RegCM5 parameterizations

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INSTALLED!
COMPILED!!!
IT RUNS!!!!!
and NOW?

```
!----------------------------------------------------------------------
!
! This README details namelist parameters for RegCM V5.0
!
!----------------------------------------------------------------------
!
! Choice of the dynamical core
!
 &coreparam
 idynamic = 1,  ! Choice of dynamical core
                ! 1 = MM4 hydrostatical core
                ! 2 = MM5 NON hydrostatical core
                ! 3 = MOLOCH NON hydrostatical core
 /
!
! Domain dimension
!
 &dimparam
 iy     = 34,   ! This is number of points in the N/S direction
 jx     = 48,   ! This is number of points in the E/W direction
 kz     = 18,   ! Number of vertical levels
 dsmin  = 0.01, ! Minimum sigma spacing (only used if kz is not 14, 18, 23, 41)
 dsmax  = 0.05, ! Maximum sigma spacing (only used if kz is not 14, 18, 23, 41)
 nsg    = 1,    ! For subgridding, number of points to decompose. If nsg=1,
                ! no subgridding is performed. CLM does NOT work as of now with
                ! subgridding enabled.
 njxcpus = -1,  ! Number of CPUS to be used in the jx (lon) dimension.
                ! If <=0 , the executable will try to figure out a suitable
                ! decomposition.
 niycpus = -1,  ! Number of CPUS to be used in the iy (lat) dimension.
                ! If <=0 , the executable will try to figure out a suitable
                ! decomposition.
 /
!
! Domain geolocation
!
 &geoparam
 iproj = 'LAMCON', ! Domain cartographic projection. Supported values are:
                   ! 'LAMCON', Lambert conformal.
                   ! 'POLSTR', Polar stereographic.
                   ! 'NORMER', Normal  Mercator.
                   ! 'ROTMER', Rotated Mercator.
                   ! 'ROTLLR', Rotated Latitude/Longitude.
 ds = 60.0,        ! Grid point horizontal resolution in km
                   ! If negative, horizontal resolution in degrees
 ptop = 5.0,       ! Pressure of model top in cbar
```

THE PARAMETERIZATIONS


icup
ibltyp
ipptls

- LAND SURFACE
- RADIATION
- BOUNDARY LAYER
- MOISTURE
- CONVECTION
- CLOUD FRACTION

- LAND SURFACE: BATS (Dickinson 1993) , CLM4.5 (Collins 2013)
- RADIATION: CCM3 (Kiehl 1996), RRTM (Mlawer1997)
- BOUNDARY LAYER
- MOISTURE
- CONVECTION
- CLOUD FRACTION

BOUNDARY LAYER SCHEME

Resolve turbulent vertical fluxes of heat, momentum, and constituents such as moisture within the planetary boundary layer

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LOCAL

$\nabla u, \nabla v, \nabla \theta, \ldots$

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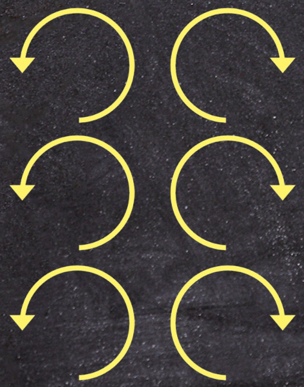

BOUNDARY LAYER SCHEME

Resolve turbulent vertical fluxes of **heat**, **momentum**, and constituents such as **moisture** within the planetary boundary layer

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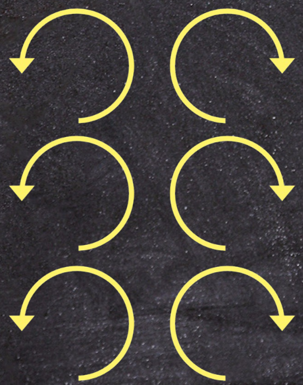
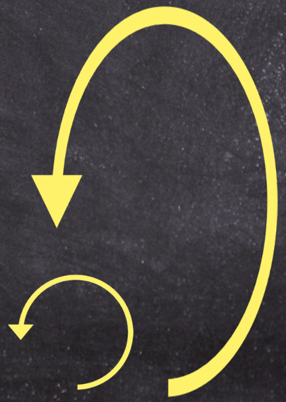


NON-LOCAL



$\nabla u, \nabla v, \nabla \theta, \ldots$

BOUNDARY LAYER SCHEME

```
ibltyp  =        !   0 => Frictionless
                 !   1 => Holtslag PBL (Holtslag, 1990)
                 !   2 => UW PBL (Bretherton and McCaa, 2004)
```

ibltyp = 1 Holtslag PBL (Holtslag, 1983)

NON-LOCAL scheme.

Origin of turbulent mixing: the surface heating due to incoming solar radiation and the related static instability.

Calculates *h (from wind,* θ_v , Ri_c*)* → diffusion coefficient = f(surface conditions, fractional height)

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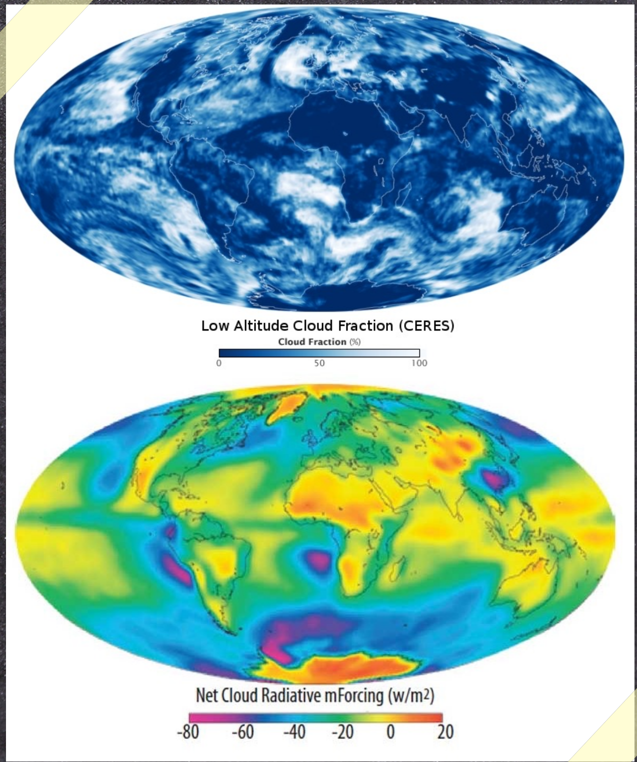
ONLY CONSIDERS SURFACE-RELATED SOURCES OF TURBULENCE

iblltyp = 2 UW PBL Bretherton et al. (2004)

Originally implemented to allow RegCM to simulate stratocumulus and coastal fog.



iblty p = 2 UW PBL Bretherton et al. (2004)

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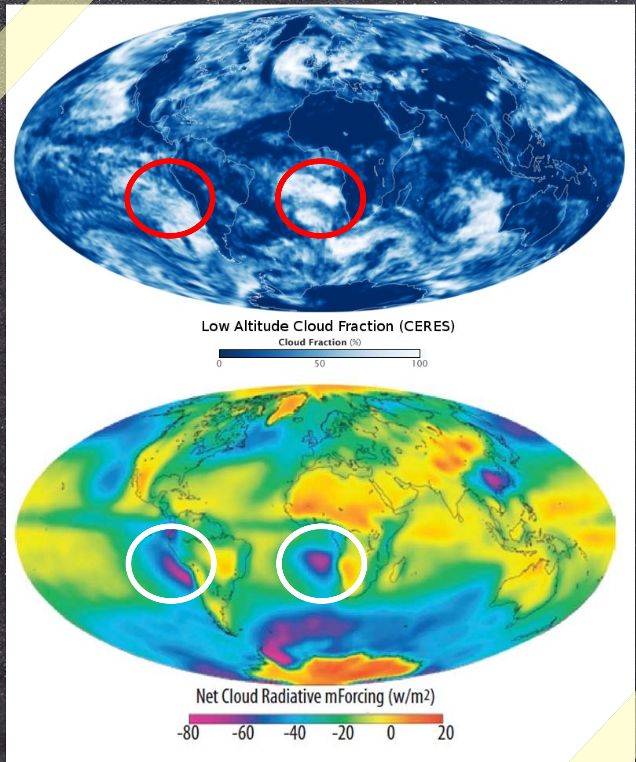


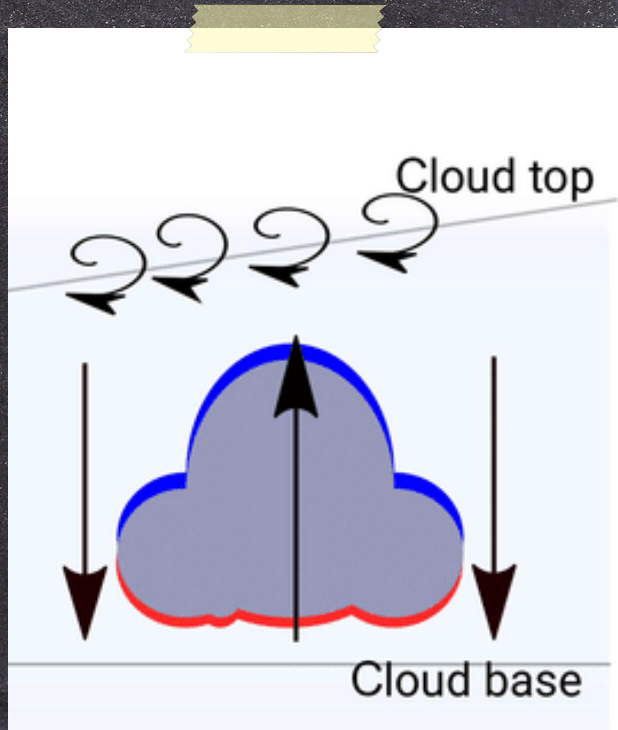
According to Bony and Dufresne (2005) they are the main responsible for the model differences in representing the cloud feedbacks.

ibltyp = 2 UW PBL Bretherton et al. (2004)

At each model timestep, the UW model does the following:

1. determines the boundary layer height, *h*
2. calculates the surface TKE
3. predicts the change in TKE due to PBL processes
4. determines the diffusivities at each height
5. predicts the change in each prognostic quantity due to vertical convergence of turbulent fluxes.

ibltyp = 2 UW PBL Bretherton et al. (2004)



accounts for the production of turbulence by cloud-top radiative cooling, which leads to the formation of stratocumulus clouds.

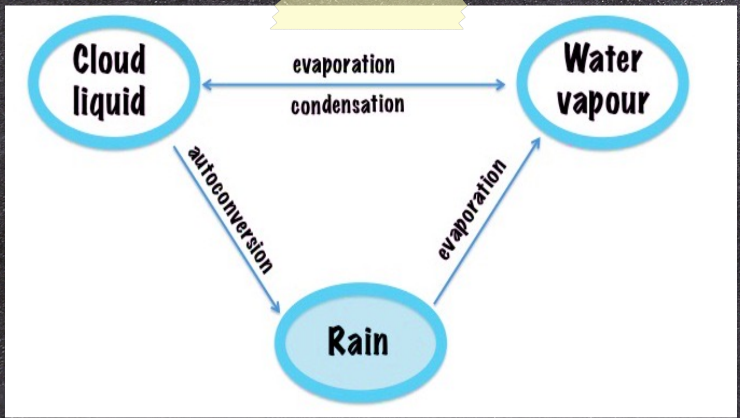
MOISTURE SCHEME

```
ipptls  =        !  1 => Explicit moisture (SUBEX; Pal et al 2000)
                 !  2 => Explicit moisture Nogherotto/Tompkins
                 !  3 => Explicit moisture WSM5
                 !  4 => Explicit moisture WSM7
                    5 => Explicit moisture WDM7
```

NEW!

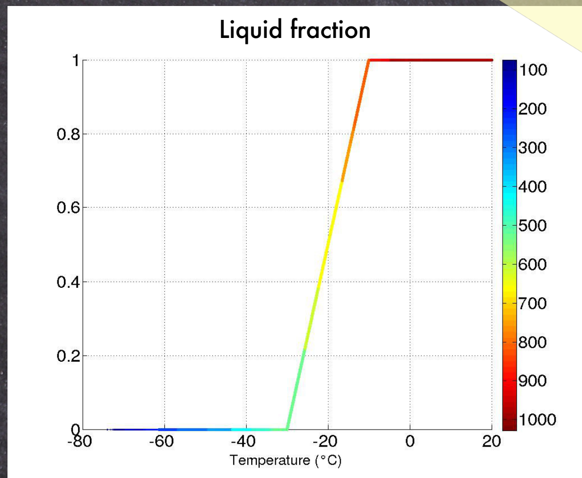
TO BE TESTED!

ipptls = 1 SUBEX SCHEME Pal et al (2000)



* 1 prognostic variable for cloud water
* divided into ice and liquid according to temperature
* 1 diagnostic variable for rain which falls out instantaneously

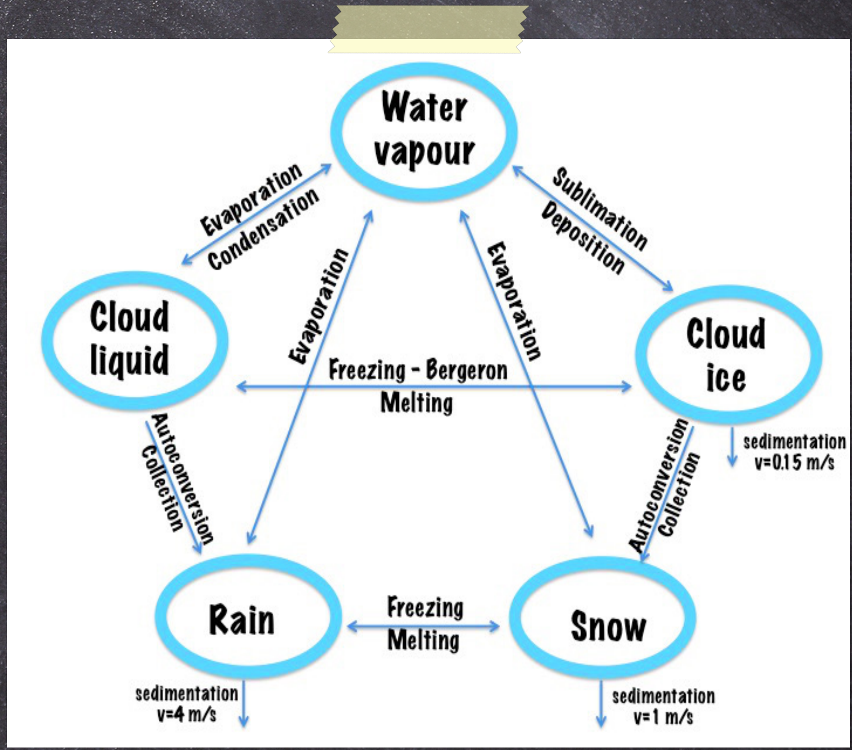
$$f_l = \frac{q_l}{q_l + q_i}$$



ipptls = 2 NOTO SCHEME

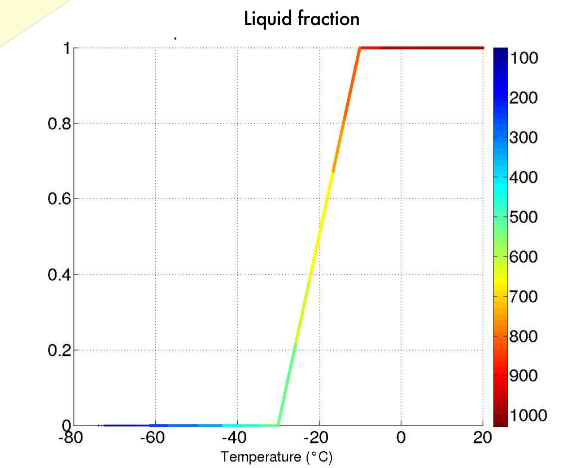
Nogherotto et al (2016)

* Numerics of the Integrated Forecast System (IFS's ECMWF scheme)
* 5 prognostic variables;
* Implicit numerics that allows longer time-steps;
* Flexibility: chance of inserting easily new variables;
* Conservation of water and energy ensured at the end of each timestep;

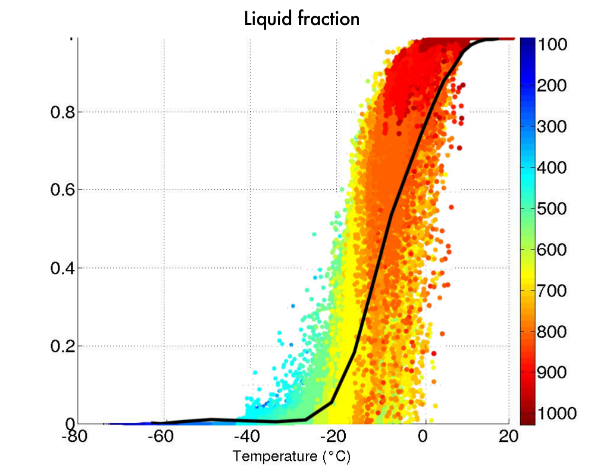


ipptls = 2 NOTO SCHEME

SUBEX SCHEME

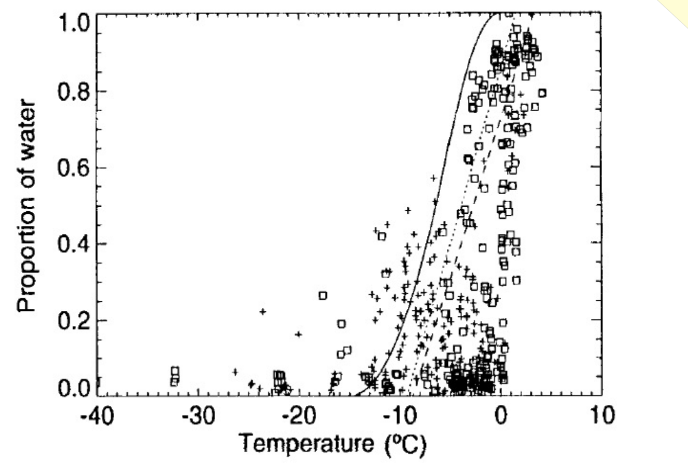


NOTO SCHEME



Nogherotto et al (2015)

OBS

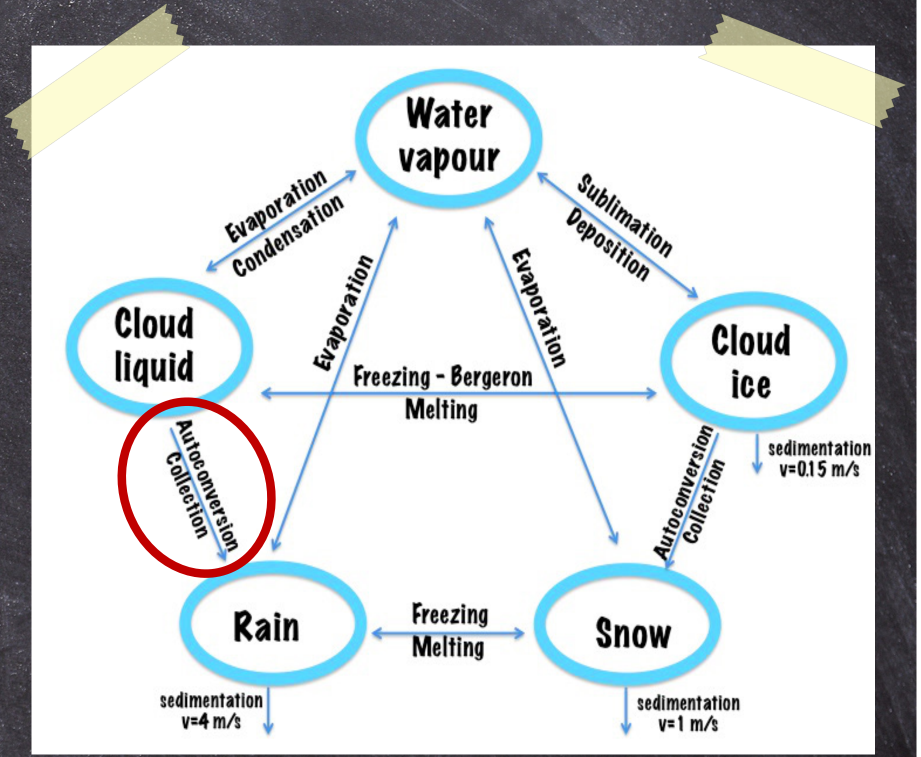


Rotstayn (1997)

ipptls = 2 NOTO SCHEME

4 different Autoconversion schemes (RAIN formation):

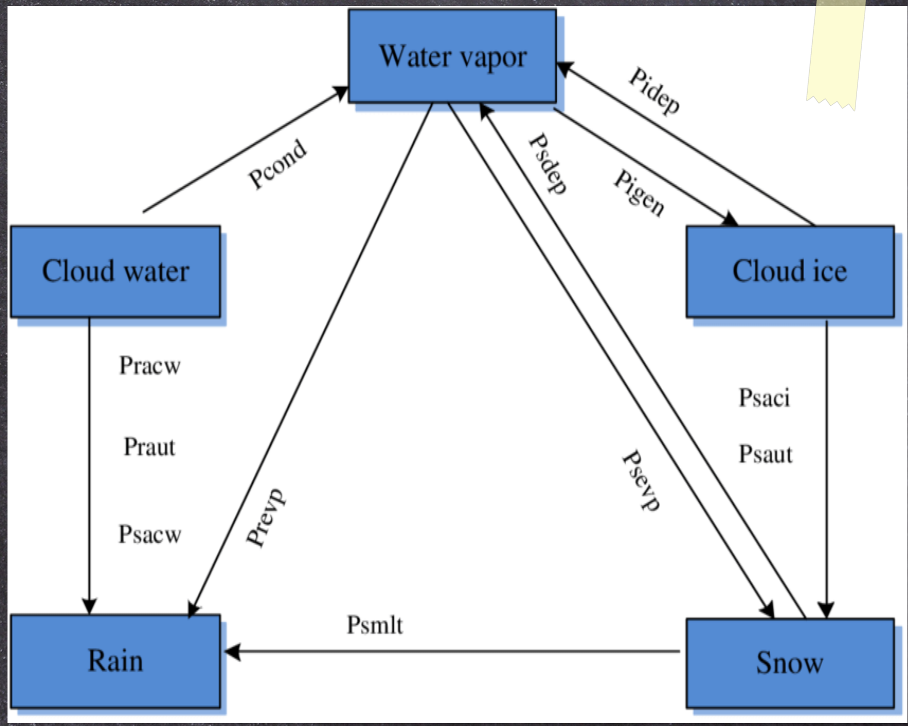
1. Kessler (1969)
2. Sundqvist (1978)
3. PIncus and Klein (2000)
4. Khairoutdinov and Kogan (2000)



Ice autoconversion uses an exponential approach

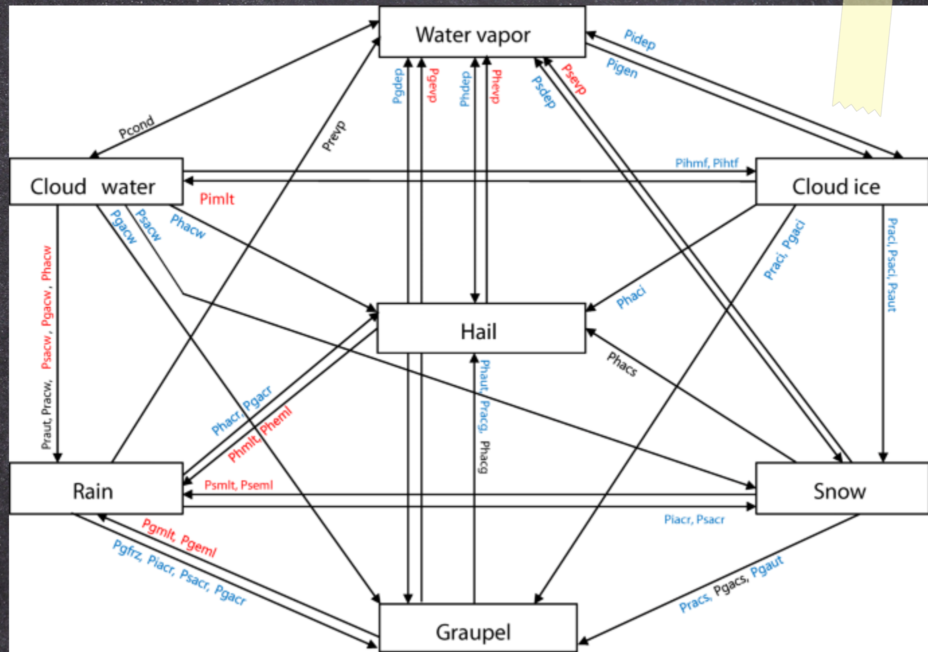
ipptls = 3 WSM5 SCHEME Hong et al (2004)

* Single moment 5-class microphysics scheme of the WRF model.
* Separately treats ice and water saturation
* distribution of particle size
* definition of the number of ice crystals based on ice mass content rather than temperature.
* Kessler autoconversion scheme for both rain and ice
* NO DEPENDENCE ON CLOUD FRACTION for condensation processes



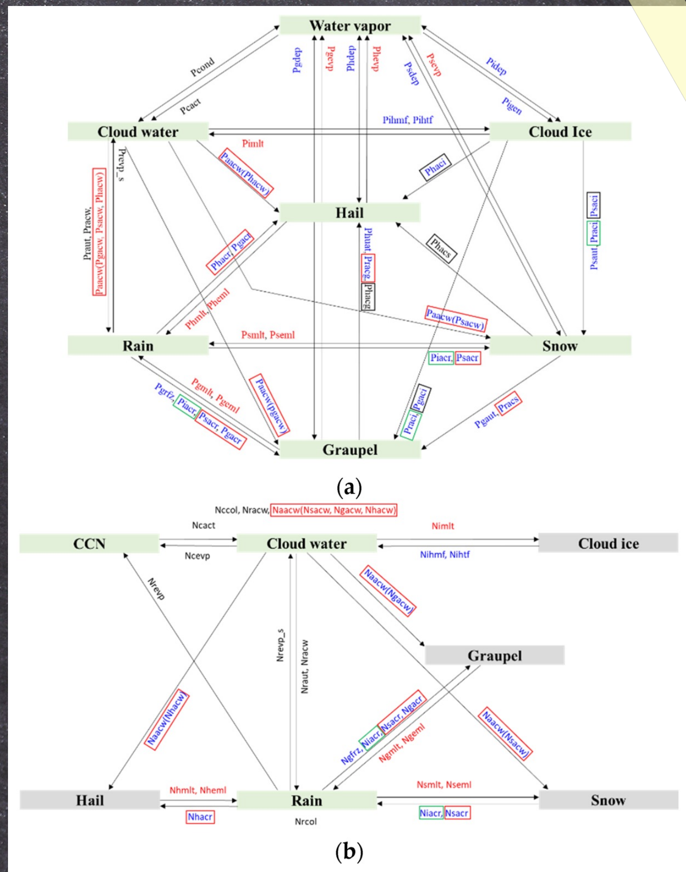
ipptls = 4 WSM7 SCHEME Hong et al (2004)

* Single moment 7-class microphysics scheme of the WRF model.
* Seven hydrometeor species included
* Mixed-phase processes: It includes processes for the interaction between ice and liquid phases
* Graupel included -> suitable for siomulating intensive convective storms
* Operational balance



ipptls = 5 WDM7 SCHEME Hong et al (2004)

- Double moment 7-class microphysics scheme of the WRF model.
- Allows for improved simulation of cloud condensation nuclei (CCN) and their impact on cloud droplet formation and precipitation processes.
- Better aerosol-cloud interactions
- Enhanced warm-rain formation through improved autoconversion and accretion processes
- Improved realism with moderate costs



CONVECTION SCHEME

Moist convection alters the environment in two different ways:

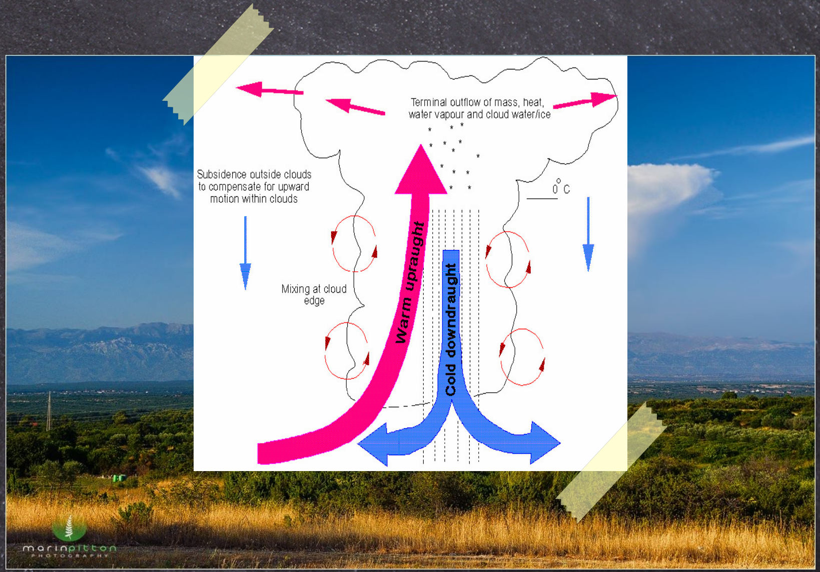
* Deep convection associated with strong updrafts and precipitation. Acts to warm and dry the environment (precipitation removes water vapor from the atmosphere)

* Shallow convection produces no net warming but is important for the radiative budget.

CONVECTION SCHEME

A convection scheme :

* predicts convective precipitation
* changes vertical stability
* generates and redistributes heat
* removes and redistributes moisture
* makes clouds

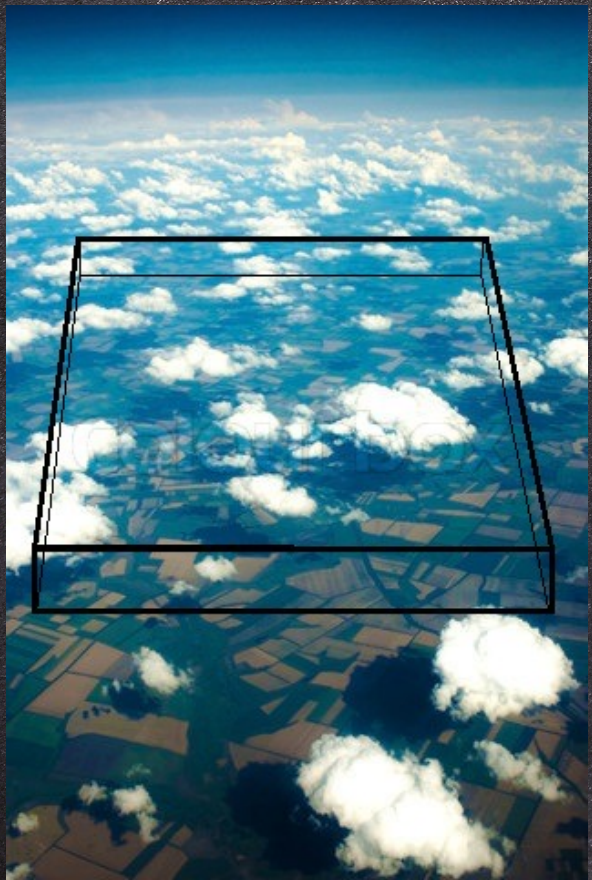


CONVECTION SCHEME

```
icup:   !   1 => Kuo
        !   2 => Grell
        !   4 => Emanuel (1991)
        !   5 => Tiedtke (1996)
        !   6 => Kain-Fritsch (1990), Kain (2004)
        !  -1 => MM5 Shallow cumulus scheme:
        !            No precipitation but only mixing.
        !   0 => Activate CP mode!
```

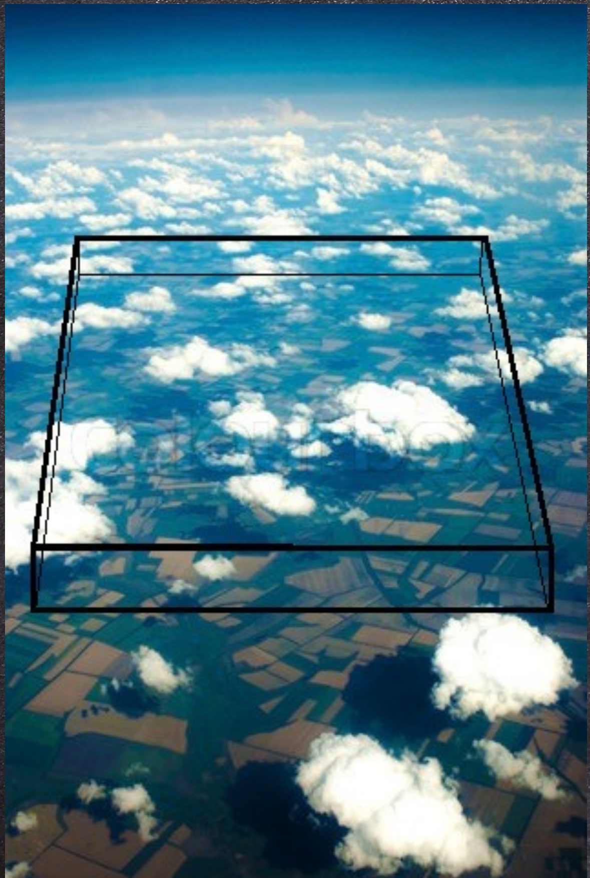
	Kuo *not with Moloch	Grell	Emanuel	Tiedtke	KF
Trigger condition	Column moisture convergence exceeds a threshold value	Lifted parcel attains moist convection	The level of buoyancy is higher than the cloud base level	Lifted parcel reaches a lifting condensation level, and penetrative convection/shallow convection is activated; otherwise, midlevel convection incurs.	Controlled by large scale velocity in the vertical direction: the parcel is assigned to a temperature perturbation linked to the magnitude of grid-resolved vertical motion.
Assumption	Large-scale moisture convergence	Fritsch–Chappell (FC) closure: available buoyant energy is released within a timescale over a given time scale	Quasi-equilibrium of updraft	Penetrative convection and midlevel convection determined by large-scale moisture convergence; shallow convection determined by supply of moisture from surface evaporation	Convection is consideredonly above the PBL
Precipitation scheme	One updraft	One updraft + one downdraft	One updraft + one downdraft	Three updrafts + one downdraft (Updraft 1. Penetrative convection, 2. Shallow convection 3. Midlevel convection)	Convective updraft Convective downdraft Compensating subsidence
References	Anthes (1977)	Grell (1993)	Emanuel (1991)	Tiedtke (1989)	Kain and Fritsch (1993)

CLOUD FRACTION SCHEME



```
icldfrac =     !   0 : Original SUBEX
               !   1 : Xu-Randall empirical
```

icldfrac=0 SUBEX SCHEME



The cloud fraction is calculated diagnostically from the relative humidity following Sundqvist et al. (1989):

$$C = 1 - \sqrt{\frac{RH_{max} - RH}{RH_{max} - RH_{min}}}$$

C==1

clouds begins to form!

icldfrac=1 XU-RANDALL SCHEME (Xu and Randall 1996)

The cloud fraction is calculated diagnostically from the cloud water and cloud ice AND from the relative humidity

$$C = \begin{cases} RH^p[1 - \exp(-\frac{\alpha_0 \bar{q}_l}{[(1-RH)q_s})]^\gamma] & \text{if } RH < 1 \\ 1 & \text{if } RH \geq 1 \end{cases}$$

icldfrac=1 XU-RANDALL SCHEME (Xu and Randall 1996)

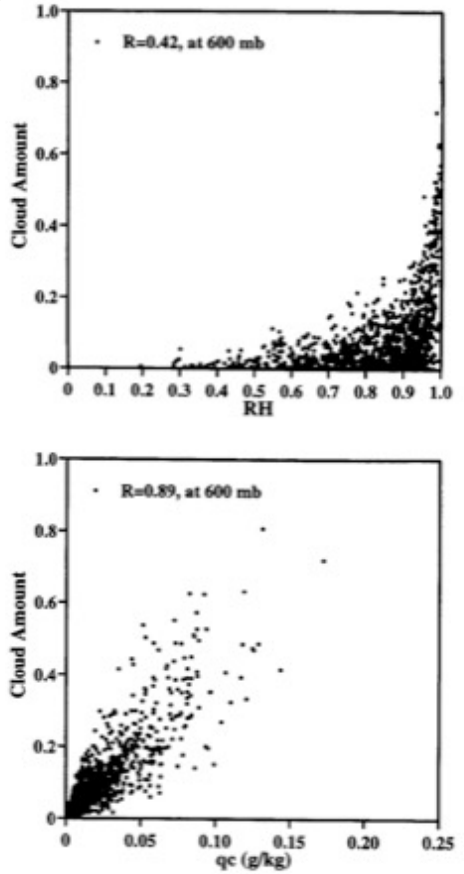


FIG. 6. Plots of cloud amount against relative humidity (top panel) and average cloud-water mixing ratio (bottom panel), as predicted by the CEM when driven by GATE data.

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$$C = \begin{cases} RH^p[1-\exp(-\frac{\alpha_0 \bar{q}_l}{[(1-RH)q_s}]^\gamma] & \text{if } RH < 1 \\ 1 & \text{if } RH \geq 1 \end{cases}$$

Have fun!