

Global warming – how is Marine exposed?

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Copenhagen – September 2007



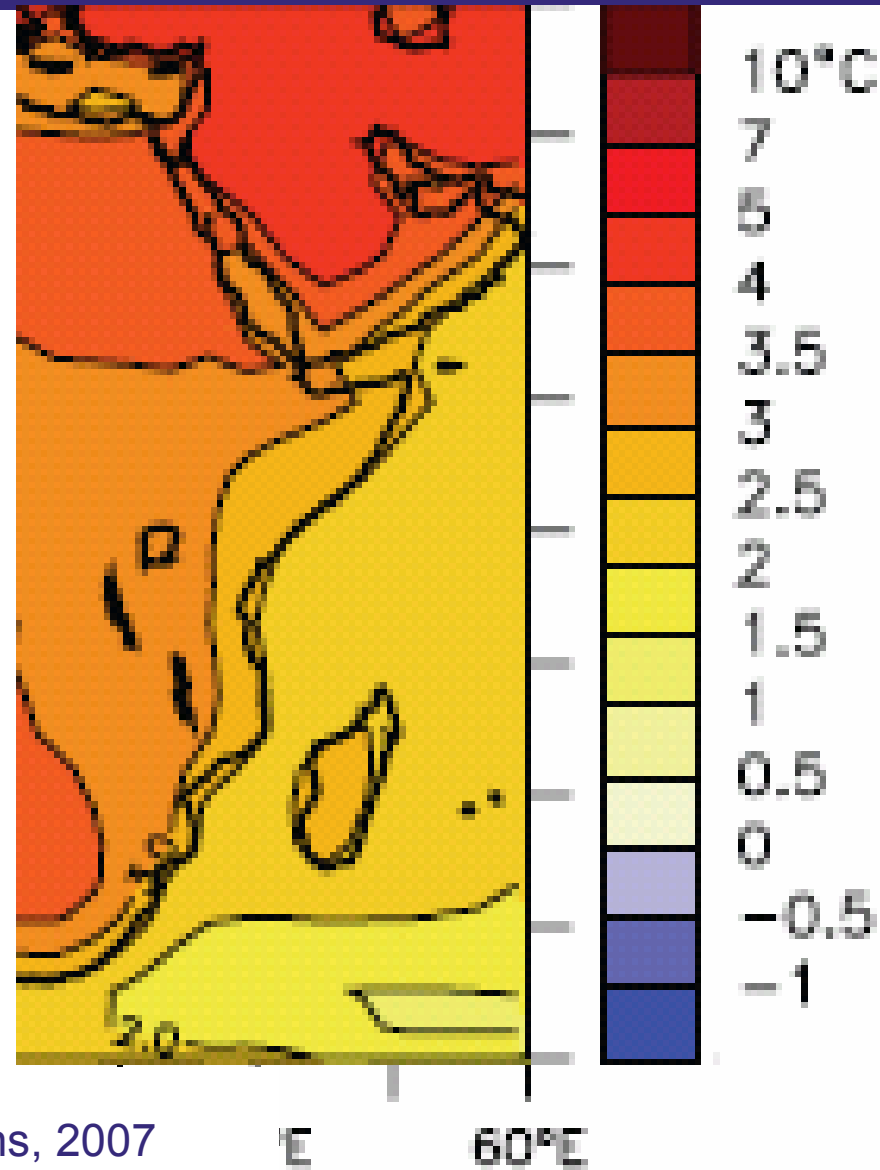
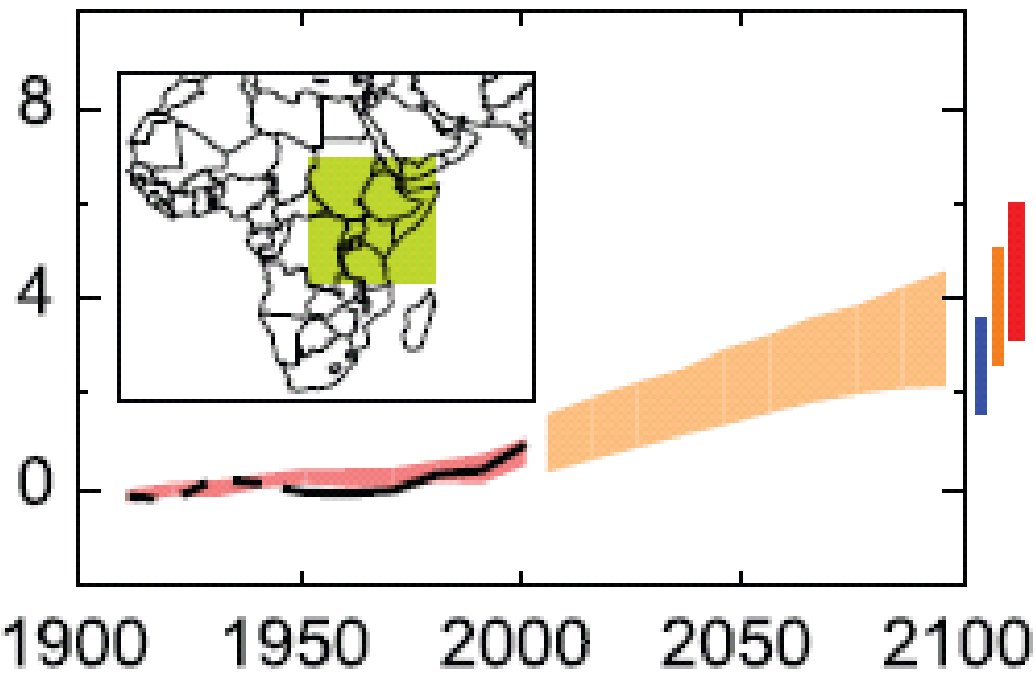


- Global warming is real
 - I believe in it and so should you
- Focus on three issues
 - Temperature changes and live cargo
 - Sea level rise
 - Rogue waves
- Further thoughts



Middle East – East Africa JJA temp change

- Change 2080-2099 from 1980-1999
- Marked regional gradient
- 1906-1950 reality vs simulation

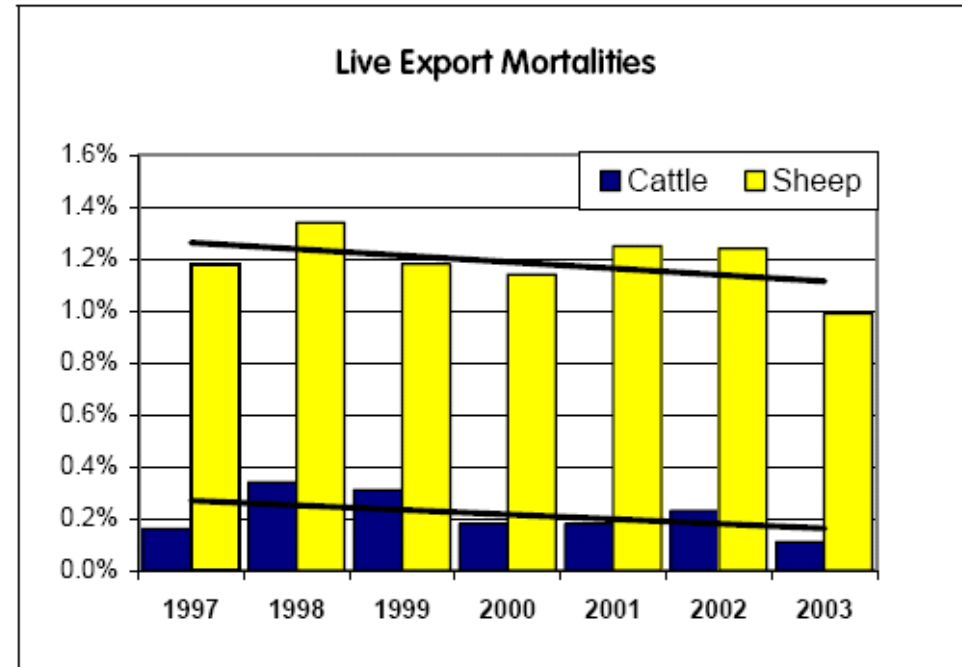


IPCC Regions, 2007



Live cargo and heat stress

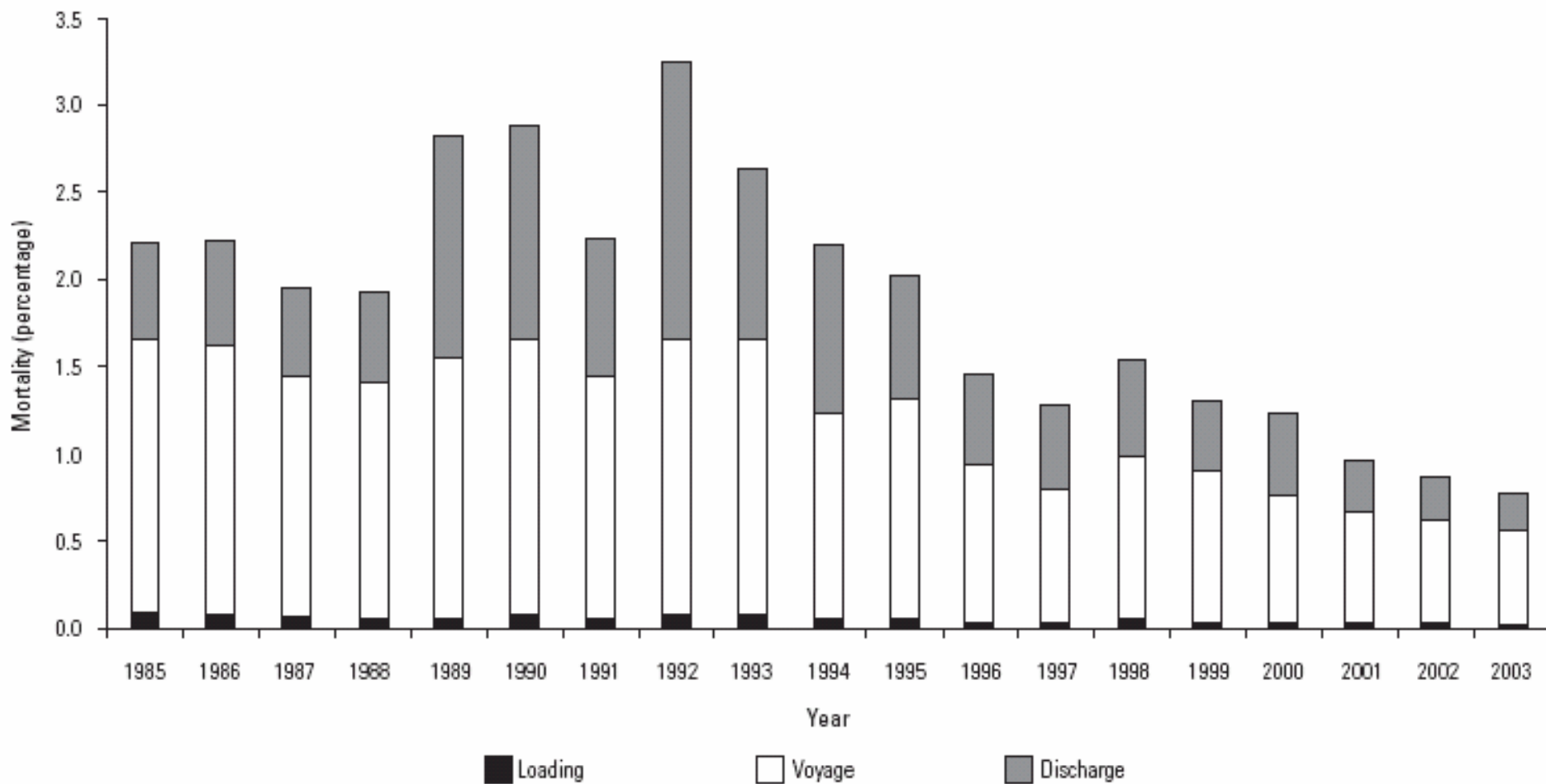
- South and West Australia to Middle East
 - Largest live sheep trade
 - 16+ day journey
 - Journey length a big factor
- Deaths <<2%
 - Heat stress a (minor?) factor
- Significant public opposition to live export trade



(Livecorp, 2004)



Annual sheep mortality – Oz to ME

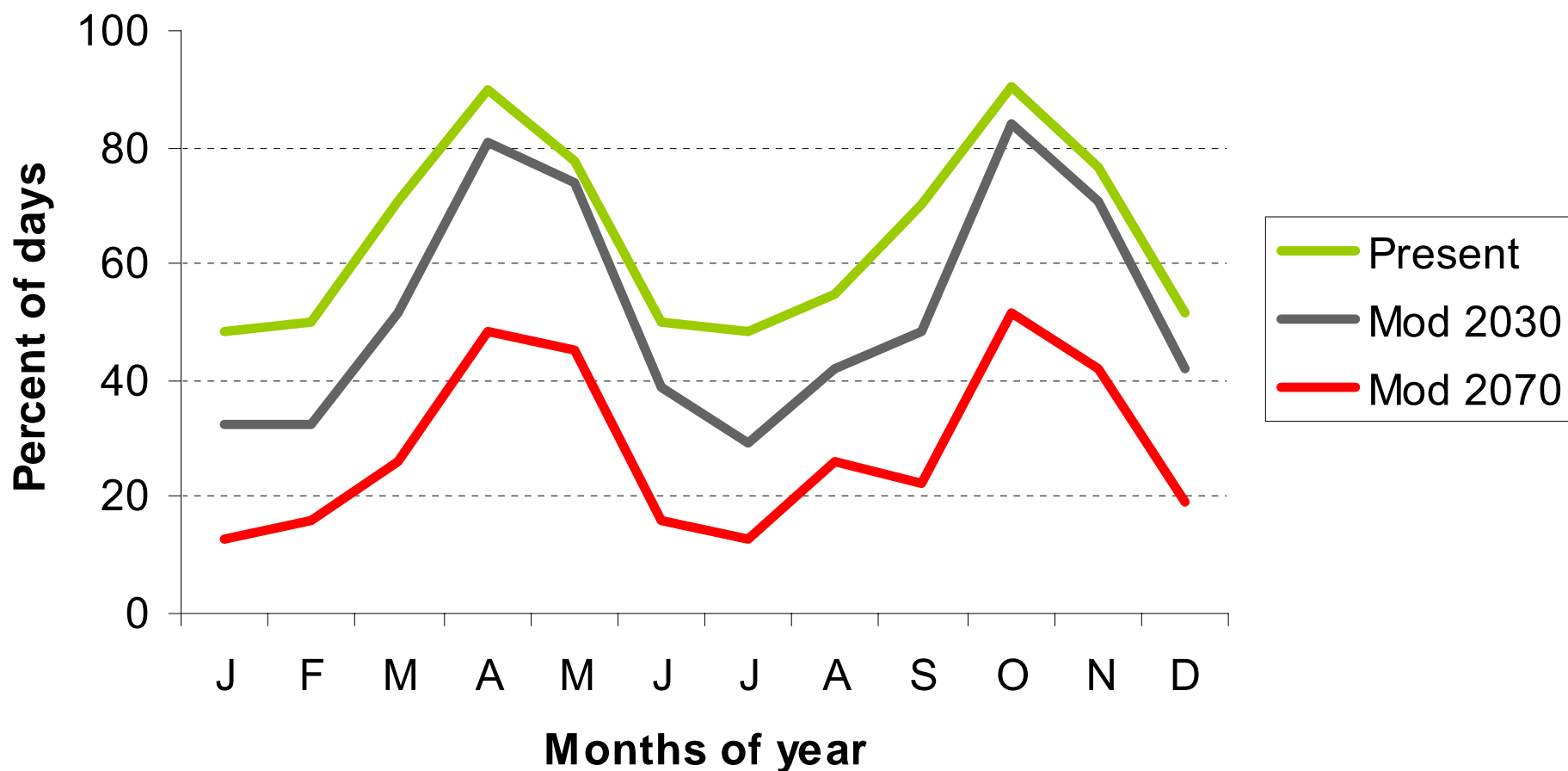


(Norris, 2005)



Percent days with HSI <32 at both ports

A possibly apocryphal version!





Heat Stress - the future

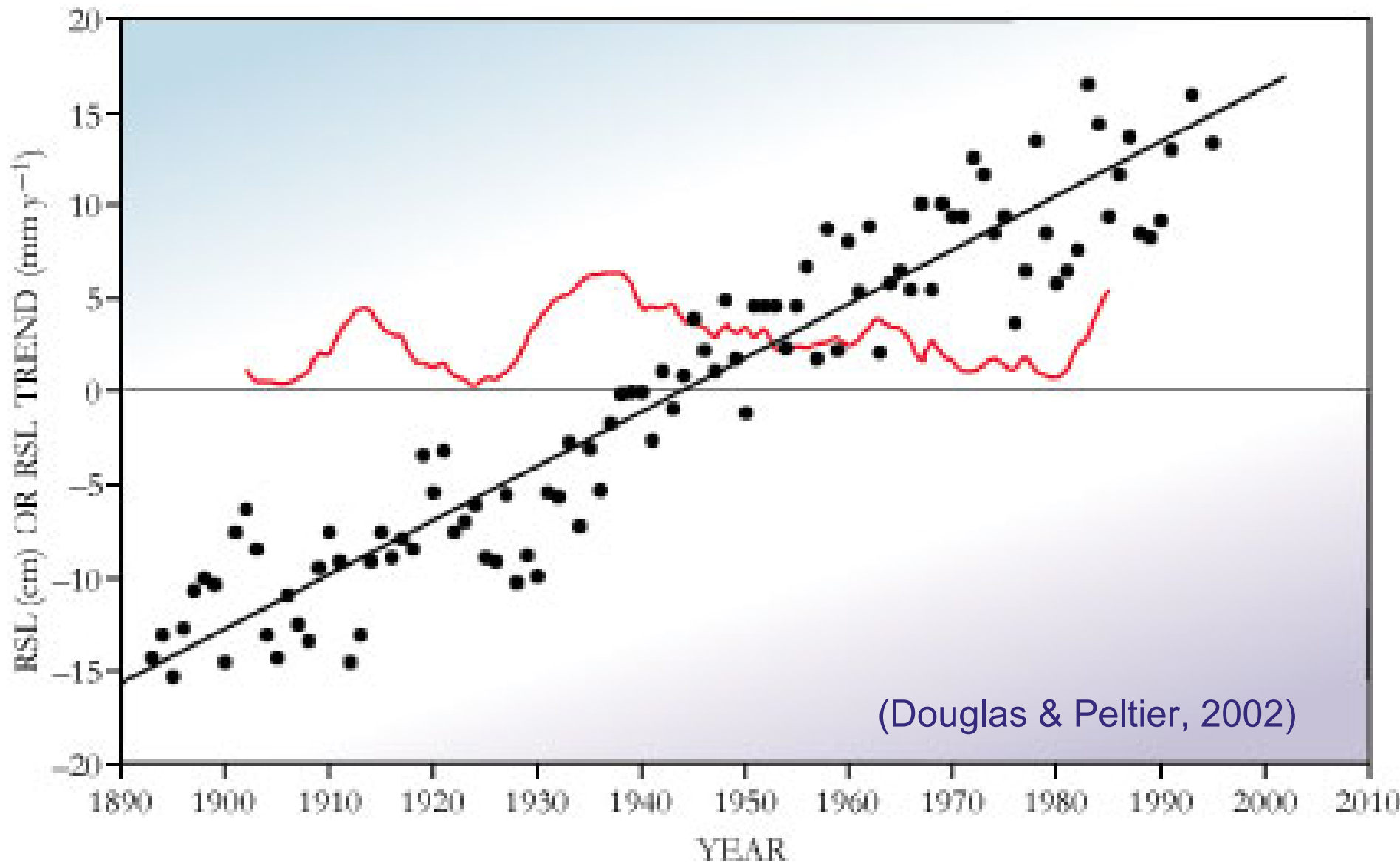


- Loading and unloading delays important
 - Unloading regulations and priorities
 - Quarantine facilities
 - Inspections – fitness for travel
 - Vet on board
 - Stock density
 - Pen arrangements
 - Accredited exporters only
 - Code of practice
 - Careful handling on discharge
- More of the above
- Fleet modernisation
- A manageable problem?



- No long term average change in GMSL 1st century A.D. to 1800 A.D.
- 20th century rise about 160 mm (about 1.6 mm/y)
- Post 1993 rise about 3 mm/y (altimeter + tide gauge data)
- Current acceleration implies rise of 280-340mm by 2100 A.D.
 - Consistent with mid range IPCC estimates
- Contributions
 - Thermal expansion ~ 57% (Ocean temp rise 0.6°C)
 - Alpine glaciers ~ 27%
 - Greenland ice sheet ~ 8%
 - Antarctic ice sheet ~ 8%

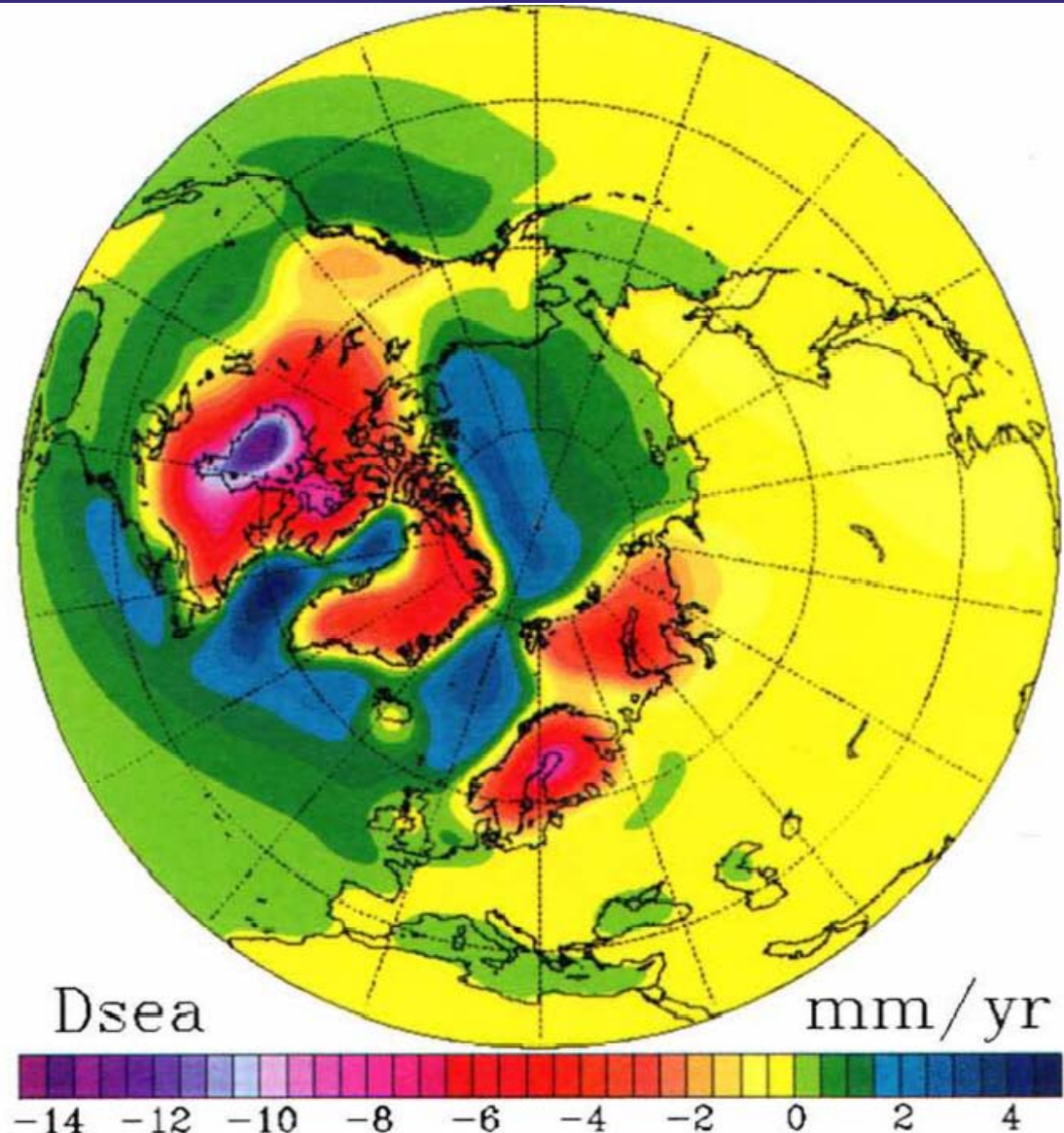
New York City relative sea level rise, 1890-2000





Absolute Sea level change not that easy to measure

- Glacio/hydro-isostasy, neotectonics
- Barometric pressure, wind, ocean currents, ocean temperature
- Alpine glaciers, Greenland and West Antarctic

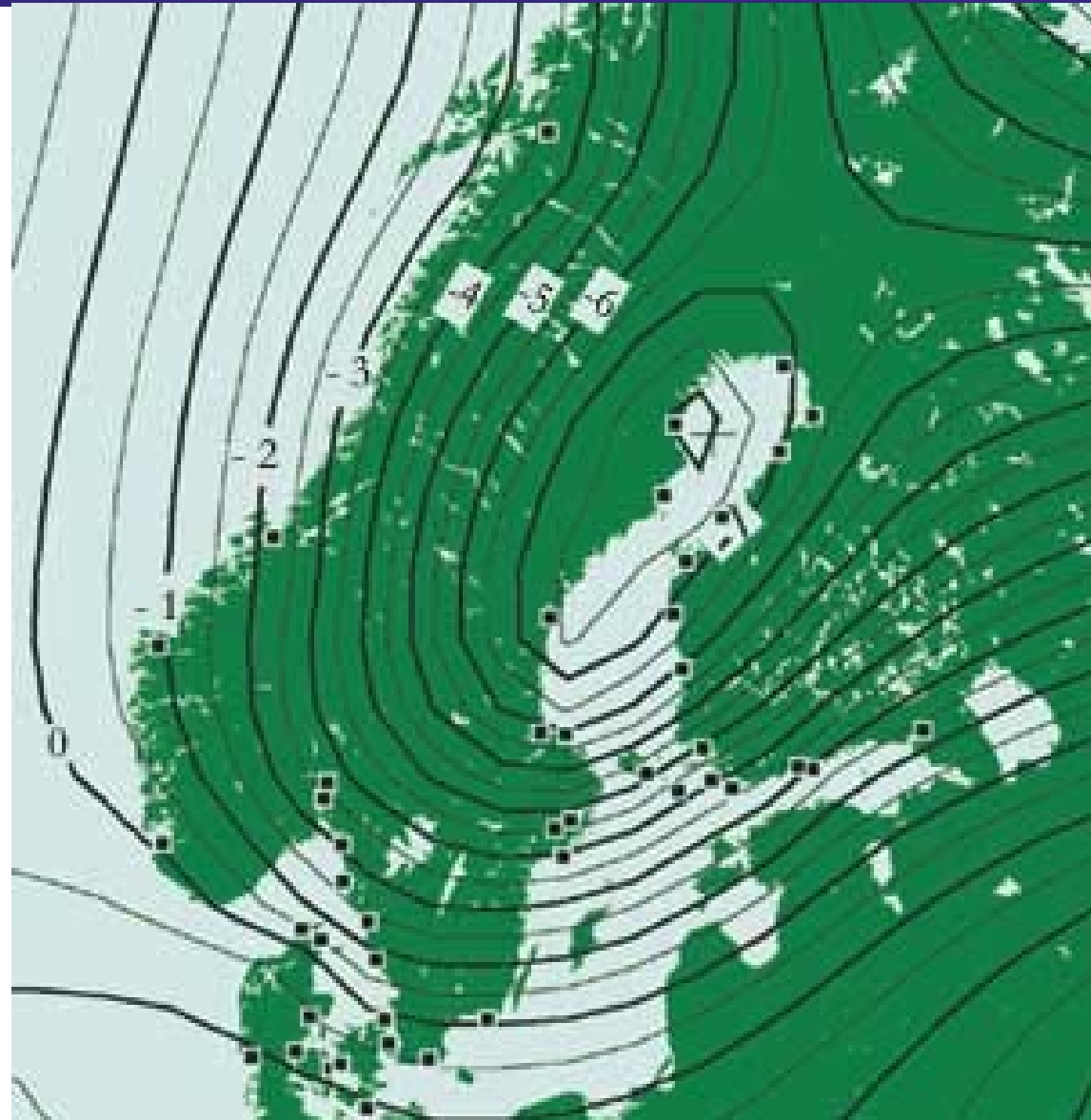


(Peltier, 2002)



Fennoscandia relative sea level change, 20th century

- Uplift/subsidence rates can be much greater than rate of sea level rise



(Douglas & Peltier, 2002)



Long Beach, California, subsidence

8.8 m subsidence

~0.5 m rebound

Shanghai ?

Bangkok ?

Venice ?

Jakarta ?

London ?





- Sea level change is a local/regional problem !
- Mitigation possible
- E.g. London/Thames Barrier
 - Expensive
 - Declining effectiveness
- Exposure growth more important than sea level change?

BUT Greenland ice sheet melting



40-300% increase in outlet glacier velocities 1995-2005

Ice quakes: ~ 1995: 6-15/y; 50km³/y; ~2005: 23-32/y; 150km³/y

Greenland melting contributes <0.5 mm/y to sea level rise in IPCC

West Antarctic Ice Sheet contributes less

Some believe IPCC estimates of sea level change too low?



Rogue Wave, Port Alberni, B.C

BENFIELD

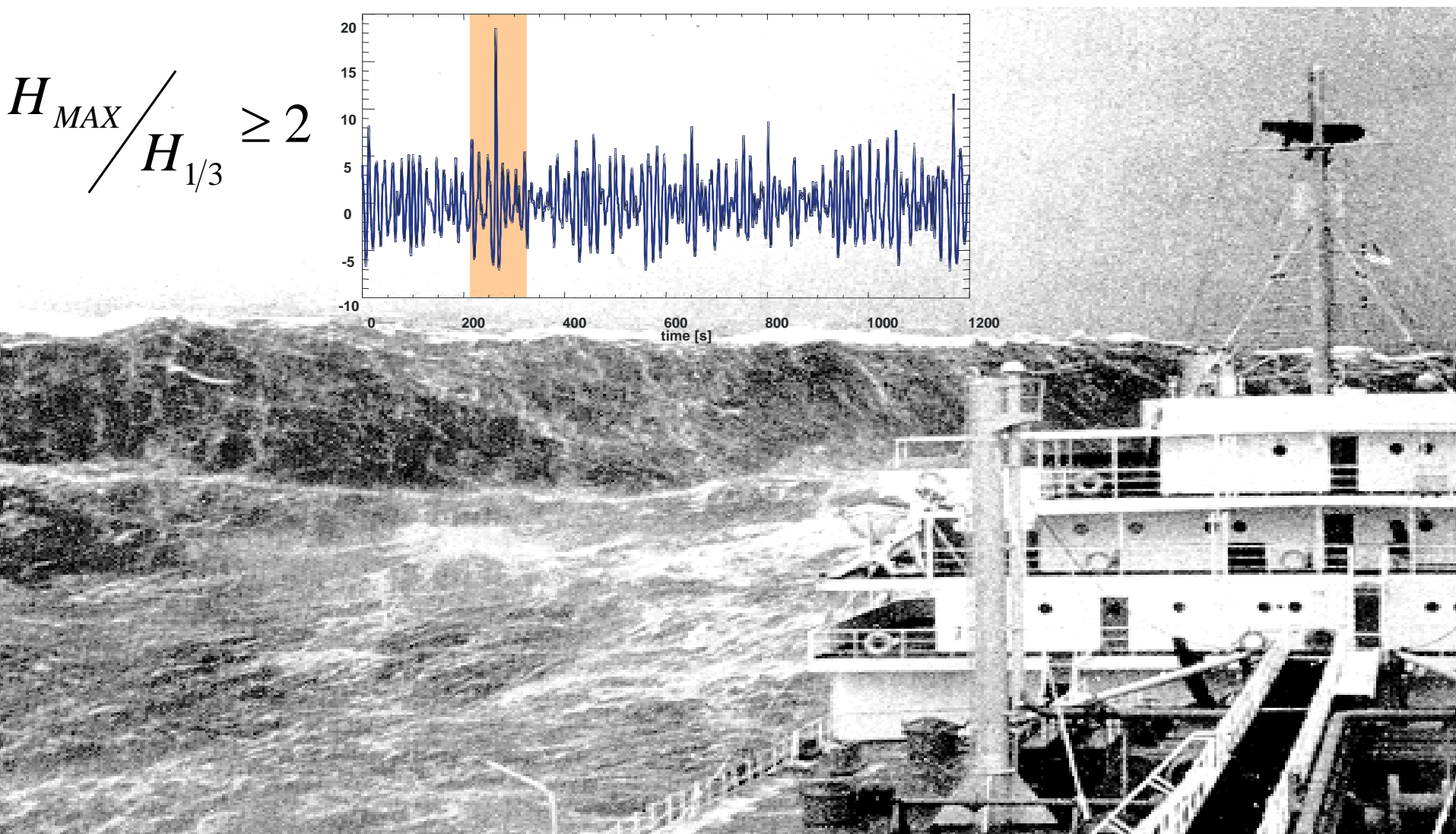
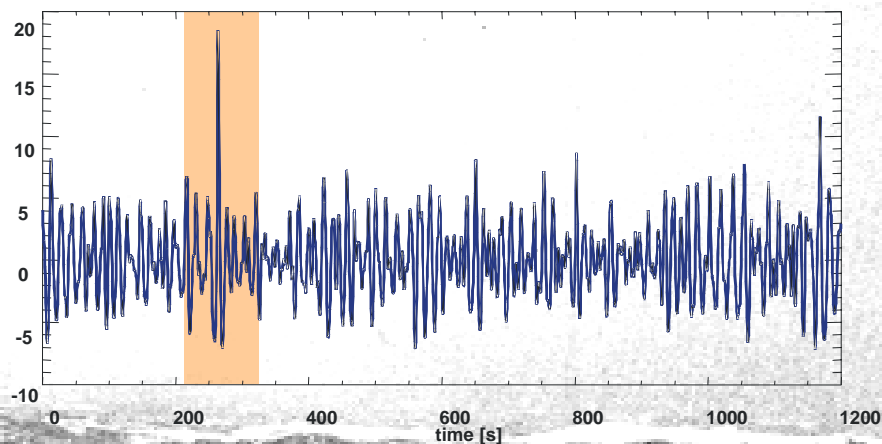



(Peregrine, 1964)



Rogue/Freak waves

$$\frac{H_{MAX}}{H_{1/3}} \geq 2$$



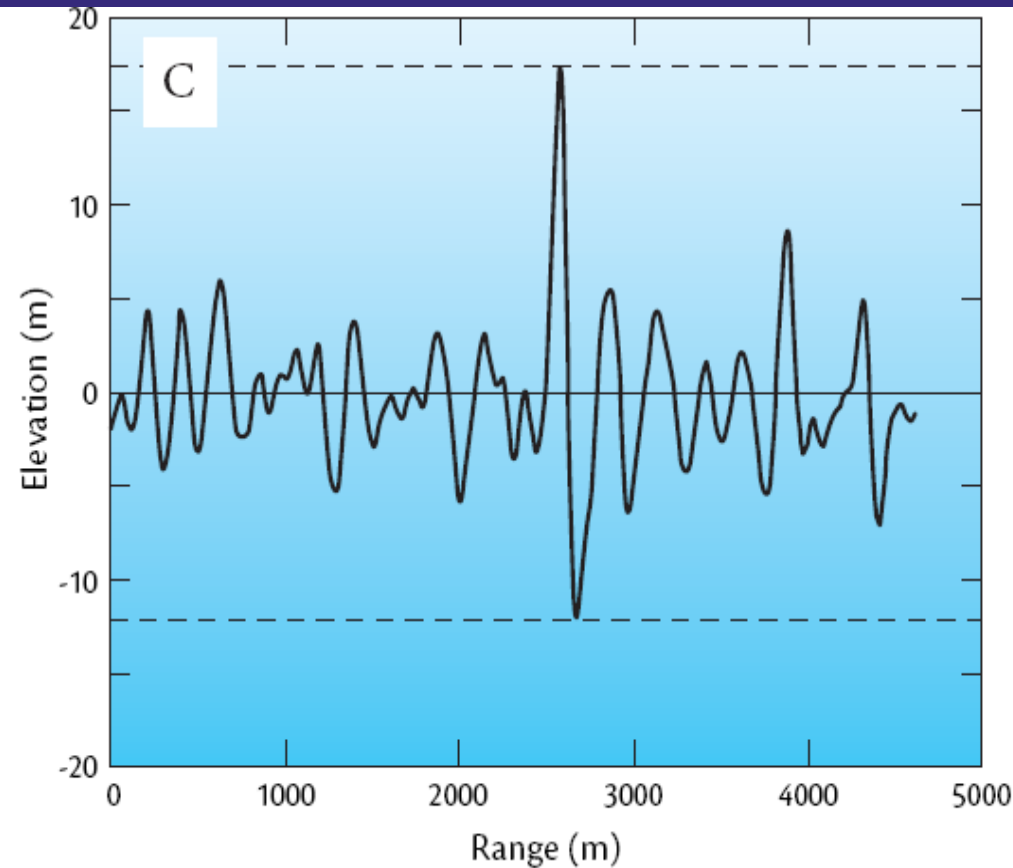
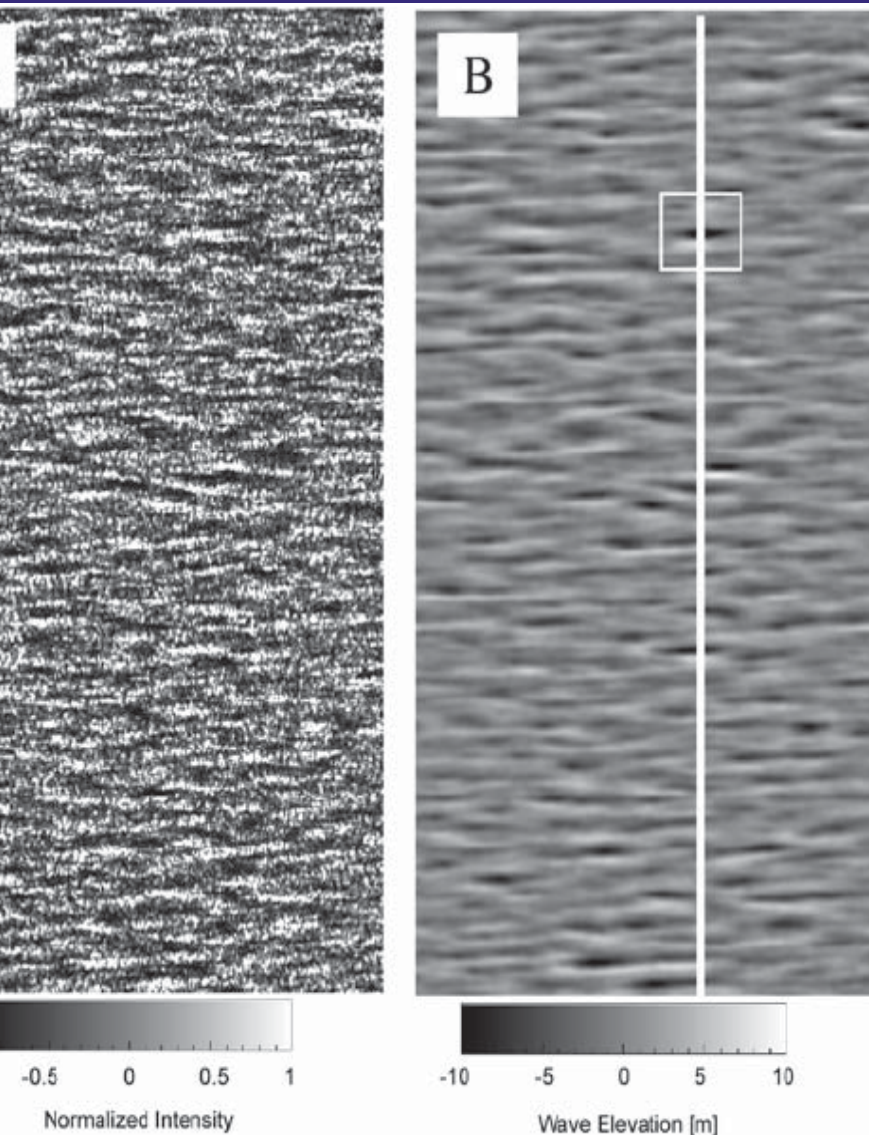


Figure 6. (A) Normalized SAR intensity in a 5 km X 10 km area at 48.45°S, 10.33° E, obtained by ERS-2 on August 27, 1996 at 2244 UTC. (B) Retrieved sea surface elevation, (C) transect along the white line inside the box in B. Figure courtesy of Susanne Lehner, University of Miami.



Causes of rogue waves

- Constructive interference
 - Different wave trains, speeds and directions
 - Heights of crests are additive
 - Draupner wave an example
 - Usually short-lived
- Focusing of wave energy
 - Storm-forced waves in current counter to wave direction
 - Shortens wave frequency, superimposition of wave trains
 - Sometimes seen in Gulf Stream and Agulhas Current
 - Tend to be longer-lived
- Normal part of wave spectrum
 - Random – possibly the only cause?
 - Individual waves higher than significant wave height
- ??Other causes
 - Hurricane winds?



- Relative importance of causes not known
- Importance of rogue waves in loss of ships unknown
- Rogue waves 10x more common than previously thought
 - Satellite altimeter surveys
 - 3000 images 10x5 km analysed
- Forecasts
 - Limited – some areas, some sea conditions
 - Agulhas current warnings

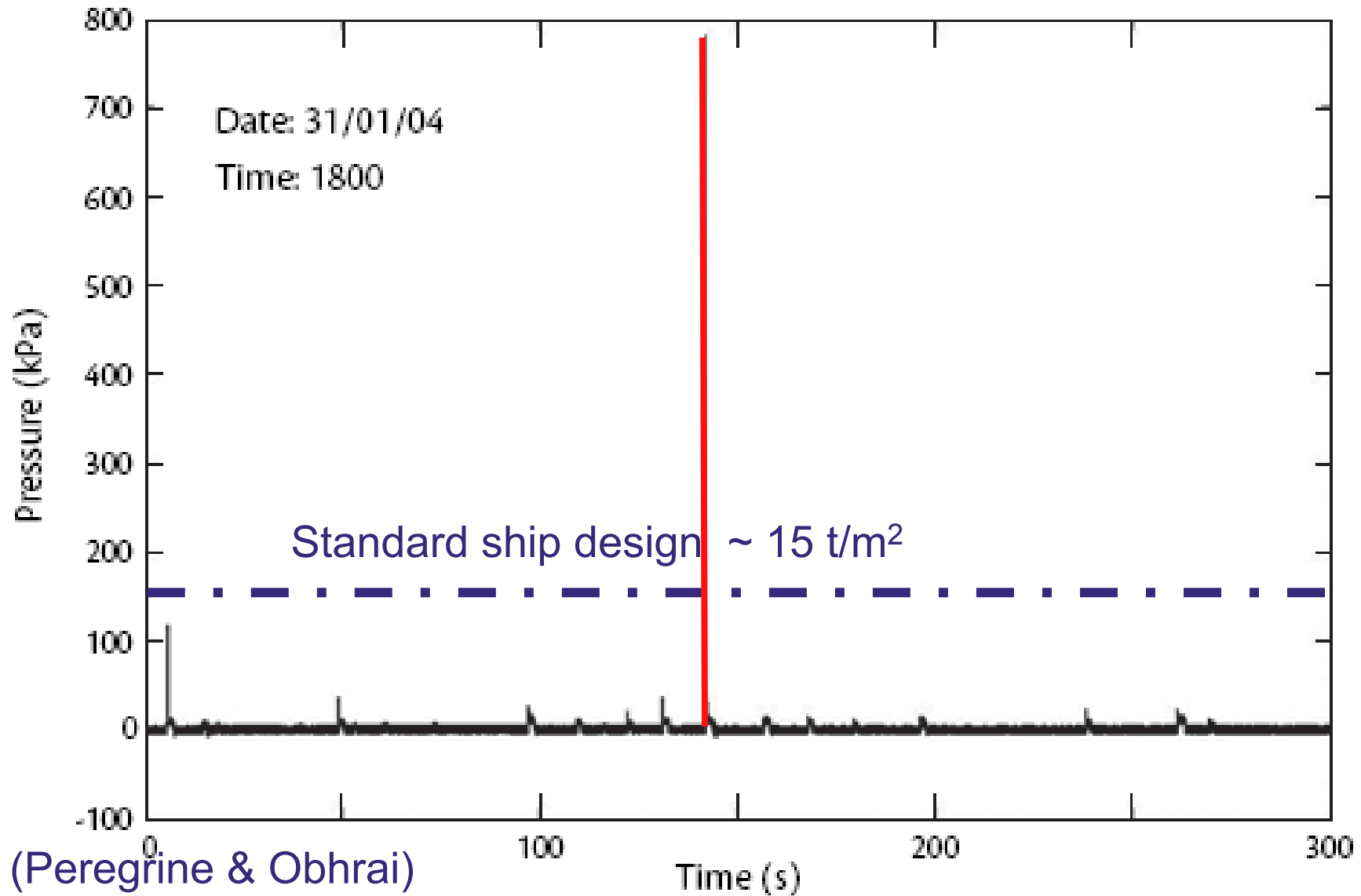


Wilstar, Agulhas current, 1974





Channel Islands breakwater, 2004





Rogue waves and Climate Change



- Causes not without argument
 - Wind may be a component
- Possible increased wind speeds under global warming
- Possible increase in rogue waves
- Satisfactory improvements in ship design not realistic
- Improved forecasting in 10 years?
- Rapidly evolving science



Conclusions

- Climate change real, large uncertainties
- Changes in temperature, sea level, rouge waves gradual
- Gradual evolution in design of ships, ports, policies
 - Design for future change
- Promote sustainability not status quo
- Changes in exposure more critical than changes in climatic extremes - maybe?
- BUT ...



Issues for a pear-shaped climatic future

- Greenland enhanced melting threshold
- Lake Vostok jökulhlaup – 5,000 km³
- Gulf Stream thermohaline circulation slows → European cold period
- Global dimming
 - Aircraft
 - Pollution and forest burning (Asia in particular)
- Amazon forest rainfall reduction and semi-permanent El Niño
- Massive release of gas hydrates from subsea permafrost
- Big volcanic eruption – explosive or effusive
- Repeat of 1859 solar flare