The Potential of Space-Based Sea Surface Salinity on Monitoring the Hudson Bay Freshwater Cycle

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Motivation: Hudson Bay (HB) is the largest semi-inland sea in the Northern Hemisphere, located at the southern margin of the Arctic Ocean. HB is completely covered by ice and snow in winter, and open water in summer. For about six months each year, satellite remote sensing of sea surface salinity (SSS) is retrieved over open water. SSS links freshwater contributions from various processes. Given the strategic importance of HB, SSS has great potential in monitoring the HB freshwater cycle and studying its relationship with climate change. However, SSS retrieved in polar regions from currently operational space-based L-band microwave instruments has large uncertainty (~ 1 psu) mainly due to sensitivity degradation in cold water (<5C) and sea ice contamination. Given this large uncertainty, we explore the potential use of satellite SSS in monitoring HB freshwater cycle.

Methods: Based on the governing equation of the mixed upper-layer salinity budget,

$$\frac{\partial S}{\partial t} = -\frac{RS_0}{h} - \frac{(P-E)S_0}{h} + H_{adv} - \frac{I_{local}S_0}{h} + \delta$$

We analyze the seasonal and interannual variation of SSS from NASA SMAP and ESA SMOS missions in the context of HB freshwater contents, including river discharge (R), surface forcing (P-E), sea ice melt/formation (I_{local}), and horizontal salt advection (H_{adv}).

Results: We found that the main source of the year-to-year SSS variability is sea ice melting, in particular, the onset time and places of ice melt in the first couple of months of open water season. The freshwater contribution from surface forcing P-E is smaller in magnitude comparing with sea ice contribution but lasts on longer time scale through the whole open water season. River discharge is comparable with P-E in magnitude but peaks before ice melt. The spatial and temporal variations of freshwater contents largely exceed the remote sensed SSS uncertainty. This fact justifies the use of remote sensed SSS for monitoring the HB freshwater cycle.

Significance: The Hudson Bay represents a scenario of the Arctic Ocean, where rapid changes related with climate warming are urgently calling for satellite monitoring. While the international remote sensing community gathering momentum for future missions better designed for polar observations, this study demonstrates that we can benefit from analyzing currently available, more than one decade of SSS data since the launch of SMOS. Studies of satellite SSS can also identify problems in the current satellite SSS products and help to develop sea ice correction to improve SSS retrieval in scene mixed with ice and water near the ice edge.

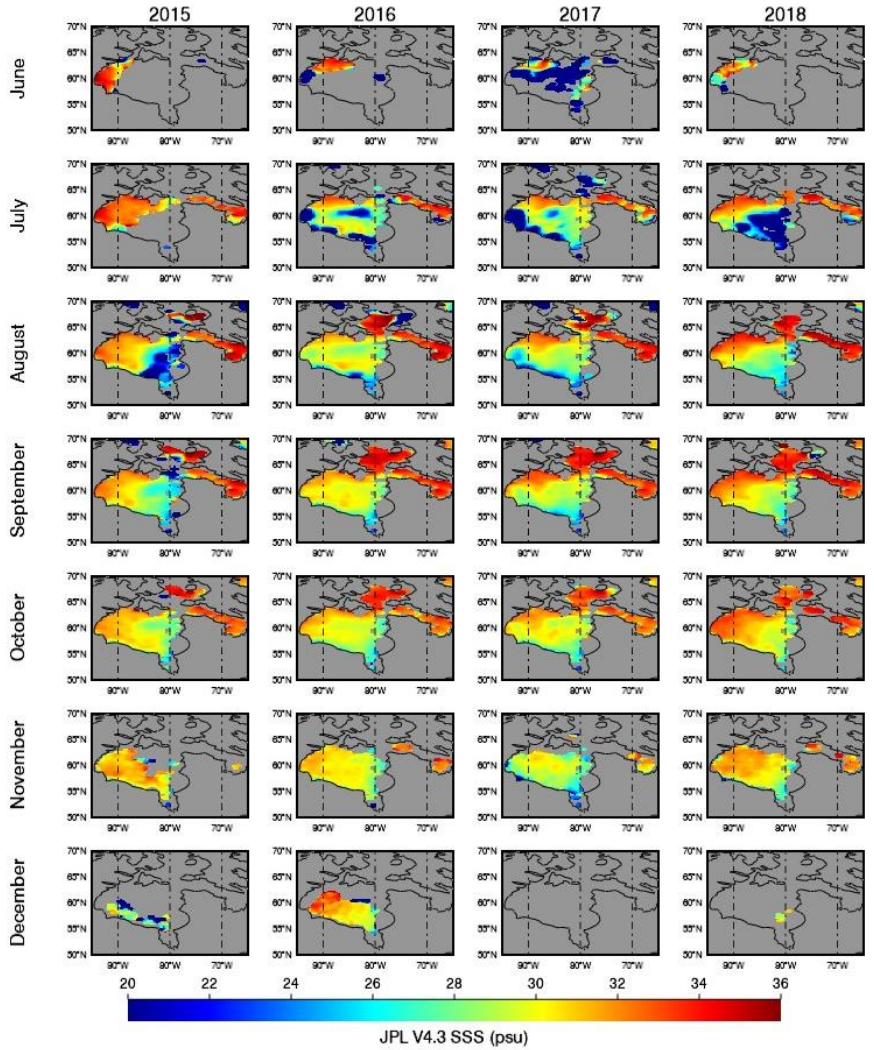

Figure Caption: *Monthly averaged Sea Surface Salinity in the Hudson Bay retrieved from SMAP radiometer (JPL V4.3) in summer when the Hudson Bay surface covered by open water.*

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