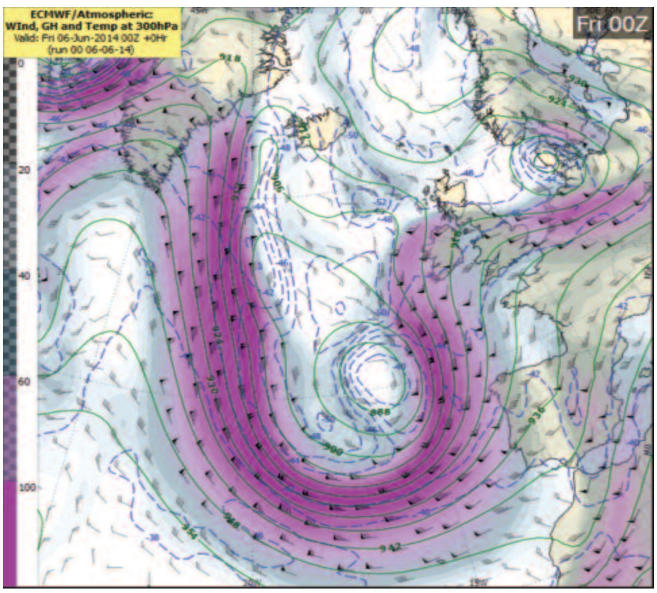
Weather forecasting – science or a stab in the dark?

I recently had a conversation with an experienced search and rescue helicopter pilot who also maintains a keen interest in the weather. He suggested that trying to forecast some of the weather he encounters in his daily work must be akin to engagement with the 'black arts' such was its apparent unpredictability. In particular, he was referring to local variations in cloud base and visibility, over small geographical areas, that he regularly observes when undertaking a flight mission.

There is no doubt that forecasting the weather is complex. To meet this challenge forecasting meteorologists are educated to understand how different atmospheric processes work to produce the weather we encounter in our daily lives. By following a systematic approach to the forecasting task and using their theoretical knowledge, coupled with a range of weather observations and forecast guidance tools, forecasters can determine the **most probable** future state of the atmosphere.

The forecast process itself consists of three phases. Firstly, one must **analyse** the current state of the atmosphere, then **diagnose** the meteorological processes working to create the current weather. The third phase is to **predict** the evolution of the atmosphere and its associated weather – i.e. the creation of the weather forecast.



vA typical broadscale graphic showing upper level winds, temperatures and pressure patterns

Analysis:

First we need to see what is happening now and over the past 24 hours. The forecaster will look at the 'big picture' and examine the atmosphere on the hemispheric scale to make what is termed his broadscale analysis. This involves looking at upper airflow patterns, jet streams and the movement of warm and cold air at middle and high levels of the troposphere. The magnitude and location of these features indicate where likely weather development areas will be at the surface. Satellite imagery also gives an immediate impression of what is actually happening now over the scale of thousands of kilometres.

Once the broadscale situation is clear the forecaster refines the analysis by examining what are called the 'synoptic' scale features of the atmosphere - those that produce the actual weather we experience. For example, he will identify areas of high and low pressure and the familiar frontal systems that we see nightly on television weather bulletins. The forecaster will determine the stability of the atmosphere and the nature of the airmass over his area of interest. It is also at this point that the value of surface observations come into their own and it becomes possible to map out areas of significant weather and identify the location of potential aviation hazards.

The analysis is then further refined to what are called the 'mesoscale' and 'microscale' levels. Now the forecaster considers the actual weather at the local level over small geographical areas or even at specific sites such as at local aerodromes. It may be surprising to some but it is this part of the analysis that takes the most time - far more than is spent analysing the entire atmosphere at the hemispheric scale. However, it is developing an understanding of the meteorological processes that cause local variations in the weather that is key to success in producing an accurate weather forecast later on.

Diagnosis:

Through his analysis the forecaster has collected enough information to allow him to diagnose the current weather situation. There are more than fifty conceptual models from which he can choose that describe weather producing features in the atmosphere – each with its' own defining meteorological characteristics and lifecycle. One cannot predict the future weather without having a complete understanding of the current weather and what is causing it. Adopting a conceptual model allows us to

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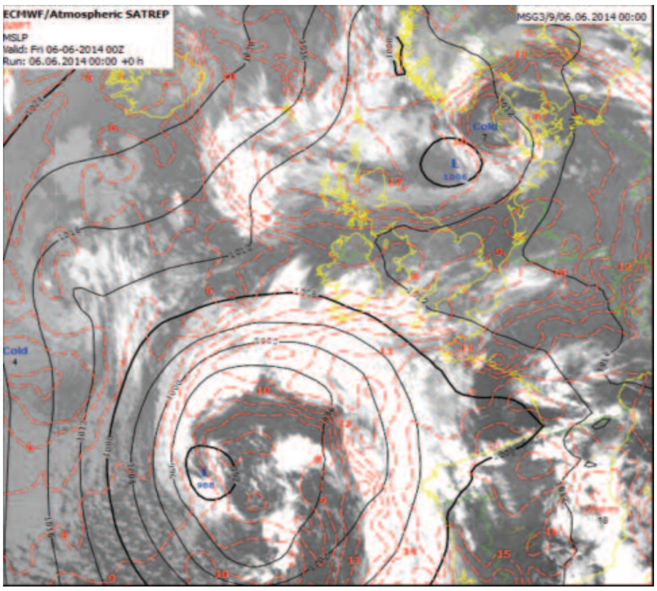
categorise observed weather and the main atmospheric processes generating it.

Prediction:

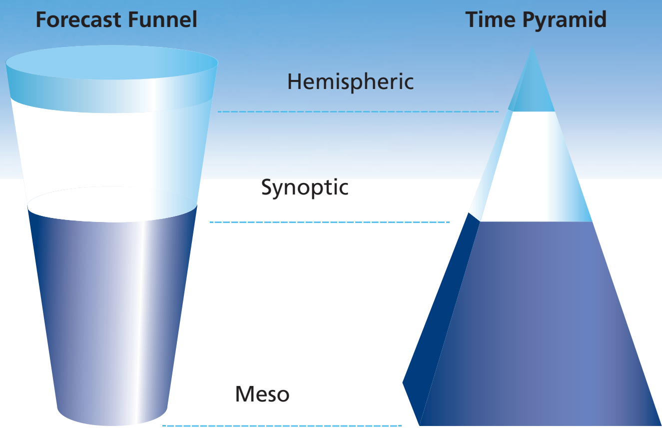
Now the forecaster understands why the current weather is happening and has a good general understanding of the way the future weather should develop – and so we can move into the forecasting phase. Forecasters use a wide range of observational data and forecasting tools to develop the analysis and diagnosis into an actual weather forecast. These include surface and upper air observations, computer model data and satellite and RADAR imagery. Knowledge of the local climatology over the forecast region is also important as it ensures that the forecaster understands local variations in weather under the same meteorological conditions.

Computer models assimilate large amounts of observed data and solve mathematical equations in order to 'model' both the current and future states of the atmosphere. The forecaster has access to many such models. Because of this he must systematically assess each one against surface and upper air observations to determine which has the best handle on the day's weather. Then the model with the best 'fit' is selected as the main guidance tool for the day.

Today's computer models have a sufficiently high resolution to do an excellent job at predicting large scale flows, airmass movements and even local winds. Yet they are less skilled at forecasting the local effects that impact on, for example, cloud ceiling and visibility – parameters that



An integrated graphic showing integrated satellite, pressure and moisture profiles



The Snellman funnel showing the relatively small amount of time spent analyzing the broad (hemispeheric) scale and the very large amount of time spent analyzing the mesoscale i.e. the local weather.

have an enormous impact on the pilot. Achieving success in this regard is down to the skill of the forecaster integrating all of the information at his disposal to determine the most likely future weather for his region. Therefore, the forecaster cannot blindly follow computer model guidance. The selected model is continuously evaluated against incoming observations to ensure that it continues to accurately represent the weather as it evolves. This process of evaluation highlights the value of the observations to a weather forecaster – quality observations act as a check against computer model inaccuracies.

Weather observations provide benefits to the forecaster beyond simply policing the computer models. They are a critical input to the weather forecast in their own right. By looking at surface weather conditions upstream of the forecast area one can predict, roughly, what will happen in our region of interest over the short-term. Of course the forecaster will modify for terrain effects and local climatology but the value of upstream observations cannot be over-emphasised in providing a first guess for a local forecast.

It's at this point that the forecaster needs to integrate all of the information he has gathered into producing his forecast. This requires the application of meteorological theory, forecasting techniques and, also, his knowledge of local climatology. At times forecasting can be straight-forward such as in a moderately unstable northwesterly flow when one may just be concerned with local shower activity. Other days it is more challenging - such as when a rapidly developing depression can be headed towards the country with definite strong winds and high intensity rainfall but with an uncertain track.

Whatever the situation on any given day, following a systematic process allows the forecaster to ensure that the **most probable** weather will always be included in his forecast.