**How to create sea ice forcing data for Atlantis model**

Our hydro data is derived from ROMS model developed by Stuart and its model used sea ice model data output (Tamura, Ohshima and Nihashi, 2008). We used satellite observed sea ice concentration data from 1998-2018 (NSDC) that they basically used to calculate sea ice model.

Firstly we produced 20 years mean monthly sea ice concentration data over the East\_Ant area. Then, to determine the habitat of ice group in our model (two phytoplanktons, one zoo and one bacteria), we counted pixel number with sea ice concentration data per each polygon and define their habitat (polygon) is Pi from following calculation.



Fig.1 20 years mean monthly sea ice concentration

Here, Ipix is the pixel derived by sea ice concentration data, p is polygon id, month is month, Ic is the sea ice condition. E.g. means the value of sea ice concentration is more than 50% and means values excluding Nan.

As the result of the calculation, we define the ice habitat is a polygon includes more than 90% of sea ice concentration pixels with more than 50 values. Figure 1 indicates 20 years mean monthly sea ice concentration per polygon. Black color is monthly ice habitat.

In creating input forcing file, essential information is polygon id which is assumes as sea ice covered, depth of sea ice and class of sea ice (sample has four classes). In this initial test, we use 1 class and depth is 1 m. According to Holland *et al.*, (2014), sea ice thickness in Antarctica is 0-2m, so I selected 1 m. This forcing file is produced by R, see sea\_ice\_forcing\_data.R and Mao\_seaice folder. Mao\_seaice folder calculates sea ice habitat area and then sea\_ice\_forcing\_data.R is code to make netcdf file for ice force input file.

Not only input forcing file, to activate sea ice, we have to edit and add inputfile, physics.prm and bio.prm file.

In input file, add

icez = 2 ;

double Ice\_Diatoms\_N(t, b, z) ;

Ice\_Diatoms\_N:units = "mg N m-3" ;

Ice\_Diatoms\_N:\_FillValue = 0. ;

Ice\_Diatoms\_N:long\_name = "Ice\_Diatoms Nitrogen" ;

Ice\_Diatoms\_N:bmtype = "tracer" ;

Ice\_Diatoms\_N:dtype = 0 ;

Ice\_Diatoms\_N:sumtype = 1 ;

Ice\_Diatoms\_N:inwc = 0 ;

Ice\_Diatoms\_N:insed = 0 ;

Ice\_Diatoms\_N:dissol = 0 ;

Ice\_Diatoms\_N:decay = 0. ;

Ice\_Diatoms\_N:partic = 1 ;

Ice\_Diatoms\_N:fill.value = 0. ;

Ice\_Diatoms\_N:passive = 1 ;

Ice\_Diatoms\_N:svel = -2.89e-06 ;

Ice\_Diatoms\_N:xvel = 0. ;

Ice\_Diatoms\_N:psize = 1.e-05 ;

Ice\_Diatoms\_N:b\_dens = 1000000000. ;

Ice\_Diatoms\_N:i\_conc = 200000000. ;

Ice\_Diatoms\_N:inice = 1;

double Ice\_Diatoms\_S(t, b, z) ;

Ice\_Diatoms\_S:units = "mg Si m-3" ;

Ice\_Diatoms\_S:\_FillValue = 0. ;

Ice\_Diatoms\_S:long\_name = "Ice\_Diatoms Silicon" ;

Ice\_Diatoms\_S:bmtype = "tracer" ;

Ice\_Diatoms\_S:dtype = 0 ;

Ice\_Diatoms\_S:sumtype = 1 ;

Ice\_Diatoms\_S:inwc = 0 ;

Ice\_Diatoms\_S:insed = 0 ;

Ice\_Diatoms\_S:dissol = 0 ;

Ice\_Diatoms\_S:decay = 0. ;

Ice\_Diatoms\_S:partic = 1 ;

Ice\_Diatoms\_S:fill.value = 0. ;

Ice\_Diatoms\_S:passive = 1 ;

Ice\_Diatoms\_S:svel = -2.89e-06 ;

Ice\_Diatoms\_S:xvel = 0. ;

Ice\_Diatoms\_S:psize = 1.e-05 ;

Ice\_Diatoms\_S:b\_dens = 1000000000. ;

Ice\_Diatoms\_S:i\_conc = 200000000. ;

Ice\_Diatoms\_S:inice = 1;

double Light\_Adaptn\_IPL(t, b, z) ;

Light\_Adaptn\_IPL:units = "PSU" ;

Light\_Adaptn\_IPL:\_FillValue = 0. ;

Light\_Adaptn\_IPL:long\_name = "Light adaption of Ice\_Diatoms" ;

Light\_Adaptn\_IPL:bmtype = "tracer" ;

Light\_Adaptn\_IPL:dtype = 0 ;

Light\_Adaptn\_IPL:sumtype = 0 ;

Light\_Adaptn\_IPL:inwc = 0 ;

Light\_Adaptn\_IPL:insed = 0 ;

Light\_Adaptn\_IPL:dissol = 1 ;

Light\_Adaptn\_IPL:decay = 0. ;

Light\_Adaptn\_IPL:partic = 0 ;

Light\_Adaptn\_IPL:fill.value = 0. ;

double Ice\_Mixotrophs\_N(t, b, z) ;

Ice\_Mixotrophs\_N:units = "mg N m-3" ;

Ice\_Mixotrophs\_N:\_FillValue = 0. ;

Ice\_Mixotrophs\_N:long\_name = "Ice\_Mixotrophs Nitrogen" ;

Ice\_Mixotrophs\_N:bmtype = "tracer" ;

Ice\_Mixotrophs\_N:dtype = 0 ;

Ice\_Mixotrophs\_N:sumtype = 1 ;

Ice\_Mixotrophs\_N:inwc = 0 ;

Ice\_Mixotrophs\_N:insed = 0 ;

Ice\_Mixotrophs\_N:dissol = 0 ;

Ice\_Mixotrophs\_N:decay = 0. ;

Ice\_Mixotrophs\_N:partic = 1 ;

Ice\_Mixotrophs\_N:fill.value = 0. ;

Ice\_Mixotrophs\_N:passive = 1 ;

Ice\_Mixotrophs\_N:svel = 0. ;

Ice\_Mixotrophs\_N:xvel = 0. ;

Ice\_Mixotrophs\_N:psize = 1.e-05 ;

Ice\_Mixotrophs\_N:b\_dens = 1000000000. ;

Ice\_Mixotrophs\_N:i\_conc = 200000000. ;

Ice\_Mixotrophs\_N:inice = 1;

double Ice\_Bacteria\_N(t, b, z) ;

Ice\_Bacteria\_N:units = "mg N m-3" ;

Ice\_Bacteria\_N:\_FillValue = 100. ;

Ice\_Bacteria\_N:long\_name = "Ice\_Bacteria Nitrogen" ;

Ice\_Bacteria\_N:bmtype = "tracer" ;

Ice\_Bacteria\_N:dtype = 0 ;

Ice\_Bacteria\_N:sumtype = 1 ;

Ice\_Bacteria\_N:inwc = 0 ;

Ice\_Bacteria\_N:insed = 0 ;

Ice\_Bacteria\_N:dissol = 0 ;

Ice\_Bacteria\_N:decay = 0. ;

Ice\_Bacteria\_N:partic = 1 ;

Ice\_Bacteria\_N:fill.value = 100. ;

Ice\_Bacteria\_N:passive = 1 ;

Ice\_Bacteria\_N:svel = 0. ;

Ice\_Bacteria\_N:xvel = 0. ;

Ice\_Bacteria\_N:psize = 1.e-05 ;

Ice\_Bacteria\_N:b\_dens = 1000000000. ;

Ice\_Bacteria\_N:i\_conc = 200000000. ;

Ice\_Bacteria\_N:inice = 1;

Note: In this stage, all ice species just exit **in ice**, not in sed or in water.

In physics. Prm, I turned on sea ice forcing file,

Boil.prm is copied from Atlantis wiki. (Nick has already added this data)

k\_bs 15.0 m^-1 blue-green light attenuation per metre in snow.

k\_bi 2.0 m^-1 blue-green light attenuation per metre in ice.  
k\_rs 35.0 m^-1 red light attenuation per metre in snow.  
k\_ri 4.0 m^-1 red light attenuation per metre in ice.  
R\_bi 0.5 fraction of photosynthetically available light in the blue-green region

albedo\_ice 0.4 Walsh 0.7 or Grenfell & Perovich 1984 0.4  
albedo\_snow 0.6 Grenfell & Perovich 1984 0.6 to 0.81

ka\_star 0.03 Soohoo 1987 (neglects wavelength dependence)  
p\_IBice 0.9 Prop. of ice. bacteria taken when detrit eaten in wc 0.6 - 1

For each primary producer group (including the ice active groups ) add the following value:

#Photoinhibition

PBmax\_D\_PS 0.44

#Photosynthetic efficiency

Beta\_D\_PS 0.002

Then for each predator we need a value that indicates how far the predator can eat into the ice - similar to how they can forage into the sediment:

The following values are the same values that are used for foraging into the sediment and therefore have not real world value at all. Do not use these values in your model!

# Depth consumers can dig into, are found down to in the ice

ICE\_KDEP\_BFS 0.003 ice penetration depth of shallow filter feeders m 0.003   
ICE\_KDEP\_BFF 0.003 ice penetration depth of other filter feeders m 0.003   
ICE\_KDEP\_BFD 0.003 ice penetration depth of deep filter feeders m 0.003   
ICE\_KDEP\_BO 0.03 ice penetration depth of meiobenthos m 0.03   
ICE\_KDEP\_BD 0.1 ice penetration depth of deposit feeder m 0.01 - 0.3   
ICE\_KDEP\_BC 0.1 ice penetration depth of infaunal carniv m 0.01 - 0.3   
ICE\_KDEP\_BG 0.005 ice penetration depth of benth grazers m 0.001 - 0.01   
ICE\_KDEP\_BMS 0.001 ice penetration depth of shallow macrozoobenthos m 0.00001 - 0.002   
ICE\_KDEP\_BMD 0.001 ice penetration depth of deep macrozoobenthos m 0.00001 - 0.002   
ICE\_KDEP\_BML 0.001 ice penetration depth of megazoobenthos m 0.00001 - 0.002   
ICE\_KDEP\_CEP 0.003 ice penetration depth of cephalopods m 0.003   
ICE\_KDEP\_PWN 0.001 ice penetration depth of prawns m 0.00001 - 0.002

# ice penetration depth for predators (m). Value read in for groups that are tagged as predators in the functionL group definition file.  
ICE\_KDEP\_FPS 1   
ICE\_KDEP\_FPL 1   
ICE\_KDEP\_FPO 1   
ICE\_KDEP\_FVD 1   
ICE\_KDEP\_FVV 1   
ICE\_KDEP\_FVS 1   
ICE\_KDEP\_FVT 1   
ICE\_KDEP\_FVO 1   
ICE\_KDEP\_FVB 1   
ICE\_KDEP\_FMM 1   
ICE\_KDEP\_FMN 1   
ICE\_KDEP\_FBP 1   
ICE\_KDEP\_FDD 1   
ICE\_KDEP\_FDS 1   
ICE\_KDEP\_FDB 1   
ICE\_KDEP\_FDC 1   
ICE\_KDEP\_FDO 1   
ICE\_KDEP\_FDE 1   
ICE\_KDEP\_FDF 1   
ICE\_KDEP\_FDP 1   
ICE\_KDEP\_FDM 1   
ICE\_KDEP\_SHD 0.01   
ICE\_KDEP\_SHC 0.01   
ICE\_KDEP\_SHP 0.01   
ICE\_KDEP\_SHB 0.01   
ICE\_KDEP\_SHR 0.01   
ICE\_KDEP\_SSK 0.01   
ICE\_KDEP\_SB 0.05   
ICE\_KDEP\_SP 0.05   
ICE\_KDEP\_REP 1   
ICE\_KDEP\_PIN 0.001   
ICE\_KDEP\_WDG 1   
ICE\_KDEP\_WHB 0.001   
ICE\_KDEP\_WHT 1   
ICE\_KDEP\_WHS 0.01   
ICE\_KDEP\_DF 0   
ICE\_KDEP\_IDF 0   
ICE\_KDEP\_ZG 0   
ICE\_KDEP\_ZL 0   
ICE\_KDEP\_ZM 0   
ICE\_KDEP\_ZS 0   
ICE\_KDEP\_IZS 0