GEOS-5 File Specification Variable Definition Glossary

11/01/2011

1 Three-dimensional Fields

CFLS, CFAN, CFCU: The horizontal fractional cloud cover of each cloud type for each layer. In the vertical, clouds are assumed to fill the layer. The sum of these fractions may exceed one. See CLOUD for the single fraction used in the radiation calculations.

CLOUD: The horizontal fractional cloud cover for each layer as seen by the radiation. In the vertical, clouds are assumed to fill the layer. This fraction is the combination of the model's predicted large-scale and convective fractions that is used for radiative purposes. See CLDTOT for a description of how these fractions are overlapped in the radiation calculations.

CMFMC: The total vertical convective mass flux through levels between model layers (edges), in kg m^{-2} s^{-1}. This is produced by the convection parameterization (RAS) and it includes the mass flux due to all cloud types crossing the level. Constituent transport due to these fluxes can be computed off-line as described in DTRAIN

DELP: Pressure thickness of model layers, in Pa. See PLE. The layer mass is $\frac{1}{g}\mathbf{DELP}$ kg m^{-2}.

DDPDTANA: Tendency of the layer's pressure thickness due to analysis, in Pa s^{-1}. The GSI analyzes the surface pressure and this is the vertical distribution of that mass increment.

DQRCON, DQRLSC, DQRANV: The layer production rate of precipitating condensate from convective, large-scale, and anvil clouds, per unit horizontal area, in kg m^{-2} s^{-1}. They include both liquid and frozen precipitating condensate, but not the production of cloud condensates.

DQRCU, DQRLSAN: The layer production rate of precipitating condensate from convective and the sum of large-scale and anvil clouds, per unit horizontal area, in kg m^{-2} s^{-1}. They include both liquid and frozen precipitating condensate, but not the production of cloud condensates.

DQVDTMST, DQLDTMST, DQIDTMST: Tendency of vapor, liquid and ice water due to moist processes, in kg kg^{-1} s^{-1}. This includes the effects of the convection parameterization and all other effects from the cloud microphysics and large scale and anvil precipitation schemes.

DQVDTDYN: Tendency of water vapor due to resolved dynamics, in kg kg^{-1} s^{-1}.

DQVDTTRB: Tendency of water vapor due to turbulence, including surface evaporation, in kg kg^{-1} s^{-1}.

DTDTANA: The analysis tendency introduced during the corrector segment of the IAU cycle, in K s^{-1}.

DTDTDYN: Temperature tendency due to dynamics, including the net of kinetic energy generation and the spurious frictional dissipation of kinetic energy by numerical processes, in K s^{-1}.

DTDTFRI: Temperature tendency due to the frictional dissipation of kinetic energy by turbulence, including surface friction, in K s^{-1}. It does not include dissipation from gravity wave drag, moist processes, or the implicit dissipation in the model's dynamics.

DTDTGWD: Temperature tendency due to the frictional dissipation of kinetic energy by gravity wave drag, in K s^{-1}.

DTDTLWR, DTDTLWRCLR: Temperature tendency due to terrestrial (longwave) radiation for all-sky and clear-sky conditions, in K s^{-1}.

DTDTMST: Temperature tendency due to moist processes, in K s^{-1}. This includes all latent heating due to condensation and evaporation plus the mixing by the convective parameterization, but does not include the heating due to frictional dissipation, which was inadvertently omitted as a diagnostic.

DTDTRAD: Temperature tendency due to radiation, in K s^{-1}. This includes both solar and terrestrial radiative heating. It is the same as the sum **DTDTSWR + DTDTLWR.**

DTDTSWR, DTDTSWRCLR: Temperature tendency due to solar (shortwave) radiation for all-sky and clear-sky conditions, in K s^{-1}.

DTDTTOT: The total diabatic temperature tendency for the model layers, in K s^{-1}. It is the same as the sum **DTDTFRI + DTDTGWD + DTDTRAD + DTDTMST + DTDTTRB** plus the heating due to frictional dissipation in the convection, which is not included in **DTDTMST** and was inadvertently omitted as a separate diagnostic. In the long-term mean, **DTDTTOT** will tend to balance DTDTDYN + DTDTANA.

DTDTTRB: Temperature tendency due to turbulence, including surface sensible heat flux, but not including the heating due to frictional dissipation (see DTDTFRI), in K s^{-1}. Above the surface it includes the diffusive effects due to the Louis and Lock turbulence schemes (see KH).

DTRAIN: The total detrained convective mass flux into each model layer, in kg m^{-2} s^{-1}. This is produced by the convection parameterization. The total entrainment mass, *E*, due to all clouds crossing a layer can be computed from $E = \delta_Z \mathrm{CMFMC} - \mathrm{DTRAIN}$, where $\delta_Z \mathrm{CMFMC} \equiv \mathrm{CMFMC}_{L-1/2} - \mathrm{CMFMC}_{L+1/2}$.

DUDTDYN, DVDTDYN: Eastward (zonal) and northward (meridional) wind tendency due to dynamics, in m s^{-2}.

DUDTGWD, DVDTGWD: Eastward (zonal) and northward (meridional) wind tendencies due to gravity wave drag, in m s^{-2}.

DUDTMST, DVDTMST: Eastward (zonal) and northward (meridional) wind tendencies due to moist processes, in m s^{-2}. Currently this represents the "cumulus friction" effect of mixing momentum in a conservative way, using the convective mass fluxes from RAS.

DUDTTRB, DVDTTRB: Eastward (zonal) and northward (meridional) wind tendencies due to turbulent processes, in m s^{-2}. This includes surface friction. Above the surface, it includes the diffusive effects due to the Louis and Lock turbulence schemes (see KM).

EPV: The Ertel's potential vorticity, approximated as $g(\zeta + f)\frac{\partial \theta_v}{\partial p}$, in K m^2 kg^{-1} sec^{-1}. Here, ζ is the vertical component of relative vorticity, f is the Coriolis parameter, and θ_v is the virtual potential temperature. Note the definition neglects the part associated with the horizontal components of vorticity.

H: Geopotential height, in m. It is simply the height, $\frac{\varphi}{g}$, interpolated linearly in $\log(p)$ from the model's edge levels to the desired pressure level. The model's edge heights are computed using the hydrostatic equation: $\frac{1}{g}\left(\mathrm{PHIS} + c_P \sum_{l=L}^{LM} \theta_v \Delta P\right)$, where ΔP is the difference in $\left(\frac{p}{p_o}\right)^{\kappa}$ at the lower and upper edges of layer l, and θ_v is the virtual potential temperature in the layer.

KH, KM, KHLS, KMLS, KHLK, KMLK, KHRAD, KHSFC: Turbulent diffusivity for heat and other scalars (**KH**) and for momentum (**KM**), in m^2 s^{-1}. The separate contributions due to the Louis (**LS**) and Lock (**LK**) turbulence schemes are also diagnosed, as well as the separation of the Lock diffusivity into that due to cloud-top radiative driving (**RAD**) and surface buoyancy forcing (**SFC**).

MFXC, MFYC, MFZ: The eastward and northward pressure weighted velocity components, in Pa m^2 s^{-1}, and the vertical component of the large-scale mass flux at the layer edges, in kg m^{-2} s^{-1}. **MF[X,Y] =** $[u_c\Delta y, v_c\Delta x]\delta_z p$, where $[u_c, v_c]$ are the velocity components as defined by the dynamical core on the Arakawa C grid and $[\Delta y,\Delta x]=[a\Delta\varphi,\ a\cos(\varphi)\Delta\lambda]$ are the meridional and zonal grid spacings in meters. These cannot be computed from **UC** and **VC** and the pressures because the time average of the product is done over every step taken by the core, so that the following continuity equation is exactly satisfied.

$$\frac{\partial(\mathrm{DELP})}{\partial t} = -\frac{1}{\mathrm{AREA}}[\delta_i(\mathrm{MFX}) + \delta_j(\mathrm{MFY})] - g\delta_k\mathrm{MFZ} + \mathrm{DDPDTANA}\ .$$

OMEGA: The kinematic vertical pressure velocity estimated by the Finite-Volume dynamics. It is defined for the layers, not the edges. For layer l, it is discretized vertically as $\omega_l = \left(\overline{\frac{\partial p}{\partial t}} + \overline{\dot{\eta}\frac{\partial p}{\partial \eta}}\right)_l + (V\bullet\nabla\overline{p})_l$, where the pressure is defined at the layer edges and the overbar indicates the average of the layer's upper and lower edges.

PL: The layer pressure defined as the average of the upper and lower edge pressures, PLE**,** in Pa (see DELP).

PLE: The time-averaged pressure at the edges of each layer. $\mathbf{PLE_1}$ = PTOP (0.01 hPa) and $\mathbf{PLE_{lev+1}} = \mathbf{PLE_{lev}} + \mathbf{DELP_{lev}}$ where lev=1,LM. This is the preferred way of obtaining edge pressures in lcv-coordinates, rather than relying on the model's hybrid-sigma coordinate system (i.e., the $\mathbf{A}_k$s and $\mathbf{B}_k$s), which may change in future releases.

PFLCU, PFICU, PFLLSAN, PFILSAN: Downward flux of precipitating liquid and ice condensate from convective and combined anvil and large-scale clouds, in kg m^{-2} sec^{-1}.

QL, QI: The liquid and ice cloud condensate mixing ratios. These are grid-averaged, not in-cloud, values. They include condensate produced by both large-scale condensation and that detrained from convective clouds. They *do not* include the condensate within convective updrafts.

QLLS, QILS, QLAN, QIAN, QCCU: The liquid and ice cloud condensate mixing ratios. These are grid-averaged, not in-cloud, values. These are the separate contributions from ice and liquid, anvil and large-scale clouds predicted by the model. **QCCU** is a diagnostic estimate of the total condensate in convective updrafts; it does not enter any model calculations, but may be useful in comparing with satellite data.

REEVAPCN, REEVAPLSAN: The re-evaporation of all precipitating condensates for convective and large-scale plus anvil, in kg kg^{-1} sec^{-1}.

RI: Bulk Richardson number used for turbulent diffusivities above the surface.

TAUCLI, TAUCLW: Each layer's total cloud optical thickness in the visible (0.40 to 0.69 micron band), for ice clouds and liquid water clouds, respectively.

TAUIR: Total (liquid + ice) in-cloud optical thickness in the infrared (540-to-980 cm^{-1} band).

2 Two-dimensional Fields

ALBEDO: The time-averaged surface albedo defined as the ratio of the time-averaged incident and reflected fluxes and should satisfy **ALBEDO =** SWGDWN**/(SWGDWN-**SWGNET**).** At night points, this is set to _FillValue [Floating-point value used to identify missing data. Will normally be set to 1e15.]

ALBVISDF, ALBVISDR, ALBNIRDF, ALBNIRDR: The direct (beam) and diffuse albedos for the "visible" (the GCM uses the same albedos for the UV and the PAR spectral regions—0.175 to 0.69 microns) and the "near-infrared" (0.69 to 3.85 microns). These are simply time-averaged surface properties, but are defined only where there was daylight at the point during the averaging interval. They do not correspond to the ratios of time-averaged incident and reflected fluxes.

AREA: Horizontal area of each grid box on the model's native grid in m^2. The full 2-D grid is written, even though they are invariant in the zonal direction. They sum to 5.115×10^{14} m^2, corresponding to an Earth radius of 6377.4 km.

BSTAR: The bouyancy scale of the surface layer in m s^{-2}. It is defined as $\frac{g}{\rho_a u^*} \frac{F_{S_v}}{c_P T_a}$, where ρ_a is the near-surface air density (RHOA) and T_a the near-surface air temperature, u^* is the friction velocity (USTAR), and F_{S_v} is the surface flux of virtual dry static energy in W m^{-2}, F_{S_v} = (HFLUX + $(1-\varepsilon)$EFLUX**).**

CLDHGH, CLDMID, CLDLOW, CLDTOT: High, middle, low, and total cloudiness. The high, middle, low level values correspond to the three super-layers used in the GEOS-5 solar and terrestrial radiation parameterizations. Clouds within these super-layers are assumed to be maximally overlapped. High clouds are those occurring above roughly 400 hPa and low clouds are those occurring below 700 hPa, although the groupings are done on the model's terrain-following coordinate and so the bounding pressures will differ significantly from these values over high topography. The model assumes that the overlap between the super-layers is random, and the total cloudiness uses this assumption. The total cloudiness is computed each time the radiation is called, and so its time mean cannot be exactly constructed from the time-mean cloudiness in the three super-layers.

CLDPRS, CLDTMP: The cloud-top temperature and pressure of the first cloud "seen" from above at 540-980 cm^{-1} in the infrared. Clouds are visible if in-cloud (not layer) optical thickness in this band exceeds 0.14, independent of their fractional areal coverage.

CN: The drag coefficient that would exist under neutral stability conditions. The neutral drag coefficient is therefore computed assuming that the surface wind speed obeys a log wind profile.

DISPH: Surface displacement height in meters. The displacement height is the height at which the log wind profile projects the wind to be zero for purposes of computing the surface layer turbulent fluxes. The displacement height accounts for the impact of surface elements (vegetation, buildings) in the calculation of the surface layer wind profile.

DTG: Change in surface temperature during the averaging interval in deg K. This refers to the area-mean surface temperature under each atmospheric column, and so it may contain contributions from land-, water-, and ice-covered parts of the grid box.

EFLUX: The upward turbulent latent heat flux at the surface in W m^{-2}. This includes the latent heat relative to liquid of all turbulent moisture fluxes through the surface (see EVAP).

EFLUXWTR, EFLUXICE: Same as EFLUX, but defined only over open water or sea ice. While the primary variable represents the area average over all tiles in the grid box, these are the mean value over the tiles classified as either open water or sea-ice.

EMIS: The surface emissivity. This is areally averaged over all surface tiles and is constant in time.

EVAP: Evaporation in kg m^{-2} s^{-1}, actually the total turbulent flux of water vapor at the surface, including fluxes from transpiration, sublimation, and surface condensation. The turbulent flux of cloud condensate (fog) is assumed to be zero.

FRLAKE, FRLAND, FRLANDICE, FROCEAN: GEOS-5 uses these four primary surface types and these are the fractions of each under each atmospheric column. For each column, they add to one, within round-off.

GRN: The "greenness" or fraction of transpiring leaves averaged over the land areas of a grid box. If there are several vegetation tiles within the land part of a grid box, the average is **LAI** weighted. **GRN** is set to _FillValue where FRLAND = 0.

GWETROOT, GWETTOP: The degree of saturation or "wetness" in the root-zone (top meter of soil) and top soil layer (top 2 cm). These are defined as the ratio of the volumetric soil moisture to the porosity. These quantities are set to _FillValue where FRLAND = 0. Elsewhere they are time-mean and area-mean values of the ratio over the land part of the grid box.

HFLUX: The upward turbulent sensible heat flux at the surface in W m^{-2}.

HFLUXWTR, HFLUXICE: Same as HFLUX, but defined only over open water or sea ice. While the primary variable represents the area average over all tiles in the grid box, these are the mean value over the tiles classified as either open water or sea-ice.

LAI: The areal average of the leaf-area index over all land parts of a grid box. **LAI** is set to _FillValue where FRLAND = 0.

LWGDWN, LWGDWNCLR: The all-sky and cloud-free fluxes of downwelling terrestrial (longwave) radiation at the surface in W m^{-2}.

LWGNET/LWGNT: The net downward flux of terrestrial (longwave) radiation at the surface in W m^{-2}. This is identical to **LWGDWN- LWGUP.**

LWGNTWTR, LWGNTICE: Same as LWGNT, but defined only over open water or sea ice. While the primary variable represents the area average over all tiles in the grid box, these are the mean value over the tiles classified as either open water or sea-ice.

LWGUP: The all-sky upwelling terrestrial (longwave) radiation at the surface in W m^{-2}. This includes both the surface emission and the reflection.

LWI: A Land-Water-Ice mask. It is 1 over continental areas, 0 over open ocean, and 2 over sea-ice covered ocean. Since in GEOS-5 a grid box can be a combination of these, continental areas are arbitrarily defined as those where FRLAND+FRLANDICE**≥0.5.** The remaining grid boxes are designated as sea-ice if the ice cover exceeds 50%; otherwise they are open (ice-free) ocean.

LWTUP, LWTUPCLR: Outgoing longwave (terrestrial) radiation at the top of the model's atmosphere (currently 0.01 hPa) for all-sky and clear-sky conditions in W m^{-2}.

PARDF, PARDR, NIRDF, NIRDR: Incident flux of diffuse and direct PAR and NIR at the surface in W m^{-2}. PAR is defined as the solar radiation between 0.4 and 0.69 microns. NIR is the solar near-infrared, defined as the solar radiation between 0.69 and 3.85 microns. These are scaled so that the total solar flux is accounted for in a band from 0.175 to 3.85 microns.

PBLH: Height above the surface of the planetary boundary layer in meters. This is obtained diagnostically at every time step from the heat diffusivity in the model layers. It is defined as the height of the lowest layer in which the diffusivity falls below 2 m^2 s^{-1}. Where no layer is above this value, the boundary layer height is set to the height of the surface layer.

PHIS: The surface geopotential, gh_s, in m^2 s^{-2}. Here h_s is the height of the surface above sea level, and g is the gravitational acceleration.

PRECANV, PRECLSC, PRECCON: The large-scale precipitation from anvils, the non-anvil large-scale precipitation, and the convective precipitation, in kg m^{-2} s^{-1}. These include both rainfall and snowfall.

PRECTOT: The total precipitation (**PRECANV+PRECLSC+PRECCON**) in kg m^{-2} s^{-1}.

PRECSNO: The "snowfall" includes all frozen precipitation, in kg m^{-2} s^{-1}.

PRECSNOOCN: Same as PRECSNO, but defined only over ocean. This is the mean value of snowfall over tiles defined as ocean in each gridbox.

PS: The surface pressure in Pa. The height at this pressure can be obtained from the surface geopotential PHIS**.** The total atmospheric mass is $\frac{1}{g}$**PS** kg m^{-2}. It represents the total atmospheric mass, including water vapor and is an analyzed variable. The model, however, does not include surface fluxes of water in its budget.

QV10M, QV2M: The specific humidity at 10 m and 2m above the displacement height (DISPH) in the surface layer, in kg kg^{-1}.

RAINOCN: Mean rainfall over tiles of each gridbox defined as ocean.

RH: The relative humidity. This is approximated by q/q_S where q is the specific humidity and q_S is its saturated value. The saturated value is computed over liquid for temperatures above 273.16 K and over ice for temperatures below 253.16 K. At intermediate temperatures the values over liquid and ice are averaged with weights that vary linearly with temperature.

RHOA: Surface air density in the lowest model layer, in kg m^{-3}. This is the density used in bulk formulae.

SGH: The isotropic standard deviation of topography used for the subgrid-scale gravity wave drag parameterization, in m. Currently the effect of orographic gravity waves is independent of the angle between the flow and the orographic ridges, so only this isotropic component is relevant.

SLP: The surface pressure reduced to sea level, in Pa. Over topography the reduction is done by assuming a lapse rate of 6.5 K km^{-1} from a free atmospheric temperature.

SNOMAS: The mass of snow per unit of ice-free land area (FRLAND), in kg m^{-2}. In grid boxes with no land it is set to _FillValue**.** Over other land areas it represents an average over the non-glaciated part.

SNODP: The geometric snow depth in meters. This accounts for packing and aging of tcalhe snow.

SPEED: Wind speed used for computing surface fluxes. It is the magnitude of the 2D wind at the top of the surface layer plus a gustiness term based on a diagnosed vertical velocity scale plus a ventilation term related to precipitation.

SWGDN, SWGDNCLR, SWTDN: Incident solar radiation (0.175 to 3.85 microns) at the surface for all-sky and clear-sky conditions and the top of the atmosphere, in W m^{-2}. Since we do a single atmospheric radiative transfer calculation in a grid box, we assume the incident radiation is the same for all surface tiles within the box. GEOS-5.6.2 uses a solar constant of 1365 W m^{-2}.

SWGNT, SWGNTCLR, SWGNTCLN, SWGNTCLRCLN, SWTNT, SWTNTCLR, SWTNTCLN, SWTNTCLRCLN: Net downward flux of solar radiation at the surface and the top of the model's atmosphere (0.01 hPa) averaged over all land tiles for all-sky, clear-sky, clean-sky, and clear-clean-sky conditions, in W m^{-2}. The term "clean-sky" refers to fluxes computed with the aerosol loading set to zero.

SWGNTWTR, SWGNTICE: Same as SWGNT, but defined only over open water or sea ice. While the primary variable represents the area average over all tiles in the grid box, these are the mean value over the tiles classified as either open water or sea-ice.

TAUGWX, TAUGWY: The eastward (zonal) and northward (meridional) components of the atmospheric stress on the surface due to atmospheric gravity wave drag, in N m^{-2}.

TAUHGH, TAUMID, TAULOW, TAUTOT: Total cloud optical thickness in the 0.40 to 0.69 micron band for the high, middle, and low cloud regions (see CLDHGH**)** and for the entire column.

TAUX, TAUY: The eastward (zonal) and northward (meridional) components of the atmospheric frictional stress on the surface, in N m^{-2}.

TAUXWTR, TAUXICE, TAUYWTR, TAUYICE: Same as TAUX and TAUY, but defined only over open water or sea ice. While the primary variable represents the area average over all tiles in the grid box, these are the mean value over the tiles classified as either open water or sea-ice.

TO3 : The vertically integrated ozone, in Dobson units.

TPW, TQV: The vertically integrated water vapor in the column, in kg m^{-2}. These are synonyms.

TQL, TQI: The vertically integrated liquid and ice water in the column, in kg m^{-2}.

TROPP: The tropopause pressure in Pa. The tropopause pressure is defined as the pressure where the function $\alpha T(p) - \log_{10} p$ reaches its first minimum above the surface. Here $\alpha = 0.03$ and p is in hPa. If no minimum is found between 550 hPa and 40 hPa, **TROPP** is set to _FillValue**.**

TROPQ: The tropopause specific humidity in kg kg^{-1}. The tropopause is defined as in **TROPP.**

TROPT: The tropopause temperature in K. The tropopause is defined as in **TROPP.**

TSRAD: The area weighted skin temperature of all surface tiles in a grid box, in K. This is the skin temperature used for radiation.

TTO3: The vertically integrated ozone in the troposphere, in Dobson units. The troposphere is defined as all levels below TROPP**. TTO3** and **TROPP** are computed at every time step and averaged separately.

U10M, U2M, V10M, V2M: The eastward and northward wind component at 10 m, and 2m in the surface layer, in m s^{-1}. These values are defined above displacement height (DISPH) and are dependent on the surface layer parameterization being used (either Louis or Monin-Obukhov).

U50M, V50M: The eastward and northward wind component at 50 m in m s^{-1}, computed as a simple interpolation in the model dynamics between the surface and the lowest model layer.

USTAR: The surface friction velocity, $u^* = \sqrt{\frac{|\tau|}{\rho_a}}$, in m s^{-1}. This mean quantity is formed by doing the areal average over the surface tiles in a grid box instantaneously for $|\tau|$, and the time averaging on u^* itself. It is thus not exactly what would be obtained from TAUX, TAUY**,** and RHOA**.**

Z0H: The surface roughness for heat, in m.

Z0M: The dynamic surface roughness, in m.