

SALINITY EFFECTS ON L-BAND MICROWAVE REMOTE SENSING OF SOIL MOISTURE

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1. INTRODUCTION

Global satellite missions for measuring soil moisture will assume that soil salinity is unimportant for soil moisture retrieval, but many parts of the world have large areas of highly saline soil. Approximately 7% of the earth's continental surface area is salt-affected [1], so failing to account for potential salinity-effects could compromise soil moisture satellite missions. Significant work has gone into correcting for effects on the signal due to vegetation, surface roughness and soil properties (e.g., [2], [3]). However, the effects of salinity have not been thoroughly tested. Existing models ([4]) and lab experiments ([5], [6]) suggest salinity may significantly reduce L-band microwave brightness temperature (T_b). While past field studies have either been inconclusive ([5], [7]) or found salinity effects were small ([8]), none were conducted in highly saline areas, where salinity-effects would be most pronounced. This study aims to test the sensitivity of L-band T_b to salinity in a highly saline area. The results of this study will have important implications for determining the error budget of L-band soil moisture missions.

2. FIELD EXPERIMENT AND DATA

A field experiment was conducted at a site near Nilpinna, South Australia, west of Lake Eyre. The site area was approximately 30 km $\times$ 50 km. The climate in this region is arid, with a mean annual rainfall of 170-220 mm/yr. The study area sits above the margin of the Great Artesian Basin, where localized faulting allows artesian water to feed the local water table. The shallow groundwater table is brought to the surface by capillary rise, where it precipitates salt while water is lost to evaporation. This process mobilizes salts, resulting in highly saline soils with salt crusts forming in some areas. Ground data were collected at 56 sites over six days in November 2008, and included soil temperature (at the surface and at depths of 5 cm and 10 cm) and soil samples, which were used to calculate soil moisture (θ_v) and soil salinity (S). The Polarimetric L-band Multibeam Radiometer (PLMR) was installed onboard an experimental light aircraft and used to measure horizontally- and vertically-polarized radiation at six incidence angles ($\pm 7^\circ$, $\pm 21.5^\circ$, $\pm 38.5^\circ$). Thermal radiometers were also installed on the aircraft at similar incidence angles to ensure coincident footprints with those of the PLMR. T_b and thermal infrared (TIR) data were collected at the study site over a single three-hour period during the field experiment, at a resolution of 500 m over the groundwater discharge area and 1000 m elsewhere.

The observed T_b was compared to T_b forward-simulated using the L-band Microwave Emission of the Biosphere (L-MEB) model [9] and the ground data. Simulations were run both with and without a correction for salinity. It was hypothesized that a systematic overestimation of observed T_b by the non-salinity-corrected (NSC) simulations, coupled with a better fit to the salinity-corrected (SC) simulations, would be evidence for a salinity effect. Similarly, observed θ_v was compared to retrieved θ_v , with and without corrections for salinity. Consequently, it was also hypothesized that a systematic overestimation of observed θ_v by the NSC simulations, coupled with a better fit to the SC simulations, would be evidence for a salinity effect.

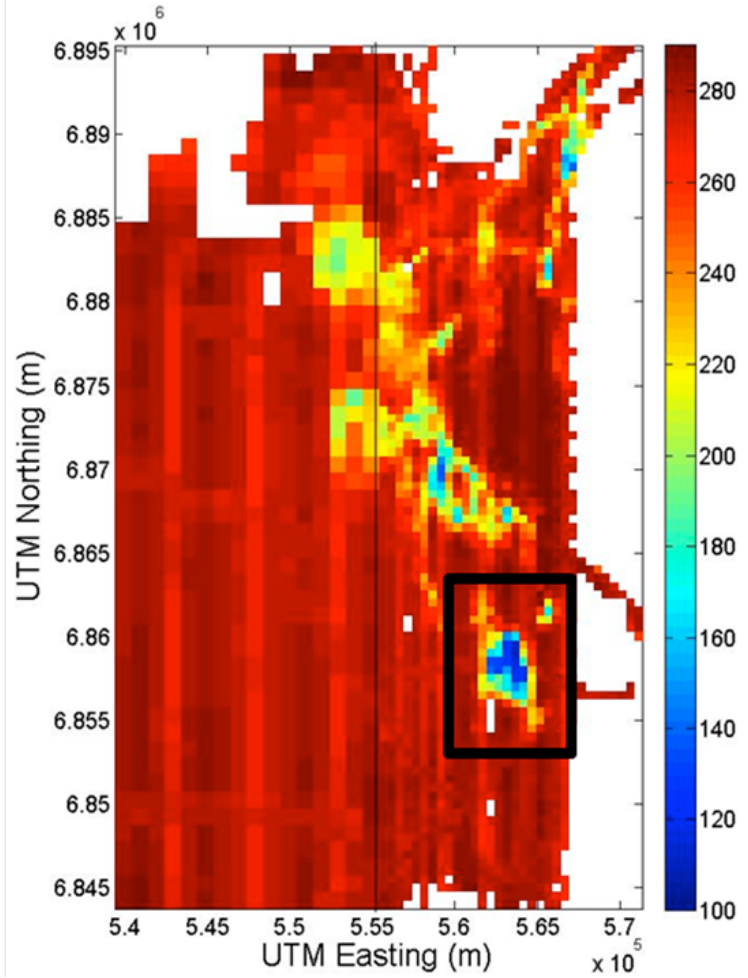
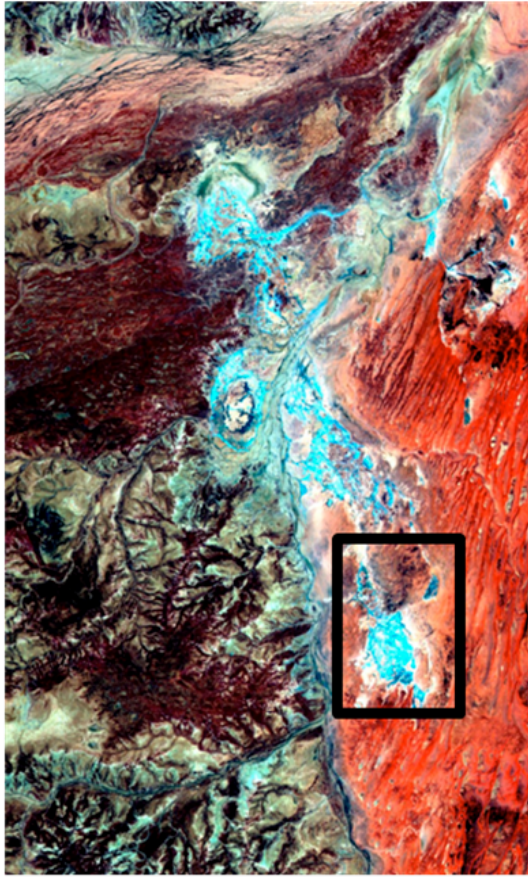


Figure 1: Landsat 5-2-1 false-colour image of the region (left) and mapped PLMR T_b (right), normalized to an incidence angle of 38.5° . Histogram modifications were made to the false-colour image to highlight the salt in cyan (bands 5, 2 and 1 were mapped in red, green and blue). The vertical black line (at approximately UTM easting 5.55×10^5) on the T_b image indicates the border between 500 m resolution grid cells (right of the line) and 1000 m grid cells (left of the line). Black boxes indicate highly saline areas.

3. RESULTS AND CONCLUSIONS

Extremely low T_b readings were observed over highly saline areas within the study region. The minimum observed T_b over the study site was 110 K. Simulations over a range of soil moisture and salinity values revealed that such a low T_b would be unrealistic without significant effects due to soil salinity; the combination of high soil moisture and high salinity, however, was found to be capable of producing such values. In total, the observed T_b was below the value physically possible for soil moisture alone in thirteen 500 m grid cells, consistent with expectations that salinity would reduce T_b . However, quantitative comparisons of forward-simulated T_b to observed T_b , and observed θ_v to inverted θ_v , did not support the hypothesis. Simulated NSC T_b fit the observed T_b better than SC T_b . However, both fits were poor (with negative Nash-Sutcliffe coefficients), suggesting the unexpected results may be due to the ground data: areas with highest salinity were not sampled, areas with high soil moisture were possibly oversampled, and the ground data resolution is probably insufficient to capture the spatial heterogeneity of the region. While simulated SC θ_v fit the observed θ_v better than NSC θ_v , this is likely due to the mentioned problems with the ground data, rather than a salinity effect. Overall, however, the extremely low

T_b observed at the site offers strong evidence that salinity can potentially have a significant effect on land surface L-band microwave emissions. This may result in overestimates of soil moisture by SMOS and other L-band soil moisture missions.

11. REFERENCES

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