WRF PHYSICS PARAMETERIZATIONS FOR COAWST

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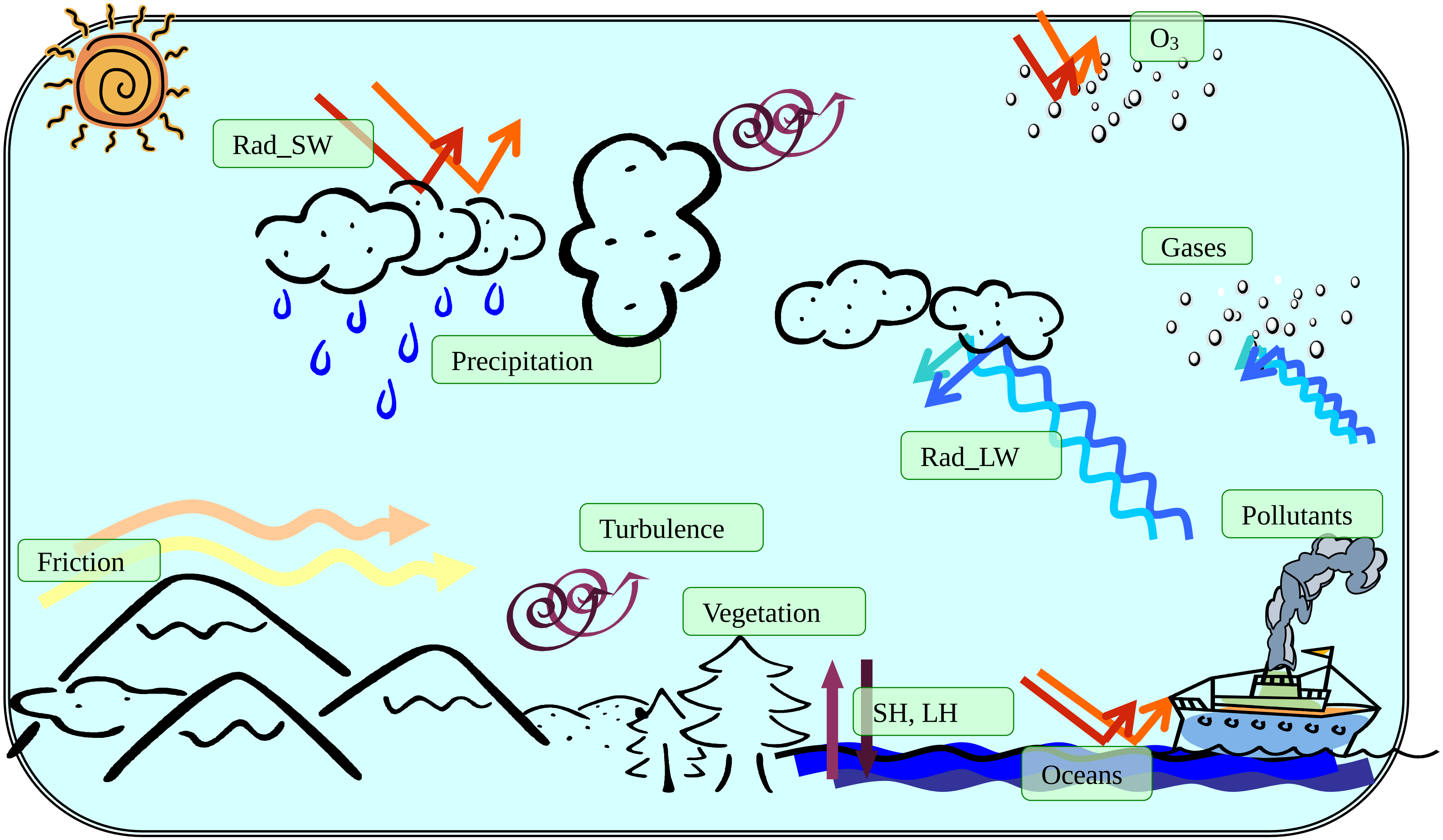
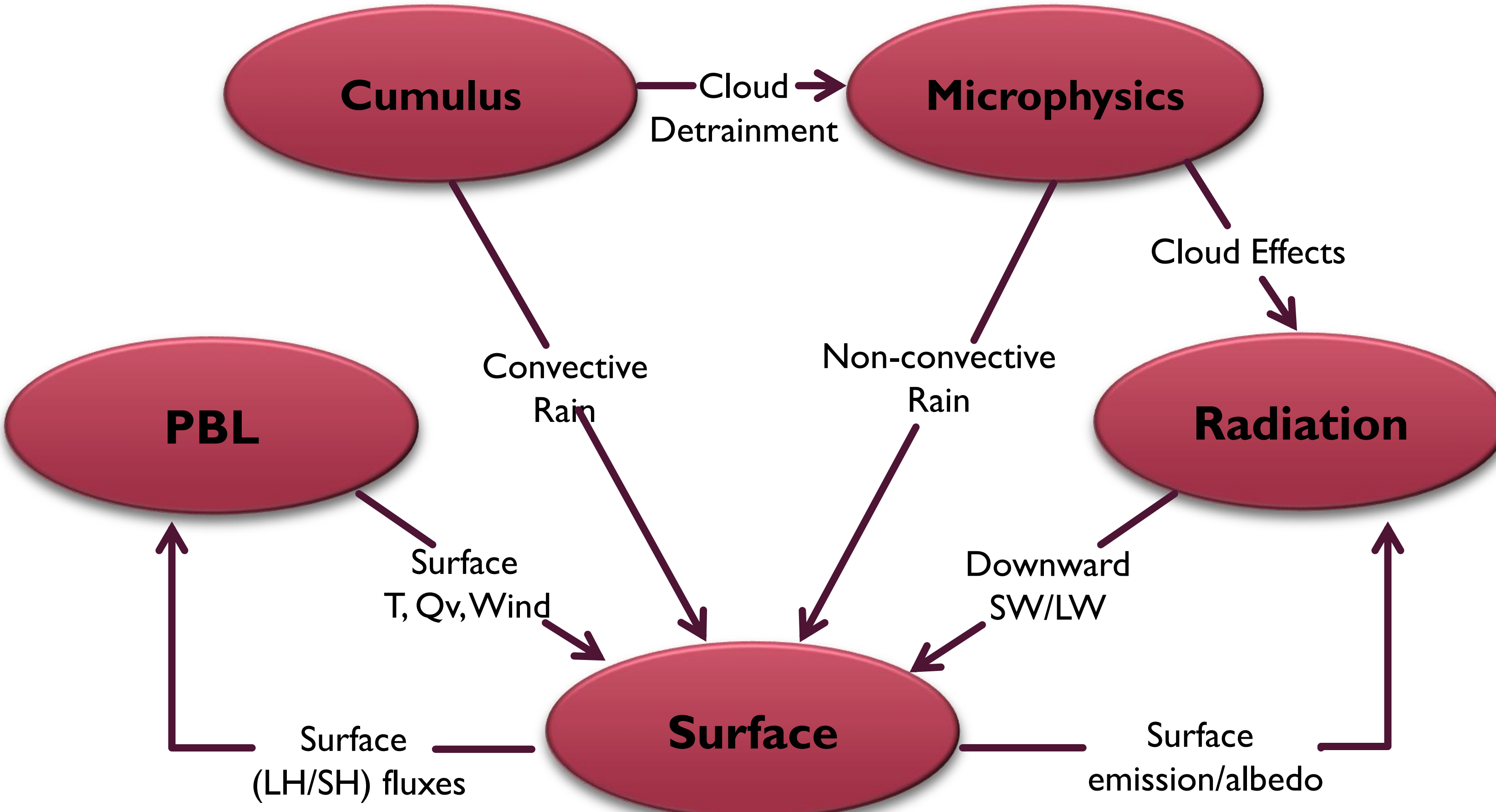
PHYSICAL PROCESSES IN THE ATMOSPHERE



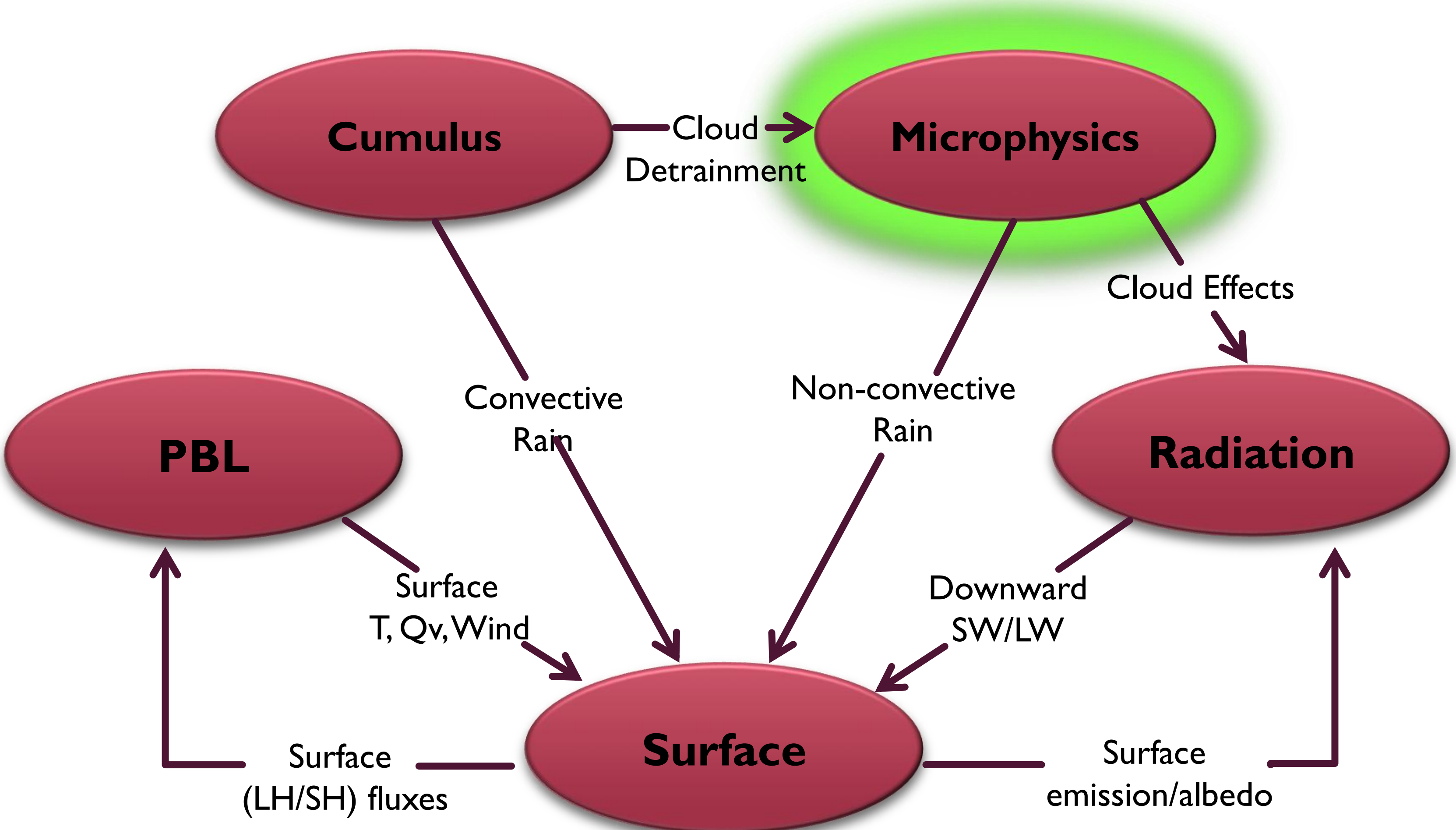
WRF PHYSICS

- Microphysics (mp_physics)
- Cumulus parameterization (cu_physics)
- Radiation
  - Longwave (ra_lw_physics)
  - Shortwave (ra_sw_physics)
- PBL (bl_pbl_physics)
- Surface
  - Surface layer (sf_sfclay_physics)
  - Land surface model (sf_surface_physics)

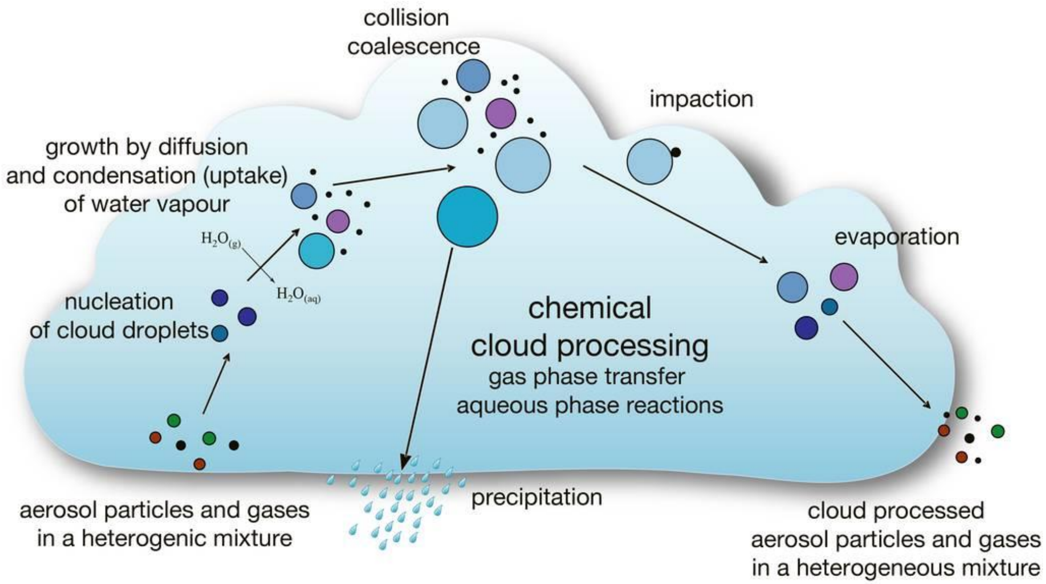
DIRECT INTERACTIONS OF PARAMETERIZATIONS



DIRECT INTERACTIONS OF PARAMETERIZATIONS



MICROPHYSICS SCHEMES



Resolves

- Water vapor processes
- Cloud processes
- Precipitation processes

Some of the parameterizations also account for ice-phase and/or mixed-phase processes.

Provides

- Atmospheric heat and moisture tendencies
- Microphysical rates
- Surface resolved-scale rainfall

AVAILABLE MICROPHYSICS OPTIONS V4.0

(*mp_physics = ?*)

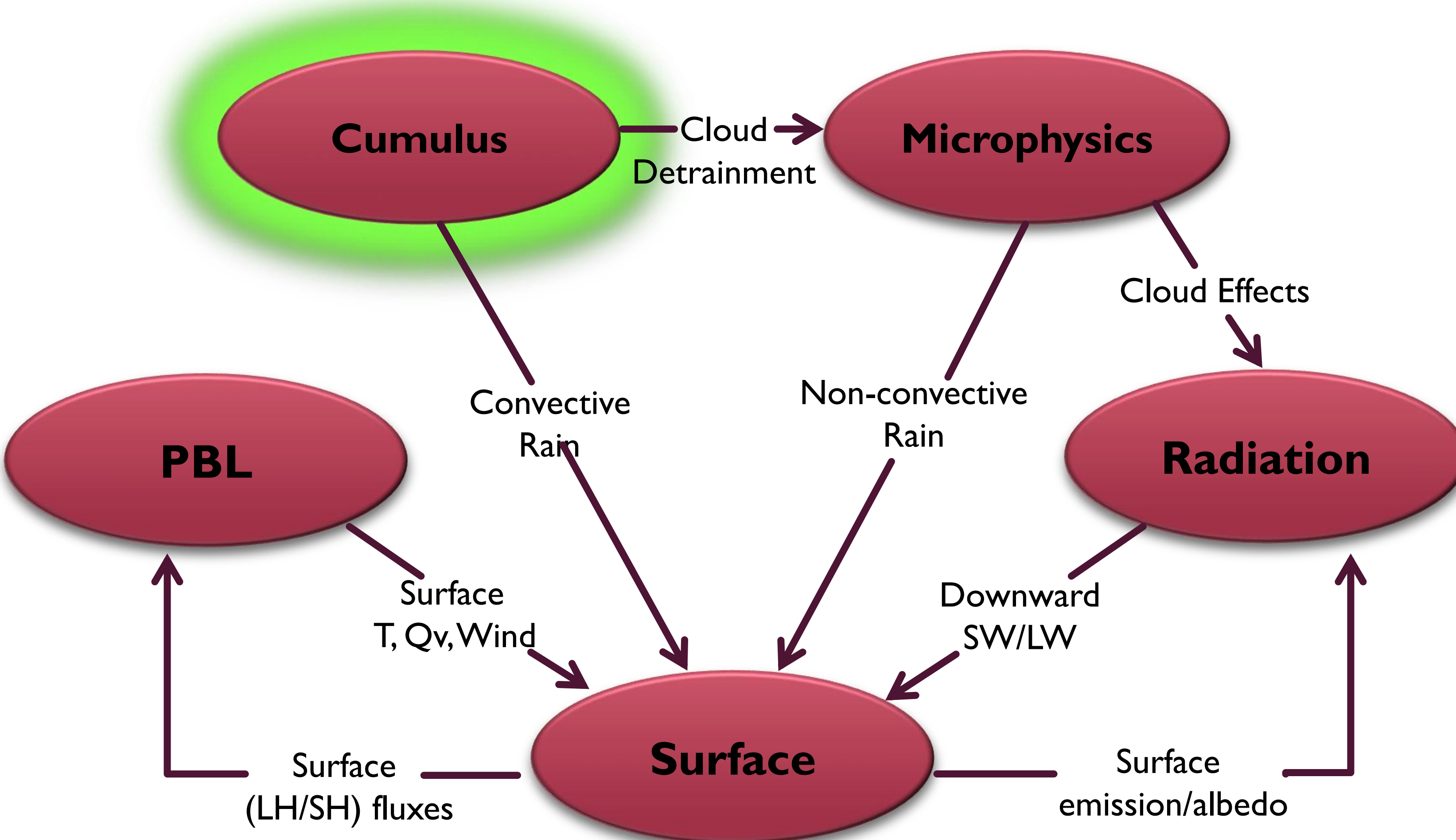
- Kesslar **(1)**
- Lin (Purdue) **(2)**
- WSM3 **(3)**
- WSM5 **(4)**
- Eta (Ferrier) **(5)**
- WSM6 **(6)**
- Goddard **(7)**
- Thompson **(8)**
- Milbrandt 2-moment **(9)**
- Morrison 2-moment **(10)**
- CAM 5.1 **(11)**
- SBU-YLin **(13)**
- WDM5 **(14)**
- WDM6 **(16)**
- NSSL 2-moment **(17)**
- NSSL 2-moment with CCN prediction **(18)**
- NSSL 1-mom, 7-class **(19)**
- NSSL 1-momlfo, 6-class **(21)**
- NSSL 2-mom w/o hail **(22)**
- Thompson aerosol-aware **(28)**
- HUJI SBM 'fast' **(30)**
- HUJI SBM full **(32)**
- P3 **(50)**
- P3-nc **(51)**
- P3-2nd **(52)**

MICROPHYSICS: CHOOSING THE BEST SCHEME

- Likely not necessary to use a graupel scheme for dx > 10km
  - Updrafts producing graupel not resolved
  - Cheaper scheme may give similar results
- When resolving individual updrafts, graupel scheme should be used
- All domains must use the same option

For scheme specific information, see Chapter 5 of the WRF Users' guide:
http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/v4.0/users_guide_chap5.html

DIRECT INTERACTIONS OF PARAMETERIZATIONS



CUMULUS PARAMETERIZATION

- Responsible for the sub-grid-scale effects of convective and/or shallow clouds

- Provides
  - Atmospheric heat and moisture/cloud tendency profiles
  - Surface sub-grid-scale (convective) rainfall

AVAILABLE CUMULUS OPTIONS V4.0

(cu_physics = ?)

- Kain-Fritsch **(1)**
- Betts-Miller-Janjic **(2)**
- Old Simplified Arakawa Schubert **(4)**
- Grell-3 **(5)**
- Tiedtke**(6)**
- Zhang and McFarlane **(7)**
- KF-CuP **(10)**
- New SAS **(14)**
- New Tiedtke **(16)**
- Grell-Devenyi **(93)**
- Old Kain-Fritsch **(99)**

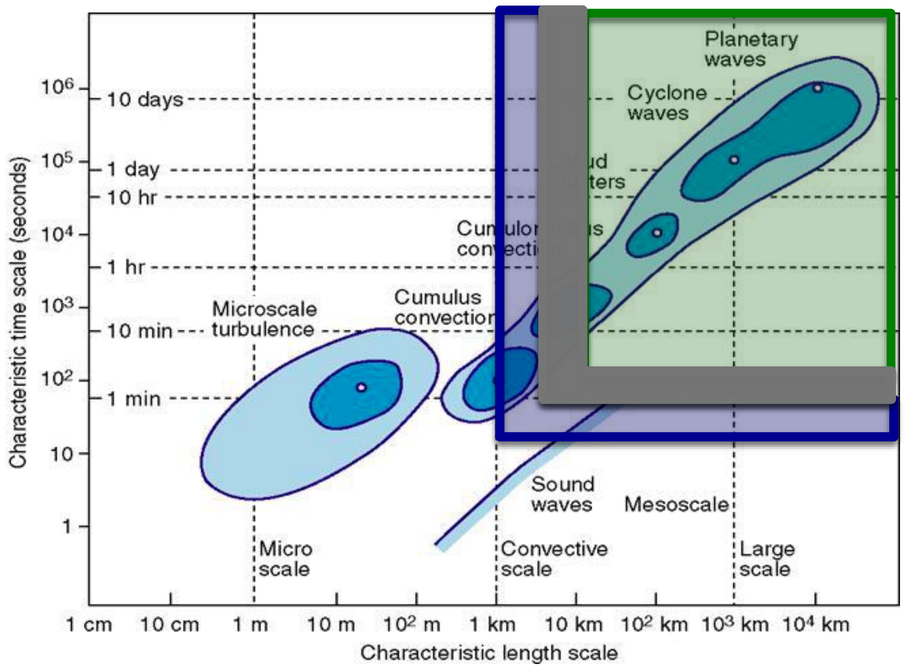
Scale aware physics

- Grell-Freitas **(3)**
- Multi-scale Kain Fritsch **(11)**

CUMULUS SCHEME USE RECOMMENDATIONS

For dx ≥ 10 km:
Probably need cumulus scheme

For dx ≤ 3 km:
probably do not need scheme
However, there are cases where the earlier triggering of convection by cumulus schemes help

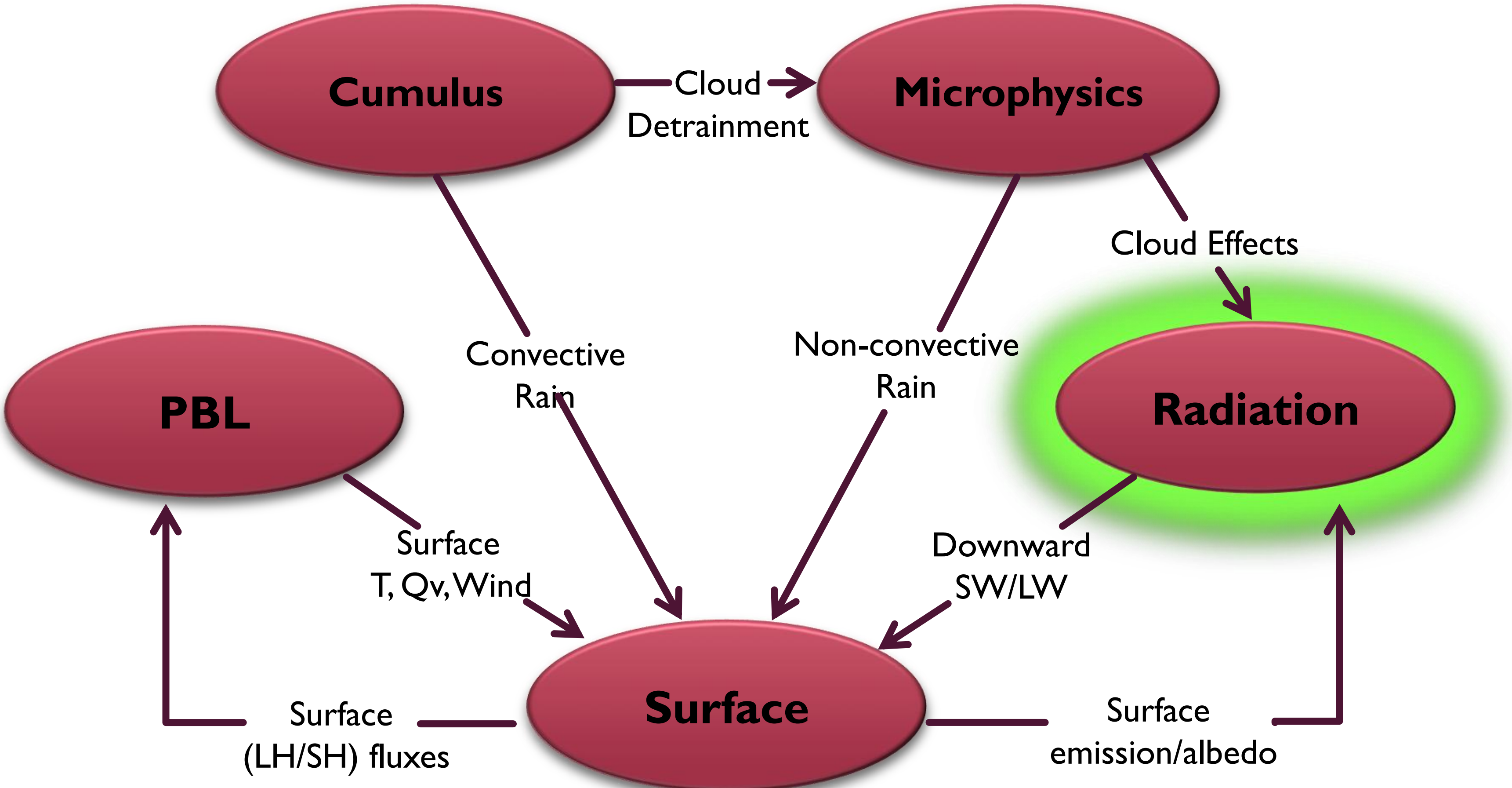


For dx = 3-10 km,
scale separation is a question

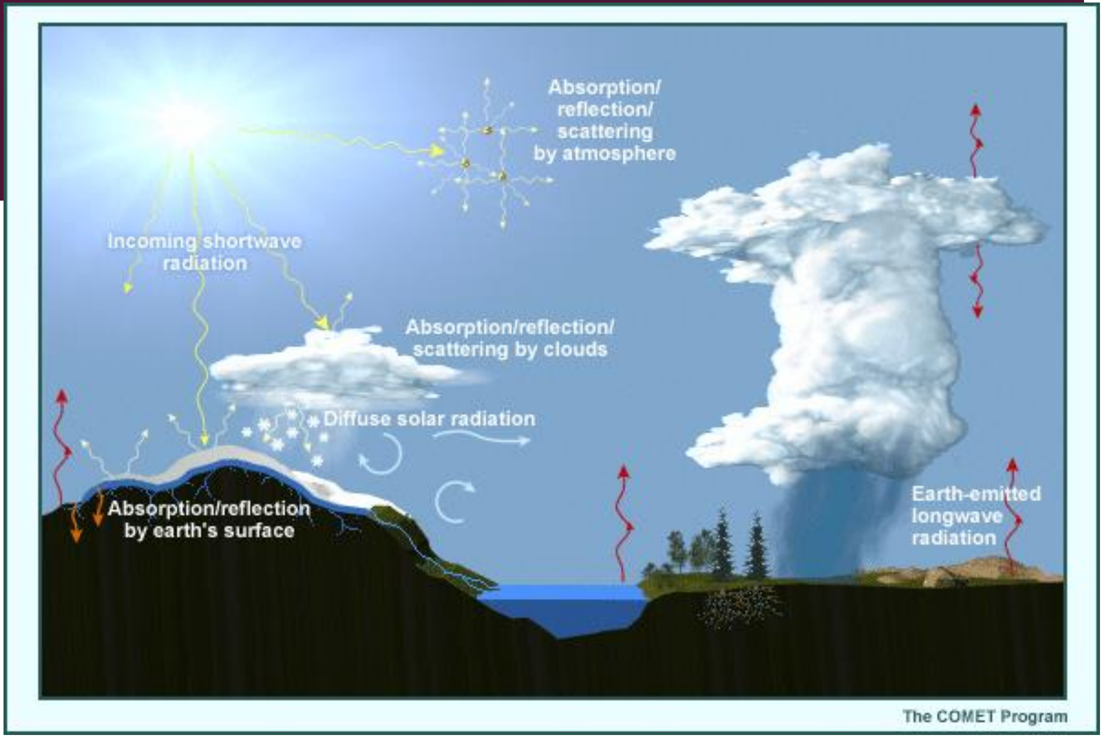
This is a 'gray zone' and it is best to avoid these grid spacings.

Few schemes are specifically designed with this range of scales in mind
e.g. Multi-scale Kain Fritsch and Grell-Freitas

DIRECT INTERACTIONS OF PARAMETERIZATIONS



RADIATION



- Provides atmospheric heating due to longwave and shortwave radiation

- Longwave radiation
  - Computes clear-sky & cloud upward/downward radiation fluxes
  - Includes infrared and thermal radiation
  - Surface emissivity is based on land-type

- Shortwave radiation
  - Computes clear-sky & cloudy solar fluxes
  - Includes annual and diurnal solar cycles
  - Includes visible wavelengths in the solar spectrum

AVAILABLE RADIATION OPTIONS V4.0

Longwave Schemes

- Rapid Radiative Transfer Model (RRTM) (1)
- Community Atmosphere Model (CAM) (3)
- RRTMG (4)
- New Goddard (5)
- Fu-Liou-Gu (FLG) (7)
- RRTMG-K (14)
- Held-Suarez (31)
- GFDL (99)

Shortwave Schemes

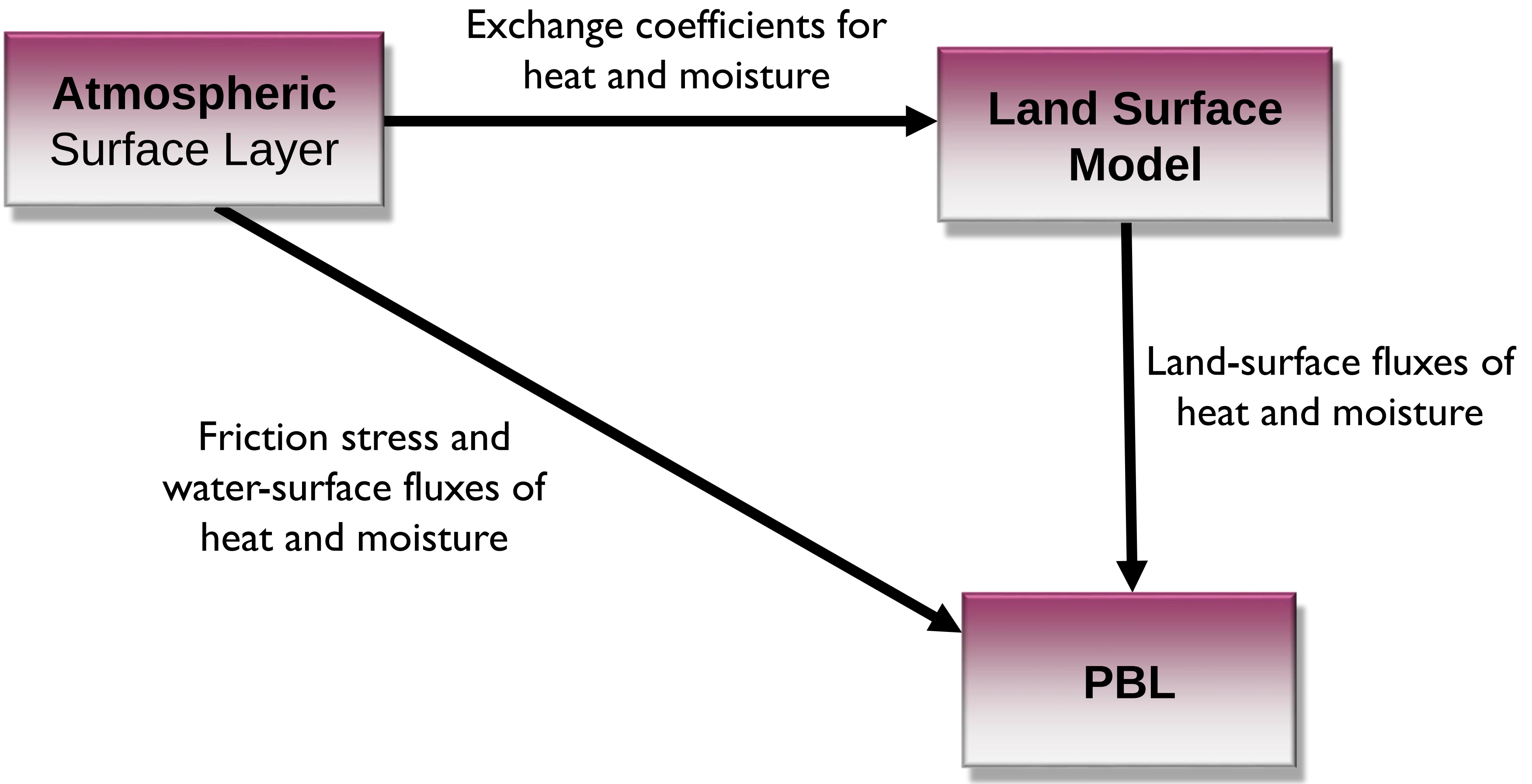
- MM5 (Dudhia) (1)
- Goddard (2)
- Community Atmosphere Model Shortwave (CAM) (3)
- RRTMG (4)
- New Goddard (5)
- Fu-Liou-Gu (FLG) (7)
- RRTMG-K (14)
- GFDL (99)

RADIATION TIME STEPS

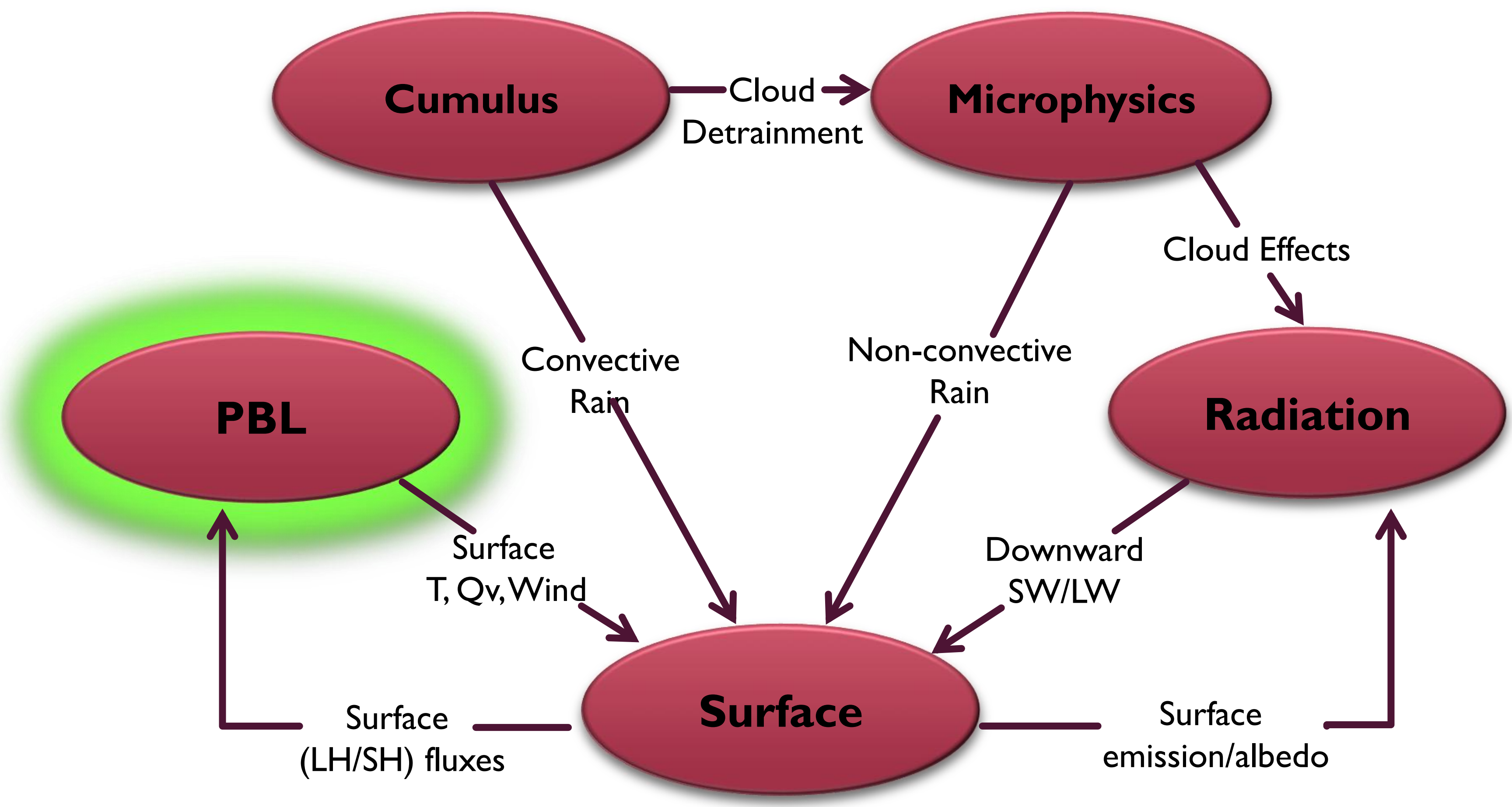
- Radiation timestep in namelist.input file (&physics) is "radt"

- Timestep recommendations
  - Radiation is too expensive to call every model time step (dt)
  - Frequency should resolve cloud-cover changes with time
  - radt = ~ 1 minute per km grid size
  - Recommend using same value on all domains for 2-way nests (feedback on)

SURFACE PHYSICS COMPONENTS

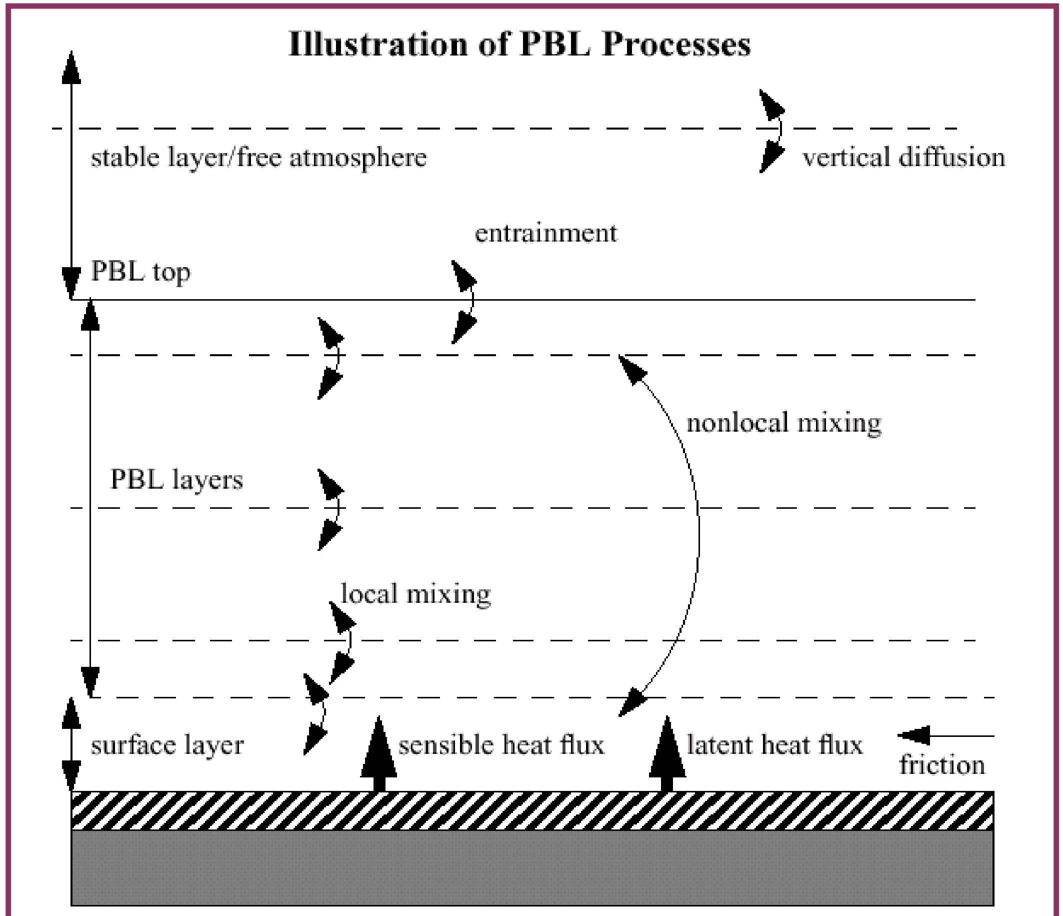


DIRECT INTERACTIONS OF PARAMETERIZATIONS



PLANETARY BOUNDARY LAYER (PBL)

- Purpose is to distribute surface fluxes with boundary layer eddy fluxes and allow for PBL growth by entrainment
- All schemes do vertical diffusion (due to turbulence) above the PBL
- Suface fluxes are provided by the surface layer and land-surface schemes



PBL GRAY-ZONE

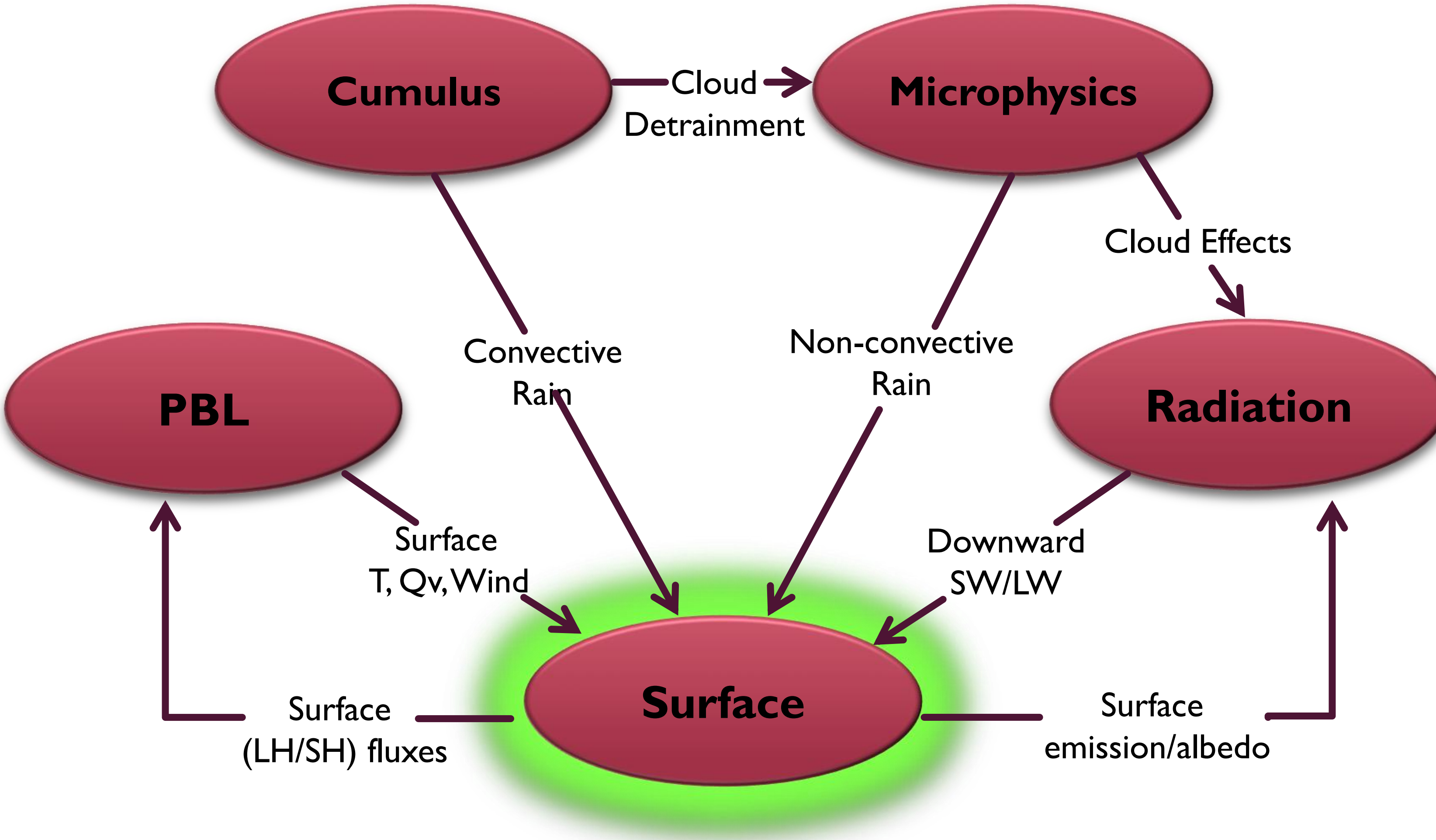
- PBL Schemes have been designed for dx > 1 km
  - Below this become a "gray-zone"
- New Shin-Hong PBL (based on YSU) is designed for sub-kilometer transition scales (200 m – 1 km)
- Other schemes **may** work in this range, but will not have correctly partitioned resolved/sub-grid energy fractions

AVAILABLE PBL OPTIONS V4.0

(bl_pbl_physics = ?)

- YSU **(1)**
- MYJ **(2)**
- GFS **(3)**
- QNSE **(4)**
- MYNN2 **(5)**
- MYNN3 **(6)**
- ACM2 **(7)**
- BouLac **(8)**
- UW **(9)**
- TEMF **(10)**
- Shin-Hong **(11)**
- GBM **(12)**
- MRF **(99)**

DIRECT INTERACTIONS OF PARAMETERIZATIONS

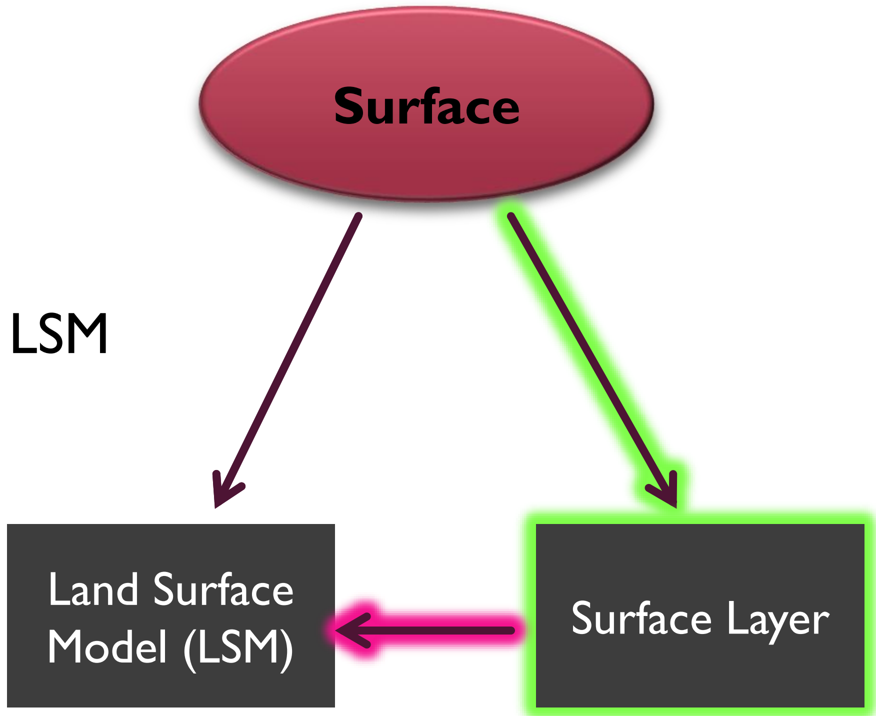


SURFACE LAYER SCHEMES

- Purpose is to calculate
  - Friction velocities
  - Exchange coefficients

- Provides exchange coefficients to LSM

- Provides friction velocity to PBL scheme
- Provide surface fluxes over water points
- Schemes have variations in stability functions, roughness lengths



AVAILABLE SFC LAYER OPTIONS (V4.0)

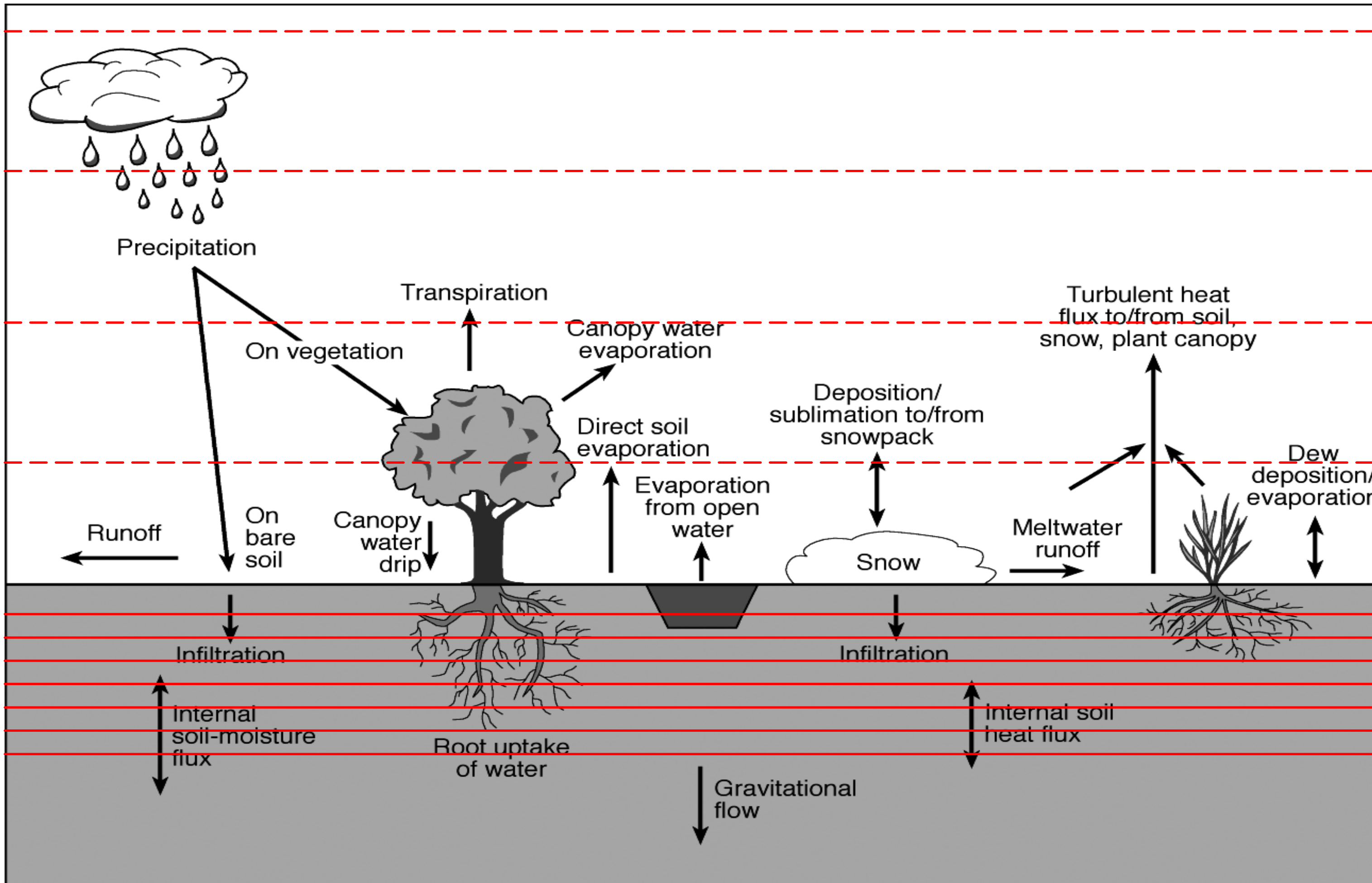
(sf_sfclay_physics = ?)

- Revised MM5 surface layer scheme **(1)**
- MYJ (Eta similarity) scheme**(2)**
- QNSE surface layer scheme **(4)**
- MYNN surface layer scheme**(5)**
- Pleim-Xiu surface layer scheme **(7)**
- TEMF surface layer scheme **(10)**

Recommendations:

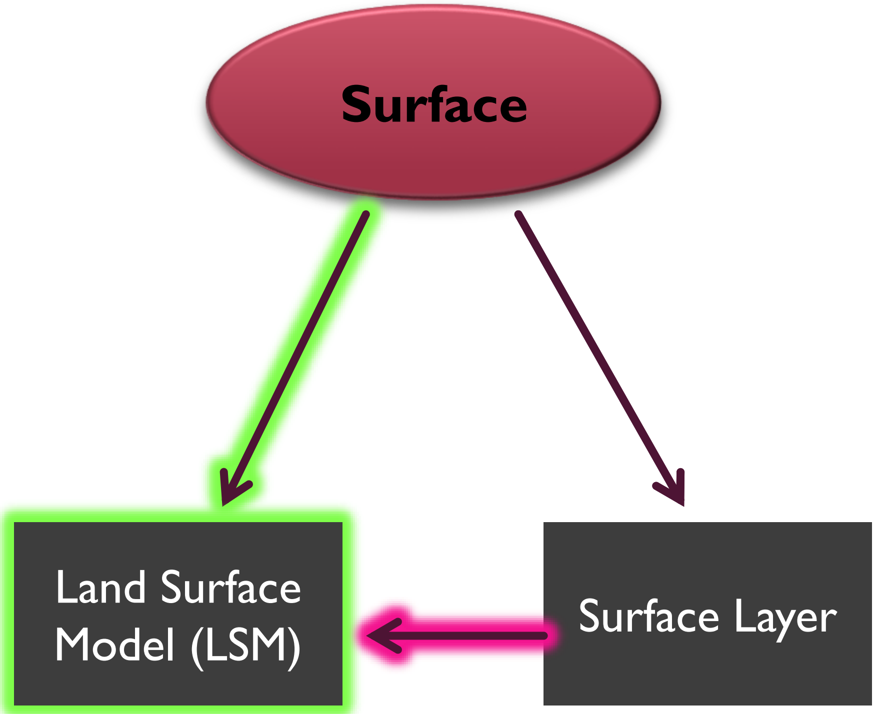
For coupling with wave model in COAWST only MYJ and MYNN have a dependence on sea surface roughness.

LAND SURFACE MODEL (LSM) PROCESSES



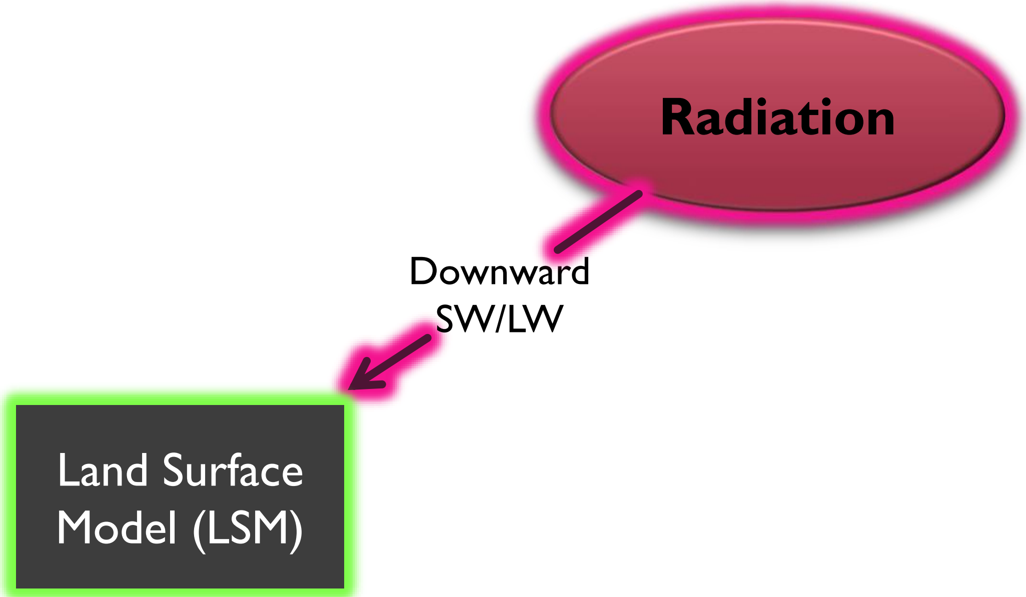
LAND SURFACE MODELS (LSM)

Uses atmospheric information from the surface layer scheme

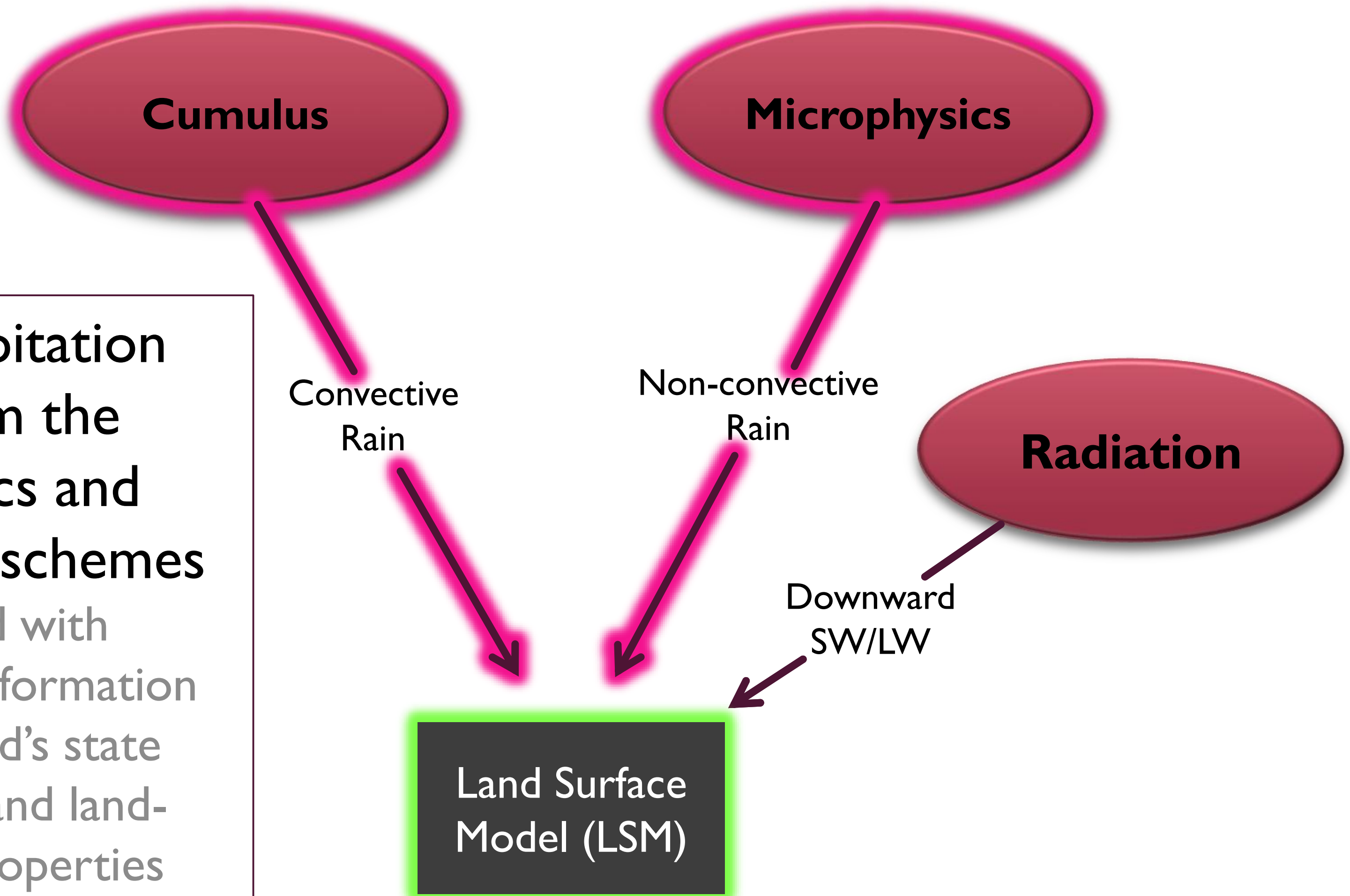


LSM FUNCTIONS

Uses radiative forcing from the radiation scheme



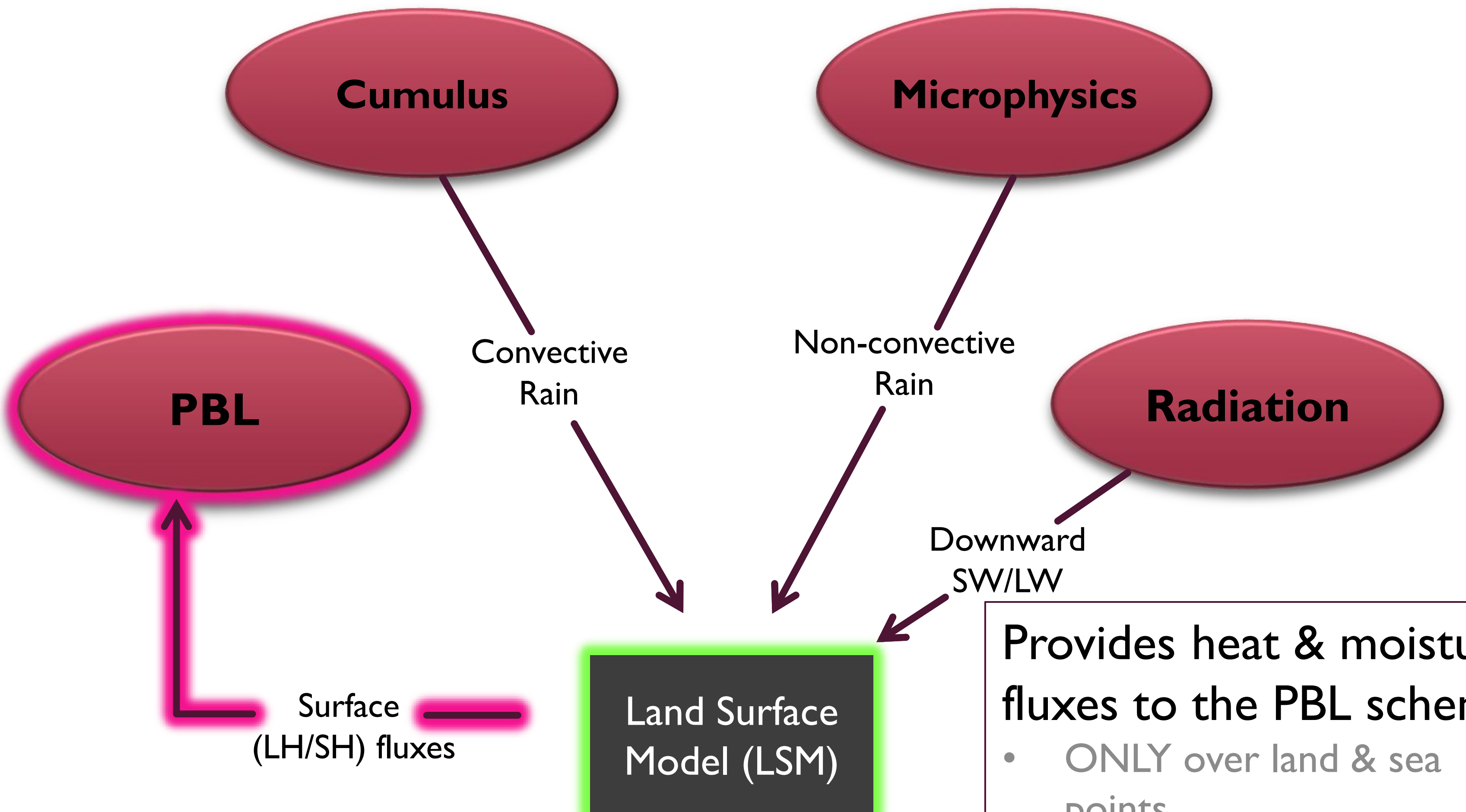
LSM FUNCTIONS



Uses precipitation forcing from the microphysics and convective schemes

- Combined with internal information on the land's state variables and land-surface properties

LSM FUNCTIONS



Provides heat & moisture fluxes to the PBL scheme

- ONLY over land & sea points

AVAILABLE LSM OPTIONS V4.0

(sf_surface_physics = ?)

very simple LSM and computationally cheap

- 5- layer thermal diffusion **(1)**

More complex but also more expensive computationally

- Noah Land Surface Model **(2)**
- RUC Land Surface Model **(3)**
- Pleim-Xiu Land Surface Model **(7)**
- SSiB Land Surface Model **(8)**

Most complex and most expensive

- CLM4 **(5)**
- Noah-MP (Multi-physics) Land Surface Model **(4)**

HOW TO CHOOSE SCHEMES

Physics Suites:

- **physics_suite = ‘CONUS’**

  mp_physics = 8, 8

  cu_physics = 6, 6

  ra_lw_physics = 4, 4

  ra_sw_physics = 4, 4

  bl_pbl_physics = 2, 2

  sf_sfclay_physics = 2, 2

  sf_surface_physics = 2, 2

- **physics_suite = ‘TROPICAL’**

  mp_physics = 6, 6

  cu_physics = 16, 16

  ra_lw_physics = 4, 4

  ra_sw_physics = 4, 4

  bl_pbl_physics = 1, 1

  sf_sfclay_physics = 91, 91

  sf_surface_physics = 2, 2

HOW TO CHOOSE SCHEMES

There are lots of published studies on the sensitivity of WRF to physics schemes.

If, none of these studies are suitable for your application, consider undertaking your own sensitivity study.

For specific details on each of the schemes, you can find a list of the publications describing them at:

www2.mmm.ucar.edu/wrf/users/phys_references.html