THE INVESTIGATIONS OF AEROSOL AND MULTIPLE SCATTERING INFLUENCE ON THE TWILIGHT SKY POLARIZATION

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The sky background measurements during the different stages of twilight give a lot of information about optical properties of the Earth's atmosphere at different layers, since the altitude of Earth's shadow and effective scattering are rising fast with the Sun depression under horizon. The most effective are polarization measurements, since they give additional information for the division of different sky background components. Polarization measurements are also effective for investigation of aerosol particles at different altitudes in the atmosphere.

One of basic problems of the atmospheric properties retrieval method is the necessity of account of multiple scattering of solar radiation, which contribution into total background may be sufficient. As the aerosol scattering, this component decreases the sky polarization and leads to reverse polarization effect far from zenith. It was the reason of mixing up the aerosol and multiple scattering which led to sufficient uncertainties in estimation of their contribution and properties. A big number of input parameters of atmosphere model and the complexity of their influence to the multiple scattering make the exact solution of reverse problem difficult.

The goal of our work is detection of aerosol and multiple scattering effects during the different twilight stages, the development of approximate empiric methods of their contribution estimation and investigation of their polarization properties. The work is based on the polarization twilight sky observations conducted in 1997-2003 in four spectral bands with effective wavelength equal to 360, 440, 550 and 700 nm.

The analysis of observational data had shown that influence of single aerosol scattering is insufficient for most part of twilights in 360, 440 and 550 nm (however, the atmospheric aerosol may influence on the multiple scattering). The effects of single aerosol scattering appear only after the sunrise (or before the sunset), when the direct solar emission radiates the troposphere. Polarization properties of twilight sky in this spectral region are defined by composition of single molecular and multiple scattering and become the base of their separation method. The method uses the fact that maximum polarization point of molecular scattering moves along the solar vertical being always at 90 degrees from the Sun, but the maximum polarization point of multiple scattered light is practically immovable, remaining near the zenith during the whole twilight period.

Using this method, we had calculated that single scattering contribution at sunrise (sunset) moment is just about 40% from total sky background at 360 nm and rising up to 60-70% at 550 nm. This results are in good agreement with numerical analysis data obtained for different atmosphere models and explain the observed color and polarization evolution of the twilight sky with the depression of Sun.

At the wavelength equal to 700 nm the single aerosol scattering becomes noticeable in the light twilight period, increasing the sky background intensity and decreasing its polarization. Basing on the analysis of differential parameters of the twilight sky near the zenith, we had estimated the polarization at 90 degrees (about 20%) and contribution of aerosol scattering into the sky background, varying from 10% to 50% depending on the atmosphere condition.