

Unraveling the atmosphere of Venus, Earth's unlucky twin

(Modeling the Venus atmosphere with Terrestrial Knowledge and
Experience)

Report of the meeting held at ISSI, Bern, 7-9 April 2008

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ISSI Proposal:
The atmosphere of Venus

WEXAG 8-9 May 2008

Development in Earth System studies which could be relevant for other planets (1)

- Climate models have been applied for a broad range of activities including:
 - Realistic simulations of the present climate
 - Simulation of complex atmospheric phenomena such as tropical cyclones, the quasi-biennial circulation etc.
 - Incorporation of increasingly advanced chemistry and the extension of models to incorporate middle and upper atmosphere.
 - IPCC climate assessment
 - Simulation of past climates including ice age-interglacial transitions
 - Experience of systematic model intercomparison

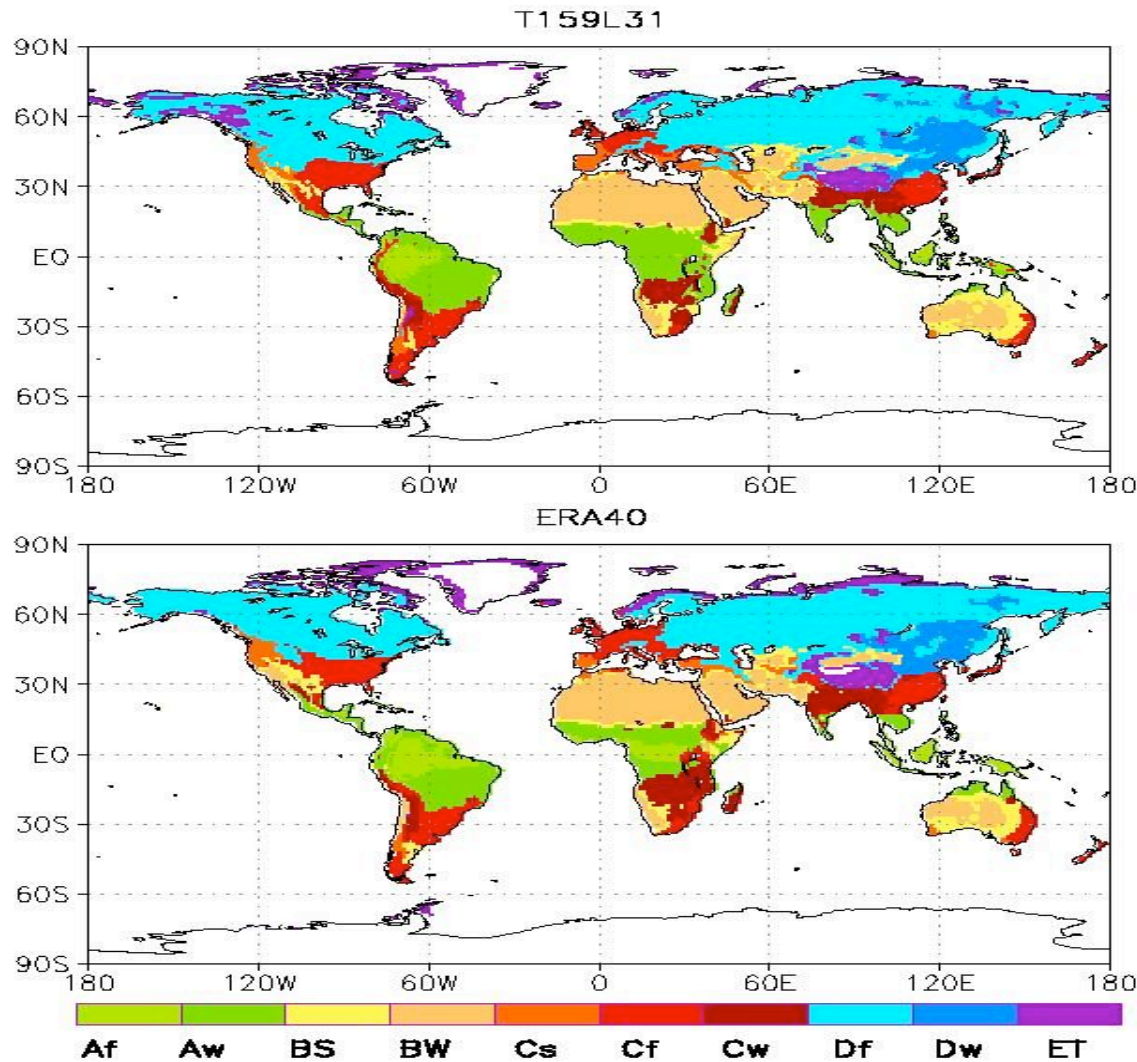
Development in Earth System studies which could be relevant for other planets (2)

- Data -assimilation methods of different complexity important to use in case of observations from different sources and with a variable distribution in time and space.
- Re-analyses of past data as more advanced models and assimilation systems are becoming available
- Systematic intercomparison and validation to explore information content in specific observing systems

Köppen climate zones

MPI,
Hamburg

ECHAM5
simulated



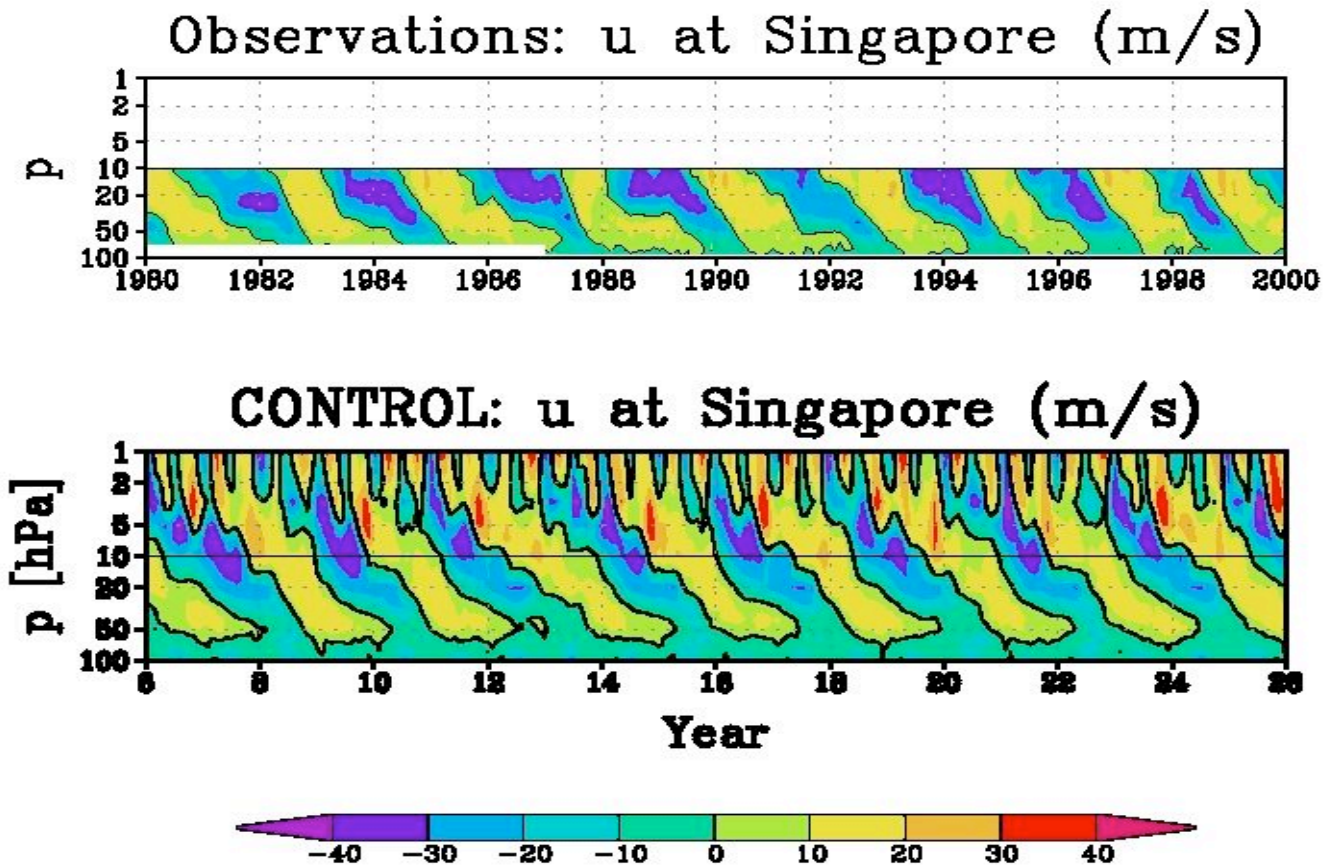
ERA40
determined
from analyses.

ISSI Proposal:
The atmosphere of Venus

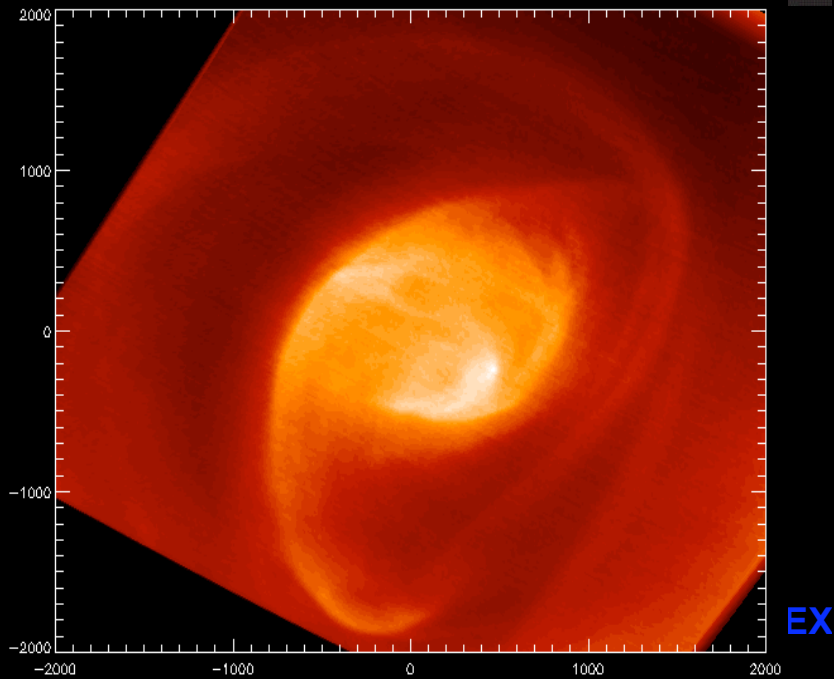
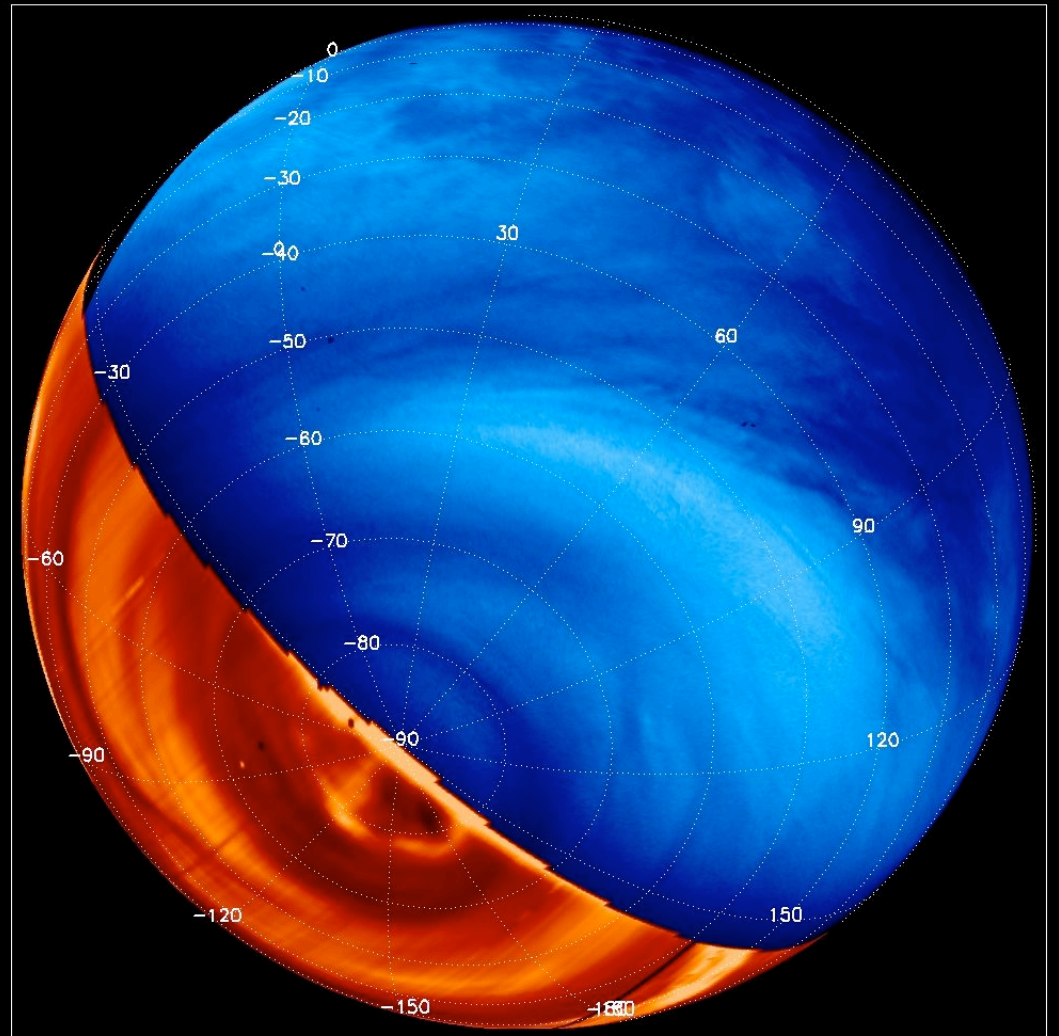
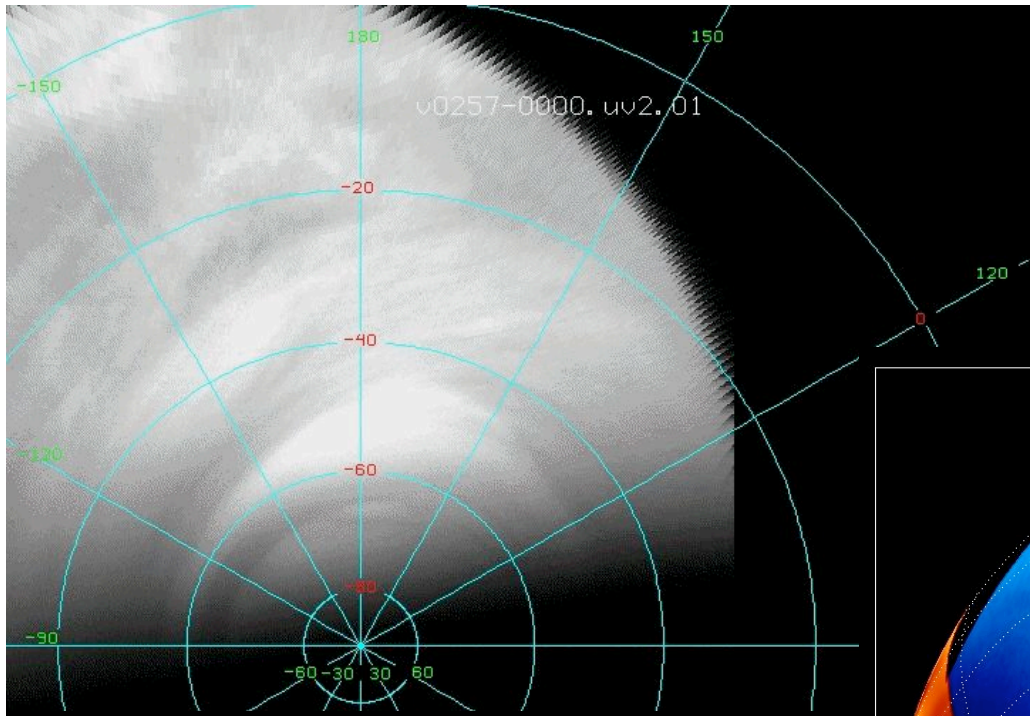
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Observes and simulated QBO

Note the marked changes in wind direction at 10-20 hPa
every 26-28 month



Atmospheric circulation by Venus Express



Thanks to G Schubert for this and the following four slides.

What do the dynamical regimes of Venus and Earth have in common?

What accounts for the differences in the atmospheric dynamics of these planets?

Why study Venus' atmospheric dynamics to understand the dynamics of Earth's atmosphere?

Major Dynamical Features of Earth's Atmosphere

Tropical Hadley cell confined to equatorial latitudes ($\pm 30^\circ$).

QBO

Ferrel cells and polar cells.

Subtropical jet stream.

Large-scale baroclinic eddies in mid-latitudes.

Thermal tides.

Planetary waves.

Mesopause over the equator is colder than over the winter pole.

Seasonal variations.

Major Dynamical Features of Venus' Atmosphere

Superrotation.

Polar vortex.

Middle latitude cloud level jet stream.

Cloud level Hadley cell extending to polar latitudes?

Thermal tides?

Planetary waves.

Mesospheric (70-100 km) temperature increase from equator to the pole.

Seasonal variations?

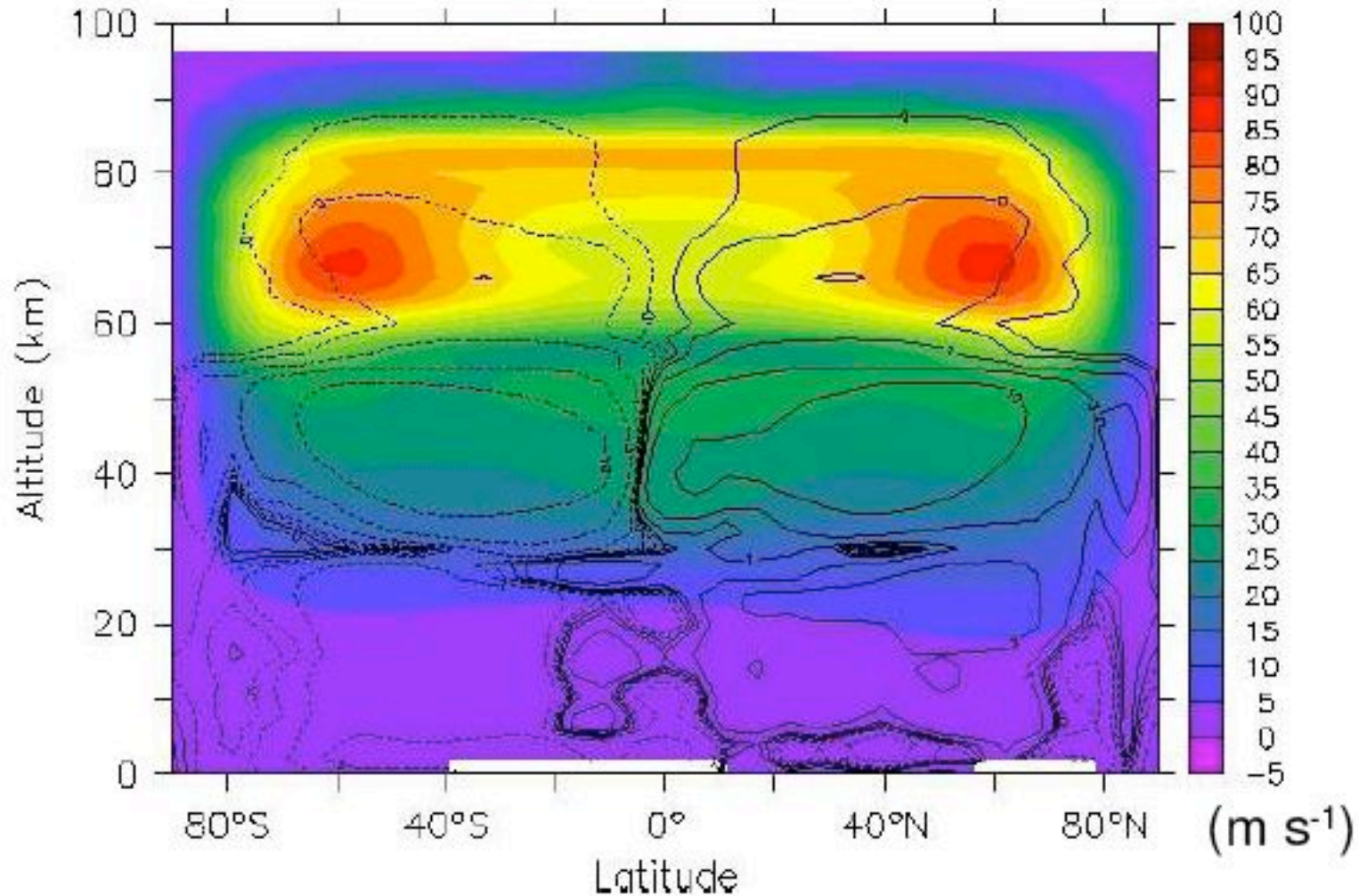
Earth and Venus

There may be more similarity between Earth and Venus than hitherto appreciated.

Earth's circulation is driven from below by solar heating variations.

On Venus, solar heating is focused at cloud heights where T, p conditions are earthlike. The cloud level circulation on Venus might have some similar characteristics as circulation on Earth. Recent Venus GCM calculations by Sebastien Lebonnois suggest that atmospheric circulation is driven largely from above, at cloud levels, where solar heating is concentrated, with the lower massive atmosphere playing a more passive role. Earthlike features include a cloud level Hadley cell and high latitude jets.

Super-rotation



Mean zonal wind and stream function after 250 Vdays
(Topography, Rayleigh friction at top boundary)

Lebonnois (2007)

Scientific rationale

- We need to better understand the atmosphere of Venus to demonstrate the generalities of models of planetary atmospheres presently mainly tested for the Earth. New observations from ESA Venus Express and soon from the Planet-C by Japan is setting a suitable time schedule.
- Venus is here a primary candidate as there are both similarities and considerable differences to the Earth
- It will provide an important test bed for climate models in a very different context.
- We may be able to obtain further insight in the evolution of the Venus atmosphere. Has there been a greenhouse run-away effect on Venus?
- We may obtain further insight into the long-term future of the Earth if being exposed to massive greenhouse gases in the future.

What is ISSI?

ISSI is a nonprofit organization set up in Bern in 1995 and founded under Swiss law with an initial endowment by the leading Swiss space company Contraves Space AG.

The European Space Agency (ESA), the Swiss Confederation, the University of Bern, and the Swiss National Science Foundation provide the financial resources for ISSI's operation.

ISSI Activities in Space Science

- ISSI has a long distinguished record in planetary sciences
- ISSI contributes by organizing forums, workshops and meetings to stimulate and activate key scientific areas
- ISSI focus on cross cutting issues addressing several disciplines
- Final deliverables are high profile publications, such as the books in the Space Sciences Series

Why does ISSI propose a Venus study initiative?

- Venus atmosphere and its climate is scientifically intriguing
- The new observations from Venus Express will provide new perspectives
- The improvements in our understanding of the Earth's atmosphere and in predicting global weather should be beneficial
- Recent progress in atmospheric data-assimilation would help to integrate different observations and for determine future observing systems

Recommendations

To set up an ISSI working group from 1 July 2008 with a two year perspective having the following objectives:

- To organize, to the extent possible, standardized comparative model simulation experiments of the Venus atmosphere with comprehensive models covering the depth of the atmosphere **up to around 100 km**. Specific aspects to explore are sensitivity to the basic model formulation (**dynamical core**), to **initialization** and to the **boundary conditions**. What is the time scale for reaching equilibrium and how does this depend on the initial state? What is the level of internal variability and what are the dominant scales?
- Comparison with analogous terrestrial phenomena
- To support this work with simpler conceptual models to help in the interpretation of the result.
- To undertake **validation** using available data sets from Venus Express and other sources (temperature, wind field, and tracers and dynamical phenomena) such as the super-rotation and the polar vortices
- To investigate whether **data-assimilation** of the data from Venus Express would be feasible
- Based on results achieved provide **advice for ongoing and future** Venus missions

A meeting to discuss scientific issues of the Venus Climate and Atmosphere took place at ISSI, Bern 7-9 April 2008 with the following participants:

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