i,j) )
          y2(i,j)=zr(i,j)*zg(i,j)
          y3(i,j)=5./y2(i,j)
          y4(i,j)=.08*y3(i,j)*y3(i,j)
          y5(i,j)=.05*y3(i,j)*y4(i,j)
          dd(i,j)=r16rf*y1(i,j)*(y3(i,j)/zr(i,j)**5+y4(i,j)/zr(i,j)**3
     1                    +y5(i,j)/zr(i,j))
         dgacr(i,j)=max(dd(i,j),0.0)
         qgacr(i,j)=dgacr(i,j)

          if (tair(i,j) .ge. t0) then
           dgacs(i,j)=0.0
crh        wgacs(i,j)=0.0
           dgacw(i,j)=0.0
           dgaci(i,j)=0.0
crh        wgaci(i,j)=0.0
           dgacr(i,j)=0.0
          else
```



```
           pgacs(i,j)=0.0
           qgacw(i,j)=0.0
           qgacr(i,j)=0.0
          endif
        enddo   !!! cccshie added by shie 7/1/02 do i=3,jles
  150   continue

c*******pgdry : dgacw+dgaci+dgacr+dgacs                                 ******
c* 17 * pgwet : wet growth of qg                                        **17**
crh       pgwet(ij)=0.0
crh       if (tair(ij) .lt. t0) then
crh         y1(ij)=1./(alf+rn17c*tairc(ij))
crh         y2(ij)=rp0-(qv(ij)+qb0)
crh         y3(ij)=.78/zg(ij)**2+r17arf/zg(ij)**bgh5
crh         y4(ij)=rn171*y2(ij)-r172r*tairc(ij)
crh         dd(ij)=y1(ij)*(y4(ij)*y3(ij)+(wgaci(ij)
crh  1                              +wgacs(ij))*(alf+rn17b*tairc(ij)))
crh        pgwet(ij)=max(dd(ij), 0.0)
crh       endif
c******** shed process (wgacr=pgwet-dgacw-wgaci-wgacs)
crh      wgacr(ij)=pgwet(ij)-dgacw(ij)-wgaci(ij)-wgacs(ij)
crh       y2(ij)=dgacw(ij)+dgaci(ij)+dgacr(ij)+dgacs(ij)
crh       if (pgwet(ij) .ge. y2(ij)) then
crh         wgacr(ij)=0.0
crh         wgaci(ij)=0.0
crh         wgacs(ij)=0.0
crh       else
crh         dgacr(ij)=0.0
crh         dgaci(ij)=0.0
crh         dgacs(ij)=0.0
crh       endif
c*******pgdry : dgacw+dgaci+dgacr+dgacs                                 ******
c* 15 * dgaci : accretion of qi by qg (wgaci for wet growth)           **15**
c* 17 * pgwet : wet growth of qg                                        **17**
c********   handling the negative cloud water (qc)    ******************
c********   handling the negative cloud ice (qi)      ******************

c$doacross local(j,i)
      do 200 j=1,1
      do 200 i=1,1
        pgwet(i,j)=0.0
           y1(i,j)=qc(i,j)/d2t
          psacw(i,j)=min(y1(i,j), psacw(i,j))
          pihms(i,j)=min(y1(i,j), pihms(i,j))
          praut(i,j)=min(y1(i,j), praut(i,j))
          pracw(i,j)=min(y1(i,j), pracw(i,j))
          psfw(i,j)= min(y1(i,j), psfw(i,j))
          dgacw(i,j)=min(y1(i,j), dgacw(i,j))
          pihmg(i,j)=min(y1(i,j), pihmg(i,j))
          qsacw(i,j)=min(y1(i,j), qsacw(i,j))
          qgacw(i,j)=min(y1(i,j), qgacw(i,j))

        y1(i,j)=d2t*(psacw(i,j)+praut(i,j)+pracw(i,j)+psfw(i,j)
     1          +dgacw(i,j)+qsacw(i,j)+qgacw(i,j)+pihms(i,j)+pihms(i,j))

        qc(i,j)=qc(i,j)-y1(i,j)
c
        if (qc(i,j) .lt. 0.0) then
           y2(i,j)=1.
            if (y1(i,j) .ne. 0.) y2(i,j)=qc(i,j)/y1(i,j)+1.
          psacw(i,j)=psacw(i,j)*y2(i,j)
          praut(i,j)=praut(i,j)*y2(i,j)
          pracw(i,j)=pracw(i,j)*y2(i,j)
          psfw(i,j)=psfw(i,j)*y2(i,j)
          dgacw(i,j)=dgacw(i,j)*y2(i,j)
          qsacw(i,j)=qsacw(i,j)*y2(i,j)
          qgacw(i,j)=qgacw(i,j)*y2(i,j)
          qc(i,j)=0.0
         endif
```

```
c
           y1(i,j)=qi(i,j)/d2t
          psaut(i,j)=min(y1(i,j), psaut(i,j))
          psaci(i,j)=min(y1(i,j), psaci(i,j))
          praci(i,j)=min(y1(i,j), praci(i,j))
          psfi(i,j)= min(y1(i,j), psfi(i,j))
          dgaci(i,j)=min(y1(i,j), dgaci(i,j))
          wgaci(i,j)=min(y1(i,j), wgaci(i,j))

        y1(i,j)=d2t*(psaut(i,j)+psaci(i,j)+praci(i,j)+psfi(i,j)
     1           +dgaci(i,j)+wgaci(i,j))

        qi(i,j)=qi(i,j)-y1(i,j)
c
         if (qi(i,j) .lt. 0.0) then
           y2(i,j)=1.
            if (y1(i,j) .ne. 0.0) y2(i,j)=qi(i,j)/y1(i,j)+1.
          psaut(i,j)=psaut(i,j)*y2(i,j)
          psaci(i,j)=psaci(i,j)*y2(i,j)
          praci(i,j)=praci(i,j)*y2(i,j)
          psfi(i,j)=psfi(i,j)*y2(i,j)
          dgaci(i,j)=dgaci(i,j)*y2(i,j)
          wgaci(i,j)=wgaci(i,j)*y2(i,j)
          qi(i,j)=0.0
         endif
c
         wgacr(i,j)=qgacr(i,j)+qgacw(i,j)
        dlt3(i,j)=0.0
         if (qr(i,j) .lt. 1.e-4) dlt3(i,j)=1.
        dlt4(i,j)=1.
         if (qc(i,j) .gt. 5.e-4) dlt4(i,j)=0.0
         if (qs(i,j) .le. 1.e-4) dlt4(i,j)=1.
          if (tair(i,j) .ge. t0) then
           dlt3(i,j)=0.0
           dlt4(i,j)=0.0
          endif
        pr(i,j)=d2t*(qsacw(i,j)+praut(i,j)+pracw(i,j)+wgacr(i,j)
     1           -qgacr(i,j))
        ps(i,j)=d2t*(psaut(i,j)+psaci(i,j)+dlt4(i,j)*psacw(i,j)
     1           +psfw(i,j)+psfi(i,j)+dlt3(i,j)*praci(i,j))
        pg(i,j)=d2t*((1.-dlt3(i,j))*praci(i,j)+dgaci(i,j)
     1          +wgaci(i,j)+dgacw(i,j)+(1.-dlt4(i,j))*psacw(i,j)) !!! cccshie 7

c*  7 * pracs : accretion of qs by qr                              ***7**
c*  8 * psacr : accretion of qr by qs (qsacr for psmlt)            ***8**

          y1(i,j)=abs( vr(i,j)-vs(i,j) )
          y2(i,j)=zr(i,j)*zs(i,j)
          y3(i,j)=5./y2(i,j)
          y4(i,j)=.08*y3(i,j)*y3(i,j)
          y5(i,j)=.05*y3(i,j)*y4(i,j)

        pracs(i,j)=r7rf*y1(i,j)*(y3(i,j)/zs(i,j)**5+y4(i,j)/zs(i,j)**3
     1                          +y5(i,j)/zs(i,j)) *tns_funT(i,j)
        qracs(i,j)=min(d2t*pracs(i,j), qs(i,j))
        psacr(i,j)=r8rf*y1(i,j)*(y3(i,j)/zr(i,j)**5+y4(i,j)/zr(i,j)**3
     1                         +y5(i,j)/zr(i,j)) *tns_funT(i,j)
        qsacr(i,j)=psacr(i,j)

         if (tair(i,j) .ge. t0) then
          pgaut(i,j)=0.0
          pracs(i,j)=0.0
          psacr(i,j)=0.0
         else
          qsacr(i,j)=0.0
          qracs(i,j)=0.0
         endif
c*  2 * pgaut : autoconversion of qs to qg                         ***2**
c* 18 * pgfr : freezing of qr to qg                               **18**
```



```
        pgfr(i,j)=0.0
        pgaut(i,j)=0.0
         if (tair(i,j) .lt. t0) then
           y1(i,j)=exp(rn18a*(t0-tair(i,j)))
          pgfr(i,j)=max(r18r*(y1(i,j)-1.)/zr(i,j)**7., 0.0)
         endif
  200 continue

c********   handling the negative rain water (qr)    ******************
c********   handling the negative snow (qs)          ******************

c$doacross local(j,i)
      do 250 j=1,1
      do 250 i=1,1
          y1(i,j)=qr(i,j)/d2t
         piacr(i,j)=min(y1(i,j), piacr(i,j))
         dgacr(i,j)=min(y1(i,j), dgacr(i,j))
         psacr(i,j)=min(y1(i,j), psacr(i,j))
         pgfr(i,j)= min(y1(i,j), pgfr(i,j))
         y1(i,j)=(piacr(i,j)+dgacr(i,j)+psacr(i,j)+pgfr(i,j))*d2t
        qr(i,j)=qr(i,j)+pr(i,j)+qracs(i,j)-y1(i,j)
        if (qr(i,j) .lt. 0.0) then
          y2(i,j)=1.
           if (y1(i,j) .ne. 0.0) y2(i,j)=qr(i,j)/y1(i,j)+1.
         piacr(i,j)=piacr(i,j)*y2(i,j)
         dgacr(i,j)=dgacr(i,j)*y2(i,j)
         pgfr(i,j)=pgfr(i,j)*y2(i,j)
         psacr(i,j)=psacr(i,j)*y2(i,j)
         qr(i,j)=0.0
        endif
        dlt2(i,j)=1.
         if (qr(i,j) .gt. 1.e-4) dlt2(i,j)=0.
         if (qs(i,j) .le. 1.e-4) dlt2(i,j)=1.
         if (tair(i,j) .ge. t0) dlt2(i,j)=0.
          y1(i,j)=qs(i,j)/d2t
         pgacs(i,j)=min(y1(i,j), pgacs(i,j))
         dgacs(i,j)=min(y1(i,j), dgacs(i,j))
         wgacs(i,j)=min(y1(i,j), wgacs(i,j))
         pgaut(i,j)=min(y1(i,j), pgaut(i,j))
         pracs(i,j)=min(y1(i,j), pracs(i,j))
         pwacs(i,j)=min(y1(i,j), pwacs(i,j))
        prn(i,j)=d2t*((1.-dlt3(i,j))*piacr(i,j)+dgacr(i,j)+pgfr(i,j)
     1             +(1.-dlt2(i,j))*psacr(i,j))
        ps(i,j)=ps(i,j)+d2t*(dlt3(i,j)*piacr(i,j)+dlt2(i,j)*psacr(i,j))
         pracs(i,j)=(1.-dlt2(i,j))*pracs(i,j)
         pwacs(i,j)=(1.-dlt4(i,j))*pwacs(i,j)

       psn(i,j)=d2t*(pgacs(i,j)+dgacs(i,j)+wgacs(i,j)+pgaut(i,j)
     1           +pracs(i,j)+pwacs(i,j))

        qs(i,j)=qs(i,j)+ps(i,j)-qracs(i,j)-psn(i,j)
         if (qs(i,j) .lt. 0.0) then
           y2(i,j)=1.
            if (psn(i,j) .ne. 0.) y2(i,j)=qs(i,j)/psn(i,j)+1.
          pgacs(i,j)=pgacs(i,j)*y2(i,j)
          dgacs(i,j)=dgacs(i,j)*y2(i,j)
          wgacs(i,j)=wgacs(i,j)*y2(i,j)
          pgaut(i,j)=pgaut(i,j)*y2(i,j)
          pracs(i,j)=pracs(i,j)*y2(i,j)
          pwacs(i,j)=pwacs(i,j)*y2(i,j)
          qs(i,j)=0.0
         endif
       psn(i,j)=d2t*(pgacs(i,j)+dgacs(i,j)+wgacs(i,j)+pgaut(i,j)
     1           +pracs(i,j)+pwacs(i,j))
        qg(i,j)=qg(i,j)+pg(i,j)+prn(i,j)+psn(i,j)
        y1(i,j)=d2t*(psacw(i,j)+psfw(i,j)+dgacw(i,j)+piacr(i,j)
     1          +dgacr(i,j)+psacr(i,j)+pgfr(i,j))-qracs(i,j)
        pt(i,j)=pt(i,j)+afcp*y1(i,j)
c* 11 * psmlt : melting of qs                                      **11**
```

```
c* 19 * pgmlt : melting of qg to qr                                **19**

          psmlt(i,j)=0.0
          pgmlt(i,j)=0.0
        tair(i,j)=(pt(i,j)+tb0)*pi0
        if (tair(i,j) .ge. t0) then
          tairc(i,j)=tair(i,j)-t0
          dd(i,j)=r11t*tairc(i,j)*(r101r/zs(i,j)**2+r102rf
     1                          /zs(i,j)**bsh5)
         psmlt(i,j)=min(qs(i,j),max(dd(i,j),0.0))
           y2(i,j)=r191r/zg(i,j)**2+r192rf/zg(i,j)**bgh5
          dd1(i,j)=tairc(i,j)*(r19t*y2(i,j)+r19at*(qgacw(i,j)
     1                                    +qgacr(i,j)))
         pgmlt(i,j)=min(qg(i,j),max(dd1(i,j),0.0))
         pt(i,j)=pt(i,j)-afcp*(psmlt(i,j)+pgmlt(i,j))
         qr(i,j)=qr(i,j)+psmlt(i,j)+pgmlt(i,j)
         qs(i,j)=qs(i,j)-psmlt(i,j)
         qg(i,j)=qg(i,j)-pgmlt(i,j)
        endif
c* 24 * pihom : homogeneous freezing of qc to qi (t < t00)        **24**
c* 25 * pidw  : deposition growth of qc to qi ( t0 < t <= t00)    **25**
c* 26 * pimlt : melting of qi to qc (t >= t0)                     **26**
c****** PIMM  : IMMERSION FREEZING OF QC TO QI (T < T0)          ******
c****** PCFR  : CONTACT NUCLEATION OF QC TO QI (T < T0)          ******

        if (qc(i,j).le.cmin) qc(i,j)=0.0
        if (qi(i,j).le.cmin) qi(i,j)=0.0
         tair(i,j)=(pt(i,j)+tb0)*pi0
         if(tair(i,j).le.t00) then
          pihom(i,j)=qc(i,j)
         else
          pihom(i,j)=0.0
         endif
         if(tair(i,j).ge.t0) then
          pimlt(i,j)=qi(i,j)
         else
          pimlt(i,j)=0.0
         endif
         pidw(i,j)=0.0
         if (tair(i,j).lt.t0 .and. tair(i,j).gt.t00) then
          if(improve.ge.3)then                                  !Lang et al. 2
007b
            if(tairc(i,j).le.-5.)then                           !meyers
             TAIRC(I,J)=TAIR(I,J)-T0
             Y1(I,J)=MAX( MIN(TAIRC(I,J), -1.), -31.)
             IT(I,J)=INT(ABS(Y1(I,J)))
             Y3(I,J)=AA2(IT(I,J))
              y4(i,j)=1./(tair(i,j)-c358)
              qsw(i,j)=rp0*exp(c172-c409*y4(i,j))
              rtair(i,j)=1./(tair(i,j)-c76)
              y2(i,j)=exp(c218-c580*rtair(i,j))
              qsi(i,j)=rp0*y2(i,j)
              SSI(i,j)=(qv(i,j)+qb0)/qsi(i,j)-1.
              xssi=min(ssi(i,j), 0.20)                          !cap at 20% su
per wrt ice
              r_nci=min(1.e-3*exp(-.639+12.96*xssi),1.)         !meyers et al.
 1992
              if(r_nci.gt.15.) r_nci=15.                        !cap at 15000/
liter
              dd(i,j)=(r00*qi(i,j)/r_nci)**y3(i,j)              !meyers
              PIDW(i,j)=min(RR0*D2T*y2(i,j)*r_nci*dd(i,j),qc(i,j))    !meyers
            endif
            pimm(i,j)=0.0
            pcfr(i,j)=0.0
            IF(QC(I,J).gt.0.)THEN
             xncld=qc(i,j)/4.e-9                                 !cloud number
             esat=0.6112*exp(17.67*tairc(i,j)/(tairc(i,j)+243.5))*10.
             rv=0.622*esat/(p0(k)/1000.-esat)
             rlapse_m=980.616*(1.+2.5e6*rv/287./tair(i,j))/
```



```
     1           (1004.67+2.5e6*2.5e6*rv*0.622/287./tair(i,j)/tair(i,j))
            delT=rlapse_m*0.5*(ww1(i,j,k)+ww1(i,j,k+1))
            if(delT.lt.0.) delT=0.
            Bhi=1.01e-2                                         !pollen (Deihl
 et al. 2006)
            pimm(i,j)=xncld*Bhi*4.e-9*exp(-tairc(i,j))*delT*d2t*4.e-9

            CPI=4.*ATAN(1.)
            Rc=1.e-3                                            !cloud droplet
 radius 10 microns
            Ra=1.e-5                                            !aerosol radiu
s 0.1 microns
            Cna=500.                                            !contact nucle
i conc per cc
            xccld=xncld*r00                                     !cloud number
concentration
            Xknud=7.37*tair(i,j)/288./p0(k)/Ra                  !Knudsen numbe
r
            cunnF=1.257+0.400*exp(-1.10/Xknud)                  !Cunningham co
rrection
            DIFFar=1.3804e-16*tair(i,j)/6./cpi/1.718e-4/Ra*cunnF
            pcfr(i,j)=4.e-9*4.*cpi*Rc*DIFFar*xccld*Cna*rr0*d2t
           ENDIF
          else
           tairc(i,j)=tair(i,j)-t0
           y1(i,j)=max( min(tairc(i,j), -1.), -31.)
           it(i,j)=int(abs(y1(i,j)))
           y2(i,j)=aa1(it(i,j))
           y3(i,j)=aa2(it(i,j))
           y4(i,j)=exp(abs(.5*tairc(i,j)))
           dd(i,j)=(r00*qi(i,j)/(r25a*y4(i,j)))**y3(i,j)
           pidw(i,j)=min(r25rt*y2(i,j)*y4(i,j)*dd(i,j),qc(i,j))

            if(improve.eq.-1)then                                !xp
              tmp=BergCon3(it(i,j))*qi(i,j)
     1         +BergCon4(it(i,j))*rrho(k)*rn25*exp(beta*(tair(i,j)-t0))
              pidw(i,j)=min(tmp*d2t,qc(i,j))
            endif

          endif
         endif

         y1(i,j)=pihom(i,j)-pimlt(i,j)+pidw(i,j)+pimm(i,j)+pcfr(i,j)

        if(y1(i,j).gt.qc(i,j))then
           y1(i,j)=qc(i,j)
           y2(i,j)=1.
           y3(i,j)=pihom(i,j)+pidw(i,j)+pimm(i,j)+pcfr(i,j)
           if(y3(i,j).ne.0.) y2(i,j)=(qc(i,j)+pimlt(i,j))/y3(i,j)
           pihom(i,j)=pihom(i,j)*y2(i,j)
           pidw(i,j)=pidw(i,j)*y2(i,j)
           pimm(i,j)=pimm(i,j)*y2(i,j)
           pcfr(i,j)=pcfr(i,j)*y2(i,j)
        endif

        pt(i,j)=pt(i,j)+afcp*y1(i,j)
        qc(i,j)=qc(i,j)-y1(i,j)
        qi(i,j)=qi(i,j)+y1(i,j)
c* 31 * pint  : initiation of qi                                 **31**
c* 32 * pidep : deposition of qi                                 **32**
        pint(i,j)=0.0
        pidep(i,j)=0.0
        if (improve.ge.3) then                                  !Lang et al. 2
007b
            tair(i,j)=(pt(i,j)+tb0)*pi0
            if (tair(i,j).lt.t0) THEN
              if (qi(i,j).le.cmin) qi(i,j)=0.
              tairc(i,j)=tair(i,j)-t0
              rtair(i,j)=1./(tair(i,j)-c76)
```

```
              y2(i,j)=exp(c218-c580*rtair(i,j))
              qsi(i,j)=rp0*y2(i,j)
              esi(i,j)=C610*y2(i,j)
              SSI(i,j)=(qv(i,j)+qb0)/qsi(i,j)-1.
              y1(i,j)=1./tair(i,j)
              y3(i,j)=SQRT(qi(i,j))
              dd(i,j)=y1(i,j)*(RN10A*y1(i,j)-RN10B)+RN10C*tair(i,j)/
     1                                                      esi(i,j)
              dm(i,j)=max(qv(i,j)+qb0-qsi(i,j),0.0)
              rsub1(i,j)=cs580*qsi(i,j)*rtair(i,j)*rtair(i,j)
              dep(i,j)=dm(i,j)/(1.+rsub1(i,j))
              if(tairc(i,j).le.-5.)then                          !meyers
                y4(i,j)=1./(tair(i,j)-c358)
                qsw(i,j)=rp0*exp(c172-c409*y4(i,j))
                xssi=min(ssi(i,j), 0.20)                        !cap at 20%
super wrt ice
                r_nci=min(1.e-3*exp(-.639+12.96*xssi),1.)       !meyers et a
l. 1992
                if(r_nci.gt.15.) r_nci=15.                      !cap at 1500
0/liter
                pidep(i,j)=max(R32RT*1.e-4*SSI(i,j)*sqrt(r_nci)*y3(i,j)/     !me
yers
     1                                                  dd(i,j),0.)
                ami50=4.8e-7
                dd(i,j)=max(1.e-9*r_nci/r00-qci(i,j,k)*1.e-9/ami50,0.) !test vs
old qci
                pint(i,j)=max(min(dd(i,j),dm(i,j)),0.)
                pint(i,j)=min(pint(i,j)+pidep(i,j),dep(i,j))
                if (pint(i,j).le.cmin) pint(i,j)=0.
                pt(i,j)=pt(i,j)+ascp*pint(i,j)
                qv(i,j)=qv(i,j)-pint(i,j)
                qi(i,j)=qi(i,j)+pint(i,j)
              endif
            endif
          endif

c      itaobraun=0 ! using original way for pint and pidep
       itaobraun=1 ! using scott braun's way for pint and pidep
       if(improve.ge.3) itaobraun=0

       if ( itaobraun.eq.0 ) then      ! tao's original
       cn0=1.e-8
cc     beta=-.6
       elseif ( itaobraun.eq.1 ) then  ! scott's
       cn0=1.e-6
c      cn0=1.e-8  ! 4/22/02 special, still use tao's
cc     beta=-.46
       endif

        if ( itaobraun.eq.1 ) then
           tair(i,j)=(pt(i,j)+tb0)*pi0
           if (tair(i,j) .lt. t0) then
c             if (qi(i,j) .le. cmin) qi(i,j)=0.
              if (qi(i,j) .le. cmin2) qi(i,j)=0.
               tairc(i,j)=tair(i,j)-t0
               rtair(i,j)=1./(tair(i,j)-c76)
               y2(i,j)=exp(c218-c580*rtair(i,j))
              qsi(i,j)=rp0*y2(i,j)
               esi(i,j)=c610*y2(i,j)
              ssi(i,j)=(qv(i,j)+qb0)/qsi(i,j)-1.
                       ami50=3.76e-8

cccshie with scott braun's help, insert "pidep" and change "betah", "c0" in rou
ccc         "consat" (2d), "consatrh" (3d)
ccc      if ( itaobraun.eq.1 ) --> betah=0.5*beta=-.46*0.5=-0.23;   cn0=1.e-6
ccc      if ( itaobraun.eq.0 ) --> betah=0.5*beta=-.6*0.5=-0.30;    cn0=1.e-8

       y1(i,j)=1./tair(i,j)
```



```
cccshie with scott braun's help, insert a restriction on ice collection that ic
ccc               should be stopped at -30 c (with cn0=1.e-6, beta=-.46)

             tairccri=tairc(i,j)          ! in degree c
             if(tairccri.le.-30.) tairccri=-30.

c            y2(i,j)=exp(betah*tairc(i,j))
             y2(i,j)=exp(betah*tairccri)
             y3(i,j)=sqrt(qi(i,j))
             dd(i,j)=y1(i,j)*(rn10a*y1(i,j)-rn10b)+rn10c*tair(i,j)
     1                                              /esi(i,j)
          pidep(i,j)=max(r32rt*ssi(i,j)*y2(i,j)*y3(i,j)/dd(i,j), 0.e0)

           r_nci=min(cn0*exp(beta*tairc(i,j)),1.)      ! cccshie 4/18/02
c          r_nci=min(1.e-6*exp(-.46*tairc(i,j)),1.)

           dd(i,j)=max(1.e-9*r_nci/r00-qi(i,j)*1.e-9/ami50, 0.)
                dm(i,j)=max( (qv(i,j)+qb0-qsi(i,j)), 0.0)
                rsub1(i,j)=cs580*qsi(i,j)*rtair(i,j)*rtair(i,j)
              dep(i,j)=dm(i,j)/(1.+rsub1(i,j))
              pint(i,j)=max(min(dd(i,j), dm(i,j)), 0.)

c             pint(i,j)=min(pint(i,j), dep(i,j))
              pint(i,j)=min(pint(i,j)+pidep(i,j), dep(i,j))  ! cccshie 4/15/02

c              if (pint(i,j) .le. cmin) pint(i,j)=0.
               if (pint(i,j) .le. cmin2) pint(i,j)=0.
              pt(i,j)=pt(i,j)+ascp*pint(i,j)
              qv(i,j)=qv(i,j)-pint(i,j)
              qi(i,j)=qi(i,j)+pint(i,j)
            endif
         endif  ! if ( itaobraun.eq.1 ) ! scott's
         if ( itaobraun.eq.0 .and. improve.le.2) then
          tair(i,j)=(pt(i,j)+tb0)*pi0
          if (tair(i,j) .lt. t0) then
          if (qi(i,j) .le. cmin2) qi(i,j)=0.
            tairc(i,j)=tair(i,j)-t0
            dd(i,j)=r31r*exp(beta*tairc(i,j))
             rtair(i,j)=1./(tair(i,j)-c76)
              y2(i,j)=exp(c218-c580*rtair(i,j))
             qsi(i,j)=rp0*y2(i,j)
             esi(i,j)=c610*y2(i,j)
             ssi(i,j)=(qv(i,j)+qb0)/qsi(i,j)-1.
            dm(i,j)=max( (qv(i,j)+qb0-qsi(i,j)), 0.)
             rsub1(i,j)=cs580*qsi(i,j)*rtair(i,j)*rtair(i,j)
           dep(i,j)=dm(i,j)/(1.+rsub1(i,j))
           pint(i,j)=max(min(dd(i,j), dm(i,j)), 0.)
              y1(i,j)=1./tair(i,j)
              y2(i,j)=exp(betah*tairc(i,j))
              y3(i,j)=sqrt(qi(i,j))
            dd(i,j)=y1(i,j)*(rn10a*y1(i,j)-rn10b)+rn10c*tair(i,j)
     1                                              /esi(i,j)
           pidep(i,j)=max(r32rt*ssi(i,j)*y2(i,j)*y3(i,j)/dd(i,j), 0.)
           pint(i,j)=pint(i,j)+pidep(i,j)
            pint(i,j)=min(pint(i,j),dep(i,j))
cc             if (pint(i,j) .le. cmin2) pint(i,j)=0.
           pt(i,j)=pt(i,j)+ascp*pint(i,j)
           qv(i,j)=qv(i,j)-pint(i,j)
           qi(i,j)=qi(i,j)+pint(i,j)
          endif
         endif  ! if ( itaobraun.eq.0 ) ! tao's original
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
  250  continue

       if (improve.ge.1) new_ice_sat=2
       if (improve.ge.3) new_ice_sat=3

c*****   tao et al (1989) saturation technique  **********************
       if (new_ice_sat .eq. 0) then ! cccshie by tao 5/3/01, shie 11/16/01 3d
```

```
c$doacross local(j,i)
       do 275 j=1,1
       do 275 i=1,1
         tair(i,j)=(pt(i,j)+tb0)*pi0
        cnd(i,j)=rt0*(tair(i,j)-t00)
        dep(i,j)=rt0*(t0-tair(i,j))
          y1(i,j)=1./(tair(i,j)-c358)
          y2(i,j)=1./(tair(i,j)-c76)
        qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
        qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
         dd(i,j)=cp409*y1(i,j)*y1(i,j)
         dd1(i,j)=cp580*y2(i,j)*y2(i,j)
        if (qc(i,j).le.cmin) qc(i,j)=cmin
        if (qi(i,j).le.cmin) qi(i,j)=cmin
        if (tair(i,j).ge.t0) then
         dep(i,j)=0.0
         cnd(i,j)=1.
         qi(i,j)=0.0
        endif
        if (tair(i,j).lt.t00) then
         cnd(i,j)=0.0
         dep(i,j)=1.
         qc(i,j)=0.0
        endif
         y5(i,j)=avcp*cnd(i,j)+ascp*dep(i,j)
          y1(i,j)=qc(i,j)*qsw(i,j)/(qc(i,j)+qi(i,j))
          y2(i,j)=qi(i,j)*qsi(i,j)/(qc(i,j)+qi(i,j))
         y4(i,j)=dd(i,j)*y1(i,j)+dd1(i,j)*y2(i,j)
        qvs(i,j)=y1(i,j)+y2(i,j)
        rsub1(i,j)=(qv(i,j)+qb0-qvs(i,j))/(1.+y4(i,j)*y5(i,j))
       cnd(i,j)=cnd(i,j)*rsub1(i,j)
       dep(i,j)=dep(i,j)*rsub1(i,j)
        if (qc(i,j).le.cmin) qc(i,j)=0.
        if (qi(i,j).le.cmin) qi(i,j)=0.
cc    ******   condensation or evaporation of qc  ******
        cnd(i,j)=max(-qc(i,j),cnd(i,j))
cc    ******   deposition or sublimation of qi    ******
        dep(i,j)=max(-qi(i,j),dep(i,j))
       pt(i,j)=pt(i,j)+avcp*cnd(i,j)+ascp*dep(i,j)
       qv(i,j)=qv(i,j)-cnd(i,j)-dep(i,j)
       qc(i,j)=qc(i,j)+cnd(i,j)
       qi(i,j)=qi(i,j)+dep(i,j)
  275  continue
       endif ! cccshie by tao 5/3/01, shie 11/16/01 3d
cccshie 11/16/01 !  call tao et al (1989) saturation technique twice
       if (new_ice_sat .eq. 1) then
c$doacross local(j,j)
          do j=1,1
          do i=1,1
             tair(i,j)=(pt(i,j)+tb0)*pi0
c            cnd1(i,j)=rt0*(tair(i,j)-t00)
c            dep1(i,j)=rt0*(t0-tair(i,j))
             cnd(i,j)=rt0*(tair(i,j)-t00)  ! cccshie by tao 5/3/01
             dep(i,j)=rt0*(t0-tair(i,j))   ! cccshie by tao 5/3/01
               y1(i,j)=1./(tair(i,j)-c358)
               y2(i,j)=1./(tair(i,j)-c76)
             qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
             qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
             dd(i,j)=cp409*y1(i,j)*y1(i,j)
             dd1(i,j)=cp580*y2(i,j)*y2(i,j)
             y5(i,j)=avcp*cnd(i,j)+ascp*dep(i,j) ! cccshie by tao 5/3/01
             y1(i,j)=rt0*(tair(i,j)-t00)*qsw(i,j) ! cccshie by tao 5/3/01
             y2(i,j)=rt0*(t0-tair(i,j))*qsi(i,j)  ! cccshie by tao 5/3/01
c            if (qc(i,j).le.cmin) qc(i,j)=cmin  ! cccshie by tao 5/3/01
c            if (qi(i,j).le.cmin) qi(i,j)=cmin  ! cccshie by tao 5/3/01
             if (tair(i,j).ge.t0) then
c                dep1(i,j)=0.0
c                cnd1(i,j)=1.
c                qi(i,j)=0.0
```



```
                 dep(i,j)=0.0 ! cccshie by tao 5/3/01
                 cnd(i,j)=1.  ! cccshie by tao 5/3/01
                 y2(i,j)=0.   ! cccshie by tao 5/3/01
                 y1(i,j)=qsw(i,j) ! cccshie by tao 5/3/01
             endif
             if (tair(i,j).lt.t00) then
                cnd(i,j)=0.0  ! cccshie by tao 5/3/01
                dep(i,j)=1.   ! cccshie by tao 5/3/01
                y2(i,j)=qsi(i,j) ! cccshie by tao 5/3/01
                y1(i,j)=0.    ! cccshie by tao 5/3/01
c               cnd1(i,j)=0.0
c               dep1(i,j)=1.
c               qc(i,j)=0.0
             endif
c            y5(i,j)=avcp*cnd1(i,j)+ascp*dep1(i,j) ! cccshie by tao 5/3/01
c            y1(i,j)=qc(i,j)*qsw(i,j)/(qc(i,j)+qi(i,j)) ! cccshie by tao 5/3/0
c            y2(i,j)=qi(i,j)*qsi(i,j)/(qc(i,j)+qi(i,j)) ! cccshie by tao 5/3/0
             y4(i,j)=dd(i,j)*y1(i,j)+dd1(i,j)*y2(i,j)
             qvs(i,j)=y1(i,j)+y2(i,j)
             rsub1(i,j)=(qv(i,j)+qb0-qvs(i,j))/(1.+y4(i,j)*y5(i,j))
            cnd(i,j)=cnd(i,j)*rsub1(i,j) ! cccshie by tao 5/3/01
            dep(i,j)=dep(i,j)*rsub1(i,j) ! cccshie by tao 5/3/01
c           cnd1(i,j)=cnd1(i,j)*rsub1(i,j)
c           dep1(i,j)=dep1(i,j)*rsub1(i,j)
c            if (qc(i,j).le.cmin) qc(i,j)=0. ! cccshie by tao 5/3/01
c            if (qi(i,j).le.cmin) qi(i,j)=0. ! cccshie by tao 5/3/01
cc    ******   condensation or evaporation of qc  ******
c           cnd1(i,j)=max(-qc(i,j),cnd1(i,j))
            cnd(i,j)=max(-qc(i,j),cnd(i,j)) ! cccshie by tao 5/3/01
cc    ******   deposition or sublimation of qi    ******
            dep(i,j)=max(-qi(i,j),dep(i,j)) ! cccshie by tao 5/3/01
            pt(i,j)=pt(i,j)+avcp*cnd(i,j)+ascp*dep(i,j) ! cccshie by tao 5/3/0
            qv(i,j)=qv(i,j)-cnd(i,j)-dep(i,j) ! cccshie by tao 5/3/01
            qc(i,j)=qc(i,j)+cnd(i,j) ! cccshie by tao 5/3/01
            qi(i,j)=qi(i,j)+dep(i,j) ! cccshie by tao 5/3/01
c           dep1(i,j)=max(-qi(i,j),dep1(i,j))
c           pt(i,j)=pt(i,j)+avcp*cnd1(i,j)+ascp*dep1(i,j)
c           qv(i,j)=qv(i,j)-cnd1(i,j)-dep1(i,j)
c           qc(i,j)=qc(i,j)+cnd1(i,j)
c           qi(i,j)=qi(i,j)+dep1(i,j)
          enddo
          enddo
        endif ! if (new_ice_sat .eq. 1)
c
cc
c
            if (new_ice_sat .eq. 2) then
          do j=1,1
          do i=1,1
          dep(i,j)=0.0
          cnd(i,j)=0.0
          tair(i,j)=(pt(i,j)+tb0)*pi0
          if (tair(i,j) .ge. 253.16) then
              y1(i,j)=1./(tair(i,j)-c358)
              qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
              dd(i,j)=cp409*y1(i,j)*y1(i,j)
              dm(i,j)=qv(i,j)+qb0-qsw(i,j)
              cnd(i,j)=dm(i,j)/(1.+avcp*dd(i,j)*qsw(i,j))
cc    ******   condensation or evaporation of qc  ******
              cnd(i,j)=max(-qc(i,j), cnd(i,j))
            pt(i,j)=pt(i,j)+avcp*cnd(i,j)
            qv(i,j)=qv(i,j)-cnd(i,j)
            qc(i,j)=qc(i,j)+cnd(i,j)
         endif
          if (tair(i,j) .le. 258.16) then
cc             cnd(i,j)=0.0
           y2(i,j)=1./(tair(i,j)-c76)
           qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
          dd1(i,j)=cp580*y2(i,j)*y2(i,j)
```

```
         dep(i,j)=(qv(i,j)+qb0-qsi(i,j))/(1.+ascp*dd1(i,j)*qsi(i,j))
cc    ******   deposition or sublimation of qi    ******
            dep(i,j)=max(-qi(i,j),dep(i,j))
            pt(i,j)=pt(i,j)+ascp*dep(i,j)
            qv(i,j)=qv(i,j)-dep(i,j)
            qi(i,j)=qi(i,j)+dep(i,j)
          endif
         enddo
         enddo
        endif
c
cc
        if (new_ice_sat .eq. 3) then                                    !Lang et al. 2
007b
          do j=1,1
         do i=1,1
           dep(i,j)=0.0
           cnd(i,j)=0.0
           tair(i,j)=(pt(i,j)+tb0)*pi0
           if (tair(i,j).ge.t00) THEN
             iter=0
             y2(i,j)=999.
             tairI(i,j)=tair(i,j)
             do while(iter.lt.10.and.y2(i,j).gt.0.01)
              y1(i,j)=1./(tair(i,j)-c358)
              qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
              dd(i,j)=cp409*y1(i,j)*y1(i,j)
              dm(i,j)=qv(i,j)+qb0-qsw(i,j)
              cnd(i,j)=dm(i,j)/(1.+avcp*dd(i,j)*qsw(i,j))
              tairN(i,j)=tairI(i,j)+avcp*cnd(i,j)*pi0
              iter=iter+1
              if(iter.eq.10) write(6,*) 'no convergence-w'
              y2(i,j)=abs(tairN(i,j)-tair(i,j))
              tair(i,j)=0.5*(tairN(i,j)+tair(i,j))
            enddo
             y1(i,j)=1./(tairN(i,j)-c358)
             qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
             dd(i,j)=cp409*y1(i,j)*y1(i,j)
             dm(i,j)=qv(i,j)+qb0-qsw(i,j)
             cnd(i,j)=dm(i,j)/(1.+avcp*dd(i,j)*qsw(i,j))
cc    ******   condensation or evaporation of qc  ******
            cnd(i,j)=max(-qc(i,j),cnd(i,j))
            pt(i,j)=pt(i,j)+avcp*cnd(i,j)
            qv(i,j)=qv(i,j)-cnd(i,j)
            qc(i,j)=qc(i,j)+cnd(i,j)
           endif
           if (tair(i,j).le.273.16) THEN
cc    ******   deposition or sublimation of qi    ******
            y1(i,j)=1./(tair(i,j)-c358)
            qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
            y2(i,j)=1./(tair(i,j)-c76)
            qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
            y3(i,j)=1.+min((qsw(i,j)-qsi(i,j))/qsi(i,j), 0.20)              !lang
 2007
            if(tair(i,j).le.268.16.and.(qv(i,j)+qb0.gt.y3(i,j)
     1                                                    *qsi(i,j)))then
             iter=0
             y4(i,j)=999.
             tairI(i,j)=tair(i,j)
             do while(iter.lt.10.and.y4(i,j).gt.0.01)
                y2(i,j)=1./(tair(i,j)-c76)
                qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
                dd1(i,j)=cp580*y2(i,j)*y2(i,j)
                dep(i,j)=(qv(i,j)+qb0-y3(i,j)*qsi(i,j))/
     1                              (1.+ascp*dd1(i,j)*y3(i,j)*qsi(i,j))
                tairN(i,j)=tairI(i,j)+ascp*dep(i,j)*pi0
                iter=iter+1
                if(iter.eq.10) write(6,*) 'no convergence-i'
                y4(i,j)=abs(tairN(i,j)-tair(i,j))
```



```
                tair(i,j)=0.5*(tairN(i,j)+tair(i,j))
             enddo
             y2(i,j)=1./(tairN(i,j)-c76)
             qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
             dd1(i,j)=cp580*y2(i,j)*y2(i,j)
             dep(i,j)=(qv(i,j)+qb0-y3(i,j)*qsi(i,j))/(1.+ascp*dd1(i,j)
     1                                                    *qsi(i,j))
            elseif(qv(i,j)+qb0.lt.qsi(i,j).and.qi(i,j).gt.cmin)then
             iter=0
             y4(i,j)=999.
             tairI(i,j)=tair(i,j)
             do while(iter.lt.10.and.y4(i,j).gt.0.01)
                y2(i,j)=1./(tair(i,j)-c76)
                qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
                dd1(i,j)=cp580*y2(i,j)*y2(i,j)
                dep(i,j)=(qv(i,j)+qb0-qsi(i,j))/
     1                                 (1.+ascp*dd1(i,j)*qsi(i,j))
                tairN(i,j)=tairI(i,j)+ascp*dep(i,j)*pi0
                iter=iter+1
                if(iter.eq.10) write(6,*) 'no convergence-i'
                y4(i,j)=abs(tairN(i,j)-tair(i,j))
                tair(i,j)=0.5*(tairN(i,j)+tair(i,j))
             enddo
             y2(i,j)=1./(tairN(i,j)-c76)
             qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
             dd1(i,j)=cp580*y2(i,j)*y2(i,j)
             dep(i,j)=(qv(i,j)+qb0-qsi(i,j))/(1.+ascp*dd1(i,j)*qsi(i,j))
             dep(i,j)=max(-qi(i,j),dep(i,j))
            endif
            pt(i,j)=pt(i,j)+ascp*dep(i,j)
            qv(i,j)=qv(i,j)-dep(i,j)
            qi(i,j)=qi(i,j)+dep(i,j)
          endif
         enddo
         enddo
       endif

         if (new_ice_sat.eq.9) then  !non-iterative
           do j=1,1
             do i=1,1
             dep(i,j)=0.0
             cnd(i,j)=0.0
             tair(i,j)=(pt(i,j)+tb0)*pi0
             if (tair(i,j).ge.t00) THEN
               y1(i,j)=1./(tair(i,j)-c358)
               qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
               dd(i,j)=cp409*y1(i,j)*y1(i,j)
               dm(i,j)=qv(i,j)+qb0-qsw(i,j)
               cnd(i,j)=dm(i,j)/(1.+avcp*dd(i,j)*qsw(i,j))
cc    ******   condensation or evaporation of qc  ******
               cnd(i,j)=max(-qc(i,j),cnd(i,j))
               pt(i,j)=pt(i,j)+avcp*cnd(i,j)
               qv(i,j)=qv(i,j)-cnd(i,j)
               qc(i,j)=qc(i,j)+cnd(i,j)
             endif
             if (tair(i,j).le.273.16) THEN
cc    ******   deposition or sublimation of qi    ******
              y1(i,j)=1./(tair(i,j)-c358)
              qsw(i,j)=rp0*exp(c172-c409*y1(i,j))
              y2(i,j)=1./(tair(i,j)-c76)
              qsi(i,j)=rp0*exp(c218-c580*y2(i,j))
              y3(i,j)=1.+min((qsw(i,j)-qsi(i,j))/qsi(i,j), 0.20)            !lan
g 2007
              y4(i,j)=qsi(i,j)*y3(i,j)
             if(tair(i,j).le.268.16.and.(qv(i,j)+qb0.gt.y4(i,j)))then
               dd1(i,j)=cp580*y2(i,j)*y2(i,j)
               dep(i,j)=(qv(i,j)+qb0-y4(i,j))/(1.+ascp*dd1(i,j)*y4(i,j))
              elseif(qv(i,j)+qb0.lt.qsi(i,j).and.qi(i,j).gt.cmin)then
               dd1(i,j)=cp580*y2(i,j)*y2(i,j)
```

```
             dep(i,j)=(qv(i,j)+qb0-qsi(i,j))/(1.+ascp*dd1(i,j)*qsi(i,j))
             dep(i,j)=max(-qi(i,j),dep(i,j))
            endif
              pt(i,j)=pt(i,j)+ascp*dep(i,j)
              qv(i,j)=qv(i,j)-dep(i,j)
              qi(i,j)=qi(i,j)+dep(i,j)
            endif
            enddo
            enddo
          endif

c
cc
c
c* 10 * psdep : deposition of qs                                    **10**
c* 20 * pgdep : deposition of qg                                    **20**
c$doacross local(j,i)
      do 280 j=1,1
      do 280 i=1,1
       psdep(i,j)=0.0
       pgdep(i,j)=0.0
       pssub(i,j)=0.0
       pgsub(i,j)=0.0
       tair(i,j)=(pt(i,j)+tb0)*pi0
       if (tair(i,j) .lt. t0) then
         if(qc(i,j)+qi(i,j).gt.1.e-5) then
          dlt1(i,j)=1.
         else
          dlt1(i,j)=0.
         endif
         rtair(i,j)=1./(tair(i,j)-c76)
         y2(i,j)=exp(c218-c580*rtair(i,j))
         qsi(i,j)=rp0*y2(i,j)
         esi(i,j)=c610*y2(i,j)
         if(improve.ge.3)then                                      !Lang et al. 20
07b
         SSI(I,J)=(QV(I,J)+QB0)/QSI(I,J)-1.
         IF(DLT1(I,J).EQ.1.) SSI(I,J)=max(SSI(I,J),0.)
         IF(DLT1(I,J).EQ.0.) SSI(I,J)=min(SSI(I,J),0.)
          DM(I,J)=QV(I,J)+QB0-QSI(I,J)
          RSUB1(I,J)=CS580*QSI(I,J)*RTAIR(I,J)*RTAIR(I,J)
          DD1(I,J)=DM(I,J)/(1.+RSUB1(I,J))
           Y3(I,J)=1./TAIR(I,J)
          DD(I,J)=Y3(I,J)*(RN10A*Y3(I,J)-RN10B)+RN10C*TAIR(I,J)/ESI(I,J)
           TAIRC(I,J)=TAIR(I,J)-T0
           tns_funT(i,j)=min(20.,exp(-0.060000*tairc(i,j)))
           Y4(I,J)=R10T*SSI(I,J)*(R101R/ZS(I,J)**2+R102RF/ZS(I,J)**BSH5)
     1                          /DD(I,J) * tns_funT(i,j)             ! Lang et a
l. 2007b
         PSDEP(I,J)=max(-QS(I,J), Y4(I,J))                          !lang 2007
          DD(I,J)=Y3(I,J)*(RN20A*Y3(I,J)-RN20B)+RN10C*TAIR(I,J)/ESI(I,J)
          Y2(I,J)=R191R/ZG(I,J)**2+R192RF/ZG(I,J)**BGH5
         PGDEP(I,J)=MAX(-qg(i,j), R20T*SSI(I,J)*Y2(I,J)/DD(I,J))     !lang 2007
c     ***************************************************************
         IF(DLT1(I,J).EQ.1.)THEN
           Y1(I,J)=MIN(PSDEP(I,J)+PGDEP(I,J), max(0.,DD1(I,J)) )
           IF(PSDEP(I,J).ge.DD1(I,J))THEN
            PSDEP(I,J)=DD1(I,J)
            PGDEP(I,J)=0.
           ENDIF
           IF(DD1(I,J).gt.PSDEP(I,J).and.(PSDEP(I,J)+PGDEP(I,J)).gt.
     1      DD1(I,J)) PGDEP(I,J)=Y1(I,J)-PSDEP(I,J)
         ENDIF
         IF(DLT1(I,J).EQ.0.)THEN
           Y1(I,J)=MAX(PSDEP(I,J)+PGDEP(I,J), min(0.,DD1(I,J)) )
           IF(DD1(I,J).gt.(PSDEP(I,J)+PGDEP(I,J)))THEN
            Y3(I,J)=(PSDEP(I,J)+PGDEP(I,J))
            IF(Y3(I,J).ne.0.0)THEN
             PSDEP(I,J)=PSDEP(I,J)/Y3(I,J)*DD1(I,J)
```



```
             PGDEP(I,J)=PGDEP(I,J)/Y3(I,J)*DD1(I,J)
            ENDIF
           ENDIF
         ENDIF
          PSSUB(i,j)=min(PSDEP(i,j), 0.)
          PSDEP(i,j)=max(PSDEP(i,j), 0.)
          PGSUB(i,j)=min(PGDEP(i,j), 0.)
          PGDEP(i,j)=max(PGDEP(i,j), 0.)
         else                                  ! original
          ssi(i,j)=dlt1(i,j)*((qv(i,j)+qb0)/qsi(i,j)-1.)
          dm(i,j)=qv(i,j)+qb0-qsi(i,j)
          rsub1(i,j)=cs580*qsi(i,j)*rtair(i,j)*rtair(i,j)
          dd1(i,j)=max(dm(i,j)/(1.+rsub1(i,j)),0.0)
          y3(i,j)=1./tair(i,j)
          dd(i,j)=y3(i,j)*(rn10a*y3(i,j)-rn10b)+rn10c*tair(i,j)
     1                                          /esi(i,j)
          y4(i,j)=r10t*ssi(i,j)*(r101r/zs(i,j)**2+r102rf/zs(i,j)
     1                                          **bsh5)/dd(i,j)
          psdep(i,j)=max(y4(i,j), 0.0)
          dd(i,j)=y3(i,j)*(rn20a*y3(i,j)-rn20b)+rn10c*tair(i,j)
     1                                          /esi(i,j)
          y2(i,j)=r191r/zg(i,j)**2+r192rf/zg(i,j)**bgh5
          pgdep(i,j)=max(r20t*ssi(i,j)*y2(i,j)/dd(i,j),0.0)
c     ***************************************************************
          y1(i,j)=min(psdep(i,j)+pgdep(i,j),dd1(i,j))
          pgdep(i,j)=y1(i,j)-psdep(i,j)
         endif

         pt(i,j)=pt(i,j)+ascp*y1(i,j)
         qv(i,j)=qv(i,j)-y1(i,j)
         qs(i,j)=qs(i,j)+psdep(i,j)+pssub(i,j)
         qg(i,j)=qg(i,j)+pgdep(i,j)+pgsub(i,j)
       endif


c* 23 * ern : evaporation of qr                                      **23**
        ern(i,j)=0.0
        if (qr(i,j) .gt. 0.0) then
         tair(i,j)=(pt(i,j)+tb0)*pi0
          rtair(i,j)=1./(tair(i,j)-c358)
           y2(i,j)=exp( c172-c409*rtair(i,j) )
          esw(i,j)=c610*y2(i,j)
          qsw(i,j)=rp0*y2(i,j)
          ssw(i,j)=(qv(i,j)+qb0)/qsw(i,j)-1.
          dm(i,j)=qv(i,j)+qb0-qsw(i,j)
           rsub1(i,j)=cv409*qsw(i,j)*rtair(i,j)*rtair(i,j)
          dd1(i,j)=max(-dm(i,j)/(1.+rsub1(i,j)),0.0)
c           y1(i,j)=r00*qrn(i,j,k)
c         ern(i,j)=(((1.6+124.9*y1(i,j)**.2046)*y1(i,j)**.525)
c    1          /(2.55e6/(p00*qsw(i,j))+5.4e5))*(-dm(i,j)
c    2                                          /(r00*qsw(i,j)))*d2t
           y3(i,j)=1./tair(i,j)
          dd(i,j)=y3(i,j)*(rn30a*y3(i,j)-rn10b)+rn10c*tair(i,j)
     1                                          /esw(i,j)
          y1(i,j)=-r23t*ssw(i,j)*(r231r/zr(i,j)**2+r232rf/
     1                                         zr(i,j)**3)/dd(i,j)
          ern(i,j)=min(dd1(i,j),qr(i,j),max(y1(i,j),0.0))
          pt(i,j)=pt(i,j)-avcp*ern(i,j)
          qv(i,j)=qv(i,j)+ern(i,j)
          qr(i,j)=qr(i,j)-ern(i,j)
         endif
  280  continue
c* 30 * pmltg : evaporation of melting qg                           **30**
c* 33 * pmlts : evaporation of melting qs                           **33**

c$doacross local(j.i)
      do 300 j=1,1
      do 300 i=1,1
        pmlts(i,j)=0.0
```

```
        pmltg(i,j)=0.0
         tair(i,j)=(pt(i,j)+tb0)*pi0
        if (tair(i,j) .ge. t0) then
c           rtair(i,j)=1./(tair(i,j)-c358)
           rtair(i,j)=1./(t0-c358)
            y2(i,j)=exp( c172-c409*rtair(i,j) )
           esw(i,j)=c610*y2(i,j)
           qsw(i,j)=rp0*y2(i,j)
           ssw(i,j)=1.-(qv(i,j)+qb0)/qsw(i,j)
           dm(i,j)=qsw(i,j)-qv(i,j)-qb0
           rsub1(i,j)=cv409*qsw(i,j)*rtair(i,j)*rtair(i,j)
          dd1(i,j)=max(dm(i,j)/(1.+rsub1(i,j)),0.0)
            y3(i,j)=1./tair(i,j)
           dd(i,j)=y3(i,j)*(rn30a*y3(i,j)-rn10b)+rn10c*tair(i,j)
     1                                        /esw(i,j)
           y1(i,j)=r30t*ssw(i,j)*(r191r/zg(i,j)**2+r192rf
     1             /zg(i,j)**bgh5)
     1                        /dd(i,j)
          pmltg(i,j)=min(qg(i,j),max(y1(i,j),0.0))
           y1(i,j)=r33t*ssw(i,j)*(r331r/zs(i,j)**2+r332rf
     1                                       /zs(i,j)**bsh5)/dd(i,j)
          pmlts(i,j)=min(qs(i,j),max(y1(i,j),0.0))
           y1(i,j)=min(pmltg(i,j)+pmlts(i,j),dd1(i,j))
          pmltg(i,j)=y1(i,j)-pmlts(i,j)
          pt(i,j)=pt(i,j)-ascp*y1(i,j)
          qv(i,j)=qv(i,j)+y1(i,j)
          qs(i,j)=qs(i,j)-pmlts(i,j)
          qg(i,j)=qg(i,j)-pmltg(i,j)
        endif
c       if (qv(i,j)+qb0 .le. 0.) qv(i,j)=-qb0
         if(qc(i,j).lt.cmin) qc(i,j)=0.0
         if(qr(i,j).lt.cmin) qr(i,j)=0.0
         if(qi(i,j).lt.cmin) qi(i,j)=0.0
         if(qs(i,j).lt.cmin) qs(i,j)=0.0
         if(qg(i,j).lt.cmin) qg(i,j)=0.0

ccc    store the forcing term and updated in main program??

       dpt(i,j,k)=pt(i,j)
       dqv(i,j,k)=qv(i,j)
       qcl(i,j,k)=qc(i,j)
       qrn(i,j,k)=qr(i,j)
       qci(i,j,k)=qi(i,j)
       qcs(i,j,k)=qs(i,j)
       qcg(i,j,k)=qg(i,j)

  300  continue
ccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccccc
cc     henry:  please take a look  (start)
           sddd=0.
           ssss=0.
           shhh=0.
           sccc=0.
           smmm=0.
           sfff=0.

       do 305 j=1,1
       do 305 i=1,1
         dd(i,j)=max(-cnd(i,j), 0.)
             cnd(i,j)=max(cnd(i,j), 0.)
             dd1(i,j)=max(-dep(i,j), 0.)
             dep(i,j)=max(dep(i,j), 0.)
  305   continue

c D. Posselt Eliminate following statistics section
!        do j=1,1
!         do i=1,1
!        tmpd(i,j,1)=cnd(i,j)
!        tmpd(i,j,2)=dd(i,j)+ern(i,j)
```



```
!        tmpd(i,j,3)=dep(i,j)+pint(i,j)+psdep(i,j)+pgdep(i,j)
!        tmpd(i,j,4)=dd1(i,j)+pmlts(i,j)+pmltg(i,j)
!        tmpd(i,j,5)=rsw(i,j,k)*dt
!        tmpd(i,j,6)=rlw(i,j,k)*dt
!        tmpd(i,j,7)=psmlt(i,j)+pgmlt(i,j)+pimlt(i,j)
!        tmpd(i,j,8)=dt*(psacw(i,j)+piacr(i,j)+psfw(i,j)
!      1             +pgfr(i,j)+dgacw(i,j)+dgacr(i,j)+psacr(i,j))
!      2             -qracs(i,j)+pihom(i,j)+pidw(i,j)
!
!         enddo
!        enddo
!        do nsum=1,8
!           sumd(nsum)=0.0
!        enddo
!
!        call RealSum3D(tmpd,sumd,8)
!
!        scc=sumd(1)
!        see=sumd(2)
!        sddd=sumd(3)
!        ssss=sumd(4)
!        shhh=sumd(5)
!        sccc=sumd(6)
!        smmm=sumd(7)
!        sfff=sumd(8)
! c
!       s_dep(k)=s_dep(k)+sddd
!       s_sub(k)=s_sub(k)+ssss
!       s_qrs(k)=s_qrs(k)+shhh
!       s_qrl(k)=s_qrl(k)+sccc
!       s_mel(k)=s_mel(k)+smmm
!       s_frz(k)=s_frz(k)+sfff
c
!       sc(k)=scc+sc(k)
!       se(k)=see+se(k)
cc     henry:  please take a look  (end)

cc    ***   statistics for convective and anvil regimes   ***********

       if (id .eq. 1) then

                   rdts=rd2t

c$doacross local(j,i)
         do 310 j=1,1
       do 310 i=1,1
            cnd(i,j)=cnd(i,j)*rdts
            dd(i,j)=dd(i,j)*rdts
            pint(i,j)=pint(i,j)*rdts
            pidw(i,j)=pidw(i,j)*rdts
            pimlt(i,j)=pimlt(i,j)*rdts
            pihom(i,j)=pihom(i,j)*rdts
            psmlt(i,j)=psmlt(i,j)*rdts
            pgmlt(i,j)=pgmlt(i,j)*rdts
            psdep(i,j)=psdep(i,j)*rdts
            pgdep(i,j)=pgdep(i,j)*rdts
            pmltg(i,j)=pmltg(i,j)*rdts
            pmlts(i,j)=pmlts(i,j)*rdts
            dd1(i,j)=dd1(i,j)*rdts
            dep(i,j)=dep(i,j)*rdts
            ern(i,j)=ern(i,j)*rdts
            qracs(i,j)=qracs(i,j)*rdts
ctao
                 physc(i,j,k)=cnd(i,j)
                 physe(i,j,k)=dd(i,j)+ern(i,j)
                 physd(i,j,k)=dep(i,j)+pint(i,j)+psdep(i,j)+pgdep(i,j)
                 physs(i,j,k)=dd1(i,j)+pmlts(i,j)+pmltg(i,j)
                 physm(i,j,k)=psmlt(i,j)+pgmlt(i,j)+pimlt(i,j)+qracs(i,j)
                 physf(i,j,k)=psacw(i,j)+piacr(i,j)+psfw(i,j)
```

```
     1              +pgfr(i,j)+dgacw(i,j)+dgacr(i,j)+psacr(i,j)
     2              +pihom(i,j)+pidw(i,j)
ctao

!         dda0(i,j)=rsw(i,j,k) ! cccshie 7/1/02
!         ddb0(i,j)=rlw(i,j,k) ! cccshie 7/1/02
!        y1(i,j)=qc(i,j)+qr(i,j)+qi(i,j)+qs(i,j)+qg(i,j)
! c
!        dm(i,j)=a0*(rho1(k)*ww1(i,j,k)+rho1(k+1)*ww1(i,j,k+1)+
!      1              y0(i,j)*(rho1(k)*wb(k)+rho1(k+1)*wb(k+1)))
!        rq(i,j)=.005*(rho1(k)*(ww1(i,j,k)+wb(k))+
!      1               rho1(k+1)*(ww1(i,j,k+1)+wb(k+1)))/r00
  310    continue

c D. Posselt Eliminate following statistics section

! c    do 1050 kc=1,7
!          kc=4
!        do mt=1,4
! c$doacross local(j,i)
!        do j=1,1
!        do i=1,1
!         ibz(i,j,mt)=0
!          if(ics5(i,j,mt).eq.1) ibz(i,j,mt)=1
!        enddo
!        enddo
!        enddo
!
! c$doacross local(j,i)
!       do 315 j=1,1
!       do 315 i=1,1
!           ibz(i,j,1)=1
!   315    continue
!
!        do mt=1,4
!
!        do 330 j=1,1
!        do 330 i=1,1
!          if(kc.eq.4) go to 330
!          if(kc.le.3) go to 36
!           if (rq(i,j).gt.rby(kc)) ibz(i,j,mt)=0
!           go to 330
!    36       if (rq(i,j).lt.rby(kc)) ibz(i,j,mt)=0
!   330    continue
!        enddo
!
! c$doacross local(mt,ij,sww,scc,see,a1,a2,a3,a4,a5,a6,a7,a8,a9,
! c$&    a10,a11,a12,a13,a14,a15,a16,a17,a18,a19,a20,a21,a22,a23,a24,
! c$&    a25,a26,a27,a28,a29,a30,a31,a32,a33,a34,a35,a36,a37,a38,a39,
! c$&    a40,a41,a42,a43,a44,a45,a46,a47,a48,a49,a50,a51,a52)
!        do 350 mt=1,4
!
!         sww=0.0
!         scc=0.0
!         see=0.0
!         a1=0.0
!         a2=0.0
!         a3=0.0
!         a4=0.0
!         a5=0.0
!         a6=0.0
!         a7=0.0
!         a8=0.0
!         a9=0.0
!         a10=0.0
!         a11=0.0
!         a12=0.0
!         a13=0.0
!         a14=0.0
```



```
!         a15=0.0
!         a16=0.0
!         a17=0.0
!         a18=0.0
!         a19=0.0
!         a20=0.0
!         a21=0.0
!         a22=0.0
!         a23=0.0
!         a24=0.0
!         a25=0.0
!         a26=0.0
!         a27=0.0
!         a28=0.0
!         a29=0.0
!         a30=0.0
!         a31=0.0
!         a32=0.0
!         a33=0.0
!         a34=0.0
!         a35=0.0
!         a36=0.0
!         a37=0.0
!         a38=0.0
!         a39=0.0
!         a40=0.0
!         a41=0.0
!         a42=0.0
!         a43=0.0
!         a44=0.0
!         a45=0.
!         a46=0.
!         a47=0.
!         a48=0.
!         a49=0.
!         a50=0.
!         a51=0.
!         a52=0.
!         a54=0.
!         a55=0.
!
!           do kk=1,55
!             do j=1,1
!               do i=1,1
!                 tmpd(i,j,kk)=0.0
!               enddo
!             enddo
!           enddo
!           do j=1,1
!             do i=1,1
!
!            if(ibz(i,j,mt).eq.1) then
!              tmpd(i,j,51)=dm(i,j)
!              tmpd(i,j,52)=cnd(i,j)*asss(i,j)
!              tmpd(i,j,53)=(dd(i,j)+ern(i,j))*asss(i,j)
!              tmpd(i,j, 1)=(pihom(i,j)+pidw(i,j))*asss(i,j)
!              tmpd(i,j, 2)=pint(i,j)*asss(i,j)
!              tmpd(i,j, 3)=pgfr(i,j)*asss(i,j)
!              tmpd(i,j, 4)=psaut(i,j)*asss(i,j)
!              tmpd(i,j, 5)=psaci(i,j)*asss(i,j)
!              tmpd(i,j, 6)=psacw(i,j)*asss(i,j)
!              tmpd(i,j, 7)=praci(i,j)*asss(i,j)
!              tmpd(i,j, 8)=piacr(i,j)*asss(i,j)
!              tmpd(i,j, 9)=praut(i,j)*asss(i,j)
!              tmpd(i,j,10)=pracw(i,j)*asss(i,j)
!              tmpd(i,j,11)=psfw(i,j)*asss(i,j)
!              tmpd(i,j,12)=psfi(i,j)*asss(i,j)
!              tmpd(i,j,13)=(pgacs(i,j)+dgacs(i,j))*asss(i,j)
!              tmpd(i,j,14)=dgacw(i,j)*asss(i,j)
```

```
!               tmpd(i,j,15)=dgaci(i,j)*asss(i,j)
!               tmpd(i,j,16)=dgacr(i,j)*asss(i,j)
!               tmpd(i,j,17)=pmltg(i,j)*asss(i,j)
!               tmpd(i,j,18)=dep(i,j)*asss(i,j)
!               tmpd(i,j,19)=pracs(i,j)*asss(i,j)
!               tmpd(i,j,20)=psacr(i,j)*asss(i,j)
!               tmpd(i,j,21)=pmlts(i,j)*asss(i,j)
!               tmpd(i,j,22)=psmlt(i,j)*asss(i,j)
!               tmpd(i,j,23)=pgmlt(i,j)*asss(i,j)
!               tmpd(i,j,24)=psdep(i,j)*asss(i,j)
!               tmpd(i,j,25)=pimlt(i,j)*asss(i,j)
!                 tmpd(i,j,26)=pgdep(i,j)*asss(i,j)
!                 tmpd(i,j,27)=dd1(i,j)*asss(i,j)
!                 tmpd(i,j,28)=praci(i,j)*dlt3(i,j)*asss(i,j)
!                 tmpd(i,j,29)=piacr(i,j)*dlt3(i,j)*asss(i,j)
! !xp             tmpd(i,j,30)=psacr(i,j)*dlt2(i,j)*asss(i,j)
!                       tmpd(i,j,30)=psacr(i,j)*asss(i,j)
!                 tmpd(i,j,31)=qracs(i,j)*asss(i,j)
!                 tmpd(i,j,32)=psacw(i,j)*dlt4(i,j)*asss(i,j)
!                 tmpd(i,j,33)=qcl(i,j,k)*asss(i,j)
!                 tmpd(i,j,34)=qrn(i,j,k)*asss(i,j)
!                 tmpd(i,j,35)=qci(i,j,k)*asss(i,j)
!                 tmpd(i,j,36)=qcs(i,j,k)*asss(i,j)
!                 tmpd(i,j,37)=qcg(i,j,k)*asss(i,j)
!                 tmpd(i,j,38)=ern(i,j)*asss(i,j)
!                 tmpd(i,j,39)=wgacr(i,j)*asss(i,j)
!                 tmpd(i,j,40)=qsacw(i,j)*asss(i,j)
!                 tmpd(i,j,41)=dda0(i,j)*asss(i,j)
!                 tmpd(i,j,42)=ddb0(i,j)*asss(i,j)
!                 tmpd(i,j,43)=(qv(i,j)+qa1(k)-qa(k))*asss(i,j)
!                 tmpd(i,j,44)=(pt(i,j)+ta1(k)-ta(k))*asss(i,j)
!                 tmpd(i,j,45)=asss(i,j)
!                 tmpd(i,j,46)=y1(i,j)*asss(i,j)
!                 tmpd(i,j,47)=(psacw(i,j)+psfw(i,j)+dgacw(i,j)+piacr(i,j)
!      1                       +dgacr(i,j)+psacr(i,j)+pgfr(i,j)-qracs(i,j)
!      2                       +pihom(i,j)-pimlt(i,j)+pidw(i,j))*asss(i,j)
!                 tmpd(i,j,48)=(y1(i,j)-qcl1(i,j,k)-qrn1(i,j,k)-qci1(i,j,k)
!      1                        -qcs1(i,j,k)-qcg1(i,j,k))*asss(i,j)
!                 tmpd(i,j,49)=(qv(i,j)-dqv1(i,j,k))*asss(i,j)
!                 tmpd(i,j,50)=(pt(i,j)-dpt1(i,j,k))*asss(i,j)
!                 tmpd(i,j,54)=pimm(i,j)*asss(i,j)
!                 tmpd(i,j,55)=pcfr(i,j)*asss(i,j)
!               endif
!             enddo
!           enddo
!           do nsum=1,55
!             sumd(nsum)=0.0
!           enddo
!
!           call RealSum3D(tmpd,sumd,55)
!
!           sww=sumd(51)
!           scc=sumd(52)
!           see=sumd(53)
!           a1 =sumd( 1)
!           a2 =sumd( 2)
!           a3 =sumd( 3)
!           a4 =sumd( 4)
!           a5 =sumd( 5)
!           a6 =sumd( 6)
!           a7 =sumd( 7)
!           a8 =sumd( 8)
!           a9 =sumd( 9)
!           a10=sumd(10)
!           a11=sumd(11)
!           a12=sumd(12)
!           a13=sumd(13)
!           a14=sumd(14)
!           a15=sumd(15)
```



```
!           a16=sumd(16)
!           a17=sumd(17)
!           a18=sumd(18)
!           a19=sumd(19)
!           a20=sumd(20)
!           a21=sumd(21)
!           a22=sumd(22)
!           a23=sumd(23)
!           a24=sumd(24)
!           a25=sumd(25)
!           a26=sumd(26)
!           a27=sumd(27)
!           a28=sumd(28)
!           a29=sumd(29)
!           a30=sumd(30)
!           a31=sumd(31)
!           a32=sumd(32)
!           a33=sumd(33)
!           a34=sumd(34)
!           a35=sumd(35)
!           a36=sumd(36)
!           a37=sumd(37)
!           a38=sumd(38)
!           a39=sumd(39)
!           a40=sumd(40)
!           a41=sumd(41)
!           a42=sumd(42)
!           a43=sumd(43)
!           a44=sumd(44)
!           a45=sumd(45)
!           a46=sumd(46)
!           a47=sumd(47)
!           a48=sumd(48)
!           a49=sumd(49)
!           a50=sumd(50)
!           a54=sumd(54)
!           a55=sumd(55)
!
!
!       smf0(k,mt,kc)=sww+smf0(k,mt,kc)
!       coc(k,mt,kc)=scc+coc(k,mt,kc)
!       coe(k,mt,kc)=see+coe(k,mt,kc)
!       thom(k,mt,kc)=thom(k,mt,kc)+a1
!       tdw(k,mt,kc)=tdw(k,mt,kc)+a2
!       tmlt(k,mt,kc)=tmlt(k,mt,kc)+a3
!       saut(k,mt,kc)=saut(k,mt,kc)+a4
!       saci(k,mt,kc)=saci(k,mt,kc)+a5
!       sacw(k,mt,kc)=sacw(k,mt,kc)+a6
!       raci(k,mt,kc)=raci(k,mt,kc)+a7
!       tacr(k,mt,kc)=tacr(k,mt,kc)+a8
!       raut(k,mt,kc)=raut(k,mt,kc)+a9
!       racw(k,mt,kc)=racw(k,mt,kc)+a10
!       sfw(k,mt,kc)=sfw(k,mt,kc)+a11
!       sfi(k,mt,kc)=sfi(k,mt,kc)+a12
!       gacs(k,mt,kc)=gacs(k,mt,kc)+a13
!       gacw(k,mt,kc)=gacw(k,mt,kc)+a14
!       gaci(k,mt,kc)=gaci(k,mt,kc)+a15
!       gacr(k,mt,kc)=gacr(k,mt,kc)+a16
!       gwet(k,mt,kc)=gwet(k,mt,kc)+a17
!       gaut(k,mt,kc)=gaut(k,mt,kc)+a18
!       racs(k,mt,kc)=racs(k,mt,kc)+a19
!       sacr(k,mt,kc)=sacr(k,mt,kc)+a20
!       gfr(k,mt,kc)=gfr(k,mt,kc)+a21
!       smlt(k,mt,kc)=smlt(k,mt,kc)+a22
!       gmlt(k,mt,kc)=gmlt(k,mt,kc)+a23
!       sdep(k,mt,kc)=sdep(k,mt,kc)+a24
!       ssub(k,mt,kc)=ssub(k,mt,kc)+a25
!       gsub(k,mt,kc)=gsub(k,mt,kc)+a26
!       pern(k,mt,kc)=pern(k,mt,kc)+a27
```

```
!       d3ri(k,mt,kc)=d3ri(k,mt,kc)+a28
!       d3ir(k,mt,kc)=d3ir(k,mt,kc)+a29
!       d2sr(k,mt,kc)=d2sr(k,mt,kc)+a30
!       d2rs(k,mt,kc)=d2rs(k,mt,kc)+a31
!       gdry(k,mt,kc)=gdry(k,mt,kc)+a32
!       erns(k,mt,kc)=erns(k,mt,kc)+a38
!       wgrs(k,mt,kc)=wgrs(k,mt,kc)+a39
!       qsws(k,mt,kc)=qsws(k,mt,kc)+a40
!       srsw(k,mt,kc)=srsw(k,mt,kc)+a41
!       srlw(k,mt,kc)=srlw(k,mt,kc)+a42
!       q1t(k,mt,kc)=q1t(k,mt,kc)+a47
!       qc0(k,mt,kc)=a33
!       qr0(k,mt,kc)=a34
!       qi0(k,mt,kc)=a35
!       qs0(k,mt,kc)=a36
!       qg0(k,mt,kc)=a37
!       qv0(k,mt,kc)=a43
!       tt0(k,mt,kc)=a44
!       sgpt(k,mt,kc)=a45
!       tsqq(k,mt,kc)=a46
!       sqhdt(k,mt,kc)=sqhdt(k,mt,kc)+a48
!       sqvdt(k,mt,kc)=sqvdt(k,mt,kc)+a49
!       sqtdt(k,mt,kc)=sqtdt(k,mt,kc)+a50
!         pim(K,MT,KC)=pim(K,MT,KC)+a54
!         cfr(K,MT,KC)=cfr(K,MT,KC)+a55
!       sqc0(k,mt,kc)=sqc0(k,mt,kc)+qc0(k,mt,kc)
!       sqr0(k,mt,kc)=sqr0(k,mt,kc)+qr0(k,mt,kc)
!       sqi0(k,mt,kc)=sqi0(k,mt,kc)+qi0(k,mt,kc)
!       sqs0(k,mt,kc)=sqs0(k,mt,kc)+qs0(k,mt,kc)
!       sqg0(k,mt,kc)=sqg0(k,mt,kc)+qg0(k,mt,kc)
!       sqv0(k,mt,kc)=sqv0(k,mt,kc)+qv0(k,mt,kc)
!       stt0(k,mt,kc)=stt0(k,mt,kc)+tt0(k,mt,kc)
!       ssgpt(k,mt,kc)=ssgpt(k,mt,kc)+sgpt(k,mt,kc)
!       tsqq1(k,mt,kc)=tsqq1(k,mt,kc)+tsqq(k,mt,kc)
!   350   continue

      endif

cc    ******************************************
c D. Posselt Eliminate following statistics section
!        if(id.eq.1) then
c-------------------------------------------------------------------------
c    condensation:  cnd(ij)
c    evaporation:   dd(ij)+ern(ij)
c    deposition:    dep(ij)+psdep(ij)+pgdep(ij)+pint(ij)
c    sublimation:   dd1(ij)+pmlts(ij)+pmltg(ij)
c    melting:       psmlt(ij)+pgmlt(ij)+pimlt(ij)+qracs(ij)
c    freezing:      pihom(ij)+pidw(ij)+psacw(ij)+psfw(ij)+dgacw(ij)
c                   +piacr(ij)+dgacr(ij)+psacr(ij)+pgfr(ij)
c    mass flux:     dm(ij)
c    cloud water:   qc(ij)
c    rain:
c    cloud ice
c    snow
c    hail/graupel:
c-------------------------------------------------------------------------
! c$doacross local(j,i,a1,a2,a3,a11,a22,a33,zdry,a44,zwet)
!        do 42 j=1,1
!        do 42 i=1,1
!       cnd(i,j)=cnd(i,j)*rft
!       ern(i,j)=(ern(i,j)+dd(i,j))*rft
!       y1(i,j)=(dep(i,j)+psdep(i,j)+pgdep(i,j)+pint(i,j))*rft
!       y2(i,j)=(dd1(i,j)+pmlts(i,j)+pmltg(i,j))*rft
!       y3(i,j)=(psmlt(i,j)+pgmlt(i,j)+pimlt(i,j)+qracs(i,j))*rft
!       y4(i,j)=(pihom(i,j)+pidw(i,j)+psacw(i,j)+psfw(i,j)
!      1        +dgacw(i,j)+piacr(i,j)+dgacr(i,j)+psacr(i,j)
!      2        +pgfr(i,j))*rft
!        y5(i,j)=dm(i,j)
!        a1=1.e6*r00*qr(i,j)
```



```
!       a2=1.e6*r00*qs(i,j)
!       a3=1.e6*r00*qg(i,j)
!       a11=ucor*(max(1.e-5,a1))**1.75
!         tns_funT(i,j)=1.
!         tairc(i,j)=min(0.,max(-50.,tair(i,j)-t0))                    !2007b
!         if(improve.ge.3) tns_funT(i,j)=exp(0.060000*tairc(i,j)*0.75)  !2007b
!       a22=ucos*(max(1.e-5,a2))**1.75 *tns_funT(i,j)                 !2007b
!       a33=ucog*(max(1.e-5,a3))**1.75
!       zdry=max(1.,a11+a22+a33)
!       dbz(i,j)=10.*log10(zdry)
!       if (tair(i,j).ge.273.16) then
!         a44=a11+uwet*(a22+a33)**.95
!         zwet=max(1.,a44)
!         dbz(i,j)=10.*log10(zwet)
!       endif
!       dbz(i,j)=dbz(i,j)*asss(i,j)
!       qc(i,j)=qc(i,j)*asss(i,j)
!       qr(i,j)=qr(i,j)*asss(i,j)
!       qi(i,j)=qi(i,j)*asss(i,j)
!       qs(i,j)=qs(i,j)*asss(i,j)
!       qg(i,j)=qg(i,j)*asss(i,j)
! c store microphysical process rates
! c             if (asss(i,j).ne.0.) THEN
!               physc(i,j,k)=cnd(i,j)*asss(i,j)
!               physe(i,j,k)=ern(i,j)*asss(i,j)
!               physd(i,j,k)=y1(i,j)*asss(i,j)
!               physs(i,j,k)=y2(i,j)*asss(i,j)
!               physm(i,j,k)=y3(i,j)*asss(i,j)
!               physf(i,j,k)=y4(i,j)*asss(i,j)
! c             endif
!
!
!    42  continue
!
!        do j=1,1
!        do i=1,1
!         tmpd(i,j,1)=0.0
!         tmpd(i,j,2)=0.0
!       if(rq(i,j) .ge. 0.) tmpd(i,j,1)=cnd(i,j)
!       if(rq(i,j) .lt. 0.) tmpd(i,j,2)=ern(i,j)
!        enddo
!        enddo
!        sumd(1)=0.0
!        sumd(2)=0.0
!
!        call RealSum3D(tmpd,sumd,2)
!
!        scu1(k)=scu1(k)+sumd(1)
!        sed1(k)=sed1(k)+sumd(2)
!
!        do 40 j=1,1
!        do 40 i=1,1
!
!         IF(dbz(i,j).GE.0.) IZZ=int(dbz(i,j)/2.+0.5)
!         IF(dbz(i,j).LT.0.) IZZ=int(dbz(i,j)/2.-0.5)
!
!         WW=0.01*(ww1(i,j,k)+ww1(i,j,k+1))/2.     ! W at theta levels
!         IF(WW.GE.0.) IWW=int(WW+0.5)
!         IF(WW.LT.0.) IWW=int(WW-0.5)
!
!        if(iww.ge.-20 .and. iww.le.40) then
!             iw1=iww+21
!           if (ics5(i,j,2) .eq. 1) then
!             cf1(iw1,k)=cf1(iw1,k)+cnd(i,j)
!             cf2(iw1,k)=cf2(iw1,k)+ern(i,j)
!             cf3(iw1,k)=cf3(iw1,k)+y1(i,j)
!             cf4(iw1,k)=cf4(iw1,k)+y2(i,j)
!             cf5(iw1,k)=cf5(iw1,k)+y3(i,j)
!             cf6(iw1,k)=cf6(iw1,k)+y4(i,j)
```

```
!              cf7(iw1,k)=cf7(iw1,k)+y5(i,j)
!              cf8(iw1,k)=cf8(iw1,k)+qc(i,j)
!              cf9(iw1,k)=cf9(iw1,k)+qr(i,j)
!              cf10(iw1,k)=cf10(iw1,k)+qi(i,j)
!              cf11(iw1,k)=cf11(iw1,k)+qs(i,j)
!              cf12(iw1,k)=cf12(iw1,k)+qg(i,j)
!              cfnum(iw1,k)=cfnum(iw1,k)+1
!            elseif (ics5(i,j,3) .eq. 1) then
!              cfs1(iw1,k)=cfs1(iw1,k)+cnd(i,j)
!              cfs2(iw1,k)=cfs2(iw1,k)+ern(i,j)
!              cfs3(iw1,k)=cfs3(iw1,k)+y1(i,j)
!              cfs4(iw1,k)=cfs4(iw1,k)+y2(i,j)
!              cfs5(iw1,k)=cfs5(iw1,k)+y3(i,j)
!              cfs6(iw1,k)=cfs6(iw1,k)+y4(i,j)
!              cfs7(iw1,k)=cfs7(iw1,k)+y5(i,j)
!              cfs8(iw1,k)=cfs8(iw1,k)+qc(i,j)
!              cfs9(iw1,k)=cfs9(iw1,k)+qr(i,j)
!              cfs10(iw1,k)=cfs10(iw1,k)+qi(i,j)
!              cfs11(iw1,k)=cfs11(iw1,k)+qs(i,j)
!              cfs12(iw1,k)=cfs12(iw1,k)+qg(i,j)
!              cfsnum(iw1,k)=cfsnum(iw1,k)+1
!            endif
!          endif
!
!        if(izz.ge.-5 .and. izz.le.35) then   ! restrict to -10 dbZ echo region
!             izz=izz+6
!             cfz(iw1,k)=cfz(iw1,k)+1.
!                  if(iww.ge.-20 .and. iww.le.40) then
!             iw1=iww+21
!             cfw(iw1,k)=cfw(iw1,k)+1.
!             endif
!          endif
!
!    40  continue
!
!        endif

 1000 continue

c     ************************************************************
c D. Posselt Eliminate following statistics section
!       if (id .eq. 1) then
!          do j=1,1
!           do i=1,1
!           tmpd(i,j,1)=ics(i,j,2)
!           tmpd(i,j,2)=ics(i,j,3)
!           enddo
!          enddo
!          sumd(1)=0.0
!          sumd(2)=0.0
!
!          call RealSum3D(tmpd,sumd,2)
!
!          lc=sumd(1)
!          ls=sumd(2)
!
!       if (lc .eq. 0) lc=1000000
!       if (ls .eq. 0) ls=1000000
!        do 400 mt=1,3
!       a1=rijl2
!        if (mt .eq. 2) a1=1./float(lc)
!        if (mt .eq. 3) a1=1./float(ls)
!
!        do k=kt1,kt2
!          do j=1,1
!          do i=1,1
!             if(ics5(i,j,mt).eq.1) then
!              tmpd(i,j,1)=dpt(i,j,k)
!              tmpd(i,j,2)=dqv(i,j,k)
```



```
!               else
!              tmpd(i,j,1)=0.0
!              tmpd(i,j,2)=0.0
!             endif
!          enddo
!          enddo
!          sumd(1) = 0.0
!          sumd(2) = 0.0
!
!          call RealSum3D(tmpd,sumd,2)
!
!          b1(k)=sumd(1)
!          b2(k)=sumd(2)
!        enddo
!
!        do 430 k=kt1,kt2
!           tb00(k,mt)=b1(k)*a1
!           qb00(k,mt)=b2(k)*a1
!   430  continue
!   400 continue
!       endif

      d2t=d22t

c      call satdt

      deallocate(tmpd)
      deallocate(sumd)
      return
      end
```