Geospatial Imagery Analysis: Applications - Time Series

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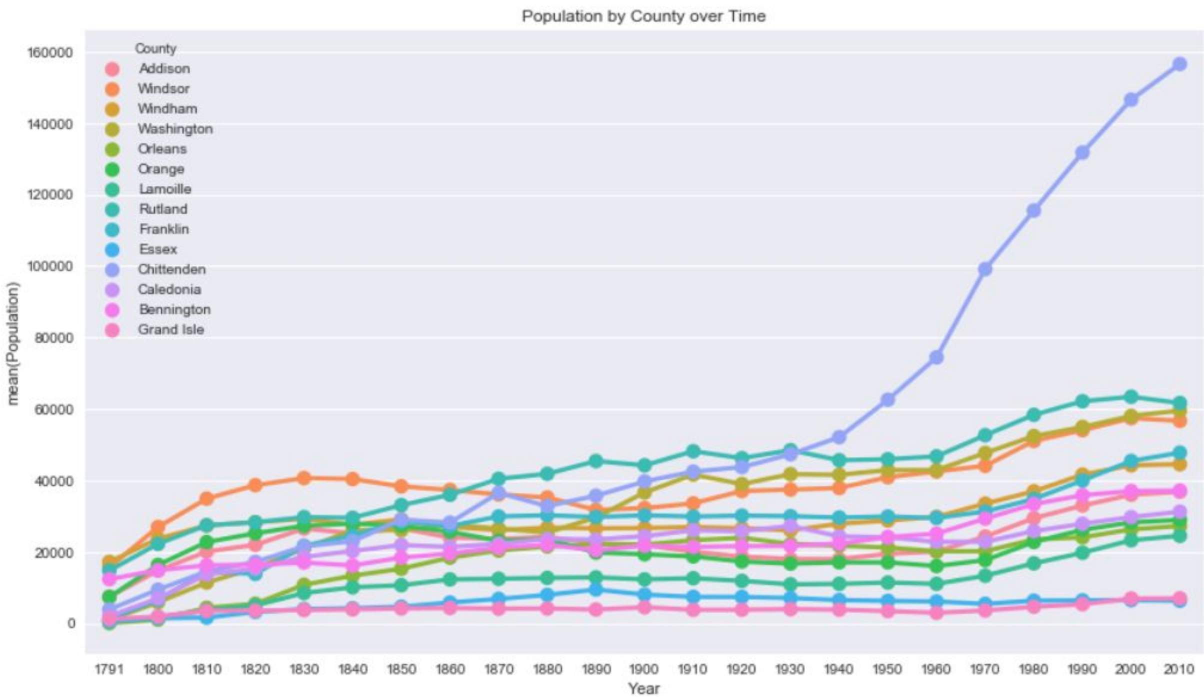
Outline

- Geospatial Imagery Analysis: Applications - Time Series
  - Intro: Time Series Data
  - Using Time Series Data in GIS Application
- Paper: Geospatial Imagery Analysis: Applications - Time Series
  - Methods & its problems - used for Landset-Like image
  - Proposed Spatial-Unmixing Method - STRUM
  - Problem in STRUM & How to fix it
- ISTRUM
- Experiments and Conclusion

What's Time Series Data?

A set of observations on the values that a variable takes at different times

Component: Repeats, Trends, Cycles



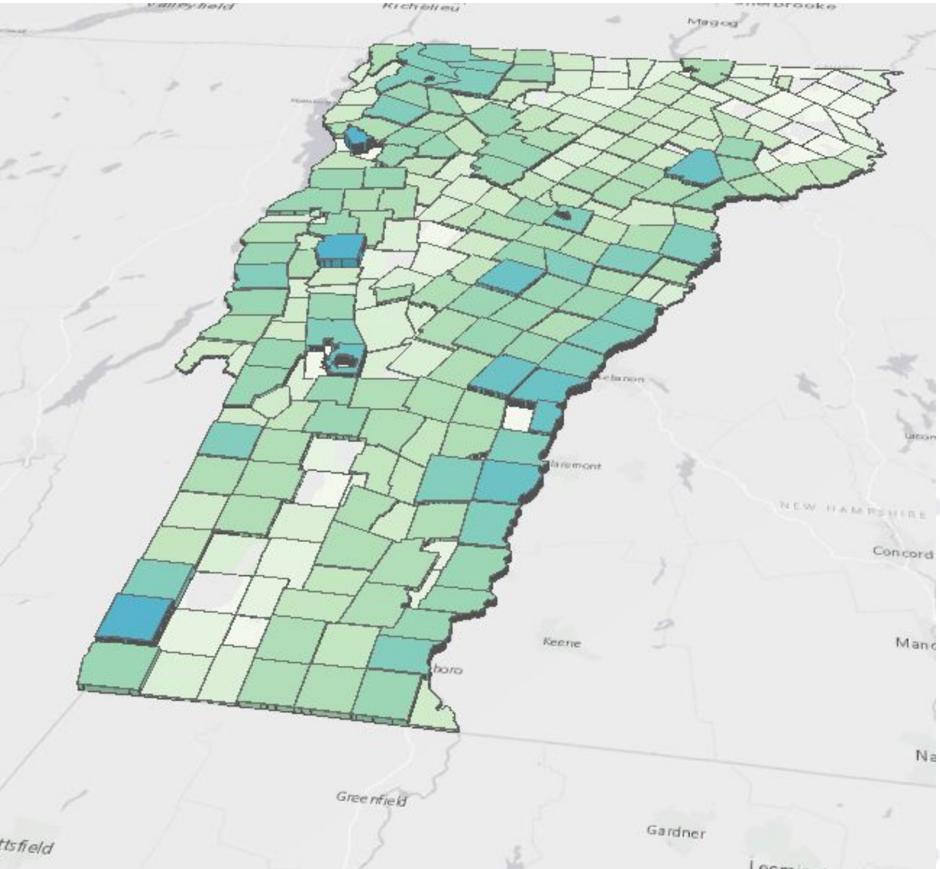
As basic as: Understanding the population change over time

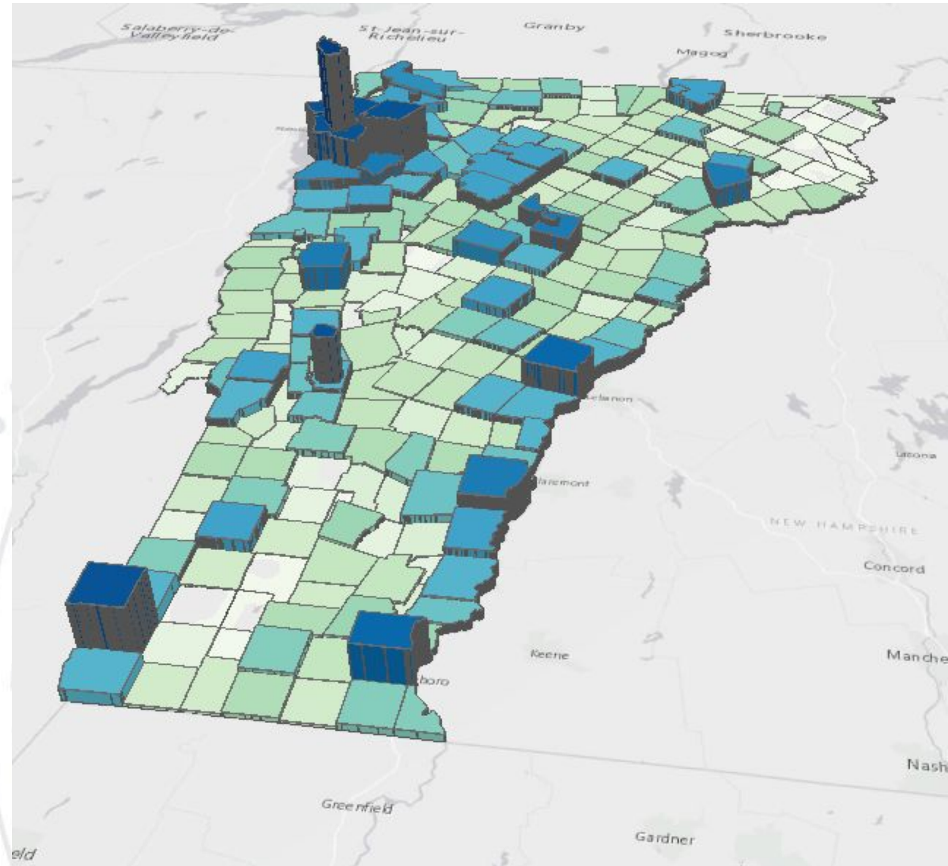
Geospatial Analysis: Time Series

For geographic understanding, GIS uses this time series data for representation

Defined by Points, Lines, Polygons

Layered level representation between time interval





Vermont in 1820 on the left, and Vermont in 2000 on the right

An Improved Spatial and Temporal Reflectance Unmixing Model to Synthesize Time Series of Landsat-Like Images

Jianhang Ma, Wenjuan Zhang, Andrea Marinoni, Lianru Gao and Bing Zhang

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Understanding the title of the paper

Spatial and Temporal Reflectance Unmixing Model

Model that divides endmembers (say image made up of range of compositions) of known size that are geospatial data that represents a state of time (reflects).

- *Lets name such model as 'M'.*

Using 'M' to Synthesize Time Series of Landsat-Like Images

Combining satellite monitored images of earth resources of different state of time using model 'M' for gathering accurate information

- *Lets name such use of gathering info as 'X'.*

Title : An Improved model 'M' to be used for 'X'

Types of spatiotemporal image fusion Methods for use of ‘X’

- **Weight function - pixel value estimated by weighing information of surroundings pixel**
  Describes more clear spatial details but does not consider mixture of bigger pixel (rough; coarse)
- **Learning Method -**
  Based on sample data, and has significant dependency of accuracy on it.
  spatiotemporal image-fusion: learning method - coarse-resolution image that learns from image at base time and fix with prediction time image
- **Spatial-Unmixing Method -** *Does model ‘M’ uses this method ?-- Do you remember ‘M’ ?*

Types of spatiotemporal image fusion Methods for use of 'X'

Okay, it's not exactly the same. But Name says it all.

Few more methods ...

- **Spectra-Unmixing Method -** opposite of method used in 'M' - Unknown size, abundance but known spectrum, color, compositions

- **Bayesian based Method -** *(nope, Thomas Bayes won't ever leave you.......)*
  Make use of multivariate arguments and assumptions on it. *Yes, this is the problem.*

Hybrid fusion Method- Combines two prediction methods

Every method misses the temporal change of image or whatever... and its not worth ignoring...

Spatial and Temporal Reflectance Unmixing Model

Zurita-Milla et al. [6], Gevaert and García-Haro

YESSS.. We knew it from beginning.. our model 'M' ---> STRUM

STRUM first **calculates** a coarse-resolution **temporal change** image by **subtracting** coarse-resolution image on **base time** from the image on **prediction time**.

Then, the difference image is **disaggregated** by **spatial-unmixing** to **combine** the fine-resolution temporal change image, which is further **added** to **Landsat image** on base time to combine Landsat-like image on prediction time.

AND therefore, the resulted image inherits spectral variability and spatial details both from Landsat image on base time......

STRUM is still STRUM and title says:

Title : An Improved model 'M' to be used for 'X'

DID YOU GOT IT?? .. Something is still missing… its not IMPROVED … 'DUH'

Classification image is applied in **spatial-unmixing process**, the temporal change image in STRUM still **lacks intra-class** spectral variability and spatial details.

Because of the **heterogeneity** of land surface is needed, and result landsat pixel has more than one land **covered** by one type land

In STRUM, the derived temporal change image based on coarse-resolution image is **directly added** to Landsat image.

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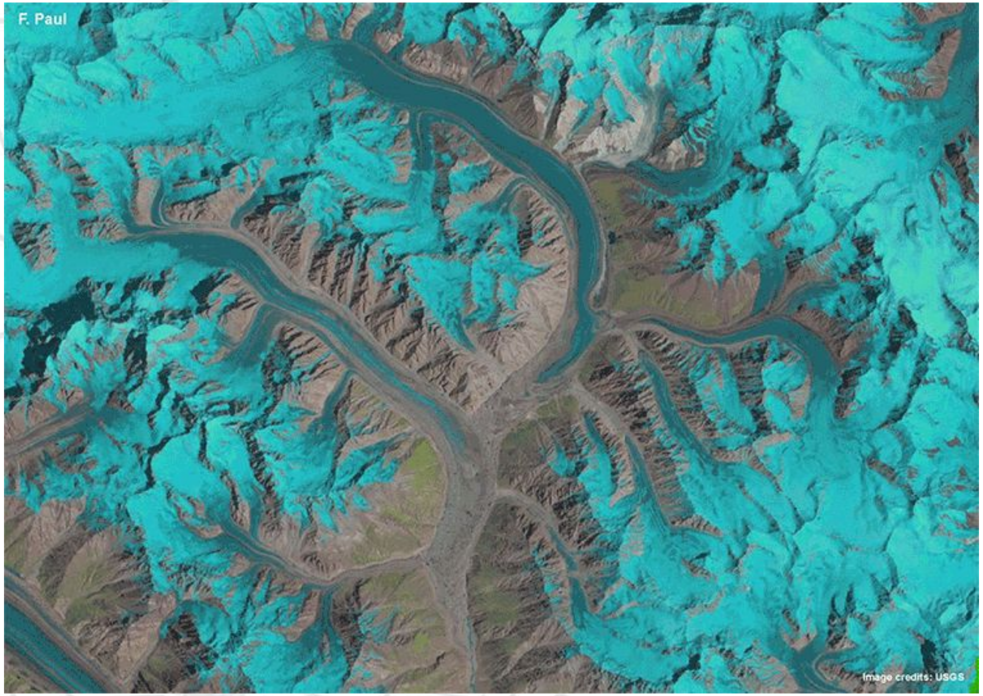
YASH, now you have to "Improve" it…

IMPROVED **STRUM**

Landsat time series Visualization



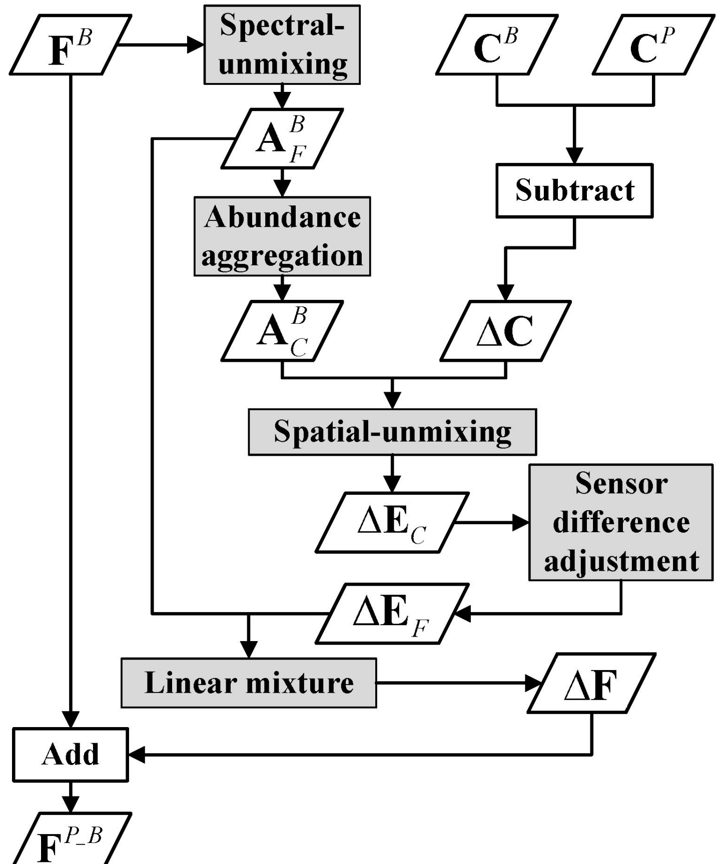
Problems with STRUM

The heterogeneity of land surface, more than one land cover types can exist in both Landsat pixels (e.g., 30 m × 30 m) and coarse pixels (e.g., 500 m × 500 m).

STRUM does not account for multiple land cover types in one pixel.

In STRUM, ΔEF is directly assigned to fine pixels with same class type according to a fine class image. However, ΔEF is linearly mixed with ABF in ISTRUM.

ISTRUM Implementation



Spectral Unmixing

Spectral-unmixing is the first step applied to F_B to obtain A_{BF} which is further used to calculate ABC.

Spectra of endmembers (i.e., E_{BF}) are extracted from F_B.

Principal Component Analysis (PCA) to F_B, and then selects pure pixels by analyzing the mixing space of the first three primary components.

The approach generally selects a suite of pure pixels for each endmember and mean spectra are used in spectral-unmixing.

Abundance Aggregation

A_{BC} is calculated with A_{BF} in this process.

If an endmember abundance is low in a coarse pixel, its errors in spatial-unmixing may be large.

Therefore, if the abundance of endmember *m* is $0<A_{BC}[ic,jc,m]<th_A$, it is merged to its spectrally most similar class whose abundance should also be greater than 0.

Sensor Difference Adjustment

Sensor difference is adjusted to obtain ΔEF from ΔEC.. The coefficient al is calculated with FB and CB. FB is firstly aggregated to coarse-resolution image FBa by averaging the band values of fine pixels that fall in an individual coarse pixel.

Then, al[b] is computed by linear regression with FBa[∗,∗,b] as dependent variable and FC[∗,∗,b] as independent variable.

Linear Mixing

The ΔEF is linearly mixed with A_{BF} to reconstruct ΔF. The mixture is only applied to fine pixels ([kic,kjc]) falling in the center coarse pixel [ic,jc] of the currently selected sliding-window. Because ΔEF represents the reflectance change of endmembers in the sliding-window.

The spatial-unmixing and linear mixture processes are performed pixel-by-pixel for each band of ΔC. When all the pixels of ΔC are processed, image ΔF is obtained and the Landsat-like image FPB predicted by one L-C pair is finally calculated by

FP_B=FB+ΔF

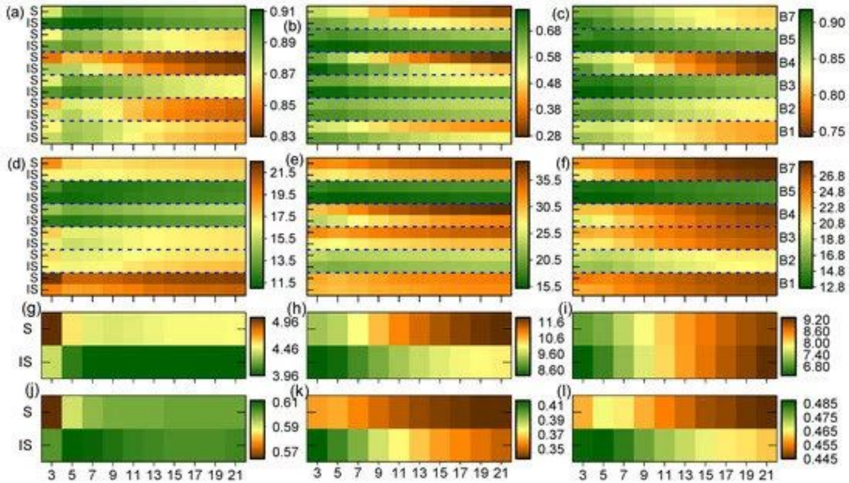
Experimental Results

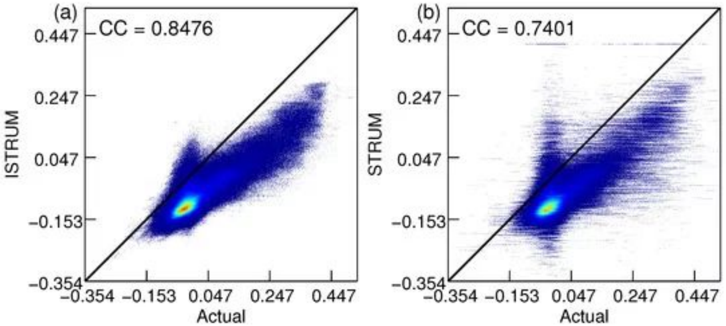
a. All three improvements contribute to improving performance of ISTRUM when compared with STRUM. ISTRUM is robust to endmember variability, and the spectra of Global SVD endmembers could be directly applied. Sliding-window size is the only parameter that needs to be defined by the user and decreases the accuracy of ISTRUM when it is large.

b. The selection of L-C image pair plays a significant role in the fusion methods. Accuracy is improved when the L-C image pair is strongly correlated with the image on prediction date.

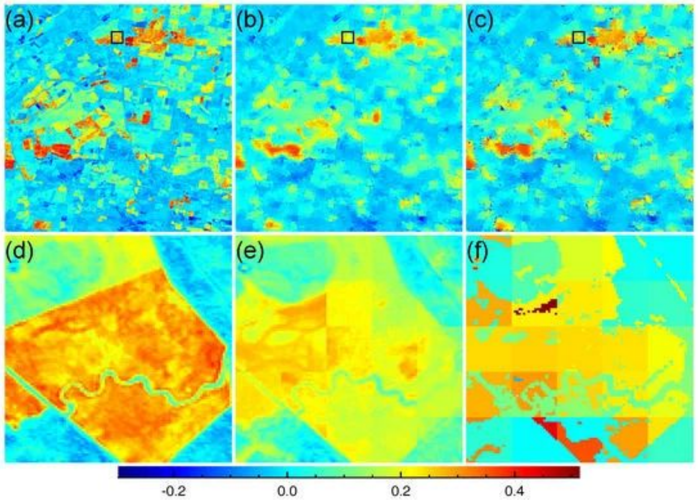
c. Performance of the fusion methods are different under different conditions. Selecting and combining different methods according to the conditions is meaningful in application. ISTRUM is an easy-to-use and efficient alternative to synthesize time series of Landsat-like images on a global scale.

Accuracy of STRUM and ISTRUM





Images generated



Comparison between actual and derived ΔF of B4: (**a**) actual ΔF; (**b**) ΔF derived by ISTRUM; and (**c**) ΔF derived by STRUM. The 100 × 100 pixels in the black square of (**a**–**c**) are enlarged and shown in (**d**–**f**), respectively.

Conclusion

To tackle the shortcomings of STRUM, this study proposed ISTRUM to improve STRUM from three aspects:

(1) apply fine-resolution abundance image rather than hard-classification image in the spatial-unmixing process

(2) adjust sensor difference between fine- and coarse-resolution images

(3) strengthen the applicability when multiple L-C image pairs are utilized

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We know photos look different than real but still, any QUESTIONS ????

THANK YOU