Geo-ICT and the role of location in Science, part 4: Meteorology and Climatology

'Meteorology and climatology are all about spatial information'

Spatial information is naturally at the centre of meteorology and climatology. This is not to say, however, that conventional GIS-systems have become an integrated part of these disciplines. When the American meteorologist Scott Shipley first considered the possibility of using GIS, in 1994, he had few expectations: "GIS is too slow and will never have value for meteorological data processing". Soon after, however, Shipley convinced himself of the potential value of the systems ['GIS does the Weather', 1996]. Extreme weather situations and climate change stimulate Shipley and others to pay even more attention to the 'location'-dimensions of their studies. Geo-ICT helps them to predict (short-term weather) and to analyse (long-term climate change) more accurately.

GIS at the Royal Netherlands Meteorological Institute

Publication titles and conferences suggest that Geo-ICT has in recent years, in Europe and the USA, become an accepted tool in meteorology. Frans van der Wel, GIS-specialist at the 'Royal Netherlands Meteorological Institute' (KNMI), relates this breakthrough only partly to the work of Shipley and other *champions*. Besides software advancements, he considers the increasing tensions between humans and their environment, especially climate change and its effects (heat waves, drought, floods, etc.) have become a "hot issue" worldwide, as an important stimulus for GIS-use in meteorology. It is particularly for predicting and dealing with extreme weather and other natural hazards, that Geo-ICT has proved itself to be a useful tool. This is not to say, however, that all meteorologists have suddenly turned to GIS.

"When I joined the KNMI in 1997, I felt like a missionary," says Van der Wel. "I gave lectures and workshops on GIS to all our departments, which was generally received positively. I coordinated five pilot-projects, designed to explore the possibilities of using Geo-ICT for visualisation, web-mapping and the integration of atmospheric and geographic data. Twelve colleagues followed a training programme, to enable them to use the systems for their research. But after a few months most of them were still using their old methods and tools, principally because it turned out to be impossible to translate their model-based environment directly into a GIS-environment."

In many ways the situation is very similar in most other European meteorology institutes. Despite some small, promising steps – colleagues who consult him about the possibility to use GIS for research or presentation purposes and students who join him for internships – Van der Well is realistic: "Still, many consider GIS to be an expensive drawing machine. It is my task to prove them wrong and show the true value of geographic information."

Time consuming conversion

How can we explain this hesitance? Based on his experiences at the KNMI, and contact with other institutes across Europe, Van der Wel gives three main reasons. "Firstly, scholars in my field tend to be sceptical about commercial software. Most meteorological institutes have, from the 1970s, developed their own data systems, which have since been gradually enhanced to process ever greater amounts of data, and to model and analyse increasingly demanding time sequences. Most of these systems, moreover, incorporate GIS-like functions, which make a switch to GIS-systems seem of little added value:

visualisation, overlay-analysis, geo-referencing, classification and spatial statistical analysis can to some extent be carried out with the standard systems. This brings us to a final point: meteorological data processing has been more or less globally standardised, which enables institutes from different parts of the world to exchange information quickly and easily. Importing these data in a standard GIS-environment, on the other hand, requires a time-consuming conversion."

It is therefore unlikely that the KNMI and other institutes will soon switch to more GIS-friendly systems. This is not to say, however, that meteorologists do not value the use of spatial, geo-referenced information. Van der Wel points out that 'location' is indeed becoming more and more important for his discipline. He illustrates this statement using examples from three of the KNMI's core tasks: weather prediction; sending out warnings for extreme and dangerous weather; and research into climate change.

Predicting and warning

The models used by the KNMI and other institutes to generate weather predictions generally work on a lower resolution than what is common in most GIS-applications. Their models enable predictions for a relatively long period (about five days), but for a relatively large geographic area. They lack the detailed geographic information needed for predicting the weather accurately for *specific* locations.

Several institutes have in recent years developed so-called 'high-resolution limited-area'-models, which cover shorter time periods, but produce more specific and accurate predictions. The KNMI combines radar data with field measurements to determine more accurately the location and quantity of rain. Farmers use this information to monitor the watering or drainage of their land.

This brings us to the second of the KNMI's main tasks: to send out warnings in case of dangerous weather. To what extent can spatial information and Geo-ICT contribute to this task? In November 1990, a sudden haze surprised car drivers along the ring road of Breda, near Holland's border with Belgium, causing a multi-car collision that took the lives of 10 people. The area had been notorious as a 'fog-sensitive' area. After the accident the KNMI investigated the possibility of placing 'fog-sensors', which proved to be a problematic operation. Radiation fog is produced by a complex interaction between a range of physical (humidity, temperature and currents) and geographic factors (relief, soil type, vegetation, the presence of 'heat islands' such as a city or industrial area, and the intensity of traffic), which the systems then in use could not incorporate. During the late 1990s Van der Wel repeated the investigation, this time with the use of a GIS. His enquiry successfully reconstructed how traffic in the area was time and time again surprised by suddenly appearing fog and located suitable spots for the sensors to be placed, resulting in more accurate fog predictions.

Elsewhere, other types of dangerous weather have been approached in similar ways with the help of Geo-ICT. The American National Weather Services, for example, has used a GIS to find an optimal location for its radar systems that trace approaching hurricanes.

Climate change research

Climate change is a third area of research to which the KNMI has been dedicating much of its efforts; a phenomenon that has recently become a 'hot issue' world wide. How does spatial information come into play in climate studies?

Meteorologists increasingly hold that there are connections between global warming and (changing) patterns of human behaviour. However, since meteorological instruments and analyses are traditionally concerned with dynamical, atmospheric processes, rather than more static processes nearer or even below the earth, it has been difficult to establish these connections scientifically. Geo-ICT, which is more suited to analysing more static processes on (and just above or below) the earth's surface, could be a helpful tool. Hence, combining the two could enhance our understanding of the land-use – climate interaction.

Recent research into the effects of climate change on the North Pole has combined atmospheric and geographic analyses. The gradual warming of the earth, resulting in summer temperatures on parts of the Pole exceeding 5°C, assumedly stimulates the growth of vegetation. But because the circumstances in the area vary greatly from place to place, satellite images alone would not produce valid data. These images have therefore been combined with small-scale measurements (research units of 1m2), for which a GIS was used.

The KNMI has used Geo-ICT surprisingly little for its recent climate studies, a missed opportunity according to Van der Wel. Above all, GIS could have been used as an effective communication tool. Using interactive map-interface, rather than numeric tables and a series of 2-D maps, the results could have been presented to the general public much more clearly and attractively.

Van der Wel does expect a further increase in the number of 'location-based' studies, as well as a further integration of GIS-functions in the existing atmospheric systems. His optimism is largely based on recent developments in the United States; the situation in Europe seems less promising.

Van der Wel has just returned from the final workshop of COST-719, an EU-funded initiative that has brought together meteorologists and climatologists from across Europe to explore the potentials of GIS. Van der Wel is the project leader of 'Data access and data availability'. The fact that COST has been running successfully for a few years is in itself a positive sign: there is a clear intention to work together and there are increasing funds to do so. On the other hand, exchanging experiences has only reinforced Van der Wel's existing impression: the activities of a small number of GIS-champions still receive little follow-up from scholars in their field. It remains a challenge to convince them of the added value of a more location-based approach, and hence of GIS.

But it is not only in the scientific application that the European meteorologists lag behind their American counterparts. The Americans use Geo-ICT effectively to translate scientific raw-data into commercial end-products. Companies like Meteorlogix play a crucial part in this conversion. They operate as an 'interface' between the weather institutes and the end users: based on raw data, they provide near real-time weather information, in GIS-format, to end users (e.g. in agriculture, industry and construction). This field has been little developed in Europe and other parts of the world. Interestingly in this respect, the KNMI has recently started the ADAGUC-project, which aims to develop filters that can be used to make atmospheric data more 'GIS-friendly'.

Contributing to Geo-ICT advancement
Unlike Geo-ICT experts in archaeology, history and marine biology (the disciplines that we have looked at so far), geo-meteorologists *have* already made a real contribution to the advancement of Geo-technology. ESRI's 'Atmospheric Special Interest Group' was closely involved in developing the NetCDF-function in ArcGIS 9.2 and advised on the incorporation of a temporal dimension in the software. As such, the wider GIS-community can benefit from meteorologists' expertise in working with time sequences.

Van der Wel believes that scholars in his field can in two other ways be of value to GIS-users in other disciplines: firstly, in their expertise of standardising data. Perhaps with the exception of military organisations, there is no organisation or discipline which has a more standardised data infrastructure than meteorology. Secondly, in meteorologists' experience with processing large quantities of data. Unlike the marine biologists who struggle to gather enough valid data, weather institutes like the KNMI process on a daily basis gigabytes of research data, from a wide variety of instruments: ranging from advanced radar systems to buckets of rainwater that more than 300 volunteers, all around the country, empty and record daily. Storing, integrating and processing these large quantities of data require software applications and analytical tool that could also be a source of inspiration for GIS-users in other fields.

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