

Assignment: Global environmental change - land use change

Mode

Partner work allowed: yes, maximum groups of four.

Create a text document of 3-5 pages (A4, 11 pt) that answers the content points listed below. You may structure the document along the given questions or as you like. Make sure that references in your text are correctly cited and that each statement is referenced. Ideally, your responses are complemented by a figure from original sources for each point. The document may be handed in as a Word, [RMarkdown](#), or [Quarto](#) document that can be added to the repository of the LES textbook (<https://geco-bern.github.io/les/>).

Present this work in a presentation of 30 min.

Supervised by Benjamin Stocker.

Content points

1. What is the present-day global distribution of croplands, pastures, and irrigated agricultural land?
 - (Ramankutty et al., 2008; Siebert et al., 2015)
2. What has been the global pattern of cropland and forest change in recent decades? What have been the CO₂ emissions from land use change in the past decades? What are the reasons for the large discrepancies in different LUC CO₂ emission estimates?
 - (Friedlingstein et al., 2023; Hansen et al., 2013; Pongratz et al., 2021; Potapov et al., 2022)
3. What has been the land use change since the Neolithic Revolution and what has been its contribution to the global land carbon balance and atmospheric CO₂?
 - (Erb et al., 2018; Stocker et al., 2011, 2017)
4. How does land use change affect biogeophysical properties of the land surface and thus the exchange of radiation, heat, and water?
 - (Bala et al., 2007; Bonan, 2008)
5. How does land use change affect the capacity of ecosystems to act as a net C sink?
 - (Stocker and Joos, 2015)
6. How are global CO₂ emissions from land use change estimated?
 - (Pongratz et al., 2021)
7. What is the potential of forest regeneration and afforestation as a climate mitigation option?
 - (Pongratz et al., 2021)

References

- Bala, G., Caldeira, K., Wickett, M., Phillips, T. J., Lobell, D. B., Delire, C., and Mirin, A.: Combined climate and carbon-cycle effects of large-scale deforestation, *Proceedings of the National Academy of Sciences*, 104, 6550–6555, <https://doi.org/10.1073/pnas.0608998104>, 2007.
- Bonan, G. B.: Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests, *Science*, 320, 1444–1449, <https://doi.org/10.1126/science.1155121>, 2008.
- Erb, K.-H., Kastner, T., Plutzer, C., Bais, A. L. S., Carvalhais, N., Fetzel, T., Gingrich, S., Haberl, H., Lauk, C., Niedertscheider, M., Pongratz, J., Thurner, M., and Luyssaert, S.: Unexpectedly large impact of forest management and grazing on global vegetation biomass, *Nature*, 553, 73–76, <https://doi.org/10.1038/nature25138>, 2018.
- Friedlingstein, P., O’Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C. E., Hauck, J., Landschützer, P., Le Quéré, C., Luijkx, I. T., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Anthoni, P., Barbero, L., Bates, N. R., Becker, M., Bellouin, N., Decharme, B., Bopp, L., Brasika, I. B. M., Cadule, P., Chamberlain, M. A., Chandra, N., Chau, T.-T.-T., Chevallier, F., Chini, L. P., Cronin, M., Dou, X., Enyo, K., Evans, W., Falk, S., Feely, R. A., Feng, L., Ford, D. J., Gasser, T., Ghattas, J., Gkritzalis, T., Grassi, G., Gregor, L., Gruber, N., Gürses, Ö., Harris, I., Hefner, M., Heinke, J., Houghton, R. A., Hurtt, G. C., Iida, Y., Ilyina, T., Jacobson, A. R., Jain, A., Jarníková, T., Jersild, A., Jiang, F., Jin, Z., Joos, F., Kato, E., Keeling, R. F., Kennedy, D., Klein Goldewijk, K., Knauer, J., Korsbakken, J. I., Körtzinger, A., Lan, X., Lefèvre, N., Li, H., Liu, J., Liu, Z., Ma, L., Marland, G., Mayot, N., McGuire, P. C., McKinley, G. A., Meyer, G., Morgan, E. J., Munro, D. R., Nakaoka, S.-I., Niwa, Y., O’Brien, K. M., Olsen, A., Omar, A. M., Ono, T., Paulsen, M., Pierrot, D., Pocock, K., Poulter, B., Powis, C. M., Rehder, G., Resplandy, L., Robertson, E., Rödenbeck, C., Rosan, T. M., Schwinger, J., Séférian, R., et al.: Global Carbon Budget 2023, *Earth System Science Data*, 15, 5301–5369, <https://doi.org/10.5194/essd-15-5301-2023>, 2023.
- Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., Thau, D., Stehman, S. V., Goetz, S. J., Loveland, T. R., Kommareddy, A., Egorov, A., Chini, L., Justice, C. O., and Townshend, J. R. G.: High-Resolution Global Maps of 21st-Century Forest Cover Change, *Science*, 342, 850–853, <https://doi.org/10.1126/science.1244693>, 2013.
- Pongratz, J., Schwingshackl, C., Bultan, S., Obermeier, W., Havemann, F., and Guo, S.: Land Use Effects on Climate: Current State, Recent Progress, and Emerging Topics, *Curr Clim Change Rep*, 7, 99–120, <https://doi.org/10.1007/s40641-021-00178-y>, 2021.
- Potapov, P., Turubanova, S., Hansen, M. C., Tyukavina, A., Zalles, V., Khan, A., Song, X.-P., Pickens, A., Shen, Q., and Cortez, J.: Global maps of cropland extent and change show accelerated cropland expansion in the twenty-first century, *Nat Food*, 3, 19–28, <https://doi.org/10.1038/s43016-021-00429-z>, 2022.
- Ramankutty, N., Evan, A. T., Monfreda, C., and Foley, J. A.: Farming the planet: 1. Geographic distribution of global agricultural lands in the year 2000, *Global Biogeochemical Cycles*, 22, <https://doi.org/10.1029/2007GB002952>, 2008.
- Siebert, S., Kummu, M., Porkka, M., Döll, P., Ramankutty, N., and Scanlon, B. R.: A global data set of the extent of irrigated land from 1900 to 2005, *Hydrology and Earth System Sciences*, 19, 1521–1545, <https://doi.org/10.5194/hess-19-1521-2015>, 2015.
- Stocker, B. D. and Joos, F.: Quantifying differences in land use emission estimates implied by definition discrepancies, *Earth System Dynamics*, 6, 731–744, <https://doi.org/10.5194/esd-6-731-2015>, 2015.
- Stocker, B. D., Strassmann, K., and Joos, F.: Sensitivity of Holocene atmospheric CO₂ and the

modern carbon budget to early human land use: analyses with a process-based model, *Biogeosciences*, 8, 69–88, <https://doi.org/10.5194/bg-8-69-2011>, 2011.

Stocker, B. D., Yu, Z., Massa, C., and Joos, F.: Holocene peatland and ice-core data constraints on the timing and magnitude of CO₂ emissions from past land use, *Proceedings of the National Academy of Sciences*, 114, 1492–1497, <https://doi.org/10.1073/pnas.1613889114>, 2017.