Quantile Regression of Springtime Equivalent Potential Temperature across the Gulf Coast Region from 1980 to 2023

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1. INTRODUCTION

Past research has documented the usage of constant pressure surfaces to identify seasonal synoptic features based on a given isentropic range in the United States[1]. One study used monthly rawinsonde data to locate isentropic surfaces (i.e., maps of the geopotential height at which a certain potential temperature occurs) related to severe storm events.[2] These types of weather events may contribute to changing humidity and temperatures across Earth. A recent study performed a near-surface equivalent potential temperature (EPT) analysis and found an increased EPT in the United States.[3] This change in atmospheric conditions may attribute to the increase frequency of billion dollar weather and climate events recorded in the Gulf of Mexico (GOM) coastal states.[4] Consequently, the GOM is prone to severe weather events based on the arrival and departure of moisture to the region. Therefore, the goal of the research is to investigate the EPT springtime characteristics of the GOM region through quantile regression (standard box plot) from 1980 to 2023 (Fig. 1).

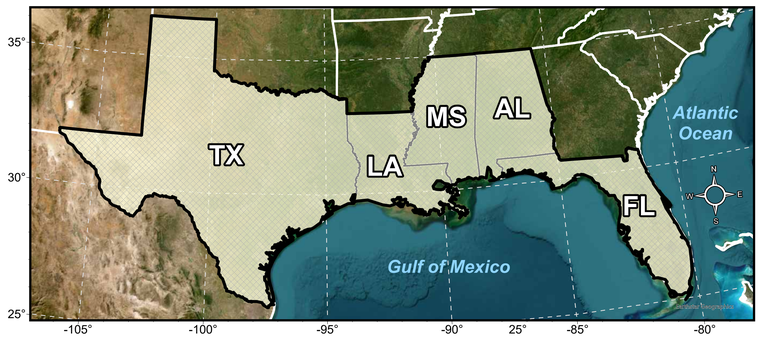


FIG 1. Geographic location of the GOM region used in this study from 1980 to 2023.

2. DATA AND METHODS

TABLE 1. A summary of the reanalysis products (i.e., NARR and ERA5) used in the study to analyze the spatial temporal patterns of EPT within the GOM region between 1980 and 2023.

Reanalysis Product	Resolution (Lat x Lon)	Temporal (UTC)	Pressure (hPa)
NCEP North American Regional Reanalysis (NARR)[5]	0.3° x 0.3° (~32 km)	8x Daily (0/3/6/9/12/15/18/21)	850/700
ECMWF Reanalysis Version 5 (ERA5)[6]	0.25° x 0.25° (~31 km)	24x Daily (0-23)	850/700

Equivalent Potential Temperature (θ_e)

$$\theta_e = T\left(\frac{10^5 Pa}{P}\right)^K \exp\left(\frac{l_v q_v}{c_p T}\right)$$

K = Gas Constant of Dry Air
l_v = Latent Heat of Vaporization (J kg^{-1})
q_v = Specific Humidity (Unitless)
c_p = Specific Heat of Dry Air (J kg^{-1} K^{-1})

FIG 2. Atmospheric thermodynamics equation used to calculate the daily springtime mean EPT.

Study Flow Pathway

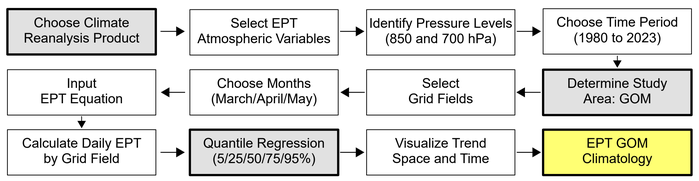


FIG 3. A flow diagram showing the datasets and methods used as part of the GOM EPT study.

3. RESULTS

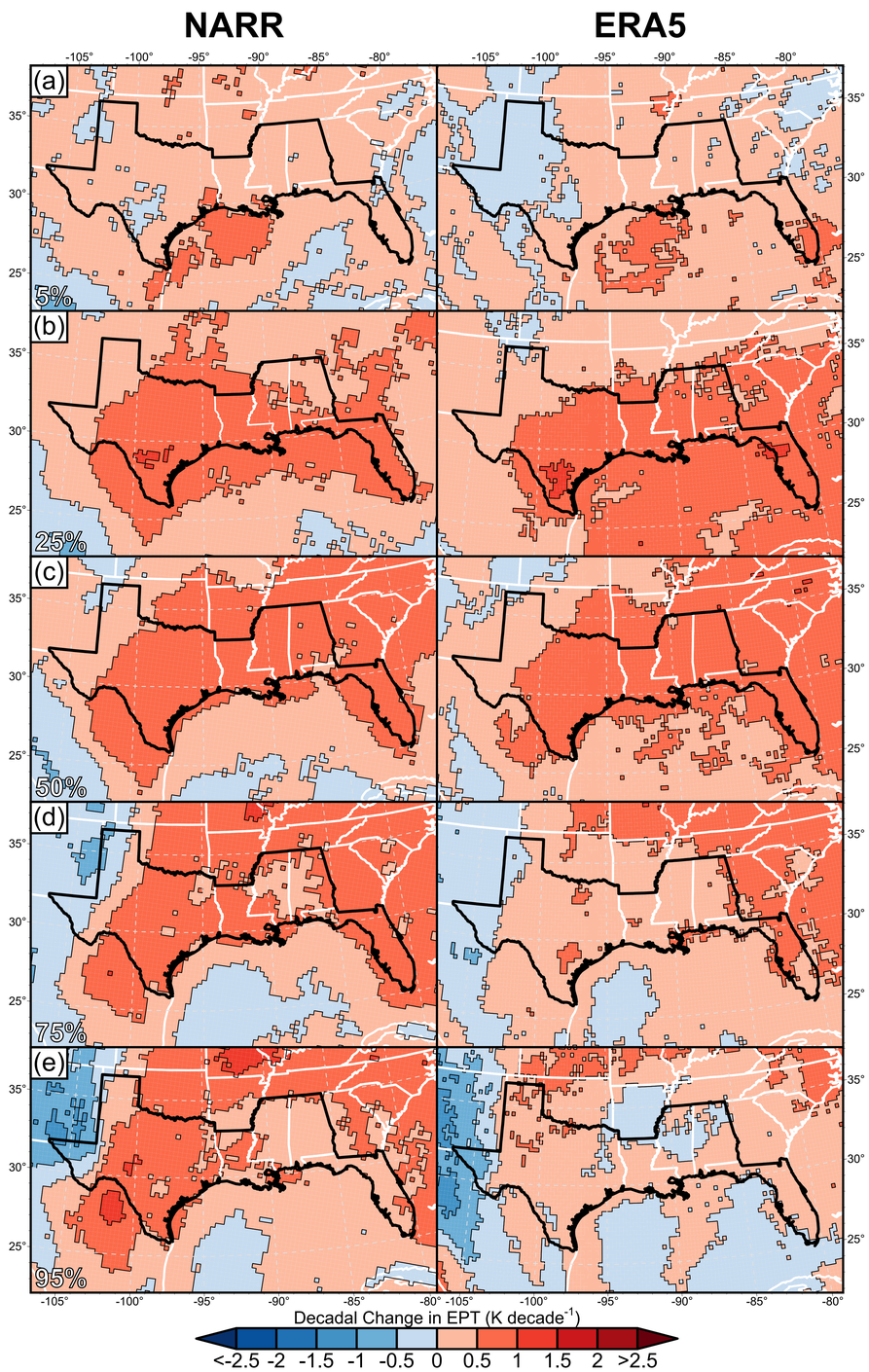


FIG 4. Decadal change in the spring (MAM) mean EPT (K per decade) at 850 hPa based on percentile (a) 5%, (b) 25%, (c) 50%, (d) 75%, and (e) 95% for NARR (left column) and ERA5 (right column) from 1980 to 2023.

4. RESULTS CTD.

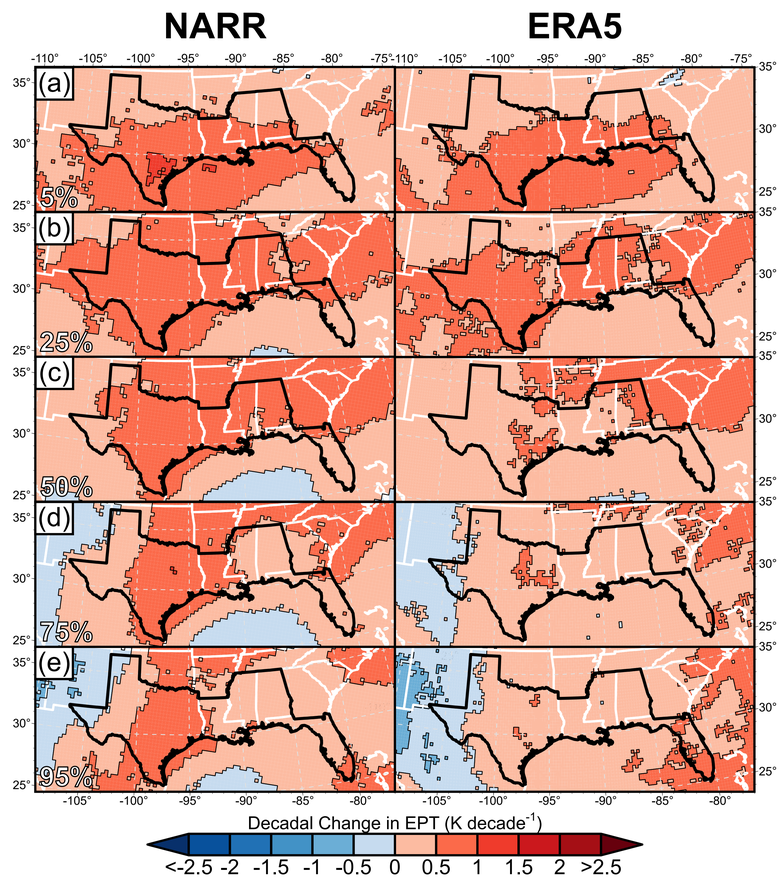


FIG 5. Same as Fig. 4 except for 700 hPa in the GOM region between 1980 and 2023.

5. CONCLUSIONS

- The goal of this research is to examine the spatiotemporal characteristics of springtime (MAM) EPT for the GOM region between 1980 and 2023.
- Increasing EPTs are observed at different percentiles (5%, 25%, 50%, 75%, and 95%) and pressure levels (850 and 700 hPa) across the GOM region.
- For both reanalyses, increasing EPT changes (0.5 to 1 K decade^{-1}) are reported at the lower and median quartiles over the 43-year study period.
- Upper (75%) and maximum (95%) percentile changes vary in magnitude based on location and reanalysis product for springtime EPT within the GOM.
- Future research should investigate the role of extremes in EPT and how it is connected to GOM severe weather and climate events.

6. REFERENCES

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