11.0 Weather

Weather: daily changes in the atmosphere
elementary understanding of the general forces that create our weather
humidity, temperature and atmospheric motion contribute to weather patterns
Buys-Ballot's Law
basics of warm and cold fronts
basic weather forecasting signs

General

Weather concern to all boaters
fair dry early morning may become stormy afternoon
wise skipper does not leave the dock when storms are forecast.
weather is changeable
does not always follow the forecast
good skipper's seamanship skills include the ability to adapt forecasts to local situations

Weather Forecasts

general forecasts for region based on simultaneous measurements of
1. air pressure
2. temperature
3. humidity
4. wind
taken at many places
time and date of issue is most important feature of any forecast
15 hours old it is out of date

general forecast for a large area is rarely accurate for every place within it
unavoidable time lag between data collection and distribution forecast
general forecast must be adjusted for local conditions
boaters should listen to local forecasts before and continue listen for up date
visual observations can supplement the forecast
important to recognize likelihood of wind direction and velocity changes, storm development, rough seas, or reduced visibility.

Atmospheric Conditions That Cause Weather

Pressure

pressure changes create wind
at any altitude above sea level, pressure is less than that at sea level.

Pressure is measured by a barometer
mean value of air pressure at sea level is 1013.25 millibars (hecctopascals) or 101.32 kilopascals universally or USA 29.92 in of mercury or 14.7 lb/in^2
changing pressure (tendency) more important for forecasting than actual pressure
pressure tendency and changes in wind direction over a few hours indicate approaching weather conditions
small marine barometer on board is a wise investment

Temperature

sun does not heat the air directly
sun's rays warm the earth's surface which heats atmosphere
reason for decrease in temperature with altitude
heat is distributed unevenly over any given area
water warms and cools more slowly than land
shade fromclouds, trees, mountains or structures create cooler patches of ground
air temperatures are not the same throughout an area

as air warms, it expands and rises
as air rises, it cools and becomes denser
continues to rise until its density and that of the surrrounding air are equal
temperature is measured with a thermometer
informative to have one aboard but not essential
changes in temperature can be sensed easily

Humidity

moisture content air
major factor in creating adverse weather conditions
capacity of air to hold moisture depends on temperature
warmer the air, the more moisture it can hold
at any temperature a maximum amount of water vapour the air can hold
when water vapour content = that amount air is said to be **saturated**

relative humidity is percentage of the maximum content possible for that water vapour content at a specific temperature
100% relative humidity = saturation

as moist air cools its ability to hold water vapour is lessened
if cooled sufficiently the air will become saturated
temperature at which this occurs is called the **dew point**
further cooling results in condensation of moisture
appears as fog or clouds or dew

Instruments to measure humidity not necessary on a boat
presence or changes in humidity usually can be sensed
radio or television forecasts mention relative humidity and temperature

Atmospheric Motion

Cloud Formation

atmosphere in almost continual motion because of daily cycle of solar heating and cooling plus changes in pressure
air warmed by ground that is heated by the sun will rise and carry its moisture content aloft
as it rises, the air cools until it reaches the dew point and its moisture condenses to produce clouds.
(See Figure 11.1)

Surface Winds

rising air from solar heating draws air at ground level towards its base producing a gentle surface wind.

Land and Sea Breezes (Local Winds) Figure 11.2 afternoon Figure 11.3 evening

when land is heated by the late morning sun (1) the air above is warmed and rises
causes a local or thermal low pressure area drawing in cooler air from the sea (2)
results in onshore breeze extending 1 - 2 miles out to sea(3)
easily noticed if no over-riding gradient wind is present.

land cools rapidly to a temperature below that of the water (1) cools and sinks
flows away from the land (2) replacing the warmer air that rises off the water
results in an offshore breeze
in calm weather offshore breezes may be all that is available to serve the sailor

Gradient Winds

world weather systems characterized by well-defined centres of:
a) LOWS - lower pressure areas than surrounding region
b) HIGHS - high pressure areas than surrounding region
(See the weather map in Figure 11.4)
air moves from high pressure to lower pressure
deeper the LOW, the more rapid the movement of air towards it
called **gradient winds**

Centres of Low Pressure

weather systems move across northern hemisphere west to east
atmospheric pressure at any place constantly changing
air flows from high to low pressure
northern hemisphere air moves around a **LOW counter clockwise** slightly towards centre (Figure 11.5)
circles represent **isobars - lines of equal pressure**
closer isobars are to each other the stronger the wind
conversely, northern hemisphere air moves **clockwise around a HIGH** slightly away centre

Buys- Ballots's Law

low pressure forms at meeting of two air masses of different temmperature and/or moisture content
Figure 11.4 LOW east of Hudson Bay is at juncture of warm and cold front - frontal depression
Buys-Ballot's Law common rule of thumb for locating centres of low pressure
"Stand with your back to the wind and the low pressure will lie to your left and slightly behind you".(N hemisphere)

Fronts

front - dividing line between two air masses that differ mainly in temperature
one air mass moves against another
temperature of the moving air mass, warm or cold, characterizes a front
comparative terms
Figures 11.6 and 11.7
warm front - warm air **mass overrtaking a stationary mass of cooler air**
cold front - cooler air mass pushing under warmer air mass

on weather map (Figure 11.4)
cold fronts are marked by spikes
warm fronts by half circles
on coloured weather map cold fronts are blue, warm fronts red
both characterized by cloud cover, precipitation and wind shifts, but their movements affect the weather differently

cold fronts move faster than warm fronts they can catch up to a warm front - **an occlusion**

lifts warm, forms a trough of warm air aloft called a TROWAL
TROWAL can produce even more cloud and precipitation
looks like backwards 7's on weather map (Figure 11.4).

Warm Front

warm air rising above the colder, denser, air
as warm air rises, stratus or layer clouds are formed due to the cooling rising air
sometimes first sign of warm front is cirrus cloouds seen up to 1000 km (540 nm) ahead of front
move more slowly than cold fronts
precipitation moves ahead of the front at ground level (Figure 11.6)

Cold Front

mass of colder air moving against a mass of warmer air forcea warmer air to rise quickly
puffy cumulus or even cumulonimbus (thunderhead) clouds formed
produce showers or thunderstorms
precipitation and storms are often severe because of high moisture content
cold front aweather usually gusty winds followed by clearing skies (Figure 11.7).

Forecasting

Clues

basis for reliable forecasts is changing

- cloud patterns
- barometric pressure
- temperature, humidity
- wind direction and velocity

most reliable clues are:

- The direction of the wind.
- The rate and direction of pressure change.
- The nature of the clouds.

weather hazards greatly reduced by adequate preparation.

Warm Front Pattern

- Barometric pressure falling
  faster fall, faster approach of severe weather.

- General and increasing cloud cover
  sequence: cirrus (mare's tails), altostratus (milky sun), and stratus (low layered, featureless cloud cover).

The presence of all three of the above signs is a reliable indication of deteriorating weather conditions such as steady precipitation from overcast skies and reduced visibility.

Cold Front Pattern

cold front gives little indication of its approach
see big puffy clouds of vertical development, such as cumulus or cumulonimbus (thunderstorm type) clouds, on the westerly horizon means the front is moist and moving rapidly

winds shift from SE to S to SW may change to W or NW with squalls AND gusty strong W TO NW winds
wind shifts associated with passage of the front
most significant wind shifts with cold front passage (over 90° of veer may occur)

Winds following cold front frequently remain gusty
If strong winds precede the wind shifts, then strong winds (usually from the northwest) follow as weather clears.
barometer riseS with cold front passage as the colder air arrives (Figure 11.8)

Signs of Improving Weather Conditions

• Barometer steady or rising

• Wind shifting E to N to NW (backing) or SE to S to SW (veering); i.e., a shift towards westerly winds in either case.

Backing - counter clockwise wind shift
Veering - clockwise wind shift

Fog

General

Fog - water droplets suspended in atmosphere
cloud at ground or sea level
formed the same as clouds
air containing water vapour cooled to dew point

Radiation Fog

forms at night when cooling earth's surface chills moist air above results in condensation
requires rapid cooling of earth's surface, high moisture content, light wind for mixing
no wind results in dew but no fog
morning sun will slowly 'burn' off this fog
earlier fog forms during the night later it I will dissipate the following day

Advection Fog or Sea Fog

Advection- the horizontal movement of air over the surface
occurs on E and W coasts of Canada
caused by condensation forming when very moist air moves over colder surface
change in wind direction required to dissipate
also occurs when very cold air flows across a warmer surface
vapour rises from the water surface and immediately condenses in the cold air
gives the impression of smoke or steam rising from the surface (Arctic Sea Smoke)
usually occurs over waters close to a cold land surface.

Frontal Fog of Warm Front Fog

continuous rain falls ahead of a warm front
some evaporates into the cooler humid air below close to dew point
when saturated cloud and fog form
may stretch from ground to base of frontal cloud above
will not disperse until the front passes