Extreme behavior of large-scale indicators for severe weather

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Background

Severe weather typically on fine scales

Historical records limited

Weak relationship with larger-scale phenomena

Concurrently high values of CAPE (J/kg) and shear (m/s) found to be indicative of conducive environments for severe weather

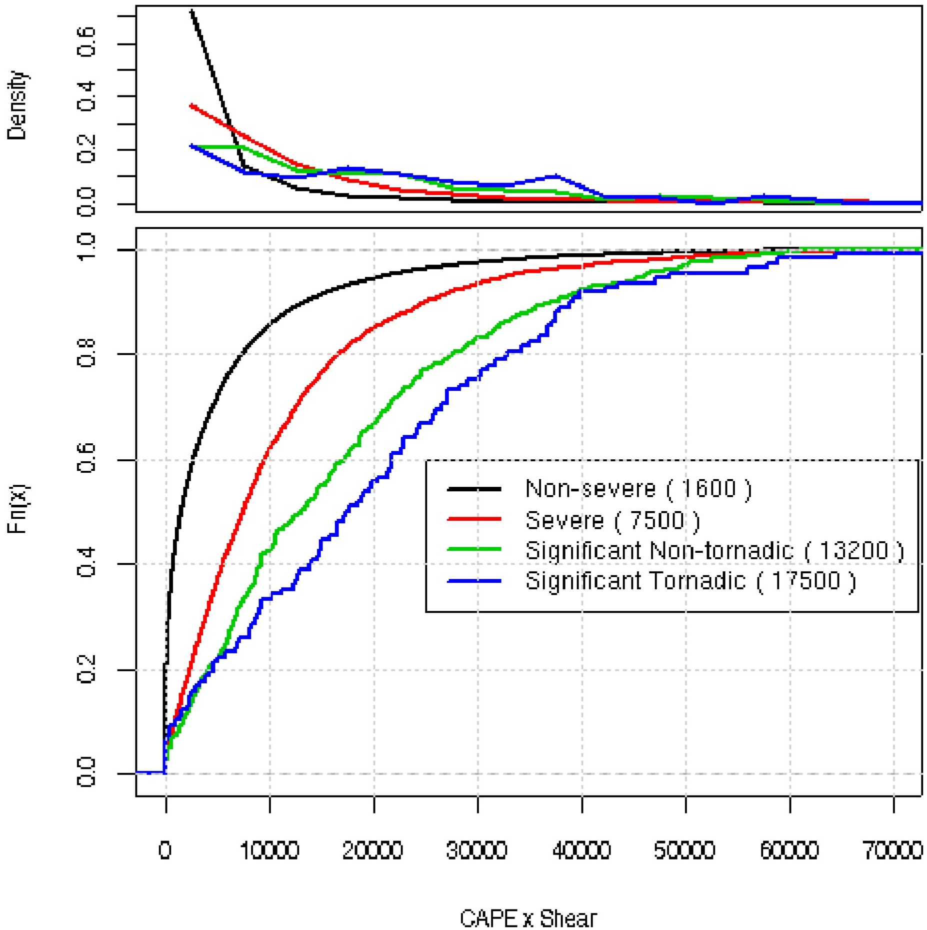
(e.g., Brooks et al., 2003)

Background

Definitons for categories of severe storms.

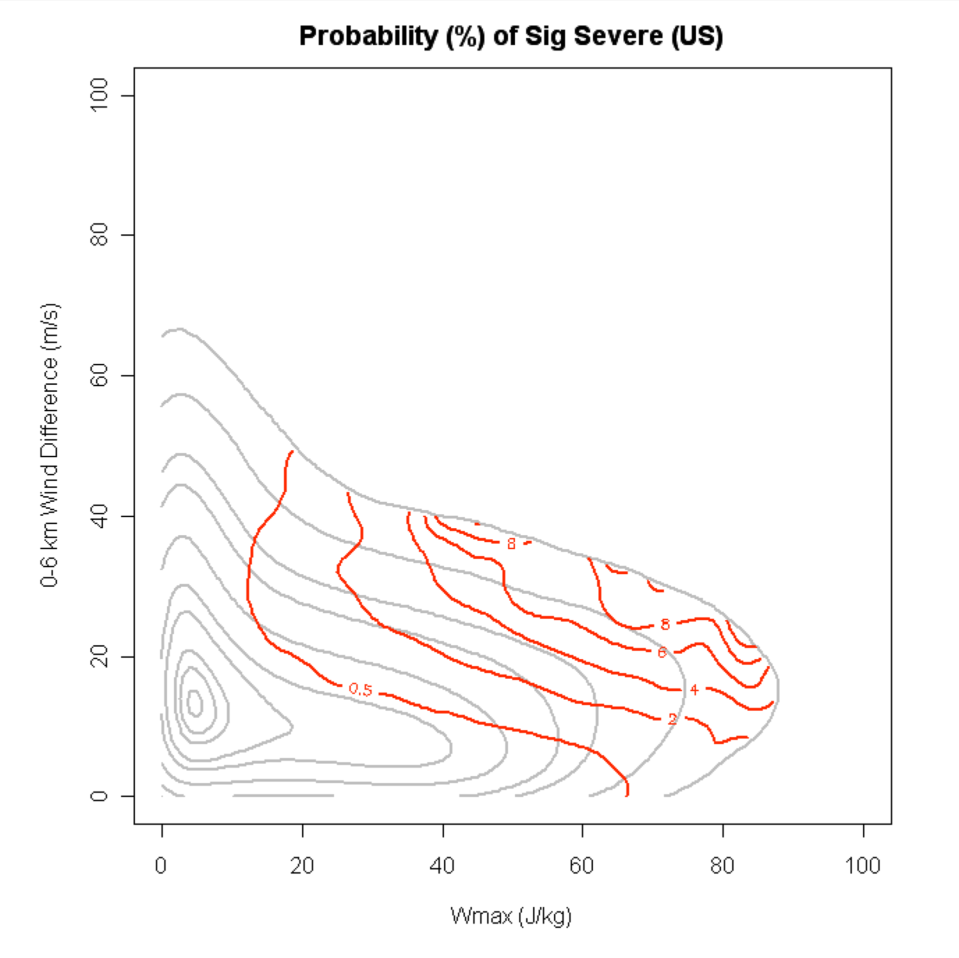
Non-severe	hail < 1.9 cm. (3/4 in.) diameter winds < 55 kts. no tornado
Severe	Hail ≥ 1.9 cm. diameter winds ≤ 55 kts. and < 65 kts. or tornado
Significant Non-tornadic	Hail ≥ 5.07 cm. (2 in.) diameter Winds ≥ 65 kts.
Significant Tornadic	Same as sig. tornadic with F2 (or greater) tornado.

Background



Density
0.0
0.2
0.4
0.6
Fn(x)
0.0
0.2
0.4
0.6
0.8
1.0
Non-severe (1600)
Severe (7500)
Significant Non-tornadic (13200)
Significant Tornadic (17500)
0
10000
20000
30000
40000
50000
60000
70000
CAPE x Shear

Background



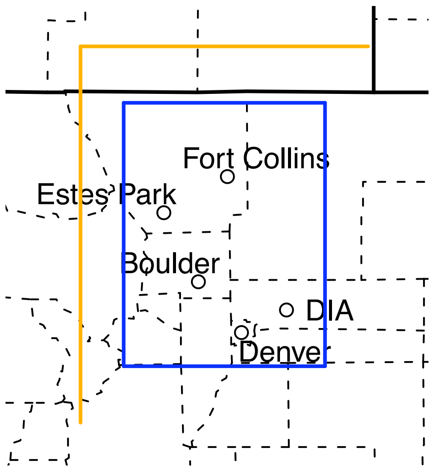
$$W_{max} = \sqrt{2 \cdot CAPE}$$

(m/s)

CAPE (W_{max}) and 0-6 km shear data, or indeed, output

Reanalysis "data" are on a $1.875^o \times 1.915^o$ lon-lat grid with over 17 thousand points covering the globe, and temporal spacing every 6 hours for 42 years (1958-1999). Further details about the reanalysis data can be found in Brooks et al. (2003).

Current climate output from the CCSM3 model for 756 grid points at $1.4^o \times 1.4^o$ resolution over the United States, with temporal spacing of 6 hourly points for 20 years from 1980-1999.

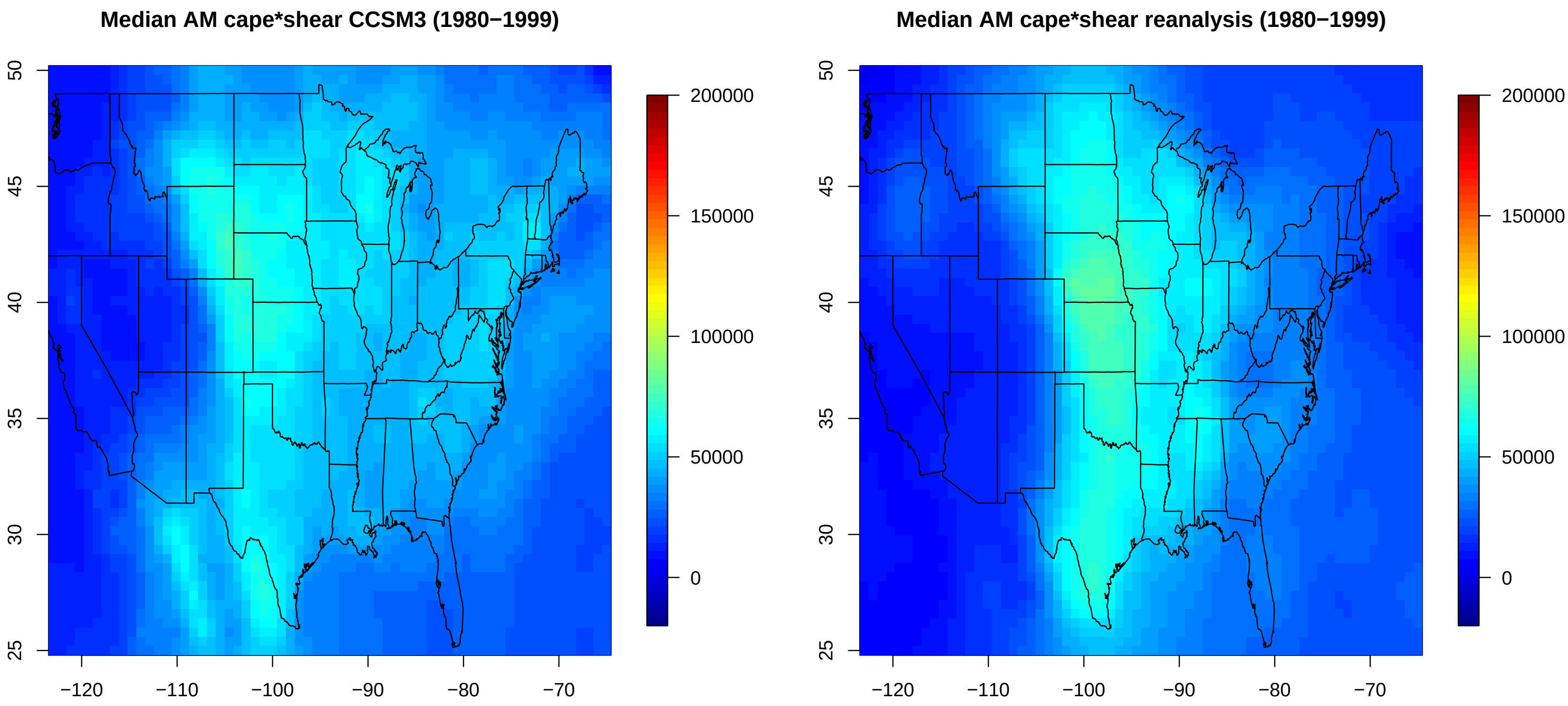


Goals/Questions

Societal Impacts

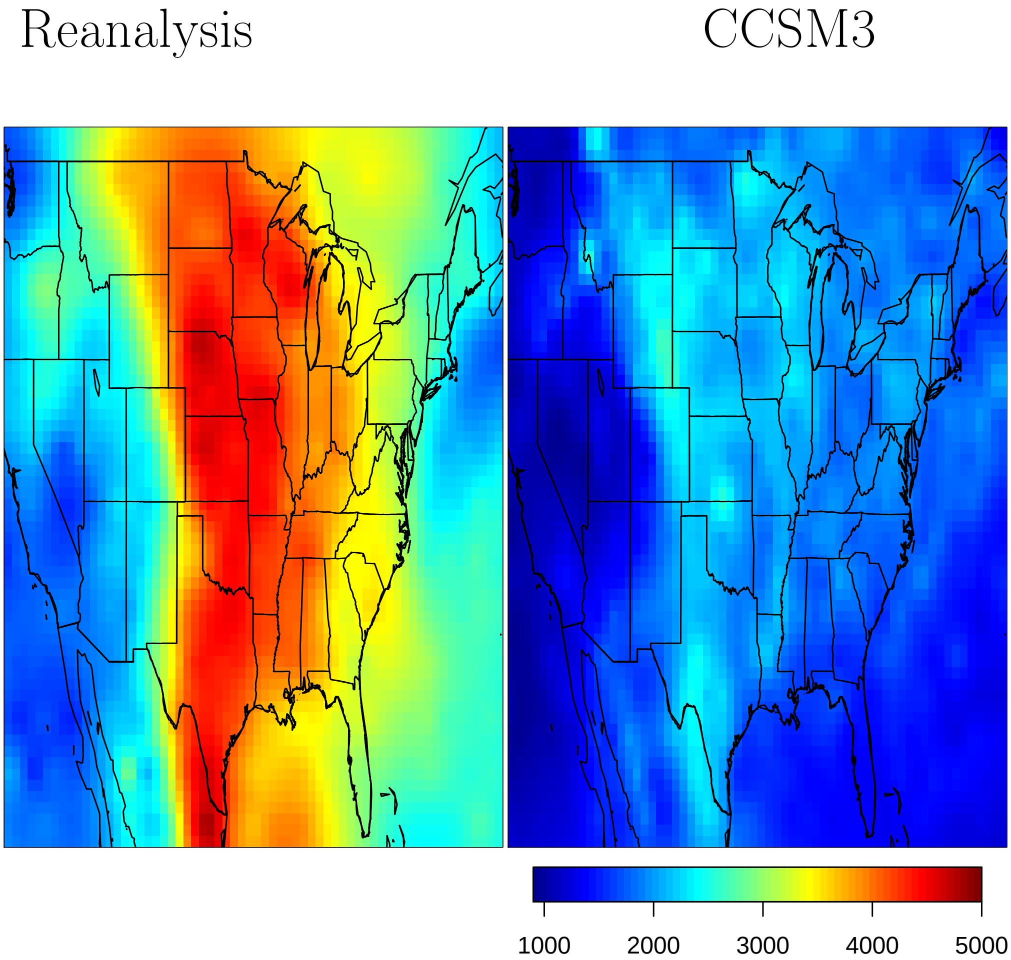
- What can be said about severe weather under a changing climate?
  - Will such events happen more/less frequently?
  - Will they be more/less intense?
- How well does the climate model output characterize the large-scale indicators? How can this be verified?

Preliminaries



Analysis: Verification of Climate Model (Distribution)

GEV-estimated 20-year Return Levels



Analysis: Verification of Climate Model (Distribution)

Are there resolutions/thresholds where CCSM3 matches well with reanalysis?

Approach:

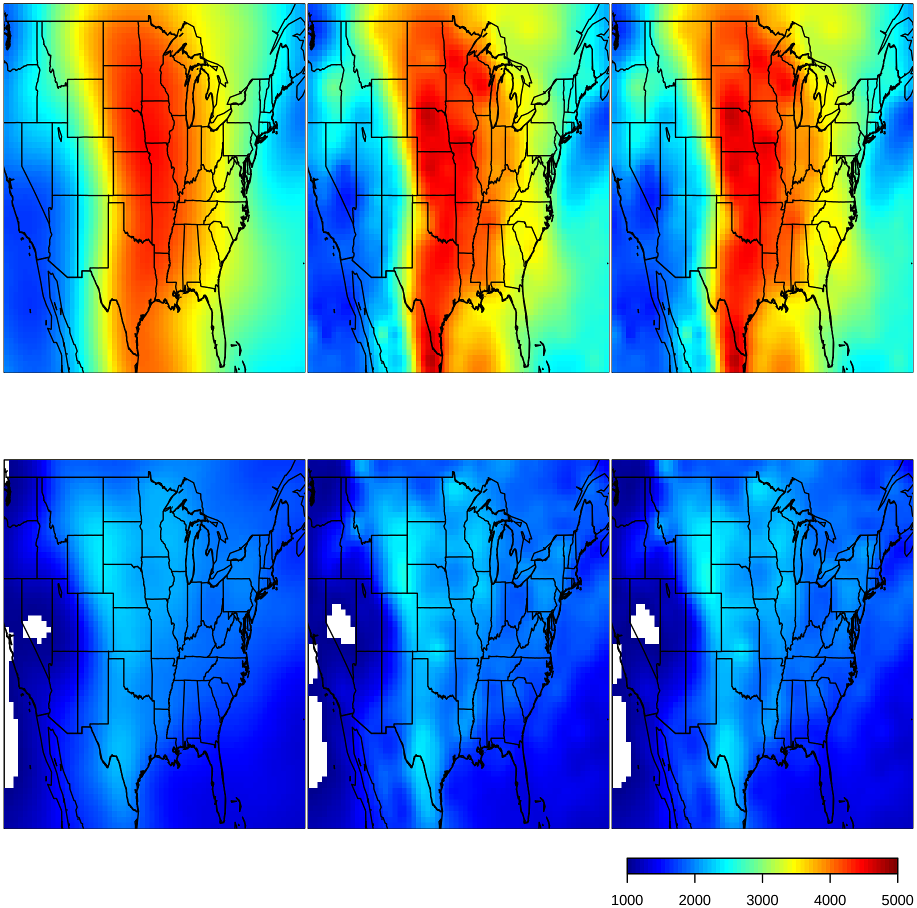
- Focus on comparisons of various GEV (GPD) estimated extreme return levels (here 20-, 50- and 100-year).
- Use thin-plate spline to smooth each field of return levels, and make comparisons between these smoothed fields for values above different thresholds.
- Calculate Baddeley's Δ metric (Baddeley, 1992b,a) for each smoothed field/threshold to investigate how similar the spatial patterns for the two fields are.
- Calculate RMSE for each smoothed field/threshold to investigate whether there is any skill at any resolution and intensity level.

Analysis: Verification of Climate Model (Distribution)

Are there resolutions/thresholds where CCSM3 matches well with reanalysis?

Rows:
Reanalysis (top)
and CSM3 (bottom)

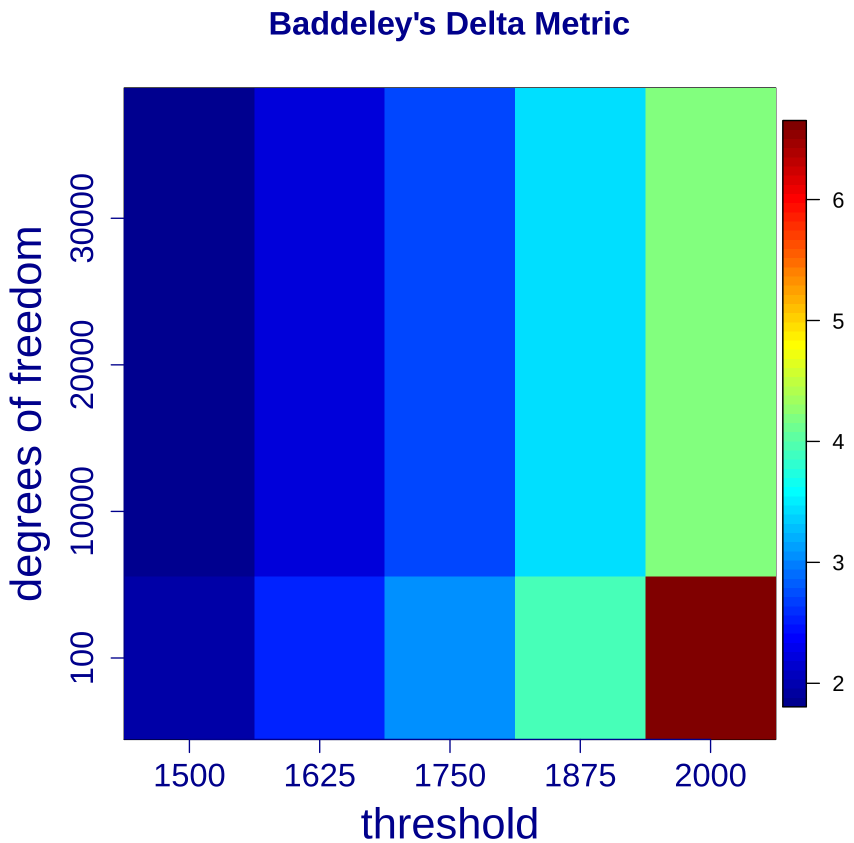
Columns:
Thin-plate spline
predicted fields using
100 (left),
2000 (middle)
and 3000 (right)
degrees of freedom.



Analysis: Verification of Climate Model (Distribution)

Are there resolutions/thresholds where CCSM3 matches well with reanalysis?

Lower values better



Analysis: Verification of Climate Model (Distribution)

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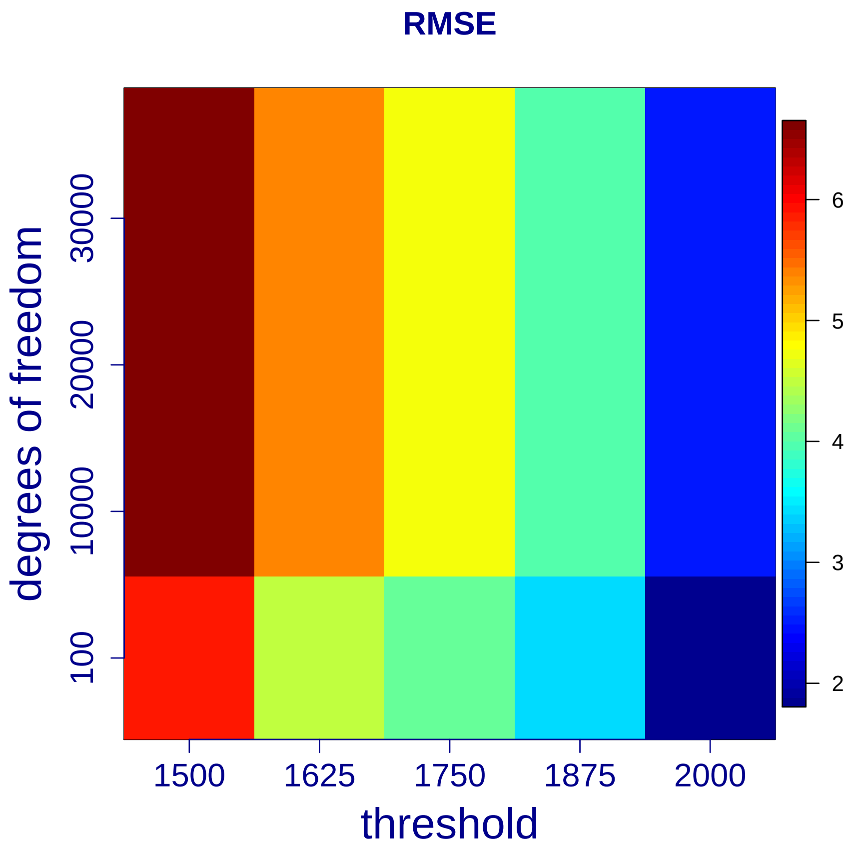

Summary and Future Work

Want to learn about how a changing climate will affect severe weather.

Climate models at too coarse scales to resolve the very fine scale severe weather phenomena. One approach is to use large-scale indicators (e.g., Wmax and shear).

Global reanalysis data set may reasonably represent intensities. Some problems in different parts of the globe. Mostly unimportant, but spatial displacement errors on lee-side of Rocky Mountains.

Look at bivariate distributions of Wmax and shear; compare with univariate approach (i.e., Wmax $\times$ shear).

Investigate trends in frequency and intensity of extreme values of the indicators.

. . .

Thank you, that's all

Questions?

References

Baddeley, A., 1992a. An error metric for binary images. Forstner and S. Ruwiedel (ed.) Robust Computer Vision Algorithms, Proceedings, International Workshop on Robust Computer Vision, Bonn. Karlsruhe: Wichmann, 559-78.

Baddeley, A., 1992b. Errors in binary images and an l_p version of the hausdorff metric. Nieuw Archief voor Wiskunde 10, 157–183.

Brooks, H., Lee, J., Craven, J., 2003. The spatial distribution of severe thunderstorm and tornado environments from global reanalysis data. Atmos. Res. 67–68, 73–94.