- For example, the warm Gulf Stream moves thermal energy toward the north pole in the north Atlantic Ocean.
- As these warm waters enter polar regions, they gradually cool.
- Eventually, they reach a landmass and begin flowing toward the equator.
- The resulting currents, such as the Labrador Current, bring cold water from higher latitudes to tropical regions.
- Ocean currents affect the weather of a region.
- For example, the Gulf Stream brings warm, moist air to the coast of the province, resulting in warmer temperatures in the winter than those experienced inland in Canada. For example, the average low temperature in January in St. John's is −8°C. Compare that to the average low temperature of −14°C in January in Ottawa.

1-2B

- Lab manual : The Labrador Current

DEEP OCEAN CURRENTS

- DEEPER OCEAN WATER MOVES AS A RESULT OF DIFFERENCES IN THE TEMPERATURE AND THE SALT CONTENT OF WATER.
- COLDER WATER IS DENSER THAN WARMER WATER. SO COLDER WATER SINKS AND DISPLACES WARMER WATER AROUND IT.
- SALTIER WATER IS DENSER THAN WATER THAT IS LESS SALTY. SO SALTIER WATER SINKS AND DISPLACES THE LESS SALTY WATER AROUND IT.
- BOTH OF THESE MOTIONS PRODUCE A MASSIVE SYSTEM OF DEEP-WATER CURRENTS CALLED THE GREAT OCEAN CONVEYOR BELT.

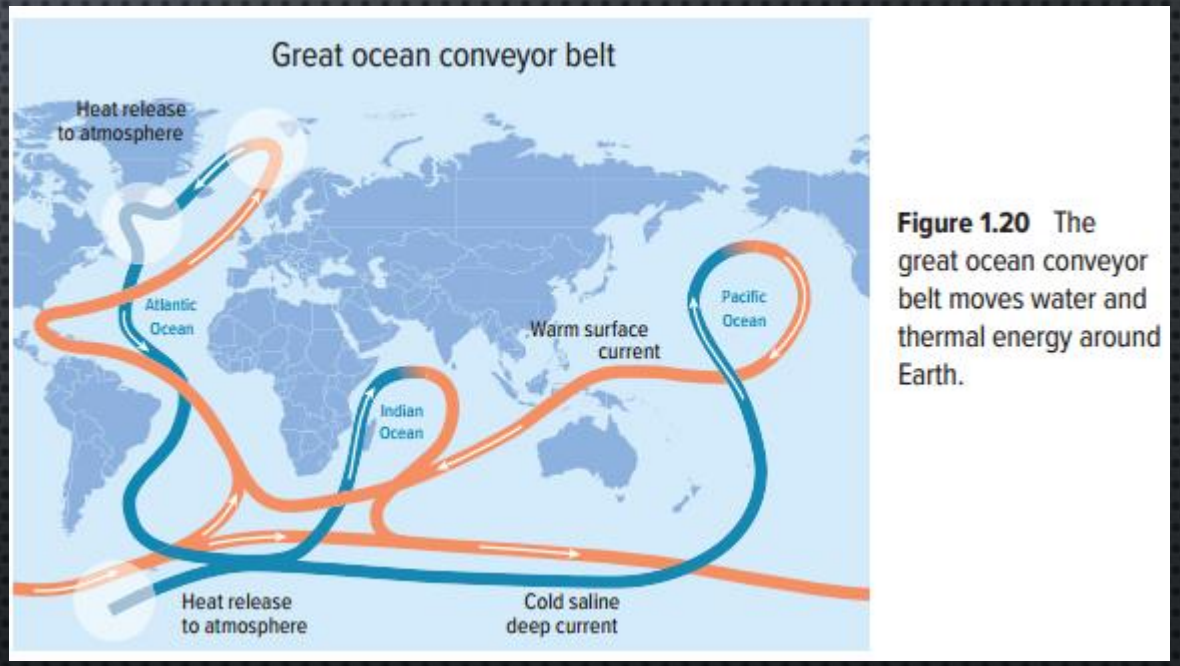


Figure 1.20 The great ocean conveyor belt moves water and thermal energy around Earth.

1-2D EXTREME WEATHER RESEARCH ASSIGNMENT

- Hurricanes
- nor'easters
- Thunderstorms
- tornadoes
- El Niño
- La Niña
- Blizzards

- How does the extreme weather form?
- What conditions does the extreme weather produce?
- What dangers are associated with the extreme weather?
- What types of warnings are issued by the weather service about the extreme weather?
- How do individuals, communities, and/or local or provincial governments prepare for the extreme weather?
- What kind of damage can result from the extreme weather?
- What is the history of the extreme weather and its effects in your area?

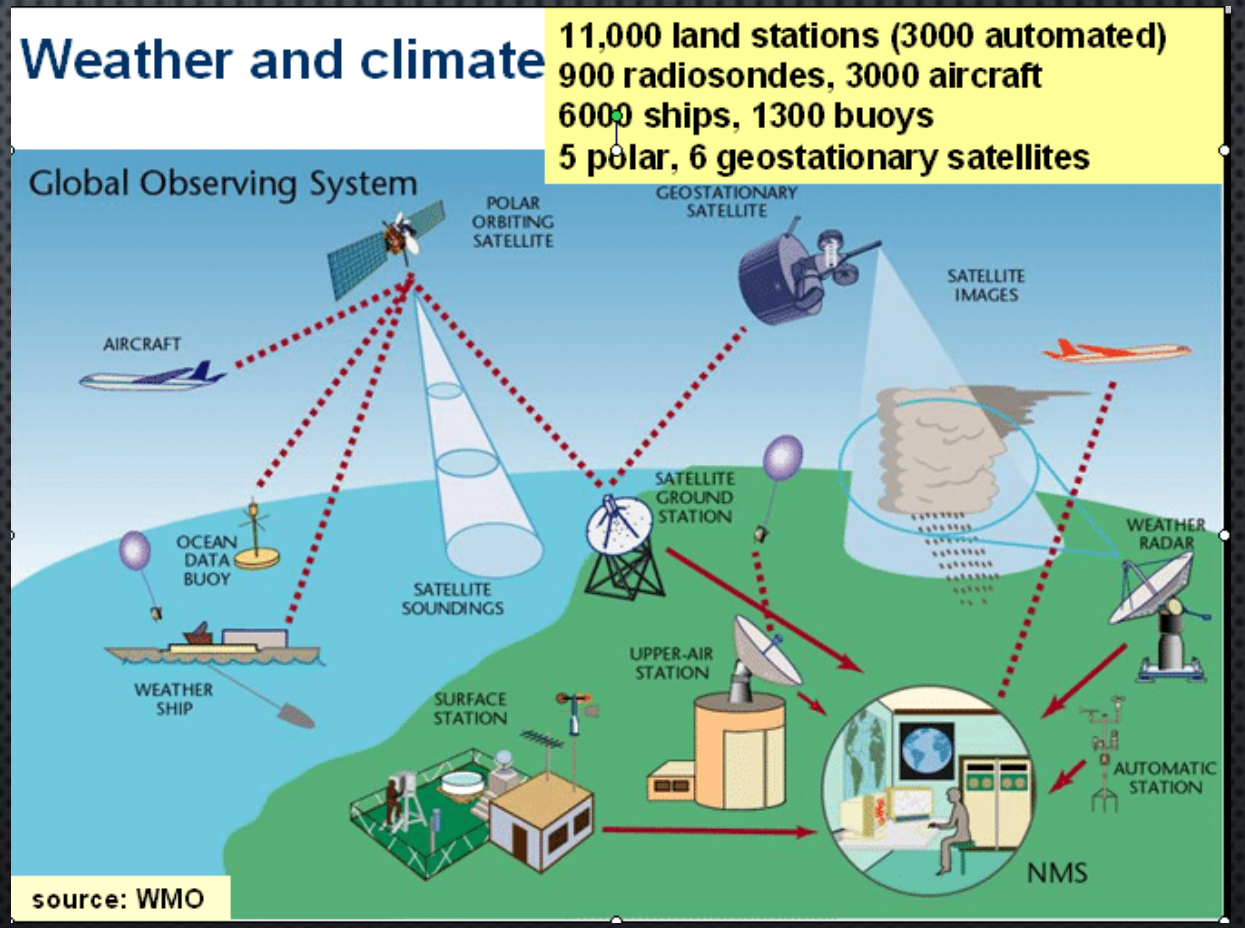
QUIZ!

WEATHER, CLIMATE CHANGE AND SOCIETY

- Lab manual
- Launch Activity 2
- Measuring Fog

MEASURING WEATHER DATA

- WEATHER FORECASTING PROCESS OF PREDICTING FUTURE WEATHER BASED ON ONGOING OBSERVATIONS OF ATMOSPHERIC CONDITIONS
- METEOROLOGISTS ALSO CONSULT WEATHER MEASUREMENTS AND RECORDS IN ORDER TO LOOK FOR PATTERNS THAT HELP THEM PREDICT WHAT WEATHER CONDITIONS WILL BE LIKE IN THE NEAR FUTURE.
- BOTH WEATHER MEASUREMENT AND RECORD KEEPING ARE PART OF THE PROCESS OF WEATHER FORECASTING.



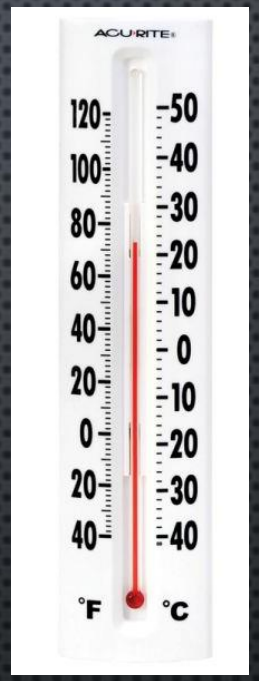
MEASURING THE COMPONENTS OF WEATHER

- METEOROLOGISTS COLLECT DATA ON
- TEMPERATURE
- WIND SPEED AND DIRECTION
- HUMIDITY
- AIR PRESSURE
- PRECIPITATION
- AND OTHER COMPONENTS OF WEATHER.

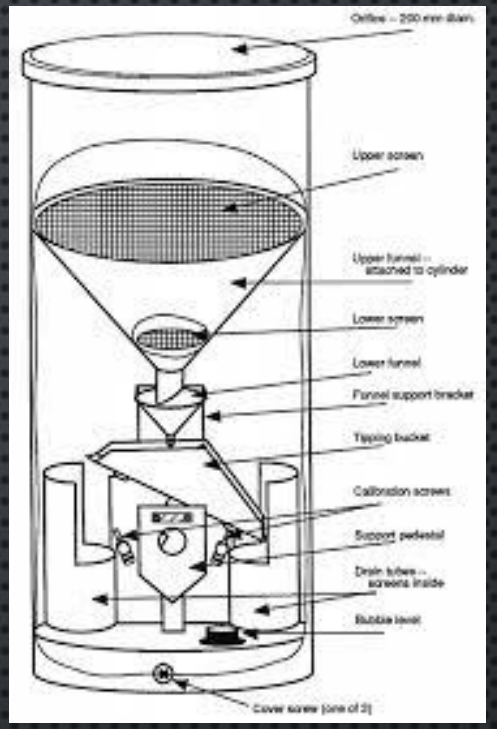
WEATHER COMPONENTS AND TOOLS

- **Air Temperature** the average kinetic energy of molecules in air

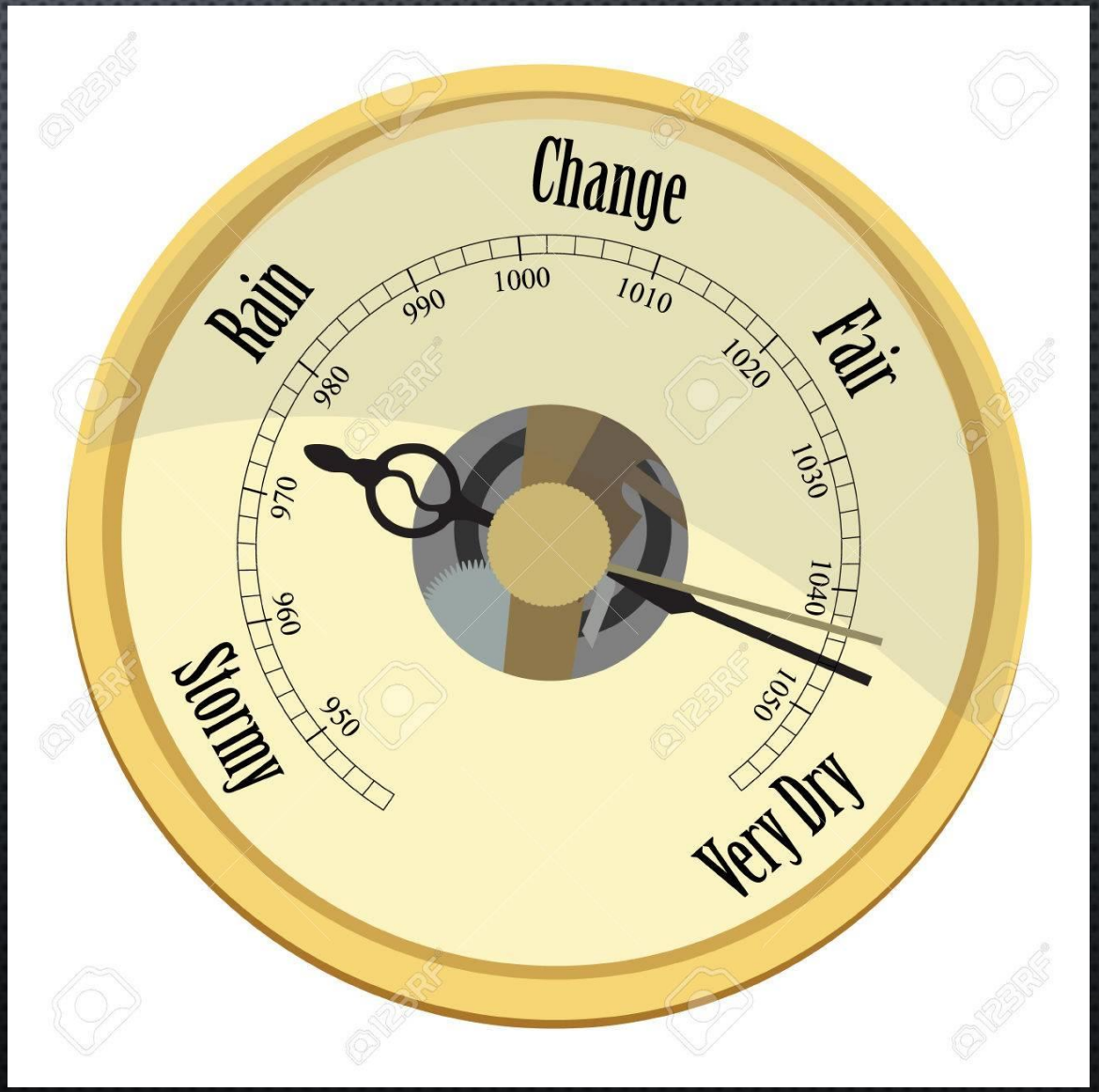
- Air temperature is measured using a **thermometer**.
- Liquid thermometers use alcohol sealed in a narrow glass tube.
- As the temperature of the alcohol increases, the density of the liquid decreases. The decrease in density results in an increase in volume of the fluid. As volume increases, the fluid rises within the tube.
- Other types of thermometers work on differences in expansion between metals or the flow of an electric current between metal wires.



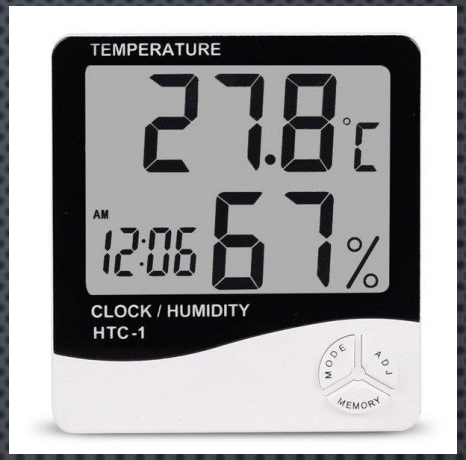
- PRECIPITATION WATER, IN LIQUID OR SOLID FORM, THAT FALLS FROM THE ATMOSPHERE; INCLUDES RAIN, SNOW, HAIL, SLEET, AND FOG
- RAINFALL IS MEASURED USING A RAIN GAUGE OR A TIPPING BUCKET RAIN GAUGE.
- A RAIN GAUGE HAS A FUNNEL AT THE TOP TO CATCH RAINFALL ACROSS A LARGE SURFACE AREA.
- THE NARROWER BODY OF THE GAUGE IS MARKED IN MILLIMETRES.
- A TIPPING BUCKET RAIN GAUGE MEASURES RAINFALL ELECTRONICALLY.
- THE SIMPLEST WAY TO MEASURE SNOWFALL IS WITH A STICK OR POLE THAT IS MARKED VERTICALLY IN CENTIMETRES.



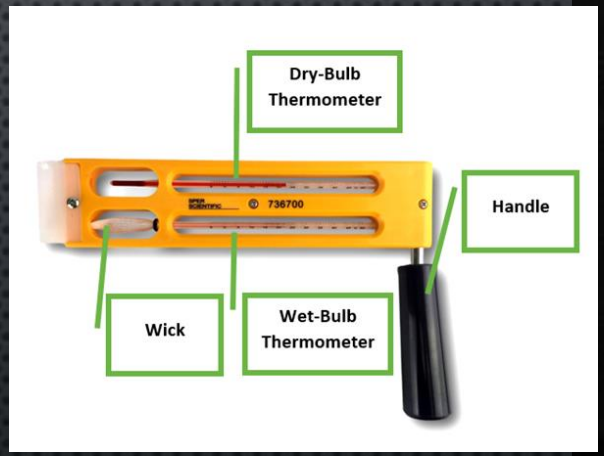
- Atmospheric Pressure
- Atmospheric pressure is measured with a barometer.
- aneroid barometer uses a flexible sealed container called an aneroid cell, which holds a small amount of air.
- Low atmospheric pressure compresses the cell less then high atmospheric pressure does.
- Resulting changes in the volume of the cell move a needle that indicates air pressure on a scale.
- atmospheric pressure can also be measured with electronic sensors.
- Atmospheric pressure is measured in kilopascals (kPA).
- Some home barometers show changes in atmospheric pressure in millibars or mmHg

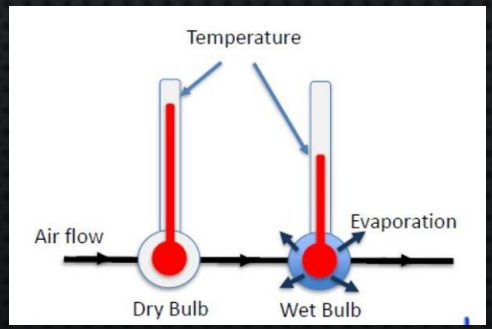


- Relative Humidity amount of water vapour in the air compared to the maximum amount of water vapour in the air at that temperature

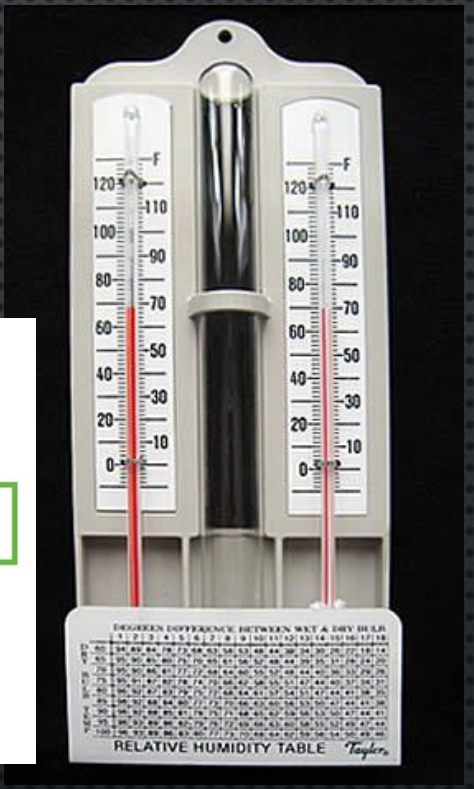


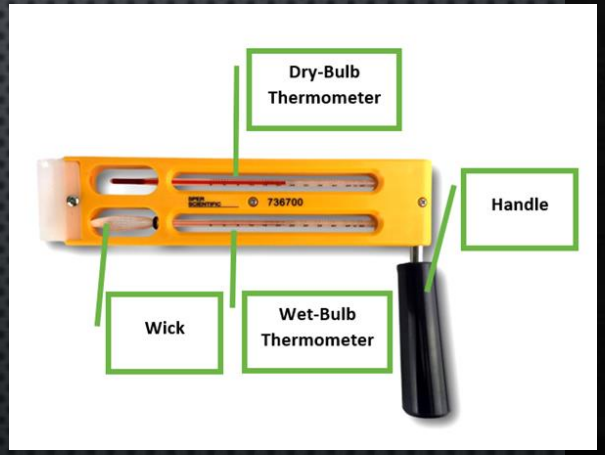
- Relative humidity is measured with a hygrometer.
- A digital hygrometer, gives electronic readings.
- Another type is based on the effects of evaporation. It uses two thermometers.
- One has its bulb open to air (dry bulb); the other has its bulb covered in wet cloth (wet bulb). A Sling Psychrometer works on the same principle

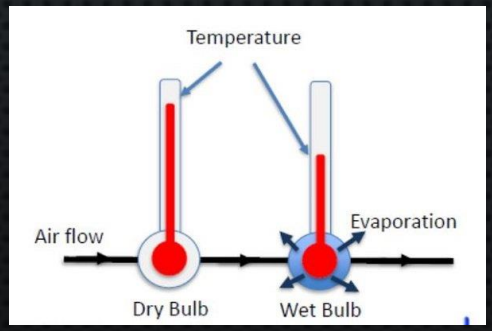




- The dry bulb measures actual air temperature. Evaporation from the wet bulb causes its temperature to drop below the actual temperature.
- If no water evaporates, the temperature of the wet bulb is the same as the temperature of the dry bulb. In this case, the relative humidity is 100%.
- If there is a temperature difference, the relative humidity can be found from a chart that records previously determined values.

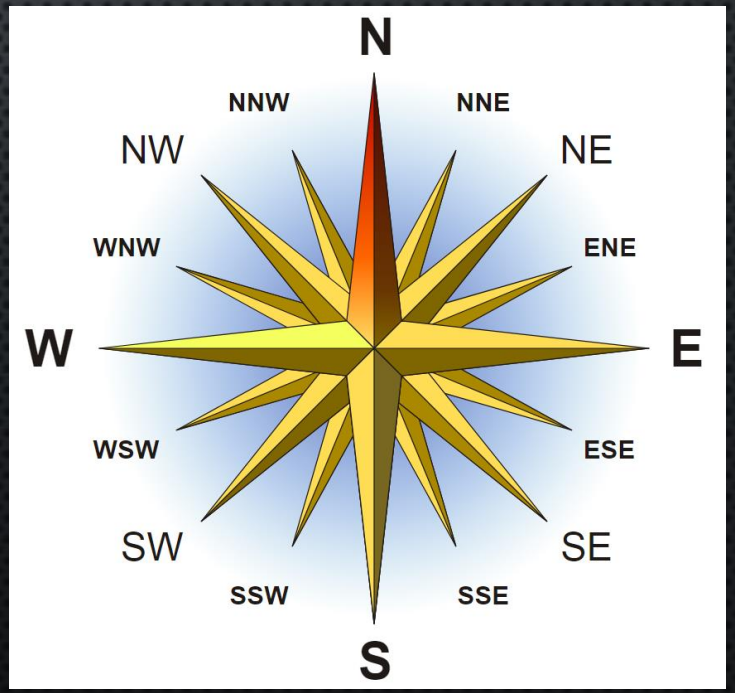






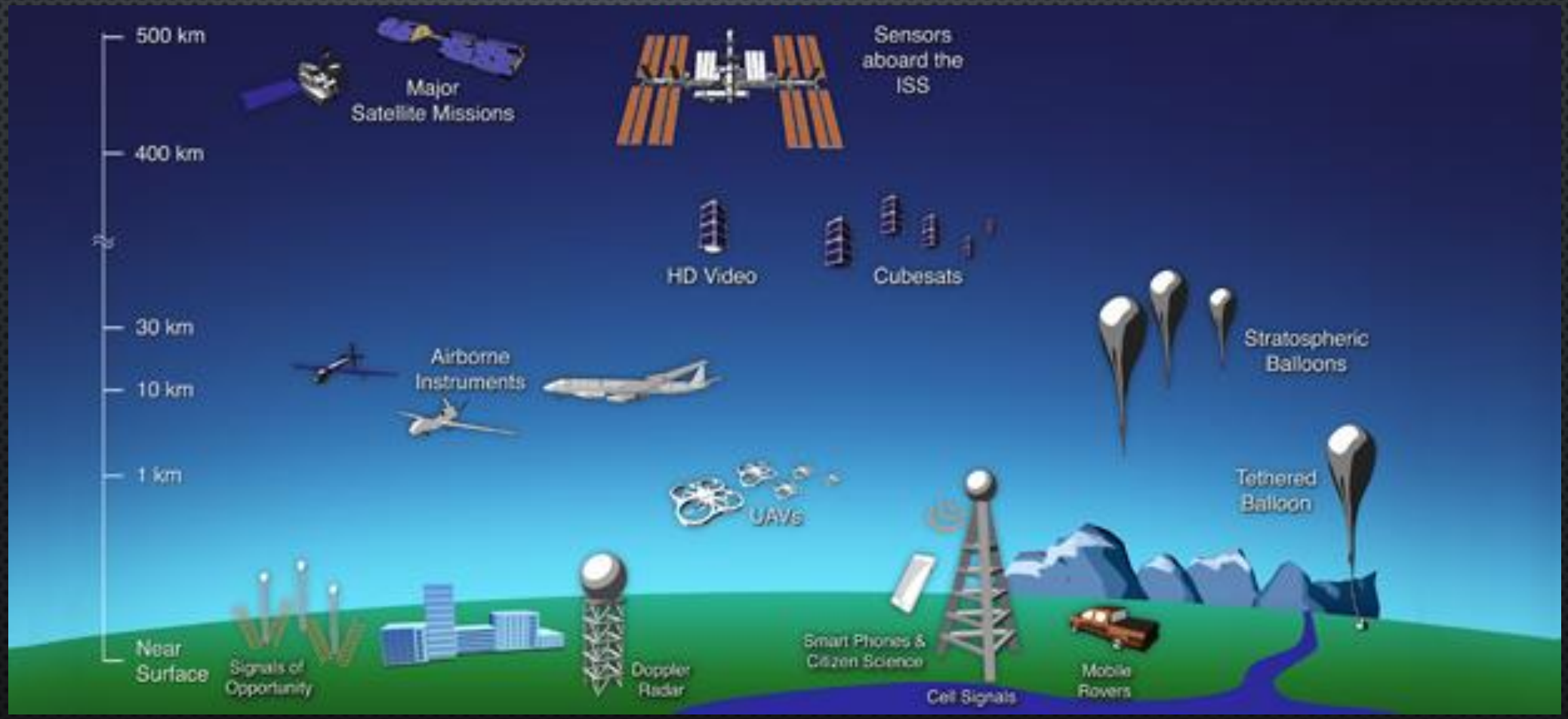
- **Wind Speed and Direction** Wind speed is the speed at which air is moving through the atmosphere parallel to Earth's surface. Wind direction is the direction from which wind originates.

- Wind speed is measured with an anemometer, and wind direction is measured with a wind vane.
- An anemometer is designed to "catch" the wind in its open cups. The wind rotates the cups and this rotation is translated into a wind speed measurement.
- A wind vane is shaped like an arrow with a large, finned tail. Wind turns the tail, pointing the arrow in the direction from which the wind originates.
- Wind speed is generally measured in km/h.
- Meteorologists typically use the 16 compass points to indicate wind direction.



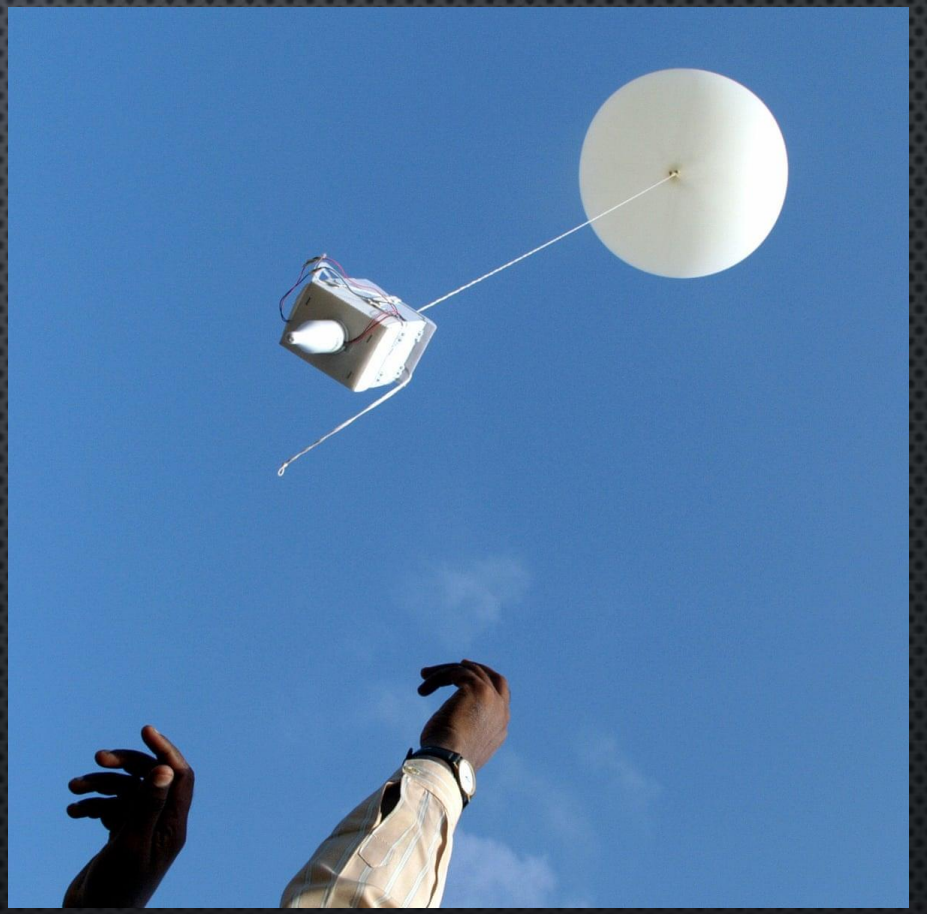
WEATHER OBSERVATION SYSTEMS

- REMOTE SENSING TECHNOLOGY TECHNOLOGY THAT COLLECTS WEATHER DATA FROM A DISTANCE WITHOUT ACTUALLY BEING IN PHYSICAL CONTACT WITH THE OBJECT BEING OBSERVED



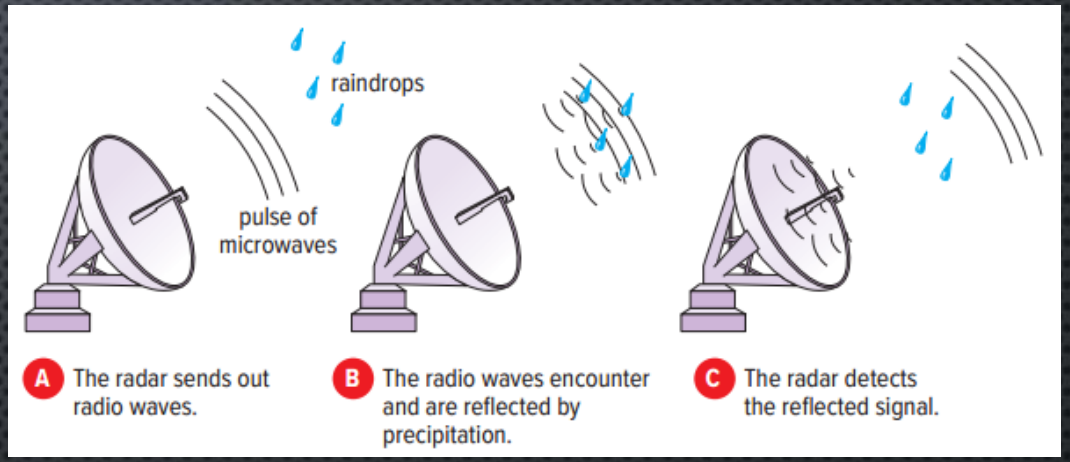
WEATHER BALLOONS

- METEOROLOGISTS OFTEN SEND WEATHER BALLOONS INTO THE ATMOSPHERE TO TAKE WEATHER MEASUREMENTS. THESE MEASUREMENTS ARE TAKEN BY A RADIOSONDE. A RADIOSONDE IS A DEVICE CARRIED BY THE BALLOON THAT CONTAINS VARIOUS WEATHER-MEASURING INSTRUMENTS.
- IT ALSO CARRIES A RADIO TRANSMITTER. A RADIOSONDE'S INSTRUMENTS MEASURE ATMOSPHERIC CONDITIONS, SUCH AS TEMPERATURE, PRESSURE, AND HUMIDITY.
- THE RADIO TRANSMITTER CONTINUOUSLY SENDS THESE DATA BACK TO RADIO RECEIVERS ON THE SURFACE.
- ADDITIONALLY, BY TRACKING THE BALLOON ITSELF, METEOROLOGISTS GATHER DATA ON WIND SPEED AND DIRECTION.
- AS THE BALLOON RISES IN THE ATMOSPHERE AND AIR DENSITY DECREASES, THE HYDROGEN GAS THAT KEEPS IT ALOFT EXPANDS. THE BALLOON EVENTUALLY BURSTS AND A SMALL PARACHUTE CARRIES THE RADIOSONDE BACK TO EARTH.



WEATHER RADAR

- WEATHER RADAR REMOTE SENSING TECHNOLOGY THAT MEASURES WEATHER DATA BY ANALYZING RADIO WAVES THAT ARE REFLECTED OFF OBJECTS IN THE ATMOSPHERE
- RADIO WAVES SENT OUT BY WEATHER RADAR ARE REFLECTED BY RAIN, SNOW, HAILSTONES, OR OTHER OBJECTS IN THE AIR. THE HEAVIER THE PRECIPITATION IS, THE GREATER THE AMOUNT OF REFLECTION. THE REFLECTED SIGNALS ARE INTERPRETED AND CONVERTED INTO IMAGES THAT SHOW THE LOCATION AND INTENSITY OF PRECIPITATION.
- BECAUSE RADAR CAN PENETRATE CLOUDS TO SEE IF PRECIPITATION IS FORMING, ITS MAIN FUNCTION IS TO DETECT PRECIPITATION.

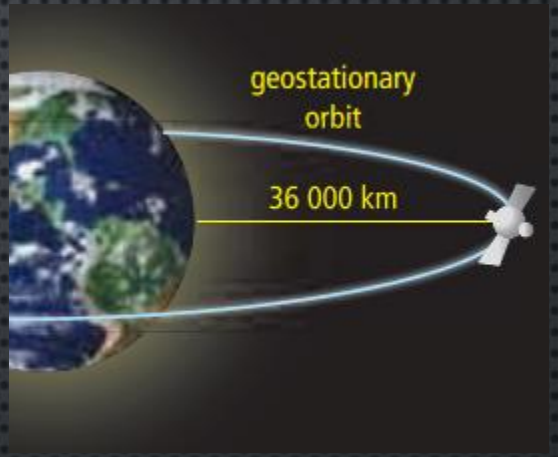


- A special radar technology called Doppler radar also determines whether the objects it detects are moving away from or toward the radar antenna.
- It can also measure their speed.
- This enables meteorologists to calculate the direction and speed of a weather system.
- Doppler radar is used to show the geographical extent, the intensity, and the movement of precipitation.
- It is an especially helpful early warning system for approaching storms

WEATHER SATELLITES

- Weather satellites contain specialized remote sensing technology that has been launched into orbit around Earth. The technology on these satellites monitors the atmosphere near Earth, and it helps meteorologists understand the development and movement of weather systems.
- They use infrared light (heat) to detect temperature or scattered visible light to detect precipitation

- There are two types of orbiting weather satellites:
- Geostationary Operating Environmental Satellites (GOES) and Polar Operating Environmental Satellites (POES).
- GOES orbit Earth about 36 000 km above the equator. They travel at the same speed as Earth rotates. These satellites are essentially hovering over a fixed location on Earth. Thus, they observe the same location on a continuous basis.
- POES orbit Earth about 14 times per day at 879 km above it. As Earth rotates beneath POES, they cover the entire globe during the course of the day. This allows them to track various weather systems.



2-1A

- Lab manual : Analyzing a weather report

SCIENCE WATCH

- Lab manual : The Maple Leaf Lands on Mars

FORECASTING THE WEATHER

- SHORT-RANGE FORECAST A FORECAST THAT PREDICTS HOW WEATHER CONDITIONS WILL CHANGE OVER A PERIOD OF UP TO 48 HOURS
- THE SIMPLEST, CALLED PERSISTENCE FORECASTING, ASSUMES THAT CURRENT WEATHER PATTERNS WILL PERSIST (CONTINUE) INTO THE FUTURE. BECAUSE ATMOSPHERIC CONDITIONS ARE ALWAYS CHANGING, PERSISTENCE FORECASTS ARE MOST ACCURATE FOR UP TO A FEW HOURS.
- ANOTHER TECHNIQUE, CALLED NOWCASTING, FORECASTS WEATHER UP TO ABOUT 6 HOURS. NOWCASTING RELIES ON REMOTE SENSING TECHNOLOGY AND IS ESPECIALLY HELPFUL IN PREDICTING STORM MOVEMENT.

	Sat Overnight	Sun Morning	Sun Afternoon	Sun Evening	Sun Overnight	Mon Morning
	Cloudy with clear breaks	Scattered flurries	Scattered flurries	Scattered flurries	Scattered flurries	Mainly cloudy
	-2°	0°	0°	-1°	-3°	-3°
Feels like	-9	-6	-6	-8	-11	-11
POP	40 %	40 %	40 %	40 %	40 %	40 %
Snow	-	<1 cm	<1 cm	<1 cm	<1 cm	-
Wind (km/h)	23 NW	26 NW	34 N	37 NW	35 NW	36 NW
Wind gust (km/h)	38	45	56	56	54	56
Humidity	93 %	93 %	93 %	86 %	80 %	80 %

2-2A FORECASTING BY OBSERVING CLOUD TYPES AND MOTION

- Lab manual

WEATHER SYMBOLS AND MAPS

Table 2.2 Some Common Weather Map Symbols

Symbol	Explanation
	*cold front*—the leading edge of an advancing cold air mass
	*warm front*—the retreating edge of a cold air mass as a warm air mass approaches
	*stationary front*—the boundary between two air masses that are not moving
	*occluded front*—the boundary formed when a fast-moving cold front overtakes a slow-moving warm front
99.6	*isobar*—line showing locations of the same atmospheric pressure
20	*isotherm*—line showing locations of the same temperature
H or **L**	*pressure system*—indicates a high pressure system or a low pressure system

ANALYZING WEATHER MAPS FOR SHORT-RANGE FORECASTING

- LAB MANUAL : 2-2B INTERPRETING WEATHER MAPS

- WHEN ANALYZING WEATHER MAPS TO CREATE A SHORT-RANGE FORECAST IS THE LOCATION OF WEATHER FRONTS, AS WELL AS THE SPEED AND DIRECTION OF THEIR MOTION.
- THE LOCATIONS OF PRESSURE SYSTEMS AND THEIR BOUNDARIES CAN ALSO HELP YOU PREDICT HOW THE WEATHER WILL CHANGE. ATMOSPHERIC CONDITIONS OFTEN BECOME UNSETTLED WHERE TWO PRESSURE SYSTEMS MEET.
- ADDITIONALLY, IF THE MAPS INCLUDE ISOTHERMS OR ISOBARS, OBSERVE HOW CLOSE OR FAR APART THE LINES ARE AND HOW THIS DISTANCE IS CHANGING WITH TIME. THIS WILL GIVE YOU AN IDEA OF HOW QUICKLY THE TEMPERATURE OR PRESSURE IS CHANGING. OFTEN, QUICKLY CHANGING TEMPERATURE OR PRESSURE INDICATES AN APPROACHING FRONT.

Figure 2.9 Quickly changing temperature or pressure often indicates that a frontal system is approaching.
Interpret *What evidence of a frontal system do you see in this photograph?*

FORECASTING THE WEATHER

- LONG-RANGE FORECAST A FORECAST THAT PREDICTS HOW WEATHER CONDITIONS WILL CHANGE OVER A PERIOD OF 3 TO 7 DAYS
- LONG-RANGE FORECASTING RELIES ON COMPUTER-BASED STATISTICAL ANALYSIS OF PAST WEATHER DATA AND COMPUTER MODELS OF ATMOSPHERIC CIRCULATION AND BEHAVIOUR
- THE FARTHER INTO THE FUTURE A FORECAST IS MADE, THE LESS RELIABLE ITS ACCURACY BECOMES.
- THE ATMOSPHERE IS STILL ONE OF THE MOST UNPREDICTABLE SYSTEMS ON EARTH.
- SEVERAL DIFFERENT COMPUTER MODELS ARE TYPICALLY USED TO PRODUCE LONG-RANGE FORECASTS AND THEIR RESULTS ARE AVERAGED.

Next 7 Days

	Sun 01/31	Mon 02/01	Tue 02/02	Wed 02/03	Thu 02/04	Fri 02/05	Sat 02/06
	Scattered flurries	Mainly cloudy	Mainly cloudy	Snow	Chance of a shower	A few flurries	Cloudy with sunny breaks
	0°	-3°	-2°	4°	4°	1°	3°
Feels like	-6	-11	-6	-2	-1	-3	-1
Night	-3°	-4°	-3°	4°	0°	0°	1°
POP	40 %	40 %	30 %	70 %	40 %	40 %	30 %
Wind (km/h)	37 N	37 NW	20 N	53 SE	33 S	19 W	27 NW
Wind gust (km/h)	56	56	30	80	50	29	41
Hrs Of Sun	1 h	1 h	1 h	0 h	4 h	4 h	2 h
24 Hr Rain	-	-	-	~5 mm	~1 mm	-	1-3 mm
24 Hr Snow	1-3 cm	-	~1 cm	5-10 cm	<1 cm	<1 cm	-

2-2D

- Lab manual : Canadian Contributions to Meteorology

2-2E

- Lab manual : Using weather maps for short-range forecasting

IMPORTANCE AND LIMITATIONS OF WEATHER FORECASTING

- CANADA EXPERIENCES A WIDE VARIETY OF WEATHER, MUCH OF WHICH CAN BE EXTREME AND HAZARDOUS.
- SUCH WEATHER EVENTS INCLUDE FLOODS, HURRICANES, ICE STORMS AND HEAT WAVES
- THEY RESULT IN LOSS OF LIFE AND HUNDREDS OF MILLIONS OF DOLLARS IN PROPERTY DAMAGE IN CANADA EACH YEAR. BECAUSE THE CONSEQUENCES OF EXTREME WEATHER ARE FREQUENTLY IN THE NEWS, PEOPLE ARE VERY AWARE OF THEM.
- OUR ABILITY TO FORECAST ALL WEATHER PLAYS A SIGNIFICANT ROLE IN THE CHOICES THAT ARE MADE ON A PERSONAL, LOCAL, AND NATIONAL LEVEL.

Figure 2.12 The consequences of weather events such as these can be very serious, even if they are forecast in advance.
Explain *How does accurate forecasting reduce the consequences of the weather events shown here?*