# Salinity Conservation Updates

HadCM3 does not conserve salinity. In the original model, water was not fully conserved because of accumulation over the ice sheet, capping of salinity in enclosed ocean basins, internally draining rivers, and sub-grid scale lakes. This was accounted for by the addition of a prescribed water flux including an estimate of iceberg melting around the two major ice sheets and a small background value elsewhere. I think the file was created based on estimates of the melt from the ice sheets and the overall drift due to water losses based on an old version of HadCM3. The flux prevented major drifts in the salinity but, because the model is often changing (e.g. from MOSES1 to MOSES2), a small residual could remain, and this would be important for long multi-millennial integrations. Moreover, when the setup was changed to a different geological time, the drift could be substantial.

In theory, it would be possible to recalculate the water flux for any new time-period. This was tried by running the model for a few hundred years, then calculating the rate of salinity drift and converting it into water flux. This was only partially successful. It greatly slowed down the salinity drift initially, but the climate would drift slightly, and this would then feedback and lead to an acceleration and further significant drift in salinity.

Hence it was decided to implement a more empirical solution. At each time step, the global mean, volume integrated ocean salinity is calculated. The difference between this value and the prescribed value is calculated and the required flux of water/salinity is calculated based on relaxing the global mean back to the prescribed value on a prescribed time scale (typically 50-200 years but see later). The flux is added uniformly to the surface in which case it basically acts identically to the waterfix file but is interactive. A new STASH output is added so that it records the water flux and hence it is also possible to calculate an updated waterfix file at the end of the run. An alternative is that the flux can be added uniformly throughout the whole volume of the ocean. The benefit of this approach is that it is a very small additional forcing but is unphysical, especially if there is no melt water from the ice sheets (though adding a flux of water everywhere is also unphysical). It was used in our transient runs of the deglaciation because these simulations included a prescribed ice sheet melt so additional forcing was inappropriate.

Note that the additional flux is added in addition to any flux prescribed using the waterfix file. This allows us to prescribe geographically varying flux, such as additional melt from ice sheets.

## Modsets

There have been a considerable number of versions of this modset, although it is now beginning to stabilise. The following table gives a brief description of the evolution.

|  |  |
| --- | --- |
| Name | Description |
| cons\_salinity\_ver02\_33.83  cons\_salinity\_ver02\_34.43  cons\_salinity\_ver02\_34.63  cons\_salinity\_ver02\_34.83  cons\_salinity\_ver02\_35.0  cons\_salinity\_ver02\_35.83 | First working version. The target salinity was hardwired into the file, hence the multiple versions. The flux correction was calculated and simply added to any prescribed waterfix. There was no time scale. The flux was simply multiplied by 0.001! |
| cons\_salinity\_ver03\_34.83  cons\_salinity\_ver03\_35.0  cons\_salinity\_ver03\_35.83 | Some improvement and tidying of code but nothing major |
| cons\_salinity\_ver04\_34.83 | Identical to ver02 but a timescale was added. Initially “5 years” (though see subsequent descriptions). |
| cons\_salinity\_ver05\_33.83  cons\_salinity\_ver05\_34.83  cons\_salinity\_ver05\_35.83  cons\_salinity\_ver05a\_33.83  cons\_salinity\_ver05a\_34.43  cons\_salinity\_ver05a\_34.63  cons\_salinity\_ver05a\_34.83 | Some further improvements in the code. Code takes account of max/min salinity. Flux overwrites the STASH output for the waterfix. now added to the waterfix. The ver05a option used a global mean salinity when converting from water to virtual salinity flux. |
| cons\_salinity\_ver06  cons\_salinity\_ver06a  cons\_salinity\_ver06b  cons\_salinity\_ver06c | The global salinity target can now be input via a namelist. This requires a new hand\_edit called salinity\_update in ~swsvalde/scripts on puma. ver06a also added the ability to output the total waterfix (calculated + prescribed). This required a new userstash file total ~swsvalde/umui\_jobs/prestash/total\_waterfix. ver06b and ver06c are as ver06a except using a relaxation period of “25” and “50” years. |
| cons\_salinity\_ver07  cons\_salinity\_ver07o | Added the ability to have a time dependent target for the global mean salinity. Used code similar to that for time varying CO2. The ver07o further added in the creation of a file salinitytarget.dat which recorded the variation. |
| cons\_salinity\_ver08o | Output .dat filename now included the RUNID name. |
| cons\_salinity\_ver09o  cons\_salinity\_ver09o\_alk  isotopes/cons\_salinity\_ver09o\_iso  isotopes/cons\_salinity\_ver09o\_iso1 | Identified major bug in the time scale code. Previous version forgot to add scaling from days to seconds with the result that it was much faster than expected. Improved the namelist inputs, and the input of time dependent global mean salinity. Can now input (via namelist) the timescale, the number of levels where the waterfix applies, and the frequency of output. ver09o\_alk added relaxation of alkalinity (when using HADOCC). ver09o\_iso added for water isotopes (18O and D). ver09o\_iso1 added for just one water isotope (18O). |
| cons\_salinity\_ver10d  cons\_salinity\_ver10d\_alk  isotopes/ cons\_salinity\_ver10d\_iso  isotopes/ cons\_salinity\_ver10d\_iso1 | Rewrote the code to make it easier to maintain when faced with lots of tracer conservation. Could not make one universal modset, but could make it so there are very small changes when adding tracers. |

## Setup of Latest Version (cons\_salinity\_ver10d and permutations)

To add the conservation update, four aspects of the umui must be changed:

1. the modset must be added
2. the file ~swsvalde/scripts/salinity\_update must be added to the hand edits
3. Add the user STASH file ~swsvalde/umui\_jobs/prestash/total\_waterfix (or waterfix\_alk or isotopes/waterfix\_iso or isotopes/waterfix\_is1) and STASH output selected for the new variables (323,324,325 respectively). Normally add as monthly means to the pf files.
4. New variables need to be added to the Sub-Model Independent -> Script Inserts and Modifications. This, together with the hand\_edit, will add the variables to the namelist.

## Description of the namelist variables.

The following variables can be added to the Sub-Model Independent -> Script Inserts and Modifications section of the umui and which control the update.

|  |  |  |  |
| --- | --- | --- | --- |
| **Description** | **Variable in umui** | **Variable in namelist** | **Default** |
| Target global volume integrated salinity | GLOBAL\_SALINITY | GLOBAL\_TRAC(2) | 34.83 |
| Relaxation time scale for salinity (in years) | RELAX\_TIME\_SAL | RELAX\_TIME\_TRAC(2) | 50.0 |
| Maximum number of layers to apply interactive salinity flux | NLAYER\_SAL | NLAYER(2) | 1 |
| Output frequency for tracer diagnostics contained in .dat file. | NOUTPUT\_TRAC | NOUTPUT\_TRAC | 12 steps |
| Target global volume integrated alkalinity | GLOBAL\_ALK | GLOBAL\_TRAC(4) | 2500 |
| Relaxation time scale for alk (in years) | RELAX\_TIME\_ALK | RELAX\_TIME\_TRAC(4) | 50 |
| Maximum number of layers to apply interactive alk flux | NLAYER\_ALK | NLAYER(4) | 0 (meaning added to all levels) |
| Target global volume integrated 18O | GLOBAL\_18O | GLOBAL\_TRAC(3) | 2005.2e-6 (or equivalently 0‰). You can also set the value by setting variable to be 0 per mill |
| Relaxation time scale for 18O (in years) | RELAX\_TIME\_18O | RELAX\_TIME\_TRAC(3) | 50 |
| Maximum number of layers to apply interactive 18O flux | NLAYER\_18O | NLAYER(3) | 0 |
| Target global volume integrated deuterium | GLOBAL\_DEU | GLOBAL\_TRAC(4) | 155.76e-6 (or equivalently 0‰). You can also set the value by setting variable to be 0 per mill |
| Relaxation time scale for deu (in years) | RELAX\_TIME\_DEU | RELAX\_TIME\_TRAC(4) | 50 |
| Maximum number of layers to apply interactive deu flux | NLAYER\_DEU | NLAYER(4) | 0 |

To add a time dependent forcing, you need to prepare a hand\_edit. It is simplest to understand by looking at ~swsvalde/scripts/deglac/sal\_deglac\_ver02 on puma.