

## DATA HEADACHES

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this chapter.

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**Abstract.** Data provide the foundation of all activities linking weather/ climate and the energy sector, yet accessing data can prove problematic. In this paper an overview of the status of access to weather and climate data is provided to guide those working on the energy side. A background history through which the current status quo has been achieved is summarised, and some useful information sources for the energy sector identified. Further the types of weather and climate information that are available and of potential concern to energy projects are reviewed briefly.

**Keywords:** Weather; climate; energy; protocols; resolution 40; observations; archives; reanalyses

### 1. The Symptoms of Data Headaches

Data are fundamental to all science, a statement transparently unnecessary to make. Data are the basis for all development and hypothesis testing of theories, for the validation of systems, for the creation of new capabilities. Without data there would be, within context, no weather or seasonal forecasts or understanding of climate change, nor would there be any capability to use weather and climate information in the energy sector. Data provide an unquestionable public good.

Yet there is a second side to data. Data are costly to collect, archive and distribute. Data, and the information contained therein, are a basis for

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authority, decision-making and wealth generation. Data may be a substantive public good, but equally may benefit, perhaps even more so the relative few, when held in confidence.

Meteorologists and climatologists have been grappling progressively over recent decades with the issues of owning and distributing data, in particular in terms of whether any services provided, including those funded originally by the public purse, are a public good or, perhaps, a commercial opportunity, in part perhaps to recompense the public purse. Such issues become complex as commercial demands, with inherent implications for competitive advantages, increase in sectors such as energy provision. In this paper the background to these affairs of data is summarised and the current situation reviewed from the perspective of weather and climate data; there are, of course, additional considerations regarding data from the energy sector side, but these will not be considered here.

## **2. A Migraine-Free Beginning**

The current UN System body with the longest traceable history is the World Meteorological Organization (WMO<sup>1</sup>), based in Geneva. Its authority is, and always has been, built on that of governmental National Meteorological and Hydrological Services (NMHSs), and their parent ministries, around the World. Although WMO itself has a history since only 1950 its predecessor organization, the International Meteorological Organization, was founded in Vienna in 1873 following discussions that stretched back a further 2 decades.

Data was the issue that brought together Heads of the then newborn Weather Services of Europe and North America. These Heads had been charged with providing weather forecasts out to 24 h in the interests of protecting shipping, both naval and commercial. Shipping losses following some major storms in the Atlantic Ocean had precipitated this demand, although the perception of credibility that accompanied the demand was recorded by the Hansard report on the passing of the UK bill in terms of the mirth amongst MPs that such a feat was conceivable. Many Weather Services originated, and some still remain, in ministries of defence or of transport as a consequence of this original focus.

To an extent the suspended belief of the UK MPs was justified. Meteorology was in a youthful stage at that time, with many of the most important mathematical insights required to produce forecasts not to exist for several decades to come. Indeed certain of the concepts circulating in the mid nineteenth century about the ways of the weather (such as that

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<sup>1</sup> <http://www.wmo.int>

rainfall decreased with height) might bring a smile today. Nevertheless it had been understood by then that atmospheric pressure as measured by a barometer was closely related to the types of weather that could occur on a particular day, that patterns of pressure could be mapped was synchronous information from different locations available, that these pressure patterns moved constantly and the weather moved with them, and therefore that by mapping and predicting the movement of pressure patterns the weather itself might be predicted. So there was hope. All that was needed was to obtain the necessary information from as many locations as possible, to map these data, and then to interpret the results.

Interpretation of the results is not a subject for this paper, but obtaining the data provided a substantive challenge on its own. Handling data within a single country was reasonably straightforward, but particular difficulties arose in transferring data between countries. Such international transfers were essential given that pressure patterns covered areas rather larger than most single countries, introducing an international interdependency that continues until today. Heads of Services at that time were more than willing to exchange data in the interests of what was perceived to be the public good, paid for by the populations through taxation and returned as free information in the form of forecasts.

In different countries what meteorological information as was recorded was often taken with diverse instruments calibrated according to national standards, with readings taken at times specific to each country. The perfidious English and Americans even used different measurement scales to the rest of Europe! Further, the archiving methods used for the data differed between countries. In sum, a system of national ad hoc approaches was patently inadequate to support the needs of the fledgling services. Hence the meetings that led to Vienna 1873.

Important aspects of data exchange covered through international agreements at that time included standardised methods of making observations (including calibration of instruments), quality control of observations, consistent methods of recording, archiving and exchanging observations, and a rapid mechanism for transferring information amongst all countries (rapid then being limited to telegraphic speeds). Those principles remain in place today, with one consequence that modern meteorological and climatological archives are perhaps the most comprehensive, inter-consistent and accessible of any for any discipline. And for many years in the twentieth century the rapid worldwide exchange of data of speedily increasing volume through the Global Telecommunication System, a customised network of communication links even including individual telephone lines, predated the World Wide Web as a beacon for swift information transfer across borders.

The internationally-agreed principle underpinning all of this activity was “the free and unrestricted international exchange of meteorological and related data and products”. Such an exchange was necessary to deliver the responsibilities of the Services and to return the public good of the costs borne by the public purse. Essentially that situation remained in place unquestioned for about a century, during which time the community of NMHSs swelled to cover all parts of the globe.

### **3. The Beginnings of Pain over the Eyes**

For numerous decades governments supported the public good nature of Weather Services, as they did those of many other services to the public within the government sector. For Weather Services this was sometimes justified in terms of a national need, including a national need for independence in capability from a strategic defence perspective. But this justification could not last forever. As government responsibilities expanded alongside populations and their demands, and as globalisation progressed inevitably, some trimming of government costs became unavoidable. Together with an equally unavoidable feedback onto the public good.

One early argument that emerged during the mid-1900s appears reasonable. Not only is weather information supplied as a public good to the public and to defence, but it is also supplied to commercial companies using that information for private gain. A counter argument that these companies had in practice contributed taxes and were therefore entitled, as was the public, to receiving information free of charge was unsuccessful. Governments determined that they could cut demands on the public purse if they charged for the increasing volumes of services previously supplied free. Weather Services were one amongst many to which this was applied.

Probably the first country to address the uncomfortable interface between the historic public good of weather services and commercialism was the US. US policy, put in place in the 1950s and essentially unchanged since, has nevertheless given birth to the world’s most active commercial weather/climate sector. Put simply the US policy is that the fundamental services to be provided for the public good, including those that serve the highest responsibility of Weather Services, the protection of life and property, will be supplied through and only through the government and paid for in their entirety by taxation. All necessary aspects of data collection and handling, and the production and distribution of forecasts, amongst other aspects, are included under the government umbrella. Given that these have all been pre-paid, all, including data, are then made available at an interface for unrestricted access and use by the public and by companies. It is a logical model that has been followed by no other government. In fact it

is a model that has caused discord when information intended only for restricted circulation originating in other countries under different government policies has been made freely available to all through US web sites in the terms of the US Freedom of Information Act.

#### **4. A Throbbing Frowning of the Brow**

The speeds at which governments became interested in reducing their fiscal responsibilities, and the approaches used, varied widely, many developing world countries not taking any steps until enforced by decisions made in Europe. Undoubtedly the most precipitous step was taken in New Zealand in 1992 where the original public service was split, one part that supplied forecast services being fully commercialised but with ownership held by the Government, another retained to provide government and privately-contracted research. Most other governments took more measured approaches, the Europeans undoubtedly being in the vanguard.

Under pressure from governments wishing to contain taxation and to recover costs from sales of services the Europeans, through WMO, introduced a slight, but significant, reinterpretation of the phrase “the free and unrestricted international exchange of meteorological and related data and products” that indicated that “free and unrestricted” means ‘non-discriminatory and without charge’ and “without charge” means ‘at no more than the costs of reproduction and delivery of data, with no charge for the data products themselves’. Thus was the door slipped open for charging for data, perhaps only a (often not modest) handling charge but sufficient to enrage users such as universities with projects under which such costs had not been budgeted.

Commercialism, or at least partial commercialism, of NMHSs was the inevitable bedfellow of data handling charges; undoubtedly opportunities existed in the later quarter of the twentieth century for creating commercial arms within NMHSs as part of the cost recovery programme, after all the feasibility of that had been demonstrated clearly in the US, and US and other commercial companies were beginning to compete directly with NMHSs across Europe. NMHSs were ideally placed to secure substantial portions of the emerging markets and to recover costs for governments, and were duly instructed to do so. Without initial proper consideration for the consequences for NMHSs attempting to run public and commercial services in parallel while still competing fairly with external companies, and without consideration for international concerns of data exchange.

Numerous factors combined to encourage NMHSs ultimately to agree through WMO a new protocol for the international exchange of meteorological and climate data, a protocol memorably named as Resolution 40<sup>2</sup> (there is an equivalent Resolution 25<sup>3</sup> that covers hydrological data). Prominent amongst these factors were:

1. The basic fact that some NMHSs became commercial competitors not only to independent commercial concerns but also to NMHSs in other countries that had not developed commercial activities and/or who wished to protect commercial activities in their own countries for themselves.
2. That government policies, including activity funding cutbacks, were enforcing the creation of commercial arms within NMHSs and/or proposals from NMHSs that the commercial side should assist in covering some of the costs for data networks.
3. That in some countries cooperation between the NMHSs and private concerns blurred the distinction between use of the public purse for public and for commercial purposes.
4. That commercial companies on occasion took clients from NMHSs, even when the NMHS was providing an equivalent free service, and undermining that NMHS through gaining free access to data collected by the NMHS.

For developing country NMHSs in particular three further issues stood out:

1. Incursions by commercial organisations into developing countries, incursions that directly threatened activities of the NMHS.
2. The standing of NMHSs in some developing countries is not strong in the eyes of governments faced with substantial issues and costs regarding development; in many of these countries the main services provided are weather forecasts to transport whereas it might be argued that a climate focus is required for national development, a focus in which national skills are often limited. Thus, in what is sometimes known as the 'CNN Effect', the authority of NMHSs can be undermined when it is perceived that satisfactory free, or perhaps even competing but better commercial, services are available from elsewhere, perhaps through CNN or perhaps through consultancy.
3. On more than one occasion NMHSs have provided data without charge to international bodies and others but without subsequent acknowledgement of their role; there are further occasions on which data were provide

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<sup>2</sup> [http://www.wmo.ch/pages/prog/www/ois/Operational\\_Information/Publications/Congress/Cg\\_XII/827\\_en.pdf](http://www.wmo.ch/pages/prog/www/ois/Operational_Information/Publications/Congress/Cg_XII/827_en.pdf)

<sup>3</sup> [http://www.wmo.ch/pages/prog/hwrp/documents/Resolution\\_25.pdf](http://www.wmo.ch/pages/prog/hwrp/documents/Resolution_25.pdf)

without benefit to the NMHS, on occasions being used to create commercial data bases, with the consequence that self-protective policies were introduced.

Within Europe government-enforced steps towards commercialisation lead to the origination of ECOMET<sup>4</sup> in 1995, one responsibility of which is to regulate the commercial activities of European NMHSs within Europe. But strains began to tell in three interacting ways, between the US with its open policy, between European countries with their progressive steps towards paid-for services and information, and between the rest of the world where in the vast majority of cases NMHSs remained public good services. Something had to be done. In 1995 that ‘something’ was Resolution 40 (and in 1999 Resolution 25).

### 5. The Core of the Headache?

Resolution 40 is a protocol agreed in 1995 amongst those NMHSs that are members of WMO (effectively all active NMHSs around the globe); it is reconsidered every 4 years at the WMO Congress but at present remains unmodified. Not all organisations involved in collecting and producing meteorological and climatological data lie within the WMO family, but many have followed similar concepts to those embraced in the Resolution in determining their own data policies.

Resolution 40 in effect splits all types of information, including data and forecasts, into three levels, with separate rules for each.

Level 1    Level 1 data (“minimum” data) may be distributed “on a free and unrestricted basis” being “essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of nations, particularly those basic data and products required to describe and forecast weather and climate, and to support WMO Programmes”. In other words these are the public good data and information that preserve the intent originated in the nineteenth century. International agreement defines exactly what data and products are covered, although national sovereignty remains the final arbiter. These data are available to all given a handling charge. Undoubtedly data and products within Level 1 are of interest to the energy sector.

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<sup>4</sup> The Economic Interest Grouping of the National Meteorological Services of the European Economic Area

- Level 2 Level 2 (“additional” data) is defined to “... also provide the additional data and products required to sustain WMO Programmes at the global, regional and national levels and, as agreed, to assist other Members in the provision of meteorological services in their countries” BUT “Members may be justified in placing conditions on the re-export of such data and products for commercial purposes outside the receiving country or group of countries forming a single economic group, for reasons relating to national legislation or costs of production”. Hence these additional data and products, which cover rather more detail both spatially and temporally than those at Level 1, may be distributed freely for data handling charges within the WMO community, and similarly within the university community for research only purposes, but may be charged for at commercial rates to others or blocked altogether (particularly to prevent resale). Level 2 data, with their greater detail, are more valuable to the energy sector than those at Level 1.
- Level 3 Anything else! Such as data from the extensive rain gauge networks that cover some countries. No international protocols cover these potentially invaluable data to the energy sector, each country or organisation determining its own policy.

While organisations other than those in the WMO family may have data policies that resemble those of Resolution 40 they might nonetheless cover other concerns within their policies. Indeed organisations may protect their data for purely commercial or other strategic considerations, or they might embargo information in order to provide academic freedom, such as for the time required by in-house scientists to prepare seminal papers prior to public release of data. Understanding of data policies of individual organisations is the recommended approach to pragmatic reduction of the symptoms of data headaches.

## 6. Pain Killers

The types of weather and climate data that have and will benefit the energy sector are wide, and include observations from the past, the present and the future, ‘re-analysed’ observations, and of course predictions/projections on all time scales from a few hours to a century or more. Weather forecasts tend to come only from WMO-related organisations, as do many, but not all, longer range (including seasonal and decadal) forecasts. Both NMHSs and universities or other research organisations produce climate change projections. Numerous bodies in addition to NMHSs hold weather and

climate observations, although not necessarily to WMO standards. Reanalyses, invaluable in that they are global estimates of weather in the past 50 years or so of greater consistency and accuracy than could have been obtained previously, have been produced mainly by WMO-related organisations.

Fortunately there are archive centres in a number of locations around the globe that are of great help to the user in acting as one-stop sources for a range of data. However original access policies still apply at the centres. Visits to such centres will also assist in clarifying data policies. A few examples follow.

US data policy has already been mentioned and is straightforward. While government organisations provide all public good services, all existing information for other activities are readily available on NOAA web sites, such as <http://www.cpc.ncep.noaa.gov/products/forecasts>.

A valuable source of information in the UK is maintained by the British Atmospheric Data Centre, a data centre with numerous European contributions: <http://www.badc.nerc.ac.uk>. Not only is this an excellent source of weather and climate information, it is also an excellent source of data policy statements, referred to on the site as 'Access Rules'. All data from the Centre are free of charge, but not necessarily free of restrictions on use which range from completely free access through to no access apart from to accredited users. By scanning the site a feeling is readily gained that there are rather more data sets with controlled access than there are with unrestricted access; several data sets have time-limited access restrictions to enable owners to produce that key paper. Additionally, the UN manages several data centres that provide information (other than weather and climate) that are of potential interest in the energy sector (such as <http://geodata.grid.unep.ch>).

Reanalyses might be described as historical global weather maps created using the most up-to-date technology. Several times each day the weather forecasting centres produce 'analyses', which are best estimates of the detailed weather conditions across the globe based on the latest observations – without doubt these are the most accurate worldwide weather maps producible. These analyses provide the starting points for the next forecasts. Naturally analyses have limitations, included amongst which are that the computer model used for making the forecasts is also used (or something equivalent) to produce the analyses and these models improve in time, and that not all observations reach the centres in time to be used for real-time forecasts. With reanalyses the latest approaches to producing analyses are applied to all available past observations to produce a sequence of historical analyses – the best and most consistent sequence of global weather details available other than series at individual high-quality observation sites. So far centres have updated their reanalyses as improved

models and more historical data become available. Reanalyses provide invaluable information for the energy sector. Examples may be found at:

- <http://www.ecmwf.int/research/era> (1958 to 2001)
- <http://www.cpc.ncep.noaa.gov/products/wesley/data.html> (1948 to present)
- <http://gmao.gsfc.nasa.gov/research/merra/> (1979 to present)
- <http://jra.kishou.go.jp/> (1979 to 2004)

The relative quality of these reanalyses produces lively debate between centres (it is worth obtaining expert advice before using them) but what can be stated is that in general reanalysis quality declines the more distant the nearest observation point and also backwards in time.

Might data extending further back in time be useful? If so the energy sector will be pleased to learn that work is currently under way on that problem, in part using techniques that assist in estimating what is happening in the upper atmosphere from surface data alone. Naturally the precision of reanalyses for 1909 will not match those for 2009, but the quality should be satisfactory for careful use. A leading project is ACRE,<sup>5</sup> in which it is intended to tap the roughly 50% of surface observations prior to 1939 that have not yet been digitised as well as extensive additional data from the Southern Hemisphere. Resulting from ACRE it is planned to produce in collaboration with other projects global reanalyses from 1891 on, to produce global surface reanalyses back to the 1840s, and then surface analyses for the North Atlantic and Europe only to as early as the mid eighteenth Century.

## 7. A Headache Cure?

It is probably not appropriate here to make any explicit predictions as to how data policy will be modified into the future, so many are the strands that are causing tensions. Without doubt by far the majority of governments around the world have adopted a commercial model of some form for their meteorological services, with the consequence that control is placed over all data apart from those defined as free access under Resolution 40. Undoubtedly most, possibly all, energy sector requirements for data will be for those on which a charge is levied. If anything the move towards commercial principles is accelerating and it is quite conceivable that more NMHSs, as that for New Zealand, will become commercialised in part or in whole – for example, a commercial sale of the UK Met Office is on the

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<sup>5</sup> <http://www.met-acre.org/Home>

current UK Government's agenda. Only in the US does a public good policy hold firm, and even there the commercial sector is continually attempting to transfer more activities from the public sector into their areas of work.

It is probably naïve to consider what might be being lost with fewer data archived for public good. Certainly larger commercial organisations should be able to adjust according to the new reality, although smaller concerns might be sidelined, while data protocols protect to a large extent the budgets of those engaged in academic research work. Undoubtedly there might be pressure on data managers to prioritise collection and archiving of information saleable today over that that might, or might not, be used tomorrow; and the principle of not archiving information for which an immediate use cannot be seen is not unknown in meteorological circles. Any pressures and priorities might differ between the developed and developing world, as well as influencing data-related interactions between countries.

There are too many imponderables, too many "what ifs" to predict the outlook for data policies. But what is guaranteed is that data headaches are certain to continue into the future.