Assessment of High Resolution Commercial Satellite Geolocation Accuracy

Alana G. Semple[1,2], Bin Tan[1,2], and Guoqing (Gary) Lin[1]

[1] NASA Goddard Space Flight Center, Greenbelt, MD, USA. [2] Science Systems and Applications, Inc., MD, USA.

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Introduction

NASA's Commercial Smallsat Data Acquisition (CSDA) Program was established to identify, evaluate, and acquire data from commercial sources that support NASA's Earth science research and application goals. These data augment and/or compliment the suite of Earth observations acquired by NASA and other U.S. government agencies and those by international partners and agencies.

Image data from a commercial satellite company, "Planet" (PS), are available for U.S. Government Federal civil agencies and National Science Foundation funded researchers. As the capabilities of commercial satellite vendors grow, NASA's Earth Sciences Division will continuously monitor the development of these companies.

Here, we evaluate geolocation accuracy and stability of two of Planet's newer satellite generations, SuperDove and Dove-R. Both have a resolution of 3m.

Information about these vendors, user licenses, and data is available on the Commercial Datasets web page [1]. As additional commercial small satellite datasets are evaluated and acquired, those datasets will also be made available.

Objectives

- Calculate relative geolocation offsets for SuperDove and Dove-R series images.
- Evaluate spatial stability in SuperDove and Dove-R geolocation accuracy.
- Evaluate temporal stability in SuperDove geolocation accuracy.

Methods

Step 1. Split reference WorldView (WV) and PS image into subset image chips and resample to a common resolution. Chips are 350 m x 350 m.

SuperDove image taken Jan 2, 2022 over San Diego, CA. White lines overlaying image represent chip boundaries.

Step 2. Impose offsets on matching chip pairs to find best Pearson Cross Correlation (PCC) value.

False color image overlaying PS (blue) and WV (red) chips at Albuquerque, NM, USA. Red and blue colors show geolocation offsets between the images.

Step 3. Calculate a metric for quality of image match[2]. Chips are evaluated with determined offsets removed.

$$\text{Match Quality}_x = \frac{1}{PkSh_x}\sqrt{1-z_{pk}^2}\;\frac{D}{NM}\frac{1}{2}\left(\frac{1}{c_1}+\frac{1}{c_2}\right)$$

$PkSh_x$: Peak sharpness

N and M : image dimensions

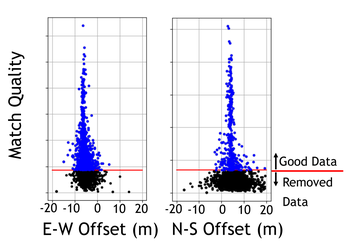
z_{pk} : refined *PCC*

c_1 & c_2: normalized contrast of two images

D: normalized contrast difference at overlap region

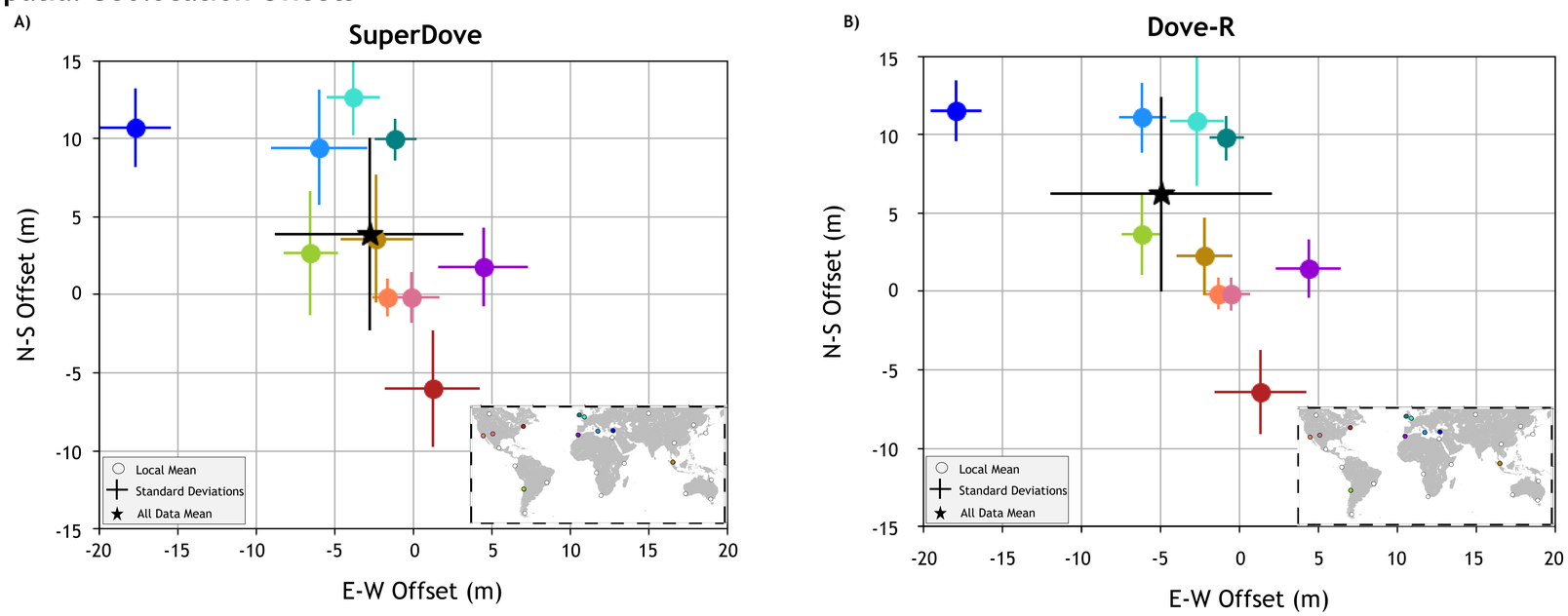
Step 4. Filter out poor quality chip matches from final assessment by approximating a gaussian fit to the data and filtering based on the derivative.

	Before Filtering		After Filtering	
	EW	NS	EW	NS
μ (m)	-8.27	-2.77	-7.52	0.16
σ (m)	4.00	8.32	1.89	7.75



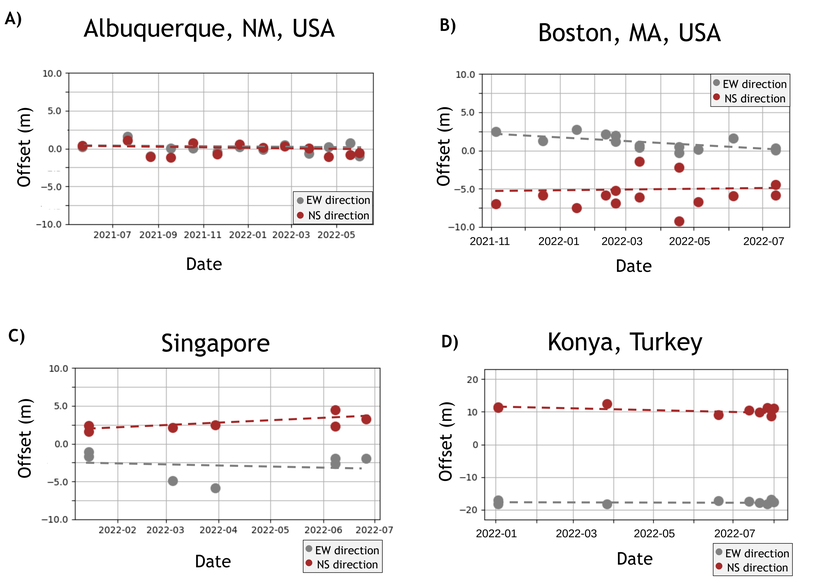
Questions? Email Alana Semple at alana.g.semple@nasa.gov

Spatial Geolocation Offsets



Map views of SuperDove (A) and Dove-R (B) series mean NS-EW offsets. Local cities (circles) and all data analyzed, (star) are plotted. Colors here correspond to colored locations in the inset map. White circles in the inset mark sites of future analysis.

SuperDove Temporal Stability



Time vs. mean geolocation offsets for each PS image analyzed at a location. Gray dots show the E-W offsets, brown dots show N-S offsets. Locations where time series were analyzed are A) Albuquerque, NM (12 mo.); B) Boston, MA (9 mo.); C) Singapore (7 mo.); and D) Konya, Turkey (8 mo.)

Results

SuperDove series geolocation accuracy

Geolocation offsets vary locally from the global mean. Albuquerque, NM in USA performs the best, while Konya, Turkey preforms the poorest. Standard deviations in the local data tend to be on the order of 1.5 pixels or less, while global are 2 pixels

Dove-R series geolocation accuracy

Locally, geolocation accuracy for the Dove-R series preforms similarly to that of the SuperDove series. Standard deviations in the local data tend to be on the order of 1.5 pixels or less. Standard deviations in the global data are slightly larger than 2 pixels.

SuperDove Series Temporal Stability

Albuquerque, NM, USA has the best temporal stability of the locations examined. Variations in mean offsets are in the sub-pixel range for both E-W and N-S directions.

Boston, MA, USA has the poorest temporal stability with variations in mean offsets at just over 2 pixels in the N-S direction and are about 1 pixel and the E-W direction. Here, offsets also drift to the west over this time period.

Summary

- SuperDove and Dove-R geolocation accuracy vary locally from the global average.
- Geolocation accuracy of SuperDove and Dove-R are best over USA and poorest over Turkey.
- SuperDove temporal stability is best at Albuquerque, NM, USA. and poorest at Boston, MA, USA. Geolocation offsets also drift to the west at Boston, MA.

References

[1] Commercial SmallSat Data Acquisition Program: https://www.earthdata.nasa.gov/esds/csda

[2] De Luccia, F. J., Houchin, S., Porter, B. C., Graybill, J., Haas, E., Johnson, P. D., Isaacson, P. J., and Reth, A. D. "Image navigation and registration performance assessment tool set for the GOES-R Advanced Baseline Imager and Geostationary Lightning Mapper", doi: 10.1117/12.2229059 (2016).