False Spring Occurrence over the Southeastern United States, 1901–2007

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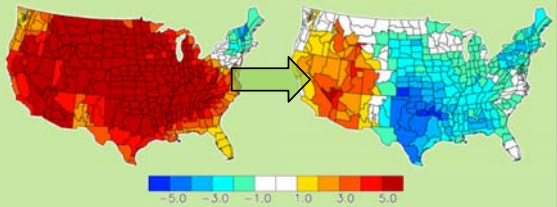
Motivation

Near–record warmth over much of the United States during March 2007 (see left below) promoted early growth of vegetation and agricultural and horticultural crops. A widespread arctic outbreak followed in early April (right), with agricultural losses exceeding two billion dollars. We call these events *false springs*.

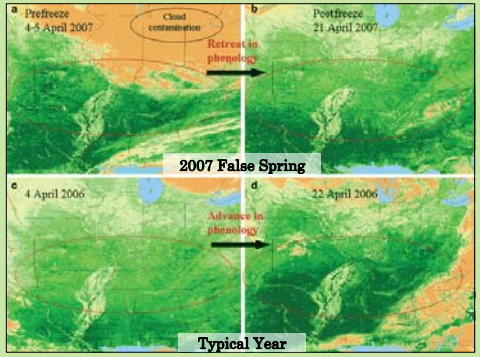
Temperatures Compared to Average (°F)
Departures based on 1961–90 averages

March 2007 *April 2007*



Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their web site at http://www.cdc.noaa.gov/.

Besides the damaging impact of false springs on crops, they can also alter the energy budget and carbon cycles of ecosystems. The images below show the Normalized Difference Vegetation Index for the southeastern United States before (a) and after (b) the 2007 freeze. Dark green indicates dense vegetation. For reference, (c) and (d) from 2006 provide a more typical spring green–up scenario. The area most affected by the freeze was the Southeast, the focus for this work.



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Data Processing & Analysis

Data

- We attempt to model the historical occurrence of false springs (and thus, changes in freeze risk) for the Southeast United States (32–39°N; 75–98°W) using daily maximum and minimum temperature observations spanning 1901 – 2007.
- Extracted the daily data from the Global Historical Climatology Network (GHCN) Daily data set, which have undergone quality assurance checks at the National Climatic Data Center (NCDC).
- Domain chosen to include agricultural and forested areas most affected by the 2007 false spring.
- Station records checked for gaps, missing data, and NCDC quality flags. 176 stations with nearly complete data (fewer than 20 years missing over the period of record) were used in the analysis.

Model for the Start of the Growing Season (SGS)

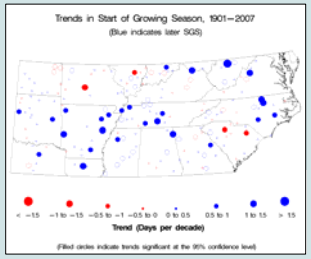
Defining SGS will indicate the timing of leaf–out, and mark when vegetation is subsequently vulnerable to late–season killing freezes. SGS was modeled for the domain through combining MODIS (Moderate Resolution Imaging Spectroradiometer) satellite observations of vegetative development with ground–based temperature "degree–day" calculations reflecting the rate of springtime warming.

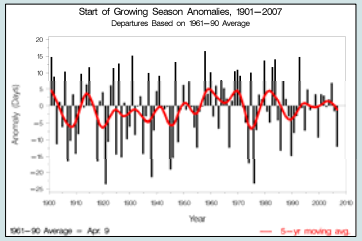
Results

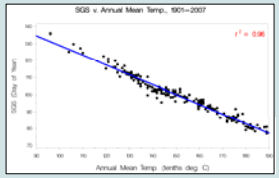
To parameterize false spring risk for the Southeast, a false spring index (FSI) was introduced that considers the relative timing of the start of the growing season (SGS), or leaf emergence, to the timing of a potentially–damaging last freeze (≤ 28°F).

False Spring Index (FSI) = Day of year (last ≤ 28°F) – Day of year (SGS)

Part 1: Start of Growing Season (SGS) / leaf–out

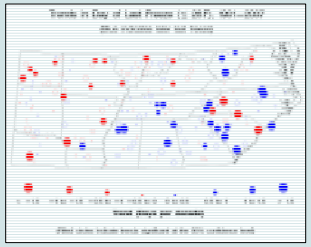


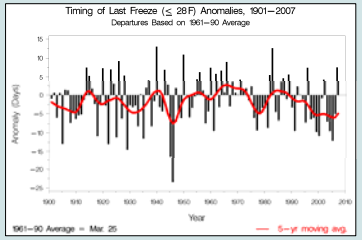


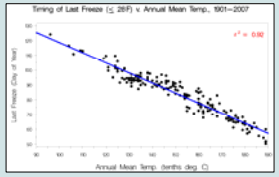


While interannual variability of the modeled SGS is large, no significant long–term trend exists.

Part 2: Timing of Last Damaging Freeze (≤ 28°F)

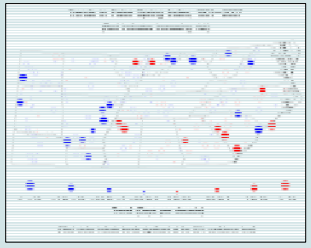


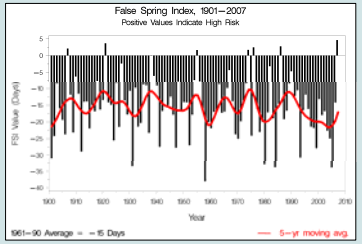


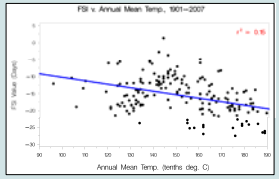


Last freezes, like SGS, show no long–term trend. Regionally, southeastern areas have experienced later last freezes.

Is false spring risk changing in a warming climate?



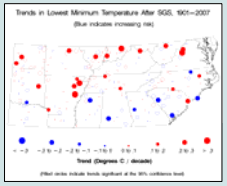


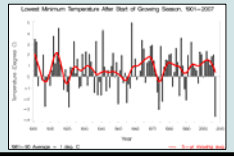


Overall, *false spring risk is not changing*. However, the southeastern (western) areas show increasing (decreasing) risk.

Additional Indicators of Risk

Minimum temperature after SGS





Measures beyond FSI can provide further indications of false spring risk.

(Left)

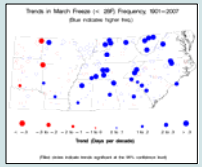
The strength of the late-season killing cold wave associated with false springs can be assessed by considering the lowest temperature realized after SGS. Results show no significant domain-averaged change since 1901.

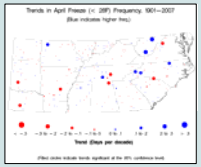
(Right)

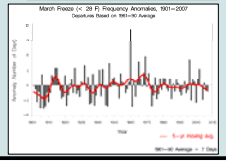
March and April (the months when false springs may occur over the domain) exhibit no overall long–term trends in freeze frequency, although areas to east have experienced significantly increasing frequencies.

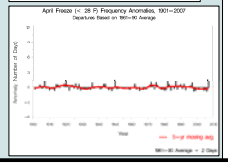
Freeze Frequency

March *April*





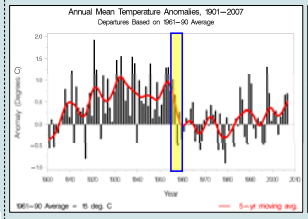


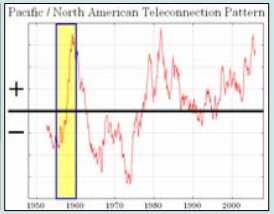


Linking Southeast U.S. Climate to Teleconnections

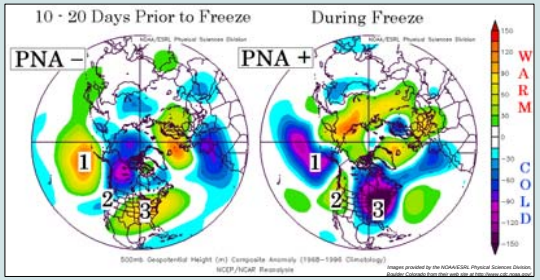
False Springs: Is there a teleconnection pattern?

Teleconnections are correlations among climatic variables separated by large distances, and are responsible for a large portion of atmospheric variability. The literature (e.g. Leathers and Palecki 1992) indicates that the Pacific North American pattern (PNA) is negatively correlated with Southeast temperatures. In the late 1950's (highlighted), Southeast temperatures quickly dropped while the PNA index rose.





A composite of the 5 top false springs, based on FSI values, indicates that false springs occur when a persistent PNA⁻ pattern is interrupted by a rapid shift to PNA⁺.



Images provided by the NOAA/ESRL Physical Sciences Division, Boulder Colorado from their web site at http://www.cdc.noaa.gov/.

Conclusions

- The historical occurrence of false springs can be accurately modeled by considering the relative timing of leaf emergence to the last freeze date. Results indicate that false spring risk over the southeastern United States has not decreased since 1901.
- The extreme Southeast stands out compared with the rest of the domain. This region has experienced increasing false spring risk.
- The behavior of many climatic variables (e.g. annual mean temp.) over the Southeast since 1901 do not follow global trends.
- Teleconnections (particularly the PNA) influence Southeast climate during spring green-up, and are linked to false spring occurrence.

Opportunities for Further Study

- Improve SGS model by incorporating more locations in domain to provide site–specific definitions of SGS.
- Analyze historical Southeast precipitation and its relationship with false spring occurrence.
- This study stresses the need for climate change research to further examine sensitivity of ecosystems to small changes in spring climate.

Acknowledgments

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