ENCELADUS' REFLECTANCE VARIABILITY OBSERVATIONS IN UV BANDS FROM STRATOSPHERIC BALLOONS.

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Introduction: Modern large telescope and spectrograph systems could be used to acquire sensitive spectra of the plumes of Enceladus and Europa and observe their bright surfaces [1]. There are two main scientific goals during this type observations: a) the separation small celestial objects from Jupiter and Saturn and b) Earth's atmosphere absorption in ultraviolet (UV) and partially in infrared (IR) wavelengths [2]. This is the main reason why the UV observations are realized from the orbital level including the astrophysical objects in the outer Solar System observations. On the other hand there is possibility to use stratospheric UAV's or balloons dedicated for UV astronomy. Autonomous or partially autonomous multisensor platform development for stratospheric altitudes was frequently implemented into different types of projects [3]. Scientific groups in Europe and India [4,5] actually are preparing experiments dedicated to this hard to observe from the Earth's ground part of the electromagnetic spectrum. The ultraviolet atmospheric window has been explored through balloons for astronomy in general for Sun measurements.

UV observations of the Enceladus' surface: Most of the UV Enceladus' observations in 2016 and 2017 were used to measure variability of water vapor in plumes near its south pole and detecting specific micron-sized particles including water ice, CO_2, NH_4, CH_4 originated from four terrain's fractures named Tiger Stripes. One of the most interesting things in Enceladus' surface reflectance spectrum is that visible and near infrared reflectance is very high (near 1.0), however at middle and far UV bands Enceladus' reflectance is lower than it would be expected for pure water-ice type of surface. Some investigations suggests that it may be indication of tholin particles presence. Tholins are multiple-chain polymers formed from simple organic compounds such as water (H_2O), methane (CH_4), ammonia (NH_3) and hydrogen (H_2). Ultraviolet radiation or electrical discharges are needed to create those polymers. The products of these reactions are ethylene, acetylenes, cyanhydrides and also nitrogen widely distributed on the surfaces of ice bodies. Their color are from reddish pink to dark brown. A wide spectrum of these compounds has been discovered on the moons of Jupiter, Saturn, Neptune and on transneptoon objects, among others on the dwarf planet - Pluto. Recently tholins have been discovered on comets and ice asteroids.

Tholins on Enceladus can be formed i.e. in the process of irradiation of ice containing methane clathates. Additionaly methane was confirmed as a component of the plumes on Enceladus [7]. The variability of Enceladus' UV reflectance continuous monitoring may help to collect data important for this scientific topic. Stratospheric balloons spectrograph or maybe telescopes observations will be important platforms in this area in the next few decades [4].

Methodology: There is a set of boundary parameters that must be met by experiment to observe celestial object in UV band. We assumed that it is possible to observe only those objects on the hemisphere where atmospheric transmittance in UV is higher than 0.2 [6]. This transmittance parameter depends on the: flight altitude h, zenith angle φ of celestial object during experiment. To calculate effective atmospheric transmittance $T_{eff}(h, \varphi)$ in the Enceladus' area on the hemisphere we calculated: a) zenith transmittance $T_{zenith}(h) = T_{eff}(h, 0°)$ for altitudes: 20km, 30km, 40km and 50km, b) effective atmospheric transmittance as a function of $T_{azimuth}$ and zenith angle φ, relation between Enceladus' zenith angle φ, balloons latitude BL and Enceladus' declination δ, balloons position variability during theoretical 18 hours flight with starting point near Krotoszyn, central Poland (numerical simulation)

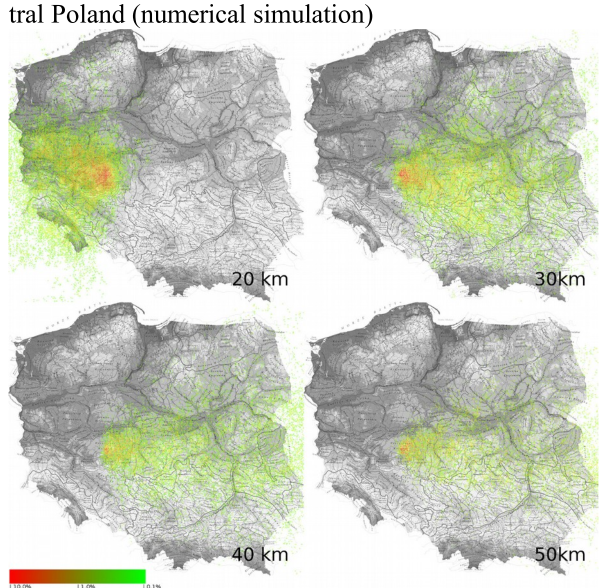

Fig. 1. Stratospheric balloon position density during 18h flight numerical simulation on five altitudes (20-50km).

Balloons position variability. The result of the balloon position variability in numerical simulation is presented on the Figure 1 and Table 1.

Balloon altitude [km]	**Longitude λ [deg]**	**Latitude φ [deg]**
20	16.02 (±1.30)	51.64 (±0.97)
30	20.32 (±1.93)	51.69 (±0.99)
40	22.48 (±3.15)	51.75 (±1.03)
50	24.53 (±4.26)	51.67 (±1.22)

Enceladus' region effective transmittance: We assumed necessary condition for Enceladus observation: effective transmittance T_{eff} should be equal or greater than threshold selected: 0.2 value regarding to Donas et al. experiment [6].

Results: For four analyzed 18-hours missions 99.5% latitude values were: for altitude 20 km: 48.73° - 54.55°, for altitude 30 km: 48.72° - 54.66°, for altitude 40 km: 48.66° - 54.84°, for altitude 50 km: 47.98° - 55.30°. Enceladus' declination may vary from -25.96° to +25.96°. We can set boundary condition for observation possibility during whole 18-hours flights: $BL < \varphi_{max} + \delta$. We calculated minimum Enceladus' declination for observations for UV bands between 200 and 400 nm (Table 2).

Altitude [km]	**Enceladus' minimum declination for observations in UV band**				
	200 nm	250 nm	300 nm	350 nm	400 nm
20	Not possible	Not possible	Not possible	-16,78	-17,76
30	-0,13	Not possible	Not possible	-16,79	-17,79
40	-4,63	-2,91	-15,18	-17,17	-18,08
50	-4,19	-10,70	-14,83	-16,82	-18,10

Enceladus' UV reflectance variability may be measured during stratospheric balloons flights over Poland in two main bands: 200 nm and 350-400 nm on the altitudes 20-30 km in 50-75% Enceladus' declination values. On the altitudes over 40km it is possible to measure reflectance variability in all UV spectrum between 200 and 400 nm. These results were calculated for atmosphere transmittance $T_{eff} > 0.2$ boundary condition. This result showed us that from the lower stratosphere (<30km) we may measure reflectance of the pure - ice surface. H_2O, NH_3 and a tholin particles detection may be possible from the altitudes over 30km. Additionally dust reflectance may be measured from the higher stratosphere (>40km). In general starting points with low latitudes (near equator) are better for this type of experiments, but stratospheric flights over european latitudes over 30km also offer sufficient conditions to conduct experiments.

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