GFDL Model Glossary

AM2 – Atmospheric component of CM2.1 (IPCC Fourth Assessment Report model) containing a 2degree resolution atmosphere using the FiniteVolume dynamical core with a latitude longitude discretization, a 2degree horizontal resolution and 24 hybrid sigma/pressure vertical layers.

AM3 – Atmospheric component of CM3 with full cloud-aerosol interactions, tropospheric and stratospheric chemistry, and a high model top (1 Pa). AM3 (Donner et al., 2011), the atmospheric component of the GFDL coupled model CM3, was designed with an awareness of key emerging issues in climate science, including aerosol-cloud interactions in climate and climate change, chemistry-climate feedbacks, land and ocean carbon cycles and their interactions with climate change, and decadal prediction. It is GFDL's first global atmospheric model to include cloud-aerosol interactions, with 20 interactive aerosol species. AM3 includes interactive tropospheric and stratospheric chemistry (85 species). AM3 uses emissions to drive its chemistry and aerosols. Its inclusion of stratospheric chemistry and dynamics will enable possible interactions between the stratosphere and troposphere on interannual scales to be included in future studies of decadal predictability. Its stratosphere has increased vertical resolution over AM2, with the uppermost level at about 1 Pascal. AM3's improved simulation of Amazon precipitation will enhance future coupling into an earth-system model.

AM4 – New generation global atmosphere model with a higher (100 km) horizontal resolution, an upgraded double-plume convection scheme, and a light chemistry package with prescribed ozone and prescribed aerosol emissions. AM4 is the atmospheric component of CM4 and SPEAR. AM4/LM4 is a new generation global atmosphere and land model that serves as a base for a new set of climate and Earth system models (CM4 and ESM4) and prediction model (SPEAR) developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL). AM4/LM4 has roughly 100 km horizontal resolution and contains an aerosol model that generates aerosol fields from emissions. AM4/LM4 has two versions, which differ primarily in the treatment of atmospheric chemistry and stratospheric vertical resolution. AM4.0/LM4.0 contains 33 vertical levels with a light chemistry mechanism designed to support the aerosol model but with prescribed ozone and it is used in CM4 and SPEAR. AM4.1/LM4.1 contains 49 vertical levels and more comprehensive treatment of atmospheric chemistry with prognostic ozone and it is used in ESM4.

AM4.1 – AM4 with more model levels, a higher model top (1 Pa), and comprehensive atmospheric chemistry with prognostic ozone. AM4.1 is the atmospheric component of ESM4.

BLING: Biogeochemical model with reduced 6 tracer version of TOPAZ-like ecological parameterization of Biogeochemistry with Light, Iron, Nutrients and Gas (BLING; Galbraith et al., 2009)

COBALT: Biogeochemical model, 30 tracer Carbon Ocean And Lower Trophics (COBALT; Stock and Dunne 2010; Stock et al., 2013), that focuses on comprehensive representation of pelagic trophic interactions among four phytoplankton and three zooplankton functional groups.

CM2.1 – IPCC Fourth Assessment Report (AR4) model containing a 2 degree resolution atmosphere (AM2), the Finite Volume dynamical core with a latitude longitude discretization, a 1degree resolution ocean (MOM4) on a tripolar grid, and the LM2 land surface model.

CM2.5 – CM2.1 upgraded to use FV3, LM3, and a higher spatial resolution in the atmosphere (0.5 deg) and ocean (0.25 deg). The CM2.5 model (Delworth et al., 2012) is a descendant of the GFDL CM2.1 model (Delworth et al., 2006) that incorporates higher spatial resolution and a significantly improved land model (LM3). As a result of these enhancements, the CM2.5 model has a significantly improved simulation of many aspects of climate, particularly hydroclimate over continental regions (Delworth et al., 2012,) and aspects of ocean circulation. This improvement has allowed GFDL scientists and their collaborators to use this model for innovative studies of regional hydroclimate change (Doi et al, 2012,2013; Kapnick and Delworth, 2013; Delworth and Zeng, 2014; Kapnick et al., 2014) and ocean circulation (Lee et al, 2013). The model has also proven very effective at simulating climate extremes, such as tropical cyclones (Kim et al., 2014) and drought (Delworth et al., 2015). A similar horizontal spatial resolution is being targeted for GFDL's next-generation model, CM4.

CM2.6 – Similar to CM2.5 but with 0.1 degree or finer ocean.

CM3 – IPCC Fifth Assessment Report (AR5) model containing the AM3 atmospheric component and the LM3 land formulation with dynamic vegetation. The ocean and sea ice components are similar to CM2.1.

CM4 – IPCC Sixth Assessment Report (AR6) model. GFDL's CM4.0 consists of: AM4.0 atmosphere at approximately 1° resolution with 33 levels and sufficient chemistry to simulate aerosols (including aerosol indirect effect) from precursor emissions, OM4 MOM6-based ocean at 1/4° resolution with 75 levels using hybrid pressure/isopycnal vertical coordinate, SIS2 sea ice with radiative transfer and C-grid dynamics for compatibility with MOM6 and LM4 land model with dynamic vegetation.

COBALT – (Carbon, Ocean Biogeochemistry and Lower Trophics), an extension of TOPAZ to include additional ecosystem comprehensiveness such as higher trophic levels (mesozooplankton).

ESM2M – IPCC Fifth Assessment Report (AR5) earth system model based on CM2.1 physical model but containing dynamic vegetation, new biogeochemical components in the ocean (TOPAZ) and land (LM3) models, and updated ocean physical parameterizations.

ESM2G – IPCC Fifth Assessment Report earth system model, twin to ESM2M but with a GOLD based ocean model replacing the MOM based ocean in ESM2M. GOLD is an ocean code that uses an isopycnal vertical coordinate.

ESM4.1 - Like CM4.0, ESM4.1 is built on the same AM4, OM4, LM4 generation coupled model infrastructure but focuses on the comprehensiveness of Earth System interactions and combines ealiers generation comprehensiveness in both interactive carbon (ESM2) and chemistry (CM3). The land component LM4.1 includes a new vegetation dynamics model with explicit treatment of plant age and height structure as well as interactions with soil microbes. The ocean biogeochemical component - Carbon Ocean Biogeochemistry And Lower Trophics version 2 (COBALTv2) - represents ocean ecological and biogeochemical interactions. Key features of ESM4.1 include: revised parameterizations relative to GFDL's previous generation ESM2 series models; doubled horizontal resolution of the atmosphere (2° to 1°) and ocean (1° to 0.5°); fully interactive atmospheric chemistry built on GFDL's previous generation CM3; improved representation of aerosols and their natural precursor emissions; representation of key land ecosystem features, such as vegetation and canopy competition with the perfect plasticity approximation, daily fire, and nitrogen cycling; fully interactive land-atmosphere-ocean system cycling of not only CO2 but also dust and iron; and fully interactive ocean-atmosphere cycling of both oxidized and reduced nitrogen species.

ESM2.6 – An Earth System model prototype based on the CM2.6 physical model but including the COBALT ocean biogeochemical model.

FLOR – Forecast-oriented Low Ocean Resolution version of CM2.5, which substitutes the 1degree ocean for the 0.25degree. This model is optimized for seasonal to decadal predictions, but used across all timescales. (Also referred to as CM2.5_FLOR)

FMS – Flexible Modeling System, unified modeling infrastructure and superstructure that is the basis of all GFDL models mentioned here.

FV3 – The GFDL Finite-Volume Cubed-Sphere Dynamical Core. All GFDL global models use FV3 as its dynamical core.

HIRAM – High Resolution Atmospheric Model: AM2.1 upgraded to FV3 and with the less-intrusive UW convection scheme, HiRAM, the GFDL global HIgh Resolution Atmospheric Model, was developed with a goal of providing an improved representation of significant weather events in a global climate model. Our intention was to produce a model capable of simulating the statistics of tropical storms, with sufficient fidelity that it can be used with confidence to study the causes of year-to-year variability in storm activity, recent trends in activity, as well as the predictability of the Atlantic hurricane season. As the credibility of the model improves, based on comparisons with observations, we will apply it to study the effects of global warming on tropical storms.

LM2 – The land component in CM2.1 (IPCC Fourth Assessment Report model).

LM3 – The land component in ESM2M, ESM2G, CM3 and other follow on models from CM2.1. Advances from LM2 include the addition of a dynamic vegetation and vegetation/soil carbon dynamics, vertically resolved soil temperature, and improved hydrology for plant/snow/soil systems, including a representation of permafrost. LM3 includes components for lake and urban systems, although the urban components only have been used in AMIP and stand-alone simulations.

LM3-TAN – The coupled LM3 and Terrestrial and Aquatic Nitrogen (TAN) model was developed by integrating global river/lake and biogeochemical cycle with the GFDL terrestrial coupled carbon-nitrogen ecosystem model LM3. The model captures coupled water, C, and N cycles within a vegetation-soil-river-lake system and simulates exchanges between and transformations within each subsystem for three N species of organic, ammonium, and nitrate plus nitrite N. LM3-TAN has been implemented regionally and globally to investigate impacts of land-climate interaction on water-pollution extremes and evaluate basin management strategies for reducing coastal hypoxia.

LM3-SNAP – LM3, augmented with a new coupled C-N cycle framework combining the C-N version of the Carbon Organisms Rhizosphere and Protection in the Soil Environment (CORPSE-N) model with an explicit model of plant-microbial symbioses - the Symbiotic Nitrogen Acquisition by Plants (SNAP). LM3-SNAP simulates plant N acquisition via the symbiotic inorganic N scavenging, soil organic matter (SOM) decomposition, and N2 fixation, with explicit representation of microbial decomposition. In addition, LM3-SNAP simulates N losses to waterways through leaching and to the atmosphere via denitrification.

LM4 – is a new generation global land physics, hydrology, biogeochemistry, and ecosystem dynamics model, that serves as a base for new land components such as LM4.0 in CM4.0 and SPEAR, LM4.1 in ESM4.1, and the ongoing developments, including improved representation of land heterogeneous hydrology (hydroblocks, LM4.2). LM4.0 builds off of the previous generation GFDL land model LM3 through updated set of input datasets, such as distribution of soil types, and improved parameters for soil/snow physics/hydrology and radiative properties for vegetation, soil, below ground hydrology. LM4.1 includes a new, second-generation dynamic vegetation model representing plants age-height structure, known as Perfect Plasticity Approximation (PPA), as well as dynamics of newly disturbed patches of land (a basis of Ecosystem Demography, ED model). Soil carbon dynamics and biogeochemistry represented through the CORPSE model with an explicit treatment of soil microbes. LM4.1 includes a new fire model FINAL. The model also includes a new treatment of stomatal conductance and plant hydraulics. The vegetation state is used to drive a dust emission model that is coupled with the atmospheric transport. The model is driven by the CMIP6 land use scenario and distinguishes croplands, pasturelands, rangelands, primary and secondary lands (up to 16 age classes). ESM4 implementation of LM4.1 does not include an interactive N cycle. The coupling of vegetation/soil/river N cycle and LM4.1, including an explicit treatment of mycorrhiza (SNAP component) is ongoing, currently referred to as LM4.3.

MOM6 – MOM6 is a new generation global ocean model that serves as a base for a new set of climate and Earth system models (CM4 and ESM4) and prediction model (SPEAR) developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL). MOM6 differs from its predecessors in the use of a new algorithm, the Arbitrary Lagrangian-Eulerian method (ALE), to permit arbitrary general vertical coordinates (Adcroft et al., 2019). MOM6 is being adopted by national centers and universities, in addition to GFDL and Princeton, including the NOAA Environmental Modeling Center (EMC) and the National Center for Atmospheric Research (NCAR). The U.S. Navy is also evaluating a pathway to merge MOM6 into its modeling systems. This rapid adoption of MOM6 is enabled by the numerical integrity of the model, GFDL's commitment to the model, and an "open development" paradigm for code management and collaboration.

OM4 – The ocean component in CM4. It is built on MOM6, with 0.25 degree horizontal resolution and 75 vertical layers using hybrid pressure/isopycnal vertical coordinate (Adcroft et al., 2019).

SIS – (Sea Ice Simulator) The sea ice model used in all of GFDL models including full ice dynamics, three layer thermodynamics (one snow, two ice), and 5 ice thickness categories all on the ocean tripolar grid.

SIS2 - sea ice component of CM4. It has been upgraded from **SIS** by recasting the dynamics on a C-grid for compatibility with MOM6 and by incorporating the layer structure and radiative transfer treatment used by the Community Ice CodE (CICE) sea ice model.

SHiELD - System for High-resolution prediction on Earth-to-Local Domains: Next-generation FV3-based unified prediction model for forecasts from a few minutes to several months.

SPEAR- (**S**eamless system for **P**rediction and **EA**rth system **R**esearch) the next generation GFDL seasonal to multidecadal prediction and projection system. SPEAR consists of coupled models built from the latest GFDL component models (AM4, MOM6, SIS2, LM4) and that are optimized for prediction. In order to achieve the computational costs and efficiency necessary for the large ensembles associated with predictions and projections, the current versions of SPEAR use a relatively low resolution ocean model (0.3-1.0 degrees) coupled to atmospheres with horizontal resolution ranging from 100 km to 25 km. Future versions of SPEAR will also incorporate earth system components, and may also use higher resolution ocean components as computational resources grow. A new Ensemble Coupled Data Assimilation system (ECDA) has been developed using MOM6 to provide initial conditions for SPEAR based predictions.

TOPAZ – (Tracers of Ocean Phytoplankton with Allometric Zooplankton) the ocean biogeochemistry component of the GFDL Earth System Models including cycles of carbon, nitrogen, phosphorus, iron, silicon, alkalinity and lithogenic material with plankton functional groups.

ZETAC- A regional atmospheric model developed at GFDL primarily for use in dynamical downscaling applications. An 18km grid Atlantic basin version of the model has been used to downscale Atlantic hurricane activity.