NASA Ames Legacy Mars GCM
Software Development Plan

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1. Introduction

1.1 Purpose

This document contains the software development plan and architectural design for the NASA Ames Legacy Mars Global Climate Model; hereinafter referred to as the “GCM.”

2. Related Documents

- NASA Ames Legacy Mars GCM Software Requirements Document

3. Architectural Design

3.1 GCM Introduction

The GCM simulates the climate of the planet Mars using the primitive equations to predict the global atmosphere given various planetary parameters and physical parameters. The GCM has two main components, the dynamical core, and the physical processes.

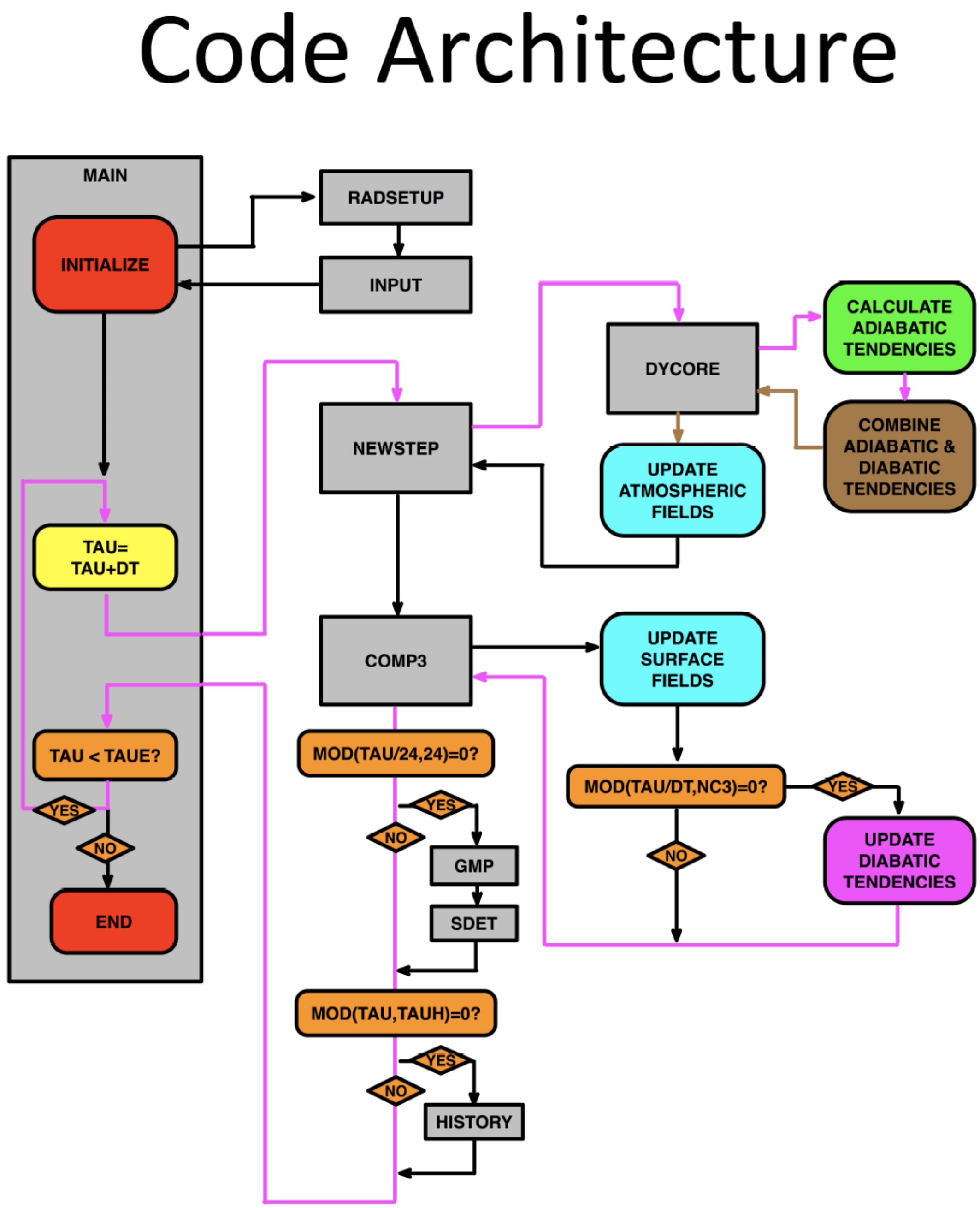
3.2 The Dynamical Core

The NASA Ames Legacy Mars GCM uses an Arakawa staggered C-Grid latitude/longitude finite difference dynamical core that was developed at Goddard Space Flight Center (Suarez and Takacs, 1995). The numerics are designed to conserve total energy and to ensure that the vertically integrated pressure gradient force is irrotational. It utilizes second-order differences for all terms except the advection of vorticity, which is fourth-order accurate. The model uses a terrain-following normalized pressure coordinate system in the vertical, with resolution decreasing from ~5 m near the surface to ~10 km at the model top (currently ~80 km). The original C-Grid transport scheme employed was inaccurate and diffusive, so we replaced it with a Van Leer I scheme with slope limitations (Hourdin and Armengaud, 1998). This is a finite-volume scheme that solves the flux form of the continuity and advection equations and allows for the zonal advection of tracers across more than one grid box in a given time step.

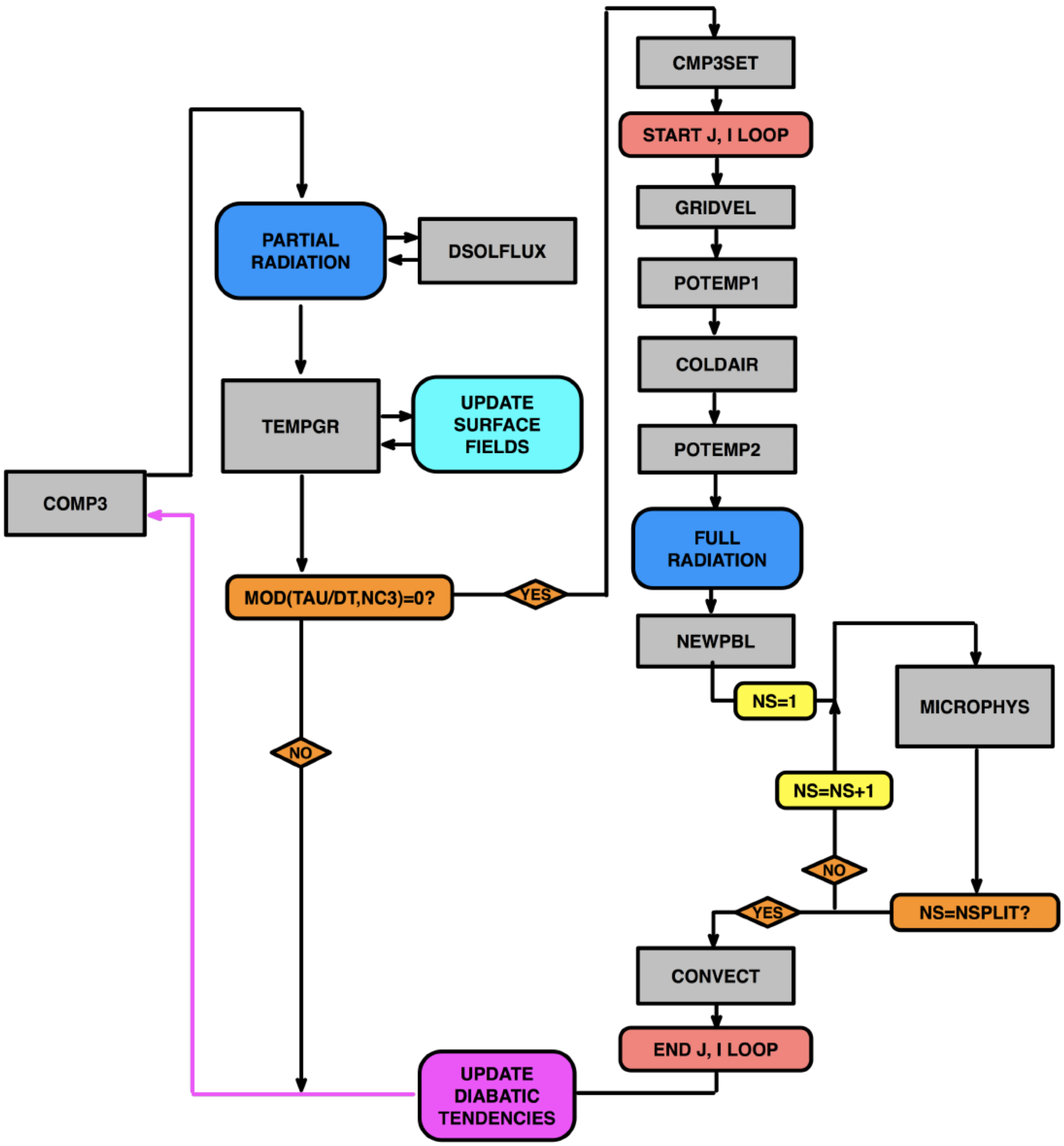
3.3 The Physical Processes

The model physics routines describe inputs to the system and conversion within the atmosphere of energy and mass; these codes compute radiation, turbulence, cloud microphysical processes, etc. The majority of the effort of developing Mars-specific GCMs goes into developing such physics routines appropriate for the Martian environment. The GCM group at NASA Ames Research Center has been developing and implementing physics packages for several decades.

3.4 Model Diagram



COMP3 Architecture



4. Implementation

The GCM is written in Fortran code. Detailed requirements are listed in the software requirements document. A standard Makefile is included with the source code. The GCM can be compiled by performing a make command. Upon successful completion, an executable called ‘gcm2.3’ will be created. This executable can be copied to a directory where the program shall be run and output shall be created. A sample namelist is included in the ‘run’ directory.

All software components of the GCM were developed and supplied using NASA resources. Surface maps for thermal inertia, albedo, and residual north polar cap boundary were supplied by collaborators at Oregon State University. Dust optical properties were supplied by Michael Wolff at Space Science Institute in Boulder, CO. All other input data was supplied by NASA.

5. Software Storage and Maintenance

The GCM shall be stored and maintained on the NASA public GitHub repository located at: https://github.com/nasa

This software has been designated as End-of-Life and shall no longer receive updates.

6. Software Costs

Because this software is at its End-of-Life, and will be stored and maintained on the NASA public GitHub, no costs have been allocated.

7. Potential Software Reuse

This GCM is designed to work as a standalone software package and not for reuse. However, certain portions of the model could be separated in order to perform specific functions within other software packages. These include the microphysics subroutines for predicting dust and water ice evolution, radiation transfer subroutines for predicting fluxes in a Mars-like atmosphere, soil temperature subroutines for predicting surface temperatures, and boundary layer mixing using a Mellor-Yamada level 2.0 prediction.

REFERENCES

Hourdin, F. and Armengaud, A., 1999. The use of finite-volume methods for atmospheric advection of trace species. Part I: Test of various formulations in a general circulation model. *Monthly weather review*, *127*(5), pp.822-837.

Suarez, M.J. and Takacs, L.L., 1995. Technical report series on global modeling and data assimilation. volume 5: Documentation of the AIRES/GEOS dynamical core, version 2.