





Supporting Cryospheric Research Since 1976





Current estimates and future projections of global mean sea level rise

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Nokuemblendgy Bentus der, CO

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- Dorthe Dahl-Jensen, Univ. of Copenhagen, lead author SWIPA Greenland chapter

Causes of sea level change







Tide gauge record







Satellite altimeter record





60-day smoothing, seasonal variations removed



Altimeter rate has slowed









Greenland 1995-2005 surface mass balance

Ice Discharge (320-420 Gt/yr)

Inbalance (50-200 Gt/yr)

Sea level rise as of IPCC AR4 (2007)

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Thanks to W. Abdalati, Earth Science and Obs. Center, Univ. Colorado

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Greenland mass balance from GRACE, 2003-2010

GRACE = Gravity Recovery And Climate Experiment

Cumulative anomaly

J. Wahr, I. Velicogna

Antarctica mass balance from GRACE, 2002-2009

Mass Balance = -169 ± 75 Gt/yr

High uncertainty due to post-glacial rebound model

J. Wahr, I. Velicogna

Acceleration in ice sheet mass loss

Greenland mass loss accelerating at -21.9 Gt/yr² (1992-2010)

Antarctica mass loss accelerating at -14.5 Gt/yr² (1992-2010)

Acceleration due to interaction of warming ocean and ice sheet dynamics

E. Rignot et al., 2011

Altimeter rate has slowed

Influence of ENSO on sea level

1993-2002 El Nino more dominant
2003-2011 La Nina more dominant

 High correlation between de-trended sea level and MEI

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Wolter and Timlin, 1993; 1998

Contributions to sea level rise

Glacier mass balance

M. Dyurgerov and M. Meier, 2005

How to project sea level rise?

- Ice sheets will become dominant contributor to sea level rise
- Dynamics of ice sheets still not well understood
- Physical models do not simulate response of ice sheets (getting better)
- Use semi-empirical approach sea level response to temperature increase: dH/dt = a(T – T₀)

Sea level projections

Observed and potential future sea level change

	93-03 Observed <i>IPCC</i> (mm/yr)	03-09 Observed <i>SWIPA</i> (mm/yr)	2100 AD <i>IPCC</i> (m)	2100 AD SWIPA (m)	Potential 3000 AD <i>SWIPA</i> (m)
Thermal Expansion	1.6	0.3	0.2-0.35	0.2 – 0.35	
Greenland & Antarctica	0.4	1.0	0.05	0.5 – 0.75) 1 – 3 (?)
Glaciers	0.8	1.4	0.2-0.3	0.2 – 0.3	
Land storage	?	-0.2	?	?	
Total	3.1	2.5	0.2 – 0.6	0.9 – 1.6	5 – 8 (?)

Summary

- Recent sea level trends modified by ENSO events
- Cryospheric contribution to sea level increasing
- Ice mass loss accelerating
- Acceleration largely due to ice sheet dynamics
 - Flow of outlet glaciers respond to surface melt and increased ocean heat
- IPCC AR4 projections likely too low

