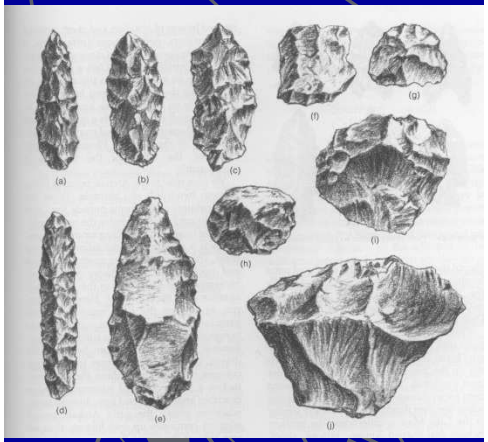
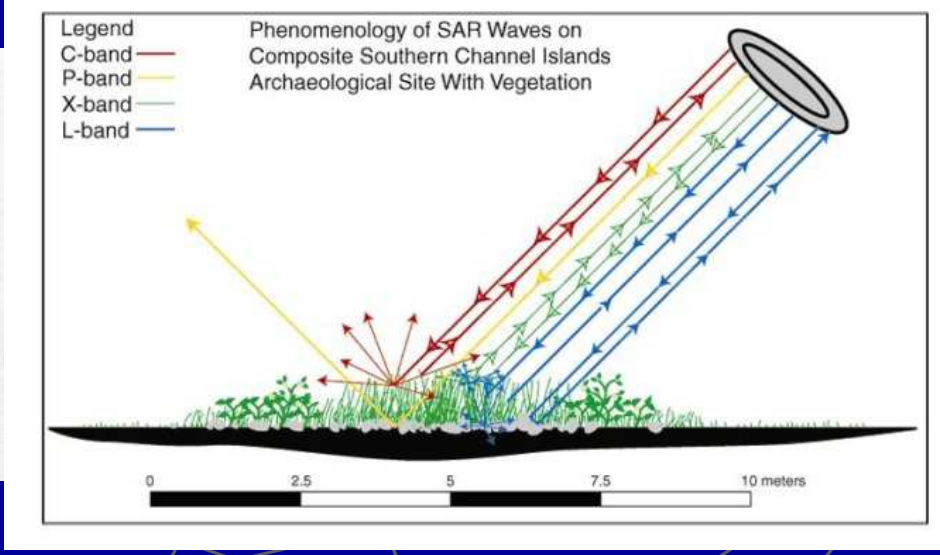
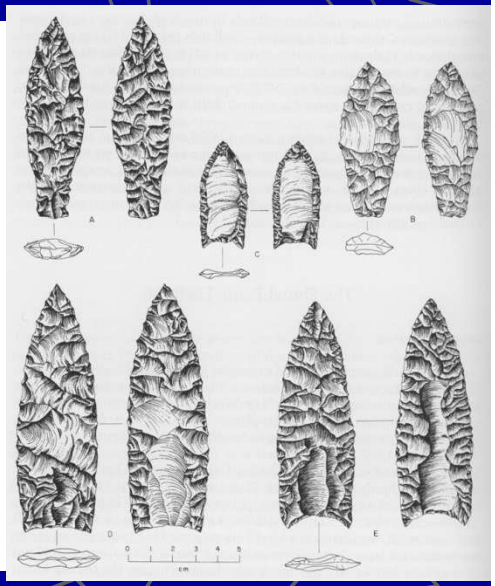
Archaeological Site and Landscape Detection with Synthetic Aperture Radar (SAR)

Sites in Context from SAR Data

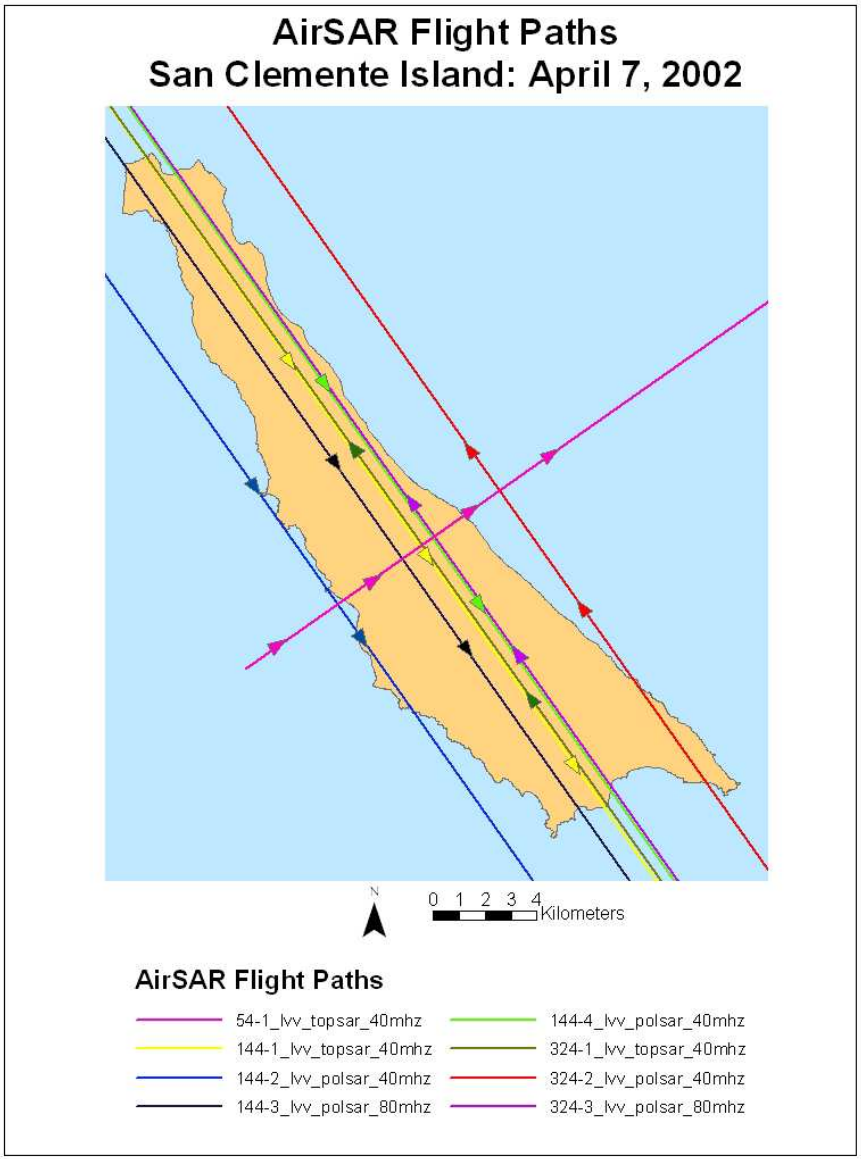


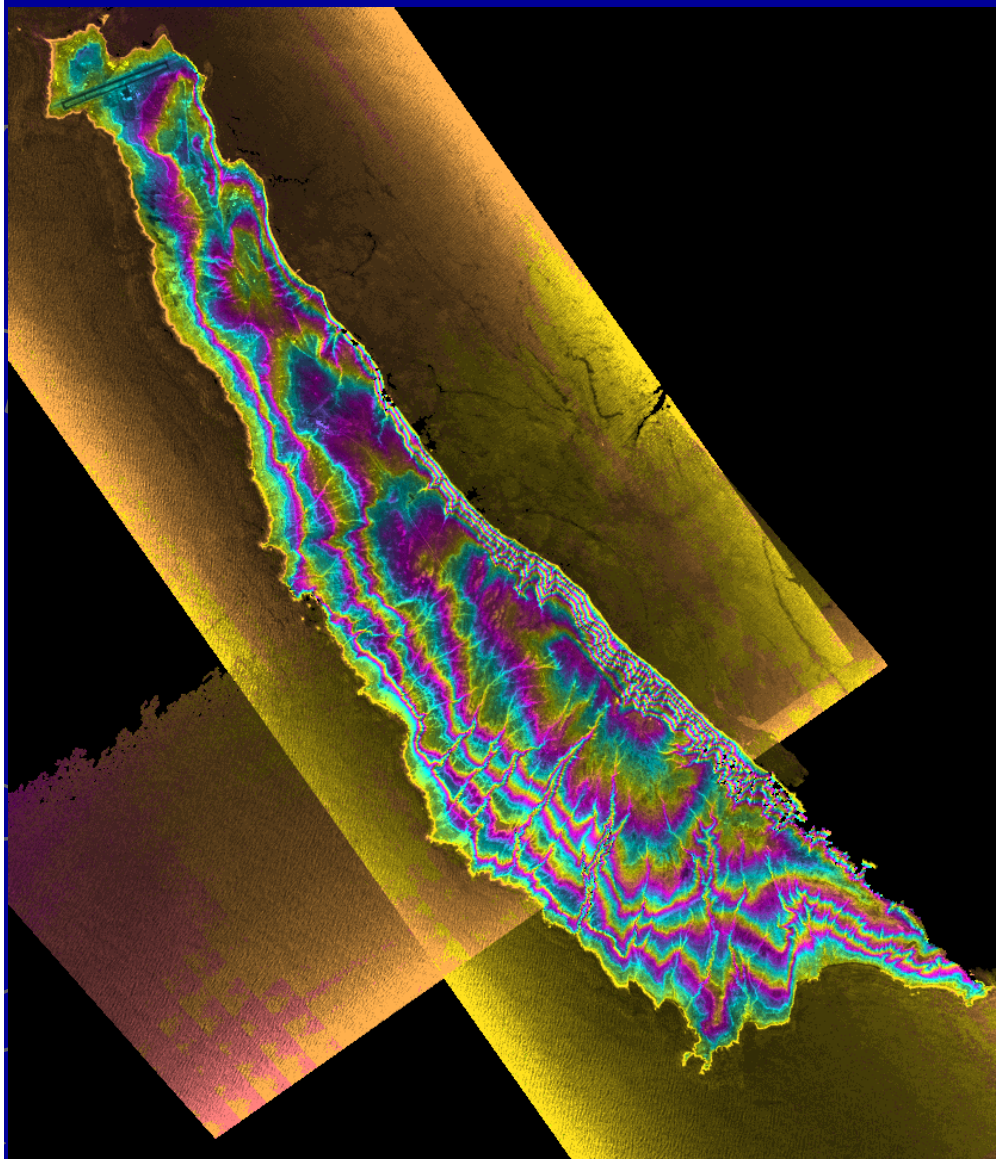




Douglas C. Comer (dcomer@culturalsite.com)

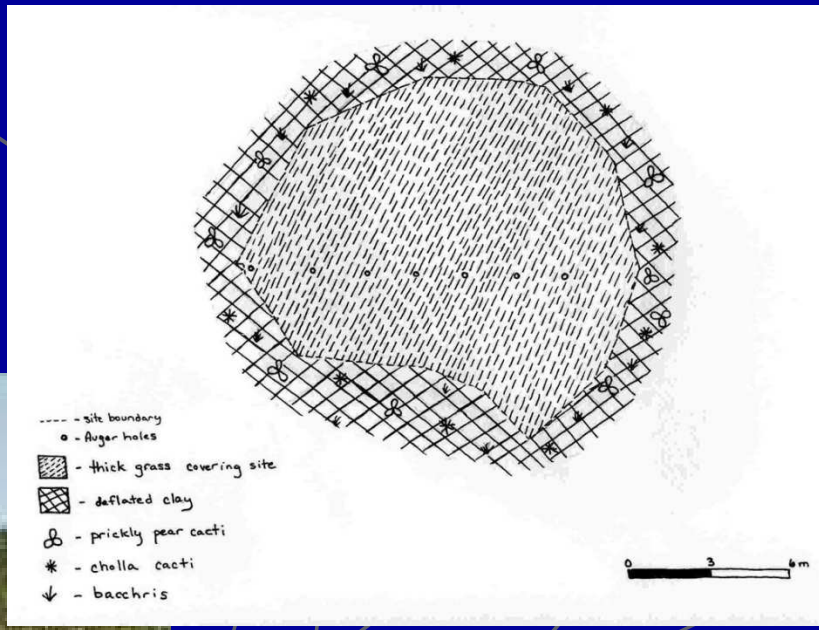
San Clemente Island





Site Detection with SAR

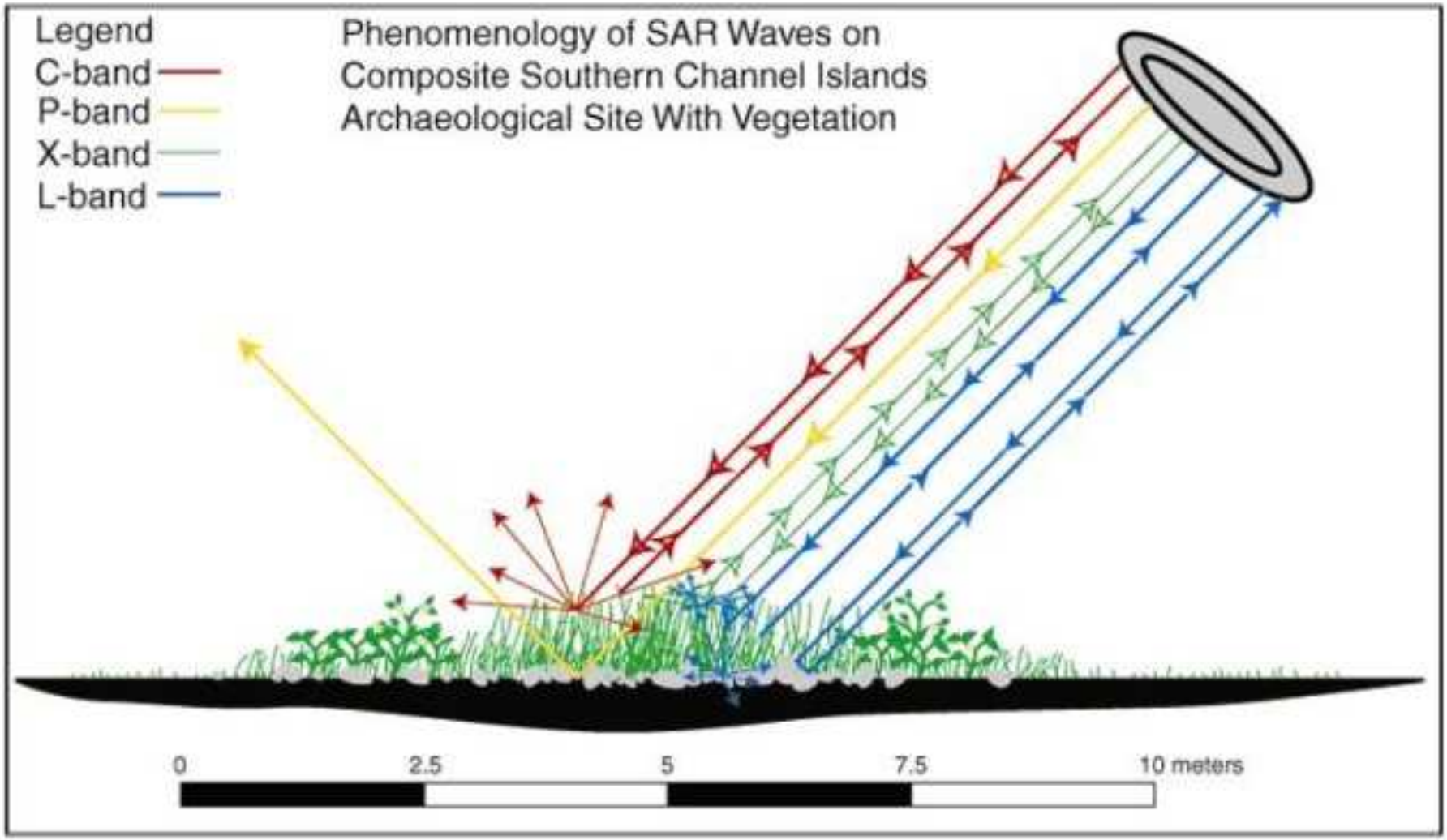
- Typical San Clemente Island Site
- Dense grasses in middle
- Species of plants that ring center vary



SCI from the air

JPL NASA NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Goddard SPACE FLIGHT CENTER CSRM

Site Detection with SAR

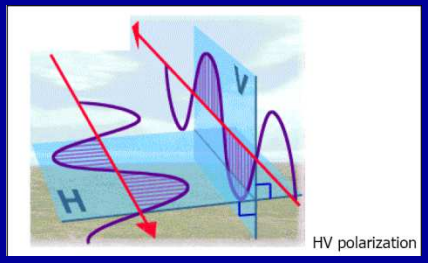


AirSAR and GeoSAR

Instrument	Frequency band	Bandwidth (MHz)	Band length (cm)	Single-look range resolution (m)	Polarizations	Interfero-metric	Pixel size in this study, after orthorectification and post-processing
AIRSAR	P	20	68	7.5	HH, VV, HV, VH	No	5,5
AIRSAR	L	40, 80	25	3.7, 1.8	HH, VV, HV, VH	Yes	5,5
AIRSAR	C	40	5.7	3.7	HH, VV, HV, VH	Yes	5,5
GeoSAR **Too Notched**	P	160 (max)	86	0.9	HH, HV or VV & VH	Yes	N/A
GeoSAR	X	160	3	0.9	VV	Yes	3,3 DEM 5,5 Image

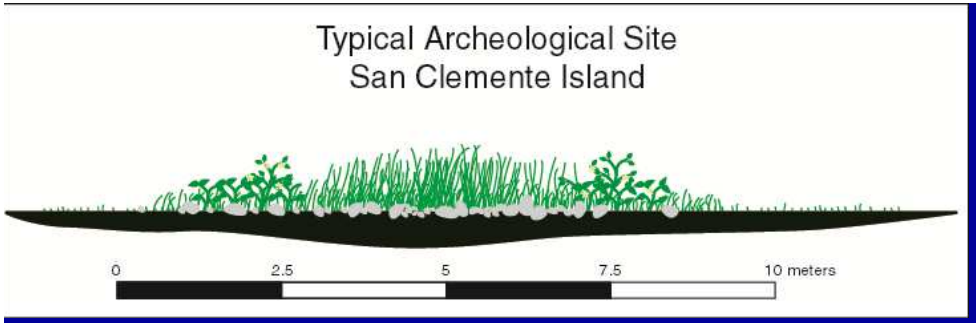
Ran tests of statistical association with archaeological sites for all bands and polarizations

PVV

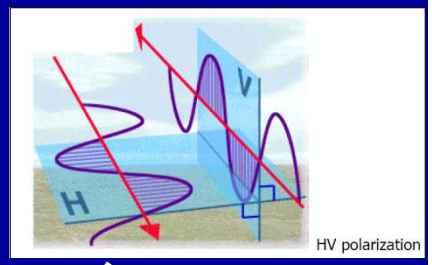


75cm long, not affected by vegetation and small rocks

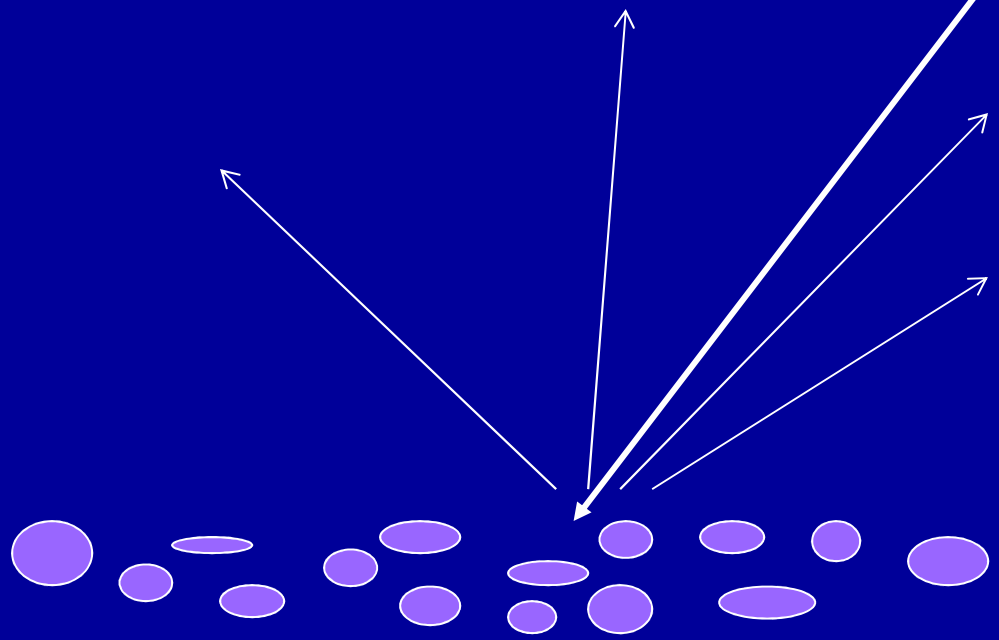
Organic soils, more moisture than surrounding soils

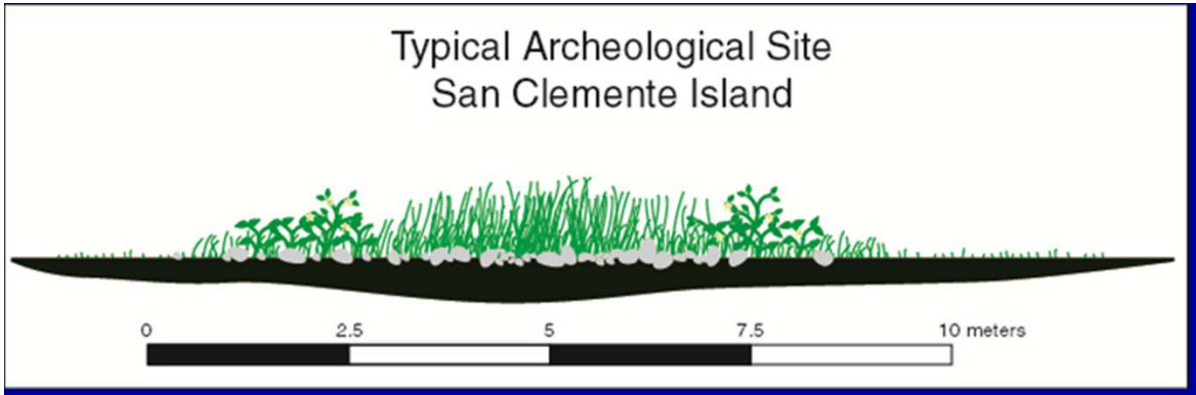


LHH



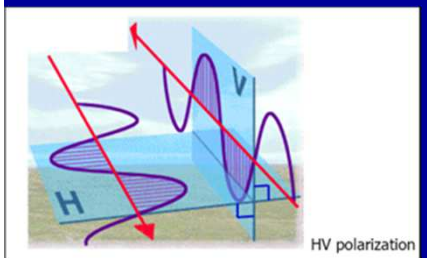
25cm long, not affected much by vertical vegetation structure, scattered by small rocks





CVV

5cm long, double-bounce from vertical grass structure

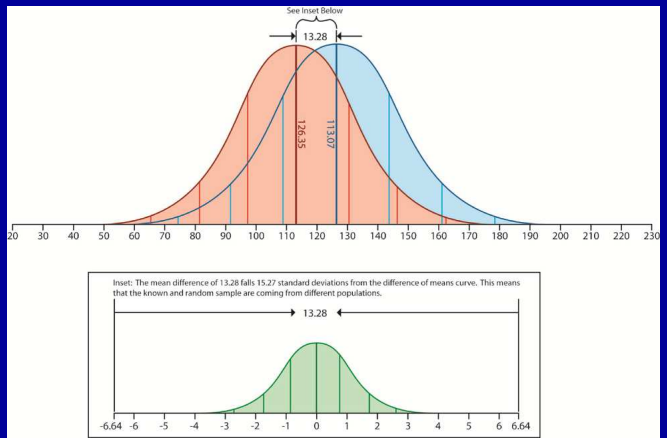


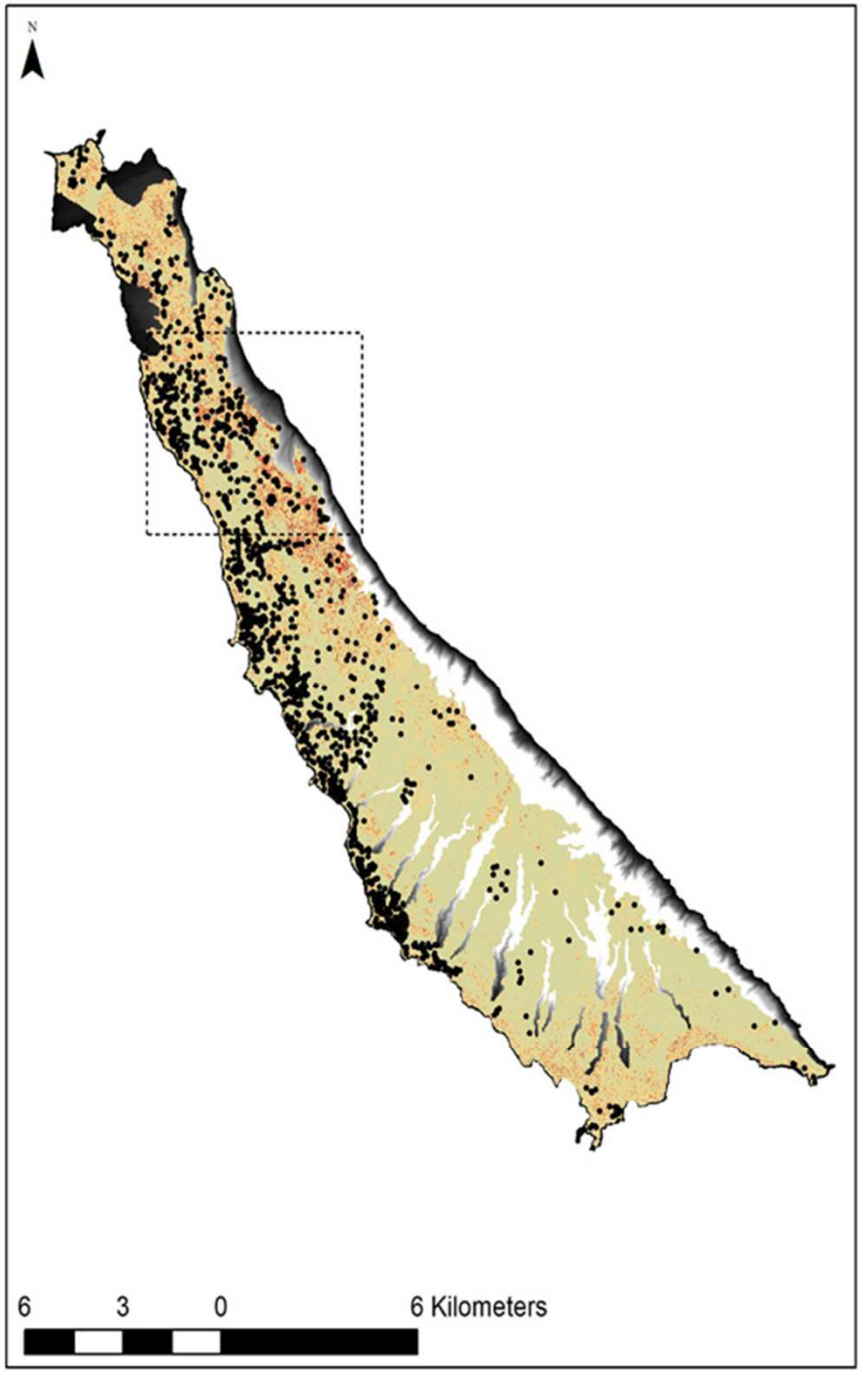
Testing the Null Hypothesis:

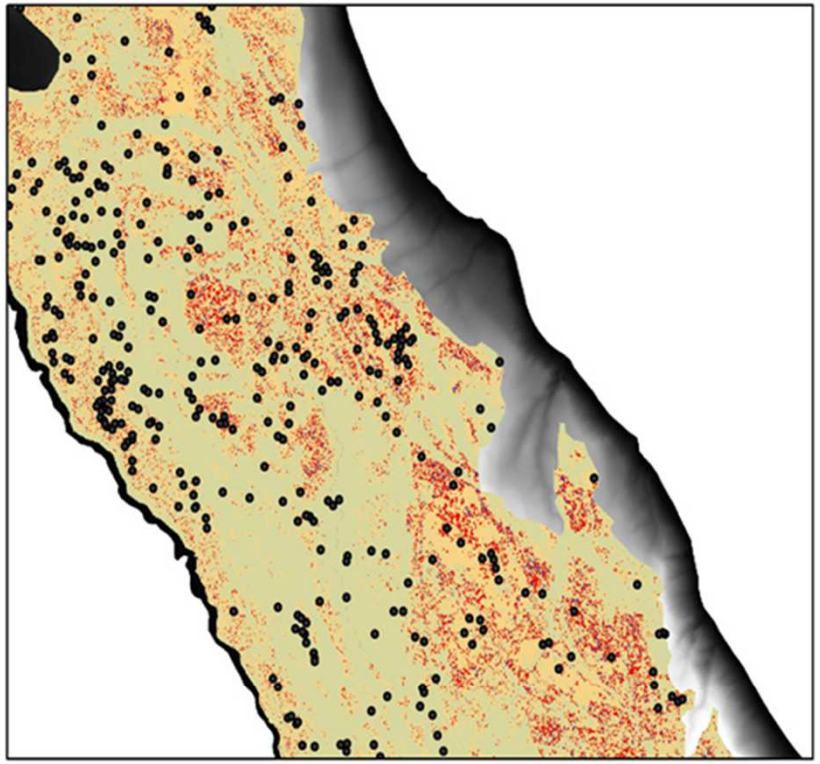
$$Ho : \bar{x}1 = \bar{x}2$$

The null hypothesis is that the two sets of samples are drawn from the same universe of values. If so, the difference between the means of the two samples will be less than 1.96 standard deviations of the difference of the means. Or:

$$\left(\sum_{n}^{1} x1/n\right) - \left(\sum_{n}^{1} x2/n\right) < 1.96\sqrt{\sigma 1/n + \sigma 2/n}$$







Model showing the number of datasets statistically associated with archaeological sites on San Clemete Island, and known archaeological sites. Datasets include PVV, CVV and LHH. Overlayed here are the locations of archaeological sites as determined by 100% survey of accessible land of the island

Legend

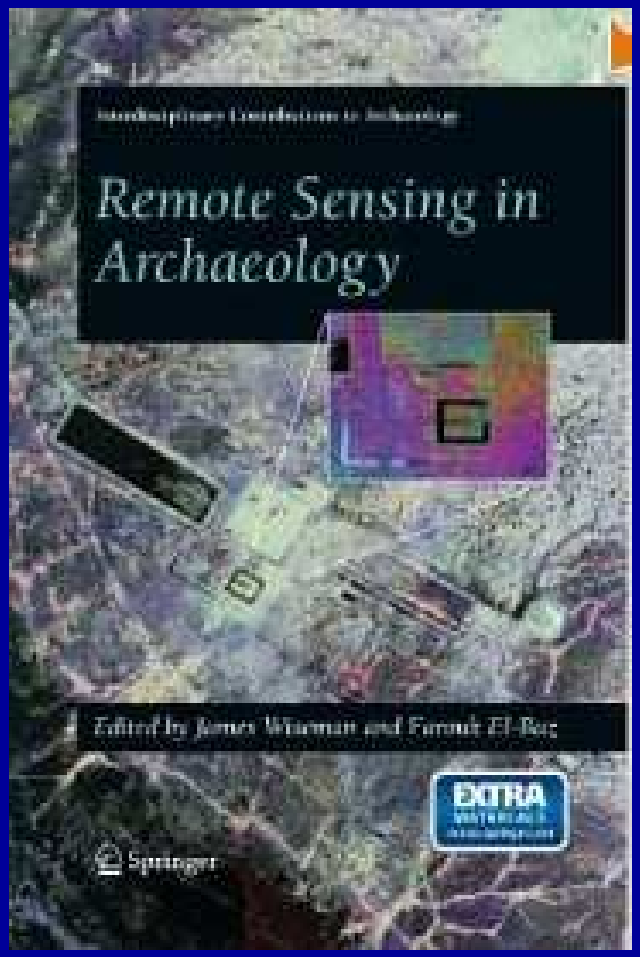
- Known Archaeological Sites

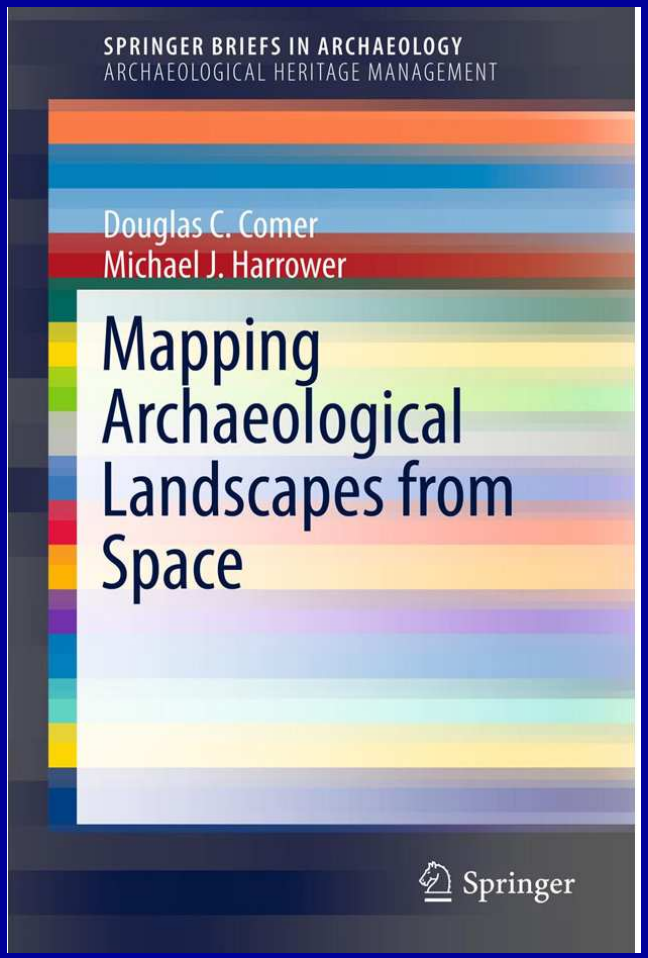
Number of datasets statistically associated with site locations

Extremely High Gain Statistic

Number of associated SAR bands	% of area	% of sites	Gain statistic
0	75.55375	16	−3.85252
1	20.92681	37	0.440908
2	3.329719	39	0.956286
3	0.189723	8.3	0.997753

Published in



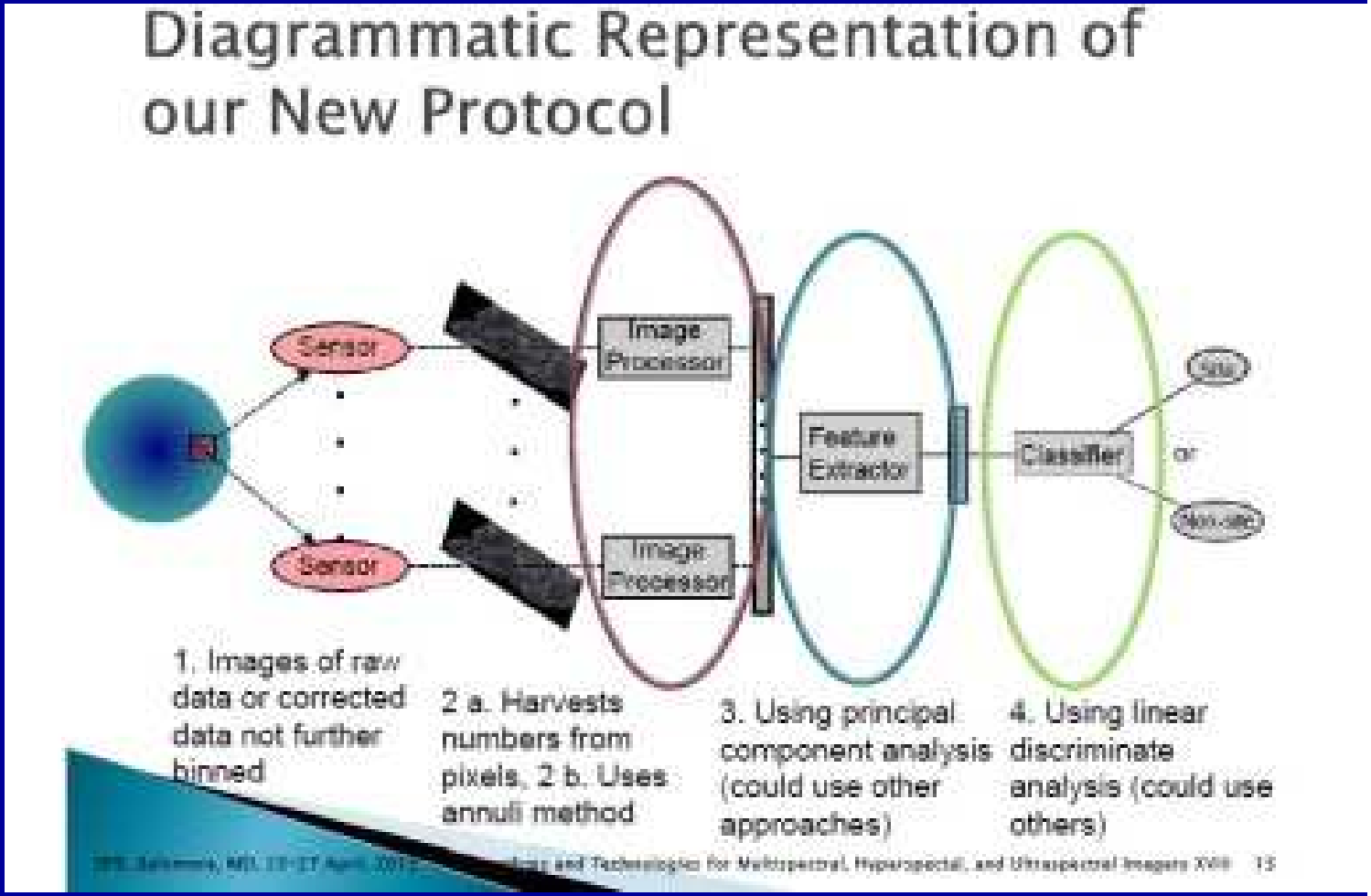


Enhancements

Machine learning

Terrain-based archaeological predictive models

Cross-validate

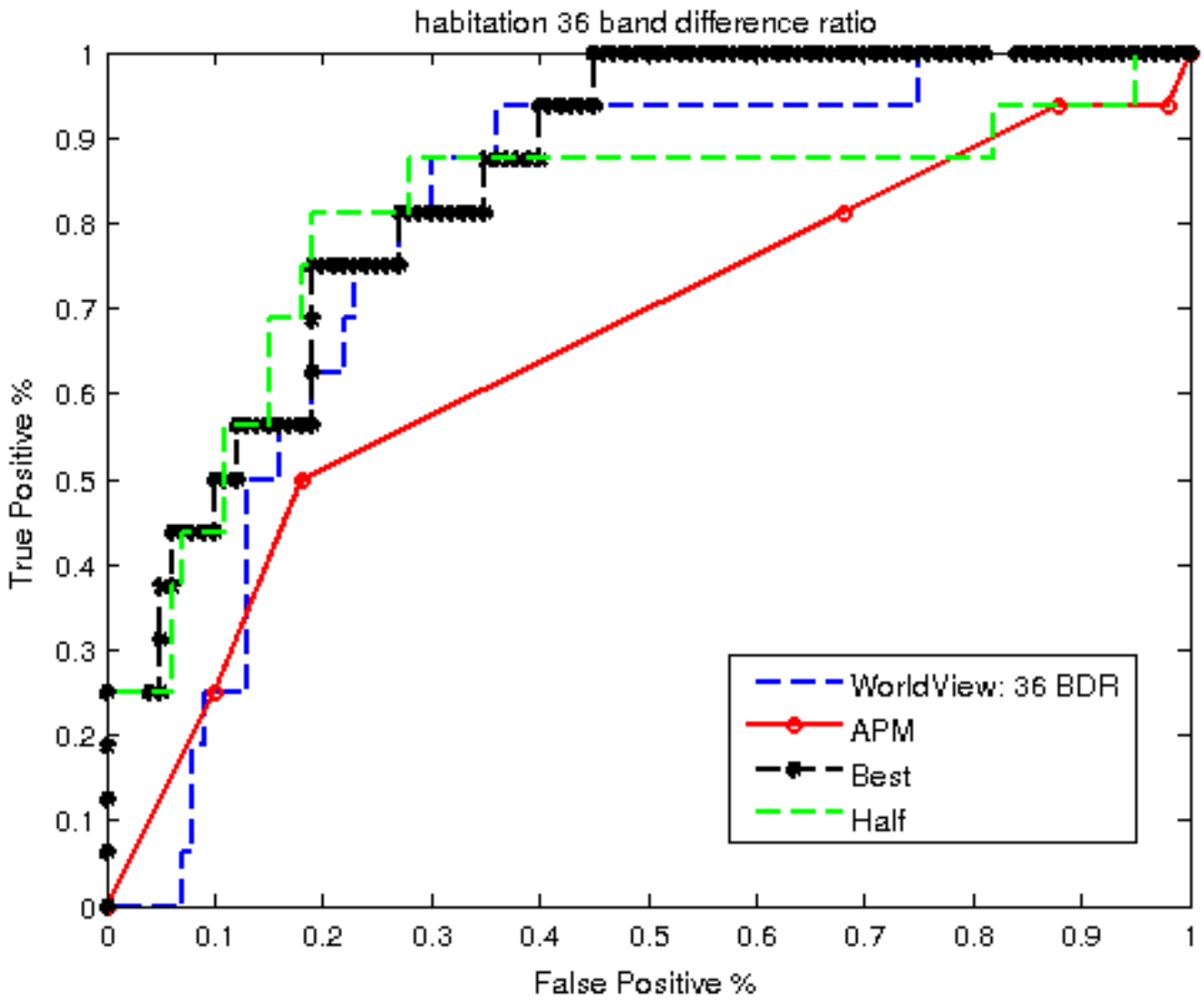


Enhancements

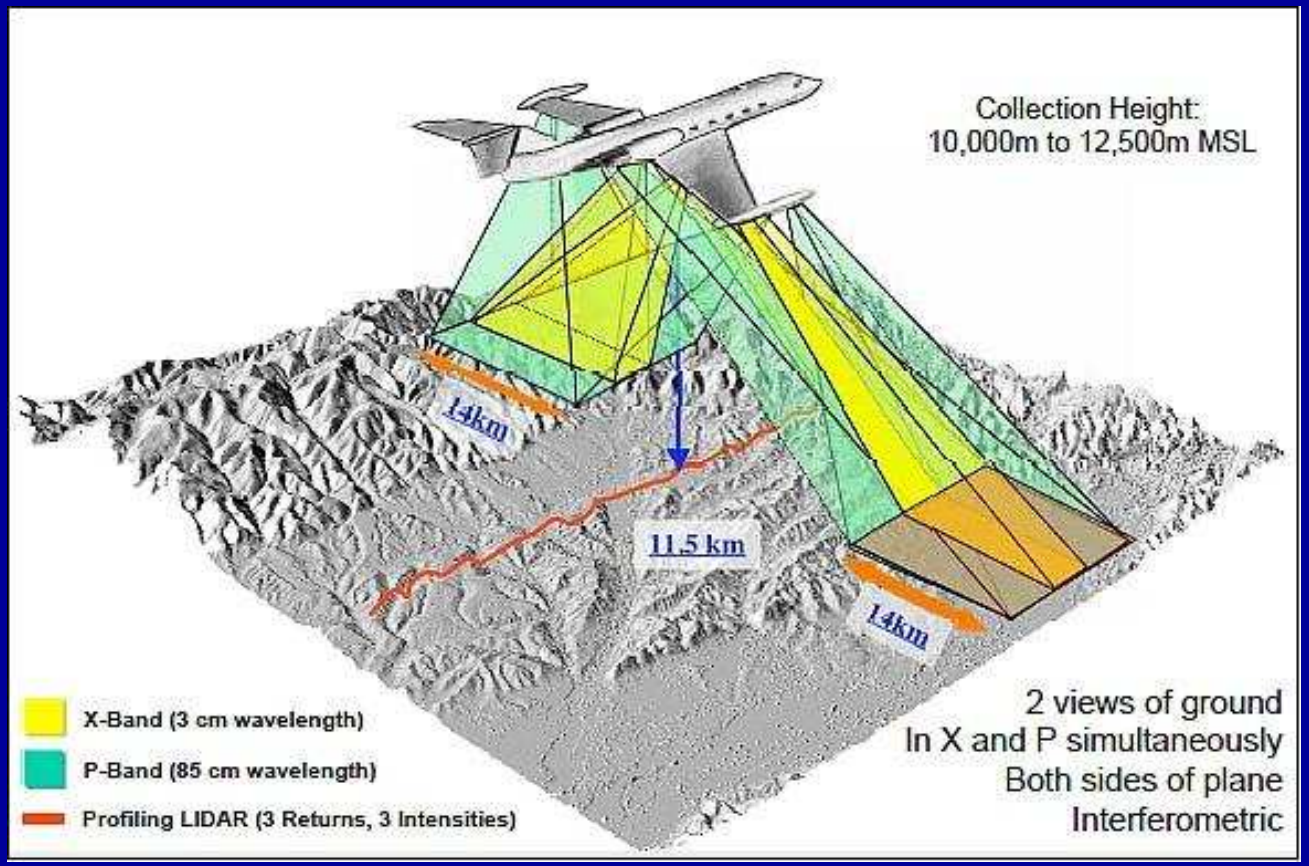
ROC curve:

Better test of model productivity

We want to run this on the SCI results



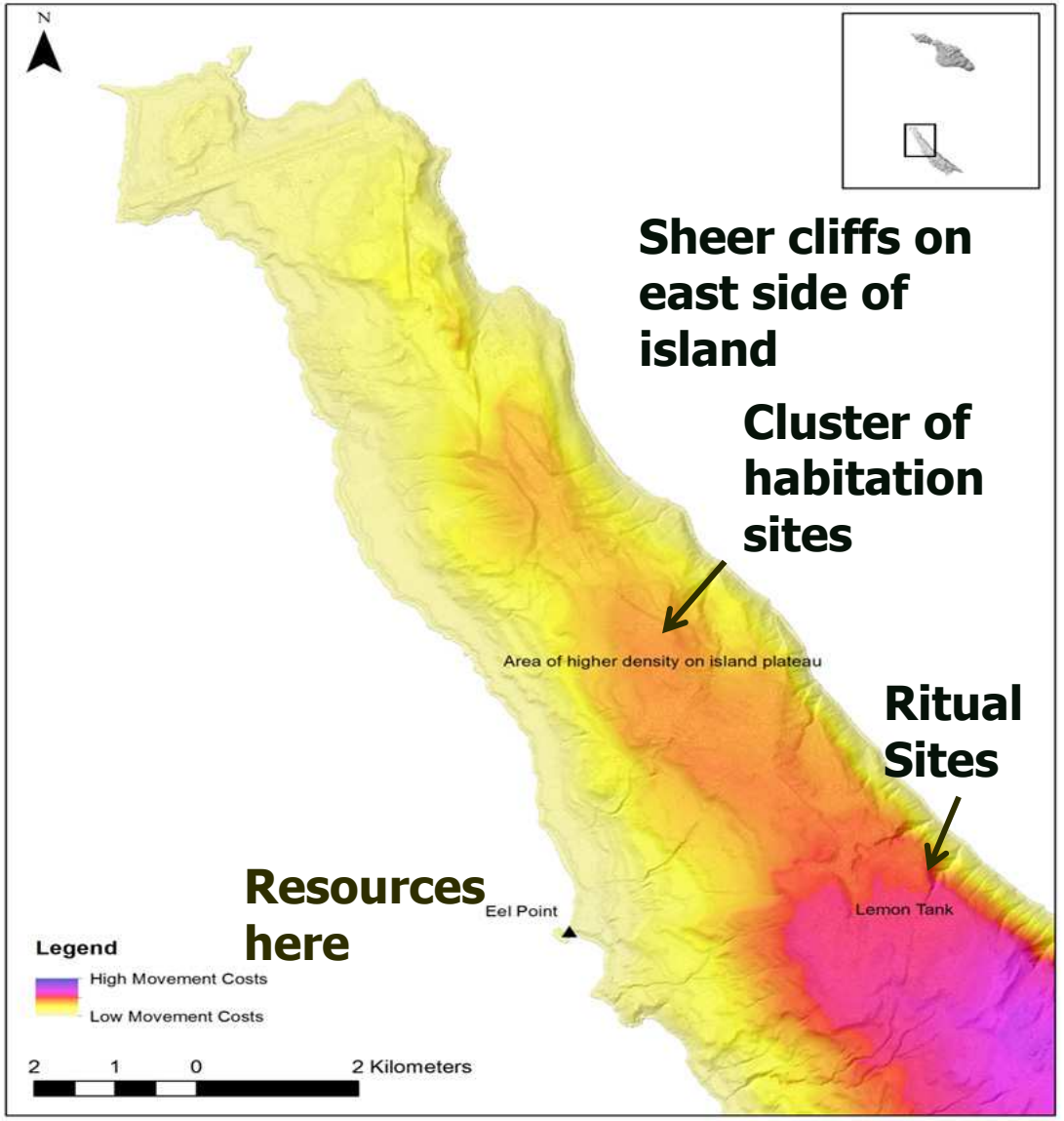
Intereferometric Analysis of C and X- Bands



SAR for Context

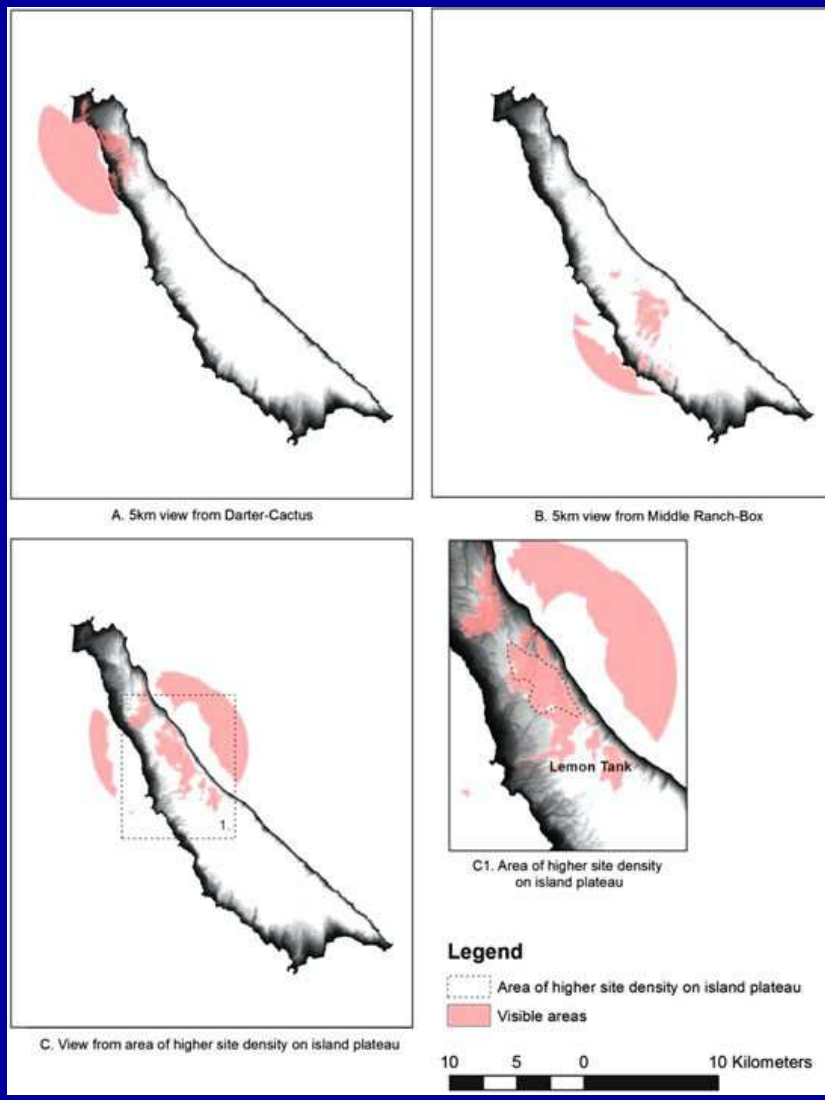
Cost surface: energy expenditure increases from light yellow to red and then blue

Why are clusters of habitation sites and a cluster of ritual sites located away from sources of food, materials, and water?



Viewshed

- Ability to see wide areas of ocean
  - Exploit windows of opportunity as pods od sea mammals, logs, and whales pass by
- Ability to coordinate with those who must mobilize quickly to exploit resources



Faroe Islands Whale Hunting

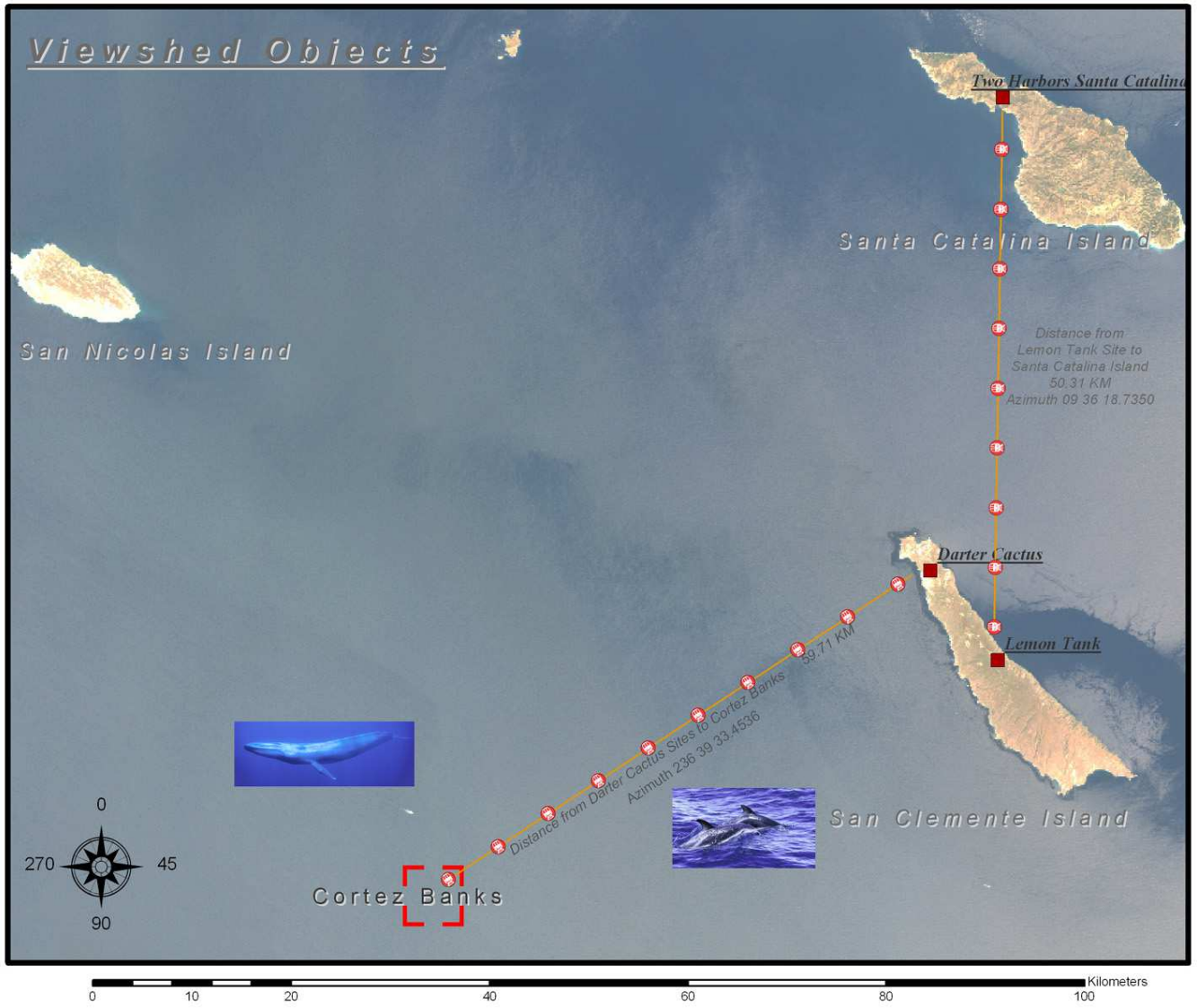
"This photo was taken from land, while the boats were hunting a group of pilot whales into a fjord. The whales were killed a few minutes later, after swimming on to the beach or near to the beach, where men were waiting. "

"The hunting is not planned, boats don't go out searching for the whales, it happens when a boat or perhaps a ferry happens to finds a group of pilot whales near land, and then they pass the message on and other boats sail out to chase them into the nearest bay or fjord. "

http://en.wikipedia.org/wiki/File:Whaling_in_the_Faroe_Islands_in_August_2012.JPG

Photos by Eileen Sanda, shared under Creative Commons license

Such opportunist hunting of sea mammals is still practiced today; it is probably similar to practice at SCI. It requires communication and coordination

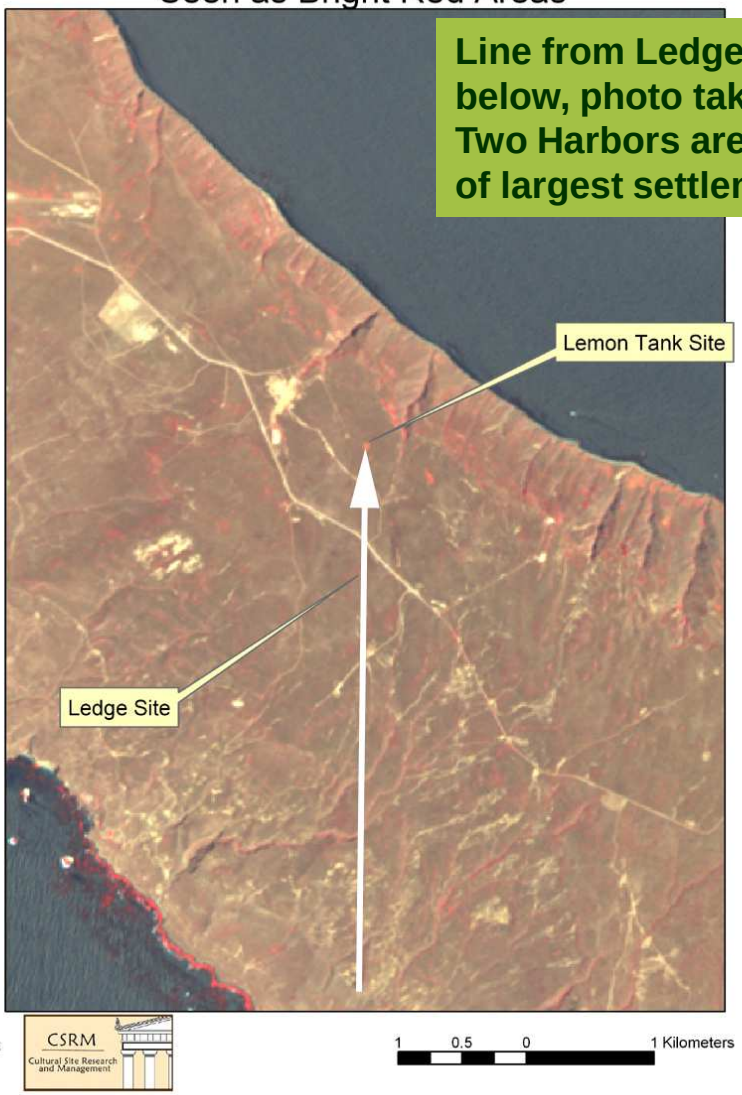

Viewshed Objects
Two Harbors Santa Catalina
Santa Catalina Island
San Nicolas Island
Distance from
Lemon Tank Site to
Santa Catalina Island
50.31 KM
Azimuth 09 36 18.7350
Darter Cactus
Lemon Tank
59.71 KM
Distance from Darter Cactus Sites to Cortez Banks
Azimuth 236 39 33.4536
San Clemente Island
Cortez Banks
0
270
45
90
Kilometers
0
10
20
40
60
80
100

Relationships Among Southern Channel Island Sites

ASTER Image
Red: NIR
Green: Red
Blue: Green

ASTER Image (April, 2002)

Large Ritual Sites
Seen as Bright Red Areas



Line from Ledge Site to Lemon Tank Site (seen below, photo taken looking north) extends to Two Harbors area of Santa Catalina Island, site of largest settlement there.

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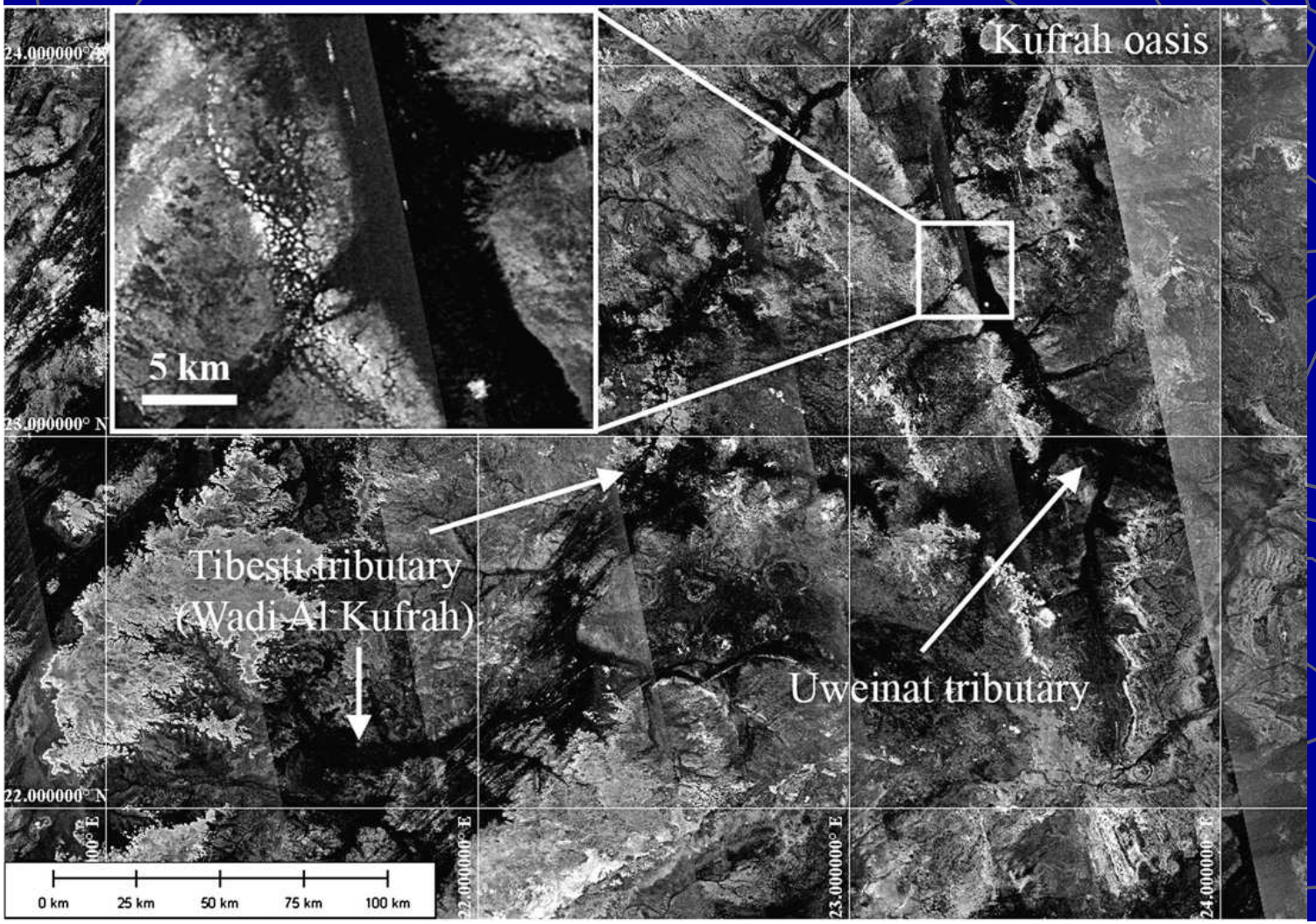
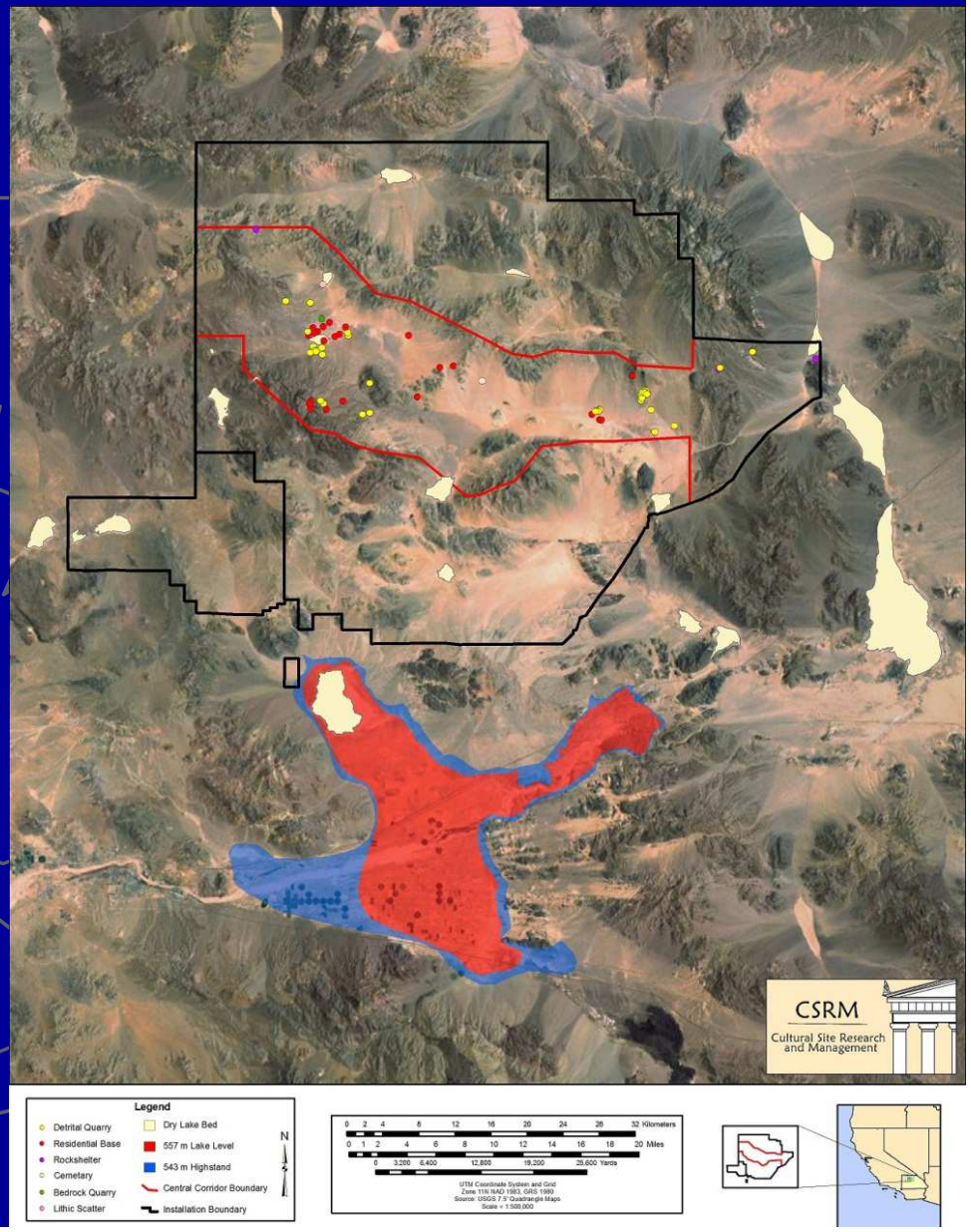
SAR Penetration of Dry Soils



PALSAR image of riverbeds and tributaries now covered by desert sand in Kufrah Basin, Libya.

Mojave Buried Shorelines

- As glaciers receded, huge lakes formed in the Mojave
- The lakes attracted mega fauna, now extinct
- These in tern attracted some of the human groups that first entered the New World
- We see remnants of these lakes as playa



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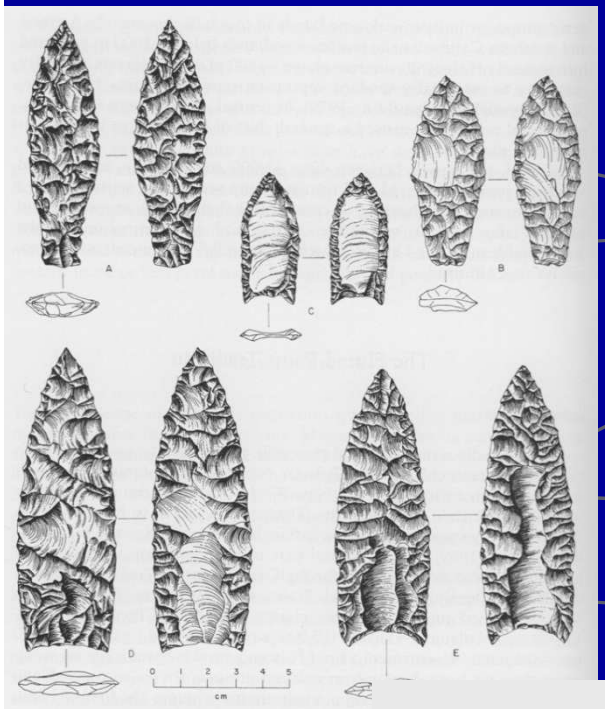
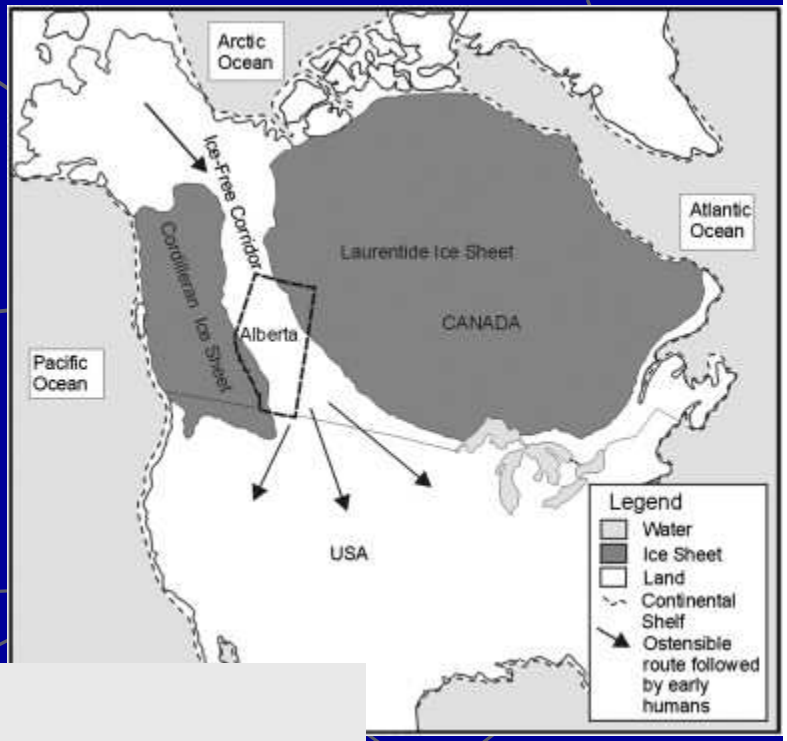
Clovis Culture

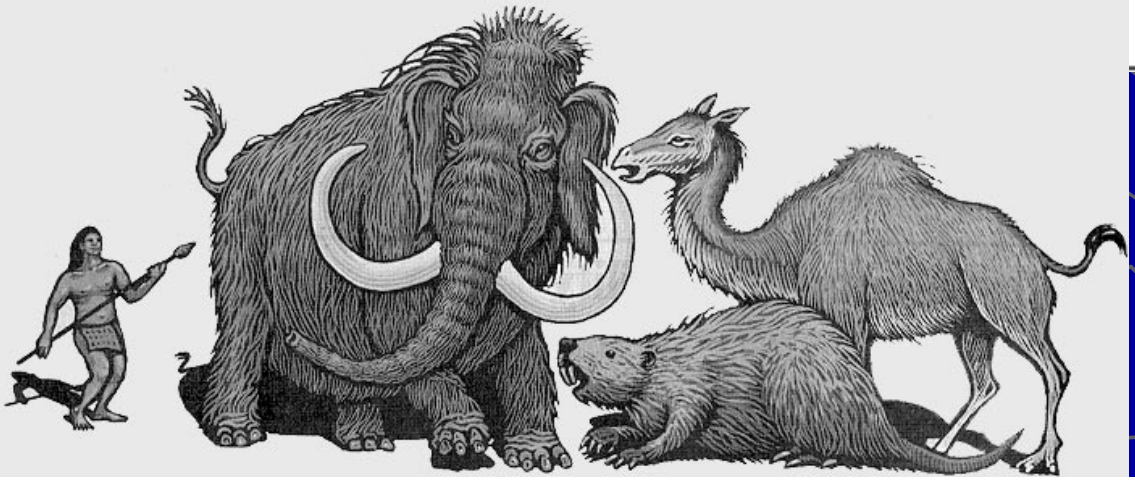


Entered New World over the Bering Land Bridge, then moved south when ice-free corridor formed

Used finely made, specialized tools



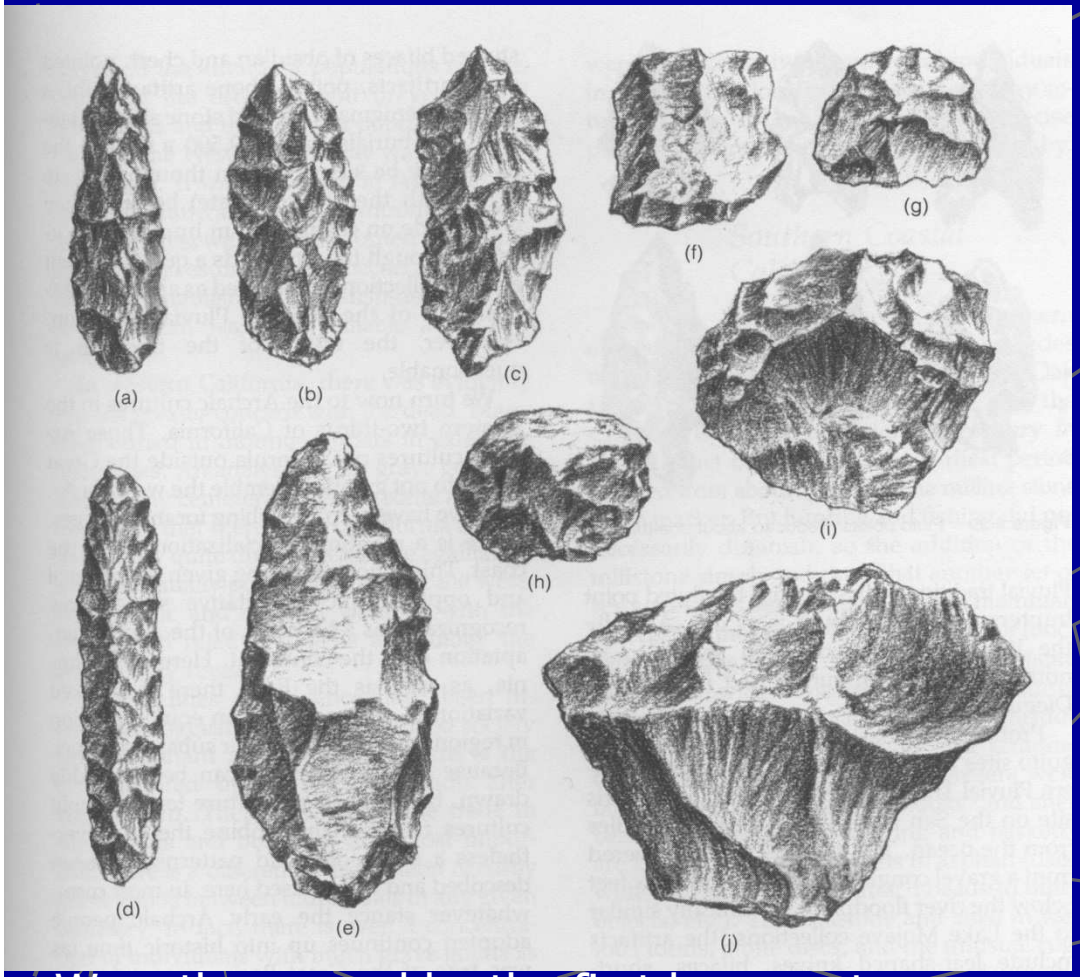
Megafauna extinct about 1,000 years after human entry, c. 13,000 B.P.



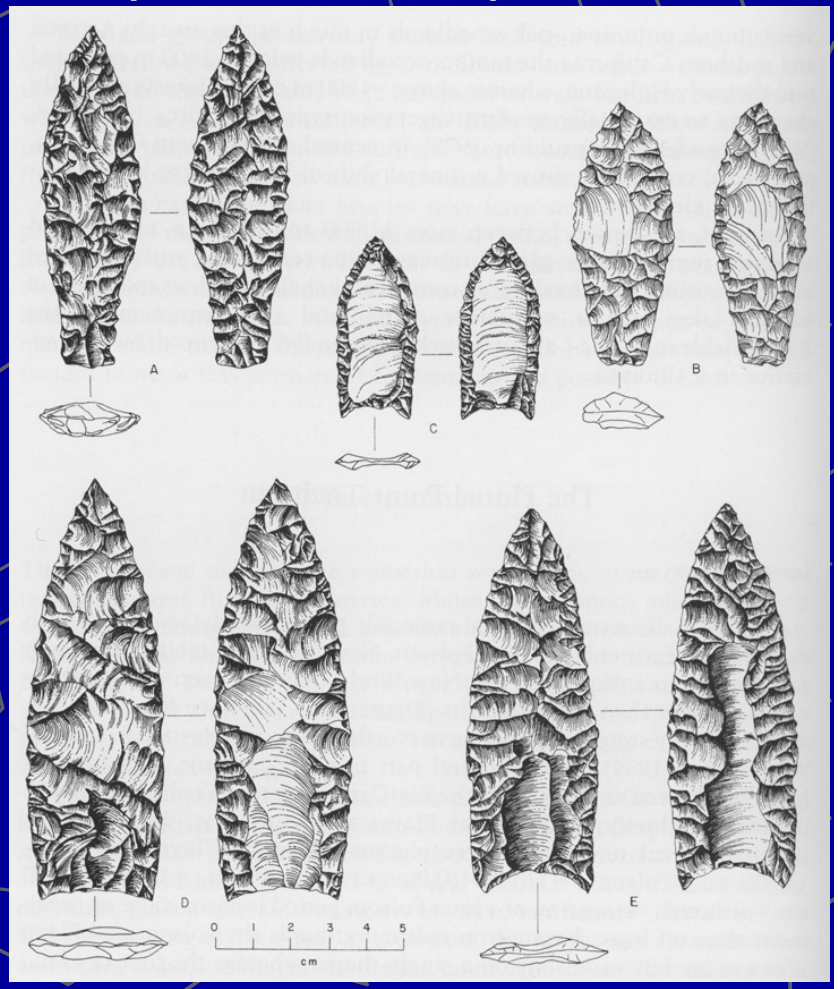
Clovis tools no longer used

Western Stemmed and Clovis

Also known as Western Pluvial, San Dieguito, etc.: 14,300 -8,000 B.P



Fluted points, 13,500-10,000 B.P. (includes Folsum)



Were these used by the first humans to enter the New World?

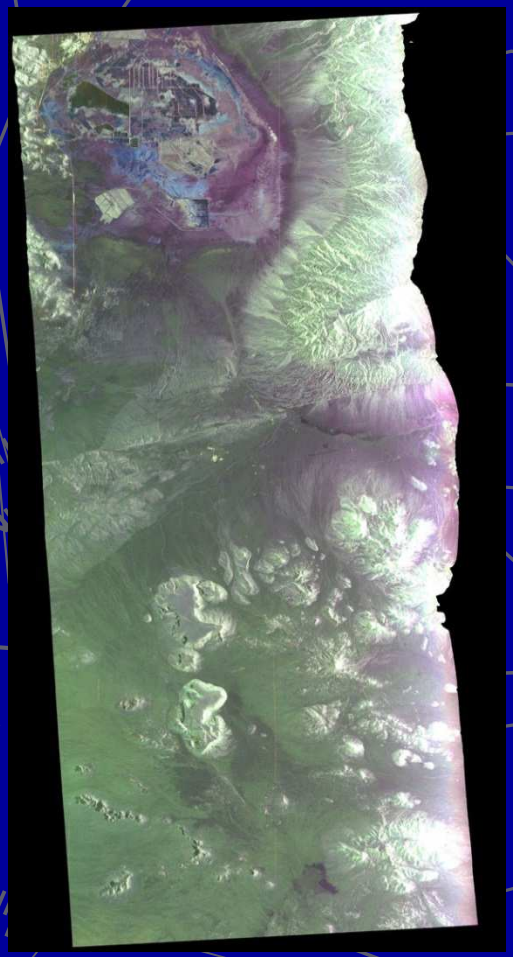
Kelp Highway

- in *Quaternary Science Reviews*, however, is evidence in the form of pollen and charcoal from soil cores in deep water within three lakes on Sanak Island in the Aleutians, which suggests that Sanak (and perhaps the corridor into the American continents) was ice free by **17,000** years ago.
- Stone tools found in Paisley Cave, Oregon, with a very reliable date of 14,300 before the present.

Interestingly, early dates for human occupation on San Clemente and all other Channel Islands

UAVSAR

UAVSAR image



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UAVSAR Home

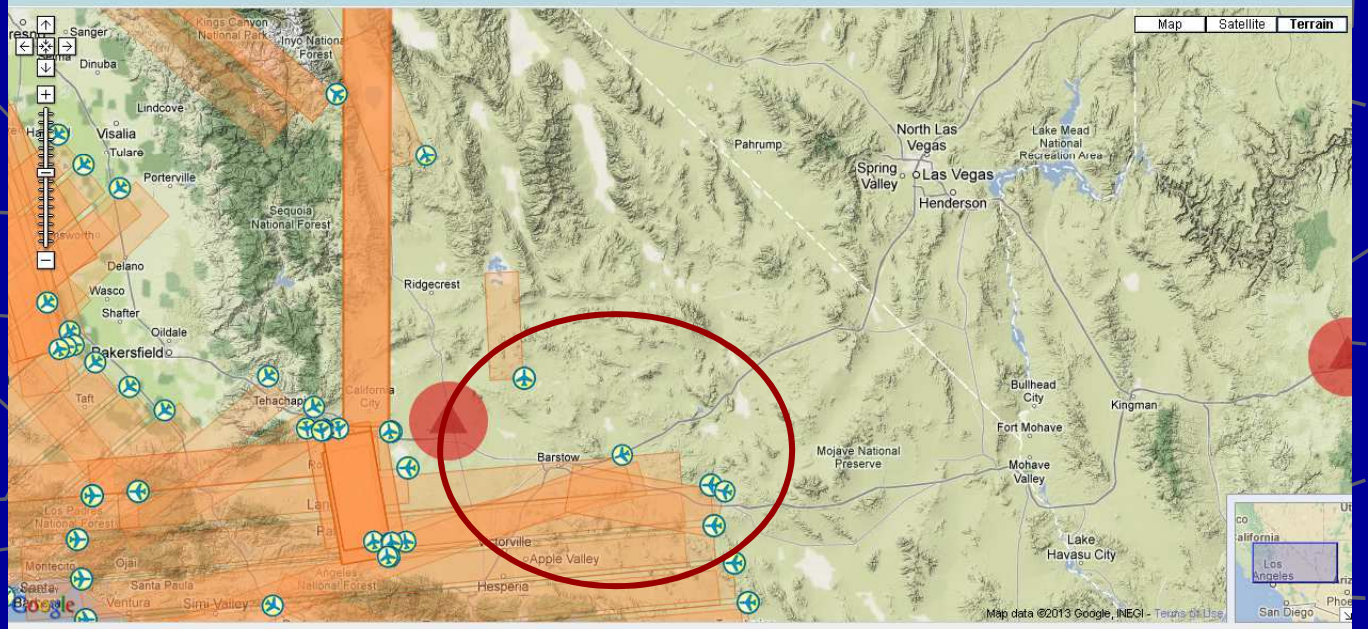
UAVSAR Data Search

Map Search (Switch to Text search)

You can search by **flight ID**, **line ID**, **line sitename**, **line description**, and **date of acquisition** (in YYMMDD format). Only flight IDs can be searched as a range (e.g. "09001-09035").
To search multiple criteria using OR, separate your search with commas (e.g. "San Andreas, 26532").
To search multiple criteria using AND, separate your search with period (e.g. "Haiti. 11042").
To search multiple criteria using NOT, separate your search with exclamation mark (e.g. "Haiti! 11042").

In the map, click on the **download icons** to download the data.

ALL | Band Selections: L P Ka | Search | Show | Show



Total Number of flightlines with data on the map: 586

Just Published: PALSAR Fusion with WV-2

- The data fusion method used in this study is the Principal Component (PC) spectral sharpening algorithm (Welch and Ahlers, 1987). It is a popular data fusion method and normally used to sharpen a low resolution multi-band image with a high resolution panchromatic band. The optical WorldView-2 multi-band data acquired on October 14, 2010 was fused with the ALOS/PALSAR L-band image acquired in HH mode on September 17, 2008. Before fusing the data sets, the PALSAR data were filtered using the refined Lee filter method with a 3 × 3 window size. The data were also interpolated from the original 12.5 m spatial resolution to 0.5 m and co-registered to the WorldView-2 panchromatic data. A color composite of the fused SAR/WorldView-2 bands 7, 4, 3 displayed as RGB rendered the best color contrast, as shown in Fig. 4.

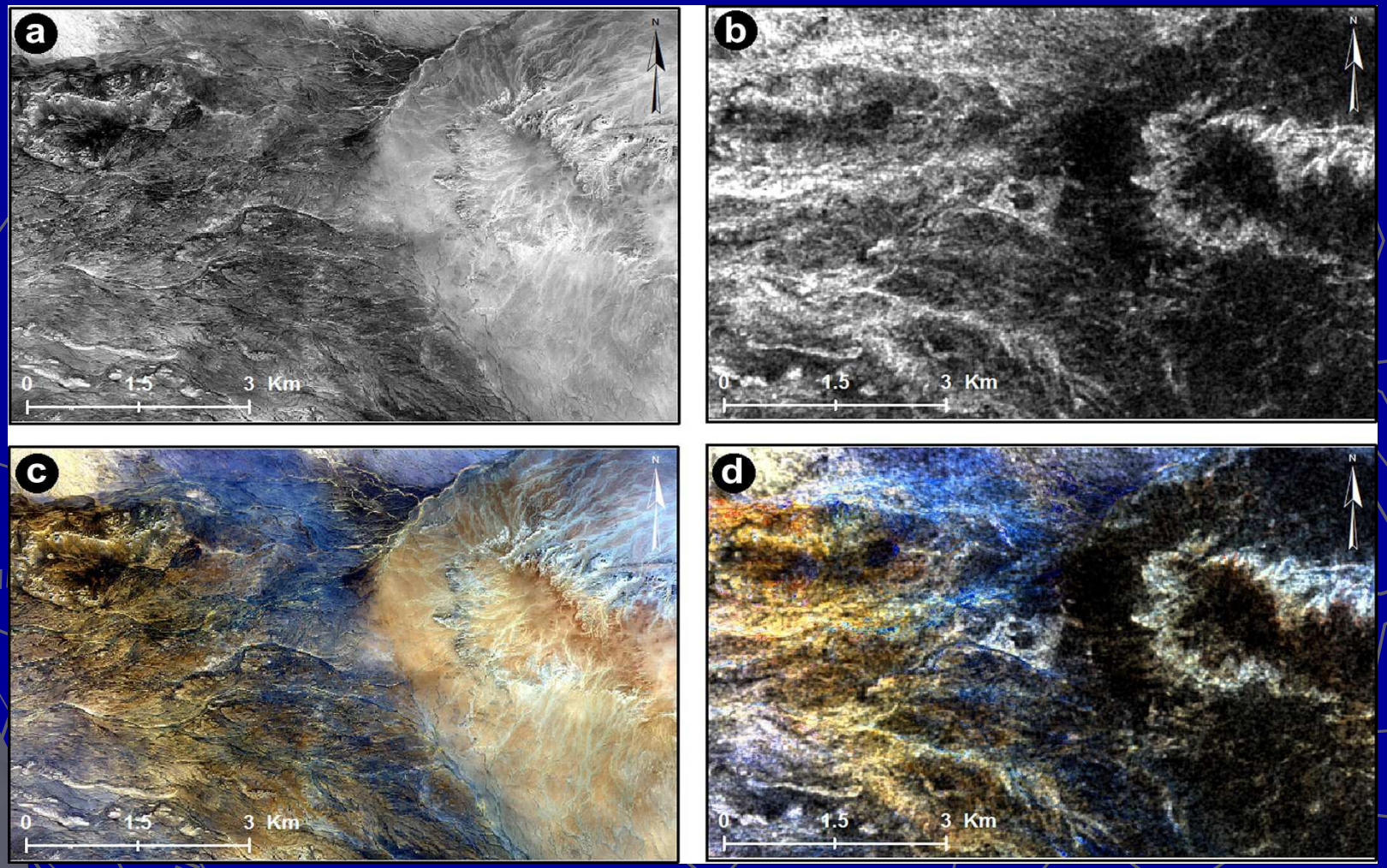


Fig.?4 (a) & (c) are the WorldView-2 panchromatic and multi-band (7, 4, 3) data, respectively, (b) is the resampled ALOS/PALSAR data and (d) is the hybrid WorldView-2/PALSAR.

Ahmed Gaber , Magaly Koch , M. Helmi Griesh , Motoyuki Sato , Farouk El-Baz

Near-surface imaging of a buried foundation in the Western Desert, Egypt, using space-borne and ground penetrating radar

Journal of Archaeological Science Volume 40, Issue 4 2013 1946 - 1955

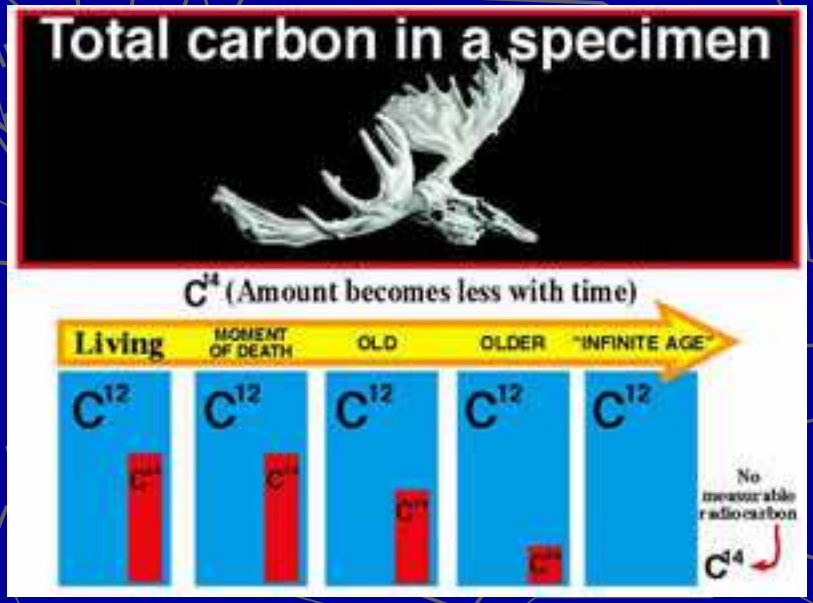
http://dx.doi.org/10.1016/j.jas.2012.12.019

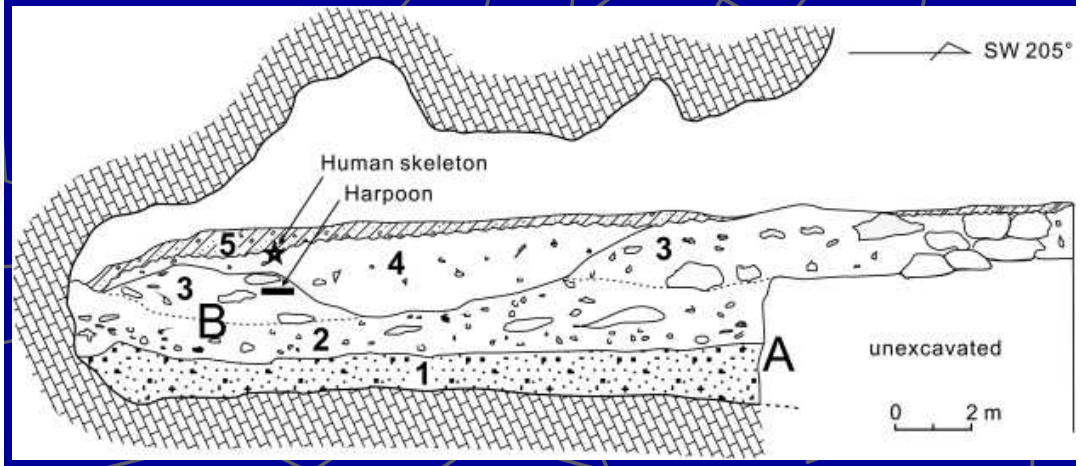
Archaeology=Material in Context

- Archaeologists analyze uncontaminated material in context

Residue analysis to reveal ancient diet

Stratigraphic integrity





Thank You

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  - Dr. Bruce D. Chapman
  - Dr. Elaine Chapin
- NASA Goddard
  - Dr. James Tilton

Thank You

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  - Prof. Carey Preibe
  - Daniel Sussman
  - Li Chen
- The DoD Strategic Research and Development Program
- NASA ROSES

Thank You

- The National Center for Preservation Technology and Training
- University of Southern California
  - Prof. . Mahta Moghaddam