18

Numerical Assistance Makes 24-hour Weather Forecast Possible, Rain or Shine

Why can we know everything in heaven above and the earth underneath? Why was Zhu Ge-liang able to borrow thousands of arrows with only 20 thatched boats? How could he know beforehand when the easterly wind would blow? Modern people can grasp the weather condition owing to the atmospheric mathematic model that predicts the weather from input atmospheric information.

As early as the 1920s, some people had made attempts on predicting the weather and achieved some results. Yet it was not until the appearance of computers and computer simulation that numerical weather forecasting became a feasible way of prediction the weather. In 1968, a number of meteorologists suggested to Academia Sinica that Meteorological Institute be reestablished. At that time, while our country was not ready yet, many countries have used electronic calculators to come up with numerical weather predictions. Only by reestablishing a research institute can theoretical and technical levels be raised.

To obtain useful forecast results, at times it is necessary to resort to the world's most powerful supercomputers for big data set manipulation and complicated calculation. In 1984, supported by Executive Yuan, the Central Weather Bureau (CWB) set up Taipei Information Observatory Center, later renamed as Meteorological Information Center, to keep making weather forecasts.

Meteorological Information Center has accomplished everything related to the public. In years it has finished implementing the infrastructures and systems for meteorological information. The infrastructures receive data from the 27 weather stations nationwide and transmit the data into a high speed numerical calculation computer. The computer is featured with 384 operation nodes, which amounts to 6144 high speed PCs doing numerical analyses at the same time. The supercomputer is equipped with a main memory of 24 Terabytes and a built-in storage space of 300 Terabytes, which to most people are virtually astronomically incredible.

Many weather forecasting models, both global and regional, have more or less offered assistance in global weather predictions. If availed at the same time, these models will be able to reduce the uncertainty of weather forecasts and extend predictable temporal dimension even further.

Tsai Ching-yen, the Chairman of Industrial Technology Research Institute (ITRI) and an internationally renowned expert on numerical weather prediction, has written a book on the technology that combines computers and meteorology. Mr. Tsai was also Director of the Central Weather Bureau from 1989 to 1995 and ex-Minister without Portfolio.

Tsai Ching-yen points out that numerical weather prediction is currently a cutting-edge technology in Meteorological Science and an inevitable trend in weather forecasting technology. Theoretically, meteorologists avail fluid mechanics and physical laws to come up with equations. They use the meteorological data about air pressure, temperature, humidity and wind speed as variables and then use the numerical approach to search for an approximate solution. Aided by the supercomputer's high speed calculation, next moment's weather condition can soon be predicted.

Many scientists may have simplified variables. However, numerical weather forecasting cannot ignore or simplify the original data. Therefore, computers are needed to demonstrate super calculation capability and to systematically get deeply into all related variables. First, after adjusting the fundamental governing equation, atmospheric fluctuation and rotation of the Earth, the concept of scale analysis is introduced to look for the acquisition of a simplified mode. Then the not simplified primitive equation model is applied to the numerical approach for the prediction.

Tsai Ching-yen led his team to build a numerical weather forecasting model and develop an operating system for the CWB's numerical weather forecasting. Integration of all the weather data needs to be done through a friendly human-machine interface so that an instantaneous plain digital or graphical weather forecast can be presented while at the same time meets the need of other meteorologists, mass media and the public.

The CWB continues to challenge how to predict the weather without issuing warnings. TVs, computers, cellphones and others all provide us with an easy access to weather conditions, including weather observations, weather forecasts, typhoon warnings, gales, torrential rains, heat waves, and so on. The accessibility hopes to provide all walks of life with preparatory precautions with the least possible losses of human lives and properties.

Numerical weather forecasts can offer predictions that span from 2 to 28 days, including analyses for small regions. There are over 100 million people visiting the CWB website per year. In conditions with extreme weather changes, visitors to the CWB website can reach 3 million on a single day. For everyone, to attend work and school or to take a day off from work and school because of the weather, only what the numerical forecast says counts.

18 預知天氣大小事 數值輔助天氣預報

上知天文，下知地理。孔明為何能草船借箭，預知會吹東風？現代人能夠預測掌握天氣，是根據大氣資料輸入，運用大氣的數學模型算出來。

儘管早在 1920 年代時已有人作出過嘗試並取得一定成果，但直到計算機和計算機模擬出現後，天氣數值預測才成為一種切實可行的實時天氣預報方法。1968 年氣象界人士就建議中央研究院恢復氣象研究所，各國多已利用電子計算機作數值天氣預報，我國還沒有準備，惟有研究機構的恢復，才能提高理論與技術水準。

為了得到有用的預測結果，有時必須用到世界上最強大的超級計算機來操縱巨大的數據集和進行複雜的計算。中央氣象局到 1984 年才在行政院支持下，成立「台北資訊測站」，後來改名「氣象資訊中心」，持續推動數值天氣預報。

氣象資訊中心投入與民眾息息相關的，完成氣象資訊基礎建設、氣象

資訊系統，氣象資訊基礎建設接收全國 27 個氣象觀測站，進入高速數值運算電腦，這套電腦有 384 個運算節點，相當 6144 台高速個人電腦同時分析數值，這套超級電腦的主記憶體是 24TB，內建 300TB 儲存空間，對多數人來說，都是天文數字。

許多天氣預測模型，無論本身是全球性或區域性，或多或少都為全球天氣預報提供幫助。將這些模型一同使用，能夠降低天氣預報的不確定性，將可預測的時間範圍延伸到更遠。

1989 年至 1995 年擔任中央氣象局局長、工研院董事長蔡清彥是國際知名的數值天氣預報專家，他曾寫書介紹這門電腦結合氣象的科技。

蔡清彥指出，數值天氣預報是目前氣象科學尖端的科技，也是氣象預報技術的必然發展趨勢。理論上，數值天氣預測是氣象學者運用流體力學、物理定律寫成方程式，再根據觀測得來的氣壓、溫度、濕度、風速等氣象資料作變數，以數值方法求得近似解，並利用電腦快速運算的性能，推算下一時刻的天氣狀況。

許多科學定理可能簡化了變數，數值天氣預測不能忽略或簡化原始的數據，所以電腦需要超強的運算能力，發展數值預報有系統的對學門所包含種種變數深入。首先透過基本控制方程式、大氣波動與地球轉動調整後，引入尺度分析概念，探討簡化模式求取，緊接數值方法必須採用未經簡化原始方程模式。

蔡清彥率領團隊建立數值天氣預報模式，發展中央氣象局數值天氣預報作業系統。天氣資料整合，還要透過友善的人機界面，以通俗即時產生數位或圖形的天氣預報呈現，滿足天氣研究同業、新聞傳播機構與民眾的需求。

中央氣象局持續挑戰「天有不測風雲」，無論是看電視、電腦或智慧手機⋯⋯都可以掌握天氣觀測、天氣預報、颱風警報、強風、豪雨、高溫，提供各行各業預防災害，減少生命財產損失。

數值天氣預報可提供 2 至 28 天的天氣預報，有小區域天氣分析，每

年超過一億人次使用中央氣象局網站資訊，劇烈天氣變化時，單日查詢氣象資訊達到 300 萬人次，無論上班上課、停班停課，全是數值天氣預報說的才算數。