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ADDENDUM

Climate fluctuations in time and space: Addendum to Zurbenko & Cyr (2011)

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ABSTRACT: Satellite imagery of weather was a major breakthrough in the technology of synoptic weather forecasts. Historically, the Earth's climate has experienced dramatic changes, and researchers have found that long-term weather patterns do exist. Such long-term changes in weather patterns have very small variations in total atmospheric variables and cannot be observed directly. Complicated space–time detection of low energy signals is required and can be done only by computationally processing space–time data. We follow on from our previous study (Zurbenko & Cyr 2011; Clim Res 46:67–76) to display time and space images of surface temperature fluctuations over the United States, based on actual data collected over the last 30 yr. Reconstruction of these images is based on 3D filtration technology, and does not use parametric models.

KEY WORDS: Separation of scales · Kolmogorov-Zurbenko spline · KZS · El Niño

1. INTRODUCTION

In this extension to a previous study (Zurbenko & Cyr 2011), we provide images (in the Supplement at www.int-res.com/articles/suppl/c057p093_supp/) of surface temperature fluctuations over the USA (48 contiguous states) in the time period January 1984 through December 2008. The USA is covered by a dense spatial monitoring of temperature (T), $T(x,y,t)$ — i.e. temperature as a function of x, y (longitude, latitude) and time (t) — allowing the creation of high definition images. The study period was selected because it contains multiple weather anomalies (e.g. flood, drought) in various regions of the United States, thus providing an ideal setting to represent long-term weather patterns using our methodology.

Fig. 1 of Zurbenko & Cyr (2011) shows evidence of 2 scales in the surface temperature records: a global scale with time periods longer than 13 yr and an El Niño scale with periods of 2 to 5 yr. The global scale can be reconstructed by applying the Kolmogorov-Zurbenko spline, KZS (2.5°, 2.5°, 5 yr, 3; see Section 2 in Zurbenko & Cyr 2011), to $T(x,y,t)$. The cut-off frequency for this filter is approximately 7 yr, and it provides very high resolution between the 2 aforementioned scales.

The output of this filter will have a strong gradient along latitude y. Thus, we subtract out the average surface temperature profile along latitude to receive 'flat' images of fluctuations (see Eq. [3] in Zurbenko & Cyr 2011). Accordingly, the global component $\mathrm{G}T(x,y,t)$ can be presented as a computer animation movie (presented in the Supplement). Due to the selected scales, these images slowly change in time and space.

Fig. 1 illustrates a single slide from this animation during the year 2005. Strong positive fluctuations in surface temperature can be observed in the Midwestern United States, which largely continued throughout the year. Observation of solar radiation and humidity data at these scales may provide the explanation for the reasons of this global anomaly. Negative fluctuations in surface temperature over the Northeast also occurred sporadically throughout 2005.

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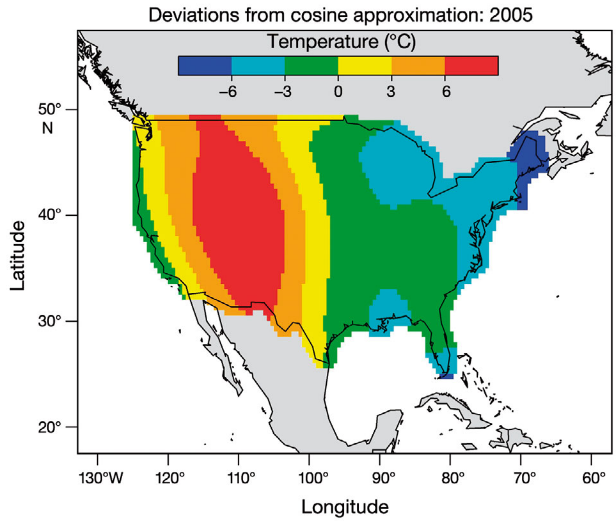

Fig. 1. A single image of the global component G$T(x,y,t)$ during the year 2005. Celsius readings have been rounded to the nearest degree

The El Niño scale can be reproduced by subtracting the global component from the original data and applying a KZS(2.5°, 2.5°, 1 yr, 3) filter to the difference to remove strong annual oscillations in surface temperature records. In other words, the El Niño scale can be obtained as

$$\text{EN } T(x,y,t) = \text{KZS}(2.5°, 2.5°, 1 \text{ yr}, 3)\{T(x,y,t) - \text{G}T(x,y,t)\} \quad (1)$$

Eq. 1 provides a spatial redistribution of energy and ocean interactions on scales of 2 to 5 yr. Such fluctuations can provide an explanation for regional

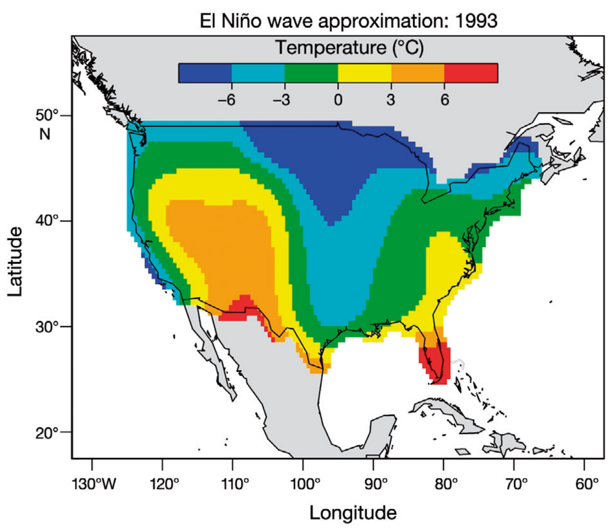

Fig. 2. A single image of the El Niño component EN $T(x,y,t)$ during the year 1993. Celsius readings have been rounded to the nearest degree

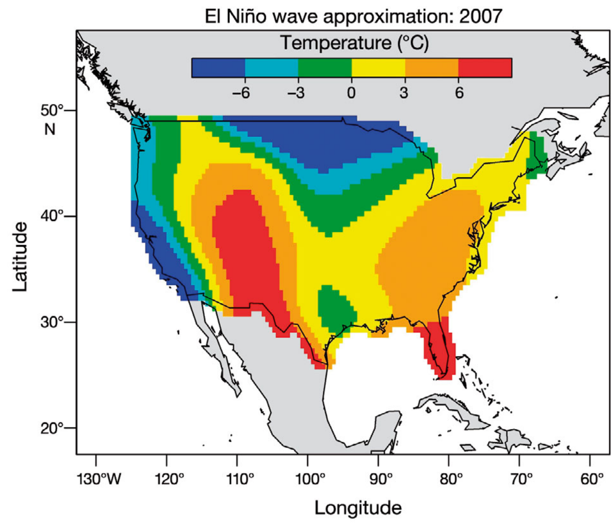

Fig. 3. A single image of the El Niño component EN $T(x,y,t)$ during the year 2007. Celsius readings have been rounded to the nearest degree

weather anomalies. The strong negative fluctuation observed around the Mississippi River in 1993 images (Fig. 2) may have attracted extra moisture in that region causing the historic and devastating 'Great Flood of 1993'. On the other hand, strong positive fluctuations in the Southeast United States in 2007, as illustrated in Fig. 3, may have caused the drought conditions that occurred in surrounding regions. Together, these 2 images suggest that strong spatial gradients in El Niño scales can provide explanations for adverse weather events.

2. DISCUSSION

Computer animations of global and El Niño scale temperature anomalies are provided in the Supplement (www.int-res.com/articles/suppl/c057p093_supp/). They are the results of high-resolution reconstruction of waves in surface temperature records; no models were applied to reproduce the scales, only information from $T(x,y,t)$ was used. These scales can be investigated by climatologists for possible predictions of climate anomalies in time and space. The same scales can be reproduced over the entire globe, even where the spatial resolution of those components is regionally damaged by sparse distribution of temperature monitoring stations.

LITERATURE CITED

Zurbenko IG, Cyr DD (2011) Climate fluctuations in time and space. Clim Res 46:67–76

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