Module 9

Joining and Merging Datasets

In this module we will:

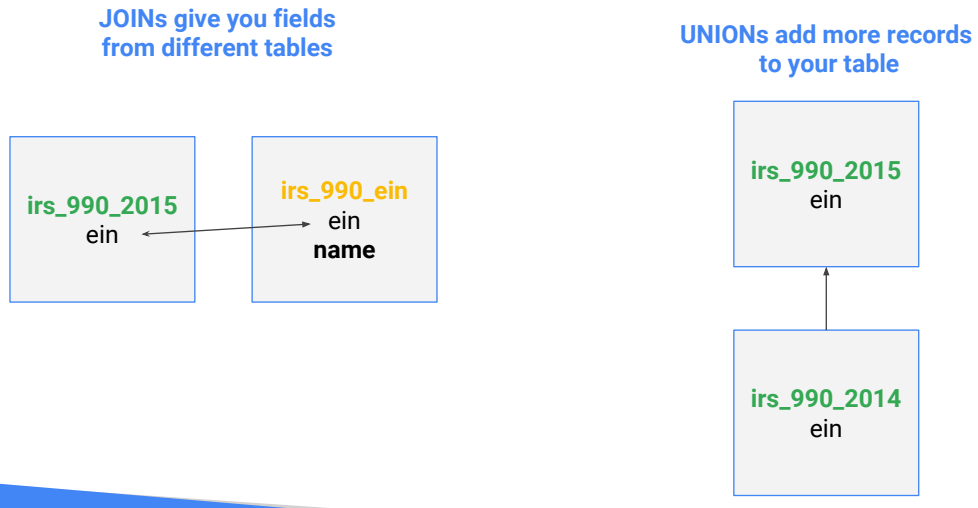
- **Merge Historical Data Tables with UNION**
- Introduce Table Wildcards for Easy Merges
- Review Data Schemas: Linking Data Across Multiple Tables
- Walkthrough JOIN Examples and Pitfalls

Google Cloud

One of the most popular topics in SQL is how mash-up multiple data sources together in a single query to answer more complex insights. In this module we will tackle how to append additional historical data vertically through unions as well as how to join together different datasets horizontally through SQL joins.

Let's walkthrough the basics and I'll highlight some common pitfalls along the way.

Enriching your Dataset through JOINs and UNIONs

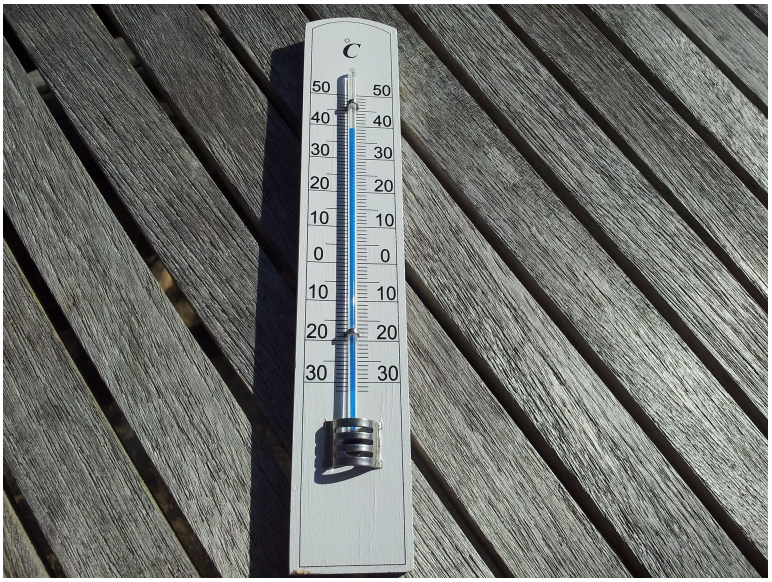


Google Cloud

JOINs enrich your dataset by potentially adding fields (horizontally)

UNIONs append more data to your table (vertically)

Walkthrough Example
Joining and Merging *Temperature* and *Weather Station* Data

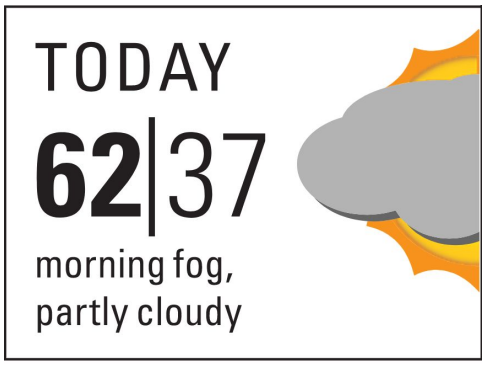


Google Cloud

Image (temperature) cc0:
https://pixabay.com/en/thermometer-heat-40-weather-693852/

Two Types of Tables in the **NOAA Weather Dataset**

Daily Temperature Readings



Weather Recording Station Locations

Victoria, Australia

Wake Island Harbor

Google Cloud

There are two table types: Daily temperature readings and the physical station locations which recorded them.

Images:
https://upload.wikimedia.org/wikipedia/commons/a/a9/Newspaper_weather_forecast_-_today_and_tomorrow.svg

https://en.wikipedia.org/wiki/File:Mildura_Airport_Weatherstation.jpg
Weather station at Mildura Airport, Victoria, Australia.

NOAA weather station at Wake Island harbor
https://en.wikipedia.org/wiki/Weather_station#/media/File:NOAA_weather_station_at_Wake_Island_harbor.jpg

Two Types of Tables in the **NOAA Weather Dataset**

Daily Temperature Readings

noaa_gsod

- **gsod1929**
- gsod1930
- gsod1931
- gsod1932
- gsod1933
- gsod1934
- gsod1935
- gsod1936
- gsod1937
- gsod1938
- gsod1939
- gsod1940
- gsod1941
- gsod1942
- gsod1943
- gsod1944
- gsod1945
- gsod1946
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- gsod1950
- gsod1951
- gsod1952
- gsod1953
- gsod1954
- gsod1955
- gsod1956
- gsod1956
- gsod1957
- gsod1958
- gsod1959
- gsod1960
- gsod1961 … current
- gsod1962
- gsod1963
- gsod1964
- gsod1965
- gsod1966
- gsod1967
- gsod1968
- gsod1969

Weather Recording Station Locations

stations

Results | Explanation | Job Information

Row	usaf	wban	name	country	state	call	lat	lon	elev	begin	end
1	912450	41606	WAKE ISLAND AIRFLD	WQ	PC	PWAK	19.283	166.65	+0003.7	19451231	20100731
2	912460	41606	WAKE ISLAND AIRFIELD	WQ	UM	PWAK	19.283	166.65	+0007.0	20100801	20170805
3	999999	41606	WAKE ISLAND	WQ	PC	PWAK	19.283	166.65	+0003.7	19491031	19721231
4	912450	99999	WAKE ISLAND AIRFLD	WQ			19.283	166.65	+0004.0	20000101	20100818
5	997387	99999	WAKE ISLAND	WQ			19.28	166.62	+0005.0	20050517	20170804

Table | JSON

Google Cloud

We have a separate **table for all daily weather temperatures since 1929**. That's a lot of tables for us to query and combine (don't worry, it won't be so bad)

Our **weather station location details** (lat, long, state, station name) is stored in a single lookup table. Key fields like Country and State are not present in the Daily Temperature table (because of a concept called normalization that we will come to later) but we can look these fields up by joining the tables together.

But, before we can link and join the two tables together, we need to first figure out what linking field they have in common.

What is our unique identifier for weather stations? Is it USAF (US Air Force Station ID) or WBAN (WEATHER BUREAU ARMY NAVY)? Well, let's investigate ….

What is our **Unique Identifier** for a Weather Station?

```
#standardSQL
# Is usaf unique over time?
  SELECT
    COUNT(usaf) AS total_stations,
    COUNT(DISTINCT usaf) AS
distinct_stations
FROM
`bigquery-public-data.noaa_gsod.stations`;
```

Row	total_count	distinct_count
1	30016	26453

no

Weather Recording Station Locations

stations

Results | Explanation | Job Information

Row	usaf	wban	name	country	state	call	lat	lon	elev	begin	end
1	912450	41606	WAKE ISLAND AIRFLD	WQ	PC	PWAK	19.283	166.65	+0003.7	19451231	20100731
2	912460	41606	WAKE ISLAND AIRFIELD	WQ	UM	PWAK	19.283	166.65	+0007.0	20100801	20170805
3	999999	41606	WAKE ISLAND	WQ	PC	PWAK	19.283	166.65	+0003.7	19491031	19721231
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5	997387	99999	WAKE ISLAND	WQ			19.28	166.62	+0005.0	20050517	20170804

Table | JSON

Google Cloud

Before we can link the two tables together, we need to find our unique row identifier...

What is our unique identifier for weather stations? Is it USAF (U.S. Air Force) number?

No, as we see from the above query, **USAF is not unique**. One station could possibly have re-used this ID over time or one station could have multiple recording devices.

Find the duplicate usaf records use this example query:

```
SELECT *
FROM (
  SELECT
     *,
     ROW_NUMBER()
        OVER (PARTITION BY usaf)
        AS station_history_change
  FROM `bigquery-public-data.noaa_gsod.stations`
)
WHERE station_history_change > 1
ORDER BY usaf, station_history_change
```

We need to use a **combination key**

Weather Recording Station Locations

```
#standardSQL
# Is usaf wban combo unique over time?
  SELECT
    COUNT(CONCAT(usaf,wban)) AS total_stations,
    COUNT(DISTINCT CONCAT(usaf,wban)) AS distinct_stations
FROM `bigquery-public-data.noaa_gsod.stations`;
```

stations

Row	total_stations	distinct_stations
1	30016	30016

Yes

Results | Explanation | Job Information

Row	usaf	wban	name	country	state	call	lat	lon	elev	begin	end
1	912450	41606	WAKE ISLAND AIRFLD	WQ	PC	PWAK	19.283	166.65	+0003.7	19451231	20100731
2	912460	41606	WAKE ISLAND AIRFIELD	WQ	UM	PWAK	19.283	166.65	+0007.0	20100801	20170805
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4	912450	99999	WAKE ISLAND AIRFLD	WQ			19.283	166.65	+0004.0	20000101	20100818
5	997387	99999	WAKE ISLAND	WQ			19.28	166.62	+0005.0	20050517	20170804

Table | JSON

Google Cloud

Since it's clear that wban by itself is not unique, what about the combination of the two?

Yes! If we CONCATENATE the two fields we get a **combined unique key** showing 30,016 stations.

Join and Union your Data for Enriched Insights

Daily Temperature Readings

- noaa_gsod
  - **gsod1929**
  - gsod1930
  - gsod1931
  - gsod1932
  - gsod1933
  - gsod1934
  - gsod1935
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  - gsod1958
  - gsod1959
  - gsod1960
  - gsod1961 … current
  - gsod1962
  - gsod1963
  - gsod1964
  - gsod1965
  - gsod1966
  - gsod1967
  - gsod1968
  - gsod1969

How are we going to JOIN so many tables?

Can't we combine the temperature readings across years somehow?

Weather Recording Station Locations

stations

Google Cloud

Introducing UNION for Vertically Merging your Data

Daily Temperature Readings

- **gsod1929**
- gsod1930

gsod1929

stn	wban	temp	year
030050	99999	49	1929
030050	99999	45.7	1929
030050	99999	48.2	1929

UNION

gsod1930

stn	wban	temp	year
037770	99999	50.7	1930
030910	99999	56	1930
038560	99999	53.2	1930

Gsod1929 UNION gsod1930

stn	wban	temp	year
030050	99999	49	**1929**
030050	99999	45.7	**1929**
030050	99999	48.2	**1929**
037770	99999	50.7	1930
030910	99999	56	1930
038560	99999	53.2	1930

Google Cloud

Union Distinct vs Union All = Union Distinct will deduplicate whereas Union All will include all values

Introducing UNION for Vertically Merging your Data

gsod1929

gsod1930

```
#standardSQL
SELECT
  stn,
  wban,
  temp,
  year
FROM

`bigquery-public-data.noaa_gsod.gsod1929`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1930`
```

Gsod1929 UNION gsod1930

stn	wban	temp	year
030050	99999	49	**1929**
030050	99999	45.7	**1929**
030050	99999	48.2	**1929**
037770	99999	50.7	1930
030910	99999	56	1930
038560	99999	53.2	1930

UNION DISTINCT removes duplicates whereas UNION ALL keeps every record

Google Cloud

Union Distinct vs Union All = Union Distinct will deduplicate whereas Union All will include all values

Wait a minute....

- **gsod1929**
- gsod1930
- gsod1931
- gsod1932
- gsod1933
- gsod1934
- gsod1935
- gsod1936
- gsod1937
- gsod1938
- gsod1939

```
#standardSQL
SELECT
  stn,
  wban,
  temp,
  year
FROM

`bigquery-public-data.noaa_gsod.gsod1929`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1930`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1931`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1932`
# This is getting out of hand...
```

.. I don't want to type 100 Unions

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Typing all those UNIONs by hand seems tedious...

Module 9

Joining and Merging Datasets

In this module we will:

- Merge Historical Data Tables with UNION
- **Introduce Table Wildcards for Easy Merges**
- Review Data Schemas: Linking Data Across Multiple Tables
- Walkthrough JOIN Examples and Pitfalls

Google Cloud

Make your UNIONs Easier with the **Table Wildcard ***

```
#standardSQL
SELECT
  stn,
  wban,
  temp,
  year
FROM

`bigquery-public-data.noaa_gsod.gsod1929`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1930`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1931`
  UNION DISTINCT
`bigquery-public-data.noaa_gsod.gsod1932`
# This is getting out of hand...
```

```
#standardSQL
SELECT
  stn,
  wban,
  temp,
  year
FROM

`bigquery-public-data.noaa_gsod.gsod*`
# All gsod tables
```


Google Cloud

Use a UNION table wildcard
https://cloud.google.com/bigquery/docs/wildcard-tables

Filtering with a Table Wildcard * and _TABLE_SUFFIX_

Use _TABLE_SUFFIX to filter out tables included

Be as granular as you can

- e.g. .gsod2* instead of .gsod* if you only care about the year 2000 onward

```
#standardSQL
SELECT
  stn,
  wban,
  temp,
  year
FROM

`bigquery-public-data.noaa_gsod.gsod*`

# All gsod tables after 1950
WHERE _TABLE_SUFFIX > '1950'
```


Google Cloud

Include a collection of tables and then filter them with _TABLE_SUFFIX_
https://cloud.google.com/bigquery/docs/wildcard-tables

Filtering with a **Table Wildcard** * and **_TABLE_SUFFIX_**

- Use Table Wildcard * vs writing many UNIONs
- Use _TABLE_SUFFIX to filter out tables wildcard included
- Use _TABLE_SUFFIX in your SELECT statements with CONCAT( )

Google Cloud

https://cloud.google.com/bigquery/docs/wildcard-tables

Avoid **Union Pitfalls** like Brittle Schemas

- Duplicate Records among tables (Use UNION DISTINCT vs UNION ALL)
- Changing Schemas and Field Names over time.
- Start with the most inclusive Table first (most fields)

Google Cloud

Unions in SQL require careful handling of schemas between tables

Review of What We've Done so Far

```
FROM `bigquery-public-data.noaa_gsod.gsod*`
```

stn	wban	temp	year
030050	99999	49	**1929**
030050	99999	45.7	**1929**
030050	99999	48.2	**1929**
...	...	...	....
037770	99999	50.7	**2017**
030910	99999	56	**2017**
038560	99999	53.2	**2017**

- We are merging all historical gsod tables into one UNION'd table through a **Table Wildcard**

Google Cloud

https://cloud.google.com/bigquery/docs/wildcard-tables

How do we **Enrich** our Temperature Data with Station Details?

```
FROM `bigquery-public-data.noaa_gsod.gsod*`
```

stn	wban	temp	year	name	state	country
030050	99999	49	**1929**			
030050	99999	45.7	**1929**			
030050	99999	48.2	**1929**		??	
...	...	...	....			
037770	99999	50.7	**2017**			
030910	99999	56	**2017**			
038560	99999	53.2	**2017**			

... by **JOIN**ing with data in other tables

Module 9

Joining and Merging Datasets

In this module we will:

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- Walkthrough JOIN Examples and Pitfalls

Google Cloud

What is a **JOIN**?

Combine **data from separate tables** that share a comment element **into one table**

```
#standardSQL
SELECT
  a.stn,
  a.wban,
  a.temp,
  a.year,
  b.name,
  b.state,
  b.country
FROM
  `bigquery-public-data.noaa_gsod.gsod*` AS a
JOIN
  `bigquery-public-data.noaa_gsod.stations` AS b
ON
  a.stn=b.usaf
  AND a.wban=b.wban

WHERE
  # Filter data
  state IS NOT NULL
  AND country='US'
  AND _TABLE_SUFFIX > '2015'
```


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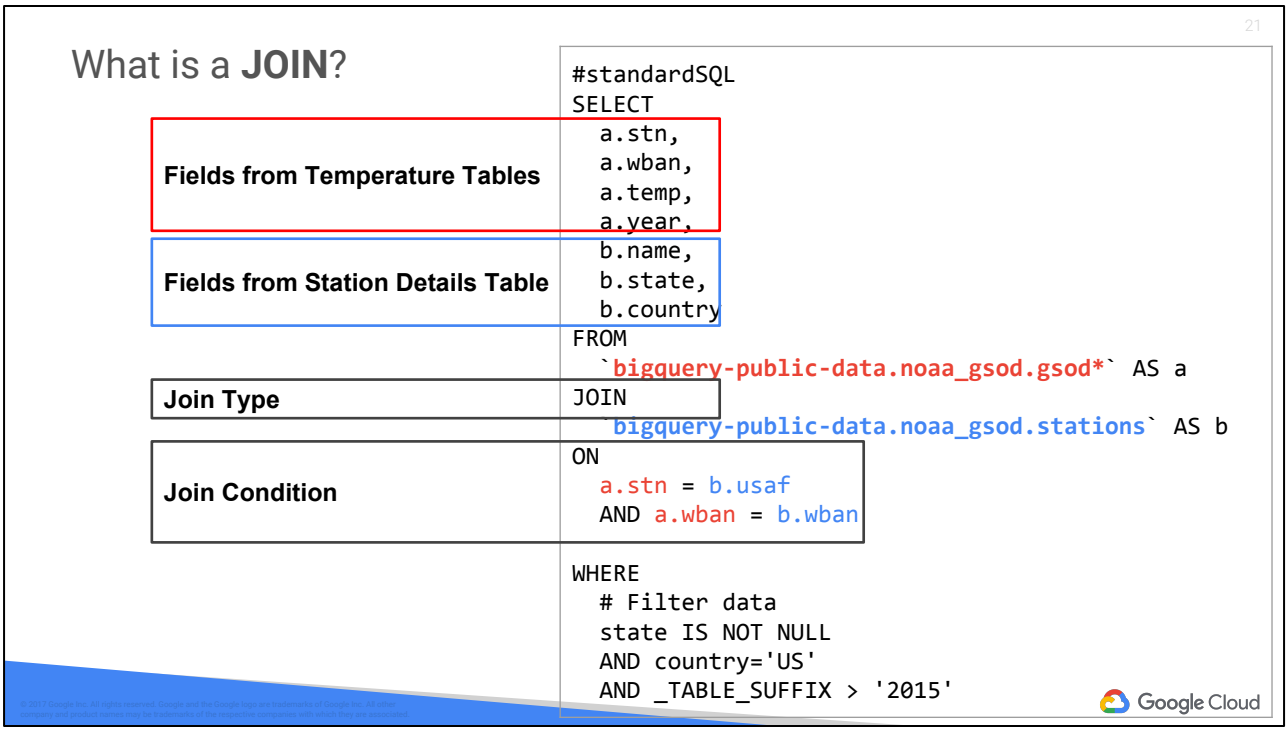

Aliases are optional in the SELECT statement if the field names are unambiguous between the tables

JOINS can have multiple linking fields to establish uniqueness like the one shown here

The default JOIN is an INNER join which means the records must exist in both tables for results to be shown. Let's cover the basic join types now.

Module 9

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Different Types of Joins

INNER JOIN	Returns rows from multiple tables where join condition is met
LEFT JOIN	Returns all rows from the left table and matched rows from the right table
RIGHT JOIN	Returns all rows from the right table and matched rows from the left table
OUTER JOIN	Returns all rows from all tables and unmatched rows are displayed as NULL

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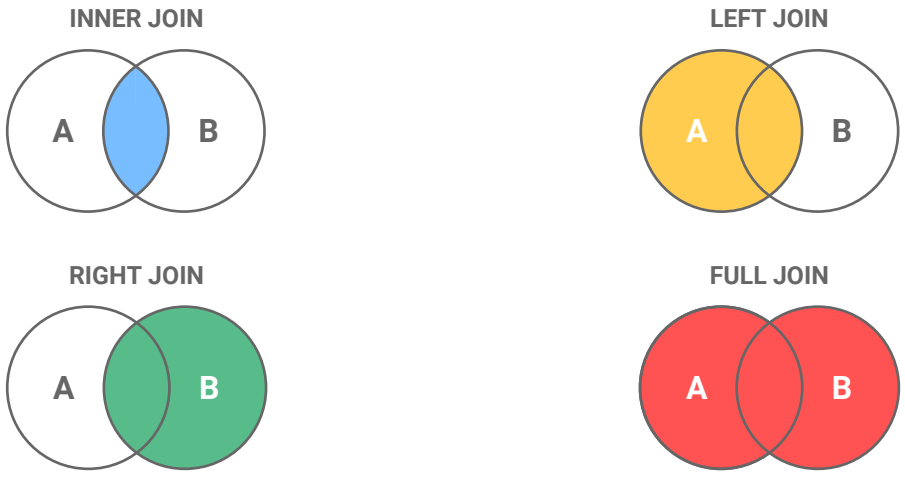
BigQuery Join types:
https://cloud.google.com/bigquery/docs/reference/standard-sql/query-syntax#join-types

Joins represented via Venn diagram



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BigQuery Join types:
https://cloud.google.com/bigquery/docs/reference/standard-sql/query-syntax#join-types

Also there is a CROSS JOIN which applies the cross product of all records from each table.

Pitfall: Joining on Non-Unique Fields Explodes your Dataset

- Doing a many-to-many JOIN could result in more rows than either of your initial tables
- This is a primary reason for exceeding your resource cap in BigQuery (unintentionally high compute)
- Know your dataset and the relationships between your tables before joining

Pitfall: Joining on Non-Unique Fields Explodes your Dataset

Woah, what happened here?

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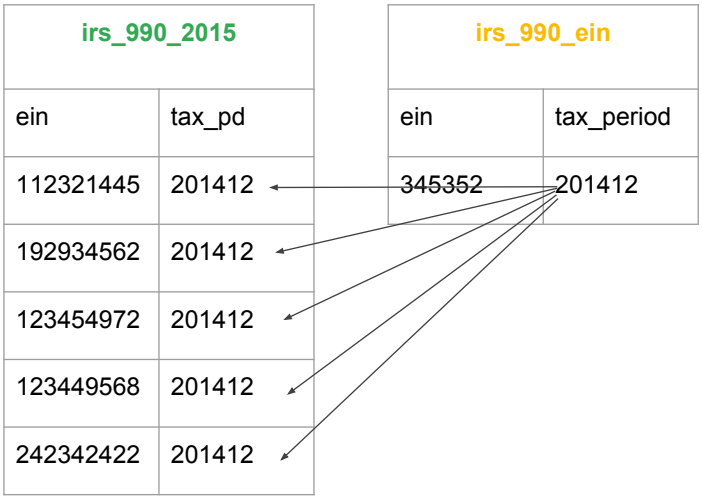
Pitfall: Joining on Non-Unique Fields Explodes your Dataset



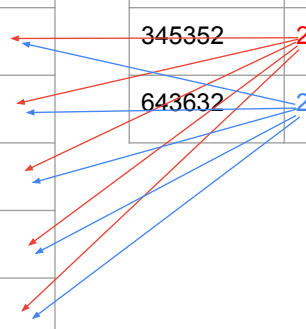
irs_990_2015	
ein	tax_pd
112321445	201412
192934562	201412
123454972	201412
123449568	201412
242342422	201412

irs_990_ein	
ein	tax_period
345352	201412

Pitfall: Creating an **Unintentional Cross Join**

irs_990_2015	
ein	tax_pd
112321445	201412
192934562	201412
123454972	201412
123449568	201412
242342422	201412

irs_990_ein	
ein	tax_period
345352	201412
643632	201412



Pitfall: Cross Joins Multiply your Data

irs_990_2015	
ein	tax_pd
112321445	201412
192934562	201412
123454972	201412
123449568	201412
242342422	201412

irs_990_ein	
ein	tax_period
345352	201412
643632	201412

ein	tax_pd
112321445	**201412**
112321445	**201412**
192934562	201412
192934562	201412
123454972	**201412**
123454972	**201412**
123449568	201412
123449568	201412
242342422	**201412**
242342422	**201412**

Google Cloud

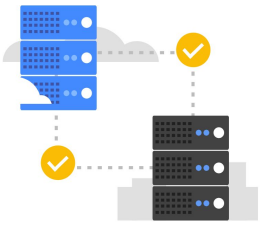
BigQuery CROSS JOIN
https://cloud.google.com/bigquery/docs/reference/standard-sql/query-syntax#cross-join

Pitfall: Understand your Data Model and Relationships

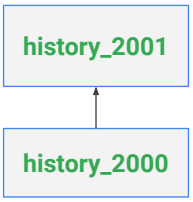
- Understand your data relationship before joining 1:1, N:1, 1:N, N:N
- Use CONCAT( ) to create composite key fields if no unique fields exist or join on more than one field
- Ensure your key fields are distinct (deduplicate)

Summary: Mashup your datasets with Joins and Unions

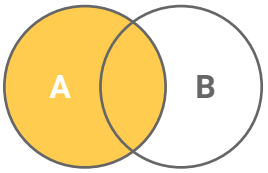
Finding the unique record identifier(s) in table is critical



Spend time exploring the data relationship model between tables



Use UNION wildcards and _TABLE_SUFFIX_ to quickly add records to a consolidated table



Use JOINs to enrich data across multiple tables

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Understanding when and how to use joins and unions in SQL is a concept that is easy to pickup but takes a while to truly master. The best advice I can give you when starting is to really understand how your data tables are supposed to be related to each other (customer to orders, supplier to inventory) and being able to verify if that is actually true though SQL. Remember: all data is dirty and it's your job to investigate and interrogate it before potentially polluting your larger dataset with joins and unions.

Once you understand the relationships between your tables, use unions to append records to a consolidated table and joins to enrich your results with data from multiple sources.

Let's practice these concepts and pitfalls in our next lab.

Image (binoculars) cc0:
https://pixabay.com/en/binoculars-old-antique-equipment-354623/
Image (servers): https://cloud.google.com/data-transfer/

Lab 8
UNIONING and JOINING Datasets

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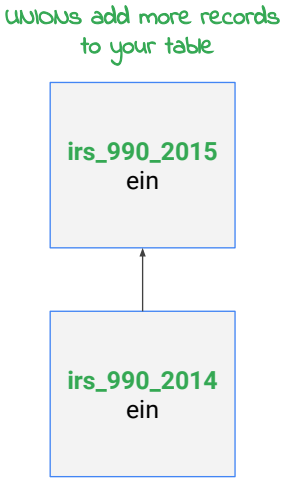
Lab 8 in Qwiklabs

UNIONING and JOINING Datasets

In this lab, you will learn how to apply SQL UNIONs and JOINs to enrich your dataset.



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