

Supplementary Materials for

Secular decrease of wind power potential in India associated with warming in the Indian Ocean

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This PDF file includes:

Section S1. Datasets used to validate the trends in wind speeds derived from MERRA-2

Fig. S1. Zonal mean vertical pressure velocity during summer averaged over the 1980–2016 period inferred from MERRA-2.

Fig. S2. Long-term trend of wind speeds at 850 hPa (in m/s per year) inferred from MERRA-2 over the 1980–2016 interval.

Fig. S3. Trends of wind speeds in India inferred from multiple data sets.

Fig. S4. WRF modeling domain.

Section S1. Datasets used to validate the trends in wind speeds derived from MERRA-2

In addition to MERRA2, multiple reanalysis data sets, and measurements of near surface wind speeds and atmospheric sounding measurements for wind speeds at 100 meters were analyzed to confirm the secular trend inferred for the period investigated here.

Four additional atmospheric reanalyses data sets are used: The National Centers for Environmental Prediction (NCEP)/National Center for Atmospheric Research Reanalysis-1 (NCEP/NCAR R1), NCEP/Department of Energy (DOE) Reanalysis-2 (NCEP/DOE R2), the European Centre for Medium-Range Weather Forecastss (ECMWF) ERA-Interim reanalysis, and the Modern-Era Retrospective analysis for Research and Applications (MERRA) reanalysis. The NCEP/NCAR R1 and NCEP/DOE R2 are on a T62 gaussian grid with 192 longitudes equally spaced and 94 latitudes unequally spaced. ERA-Interim reanalysis employs T255 spectral resolution with 512 longitude grids and 256 latitude grids. MERRA reanalysis was performed with a horizontal resolution of 2/3-degree longitude by 1/2-degree latitude.

The measurements of wind speeds at 10 meters over India were taken from the National Oceanic and Atmospheric Administration website (NOAA, <https://gis.ncdc.noaa.gov/maps/ncei>). The measurements of wind speeds from atmospheric soundings were obtained from the University of Wyoming website (<http://weather.uwyo.edu/upperair/sounding.html>). Data from 57 surface sites and 16 atmospheric sounding sites (locations are shown in Fig. 3B) over India exhibit good coverage over the study period, and were analyzed. Atmospheric soundings measure vertical profiles of wind speeds twice a day (at 00 and 12 Coordinated Universal Time), and measurements of vertical distributed wind speeds are interpolated to 100 meters for comparison. The comparisons using surface and atmospheric sounding measurements were implemented on a site-by-site, and hour-by-hour basis. The averaged trends from all sites over India are shown in fig. S3C and fig. S3D. The trends derived from all five reanalysis data sets, and from both surface and atmospheric sounding measurements are mutually consistent.

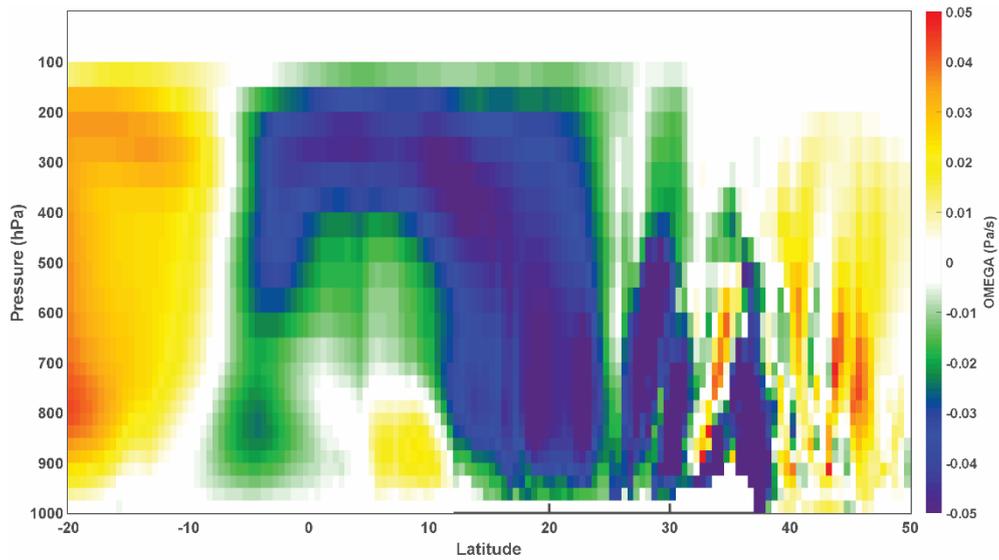


Fig. S1. Zonal mean vertical pressure velocity during summer averaged over the 1980–2016 period inferred from MERRA-2.

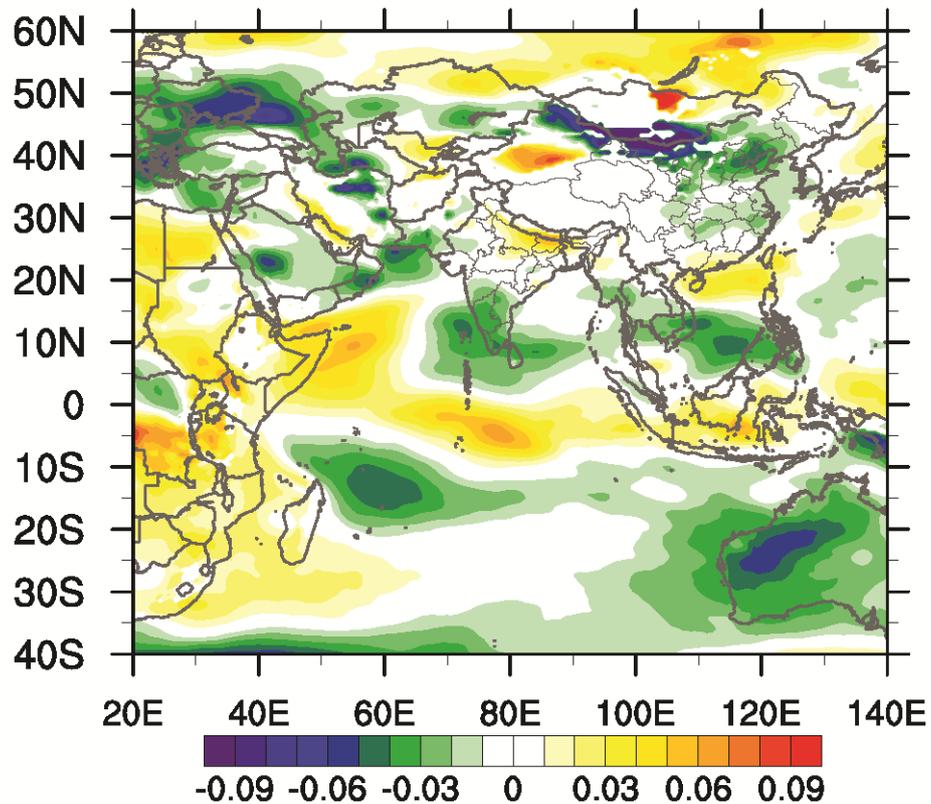


Fig. S2. Long-term trend of wind speeds at 850 hPa (in m/s per year) inferred from MERRA-2 over the 1980–2016 interval.

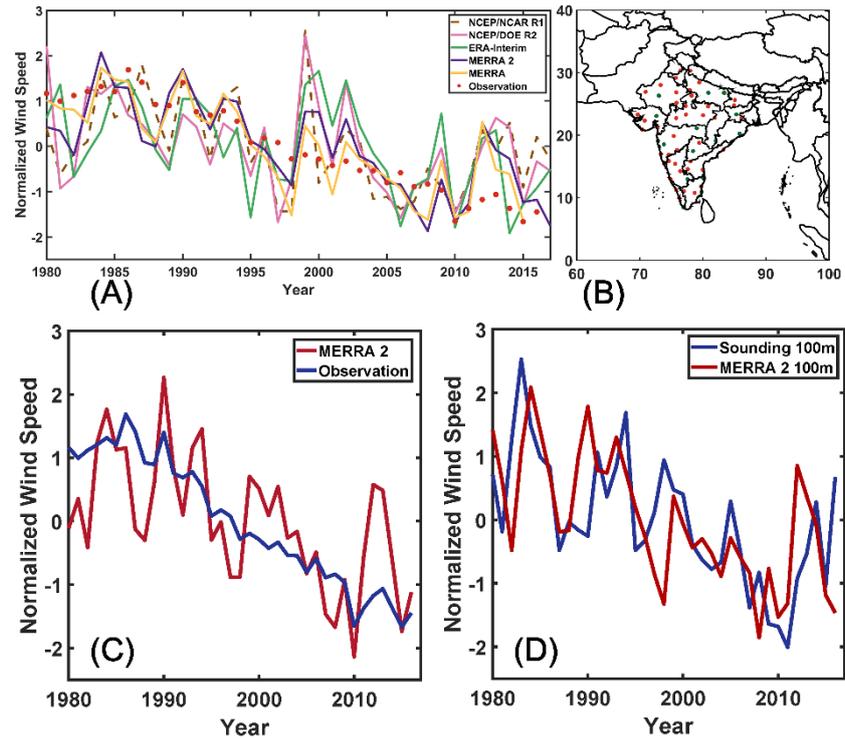


Fig. S3. Trends of wind speeds in India inferred from multiple data sets.

(A) Comparisons between normalized India mean surface wind speeds derived from multiple reanalysis datasets and observations; (B) the locations of measurements employed (red points denote surface measurements; green points represent atmospheric sounding measurements); (C) site-by-site comparisons between MERRA 2 and observed normalized near surface wind speed; (D) site-by-site comparisons between MERRA 2 and atmospheric sounding observed normalized wind speeds at 100 meters.

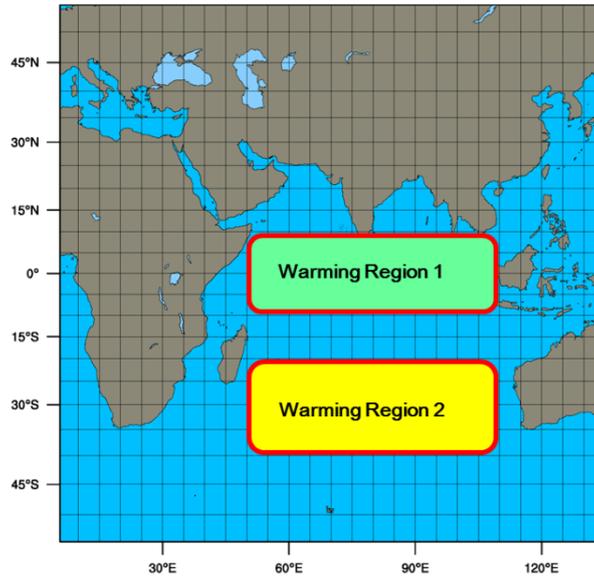


Fig. S4. WRF modeling domain.