**LOW-FREQUENCY MOON-BASED RADIO-INTERFEROMETER FOR EARTH STUDIES**

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We suggest that the concept of a Moon-based array of microwave antennas and up-gradable electronics, facing the Earth, to measure soil moisture, sea surface salinity, etc. be matured.

Measurements of the water cycle provide essential information for an important climate variable. The capabilities of the measuring instruments lags somewhat behind the development of the models, and the existing blueprints cannot be easily scaled to provide the spatial (5 km footprint, Nyquist –sampled) and temporal (1 day revisit time or shorter) resolutions that are needed to validate the details of the models. Improvement in radiometric sensitivity would be welcome, but the advantage from any technological advance in the performance of front-end amplifiers is limited by the inevitable thermal noise in the scene being measured.

The study of soil moisture content and temporal evolution requires fine spatial resolution and frequent revisit. There is no conceivable architecture that can better deliver the low-frequency (for soil penetration) long baseline (for spatial resolution) and daily revisit than an instrument sited on the Earth-facing surface of the Moon.

Although the Earth science community has long sought the means to perform high-spatial-resolution measurements in the 1 GHz range of geophysical phenomena, this need has historically been satisfied with more complex missions flown in Low Earth Orbit. It is conclusive that such an approach is capable of producing a modest factor of improvement within the next decade. And it will succeed if public interest (funding) is high enough. Beyond that next step, the antennas or antenna arrays would have to be so large that it raises the question of whether it is more practical to build them on the surface of the Moon -- even with the factor of 500 distance penalty -- rather than trying to construct them in LEO (whether as enormous real apertures which upscale NASA's SMAP mission or as constellations of antennas in which the exact relative positions of the elements must be precisely known and somewhat controlled, similar to ESA's successful SMOS interferometer mission).

The advantage of an interferometer on the surface of the Moon to Earth studies are evident and remarkable. - Continuous and unbroken temporal coverage. - Spatial resolution that is only limited by the (easily-adjustable) separation of the antennas, - Sensitivity which is limited by the number of antennas (also easily scalable).

The drawbacks are also evident. - Any evolving weather situation can go out-of-sight for 14 hours as the Moon sets. - Look angle and beam footprint are modulated by the lunar orbit and libration. – Radiometric performance must account for extreme monthly temperature excursions on the electronics and mechanical components. But these difficulties should be seen as engineering challenges, rather than scientific limitations.

The art of building long-baseline interferometers is well proven on the earth's surface (radio astronomy arrays), and the usefulness of this facility can be proven even with a small array, making the instrument easily up-scaleable in size and performance. Even a better-than-1-km resolution is achievable.The hardware would be semi-permanent: after the problems of first construction are overcome, it becomes relatively easy to replace any component that fails from age or exposure to the space environment (e.g. meteorite hit). This architecture is in line with business plans to extend the commercial sphere of humanity to the Moon. We envision assisting private industry, academia, and possibly other nations to be the principle actors, with U.S. government playing only a supportive role.

Antenna arrays on the Moon would also be well suited for other applications – such as communications with Earth and with deep space; and very long baseline interferometry (VLBI) in which Earth antennas and Moon antennas combine to form baselines which are much longer than those achieved on Earth alone, with applications to astrometry and other areas of radio astronomy and to spacecraft tracking.

From an emotionless technological perspective, the answer to the question of LEO versus lunar surface is not easy to foresee. Though the answer could be explored, we note that the public are not emotionless system engineers. Building things on the Moon adds additional facets of public interest and enthusiasm. Coupling that with public desire for better Earth science can create a win-win situation, uniting the passions for Earth science, planetary exploration/science, and human exploration. It therefore seems plausible that a Moon-based microwave instrument is more likely (than LEO instruments) to be funded sufficiently to achieve long-term Earth science objectives.