Annex I: Observations

Coordinating Lead Authors:
Blair Trewin (Australia)

Lead Authors:
Lisa Bock (Germany), Josep Canadell (Australia), Prodromos Zanis (Greece), Prabir Patra (Japan), Olga Zolina (Russia), Yongqiang Yu (China), Mansour Almazroui (Saudi Arabia), Rafiq Hamdi (Belgium), Jin-Ho Yoon (Republic of Korea), Shilong Piao (China), Pedro Monteiro (South Africa), Masao Ishii (Japan)

Contributing Authors:

Review Editors:

Date of Draft: 29 April 2019

Notes: TSU Compiled Version

Table of Content

AI.1 Introduction to the observational data sets annex

The purpose of this annex is to document observational data sets used by Working Group I in the Sixth Assessment Report. This includes details of the types and versions of data sets, the time period they cover, the chapters in which they appear, and citations and (where available) web links to the data.

This list includes those observational data sets which contribute to values reported in the text or in figures, unless they are citing a specific result from a paper (as opposed to an ongoing data set for which that paper is a reference).

Reanalyses are within the scope of this annex, but historical climate model simulations are not. Proxy data sets are also outside the scope of this annex [*cross-reference to separate annex to be added*].

Data sets which are updated regularly on an operational basis are shown as ending in 2019, even if no 2019 data have yet been published at the time of writing.

[*Notes for First Order Draft: the annex is known to be incomplete and only contains input from a limited range of chapters, with some citations and/or links to data set locations missing. There is also no particular sequence to the entries in the table; in later drafts there will be a more systematic grouping, although it has not yet been determined whether this will be by author, data set name, data set type or order of appearance in AR6*].

Name	Ver-sion	Type	Resolution (time and space)	Chap-ter	Time period	Citation and link (where available)
Hadley Centre HadSST sea surface temperature	3.1.1.0	In situ	Monthly, 5° x 5°	2	1850-2019	Kennedy et al., 2011b, 2011a https://www.metoffice.gov.uk/hadobs/hadsst3/
NOAA ERSST sea surface temperature	5	In situ	Monthly, 2° x 2°	2	1880-2019	Huang et al., 2017 https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v5
NOAA ERSST sea surface temperature	3b	In situ	Monthly, 2° x 2°	3	1854-2019	Smith et al., 2008 https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v3b
Hadley Centre HadNMAT2 night marine air temperature	2	In situ	Monthly, 5° x 5°	2	1880-2010	Kent et al., 2013 https://www.metoffice.gov.uk/hadobs/hadnmat2/
ECMWF ERA-Interim reanalysis		Reanalysis	6-hourly, T255 spectral (approx. 80 km), 60 vertical levels	2, 3, 8, Atlas	1979-2019	Dee et al., 2011 https://www.ecmwf.int/en/forecasts/datasets/ reanalysis-datasets/era-interim
ECMWF ERA-Interim reanalysis - Land		Reanalysis	6-hourly, T255 spectral (approx. 80 km), 60 vertical levels	8	1979-2010	Balsamo et al., 2015
ECMWF 40 year reanalysis (ERA-40)		Reanalysis	3-hourly, T159 (approx. 125 km)	Atlas	1958-2001	Uppala et al., 2005
Remote Sensing Systems RSS satellite temperature	4.0	Remote sensing	Monthly, 2.5° x 2.5°, 5 vertical layers	2	1979-2019	Mears and Wentz, 2017 http://www.remss.com/measurements/upper-air-temperature/
Global Space-based Strato-spheric Aerosol Climatology (GloSSAC)	1.0	Remote sensing	Monthly, 5° zonal means	2	1979-2016	Thomason et al., 2018 https://eosweb.larc.nasa.gov
Historical greenhouse gas concen-trations for climate modelling		In situ	Monthly, 15° zonal means	2	1850-2014	Meinshausen et al., 2017 http://www.climatecollege.unimelb.edu.au/cmip6
Advanced Global Atmospheric Gases Experiment (AGAGE)		In situ	Up to 36 times per day, point-based	2, 5	1978-2019	Prinn et al., 2018 http://agage.mit.edu/data
NOAA atmospheric gas measure-ments		In situ	Point-based, time resolution depends on gas	2, 3, 5	Varies depend ing on gas	Masarie and Tans, 2004; Montzka et al., 2009; Hall et al., 2011
University of California at Irvine (UCI) atmospheric gas measure-ments		In situ	Point-based, several sampling periods per year	2	1984-2019	Simpson et al., 2012 http://cdiac.ornl.gov/tracegases.html

CSIRO atmospheric gas measure-ments		In situ	Monthly, point-based	2	1976-2019	Langenfelds et al., 2002; Kirschke et al., 2013
WMO Global Atmosphere Watch greenhouse gas measure-ments		In situ	Annual, point-based and global means.	2	1984-2019	Tsutsumi et al., 2009 https://gaw.kishou.go.jp/publications/global_mean_mole_fractions
Scripps atmospheric CO_2 data		In situ	Weekly, point-based	2, 5	1958-2019	Keeling et al., 2001a http://scrippsco2.ucsd.edu/data/atmospheric_co2/
Strato-spheric Water and Ozone Satellite Homogen-ized (SWOOSH)	2.5	Remote sensing	Monthly, 2.5° zonal mean, 12 vertical levels	2	1984-2019	Davis et al., 2016 https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00958
Boulder stratospheric water vapour		In situ	Point-based, profiles approx.. monthly	2	1980-2010	Hurst et al., 2011
Ozone multi-sensor reanalysis (MSR)	2	Reanalysis	6-hourly, 1 x 1°	2	1970-2019	van der A et al., 2015
World Ozone and UV Data Center (WOUDC) ozone data set		In situ	Monthly, global and zonal means	2	1964-2019	Fioletov et al., 2002
GOME global total ozone (GTO) data set		Remote sensing	Monthly, 1 x 1°	2	1996-2019	Coldewey-Egbers et al., 2015
GOME GSG ozone data set		Remote sensing	Monthly, 5° zonal means	2	1995-2019	Weber et al., 2011 http://www.iup.uni-bremen.de/gome/wfdoas/merged/
NASA Merged Ozone Data (MOD)	8.6	Remote sensing	Monthly, 5° zonal means	2	1970-2019	Frith et al., 2017 https://acd-ext.gsfc.nasa.gov/Data_services/merged/index.html
NOAA Merge ozone data	8.6	Remote sensing	Daily, 5° zonal means	2	1978-2019	Wild and Long, 2018 (in preparation) ftp://ftp.cpc.ncep.noaa.gov/SBUV_CDR/
Tropo-spheric Ozone Assessment Report (TOAR) surface ozone database		In situ	Hourly, point-based	2, 6	1970-2019	Schultz et al., 2017; Tarasick et al., 2019 http://www.igacproject.org/activities/TOAR
International Compre-hensive Ocean - Atmosphere Data Set (ICOADS)	3.0	In situ	Point-based, frequency varies; monthly, 1 x 1°	2	1662-2019	Freeman et al., 2017 https://icoads.noaa.gov/
COBE Sea Surface Temperature	2	In situ	Daily, 1 x 1°	2	1845-2019	Hirahara et al., 2014
Global Historical Climatology Network	4	In situ	Monthly, point-based	2	1880-2019	Menne et al., 2018 https://www.ncdc.noaa.gov/ghcnm/

(GHCN) - Monthly						
Global Historical Climatology Network (GHCN) - Monthly	2	In situ	Monthly, point-based	2	1880-2019	Peterson and Vose, 1997 https://www.ncdc.noaa.gov/ghcnm/
China Land Surface Air Temperature (CLSAT)		In situ	Monthly, point-based	2	1900-2019	Xu et al., 2018
NOAA Global Temp	4.0.1	In situ	Monthly, 5 x 5°	2, 3	1880-2019	Vose et al., 2012 https://www.ncdc.noaa.gov/data-access/marineocean-data/noaa-global-surface-temperature-noaaglobaltemp
HadCRUT	4	In situ	Monthly, 5 x 5°	2, 3	1850-2019	Morice et al., 2012 https://www.metoffice.gov.uk/hadobs/hadcrut4/
HadCRUT	3	In situ	Monthly, 5 x 5°	3	1998-2012	Brohan et al., 2006 https://www.metoffice.gov.uk/hadobs/hadcrut3/
GISTEMP	3	In situ	Monthly, 2°x2°	2, 3	1880-2019	GISTEMP Team, 2019; Hansen et al., 2010 https://data.giss.nasa.gov/gistemp/
Cowtan and Way	2.0	In situ	Monthly, 5 x 5°	2	1850-2019	Cowtan and Way, 2014 http://www-users.york.ac.uk/~kdc3/papers/coverage2013/series.html
Berkeley Earth surface air temperature		In situ	Monthly, 1 x 1° (or equivalent equal-area grid)	2, 3	1750-2019	Rohde et al., 2013 http://www.berkeleyearth.org
CRU TS	4.02	In situ	Monthly, 0.5 x 0.5°	2, 3, 8	1901-2017	Harris et al., 2014 https://crudata.uea.ac.uk/cru/data/hrg/cru_ts_4.02/
HadEX	2	In situ	Monthly, 3.75 x 2.5°	2	1901-2010	Donat et al., 2013a http://www.climdex.org
GHCNDEX		In situ	Monthly, 2.5 x 2.5°	2, 3	1951-2019	Donat et al., 2013b http://www.climdex.org
Japan Meteorological Agency JRA-55 reanalysis		Reanalysis	3-hourly, TL319 (~55 km), 60 vertical levels	2, 3, 8, Atlas	1958-2019	Harada et al., 2016 https://jra.kishou.go.jp/JRA-55/index_en.html
MERRA-2 reanalysis	2	Reanalysis	6-hourly, 0.5 x 0.66°, 72 vertical levels	2, 3, 8, Atlas	1980-2019	Gelaro et al., 2017 https://gmao.gsfc.nasa.gov/reanalysis/MERRA-2/
MERRA-2 reanalysis - Land	2	Reanalysis	6-hourly, 0.5 x 0.66°, 72 vertical levels	8	1980-2019	Reichle, 2012 http://gmao.gsfc.nasa.gov/pubs/office_notes.
MERRA reanalysis	1	Reanalysis	3-hourly, 0.5° x 0.66°	8, Atlas	1979-2016	Rienecker et al., 2011
RAOB-CORE radiosonde data set	1.5.1	In situ	Monthly, 10 x 5°, 12 vertical levels	2	1958-2019	Haimberger et al., 2012 https://www.univie.ac.at/theoret-met/research/raobcore/
RICH radiosonde data set	1.5.1	In situ	Monthly, 10 x 5°, 12 vertical levels	2	1958-2019	Haimberger et al., 2012 https://www.univie.ac.at/theoret-met/research/raobcore/
UNSW radiosonde data set	2	In situ	Monthly, point-based, 12 vertical levels	2	1959-2013	Sherwood and Nishant, 2015
University of Alabama at Huntsville (UAH) satellite temperature	6.0	Remote sensing	Monthly, 3 vertical layers	2	1979-2019	Spencer et al., 2017 https://www.nsstc.uah.edu/climate/
NOAA STAR satellite temperature	3.0	Remote sensing	Monthly, 2.5 x 2.5°, 3 vertical layers	2	1979-2019	Zou and Wang, 2011 https://www.star.nesdis.noaa.gov/smcd/emb/mscat/

Wegener Centre radio occultation data set		Remote sensing	Monthly, 0.1 km vertical	2	2001-2019	Angerer et al., 2017
HadISDH	4.0.0.2017f	In situ	Monthly, 5 x 5°	2	1973-2019	Willett et al., 2014 https://www.metoffice.gov.uk/hadobs/hadisdh/
ERA-5		Reanalysis	Hourly, 30 km, 137 vertical levels	2, 8	1979-2019	Copernicus Climate Change Service, 2017 https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5
Global Precipitation Climatology Centre (GPCC)	8	In situ	Monthly, 0.25 x 0.25°	2, 3, 8	1981-2019	Schneider et al., 2017 ftp://ftp.dwd.de/pub/data/gpcc/html/fulldata-monthly_v2018_doi_download.html
PERSIANN-CDR		Remote sensing	Daily, 0.25 x 0.25°	2, 8	1982-2019	Ashouri et al., 2015 https://www.ncdc.noaa.gov/cdr/atmospheric/precipitation-persiann-cdr
Global Precipitation Climatology Project (GPCP)	2.3	Remote sensing and in situ	Monthly, 2.5 x 2.5°	2, 8	1979-2019	Adler et al., 2018 https://www.esrl.noaa.gov/psd/data/gridded/data.gpcp.html
Global Precipitation Climatology Project (GPCP)	2.2	Remote sensing and in situ	Monthly, 2.5 x 2.5°	3, 8	1979-2019	Adler et al., 2003; Huffman and Bolvin, 2013 https://www.esrl.noaa.gov/psd/data/gridded/data.gpcp.html
FLO1K flow metrics data set		In situ	Annual, 1 km	2	1960-2015	Barbarossa et al., 2018
Global Streamflow Indices and Metadata Archive (GSIM)		In situ	Daily, point-based	2	1806-2016	Do et al., 2018
HadISD	2.0.2.2017f	In situ	Sub-daily, point-based	2	1973-2019	Dunn et al., 2012 https://www.metoffice.gov.uk/hadobs/hadisd/
Cross-calibrated multi-platform wind data set		Remote sensing and in situ	6-hourly, 25 km	2	1987-2019	Atlas et al., 2011
OAFlux		Remote sensing	Daily, 0.25 x 0.25°	2	1987-2019	Yu et al., 2008 http://oaflux.whoi.edu/
National Sea and Ice Data Center (NSIDC) sea ice index	3	Remote sensing	Daily, 25 km	2, 3	1978-2019	Fetterer et al., 2017 https://nsidc.org/data/G02135/versions/3
Walsh et al sea ice data		Remote sensing and in situ	Monthly	2, 9	1850-2019	Walsh et al., 2017
NOAA/ Rutgers University snow cover extent data set	V01r01	Remote sensing	Weekly, 100-200 km	2, 3, 9	1966-2019	Estilow et al., 2015 https://climate.rutgers.edu/snowcover/
NOAA reconstruct-ed snow cover data set		Remote sensing and in situ	Monthly, hemi-spheric time series	2, 3	1915-1997	Brown, 2002; Brown and Robinson, 2011 https://nsidc.org/data/g02131
AMOC data set		In situ and reanalysis	Monthly, regional time series	2	2004-2017	Smeed et al., 2018
Southern Oscillation Index (SOI)		In situ	Monthly, regional time series	2	1876-2019	Troup, 1965 http://www.bom.gov.au/climate/current/soihtm1.shtml
Climate Prediction Center		In situ	Monthly, regional time series	2	1950-2019	https://www.cpc.ncep.noaa.gov/data/indices/ Derived from ERSSTv5

(CPC) Niño indices						
Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST)	1	In situ and remote sensing	Monthly, 1 x 1°	2, 3	1871-2019	Rayner et al., 2003 https://www.metoffice.gov.uk/hadobs/hadisst/
HadISST sea ice concent-ration	2.2.0.0	In situ and remote sensing	Monthly, 1 x 1°	9	1850-2019	Titchner and Rayner, 2014 https://www.metoffice.gov.uk/hadobs/hadisst2/
Kaplan Extended SST data set	2	In situ	Monthly, 5 x 5°	2	1856-2019	Kaplan et al., 1998 https://www.esrl.noaa.gov/psd/data/gridded/data.kaplan_sst.html
NOAA Optimum Interpolation SST (OISST)	2	In situ and remote sensing	Daily, 0.25 x 0.25°	2	1981-2019	Banzon et al., 2016 https://www.ncdc.noaa.gov/oisst
CPC teleconnec-tion indices (AAO, AO, NAO, PNA)		In situ	Daily, regional means	2	1950-2019 (1979-2019 for AAO)	https://www.cpc.ncep.noaa.gov/products/precip/CWlink/daily_ao_index/teleconnections.shtml
Thompson and Wallace AO index		In situ	Monthly, regional means	2	1900-2019	Thompson and Wallace, 2000
Marshall SAM index		In situ	Monthly, regional means	2	1957-2019	Marshall, 2003 http://www.nerc-bas.ac.uk/icd/gjma/sam.html
Hadley Centre Sea Level Pressure (HadSLP)	2r	In situ and reanalysis	Monthly, 5 x 5°	2, 3	1850-2019	Allan and Ansell, 2006 https://www.metoffice.gov.uk/hadobs/hadslp2/
ERA 20th Century (ERA-20C) reanalysis		Reanalysis	3-hourly, ~125 km, 128 vertical levels	2, 3, 8, Atlas	1900-2010	Poli et al., 2016 https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era-20c
ERA 20th Century (ERA-20C) reanalysis ensemble		Reanalysis	3-hourly, ~125 km, 128 vertical levels	8	1889-2009	Hersbach et al., 2015
NOAA-CIRES 20th Century Reanalysis (20CR)	2c	Reanalysis	3-hourly, 2 x 2°, 24 vertical levels	2, 3, 8, Atlas	1851-2014	Compo et al., 2011 https://www.esrl.noaa.gov/psd/data/20thC_Rean/
NOAA-CIRES 20th Century Reanalysis (20CR)	3	Reanalysis	3-hourly, 0.5° x 0.5°	8	1851-2019	Sliviniski et al., submitted
The Japanese 55-year Reanalysis Using Convention-al Data Only (JRA-55C)	C	Reanalysis	3-hourly, 0.562° x 0.562°	8	1972-2012	Kobayashi et al., 2015
AIRS specific humidity	RetStd-v5	Remote sensing	Monthly,1° x1°	3	2003-2010	Susskind et al., 2006; Tian et al., 2013 https://esgf-node.llnl.gov/search/obs4mips/
CERES EBAF	Ed2.8	Remote sensing	Monthly,1° x1°	3	2000-2018	Loeb et al., 2009, 2012 https://esgf-node.llnl.gov/search/obs4mips/
CMAP precipitation		Remote sensing	Monthly, 2.5°x2.5°	3	1980-2005	Xie and Arkin, 1997 https://www.esrl.noaa.gov/psd/data/gridded/data.cmap.html
ESA CCI Aerosol	SU-v4.21	Remote sensing	Monthly,1° x1°	3	1997-2011	Popp et al., 2016 ftp://anon-ftp.ceda.ac.uk/neodc/esacci/aerosol/data/

ESA CCI Cloud Total cloud cover	AVHRR-fv3.0	Remote sensing	Monthly, 0.5°x0.5°	3	1982-2016	Stengel et al., 2017 https://public.satproj.klima.dwd.de/data/ESA_Cloud_CCI/CLD_PRODUCTS/v3.0/
ESA CCI Ozone	L3	Remote sensing	Monthly,1° x1°	3	1997-2010	ESA Ozone CCI project team, 2016 ftp://anon-ftp.ceda.ac.uk/neodc/esacci/ozone/data/
ESA CCI Soil Moisture	L3S-SSMV-COMBINED-v4.2	Remote sensing	Monthly, 0.25°x0.25°	3	1979-2016	Dorigo et al., 2017; Gruber et al., 2017; Liu et al., 2012 ftp://anon-ftp.ceda.ac.uk/neodc/esacci/soil_moisture/data/
ESA CCI sea surface temperature	L4-GHRSST-SSTdepth-OSTIA-GLOB	Remote sensing	Monthly, 0.05°x0.05°	3	1992-2010	Merchant et al., 2014a, 2014b ftp://anon-ftp.ceda.ac.uk/neodc/esacci/sst/data/
ESACCI-SSMI		Remote sensing	Monthly,25 km x 25 km	3	1992-2008	Sandven, 2015 ftp://anon-ftp.ceda.ac.uk/neodc/esacci/sea_ice/data/sea_ice_concentration/
FLUXNET		In situ	Point-based	3	1991-2019	https://fluxnet.fluxdata.org/
Global Carbon Project		In situ	Global, spatial average	3, 5	1959-2019	Le Quéré et al., 2018
GHCN precipitation		In situ	Monthly, 5°x5°	3	1900-2014	Jones and Moberg, 2003 https://www.esrl.noaa.gov/psd/data/gridded/data.ghcngridded.html
GLDAS		Reanalysis	Monthly, 1°x1°	3, 8	1951-2010	Rodell et al., 2004 https://hydro1.gesdisc.eosdis.nasa.gov/data/GLDAS/GLDAS_NOAH10_M.2.0/
HWSD soil carbon content		In situ	Monthly, 1°x1°	3	2014	Wieder et al., 2014
JMA-TRANS-COM		Reanalysis	Monthly, 1°x1°	3	1985-2008	Gurney et al., 2003
LAI3g		Remote sensing	Monthly, 0.5°x0.5°	3	1982-2011	Zhu et al., 2013
LandFlux-EVAL		In situ	Monthly	3	2000-2004	Mueller et al., 2013 http://www.iac.ethz.ch/groups/seneviratne/research/LandFlux-EVAL
MODIS Aerosol optical depth 550nm	MYD08_M3	Remote sensing	Monthly, 1°x1°	3	2003-2011	Platnick et al., 2003 https://ladsweb.modaps.eosdis.nasa.gov/search/order
MTE Gross Primary Productivity		Reanalysis	Monthly, 0.5°x0.5°	3	1982-2011	Jung et al., 2011
NCEP-NCAR Reanalysis		Reanalysis	Daily and monthly, 2.5°x2.5°	3, 9, Atlas	1980-2019	Kalnay et al., 1996 http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis.html
NIWA-BS Total Column Ozone	V3.3	Remote sensing	Monthly, 1.25°x1°	3	1979-2016	Bodeker et al., 2005 http://www.bodekerscientific.com/data/total-column-ozone
NOAA ESRL MLO Carbon dioxide		In situ	Monthly, point-based	3	1980-2014	Zeng et al., 2014 https://www.esrl.noaa.gov/gmd/ccgg/trends/data.html
PATMOS-x total cloud cover		Remote sensing	Monthly, 1°x1°	3	1982-2016	Heidinger et al., 2014 https://www.ncdc.noaa.gov/cdr/atmospheric/avhrr-cloud-properties-patmos-x
WOA		In situ	Monthly, 1°x1°	3	2009	Levitus et al., 2012 https://data.nodc.noaa.gov/woa/WOA13/DATAv2/
MODIS/ Terra Aerosol 5-Min L2 Swath 10km	MOD08_D3	Remote sensing	Global, 10x10 km. Column AOD	6	2000-2019	Levy and Hsu, 2015 http://dx.doi.org/10.5067/MODIS/MOD04_L2.006
MISR Component Global Aerosol Product	V4, Level 3	Remote sensing	Yearly, 0.5° x 0.5° grid	6	2000-2019	Diner, 2009 https://eosweb.larc.nasa.gov/project/misr/mil3yaen_table

NOAA δ^{13}C-CH_4	2019	In situ	Weekly-monthly	5	1998-2017	White et al., 2019; www.esrl.noaa.gov/gmd/dv/ftpdata.html
PDX CH_4, δ^{13}C- CH_4	2017	In situ	Daily-monthly	5	1977-2010	Rice et al., 2016
GOSAT XCH_4	2019	Remote sensing	Hourly-monthly	5	2009-2017	Yoshida et al., 2011 www.gosat.nies.go.jp/en/recent-global-ch4.html
Multivariate ENSO Index (MEI)		In situ	Monthly	5	1977-2017	Wolter and Timlin, 1998 https://www.esrl.noaa.gov/psd/enso/mei/
SIO O_2	2019	In situ	Weekly-monthly	5	1991-2018	Keeling and Garcia, 2002 http://scrippso2.ucsd.edu
SIO δ^{13}C-CO_2	2019	In situ	Weekly-monthly	5	1978-2018	Keeling et al., 2001b http://scrippso2.ucsd.edu
NIWA δ^{13}C-CO_2	2019	In situ	Monthly	5	1957-2015	Turnbull et al., 2017
Tohoku Univ. N_2O, δ^{15}N, δ^{15}Nα	2018	In situ	Irregular	5	1950-2000	Ishijima et al., 2007
UC Berkeley, N_2O, δ^{15}N, δ^{15}Nα	2018	In situ	Event	5	1900-1995	Park et al., 2012
EDGARv4.3.2	2019	In situ	Monthly, 0.1° x 0.1°	5	1970-2012	Janssens-Maenhout et al., 2019 http://edgar.jrc.ec.europa.eu/overview.php?v=432_GHG&SECURE=123
MIROC4-ACTM emission flux data	2018	Reanalysis	Monthly, 1 x 1°	5	1996-2016	Patra et al., 2016, 2018; Saeki and Patra, 2017 https://ebcrpa.jamstec.go.jp/~prabir/data/co2l2r84/s042_FaChOt_srcdf1/ https://ebcrpa.jamstec.go.jp/~prabir/data/ch4l2r53/gcp2019/ https://ebcrpa.jamstec.go.jp/~prabir/data/n2ol2r84/s037_edgman1/
NCEP Climate Forecast System Reanalysis (CFSR)		Reanalysis	Hourly, T382 (approx. 38 km)	8, Atlas	1979-2019	Saha et al., 2010
Global Earth Observation for Integrated Water Resource Assessment (Earth2Observe) Water Resources Reanalysis v2 (WRR2)	2	Reanalysis	Monthly, 0.5° x 0.5°	8	1979-2012	Schellekens et al., 2017
Remote Sensing Systems (RSS)	7	Remote sensing	2 per day, 0.25° x 0.25°	8	1987-2019	Wentz, 2013
Tropical Rainfall Measuring Mission Precipitation Radar (TRMM PR)	PR	Remote sensing	Monthly, 0.5° x 0.5°	8	1997-2015	Haddad et al., 1997
TRMM GPOF	GPOF	Remote sensing	Daily, 0.25° x 0.25°	8	1997-2015	Stocker et al., 2018
TRMM 3A25	3A25	Remote sensing	Monthly, 0.5° x 0.5°	8	1979-2015	Caylor et al., 1997
TRMM Microwave Imager (TRMM TMI)	TMI	Remote sensing	3-days, 0.25° x 0.25°	8	1997-2015	Wentz et al., 2001
TRMM Microwave Imager	3B42	Remote sensing	3-hourly, 0.25° x 0.25°	8	1997-2018	TRMM, 2011 https://disc.gsfc.nasa.gov/datasets/TRMM_3B42_7/summary

(TRMM 3B42)						
Tropical Rainfall Measuring Mission (TRMM) Precipitation	7.0	Remote sensing	Sub-daily, Daily, Monthly 0.25°×0.25 °	10	1998-2019	Huffman et al., 2014
Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite data record (HOAPS4)		Remote sensing	6-hourly, 0.5° x 0.5°	8	1987-2014	Andersson et al., 2010
IFREMER4	4	Remote sensing	Daily, 0.25° x 0.25°	8	1992-2017	Bentamy et al., 2017
Japanese Ocean Flux Data Sets with Use of Remote Sensing Observations (J-OFURO3)	3	Remote sensing	Daily, 0.25° x 0.25°	8	1988-2013	Tomita, 2017
Princeton MEaSURES		Reanalysis, remote sensing and in situ	Monthly, 0.5° x 0.5°	8	1950-2019	Pan et al., 2012
GRID-Sat		Remote sensing	15-minute, 4 km	8	1994-2016	Inamdar and Knapp, 2015
Multi-Source Weighted-Ensemble Precipitation dataset (MSWEP)		Reanalysis, remote sensing and in situ	3-hourly, 0.25° x 0.25°	8	1979-2015	Beck et al., 2017
E-OBS		In situ	Daily, 0.1° and 0.25°	8, 10	1950-2019	Cornes et al., 2018
STAMMEX		In situ	Daily, 0.1°, 0.25° and 0.5°	8	1931-2000	Zolina et al., 2014
CPC Merged Analysis of Precipitation (CMAP)		Reanalysis, remote sensing and in situ	Monthly and pentad, 2.5° x 2.5°	8	1979-2019	Xie and Arkin, 1997
CPC Unified Gauge-Based Analysis of Global Daily Precipitation		In situ and remote sensing	Daily, 0.5° x 0.5°	8	1979-2019	Xie et al., 2010
CloudSat Cloud Profiling Radar (CPR)		Remote sensing	1.5 km horizontal, 0.5 km vertical	8	2006-2019	Tanelli et al., 2008
Aqua's Advanced Microwave Scanning Radiometer for Earth Observing System (AMSR-E)		Remote sensing	5.4 to 56 km	8	2002-2011	Kawanishi et al., 2003
Soil Moisture Active Passive (SMAP)		Remote sensing	Daily, 3 km	8	2015-2019	Entekhabi et al., 2010
Advanced SCATtero-		Remote sensing	Daily, 25 km	8	2006-2016	Wagner et al., 1999

meter (ASCAT)						
Advanced Microwave Scanning Radiometer 2 (AMSR2)		Remote sensing	3-hourly	8	2012-2019	Kummerow, 2015 https://lance.nsstc.nasa.gov/amsr2-science/data/level2/rainocean/
Moderate resolution imaging spectro-radiometer (MODIS)	MCD12Q1	Remote sensing	Annual, 500 m	8	2001-2019	Loveland and Belward, 1997
Gravity Recovery and Climate Experiment (GRACE)		Remote sensing	3 days, 400 m	8	2002-2017	Tapley et al., 2004
International Soil Moisture Network		In situ	Point-based	8	1950-2019	Dorigo et al., 2011
ESA CCI Soil Moisture data set		Remote sensing	Daily, global images	8	1978-2016	Dorigo et al., 2017
Landsat Global Land Survey (GLS) database		Remote sensing	Daily, global images	8	1972-2019	Gutman et al., 2013
Integrated Global Radiosonde Archive (IGRA)		In situ	Point-based	8	1900-2019	Durre et al., 2006
OSISAF/ CCI sea-ice concent-ration	450	Remote sensing	Monthly, 25 km	9	1979-2015	Lavergne et al., 2019 http://osisaf.met.no/p/ice/
NOAA CDR of sea-ice concent-ration	3.0	Remote sensing	Monthly, 25 km	9	1979-2019	Peng et al., 2013 https://nsidc.org/data/g02202
Bootstrap Sea Ice Concent-rations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS	3	Remote sensing	Monthly, 25 km	9	1979-2019	Comiso, 2017 https://nsidc.org/data/nsidc-0079
NASA Team Sea Ice Concent-rations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS Passive Microwave Data	1	Remote sensing	Monthly, 25 km	9	1979-2019	Cavalieri et al., 1996 https://nsidc.org/data/nsidc-0051
GTN-P (Global Terrestrial Network for Permafrost)		In situ	Point-based	9	Varies	Biskaborn et al., 2015 gtnpdatabase.org/
World Glacier Monitoring Service (WGMS)		In situ and remote sensing	Seasonal to annual, point-based	9	1600s-2019	WGMS, 2017 https://wgms.ch/ggcb/

Randolph Glacier Inventory	6	Remote sensing	Decametric shape files of glacier outlines, global. 0.5° global grid of glacierized area	9	1955-2014	Scherler et al., 2018 http://www.glims.org/RGI/rgi60_dl.html
NCEP Ocean Heat Content		In situ	Annual, 1° x 1°	9	2006-2017	Levitus et al., 2012 http://www.nodc.noaa.gov/OC5/3M_HEAT_CONTENT/
Climate Prediction Centre (CPC) Precipitation		In situ	Hourly 2.0° x 2.5°, daily 0.25° x 0.25°	10	1948-2006	Higgins et al., 2000; Xie et al., 2007; Chen et al., 2008
Asian Precipitation - Highly-Resolved Observ-ational Data Integration Towards Evaluation (APHRO-DITE's) Precipitation		In situ	Daily, 0.05° x 0.05°	10	1900-2019	Kamiguchi et al., 2010; Yatagai et al., 2012
Norwegian seNorge2 precipitation	2.0	In situ	Daily 0.008°× 0.008°	10	1957-2019	Lussana et al., 2018
Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)	2.0	Remote sensing	Daily, Monthly 0.25°x 0.25°	10	1981-2018	Funk et al., 2015
High-Resolution Gridded Daily Meteorologi-cal Dataset over Sub-Saharan Africa		Reanalysis	Daily 0.1°×0.1°	10	1979-2005	Chaney et al., 2014
African Rainfall Climatology	2.0	Remote sensing	Daily 0.1°×0.1°	10	1983-2010	Novella and Thiaw, 2013
Alpine precipitation grid dataset (EURO4M-APGD)	1.0	In situ	Daily 0.04°× 0.04°	10	1971-2008	Isotta et al., 2014
European Climate Assessment & Dataset (ECA&D)		In situ	Daily, point-based	10	1775-2019	Klein Tank et al., 2002
MSG-based gridded datasets of clouds, precipitation and radiation		Remote sensing	Daily, 0.27° x 0.27°	10	2005-2019	Roebeling and Holleman, 2009
Combined satellite and station data		Remote sensing and in situ	10-day 0.0375°× 0.0375°	10	1983-2012	Maidment et al., 2014

3D-VAR regional reanalysis		Reanalysis	6-hourly, 0.2° x 0.2°	10	1989-2010	Dahlgren et al., 2016
Spain02	5.0	In situ	Daily 0.1°×0.1°	10	1948-2002	Herrera et al., 2016
Daily Dataset Romania ROCADA	1.0	In situ	Daily 0.1°×0.1°	10	1961-2013	Dumitrescu et al., 2016
Central European high-resolution gridded daily data sets (HYRAS)	1.0	In situ	Daily 0.5°×0.5° 0.25°×0.25	10	1951-2006	Frick et.al., 2014
Gridded dataset of hourly precipitation in Germany		In situ	Hourly 0.06°× 0.06°	10	2001-2004	Paulat et al., 2008
Australian Gridded Climate Data (AGCD)	1.0	In situ	Daily 0.05° × 0.05°	10	1900-2019	Jones et al., 2017
A gridded daily dataset over China CN05.1	5.1	In situ	Daily 0.25° × 0.25°	10	1961-2005	Wu and Gao, 2013
Cyprus precipitation		In situ	Daily 0.01° × 0.01°	10	1980-2010	Camera et al., 2014
Finland Climate		In situ	Daily 0.1° × 0.1°	10	1961-2010	Aalto et al., 2016 https://www.csc.fi/-/paituli
Chile precipitation		In situ	Daily 0.04° × 0.04°	10	2009-2014	Yang et al., 2017 http://www.climatedatalibrary.cl/SOURCES/
Mexican climate		In situ	Monthly 30 arc sec	10	1910-2009	Cuervo-Robayo et al., 2014
Ethiopian precipitation		In situ	Sub-monthly 0.1° × 0.1°	10	1983-2013	Dinku et al., 2014
Brazil		In situ	Daily 0.25° × 0.25°	10	1980-2013	Xavier et al., 2016 http://careyking.com/data-downloads/
Czech Republic precipitation		In situ	10 min 0.01° × 0.01°	10	2002-2011	Bližňák et al., 2018
SAFRAN temperature and precipitation for France		Reanalysis	Hourly 8km^2	10	1958-2008	Vidal et al., 2010
Belgium precipitation		In situ	Daily 4km^2	10	1981-2010	Journée et al., 2015
High Resolution Gridded Data for India	1.0	In situ	Daily 1° × 1°	10	1951-2003	Rajeevan et al., 2006
Indian Monsoon Data Assimilation and Analysis (IMDAA)		Reanalysis	Sub-daily 0.11°× 0.11°	10	1979-2016	Mahmood et al., 2018
HadUK-Grid	1.0	In situ	Daily 0.009° × 0.009°	10	1862-2019	https://www.metoffice.gov.uk/climate/uk/data/haduk-grid/haduk-grid
Israel precipitation		Reanalysis	Seasonal 0.02°× 0.02°	10	1991-2009	Rostkier-Edelstein et al., 2014

USA temperature		In situ	Daily 30-arcsec	10	1948-2012	Oyler et al., 2015
Ghana Meteorological Agency (GMet) precipitation	1.0	In situ	Monthly 0.5°×0.5°	10	1990-2012	Aryee et al., 2018
Swiss Alps		Remote sensing	Sub-daily 0.01° × 0.01°	10	2005-2017	Panziera et al., 2018
Merged precipitation in China		In situ	Hourly 0.01° × 0.01°	10	2015	Shen et al., 2018
UrBAN (Helsinki)		In situ	Sub-hourly	10	2004-2019	Wood et al., 2013 http://urban.fmi.fi
NYCMET-NET (New York)	2.0.0	In situ	15 minutes	10	On-going	http://nycmetnet.ccny.cuny.edu
Co-WIN (Hong Kong)		In situ	15 minutes	10	2007-2019	Hung and Wo, 2012
METROS (Tokyo)		In situ	15 minutes	10	2000-2005	Takahashi et al., 2011
MOCCA (Ghent)		In situ	15 minutes	10	2016-2019	Vandemeulebroucke et al., 2019
BUCL (Birmingham)		In situ	Hourly	10	2013-2019	Chapman et al., 2015
Berlin City Measurement Network		In situ	1-minute	10	On-going	www.geo.fu-berlin.de/en/met/service/stadtmessnetz/index.html
LAQN (London)		In situ	15 minutes	10	1993-2019	www.londonair.org.uk
TWIN (Taipei)		In situ	Hourly	10	2004-2019	Chang et al., 2010
DCNet (Washington)		In situ	Hourly	10	On-going	Hicks et al., 2012
Arctic System Reanalysis		Reanalysis	3-hourly, 10 and 30 km, 71 vertical levels	Atlas	2000-2011	Bromwich et al., 2010
COSMO reanalyses (COSMOS-REA)		Reanalysis	15-minute, 6 km and 2 km	Atlas	1995-2015	Wahl et al., 2017 http://reanalysis.meteo.uni-bonn.de/
NCEP North American Regional Reanalysis (NARR)		Reanalysis	3-hourly, 32 km	Atlas	1979-2019	Mesinger et al., 2006 https://www.esrl.noaa.gov/psd/data/gridded/data.narr.html
GIMMS NDVI vegetation greenness index		Remote sensing	Bi-weekly; 0.083 deg	5	1982-2018	Tucker et al., 2005 https://nex.nasa.gov/nex/projects/1349/
MODIS NDVI/EVI vegetation greenness index	6	Remote sensing	16-day; 1km	5	2000-2019	Myneni et al., 2015 doi:10.5067/MODIS/MCD15A2H.006
Jena-MLS air-sea CO2 fluxes	2018	In situ	Daily, 4° x 5°	5	1982-2017	Rödenbeck et al., 2013, 2014 http://www.bgc-jena.mpg.de/CarboScope/?ID=oc
MPI-SOMFFN air-sea CO2 fluxes	2016	In situ	Monthly, 1° x 1°	5	1982-2015	Landschützer et al., 2016 https://www.nodc.noaa.gov/ocads/oceans/SPCO2_1982_2015_ETH_SOM_FFN.html
JMA-MLR air-sea CO2 fluxes	2018	In situ	Monthly, 1° x 1°	5	1990-2017	Takatani et al., 2014; Iida et al., 2015 http://www.data.jma.go.jp/gmd/kaiyou/english/co2_flux/co2_flux_data_en.html

UEA-SI air-sea CO2 fluxes	2015	In situ	Monthly, 2.5° x 2.5°	5	1985-2011	Jones et al., 2015 https://doi.pangaea.de/10.1594/PANGAEA.849262
CSIR-ML6 air-sea CO2 fluxes	2019	In situ	Monthly, 1° x 1°	5	1982-2015	Gregor, 2019 https://doi.org/10.6084/m9.figshare.7894976
The Surface Ocean CO2 Atlas (SOCAT)	6	In situ	Point-based	5	1957-2017	Bakker et al., 2016 https://www.socat.info/
Global Ocean Data Analysis Project (GLODAP)	2	In situ	Point-based	5	1972-2013	Olsen et al., 2016 https://www.glodap.info/
Hawaii Ocean Time-series Data		In situ	Point-based	5	1988-2018	Dore et al., 2009 http://hahana.soest.hawaii.edu/hot/hot-dogs/interface.html
Bermuda Atlantic Time-series Study Data		In situ	Point-based	5	1988-2016	Bates et al., 2014 http://bats.bios.edu/bats-data/
JMA Oceano-graphic and Marine Meteorologi-cal Observations by Research Vessels		In situ	Point-based	5	1997-2018	Ishii et al., 2011; Midorikawa et al., 2012; Sasano et al., 2018 https://www.data.jma.go.jp/gmd/kaiyou/db/vessel_obs/data-report/html/ship/ship_e.php
JAMSTEC Database for time-series stations K2 and S1		In situ	Point-based	5	1997-2018	Wakita et al., 2017 http://www.godac.jamstec.go.jp/catalog/data_catalog/metadataDisp/JAMSTEC_K2_S1?lang=en
Munida time series data in the western South Pacific		In situ	Point-based	5	1998-2017	Currie et al., 2011 https://www.st.nmfs.noaa.gov/copepod/time-series/nz-10101/
European Station for Time series in the Ocean Canary Islands (ESTOC)		In situ	Point-based	5	1995-2018	González-Dávila et al., 2010 http://data.plocan.eu/thredds/catalog/aggregate/public/ESTOCInSitu/EMSOservices/Biogeochemistry/catalog.html
Data of DYFAMED station in the Ligurian Sea		In situ	Point-based	5	1991-2016	Merlivat et al., 2018 http://dyfbase.obs-vlfr.fr/
Data of CARIACO ocean time-series program in the Cariaco Basin		In situ	Point-based	5	1996-2017	Bates et al., 2014 http://imars.marine.usf.edu/cariaco
LDEO Global Ocean Surface Water Partial Pressure of CO2 Database		In situ	Point-based	5	1957-2018	Takahashi et al., 2014 https://www.nodc.noaa.gov/ocads/oceans/ LDEO_Underway_Database/NDP-088_V2018.pdf

References

Aalto, J., Pirinen, P., and Jylhä, K. (2016). New gridded daily climatology of Finland: Permutation-based uncertainty estimates and temporal trends in climate. *J. Geophys. Res. Atmos.* 121, 3807–3823. doi:10.1002/2015JD024651.

Adler, R. F., Huffman, G. J., Chang, A., Ferraro, R., Xie, P.-P., Janowiak, J., et al. (2003). The Version-2 Global Precipitation Climatology Project (GPCP) Monthly Precipitation Analysis (1979–Present). *J. Hydrometeorol.* 4, 1147–1167. doi:10.1175/1525-7541(2003)004<1147:TVGPCP>2.0.CO;2.

Adler, R. F., Sapiano, M. R. P., Huffman, G. J., Wang, J. J., Gu, G., Bolvin, D., et al. (2018). The Global Precipitation Climatology Project (GPCP) monthly analysis (New Version 2.3) and a review of 2017 global precipitation. *Atmosphere (Basel).* 9. doi:10.3390/atmos9040138.

Allan, R., and Ansell, T. (2006). A new globally complete monthly historical gridded mean sea level pressure dataset (HadSLP2): 1850-2004. *J. Clim.* 19, 5816–5842. doi:10.1175/JCLI3937.1.

Andersson, A., Fennig, K., Klepp, C., Bakan, S., Graßl, H., and Schulz, J. (2010). The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data – HOAPS-3. *Earth Syst. Sci. Data* 2, 215–234. doi:10.5194/essd-2-215-2010.

Angerer, B., Ladstädter, F., Scherllin-Pirscher, B., Schwärz, M., Steiner, A. K., Foelsche, U., et al. (2017). Quality aspects of the Wegener Center multi-satellite GPS radio occultation record OPSv5.6. *Atmos. Meas. Tech.* 10, 4845–4863. doi:10.5194/amt-10-4845-2017.

Aryee, J. N. A., Amekudzi, L. K., Quansah, E., Klutse, N. A. B., Atiah, W. A., and Yorke, C. (2018). Development of high spatial resolution rainfall data for Ghana. *Int. J. Climatol.* 38, 1201–1215. doi:10.1002/joc.5238.

Ashouri, H., Hsu, K. L., Sorooshian, S., Braithwaite, D., Knapp, K. R., Cecil, L. C., et al. (2015). PERSIANN-CDR: Daily Precipitation Climate Data Record from Multisatellite Observations for Hydrological and Climate Studies. *Bull. Amer. Meteor. Soc*, 69–84. doi:10.1175/BAMS-D-13-00068.1.

Atlas, R., Hoffman, R., Ardizzone, J., Leidner, S., Jusem, J., Smith, D., et al. (2011). A cross-calibrated mutiplatform ocean wind velocity product for meteorlogical and oceanographic applications. *Bull. Am. Meteorol. Soc.* 92, 157–174.

Bakker, D. C. E., Pfeil, B., Landa, C. S., Metzl, N., O'Brien, K. M., Olsen, A., et al. (2016). A multi-decade record of high-quality fCO$_{2}$ data in version 3 of the Surface Ocean CO$_{2}$ Atlas (SOCAT). *Earth Syst. Sci. Data* 8, 383–413. doi:10.5194/essd-8-383-2016.

Balsamo, G., Albergel, C., Beljaars, A., Boussetta, S., Brun, E., Cloke, H., et al. (2015). ERA-Interim/Land: A global land surface reanalysis data set. *Hydrol. Earth Syst. Sci.* 19, 389–407. doi:10.5194/hess-19-389-2015.

Banzon, V., Smith, T. M., Chin, T. M., Liu, C., and Hankins, W. (2016). A long-term record of blended satellite and in situ sea-surface temperature for climate monitoring, modeling and environmental studies. *Earth Syst. Sci. Data* 8, 165–176. doi:10.5194/essd-8-165-2016.

Barbarossa, V., Huijbregts, M. A. J., Beusen, A. H. W., Beck, H. E., King, H., and Schipper, A. M. (2018). Data Descriptor: FLO1K, global maps of mean, maximum and minimum annual streamflow at 1 km resolution from 1960 through 2015. *Sci. Data* 5, 1–11. doi:10.1038/sdata.2018.52.

Bates, N. R., Astor, Y., Church, M., Currie, K., Dore, J., Gonzalez-Davila, M., et al. (2014). A Time-Series View of Changing Ocean Chemistry Due to Ocean Uptake of Anthropogenic CO2 and Ocean Acidification. *Oceanography* 27, 126–141. Available at: https://doi.org/10.5670/oceanog.2014.16.

Beck, H. E., van Dijk, A. I. J. M., Levizzani, V., Schellekens, J., Miralles, D. G., Martens, B., et al. (2017). MSWEP: 3-hourly 0.25{\degree} global gridded precipitation (1979--2015) by merging gauge, satellite, and reanalysis data. *Hydrol. Earth Syst. Sci.* 21, 589–615. doi:10.5194/hess-21-589-2017.

Bentamy, A., Piollé, J. F., Grouazel, A., Danielson, R., Gulev, S., Paul, F., et al. (2017). Review and assessment of latent and sensible heat flux accuracy over the global oceans. *Remote Sens. Environ.* 201, 196–218. doi:https://doi.org/10.1016/j.rse.2017.08.016.

Biskaborn, B. K., Lanckman, J.-P., Lantuit, H., Elger, K., Streletskiy, D. A., Cable, W. L., et al. (2015). The new database of the Global Terrestrial Network for Permafrost (GTN-P). *Earth Syst. Sci. Data* 7, 245–259. doi:10.5194/essd-7-245-2015.

Bližňák, V., Kašpar, M., and Müller, M. (2018). Radar-based summer precipitation climatology of the Czech Republic. *Int. J. Climatol.* 38, 677–691. doi:10.1002/joc.5202.

Bodeker, G. E., Shiona, H., and Eskes, H. (2005). Indicators of Antarctic ozone depletion. *Atmos. Chem. Phys.* 5, 2603–2615. doi:10.5194/acp-5-2603-2005.

Brohan, P., Kennedy, J. J., Harris, I., Tett, S. F. B., and Jones, P. D. (2006). Uncertainty estimates in regional and global observed temperature changes: A new data set from 1850. *J. Geophys. Res. Atmos.* 111.

Bromwich, D., Kuo, Y.-H., Serreze, M., Walsh, J., Bai, L.-S., Barlage, M., et al. (2010). Arctic System Reanalysis: Call for Community Involvement. *Eos, Trans. Am. Geophys. Union* 91, 13–14. doi:10.1029/2010EO020001.

Brown, R. D. (2002). Reconstructed North American, Eurasian, and Northern Hemisphere Snow Cover Extent, 1915-1997, Version 1. National Snow and Ice Center, Boulder, Colorado, USA. doi:10.7265/N5V985Z6.

Brown, R. D., and Robinson, D. A. (2011). Northern Hemisphere spring snow cover variability and change over 1922–

2010 including an assessment of uncertainty. *Cryosph.* 5, 219–229. doi:10.5194/tc-5-219-2011.

Camera, C., Bruggeman, A., Hadjinicolaou, P., Pashiardis, S., and Lange, M. A. (2014). Evaluation of interpolation techniques for the creation of gridded daily precipitation (1 × 1 km2); Cyprus, 1980–2010. *J. Geophys. Res. Atmos.* 119, 693–712. doi:10.1002/2013JD020611.

Cavalieri, D. J., Parkinson, C. L., Gloersen, P., and Zwally, H. J. (1996). Sea ice concentrations form Nimbus-7 SMMR and DMSP SSM/I passive microwave data, Version 1. *Boulder, Color. USA. NASA Natl. Snow Ice Data Cent. Distrib. Act. Arch. Center.* doi:10.5067/8GQ8LZQVL0VL.

Caylor, I. J., Heymsfield, G. M., Meneghini, R., and Miller, L. S. (1997). Correction of Sampling Errors in Ocean Surface Cross-Sectional Estimates from Nadir-Looking Weather Radar. *J. Atmos. Ocean. Technol.* 14, 203–210. doi:10.1175/1520-0426(1997)014<0203:COSEIO>2.0.CO;2.

Chaney, N. W., Sheffield, J., Villarini, G., and Wood, E. F. (2014). Development of a High-Resolution Gridded Daily Meteorological Dataset over Sub-Saharan Africa: Spatial Analysis of Trends in Climate Extremes. *J. Clim.* 27, 5815–5835. doi:10.1175/JCLI-D-13-00423.1.

Chang, B., Wang, H. Y., Peng, T. Y., and Hsu, Y. S. (2010). Development and evaluation of a city-wide wireless weather sensor network. *Educ. Technol. Soc.* doi:10.1172/JCI37539.as.

Chapman, L., Muller, C. L., Young, D. T., Warren, E. L., Grimmond, C. S. B., Cai, X.-M., et al. (2015). The Birmingham Urban Climate Laboratory: An Open Meteorological Test Bed and Challenges of the Smart City. *Bull. Am. Meteorol. Soc.* 96, 1545–1560. doi:10.1175/BAMS-D-13-00193.1.

Chen, M., Shi, W., Xie, P., Silva, V. B. S., Kousky, V. E., Wayne Higgins, R., et al. (2008). Assessing objective techniques for gauge-based analyses of global daily precipitation. *J. Geophys. Res.* 113, D04110. doi:10.1029/2007JD009132.

Coldewey-Egbers, M., Loyola, D. G., Koukouli, M., Balis, D., Lambert, J.-C., Verhoelst, T., et al. (2015). The GOME-type Total Ozone Essential Climate Variable (GTO-ECV) data record from the ESA Climate Change Initiative. *Atmos. Meas. Tech.* 8, 3923–3940. doi:10.5194/amt-8-3923-2015.

Comiso, J. C. (2017). Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I-SSMIS, Version 3. *Boulder, Color. USA. NASA Natl. Snow Ice Data Cent. Distrib. Act. Arch. Cent.* doi:10.5067/7Q8HCCWS4I0R.

Compo, G. P., Whitaker, J. S., Sardeshmukh, P. D., Matsui, N., Allan, R. J., Yin, X., et al. (2011). The twentieth century reanalysis project. *Q. J. R. Meteorol. Soc.* 137, 1–28.

Copernicus Climate Change Service (2017). ERA5: Fifth generation of ECMWF atmospheric reanalyses of the global climate.

Cornes, R. C., van der Schrier, G., van den Besselaar, E. J. M., and Jones, P. D. (2018). An Ensemble Version of the E-OBS Temperature and Precipitation Data Sets. *J. Geophys. Res. Atmos.* 123, 9391–9409. doi:10.1029/2017JD028200.

Cowtan, K., and Way, R. G. (2014). Coverage bias in the HadCRUT4 temperature series and its impact on recent temperature trends. *Q. J. R. Meteorol. Soc.* 140, 1935–1944. doi:10.1002/qj.2297.

Cuervo-Robayo, A. P., Téllez-Valdés, O., Gómez-Albores, M. A., Venegas-Barrera, C. S., Manjarrez, J., and Martínez-Meyer, E. (2014). An update of high-resolution monthly climate surfaces for Mexico. *Int. J. Climatol.* 34, 2427–2437. doi:10.1002/joc.3848.

Currie, K., Reid, M., and Hunter, K. (2011). Interannual variability of carbon dioxide drawdown by subantarctic surface water near New Zealand. *Biogeochemistry* 104, 23–34. doi:10.1007/s10533-009-9355-3.

Dahlgren, P., Landelius, T., Kållberg, P., and Gollvik, S. (2016). A high-resolution regional reanalysis for Europe. Part 1: Three-dimensional reanalysis with the regional HIgh-Resolution Limited-Area Model (HIRLAM). *Q. J. R. Meteorol. Soc.* 142, 2119–2131. doi:10.1002/qj.2807.

Davis, S. M., Rosenlof, K. H., Hassler, B., Hurst, D. F., Read, W. G., Vömel, H., et al. (2016). The Stratospheric Water and Ozone Satellite Homogenized (SWOOSH) database: a long-term database for climate studies. *Earth Syst. Sci. Data* 8, 461–490. doi:10.5194/essd-8-461-2016.

Dee, D. P., Uppala, S. M., Simmons, A. J., Berrisford, P., Poli, P., Kobayashi, S., et al. (2011). The ERA-Interim reanalysis: configuration and performance of the data assimilation system. *Q. J. R. Meteorol. Soc.* 137, 553–597. doi:10.1002/qj.828.

Diner, D. (2009). MISR Level 3 component global aerosol product in netCDF format covering a year - Version 4. NASA Langley Atmospheric Science Data Center DAAC. doi:10.5067/terra/misr/mil3yaen_l3.004.

Dinku, T., Hailemariam, K., Maidment, R., Tarnavsky, E., and Connor, S. (2014). Combined use of satellite estimates and rain gauge observations to generate high-quality historical rainfall time series over Ethiopia. *Int. J. Climatol.* 34, 2489–2504. doi:10.1002/joc.3855.

Do, H. X., Gudmundsson, L., Leonard, M., and Westra, S. (2018). The Global Streamflow Indices and Metadata Archive (GSIM)-Part 1: The production of a daily streamflow archive and metadata. *Earth Syst. Sci. Data* 10, 765–785. doi:10.5194/essd-10-765-2018.

Donat, M. G., Alexander, L. V., Yang, H., Durre, I., Vose, R., and Caesar, J. (2013a). Global Land-Based Datasets for Monitoring Climatic Extremes. *Bull. Am. Meteorol. Soc.* 94, 997–1006. doi:10.1175/bams-d-12-00109.1.

Donat, M. G., Alexander, L. V., Yang, H., Durre, I., Vose, R., Dunn, R. J. H., et al. (2013b). Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset.

J. Geophys. Res. Atmos. doi:10.1002/jgrd.50150.
Dore, J. E., Lukas, R., Sadler, D. W., Church, M. J., and Karl, D. M. (2009). Physical and biogeochemical modulation of ocean acidification in the central North Pacific. *Proc. Natl. Acad. Sci.* 106, 12235–12240. doi:10.1073/pnas.0906044106.
Dorigo, W. A., Wagner, W., Hohensinn, R., Hahn, S., Paulik, C., Xaver, A., et al. (2011). The International Soil Moisture Network: a data hosting facility for global in situ soil moisture measurements. *Hydrol. Earth Syst. Sci.* 15, 1675–1698. doi:10.5194/hess-15-1675-2011.
Dorigo, W., Wagner, W., Albergel, C., Albrecht, F., Balsamo, G., Brocca, L., et al. (2017). ESA CCI Soil Moisture for improved Earth system understanding: State-of-the art and future directions. *Remote Sens. Environ.* 203, 185–215. doi:10.1016/j.rse.2017.07.001.
Dumitrescu, A., Birsan, M.-V., and Manea, A. (2016). Spatio-temporal interpolation of sub-daily (6 h) precipitation over Romania for the period 1975–2010. *Int. J. Climatol.* 36, 1331–1343. doi:10.1002/joc.4427.
Dunn, R. J. H., Willett, K. M., Thorne, P. W., Woolley, E. V, Durre, I., Dai, A., et al. (2012). HadISD: A Quality Controlled global synoptic report database for selected variables at long-term stations from 1973-2011. *Clim. Past* 8, 1649–1679.
Durre, I., Vose, R. S., and Wuertz, D. B. (2006). Overview of the Integrated Global Radiosonde Archive. *J. Clim.* 19, 53–68. doi:10.1175/JCLI3594.1.
Entekhabi, D., Njoku, E. G., O'Neill, P. E., Kellogg, K. H., Crow, W. T., Edelstein, W. N., et al. (2010). The Soil Moisture Active Passive (SMAP) Mission. *Proc. IEEE* 98, 704–716. doi:10.1109/JPROC.2010.2043918.
ESA Ozone CCI project team (2016). ESA Ozone Climate Change Initiative (ESA Ozone_cci) data: L3S-TC-MERGED-DLR v1.0 via Centre for Environmental Data Analysis, 2 August 2013.
Estilow, T. W., Young, A. H., and Robinson, D. A. (2015). A long-term Northern Hemisphere snow cover extent data record for climate studies and monitoring. *Earth Syst. Sci. Data*. doi:10.5194/essd-7-137-2015.
Fetterer, F., Knowles, K., Meier, W. N., Savoie, M. H., and Windnagel, A. K. (2017). Sea ice index: version 3. National Snow and Ice Data Center, Boulder, Colorado, USA. doi:10.7265/N5K072F8.
Fioletov, V. E., Bodeker, G. E., Miller, A. J., McPeters, R. D., and Stolarski, R. (2002). Global and zonal total ozone variations estimated from ground-based and satellite measurements: 1964–2000. *J. Geophys. Res. Atmos.* 107, ACH 21-1-ACH 21-14. doi:10.1029/2001JD001350.
Freeman, E., Woodruff, S. D., Worley, S. J., Lubker, S. J., Kent, E. C., Angel, W. E., et al. (2017). ICOADS Release 3.0: a major update to the historical marine climate record. *Int. J. Climatol.* 37, 2211–2232. doi:10.1002/joc.4775.
Frith, S. M., Stolarski, R. S., Kramarova, N. A., and McPeters, R. D. (2017). Estimating uncertainties in the SBUV Version 8.6 merged profile ozone data set. *Atmos. Chem. Phys.* 17, 14695–14707. doi:10.5194/acp-17-14695-2017.
Funk, C., Peterson, P., Landsfeld, M., Pedreros, D., Verdin, J., Shukla, S., et al. (2015). The climate hazards infrared precipitation with stations - A new environmental record for monitoring extremes. *Sci. Data*. doi:10.1038/sdata.2015.66.
Gelaro, R., McCarty, W., Suárez, M. J., Todling, R., Molod, A., Takacs, L., et al. (2017). The Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2). *J. Clim.* 30, 5419–5454. doi:10.1175/JCLI-D-16-0758.1.
GISTEMP Team (2019). GISS Surface Temperature Analysis (GISTEMP). NASA Goddard Institute for Space Studies. Dataset accessed 20YY-MM-DD at https://data.giss.nasa.gov/gistemp/.
González-Dávila, M., Santana-Casiano, J. M., Rueda, M. J., and Llinás, O. (2010). The water column distribution of carbonate system variables at the ESTOC site from 1995 to 2004. *Biogeosciences* 7, 3067–3081. doi:10.5194/bg-7-3067-2010.
Gregor, L. (2019). Global surface ocean pCO2 from CSIR-ML6 (version 2019a). doi:10.6084/m9.figshare.7894976.v1.
Gruber, A., Dorigo, W. A., Crow, W., and Wagner, W. (2017). Triple Collocation-Based Merging of Satellite Soil Moisture Retrievals. *IEEE Trans. Geosci. Remote Sens.* 55, 6780–6792. doi:10.1109/TGRS.2017.2734070.
Gurney, K. R., Law, R. M., Denning, A. S., Rayner, P. J., Baker, D., Bousquet, P., et al. (2003). TransCom 3 CO2inversion intercomparison: 1. Annual mean control results and sensitivity to transport and prior flux information. *Tellus, Ser. B Chem. Phys. Meteorol.* 55, 555–579. doi:10.1034/j.1600-0889.2003.00049.x.
Gutman, G., Huang, C., Chander, G., Noojipady, P., and Masek, J. G. (2013). Assessment of the NASA–USGS Global Land Survey (GLS) datasets. *Remote Sens. Environ.* 134, 249–265. doi:https://doi.org/10.1016/j.rse.2013.02.026.
Haddad, Z. S., Smith, E. A., Kummerow, C. D., Iguchi, T., Farrar, M. R., Durden, S. L., et al. (1997). The TRMM ‘Day-1’ Radar/Radiometer Combined Rain-Profiling Algorithm. *J. Meteorol. Soc. Japan. Ser. II* 75, 799–809. doi:10.2151/jmsj1965.75.4_799.
Haimberger, L., Tavolato, C., and Sperka, S. (2012). Homogenization of the Global Radiosonde Temperature Dataset through Combined Comparison with Reanalysis Background Series and Neighboring Stations. *J. Clim.* 25, 8108–8131. doi:10.1175/JCLI-D-11-00668.1.
Hall, B. D., Dutton, G. S., Mondeel, D. J., Nance, J. D., Rigby, M., Butler, J. H., et al. (2011). Improving measurements of SF6 for the study of atmospheric transport and emissions. *Atmos. Meas. Tech.* doi:10.5194/amt-4-2441-2011.
Hansen, J., Ruedy, R., Sato, M., and Lo, K. (2010). Global surface temperature change. *Rev. Geophys.* 48.

Harada, Y., Kamahori, H., Kobayashi, C., Endo, H., Kobayashi, S., Ota, Y., et al. (2016). The JRA-55 Reanalysis: Representation of atmospheric circulation and climate variability. *J. Meteorol. Soc. Japan* 94, 269–302. doi:10.2151/jmsj.2016-015.

Harris, I., Jones, P. D., Osborn, T. J., and Lister, D. H. (2014). Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset. *Int. J. Climatol.* 34, 623–642. doi:10.1002/joc.3711.

Haylock, M. R., Hofstra, N., Klein Tank, A. M. G., Klok, E. J., Jones, P. D., and New, M. (2008). A European daily high-resolution gridded data set of surface temperature and precipitation for 1950–2006. *J. Geophys. Res.* 113, D20119. doi:10.1029/2008JD010201.

Heidinger, A. K., Foster, M. J., Walther, A., and Zhao, X. (Tom) (2014). The Pathfinder Atmospheres–Extended AVHRR Climate Dataset. *Bull. Am. Meteorol. Soc.* 95, 909–922. doi:10.1175/BAMS-D-12-00246.1.

Herrera, S., Fernández, J., and Gutiérrez, J. M. (2016). Update of the Spain02 gridded observational dataset for EURO-CORDEX evaluation: Assessing the effect of the interpolation methodology. *Int. J. Climatol.* doi:10.1002/joc.4391.

Hersbach, H., Peubey, C., Simmons, A., Berrisford, P., Poli, P., and Dee, D. (2015). ERA-20CM: a twentieth-century atmospheric model ensemble. *Q. J. R. Meteorol. Soc.* 141, 2350–2375. doi:10.1002/qj.2528.

Hicks, B. B., Callahan, W. J., Pendergrass, W. R., Dobosy, R. J., and Novakovskaia, E. (2012). Urban turbulence in space and in time. *J. Appl. Meteorol. Climatol.* doi:10.1175/JAMC-D-11-015.1.

Higgins, R., Shi, W., Yarosh, E., and Joyce, R. (2000). Improved United States Precipitation Quality Control System and Analysis. *NOAA, Natl. Weather Serv. Natl. Centers Environ. Predict. Clim. Predict. Cent.*

Hirahara, S., Ishii, M., and Fukuda, Y. (2014). Centennial-Scale Sea Surface Temperature Analysis and Its Uncertainty. *J. Clim.* 27, 57–75. doi:10.1175/JCLI-D-12-00837.1.

Huang, B., Thorne, P. W., Banzon, V. F., Boyer, T., Chepurin, G., Lawrimore, J. H., et al. (2017). Extended Reconstructed Sea Surface Temperature, Version 5 (ERSSTv5): Upgrades, Validations, and Intercomparisons. *J. Clim.* 30, 8179–8205. doi:10.1175/JCLI-D-16-0836.1.

Huffman, G. J., and Bolvin, D. T. (2013). GPCP version 2.2 SG combined precipitation data set documentation. *NASA GSFC Doc*.

Huffman, G. J., Bolvin, D. T., Braithwaite, D., Hsu, K., Joyce, R., Xie, P., et al. (2014). Algorithm Theoretical Basis Document (ATBD) NASA Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrievals for GPM (I- MERG) Prepared by :

Hung, T. K., and Wo, O. C. (2012). Development of a Community Weather Information Network (Co-WIN) in Hong Kong. *Weather* 67, 48–50. doi:10.1002/wea.1883.

Hurst, D. F., Oltmans, S. J., Vömel, H., Rosenlof, K. H., Davis, S. M., Ray, E. A., et al. (2011). Stratospheric water vapor trends over Boulder, Colorado: Analysis of the 30 year Boulder record. *J. Geophys. Res. Atmos.* 116. doi:10.1029/2010JD015065.

Iida, Y., Kojima, A., Takatani, Y., Nakano, T., Sugimoto, H., Midorikawa, T., et al. (2015). Trends in pCO2 and sea--air CO2 flux over the global open oceans for the last two decades. *J. Oceanogr.* 71, 637–661. doi:10.1007/s10872-015-0306-4.

Inamdar, A. K., and Knapp, K. R. (2015). Intercomparison of Independent Calibration Techniques Applied to the Visible Channel of the ISCCP B1 Data. *J. Atmos. Ocean. Technol.* 32, 1225–1240. doi:10.1175/JTECH-D-14-00040.1.

Ishii, M., Kosugi, N., Sasano, D., Saito, S., Midorikawa, T., and Inoue, H. Y. (2011). Ocean acidification off the south coast of Japan: A result from time series observations of CO2 parameters from 1994 to 2008. *J. Geophys. Res. Ocean.* 116. doi:10.1029/2010JC006831.

Ishijima, K., Sugawara, S., Kawamura, K., Hashida, G., Morimoto, S., Murayama, S., et al. (2007). Temporal variations of the atmospheric nitrous oxide concentration and its δ15N and δ18O for the latter half of the 20th century reconstructed from firn air analyses. *J. Geophys. Res.* 112, D03305. doi:10.1029/2006JD007208.

Isotta, F. A., Frei, C., Weilguni, V., Perčec Tadić, M., Lassègues, P., Rudolf, B., et al. (2014). The climate of daily precipitation in the Alps: Development and analysis of a high-resolution grid dataset from pan-Alpine rain-gauge data. *Int. J. Climatol.* doi:10.1002/joc.3794.

Janssens-Maenhout, G., Crippa, M., Guizzardi, D., Muntean, M., Schaaf, E., Dentener, F., et al. (2019). EDGAR v4.3.2 Global Atlas of the three major Greenhouse Gas Emissions for the period 1970-2012. *Earth Syst. Sci. Data Discuss.* 2010, 1–52. doi:10.5194/essd-2018-164.

Jones, D., Wang, W., and Fawcett, R. (2017). High-quality spatial climate data-sets for Australia. *Aust. Meteorol. Oceanogr. J.* doi:10.22499/2.5804.003.

Jones, P. D., and Moberg, A. (2003). Hemispheric and large-scale surface air temperature variations: An extensive revision and an update to 2001. *J. Clim.* 16, 206–223.

Jones, S. D., Le Quéré, C., Rödenbeck, C., Manning, A. C., and Olsen, A. (2015). Data and Code archive for the interpolation of surface ocean carbon dioxide. doi:10.1594/PANGAEA.849262.

Journée, M., Delvaux, C., and Bertrand, C. (2015). Precipitation climate maps of Belgium. *Adv. Sci. Res.* 12, 73–78. doi:10.5194/asr-12-73-2015.

Jung, M., Reichstein, M., Margolis, H. A., Cescatti, A., Richardson, A. D., Arain, M. A., et al. (2011). Global patterns of land-atmosphere fluxes of carbon dioxide, latent heat, and sensible heat derived from eddy covariance, satellite, and meteorological observations. *J. Geophys. Res. Biogeosciences* 116, 1–16. doi:10.1029/2010JG001566.

Kalnay, E., Kanamitsu, M., Kistler, R., Collins, W., Deaven, D., Gandin, L., et al. (1996). The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Am. Meteorol. Soc.* 77, 437–472. doi:10.1175/1520-0477(1996)077<0437:TNYRP>2.0.CO;2.

Kamiguchi, K., Arakawa, O., Kitoh, A., Yatagai, A., Hamada, A., and Yasutomi, N. (2010). Development of APHRO_JP, the first Japanese high-resolution daily precipitation product for more than 100 years. *Hydrol. Res. Lett.* 4, 60–64. doi:10.3178/hrl.4.60.

Kaplan, A., Cane, M. A., Kushnir, Y., Clement, A. C., Blumenthal, M. B., and Rajagopalan, B. (1998). Analyses of global sea surface temperature 1856–1991. *J. Geophys. Res. Ocean.* 103, 18567–18589. doi:10.1029/97JC01736.

Kawanishi, T., Sezai, T., Ito, Y., Imaoka, K., Takeshima, T., Ishido, Y., et al. (2003). The Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E), NASDA's contribution to the EOS for global energy and water cycle studies. *IEEE Trans. Geosci. Remote Sens.* 41, 184–194. doi:10.1109/TGRS.2002.808331.

Keeling, C. D., Piper, S. C., Bacastow, R. B., Wahlen, M., Whorf, T. P., Heimann, M., et al. (2001a). Exchanges of atmospheric CO2 and 13CO2 with the terrestrial biosphere and oceans from 1978 to 2000. I. Global Aspects, SIO Reference Series, No.01-06, Scripps Institution of Oceanography. San Diego.

Keeling, C. D., Whorf, T. P., Wahlen, M., and van der Plicht, J. (2001b). Exchanges of atmospheric CO2, and 13CO2, with the terrestrial biosphere and oceans from 1978 to 2000.

Keeling, R. F., and Garcia, H. E. (2002). The change in oceanic O2 inventory associated with recent global warming. *Proc. Natl. Acad. Sci.* 99, 7848–7853. doi:10.1073/pnas.122154899.

Kennedy, J. J., Rayner, N. A., Smith, R. O., Parker, D. E., and Saunby, M. (2011a). Reassessing biases and other uncertainties in sea surface temperature observations measured in situ since 1850: 1. Measurement and sampling uncertainties. *J. Geophys. Res. Atmos.* 116. doi:10.1029/2010JD015218.

Kennedy, J. J., Rayner, N. A., Smith, R. O., Parker, D. E., and Saunby, M. (2011b). Reassessing biases and other uncertainties in sea surface temperature observations measured in situ since 1850: 2. Biases and homogenization. *J. Geophys. Res. Atmos.* 116. doi:10.1029/2010JD015220.

Kent, E. C., Rayner, N. A., Berry, D. I., Saunby, M., Moat, B. I., Kennedy, J. J., et al. (2013). Global analysis of night marine air temperature and its uncertainty since 1880: The HadNMAT2 data set. *J. Geophys. Res. Atmos.* 118, 1281–1298. doi:10.1002/jgrd.50152.

Kirschke, S., Bousquet, P., Ciais, P., Saunois, M., Canadell, J. G., Dlugokencky, E. J., et al. (2013). Three decades of global methane sources and sinks. *Nat. Geosci.* doi:10.1038/ngeo1955.

Klein Tank, A. M. G., Wijngaard, J. B., Können, G. P., Böhm, R., Demarée, G., Gocheva, A., et al. (2002). Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. *Int. J. Climatol.* doi:10.1002/joc.773.

Kobayashi, S., Ota, Y., Harada, Y., Ebita, A., Moriya, M., Onoda, H., et al. (2015). The JRA-55 reanalysis: General specifications and basic characteristics. *J. Meteorol. Soc. Japan. Ser. II* 93, 5–48.

Kummerow, C. (2015). NRT AMSR2 L2B Global Swath Goddard Profiling Algorithm 2010: Surface Precipitation, Wind Speed Over Ocean, Water Vapor over Ocean and Cloud Liquid Water over Ocean. doi:10.5067/AMSR2/A2_RainOcn_NRT.

Landschützer, P., Gruber, N., and Bakker, D. C. E. (2016). Decadal variations and trends of the global ocean carbon sink. *Global Biogeochem. Cycles* 30, 1396–1417. doi:10.1002/2015GB005359.

Langenfelds, R. L., Francey, R. J., Pak, B. C., Steele, L. P., Lloyd, J., Trudinger, C. M., et al. (2002). Interannual growth rate variations of atmospheric CO2 and its δ13C, H2, CH4, and CO between 1992 and 1999 linked to biomass burning. *Global Biogeochem. Cycles*. doi:10.1029/2001GB001466.

Lavergne, T., Sørensen, A. M., Kern, S., Tonboe, R., Notz, D., Aaboe, S., et al. (2019). Version 2 of the EUMETSAT OSI SAF and ESA CCI sea-ice concentration climate data records. *Cryosph.* 13, 49–78. doi:10.5194/tc-13-49-2019.

Le Quéré, C., Andrew, R. M., Friedlingstein, P., Sitch, S., Pongratz, J., Manning, A. C., et al. (2018). Global Carbon Budget 2017. *Earth Syst. Sci. Data* 10, 405–448. doi:10.5194/essd-10-405-2018.

Levitus, S., Antonov, J. I., Boyer, T. P., Baranova, O. K., Garcia, H. E., Locarnini, R. A., et al. (2012). World ocean heat content and thermosteric sea level change (0-2000m), 1955-2010. *Geophys. Res. Lett.* 39. doi:10.1029/2012GL051106.

Levy, R., and Hsu, C. (2015). MODIS Atmosphere L2 Aerosol Product. NASA MODIS Adaptive Processing System, Goddard Space Flight Center, USA. doi:10.5067/MODIS/MOD04_L2.006.

Liu, Y. Y., Dorigo, W. A., Parinussa, R. M., De Jeu, R. A. M., Wagner, W., McCabe, M. F., et al. (2012). Trend-preserving blending of passive and active microwave soil moisture retrievals. *Remote Sens. Environ.* 123, 280–297. doi:10.1016/j.rse.2012.03.014.

Loeb, N. G., Lyman, J. M., Johnson, G. C., Allan, R. P., Doelling, D. R., Wong, T., et al. (2012). Observed changes in top-of-the-atmosphere radiation and upper-ocean heating consistent within uncertainty. *Nat. Geosci.* 5, 110–113.

doi:10.1038/ngeo1375.
Loeb, N. G., Wielicki, B. A., Doelling, D. R., Smith, G. L., Keyes, D. F., Kato, S., et al. (2009). Toward optimal closure of the Earth's top-of-atmosphere radiation budget. *J. Clim.* 22, 748–766. doi:10.1175/2008JCLI2637.1.
Loveland, T. R., and Belward, A. S. (1997). The IGBP-DIS global 1km land cover data set, DISCover: First results. *Int. J. Remote Sens.* 18, 3289–3295. doi:10.1080/014311697217099.
Lussana, C., Saloranta, T., Skaugen, T., Magnusson, J., Einar Tveito, O., and Andersen, J. (2018). SeNorge2 daily precipitation, an observational gridded dataset over Norway from 1957 to the present day. *Earth Syst. Sci. Data*. doi:10.5194/essd-10-235-2018.
Mahmood, S., Davie, J., Jermey, P., Renshaw, R., George, J. P., Rajagopal, E. N., et al. (2018). Indian monsoon data assimilation and analysis regional reanalysis: Configuration and performance. *Atmos. Sci. Lett.* 19, e808. doi:10.1002/asl.808.
Maidment, R. I., Grimes, D., Allan, R. P., Tarnavsky, E., Stringer, M., Hewison, T., et al. (2014). The 30 year TAMSAT African Rainfall Climatology And Time series (TARCAT) data set. *J. Geophys. Res. Atmos.* 119, 10, 610–619, 644. doi:10.1002/2014JD021927.
Marshall, G. J. (2003). Trends in the Southern Annular Mode from observations and reanalyses. *J. Clim.* 16, 4134–4143.
Masarie, K. A., and Tans, P. P. (2004). Extension and integration of atmospheric carbon dioxide data into a globally consistent measurement record. *J. Geophys. Res. Atmos.* 100, 11593–11610. doi:10.1029/95JD00859.
Mears, C. A., and Wentz, F. J. (2017). A Satellite-Derived Lower-Tropospheric Atmospheric Temperature Dataset Using an Optimized Adjustment for Diurnal Effects. *J. Clim.* 30, 7695–7718. doi:10.1175/JCLI-D-16-0768.1.
Meinshausen, M., Vogel, E., Nauels, A., Lorbacher, K., Meinshausen, N., Etheridge, D. M., et al. (2017). Historical greenhouse gas concentrations for climate modelling (CMIP6). *Geosci. Model Dev.* 10, 2057–2116. doi:10.5194/gmd-10-2057-2017.
Menne, M. J., Williams, C. N., Gleason, B. E., Rennie, J. J., and Lawrimore, J. H. (2018). The Global Historical Climatology Network Monthly Temperature Dataset, Version 4. *J. Clim.* 0, null. doi:10.1175/JCLI-D-18-0094.1.
Merchant, C. J., Embury, O., Roberts-Jones, J., Fiedler, E., Bulgin, C. E., Corlett, G. K., et al. (2014a). Sea surface temperature datasets for climate applications from Phase 1 of the European Space Agency Climate Change Initiative (SST CCI). *Geosci. Data J.* 1, 179–191. doi:10.1002/gdj3.20.
Merchant, C. J., Embury, O., Roberts-Jones, J., Fiedler, E. K., Bulgin, C. E., Corlett, G. K., et al. (2014b). "ESA Sea Surface Temperature Climate Change Initiative (ESA SST CCI): Analysis long term product version 1.0," in *NERC Earth Observation Data Centre, 24th February 2014* doi:10.5285/2262690A-B588-4704-B459-39E05527B59A.
Merlivat, L., Boutin, J., Antoine, D., Beaumont, L., Golbol, M., and Vellucci, V. (2018). Increase of dissolved inorganic carbon and decrease in pH in near-surface waters in the Mediterranean Sea during the past two decades. *Biogeosciences* 15, 5653–5662. doi:10.5194/bg-15-5653-2018.
Mesinger, F., DiMego, G., Kalnay, E., Mitchell, K., Shafran, P. C., Ebisuzaki, W., et al. (2006). North American Regional Reanalysis. *Bull. Am. Meteorol. Soc.* 87, 343–360. doi:10.1175/BAMS-87-3-343.
Midorikawa, T., Ishii, M., Kosugi, N., Sasano, D., Nakano, T., Saito, S., et al. (2012). Recent deceleration of oceanic pCO2 increase in the western North Pacific in winter. *Geophys. Res. Lett.* 39. doi:10.1029/2012GL051665.
Montzka, S. A., Hall, B. D., and Elkins, J. W. (2009). Accelerated increases observed for hydrochlorofluorocarbons since 2004 in the global atmosphere. *Geophys. Res. Lett.* doi:10.1029/2008GL036475.
Morice, C. P., Kennedy, J. J., Rayner, N. A., and Jones, P. D. (2012). Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 data set. *J. Geophys. Res. Atmos.* 117. doi:10.1029/2011JD017187.
Mueller, B., Hirschi, M., Jimenez, C., Ciais, P., Dirmeyer, P. A., Dolman, A. J., et al. (2013). Benchmark products for land evapotranspiration: LandFlux-EVAL multi-data set synthesis. *Hydrol. Earth Syst. Sci.*
Myneni, R., Kynazikhin, Y., and Park, T. (2015). MCD15A2H MODIS/Terra+Aqua Leaf Area Index/FPAR 8-day L4 Global 500m SIN Grid V006 [Data set]. NASA EOSDIS Land Processes DAAC. doi:10.5067/MODIS/MCD15A2H.006.
Novella, N. S., and Thiaw, W. M. (2013). African rainfall climatology version 2 for famine early warning systems. *J. Appl. Meteorol. Climatol.* doi:10.1175/JAMC-D-11-0238.1.
Olsen, A., Key, R. M., van Heuven, S., Lauvset, S. K., Velo, A., Lin, X., et al. (2016). The Global Ocean Data Analysis Project version 2 (GLODAPv2) -- an internally consistent data product for the world ocean. *Earth Syst. Sci. Data* 8, 297–323. doi:10.5194/essd-8-297-2016.
Oyler, J. W., Ballantyne, A., Jencso, K., Sweet, M., and Running, S. W. (2015). Creating a topoclimatic daily air temperature dataset for the conterminous United States using homogenized station data and remotely sensed land skin temperature. *Int. J. Climatol.* 35, 2258–2279. doi:10.1002/joc.4127.
Pan, M., Sahoo, A. K., Troy, T. J., Vinukollu, R. K., Sheffield, J., and Wood, E. F. (2012). Multisource Estimation of Long-Term Terrestrial Water Budget for Major Global River Basins. *J. Clim.* 25, 3191–3206. doi:10.1175/JCLI-D-11-00300.1.
Panziera, L., Gabella, M., Germann, U., and Martius, O. (2018). A 12-year radar-based climatology of daily and sub-

daily extreme precipitation over the Swiss Alps. *Int. J. Climatol.* 38, 3749–3769. doi:10.1002/joc.5528.

Park, S., Croteau, P., Boering, K. A., Etheridge, D. M., Ferretti, D., Fraser, P. J., et al. (2012). Trends and seasonal cycles in the isotopic composition of nitrous oxide since 1940. *Nat. Geosci.* 5, 261–265. doi:10.1038/ngeo1421.

Patra, P. K., Saeki, T., Dlugokencky, E. J., Ishijima, K., Umezawa, T., Ito, A., et al. (2016). Regional methane emission estimation based on observed atmospheric concentrations (2002-2012). *J. Meteorol. Soc. Japan* 94. doi:10.2151/jmsj.2016-006.

Patra, P. K., Takigawa, M., Watanabe, S., Chandra, N., Ishijima, K., and Yamashita, Y. (2018). Improved Chemical Tracer Simulation by MIROC4.0-based Atmospheric Chemistry-Transport Model (MIROC4-ACTM). *SOLA* 14, 91–96. doi:10.2151/sola.2018-016.

Paulat, M., Frei, C., Hagen, M. ., and Wernli, H. (2008). A gridded dataset of hourly precipitation in Germany: Its construction, climatology and application. *Meteorol. Zeitschrift* 17, 719–732. doi:10.1127/0941-2948/2008/0332.

Peng, G., Meier, W. N., Scott, D. J., and Savoie, M. H. (2013). A long-term and reproducible passive microwave sea ice concentration data record for climate studies and monitoring. *Earth Syst. Sci. Data* 5, 311–318. doi:10.5194/essd-5-311-2013.

Peterson, T. C., and Vose, R. S. (1997). An Overview of the Global Historical Climatology Network Temperature Database. *Bull. Am. Meteorol. Soc.* 78, 2837–2850. doi:10.1175/1520-0477(1997)078<2837:AOOTGH>2.0.CO;2.

Platnick, S., King, M. D., Ackerman, S. A., Menzel, W. P., Baum, B. A., Riédi, J. C., et al. (2003). The MODIS cloud products: Algorithms and examples from terra. *IEEE Trans. Geosci. Remote Sens.* 41, 459–472. doi:10.1109/TGRS.2002.808301.

Poli, P., Hersbach, H., Dee, D. P., Berrisford, P., Simmons, A. J., Vitart, F., et al. (2016). ERA-20C: An Atmospheric Reanalysis of the Twentieth Century. *J. Clim.* 29, 4083–4097. doi:10.1175/JCLI-D-15-0556.1.

Popp, T., Leeuw, G. De, Bingen, C., Brühl, C., Capelle, V., Chedin, A., et al. (2016). Development, Production and Evaluation of Aerosol Climate Data Records from European Satellite Observations. *Remote Sens. Environ. Elsevier.* 8, 1–34. doi:10.3390/rs8050421.

Prinn, R. G., Weiss, R. F., Arduini, J., Arnold, T., Langley Dewitt, H., Fraser, P. J., et al. (2018). History of chemically and radiatively important atmospheric gases from the Advanced Global Atmospheric Gases Experiment (AGAGE). *Earth Syst. Sci. Data*. doi:10.5194/essd-10-985-2018.

Rajeevan, M., Bhate, J., Kale, J. D., and Lal, B. (2006). High resolution daily gridded rainfall data for the Indian region: Analysis of break and active monsoon spells. *Curr. Sci.* doi:10.1007/s12040-007-0019-1.

Rayner, N. A., Parker, D. E., Horton, E. B., Folland, C. K., Alexander, L. V, Rowell, D. P., et al. (2003). Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J. Geophys. Res. Atmos.* 108. doi:10.1029/2002JD002670.

Reichle, R. H. (2012). The MERRA-Land Data Product. GMAO Office Note No. 3 (Version 1.2).

Rice, A. L., Butenhoff, C. L., Teama, D. G., Röger, F. H., Khalil, M. A. K., and Rasmussen, R. A. (2016). Atmospheric methane isotopic record favors fossil sources flat in 1980s and 1990s with recent increase. *Proc. Natl. Acad. Sci.* 113, 10791–10796. doi:10.1073/pnas.1522923113.

Rienecker, M. M., Suarez, M. J., Gelaro, R., Todling, R., Bacmeister, J., Liu, E., et al. (2011). MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications. *J. Clim.* 24, 3624–3648. doi:10.1175/JCLI-D-11-00015.1.

Rodell, M., Houser, P. R., Jambor, U. E. A., Gottschalck, J., Mitchell, K., Meng, C.-J., et al. (2004). The global land data assimilation system. *Bull. Am. Meteorol. Soc.* 85, 381–394.

Rödenbeck, C., Bakker, D. C. E., Metzl, N., Olsen, A., Sabine, C., Cassar, N., et al. (2014). Interannual sea–air CO$_{2}$ flux variability from an observation-driven ocean mixed-layer scheme. *Biogeosciences* 11, 4599–4613. doi:10.5194/bg-11-4599-2014.

Rödenbeck, C., Keeling, R. F., Bakker, D. C. E., Metzl, N., Olsen, A., Sabine, C., et al. (2013). Global surface-ocean p^{CO}_{2}$}$ and sea–air CO$_{2}$ flux variability from an observation-driven ocean mixed-layer scheme. *Ocean Sci.* 9, 193–216. doi:10.5194/os-9-193-2013.

Roebeling, R. A., and Holleman, I. (2009). SEVIRI rainfall retrieval and validation using weather radar observations. *J. Geophys. Res. Atmos.* doi:10.1029/2009JD012102.

Rohde, R., Muller, R., Jacobsen, R., Perlmutter, S., Rosenfeld, A., Wurtele, J., et al. (2013). Berkeley Earth Temperature Averaging Process. *Geoinformatics Geostatistics An Overv.* 1. doi:10.4172/gigs.1000103.

Rostkier-Edelstein, D., Liu, Y., Wu, W., Kunin, P., Givati, A., and Ge, M. (2014). Towards a high-resolution climatography of seasonal precipitation over Israel. *Int. J. Climatol.* 34, 1964–1979. doi:10.1002/joc.3814.

Saeki, T., and Patra, P. K. (2017). Implications of overestimated anthropogenic CO2 emissions on East Asian and global land CO2 flux inversion. *Geosci. Lett.* 4, 9. doi:10.1186/s40562-017-0074-7.

Saha, S., Moorthi, S., Pan, H.-L., Wu, X., Wang, J., Nadiga, S., et al. (2010). The NCEP Climate Forecast System Reanalysis. *Bull. Am. Meteorol. Soc.* 91, 1015–1058. doi:10.1175/2010BAMS3001.1.

Sandven, S. (2015). ESA Sea Ice Climate Change Initiative (ESA Seaice:cci) data: ESA CCI SIC v1.11, via Centre for Environmental Data Analysis, 16 Feb 2016.

Sasano, D., Takatani, Y., Kosugi, N., Nakano, T., Midorikawa, T., and Ishii, M. (2018). Decline and Bidecadal

Oscillations of Dissolved Oxygen in the Oyashio Region and Their Propagation to the Western North Pacific. *Global Biogeochem. Cycles* 32, 909–931. doi:10.1029/2017GB005876.
Schellekens, J., Dutra, E., la Torre, A., Balsamo, G., van Dijk, A., Sperna Weiland, F., et al. (2017). A global water resources ensemble of hydrological models: the eartH2Observe Tier-1 dataset. *Earth Syst. Sci. Data* 9, 389–413. doi:10.5194/essd-9-389-2017.
Scherler, D., Wulf, H., and Gorelick, N. (2018). Global Assessment of Supraglacial Debris-Cover Extents. *Geophys. Res. Lett.* 45, 11,798-11,805. doi:10.1029/2018GL080158.
Schneider, U., Finger, P., Meyer-Christoffer, A., Rustemeier, E., Ziese, M., and Becker, A. (2017). Evaluating the hydrological cycle over land using the newly-corrected precipitation climatology from the Global Precipitation Climatology Centre (GPCC). *Atmosphere (Basel).* 8, 52. doi:10.3390/atmos8030052.
Schultz, M. G., Schröder, S., Lyapina, O., Cooper, O., Galbally, I., Petropavlovskikh, I., et al. (2017). Tropospheric Ozone Assessment Report: Database and Metrics Data of Global Surface Ozone Observations. *Elem Sci Anth* 5, 58. doi:10.1525/elementa.244.
Shen, Y., Hong, Z., Pan, Y., Yu, J., and Maguire, L. (2018). China's 1 km Merged Gauge, Radar and Satellite Experimental Precipitation Dataset. *Remote Sens.* 10. doi:10.3390/rs10020264.
Sherwood, S. C., and Nishant, N. (2015). Atmospheric changes through 2012 as shown by iteratively homogenized radiosonde temperature and wind data (IUKv2). *Environ. Res. Lett.* 10, 54007. Available at: http://stacks.iop.org/1748-9326/10/i=5/a=054007.
Simpson, I. J., Andersen, M. P. S., Meinardi, S., Bruhwiler, L., Blake, N. J., Helmig, D., et al. (2012). Long-term decline of global atmospheric ethane concentrations and implications for methane. *Nature* 488, 490–494. doi:10.1038/nature11342.
Smeed, D. A., Josey, S. A., Beaulieu, C., Johns, W. E., Moat, B. I., Frajka-Williams, E., et al. (2018). The North Atlantic Ocean is in a state of reduced overturning. *Geophys. Res. Lett.* 45, 1527–1533.
Smith, T. M., Reynolds, R. W., Peterson, T. C., and Lawrimore, J. (2008). Improvements to NOAA's historical merged land--ocean surface temperature analysis (1880--2006). *J. Clim.* 21, 2283–2296.
Spencer, R. W., Christy, J. R., and Braswell, W. D. (2017). UAH Version 6 Global Satellite Temperature Products: Methodology and Results. *Asia-Pacific Jouurnal Atmos. Sci.* 53, 121–130. doi:10.1007/s13143-017-0010-y.
Stengel, M., Sus, O., Stapelberg, S., Schlundt, C., Poulsen, C., and Hollmann, R. (2016). ESA Cloud Climate Change Initiative (ESA Cloud_cci) data: AVHRR-PM CLD_PRODUCTS v2.0 via Deutscher Wetterdienst.
Stocker, E. F., Alquaied, F., Bilanow, S., Ji, Y., and Jones, L. (2018). TRMM Version 8 Reprocessing Improvements and Incorporation into the GPM Data Suite. *J. Atmos. Ocean. Technol.* 35, 1181–1199. doi:10.1175/JTECH-D-17-0166.1.
Susskind, J., Barnet, C. D., Blaisdell, J., Iredell, L., Keita, F., Kouvaris, L., et al. (2006). Accuracy of geophysical parameters derived from Atmospheric Infrared Sounder/Advanced Microwave Sounding Unit as a function of fractional cloud cover. *J. Geophys. Res. Atmos.* 111. doi:10.1029/2005JD006272.
TAKAHASHI, K., MIKAMI, T., and TAKAHASHI, H. (2011). Influence of the Urban Heat Island Phenomenon in Tokyo on the Local Wind System at Nighttime in Summer. *J. Geogr. (Chigaku Zasshi).* doi:10.5026/jgeography.120.341.
Takahashi, T., Sutherland, S. C., Chipman, D. W., Goddard, J. G., Ho, C., Newberger, T., et al. (2014). Climatological distributions of pH, pCO2, total CO2, alkalinity, and CaCO3 saturation in the global surface ocean, and temporal changes at selected locations. *Mar. Chem.* 164, 95–125. doi:https://doi.org/10.1016/j.marchem.2014.06.004.
Takatani, Y., Enyo, K., Iida, Y., Kojima, A., Nakano, T., Sasano, D., et al. (2014). Relationships between total alkalinity in surface water and sea surface dynamic height in the Pacific Ocean. *J. Geophys. Res. Ocean.* 119, 2806–2814. doi:10.1002/2013JC009739.
Tanelli, S., Durden, S. L., Im, E., Pak, K. S., Reinke, D. G., Partain, P., et al. (2008). CloudSat's Cloud Profiling Radar After Two Years in Orbit: Performance, Calibration, and Processing. *IEEE Trans. Geosci. Remote Sens.* 46, 3560–3573. doi:10.1109/TGRS.2008.2002030.
Tapley, B. D., Bettadpur, S., Watkins, M., and Reigber, C. (2004). The gravity recovery and climate experiment: Mission overview and early results. *Geophys. Res. Lett.* 31. doi:10.1029/2004GL019920.
Tarasick, D., Galbally, I. E., Cooper, O. ., and Schultz, M. G. (2019). Tropospheric Ozone Assessment Report: Tropospheric ozone observations – How well do we know tropospheric ozone changes? Submitted. *Elementa*.
Thomason, L. W., Ernest, N., Millán, L., Rieger, L., Bourassa, A., Vernier, J.-P., et al. (2018). A global space-based stratospheric aerosol climatology: 1979–2016. *Earth Syst. Sci. Data* 10, 469–492. doi:10.5194/essd-10-469-2018.
Thompson, D. W., and Wallace, J. M. (2000). Annular modes in the extratropical circulation. Part I: Month-to-month variability. *J. Clim.* 13, 1000–1006.
Thompson, R. L., Lassaletta, L., Patra, P. K., Wilson, C., Wells, K., Gressent, A., et al. Acceleration of global N2O emissions seen from two decades of atmospheric inversion. *J. Geophys. Res.*
Tian, B., Fetzer, E. J., Kahn, B. H., Teixeira, J., Manning, E., and Hearty, T. (2013). Evaluating CMIP5 models using AIRS tropospheric air temperature and specific humidity climatology. *J. Geophys. Res. Atmos.* 118, 114–134. doi:10.1029/2012JD018607.
Titchner, H. A., and Rayner, N. A. (2014). The Met Office Hadley Centre sea ice and sea surface temperature data set,

version 2: 1. Sea ice concentrations. *J. Geophys. Res. Atmos.* 119, 2864–2889. doi:10.1002/2013JD020316.
Tomita (2017). Correction of J-OFURO3 air specific humidity product from microwave radiometers. J-OFURO3 official document J-OFURO3-DOC-005 (in Japanese).
TRMM (2011). TRMM (TMPA) Rainfall Estimate L3 3-hour 0.25 degree x 0.25 degree V7, Greenbelt, MD, Goddard Earth Sciences Data and Information Services Center (GES DISC). doi:10.5067/TRMM/TMPA/3H/7.
Troup, A. J. (1965). The 'southern oscillation.' *Q. J. R. Meteorol. Soc.* 91, 490–506. doi:10.1002/qj.49709139009.
Tsutsumi, Y., Mori, K., Hirahara, T., Ikegami, M., and Conway, T. J. (2009). Technical Report of Global Analysis Method for Major Greenhouse Gases by the World Data Center for Greenhouse Gases, Global Atmosphere Watch Report No. 184. Geneva, Switzerland Available at: www.wmo.int/pages/prog/arep/gaw/documents/TD_1473_GAW184_web.pdf.
Tucker, C. J., Pinzon, J. E., Brown, M. E., Slayback, D. A., Pak, E. W., Mahoney, R., et al. (2005). An extended AVHRR 8-km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data. *Int. J. Remote Sens.* 26, 4485–4498. doi:10.1080/01431160500168686.
Turnbull, J. C., Mikaloff Fletcher, S. E., Ansell, I., Brailsford, G. W., Moss, R. C., Norris, M. W., et al. (2017). Sixty years of radiocarbon dioxide measurements at Wellington, New Zealand: 1954–2014. *Atmos. Chem. Phys.* 17, 14771–14784. doi:10.5194/acp-17-14771-2017.
Uppala, S. M., KÅllberg, P. W., Simmons, A. J., Andrae, U., Bechtold, V. D. C., Fiorino, M., et al. (2005). The ERA-40 re-analysis. *Q. J. R. Meteorol. Soc.* 131, 2961–3012. doi:10.1256/qj.04.176.
van der A, R. J., Allaart, M. A. F., and Eskes, H. J. (2015). Extended and refined multi sensor reanalysis of total ozone for the period 1970–2012. *Atmos. Meas. Tech.* 8, 3021–3035. doi:10.5194/amt-8-3021-2015.
Vandemeulebroucke, I., Calle, K., Caluwaerts, S., De Kock, T., and Van Den Bossche, N. (2019). Does historic construction suffer or benefit from the urban heat island effect in Ghent and global warming across Europe? *Can. J. Civ. Eng.* doi:10.1139/cjce-2018-0594.
Vidal, J.-P., Martin, E., Franchistéguy, L., Baillon, M., and Soubeyroux, J.-M. (2010). A 50-year high-resolution atmospheric reanalysis over France with the Safran system. *Int. J. Climatol.* 30, 1627–1644. doi:10.1002/joc.2003.
Vose, R. S., Arndt, D., Banzon, V. F., Easterling, D. R., Gleason, B., Huang, B., et al. (2012). NOAA's Merged Land–Ocean Surface Temperature Analysis. *Bull. Am. Meteorol. Soc.* 93, 1677–1685. doi:10.1175/BAMS-D-11-00241.1.
Wagner, W., Lemoine, G., and Rott, H. (1999). A Method for Estimating Soil Moisture from ERS Scatterometer and Soil Data. *Remote Sens. Environ.* 70, 191–207. doi:https://doi.org/10.1016/S0034-4257(99)00036-X.
Wahl, S., Bollmeyer, C., Crewell, S., Figura, C., Friederichs, P., Hense, A., et al. (2017). A novel convective-scale regional reanalysis COSMO-REA2: Improving the representation of precipitation. *Meteorol. Zeitschrift* 26, 345–361. doi:10.1127/metz/2017/0824.
Wakita, M., Nagano, A., Fujiki, T., and Watanabe, S. (2017). Slow acidification of the winter mixed layer in the subarctic western North Pacific. *J. Geophys. Res. Ocean.* 122, 6923–6935. doi:10.1002/2017JC013002.
Walsh, J. E., Fetterer, F., Scott Stewart, J., and Chapman, W. L. (2017). A database for depicting Arctic sea ice variations back to 1850. *Geogr. Rev.* doi:10.1111/j.1931-0846.2016.12195.x.
Weber, M., Dikty, S., Burrows, J. P., Garny, H., Dameris, M., Kubin, A., et al. (2011). The Brewer-Dobson circulation and total ozone from seasonal to decadal time scales. *Atmos. Chem. Phys.* 11, 11221–11235. doi:10.5194/acp-11-11221-2011.
Wentz, F. J. (2013). SSM/I Version-7 Calibration Report. Report number 011012, Remote Sensing Systems, Santa Rosa, CA. Available at: http://images.remss.com/papers/rsstech/2012_011012_Wentz_Version-7_SSMI_Calibration.pdf.
Wentz, F. J., Ashcroft, P. D., and Gentemann, C. L. (2001). Post-launch calibration of the TRMM microwave imager. *IEEE Trans. Geosci. Remote Sens.* 39, 415–422.
WGMS (2017). *Global Glacier Change Bulletin No. 2 (2014-2015).* , eds. M. Zemp, S. U. Nussbaumer, I. Gärtner-Roer, J. Huber, H. Machguth, F. Paul, et al. ICSU(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland doi:10.5904/wgms-fog-2017-10.
White, J. W. C., Vaughn, B. H., and Michel, S. E. . (2019). Stable Isotopic Composition of Atmospheric Methane (13C) from the NOAAESRL Carbon Cycle Cooperative Global Air Sampling Network.
Wieder, W. R., Boehnert, J., Bonan, G. B., and Langseth, M. (2014). Regridded Harmonized World Soil Database v1.2. *Data set. Available on-line [http//daac.ornl.gov] from Oak Ridge Natl. Lab. Distrib. Act. Arch. Center, Oak Ridge, Tennessee, USA.* doi:10.3334/ORNLDAAC/1247.
Willett, K. M., Dunn, R. J. H., Thorne, P. W., Bell, S., Podesta, M. De, Parker, D. E., et al. (2014). HadISDH land surface multi-variable humidity and temperature record for climate monitoring. *Clim. Past* 10, 1983–2006. doi:10.5194/cp-10-1983-2014.
Wolter, K., and Timlin, M. S. (1998). Measuring the strength of ENSO events: How does 1997/98 rank? *Weather* 53, 315–324. doi:10.1002/j.1477-8696.1998.tb06408.x.
Wood, C. R., Järvi, L., Kouznetsov, R. D., Nordbo, A., Joffre, S., Drebs, A., et al. (2013). An Overview of the Urban Boundary Layer Atmosphere Network in Helsinki. *Bull. Am. Meteorol. Soc.* 94, 1675–1690. doi:10.1175/BAMS-

D-12-00146.1.
Wu, J., and Gao, X.-J. (2013). A gridded daily observation dataset over China region and comparison with the other datasets. *Chinese J. Geophys.* doi:10.6038/cjg20130406.
Xavier, A. C., King, C. W., and Scanlon, B. R. (2016). Daily gridded meteorological variables in Brazil (1980–2013). *Int. J. Climatol.* 36, 2644–2659. doi:10.1002/joc.4518.
Xie, P., and Arkin, P. A. (1997). Global precipitation: A 17-year monthly analysis based on gauge observations, satellite estimates, and numerical model outputs. *Bull. Am. Meteorol. Soc.* 78, 2539–2558.
Xie, P., Chen, M., and Shi, W. (2010). CPC unified gauge-based analysis of global daily precipitation. in *24th Conference of Hydrology, Atlanta, 16-21 January 2010*.
Xie, P., Chen, M., Yang, S., Yatagai, A., Hayasaka, T., Fukushima, Y., et al. (2007). A Gauge-Based Analysis of Daily Precipitation over East Asia. *J. Hydrometeorol.* 8, 607–626. doi:10.1175/JHM583.1.
Xu, W., Li, Q., Jones, P., Wang, X. L., Trewin, B., Yang, S., et al. (2018). A new integrated and homogenized global monthly land surface air temperature dataset for the period since 1900. *Clim. Dyn.* 50, 2513–2536. doi:10.1007/s00382-017-3755-1.
Yang, Z., Hsu, K., Sorooshian, S., Xu, X., Braithwaite, D., Zhang, Y., et al. (2017). Merging high-resolution satellite-based precipitation fields and point-scale rain gauge measurements-A case study in Chile. *J. Geophys. Res. Atmos.* 122, 5267–5284. doi:10.1002/2016JD026177.
Yatagai, A., Kamiguchi, K., Arakawa, O., Hamada, A., Yasutomi, N., and Kitoh, A. (2012). APHRODITE: Constructing a Long-Term Daily Gridded Precipitation Dataset for Asia Based on a Dense Network of Rain Gauges. *Bull. Am. Meteorol. Soc.* 93, 1401–1415. doi:10.1175/BAMS-D-11-00122.1.
Yoshida, Y., Ota, Y., Eguchi, N., Kikuchi, N., Nobuta, K., Tran, H., et al. (2011). Retrieval algorithm for CO2 and CH4 column abundances from short-wavelength infrared spectral observations by the Greenhouse gases observing satellite. *Atmos. Meas. Tech.* 4, 717–734. doi:10.5194/amt-4-717-2011.
Yu, L., Jin, X., and Weller, R. A. (2008). Multidecade Global Flux Datasets from the Objectively Analyzed Air-sea Fluxes (OAFlux) Project: Latent and sensible heat fluxes, ocean evaporation, and related surface meteorological variables. Woods Hole Oceanographic Institution, OAFlux Project Technical Report. OA-2008-01, Woods Hole. Massachusetts.
Zeng, N., Zhao, F., Collatz, G. J., Kalnay, E., Salawitch, R. J., West, T. O., et al. (2014). Agricultural Green Revolution as a driver of increasing atmospheric CO 2 seasonal amplitude. *Nature* 515, 394–397. doi:10.1038/nature13893.
Zhu, Z., Bi, J., Pan, Y., Ganguly, S., Anav, A., Xu, L., et al. (2013). Global data sets of vegetation leaf area index (LAI)3g and fraction of photosynthetically active radiation (FPAR)3g derived from global inventory modeling and mapping studies (GIMMS) normalized difference vegetation index (NDVI3G) for the period 1981 to 2. *Remote Sens.* 5, 927–948. doi:10.3390/rs5020927.
Zolina, O., Simmer, C., Kapala, A., Shabanov, P., Becker, P., Mächel, H., et al. (2014). Precipitation Variability and Extremes in Central Europe: New View from STAMMEX Results. *Bull. Am. Meteorol. Soc.* 95, 995–1002. doi:10.1175/BAMS-D-12-00134.1.
Zou, C.-Z., and Wang, W. (2011). Intersatellite calibration of AMSU-A observations for weather and climate applications. *J. Geophys. Res. Atmos.* 116. doi:10.1029/2011JD016205.