

# THERMAL EXPANSION & HEAT

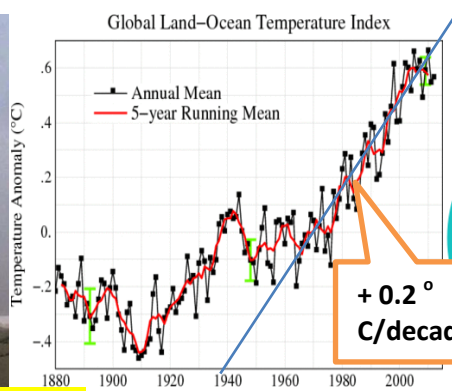
Unit 19

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[jpcise@austincc.edu](mailto:jpcise@austincc.edu) & New York Times, Jan. 18, 2016 by New York Times

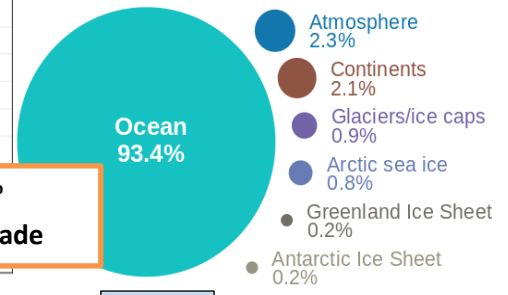
## Satellite Tracking Rising Seas Launches Successfully



Space-X's Falcon 9 rocket with the Jason-3 satellite on board. 4 minutes from launch at Vandenberg Air Force Base in California on Sunday. Credit: NASA



Where is global warming going?

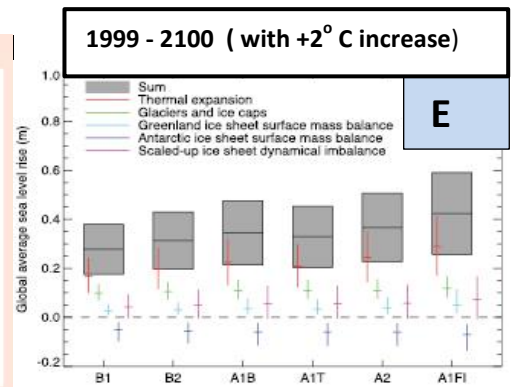
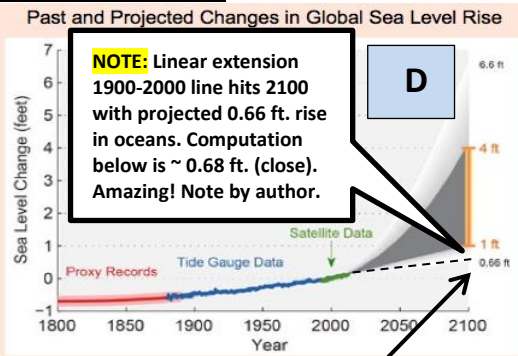
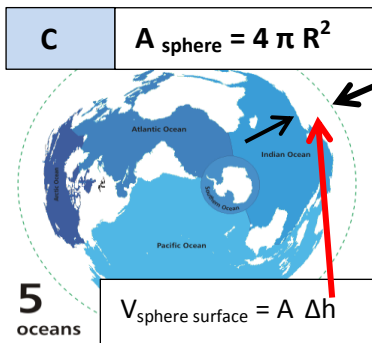


A satellite (to measure the heights of the oceans) was launched successfully on Sunday from Vandenberg Air Force Base in California.

The Jason-3 mission, led by the National Oceanic and Atmospheric Administration and Eumetsat, a European weather satellite agency, will bounce radar signals off the water to precisely measure the sea surface height within a couple of inches. The data will help scientists track rising seas as global

temperatures increase. The data will also be used to track the speed and direction of ocean currents, aiding the forecasts of hurricanes. The Space Exploration Technologies Corporation, or SpaceX, which launched the satellite on one of its Falcon 9 rockets, had aimed to recover the first-stage booster but was unable to do so. Last month, SpaceX successfully landed a Falcon 9 booster at Cape Canaveral Air Force Station in Florida. This time, one of the landing legs failed to lock, and the booster tipped over as it attempted to set down on a platform in the Pacific

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**INTRODUCTION:** Data & Charts from NASA & Wikipedia & IPCC (intergov. Panel on Climate Change). Most earth temperature rise (~ 0.2 C/decade see Chart A) ends up as heat in oceans (see chart B). This is due to water having a much higher specific heat than air. Top 500 meter (1640 feet) of oceans is affected by air temperature changes. The purpose of this application is to find the approximate ocean rise ( $\Delta h$ ) due to a potential temperature rise of 2 °C. Water Coefficient of volumetric expansion ( $\beta$ ) at 20° C is 0.000207/°C.

**HINTS:**  $\Delta V = \beta V \Delta t$  ( eq. 1 ), in our case  $V$  = volume of upper 1640 ft. of earth oceans. Oceans cover 71 % of earth surface ( $R_{earth} = 3959$  miles).  $\Delta V$  due to expansion of water =  $A \Delta h$ ,  $V = A \times 1640$  ft., thus eq. 1 becomes  $A \Delta h = \beta A (1640) \Delta t$ ,  $\Delta h = \beta 1640$  ft.  $\Delta t$ . We assume until 2100 uniform  $\Delta t/\text{decade} = 0.2^\circ\text{C}/\text{decade}$ .

**QUESTIONS:** (a) Find approximate rise in oceans if temperature rose 2° C? (b) Compare to IPCC chart E) ? We assume NO exponential rise in temperature. which could happen as in chart D ? possibly?

**ANSWERS:** (a) ~ 0.68 ft. (~ 0.2 m), (b) Chart E(IPCC) most  $\Delta h$  is due to thermal expansion (red line ~ 0.2 m).