Requirements for Climate Monitoring of Upper Air Temperature: Experiments with Reanalysis Data

Dian Seidel and Melissa Free

NOAA Air Resources Lab.

Issues

1. Precision of measurements

2. Temporal resolution
    a. Within the day
    b. Within the month

3. Long-term stability

4. Network size and location

1. Start with **6-hour** NCEP reanalysis temperature data

    15 locations
    56 years (1948-2003)
    6 levels (surface, 850, 500, 250, 100, 30)

2. Modify or subsample

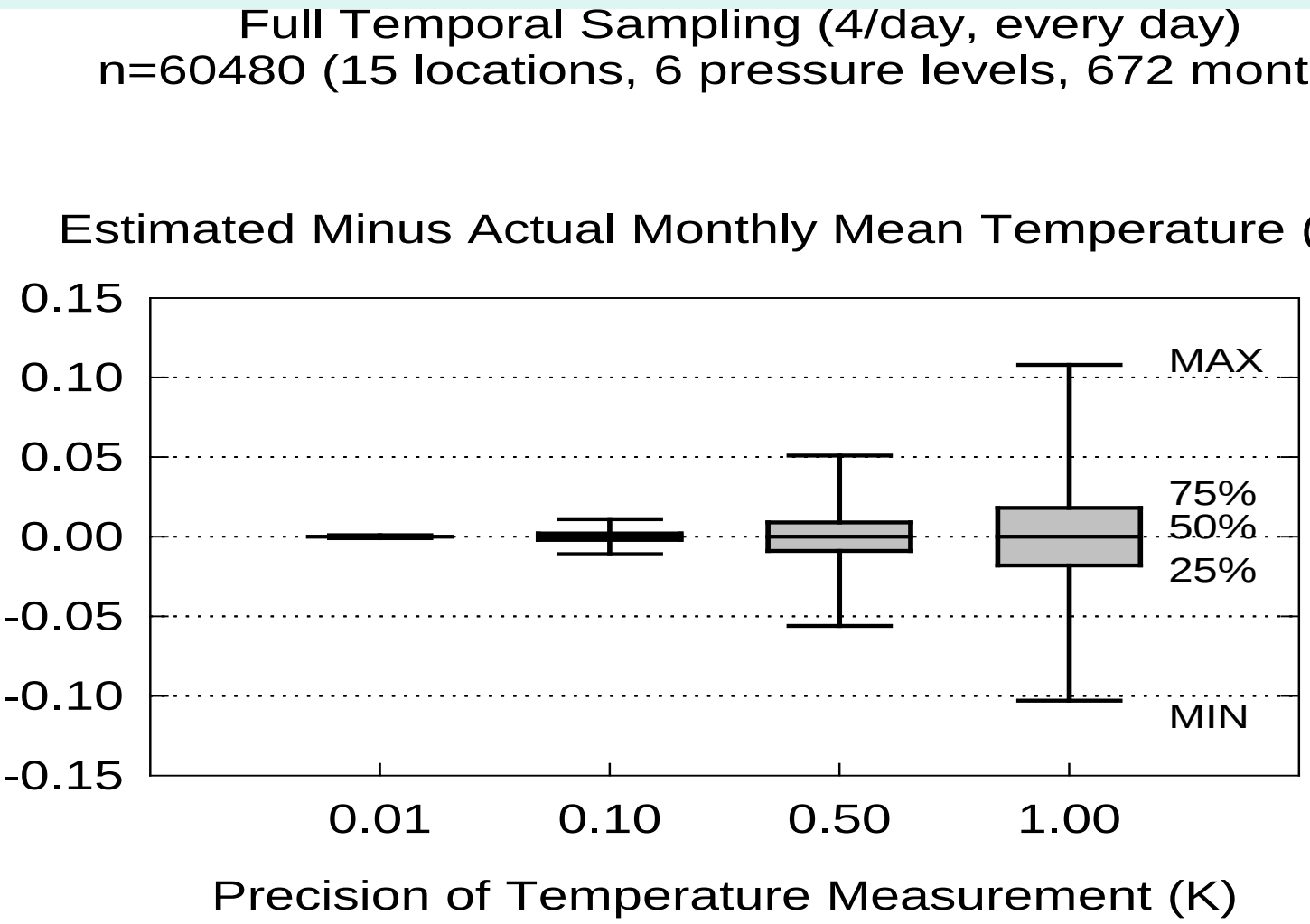
3. Compare to unaltered data

    a. Percent of cases in which test monthly means, variances or trends are significantly different from those in original data

    b. Maximum effect of the test scenario on monthly means, variances and/or trends

(See preliminary report by Seidel and Free for details)

Precision



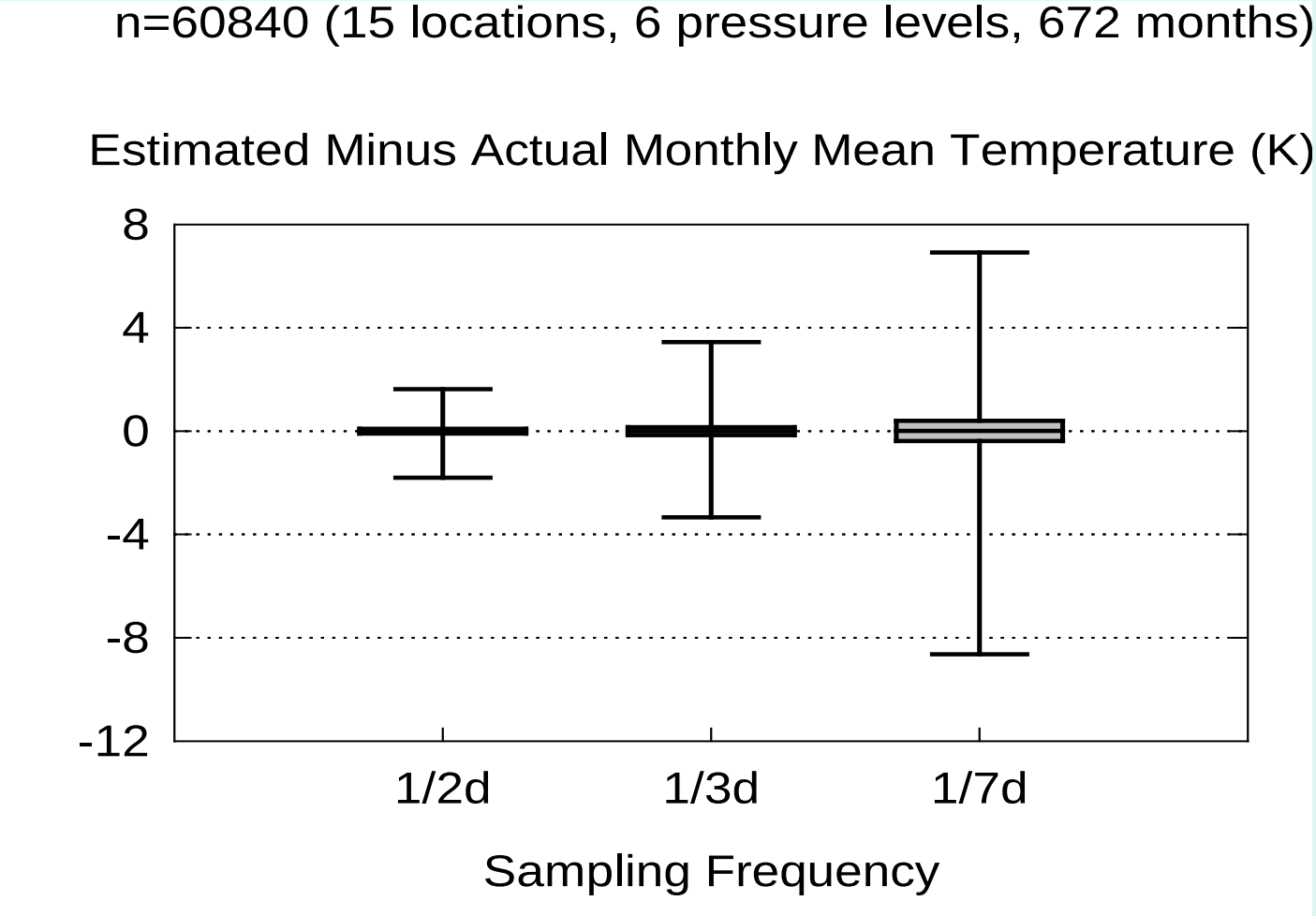
For monthly means within 0.05 K, need precision of at least 0.50 K.

Reduced Diurnal Sampling:

- Effect varies with size and shape of diurnal cycle
- Going from 4 to 2 obs/day makes significant change in monthly means in only 2.3% of cases
- For only 1/day, means change in 13-17% of cases

Conclusion: 2 obs/day is enough

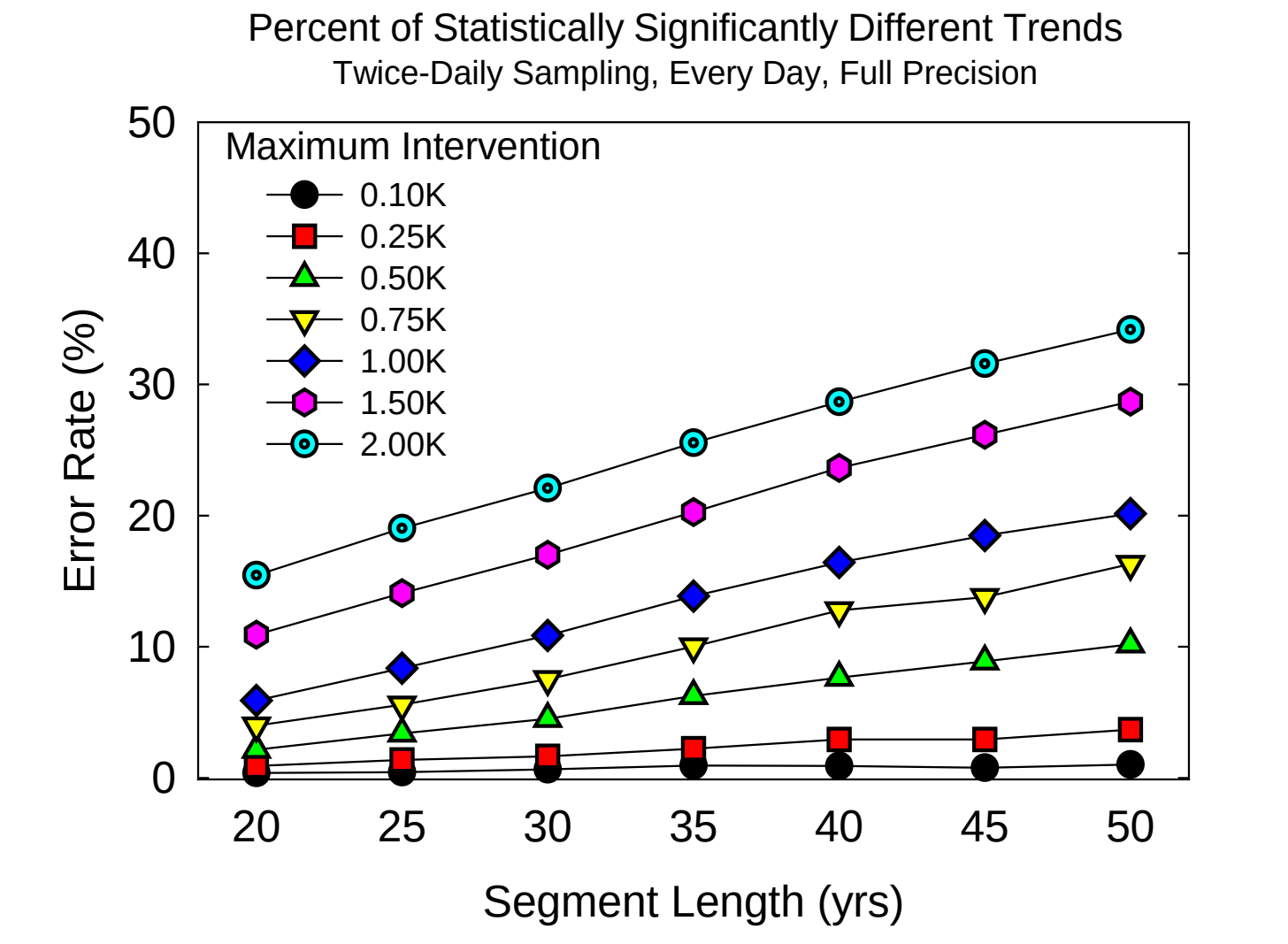
Number of Observation Days per Month:



Observations every other day give

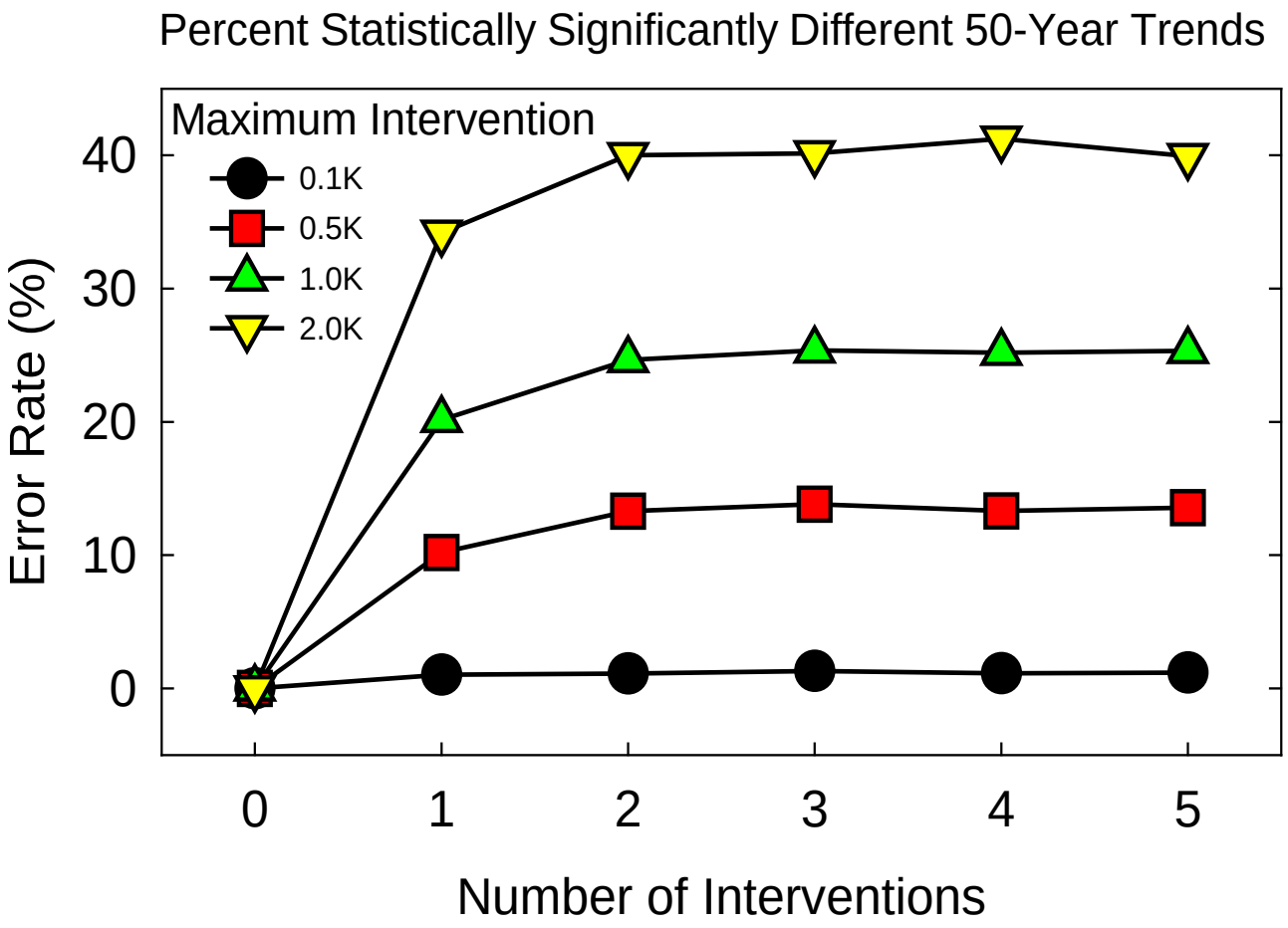
- monthly means accurate to within 2 K or better and
- trends that are not statistically different in 90% of cases.

Effects of Data Stability on Trends - 1 event



Reliable trend estimates require measurement stability within 0.5 K over 20-50 years.

Effects of multiple changes = More errors



But the first event causes most of the error

Station networks

Start with NCEP monthly data

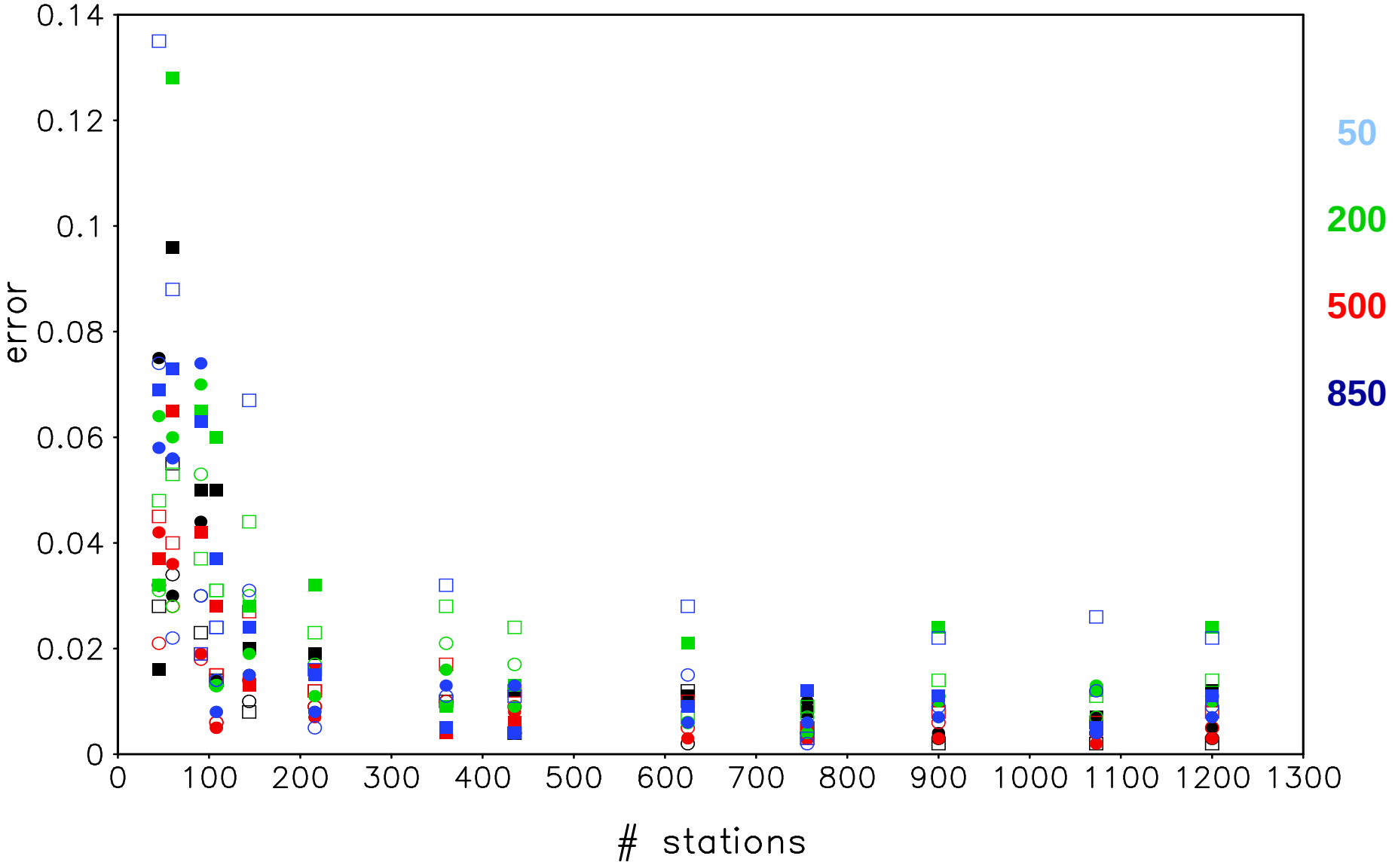
1. Sample at various numbers of ~evenly spaced spots.

2. Sample at locations of 7 radiosonde networks.

3. Subtract trends from those in full global dataset.

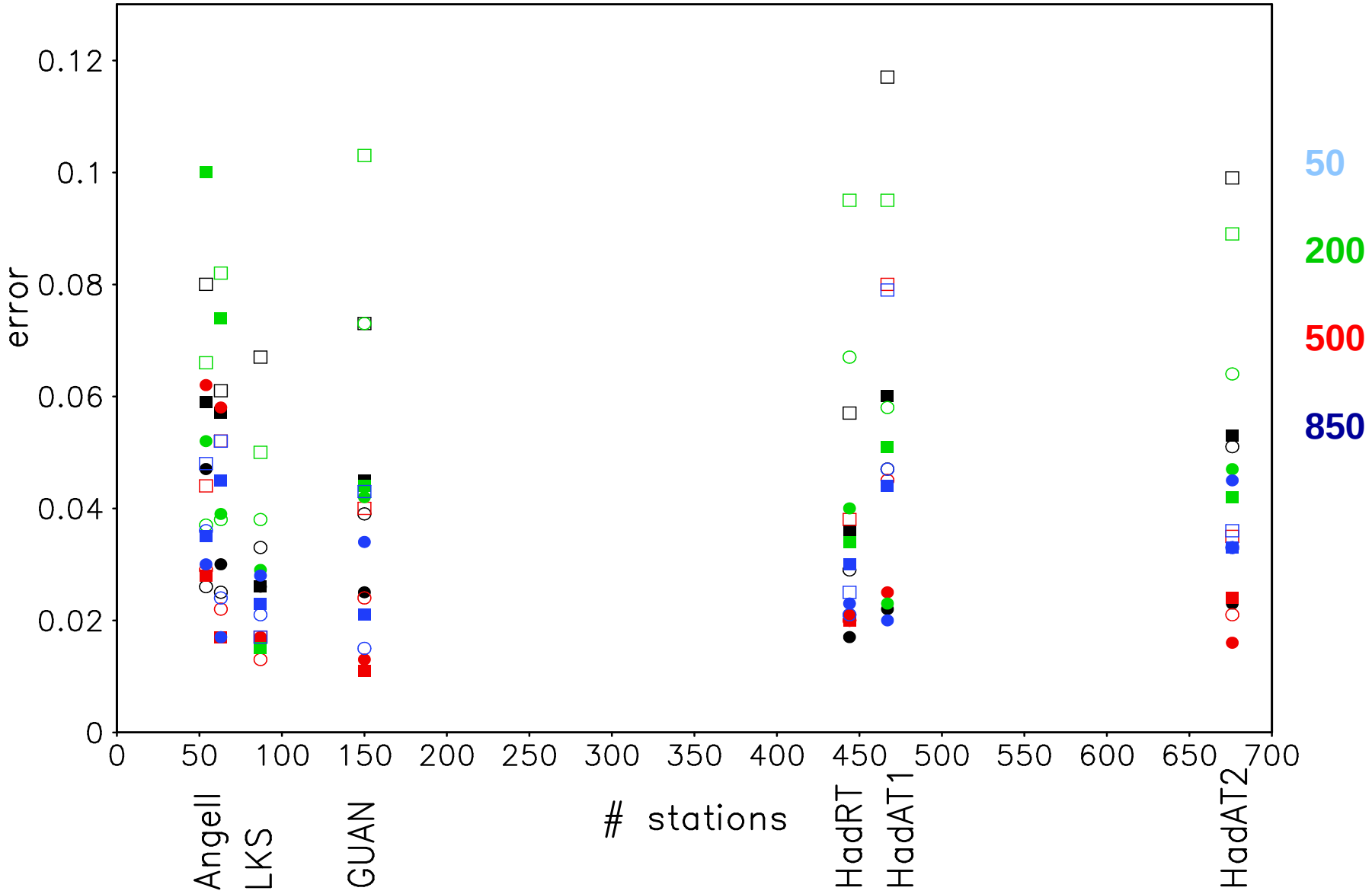
Done for 4 pressure levels, for hemispheres, tropics and globe

Spatial sampling errors in trends from hypothetical networks from reanalysis– decrease with increasing size



Error = trend in subsampled minus trend in complete network

Spatial sampling errors in trends from actual radiosonde networks using reanalysis- no decrease with increasing size



Large-scale spatial sampling effects are similar for the larger and smaller radiosonde networks

Fewer than 100 stations may be enough?

(This ignores time sampling as well as subgrid scale spatial sampling)

Free and Seidel, Causes of differing temperature trends in radiosonde upper-air datasets (2005), J. G. R., *accepted*.

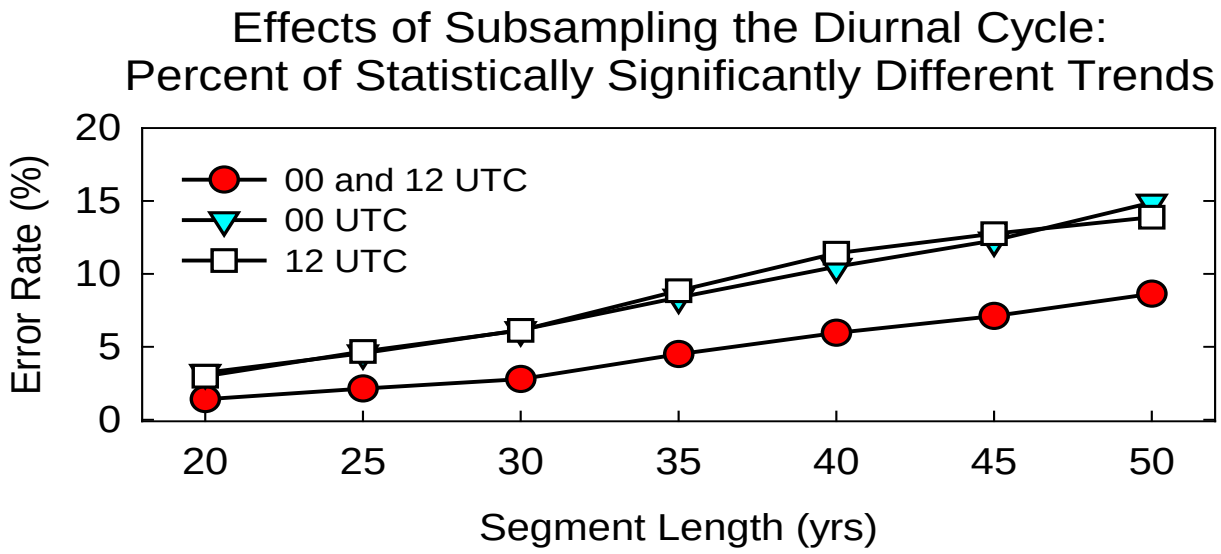
Summary of Requirements

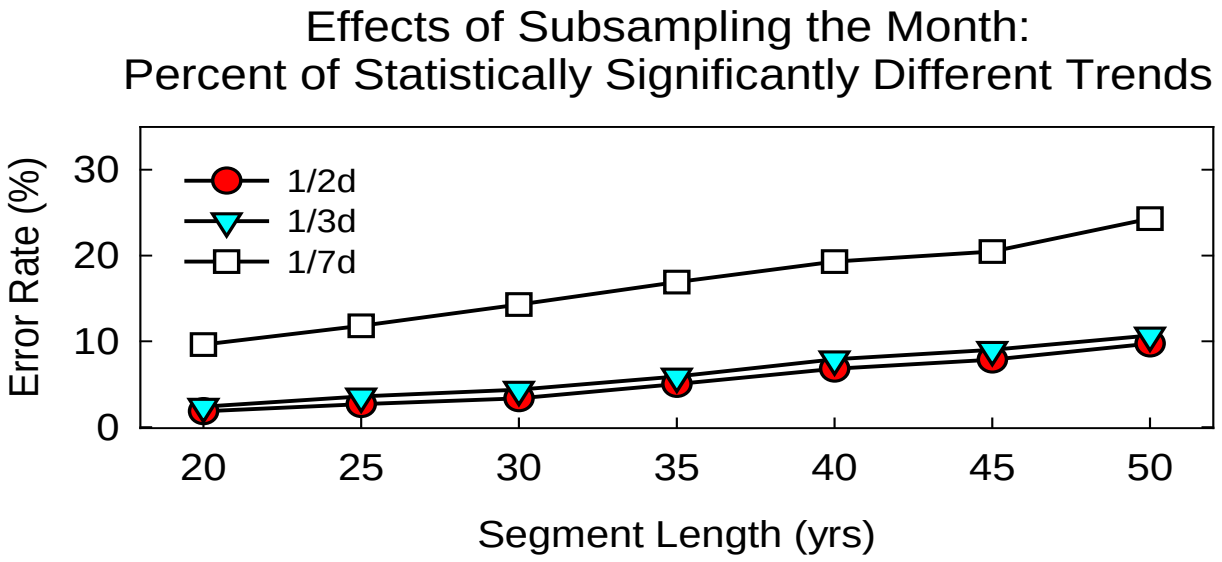
- Precision: 0.50 K
- Frequency: 2 per day, every other day
- Stability: No more than 0.5 K change
- Network: <100 stations may be enough?

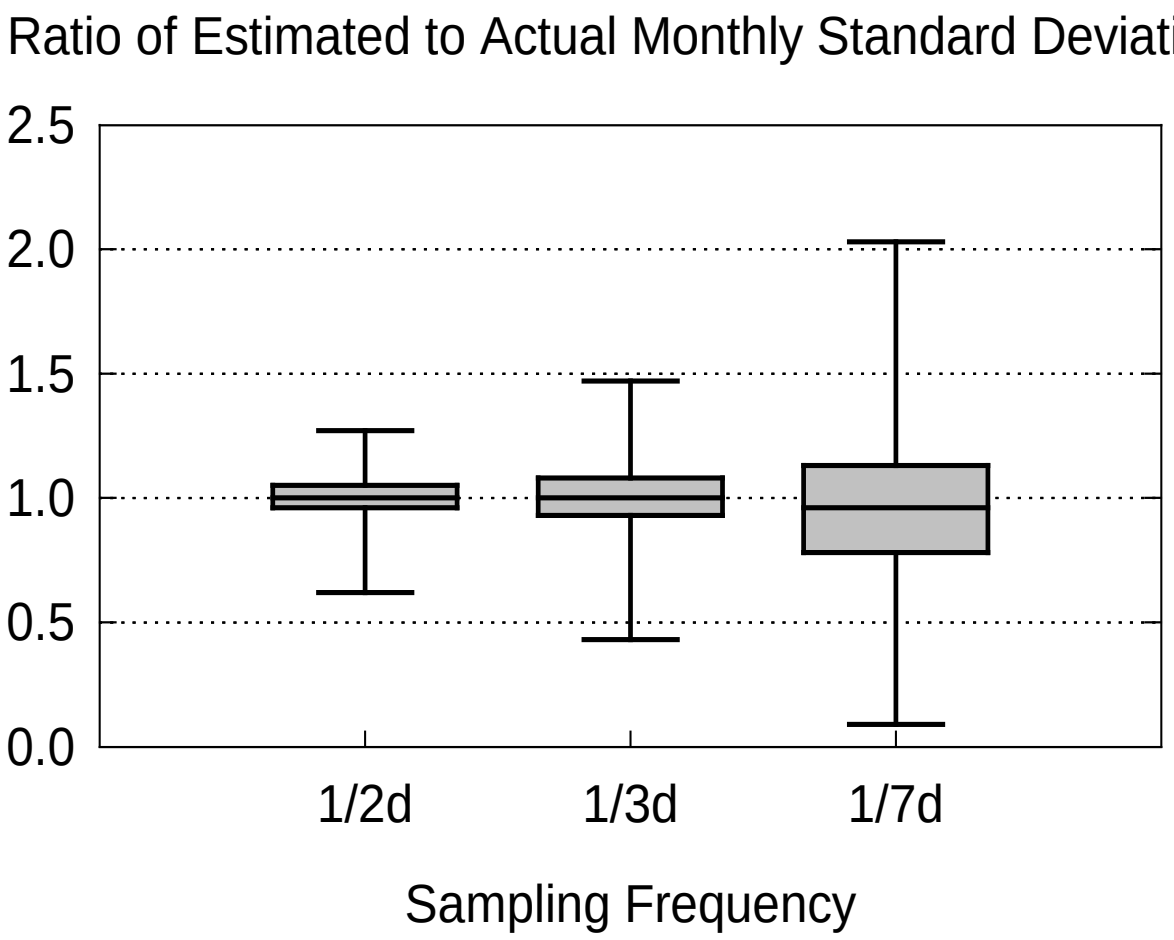
Caveats

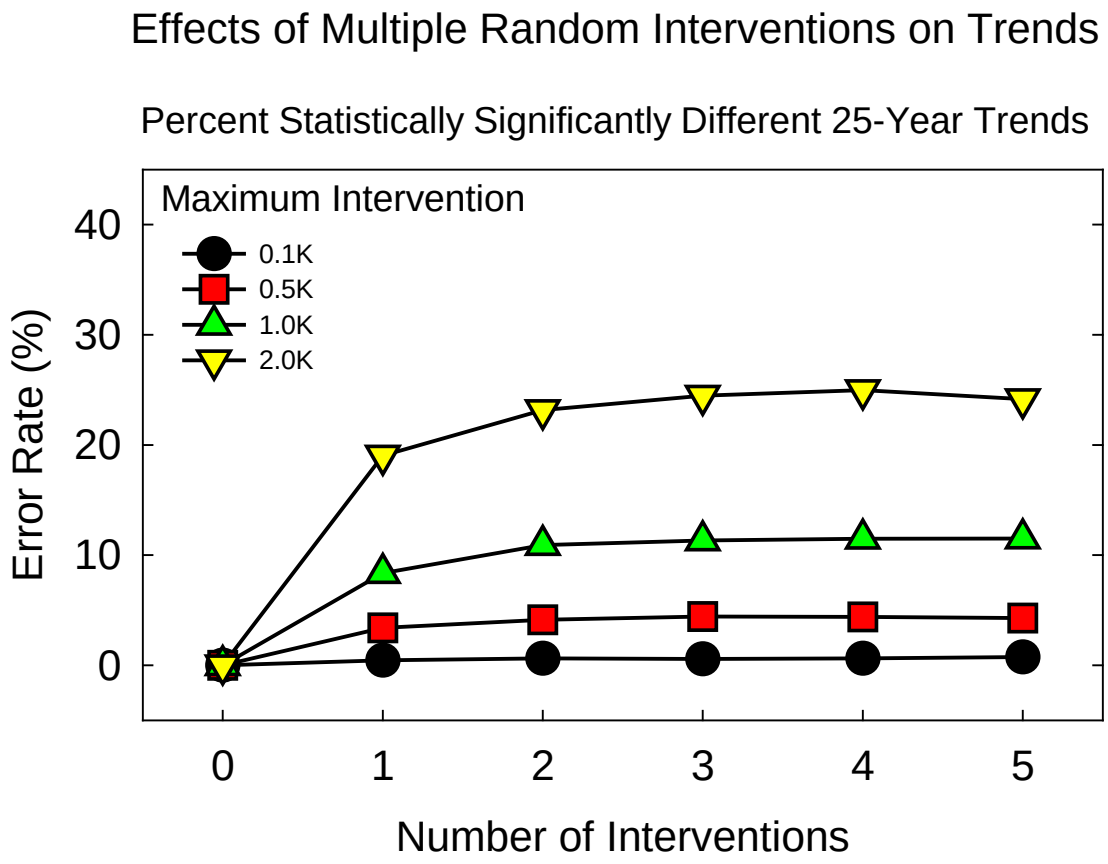
- Is reanalysis an adequate proxy?
- Are our statistical tests reasonable?
- Will future variability be similar to that of the past?

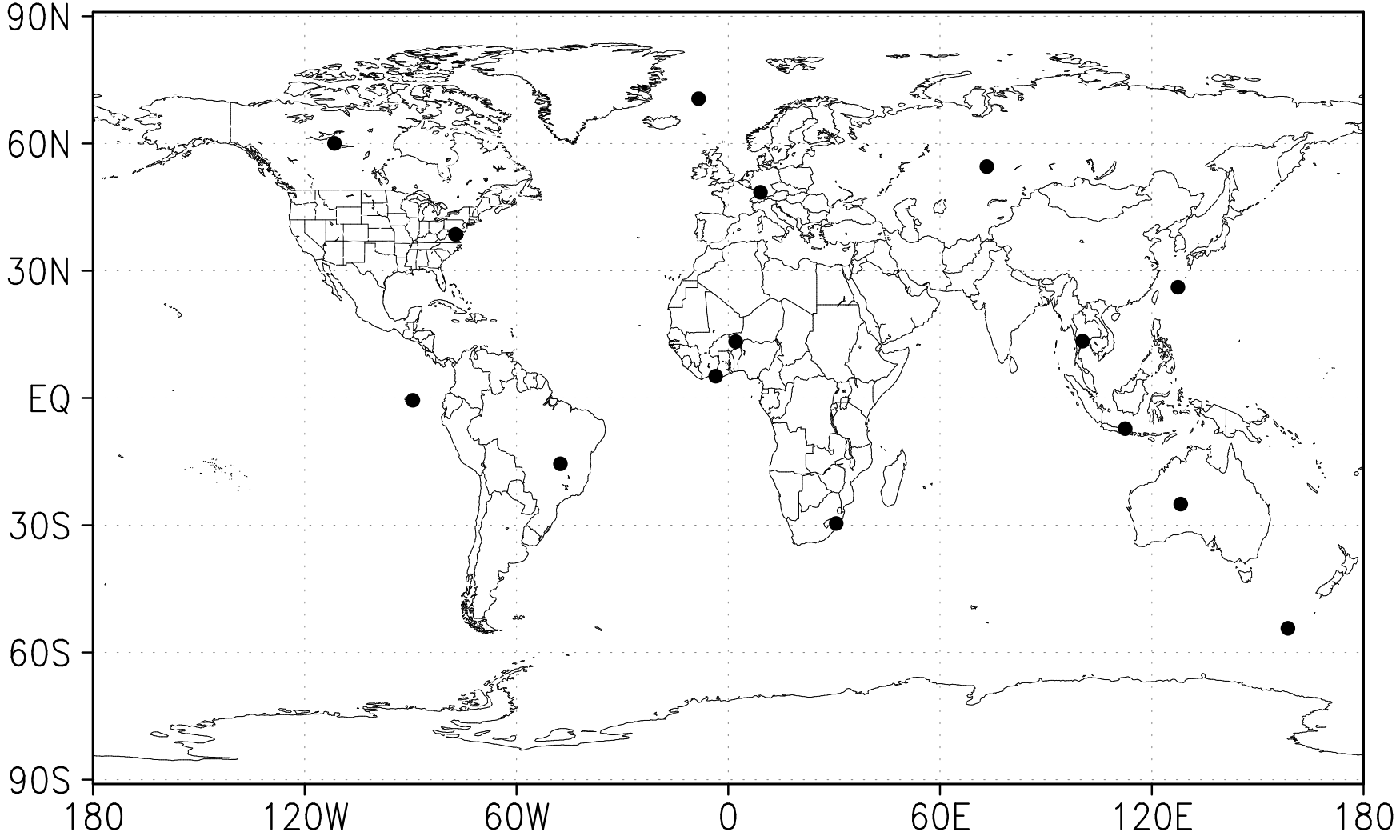
- BUT our analysis is based on conservative assumptions (e.g. use of parametric statistics)


Effects of Subsampling the Diurnal Cycle:
Percent of Statistically Significantly Different Trends
Error Rate (%)
0
5
10
15
20
00 and 12 UTC
00 UTC
12 UTC
20
25
30
35
40
45
50
Segment Length (yrs)


Effects of Subsampling the Month:
Percent of Statistically Significantly Different Trends
Error Rate (%)
0
10
20
30
1/2d
1/3d
1/7d
20
25
30
35
40
45
50
Segment Length (yrs)


Ratio of Estimated to Actual Monthly Standard Deviation
2.5
2.0
1.5
1.0
0.5
0.0
1/2d
1/3d
1/7d
Sampling Frequency


Effects of Multiple Random Interventions on Trends
Percent Statistically Significantly Different 25-Year Trends
Maximum Intervention
0.1K
0.5K
1.0K
2.0K
Error Rate (%)
0
10
20
30
40
0
1
2
3
4
5
Number of Interventions


90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180