Overview of the Findings of Climate Change on the Marine and Coastal Environment

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IPCC Fourth Assessment Report

- 450+ Authors (Coordinating & Lead)
- 800+ Contributing Authors
- 4 Review Cycles
- 2,500 Expert Reviewers
- ~50,000 Review Comments
- Five year process 2003 –2007
- WG1, WG2 and WG3 reports approved in Paris, Brussels and Bangkok in Feb, April and May 2007 respectively

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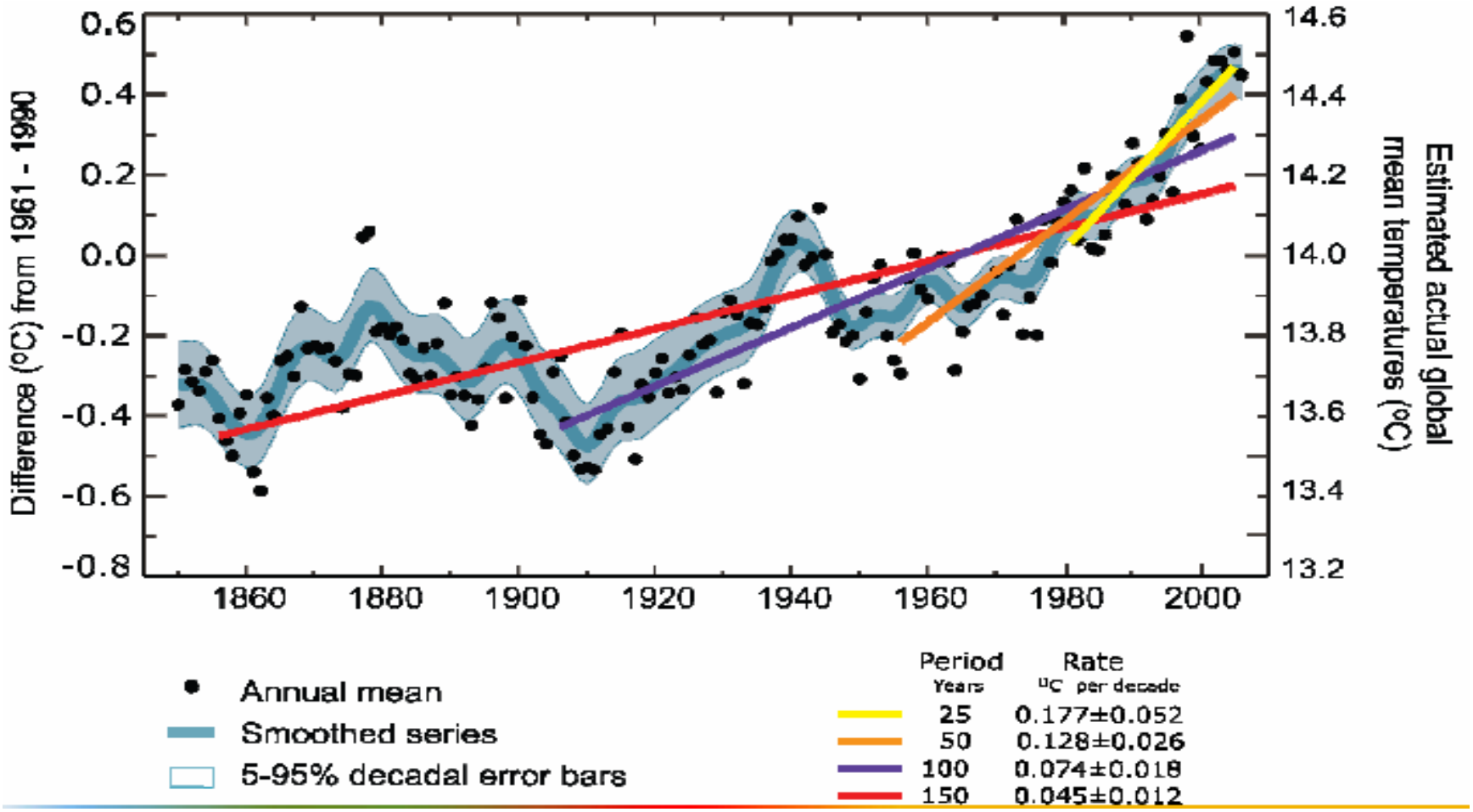
Global average temperature



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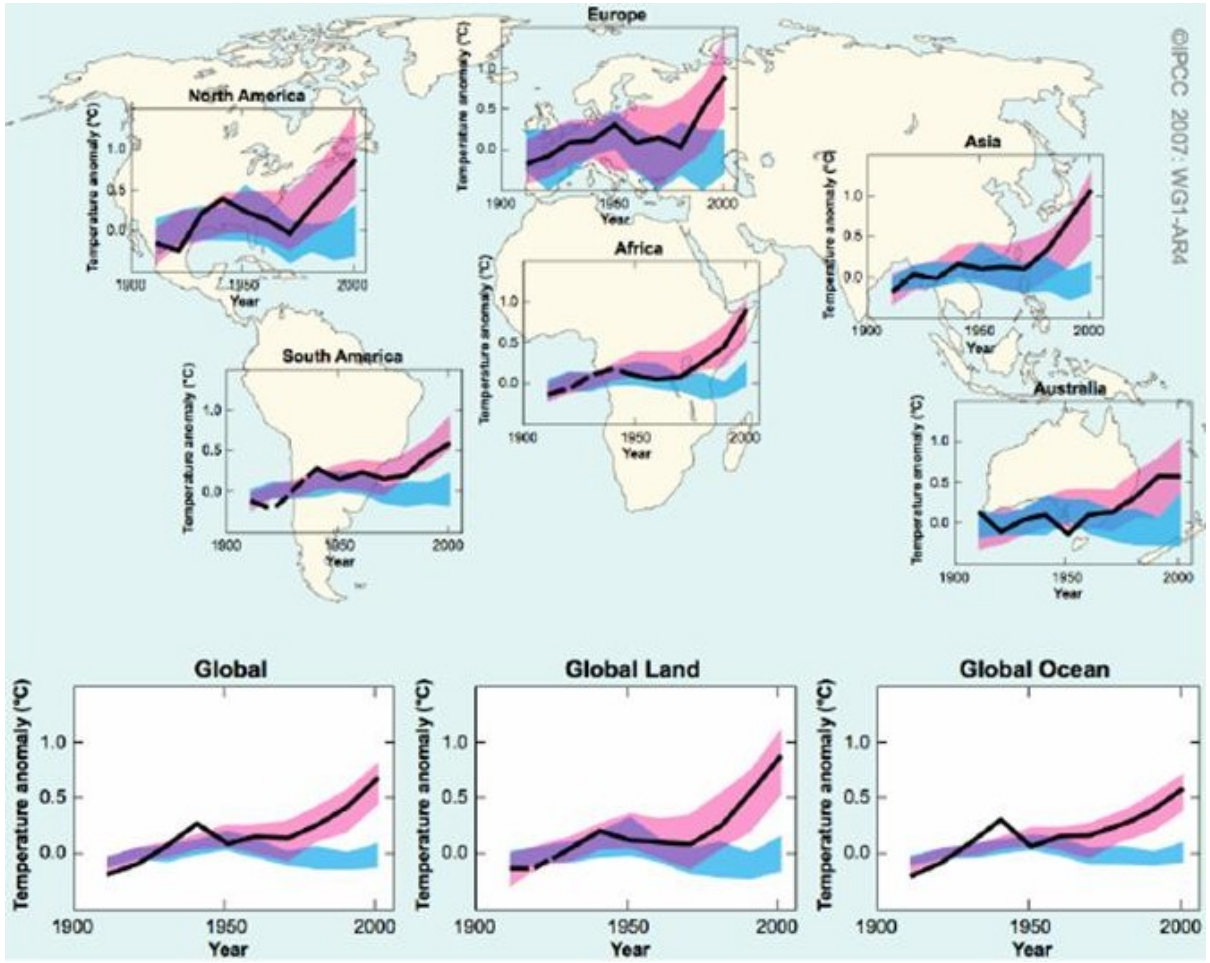
Global and continental temperature change



Significant anthropogenic warming over the past 50 years averaged over each continent except Antarctica.

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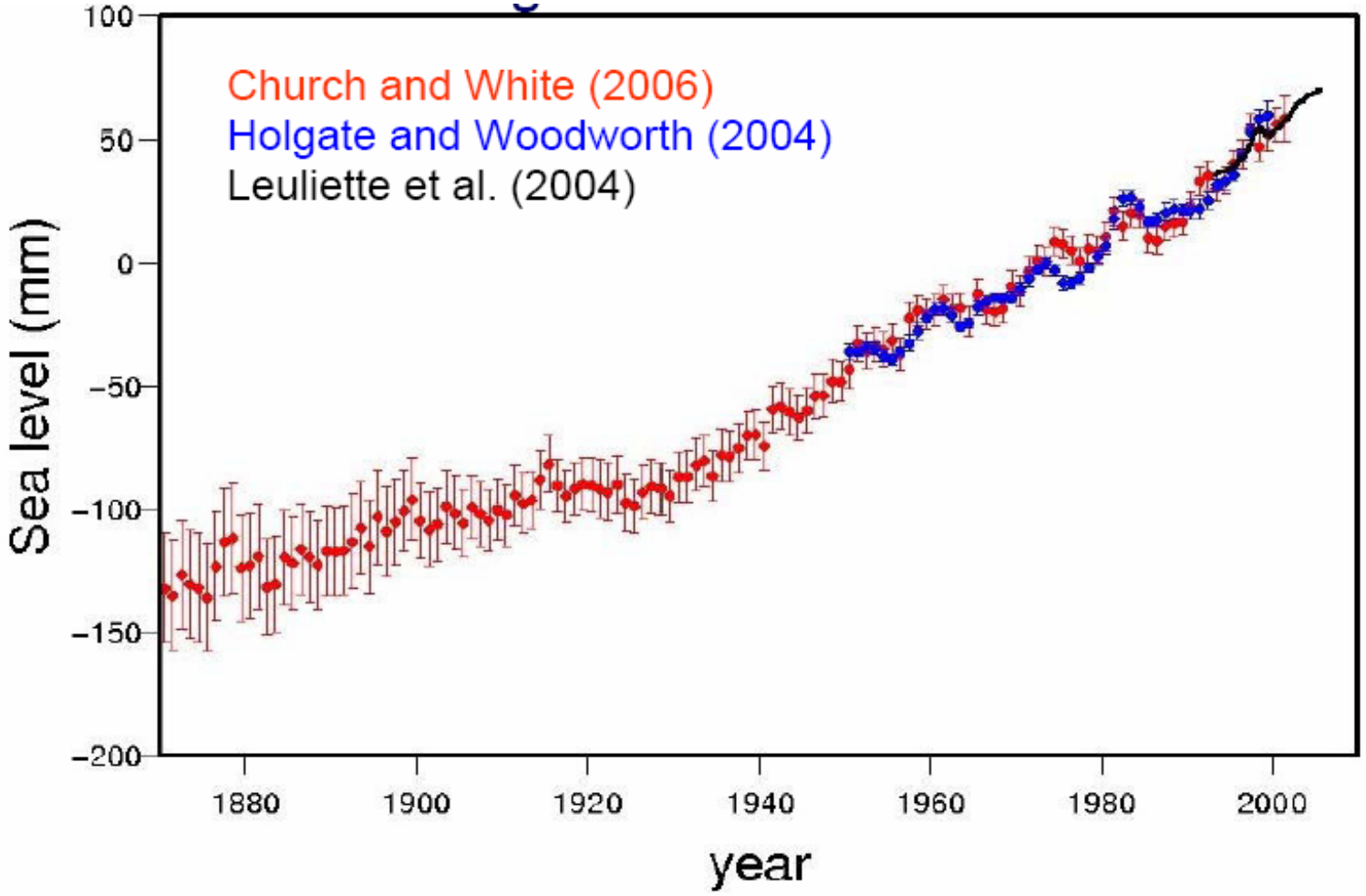
Observed sea-level rise



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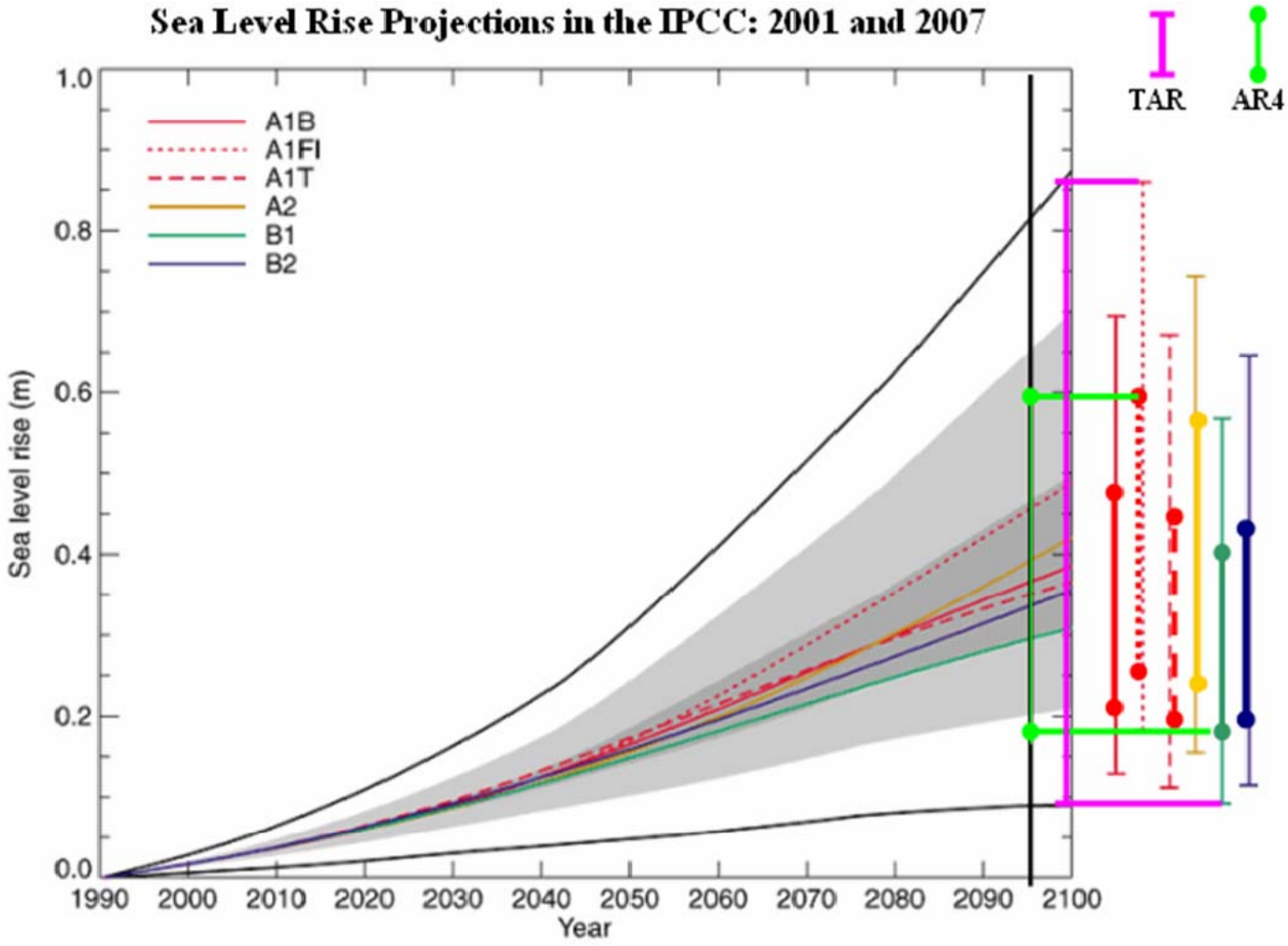
Projected sea-level rise



TAR 9-88 cm

AR4 18-59 cm

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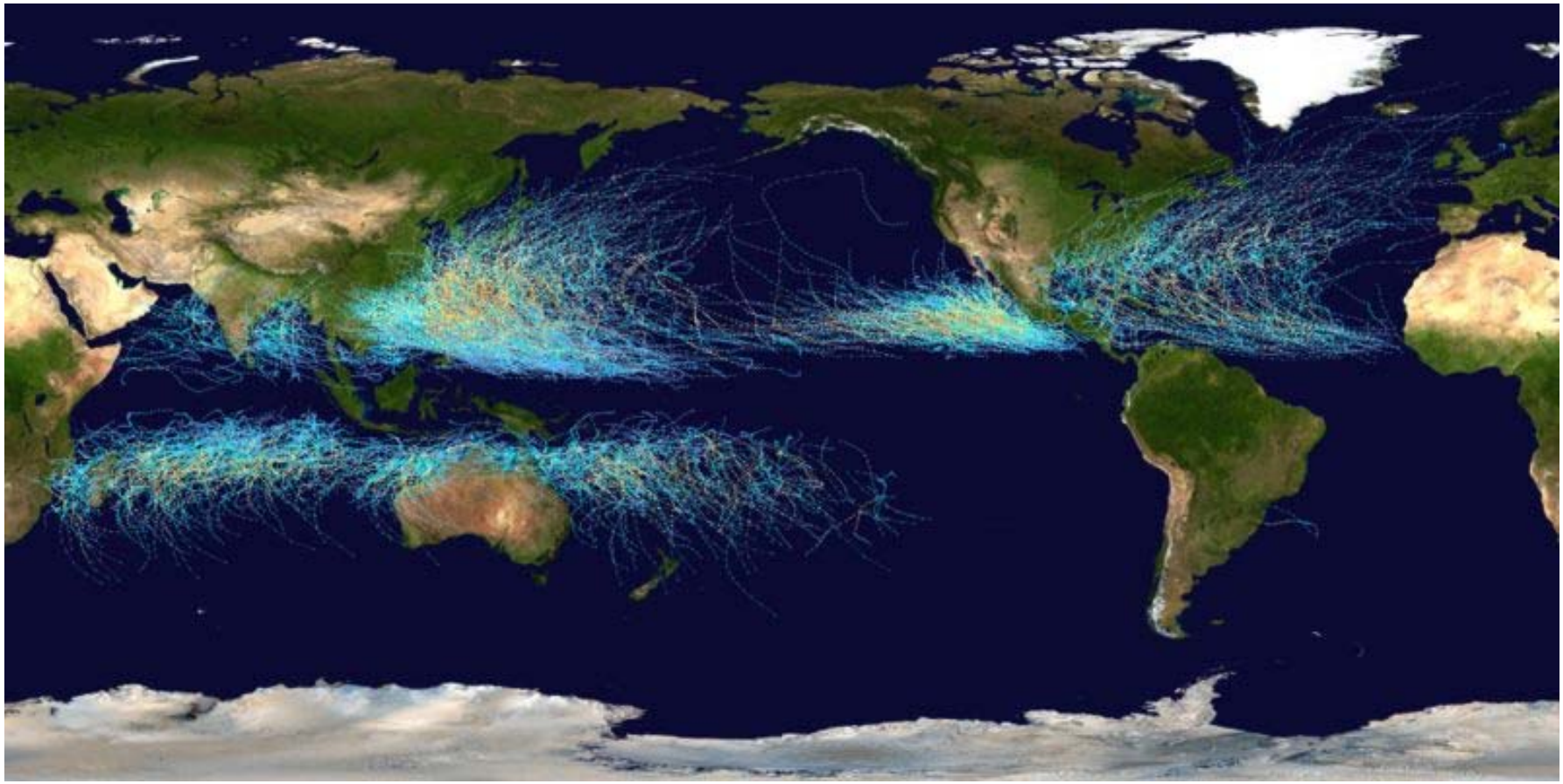
Tropical cyclone tracks 1985-2005



The Pacific Ocean west of the International Date Line sees more tropical cyclones than any other basin, while there is almost no activity in the Atlantic Ocean south of the Equator.

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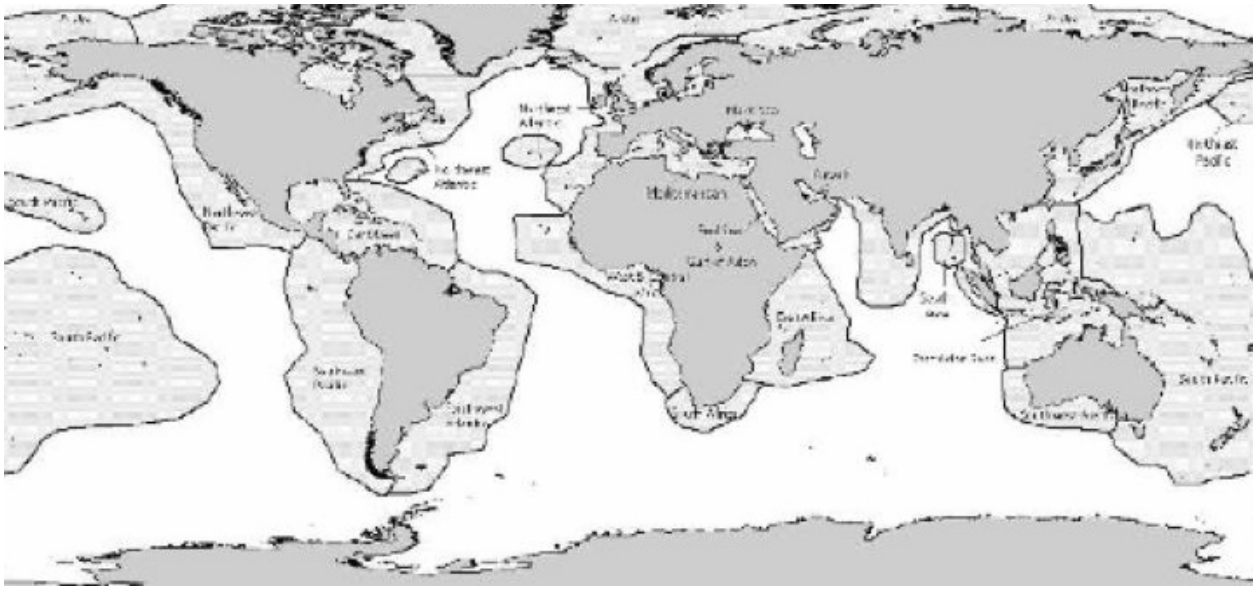
Marine and coastal environment



Coverage of marine and coastal environment in :

- Sectoral chapters on Coasts (chapter 6), Ecosystems (Chapter 4), Polar areas (Chapter 15), Small islands (Chapter 16).
- Regional chapters : section on coastal and marine environment.
- Cross-chapter studies, e.g. coral reefs, megadeltas.

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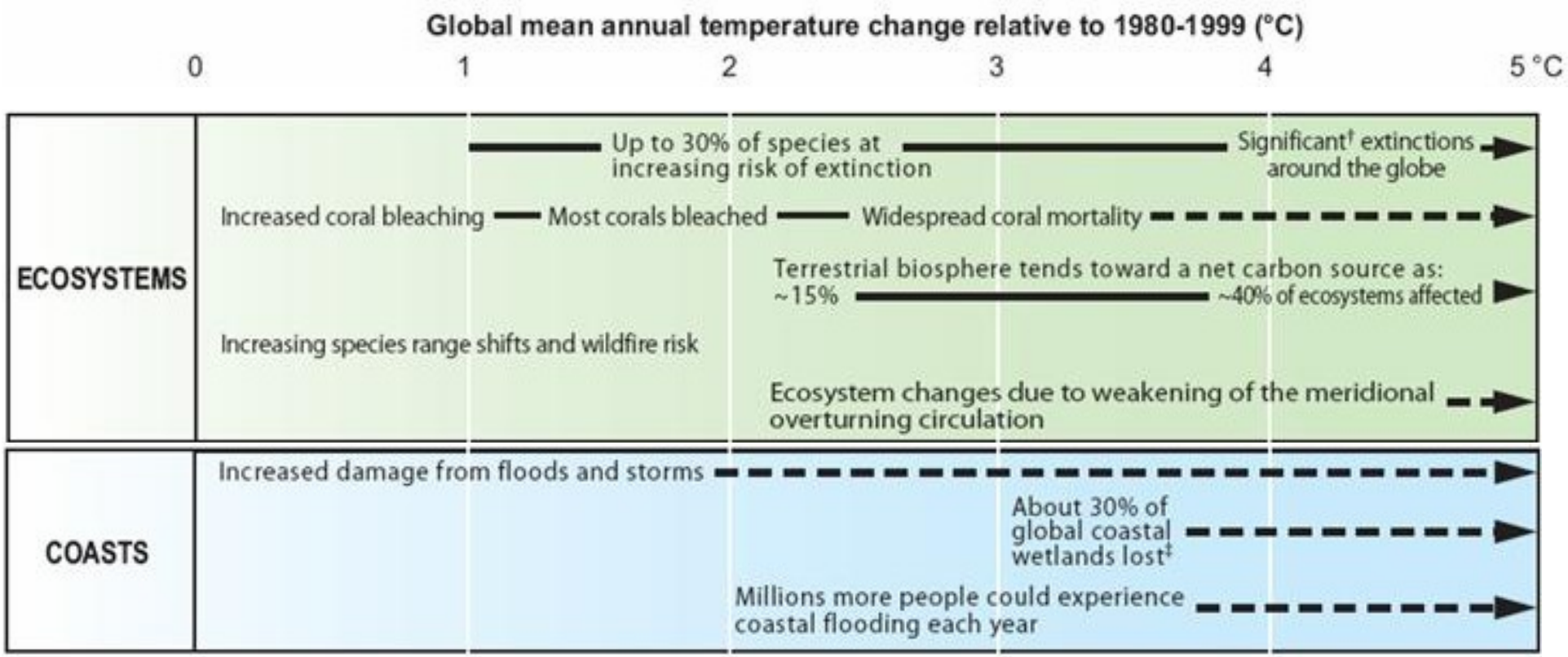
Selected impacts on marine and coastal environments



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Chapter 6:

Coastal Systems and Low-lying Areas

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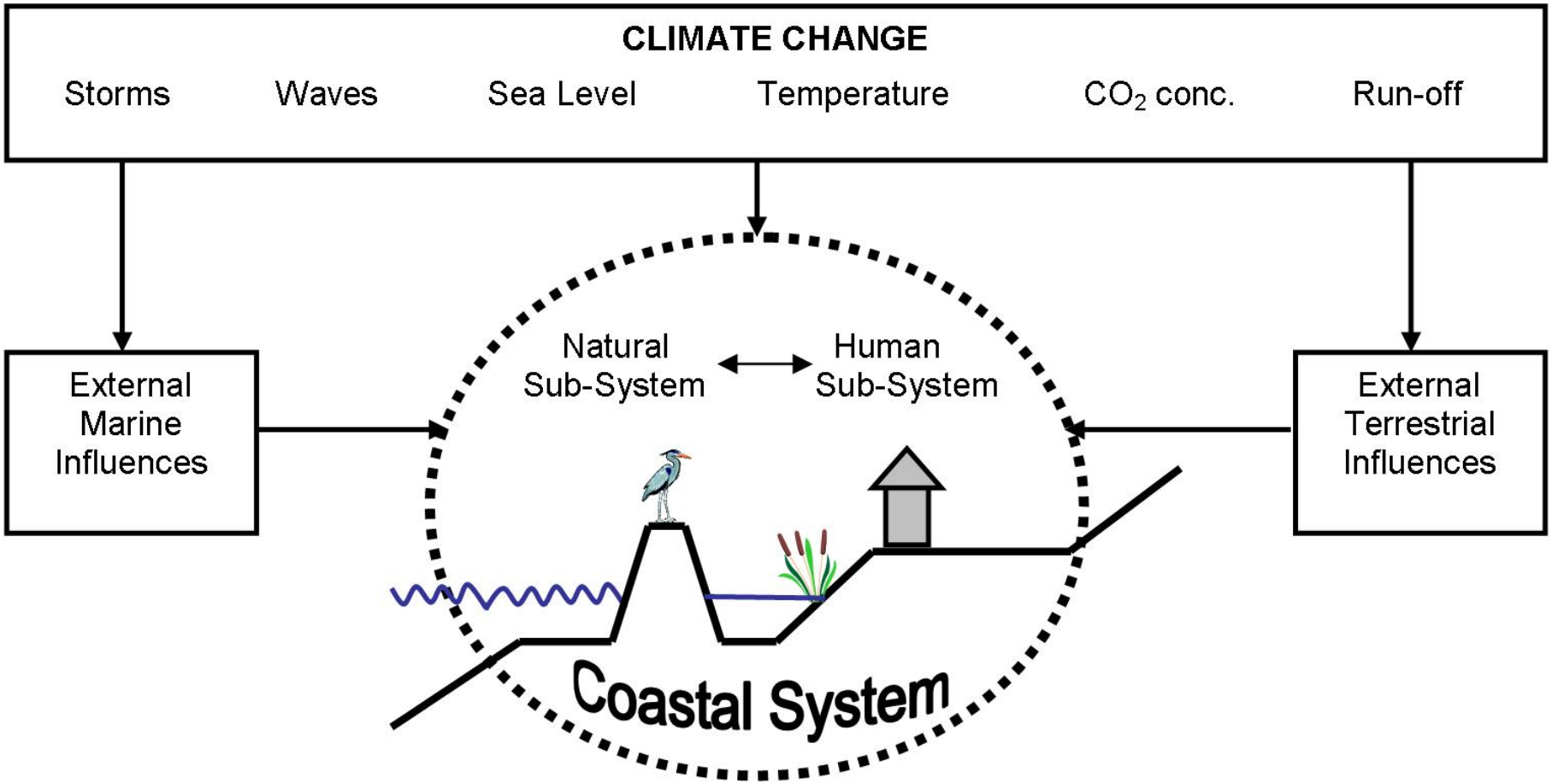
Coastal system



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Summary points

- Coasts are experiencing the adverse consequences of hazards related to climate and sea level.
- Coasts will be exposed to increasing risks over coming decades due to many compounding climate-change factors.
- Impact of climate change on coasts is exacerbated by increasing human-induced pressures.
- Adaptation for the coasts of developing countries will be more challenging than for coasts of developed countries, due to constraints on adaptive capacity.
- Adaptation costs for vulnerable coasts are much less than the costs of inaction.
- Unavoidability of sea-level rise even in the longer-term frequently conflicts with present-day human development patterns and trends.

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Observed impacts

(due to climate variability and change)

- Through the 20th Century, global rise of sea level has contributed to increased coastal inundation, erosion and ecosystem losses, but with considerable local and regional variation due to other factors.
- Late 20th Century effects of rising air and sea surface temperature include loss of sea ice, thawing of permafrost and associated coastal retreat (at high latitudes), and more frequent coral bleaching and mortality (at low latitudes).

Major impact types

- Corals are threatened with increased bleaching and mortality due to rising sea surface temperatures.
- Coastal wetland ecosystems, such as salt marshes and mangroves are threatened, especially where they are sediment-starved or constrained on their landward margin.
- Degradation of coastal ecosystems, especially wetlands and coral reefs, has serious implications for the well-being of societies dependent on the coastal ecosystems for goods and services.
- Increased flooding and the degradation of freshwater, fisheries and other resources could impact hundreds of millions of people and socio-economic costs will escalate as a result of climate change for coasts.

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Climate risks through 21st century

(Trend: ↑ increase; ? Uncertain; R regional variability)

Climate Driver (trend)		Main Physical and Ecosystem Effects on Coastal Systems
CO_2 concentration (↑)		Increased CO_2 fertilisation; Decreased seawater pH (or 'ocean acidification') negatively impacting coral reefs and other pH sensitive organisms.
Sea surface temperature (SST) (↑, R)		Increased stratification/changed circulation; Reduced incidence of sea ice at higher latitudes; Increased coral bleaching and mortality; Poleward species migration; Increased algal blooms.
Sea level (↑, R)		Inundation, flood and storm damage; Erosion; Saltwater Intrusion; Rising water tables/ impeded drainage; Wetland loss (and change).
Storm	Intensity (↑, R)	Increased extreme water levels and wave heights; Increased episodic erosion, storm damage, risk of flooding and defence failure;
Storm	Frequency (?, R)	Altered surges and storm waves and hence risk of storm damage and flooding.
Storm	Track (?,R)	
Wave climate (?, R)		Altered wave conditions, including swell; Altered patterns of erosion and accretion; Re-orientation of beach planform.
Run-off (R)		Altered flood risk in coastal lowlands; Altered water quality/salinity; Altered fluvial sediment supply; Altered circulation and nutrient supply.

These phenomena will vary considerably at regional and local scales, but the impacts are virtually certain to be overwhelmingly negative.

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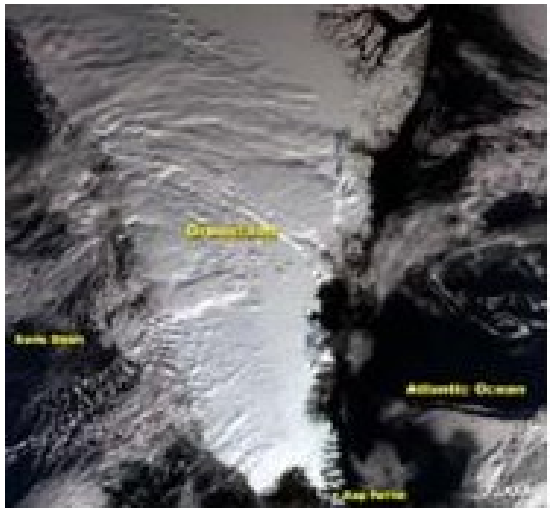
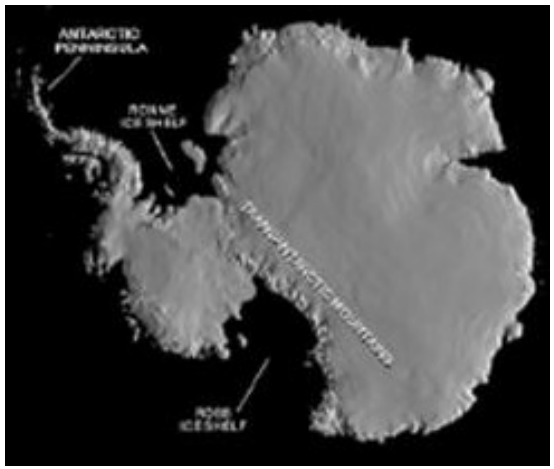
Sea level rise will continue beyond 2100

- Sea-level rise has substantial inertia and will continue beyond 2100 for many centuries.
- Irreversible breakdown of the West Antarctica and/or Greenland ice sheets, if triggered by rising. temperature, would make this long-term rise significantly
- This would ultimately question the viability of many coastal settlements across the globe.





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Hot spots of vulnerability

- Hotspots of coastal vulnerability occur where the stresses on natural systems coincide with low human adaptive capacity and high exposure.
- Vulnerable coastal types
  - Populated deltas (especially Asian megadeltas);
  - Low-lying coastal urban areas;
  - Atolls.
- Vulnerable regions
  - South, South-East and East Asia;
  - Africa;
  - Small islands (Caribbean, Indian Ocean, and Pacific Ocean).
- Climate change therefore reinforces the desirability of managing coasts in an integrated manner.

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Threatened deltas

Indicative population potentially displaced by current sea-level trends to 2050:

Extreme ≥1 million people displaced
High 1 million to 50,000 people displaced
Medium 50,000 to 5,000 people displaced

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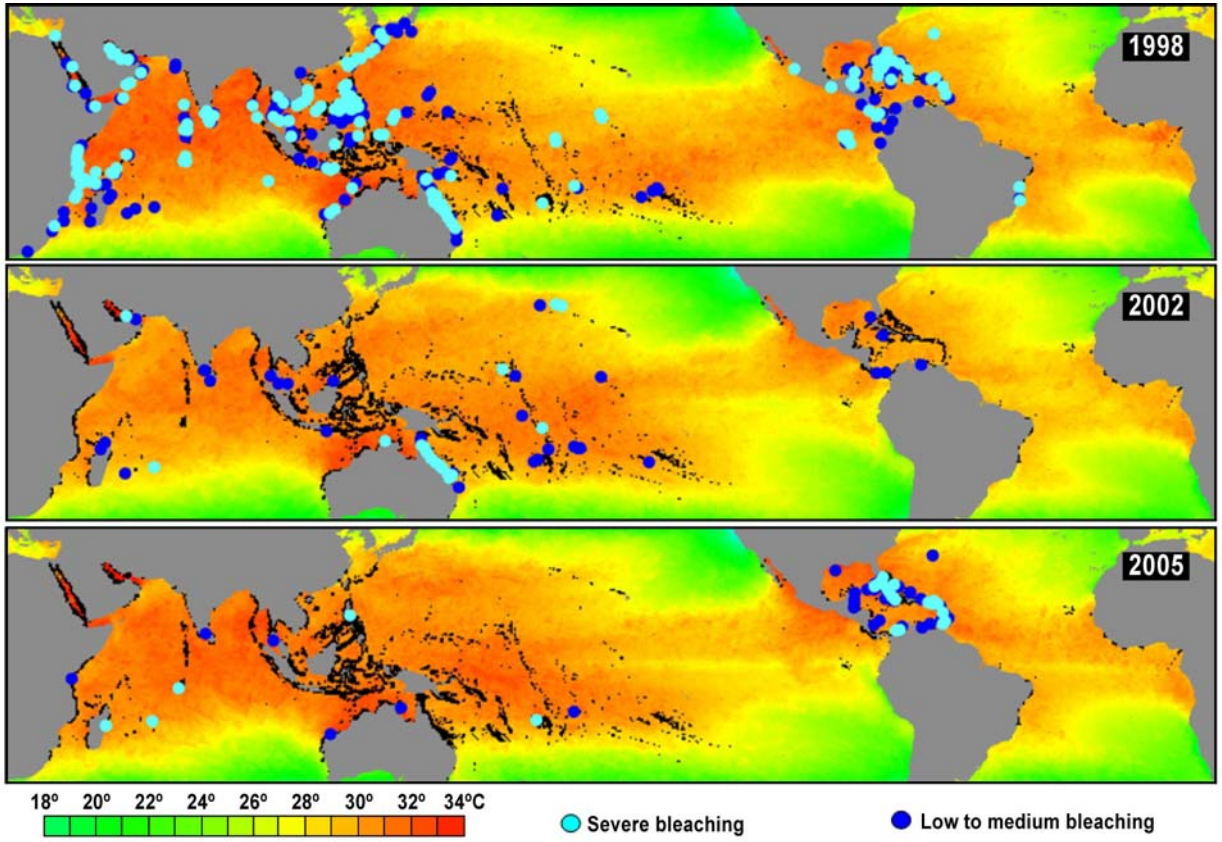
Recent coral bleaching events



Threshold - about 0.8-1ºC above mean summer maximum levels for at least 4 weeks

Mass coral-bleaching events correlated with rises of sea surface temperature of short duration above summer maxima

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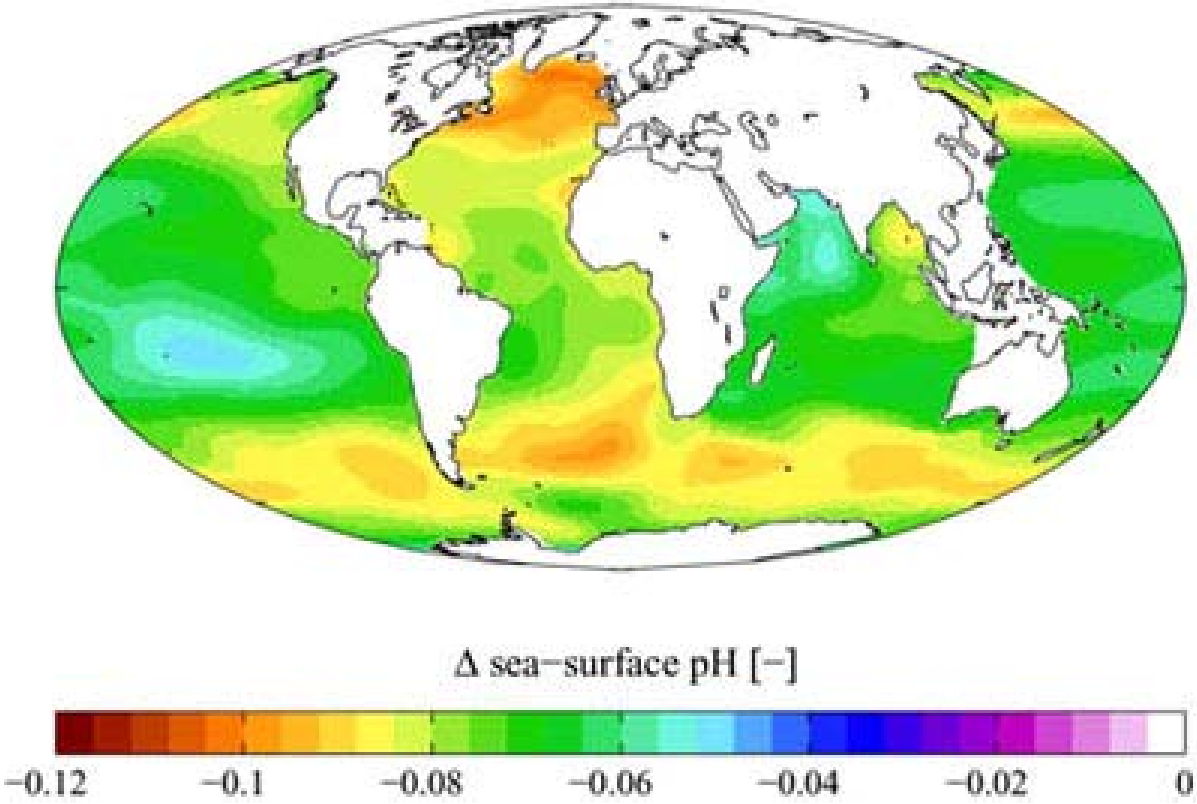
Ocean acidification



Increased concentrations of CO_2 in seawater will lead to ocean acidification

Affects aragonite saturation state and reduces calcification rates of calcifying organisms, e.g. corals

Changes in sea-surface pH from Anthropogenic CO_2 emissions (pre-industrial to 1990s)
Source : Pacific Science Association 2007

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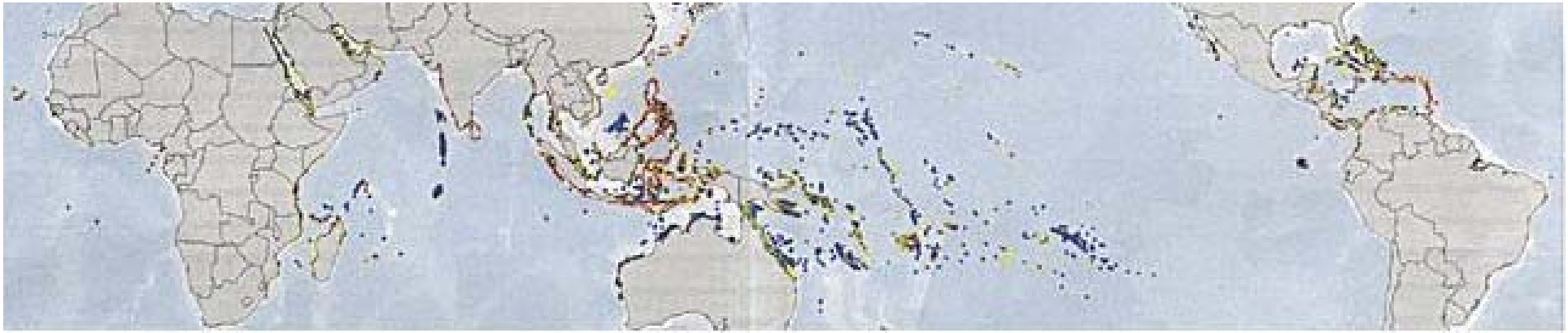
Coral reefs : human-threat factors



Blue - low risk; Yellow - medium risk; Red - high risk. Source : Bryant et al. 1998

Four human-threat factors: coastal development, marine pollution, overexploitation and destructive fishing, and sediment and nutrients from inland, provide a composite indicator of the potential risk to coral reefs associated with human activity for 800 reef sites.
Low risk is common in the insular central Indian and Pacific Oceans and high risk is common in maritime Southeast Asia and the Caribbean archipelago.

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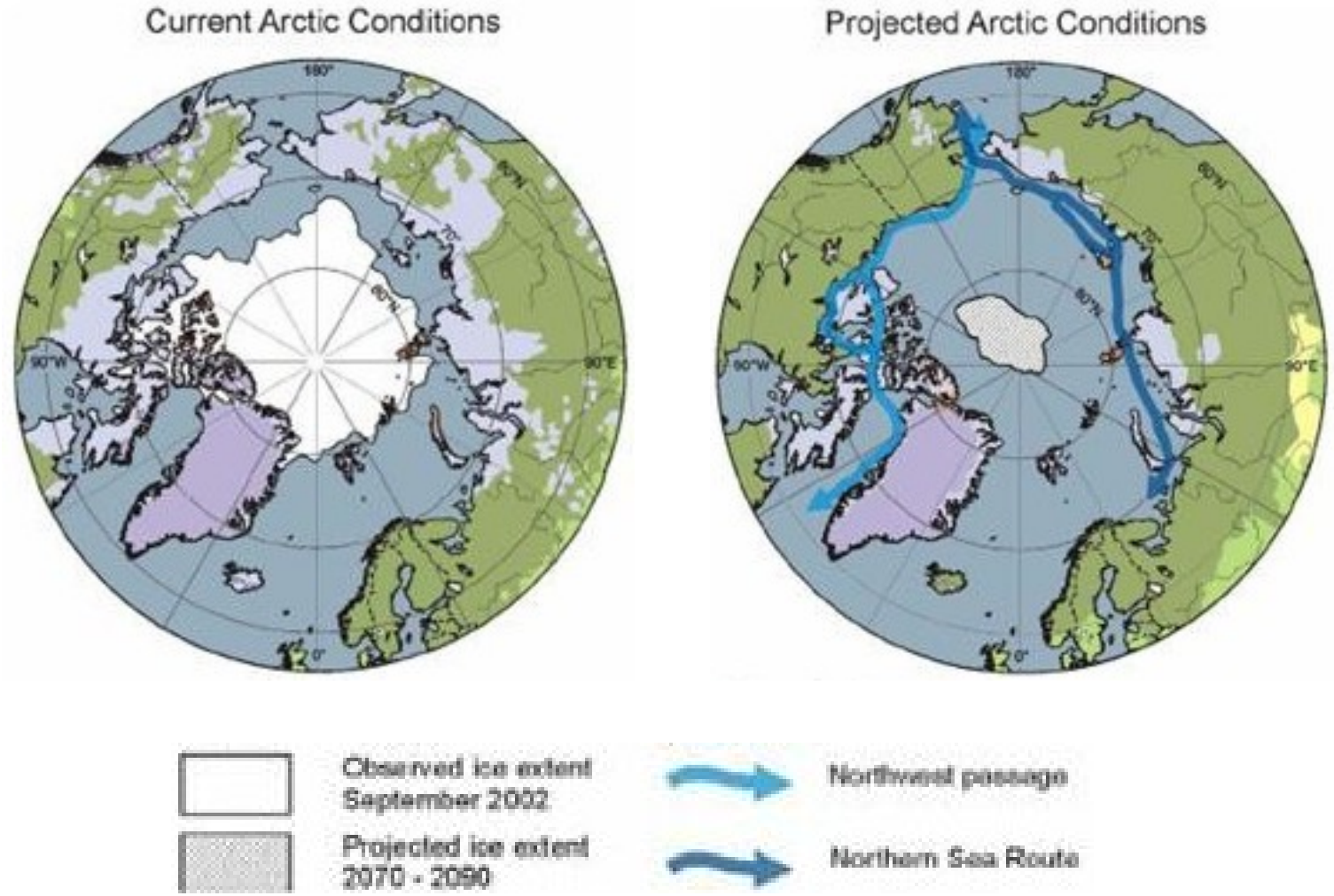
Arctic sea ice



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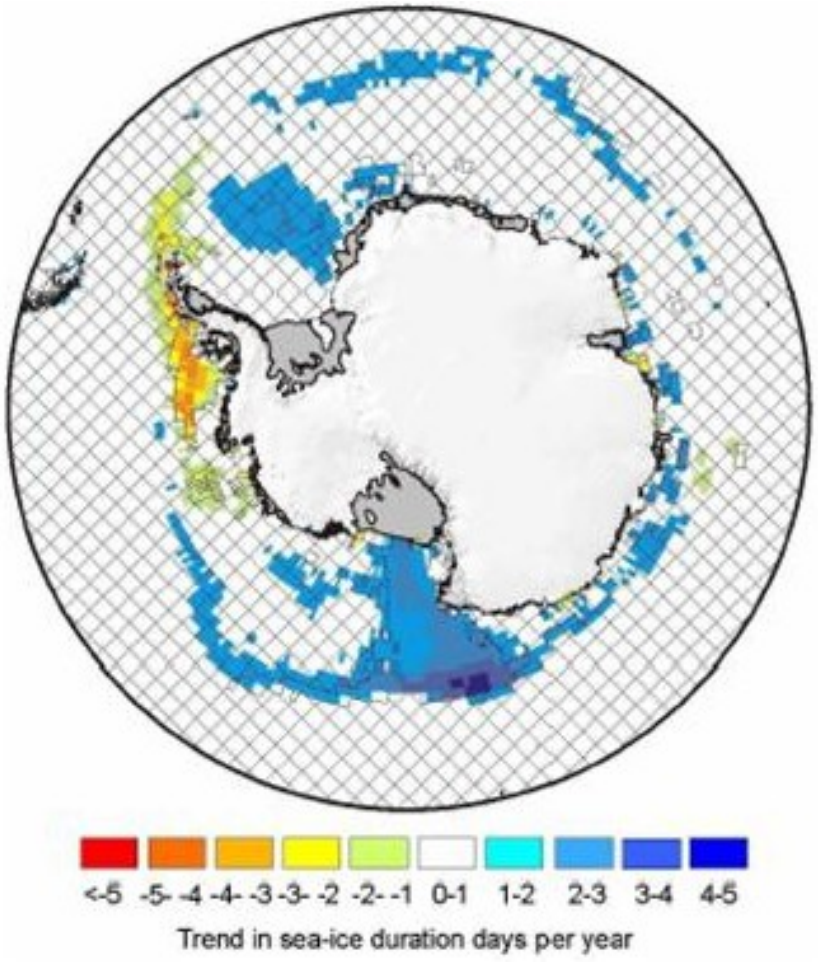
Antarctic sea ice



- Antarctica sea ice shows inter-annual variability and localized changes

- No statistically significant averaged trends, consistent with lack of warming reflected in atmospheric temperature averaged across region

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Europe : main expected impacts on coastal & marine environment

Sectors and Systems	Impact	Area				
		North	Atlantic	Central	Mediterr.	East
Coastal and marine systems	Beach, dune: low-lying coast erosional 'coastal squeeze'	↓↓↓	↓↓↓	na	↓↓	↓↓
	SLR- and surge-driven flooding	↓↓↓	↓↓	na	↓↓	↓↓↓
	River sediment supply to estuaries and deltas	↓↓	↓	na	↓↓↓	↓
	Saltwater intrusion to aquifers	↓	↓	na	↓↓	↓
	Northward migration of marine biota	↑	↑↑↑	na	↑	↑
	Rising SSTs, eutrophication and stress on biosystems	↓↓↓	↓↓	na	↓↓	↓
	Development of ICZM	↑↑	↑↑	na	↑↑	↑
	Deepening and larger inshore waters	↑↑	↑	na	↑	↑↑
Wetlands and aquatic ecosystems	Drying/transformation of wetlands	↓↓	↓	↓	↓↓↓	↓↓↓
	Species diversity	↑ to ↓	↑	??	↓↓	↓
	Eutrophication	↓	↓↓	↓↓	↓↓↓	↓
	Disturbance of drained peatlands	↓↓↓	↓	↓↓	na	↓↓↓
Biodiversity	Low-lying coastal birds	↓↓↓	↓↓↓	na	↓↓↓	??
	Freshwater biodiversity	↑ to ↓	??	??	↓↓↓	??
Fisheries	Marine fisheries	↑↑	↑	na	↓	na

Proposed magnitude of impacts increases with the number of arrows (one to three).
Blue - positive impact. Red - negative impact.

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Baltic Sea

The Baltic Sea is the world's largest brackish water area, and increasing temperature will increase the frequency of algal growth and anoxia. This is exacerbated by increased runoff and nutrient load.

Marine phytoplankton bloom captured on image by Evisat's MERIS on 13 July 2005.
Source : ESA

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Africa : vulnerabilities

Vulnerabilities to coastal & marine environment

- Sea-level rise
- Cyclones
- Coastal erosion
- Coral bleaching

Source : UNEP-GRID Arendal

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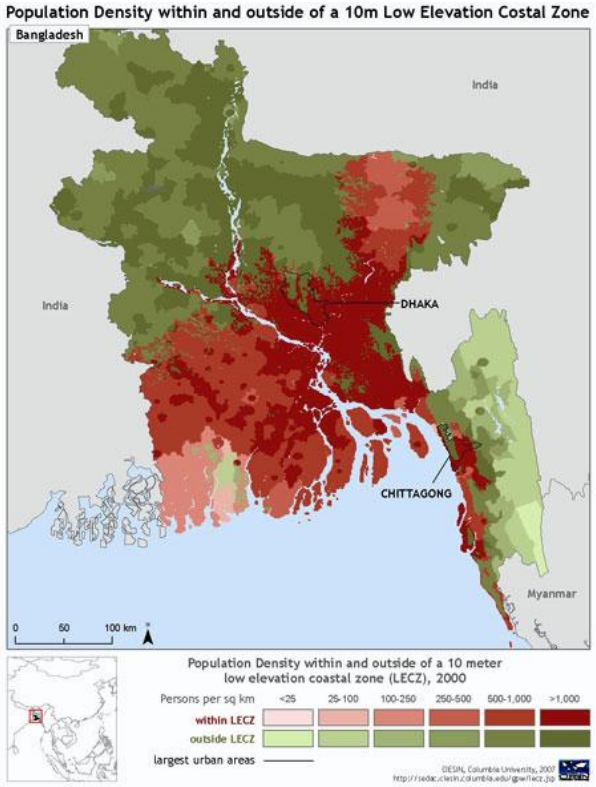
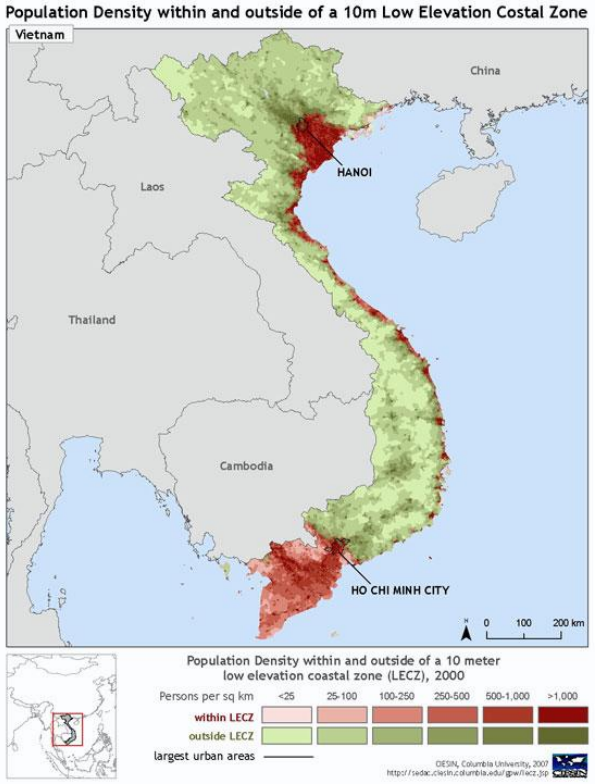
Bangladesh and Vietnam





Bangladesh and Vietnam with deltas and coasts at high risk from flooding, sea-level rise and stronger storms due to climate change.

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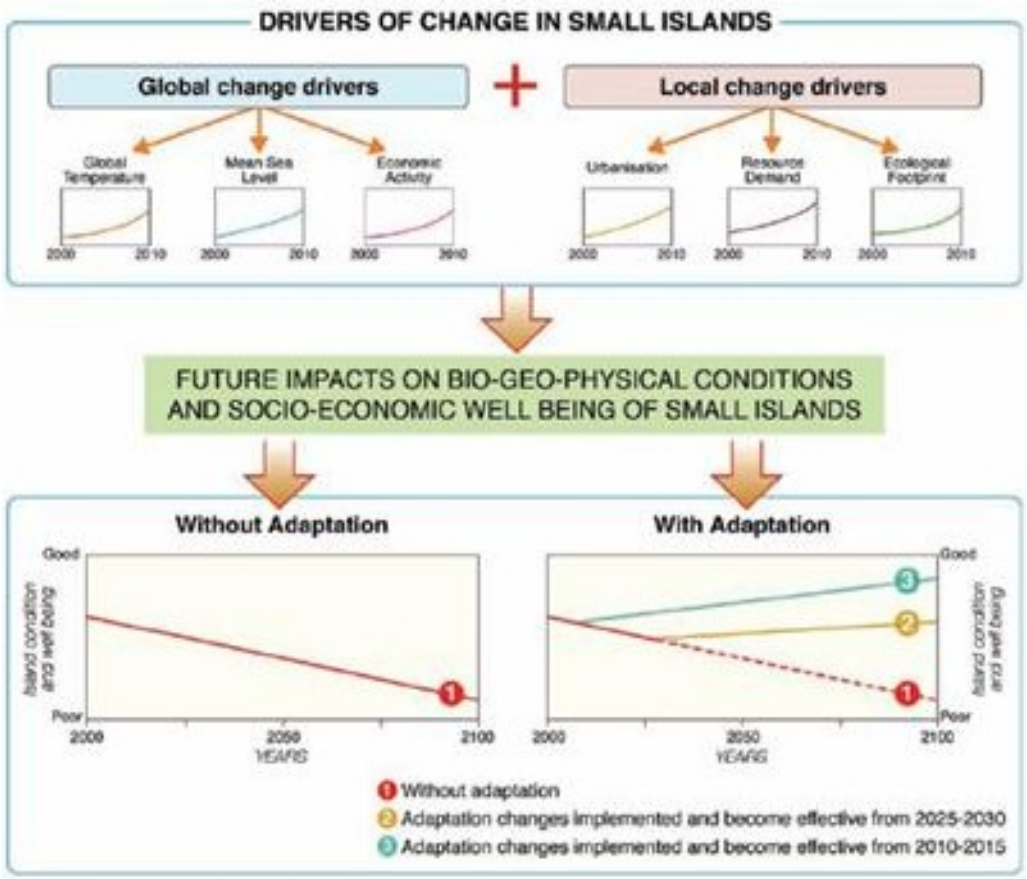
Small islands : future conditions and adaptation



- Global change drivers
  - Global temperature
  - Mean sea level
  - Economic activity
- Local change drivers
  - Urbanization
  - Resource demand
  - Ecological footprint

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Adaptation options

Coastal Adaptation (IPCC CZMS, 1990)	*Adaptation Objectives (Klein and Tol, 1997)*	*Adaptation Responses (after Cooper et al., 2002; DEFRA, 2001)*	*Examples*
		Advance the line	Land claim; polders
Protect	Increased robustness	Hold the line	Dyke; beach nourishment
Accommodate	Increased flexibility		'Flood proof' buildings Floating agricultural systems
		Retreat the line	Managed realignment
Retreat	Enhanced adaptability	Limited intervention	Ad hoc seawall
		No intervention	Monitoring only
	Reversing maladaptive trends	Sustainable adaptation	Wetland restoration
	Improved awareness and preparedness	Community-focussed adaptation	Flood hazard mapping; flood warnings

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Inaction will cost more than adaptation

- Adaptation costs for climate change are much lower than damage costs without adaptation for most developed coasts, even considering only property losses and human deaths.
- As post-event impacts on coastal businesses, people, housing, public and private social institutions, natural resources, and the environment generally go unrecognised in disaster cost accounting, the full benefits of adaptation are even larger.
- Without adaptation, the high-end sea-level scenarios combined with other climate change (e.g., increased storm intensity) are as likely as not to make some islands and low-lying areas uninhabitable by 2100.
- Hence, effective adaptation is urgently required.

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Research needs

- Better baselines of actual coastal changes, including local factors and sea-level rise, and the climate and non-climate drivers, through additional observations and expanded monitoring.
- Improve predictive capacity for future coastal change due to climate and other drivers, through field observations, experiments and model development.
- Develop a better understanding of the adaptation of the human systems in the coastal zone.
- Improve impact and vulnerability assessments within an integrated assessment framework that includes natural-human sub-system interactions.
- Developing methods for identification and prioritisation of coastal adaptation options.
- Develop and expand networks to share knowledge and experience on climate change and coastal management among coastal scientists and practitioners.

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Acknowledgements

- IPCC WGII chapters 6 and other chapters including the TS and SPM.
- Presentations from WGI and WGII in IPCC website www.ipcc.ch

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Thank you

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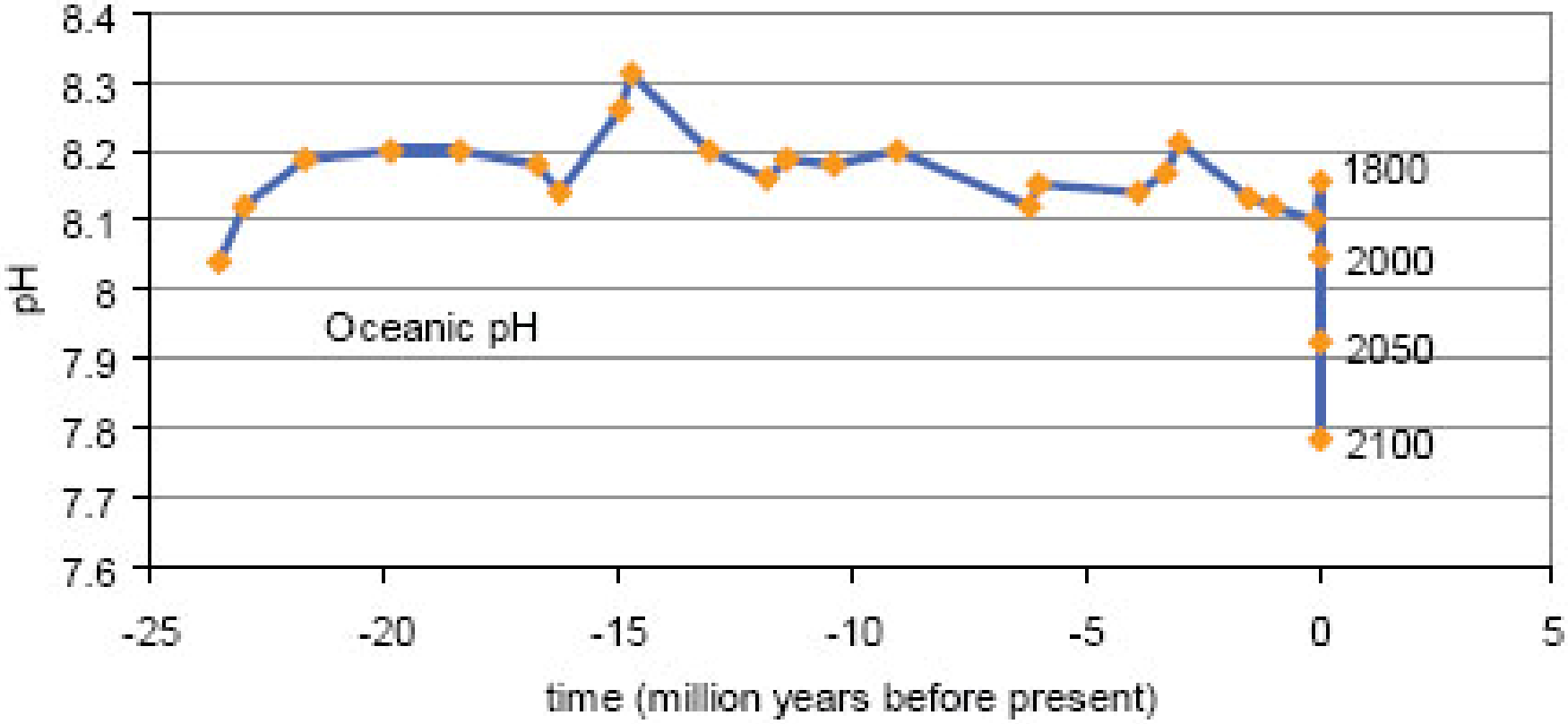
Past and projected oceanic pH levels



Source: EUR-OCEANS 2007

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