

COSMIC-2: THE FUTURE OF GLOBAL NAVIGATION SATELLITE SYSTEM – REMOTE OBSERVATION (GNSS-RO) SENSING

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1. BACKGROUND

COSMIC is a joint U.S.-Taiwan 6-microsatellite demonstration mission that was launched in April 2006 and is being operated by Taiwan's National Space Organization (NSPO). Its mission is to demonstrate the value of near-real-time GPS Radio Occultation (GPS-RO) data to global users. It is the world's first operational GPS-RO mission for global Earth weather forecast; climate monitoring; atmospheric, ionospheric, and geodetic research. The National Oceanic and Atmospheric Administration (NOAA) has been providing ground station services for the mission from two locations in the U.S. and one in Norway since April 2008. The satellite system is currently operating with high reliability and providing global data in near-real-time to over 1,000 users worldwide, including NOAA. The GPS-RO data has been demonstrated to be valuable to the climate, meteorology, and space weather communities. These communities include both real-time forecasting users, as well as U.S. and international research communities. COSMIC has proven to increase the accuracy of the predictions of hurricane behavior, significantly improve long-range weather forecasts, and monitor climate change with unprecedented accuracy. An example of the increase in weather forecast accuracy is the Ensemble Forecasts of Typhoon Sinlaku in 2008. The following figure illustrates the typhoon forecast with and without COSMIC data.

The red line is the observed track of the typhoon, the black lines are the forecasts of each of the forecasting ensemble members, and the green line is the ensemble mean. As illustrated, the leftward-turning tendency of the typhoon track is predicted significantly better with the assimilation of COSMIC data.

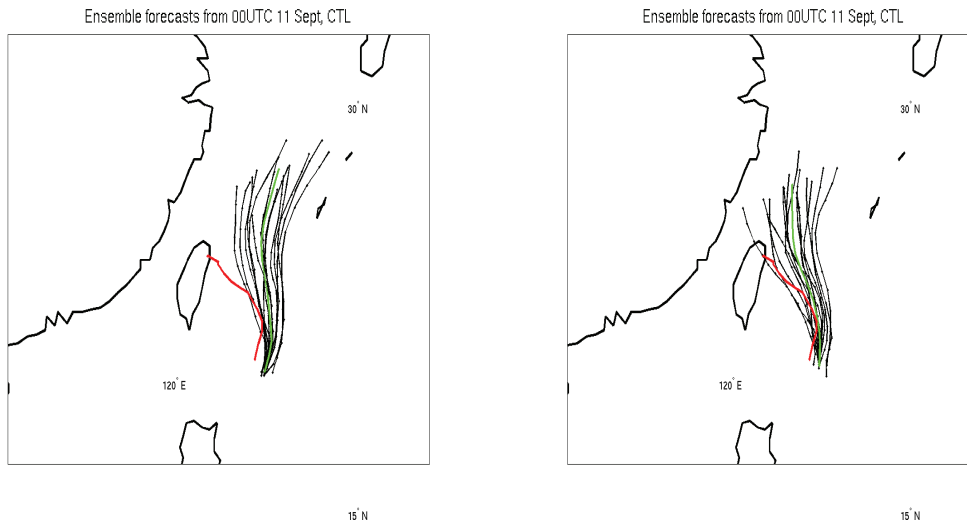


Figure 1. Ensemble Forecasts of Typhoon Sinlaku With and Without COSMIC Data [1], [2]

Unfortunately, the COSMIC mission will reach the end of its design life in 2011, and the critical real-time satellite observing capability will begin to degrade as satellites become no longer operational. It is expected that these spacecraft will begin to degrade in the 2011 timeframe, with the loss of 2-3 spacecraft between 2011 and 2015. In February 2008, NOAA's Under Secretary of Commerce for Oceans and Atmosphere directed the NOAA Satellite Mission Sub-goal in his FY10–FY14 Program Decision Memorandum to “develop a follow-on plan for the Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC).” As a result, NOAA intends to provide data continuity and improve sensing capability with the next-generation COSMIC-2.

2. COSMIC-2 OBJECTIVES

The objective of COSMIC-2 is similar to that of COSMIC: to collect a large amount of atmospheric data for meteorological, climatic, ionospheric, and geodetic research, as well as for weather forecasting and space weather monitoring. Additionally the system will allow scientists to collect data over un-manned and remote regions (such as the poles and oceans) in support of research in these areas.

3. COSMIC-2 CONSTELLATION

COSMIC-2 will be comprised of 12 micro-satellites with a Tri-G GNSS receiver that has the capability to track three navigation systems: GPS, GLONASS, and Galileo. The constellation is planned to be comprised of 8 satellites at 72 degree inclination, and 4 satellites at 24 degree inclination, which will enhance observations in the

equatorial region over what is currently being collected with COSMIC. This constellation will produce more than 8,000 soundings per day, compared to the approximate 2,000 soundings per day currently produced by COSMIC. The following figure illustrates the comparison of sounding distribution over a three hour period between COSMIC and COSMIC-2.

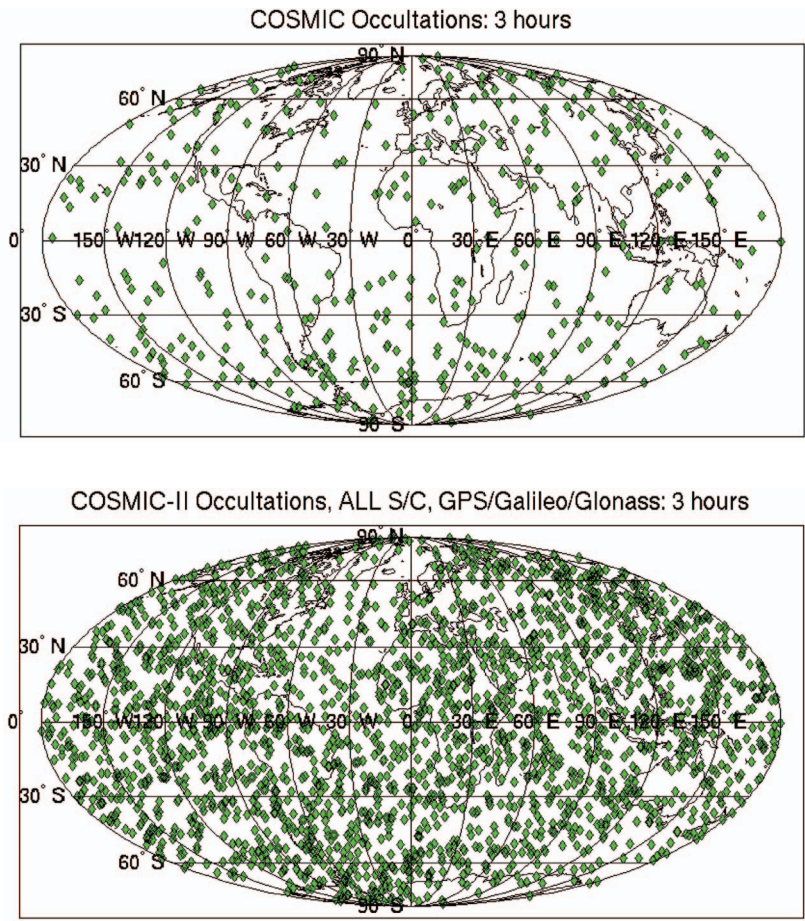


Figure 2. COSMIC vs. COSMIC-2 Sounding Comparison [1]

The first COSMIC-2 launch is planned for the first quarter of FY2014. Initial Operational Capability (IOC) of COSMIC-2 is expected to be in the second quarter of FY14, and Final Operational Capability (FOC) is targeted for FY17. Similar to the current COSMIC satellites, the COSMIC-2 satellites are nominally expected to be 50-60kg each, and therefore several can be launched on one small rocket – in the class of Minotaur 1, Falcon 1E or Pegasus. The plan is to launch 2 or more rockets with 4-8 satellites on each rocket. They will be launched and then positioned into their final orbits (nominally 800km altitude) [3].

The original COSMIC mission had an operational concept of allowing for one data downlink per orbit. The plan for COSMIC-2 is to allow for 2 data downlinks per orbit, which will considerably reduce the data latency. Consequently, COSMIC-2 will require more satellite ground stations for receiving the data. As with COSMIC, the COSMIC-2 collected data will be downlinked to the tracking station, then transmitted to the COSMIC processing center (CDAAC in Boulder, CO) as well as to the Taiwan processing center (TACC) for processing. The processed products will then be provided to NOAA Global Transmission System (GTS) for distribution to the worldwide weather prediction centers. Command and Control for the COSMIC-2 constellation will continue to be provided by the NSPO Satellite Operations Control Center (SOCC). Payload operational configurations will continue to be managed by a joint effort between UCAR (University Corporation for Atmospheric Research) and JPL (Jet Propulsion Laboratory) with NOAA and NSPO concurrence for updates and changes [3].

4. CONCLUSION

COSMIC's contribution to weather prediction is considered to be "significant" by the National Weather Service (NWS) and represents an immense benefit to worldwide forecasting capability. This data is not available globally from other sources, and allowing this data to deteriorate due to the COSMIC satellites' end-of-life will result in a significant diminution of performance of the NOAA Numerical Weather Models. This will result in diminished weather prediction capability which may lead to increased costs and loss of life due to natural disasters. The realization of COSMIC-2 will continue to fulfill this important mission and further increase weather forecast capabilities.

5. REFERENCES

- [1] Courtesy of UCAR (University Corporation for Atmospheric Research, Boulder, CO)
- [2] Courtesy of CWB (Taiwan's Central Weather Bureau)
- [3] COSMIC-2 Management Control Plan