An Evaluation of Fire-Weather Related Variables from the 20th Century Reanalysis, Version 3

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Abstract

Our goal is to develop reliable fire-weather risk indices based on temperature, wind speed, and humidity data and use them for monitoring in as long-term a historical context as possible. Here we demonstrate the suitability of using the 200-yr NOAA-CIRES-DOE 20th Century Reanalysis dataset version 3 (20CRv3) for this purpose. We show that the local 3-hourly 20CRv3 values of these variables agree well with those in the more comprehensive and higher-resolution but shorter ERA5 reanalysis of the 1946-2015 period. This agreement is illustrated here over North America for the months of May and August corresponding to the beginning and middle of the fire season, respectively. Over much of North America, the rank correlations of the 20CRv3 and ERA5 values are >0.80 for 2-meter air temperature (Air 2m), 10-meter wind speed (WS 10m), and 2-meter vapor pressure deficit (VPD 2m). Another particularly appealing feature of using the 20CRv3 dataset is that because it is an 80-member ensemble reanalysis, it provides reliable time-dependent uncertainty estimates of changing fire-weather risks and also how far back in time the indices can be trusted before the uncertainties become too large due to fewer and less accurate available observations.

1. Background

The NOAA-CIRES-DOE 20th Century Reanalysis, Version 3 (20CRv3) provides the only globally-complete, 200-year reconstruction of sub-daily weather. It is generated by assimilating surface pressure observations into a NOAA weather model using an Ensemble Kalman Filter data assimilation system. It provides an ensemble of 80 estimates of global fields of, e.g., temperature, humidity, and winds. (Compo et al. 2011; Slivinski et al. 2019, 2021).

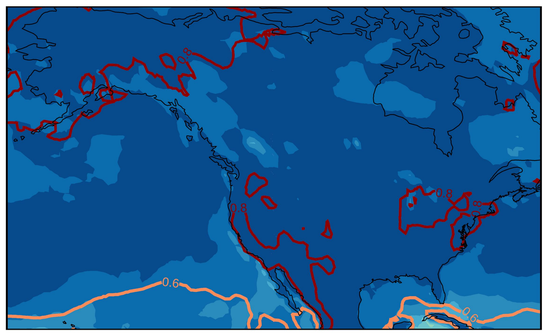
- 75 km horizontal, 64 level grid (up to ~0.3 hPa)
- 3-hourly temporal resolution.
- Spans the time period of 1806-2015

Its 80 ensemble members can be used to quantify the uncertainty or the "confidence" (Slivinski et al. 2019) of each variable at each time and grid point. For comparison, ERA5 (Hersbach et al. 2020) is widely considered the "best" full-input reanalysis. It assimilates, e.g., satellite, aircraft, radiosonde, and surface weather observations into an ECMWF weather model using a 4D Variational data assimilation system.

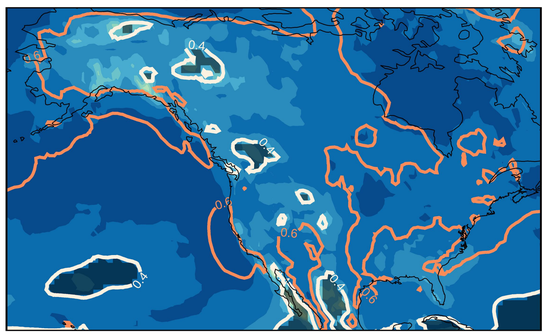
2. Is 20CRv3 of sufficient quality to be used for Fire-Weather monitoring over North America?

Confidence and Rank Correlations comparing 20CRv3 and ERA5 for Air Temperature 2m, Wind Speed 10m, and Vapor Pressure Deficit 2m

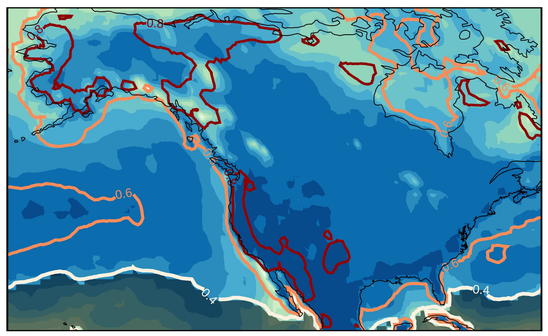
Air Temperature 2m May 2006-2015 Rank Correlation and Confidence



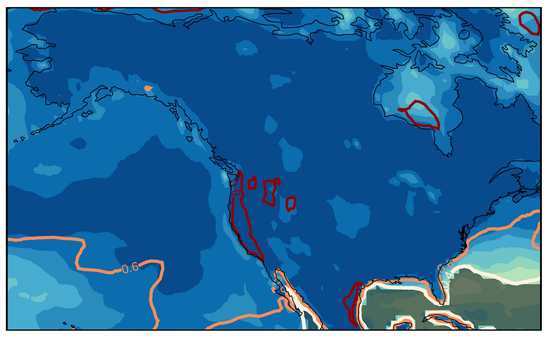
Wind Speed 10m May 2006-2015 Rank Correlation and Confidence



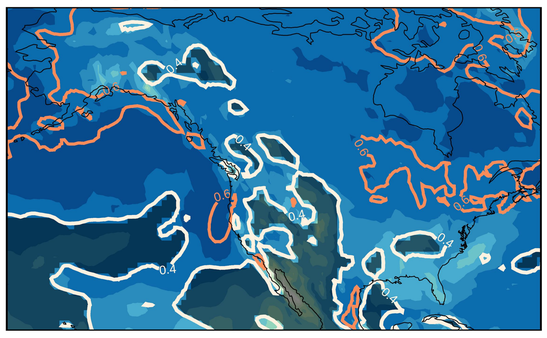
Vapor Pressure Deficit 2m May 2006-2015 Rank Correlation and Confidence



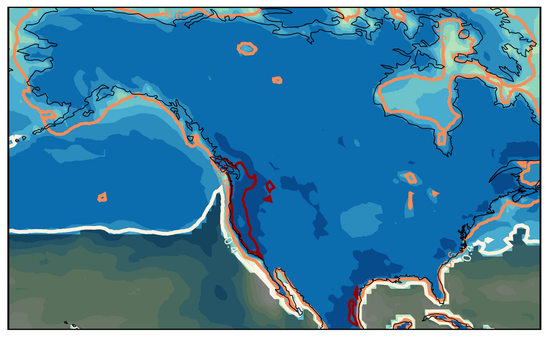
Air Temperature 2m August 2006-2015 Rank Correlation and Confidence



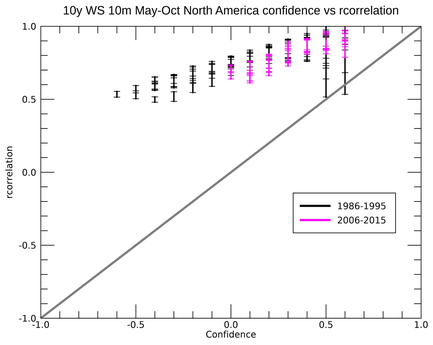
Wind Speed 10m August 2006-2015 Rank Correlation and Confidence



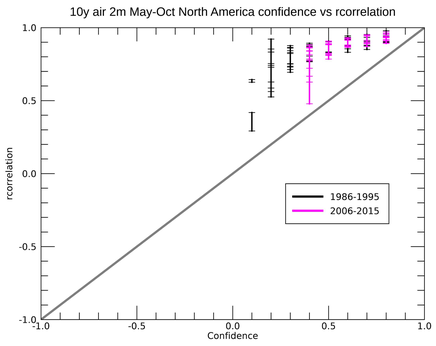
Vapor Pressure Deficit 2m August 2006-2015 Rank Correlation and Confidence



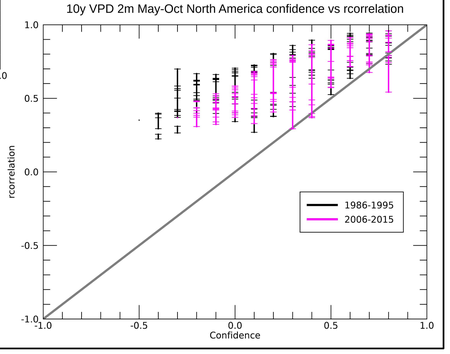
10y WS 10m May-Oct North America confidence vs rcorrelation



10y air 2m May-Oct North America confidence vs rcorrelation



10y VPD 2m May-Oct North America confidence vs rcorrelation



The maps illustrate (line contours) 10 year averaged Confidence of 20CRv3 and (shading) 10-year Rank Correlations (R) comparing 3-hourly 20CRv3 and ERA5 values for 2-meter Air Temperature, 10-meter Wind Speed, and 2-meter Vapor Pressure Deficit. R is calculated for the months of (top row) May and (bottom row) August over the 10 year period 2006-2015 (2480 values). The translucent mask shows regions with Confidence < 0.4, which are represented by the dark brown-green colors on the maps.

***Confidence* = 1 - σ_{ens} / σ_{clim} : Confidence is defined as the difference of the normalized ensemble standard deviation (σ_{ens} / σ_{clim}) from 1**

where σ_{ens} = 80-member ensemble standard deviation or "spread" and σ_{clim} = 20CRv3 climatological standard deviation for a 10 year reference period of 2006-2015. Confidence is then averaged over the periods indicated. The scatterplots illustrate the mean R as a function of the co-located Confidence (bin size=0.1) for May through October for the decades of (black) 2006-2015 and (pink) 1986-1995 over the map region. Error bars show ±1 standard deviation of R in each Confidence bin. **The Confidence versus rank correlation R comparisons suggest that the 20CRv3 confidences are reliable and can be used to estimate the quality of derived fire-weather indices.**

3. Conclusions and Future Plans

Despite assimilating only surface pressure observations, the 20CRv3 three-hourly values of 2-meter air temperature, 10-meter wind speed, and 2-meter vapor pressure deficit compare surprisingly well with the full-input ERA5 reanalysis. The results suggest that 20CRv3, with its quantified uncertainties, is of sufficient quality to be used for Fire-Weather monitoring over North America. An unexpected result is that, through the use of its "confidence," 20CRv3 can self-identify regions and times when it is not of sufficient quality for this purpose. This investigation will be expanded to include additional variables at pressure levels from the surface to 500 hPa and all months.

4. Data Availability

There are 49 new 20CRv3 variables available in NetCDF for all 80 members, as a part of the project, which include geopotential height, specific humidity, temperature, zonal and meridional wind at multiple pressure levels. Files with subdaily and monthly-averaged data for the time period of 1907-2015 are currently available at NERSC from this project. We plan to produce these same variables back to 1806. Other variables already available for every member include: precipitation rate, precipitable water, soil moisture, evaporation, radiation fluxes, and pressure. The URL address for the NERSC Portal is https://portal.nersc.gov/archive/home/projects/incite11/www/20C_Reanalysis_version_3. Ensemble mean and spread data are available from NOAA PSL at http://go.usa.gov/XTd and NCAR at http://rda.ucar.edu/datasets/ds131.3.

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