Announcements

- Not quite done with exams. (Will need to work on them this weekend.)
- ESCI 322: Bellingham Bay sampling – we’re on, but it will be cold and wet. Meet at Taylor St dock.
- First problem set due on Thursday

Primary Fields of Oceanography

Geology

Sediment erosion deposition

Water depth Basin geometry

Circulation pattern mixed-layer depth upwelling

Physics

Light attenuation Bottom topography

Chemistry

Sediment erosion deposition

Water depth Basin geometry

Circulation pattern mixed-layer depth upwelling

Biology

Light attenuation Bottom topography

Physical Oceanography

Patterns of Ocean circulation

I. Pressure gradients and geostrophic flow
II. Wind-driven circulation
III. Surface currents
IV. Wind currents
   a. Antarctic circumpolar current
   b. Equatorial convergence and divergence zones
   c. Greenland-Iceland-Norwegian Seas
V. Upwelling and El Nino
VI. Recent advances in physical oceanography

Pressure gradients, Coriolis, and wind-driven circulation

I. Geostrophic flow: (Pressure-gradient, coriolis balance)

II. Wind-driven circulation

Ekman spiral

Ekman depth

(opposite of surface current direction)

Balance of forces on a water parcel in the Northern Hemisphere

Geostrophic flow

Pressure gradient

Velocity

Coriolis

Friction

Wind-driven flow

Wind stress

Velocity

Coriolis

Force

Pressure gradient terms

- Barotropic fields
  Isobars and isopycnals parallel

- Baroclinic fields
  Isobars and isopycnals inclined
Calculating the baroclinic component of geostrophic flow from salinity and temperature distributions

Distance offshore (km)

Salinity contours in (psu)

Water depth (m)

Distance offshore (km)

Blue (negative velocity) is into the page
Red indicates low velocity

Contour velocities in cm s\(^{-1}\)

Large-scale patterns of atmospheric circulation

Polar Cell
Ferrel Cell
Hadley Cell

Why doesn’t the Antarctic circumpolar current turn left?

Pressure Gradient
Sea-surface slope
Downwelling
Upwelling
Convergence
Divergence
Terrigenous
Abyssal clay
Siliceous radiolarian ooze
Siliceous diatom ooze
Calcareous ooze

North Atlantic Deepwater formation and East Greenland Current

Pressure, wind and flow in EGC (from Hopkins 1991)
Ocean circulation

- Rules of thumb:
  - Geostrophic flow
    - Water moves right of pressure gradient in NH
    - Water moves left of pressure gradient in SH
  - Wind-driven flow
    - Surface water moves ~ 45° right of wind in NH (left in SH)
    - Average flow 90° right of wind in NH (left of wind in SH)

Computed sea level + satellite altimetry
Thermohaline circulation (Formation and transport of water masses in the deep ocean)

Atlantic:

- N. Atlantic Central water (9°C, 35.3%o)
- N. Atlantic Deep Water (2.5°C, 35.03%o)
- Norwegian Sea Deep Water (-0.5°C, 34.9%o)

Some of the water sources for NADW. NADW sinks in winter, assisted by wind-driven evaporative cooling.
Coastal Upwelling

- Patterns are due to combination of wind, coriolis and pressure
- Net results:
  - Delivery of cold, nutrient-rich water to the shoreline
  - Enhancement of coastal productivity

Enso – El Nino/La Nina Southern Oscillation

- Current conditions: El Nino neutral
- Average winter conditions
- Moderate snow at Mt. Baker this winter
Current research topics:
Satellite oceanography – Ocean surface topography

Surface wind-velocity field from satellite images of surface waves

Satellite oceanography – Sea-surface temperature

Important topics in physical oceanography:
Weather forecasting – winds, currents and sea surface temperature
Global climate change – heat and mixing in the ocean
Coupled physical-biological models of the ocean
Coastal processes – coastal erosion, sediment transport
Climate change effects on circulation, mixing and sea ice
Model of ocean circulation (NOAA, NASA).

Fukushima-derived $^{134}$Cs

From Buesseler et al. PNAS 2012
Computer simulation of the spread of radioactive $^{137}\text{Cs}$ from Fukushima