

Simplified General Circulation Model

Prognostic Equations

$$\frac{\partial}{\partial t} u = -\mathbf{u} \cdot \nabla \bar{u} + f v + \frac{uv}{R_E} \tan \phi$$

[Advection]

[Coriolis term]

$$-g \frac{\partial}{\partial x} z - \frac{RT}{p_s} \frac{\partial}{\partial x} p_s$$

[Pressure Gradient]

$$+\nu_H \nabla_H^2 u + \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} \left(\nu_V \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} u \right)$$

[Diffusion]

$$\frac{\partial}{\partial t} v = -\mathbf{u} \cdot \nabla v - f u - \frac{2u^2}{R_E} \tan \phi$$

[Advection]

[Coriolis term]

$$-g \frac{\partial}{\partial y} z - \frac{RT}{\bar{p}_s} \frac{\partial}{\partial y} p_s$$

[Pressure Gradient]

$$+\nu_H \nabla_H^2 v + \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} \left(\nu_V \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} v \right)$$

[Diffusion]

$$\frac{\partial}{\partial t} \theta = -\mathbf{u} \cdot \nabla \theta$$

[Advection]

$$+\nu_H \nabla_H^2 \theta + \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} \left(\nu_V \frac{g\sigma}{RT} \frac{\partial}{\partial \sigma} \theta \right)$$

[Diffusion]

$$-\frac{1}{\tau} \theta$$

[Damping]

$$+\frac{\theta}{T} Q'$$

[Forcing]

$$\frac{\partial}{\partial t} p_s = - \int_{\sigma_{top}}^1 \nabla \cdot (p_s \mathbf{u}) d\sigma$$

[Convergence]

Diagnostic Equation

$$\frac{\partial z}{\partial \sigma} = - \frac{RT}{g\sigma}$$

$$\dot{\sigma} = - \frac{1}{\bar{p}_s} \int_{\sigma_{top}}^{\sigma} \nabla \cdot (p_s \mathbf{u}) d\sigma' - \frac{\sigma}{\bar{p}_s} \frac{\partial}{\partial t} p_s$$

Method

Horizontal Domain: The whole Northern Hemisphere/the whole globe,

Horizontal Grid Interval: 2.5° longitude \times 2.5° latitude,

Integration Time: 100 days,

Time Step: 180 sec.

Initial Conditions

Isothermal static atmosphere:

$$u = 0,$$

$$v = 0,$$

$$T = 298 \text{ K},$$

$$p_s = 1013.25 \text{ hPa}.$$

Boundary Conditions

$$u' = 0 \text{ (at the bottom),}$$

$$v' = 0 \text{ (at the bottom),}$$

$$p = p_{top} = 101.325 \text{ hPa (const.) (at the top).}$$

Parameters

$$\begin{aligned}R_E &= 6.368 \times 10^6 \text{ m}, \\ \Omega &= 7.292 \times 10^{-5} \text{ /s}, \\ f &= 2 \Omega \sin \phi, \\ \nu_H &= 1 \times 10^5 \text{ m}^2/\text{s}, \\ \nu_V &= 1 \text{ m}^2/\text{s}, \\ \tau &= 20 \text{ days}.\end{aligned}$$