remote sensing

MDPI

Supplementary Materials for

An Improved Gap-filling Method for Reconstructing Dense Time-series Images from LANDSAT 7 SLC-off Data

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Since the main manuscript is too long to include more pages, we provide the new experiment results only in the supplementary materials. We tested the three methods on two benchmark datasets, CIA [1] and Daxing [2], and the findings are in the supplementary materials. According to these validation results, the IROBOT method is more effective in image reconstruction than the Linear-ROBOT and IDW-ROBOT methods. Since these datasets do not include SLC-off data, we copied strips from SLC-off data, masked them in these datasets, and created simulated data to verify the results of the three methods. The results in the supplementary material are as follows:

Site A: The first study site is the Coleambally Irrigation Area (CIA), located in southern New South Wales (NSW, Australia; 145.0675°E, 34.0034°S). There are 11 pairs of Landsat 7 ETM+ and MOD09GA images obtained from the year 2002, covering an area of approximately 15 km × 15 km (500 × 500 pixels, 30 m spatial resolution). The true color composites are shown in Figure S1. The CIA site has a heterogeneous landscape consisting of many small parcels of rice croplands and woodlands. Strong temporal changes have taken place in this area, including phenological changes of the vegetations and land cover changes caused by agricultural activities. We use Landsat-MODIS time-series images of 10 dates in Figure S1 to reconstruct the image of January 11.

The reconstructed images are shown in Figure S2. Figure S2.(b) and Figure S2.(d) are very similar to Figure S2.(a), with the gap basically repaired. However, gap traces are noticeable in the output of the Linear-ROBOT method (Figure S2.(c)) due to poor interpolated results (Figure S3). Table S2 presents the accuracy of the reconstructed images from the three methods compared to the true image on January 11. The results indicate that the IROBOT method exhibits superior overall accuracy.

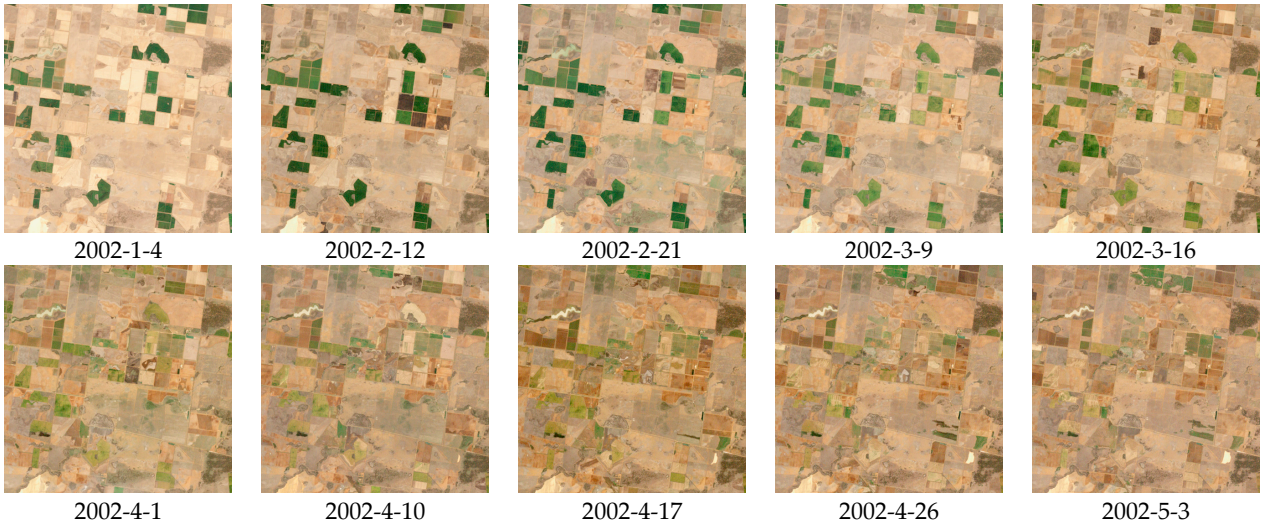


Figure S1. Landsat images in CIA.

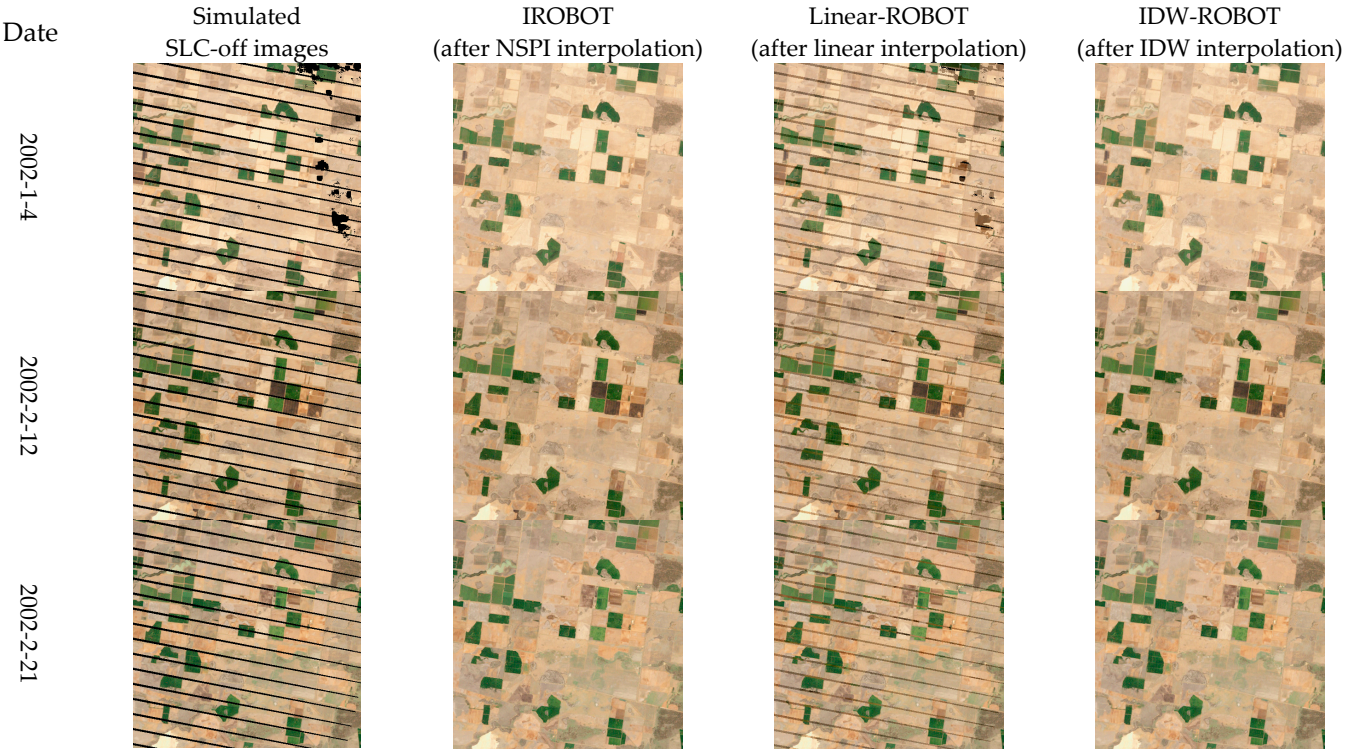


(**a**) (**b**) (**c**) (**d**)

Figure S2. Images on January 11, 2002. (**a**) The reference image. (**b**) The reconstructed image based on the IROBOT method. (**c**) The reconstructed image based on the Linear-ROBOT method. (**d**) The simulated gap image after gap filling based on the IDW-ROBOT method.

Table S1. The accuracy of three methods on January 11, 2002.

Evaluation Metrics	IROBOT				Linear-ROBOT				IDW-ROBOT			
	Blue	Green	Red	NIR	Blue	Green	Red	NIR	Blue	Green	Red	NIR
MAE	**6.9570**	**9.2501**	**15.3295**	**18.1744**	9.6394	15.5943	24.9013	33.2556	7.0585	9.5176	15.8053	18.6866
BIAS	3.8422	**1.3093**	**-0.3280**	2.8676	**-2.8538**	-7.1692	-10.5531	-14.9183	3.8040	1.2920	-0.3635	**2.7904**
CC	**0.9368**	**0.9375**	**0.9361**	**0.9250**	0.8533	0.8505	0.8600	0.7822	0.9334	0.9336	0.9323	0.9198
SSIM	**0.7903**	**0.8175**	**0.7879**	**0.8348**	0.5969	0.5953	0.5606	0.5628	0.7786	0.8037	0.7724	0.8208



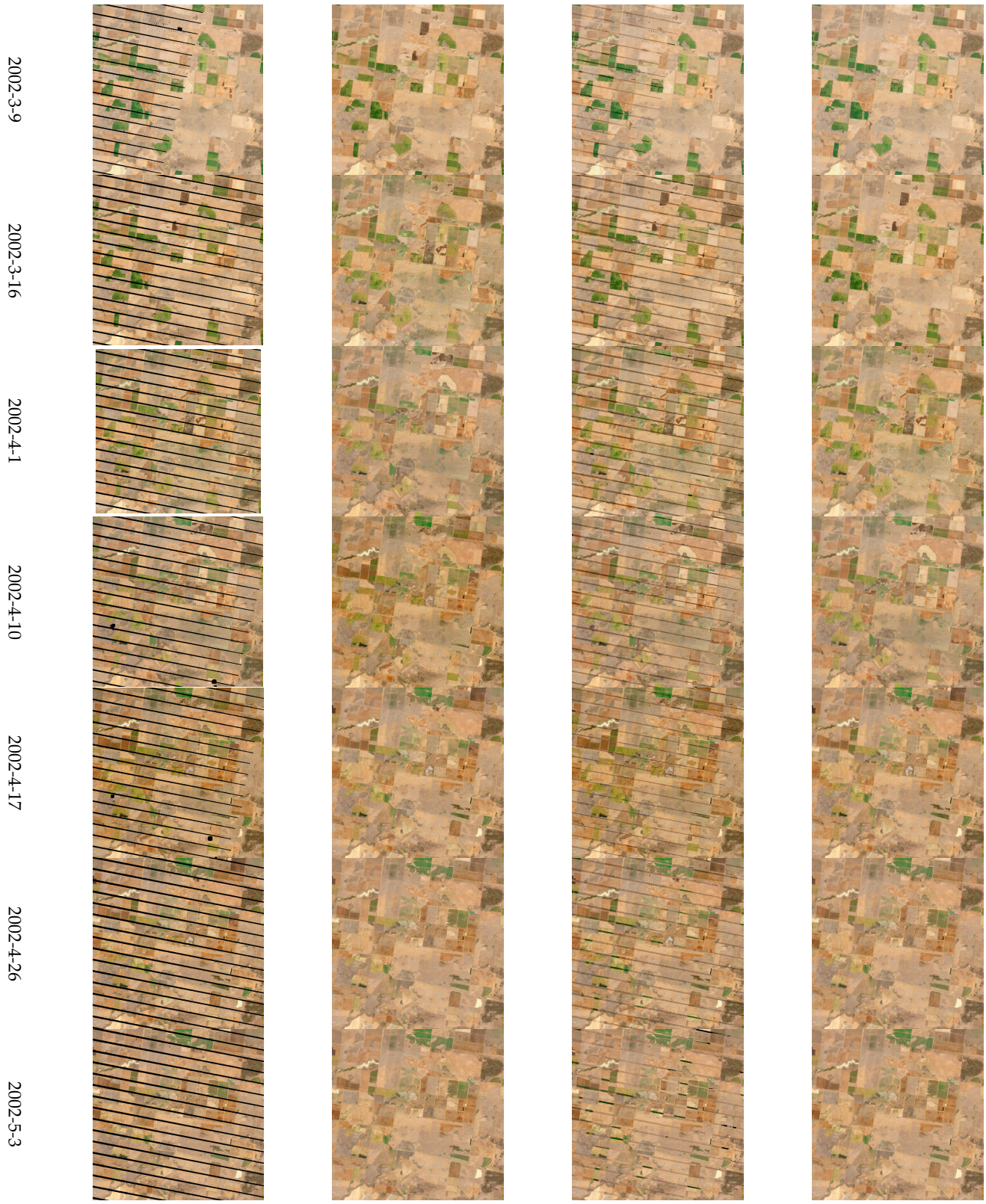


Figure S3. Images before and after gap filling in CIA.

Site B: The Daxing dataset includes 11 cloud-free Landsat-MODIS image pairs from September 2013 to May 2015, collected from the Daxing district (39.0009°N, 115.0986°E) located in the south of Beijing city. We clipped an area of roughly 15 km × 15 km (500 × 500 pixels, 30 m spatial resolution), and the true color composites are shown in Figure S4.

The Daxing dataset shows a clear phenological change and a gradual land cover change. We used 10 pairs of simulated Landsat and MODIS images to reconstruct the image on August 8, 2014. Figure S6 displays the input images before and after gap-filling. The reconstructed images are shown in Figure S5. It can be seen that the reconstructed images of the three methods are similar to Figure S5.(a), with the gap basically repaired. However, thin traces can be observed in Figure S5.(c). Table S2 presents the accuracy of the reconstructed images from the three methods compared to the true image on August 8. The IROBOT method achieves higher overall accuracy.

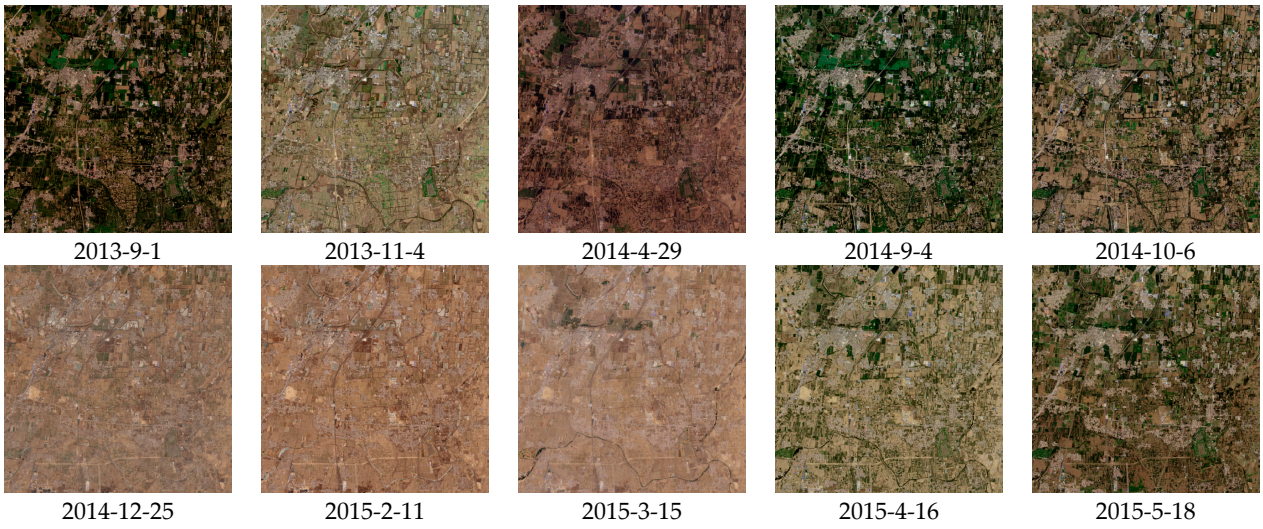


Figure S4. Landsat images in Daxing.



Figure S5. Images on August 8, 2014. (**a**) The true color image. (**b**) The reconstructed image based on the IROBOT method. (**c**) The reconstructed image based on the Linear-ROBOT method. (**d**) The reconstructed image based on the IDW-ROBOT method.

Table S2. The accuracy of three methods on August 8, 2014.

Evaluation Metrics	IROBOT				Linear-ROBOT				IDW-ROBOT			
	Blue	Green	Red	NIR	Blue	Green	Red	NIR	Blue	Green	Red	NIR
MAE	**2.1540**	**2.3693**	**3.1977**	**7.0839**	2.3290	2.7357	3.8432	11.0229	2.1685	2.3937	3.2582	7.3307
BIAS	0.6426	**0.4374**	0.6982	**-1.0615**	**0.5072**	0.0585	**0.4662**	-6.6301	0.6755	0.4641	0.7295	1.1106
CC	**0.8836**	**0.8833**	**0.8709**	**0.8821**	0.8502	0.8398	0.8200	0.7420	0.8804	0.8795	0.8662	0.8734
SSIM	**0.7791**	**0.7968**	**0.7677**	**0.7965**	0.7283	0.7411	0.6769	0.6502	0.7764	0.7926	0.7610	0.7808

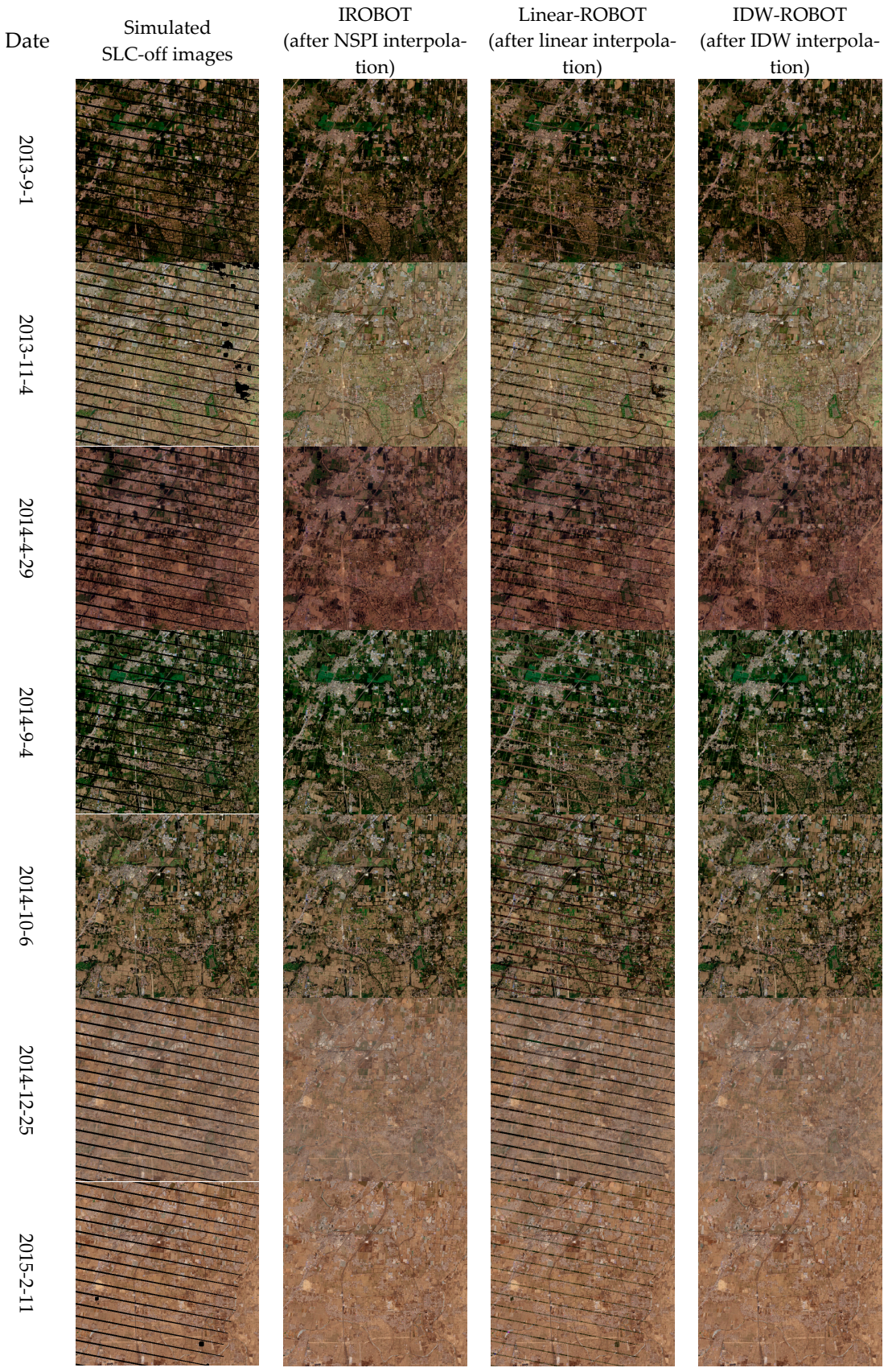

Date
Simulated SLC-off images
IROBOT (after NSPI interpolation)
Linear-ROBOT (after linear interpolation)
IDW-ROBOT (after IDW interpolation)
2013-9-1
2013-11-4
2014-4-29
2014-9-4
2014-10-6
2014-12-25
2015-2-11



Figure S6. Images before and after gap filling in Daxing.

References

[1] Emelyanova, I. V., McVicar, T. R., Van Niel, T. G., Li, L. T., & van Dijk, A. I. J. M. (2013). Assessing the accuracy of blending Landsat–MODIS surface reflectances in two landscapes with contrasting spatial and temporal dynamics: A framework for algorithm selection. Remote Sensing of Environment, 133, 193–209. https://doi.org/10.1016/j.rse.2013.02.007.

[2] Li, J., Li, Y., He, L., Chen, J., & Plaza, A. (2020). Spatio-temporal fusion for remote sensing data: an overview and new benchmark. Science China. Information Sciences, 63(4), 140301-. https://doi.org/10.1007/s11432-019-2785-y