

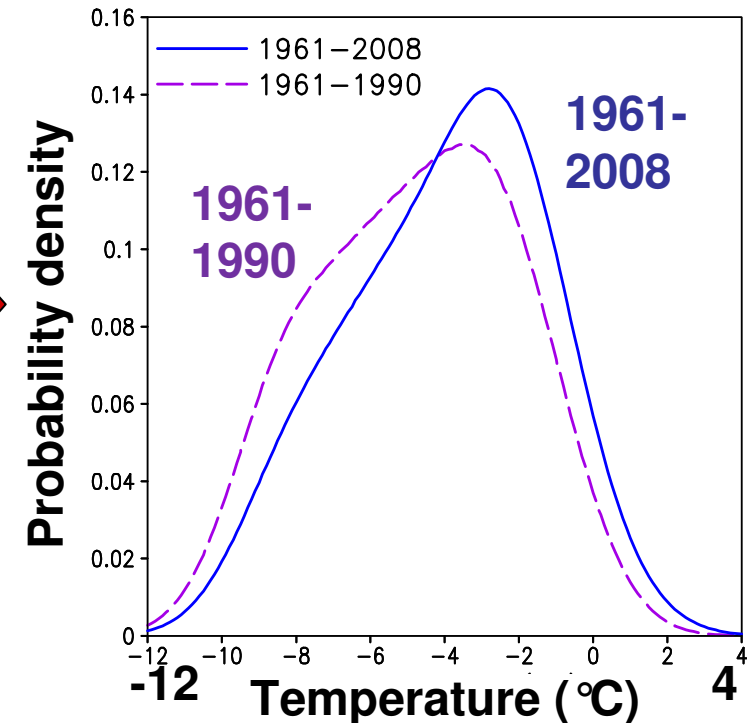
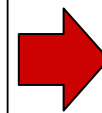
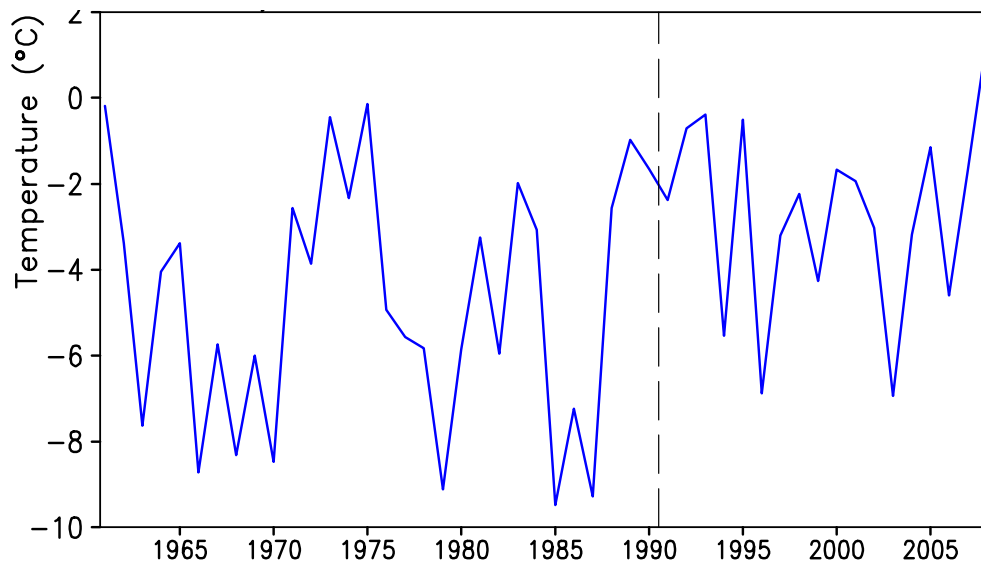
**Probability distributions of
monthly-to-annual mean
temperature and precipitation in a
changing climate**

Jouni Räisänen

Department of Physics, University of
Helsinki

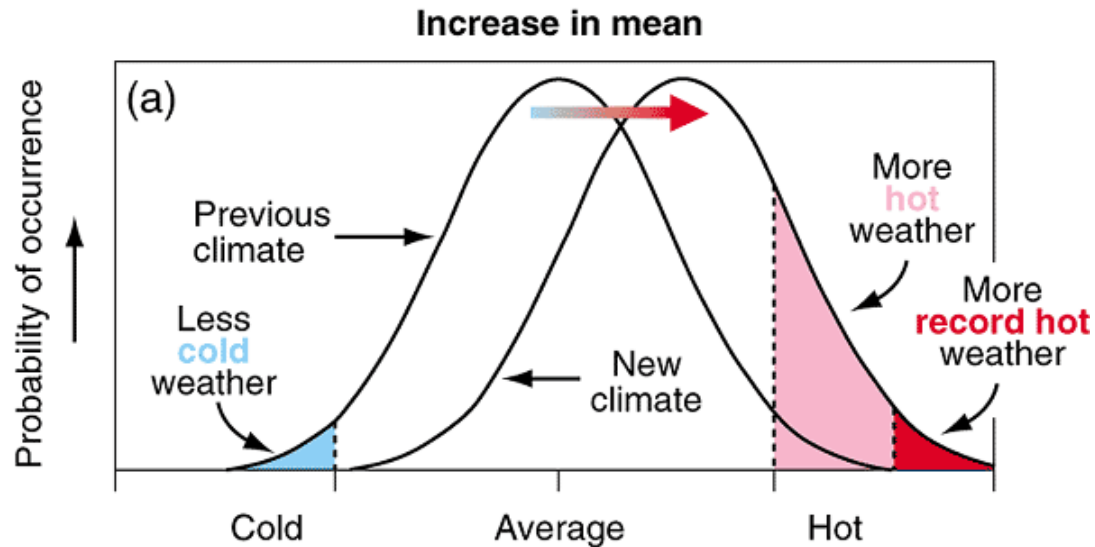
Climate \approx probability distribution of weather

Winter mean T in Helsinki (1961-2008)



- **Traditionally**, these distribution have been estimated from observations (e.g., WMO normal period 1961-1990)
- **In a changing climate**, this becomes problematic: past observations not representative of present or future climate conditions?

Simplest case: change in mean climate,
with no change in the magnitude of variability



IPCC (2001)

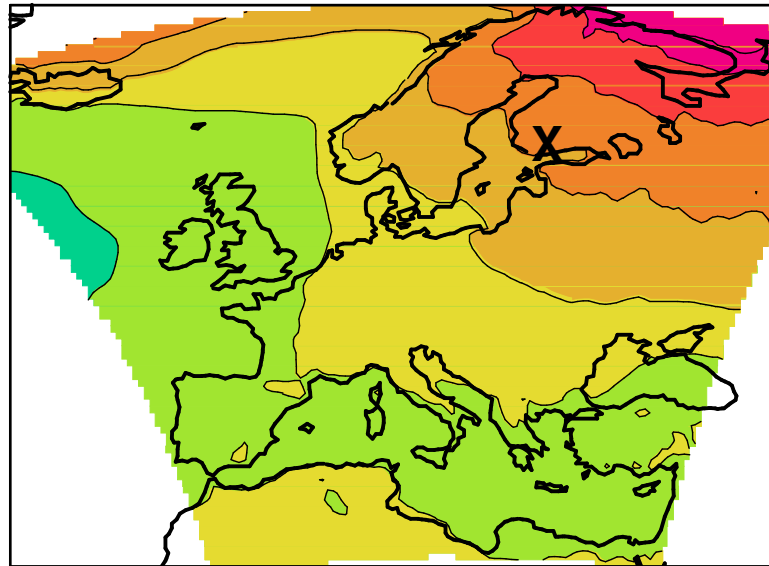
If variability changes as well, the two tails of the distribution (e.g., warm and cold) will be affected differently.

Estimating probability distributions in present & future climates

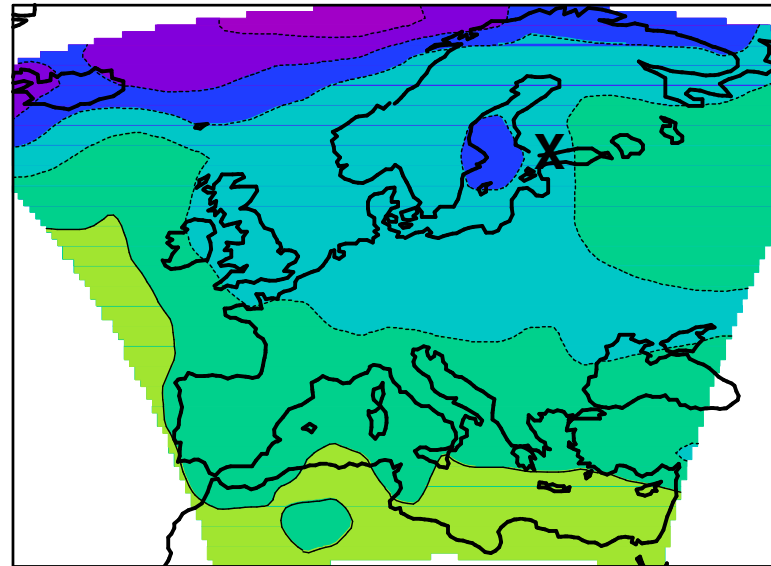
- **Starting point: time series of observed climate variability**
 - monthly, seasonal and annual means of temperature and precipitation
 - period 1961-2008
- **Past observations are modified, to make them representative of present / future climate, using**
 - changes in mean climate and variability in (global and regional) climate models
 - observed and simulated changes in global mean temperature
- **Pattern scaling approach**
 - changes in mean climate and variability assumed to be proportional to the change in global mean temperature

Regression coefficients of winter mean temperature: how much is climate on the average simulated to change per 1 °C of global warming?

Mean temperature



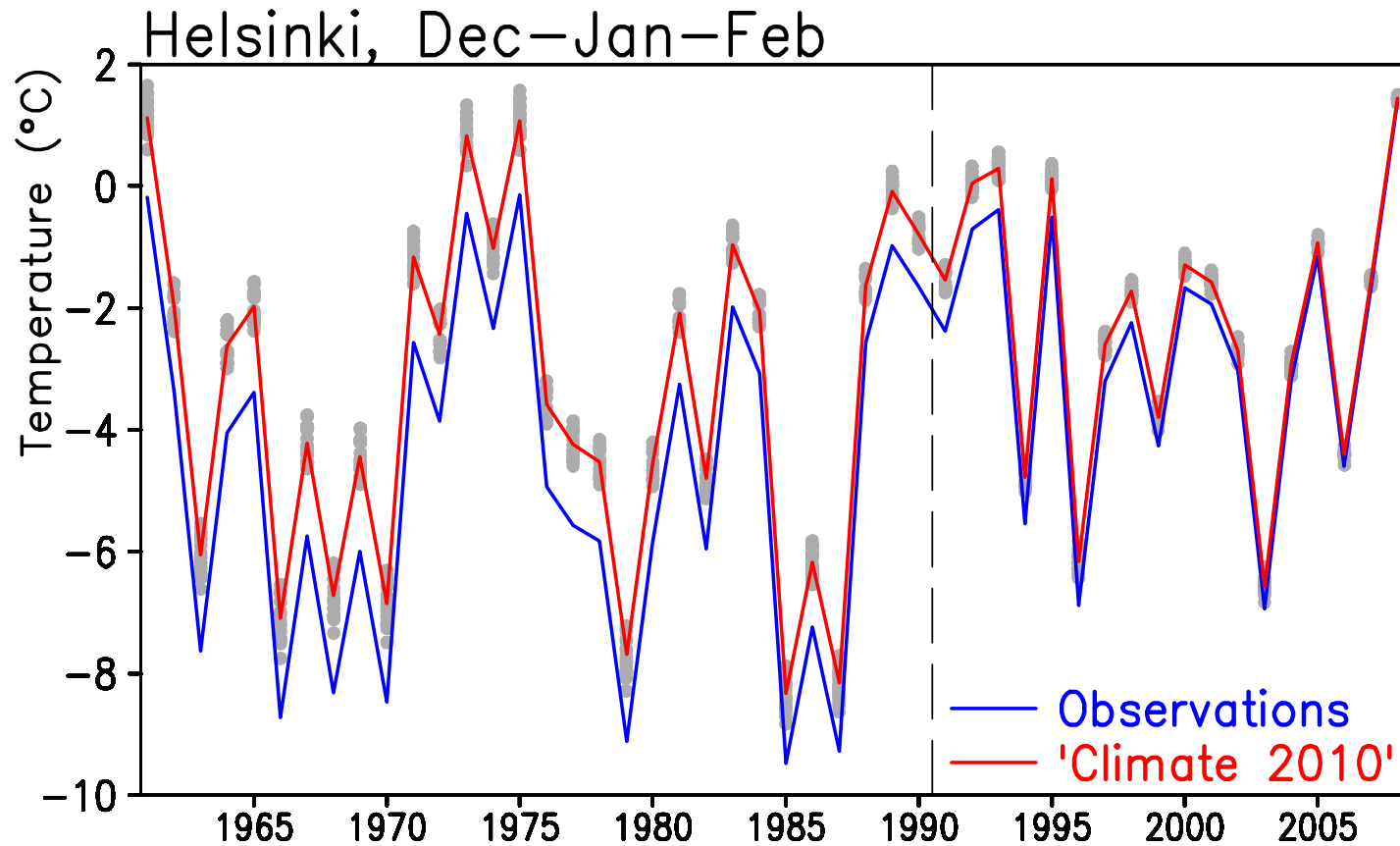
Standard deviation



Helsinki (60°N, 25°E): On average, the mean winter temperature increases by **2.1°C**, and the interannual standard deviation decreases by **6%**, when the simulated global mean T increases by 1°C.

Of course, there is variation between different models!

Time series of winter mean temperature in Helsinki (1961-2008)

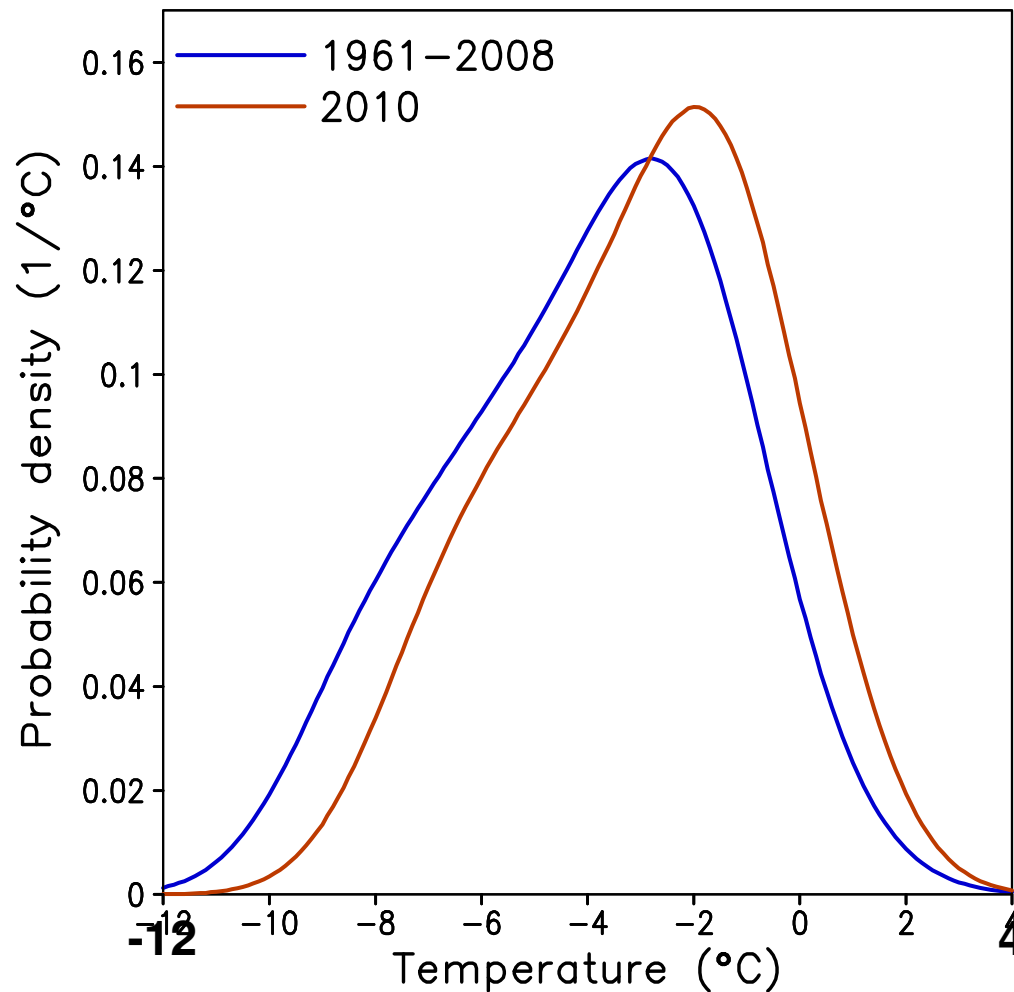


Blue line = observations

Red line = best-estimate present-day (2010) climate

Grey dots = results for individual models

Probability distribution of winter mean temperature in Helsinki: 1961-2008 vs. 2010



Shift to right:

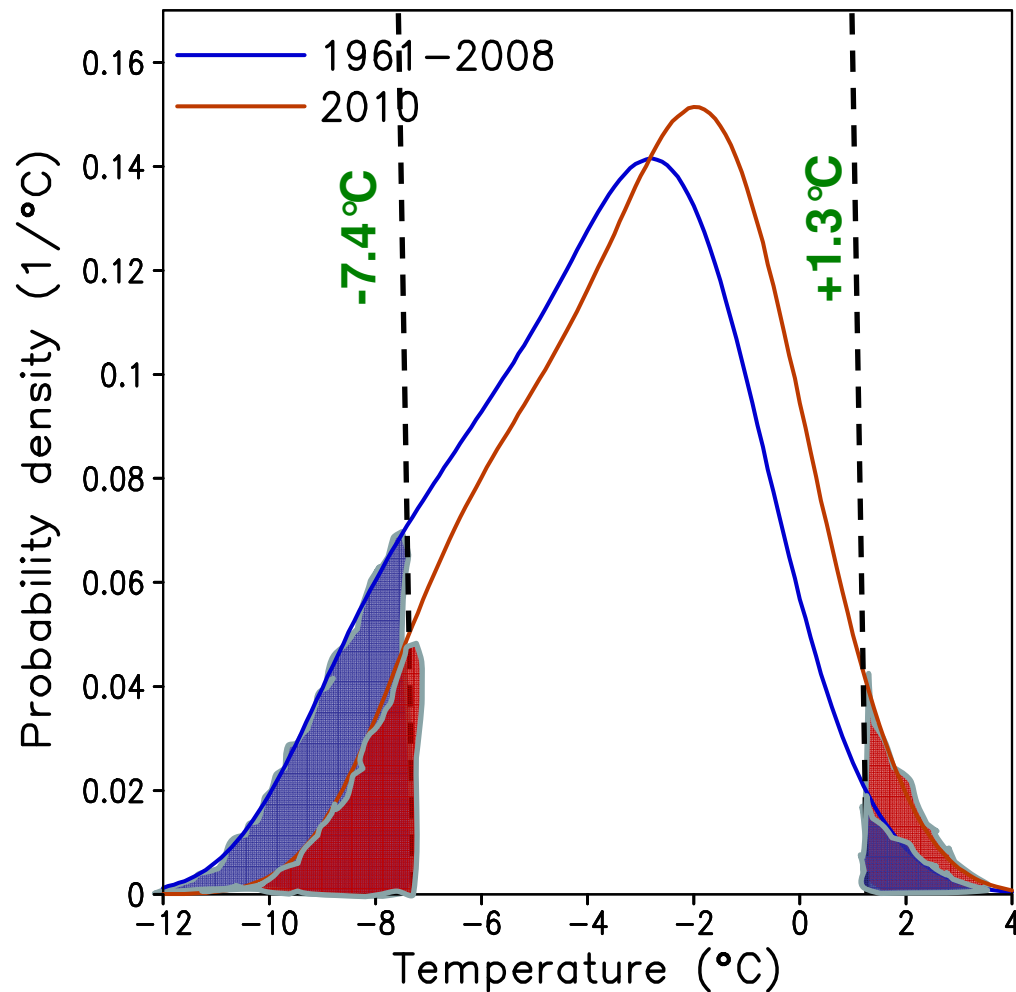
mild winters more common, cold winters less common

Narrower distribution with a higher peak:

a slight decrease in variability, i.e., largest warming of coldest winters

Only best (multi-model average) **estimates are shown here**

Probability distribution of winter mean temperature in Helsinki: 1961-2008 vs. 2010



How frequently at least as mild as in winter 2007-08 (+1.3°C)?

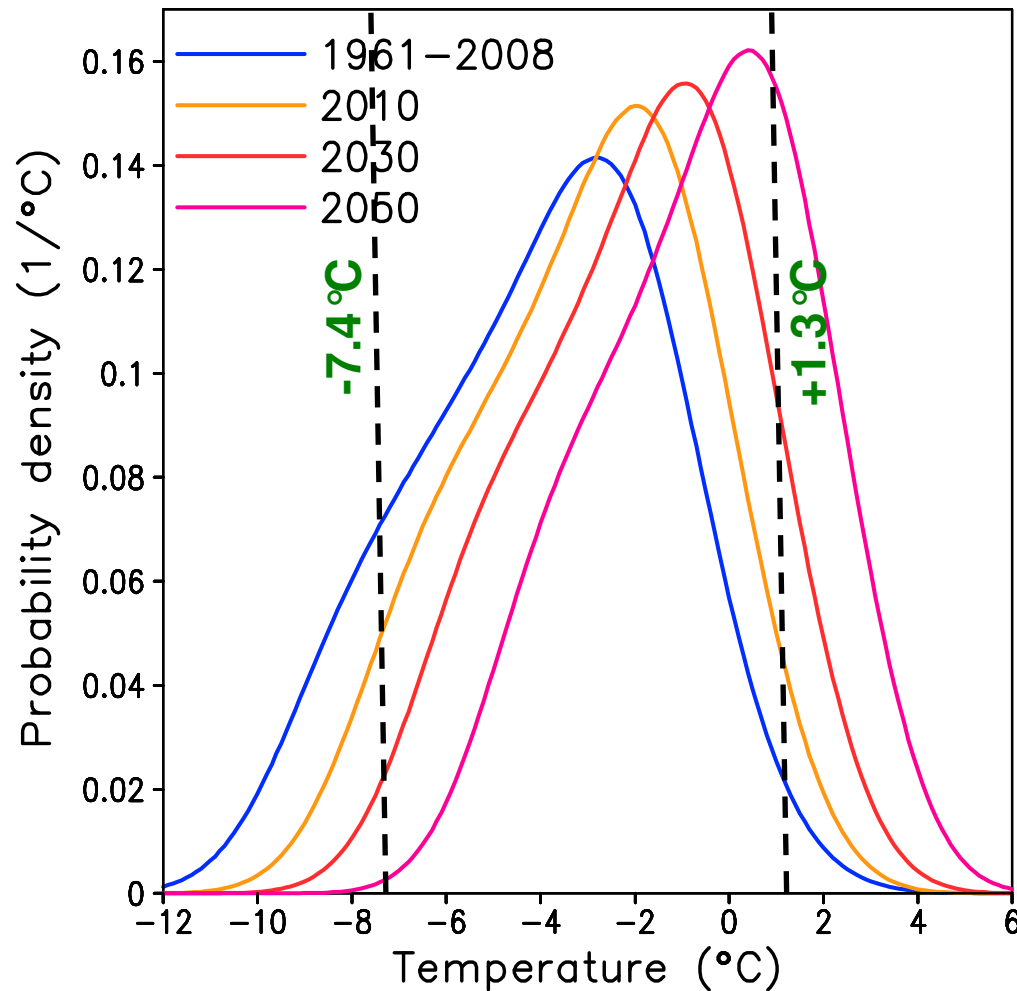
1961-2008: 1-2%
2010: 3-4%

How frequently at least as cold as in winter 2009-10 (-7.4°C)?

1961-2008: 14%
2010: 6%

Note: probability ~ area

Probability distribution of winter mean T in Helsinki: **the best-estimate future?**



How frequently at least as mild as 2007-08 (+1.3°C)?

1961-2008: **1-2%**

2010: **3-4%**

2030: **9%**

2050: **23%**

How frequently at least as cold as 2009-10 (-7.4°C)?

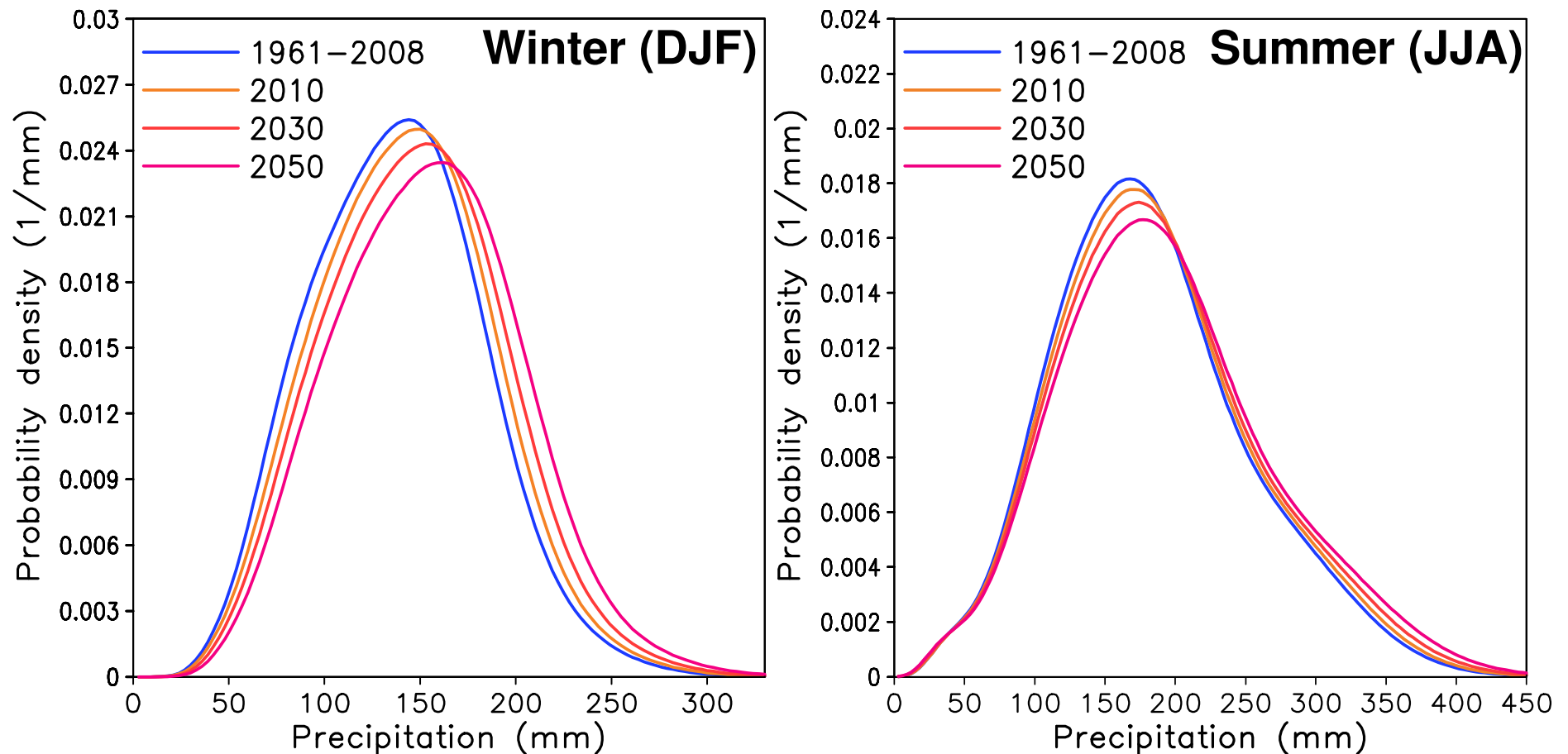
1961-2008: **14%**

2010: **6%**

2030: **2%**

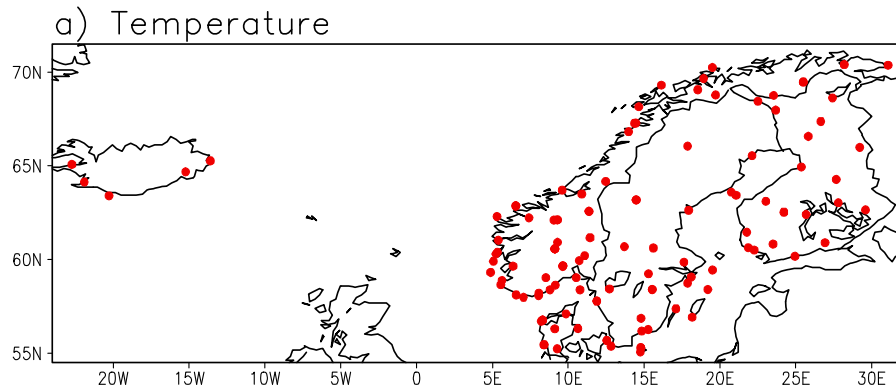
2050: **<1%**

Best-estimate probability distributions of winter and summer precipitation in Helsinki

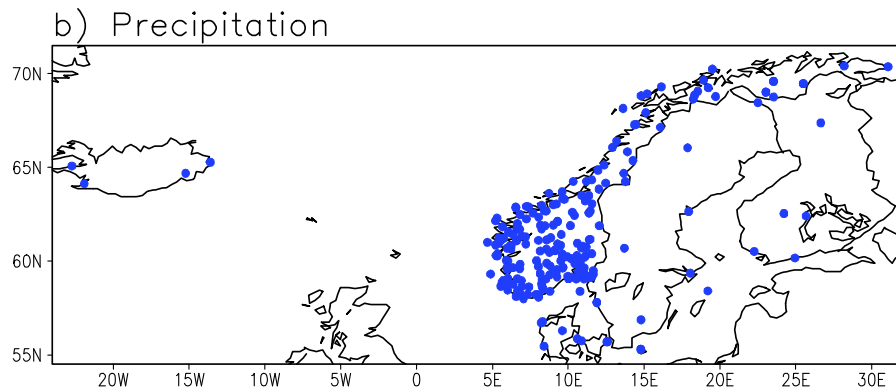


**A gradual shift towards more frequent "wet" winters and summers
- but climate change relatively much weaker than for temperature**

Similar analysis has been repeated for other Nordic stations, using observations from the ECA&D dataset (<http://eca.knmi.nl>)



Temperature: **120** stations



Precipitation: **230** stations

Results available in tabular format at:

http://www.atm.helsinki.fi/~jaraisan/CES_D2.4/Tables_T

http://www.atm.helsinki.fi/~jaraisan/CES_D2.4/Tables_P

Example: June mean temperature at station Oslo-Blindern

OSLO BLINDERN, June

	5%	10%	25%	50%	75%	90%	95%	VC	C	W	VW
6190	127	132	141	151	161	172	178	10	50	50	10
6108	126	131	140	150	161	171	177	11	52	48	8
2010	130	135	144	154	165	175	182	7	42	58	14
2030	134	139	148	159	170	180	187	4	31	69	22
2050	140	145	154	165	176	186	193	1	19	81	34

5th, 10th, 25th, 50th, 75th, 90th and 95th percentiles of temperature (unit: 0.1 °C) for two alternative baseline periods (1961-1990 and 1961-2008), for present-day climate (2010) and for the future (2030 and 2050)

Probabilities (%) of "very cold", "cold", "warm" and "very warm" Junes, using threshold values from the WMO normal period 1961-1990

Summary

- **Because of ongoing climate change, past observations are not necessarily representative of present and (particularly) future climates**
 - issue larger for temperature than for precipitation
- **The distributions of present-day (and future) climate variability can be – at least crudely – estimated by combining observations with climate model results**
- **Results for many Nordic locations are available at**
http://www.atm.helsinki.fi/~jaraisan/CES_D2.4/Tables_T
http://www.atm.helsinki.fi/~jaraisan/CES_D2.4/Tables_P.
- **More comprehensive documentation is available at**
http://www.atm.helsinki.fi/~jaraisan/CES_D2.4/CES_D2.4_task1.pdf