Meteorology:
Numerical Weather Prediction

The calculation of weather data

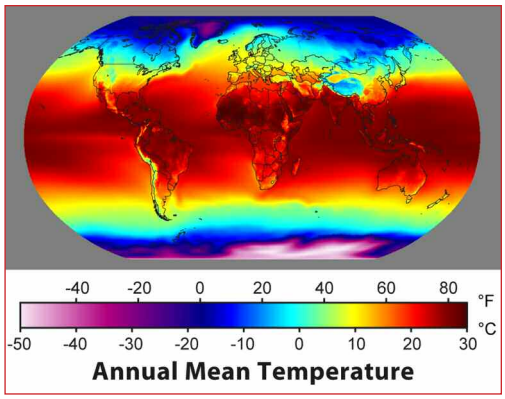
What is the weather going to be like tomorrow? For a long time, people have tried to predict weather conditions using the hydrologic climate cycle.

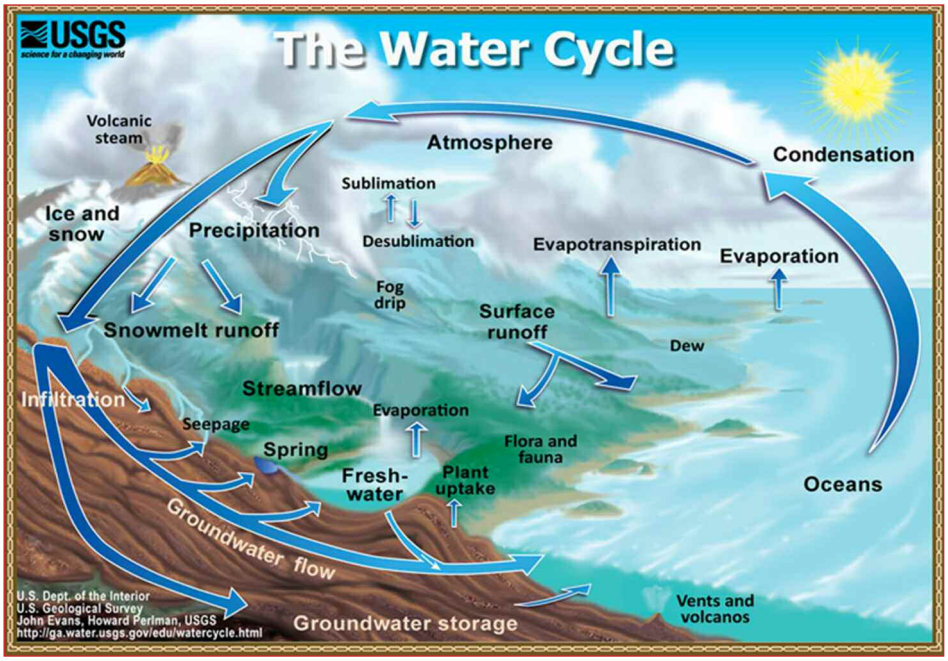
In the early 1920's scientists were able to compile a six hour forecast. Back then it took six weeks to analyze weather data collected at only two points in Europe and calculate, by hand, a useful illustrative model.

Today, supercomputers are used to predict the weather for a period of several weeks. The complex modelling programs require several million data points for parameters such as temperature, humidity, pressure, vertical & horizontal wind velocity with time stamps and absolute coordinates.

Facts & Figures

- 7 inches is the diameter of the largest hailstone ever recorded.
- Sukkur City in Pakistan is one of the most humid places in the world with 30 °C dew point & a felt air temperature of 65 °C.
- A study showed that a small thunderstorm system holds more than 10 million tons of water.
- No two weather patterns are completely alike.
- Some weather models assimilate data obtained from more than 25,000 weather stations.





Clockwise from top left: Map of the average temperature over 30 years. . . . Weather station on Mount Vesuvius. . . . Water cycle summary.

To create a correlation between the data and the environment, scientists "slice" the atmosphere virtually into smaller horizontal & vertical parts—this process is called *discretization*. It is more useful to compute the chronological change of the parameters using this model.

continued

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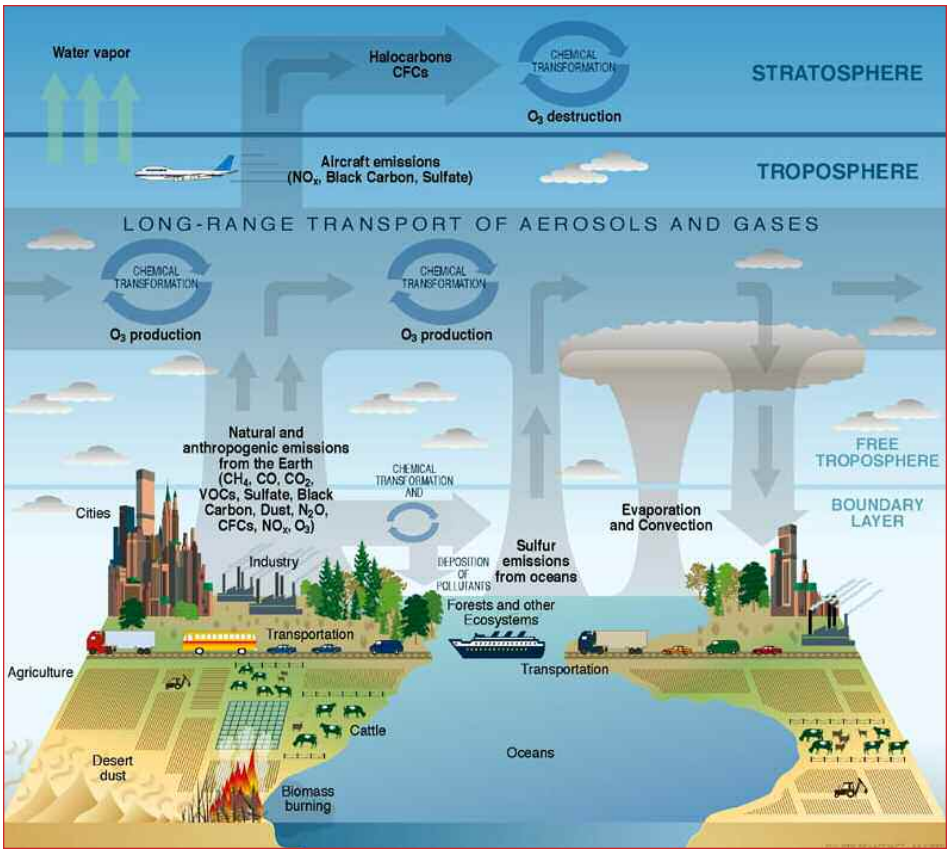
The calculation of weather data *(continued)*

Meteorological events that are too "small" such as a single thunderhead, layer clouds or smaller turbulences will be parameterized through variables. This *parameterization* is a science of its own that aims to reduce uncertainties as best as possible.

Every forecast calculation starts with the current weather conditions. The quality of this input is crucial for the accuracy of the final forecast. Meteorologists link the forecast of yesterday's weather with the actual measured parameters. Only large data centers are capable of computing this *data assimilation.* The overall result is a best possible calculation basis to predict the weather for the next day. If this groundwork is flawed the forecast may be incorrect. For example, it could report rain at the wrong location.

Today's meteorological mathematicians also take parameters into account that change extremely slowly compared to the other factors. Growth and the reduction of polar ice, or the temperature of the oceans are summarized as boundary values. After a model is run using all the available data, meteorologists process and customize reports for a wide range of target groups such as public authorities, flight control centers, energy producers, industries and many more. These reports also include specific weather warnings.



Atmosphere composition diagram

Why the need to measure humidity?

As described above, the daily weather forecast relies on the precise measurement of weather parameters. The science of numerical weather prediction aims to describe the daily hydrologic cycle in numbers. Humidity plays an important role. Typically, data errors will multiply during calculations.

Humidity values influence weather calculations e.g. through the water vapor balance equation—this formula expresses the influence of humidity through rain & condensation, and vice versa.

Incorrect measurement or incomplete humidity data directly leads to wrong predictions of a huge number of weather phenomena such as the condensation altitude of clouds, locations of hyetal regions, fog layers and storms.

In 1999, incorrect data sent by a weather station in Nova Scotia, Canada led to an incorrect forecast for Hurricane Lothar two days before it hit Central Europe. Authorities were insufficiently prepared to alert people in time.

The prediction of rain and snowfall is still challenging for meteorologists. Only more extensive networks of weather stations and enhanced mathematical models will reduce problems due to unknown factors.

135 Engineers Road, Hauppauge, NY 11788
Tel. 631-427-3898 • Fax. 631-427-3902 • info@rotronic-usa.com

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