T24

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Development of GCM for the Venus middle atmosphere

-- Tests and sensitivities to vertical eddy diffusion --

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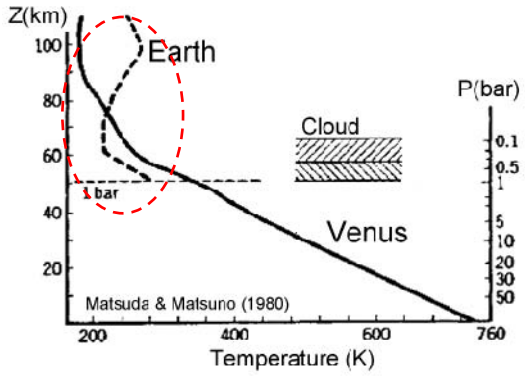
Objective

T and P on Earth are similar to those on Venus above 50 km

⇒ Earth's GCM is used as a tool for investigating atmospheric circulation and waves in the Venus middle atmosphere after appropriately improving it.



Previous works

Spectral model with low zonal wavenumbers (s = 1,2)
e.g., Newman and Leovy (1992, thermal tides)
Yamamoto and Tanaka (1997, Kelvin wave)

Optical properties of clouds → Nonlinear wave interaction

Present work

GCM for the Venus middle atmosphere, into which radiative effects of clouds are incorporated.

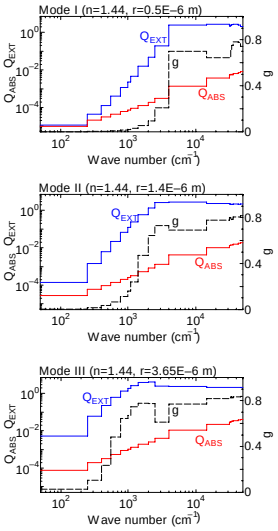
In this presentation, we examine the superroation and the sensitivity to vertical eddy diffusion (~4 m² s⁻¹, Woo and Ishimaru 1981 near the cloud).

Model

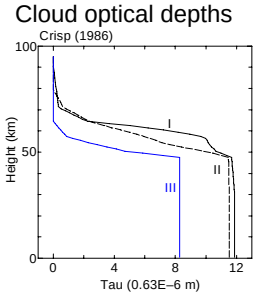
CCSR/NIES AGCM ver.5.4 (Numaguti et al. 1995)
T10 spectral model with 100 layers (0-100 km)
Two-stream k-distribution method with 18 ch.
(Nakajima and Tanaka 1986)
CO2 radiative effects are included in channels of λ = 13.0 to 18.2 μm.

- *Zonal mean flow of 50 cosϕ m/s and standard temperature (Shiff et al 1980) are set as the initial conditions.*
- *Time integration for ≥ 30 km (radiative flux is calculated over the whole domain)*
- *Rayleigh friction of 6 hours at the top boundary.*
- *Vertical eddy diffusion coefficients K_V of 2.5 and 5.0 m²s⁻¹ are set as constant. (K_V = 4 m²s⁻¹ near 60 km from radio scintillation measurements, Woo and Ishimaru 1981)*

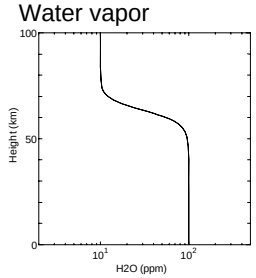
Cloud properties



Cloud optical depths



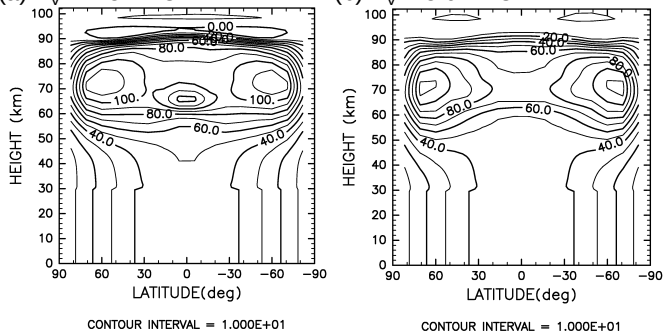
Water vapor



Results

Longitudinally averaged zonal flow

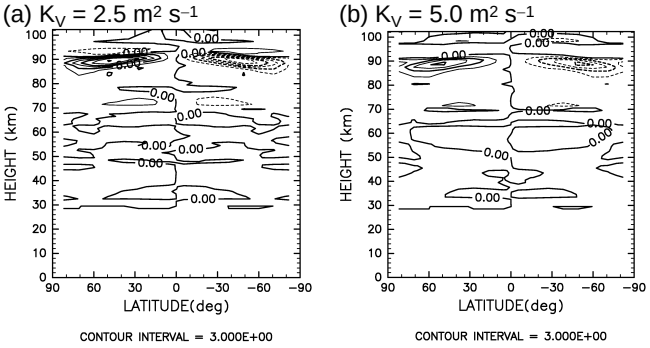
(a) K_V = 2.5 m² s⁻¹ (b) K_V = 5.0 m² s⁻¹



Strong equatorial superrotation is seen for small Kv.

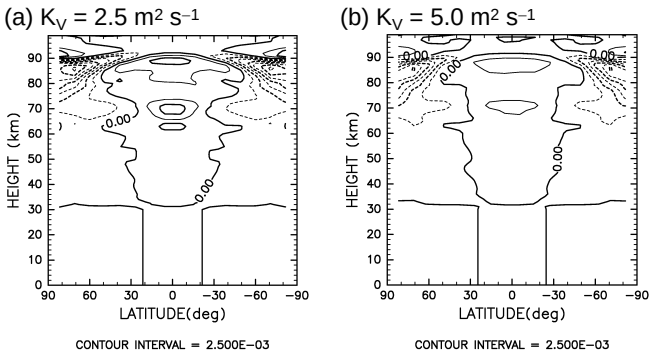
Residual mean meridional flow

(a) K_V = 2.5 m² s⁻¹ (b) K_V = 5.0 m² s⁻¹



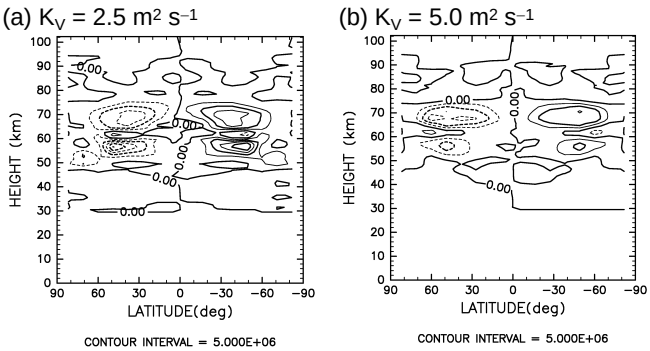
Residual mean meridional flow is enhanced for small Kv in comparison with large Kv.

Residual mean vertical flow



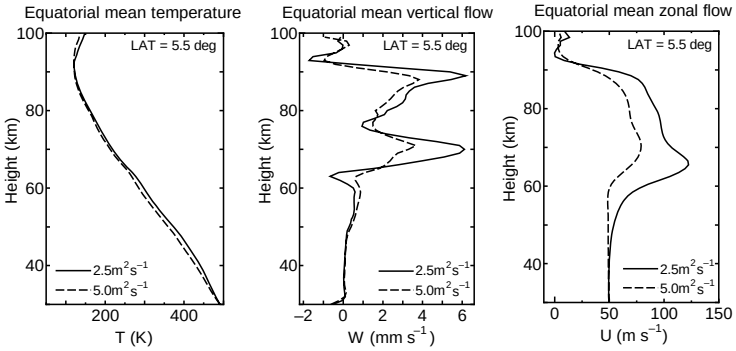
Residual mean vertical flow is enhanced for small Kv in comparison with large Kv.

Horizontal eddy angular momentum flux



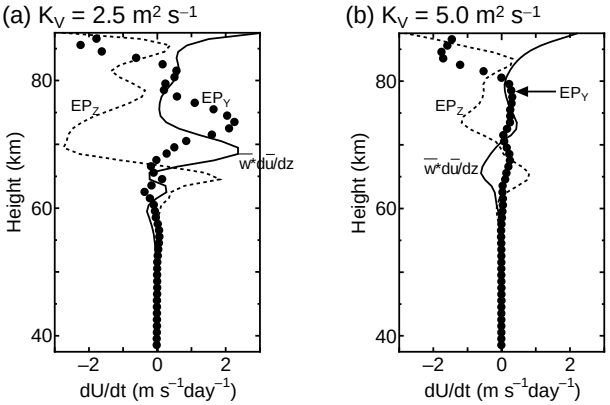
Horizontal eddy angular momentum flux is enhanced near the cloud base for small Kv, while the fluxes for both cases have almost the same amplitude at the cloud top.

Comparisons in the equatorial region



The temperature for small Kv is somewhat larger than that for large Kv.
The large vertical flow for small Kv is enhanced above the cloud top.
The equatorial superrotation for small Kv is enhanced near the cloud top.

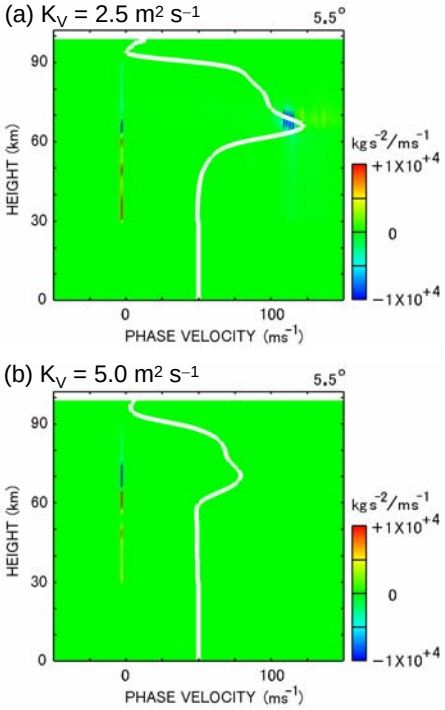
Acceleration/deceleration at the equator



Large acceleration due to EPZ is located at the cloud top. This leads to the strong equatorial cloud-top superrotation. Above the cloud, EPY and advection balance with EPZ.

For large Kv, acceleration due to EPZ is small at the cloud top. The equatorial superrotation is weak in this case.

Vertical eddy angular momentum flux



The enhancement of the acceleration due to EPZ for small Kv is caused by small-scale equatorial gravity waves of c ~ 100 m/s. Thus the vertical propagation of the gravity waves enhances the equatorial cloud-top superrotation.

Summary

We are developing a GCM for the Venus middle atmosphere and test it. In this work, we check the influence of the vertical eddy diffusion on the atmospheric circulation. The results are sensitive to vertical eddy diffusion in our preliminary experiments.

Small K_V (= 2.5 $m^2 s^{-1}$) leads to the enhancements of zonal-flow accelerations due to waves and meridional circulation.

Thus the superrotation is also enhanced near the cloud top in the small K_V experiment.

At the next step, we improve radiation properties of CO2 and aerosols, and apply this model to dynamics of superrotation and cloud patterns.