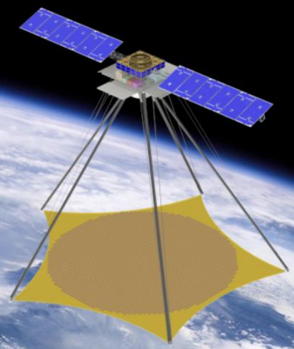
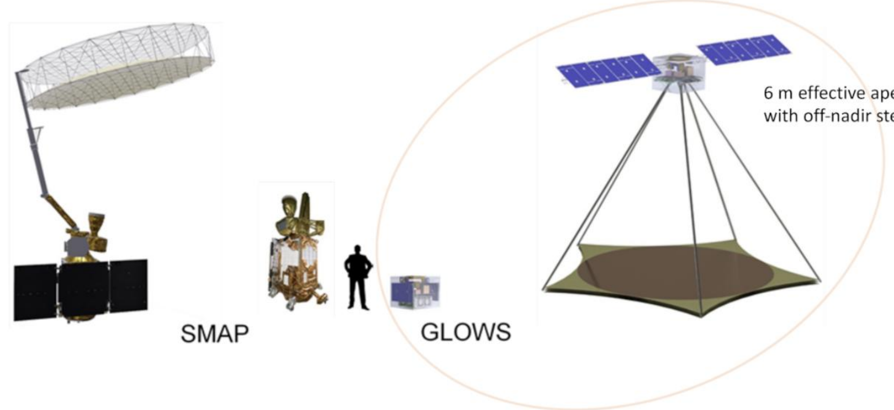
High Resolution L-band Wind Speeds from the Global L-band Observatory for Water Studies (GLOWS)



David Long, Rajat Bindlish, Jeff Piepmeier, Giovanni De Amici, Mark Bailey

IOVWST Meeting 2023
Virtual Poster

Comparing GLOWS and SMAP

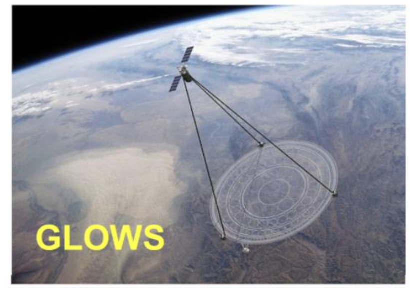


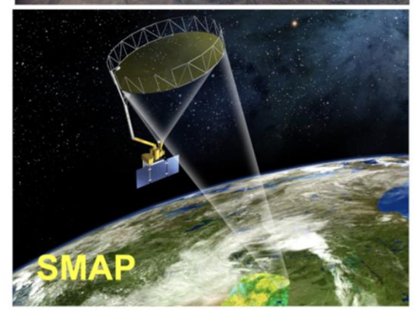
GLOWS Mission Objectives

- **Soil Moisture Active Passive (SMAP) data continuity**
  - L-band polarimetric radiometer *and* radar
  - SMAP-level accuracy to continue data (same resolution/swath/accuracy)
  - Radar provides <5 km resolution wind speed retrieval
- Lost cost mission achieved by
  - Small size: stow within a rideshare volume
  - Use meta-material lens as a refractor
  - Use multi-element patch array feed
  - Update radiometer to reduce volume and improve performance
  - Leverage SOA commercial radar technologies
- Funded by NASA IIP

GLOWS Design

- GLOWS similar to SMAP:
- Four **radiometer** channels
  - H, V, 3[rd] and 4[th] Stokes @ 1.41 GHz
  - ~15 ms integration interval with 24/80 MHz BW
  - ~40 km resolution
  - 1000 km wide swath
  - **6 m membrane lens antenna vs reflector**
- Quad Pol rotating **SAR**
  - HH, VV, HV/VH @ H 1.26, V 1.29 GHz
  - PRF=2.8 kHz, Tp=15 us w/1 MHz BW chirp
  - Peak Xmit power 500 W
  - 250 m SAR resolution averaged to 1 & 5 km
  - 1200 km wide swath
- Orbit
  - 685 km, 8-day repeat orbit

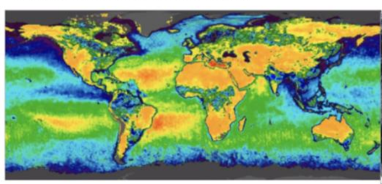




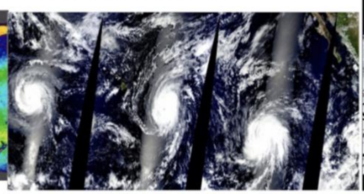
SMAP Science Continuity

Soil Moisture	Ocean Surface Salinity	Ocean Surface Winds	Vegetation Biomass
• High-resolution and frequent-revisit • Understand processes that link the terrestrial water, energy and carbon cycles • Estimate global water and energy fluxes at the land surface • Enhance weather, flood and drought prediction	• Ocean circulation governed by salinity + temperature • Global water cycle: Salinity reflects balance between precipitation and evaporation • Freshening due to ice melt in Arctic • Balance between Atlantic and Pacific • Changes in coastal salinity due to increased run off	• L-band not affected by rain or clouds • L-band does not saturate with wind speed • Effective in intense tropical cyclones *(Unfortunately, SMAP radar failed shortly after launch)*	• Radar observations provide all-weather vegetation biomass • Microwaves observations saturate at higher biomass • Food security and agriculture • Quantify net carbon flux in boreal landscapes **Thin Sea Ice** • Sea ice thickness up to 0.5 m • Complementary observations to altimeter - thin sea ice • Summer melt of sea ice and ice sheets can cause freshwater lenses

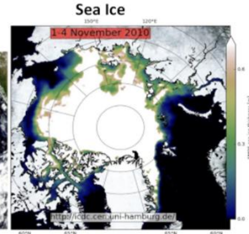
Soil Moisture and SSS from SMAP



Ocean Winds using L-band

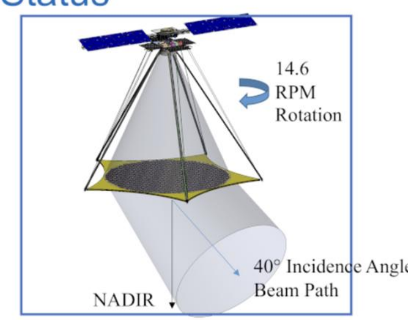


Sea Ice



GLOWS Instrument Development Status

- Lens RF Design
  - Membrane L-band waveguide transmissivity testing
  - Lens design and model validation
  - – 2 m x 4 m full scale antenna slice
- Feed Design
  - 12 element test completed, studying 16 element
  - 1/6 scale testing complete
- Lens Structural Design
  - 6 m prototype deployment demonstration successful
  - 6 m positional deployment stability test complete
  - Satellite packaging study completed – Systems fits in EPSA Grande envelope
  - Completed buckling test of slit tube struts to validate FEA subassembly model
- SMAP Diplexer Upgrade



High Resolution L-band Wind speeds from the Global L-band Observatory for Water Cycle Studies (GLOWS)

David Long[1], Rajat Bindlish[2], Jeffrey Piepmeier[2], Giovanni De Amici[2], and Mark Bailey[3]

[1]Brigham Young University, Provo, UT, USA.
[2]NASA Goddard Space Flight Center, Greenbelt, MD, USA.
[3]MMA Design, LLC.

The Global L-band active/passive Observatory for Water cycle Studies (GLOWS) is proposed as a NASA Soil Moisture Active Passive (SMAP) data continuity mission and is under study with funding from the NASA Instrument Incubator Program. SMAP, launched in 2015, collected L-band radiometer and radar measurements over land and ocean [1,2]. SMAP observations have demonstrated utility in measuring sea surface salinity and ocean vector winds over the ocean, as well as sea ice thickness. Unfortunately, the SMAP quad-polarization radar failed soon after launch after collecting only 100 days data. However, the SMAP polarimetric radiometer continues to provide high quality radiometer measurements to the present.

To address the need for L-band radiometer data continuity, as well as provide radar measurements to support improved soil moisture estimates and L-band wind measurements, we are developing a mission concept known as the Global L-band active/passive Observatory for Water cycle Studies (GLOWS). The GLOWS mission will continue the science observations of SMAP at the same resolution and accuracy at substantially lower cost, size, and weight with both active and passive channels [3].

The key technology enabling a smaller, lower-cost instrument is the development of a new deployable meta-material lens antenna [4,5]. Because the lens antenna is rotationally symmetric (flat—see Fig. 1) and low mass, it is much easier to balance and rotate than traditional offset fed large-aperture reflectors, such as the one used on SMAP. Further, the lens antenna can be densely packed into a small volume for launch. These permit a much smaller support spacecraft. In addition, the GLOWS radar and radiometer electronics will exploit recent developments in flight hardware to minimize the size, weight, and power (SWaP) of the radar and radiometer components of the GLOWS instrument system. A size comparison of SMAP and GLOWS is shown in Fig. 1.

GLOWS measurements will support critical ocean measurements such as sea surface salinity (SSS), sea ice, and ocean vector winds using a quad-polarization, multi-azimuth radar. While L-band measurements only enable wind speed measurements, they are less affected by rain than higher frequency measurements, which makes them particularly valuable for wind measurement in tropical cyclones and hurricanes [4]. The GLOWS radar will have ~250 m resolution that will be averaged onto a 1 km resolution reporting grid. This will support global high resolution wind retrieval, that will be particularly useful in near-coastal regions. The cross-polarization measurements from the radar will ameliorate the need for additional incidence angles in solving for the wind.

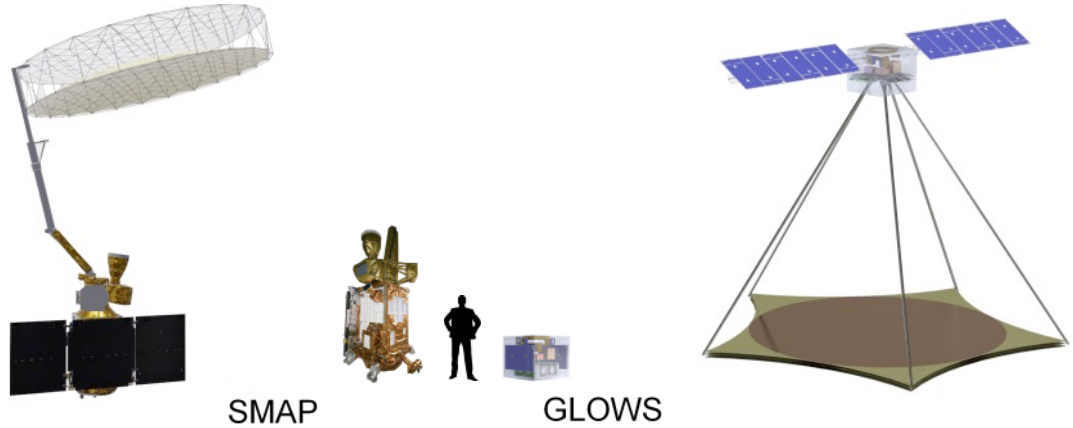


Figure 1. Size comparison of SMAP and GLOWS integrated in an ESPA-class spacecraft. Note the similarity of the deployed antenna aperture and the contrast in launch configurations.

REFERENCES

[1] D. Entekhabi, et al., "The Soil Moisture Active Passive (SMAP) mission," *Proc. IEEE*, vol. 98, no. 5, pp. 704–716, May 2010.

[2] J.R. Piepmeier et al., "SMAP L-Band Microwave Radiometer: Instrument Design and First Year on Orbit," *IEEE Trans. Geosci. Remote Sensing*, vol. 55, no. 4, pp. 1954–1966, 2017.

[3] D. Long et al., "Status Update: The Global L-band Observatory for Water Cycle Studies (GLOWS)," *Proceedings of the International Geoscience and Remote Sensing Symposium*, Pasadena, CA, July 2023.

[4] F. Ulaby and D.G. Long, *Microwave Radar and Radiometric Remote Sensing*, University of Michigan Press, Ann Arbor, MI, 2013.