NASA SBIR 2004 Phase I Solicitation

E1.04 Passive Microwave

Lead Center: GSFC

Proposals are sought for the development of innovative passive microwave technology in support of Earth System Science measurements of the Earth's atmosphere and surface. These microwave radiometry technology innovations are intended for use in the frequency band from about 1 GHz to 1 THz. The key science goal is to increase our understanding of the interacting physical, chemical and biological processes that form the complex Earth system. Atmospheric measurements of interest include climate and meteorological parameters including temperature, water vapor, clouds, precipitation, and aerosols; air pollution; and chemical constituents such as ozone, NO\textsubscript{X}, and carbon monoxide. Earth surface measurements of interest include water, land, and ice surface temperatures, land surface moisture, snow coverage and water content, sea surface salinity and winds, and multispectral imaging.

Technology innovations are sought that will provide the needed concepts, components, subsystems, or complete systems that will improve these needed Earth System Science measurements. Technology innovations should address enhanced measurement capabilities such as improved spatial or temporal resolution, improved spectral resolution, or improved calibration accuracies. Technology innovations should provide reduced size, weight, power, improved reliability, and lower cost. The innovations should expand the capabilities of airborne systems (manned and unmanned), as well as next generation spaceborne systems. Highly innovative approaches that open new pathways are an important element of competitive proposals under this solicitation.

Specific technology innovation areas include:

- Imaging radiometers, receivers or receiver arrays on a chip, and flux radiometers.
- Large aperture, deployable antenna systems suitable for highly reliable space deployment with root mean square (RMS) surface accuracy approaching 1/50th wavelength. Such large apertures can be real or synthetic apertures. Of key importance is the ability for a highly compact launch configuration, followed by a highly reliable erection and resultant surface configuration.
- Focal plane array modules for large-aperture passive microwave imaging applications.
- Wideband and ultra-wideband sensors with >15dB cross-pole isolation across the bandwidth.
• Sensors with low surface currents enabling scanning up to +/-50° without grating lobes, and collimation in one direction with low side lobes for 1-D aperture synthesis.

• Bi-static GPS receiving systems for application as altimeters and scatterometers.

• Enhanced onboard data processing capabilities that enable real-time, reconfigurable computational approaches which enhance research flexibility. Such approaches should improve image reconstruction, enable high compression ratios, improve atmospheric corrections, and the geolocation and geometric correction of digital image data.

• Techniques for the detection and removal of Radio Frequency Interference (RFI) in microwave radiometers are desired. Microwave radiometer measurements can be contaminated by RFI that is within or near the reception band of the radiometer. Electronic design approaches and subsystems are desired that can be incorporated into microwave radiometers to detect and suppress RFI, thus insuring higher data quality.

• New technology calibration reference sources for microwave radiometers that provide greatly improved reference measurement accuracy. High emissivity (near-black-body) surfaces are often used as onboard calibration targets for many microwave radiometers. NASA seeks ways to significantly reduce the weight of aluminum core target designs, while reliably improving the uniformity and knowledge of the calibration target temperature. NASA seeks innovative new designs for highly stable noise-diode or other electronic devices as additional reference sources for onboard calibration. Of particular interest are variable correlated noise sources for calibrating correlation-type receivers used in interferometric and polarimetric radiometers.

• New approaches, concepts and techniques are sought for microwave radiometer system calibration over or within the 1–300 GHz frequency band, which provide end-to-end calibration to better than 0.1°, including corrections for temperature changes and other potential sources of instrumental measurement drift and error.

• Microwave and millimeter wave frequency sources are sought as an alternative to Gunn diode oscillators. Compact (3) self contained oscillators with output frequency between 40 GHz and 120 GHz, low phase noise 100 mW) are needed.

• Low noise (3) heterodyne mixers requiring low local oscillator drive power (Low power lightweight microwave radiometers are desired which are able to operate stably over long periods, with DC power consumption of less than 2 W and preferably less than 1 W, not including any mechanisms.

• Monolithic microwave integrated circuit (MMIC) low noise amplifier (LNA) for space-borne microwave radiometers, covering the frequency range of 165 to 193 GHz, having a noise figure of 6.0 dB or better (and with low 1/f noise).

NASA is developing satellite systems that will use passive and active microwave sensing at L-band and other frequencies to measure sea surface salinity, and soil moisture to a depth of ~10 cm. In support of these global research efforts, the following ancillary measurement systems are required:

• Inexpensive approaches to ground sensors are desired that are capable of measuring areas at least 100,000 km², with a spatial resolution of 20 km. These ground sensors will be needed to validate those space-borne measurements. Measurement of ground-wave propagation characteristics of radio signals from commercial sources may satisfy that need. Although absolute values of soil moisture are desirable, they are not required if the technique can be calibrated frequently at suitable sites. Cost per covered area, autonomous operation, anticipated accuracy, and depth resolution of the soil moisture measurement will be considerations for selection.

• Autonomous GPS-located ocean platforms are needed which can measure upper ocean and lower
atmosphere properties including temperature, salinity, momentum, light, precipitation, and biology, and can communicate the resultant data and computational or configuration instructions to and from remote terminals. Similar sensor packages are desired for use onboard ships while under way. This includes the development of intelligent platforms that can change measurement strategy upon receipt of a message from a command center.

- **Autonomous low-cost systems** are desired that can measure Earth and ocean surface and lower atmospheric parameters including soil moisture, precipitation, temperature, wind speed, sea surface salinity, surface irradiance, and humidity.

- **Novel approaches to beam steering** for these very large aperture antenna systems are also desired: 1) lightweight, electronically steerable, dual-polarized, phased-array antennas; 2) shared aperture, multi-frequency antennas; 3) high-efficiency, high power, low-cost, lightweight, phase-stable transmit/receive modules; 4) advanced antenna array architectures including scalable, reconfigurable and autonomous antennas; 5) sparse arrays, digital beamforming techniques, time domain techniques, phase correction techniques; 6) distributed digital beamforming and onboard processing technologies; and 7) brightness temperature/scatter co-registration data processing algorithms, data reduction, and merging techniques.

Ground-based microwave radiometer instrumentation, subsystems, and techniques for validating space-borne precipitation measurements. Passive microwave instrumentation, or subsystems, capable of ground-based retrievals of precipitation. The instrumentation, or subsystems, shall operate in inclement weather conditions without the interfering affects of liquid water accumulation on the aperture or field-of-view obstructions. Capabilities for volumetric scanning of the atmosphere and autonomous operation are of great interest.