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Version: 3.1

Alan Di Vittorio

Some references updated May 2022

Original dated October 2020

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Please use the following citations when using Moirai:

Monfreda, C., Ramankutty, N. & Foley, J. A. 2008. Farming the planet: 2. Geographic distribution of crop areas, yields, physiological types, and net primary production in the year 2000, *Global Biogeochem. Cycles*, 22, GB1022.

Ramankutty, N., Evan, A. T., Monfreda, C. & Foley, J. A. 2008. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. *Global Biogeochem. Cycles*, 22, GB1003.

Ramankutty, N. & Foley, J. A. 1999. Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochem. Cycles*, 13, 997-1027.

Klein-Goldewijk, K., Beusen, A., Doelman, J. & Stehfest, E. 2017. Anthropogenic land use estimates for the Holocene – HYDE 3.2. *Earth Syst. Sci. Data*, 9, 927-953.

PORTMANN, F. T., SIEBERT, S. & DÖLL, P. 2010. MIRCA2000—Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling. *Global Biogeochemical Cycles*, 24, GB1011, doi: 10.1029/2008GB003435. Units are hectares.

Please cite these data and the forthcoming ISAM data paper when using Moirai.

Prior ISAM data version paper:

Meiyappan, P., A.K. Jain (2012). Three distinct global estimates of historical land-cover change and land-use conversions for over 200 years.

Mekonnen, M.M. & Hoekstra, A.Y. (2011) The green, blue and grey water footprint of crops and derived crop products, *Hydrology and Earth System Sciences*, 15(5): 1577-1600.

Lee, H.-L., Hhertel, T. W., Rose, S., Avetisyan, M. An integrated global land use data base for CGE analysis of climate policy options. Chapter 4, pp. 72-88, in Hertel, T. W., S. Rose and R. Tol (eds.) (2009). *Economic Analysis of Land Use in Global Climate Change Policy*. Abingdon: Routledge.

Spawn, S.A., and H.K. Gibbs. 2020. Global Aboveground and Belowground Biomass Carbon Density Maps for the Year 2010. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAAC/1763>

Spawn, S.A., Sullivan, C.C., Lark, T.J. et al. Harmonized global maps of above and belowground biomass carbon density in the year 2010. *Sci Data* 7, 112 (2020). <https://doi.org/10.1038/s41597-020-0444-4>.

Hengl, T., Mendes de Jesus, J., Heuvelink, G.B., Ruiperez Gonzalez, M., Kilibarda, M., Blagotic, A., ... & Guevera, M.A. (2017). SoilGrids250m: Global gridded soil information based on machine learning. *PLoS One*, 12(2), e0169748.

Fischer, G., F. Nachtergaele, S. Prieler, H.T. van Velthuisen, L. Verelst, D. Wiberg, 2008. Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2008). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

Florian Zabel, Birgitta Putzenlechner, & Wolfram Mauser. (2014). Global Agricultural Land Resources – A High Resolution Suitability Evaluation and Its Perspectives until 2100 under Climate Change Conditions (Version 2.0) [Data set]. Zenodo. <http://doi.org/10.5281/zenodo.3748350>

Zabel F., Putzenlechner B., Mauser W. (2014): Global agricultural land resources – a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. Online available: PLOS ONE.

Delzeit, Zabel, Meyer, and Vaclavic: (2016). Addressing future trade-offs between biodiversity and cropland expansion to improve food security. *Regional Environmental Change* 17(5): 1429-1441.

Thenkabail, P.S., Teluguntla, P., Xiong, J., Oliphant, A., Congalton, R., Ozdogan, M., Gumma, M.K., Tilton, J., Giri, C., Phalke, A., Yadav, K., Massey, M., Milesi, C., Sankey, T., Zhong, Y., Aneece, Y., Foley, D. 2020. Global Cropland Extent Map at 30m (GCEM30) derived using Landsat Satellite Time-series Data for the Year 2015 using Multiple Machine Learning Algorithms on the Google Earth Engine (GEE) Cloud. U.S. Geological Survey Professional Paper 1868, 63 p., <https://doi.org/10.3133/pp1868>.

USGS & NASA (2017) Release of GFSAD 30 meter cropland extent products: U.S. Geological Survey–National Aeronautics and Space Administration Land Processes Distributed Active Archive Center website: <https://lpdaac.usgs.gov/news/release-of-gfsad-30-meter-cropland-extent-products/>.

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." *Science* 342 (15 November): 850–53. Data available on-line from: <https://glad.earthengine.app/view/global-forest-change>.

IUCN (2018) Protected area vector data, March 2018 (WDPA_Mar2018_Public)
Only the newest version is available at:
<https://www.protectedplanet.net/en/thematic-areas/wdpa>

C NetCDF library (v4.1.1)

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SAGE 175 crop harvested area and yield data, circa 2000, potential vegetation, physical cropland area, and land fraction

Available at: <http://www.earthstat.org/data-download/>

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Ramankutty, N., Evan, A. T., Monfreda, C. & Foley, J. A. 2008. Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000. *Global Biogeochem. Cycles*, 22, GB1003.

Ramankutty, N. & Foley, J. A. 1999. Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochem. Cycles*, 13, 997-1027.

Greenland has been added to the potential vegetation data, mostly as ice, but with some tundra where the HYDE data show land area.

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HYDE 3.2.000 baseline land use data

Available at: ftp://ftp.pbl.nl/hyde/hyde3.2/2017_beta_release/

Please cite these data when using Moirai: Klein-Goldewijk, K., Beusen, A., Doelman, J. & Stehfest, E. 2017. Anthropogenic land use estimates for the Holocene – HYDE 3.2. Earth Syst. Sci. Data, 9, 927-953.

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MIRCA 2000 crop irrigated and rainfed harvested area data, circa 2000

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Please cite the MIRCA journal article when using Moirai: PORTMANN, F. T., SIEBERT, S. & DÖLL, P. 2010. MIRCA2000—Global monthly irrigated and rainfed crop areas around the year 2000: A new high-resolution data set for agricultural and hydrological modeling. *Global Biogeochemical Cycles*, 24, GB1011, doi: 10.1029/2008GB003435. Units are hectares.

ISAM land cover data

Available from Dr. Atul Jain.

Please cite these data and the forthcoming ISAM data paper when using Moirai.

Prior version available at:

<http://climate.atmos.uiuc.edu/atuljain/AvailableData.html>

Prior version paper:

Meiyappan, P., A.K. Jain (2012). Three distinct global estimates of historical land-cover change and land-use conversions for over 200 years.

Water footprint data, circa 2000

Available at: <http://waterfootprint.org/en/resources/waterstat/water-footprint-statistics/>

Please cite these data when using Moirai: Mekonnen, M.M. & Hoekstra, A.Y. (2011) The green, blue and grey water footprint of crops and derived crop products, *Hydrology and Earth System Sciences*, 15(5): 1577-1600.

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Bureau of Labor Statistics historical Consumer Price Index

Available at: <https://www.bls.gov/cpi/data.htm>

All urban consumers, centered at 1982-1984 (June 2018). The original file is available as well as a reformatted input file for Moirai.

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Food and Agriculture Organization of the United Nations crop statistics

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Global Trade Analysis Project land rent data and original Agro-Ecological Zone boundaries

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The land rent data have been extracted from the larger dataset and reformatted for input to Moirai.

Please cite these data when using Moirai: Lee, H.-L., Hertel, T. W., Rose, S., Avetisyan, M. An integrated global land use data base for CGE analysis of climate policy options. Chapter 4, pp. 72-88, in Hertel, T. W., S. Rose and R. Tol (eds.) (2009). Economic Analysis of Land Use in Global Climate Change Policy. Abingdon: Routledge.

Vegetation carbon density data, circa 2010

Available at:

https://daac.ornl.gov/VEGETATION/guides/Global_Maps_C_Density_2010.html

These data have been processed to obtain the Moirai inputs, and the processing script is included at .../moirai/ancillary/bash_scripts.

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SoilGrids carbon density data, 250m version 2.0, circa 2010

Available at:

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These data have been processed to obtain the Moirai inputs, and the processing scripts are included at .../moirai/ancillary/.

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Harmonized World Soil Database v 1.2, carbon density data, circa 2000

Available at:

<http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/>

These data have been processed to obtain the Moirai inputs, and the processing script is included at .../moirai/ancillary/bash_scripts.

Please cite these data when using with Moirai: Fischer, G., F. Nachtergaele, S. Prieler, H.T. van Velthuizen, L. Verelst, D. Wiberg, 2008. Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2008). IIASA, Laxenburg, Austria and FAO, Rome, Italy.

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Agricultural suitability and protected area data, circa 2010

These data were provided by researchers at U.S. Environmental Protection Agency (EPA) in support of research with the Global Change Analysis Model (GCAM). Contact Aaron Sobel (Sobel.Aaron@epa.gov) for availability.

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Florian Zabel, Birgitta Putzenlechner, & Wolfram Mauser. (2014). Global Agricultural Land Resources – A High Resolution Suitability Evaluation and Its Perspectives until 2100 under Climate Change Conditions (Version 2.0) [Data set]. Zenodo. <http://doi.org/10.5281/zenodo.3748350>

Zabel F., Putzenlechner B., Mauser W. (2014): Global agricultural land resources – a high resolution suitability evaluation and its perspectives until 2100 under climate change conditions. *PLoS ONE*, **9**, e107522.

Delzeit, Zabel, Meyer, and Vaclavic: (2016). Addressing future trade-offs between biodiversity and cropland expansion to improve food security. *Regional Environmental Change* 17(5): 1429-1441.

GFSAD30 cropland extent, 2015, 30m, v1.0

Available at: <https://lpdaac.usgs.gov/news/release-of-gfsad-30-meter-cropland-extent-products/>.

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Please cite as: Thenkabail, P.S., Teluguntla, P., Xiong, J., Oliphant, A., Congalton, R., Ozdogan, M., Gumma, M.K., Tilton, J., Giri, C., Phalke, A., Yadav, K., Massey, M., Milesi, C., Sankey, T., Zhong, Y., Aneece, Y., Foley, D. 2020. Global Cropland Extent Map at 30m (GCEM30) derived using Landsat Satellite Time-series Data for the Year 2015 using Multiple Machine Learning Algorithms on the Google Earth Engine (GEE) Cloud. U.S. Geological Survey Professional Paper 1868, 63 p., <https://doi.org/10.3133/pp1868>.

Data citation: USGS & NASA (2017) Release of GFSAD 30 meter cropland extent products: U.S. Geological Survey–National Aeronautics and Space Administration Land Processes Distributed Active Archive Center website: <https://lpdaac.usgs.gov/news/release-of-gfsad-30-meter-cropland-extent-products/>.

ESA CCI Cropland, urban area, water, 2015, 300m

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IUCN Protected area, March 2018 (WDPA Mar2018 Public), vector

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