science for a changing world

Assessing the Accuracy of Gap-Filled Land Surface Temperature Time Series for Surface Urban Heat Island Study

Hua Shi[1] and George Xian[2]

[1]ASRC Federal Data Solutions (AFDS), contractor to the U.S. Geological Survey (USGS), Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, U.S.A.
Work performed under USGS contract 140G0119C0001. hshi@contractor.usgs.gov. [2] USGS EROS Center, Sioux Falls, SD 57198, U.S.A.

paper number: B21E-2003

I. Introduction

The accuracy of Landsat gap-filled products was assessed using randomly selected clear observations of Landsat and uncertainty products from the gap-filling model and was evaluated using various existing temperature datasets (table 1). The result also suggests that the Gap-filled Landsat LST has significant correlations with existing datasets including field observation and remote sensing data derived from other sensors that have similar monthly and seasonal variation patterns. The uncertainty maps show spatial distributions of uncertainty for gap-filled pixels that have high or low uncertainties. The Landsat gap-filled time-series datasets can be used to measure annual, seasonal, or even monthly landscape thermal conditions, which are useful for SUHI and relevant research.

Table 1. Main data sources used in the study.

Data	Temporal	Spatial	Spectral Accuracy	Source
Landsat ARD LST Collections	7 days	30 m	~0.5 kelvin (vary by pixel (VP))	USGS
GHCN	Daily	points	NA	NOAA
MODIS LST	Weekly	1000 m	1.5~2.5 kelvin (VP)	NASA
VIIRS LST	Weekly	1000 m	1.5~2.5 kelvin (VP)	NASA
ECOSTRESS	Daily	70 m	~ 2-3 kelvin (VP)	NASA
DAYMET	Monthly	1000 m	NA	ORNL

II. Methods

This research was carried out through several steps. Reference datasets were collected from various existing sources with multiple spatial resolutions and temporal frequencies. For each date of the time series within selected years, reference temperature for each date was taken the same date (or as close as possible) as the gap-filled Landsat LST date. These reference datasets provided the basis for the accuracy estimates. The accuracy assessment was computed following protocols of consistent estimation required for a statistically rigorous analysis. The statistical parameters of R-Square (R^2) and Root Mean Square Error

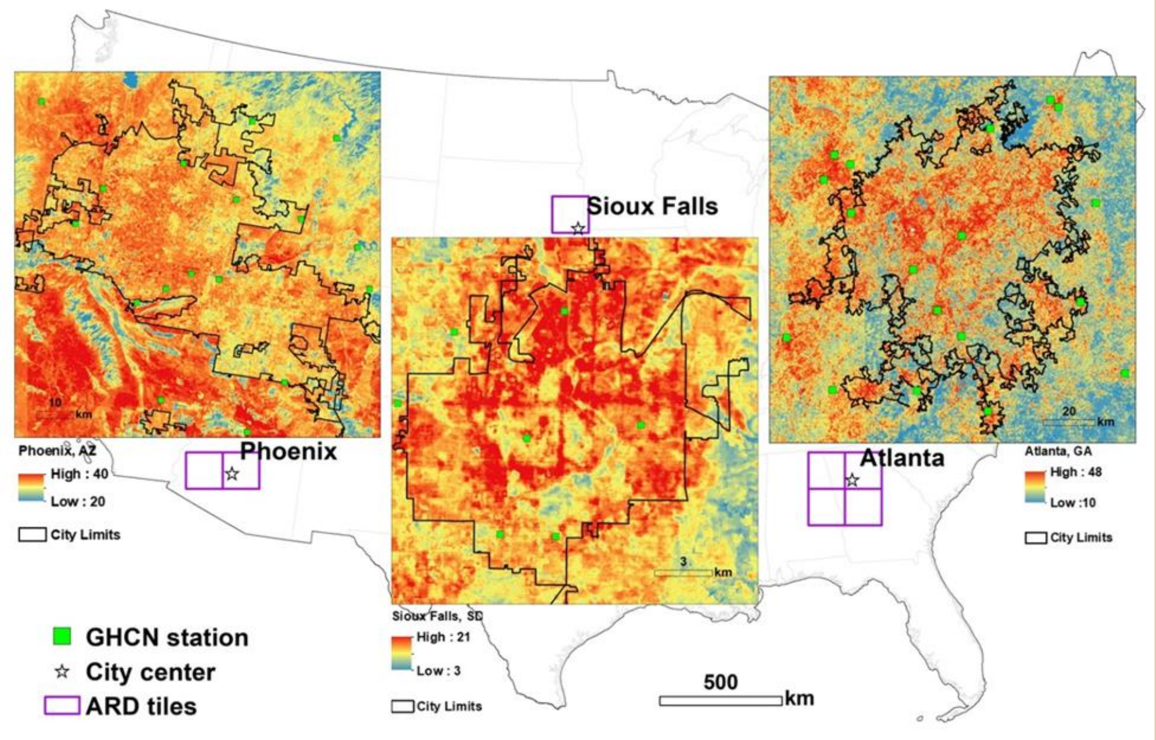

Figure 1. The study conducted in Atlanta, GA; Phoenix, AZ; and Sioux Falls, SD during selected years (1991, 2000, 2016 and 2020) demonstrated that the Landsat ARD gap-filled products can better differentiate the performances of the spatiotemporal gap filling model with improved training data strategy. These Landsat surface temperature images of individual cities are not at the same scale

II. Methods (Cont.)

(RMSE) were used. To analyze uncertainty that is from gap-filling models with input Landsat data and the uncertainty from comparison datasets, standard errors were estimated by gap-filling models and reported to quantify the uncertainty of the users, reference data, and overall accuracies. The results depended on the accuracy of NOAA GHCN observation data and other remote-sensing-derived LST.

III. Results and discussion

This section presents the summary of Landsat gap-filled ST, and the results of the accuracy assessment, uncertainty analysis, and comparison of existing remote-sensing-derived LST datasets. In parallel to the presentation of accuracy assessment results, we discuss the limitations of accuracy, uncertainty, and comparison between GHCN air temperature with different solution LST products due to spatial and temporal constraints.

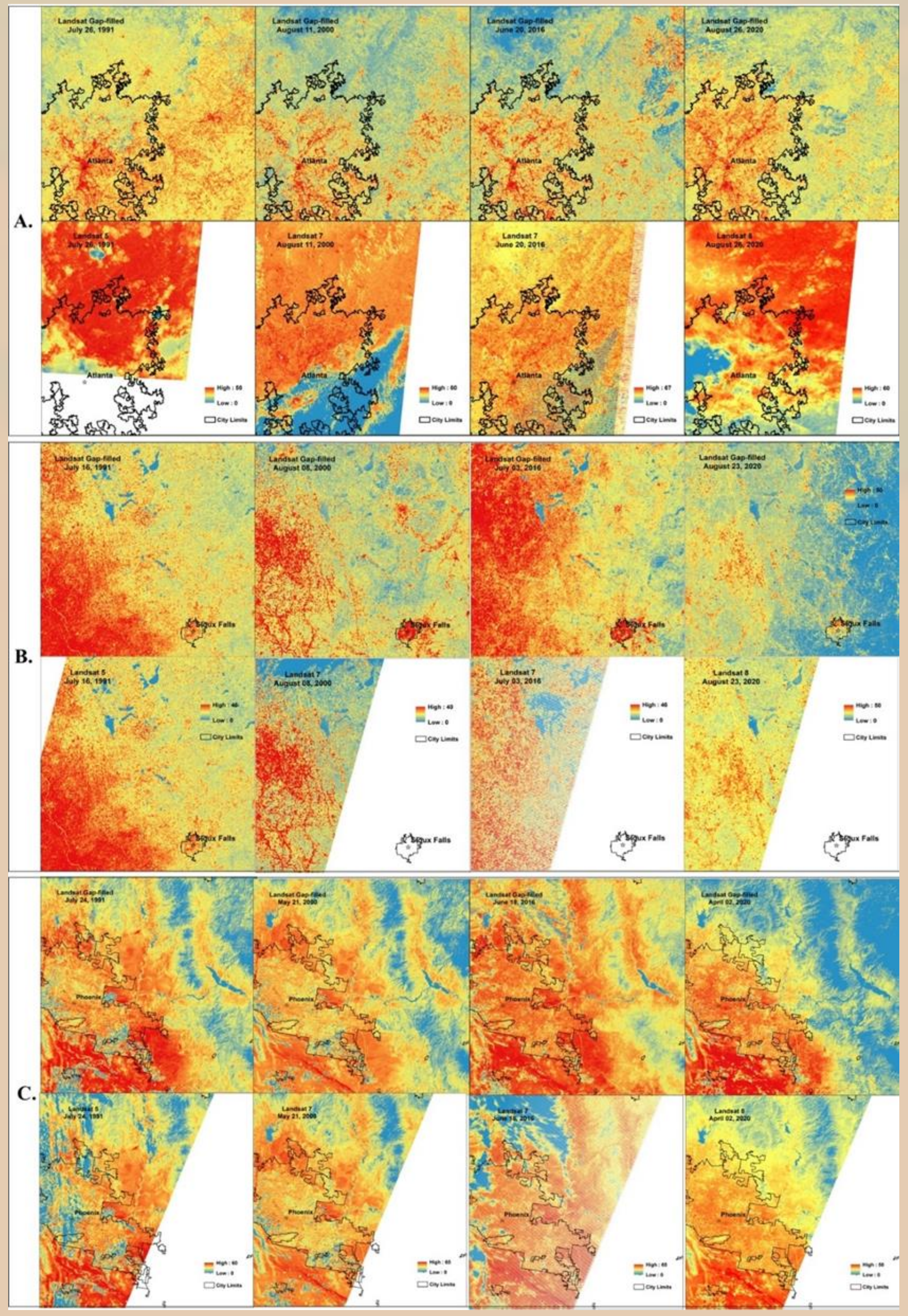

Figure 2. Gap-filled Landsat ST (top) and Original Landsat (5, 7, and 8) ST (bottom) in Atlanta (A), Sioux Falls (B), and Phoenix (C) in 1991, 2000, 2016 and 2020.

III. Results and Discussion (Cont.)

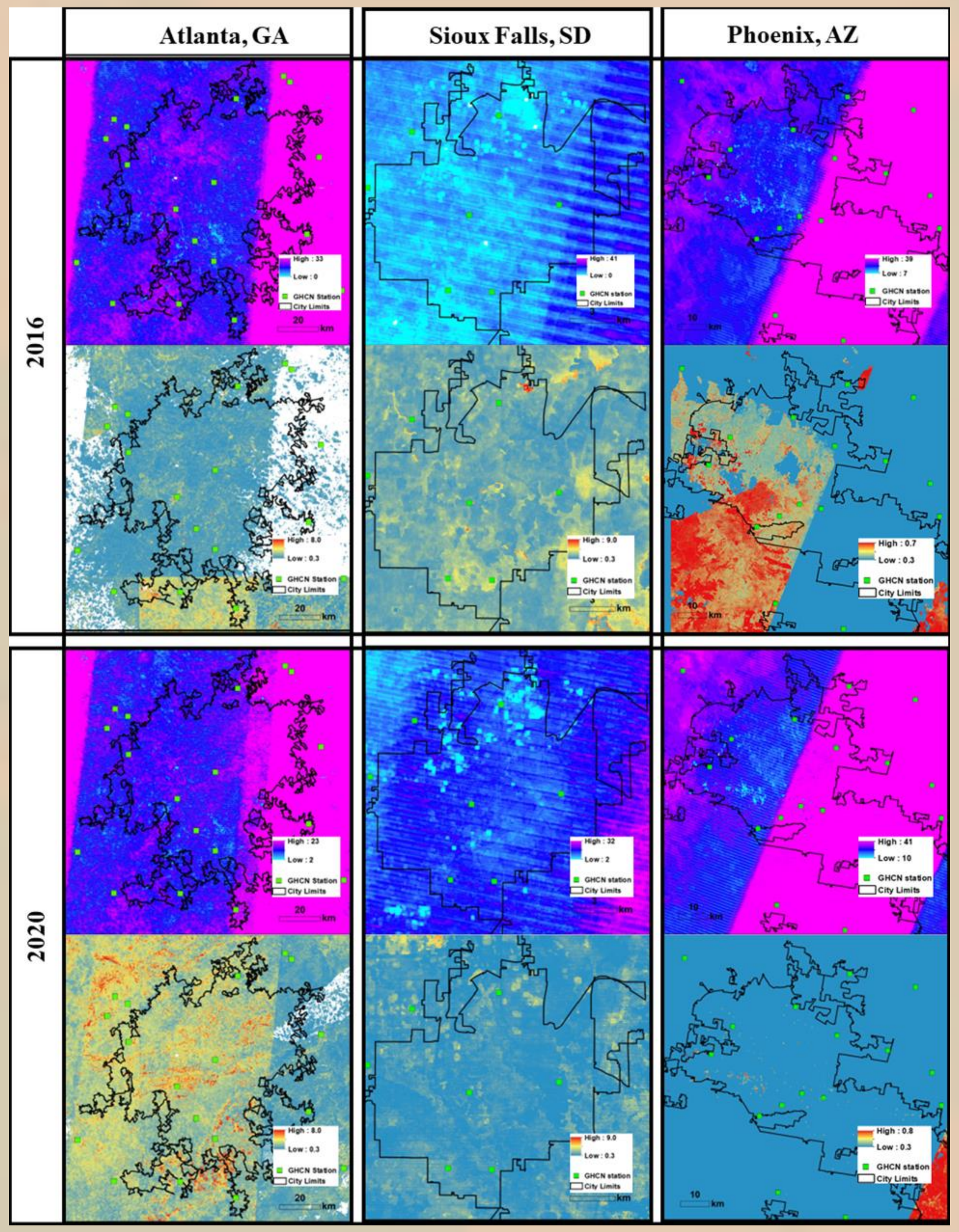

Figure 3. Annual clear observation (top) and annual mean of gap-filled uncertainty (bottom). The gap-filled uncertainty was calculated by one standard deviation.

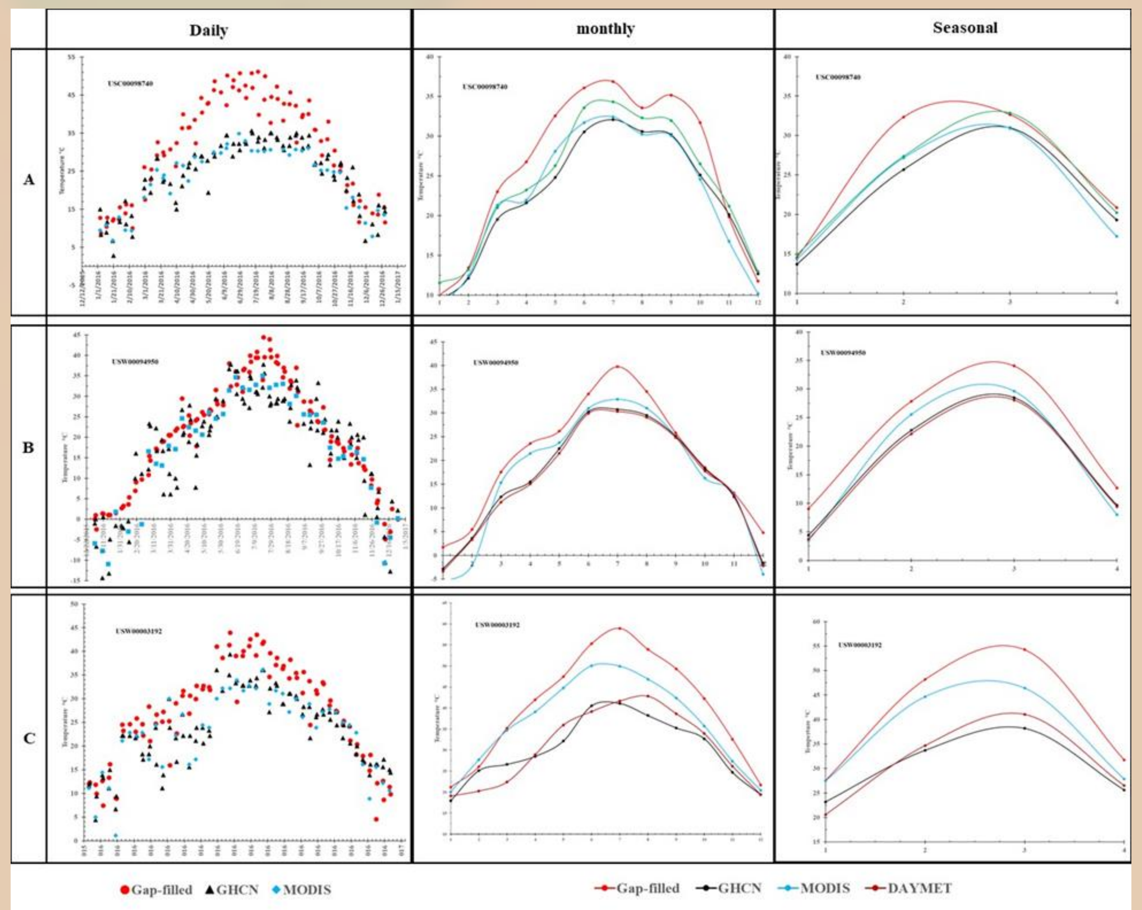

Figure 4. Comparison among Landsat gap-filled, GHCN, MODIS, and DAYMET 2016 data for three selected GHCN stations from Atlanta, GA, Sioux Falls, SD, and Phoenix, AZ

III. Results and Discussion

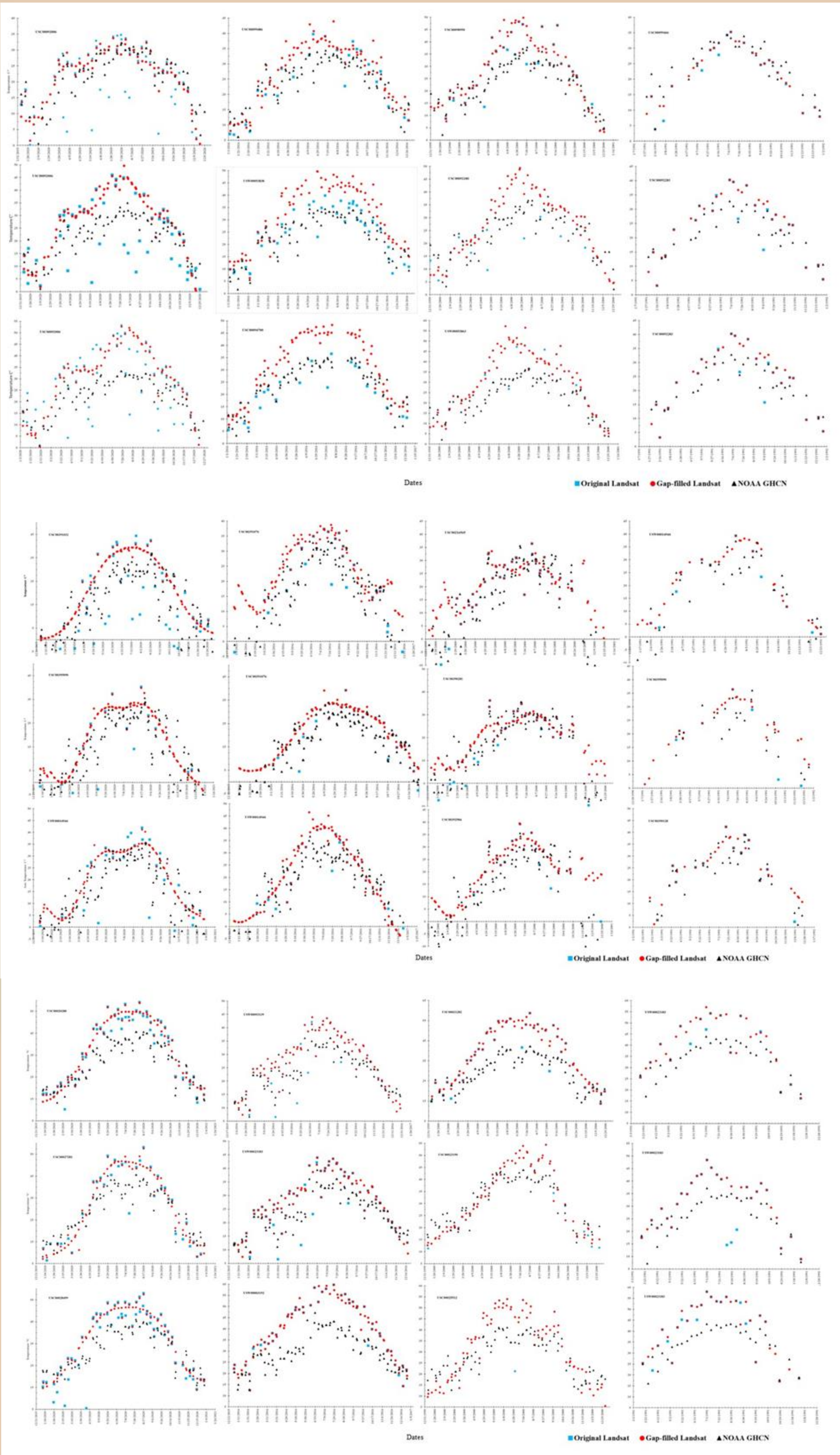

Figure 3. Time series of land surface temperature and air temperature at 12 stations in three study areas: Atlanta (top), Sioux Falls (middle), and Phoenix (bottom).

VI. Conclusion

The Landsat ST with gap-filling substantially added temporal density for monthly Landsat ST records. The gap-filled Landsat ST has significant correlations with air temperature recorded from gridded weather records, suggesting similar monthly and seasonal variation patterns between the two datasets. The uncertainty maps show spatial distributions of uncertainty for gap-filled pixels that have high or low uncertainties. Using gap-filled Landsat ST data allows us to perform multi-decade time series Landsat ST change analysis consistently.