Model Descriptions

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Model Name and History:

- Long Name: NCEP Global Forecast System Single Column Model
- Acronym: NCEP GFS SCM
- Short/conversational name:
- Generic predecessor or relative :

Model Type: 1D

Numerical Domain:

- Domain size in x-direction: N/A
- Domain size in y-direction: N/A
- Domain size in z-direction:
  This domain is divided into 64 layers with enhanced resolution near the bottom and the top. For a surface pressure of 1000 hPa, the lowest atmospheric level is at a pressure of about 997.3 hPa and the top level is at about 0.27 hPa.
- Number of grid points in x-direction: N/A
- Number of grid points in y-direction: N/A
- Number of grid points in z-direction: 64
- Grid size in x-direction: N/A
- Grid size in y-direction: N/A
- Grid size in z-direction:
  NCEP GFS sigma coordinate, Lorenz grid, Quadratic-conserving finite difference scheme by Arakawa and Mintz (1974).
  For a surface pressure of 1000 hPa, 15 levels are below 800 hPa, and 24 levels are above 100 hPa.
- Time step: 5 minutes

Numerical Technique:

- Numerical method (finite-difference, spectral, etc.):
  Spectral (spherical harmonic basis functions) with transformation to
  a Gaussian grid for calculation of nonlinear quantities and physics (Sela 1980).

- Time scheme and its order of accuracy:
  The main time integration is leapfrog for nonlinear advection terms,
  and semi-implicit for gravity waves and for zonal advection of vorticity
  and moisture. An Asselin (1972) time filter is used to reduce computational modes.

The dynamics and physics are split. The physics are written in the form of an adjustment and executed in sequence. For physical processes, implicit integration with a special time filter (Kalnay and Kanamitsu, 1988) is used for vertical diffusion.
The time step is 5 minutes for computation of dynamics and physics, except that the full calculation of longwave radiation is done once every 3 hours and shortwave radiation every hour (but with corrections made at every time step for diurnal variations in the shortwave fluxes and in the surface upward longwave flux)

- Dynamical equations (elastic, anelastic, etc.):
Primitive equations with vorticity, divergence, logarithm of surface pressure, specific humidity virtual temperature, and cloud condensate as dependent variables

- Numerical diffusion (type, order, magnitude of coefficient)
Horizontal Diffusion: Scale-selective, second-order horizontal diffusion after Leith (1971) is applied to vorticity, divergence, virtual temperature, and specific humidity and cloud condensate. The diffusion of temperature, specific humidity, and cloud condensate are performed on quasi-constant pressure surfaces (Kanamitsu et al. 1991).
Vertical Diffusion: Troen and Mahrt (1986) first-order vertical diffusion scheme. There is a diagnostically determined pbl height that uses the bulk-Richardson approach to iteratively estimate a pbl height starting from the ground upward. Once the pbl height is determined, the profile of the coefficient of diffusivity is specified as a cubic function of the pbl height. The actual values of the coefficients are determined by matching with the surface-layer fluxes. There is also a counter-gradient flux parameterization that is based on the fluxes at the surface and the convective velocity scale (Hong and Pan 1996).

- Lateral boundary conditions: N/A
- Upper boundary condition (Sponge layer, specification, ...): free atmosphere
- Translation velocity of the reference frame: N/A
- Other information

Physical Parameterizations:

- Surface flux parameterization for heat, moisture, momentum:
The lowest model layer is assumed to be the surface layer (sigma= 0.996) and the Monin-Obukhov similarity profile relationship is applied to obtain the surface stress and sensible and

latent heat fluxes. The formulation was based on Miyakoda and Sirutis (1986) and has been modified by P. Long in the very stable and very unstable situations. A bulk aerodynamic formula is used to calculate the fluxes once the turbulent exchange coefficients have be obtained. Land surface evaporation is comprised of three components: direct evaporation from the soil and from the canopy, and transpiration from the vegetation (Pan and Mahrt 1987).

- Longwave radiation parameterization:
Rapid Radiative Transfer Model (RRTM) developed at AER (Mlawer et al. 1997)

- Shortwave radiation parameterization:
The shortwave (SW) radiative transfer parameterization (Hou et al., 2002) is based on Chou's work (1992) and his later improvements (Chou and Lee, 1996; Chou and Suarez, 1999).

- How were radiative fluxes above the computational domain handled? N/A

- Microphysical (2D/3D models) or cloud/convective (1D model) parameterization: type, number of hydrometeor classes, ...
The prognostic cloud condensate has two sources, namely convective detrainment and grid-scale condensation. The grid-scale condensation is based on Zhao and Carr(1997), which in turn is based on Sundqvist et al. (1989). The sinks of cloud condensate are grid-scale precipitation which is parameterized following Zhao and Carr (1997) for ice, and Sundqvist et al. (1989) for liquid water, and evaporation of the cloud condensate which also follows Zhao and Carr (1997). Evaporation of rain in the unsaturated layers below the level of condensation is also taken into account. All precipitation that penetrates the bottom atmospheric layer is allowed to fall to the surface.
Penetrative convection is simulated following Pan and Wu (1994), which is based on Arakawa and Schubert(1974) as simplified by Grell (1993) and with a saturated downdraft.
Following Tiedtke (1983), the simulation of shallow (nonprecipitating) convection is parameterized as an extension of the vertical diffusion scheme. The shallow convection occurs where convective instability exist but no convection occurs. The cloud base is determined from the lifting condensation level and the vertical diffusion is invoked between the cloud top and the bottom. A fixed profile of vertical diffusion coefficients is assigned for the mixing process.
The fractional area of the grid point covered by the cloud is computed diagnostically following the approach of Xu and Randall (1996).

- Turbulence closure scheme (turbulence closure type, variables

predicted and diagnosed by - - the turbulence closure, closure for turbulent length scale, ...)

- Other information

Documentation:
Please provide references that more fully describe your model.
- Documentation (present model), if available:
http://www.emc.ncep.noaa.gov/modelinfo/
Fanglin Yang, Hua-Lu Pan, Steve Krueger, Shrinivas Moorthi, Stephen Lord, 2006: Evaluation of the NCEP Global Forecast System at the ARM SGP Site. Monthly Weather Review, In Press.

- Documentation (predecessor or relative).
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