Project Report
Milestone 3

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02/05/2023

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Introduction to Database Systems

(COL 362/COL 632)

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Overall Architecture

We've created a webapp that can be used following:

1. Visualization of different weather parameters like temperature, rainfall, etc. for different cities in India.
2. Current weather
3. Weather Forecast
4. Weather Alerts

When the server is started, the user would be on the landing page. On this page the user can select one of the parameters to visualize the data for that, sign up for alerts or see the current weather and forecasts. Once the user makes their selection, they are directed to the corresponding page.

For the weather parameters, once on the page, the user can select the states, cities, subdivisions, date(range or single), different attributes from the available options for each parameter after which the selections are appropriately visualized. For each attribute selected, a graph will be plotted in a new tab.

Next up, on the landing page, there is an option to see the current weather and weather forecasts. Once the user clicks on it, they are redirected to a page where they can select a state. After that they can select a city. Then the current weather details of the selected city are shown. Below that, there is dropdown from which the user can select the granularity of forecasts that they want.

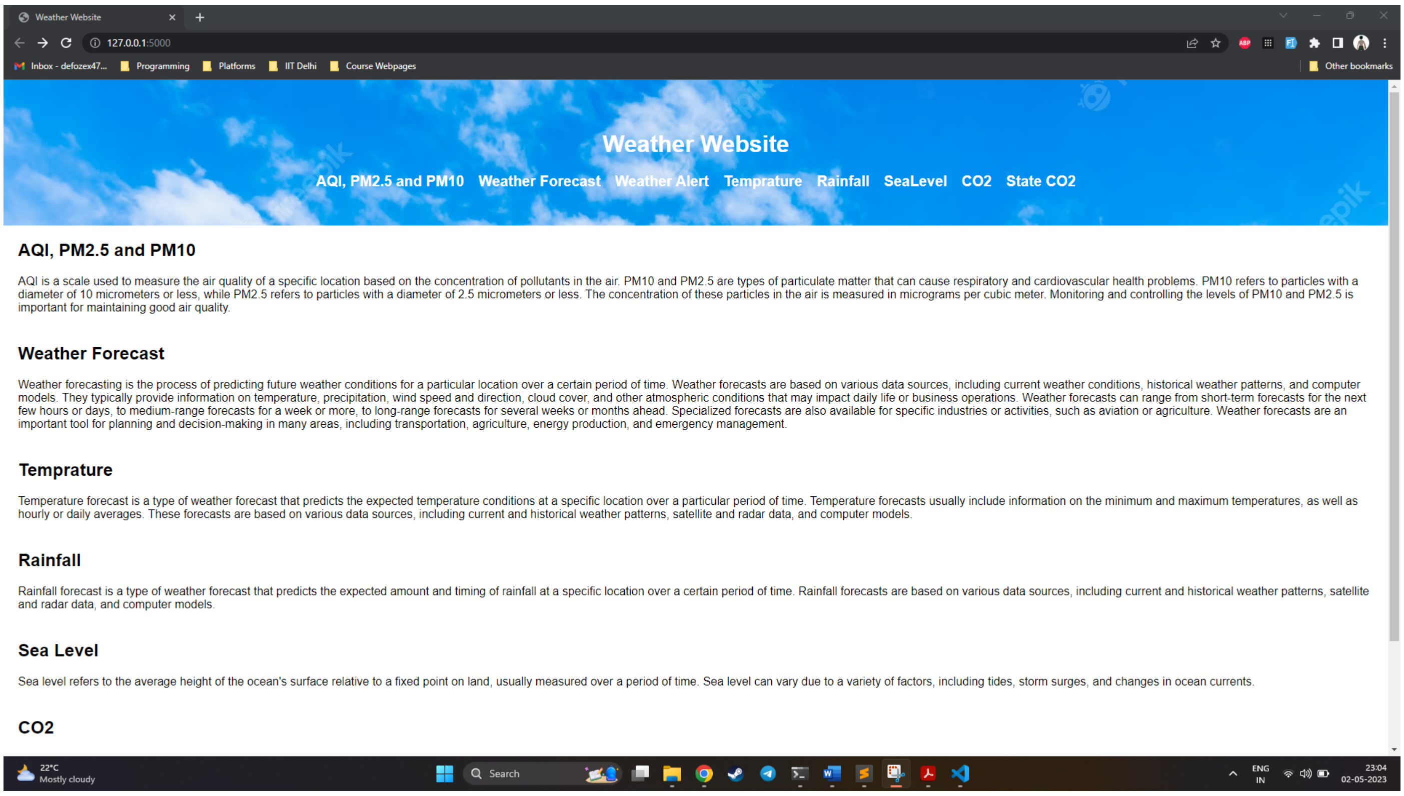
Also, on the landing there is an option for weather alerts. Once the user clicks on that, they are redirected to new page. On this page the user can sign up for weather alerts or can deregister from the same.

The dropdowns are populated by running appropriate SQL queries in the backend.
The data for current weather details, forecasts and alerts are fetched from OpenWeatherMap API. Ideally this should be done on the basis of database but since we could only find outdated data, we're fetching these from the API.
Before the demo, we might make some changes to the UI and add new features if the time permits.

We've used flask along with SQLAlchemy for the implementation along with some helper libraries.

Application Front End Design and Queries/Transactions

Landing page:



AQI, PM2.5 and PM10

AQI is a scale used to measure the air quality of a specific location based on the concentration of pollutants in the air. PM10 and PM2.5 are types of particulate matter that can cause respiratory and cardiovascular health problems. PM10 refers to particles with a diameter of 10 micrometers or less, while PM2.5 refers to particles with a diameter of 2.5 micrometers or less. The concentration of these particles in the air is measured in micrograms per cubic meter. Monitoring and controlling the levels of PM10 and PM2.5 is important for maintaining good air quality.

Weather Forecast

Weather forecasting is the process of predicting future weather conditions for a particular location over a certain period of time. Weather forecasts are based on various data sources, including current weather conditions, historical weather patterns, and computer models. They typically provide information on temperature, precipitation, wind speed and direction, cloud cover, and other atmospheric conditions that may impact daily life or business operations. Weather forecasts can range from short-term forecasts for the next few hours or days, to medium-range forecasts for a week or more, to long-range forecasts for several weeks or months ahead. Specialized forecasts are also available for specific industries or activities, such as aviation or agriculture. Weather forecasts are an important tool for planning and decision-making in many areas, including transportation, agriculture, energy production, and emergency management.

Temprature

Temperature forecast is a type of weather forecast that predicts the expected temperature conditions at a specific location over a particular period of time. Temperature forecasts usually include information on the minimum and maximum temperatures, as well as hourly or daily averages. These forecasts are based on various data sources, including current and historical weather patterns, satellite and radar data, and computer models.

Rainfall

Rainfall forecast is a type of weather forecast that predicts the expected amount and timing of rainfall at a specific location over a certain period of time. Rainfall forecasts are based on various data sources, including current and historical weather patterns, satellite and radar data, and computer models.

Sea Level

Sea level refers to the average height of the ocean's surface relative to a fixed point on land, usually measured over a period of time. Sea level can vary due to a variety of factors, including tides, storm surges, and changes in ocean currents.

CO2

Once the user makes a selection, they are directed to the appropriate page. For example, we'll select AQI. The user is then redirected to this page. Firstly, the dropdown for selection of a state is populated based on the data in the AQI table. The following query is used for this purpose:

```
        SELECT DISTINCT State FROM AQI;
```

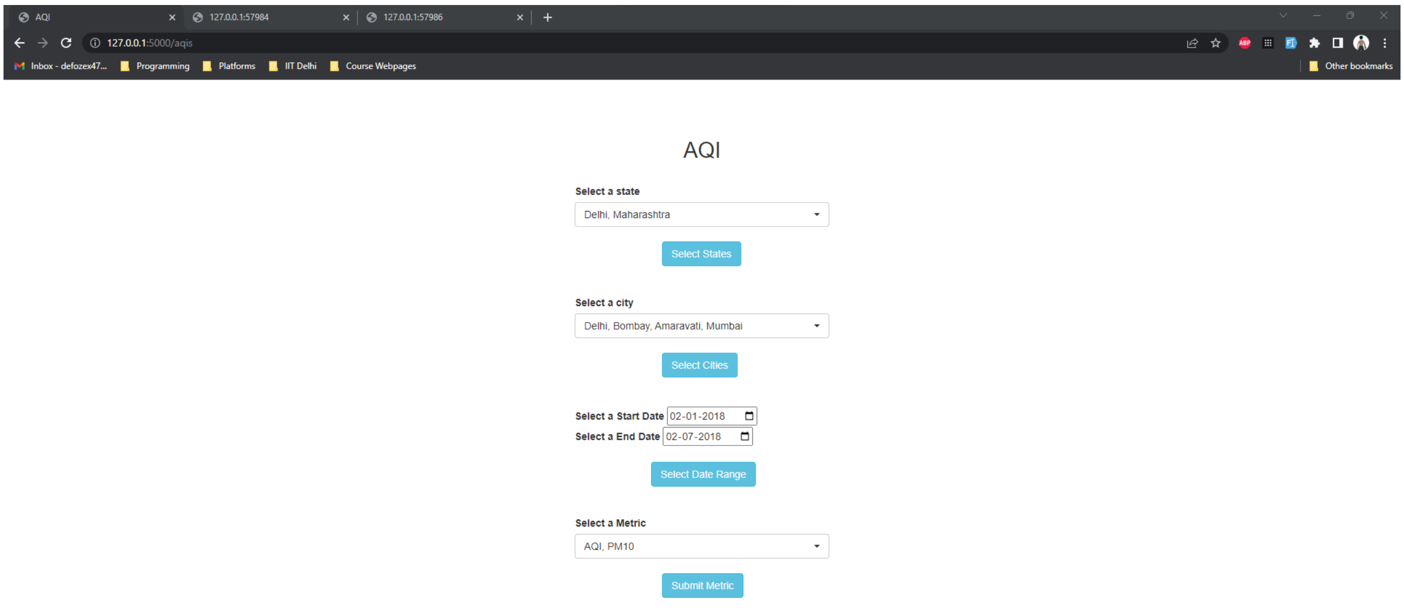
The based on the selected state(s), the dropdown for selection of a city is populated with the help of the following query:

```
        SELECT DISTINCT City FROM AQI WHERE State='Delhi' OR state = "Maharashtra";
```

Then the user selects a single date or a range of dates. One of the following queries is ran in the background after this selection and all the rows which satisfy all the conditions are fetched from the AQI table.

```
    --For dropdown--
        SELECT * FROM AQI WHERE State ='Gujarat';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE)='2015';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE)='2015' AND EXTRACT(MONTH FROM DATE)='01';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE)='2015' AND EXTRACT(MONTH FROM DATE)='01' AND EXTRACT(DAY FROM DATE)='01';
    --For dropdown and range--
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE) BETWEEN '2015' AND '2016';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE)='2015' AND EXTRACT(MONTH FROM DATE) BETWEEN '01' AND '03';
        SELECT * FROM AQI WHERE State='Gujarat' AND City='Ahmedabad' AND EXTRACT(YEAR FROM
DATE)='2015' AND EXTRACT(MONTH FROM DATE)='01' AND EXTRACT(DAY FROM DATE) BETWEEN '1' AND
'15';
```

The user then selects the attributes for which they want to visualize the data. For each attribute, we get a separate graph in a new tab.



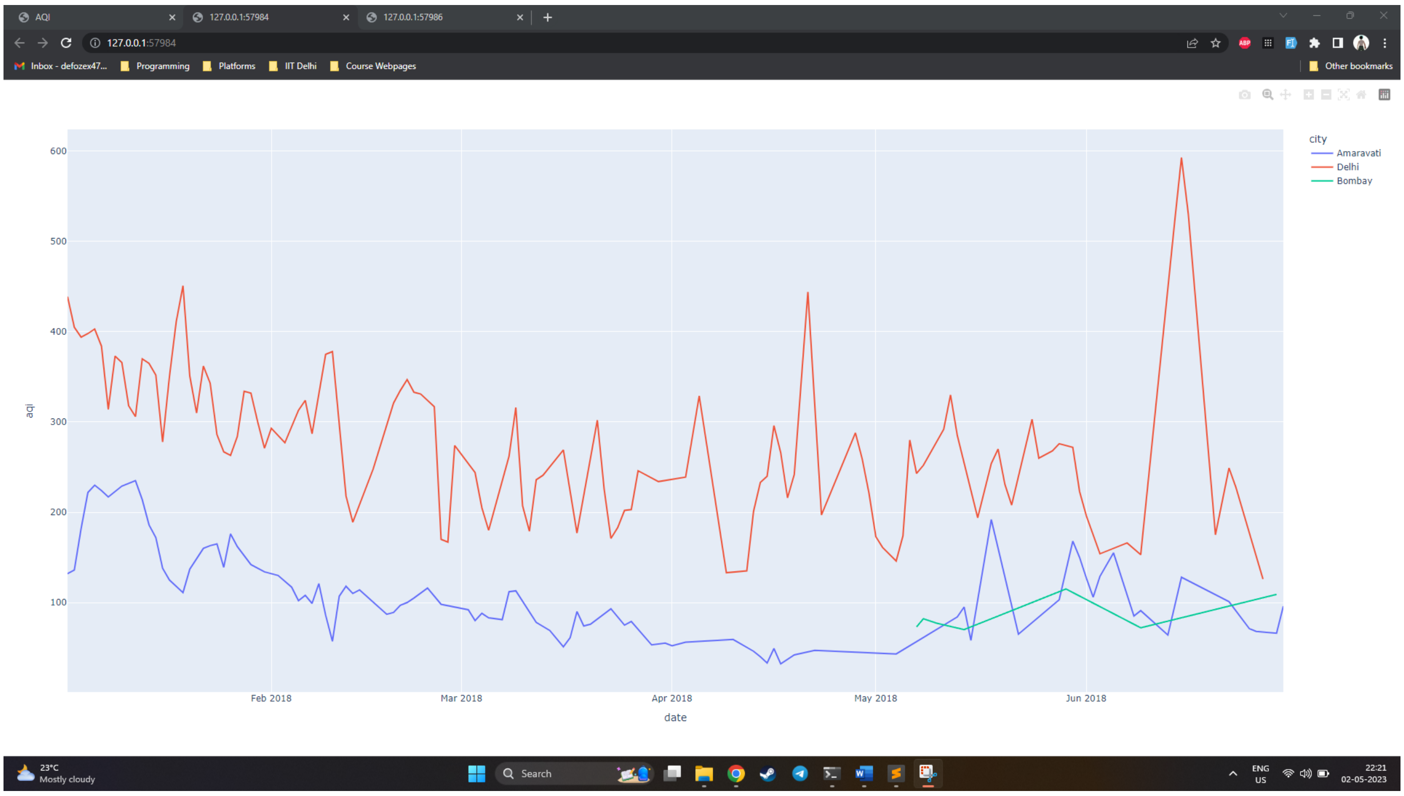
AQI

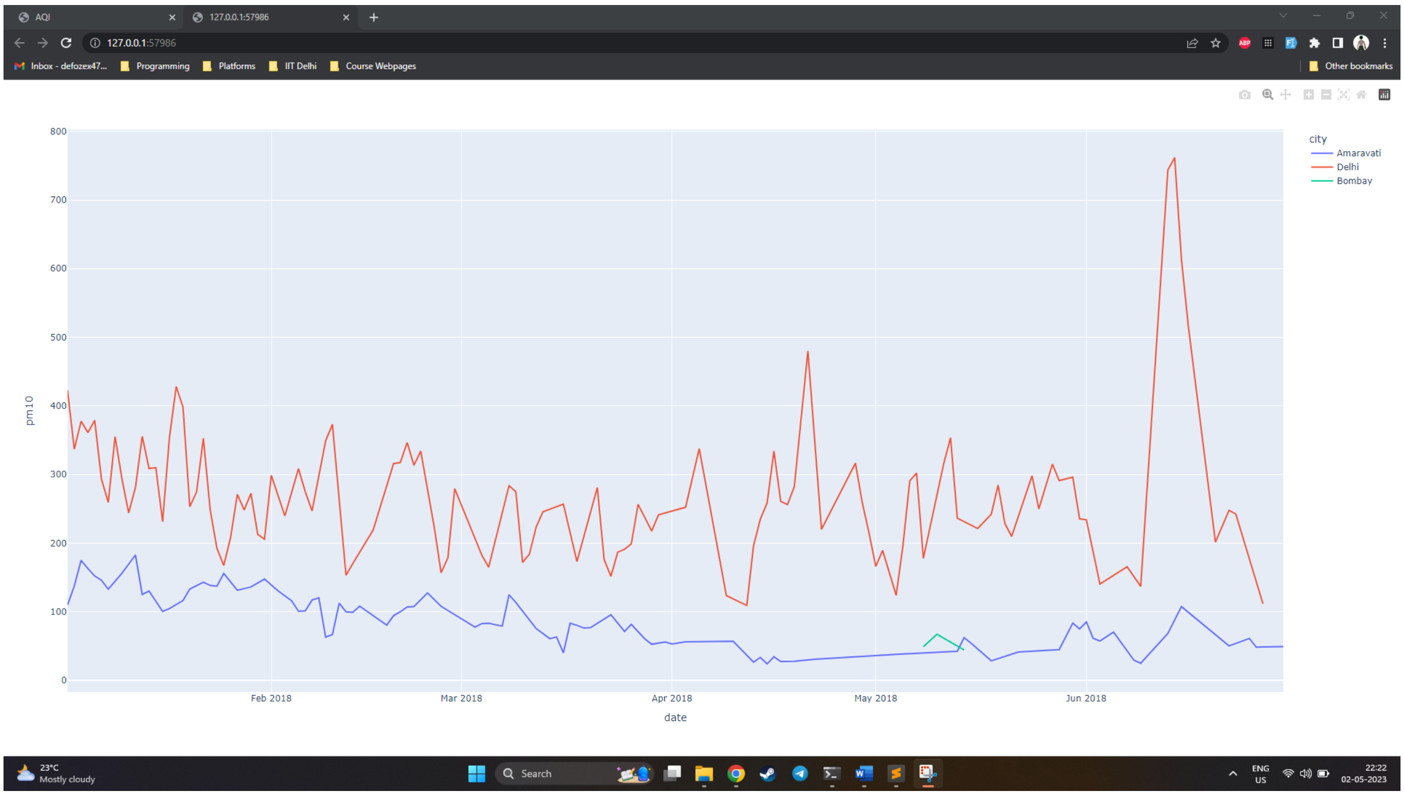
Select a state
Delhi, Maharashtra
Select States

Select a city
Delhi, Bombay, Amaravati, Mumbai
Select Cities

Select a Start Date 02-01-2018
Select a End Date 02-07-2018
Select Date Range

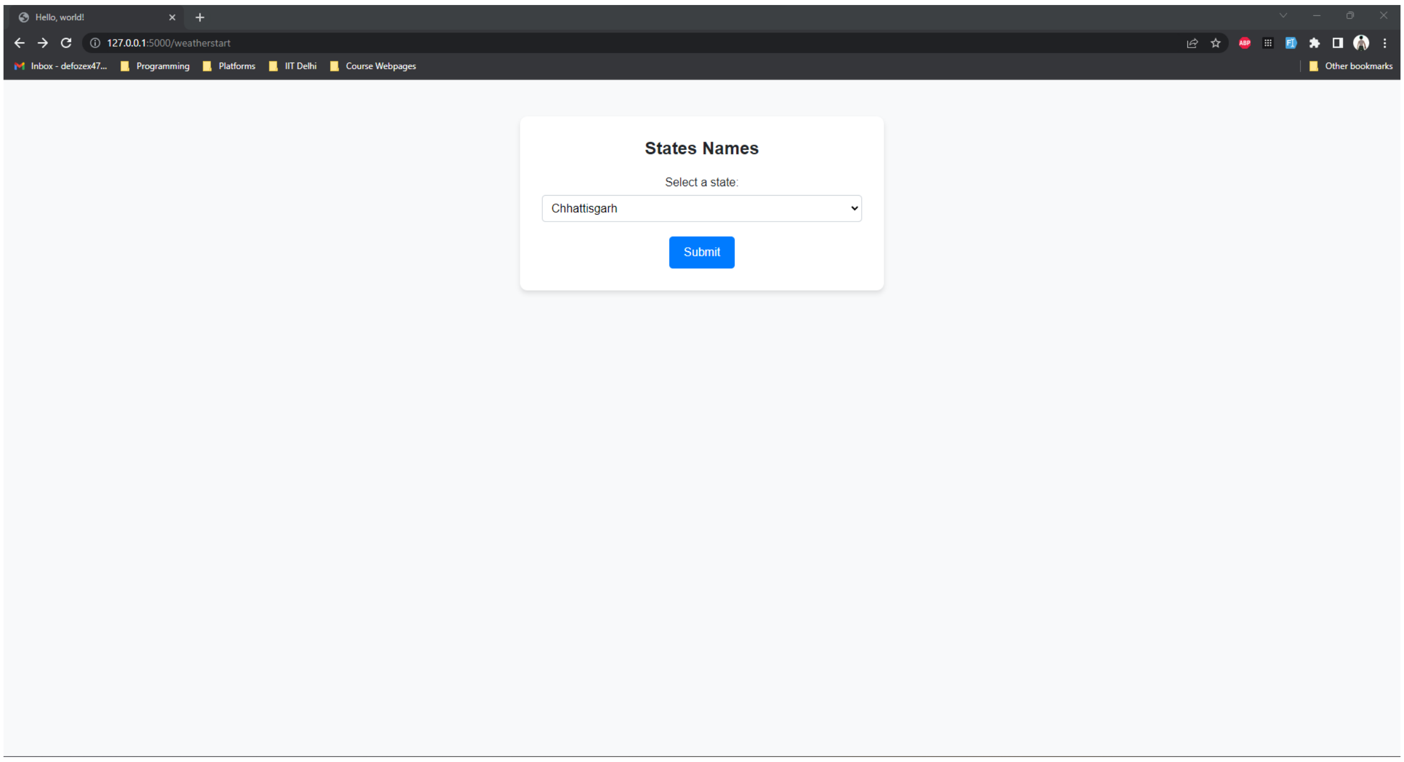
Select a Metric
AQI, PM10
Submit Metric

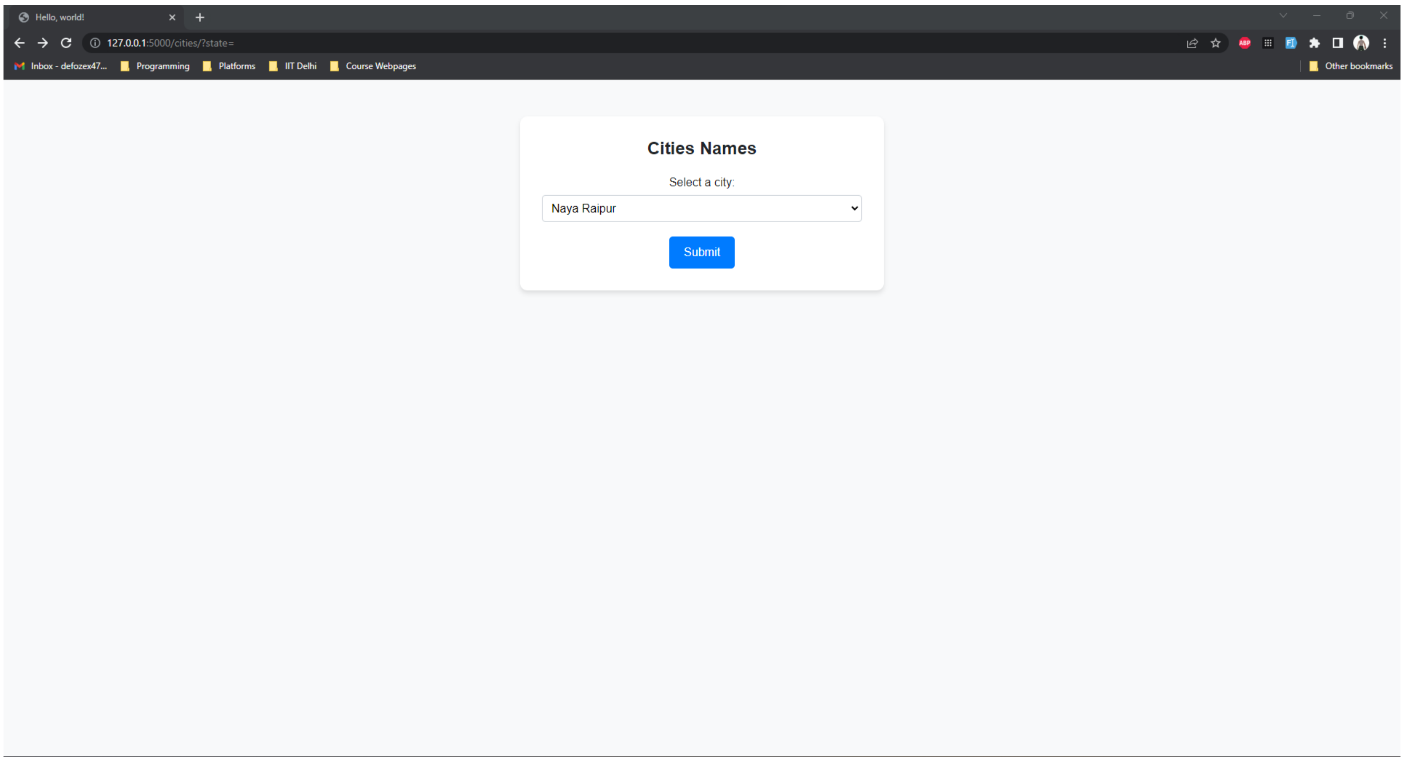

AQI
127.0.0.1:57984
127.0.0.1:57986
127.0.0.1:57984
Inbox - defozex47...
Programming
Platforms
IIT Delhi
Course Webpages
Other bookmarks
city
Amaravati
Delhi
Bombay
aqi
600
500
400
300
200
100
Feb 2018
Mar 2018
Apr 2018
May 2018
Jun 2018
date
23°C
Mostly cloudy
Search
ENG
US
22:21
02-05-2023


AQI
127.0.0.1:57986
127.0.0.1:57986
Inbox - defozex47...
Programming
Platforms
IIT Delhi
Course Webpages
Other bookmarks
city
Amaravati
Delhi
Bombay
pm10
800
700
600
500
400
300
200
100
0
Feb 2018
Mar 2018
Apr 2018
May 2018
Jun 2018
date
23°C
Mostly cloudy
Search
ENG
US
22:22
02-05-2023

Current weather and forecasts:

Once the user selects a state and a city, they are shown the current weather for that region. Below that they have the options to see weather forecasts for that region with different granularities. The daily forecasts are also stored in the database.

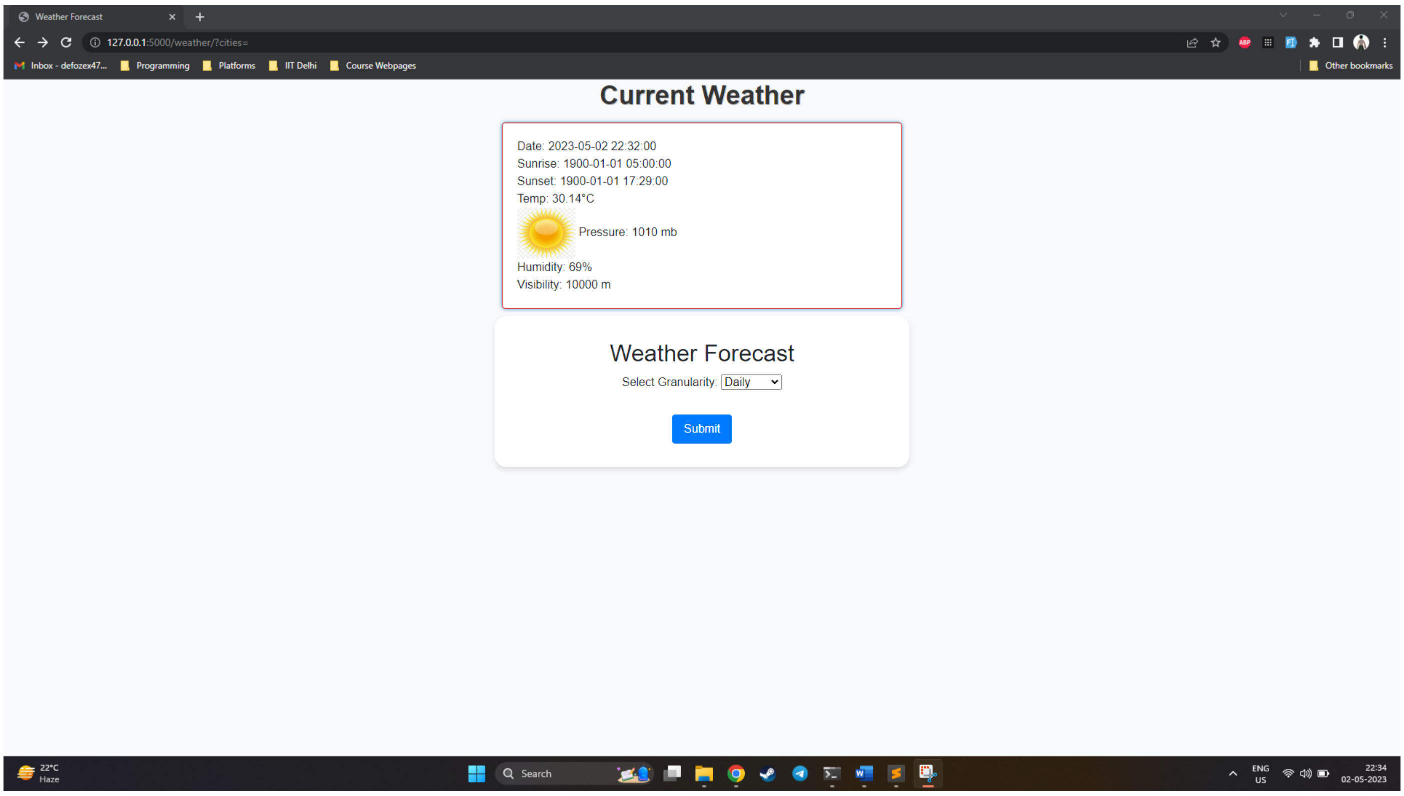




Cities Names

Select a city: Naya Raipur

Submit



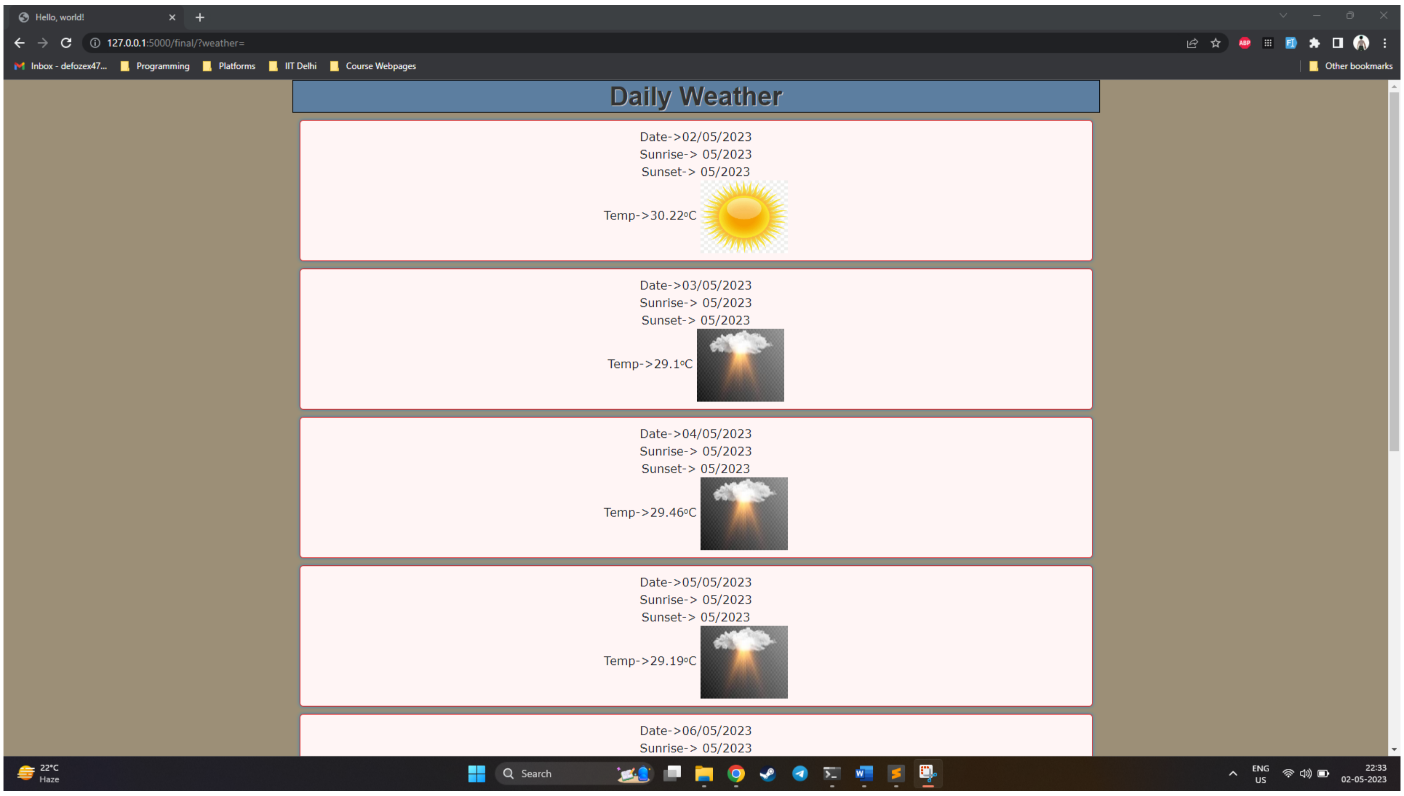
Current Weather

Date: 2023-05-02 22:32:00
Sunrise: 1900-01-01 05:00:00
Sunset: 1900-01-01 17:29:00
Temp: 30.14°C
Pressure: 1010 mb
Humidity: 69%
Visibility: 10000 m

Weather Forecast

Select Granularity: Daily

Submit


Daily Weather

Date->02/05/2023
Sunrise-> 05/2023
Sunset-> 05/2023
Temp->30.22ºC

Date->03/05/2023
Sunrise-> 05/2023
Sunset-> 05/2023
Temp->29.1ºC

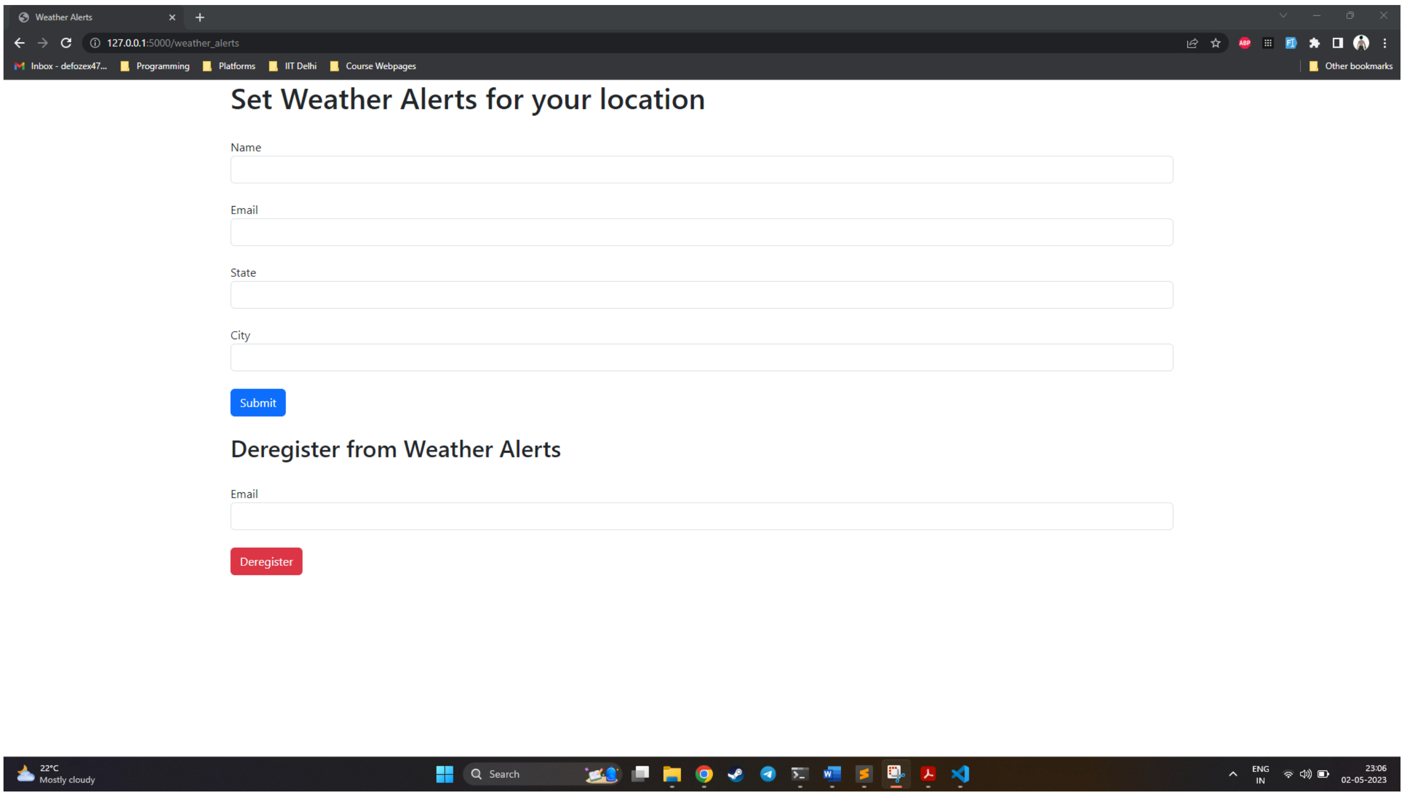
Date->04/05/2023
Sunrise-> 05/2023
Sunset-> 05/2023
Temp->29.46ºC

Date->05/05/2023
Sunrise-> 05/2023
Sunset-> 05/2023
Temp->29.19ºC

Date->06/05/2023
Sunrise-> 05/2023

Weather Alerts:

Once a user signs up for alerts, their details are stored in the database. Then everytime the server is started, a procedure calls the OpenWeatherMap API for every entry in the "weather_alerts" table. If there is an alert in the area, a email is sent to the user with the details of the alert.
The user can opt out of the alerts through the same page. On opting out, the users details are deleted from the database.



127.0.0.1:5000/weather_alerts

Set Weather Alerts for your location

Name

Email

State

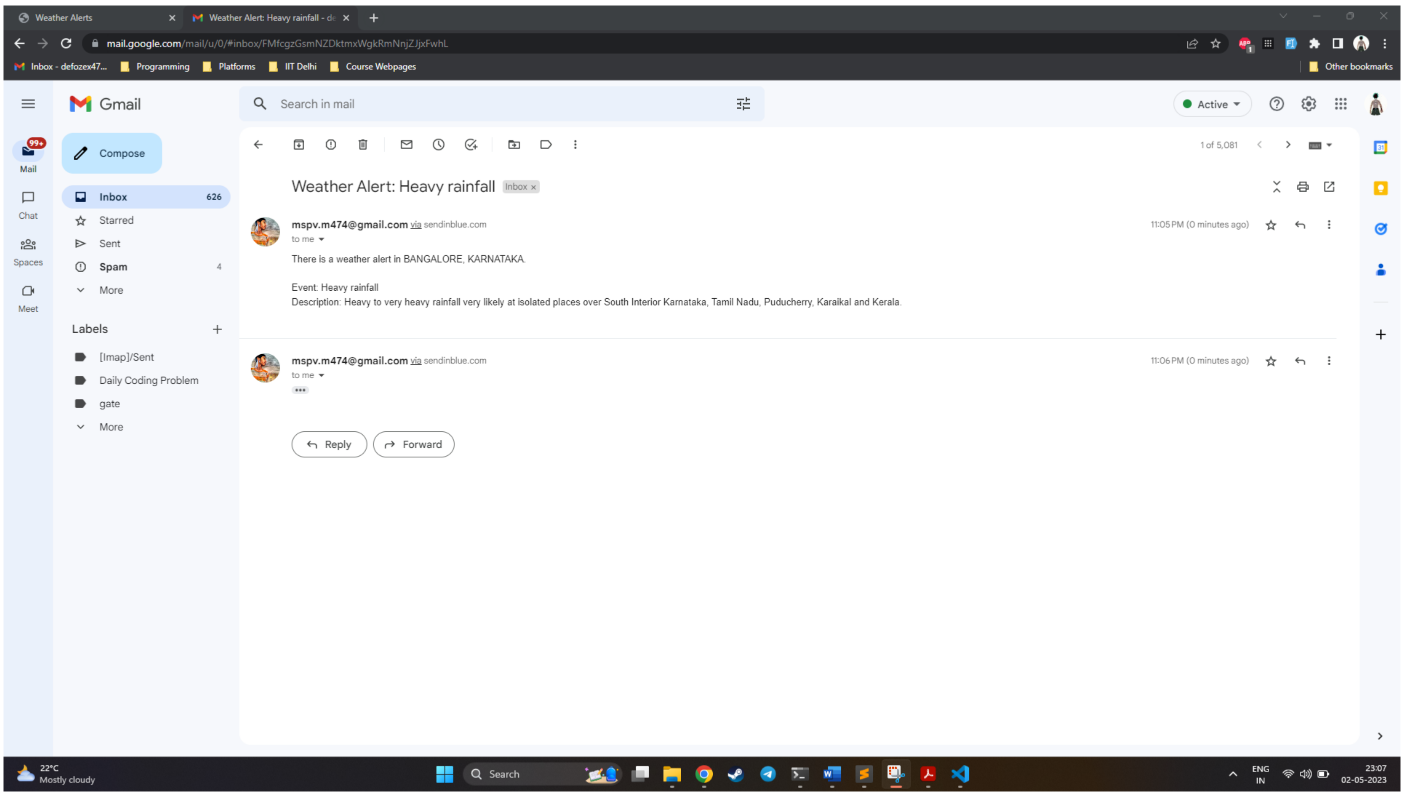
City

Submit

Deregister from Weather Alerts

Email

Deregister



mail.google.com/mail/u/0/#inbox/FMfcgzGsmNZDktmxWgkRmNnjZJjxFwhL

Weather Alert: Heavy rainfall Inbox

mspv.m474@gmail.com via sendinblue.com 11:05 PM (0 minutes ago)
to me

There is a weather alert in BANGALORE, KARNATAKA.

Event: Heavy rainfall
Description: Heavy to very heavy rainfall very likely at isolated places over South Interior Karnataka, Tamil Nadu, Puducherry, Karaikal and Kerala.

mspv.m474@gmail.com via sendinblue.com 11:06 PM (0 minutes ago)
to me

Reply Forward

Database Features Implemented

1. Deferred foreign key constraints on states and cities mitigating the circular dependency.
2. ON DELETE CASCADE on all the foreign keys.
3. Indexes
4. Trigger for data integrity.

   Ensuring that a new entry in the Average_Temperature table has a valid temperature value.

```
CREATE OR REPLACE FUNCTION check_valid_temperature()
RETURNS TRIGGER AS $$
BEGIN
IF NEW.Average_Temperature < -273.15 THEN
    RAISE EXCEPTION 'Invalid temperature value: below absolute zero.';
END IF;
RETURN NEW;
END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER trg_check_valid_temperature
BEFORE INSERT OR UPDATE ON Average_Temperature
FOR EACH ROW
EXECUTE PROCEDURE check_valid_temperature();
```

5. Trigger for cascading actions.

   If the capital of a state is updated, then it is also updated in all the relevent tables.

```
CREATE OR REPLACE FUNCTION update_state_capital()
RETURNS TRIGGER AS $$
BEGIN
-- Check if the capital has changed
IF OLD.Capital <> NEW.Capital THEN
    -- Update the capital in the Cities table
    UPDATE Cities
    SET City = NEW.Capital
    WHERE City = OLD.Capital
    AND State = NEW.State;

    -- Update the capital in the Sealevel table
    UPDATE Sealevel
    SET Sea_Shore_City = NEW.Capital
    WHERE Sea_Shore_City = OLD.Capital
    AND State = NEW.State;
END IF;
RETURN NEW;
END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER trg_update_state_capital
AFTER UPDATE ON States
FOR EACH ROW
EXECUTE PROCEDURE update_state_capital();
```

6. Trigger for auto updates.

   Automatically calculating the Annual and quarterly rainfall in the Rainfall table based on the monthly values.

```
CREATE OR REPLACE FUNCTION calculate_annual_quarterly_rainfall()
RETURNS TRIGGER AS $$
BEGIN
    -- Calculate Annual rainfall
    NEW.Annual = COALESCE(NEW.January, 0) + COALESCE(NEW.February, 0) +
COALESCE(NEW.March, 0) + COALESCE(NEW.April, 0)
                + COALESCE(NEW.May, 0) + COALESCE(NEW.June, 0) + COALESCE(NEW.July, 0) +
COALESCE(NEW.August, 0)
                + COALESCE(NEW.September, 0) + COALESCE(NEW.October, 0) +
COALESCE(NEW.November, 0) + COALESCE(NEW.December, 0);

    -- Calculate quarterly rainfall
    NEW.January_February = COALESCE(NEW.January, 0) + COALESCE(NEW.February, 0);
    NEW.March_May = COALESCE(NEW.March, 0) + COALESCE(NEW.April, 0) + COALESCE(NEW.May,
0);
    NEW.June_September = COALESCE(NEW.June, 0) + COALESCE(NEW.July, 0) +
COALESCE(NEW.August, 0) + COALESCE(NEW.September, 0);
    NEW.October_December = COALESCE(NEW.October, 0) + COALESCE(NEW.November, 0) +
COALESCE(NEW.December, 0);

    RETURN NEW;
END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER trg_calculate_annual_quarterly_rainfall
BEFORE INSERT OR UPDATE ON Rainfall
FOR EACH ROW
EXECUTE PROCEDURE calculate_annual_quarterly_rainfall();
```

7. Logging - Created a log table which tracks changes in the average_temperature table.
8. Trigger for logging.

   Created a trigger to log changes in the average_temperature table.

```
CREATE OR REPLACE FUNCTION average_temperature_audit_trigger_func()
RETURNS TRIGGER AS $$
BEGIN
    IF TG_OP = 'UPDATE' THEN
        INSERT INTO average_temperature_audit (
            operation, state, month, year,
            old_avg_temperature, new_avg_temperature,
            old_avg_temperature_uncertainty, new_avg_temperature_uncertainty,
            changed_by, changed_at
        )
        VALUES (
            'UPDATE', NEW.state, NEW.month, NEW.year,
            OLD.average_temperature, NEW.average_temperature,
            OLD.average_temperature_uncertainty, NEW.average_temperature_uncertainty,
            current_user, current_timestamp
        );
        RETURN NEW;
    ELSIF TG_OP = 'DELETE' THEN
        INSERT INTO average_temperature_audit (
            operation, state, month, year,
            old_avg_temperature, new_avg_temperature,
            old_avg_temperature_uncertainty, new_avg_temperature_uncertainty,
            changed_by, changed_at
        )
        VALUES (
            'DELETE', OLD.state, OLD.month, OLD.year,
            OLD.average_temperature, NULL,
            OLD.average_temperature_uncertainty, NULL,
            current_user, current_timestamp
        );
        RETURN OLD;
    ELSIF TG_OP = 'INSERT' THEN
        INSERT INTO average_temperature_audit (
            operation, state, month, year,
            old_avg_temperature, new_avg_temperature,
            old_avg_temperature_uncertainty, new_avg_temperature_uncertainty,
            changed_by, changed_at
        )
        VALUES (
            'INSERT', NEW.state, NEW.month, NEW.year,
            NULL, NEW.average_temperature,
            NULL, NEW.average_temperature_uncertainty,
            current_user, current_timestamp
        );
        RETURN NEW;
    END IF;
END;
$$ LANGUAGE plpgsql;

CREATE TRIGGER average_temperature_audit_trigger
AFTER INSERT OR UPDATE OR DELETE ON average_temperature
FOR EACH ROW
EXECUTE PROCEDURE average_temperature_audit_trigger_func();
```

9. Materialized Views

Created a materialized view to display the total CO2 emissions for each state.

```
        CREATE MATERIALIZED VIEW total_state_co2_emissions AS
        SELECT State, SUM(CO2_Emissions) as total_co2_emissions
        FROM State_CO2
        GROUP BY State;
```

Created a materialized view that'll keep tab on all the cities where aqi quality bucket has been "Very Poor" in the past decade.

```
              CREATE MATERIALIZED VIEW severe_aqi_cities_past_decade AS
        SELECT
            City,
            State,
            COUNT(*) AS num_severe_days
        FROM
            AQI
        WHERE
            AQI_Bucket = 'Very Poor'
            AND Date >= (current_date - INTERVAL '10 years')
        GROUP BY
            City, State
        HAVING
            COUNT(*) > 0
        ORDER BY
            num_severe_days DESC;
```

Demonstration Senario

All the features mentioned above will be available during demonstration. We might add some new features if time permits.

Notes:

1. Will make changes to the UI after the majors.
2. We don't have a lot of update/inserts/deletion queries as they don't make much sense since this is visualization project. That being said, inserts are done in a couple of transactions like signing up for weather alerts, daily weather forecasts and for logging.
3. Will add more database features later if they make sense.
4. For triggers, we've implemented one trigger for each valid use case that we can think of. No unnecessary stuff or features are implemented.
5. We've used SQLAlchemy for interaction with the database. Since it is ORM, the queries that we provided in the milestone 2 are not run as it is, like in the case of psycopg2.
6. For the most part, the queries are simple. But they will change a bit based on the selections that the user makes.