Lab 01 Conversion from Matlab

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This file aims to convert a series of Matlab scripts and data files into a R Markdown file that replicates the Tol (2023) Lab 1 for the economics of climate change. https://github.com/rtol/ClimateEconomics

The Matlab files this replicates are:

- MLIAM01.m
- MLIAM.mat
- init01.m
- MRHparam.m
- MRH.m
- RFparam.m
- RadForc.m
- STparam.m
- ST.m

Overview - the MLIAM01.m script

```
# clear all
# load MLIAM (Step 1 below)
# init01 (Step 2 below)
#
# (Loop is Step 3)
# for t=StartYear+1:EndYear,
# i = t - StartYear + 1;
# MRHbox(i,:) = MRH(MRHbox(i-1,:),CO2emit(i-1),MRHlife,MRHshare,CO2convert);
# CO2conc(i) = sum(MRHbox(i,:));
# RF(i) = RadForc(CO2conc(i),RF0,CO20);
# [atmtemp(i) oceantemp(i)] = ST(atmtemp(i-1),oceantemp(i-1),RF(i),STpar);
# end
```

Step 1 - load the MLIAM.mat file

```
library(R.matlab)
```

```
## R.matlab v3.7.0 (2022-08-25 21:52:34 UTC) successfully loaded. See ?R.matlab for help.
```

```
##
## Attaching package: 'R.matlab'
```

```
## The following objects are masked from 'package:base':
##
##     getOption, isOpen
```

```
MLIAM <- readMat("../TolMatlabFiles/MLIAM.mat")
ls.str()
```

```
## MLIAM : List of 11
##  $ CO2global   : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ CO2emit     : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2concobs  : num [1:689, 1:2] 2006 2005 2004 2003 2002 ...
##  $ population  : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ output      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ atmtempobs  : num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ oceantempobs: num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2emitobs  : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ outputobs   : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ energy      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ NReg        : num [1, 1] 3
```

```
# CO2global <- MLIAM$CO2global        # should we use this?
CO2emit <- MLIAM$CO2emit
# CO2concobs  <- MLIAM$CO2concobs
# population  <- MLIAM$population
# output  <- MLIAM$output
# atmtempobs  <- MLIAM$atmtempobs
# oceantempobs  <- MLIAM$oceantempobs
# CO2emitobs  <- MLIAM$CO2emitobs    # should we use this?
# outputobs  <- MLIAM$outputobs
# energy  <- MLIAM$energy
# NReg  <- MLIAM$NReg
```

Step 2 - run the init01.m script

```
# %initialize
#
# climsens = 4.260547;
# EndYear = 2300;
# StartYear = 1750;
# NYear = EndYear-StartYear+1;
# year = zeros(NYear,1);
# year(1) = StartYear;
# for i=2:NYear
# year(i) = year(i-1)+1;
# end
#
# MRHparam; #Step 2a
# RFparam; # Step 2b
# STparam; # Step 2c
```

and now in R

```
climsens = 4.260547;
EndYear = 2300;
StartYear = 1750;
year = StartYear:EndYear
NYear = length(year)
```

Step 2a - MRHparam

```
# %MRHparam
#
# MRHlife(1) = 0;
# MRHlife(2) = 1-exp(-1/363);
# MRHlife(3) = 1-exp(-1/74);
# MRHlife(4) = 1-exp(-1/17);
# MRHlife(5) = 1-exp(-1/2);
#
# MRH1750(1) = 275;
# MRH1750(2) = 0;
# MRH1750(3) = 0;
# MRH1750(4) = 0;
# MRH1750(5) = 0;
#
# MRHshare(1) = 0.13;
# MRHshare(2) = 0.20;
# MRHshare(3) = 0.32;
# MRHshare(4) = 0.25;
# MRHshare(5) = 0.10;
#
# CO2convert = 1/2.13/1000;
#
# MRHbox = zeros(NYear,5); %five boxes
# MRHbox(1,:) = MRH1750;
# CO2conc = zeros(NYear,1);
# CO20 = sum(MRH1750);
# CO2conc(1) = CO20;
```

in R

```
# %MRHparam
MRHlife <- c(0, 1-exp(-1/363), 1-exp(-1/74), 1-exp(-1/17), 1-exp(-1/2))
#
MRH1750 <- c(275, 0, 0, 0, 0);
#
MRHshare <- c(0.13, 0.20, 0.32, 0.25, 0.10);
#
CO2convert = 1/2.13/1000;
#
MRHbox = matrix(0, NYear, 5); # "five boxes" for each year
MRHbox[1, ] = MRH1750;
CO2conc = matrix(0, NYear, 1);
CO20 = sum(MRH1750);
CO2conc[1] = CO20;
```

Step 2b - RFparam

```
# %RFparam
#
# RF0 = 5.35;
# RF = zeros(NYear,1);
# RF(1) = RadForc(CO20,RF0,CO20); #Need the RadForc function
```

First, create the RadForc function

```
### RadForc
RadForc <-function(CO2,RF0,CO20) RF0*log(CO2/CO20);
```

Then run the RFparam

```
# %RFparam
#
RF0 = 5.35;
RF = matrix(0, NYear, 1);
RF[1] = RadForc(CO20, RF0, CO20) #Needs the RadForc function
```

Step 2c - ST param

```
# %STparam
#
# atmtemp0 = 0;
# oceantemp0 = 0;
#
# atmtemp = zeros(NYear,1);
# oceantemp = zeros(NYear,1);
#
# atmtemp(1) = atmtemp0;
# oceantemp(1) = oceantemp0;
#
# STpar(1) = climsens/RF0/log(2);
# STpar(2) = 0.0256;
# STpar(3) = 0.00738;
# STpar(4) = 0.00568;
```

```
# %STparam

atmtemp0 = 0;
oceantemp0 = 0;

atmtemp = matrix(0, NYear, 1);
oceantemp = matrix(0, NYear, 1);

atmtemp[(1)] = atmtemp0;
oceantemp[(1)] = oceantemp0;

STpar <- c(climsens/RF0/log(2), 0.0256, 0.00738, 0.00568)
```

Loop is Step 3

But we need some functions - MRH and ST

```
### MRH - Maier-Reimer Hasselmann model
# function CO2concnew = MRH(CO2concold,CO2emit,CO2life,CO2share,CO2convert)
# %function CO2concnew = MRH(CO2concold,CO2emit,CO2life,CO2share,CO2convert)
# %
# %updates the atmospheric concentration of carbon dioxide using the
# %Maier-Reimer Hasselmann model
#
# CO2concnew = (1-CO2life).*CO2concold + CO2convert*CO2share*CO2emit;
```

MRH in R

```
### MRH - Maier-Reimer Hasselmann model
MRH <- function(CO2concold, CO2emit, CO2life, CO2share, CO2convert) {
  CO2concnew = (1-CO2life)*CO2concold + CO2convert*CO2share*CO2emit
  CO2concnew
}
```

```
### Schneider-Thompson model of Ocean and Atm Temps
# function [atmtempnew oceantempnew] = ST(atmtempold,oceantempold,radforc,STpar)
# %function [atmtempnew oceantempnew] = ST(atmtempold,oceantempold,radforc,STpar)
# %
# %updates the temperature of the atmosphere and the ocean using the Schneider-Thompson model
#
# atmtempnew   = atmtempold   + STpar(2)*(STpar(1)*radforc-atmtempold) + STpar(3)*(oceantempold-atmtemp
# oceantempnew = oceantempold                                          + STpar(4)*(atmtempold-oceantemp
```

```
### Schneider-Thompson model of Ocean and Atm Temps
# updates the temperature of the atmosphere and the ocean using the Schneider-Thompson model
ST <- function(atmtempold,oceantempold,radforc,STpar) {
atmtempnew   = atmtempold   +
    STpar[2]*(STpar[1]*radforc-atmtempold) +
    STpar[3]*(oceantempold-atmtempold)
oceantempnew = oceantempold +
  STpar[4]*(atmtempold-oceantempold)
temps <- c(atmtempnew, oceantempnew)
names(temps) <- c("atm", "ocean")
temps
}
```

Step 3 - the main loop!

```
# for t=StartYear+1:EndYear,
# i = t - StartYear + 1;
# MRHbox(i,:) = MRH(MRHbox(i-1,:),CO2emit(i-1),MRHlife,MRHshare,CO2convert); # need the MRH function
# CO2conc(i) = sum(MRHbox(i,:));
# RF(i) = RadForc(CO2conc(i),RF0,CO20);
# [atmtemp(i) oceantemp(i)] = ST(atmtemp(i-1),oceantemp(i-1),RF(i),STpar); # need the ST function
# end
```

in R

```
# for t=StartYear+1:EndYear,
# i = t - StartYear + 1;
for (i in 2:(EndYear-StartYear+1)) {
MRHbox[i, ] = MRH(MRHbox[i-1,], CO2emit[i-1], MRHlife, MRHshare, CO2convert); # need the MRH function
CO2conc[i] = sum(MRHbox[i, ]);
RF[i] = RadForc(CO2conc[i], RF0, CO20);
temps <- ST(atmtemp[i-1], oceantemp[i-1], RF[i], STpar); # need the ST function
atmtemp[i] <- temps[["atm"]]
oceantemp[i] <- temps[["ocean"]]
}
```

End of Matlab Scripts

```
ls.str()
```

```
## atmtemp :  num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
## atmtemp0 :  num 0
## climsens :  num 4.26
## CO20 :  num 275
## CO2conc :  num [1:551, 1] 275 275 275 275 275 275 275 275 275 275 ...
## CO2convert :  num 0.000469
## CO2emit :  num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
## EndYear :  num 2300
## i :  int 551
## MLIAM : List of 11
##  $ CO2global   : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ CO2emit     : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2concobs  : num [1:689, 1:2] 2006 2005 2004 2003 2002 ...
##  $ population  : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ output      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ atmtempobs  : num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ oceantempobs: num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
##  $ CO2emitobs  : num [1:551, 1] 0 3 3 3 3 3 3 3 3 3 ...
##  $ outputobs   : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ energy      : num [1:551, 1:3] 0 0 0 0 0 0 0 0 0 0 ...
##  $ NReg        : num [1, 1] 3
## MRH : function (CO2concold, CO2emit, CO2life, CO2share, CO2convert)
## MRH1750 :  num [1:5] 275 0 0 0 0
## MRHbox :  num [1:551, 1:5] 275 275 275 275 275 275 275 275 275 275 ...
## MRHlife :  num [1:5] 0 0.00275 0.01342 0.05713 0.39347
## MRHshare :  num [1:5] 0.13 0.2 0.32 0.25 0.1
## NYear :  int 551
## oceantemp :  num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
## oceantemp0 :  num 0
## RadForc : function (CO2, RF0, CO20)
## RF :  num [1:551, 1] 0 0 0 0 0 0 0 0 0 0 ...
## RF0 :  num 5.35
## ST : function (atmtempold, oceantempold, radforc, STpar)
## StartYear :  num 1750
## STpar :  num [1:4] 1.14891 0.0256 0.00738 0.00568
## temps :  Named num [1:2] 1.09 1.05
## year :  int [1:551] 1750 1751 1752 1753 1754 1755 1756 1757 1758 1759 ...
```

How should we display the output?

Plot the output data for comparison?

Are these outouts consistent with the Excel file results?

Make sure we are using the correct inputs?

- CO2emit vs. CO2emitobs vs. CO2global