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WRF parameterizations for COAWST

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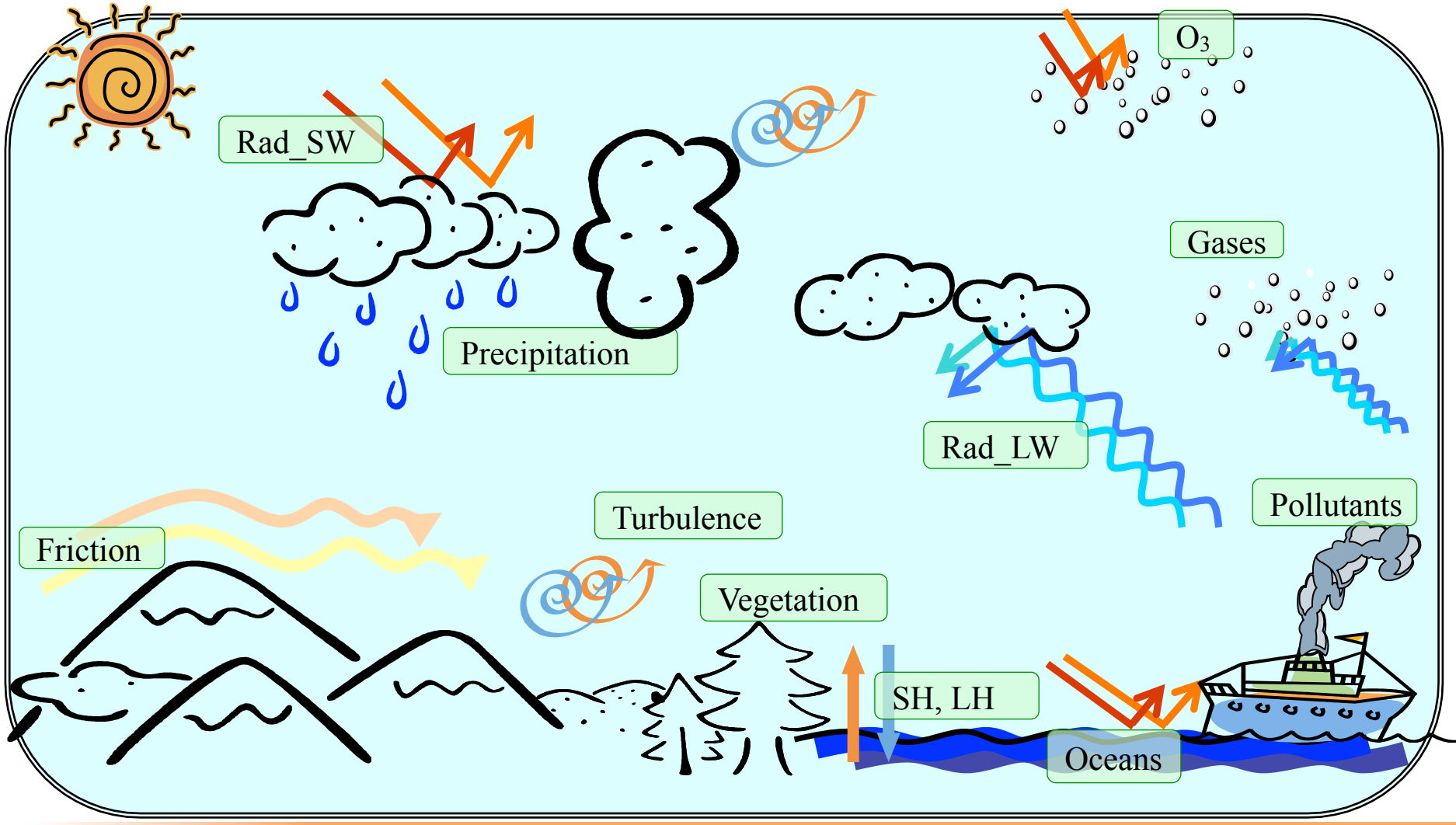
Physical Processes in the Atmosphere



Modelling on a grid

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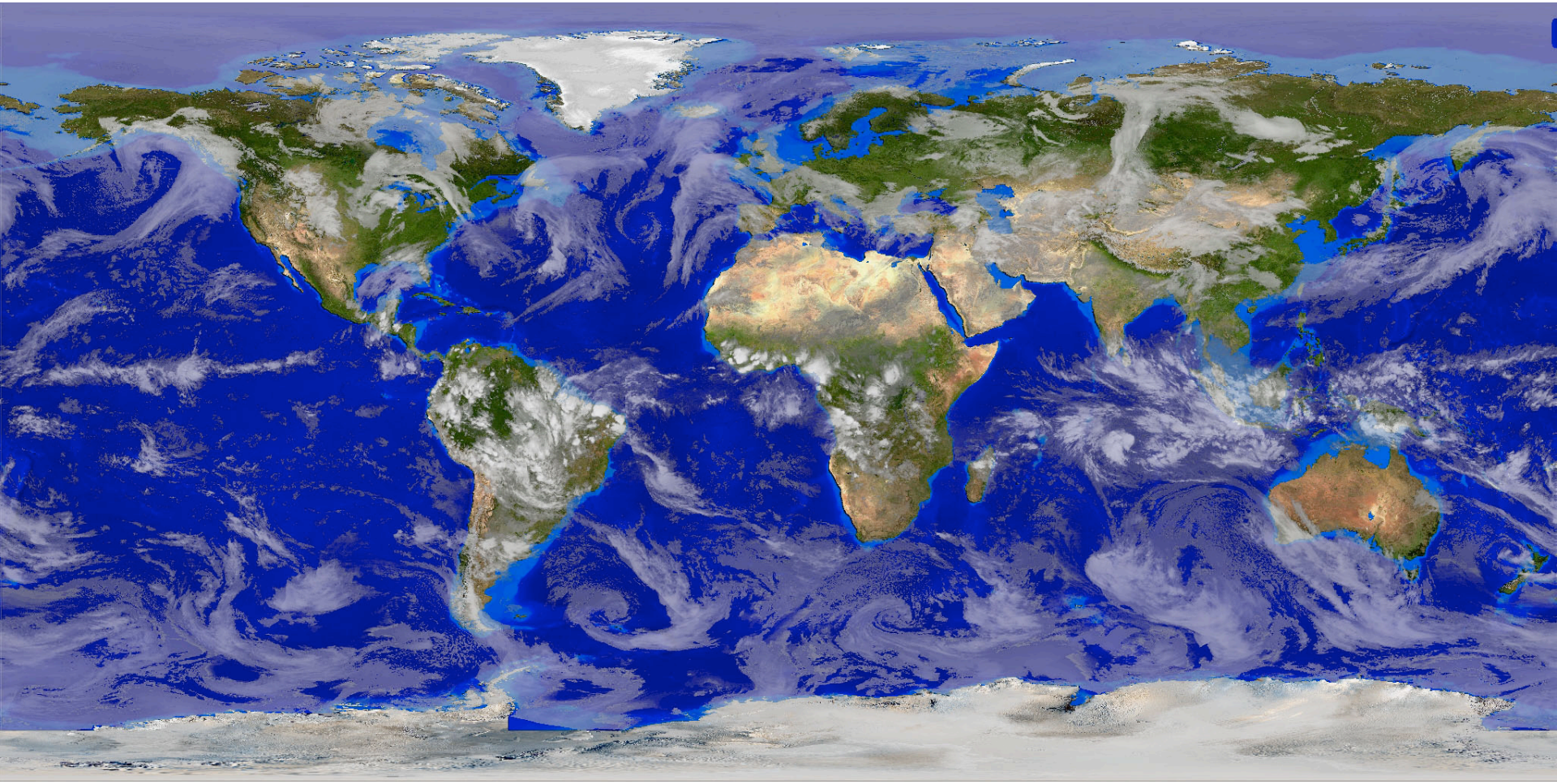

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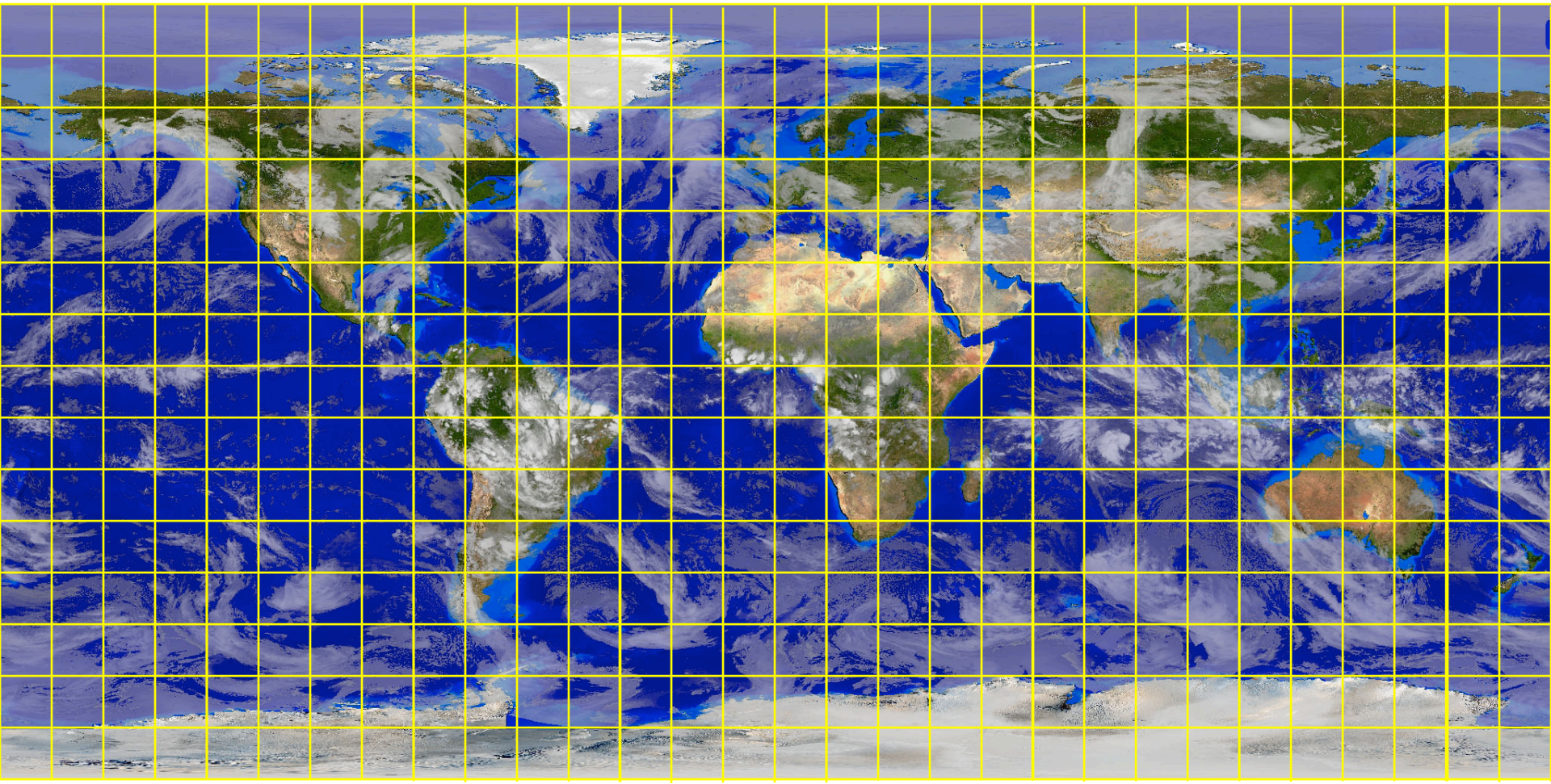
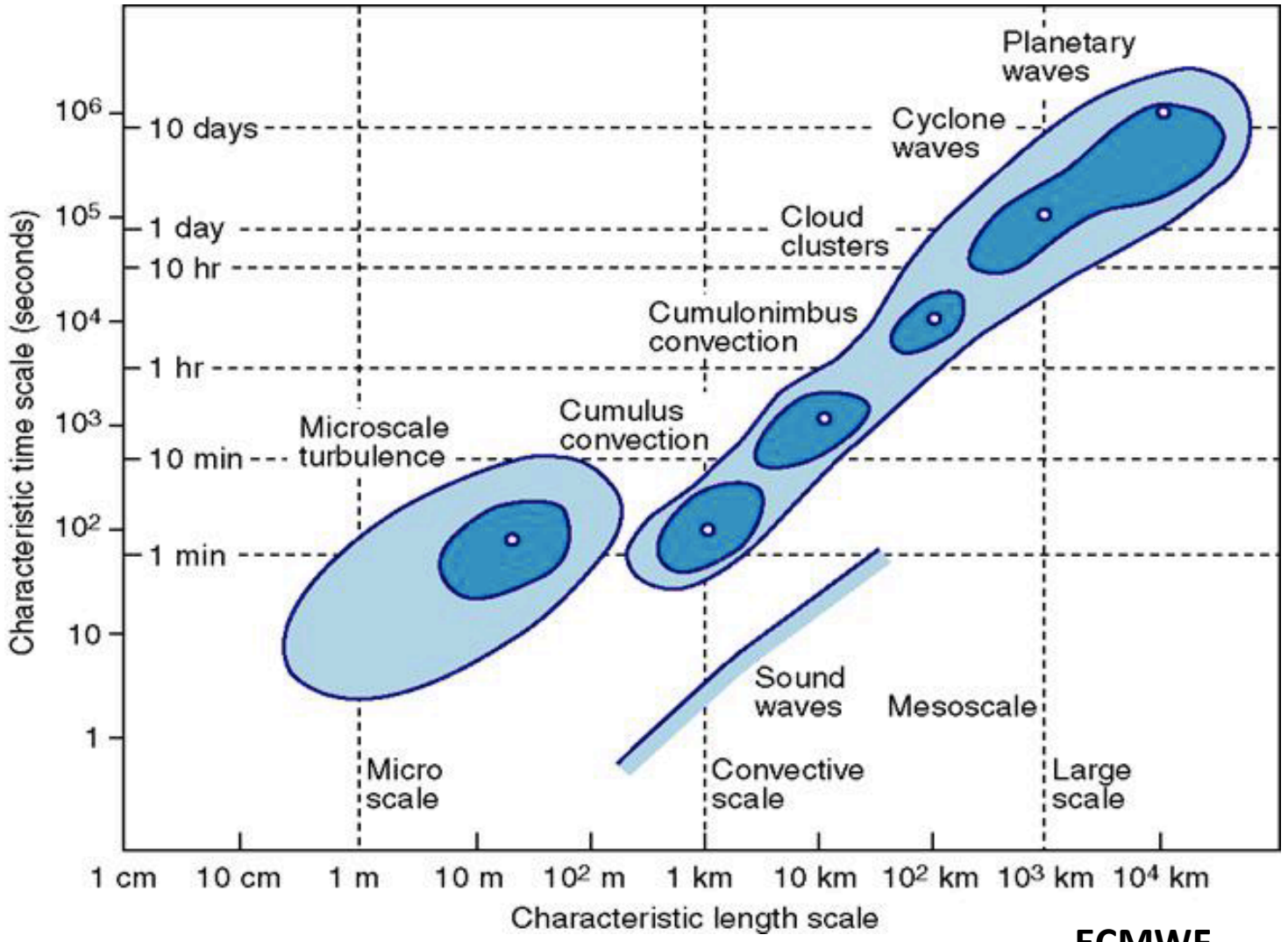
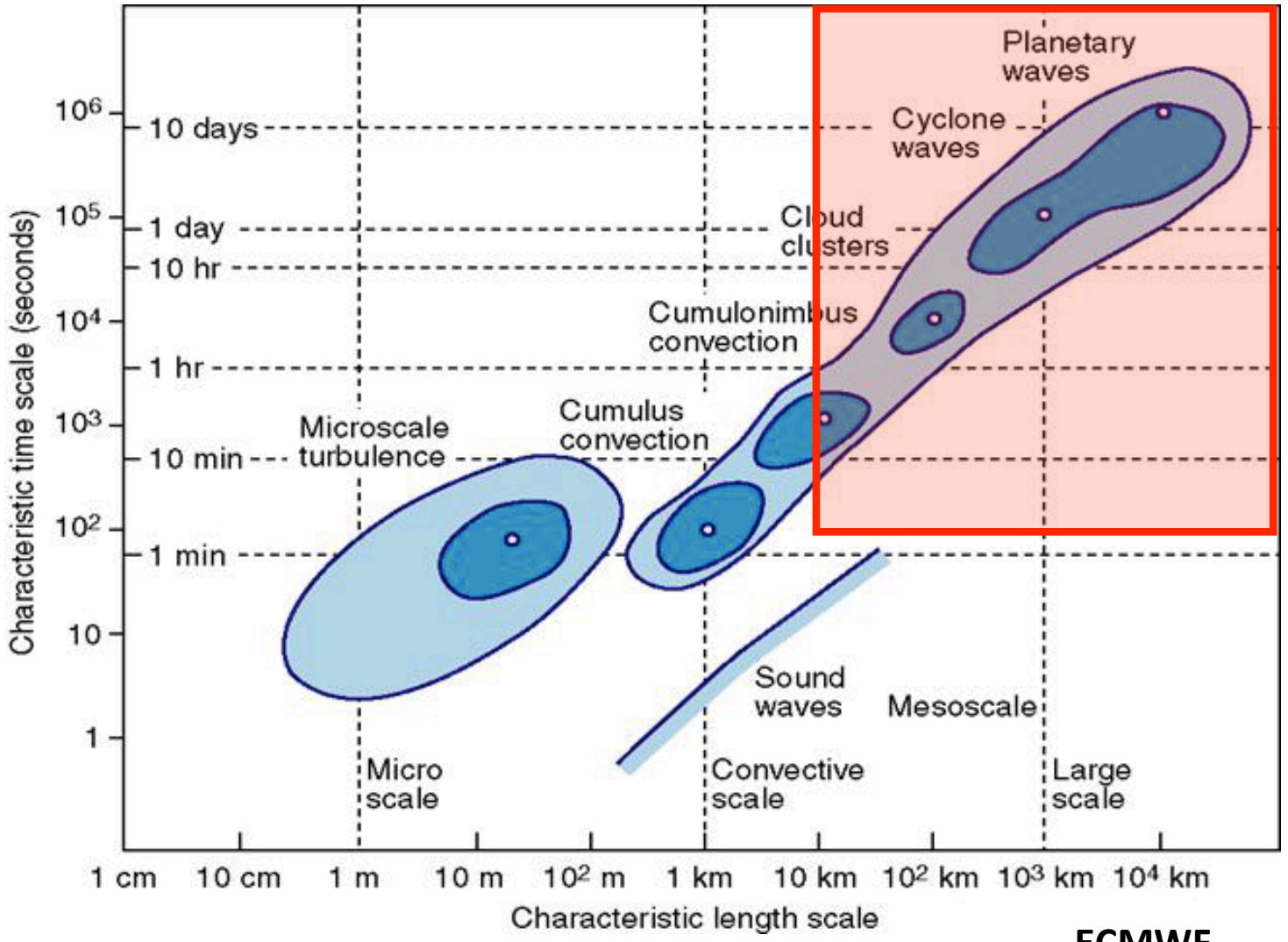


Temporal-Spatial scales



ECMWF

Temporal-Spatial scales



ECMWF

Physical Parameterizations

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In atmospheric models parameterization is performed by one of the following methods:

1. Simplification of complex processes based on some assumptions

2. Statistical/empirical relationships and approximations based on observations

WRF Physics

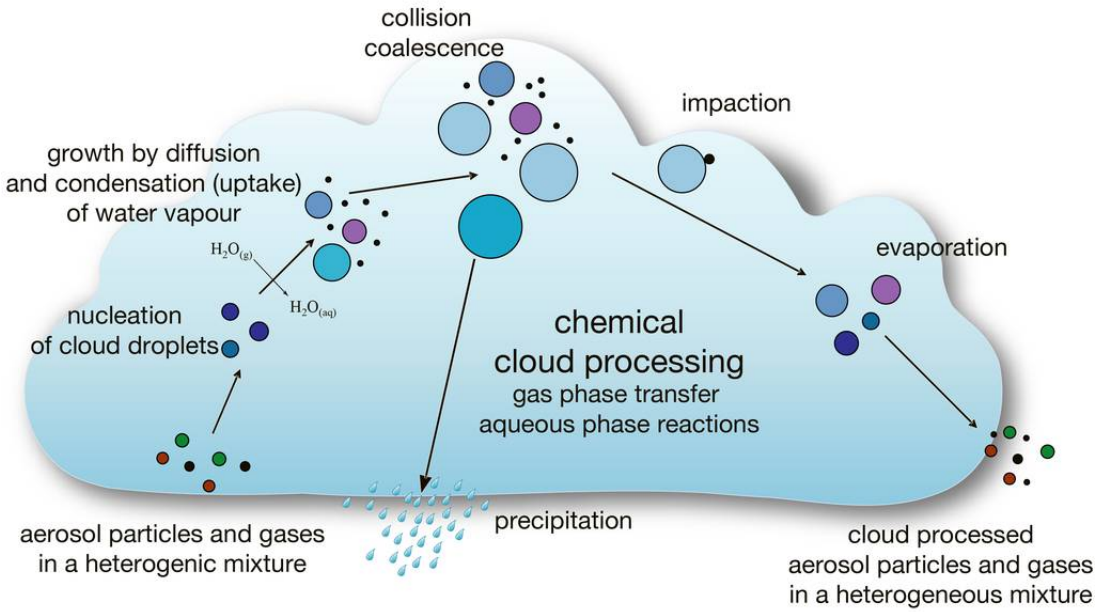
1. Microphysics (mp_physics)
2. Cumulus parameterization (cu_physics)
3. Radiation
   - Longwave (ra_lw_physics)
   - Shortwave (ra_sw_physics)
4. PBL (bl_pbl_physics)
5. Surface
   - Surface layer (sf_sfclay_physics)
   - Land/water surface (sf_surface_physics)

1. Microphysics

Resolves

- water vapour processes,
- cloud processes
- precipitation processes.

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



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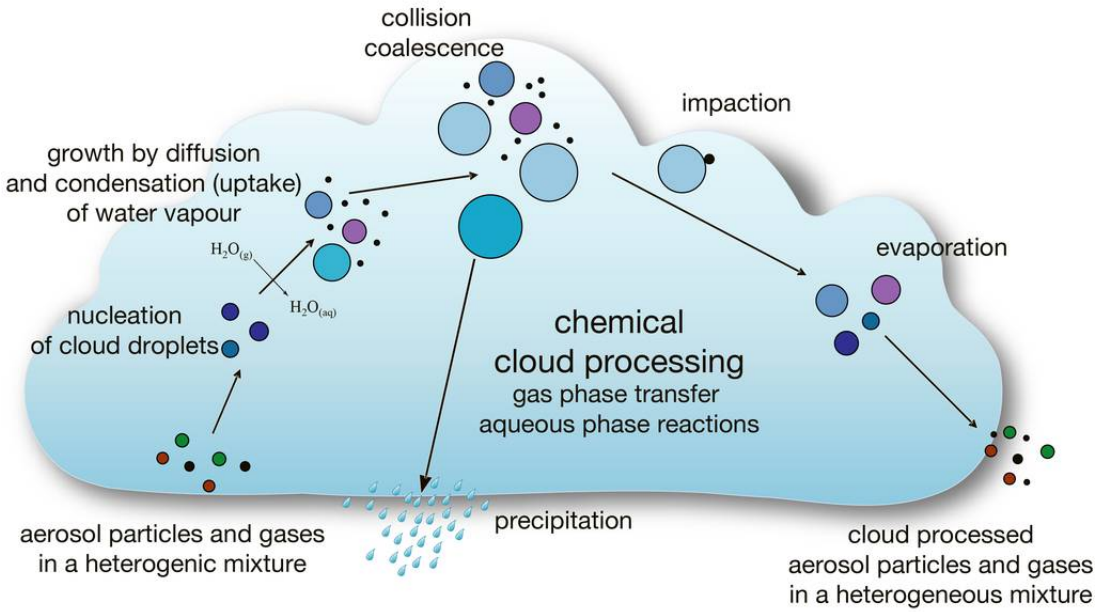

Provides

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

1. Microphysics

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Microphysics in WRF (V3.8)
(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 **(19)**
- NSSL 1-momlfo **(21)**
- NSSL 2-mom w/o hail **(22)**
- Thompson aerosol-aware **(28)**
- HUJI SBM 'fast' **(30)**
- HUJI SBM full **(32)**

1. Microphysics

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Recommendations about choice

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

2. Cumulus

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

2. Cumulus

Cumulus Schemes in WRF (V3.8)

(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)**

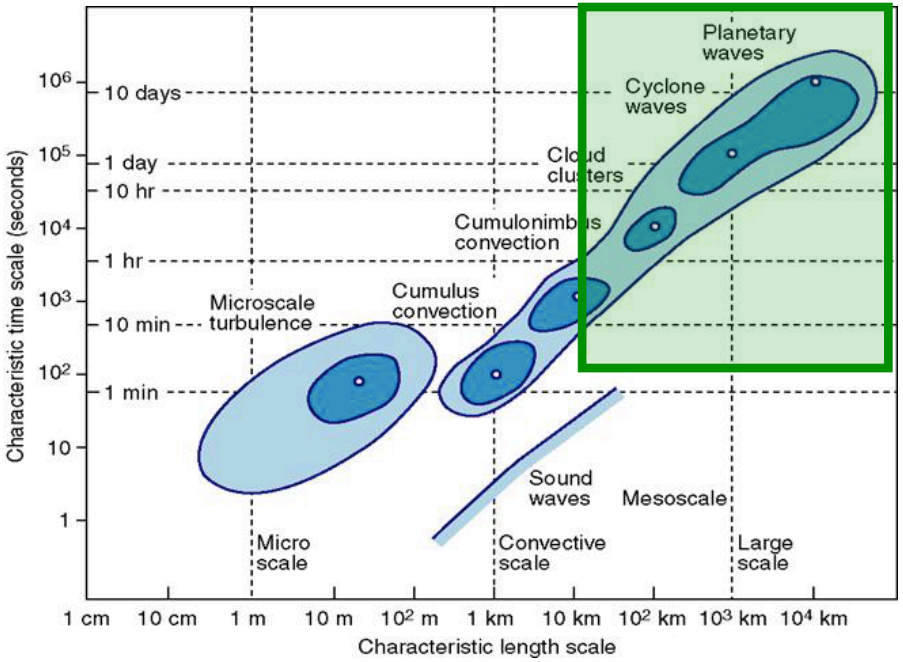
Scale aware physics

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

2. Cumulus

Recommendations about use

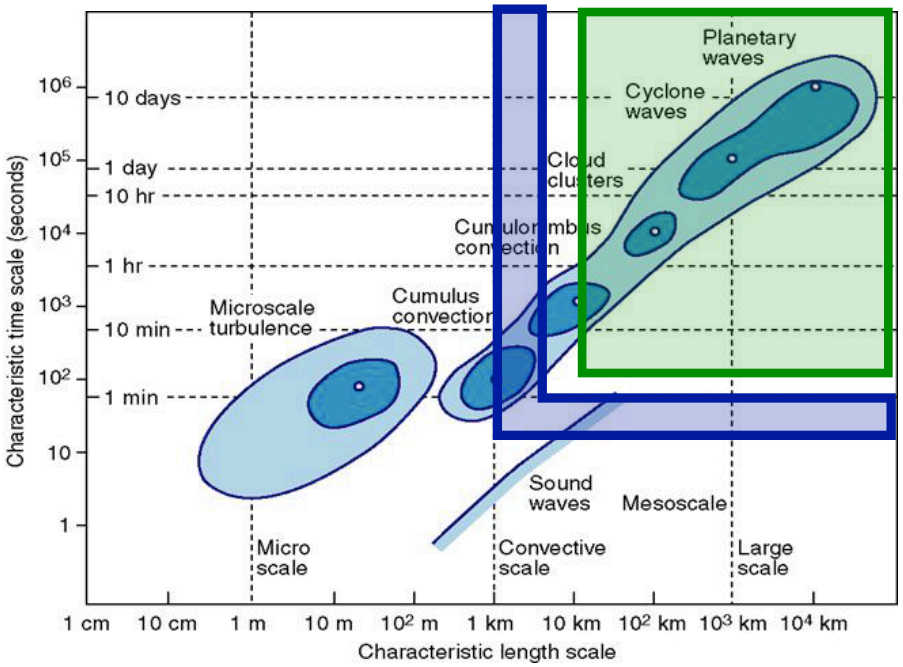
For dx ≥ 10 km:
probably need cumulus scheme



2. Cumulus

Recommendations about use

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



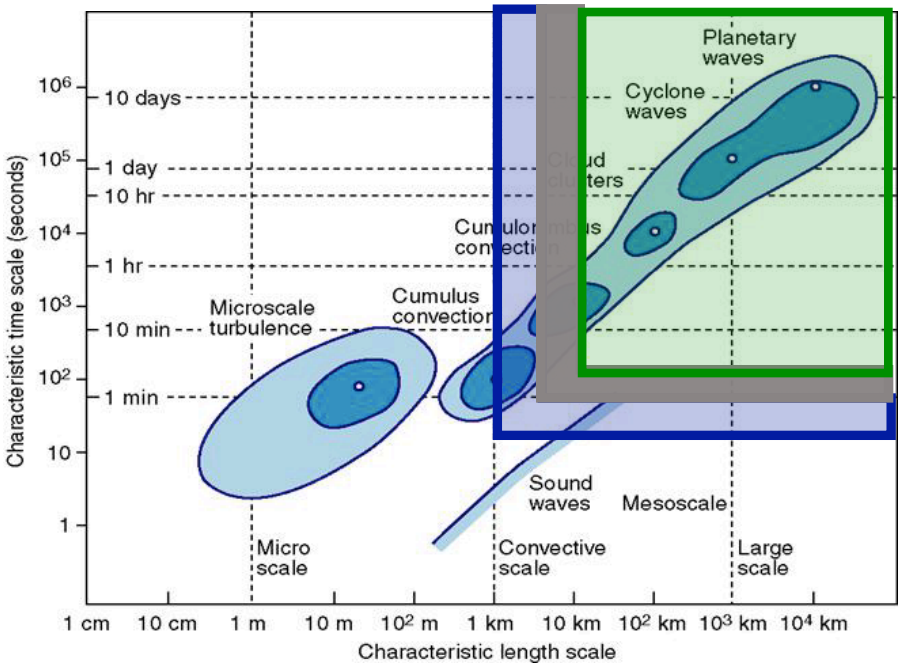
2. Cumulus

Recommendations about use

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

This is a 'grey 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



2. Cumulus

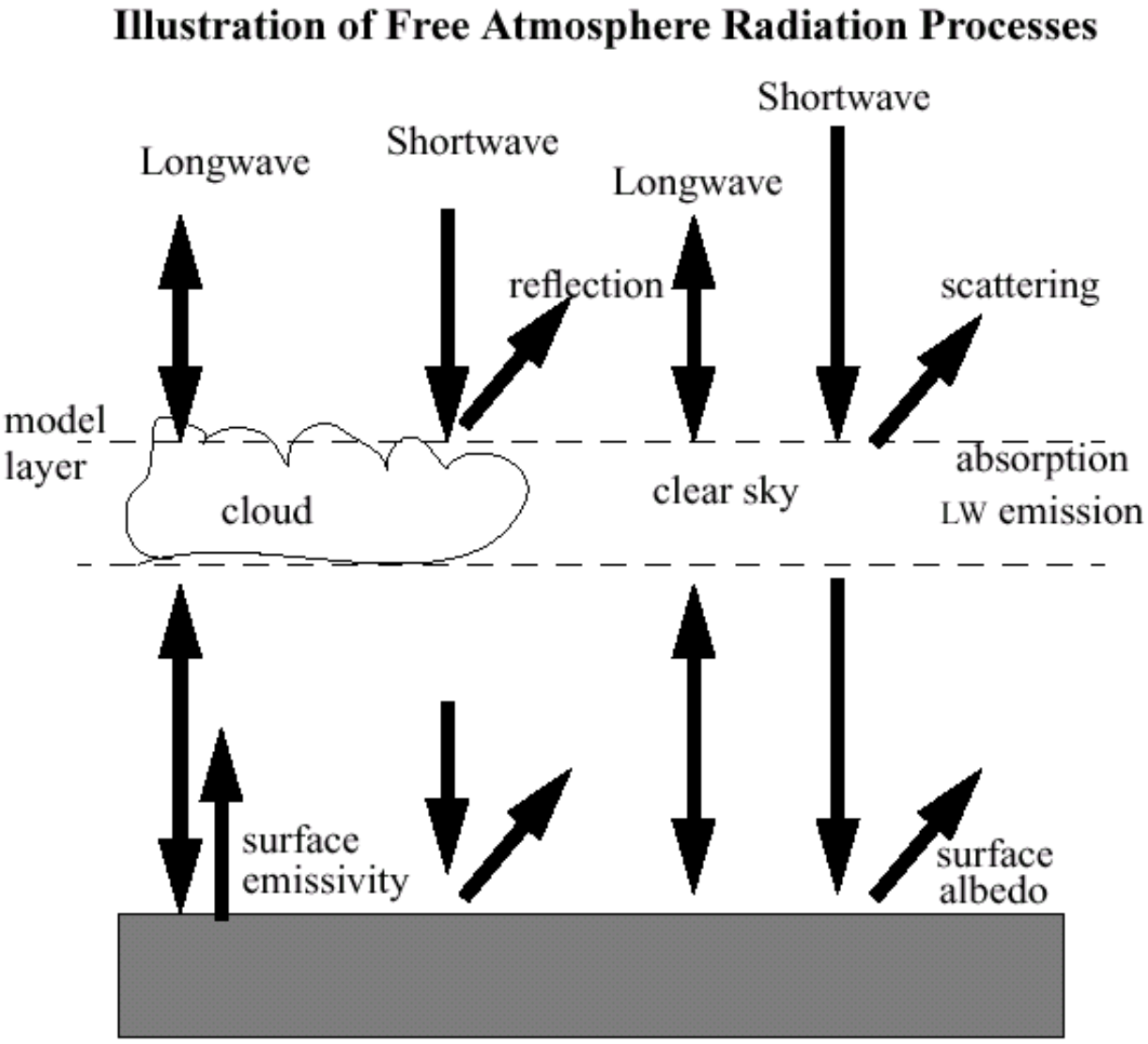
Recommendations about use

Issues with 2-way nesting when physics differs across nest boundaries (seen in precipitation field on parent domain)

best to use same physics in both domains or 1-way nesting

3. Radiation

- provides atmospheric heating due to longwave and shortwave radiation.
- Longwave radiation includes infrared or thermal radiation.
- Shortwave radiation includes visible wavelengths in the solar spectrum.



3. Radiation

Radiation schemes in the WRF (V3.8) model;

a) Longwave Parameterization Schemes

- Rapid Radiative Transfer Model (RRTM) scheme **(1)**
- Community Atmosphere Model (CAM) sheme **(3)**
- RRTMG scheme **(4)**
- New Goddard scheme **(5)**
- Fu-Liou-Gu (FLG) scheme **(7)**
- Geophysical Fluid Dynamics Laboratory (GFDL) scheme **(99)**

b) Shortwave Parameterization Schemes

- MM5 (Dudhia) Shortwave **(1)**
- Goddard Shortwave **(2)**
- Community Atmosphere Model Shortwave **(3)**
- RRTMG scheme **(4)**
- Fu-Liou-Gu (FLG) scheme **(7)**
- Geophysical Fluid Laboratory (GFDL) Shortwave **(99)**

3. Radiation

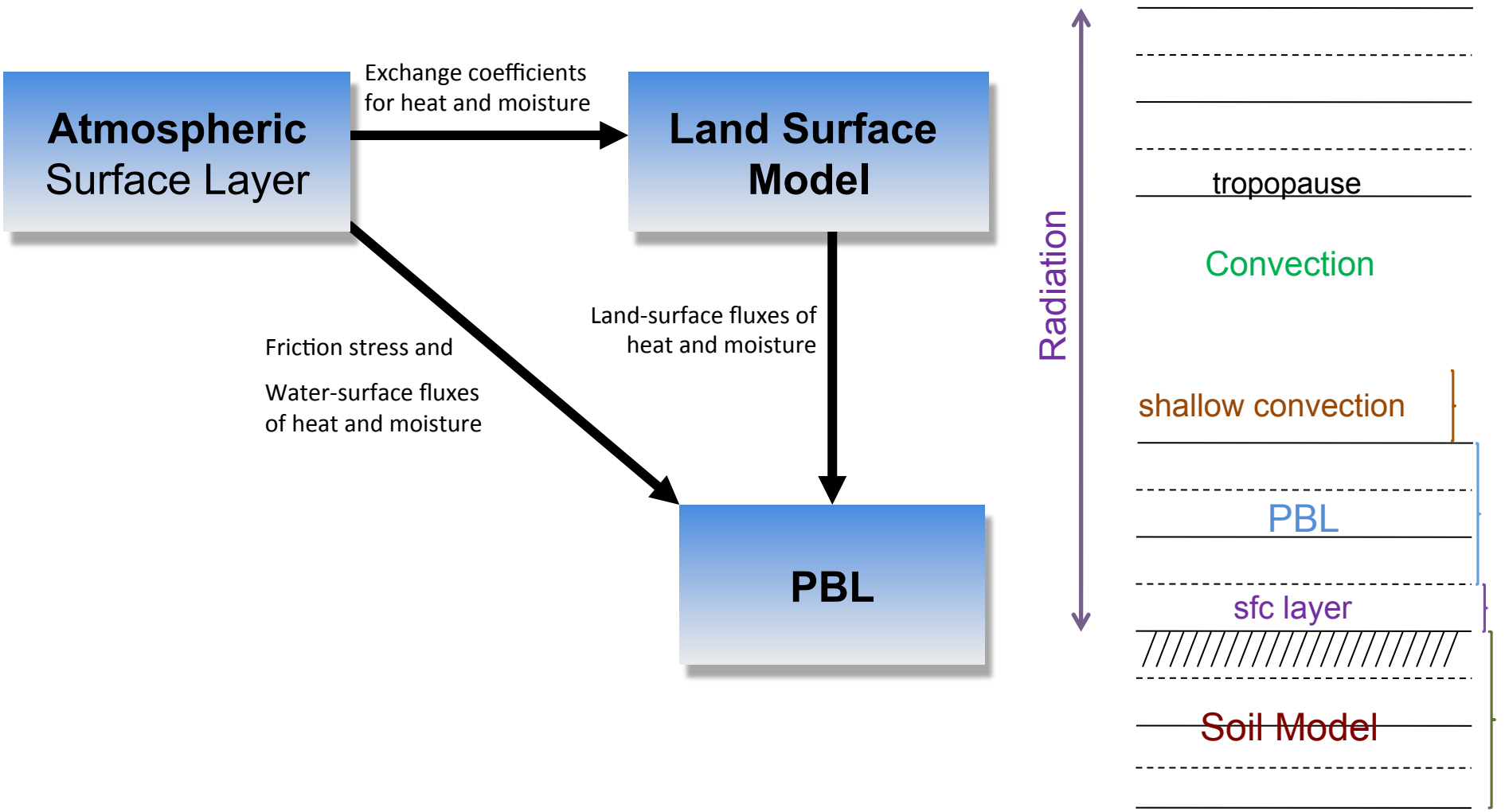
Radiation timestep in namelist.input file is

`radt`

Time step recommendations

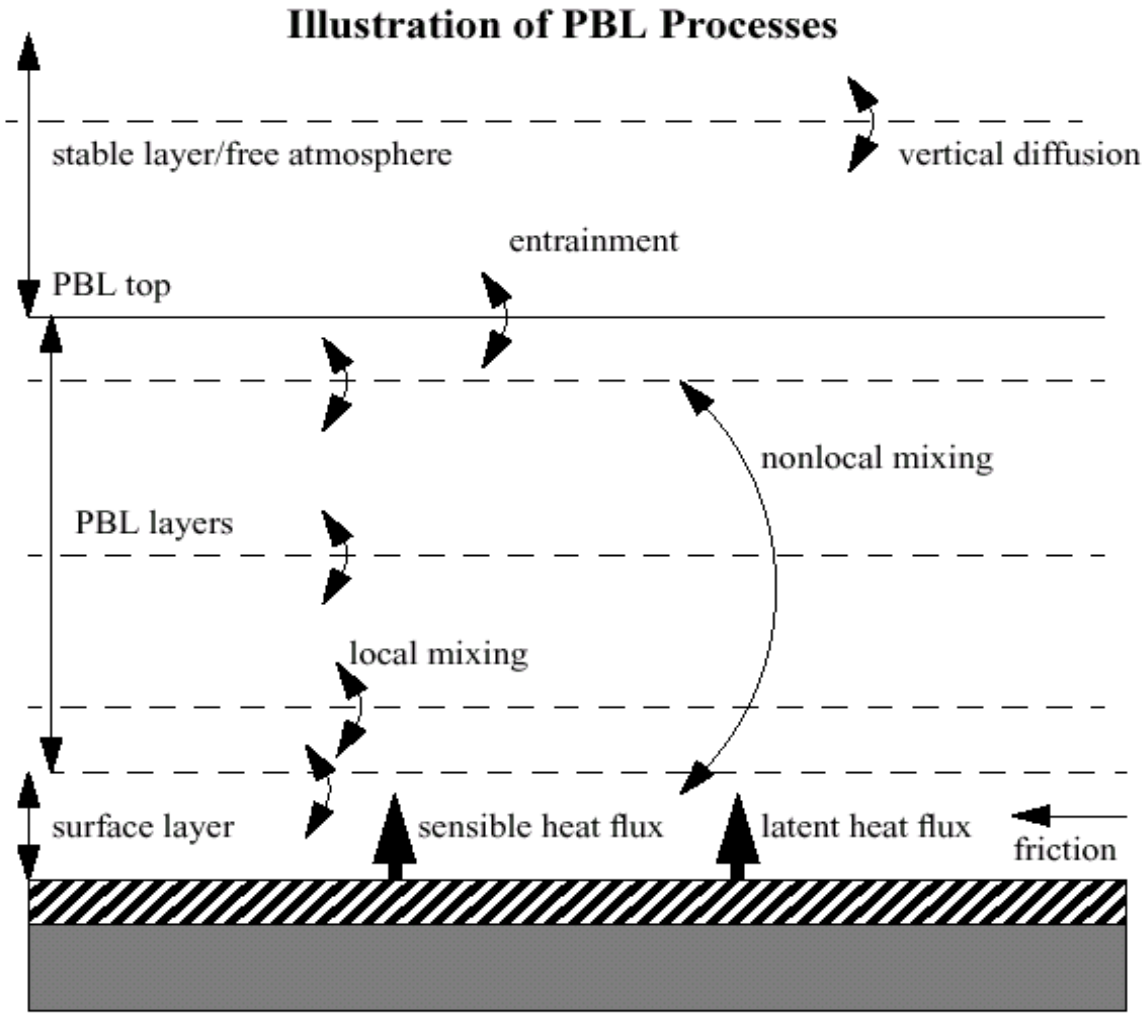
- Radiation is too expensive to call every model time step (dt)
- Frequency should resolve cloud-cover changes with time
- Roughly speaking, `radt` = 1 minute per km grid size (e.g. radt=10 for dx=10 km)
- Recommend using same value on all domains in 2-way nests

Surface Physics Components



4. Planetary Boundary Layer

- Purpose is to distribute surface fluxes with boundary layer eddy fluxes and allow for PBL growth by entrainment
- Above PBL all these schemes also do vertical diffusion due to turbulence
- surface fluxes are provided by the surface layer and land-surface schemes



4. Planetary Boundary Layer

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PBL schemes in the WRF (V3.8) model;

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

5. Surface Layer schemes

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Calculates

- friction velocities
- and exchange coefficients

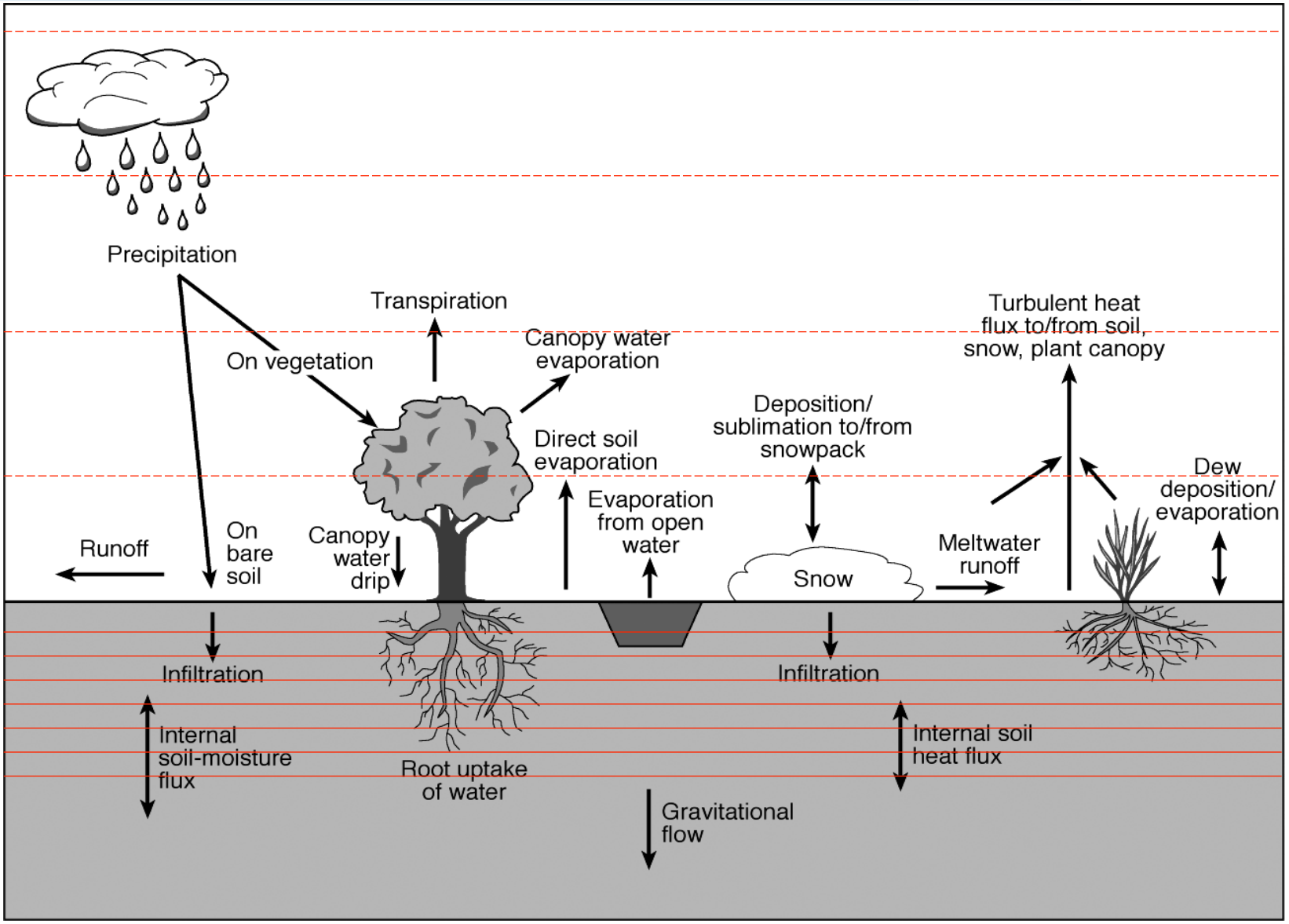
Provide exchange coefficient to land-surface models
Provide friction velocity to PBL scheme
Provide surface fluxes over water points
Schemes have variations in stability functions, roughness lengths

5. Surface Layer schemes

Surface Layer schemes in the WRF (V3.8) model;
CLM4 **(sf_sfclay_physics)**

- MM5 Similarity **(91)**
- Eta similarity sheme **(3)**
- Pleim-Xiu surface layer scheme **(7)**
- QNSE surface layer scheme **(4)**
- MYNN surface layer scheme **(5)**
- TEMF surface layer scheme **(?)**
- Revised MM5 surface layer scheme **(1)**

6. Land Surface Models

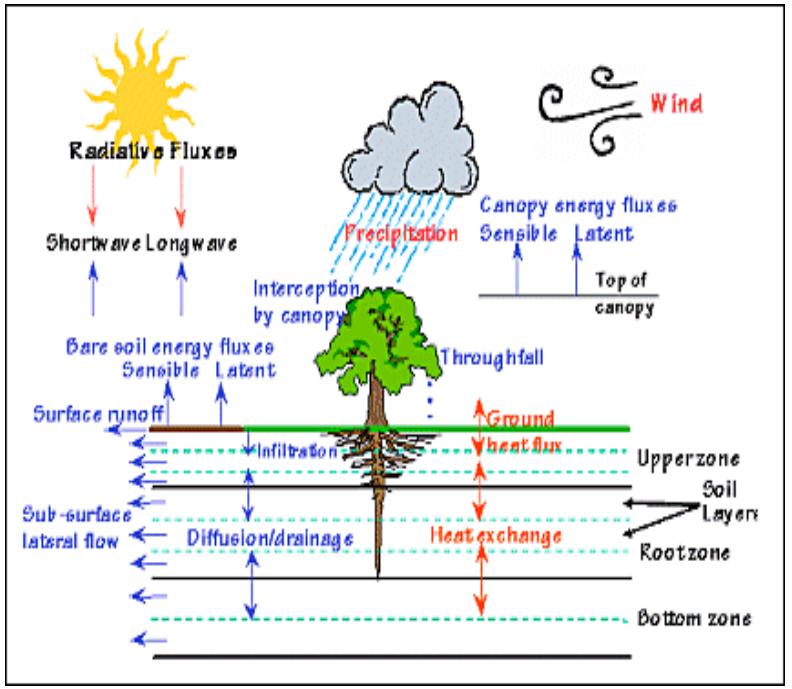


6. Land Surface Models

Uses:

- ***atmospheric information*** from the ***surface layer scheme***,
- ***radiative forcing*** from the ***radiation scheme***,
- and ***precipitation forcing*** from the ***microphysics*** and ***convective schemes***,
- together with internal information on the land's state variables and land-surface properties

provides heat and moisture fluxes
to the PBL shceme
only over land and sea-ice points



6. Land Surface Models

Land surface models in the WRF (V3.8) model;
(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)**
- CLM4 **(5)**

Most complex and most expensive

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

But what schemes should I use?

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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.