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UNSW

Digital Elevation Model generation using ascending and descending multi-baseline ALOS/PALSAR radar images

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www.fig2010.com

FIG SYDNEY 2010

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Outline

1. Radar remote sensing & InSAR
2. SAR geometric problem
3. Ascending and descending InSAR
4. Result
5. Concluding Remarks

FIG SYDNEY 2010

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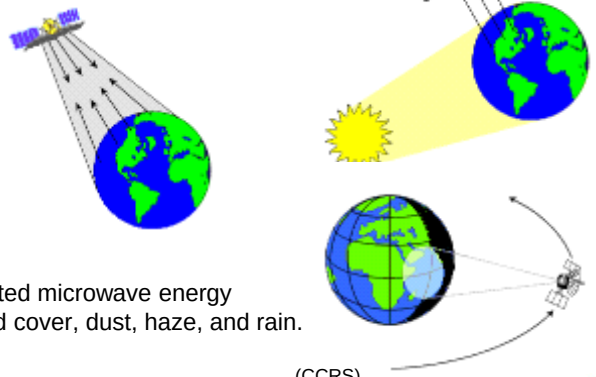
SSSI

Active sensor

An active sensor provides their own energy source for illumination

- ***Day or Night Operation:***

- Radar sensors can operate both day or night since they do not require an external energy source.



- ***All-weather Operation:***

- the transmitted and reflected microwave energy penetrates through cloud cover, dust, haze, and rain.

(CCRS)

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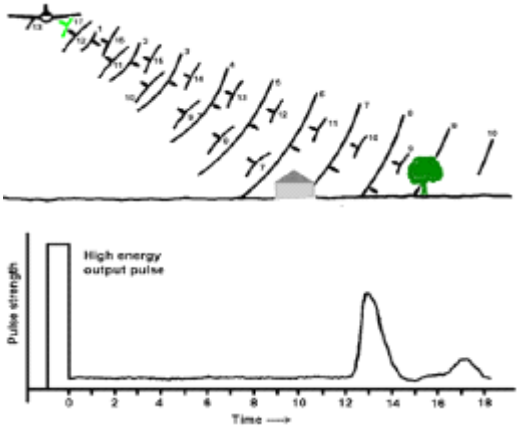
Radar

(**RA**dio **D**etection **A**nd **R**anging)

- the transmission of an electromagnetic signal and recording of the backscattered response from the target



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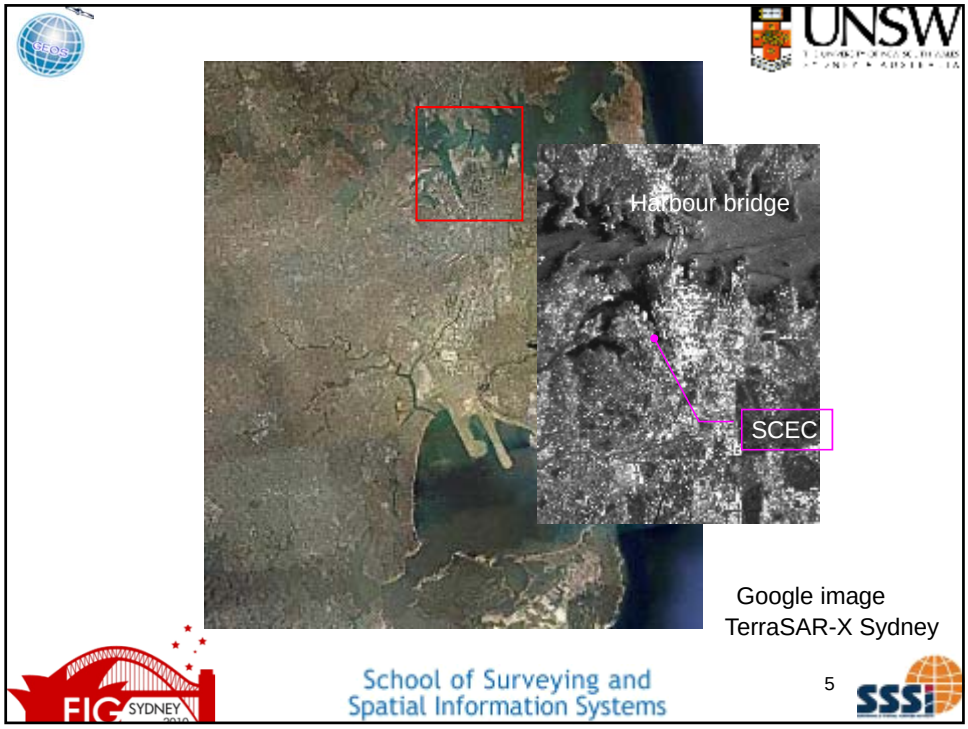
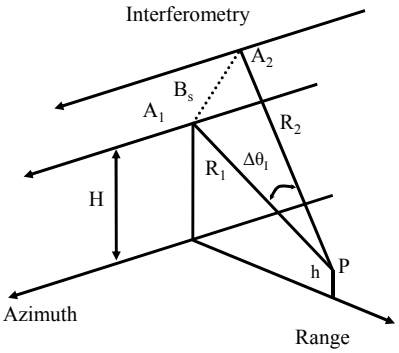


Interferometric Synthetic Aperture Radar

- Phase information from a single SAR image has limited value.
- InSAR exploits phase differences between two radar acquisitions.
- The interferometric phase is calculated using two SAR images, acquired either by different antennae or by repeat-pass antennae.

(NPA)

Interferometric SAR geometry



$$\phi = \frac{4\pi}{\lambda}(R_1 - R_2)$$

R_1 and R_2: the distance from a resolution pixel on the ground surface

$$h = \frac{\lambda}{4\pi}\frac{R_1 \sin\theta}{B_\perp}\phi$$

$B_\perp$: Perpendicular baseline

Figure: Geometry of Interferometric SAR (InSAR)

Interferometric phase

The interferometric phase can be written as

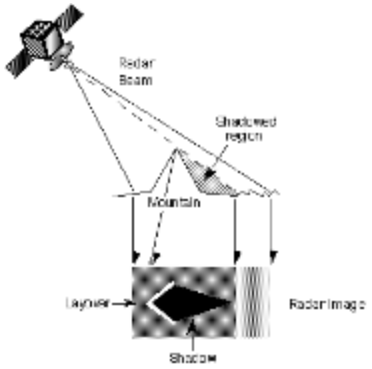
$$\phi = \phi_{flat} + \phi_{topo} + \phi_{defo} + \phi_{atm} + \phi_{noi}$$

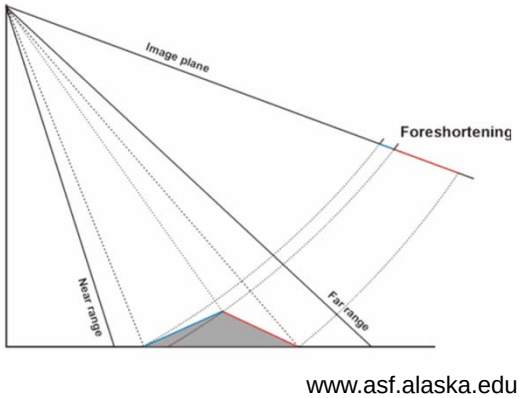
ϕ is the interferometric phase
ϕ_{flat} is the flat earth phase
ϕ_{topo} is the topographic phase
ϕ_{defo} is the deformation phase
ϕ_{atm} is the atmospheric delay phase
ϕ_{noi} is the noise.

In above equation, the "flat earth" phase and noise can be removed by using the orbit information correction and applying an interferogram filtering method. When the imaging interval is sufficiently short, there is no deformation phase. If the atmospheric delay phase can be ignored, then equation (1) reduces to:

$$\phi = \phi_{topo}$$

SAR image geometric problems
(slant-range distortion)





(NASA)

www.asf.alaska.edu

SAR: Side-looking

Photogrammetry: Central projection

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Geometric distortion

Looking direction

LPMA

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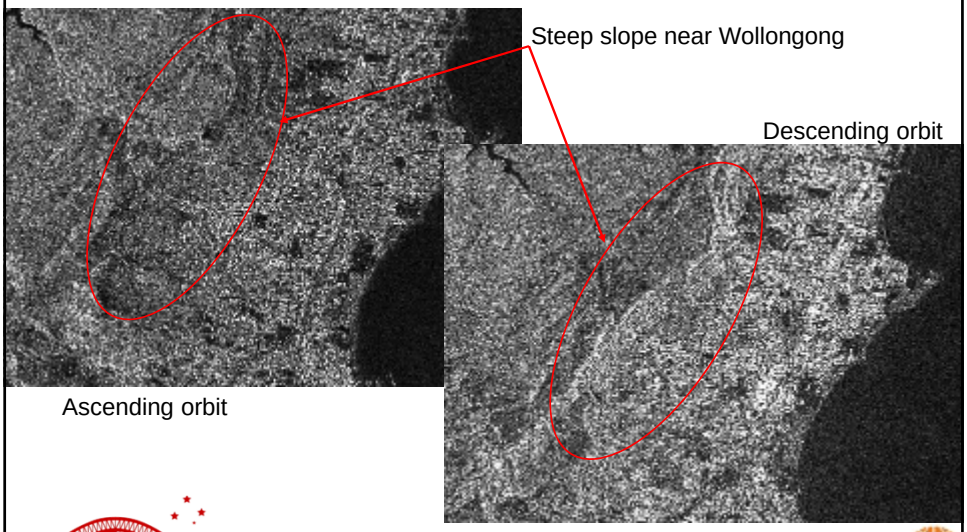
Geometric distortion



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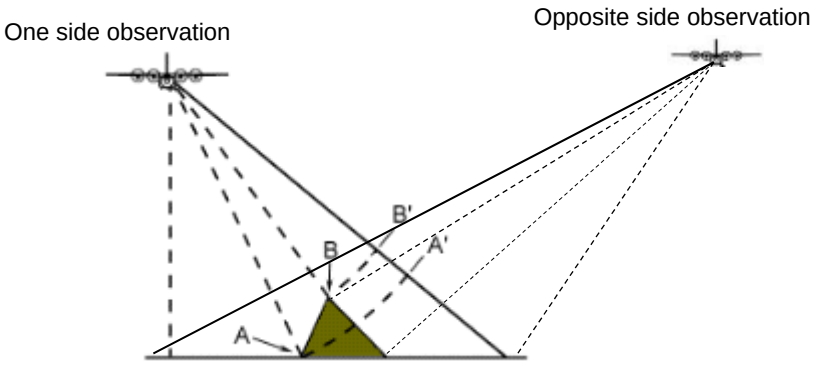
Research concept



Limitation of data acquisition

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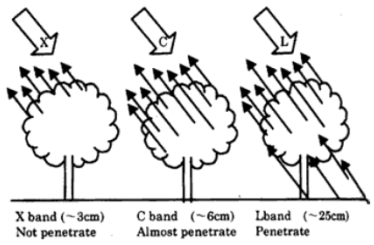
ALOS/PALSAR

Advanced Land Observing Satellite (ALOS)

Phased Array type L-band Synthetic Aperture Radar (PALSAR)



(*Wada and Shibasaki, 1999*)

(*JAXA*)

Mission	Year	Band	Wavelength (cm)	Repeat cycle (days)	Incidence angle	Resolution	Polarization	Swath Width	Altitude
ALOS	2006	L	23.5	46	9.9°-50.8°	7-100m	Selectable	40km-350km	568km

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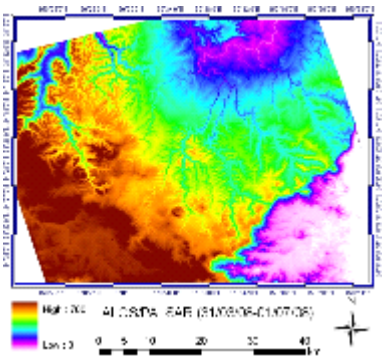
Test area



Single orbit InSAR DEM

The coverage is approximately 55 km × 60 km areas

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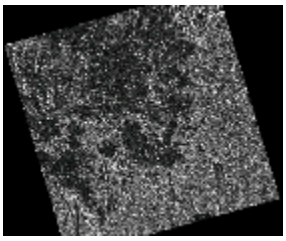
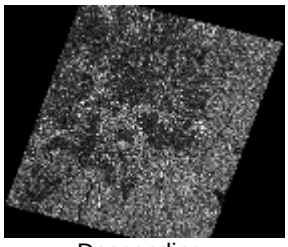
Data information

Orbit direction	Master date	Slave date	Bperp (m)	Btemp (days)
Ascending	14/11/2007	30/12/2007	757	46
Ascending	31/03/2008	01/07/2008	2992	92
Descending	01/06/2008	17/07/2008	2809	46
Descending	17/07/2008	01/09/2008	2245	46



Ascending

(14/11/07-30/12/07)



Descending

(31/03/08-01/07/08)

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Single orbit InSAR DEM

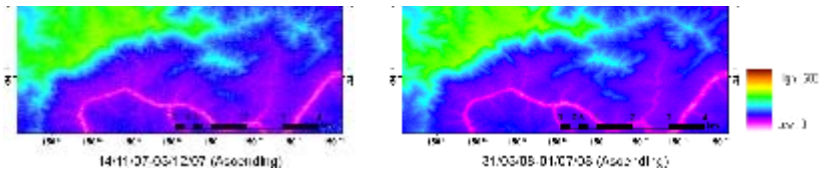

Figure ALOS ascending (14/11/07-30/12/07-left) and ALOS ascending (31/03/08-01/07/08-right) InSAR-generated DEMs.

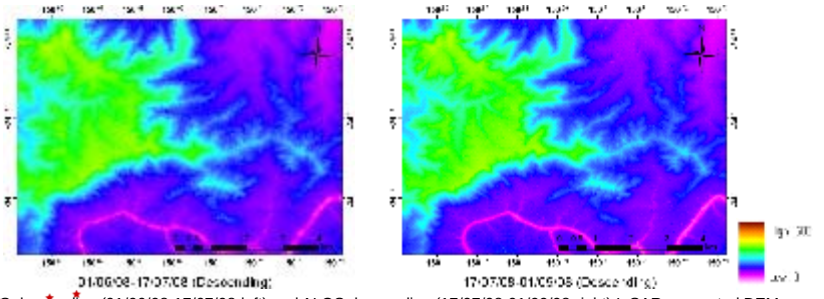

Figure ALOS descending (01/06/08-17/07/08-left) and ALOS descending (17/07/08-01/09/08-right) InSAR-generated DEMs

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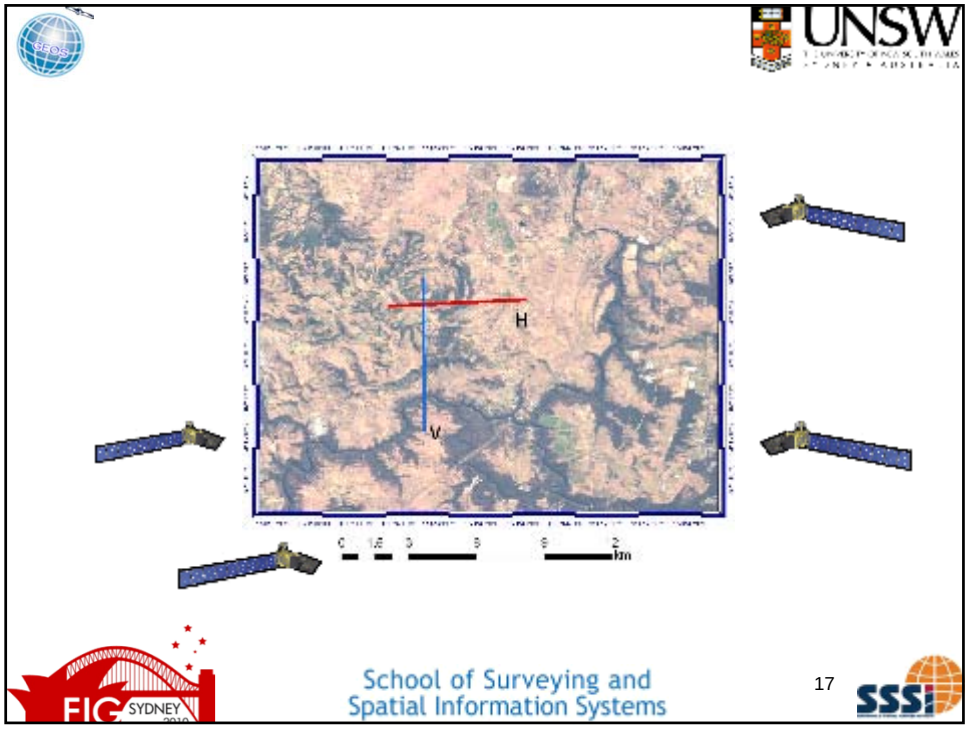
H
V
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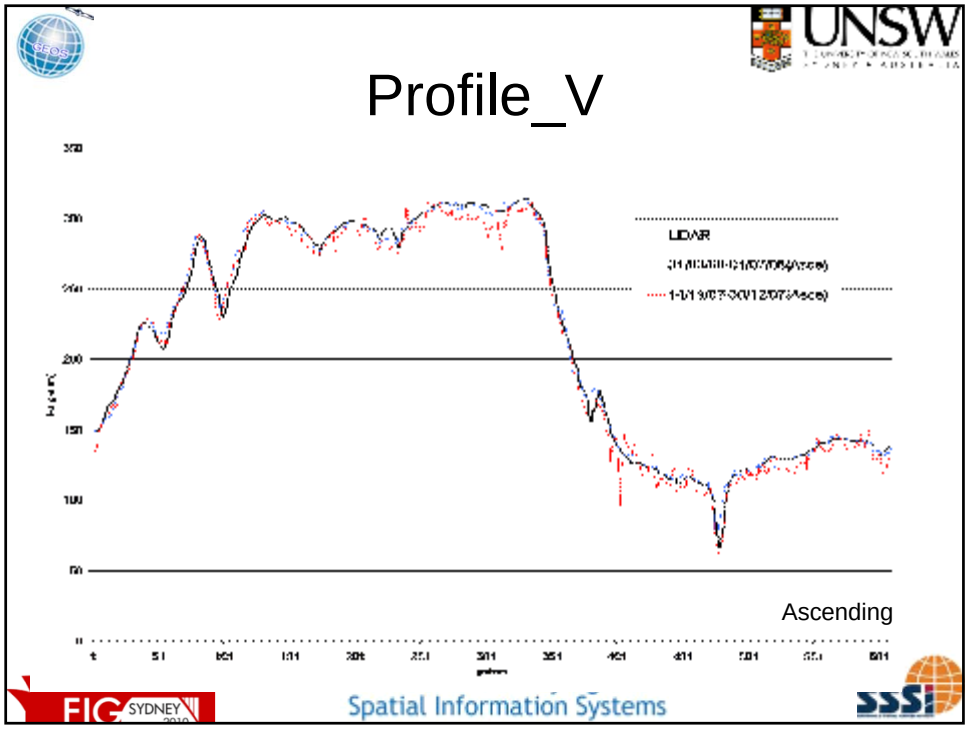
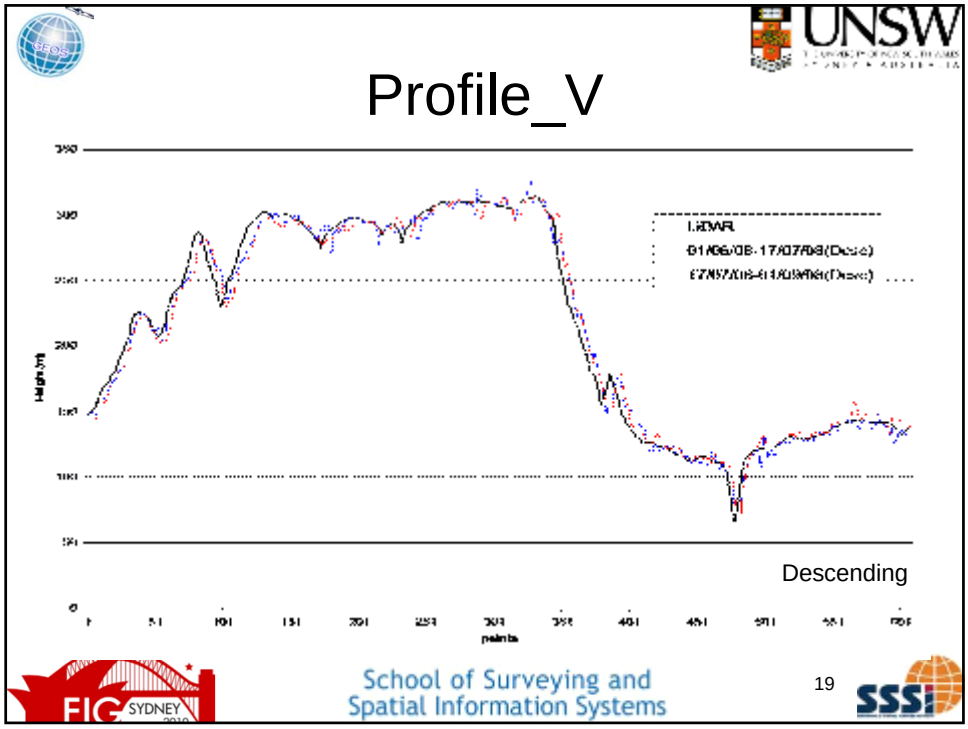

Profile_V
LIDAR
Ascending
Spatial Information Systems


Profile_V
Descending
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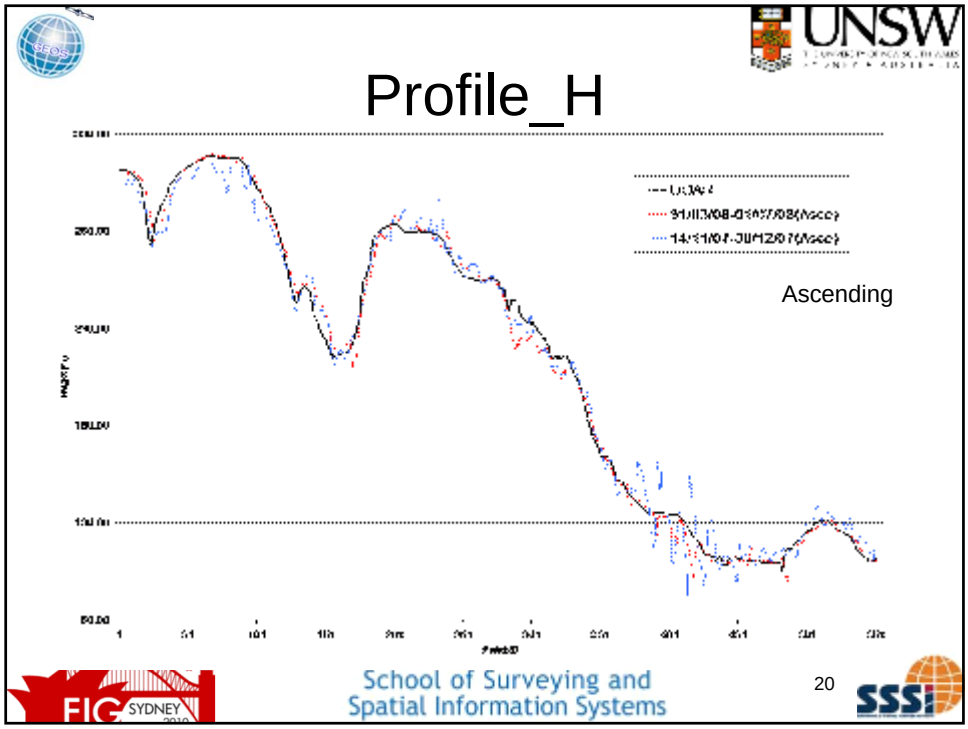
Profile_H
Ascending
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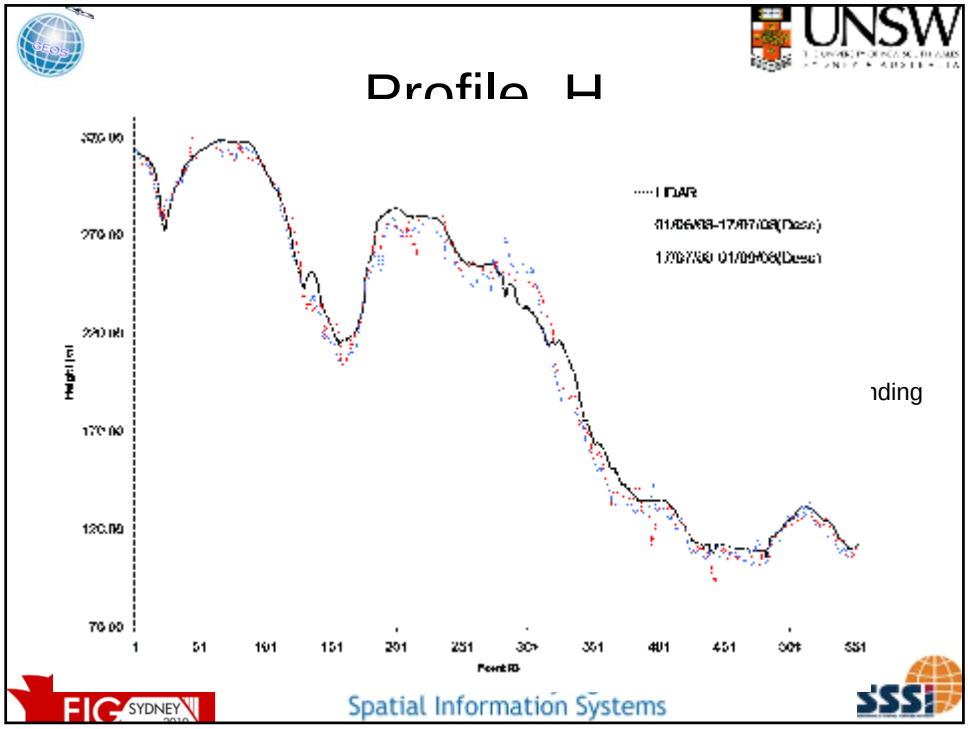
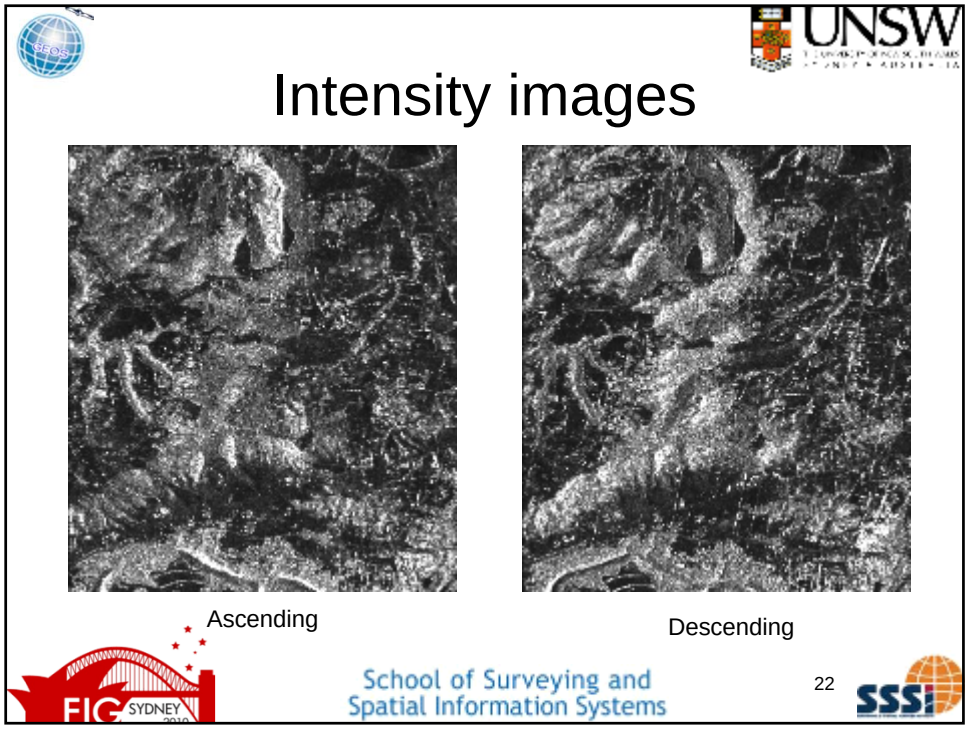

Profile H
LiDAR
Height [m]
320.00
270.00
220.00
170.00
120.00
70.00
1
51
101
151
201
251
301
351
401
451
501
551
nding
Spatial Information Systems


Intensity images
Ascending
Descending
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Combined DEM (same orbit direction)

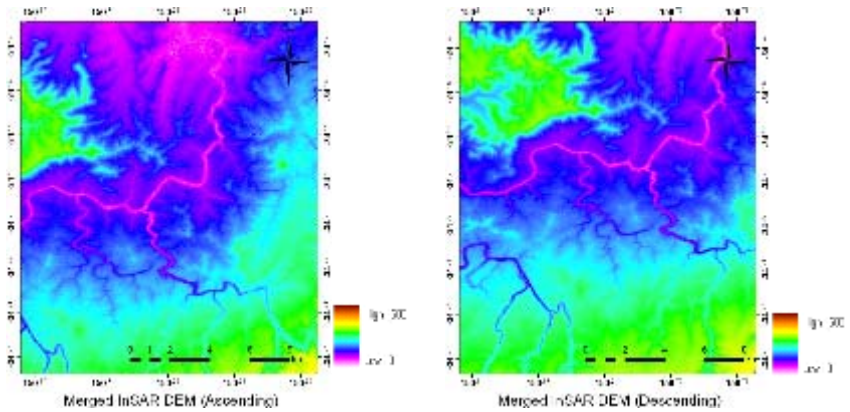

Figure Merged InSAR-generated DEM from asending and descending passes.

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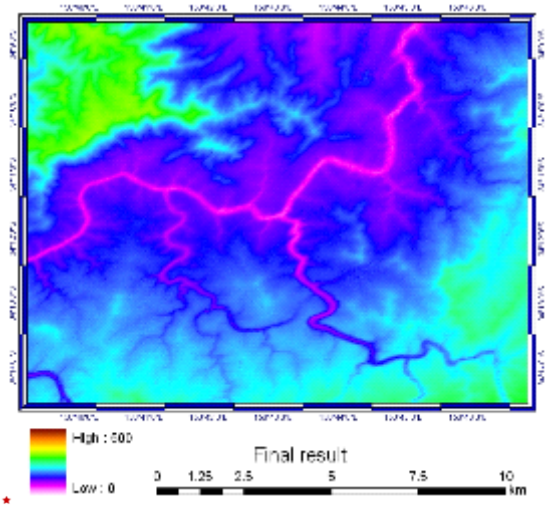
Final combined DEM



15km ×20km

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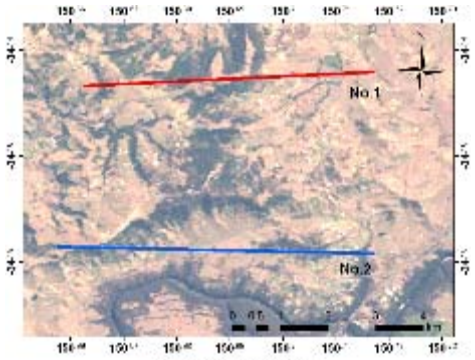
Profiles



Landsat and Profiles

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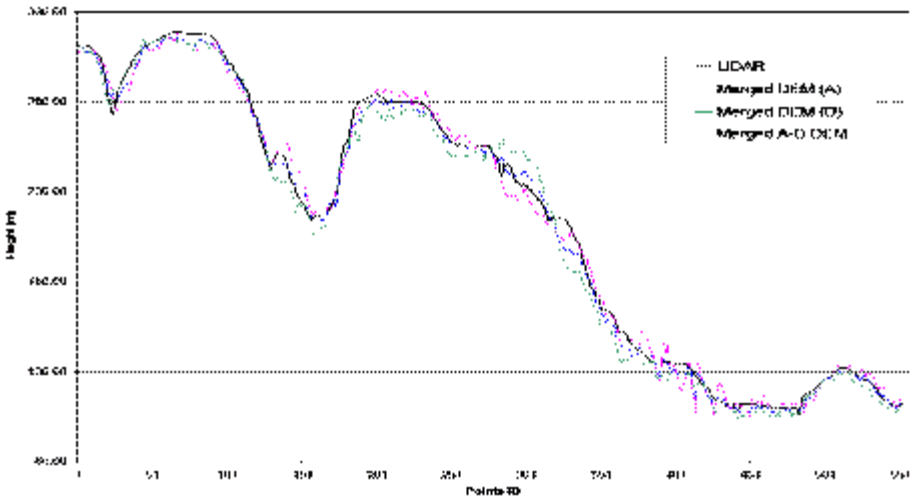
Proflie-1



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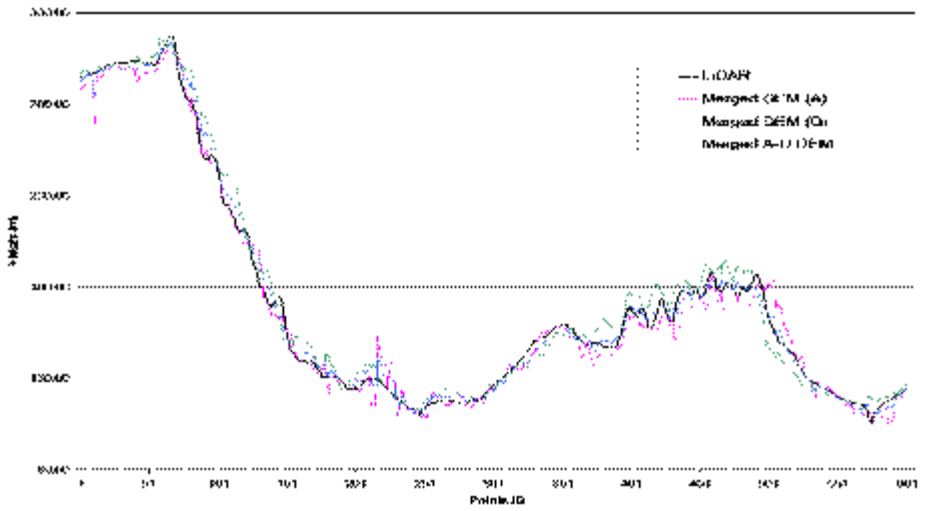
Profile-2



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RMSE

Unit: m

01/06/08-17/07/08 (Descending)	17/07/08-01/09/08 (Descending)	31/03/08-01/07/08 (Ascending)	14/11/07-30/12/07 (Ascending)
8.49	9.55	5.16	7.54
7.85	9.01	5.85	7.91

Unit: m

Descending	Ascending	Combined A-D
7.86	5.82	4.36
7.94	6.74	4.46

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Concluding Remarks

- The approximately 15km × 20km area is generated from ascending and descending orbit combination (4 pairs).
- Side-looking effects (terrain shift) are removed in re-generated DEM
- Incorrect data areas due to the InSAR geometrical problem (foreshortening, layover and shadow) are interpolated by opposite site observation.
- Ascending and descending orbit combination can generate the accurate InSAR DEM

Acknowledgement

This study has been supported by the Cooperative Research Centre for Spatial Information (CRC-SI) and the satellite imagery is supported by Earth remote sensing data analysis centre (ERSDAC) for providing the ALOS/PALSAR data.