WRF Physics Options

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WRF Physics

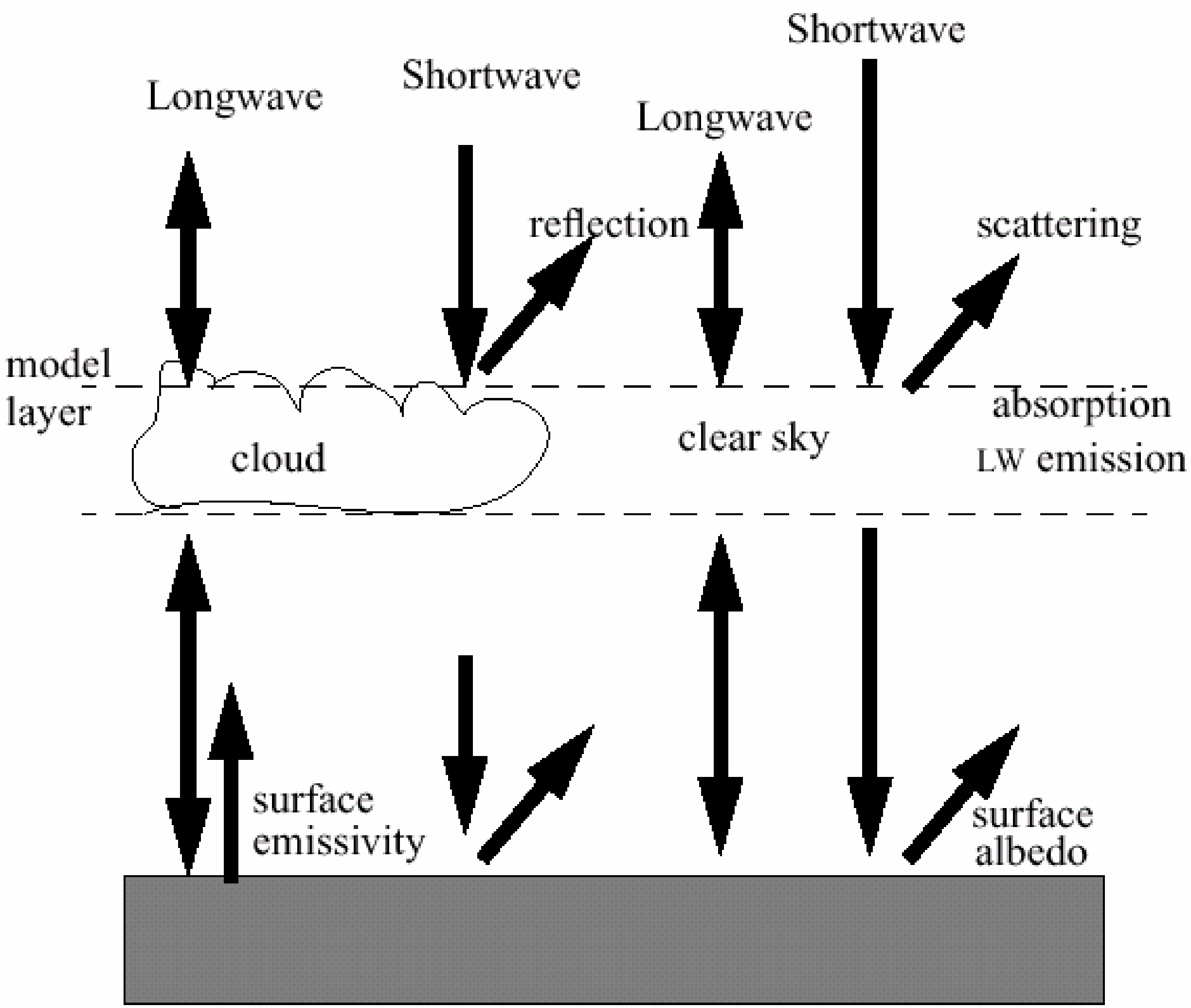
- Turbulence/Diffusion (diff_opt, km_opt)
- Radiation
  - Longwave (ra_lw_physics)
  - Shortwave (ra_sw_physics)
- Surface
  - Surface layer (sf_sfclay_physics)
  - Land/water surface (sf_surface_physics)
- PBL (bl_physics)
- Cumulus parameterization (cu_physics)
- Microphysics (mp_physics)

Radiation

Atmospheric temperature tendency

Surface radiative fluxes

Illustration of Free Atmosphere Radiation Processes



ra_lw_physics=1

RRTM scheme

- Spectral scheme
- K-distribution
- Look-up table fit to accurate calculations
- Interacts with clouds
- Ozone/CO_2 from climatology

ra_lw_physics=99

GFDL longwave scheme

- used in Eta/NMM
- Can only be called with Ferrier microphysics
- Spectral scheme from global model
- Also uses tables
- Interacts with clouds
- Ozone/CO_2 from climatology

ra_sw_physics=1

MM5 shortwave (Dudhia)

- Simple downward calculation
- Clear-sky scattering
- Water vapor absorption
- Cloud albedo and absorption

ra_sw_physics=2

Goddard shortwave

- Spectral method
- Interacts with clouds
- Ozone effects

ra_sw_physics=99

GFDL shortwave

- Used in Eta/NMM model
- Can only be used with Ferrier microphysics
- Ozone effects
- Interacts with clouds

nrads/nradl

Radiation time-step recommendation

- Number of fundamental steps per radiation call
- Operational setting should be 3600/dt
- Higher resolution could be used, e.g. 1800/dt

Surface schemes

- Surface layer of atmosphere diagnostics (exchange/transfer coeffs)
- Land Surface: Soil temperature /moisture /snow prediction /sea-ice temperature

sf_sfclay_physics=1

Monin-Obukhov similarity theory

- Taken from standard relations used in MM5 MRF PBL
- Provides exchange coefficients to surface (land) scheme
- Should be used with bl_pbl_physics=1 or 99

sf_sfclay_physics=2

Monin-Obukhov similarity theory

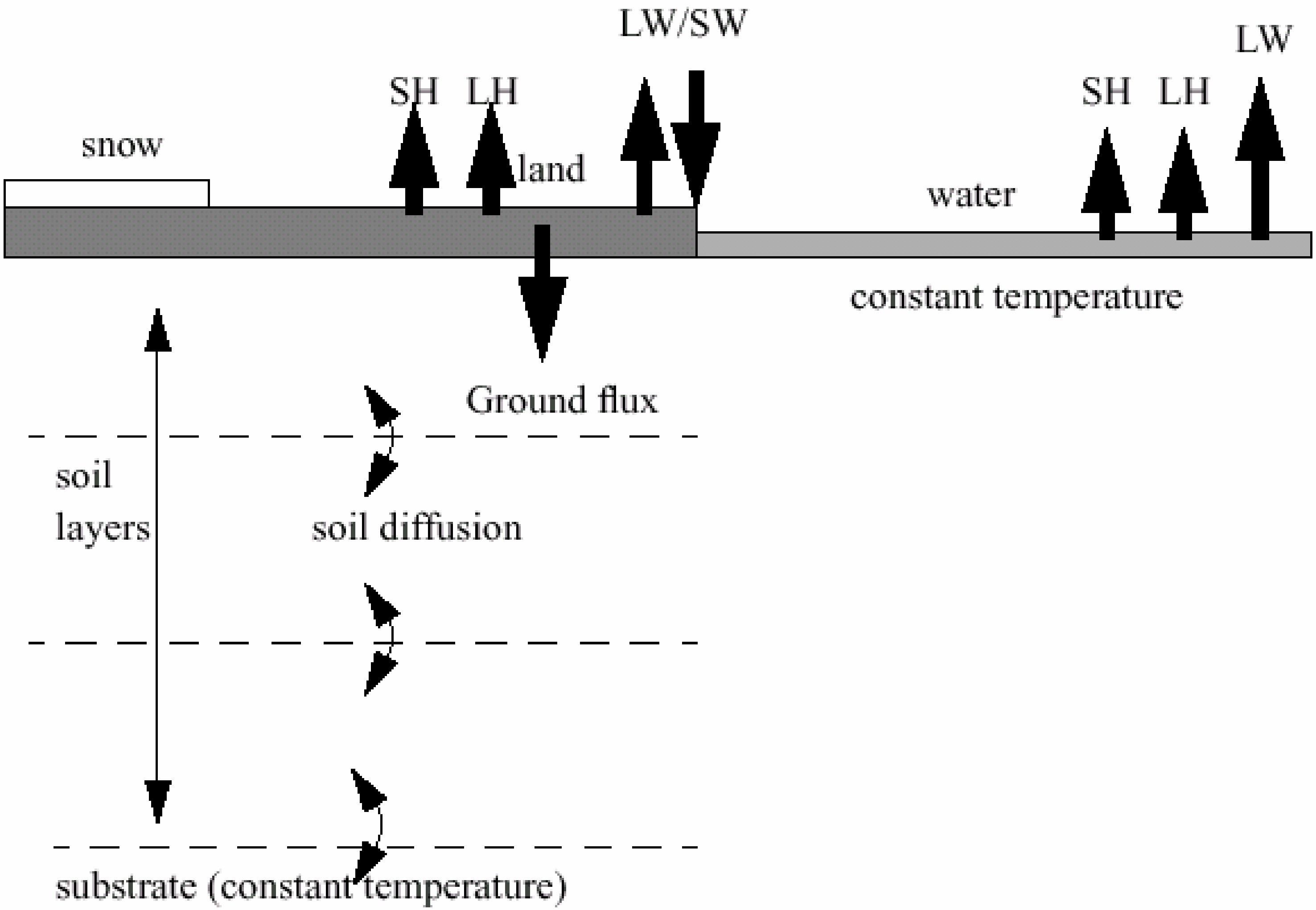
- Modifications due to Janjic
- Taken from standard relations used in NMM model, including Zilitinkevich thermal roughness length
- Should be used with bl_pbl_physics=2

sf_sfclay_physics=3

GFS Monin-Obukhov similarity theory

- For use with NMM-LSM
- Should be used with bl_pbl_physics=3

Illustration of Surface Processes



sf_surface_physics=1

5-layer thermal diffusion model from MM5

- Predict ground temp and soil temps
- Thermal properties depend on land use
- No effect for water
- Provides heat and moisture fluxes for PBL

sf_surface_physics=99

NMM Land Surface Model (NCEP Noah)

- Vegetation effects included
- Predicts soil temperature and soil moisture in four layers
- Predicts snow cover and canopy moisture
- Handles fractional snow cover and frozen soil
- Diagnoses skin temp and uses emissivity
- Provides heat and moisture fluxes for PBL

sf_surface_physics=3

RUC Land Surface Model (Smirnova)

- Vegetation effects included
- Predicts soil temperature and soil moisture in six layers
- Multi-layer snow model
- Provides heat and moisture fluxes for PBL

LANDUSE.TBL

LANDUSE.TBL file (ascii) has land-use properties (vegetation, urban, water, etc.)

- 24 USGS categories from 30” global dataset
- Each type is assigned summer/winter value
  - Albedo
  - Emissivity
  - Roughness length
- Other table properties (thermal inertia, moisture availability, snow albedo effect) are used by 5-layer model
- Other tables (VEGPARM.TBL, etc.) are used by Noah
- RUC LSM has internal values

Initializing LSMs

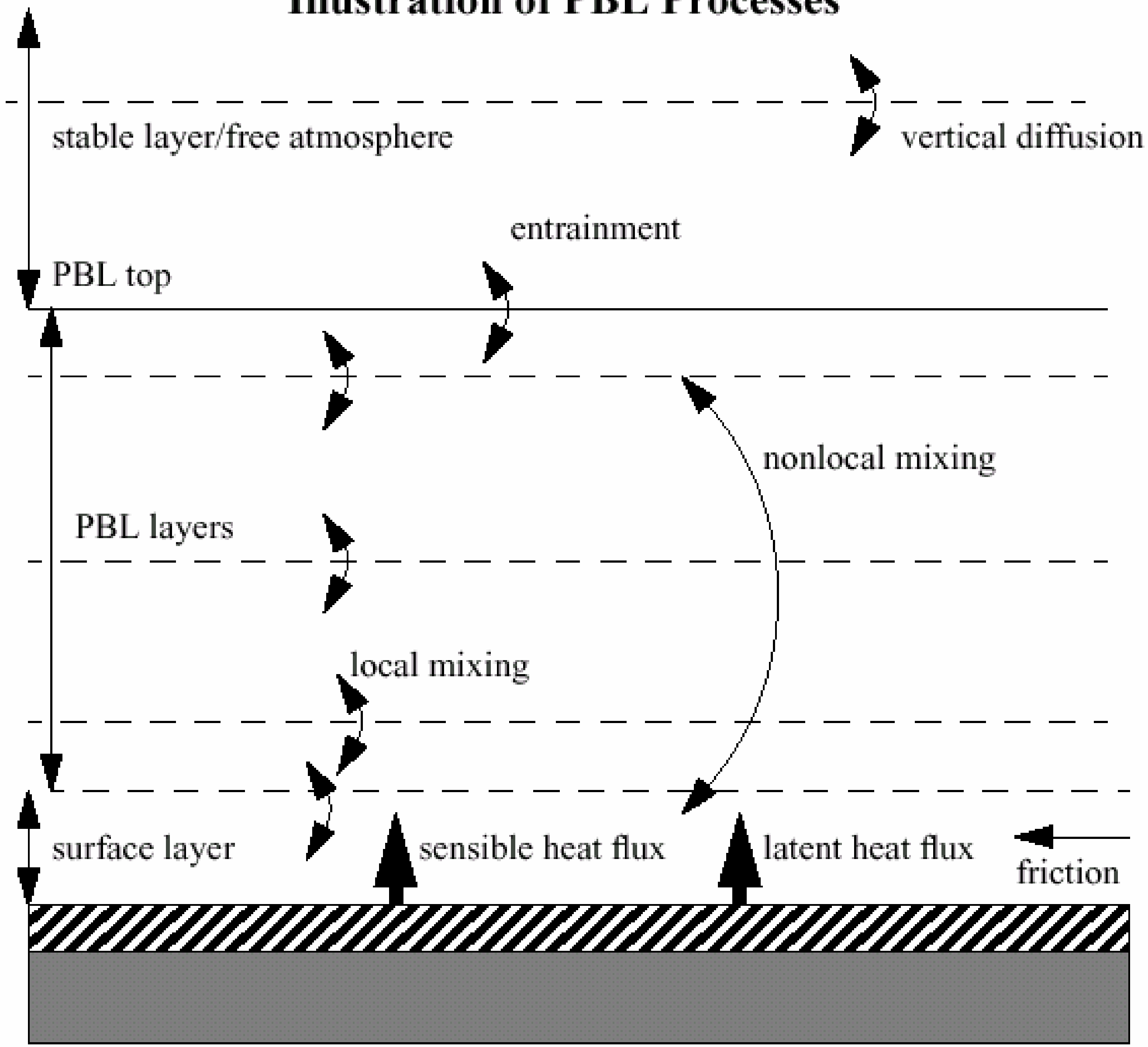
- Noah and RUC LSM require additional fields for initialization
  - Soil temperature
  - Soil moisture
  - Snow liquid equivalent
- Best source is a consistent model-derived dataset
  - Eta/GFS/AGRMET/NNRP for Noah (although some have limited soil levels available)
  - RUC for RUC
- Optimally the resolution, land-use, soil texture, should match the data source model, otherwise there will be a spin-up issue

Planetary Boundary Layer

Boundary layer fluxes (heat, moisture, momentum)

Vertical diffusion

Illustration of PBL Processes



bl_pbl_physics=1

YSU PBL scheme (Hong and Noh)

- Parabolic non-local-K mixing in dry convective boundary layer
- Depth of PBL determined from thermal profile
- Explicit treatment of entrainment
- Vertical diffusion depends on Ri in free atmosphere

bl_pbl_physics=2

Mellor-Yamada-Janjic (Eta/NMM) PBL

- 1.5-order, level 2.5, TKE prediction
- Local TKE-based vertical mixing in boundary layer and free atmosphere

bl_pbl_physics=3

GFS PBL

- 1st order Troen-Mahrt
- Closely related to MRF PBL
- Non-local-K vertical mixing in boundary layer and free atmosphere

bl_pbl_physics=99

MRF PBL scheme (Hong and Pan 1996)

- Non-local-K mixing in dry convective boundary layer
- Depth of PBL determined from critical Ri number
- Vertical diffusion depends on Ri in free atmosphere

nphs

- Time steps between PBL/turbulence/LSM calls
- Typical value is 10 for efficiency
- Also used for microphysics

PBL Scheme Options

PBL schemes can be used for most grid sizes when surface fluxes are present

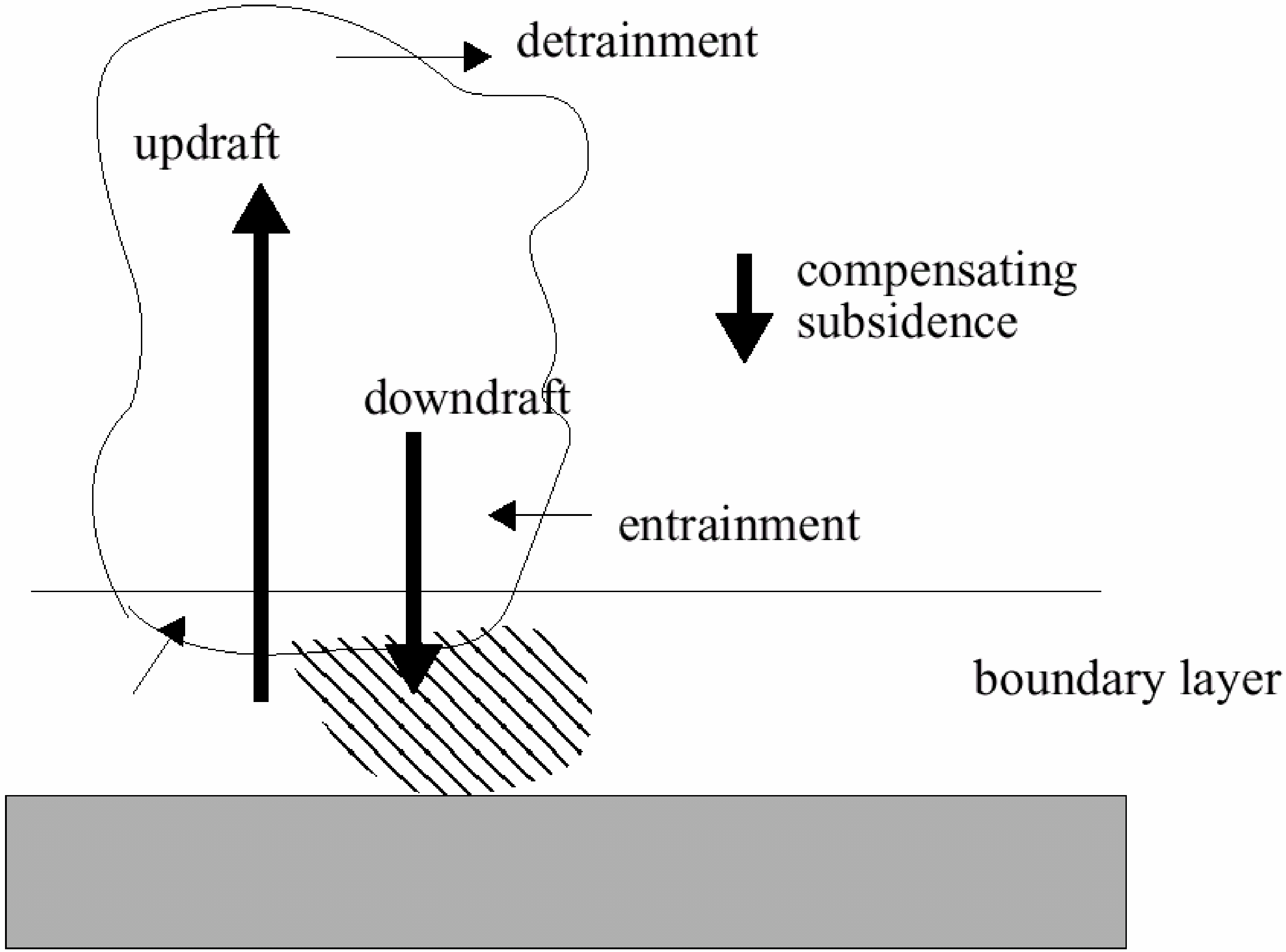
- Assumes that PBL eddies are not resolved
- With PBL scheme, lowest full level should be .99 or .995 (not too close to 1)
- At grid size dx << 1 km, this assumption breaks down
- Can use 3d tke diffusion, but, this is not yet coupled to the actual surface fluxes
- Currently 3d tke can only be used with constant specified surface fluxes

Cumulus Parameterization

Atmospheric heat and moisture/cloud tendencies

Surface rainfall

Illustration of Cumulus Processes



cu_physics=1

New Kain-Fritsch

- As in MM5 and Eta/NMM test version
- Includes shallow convection
- Low-level vertical motion in trigger function
- CAPE removal time scale closure
- Mass flux type with updrafts and downdrafts, entrainment and detrainment
- Includes cloud detrainment

cu_physics=2

Betts-Miller-Janjic

- As in NMM model (Janjic 1994)
- Adjustment type scheme
- BM saturated profile modified by cloud efficiency, so post-convective profile can be unsaturated in BMJ
- No explicit updraft or downdraft

cu_physics=3

Grell-Devenyi Ensemble

- Multiple-closure (e.g. CAPE removal, quasi-equilibrium)
- Multi-parameter (e.g maximum cap, precipitation efficiency)
- Explicit updrafts/downdrafts
- Mean feedback of ensemble is applied
- Weights can be tuned (spatially, temporally) to optimize scheme (training)

cu_physics=4

Simpified Arakawa-Schubert (SAS) GFS scheme

- Quasi-equilibrium scheme
- Related to Grell scheme in MM5
- Downdrafts and single, simple cloud

ncnvc

- Time steps between cumulus parameterization calls
- Typically 10 - same as NPHS

Cumulus scheme

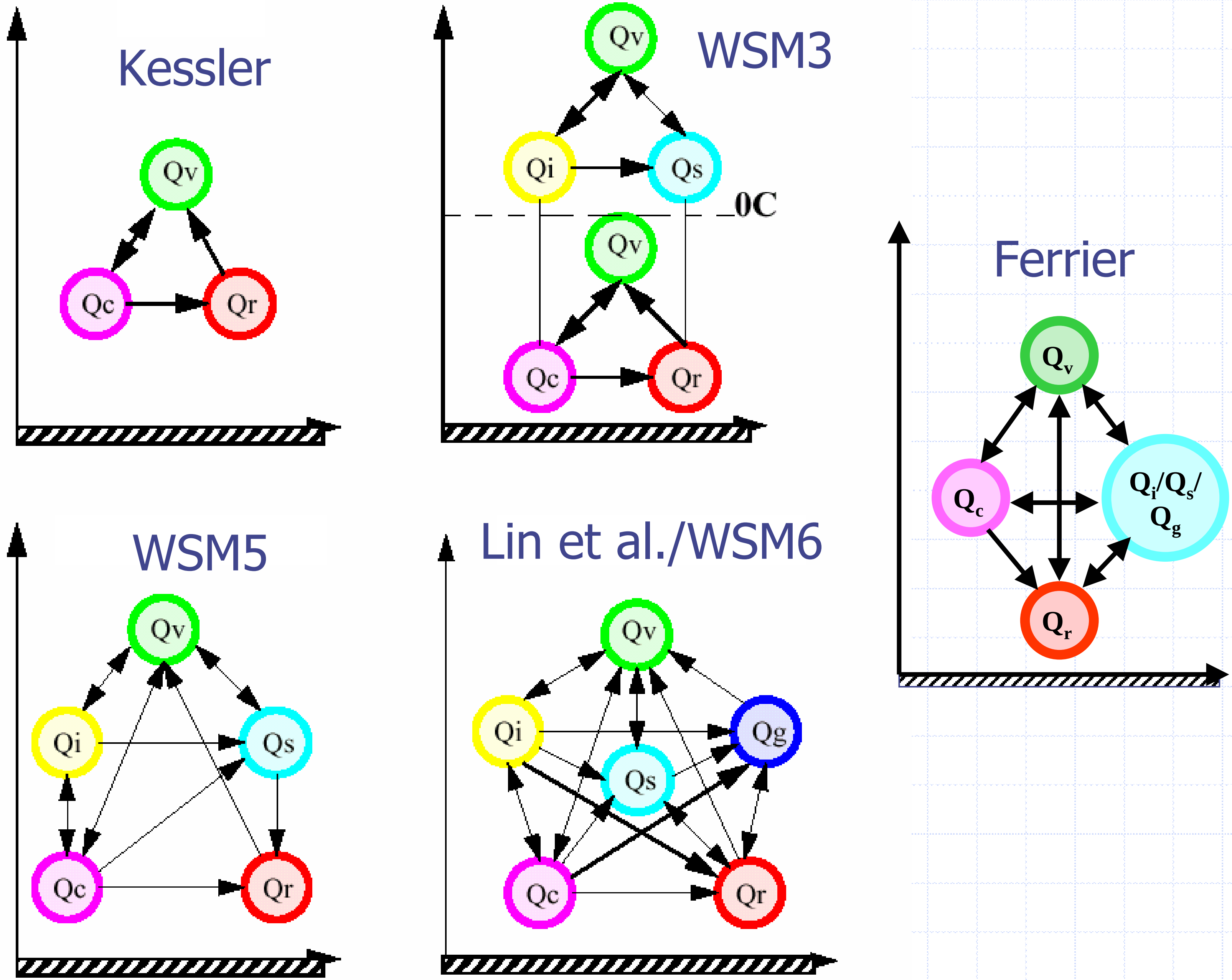
Recommendations about use

- 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 ?
  - No schemes are specifically designed with this range of scales in mind

Microphysics

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

Illustration of Microphysics Processes



mp_physics=1

Kessler scheme

- Warm rain – no ice
- Idealized microphysics
- Time-split rainfall

mp_physics=2

Purdue Lin et al. scheme

- 5-class microphysics including graupel
- Includes ice sedimentation and time-split fall terms

mp_physics=3

WSM 3-class scheme

- From Hong, Dudhia and Chen (2004)
- Replaces NCEP3 scheme
- 3-class microphysics with ice
- Ice processes below 0 deg C
- Ice number is function of ice content
- Ice sedimentation and time-split fall terms

mp_physics=4

WSM 5-class scheme

- Also from Hong, Dudhia and Chen (2004)
- Replaces NCEP5 scheme
- 5-class microphysics with ice
- Supercooled water and snow melt
- Ice sedimentation and time-split fall terms

mp_physics=5

Ferrier (current NAM) scheme

- Designed for efficiency
  - Advection of total condensate
  - Cloud water, rain, & ice (cloud ice, snow/graupel) from storage arrays – assumes fractions of water & ice within the column are fixed during advection
- Supercooled liquid water & ice melt
- Variable density for precipitation ice (snow/graupel/sleet) – “rime factor”

mp_physics=6

WSM 6-class scheme

- From Hong and Lim (2006, JKMS)
- 6-class microphysics with graupel
- Ice number concentration as in WSM3 and WSM5
- Modified accretion
- Time-split fall terms with melting

mp_physics=8

Thompson et al. graupel scheme

- From Thompson et al. (2004, MWR)
- Newer version of Reisner2 scheme
- 6-class microphysics with graupel
- Ice number concentration also predicted (double-moment ice)
- Time-split fall terms

mp_physics=98,99

NCEP3,NCEP5

- Old options from Version 1.3 still available for comparison
- Originally from Regional Spectral Model
- To be phased out later

mp_zero_out

Microphysics switch (also mp_zero_out_thresh)

- 1: all values less than threshold set to zero (except vapor)
- 2: as 1 but vapor also limited ≥ 0
- Note: this option will not conserve total water
- NMM: Recommend mp_zero_out=0

nphs

- Time steps between microphysics calls
- Same as parameter for turbulence/PBL/LSM
- Typical value is 10 for efficiency

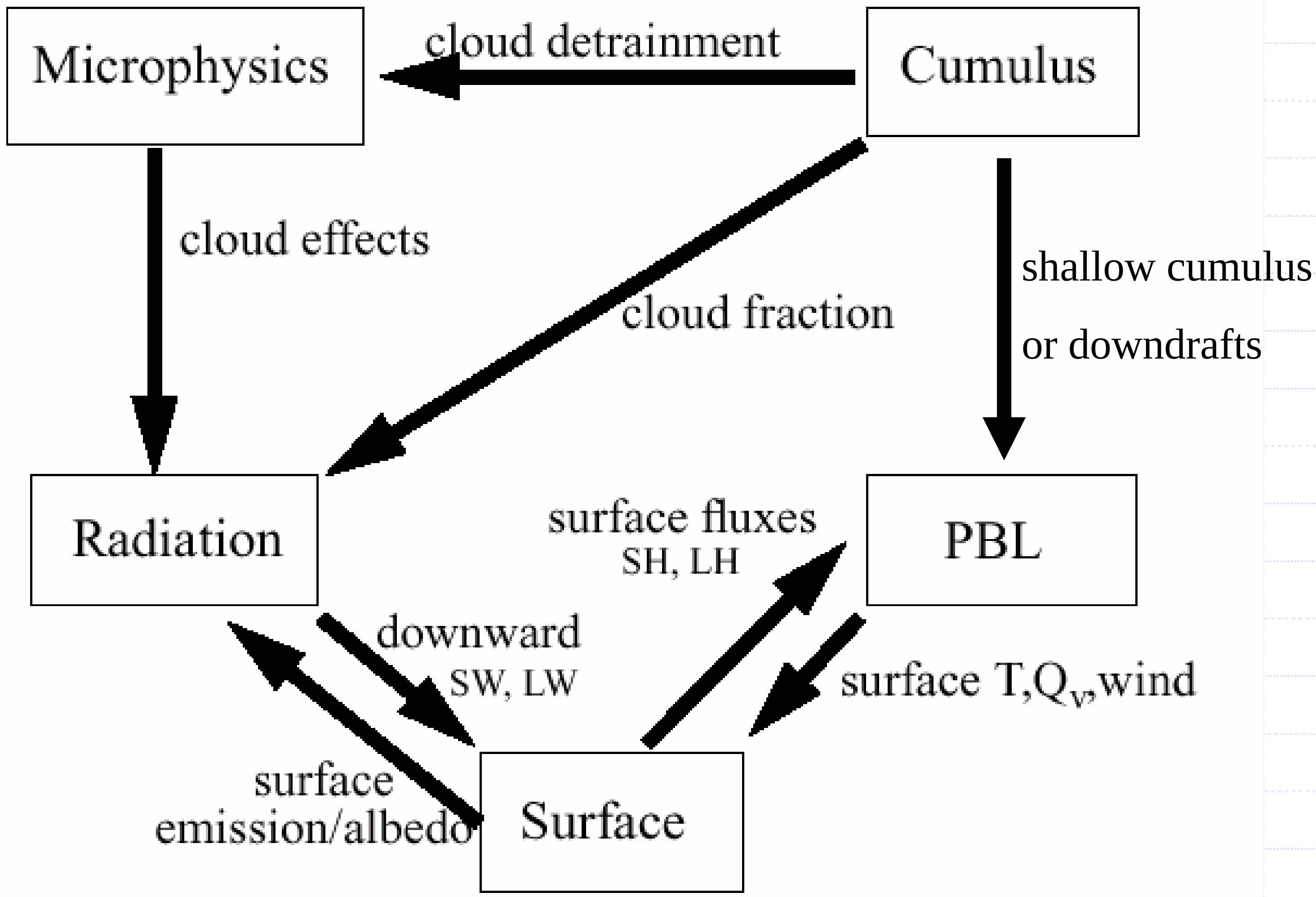
Microphysics Options

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

Physics Interactions

Direct Interactions of Parameterizations



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