Supplementary Materials for

Automated Reference Points Selection for InSAR Time Series Analysis on Segmented Wetlands

Boya Zhang, Erin Hestir, Zhang Yunjun, *Member, IEEE*, Matthew E. Reiter, Joshua H. Viers, Danica Schaffer-Smith, Kristin Sesser, Talib Oliver-Cabrera

Contents:

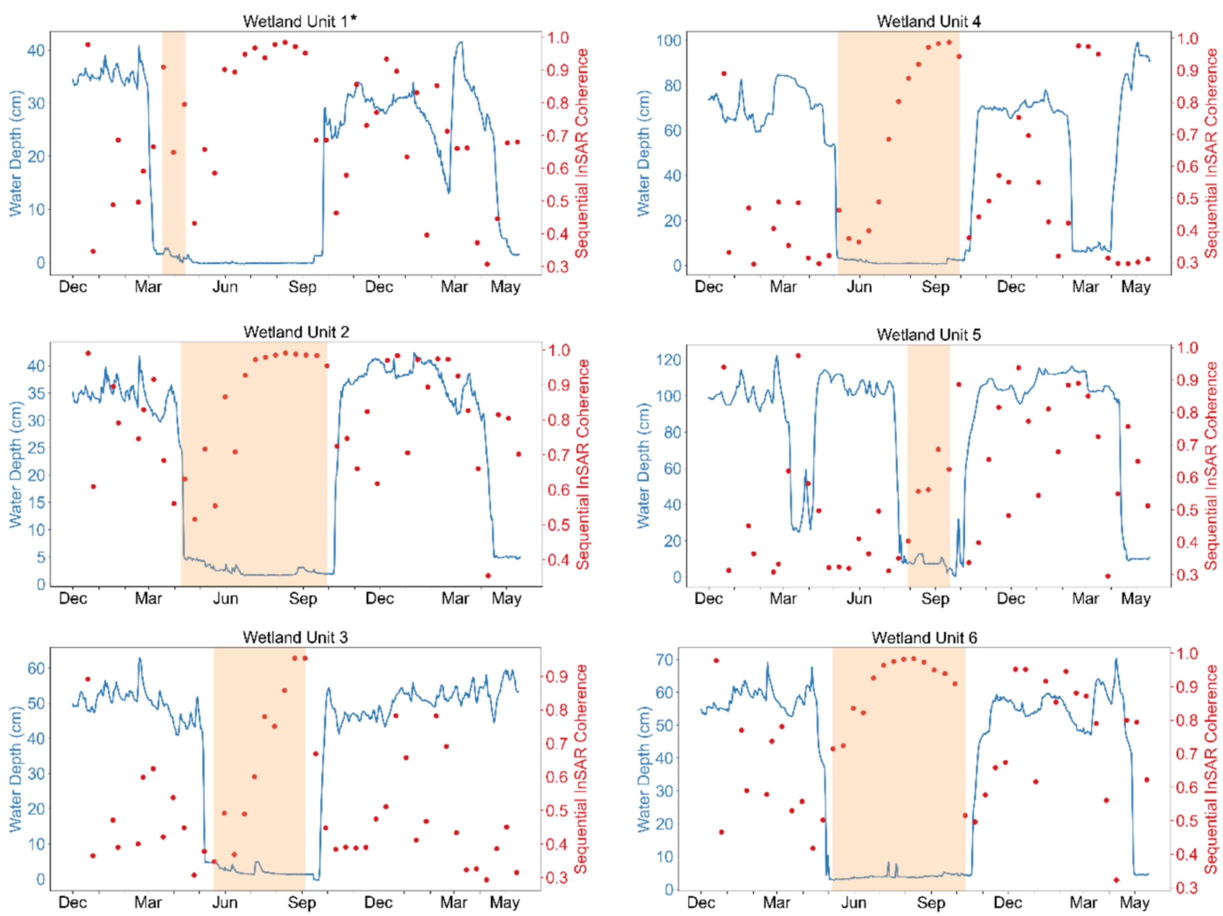

Fig. S1. The water depth and spatial-average InSAR coherence time series for all six wetland units. For each unit, the entire area was used to calculate the average coherence value (red dot). The shaded area is the period used for InSAR analysis with water depth below 10 cm. The only exception is Unit 1 with a shorter time series because some of the measured water depths were negative values, indicating invalid measurement values for the rest of the time series until September. Asterisk ('*') for wetland unit 1 indicates an extended time series is illustrated in Figure S3.

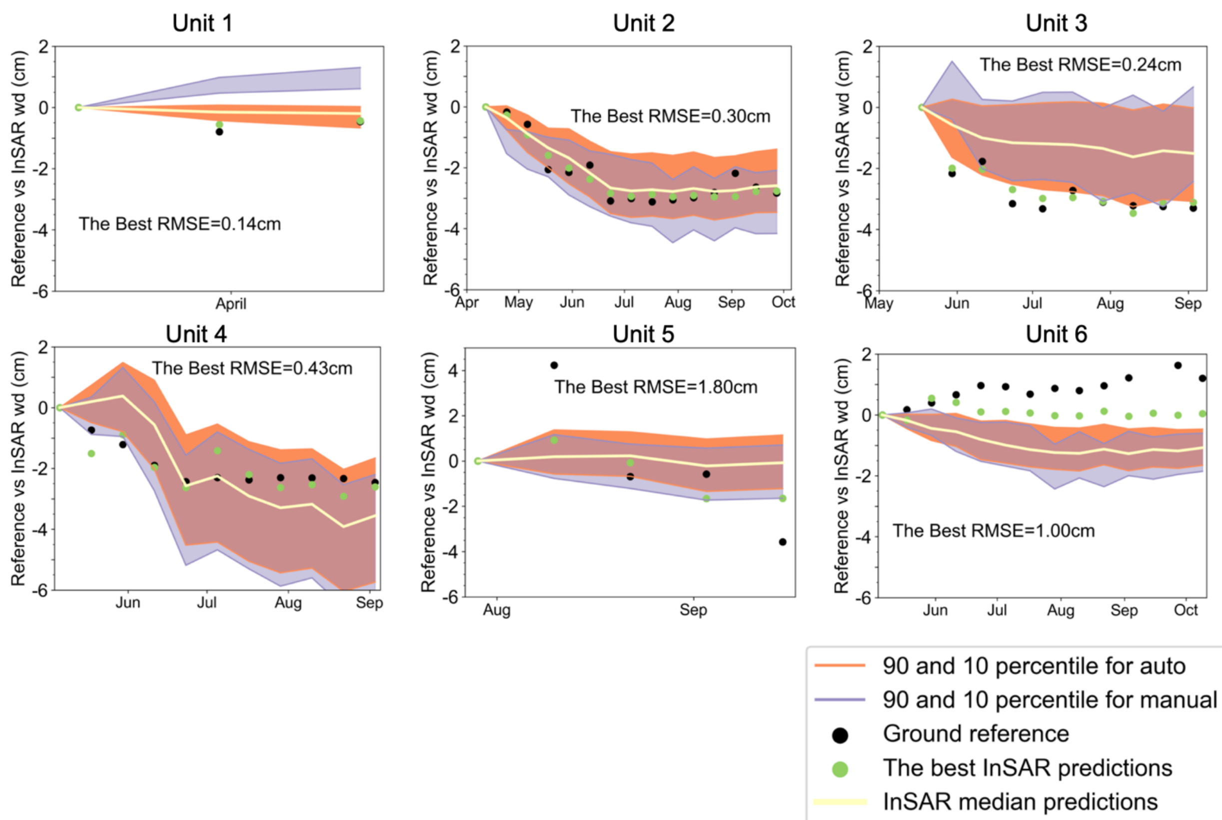

Fig. S2. Comparison of the InSAR RMSE uncertainty between automatic reference selection and manual reference selection. Orange and purple upper and lower lines were the 90% and 10% RMSE percentile for the entire wetland unit. The green dots are from the automatic reference selection method with the lowest RMSE. All units share the same y-axis scale for comparison, except Unit 5 because of its larger water depths variations. According to the InSAR and ground truth of water depths for Unit 5, there are rise and fall of water depths as much as 4 or 5 cm in early August. In this case, the errors of the estimated water depths are mostly due to the unwrapping errors, instead of the selection of reference point. Phase unwrapping requires a phase gradient < half cycle per pixel, i.e. the phase difference between adjacent pixel should be smaller than pi [15], which is 1.4 cm for C-band Sentinel-1. Given the relatively homogeneous water level change in the wetlands, the phase gradients are concentrated along the wetland boundary, which is only 1-2 pixels wide for unit 5. Then the max phase change InSAR can measure between two dates here is 2 * 1.4 = 2.8 cm, anything beyond that will results in unwrapping error. This paper focuses on reference point selection, which only minimizes unwrapping errors due to decorrelated targets, e.g. vegetations, which acts as an incoherence barrier between the reference point and the area of interest. However, we could not correct errors due to the large spatial phase gradients, as occurred along the wetland unit boundary.

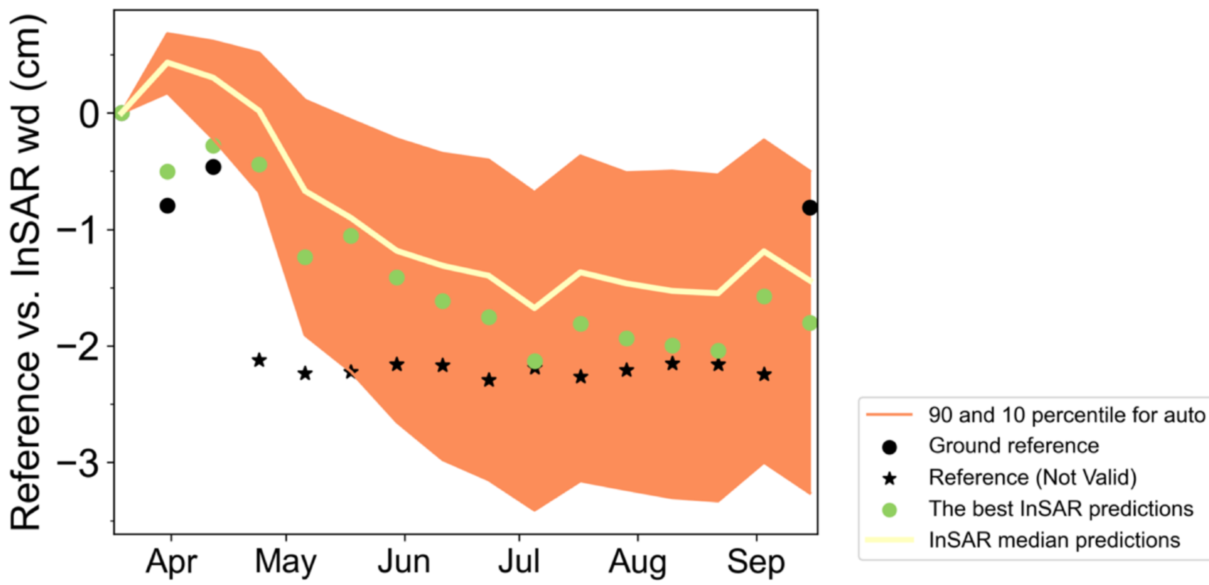

Fig. S3. The InSAR time series results for Unit 1 with an extended period. No results from the manual selection reference point because the manual reference is not located in any connected component and thus cannot be used as a reference.

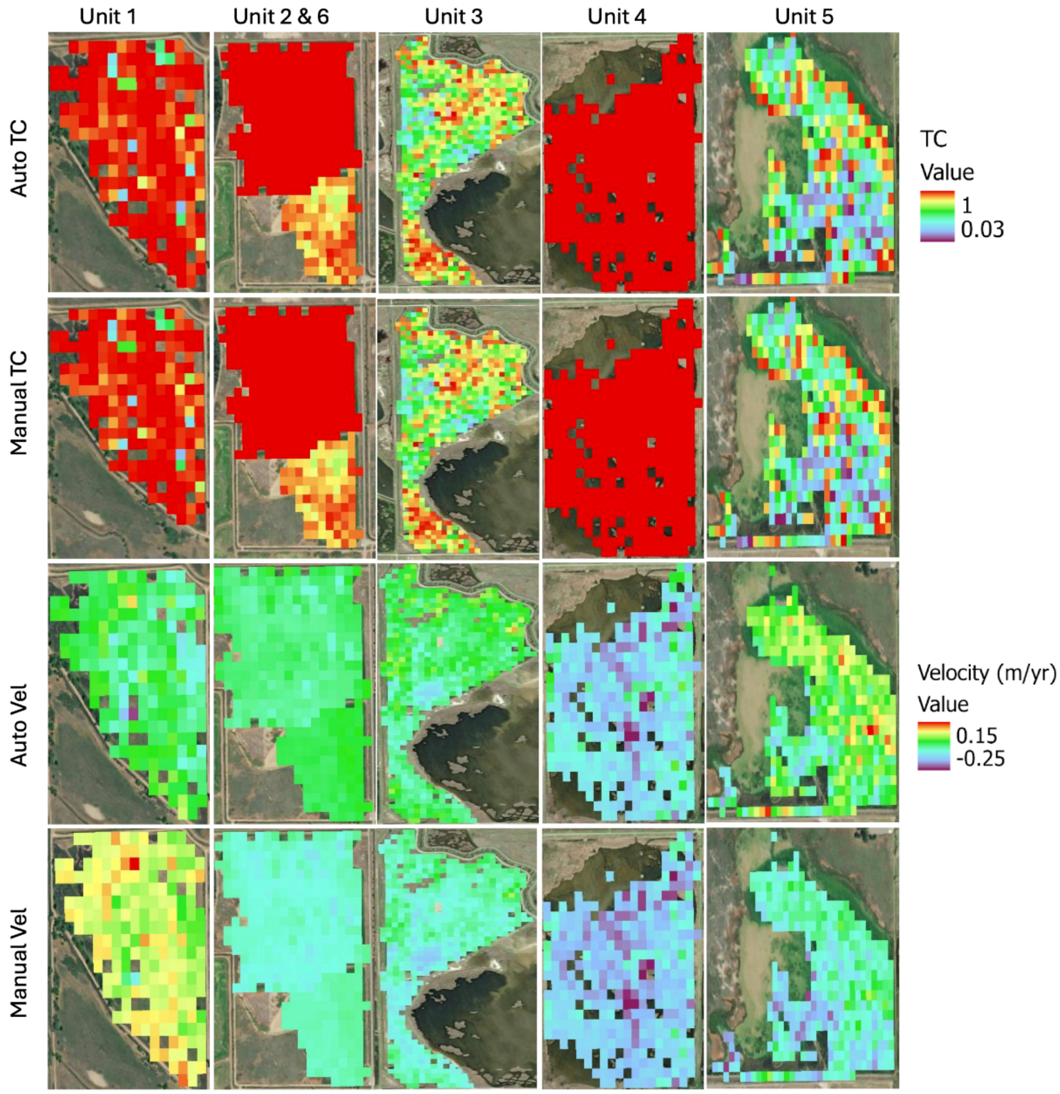

Fig. S4. The temporal coherence and water depth change velocity for all six units. The temporal coherence are very similar between automatic and manual points, but the velocity of water depth changes varies.

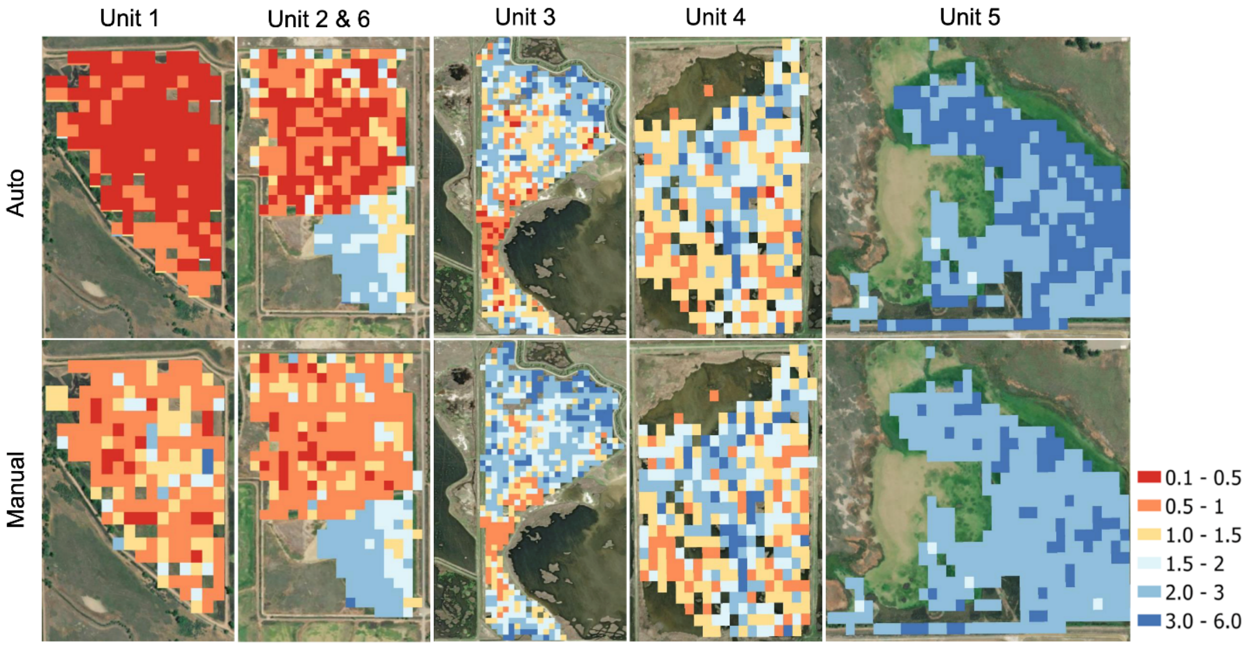

Fig. S5. The RMSE (cm) maps for all six units. The legend is the same as Figure 5 in the manuscript.

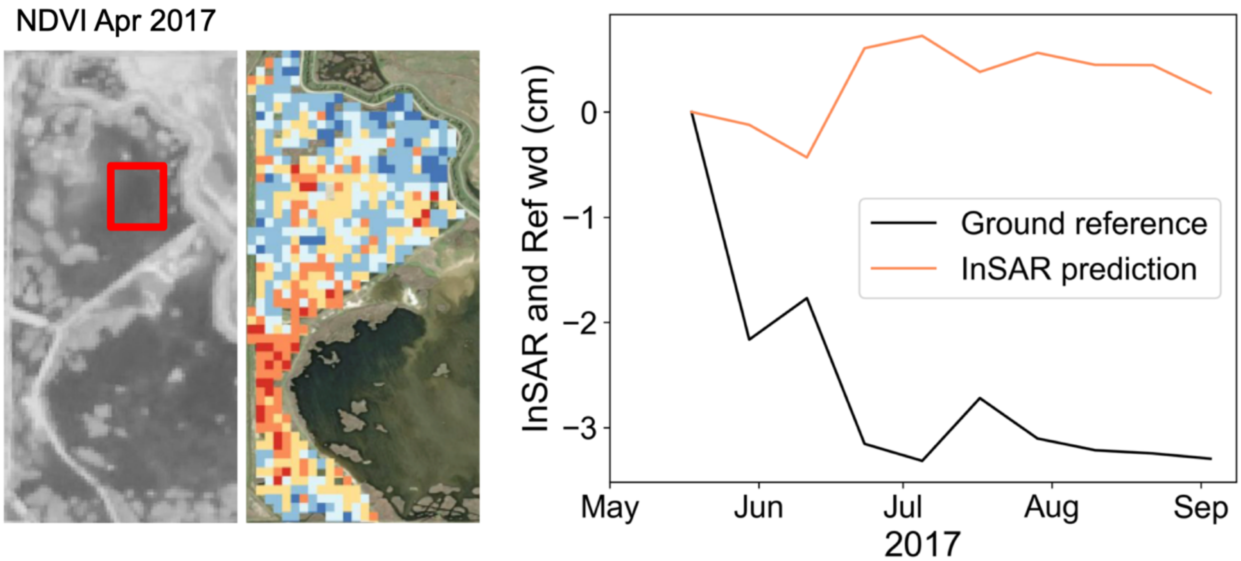

Fig. S6. Sentinel-2 Normalized Difference Vegetation Index (NDVI) for wetland unit 3 for April 20, 2017. The dark part in the red frame showed low NDVI value, which indicates mostly open water areas without much emergent vegetation. We selected April because NDVI is supposed to be high according to Zhang et al. [16] due to the growth season of vegetation. This water area corresponds to high-RMSE values and we select one pixel in this area to show the InSAR-derived water depths have large errors compared to the ground reference. The result of using a manually selected point has higher RMSE values, which are shown in Fig. S5.