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5th TerraSAR-X / 4th TanDEM-X Science Team Meeting

The application of X-Band SAR interferometry in archaeology – first results from test sites in Turkey

Ralph Rosenbauer, Mirko Novák, Susanne Rutishauser –
University Bern

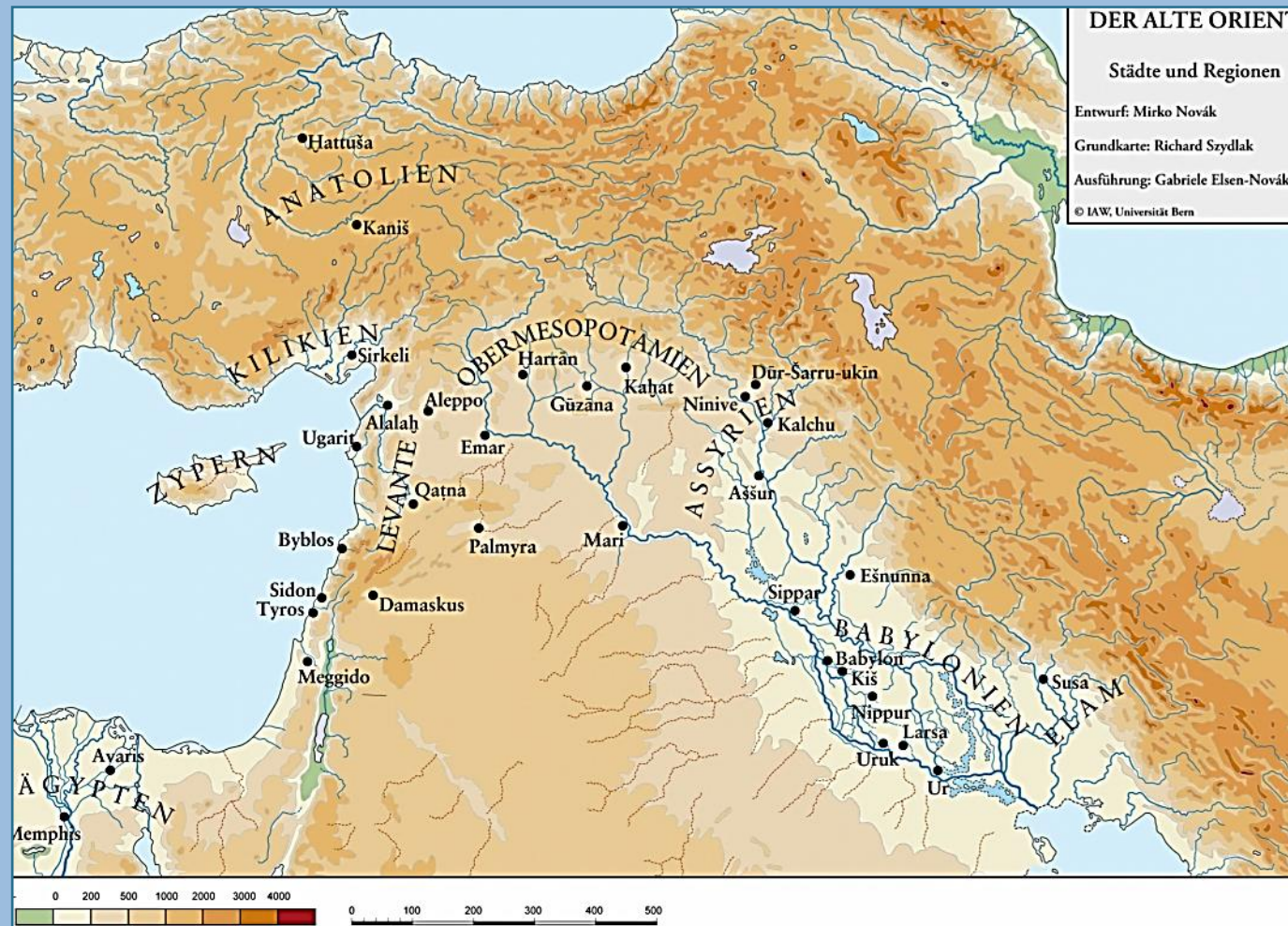
Stefan Erasmi, Ralf Buchbach –
University of Göttingen



Topics

- > Cilicia Pedias – An important pivot point between Anatolia and Syria
- > Project works in the Cilicia Pedias: Geophysical surveys and excavations
- > The search for the location of the city of Mallos
- > Major TanDEM-X Test Sites within Plain Cilicia
- > Test-Sites I: Uzunoğlan Tepesi, a hilltop sanctuary with roman temple
- > Test-Sites II: Sirkeli Höyük: a bronze and iron age mound
- > Coverage of TanDEM-X data in Cilicia Pedias
- > Test-Sites III: a fortified harbor settlement at the edge of Plain Cilicia
- > TanDEM-X workflow for DEM extraction (SM and HS)
- > Outlook: Protection of Cultural Heritage
- > The Virtual Cilicia Project

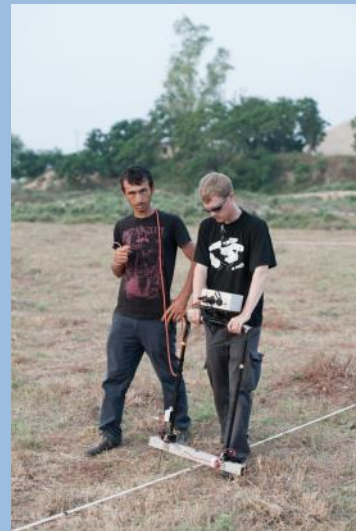
Cilicia Pedias



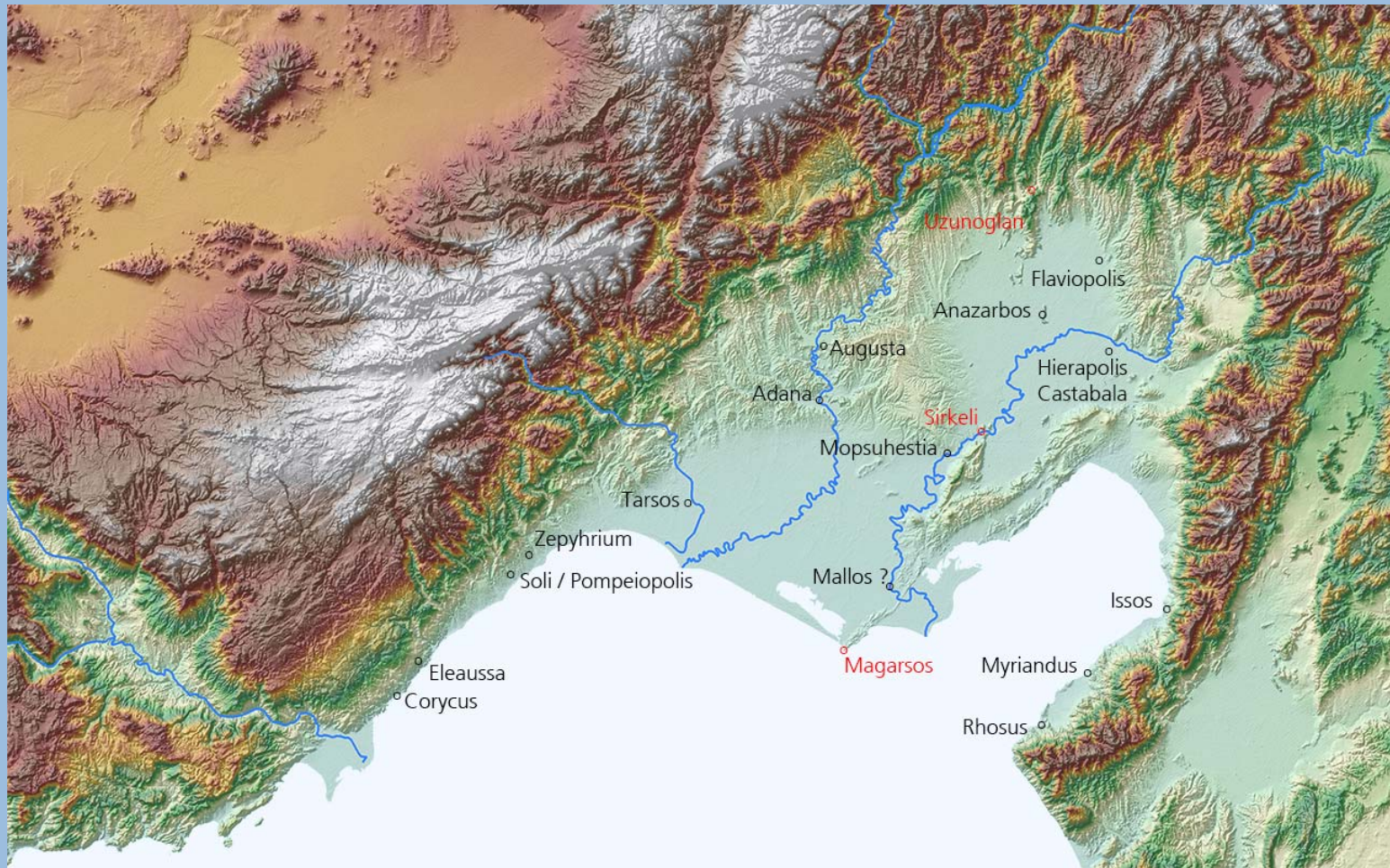
Mallos – An important city still to be discovered



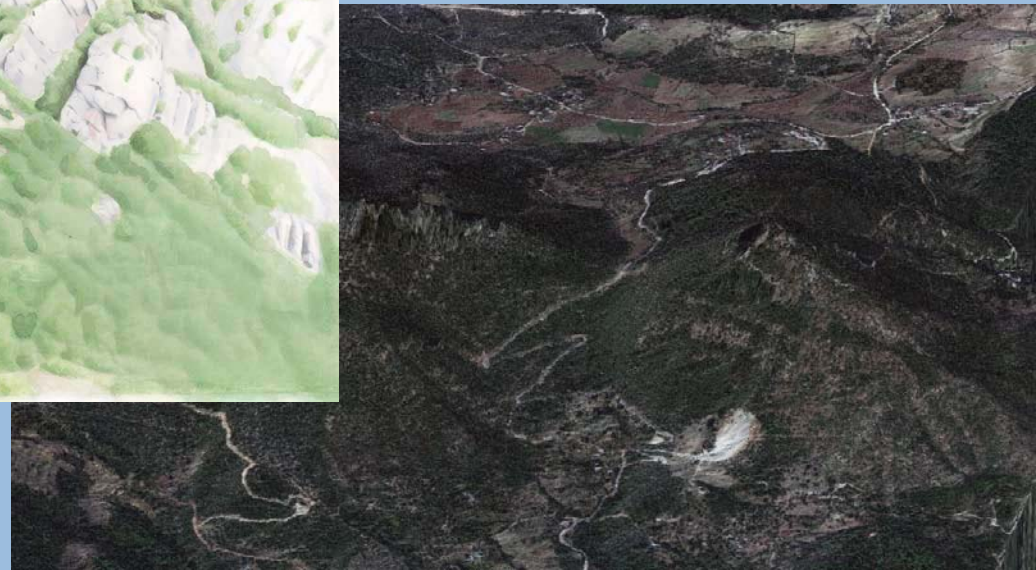
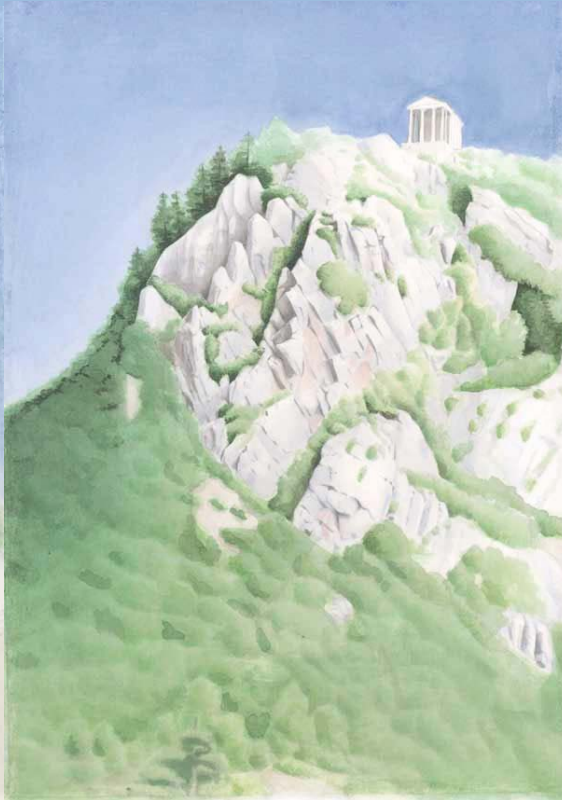
Methods and technics used during the surveys



Major TanDEM-X Test Site within Plain Cilicia



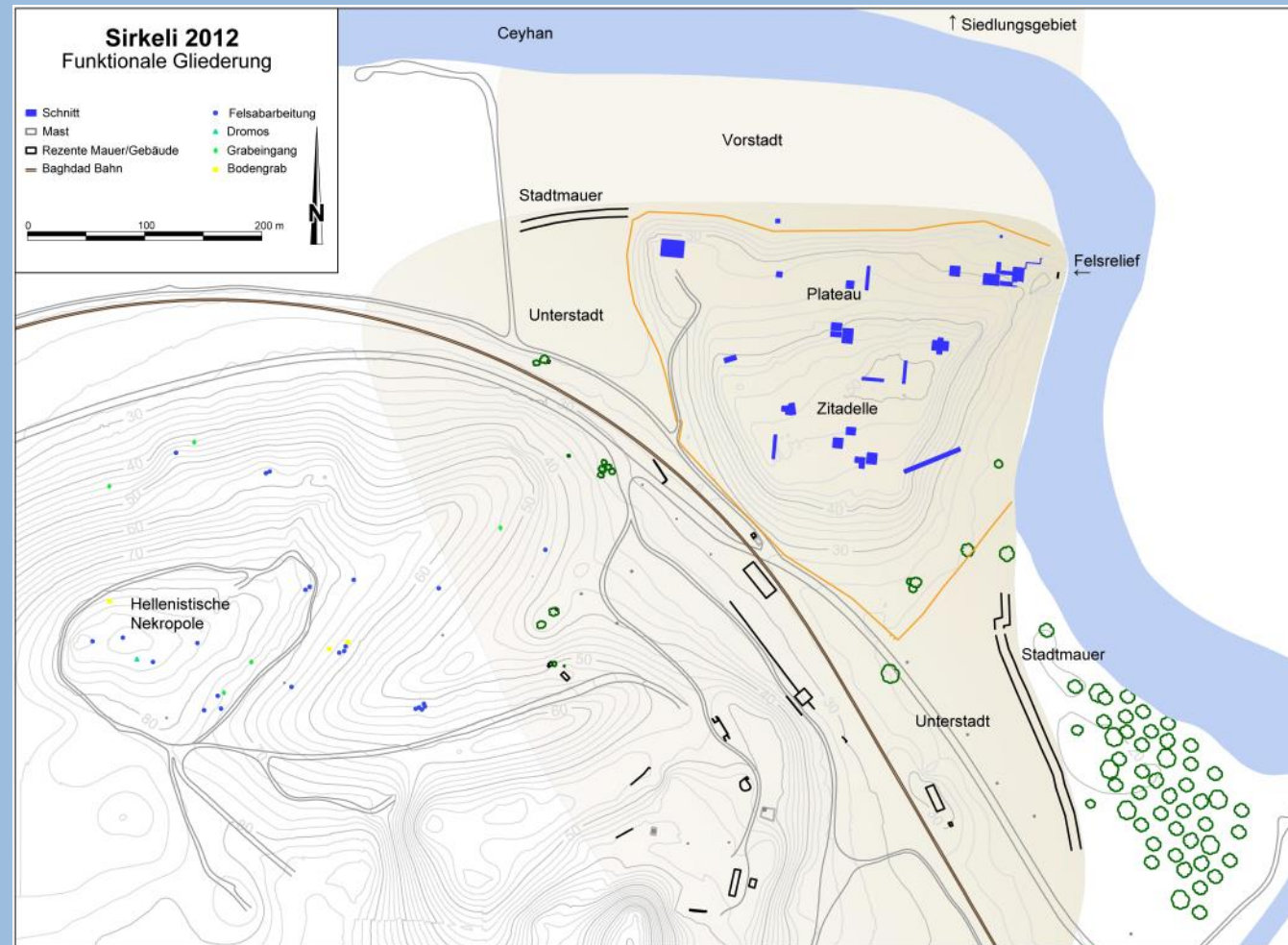
Major TanDEM-X Test Sites I: Uzunoğlan Tepesi with roman temple



Major TanDEM-X Test Sites: Sirkeli Höyük a bronze and iron age mound



Sirkeli Höyük – one of the largest settlement mounds within Cilicia



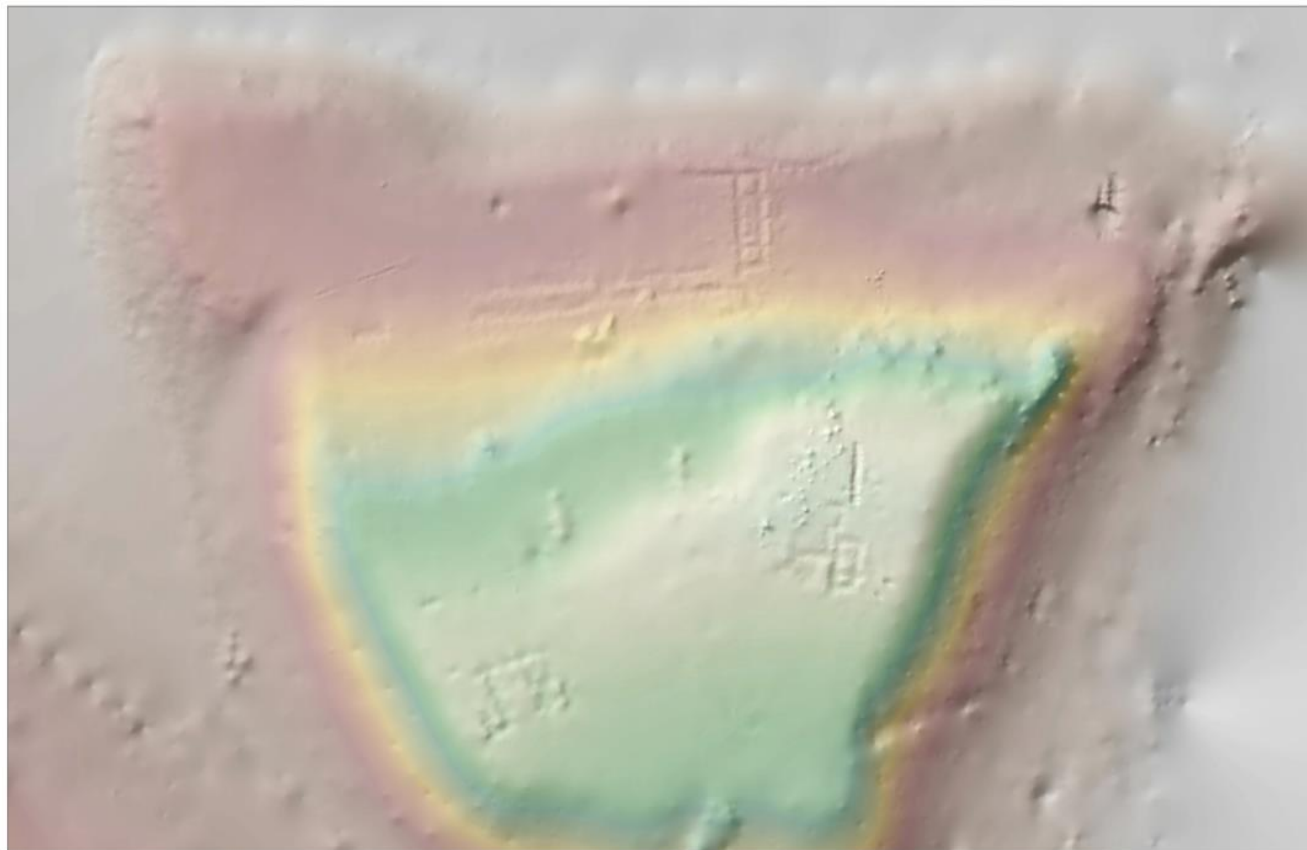
Sirkeli Höyük – Rock Reliefs Muwatalli II. (1290–1272 BC.) + ?



Sirkeli Höyük - clearly visible building structures in WordView1 data



Sirkeli Höyük – DEM of the top of the tell with ditches from Spoliation (?)



Sirkeli Höyük

0 15 30 60 90 120 Meters
1:500

DEM generated from RTK-GPS measurements showing clearly visible archaeological structures

Sirkeli Höyük – magnetic prospection of the lower city with city wall



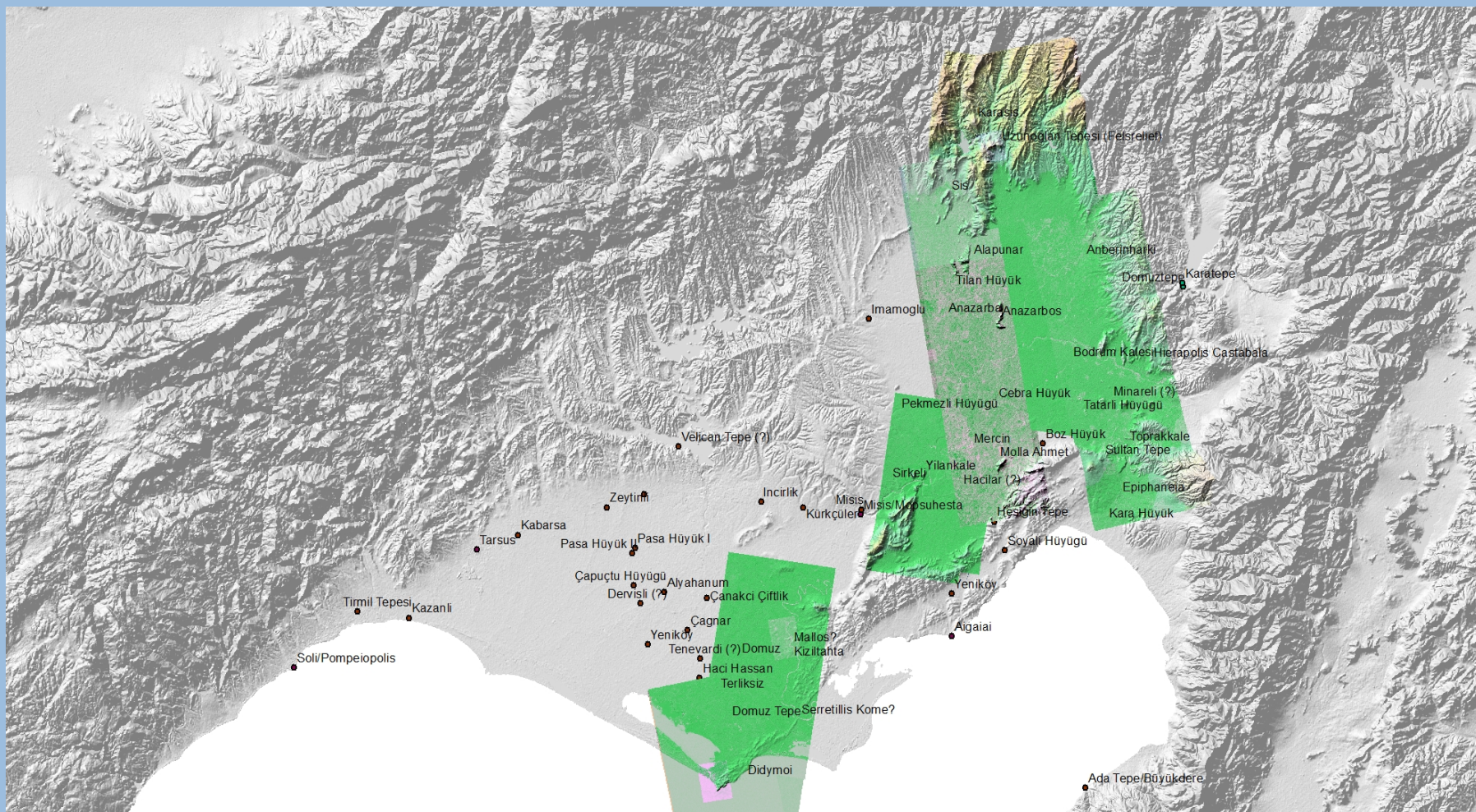
Sirkeli Höyük

0 25 50 100 150 200 Meters

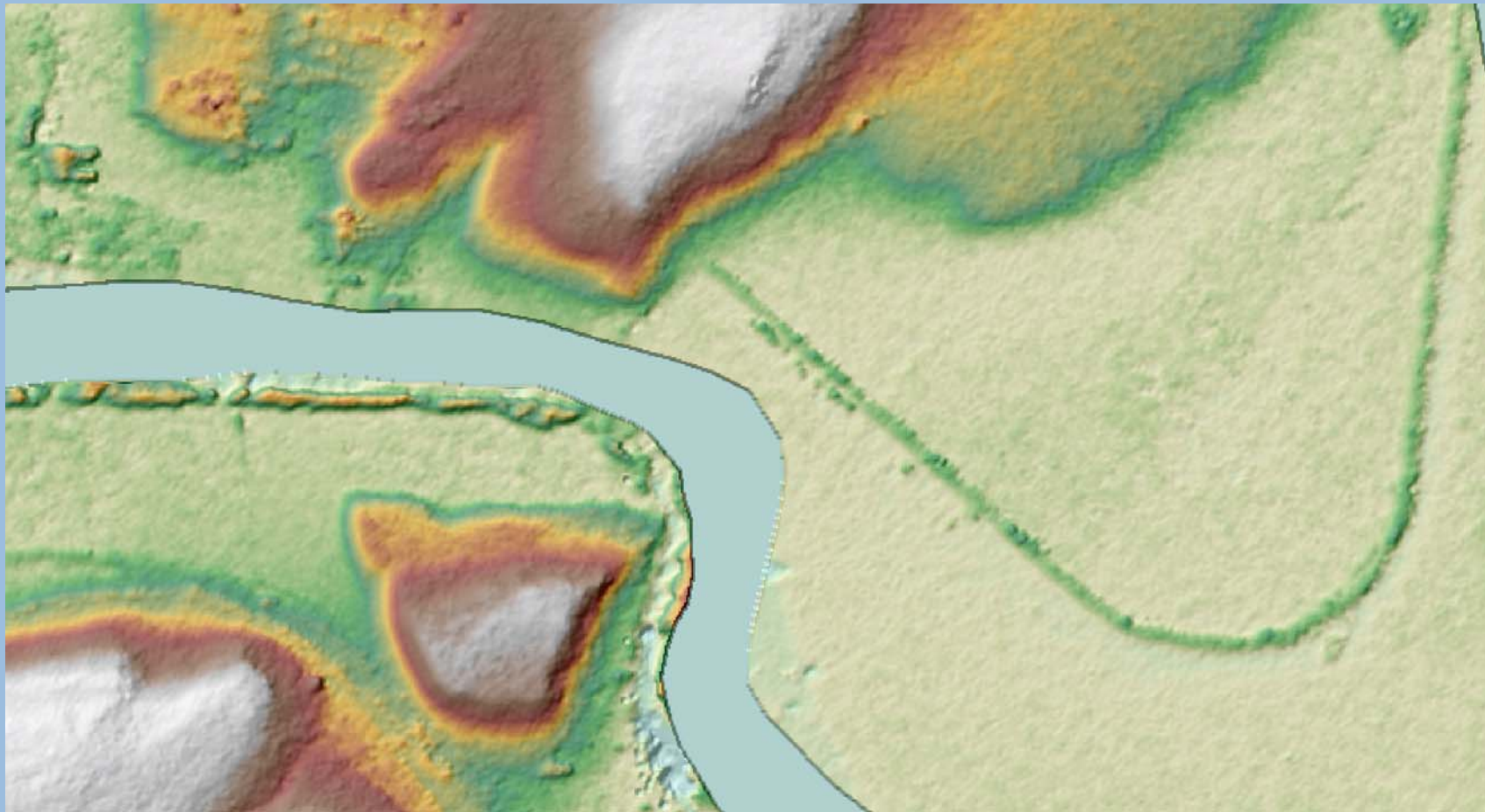
1:750



Plain Cilicia (Cilicia Pedias) Coverage of TanDEM-X data

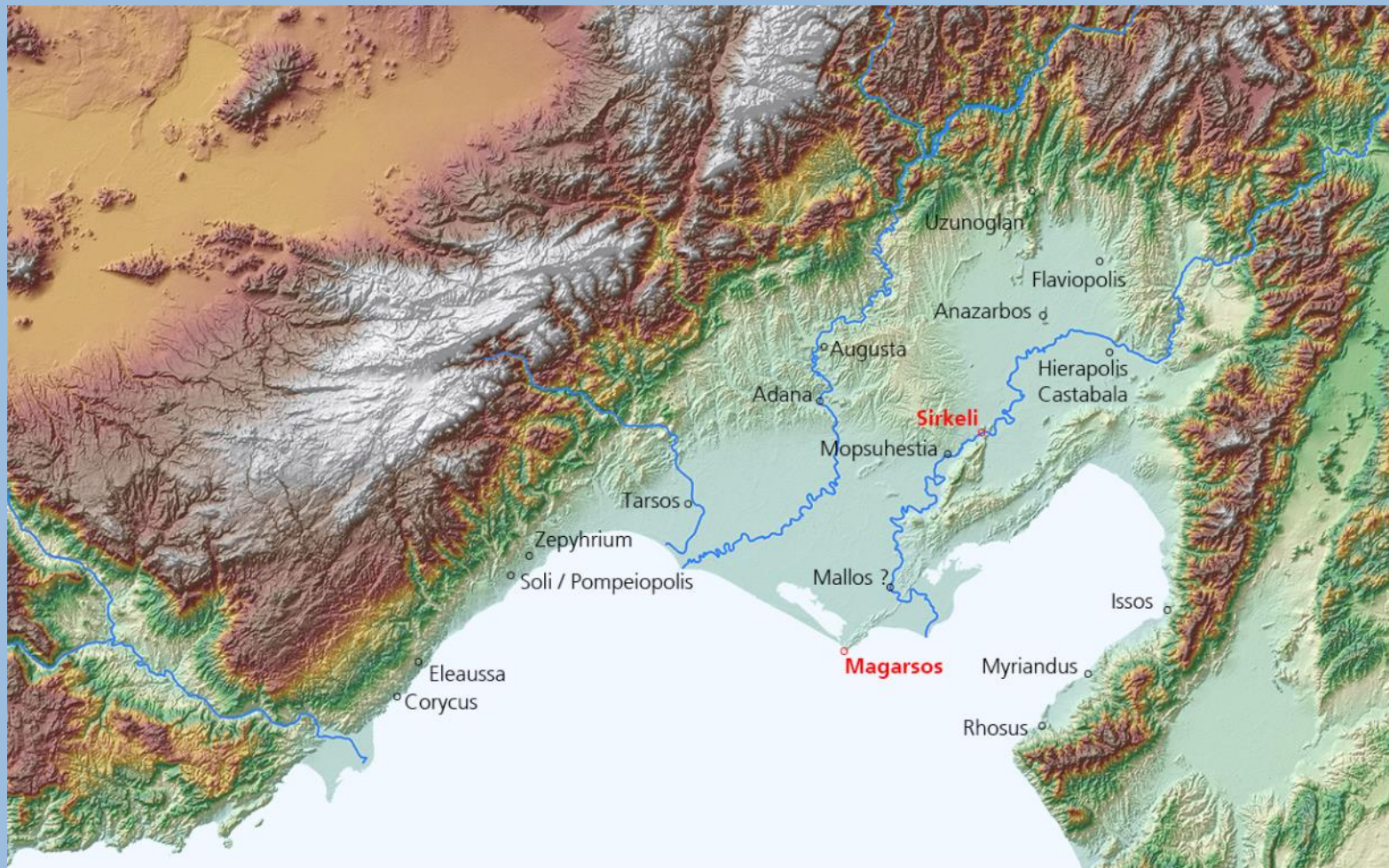


Sirkeli Höyük – digital surface model created with TanDEM-X Spotlight data

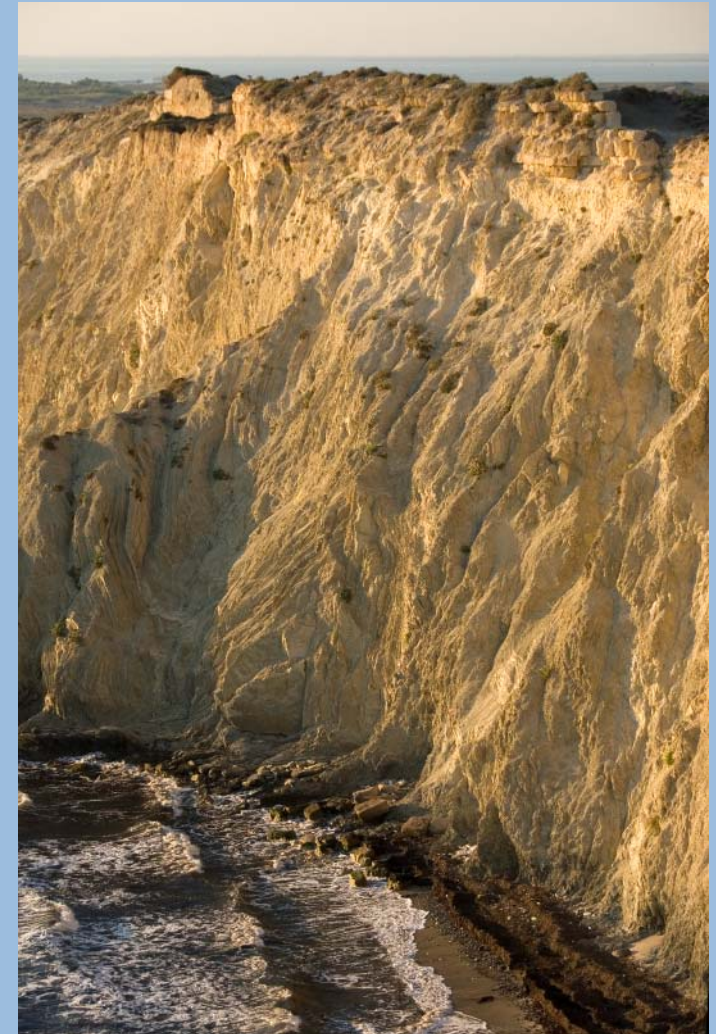


Srkeli Höyük: DEM with 2m spatial resolution generated by HS-Spotlight HH-HH (300Mhz)

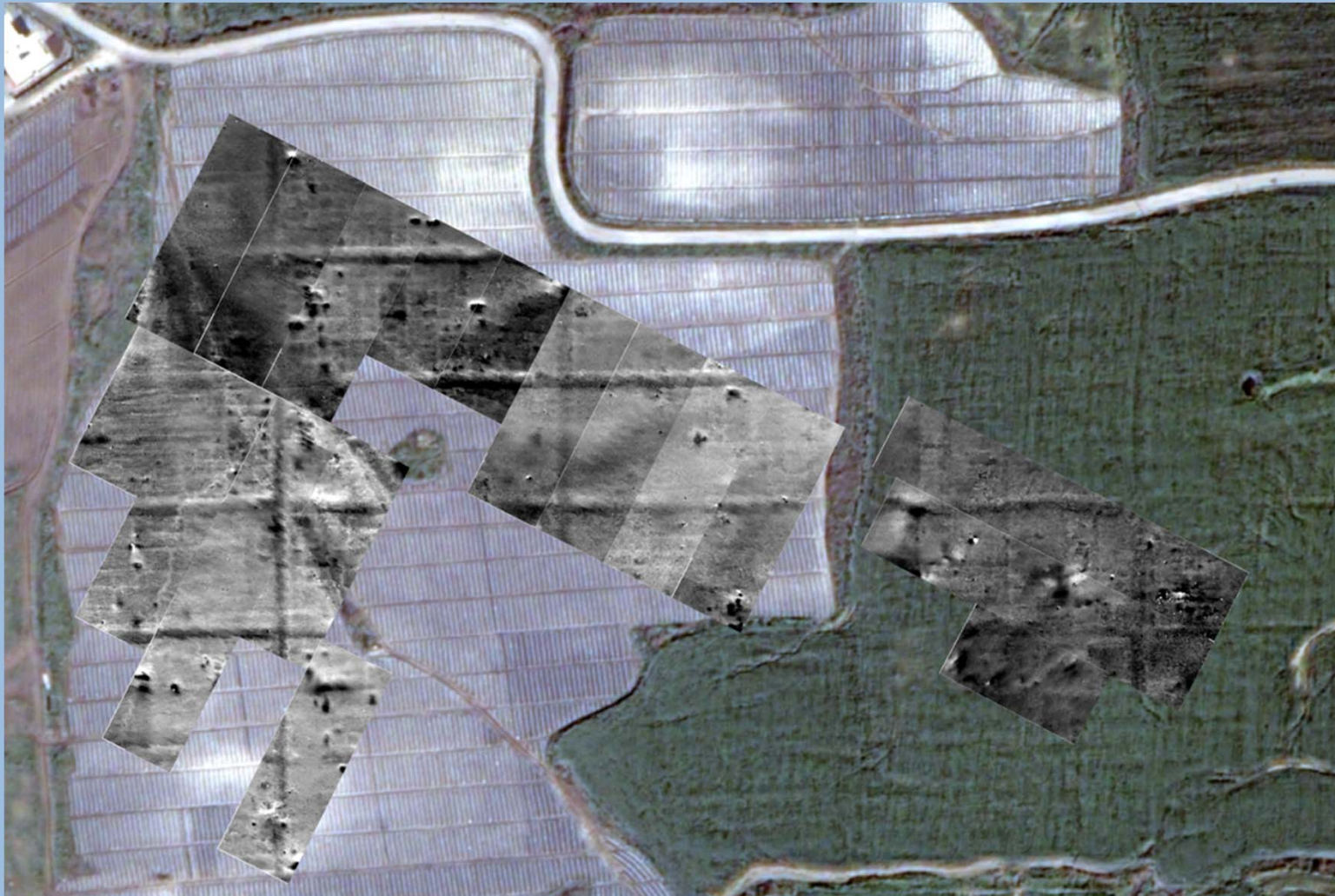
Magarsos – a fortified harbor settlement at the edge of Plain Cilicia



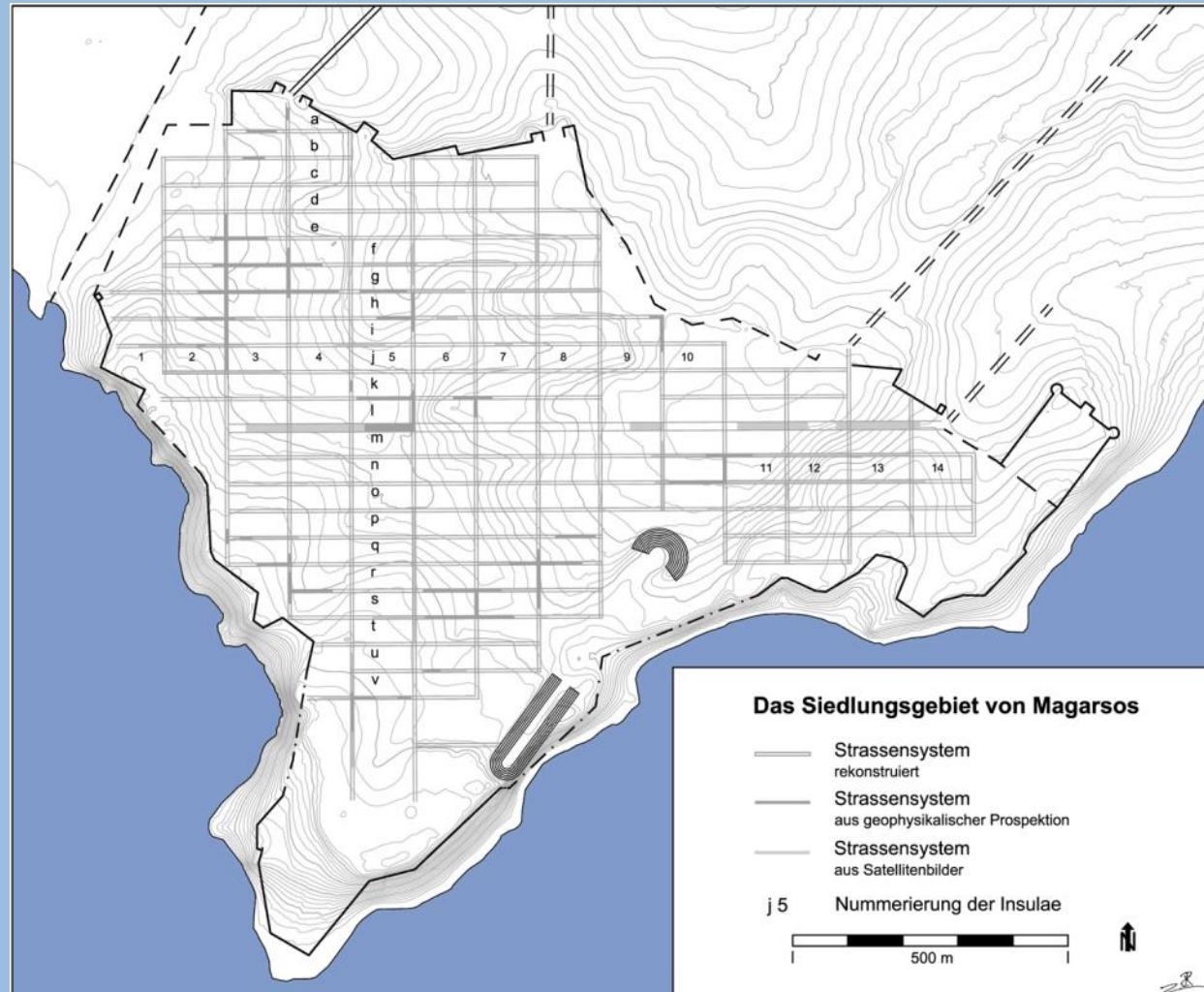
Magarsos – today's scenery



Magarsos – Combination of geophysics and orthorectified satellite image



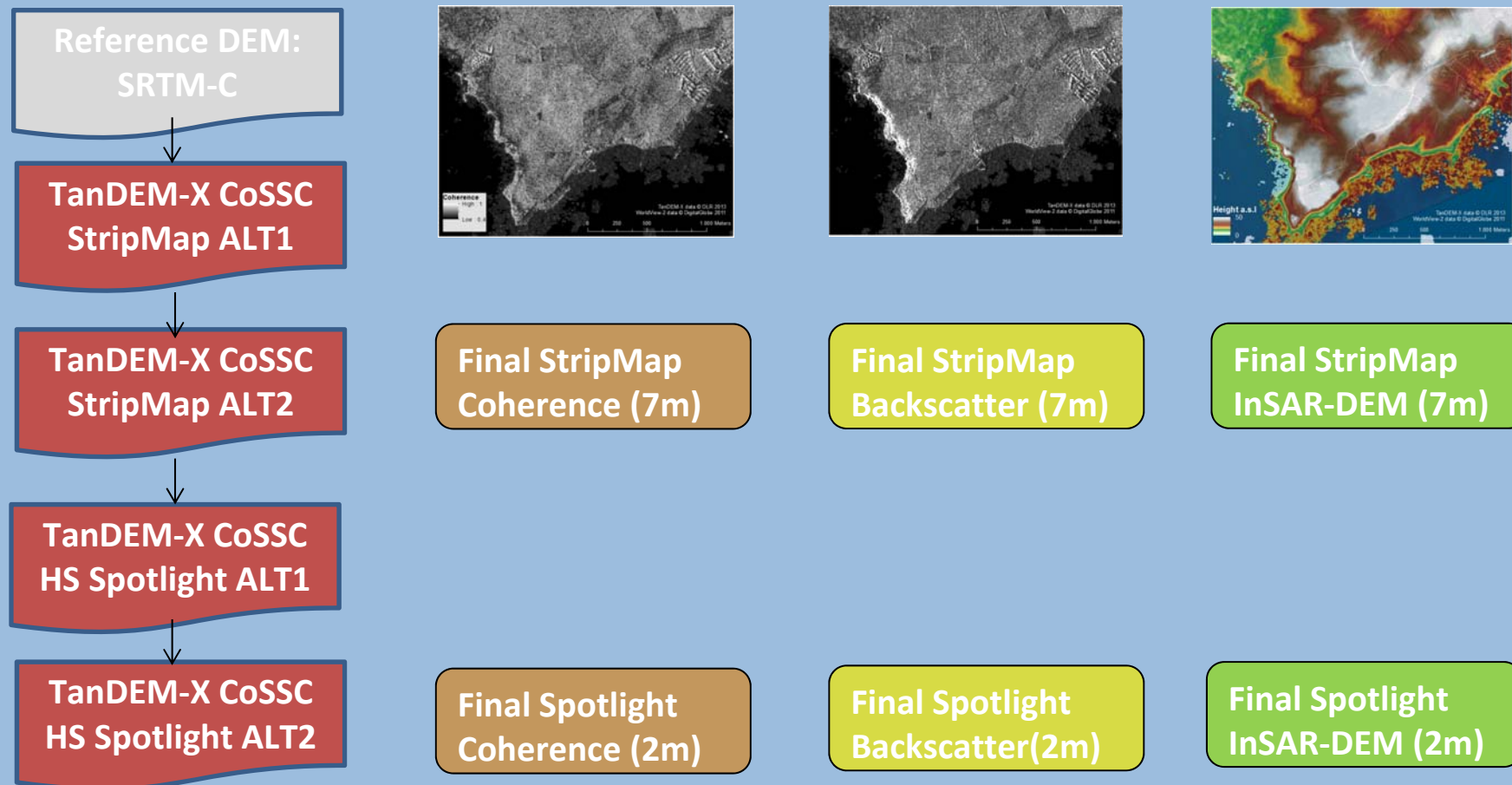
Magarsos – Reconstruction of the city's layout



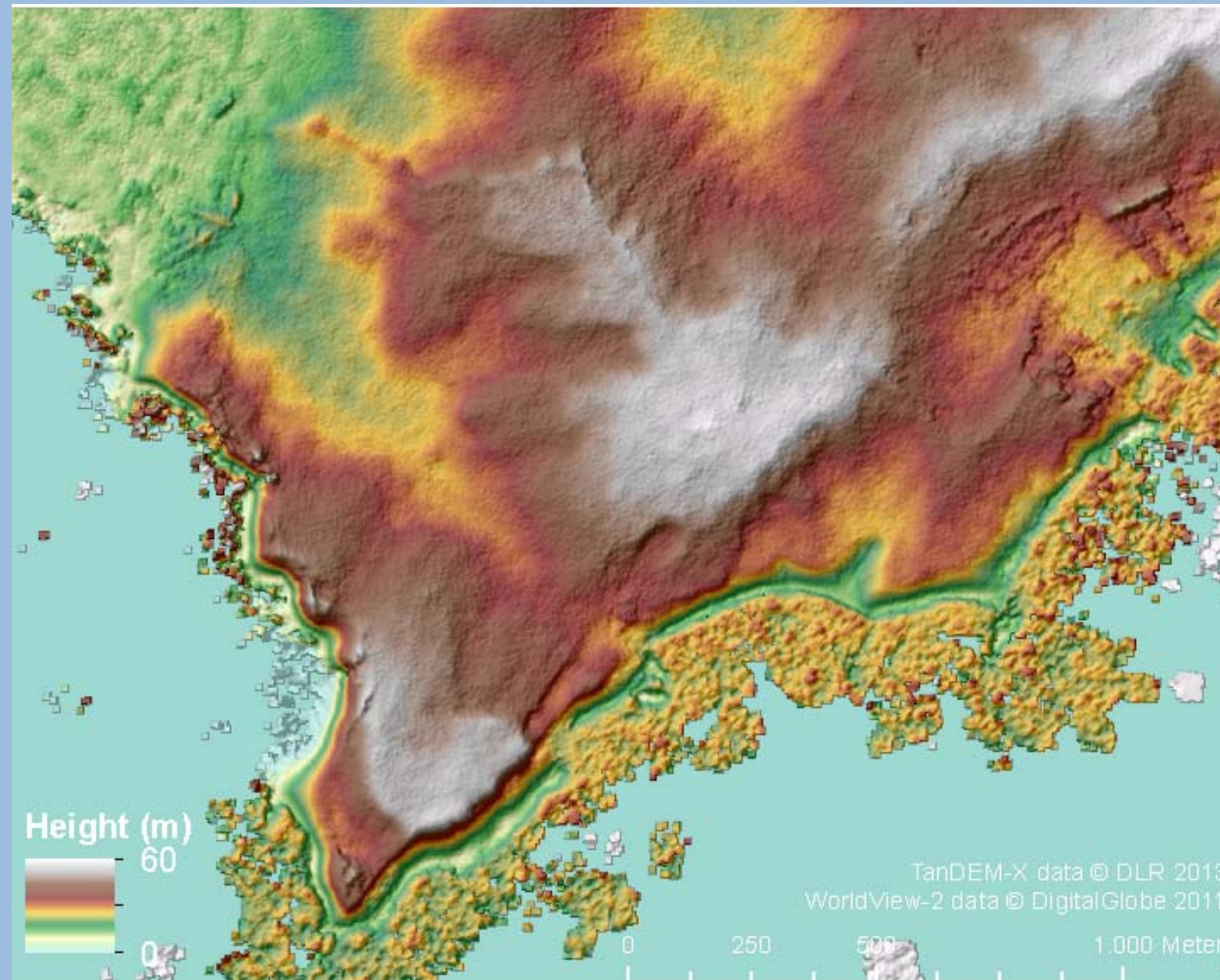
Magarsos – TanDEM-X scenes used for DEM-generation (StripMap & Spotlight)

| Imaging Mode | StripMap | HS Spotlight |
|----------------------|----------------------|----------------------|
| Interferometric Mode | alternating bistatic | alternating bistatic |
| Polarization Mode | Single (HH/HH) | Single (HH/HH) |
| Incidence Angle | 33,7 | 57,7 |
| Slant range res. (m) | 1,18 | 0,45 |
| Azimuth res. (m) | 2,54 | 1,13 |
| Acquisition date | 16.02.2012 | 20.08.2012 |

Magarsos – TanDEM-X workflow for DEM generation (SM and HS)

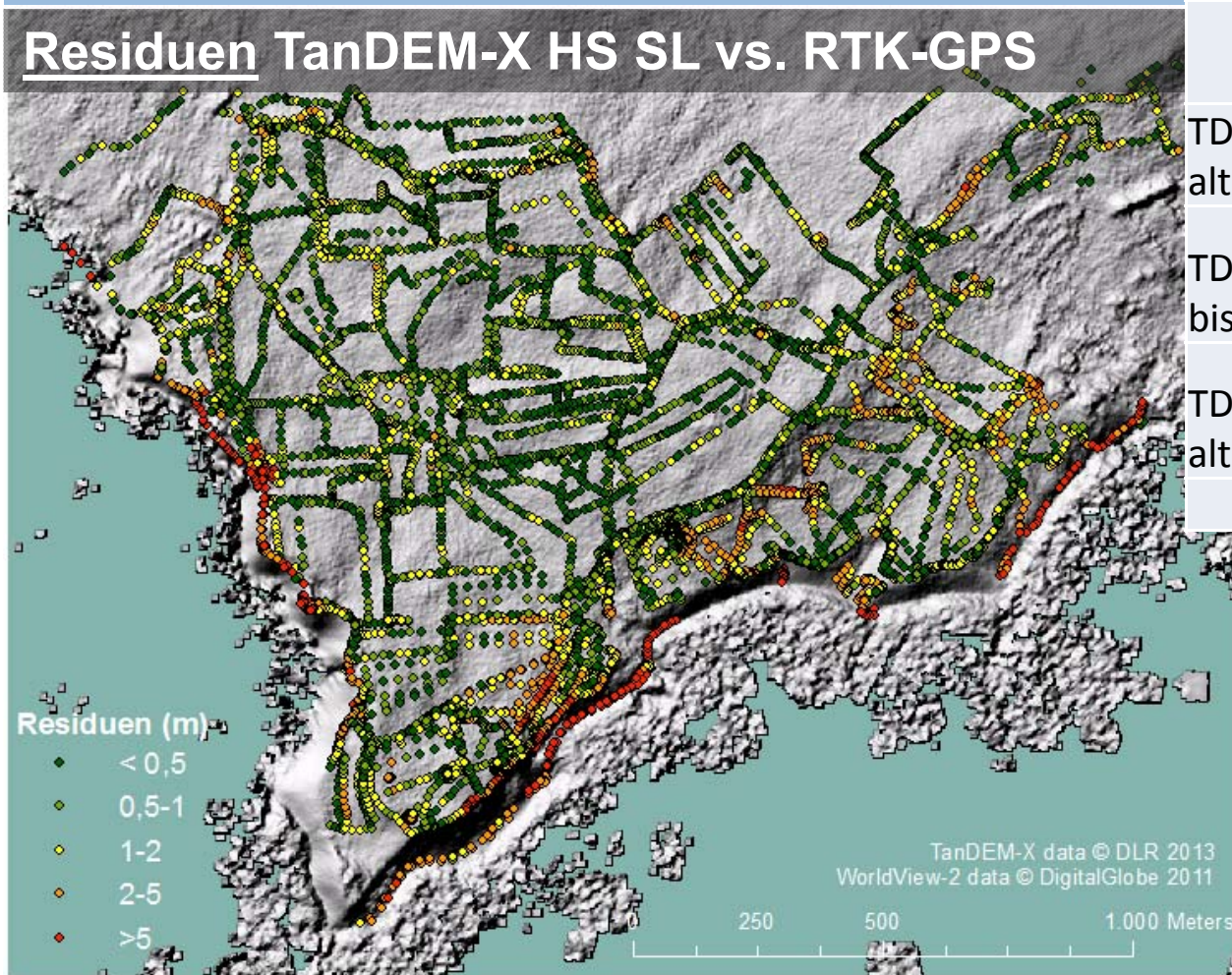


Digital surface (TanDEM-X Spotlight) with visible archaeological structures



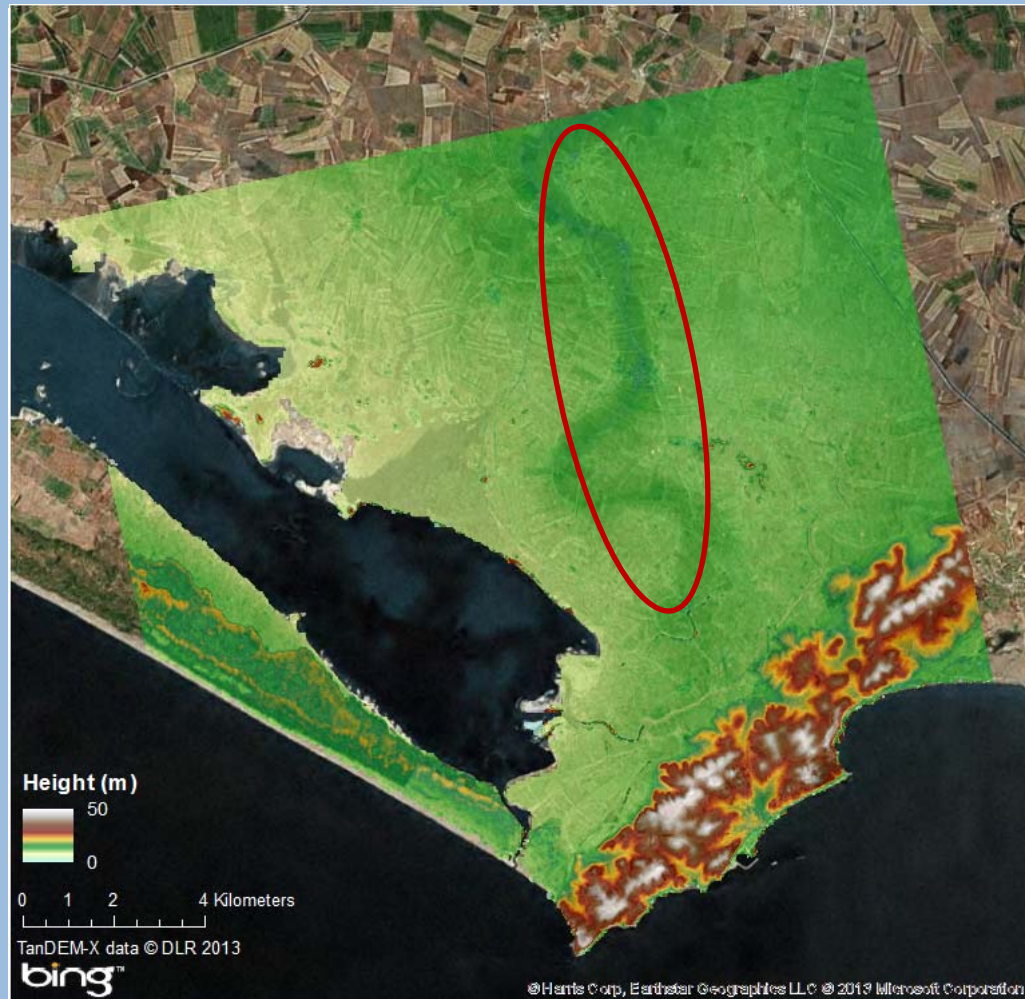
Accuracy of the DEM generated with TanDEM-X spotlight in for Magarsos

Residuen TanDEM-X HS SL vs. RTK-GPS



| | RMSE (all) | RMSE (< 20%) |
|--------------------------------|------------|--------------|
| TDX StripMap alt. bistatic | 1.61 | 1.24 |
| TDX HS Spotlight bistatic | 4.95 | 4.25 |
| TDX HS Spotlight alt. bistatic | 1.80 | 1.40 |

Palaeochannel north of Magarsos (detected by TanDEM-X data)



- (1) Intensity mean
- (2) Coherence
- (3) Height

Conclusion (results from Test site at Magarsos)

- An easy-to-use and stable processing chain for TanDEM-X Alternating Bistatic scenes has been tested and adopted to the special needs of landscape archaeology.
- The HS Spotlight DEMs with 2m resolution offer a very good visual quality, thus providing a perfect base for the interpretation of archaeological features, like buried city walls or streets causing height anomalies on the surface
- The „Alternating Bistatic Merge“ offers a significant improvement of the quality of the DEM (residues / RMSE)
- The choice of the reference DEM plays a crucial role for the interferogram flattening!

Körtik Tepe – a Neolithic key-site at the Tigris (will be destroyed by artificial lake)



Körtik Tepe: RGB- Composite of Coherence and Intensity with resolution overlay

Outlook

- Increasing demand for cultural heritage monitoring due to urban growth, irrigation projects and general land use intensification
- Development of technics for looting monitoring

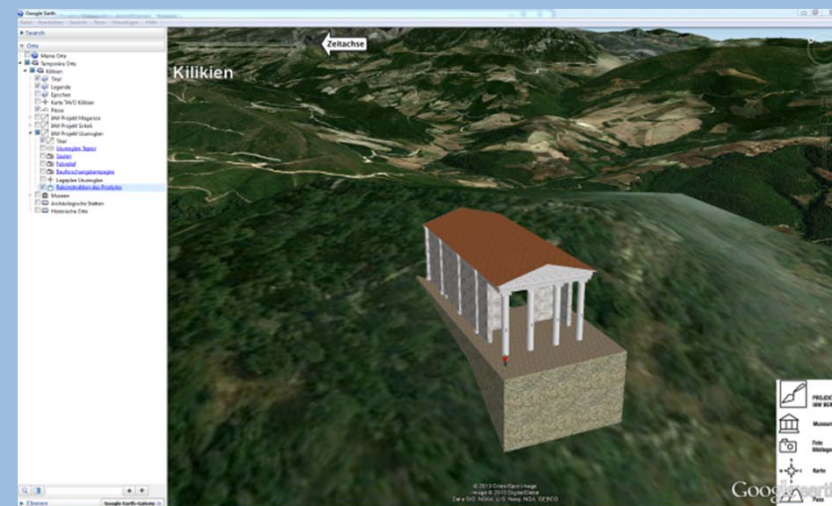


Outlook

- Unique Potential of future TanDEM-X modes (as TerraSAR-X Experimental *Staring* Spotlight Data) and successor missions like (“TerraSAR-X next generation”)
- Synergistic use of multifrequency SAR-Systems (especially ALOS 2 / PALSAR 2 and RADARSAT 2)

The Virtual Cilicia Project

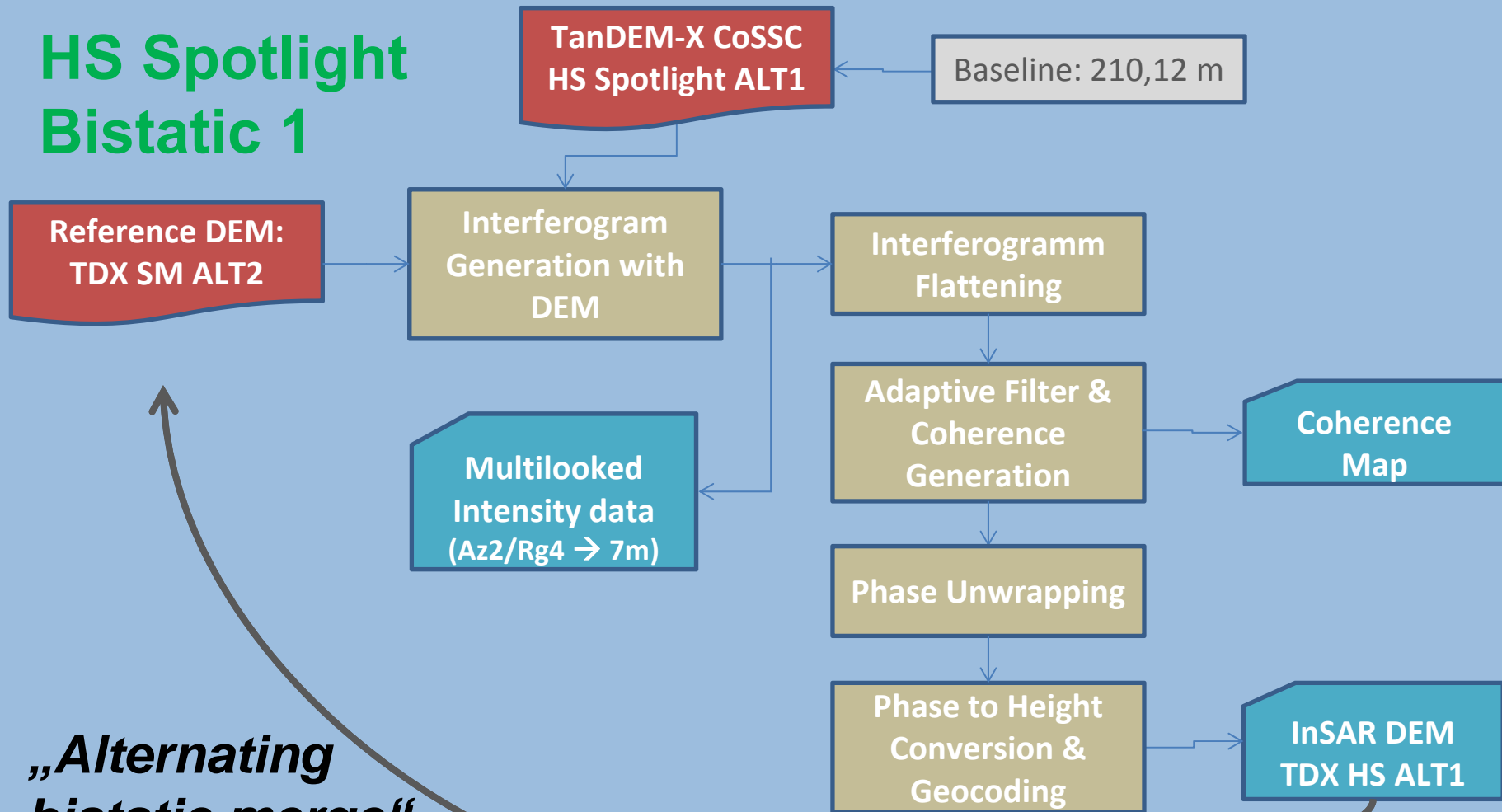
www.arch.unibe.ch/virtual-cilicia



The Virtual Cilicia Project

www.arch.unibe.ch/virtual-cilicia

HS Spotlight Bistatic 1



*„Alternating
bistatic merge“*