Universidad Politécnica de Madrid

Escuela técnica superior de ingenieros informáticos (ETSIINF)

ATMOSFERIC DYNAMIC MODELS

POLITÉCNICA

"Ingeniamos el futuro"

CAMPUS
DE EXCELENCIA
INTERNACIONAL

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INDEX:

SUMMARY:

The atmosphere is a crucial component of the Earth system and plays a fundamental role in climate, weather and air quality. Understanding the processes that occur in the atmosphere and its interaction with the environment is essential for predicting climate and air quality. Atmospheric dynamics models are useful tools for understanding and predicting atmospheric behavior.

Atmospheric dynamics models are essential for understanding and predicting climate and climate change. They allow scientists to study how different factors, such as greenhouse gas emissions or changes in land use, can affect the climate in the future. They are also an important tool for developing mitigation and adaptation strategies to climate change.

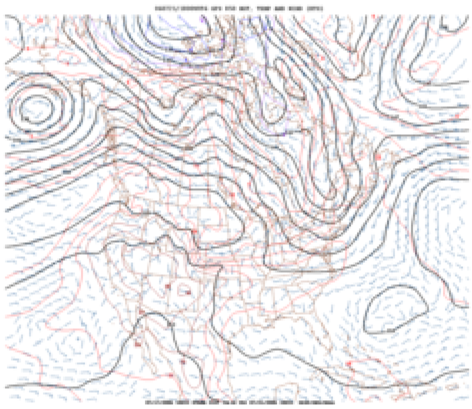
INTRODUCTION:

The atmosphere is a crucial component of the Earth system, playing a fundamental role in climate, weather, and air quality. Understanding the processes that occur in the atmosphere and its interaction with the environment is essential for predicting climate and air quality. Atmospheric dynamics models are useful tools for understanding and predicting atmospheric behavior.

In this report, different topics related to atmospheric dynamics will be explored, including atmospheric dynamics models, boundary layer, altitude measurements, turbulence, interaction of solar radiation with the atmosphere, simulation of emissions from specific sources, the Courant-Levy-Friedrich criterion, size of the atmosphere, spectral treatment, computational fluid dynamics, greenhouse effect, air composition, biosphere-atmosphere-soil exchanges, absorption and reflection of energy in the soil, models for climate and air quality prediction, land use information, cell size for modeling, emissions and population density, EMIMO emissions model, simple and complex air quality models, spatial and temporal coverage of air quality models, systems for modeling air quality, and methodologies for air quality prediction.

ATMOSFERIC DYNAMIC MODELS:

Atmospheric dynamics models are mathematical tools that allow for simulating and predicting the behavior of the Earth's atmosphere and its interactions with other components of the climate system. These models are based on the conservation equations of mass, momentum, and energy for the compressible fluids that constitute the atmosphere, as well as the equations that describe the physical and chemical processes that occur within it. Additionally, computational fluid dynamics (CFD) is employed, a branch of fluid mechanics that uses numerical methods to analyze and solve complex problems involving turbulent, multiphase, reactive, or compressible flows.

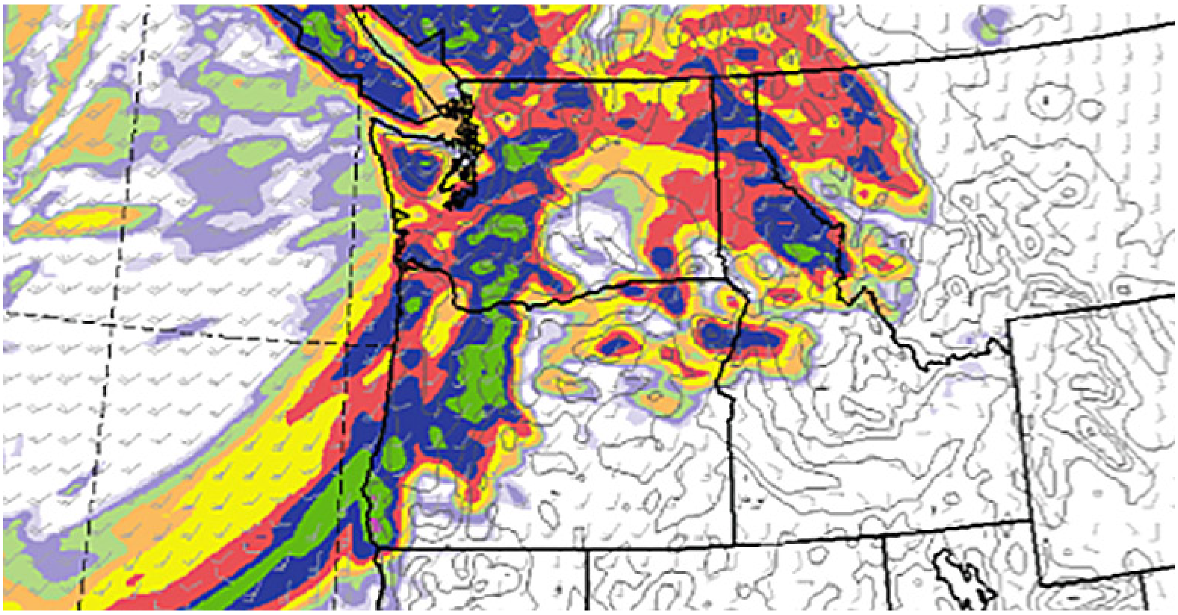


FACTORS TO CONSIDER IN ATMOSFERIC DYNAMIC:

Among the aspects considered in these models are the planetary boundary layer, where strong vertical gradients of temperature, pressure, humidity, and wind occur due to friction and diurnal heating or cooling. Altitude measurements are also considered, as temperature decreases with altitude until reaching a minimum in the tropopause (around 10 km), then increases in the stratosphere (up to around 50 km) due to the absorption of ultraviolet radiation by ozone, and decreases again in the upper layers.

The composition of the air is critical for understanding atmospheric processes. The atmosphere is composed mostly of nitrogen and oxygen, with smaller amounts of other gases such as carbon dioxide, water vapor, and methane. Changes in the concentration of these gases can have significant impacts on the atmosphere and the climate.

Another important factor is turbulence, which generates vertical and horizontal mixing of atmospheric properties such as temperature, humidity, or pollutant concentration. In addition, the interaction of solar radiation with the atmosphere is studied, which determines the global and regional radiative balance of the planet and affects climate and weather. The simulation of emissions from specific sources, such as volcanoes, forest fires, vehicles, or industries, is also carried out to study their impact on air quality or the greenhouse effect.

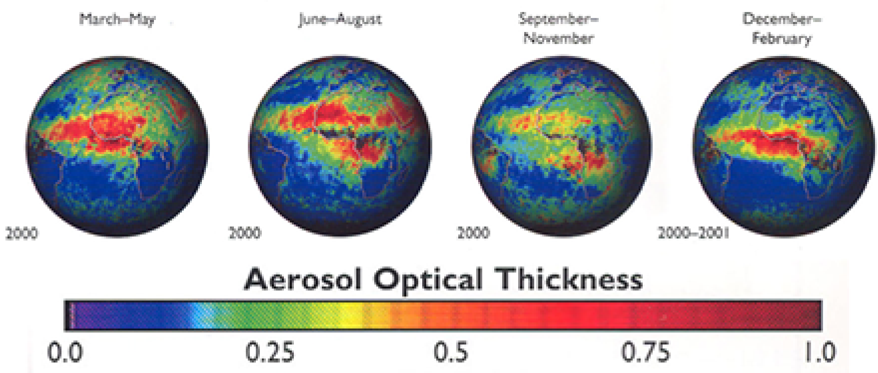


Regarding the Courant-Levy-Friedrich law, it is a numerical criterion that establishes that the time step used in models must be smaller than the time it takes an acoustic wave to travel a distance equal to the spatial size of the discretized cells of the model. This ensures the numerical stability of the model but limits its temporal resolution. In addition, atmospheric size is taken into account, an approximate measure of the total vertical thickness of the Earth's atmosphere estimated to be about 100 km from the surface to the upper limit where atmospheric pressure is practically zero.

Information about land use is also crucial for air quality models, as it can directly affect emissions and the transport of pollutants. Data on the distribution of population, industry, and economic activities can be used to predict pollution sources and their impact on air quality.

The size of the cells used in air quality models is also important, as it can affect the accuracy of predictions. Smaller cells can provide higher spatial resolution but may also require more time and resources to run the models.

The quality of air quality models can range from simple models to more complex and detailed models. The choice of model depends on the user's needs and the level of accuracy required.



Multi-angle Imaging SpectroRadiometer measurements of aerosols over Africa, showing large amounts of airborne Saharan desert dust.

The spatial and temporal coverage of air quality models is also important, as it can affect the accuracy of predictions. Models with higher spatial and temporal resolution can provide greater accuracy, but may also require more time and resources to run.

Air quality modeling systems can be very complex and require a large amount of data and computational resources. These systems may include emission models, transport and dispersion models, and chemical reaction models.

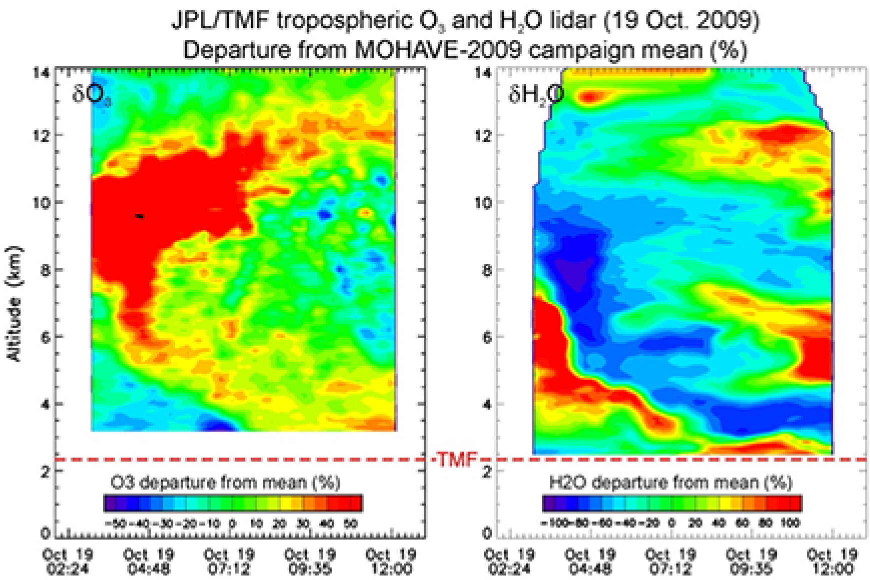
Air quality prediction methodologies can vary from statistical approaches to complex numerical models. The choice of methodology depends on the user's needs and the required level of accuracy.

Air quality monitoring networks are essential for the assessment of air quality and validation of air quality models. These networks can provide accurate and real-time data on air quality in different locations.

WEATHER RESEARCH AND FORECASTING MODEL(WRF):

The Weather Research and Forecasting Model (WRF) is a numerical weather and meteorology prediction model used worldwide to make high-resolution weather forecasts. This model is based on mathematical equations that describe the dynamics of the atmosphere and uses observation data from satellites, radars, and weather stations to initialize its forecasts.

The WRF is a highly configurable prediction model, meaning it can be adjusted and customized to fit different climatic and geographic conditions. For example, the model can be adjusted to include different topography factors, vegetation, bodies of water, and other local aspects that can affect the climate. This makes it a valuable tool for decision-making in a wide range of applications, from water and energy management to urban planning and public safety..



During tropopause folding events, the origin of the air masses is inferred from the anticorrelation relation between measured ozone (left) and water vapor (right), obtained from lidar sounding. Dry, ozone-rich air comes from middle or high latitudes (north of the subtropical jet), while moist and ozone-poor air comes from the tropical upper troposphere (south of the subtropical jet). Regions where the anticorrelation breaks down (e.g. 12 km near 12:00 UT) suggest mixing within the jetstream.

EMISSION MODEL: EMIMO:

On the other hand, the EMIMO is an atmospheric emission model used to evaluate air quality and exposure to pollutants. This model is based on data on emission sources such as industry, transportation, and energy generation and uses mathematical equations to predict the quantity and distribution of pollutants in the atmosphere.

EMIMO is an important tool for environmental management and public health, as it allows researchers and policymakers to evaluate the effects of emissions on air quality and population health. For example, EMIMO can be used to evaluate the effects of changes in energy policy or transportation infrastructure on air quality and to identify areas where emissions are higher and mitigation measures are necessary.

CONCLUSION:

In conclusion, atmospheric dynamic models are essential for understanding and anticipating atmospheric phenomena that affect human life and the environment.

These models require constant updating and validation to ensure their reliability and accuracy. WRF and EMIMO are examples of advanced models that offer various options to address meteorological and climatic issues from a regional perspective, such as calculating emissions from a factory or predicting the weather over a two-week period.

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