



Plumes on Venus: Clues to the Planet's Interior

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Goals



To determine the composition, flow, and state of materials in the interior of Venus

To answer the question of whether the mantle of Venus is heating up.



Available observation data

There is currently no seismic data available for Venus (seismometers will not last on its very hot surface).

Topographic and thermal emissivity of the surface, composition of the atmosphere, and gravity are the main data sets available (primarily from the Magellen and Venus Express missions).

There appear to be ~9 active plumes extending from the core-mantle boundary, through the mantle, to the crust.



Approach

Create a supercomputer model of the mantle of Venus with a plausible set of parameter values.

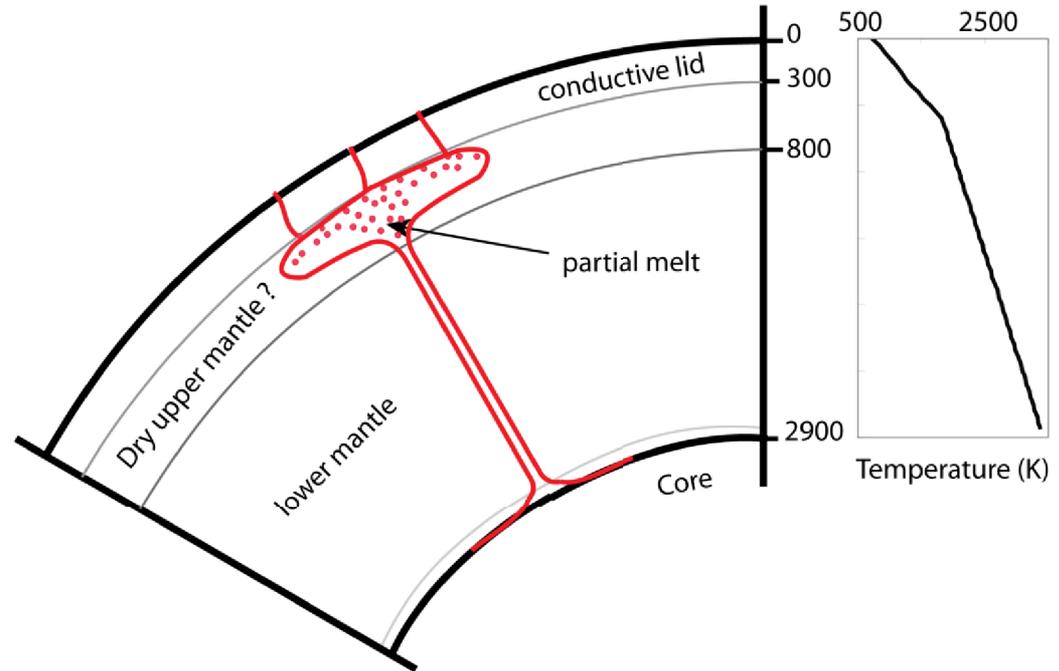
Vary the parameter values through many runs until the model results for surface topography, emissivity, and atmospheric water concentration match the observed data.

Model constraints and characteristics



Create a model of interior convection that has:

- ~9 plumes globally
- Has a conductive lid (crust) on the order of 100-300km thickness
- Has realistic internal heating
- Has a 3D spherical geometry
- Has a highly temperature-dependent viscosity



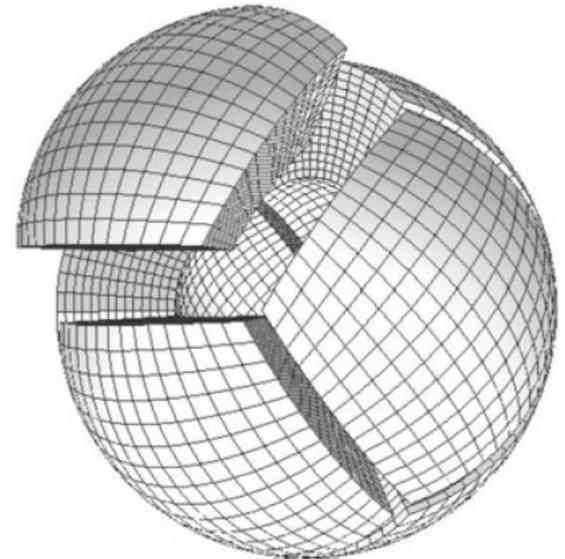
The Venus interior convection model



The model used is OEDIPUS (Choblet 2005)

It utilizes a three-dimensional, cubed sphere of elements
(either $128 \times 128 \times 128$ or $256 \times 128 \times 128$)

The parameters are not pressure dependent





Parameters explored

- **Highly temperature dependent viscosity**
- **Interior Rayleigh number**
- **Interior viscosity**
- **Interior temperature differences**
- **Internal heating**
- **Free slip and no slip top and bottom boundaries**



Conclusions

The presence of a limited number of mantle plumes with melting implies a relatively high Rayleigh number, low internal heating and low mantle viscosity in Venus.

Current outgassing could provide significant atmospheric volatiles.

The mantle of Venus may be heating up, causing the dynamo to shut down.