

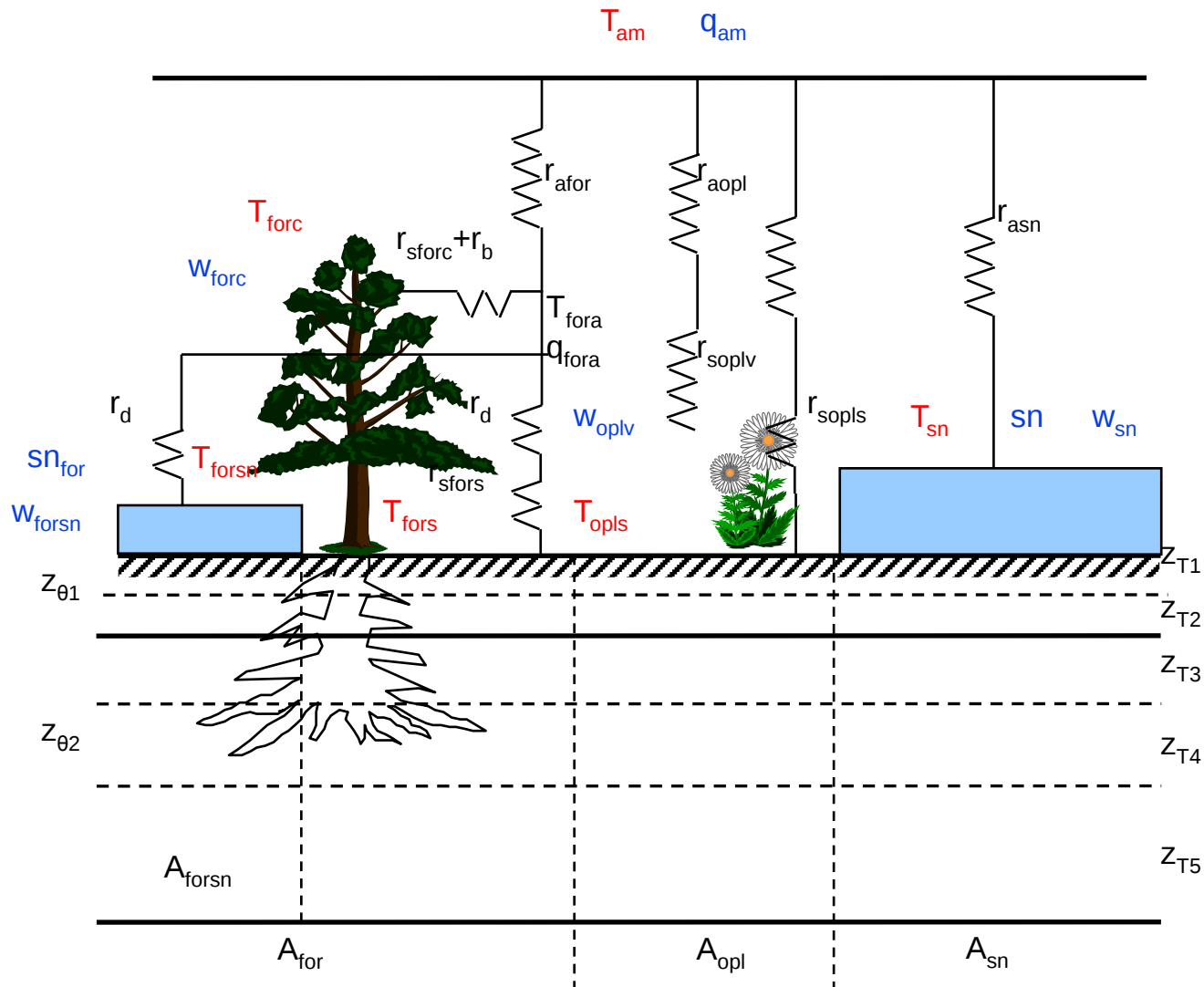
From BALTEX research to adaptation to climate change – a Swedish perspective

Sten Bergström

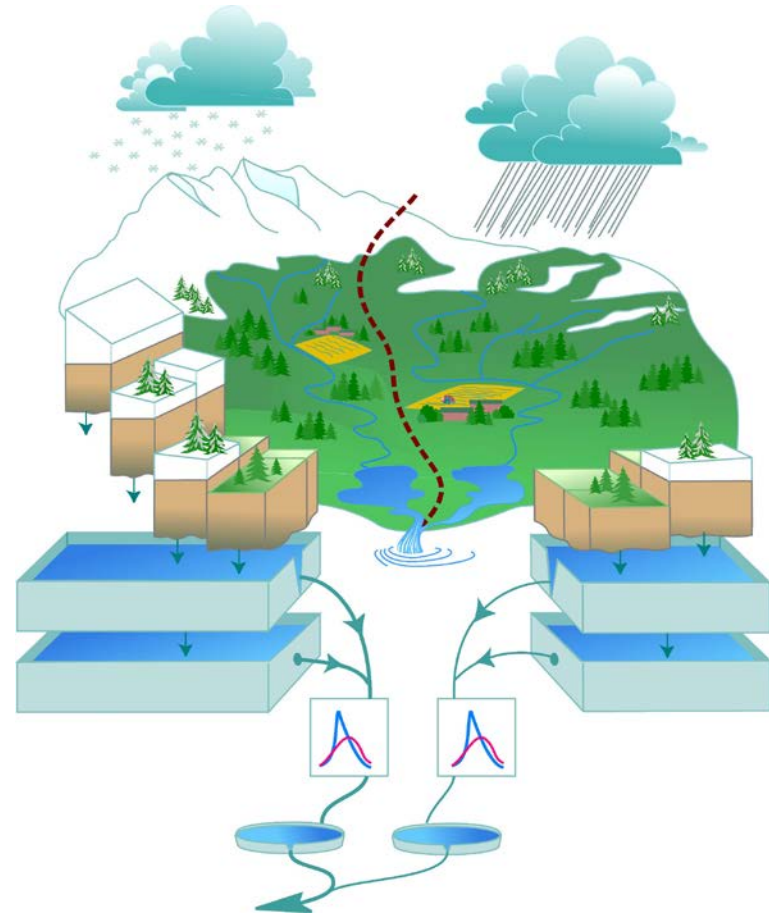
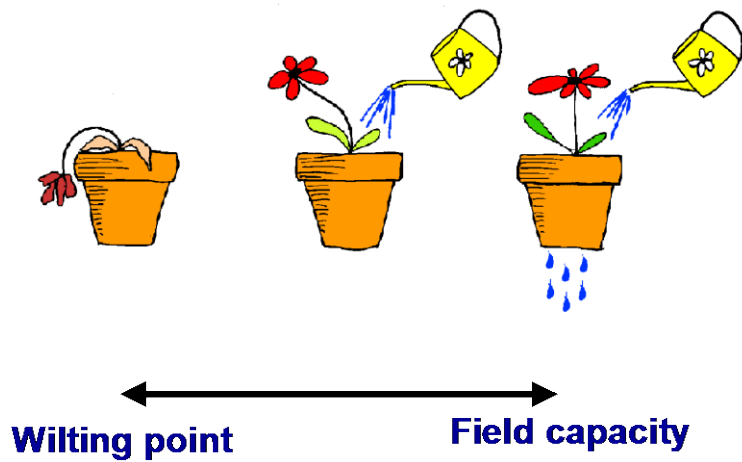
Different perspectives on Mother Nature



A meteorologist's view



A hydrologist's view



Which model can fly?



Conceptual hydrological modelling of the overall water balance of the Baltic basin - the HBV approach

Sten Bergström, Göran Lindström

Swedish Meteorological and Hydrological Institute, Norrköping

L. Phil Graham

Royal Institute of Technology, Stockholm

Daniela Jacob

Max-Planck-Institute for Meteorology, Hamburg

Contribution to the NEWBALTIC project, contract No. ENV4-CT95-0072

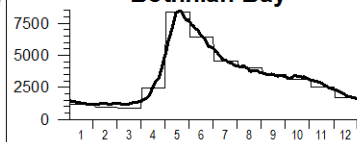
1981-1991 (m^3/s)

— observations

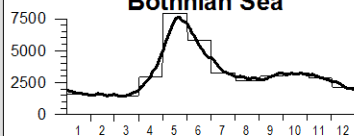
— modelled

SMHI

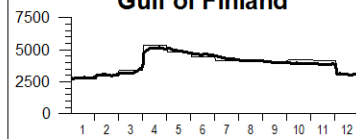
Bothnian Bay



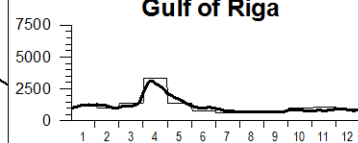
Bothnian Sea



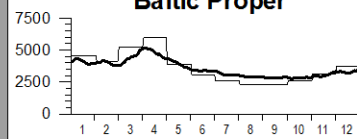
Gulf of Finland



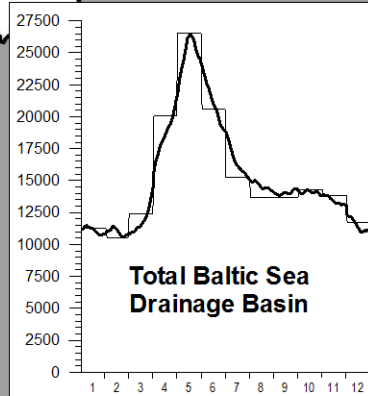
Gulf of Riga



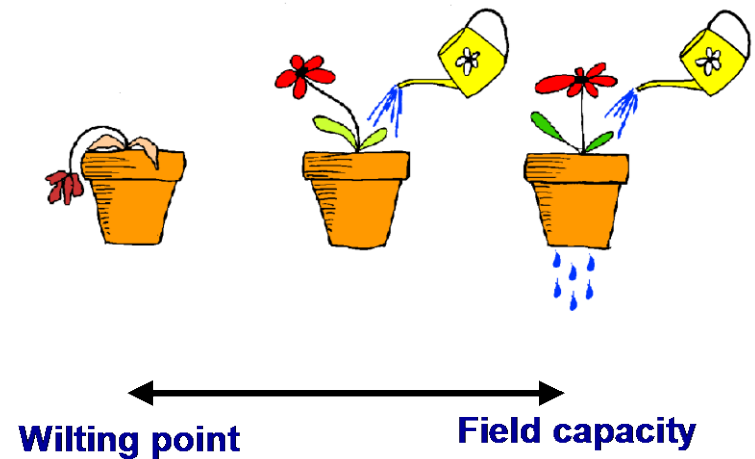
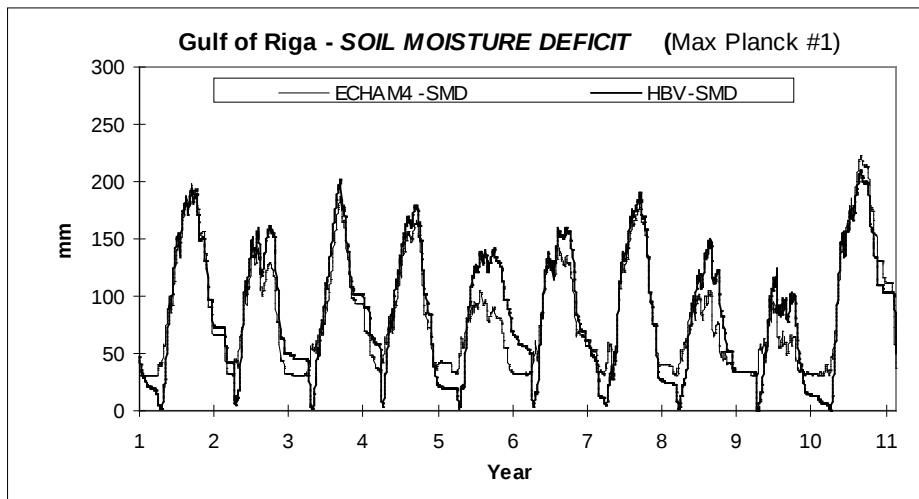
Baltic Proper



**Total Baltic Sea
Drainage Basin**



United at last??



Comparison between the dynamics of the soil moisture accounting of the ECHAM-4 model and HBV-96 for the Gulf of Riga catchment. The HBV model is driven by precipitation and air temperature data from ECHAM-4 in this case.

Practical applications in Sweden

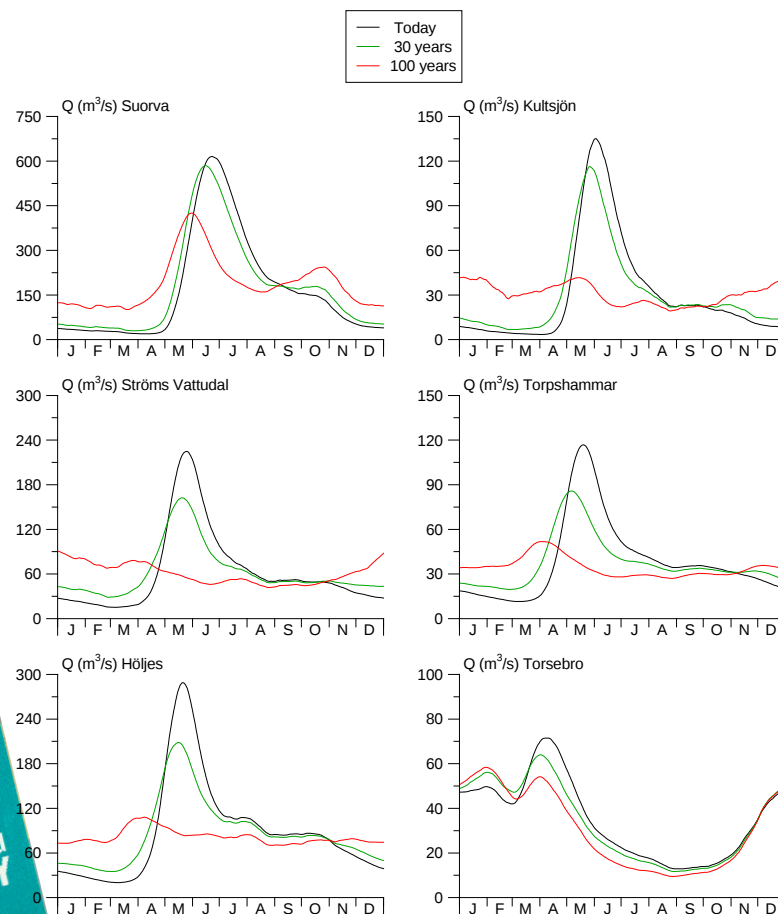
Hydropower in the forefront



The first Nordic project 1991-1996



0, 30 and 100 years from today



Reported in 1998

Nordic-Baltic projects on the impact of climate change on renewable energy

Climate Water and
Energy 2001-2002

Climate and Energy
2003-2006

Climate and Energy
Systems 2007-2010

Dam safety and design floods!



The Swedish guidelines for design floods for dams

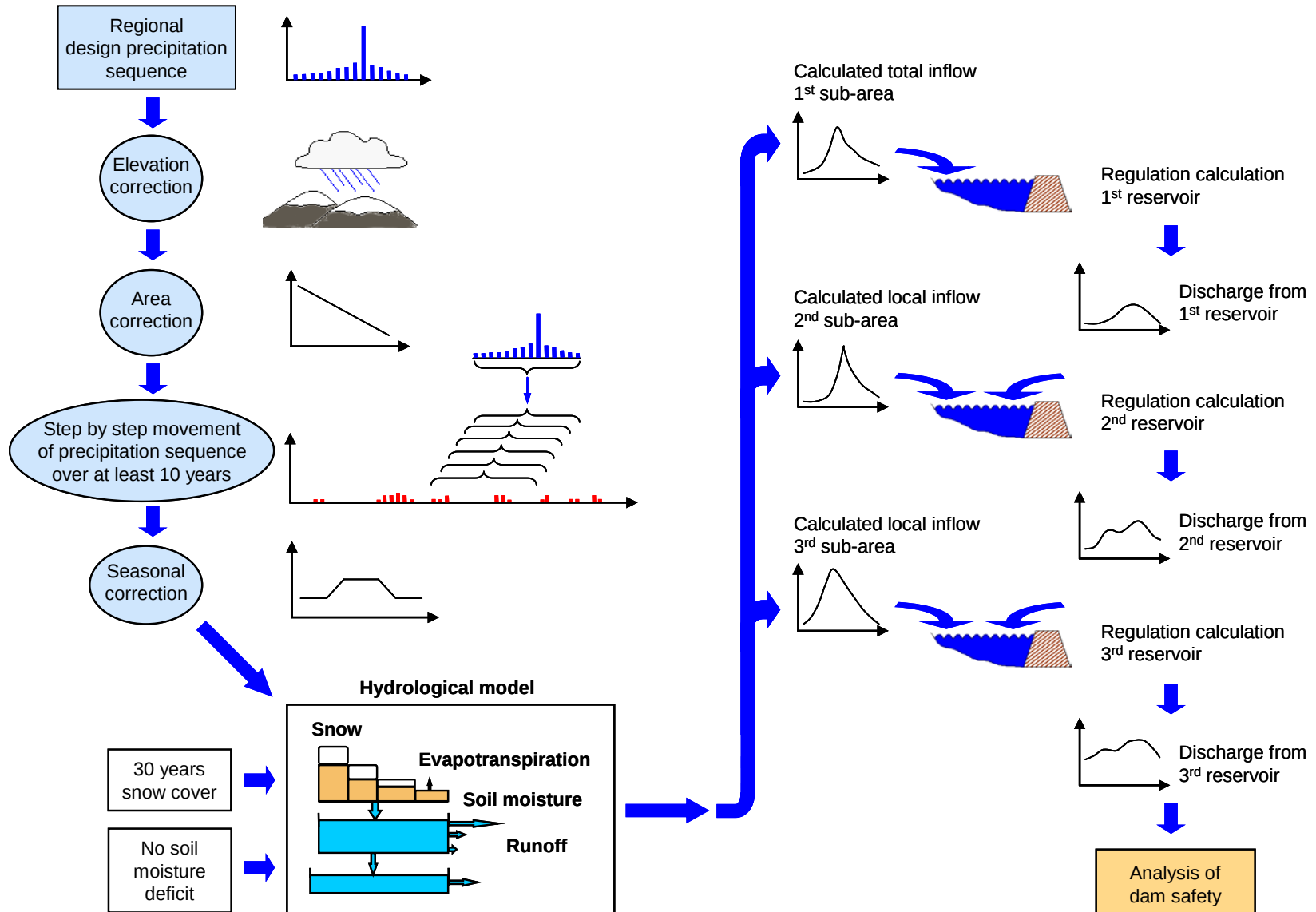
First edition in 1990

New edition in 2007

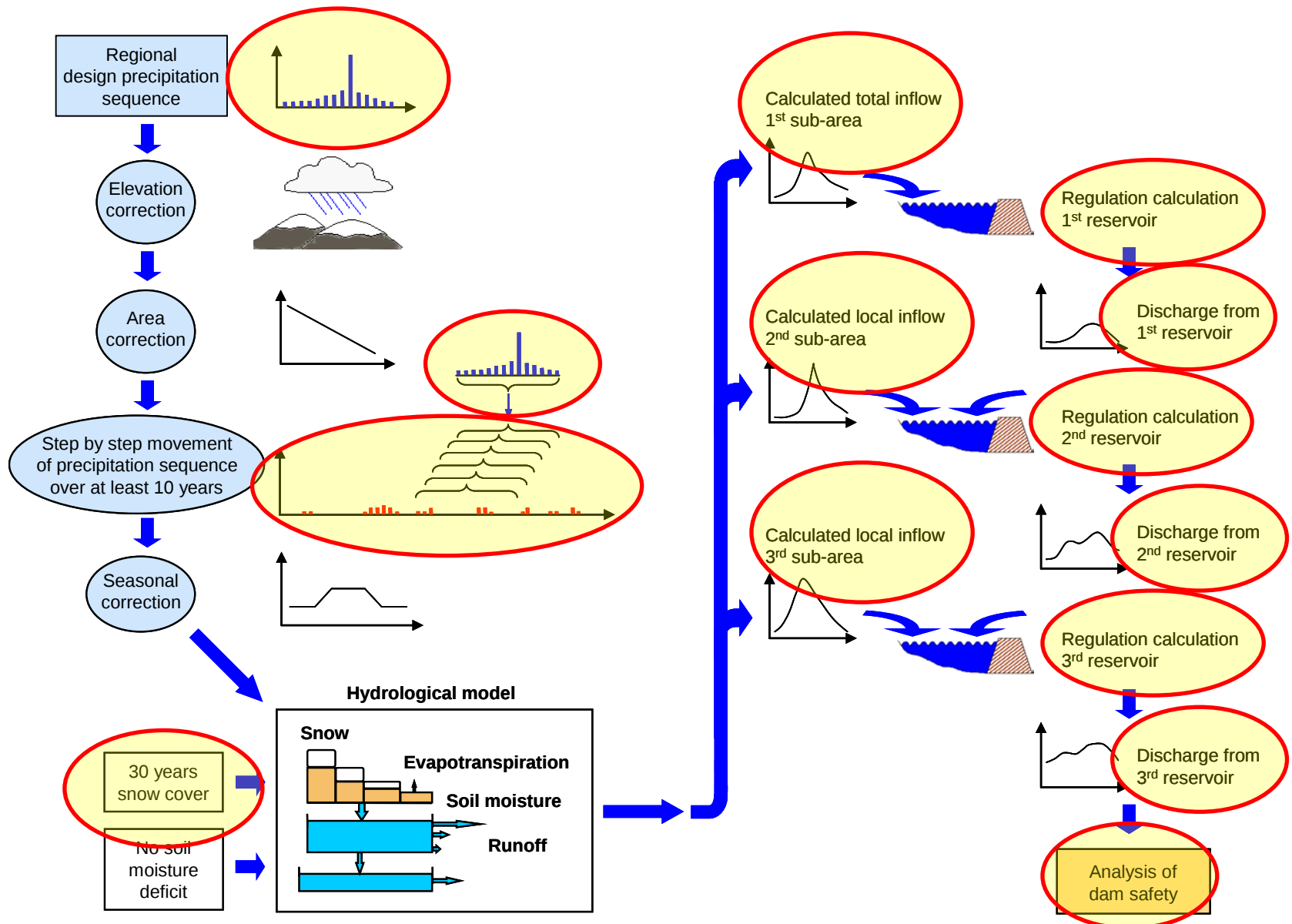
**Adaptation to Climate Change
is prescribed!**



Calculation scheme for Flood Design Category I



Components affected by climate change



Reports on dam safety and climate

ELFOR

DAMMSÄKERHET
Känslighetsanalys av ett framtida

ELFORSK

DAMMSÄKERHET
Känslighetsanalys av Flödet i ett framtida förändrat klimat kompletterad med analys

ELFORSK

DAMMSÄKERHET

Dimensionerande flöden för dammanläggning i ett klimat i förändring - metodutveckling och scenarier

Rapport

ELFORSK

DAMMSÄKERHET

Analys av osäkerheter vid beräkning av dimensionerande flöden för dammar i flödesdimensioneringsklass I

Elforsk rapport 11:31

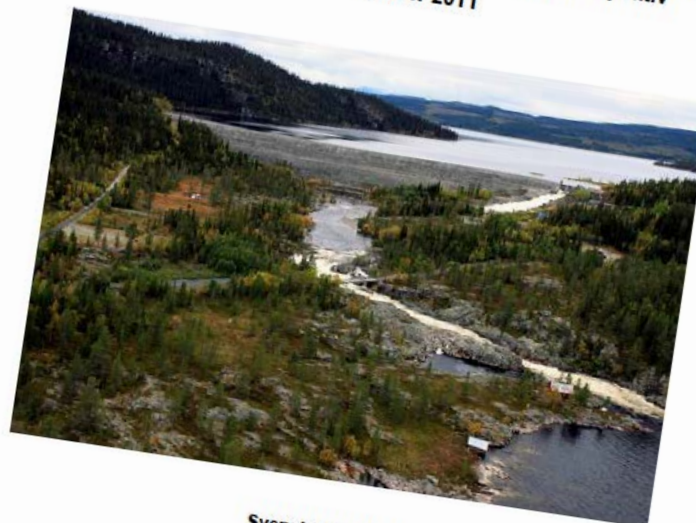
The "Climate Committee" set up by the power and mining industries, the dam safety authority and SMHI.



Final recommendations
by the climate committee

Dammsäkerhet och klimatförändringar

Slutrapport från Kommittén för dimensionerande flöden för
dammanläggningar i ett klimatförändringsperspektiv
December 2011



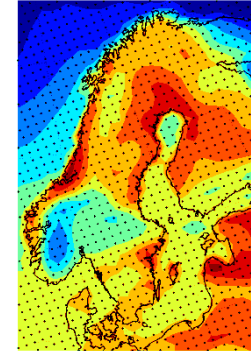
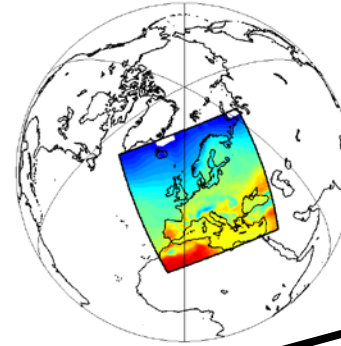
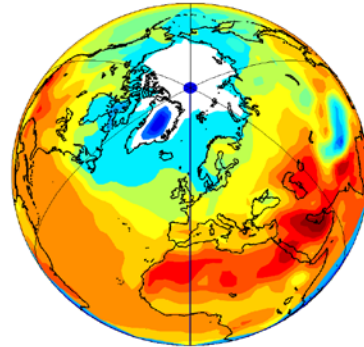
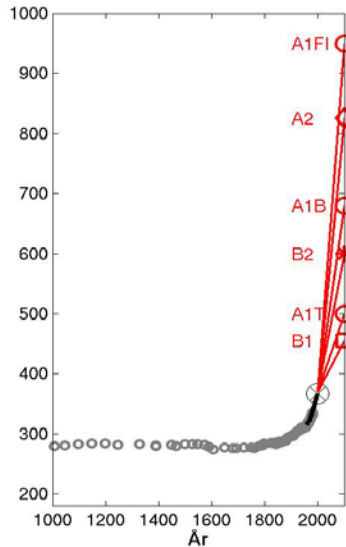
Svenska Kraftnät
Svensk Energi
SveMin
SMHI

From emissions to design floods

Emissions

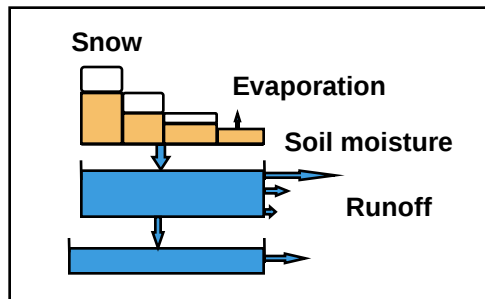
Global climate model

Regional climate model



Bias correction

Hydrological model



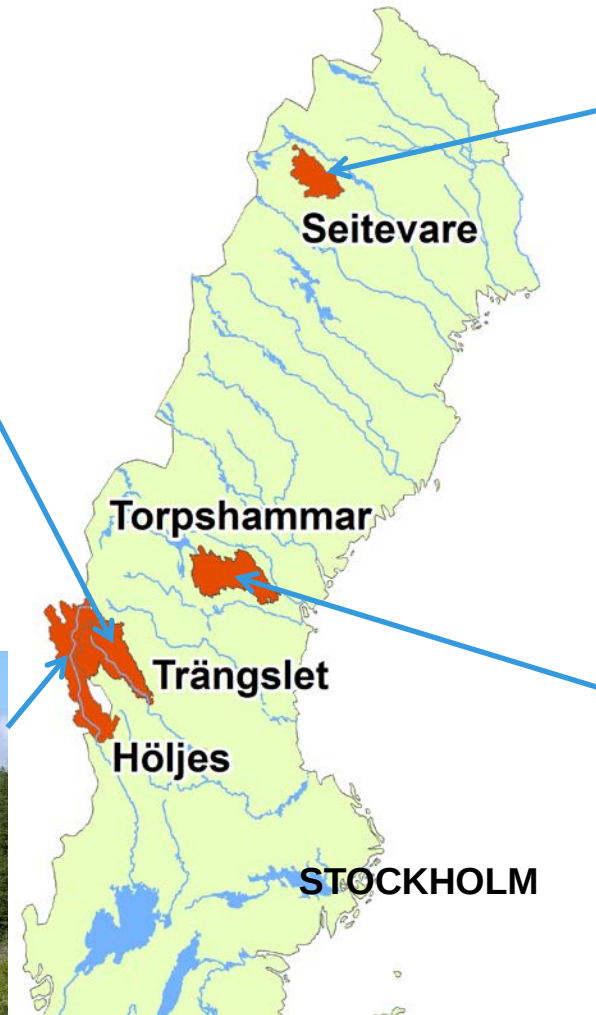
Calculation according to Flood Design Category I

Summary of 16 regional climate scenarios used

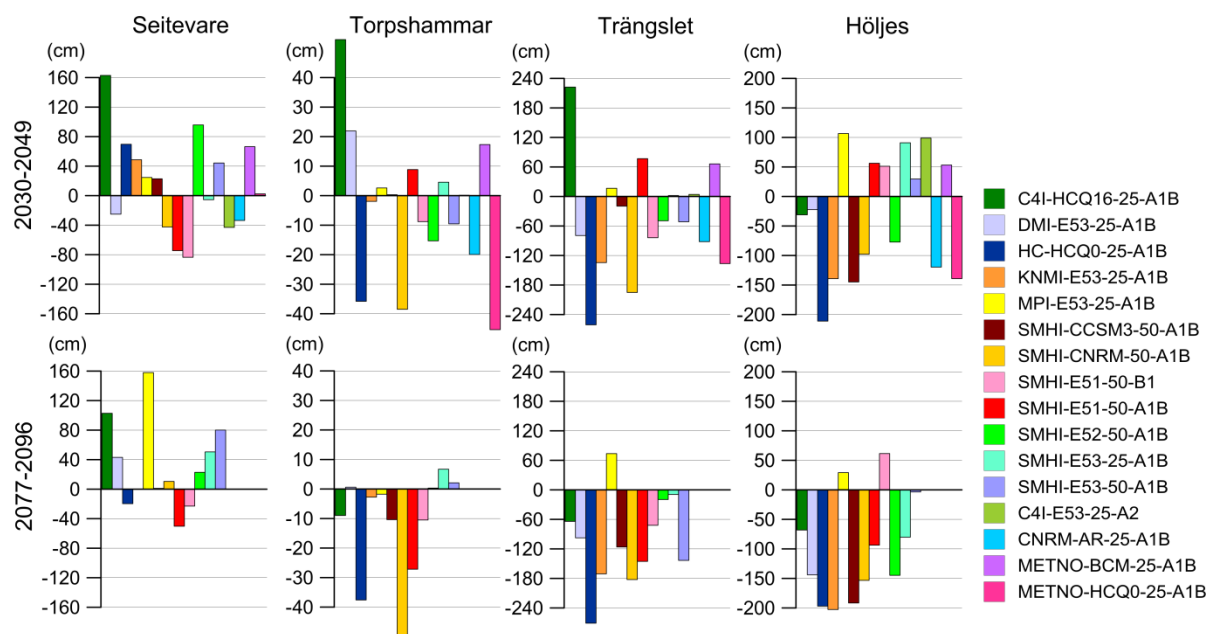
Emission Scenario	Global Climate Model (GCM)	Regional Climate Model (RCM)	Resolution	Period simulated	Comments on the GCMs
A1B	ECHAM5(1)	RCA3	50 km	1961-2100	(1) denotes No 1 of 3 different initial conditions
A1B	ECHAM5(2)	RCA3	50 km	1961-2100	(2) denotes No 2 of 3 different initial conditions
A1B	ECHAM5(3)	RCA3	50 km	1961-2100	(3) denotes No 3 of 3 different initial conditions
A1B	ECHAM5(3)	RCA3	25 km	1961-2100	(3) denotes No 3 of 3 different initial conditions
A1B	CNRM	RCA3	50 km	1961-2100	
A1B	CCSM3	RCA3	50 km	1961-2100	
A1B	CNRM	Aladin	25 km	1961-2050	
A1B	ECHAM5(3)	RACMO	25 km	1961-2100	(3) denotes No 3 of 3 different initial conditions
A1B	ECHAM5(3)	REMO	25 km	1961-2100	(3) denotes No 3 of 3 different initial conditions
A1B	HadCM3(Q0)	HadRM3	25 km	1961-2100	(Q0) denotes medium climate sensitivity
A1B	HadCM3(Q16)	RCA3	25 km	1961-2100	(Q16) denotes high climate sensitivity
A1B	BCM	HIRHAM	25 km	1961-2050	
A1B	HadCM3(Q0)	HIRHAM	25 km	1961-2050	(Q0) denotes medium climate sensitivity
A1B	ECHAM5(3)	HIRHAM	25 km	1961-2100	(3) denotes No 3 of 3 different initial conditions
B1	ECHAM5(1)	RCA3	50 km	1961-2100	(1) denotes No 1 of 3 different initial conditions
A2	ECHAM5(3)	RCA3	25 km	1961-2050	(3) denotes No 3 of 3 different initial conditions

4 test basins out of a total of 11

SMHI



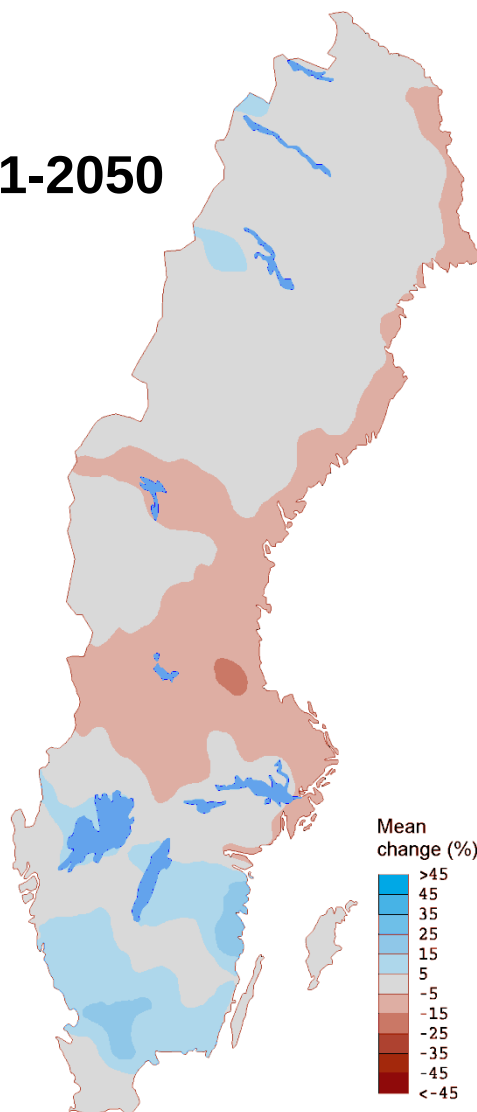
Summary of the simulated effects on the changes in the design reservoir levels for the four reservoirs



Change in the 100-year flood from 1963-1992...

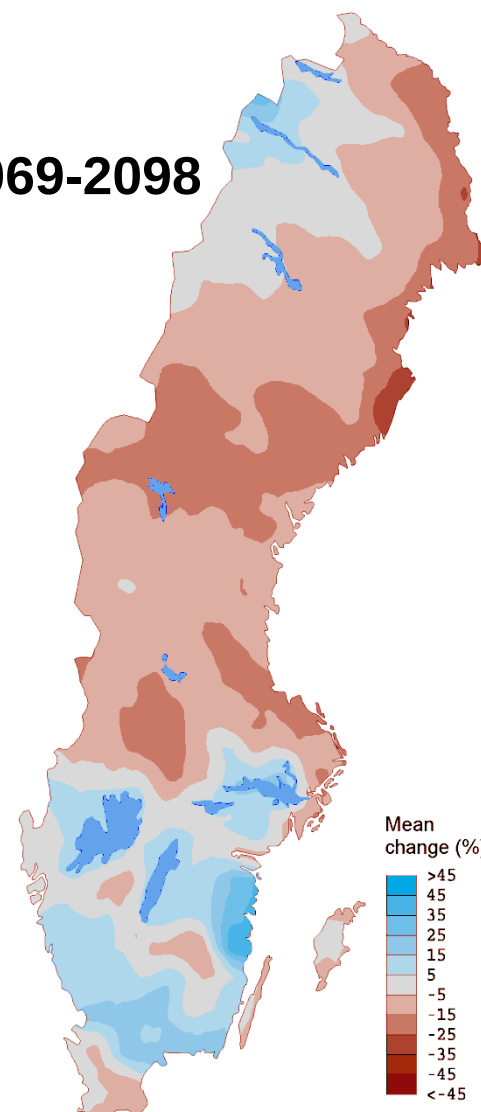
...until 2021-2050

Mean of 16
climate
scenarios



...until 2069-2098

Mean of 12
climate
scenarios







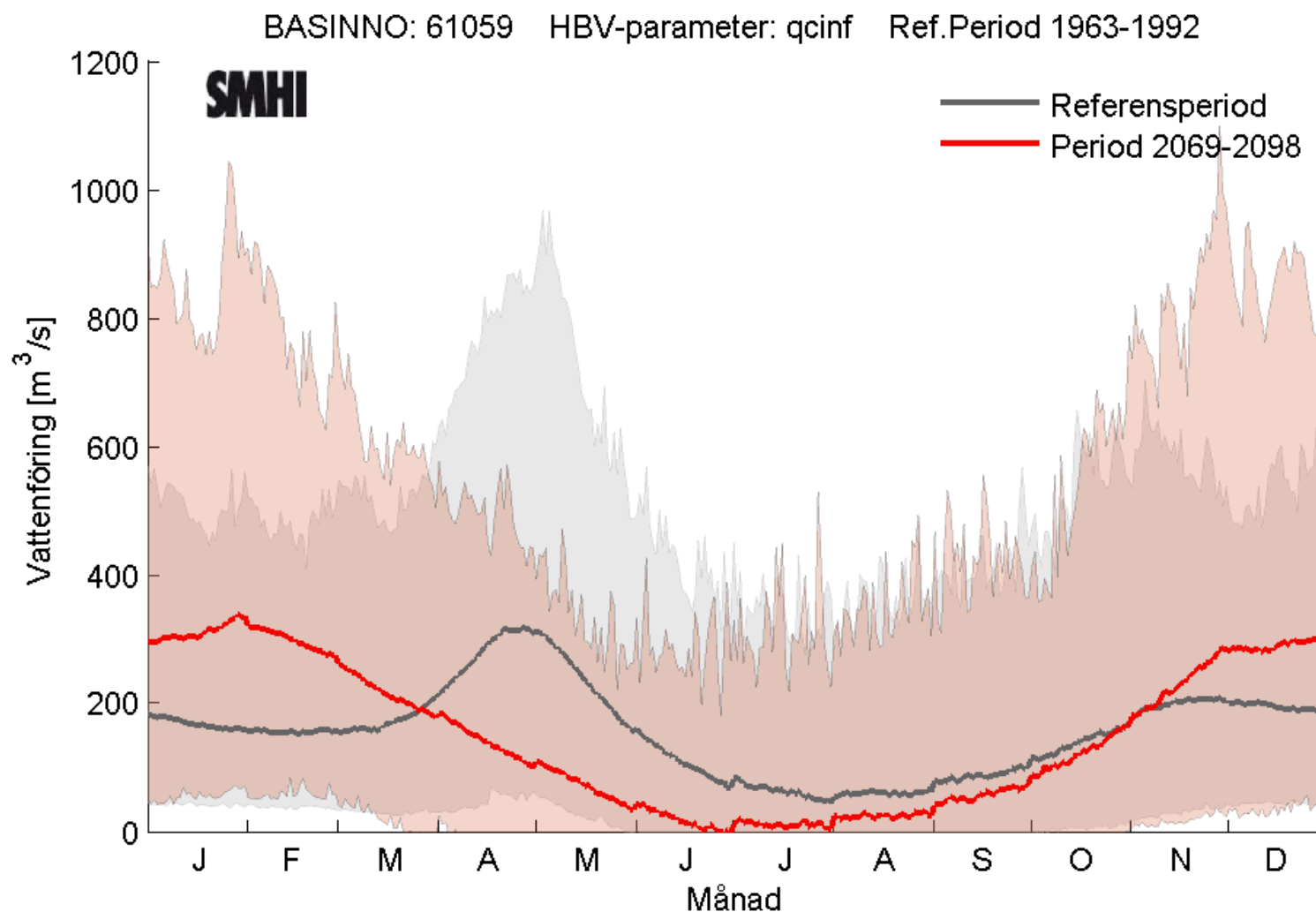
Lake Mälaren at + 70 cm

The Baltic Sea

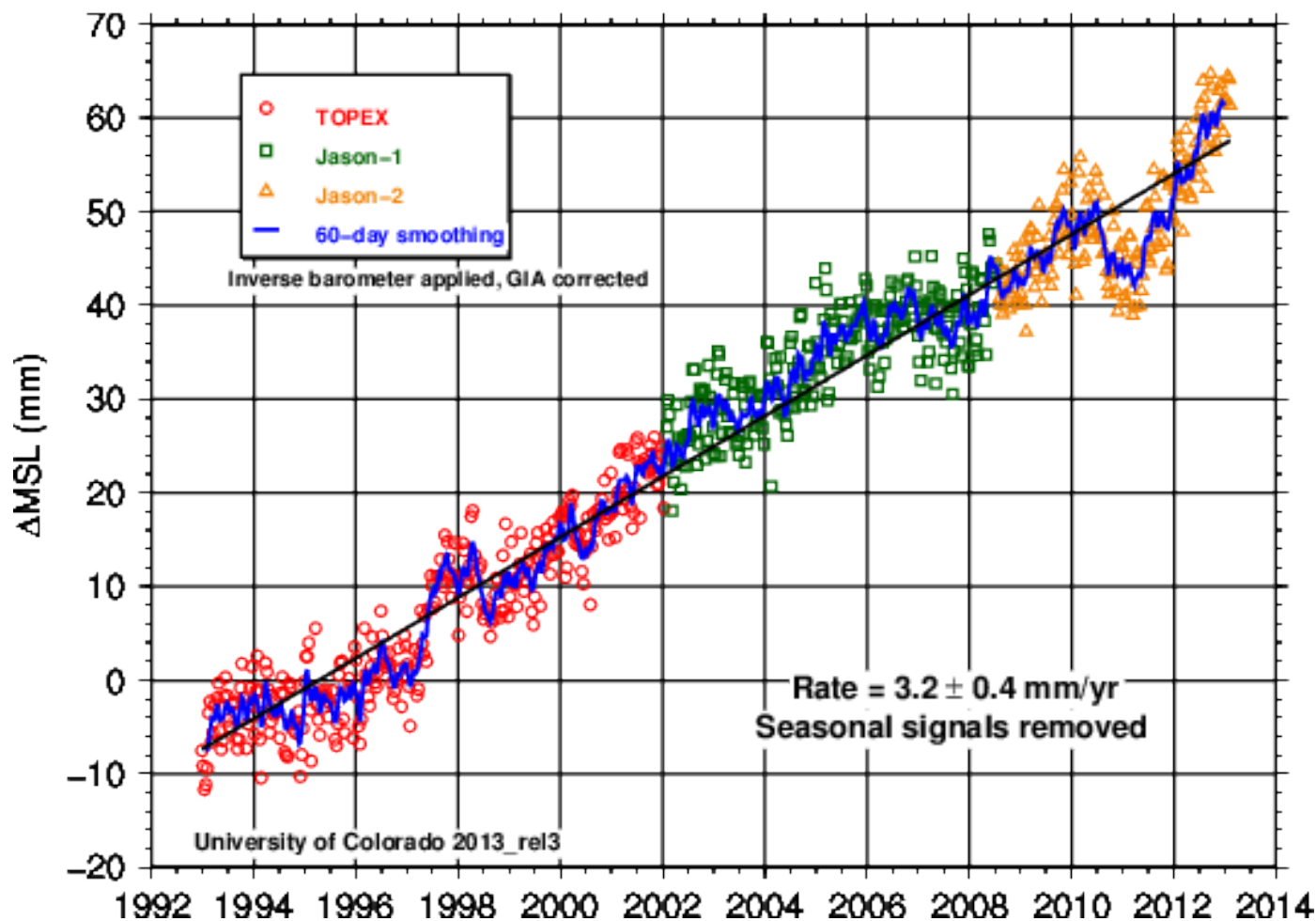




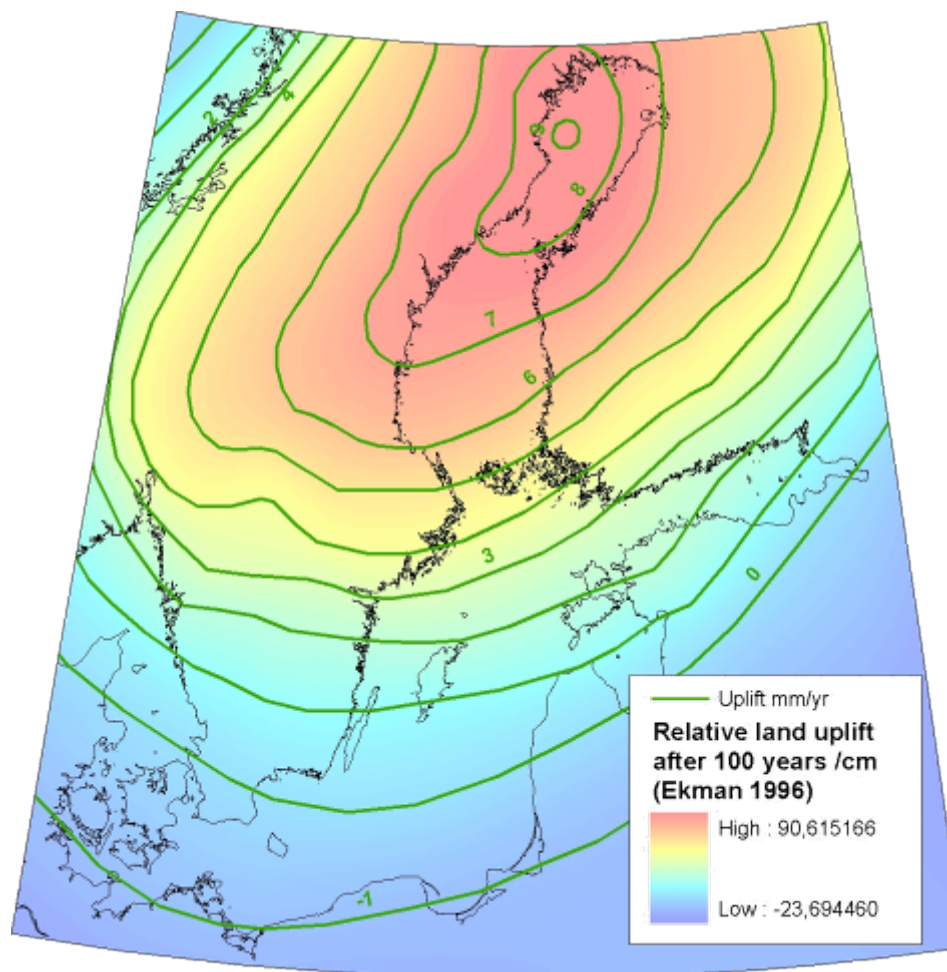
New inflow dynamics from rivers to Lake Mälaren



Sea levels up to 2013-04-20



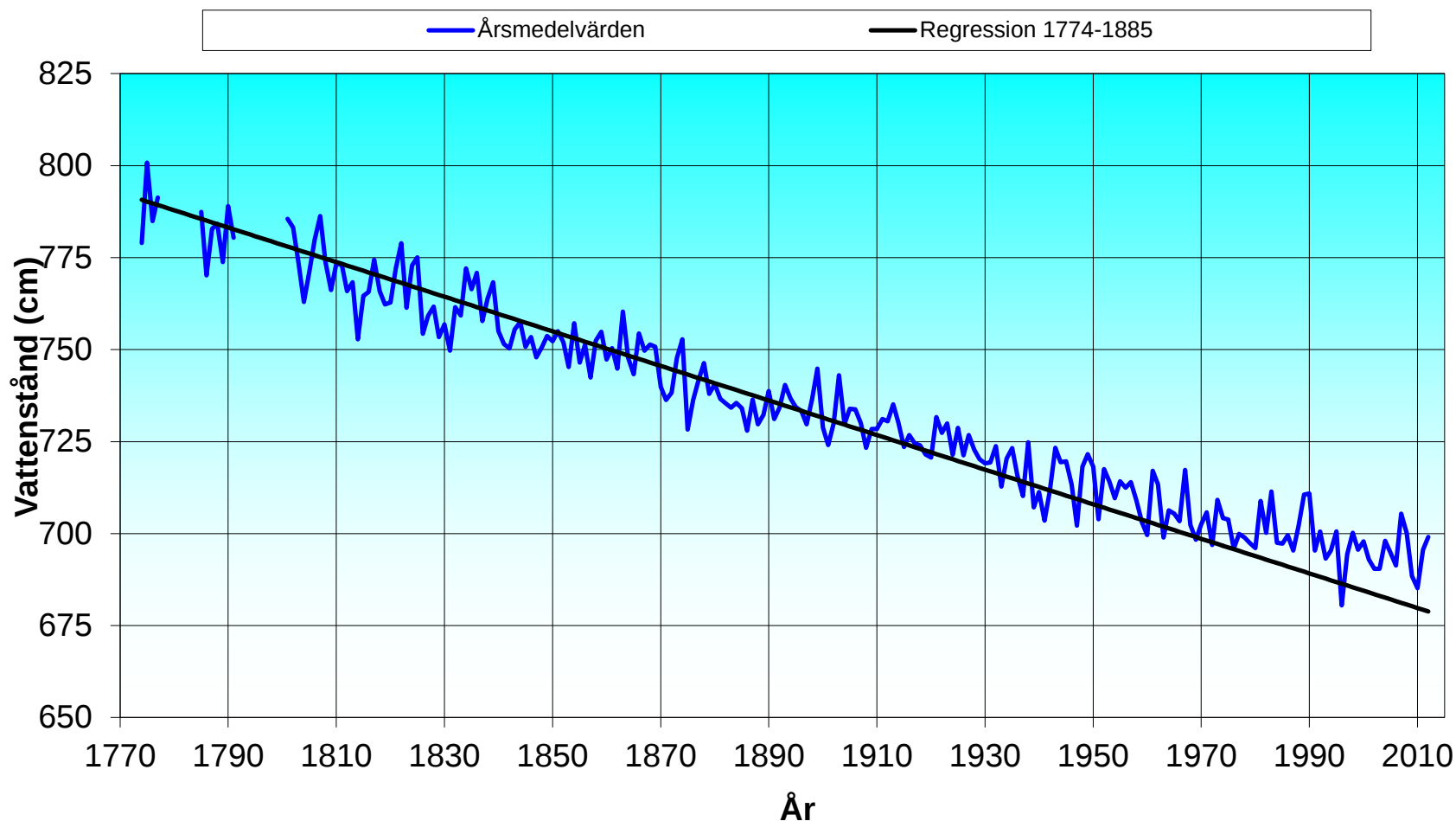
Relative uplift of land in 100 years



Sea levels in Stockholm 1774-2012

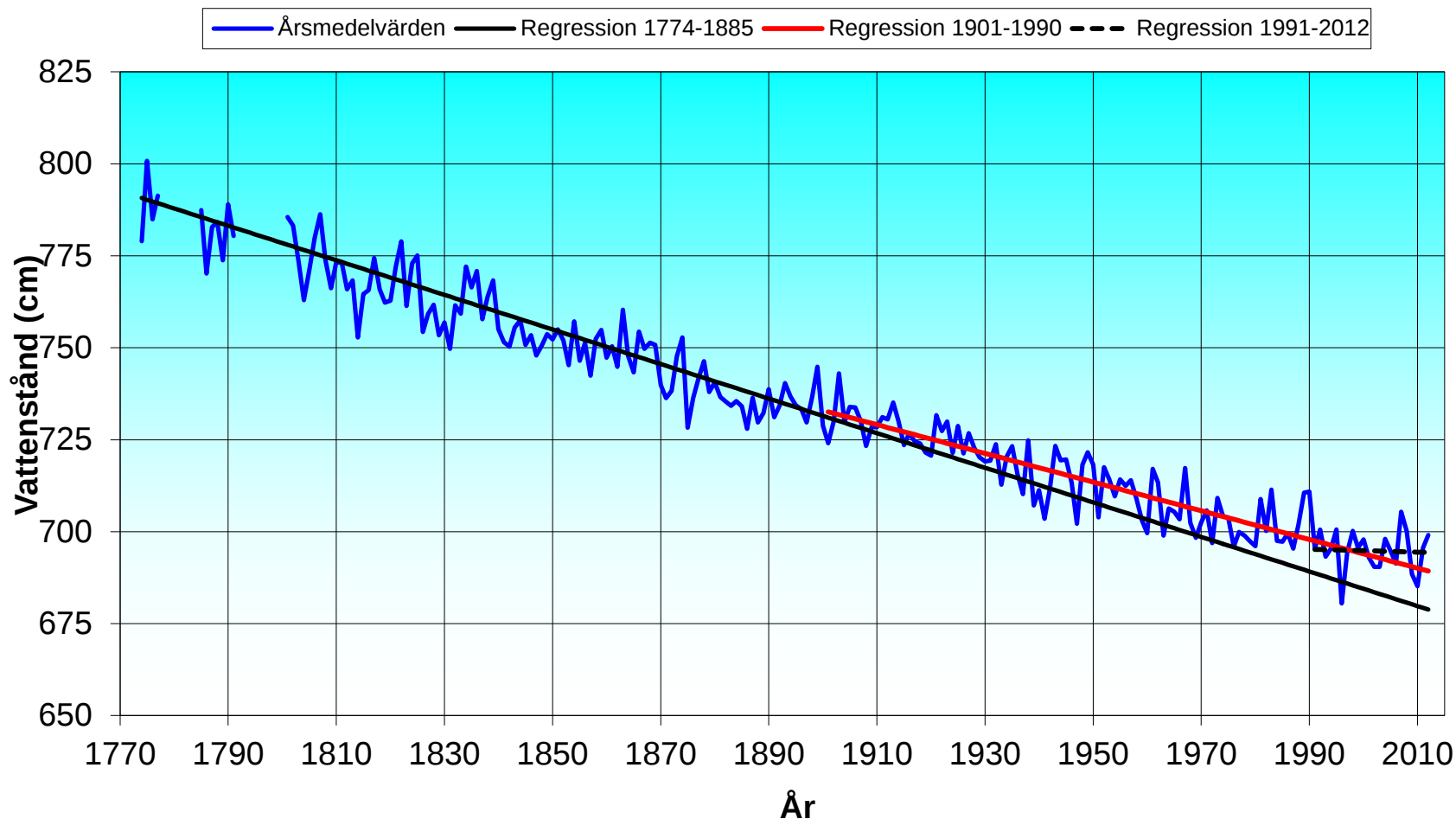


Havsvattenstånd Stockholm 1774 - 2012

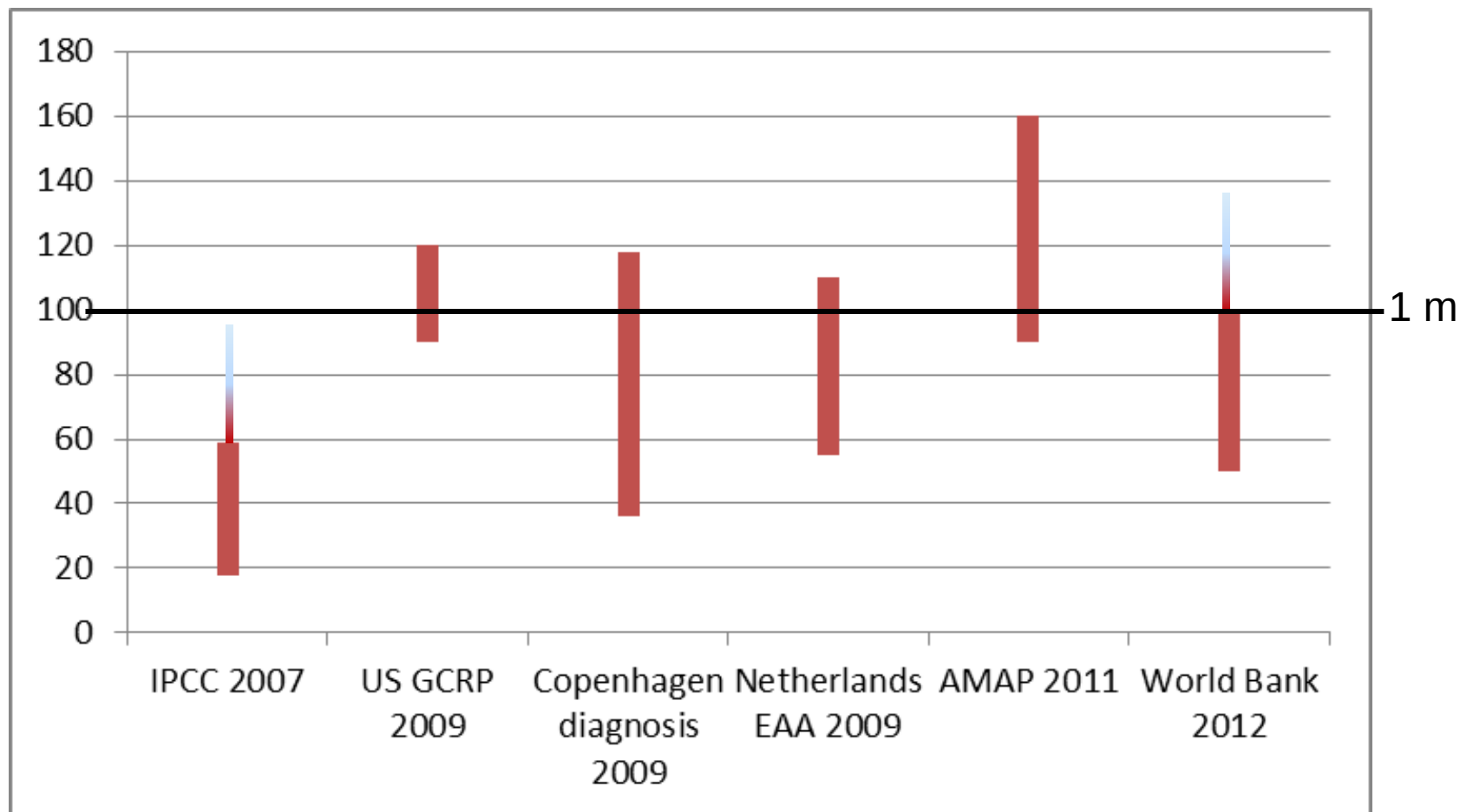


Sea levels in Stockholm 1774-2012

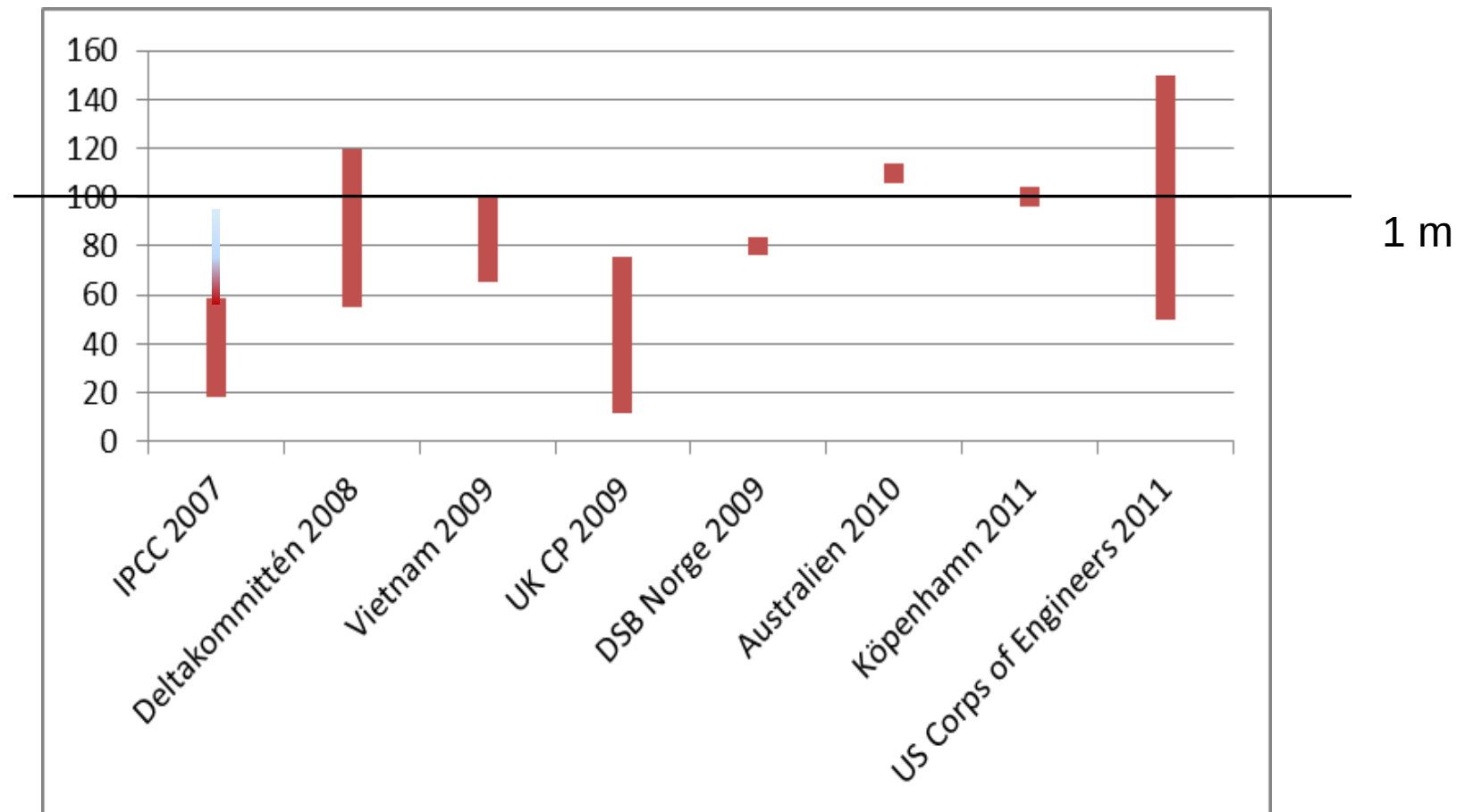
Havsvattenstånd Stockholm 1774 - 2012



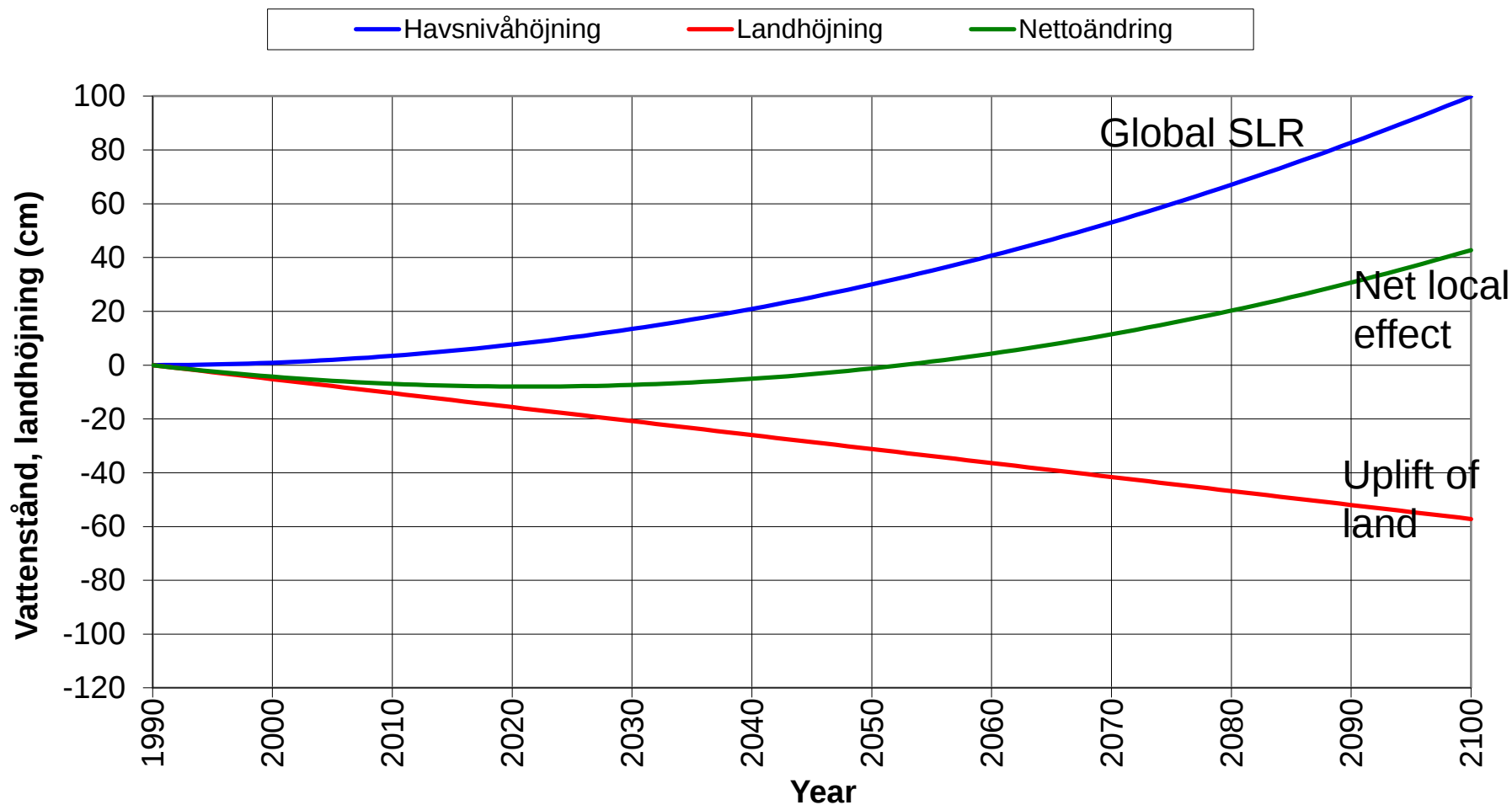
Some recent scientific assessments of Sea Level Rise until 2100



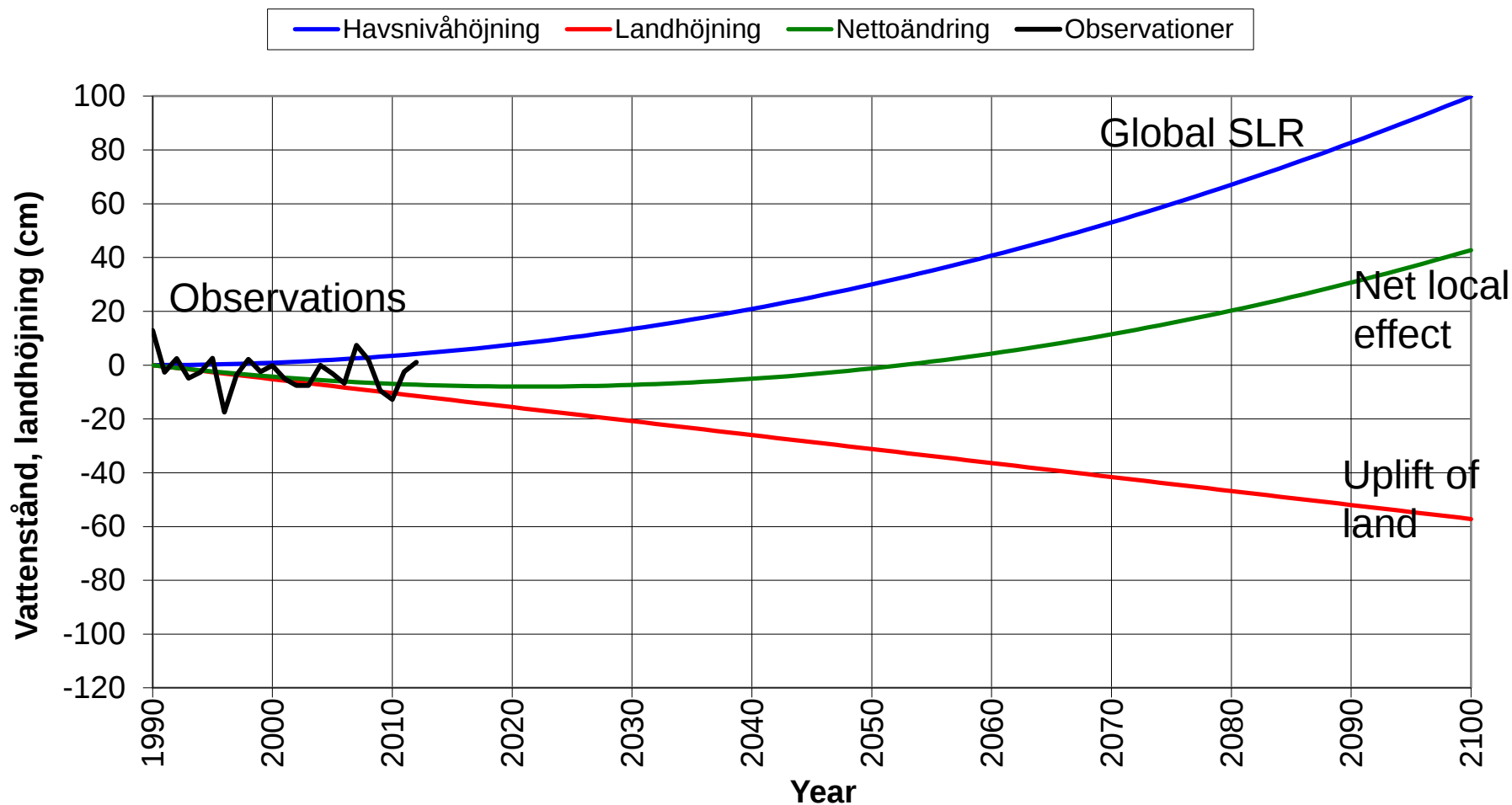
Some recent national interpretations for adaptation to Sea Level Rise until 2100



Stockholm 1990 - 2100



Stockholm 1990 - 2100



Lake Vänern and River Göta älv

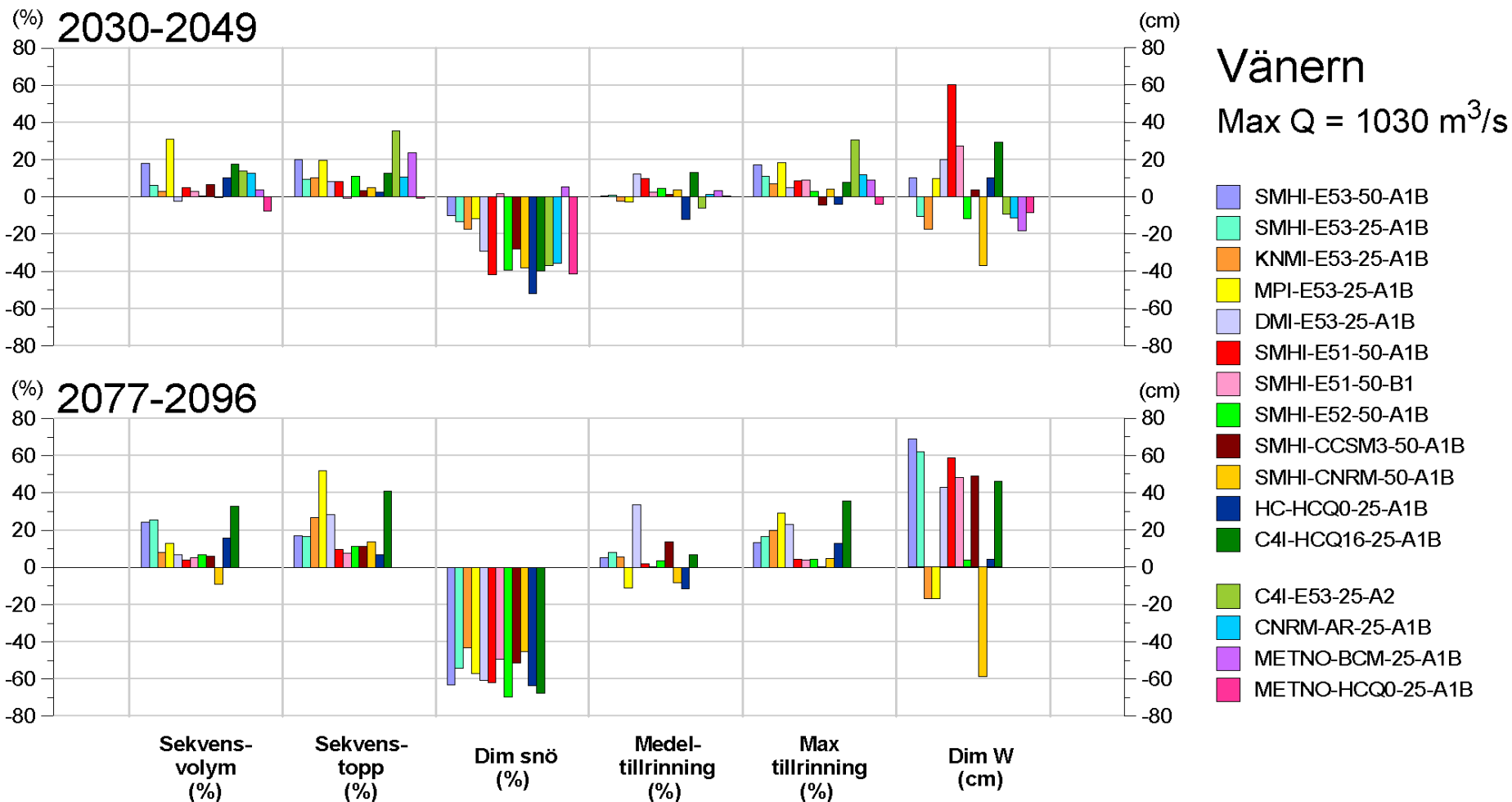


Lake Vänern and River Göta älv





Karlstad



Vargöns hydropower plant



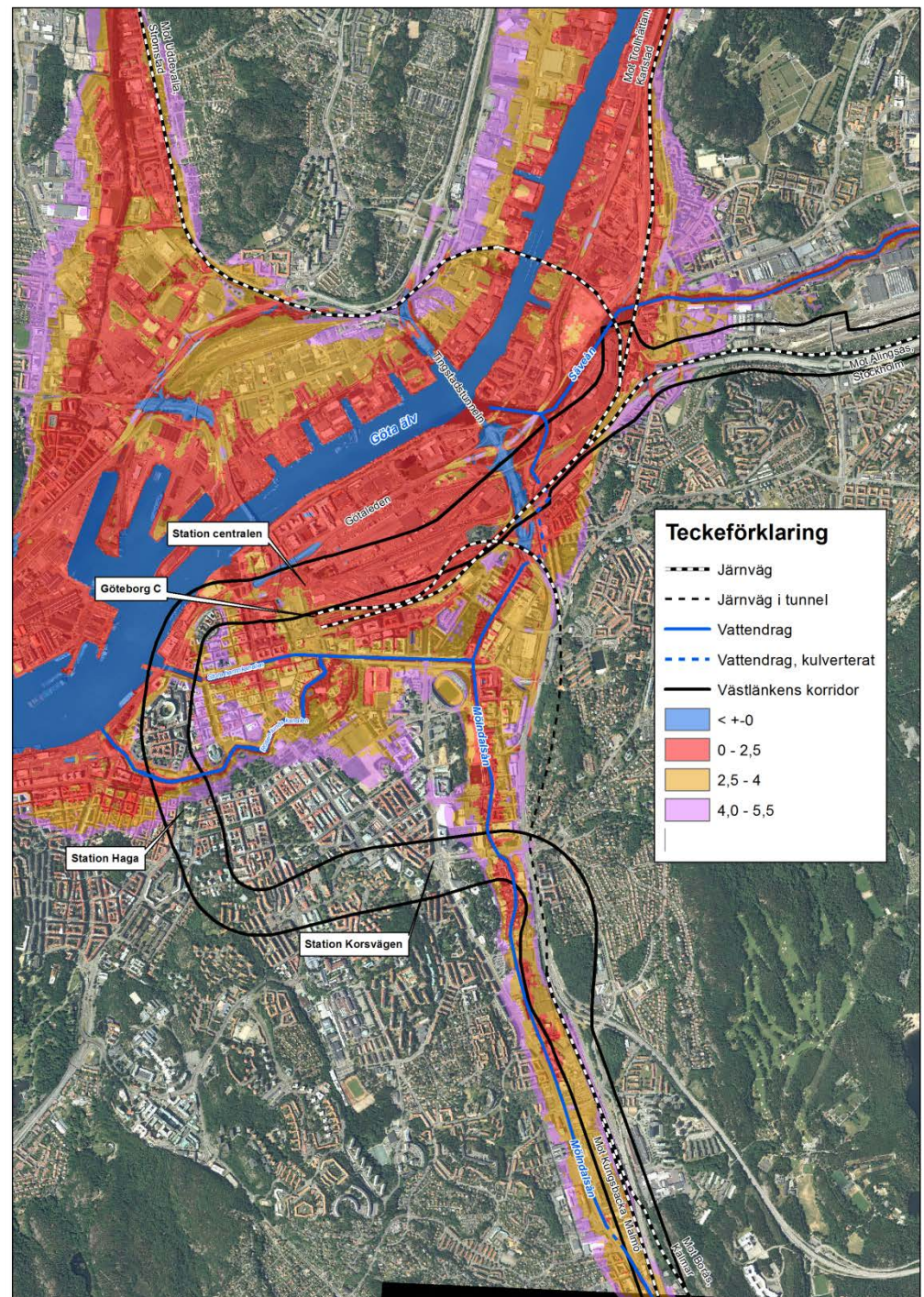
Risks for inundation and landslides in the river valley



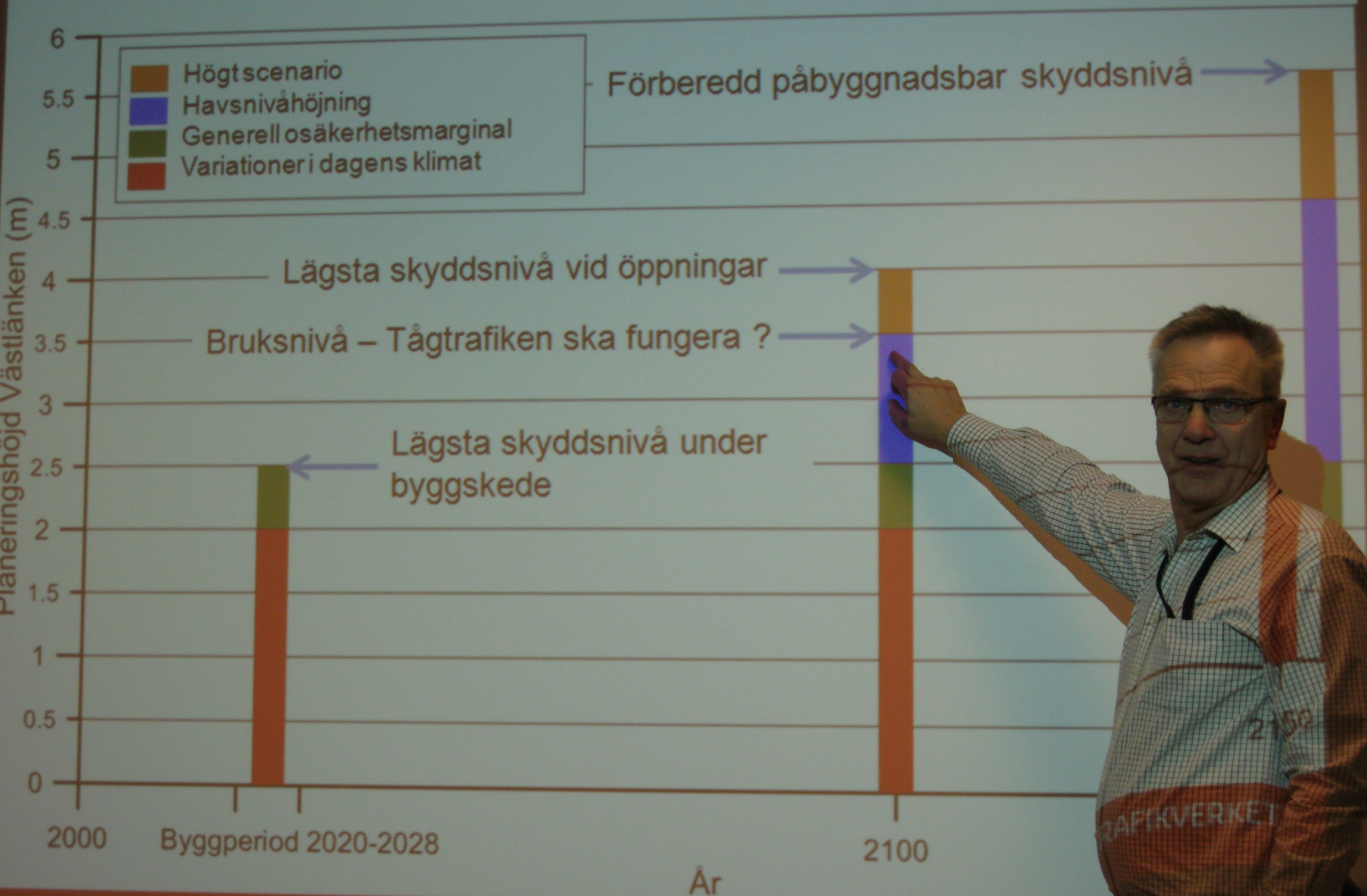
Göteborg



Västlänken, a new infrastructural project In the city of Gothenburg



Skyddsnivå mot havet Olskroken-Haga



Briefing december 11, 20012



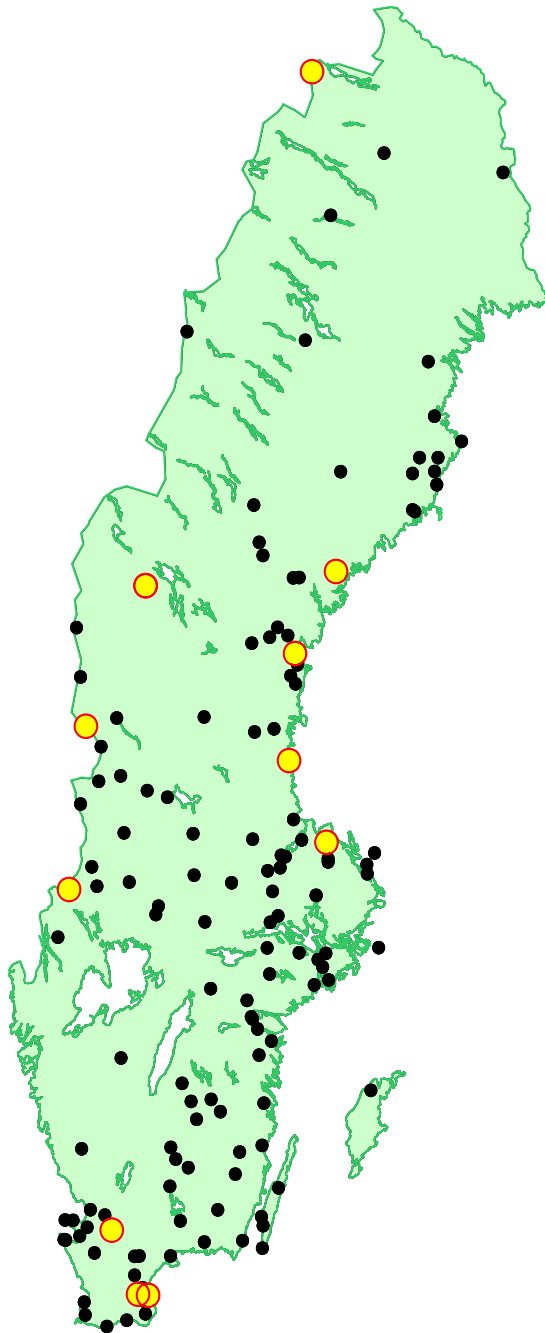
Copenhagen July 2, 2011



July 2011 - damages

- More 150 mm rain within 2 hours
- Close to 1 billion euros in insurance claims
- Damage to critical infrastructure
- Hospitals minutes from evacuation
- Emergency services threatened



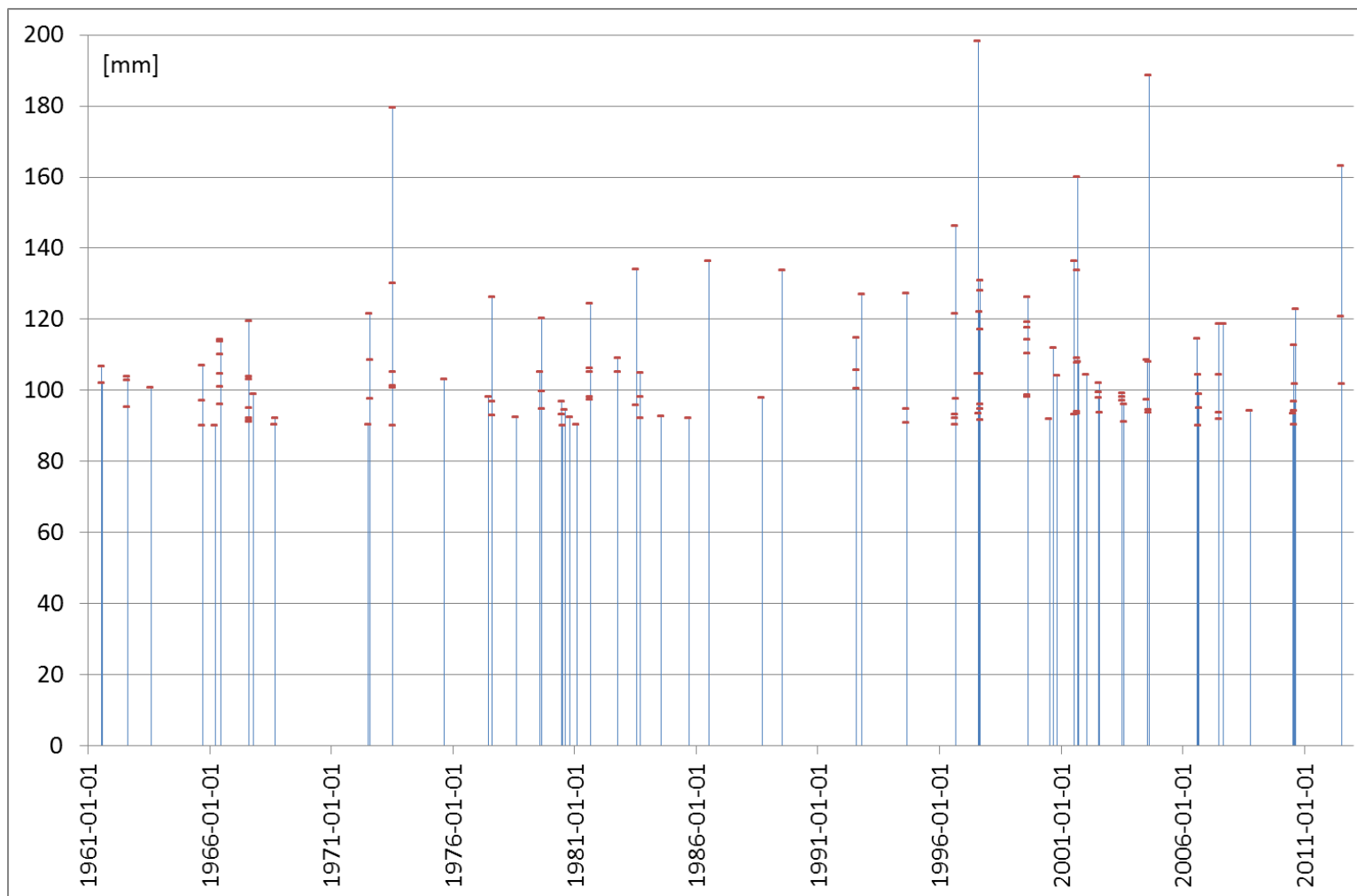


It could happen almost everywhere

Observations of more than
90 mm rainfall in 24 hours
during the period 1961-2011.

Yellow marking means twice.

Swedish observations of more than 90 mm rainfall in 24 hours during the period 1961-2011



Adaptation to climate change has become standard but there are remaining issues:

Extreme rainfalls in growing cities

Representative regional climate scenarios for operational use

How to get rid of bias corrections?

Sea level rise

Evapotranspiration in a changing climate

**Thanks BALTEX, and all the best
Baltic Earth!**



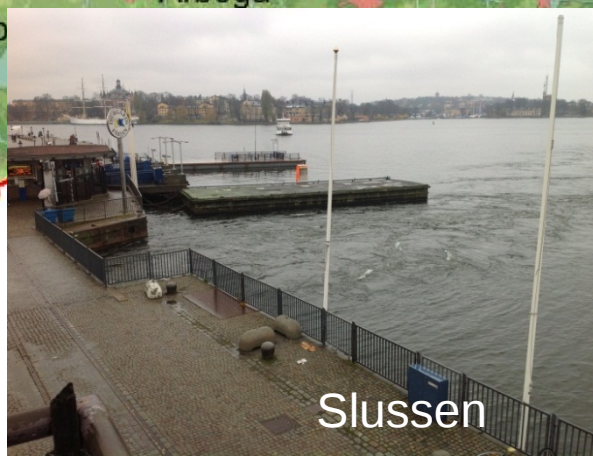
Ett annat perspektiv...



Arbogaån



Fyrisån



Slussen



Stallkanalen
och Norrström



Nya Slussen och ny reglering av Mälaren

Monica Granberg
2 mars 2012

Upgrading the Håckren dam



Two design categories, depending on the consequences of a dam failure:

Category I (high hazard) is based on hydrological modelling and simulations of the river system.

Category II (low hazard) is based on statistical methods (frequency analysis).