Supplementary Materials for


Contents of this supplementary material:

Supplementary Table S1 and Figures S1-S16, which are referenced in the main manuscript.
<table>
<thead>
<tr>
<th>Name</th>
<th>20CR</th>
<th>ERAI</th>
<th>JRA55</th>
<th>MERRA2</th>
<th>NCEP1</th>
<th>NCEP2</th>
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<td>ECMWF</td>
<td>JMA</td>
<td>NASA</td>
<td>NCEP-NCAR</td>
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<td>Four-dimensional variational data assimilation (4DVAR)</td>
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<td>/</td>
<td>Fast Radiative Transfer Model</td>
<td>Fast Radiative Transfer Model</td>
<td>Community Radiative Transfer Model</td>
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<td>Spatial resolution</td>
<td>$2^\circ \times 2^\circ \times 24$ levels</td>
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<td>$2.5^\circ \times 2.5^\circ \times 17$ levels</td>
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Fig. S1 Latitude-height profile of annual MRE (a) $v'^2$ (m$^2$ s$^{-2}$) and (b) $u'v'$ (m$^2$ s$^{-2}$) for linear trend (shaded) and climatology (contour) during 1980-2014. $u$ and $v$ are synoptic-scale zonal and meridional winds, respectively. Linear trends are shown in the unit of decade$^{-1}$. Dots indicate that the significance level reaches 90%.
Fig. S2 Latitude-height profile of annual vertical velocity ($10^{-3}$ Pa s$^{-1}$) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S3 Latitude-height profile of annual MRE vertical velocity ($10^{-3}$ Pa s$^{-1}$) for linear trend (shaded) and climatology (contour) during 1980-2014 without (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S4 Latitude-height profile of annual meridional mass streamfunction ($10^{10}$ kg s$^{-1}$) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S5 Latitude-height profile of annual MRE meridional mass streamfunction ($10^{10}$ kg s$^{-1}$) for linear trend (shaded) and climatology (contour) during 1980-2014 without
(a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S6 Latitude-height profile of annual relative humidity (%) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S7 Latitude-height profile of annual specific humidity \(10^{-3} \text{ kg kg}^{-1}\) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S8 Latitude-height profile of annual moisture convergence ($10^{-8}$ kg kg$^{-1}$ s$^{-1}$) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S9 Spatial pattern of annual 500hPa relative humidity (%) for linear trend (shaded) and climatology (contour) during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S10 Linear trends of OLR (contour, W m\(^{-2}\) decade\(^{-1}\)) and MRE of (a) skin temperature (ST, shaded, K decade\(^{-1}\)), and b) surface air temperature (SAT, shaded, K decade\(^{-1}\)) during 1980-2014, showing strong warming trend in extratropical land in the northern hemisphere, coinciding with regions with strong positive OLR trend. Dots indicate that the significance level of ST/SAT reaches 90%.
Fig. S11 Linear trend of vertical velocity (Pa s\(^{-1}\) decade\(^{-1}\)) within 60°S-60°N as a function of precipitation during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S12 Linear trend of MRE vertical velocity (Pa s\(^{-1}\) decade\(^{-1}\)) within 60\(^\circ\)S-60\(^\circ\)N as a function of precipitation during 1980-2014 without (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, and (e) NCEP2.
Fig. S13 Linear trend of temperature (K decade$^{-1}$) within 60°S-60°N as a function of precipitation during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S14 Linear trend of MRE temperature (K decade$^{-1}$) within 60°S-60°N as a function of precipitation during 1980-2014 without (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, and (e) NCEP2.
Fig. S15 Linear trend of relative humidity (\% decade\(^{-1}\)) within 60°S-60°N as a function of precipitation during 1980-2014 from (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, (e) NCEP1, and (f) NCEP2.
Fig. S16 Linear trend of MRE relative humidity (\% decade$^{-1}$) within 60°S-60°N as a function of precipitation during 1980-2014 without (a) 20CR, (b) ERAI, (c) JRA55, (d) MERRA2, and (e) NCEP2.
Reference


