**REMS At Home - An Environmental Miscellany**

On 10 January 71 members and guests were educated and entertained by 5 invited speakers. The meeting was organised and orchestrated by George Freeman, who unfortunately could not attend during recuperation following an operation. Mike Quinton introduced the speakers.

**"The Barometer and its early use in forecasting on land and on sea"**

Anita McConnell, shown in the first picture, read a very detailed story from the early days of finding out why water cannot be lifted more the 9 meters in a pump to the first successful, but short lived network of weather predicting stations.

It was Torricelli and Viviani who showed in 1643-4 that there is such a thing as a vacuum and that the atmosphere has weight that is balanced by the column of mercury in a barometer. They noted that the height of the column varied daily with changes in the weather, but also with temperature. Meanwhile in 1648 Pascal noted that a barometer recorded a lower pressure when taken up a mountain, the Puy de Dôme. In 1653 Henry Power of Halifax performed the first mountain experiment in England.

In Oxford Boyle and Hooke also realised that the stick barometer also responded to temperature, but Hooke sought to magnify the small daily movements of the meniscus using his wheel barometer of 1664, which he realised was less accurate because of friction in the drive to the pointer and the increased likelihood of dirt on the meniscus. Robert Hooke later made what some called a double barometer, but it was actually a manometer mounted on a board with a sealed spirit thermometer and an open water thermometer, containing a little acid to stop it freezing. Anita was emphatic that it has been erroneously described as Hooke's Marine Barometer. Hooke also sought to record automatically all manner of weather related measurements in modifying Wren's Weather Wiser, but the project never got off the drawing board. He was too busy doing other things at the Royal Society.

Other people were more concerned about being able to read changes in the height of the meniscus. Sir Samuel Moreland made inclined and angled barometers from 1669. However there was then the problem of reading even the change in the height of the meniscus. Despite the shortcomings, both the wheel and the angled barometers became popular through promotion by Francis North, Baron Guilford, and by the skill of the Huguenots arriving in East London. There is a collection of their instruments at Hampton Court.

By 1689 Roger North, Francis's brother, was predicting the weather in East Anglia but discovered that barometers of the time didn't survive well at sea, because the glass was easily broken. His 200 page manuscript on meteorology was not published by the time he died in 1734, but the British Library has acquired a copy, which Anita reported makes fascinating reading.

In the late 1600s William Dampier circumnavigated the world three times recording warning signs of coming hurricanes, typhoons and other weather phenomena and related them to Samuel Pepys among others, but had no use for a barometer.

Meanwhile, Ralph Bowen in 1671 had listened to many sailors returning from their travels and realised that cloud shape could predict storms a few hours ahead. He suggested that those living near the coast could also, with the help of a barometer, predict the weather. He and Roger North became adamant that a barometer at sea would be useful in predicting the weather. It could be assembled at each landfall and used there, but the oscillations of the mercury, while on board a rolling ship, could break the glass, when the mercury hit the top of the vacuum.

Various changes to the form of the barometer tube were tried, but none worked until 50 years later when glass itself was improved by a Parisian glassmaker.

Captain Cooke was issued with a barometer using a simple constriction to reduce the oscillation just below the scale plate in 1772 in time for his second voyage. It was made by Edward Nairne. It was so successful that other nations' ships called at London to be issued with the same model.

Back on land the Medicis had a number of identical sealed thermometers made and set up at places as far apart as Florence, Pisa, Paris and Innsbruck. It was early days in the science of temperature measurement and died when the Grand Duke of Tuscany died, but the idea of a network of weather stations was born.

Anita then described and illustrated the weather stations set up in between 15 and 33 monasteries in the Palatinate, centred on Mannheim, to take readings with barometers, thermometers, hygrometers and anemometers, together with observations of cloud cover, rainfall, wind direction, phase of the moon, magnetic declination etc and record the results taken regularly at 7am, 2pm, and 9pm at local time every day between 1781 and 1792 and published in Latin. Even the language was standardised! The Napoleon invaded in 1794 ending the project and this lecture.

**"The Story of Navigation from 2000BC to 2020AD"**

From the outset we decided that Jeremy Batch, shown in the second picture, would get as far as he could in 50 minutes to leave time for questions. In a very clear, gentle and superbly illustrated and amusing way he surveyed the contributions of the world's civilisations for the tools needed for navigation.

He started by reminding us of Babylonian numerals and their base of 60, the problem of dividing up the circle (a bit more than 3 diameters!) and why they used 360 degrees, meaning that for us base ten users the right angle is an awkward number of degrees. Navigation at night then was strictly by the stars, which they noticed fall into a fixed pattern rotating about one that didn't move much (not Polaris in 2000BC). By 1500 BC lodestones were found to useful day or night.

As Jeremy said, the Polynesians were great navigators of the Pacific (1500BC – 1800AD) – at least those that arrived were! They used sails the right way up – with the wide bit at the top, where the wind is. They had charts with shells marking positions of stars (or were they islands?) and canes marking ocean currents or swells. Apparently, their training entailed imagining that they were stationary and the world rushed by – a thinking in advance of Einstein. One of their number, Tupia, sailed with

Captain Cooke. When he was brought up on deck and asked where Tahiti was, he was always pointed within a degree of the “correct” direction.

Back in the lands around the Mediterranean, when the Egyptians wanted to sail round “Libya”, they called upon their local cruising association (Jeremy’s talk was punctuated with these amusing asides), the Phoenicians at Carthage, to do the job. 150 years later Herodotus reported that they had sailed around “Libya”, which must have meant the whole of Africa, after all they had reported that at one point, the sun was in the north!

Meanwhile the Greeks were busy too. In 530BC Pythagoras and his followers proposed that the Earth was spherical and travelled round the sun. Lighthouses were essential to navigation and the granddaddy was build around 283BC on the island of Pharos off Alexandria. Its light was visible from 35 miles away, indicating that it was 450 feet high. Eratosthenes was the librarian at Alexandria. We heard the story of his measurements leading to his remarkably accurate estimate of the circumference of the Earth. Hipparchus of Rhodes provided the grid of latitude, determined by measuring the angular altitude of a star. We didn’t get to longitude.

The Chinese pioneered the use of lodestones to indicate south, but the use of the compass only reached Europe in 1380. The Roman contribution to the story was the combination of the words “navis”, a ship and “agere” to steer – navigation.

Next we were introduced to the kamal, which consisted of a piece of wood and a length of string. By lining up a star with the top edge and the horizon with the bottom edge, it enabled the operator to measure latitude to ¼ degree or 15 miles on the earth’s surface. In about 1460 sailors at Henry the Navigator’s school in Portugal taught Arabic mathematics and introduced the students to the quadrant, which incorporated a plumb line so that sight of the horizon was not needed, although a calm sea to use it was! The astrolabe was stripped down to become the mariners’ astrolabe. The advance it brought was that the sun could cast a spot of light through the 2 holes of the sight, thus obviating looking at the sun.

Jeremy pointed out that, although Columbus (4 voyages between 1492 and 1504) had a compass it was divided into 32 points each of an inconvenient $11.25^0$, whereas in China they still use a 24 point compass of $15^0$ points. Magellan didn’t survive to discover he’d lost a day in the 1519 to 1522 circumnavigation through crossing the international-date-line. His crew used an armillary sphere – a cross between an astrolabe and a globe.

The next instrument for measuring the altitude of a star was the cross staff, which was like a kamal, but the cross piece slid on a bar, rather than being on the end of a taught string.

The archaeologists found not only a gimbal mounted compass on the Mary Rose, which sank in 1549 but a log reel and hour glass for measuring speed. The number of knots spaced 1/120 nautical mile apart than ran out in 1/120 hour (30 seconds) gave the speed in nautical miles per hour (knots). When it was realised that the nautical mile was 6000ft rather than 5040ft, they changed the spacing of the knots, so that their estimated time of arrival remained the same. Francis Drake was so equipped for his circumnavigation (1577-80) and also had an astrolabe and cross staff.

The next advance was the John Davies's back staff of 1594, which also allowed viewing a spot of light rather than looking toward the sun, but it was too expensive and delicate for use by some navies (the Dutch East Indies Company) and so the cross staff continued to be used. It was actually more accurate anyway.

!707 saw the worst English peacetime naval disaster, when Sir Cloudesley Shovell's fleet ran into rocks off the Scilly Isles. It highlighted the need for determination of not only longitude (they were 100 miles out), but also latitude (they were 120 miles out and only 3 of their 145 compasses were found later to be serviceable. In the questions afterwards, Michael Fox pointed out that the charts of the time were wrong as well.

As Jeremy said, we would need a separate lecture for John Harrison and his marine chronometer for keeping the time at Greenwich while at sea. He had embarked on his first model, H1, in the same year 1730 as John Hadley had introduced mirrors into his reflecting quadrant or octant to ease finding midday at sea.

Jeremy finished his talk by telling the story of Joshua Slocum who singlehandedly circumnavigated the world between 1895 and 1898 using the lunar distance method measuring the angle between the moon and a chosen star and astronomical tables, but claiming rather theatrically that it was all down to his $1 watch with no minute hand.

**"The RNLI and its Boats"**

David Richmond-Coggan, in the third picture, took us through the history of the Royal National Lifeboat Institution and showed some pretty hair-raising videos. He apologised for showing the latter straight after lunch, but they did illustrate just what he was talking about.

1824 was the official start of the Institution, although many formal arrangements for lifesaving had been made around the coast. The Liverpool Docks Trust, formed in 1776, was the first in the world. Soon after that there was a disaster in the mouth of the Tyne, where onlookers watched helplessly as sailors drowned. A competition resulted in Henry Greathead designing and building an open rowing boat in 1790. "The Original", as it was called, was manned by strong men and launched by strong women. In the next 100 years the only change to lifeboats was to add auxiliary sails.

Then in 1889 steam power was introduced. The boat was powered by a 170 hp compound steam engine, weighed 24 tons and was 50 feet long. The firebox had to be lit and stokers had to be in attendance continuously, so that the boat was always ready to go. Between 1889 and 1923, when it was sold, it embarked on 175 sorties, and rescued 295 people. It did the job. 6 of this model were built, all with the engine pushing out water jets from the bows as well as the stern to give them great manoeuvrability as well as speed.

Petrol engines were used from early 1900s. Being unreliable then and dangerous in a tossing boat, they were restricted to auxiliary use. 1936 saw the first diesel powered lifeboat at Yarmouth on the Isle of Wight.

David had a display stand set up at the back of the Rutherford Centre and on it was a very useful sheet showing the current models in the RNLI fleet of over 330 lifeboats. They range from 3.8 to 17 metres in length and some are designed to be launched down a slipway and others across a beach, from davits or already afloat. The oldest are the Tyne class from 1982 and Mersey of 1988, which are still serviceable and will be sold on to other countries, eg China has 20 already and pays well for advice and maintenance.

This year, 2013, will see the introduction of the Shannon class, which at 13.6 metres long is designed to cope with 16 metre waves and will be capable of 25 knots even in 60 knot winds. Its range is 250 miles and so can go more than 100 miles out to sea. It has 2 engines driving water jets for manoeuvrability, and also shallow water use. It will be carriage launched from a beach and can also be recovered that way. Each of the 6 crew has a consol in front of his seat with all navigational information displayed. David went into the need for safety of the crew, space for casualties, costs of the boats and their launch gear and we saw videos of life on board.

Most of the talk concerned the all-weather fleet, but the inshore fleet of smaller, faster (up to 40 knots) vessels built to cope with mud flats, river estuaries and floods on land were also mentioned. The RNLI even uses hovercraft.

**Radiosondes: their history and importance**

Keri Nicoll, see picture number four, came from the Department of Meteorology at Reading University to address us. Thousands of radiosondes, containing a variety of sensors, are released around the world every day at midday and midnight into the upper atmosphere to aid weather forecasting and research by recording a vertical profile of temperature, pressure, humidity, cloud height and so on. Keri's own work involves developing sensors for other measurements that are light enough to piggyback on radiosondes to keep costs to a minimum.

In 1749 an advance was made from climbing a hill to take readings to flying a kite. Alexander Wilson flew kites to 1 km with 3 or 4 thermometers tied at intervals to the line. He had to reel it in quickly to take the readings. High winds were a problem!

In the 1900s WH Dines made a great advance with his meteorograph. In a package weighing only 63g hanging under a balloon he had an aneroid device to measure pressure, a bi-metallic strip for temperature and a hair hygrometer for humidity, all of which had a point at the physical end of the sensor to scratch the reading on a silver film, which could be examined under a microscope when the balloon was recovered.

Only 10 days after the Montgolfier Brothers first manned flight in a hot air balloon, Jacques Charles and Nicolas Robert flew their hydrogen balloon on 1 December 1783 carrying a thermometer and a barometer and so they could record measurements while aloft and also describe what they saw. It took 4 days to fill the balloon with the fumes from sulphuric acid and scrap iron and Professor Charles reached 3km on his own before feeling unwell and releasing the gas valve to descend safely.

Despite the dangers, Henry Coxwell and James Gaisher made 27 flights in hydrogen balloons from 1862 measuring pressure temperature and humidity up to 10km in altitude. However, after they nearly passed out due to lack of oxygen and others had had explosions on board. It was realised that unmanned balloons, which needed less of the expensively produced gas, and automatic data recording was the way to go, after all they had been using small paper pilot balloons for years to assess wind direction.

In 1898 de Bort discovered that at 16km altitude the temperature no longer fell with increasing height. He had discovered the stratosphere. The only trouble was he had to rely on others posting him the records of his readings when the balloons returned to earth. By offering small rewards he did get 97% back after a few days or weeks.

In 1927 Idrac and Bureau first flew a radio transmitter into the stratosphere. By 1929 Robert Bureau had received meteorological data back by radio and had coined the word "radiosonde", sonde being French for probe. The Russian, Molchanov, was the first to use the data in real time for weather forecasting when he transmitted the results directly to the radio station in Moscow in 1930.

All national radio stations wanted to do the same. The UK Meteorological Office designed its own radiosondes and used them from the 1930s until the 1980s, when they changed to the Finnish Vaisala ones which use the more reliable capacitive transducers to modulate the radio waves rather than inductive ones.

Keri showed pictures of the many different designs of radiosondes available now. They still measure the same quantities, but electrically: pressure is still detected with an aneroid capsule but the change is turned into an electrical signal; temperature by change in resistance of a platinum wire, and humidity by using a porous dielectric in a capacitor. GPS is used to determine position. Data is transmitted at 1Hz and so as the balloons ascend at about $5ms^{-1}$ readings are taken at 5m intervals, a vertical resolution not possible with aircraft. These days the results are received by radio and displayed on one's computer in the balloon shed or wherever.

The latex balloons are filled with helium these days and expand from 1m diameter to 10 or 15m as they rise and then burst. The parachute below the balloon returns the radiosonde gently to earth, which is actually disposable. Keri showed in a video some of the difficulties in launching radiosonde attached to a balloon.

Specialist radiosondes have been developed. Cells to detect ozone by allowing it to react with potassium iodide to release iodine and an electric current were introduced in the 1960s. Particles can be counted and sized when they pass in front of a beam of light. The effects of volcanic eruptions can now be followed. Aerosols can remain in the stratosphere for months. Electric fields up to $10^9$ $Vm^{-1}$ in thunderstorms have been measured, but so far their cause is not understood, but work continues in measuring the charge on individual aerosols.

Victor Hess discovered cosmic rays in 1912, while on a balloon flight. They are charged particles, which collide with and ionise atmospheric nitrogen and oxygen. Staff at the Lebedev Institute in Moscow have been examining cosmic rays using Geiger Counters on balloon flights for the last 50 years. The hope is that they will be able to continue.

Keri then described her own work. She is developing sensors that are light enough to piggyback on radiosondes to keep costs to a minimum. Examples for such sensors are for: ozone concentration; cloud tops and bases by optical rather than thermodynamic means giving answers within 10 metres, which is much more precise; cloud droplet size; turbulence by changes in a magnetometer output, which is constant when not swung around; the charge on Saharan dust to find out whether it is the reason for alignment of the particles, which interfere with satellite retrieval. She is still investigating why the Icelandic volcanic plume of a few years ago managed to remain electrically charged by the time it reached Scotland.

Keri finished by showing a video of Reading University's latest venture into Unmanned Ariel Vehicles (UAV), which are electrically powered model aeroplanes only 50cm wingspan but capable of carrying sensors up to 2km altitude.

**Vegetation patterns in meadows are explained by patterns in hydrology**

Professor David Gowing, shown in the 5th picture, began by showing some beautiful pictures of wild flowers in a flood plain meadow lying between the River Thames and the River Churn. The question was, "Why did the various species clump together and sort themselves into particular areas of the meadow, when the ground appeared to be the same everywhere?"

Flood plains were well managed in medieval times and were common land so that no one owner was able to change it. The one chosen here is owned by National England and the medieval regime has been maintained. Hay is cut every June. Then cattle feed on the stubble for a time. Otherwise it is left to do its job of coping with floods from the rivers with a little help from surface drainage channels.

David described how he and his team from the Open University looked into the hydrology of the area and how the water table varied through the seasons. Winter rain causes the table to rise at points between the rivers and summer evaporation causes it to fall so that the meadow becomes driest in the middle of the meadow. There is a capillary fringe above the water table, where the soil is neither waterlogged nor completely dry. So, the water table rises and falls most away from the rivers.

He showed diagrammatically the degree of water logging and the degree of soil drying on a sum exceedence value (SEV) plot of depth of the water table against month of the year. Water logging excludes oxygen above a certain threshold and soil will be too dry below the soil drying threshold. This information has been fed into a computer model to try and predict which species will favour which conditions.

By plotting SEVs in metre weeks (water table depth x time) of water logging versus SEV of soil drying in metre weeks and by marking on the diagram the frequency of occurrence less than, as expected, and more than likely by chance a picture emerged of the conditions certain species favoured. Thus in the buttercup family, it became clear that meadow buttercups favour a constant water table, creeping buttercup favours wet soil and bulbous buttercup favours dry soil. The plants are counted by many volunteers every April.

Each year's hydrology is different and so no one species becomes dominant. This dynamism explains the high diversity of species – up to 40 different species in 1 square metre.

Each talk drew a number of questions and answers and more questions, which is just as it should be. My special thanks go to Kate Quinton for taking notes and to Andy for making available a sound recording of the whole of the proceedings.

Mike Quinton