GLY 558

Coastal Management

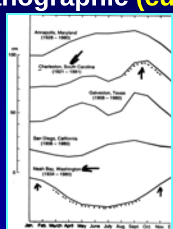
Sea Level Changes

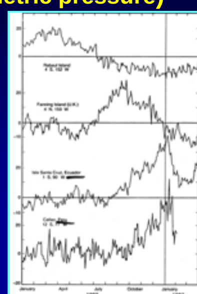
Sea Level

- Most important variable that controls position of shoreline
- Affects position where processes operate
- Datum from which we evaluate topographic & bathymetric variations
- Since occupation of coasts several thousand years ago *SL* has risen < 3m
- A 3- 4mm/y *SL r*ise creates serious problems for populated areas
- Mean height of sea surface measured at hourly intervals for all tide stages over 19 yr Period.

Sea Level Irregularities

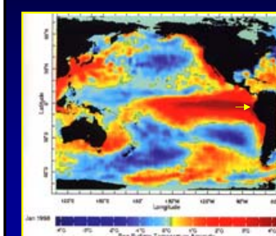
- Never level over meaningful spatial or temporal scale. Irregularities due to:
- Meteorological (wind/barometric pressure)
- River discharge
- Oceanographic (currents)

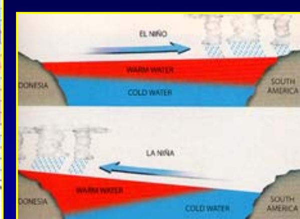




Sea Level (ENSO)

- El Nino/Southern Oscillation produces variations in SL across the Pacific Basin on a periodic basis.





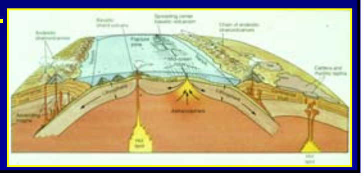
Venice, Italy NW Adriatic Sea

St. Mark's Square,Venice

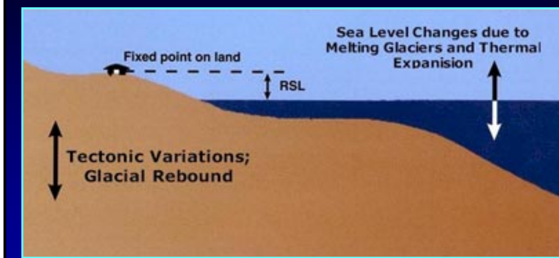
Aqua Alta

Controls on Sea Level

- Factors- Two categories
  - Geological – local and large scale
  - Climatic- world wide
- Geological factors involve bathymetric (shape) changes in ocean basin. Determines holding capacity
- Due to spreading rates of MOR, accounts for 300m over last 80 million yr
- Changes small.

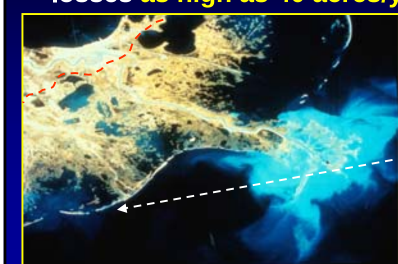


Important Contributing Factors



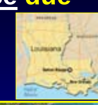
Sea Level (Geological - Local Scale)

- Areas may be rising or sinking
- Coastal LA is sinking at rate of >100km^2/y, losses as high as 40 acres/y & 1m/C



Sea Level Relative Rise

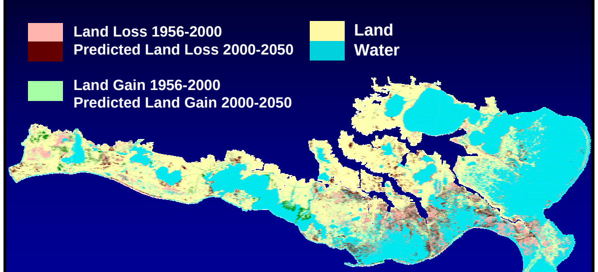
- Groundwater or hydrocarbon withdrawal can cause subsidence due to compaction of aquifer.
- Examples: Galveston Bay, New Orleans



Rise and Fall of Coastal Louisiana

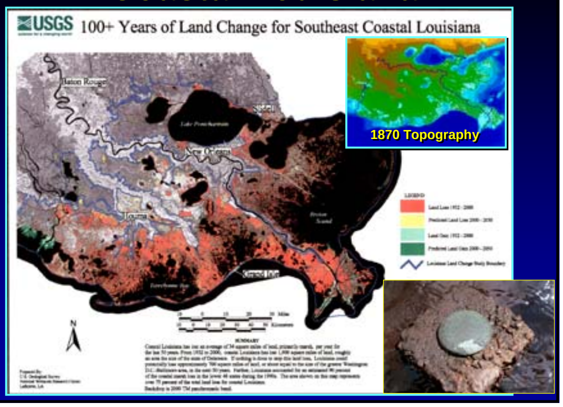
Years Before / After Present

Coastal Louisiana Trends: 1956-2050



USGS

Coastal Louisiana



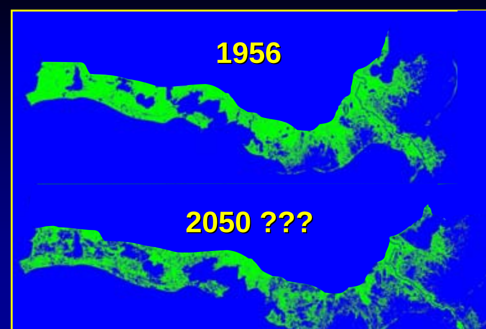
Mississippi River Drainage Basin

Importance of Coastal LA

- Billion $ Fisheries
- 30 % of nation's production
- Greater > all Atlantic Seaboard
- Infrastructure for ~20 % of hydrocarbon production in USA
- Navigation Projects for # 1 Port

- Hurricane Protection for 2 million people
- Habitat for millions of birds and animals
- 70 % of migratory waterfowl of Miss. Flyway overwinter in area
- Renowned for sport fishing,hunting and boating

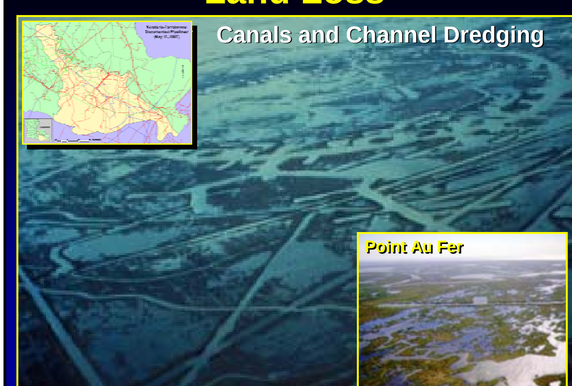
Land Loss Projection

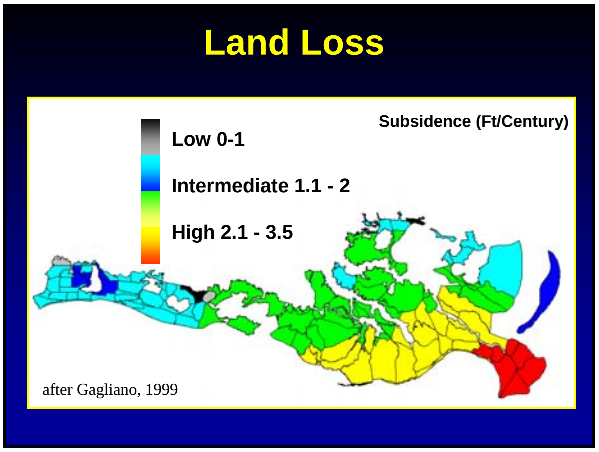


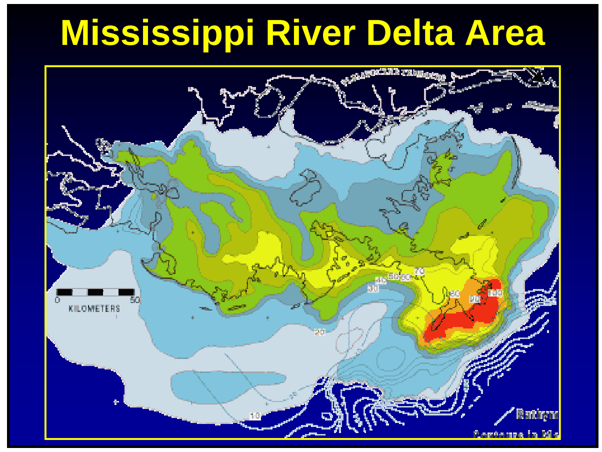
By 2050 1,000 mi^2 of wetlands will be open water

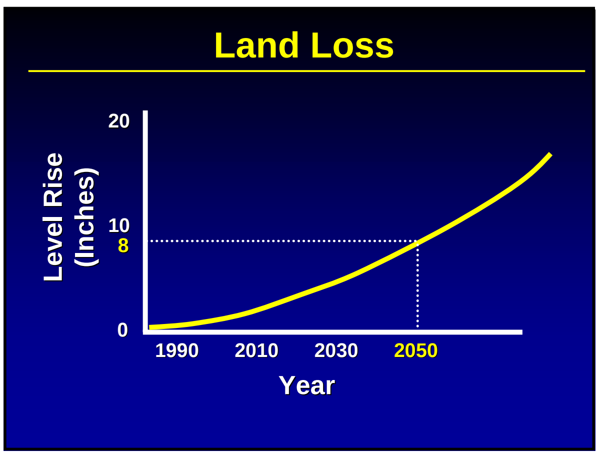
Land Loss

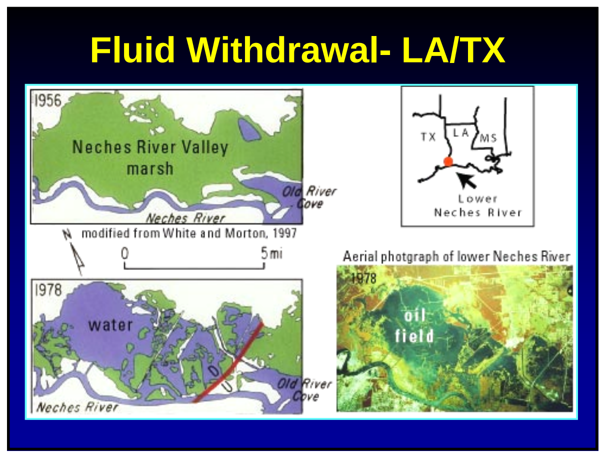
Land Loss

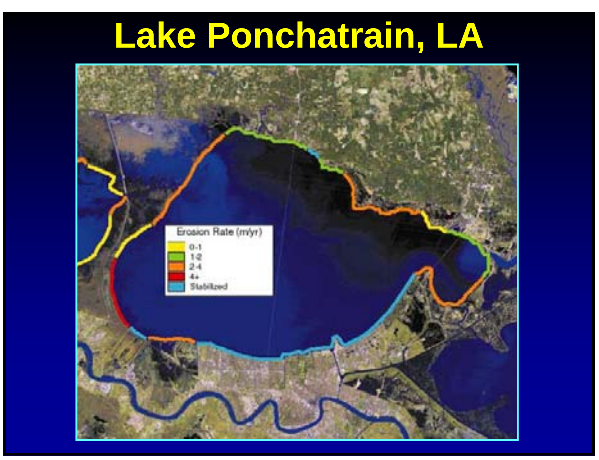


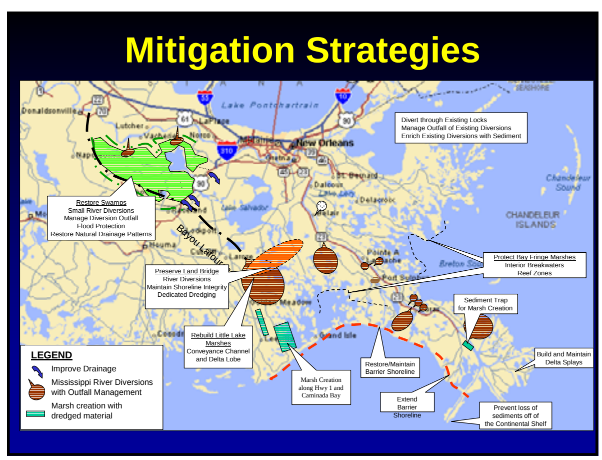

Land Loss
Subsidence (Ft/Century)
Low 0-1
Intermediate 1.1 - 2
High 2.1 - 3.5
after Gagliano, 1999


Mississippi River Delta Area
KILOMETERS
0
50


Land Loss
Level Rise
(Inches)
20
10
8
0
1990
2010
2030
2050
Year


Fluid Withdrawal- LA/TX
1956
Neches River Valley
marsh
Old River
Cove
Neches River
modified from White and Morton, 1997
N
0
5 mi
TX
LA
MS
Lower
Neches River
Aerial photograph of lower Neches River
1978
oil
field
1978
water
Old River
Cove
Neches River


Lake Ponchatrain, LA
Erosion Rate (m/yr)
0-1
1-2
2-4
4+
Stabilized


Mitigation Strategies
Lake Pontchartrain
New Orleans
Divert through Existing Locks
Manage Outfall of Existing Diversions
Enrich Existing Diversions with Sediment
Restore Swamps
Small River Diversions
Manage Diversion Outfall
Flood Protection
Restore Natural Drainage Patterns
CHANDELEUR ISLANDS
Preserve Land Bridge
River Diversions
Maintain Shoreline Integrity
Dedicated Dredging
Protect Bay Fringe Marshes
Interior Breakwaters
Reef Zones
Sediment Trap
for Marsh Creation
Rebuild Little Lake
Marshes
Conveyance Channel
and Delta Lobe
Build and Maintain
Delta Splays
Restore/Maintain
Barrier Shoreline
Marsh Creation
along Hwy 1 and
Caminada Bay
Extend
Barrier
Shoreline
Prevent loss of
sediments off of
the Continental Shelf
LEGEND
Improve Drainage
Mississippi River Diversions
with Outfall Management
Marsh creation with
dredged material

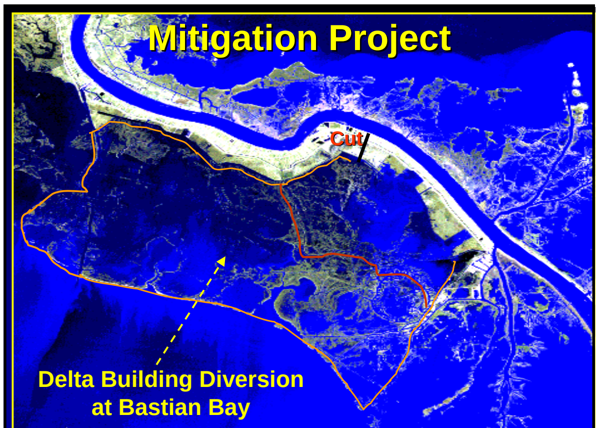
Mitigation Project

- Dredge & Fill
- Terracing
- Vegetation Plantings

Mitigation Project

- Fill material from offshore shoals
- Ebb-tidal deltas
- Mississippi River
- Coastal Structures

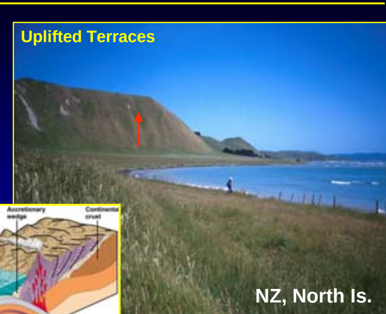
Mitigation Project

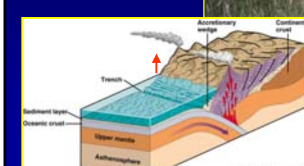


Tectonic Uplift (Local)

- Some areas along tectonically active coasts uplifted on a continual basis
- West coast of S. America & portions of New Zealand

Tectonic Uplift (Local)



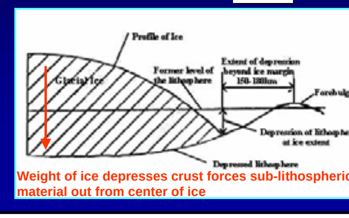


Uplift Related to Volcanic Activity

- Rise and fall of land due to buildup and release of gas in magma chamber under flanks of volcanoes (Brady seism).
- 6m rise & fall since Roman times around Naples, Italy

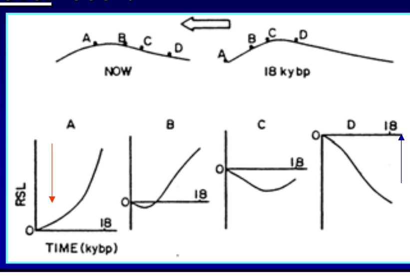
Sea Level Changes (Glacio-isostatic)

- Some areas in northern hemisphere are being uplifted (emerging) at rates of 1m/C.
- Harbors shoaling, channels are high/dry
- Land rebounding as ice removed
- Change is fast and dramatic but local

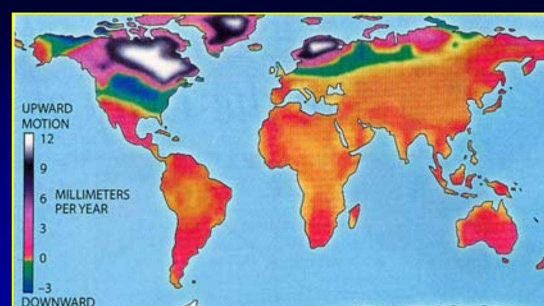


Peripheral Bulge Movement

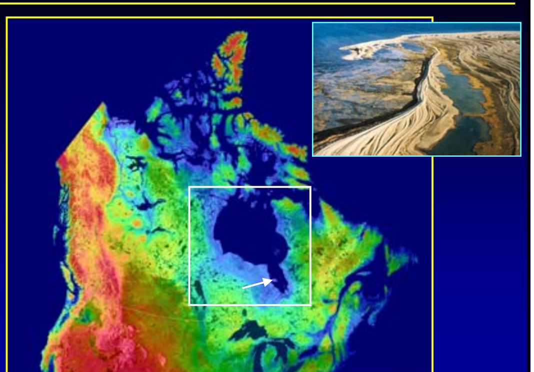
- As ice melts peripheral bulge moves as crustal material flows toward center
- Position of bulge with time determines sea level record.



Isostatic Uplift

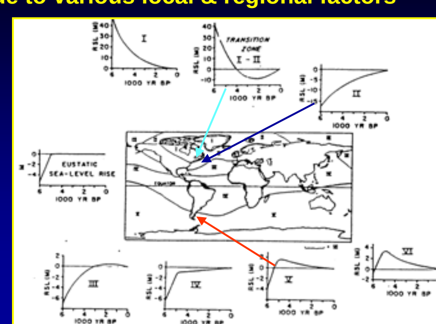


Hudson's Bay Uplift



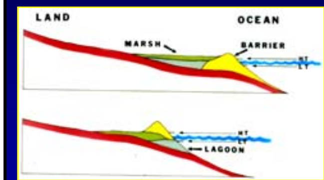
Sea Level Curves

- One SL curve will not work for all coastal areas due to various local & regional factors

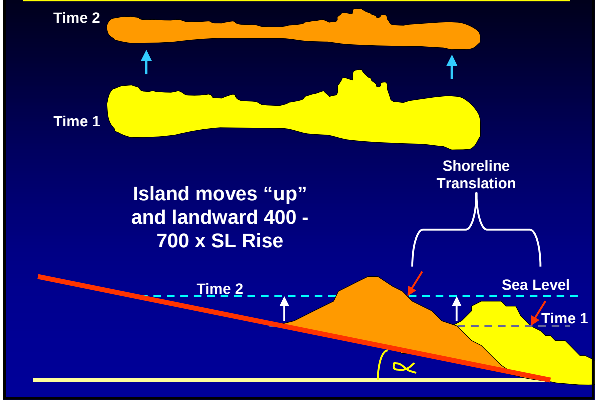


Sea Level Rise Effects on Barrier Shorelines

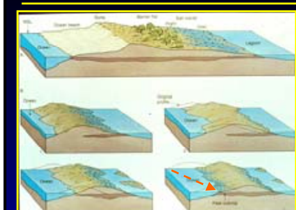
- Barriers move up and landward as SL rises – rollover of landward environments



Effects of Sea Level Rise

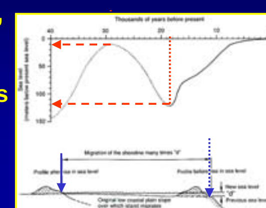


Sea Level Rise and Island Rollover



Sea Level (Climate)

- Oceans have had the same ~ volume over the past 2 B. yr but SL has fluctuated often. How ?
- Predictions .. SL will rise 2 - 5 ft by 2150
- Over the past 2 million yr SL has been 10m higher and 150m lower. Evidence for …….
- Low SL –peat, stumps, mammal bones on shelf, oysters below surface
- High stands - scarps, terraces & marine fossils

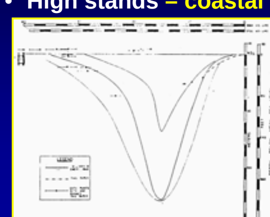


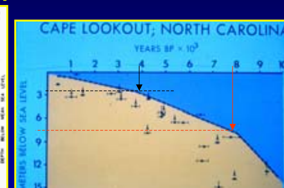
Climatic Effects on Sea Level

- Concerns related to climate. In past, effects have been slow to materialize. Climate change is expected to produce accelerated Sea Level rise
- Climate & SL linkage: climate controls volume of water in basin & T^0 (hence density)
- During cold periods avg T^0 was $5C^0$ ($9F^0$) colder – SL was 50-150m lower
- During warm periods (interglacials) was warm as today or warmer - SL ~ 5m higher

Quaternary Sea Level Changes

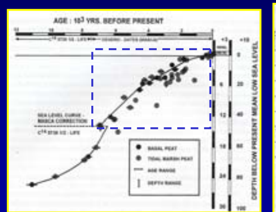
- Major oscillations due to growth and disintegration of ice sheets caused SL changes of ~140m
- Low stands – shelf exposed
- High stands – coastal plain inundated

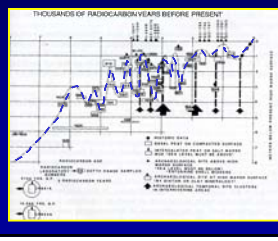




Late Pleistocene SL Changes

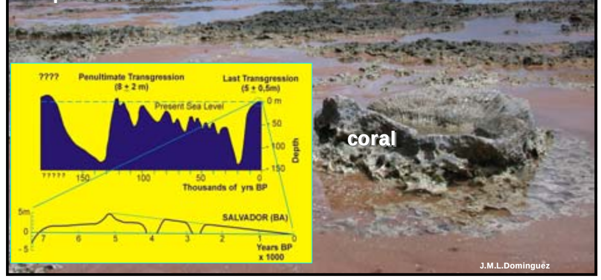
- SL rose rapidly 1m/100yr between 18 – 4ka
- Since 4ka SL rising slowly
- Since 1880 ~<u>20-30cm</u> rise related to warming of ocean surface water and subsequent expansion of water column



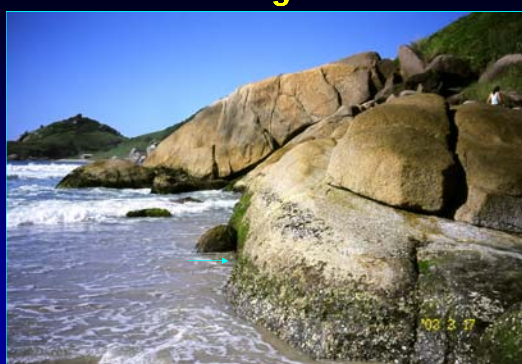


Brazil Quaternary Sea-Level History

- The high sea level of 5,600 BP was 3 to 5 m above present sea level
- The high sea level of 120,000 yrs BP – 8 m above present sea level

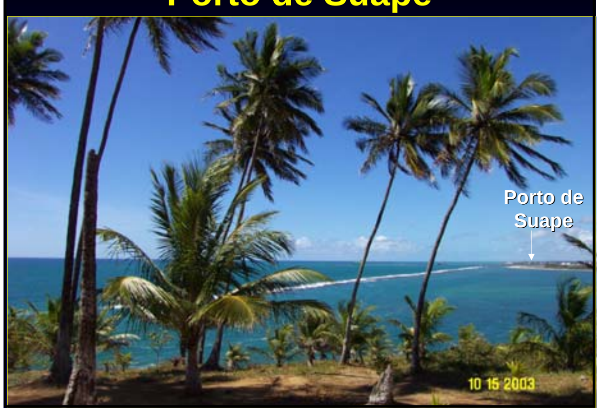


Evidence for Higher Sea Level



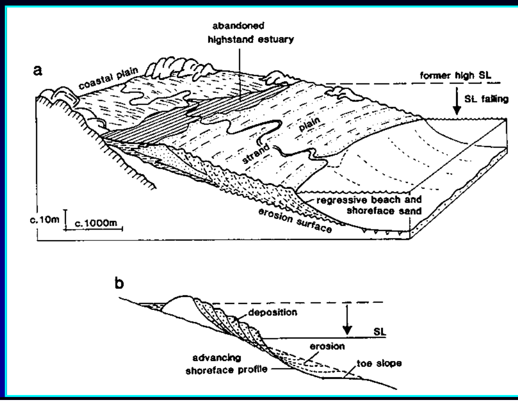
Muro Alto

Porto de Suape



Recife (Boa Viagem)

Regressive Phase (Falling Sea level)



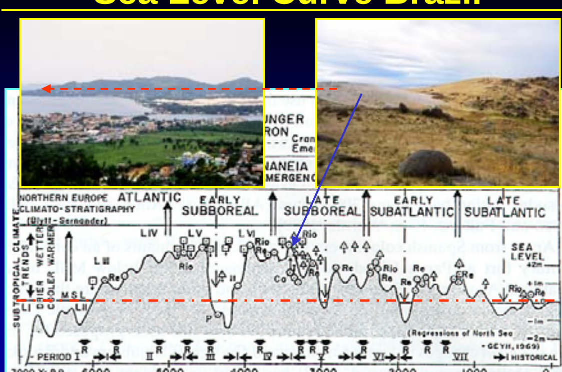
Tramandai, RS, Brazil

Praia Rincao, SC Brazil

THE SEDIMENT STARVED COAST OF NE BRAZIL PARAIBA

J.M.L.Dominguez

Sea Level Curve Brazil

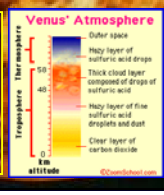


Sea Level & Atmosphere Linkage

- What controls Earth's Temperature and how are these variables related to the linkage between SL and atmosphere?
- Three factors control Earth's temperature
- Sunlight it receives (insolation)
- Sunlight it reflects (albedo)
- Amount of Infra-red radiation absorbed by atmosphere
- Earth's atmosphere unique: Contains mostly Nitrogen & Oxygen (99%), CO_2, water vapor & methane. CO_2, H_2O and CH_4 behave as greenhouse gases. Ability to trap heat.

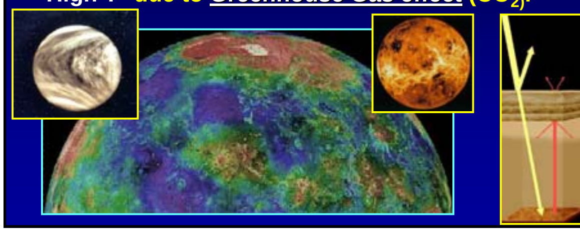
Consider Venus & Its Atmosphere

- Venus closest planet to Earth. Closer to Sun
- Atmosphere composed of 96.5% CO_2 & 3+% N_2.
- T° on Venus ~480C° (900F°)
- Atmosphere thick ~70km, 3 layers

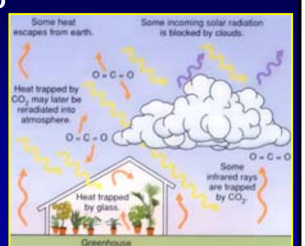
Atmosphere on Venus

- Mass of Venus' atmosphere is 90x that of earth Pressure (Avg) is 90 bars (900m below water).
- High pressure partially accounts for high T°, compressed "carbon dioxide" has increased ability to absorb thermal radiation
- High T° due to Greenhouse Gas effect (CO_2).



Greenhouse Effect

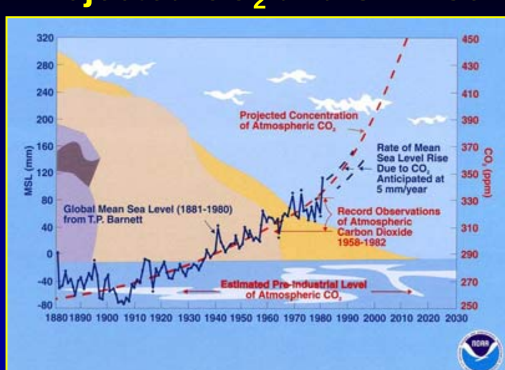
- Certain gases CO_2, H_2O & CH_4 absorb heat. Mimic effects of greenhouse.
- Incoming short-wave lengths converted to long-wavelength heat energy
- Long-wave lengths trapped by clouds (glass) temperature climbs



CO_2 in Earth's Atmosphere

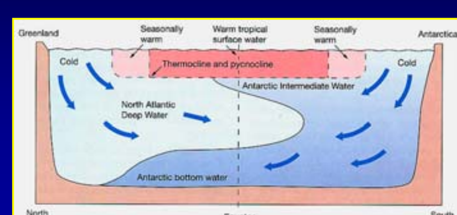
- Amount of CO_2 on earth is ~ 0.04% (~400ppm)
- Before Industrial Revolution concentration was 280 ppm, since 1958 increased from 315 ppm to ~ 400 ppm
- CO_2 pumped into atmosphere that was once stored in fuels. By 2100, 2 - 3 times increase
- If CO_2 doubles T° will rise 4.5 C° (9 F°); addition of other gases will double T°
- If 3 C° warmer, San Francisco will be as warm as San Diego. If 9 C° warmer, NY will be as warm as Daytona

Projected CO_2 and SL Rise



How Oceans Responds

- Heat trapped in atmosphere will be transferred to oceans that play a short delaying role.
- Oceans play a key role because of water's high heat capacity (ability to store heat)

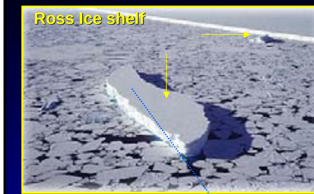


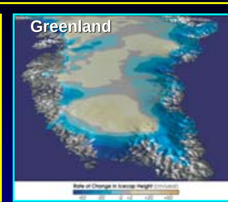
Ocean's Response

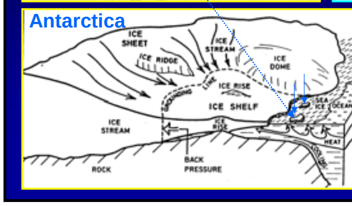
(Heat Absorption)

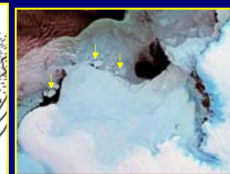
- Ocean responds in two ways 1). warming water causes thermal expansion (decrease in density & increase in volume). How much expansion depends upon how much heat absorbed (depth)
- 2nd response is melting of ice sheets/shelves (add water to ocean from land ice)

Ice Sheets and Shelves



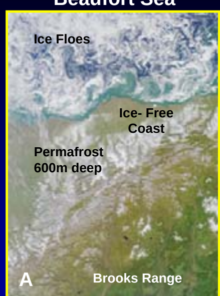




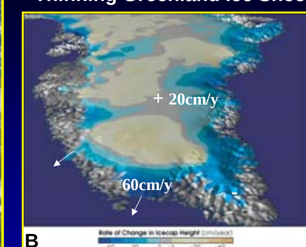


Arctic Ice

Beaufort Sea

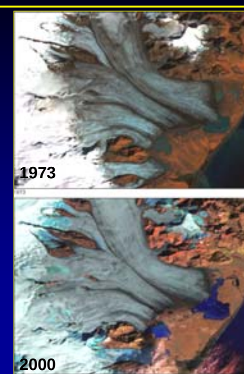


Thinning Greenland Ice Sheet

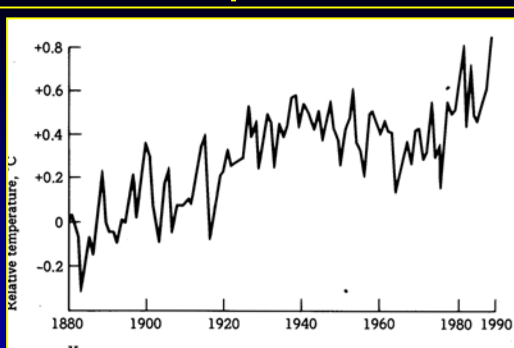


Loss = 50km³/y from melting and calving.

Glacier Retreat - Iceland



Recent Temperature Trends



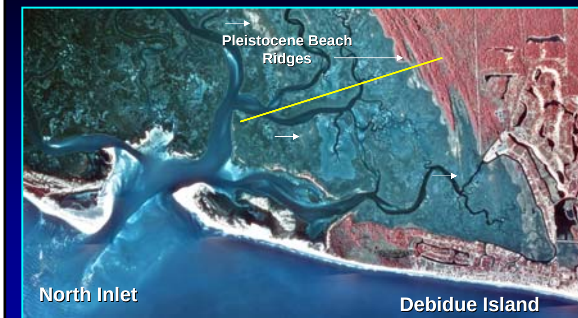
Contemporary Sea Level

- Measured by tide gauge data, not evenly distributed. Near population centers.
- Data from areas that are being uplifted or subsiding.
- SL rise rate of 1.3 - 2.0mm/y over past century
- Highly variable along US East Coast: 1.9mm/y @ Cape Fear, to 4.0mm/y along NJ.
- Most of SL rise due to thermal expansion

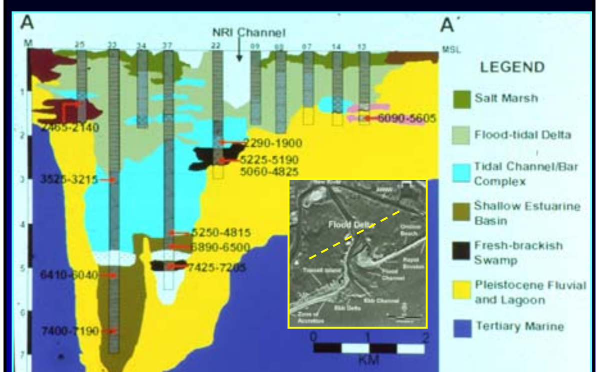
Measuring Sea Level Changes

- Easy to demonstrate that sea level has changed. Difficult to quantify
- To determine rates need a series of dates on salt marsh (peat) that mark former SL position
- Most datable features are submerged
- As SL rises marsh surface grows upward & landward over upland soils. Base of high marsh marks leading edge of transgression (MHW)
- Problems involve compaction & contamination

Marsh Islands-North Inlet, SC



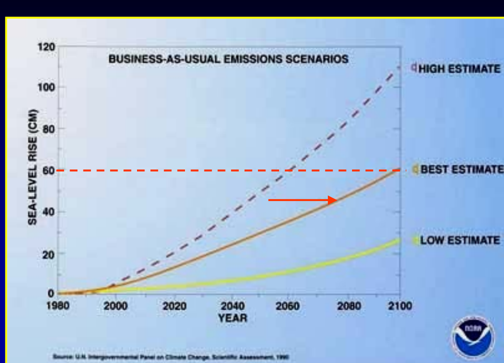
New River Estuary Fill



Predicted Sea level Rise

- NAS revised estimates indicate an increase in greenhouse gases, temperature and SL rise.
- By 2075 SL likely to rise by 30 cm (solely due to thermal expansion). Perhaps more depending upon models used.
- Impacts severe for sandy coasts and wetlands. Rise translates to more than 100 x 1') = >100ft land loss

Estimates of SL Rise

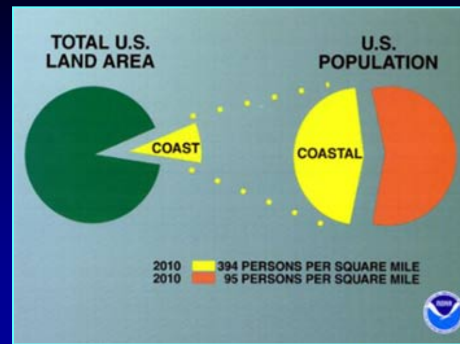


Land Loss

If all of land ice melts

Sea Level Rise Impacts

Seal Level and Population Impacts



Atolls (Maldives)

Holland