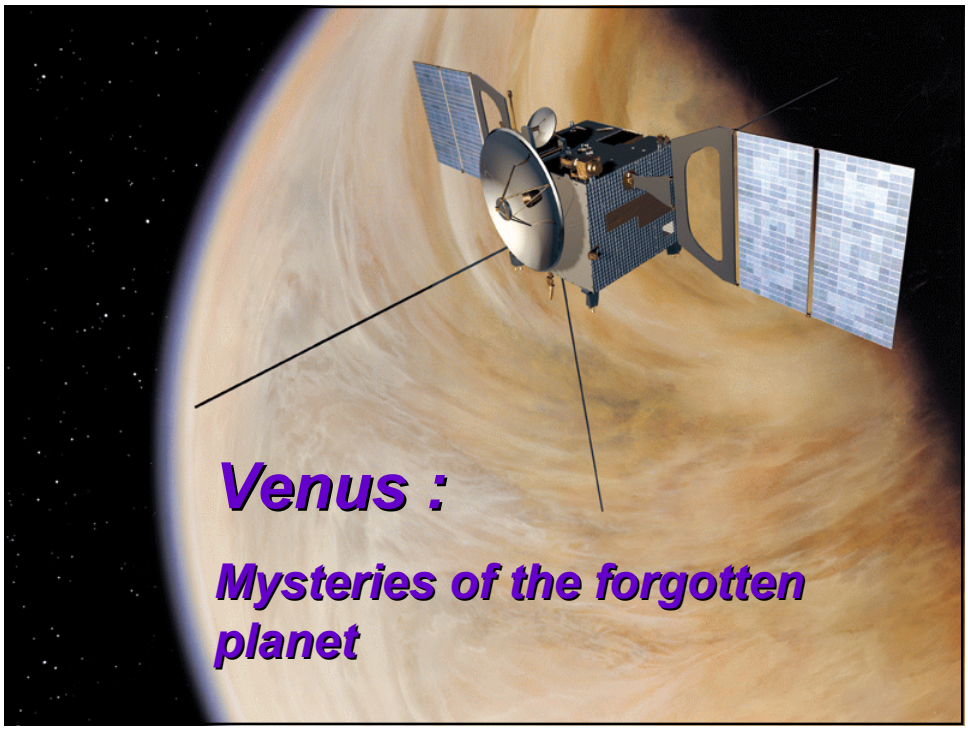
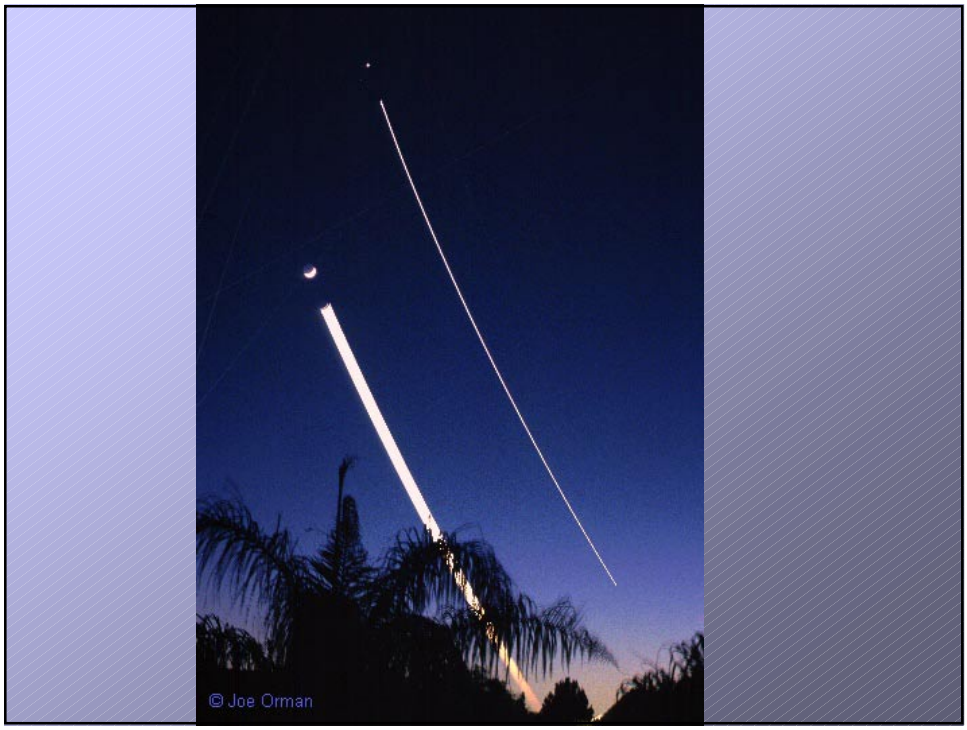
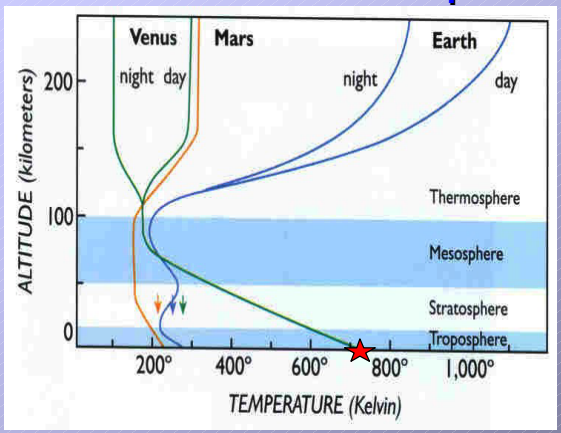


# Venus :

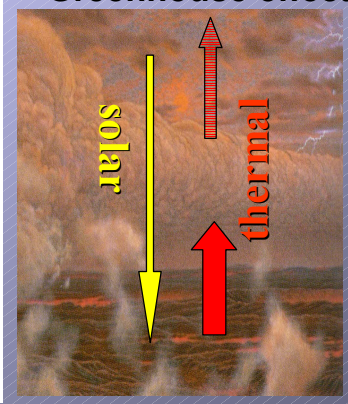
## Mysteries of the forgotten planet



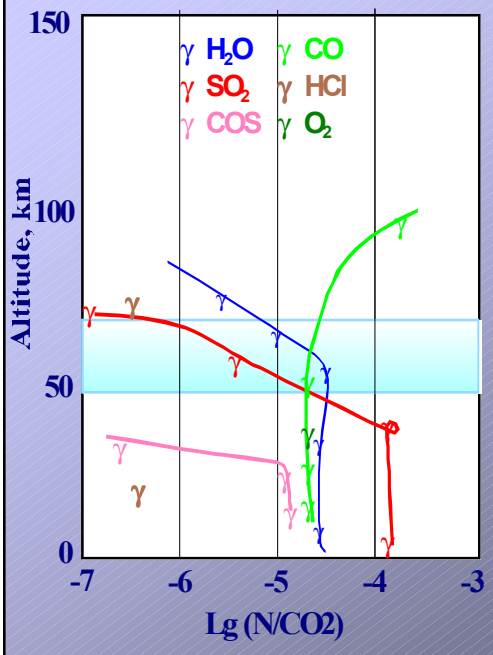
## Structure of the Atmosphere




## Greenhouse effect



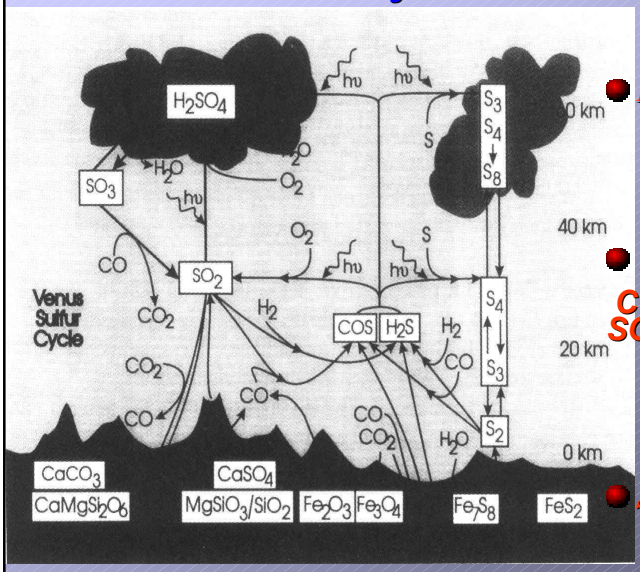

- *Thermosphere: very cold and highly variable*
- *Very high surface temperature*
- *No day/night and equator/pole contrasts*




## Atmospheric composition

- *Main gases:*
  *$CO_2$ (96,5%), $N_2$ (3.5%)*
- *$SO_2$, COS, $H_2S$ – sulfur cycle*
- *CO – photodissociation*
- *$H_2O$ – greenhouse agent*

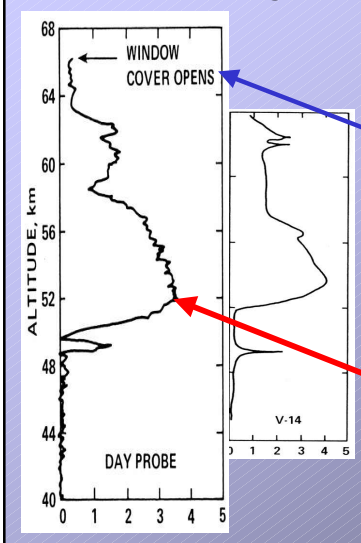
## Chemical Cycles



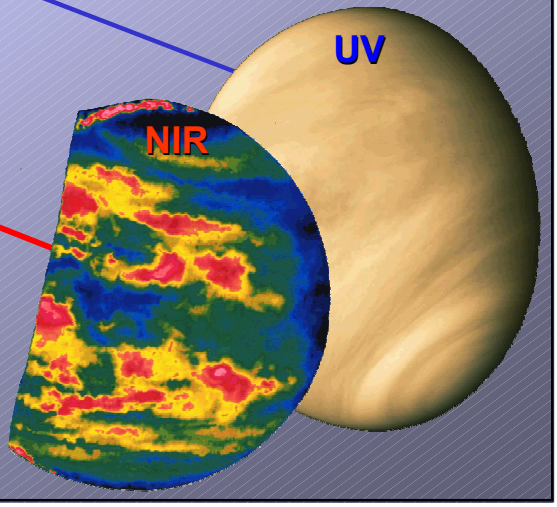

- *Photochemistry*
  *$HO_x$, $Cl_x$, $SO_x$, $O_x$*
- *Thermochemistry*
  *COS, CO, $H_2SO_4$, $SO_3$*
- *Surface- atmosphere interactions*

## Cloud Layer

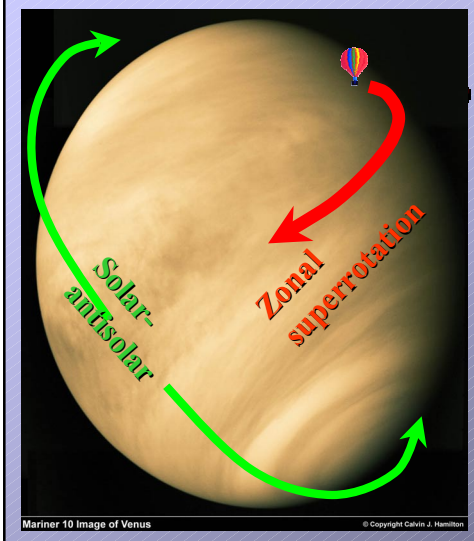
- *Visibility > 300 m*
- *Total opacity 20-40*
- *Particles: 1-10 μm, 100-1000 $cm^{-3}$*
- *Composition:*
  *$H_2SO_4$ + ? ($S_n$, $AlCl_3$, $H_3PO_4$, …)*




Aerosol extinction, $km^{-1}$



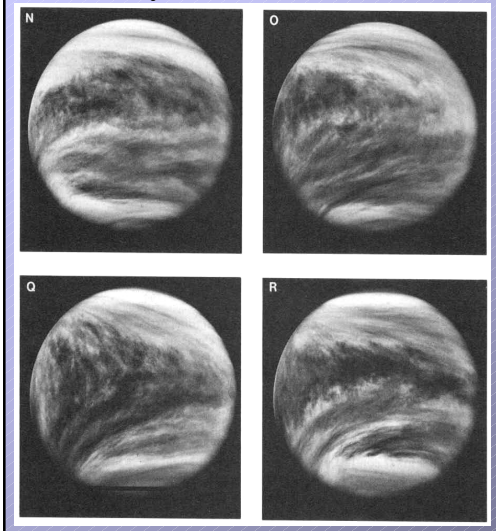
## Atmospheric Dynamics



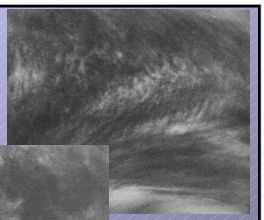

- *Troposphere and mesosphere*
  - *Zonal superrotation (>100 m/s)*
  - *Poleward winds v ~ 10 m/s*
  - *Cyclostrophic balance*
- *Thermosphere (> 120 km): Solar – antisolar circulation*


## Wave phenomena

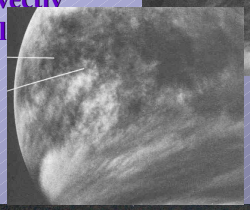
Planetary waves: "Y" feature



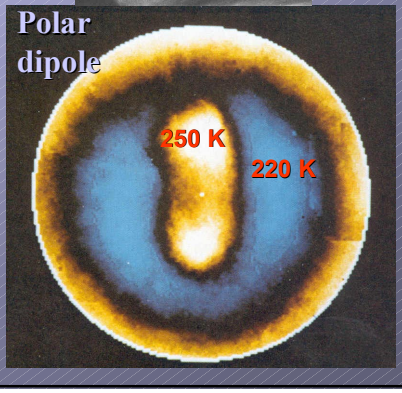

Wave trains

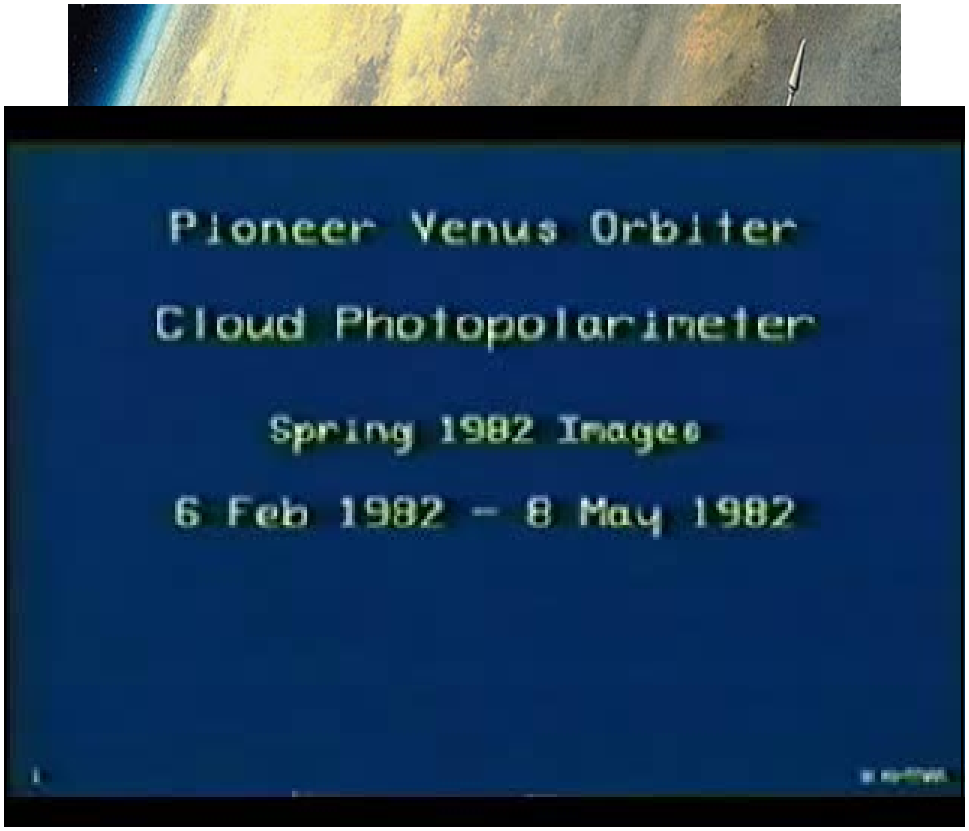


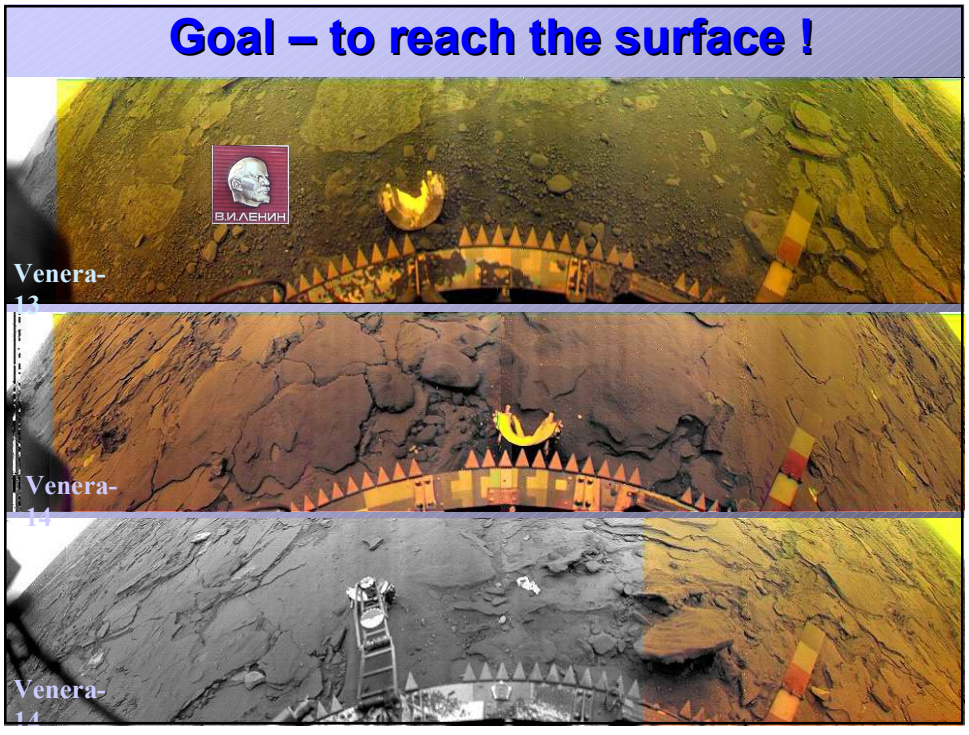
Convective cell

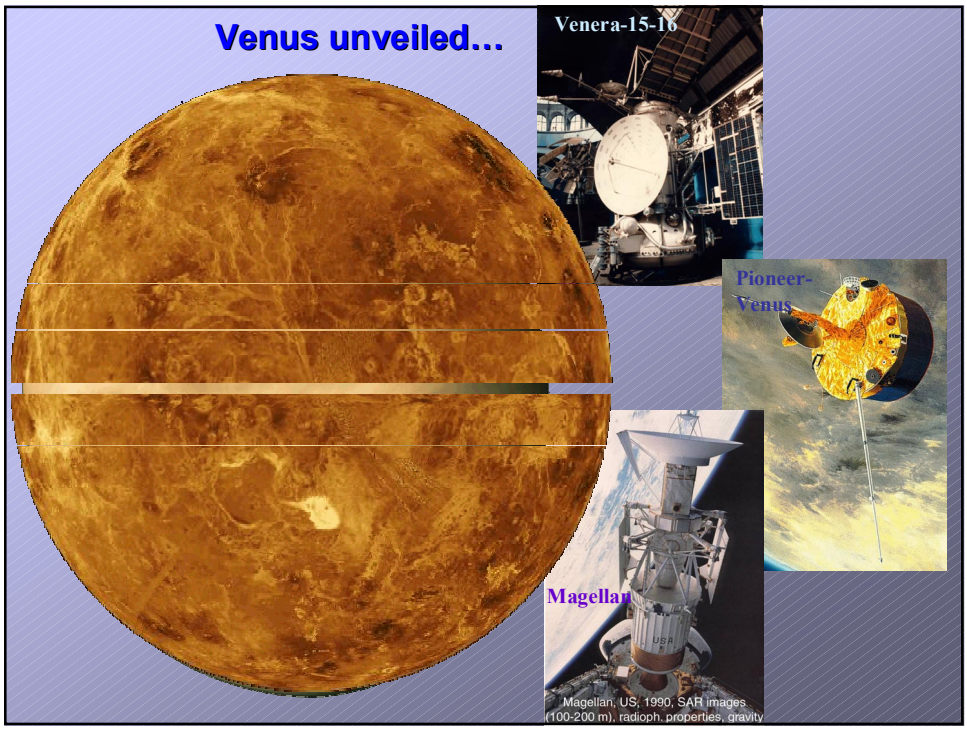


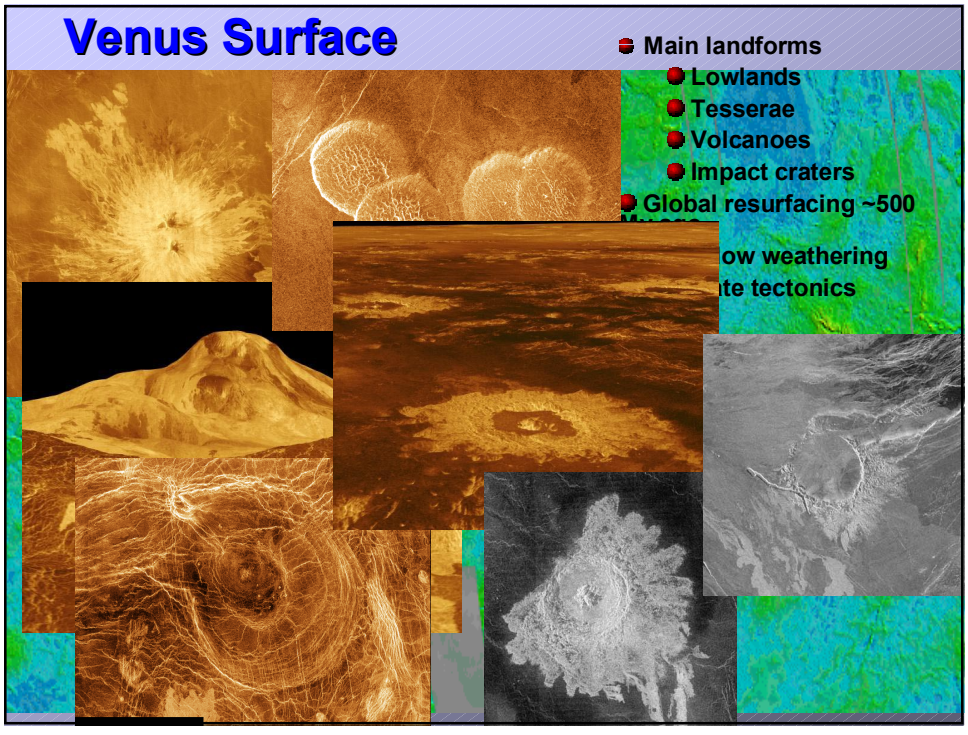
Polar dipole



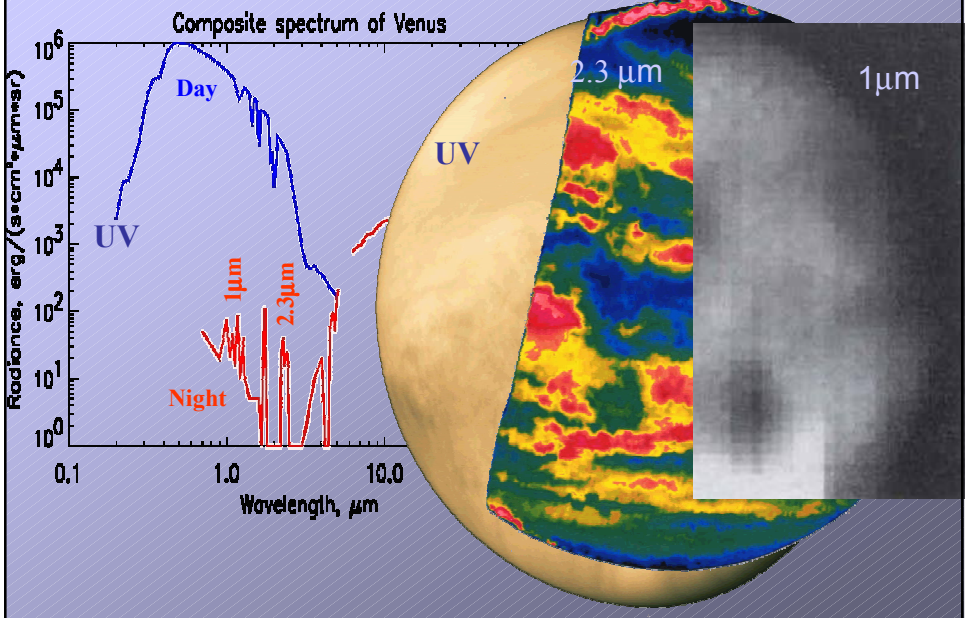

Pioneer Venus Orbiter
Cloud Photopolarimeter
Spring 1982 Images
6 Feb 1982 - 8 May 1982


Goal – to reach the surface !
В.И.ЛЕНИН
Venera-13
Venera-14
Venera-14


Venus unveiled…
Venera-15-16
Pioneer-Venus
Magellan
Magellan, US, 1990, SAR images (100-200 m), radioph. properties, gravity

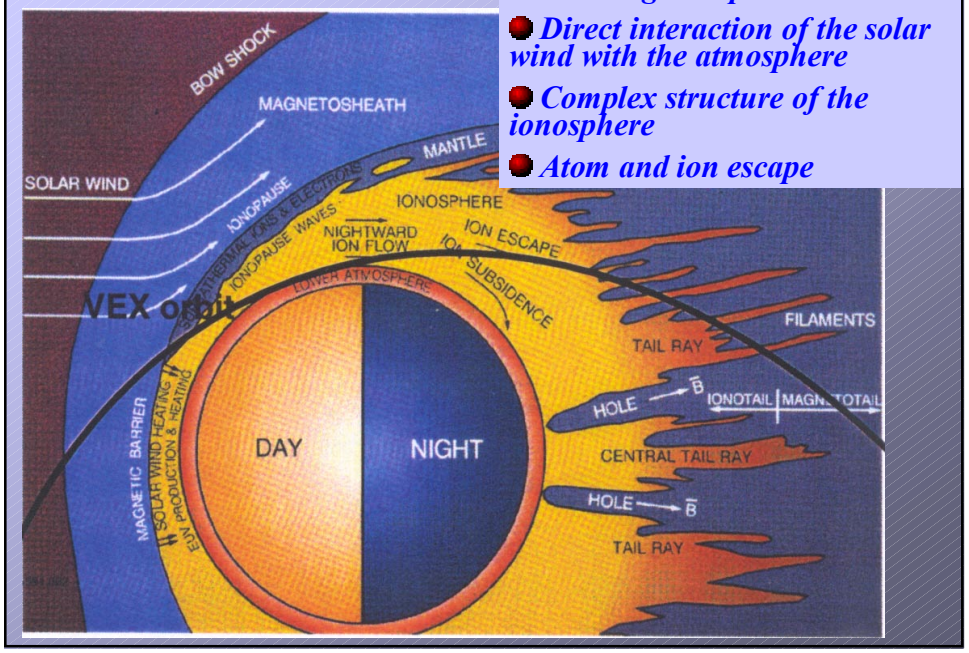

Venus Surface
Main landforms
Lowlands
Tesserae
Volcanoes
Impact craters
Global resurfacing ~500
ow weathering
te tectonics

## Peeping through the cloud curtain



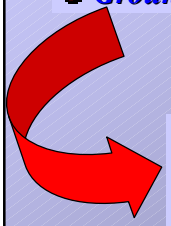

## Plasma Environment

- *Non-magnetic planet*
- *Direct interaction of the solar wind with the atmosphere*
- *Complex structure of the ionosphere*
- *Atom and ion escape*



## Summary of the first phase of Venus exploration /1962 – 1990/

- *Flotilla of more than 20 spacecraft visited the planet*
- *Fly-bys, orbiters, descent probes, balloons*
- *Groundbased observations*



- *Basic understanding of the conditions on the planet*
- *Complete mapping of the surface*
- *Power of remote sensing tools*
- *Great number of unsolved fundamental problems*

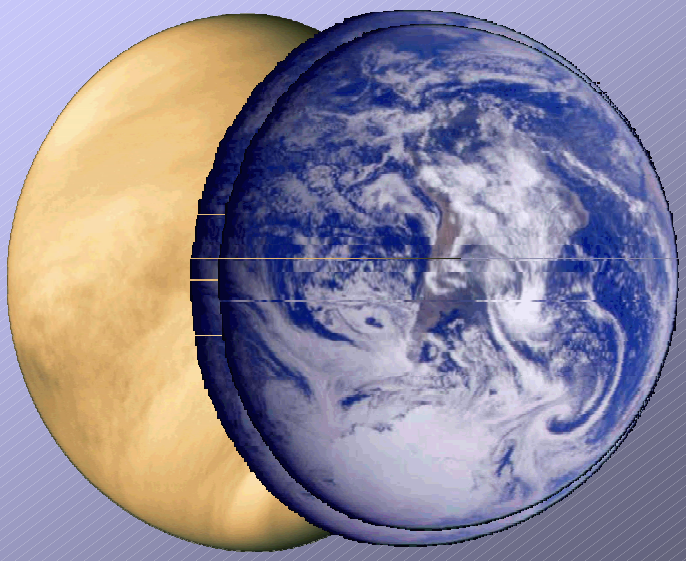
## Mysteries of Venus

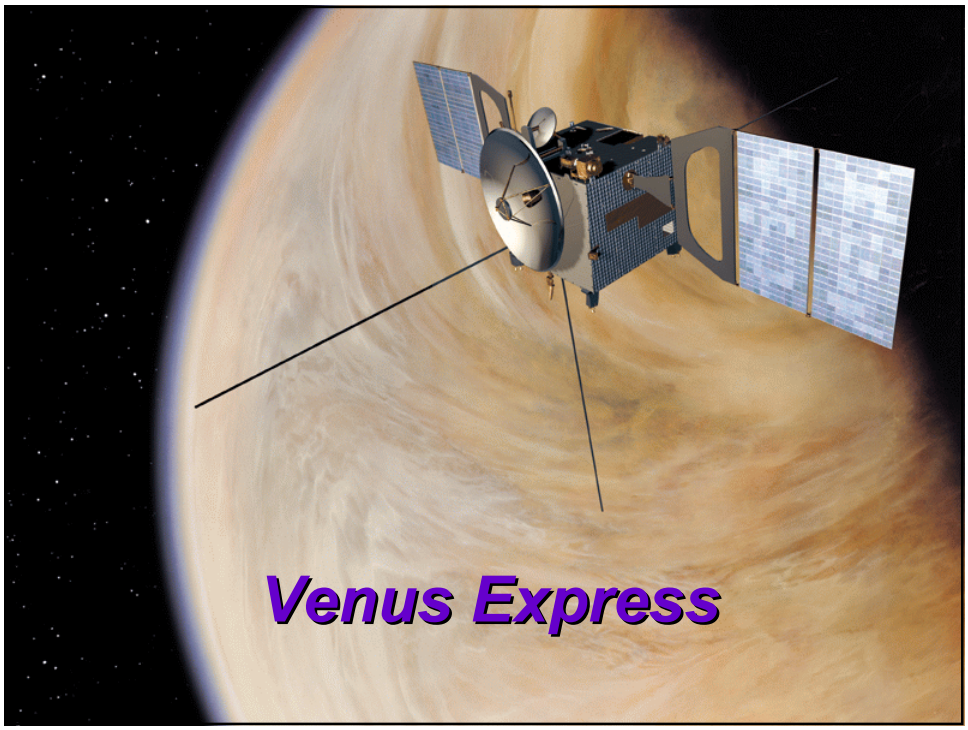
- *Composition and chemistry of the lower atmosphere*
- *Physics and chemistry of the cloud layer*
- *Nature and mechanism of the general circulation*
- *Details of greenhouse effect*
- *Evolution of the atmosphere and the surface*
- *Plasma environment and its interaction with the solar wind*

## Uniqueness of Venus

- *Natural laboratory to study thermochemistry and surface-atmosphere interactions*
- *Atmospheric dynamics on a slowly rotating planet*
- *Radiative transfer at extreme conditions*
- *Surface is one of the youngest in the Solar System*
- *Plasma around non-magnetic planet*

## Key Question






## Venus Express mission goal

*Global investigation of the Venus' atmosphere, plasma environment, and some important aspects of geology and surface physics from orbit*

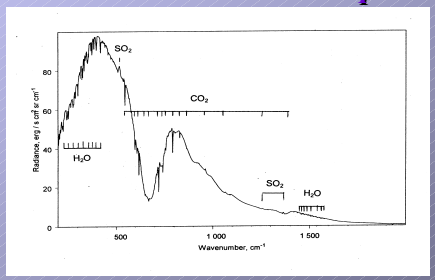
# Venus Express payload

- **PFS (V. Formisano)** - high resolution IR Fourier spectrometer
- **SPICAV / SOIR (J.-L. Bertaux, O. Korablev, P. Simon)** -UV & IR spectrometer for solar/stellar occultations and nadir observations
- **VIRTIS (P. Drossart, G. Piccioni)** - UV-vis-near IR imaging and high resolution spectrometer
- **VMC (W.J. Markiewicz)** - Venus Monitoring Camera
- **VeRa (B. Häusler, M.Pätzold)** - radio science experiment
- **ASPERA (S. Barabash)** - Analyzer of Space Plasmas and Energetic Atoms
- **MAG (T. Zhang)** - Magnetometer

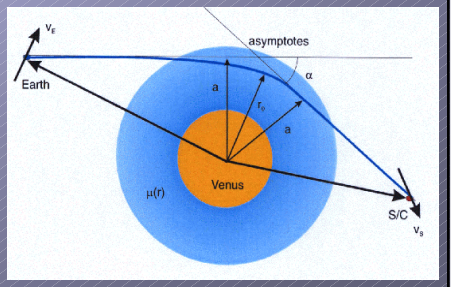
## Temperature structure: SPICAV, PFS, VIRTIS, VeRa

- **Thermosphere and ionosphere**
  - **Solar & stellar occultation by SPICAV/SOIR (80-150 km)**
  - **Radio occultation by VeRa (140-600 km)**
- **Mesosphere**
  - **PFS and VIRTIS (60-100 km)**
  - **VeRa (40- 100 km)**
- **Lower troposphere (0 - 8 km)**
  - **PFS, VIRTIS, and VMC**

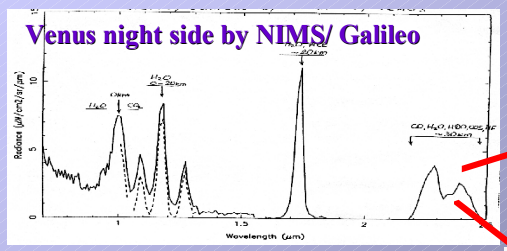
***PFS thermal IR spectru***

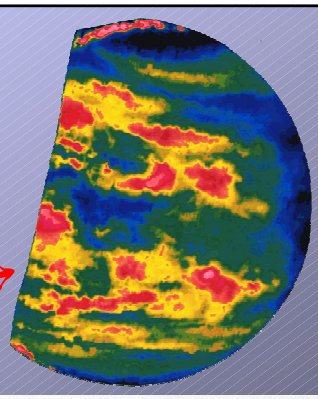


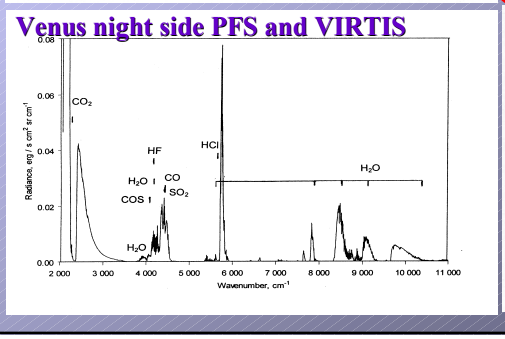

**VeRa radio occultatio**

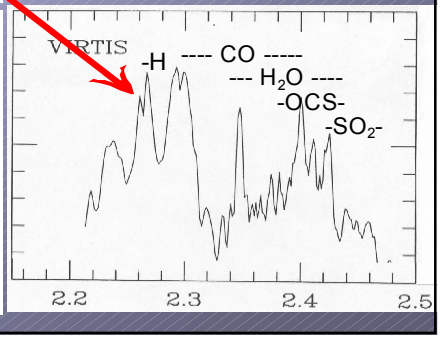


## Lower atmosphere composition: VIRTIS, PFS, SPICAV, VMC



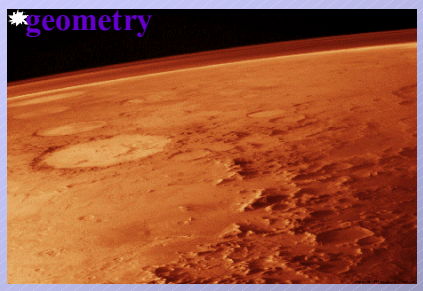





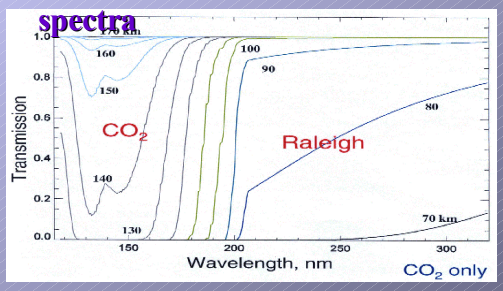




## Composition of the upper atmosphere: SPICAV / SOIR

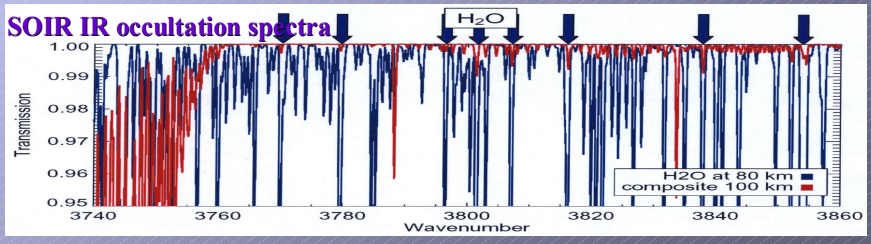
Star occultation geometry



SPICAV UV occultation spectra

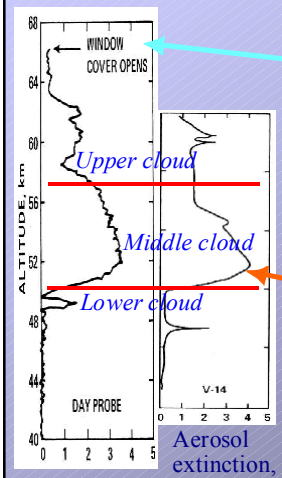


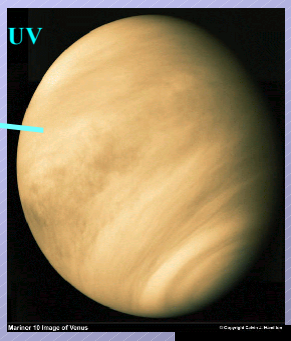

SOIR IR occultation spectra

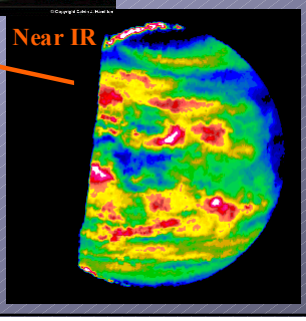


## Cloud layer: VIRTIS, PFS, SPICAV, VMC

Vertical structure



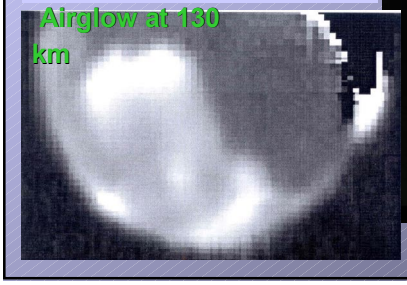



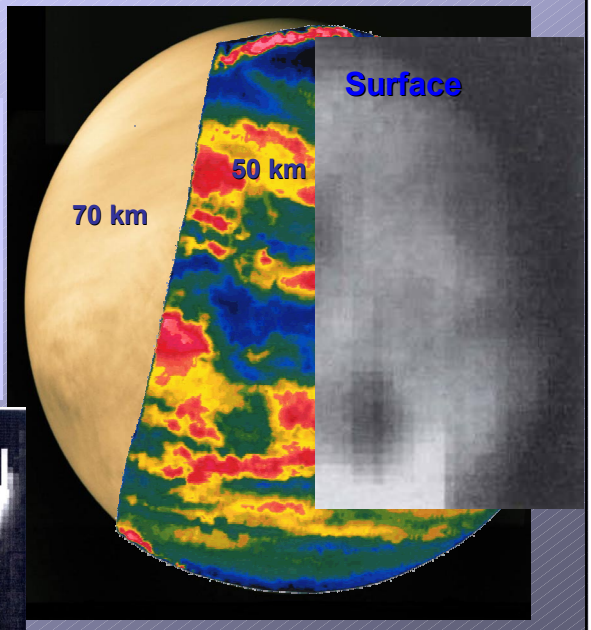




- Optical properties
- Microphysical parameters
- Vertical structure
- Aerosol composition
- Cloud layer formation
- Atmospheric dynamics

## Atmospheric Dynamics

- *VIRTIS spectral mapping*
- *VMC global imaging*
- *PFS thermal wind field*
- *Time varying 3-D picture*



## Plasma and escape processes: ASPERA, MAG, SPICAV, VeRa

**ASPERA and Magnetometer**

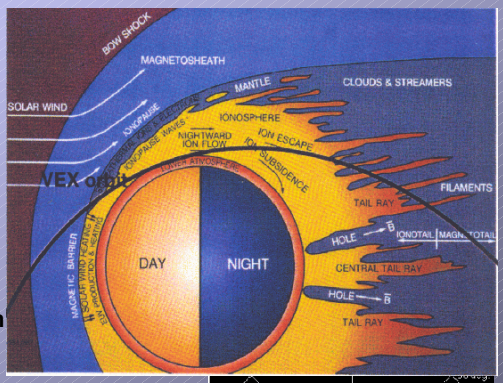
- Global plasma and neutral gas distribution and velocities
- Magnetic field measurements
- Solar wind - atmosphere interaction
- Study of escape processes

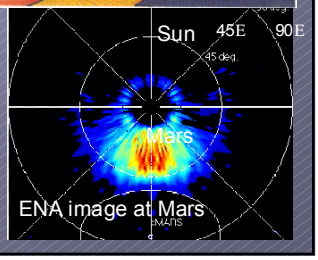
**SPICAV/ SOIR**

- Neutral atmosphere up to ~ 180 km

**VeRa**

- Ionosphere up to ~ 600 km

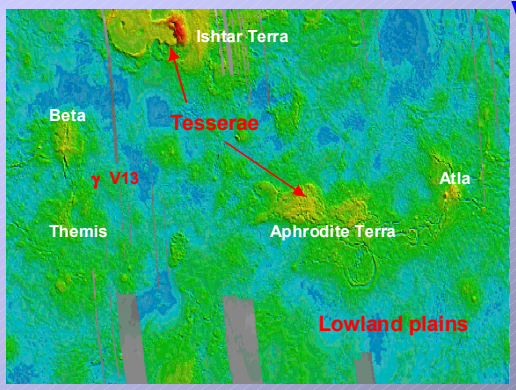


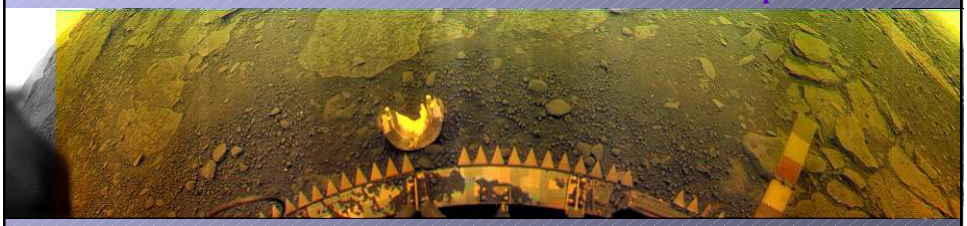

## Surface studies: VeRa, VIRTIS, PFS, SPICAV, VMC

- VeRa bistatic sounding
- Thermal imaging of the surface
- Correlation with earlier radar investigations
- Search for volcanic activity
- Gravity anomalies

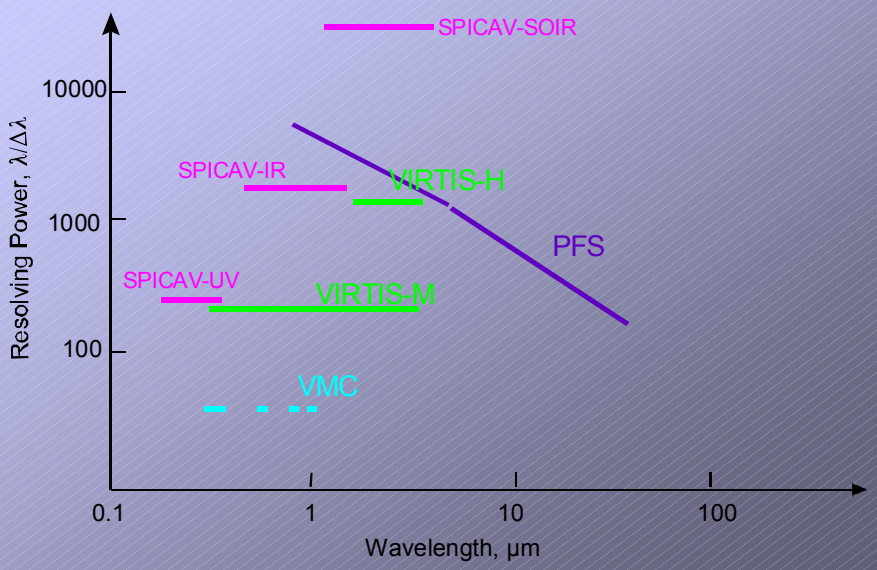
Magellan radar map



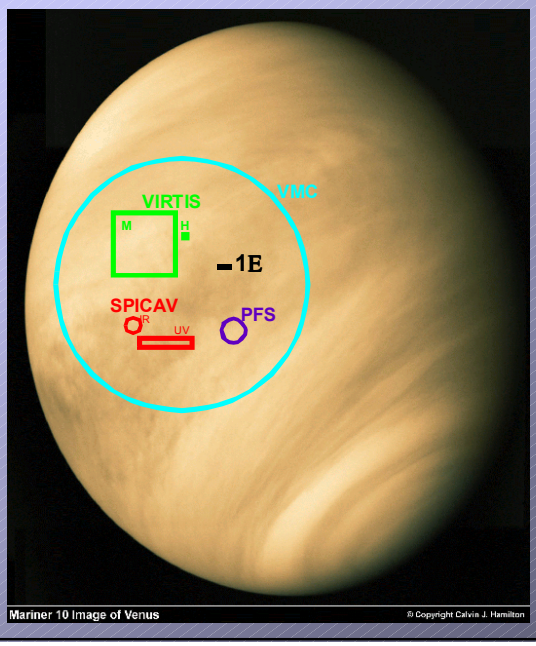

Venera-13 panorama



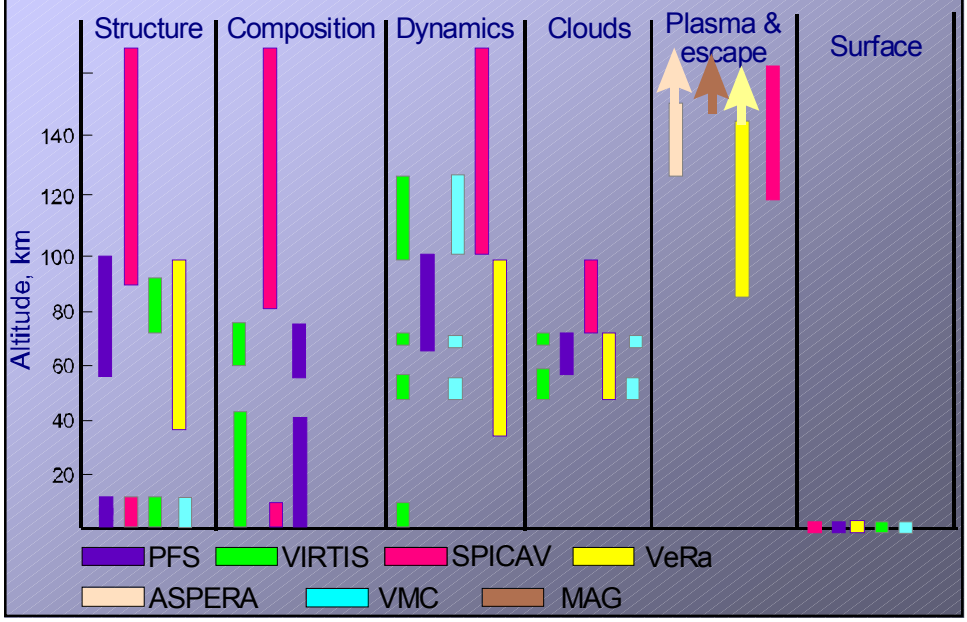
## Spectral characteristics of the payload



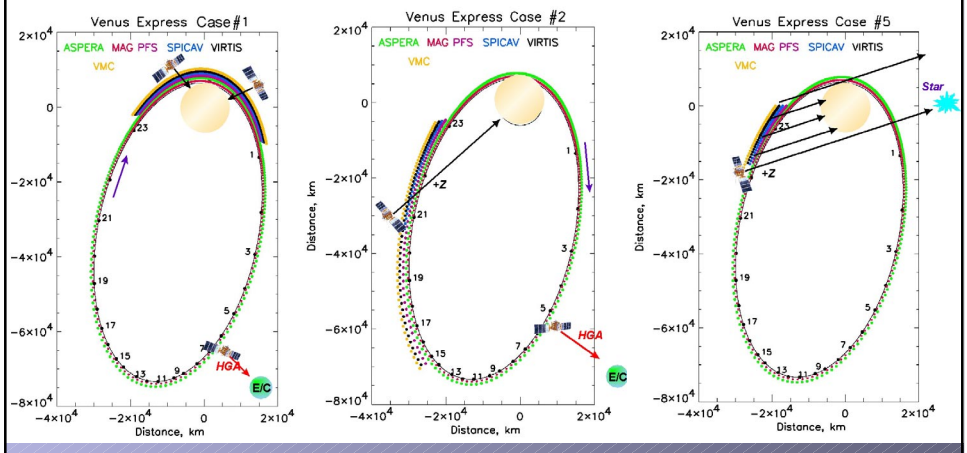

## Fields of view of the instruments at 20,000 km



## Coverage of the science themes




## VENUS EXPRESS ORBIT and SCIENCE OPERATIONS



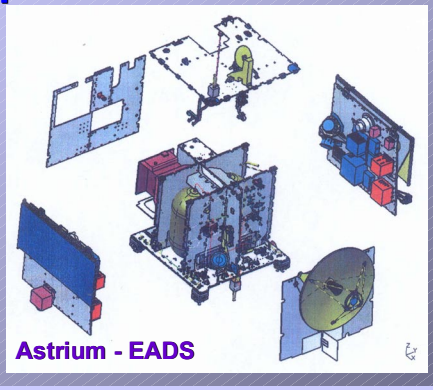

- Pericentre obs
- Off-Pericentre and apocentre obs
- Limb obs
- Solar and stellar occultation
- Earth occultation
- Bi-static and solar corona sounding

# Mission scenario

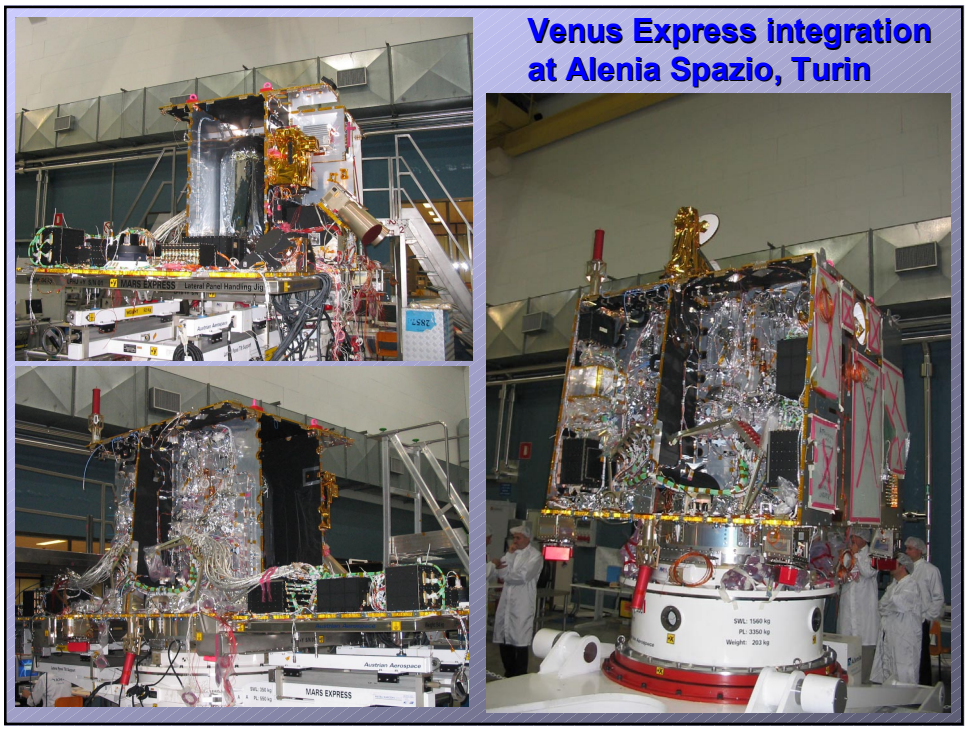
- Launch: Oct-Nov 2005 by Sojuz-Fregat from Baykonur (Kazakhstan)
- Arrival to Venus: April 2006
- Polar orbit
  - Pericentre latitude 80N
  - Pericentre altitude 250 km
  - Apocentre altitude ~65,000 km
  - Period ~ 24h
- Mission duration 4 Venus siderial days
- Complete latitude and local time coverage

# The spacecraft






- Solar panels:
  smaller and different composition
- Smaller dish of the main antenna
- Second antenna
- Modified thermal design


Venus Express integration
at Alenia Spazio, Turin
MARS EXPRESS
Austrian Aerospace
MARS EXPRESS