# Real-Time Air Quality Monitoring & Weather Forecasting System

## by team

## code warriors

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**SUMMARY**

The project is about creating user interactive dashboards on weather and air quality index by using different types of analytical tools . The main agenda of this project is to show the air quality index of the cities and weather data to the user. Data is collected from different resources and used those data for creating dashboards using analytical tools and a website is created so that user can interact with these dashboards effectively.

**Abstract**

Air pollution represents a serious environmental problem. Each year, millions premature deaths are attributed to air pollution, with huge economic consequences . Furthermore, air pollution is detrimental for ecosystems, damages property, impacts visibility and haze, and threatens food and water security.Air Quality Forecasts, if they are reliable and sufficiently accurate, can play an important role as part of an air quality management system The air quality (AQ) Forecast lets the public know expected air quality conditions for next 72 hours so that Government authorities can take action to manage the air quality and issue health advisories. Local air quality affects how you live and breathe.With the help of WeatherAPI we can get immediate access to local weather conditions and upcoming forecast, It will Providing real-time notifications about prevailing and expected weather conditions.which Helps governments and local administrations prepare for natural disasters and save lives.

# 1) INTRODUCTION

## 1.1) Overview & Purpose

Energy consumption and its consequences are inevitable in modern age human activities. The anthropogenic sources of air pollution include emissions from industrial plants,automobiles, planes, burning of straw, coal, and kerosene, aerosol cans, etc. Various dangerous pollutants like CO, CO2, Particulate Matter (PM), NO2, SO2, O3, NH3, Pb, etc. are being released into our environment every day. Chemicals and particles constituting air pollution affect the health of humans, animals, and even plants. Air pollution can cause a multitude of serious diseases in humans, from bronchitis to heart disease, from pneumonia

to lung cancer, etc. Poor air conditions lead to other contemporary environmental issues like global warming, acid rain, reduced visibility, smog, aerosol formation, climate change, and premature deaths. The greenhouse gases adversely affect climate conditions and consequently, the growth of plants.The Air Quality Index (AQI), an assessment parameter is related to public health directly. A higher level of AQI indicates more dangerous exposure for the human population.

Weather forecasting means the prediction of the weather through the application of the principles of physics, supplemented by a variety of statistical and empirical techniques. In addition to predictions of atmospheric phenomena themselves, weather forecasting includes predictions of changes on the Earth's surface climate. These changes are caused by atmospheric conditions like snow and ice cover, storm tides, and floods. This is used today in weather stations and on television weather reports all over the world. All can happen only through a comprehensive weather forecast. Any weather prediction needs a systematic collection of weather record of various places and proper analysis using the data for prediction.

## 2) LITERATURE SURVEY

### 2.1 Existing problem

There are different Air Quality Prediction Models operationally run under the air quality early warning system (AQ-EWS).

(i) Weather Research and Forecasting model coupled with chemistry (WRF-Chem).

(ii) System for Integrated modeLling of Atmospheric composition (SILAM) .

(iii) High resolution model ENvironmental information FUsion SERvice (ENFUSER).

(iv) NCMRWF Unified Model (NCUM) Dust-Forecast

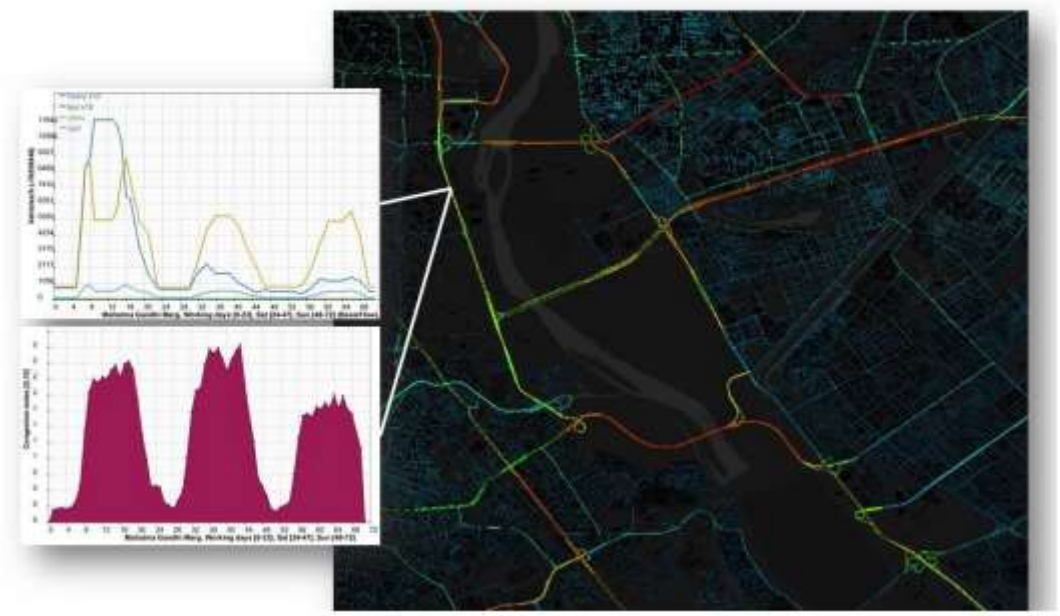
(v) HYSPLIT Backward and Forward Trajectories.

**2.2)Proposed Solution**

**Analytical tools used:**

1. seaborn
2. pandas
3. matplotlib
4. tensorflow
5. sklearn
6. plotpy
7. statistic models
8. flask

**Statistics of various pollutants and AQI in the CPCB datase**



## Data preprocessing

The preprocessing steps help in reducing the noise present in the data which eventually increases the processing speed and generalization capability of ML algorithms.

Outliers and missing data are the two most common errors in data extraction and monitoring applications. The data preprocessing step performs various operations on data such as filling out not-a-number (NAN) data, removing or changing outlier data, etc.A large number of missing values may be existing due to a variety of factors, such as a station that can sense data but does not possess a device to record it.

All the missing values are filled with the median values against each feature to solve the missing data problem. Next, a normalisation process has been applied to standardize the data, ensuring that the significance of variables is unaffected by their ranges or units.

## Feature selection

The CPCB dataset under study involves a specific parameter viz, AQI and government agencies use this parameter to alert people about the quality of the air and also practice forecasting it. According to the National Ambient Air Quality Standards, there are six AQI categories: good (0–50), satisfactory (51–100), moderate (101–200), poor (201–300), very poor (301–400), and severe (401–500). Scholars in the realm suggest that reducing input variables lowers the computational cost of modeling and enhances prediction performance.Since many ML algorithms are sensitive to outliers, any feature in the input dataset which does not follow the general trend of that data must be found. For the present dataset, a correlation-based statistical outliers detection method has been applied to identify the outliers.

| AQI Category (Range) | $PM_{10}$ 24-hr | $PM_{2.5}$ 24-hr | $NO_2$ 24-hr | $O_3$ 8-hr | CO 8-hr (mg/m$^3$) | $SO_2$ 24-hr | $NH_3$ 24-hr | Pb 24-hr |
|---|---|---|---|---|---|---|---|---|
| Good (0-50) | 0-50 | 0-30 | 0-40 | 0-50 | 0-1.0 | 0-40 | 0-200 | 0-0.5 |
| Satisfactory (51-100) | 51-100 | 31-60 | 41-80 | 51-100 | 1.1-2.0 | 41-80 | 201-400 | 0.6-1.0 |
| Moderate (101-200) | 101-250 | 61-90 | 81-180 | 101-168 | 2.1- 10 | 81-380 | 401-800 | 1.1-2.0 |
| Poor (201-300) | 251-350 | 91-120 | 181-280 | 169-208 | 10.1-17 | 381-800 | 801-1200 | 2.1-3.0 |
| Very poor (301-400) | 351-430 | 121-250 | 281-400 | 209-748* | 17.1-34 | 801-1600 | 1201-1800 | 3.1-3.5 |
| Severe (401-500) | 430 + | 250+ | 400+ | 748+* | 34+ | 1600+ | 1800+ | 3.5+ |

## Exploratory data analysis

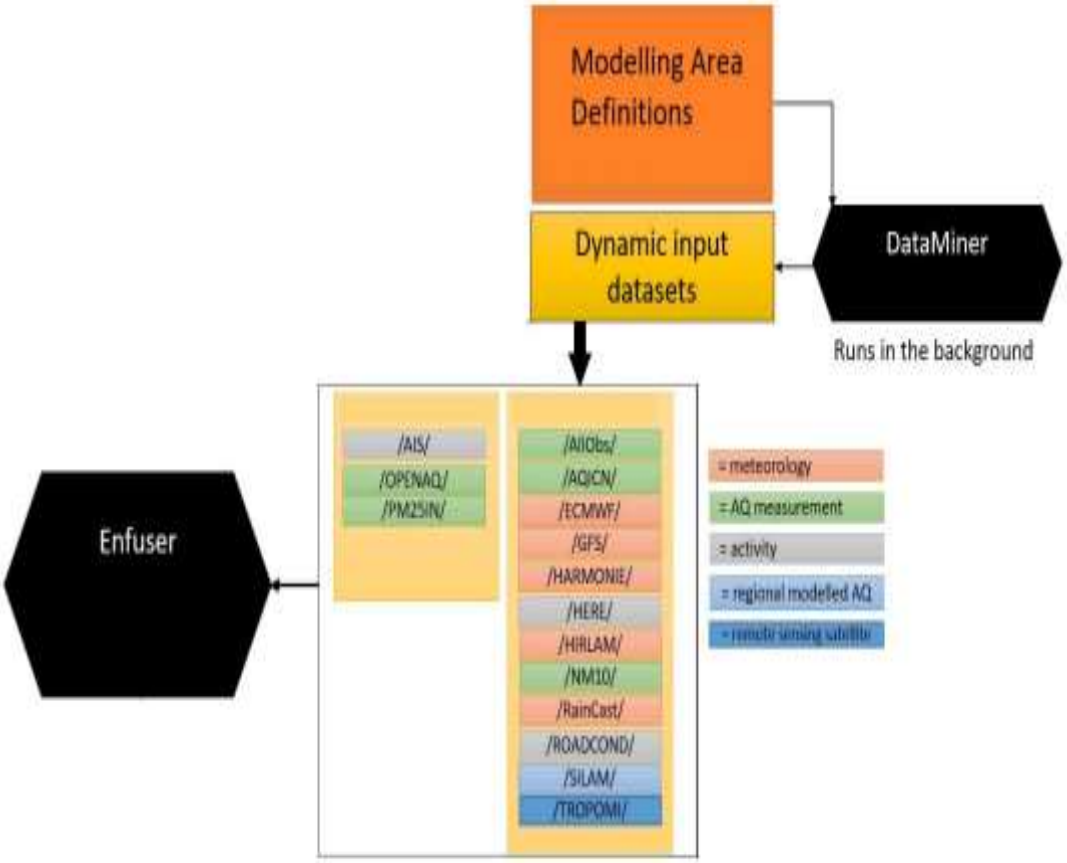
This section of the present study deals with data exploration and analysis for finding various hidden patterns present in the dataset. Exploratory data analysis is the first step in data analytics which is performed before applying any ML model. Under this, the following important things are being analyzed:

1. exploring statuses and trends of air pollutants over the past six years i.e. from 2015 to 2020.
2. exploring the distribution of pollutants in the air along with top-six polluted cities with their average AQI values.
3. estimating top four pollutants which are directly involved in increasing the AQI values.

## Exploring the trends of air pollutants over the last six years

India has become one of the few countries having the most severe air pollution resulting from rapid industrialization and booming urbanization over the last several years. Air pollution is among grave public health and environmental issues, and the Health Effects Institute (HEI) ranks it among the top five global risk factors for mortality (IHME 2019). According to the HEI research, the emission of PM was the third leading cause of death in 2017, and this rate was highest in India. Based on the emissions of PM2.5 and other pollutants, the World Health Organization (WHO) ranked India as the fifth most polluted country (Gurjar, 2021).The year 2020 witnessed the most strict lockdown in the history of mankind and ceased industrial, automobile, and aviation activities in India and the world served as some ambrosia for the ailing environment and air.

## 3)THEORITICAL ANALYSIS



## 3.2)Hardware/ Software designing

head node:

Intel(R) Xeon(R) CPU E5-2620 v2 (6 core) *2

64GB RAM

HDD: depend on your. recommend system disk with RAID1

2) compute nodes:

Intel(R) Xeon(R) CPU E5-2670 v2 (10 core) *2

64GB RAM

HDD: only need base system, so we chose 32GB SSD

3) inter-connect:  DDR Infiniband (20Gbps) <== keep from our old system. Now SHOULD upgrade to QDR or FDR

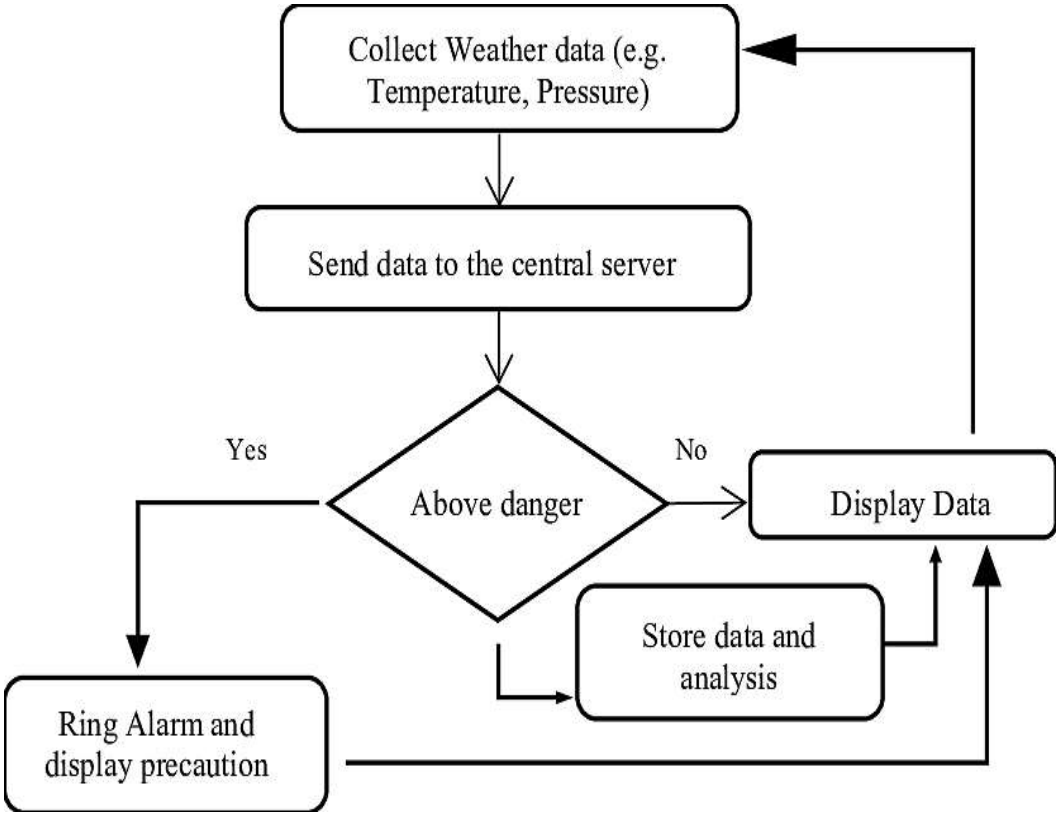
4) compiler & OS: CentOS 6.3 & INTEL 2015 compier (For our experiences, INTEL compiler + INTEL CPU ==> best performance)

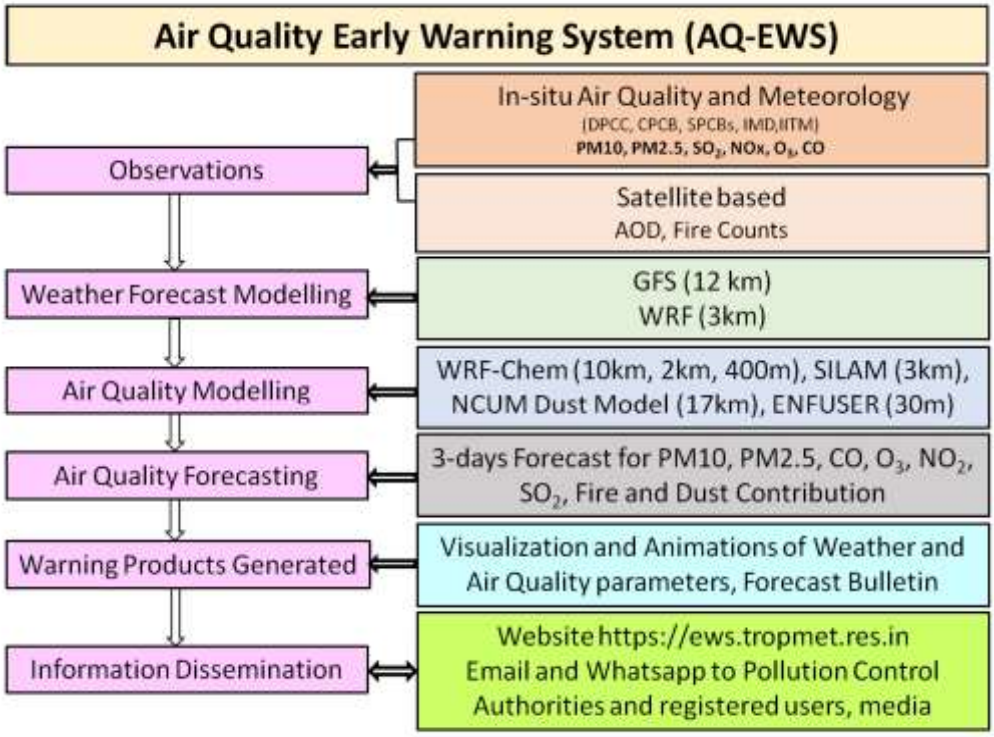
So, our system has  80 cores (4 nodes) system and the budget very similar to yours (~$45000 USD).

I think u can find better configuration now, because the configuration above is 1yr ago when I upgraded our lab cluster. We use the server from "SUPERMICRO"

P.S: If u care about the service and warranty, I will suggest u go IBM, HP or DELL.....

## 5. FLOWCHART


Collect Weather data (e.g. Temperature, Pressure)
Send data to the central server
Above danger
Yes
No
Display Data
Store data and analysis
Ring Alarm and display precaution


Air Quality Early Warning System (AQ-EWS)
In-situ Air Quality and Meteorology
(DPCC, CPCB, SPCBs, IMD,IITM)
PM10, PM2.5, SO2, NOx, O3, CO
Observations
Satellite based
AOD, Fire Counts
Weather Forecast Modelling
GFS (12 km)
WRF (3km)
Air Quality Modelling
WRF-Chem (10km, 2km, 400m), SILAM (3km), NCUM Dust Model (17km), ENFUSER (30m)
Air Quality Forecasting
3-days Forecast for PM10, PM2.5, CO, O3, NO2, SO2, Fire and Dust Contribution
Warning Products Generated
Visualization and Animations of Weather and Air Quality parameters, Forecast Bulletin
Information Dissemination
Website https://ews.tropmet.res.in
Email and Whatsapp to Pollution Control Authorities and registered users, media

## 6. RESULT

Graphical Representaion of result

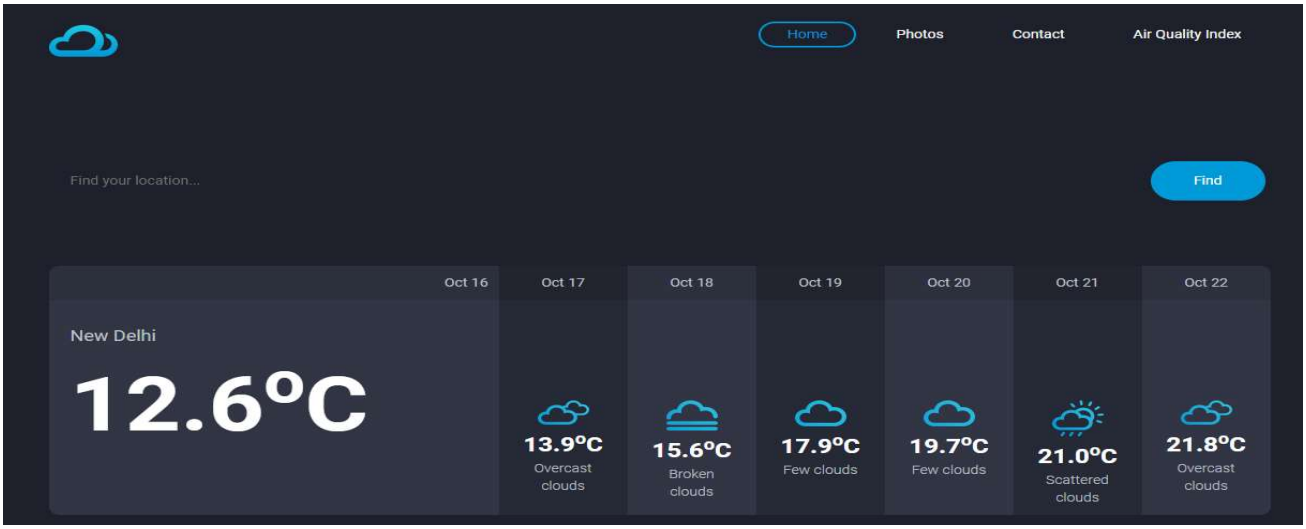



Fig. One Week Weather Forecasting

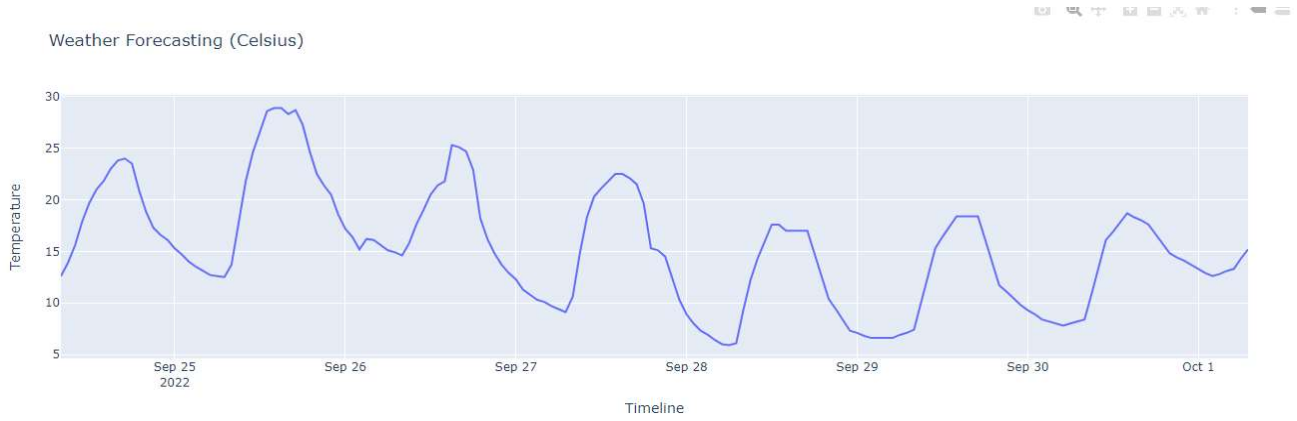
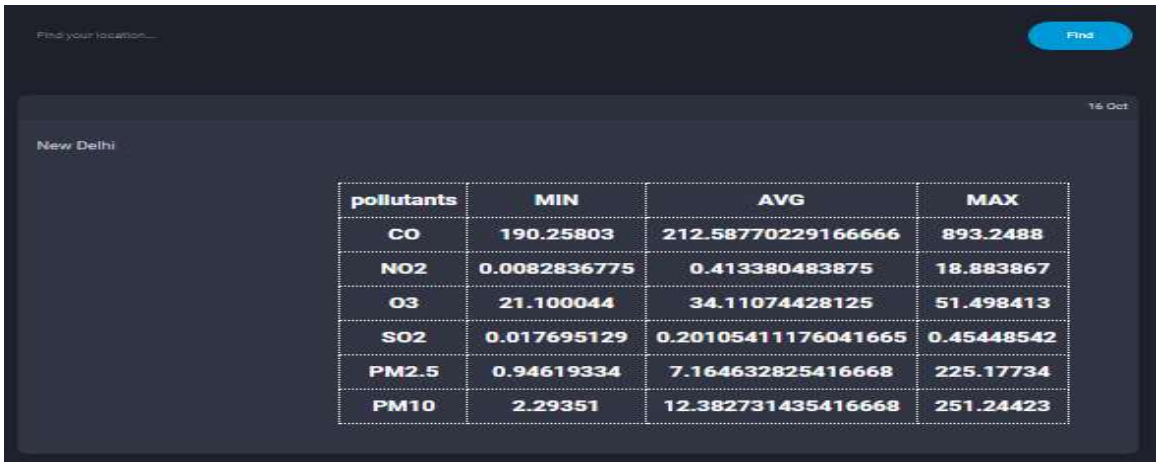



Fig. One Week Weather Gragh




| pollutants | MIN | AVG | MAX |
|---|---|---|---|
| CO | 190.25803 | 212.58770229166666 | 893.2488 |
| NO2 | 0.0082836775 | 0.413380483875 | 18.883867 |
| O3 | 21.100044 | 34.11074428125 | 51.498413 |
| SO2 | 0.017695129 | 0.20105411176041665 | 0.45448542 |
| PM2.5 | 0.94619334 | 7.164632825416668 | 225.17734 |
| PM10 | 2.29351 | 12.382731435416668 | 251.24423 |

Fig . Air Quality Index of the day

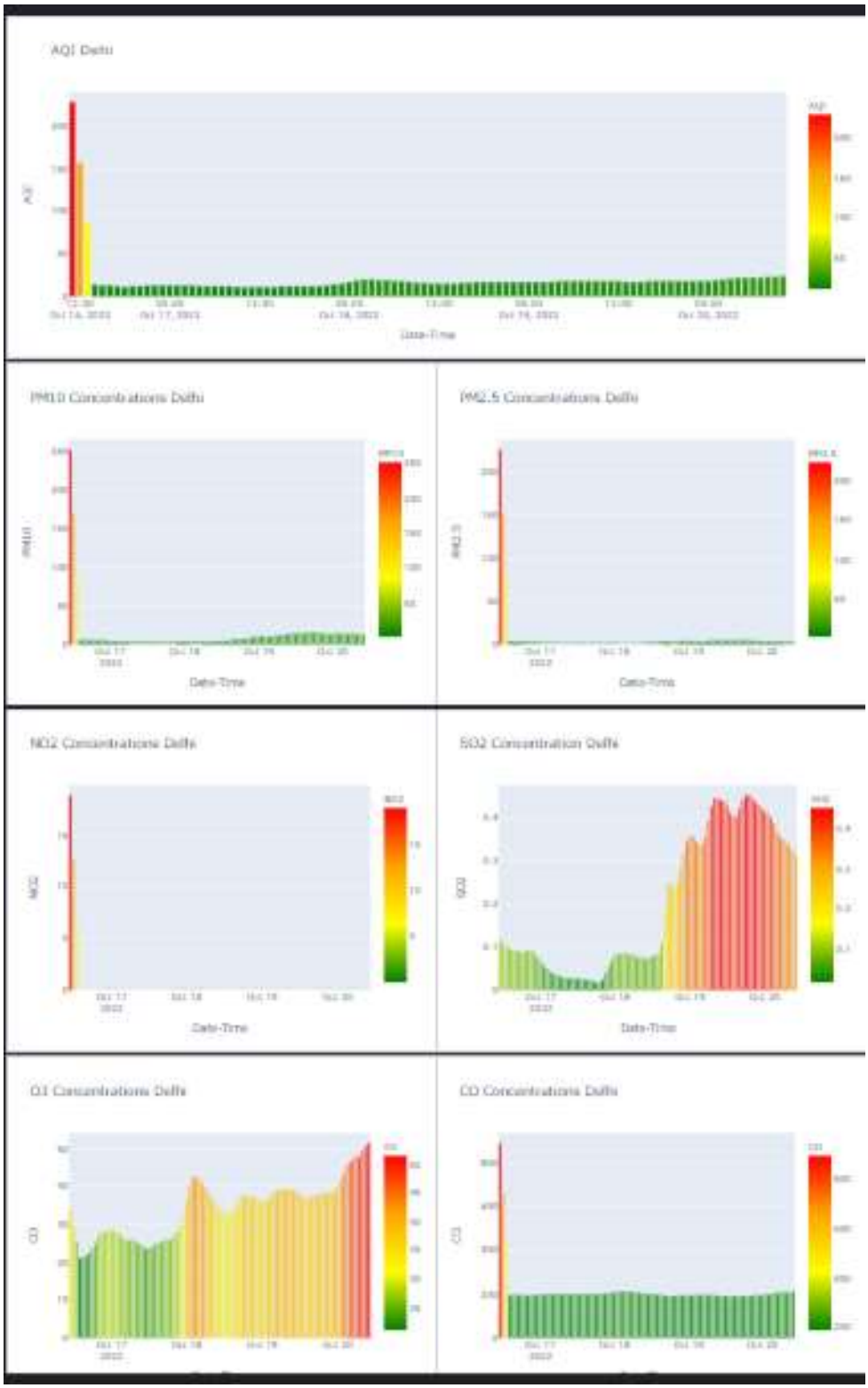



Fig. One Week Air Quality Forecasting

## 7.ADVANTAGES AND DISADVANTAGES

**1. High quality of data:**

One of the main advantages of weather radar is the fact that the data collected by the radar is of high quality and can be used to determine various aspects of the weather reliably.

**2. Reliable weather forecasts:**

The forecasting of the weather is one of the most important uses of weather radar. Through radar technology, experts have been able to reliably predict the weather and sometimes even measure the exact amount of rainfall or precipitation.

**3. More accurate results**: Using weather radar to determine the weather and even to predict the weather results in much more accurate results. Radar can easily measure the exact amount or quantity of a particular weather element and use this to determine the expected forecasts.

**4. Locate precipitation**: Weather radar can also be used to locate precipitation in any given area of the earth. This information comes in handy when determining the exact amount of rainfall that is expected.

**5. Can calculate the speed of precipitation:**

Besides locating precipitation, weather radar can also be used to calculate the exact speed of precipitation, a fete that was previously impossible using conventional means.

**6. Can determine the structure of storms:**

Weather radar has been used extensively by experts to determine the structure of storms. This information is then used to build the profile of expected storms and put in place mitigating measures.

**7. Hail detection:**

We can also use weather radar to detect hailstorms that are expected within a particular

locality. This information is important in determining the exact nature of the hailstorms and helps prevent their effects.

**8. Research**: Weather radar also comes in handy in the field of research where experts can use it to profile the weather of a given area and use the patterns to predict the climate of that area and help people in planning.

**9. Flood forecasting**: Weather radar can also be used for flood forecasting to predict the occurrence of floods.

**10. Weather surveillance**: Weather radar helps in profiling the weather of a given area provides people with the confidence of the climate and also advises on the expected weather at a given time.

## Disadvantages

**1. Cannot detect fog**:
Weather radar has the limitation of not being able to detect fog. This creates a gap in weather forecasting where an area that is likely to receive fog is not properly profiled.

**2. Cannot detect wind independently:**
A weather radar is not known to detect wind independently unless with the use of additional remote sensing. This also creates a gap in weather forecasting.

**3. Not entirely reliable:**
Weather radar has a variety of limitations that makes it lack some of the most important forecasting principles. This means the radar is not entirely reliable in terms of weather forecasting.

**4. Requires expertise to analyze**: The usage of weather radar to forecast the weather is not

an easy thing and requires some level of expertise to analyze the data that comes through it.

**5. Relies on intense datasets:**
There is a huge dataset associated with the weather radar that needs to be analyzed before any decision is made. This data is so big that it may take a considerable amount of time to analyze fully.

**6. The analysis is not instant**: The weather analysis done through weather radar is not always instant and therefore the information is not real-time.

**7. Weather changes all the time**: The weather is a phenomenon that changes all the time. This means that any delay in data collection may sometimes result in useless data.

**8. The estimates can be wrong**: The estimates obtained from weather radar are not 100 percent accurate. This means that the data may be wrong in some cases and this may impact the final decision making.

**9. Radar technology keeps growing**: Radar technology is not static. It is dynamic and it keeps growing at a really fast pace. This means that scientists need to keep up with the technology which can be expensive and time-consuming.

**10. More interference**: Radar technology experiences interference from various aspects of the weather including water, wind, and so on. This may affect the quality of the data and hence the results of the analysis.

## 8.APPLICATIONS

**1. Weather Forecasting benefits tourism**

No doubt, tourism is strongly affected by climate and weather. The increasing fluctuations

of weather may affect tourists and tourism businesses. Thus, weather forecasting helps in planning tourism facilities to minimize the damage caused by severe weather, as well as increase profitability. In particular, by checking the weather forecasts, tourists are able to choose proper destinations for the best experience, plan their trips to avoid possible risks.

The **importance of weather forecasting** is undeniable.

#2.Weather forecasting improves transportation safety

Weather strongly impacts the safety and operation of roads. Driving abilities can be impaired by severe weather conditions like snow, rain, or storm. Moreover, There has been a slew of traffic accidents reportedly caused by bad weather.

For air transportation, weather forecasters help reduce flight delays, flight times, and energy savings, and ensure the safety and comfort of passengers. The key **importance of weather forecasting** for this industry is the provided information on critical weather conditions that could endanger an aircraft at takeoff, landing, and during flight, e.g. strong winds, thunderstorms, tornadoes, and ice.

Marine meteorologists prepare advisory information for ships, including information on the

position, trajectory, and intensity of strong storms and warnings of strong winds, fog, and hazards. other risks, as well as general forecasts about weather and sea conditions. Vessels may accordingly change course to avoid adverse weather conditions. As a result, the safety of ships, cargo and passengers is enhanced, and fuel is saved at the same time.

***Importance of weather forecasting*** *for transportation*

Hence, the **importance of weather forecasting** in the transport sector needless to say.

#3. Weather forecasting beneficial to dressing

It's true that weather affects how we choose outfits. It's not easy to dress well in unusual weather conditions, though your wardrobe is filled with multiple items.

For example, you have an outdoor meeting tomorrow but you don't know how to dress properly. That's where weather forecasts come in handy.

By checking whether, before the event, you can get an overview of how the weather would look like to choose the best clothing without being affected by the weather.

This helps save your time and solves the headache matter of what to wear.

Is this **importance of weather forecasting** significant?

*Importance of Weather Forecasting: Dressing properly*

#4. Weather forecasting is beneficial to farmers

Temperature, humidity, and precipitation play an important role in the cultivation of fruits and vegetables.

Farmers previously predicted the weather based on observations of the sky. However, the development of meteorology these days has provided them with accurate weather forecasts by using supercomputers to collect data.

By regularly checking weather forecasts, farmers are able to know the best time for crops and farming practices and better understand and track the growth status to make potentially costly decisions.

The **importance of weather forecasting** for precision agriculture is obvious.

Share

*The importance of Weather Forecasting for agriculture*

**#5. Weather forecasting enables planning properly**

One of the most noticeable benefits of weather forecasting is to make proper plans. Checking weather forecasts online before the trip or before you join outdoor activities to know what the weather is going to be like and to have a good preparation.

**#6. Weather forecasting & forestry**

Weather forecasting is crucial for preventing and controlling wildfires.

Various indicators, such as the Forest Fire Weather Index and the Haines Index, have been developed to predict areas prone to fire caused by natural or human. Growth conditions for insects can also be predicted by forecasting the course of the weather.

**#7. Weather forecasting & utility companies**

Thanks to weather forecasts, electricity and gas companies can predict demand that is strongly affected by the weather.

They used the quantity known as the degree day to determine how much use would be

available for heating (heating degree day) or cooling (cooling degree day). These quantities are based on an average daily temperature of 65 ° F (18 ° C).

Extreme cold weather in winter can cause demand to skyrocket as people have to increase heating. Likewise, in the summer, the soaring demand may be related to the increased use of air conditioning systems in hot weather. By anticipating soaring demand, utilities can buy more energy or natural gas supplies before prices rise, or in some cases, limited supply through use. electronics stores and power outages.

**#8. Check accurate weather forecasting**

Being aware of the **importance of weather forecasting** can be helpful for individuals and organizations. A lot of weather forecast apps available on the market provide you weather information. One of the most popular ones is the Weather Forecast application.

Here are some typical features of the app

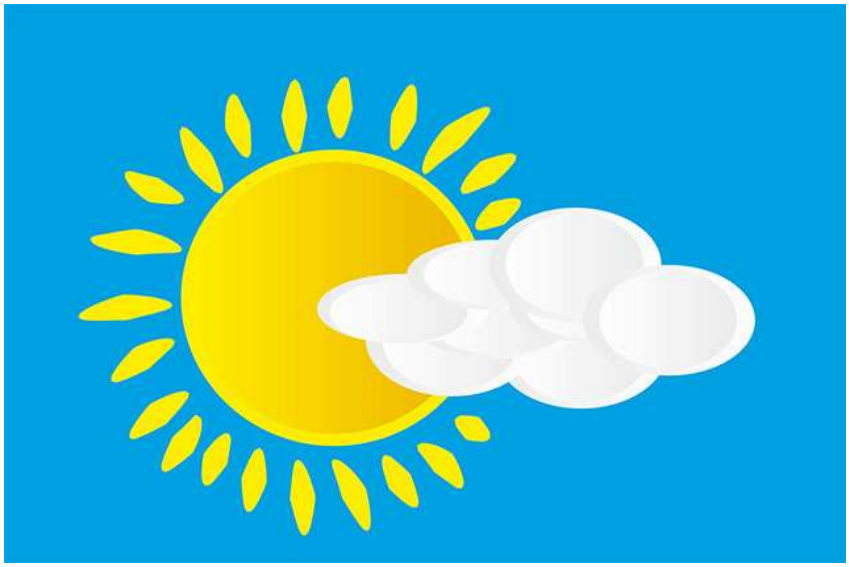
Provide detailed weather conditions

The tool provides accurate weather conditions for a given location and time. Weather Forecast has been widely appreciated by providing detailed weather information such as day and night temperature, humidity, wind, and precipitation.

The information is constantly updated, which gives users hourly, daily weather forecasts.

**2. Weather forecast for 7 days or 14 days**

The app gives you accurate 7 day weather forecasts or even 14-day weather forecasts. You've known the **importance of weather forecasting** in making proper plans for trips or outdoor activities.



**3. View the weather forecast for locations you want**

Weather Forecast also allows you to search and view the weather forecasts for your preferred location.

Visit goweatherforecast.com, enter the name of the location you want to check the weather at the search bar. The app will show you the specific temperature, wind speed, precipitation, and other key weather elements.

This is come in handy for those who plan to have trips and want to know what the weather is like in the place they are going to.

**4. Simple & easy to use**

The app is simple, intuitive, and exceptionally easy to use. Just open the app, enter the location you want to check the weather and it will then display all the important information such as temperature, humidity, the chance of rain, weather tomorrow, and weather next 5 days.

The **importance of weather forecasting** is transparent. Download the app now to your iPhone and Android and make use of its benefits.

**Is Weather Forecasting Accurate?**

Many apps provide 24-hour weather forecasts with an accuracy of up to 97%. If you want to know how the weather is going to be in the next 5 days, a weather forecast can give 90% of what you expect.

80% is for an accurate 7 day weather forecast. Many meteorologists agree that weather can be predicted with high accuracy for up to 10 days in advance.

*Considerable importance of Weather Forecasting*

It's impossible to collect data from the future. Hence, weather forecasts use estimates and assumptions, which can be less accurate for the further future as the weather constantly changes.

Understanding the enormous benefits of weather forecasting, many sites try to offer long-term weather forecasts in advance (more than 10 days forwards).

## Conclusion

In short, the **importance of weather forecasting** is pronounced. That's why hydrometeorology continues to invest in improving its capacity, coordinating relevant

industries in professional activities and scientific research to improve the ability to forecast weather fluctuations.