

Corresponding Author: Sidharth Misra
SIDHARTH.MISRA@JPL.NASA.GOV
Career Status: None of the above
Affiliation/Country: NASA JPL, CalTech, USA

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Topic: Critical drivers for ocean salinity science and applications and the future need for high-resolution technologies

Title: Coastal and Polar Salinity Remote Sensing Solutions – Near-surface, Airborne, and Spaceborne

Abstract: Highly dynamic sea surface salinity (SSS) in coastal regions are critical to understand the ocean-land water cycle, marine ecosystem health, coastal circulation, as well as human economic impact. Similarly, SSS in high latitude regions are required to truly understand the interactions between the ocean, atmosphere, and cryosphere. Despite their importance, coastal and polar SSS remains one of the most under-sampled geophysical parameters.

L-band (1.4 GHz) passive radiometry is the only true solution for global remote sensing salinity measurements. Missions such as ESA's SMOS, and NASA's Aquarius and SMAP, and soon ESA's Copernicus CIMR mission provide L-band measurements. These missions though are limited in their ability to measure coastal or polar salinity. At higher latitudes the sensitivity of the radiometric L-band brightness temperature to salinity reduces by a factor of 3 relative to warm waters. Similarly for coastal salinity dynamics, higher spatial resolution (<10 km) is required.

Here we present several technological solutions that can potentially satisfy these next generation SSS needs. As the observation frequency decreases below 1.4 GHz, the brightness temperature sensitivity increases at lower SST. We present results from the LOBSTER (Low-frequency Observations of Brightness Temperature and Salinity for Tomorrow's Earth Research) wide-band radiometer operating from 1.1 to 1.7 GHz. LOBSTER was deployed in a ground-based experiment at the Piscataqua River and observed a high dynamic range of salinity at temperatures as low as 2 degree C. LOBSTER successfully demonstrated the improved sensitivity of Tb to salinity at lower frequencies compared to 1.4GHz. We will also discuss technical challenges of such wide bandwidth systems, such as Radio Frequency Interference (RFI) and complex internal instrument systematics, necessitating robust digital filtering and sophisticated calibration architectures to maintain stability.

Though low-frequency systems can help with low SST salinity sensitivity, they cannot resolve the necessary spatial resolution required for coastal salinity. For spaceborne missions, achieving the necessary resolution for these regions necessitates larger antenna apertures which requires technological innovations in interferometric or large-mesh deployable reflector radiometry. Interestingly, increased spatial resolution must be accompanied with lower sensor noise as the amount of salinity variability observed becomes finer with finer spatial resolutions. Lowering noise not only satisfies observing coastal and sub-mesoscale ocean dynamics, but also the increased sensitivity required for polar observations.

Targeted airborne solutions for coastal salinity can help satisfy immediate application needs at high spatial resolution and time scales while sacrificing global coverage. We will briefly present results from L-band radiometry measurements obtained during the SASSIE (Salinity and Stratification at the Sea-Ice Edge) airborne campaign over the Beaufort Sea. Though salinity retrieval was possible, imprecise ancillary data such as SST, wind speed, platform attitude made retrieval challenging. We will briefly discuss future high altitude platform airborne concept, that help solve several of these challenges and allow continuous high resolution coastal salinity coverage.

Finally, we will present a brief introduction on potential technology development for spaceborne concepts to allow daily wide swath salinity observations at high spatial resolution of ~10 km and very low noise to

be sensitive to coastal salinity and sub-mesoscale salinity variability. We will briefly introduce the need for an innovative beamforming synthetic aperture radiometer that would eliminate the need for extremely large mesh antennas that drive cost due to increased mass and spun momentum, would achieve the required high spatial resolution, and would allow noise to be driven down to the required salinity sensitivity.

Author 2: Alex Akins
NASA JPL, CalTech, USA

Author 3: Shannon Brown
NASA JPL, CalTech, USA

Author 4: Mehmet Ogut
NASA JPL, CalTech, USA

Author 5: Douglas Vandemark
UNH, USA

Author 6: Shawn Shellito
UNH, USA

Author 7: Severine Fournier
NASA JPL, CalTech, USA

Author 8: Ian Fenty
NASA JPL, CalTech, USA

Author 9: Tony Lee
NASA JPL, CalTech, USA

Author 10: Michelle Gierach
NASA JPL, CalTech, USA