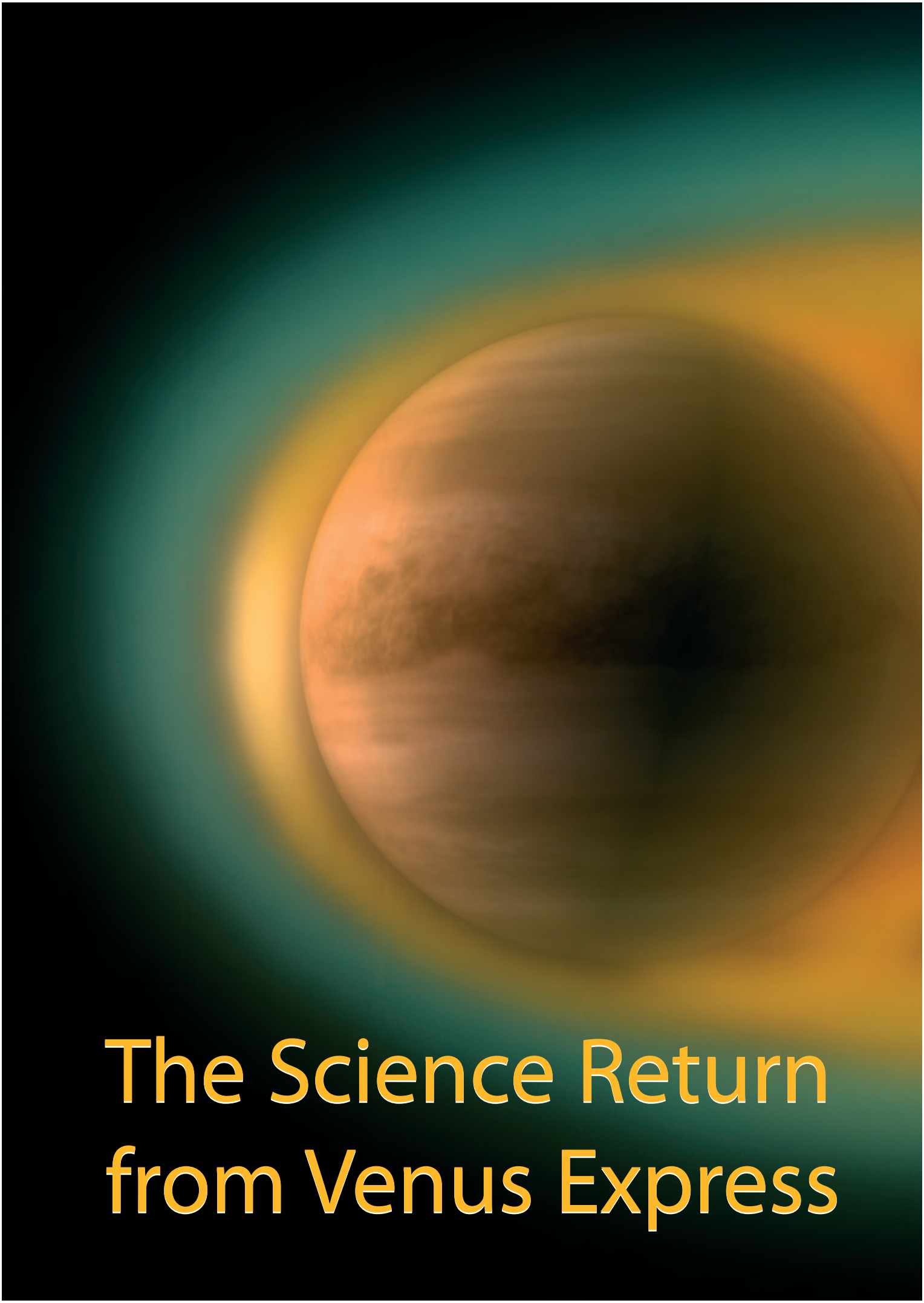
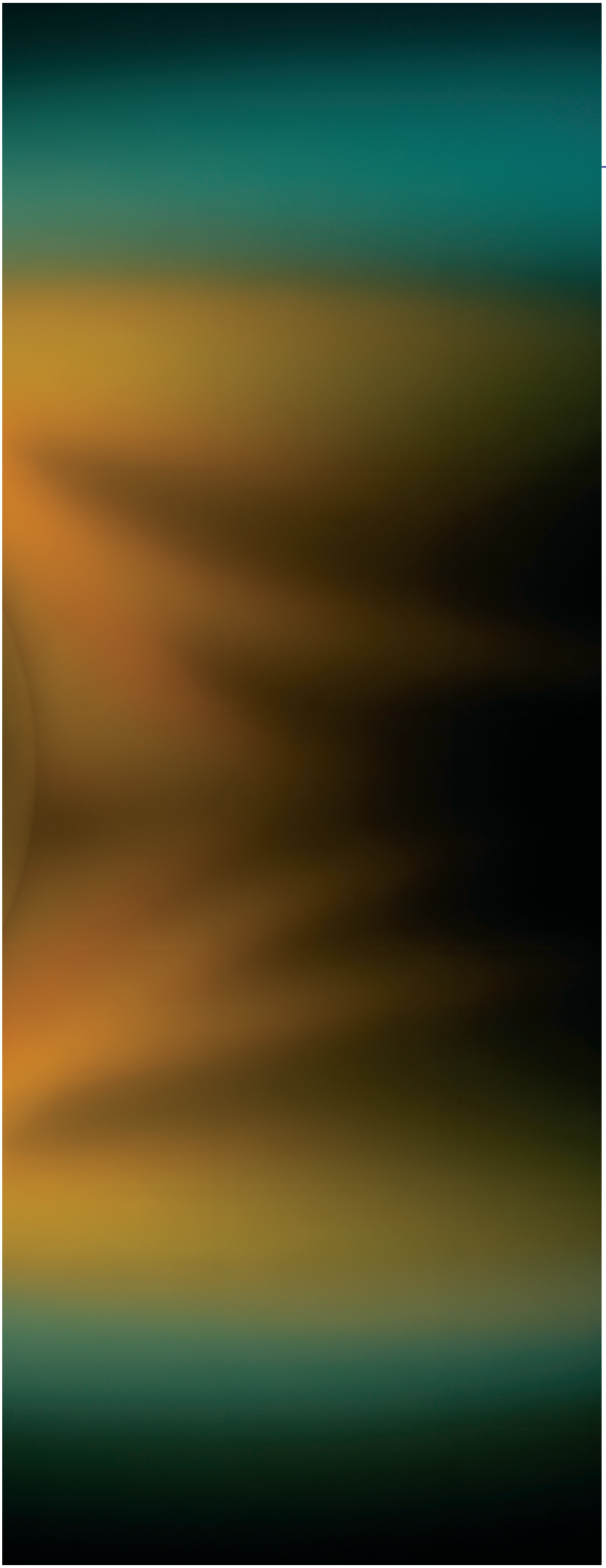


The Science Return from Venus Express



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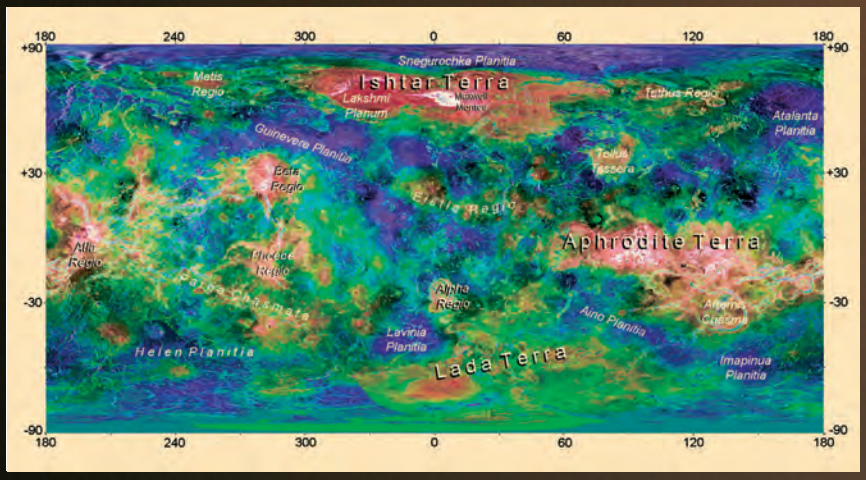
Since the beginning of the space era, Venus has been an attractive target for planetary scientists. Our nearest planetary neighbour and, in size at least, the Earth's twin sister, Venus was expected to be very similar to our planet. However, the first phase of Venus spacecraft exploration (1962-1985) discovered an entirely different, exotic world hidden behind a curtain of dense cloud. The earlier exploration of Venus included a set of Soviet orbiters and descent probes, the Veneras 4 to14, the US Pioneer Venus mission, the Soviet Vega balloons and the Venera 15, 16 and Magellan radar-mapping orbiters, the Galileo and Cassini flybys, and a variety of ground-based observations. But despite all of this exploration by more than 20 spacecraft, the so-called 'morning star' remains a mysterious world!

Introduction

All of these earlier studies of Venus have given us a basic knowledge of the conditions prevailing on the planet, but have generated many more questions than they have answered concerning its atmospheric composition, chemistry, structure, dynamics, surface-atmosphere interactions, atmospheric and geological evolution, and plasma environment. It is now high time that we proceed from the discovery phase to a thorough investigation and deeper understanding of what lies behind Venus' complex chemical, dynamical, and geological phenomena.

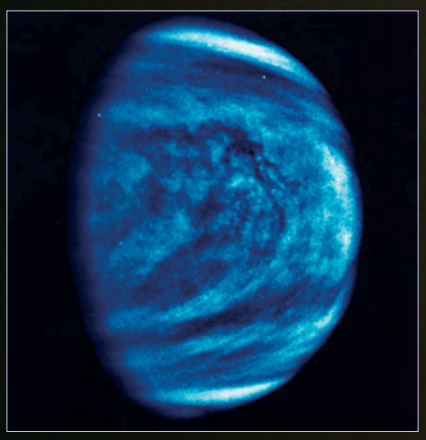


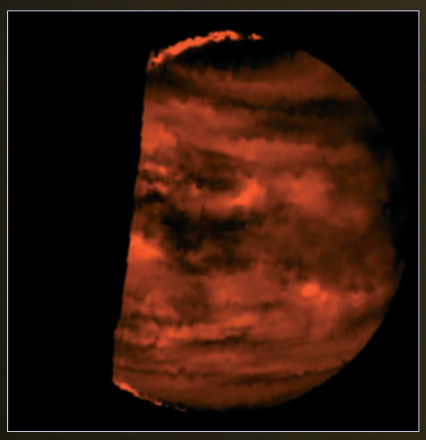
A topographic map of Venus based on radar data from the US Magellan mission (1990-1994). The purple/blue areas correspond to the lowest elevations and the red/white areas to the highest. There are several regions with dramatic features, but a large portion of the planet is dominated by smoothly rolling plains. 90% of the surface lies within an altitude range of only 3 km. At the top centre is the large highland area of Ishtar Terra with the highest mountain on the planet, Maxwell Montes, rising to an altitude 11000 m above the mean surface level. Due to the planet's low rotation speed, Venus is almost perfectly spherical

The Russian Venera 13 lander and its twin Venera 14 returned the first colour images from the surface and allowed investigation of the surface composition. Basaltic rock and soil dominate these landing sites. These panoramic images from Venera 13 (top) and 14 (bottom) show a very flat landscape and a part of the horizon at the upper corners

The data from ground-based observations and previous space missions are very limited in term of their spatial and temporal coverage and, prior to the discovery of the near-infrared 'spectral windows' in the planet's atmosphere, lacked the ability to sound the lower atmosphere of Venus remotely and to study from orbit the phenomena hidden below the thick cloud deck. A survey of the Venusian atmosphere is therefore long overdue. The Pioneer Venus, Venera 15 and 16, and Magellan missions provided global comprehensive radar mapping of the surface and investigated its properties.

While a fully comprehensive exploration of Venus will require, in the long term, in-situ measurements from probes, balloons and sample return, so many key questions about Venus remain unanswered that even a basic orbiter mission, carrying an appropriate combination of modern instruments to the planet, can bring a rich harvest of high-quality scientific results. Venus Express, based on the Mars Express spacecraft bus and equipped with selected instruments designed originally for the Mars Express and Rosetta projects, together with two new instruments, is very appropriate in this regard. It offers an excellent opportunity to make major progress in the study of the planet.





(Left) mage of Venus in daylight, taken by the NIMS instrument onboard the Galileo spacecraft during its fly-by en route to Jupiter. The image was taken with a violet filter to show the structure of the upper cloud layer. The contrast, which is not visible at other wavelengths, is produced by a still unknown substance

(Right) This image from the Galileo/NIMS instrument was taken over the nightside of Venus at an infrared wavelength of 2.3 μm. At this wavelength, the atmosphere is partly transparent to light and so the radiation from the hot lower part of the atmosphere can penetrate the upper atmosphere and the cloud layer. Brightness distribution shows cloud patchiness: the darker the region the higher the cloud opacity

Previous Successful Missions to Venus*

Year	Mission	Country	Type of mission
1962	Mariner 2	USA	Flyby
1967	Mariner 5	USA	Flyby
1967	Venera 4	USSR	Atmospheric probe
1969	Venera 5 & 6	USSR	Atmospheric probes
1970	Venera 7	USSR	Lander
1972	Venera 8	USSR	Lander
1974	Mariner 10	USA	Flyby
1975	Venera 9 & 10	USSR	2 orbiters and 2 landers
1978	Venera 11 & 12	USSR	Landers
1978-1992	Pioneer Venus 1 & 2	USA	1 orbiter and 4 atmospheric probes
1981	Venera 13 & 14	USSR	Landers
1983	Venera 15 & 16	USSR	Orbiters
1985	Vega 1 & 2	USSR	Flyby + 2 balloons + 2 landers
1990-1994	Magellan	USA	Orbiter (radar)
1990	Galileo	USA	Flyby
1998, 1999	Cassini	USA	Flyby

** The exploration of Venus started in the early days of space exploration and several missions failed at different stages.*

Venus before Venus Express

The ground-based observations made before space exploration began could provide only very limited information about Venus. From the first flyby of Venus, by Mariner 2 which discovered that the planet has no magnetic field, to the most recent brief visit, the Cassini flyby on its way to Saturn in 1999, we have come to a point of at least a basic understanding. So what do we really know about Venus today?

The major planetary parameters are indeed very similar to those of the Earth. The radius of Venus is 6051 km (versus 6378 km for the Earth) and its average density is 5.25 g/cm^3 (versus 5.52 g/cm^3 for the Earth). Consequently, the masses, volumes, surface gravities, and escape velocities are also similar for the two planets. The distance to the Sun is 0.72 Astronomical Units (AU) for Venus, versus 1 AU for the Earth (where 1 AU = 150 million km and is the average distance from the Earth to the Sun).

Here, however, the similarities end. Venus rotates very slowly, once in 243 Earth days, and in the opposite direction to Earth (so-called retrograde rotation). The length of a Venusian year is 224 Earth days. The planet's atmosphere is composed mainly of carbon dioxide (96.5%), with molecular nitrogen as a minor constituent (3.5%). Water vapour, sulphur dioxide, carbon monoxide and other compounds also exist in small amounts. The average surface temperature is 464°C, and the atmospheric pressure is 92 bars. Clouds mainly made up of sulphuric-acid droplets cover the whole planet. Venus is indeed an inhospitable world!

The surface: Venus is one of the most geologically active planets in the Solar System. Its surface is rather young and it appears that it has been completely altered by a global outburst of volcanic activity about 500 million years ago. The surface therefore does not carry any record of the first 90% of the planet's life, and is roughly divided into plains covering 80% of the planet and highlands. Geological features such as mountains and canyons are also found, as well as craters larger than 2 km. Smaller craters have not been formed due to the destruction of small meteorites by the dense planetary atmosphere. It is likely that there is still active volcanism. Earth-like plate tectonics have not been observed. Our knowledge about the surface has benefited dramatically from the Magellan radar sounding; only a very limited number of optical images of the surface exist, but a few such panoramas were sent back by the Venera landers (see accompanying images).

The lower atmosphere and cloud layer: The physics and the chemistry of the first 60 km of the atmosphere are largely unknown. This is especially true as far as the atmospheric dynamics and the composition of the lower atmosphere and the cloud layer are concerned. The nature of the UV-absorbing substance at the cloud tops that produces patterns on the Venus disc (see accompanying figure) and absorbs a large fraction of the solar radiation, and the origin of the large solid particles detected by Pioneer Venus, are also poorly understood.

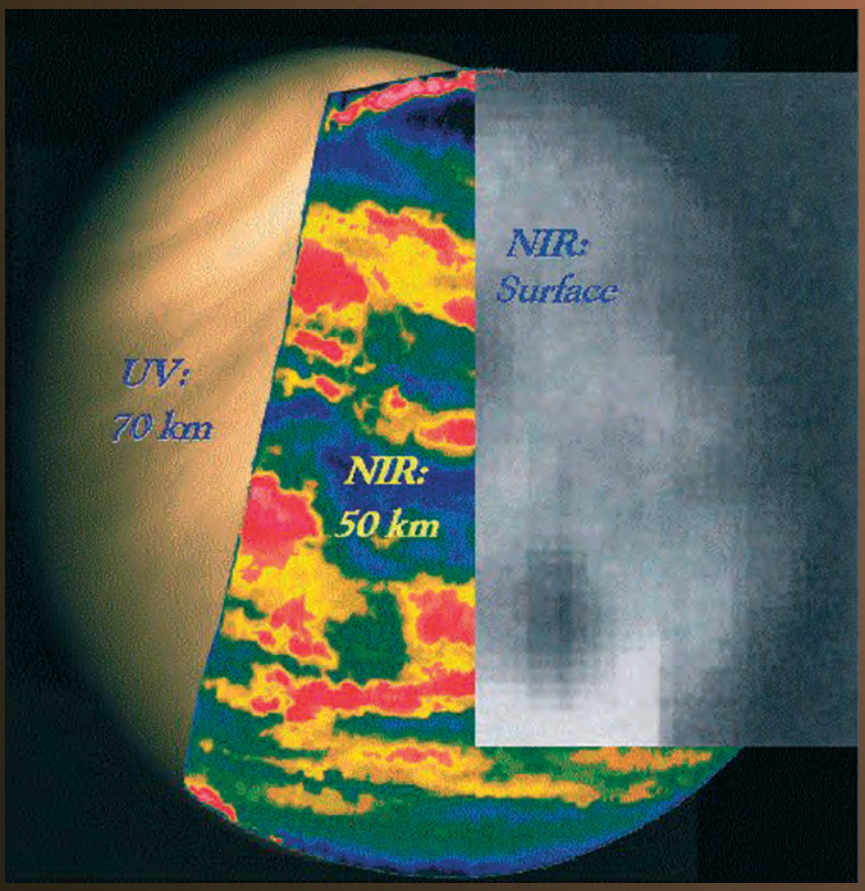
The winds at an altitude of about 70 km exceed 100 m/s, which makes the atmosphere at this level circulate the planet in only four days, whilst the planet itself rotates very slowly, with a period 60 times longer. This 'super-rotating' wind gradually reduces with decreasing altitude, becoming approximately zero at the surface. The process generating these strong winds cannot presently be explained. Polar vortices, observed by earlier missions but also not explained, may well have some link with this super-rotating atmosphere.

The cloud layer extends between 50 and 70 km altitude and is possibly made up of two or more distinctly separate layers governed by different processes. The transparency is strongly wavelength-dependent and at a few wavelengths in the near infrared it is possible to see through to the lower cloud layers and even down to the surface (see figure).

Venus's climate is strongly driven by the 'greenhouse effect' produced mainly by the high content of CO_2, which is transparent to incoming solar radiation in the visible range, but blocks the outgoing thermal-infrared radiation from the surface and the lower atmosphere. This causes the surface of Venus to be the hottest place of all in the Solar System.

The middle and upper atmosphere: Also above 60 km altitude, the processes in the atmosphere are poorly known. In the middle atmosphere (60 to 110 km), carbon dioxide and sulphur dioxide are photo-dissociated by the solar flux, leading to an interesting chemistry that is important to understand in order to grasp how the clouds are formed below. The temperature and cloud structure show significant latitudinal variability. Strong day/night contrasts exist above 110 km in the thermosphere. These differences should lead to much stronger differential winds than are currently observed.

The plasma environment: Since Venus lacks an internal magnetic field, the upper atmosphere is interacting directly with the solar wind. As a result, via a complex process, part of the atmosphere is escaping to space. This may have been the mechanism that has removed the water and other volatiles, which are likely to have been present after the formation of the planet. The deuterium abundance is much higher on Venus than on the Earth, which indicates that large amounts of hydrogen have been lost in the past. This point is particularly important for understanding the evolution of the atmosphere.



A collage of the sorts of imagery that can be produced by Venus Express's VMC camera using three of its four filters. The altitude in the atmosphere from which most of the radiation originates in each case is indicated. The rightmost element, which shows the surface, is extracted from an Earth-based telescope image taken at 1.0 μm and therefore both the contrast and resolution are limited

Key Questions and Mission Objectives

The information we have has certainly advanced our knowledge about Venus, but it has also enabled us to more precisely formulate what we do not know, and in particular what it is important to understand next. Some of the key questions that have been identified are:

– What is the mechanism and what is the driving force of the super-rotation of the atmosphere?
– What are the basic processes in the general circulation of the atmosphere?
– What is the composition and chemistry of the lower atmosphere and the clouds?
– What is the past and present water balance in the atmosphere?
– What is the role of the radiative balance and greenhouse effect in the past, present and future evolution of the planet?
– Is there currently volcanic and/or tectonic activity on the planet?

The answers to these questions, together with the comprehensive studies under the different themes described below, will lead to an improved understanding of perhaps the most fundamental question of all, namely: *Why has Venus evolved so differently compared to the Earth, in spite of the similarities in terms of size, basic composition and distance to the Sun?*

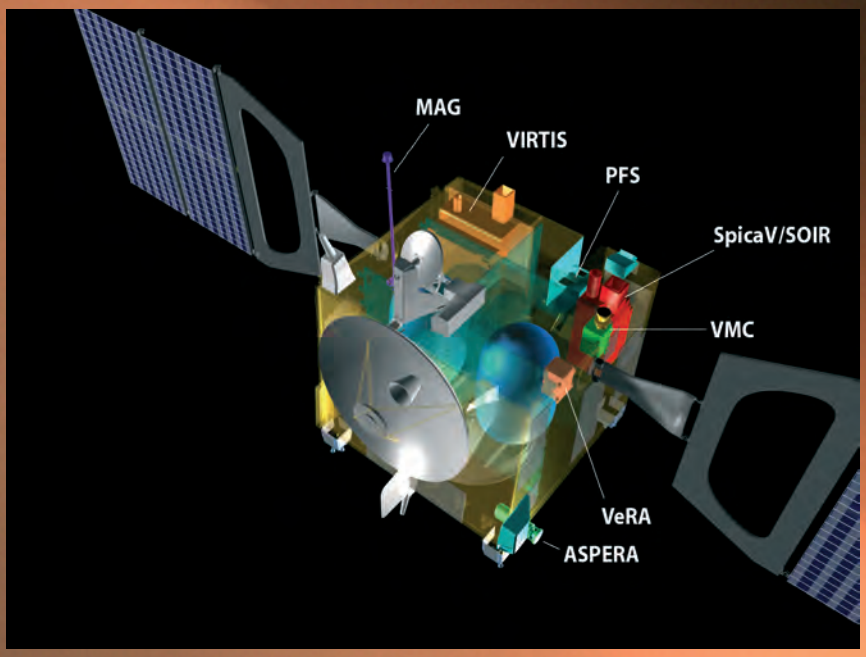
The scientific objectives of the Venus Express Mission have been concisely expressed within seven 'Scientific Themes'. The aim is to carry out a comprehensive study of the atmosphere of Venus and to study the planet's plasma environment and its interaction with the solar wind in some detail. Dedicated surface studies will also be performed. The seven Scientific Themes are:

- Atmospheric Dynamics
- Atmospheric Structure
- Atmospheric Composition and Chemistry
- Cloud Layer and Hazes
- Radiative Balance
- Surface Properties and Geology
- Plasma Environment and Escape Processes.

The first three themes are divided into sub-themes that refer to the upper, middle and lower parts of the atmosphere. The corresponding approximate limits for these regions are, above 110 km, between 110 and 60 km, and below 60 km. The scientific requirements within the sub-themes are broken down into units that can be directly addressed by individual measurements.

The Scientific Payload

As there were already strict requirements on the payload in the 'Call for Ideas' in that



Locations of the seven scientific instruments on the Venus Express spacecraft

the individual instruments had to be available to match the challenging schedule of the mission, the list of instruments that could be chosen was fairly restricted. The obvious candidates were the spare models from the Mars Express and Rosetta projects. After a detailed assessment, three Mars Express instruments were chosen together with two Rosetta instruments, enhanced with a newly developed miniaturised four-band camera and a new magnetometer (with heritage from the Rosetta lander). In addition, a very high-resolution solar-occultation spectrometer was added to one of the original Mars Express instruments. This resulted in a payload complement including a combination of different spectrometers, an imaging spectrometer and a camera, covering the UV to thermal-IR range, along with a plasma analyser and a magnetometer. The Radio Science team will utilise the communication link to the Earth, enhanced with an ultrastable oscillator, to conduct atmospheric investigations with high vertical resolution. This payload can sound the entire atmosphere from the planet's surface to 200 km altitude.

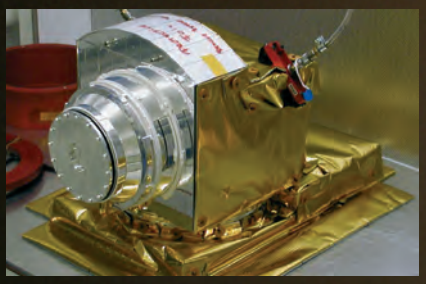
The elements of the scientific payload and their respective Principal Investigators are listed in the adjacent table. As it turned out, despite the limitations on the freedom of choice, the payload is close to optimal for the mission, with all of the scientific objectives able to be addressed in the proper depth. The payload has shown excellent performance in pre-launch testing, with accurate calibration being achieved for all instruments.

ASPERA

The ASPERA-4 experiment is designed to study the solar-wind/atmosphere interaction and to characterise the plasma and neutral-gas environment in near-Venus space through the imaging of Energetic Neutral Atoms (ENAs) and local charged-particle measurements. The studies to be performed address the fundamental

Venus Express Scientific Payload

Instrument	Description	Principal Investigator
ASPERA	Ion and electron analyser and energetic neutral atoms imager	S. Barabash, IRF, Kiruna, Sweden
MAG	Magnetometer	T. Zhang, IWF, Graz, Austria
PFS	High-resolution infrared Fourier spectrometer	V. Formisano, IFSI-INAF, Rome, Italy
SPICAV	UV and IR atmospheric spectrometer for solar/ stellar occultation and nadir and limb direct observations	J.-L. Bertaux, SA/CNRS, Verrieres-le-Buisson, France
VeRa	Radio-science investigation of the ionosphere, atmosphere, surface, and interplanetary plasma	B. Häusler, Universität der Bundeswehr, München, Germany
VIRTIS	UV/visible/IR imaging and high-resolution spectromery	P. Drossart, CNRS/LESIA, Observatoire de Paris, France G. Piccioni, IASF-CNR, Rome, Italy
VMC	Venus Monitoring Camera with filters in four wavelength bands	W.J. Markiewicz, MPS, Katlenburg-Lindau, Germany



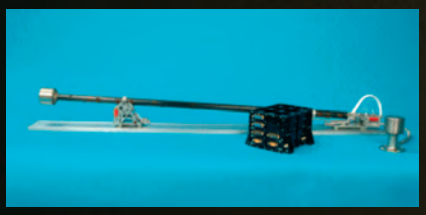
The main unit of the ASPERA-4 instrument

question: How strongly do the interplanetary plasma and electromagnetic fields affect the Venusian atmosphere?

The ASPERA-4 instrument has four sensors: two ENA sensors, an electron spectrometer and an ion spectrometer. The Neutral Particle Imager (NPI) provides measurements of the integral ENA flux (0.1 - 60 keV) with no mass and energy resolution, but with a relatively high angular resolution of 4 deg x 11 deg. The Neutral Particle Detector (NPD) provides measurements of the ENA flux, resolving velocity (0.1 - 10 keV) and mass (hydrogen and oxygen) with a coarse angular resolution of 4.5 deg x 30 deg. The Electron Spectrometer (ELS) is a top-hat electrostatic analyser of very compact design, to measure electron fluxes in the energy range 1 eV - 20 keV with an 8% energy resolution. These three sensors are located on a scanning platform providing full sky_ coverage. The fourth sensor is a spacecraft-fixed Ion Mass Analyser (IMA), providing ion measurements in the energy range 0.01 - 36 keV/q for the main ion components H^+, H_2^+, He^+, O^+, O_2^+, and CO_2^+ ion group with M/q > 40 amu/q.

MAG

The magnetic-field observations are intended to define the plasma boundary and to study the solar wind's interaction with the Venusian atmosphere. The magnetic field data will also provide important information to other instruments onboard, for example ASPERA, for combined studies of the Venus plasma environment.



The MAG instrument

The Magnetometer is a miniaturised digital fluxgate magnetometer that uses two fluxgate sensors to measure the magnetic field's magnitude and direction. One sensor is mounted on the tip of a 1 m-long deployable boom, and the other on the top surface of the spacecraft. This sensor configuration enables the ambient magnetic field, which is the scientific parameter of interest, to be separated from stray spacecraft fields and disturbances. This very-high-sensitivity instrument can detect magnetic variations as small as a few pico-Tesla.

PFS

The Planetary Fourier Spectrometer (PFS) is an infrared spectrometer optimised for atmospheric studies. Its two channels together cover the spectral range from 0.9 to 45 µm. The relative spectral resolution ranges from 200 at the longest wavelength to 8000 at the shortest. The field of view is about 1.6 deg for the short-wavelength and 2.8 deg for the long-wavelength channel.

The PFS instrument

PFS addresses several atmospheric and surface goals on Venus by measuring:

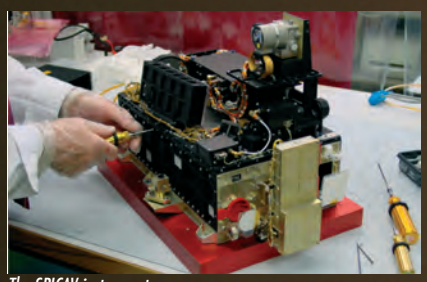
– temperature and cloud structure from 60 to 100 km altitude
– abundance of several important trace molecular species at the cloud tops and in the lower atmosphere
– pressure at the cloud tops
– cloud opacity and its variations
– thermal surface flux at several wavelengths near 1 micron, with concurrent constraints on surface temperature and emissivity (indicative of composition)
– oxygen airglow near the 100 km level.

It will also search for and characterise current volcanic activity by measuring spatial and temporal anomalies in both the surface thermal flux and the abundances of volcanic trace species in the lower atmosphere.

SPICAV

SPICAV is a suite of three optical spectrometers designed to study the present state of Venus's atmosphere and provide clues to its evolution. On the nightside, the near-IR thermal emission emanating from the deep atmosphere will be analysed (0.7 to 1.65 µm, resolution ~1500) to learn more about the composition of the lower atmosphere and H_2O content, and to detect hot spots on the surface. In the UV range (measured by an imaging spectrometer with intensified CCD at 110-320 nm, resolution 1.5 nm) upper atmosphere natural emissions will be studied. NO and O_2 emissions are tracers of the thermosphere global circulation. Precipitation of energetic electrons produces emissions of atomic oxygen at 130.4 and 135.6 nm. On the dayside, Lyman-α hydrogen and oxygen emission will allow the escape of H and O atoms to be studied. The UV spectrometer will probe the vertical distribution of SO_2 and haze layers using the star-occultation technique.

The SOIR (Solar Occultation in the Infra-Red) channel is a new type of high-resolution spectrometer ($\lambda/\Delta\lambda$ = 20 000) to measure many atmospheric constituents, in particular HDO and H_2O, above the clouds together with their vertical distributions; this will have a direct impact on our understanding of how water has escaped from Venus. The instrument consists of a



The SPICAV instrument

high-dispersion grating spectrometer (2.2 to 4.4 µm) working in high diffraction orders, combined with an Acousto-Optic Tuneable Filter (AOTF).

VeRa

The Venus Express Radio Science Experiment (VeRa) will use radio signals at X- and S-band (3.5 cm and 13 cm wavelengths) from the spacecraft's telecommunications system to probe the planet's surface, ionosphere and neutral atmosphere, the gravity field and the interplanetary medium. An Ultra Stable Oscillator (USO) will provide a high-quality onboard frequency reference to the spacecraft transponder. Instrumentation on Earth will sample the amplitude, phase, propagation time and polarisation of the received signals. Simultaneous coherent measurements at the two wavelengths will allow separation of the dispersive effects caused by the solar-wind plasma and the Earth's ionosphere. The USO is a direct derivative of the Rosetta USO.

VeRa science objectives include:

- determination of neutral atmospheric structure from 40 to 100 km altitude and derivation of vertical profiles of neutral mass density, temperature, and pressure as a function of local time and season
- study of the H_2SO_4 vapour absorbing layer in the atmosphere via signal intensity variations
- investigation of ionospheric structure from approximately 80 km altitude to the ionopause (< 600 km)
- observation of back-scattered surface echoes from high-elevation targets with anomalous radar properties (such as Maxwell Montes) to determine surface roughness and dielectric properties
- investigation of dynamical processes in the solar corona and the solar wind.

VIRTIS

VIRTIS (the ultraviolet, visible and infrared imaging and high-resolution spectrometer) will map Venus from the surface to the mesosphere. Its scientific objectives cover a wide field, ranging from the meteorology of the middle atmosphere to the surface mineralogy. It will make ample use of the recently discovered infrared 'windows' enabling the atmosphere to be sounded at different depths down to the surface, and three-dimensional mapping of the region between the surface and 150 km altitude. These maps, regularly repeated to provide a temporal dimension, will be used to study the dynamics of the atmosphere with unprecedented precision. The scientific studies will address the atmospheric super-rotation, the cloud structure along with the specific question of the UV absorbers, and the dynamics of the mesosphere, together with specific questions related to atmospheric escape. Volcanism, atmospheric composition and surface–atmosphere interactions will also be addressed.

Particular VIRTIS scientific goals are:

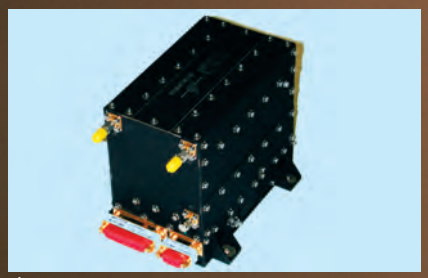
- study of the lower atmosphere composition (CO, OCS, SO_2, H_2O)
- study of the cloud structure, composition and scattering properties
- cloud tracking in the UV and IR, to retrieve the wind velocity field
- sounding of the mesospheric temperature and cloud structure
- search for lightning
- search for variations related to surface/atmosphere interaction
- temperature mapping of the surface and search for volcanic activity
- search for seismic-wave activity (tentative).

VIRTIS will also provide true-colour images of Venus for science communication and education purposes.

VMC

The Venus Monitoring Camera (VMC) is an innovative compact design with four independent lenses (channels) that share a single CCD. The four channels have individual narrow-band filters at wavelengths chosen for specific science objectives.

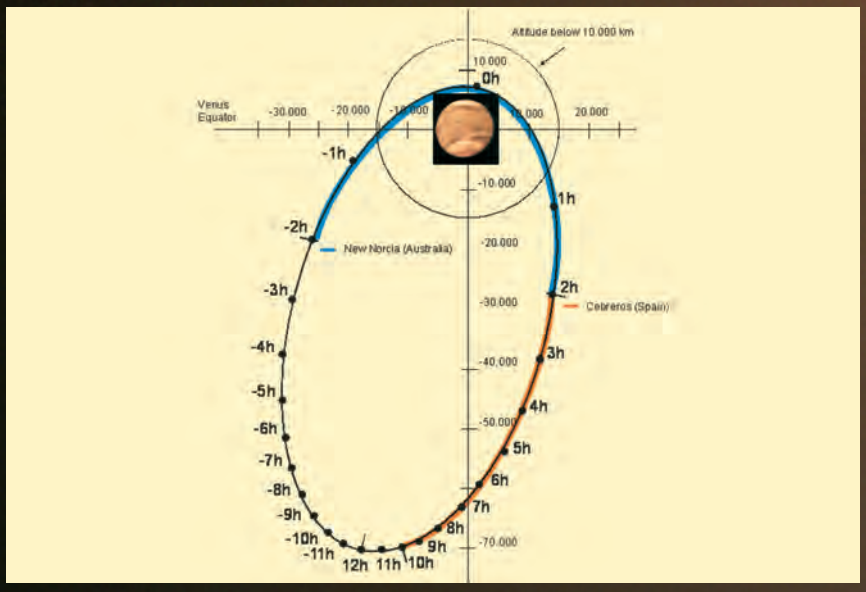
A collage of possible outputs from three of the VMC channels is shown in the figure on page 28. An ultraviolet (UV) channel is centred on 365 nm. At this wavelength the top layer of the Venus clouds exhibits an absorption feature due to an unknown substance. The yellowish part at the left of the figure shows a UV image of Venus captured by Mariner-10. Tracking motions of these features will be used to study the atmospheric dynamics at the cloud tops (at about 70 km) with the goal to understand the mechanism of the super-rotation, the mysterious polar vortex and to observe atmospheric waves and other small-scale phenomena. VMC has also two near infrared filters. The first, centred at 1.01 µm, will be used to study the nighttime emission from the hot surface of Venus. This channel will map the surface brightness temperature distribution, allowing for a search for "hot spots" associated with possible volcanic activity. Brightness variations and their motions across the disc in this channel will also give a clue about cloud patchiness and atmospheric dynamics at 50 km altitude. The second near infrared filter, centred at 935 nm, will be used to study the global distribution of water vapour at the cloud top and in the lower atmosphere. A visible wavelength filter, at 513 nm, will observe O_2 nightglow. Mapping its spatial distribution and temporal variations will contribute to the study of the circulation of the lower thermosphere (100 - 130 km). In



The VeRa instrument

The VIRTIS instrument

The VMC instrument's four lenses



The operational orbit of Venus Express. The ticks mark every hour of the 24 hour orbit. The main scientific observations will be made at the orbit's pericentre, below 10 000 km, close to apocentre, between 10 h and –10 h, and at the ascending branch, between –10 h and –2 h. Communication with the Earth and data downlinking will occur between 2 h and 10 h orbital time each day. The timing of the orbit is such that this period coincides with the spacecraft's visibility from the ESA station at Cebreros in Spain

addition, the VMC observations will also continue the search for lightning, and limb imaging will be used to study the high-altitude haze layers.

Operations and Scientific Observations

To capture a spacecraft into orbit around Venus from an interplanetary trajectory requires a significantly higher velocity increment (delta-V), and thus more fuel, compared to orbit insertion at Mars. This is due to the fact that the differential speed between the spacecraft and the planet is higher at Venus than at Mars. In addition, Venus has significantly more mass than Mars and therefore a greater delta-V is required to lower the orbit to the desired operational altitude.

With the fixed size of the fuel tanks on the spacecraft, the choice of possible orbits was limited. After studying several options, an elliptical polar orbit with a period of 24 hours and a pericentre at about 80°N was selected. This orbit has a pericentre altitude of 250 km and an apocentre altitude of 66 000 km. This is an ideal orbit for combining global studies of large-scale phenomena from the apocentre part of the orbit with detailed studies at high resolution at pericentre. An operational advantage of such an orbit is that the communication with the Earth can be achieved with only one ground station and that the time slot will be at the same time of day throughout the mission (see figure).

On arrival at Venus, the spacecraft will, for technical reasons, be inserted into a temporary 10-day orbit by a first burn with the main engine. This first orbit will be used for scientific observations at very high altitudes during which a first set of pictures of the southern hemisphere of Venus will be made and the dynamics around the South Pole will be studied for an extended period.

The Venus Express science operations will include observations at pericentre with the spacecraft in nadir pointing mode, off-pericentre observations, limb observations, observations in stellar- and solar-occultation geometry, and Earth radio-occultation observations. When operational constraints allow, different kinds of observations will be combined in one orbit in order to use the spacecraft and payload capabilities most effectively and thereby maximise the scientific return. The planned duration of the nominal mission is 2 Venus sidereal days (~ 500 Earth days), during which with about 1 Terabit of science data will be returned to the ground. The spacecraft design and available resources will also allow for a mission extension of another 500 days.

With the chosen orbit and the high performance of the spacecraft and its payload, Venus Express mission will achieve the following scientific 'firsts':

- *First global monitoring of the composition of the lower atmosphere via the near-infrared transparency 'windows'.*
- *First coherent study of the atmospheric temperature and dynamics at different levels of the atmosphere from the surface up to ~200 km.*
- *First coherent observations of Venus in the spectral range from the ultraviolet to the thermal infrared.*
- *First application of the solar/stellar occultation technique at Venus.*
- *First measurements of the global surface temperature distribution from orbit.*
- *First study of the middle and upper atmosphere dynamics from O_2, O, and NO emissions.*
- *First measurements of the non-thermal atmospheric escape.*
- *First use of a 3D ion-mass analyser, high-energy-resolution electron spectrometer, and energetic neutral-atom imager at Venus.*

Conclusion

Venus Express has triggered a worldwide revival of scientific interest in Venus. After more than a decade of being the 'forgotten' planet, Venus is again receiving the attention it deserves. This comes just in time since many of the scientists and engineers involved in the early missions now are coming to the end of their careers, while a large group of young people are prepared to take up activities in the field. The newcomers can therefore still benefit by learning from the experts who were active during the early days of Venus exploration. Old and new Venus explorers all over the world are therefore looking forward with great interest to Venus Express arriving at the planet and seeing the first data on their computer screens.

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