

IMPACTS OF LAND SURFACE PROPERTIES ON TEMPERATURE TRENDS USING NORTH AMERICAN REGIONAL REANALYSIS OVER THE USA

(Submitted, IJOC)

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BACKGROUND

- The impact of land use changes on **near-surface temperatures** can be estimated by using the **OMR** (observation minus reanalysis) method
 - Surface observations are sensitive to local or regional near-surface properties
 - Reanalysis does not use such information in its data assimilation process
 - The impact of land surface can be estimated by comparing temperature trends of surface observations with near-surface trends derived from the reanalysis data

BACKGROUND

- The method has been used in a number of recent studies, e.g.
 - *Kalnay and Cai, 2003*
 - *Zhou et al., 2004*
 - *Frauenfeld et al., 2005*
 - *Lim et al., 2005*
 - *Kalnay et al., 2006*
 - *Lim et al., 2007*

Reanalysis datasets used these studies: NCEP Global Reanalysis (R1 and R2), ECMWF (ERA 40)

OVERVIEW

- Use the OMR approach to investigate monthly mean temperature anomalies and trends
 - Evaluate the NARR dataset with respect to observations (USHCN, *Easterling et al., 1996*)
 - NARR has been developed as a major improvement upon the earlier R1 and R2 in both resolution and accuracy (*Mesinger et al., 2006*)
 - Analyze the temporal and spatial patterns of temperature anomalies and trends
 - Look at the sensitivity of surface temperature to land surface types over the conterminous United States (land use classification from AVHRR, *Hansen et al., 2000*)

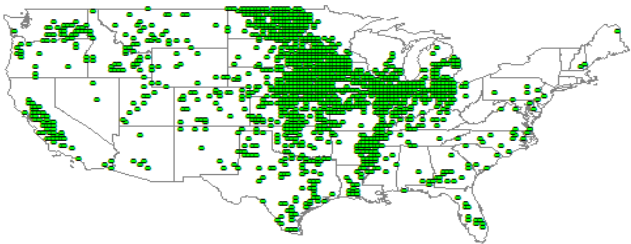
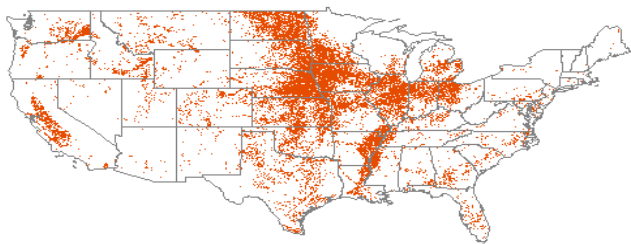
METHODS

- Linearly interpolate the NARR gridded data to observational sites (both rural and urban stations)
- Use both raw and adjusted USHCN temperatures
- Remove the monthly mean annual cycle from both interpolated reanalysis and observations
- Compare the resulting time series
 - Linear trends of 10-year running windows for each station
 - Mean square differences between observations (both unadjusted and adjusted) and NARR
 - Comparison of USHCN and NARR time series of spatially cosine weighted averages over the whole CONUS and selected averaging domains
 - Spatial patterns of OMR

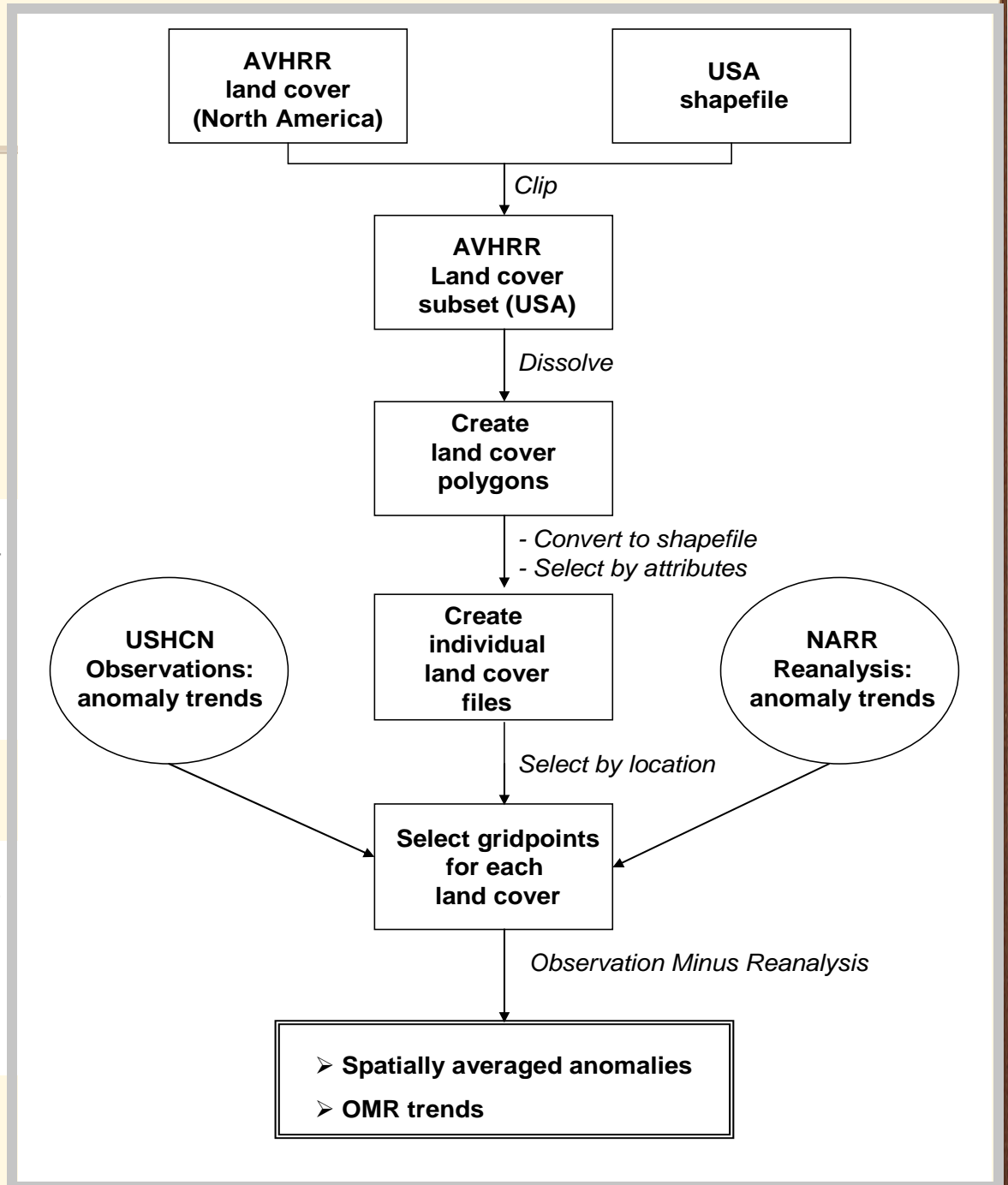
METHODS

Use GIS to link the land use types to USHCN and NARR outputs

Croplands

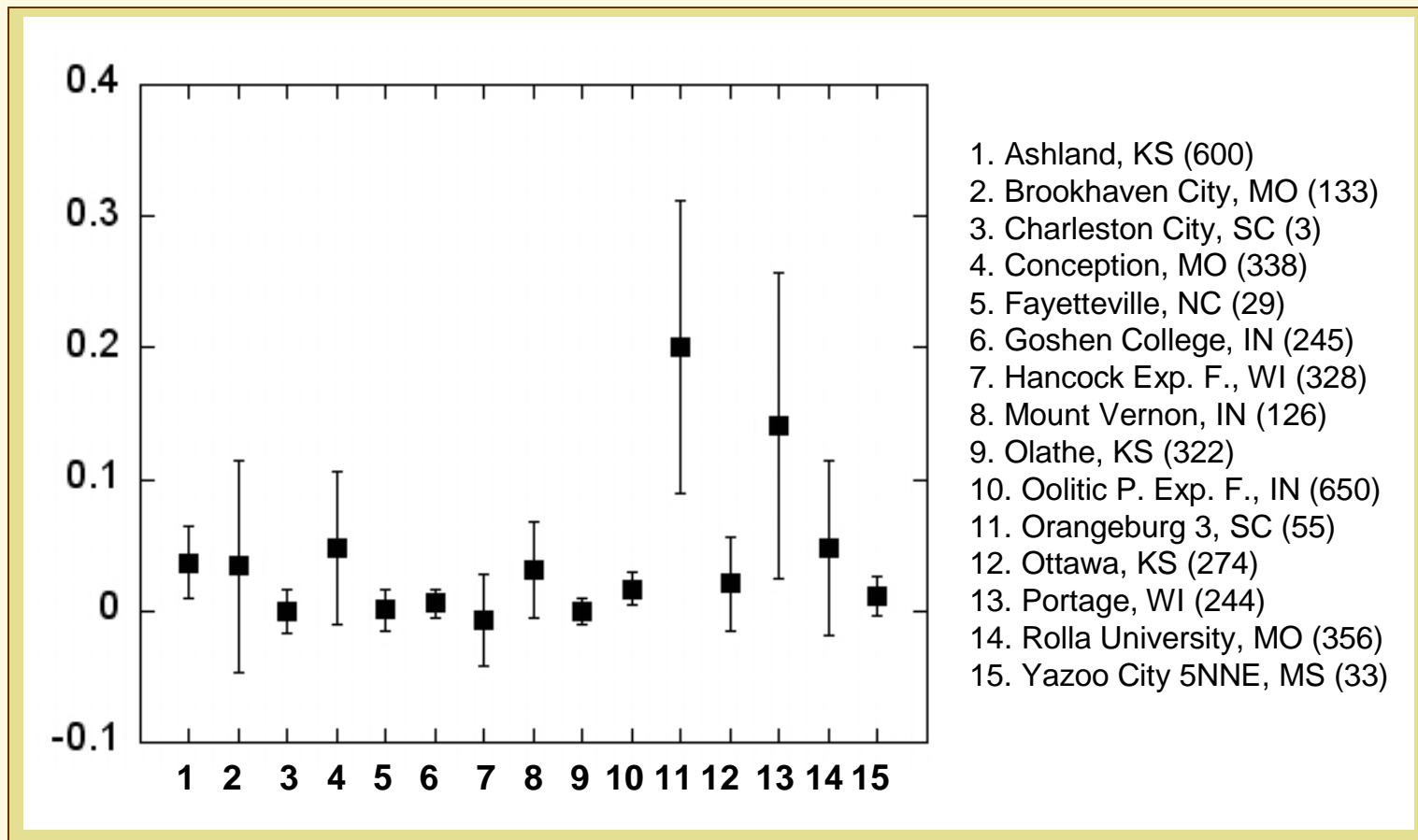


Gridpoints falling within croplands



ANOMALIES:USHCN vs. NARR

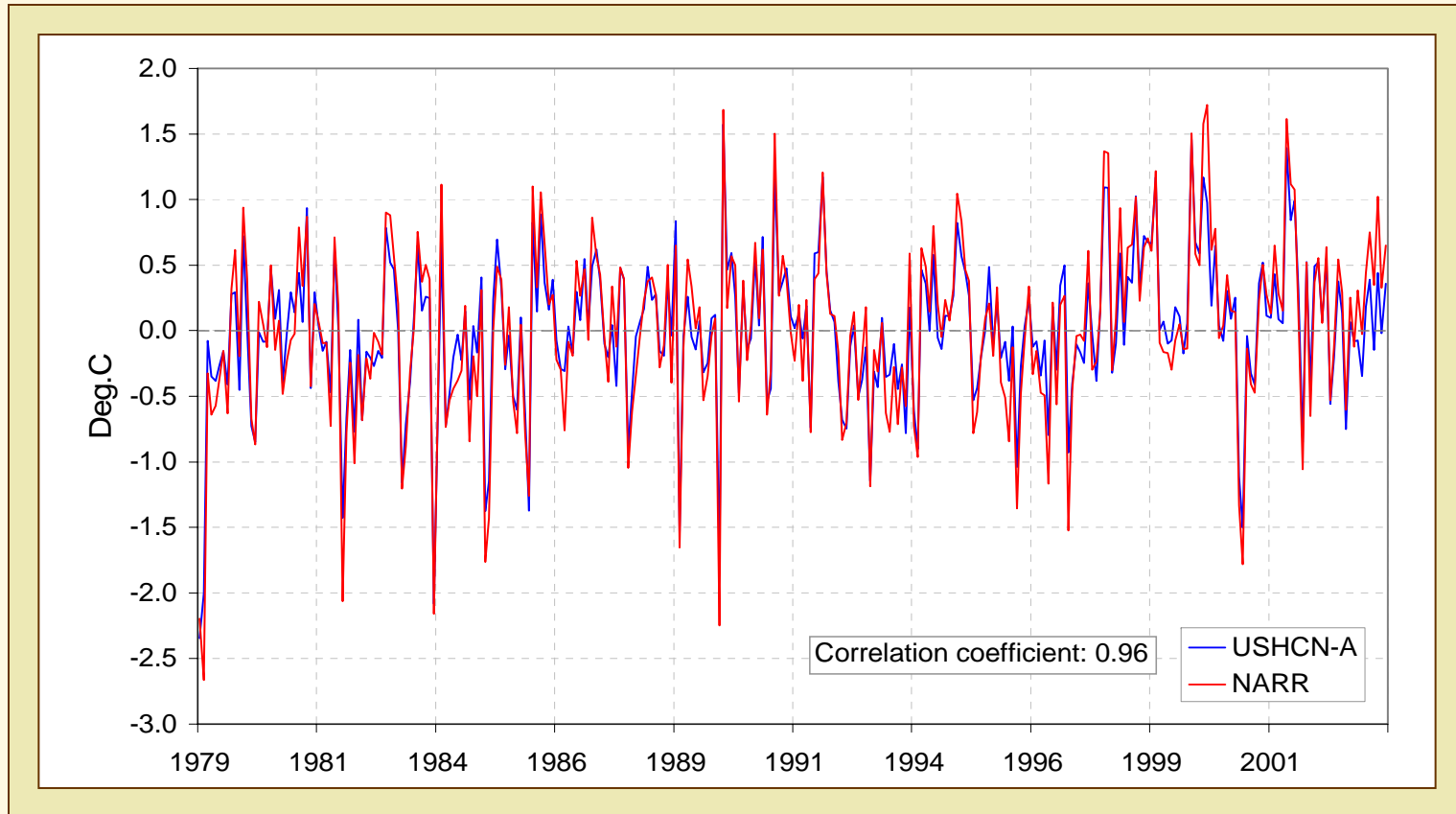
At the station level



Mean square differences (MSDs) of OMRs (filled squares) and their error bars (vertical lines) at 90% confidence level for selected stations (elevation in meters)

ANOMALIES: USHCN vs. NARR

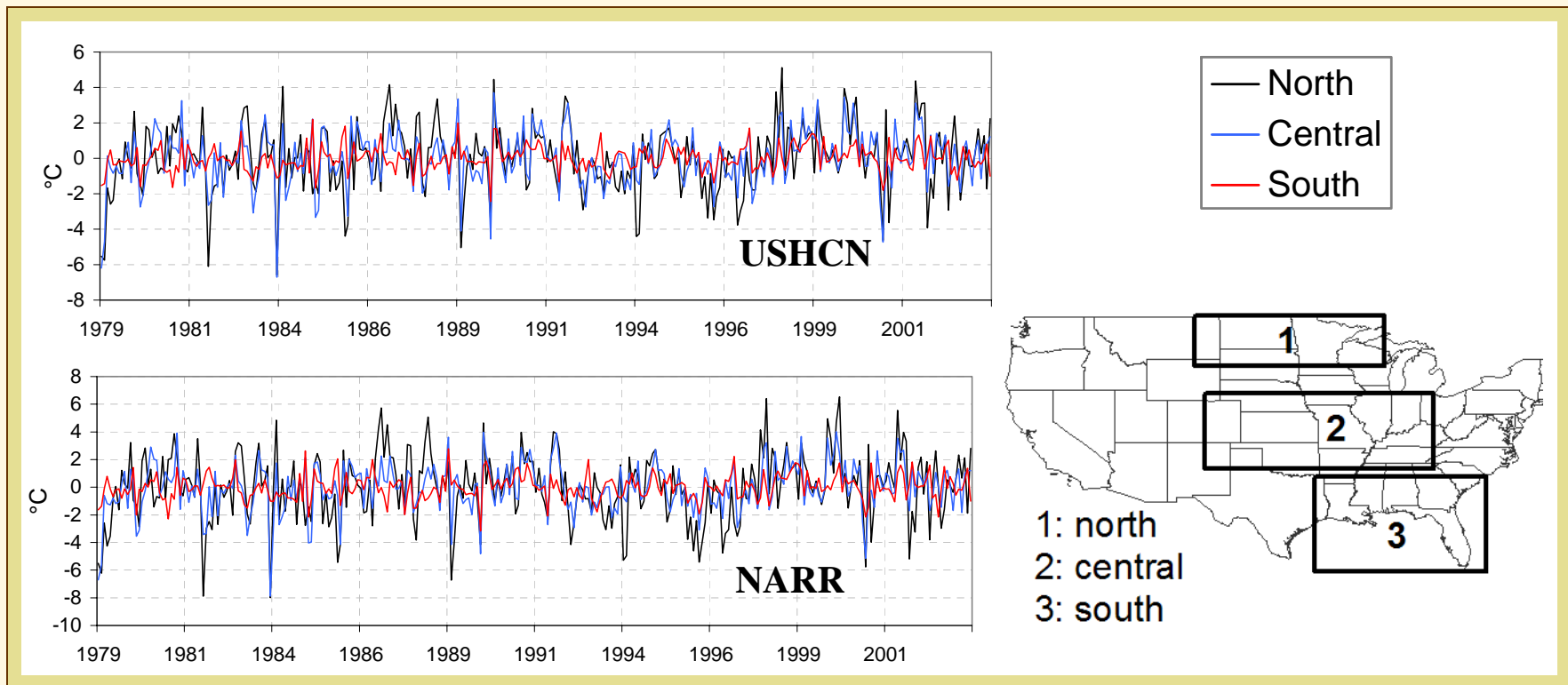
Over the USA



Spatially averaged temperature anomalies (area-weighted by cosine of the latitude) for adjusted USHCN observations and NARR over the United States (1979 – 2003).

ANOMALIES: USHCN vs. NARR

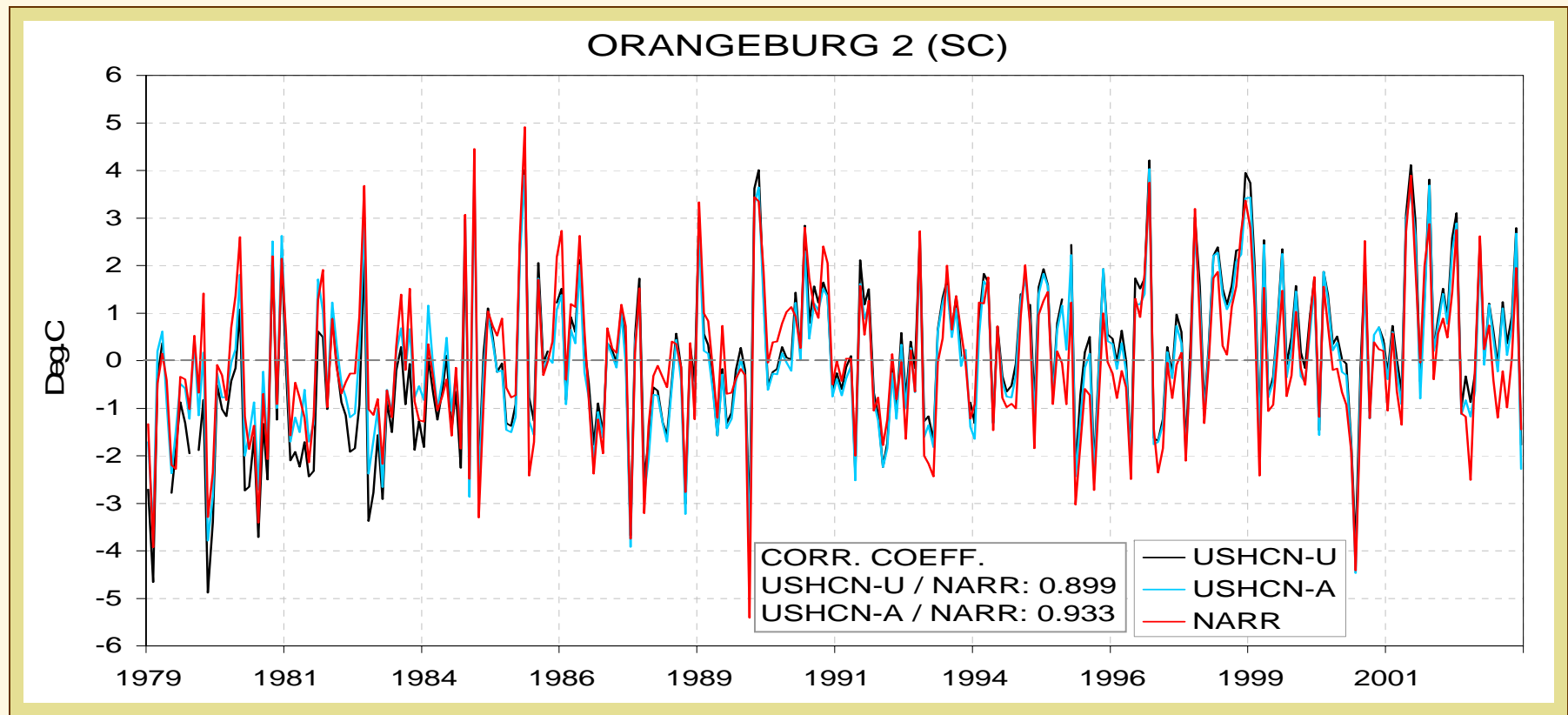
Regionally



Spatially averaged temperature anomalies (area-weighted by cosine of the latitude) for adjusted USHCN observations and NARR over the selected areas of the United States

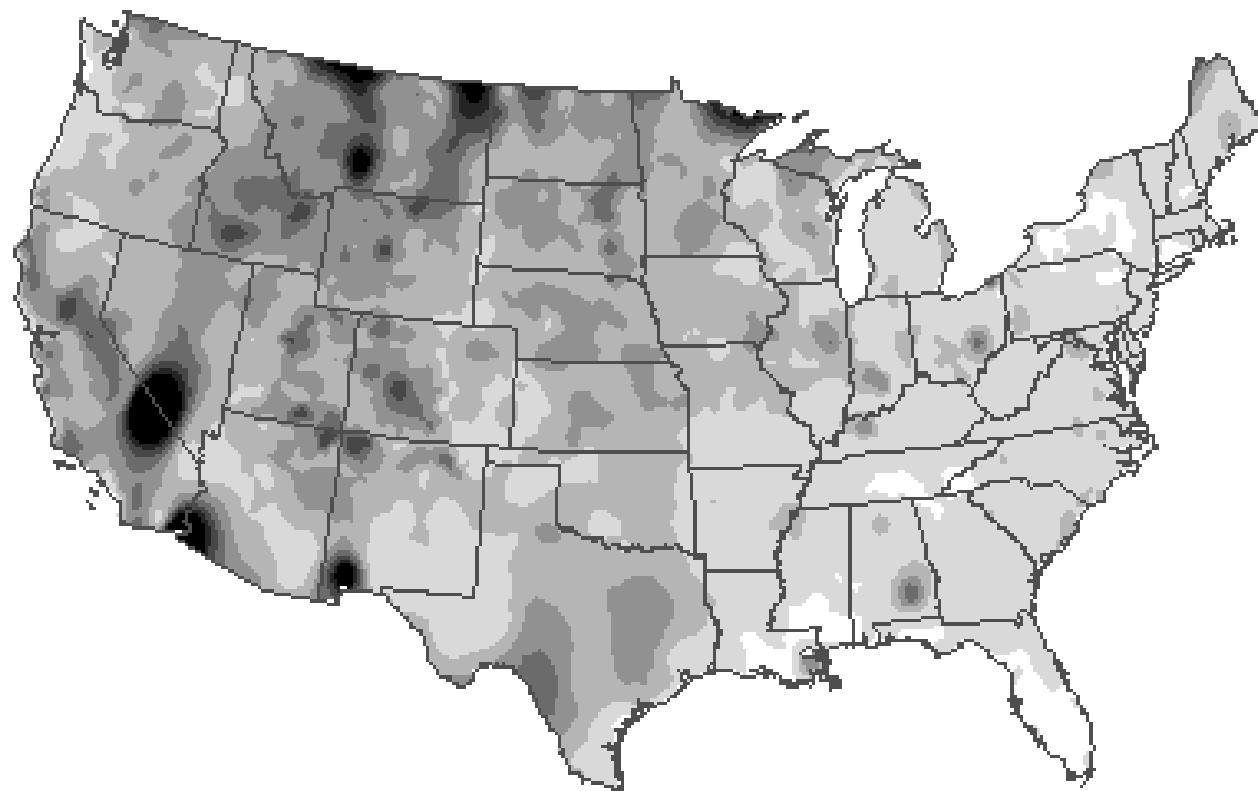
ANOMALIES: USHCN vs. NARR

Detecting the changes that take place at the vicinity of stations: the anomaly differences can be in part attributed to observation practices or land use changes that are not included in the Reanalysis

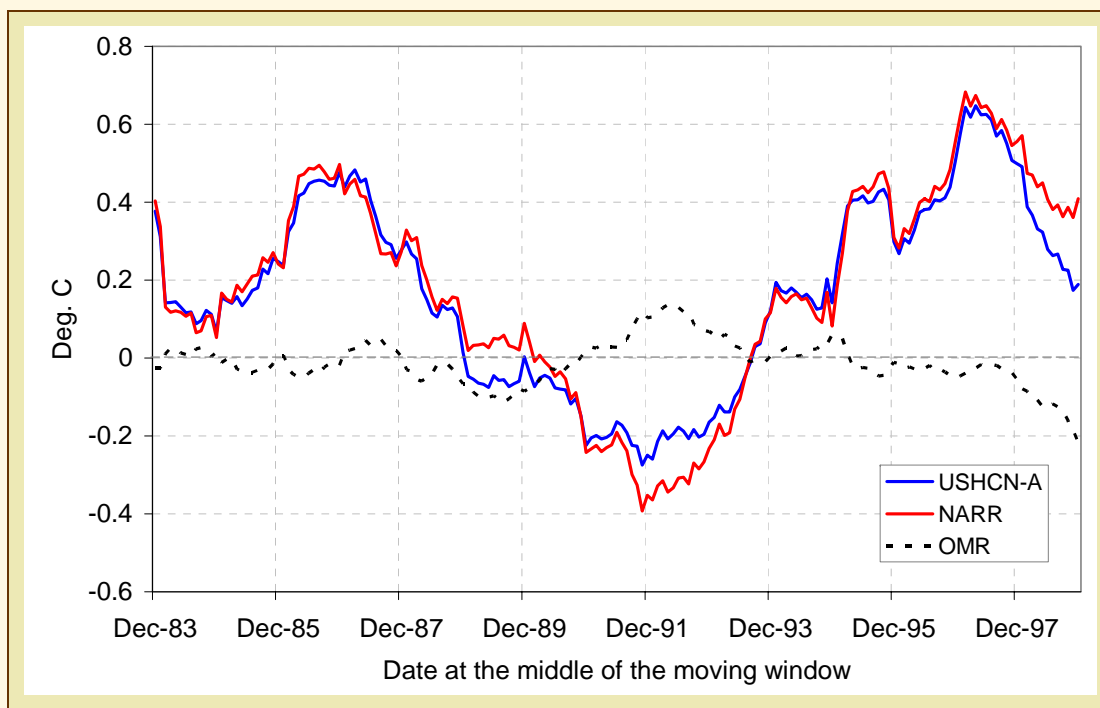


ANOMALIES:USHCN vs. NARR

Spatial patterns of RMS differences of monthly temperature anomalies for USHCN (adjusted) and NARR. The smallest differences (0.29°C to 0.6°C) depict a relatively good agreement over the eastern United States



TRENDS



Trends of 10-year running windows for USHCN-A and NARR temperature anomalies averaged over the United States and the resulting OMR

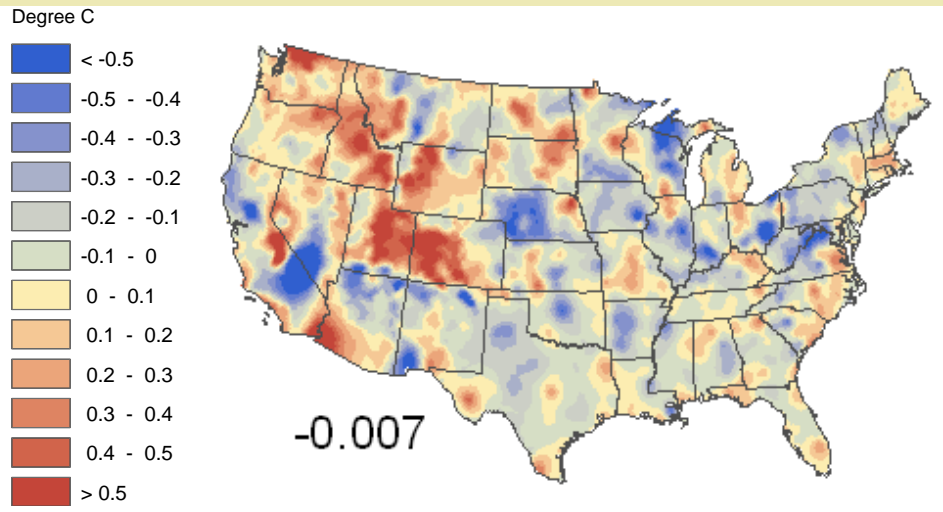
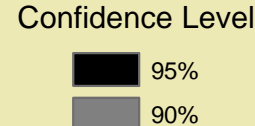
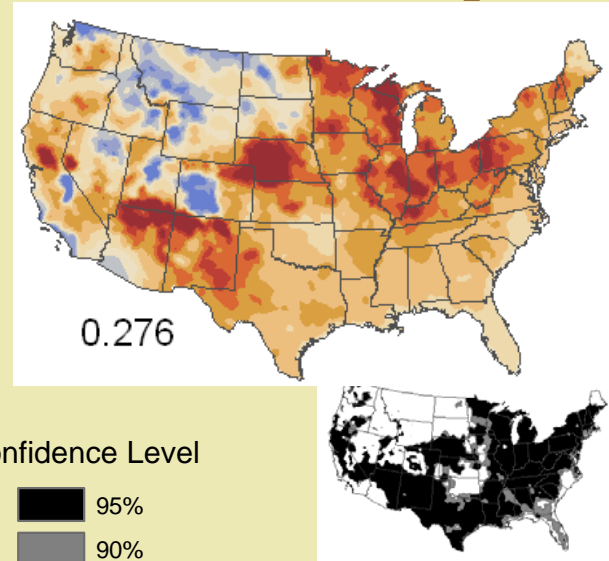
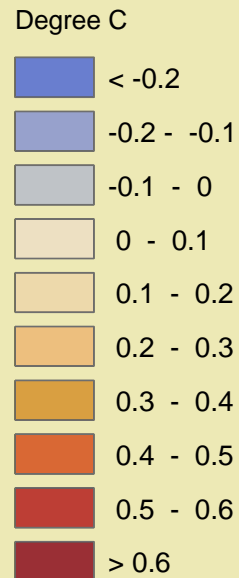
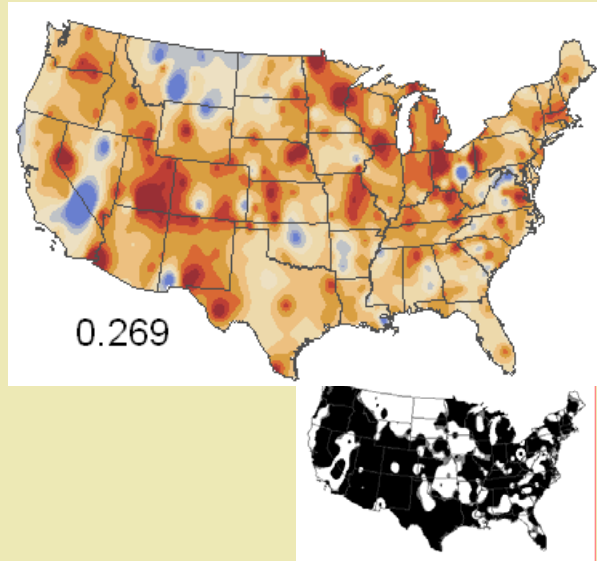
Region	USHCN-A	NARR	OMR
North	0.252	0.312	-0.060
Central	0.300	0.384	-0.084
South	0.132	0.144	-0.012
USA	0.158	0.200	-0.042

Decadal anomaly trends (units: °C)

- Regional variations over the USA
- NARR trends are larger

DECADAL ANOMALY TRENDS

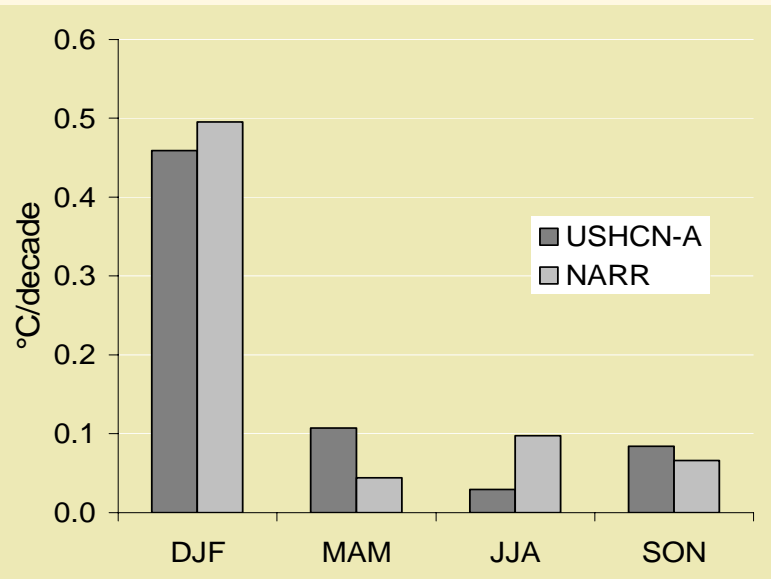
USHCN: more local variations NARR: more uniform patterns



The overall OMR is generally negative, especially over the eastern USA

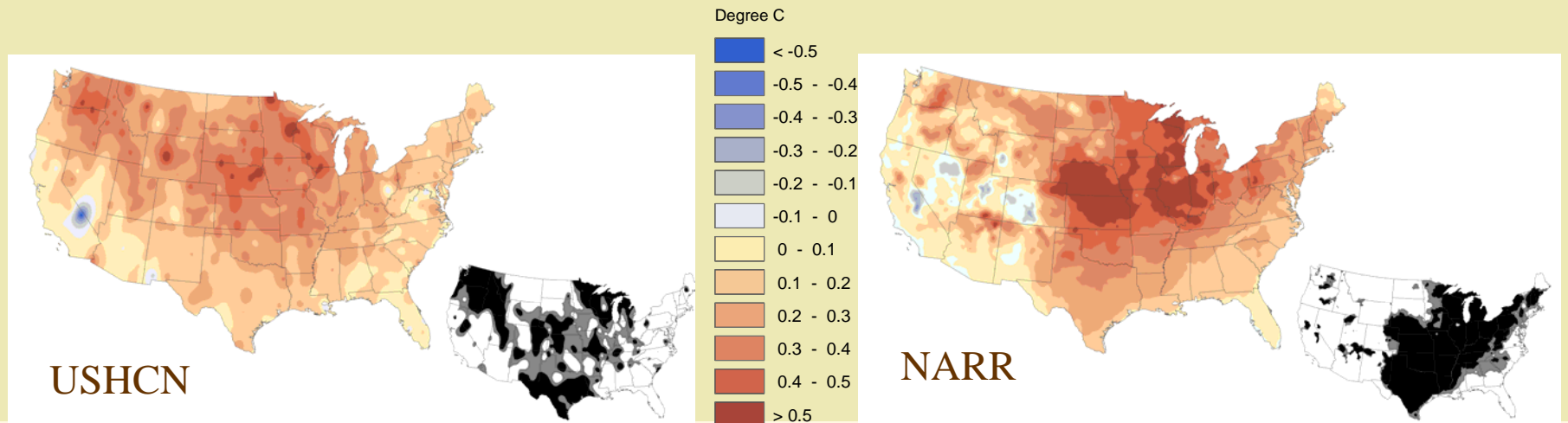
DECADAL ANOMALY TRENDS

Seasonal temperature anomaly trends: winter warming



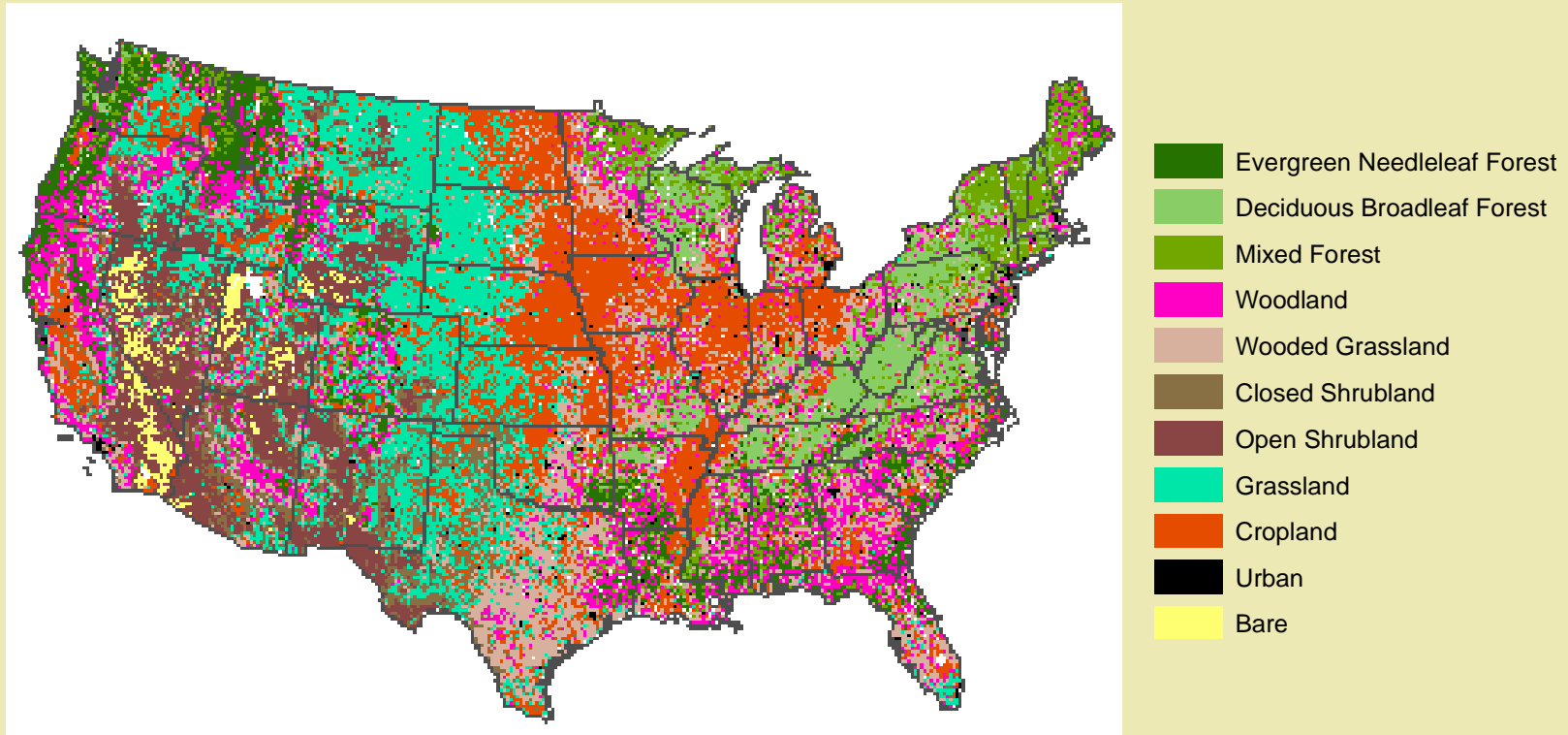
Most of the increase in near-surface temperatures has occurred during winter

Most of the winter increase occurs in the Midwest



SENSITIVITY OF SURFACE TEMPERATURES TO LAND COVER TYPES

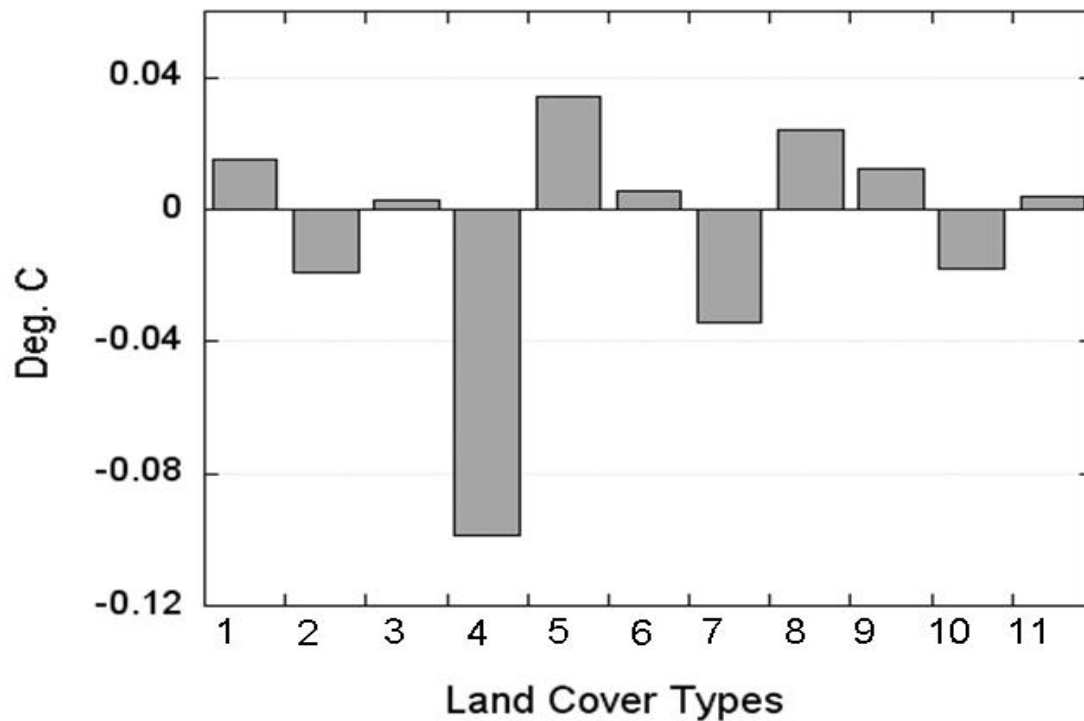
Associate OMR trends with land cover types



1-km increment land cover classification derived from AVHRR

SENSITIVITY OF SURFACE TEMPERATURES TO LAND COVER TYPES

OMRs as a function of land cover types

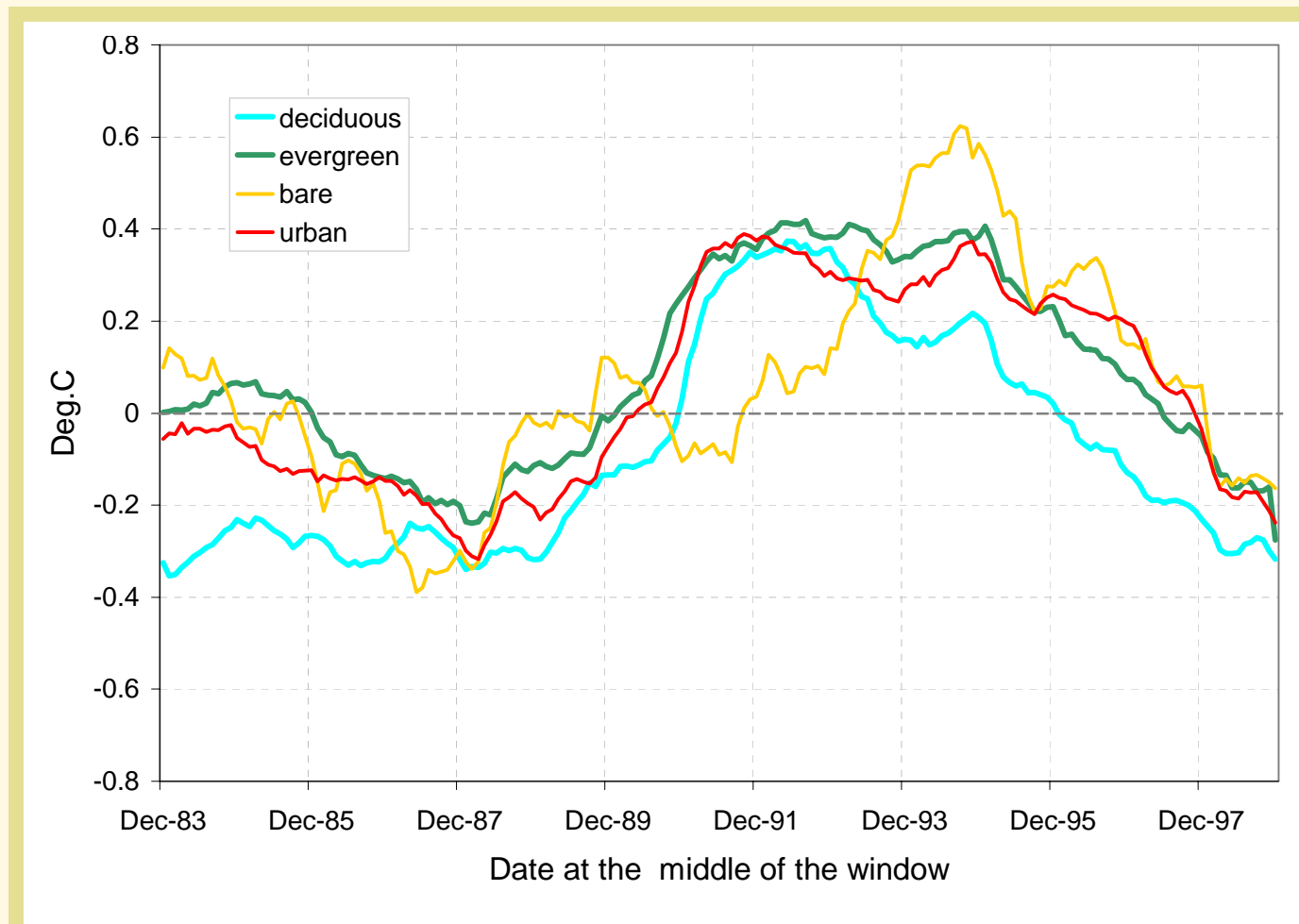


1. Bare
2. Closed Shrubland
3. Cropland
4. Deciduous Broadleaf Forest
5. Evergreen Needleleaf Forest
6. Grassland

7. Mixed Forest
8. Open Shrubland
9. Urban
10. Wooded Grassland
11. Woodland

SENSITIVITY OF SURFACE TEMPERATURES TO LAND COVER TYPES

OMR trends of 10-yr moving window as a function of
AVHRR land cover types



CONCLUSIONS

- Our results further demonstrate the robustness of the OMR method for
 - faithfully capturing the climate variability at various time scales
 - detecting non climatic changes at the station level, including observation practices and land use changes
 - evaluating the impacts of adjustments performed on raw observations
 - assessing surface temperature trends with respect to land cover types

CONCLUSIONS

Limits to this study

- Only 15 stations located in the eastern USA have been used
- the USHCN raw (unadjusted) observations often have missing data over the study period

What's next?

- Investigate trends in the surface air heat content for different landscape types in the eastern USA using NARR dataset