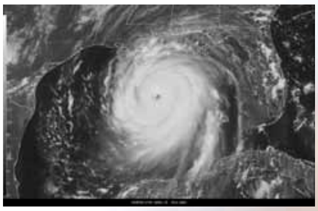
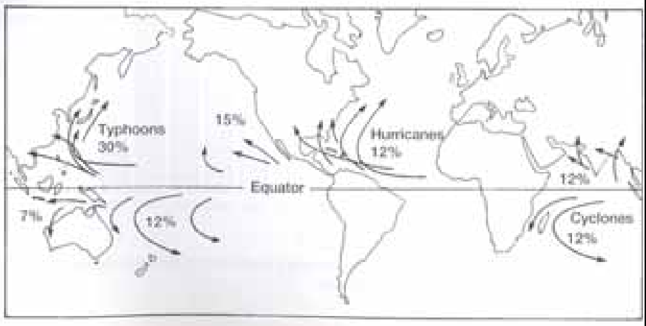
Regional Technical Workshop, 28-31 August 2006, Khao Lak, Thailand
Coastal protection in the aftermath of the Indian Ocean tsunami:
what role for forests and trees?

Role of Forests and Trees in Protecting Coastal Areas against Cyclones

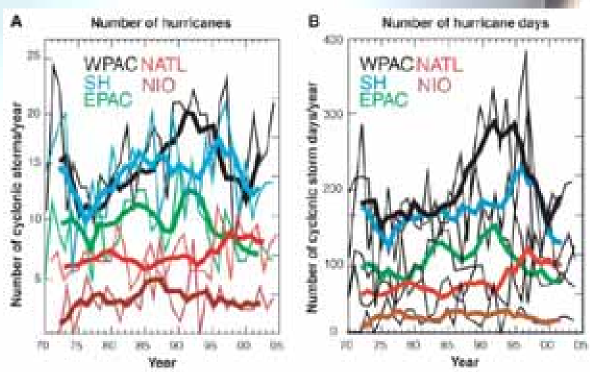


Dr. Hermann Fritz

Tropical Cyclone occurrence



Tropical Cyclone occurrence



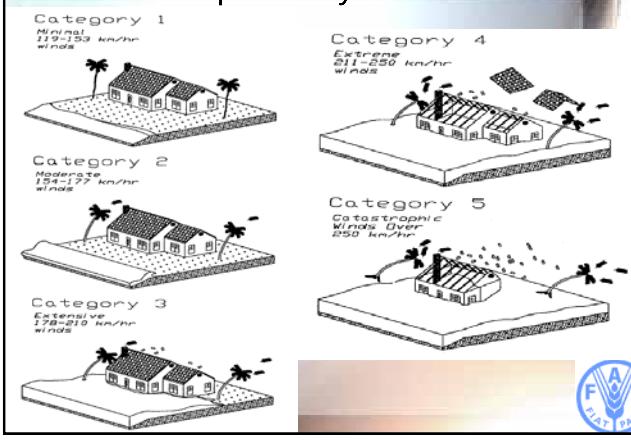
Saffir-Simpson Cyclone Scale – wind speed based

	Description	m/s	km/h	mph
1	Weak	32.7–42.6	118–153	73–95
2	Moderate	42.7–49.5	154–177	96–110
3	Strong	49.6–58.5	178–209	111–130
4	Very strong	58.6–69.4	210–249	131–155
5	Devastating	69.5–	250–	156–

Cyclone Damage Potential Scale

Cat	*Central Pressure (mb)*	*Wind Speed (mph)*	*Peak Storm Tide Elevation above MSL (ft)*	*Event Forward Speed (mph)*	*Storm Tide Rise Time (hr)*	*Average Erosion Volume (YDS(3)/ft)*	*Maximun Erosion Volume (yds (3)/ft)*	*Damage Potential*
1	>980	74-95	4-5.5	31-55	2.5-4.5	1.2-3.3	2.5-7	Minimal
2	965-979	96-110	5.5-8.5	18-31	4.5-7.5	3.3-10	7-21	Moderate
3	945-964	111-130	8.5-12.5	12-18	7.5-11	10-25	21-53	Extensive
4	920-944	131-155	12.5-18	6.5-12	11-21	25-75	53-158	Extreme
5	<920	155	18	<6.5	21	75	158	Catastrophic

Saffir Simpson Cyclone Scale



Cyclone Hazards

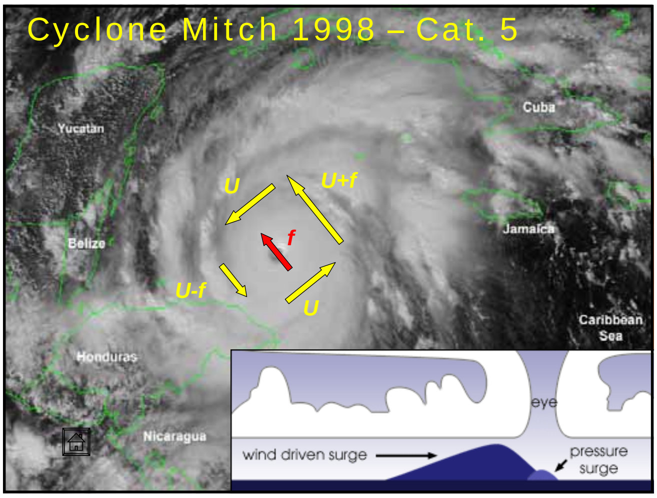
Storm surge
- **Storm Surge Height < 10m**
- **Storm Surge Inundation < 50 km inland**
- **Storm Surge Duration up to 24 hours**
- **Massive Erosion / Deposition both long and cross-shore**

Storm Waves
- **Storm Waves up to 15m high offshore**
- **Typical periods order 10s**

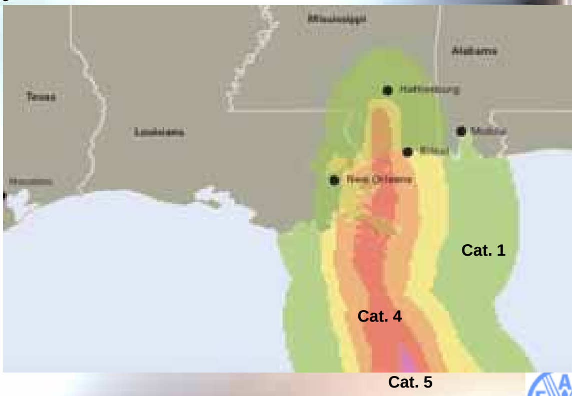
Rain Fall and Inland Flooding
- **Precipitation up to 0.5 m / m²**
- **Massive increase in river stages and inland flooding**

Wind field
- **Peak velocities of 250 km / h**
- **Maximum radius of cyclone force winds 250 km**

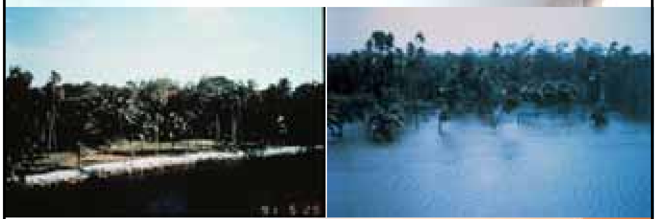
Cyclone Mitch 1998 – Cat. 5



Cyclone Katrina windfield



Tropical Cyclone Rainfall up to 0.5m / m^2 precipitation!

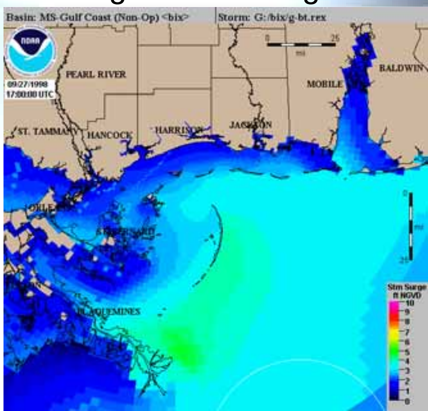


Miami River – Normal Day

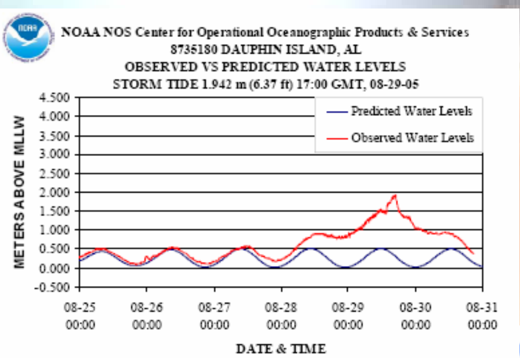
Cyclone Andrew - Cat. 5, 1992

Massive Inland Flooding Dramatically Increasing River Stages Often Killing more people than the cyclone directly

Storm Surge Modeling



Duration of Storm Surge >> Tsunami Wave Period



Coastal Cyclone Vulnerability

- **shallow on and offshore bathymetry**
- **favourable cyclone track**
- **convergence of the coastline / bay**
- **Inlets and river systems**
- **high astronomical tides**
- **densly populated low-lying islands**

Most vulnerable locations:

- **Bay of Bengal (Ganga-Brahmaputra-Meghna)**
- **Gulf of Mexico (Mississippi)**

Coastal Cyclone Vulnerability

shallow offshore

- high storm surge
- massive inundation
- moderate storm waves

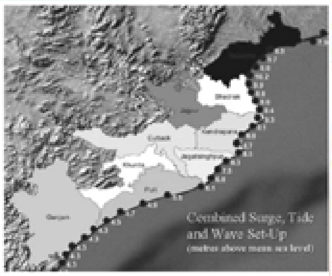
- tsunami bore formation
- small tsunami runup

deep offshore

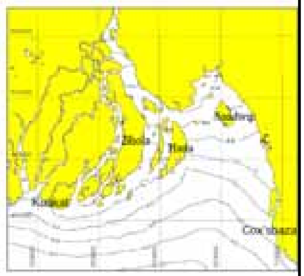
- low storm surge
- high storm waves
- limited inundation

- high tsunami run-up

Bay of Bengal Super-Cyclones

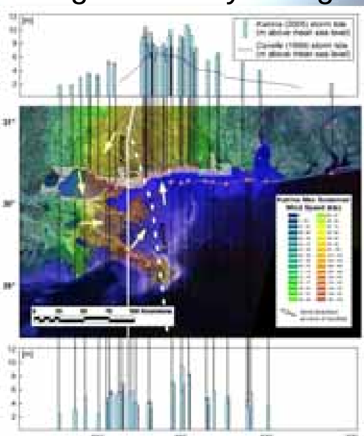


Total water level on a 50 year return basis.

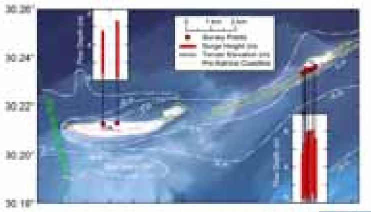


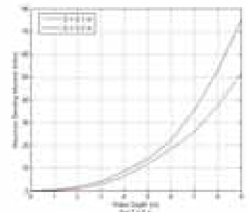
Bangladesh 100 year return period

Storm Surge Survey Heights



Storm wave loading on top of surge





Storm Surge Damage Trimline

No Wind Damage!

Uplift on Structures

Massive Erosion / Deposition

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Mangroves

- tend to grow in low wave energy environments behind coral reefs or in inlets
→ hence multiple factors contribute to the impact reduction image of mangroves

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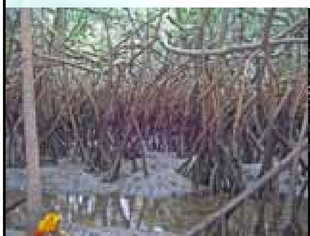
Mangroves

Low Tide



High Tide

- very dense woodwork in the intertidal zone
→ high flow resistance at normal waterlevel
- decreasing flow resistance with increasing surge
→ limited effect on surge and storm waves

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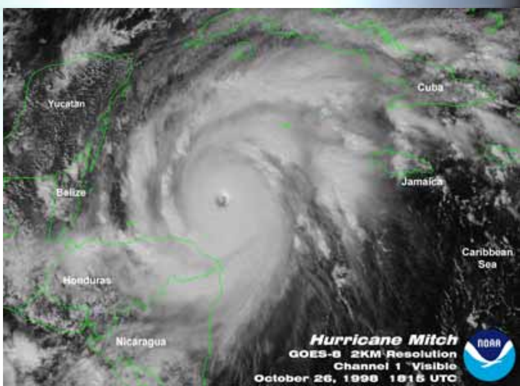
Cyclone Mitch 1998 – Cat. 5



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Mangrove Deleafing Damage

Hurricane Mitch 1998 – Cat. 5
Honduras, Centro America

Georgia Tech Savannah Campus

Mangrove Erosion & Uprooting Damage

Hurricane Mitch 1998 – Cat. 5
Honduras, Centro America

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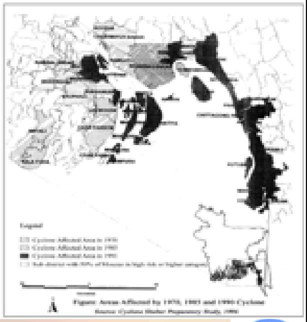
Sundarban Mangrove Forest Cyclone Protection, Bangladesh



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Sundarban Mangrove Forest Cyclone Protection, Bangladesh

- Mangroves preserve giant wetland
- Extends 80 km inland
- 10’s of km of wetland significantly reduce surge
- Typically < 0.5m surge height reduction / km
- “foot / mile” FEMA rule of thumb

→ PRESERVE COASTAL WETLANDS

- Wetland loss makes coast more vulnerable

→ New Orleans as sad example

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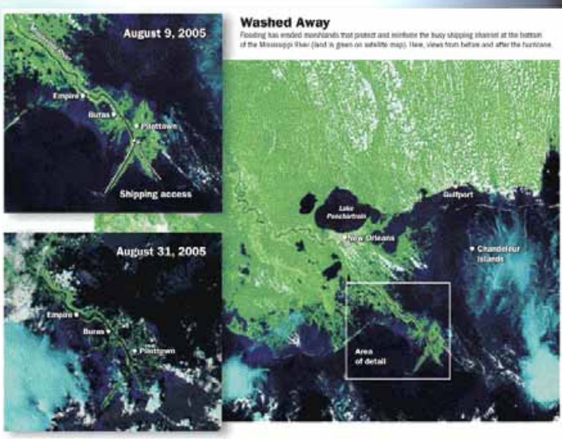
New Orleans Wetland loss



Man-made Coastal Structures – an Alternative?

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CONCLUSIONS

- Coastal Forests efficient at reducing wind and storm wave impacts
- Mangroves provide coastal erosion protection and preserve wetlands
- Coastal forests and mangroves in narrow belts are inefficient at reducing the storm surge
- 10s of kilometers wide wetlands and coastal forests are necessary to dampen the storm surge

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