Coastal GIS Workshop

Data for Mapping, Analysing & Modelling Coastal Issues and Processes

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Practice Leader Imagery & Aerial Survey

Overview

- Coastal Analysis using Aerial Photography
- Look at Sydney's Coast in 1943
- LiDAR Derived DEMs and the Importance of Hydrological Enforced & Conditioned DEMs for Inundation Modelling
- Opportunities for acquiring inshore Bathymetry using WorldView 2 Satellite Imagery

Coastal Analysis Using Aerial Photography

- Historical archive of coastal aerial photography held by DECCW, LPMA and others
- Photography available back to the early 1940's
- Issues to consider:
  - Accuracy achievable depends on the scale of the source imagery
    - 1940's typically 1:30,000 +/-2 to 3m H 1.5m V
    - After 1980 typically about 1:10,000 +/- 0.45m H +/-0.25m V
  - Controlling the imagery
    - Relative accuracy is often more important than absolute accuracy

Coastal Analysis Using Aerial Photography

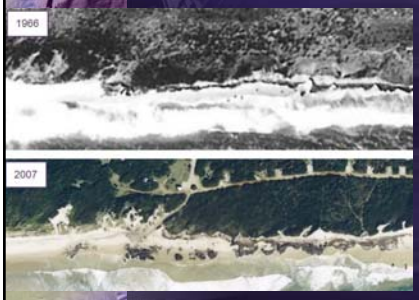
- Identify area of interest
- Search for available imagery
- Research storm events and when they fall in relation to available photograph
- Assess scale and accuracy requirements to select suitable photography
- Control the imagery
- Extract 3D data
- Analyse the data by comparing areas, heights and volumes between epochs

Bundjalung National Park – Erosion Study

- Historical measurements of 500m of beach (between Yamba and Evan Head)
- From 1958 to 2007

Bundjalung National Park – Erosion Study

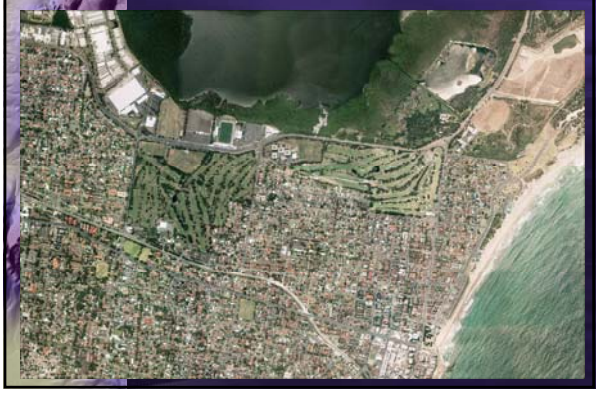
- 3D CAD data extracted & analysed



Cooks River 2007

Cooks River 1943

Cronulla / Woolooware Bay 2009



Cronulla / Woolooware Bay 1943

Curl Curl Lagoon 2009

Curl Curl Lagoon 1943

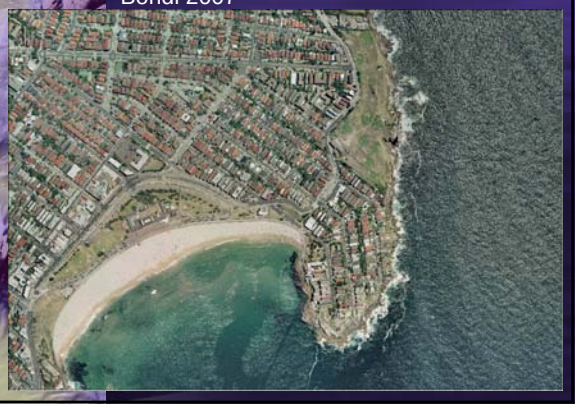
Dee Why Lagoon 2007

Dee Why Lagoon 1943

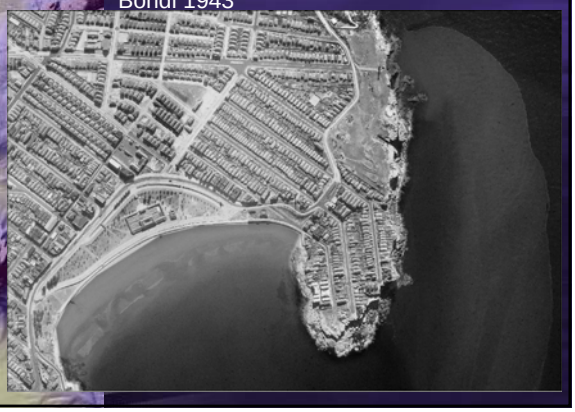
Parramatta River 2007

Parramatta River 1943

Bondi 2007



Bondi 1943



Terrain Data Acquisition

- Current technologies based on remote sensing the terrain & sea floor from above.
- Include:
  - ALS - Airborne Laser Scanning or LiDAR
  - IfSAR – Interferometric Synthetic Aperture Radar
  - SONAR – Sound Navigation and ranging
  - ALB - Airborne Laser Bathymetry
- These technologies capture a reflective surface and therefore contain buildings & vegetation as well as bare earth

LiDAR Data

- Must be classified to separate point measurements into ground and non-ground points
- Non-ground points can be further classified into vegetation, structures, buildings, water, power lines, etc
- Accuracy of DEM derived from LiDAR is a function of:
  - fundamental accuracy of the survey AND
  - the reliability of the point classification process
- For some analysis & modelling further work is required on the DEM to Hydrologically Enforce and Condition it to form a HDEM

Modelling Sea Level Rise & Tidal Surges

Inundation modelled using a LiDAR derived DEM

Modelling Sea Level Rises & Tidal Surges

Inundation modelled using a LiDAR derived HDEM

What does hydrological enforcement and conditioning mean?

- *The essence of the drainage enforcement is to find for each sink point the lowest adjacent saddle point that leads to a lower data point…….. enforcing a descending chain condition from the sink, via the intervening saddle, to the lower data point,……..(Hutchinson 1989).*
- It is about getting the hydrological connectivity right to enable water to flow correctly over the surface.
- Achieved by removing sink points - other than legitimate sinks such as terminal lakes or dams.
- Sinks can be addressed in two ways – breaching or filling

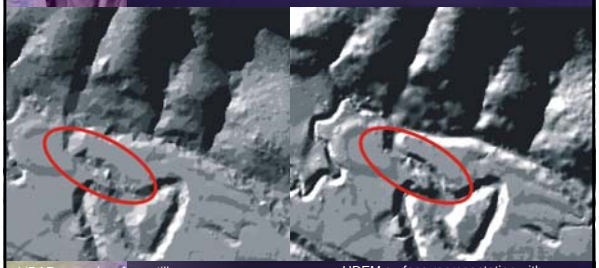
What does hydrological enforcement and conditioning mean?...

- Removal of noise. In flat areas noise creates multiple shallow sinks which need to be removed by filling.
- Unnecessarily filling sinks or filling sinks to a high level can seriously degrade the quality of a DEM.
- In many instances it is better to 'breach' a sink than to 'fill' it.
- Breaching can be used to:
  - Remove unfiltered vegetation points in streamlines
  - Remove undesirable features - like road surfaces over culverts.

What does hydrological enforcement and conditioning mean?...

> Removal of unfiltered vegetation from the DEM.

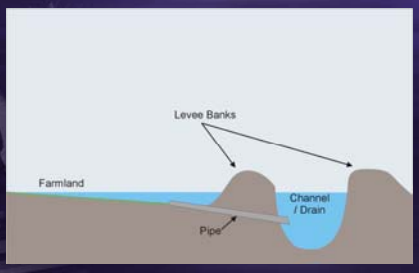
Before After



LiDAR ground surface still containing vegetation points

HDEM surface representation with correct stream flow

What does hydrological enforcement and conditioning mean?...



HDEM not only considers misclassification of features but also takes into account man made structures.

What does hydrological enforcement and conditioning mean?...

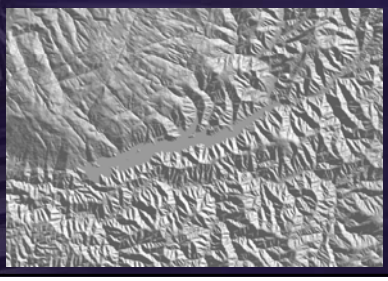
> Forcing Hydrological Flow through culverts

The Western red arrow shows clearly a large entrance to an underground drain. The Eastern red arrow could be the exit point of the drain

This is a mock up of a possible inundation polygon scenario. The thin part of the polygon is for connection purposes only, no water would be on the surface.

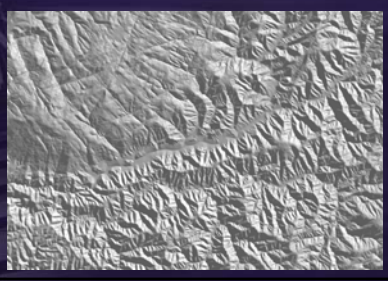
Treatment of Water Bodies

> Terrain + Surface of Water
  - Used for groundwater and surface water interaction studies



Treatment of Water Bodies

> Terrain + Bathymetry
  - Used for erosion / sedimentation studies



Treatment of Water Bodies

> Terrain + Null Data

Creating a HDEM

- Iterative process.
- Start with primary source eg LiDAR ground points
- Use or derive reference data in an iterative process to enhance the flow properties of the model until a satisfactory product is achieved
- Reference data may consist of directioned streams, break lines, culverts, drains or other hydrological structures.

Steps in creating a HDEM from LiDAR Data

1. Create DEM from source (eg. LiDAR).
2. Source stream pattern or derive a stream pattern from the above DEM.
3. Edit the stream pattern to be an accurate representation of the stream network aligned to high precision LiDAR as opposed to generalised cartographic streams.
4. Create a new DEM using both LiDAR and the directioned streams to create an accurate flowing model.
5. Fill small noise from the DEM.
6. Ensure streams flow.
7. Create pseudo-drainage lines to make the entire DEM flow through obstacles such as roads.
8. Remove further noise using the same pseudo-drain method rather than filling which would raise elevations too much for purposes of inundation analysis.

Creating a HDEM

> Processing largely uses a heuristic or intuitive approach.

> A completely different approach would be required for a desert sand dune environment as opposed to an Alpine area

> A different approach would be used for a Rural environment compared to an a Urban environment with many manmade structures.

Creating HDEMs - Summary

> Each iteration should always refer back to the primary source data

> No common approach for all terrain types

> No completely automated solutions are available

> An iterative process involving both automatic and manual processes

> Over filling sinks will not create a useful HDEM

Applications that Require HDEMs

> Analysis of drainage basis and catchments

> Flood modelling

> Improved cartographic streams and contours for map production

> Indentifying sites for water harvesting structures

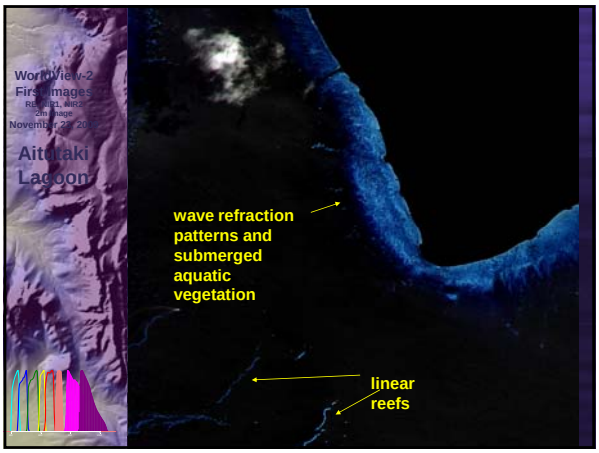
> Modelling transport of contamination

> Study of surface and ground water interface

> Sedimentation/soil erosion studies

> Modelling sea level rise and storm surge events

Bathymetry from WorldView 2 Satellite Imagery


WorldView-2
First Images
R, RE, NIR1
2m Image
November 23, 2009
Aitutaki
Lagoon
wave refraction
patterns and
submerged
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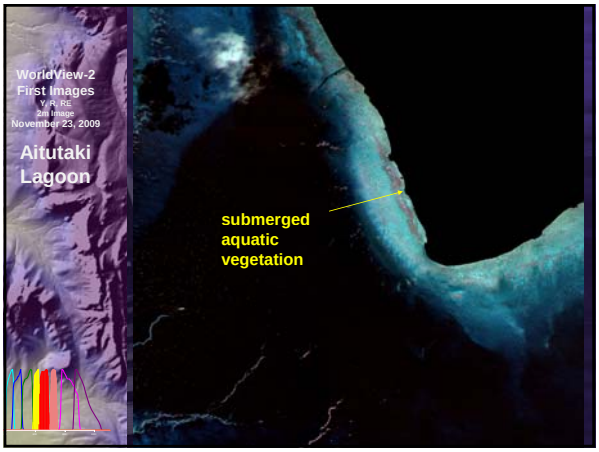
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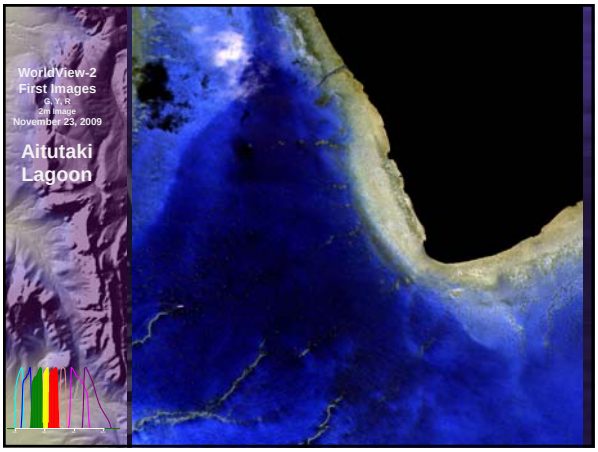
WorldView-2
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G, Y, R
2m Image
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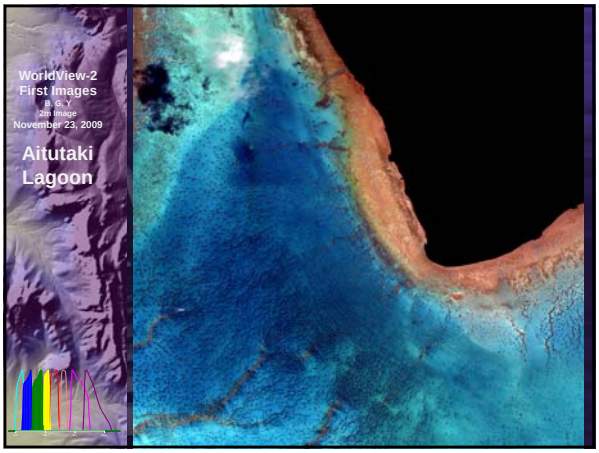
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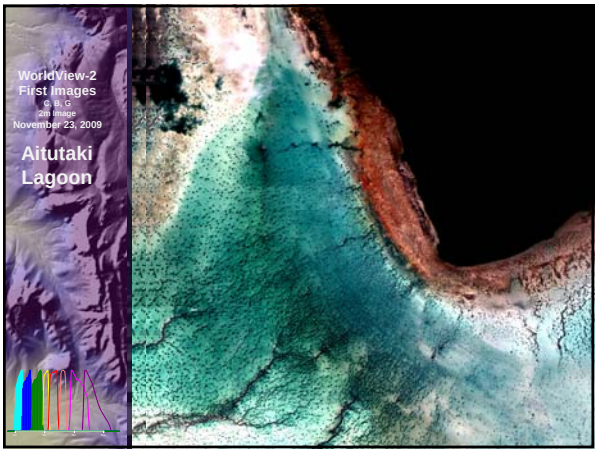
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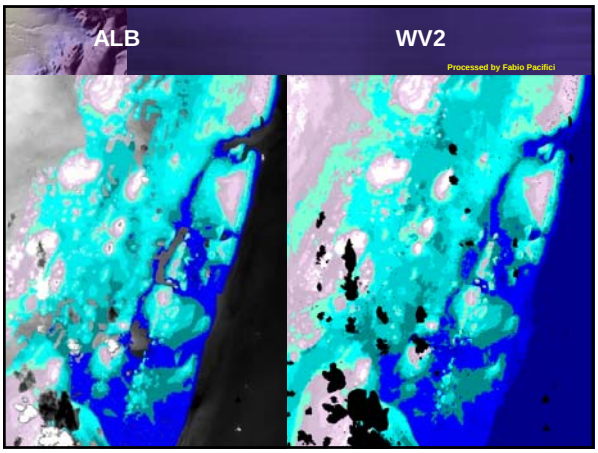
Bathymetry from WorldView 2 Satellite Imagery

- Radiometric approach
  - exploits the fact that different wavelengths of light are attenuated by water to different degrees with red attenuating much more readily than blue.
  - By measuring the relative absorption of the coastal, blue and green bands depths up to 30m can be calculated
- Photogrammetric Approach
  - Uses stereo images of shallow water to photogrammetrically extract bathymetry
  - Limited by air/water interface reflecting light at high angle of incidence and by limited depth penetration
  - WorldView 2's enhanced agility enables acquisition at an ideal angle of water penetration and its Coastal Band allows for increased depth penetration



Bathymetry from WorldView 2 Satellite Imagery

- Like ALB these techniques are limited by water turbidity
- Further benchmarking is required before these approaches can be readily accepted as valid alternatives to ALB for near shore bathymetry
- SKM hopes to do some work in the near future with the CRC-SI to test these methodologies in Australian waters where existing ALB data is avilable.

Questions?

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