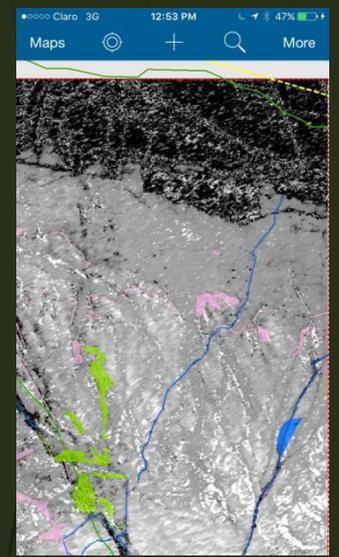
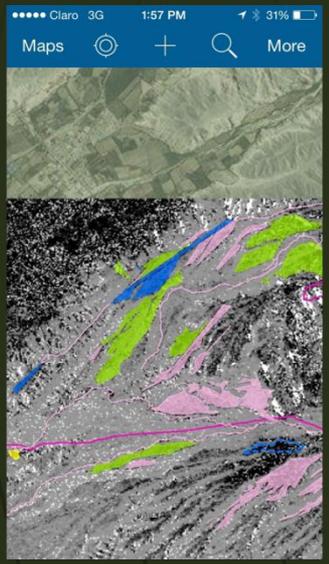




Using NASA SAR Correlation Imagery to Preserve the Lines and Geoglyphs of Nasca and Pampas de Jumana World Heritage Site



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Governing Board Member, HIST

13 September 2016
2nd Huangshan Dialogue on UNESCO Sites
Huangshan, China

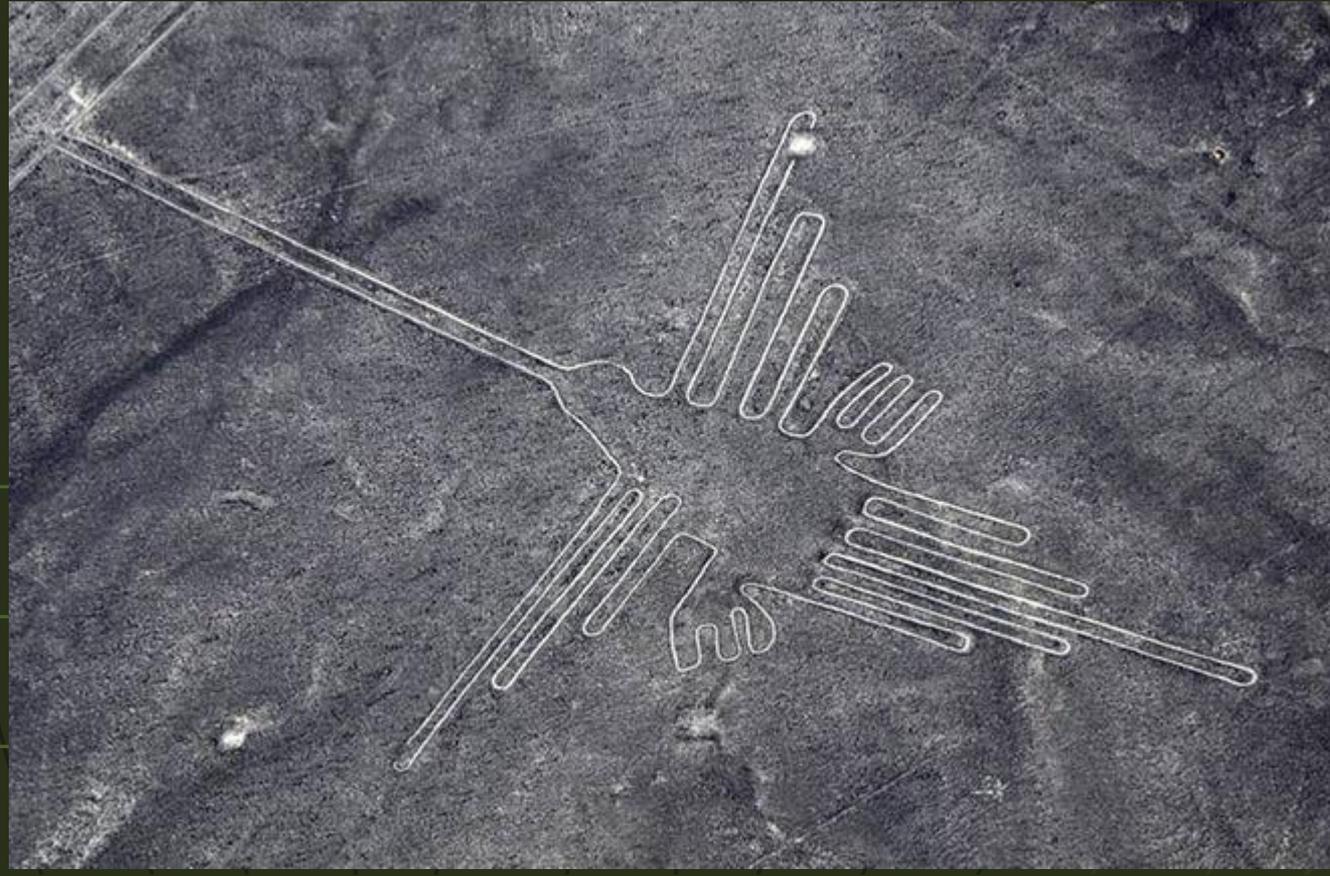
Nasca Lines

Lines, geometric shapes, figures outlining animals, plants, humans, and mythological figures. Some date to the earlier Paracas culture. These same designs are seen on Nasca pottery.



Trapezoid: ritual areas?

Whale, symbolizing importance of coastal environment



Nasca Lines: Role in Protecting the Environment

Rivers and stream begin in the high Andes, run through Nasca Lines WHS, and deliver water, nourishment, and pollutants to the coastal Pacific



Coastal Protected Areas

National Reserve of Paracas

San Fernando Bay National Reserve



UAVSAR Platform and Flight line



Two flights: The first set of UAVSAR data was collected on 19 March 2013 and the second on 23 March 2015.

UAVSAR correlation over Nasca

Greenpeace disturbance area, December 2014.

A path taken to the *pampas* can be easily traced

A large area where the equipment was left and the participants congregated is prominently decorrelated

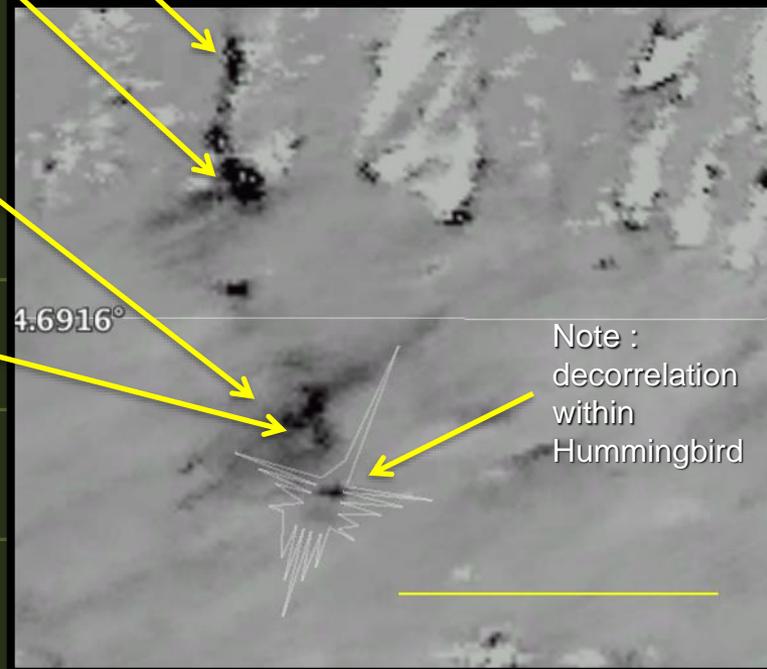
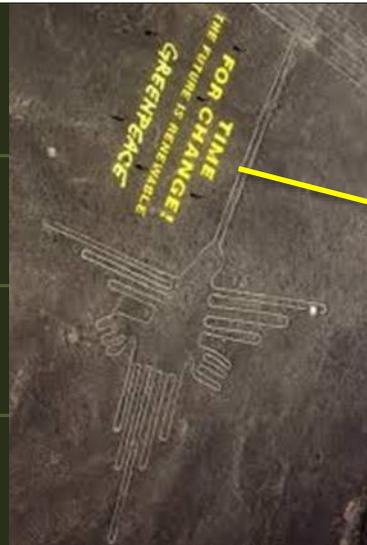
Area where the banner was placed is represented by the area of decorrelation near the hummingbird geoglyph.

Grey areas have correlation near 1.
Black areas indicate lower values.

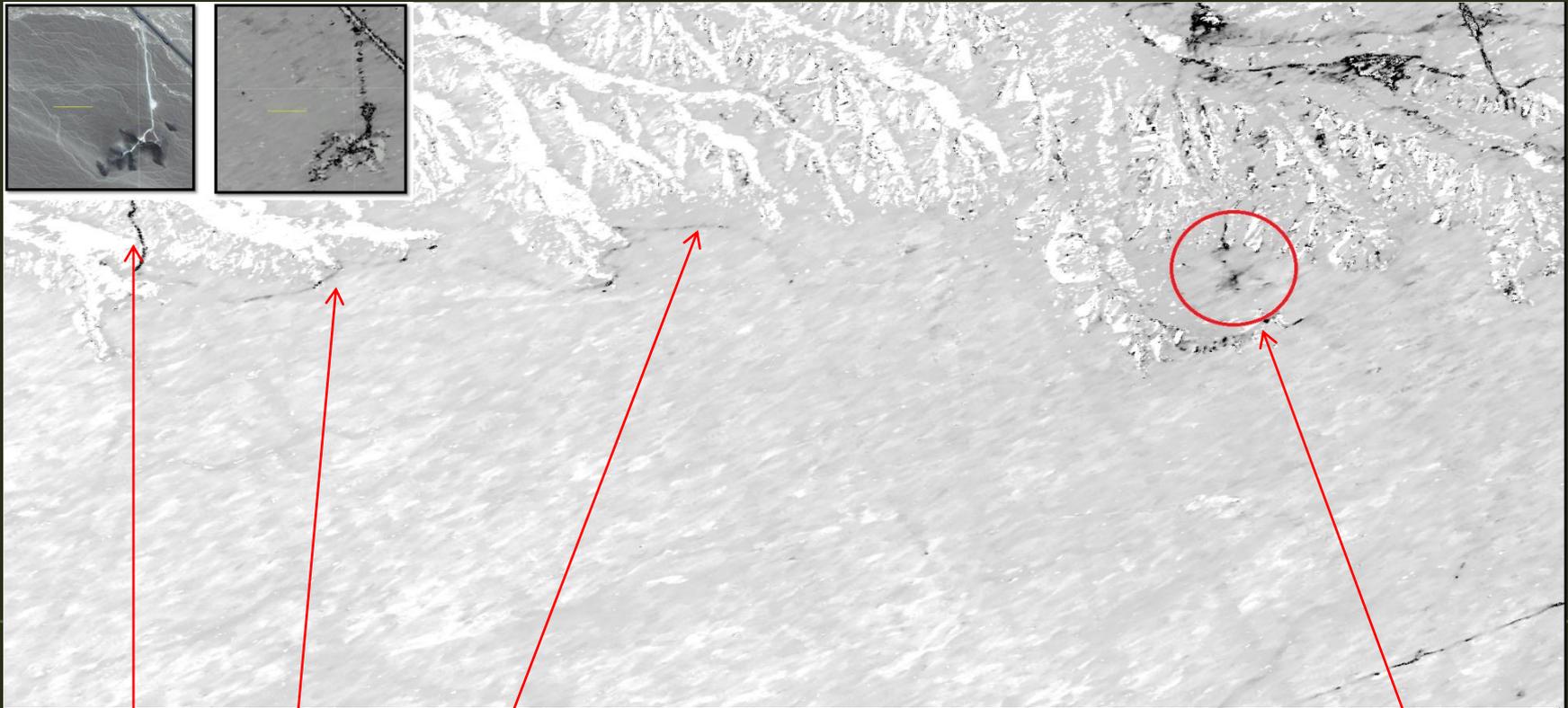
Google Earth



UAVSAR



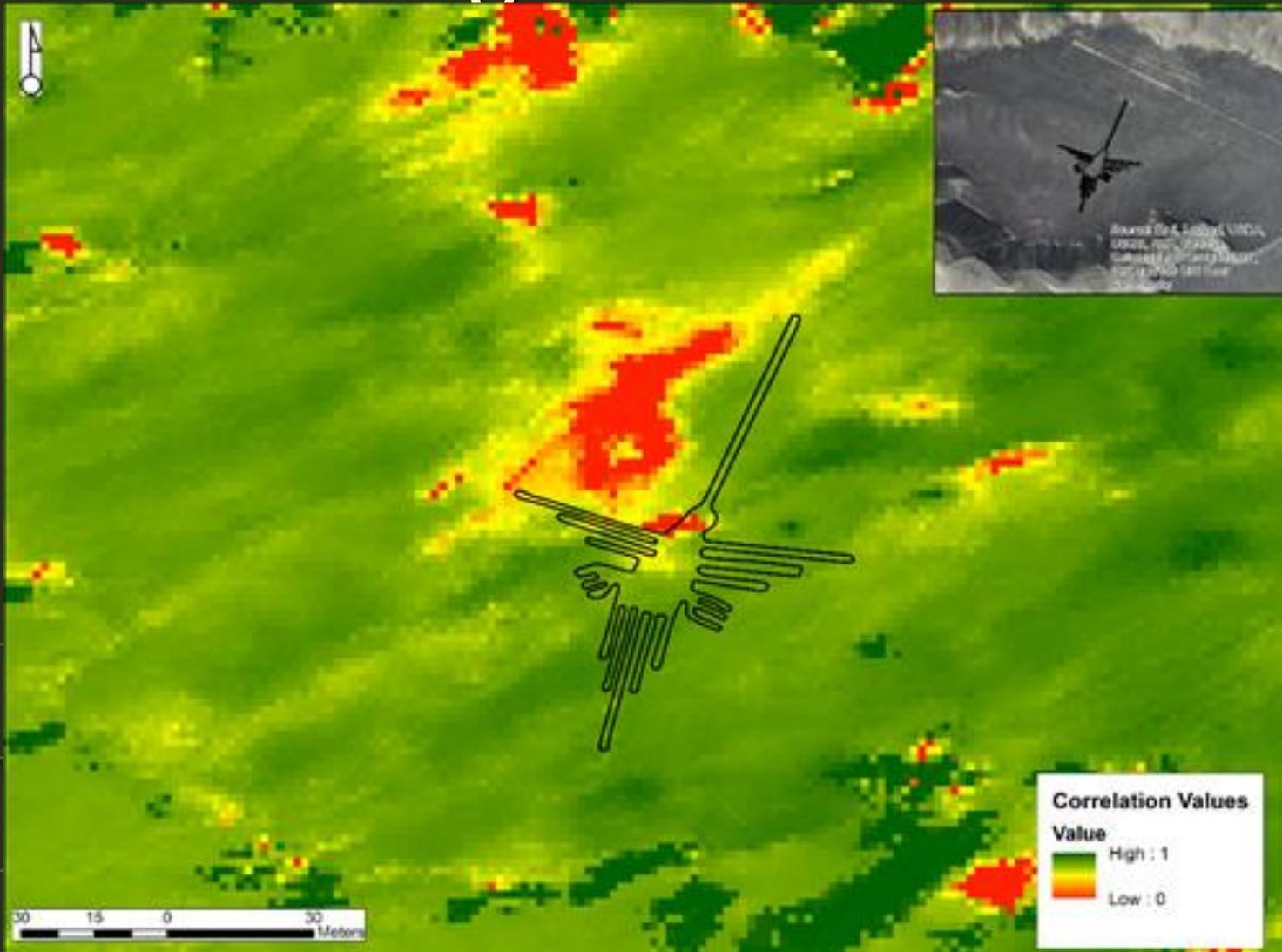
UAVSAR Correlation Image



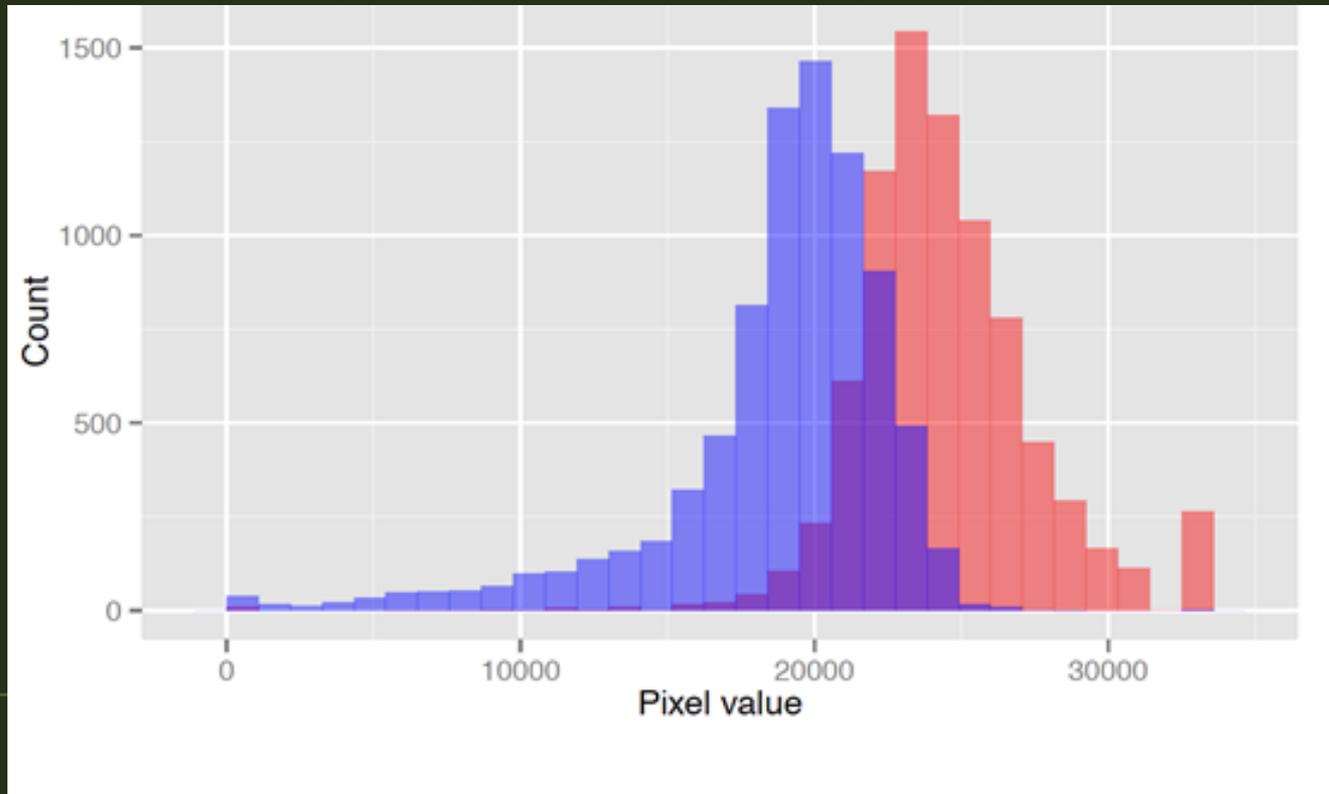
Road and pedestrian traffic

Hummingbird

Filtered and Colorized Image of Hummingbird Disturbance



Histogram: Inside and Out of Hummingbird Area

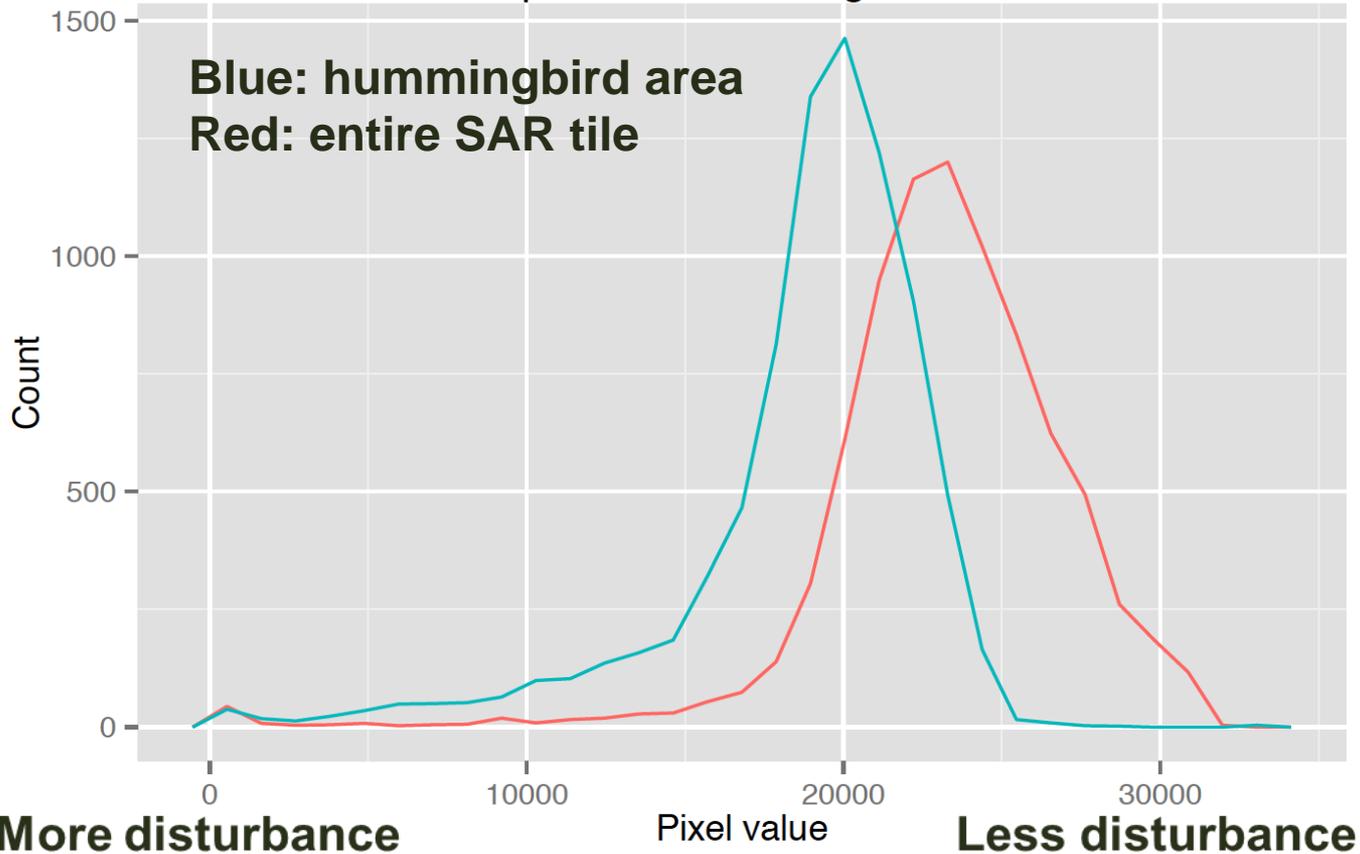


A Wilcoxon rank-sum test indicates, at a confidence level greater than 0.999, that the correlation values within and around the Hummingbird are lower than those of the general area.

Histogram Comparison

Pixel value comparison: hummingbird versus entire tile

Blue: hummingbird area
Red: entire SAR tile



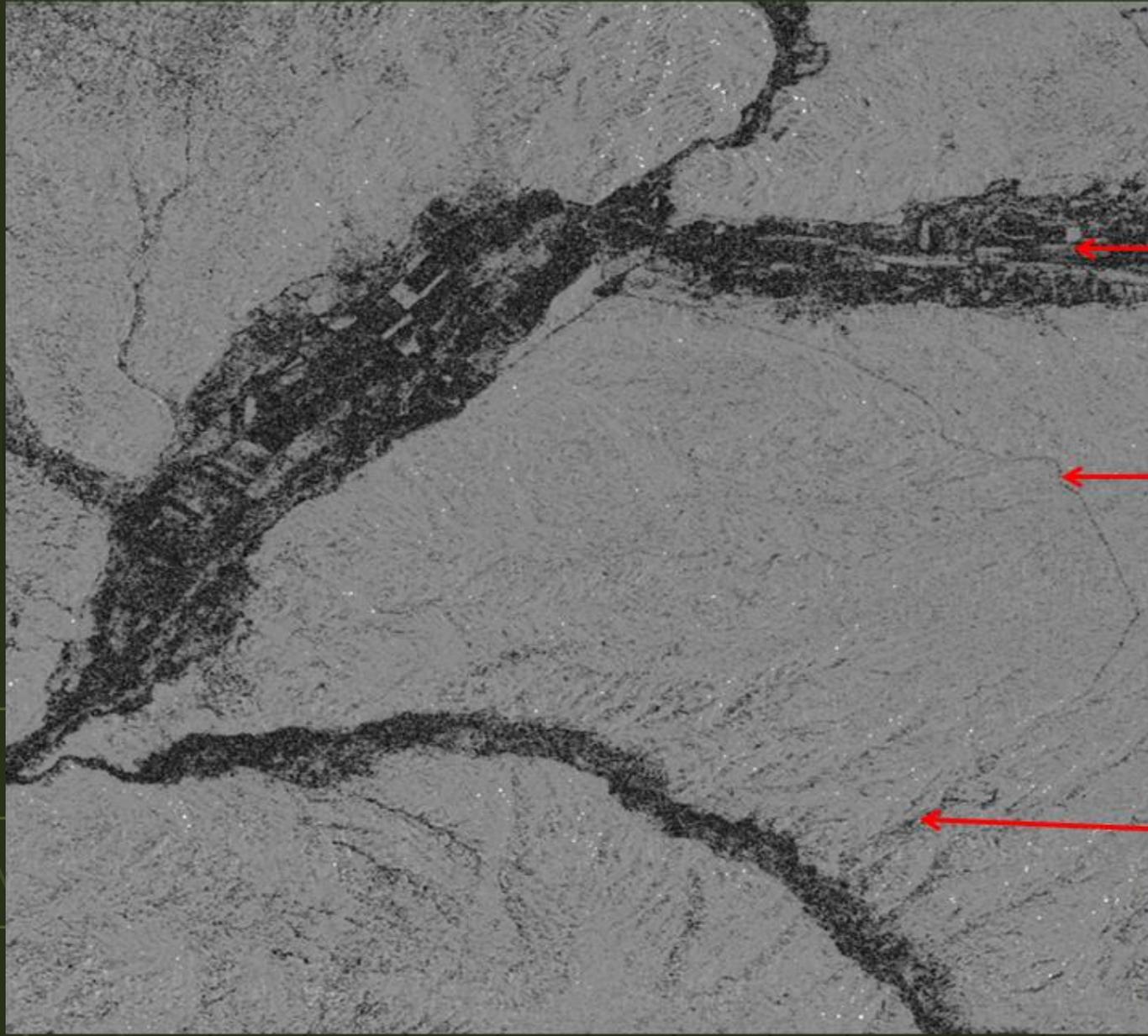
Wilcoxon rank
sum test with continuity
correction

data: testbirdvals
and t
W = 10872000, p-value
< 2.2e-16

Statistical test of
difference
between the two
sets of pixel
values indicates
that they are from
different
populations with
virtual certainty

Red is entire correlation tile, blue is area around Hummingbird

Sentinel-1 Satellite Correlation

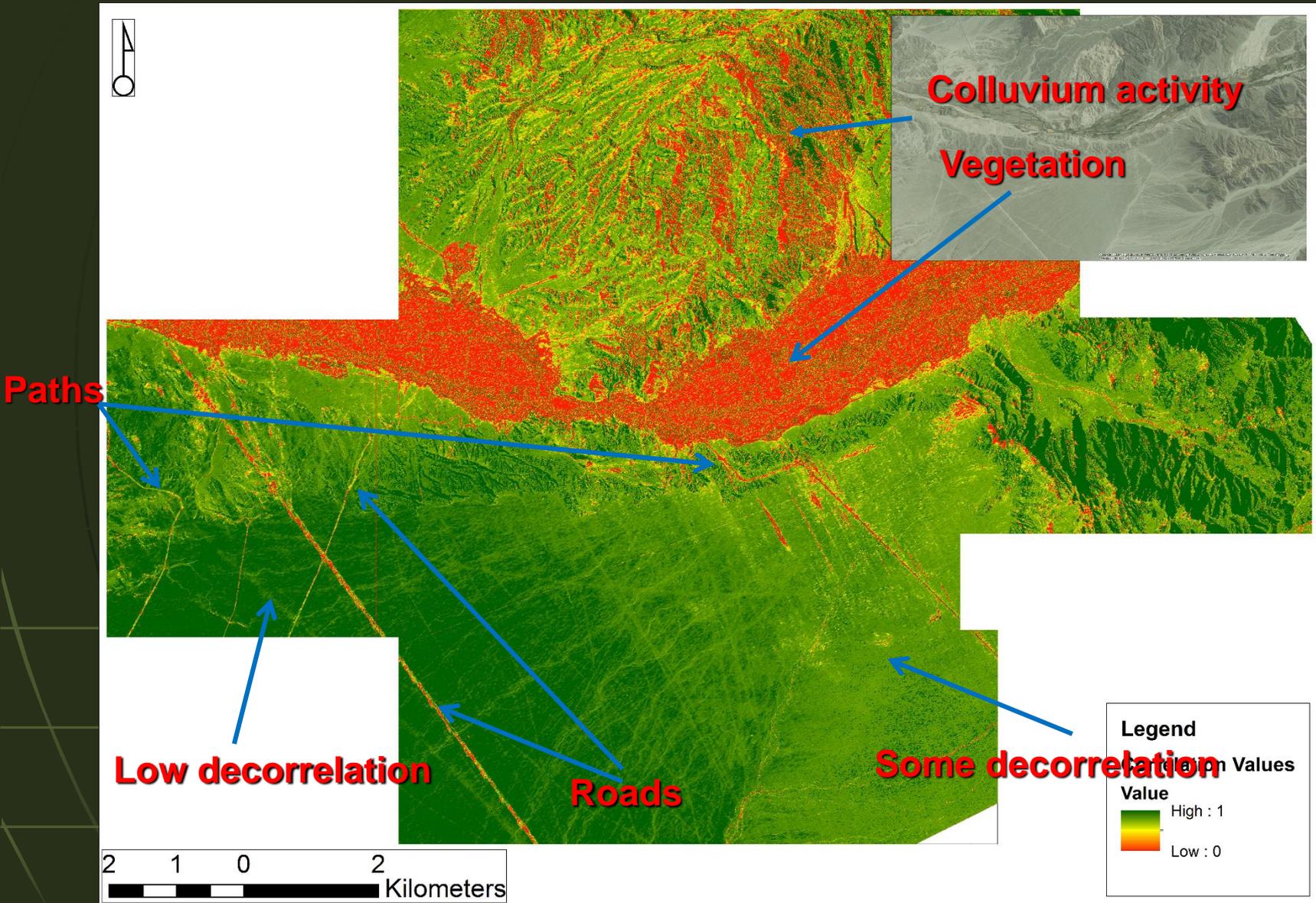


Returns (and patterns) are different for crops and natural vegetation

Road used during 16-day window

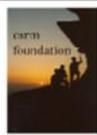
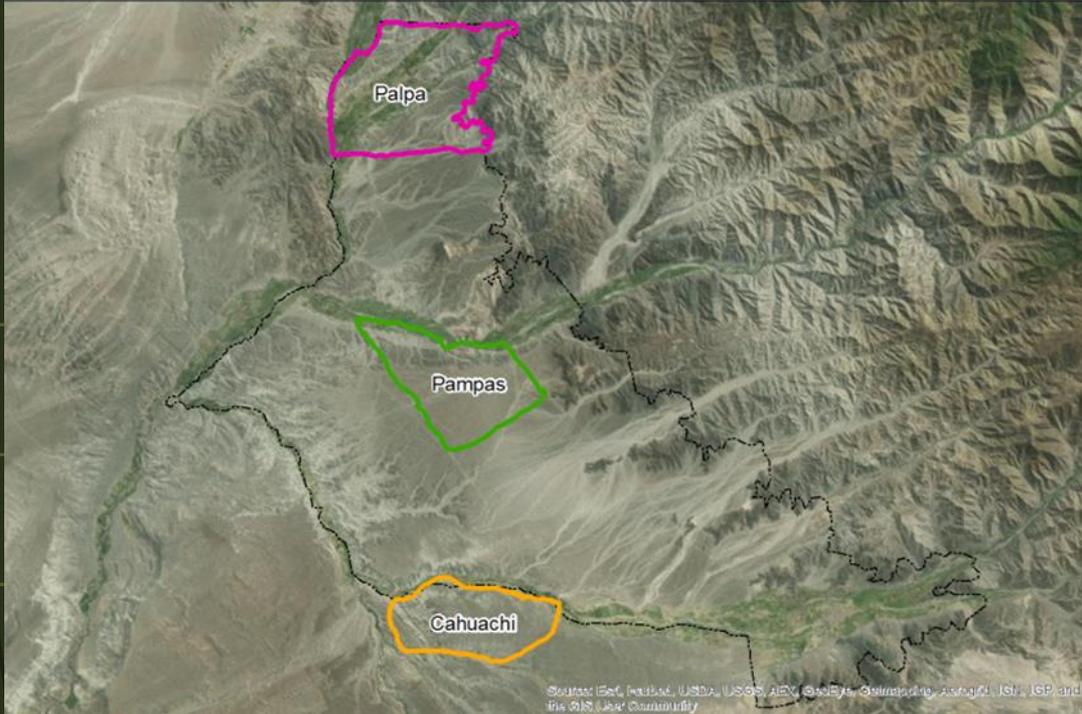
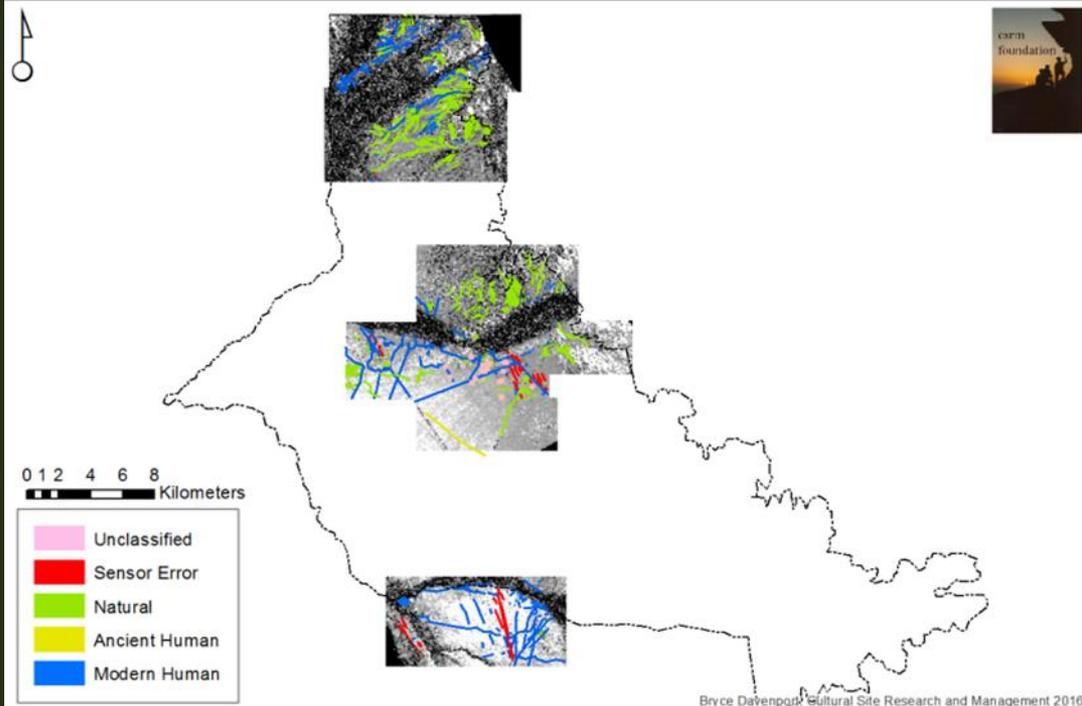
Water erosion during 16-day window

Decorrelation in the Wider Landscape



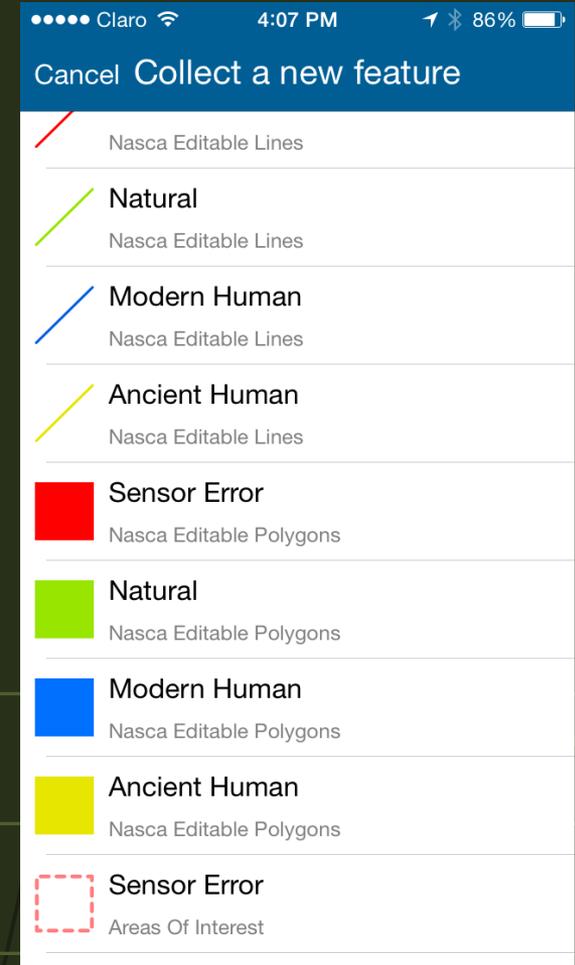
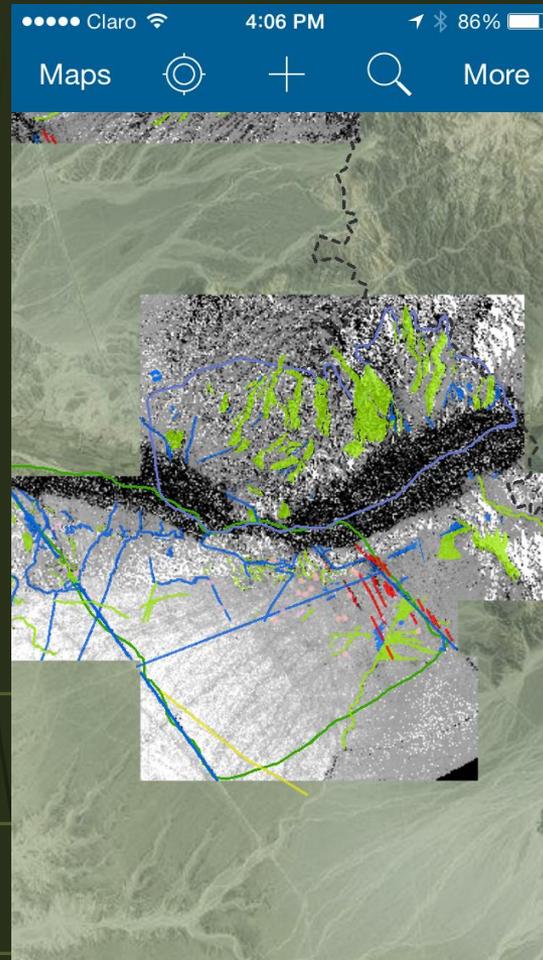
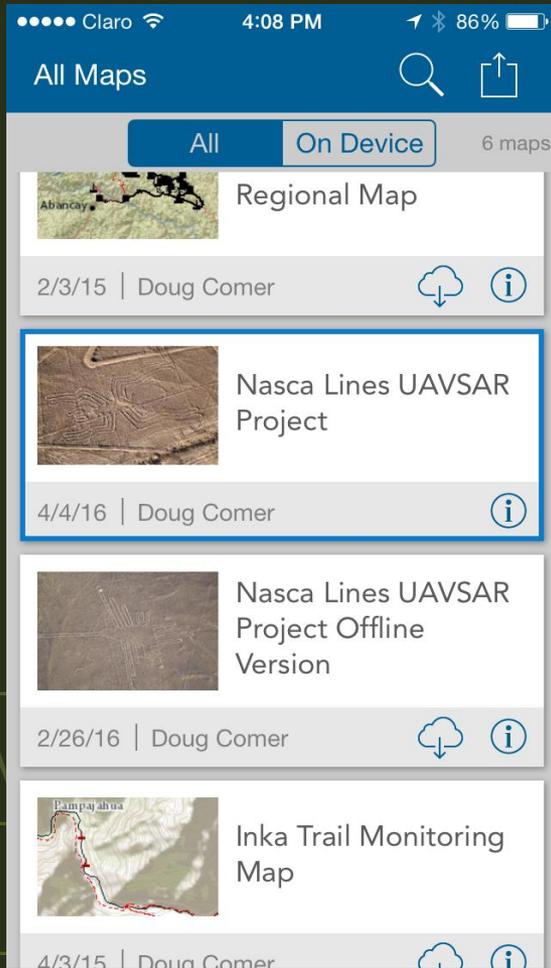
Current Project Selected Sites

- Palpa
 - Contains the most significant disturbance
- Pampa
 - Contains best known glyphs
- Cahuachi
 - Capital, threatened by looting and development



Access to GIS Database

Ministerio, CSRM Foundation, JPL/NASA



Real-Time Data and Analysis Sharing Is In Place



Database Server ArcGIS for Server



Real-Time

Reporting

Data sent to and from CSR, Ministerio de Cultura, JPL/NASA



Real-time Website

JPL/NASA develops correlation images

CSR digitizes disturbance areas and conducts spatial and statistical analyses

Ministerio de Cultura verifies and identifies on the ground

Extensive Looting

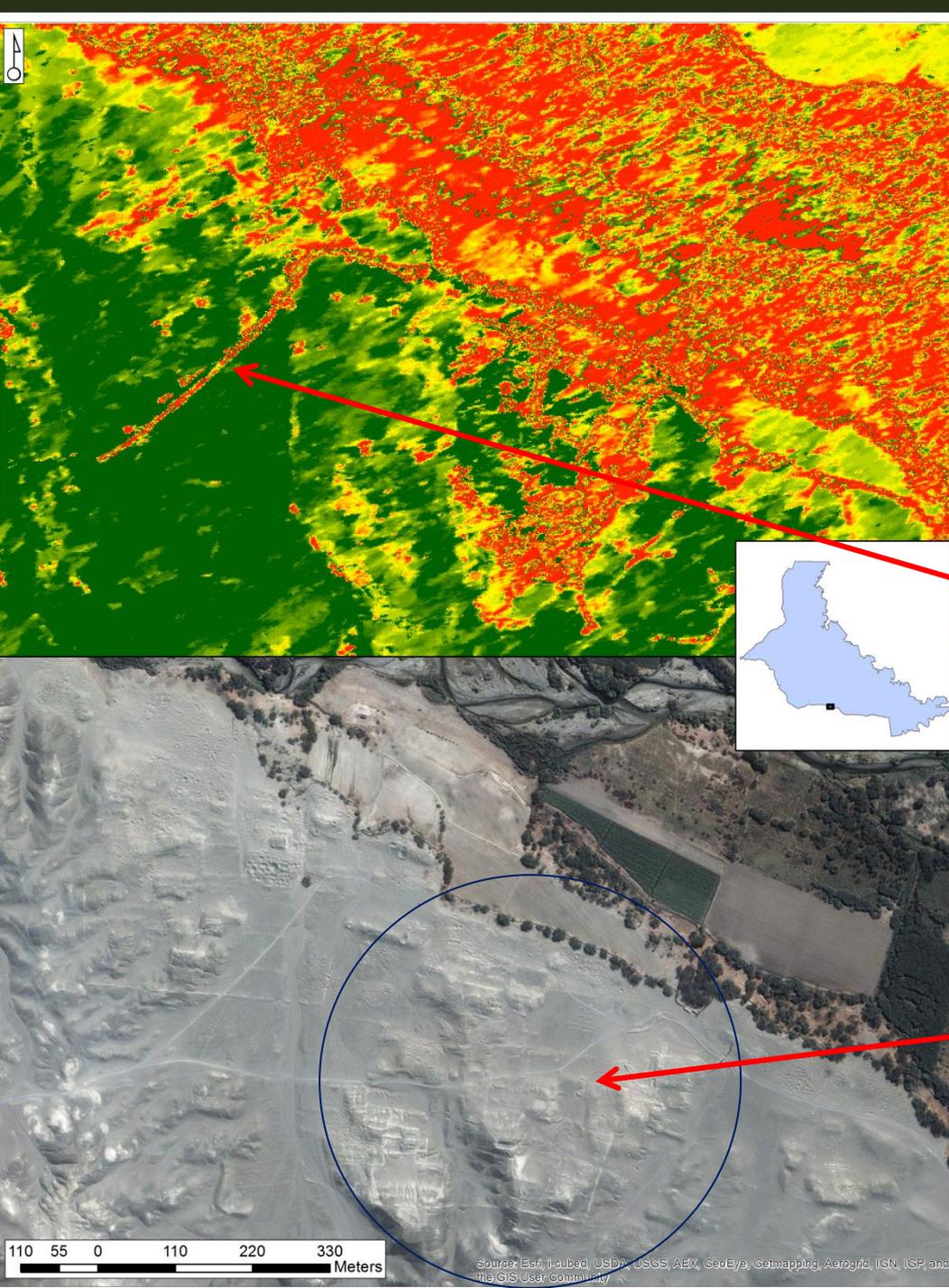


Cahuachi

Vegetation can be differentiated, crops vs. native

Road. Decorrelation indicates that it has been used. SAME CAN BE DONE EVERY 8 DAYS W SENTINAL 1 CORTRELATION

A single disturbance area of the pyramid complex at Cahuachi, showing looting activity and excavated dirt piled up in the season streambed to the southwest of the complex



Interferogram of Mining Area

Mina Marcona, Peru

20150505_20150716

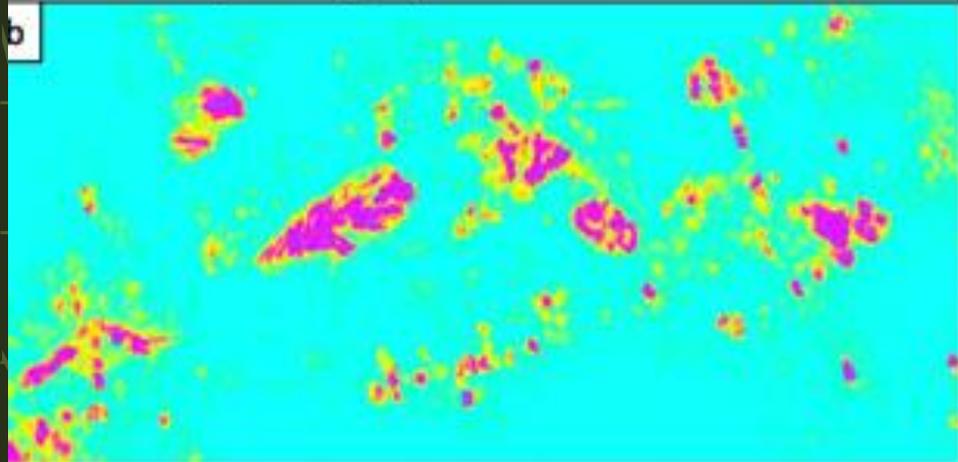
Google Earth

a



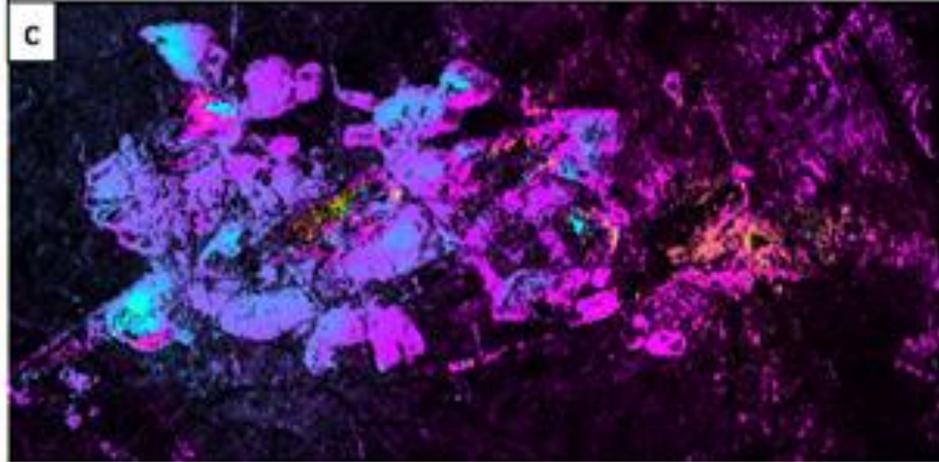
Sentinel 1A ARIA correlation image
Colors indicate amount of disturbance between observations (red – largest)

b



Sentinel 1A ARIA Interferogram
Colors indicate relative change in surface height

c



Applications

- Monitoring landscape disturbance in arid regions
- Monitoring vegetative change
- Monitoring mining and looting
- Used in conjunction with optical imagery, monitoring more specific effects of landscape disturbance
- Monitoring land slides, mudslides
- All done in a way that provides immediate and ongoing collaboration