Elevation and LiDAR Activities at NRCan

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Overview

- National Elevation Project
- LiDAR Acquisition Guidelines
- Geohash Table

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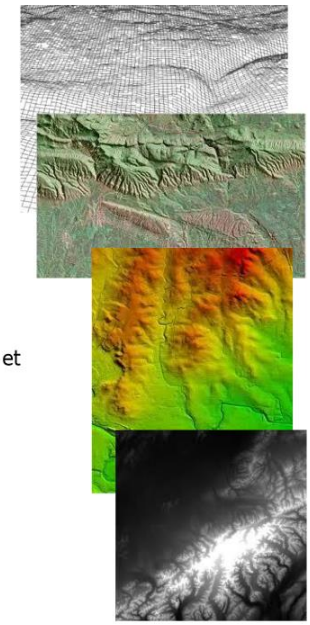
National Elevation Project
Projet d'altimétrie nationale

- Why / pourquoi?
  - Most popular geospatial data theme / Le plus populaire
  - Limited data and products / Solution courante limitée
  - Better meet government priorities / Mieux rencontrer les besoins du gouvernement
- What / quoi?
  - Easy creation and integration of better data / Faciliter l'introduction de meilleurs données
  - Client-user driven system / Selon les désirs du clients
  - Products and services for non-experts / Prises de décision et politiques
  - Open system to facilitate contributions and utilisations / Ouvert à la communauté
- How / comment?
  - Environmental Scan / Revue de l'environnement
  - User Liaison / Échange avec les utilisateurs
  - System prototyping and implementation / Prototypage et implantation
  - Yearly incremental implementation / incrément annuel



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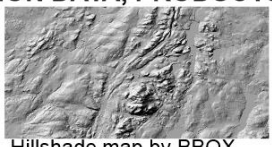
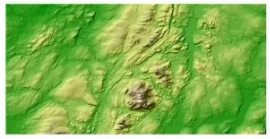
SUITE OF ELEVATION DATA, PRODUCTS AND SERVICES

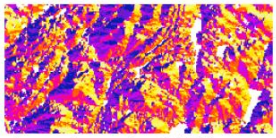
Color map by BBOX



Hillshade map by BBOX

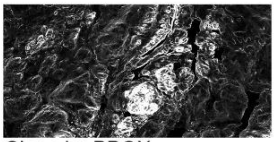


Color hillshade map by BBOX

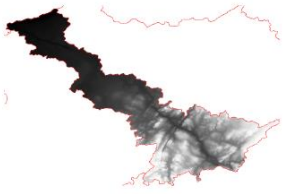


Aspect map by BBOX

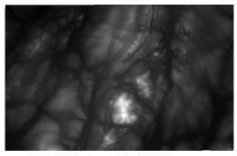
Extraction web service interface



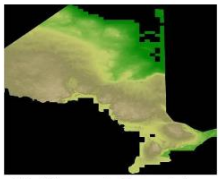
Slope by BBOX



DEM by watershed



DEM by BBOX



Multi-resolution data

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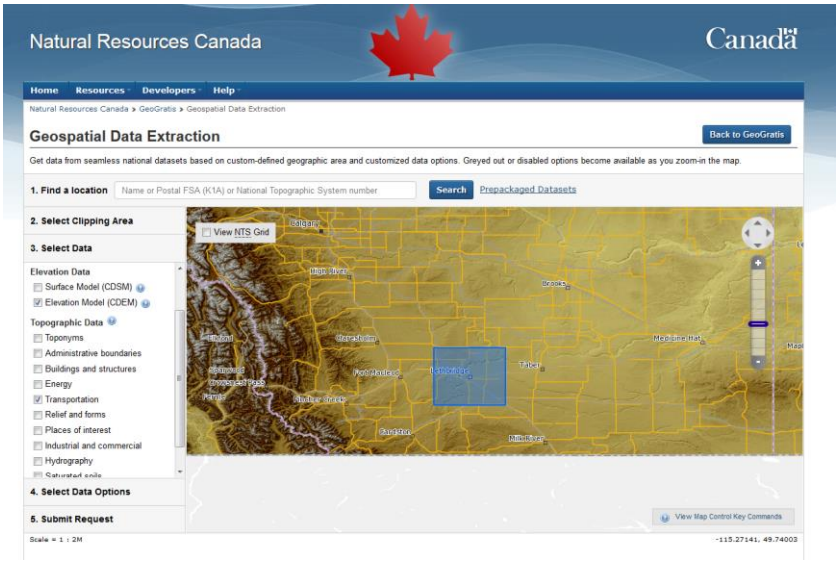
Demo: http://geogratis.gc.ca/site/extraction/



Major Ongoing Tasks

1. **System of National Elevation integrated to the MIB Integrated System:** Environment to allow input, storage, edition, and to better serve elevation data in order to facilitate their use in decision making

2. **Point Cloud (LiDAR and other):** Capacity for the management and exploitation of very large volume point cloud type data. This innovative component of the project is based on an open architecture

Canadian Airborne LiDAR Acquisition Guidelines

Canadian Airborne LiDAR Acquisition Guidelines

- Objectives
  - Create a standard for the National Elevation System
  - Support planning and management of LiDAR acquisitions within canada, for all levels of government and the private sector
  - Support the creation of a National Master Standing Offer (NMSO) for LiDAR acquisitions

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History

- Summer 2012 – First Draft
  - Significant expression of interest and feedback
  - Smaller group of respondents with substantial feedback
- Major feedback themes
  - Clarity from the perspective of users
    - Requirements / Accuracy / Reporting / Formats
  - Clarity from the perspective of providers
    - Expectations / Accuracy / Reporting / Formats
  - Who has which roles & responsibilities??
- Summer 2013 – Second Draft

(elevation@nrcan-rncan.gc.ca)

2nd Draft

- There are a lot of different viewpoints even within 'camps' in this field.
- To create the best, first official guidelines document, we'd like the 2nd round of feedback to focus on those issues that had a higher diversity of opinions the first time.
- Although we welcome questions now, the intention here is to focus the conversation for formal feedback with the 2nd draft.

Sectional Breakdown

- Project Planning and Contracting
- General LiDAR Survey
- LiDAR Point Cloud
- LiDAR Derivative Data
- Data Supply
- Project Planning and Reporting
- Quality Assurance

General LiDAR Survey Guidelines

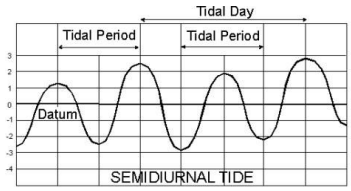
- 3.2 Environmental Conditions
  - **Snow/Cloud/Fog/Smoke Free**
  - **Leaf-on / Leaf-off**
    - Based on overall response leaf-off is currently stipulated as the 'default' requirement. Naturally this can be matched to the requirements of the client.
    - One concern is that for clients who have interest in sharing their data, a leaf-off acquisition may limit the applications for other users, we welcome feedback on this.

General LiDAR Survey Guidelines

- 3.2 Environmental Conditions
  - **Coastal Applications & Low Tide**

In coastal applications data must be collected within 2 hours either side of low tide unless otherwise stipulated.

- Some respondents indicated interest in clarifying for areas with semi-diurnal tides and incorporating that into the specification



General LiDAR Survey Guidelines

- 3.3 Nominal Pulse Spacing (NPS)
  - One of the most contentious specifications
  - 3 NPS are defined
    - Low 1 pulse / 2 m^2
    - Standard 1 pulse / 1 m^2
    - High 2 pulse / 1 m^2

General LiDAR Survey Specifications

- 3.4 Data Voids & 3.5 Flight Lines
  - 3.8 Scan Angle
  - 3.12 Spatial Accuracy Requirements

  - Data Voids (areas => 4 x NPS2), are not acceptable, except:
    - a. Where caused by water bodies.
    - b. Where caused by areas of low near infra-red (NIR) reflectivity such asphalt or composition roofing.
    - c. Where caused by object shadowing (i.e. buildings etc) unless previously stipulated that shadowed areas must be collected with subsequent flight lines

  - Flight line overlap must be 10% or greater, as required to ensure there are no data gaps between the usable portions of the swaths.

General LiDAR Survey Guidelines

- 3.12 Spatial Accuracy Requirements
  - Fundamental Vertical Accuracy
    - <= 30cm, 95% confidence interval (1.96 x RMSE)
  - Fundamental Horizontal Accuracy
    - <= 80cm, 95% confidence interval (1.96 x RMSE)

  - Supplemental Vertical Accuracy and Consolidated Vertical Accuracy may also be requested, using following accuracies
  - Supplemental Vertical Accuracy
    - <= 60cm, 95% confidence interval (1.96 x RMSE)
  - Consolidated Vertical Accuracy
    - <= 50cm, 95% confidence interval (1.96 x RMSE)

General LiDAR Survey Guidelines

- 3.14 Data Ownership Model
  - The standard model for LiDAR projects is for the client to obtain full ownership of the LiDAR point clouds and derived data products, although other possibilities exist. The Canadian federal government is committed to an open data policy and strongly encourages LiDAR acquisition belonging to ownership model A

Ownership Model	
A	Ownership of LiDAR data transferred to Client including right to redistribute or place in public domain
B	Ownership of LiDARdata transferred to Client without right to redistribute or place in public domain.
C	Ownership of LiDAR data remains with provider, including the right to redistribute or place in the public domain

LiDAR Point Clouds

- **Point Cloud Classification**

Class	#	Point class	Description
0	Unclassified		Created, never classified
1	Default		Unclassified (last and only return)
2	Ground		Bare ground (last and only return)
3	Low vegetation		0 – 0.3m (essentially sensor 'noise')
4	Medium vegetation		0.3 – 2m
5	High vegetation		2m >
6	Buildings, structures		Buildings, houses, sheds, silos etc. (all returns)
7	Low / high points		Spurious high/low points (unusable)
8	Model key points		Reserved for 'model key points' only
9	Water		Any point in water
10	Bridge		Any bridge or overpass
11	Withheld		*(used if processing software does not permit withheld flag)*
12	Overlap points		*(Discouraged)* Flight line overlap points
13-31	not used		Reserved for future definition

Lidar Point Clouds

Level 0 – No Classification

Considered below minimum required

- **Point Cloud Classification**

Class	#	Point class	Description
0	Unclassified		Created, never classified
1	Default		Unclassified (last and only return)
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13-31	not used		Reserved for future definition

LiDAR Point Clouds

Level 1 – Ground / Non-Ground

Considered bare minimum level of classification

- **Point Cloud Classification**

Class	#	Point class	Description
0	Unclassified		Created, never classified
1	Default		Unclassified (last and only return)
2	Ground		Bare ground (last and only return)
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13-31	not used		Reserved for future definition

LiDAR Point Clouds

Level 2 – Standard

Standard level of classification

- **Point Cloud Classification**

Class	# Point class	Description
0	Unclassified	Created, never classified
1	Default	Unclassified (last and only return)
2	Ground	Bare ground (last and only return)
3	Low vegetation	0 – 0.3m (essentially sensor 'noise')
4	Medium vegetation	0.3 – 2m
5	High vegetation	2m >
6	Buildings, structures	Buildings, houses, sheds, silos etc. (all returns)
7	Low / high points	Spurious high/low points (unusable)
8	Model key points	Reserved for 'model key points' only
9	Water	Any point in water
10	Bridge	Any bridge or overpass
11	Withheld	*(used if processing software does not permit withheld flag)*
12	Overlap points	*(Discouraged)* Flight line overlap points
13-31	not used	Reserved for future definition

Data Supply Specifications

- 6.3 Metadata
  - Metadata is to be provided for all data products, interim and final, compliant with ISO 19115 or ISO 19115-2 as applicable.
  - One metadata file per tiled product
  - Non-mandatory metadata fields which are adequately described in project reports or through other ancillary reports can be omitted, but the metadata should reference these reports
  - All constraint information for the ISO standards should be considered mandatory.
  - If applicable, the data ownership model and the fact that these guidelines were used should be noted in the 'userNote' field.

Project Planning and Reporting Specifications

- Expected plans and reports
  - Project Plan
  - Pre-Survey Quality Assurance Plan
  - Post-Survey Spatial Accuracy Report
  - Flight Trajectories
  - Progress Reports (if desired)
  - Project Report

GeoHash Tree and LiDAR Spatial Architecture

GeoHash Tree

- GeoHash Tree is one element of a file format system that will be used in the National Elevation Framework and is being investigated for use by other Canadian organization and other governmental organizations as well
- It's actually part of a system of elements for working with point cloud data. Amongst our technical staff it's collectively known as:
  - open source LiDAR developments: PDAL, PostgreSQL, PostGIS, PointCloud and libGHT

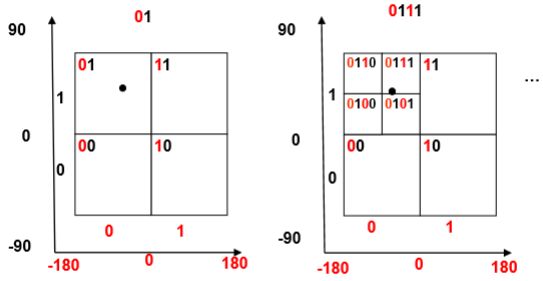
Conventional LiDAR Data Storage

- LAS, CSV, LAZ, etc - Existing formats suitable for storage, but less suitable for data management
  - Example with LAS file format
    - Fixed Attribute Format
    - No random access (native format)
- Database based solution
  - Single point approach:
    - Each single point is stored individually
    - Points should be indexed, but the size of the index can exceed the size of data
  - Multipoint approach
    - A set of points are grouped together
    - Need double indexing: indexing blocks in each table and indexing each point in each block
- So existing solutions are very limited

GeoHashTree (GHT)

- GeoHashTree is a global, hierarchical, variable-sized cell structure
- GeoHashTree allows the transformation of point clouds into a hierarchical data structure enriched with many statistics
- GeoHashTree can manage multi-resolution elevation data allowing to considerably minimise the amount of data storage
- GeoHashTree allows to facilitate the extraction, processing, updating and improvement of elevation data

GeoHashTree (GeoHash creation)



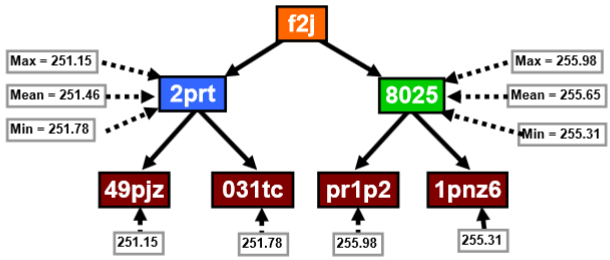
Result in binary: 01110000100010101100010111

In decimal:
01110-00010-00101- 01100-10111 = 14-2-5-12-23

In characters
using the conversion table:
14-2-5-12-23 = f25dr

Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Base 32	0	1	2	3	4	5	6	7	8	9	b	c	d	e	f	g
Decimal	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Base 32	h	j	k	m	n	p	q	r	s	t	u	v	w	x	y	z

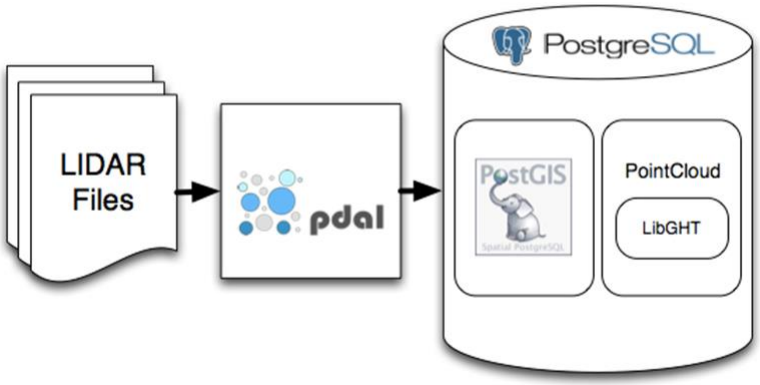
GeoHashTree
(multi-level data and statistics)

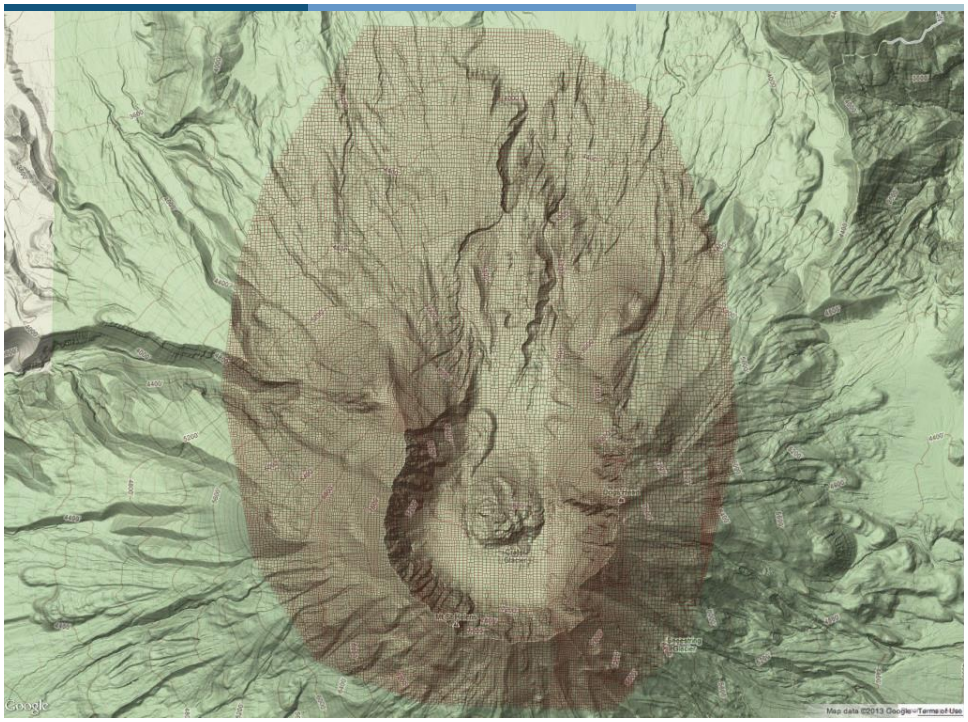


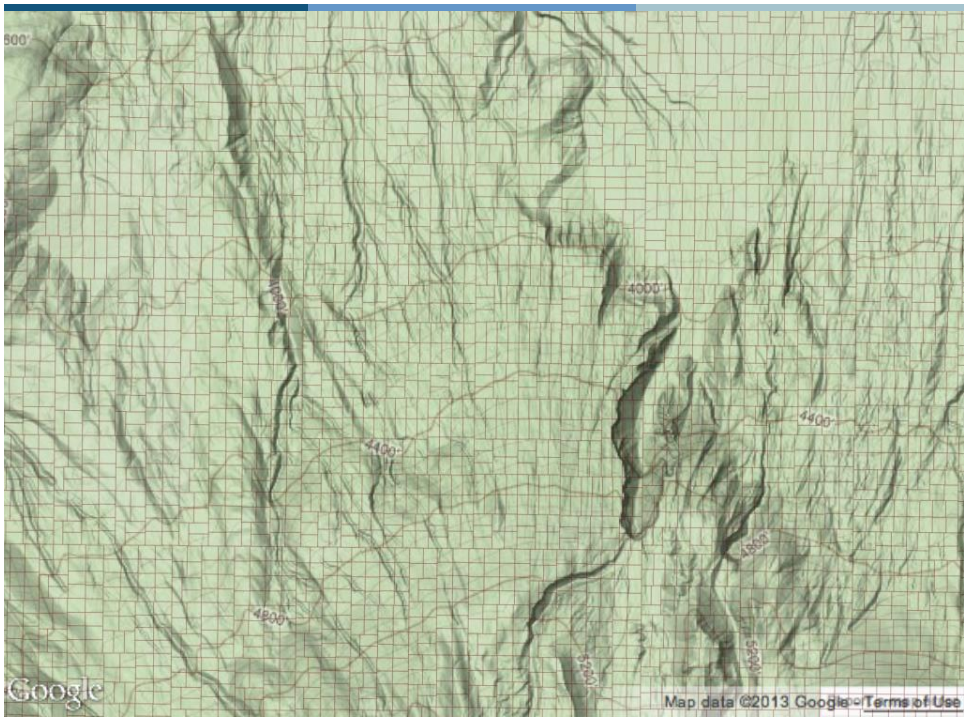
Allowing to:
- **Facilitate query an visualization**
- **Facilitate lossy compression**
- **Have multiple representation of the same data**

Point Cloud Data

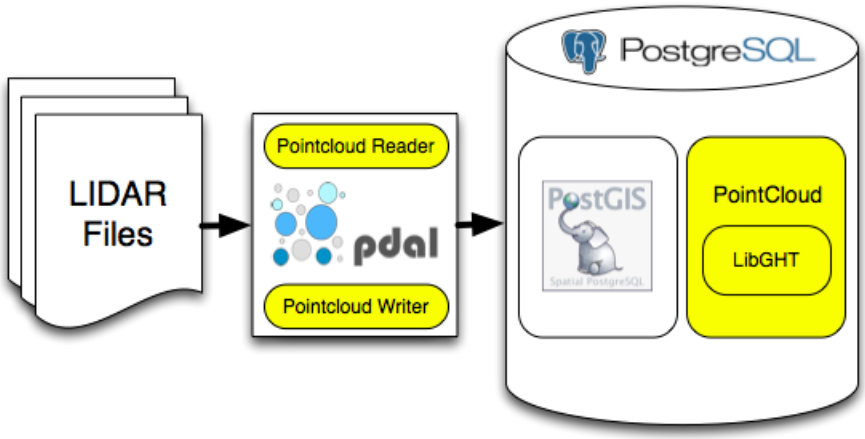
- GHT is a part of working with point cloud data




Google
Map data ©2013 Google - Terms of Use


4000'
4400'
4800'
5200'
Google
Map data ©2013 Google - Terms of Use

Point Cloud Data



Get It

- Pointcloud
  http://github.com/pramsey/pointcloud
- PDAL
  http://github.com/PDAL/PDAL

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Contact Information

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- Darren Janzen: Lead – Lidar Acquisition Guidelines
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- David Bélanger: Lead – GHT
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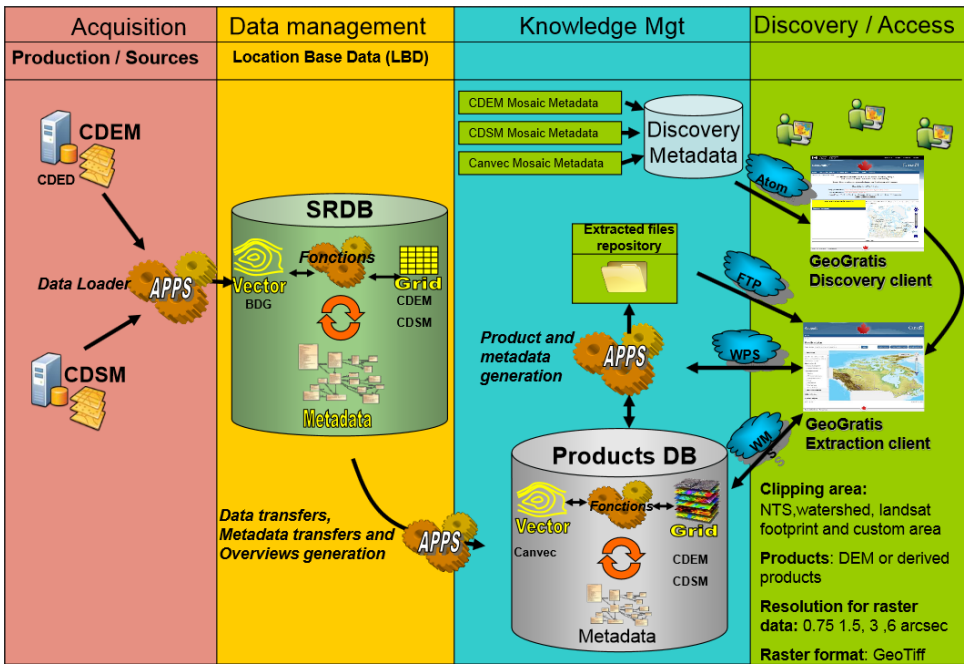

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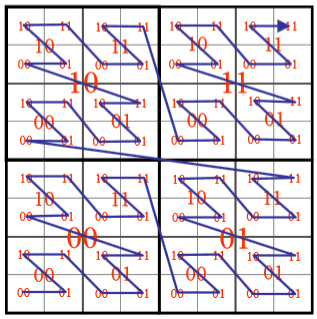
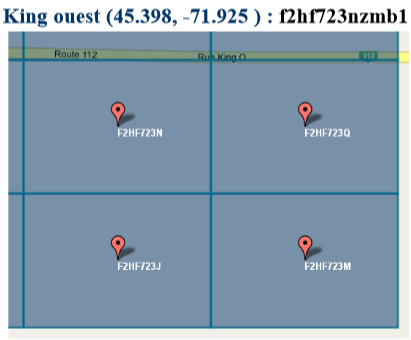
GeoHash: proximity

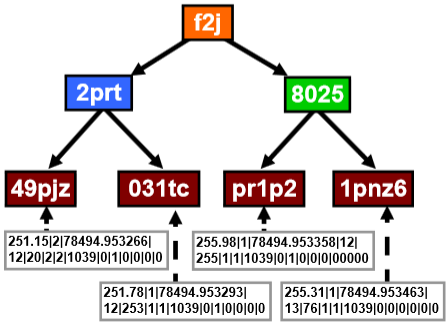
- GeoHash is a kind of Z-order (Morton order)
- The Z-order is a curve that allows mapping between multidimensional and one-dimensional data



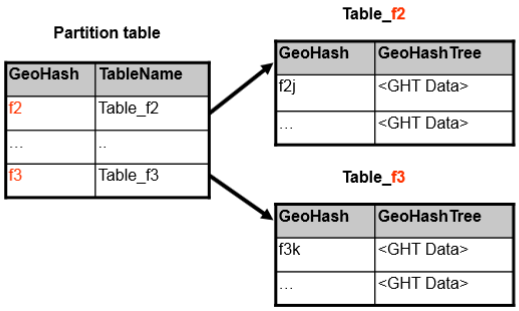


GeoHashTree (structuration)

GeoHash	Z	C	T	A	I	N	R	P	E	D	U	r	g	b
f2j2prt49pjz	251.15	2	78494.953266	12	20	2	2	1039	0	1	0	0	0	0
f2j2prt031tc	251.78	1	78494.953293	12	253	1	1	1039	0	1	0	0	0	0
f2j8025pr1p2	255.98	1	78494.953358	13	255	1	1	1039	0	0	0	0	0	0
f2j80251pnz6	255.31	1	78494.953463	13	76	1	1	1039	0	0	0	0	0	0



GeoHashTree (storage)



GeoHashTree PROTOTYPE : Preliminary results

Initial LAS: 570 MB
In the database: 321 MB (lossless)
GHT creation: 4 minutes

SELECT X,Y,Z INCLUDED IN a big area and create a CSV file			SELECT X,Y,Z INCLUDED IN a small area and create a CSV file		
Condition	Number of points	Processing Time (sec)	Condition	Number of points	Processing Time (sec)
All	21 364 937	73	All	580 150	2.1
R = 2 (*)	617 214	17	R = 2	5 079	0.4
Z >= 309	1072	20	Z >= 309	2	0.3

(*) The same operation using LAS is about 32 seconds