The MAOAM Project

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Introduction: MAOAM (The Martian atmosphere: observation and modeling) is a new project within the framework of the current priority programme 'Mars and the terrestrial planets' of the Deutsche Forschungsgemeinschaft (DFG). The project started in 2002 and is planned to be completed in 2007. MAOAM is dedicated to the preparation of future microwave experiments operating in the mm- und submm wave range which will strongly improve our knowledge of the structure, dynamics and chemistry of the Martian atmosphere. Air- and spaceborne telescopes as well as limb- and nadir sounders in low Mars orbits will provide highly resolved altitude profiles of temperature, wind, water vapour and minor species from ground to about 130 km altitude and therefore make an important contribution to a better understanding of the general circulation and the climate on short and long time scales. For modeling of the general circulation of Mars, we use Mart ACC (Martian Atmosphere- Circulation and Climate Model) describing the general circulation of the Martian atmosphere in the altitude range of 0-130 km. As a first step Mart ACC will be refurbished by a state-of-the-art non-LTE code.

Present Status and Plans for Microwave Experiments: Based on technology derived from the Microwave Instrument for the Rosetta Orbiter (MIRO) which will be launched in January 2003 (during this workshop) a Mars orbiter experiment has been proposed called MIME (Microwave Investigation on Mars Express). MIME was planned to operate in the wavelength range of 550 µm around the rotational ground state of water vapour. Additionally to water vapour and some of its isotopes MIME would detect CO, temperature and winds in limb and nadir mode from ground to maximum 130 km altitude with an altitude resolution of > 5 km and a horizontal resolution of about 20 km to a few hundred km. Due to a lack of funding in Germany in 1998, MIME has not been selected as a Mars Express payload. Follow on proposals are the Mars Atmosphere Microwave Brightness Observer (MAMBO) as a scientific payload onboard the CNES 2007(9) Premier orbiter and the microwave part of the Mars Volcanic Emission and Live Scout (MARVEL). Two further experiments are already in the design and production phase: the Heterodyne Instrument for the Far Infrared (HIFI) and the German Receiver for Astronomy at Terahertz frequencies (GREAT). HIFI as part of the Herschel Space Observatory will cover the wavelength range from 160 µm to 670 µm and provide the opportunity to sound the Martian atmosphere from an L2 orbit near the Earth. GREAT as an experiment on the Stratospheric Observatory for Infrared Astronomy (SOFIA) will operate in the wavelength range from about 330 µm to 60 µm and give the opportunity to sound the Martian atmosphere with an airplane flying in 10-14 km altitude. Both instruments will provide new insights into the composition of the Martian atmosphere.

Present Mart ACC Status and near Future Plans: Mart ACC has been developed in the early nineties as a German contribution to the Mars96 mission. To summarize the major characteristics of Mart ACC we mention the following points. Mart ACC is a fully non-linear, global and three-dimensional Eulerian gridpoint model which extends from the ground to the lower thermosphere (0 - 130 km) exceptionally using a vertical grid refinement (Δ z = 1.0 km) to resolve the probable deep structures of tidal wave layers in the upper Martian atmosphere. The horizontal resolution is a 5 deg latitude versus 5.625 deg longitude grid. The nonlinear ('primitive') atmospheric equations are integrated with a time step of 225 seconds. A gravity wave drag parameterization is used according to Holton and Zhu. In this scheme at each time step the actual gravity wave momentum deposition is computed near critical and breaking levels due to a family of gravity waves with horizontal phase velocities of 5, 25, 50 m/s propagating into four directions (0, 90, 180 and 270 deg) simultaneously. Then the gravity wave coefficient K_{zz} is used as the actual eddy diffusion parameter for computing the vertical heat transport, cooling due to the divergence of the vertical heat flux and the heating from dissipation of turbulent gravity wave energy (Prandtl number P_r = 3). The radiative module includes a simplified parameterization for solar and infrared absorption by CO_2 taking into account a detailed computation of the surface energy budget through a planetary boundary layer. The resulting net heating rates determine the general diabatic circulation of the model atmosphere. So far, two assumption are valid for Mart

ACC. We restrict on a dustless atmosphere in combination with a smoothed topography (50 % of real orography).

In its present state, Mart ACC is able to simulate reasonable climatology patterns of winds and temperature fields for different seasons. As a first step of refurbishment the radiative module of Mart ACC will be improved. A new model of infrared radiation in significant molecular constituents will be applied to MART ACC. The model will account for deviations from vibrational local thermal equilibrium, line overlapping, extinction to dust particles, ground albedo, and absorption and transformation of near-infrared solar radiation. It will utilise techniques developed recently for modeling stellar spectra. The following spectral regions will be covered by the radiative model: 1) spectral region around 10 µm with CO_2 and O_3, 2) spectral region around 6.3 µm fundamental band of H_2O, 3) spectral region around 15 µm with CO_2. This non-LTE model will allow detailed modelling of the exchange of radiation between various atmospheric layers and, therefore, can adequately model the radiative impact of the lower atmosphere on the upper atmospheric layers. The heating and cooling rates are the major component of the atmospheric energy budget equation. Its detailed modeling will provide the reference data for the development of an computational efficient parameterization to be used in our GCM Mart ACC. Mart ACC will be applied to the analysis of the observed interaction of the upper martian atmosphere with its lower layers.

Data derived from Mart ACC will be used for microwave radiative transfer modeling. As a first step we will focus on temperature and winds.