Mer vann og mer uvær?

Utfordringer for vannkraft ved endret klima

(og litt om tilpasning til nytt klimaregime)

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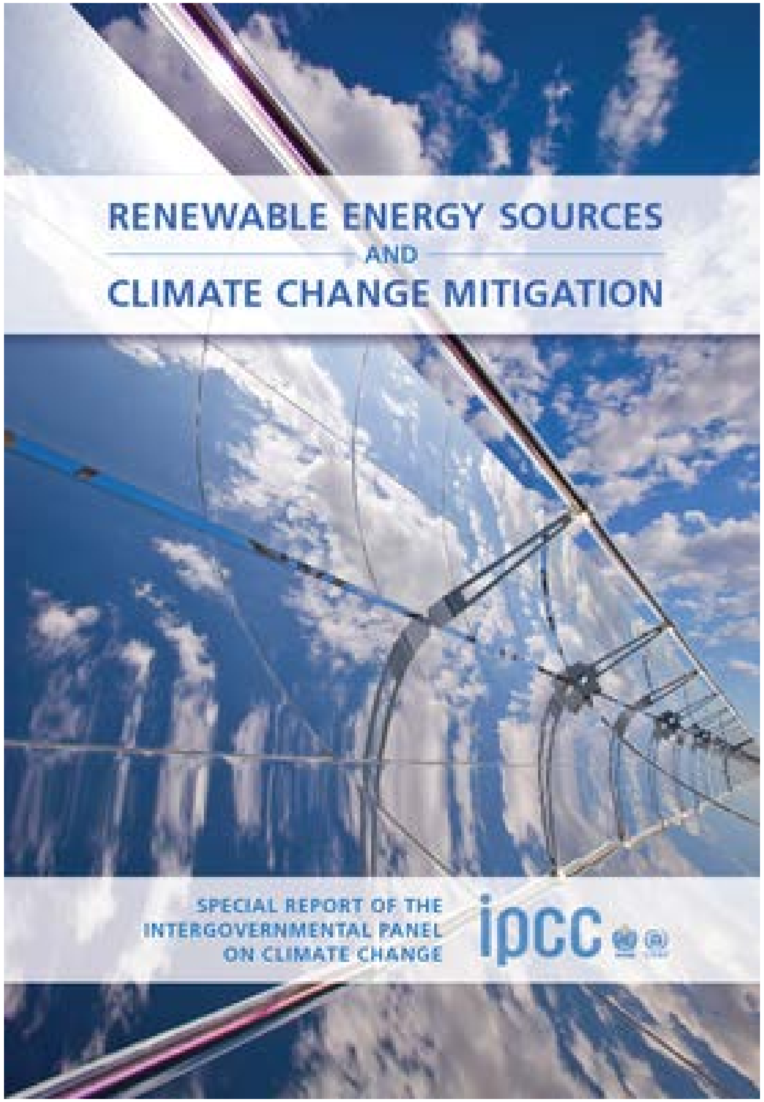
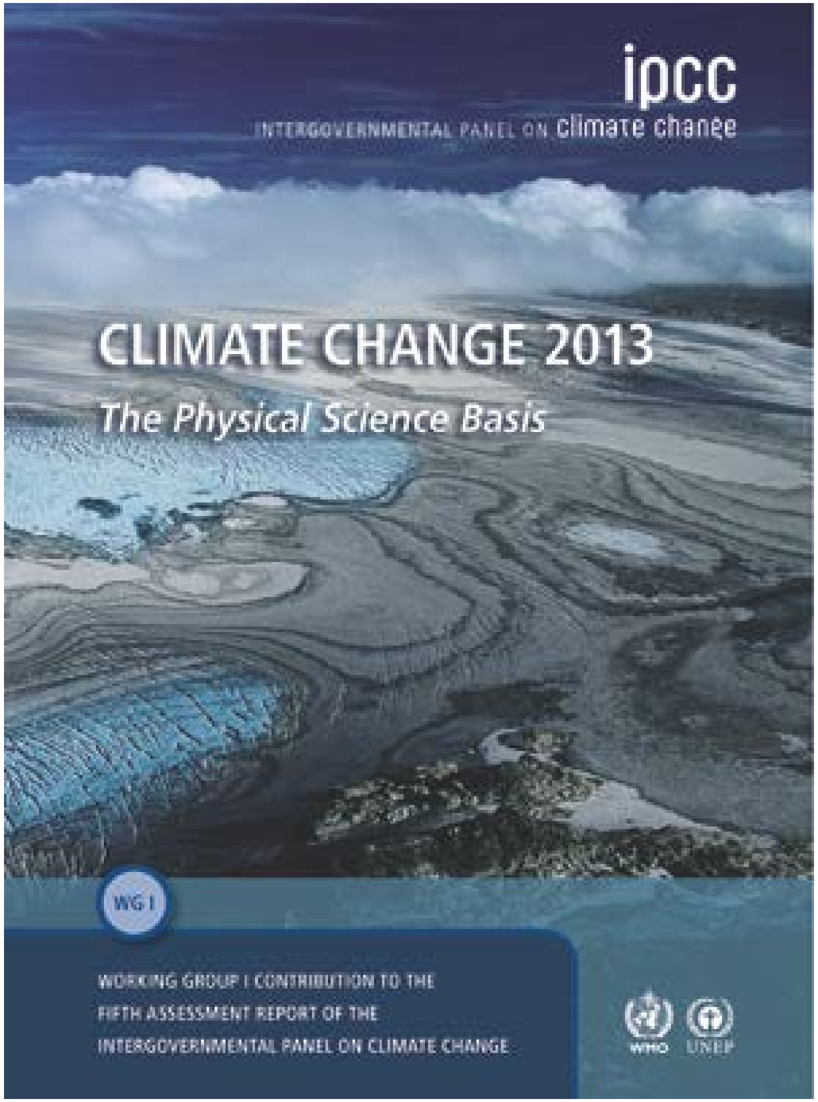
IPCC gives the scientific basis for predictions about Climate Change (CC)





Climate Change (CC) is here now, according to IPCC

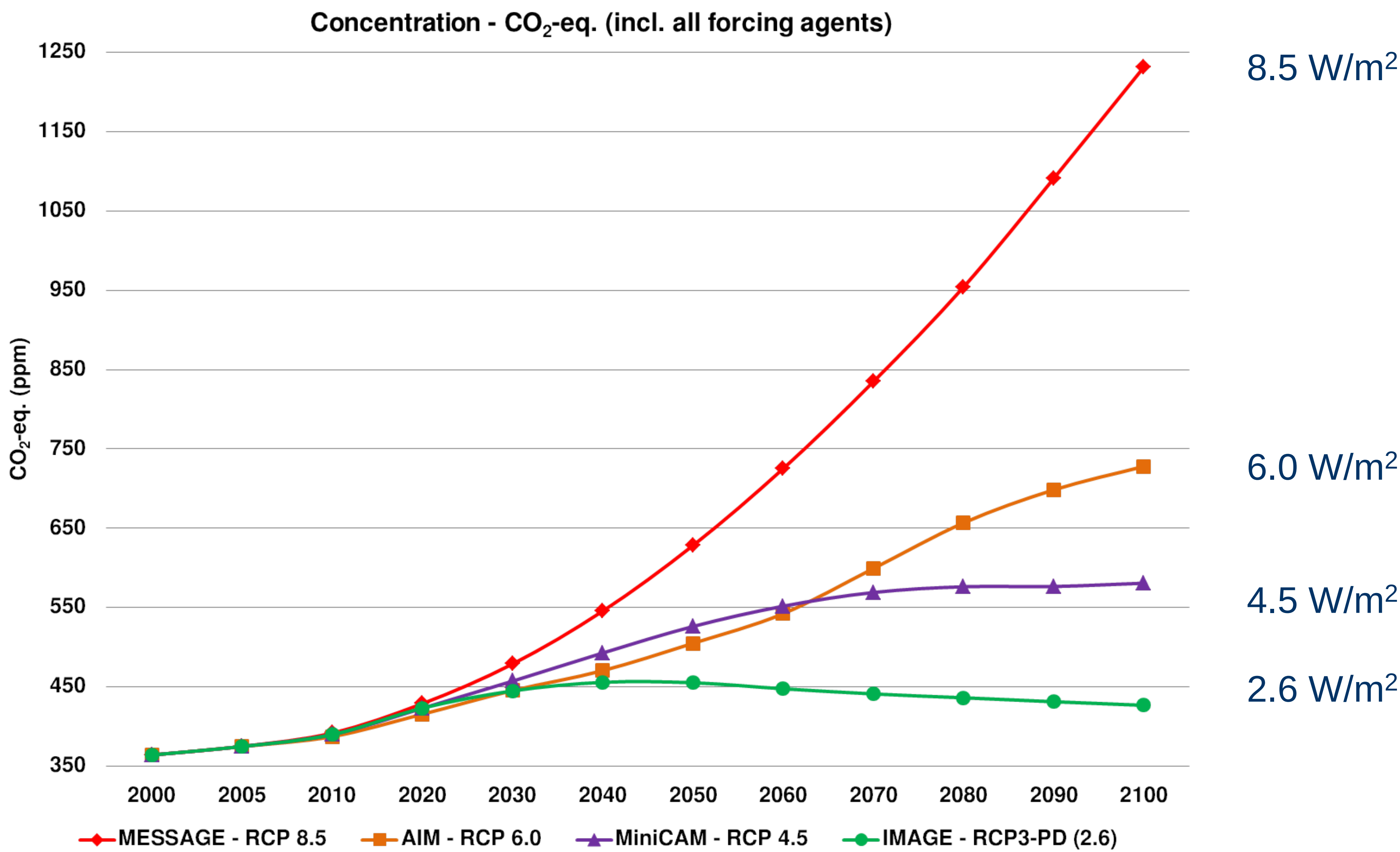
"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia"

"Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system"

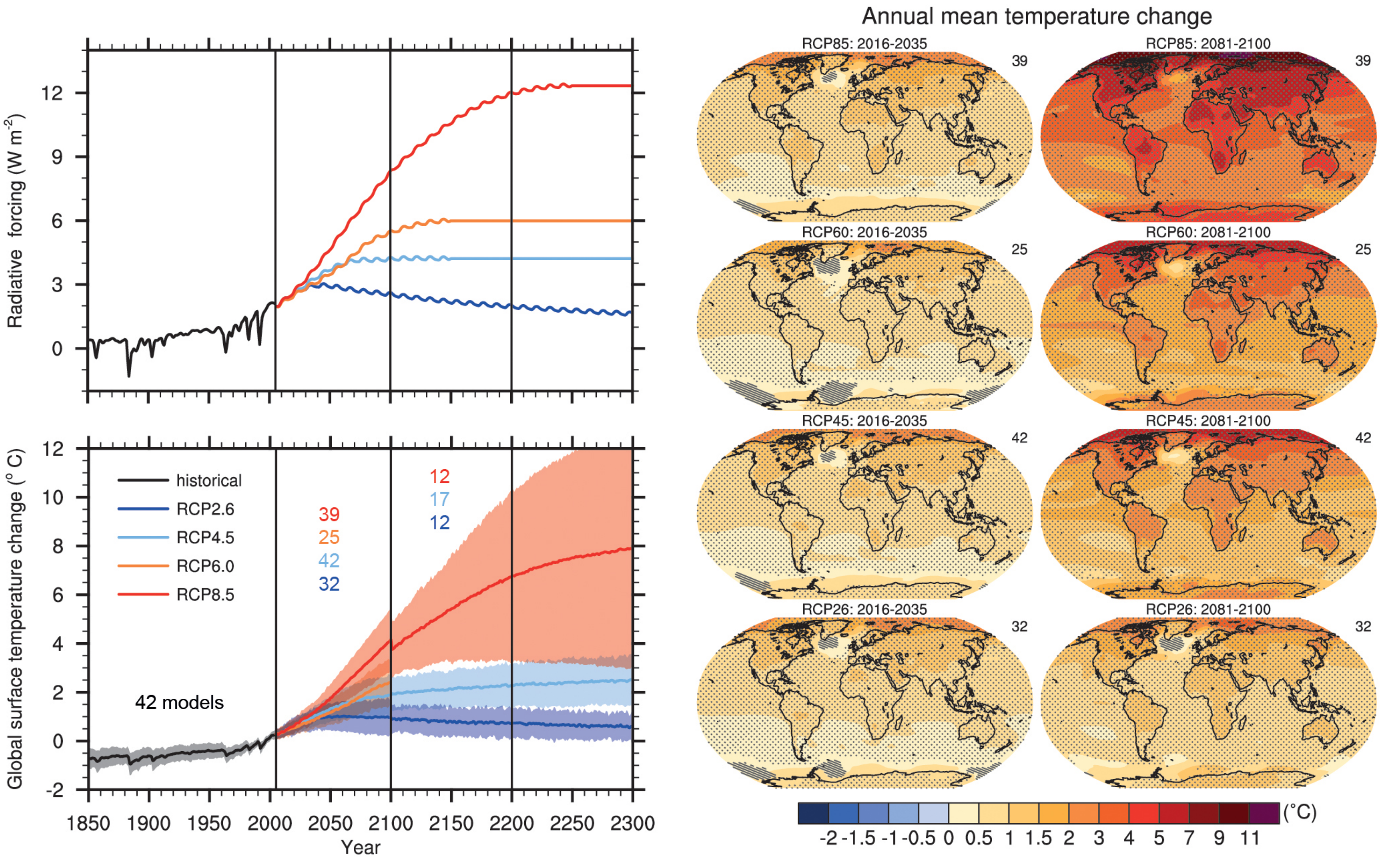
"It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century"

All statements are from IPCC Assessment Report 5 (AR5)

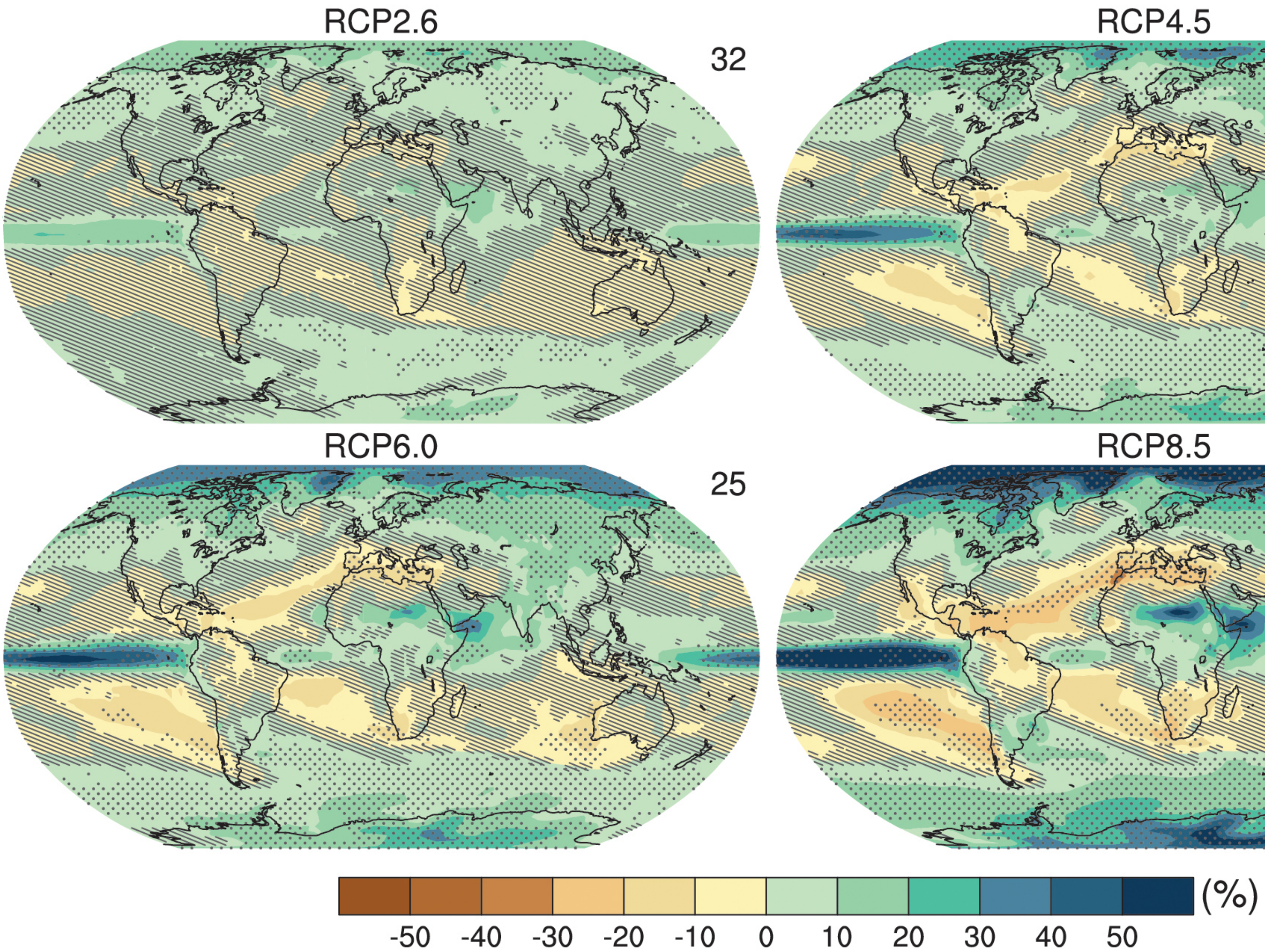
AR5 use «Representative Concentration Pathways» - RCP



Global temperature change according to AR5



Global precipitation change according to AR5



We will most likely see a global CC of +2º (or more)

Mitigation of CC must continue with highest priority

Still, we must be realistic, preparing for changes of +2º

Even “only” +2º will have very significant consequences

The Water Cycle is strongly affected by CC

Some of the most important impacts will be on River Flow

Hydropower will therefore also be potentially vulnerable

Adaption strategies may help to handle the problems

Connections between CC and Hydropower

Global Climate Change

Change in Local Climate

Change in Hydrology/Water Resources

Change in Hydropower resources

But also feedback
Hydropower and other REN
can mitigate CC

Possible Impacts of CC on the Hydropower system

Direct impacts:

More/less water runoff may increase/decrease generation potential

Changes in seasonal distribution of runoff

Reservoir sedimentation may decrease storage capacity

More extreme floods may be a threat to dams/hydraulic structures

Indirect impacts:

Change in consumption/Market structure

Composition of power system (more wind/solar, less thermal/nuclear)

New environmental restrictions (more flow, reduced peaking, ..)

Mitigation and Adaption – What can we do?

Mitigating Climate Change (1st priority!)

Reduce emissions of GHG
Reducing deforestation
Reducing use of fossile fuels ➔ Renewable energy ➔ Hydropower

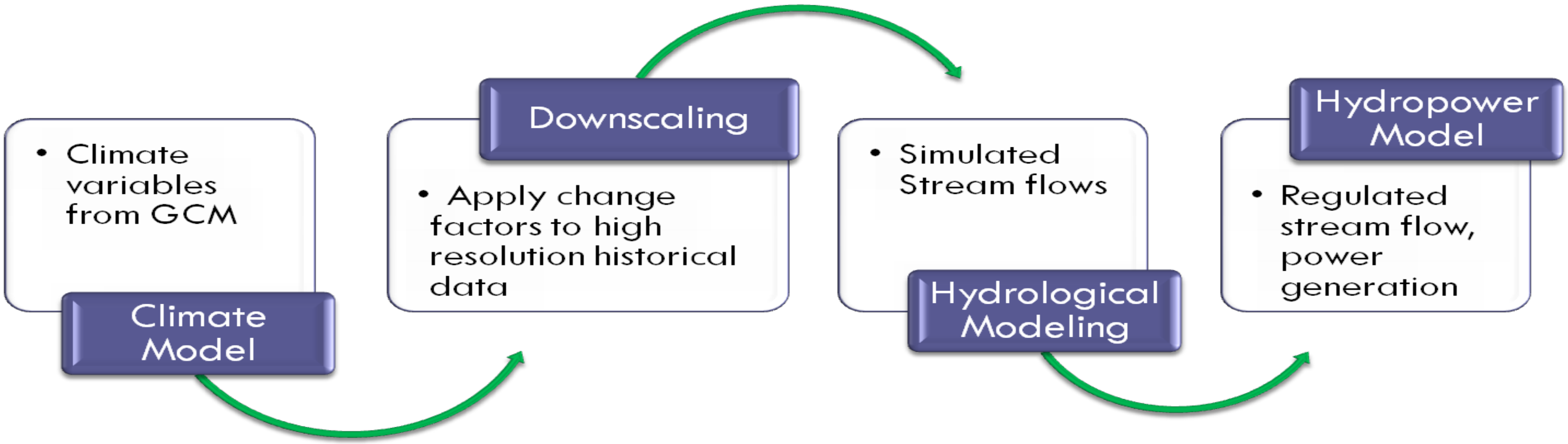
Adaption to the changes that can not be avoided

Mitigation don't help much the first 40-50 years
Impacts will continue for decades or hundreds of years
We should start adapting to reduce negative impacts

Reduce impacts and vulnerability

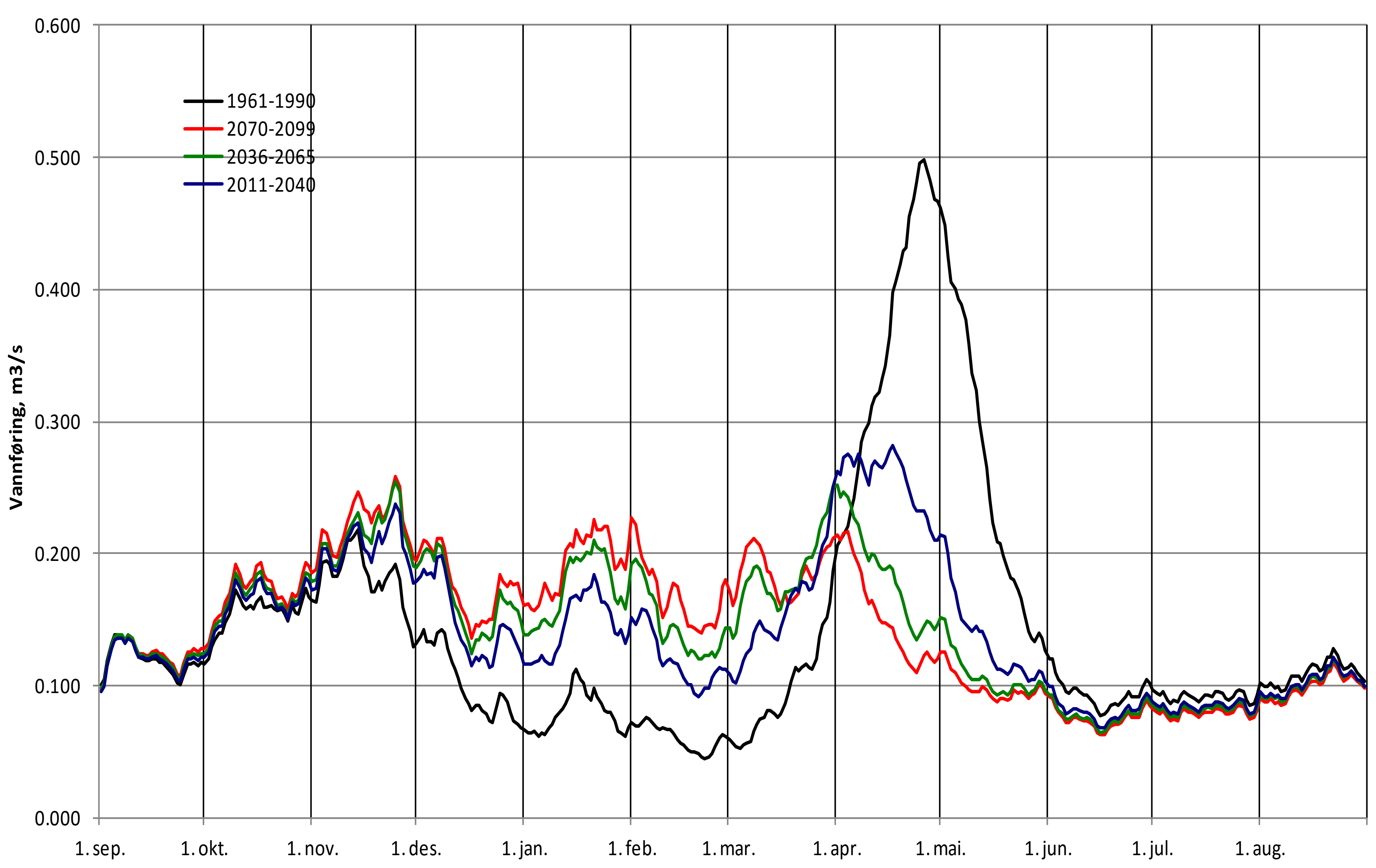
Understand type of impacts and where (floods, storm, landslides …)
Use this knowledge in planning counter-measures
Ensure that new development is less vulnerable
Optimize & design
Implement & Operate

From Global studies to impact on a Hydropower plant - Series of processes used to assess impacts

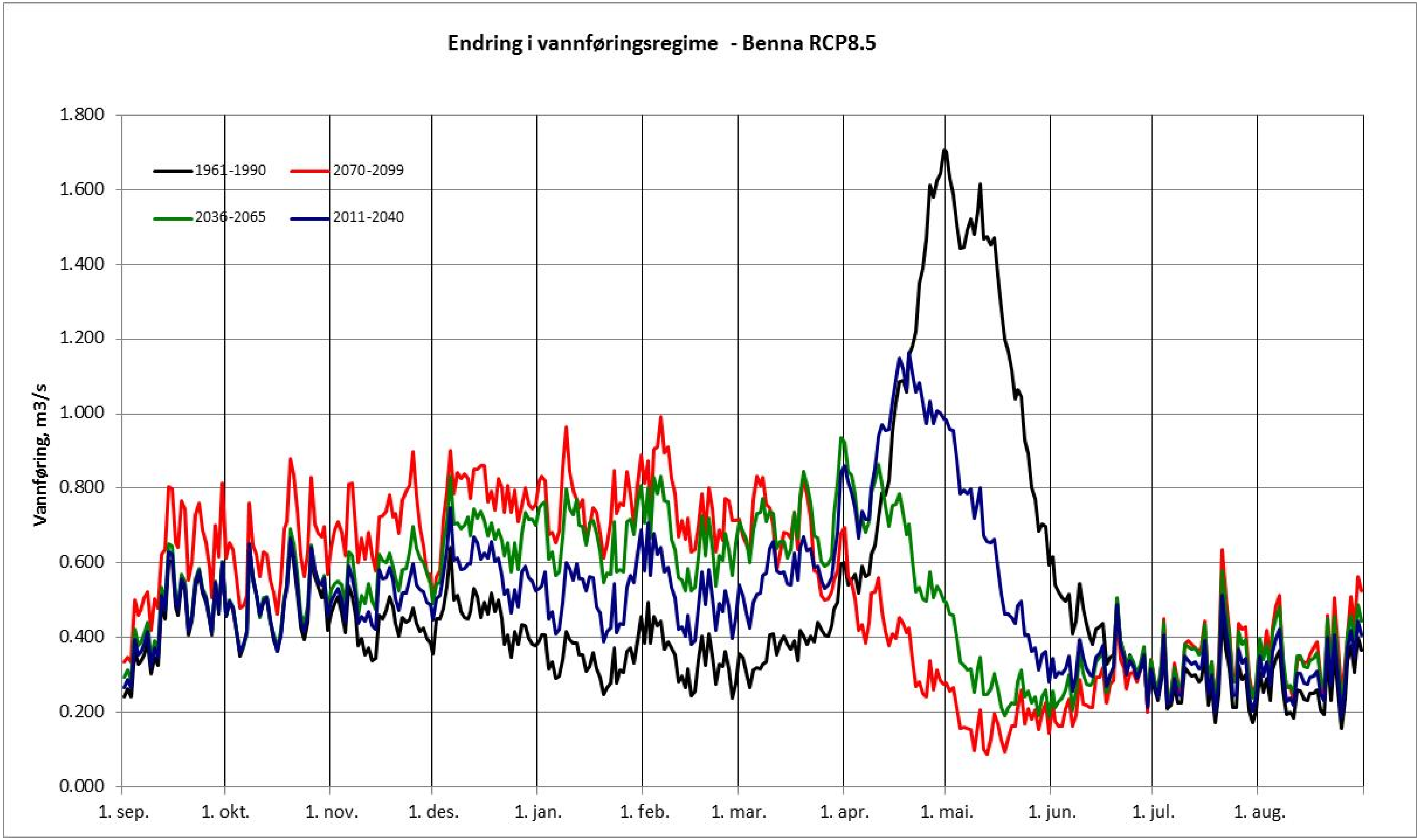


- **Data sources**
  - Observed data (GHCN, GRDC, met offs)
  - Reanalysis data (NCEP, ERA 40/15)
  - GCMs data (PCMDI, CERA)

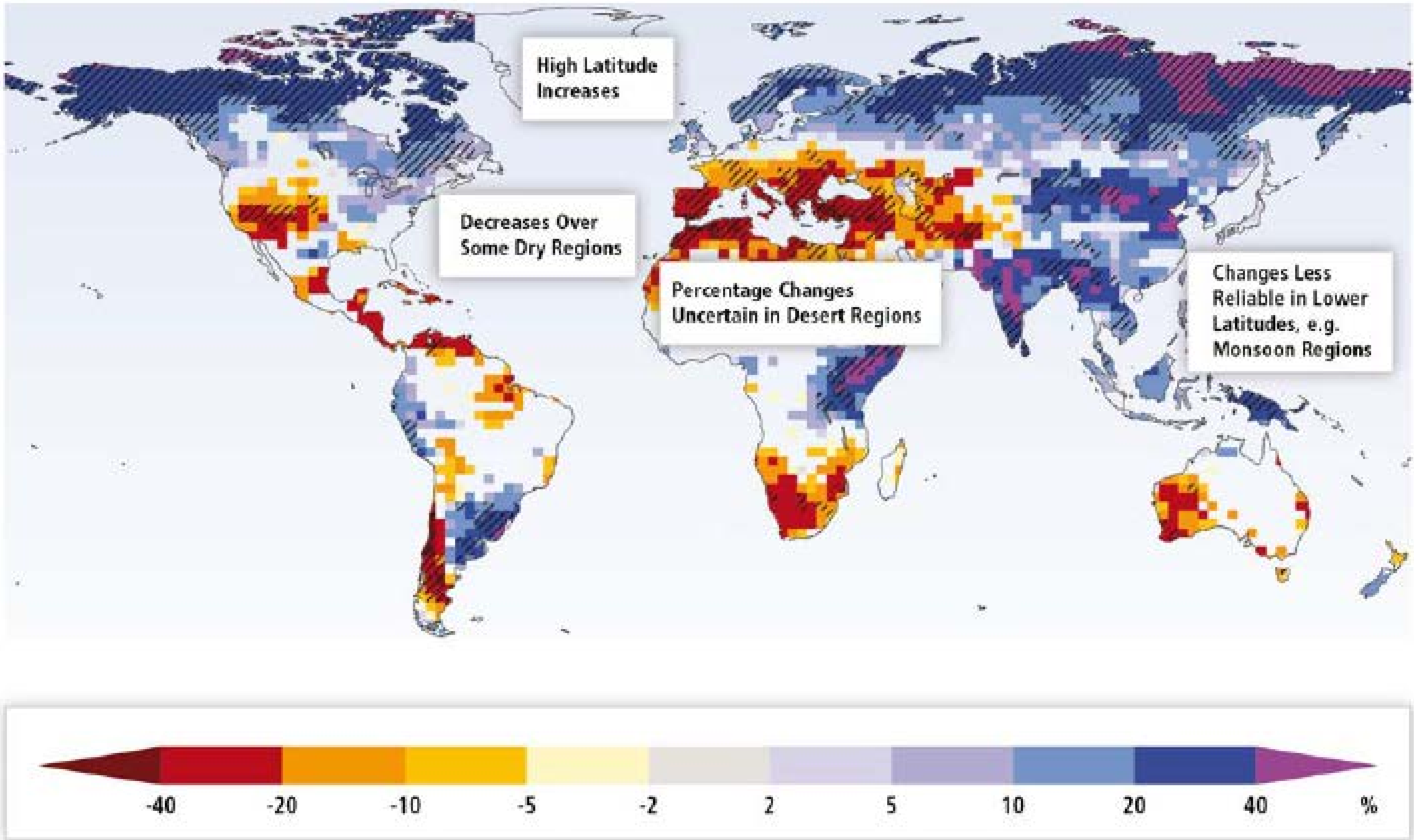
Change in seasonal runoff distribution – Oslo, Norway



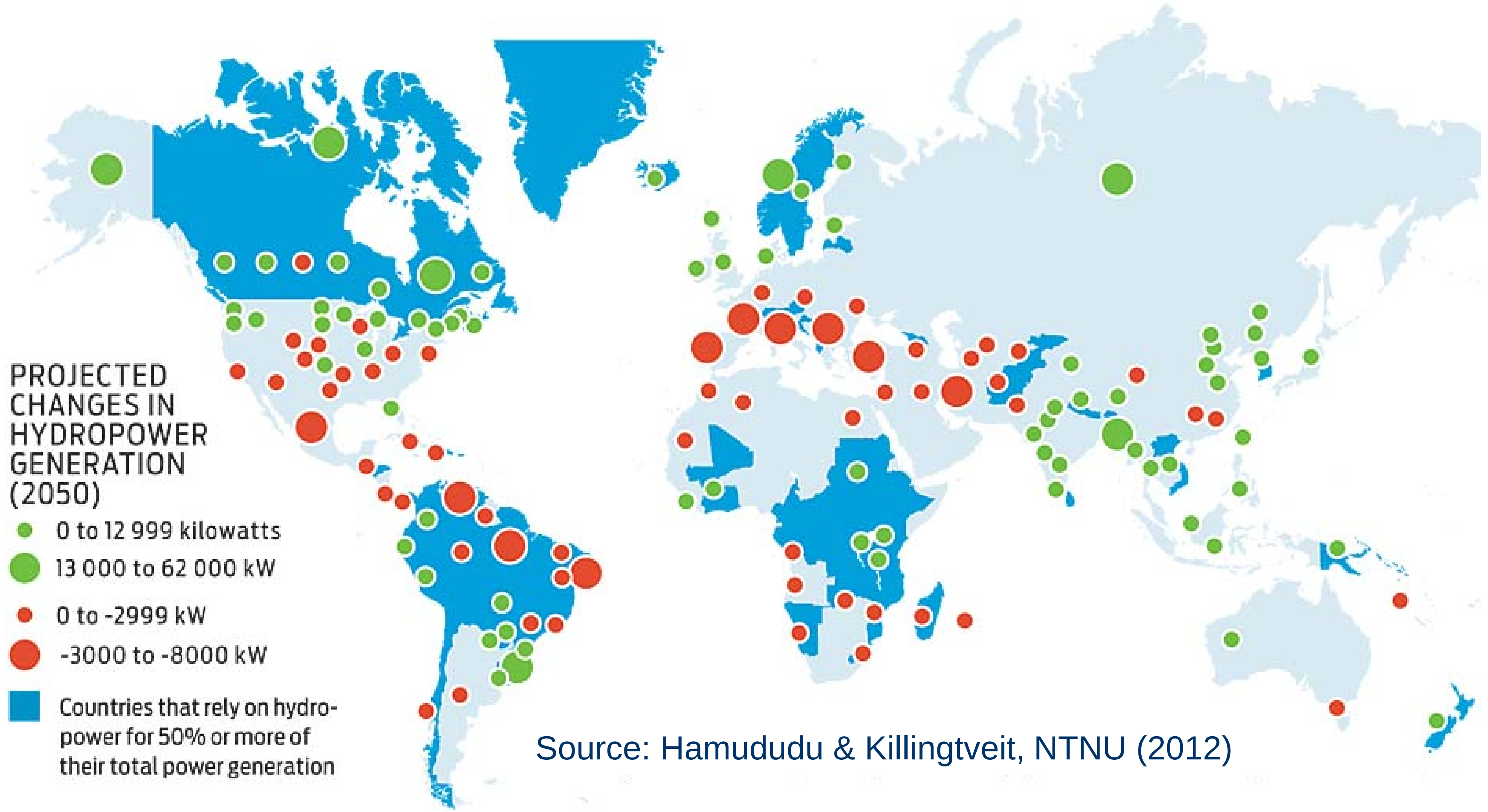
Benna, S-T: Endring i tilsig fram mot 2100 RCP8.5



Global impact on water resources by 2090 (IPCC SRREN)



Hydropower and Climate Change – A Global view



Source: Hamududu & Killingtveit, NTNU (2012)

Adaption (hydropower) can be triggered by many drivers

Drivers

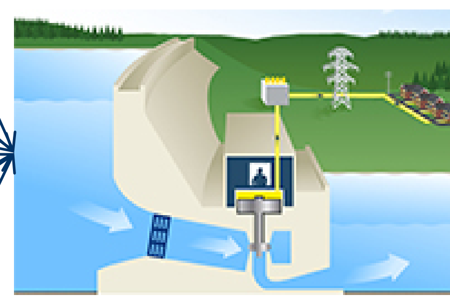
Climate change

Market change

New technology

Environmental policy

Adaption and reconstruction



What do we need to know for planning the adaption?

Future climate and its development in time (2030, 2050, …)

Impacts on hydrology and in particular river flow

- Total volume of runoff
- Seasonal distribution
- Impacts on snow/glaciers
- Extremes

Impacts on other important hydrological properties

- Sediment generation, transport and deposition
- Water temperature
- River and lake ice
- Ecosystem impacts (fish, invertebrates, …)
- Water quality (pH, GHG emissions, oxygen, …)

Adapting to CC-Impacts on Hydropower - Examples

Direct adaption:

Increasing capacity to utilize more water

Creating (more) storage to meet increased variability

Reduce or remove Reservoir sedimentation

Increase spillway capacity and strengthen Dam safety

Indirect adaption:

Adapt to new market opportunities (peaking, load balancing…)

Cooperate with other renewables (wind/solar/bio/geothermal …)

Take a proactive environmental role (look for win-win situations)

High research activity – be prepared for surprises and know what to do

Adaption to Climate Change – Coordinated with other Maintenance and Refurbishing Schedules

Hydropower system components typically have different life-time

- Control and communication equipment 10-15 years
- Turbines and generators 20-40 years
- Civil structures 50-100 years
- Tunnels and rock caverns – > 100 years?

Licensing/Concessions are often given for 40-50 years

Environmental restrictions must be reanalyzed at regular intervals

- Water Framework Directive in Europe – 6 to 15 year cycles

Dam safety regulations often prescribe re-analysis at regular intervals

- Reanalysis every 15 years in Norway

Demand/Market change may trigger refurbishing (peaking, pumping, …)

Possible adaption - Four Possible Cases

1) Increased runoff from CC. More water, but to what purpose? More water to hydropower plants or to improving the ecosystem? Discussion ongoing for rIvers in Canada and Norway

2) Increased runoff from CC ➔ Increasing full load hours ➔ more losses Typical adaption: Increasing tunnel size and capacity in PP. Increased generation and increased value without new projects

3) No change in runoff, but other RE triggers need for more peaking and load balancing power. Hydropower is ideal for this purpose, adaption to a new operational regime may increase benefit of hydro

4) Reduced flow from CC. Who will give up his previous water rights? Hydropower, Irrigation, Water Supply, Industry? An adaption can be to increase other RE (wind, solar..) and modify hydro system for more peaking and load balancing.

For more information –
visit CEDREN at or our web-site

http://www.cedren.no/