Australian Meteorological Association Inc

# Monana

THE OFFICIAL PUBLICATION OF THE AUSTRALIAN METEOROLOGICAL ASSOCIATION INC

September 2020 Edition

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*The next PWS Edition of the Monana magazine is due to be published on the 20th November 2020. Please submit all PWS items for publication by the 6th November 2020 to:*

***monana@ameta.org.au***

*But don't forget to also send non-PWS items for inclusion in the more general February edition of Monana.*

> *"The more a man knows, the more willing he is to learn. The less a man knows, the more positive he is that he knows everything..."*
>
> — **Robert G. Ingersoll**

Mac's webinar on the recovery of historical weather observation records was very interesting. Apart from the excellent work taken to digitise and present the old observations, Mac touched on the subject of "*homogenisation of observations*".

*Homogenisation of observations* is commonly used as "evidence" by conspiracy theorists that meteorological organisations around the world are conspiring to "fudge" historical observations so that they can fake evidence of a rise in global temperatures. Unfortunately, it is clear that this is often a result of people not understanding what homogenisation is, and the much larger process to adjust readings to reflect physical reality as closely as possible. This edition has a look at some methods used to give the most accurate representation possible of the weather conditions being observed, including homogenisation.

## Your Thoughts on Monana

It has been some months since the *Monana* format has been changed. While there has been a bit of feedback about the editions this year, it is time to let the people taking the time to produce the magazine know what you like, and what you don't like. Please send your opinion to monana@ameta.org.au and let us know what you think. If sufficient members like the recent magazines (or parts of it), we will make sure that it continues, but if quite a few members aren't enjoying aspects of their magazine, then we will look to improving it. However, the best way to improve the magazine is to make a contribution. The magazine cannot improve without the assistance of its members and it cannot be left to just a couple of people to do all the work—they will burn out.

## Physical Meetings

Next year will hopefully see conditions where the resumption of physical meetings is practical. Your Committee will take into account the current advice before making a decision to attempt a physical meeting.

However, since the Committee does not, and cannot, know an individual member's state of health, it will be up to you and your health professional to make the final decision on whether attending would be an unacceptable health risk to you. For people that decide not to risk attending a physical meeting, we will attempt to stream the meeting on-line.

***Keep Happy, Keep Safe.***

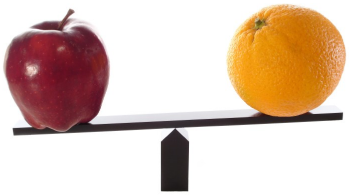
Mark Little
**email:** president@ameta.org.au
**mobile:** 0434 602 091

# Errors & Inaccuracies

## *Scientists may seek Truth, but*
## *Science is the Art of Approximation*

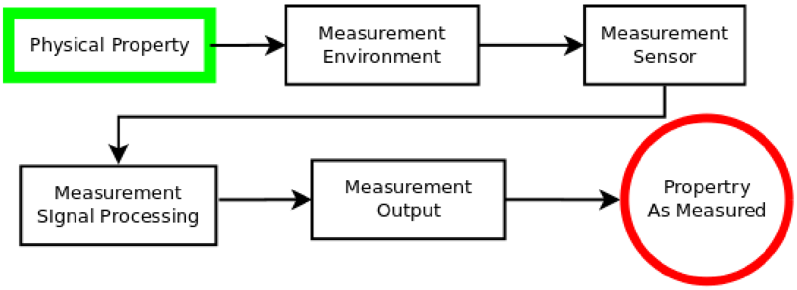
—**William Hooke**

The only thing that we can be sure of is that every measurement that has ever been taken is only approximate. No matter how many resources we throw at a measurement now, at some time on the future it will be seen to be less accurate than it could be.



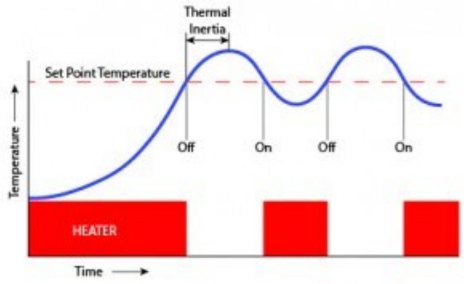
This causes two basic problems that scientists and engineers are always trying to overcome. The first is that the reading does not reflect the actual environment and closely as it could, and secondly, when an old measurement is compared to a measurement made with new equipment and procedures, it is an "apples and oranges comparison", not an "apples and apples" comparison.

To make a sensible comparison between the old and new measurements, first we need to understand how both measurements were made and determine the relationship between the two sets of measurements. The diagram to the left represents some of the step involved in making a measurement of a physical property.

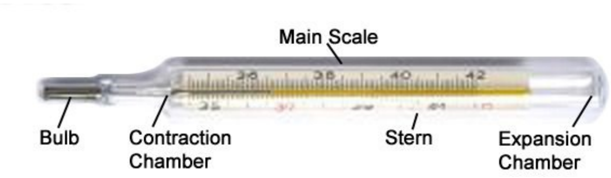


The green box represents the physical property that is going to be measured. If the measurement system was perfect, the red circle representing the physical property as measured would be exactly the same as the value of the physical property. Unfortunately, this is never the case. Each step between the physical property and the measurement will introduce unwanted artefacts into the measurement.

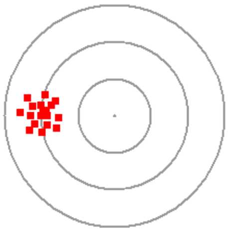
If we look at the outside air temperature as the physical property that we wish to measure, the Physical Environment includes such things are the general environments such as local obstructions like vegetation which may obstruct the air flow to the sensor, creating a  pocket of air that does not fully mix with the wider atmosphere.



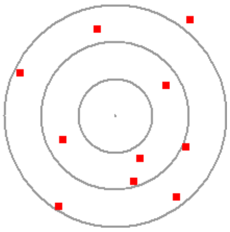
The measurement sensor can either a glass thermometer or an electronic temperature sensor.  In both cases, they do not give a 100% accurate representation of the temperature that they are measuring. As illustrated in diagram to the left about temperature control, the thermal mass of the heater means that temperature changes do not occur instantly. The environment in which they are located has a physical mass with its own thermal inertia. This means that the local environment does not necessarily accurately record rapid fluctuations in temperature. The use of  the slatted Stephenson screen allows for the atmospheric to circulate around the thermometers and in some cases, the thermometers are aspirated (outside air is blown over the thermometer) to reduce the effects of thermal inertia. Other major environmental factor that can affect readings is the Sun. Who does not understand that while the air temperature may be cold, you feel warmer if you stand in the Sun, or that a closed car in the sunlight can reach scorching temperature well in excess of the air temperature?



It doesn't take much imagination to realise that if the tube in the mercury thermometer had an imperfection that caused one section of the tube from the bulb to be wider than the rest that it would take more mercury to fill that part of the tube and that would mean that it would take a greater increase in temperature to make the mercury in the bulb to expand enough. Any of us with aging eyes also know that it is much harder to accurately see where the mercury is against the scale. Electronic sensors don't have those problems, but they do have errors of their own.



Systematic Error

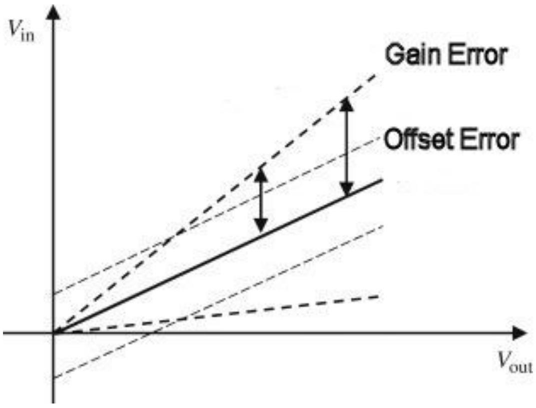


Random Error

All of the errors in measurement can be broadly put down to two types of error: Random or Systematic. To understand what the two types are, let’s look at the process of a tradesperson estimating the cost of a job of putting down a concrete slab. A random issue may be that a truck bringing material to the site has a crash and delays delivery of the material. This is an event that could not be accurately predicted, even though it known to happen and the effect of such an event can be estimated. However, the fact that the foreman regularly over-estimates the amount of labour required for a job by 20% is a systematic failure that can be accounted for to get a more accurate estimate.

In many cases, we can’t do much about random errors, except attempt to quantify them and understand that this may determine the best accuracy we can expect from our sensors. That is, if we get random fluctuations of ±0.1°C from out electronic thermometer, we can never be sure of an individual readings to a greater degree. Depending on what we are doing, we might be able to take multiple readings to reduce the effect of random noise, but this may hid actual changes to the parameter being measured.

Systematic errors, on the other hand, can be addressed to get a reading that reflects reading more accurately, even if not exactly. There are commonly two types of simple correction applied to meteorological readings: calibration and harmonisation.



Calibration is a scheme were we look at a particular measurement setup, determine the errors apparent in that system and how they affect the readings, and then apply a correction to the readings to make it better reflect the actual parameter being measured. The diagram to the left relating to analogue to digital converters illustrates two of the most common systematic errors with sensors: Offset and Gain errors. In the diagram to the left, the solid line is the expected relationship between the measured parameter ($V_{in}$) and what the sensor outputs ($V_{out}$). The solid black line represents an error free measurement. The light dotted line represents an offset error. An offset error is one where the output reading is always offset by some fixed value.

The heavy dotted line represents a gain (or scale) error. In this case, the reading is multiplied by some value to give the output reading. For example, if the gain error was +10%, then the reading would match at 0, but when the actual value was 10, the output reading would be 11 (10 + 10% of 10). If the gain error was –10%, they would be same at 0, but at a actual value of 10, the reading would be 9.

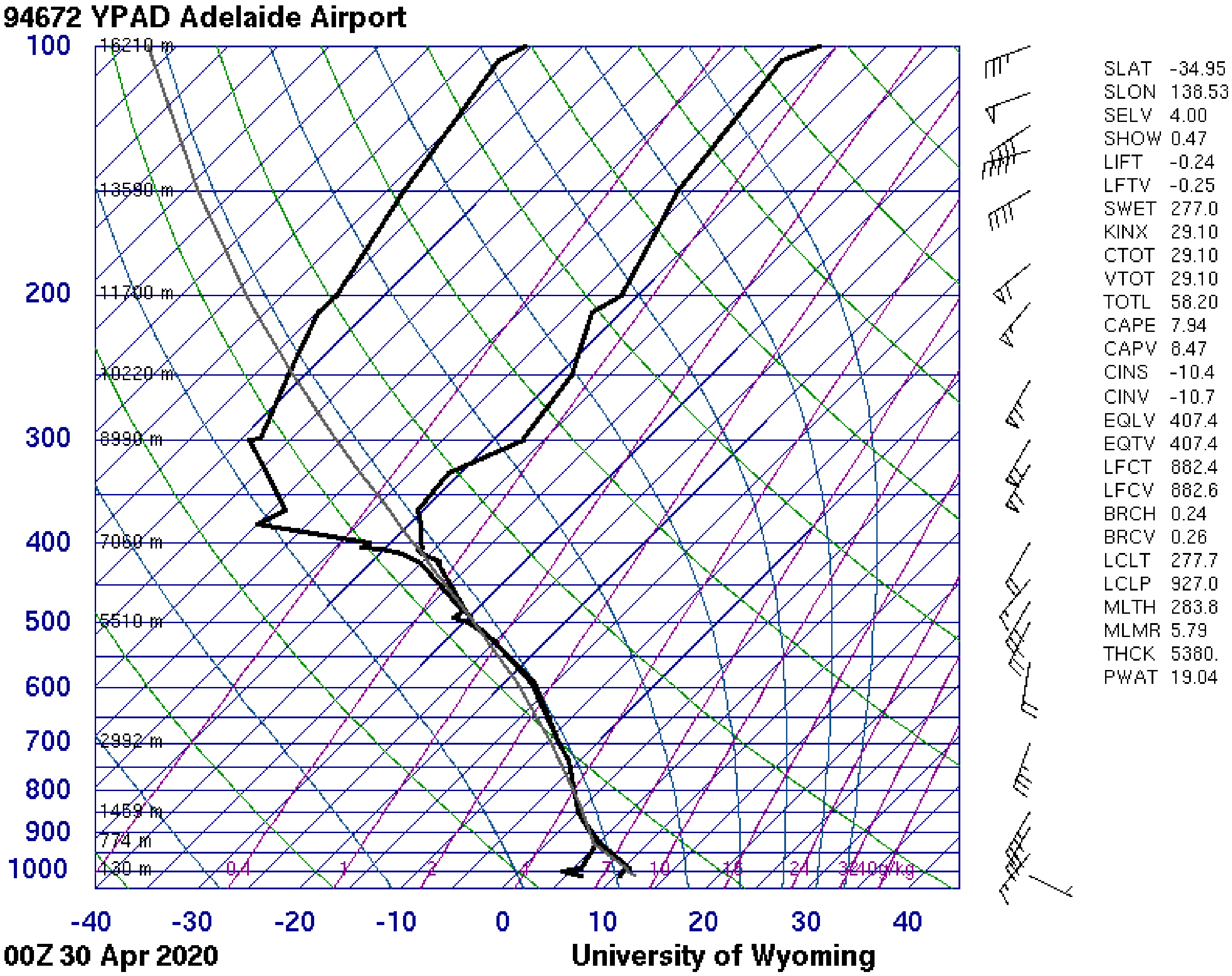
To remove the offset error, it is a simple matter of subtracting the offset from the reading to give the actual measurement. In case of the scale error, it a bit more complex. If the gain error is 10%, multiply by a factor that reduces the reading by 10% (.9). If we do, we would use 11 * 0.9, giving an answer of 9.9, instead we need to multiply by a factor which is actual/measured with in this case is 10/11. Now if we multiply the actual reading by 10/11, we get 10 which is the correct value.

Adjustments to the output reading caused by issues within the measurement device is called “calibration” and is most common reason for adjusting measurements. There is another reason for making adjustments to readings, and that is where the measurement environment changes and that is called “harmonisation”.

An example of harmonisation is where the official weather station moved from Kent Town to West Terrace. If observations are taken simultaneously take at Kent Town and West Terrace there will be difference even though the equipment is the same type and calibrated in the same manner. This is because the physical environment is different. To more accurately compare past Adelaide weather conditions with current conditions, the systematic differences between the readings at both sites must be gathered and analysed. Then adjustments can be applied to the old readings to match them more closely with what would have been read at West Terrace.

An anecdotal case of “harmonisation” is when the residents of the Salisbury-Elizabeth area hear the forecast maximum for Adelaide, they automatically add 1°C to get the local area maximum forecast. Although not an especially scientific analysis like the official harmonisations, as a local I think that it is pretty accurate most of the time.

# Improving Cloud Observations With The Skew-T Diagram (Part 2)



In the last PWS edition, we looked at identifying the wind speed and direction across the height profile of the balloon flight. This month, we will be looking at the mass of scale lines on the chart, as well as the readings plotted on the graph.

The vertical axis is the only scale on the chart that is parallel to an edge of the chart. The scale is a logarithmic scale of atmospheric pressure, not altitude. The log scale reflects the fact that the atmospheric pressure reduces logarithmically with height. Well, that would be the case if the atmosphere was totally homogeneous in the vertical profile. Because that is not quite correct, altitude corresponding to various pressure levels is placed on the chart near the pressure scale. Normally, the altitude is plotted at specific pressures such as 1000 hPa, 850 hPa, 700 hPa and so. As you can imagine, it is difficult to interpolate the height reading on the graph to get the height of a point of interest. Luckily, one can swap from viewing the Skew-T diagram to the sounding chart with all the readings taken during the flight if bit more accuracy is required.

The mass of scales along the horizontal axis is a bit of a dog's breakfast, but luckily after having a quick look at them, they can be ignored. The atmospheric temperature scale is represented by the blue straight, parallel lines sloping up to the right—hence the chart's name Skew-T (skewed temperature). The dry adiabats are the blue lines that curve up the left from the temperature axis. The saturation adiabats are the green lines that have a varying curve up from the temperature line. Finally, the saturation mixing-ratio lines are the purple lines that curve up to the right from the horizontal axis.

Reading the Skew-T chart let alone understanding all that it can tell you about the atmosphere can be daunting and difficult, but luckily we won’t need to understand them at all for the limited use to which we will put the charts.

On the other hand, it is good to have just a basic inkling of what those lines are about, and I might add it is just a basic inkling, because that is the limit of my understanding. The dry adiabats indicate the rate of temperature change in a parcel of dry air which is rising or falling adiabatically (occurring without gain or loss of heat). The saturated adiabats indicate the temperature change of a saturated parcel of air rising pseudo-adiabatically through the atmosphere. Pseudo-adiabatically means that it is assumed that all condensed water vapour is assumes to automatically fall out of the parcel of air as it rises. Lastly, the saturation-mixing-ratio indicates the mass of water vapour that must be mixed to a dry parcel of air to make it saturated. That is, the grams of water vapour required to make a kilogram of dry air saturated.

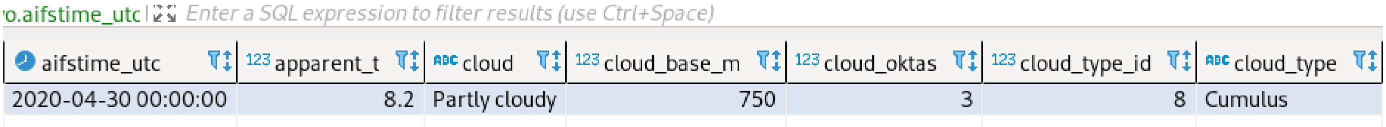
Now that all of coloured wavey lines are out of the way, it is time to look at the two plot lines. They, of course, the environmental (air) temperature and the dew point temperature. There is no colour coding or dashes on these lines, because their relative positions identify them. This is because the dew point temperature can never be higher than the air temperature, making the line to the right air temperature and the line to the left dew point.

It is looking by looking at these two lines that we can get an indication of the where there is likely to be cloud at the time of the balloon flight. In simplistic terms, if the dew point is the same as the air temperature, the relative humidity will be 100%. If the relative humidity is 100%, the water vapour in the air will begin to condense and form clouds. So, looking at the Skew-T, anytime that the two temperature lines overlap, we can consider that the sonde is passing through a region of cloud.

Looking at the image on the previous page, it looks like there was cloud from a bit less than 774 metres up to about 5,500 metres. I don’t have an all-sky camera, my weather camera does show that there are significant patches of clear sky with Cumulus cells in the area.

Assuming that the rest of the sky is similar to what is in view, one would expect that the total sky coverage would be around 2 to 4 oktas (1/8ths of the sky). The camera is pointing South and the Sun is shining directly on the bit of roof visible at the bottom of the image, indicating that, at least to the East, it is only partially cloudy as well. I have to say that I do cheat a bit when identifying clouds by using charts such as the International Cloud Atlas Cloud Identification Guide. The BOM presentation on YouTube What’s That Cloud also gives some information about cloud types.

So, let’s see what the professionals were thinking at the time. Below is an extra from my database that I use to check the readings of my weather station. In this case, it is the 00Z observation at Adelaide Airport which SSW from my location.


'o.aifstime_utc | Enter a SQL expression to filter results (use Ctrl+Space)

| aifstime_utc | 123 apparent_t | ABC cloud | 123 cloud_base_m | 123 cloud_oktas | 123 cloud_type_id | ABC cloud_type |
|---|---|---|---|---|---|---|
| 2020-04-30 00:00:00 | 8.2 | Partly cloudy | 750 | 3 | 8 | Cumulus |

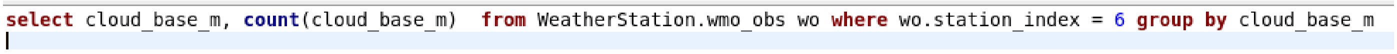
It would be fair to say that my observations matched the official observation pretty well, but I’m afraid that I couldn’t honestly claim that I am able to give any sort of sensible cloud base estimation. When I was training to be a Technician/Weather Observer for a stint on Macquarie Island (about 45 years ago), estimating the cloud base was one of the things that took me a long time to get the hang of. Since a very common cloud condition was 8 oktas of low stratus, my favourite things in those days was the plateau of the island that gave a fixed height indication, as well as the cloud base searchlight and clinometer where the cloud base could be measured by a bit of simple trigonometry.

Looking at that observation, the one thing that I have never been able to figure out is how to decode the cloud-type-id field in the observation, I would be interested in hearing from anyone who does know how to decode it.

I was hoping to put in a nice picture or graphic of using an clinometer to measure the cloud base, but it appears that it is too pre-internet and boring to rate. So, instead here is a YouTube presentation by Eddie Woo on using an clinometer to measure height. https://www.youtube.com/watch?v=775XrAIKUwo.

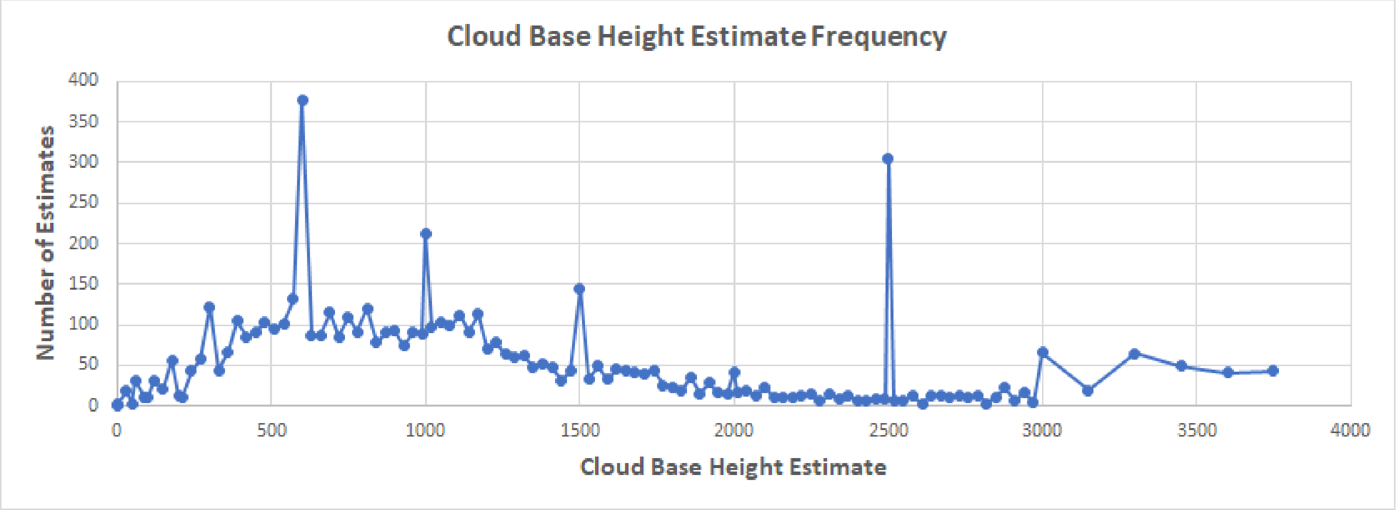
# Cloud Base Height Detective Work

While I was looking at the official cloud base estimates, I thought that it would be interesting to look at the distribution of cloud base estimates that have been made over the period that I have been doing comparisons with my weather station. To do that I queried my database so that it gave the number of estimates for each height in the table using the following query

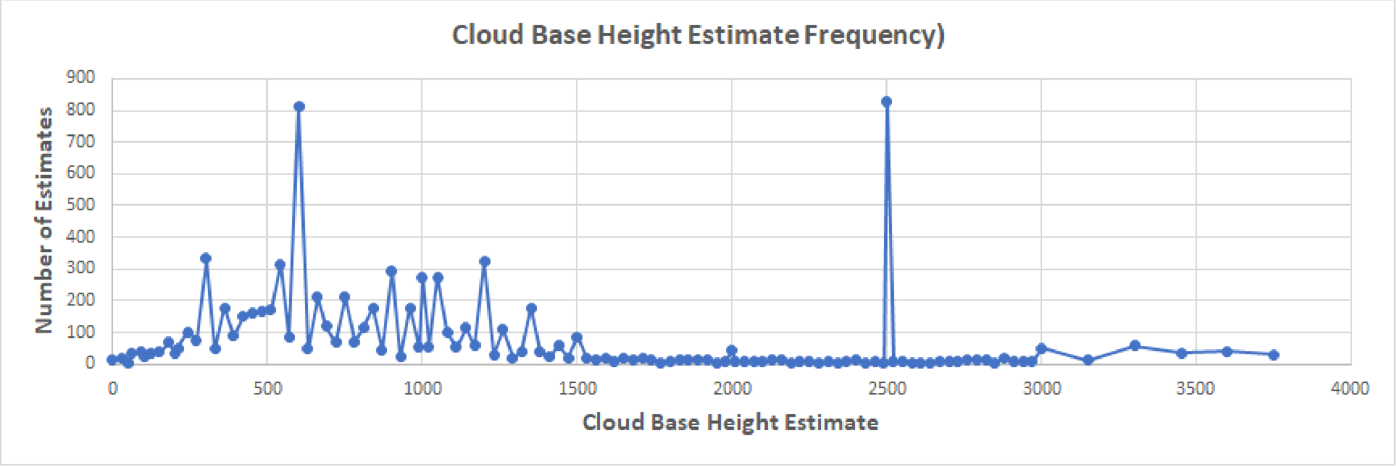


```
select cloud_base_m, count(cloud_base_m)  from WeatherStation.wmo_obs wo where wo.station_index = 6 group by cloud_base_m
```

What this does is select the cloud base height and the number of times that each cloud base height has been entered over the span of my database ( 11-Dec-2019 to 13-Sep-2020) for Parafield Airport. I was expecting that there would be a bit of smooth curve of height estimates, perhaps with maybe a couple of peaks for the common low level cloud heights. The resulting graph was a bit unexpected.

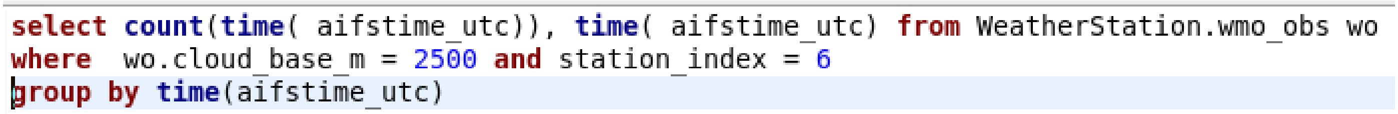


There was a curve with a hump as I expected, but there are anomalous peaks at (possibly)300 metres, 600 metres, 1000 metres 1500 metres and 2500 metres. It seemed unlikely that these peaks reflect an actual narrow range of cloud base heights. I did a quick plot of Adelaide Airport and I got unexpected peaks as well, predominantly at 600 metres and 2500 metres.

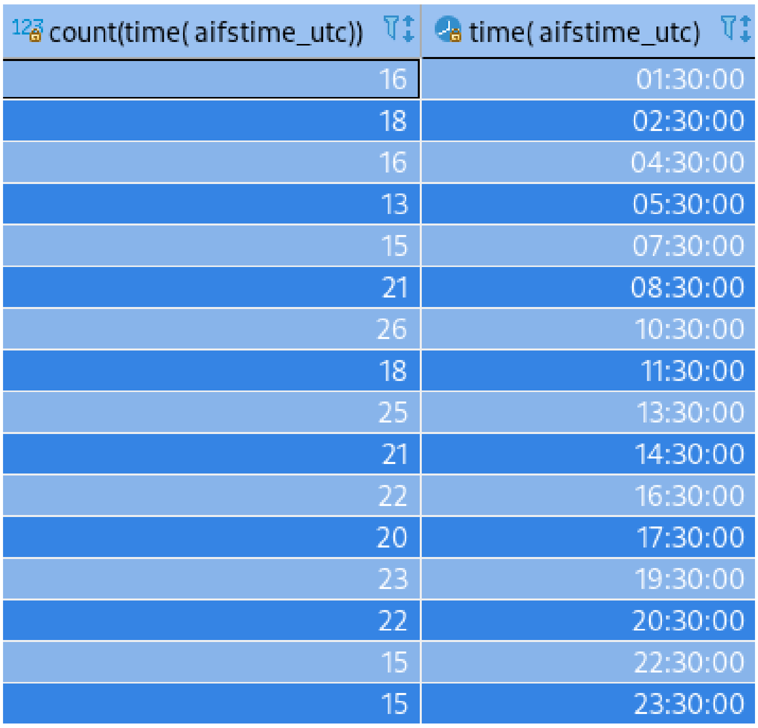


These graphs set me wondering why there were such high anomalous peaks in the height estimations.

In an attempt to gain more information, I ran the following script for Parafield airport:



```
select count(time( aifstime_utc)), time( aifstime_utc) from WeatherStation.wmo_obs wo
where  wo.cloud_base_m = 2500 and station_index = 6
group by time(aifstime_utc)
```

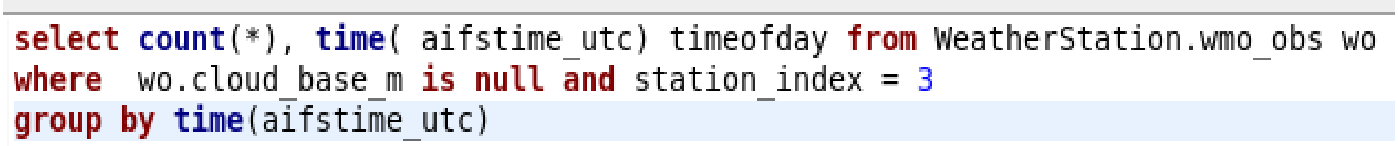


| count(time( aifstime_utc)) | time( aifstime_utc) |
|---:|---:|
| 16 | 01:30:00 |
| 18 | 02:30:00 |
| 16 | 04:30:00 |
| 13 | 05:30:00 |
| 15 | 07:30:00 |
| 21 | 08:30:00 |
| 26 | 10:30:00 |
| 18 | 11:30:00 |
| 25 | 13:30:00 |
| 21 | 14:30:00 |
| 22 | 16:30:00 |
| 20 | 17:30:00 |
| 23 | 19:30:00 |
| 22 | 20:30:00 |
| 15 | 22:30:00 |
| 15 | 23:30:00 |

The result of the script was interesting, so re-ran it for Adelaide Airport and got the same type of anomalies as the Parafield Airport. What caught my eye was that over the period of about 10 months, there were no cloud base height measurement of exactly 2500 metres every three hours.

The difference between UTC and Australian Central Standard Time (ACST) is +9hr 30 minutes. Adjusting the UTC times in the table to ACST shows that the 2500 metre readings are missing from observations at 18:00, 21:00, 00:00, 03:00, 06:00, 09:00 and 12:00 ACST.

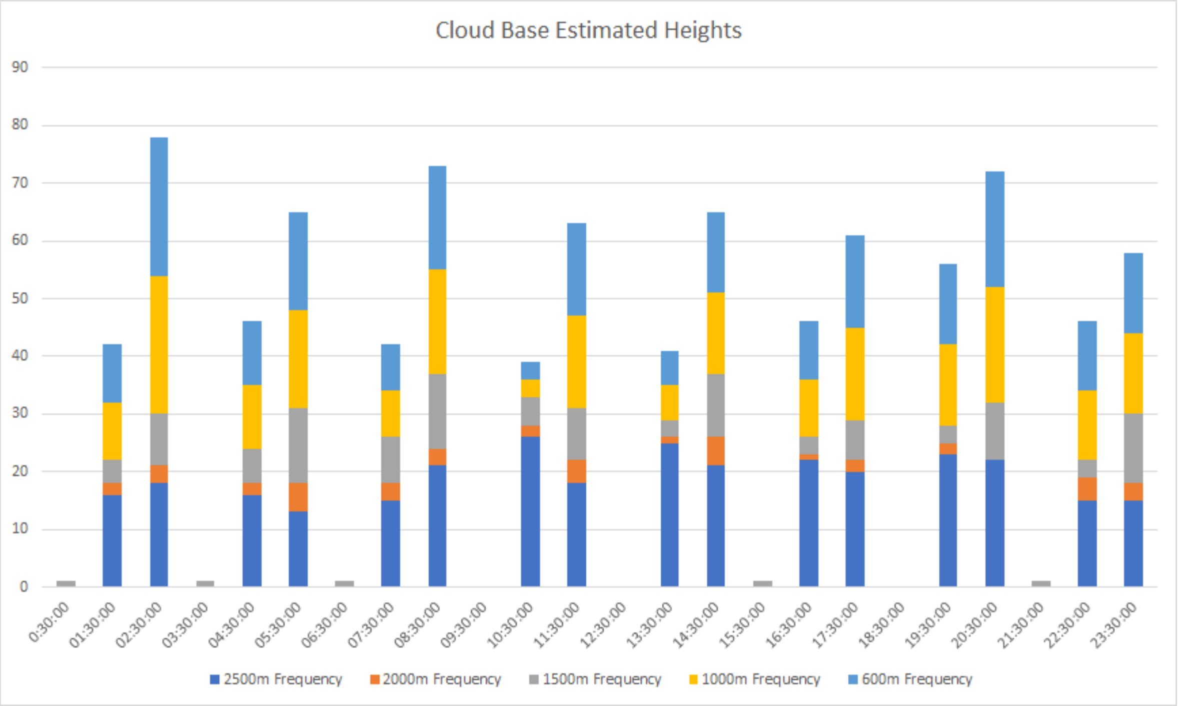
By my understanding, this is the time for the synoptic observations to be carried out manually. Possibly, this could mean that the anomalous 2500 metre readings could be coming from an automatic ceilometer? Because I believe that the cloud base field is left empty when there is no measurable cloud base, the next step is to determine if empty fields are missing from those periods that have 2500 metre values. This was checked with the following script for Adelaide Airport:



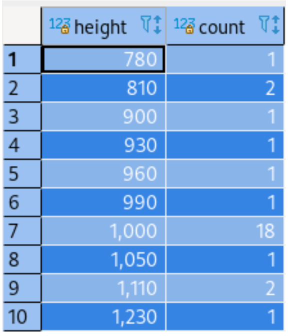
```
select count(*), time( aifstime_utc) timeofday from WeatherStation.wmo_obs wo
where  wo.cloud_base_m is null and station_index = 3
group by time(aifstime_utc)
```

This result of the query is too big to fit neatly in the magazine, but it showed that there were cloud base readings in every half hour where no cloud bases were recorded. This means that the theory that the clinometer is using 2500 when there is no measurable cloud base does not seem valid.

I combined the queries for 600m, 1000m, 1500m, 2000m and 2500m and got an interesting  graph.

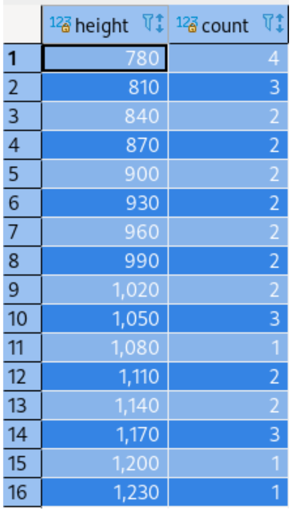


While there are cloud base height observations every 30 minutes the cloud base estimates of exactly 600m, 1000m, 1500m, 2000m and 2500m, these values go missing every three (3) hours. A check of the observations indicates that cloud base heights are being recorded above and below those specific heights in those periods where the exact heights are missing. I looked at the breakdown of 08:30 and 09:30 readings  looking at the cloud bases around 1000 metres (750 metres to 1250 metres) as recorded at Parafield Airport (as the odd peaks are more prominent) with the following results.

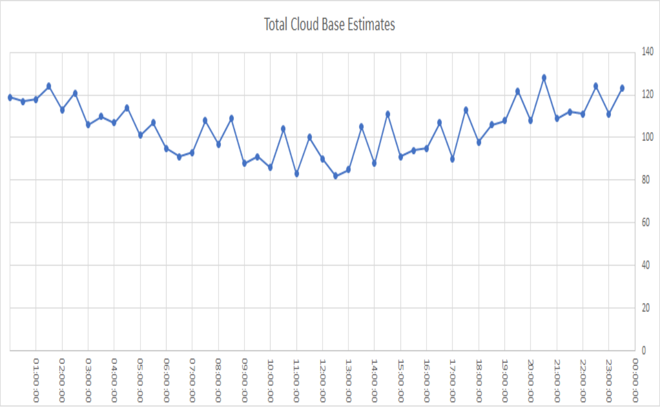


| | height | count |
|---|---|---|
| 1 | 780 | 1 |
| 2 | 810 | 2 |
| 3 | 900 | 1 |
| 4 | 930 | 1 |
| 5 | 960 | 1 |
| 6 | 990 | 1 |
| 7 | 1,000 | 18 |
| 8 | 1,050 | 1 |
| 9 | 1,110 | 2 |
| 10 | 1,230 | 1 |

On the left is the cloud base readings for the 08:30 observations from Parafield Airport. On the right are the 09:30 cloud base observations at Parafield. The difference is quite pronounced. I then wondered if there was a trend in cloud base heights through the day, and it was that I realised another apparent anomaly Looking the graph on the bottom of the previous page there is a repeating 3-hour cycle of getting exactly the readings that I've been looking at.  Wondering the total number of estimates followed that 3- hourly cycle, I plotted out the total number of estimates. It appeared to have a diurnal cycle, as well as a 3-hourly cycle.



| | height | count |
|---|---|---|
| 1 | 780 | 4 |
| 2 | 810 | 3 |
| 3 | 840 | 2 |
| 4 | 870 | 2 |
| 5 | 900 | 2 |
| 6 | 930 | 2 |
| 7 | 960 | 2 |
| 8 | 990 | 2 |
| 9 | 1,020 | 2 |
| 10 | 1,050 | 3 |
| 11 | 1,080 | 1 |
| 12 | 1,110 | 2 |
| 13 | 1,140 | 2 |
| 14 | 1,170 | 3 |
| 15 | 1,200 | 1 |
| 16 | 1,230 | 1 |



So at this stage, it was getting late, so I decided to review the information that I had gleaned and see if I could come to some conclusions. I did come to some initial conclusions, but discussing with Beth and Bruce shot some of my theories down if flames. My discredited musings have been removed without any definitive replacement. ☹

Beth put me in touch with a person who had been involved in the management of the observations, and confirmed that the cloud base heights were measured with a ceilometer. Effectively scuppering my theory that a combination of automatic instruments and Weather Observers were providing the cloud base heights.

He did indicate that I should get in touch with the climate people at the BOM, which I have done. I have receive an initial response from the BOM that my query has been passed on to the Observations area and that they are waiting for a response.

I have examined my code and I can't see anything that would have falsely caused those peaks to appear in the data, but you never know. However, it also seems unlikely that an automated measurement would cause the peaks either.

No matter what the outcome, I'm sure it will be informative, but for the time being, I will stick to using the Skew-T diagrams for cross-checking my height estimates. I'll use the chart to estimate the cloud bases, and look at the time lapse movies to see which way the cloud bases are moving.

For those are interested in in my time lapse sky camera movies, they can be found at the bottom of this web page: http://brigadoon.power.on.net/projects/extended_pws/addsensors/skycamera.html To look at some older movies click on the Sky Camera History link. Downloading a movie may take a bit of time as the files are location on my home computer, not a commercial server.

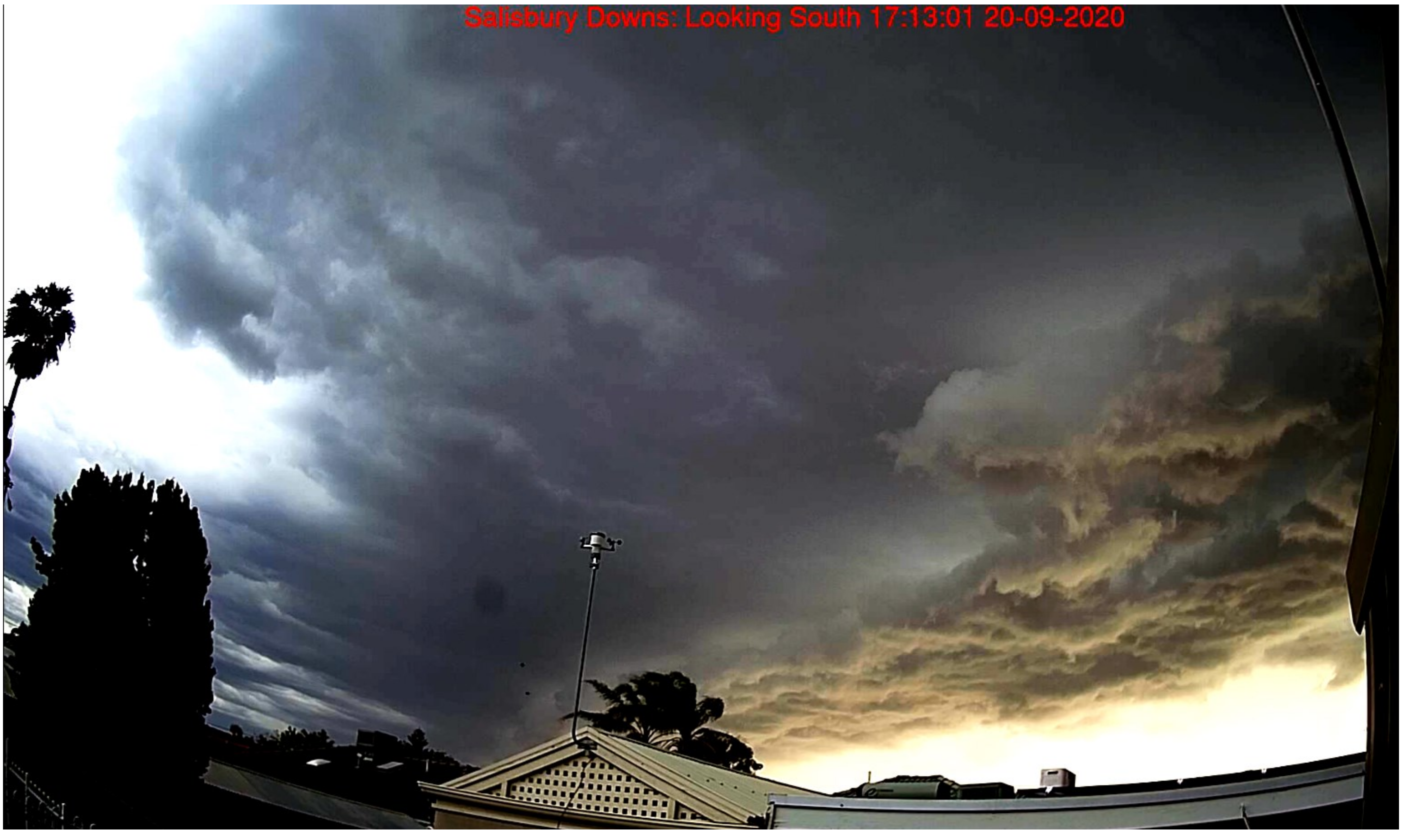
If you want to look at the latest Skew-T charts from the BOM, Bruce has supplied the following link: http://www.bom.gov.au/aviation/observations/aerological-diagrams/ These charts plot the last two (2) flights and are plotted in colour.

If you want to look back further than the last two (2) flights, or outside the Australia/New Zealand region, the University of Wyoming is a good place to start looking. http://weather.uwyo.edu/upperair/sounding.html

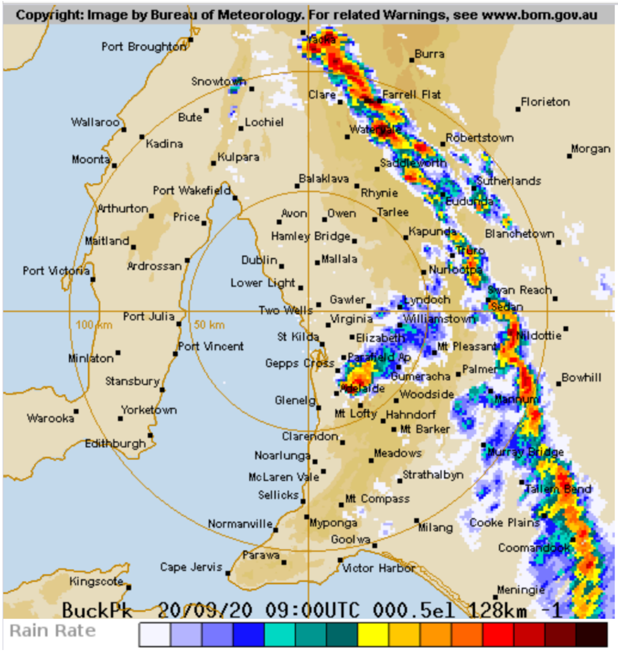
# Watching the Front (20-Sept-2020)

I was pondering what to write for a final article in this edition of Monana on the afternoon of the 20th September 2020. Alexa and I were talking about the potential storm that was to hit the Riverland where our houseboat was moored. As the day has progressed, the warnings faded away. Later Alexa happened to comment that there was a strange thin line on the weather radar moving in from the West. The front was on it way.

Looking back at the weather camera's time lapse movie, the first scrappy Cumulus became visible on the sky camera coming from the North West. At 15:19 the cloud started to build up. The cloud cells came across the sky in waves. By 15:40 the cloud started to darken and gain some vertical extent. By 17:13, the sky was looking quite spectacular.



The dark band looked quite narrow and this seemed to tally with the weather radar image. Unfortunately, I didn't have the presence of mind to capture the map when the front was just a very narrow strip of red and black, but here is one that was taken later. Even though this  image as taken at 18:30, and the front was starting to spread, the narrowness of the edge can still be seen.

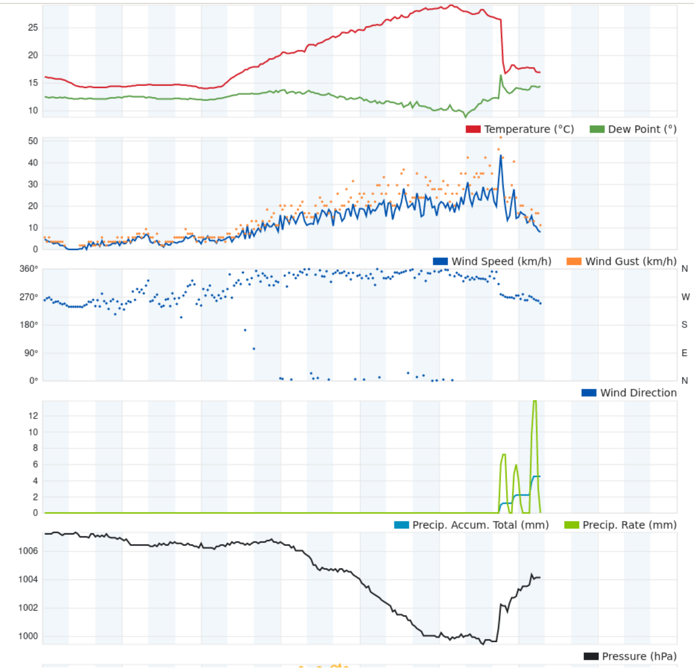


The data from my weather station is uploaded  to the Weather Observations Website (WOW) supported by the BOM, the Weather Underground (WU) and the Ecowitt Weather site, as well as being recorded on my own database. While I like supporting the WOW website, as I've said before, I find that the WU site provides the best plots of the data along with a moveable cursor so that you can match events on all plots.

Although WOW and WU capture my sky camera images, the best images can be found on my own website. If you want to see the current images from the sky camera and the current day's time lapse movie, select "Return to Sky Camera".

Since I have been extolling the virtues of the Weather Underground, let's look at their plot from my weather station data for the event.

Just a quick glance at the graphs makes it obvious when the front



came past my place. If you draw vertical line down from the temperature graph where the temperature drops to the other graphs, you can see what happened to the other parameters.

If you were viewing this graph on-line a cursor is available so that you can pick a point on any graph and it will give you the time of day and the value at that time on all the graphs.

The temperature graph shows that the temperature drops 10° C over a period of 15 minutes. This corresponds to the time when the wind gusts up to over 50 kph, the rain commences and the barometer rises from 999 hPa to 1002 hPa in about 7 minutes.

What wasn't recorded by the weather station or the camera was the thunder and lightning just before and after the front passed. The first clap of thunder was detected, however—by the dog who went mental as it was the first loud clap that he had ever heard. By the second clap of thunder, he had realised that it wasn't in the yard or just outside in the street and lost interest.

# Photos Fillers

Moai in Easter Island Quarry (14-Jan-2017)

Machu Pitchu (21-Feb-2017)

Rua Reidh Lighthouse (15-May-2019)

Dunnotar Castle (22-May-2019)