Supplementary material for

Using generalized regression neural network to retrieve bare surface soil moisture from Radarsat-2 backscatter observations, regard less of roughness effect

**Ling Zeng 1，\*, Quanming Liu 2, \*, Linhai Jing 3, Jun Feng 1**

1 Chengdu Technological University, Chengdu, China

2 College of Water Conservancy and Civil Engineering, Inner Mongolia Agricultural University, Huhhot, China

3 Aerospace Information Research Institute, Chinese Academy of Sciences, No. 9 Dengzhuang South Road, Beijing, China

**Table S1** Description of soil moisture (), correlation length (), and RMS height () from ground measurements of 147 sampling sites, full-polarized backscattering coefficients (, , , ) extracted from Radarsat-2 scene corresponding to those ground measurement sites.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site ID | Latitude (E) | Longtitude (N) | (cm) | (cm) | (vol.%) | (dB) | (dB) | (dB) | (dB) |
| 1 | 40.778 | 107.189 | 0.91 | 46.41 | 17.341 | -8.26 | -9.69 | -15.59 | -16.45 |
| 2 | 40.778 | 107.174 | 0.84 | 25.31 | 20.560 | -11.70 | -13.20 | -17.85 | -17.55 |
| 3 | 40.778 | 107.164 | 0.8 | 8.73 | 17.093 | -13.39 | -13.56 | -18.50 | -17.90 |
| 4 | 40.778 | 107.150 | 0.82 | 46.31 | 18.112 | -7.14 | -6.08 | -17.68 | -17.28 |
| 5 | 40.777 | 107.139 | 0.38 | 17.39 | 22.557 | -12.78 | -11.09 | -21.92 | -21.73 |
| 6 | 40.776 | 107.118 | 1.05 | 35.35 | 20.567 | -12.55 | -12.80 | -26.95 | -26.99 |
| 7 | 40.774 | 107.104 | 0.78 | 26.39 | 21.635 | -7.42 | -7.44 | -19.07 | -18.82 |
| 8 | 40.774 | 107.079 | 0.5 | 44.3 | 19.102 | -12.27 | -13.34 | -20.02 | -19.47 |
| 9 | 40.771 | 107.061 | 0.87 | 5.04 | 15.875 | -11.74 | -11.77 | -23.85 | -24.76 |
| 10 | 40.770 | 107.052 | 0.77 | 27.51 | 15.217 | -7.75 | -8.07 | -20.79 | -20.53 |
| 11 | 40.764 | 107.034 | 0.59 | 17.98 | 15.881 | -10.58 | -10.30 | -21.93 | -22.18 |
| 12 | 40.742 | 106.969 | 0.69 | 11.48 | 15.766 | -10.09 | -12.31 | -19.99 | -19.51 |
| 13 | 40.763 | 106.932 | 1.32 | 18.49 | 15.056 | -10.92 | -9.53 | -21.72 | -21.88 |
| 14 | 40.772 | 106.960 | 0.49 | 6.4 | 17.863 | -11.68 | -11.63 | -25.45 | -25.57 |
| 15 | 40.773 | 106.971 | 0.48 | 2.74 | 18.910 | -10.27 | -9.45 | -22.86 | -23.70 |
| 16 | 40.766 | 106.996 | 0.42 | 1.87 | 18.980 | -9.09 | -12.47 | -17.99 | -18.10 |
| 17 | 40.780 | 106.994 | 1 | 22.91 | 20.721 | -9.01 | -8.59 | -19.63 | -19.82 |
| 18 | 40.785 | 107.004 | 0.46 | 5.47 | 25.711 | -10.80 | -9.98 | -20.63 | -20.47 |
| 19 | 40.789 | 107.015 | 0.53 | 41.03 | 18.281 | -8.77 | -9.23 | -20.67 | -20.89 |
| 20 | 40.797 | 107.031 | 0.89 | 9.7 | 14.881 | -12.31 | -11.99 | -23.49 | -24.08 |
| 21 | 40.800 | 107.059 | 0.55 | 41.89 | 18.496 | -6.73 | -7.58 | -21.70 | -20.95 |
| 22 | 40.811 | 107.074 | 0.47 | 7.91 | 23.317 | -9.27 | -10.50 | -22.50 | -23.76 |
| 23 | 40.824 | 107.092 | 0.98 | 29.8 | 17.190 | -9.14 | -8.50 | -20.24 | -20.45 |
| 24 | 40.838 | 107.117 | 0.66 | 14.88 | 16.398 | -13.25 | -12.68 | -28.61 | -29.95 |
| 25 | 40.834 | 107.139 | 0.43 | 4.48 | 18.739 | -11.95 | -10.94 | -22.71 | -23.97 |
| 26 | 40.814 | 107.142 | 0.6 | 2.88 | 16.685 | -9.88 | -10.64 | -26.47 | -27.00 |
| 27 | 40.797 | 107.143 | 0.81 | 26.65 | 16.078 | -8.41 | -9.53 | -22.71 | -22.60 |
| 28 | 40.799 | 107.157 | 1.33 | 26.99 | 16.617 | -12.75 | -13.44 | -21.94 | -21.57 |
| 29 | 40.848 | 107.128 | 1.02 | 9.74 | 23.209 | -8.40 | -8.13 | -17.29 | -16.53 |
| 30 | 40.876 | 107.130 | 0.97 | 17.46 | 17.483 | -7.54 | -8.64 | -15.92 | -15.76 |
| 31 | 40.862 | 107.103 | 0.78 | 11.31 | 19.125 | -8.37 | -8.86 | -20.97 | -21.17 |
| 32 | 40.856 | 107.097 | 0.61 | 22.78 | 14.843 | -11.90 | -11.57 | -21.26 | -21.59 |
| 33 | 40.852 | 107.082 | 1 | 28.87 | 21.293 | -8.15 | -8.12 | -17.60 | -16.96 |
| 34 | 40.844 | 107.076 | 0.99 | 6.71 | 18.216 | -10.63 | -10.39 | -17.59 | -17.83 |
| 35 | 40.837 | 107.057 | 0.65 | 11.54 | 18.438 | -13.70 | -13.77 | -26.13 | -25.72 |
| 36 | 40.800 | 106.920 | 0.79 | 17.24 | 20.871 | -8.44 | -10.45 | -19.12 | -19.47 |
| 37 | 40.829 | 107.044 | 0.78 | 26.06 | 19.514 | -7.70 | -7.30 | -19.13 | -19.29 |
| 38 | 40.823 | 107.034 | 0.8 | 24.53 | 16.314 | -9.35 | -9.32 | -19.95 | -19.23 |
| 39 | 40.826 | 107.022 | 0.45 | 19.9 | 19.431 | -9.81 | -8.94 | -18.23 | -18.72 |
| 40 | 40.835 | 107.014 | 0.85 | 19.96 | 16.859 | -11.79 | -11.43 | -26.68 | -26.60 |
| 41 | 40.833 | 107.002 | 0.37 | 28.47 | 18.561 | -11.72 | -11.33 | -21.52 | -22.19 |
| 42 | 40.854 | 106.990 | 0.39 | 42.98 | 12.587 | -15.19 | -15.31 | -28.71 | -30.73 |
| 43 | 40.855 | 106.965 | 0.75 | 36.53 | 20.242 | -6.96 | -6.99 | -22.81 | -22.53 |
| 44 | 40.847 | 106.973 | 0.49 | 31.62 | 21.211 | -8.66 | -8.06 | -26.28 | -26.18 |
| 45 | 40.841 | 106.979 | 0.62 | 16.42 | 10.181 | -7.34 | -8.58 | -16.71 | -16.72 |
| 46 | 40.836 | 106.978 | 0.51 | 19.05 | 19.466 | -7.84 | -9.50 | -16.53 | -15.87 |
| 47 | 40.827 | 106.978 | 0.9 | 13.4 | 16.161 | -9.80 | -11.38 | -19.09 | -18.99 |
| 48 | 40.816 | 107.013 | 0.62 | 42.01 | 17.291 | -12.44 | -9.57 | -18.85 | -18.58 |
| 49 | 40.808 | 106.963 | 0.61 | 6.72 | 17.487 | -5.88 | -11.70 | -17.43 | -17.20 |
| 50 | 40.815 | 106.961 | 0.99 | 25.65 | 18.343 | -10.08 | -10.87 | -21.78 | -21.73 |
| 51 | 40.822 | 106.981 | 0.39 | 3.46 | 17.728 | -6.38 | -6.82 | -23.76 | -23.80 |
| 52 | 40.831 | 106.967 | 0.91 | 31.61 | 14.851 | -12.68 | -12.18 | -24.21 | -25.64 |
| 53 | 40.836 | 106.951 | 0.74 | 32.26 | 20.449 | -10.21 | -10.48 | -24.83 | -25.51 |
| 54 | 40.832 | 106.952 | 0.67 | 11.85 | 19.956 | -10.25 | -8.14 | -23.56 | -22.80 |
| 55 | 40.827 | 106.949 | 0.58 | 19.26 | 21.133 | -11.12 | -11.08 | -21.69 | -21.37 |
| 56 | 40.836 | 106.944 | 0.73 | 10.04 | 16.597 | -7.89 | -7.72 | -24.40 | -24.55 |
| 57 | 40.827 | 106.941 | 0.8 | 36.53 | 18.593 | -10.36 | -10.88 | -22.65 | -22.31 |
| 58 | 40.811 | 106.944 | 0.83 | 6.58 | 24.641 | -12.03 | -9.70 | -20.55 | -20.25 |
| 59 | 40.806 | 106.941 | 0.94 | 25.27 | 18.119 | -8.55 | -8.07 | -22.52 | -21.84 |
| 60 | 40.794 | 106.947 | 0.7 | 14.49 | 22.107 | -6.58 | -6.12 | -22.51 | -22.15 |
| 61 | 40.789 | 106.939 | 0.79 | 38.49 | 17.579 | -8.51 | -7.36 | -21.24 | -22.56 |
| 62 | 40.787 | 106.932 | 0.42 | 8.44 | 20.924 | -8.90 | -9.04 | -23.06 | -23.42 |
| 63 | 40.784 | 106.922 | 0.26 | 25.41 | 18.509 | -5.64 | -6.72 | -21.06 | -21.00 |
| 64 | 40.789 | 106.922 | 0.57 | 12.31 | 18.510 | -8.17 | -7.61 | -23.19 | -21.91 |
| 65 | 40.793 | 106.924 | 0.34 | 15.05 | 20.932 | -9.06 | -8.16 | -18.81 | -18.57 |
| 66 | 40.797 | 106.937 | 0.27 | 26.49 | 21.609 | -11.30 | -11.01 | -19.97 | -21.03 |
| 67 | 40.809 | 106.921 | 0.76 | 2.98 | 18.384 | -5.88 | -11.66 | -23.48 | -22.88 |
| 68 | 40.816 | 106.921 | 0.88 | 36.54 | 19.236 | -11.36 | -11.26 | -21.88 | -21.11 |
| 69 | 40.821 | 106.921 | 0.64 | 3.31 | 15.997 | -10.90 | -11.15 | -23.19 | -22.23 |
| 70 | 40.823 | 106.916 | 0.88 | 9.51 | 18.264 | -6.50 | -9.06 | -19.60 | -20.17 |
| 71 | 40.824 | 106.913 | 1.33 | 31.88 | 18.965 | -11.06 | -10.62 | -21.47 | -21.33 |
| 72 | 40.824 | 106.909 | 0.77 | 34.38 | 17.628 | -8.55 | -6.98 | -22.57 | -23.67 |
| 73 | 40.825 | 106.907 | 0.85 | 39.23 | 18.622 | -8.87 | -9.40 | -22.97 | -23.69 |
| 74 | 40.830 | 106.907 | 0.72 | 7.67 | 15.267 | -8.53 | -8.16 | -21.72 | -21.92 |
| 75 | 40.833 | 106.907 | 0.75 | 5.97 | 19.418 | -11.71 | -12.39 | -22.50 | -22.89 |
| 76 | 40.833 | 106.909 | 1.43 | 15.04 | 16.595 | -12.46 | -13.11 | -24.18 | -24.59 |
| 77 | 40.837 | 106.908 | 1.05 | 6.34 | 18.636 | -9.80 | -9.66 | -23.71 | -23.50 |
| 78 | 40.839 | 106.907 | 0.44 | 4.6 | 18.067 | -11.22 | -11.88 | -25.43 | -25.11 |
| 79 | 40.835 | 106.914 | 0.86 | 13.91 | 20.433 | -13.03 | -13.84 | -27.09 | -24.23 |
| 80 | 40.828 | 106.917 | 0.73 | 13.57 | 20.080 | -12.32 | -11.37 | -25.59 | -26.19 |
| 81 | 40.829 | 106.926 | 0.54 | 6.66 | 24.871 | -6.84 | -7.60 | -21.90 | -21.89 |
| 82 | 40.837 | 106.922 | 0.64 | 13.36 | 17.884 | -7.46 | -7.01 | -22.60 | -23.06 |
| 83 | 40.843 | 106.911 | 0.94 | 16.31 | 19.631 | -9.49 | -10.41 | -23.13 | -22.59 |
| 84 | 40.843 | 106.914 | 0.84 | 68.59 | 17.169 | -9.91 | -10.19 | -23.53 | -23.26 |
| 85 | 40.844 | 106.926 | 1.05 | 15.68 | 17.877 | -11.58 | -10.86 | -22.37 | -21.78 |
| 86 | 40.846 | 106.926 | 0.95 | 40.49 | 14.625 | -10.05 | -9.64 | -23.55 | -24.32 |
| 87 | 40.849 | 106.923 | 0.87 | 49.03 | 22.962 | -11.66 | -11.58 | -25.52 | -25.49 |
| 88 | 40.851 | 106.926 | 1.07 | 31.87 | 19.361 | -6.73 | -8.63 | -20.88 | -20.32 |
| 89 | 40.853 | 106.931 | 1.21 | 36.45 | 16.569 | -5.94 | -7.15 | -16.67 | -15.97 |
| 90 | 40.854 | 106.935 | 0.5 | 5.75 | 17.091 | -7.55 | -8.13 | -19.90 | -20.02 |
| 91 | 40.853 | 106.941 | 1.32 | 10.32 | 17.517 | -11.15 | -10.92 | -25.05 | -26.03 |
| 92 | 40.852 | 106.945 | 0.68 | 54.88 | 17.396 | -10.45 | -10.55 | -18.31 | -17.66 |
| 93 | 40.849 | 106.944 | 0.73 | 40.88 | 17.346 | -6.39 | -6.39 | -22.60 | -23.97 |
| 94 | 40.845 | 106.943 | 0.55 | 15.87 | 16.639 | -7.45 | -7.04 | -23.15 | -24.69 |
| 95 | 40.843 | 106.945 | 0.49 | 38.36 | 17.733 | -6.90 | -6.44 | -19.27 | -18.69 |
| 96 | 40.843 | 106.953 | 0.93 | 37.02 | 16.962 | -11.56 | -12.99 | -25.04 | -26.31 |
| 97 | 40.857 | 106.970 | 1.02 | 29.09 | 19.279 | -8.56 | -12.77 | -20.69 | -21.68 |
| 98 | 40.862 | 106.978 | 0.67 | 21.9 | 16.782 | -10.42 | -11.78 | -23.13 | -23.05 |
| 99 | 40.864 | 106.984 | 1.02 | 18.07 | 16.754 | -10.69 | -11.37 | -24.91 | -25.44 |
| 100 | 40.869 | 106.994 | 0.48 | 3.02 | 20.040 | -8.96 | -8.14 | -25.32 | -25.04 |
| 101 | 40.867 | 106.993 | 1.1 | 56.72 | 16.362 | -11.38 | -11.04 | -22.43 | -23.16 |
| 102 | 40.863 | 106.992 | 0.91 | 2.63 | 14.141 | -10.64 | -11.63 | -24.27 | -25.15 |
| 103 | 40.860 | 107.000 | 0.59 | 7.47 | 15.780 | -13.53 | -13.62 | -24.64 | -25.09 |
| 104 | 40.860 | 107.002 | 1.68 | 34.55 | 16.912 | -10.30 | -8.76 | -13.51 | -13.82 |
| 105 | 40.861 | 107.005 | 0.55 | 48.26 | 22.245 | -12.45 | -10.60 | -20.65 | -21.29 |
| 106 | 40.859 | 107.014 | 1.15 | 23.41 | 12.213 | -10.82 | -9.52 | -23.65 | -23.24 |
| 107 | 40.856 | 107.004 | 0.94 | 18.39 | 15.187 | -6.68 | -8.16 | -21.45 | -21.89 |
| 108 | 40.851 | 107.013 | 0.82 | 45.37 | 20.741 | -10.63 | -10.81 | -21.32 | -21.05 |
| 109 | 40.847 | 107.019 | 1.46 | 70.82 | 13.292 | -14.79 | -13.69 | -23.71 | -24.53 |
| 110 | 40.842 | 107.007 | 0.85 | 21.46 | 13.201 | -8.42 | -8.98 | -23.54 | -22.60 |
| 111 | 40.847 | 107.029 | 0.64 | 30.18 | 18.776 | -9.08 | -9.10 | -21.24 | -21.64 |
| 112 | 40.858 | 107.022 | 0.88 | 7.58 | 10.842 | -11.94 | -11.13 | -25.37 | -26.24 |
| 113 | 40.863 | 107.028 | 0.72 | 16.06 | 15.646 | -9.05 | -10.03 | -22.69 | -22.91 |
| 114 | 40.854 | 107.036 | 0.54 | 36.53 | 19.147 | -7.48 | -9.44 | -22.11 | -21.76 |
| 115 | 40.850 | 107.043 | 0.66 | 12.77 | 19.885 | -10.72 | -11.12 | -21.95 | -21.56 |
| 116 | 40.849 | 107.056 | 1.28 | 32.2 | 16.271 | -8.60 | -7.35 | -24.67 | -25.58 |
| 117 | 40.854 | 107.071 | 1.06 | 15.62 | 14.553 | -5.75 | -5.92 | -20.69 | -20.47 |
| 118 | 40.859 | 107.074 | 0.7 | 14.14 | 16.629 | -11.21 | -10.36 | -23.64 | -22.58 |
| 119 | 40.858 | 107.062 | 0.93 | 8.12 | 16.104 | -8.64 | -11.50 | -17.77 | -17.23 |
| 120 | 40.863 | 107.062 | 0.53 | 28.71 | 19.661 | -9.71 | -9.74 | -23.14 | -22.48 |
| 121 | 40.868 | 107.076 | 0.54 | 34.01 | 18.635 | -7.29 | -6.96 | -21.52 | -21.89 |
| 122 | 40.876 | 107.057 | 0.7 | 36.57 | 14.798 | -8.49 | -7.56 | -23.59 | -23.55 |
| 123 | 40.877 | 107.041 | 0.58 | 1.92 | 12.975 | -10.48 | -13.08 | -22.31 | -22.78 |
| 124 | 40.873 | 107.010 | 0.67 | 21.1 | 17.259 | -6.60 | -6.09 | -19.59 | -19.27 |
| 125 | 40.869 | 106.999 | 0.68 | 13.57 | 19.990 | -6.38 | -7.49 | -22.40 | -23.60 |
| 126 | 40.880 | 107.075 | 1.09 | 26.99 | 15.573 | -8.65 | -8.29 | -23.44 | -23.12 |
| 127 | 40.883 | 107.098 | 0.5 | 28.35 | 14.224 | -9.18 | -8.43 | -22.01 | -22.62 |
| 128 | 40.884 | 107.080 | 0.93 | 10.58 | 19.437 | -7.62 | -7.16 | -18.75 | -18.37 |
| 129 | 40.884 | 107.076 | 1.07 | 21.84 | 17.199 | -7.80 | -8.48 | -20.50 | -20.31 |
| 130 | 40.890 | 107.075 | 0.74 | 38.65 | 18.984 | -4.85 | -6.08 | -23.52 | -24.24 |
| 131 | 40.890 | 107.064 | 0.44 | 42.34 | 19.901 | -8.90 | -6.42 | -21.80 | -21.26 |
| 132 | 40.889 | 107.050 | 1.48 | 40.54 | 19.062 | -8.08 | -8.08 | -18.06 | -17.77 |
| 133 | 40.876 | 107.032 | 0.82 | 38.32 | 20.713 | -10.42 | -10.39 | -17.17 | -17.23 |
| 134 | 40.882 | 107.030 | 0.97 | 5.83 | 18.653 | -8.36 | -9.03 | -22.28 | -22.59 |
| 135 | 40.893 | 107.029 | 0.77 | 44.25 | 16.303 | -9.83 | -10.51 | -22.64 | -22.77 |
| 136 | 40.893 | 107.020 | 0.85 | 16.51 | 17.130 | -9.84 | -10.41 | -24.36 | -25.42 |
| 137 | 40.893 | 107.011 | 1.48 | 29.24 | 20.342 | -5.04 | -10.23 | -16.54 | -16.67 |
| 138 | 40.891 | 107.006 | 1.01 | 11.06 | 16.839 | -9.23 | -7.56 | -27.56 | -27.76 |
| 139 | 40.891 | 107.002 | 1.03 | 34.03 | 14.198 | -11.31 | -12.09 | -18.95 | -19.56 |
| 140 | 40.892 | 106.999 | 0.96 | 10.69 | 16.644 | -10.51 | -11.16 | -21.77 | -22.23 |
| 141 | 40.892 | 106.997 | 0.42 | 5.59 | 20.660 | -10.19 | -9.56 | -22.19 | -22.24 |
| 142 | 40.887 | 107.004 | 0.66 | 26.91 | 13.772 | -10.10 | -9.71 | -24.64 | -25.31 |
| 143 | 40.861 | 106.954 | 1.03 | 19.58 | 18.839 | -10.30 | -10.43 | -15.54 | -15.19 |
| 144 | 40.874 | 106.955 | 0.7 | 53.22 | 16.331 | -8.88 | -9.02 | -26.51 | -25.54 |
| 145 | 40.883 | 106.955 | 0.86 | 45.01 | 19.251 | -7.05 | -8.12 | -19.60 | -20.47 |
| 146 | 40.898 | 106.958 | 0.85 | 50.61 | 14.659 | -8.81 | -9.33 | -25.25 | -24.76 |
| 147 | 40.909 | 106.952 | 0.68 | 47.29 | 22.997 | -8.44 | -8.37 | -23.45 | -23.06 |

Ground measurement was carried out under the soil temperature of 10.4 . And soil textures are composed of 8.27% clay, 40.44% sand, and 51.29% silt