The different developments and uses of NEMO surface restoring (sbcssr.F90) at BSC

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Nemo meeting, October 11th 2018

EXCELENCIA SEVERO OCHOA

BSC Barcelona Supercomputing Center
Centro Nacional de Supercomputación

MARIE CURIE ACTIONS
INADEC

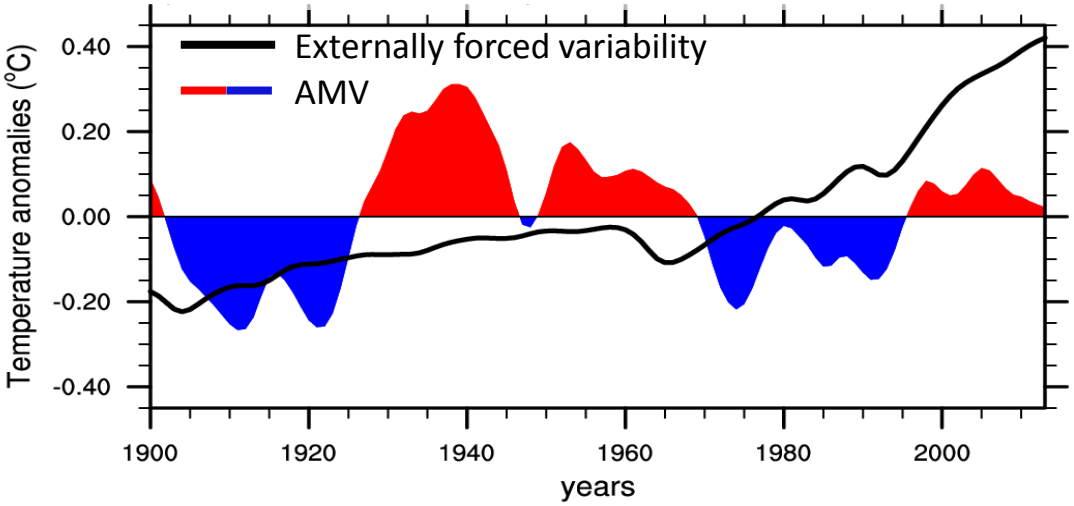
Decadal Climate Prediction Panel of CMIP6

DCPP Component C: Predictability, mechanisms and case studies (Boer et al. 2016)

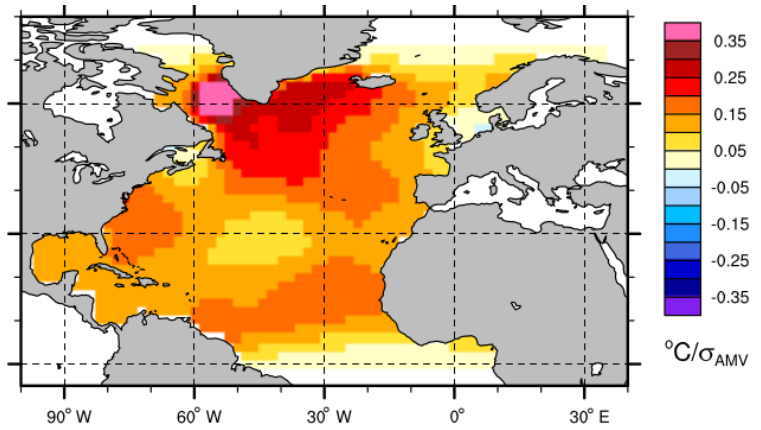
- Experiments to understand **coupled climate model** decadal variability
- Attribution of observed decadal climate variability to Atlantic / Pacific SST variations

In particular: Idealized Atlantic Multidecadal Variability (AMV) experiments

North Atlantic SST time series (Ting et al. 2009)

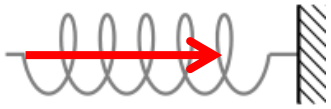


AMV pattern



(dataset: Ersst_v4)

Decadal Climate Prediction Panel of CMIP6

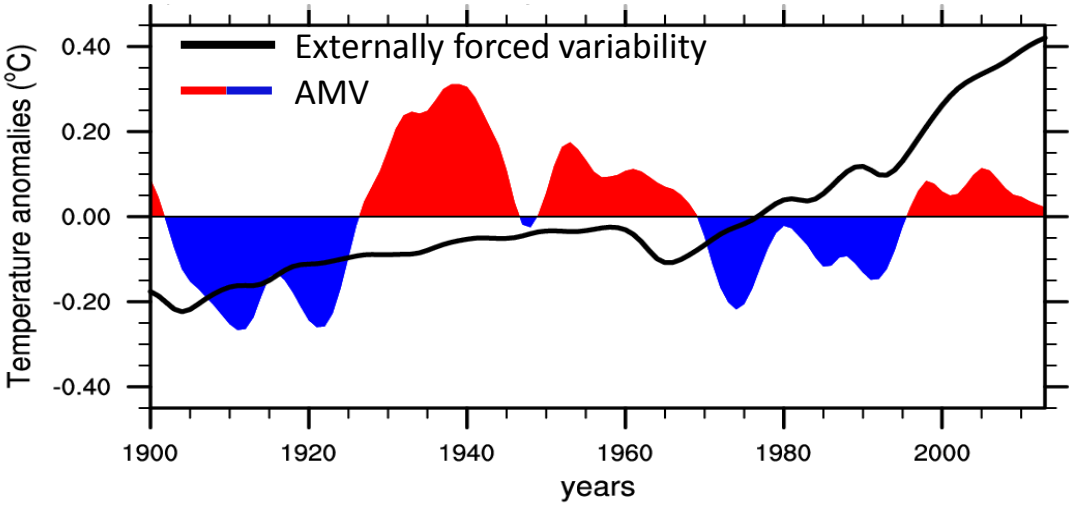
Coupled model daily North Atlantic SST  Climatology **+/- AMV pattern**

Restoring of SST through non-solar surface surface fluxes (cf. **sbcssr.F90**):

$$Q_k = Q_k^o + \gamma(SST_k^o - SST_{AMV})$$

- Restoring coefficient of **γ = -40W/m²/K** over North Atlantic (Eq-70°N)
- Free ocean-ice-land-atmosphere interactions outside of North Atlantic

North Atlantic SST time series (Ting et al. 2009)



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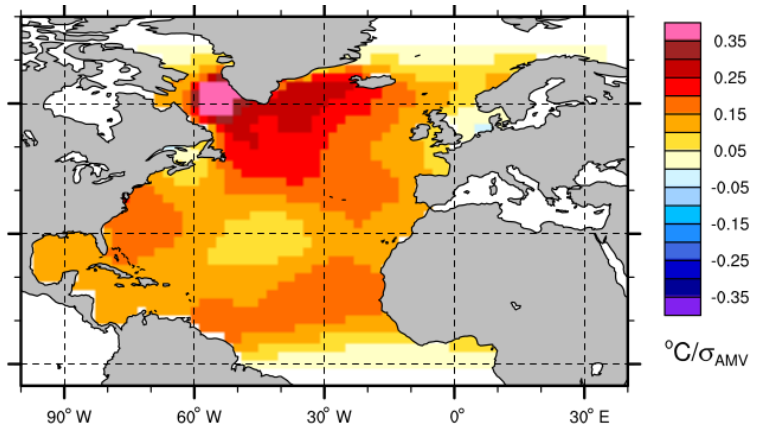


(dataset: Ersst_v4)

Sbcssr.F90 namelist

```
!-----------------------------------------------------------------------
&namsbc_ssr    !   surface boundary condition : sea surface restoring
!-----------------------------------------------------------------------
!             !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights
!             !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename
   sn_sst     = 'sst_data'  ,        24         ,  'sst'    ,    .false.   , .false., 'yearly'  , ''
   sn_sss     = 'sss_data'  ,        -1         ,  'sss'    ,    .true.    , .true. , 'yearly'  , ''

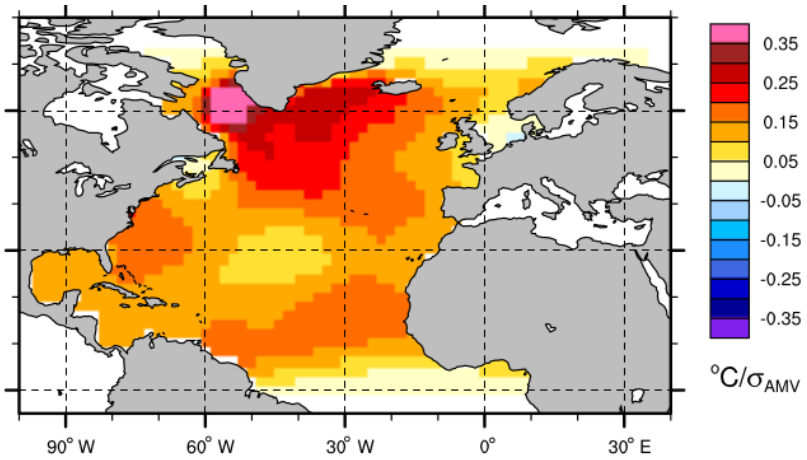
   cn_dir     = './'      !  root directory for the location of the runoff files
   nn_sstr    =     0     !  add a retroaction term in the surface heat       flux (=1) or not (=0)
   nn_sssr    =     2     !  add a damping     term in the surface freshwater flux (=2)
                          !  or to SSS only (=1) or no damping term (=0)
   rn_dqdt    =   -40.    !  magnitude of the retroaction on temperature   [W/m2/K]
   rn_deds    =  -166.67  !  magnitude of the damping on salinity   [mm/day]
   ln_sssr_bnd =   .true.  !  flag to bound erp term (associated with nn_sssr=2)
   rn_sssr_bnd =   4.e0    !  ABS(Max/Min) value of the damping erp term [mm/day]
/
```

- sn_sst / sn_sss: information on sst/sss restoring files to use
- nn_sstr / nn_sssr: activation keys for sst/sss restoring
- rn_dqdt / rn_deds: strenght of the restoring coefficent

rn_dqdt = **ɣ = -40W/m²/K**

$$Q_k = Q_k^o + \gamma(SST_k^o - SST_{AMV})$$

Question 1: what to do over region where model simulates too much sea-ice?



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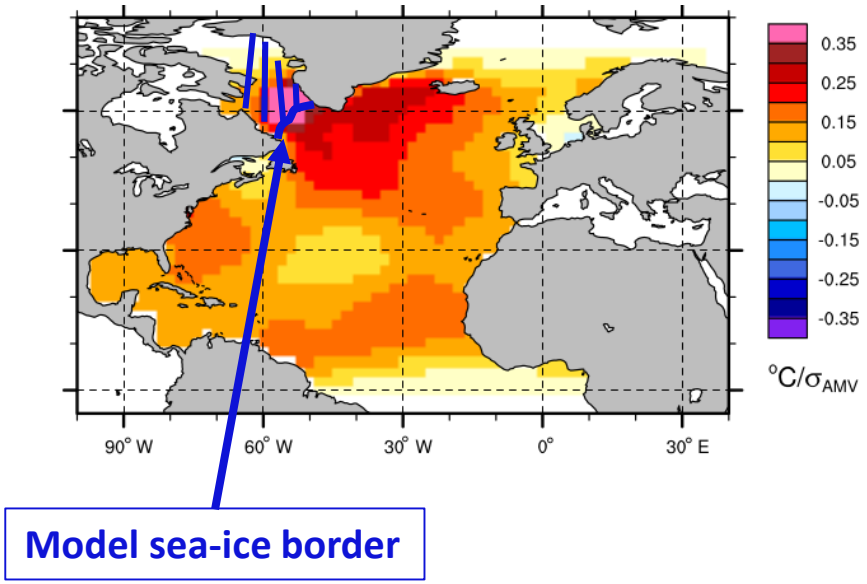

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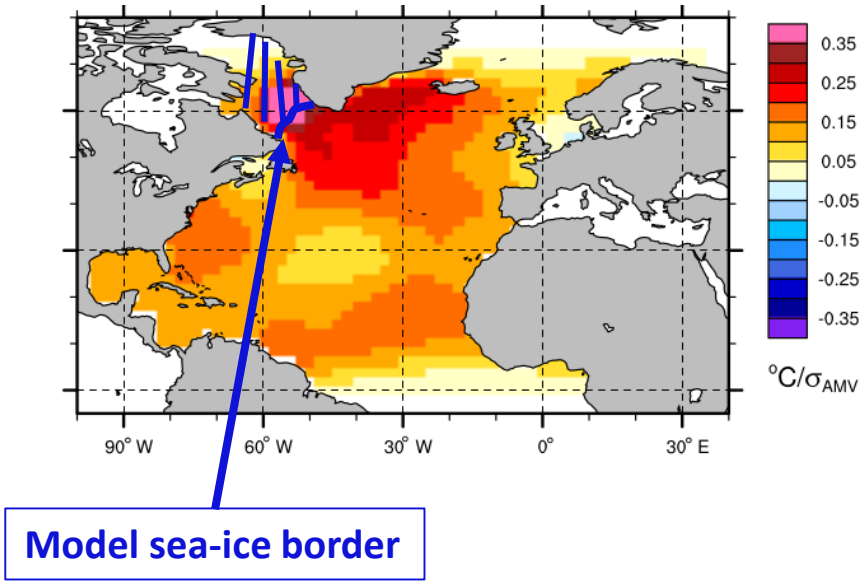

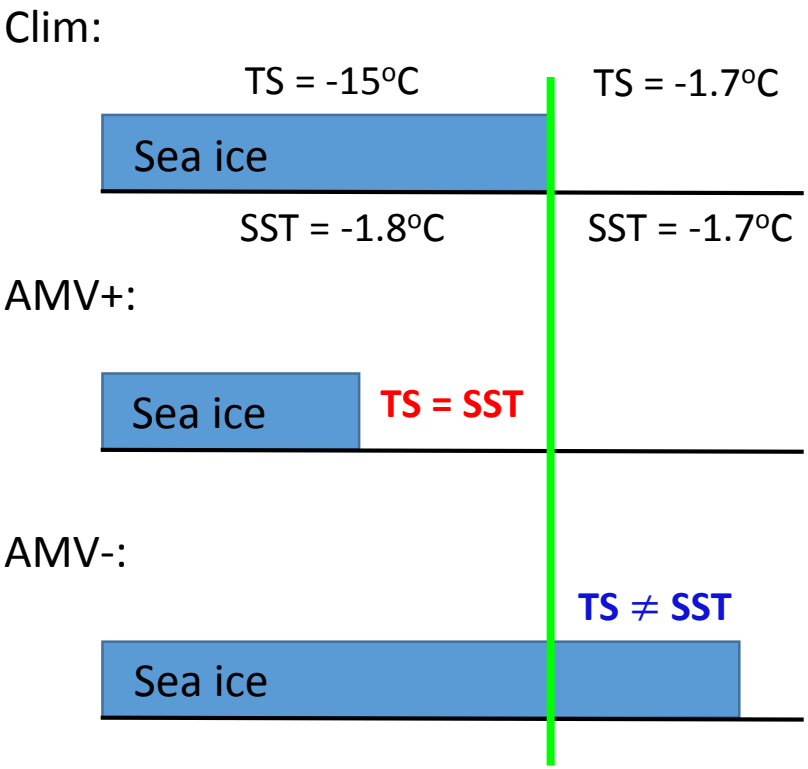

Conclusion: No restoring over sea-iced regions

➔ Introduction of a key in the namelist:

nn_icedmp

ΔTS = 15°C

➔ introduction of spurious anomalies!!

Sbcssr.F90 namelist

```
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&namsbc_ssr    !   surface boundary condition : sea surface restoring
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!             !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights
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   nn_sssr    =     2     !  add a damping     term in the surface freshwater flux (=2)
                          !  or to SSS only (=1) or no damping term (=0)
   nn_icedmp  = 0         !  Cntrl of surface restoration under ice nn_icedmp
                          !  ( 0   =  no restoration under ice )
                          !  ( 1   =  restoration everywhere  )
   rn_dqdt    =   -40.    !  magnitude of the retroaction on temperature   [W/m2/K]
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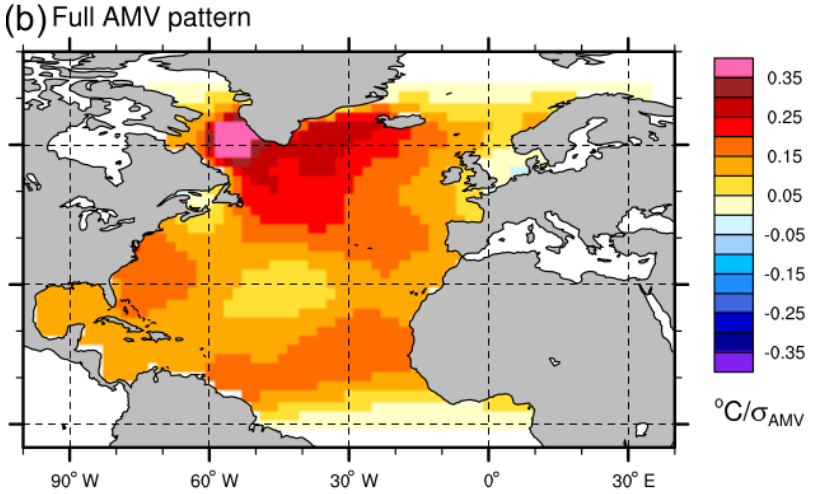
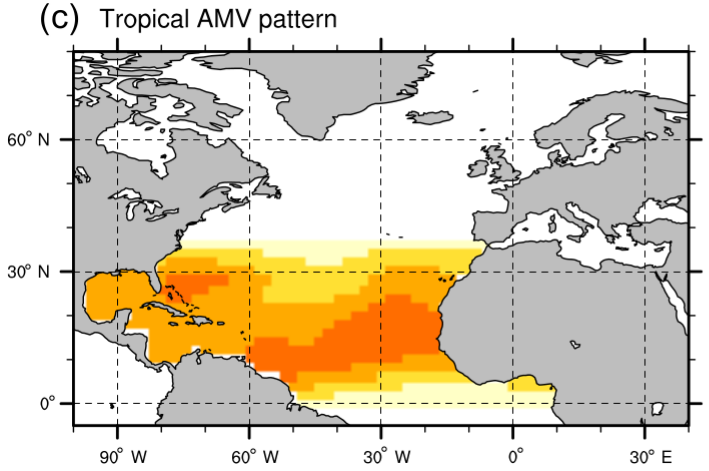
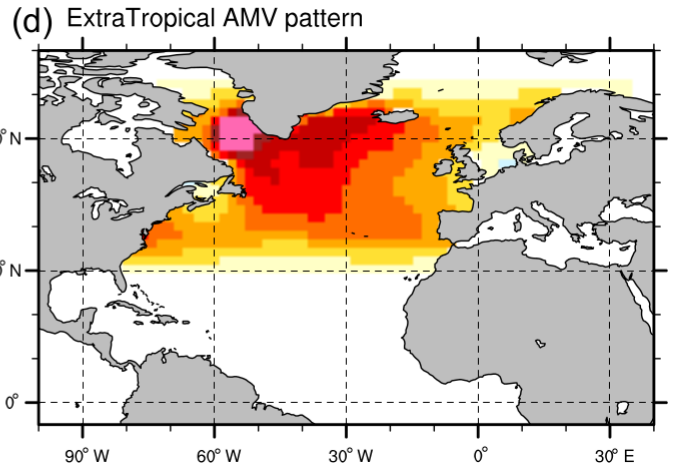
- nn_sstr / nn_sssr: activation keys for sst/sss restoring
- rn_dqdt / rn_deds: strenght of the restoring coefficent
- **nn_icedmp: activation key for surface restoring under ice**

Question 2: Do I need to change the restoring files to change the region of restoring?



Masking the data will do the trick
➔ Introduction of a mask file:
sn_msk





Sbcssr.F90 namelist

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!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights
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   sn_sst      = 'sst_data'   ,        24         ,  'sst'    ,    .false.    , .false., 'yearly'   , ''
   sn_sss      = 'sss_data'   ,        -1         ,  'sss'    ,    .true.     , .true. , 'yearly'   , ''
   sn_msk      = 'mask_restore' ,     -12.        , 'mask_ssr',    .false.    , .true. , 'yearly'   , ''

   cn_dir      = './'      !  root directory for the location of the runoff files
   nn_sstr     =     0     !  add a retroaction term in the surface heat       flux (=1) or not (=0)
   nn_sssr     =     2     !  add a damping     term in the surface freshwater flux (=2)
                           !  or to SSS only (=1) or no damping term (=0)
   nn_icedmp   = 0         !  Cntrl of surface restoration under ice nn_icedmp
                           !  ( 0   =  no restoration under ice )
                           !  ( 1   =  restoration everywhere  )
   nn_msk      = 1         !  add a sub-regional masking to the surface restoring (=1) or not (=0)
   rn_dqdt     =   -40.    !  magnitude of the retroaction on temperature   [W/m2/K]
   rn_deds     =  -166.67  !  magnitude of the damping on salinity   [mm/day]
   ln_sssr_bnd =   .true.  !  flag to bound erp term (associated with nn_sssr=2)
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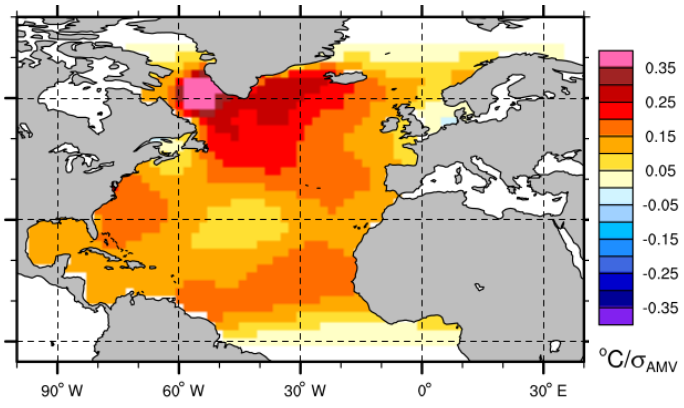
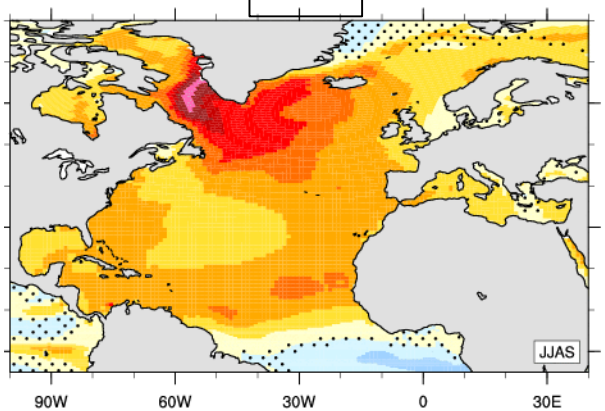
- sn_sst / sn_sss: information on sst/sss restoring files to use
- nn_sstr / nn_sssr: activation keys for sst/sss restoring
- rn_dqdt / rn_deds: strenght of the restoring coefficent
- **nn_icedmp: activation key for surface restoring under ice**
- **nn_msk/sn_msk: activation key for and information on restoring mask**

Decadal Climate Prediction Panel of CMIP6

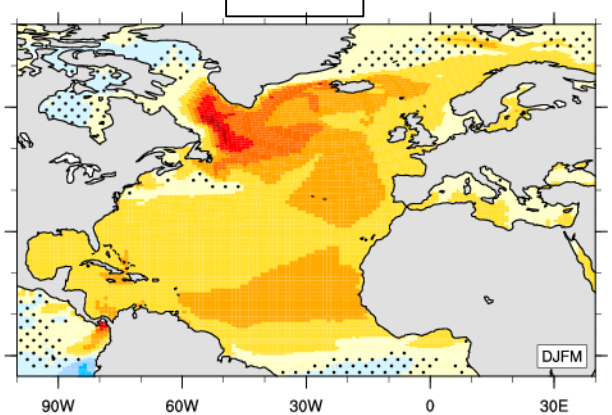
Question 3: SST not constrained the same way over all grid points, what can we do about it?



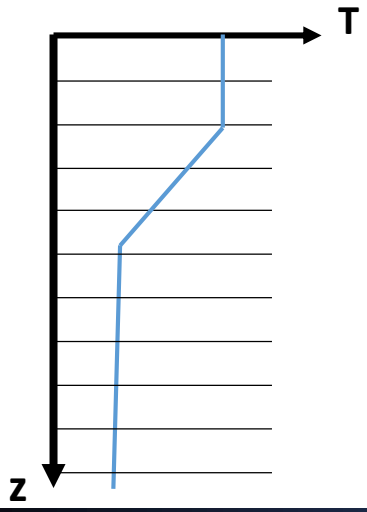
JJAS



DJFM



<u>JJAS</u>:
shallow mixed layer



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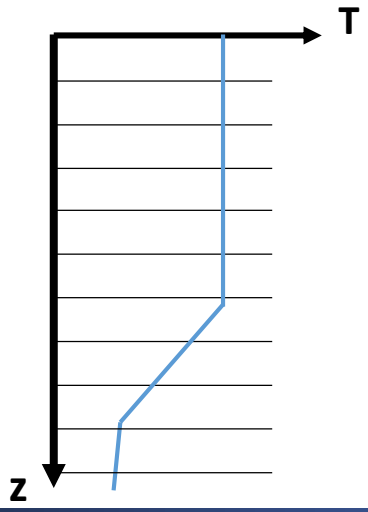
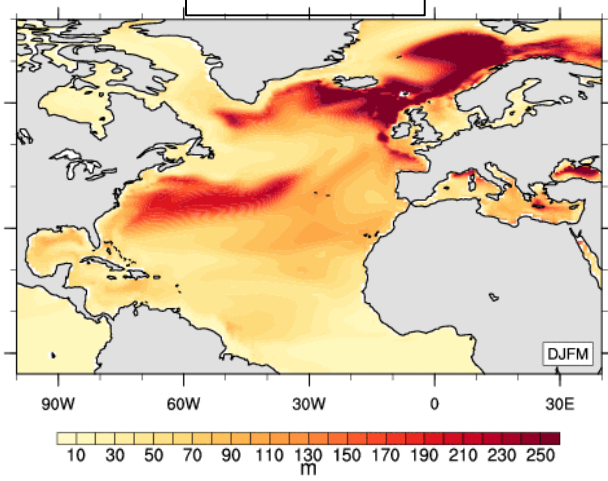


DJFM - mld



Decadal Climate Prediction Panel of CMIP6

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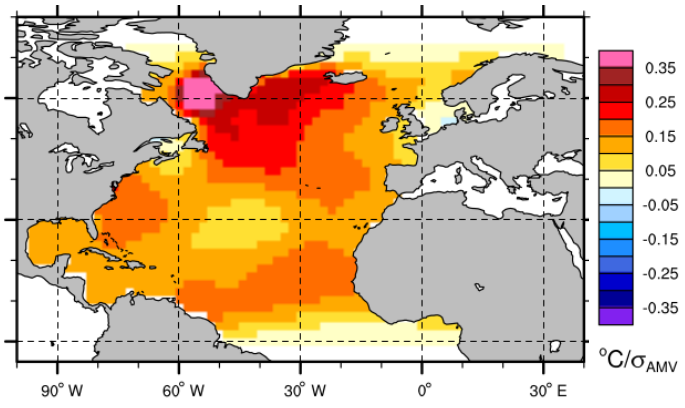
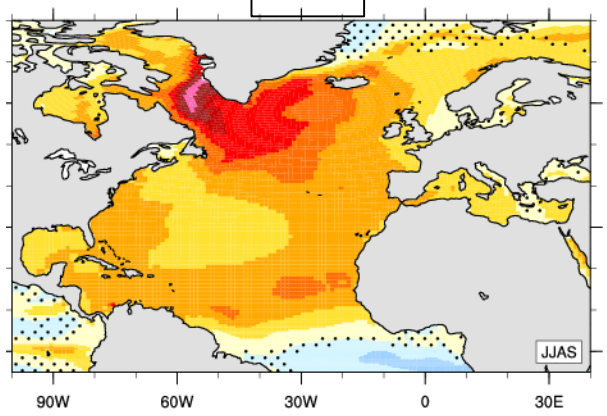
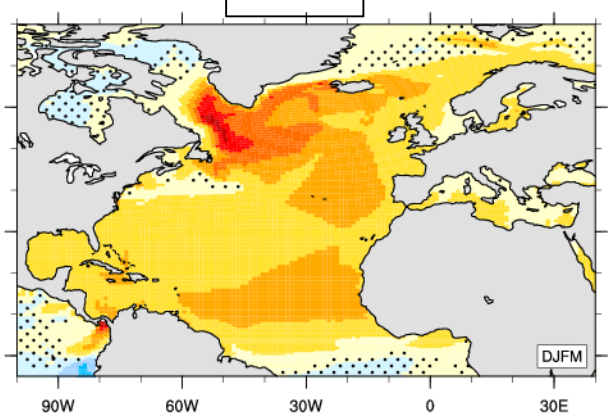


JJAS



DJFM



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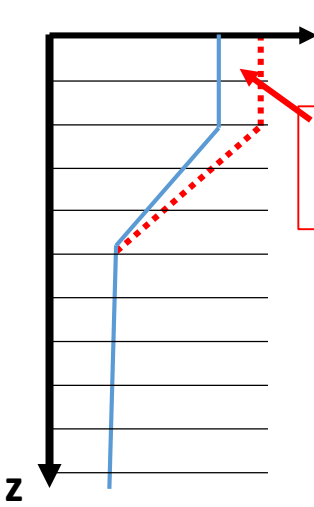
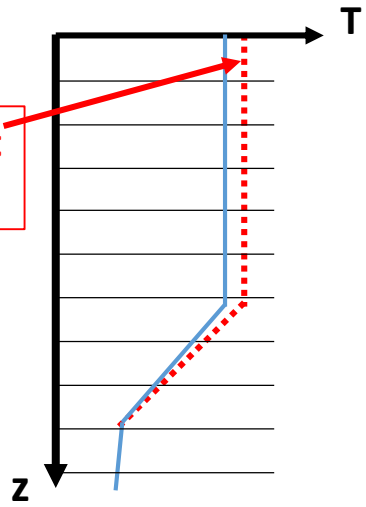
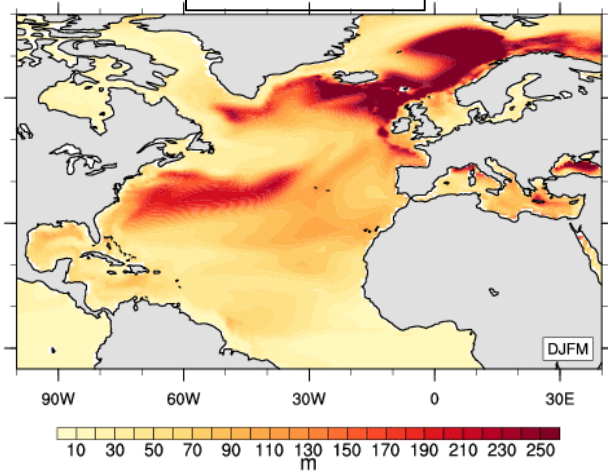


DJFM:
deep mixed layer



Same amount of heat

DJFM - mld



Decadal Climate Prediction Panel of CMIP6

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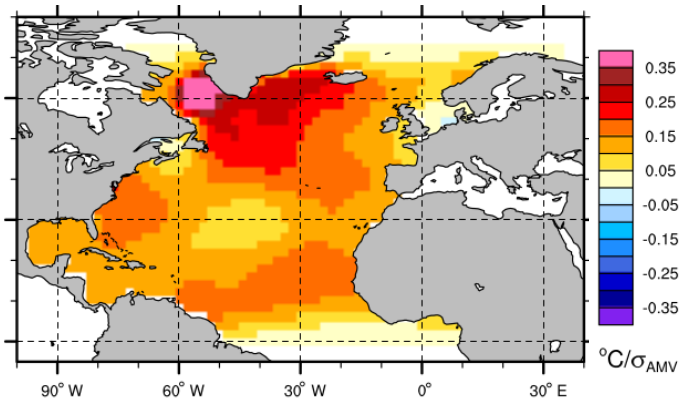

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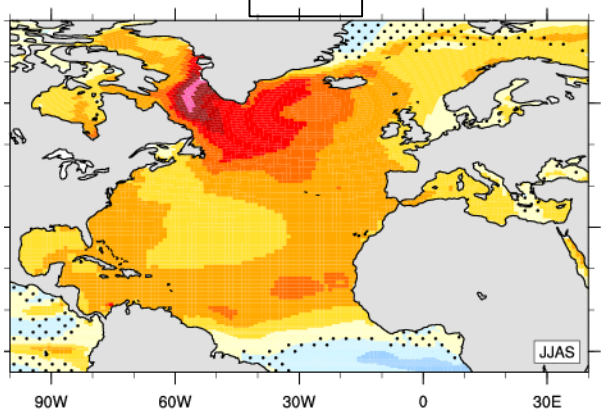

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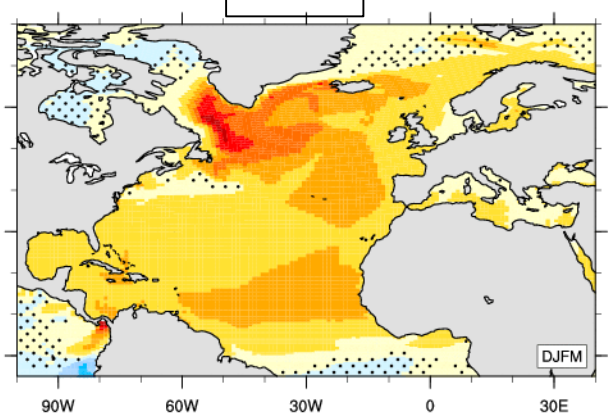


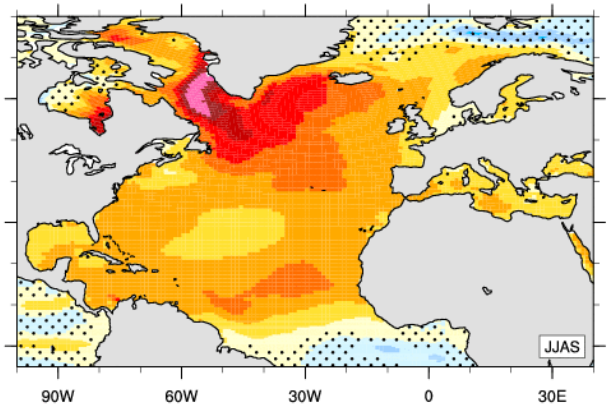
$$Q_k = Q_k^o + \gamma(SST_k^o - SST_{AMV})$$

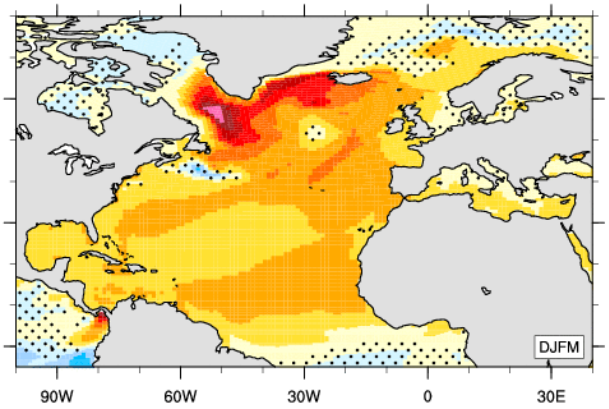
γ fixed to -40W/m^2/K

⬇

γ function of mixed layer depth

$$\gamma(t) = \gamma_{ref} \times \frac{mld(t)}{mld_{ref}}$$





http://forge.ipsl.jussieu.fr/decennal/wiki/vargamma

Decadal Climate Prediction Panel of CMIP6

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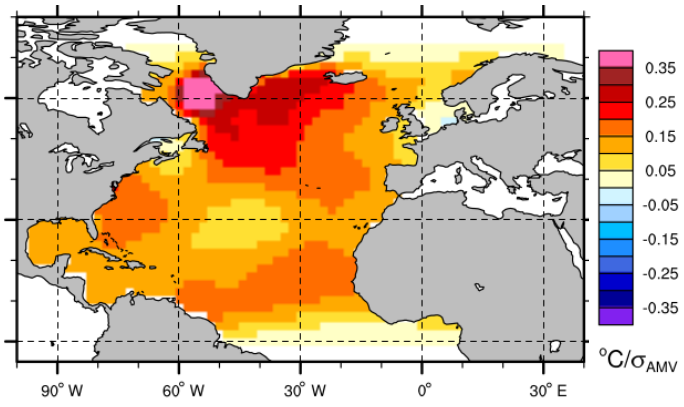

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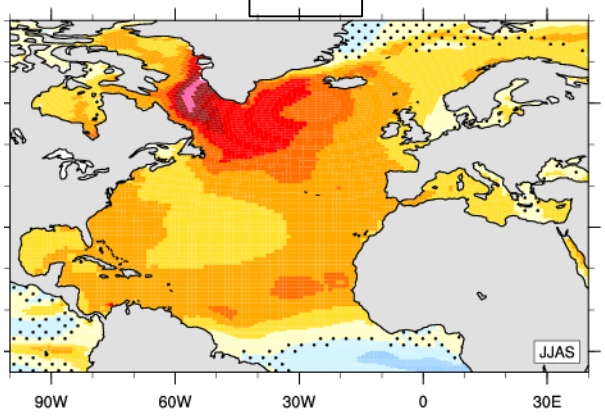
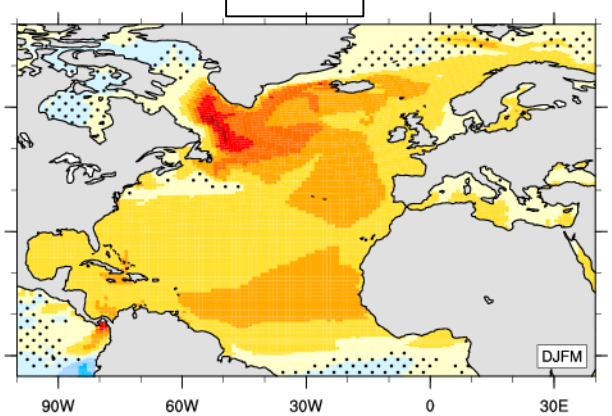


DJFM



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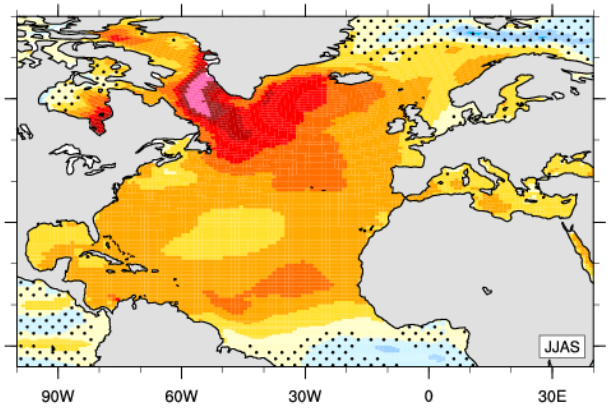
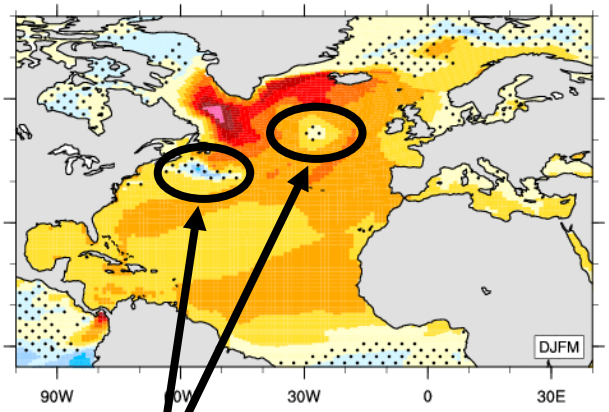




Not fully satisfying: further test ongoing

http://forge.ipsl.jussieu.fr/decennal/wiki/vargamma

APPLICATE

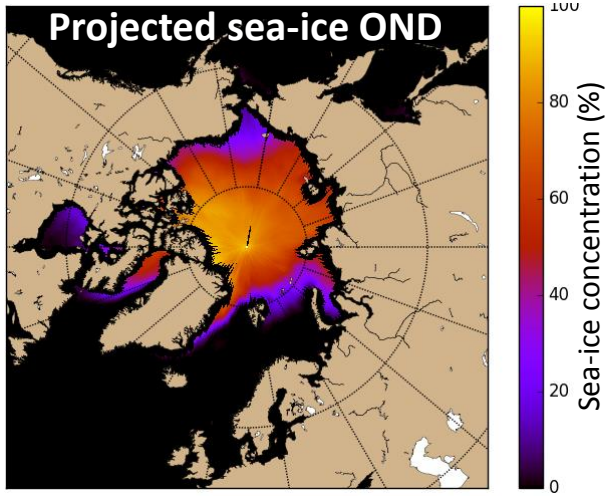
APPLICATE WP5: isolate climate impacts of sea-ice reduction due to global warming

- Impose projected sea-ice in present climate state simulations

Straightforward approach:

Remove sea-ice in sea-ice model

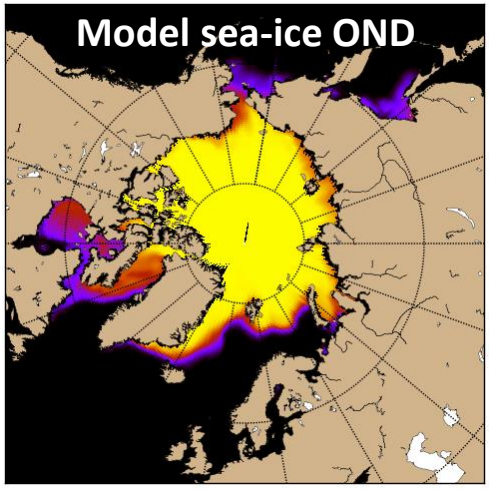
- somebody knows LIM3?



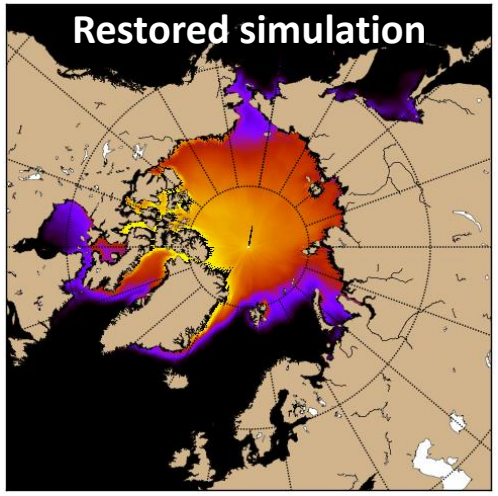
Player approach:

There is ice only if SST cold enough

- surface restoring!!



Sea surface temperature restoring ponderated by sea-ice differences: (projected - model)

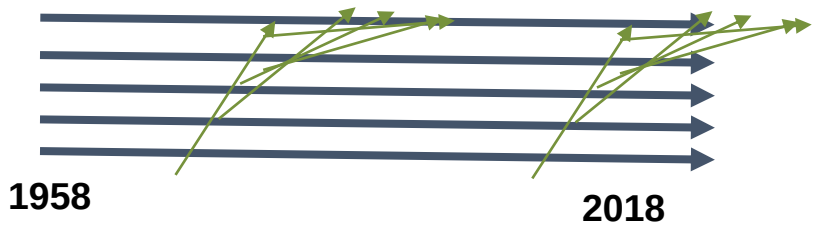


xavier.levine@bsc.es

Climate Prediction: Shock and drift characterization

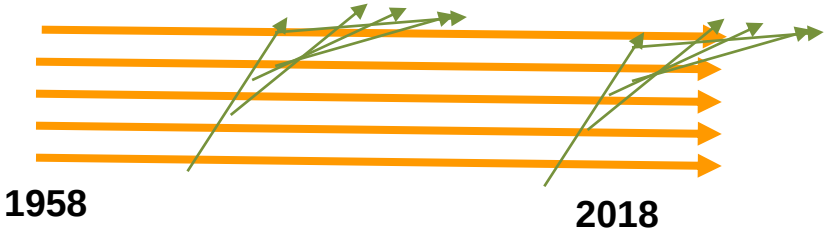
Reconstruction I

SSS and SST surface restoring
3D nudging



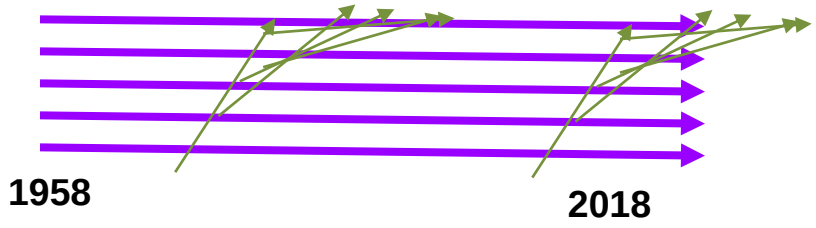
Reconstruction II 1958-2018

SST surface restoring
3D nudging



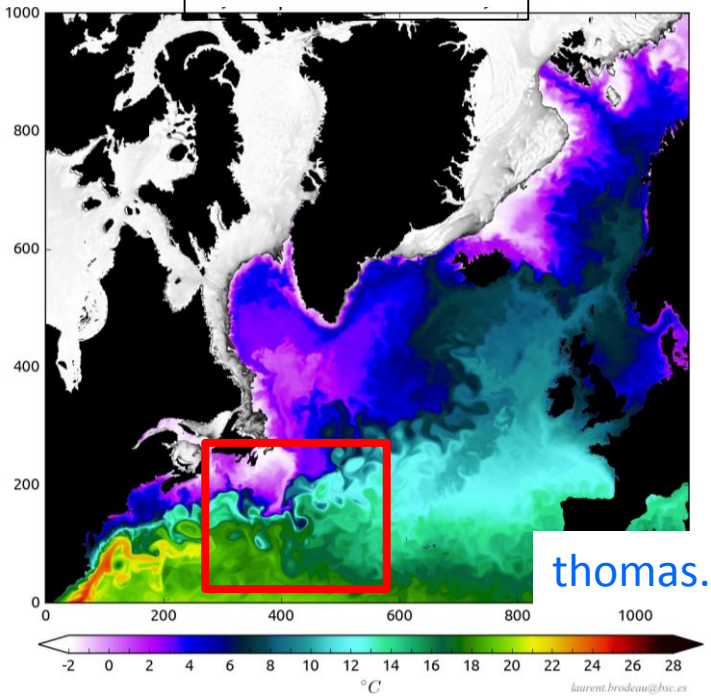
Reconstruction III 1958-2018

SSS and SST surface restoring

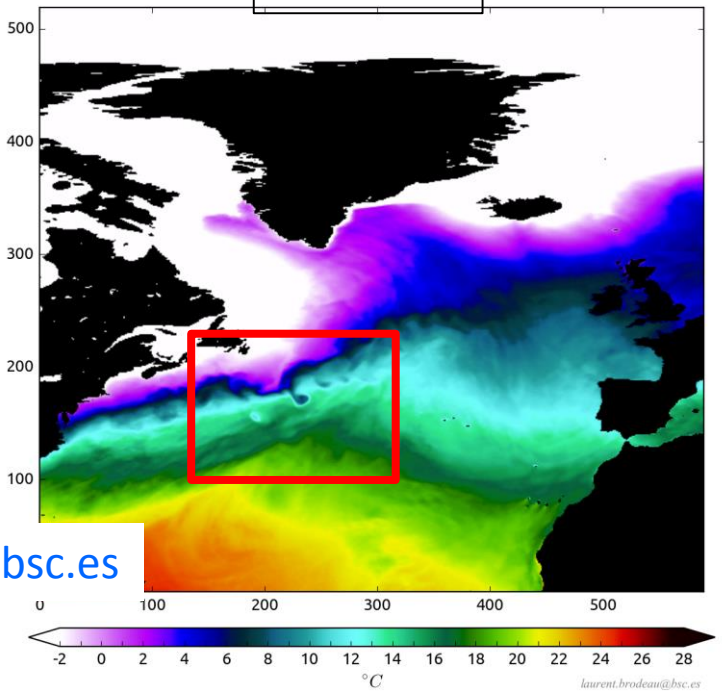


Global 12km resolution coupled simulation

NEMO ORCA12



IFS T1279



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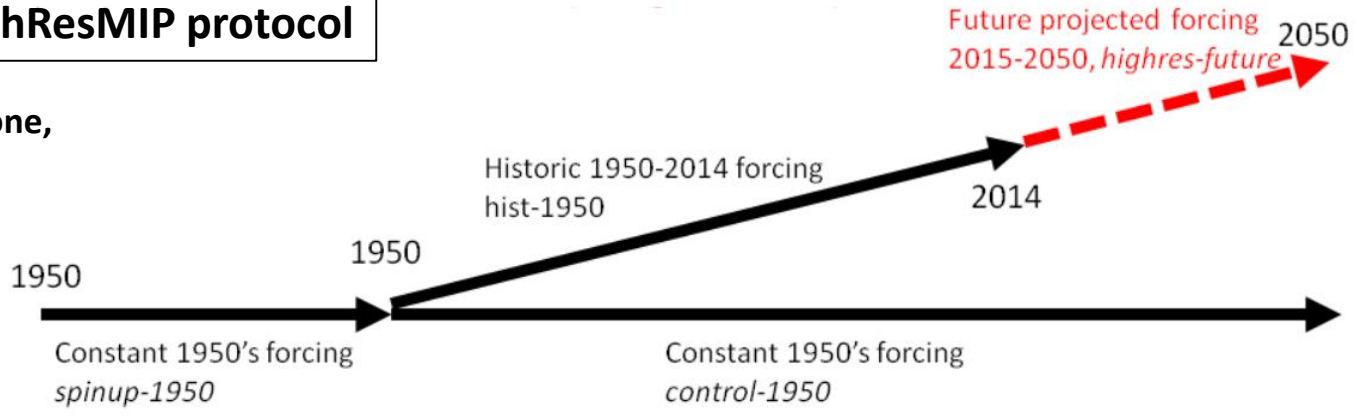
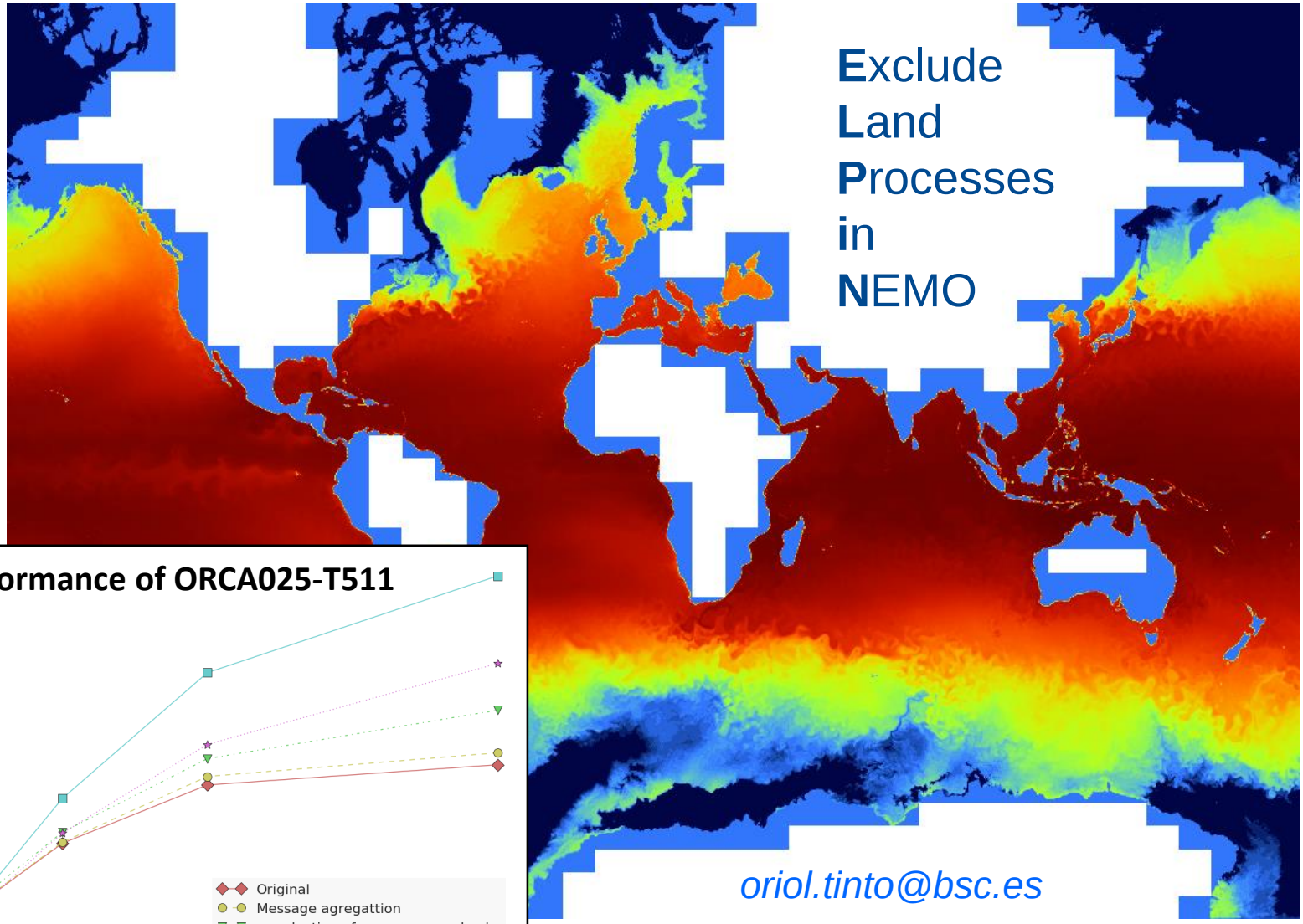
HighResMIP protocol

**(7yr of spinup done,
SDPY: 0.45/0.33)**



ELPiN



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EXCELENCIA SEVERO OCHOA

MARIE CURIE ACTIONS

INADEC
H2020-MSCA-800154

Thank you

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Climate Prediction