SPECULAR REFLECTION OF SUNLIGHT FROM EARTH

T. Várnai[1] and A. Marshak[2], [1]Univ. of Maryland Baltimore County and NASA GSFC (tamas.varnai@nasa.gov), [2]NASA GSFC (alexander.marshak@nasa.gov).

Benefits of the vantage point: The unique vantage point of the Deep Space Gateway offers some excellent opportunities for Earth observations, including observations of sun glint. For simplicity, the word "glint" is used here for any specular reflection, regardless of whether it occurs at the surface (especially water) or in ice clouds. The Deep Space Gateway can provide two main advantages for glint observations when images of Earth are taken repeatedly through full lunar cycles:

(1) A single fixed narrow field-of-view camera can detect and characterize glints for all solar elevations;

(2) Glint observations can be obtained throughout the (daytime) diurnal cycle at all longitudes.

Since neither low Earth orbits nor geostationary orbits can offer the combination of these two advantages, the Deep Space Gateway could provide glint observations at unprecedented detail and coverage. The key limitation would be that instruments near the Moon can observe glints only at low latitudes.

Science questions: Space-based glint observations can help in addressing science questions such as:

(1) What are the rates of occurrence, characteristics, and radiative impacts of ice crystals that, instead of tumbling in the air in random orientation, float in a systematic horizontal orientation? Specular reflection from such ice crystals has been the focus of several satellite studies (e.g., [1], [2], [3]); future observations can characterize these crystals and their radiative impacts more comprehensively (for example by observing the daytime diurnal cycle of glint occurrence and properties).

(2) How much sunlight do atmospheric aerosols absorb? Recent studies explored the use of satellite images of ocean glints in estimating aerosol absorptivity (e.g., [4], [5]). Such observations can help estimate the impact of aerosols on atmospheric and surface energy budgets, and can also help distinguish aerosol types that have different absorptivity and air quality implications (for example soot and sulfates).

Since glint observations may be obtained as part of imaging the entire Earth disc facing the Moon, they may also be used for testing algorithms that rely on glint signals in seeking to detect oceans on exoplanets (e.g., [6]). They could also give information on the role glints play in shaping the angular distribution of the sunlight reflected from our planet, and may help testing the models of this angular distribution that are used in estimating Earth's energy budget (e.g., [7]).

Instrument considerations: Glint observations could be collected by an imaging radiometer that may also serve other purposes and image even the entire Earth disc. The key features for glint oservations are a wide dynamic range (to avoid saturation at the bright glints and to also image the darker areas where glint does not appear), and an ability to take frequent images of a small area around the location of possible glints (this is needed to obseve glints at a high angular resolution as the Earth rotates). A spatial resolution in the order of a km would also be desirable to resolve cloud structures. As for spectral coverage, an Oxygene absorption band and a nearby near-infrared band would be most helpful for detecting glints and determining their altitude (which also allows distinguishing surface glints from cloud glints). Visible and ultraviolet wavelengths would help estimate aerosol absorption, while polarization and shortwave infrared observations could provide additional information on particle size and shape. The data volume could be controlled by adjusting the frequency and spatial extent of the data archived and transmitted back to Earth. Most likely, the instrument could be mounted externally and would not need astronaut intervention once installed. Most lunar orbits could be suitable; orbits allowing longer unobstructed views of Earth would work better.

References:

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