Water sublimation and surface temperature simulations of Ceres. M.Formisano[1,*], M.C.De Sanctis[1], M.T. Capria[1], E.Ammannito[1,2], F.Capaccioni[1], G.Magni[1], D.Bockelee-Morvan[3], C.A.Raymond[4], and C.Russell[2], [1] INAF-IAPS, Roma, Italy, [2] IGPP, UCLA, CA, USA, [3] LESIA, Observatoire de Paris, France [4] JPL, Pasadena, CA, USA. *michelangelo.formisano@iaps.inaf.it

Introduction: Ceres is the biggest body of the main belt and it represents a peculiar object. In fact, it is the link between the rocky and icy asteroids of the belt and possibly one the key to understand the main phases of the evolution of the solar system. NASA mission DAWN scheduled to arrive at Ceres in the spring 2015 [1].

Theoretical models suggest that Ceres has a differentiated interior, consisting in a silicate core (with a weak presence of metals), an icy mantle [2,3,4] and hydrated minerals at surface [5].

Water vapor presence has been recently observed by Herschel [6]: the observations give a flux of at least of 10^{26} molecules for second from mid-latitude localized sources. Water emission was also suggested for the first time by [7].

Thermo-physical Model: In the literature we can find several works dedicated to the study of Ceres, in particular to the formation and internal evolution [2,3,4]. These models consider Ceres like an icy satellite and deal with its geophysical evolution.

Our model, conversely, derives from the the study of the thermal evolution of cometary nuclei [8,9,10].

The model contemporary solves the 1-D heat diffusion equation, taking into account the energy gained or lost by the solid matrix due to sublimation and recondensation of H_2O ice, and the mass conservation equation that controls the gas flow through the pore system.

The model is a “quasi-3D” model, since the illumination for each facets (which cover the entire surface of the body), is calculated by the insulation on the body. Surface temperature derives from the balance of solar input and the energy re-emitted in space, conducted in the interior and used the sublimate surface ices.

We assume Ceres as a spherical body, composed by water ice, dust and organics in well-defined proportions. Dust grains are distributed in different size classes having different physical and thermal features. The physical and orbital parameters used in the model are reported in the following Table.

Results: We developed several scenarios in order to study the effects of the different physical parameters on the sublimation. First, we explored the dependence of the water emission (and, generally, of the thermal evolution) on the initial internal temperature:

Albedo	0.09
Dust/ice ratio on surface	2.5
Porosity	0.4 ; 0.6
Mean pore radius	1×10^{-4}
Initial temperature	80 K ; 163 K
Dust grain thermal conductivity	3 $\mathrm{WK^{-1}m^{-1}}$
Dust grain density	1000 $\mathrm{kgm^{-3}}$
Hertz factor	0.05
Initial radius	467 km
Rotation period	9.074 h
Spin axis	9°
Semi-great axis	2.77 AU
Eccentricity	0.076
Orbital period	4.60 yr

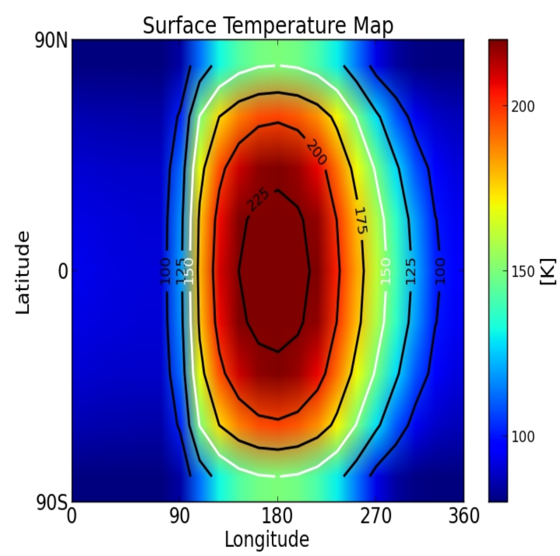

Fig.1: Typical surface temperature.

we examined the cases of 163 K, i.e. equilibrium surface temperature assuming a solar constant of 1330 W m^{-2} and an emissivity of 0.9, and the case of a lower temperature, i.e. 80 K. The water ice has been considered on the surface or at different distance from the surface: 0.25 m (comparable with the diurnal skin depth of 0.15 m) and 100 m (below the annual skin depth of about 9 m). A typical surface temperature map, in case of silicatic crust (no ice on the surface), is shown in Fig.1.

The maximum temperatures achieved with the different models is about 235 K at 2.72 AU, consistent with measured temperature of the warmest area (235 ± 4)K [11]. In Fig.2 we show a flux profile vs time, in case of porosity of 0.6, at top with initial temperature of 80 K and on the bottom with initial temperature of 163 K.

Conclusions: We applied a cometary-like model [8,9,10] in order to study the surface temperature and water sublimation of Ceres, one of the targets of the DAWN NASA mission. We have seen that ice on surface at the equator is stable for very few orbits. Thus if the water emission comes from the equatorial surface we should have a continuos replinishment of water on the surface. In this case, relatively small active area is necessary to fit the Herschel observations. Conversely, water ice is quite stable for very long time if buried below few tens of centimeters of dust. In this case, the water flux is small.

Our simulations will be an useful support for Dawn to better understand the phyiscal conditions for water sublimation and ice stability.

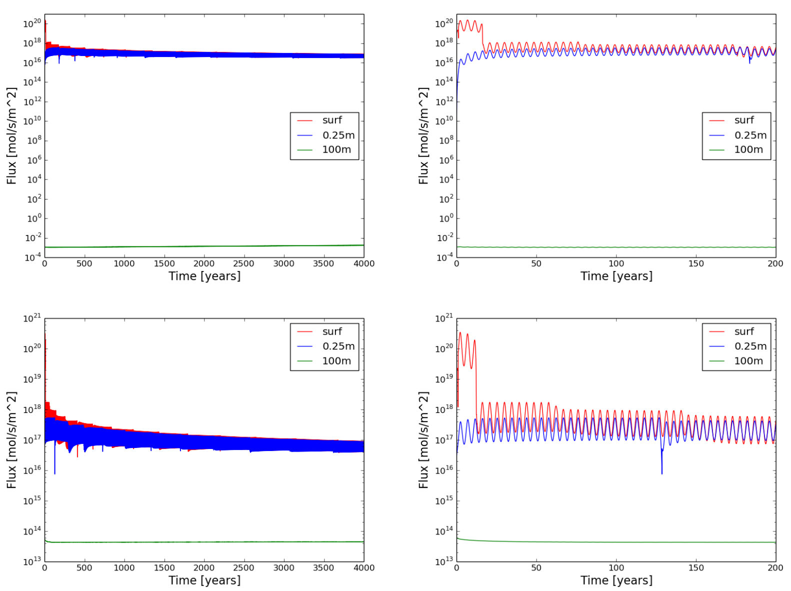

Fig.2: Water flux vs time at the equator for initial temperature of 80 K (on the top) and 163 K (on the bottom) for porosity of 0.6.

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