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European Venus Explorer : an in-situ mission to Venus using a balloon platform

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Abstract

Venus is the most Earthlike planet in the Solar System, in terms of its size and distance from its parent star. It was probably formed from the same materials as the Earth and Mars, at a similar time - why then has it become so different? To address this key question, a team of 170 scientists from around the world formulated the European Venus Explorer (EVE) mission proposal to the European Space Agency's Cosmic Vision Programme in 2007. Although it was not chosen in the 2007 selection round for programmatic reasons, it was rated a high priority for the future European Space Science. The EVE mission will be proposed again to ESA in 2010 or 2011. A phase 0 study of the EVE mission is presently conducted by CNES, in order to prepare the submission of the new proposal, in a new context which is described below.

1. Introduction

Venus is the twin sister of the Earth, with similar size and inventories of carbon dioxide and nitrogen. However, it has evolved quite differently and now has a massive carbon dioxide atmosphere and a thick layer of sulfuric acid clouds, generating a massive greenhouse effect which heats the surface up to ~450°C. The complex radiative, dynamical and chemical processes in the lower atmosphere and in the cloud layer, which are crucial to determining the current greenhouse warming and circulation, are still poorly understood. Also poorly known are current exchanges of atmospheric constituents with the surface and interior of the planet and at the interface with space, both of which are important for determining climate evolution. It is thought that the atmosphere of Venus could be more primitive than the Earth's atmosphere, and therefore be representative of our early atmosphere.

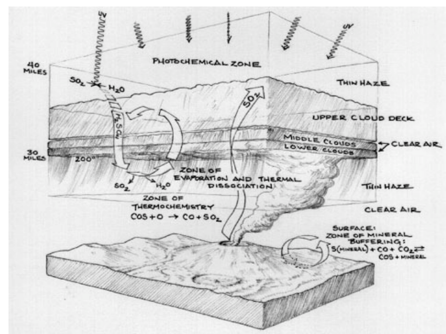

Fig. 1 : Schematic drawing of the coupled surface-atmosphere-cloud chemical system (from Carter Emmart, 1998)

An in situ mission to Venus is urgently needed, for two main purposes. Firstly, detailed measurements of noble gas abundances and isotopic ratios are needed to understand the evolution of Venus, providing an essential reference for the study of evolution of Earth and the terrestrial planets. Secondly, in situ measurements of radiative, dynamical and chemical processes in the cloud layer of Venus are needed in order to understand its greenhouse effect and circulation, which determine the climate of Venus today. Understanding why an ocean of water developed on Earth, but not on Venus, or why the tectonic regime of Venus is so different of Earth's one, definitely requires an in-situ mission to Venus. Such a mission will also be of crucial importance to prepare the interpretation of future observations of Earth-type exoplanets.

The general objective of the EVE mission ([1], [2], [3]), following the European Venus-Express mission, is to understand the evolution of Venus and its climate, with relevance to terrestrial planets everywhere. It was proposed for the first time to the European Space Agency in 2007, as an M-class mission under the Cosmic Vision Program. Although it was not chosen for programmatic reasons, it was "seen by the SSWG as an attractive mission which was highly ranked scientifically".

Fig. 2 : Artist view of the EVE balloon

2. Baseline EVE mission concept

2.1 Concept of the 2007 proposal

EVE is an M-class mission. In the 2007 proposal, it consisted of one balloon platform floating at an altitude of 50-60 km, one descent probe provided by Russia, and an orbiter with a polar orbit to relay data from the balloon and descent probe, and perform science observations. The nominal balloon lifetime was 7 days – enough for one full circumnavigation of the planet. The descent of the probe through the atmosphere takes 60 minutes, followed by 30 minutes of operations at the surface. The nominal orbiter life time is 2 years.

The EVE balloon carries comprehensive chemistry and isotopic analysers, focussing on cloud-level processes. The key instrument is a state of the art GCMS (Gas Chromatograph/ Mass Spectrometer) system to analyse cloud and gas composition. Other instruments provide optical investigations of aerosol composition, microphysical properties, and radiative balance. In particular, the balloon provides a stable platform for the long integration times (~hours) required for isotopic mass spectrometry.

The orbiter carries a range of instruments to complement the *in situ* measurements of the probes. The Japanese space agency (JAXA) may provide a small, water vapour-inflated balloon which would be deployed at 35 km altitude and would carry a few meteorological sensors. The JAXA balloon is an optional element of this mission.

2.2 Concept envisaged for the next proposal

Due to the evolution of the Russian space program, which now includes the Venera-D mission to Venus (orbiter, balloons, descent probes) to be launched before 2020 in a time frame not compatible with the ESA M3 schedule (launch in 2022-2023), the mission scenario has to be revised.

Two options are being studied during the phase 0 study, being led under CNES support in 2010: (i) an ESA-alone balloon mission, with direct transmission of data to Earth, (ii) a balloon + orbiter mission, assuming that an international partner will provide the orbiter, which will be used for both data relay and additional context science. As in the 2007 proposal, the balloon envelope and its inflation system will be provided by CNES. The gondola will be provided by ESA, as well as all systems required to launch, transfer and deploy the balloon in the Venus atmosphere. A possible participation of Russia, and/or India, under the form of an orbiter, and possibly other subsystems, is under study.

The EVE mission, in its 2010 version, will take into account the general evolution of international Venus exploration plans (USA, Russia, Japan…). EVE could constitute an important piece of a co-ordinated international Venus exploration programme in 2020-2030.

References

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