

14 Health: Temperature-related mortality (TRM)

There are no restrictions regarding the type of (empirical) models (GAMs, DLNMs, linear threshold model, etc.) to be used as long as the methodology has been documented in previous peer-reviewed publications. It also does not matter at which spatial scale the model operates (city-scale, regional, national, global), with the possible restrictions stemming from the input data provided.

14.1 Experiments

See **Table 6** for a general explanation of the pressoc, and varsoc experiments. Specification for TRM models are

- pressoc: no long-term trend in the relationship between temperature and mortality. E.g., constant exposure-response function (ERF), if possible, estimated from observational data in period centred on the year 2000
- varsoc: reflecting historical trend in the relationship between temperature and mortality. E.g., varying ERF, as estimated from observations in adjacent subperiods; if possible, extrapolate to reporting years outside of observational period using external factors (such as climatic factors, etc.).

Table 37: Summary of experiments for TRM models.

Climate Data	Scenario	Human Impacts	# runs
WATCH-WFDEI	Hist	pressoc varsoc	2
GSWP3-W5E5	Hist	pressoc varsoc	2
GSWP3-EWEMBI	Hist	pressoc varsoc	2
GSWP3	Hist	pressoc varsoc	2
PGMFD v.2 (Princeton)	Hist	pressoc varsoc	2

14.2 Output data

Table 38: Output variables to be reported by TRM models

Variable (long name)	Variable name	Unit	Temporal resolution	Comments
Number of deaths attributable to cold	ancold-<r>	1	daily	For ERF models, this occurs when temperature is below threshold (e.g., minimum mortality temperature (MMT)). Report 0 if temperature above threshold. Can have gender, age, etc. dimensions; see below.
Number of deaths attributable to heat	anheat-<r>	1	daily	Temperature above threshold (ERFs). Report 0 if temperature below threshold. Can have gender, age, etc. dimensions; see below.
Baseline total mortality	btm	1	daily	To be reported as annual series of mean daily total mortality, or as a single number of mean daily mortality; to be used for computations of attributable fractions. Can have gender, age, etc. dimensions; see below.
Population	pop	1	annual or 5-year intervals	Baseline population data should be provided for computations of mortality rates (i.e. deaths per total population). Can have gender, age, etc. dimensions; see below.

Instructions on reporting results:

- If different **realizations** of the model are applied, then these should be indicated by the specifier **<r>**. E.g. to reflect a central, upper, and lower estimate of the ERF:
<r> = lower, central, upper
Please explain the meaning of these realizations in the online model documentation; contact the ISIMIP coordination team in case of questions.
- If data are disaggregated e.g. by **age group, gender**, etc., they should be reported along an additional dimension, described by an auxiliary coordinate variable, in the NetCDF files. See the example provided at <https://www.isimip.org/protocol/preparing-simulation-files/>.
- For local (non-gridded) data, **locations (cities/regions/countries)** should be reported along an additional dimension called *location*, with the location name given as string in an auxiliary coordinate variable called *location_name*, in the NetCDF files. In addition, coordinates of

the location should be reported in auxiliary variables called *location_lat* and *location_lon*. See the example provided at <https://www.isimip.org/protocol/preparing-simulation-files/>. The <region> specifier in the file name should be set to “local”.

- For gridded data, the <region> specifier in the file name should be “global” or indicate a region or country.

15 References

- Arnell, N. (1999). A simple water balance model for the simulation of streamflow over a large geographic domain. *Journal of Hydrology*, 217(3-4), 314-335.
- Cescatti, A., & Piutti, E. (1998). Silvicultural alternatives, competition regime and sensitivity to climate in a European beech forest. *Forest Ecology and Management*, 102(2), 213-223.
- Choulga, M., Kourzeneva, E., Zakharova, E., & Doganovsky, A. (2014). Estimation of the mean depth of boreal lakes for use in numerical weather prediction and climate modelling. *Tellus A. Dyn. Meteorol. Oceanogr.*, 66(1), 21295.
- Davie, J. C., Falloon, P. D., Kahana, R., Dankers, R., Betts, R., Portmann, F. T., . . . Arnell, N. (2013). Comparing projections of future changes in runoff and water resources from hydrological and ecosystem models in ISI-MIP. *Earth System Dynamics Discussions*, 4(1), 279-315.
- De Lary, R. (October, 2015). *Massif des Landes de Gascogne. II – ETAT DES CONNAISSANCES TECHNIQUES*. Bordeaux: CRPF Aquitaine.
- Dlugokencky, E., & Tans, P. (2019). *Trends in atmospheric carbon dioxide*. Retrieved November 2, 2019, from National Oceanic & Atmospheric Administration, Earth System Research Laboratory (NOAA/ESRL): https://www.esrl.noaa.gov/gmd/ccgg/trends/gl_data.html
- Döll, P., & Schmied, H. M. (2012). How is the impact of climate change on river flow regimes related to the impact on mean annual runoff? A global-scale analysis. *Environmental Research Letters*, 7(1), 14037.
- Döll, P., Kaspar, F., & Lehner, B. (2003). A global hydrological model for deriving water availability indicators: Model tuning and validation. *Journal of Hydrology*, 270(1-2), 105-134.
- Duncker, P. S., Barreiro, S. M., Hengeveld, G. M., Lind, T., Mason, W. L., Ambrozy, S., & Spiecker, H. (2012). Classification of Forest Management Approaches: A New Conceptual Framework and Its Applicability to European Forestry. *Ecology and Society*, 17(4).
- Elliott, J., Müller, C., Deryng, D., Chryssanthacopoulos, J., Boote, K. J., Büchner, M., . . . Ruane, A. C. (2015). The Global Gridded Crop Model Intercomparison: Data and modeling protocols for Phase 1 (v1.0). *Geosci. Model Dev.*, 8, 261-277.

- Fekete, B. M., Vörösmarty, C. J., & Grabs, W. (2000). Global Composite Runoff Fields on Observed River Discharge and Simulated Water Balances. *GRDC Reports*, 22(115).
- Foley, J. A., Ramankutty, N., Brauman, K. A., Cassidy, E. S., Gerber, J. S., Johnston, M., . . . Hill. (2011). Solutions for a cultivated planet. *Nature*, 478(7369), 337-342.
- Fürstenau, C., Badeck, F. W., Lasch, P., Lexer, M. J., Lindner, M., Mohr, P., & Suckow, F. (2007). Multiple-use forest management in consideration of climate change and the interests of stakeholder groups. *Eur J Forest Res*, 126, 225-239.
- González, J. R., & Palahí, M. (2005). Optimising the management of *Pinus sylvestris* L. stand under risk of fire in Catalonia (north-east of Spain). *Ann. For. Sci.* 62, 62, 493-501.
- Gosling, S. N., & Arnell, N. W. (2011). Simulating current global river runoff with a global hydrological model: Model revisions, validation, and sensitivity analysis. *Hydrological Processes*, 25(7), 1129–1145.
- Gosling, S. N., Warren, R., Arnell, N. W., Good, P., Caesar, J., Bernie, D., . . . Smith, S. M. (2011). A review of recent developments in climate change science. Part II: The global-scale impacts of climate change. *Progress in Physical Geography*, 35(4), 443–464.
- Gutsch, M., Lasch, P., Suckow, F., & Reyer, C. (2011). Management of mixed oak-pine forests under climate scenario uncertainty. *Forest Systems*, 20(3), 453-463.
- Haddeland, I. C. (2011). Multimodel estimate of the global terrestrial water balance: setup and first results. *Journal of Hydrometeorology*, 110531121709055.
- Haith, D. A., & Shoemaker., L. L. (1987). Generalized Watershed Loading Functions for stream flow nutrients. *Water Resour. Bull.*, 23, 471-478.
- Håkanson, L. (1995). Models to predict Secchi depth in small glacial lakes. *Aquatic Science*, 57(1), 31–53.
- Hanewinkela, M., & Pretzsch, H. (2000). Modelling the conversion from even-aged to uneven-aged stands of Norway spruce (*Picea abies* L. Karst.) with a distance-dependent growth simulator. *Forest Ecology and Management*, 134, 55-70.

- Hein, S., & Dhôte, J.-F. (2006). Effect of species composition, stand density and site index on the basal area increment of oak trees (*Quercus* sp.) in mixed stands with beech (*Fagus sylvatica* L.) in northern France. *Ann. For. Sci.*, *63*, 457-467.
- Hijmans, R., Cameron, S., Parra, J., Jones, P., & Jarvis, A. (2005). Very high resolution interpolated climate surfaces for global land areas. *International Journal of Climatology*, *25*, 1965-1978.
- Hurttt, G., Chini, L., Sahajpal, R., Frohking, S., & et al, .. (In prep.). Harmonization of global land-use change and management for the period 850-2100. *Geoscientific Model Development*.
- Kerr, G. (1996). The effect of heavy or 'free growth' thinning on oak (*Quercus petraea* and *Q. robur*). *Forestry: An International Journal of Forest Research*, *69*(4), 303-317.
- Kim, H. (. (n.d.). *Global Soil Wetness Project Phase 3*. Retrieved from Global Soil Wetness Project Phase 3: <http://hydro.iis.u-tokyo.ac.jp/GSWP3/>
- Klein Goldewijk, D. i. (2016). *A historical land use data set for the Holocene; HYDE 3.2 (replaced)*. Utrecht University. DANS.
- Koster, R. D., Fekete, B. M., Huffman, G. J., & Stackhouse, P. W. (2006). Revisiting a hydrological analysis framework with International Satellite Land Surface Climatology Project Initiative 2 rainfall, net radiation, and runoff fields. *Journal of Geophysical Research*, *111*(D22), D22S05.
- Kourzeneva, E. (2010). External data for lake parameterization in Numerical Weather Prediction and climate modeling. *Boreal Environ. Res.*, *15*(2), 165-177.
- Lähde, E., Laiho, O., & Lin, J. C. (2010). Silvicultural alternatives in an uneven-sized forest dominated by *Picea abies*. *Journal of Forest Research*, *15*(1), 14-20.
- Lange, S. (2019a). WFDE5 over land merged with ERA5 over the ocean (W5E5). V. 1.0. doi:10.5880/pik.2019.023
- Lange, S. (2019b). Earth2Observe, WFDEI and ERA-Interim data Merged and Bias-corrected for ISIMIP (EWEMBI) v1.1. *GFZ Data Services*. doi:10.5880/pik.2019.004
- Lascha, P., Badecka, F.-W., Suckowa, F., Lindnera, M., & Mohr, P. (2005). Model-based analysis of management alternatives at stand and regional

level in Brandenburg. *Forest Ecology and Management*, 207, 59-74.

Lehner, B., & Döll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. *J. Hydrol.*, 296(1-4), 1-22.

Liu, J., You, L., Amini, M., Obersteiner, M., Herrero, M., Zehnder, A. J., & Yang, H. (2010). A high-resolution assessment on global nitrogen flows in cropland. *National Academy of Sciences*, 107(17), 8035-8040.

Loustau, D., Bosc, A., Colin, A., Ogée, J., Davi, H., Francois, C., . . . Delage, F. (2005). Modeling climate change effects on the potential production of French plains forests at the sub-regional level. *Tree physiology*, 25, 813-23.

Meinshausen, M., Raper, S. C., & Wigley, T. M. (2011). Emulating coupled atmosphere-ocean and carbon cycle models with a simpler model, MAGICC6 – Part 1: Model description and calibration. *Atmospheric Chemistry and Physics*, 11(4), 1417–1456.

Millero, F., & Poisson, A. (1981). International one-atmosphere equation of state of seawater. *Deep-Sea Research*, 28, 625-629.

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

Mueller, N., Gerber, J., Johnston, M., Ray, D., Ramankutty, N., & Foley, J. (2012). Closing yield gaps through nutrient and water management. *Nature*, 490, 254-257.

Mund, M. (2004). *Carbon pools of European beech forests (Fagus sylvatica) under different silvicultural management*. Göttingen: Forschungszentrum Waldökosysteme.

Oleson, K. W., Niu, G.-Y., Yang, Z.-L., Lawrence, D. M., Thornton, P. E., Lawrence, P. J., . . . Qian, T. (2008). Improvements to the Community Land Model and their impact on the hydrological cycle. *Journal of Geophysical Research*, 113(G1), G01021.

Pape, R. (1999). Effects of Thinning Regime on the Wood Properties and Stem Quality of *Picea abies*. *Scandinavian Journal of Forest Research*, 14(1), 38-50.

Portmann, F., 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(1).

- Potter, P., Ramankutty, N., Bennett, E. M., & Donner, S. D. (2011). Global fertilizer and manure, version 1: nitrogen fertilizer application. NASA Socioeconomic Data and Applications Center.
- Pukkala, T., Miina, J., Kurttila, M., & Kolström, T. (1998). A spatial yield model for optimizing the thinning regime of mixed stands of *Pinus sylvestris* and *Picea abies*. *Scandinavian Journal of Forest Research*, 13(1-4), 31-42.
- Sacks, W. J., Deryng, D., Foley, J. A., & Ramankutty, N. (2010). Crop planting dates: an analysis of global patterns. *Global Ecology and Biogeography*, 19(5), 607-620.
- Schneiderman, E. M., Pierson, D. C., Lounsbury, D. G., & Zion, M. S. (2002). Modeling the hydrochemistry of the Cannonsville watershed with Generalized Watershed Loading Functions (GWLF). *J. Am. Water Resour. Assoc.*, 38, 1323-1347.
- Schütz, J.-P., Götz, M., Schmid, W., & Mandallaz, D. (2006). Vulnerability of spruce (*Picea abies*) and beech (*Fagus sylvatica*) forest stands to storms and consequences for silviculture. *Eur J Forest Res*, 125, 291-302.
- Shatwell, T., Thiery, W., & Kirillin, G. (2019). Future projections of temperature and mixing regime of European temperate lakes. *Hydrology and Earth System Sciences*, 23(3), 1533-1551.
- Sheffield, J., Goteti, G., & Wood, E. F. (2006). Development of a 50-Year High-Resolution Global Dataset of Meteorological Forcings for Land Surface Modeling. *Journal of Climate*, 19(13), 3088-3111.
- Štefančík, I. (2012). Growth characteristics of oak (*Quercus petraea* [Mattusch.] Liebl.) stand under different thinning regimes. *Journal of Forest Science*, 58(2), 67-78.
- Sterba, H. (1987). Estimating Potential Density from Thinning Experiments and Inventory Data. *Forest Science*, 33(4), 1022-1034.
- Stock, C. A., Dunne, J. P., & John, J. G. (2014). Global-scale carbon and energy flows through the marine planktonic food web: An analysis with a coupled physical-biological model. *Progress in Oceanography*, 120, 1-28.

- Subin, Z. M., Riley, W. J., & Mironov, D. (2012). An improved lake model for climate simulations: Model structure, evaluation, and sensitivity analyses in CESM1. *J. Adv. Model. Earth Syst.*, 4(1), M02001.
- Thivolle-Cazat, A. (2013). *Disponibilité en bois en Aquitaine de 2012 à 2025*. Bordeaux: FCBA, IGN, INRA, CRPF Aquitaine.
- Tian, H., Yang, J., Lu, C., Xu, R., Canadell, J. G., Jackson, R., . . . Wini. (2018). The global N2O Model Intercomparison Project (NMIP): Objectives, Simulation Protocol and Expected Products. *B. Am. Meteorol. Soc.*
- Weedon, G. P., Balsamo, G., Bellouin, N., Gomes, S., Best, M. J., & Viterbo, P. (2014). The WFDEI meteorological forcing data set: WATCH Forcing Data methodology applied to ERA-Interim reanalysis data. *Water Resources Research*, 50, 7505–7514.
- Weedon, G. P., Gomes, S., Viterbo, P., Shuttleworth, W. J., Blyth, E., Österle, H., . . . Best, M. (2011). Creation of the WATCH Forcing Data and Its Use to Assess Global and Regional Reference Crop Evaporation over Land during the Twentieth Century. *Journal of Hydrometeorology*, 12(5), 823–848.
- Wu, B., Yu, B., Yue, W., Shu, S., Tan, W., Hu, C., . . . Liu, H. (2013). A Voxel-Based Method for Automated Identification and Morphological Parameters Estimation of Individual Street Trees from Mobile Laser Scanning Data. *Remote Sensing*, 5(2), 584–611.
- Yoshimura, K., & Kanamitsu, M. (2008). Dynamical Global Downscaling of Global Reanalysis. *Monthly Weather Review*, 136(8), 2983–2998.
- Yoshimura, K., & Kanamitsu, M. (2013). Incremental Correction for the Dynamical Downscaling of Ensemble Mean Atmospheric Fields. *Monthly Weather Review*, 141(9), 3087–3101.