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Intense decadal variations of Venus’ UV albedo, and its
impact on solar heating rate and atmospheric dynamics

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Abstract

We report the first quantitative study on the variabil-
ity of Venus’ cloud albedo at 365 nm using data ac-
quired by four independent space-based instruments. 
We show a factor of 2 albedo variation had been oc-
curred in the past decade. This is sufficient amount to 
alter solar heating rate at the cloud top level, which 
consequently can affect atmospheric dynamics, i.e., 
zonal winds near the cloud top level.

1. Introduction

An unidentified absorber in the Venuesian clouds cre-
ates broad absorption spectrum in the UV-to-visible 
wavelength range that peaks around 340–380 nm 
around the cloud top level, 70 km above the surface. 
This unknown absorber is known to absorb about half 
of the solar energy deposited in the atmosphere ac-
cording to model calculations [1]. As a result, this ab-
sorber plays a critical role in the atmospheric energy 
balance. Therefore, monitoring its temporal variation 
is crucial to understand radiative energy balance of 
the planet.

2. 365-nm albedo observations

We analyse 365-nm images acquired by the Venus 
Monitoring Camera (VMC) on board Venus Express 
(2006–2014) and the UV imager (UVI) on board Akatsuki (2011 and December 2015–May 2017) [2], and UV spectral data by MASCS on board MESSENGER (June 2007) [3] and STIS on board Hubble Space Tele-
scope (January 2011) [4]. These results show that

Figure 1: 365-nm albedo observations taken from 
and STIS (2011). MASCS’ data is not shown. (Top) 
Mean values at low latitudes (0–30S) and high lati-
tudes (50S–70S) at the 75–80° phase angle. Stan-
dard deviations are shown with errorbars. (Bottom) 
Relative variations of whole-disk albedo from VMC 
certainties of VMC’s start calibration is omitted in the 
figure (82%), while that of UVI, 18%, is shown with 
errorbars.
the 365-nm albedo has been varied by a factor of 2 from 2006 to 2017 at all of high and low latitudes (Fig. 1). The same trend is retrieved from the whole-disk (disk-integrated) albedo that includes UVI’s 2011 data (Fig. 1).

3. Solar heating rate variations

We take into account this observed range of 365-nm albedo variations in our radiative transfer calculations, fitting the observed albedo by multiplying factors to the mode-1’s assumed absorption coefficient for the unknown absorber in the spectral range of 310–780 nm [1]. The results show that the observed albedo variance can produce a ~25–40% variance in solar heating rate at low latitude local noon time. This means that the cloud top level atmosphere should have experienced considerable solar heating variations over the decade.

4. Impacts on atmospheric dynamics

This variable solar heating rate would drive dynamical changes at the same altitudes. Simulations in a Venus global circulation model (IPSL-VGCM, [5]) shows that considerable zonal wind speed variations can be caused by the above calculated solar heating rate changes. The simulated wind speed range is comparable to the observed Venus’ zonal wind variations from 2006 to 2017 [6, 7].

5. Summary and Conclusions

We find intense decadal variations in the 365-nm albedo of Venus between 2006 and 2017. This should involve significant solar heating rate variances, which can affect atmospheric dynamics. This provides the evidence of current climate change on Venus, and future observations are required to verify reasons of UV albedo changes.

References