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Description of the current-day and future climate forcing data set for the S-14 project (S14 Forcing Data or "S14FD")

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- Version: 20151013
- Spatial coverage: Global, including sea and Antarctica. Note however that the data over the sea and Antarctica are not bias-corrected (i.e., the raw data of the JRA-55 reanalysis were used). Only the data over the land were bias-corrected.
- Spatial resolution: 0.5° regular grid coordinate system
- Time coverage: Jan. 1, 1958 to Dec. 31, 2013
- Time resolution: 3-hourly, daily & monthly
- Variables:
  - 3-hourly: 2-m air temperature (*tmp2m*, °C), precipitation (*precsfc*, mm/3-hour), downward shortwave radiation flux (*dswrfsfc*, W m^{-2}), downward longwave radiation flux (*dlwrfsfc*, W m^{-2}), 2-m relative humidity (*rh2m*, %), 2-m specific humidity (*spfh2m*, kg kg^{-1}), 2-m vapor pressure (*vap2m*, hPa),10-m wind speed (*wind10m*, m s^{-1}) and surface pressure (*pressfc*, hPa)
  - Daily: daily mean 2-m air temperature (*tave2m*, °C), daily maximum 2-m air temperature (*tmax2m*, °C), daily minimum 2-m air temperature (*tmin2m*, °C),

daily total precipitation (*precsfc*, mm d^{-1}), daily mean downward shortwave radiation flux (*dswrfsfc*, W m^{-2}), daily mean downward longwave radiation flux (*dlwrfsfc*, W m^{-2}), daily mean 2-m relative humidity (*rh2m*, %), daily mean 2-m specific humidity (*spfh2m*, kg kg^{-1}), daily mean 2-m vapor pressure (*vap2m*, hPa), daily mean 10-m wind speed (*wind10m*, m s^{-1}) and daily mean surface pressure (*pressfc*, hPa)

  - ➢ Monthly: monthly mean 2-m air temperature (*tave2m*, °C), monthly mean daily maximum 2-m air temperature (*tmax2m*, °C), monthly mean daily minimum 2-m air temperature (*tmin2m*, °C), monthly total precipitation (*precsfc*, mm $month^{-1}$), monthly mean downward shortwave radiation flux (*dswrfsfc*, W m^{-2}), monthly mean downward longwave radiation flux (*dlwrfsfc*, W m^{-2}), monthly mean 2-m relative humidity (*rh2m*, %), monthly mean 2-m specific humidity (*spfh2m*, kg kg^{-1}), monthly mean 2-m vapor pressure (*vap2m*, hPa), monthly mean 10-m wind speed (*wind10m*, m s^{-1}), monthly mean surface pressure (*pressfc*, hPa) and number of wet days in a month (*wet*, days)

- File format: 4-byte real plain binary (for GrADS) and NetCDF4
- Note for users:
  - ➢ This data set is currently available for participants of the S-14 project. After the publication of a data set description paper, the data set will be open for scientific communities.
  - ➢ Contact person:

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Detailed description of the bias-correction methods

1.1. Bias correction of the JRA-55 reanalysis 3-hourly data

The data obtained from the JRA-55 reanalysis (Kobayashi et al., 2015, Harada et al.,

2016) were spatially interpolated to 0.5° grid cells in the regular grid system from the original reduced Gaussian grid system with the grid interval of ~55 km (or ~0.563°) by applying the inverse-distance-weighted averaging method to four nearest neighboring grid points. In the bias correction, first, the reanalysis surface pressure was corrected for the elevation. The reanalysis 2-m air temperature was corrected for the elevation as well as the monthly biases in mean temperature and diurnal temperature range using the CRU-TS3.22 data (Harris et al., 2013) as the reference. For the reanalysis 10-m wind speed, the 12-monthly climatologies of the climatic variable in 1961–1990 were adjusted to be the same with those of the reference data, the CRU-CL1.0 (New et al., 1999). The reanalysis downward shortwave and longwave radiation fluxes were corrected in the similar manner with the wind speed but using the 12-month climatologies calculated using the NASA-POWER data in 1983–2007. The reanalysis vapor pressure was derived from the reanalysis specific humidity and surface pressure and then corrected for the monthly biases in vapor pressure based on the CRU-TS3.22 data (Harris et al., 2013). Using the corrected temperature and vapor pressure mentioned above, relative humidity was re-calculated (referred to as the corrected reanalysis relative humidity). Similarly, the corrected specific humidity was computed using the corrected reanalysis surface pressure and vapor pressure. Finally, the reanalysis precipitation was corrected for the monthly biases in precipitation amount using the GPCCv7 data (Schneider et al., 2015) as well as the number of wet days in a month using the CRU-TS3.22 data (Harris et al., 2013). The precipitation was further corrected for the gauge type using the data collected in Motoya et al. (2002) as well as wind-induced rainfall and snowfall undercatch by applying the precipitation phase detection method of Yamazaki (2001) and the corrected wind speed, temperature and vapor pressure. These corrections were applied to the 3-hourly data and the daily and monthly data were calculated using the corrected 3-hourly data.

1.1.1. Surface pressure

The reanalysis surface pressure at the 0.5° CRU mean elevation (available at: https://crudata.uea.ac.uk/~timm/grid/CRU_TS_2_1.html) was calculated by incorporating the effect of elevation correction on the reanalysis temperature, as in previous work (Ngo-Duc et al., 2005, Weeden et al., 2011, 2014):

$$PS'_{\mathrm{JRA},y,m,d,h} = PS_{\mathrm{JRA},y,m,d,h}\left(\frac{T_{z,\mathrm{JRA},y,m,d,h}}{T_{0,\mathrm{JRA},y,m,d,h}}\right)^{g/\lambda R_{\mathrm{a}}}, (1)$$

where the suffix *y*, *m*, *d*, *h* indicates year, month, day and 3-hourly interval in a day, respectively; PS'_{JRA} and PS_{JRA} is the reanalysis pressure at the CRU elevation and sea level, respectively (hPa); $T_{z,\mathrm{JRA}}$ and $T_{0,\mathrm{JRA}}$ is the reanalysis temperature at the CRU elevation and sea level, respectively (°C); g is the acceleration of gravity (9.81 m s^{-2}); γ is the environmental lapse rate (0.0065 K m^{-1}); and R_{a} is the gas constant of air (287 J kg^{-1} K^{-1}).

1.1.2. Temperature

The bias-correction method applied to the reanalysis 2-m air temperature was the same with that used in the generation of major forcing data sets (Sheffield et al., 2006, Weedon et al., 2010, 2014). The reanalysis temperature was corrected for the elevation by assuming the environmental lapse rate to adjust the elevation difference between the reanalysis and reference data (the CRU-TS3.22, Harris et al., 2013). The elevation correction was important for some land grid cells with complex topography (e.g., around the Himalayas), but relatively less contributed to remaining land grid cells because of the relatively small gap in the grid size between the reanalysis (0.563°) and reference data (0.5°) used in this study.

The monthly biases in mean temperature relative to the reference data were removed:

$$T'_{\mathrm{JRA},y,m,d,h} = T_{\mathrm{JRA},y,m,d,h} + \left(\overline{T}_{\mathrm{CRU},y,m} - \overline{T}_{\mathrm{JRA},y,m}\right), (2)$$

where T'_{JRA} is the reanalysis temperature corrected for the monthly bias in mean temperature (°C); T_{JRA} is the reanalysis temperature (°C); and $\overline{T}_{\mathrm{CRU}}$ and $\overline{T}_{\mathrm{JRA}}$ is the monthly mean reference and reanalysis temperature, respectively (°C). The corrected reanalysis temperature (T'_{JRA}) was further adjusted so that the monthly mean reference and reanalysis diurnal temperature range matched each other:

$$T''_{\mathrm{JRA},y,m,d,h} = T'_{\mathrm{JRA},y,m,d,h} + \frac{\overline{DTR}_{\mathrm{CRU},y,m}}{\overline{DTR}_{\mathrm{JRA},y,m}} \times \left(T'_{\mathrm{JRA},y,m,d,h} - T'_{\mathrm{JRA},y,m,d}\right), (3)$$

where $T''_{\mathrm{JRA},}$ is the reanalysis temperature corrected for the monthly bias in diurnal temperature range (°C); $\overline{DTR}_{\mathrm{CRU}}$ and $\overline{DTR}_{\mathrm{JRA}}$ is the monthly mean reference and reanalysis diurnal temperature range, respectively (°C); and $T'_{\mathrm{JRA},y,m,d}$ is the reanalysis daily mean temperature calculated from the corrected 3-hourly data (°C).

1.1.3. Wind speed and downward shortwave and longwave radiation fluxes

The reanalysis wind speed and radiation fluxes were corrected using the method described in Iizumi et al. (2014). The reanalysis 10-m wind speed was scaled so that the 12-monthly climatologies of the reanalysis data in 1961-1990 were the same with those of the reference data (the CRU-CL1.0, New et al., 1999):

$$U'_{\mathrm{JRA},\,y,m,d,h} = \frac{\overline{U}_{\mathrm{CRU},\,m}}{\overline{U}_{\mathrm{JRA},\,m}} \times U_{\mathrm{JRA},\,y,m,d,h}, \quad (4)$$

where U'_{JRA} is the reanalysis wind speed corrected for the monthly climatology (m s^{-1}); $\overline{U}_{\mathrm{CRU}}$ and $\overline{U}_{\mathrm{JRA}}$ is the monthly climatology of the reference and reanalysis wind speed, respectively (m s^{-1}); and U_{JRA} is the reanalysis wind speed (m s^{-1}). No time series reference wind speed data at the global scale was the reason for the use of this correction method. The original 10-m reanalysis wind speed was directly used when the reference wind speed climatologies were not available for a given land grid cell.

The reanalysis downward shortwave and longwave radiation fluxes (W m^{-2}) were corrected in a similar fashion with the wind speed, but using the 12-monthly climatologies derived from the NASA-POWER data (http://power.larc.nasa.gov/index.php) in 1983–2007 as the reference data.

1.1.4. Vapor pressure, relative humidity and specific humidity,

For the consistent bias-correction across the moisture variables considered in this study, we first computed “reanalysis” vapor pressure using the specific humidity and surface pressure, both were obtained from the reanalysis data:

$$e_{\mathrm{JRA},\,y,m,d,h} = \frac{Q_{\mathrm{JRA},\,y,m,d,h} \cdot PS_{\mathrm{JRA},\,y,m,d,h}}{0.378\, Q_{\mathrm{JRA},\,y,m,d,h} + 0.622}, \quad (5)$$

where e_{JRA} is the reanalysis vapor pressure (hPa); Q_{JRA} is the reanalysis specific humidity (kg kg^{-1}); and PS_{JRA} is the reanalysis surface pressure (hPa). Then the calculated reanalysis vapor pressure was scaled so that the monthly mean reference and reanalysis vapor pressure matched each other:

$$e'_{\mathrm{JRA},\,y,m,d,h} = \frac{\overline{e}_{\mathrm{CRU},\,y,m}}{\overline{e}_{\mathrm{JRA},\,y,m}} \times e_{\mathrm{JRA},\,y,m,d,h}, \quad (6)$$

where $e'_{\mathrm{JRA},3hr}$ is the reanalysis vapor pressure corrected for its monthly bias (hPa); and $\bar{e}_{\mathrm{CRU}}$ and $\bar{e}_{\mathrm{JRA}}$ is the monthly mean reference and reanalysis vapor pressure, respectively (hPa). The corrected reanalysis vapor pressure was again converted into specific humidity using the corrected reanalysis surface pressure:

$$Q'_{\mathrm{JRA},y,m,d,h} = \frac{0.622\, e'_{\mathrm{JRA},y,m,d,h}}{PS'_{\mathrm{JRA},y,m,d,h} - 0.378\, e'_{\mathrm{JRA},y,m,d,h}}, \quad (7)$$

where Q'_{JRA} is the corrected reanalysis specific humidity (kg kg^{-1}); and PS'_{JRA} is the corrected reanalysis pressure obtained in the earlier step (hPa).

The corrected reanalysis relative humidity was computed using the corrected vapor pressure and saturation vapor pressure calculated using the corrected reanalysis temperature:

$$RH'_{\mathrm{JRA},y,m,d,h} = \frac{e'_{\mathrm{JRA},y,m,d,h}}{e'_{\mathrm{sat,JRA},y,m,d,h}} \times 100, \quad (8)$$

where RH'_{JRA} is the reanalysis relative humidity (%); and $e'_{\mathrm{sat,JRA}}$ (hPa) is the saturation vapor pressure under the corrected reanalysis temperature (T''_{JRA}) which was derived using Tetens equation (Kondo, 1994):

$$e_{\mathrm{sat}} = 6.1078 \times 10^{aT/(b+T)}, \quad (9)$$

where T is the temperature (°C); and a and b are the empirical coefficients (a=7.5 and b=237.3 for above water; and a=9.5 and b=265.3 for above ice).

1.1.5. Precipitation

In the precipitation correction, we had three steps: first the reanalysis monthly biases in wet-day frequency and precipitation amount were corrected; the reanalysis precipitation was then divided into rainfall and snowfall; and finally the reanalysis rainfall and snowfall were separately corrected for the wind-induced undercatch.

To correct monthly biases in precipitation frequency, the reanalysis 3-hourly precipitation below a threshold was replaced by zero:

$$P'_{\mathrm{JRA},y,m,d,h} = \begin{cases} 0 & \text{if } P_{\mathrm{JRA},y,m,d,h} \le P_{\mathrm{tr},y,m} \\ P_{\mathrm{JRA},y,m,d,h} & \text{if } P_{\mathrm{JRA},y,m,d,h} > P_{\mathrm{tr},y,m} \end{cases}, \quad (10)$$

where P'_{JRA} is the reanalysis precipitation corrected for the bias in monthly wet-day frequency (mm 3-hr^{-1}); P_{JRA} is the reanalysis precipitation (mm 3-hr^{-1}); and $P_{\mathrm{tr},\,y,\,m}$ is the monthly threshold of 3-hourly precipitation amount (mm 3-hr^{-1}). This correction was for the "too many wet days" case so that the number of wet days in a month calculated using the corrected 3-hourly data at this step had a closer match with that of the reference (the CRU-TS3.22, Harris et al., 2013). Wet day was defined as a day with daily precipitation >0.1 mm d^{-1} as in New et al. (1999) to be consistent with the reference data. A specific threshold value that gave the closest match between the reference and reanalysis wet-day frequency was determined for each year, month and grid cell by examining possible threshold values within the range of 0.1–20 mm 3-hr^{-1} with the interval of 0.01 mm 3-hr^{-1}, as in Iizumi et al. (2014). However, no correction of the "too few wet days" case was made for this study. The following steps were applied to the corrected reanalysis precipitation with non-zero value.

The reanalysis 3-hourly precipitation was scaled so that the monthly reference and reanalysis precipitation amount matched each other:

$$P''_{\mathrm{JRA},\,y,\,m,\,d,\,h} = \frac{\overline{P}_{\mathrm{GPCC},\,y,\,m}}{\overline{P'}_{\mathrm{JRA},\,y,\,m}} \times P'_{\mathrm{JRA},\,y,\,m,\,d,\,h}, \quad (11)$$

where P''_{JRA} is the reanalysis precipitation corrected for the monthly bias in precipitation amount (mm 3-hr^{-1}); $\overline{P}_{\mathrm{GPCC}}$ and $\overline{P'}_{\mathrm{JRA}}$ is the monthly reference and reanalysis precipitation amount (mm month^{-1}), respectively. The GPCC Full Data Reanalysis Version 7 (Schneider et al., 2015) was used as the reference data. The ratio values ($\overline{P}_{\mathrm{GPCC}} / \overline{P'}_{\mathrm{JRA}}$) were truncated by a certain value (=10.0) to avoid exceptionally large ratio and subsequent unrealistic precipitation values. Although this monthly scaling might cause the discrepancies in the wet-day frequency between the reference and corrected reanalysis data, we thought that the number of grid cells with this problem would be small and left them as they were.

Next the correction of wind-induced undercatch of the corrected reanalysis 3-hourly precipitation (P''_{JRA}) was separately conducted for rainfall and snowfall. The equation of Yamazaki (2001) was used to divide the corrected reanalysis 3-hourly precipitation into rainfall and snowfall:

$$s = \begin{cases} 1 - 0.5\exp\left[-2.2\left(1.1 - T_{\mathrm{W}}\right)^{1.3}\right], & T_{\mathrm{W}} < 1.1 \\ 0.5\exp\left[-2.2\left(T_{\mathrm{W}} - 1.1\right)^{1.3}\right], & T_{\mathrm{W}} \geq 1.1 \end{cases}, \quad (12)$$

where s is the proportion of snowfall in the 3-hourly precipitation; and T_{W} is the wet-bulb temperature (°C). The wet-bulb temperature was computed (Yamazaki, 2001):

$$T_{\mathrm{W}} = 0.584\,T + 0.875\,e - 5.32, \quad (13)$$

where T and e is the corrected reanalysis temperature (°C, T''_{JRA}) and vapor pressure (hPa, e''_{JRA}). For rainfall, as in previous work (Motoya et al., 2002, Hirabayashi et al., 2008b, Hanasaki et al., 2008), the equation of Kondo et al. (1994) was used:

$$CR_{\mathrm{rain}} = 100 - 1.51U - 0.21U^{2}, \quad (14)$$

where CR_{rain} is the catch ratio of the precipitation gauge for rainfall; and U is the 2-m wind speed (m s^{-1}). The corrected reanalysis 3-hourly 10-m wind speed (U'_{JRA}) was used after adjusting the elevation by assuming the logarithmic profile:

$$U = U'_{\mathrm{JRA}} \cdot \ln\left(\frac{2}{z_0}\right) \Big/ \ln\left(\frac{10}{z_0}\right), \quad (15)$$

where z_0 is the roughness length (m) collected and used in Hirabayashi et al. (2008b). U values were truncated by a certain value (=6.0) to avoid unrealistically large rainfall values after the correction. For snowfall, the gauge-type-specific correction factors of Motoya et al. (2002) were used, as in previous work (Hirabayashi et al., 2008b, Hanasaki et al., 2008):

$$CR_{\mathrm{snow}} = \begin{cases} a\exp(bU) & \text{for known gauge type} \\ 50\exp(-0.182U) + 50\exp(-0.112U) & \text{for unknown gauge type} \end{cases}, \quad (16)$$

where CR_{snow} is the catch ratio of the precipitation gauge for snowfall; and a and b are the empirical coefficients (Table 2). U values were truncated as in the rainfall.

Then the corrected 3-hourly rainfall and snowfall amounts were combined:

$$P'''_{\mathrm{JRA}\ y,m,d,h} = CR_{\mathrm{rain}}(1 - s)\,P''_{\mathrm{JRA}\ y,m,d,h} + CR_{\mathrm{snow}}\ s \cdot P''_{\mathrm{JRA},\,y,m,d,h}, \quad (17)$$

where P'''_{JRA} is the reanalysis precipitation corrected for the wind-induced undercatch (mm 3-hr^{-1}).

1.2. Bias correction of the CMIP5 GCM daily data

The cumulative distribution function-based statistical downscaling method (CDFDM, Iizumi et al., 2010, 2011, 2012) was applied to the bias-correction of the GCM daily data obtained from the WCRP CMIP5 multimodel ensemble data set (Taylor et al., 2012) under four different Representative Concentration Pathways (RCP) scenarios with the radiative forcing of 2.6, 4.5, 6.0 and 8.5 W m^{-2} (Moss et al., 2010). As listed below, the eight different GCMs, GFDL-ESM2M, IPSL-CM5A-LR, MIROC-ESM-CHEM, HadGEM2-ES, NorESM1-M, MIROC5, MIROC-ESM and MRI-CGCM3, were considered in this study. These GCMs were selected based on the availability of climatic variables at a daily time step which are necessary to run impact models across major sectors (e.g., crop models, hydrological models, terrestrial vegetation models). Also we covered all GCMs used in the ISI-MIP data set (Hempel et al., 2013) so that impact modelers can compare the two different data sets.

The GCM daily data were spatially interpolated to 0.5° grid cells in the regular grid coordinate system by applying the inverse-distance weighted averaging method to four nearest neighboring grid points of a GCM. The CDFDM was commonly applied nine different climatic variables, including daily mean, maximum and minimum 2-m air temperature, precipitation, downward shortwave and longwave radiation, specific humidity, relative humidity and 10-m wind speed. Vapor pressure was excluded because specific humidity or relative humidity are more common as a climate input for many impact models. Also surface pressure was not considered in the bias-correction of the GCM data because no GCM daily surface pressure data were available in the CMIP5 data set.

The procedure of the CDFDM was the same for all climatic variables considered here. If precipitation was used as the example for explanatory purpose, the error of a GCM in daily precipitation was defined for each percentile of the empirical cumulative distribution functions provided from the daily GCM and observations (i.e., the corrected JRA-55 daily data elaborated earlier) for the baseline period 1961–2000, grid cell by grid cell, for each of mid-latitudinal warm (May–October) and cold (November–April) seasons. The 40-year baseline period was selected to allow consistent comparison with the ISI-MIP data set (Hempel et al., 2013) which uses the same 40-year baseline period derived from the WATCH Forcing Data (WFD, Weeden et al., 2011).

1.3. Differences of the S14 Forcing Data compared to other major forcing data sets.

The bias-correction methods applied to the surface pressure and temperature were the almost same with those used in previous work (Ngo-Duc et al., 2005, Sheffield et al., 2006, Weeden et al., 2011, 2014). A difference could be found for the method for correcting the wind speed because this study corrected the 12-monthly climatologies of the climatic variable as in Iizumi et al. (2014) whereas many other forcing data sets used reanalysis wind speed data without any correction (Zhao & Dirmeyer, 2003, Ngo-Duc et al., 2005, Sheffield et al., 2006, Weeden et al., 2011, 2014) or only with the elevation correction based on the logarithm profile (Hirabayashi et al., 2008b, Hanasaki et al., 2008). The correction method used for the downward shortwave radiation flux was the same with that used in previous work (Ngo-Duc et al., 2005, Iizumi et al., 2014) which was relatively simple compared to other forcing data sets (Zhao & Dirmeyer, 2003, Sheffield et al., 2006, Weeden et al., 2011, 2014). As for the downward longwave radiation, we made the correction for the 12-monthly climatologies of the climatic variable as in Ngo-Duc et al. (2005) and Iizumi et al. (2014) which is different with the method solely based on the elevation correction (Weeden et al., 2011, 2014) but simpler than the method of Sheffield et al. (2006) that combined the CRU-TS cloud cover data and SRB downward longwave radiation flux data. In this study, the vapor pressure was corrected for the monthly biases, as in Iizumi et al. (2014), using the CRU-TS3.22 data and the specific and relative humidity were re-calculated to be consistent with the corrected vapor pressure, surface pressure and temperature. This method is different with previous work which modified specific humidity values by incorporating the elevation correction effect on temperature and surface pressure with the reanalysis relative humidity unchanged (Zhao & Dirmeyer, 2003, Ngo-Duc et al., 2005, Sheffield et al., 2006, Hanasaki et al., 2008, Weeden et al., 2011, 2014). As for the precipitation, the correction for the monthly biases in precipitation amount is the common procedure across the studies. However, large differences in the wet-day frequency correction, rainfall/snowfall partition and wind-induced undercatch correction exist. No wet-day frequency correction was considered in some studies (Zhao & Dirmeyer, 2003, Ngo-Duc et al., 2005, Hanasaki et al., 2008). However, many studies accounted for some sort of the wet-day frequency correction (Sheffield et al., 2006, Hirabayashi et al., 2008a, Weeden et al., 2011, 2014, Iizumi et al., 2014) although the methodological details varied by study. Also the rainfall/snowfall partition was made by varying methods, including the original reanalysis separation (Zhao & Dirmeyer, 2003, Weeden et al., 2011), temperature threshold (Ngo-Duc et al., 2005) and empirical function of temperature (Weeden et al., 2014) or wet bulb temperature (Hirabayashi et al., 2008b, Hanasaki et al., 2008). Sheffield et al. (2006) and Iizumi et al. (2014) did not separate rainfall and snowfall. Wind-induced undercatch was considered in most studies (Zhao & Dirmeyer, 2003, Sheffield et al., 2006) except Ngo-Duc et al. (2005) and Iizumi et al. (2014). Some studies (Hirabayashi et al., 2008b, Hanasaki et al., 2008, Weeden et al., 2011, 2014) separately conducted the wind-induced undercatch correction for rainfall and snowfall.

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Table 1. Summary of variables, symbols, units and correction methods used.

Variable	Symbol	Unit	Bias correction
Surface pressure	*Ps*	hPa	Elevation correction on *T*
2-m air temperature	*T*	°C	Elevation correction using the environmental lapse rate, CRU-TS3.22 monthly mean temperature and diurnal temperature range
10-m wind speed	*U*	$m\ s^{-1}$	CRU-CL1.0 12-monthly mean wind speed climatology (1961–1990)
Downward longwave radiation flux	*LW*	$W\ m^{-2}$	NASA-POWER-based 12-monthly mean downward longwave radiation flux climatology (1983–2007)
Downward shortwave radiation flux	*SW*	$W\ m^{-2}$	NASA-POWER-based 12-monthly mean downward shortwave radiation flux climatology (1983–2007)
2-m vapor pressure	*e*	hPa	CRU-TS3.22 monthly mean vapor pressure
2-m specific humidity	*Q*	kg/kg	Re-calculated corrected *Ps* and *e*
2-m relative humidity	*RH*	%	Re-calculated corrected *T* and *e*
Precipitation rate	*P*	mm/3hr[1]	CRU-TS3.22 monthly number of wet days, GPCCv7 monthly precipitation amount, wet bulb temperature-based rainfall/snowfall separation, gauge-type-specific wind-induced rainfall/snowfall undercatch correction

[1] The unit of precipitation rate varies by temporal resolution: daily, $mm\ d^{-1}$; and monthly, $mm\ month^{-1}$.

Table 2. A list of gauge-specific coefficients used in the wind-induced snowfall undercatch correction (Eq. 16). The list was first appeared in Motoya et al. (2002), Hirabayashi et al. (2008b) and Hanasaki et al. (2008).

Gauge type	*a*	*b*
Canadian Nipher	112.78	-0.08215
Chinese standard	100.00	-0.05600
Hellmann-like	120.95	-0.25425
Wild-like	108.98	-0.25637
Tretyakov	105.38	-0.13125
Norwegian standard	106.95	-0.18622
Japanese (average)	96.63	-0.10040
NWS 8-inch-like	98.00	-0.05405