Chapter 13:
1. Mission of National Weather Service
   a. Generation of Watches, Warnings, and Advisories
2. Acquisition of Weather Information
3. Forecasting Methods
   a. problems with computer models
      i. assumptions about how the atmosphere works and what is important
      ii. boundary problems
      iii. sparse observations
      iv. grid spacing too large
      v. inadequate treatment of surface features
      vi. chaos
   b. forecasting methods
      i. persistence forecast
      ii. steady-state or trend forecast
      iii. analogue method, pattern recognition, or weather types
      iv. ensemble forecast
      v. climatological forecast
   c. the interpretation of a percentage or probability forecast
   d. accuracy and skill in forecasting
4. Forecasting Using local Signs (general acquaintance)
5. Forecasting with Surface Charts - rules of thumb

Chapter 14:
1. Ordinary Thunderstorms
   a. life cycle: cumulus stage, mature stage, dissipating stage, lasts about 1 hour
   b. entrainment, updraft, downdraft, cell, overshooting, multicell storms
2. Severe Thunderstorms
   a. definition: hail ≥ 3/4 inch, surface wind gusts ≥ 50 knots, produce tornadoes (any one or more)
   b. gust front, mesohigh, downburst, microburst, macroburst, wind shear
   c. Supercell storm
      i. structured to be self-sustaining
      ii. very high updrafts, large hail, tornadoes, high surface winds, sometimes corkscrew shape (LP supercell)
      iii. high precipitation supercell, low precipitation supercell
   d. squall line, pre-frontal squall line thunderstorms, ordinary squall lines
   e. flash floods
   f. mesoscale convective complex: organized thunderstorms lasting up to 12 hours
   g. motion of thunderstorm
3. Distribution of Thunderstorms: maximum in Florida, minimum along Pacific Coast, small bump in Colorado
4. Distribution of hail: peak in Colorado, Wyoming, Nebraska, Kansas
5. Lightning and Thunder
   a. ~20% of strokes are cloud-to-ground
   b. current typically 18,000 amps, temperature typically 30,000°C
   c. what causes thunder?
   d. speed of sound (330 m/sec, 1100 ft/sec), 3 sec/km, 5 sec/mi
   e. thunder heard when lightning is 100 m to 5 km away
   f. electrification of clouds
      i. probably from falling hail or graupel colliding with rising ice crystals or supercooled water
      ii. top positive, middle negative, bottom mostly negative with positive regions
   g. lightning stroke (cloud-to-ground)
      i. induced charge below the cloud
      ii. step leader usually starts at negative end (base of cloud), advances about 50 m/step
      iii. return stroke goes the opposite direction - most of the current
      iv. dart leader for successive strokes
      v. forked lightning, ribbon lightning, ball lightning, sheet lightning, heat lightning, corona discharge, St. Elmo’s fire, sprites, ELVES, jets
   h. lightning detection
i. lightning safety
j. first aid for lightning strikes: most important is CPR; burns are usually on the surface

6. Tornadoes, twisters, cyclones
   a. “rapidly rotating winds that blow around a small area of intense low pressure”
   b. funnel cloud
   c. typical characteristics: direction or rotation, size, motion, duration
   d. life cycle: dust-whirl stage, organizing stage, mature stage, shrinking stage, decay stage
   e. tornado families and tornado outbreaks (6 or more in the same storm)
   f. occurrence: where, when (U.S. has the most of any country)
   g. winds
      i. typically 125 knots, up to 280 knots
      ii. wind speed - usually highest on the tornado’s right due to addition of rotation and translation speeds
      iii. multi-vortex tornado and suction vortices (about 10 m diameter)
      iv. Fujita Scale - based on damage, not on measured wind speeds
      v. be acquainted with which is considered weak, strong, or violent, and have a rough idea of relative wind speeds (exact values are not necessary)
      vi. about one F5/year, a few percent are over F3
   h. formation
      i. understand the “typical” conditions for formation
      ii. typical vertical temperature profile - weak inversion stops small thunderstorms; only strong storms will develop
      iii. convective instability
      iv. vertical wind shear necessary to develop the rotation; mesocyclone forms (5-10 km across) in the middle of the cloud and descends; mesocyclone stretches vertically and shrinks horizontally, turns into tornado cyclone (2-4 km across) which may descend from the cloud
      v. landspouts are weak tornadoes that form without a mesocyclone
      vi. supercell thunderstorms are the most likely to produce tornadoes
   i. observing tornadoes
      i. tornado watch - conditions are likely for tornado formation within the next few hours;
      tornado warning - a tornado has been detected
      ii. tornado preceded by rotating clouds in the base of the storm and a wall cloud extending below the base
      iii. funnel cloud may not be visible
      iv. Doppler Radar can detect wind shear but not sufficient resolution to see an individual tornado; Doppler Lidar can see an individual tornado (experimental)
   j. waterspouts; “rotating column of air over a body of water”

Chapter 15: Hurricanes, Cyclones, Typhoons, Tropical Cyclones
1. Tropical weather
   a. non-squall cluster, tropical squall cluster, squall line
   b. wind streamlines generally used rather than isobars on tropical weather maps
   c. tropical wave or easterly wave
2. Anatomy of a Hurricane
   a. an organized mass of thunderstorms with sustained winds exceeding 64 knots, eye, eye wall, spiral rain bands
3. Formation and Dissipation
   a. generally form between 5° and 20° latitude - have to have sufficient Coriolis force for rotation
   b. conditions for formation: warm water (≥ 26°C) to a depth of about 200 m (or less), deep region of high humidity, converging surface winds, light to moderate diverging upper-level winds, no subsidence inversion (trade wind inversion associated with the subtropical high)
   c. El Niño and La Niña - their effect on hurricane formation
   d. Stages of development: tropical disturbance or tropical wave, tropical depression - winds of 20-34 knots and several closed isobars, tropical storm - winds of 35-64 knots and closely packed isobars, hurricane - winds over 64 knots
   e. typical hurricane movement
   f. differences between a hurricane and a mid-latitude cyclone
4. Destruction
   a. hurricane watch issued when storm may arrive within 24-48 hours; hurricane warning issued when storm may arrive within less than 24 hours
   b. usually overwarn by about 3 times the damage swath of the hurricane
c. high winds inflict considerable damage
d. flooding, huge waves, and high seas produce most of the damage
e. **storm surge** caused by **Ekman transport** pushing water ahead of the storm, large waves (10-15 m) due to high winds, and up 1/2 meter sea level rise due to the low air pressure
f. embedded tornadoes: in about 1/4 of hurricanes; usually in right front quadrant
g. **spin-up vortices** or **mini-swirls**: very high winds due to the horizontal shrinking of the vortex; typically 30-100 m in diameter; rotation speeds up to 70 knots
h. translation speed, rotation speed, and speed of any embedded tornadoes or spin-up vortices add (and subtract) just as they do in a tornado
i. **Saffir-Simpson scale**: ranking and roughly what the associated wind speeds are

5. Naming