Create Uber-Fast Maps with 23ai Vector Tiles and H3 Indexing

Jim Czuprynski
Chief StoryTeller
Zero Defect Computing, Inc.

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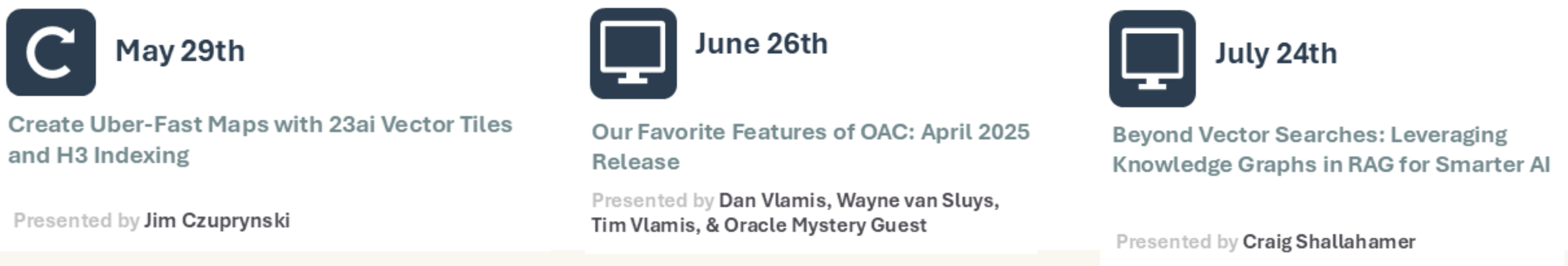

May 29th

Create Uber-Fast Maps with 23ai Vector Tiles and H3 Indexing

Presented by **Jim Czuprynski**

June 26th

Our Favorite Features of OAC: April 2025 Release

Presented by **Dan Vlamis, Wayne van Sluys, Tim Vlamis, & Oracle Mystery Guest**

July 24th

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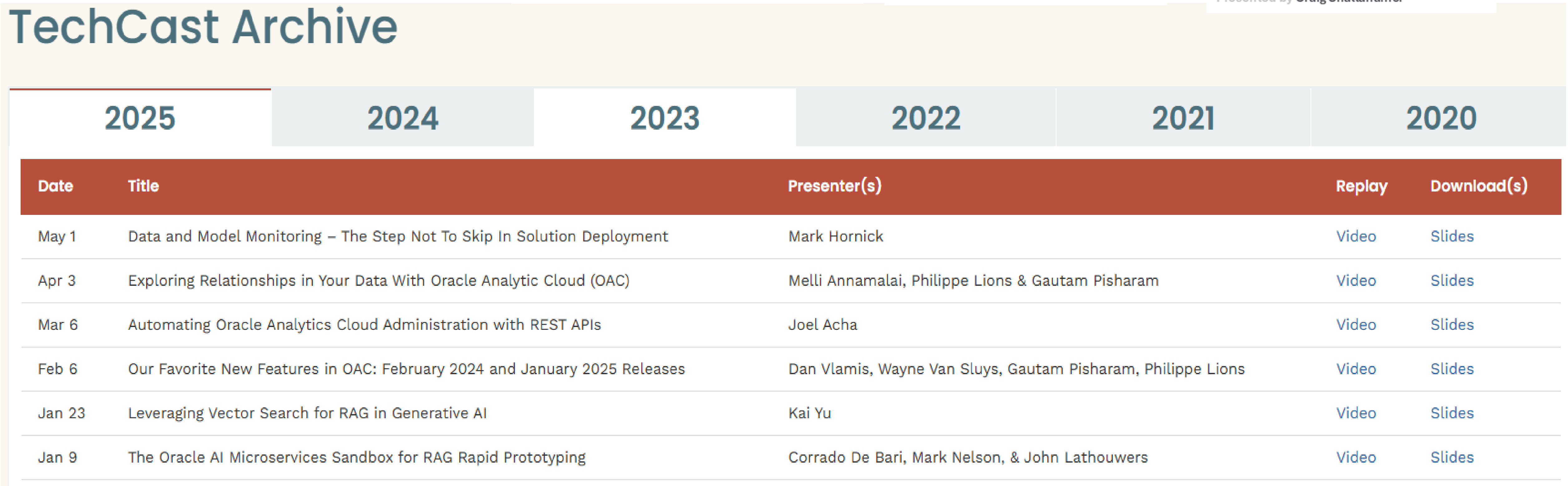
Presented by **Craig Shallahamer**



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- ➢E-mail me at jim@jimthewhyguy.com
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“There Is No Planet B”: Shifting Priorities …

Wind and Solar Overtake Coal Power for First Time in U.S.

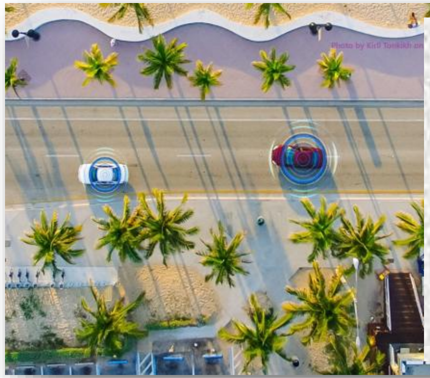
- *Wall Street Journal*, 13 March 2025

Overall, the U.S. installed 50 gigawatts of new solar capacity in 2024. … Wind and solar ***have overtaken coal in 24 states***, according to Ember, with Illinois the latest to join the ranks in 2024, following Arizona, Colorado, Florida and Maryland in 2023.

California now has 48% more EV chargers than gasoline nozzles in the state

- *State of California*, 20 March 2025

In a significant milestone for the state, California now has ***48% more public and shared private EV chargers*** than the number of gasoline nozzles. The California Energy Commission (CEC) estimates there are about 120,000 gas nozzles in the state, compared to 178,000 public and shared private chargers.



Study: EV charging stations boost spending at nearby businesses

- *MIT News*, 4 September 2024

“The positive impacts of EV charging stations on businesses ***are not constrained solely to some high-income neighborhoods***,” Wang says. “It highlights the importance for policymakers to develop EV charging stations in marginalized areas, because they not only foster a cleaner environment, but also serve as a catalyst for enhancing economic vitality.”

Business Case: Where Do We Locate All These Resources?

Solar, wind, and **nuclear** power generation strategies offer **wildly divergent** capabilities

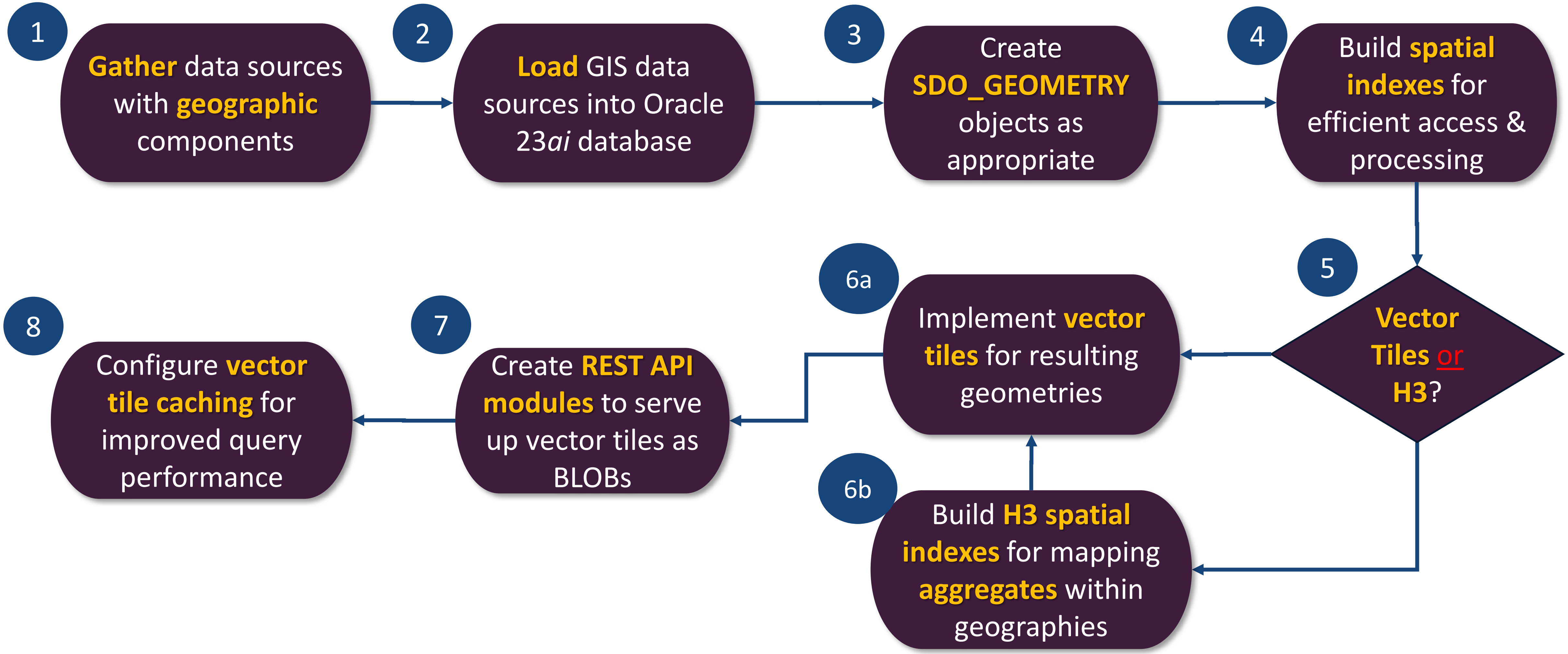
Current and future alternative energy production sites are **unevenly distributed** across the USA

Solar and **wind** are **weather-dependent** … so reliable **battery storage systems** to capture excess power should be centrally-located

Storage systems should be built near **existing and future electrical grid access points** to minimize power loss over long distances

Photo by Roger Starnes Sr on Unsplash

Steps for Implementing Vector Tiles and H3 Indexing



1 **Gather** data sources with **geographic** components

2 **Load** GIS data sources into Oracle 23*ai* database

3 Create **SDO_GEOMETRY** objects as appropriate

4 Build **spatial indexes** for efficient access & processing

5 **Vector Tiles** or **H3**?

6a Implement **vector tiles** for resulting geometries

6b Build **H3 spatial indexes** for mapping **aggregates** within geographies

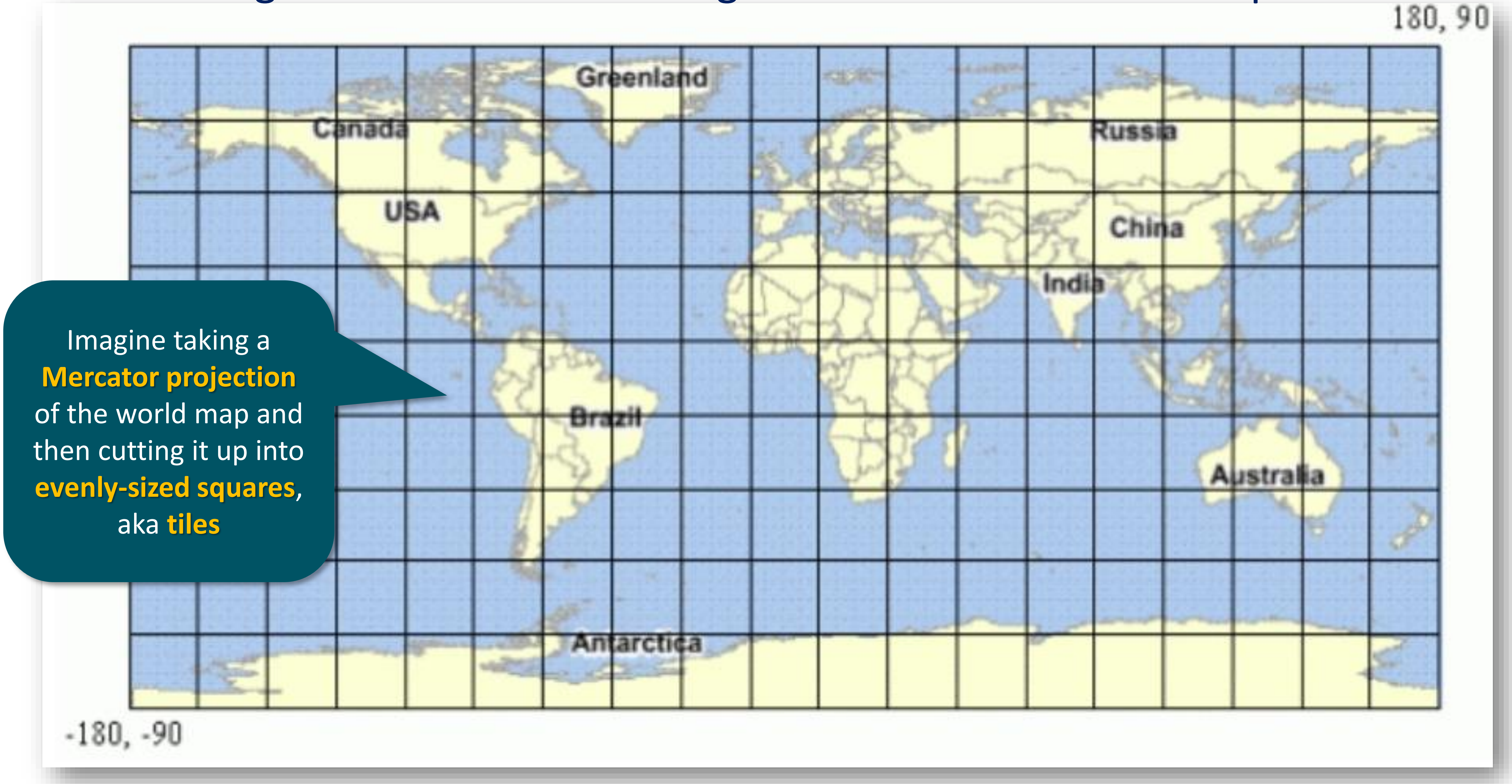
7 Create **REST API modules** to serve up vector tiles as BLOBs

8 Configure **vector tile caching** for improved query performance

Vector Tiles

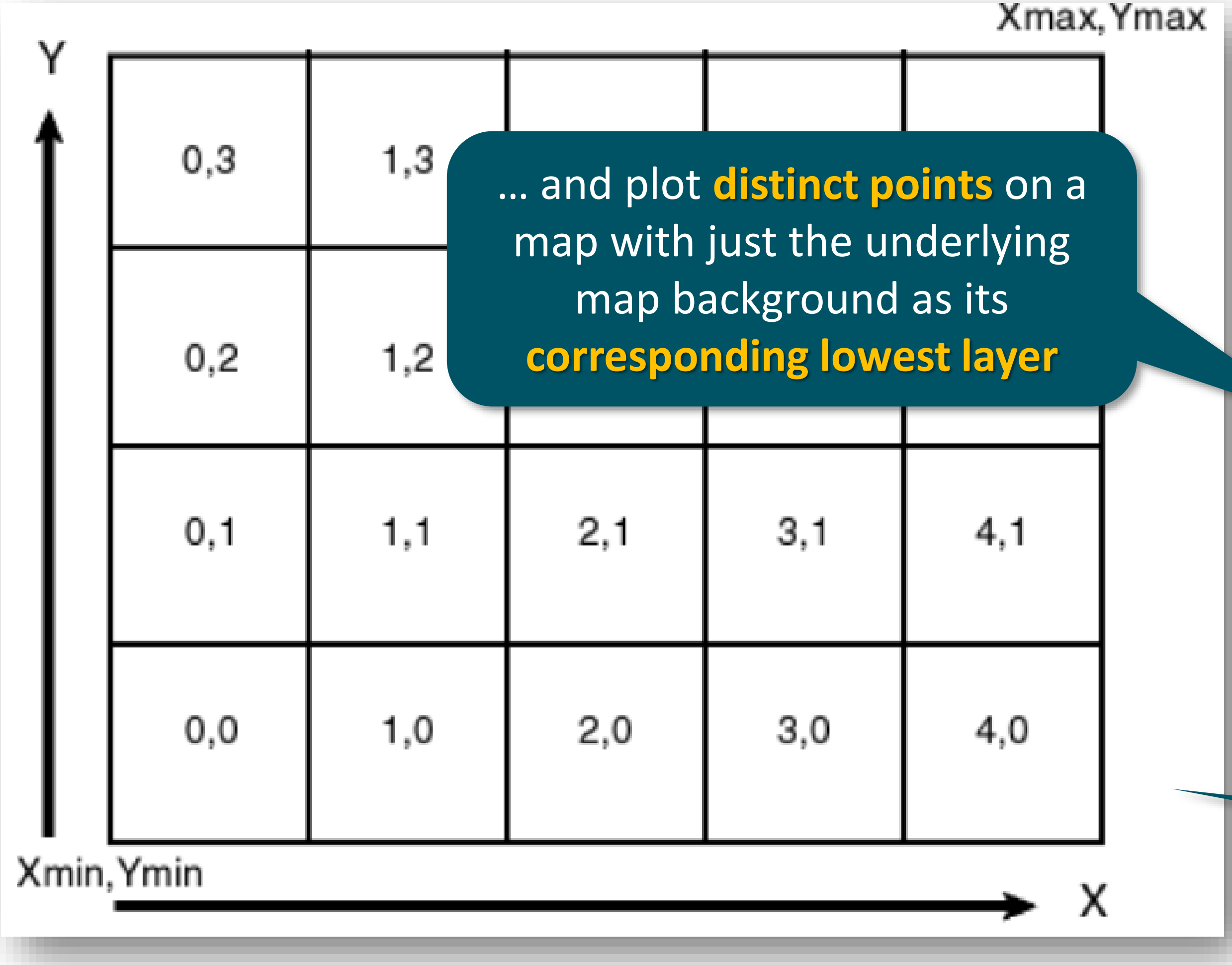
Photo by Brandon Griggs

Understanding Vector Tiles: Visualizing a Series of Ever-Smaller Squares

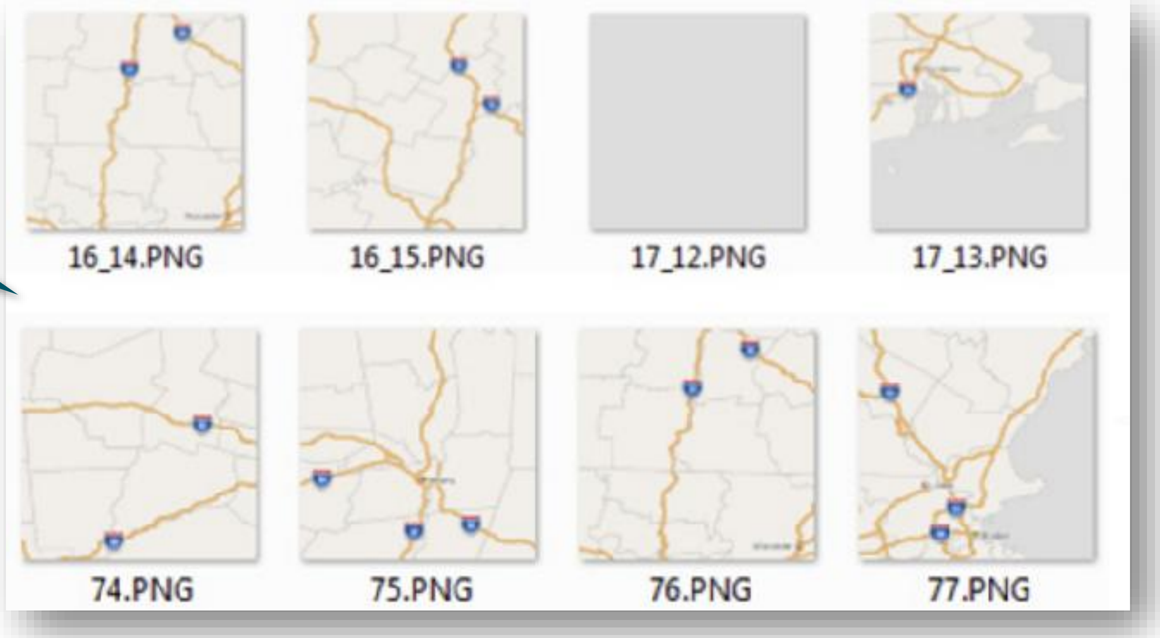


Imagine taking a **Mercator projection** of the world map and then cutting it up into **evenly-sized squares**, aka **tiles**

Understanding Vector Tiles: Visualizing a Series of Ever-Smaller Squares

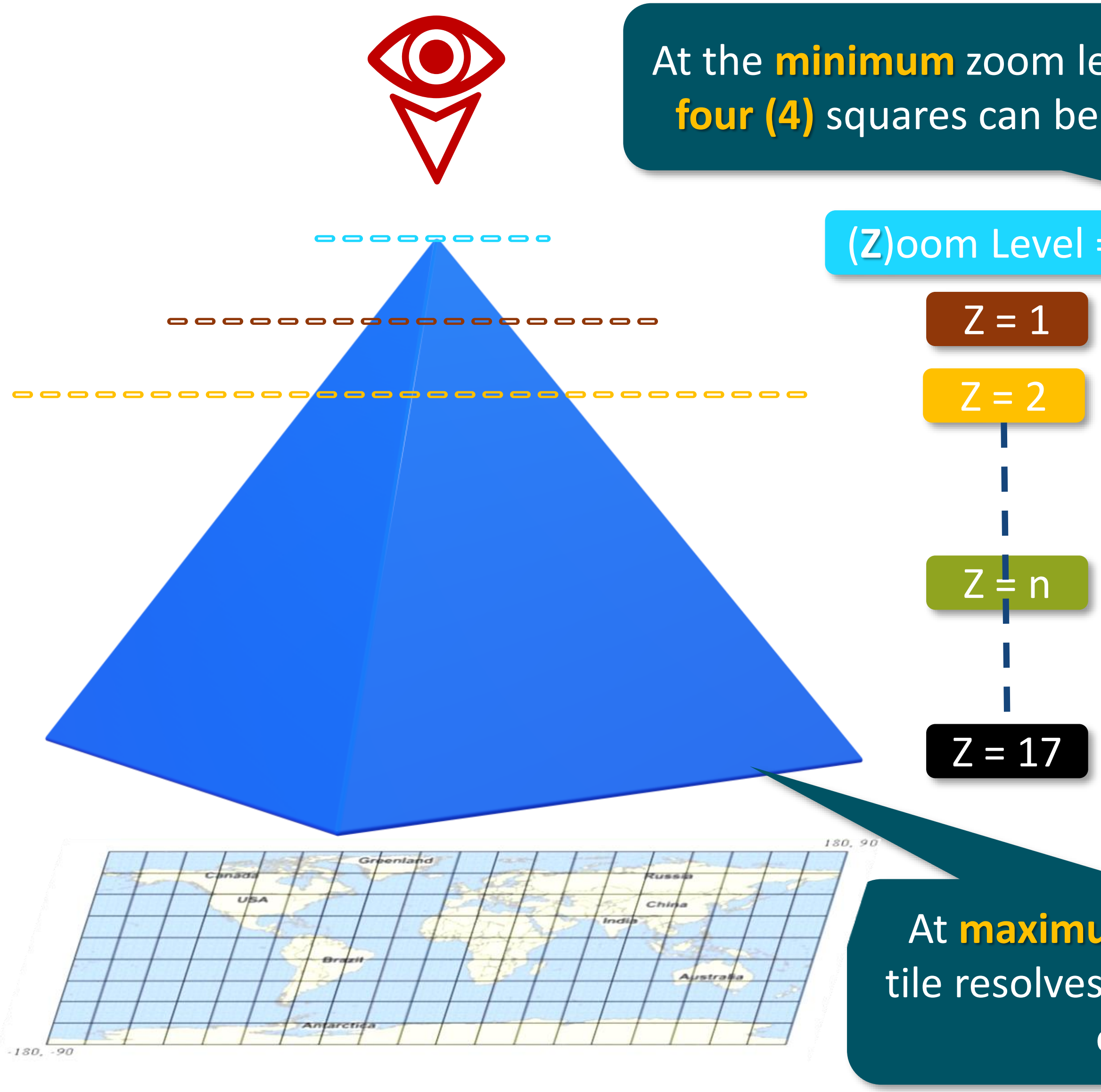


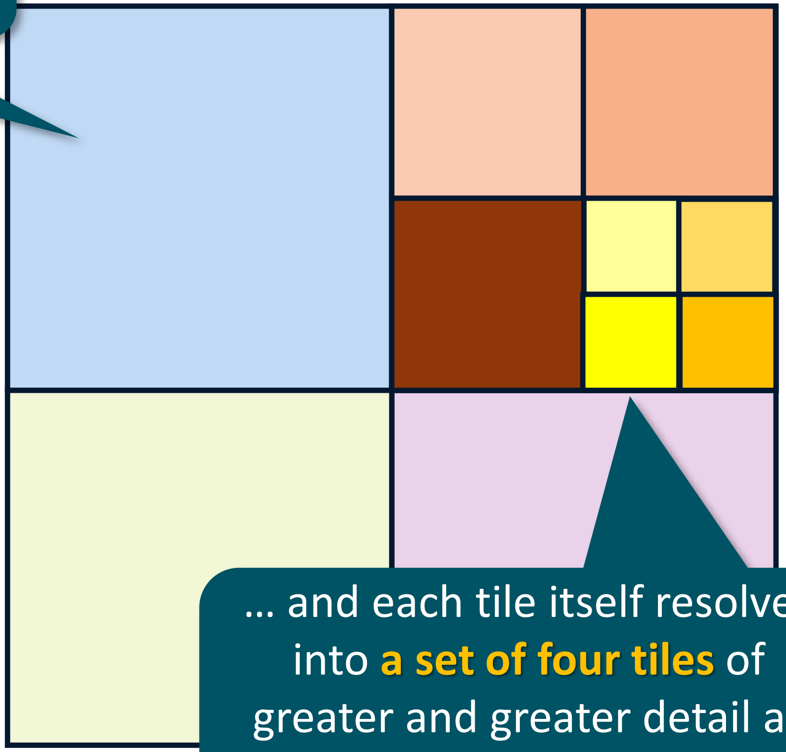
… and plot **distinct points** on a map with just the underlying map background as its **corresponding lowest layer**



We can then reference ***any place*** in the world by its tile's **{X,Y} pair** …

Understanding Vector Tiles: Visualizing a Series of Ever-Smaller Squares





At the **minimum** zoom level, precisely **four (4)** squares can be observed …

… and each tile itself resolves into **a set of four tiles** of greater and greater detail as each zoom level is **traversed**

At **maximum** zoom level, each tile resolves to **just a few meters** on a side!

Handling Vector Tiles: SDO_UTIL Functions and Procedures

Procedure or Function	Purpose
GET_VECTORTILE	Generates a BLOB that represents a **Mapbox Vector Tile** (MVT)
GET_TILE_ENVELOPE	Converts a **tile address** back into a **tile envelope** (i.e. an SDO geometry describing a square)

Yep, it’s really that simple!
Of course, the devil is in the details **here**

GET_VECTORTILE: A Simple Example

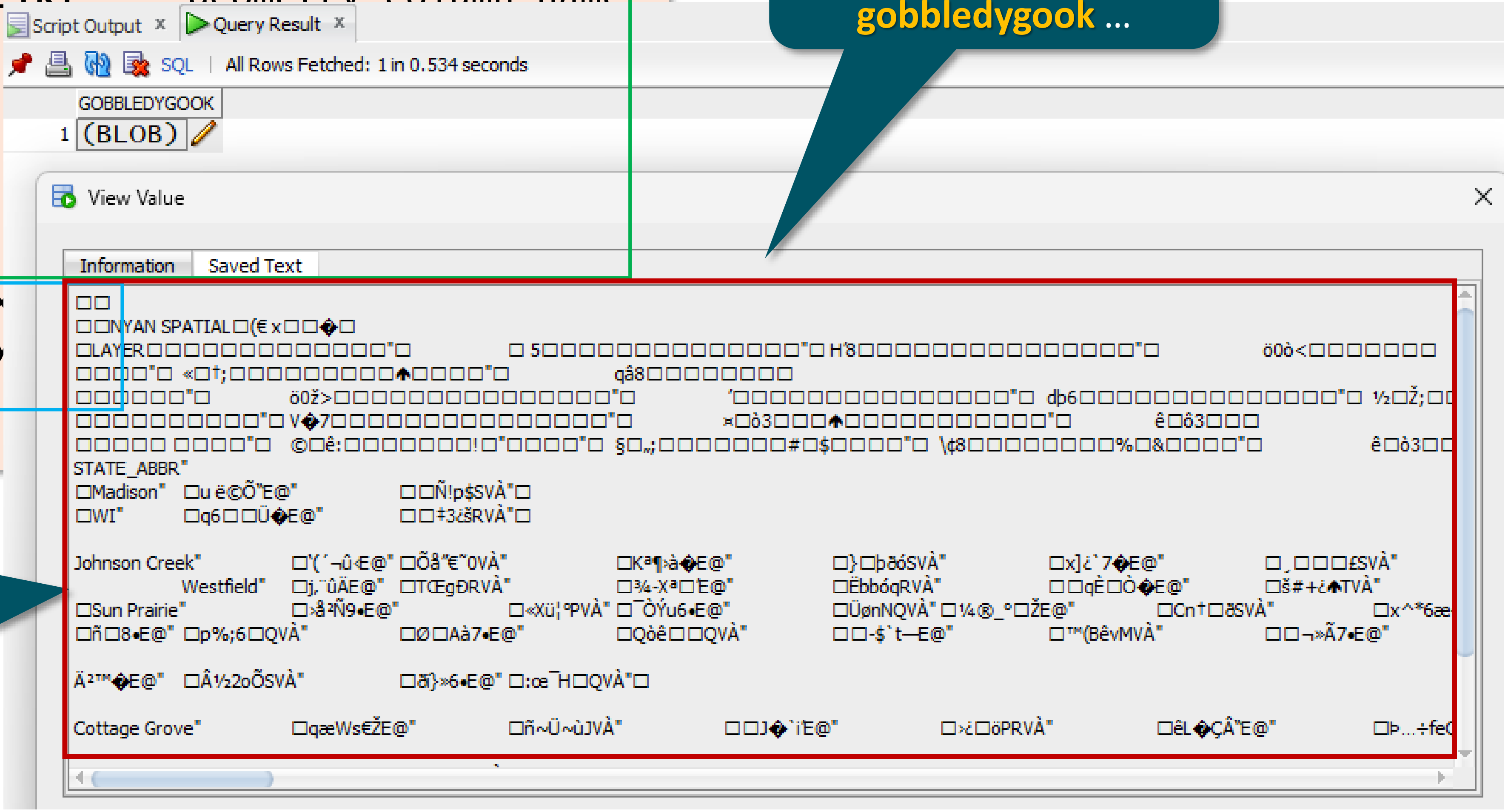
```
SELECT
  SDO_UTIL.GET_VECTORTILE(
    table_name => 'EV_CHARGING_STATIONS’ -- table name
  , geom_col_name => 'GEOMETRY’ -- geometry column name
  , att_col_names =>
    SDO_STRING_ARRAY(
      'CITY’
     ,'STATE_ABBR’
     ,'LONGITUDE’
     ,'LATITUDE’) -- other table attributes
  , tile_x => 129 -- tile x
  , tile_y => 187 -- tile y
  , tile_zoom => 9 -- tile zoom
  ) AS gobbledygook;
```

This query retrieves data from the specified table, its standard columns, and one with a datatype of **SDO_GEOMETRY** …

… but only for this **specific X:Y tile** found at this **specified (Z)oom level**

GET_VECTORTILE: A Simple Example

```
SELECT
  SDO_UTIL.GET_VECTORTILE(
    table_name => 'EV_CHARGING_STATIONS' -- table name
  , geom_col_name => 'GEOMETRY' -- geometry column name
  , att_col_names =>
    SDO_STRING_ARRAY(
      'CITY'
     ,'STATE_ABBR'
     ,'LONGITUDE'
     ,'LATITUDE') -- other
  , tile_x => 129 -- tile x
  , tile_y => 187 -- tile y
  , tile_zoom => 9 -- tile
  ) AS gobbledygook;
```



All Rows Fetched: 1 in 0.534 seconds

	GOBBLEDYGOOK
1	(BLOB)

View Value

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```

To the naked eye, these results appear as total **gobbledygook** ...

... but to a compatible ***mapping tool***, this is a rich source of **points, polygons,** and **descriptors!**

GET_VECTORTILE: Filtering Data Before Tile Creation

```
SELECT
   SDO_UTIL.GET_VECTORTILE(
     table_name => 'EXISTING_PV_SITES'
    ,geom_col_name => 'GEOMETRY'
    ,tile_zoom => 9
    ,tile_x => 129
    ,tile_y => 187
    ,att_col_names => SDO_STRING_ARRAY(
        'USGS_CASE_ID', 'COUNTY', 'STATE_ABBR'
       ,'PV_ARRAY_AREA', 'LONGITUDE', 'LATITUDE')
    ,simple_predicate => SDO_STRING_ARRAY('STATE_ABBR', '=', 'WI')
    ) AS vector_tile
  FROM DUAL;
```

This points to a **single specific tile** at a known zoom level …

… and you can also use simple WHERE clause selection criteria to **limit retrieval of specific data** within that vector tile

Using GET_TILE_ENVELOPE With GET_VECTORTILE

```
SELECT
   SDO_UTIL.GET_VECTORTILE(
     CURSOR(
       WITH cur_tile_envelope(y) AS
         (SELECT SDO_UTIL.GET_TILE_ENVELOPE(tile_zoom => 9, tile_x => 129, tile_y => 187))
       SELECT geometry, usgs_case_id, county, state_abbr, pv_array_area, longitude, latitude
         FROM
           existing_pv_sites
          ,cur_tile_envelope
        WHERE state_abbr = 'WI' AND county IN ('Dane', 'Rock', 'Iowa', 'Grant')
         AND SDO_RELATE(
               geometry, cur_tile_envelope.y
              ,'mask=anyinteract minresolution=' ||
               ((40075016.0 / POWER(2,9)) * 0.001) ||
               ' bypass_point=true') = TRUE)
    ,tile_zoom => 9, tile_x => 129, tile_y => 187, max_features=>256
    ) AS vector_tile
  FROM DUAL;
```

This retrieves **only** data within this single specific tile at its specific zoom level …

… which **SDO_RELATE** can then compare to **any other matching points** within this larger set of data

Note this calculation – it formulates the **minimum size** of the boundary square based on the vector tiles' **zoom factor**

GET_VECTORTILE and Other Spatial Functions: A Final Complex Example

```
WITH g AS (
  SELECT geometry AS g
    FROM existing_pv_sites
   WHERE usgs_case_id = 404985)
SELECT
  SDO_UTIL.GET_VECTORTILE(
    CURSOR(
      WITH x(y) AS (
        SELECT SDO_UTIL.GET_TILE_ENVELOPE(tile_zoom => 9, tile_x => 129, tile_y => 187)
        )
      SELECT
         geometry, usgs_case_id, county, state_abbr, pv_array_area, longitude, latitude
         FROM existing_pv_sites, x, g
        WHERE SDO_WITHIN_DISTANCE(geometry, g, 'distance=' || 2500) = 'TRUE'
          AND SDO_RELATE(
                  geometry, x.y
                 ,'mask=anyinteract minresolution=' ||
                   ((40075016.0 / POWER(2,9)) * 0.001) ||
                 ' bypass_point=true') = TRUE)
       ,tile_zoom => 9, tile_x => 129, tile_y => 187
      ) AS vector_tile
  FROM DUAL;
```

This query compares whether this **single PV array site** …

… exists within a distance of **2500 meters** of the boundary of another larger geographic area

Demo: Leveraging Vector Tiles

Photo by Simon L @ Unsplash

Accessing Vector Tiles Via ORDS REST APIs

```
BEGIN
  ORDS.DEFINE_MODULE(
    P_MODULE_NAME => 'ev_chargers'
  , P_BASE_PATH => '/existing_chargers/'
  , P_ITEMS_PER_PAGE => 50
  , P_STATUS => 'PUBLISHED');
  COMMIT;
END;
/

BEGIN
  ORDS.DEFINE_TEMPLATE(
    P_MODULE_NAME => 'ev_chargers'
  , P_PATTERN => 'vt/:z/:x/:y'
  , P_PRIORITY => 0
  , P_ETAG_TYPE => 'HASH');
  COMMIT;
END;
/
```

First, create the **ORDS REST API module** and **template** …

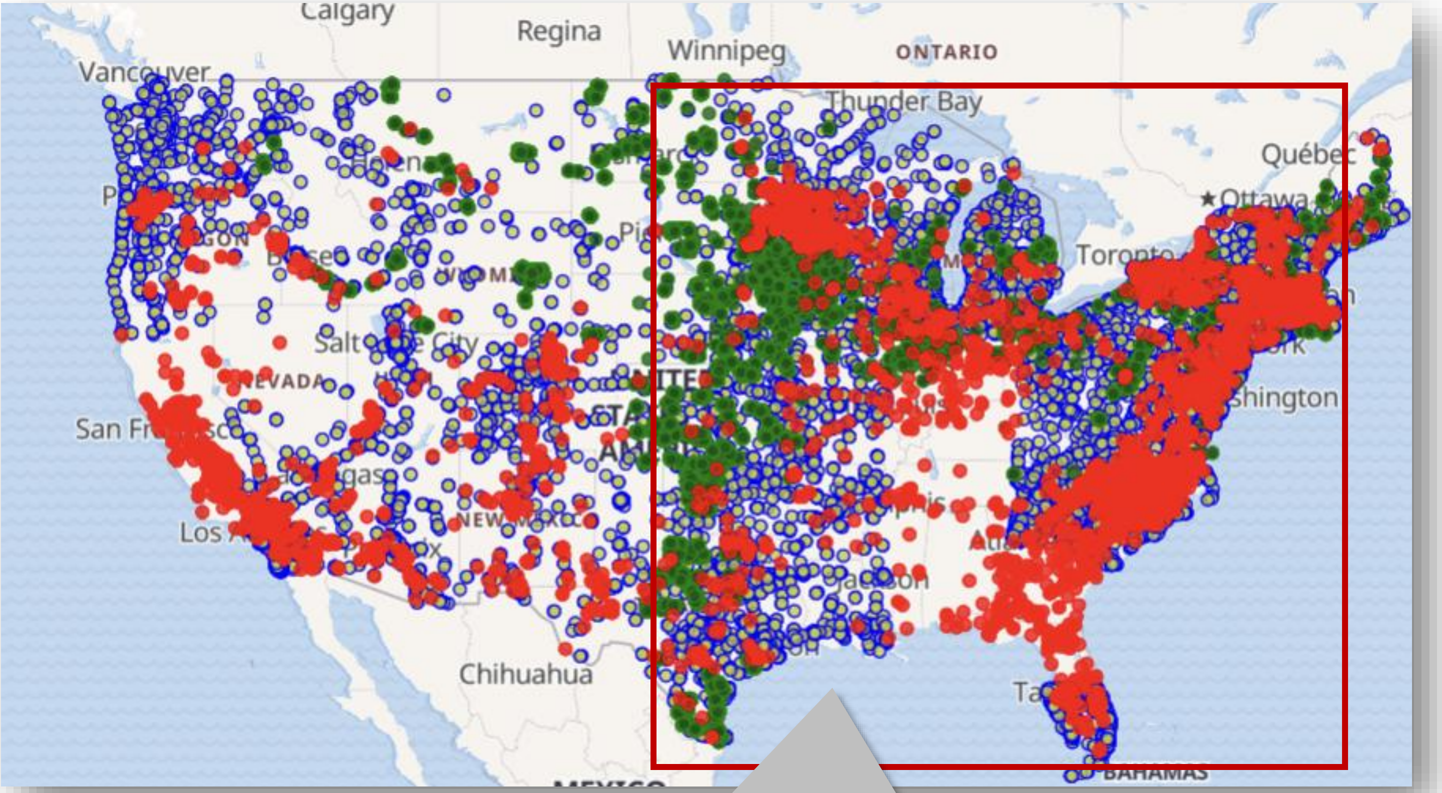
Accessing Vector Tiles Via ORDS REST APIs

```
BEGIN
  ORDS.DEFINE_HANDLER(
    P_MODULE_NAME => 'ev_chargers'
  , P_PATTERN => 'vt/:z/:x/:y'
  , P_METHOD => 'GET'
  , P_SOURCE_TYPE => ORDS.SOURCE_TYPE_MEDIA
  , P_SOURCE => 'SELECT ''application/vnd.mapbox-vector-tile'' AS mediatype
       ,SDO_UTIL.GET_VECTORTILE(
         TABLE_NAME => ''EV_CHARGING_STATIONS''
        ,GEOM_COL_NAME => ''GEOMETRY''
        ,ATT_COL_NAMES => SDO_STRING_ARRAY(''ADDRESS'',''CITY'',''STATE_ABBR‘’
           ,''EV_LEVEL_1'',''EV_LEVEL_2'',''EV_LEVEL_3'',''LATITUDE'',''LONGITUDE'')
        ,TILE_X => :x
        ,TILE_Y_PBF => :y
        ,TILE_ZOOM => :z) AS vtile
      FROM DUAL'
  , P_ITEMS_PER_PAGE => 50);
  COMMIT;
END;
/
```

This tells ORDS to output the result as a defines the output as a BLOB containing **vector tiles** instead of text or other formats

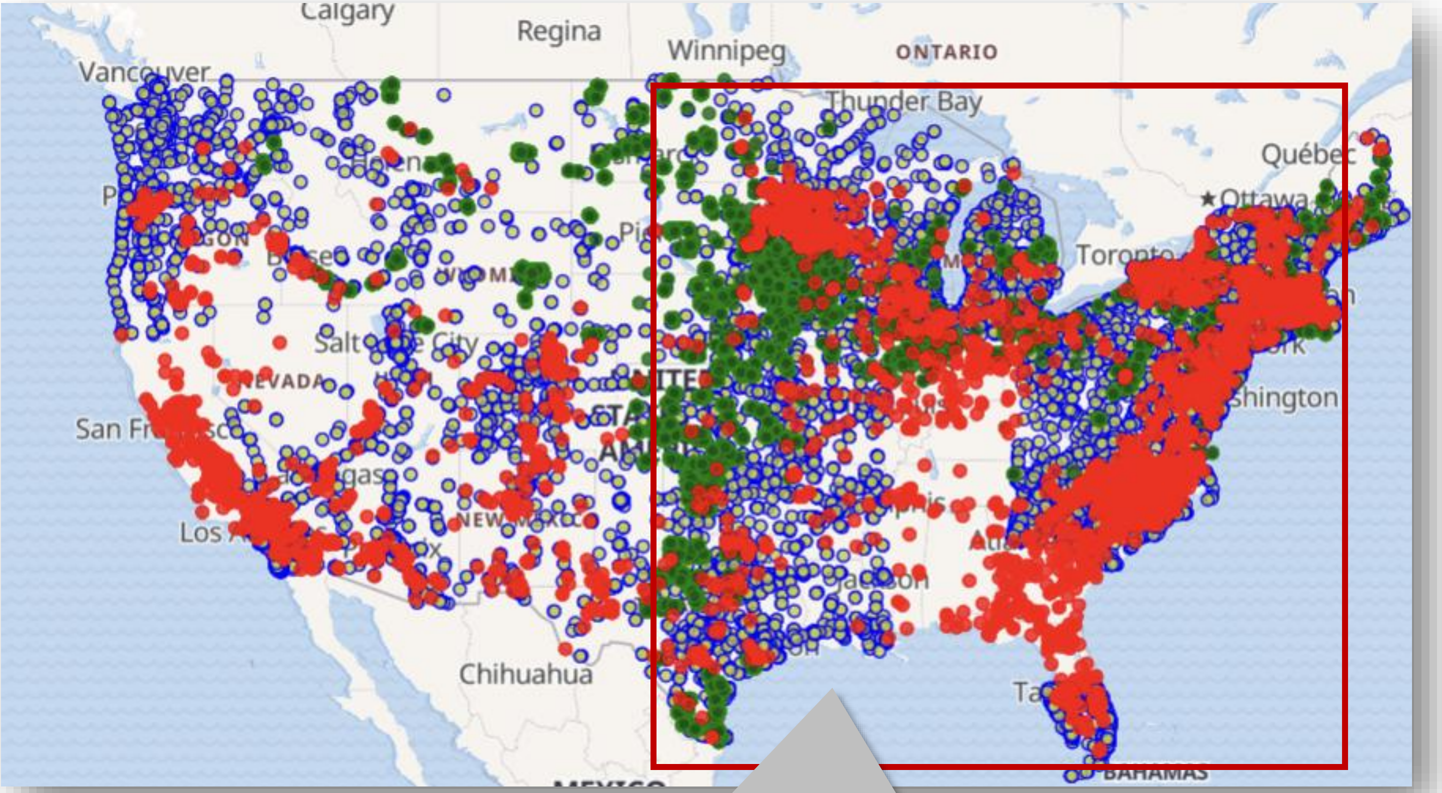
Note we’re mentioning several additional columns here so we can display them in a **pop-up** after a **mouse click**

Displaying Vector Tiles in Multiple Layers



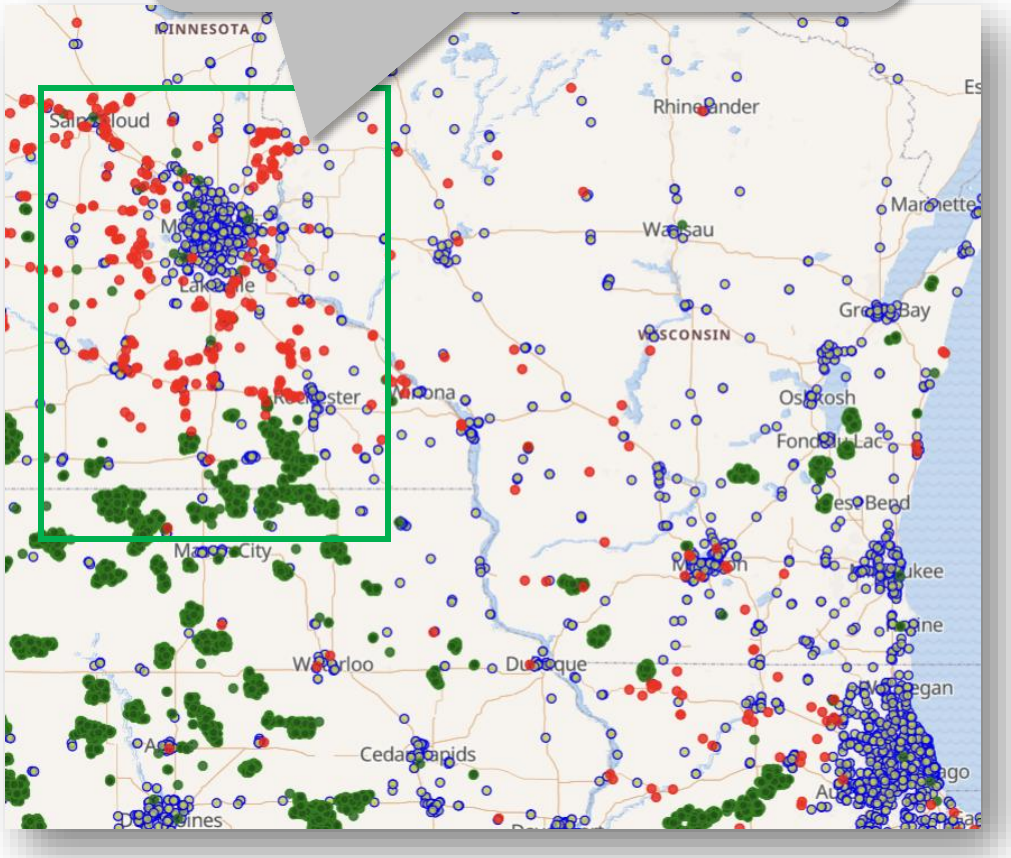
Multiple types of point detail can be layered onto a map – for example, EV chargers, PV arrays, and wind turbines are shown here

Displaying Vector Tiles in Multiple Layers

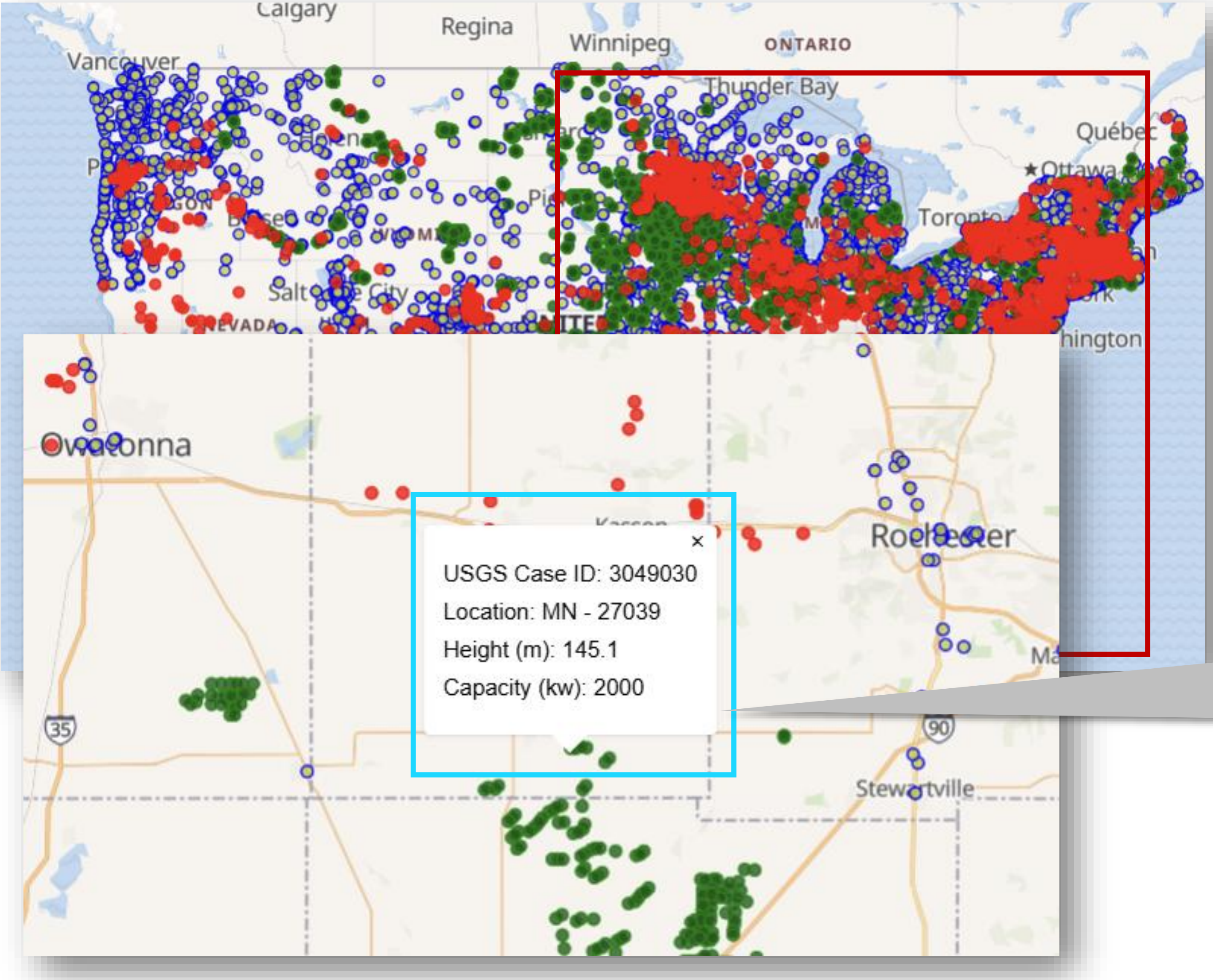


Multiple types of point detail can be layered onto a map – for example, **EV chargers**, **PV arrays**, and **wind turbines** are shown here

We can also drill down to additional detail at lower and lower **zoom levels** to discover additional information at each level …



Displaying Vector Tiles in Multiple Layers



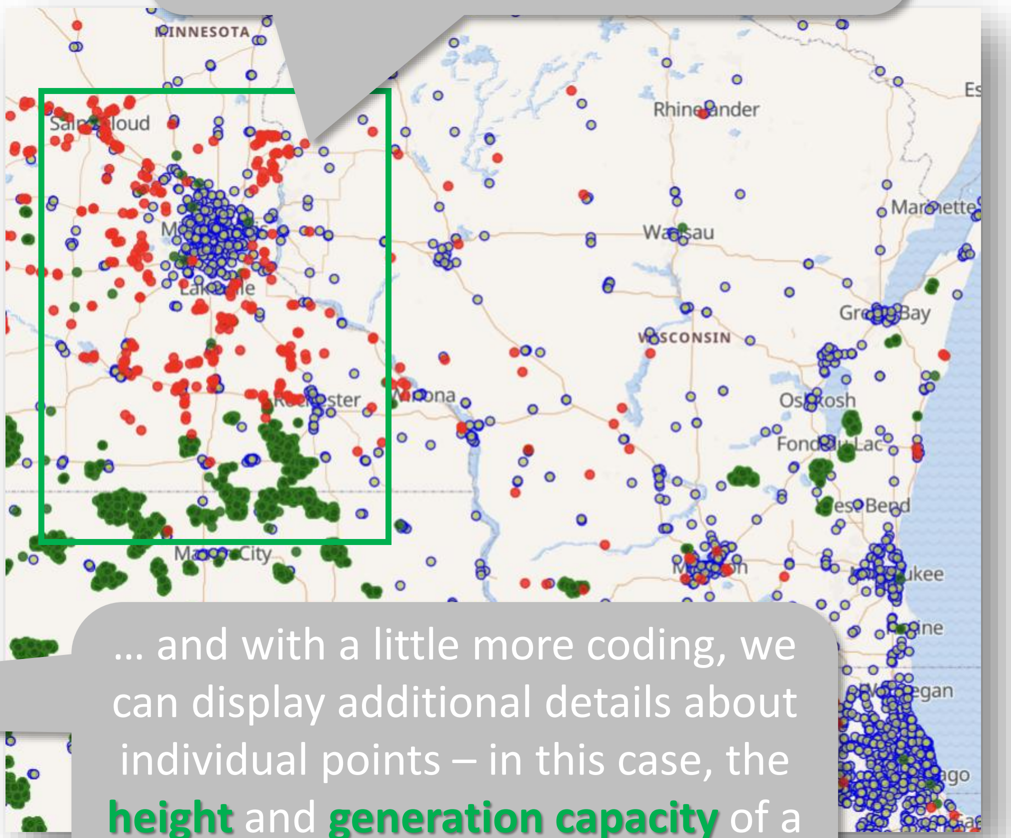
USGS Case ID: 3049030

Location: MN - 27039

Height (m): 145.1

Capacity (kw): 2000

We can also drill down to additional detail at lower and lower zoom levels to discover additional information at each level …



… and with a little more coding, we can display additional details about individual points – in this case, the **height** and **generation capacity** of a single **wind turbine**

Vector Tile Caching

Vector Tile Caching: Saving Frequently-Used Vector Tiles

```
BEGIN
   SDO_UTIL.ENABLE_VECTORTILE_CACHE(
     table_name => 'EXISTING_WIND_TURBINES'
   , geom_col_name => 'GEOMETRY'
   , ts_name => 'DATA'
   , min_zoom => 0
   , max_zoom => 23);
   SDO_UTIL.ENABLE_VECTORTILE_CACHE(
     table_name => 'EXISTING_PV_SITES'
   , geom_col_name => 'GEOMETRY'
   , ts_name => 'DATA'
   , min_zoom => 0
   , max_zoom => 15);
END;
/
```

Oracle 23*ai* also offers the option to **cache vector tiles** for frequent re-use

- Grantable across schemas, should the need arise
- Analogous to the ability to cache **SQL result sets** for queries that gather **a lot** of data that **changes infrequently** (for example, the **master product list** of an automotive company's vehicles)

Vector Tile Caching: Saving Frequently-Used Vector Tiles

```
BEGIN
   SDO_UTIL.ENABLE_VECTORTILE_CACHE(
     table_name => 'EXISTING_WIND_TURBINES'
   , geom_col_name => 'GEOMETRY'
   , ts_name => 'DATA'
   , min_zoom => 0
   , max_zoom => 23);
   SDO_UTIL.ENABLE_VECTORTILE_CACHE(
     table_name => 'EXISTING_PV_SITES'
   , geom_col_name => 'GEOMETRY'
   , ts_name => 'DATA'
   , min_zoom => 0
   , max_zoom => 15);
END;
/
```

This table’s vector tiles will be cached **down to level 23**, the maximum …

… while this table may have more extensive detail at lower levels, but **they’re rarely queried that often**

Vector Tile Caching: Saving Frequently-Used Vector Tiles

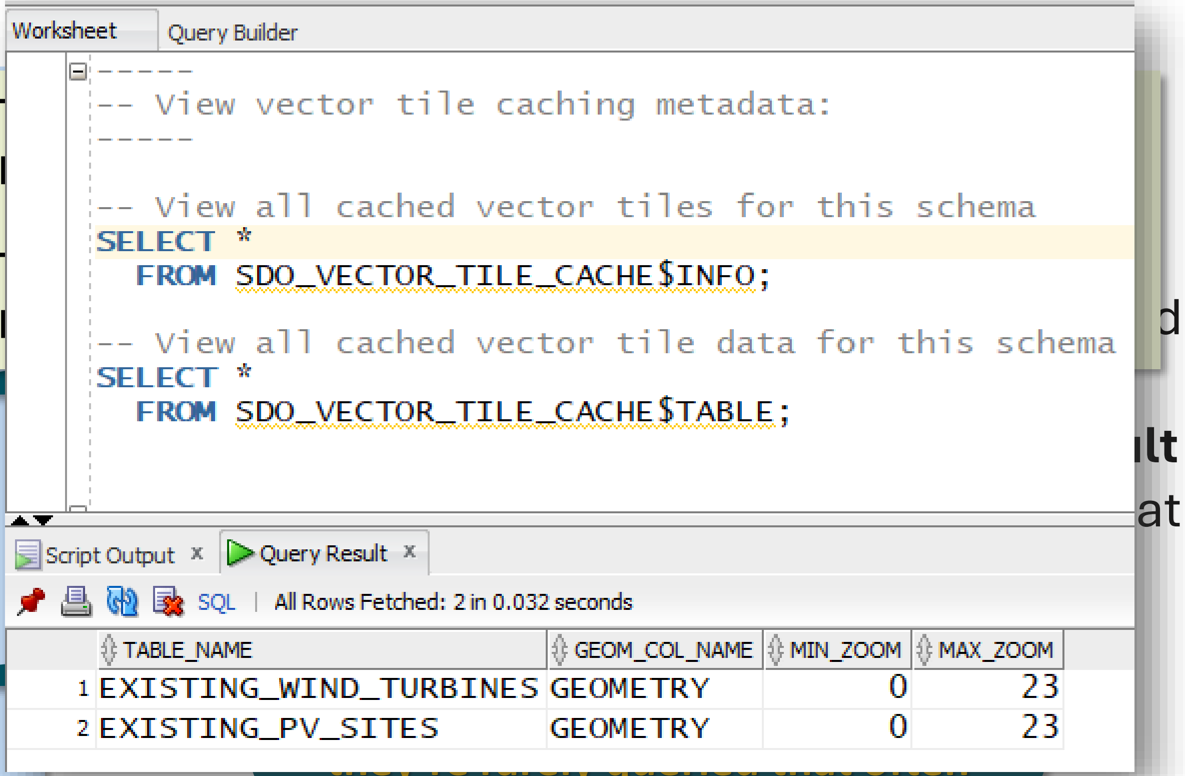
```
BEGIN
                                        CACHE(
                                        RY'

  , max_zoom => 23);
  SDO_UTIL.ENABLE_VECTORTILE_CACHE(
    table_name => 'EXISTING_PV_SITES'
  , geom_col_name => 'GEOMETRY'
  , ts_name => 'DATA'
  , min_zoom => 0
  , max_zoom => 15);
END;
/
```

```
-- View a
SELECT *

-- View a
SELECT *
```

Report which vector tile caches **are in use**, and **what data** they actually contain



```
-----
-- View vector tile caching metadata:
-----

-- View all cached vector tiles for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$INFO;

-- View all cached vector tile data for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$TABLE;
```

	TABLE_NAME	GEOM_COL_NAME	MIN_ZOOM	MAX_ZOOM
1	EXISTING_WIND_TURBINES	GEOMETRY	0	23
2	EXISTING_PV_SITES	GEOMETRY	0	23

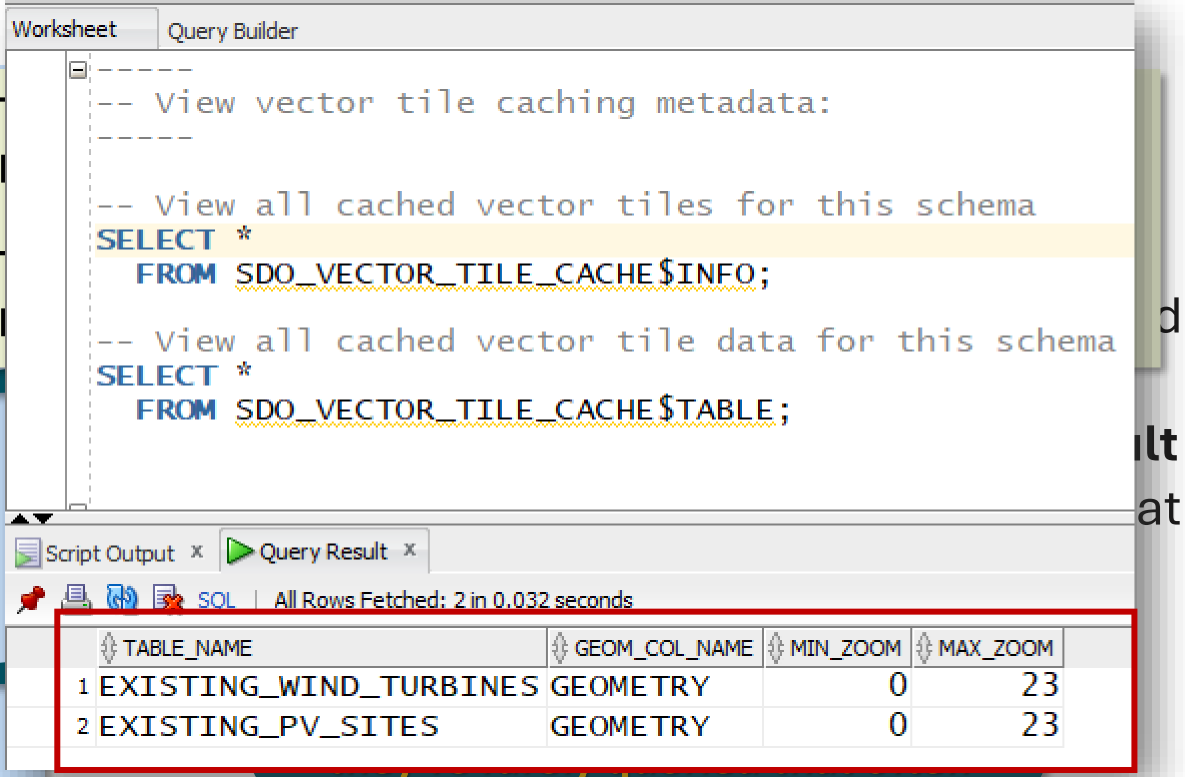
Vector Tile Caching: Saving Frequently-Used Vector Tiles

```
BEGIN
                                            CACHE(
                                          RY'
  , max_zoom => 23);
  SDO_UTIL.ENABLE_VECTORTILE_CACHE(
     table_name => 'EXISTING_PV_SITES'
   , geom_col_name => 'GEOMETRY'
   , ts_name => 'DATA'
   , min_zoom => 0
   , max_zoom => 15);
END;
/
```

Report which vector tile caches **are in use**, and **what data** they actually contain

```
-- View a
SELECT * 

-- View a
SELECT * 
```



```
-----
-- View vector tile caching metadata:
-----

-- View all cached vector tiles for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$INFO;

-- View all cached vector tile data for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$TABLE;
```

All Rows Fetched: 2 in 0.032 seconds

	TABLE_NAME	GEOM_COL_NAME	MIN_ZOOM	MAX_ZOOM
1	EXISTING_WIND_TURBINES	GEOMETRY	0	23
2	EXISTING_PV_SITES	GEOMETRY	0	23

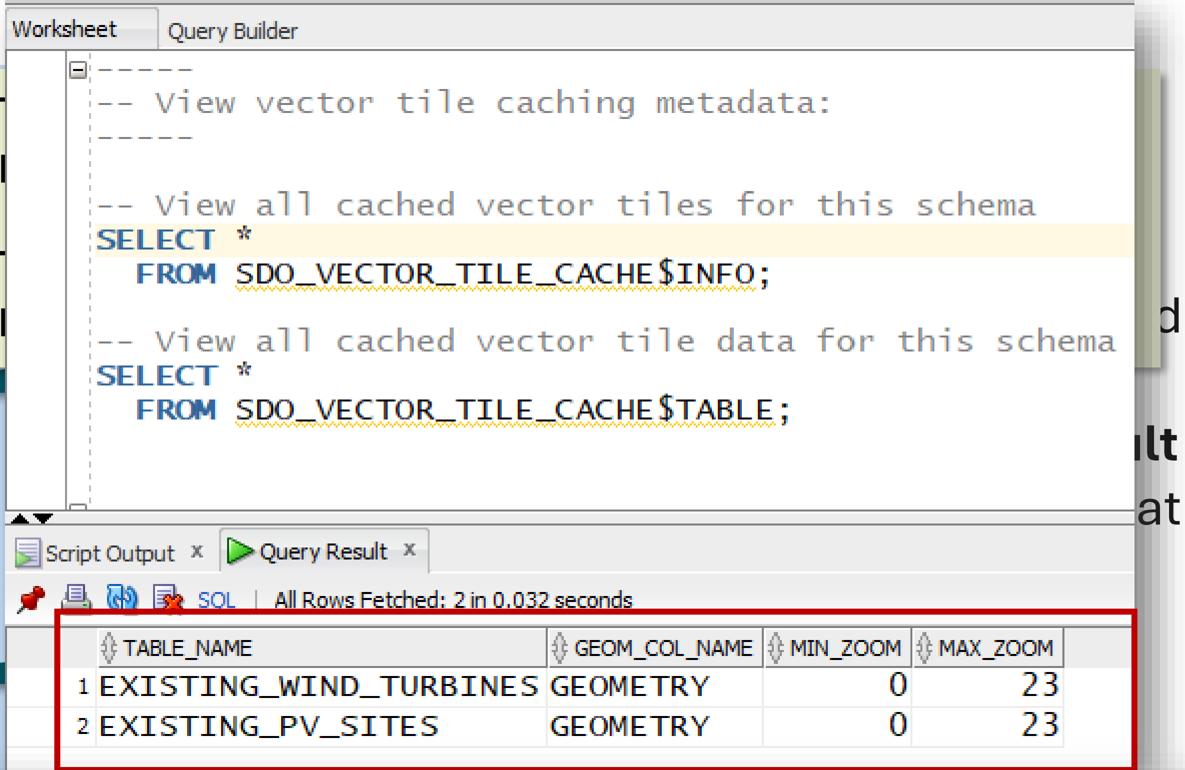
Vector Tile Caching: Saving Frequently-Used Vector Tiles

```
BEGIN
                                        CACHE(
                                         RY'
  , max_zoom => 23);
  SDO_UTIL.ENABLE_VECTORTILE_CACHE(
    table_name => 'EXISTING_PV_SITES'
  , geom_col_name => 'GEOMETRY'
  , ts_name => 'DATA'
  , min_zoom => 0
  , max_zoom => 15);
END;
/
```

Report which vector tile caches **are in use**, and **what data** they actually contain

```
-- View a
SELECT * F

-- View a
SELECT * F
```



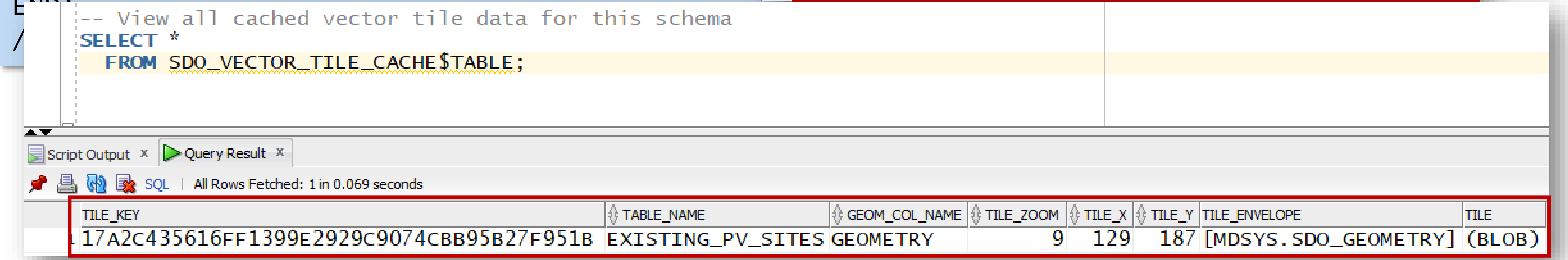
```
-----
-- View vector tile caching metadata:
-----

-- View all cached vector tiles for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$INFO;

-- View all cached vector tile data for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$TABLE;
```

All Rows Fetched: 2 in 0.032 seconds

	TABLE_NAME	GEOM_COL_NAME	MIN_ZOOM	MAX_ZOOM
1	EXISTING_WIND_TURBINES	GEOMETRY	0	23
2	EXISTING_PV_SITES	GEOMETRY	0	23



```
-- View all cached vector tile data for this schema
SELECT *
  FROM SDO_VECTOR_TILE_CACHE$TABLE;
```

All Rows Fetched: 1 in 0.069 seconds

	TILE_KEY	TABLE_NAME	GEOM_COL_NAME	TILE_ZOOM	TILE_X	TILE_Y	TILE_ENVELOPE	TILE
1	17A2C435616FF1399E2929C9074CBB95B27F951B	EXISTING_PV_SITES	GEOMETRY	9	129	187	[MDSYS.SDO_GEOMETRY]	(BLOB)

Vector Tile Caching:Managing Retention and Access

```
BEGIN
   SDO_UTIL.PURGE_VECTORTILE_CACHE(
       table_name => 'EXISTING_WIND_TURBINES’
   );
END;
/

BEGIN
   SDO_UTIL.DISABLE_VECTORTILE_CACHE(
      table_name => 'EXISTING_WIND_TURBINES'
    , geom_col_name => 'GEOMETRY'
   );
END;
/
```

Purge all cached vector tile data for the **EXISTING_WIND_TURBINES** table

Disable vector tile caching for **only** the **GEOMETRY** column in **EXISTING_WIND_TURBINES**

Vector Tile Caching:Managing Retention and Access

```
BEGIN
   SDO_UTIL.PURGE_VECTORTILE_CACHE(
      table_name => 'EXISTING_WIND_TURBINES'
   );
END;
/

BEGIN
                                                S'
E
/
```

```
BEGIN
   SDO_UTIL.GRANT_VECTORTILE_CACHE(
     schema_name => 'GEOSWARM'
   , read_only => TRUE
   );
END;
/

BEGIN
   SDO_UTIL.REVOKE_VECTORTILE_CACHE(
     schema_name => 'HOL23'
   );
END;
/
```

Purge all cached vector tile data for the **EXISTING_WIND_TURBINES** table

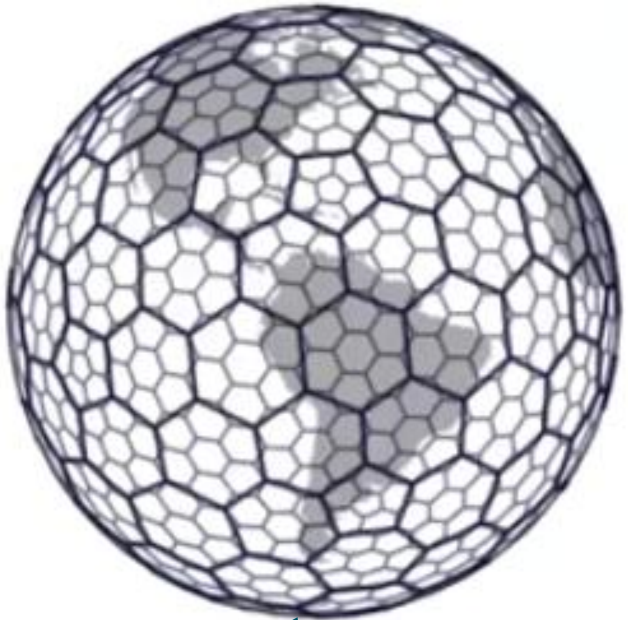
Disable vector tile caching for **only** the **GEOMETRY** column in **EXISTING_WIND_TURBINES**

Grant a different schema to access all cached vector tile data in the current schema

Revoke vector tile caching capabilities for a specific schema

Hexagonal Hierarchical (H3) Spatial Indexing

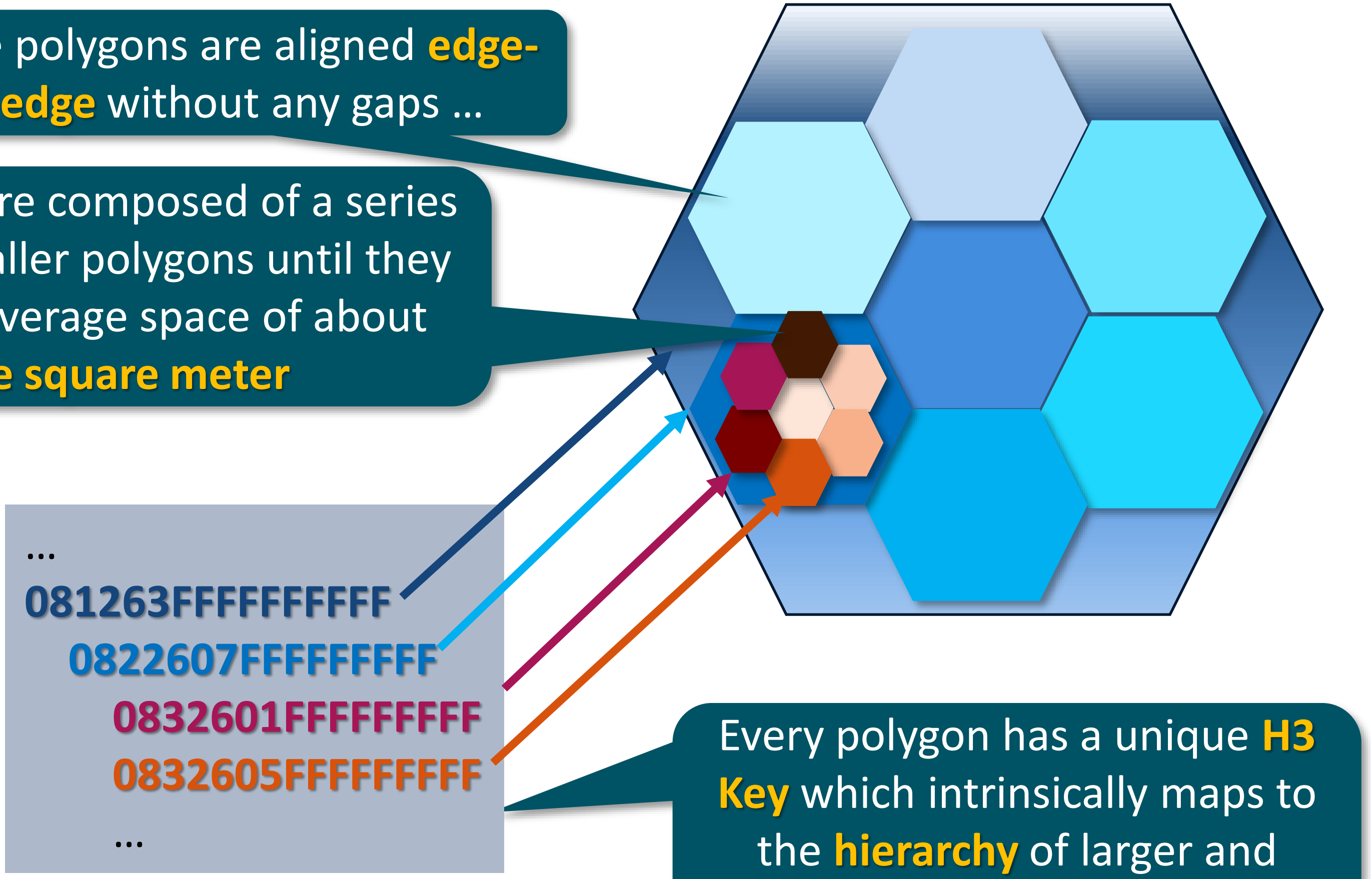
H3 Spatial Indexing: Why Our Uber Driver **Always** Finds Us.



Back in November 2018, engineers at Uber built a new **geographic indexing system** that covers every square meter of our planet as a series of 110 **hexagons** (and 12 **pentagons**)

These polygons are aligned **edge-to-edge** without any gaps …

… and they're composed of a series of ever-smaller polygons until they reach a coverage space of about **one square meter**



…
081263FFFFFFFFF
0822607FFFFFFFF
0832601FFFFFFFF
0832605FFFFFFFF
…

Every polygon has a unique **H3 Key** which intrinsically maps to the **hierarchy** of larger and smaller polygons

Exhaustive detailed information on the H3 standard is **here**

H3 SDO_UTIL Functions & Procedures: The Basics

Procedure or Function	Purpose
H3_KEY	Computes **H3 cell** for a given geodetic point and returns requested **statistic** for the given H3 level
H3_MEMBER	Returns the **MBR** of the given H3 **cell**
H3_PARENT	Computes **containing H3 cell** (64-bit (8 byte RAW)) for given **cell** based on the H3 **hierarchy**
H3SUM_CREATE_TABLE	**Creates** an H3 summary table for geodetic point data
H3SUM_AS_TABLE	**Returns rows** from an H3 summary table as table of type **H3SUM_TAB_T**
H3SUM_GET_CURSOR	Creates a **cursor** for results of searching an H3 summary table with specified level number and search MBR
H3SUM_VECTORTILE	Creates and returns specified **MVT vector tile** from an H3 summary table created with **H3SUM_CREATE_TABLE**

Combining Disparate GIS Datasets Based On H3 KEY Values

```
SELECT h3key
, COUNT(pv_case_id) AS num_h3_locations
, SUM(facility_capacity_ac) AS tot_pv_ac_cap
, SUM(facility_capacity_dc) AS tot_pv_dc_cap
, SUM(turbine_capacity) AS tot_wt_cap
  FROM (
    WITH pv AS (
      SELECT usgs_case_id AS pv_case_id
        , state_abbr
        , county
        , pv_array_area
        , facility_capacity_ac
        , facility_capacity_dc
        , SDO_UTIL.H3_KEY(longitude, latitude,
          FROM existing_pv_sites)
 ,wt AS (
      SELECT usgs_case_id AS wt_case_id
        , state_abbr
        , county
        , turbine_capacity
        , SDO_UTIL.H3_KEY(geometry, 5) AS h3key
          FROM existing_wind_turbines)
. . .
```

```
. . .
SELECT pv.h3key
      , pv.pv_case_id
      , pv.state_abbr
      , pv.county
      , pv.pv_array_area
      , pv.facility_capacity_ac
      , pv.facility_capacity_dc
      , wt.wt_case_id
      , NVL(wt.turbine_capacity,0) AS turbine_capacity
   FROM pv, wt
  WHERE pv.h3key = wt.h3key
  ORDER BY pv.state_abbr, pv.county)
GROUP BY h3key;
```

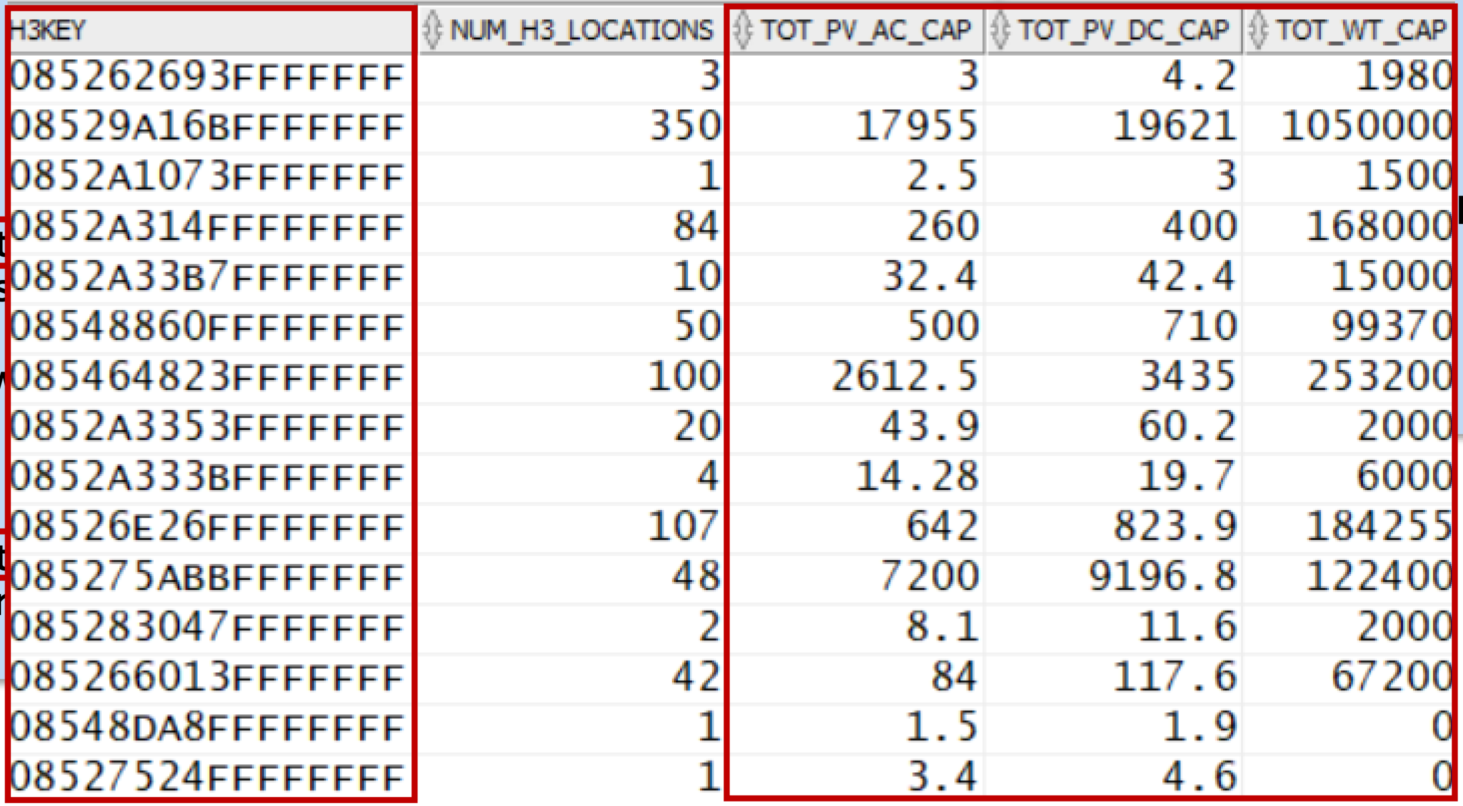
… so these two areas can be **joined together at that same resolution** to see what overlaps occur in those geographies

Combining Disparate GIS Datasets Based On H3 KEY Values

```
SELECT h3key
, COUNT(pv_case_id) AS num_h3_locations
, SUM(facility_capacity_ac) AS tot_pv_ac_cap
, SUM(facility_capacity_dc) AS tot_pv_dc_cap
, SUM(turbine_capacity) AS tot_wt_cap
  FROM (
    WITH pv AS (
      SELECT usgs_case_id AS pv_case_id
      , state_abbr
      , county
      , pv_array_area
      , facility_capacity_ac
      , facility_capacity_dc
      , SDO_UTIL.H3_KEY(longit
        FROM existing_pv_sites
 ,wt AS (
      SELECT usgs_case_id AS w
      , state_abbr
      , county
      , turbine_capacity
      , SDO_UTIL.H3_KEY(geomet
        FROM existing_wind_tur
. . .
```

```
. . .
SELECT pv.h3key
      , pv.pv_case_id
      , pv.state_abbr
      , pv.county
                                    pacity
```

There is indeed at least some overlap between those two areas; we can calculate the **combined power capacities** for both disjoint data sets



H3KEY	NUM_H3_LOCATIONS	TOT_PV_AC_CAP	TOT_PV_DC_CAP	TOT_WT_CAP
085262693FFFFFFF	3	3	4.2	1980
08529A16BFFFFFFF	350	17955	19621	1050000
0852A1073FFFFFFF	1	2.5	3	1500
0852A314FFFFFFFF	84	260	400	168000
0852A33B7FFFFFFF	10	32.4	42.4	15000
08548860FFFFFFFF	50	500	710	99370
085464823FFFFFFF	100	2612.5	3435	253200
0852A3353FFFFFFF	20	43.9	60.2	2000
0852A333BFFFFFFF	4	14.28	19.7	6000
08526E26FFFFFFFF	107	642	823.9	184255
085275ABBFFFFFFF	48	7200	9196.8	122400
085283047FFFFFFF	2	8.1	11.6	2000
085266013FFFFFFF	42	84	117.6	67200
08548DA8FFFFFFFF	1	1.5	1.9	0
08527524FFFFFFFF	1	3.4	4.6	0

H3 SDO_UTIL Functions & Procedures: Cell Boundaries, Areas, & Accuracy

Procedure or Function	Purpose
H3_BASE_CELL	Returns H3 **base** cell (64-bit, 8 byte RAW) matching given H3 cell
H3_BOUNDARY	Computes a **polygon** representing the given cell
H3_CENTER	Computes center of the given H3 cell
H3_PENTAGON_AREA	Returns **size** of a pentagon at given resolution
H3_PENTAGON_EDGELEN	Returns **length of an edge** of a pentagon at given resolution
H3_RESOLUTION	Returns **resolution** of an H3 cell from **0** (coarsest) to **15** (finest)
H3SUM_ESTIMATE_RESOLUTION	Provides an H3 resolution returning ***approximately*** requested number of hexes in given tile

H3 SDO_UTIL Functions & Procedures: Cell-Level

Procedure or Function	Purpose
H3_NUM_CELLS	Returns **number of H3 cells** covering the Earth at the specified **resolution**
H3_HEX_AREA	Returns **minimum**, **maximum** or **average area** of hexes for given H3 level
H3_HEX_EDGELEN	Returns **minimum**, **maximum** or **average edge length** (EDGELEN) of hexes at the given resolution
H3_IS_CLASS3	Returns **BOOLEAN** value that determines if the given cells at the given resolution are “Class 3” in Uber’s H3 system
H3_IS_PENTAGON	Returns **BOOLEAN** value that determines whether a given cell is a **pentagon** (instead of a **hexagon**) or not
H3_IS_VALID_CELL	Returns **TRUE** if the given H3 key is **correctly formed** and identifies an H3 cell; otherwise, the procedure returns **FALSE**

Demo: Vector Tiles and H3 Indexing In Combination

Photo by Simon L @ Unsplash

H3 Indexes: Creating a Summary Table

```
DROP TABLE IF EXISTS h3sum_wind_turbines;

DELETE FROM user_sdo_geom_metadata
 WHERE table_name = 'H3SUM_WIND_TURBINES';

BEGIN
  SDO_UTIL.H3SUM_CREATE_TABLE(
    table_out     => 'H3SUM_WIND_TURBINES'
  , table_in      => 'EXISTING_WIND_TURBINES'
  , geomcol_spec => 'GEOMETRY'
  , col_spec      => '1,CNT;TURBINE_CAPACITY,MIN;TURBINE_CAPACITY,MAX; TURBINE_CAPACITY,AVG'
  , max_h3_level => 7
  );

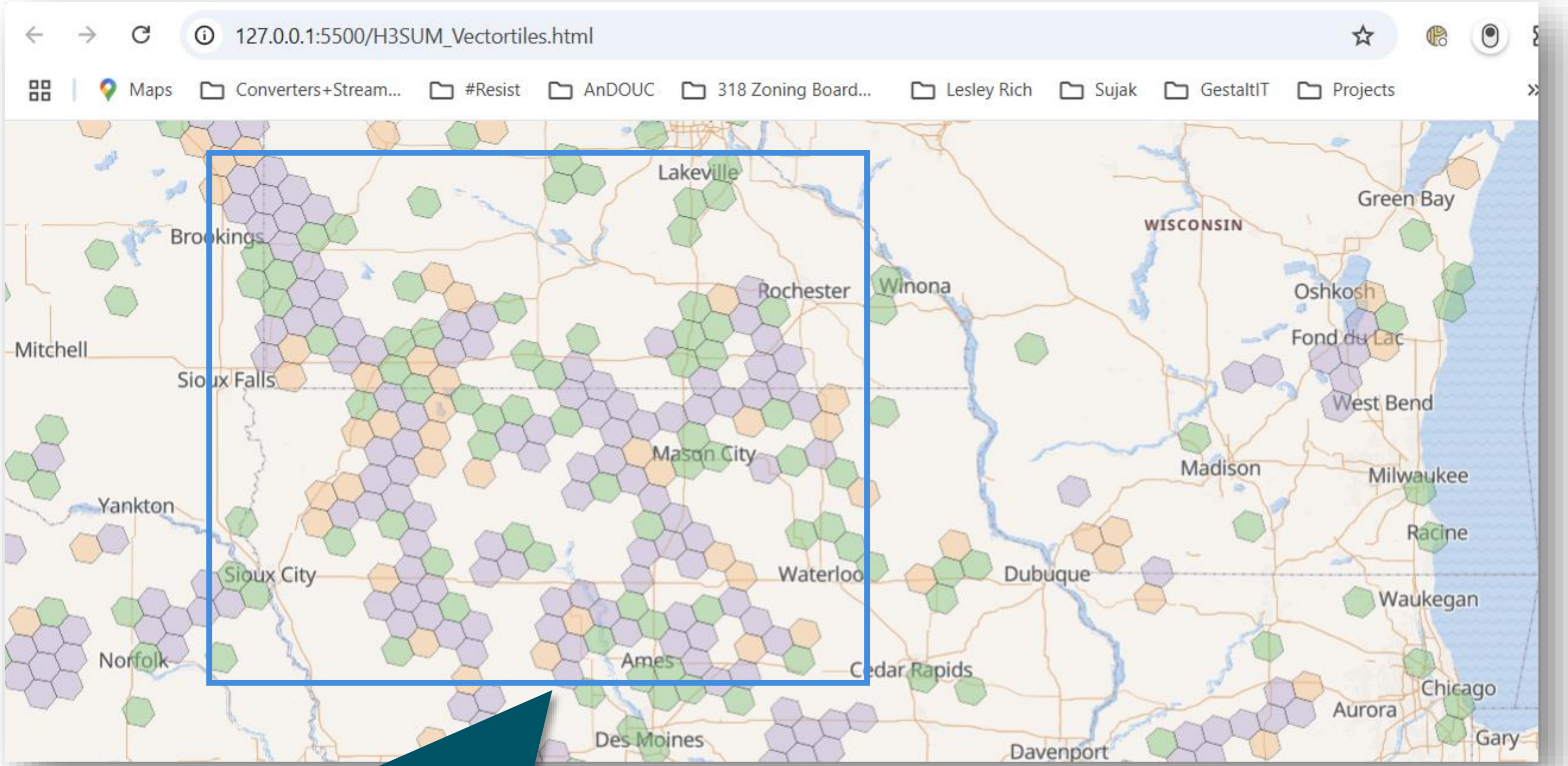
END;
/
```

This describes which tables to use as **source and target** of the H3 summary table operation …

… and this specifies which column(s) should be **aggregated per function** (e.g. MIN, MAX, AVG) or simply counted (CNT)

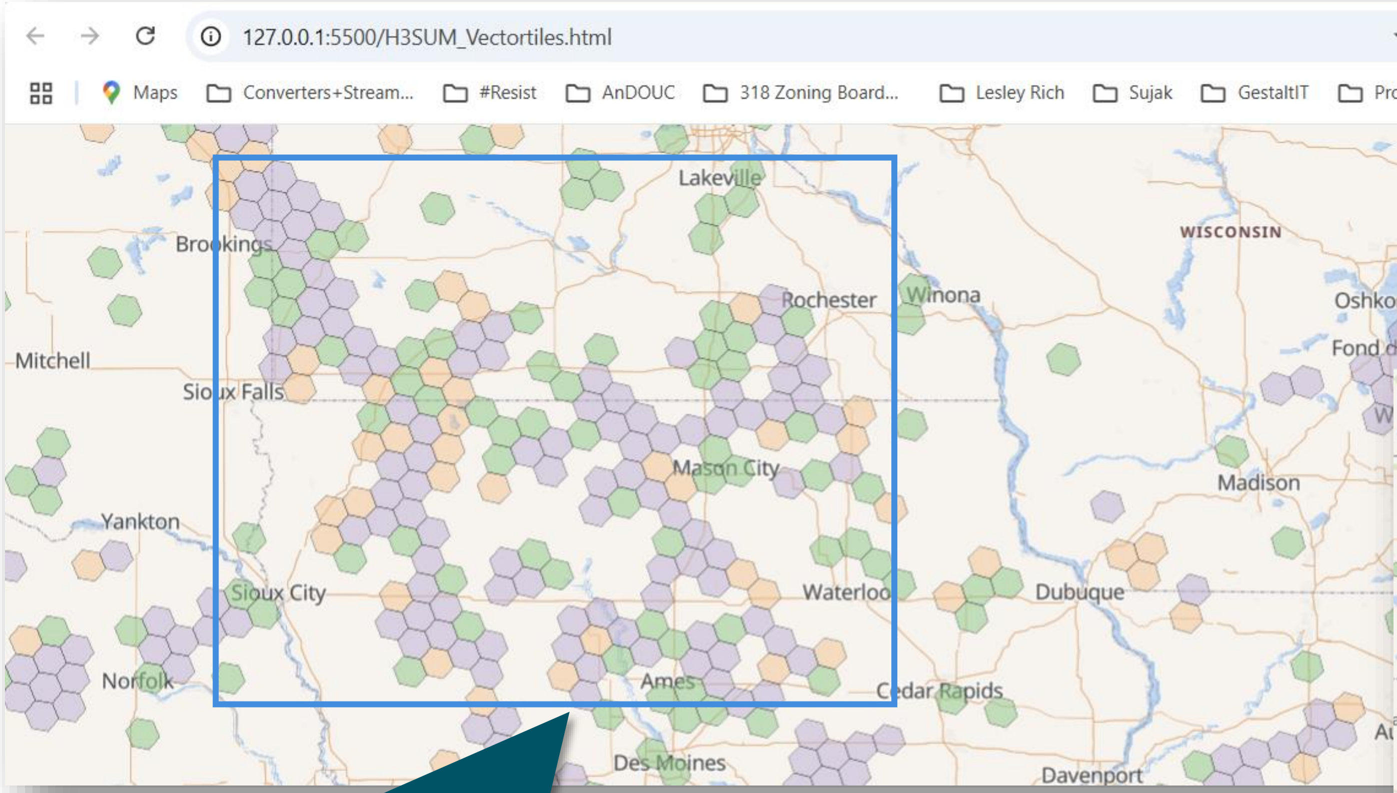
Since there are **16 levels** of H3 key hierarchy, we can set a reasonable limit for the **total number of levels** at which data should be aggregated

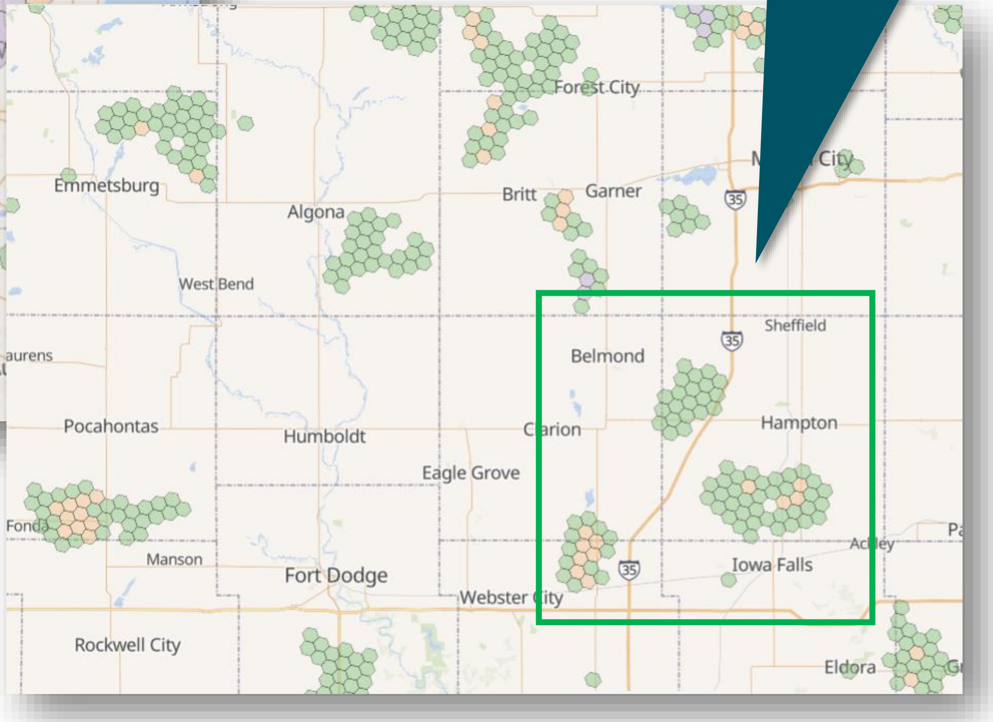
Displaying Vector Tiles Leveraging H3 Summary Information



Each set of H3 summary tiles are **color-coded** to highlight which ones have the **most** wind turbines within their boundaries

Displaying Vector Tiles Leveraging H3 Summary Information



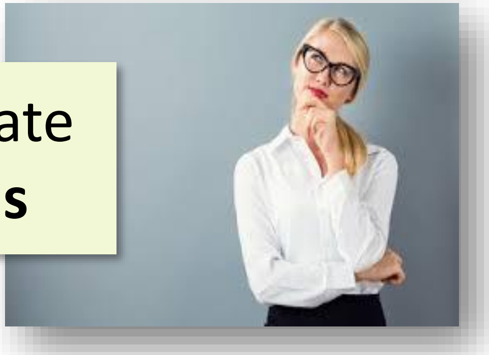


We can also drill down to additional detail at lower and lower **zoom levels** to discover additional information at each level

Each set of H3 summary tiles are **color-coded** to highlight which ones have the **most** wind turbines within their boundaries

Vector Tiling and H3 Indexing: Lessons Learned

Vector tiles offer extremely fast display of **huge** numbers of disparate points in **myriad mapping layers** and **across different zoom levels**



Likewise, **H3 Indexing** offers the ability to display aggregate data **extremely efficiently** within modern GIS systems

These features are accessible through **Oracle Spatial Studio** and **MapBox HTML JavaScript** … and may be coming soon to a **future Oracle APEX release**

Oracle Live Labs, Blog Posts, and Articles on New Spatial Features

Video: Add Fast and Scalable Maps to your Apps with Vector Tiles and H3 in Oracle Database 23ai
https://youtu.be/cQOcNAwHHDc?si=kBJxU8D4VF2VsJ1y

Blog: Add Fast and Scalable Maps to your Apps with Vector Tiles and H3 in Oracle Database 23ai
https://blogs.oracle.com/database/post/make-better-maps-for-your-apps-with-spatial-vector-tiles-and-h3-in-oracle-database-23ai

Video: AskTom Session on OAC, Vector Tile Caching, and SELECT AI:
https://www.youtube.com/watch?v=bKFfTfNUx2A&ab_channel=OracleDevelopers

H3 Indexing:
https://docs.oracle.com/en/database/oracle/oracle-database/23/spatl/h3-indexing.html

Vector Tiles & Vector Tile Cache:
https://docs.oracle.com/en/database/oracle/oracle-database/23/spatl/vector-tiles.html#GUID-77640B2D-C3B2-438F-A46A-0AAD78DB7AB9

Useful Resources, Documentation, and Technical Details

Oracle Spatial & Graph Developers Guide:
https://docs.oracle.com/en/database/oracle/oracle-database/23/vsiad/aivs_genarch.html

Mapbox GL JavaScript Guides:
https://docs.mapbox.com/mapbox-gl-js/guides/

Mapbox GL JavaScript Feature Examples:
https://docs.mapbox.com/mapbox-gl-js/example/

H3: Uber's Hexagonal Hierarchical Spatial Index:
https://www.uber.com/blog/h3/

H3-js - Hexagons in the Browser Video:
https://www.youtube.com/watch?v=BsMIrBHLfLE

Other Interesting Reading

California now has 48% more EV chargers than gasoline nozzles in the state
https://www.gov.ca.gov/2025/03/20/california-now-has-48-more-ev-chargers-than-gasoline-nozzles-in-the-state/

Wind and Solar Overtake Coal Power for First Time in U.S.
https://www.wsj.com/articles/wind-and-solar-overtake-coal-power-for-the-first-time-in-the-u-s-a52e9d8f

Solar Farms Have a Superpower Beyond Clean Energy
https://www.nytimes.com/2024/09/05/climate/solar-power-pollinators-wildlife.html

Promoters of clean-energy data centers in Virginia coal country unfazed by doubters
https://energynews.us/2024/09/10/promoters-of-clean-energy-data-centers-in-virginia-coal-country-unfazed-by-doubters/

Study: EV charging stations boost spending at nearby businesses
https://news.mit.edu/2024/study-ev-charging-stations-boost-nearby-business-spending-0904

IRA credits and energy demand continue to drive renewables investments
https://www.utilitydive.com/news/inflation-reduction-act-credits-energy-demand-investment-financing-trump/742485

Helpful Links –

ORACLE ANALYTICS VIDEOS:
https://www.youtube.com/@OracleAnalytics/videos

OAC SEPTEMBER NEW FEATURES VIDEOS BY ORACLE:
https://bit.ly/OACSept24Features

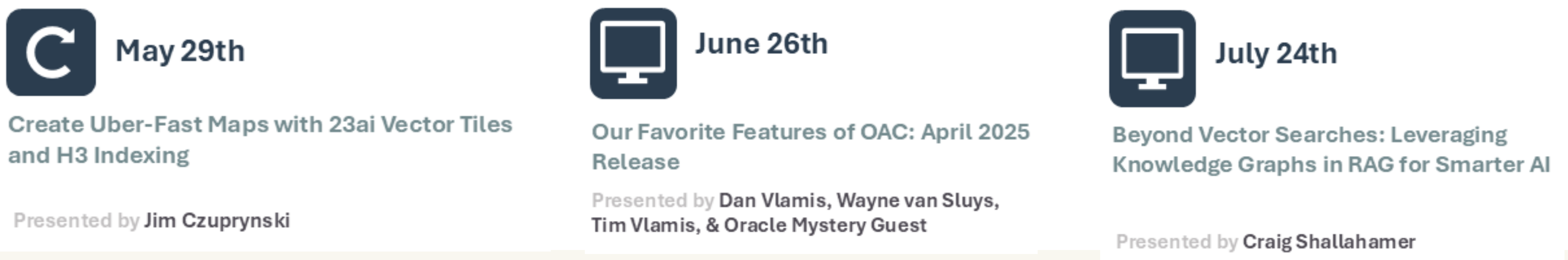
OAC NEW FEATURES DOCUMENTATION BY ORACLE:
https://docs.oracle.com/en/cloud/paas/analytics-cloud/acswn/index.html#GUID-CFF90F44-BCEB-49EE-B40B-8D040F02D476

ORACLE ANALYTICS COMMUNITY:
https://community.oracle.com/products/oracleanalytics

ORACLE ANALYTICS LIBRARY/EXAMPLES:
https://www.oracle.com/business-analytics/data-visualization/examples/

ORACLE ANALYTICS LIVE DEMOS:
https://www.oracle.com/business-analytics/data-visualization/demos/

Future & Past TechCasts:



May 29th

Create Uber-Fast Maps with 23ai Vector Tiles and H3 Indexing

Presented by **Jim Czuprynski**

June 26th

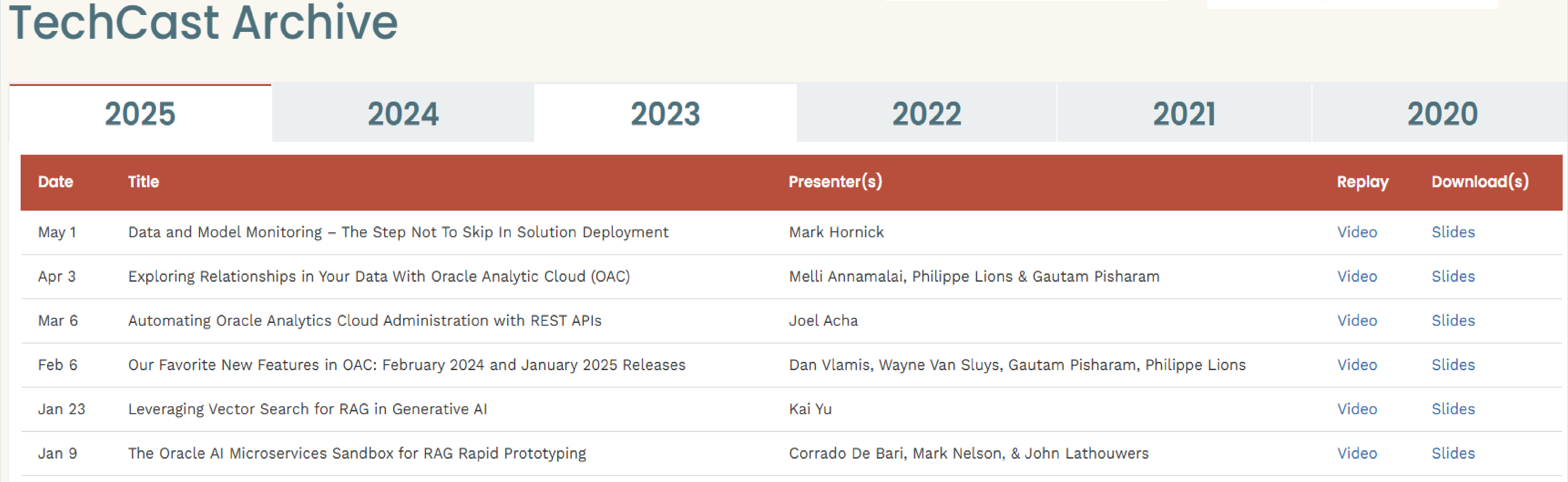
Our Favorite Features of OAC: April 2025 Release

Presented by **Dan Vlamis, Wayne van Sluys, Tim Vlamis, & Oracle Mystery Guest**

July 24th

Beyond Vector Searches: Leveraging Knowledge Graphs in RAG for Smarter AI

Presented by **Craig Shallahamer**



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Mar 6	Automating Oracle Analytics Cloud Administration with REST APIs	Joel Acha	Video	Slides
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