Name of the module

Fog Deposition EStimation (FogDES) scheme for WRF after version 3.5.1

Short description of the module

FogDES scheme developed by the Japan Atomic Energy Agency (JAEA) calculates fogwater (cloud water) deposition at various types of earth surface with a low calculation cost (Katata 2014; Katata et al., 2014). The calculation of fog deposition is made based on the simple linear function of liquid water content (LWC) at the ground surface and fog deposition velocity. The LWC is obtained from the standard output of WRF at the lowest atmospheric layer (20~50 m in altitude is expected). The fog deposition velocity is represented as a function of Leaf Area Index (LAI) and canopy height, parameterized from the numerical experiments using the detailed multilayer atmosphere-SOil-VEGetation model (SOLVEG) (Katata et al., 2008). Fog deposition due to turbulent diffusion and gravitational settling is calculated for vegetative land use categories (e.g., cropland, grassland, shrubland, and forest). For other categories with a smooth surface (e.g., bare soil and ocean), only the mechanism of gravitational settling is considered to fog deposition calculations with mean droplet diameter of fog computed from LWC (Katata et al., 2008). As a result of fog deposition, the scheme also calculates the removal of LWC at the lowest atmospheric layer (Katata et al., 2011) and the water supply from fog water deposition to the ground surface. Details of FogDES scheme are provided by Katata et al. (2011) and Katata (2014).

How to use the module in WRF

Modifications in the source code

The following modules in the original WRF source code and new modules of ‘module_bl_fogdes.F’ and ‘module_sf_fogdes.F’ have been modified and added, respectively:

In ‘WRFV3/phys’ directory:

‘Makefile’, ‘module_bl_mynn.F’, ‘module_pbl_driver.F’, ‘module_physics_init.F’, ‘module_sf_fogdes.F’, ‘module_bl_fogdes.F’, and ‘module_surface_driver.F’;

In ‘WRFV3/dym_em’ directory:

‘module_first_rk_step_part1.F’, and ‘start_em.F’;

In ‘WRFV3/Registry’ directory:

‘Registry.EM_COMMON’.

The major part of the fog deposition calculation is involved in 'module_sf_fogdes.F'. The module calculates the fog deposition velocity with a dependence on the land use categories with vegetation parameters. The water input to the ground soil due to fog deposition is computed in

‘module_surface_driver.F’ (Katata 2014). Registry.EM_COMMON file has been modified to output the several new variables (see *Output variables*).

To compile and run

To use this scheme, the parameter of ‘bl_pbl_physics’ in WRFV3/run/namelist.input should be set to either 5 or 6 (MYNN scheme). In addition, the option of ‘grav_settling’ is set to 2 to activate FogDES scheme. After all modules shown in *Modifications in the source code* are updated, the steps to compile and run the model are same as the original code, i.e.: (1) configure: generate a configuration file for compilation, (2) compile: compile the code with em_real, and (3) run WRF model.

Output variables

The new output variables of fgdp, dfgdp, and vdfg will be shown in the WRF output files "wrfout_*.nc", where fgdp (mm) is the accumulated fog deposition, dfgdp (mm) the fog deposition in timestep, and vdfg (m s^{-1}) the deposition velocity of fog. All output variables have horizontal two-dimensional fields at the ground surface.

Extra input files

No external input file is needed to use FogDES scheme. In the current version, the scheme works with both USGS and IGBP-Modified MODIS land use categories (with or without lake category) that provide the input data of LAI for each land use category.

References

Katata, G., H. Nagai, T. Wrzesinsky, O. Klemm, W. Eugster, and R. Burkard, 2008. Development of a land surface model including cloud water deposition on vegetation. *J. Appl. Meteorol. Climatol.*, **47**, 2129-2146.

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