TRACMASS - A mass conserving trajectory code for ocean and atmosphere general circulation models

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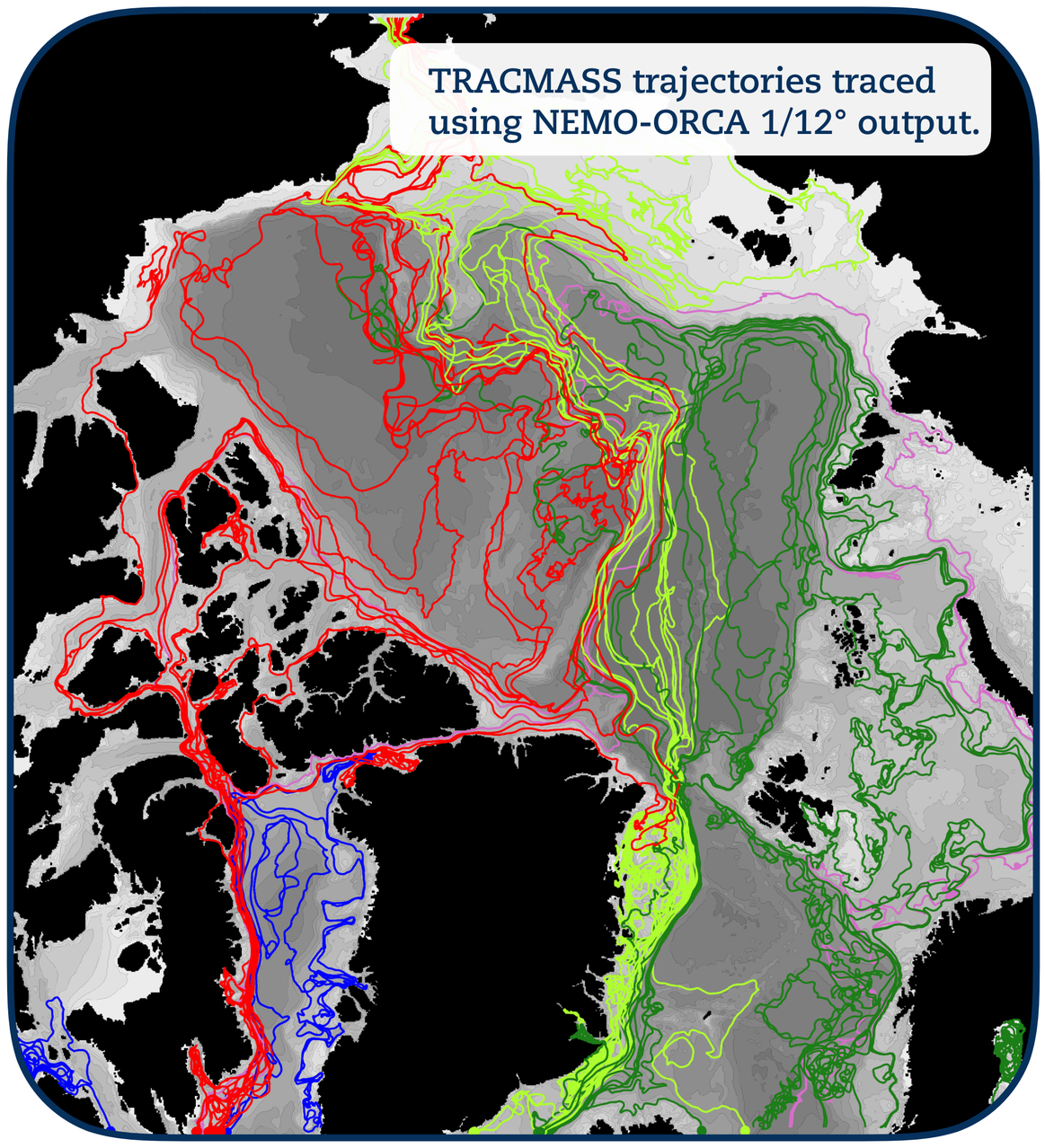
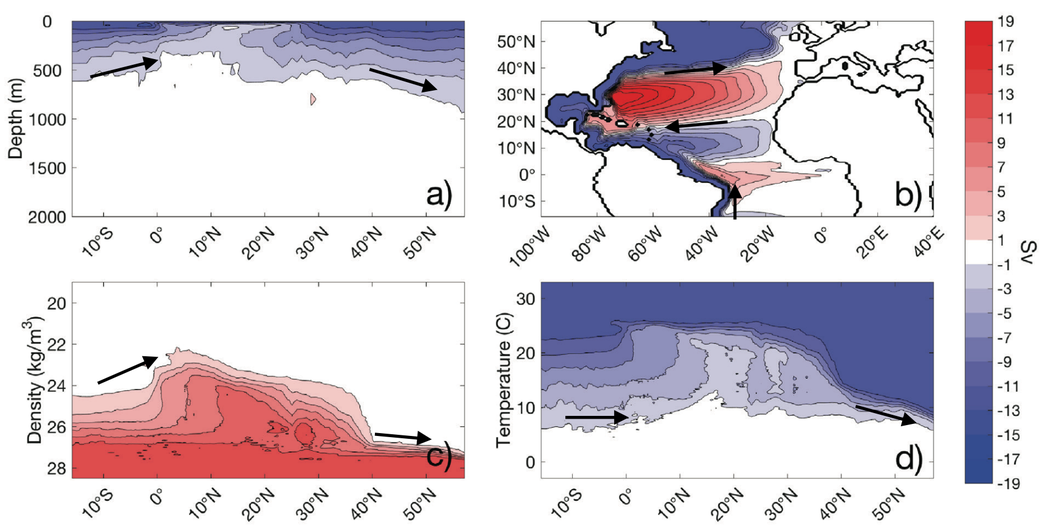
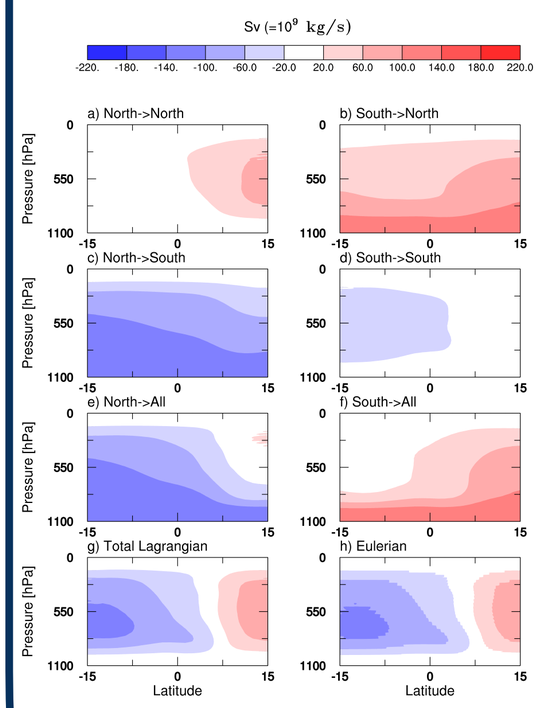
What's TRACMASS?

- TRACMASS is a Lagrangian trajectory code for ocean and atmospheric general circulation models (GCM).
- The TRACMASS scheme is **mass conserving** within the grid cell in the same way as the GCM.
- The code makes it possible to estimate water paths, **Lagrangian stream functions** (barotropic and overturning), exchange times, etc.
- TRACMASS has been set up to run with velocities integrated with models such as **NEMO, ROMS, MOM, ECMWF-IFS (ERA 5 and EC-Earth)**.



Example of Lagrangian stream functions





Top: Different lagrangian stream functions associated to the northward transport in the Atlantic Ocean: (a) meridional, (b) barotropic, (c) latitude–density, and (d) latitude–temperature stream functions. Taken from [2].

Left: Decomposition of the Hadley cells. The upper three rows show the Lagrangian stream function of transport between the different latitudes.

Quick start

1- Set up TRACMASS:

Enter the tracmass directory and copy the template Makefile

```
cd tracmass
cp Makefile_tmpl Makefile
```

Modify the Makefile to fit your system. You will also need to configure how TRACMASS should find the netCDF libraries, if at all. Then you can run the make command.

```
make
```

2- Running a test case:

Run the test case for TRACMASS by letting PROJECT and CASE be "theoretical" in the Makefile (which is the default).

In this case, TRACMASS will use a simple oscillating velocity field to trace trajectories. You can run this case by setting

```
./runtracmass
```

Get the code here →

GitHub repository: ***https://github.com/TRACMASS/tracmass***

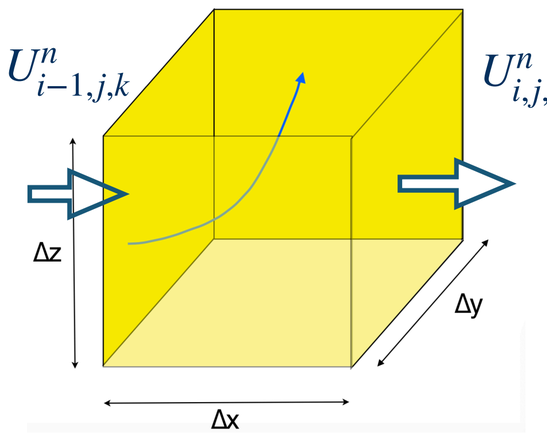
TRACMASS - A mass conserving trajectory code for ocean and atmosphere general circulation models

Mass conservation in TRACMASS

- TRACMASS uses **mass fluxes [kg/s]** instead of velocities [m/s]:

$$U^n_{i,j,k} = \rho^n_{i,j,k} \Delta y_{i,j} \Delta z_{i,j,k} u^n_{i,j,k}$$

which works with any vertical coordinate (z, p, z*, hybrid, σ levels, etc.) and both hydrostatic and non-hydrostatic settings.

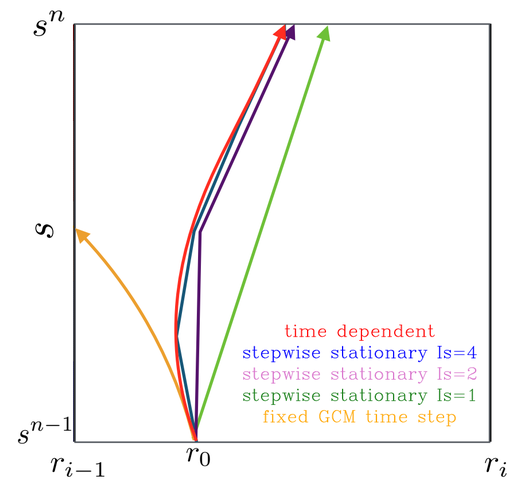


- The vertical mass fluxes are computed from the **continuity equation**:

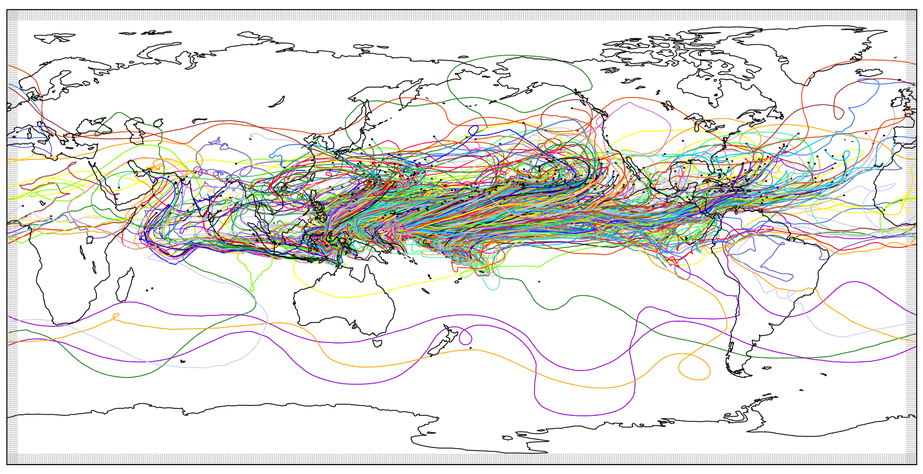
$$\frac{\partial M_{i,j,k}}{\partial t} + U_{i,j,k} - U_{i-1,j,k} + V_{i,j,k} - V_{i,j-1,k} + W_{i,j,k} - W_{i,j,k-1} = 0$$

- **Bilinear interpolation (space and time)** within the grid box of the mass transport.

- Analytical trajectory solution through the grid box.



More examples: Atmosphere



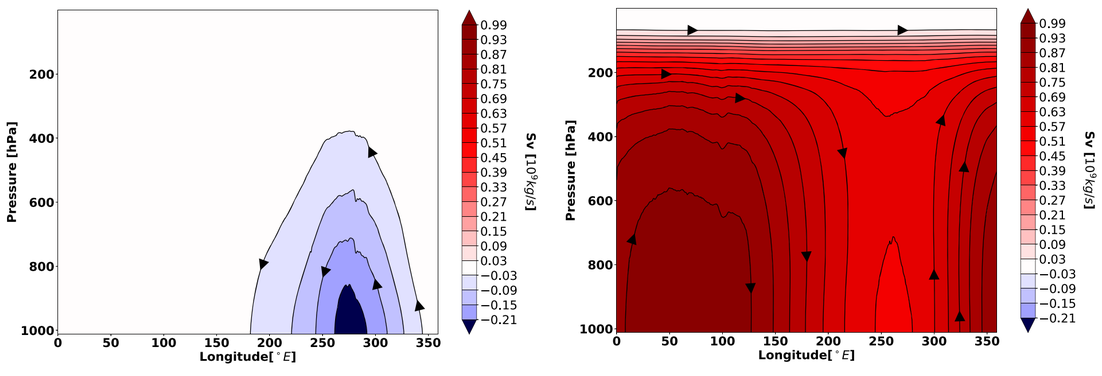
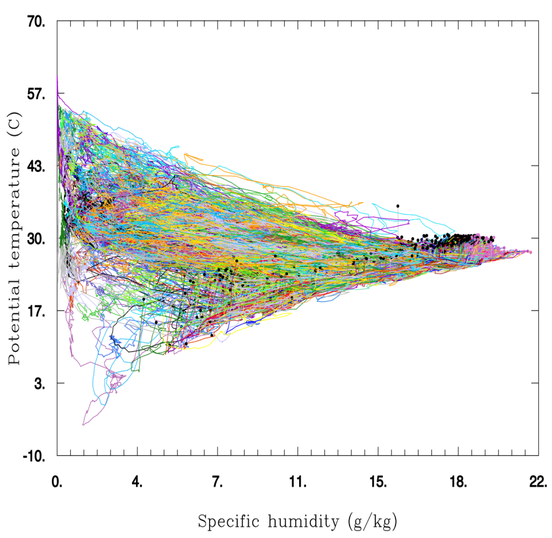


Figure taken from [3]



Ocean

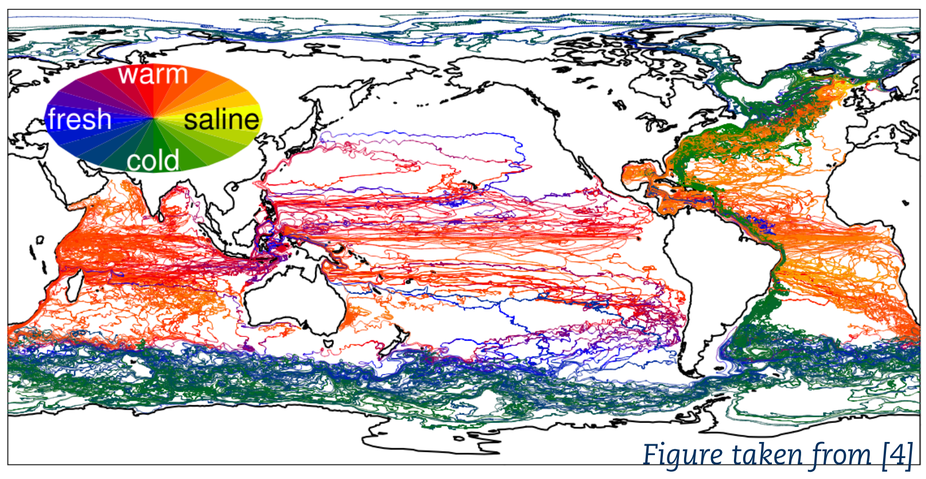
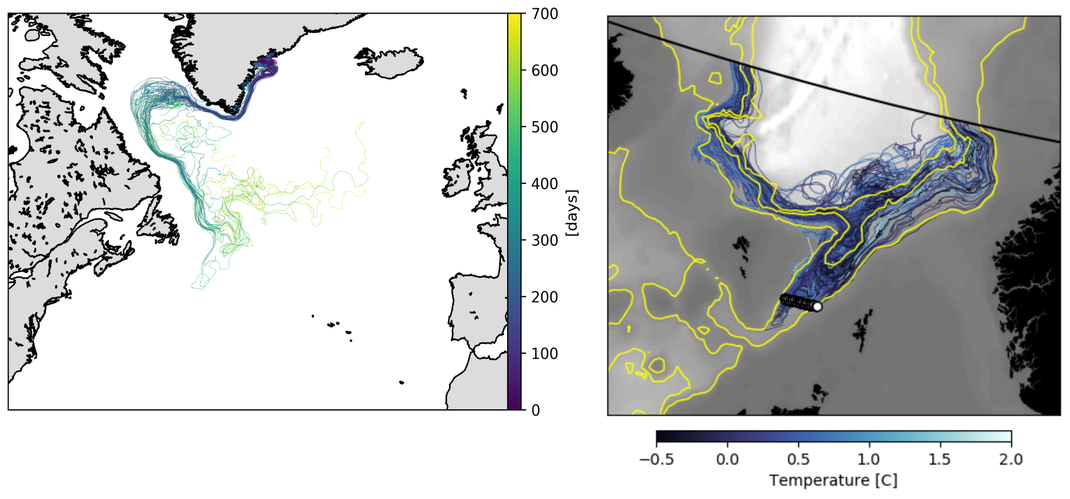


Figure taken from [4]



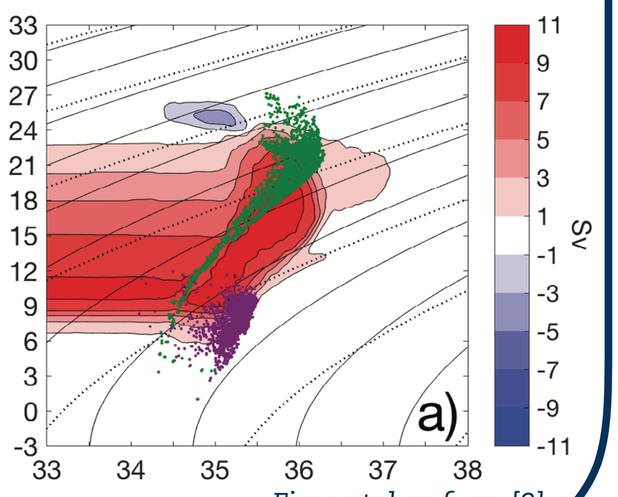


Figure taken from [2]

References

[1] Döös, K., Jönsson, B., and Kjellsson, J.: Evaluation of oceanic and atmospheric trajectory schemes in the TRACMASS trajectory model v6.0, Geosci. Model Dev., 10, 1733–1749, https://doi.org/10.5194/gmd-10-1733-2017, 2017.

[2] Sara Berglund, Kristofer Döös & Jonas Nycander (2017) Lagrangian tracing of the water–mass transformations in the Atlantic Ocean, Tellus A: Dynamic Meteorology and Oceanography, 69:1, DOI: 10.1080/16000870.2017.1306311

[3] Dey, Dipanjan & Döös, Kristofer. (2020). Atmospheric freshwater transport from the Atlantic to the Pacific Ocean: a Lagrangian analysis. Geophysical Research Letters. 10.1029/2019GL086176.

[4] Döös, K., J. Nilsson, J. Nycander, L. Brodeau, and M. Ballarotta, 2012: The World Ocean Thermohaline Circulation. J. Phys. Oceanogr., 42, 1445–1460, https://doi.org/10.1175/JPO-D-11-0163.1

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