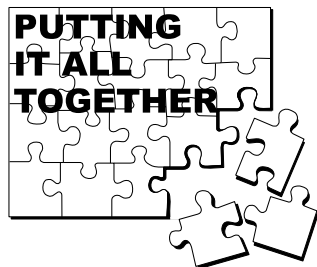


In this chapter

- **Forecasting Without Computers**
Observing • Weather Lore • Analysing • Disseminating
- **Forecasting With Computers**
Observing • Analysing • Disseminating



FORECASTING WITHOUT COMPUTERS

There are 3 steps to delivering a forecast - observing, analysing and disseminating. This is where you have the chance to do all three.

Observing

For thousands of years, men and women forecast the weather by observing what was happening around them — where the wind was coming from, what clouds were in the sky and whether they were having a bad hair day. Well, perhaps not that. But remember, hair stretches, especially if it is blond, on days when the relative humidity is high and rain may be approaching.

You can develop an eye for weather by using the information you collect from your Sky Watchers weather station and by paying attention to what is happening around you. The sun, moon, clouds, ponds, flowers and even the flies are some of the natural sign posts of the weather which may lie ahead.

First, take a hint from Sky Watchers and be a sky watcher. Observe the skies and, in particular, the clouds, where they move and how they develop.

Clouds

When you see a bank of wispy cirrus clouds coming in high in the sky on a sunny day, you may expect a change in the weather. Cirrus clouds are sometimes the first sign of an approaching warm front.

Nimbostratus is the dull, gray cloud that covers the sky from horizon to horizon in a blanket of gloom. This cloud usually means rain or drizzle — all day.

On hot, humid days, if towering cumulus clouds pop up rapidly, then showers are likely. There is also a possibility a thunderstorm will develop.

Generally speaking, the more types of clouds there are in the sky, the greater the chance of rain or snow.

On a brighter note, if you see the sun shining behind a thundercloud, you know the cumulonimbus cloud is moving on, and the end of that particular thunderstorm is in sight.

Jet trails

If you look up on a sunny day and see in the cloudless sky a jet leaving a long, white plume, then rain, snow or some other form of precipitation may be on the way. That white plume is called a contrail. It is the condensation trail of

CHAPTER 1

ice crystals left behind by the exhaust of a flying jet aircraft. These aircraft fly 8 to 12 kilometres above the ground pulling in very cold, dry air and spewing out hot, water-filled exhaust. The hot water vapour mixes with the colder surrounding air, and in the process, expands and then freezes in 1 or 2 seconds forming a trail of ice crystals.

If a jet leaves no trail or only a short trail or if the trail fades quickly then the air at that level is relatively dry. This means the fair weather is likely to continue. But, if the exhaust trail lingers for an hour or more or spreads across the sky, that means the surrounding air is moist and rain or some other form of precipitation may be on the way.

Sundogs and halos

Halos around the sun during the day or the moon at night are caused by the refraction of the sun's or moon's rays through the ice crystals in cirrostratus clouds. These clouds are an early sign that a warm front is approaching and that rain may be on the way within the next 20 to 24 hours.

Sundogs or mock suns are bright spots on either or both sides of the sun. Their technical name is parhelia. These bright spots can also occur around the moon, in which case they are known as moon dogs. Sun or moon dogs are images of the sun formed as a result of light bending through tiny, floating ice crystals in the air or high clouds such as cirrus or cirrostratus. Like halos, sundogs may mean rain or snow will arrive within 18 to 36 hours.

Be careful though — the most brilliant sundogs occur on cold, clear winter mornings or evenings under high pressure systems, when the air is loaded with ice crystals and the sun is low on the horizon.

Now lower your sights and check out the world around you

Plants

Pine cones close and so do some flowers such as tulips and daisies when the relative humidity is high and rain may be on the way. One theory suggests the flowers do this to prevent the pollen necessary for reproduction from washing away.

Dew

When dew or frost appear on the ground early in the morning, there is a good chance of a bright day ahead. That is because frost, dew or fog form more readily on clear, cool and calm nights when there are no clouds to interfere with the cooling of the ground. As calm, clear nights are typical of high pressure areas, the fair weather is likely to continue for at least another day.

Flies

Flies swarm more readily on humid days because they find flying more difficult in warm moist air. Consequently they sit on the nearest available object.

Ponds

If you think the pond or ditch smells stronger just before rain, you are probably right. When organic debris such as leaves and grass decay in stagnant ponds, drains or gutters, it produces methane and other gases, all of which have a pungent odour. When the air pressure is high, these gases stay trapped in the mud. But when low pressure systems — which are usually associated with stormy weather — move in, the bubbles of these gases expand, rise to the surface and break loose scenting the air above with the odour of decay.

Winds

If the wind changes direction, then the weather may also change. Further, the direction the wind is blowing from may give you a hint at the type of weather in store for your area.

Generally speaking, winds blowing from the southeast, northeast and north are likely to bring steady rain or snow. More pleasant weather may be en route when the winds are blowing from the west to the northwest.

If the wind shifts to the north or northwest from the south or southwest, the temperature may start falling. Again, conversely, if the wind shifts to the south or southwest from the north, then temperatures may rise.

Weather Lore

Weather lore is another source of information about the weather but be careful which weather lore you use. Most weather lore, you may want to file under interesting but fanciful. But some weather lore has firm meteorological foundations. These folk sayings often link one weather sign to the coming weather. They are the product of years of careful observation and probably painful experience. Still, even these do not ring true every time and in every place. For instance, some weather lore does not travel well and what works in one part of the world, such as Europe, does not work in another, such as Canada.

Cows lie down in a pasture when rain is coming.

Perhaps, but cows also lie down when they are tired.

Red sky at night,
sailor's delight
Red sky in the morning
sailor's warning.

Yes. You may also have heard this saying with shepherds instead of sailors because sailors, shepherds and farmers needed to know what the next day's weather would be. In any case, this rhyme works well in Canada because the prevailing winds come from the west. High pressure systems which usually bring fair weather are characterized by settling air which traps dust and small particles. When the sun's rays shine through the particles, they colour the sky red. So if the sky is red in the west at night, then the high pressure area and the fair weather usually associated with high pressure systems are coming towards you. If the sky is red in the morning, though, that means the high pressure area and its fair weather have passed you by.

Showers before seven,
fine before eleven.

Yes. Showers in the morning usually do not last long — for good reason. If they formed during the night when it was cool, then when the sun comes up and heats up the day, the humidity drops, the clouds dry out and the rain ends. It is a well recognized and well researched bit of folk

Aches and pains
Coming rain.

wisdom that changing weather causes existing aches and pains to intensify. One reason is that when the air pressure drops, tissue expands and nerve cells become more sensitive.

Thunder and lightning
turn milk sour.

Only if you leave it out
of the refrigerator for the
whole day (or night).

Rain long foretold,
long last
Short notice,
soon past.

Yes. This simple verse talks about the scale of weather in time and distance. A large low pressure area with clouds that covers the whole sky and steady rain, often announces its presence with a thin layer of cirrus cloud which moves in about 24 hours beforehand. In contrast, showers or storms from towering cumulus or cumulonimbus clouds often arrive with little warning and leave almost as rapidly.

○ **Activity:**

Ask your students to interview their grandparents or senior citizens in your community about weather lore or folk sayings. Then ask your students to select and test two or three sayings. Do they work?

Analysing or Bringing It All Together

Now, you are ready to forecast the day's weather, using everything at your disposal -- the readings from the instruments in your Sky Watchers weather station, your observations of the sky and the world around you as well as your knowledge of weather lore. Here are a few guidelines to help you.

Look for cloudy, unsettled weather when:

- the barometer falls;
- the wind blows strongly in the early morning;

- the temperature at night is higher than usual;
- the clouds move in different directions at different levels;
- high, thin, wispy cirrus clouds increase, sometimes producing a ring around the sun or moon;
- the clouds darken on a summer afternoon;
- the sunrise is red.

Expect steady rain or snow when there have been signs of unsettled weather and:

- the wind is south or southeast;
- the pressure is falling; (A hint: If the pressure falls slowly, rain or snow will come within a day; if it falls rapidly, expect rain soon.)
- the clouds are low and uniformly flat and gray;
- there is a ring around the moon or sun;
- leaves show their undersides.

Look for showers and, perhaps, thunderstorms when:

- the barometer falls;
- dark, threatening thunderclouds accompany a west wind;
- thick, towering cumulus clouds develop rapidly in the spring or summer during early afternoon;
- winds blow from the south or southeast;
- you hear loud static on your AM radio.
(thunderstorms are an hour away)

Look for clearing skies when:

- the barometer rises;
- the wind shifts into the west or northwest;
- the temperature falls rapidly, especially in the afternoon;
- the dark clouds become lighter and rise steadily in altitude;
- the humidity decreases.

Look for continued pleasant weather when:

- the barometer is steady or rising slowly;
- the wind continues to blow from the west or northwest;
- the number of clouds decreases in the afternoon;
- the clouds are higher in the sky;
- the evening sky is clear and the setting sun looks like a ball of fire;
- the morning fog breaks within 2 hours of sunrise;
- there is heavy dew or frost on the ground in the early morning;
- the moon shines brightly and the wind at night is light.

Look for heavy snow when:

- the temperature is between -10°C and -1°C ;
- the barometer falls rapidly;
- the winds blow from the east or northeast;
- a storm lies to the south and east of you.

Look for temperatures to rise when:

- the winds shift from the north or west to the south;
- the night sky is overcast and there is a moderate wind from the south;
- the sky is clear all day;
- in the winter, the barometer falls.

Look for temperatures to fall when:

- in the winter, the barometer rises steadily;
- the wind shifts from the south to the north or northwest;
- the wind is light and the sky is clear at night;
- the skies are clearing - this is especially true in the winter;
- snow flurries fall with a west or north wind.

Look for fog when:

- warm winds are blowing humid air across a large body of much colder water or a large stretch of cold land;

- the night before the sky is clear, the winds are light and the air is humid;
- warm rain is falling ahead of warm air;
- the temperature of the water is warm and the air is much colder.

One last suggestion to help you when you forecast the weather. This comes from Blame it on the Weather, by David Phillips, a senior climatologist at Environment Canada, "One indicator makes lucky your guess, two indicators make errors much less; so take the weather sign at its word if you look again and see a third."

Disseminating

Activity:

Ask your students to form forecast teams. Using the information they have collected from their Sky Watchers weather station, their observations of the sky and the world around them and the weatherlore they have collected, ask the teams to put together a weather forecast for the next day. Then ask the teams to suggest how they plan to tell others about their forecasts. They could, for example, do a weather forecast each afternoon before they go home, broadcast it over the school's public announcement system or post the forecast on the bulletin board in the classroom or the school hall. Next, ask the teams what clothes and outdoor activities are suitable for the weather they have forecast for the next day. Finally, your students may want to keep a record of their forecasts and of the weather which actually occurred.

If your students had fun with this activity, they could be tomorrow's forecasters. Environment Canada has a continuing requirement for meteorologists, atmospheric scientists, hydrological technicians, and electronic technicians, to name just a few of the career opportunities. To keep these career choices open, students need only maintain math and science courses as they progress through school. For more information, contact your Sky Watchers co-ordinator.

Forecast Activity

Today's Weather: _____

Date and time of Weather Observation: _____

Cloud type and cloud cover: _____

Weather: _____

Air pressure: _____ *rising* *falling*

Wind speed and direction: _____

Precipitation: (type and amount in millimetres) _____

Temperature: _____

Tomorrow's Weather Forecast: _____

Sky condition: (ie, sunny, overcast, etc.) _____

Weather: _____

Wind speed and direction: _____

Precipitation: (type and amount) _____

Afternoon temperature: _____

Based on my forecast, I recommend the following activities

A short walk not too far from shelter

A long hike

Outdoor sports such as baseball, swimming, skiing, snow boarding

Cycling in the park or through open space

Camping

A trip to the local museum, library or art gallery by bus

A long car trip to visit relatives

Indoor activities such as playing board games or reading a book

Cleaning up the school yard

Other: _____

FORECASTING WITH COMPUTERS

Environment Canada's meteorologists follow the same 3 steps which Sky Watchers do when preparing and delivering a forecast - observing, analysing and disseminating.

Observing

Meteorologists use the same type of information collected by Sky Watchers. The staff at Environment Canada, however, rely increasingly on sophisticated new remote-sensing technologies which pull in data from orbiting satellites, weather radars, lightning detectors, and weather balloons.

Satellites

The United States launched the first weather satellite — called TIROS — in 1960. Soon after, in 1963, Canada opened a laboratory in Toronto to process satellite pictures. Today, each of Environment Canada weather centres has its own satellite receiver to pick up photos transmitted from space.

Weather satellites have become an indispensable tool for observing and forecasting weather. Previously, forecasters could not see entire weather systems. With the photographs sent from the satellites, though, they are able to observe cloud formations over large areas of the globe, even areas where weather observing stations are sparse — such as in the Arctic or over the oceans.

In the past, forecasters laboriously collected weather reports, drew up weather maps, and identified weather systems. By repeating this procedure every 6 to 12 hours, they estimated the speed and direction of movement of each system. Today, forecasters can string together successive satellite pictures and then

animate them. From the animated loop, they get precise information on the motion of and changes to weather systems over a set time period. In addition to weather forecasting, meteorologists and other scientists use satellite pictures to determine snow cover, monitor ice conditions, and detect forest fires.

Environment Canada uses images from 2 types of weather satellites: the geostationary satellite and the polar orbit satellite.

A geostationary satellite orbits around the earth's equator at an altitude of about 36,000 kilometres. This satellite completes one orbit every 24 hours, which is the same length of time it takes for the earth to rotate on its axis. The result is that the satellite remains over the same spot on the earth's surface.

Each geostationary satellite, then, monitors the same portion of the earth continuously, producing a picture every 15 minutes. Because its position relative to the earth stays the same, forecasters are able to put together and animate consecutive pictures from the same satellite to show a movie of the weather. This is the view normally seen on the evening news.

A polar orbit satellite travels at a much lower altitude, about 860 kilometres above the earth and provides more detailed images. As the name suggests, when this satellite circles the earth, its orbit carries it over the North and South Poles. The polar orbiter circles the earth about 14 times each day. However, as the earth rotates under it, each successive orbit covers a swath about 2 time zones further west. For example, the satellite's 10:00 a.m. pass may take it north to south over the province of Ontario. By the time it goes all the way down over the South Pole and back up the other side of the earth, the earth has rotated enough that the satellite's next sweep may be over Saskatchewan.

These weather satellites produce 2 main types of images. The first type requires visible light (light you can see) just like 35 millimetre cameras. These visual shots are the easiest to interpret, as they are comparable to what you would see with your own eyes if you were on the satellite. However this type of image is only transmitted during the daylight hours and cannot be used overnight. The second type of image is infrared. The equipment senses temperatures and displays them in shades of grey — the colder the temperature of the ground or cloud top, the whiter it appears on the image. Conversely, the warmer a surface, the darker it appears. This type of picture allows forecasters to monitor clouds overnight as well.

Weather radar

Radar

The word radar is an acronym for radio detection and ranging. This technology was developed prior to the Second World War as a way of detecting and locating hostile aircraft. Sometime later, meteorologists began to use it as a means of detecting and locating precipitation in clouds.

Weather radar uses microwave energy to measure the size, motion, and concentration of water droplets or ice crystals within a storm. This energy is transmitted in a burst. Then the antenna on the radar listens to see how much is bounced back by the precipitation. That is why, when precipitation is detected, it is called an echo. The greater the size or density of water droplets, the more microwave energy is scattered back to the antenna.

Conventional radars are used to determine the severity of storms and their motion. Their range is limited to 200 to 400 kilometres.

Doppler radars

In addition to measuring the intensity of precipitation, Doppler radar measures the speed and direction of the motion of precipitation within storms. This helps forecasters to identify the tell-tale circular rotation typical of budding funnel clouds. Further, this radar can detect areas of high winds in the atmosphere not observable from the ground. It can also sense areas of wind-shear. These are regions where the wind's direction and/or its speed changes dramatically within a relatively narrow layer of the atmosphere. Meteorologists believe this to be an indicator of severe weather including the development of tornadoes.

Doppler radars are named after the Austrian physicist J.C. Doppler. He hypothesized that the frequency of the sound waves from a moving source would increase as they approached an observer and decrease as it moved away. You have probably observed it — or more accurately, heard it — sometime in the past week when a train passed by blowing its whistle or when a car or truck passed by with its horn blaring.

The whistle's pitch climbs as the train comes towards you and then drops noticeably as it speeds away. This happens because as the train approaches you, its motion combines with the motion of the sound wave from the whistle and compresses it. When the train continues off into the distance, the pitch of the sound drops because the sound wave you hear is no longer being compressed by the motion. This process is called a frequency shift and is known as the Doppler effect.

Doppler weather radar is not the only place where the Doppler effect is put to good use. Radar guns are also based on the Doppler effect. Baseball officials use these radar guns to measure the speed of a baseball when it leaves the pitcher's hand. The police use them to detect speeders.

Environment Canada has a Doppler weather radar network. Doppler radars are located across Canada, from Vancouver Island in British Columbia to Holyrood, near St. John's, Newfoundland.

These new radars have a range of 250 kilometres. The full network covers those areas of the country which are prone to severe weather. About 90 per cent of the country's population lives in these areas.

Lightning detectors

Canada has a network of 81 lightning detection units across the country. The sensors on these units can accurately place lightning strikes to within 500 metres of where the lightning hits, and are capable of detecting more than 90 per cent of the lightning strokes.

The data from the sensors are relayed to a satellite and then to Environment Canada's weather centres. Lightning detectors relay information about lightning strikes, including their location and whether they were cloud-to-cloud or cloud-to-ground lightning. Meteorologists use this information to help track the motion and intensity of thunderstorms. On a day when large thunderstorms develop, the lightning detection system can record upwards of 15,000 lightning strikes per hour over an area the size of southern Ontario.

Canada's lightning detection network is integrated with the system in the United States creating the first North American lightning detection system. This allows Canadian and American meteorologists to exchange data on weather and work more closely together.

Weather Observations

At the surface:

Staffed and automatic weather stations transmit weather data at least once an hour from all over the continent. They send information on everything from air pressure to

visibility, giving forecasters an hourly snapshot of surface weather patterns.

To compare weather reports from different parts of the country or different parts of the world, though, it is essential to establish that the observations were taken at the same time. But local time varies even from one end of Canada to the other. Because of the earth's rotation, the sun rises first in eastern parts of the country — when it's 8 a.m. in Halifax, it is only 4 a.m. in Vancouver. To clearly identify the time the observations are taken, all countries label their weather observations in Universal Time, formerly called Greenwich Mean Time.



Greenwich Mean Time got its name by virtue of the fact that the prime meridian (0° longitude) runs through Greenwich, England.

Activity

Have your students convert the present time to Universal Time. To help them do this, have them record the local time in hours and minutes. Convert this to the 24-hour clock by adding 12 hours if it is past noon. Then apply the correction for Universal Time from the chart below. (If you are on Daylight Savings Time right now, the offset will be 1 hour less.)

Time Zone	Offset for Standard Time
Newfoundland	+ 3 ½ hours
Atlantic	+ 4 hours
Eastern	+ 5 hours
Central	+ 6 hours
Mountain	+ 7 hours
Pacific	+ 8 hours

Environment Canada uses several different types of automatic weather stations to supplement reports from human observers. Most automatic stations transmit their observations by telephone line. In remote locations, however these stations can be set up to use solar-charged batteries as a power source and relay their observations by communications satellites.

Environment Canada's newest type of automatic weather station uses the very latest in remote-sensing technology. For example, the height of a cloud is measured by transmitting a laser beam up into the sky and timing the reflection of that light by the bases of the cloud. The precipitation sensor is basically a Doppler radar that measures the speed at which precipitation particles are falling. This, combined with the air temperature, identifies the type of precipitation. That is because droplets of different size and composition fall at different rates. To measure depth of snow, a high-frequency pulse of sound is transmitted toward the ground and the length of time required for it to travel to the ground and back tells meteorologists how far it is to the snow's surface. Some stations are even equipped with video cameras so that forecasters can dial in to see a digital picture of the weather at that location.

In the upper atmosphere:

Because weather is a process involving the entire atmosphere, Environment Canada also releases weather balloons twice a day from selected sites. These balloons carry instruments and transmitters as high as 30 kilometres into the atmosphere. As the balloons rise, the equipment sends back information about the temperature, air pressure, relative humidity, and winds at various levels in the atmosphere. When the balloons finally expand enough to burst, the small, white disposable instrument boxes float back to earth on parachutes.

Further, Environment Canada relies heavily on volunteer weather observers who collect information. For example, in the climate network, volunteers record daily temperatures and precipitation from weather stations in their own backyards. CANWARN volunteers are ham radio operators who have been trained in severe weather reporting. They watch the skies when severe weather is

expected and alert Environment Canada if they witness severe weather such as hail or funnel clouds.

Finally, because weather really is a global affair, meteorologists use observations gathered by weather services all over the world.

Analysing

Regardless of the technology used to collect the data, all the information plays a role in preparing the daily weather forecast. To produce a forecast for a particular town or region, the meteorologists need to know what the present weather is at that location and what is happening hundreds of miles up stream of the community. In addition, meteorologists must also consider how the weather system approaching the community is likely to change as it advances.

For example, they look at satellite and radar images to track the movement and development of storms. The rate of change in air pressure at observing stations tells meteorologists where and how quickly the high and low air pressure systems are moving. Information about the direction and speed of the wind at the mid-point of the atmosphere — 5.5 kilometres above the earth's surface — shows meteorologists what currents are steering the weather. Although the prevailing movement of weather across Canada is from west to east, weather systems can move up from the south, push down from the north, or back in from the east.

Today, computers are an essential tool for producing forecasts. Meteorologists use computers to store, display, analyse, and manipulate data from all of these sources. The supercomputer in Environment Canada's Montreal office is the largest in Canada. The computer has been programmed with the laws of physics that govern the behaviour of the atmosphere. That computer

ingests information from all sources, analyses it, and projects the movement and development of weather systems in a series of 12-hour snapshots. These theoretical projections of how weather systems may evolve provide guidance for meteorologists as they prepare the forecasts.

Disseminating

Once the forecast is written, the next and equally important step is to tell people what it is. Today, meteorologists use a mix of the many technologies available to get the forecasts out to the public. They are sent to television and radio stations and newspapers, posted on the Internet, included on telephone recordings, and broadcast over Environment Canada's Weatheradio network.

