Explore the airlines data using dplyr and sql chunks

USCOTS 2025 breakout session

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Introduction

The current Quarto file analyzes airline flight data from the American Statistical Association's Data Expo 2024. Once the `1_download_data.qmd` Quarto file has been successfully rendered, you should be able to render the current file (`3_explore_dplyr.qmd`) which shows off **dplyr** syntax and `sql` chunks while analyzing the downloaded data.

See https://community.amstat.org/dataexpo/home for more information on the data.

See https://beanumber.github.io/abdwr3e/12-large.html and https://mdsr-book.github.io/mdsr3e/15-sqlI.html for resources on databases in R.

See https://hardin47.netlify.app/courses/sds261-sql/ for an accessible overview of SQL and databases.

Check for files

First we check that the files are where we expect. If you run the code below with no errors, you are ready to go! (If you run into problems, try rendering the file or "Change Working Directory" to "File Location" under the "Session" Menu in RStudio.

```
folder_name <- "data_airlines"
stopifnot(file.exists(folder_name))
stopifnot(file.exists(paste0(folder_name, "/Year=2024/data_0.parquet")))
```

Check reading via DuckDb

We begin by creating an in-memory database using DuckDb, which is just a placeholder that we can reference.

```
con_duckdb <- DBI::dbConnect(duckdb::duckdb())
```

Accessing databases using dplyr

Here we use a `tbl` (like a `tibble`, but it lives remotely) to create a shadow data frame from which we can query using **dplyr** wrangling verbs. Note that the work done on the `tbl` **feels** just like working on a `tibble`, but the `tbl` object does not live in your local R environment.

```
flights_duckdb <- tbl(
  con_duckdb,
  paste0("read_parquet('", folder_name, "/Year*/*.parquet')"))

# size of pointer:
object.size(flights_duckdb |> filter(Year == 2024, Month == 3))
```

```
75784 bytes
```

```
# size if you collect the object:
object.size(flights_duckdb |> filter(Year == 2024, Month == 3) |> collect())
```

```
522179168 bytes
```

Which destinations are most delayed?

The following query uses the `flights_duckdb` object to group by destination and summarize the number of flights and average arrival delay.

```
delayedflights <- flights_duckdb |>
  group_by(Dest) |>
  summarise(n = n(),
            avg_delay = mean(ArrDelay, na.rm = TRUE),
            .groups = "drop") |>
  arrange(desc(avg_delay)) |>
  head(10)

delayedflights
```

```
# Source:     SQL [?? x 3]
# Database:   DuckDB v1.1.2 [root@Darwin 24.5.0:R 4.4.2/:memory:]
# Ordered by: desc(avg_delay)
   Dest      n avg_delay
   <chr> <dbl>     <dbl>
 1 HOB      78      92.3
 2 PVU    3003      31.6
 3 SMX     160      26.4
 4 PSE    1675      22.3
 5 BQN    4267      20.5
 6 OWB      43      19.0
 7 SFB   14023      18.1
 8 CMX    1068      17.9
 9 ASE   10899      17.6
10 PRC    1087      17.3
```

```
show_query(delayedflights)
```

```
<SQL>
```

```
SELECT Dest, COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM (FROM read_parquet('data_airlines/Year*/*.parquet')) q01
GROUP BY Dest
ORDER BY avg_delay DESC
LIMIT 10
```

We note that the largest delays tend to be for airports that have relatively few flights (e.g., `HOB` is Lea County Regional Airport near Hobbs, Nevada, Wikipedia). An exception is Orlando Airport (`SFB`, https://flysfb.com), which has a large number of flights and relatively large average delay.

How many flights are there each month?

```
aggregation_query <- flights_duckdb |>
  filter(Month %in% c(1,2,3,4,5)) |>
  group_by(Month, Year) |>
  summarise(
    n = n(),
    avg_delay = mean(ArrDelay, na.rm = TRUE),
    .groups = "drop"
  ) |>
  arrange(Year, Month)

aggregation_query
```

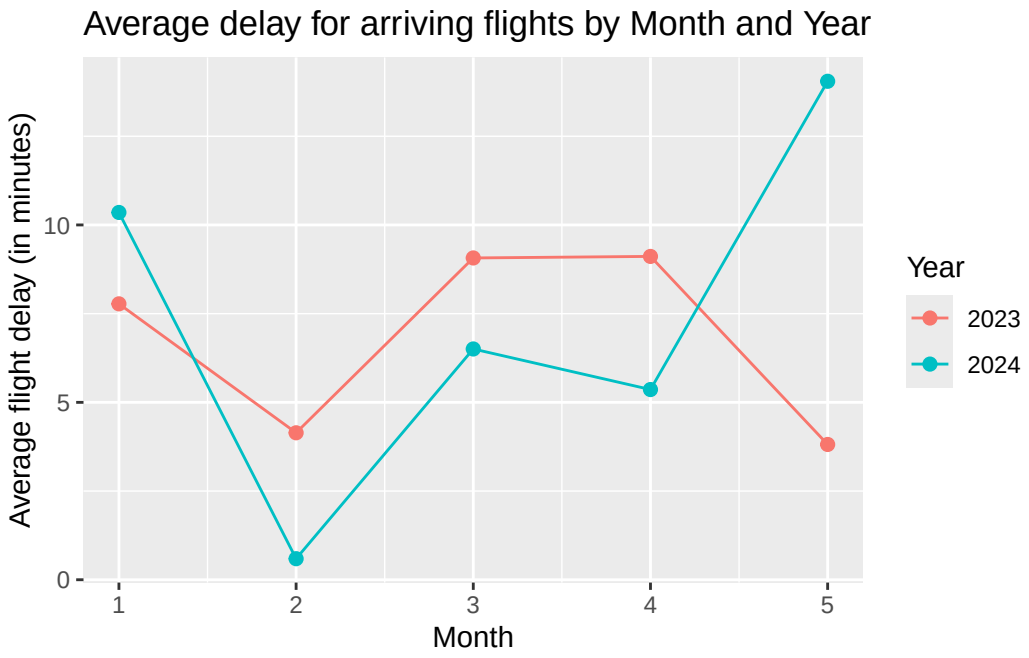
```
# Source:     SQL [?? x 4]
# Database:   DuckDB v1.1.2 [root@Darwin 24.5.0:R 4.4.2/:memory:]
# Ordered by: Year, Month
   Month  Year      n avg_delay
   <dbl> <dbl>  <dbl>     <dbl>
 1     1  2023 538837     7.78
 2     2  2023 502749     4.14
 3     3  2023 580322     9.07
 4     4  2023 561441     9.11
 5     5  2023 579958     3.81
 6     1  2024 547271    10.4
 7     2  2024 519221     0.593
 8     3  2024 591767     6.50
 9     4  2024 582185     5.36
10     5  2024 609743    14.0
```

```
show_query(aggregation_query)
```

```
<SQL>
SELECT "Month", "Year", COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM (
  SELECT q01.*
  FROM (FROM read_parquet('data_airlines/Year*/*.parquet')) q01
  WHERE ("Month" IN (1.0, 2.0, 3.0, 4.0, 5.0))
) q01
GROUP BY "Month", "Year"
ORDER BY "Year", "Month"
```

Even though the `tbl` (and the results from the SQL query) are remote objects that do not live in your environment, you can use them as if they were local, for example, by inputting the `tbl` into a ggplot. Here we both run the query and provide the translation to the underlying SQL call (see `2_explore_sql.qmd` for more SQL examples).

```
flights_duckdb |>
  filter(Month %in% c(1,2,3,4,5)) |>
  group_by(Month, Year) |>
  summarise(
    n = n(),
    avg_delay = mean(ArrDelay, na.rm = TRUE),
    .groups = "drop"
  ) |>
  arrange(Year, Month) |>
  ggplot(aes(x = Month, y = avg_delay, color = as.factor(Year))) +
  labs(
    title = "Average delay for arriving flights by Month and Year",
    x = "Month",
    y = "Average flight delay (in minutes)",
    color = "Year"
  ) +
  geom_point(size = 2) +
  geom_line()
```



Extension in dplyr

Use the following code chunk to answer your own question about the data using the `dplyr` interface.

Accessing databases using SQL chunks

Which destinations are most delayed?

We can re-use the SQL code that was translated from **dplyr**! (We don't need two `FROM` commands, but that is a conversation for a different day… or ask us!)

```sql
SELECT Dest, COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM read_parquet('data_airlines/Year*/*.parquet')
GROUP BY Dest
ORDER BY avg_delay DESC
LIMIT 10;
```

Table 1: Displaying records 1 - 10

Dest	n	avg_delay
HOB	78	92.32000
PVU	3003	31.60939
SMX	160	26.38217
PSE	1675	22.30938
BQN	4267	20.45772
OWB	43	19.02326
SFB	14023	18.12228
CMX	1068	17.93145
ASE	10899	17.61999
PRC	1087	17.26866

How many flights are there each month?

First, we'll re-use the SQL code that was translated from **dplyr**.

```
SELECT Month, Year, COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM (
  SELECT q01.*
  FROM (FROM read_parquet('data_airlines/Year*/*.parquet')) q01
  WHERE (Month IN (1.0, 2.0, 3.0, 4.0, 5.0))
) q01

GROUP BY Month, Year
ORDER BY Year, Month
```

Table 2: Displaying records 1 - 10

Month	Year	n	avg_delay
1	2023	538837	7.7763929
2	2023	502749	4.1419877
3	2023	580322	9.0699067
4	2023	561441	9.1129598
5	2023	579958	3.8132541
1	2024	547271	10.3522984
2	2024	519221	0.5934551
3	2024	591767	6.5044763
4	2024	582185	5.3605436

Month	Year	n	avg_delay
5	2024	609743	14.0494104

But there really isn't any need to do the nested `SELECT` & `FROM`. We could write more succinct SQL code that does the same thing.

```
SELECT Month, Year, COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM read_parquet('data_airlines/Year*/*.parquet')
WHERE (Month IN (1.0, 2.0, 3.0, 4.0, 5.0))
GROUP BY Month, Year
ORDER BY Year, Month
```

Table 3: Displaying records 1 - 10

Month	Year	n	avg_delay
1	2023	538837	7.7763929
2	2023	502749	4.1419877
3	2023	580322	9.0699067
4	2023	561441	9.1129598
5	2023	579958	3.8132541
1	2024	547271	10.3522984
2	2024	519221	0.5934551
3	2024	591767	6.5044763
4	2024	582185	5.3605436
5	2024	609743	14.0494104

Extension in SQL

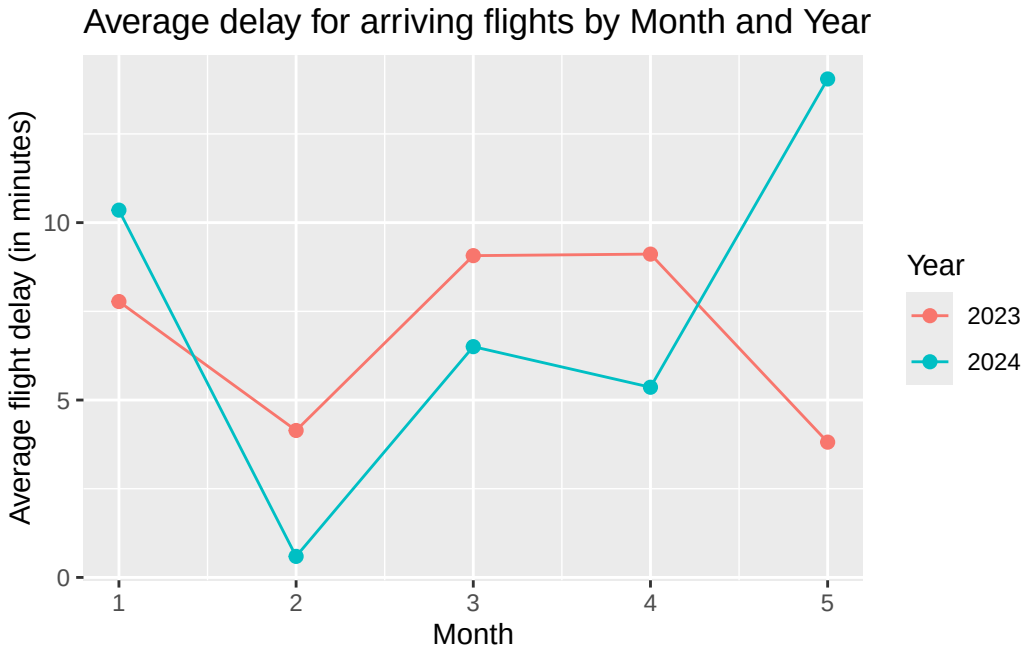
Use the following code chunk to answer your own question about the data using a `sql` chunk. (Also, change the other argument to `eval: true`.)

From SQL to R

But if you use a `sql` chunk, how can you plot the data? Within the `sql` chunk, add an argument specifying the name of the (local!) dataframewhich will be created from the SQL query. Note that ggplot above is plotting `flights_duckdb` (which is a `tbl` that lives on the hard drive) and here we are plotting `flights_from_sql` (which is a `tibble` that lives in RAM).

```
SELECT Month, Year, COUNT(*) AS n, AVG(ArrDelay) AS avg_delay
FROM read_parquet('data_airlines/Year*/*.parquet')
WHERE (Month IN (1.0, 2.0, 3.0, 4.0, 5.0))
GROUP BY Month, Year
ORDER BY Year, Month
```

```
flights_from_sql |>
  ggplot(aes(x = Month, y = avg_delay, color = as.factor(Year))) +
  labs(
    title = "Average delay for arriving flights by Month and Year",
    x = "Month",
    y = "Average flight delay (in minutes)",
    color = "Year"
  ) +
  geom_point(size = 2) +
  geom_line()
```



Closing the SQL connection

It is always good practice to close your connection when you are through with it (particularly important if you are accessing a remote database).

```r
DBI::dbDisconnect(con_duckdb)
```