

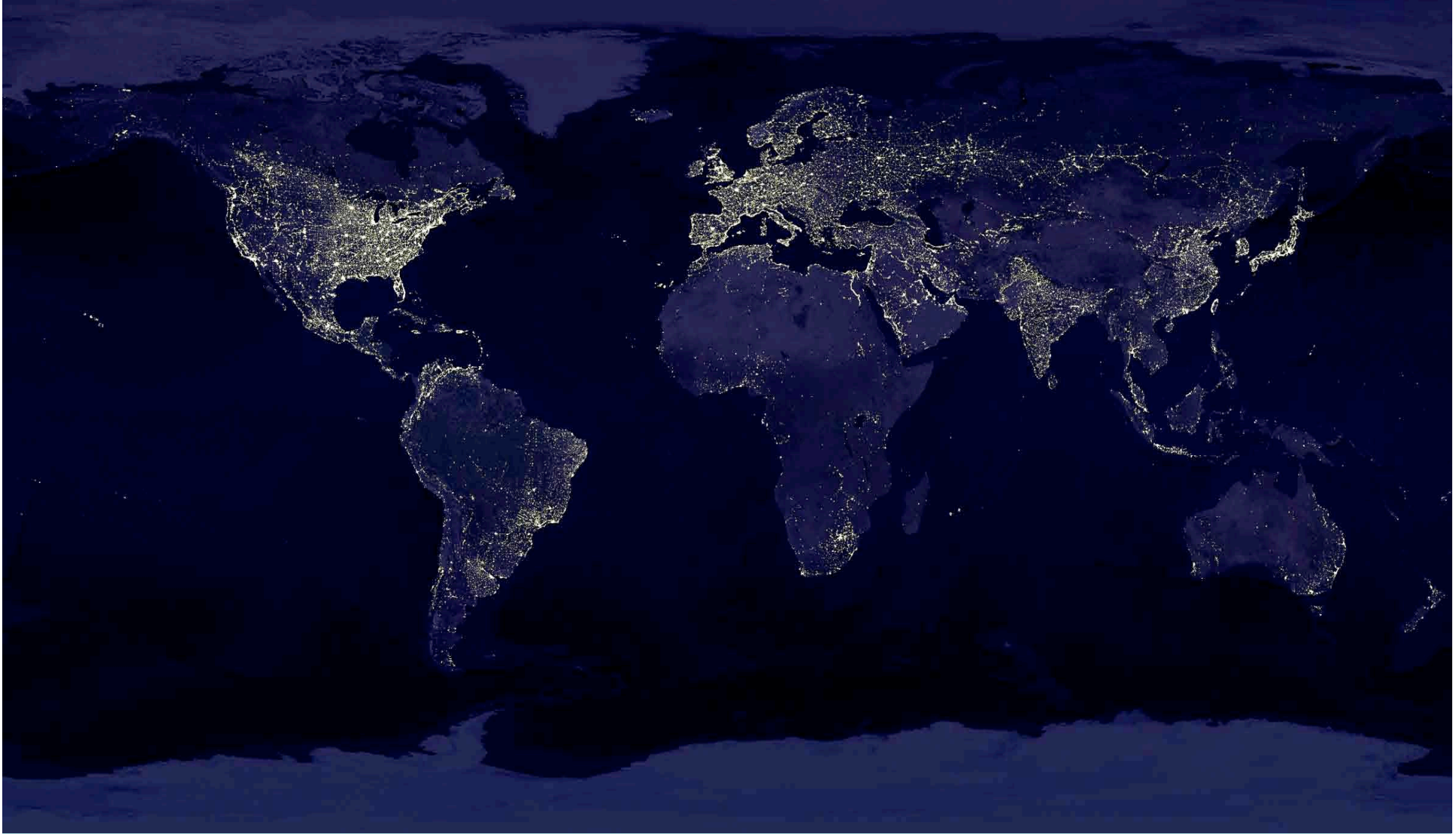


Koninklijk Nederlands  
Meteorologisch Instituut  
*Ministerie van Verkeer en Waterstaat*

# Sea level change in a vulnerable delta

Dr. Wilco Hazeleger

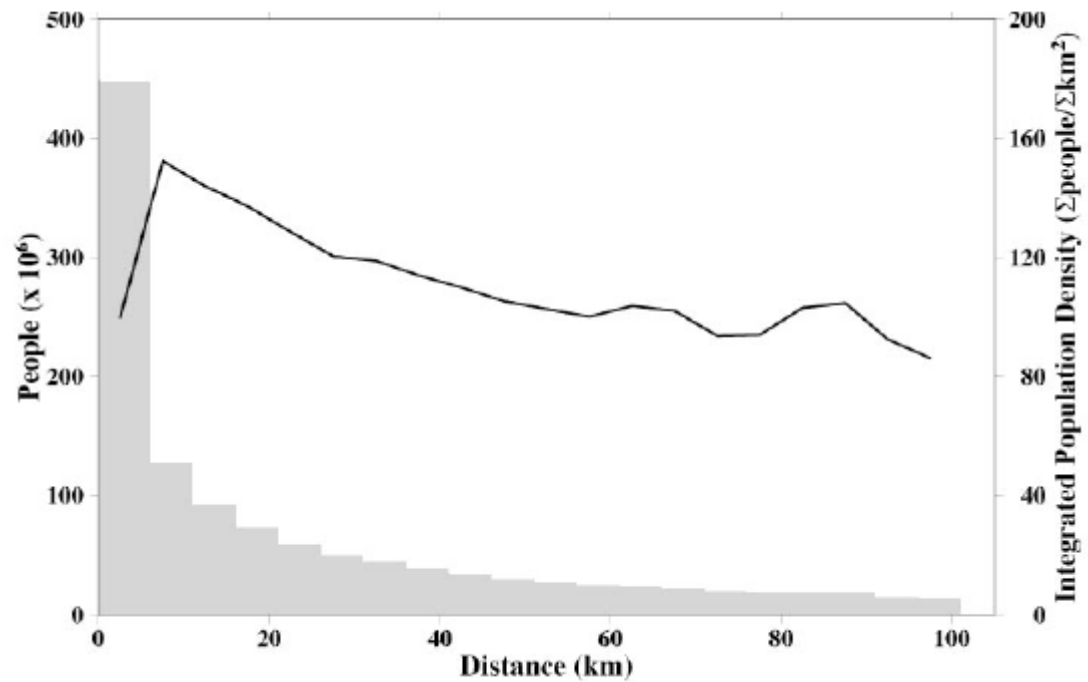
Dr. Caroline Katsman



Source: NASA, GSFC



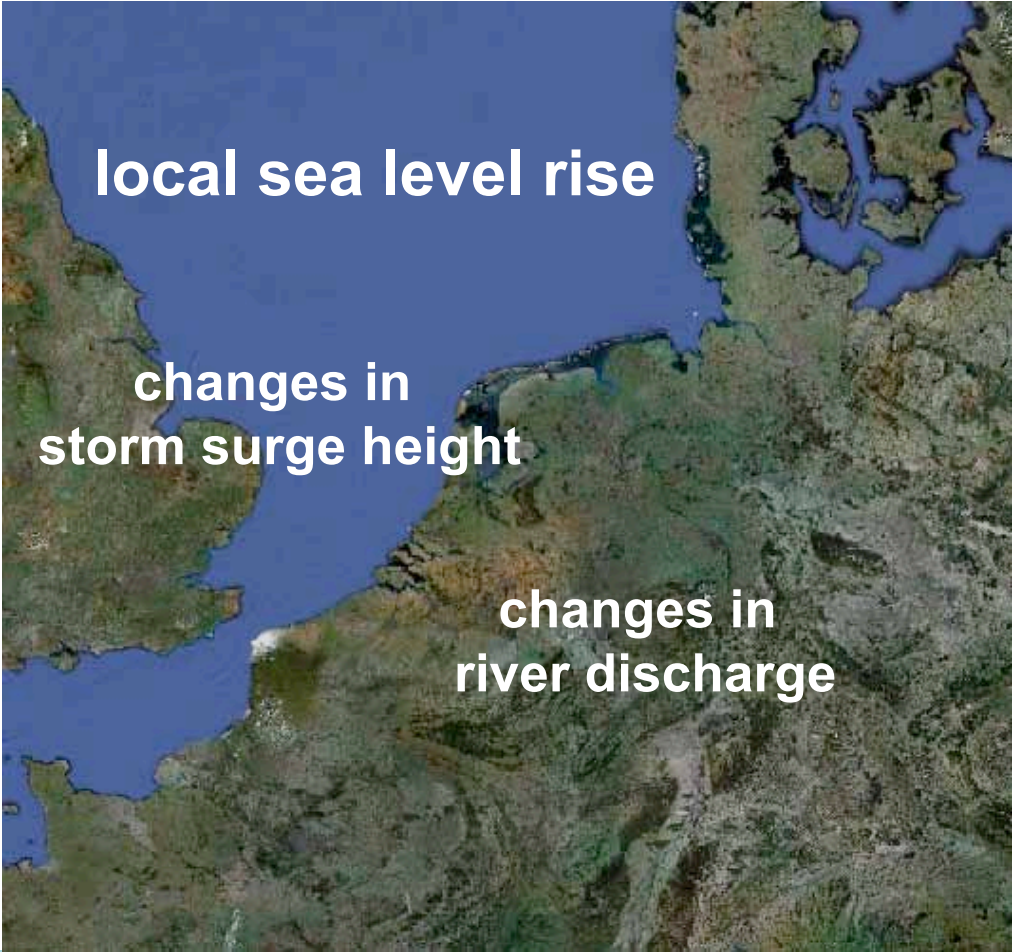
25% world population lives < 50 km from coast



Source, e.g. CIESIN, Columbia University

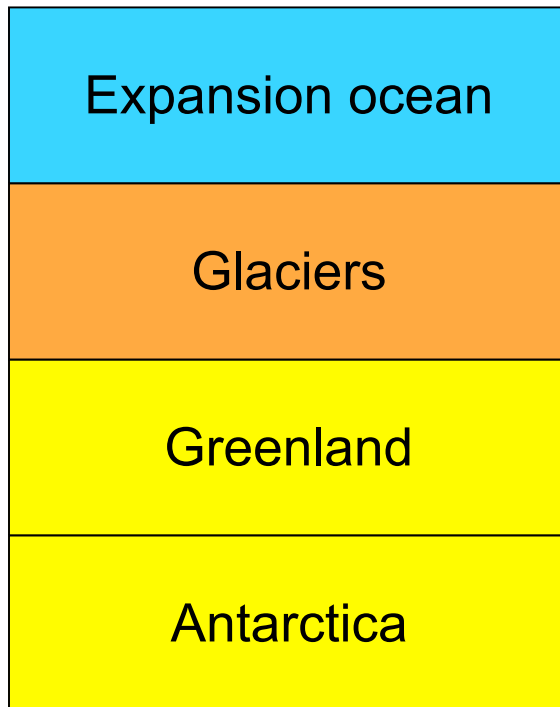


# Multiple threats for a low-lying delta





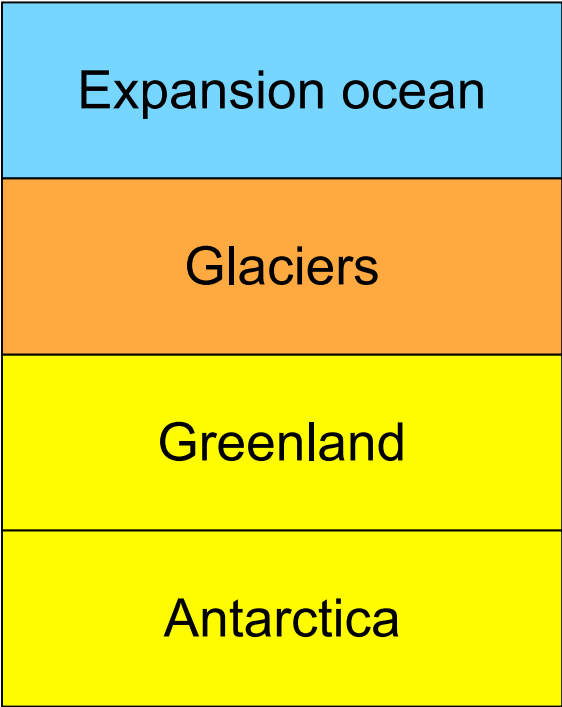
Sea level change = sum of components  
**global**



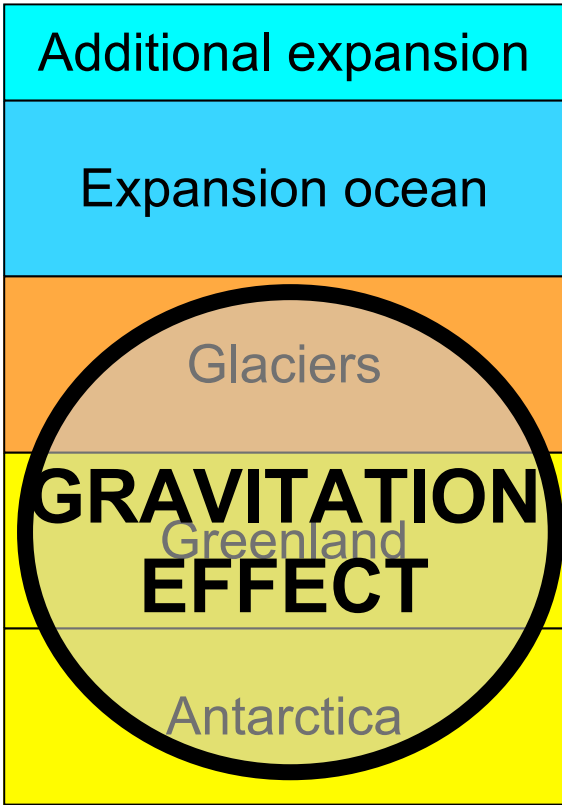


# Sea level change = sum of components

**global**



**local**





## Observing sea level change: integrated observing system

- **Tide gauges**

- **Hydrography**

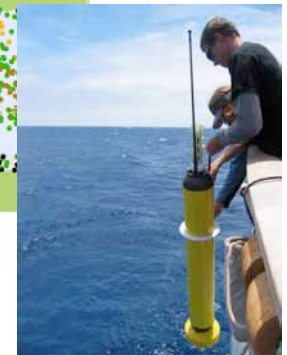
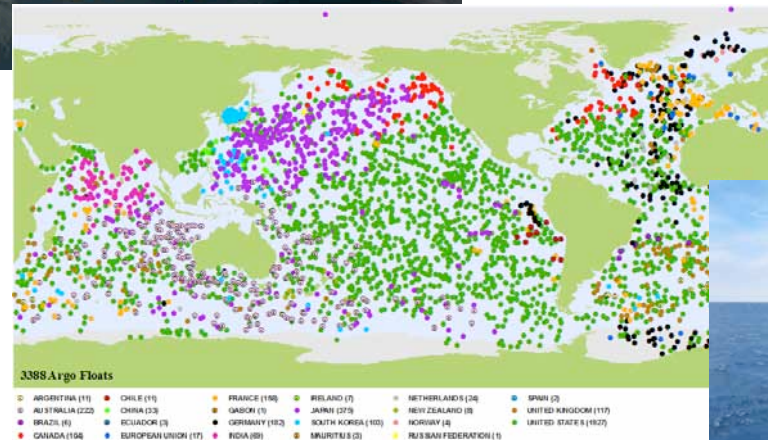
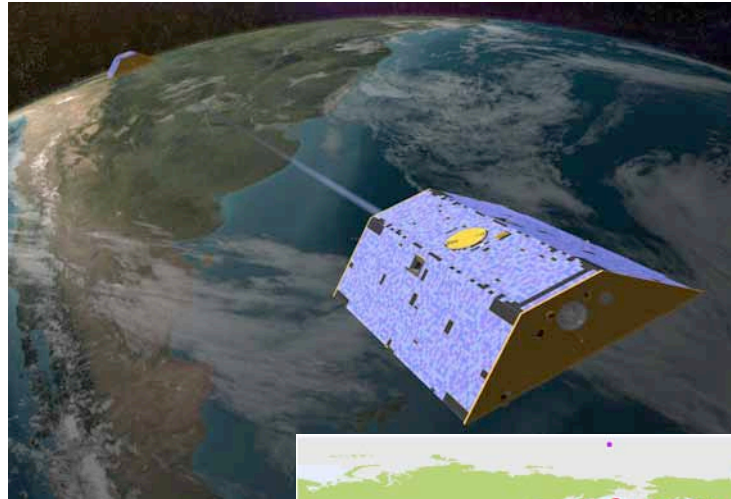
- . Ships
- . ARGO buoys

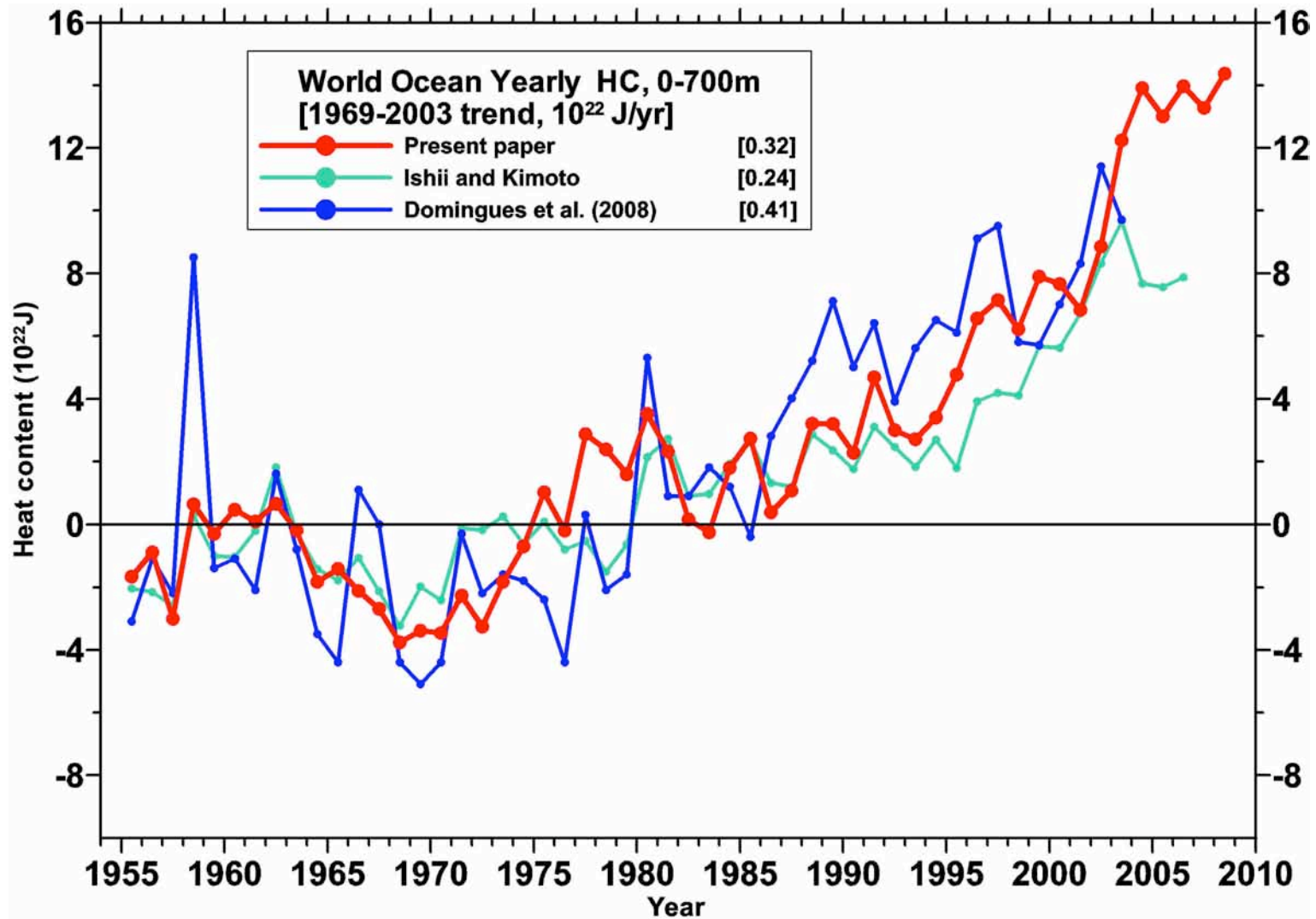
- **Satellite**

- . Altimetry
- . Gravity

- **In situ ice measurements**

- . Station data
- . GPS

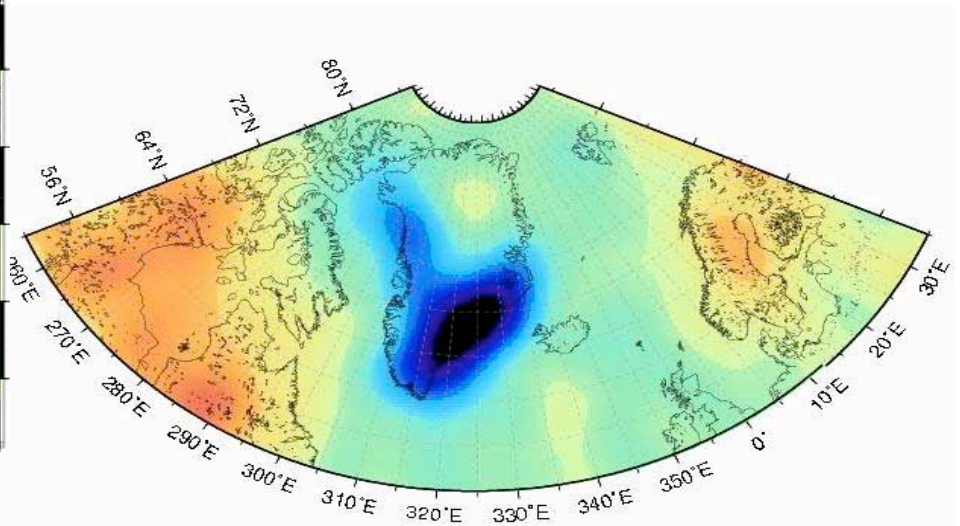
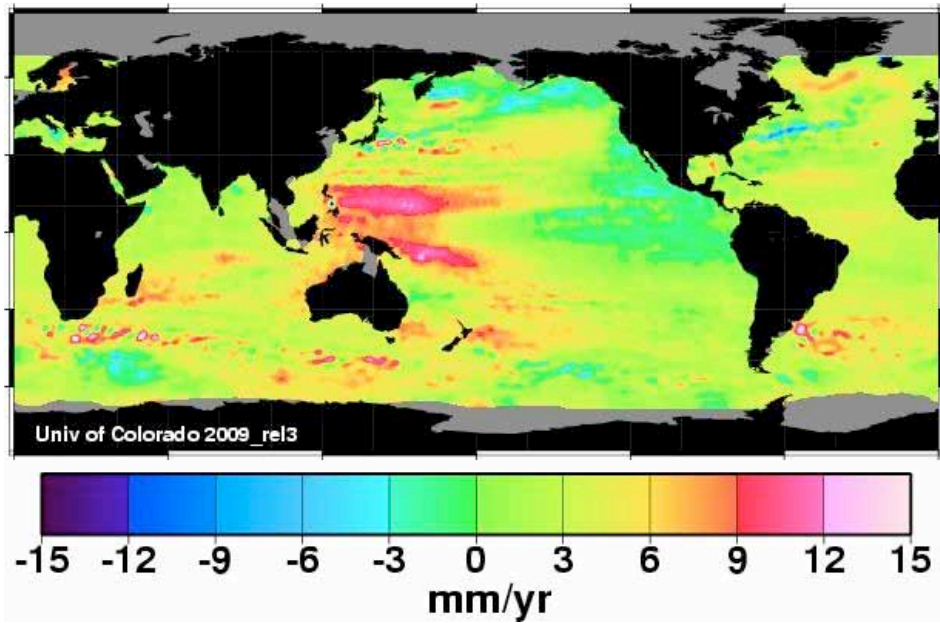




Source: Levitus et al 2009



# Regionalized trends

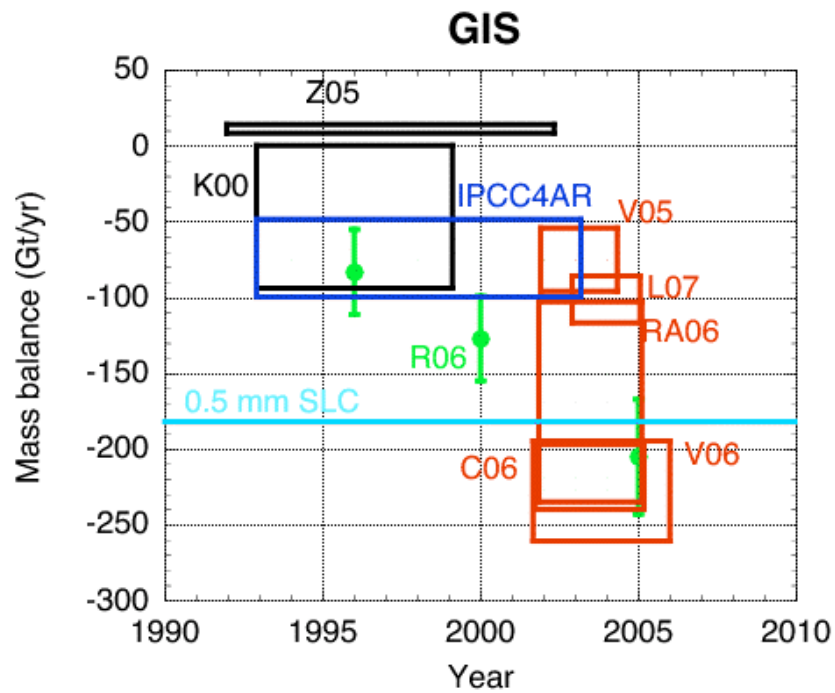


Source: Univ of Colorado; Wouters et al 2008



# Ice sheets

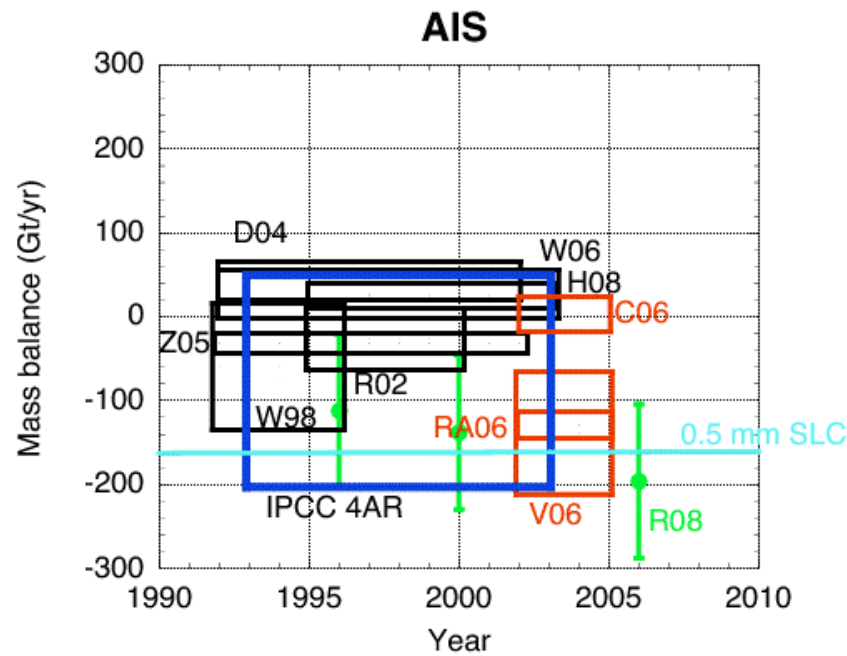
Most uncertain component. Limited understanding → make use of observations





# Ice sheets

Most uncertain component. Limited understanding → make use of observations





## Global Earth Observing System (of Systems)

### **< 2010: Understanding sea level change:**

*closing the budget, role of ice caps → Attribution of changes*

### **Up to 2035: Initialized near-term predictions**

*Planetary waves, heat content → small signal, attribution*

### **Beyond 2035: Long-term scenario's**

*Guiding experts → Ice cap contributions, gravity*

**All time horizons: early warning**



## The Dutch example Vulnerability to sea level rise

Vulnerability = f (adaptive capacity, **exposure** )

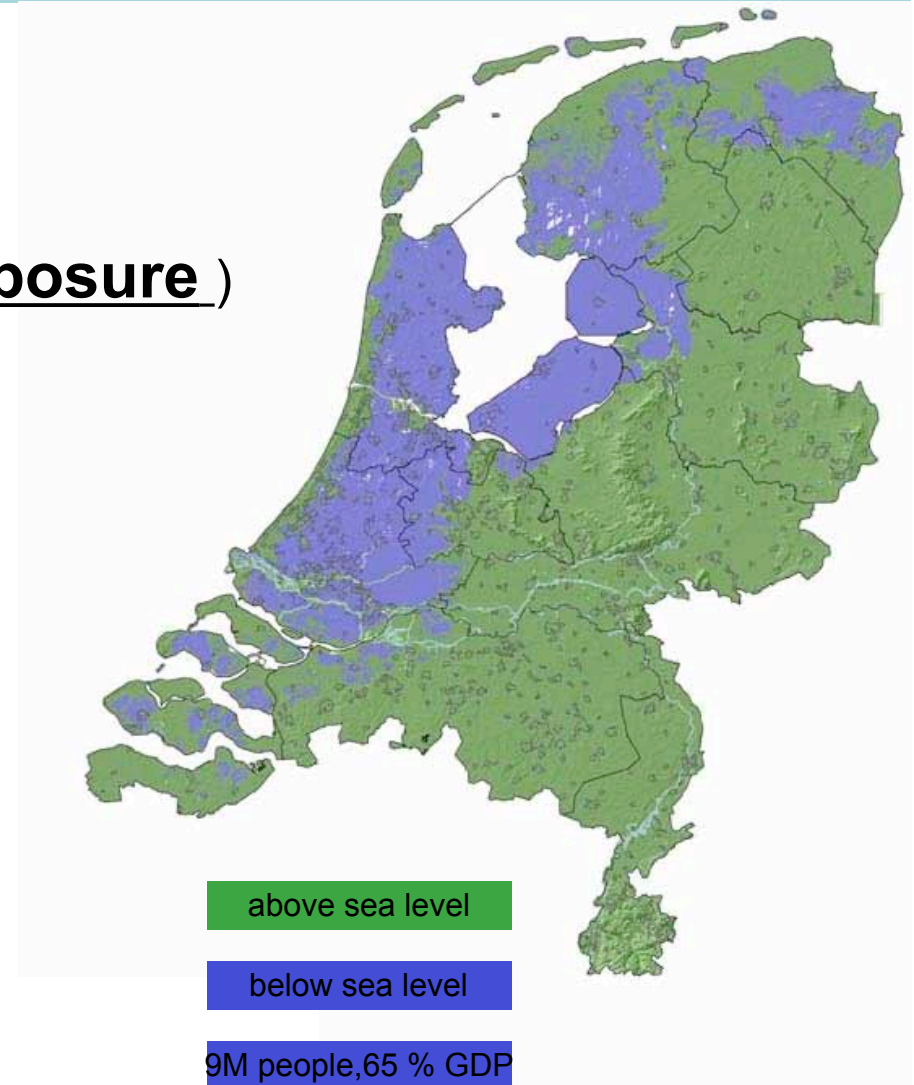
Risk = f (impact, probability)

Uncertainty too large for predictions

→ Scenario's tailored to stakeholder

→ Strong guidance needed

- High impact, low probability scenario
- Average impact, likely scenario
- ...





# Adaptation

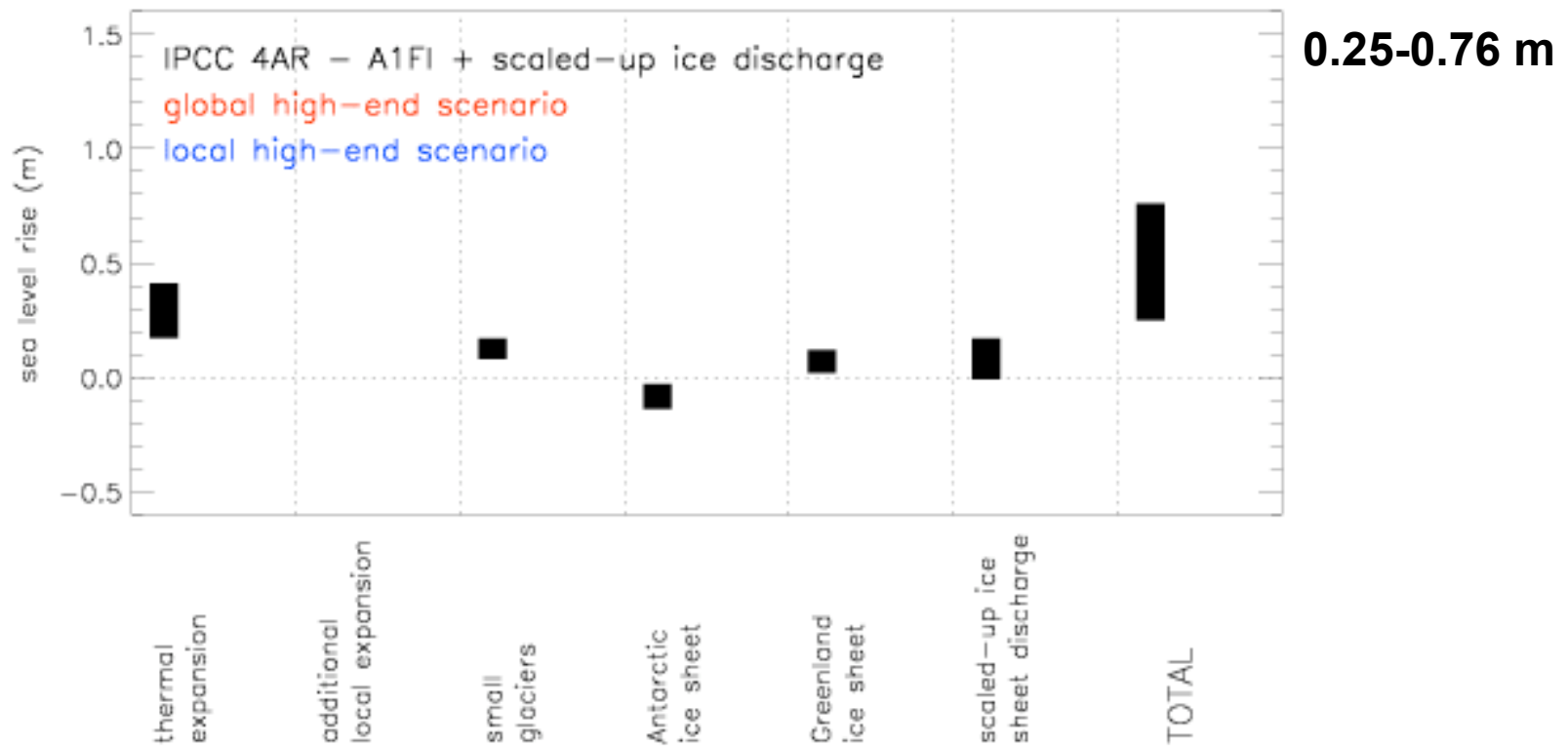
Coastal adaptation (IPCC CZMS, 1990)	Adaptation objectives (Klein and Tol, 1997)	Adaptation responses (after Cooper et al., 2002; Defra, 2001)	Example
Protect	Increased robustness	Advance the line	Land claim; empoldering Estuary closure
		Hold the line	Dyke; beach nourishment
Accommodate	Increased flexibility		'Flood proof' buildings Floating agricultural systems
Retreat	Enhanced adaptability	Retreat the line	Managed realignment
		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

Source: IPCC 4 AR



# Example: High end regional sea level scenario

Combination of observational evidence and climate model projections

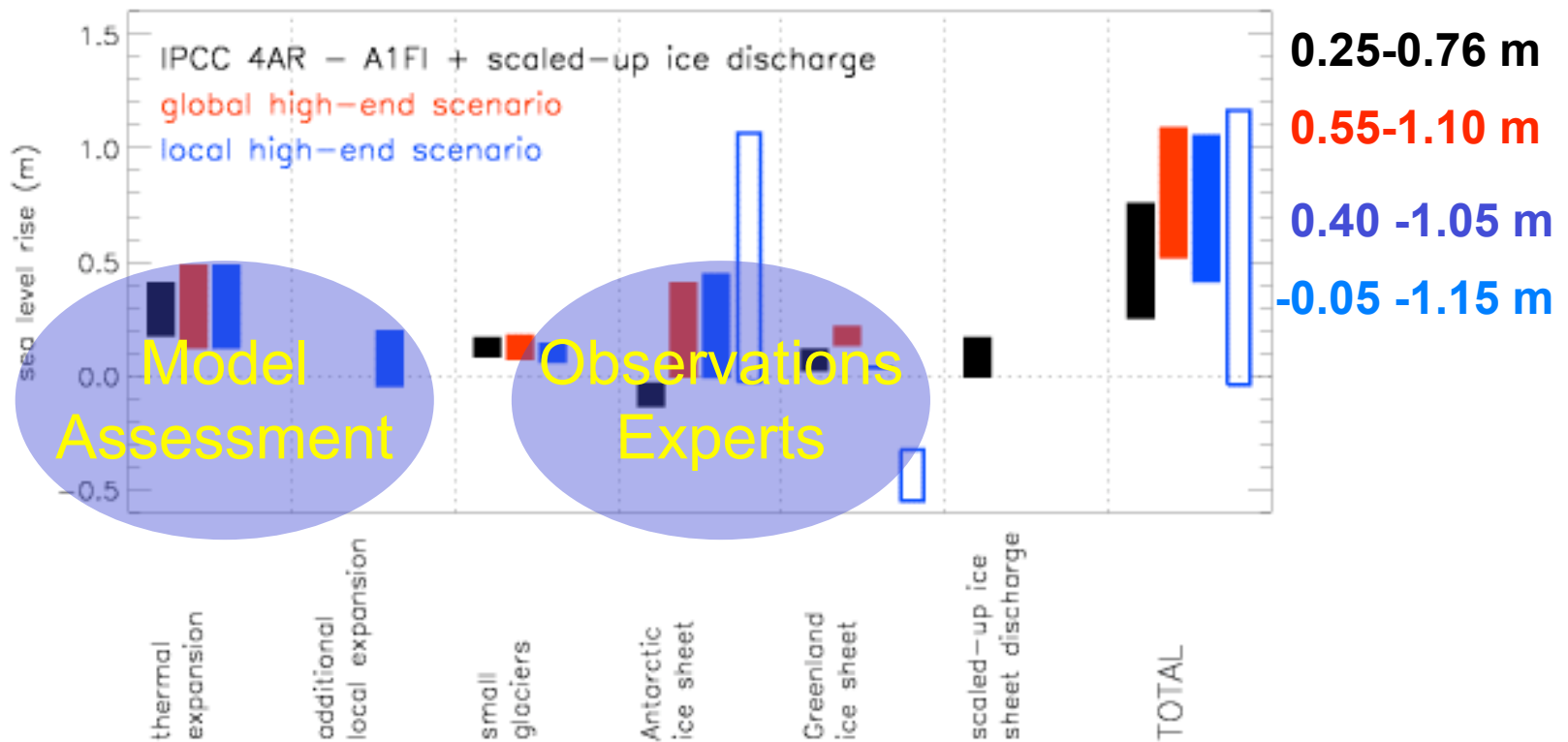


Source: Katsman et al 2009



# Example: High end regional sea level scenario

## Combination of observational evidence and climate model projections

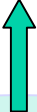


Source: Katsman et al 2009

Stakeholder  
Vulnerability assessment



Tailoring & expert guidance  
User friendly data delivery  
Scenario construction



Integrated  
Observing  
System

Expert  
Knowledge

Climate  
Predictions &  
Projections

Water managers  
Flood risk

Expert guidance on uncertainties  
Web services  
Regional sea level scenario's

GRACE  
TOPEX  
ARGO

Oceanographers  
Glaciologists  
Climate modellers

IPCC AR5 models  
Surge models

