National Aeronautics and Space Administration

Postdoc Research

Assessment of SMOS and SMAP sea surface salinity against SASSIE in situ measurements in the Arctic Ocean

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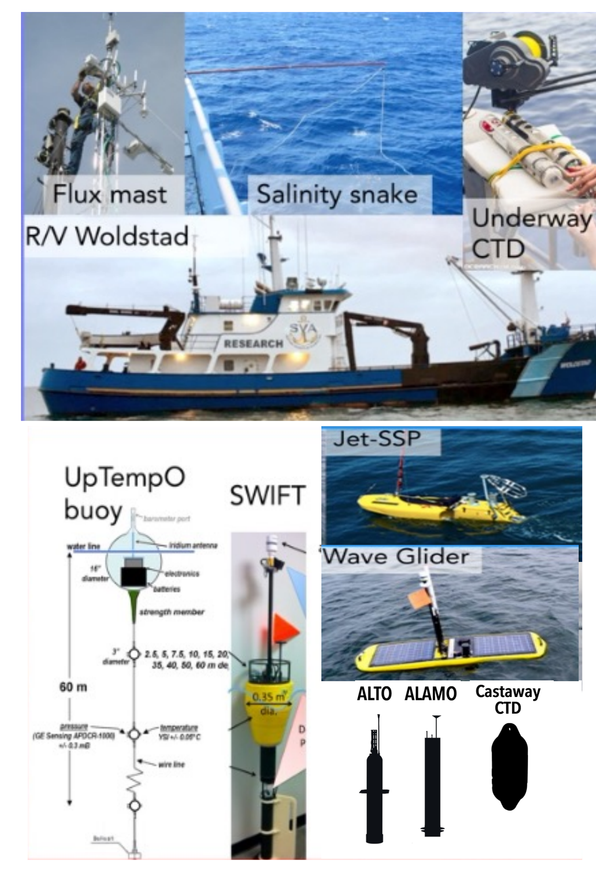
Background and Objectives

Sea Surface Salinity (SSS) anomalies and near surface thermohaline stratification are key parameters to improve our understanding of sea ice retreat and formation in polar regions. In the western Arctic Ocean salinity controls upper ocean stratification and stored subsurface heat. The NASA's SASSIE (Salinity and Stratification at Sea Ice Edge) project aims at analyzing the temporal evolution of SSS and near surface thermohaline stratification in the Arctic Ocean to test the hypothesis that the fresh water layers (low SSS water lens) induced by summer ice melt would precondition the sea ice advance during the following autumn season. Since 2010, the remote sensing salinity missions ESA SMOS (Soil Moisture and Ocean Salinity) and NASA SMAP (Soil Moisture Active Passive) offer unprecedented observations of SSS globally. As part of the SASSIE project, the main goal of this study, is to evaluate these satellite SSS observations against 9 different in situ instruments (Fig 1) provided by the campaign during the fall of 2022.



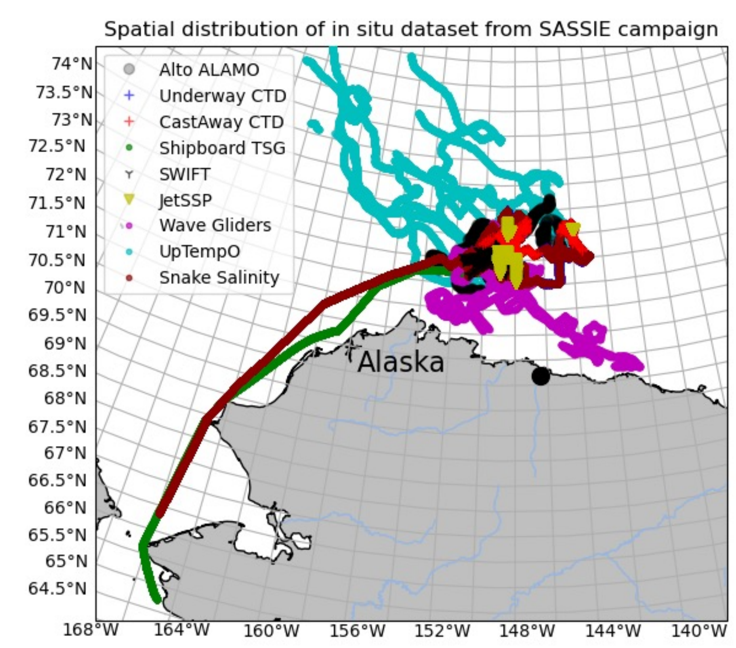


Fig.1 SASSIE in situ instruments and dataset track lines during the campaign of the Fall of 2022. SASSIE in situ data consist of 9 platforms: ALTO ALAMO floats, castaway CTD, underway CTD, SWIFT, shipboard TSG, JetSSP, Wave Gliders, UpTempO drifter and Snake Salinity

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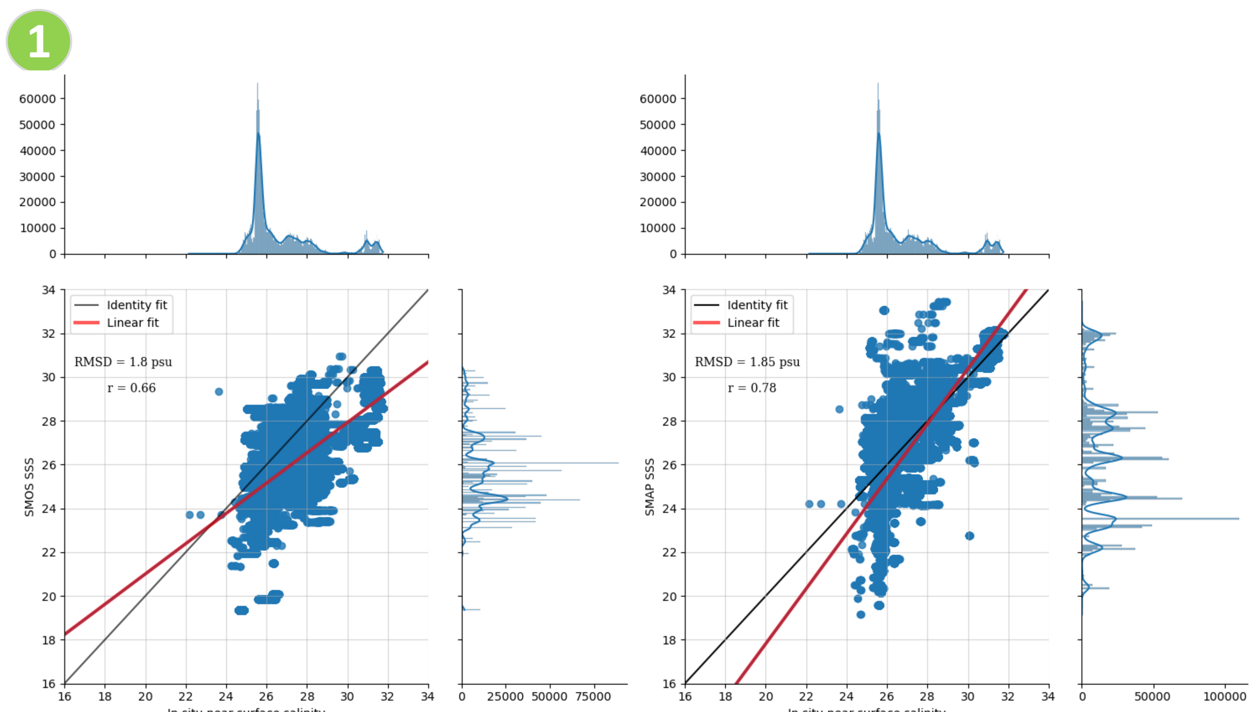

Fig.2 Scatterplots of SASSIE in situ salinity dataset vs (left) SMOS SSS and (right) JPL SMPA SSS. The solid red line represents the linear regression of in situ data against satellite measurement for each case and the solid black line represents the identity line as reference.

Approach and Results

Because satellite accuracy of salinity measurement is impacted by land and ice contamination, cold temperatures, and surface roughness, mean differences and RMSD (Root Mean Square Difference) between satellite and in situ salinity are examined as a function of distance from the coast and the sea ice edge, sea surface temperature and wind speed. Nearest surface salinity values from each in situ instrument are collocated in time and space (by a radius of 25km) with satellite SSS. We found that SMOS and SMAP SSS have a good correlation (0.66 and 0.78 resp.) with RMSD of 1.8 and 1.85 against in situ measurements respectively. SMOS SSS exhibit a relatively fresh mean difference (about -2psu) overall with an increased difference at the proximity of the coast (0-200km), whereas SMAP SSS mean difference is low (less than -1psu). However, near the sea ice edge (0-150km), SMAP SSS show large mean differences up to -5psu, whereas SMOS SSS mean differences are low (less than -2psu). In cold surface water (± 1.5˚ C) and low wind speed (0-7 $m.s^{-1}$) conditions, both satellite SSS products are consistent with each other and show a fresh mean difference.

2 At proximity of the coast (0-200km) SMAP SSS differences are low (about 1psu) whereas SMOS SSS differences are negative up to -4psu.

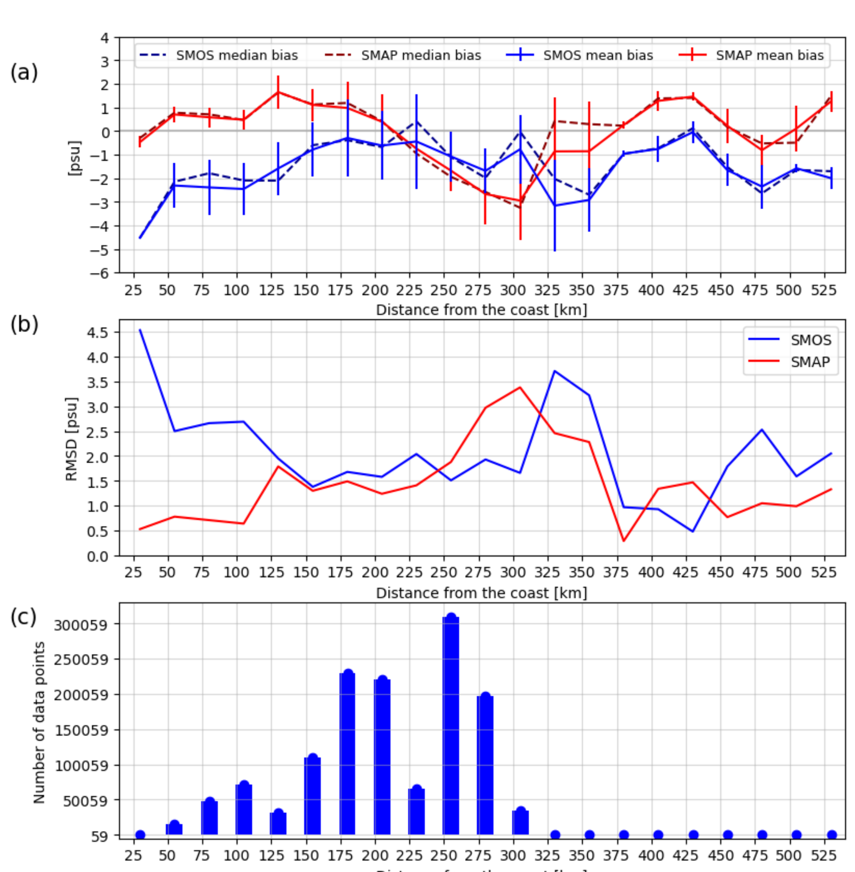

Fig.3 (a) Satellite SSS differences as function of distance from the coast (per 25km bin): SMOS SSS mean (solid blue curve) and median (dashed blue curve) difference, and SMAP SSS mean (solid red curve) and median (dashed curve) difference. Vertical bars are STD of SSS biases within each grid. (b) RMSD between SASSIE in situ salinity and satellite SSS of SMOS (blue curve) and SMAP (red curve) as function of distance from the coast. (c) Number of data points as function of distance from the coast.

3 At the proximity of sea ice edge (0-150km) SMOS SSS differences are low (less than -2psu) while SMAP SSS differences are large up to -5psu.

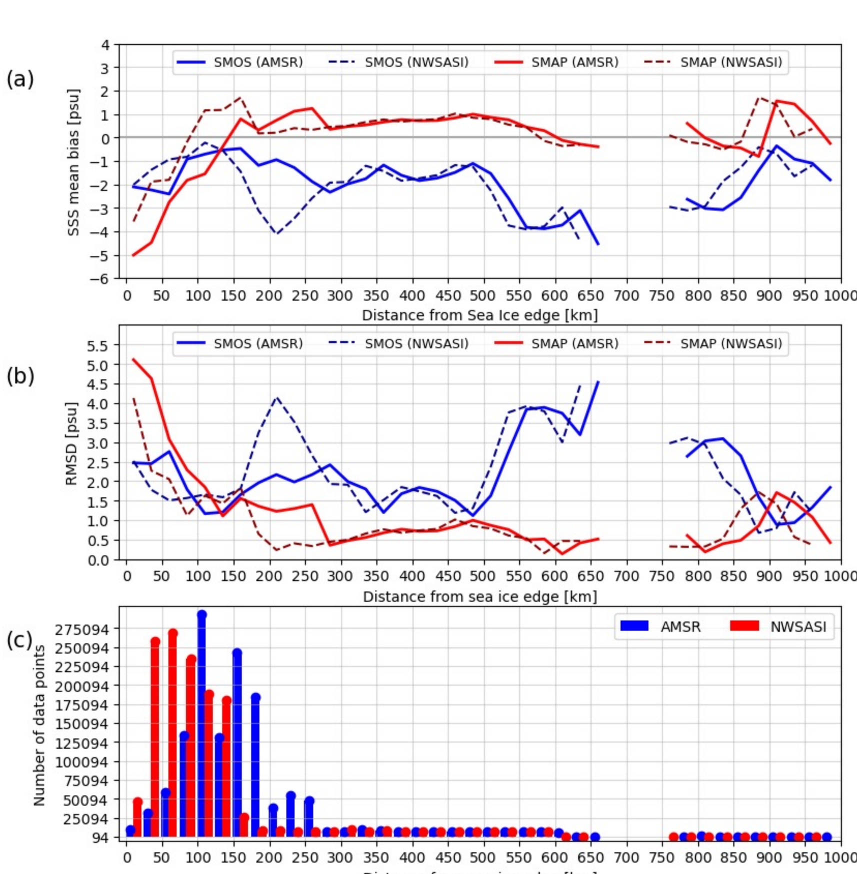

Fig.4 (a) Satellite SSS differences as function of distance from the sea ice edge (per 25km bin): SMOS SSS mean bias (solid blue curve with AMSR and dashed blue curve with NWSASI), and SMAP SSS mean bias (solid red curve with AMSR and dashed red curve with NWSASI). (b) RMSD between SASSIE in situ salinity and satellite SSS of SMOS (blue curve with AMSR and dashed blue with NWSASI) and SMAP (red curve with AMSR and dashed red with NWSAS) as function of distance from the sea ice edge. (c) Number of data points per aforementioned bin with AMSR (blue bars) and NWSASI (red bars).

4 Both SMOS and SMAP SSS differences and RSMD are consistent with each other in cold surface water with temperature of ±1.5˚C

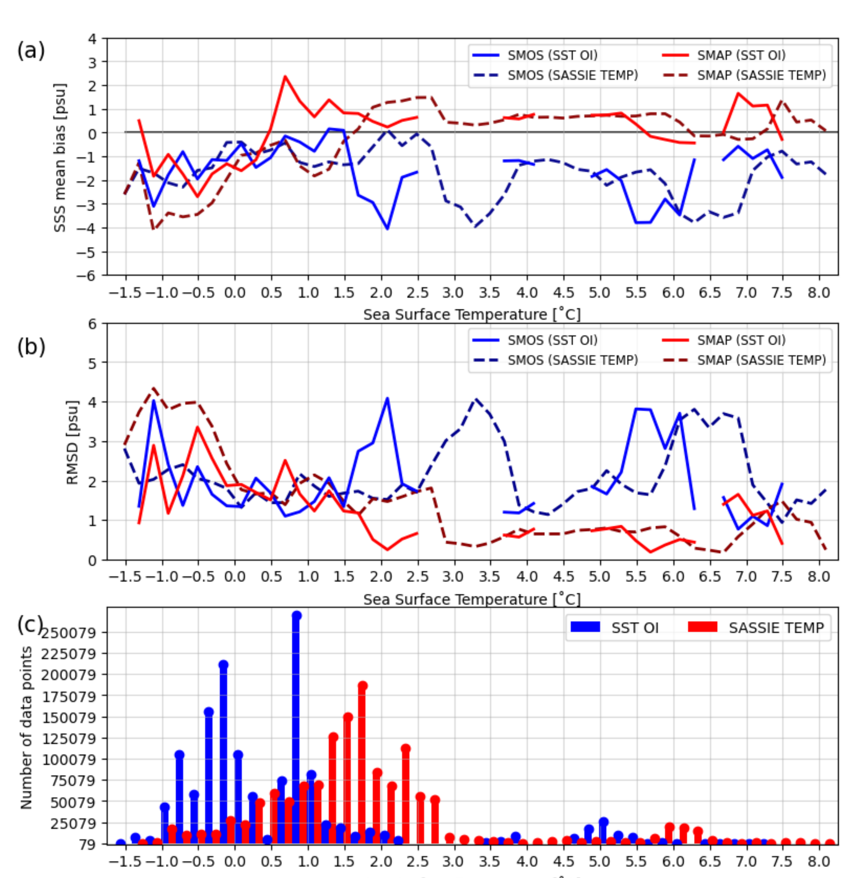

Fig.5 (a) Satellite salinity differences as function of Sea Surface Temperature (per 0.2˚ C bin): SMOS SSS mean difference (solid blue curve with NOAA/SST OI and dashed blue curve with SASSIE TEMP) and SMAP SSS mean difference (solid red curve with NOAA/SST OI and dashed red curve with SASSIE TEMP). (b) RMSD between SASSIE in situ salinity and satellite SSS of SMOS (solid blue curve with NOAA/SST OI and dashed blue curve with SASSIE TEMP) and SMAP (solid red curve with NOAA/SST OI and dashed red curve with SASSIE TEMP). (c) Number of data points per aforementioned bin with NOAA/SST OI (blue bars) and SASSIE TEMP (red bars). SASSIE TEMP for in situ surface water temperature.

5 At low surface wind speed conditions, both SMOS and SMAP SSS differences and RSMD are low and consistent with each other against in situ salinity.

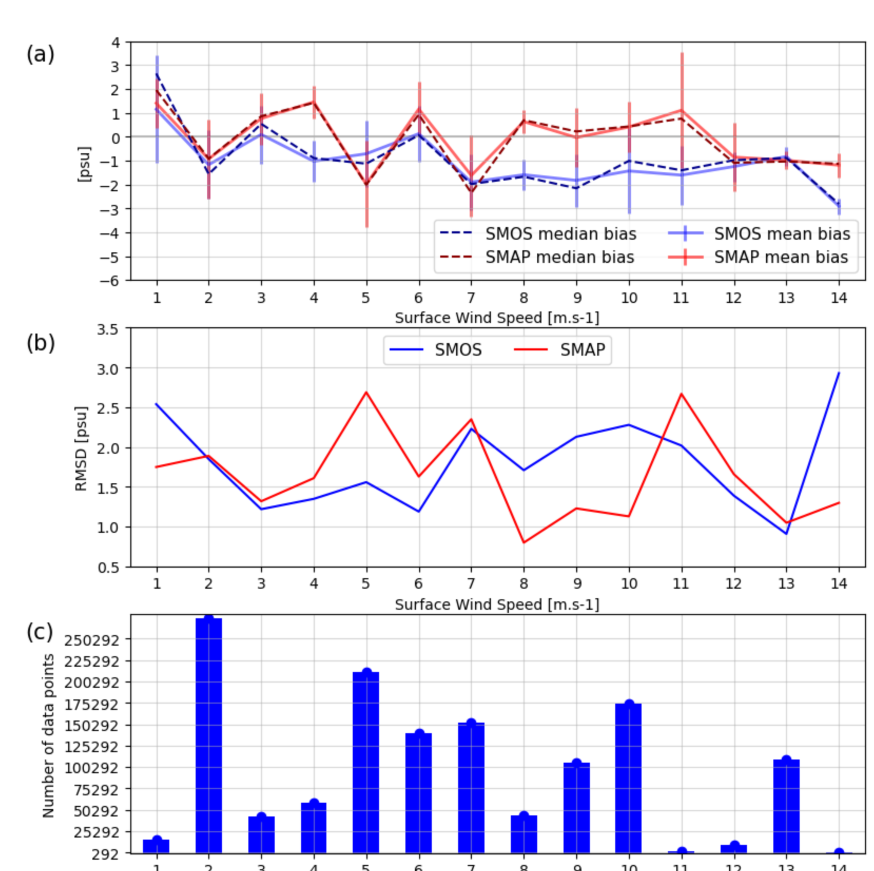

Fig.6 (a) Satellite SSS differences as function of surface wind speed (per 1m.s-1 bin): SMOS SSS mean difference (solid blue curve) and median difference (dashed blue curve), and SMAP SSS mean difference (solid red curve) and median difference (dashed red curve). Vertical bars are STD of associated SSS differences per grid. (b) RMSD between SASSIE in situ salinity and satellite SSS of SMOS (blue curve) and SMAP (red curve) as function surface wind speed. (c) Number of data points per aforementioned bin.

Significance of Results/Benefits to NASA/JPL

The results of the present study are significant for calibration, improving the retrieval processes and validation of satellite SSS in the polar regions. This study gives feedback to the various satellite SSS teams to improving the consistency among different satellite SSS products.

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