AMORE: An Autonomous Microsatellite Constellation Concept for Atmospheric and Ocean Observation

T. P. Yunck[1], L.-L. Fu[1], G. A. Hajj[1], B. A. Herman[2], E. R. Kursinski[1], C. McCormick[3], G. R. North[4], M. M. Watkins[1], L. E. Young[1]

The Atmospheric Moisture and Ocean Reflection Experiment (AMORE) is a proposed microspacecraft constellation to observe the atmosphere and oceans and their effects on climate. The mission would feature 12 low Earth orbiters (LEOs) making three types of measurements: 1) GPS and GLONASS (GNSS) L-band occultations to observe atmospheric refractivity and numerous derived quantities; 2) LEO-LEO crosslink atmospheric occultations at 10-23 GHz to recover precise profiles of tropospheric water vapor; and 3) GNSS ocean reflections to observe ocean topography and state. All measurements would be made by a modified GPS occultation receiver developed by NASA for a number of upcoming flight experiments. The mission will observe:

- global water vapor distribution throughout the troposphere at <1 km vertical resolution;
- atmospheric temperature and geopotential heights from the surface to 85 km;
- global profiles of cloud liquid water;
- sea-surface topography accurate to a few cm, with eddy scale (~25 km) resolution.

AMORE data will illuminate critical shorter-term climate processes and the climate system's response to various external forcings, including varying greenhouse-gas concentrations, solar irradiance, sulfate content and distribution, and isolated volcanic events. The data will also have broad application in meteorology, physical oceanography, and space weather.

The 12 spacecraft are proposed to fly in two nested arrays of 6 each at 700 and 850 km. By exploiting the real-time data acquired from GNSS, AMORE will operate fully autonomously, gathering science data, maintaining pre-assigned orbit stations to ±2 km, controlling attitude and antenna pointing to complete the crosslinks, and downlinking to a network of ground stations.

The core science instrument is an advanced GNSS receiver which serves several functions. In addition to acquiring science data, it will determine real-time position, velocity, attitude, and time; provide onboard computing for all instrument operations; and provide onboard science data storage. It is also equipped with an integrated star camera, developed for the GRACE mission, for precise attitude determination. The spacecraft includes a power system, three reaction wheels, three magnetic torque rods, S-band up- and downlinks, crosslink transmitters, hydrazine propulsion, and an array of antennas. One solar panel opens to a fixed angle and is not articulated. There is a single zenith GNSS antenna to provide real time nav and after-the-fact precise orbit determination. Each of eight side panels holds 28 GNSS patch antennas, forming an electrically steered phased array for collecting GNSS ocean reflections. On a boom below the spacecraft a horn antenna pivots ±180° in azimuth for crosslinking. Total orbital average power consumption is about 115 W.

Today we can realize this mission at an affordable cost by exploiting modern microspacecraft and microelectronic technology, low cost radio instruments, and the huge space infrastructure—that is, GPS and GLONASS—built by national governments. AMORE will unite several distinct GNSS sensing techniques with high-frequency radio occultation crosslinks to provide powerful new data sets for Earth science. At present AMORE is in the concept and proposal stage. We are hopeful that it will become an approved international mission in the near future.

---

[1] *Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California*
[2] *The University of Arizona, Tucson, Arizona*
[3] *Broad Reach Engineering, Indian Hills, Colorado*
[4] *Texas A&M University, College Station, Texas*