Solar system science using JCMT

Observation of Venus atmosphere in coordination with Akatsuki Venus orbiter

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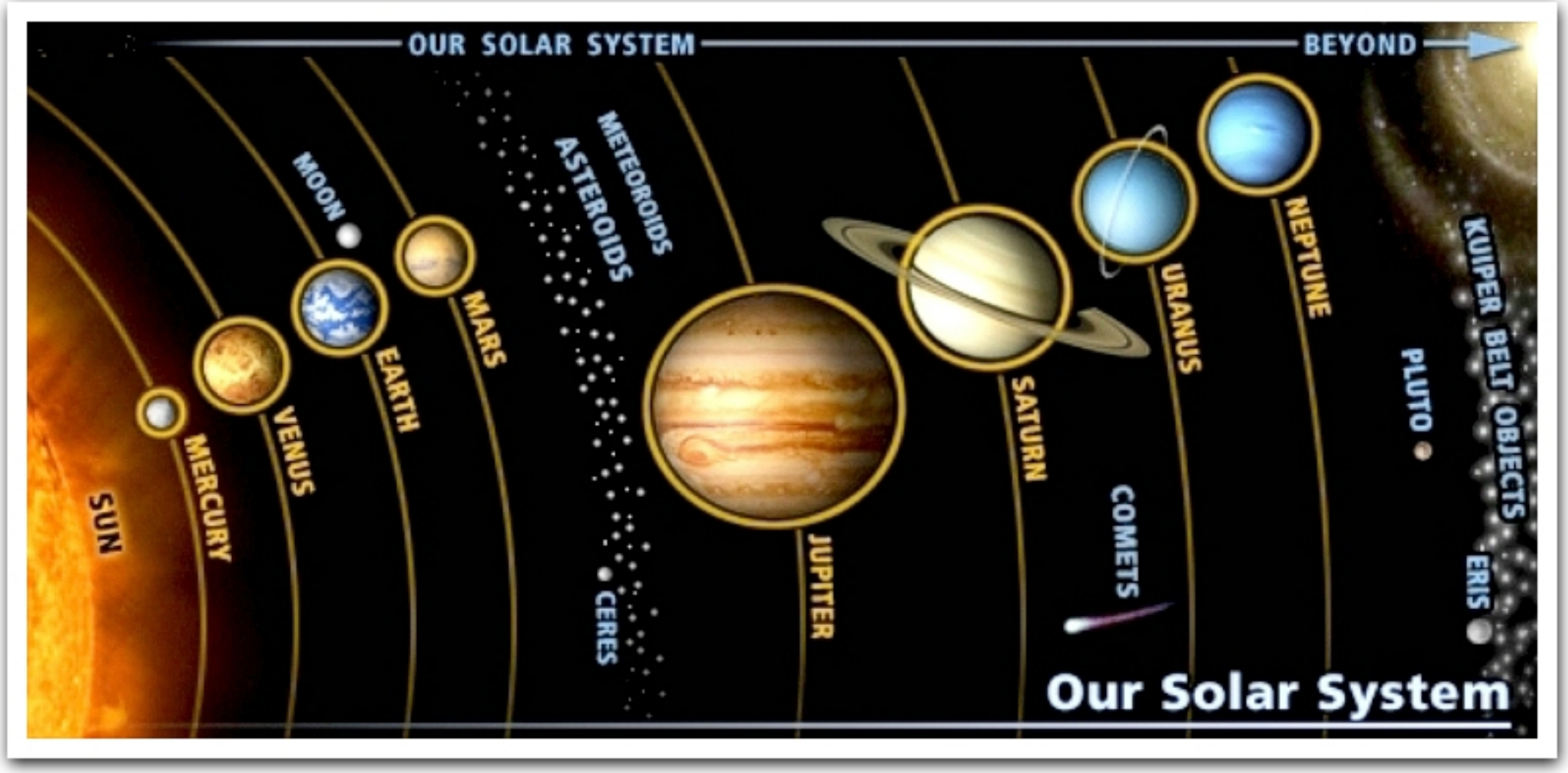
Why Venus?

We (planetary scientists) are interested in understanding "*How the planets really look like*".



Picture taken from the webpage of NASA

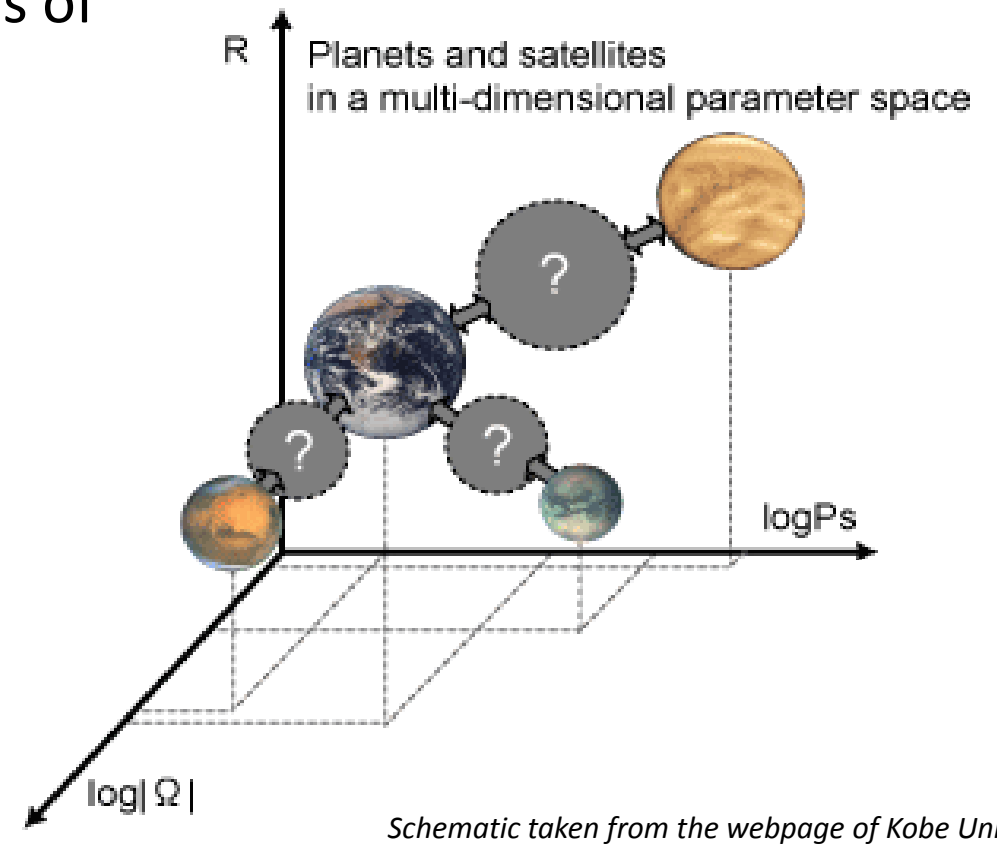
Why Venus?

We (planetary scientists) are interested in understanding "*How the planets really look like*".

→ Search for *key* physical (chemical) processes to describe each object in the solar system;

→ Understand the evolution of the solar system and its current diverse state;

→ Trying to develop a seamless connection with studies of the planetary formation, exoplanets, etc.

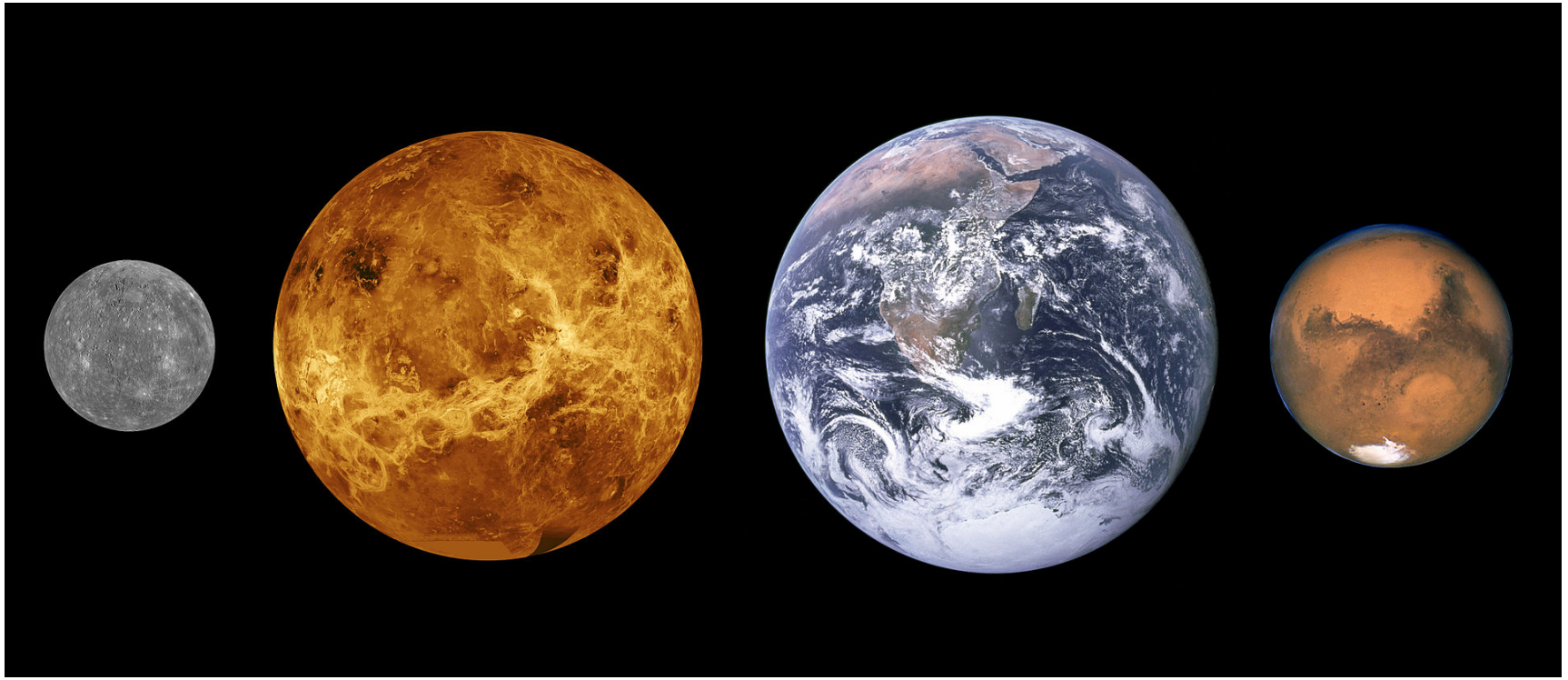


Schematic taken from the webpage of Kobe Univ.

Why Venus?

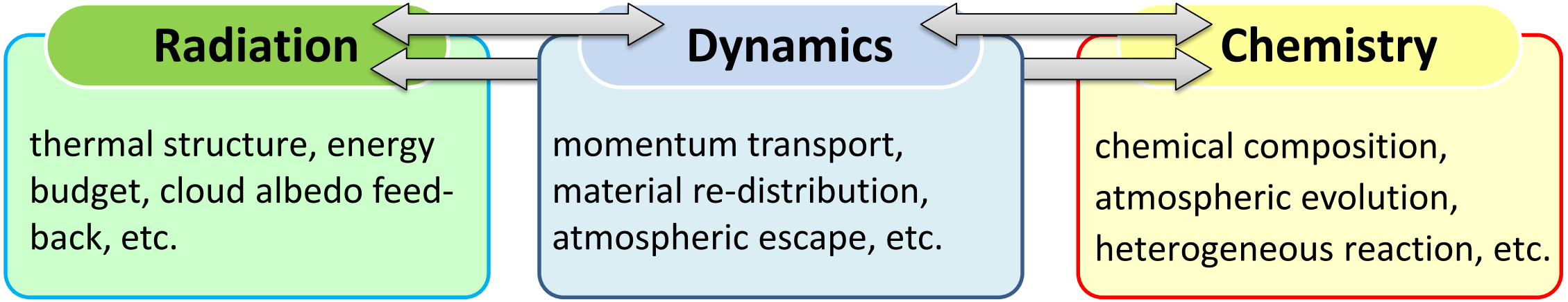
Venus: As one of the archetypes of the rocky (i.e. Earth-like) planet.

- Slow planetary rotation —— A hint for the tidally locked exoplanets. Are they habitable?
- Very thick atmosphere —— A challenge to fully understand the meteorological difference between the Earth. “Planetary Meteorology”



Key points to understand the planetary atmospheres

Following processes mainly control the atmospheric state of a planet.

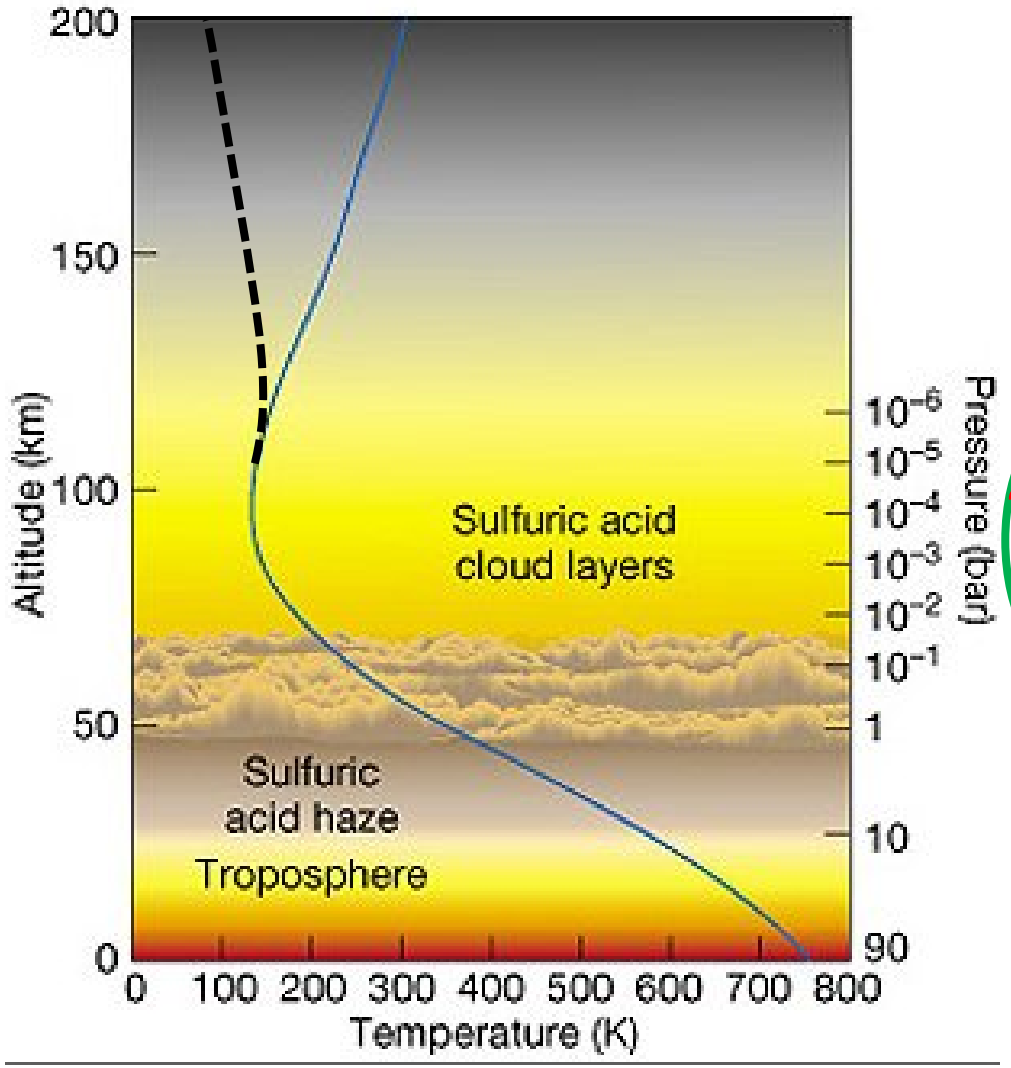


…and these processes closely interacts each other.

→ thus, it's important to understand (observe) **the atmospheric temperature**, **wind**, and **chemical compositions** all together.

…and all of these are measurable with JCMT!

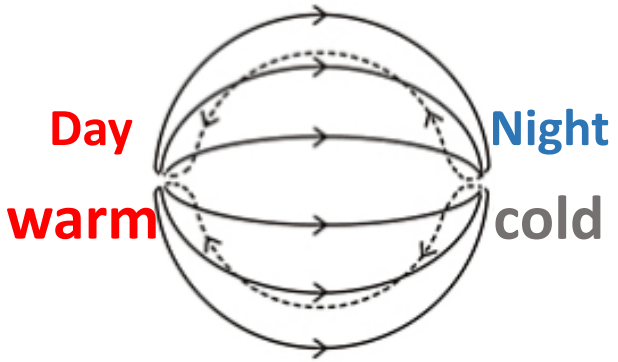
Quick introduction about Venus atmosphere



Dynamics in thermosphere

Day-to-Night thermal contrast exist in the upper atmosphere, thus wind blows from dayside to nightside: **S**ub-**S**olar–to–**A**nti-**S**olar flow.

Schematics of SS-AS flow



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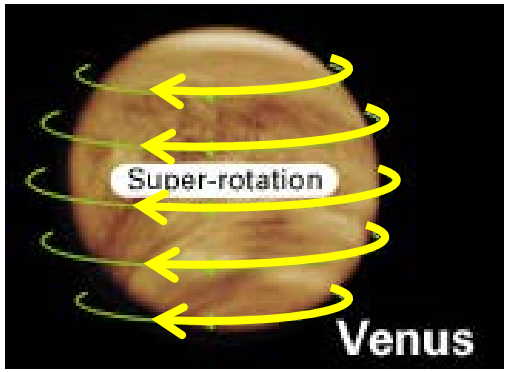
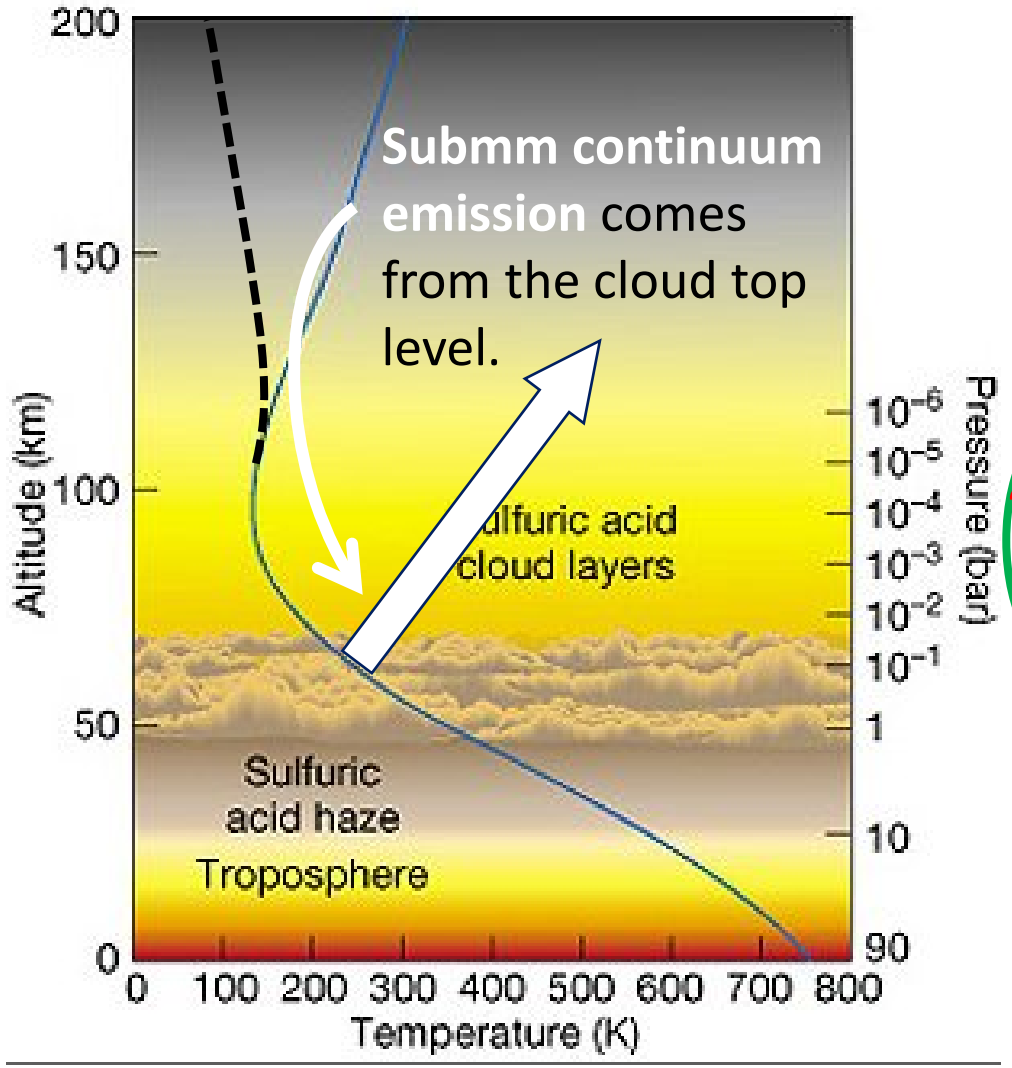
How is the dynamics in the middle atmosphere?

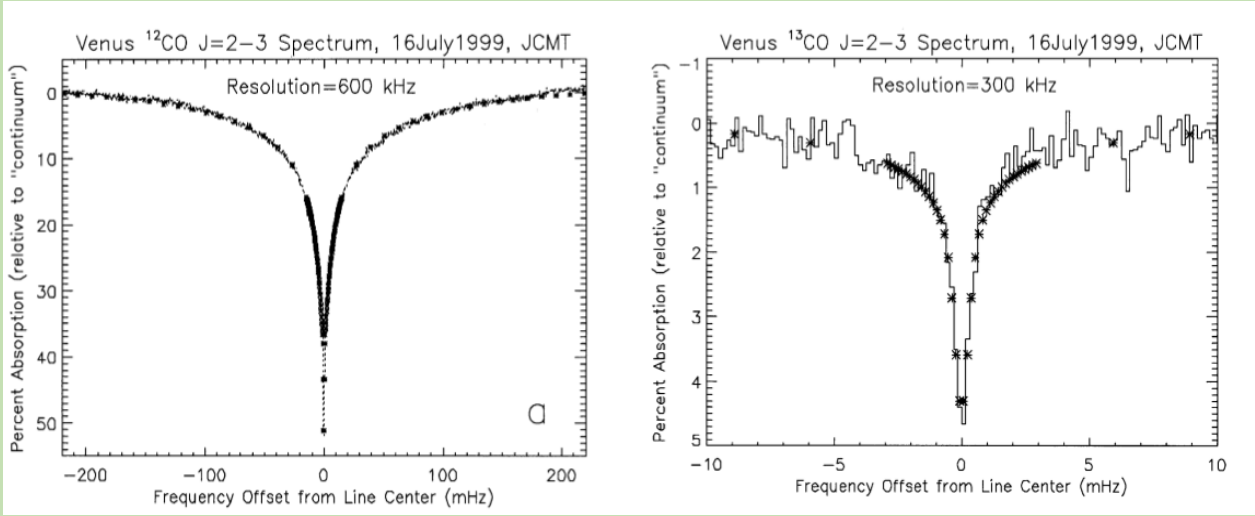
Very fast (~100 m/s …60 times faster than the solid rotation) westward wind: **Super-Rotation** (**R**etrograde **Z**onal flow).

Dynamics in the lower atmosphere



Submm wavelength can measure the middle atmosphere



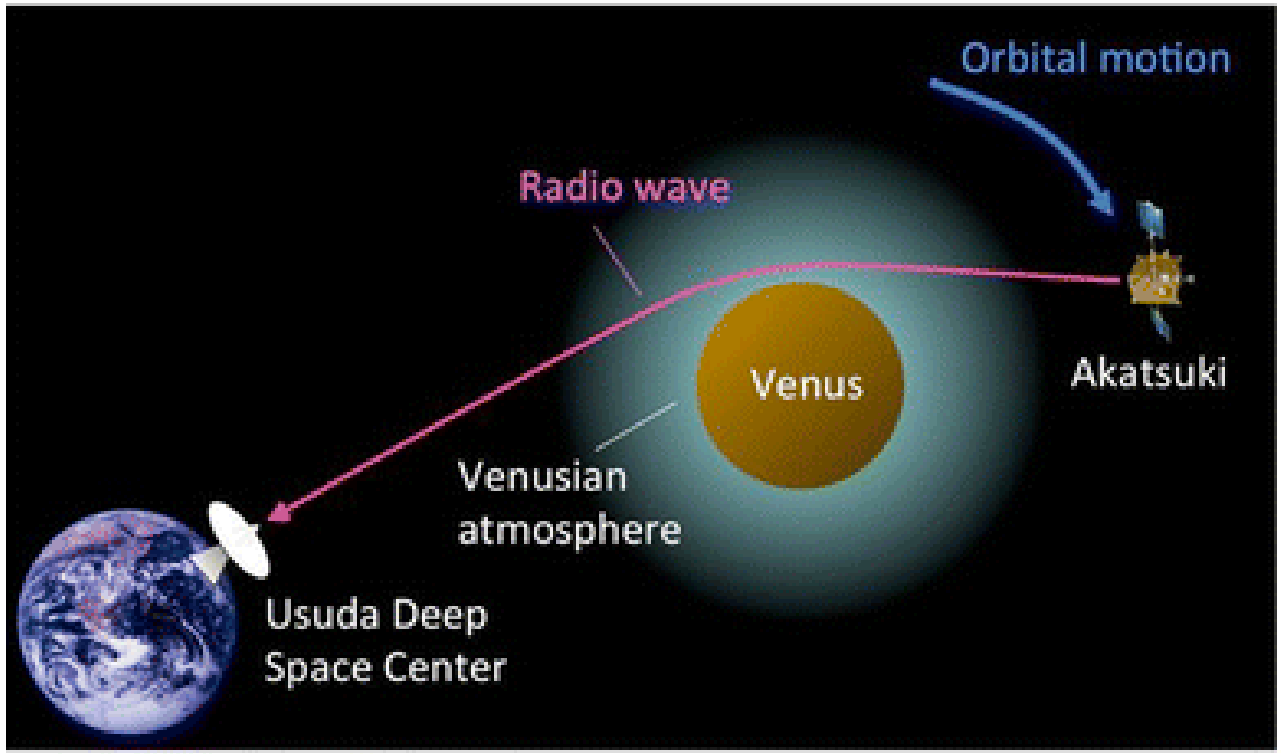


- CO in the middle/upper atmosphere absorbs the submm continuum emitted from the cloud top.
- **Temperature** & **CO abundance altitude profiles** are obtained by coordinated retrieval from simultaneous, co-located observations **12CO** (optically thick) and **13CO** (optically thin) spectra.
- **Both lines are required**, as use of only one (12CO or 13CO) does not allow separation of CO abundance from temperature.

Coordinated observations with JAXA's Akatsuki mission

Venus temperature observations with the JCMT in coordination with the Akatsuki radio occultation measurements

- Radio waves (X-band) are emitted from Akatsuki toward the ground tracking station.
- When the spacecraft goes behind Venus, Venus atmosphere causes bending and attenuation of the radio waves.
- By analyzing the frequency & the signal intensity time series obtained at the tracking station, we can obtain vertical profiles of the refractive index and the absorption coefficient.
- Refractive index gives us the information about **temperature** and **density**.



Imamura et al. (2014)

Coordinated observations with JAXA's Akatsuki mission

Venus temperature observations with the JCMT in coordination with the Akatsuki radio occultation measurements

- On 4 dates in May-June 2017 on which JAXA's Akatsuki mission made radio occultation observations for retrieval of Venus atmospheric temperature – altitude profiles, simultaneous observations with the JCMT were made for retrieval of complimentary T(z) maps of the Venus disk.
- Akatsuki's data support measurement of two temperature-altitude profiles on each date, corresponding to ingress and egress occultations, **at spatially localized positions** on the Venus limb.
- **JCMT observations of 12CO, 13CO spectral lines support measurement of temperature – altitude profiles at multiple disc positions, limited by coarser (14") beam resolution.**
- **Akatsuki altitude sensitivity (60-85 km; resolution based upon geometry) overlaps that of JCMT (75- 105 km; resolution from shape of pressure – broadened spectra).**

Coordinated observations with JAXA's Akatsuki mission

Sorry… the contents hereafter are removed from the online material.

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Summary

- We are observing Venus with JCMT in order to understand the atmospheric structure, dynamics and photo-chemistry.
- We newly carried out the simultaneous coordinated observations with JCMT and JAXA's Venus orbiter Akatsuki.
- Temperature profiles at the middle atmosphere are retrieved from the both measurements, enabling us to increase the sounding altitude range —— which provides an important information about the vertical transition of Venus atmospheric structure (which previously had been hampered by absence of data).

- Detailed comparison, including the consideration of the gap of the spatial resolution, is now on going.