A COMPARISON OF THE MESOSPHERIC CLOUDS ON MARS AND ON THE EARTH. A. Määttänen[1], K. Pérot[1], A. Hauchecorne[1], F. Montmessin[1], J.-L. Bertaux[1], [1]Laboratoire atmospheres, milieux, observations spatiales (LATMOS), Université Versailles St Quentin, CNRS, Guyancourt, France (11 boulevard d'Alembert, 78280 Guyancourt, France, firstname.lastname@latmos.ipsl.fr)

Introduction: Terrestrial polar mesospheric clouds (PMCs), also called noctilucent clouds, are the highest clouds in the Earth's atmosphere. Because of their extraordinary height of about 83 km, at the edge of space, they can become visible to the naked eye when the sun sinks below the horizon, providing a dazzling display of bluish light. Since these clouds are extremely sensitive to changes in their environment, their observation conveys unique information concerning the various chemical and dynamical processes taking place in the mesosphere. Moreover, they seem to occur more frequently and to appear brighter since the last decades. This evolution suggests a possible link with the global change [1], which is the reason for the recent great interest in these clouds.

The Martian mesospheric clouds have been identified and observed with imagery and spectroscopic methods very recently, they form frequently in the near-equatorial regions in the northern summer season, in mid-latitudes during local autumn, and they exhibit different morphologies. Several speculations on the possibility of the atmospheric CO_2 to condense at the poles and very high in the atmosphere were presented quite early in the history of Martian atmospheric reserach. Several observations were thought to have seen these clouds, but the final (spectroscopic) proof came only very recently [2]. Only few instruments are able to identify what the clouds are composed of, but most observations point to the direction of CO_2, with some limb observations suggesting that a part of the clouds may be composed of H_2O.

Terrestrial Mesospheric Clouds:

In the Earth mesosphere, the meridional and vertical general circulation is the result of interactions between the mean zonal wind and gravity waves. This circulation leads to extremely cold conditions in the upper mesosphere. During the summer months, temperature can drop below 130K above the poles, where the mesopause becomes the coldest place on Earth!

Extreme conditions of temperature and humidity that characterize this atmospheric region, and the presence of condensation nuclei (most probably meteoric smoke [3]) contribute to the formation of water ice crystals [4].

Noctilucent clouds are the visible manisfestation of these ice particles persistently present near the mesopause. They can be observed each summer, in both hemispheres, at high latitudes. They often exhibit wavy structures.

For a long time, the prevailing observation method was the naked eye, but today they can be observed by a variety of instruments. Many satellites are looking at these clouds and related processes. GOMOS [5], a spectrometer flying aboard the european platform ENVISAT, is one of them. In 2007, NASA launched The Aeronomy of Ice in the Mesosphere (AIM) satellite, which is the first space mission entirely dedicated to these questions [6]. PMCs are also observed by lidar and rockets. In addition, modeling studies are conducted on this subject. Ground-based and space-based instruments, in-situ measurements and modelisation are all complementary.

GOMOS data set consists of more than 20 000 mesospheric clouds observations all over the sixteen seasons studied, from 2002 to 2010. The main properties of these clouds (occurrence frequency, peak altitude, radiance) could be accurately retrieved. A comprehensive climatology of these parameters could be established, focusing on their seasonal and spatial distribution [7].

Severals instruments also allow to retrieve the size distributions of ice crystals [8-10]. A better knowledge of this parameter is essential to the understanding of the formation of noctilucent clouds and of the complex processes that govern the state of the mesosphere.

Mars Mesospheric Clouds:

The major constituent of the Martian atmosphere, CO_2, condenses as ice on the surface during local winter and as CO_2 ice clouds in the very cold polar winter atmosphere [11,12]. However, the polar CO_2 ice clouds are tropospheric clouds and remain in the lowest 10 km of the atmosphere.

Quite recently CO_2 ice clouds have been observed also in the equatorial mesosphere (above 40 km) [13-16,2,17-20] and at northern and southern midlatitudes in the local late autumn [21,2,17-19]. Atmospheric models were not able to predict these clouds even though their existence was speculated based on very cold temperatures attainable in the Martian atmosphere (and seen, for example, in the Mars Pathfinder landing profile, [22]). Even presently, modeling efforts have not been able to thoroughly explain the atmospheric circulations involved, or the small particle sizes observed [23].

The aforementioned datasets on Martian mesospheric clouds span altogether more than 6 Martian years of observations out of which a global picture of these clouds is emerging. The seasonal and spatial distribution of these clouds have been mapped, their altitudes have been defined in several cases, and new information on mesospheric wind speeds has been acquired through the cloud observations. Some information on particle sizes as well as diurnal variations of cloud formation and properties have been acquired. A lot of work still remains, since many questions are yet unanswered, but many datasets have not been thoroughly exploited and future instruments may be able to reveal new properties of these quite exotic clouds.

Already Ref. [16] suggested that the mesospheric cloud formation might be driven by the thermal tide temporal and spatial variations. Ref. [24] showed through climate modeling that the diurnal variation in the cloud formation altitudes was shown to follow the altitude of the temperature minimum (antinode) of the thermal tide. However, temperatures did not reach below the CO_2 condensation level at observed cloud formation times. Ref. [25] showed theoretically that most of the mesospheric clouds have been observed in the regions where gravity waves are not filtered out by the thermal structure or the large-scale winds. This supports a hypothesis of the Martian mesospheric CO_2 clouds forming through an interplay between atmospheric general circulation and gravity waves.

However, the microphysical formation pathway remains a mystery: if these clouds form through heterogeneous nucleation, what are the condensation nuclei (meteoric smoke, dust grains, other)?

Hypotheses on possible moist convection cloud dynamics through the latent heat released in the condensation of the major component of the atmosphere have been presented [2,23], but convective potential calculations [17] and high-resolution imaging [18,19,20] seem to be pointing to a more cirrus-type cloud morphology.

Discussion:

The mesospheric clouds are rare, but quite regular phenomena both on the Earth and on Mars, and there is a growing body of observational evidence on both cloud types. We will present an overview of the observations on both planets, the nature of the clouds, their specificities, and a comparison of their properties. We will also discuss what is known about their formation mechanisms and assess the similarities and differences of the processes. We will finally show that this comparative work can be very rewarding for both scientific communities, specialized on the martian and terrestrial atmospheres.

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