Verification of probabilistic forecasts of temperature and precipitation change from 1971-2000 to 2011-2020

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TELLUS

Probabilistic forecasts of near-term climate change based on a resampling ensemble technique

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- **Räisänen & Ruokolainen** (2006) **presented probabilistic forecasts of climate change from** 1971-2000 **to** 2011-2020, **taking into account the two main sources of uncertainty in near-term climate change:**
  - Internal climate variability
  - Differences between climate models

Example: forecasts of temperature change at (60ºN, 25ºE) → **Helsinki**

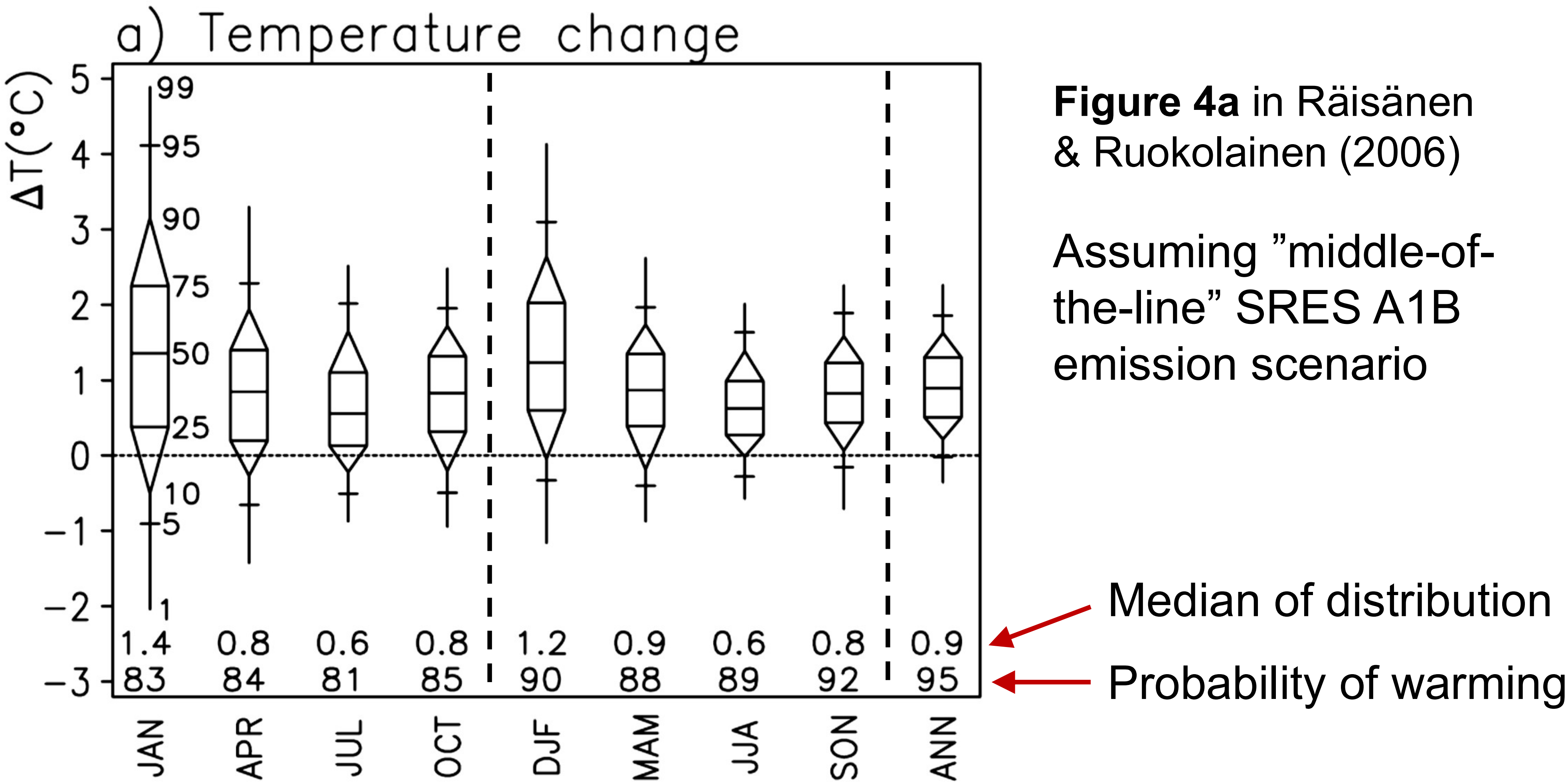
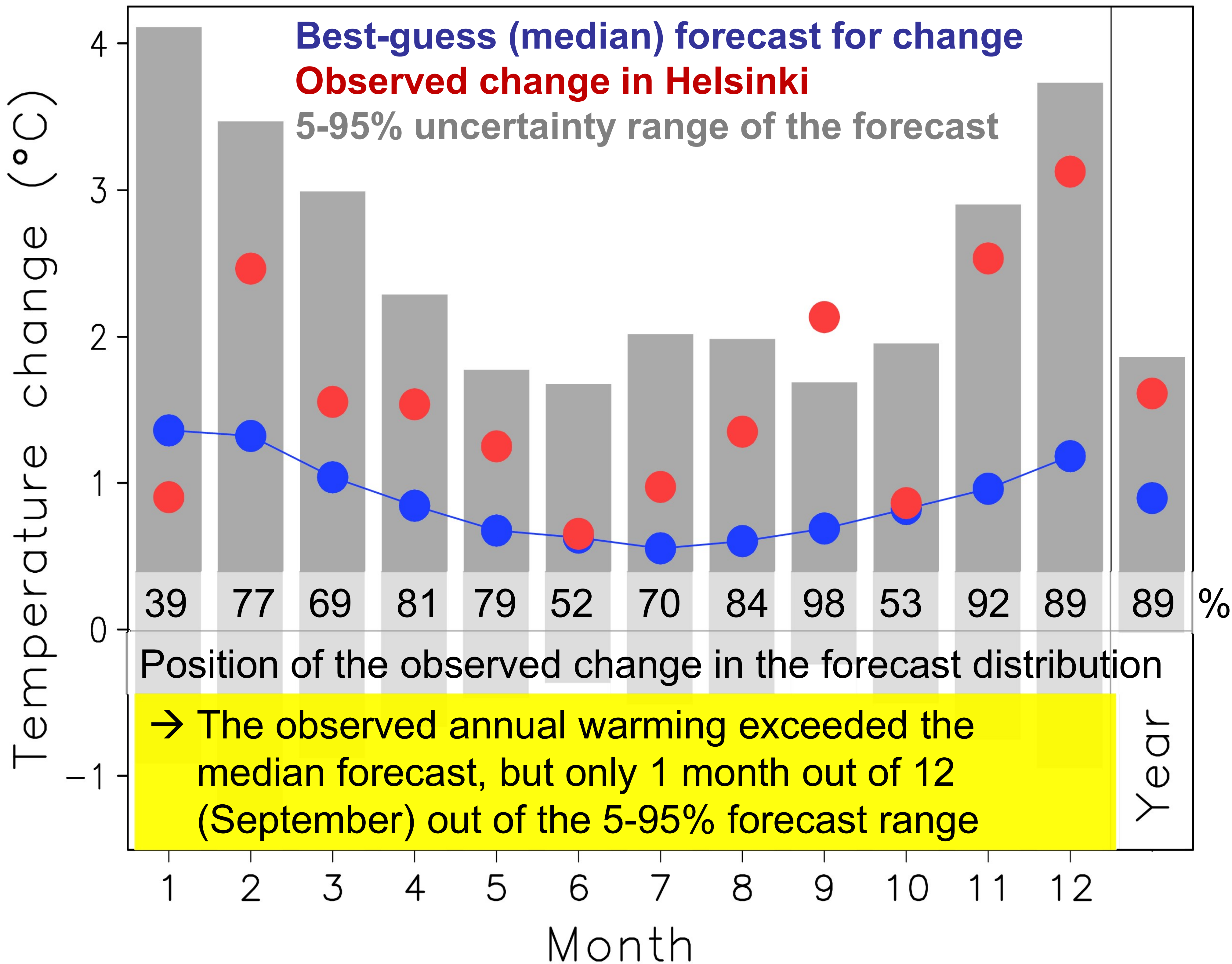


Figure 4a in Räisänen & Ruokolainen (2006)

Assuming "middle-of-the-line" SRES A1B emission scenario

→ **How well did these forecasts compare with the observed climate changes from** 1971-2000 **to** 2011-2020**?**



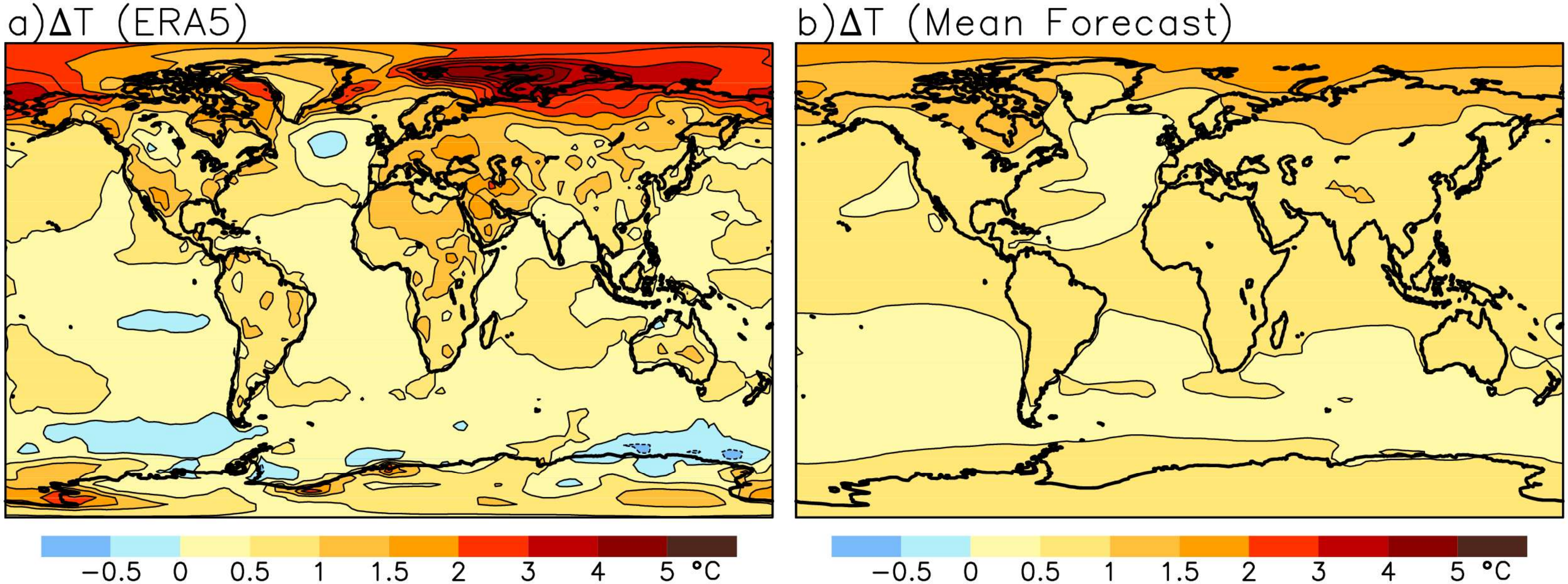
Best-guess (median) forecast for change
Observed change in Helsinki
5-95% uncertainty range of the forecast
Temperature change (°C)
4
3
2
1
0
−1
39
77
69
81
79
52
70
84
98
53
92
89
89
%
Position of the observed change in the forecast distribution
→ The observed annual warming exceeded the median forecast, but only 1 month out of 12 (September) out of the 5-95% forecast range
Year
1
2
3
4
5
6
7
8
9
10
11
12
Month

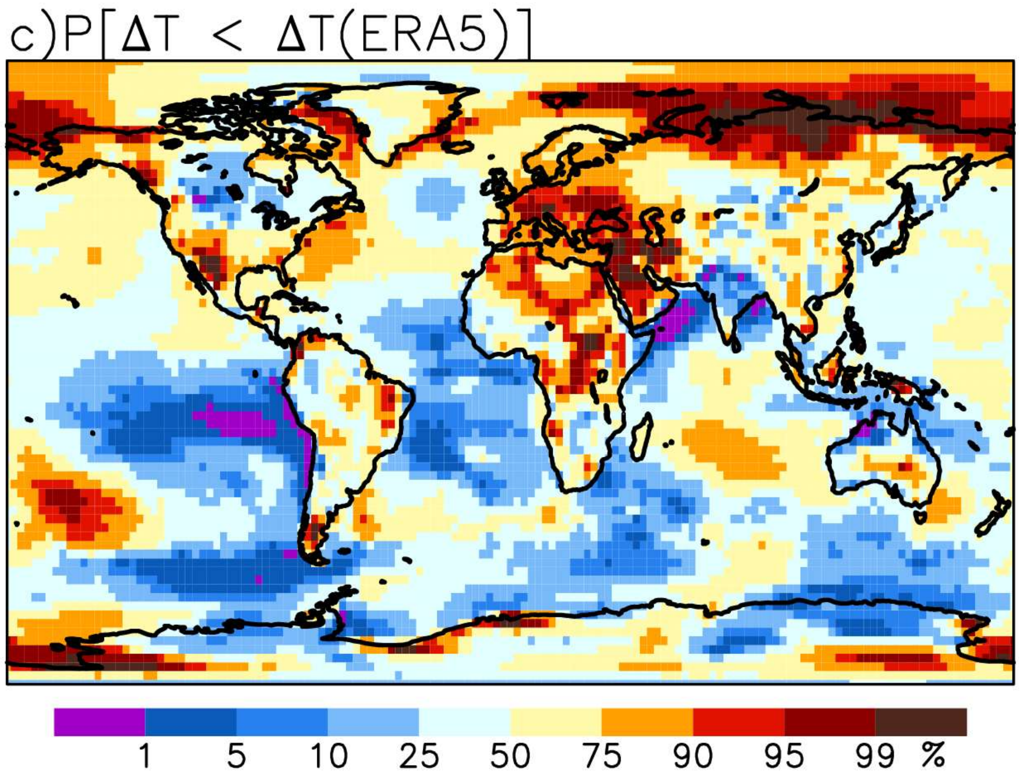
Conclusion from this first look

Not too bad (at least in this case …)

What about the bigger picture:

→ Comparison with temperature changes in ERA5 reanalysis (in 2.5° × 2.5° grid)





Position of the observed change in the forecast distribution

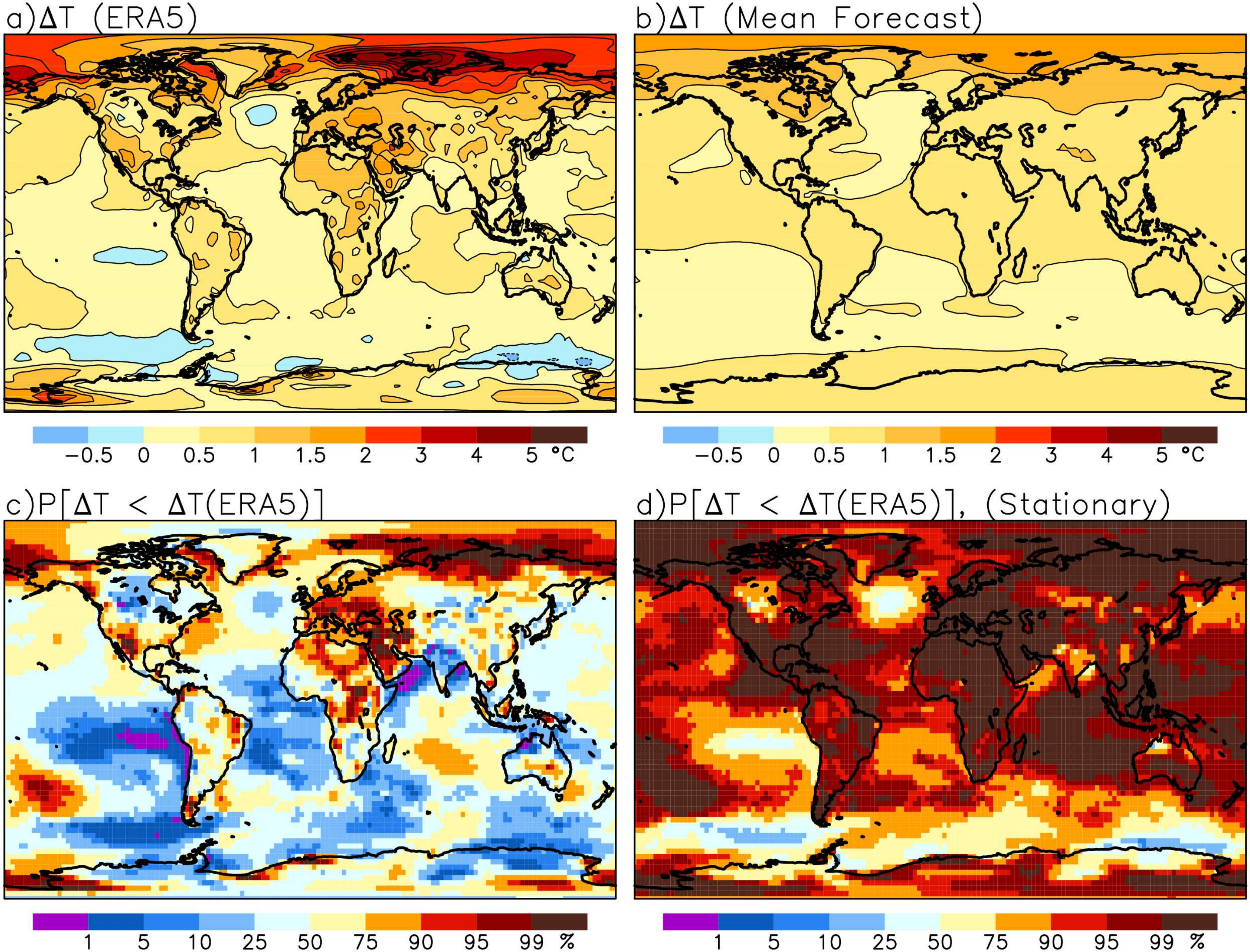
%-fraction of global area where ΔT(ERA5) falls in x-y% of the forecast distribution

	Theory	**Annual**	**Monthly**
0-5%	5	**5.4**	**6.5**
0-25%	25	28.4	29.1
25-50%	25	29.0	26.8
50-75%	25	25.0	25.1
75-100%	25	17.6	19.0
95-100%	5	**3.8**	**3.6**

9.2% of annual and **10.1%** of monthly changes outside the **5-95%** forecast range

→Pretty good as a whole
(although slightly bottom-heavy verification distribution)

What if we had neglected forced (anthropogenic) climate change in forming the probabilistic forecast, only accounting for internal variability?



a)ΔT (ERA5)
b)ΔT (Mean Forecast)
−0.5 0 0.5 1 1.5 2 3 4 5 °C
−0.5 0 0.5 1 1.5 2 3 4 5 °C
c)P[ΔT < ΔT(ERA5)]
d)P[ΔT < ΔT(ERA5)], (Stationary)
1 5 10 25 50 75 90 95 99 %
1 5 10 25 50 75 90 95 99 %

%-fraction of global area where ΔT(ERA5) falls in x-y% of the forecast distribution

	Theory	Annual	Monthly	Annual	Monthly
0-5%	5	5.4	6.5	0	0.3
0-25%	25	28.4	29.1	0.7	2.4
25-50%	25	29.0	26.8	2.7	5.5
50-75%	25	25.0	25.1	6.5	12.4
75-100%	25	17.6	19.0	90.1	79.6
95-100%	5	3.8	3.6	**60.7**	**42.2**

Forecast including forced climate change (first Annual and Monthly columns)

Forecast excluding forced climate change (second Annual and Monthly columns)

Conclusions for temperature change

- This probabilistic forecast was pretty good
- In any case, it was much better than a forecast neglecting forced climate change

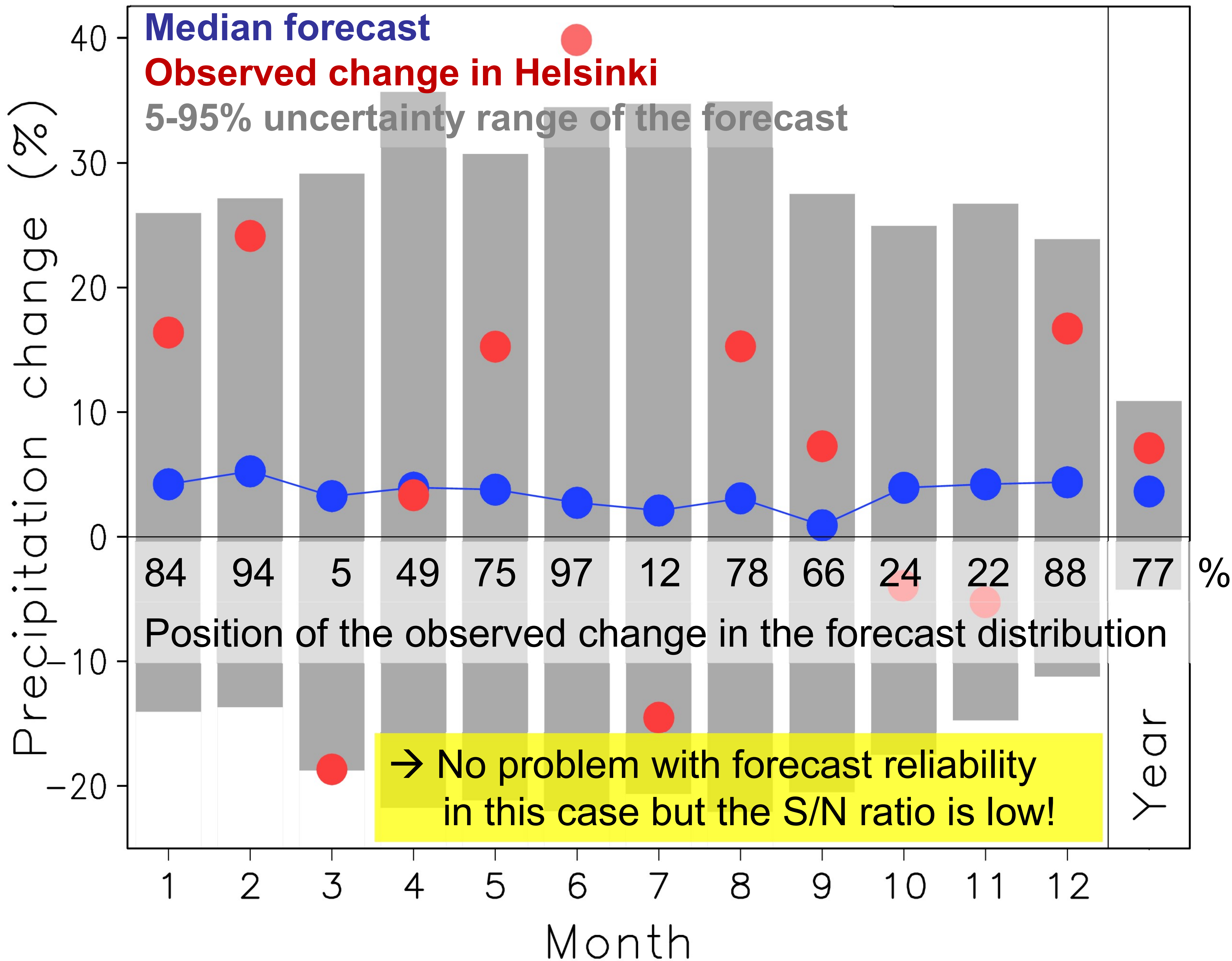
Unfortunately, precipitation change turns out to be more problematic …

Problems with precipitation

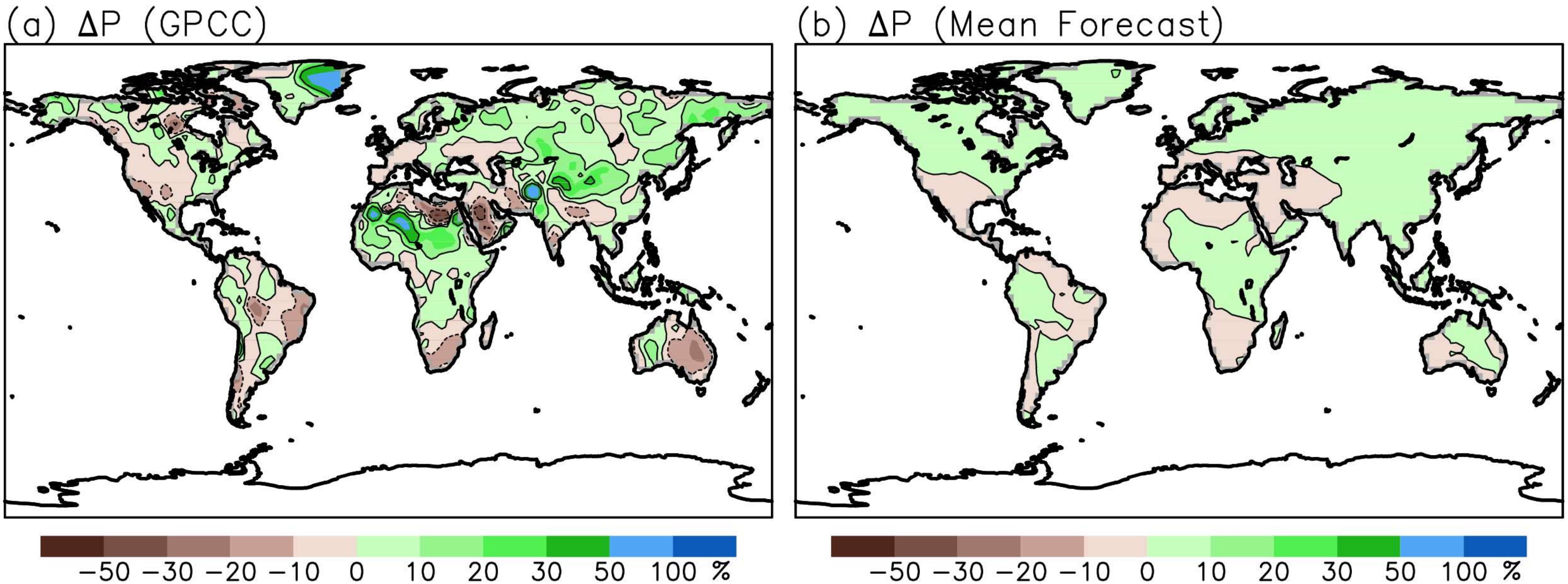
1. **Low signal-to-noise ratio** between greenhouse-gas-induced climate change and internal variability

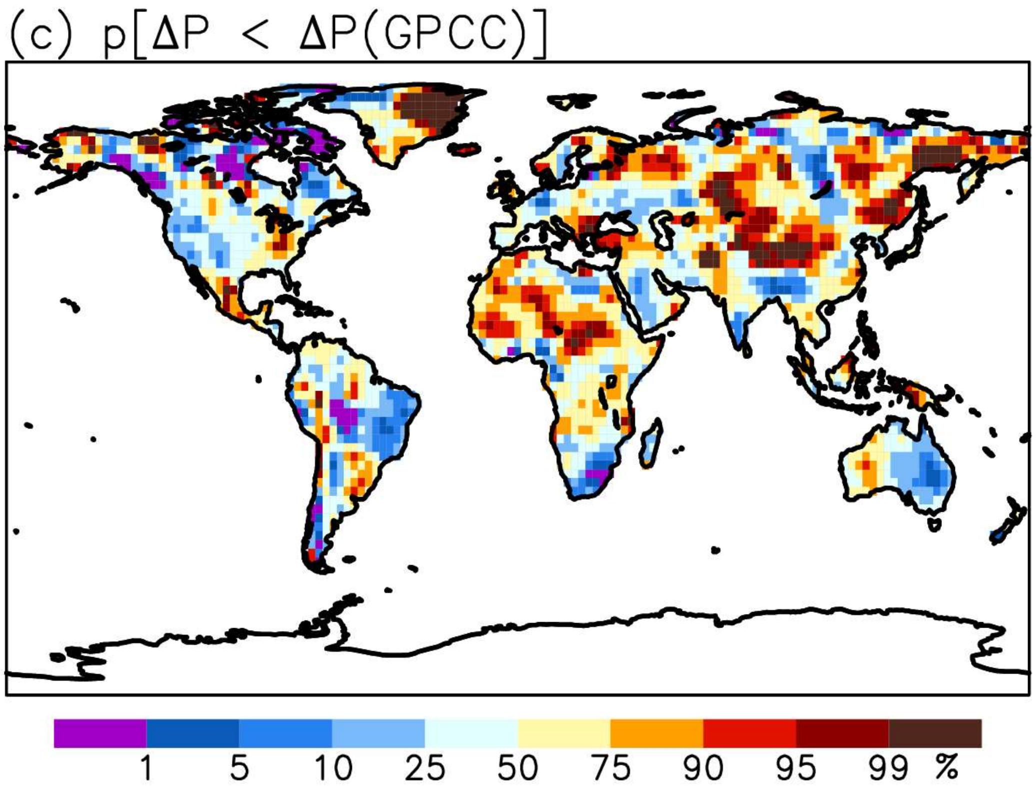
2. **Uncertainty in observations**: how did precipitation actually change?

3. **Climate models may simulate precipitation change less reliably than temperature change**
   - but because of 1-2, it is difficult to be sure!



Median forecast
Observed change in Helsinki
5-95% uncertainty range of the forecast
Precipitation change (%)
40
30
20
10
0
−10
−20
84 94 5 49 75 97 12 78 66 24 22 88 77 %
Position of the observed change in the forecast distribution
→ No problem with forecast reliability in this case but the S/N ratio is low!
Year
1 2 3 4 5 6 7 8 9 10 11 12
Month





Position of the observed change in the forecast distribution

%-fraction of land area where ΔP(GPCC) falls in x-y% of the forecast distribution

	Theory	**Annual**	**Monthly**
0-5%	5	**5.5**	**4.2**
0-25%	25	24.8	23.2
25-50%	25	22.1	25.9
50-75%	25	23.4	25.0
75-100%	25	29.8	25.9
95-100%	5	**8.7**	**6.1**

14.2% of annual and **10.3%** of monthly changes outside the **5-95%** forecast range

A slightly unreliable forecast, at least for annual precipitation changes … (if the observations are good!)

%-fraction of land area where ΔP(GPCC) falls in x-y% of the forecast distribution

	Theory	Annual	Monthly	Annual	Monthly
0-5%	5	5.5	4.2	4.7	3.4
0-25%	25	24.8	23.2	21.6	20.4
25-50%	25	22.1	25.9	21.0	24.4
50-75%	25	23.4	25.0	21.9	26.1
75-100%	25	29.8	25.9	35.5	29.1
95-100%	5	**8.7**	6.1	**12.9**	7.4

Forecast including forced climate change

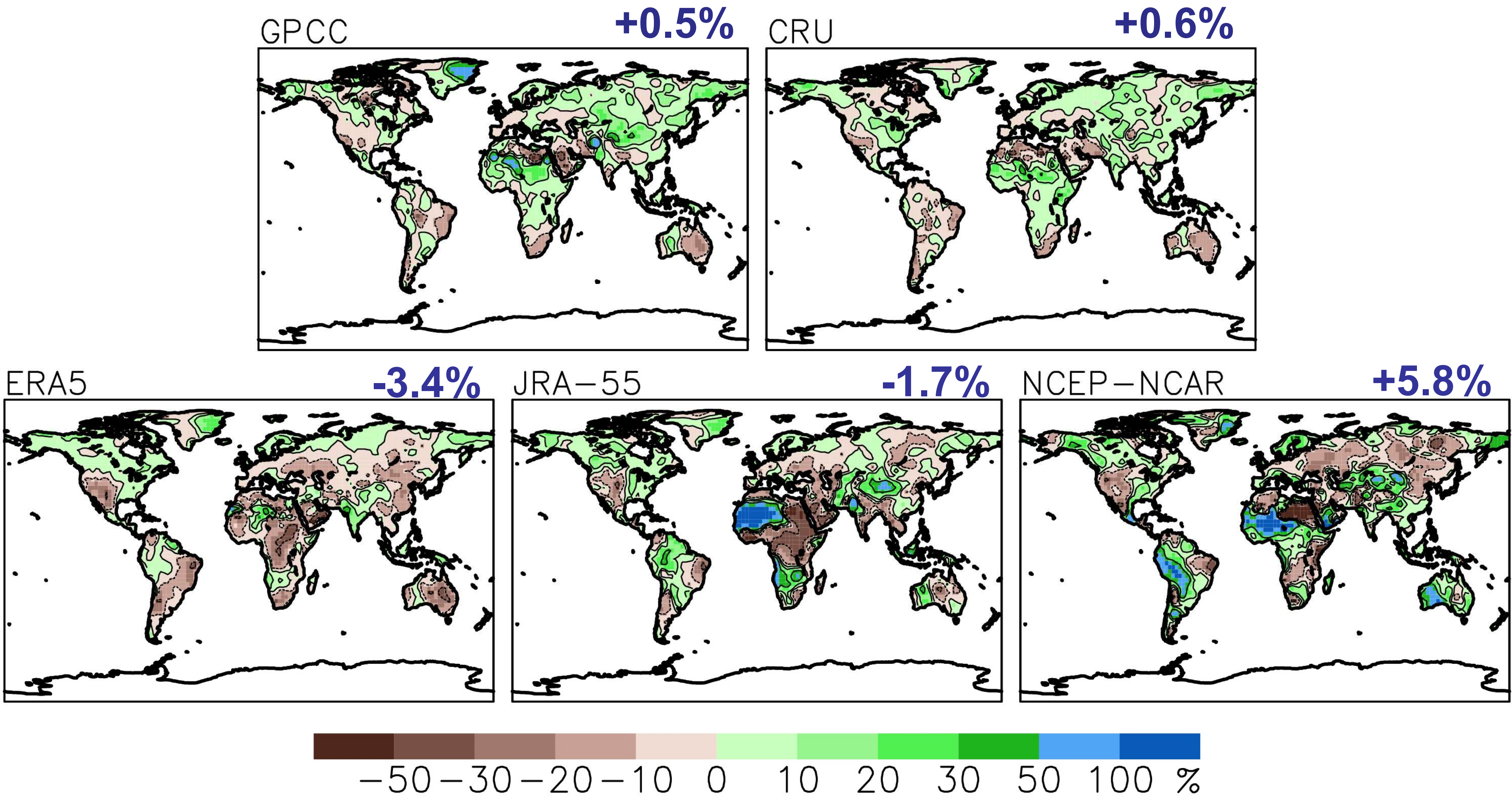
Forecast excluding forced climate change

→ **Inclusion of forced climate change improves the verification statistics, but much less than for temperature!**

How are these results affected by observational uncertainty?

- **The next slide shows the annual mean precipitation change (**1971-2000 **to** 2011-2020**) in five data sets**
  - GPCC = Global Precipitation Climatology Centre
  - CRU = Climate Research Unit
  - ERA5 reanalysis
  - JRA-55 reanalysis
  - NCEP-NCAR reanalysis

Change in annual precipitation



Blue numbers: mean over land at 60ºS-90ºN (!)

Fraction of annual precipitation changes that fall outside the forecasted 5-95% range

(land, latitudes 60ºS-90ºN)

GPCC	**14.2 %**
CRU	**13.2 %**
ERA5	**27.7 %**
JRA-55	**39.2 %**
NCEP-NCAR	**52.3 %**

>> 10% for all 3 reanalyses:
changes in observing system
→ inhomogeneity of data

Similar (but smaller) inhomogeneity might also affect the station-based GPCC and CRU analyses

Conclusions

Temperature	**Precipitation**
• Forecasts **reliable** in a probabilistic sense • Reasonably high S/N ratio → **large improvement** over neglecting forced climate change	• Forecasts (at least apparently) slightly **unreliable** • Low S/N ratio → only **modest improvement** --||-- ---------------- || -----------------

When internal variability has similar or larger magnitude than the forced climate change, verification is much more meaningful in probabilistic than deterministic terms

Verification for decade 2021-2030: **NMM37** in **2032?**

More in this article

Probabilistic forecasts of near-term climate change: verification for temperature and precipitation changes from years 1971–2000 to 2011–2020

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