NASA Ames Mars Global Climate Model Software Requirements Document

[**1. Introduction**](#_mttq80ao0i3z) **3**

[1.1 Purpose](#_sprnk4ale8ju) 3

[1.2 System Description](#_ltvlx7ry58ur) 3

[**2. Requirements Specification**](#_kx6s9kcrfgcz) **3**

[2.1 External Library Requirements](#_ntc5x6wo4x1s) 3

[2.2 Input Data Requirements](#_4hx3cnw1xfer) 3

[2.3 Namelist Requirements](#_5tm5nlx48iph) 4

[2.4 Software Quality Requirements](#_o26zkz7v0yg5) 8

[**3. Tracking Requirements Changes**](#_koanoppwjzm) **9**

# 1. Introduction

## 1.1 Purpose

This Software Requirements Document (SRD) establishes the requirements for the NASA Ames Mars Global Climate Model; hereinafter referred to as the “GCM.”

## 1.2 System Description

The GCM simulates the climate of the planet Mars using an external finite volume dynamical core to predict the global atmosphere given various planetary parameters and physical parameters. The software described in this document includes only the physical processes, as the dynamical core is a third party software package available at GitHub.com developed by the Geophysical Fluid Dynamics Laboratory (GFDL) at the National Oceanic and Atmospheric Administration (NOAA).

# 2. Related Documents

* NASA Ames Mars Global Climate Model Software Requirements Document
* NASA Ames Mars Global Climate Model Verification and Validation Plan

# 3. Requirements Specification

This software is released as a submodule whose intent is to work with the publicly available Atmosphere Model (AM4) released by NOAA/GFDL. When added as a submodule to AM4, the provided patches integrate this software with the external software to convert the model to a Mars simulator. The NetCDF4 library is required for input and output, and an MPI library is required for parallel processing.

## 3.1 External Library Requirements

* Fortran Compiler. Intel Fortran is supported
* NetCDF4
* NOAA/GFDL Atmosphere Model Version 4
* Git
* MPI

## 3.2 Input Data Requirements

* The GCM shall include the files Dust\_ir\_wolff2010\_JD\_12bands.dat, and Dust\_vis\_wolff2010\_JD\_12bands.dat or Dust\_ir\_wolff2010\_JD\_15bands.dat, and Dust\_vis\_wolff2010\_JD\_15bands.dat for dust optical properties
* The GCM shall include the file mars\_topo.nc for the Mars topography
* The GCM shall include the files waterCoated\_ir\_JD\_12bands.dat, and waterCoated\_vis\_JD\_12bands.dat or waterCoated\_ir\_JD\_15bands.dat, and waterCoated\_vis\_JD\_15bands.dat for the water ice cloud optical properties
* The GCM shall include the files CO2H2O\_IR\_12\_95\_INTEL, and CO2H2O\_V\_12\_95\_INTEL or CO2H2O\_IR\_2013\_32, and CO2H2O\_V\_2013\_32 for the CO2 and H2O gas correlated-k optical properties
* The GCM shall include the file npcflag8.nc for the north polar residual cap map
* The GCM shall include the file albedo.nc for the surface albedo
* The GCM shall include the file thermal\_inertia.nc for the surface thermal inertia
* The GCM shall include the file Luca\_dust\_backgrnd\_v4.nc for the annual dust cycle

## 3.3 Namelist Requirements

* The GCM shall include a namelist file or inline namelist within the run script at execution time
* The GCM shall use ka to set the timescale for newtonian damping
* The GCM shall use sigma\_b to set the minimum sigma to apply rayleigh damping
* The GCM shall use ks to set the timescale for the special case of newtonian damping
* The GCM shall use kf to set the timescale for rayleigh damping
* The GCM shall use do\_conserve\_energy to activate energy conservation from damping
* The GCM shall use sponge\_flag to activate the sponge damping layers at the top of the model
* The GCM shall use do\_vert\_diff to activate vertical turbulent mixing
* The GCM shall use do\_ames\_pbl to activate the Ames Mellor-Yamada 2.0 vertical mixing
* The GCM shall use GW\_drag\_TOG to set the gravity wave parameterization
* The GCM shall use do\_co2\_condensation\_cycle to activate the CO2 condensation mass feedback
* The GCM shall use do\_co2\_condensation to activate the CO2 condensation in the atmosphere
* The GCM shall use do\_convective\_adjust to activate the convective adjustment
* The GCM shall use do\_mars\_surface to activate surface and subsurface temperature and surface condensation
* The GCM shall use do\_mars\_radiation to activate the Mars radiation calculation
* The GCM shall use do\_dust\_source\_sink to activate the binned dust microphysics
* The GCM shall use do\_bin\_water\_cycle to activate the binned water microphysics
* The GCM shall use do\_fv3\_convect to use the original convective adjustment; else use the Legacy model convective adjustment
* The GCM shall use do\_moment\_micro to activate the moment microphysics
* The GCM shall use obliquity to set the planet’s obliquity
* The GCM shall use eccentricity to set the orbit eccentricity
* The GCM shall use equinox\_fraction to set the position in orbit for equinox
* The GCM shall use days\_in\_year to set the length of the year in days
* The GCM shall use solar\_constant to set the average solar constant at the top of the atmosphere
* The GCM shall use zero\_date to set the start date of the model
* The GCM shall use zoland to set the default surface roughness
* The GCM shall use soil\_ti to set the default soil thermal inertia
* The GCM shall use do\_subsfc\_ice to activate subsurface ice for the thermal calculation
* The GCM shall use subsfc\_ice\_case to set the treatment of subsurface ice
* The GCM shall use albedo\_ice\_np to set the north polar CO2 ice albedo
* The GCM shall use albedo\_ice\_sp to set the south polar CO2 ice albedo
* The GCM shall use emiss\_ice\_np to set the north polar CO2 ice emissivity
* The GCM shall use emiss\_ice\_sp to set the south polar CO2 ice emissivity
* The GCM shall use np\_cap\_ti\_max to set the CO2 ice thermal inertia limit
* The GCM shall use frost\_threshold to set the minimum depth of H2O ice of albedo feedback
* The GCM shall use nlayers to set the number of soil layers
* The GCM shall use do\_co2\_condensation to activate CO2 condensation at the surface
* The GCM shall use conrath to set conrath parameter for fixed background dust
* The GCM shall use conrath\_type to set top of dust distribution
* The GCM shall use optical\_depth\_inpt to set constant background dust
* The GCM shall use do\_inpt\_dust\_cycle to activate annual cycle
* The GCM shall use do\_lat\_vary\_dust to apply latitudinal variation to background dust
* The GCM shall use do\_inpt\_dust\_cycle\_ktop to calculate dust top
* The GCM shall use dust\_cycle\_scheme to select method to calculate dust top
* The GCM shall use inpt\_dust\_cycle\_dust\_index to set index for dust tracer
* The GCM shall use do\_assimilated\_dust to combine background and dust tracer
* The GCM shall use do\_interactive\_dust\_rad for free binned dust mode
* The GCM shall use optical\_depth\_pulse to set opacity for detached dust
* The GCM shall use pulse\_width to set depth in log(sigma) of pulse
* The GCM shall use pulse\_center to set pressure center of pulse
* The GCM shall use sscat\_cnst to set reference single scattering albedo for binned dust
* The GCM shall use gfac\_cnst to set reference asymmetry parameter for binned dust
* The GCM shall use scale\_inpt\_dust\_column to set scale factor for transported dust for assimilated dust
* The GCM shall use dust\_rad\_size to set dust radius
* The GCM shall use irad\_tracer to set reference tracer for opacity
* The GCM shall use nrad\_tracers to set number of active tracers
* The GCM shall use do\_spectrum\_ir to use binned dust sizes for IR
* The GCM shall use do\_cloud\_rad to calculate binned cloud radiative effects
* The GCM shall use scale\_rad\_ice to scale amount of clouds
* The GCM shall use scale\_rad\_ice\_np to scale amount of clouds over north pole
* The GCM shall use scale\_rad\_ice\_sp to scale amount of clouds over south pole
* The GCM shall use rad\_ice\_scheme to set different cloud spatial distributions
* The GCM shall use sscat\_sw\_ice to set shortwave ice single scattering
* The GCM shall use gfac\_sw\_ice to set shortwave ice asymmetry
* The GCM shall use nrad\_tracers to set number of active tracers
* The GCM shall use inject\_pbl to inject dust throughout the boundary layer
* The GCM shall use replenish\_dust to replenish binned dust reservoir
* The GCM shall use convective\_dust\_source to activate binned dust devil lifting
* The GCM shall use source\_input to scale strength of dust devils
* The GCM shall use dust\_temp\_threshhold to set temperature threshold for dust injection
* The GCM shall use stress\_lifting to activate wind stress lifting
* The GCM shall use stress\_fac\_inpt to scale stress lifting
* The GCM shall use stress\_thresh\_inpt to set stress threshold
* The GCM shall use stress\_scheme to set stress lifting scheme
* The GCM shall use co2\_ice\_thresh to limit dust lifting above CO2 ice
* The GCM shall use optd\_thresh to limit dust lifting when column dust opacity is high
* The GCM shall use do\_sfc\_dust\_reservoir to limit dust lifting depending on surface reservoir
* The GCM shall use accxl\_fact to set threshold coefficient
* The GCM shall use lifting\_thresh\_min to set minimum threshold for lifting
* The GCM shall use specified\_source\_scheme to include other lifting schemes
* The GCM shall use do\_inpt\_dust\_source to lift binned dust according to dust cycle file
* The GCM shall use dust\_indx\_inpt to set tracer index for specified source scheme
* The GCM shall use storm\_amp to set strength of dust storm
* The GCM shall use do\_assimilated\_dust to use dust maps
* The GCM shall use dust\_frac\_adjust to inject less dust than needed to match scenario
* The GCM shall use assim\_t\_thresh (dust\_source) to set minimum surface temperature for lifting
* The GCM shall use assim\_no\_sink to turn off dust subtraction from column when comparing to scenario
* The GCM shall use no\_assim\_over\_ice\_cap to turn off dust assimilation above ice caps
* The GCM shall use do\_enhanced\_cap\_sed to enhance dust sedimentation over ice caps
* The GCM shall use source\_from\_moment use sources from moment dust as reference for binned dust
* The GCM shall use dgdm\_type to select if dust map should be read in at visible reference wave band or infrared
* The GCM shall use kfix to select level where moment dust should be injected
* The GCM shall use dust\_surf\_ini to set initial surface dust reservoir
* The GCM shall use dual\_mode to select background or interactive dust or both
* The GCM shall use dual\_scale to scale the dust scenario
* The GCM shall use interact to activate interactive dust lifting
* The GCM shall use stress\_lift to activate wind stress lifting
* The GCM shall use stress\_scheme to select wind stress lifting scheme
* The GCM shall use inject\_pbl\_stress to inject wind stress dust into boundary layer
* The GCM shall use alfa to set the lifting coefficient
* The GCM shall use Reff\_stress to set the effective radius for wind stress dust
* The GCM shall use threshold\_stress to set the stress threshold for lifting
* The GCM shall use ws\_co2\_ice\_thresh\_N to limit wind stress lifting over CO2 ice in the north
* The GCM shall use ws\_co2\_ice\_thresh\_S to limit wind stress lifting over CO2 ice in the south
* The GCM shall use ws\_h2o\_ice\_thresh to limit wind stress lifting over H2O ice
* The GCM shall use optd\_thresh to limit lifting for opacity higher than value
* The GCM shall use limited\_reservoir to set limited reservoir
* The GCM shall use limres\_xfac to set factor for limited reservoir stress threshold calculation
* The GCM shall use limres\_dec to set linear decrease of threshold for refilling dust into the system
* The GCM shall use delta\_thres to set critical increase of wind stress threshold from which dust devil lifting is cut
* The GCM shall use convective\_lift to activate dust devil lifting
* The GCM shall use dd\_co2\_ice\_thresh\_N to limit dust devil lifting over CO2 ice in the north
* The GCM shall use dd\_co2\_ice\_thresh\_S to limit dust devil lifting over CO2 ice in the south
* The GCM shall use ws\_h2o\_ice\_thresh to limit dust devil lifting over H2O ice
* The GCM shall use inject\_pbl\_dd to inject dust devil dust into boundary layer
* The GCM shall use Reff\_dd to set the effective radius for dust devil dust
* The GCM shall use DDA to select sensible heat flux dust devil lifting
* The GCM shall use alpha\_dda to set dust devil lifting coefficient
* The GCM shall use thres\_shflx to set threshold for dust devils
* The GCM shall use DTH to select tangential wind lifting
* The GCM shall use alpha\_dth to set scaling for dth lifting
* The GCM shall use Dlift to set diameter of lifted dust particles for dust devils lifting DTH
* The GCM shall use devils\_fv3 to use fv3 style dust devil lifting
* The GCM shall use conv\_delt\_threshold to set threshold tsfc-tatm difference for dust devils
* The GCM shall use source\_ddfv3 to set rough conversion from opacity to mixing ratio
* The GCM shall use reff\_ddfv3 to set effective radius for fv3 style dust devil lifting
* The GCM shall use Background to use lift dust according to dust scenario
* The GCM shall use inject\_pbl\_bd to inject background dust into boundary layer
* The GCM shall use injscale to set background dust injection coefficient
* The GCM shall use sink\_bd to use sinks to remove dust to match dust scenario
* The GCM shall use sinkscale to set sink removal scale
* The GCM shall use bottom\_sink to remove dust from the bottom (near surface)
* The GCM shall use assim\_t\_thresh (dust\_update) to set minimum surface temperature for lifting
* The GCM shall use no\_assim\_over\_caps to turn off assimilation over ice caps
* The GCM shall use Reff\_backgd to set effective radius for background dust
* The GCM shall use Qext\_dt to set extinction efficiency of background dust
* The GCM shall use tauscale to scale the dust scenario
* The GCM shall use south\_cap\_latitude to set the latitude boundary of the south polar ice cap
* The GCM shall use do\_lmd\_clouds to calculate cloud formation with the LMD scheme
* The GCM shall use do\_simple\_surface to turn off skip water sublimation
* The GCM shall use do\_h2o\_flux\_calc to calculate the water sublimation
* The GCM shall use micro\_growth\_fac to set growth factor for cloud particles
* The GCM shall use water\_col\_max to limit water column over north polar cap
* The GCM shall use do\_3d\_ice\_sed to activate ice sedimentation
* The GCM shall use use\_dust\_profile to use binned dust for nucleation
* The GCM shall use dust\_number\_scale\_fac to set scaling factor for dust
* The GCM shall use cld\_dust\_bin to set index number of dust for clouds
* The GCM shall use rfix0 to set prescribed dust radius
* The GCM shall use nfix0 to set prescribed dust number
* The GCM shall use use\_fixed\_profile to use nfix0 for dust
* The GCM shall use microtimestep to define the moment microphysics time step
* The GCM shall use latent\_heat to calculate the latent heat contribution from moment clouds
* The GCM shall use makeclouds to perform moment cloud formation
* The GCM shall use scaveng to activate moment dust scavenging
* The GCM shall use use\_ames\_lw\_rad to use ames infrared radiation calculation
* The GCM shall use use\_ames\_sw\_rad to use ames visible radiation calculation
* The GCM shall use rad\_calc\_intv to set the radiation time step
* The GCM shall use use\_forget\_swheat to include Forget non-LTE visible correction. Skipped if use\_ames\_sw\_rad is set
* The GCM shall use do\_diurnal\_avg\_rad to use a diurnally averaged zenith angle
* The GCM shall use use\_newton\_damping to use netownian damping for heating
* The GCM shall use rtdata\_path to set the radiation input data
* The GCM shall use radactive\_cloud to make clouds radiatively active
* The GCM shall use radactive\_dust\_TOG to select radiative treatment of dust
* The GCM shall use radactive\_water to make water vapor radiatively active
* The GCM shall use do\_nlte to do non-LTE correction in infrared
* The GCM shall use ames\_15band to use 15 band version. If false, use 12 band
* The GCM shall use use\_boxinterp12 to use boxinterp for k-coef interpolation

## 3.4 Software Quality Requirements

* The data produced by the GCM run with the provided default run script shall match the results provided
* The GCM shall receive regular updates at the public github.com repository including bug fixes and model capability improvements

# 4. Tracking Requirements Changes

The requirements document shall be updated to reflect changes to requirements as new releases are made.