

Visualization, Analysis and Management of 3D LiDAR Topography in Oracle Spatial 11g

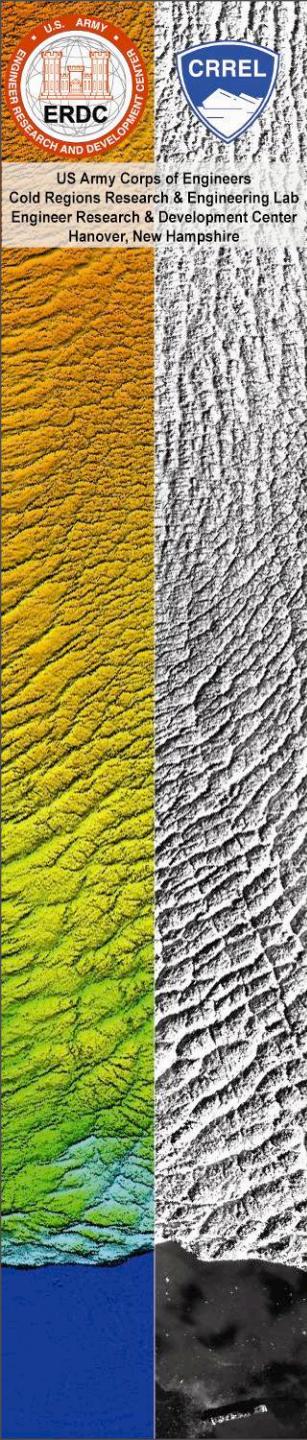
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&
David C. Finnegan**

*Oracle Spatial Users Conference
Tampa, Florida
April 23, 2009*

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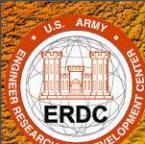


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Overview

- LiDAR overview and data management challenges
- Testing and implementation of Oracle 11g point clouds (e.g. SDO_PC)
- Leveraging and enhancement of open source libraries
- 3rd party vendor support
- Example Visualization / management use

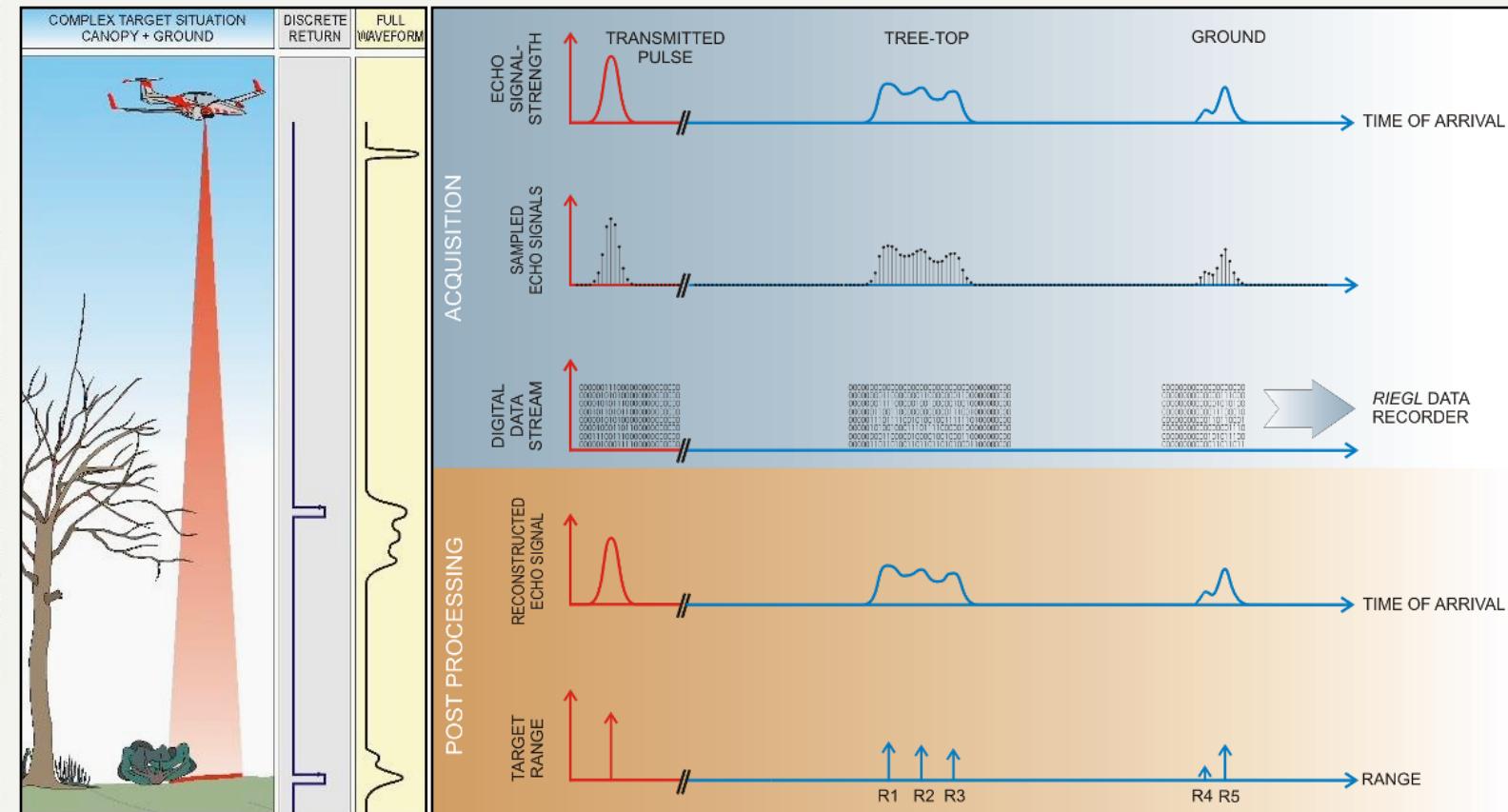


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LiDAR Overview

- **Light Detection and Ranging (LiDAR)**

- The use of pulsed laser technology from a satellite, airborne or ground-based platform to generate accurate elevation data. For each laser pulse emitted, a returned spatial vector from the platform to the point of reflection is established. When combined with precision GPS and aircraft motion an extremely precise XYZ coordinate of the laser footprint can be determined.
- LAS – LiDAR standard file format, established by ASPRS





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Challenges: Managing LiDAR Data

• Data Management Challenges

- Increasing LiDAR densities with technology (multi-return, full waveform) – Billions of points
 - Multi-return $150\text{ KHz} * 4 = 600\text{k/sec}$
 - Full-waveform $250\text{ KHz} * 2048 = 512,000,000/\text{sec}$
- Lag-time from acquisition to analysis
- Metadata access and management
- Fusion with other geospatial data (terabytes)
- Multi-user access and security
- Versioning, Archiving – (terabytes, petabytes)
- Backup, Recovery and minimizing downtime

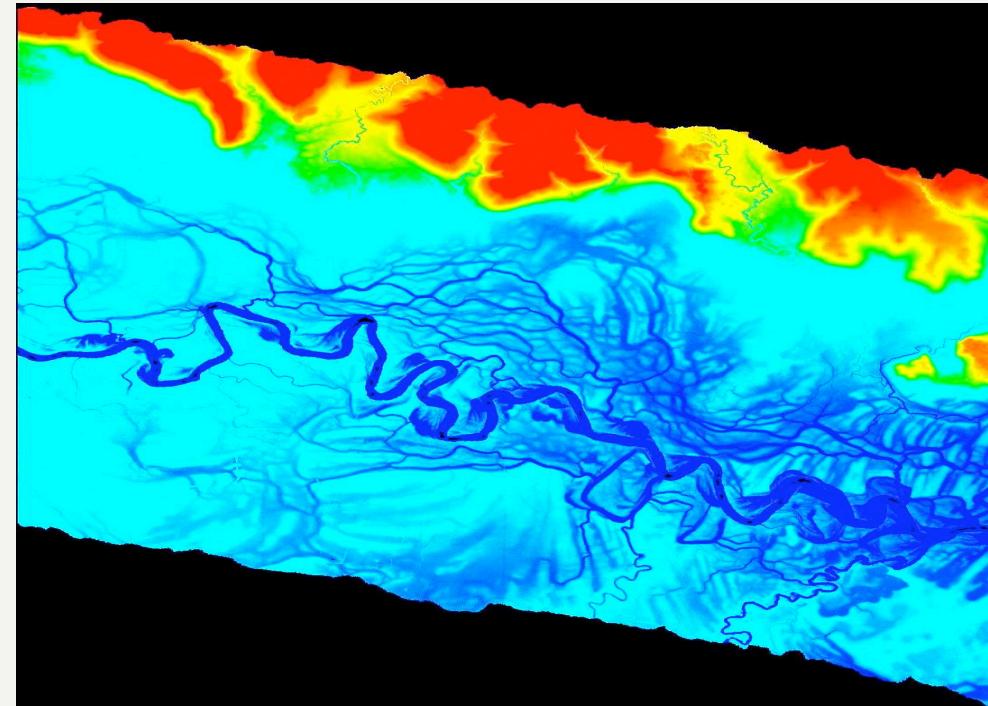


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Challenges: *cont.*

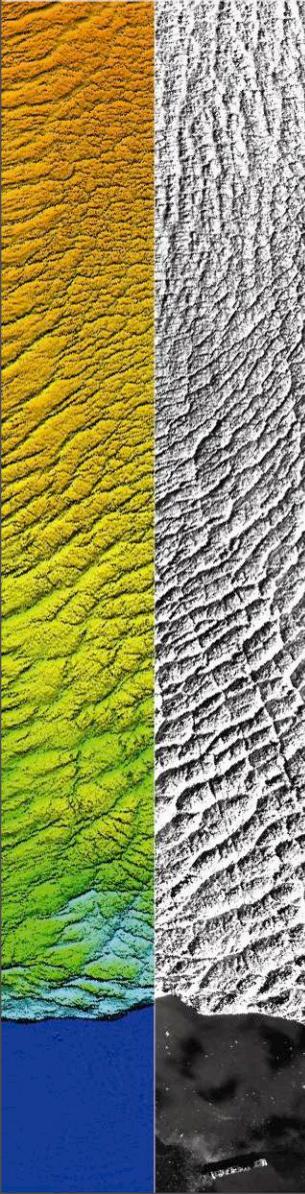
- Data Transformation
 - Surfaces (TIN, DEM, vector transformation)
 - Projections
 - Data integration
 - Filtering, Visualization and Analysis



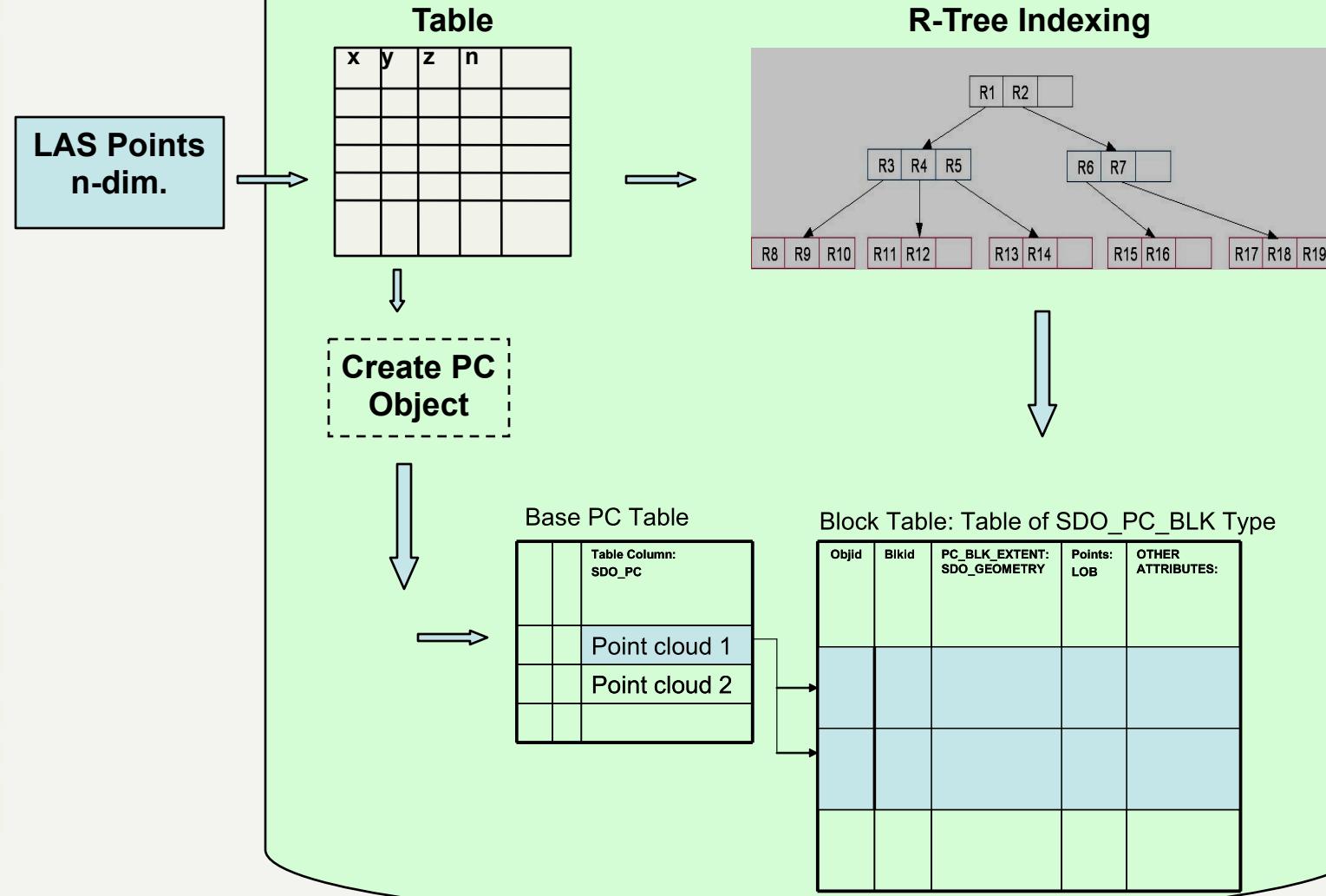


Point Cloud Creation Overview

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Oracle 11g





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Scalable Storage Framework For a Point Cloud

Base PC Table

| | | Table Column: SDO_PC |
|--|--|--------------------------------|
| | | Point cloud 1 |
| | | Point cloud 2 |
| | | |

- Ordinary Oracle table with a **POINT_CLOUD** column
- Each point cloud is associated with a block table

Block Table: Table of SDO_PC_BLK Type

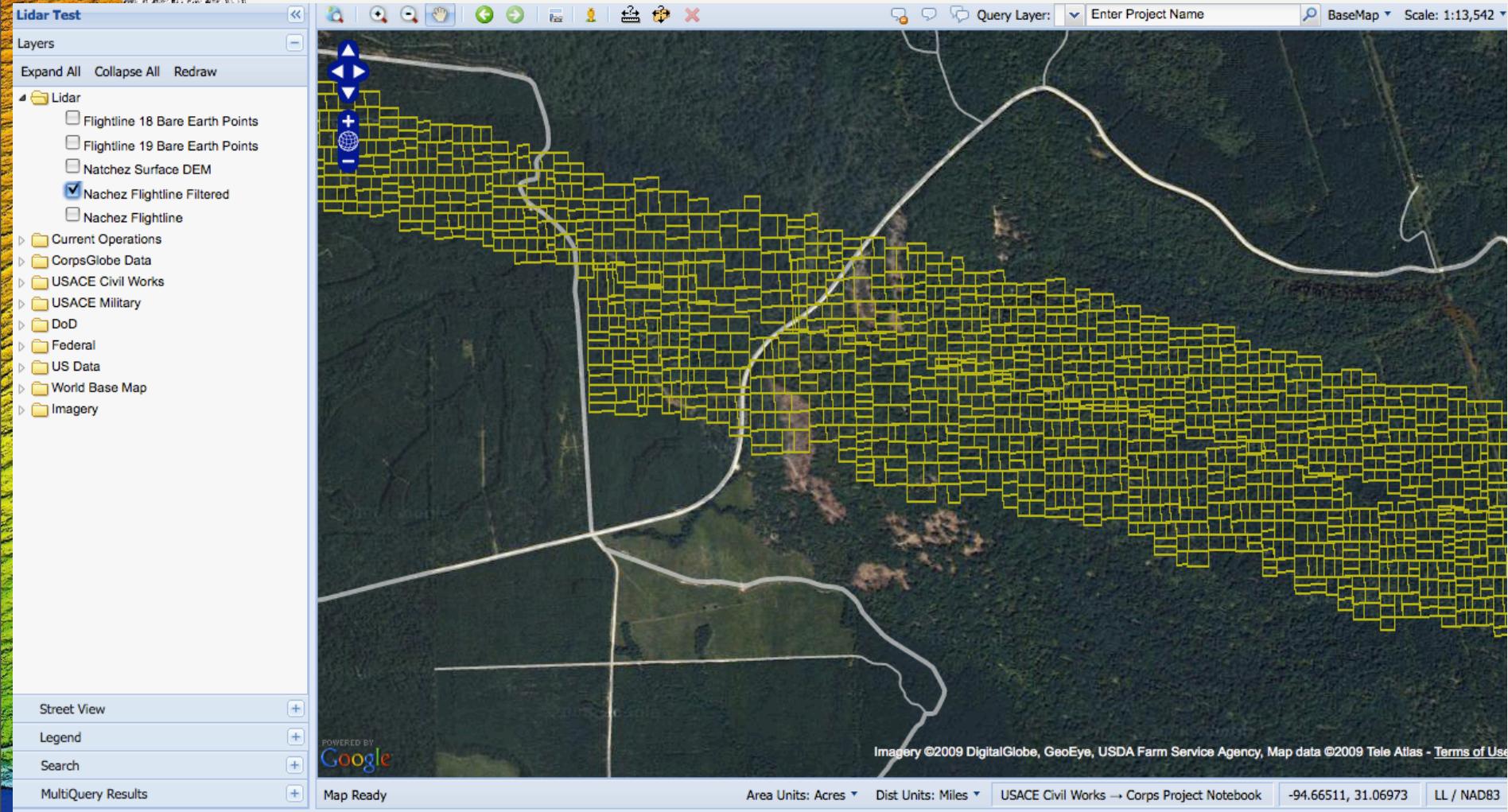
| Objid | Blkid | PC_BLK_EXTENT: SDO_GEOMETRY | Points: LOB | OTHER ATTRIBUTES: |
|-------|-------|---------------------------------------|----------------|-------------------|
| | | Block 1 | | |
| | | Block 2 | | |
| | | | | |

- Point cloud partitioned into multiple blocks
- Each block is uniquely identified by Objid and Blkid
- Each point in the lob can have attributes stored in an optional separate table



Blocks just within Flight Line

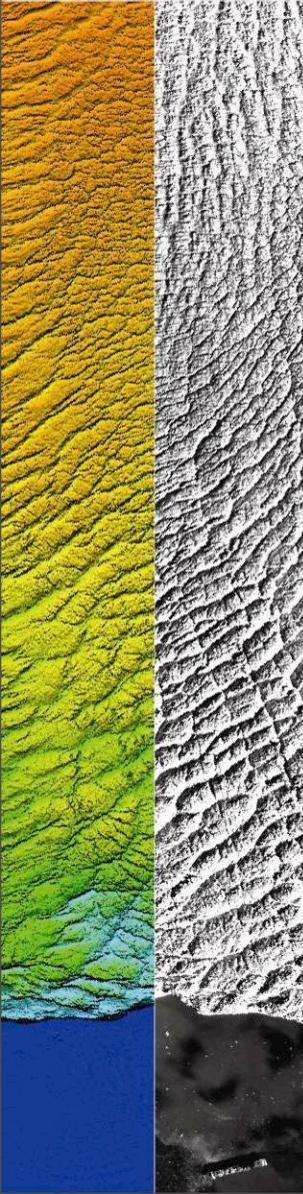
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Advanced Spatial Data Management

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Spatial Operators

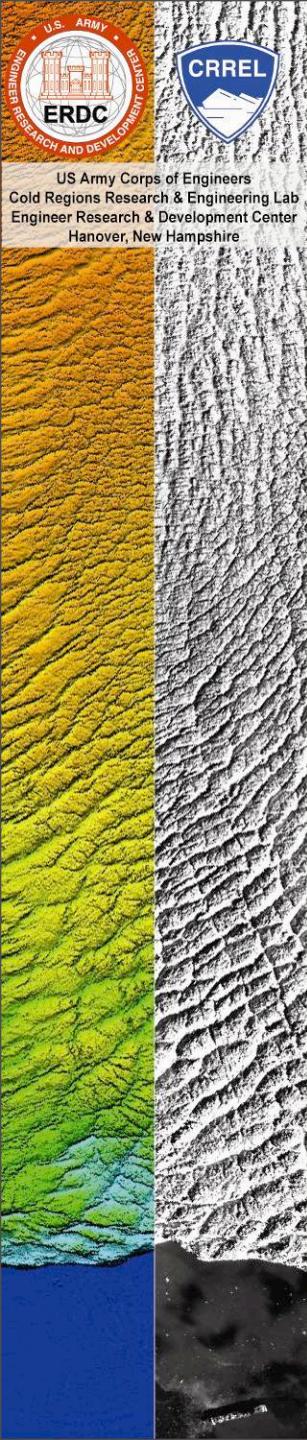
- Any spatial operator to search through point blocks
 - - SDO_ANYINTERACT
 - - SDO_NN
 - - SDO_FILTER

CLIP_PC (Clip Point Cloud)

- - 2D or 3D query window
- - Returns points for any block whose extent intersects the query window
- - Only points that intersect the query window are returned
- - Creates a new SDO_PC, can be stored or used in Queries

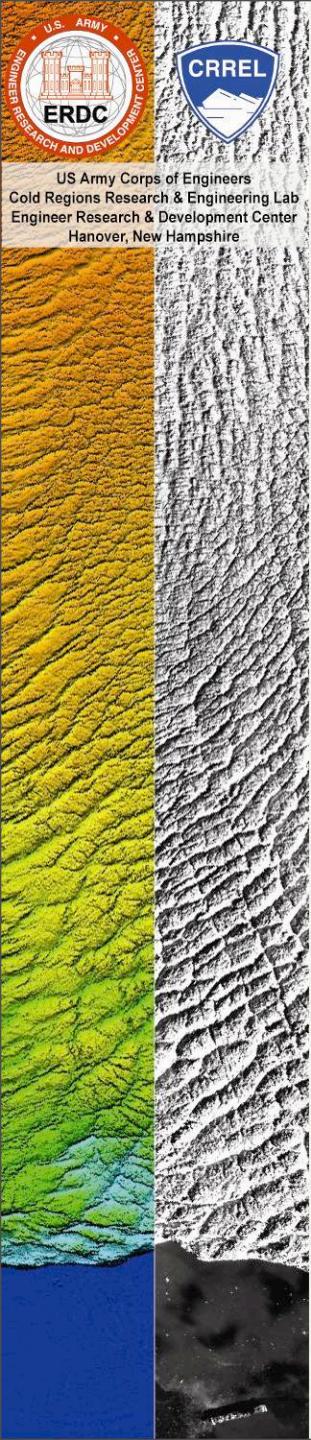
TO_GeOMETRY

- - Gets the points (as a Point Cluster) from a PC
- - Can be from a CLIP_PC operation



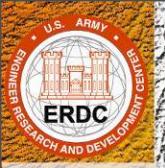
Performance Testing and Optimization

- Point cloud creation
 - Time to load data to a DB table
 - Pre-processed table versus JAVA loaders
 - Time to create an indexed point cloud object from an Oracle table of point values
 - Multi session results
- Retrieval query performance
- Inflation of Point Cloud file sizes once PC is created
 - Size of original file vs. Size of indexed point cloud
 - Use of SecureFiles versus LOBs

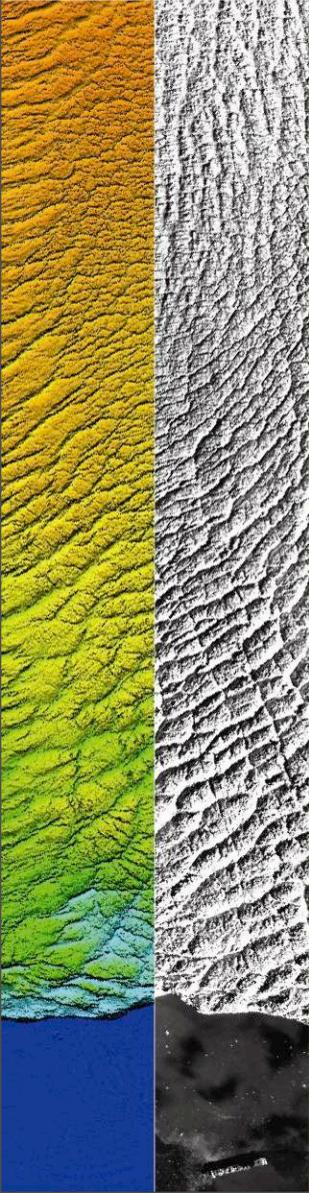


Getting LAS data into Oracle

- Testing Machines
 - Sun t5240 2 UltraSparcT2+ 1.2Ghz - 64Gb Ram
 - Sun x4150 x86 2 Xeon X5460 3.16GHz - 8Gb Ram

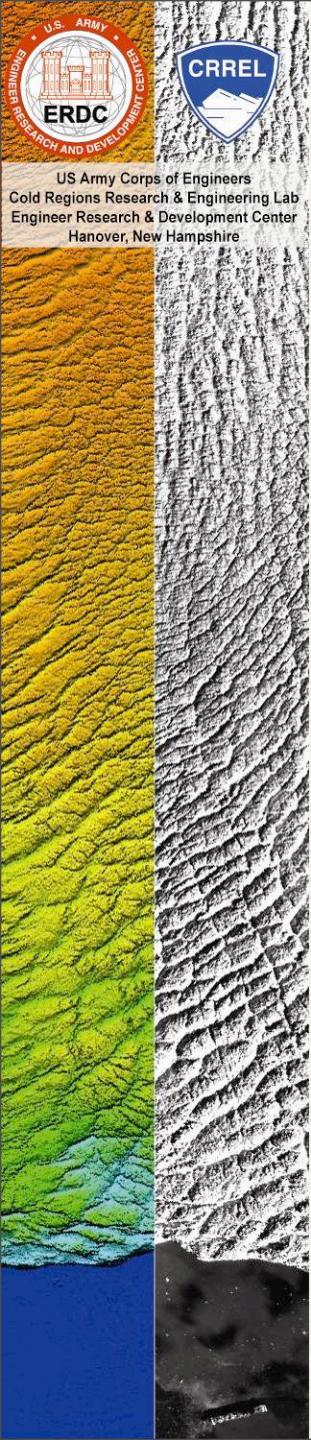


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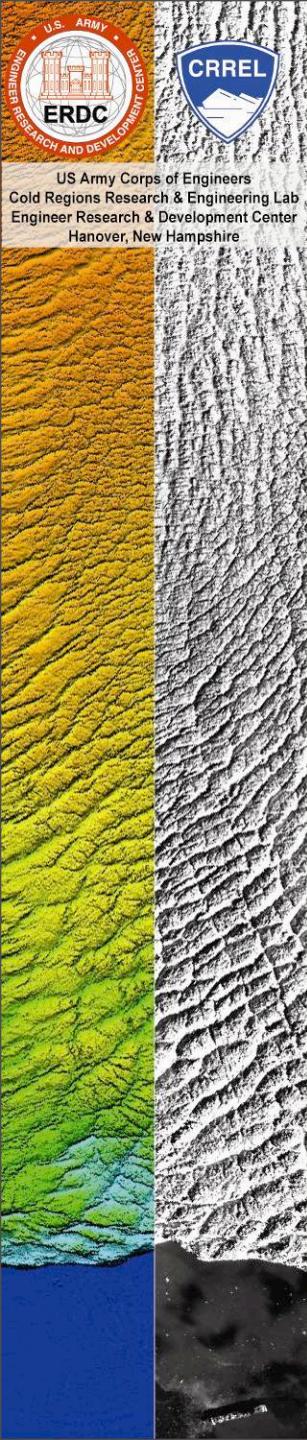
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 - x86 faster than Sparc



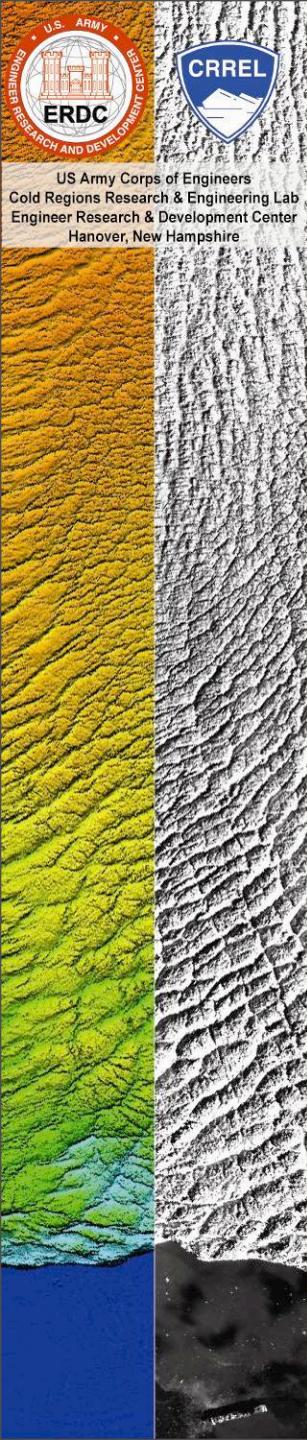
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 - not needed and saved ~20% time

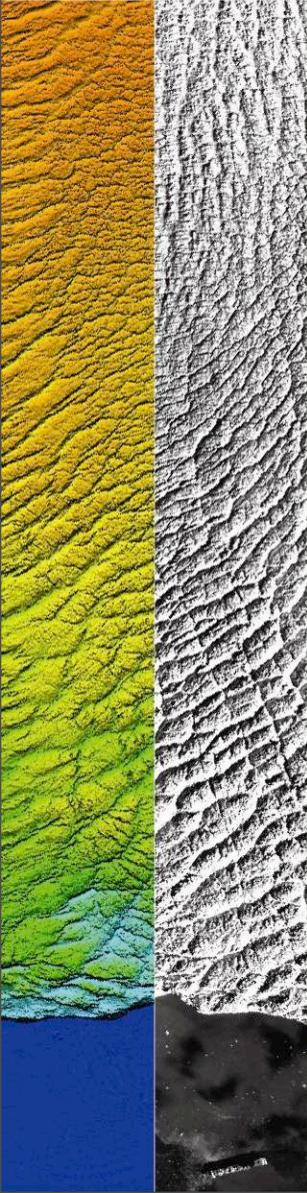


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- Speed of Temp location made a difference
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- Create PC without the results table
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- Effect of Block Size
 - small increase with larger size

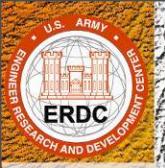


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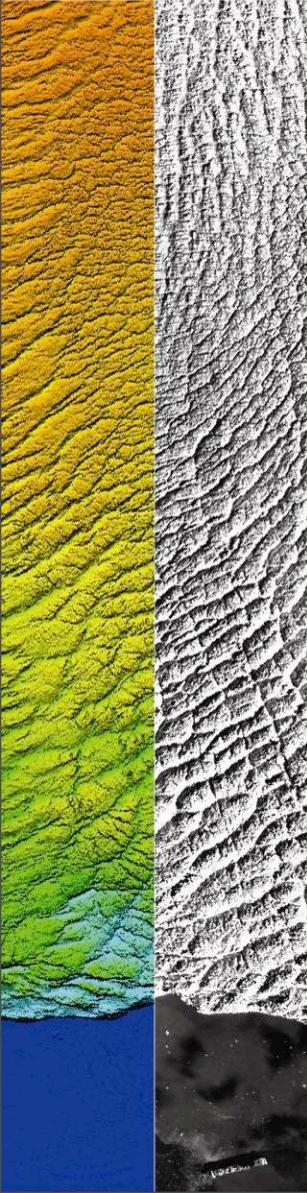


Converting LAS data to Points

- Java LAS loader to Normal Table
 - Sparc: 3.8 Mpts/min
 - x86: 22.7 Mpts/min
- External Table and LibLAS
 - new in 11.1.0.7, preprocessor option
 - PREPROCESSOR exec_dir:'las2txt'
OPTIONS '--parse Mxyz --stdout'
 - Sparc: 41.2Mpts/min
 - x86: 99.96 Mpts/min

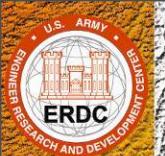


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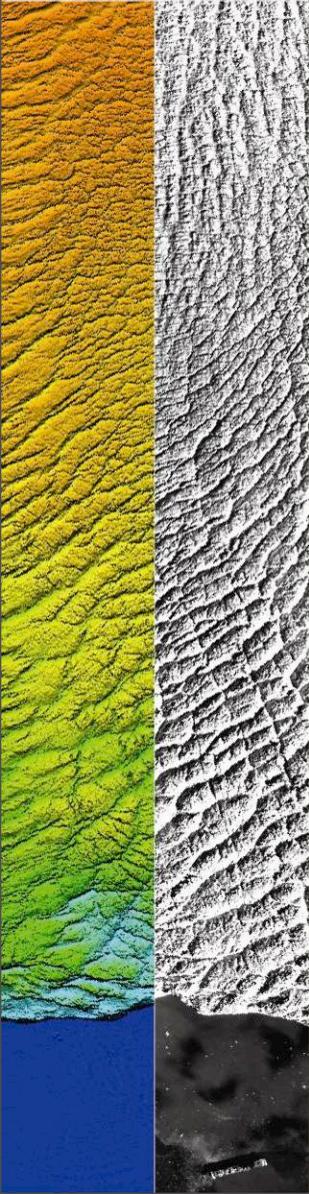


Creating Point Clouds

- Single Session
 - Sparc: 1.8 Mpts/min - 5k block size – ram temp
 - x86: 8.2 Mpts/min - 5k block size – ram temp
 - x86: 8.7 Mpts/min – 100K block size – ram temp
- Multiple Sessions
 - Used Apache Jmeter
 - Sparc:
 - 10, 20, 50, 100 simultaneous sessions
 - 1.2 – 2.5 Mpts/min
 - x86:
 - 6, 10, 20 sessions
 - 2.2 – 7.8 Mpts/min

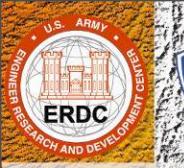


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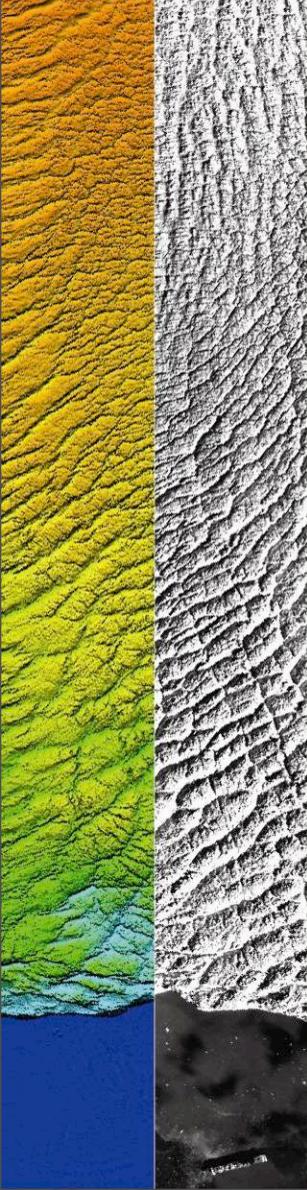


Retrieving Point Cloud Data

- 1 km circular buffer moving in data range
- calculate average Z value, max Z value
- Sparc:
 - 30 sessions – avg: 8.46 sec / session
 - 300 sessions – avg: 8.64 sec / session
- x86:
 - 30 sessions – avg: 0.66 sec / session
 - 250 sessions – avg: 1.14 sec / session

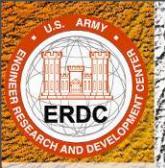


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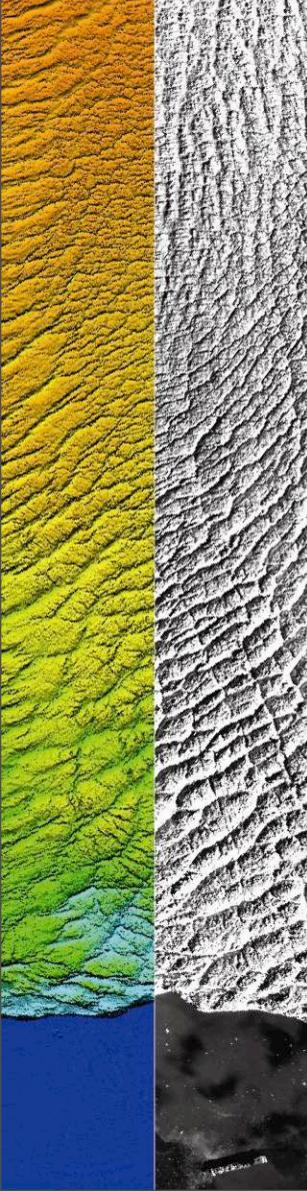


Size Inflation

- Original LAS File: 505Mb, 26M pts
- Table and Index size:
 - Lobs (BasicFiles): 839.5 Mb
 - SecureFiles (no compression): 826.2 Mb
 - SecureFiles (medium compression):

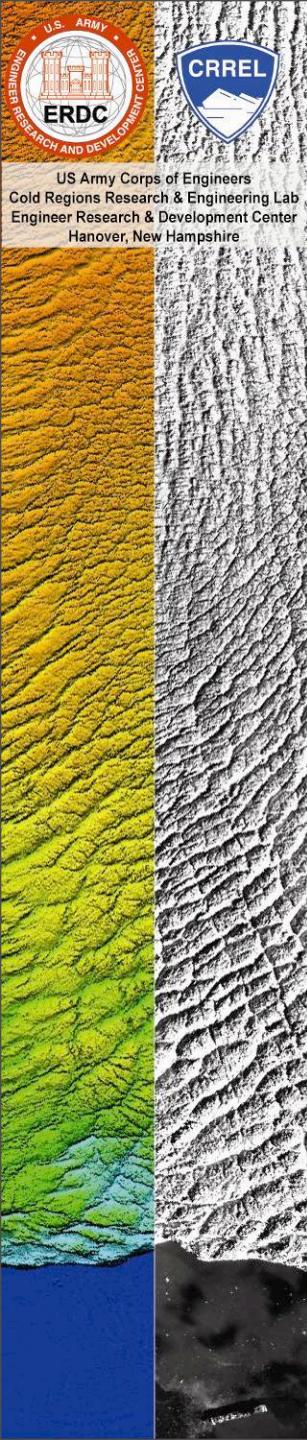


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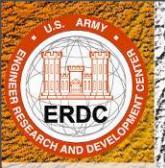
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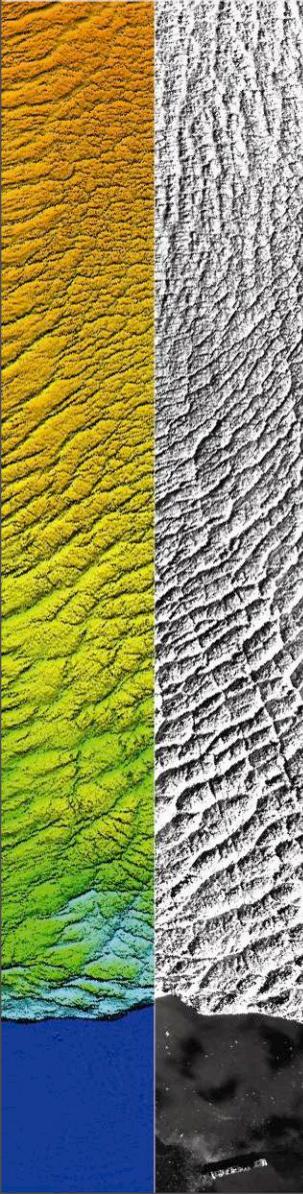


Impacts to the Geospatial Community

- Identification of specific performance related enhancements to Oracle Spatial
- Identification of specific API interfaces and calls that will enhance the ability of the wider geospatial community to utilize the point cloud functionality
- Enhancements to open source libraries.
 - LibLAS - LAS to Oracle via OCI
 - GDAL
 - OGR
- Enhancements to 3rd party vendors
 - Quick Terrain Modeler (Applied Imagery)
 - Riegl - (LiDAR hardware/software)
 - ERDAS
 - Certain3D – (CAD DOT software)

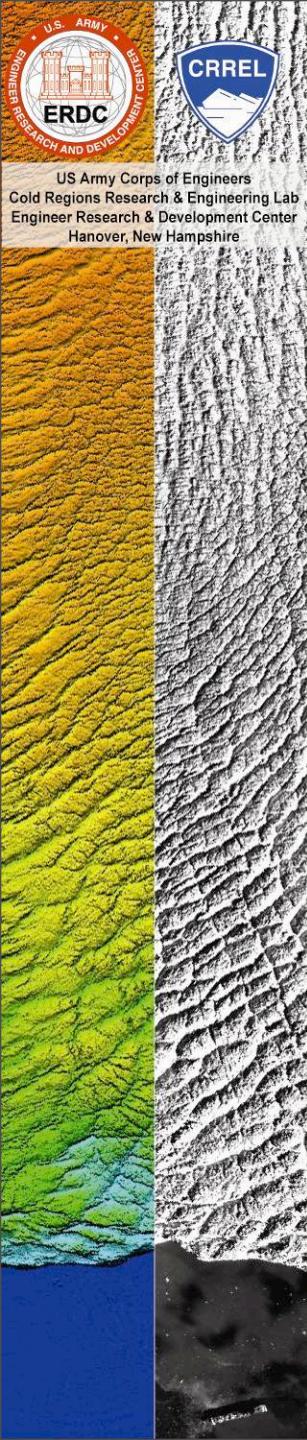


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Enhancements to Oracle Spatial API

- Refined granular access to SDO_PC
 - Create PC without needing input table
 - Insert/Update new Blocks of PC
 - Increase maximum dimensionality from 8 to 10
- Enable query /update / indexing of values beyond spatial in PC
- Identify and address any issues with additional features (SecureFiles, Flashback Data Archive, etc)
 - None found so far
 - Recommend (preliminary) use SecureFiles over Basic Lobs



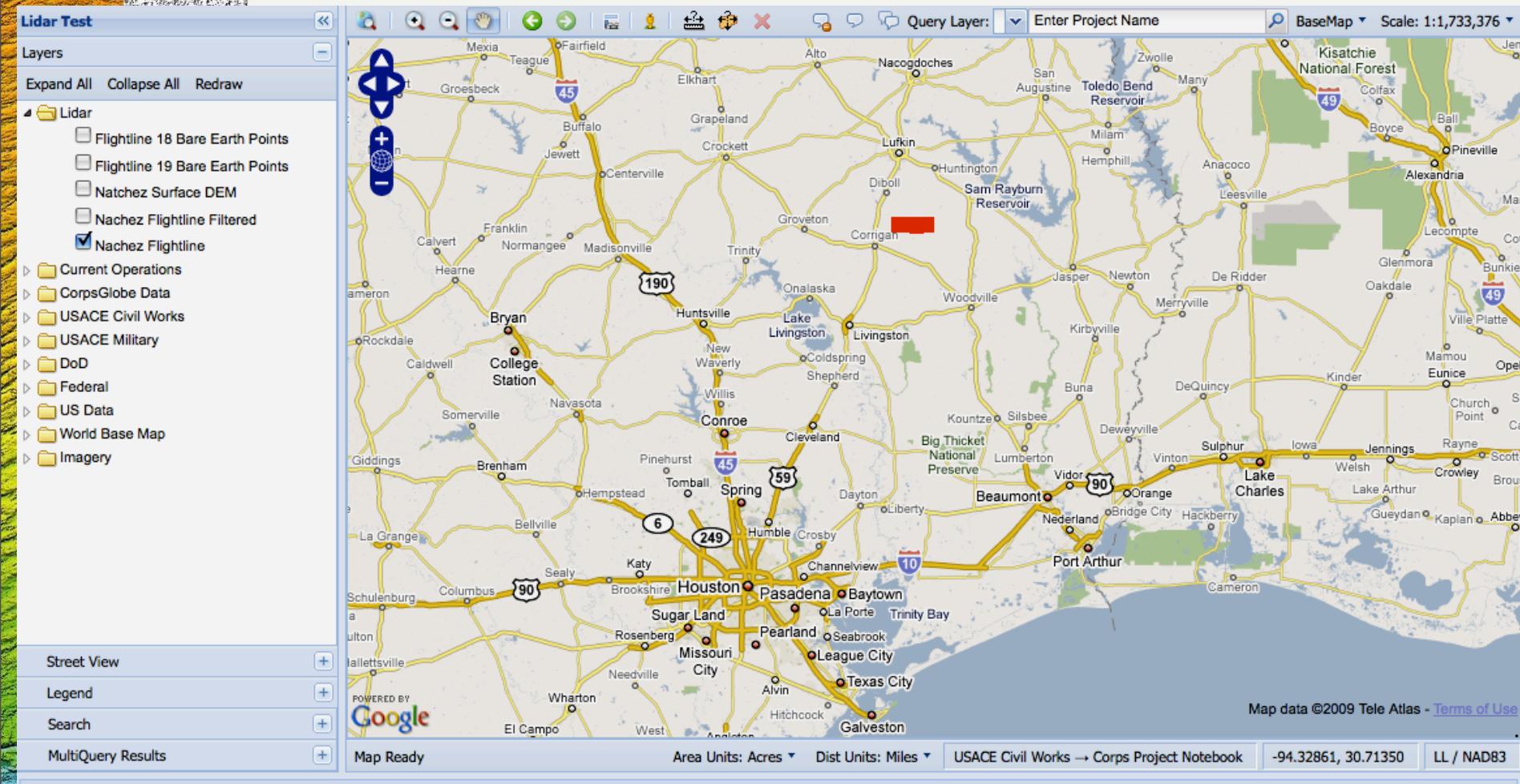
Open Source Enhancements

- Funding development of LibLAS library
 - write SDO_PC from LAS
 - write LAS from SDO_PC
 - extend LibLAS to read other formats
 - TerraSolid .bin files
 - Others
 - Encourage 3rd party developers to make use of library
- Coordination with GDAL/OGR
 - LibLAS can currently write to OGR data types
 - GDAL can read/write SDO_RASTER
 - Enable GDAL to read from LibLAS as an OGR type



Simple Visualization

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Showing the Blocks of an SDO_PC

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Lidar Test

Layers

Expand All Collapse All Redraw

Lidar

- Flightline 18 Bare Earth Points
- Flightline 19 Bare Earth Points
- Natchez Surface DEM
- Nachez Flightline Filtered
- Nachez Flightline

Current Operations

CorpsGlobe Data

USACE Civil Works

USACE Military

DoD

Federal

US Data

World Base Map

Imagery

Street View

Legend

Search

MultiQuery Results

59

Query Layer: Enter Project Name

BaseMap Scale: 1:108,3

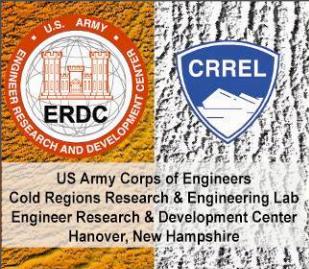
Pleasant Hill

Pluck

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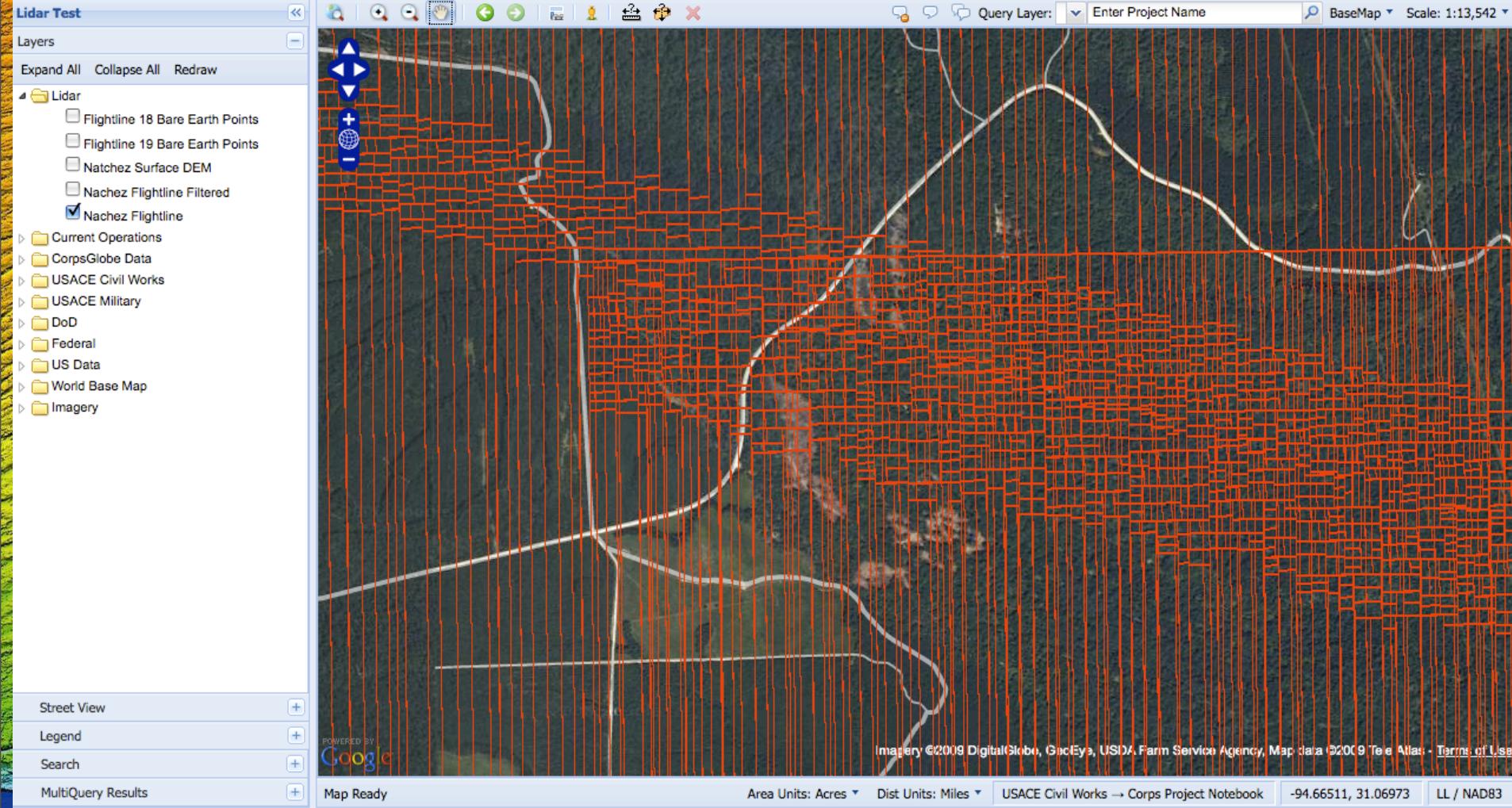
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Map Ready Area Units: Acres Dist Units: Miles USACE Civil Works → Corps Project Notebook -94.80549, 31.08734 LL / NAD83



Block Detail – Variable by density of points

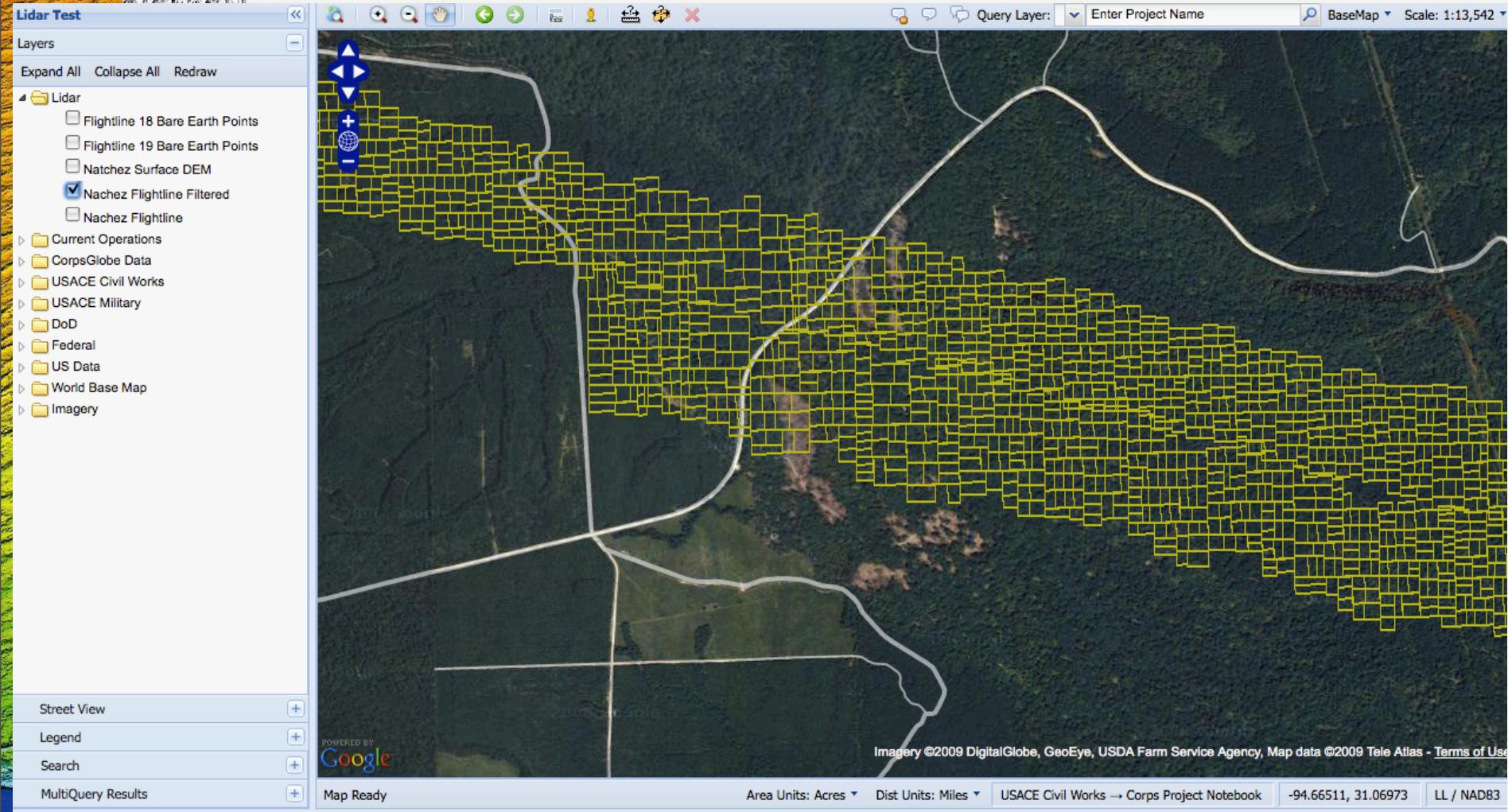
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Blocks just within Flight Line

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Bare Earth individual Points from SDO_PC

Lidar Test

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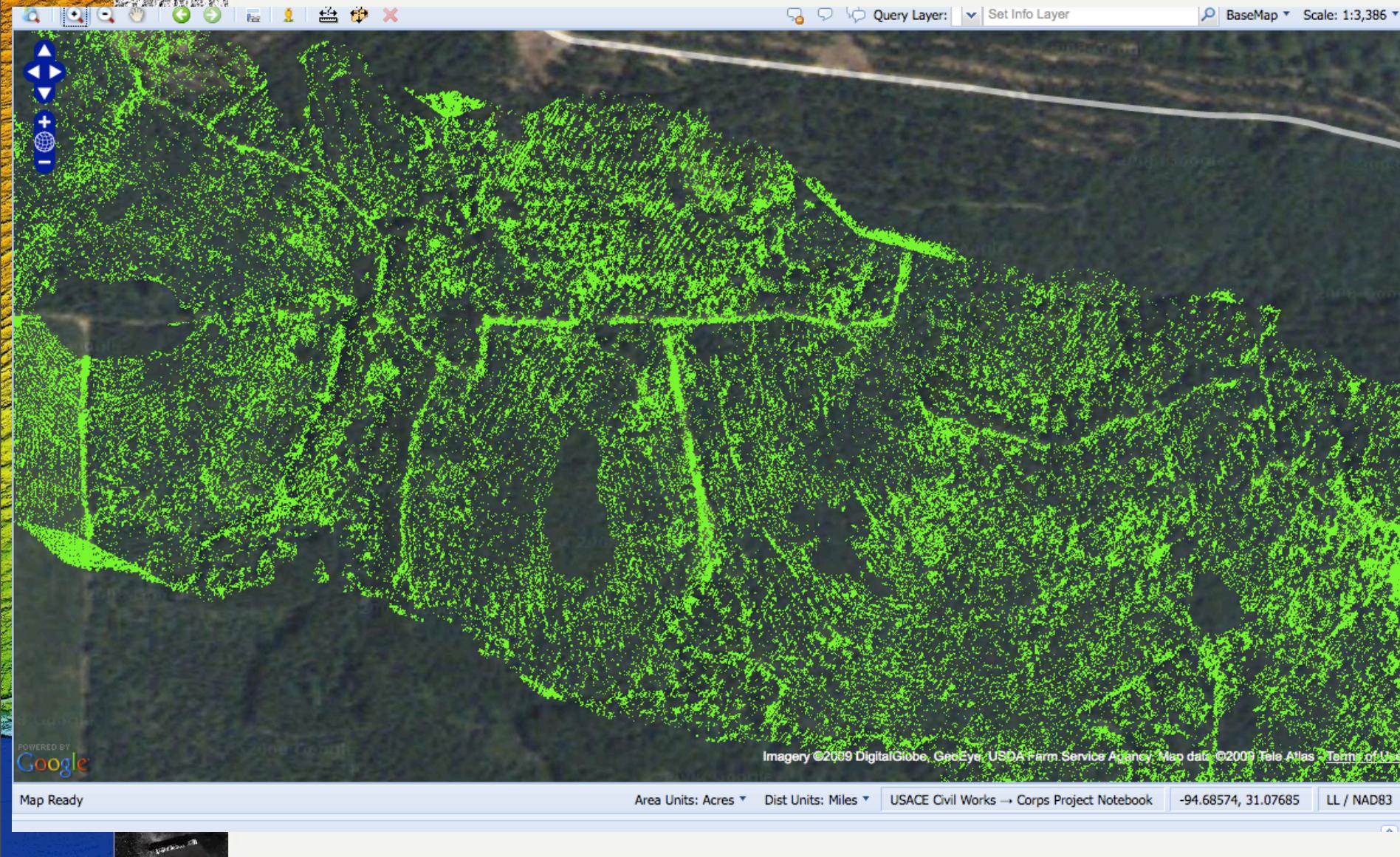
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Map Ready Area Units: Acres ▾ Dist Units: Miles ▾ USACE Civil Works → Corps Project Notebook -94.65490, 31.06422 LL / NAD83

The screenshot shows a map application window titled "Lidar Test". The main area displays a dense point cloud of bare earth individual points from SDO_PC, colored green. The map interface includes a legend, search, and multi-query results panel on the left. A toolbar at the top provides various map functions. The bottom of the screen shows copyright information for Imagery and Map data, along with map coordinates and units.

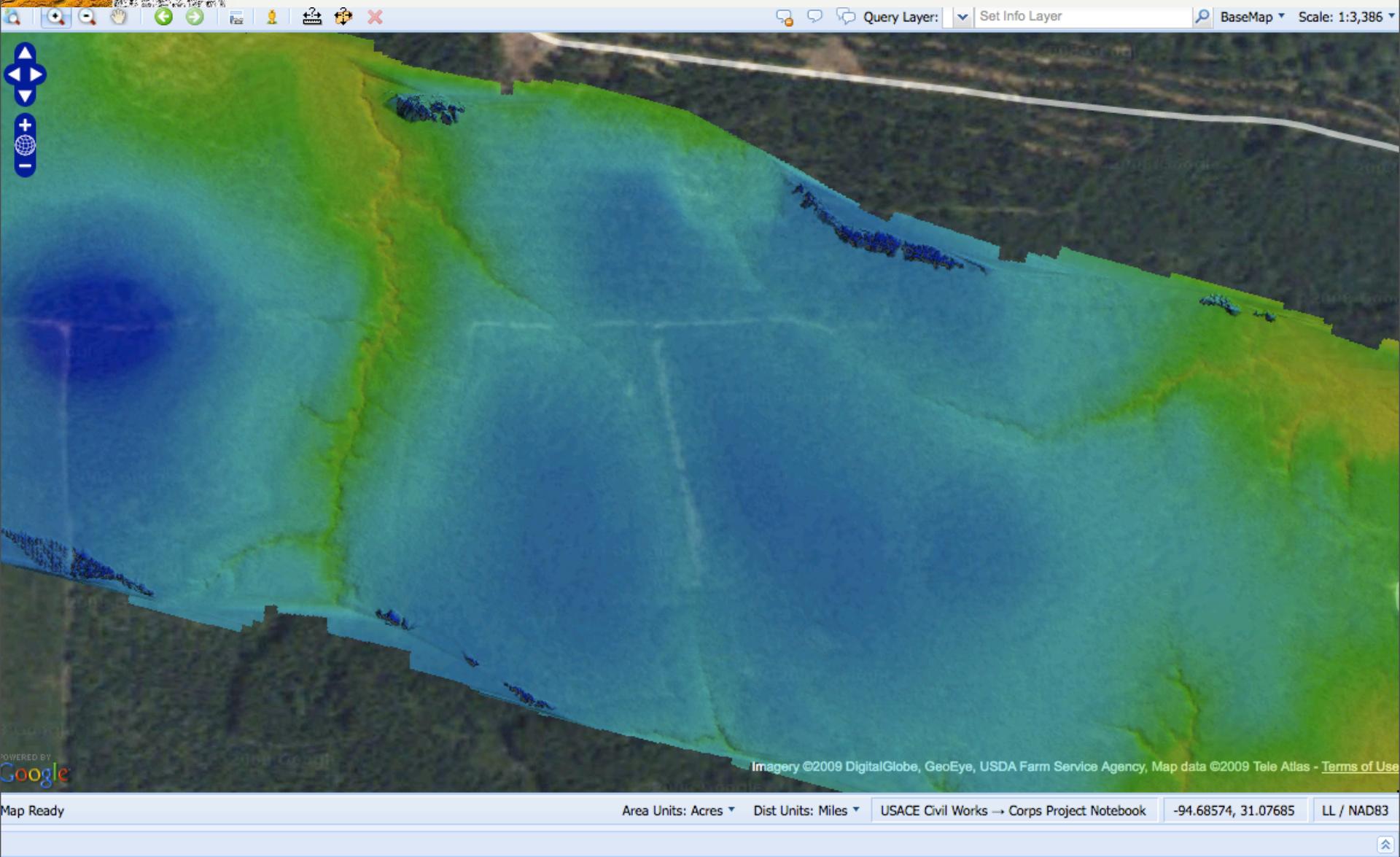


Bare Earth Points





DEM from LAS Data



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Google

Map Ready

Area Units: Acres ▾

Dist Units: Miles ▾

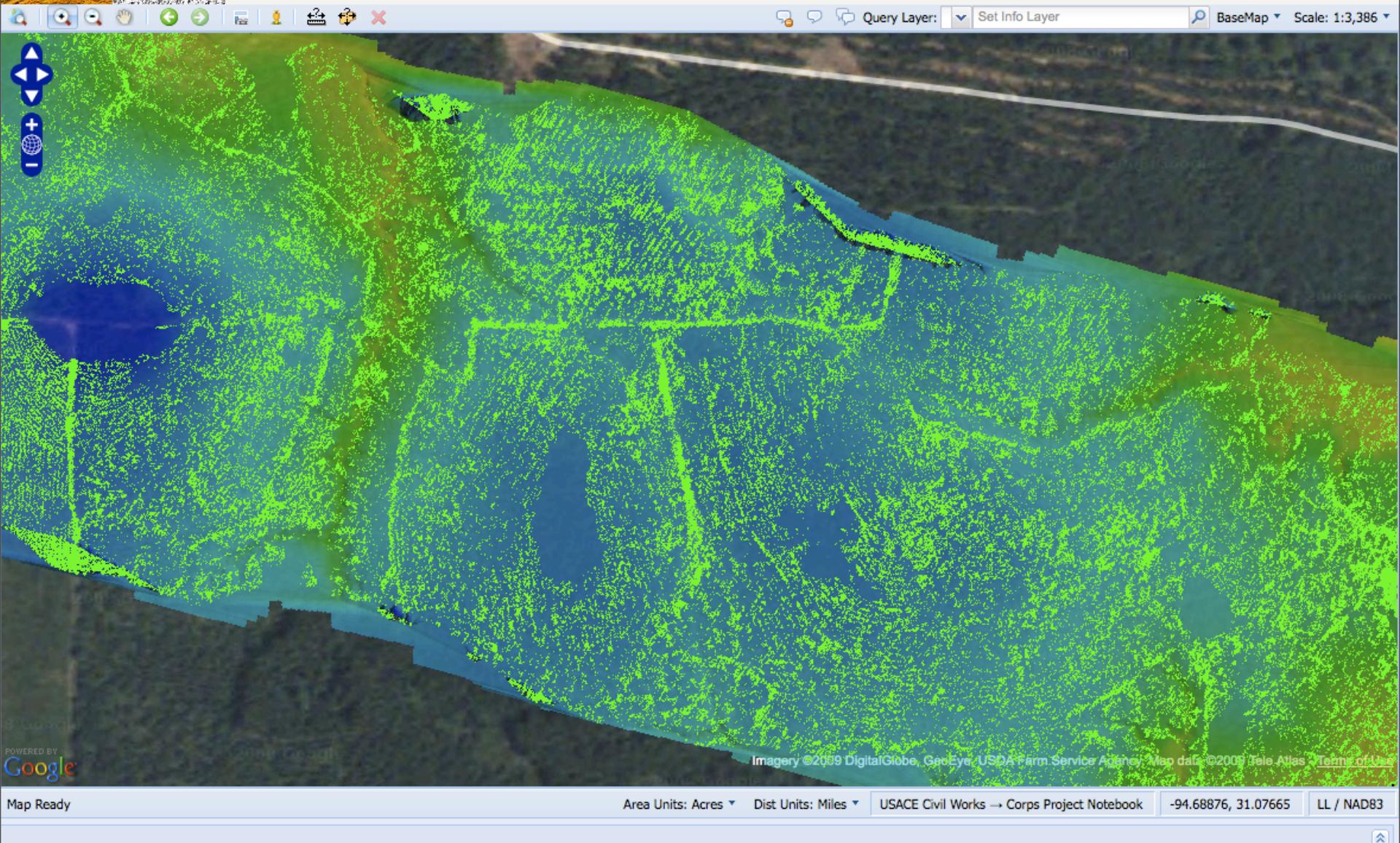
USACE Civil Works → Corps Project Notebook

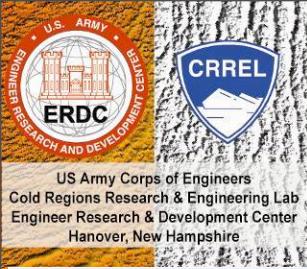
-94.68574, 31.07685

LL / NAD83



Bare Earth & DEM





DEM Generated from LAS file

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Layers

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