The Log of *Moira*
The 5% You Need to Know (to be an intelligent consumer of weather forecast products)

This class will help you understand:
- how to interpret the most useful National Weather Service (NWS) forecast products, and build expectations about what will happen to weather near term
- how to modify offshore forecasts for coastal conditions.

This class will NOT teach you:
- how to make your own forecasts
- how to get the forecasts (SSB, satphone, Sailmail, etc.).

Topics are arranged in order of decreasing "bang for the buck" or increasing return for increasing effort.

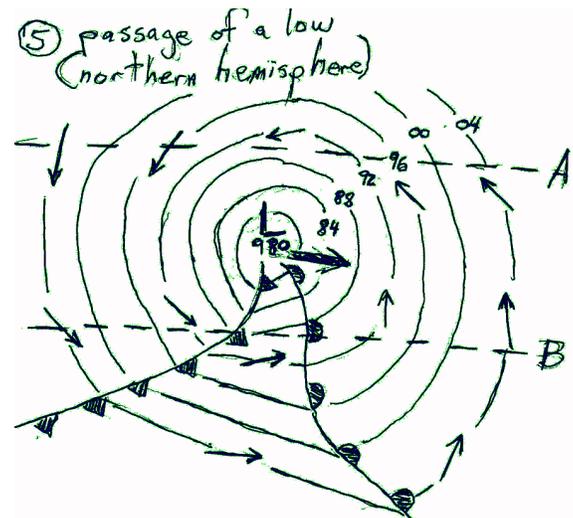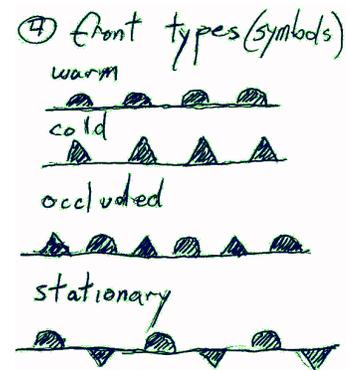1. Text forecast ("offshore")
   a. Gradient wind offshore, mostly powered by highs/lows/fronts
   b. Wind speed is average, figure gusts 50% above average, more if wind off land
   c. "Significant wave height" quoted is average of highest 1/3 of waves, so some will be higher (see "Breaker, Breaker")
   d. No consideration for "coastal effects" (see below)
   e. Average over a large area (>300 nm x 300 nm) and time (24 hours)
   f. Pull reports every day, at the *same time* every day
   g. Pay attention to issue time and valid time (true for all products)
   h. Watch out for *changes* in forecast especially *increases* (e.g., on Monday, the 72hr forecast/Thursday is for 15 kt, but on Tuesday, the 48 hr forecast/Thursday is for 20 kt). NWS tends to "undercorrect"
   i. Absolute numbers are less important than trend (if the forecast for Tuesday is for 15 kt and Wednesday is for 20 kt, but you only see 10 kt on Tuesday, you'll likely see "more" maybe 15kt, on Wednesday)
2. Modifying the forecast for coastal effects
   a. Land and sea breezes out to about 20nm may: (Fig 1)
      i. Reinforce
      ii. Counteract
      iii. Change direction
      iv. Closer to coast, effect is stronger and longer
      v. Strong sea breeze depends on sunny day: watch for a roll of cloud on the coast
      vi. Examples:
         1. LA afternoon breeze vs. Santa Ana (katabatic)
         2. Coastal lift off Punta San Blas
   b. Cape effects (Fig 2)

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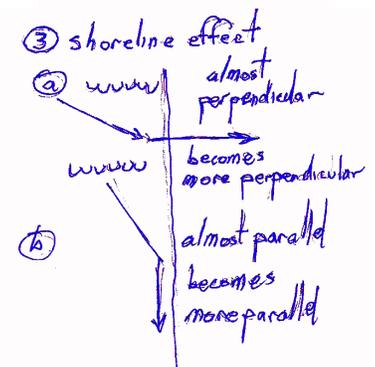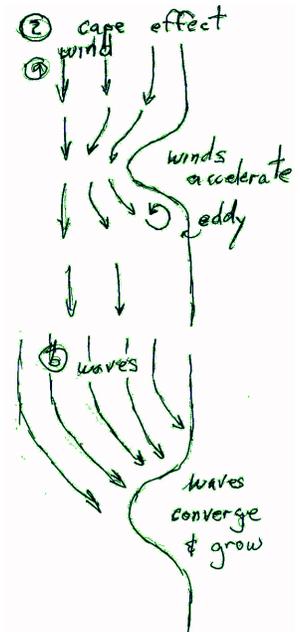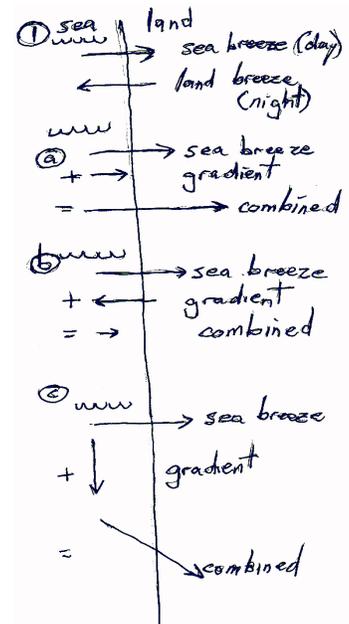
    i. Acceleration
    ii. Bending
    iii. Wind and wave refraction
  c. Shoreline effects (Fig 3)
    i. Onshore winds nearly parallel to coast become more parallel
    ii. Onshore winds nearly at right angles to coast become more perpendicular
  d. Gusting, especially winds coming off the land
  e. Wind against current (see pilot charts)
3. Wind and wave forecast (24, 48, & 72 hours)
  a. Gradient wind and significant wave height as for text forecast
  b. Wind arrows
    i. Short feather = 5 kts, long feather = 10 kts, pennant (triangle) = 50 kts
    ii. Arrow head points toward direction wind will blow toward, feathers are at end wind will blow from
  c. Must modify for local/coastal effects as for text forecast
  d. Fronts (Fig 4)
    i. Seldom dip below 20 degrees latitude
    ii. Warm: rounded bumps ("melted"), usually gentler
    iii. Cold: triangles ("frozen"), often violent
    iv. Occluded (cold catches warm)
    v. Stationary
    vi. Wind often suddenly shifts 90 degrees (clockwise in northern hemisphere) on passage of cold front
      1. Cross sea
      2. Untenable anchorage
  e. Highs and lows discussed below
4. Wave period and swell direction forecast
  a. Long period swell from distant storm
    i. Max swell period for 20 kt wind is 7.5 sec. Add 2 sec. for each 5 kt above 20 kt. E.g., 35 kt = 13.5 sec. (typical period about 60-75% of max)
    ii. Speed of a wave *group* (not individual waves) is 1.5 knots x period (sec.)
  b. Storm may be approaching
  c. Anchorage or passage may become uncomfortable
5. Surface analysis and surface forecasts (24, 48, & 72 hours)
  a. Surface analysis ("nowcast") and surface forecasts vs. wind/wave forecasts
    i. Wind arrows on surface *analysis* are actual ship reports, warts and all
    ii. Wind arrows on wind/wave *forecasts* are model output
    iii. If no arrows on surface analysis, no local reports, so be cautious about validity of forecast
  b. Pressure centers
    i. High ("H")
      1. Cooler air, more stable
      2. Clockwise rotation in northern hemisphere
      3. Ridge with wind shift
    ii. Low ("L")
      1. Warmer air, less stable, sometimes violent, strong wind shift, veer vs. back

④ front types (symbols)

warm

cold

occluded

stationary

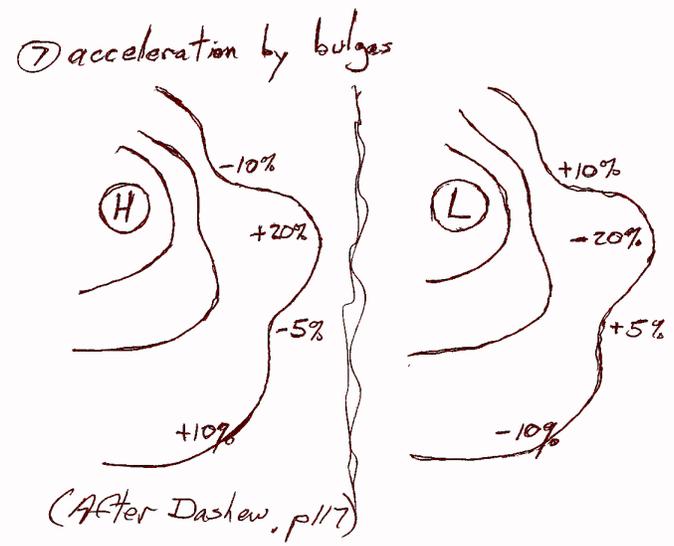⑤ passage of a low (northern hemisphere)

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2. Counterclockwise rotation in northern hemisphere
3. Fronts stem off of low
4. Trough ("TROF") with wind shift
5. Thermal vs. frontal lows

iii. Center symbol also shows
  1. Central pressure in millibars (mb/hPa), underlined, e.g. "<u>1008</u>"
  2. Where center will be in 24 hours, and underlined forecast pressure, last 2 digits only "<u>95</u>"=995, "<u>10</u>"=1010
  3. Watch *trend* in pressure *(low will be more vigorous if pressure deepens!)*
  4. Watch acceleration due to motion of center
     a. "Dangerous quadrant" on front right side of Low in northern hemisphere
     b. Higher winds on front left side of High in northern hemisphere

iv. NEW (new high or low will appear within 24 hrs after valid time of forecast)
v. DISPT (dissipating)
vi. STNRY (stationary)
vii. RAPIDLY INTSFY (rapidly intensifying)
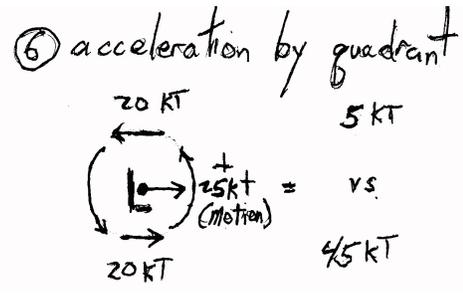
c. Isobars
  i. Lines of equal pressure
  ii. Usually every 4mb
  iii. Compare with *calibrated* barometer
     1. To adjust timing of passage of a center or front
     2. Must know local diurnal barometer pattern (e.g., in tropics barometer rises 3mb 4am-10am, falls 3mb 10am-4pm, etc.), compare to 24 hrs earlier
  iv. Wind blows mostly parallel to isobars, clockwise around High/ridge, counterclockwise around Low/trof (northern hemisphere)
  v. Isobars closer together = more wind
  vi. "Squash zone" where low and high are close together (barometer may not change)
  vii. Wind accelerates (10-20%) at bulge (ridge) around a high, decelerates at concavity (beyond what isobar spacing would forecast)
  viii. Wind decelerates at bulge ("trof") around a low, accelerates at concavity

d. Intertropical Convergence Zone (ITCZ)
  i. Moves 0 N to 10 N with seasons

⑥ acceleration by quadrant

20 KT   5 KT

25 kt (motion) = vs

20 KT   45 KT

Geostrophic Wind Force (after Dashew P.113)					
Wind speed (Kts) given latitude and spacing in degrees between 4mb isobars ("G" = "gusting to")					
Degrees Between 4mb Isobars	Latitude of observation				
	10°	20°	30°	40°	50°
1	--	78 G 116	54 G 80	42 G 62	36 G 52
2	76 G 115	39 G 58	27 G 40	21 G 31	18 G 26
3	50 G 75	26 G 39	18 G 26	14 G 20	12 G 18
4	36 G 55	19 G 30	14 G 20	10 G 15	9 G 13
5	29 G 44	16 G 23	10 G 16	8 G 13	7 G 10

⑦ acceleration by bulges

H   -10%   +20%   -5%   +10%

L   +10%   -20%   +5%   -10%

(After Dashew, p.117)

  ii. In ITCZ squally, unsettled weather, cloudy, with light/variable wind

  iii. N of ITCZ, winds mostly out of N

  iv. S of ITCZ, winds mostly out of S

6. Pilot charts

 a. Passage planning, statistical averages drawn from ships' logs over several centuries of observations

 b. Percent of time with wave heights > 12 feet (8 feet in Caribbean—see notes)

 c. Currents

 d. Wind rose

  i. Percent of winds from each direction, with average wind strength. Number of feathers = Beaufort force number (BFN)[*]

   1. Wind speed and wave height for BFN 1-8, approximately,

    wind speed (knots) = (BFN - *1*) x 5)

    max deep-water significant wave height (feet) = $((BFN - 1)^2) / 2$

    (for BFN 9-10, don't "subtract 1")

   2. Duration needed (hours) *from flat calm* approximately,

    a. For 90% of max wave height, 24 hours

    b. For 75% of max wave height, 12 hours

    c. For 50% of max wave height, 6 hours

   3. Fetch needed (nautical miles) for BFN ≥ 4 *from flat calm* approximately,

    a. For 90% of max wave height, fetch = ((BFN - 3) x 100) - *50*

     (for BFN 9+, don't "subtract 50")

    b. For 75% of max wave height = ½ of formula value

    c. For 50% of max wave height = 1/6 of formula value

   4. With pre-existing swell, duration needed may fall by 3-4 hours

   5. If you don't want to do the math, 2/3 - 3/4 of max height is a good guess

  ii. Number in center of wind rose is percent of calms

 e. Separate charts for percent of gales, fog, etc.

 f. Note that ships avoid forecasted bad weather, so bad weather is statistically under-reported

7. GRIB files

 a. "GRIdded Binary", not "Gospel wRitten In Bits"

 b. Output of a single computer model

 c. Always cross-check with NWS forecast—at least some human has looked at the forecast!

 d. Useful for

  i. Interpolating from above reports for land effects

  ii. Driving performance/routing software

8. Forecast discussion

 a. Forecaster may discuss uncertainties about forecast, e.g. computer models disagree, or forecaster disagrees with model, and alternative possibilities

 b. Forecasts generally show only "most likely" weather, with no mention of low-probability outcomes

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[*] Wave height, fetch, and duration formulae loosely based on W. G. Van Dorn, *Oceanography and Seamanship*, 2nd edition, Cornell Maritime Press, 1993

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Breaker, Breaker!

A short summary of information about breaking waves in shallow water.

Whether a wave will break in shallow water is primarily a function of its height and of the water's depth, though other influences apply.

A consensus value for the critical depth that will cause breaking is 1.5x the wave height.

But what is the wave height? Any sea state is a spectrum of heights. Most forecasts and descriptions of sea state use the *significant wave height* (also called "H_3"), the average of the heights of the highest 1/3 of the waves. Most observers, when asked to state how high the waves are, report a value close to significant wave height. But some waves will be higher than the significant wave height, and *those will be the waves that break first*. The following adjustments apply:

- The average of the heights of the highest 10% of the waves (also called "H_{10}") is 1.27x the significant wave height. (Statistically, one in every 80 waves—about 13 minutes, assuming a 10 second period—will be 25% higher than H_{10}. One in every 800 waves—about 2 hours—will be 50% higher than H_{10}, or about twice the significant wave height.)
- As waves move into shallow water, their height increases, reaching 1.33x the deep water height before breaking.

Taking these three factors together (1.5 x 1.27 x 1.33):

➔ **A sea state described as a certain significant wave height will begin to break when the water depth becomes less than about 2.5x the (deep-water) significant wave height**.

For example, a 25-knot breeze (force 6) can generate a significant wave height of about 12 feet. The highest 10% of the waves in the spectrum will average about 15 feet. As the 15-foot waves move into shallow water, they will grow to about 20 feet before breaking in water about 30 feet deep. A harbor entry with a 30-foot depth, or a 30-foot deep shoal, would have breakers.

Other influences

The other influences on wave steepness are based mostly upon the wave length (crest-to-crest distance), which can be calculated from its period (crest-to-crest time in seconds) as:

$$\text{length (feet)} = 5 \times \text{period}^2$$

(Note: If you attempt to time the period from a moving vessel, the velocity of the vessel will artificially increase or decrease the observed period and must be adjusted for.)

- When depth = length/3, the wave height and steepness (height/length) locally decrease slightly. If you are paralleling a coast, you may be able to find a smooth avenue at the right distance off the beach, traveling on the surface above this depth contour.
- When depth < length/4, the wave steepness climbs past its open-ocean value and continues to increase as depth decreases.
- Also when depth < length/4, refraction begins. A convex depth boundary (e.g., a round shoal, or a river bar that sticks out like a tongue) will bend (focus) wave energy from either side into its center like a lens, causing breaking to occur over deeper water than otherwise. A concave boundary (e.g., a trough, or a deep river mouth with shoals on either side) will cause energy from the central axis to be drawn away to either side, reducing or postponing breaking.
- Wind against current will cause steeper seas and earlier breaking. Entering a river mouth with an onshore wind should be done with a flood current if the situation is in doubt.

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