~~Refined global atmospheric energy budget from ERA5~~

Mass-consistent monthly atmospheric energy and moisture budget data from 1979 to present derived from ERA5

Johannes Mayer[(1,⋆)], Michael Mayer[(1,2)], Leopold Haimberger[(1)]

[(1)] Department of Meteorology and Geophysics
University of Vienna, Vienna, Austria

[(2)] European Centre for Medium-Range Weather Forecasts
Bonn, Germany

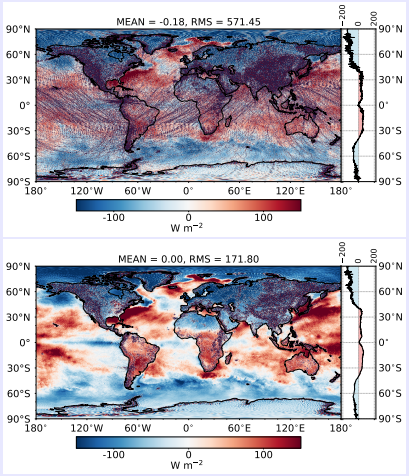
[(⋆)] johannes.mayer@univie.ac.at

universität wien imgw Institut für Meteorologie und Geophysik FWF Der Wissenschaftsfonds. ECMWF

Dataset

Aim	Provide mass-consistent monthly energy and moisture budget fields
Resolution	$0.25° \times 0.25°$, monthly averages
Coverage	Global, 1979–present
Input	1-hourly analyzed ERA5 data
Variables	Vertical integral of lateral fluxes, divergence, and tendency of total energy, latent heat, and moisture
Publication	in the Copernicus Climate Data Store $\Rightarrow$ will be published soon!

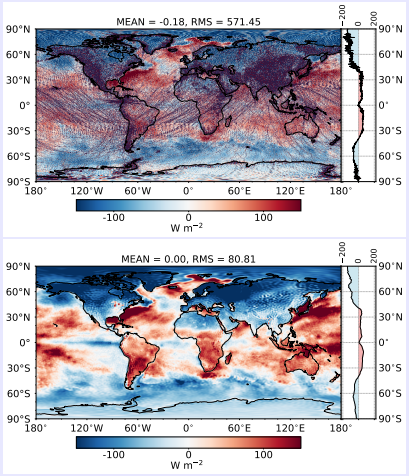
$$\nabla \cdot \frac{1}{g} \int_0^{ps} [(1-q)\mathbf{v}]\, dp + \frac{1}{g} \frac{\partial}{\partial t} \int_0^{ps} (1-q) dp = R_{mass},$$



Dataset

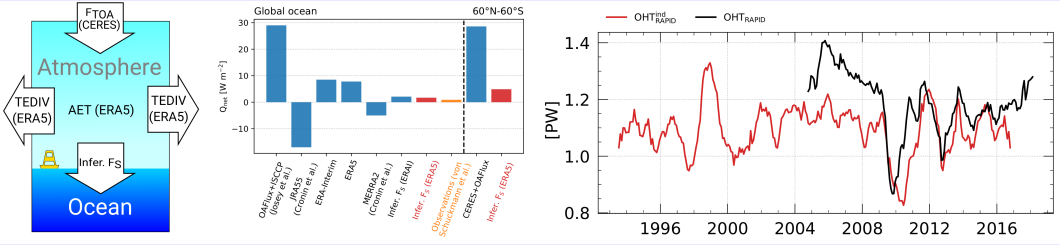
Aim	Provide mass-consistent monthly energy and moisture budget fields
Resolution	$0.25° \times 0.25°$, monthly averages
Coverage	Global, 1979–present
Input	1-hourly analyzed ERA5 data
Variables	Vertical integral of lateral fluxes, divergence, and tendency of total energy, latent heat, and moisture
Publication	in the Copernicus Climate Data Store $\Rightarrow$ will be published soon!

$$\nabla \cdot \frac{1}{g} \int_0^{ps} [(1-q)\mathbf{v}]\, dp + \frac{1}{g} \frac{\partial}{\partial t} \int_0^{ps} (1-q) dp = R_{mass},$$



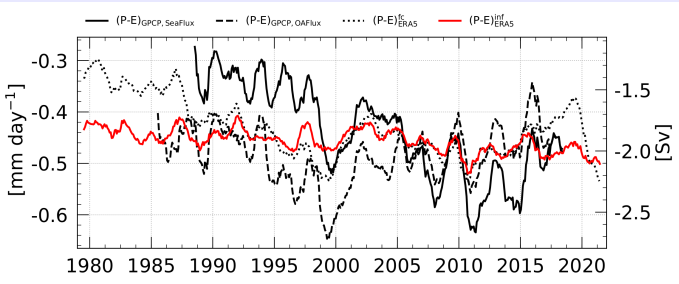
Applications I

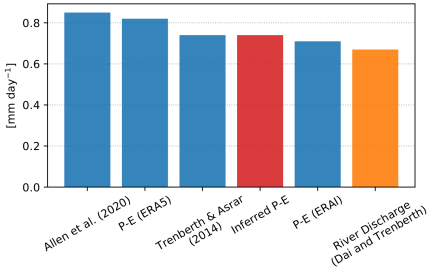
1. Assessment of the global atmospheric (and oceanic) energy budget → *small bias, good closure*
2. Evaluation of energy and moisture transports (meridional, ocean-land, ...)



Applications II

3. Indirect estimation of global P-E
4. ...





Check out relevant literature ☺

- Mayer, J., Mayer, M., Haimberger, L., and Liu, C. (2022). Comparison of Surface Energy Fluxes from Global to Local Scale. Journal of Climate (published online ahead of print 2022), available from: https:/doi.org/10.1175/JCLI-D-21-0598.1
- Mayer, J., Mayer, M., and Haimberger, L. (2021). Consistency and Homogeneity of Atmospheric Energy, Moisture, and Mass Budgets in ERA5. Journal of Climate 34, 10, 3955-3974, available from: https://doi.org/10.1175/JCLI-D-20-0676.1
- Mayer, M., Tietsche, S., Haimberger, L., Tsubouchi, T., Mayer, J., and Zuo, H. (2019). An Improved Estimate of the Coupled Arctic Energy Budget. Journal of Climate 32, 22, 7915-7934, available from: https://doi.org/10.1175/JCLI-D-19-0233.1
- Mayer, M., Haimberger, L., Edwards, J. M., and Hyder, P. (2017). Toward Consistent Diagnostics of the Coupled Atmosphere and Ocean Energy Budgets. Journal of Climate 30, 22, 9225-9246, available from: https://doi.org/10.1175/JCLI-D-17-0137.1

References

- Cronin, M. F., and Coauthors, 2019: *Air-sea fluxes with a focus on heat and momentum*. Front. Mar. Sci., 6, 430, https://doi.org/10.3389/fmars.2019.00430.
- von Schuckmann, K., and Coauthors, 2020: *Heat stored in the Earth system: Where does the energy go?*. Earth Syst. Sci. Data, 12, 2013-2041, https://doi.org/10.5194/essd-12-2013-2020
- Hersbach, H., and Coauthors, 2020: *The ERA5 global reanalysis*. Quart. J. Roy. Meteor. Soc., 146, 1999–2049, https://doi.org/10.1002/qj.3803.
- Johns, W. E., and Coauthors, 2011: *Continuous, array-based estimates of Atlantic Ocean heat transport at 26.5° N*. J. Climate, 24, 2429–2449, https://doi.org/10.1175/2010JCLI3997.1.
- Dai, A., and K. E. Trenberth, 2002: *Estimates of freshwater discharge from continents: Latitudinal and seasonal variations.* J. Hydrometeor., 3, 660–687, https://doi.org/10.1175/1525-7541(2002)003,0660:EOFDFC.2.0.CO;2.
- Josey, S. A., Gulev, S., and Yu, L. (2013). *Exchange through the ocean surface*, in Ocean Circulation and Climate: A 21st Century Perspective, Int. Geophys. Ser, Vol. 103, eds G. Siedler, et al. (Oxford: Academic Press), 115-140.
- Trenberth, K. E. and Asrar, G. R.: *Challenges and Opportunities in Water Cycle Research: WCRP Contributions*, Surv. Geophys., 35, 515–532, https://doi.org/10.1007/s10712-012-9214-y, 2014.
- Allan, R. P., and Coauthors: Advances in understanding large-scale responses of the water cycle to climate change, Ann. NY Acad. Sci., 1472, 49–75, https://doi.org/10.1111/nyas.14337, 2020.

Thank you for your attention!

Budget equations

Moisture budget equation:

$$\nabla \cdot \frac{1}{g} \int_0^{ps} (\mathbf{v}q) dp + \frac{1}{g} \frac{\partial}{\partial t} \int_0^{ps} q dp + P + E = 0 \tag{1}$$

Energy budget equation:

$$F_S = F_{TOA} - \nabla \cdot \frac{1}{g} \int_0^{ps} [(1-q)c_a T_a + L_v(T_a)q + \Phi + k]\mathbf{v} dp - AET \tag{2}$$

Oceanic energy budget equation:

$$\nabla \cdot \int_0^{Z} \rho_o c_o (T_o(z) - T_{ref})\mathbf{c} dz = F_S - MET - \rho_o c_o \frac{\partial}{\partial t} \int_0^{Z} (T_o(z) - T_{ref}) dz \tag{3}$$

Truncated Fields

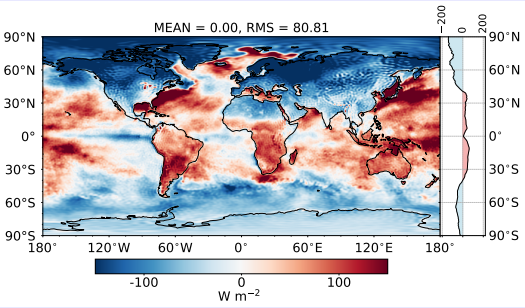


Figure: TEDIV from this dataset truncated at wave number 180.

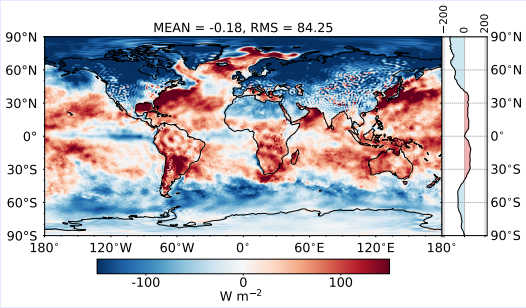


Figure: TEDIV from ERA5 truncated at wave number 180.

CDS web interface