Elmer/Ice - NEMO coupled framework

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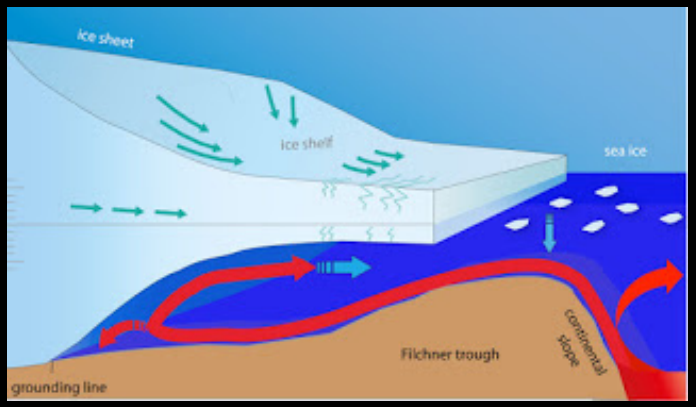
Ocean − Ice shelf interactions

↓

Melting

↓

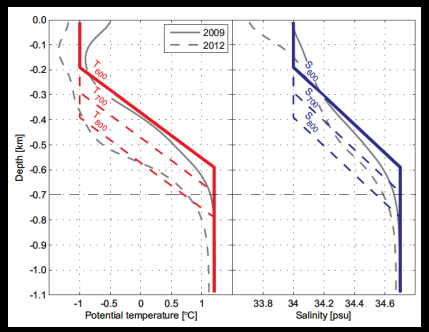
Ice dynamics

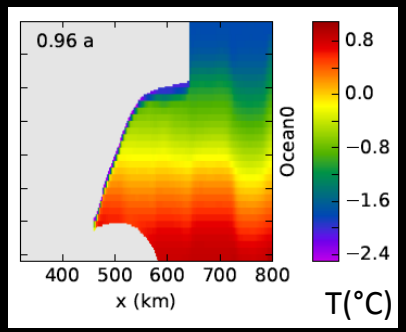


Why using ocean/ice coupled models rather than melt parameterizations?

- Accounting for the temperature profile and its modification in the ice shelf cavity

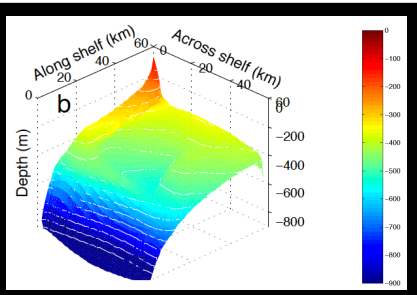
De Rydt et al. (2014)





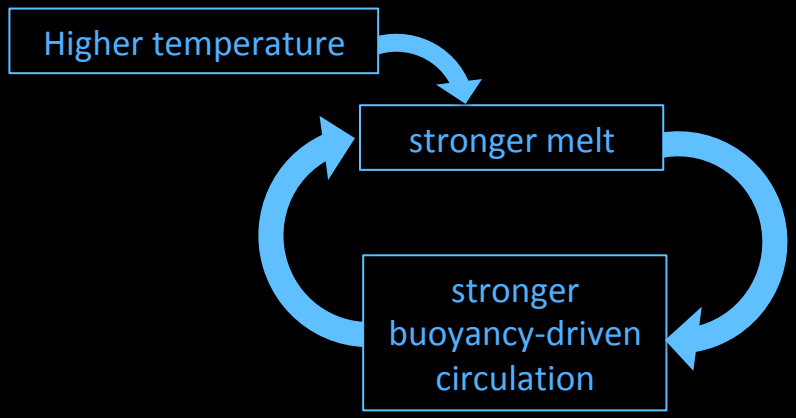
Asay-Davis et al. (2016)

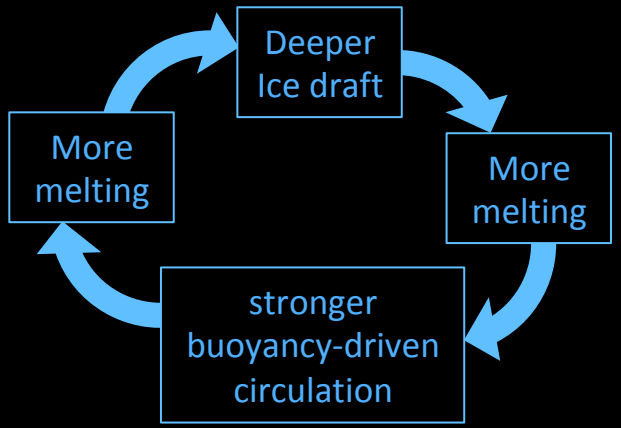
- Accounting for the "Coriolis Jet" and channelized melting



Jordan et al. (2017)

- Accounting for ice/ocean feedbacks :

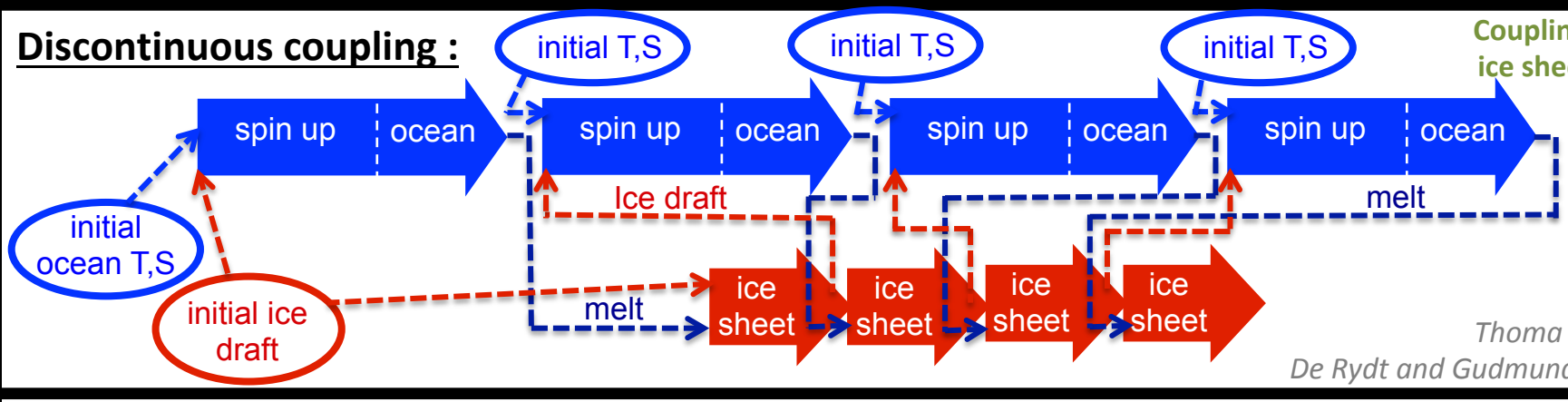




+ feedbacks involving the entire Southern Ocean (Asay Davis et al. 2017)

Different approaches to couple ocean and ice sheet models (*Jordan et al. 2017*) :

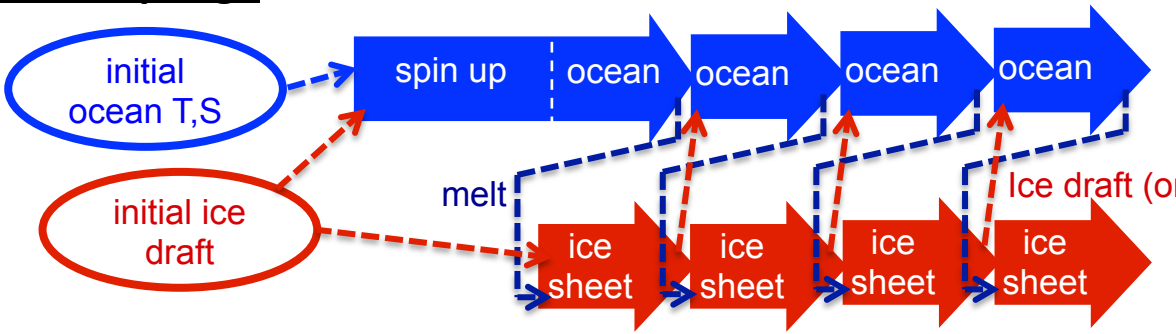
Discontinuous coupling :



Coupling every few ice sheet time step

Thoma et al. (2015)
De Rydt and Gudmundsson (2016)

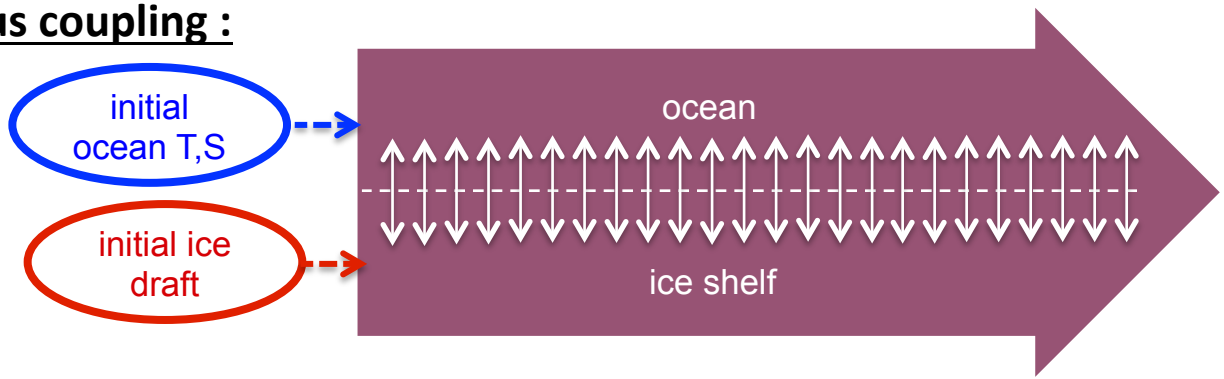
Asynchronous coupling :



Coupling every few ice sheet time step

Seroussi et al. (2017)
Elmer/Ice & ROMS
Elmer/Ice & NEMO

Synchronous coupling :



Coupling every ocean time step

Same grid for ice sheet and ocean

Jordan et al. (2017)

Two existing coupled frameworks to couple Elmer/Ice to an ocean model :

- **FISOC** (Rupert Gladstone's presentation)
- **Grenoble's framework** (the following slides)

Grenoble's coupling framework (Elmer/Ice – NEMO)

Icexxpar0002.vtu

MISOMIP_Melt_Consv.F90

```
SUBROUTINE MISOMIP_Melt_Consv( Model,Solver,dt,Transient )
!------------------------------------------------------------------------------
SUBROUTINE BilinealInterp(xP,yP,NETCDFValues,meltInterp, dxarg, dyarg, xInitarg, yInitarg)
```

bi-linear interp. of melt rates + overall conservation

Interpolation
(weights from VTK)
C++

isf_draft_meter.nc

Implemented in the standard release (from v3.7)

Simply set :

```
ln_iscpl = .true.                    (namelist)
<field field_ref="fwfisf" />         (iodef.xml)
```

→ Extrapolation of T,S and conservation of barotropic velocities

melt_rates.nc

Models run sequentially
(starting from restart files)

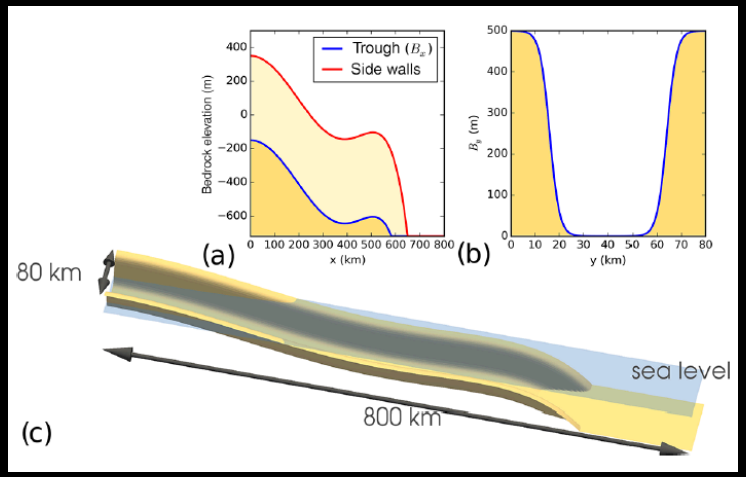
Libraries: VTK, Netcdf, Netcdf-c++

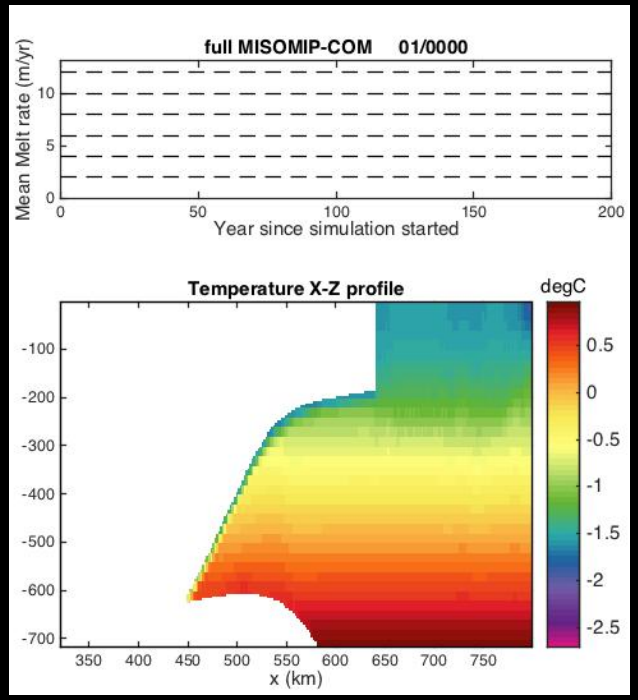
in terms of sif specifications:

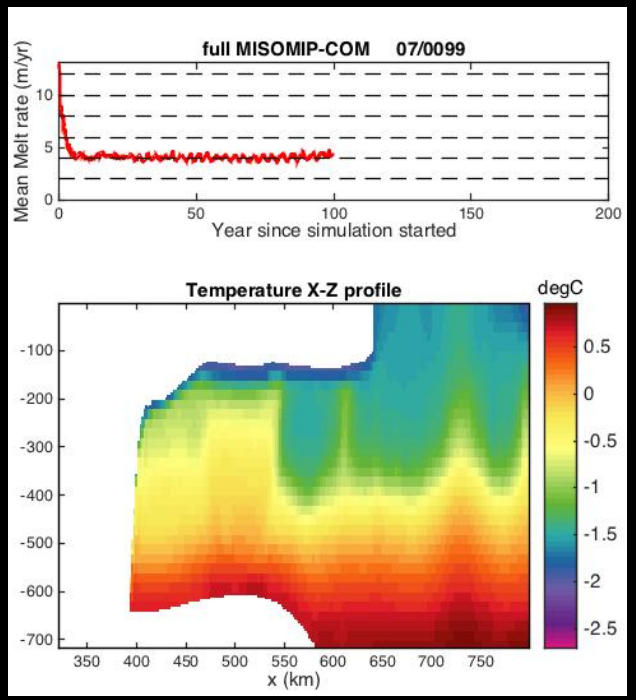
```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Body Force 1
  Flow BodyForce 1 = Real 0.0
  Flow BodyForce 2 = Real 0.0
  Flow BodyForce 3 = Real $gravity
  Top Surface Accumulation = Real $accu
  Bottom Surface Accumulation = equals Melt
  !Water Pressure for effective pressure calculation
    Water Pressure = Variable Zb
     Real procedure "/scratch/shared/egige60/ELMER_MISOMIP/CPL_MISOMIPr/Executables//USF_WaterPressure" "WaterPressure"
End
```

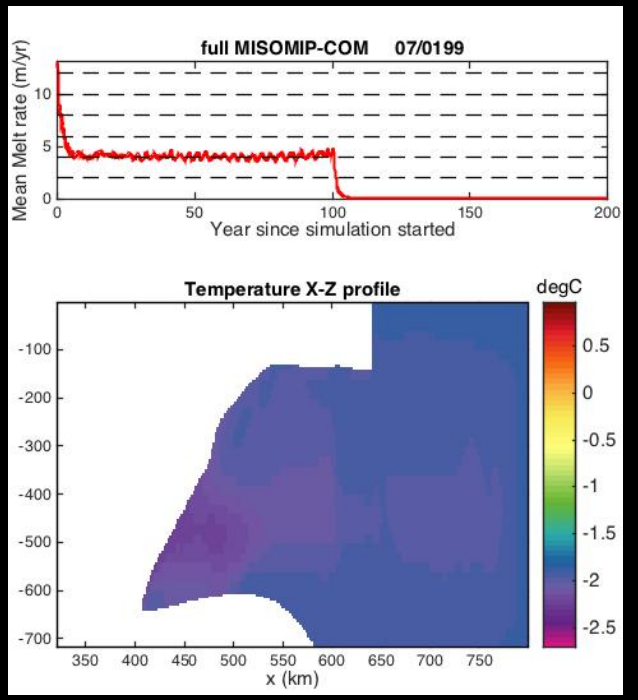
```
Solver 7
   Exec Solver = Before Simulation
   Equation = "MISOMIP_MELT"
   Variable = Melt
   Procedure = "/scratch/shared/egige60/ELMER_MISOMIP/CPL_MISOMIPr/Executables//MISOMIP_Melt_Consv" "MISOMIP_Melt_Consv"
   Draft file = File "isf_draft_meter.nc"
   Melt rates file = File "/home/njourd/CM_MISOMIP/RUNS/CPL_MISOMIPr/melt_rates.nc"
End
```

Example : MISOMIP

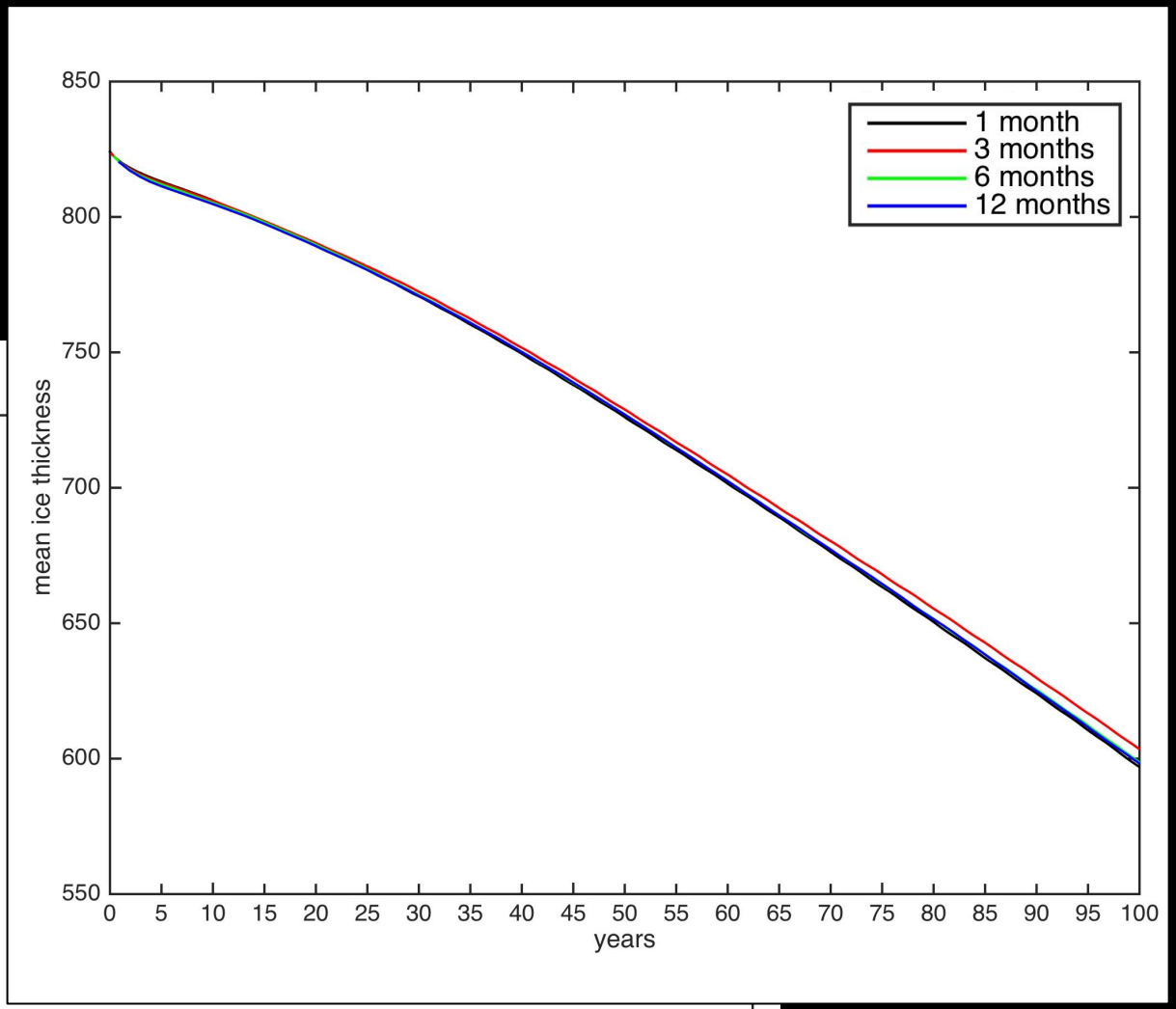


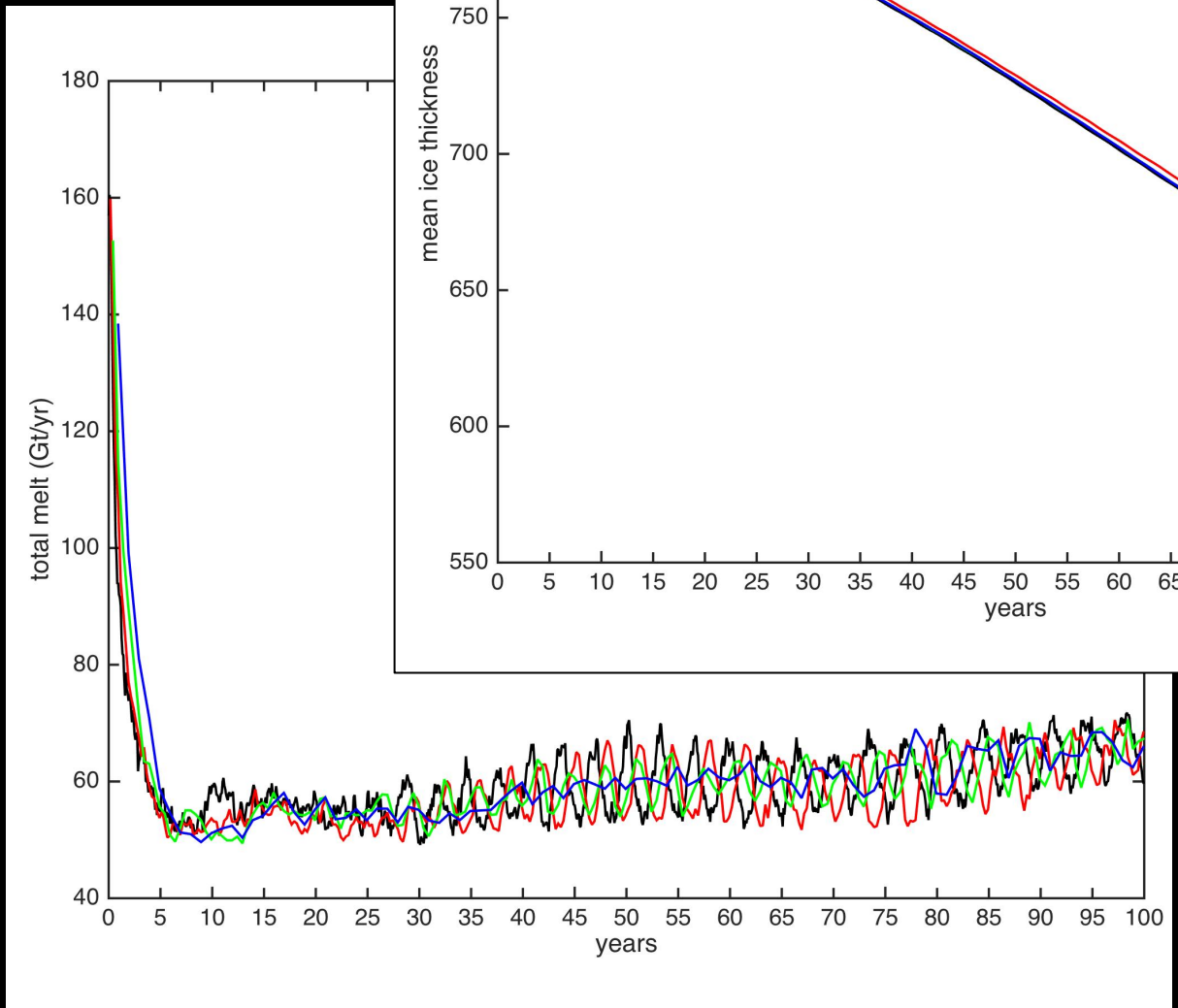




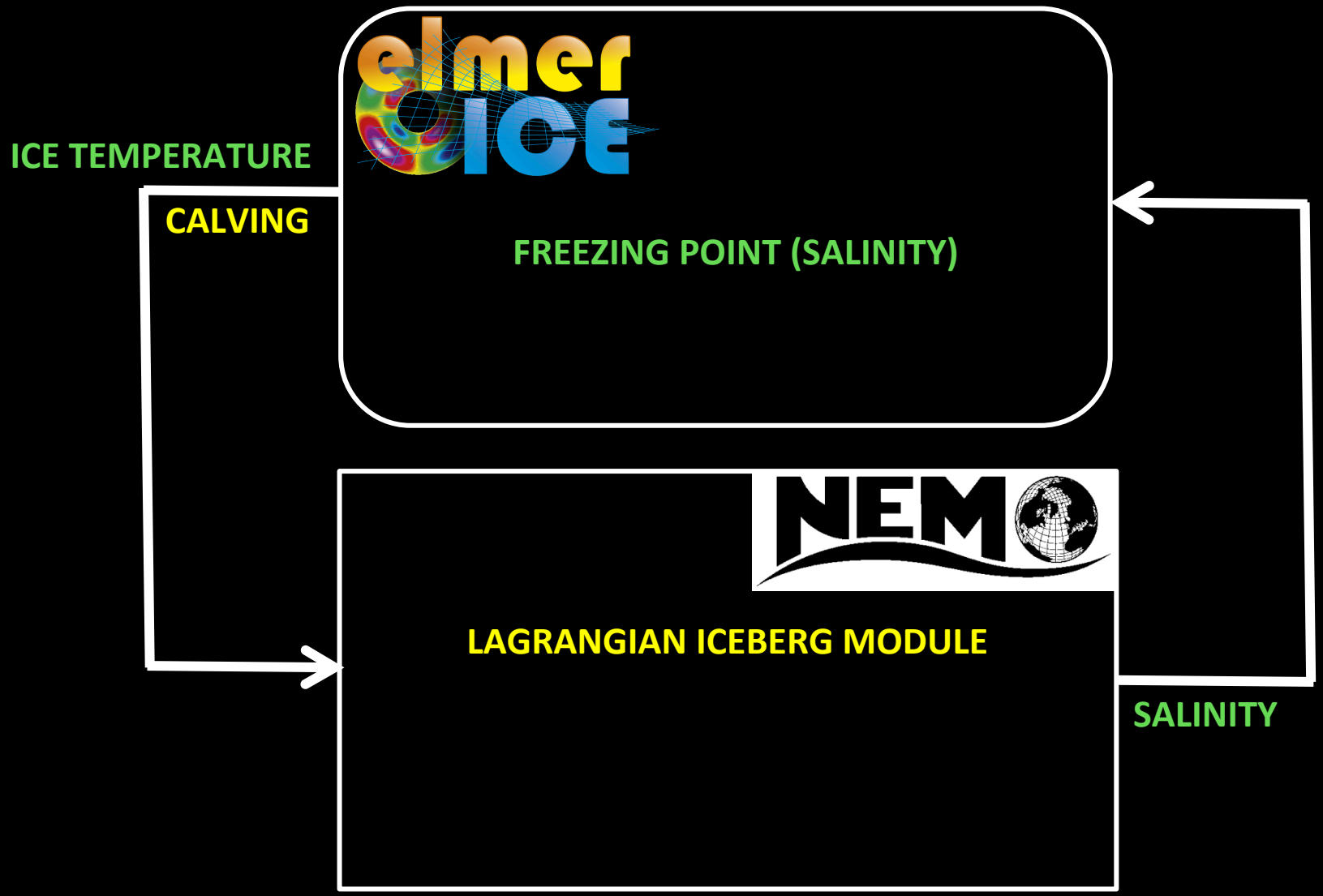


Sensitivity to the coupling time step





Future possible developments:



Conclusion :

- Can be implemented in any ESM based on NEMO (UKMO, CNRM, IPSL, EC-EARTH) with limited modifications of the production scripts (just need to call Elmer/Ice then the interpolation script every few months/years of ocean/atmosphere).
- Should be relatively easy to use with Elmer/Ice and other ocean models.
- “Config Manager” (bash package) to very easily launch multiple MISOMIP-like simulations, to choose initial conditions, time steps, etc (Nacho Merino).
- On-going work to develop the Config Manager for realistic configurations (Lionel Favier).
- Full package soon on the Elmer/Ice wiki and my personal github with documentation.