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THE ATMOSPHERE AS A LENS

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16. Abstract The advent of manned satellites has made it possible for man to observe Earth from great distances. Many new phenomena have been discovered in the atmosphere. These are evidently caused by reflection, scattering or refraction of light on crystals and drops of water. It is possible to see small objects on the surface of Earth because of these anomalies.

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THE ATMOSPHERE AS A LENS

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It is well known that in the atmosphere many optical phenomena are observed some of which are the result of reflection, scattering or refraction of beams on crystals and drops of water. Now from orbit the cosmonauts have begun to report completely new phenomena--observations of relatively small objects found on the surface of Earth. For instance, on June 22, 1975, on the 30th day of flight, pilot and cosmonaut of the USSR, V. Sevast'yanov saw the house of his parents in the city of Sochi. /43*

This is how he descirbes it: "...today I saw Sochi. I saw that the weather was sunny and clear. Very clearly I saw the port, saw our house...it is difficult to prove, right? But I actually saw from space this tiny two-floor dwelling in Sochi in which I grew up and in which my parents live today. How could I find this house? At first I looked at the Caucasus shore of Cape Adler. The Mzymta river flowing in the Adler region to the sea colors the sea water with its silt. This is a very precise reference point. For a further reference point I found Adler and a little farther on I saw the Sochi port. And directly on the axis of the main wharf and a little higher at the base of the television tower I found my own house. I saw it as a tiny point among the trees--our house is surrounded by cypress trees."

Pilot and cosmonaut of the USSR, V. Kovalenok observed fine details in the terrain. During a brief time period he several times got the impression that he saw objects and formations on the surface of Earth through a magnifying glass.

With an increase in the duration of space flights the incidences of anomolously large resolution capability during observations through the atmosphere have been reported more and more

*Numbers in the margin indicate pagination in the foreign text.

frequently by the cosmonauts. For instance, one of them saw a truck moving along a desert highway. They regularly report that in the wake thrown up by ships on the surface of the sea they observe the ships themselves.

We can ask whether this is actually psychological conjectures on the part of the cosmonauts. It is important to analyze this inasmuch as the optical studies from space are one of the most informative methods of studying natural resources of Earth and the physical properties of the atmosphere.

According to experimental investigation, sharpness of human vision comprises an angular minute. This figure is practically unchanged in space; we are taking about observations by cosmonauts of point light sources. For instance, from the Voskhod ship point sources were visible 120 m apart whereas they merged when the distance was shortened to 60 m.

How do we explain the fact of superresolution during observations from space?

One of the causes could be the focusing properties of the atmosphere which create the effect of apparent magnification. It is well known that with a certain distribution of temperature, the gas medium becomes self-focusing, that is, it works as a lens. Soviet scientists have made theoretical calculations and pointed out that for conditions of a standard atmosphere magnification can amount to 4 to 15% depending on the altitude of the flight of the spacecraft. But this is inadequate to explain the cases described. Obviously one must assume that special aerosynoptic conditions or baric formations exist in which the atmosphere is converted into a self-focusing medium.

For evaluating their role, the indices of refraction of such formations as high cold cyclones and warm anticyclones must be calculated. Inasmuch as these baric formations occupy a broad area, the change in index of refraction is small. One should look at

formations not on a synoptic scale but on a mezo-scale. This can apply to clearly pronounced thermal conditions (stable and strongly ascending convection currents) and leeward waves in mountain regions. Calculation for thermal conditions has given the opposite result--a decrease in reflection because the temperature inside them is higher than outside. This study of leeward waves close to mountain ridges showed that indices of refraction change sharply even at a distance of 100 m. This makes it possible for the indicated mezo-scale formations to be looked at as pieces of a self-focusing lens. Therefore, it is completely possible that cosmonaut V. Sevast'yanov saw his own house.

On the whole during observations from space, from the point of view of optics, the atmosphere can be looked at as a self-focusing magnifying gas lens with varying thickness (for the winter and summer hemispheres) with a large number of nonuniform particles. Most of them such as clouds, fog, thick smoke and different aerosol admixtures worsen or completely exclude transparency of the lens-atmosphere. A small part of the irregularity we pointed out as the leeward waves sharply increases the image which the cosmonauts report. If the atmosphere itself magnifies by a total of 10--15%, then dissemination to a large degree of the change of index of refraction, as in the leeward waves in mountain regions, can increase it by several times. It is just this that makes it possible, in our opinion, for the cosmonaut to see small objects, whose angular dimensions are much smaller than the limit of resolution of the human optical system.