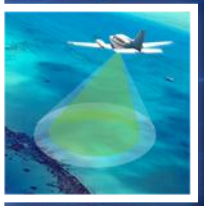
TELEDYNE OPTECH
Everywhereyoulook™

CZMIL Project Program
First year in review

JALBTCX Conference 2015



Max Elbaz, Scott Ebrite, Jen Aitken, Norma Clark
& Brant Smith
06/19/2015
Corvallis, OR

Accuracy
& Productivity
Matter

TELEDYNE OPTECH
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Coastal Zone Mapping and Imaging Lidar
CZMIL Nova & HydroFusion

- **Sensor Fusion**

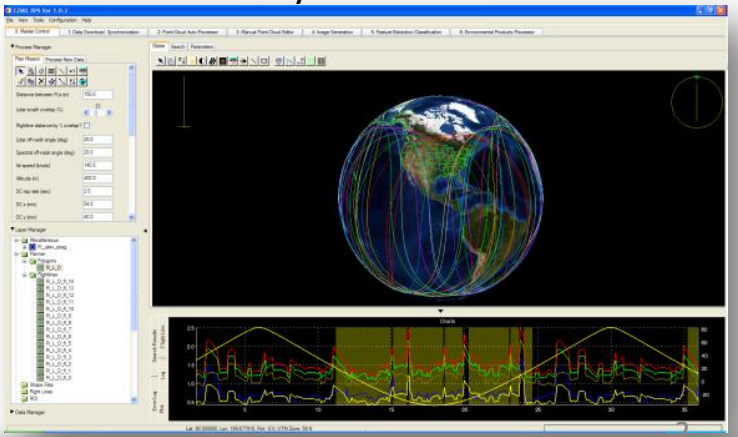
  Integrates several sensors
  - Lidar (Green and IR)
  - RGB camera
  - Hyperspectral camera

Topo-bathy lidar

- **Data Fusion**

  HydroFusion software fusing Lidar, hyperspectral and digital camera data
  - Fully integrated workflow software suite from mission Planning, Capture, Processing, Analysis and Visualization
  - Turbid Water Module Software

HydroFusion

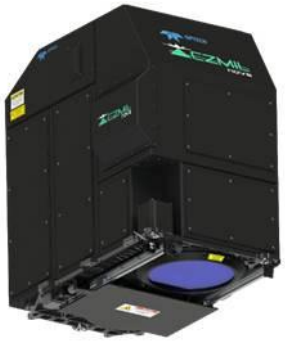


CZMIL Nova

Operator Unit
Control Unit
Thermal Management System
Lidar Sensor Head
CASI-1500

CZMIL Nova

Maximum depth, single pulse	**≥4.2/K_d, bottom reflectivity > 15%**
Minimum depth	Seamless topo/bathy maps
PRF	10 kHz Deep bathy, 70 kHz Shallow bathy and 80 kHz Topo
Pulse duration	< 2ns
Pulse energy	3 mJ (1.5 MW per pulse)



- Simultaneous & seamless high-resolution topo-bathy maps
- High SNR: Narrow spectral selector + Optimized detector + Wide receiver + High PRF
- Proven detection of one meter-sized sensor on seafloor in 14 m
- Validated and in use by multiple government agencies

CZMIL Platform Integration

- Piper Navajo
- Beechcraft King Air E90
- Beechcraft King Air B200
- YUN-12

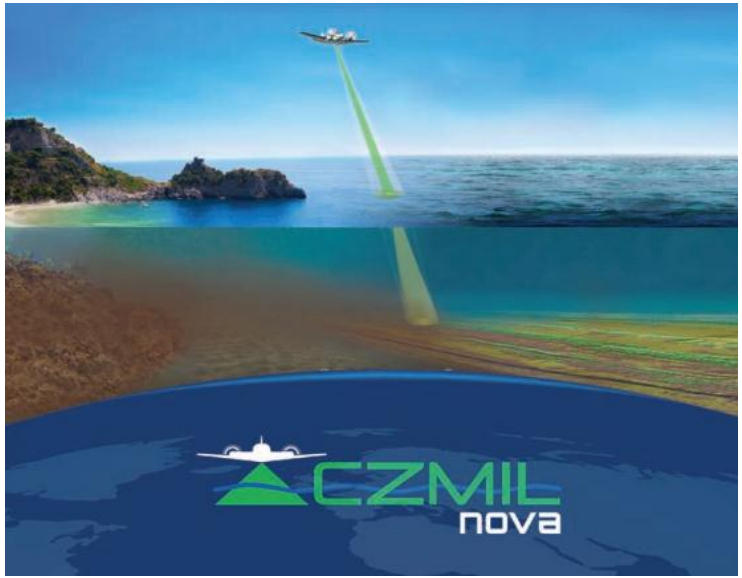
Piper Navajo

Beechcraft King Air E90

CZMIL installed in Piper Navajo aircraft

CZMIL Project Program

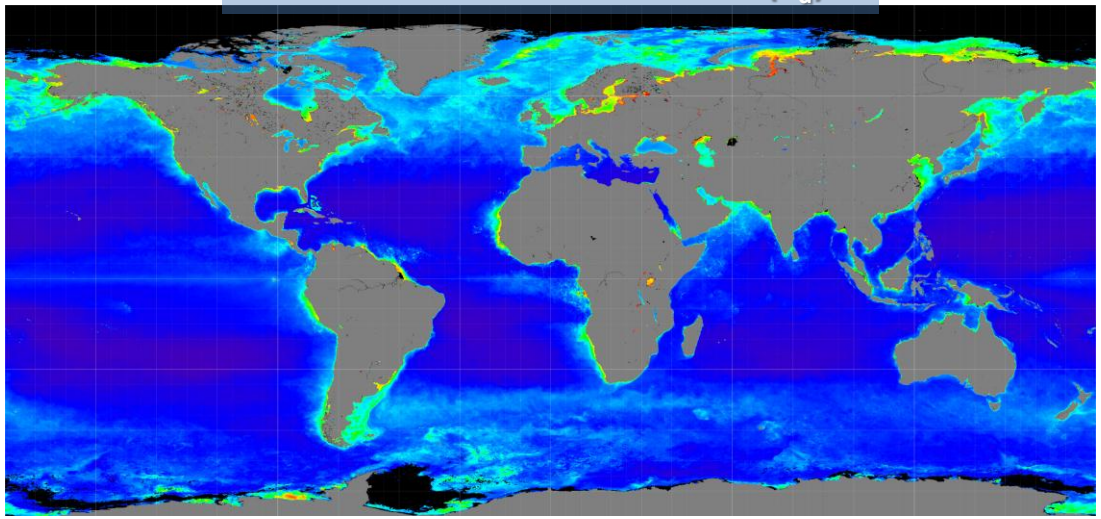
- CZMIL Nova utilized for large projects run by Government Agencies
- Now available to be used by Commercial airborne service providers on a rental basis
- The program is a comprehensive package to meet project needs
  - Sensor systems
  - Survey operators
  - Technical expertise
    - Mission planning
    - Data acquisition
    - Data processing

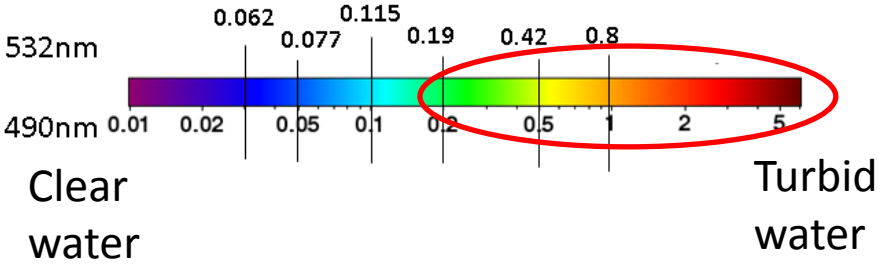


The Coastal Water Clarity Challenge

- Satellite derived K_d maps
  - Seasonal maps available online that can be downloaded and used for prediction
  - Is a good prediction and validation tool for open ocean waters
  - Pixel resolution: 250m
    - Satellite derived K_d products are applicable only for coastal/open ocean waters
    - Not practical for rivers and small lakes

Diffuse Attenuation Coefficient (K_d)*



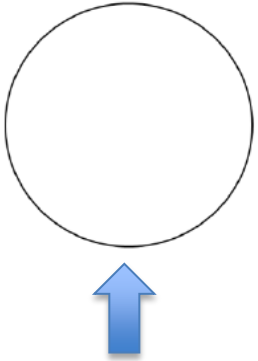


* Based on Spring 2013 NASA Aqua-MODIS space satellite derived diffuse attenuation coefficients (K_d) at 490nm and recalculated at 532nm

The Coastal Water Clarity Challenge

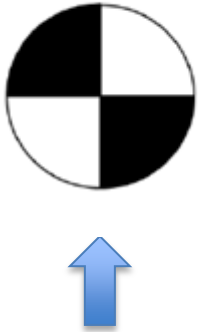
- Secchi depth measurements
  - Reliable source for all water bodies including lakes and rivers
  - Require ground personnel and is time consuming
  - For reliable results standard measurement guidelines have to strictly followed*

30 cm "classical" marine white disk



Coastal waters

20 cm black & white disk



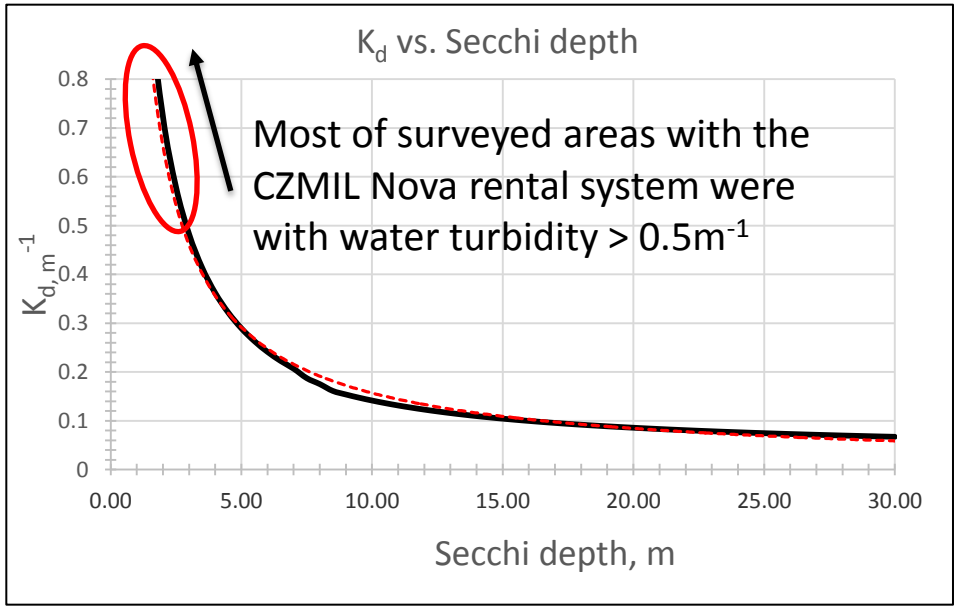
Lakes & Rivers

The key factors that affect Secchi depth are sun angle, shadow of the boat, etc

*Standard secchi depth operating procedure:
http://www.epa.gov/greatlakes/monitoring/sop/chapter_4/LG402.pdf

K_d vs. Secchi depth (SD)

- K_d * D_{max} is the bathymetric performance coefficient (CZMIL = ≥4.2)

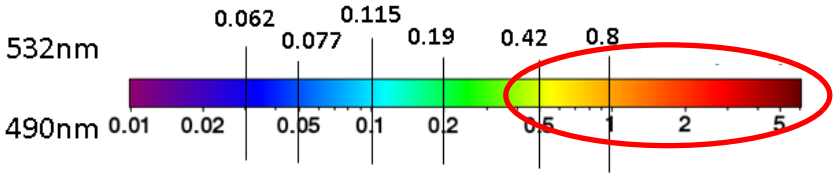


Black curve is a sum of regressions:

$$K_d = 1.448 / S_d$$
$$K_d = 1.15 / S_d + 0.03$$

Red curve is trend line

$K_d = 1.2325 \cdot SD^{-0.8951}$



Water Turbidity Measurements & Challenges

CZMIL bathymetric performance coefficient (K_d*D_{max}) **(for bottom reflectivity ≥ 15% and 0.07 m^{-1} < K_d < 0.4 m^{-1})**	≥4.2, Deep channel ≥2.0, Shallow channels

- However, it is not possible to accurately predict the maximum depth measurement
  - If bottom reflectance less than 5%
  - If K_d (or Secchi depth) measurements are outside the above valid range

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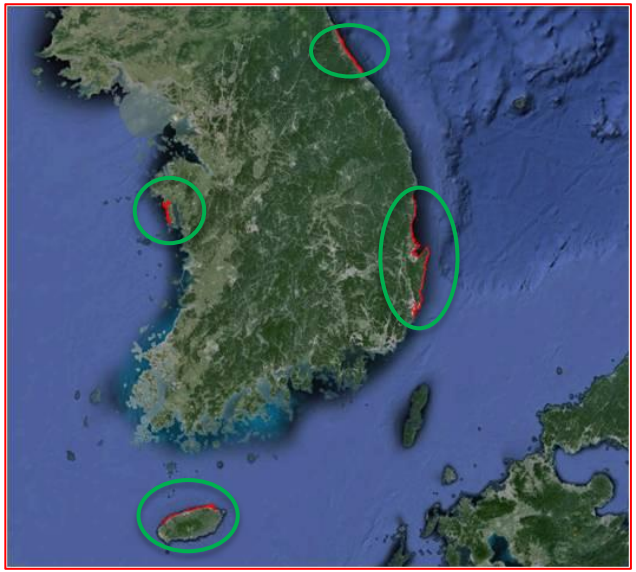
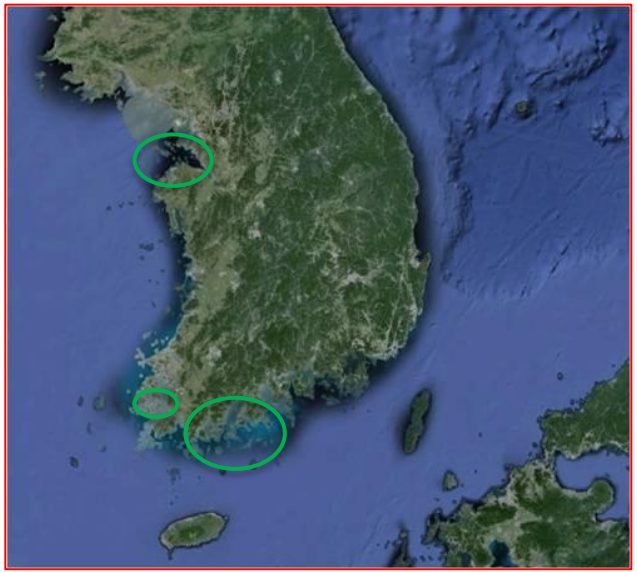
CZMIL Rental Locations: 1st year

Survey Area - South Korea

- Service Provider: Geomonitoring Inc.
- End User: Korea Hydrographic and Oceanographic Administration (KHOA)
- Area: >2000 km^2
- Altitude: 400m & 600m



2014 Survey Area

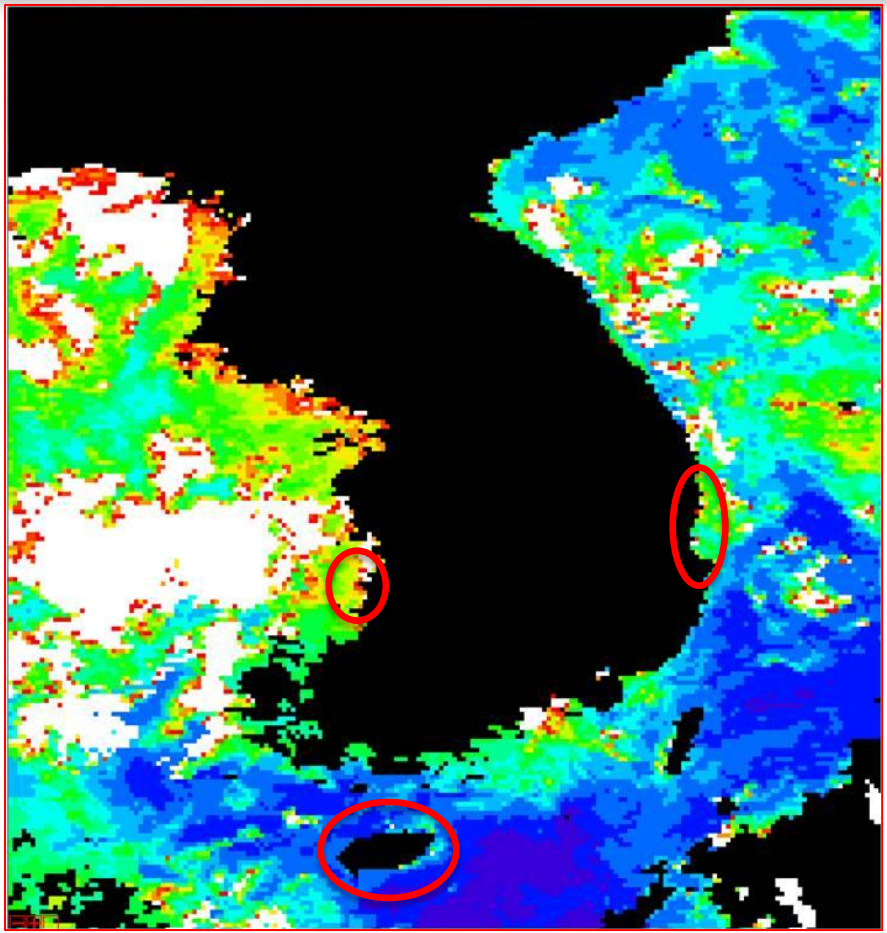


2015 Survey Area

E-90 Aircraft - South Korea

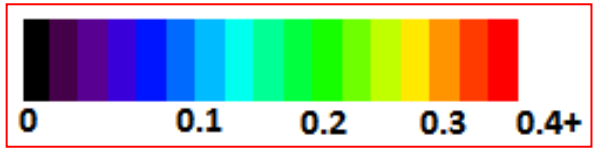
CZMIL installed in KingAir E-90

Environmental Information – South Korea



April 2015 K_d Map of Korea

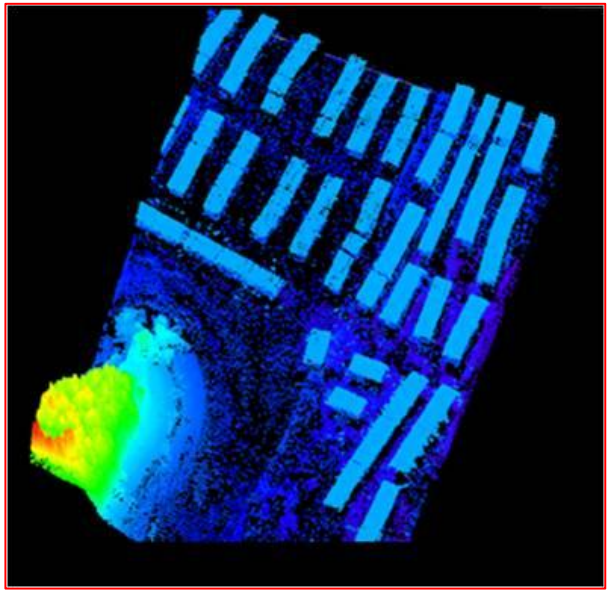
K_d (m^{-1})



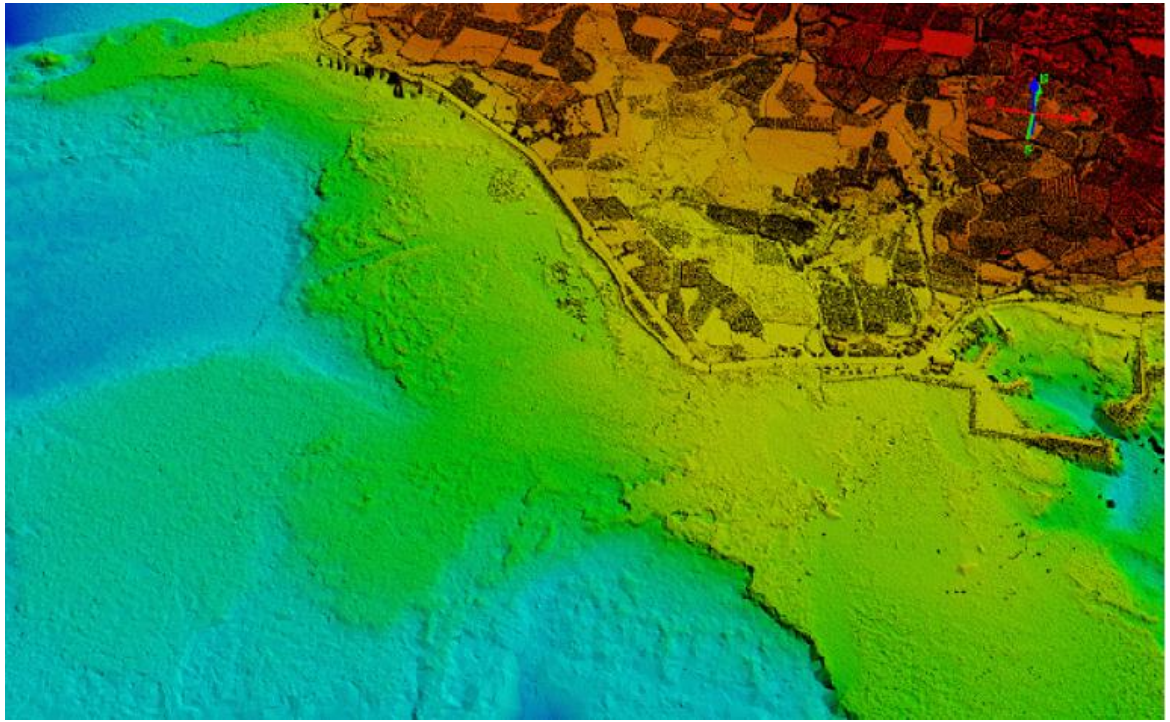
Clear water

Turbid water

Survey Results - South Korea



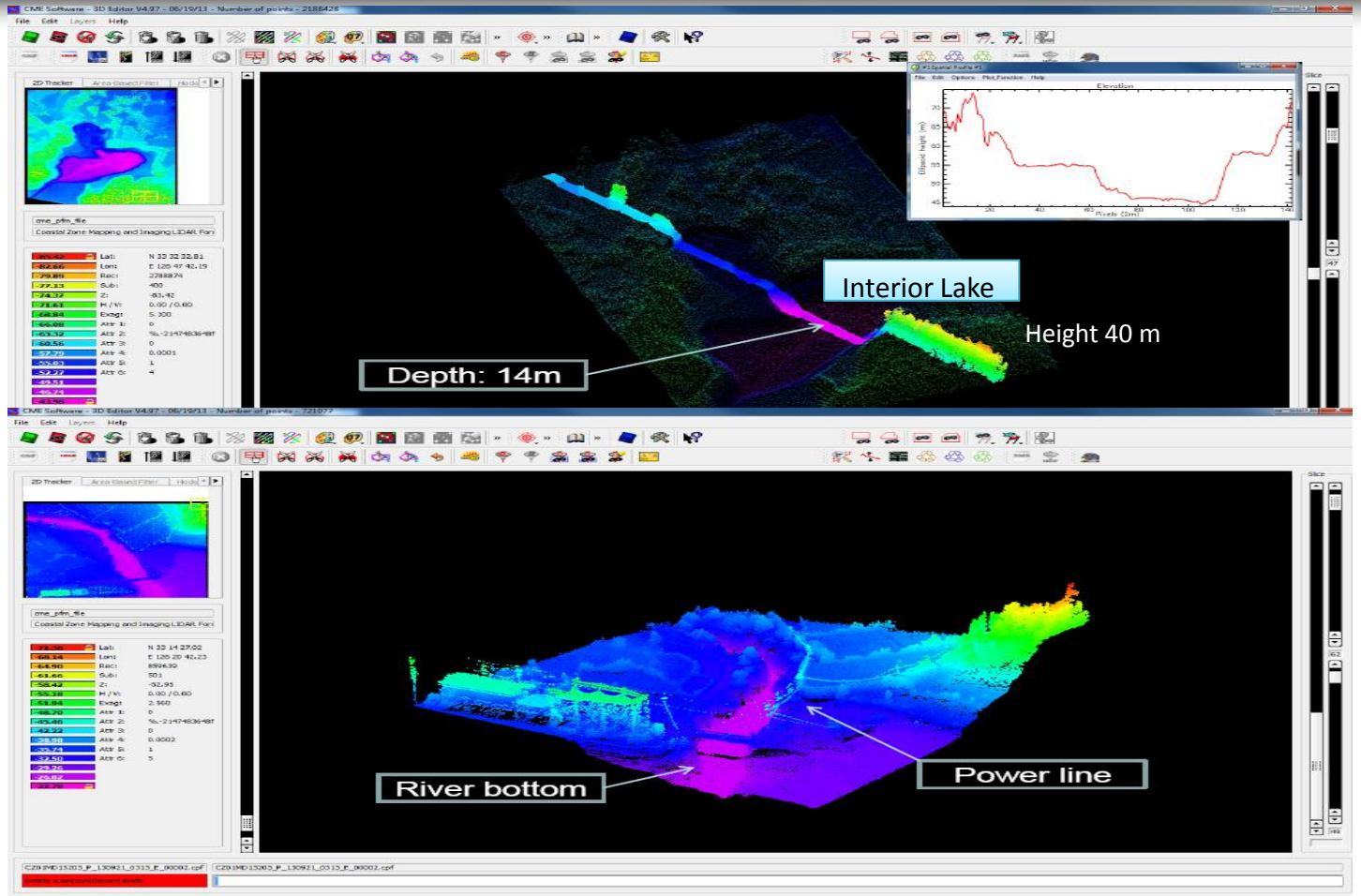
South Sea Aquaculture – CZMIL 3D Point Cloud



Seamless topo-bath DEM

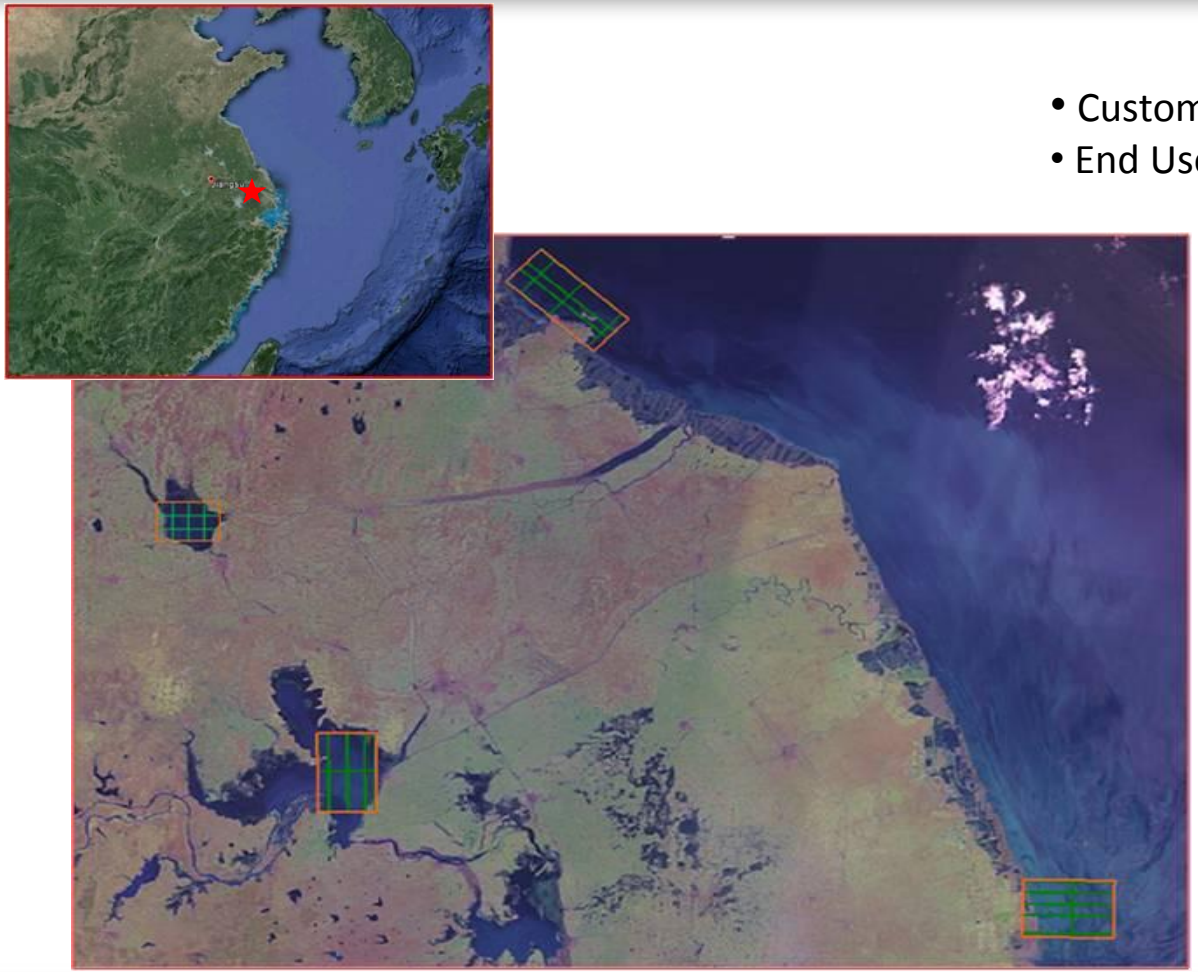
CZMIL data courtesy of Korea Hydrographic and Oceanographic Administration

Survey Results - South Korea



CZMIL data courtesy of Korea Hydrographic and Oceanographic Administration

Survey Area - Jiangsu Province, China



- Customer: Beijing Zhonghan Instrument Co.
- End User: Jiangsu Bureau of Surveying Mapping

- Area: 450 km^2
- Altitude: 400m

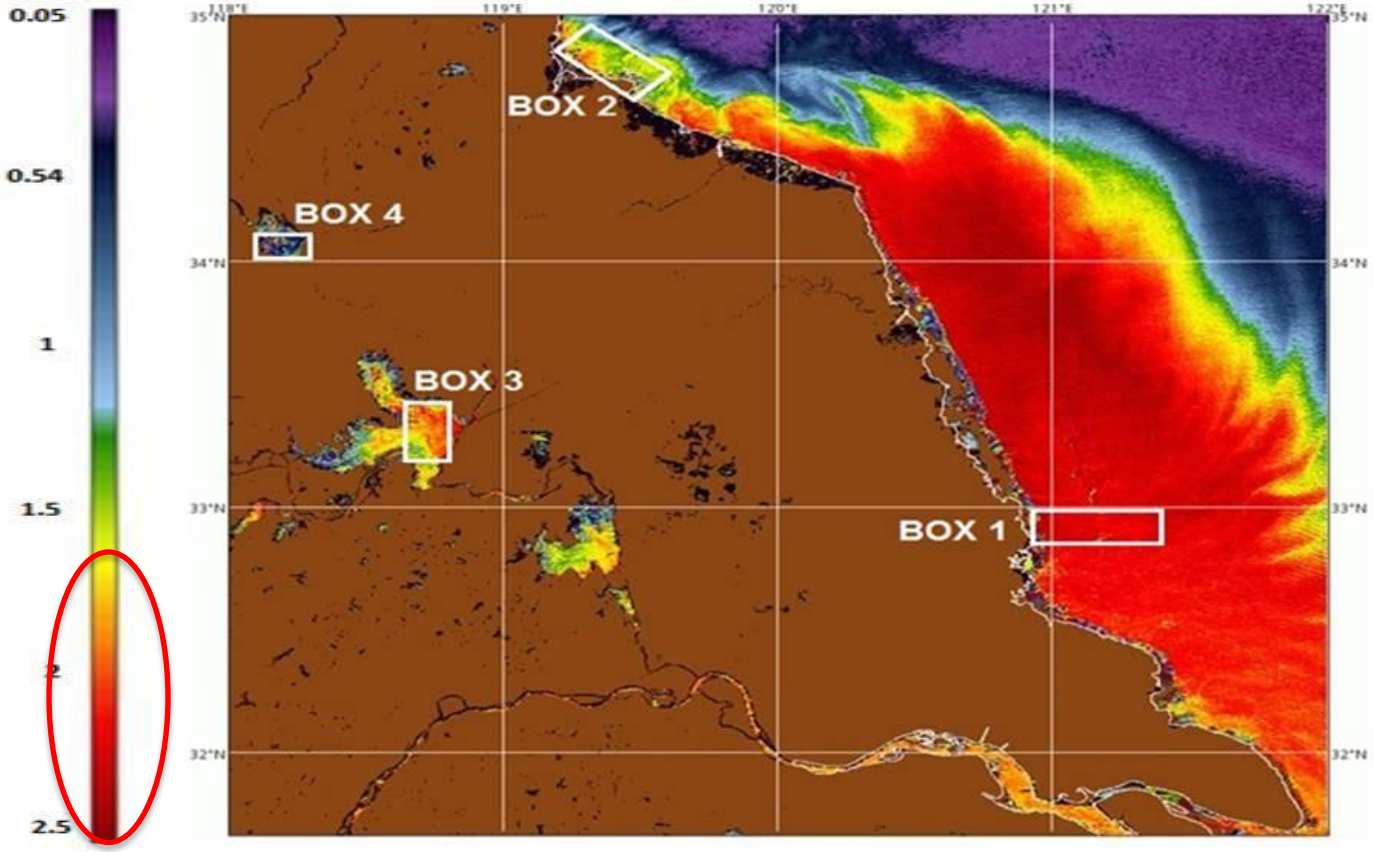
Survey Area - Jiangsu Province, China

YUN-12 Aircraft

Environmental Information – Jiangsu Region

Clear water

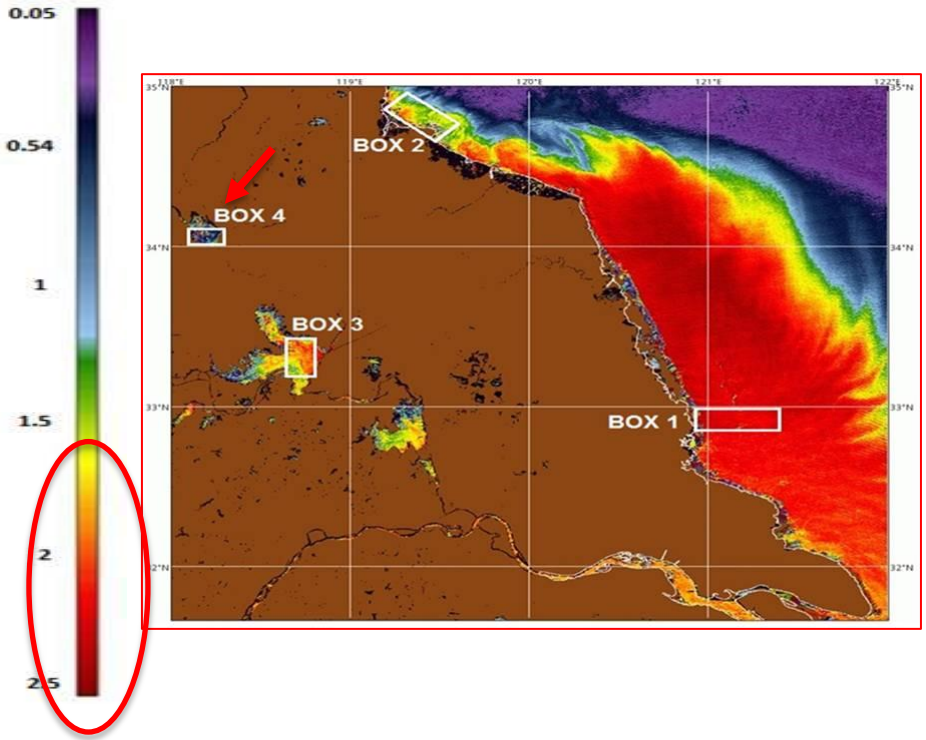
Turbid water



Kd map of Jiangsu Province showing turbid water

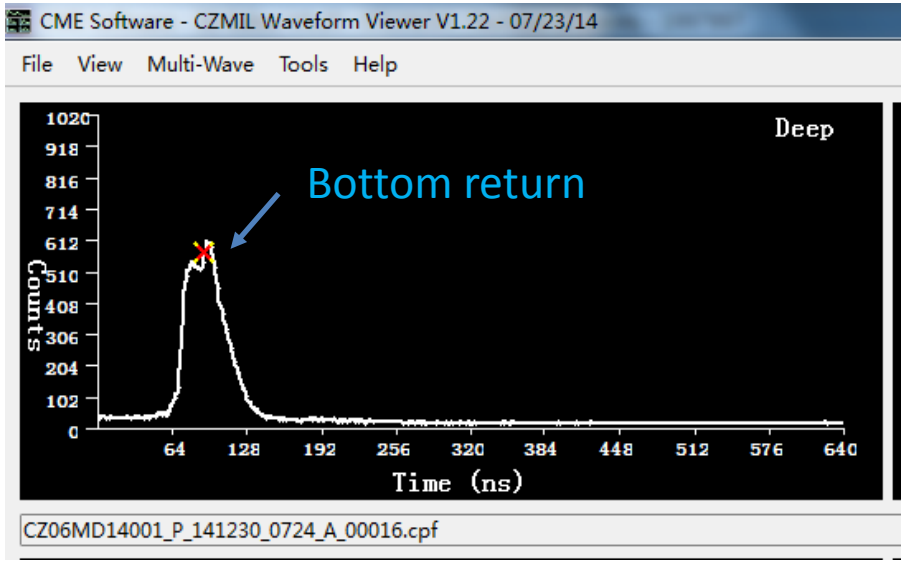
Survey Results - China

Clear water



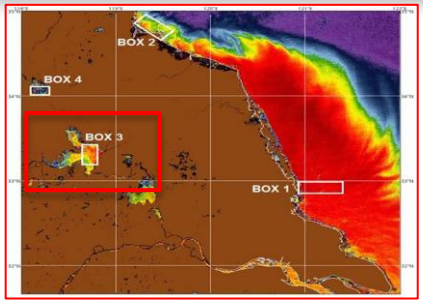
Turbid water

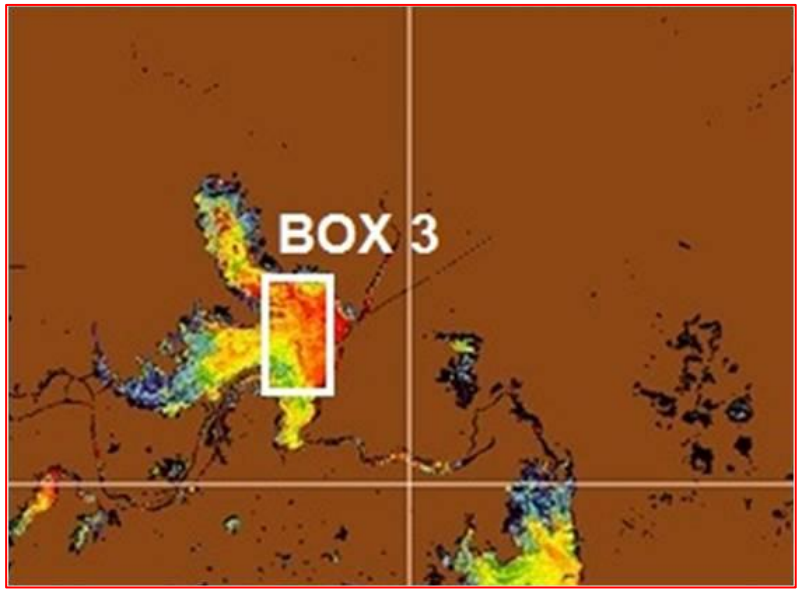
CZMIL Deep channel



CZMIL data courtesy of Jiangsu Bureau, China Administration

Survey Results - China

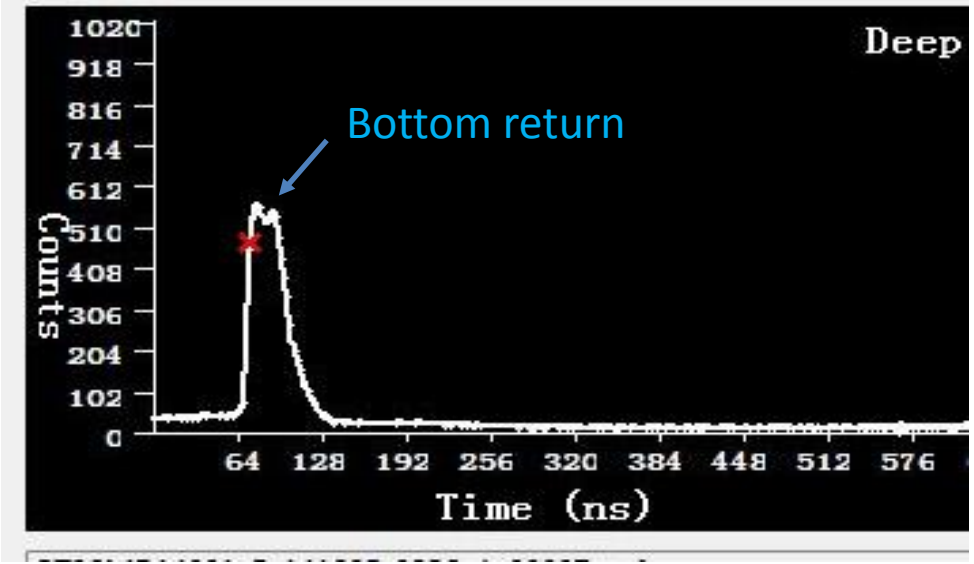




Hung-tse lake

Survey Results - China

CZMIL Deep channel

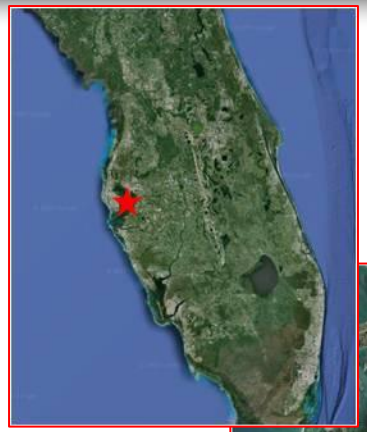


Despite low bottom reflectance, high K_d values and turbid water conditions, CZMIL was able to detect bottom in all the surveyed areas

Hung-tse lake

CZMIL data courtesy of Jiangsu Bureau, China Administration

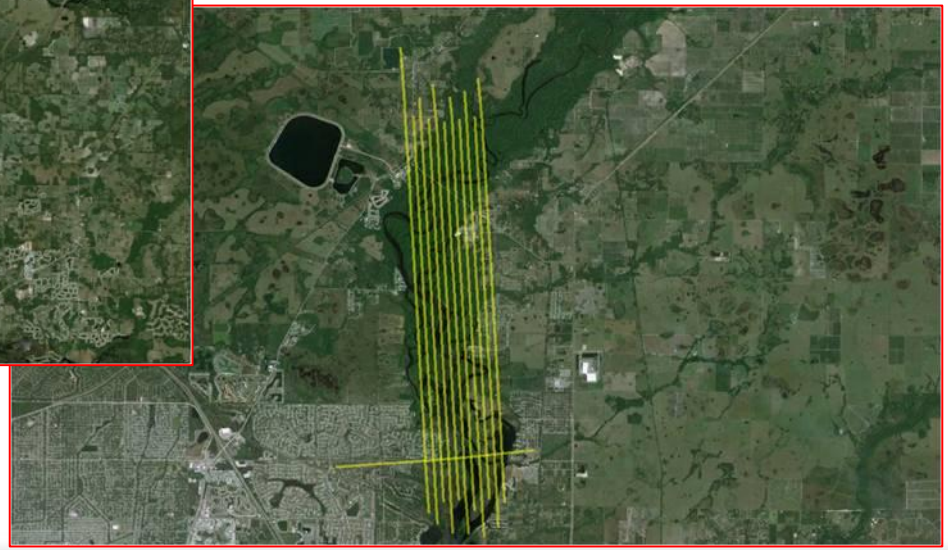
Mission Area – Tampa Bay/Peace River, FL



Tampa Bay, FL

- Customer: Dewberry
- End User: SWFWMD
- Area: 35 km^2
- Altitude: 400 m

Peace River, FL

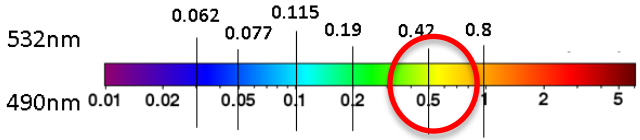


Piper Navajo Aircraft –Tampa Bay/Peace River

CZMIL installed in Piper Navajo aircraft

Environmental Information - Tampa Bay River

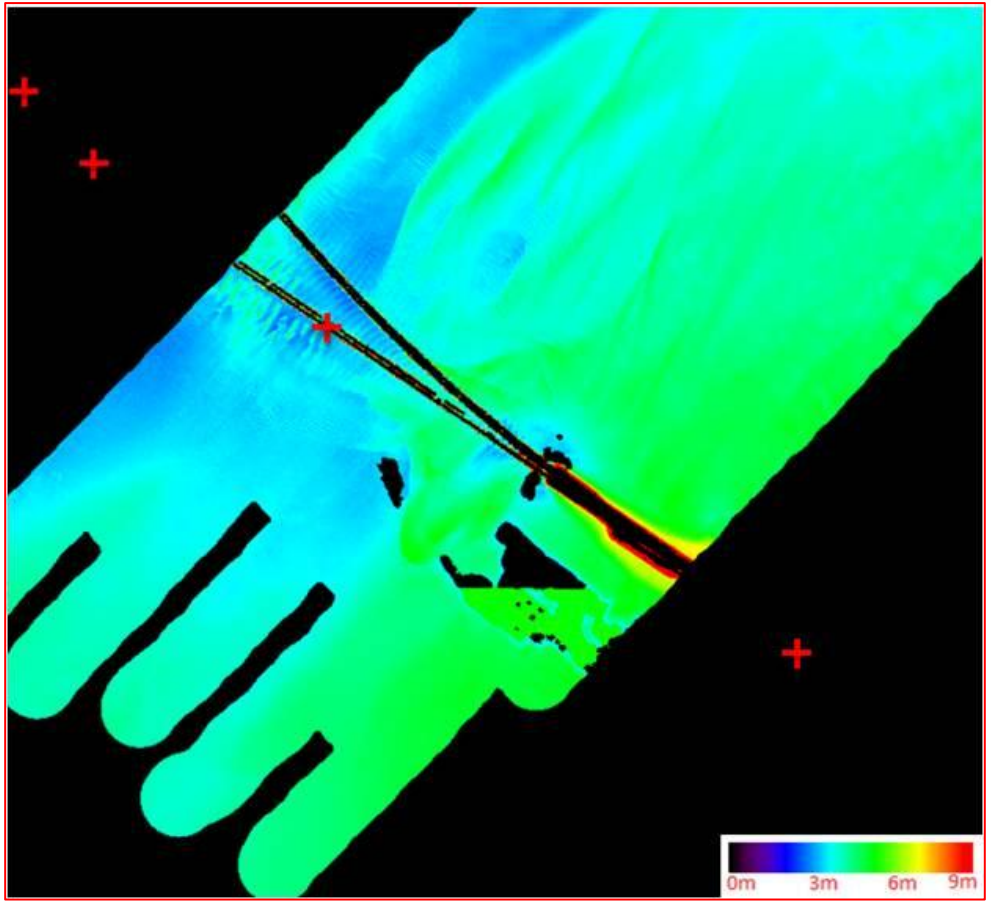
Tampa Bay



Clear water

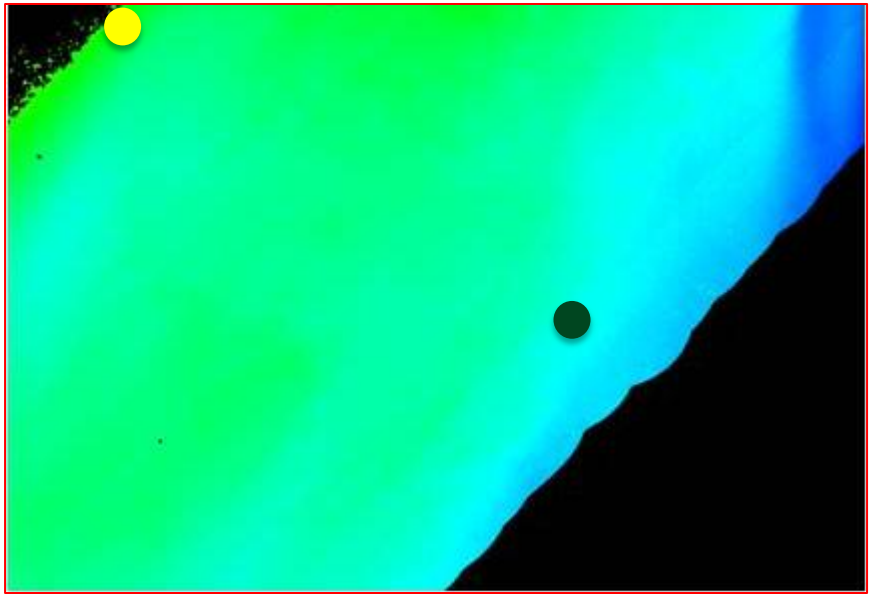
K_d (m^{-1})

Turbid water

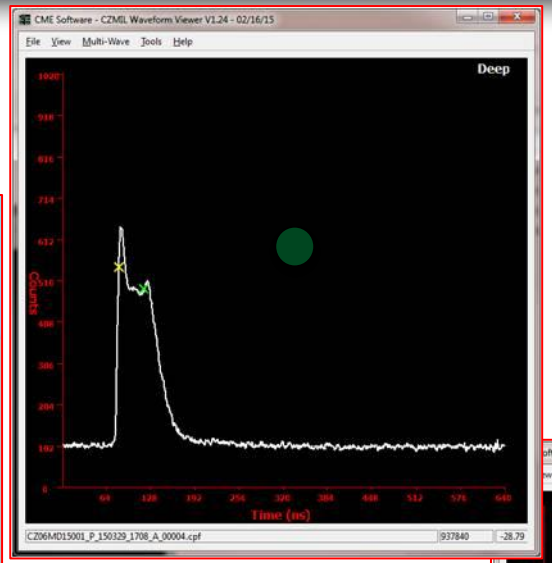


Lidar Depth Map

Survey Results – Tampa Bay

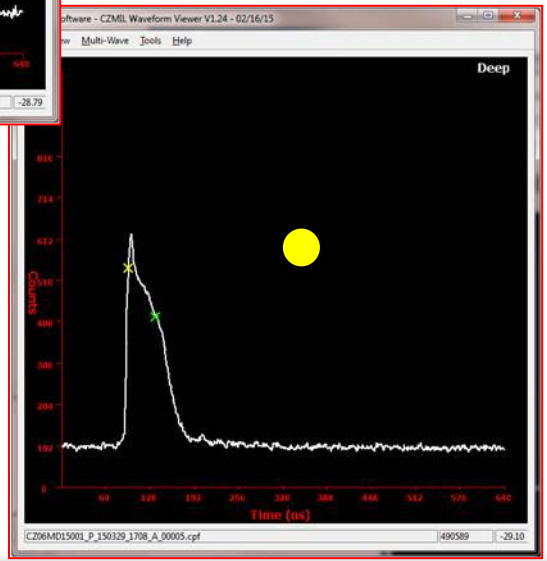


Tampa Bay, FL

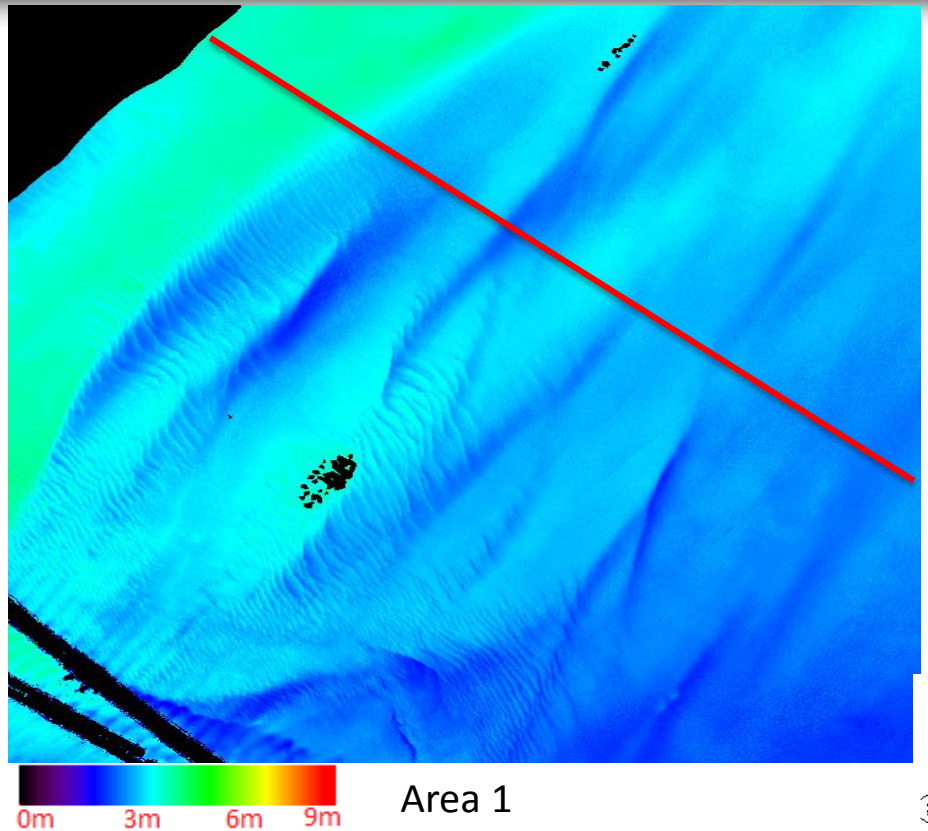


Traditional depth extraction

Detected with the
Turbid Water Module (TWM)

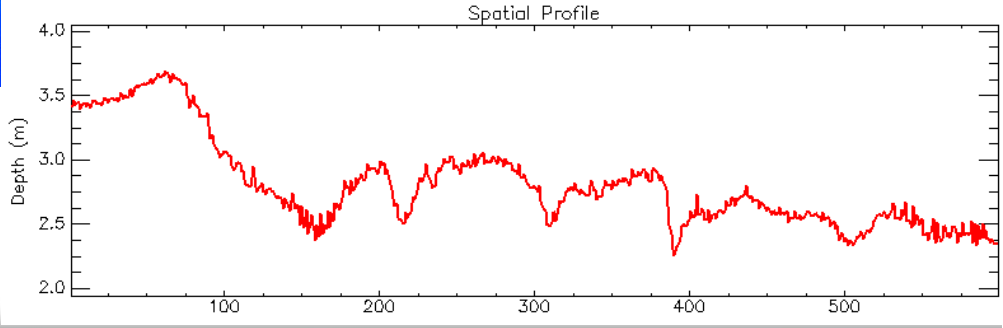


Survey Results – Tampa Bay



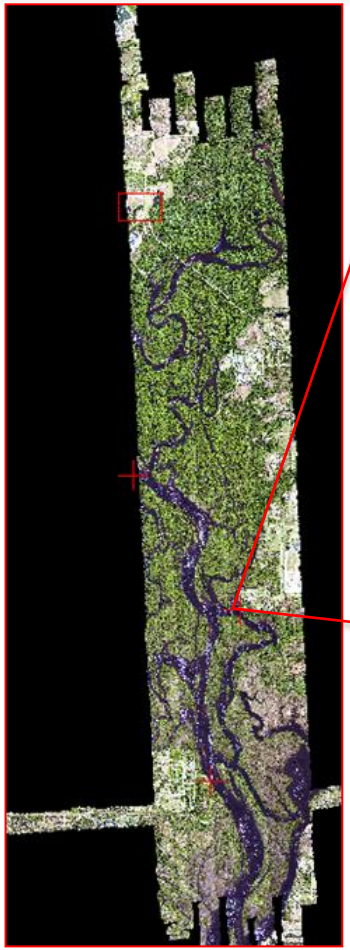
Area 1

Area 2

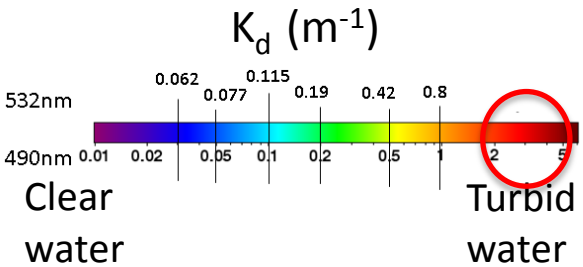


Max Depth: ~6.5m (Tampa)

Environmental Information - Peace River

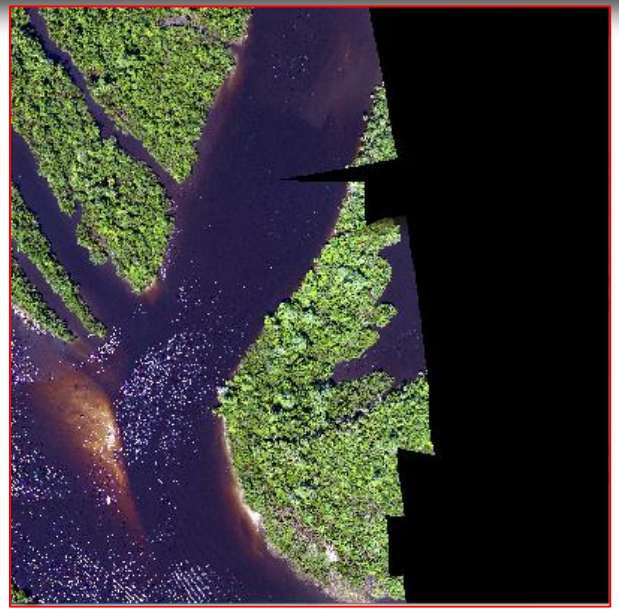


Optech T4800i OrthoMosaic

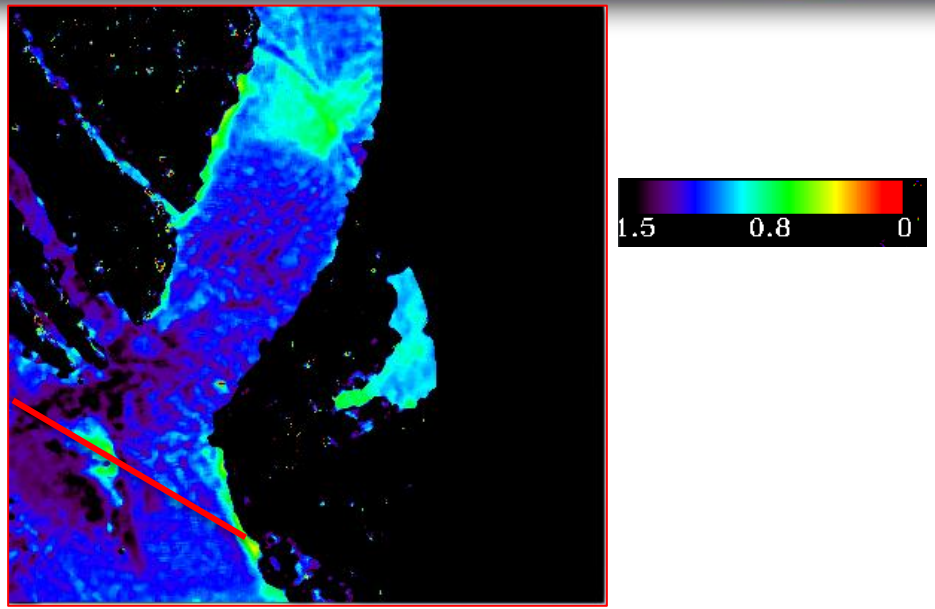


Dark river bottom reflectance close to 5% due to biological activity

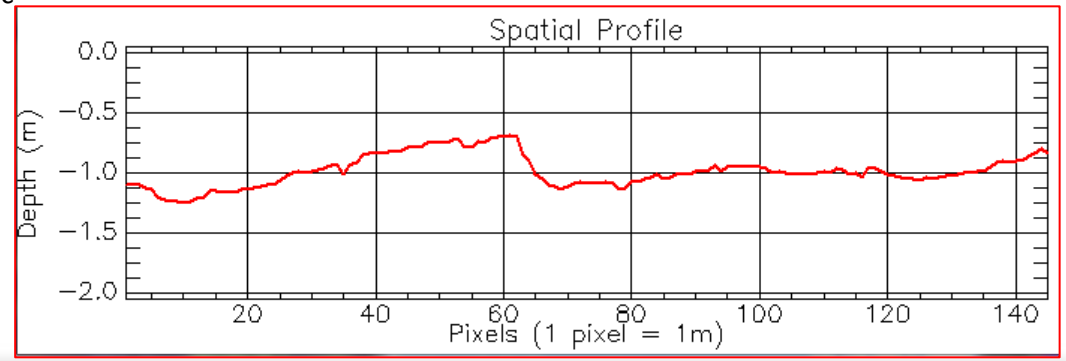
Survey Results – Peace River



T4800i OrthoMosaic

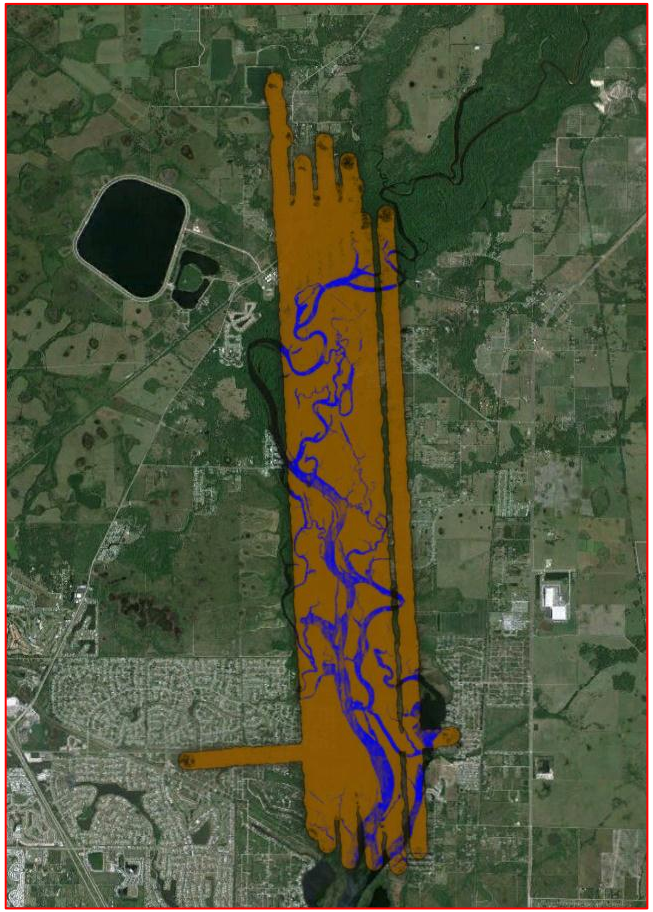


Lidar DEM



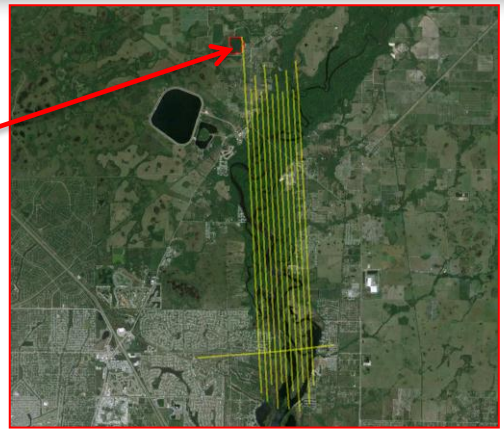
Preliminary results

Survey Results – Peace River

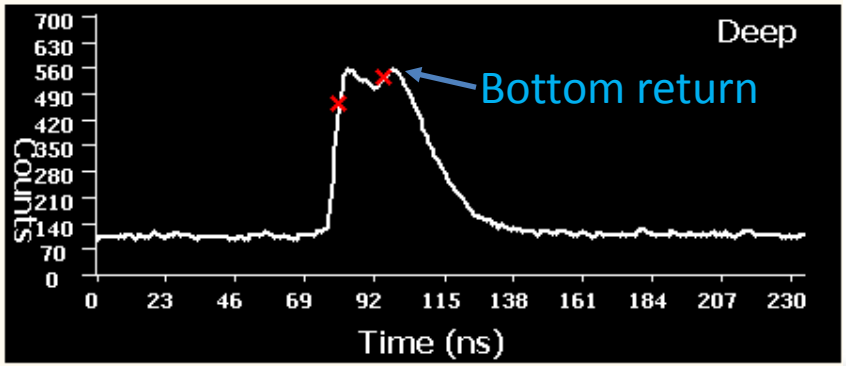


CZMIL automatic Land/Water Classification Map

Peace River "Lake"

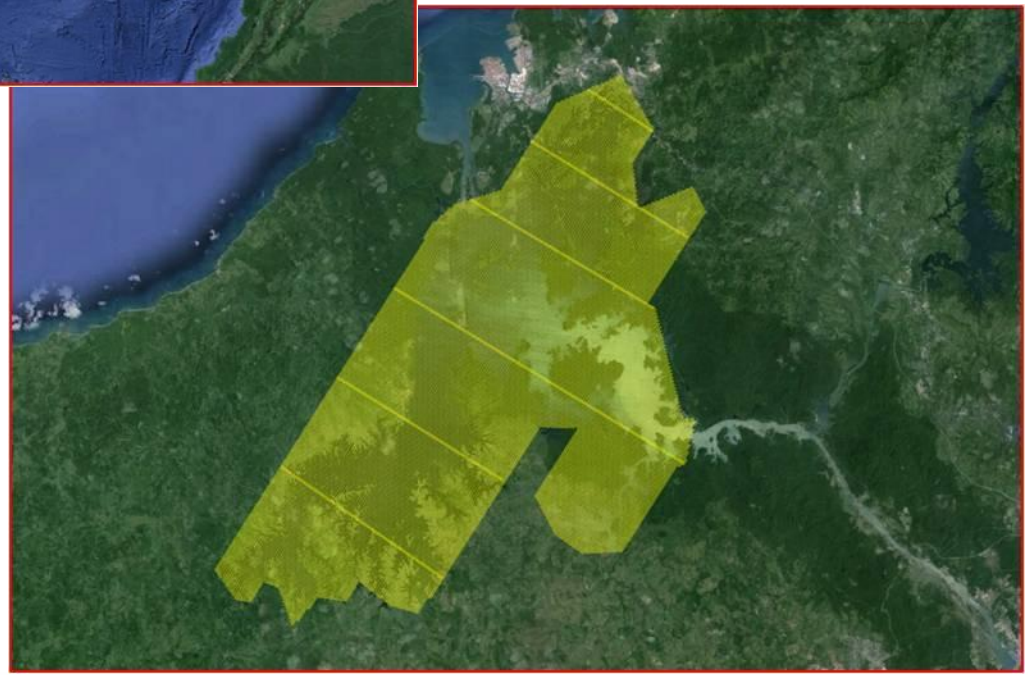


~3m Depth Detected



Mission Area – Gatun Lake, Panama

- Service Provider: IIC Technologies
- End User: Panama Canal Authority (ACP)
- Area: 858 km^2
- Altitude: 400m & 600m



Piper Navajo Aircraft - Panama

CZMIL installed in Piper Navajo aircraft

Conclusion

- CZMIL Nova Project Program was well received by the industry since its launch less than a year ago
- Commercial airborne service providers successfully won projects around the world including surveying and mapping of lakes, rivers & coastal waters, even in very turbid water conditions covering over 3500 km^2
- The CZMIL Project Program will keep supporting the needs of airborne service providers in the months/years to come