Tides
Chapter 11

Flood: coming in

Ebb: going out

Tides: What are they?

• Fall (ebb) and rise (flood) of sea-level with an avg. period of 12.4 hrs. (12 h, 25 min)

• Periodic on many time scales
  – ~ Daily
  – ~ Monthly
  – Yearly

[caption: Diagram of tidal cycle]
Newton's Law of Gravitation

- All objects are attracted towards each other...this attraction is gravity, (G)
- G is a function of mass and distance

- Gravitational Force = $m_1m_2/(r_{12})^2$
  (same as centripetal force)

- Tidal Force = $G(m_1m_2)/(r_{12})^3$

Size is important, but distance is MORE important!
What causes tides?

• They are just big waves…

Equilibrium Model

• We assume the moon and the sun are the most important objects
• We get rid of friction
• We also get rid of the continents
• End result would be a diurnal tide where we go through a high/low “bulge” about once every 12 hours…..
Definitions:

- **Spring** tide--big (highest/lowest height) change in water level
- **Neap** tide--small change in water level
- **Diurnal** Tide--1 high/low per day
- **Semi-diurnal** tide--2 max/min per day
- **Mixed** tide--a big mess!

Spring vs. Neap Tide

- Spring tides, everything lines up and “pulls” more
- Neap tide, the moon and sun are working against each other.
Lunar Time vs. Solar Time

- The Earth revolves once every 24 h
- The moon also rotates during that 24 h
- Net result: tides repeat every 24 h 50 minutes (so high tide every 12 h 25 min)

Every 24 hours, the Moon rotates 12 degrees
• Although the Sun’s force is a much smaller tidal force than the moon, it is important
The Ecliptic Effect

- The Earth is tilted, which affects the tides...
- The Moon is also 5 degrees off-plane, so the net result is a 28.5 deg. wander

Types of Tide
- **Diurnal** (once daily)--Gulf of Mexico
- **Semidiurnal** (twice daily; about same size)--Atlantic Coast
- **Mixed** (highs and lows are of different heights) Pacific Coast
Equilibrium Model…

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The cold, harsh reality of predicting tides…

PESSIMISM

Every dark cloud has a silver lining, but lightning kills hundreds of people each year who are trying to find it.
Precession and Ecliptics

- Combine the eccentric orbits of the earth and moon
- Over 18.6 years, the earth-moon plane wanders, while over one year, the earth orbits the sun, while over 1 lunar month, the moon wanders

Dynamic Theory of Tides

- Continents, friction, etc. mess up the perfect tidal theory
- Amphidromic Points are where tide bulges actually occur
- Cotidal Lines connect the amphidromic points
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Progressive & Standing Waves

- Tidal currents have very long periods, so have corresponding fast speeds and large wavelengths
- Tides act as shallow-water waves in most basins

Summary of Dynamical Tides

- Must account for all large objects, including the sun, moon, other planets
- Takes into account orbits, precession, and the tilt of the earth
- Assumes tides are forced waves, and that they form cells or amphidromic points because of friction, continents
- For 1995 (San Francisco Bay), predictions were off by an average of 0.25 feet!
Tides Summary

- Tides are just big shallow-water waves
- Can describe basic patterns with gravity and centripital force of moon and sun--this explains diurnal and semi-diurnal tides

- Need to include all forces (other planets, tilt of the earth, friction, continents, etc) to make accurate predictions!

- Tides oscillate (like a seesaw) around amphidromic points, with the same tide height following cotidal lines