;This is a NCL script used to plot the time series of SMAP Soil moisture with simulated soil mositure

load "$NCARG\_ROOT/lib/ncarg/nclscripts/csm/gsn\_code.ncl"

load "$NCARG\_ROOT/lib/ncarg/nclscripts/csm/gsn\_csm.ncl"

load "$NCARG\_ROOT/lib/ncarg/nclscripts/csm/contributed.ncl"

; Read time variable from all individual annual 2015-2019 files and

; concatenate time variable to get dates from 2015-2019 in an array

;2015

fili = "sm\_2015\_regridded.nc"

diri = "/SMAP\_L3\_regrid/2015/"

ncdf = addfile (diri+fili, "r")

time = ncdf->time

printVarSummary(time)

time1 = cd\_calendar(time,2)

printVarSummary(time1)

print(time1)

;2016

fili = "sm\_2016\_regridded.nc"

diri = "/SMAP\_L3\_regrid/2016/"

ncdf = addfile (diri+fili, "r")

time\_2016 = ncdf->time

printVarSummary(time\_2016)

time2 = cd\_calendar(time\_2016,2)

printVarSummary(time2)

print(time2)

;2017

fili = "sm\_2017\_regridded.nc"

diri = "/SMAP\_L3\_regrid/2017/"

ncdf = addfile (diri+fili, "r")

time\_2017 = ncdf->time

printVarSummary(time\_2017)

time3 = cd\_calendar(time\_2017,2)

printVarSummary(time3)

print(time3)

;2018

fili = "sm\_2018\_regridded.nc"

diri = "/SMAP\_L3\_regrid/2018/"

ncdf = addfile (diri+fili, "r")

time\_2018 = ncdf->time

printVarSummary(time\_2018)

time4 = cd\_calendar(time\_2018,2)

printVarSummary(time4)

print(time4)

;2019

fili = "sm\_2019\_regridded.nc"

diri = "/SMAP\_L3\_regrid/2019/"

ncdf = addfile (diri+fili, "r")

time\_2019 = ncdf->time

printVarSummary(time\_2019)

time5 = cd\_calendar(time\_2019,2)

printVarSummary(time5)

print(time5)

time\_2015\_16 = array\_append\_record(time1,time2,0)

time\_2015\_16\_17 = array\_append\_record(time\_2015\_16,time3,0)

time\_2015\_16\_17\_18 = array\_append\_record(time\_2015\_16\_17,time4,0)

time\_total = array\_append\_record(time\_2015\_16\_17\_18,time5,0) ;concetenated time variable

print(time\_total)

printVarSummary(time\_total)

printMinMax(time\_total,1)

;-------------function to derive average value for a given basin for one day----

function avg\_sim(diri:string,field1:string,river:integer)

begin

  n = dimsizes(time\_total)

  ncdf = addfile("/rivermask/rivermask\_hu2\_v6\_new.nc","r")

  rivermask = (/ncdf->landmask(:,:)/)

    x = 0

  do t = 0, dimsizes(time\_total) - 1

    diri = "/Noah\_data/results/exp1/daily/"

    fili = "dailymean" + time\_total(x) + ".nc"    ;use index of time\_total to match with SMAP L3 data dates

    ncdf = addfile (diri+fili, "r")

    print(diri+fili)

    var\_avg = new(n,float)

     var  = (/ncdf->$field1$(:,0,:)/)         ;get values for the surface soil moisture layer

     var\_new = mask(var, (var.gt.-99999.), True)

     var\_new = mask(var\_new, (rivermask.eq.river), True)

     var\_avg(x) = avg(var\_new)

     x = x + 1

  end do

  return(var\_avg)

end

;-------------function to derive average value for a given basin for one day----

function avg\_obs(diri:string,field2:string,river:integer)

begin

n = dimsizes(time\_total)

  ncdf = addfile("/rivermask/rivermask\_hu2\_v6\_new.nc","r")

  rivermask = (/ncdf->landmask(:,:)/)

    x = 0

  do t = 0, dimsizes(time\_total) - 1

    diri = "/soilmoisture/SMAP\_L3\_regrid/2015-2019/"

    fili = time\_total(x) + ".nc"

    ncdf = addfile (diri+fili, "r")

    print(diri+fili)

    var\_avg = new(n,float)

     var  = (/ncdf->$field2$(:,:)/)

     var\_new = mask(var, (var.gt.-99999.), True)

     var\_new = mask(var\_new, (rivermask.eq.river), True)

     var\_avg(x) = avg(var\_new)

     x = x + 1

  end do

  return(var\_avg)

end

; function model\_nse(nsample,simu,obs)    ;this is to calculate nash-sutcliffe efficiency (NSE)

; begin

;   N = 0

;   mean\_obs= 0.

;   do i = 0,nsample-1

;     if(obs(i).gt.-999.) then

;       N = N +1

;       mean\_obs = mean\_obs + obs(i)

;     end if

;   end do

;   mean\_obs = mean\_obs / N

;   var\_obs = 0.

;   do i = 0,nsample-1

;     if(obs(i).gt.-999.) then

;       var\_obs = var\_obs + (obs(i) - mean\_obs) \* (obs(i) - mean\_obs)

;     end if

;   end do

;   var\_so = 0.

;   do i = 0,nsample-1

;     if(obs(i).gt.-999.) then

;       var\_so = var\_so + (simu(i) - obs(i)) \* (simu(i) - obs(i))

;     end if

;   end do

;   nse = (var\_obs - var\_so) / var\_obs

;   return(nse)

; end

; function model\_rb(nsample,simu,obs) ;compute relative bias for values greater than zero

; begin

;   bias = 0.

;   do i = 0,nsample-1

;     if(obs(i).gt.0.) then

;       bias = (simu(i) - obs(i)) / obs(i)

;     end if

;   end do

;  rb = avg(bias)

;   return(rb)

; end

;---------define plot resources------------------------

begin

    res = True

    wks = gsn\_open\_wks("png","SMC\_1")

;---------------------------Title------------------------------------------------

    n     = dimsizes(time\_total)     ;2015-2019

    n\_new = n

    field1 = "SMC"

    field2 = "sm\_total"

;------Axis font and size----

     res@tiXAxisFont  = 21

    res@tiXAxisFontHeightF=0.015

;------------------- X- axis ----------------------------------------------------

    res@tmXTOn                 = False       ; Don't draw top axis tick marks.

    res@tmXBLabelFontHeightF   = 0.07       ; 0.02 for a viewport width of 0.6

    res@tmXBLabelFont          = 21          ; Change font and size of

    res@tmBorderThicknessF     = 1.0         ; Default thickness is 2.0

    res@tmXBMajorLengthF       = 0.003      ; Default is 0.02.

    res@tmXBMajorThicknessF    = 1.0         ; Default is 2.

    res@tmXBMinorOn            = False

    res@tmXBMode               = "Explicit"  ;Set tick mark mode.

    res@tmXBValues             =  (/1,1\*365,2\*365,3\*365,4\*365/)

    res@tmXBLabels             =  (/"2015","2016","2017","2018","2019"/)

    res@tmXBLabelDeltaF        = -0.9  ;Set the distance between number and XB Boarder

    res@tmXBTickStartF         = 0

    res@tmXBTickEndF           = n\_new

    res@tmXBTickSpacingF       = n

    res@gsnScale              = True ; Draw X/Y axes labels in same size.

;------------------- Y- axis ----------------------------------------------------

    res@tmYROn                 = False       ; Don't draw top axis tick marks.

    res@tmYLLabelFontHeightF   = 0.07       ; 0.02 for a viewport width of 0.6

    res@tmYLLabelFont          = 21          ; Change font and size of

    res@tmYLMajorLengthF       = 0.003      ; Default is 0.02.

    res@tmYLMajorThicknessF    = 1.0         ; Default is 2.

    res@tmYLMinorOn            = False

    res@tmYLLabelDeltaF        = -0.9 ;Set the distance between number and XB Boarder

    res@tmYLMode               = "Manual"

    res@tmYLTickStartF           = 0.

    res@tmYLTickEndF           = 200.

    res@tmYLTickSpacingF       = 50.

;--------------------------- Legend -------------------------------------------

   res@pmLegendDisplayMode    = "Always"  ;show the legend

   res@pmLegendSide           = "Top"     ;put the legend at the top of plot

   res@lgJustification        = "TopLeft"

   res@pmLegendOrthogonalPosF = -0.55     ; vertical pos close to plot

   res@pmLegendParallelPosF   = 0.33      ; horizonal pos

   res@pmLegendHeightF        = 0.18      ;legend size default is 0.18 for 0.6 width

   res@pmLegendWidthF         = 0.95      ;legend size default is 0.55 for 0.6 width

   res@lgLabelsOn             = True

   res@xyExplicitLegendLabels = (/"SMAP ","Soil Moisture"/)

   res@lgAutoManage           = True

   res@lgPerimOn              = False       ; do not show the box perim

   res@lgLabelFont            = 21

   res@lgLabelFontHeightF     = 0.07

   res@lgOrientation          = "Horizontal"   ;default is vertical

   res@lgLabelPosition        = "center"  ;set center when the orientation is horizontal

   res@lgLabelAlignment       = "AboveItems" ; set text right of legend

   res@lgBoxMajorExtentF      = 0.1

   res@lgBoxMinorExtentF      = 0.1

   res@lgTitleFont            = 21

   res@lgTitleFontHeightF     = 0.01

; -------------------- Date Range --------------------------------------------------

   res@trXMinF                = 1

   res@trXMaxF                = n

   res@trYMinF                = 0.

   res@trYMaxF                = 1.2

; ---------------------- line ------------------------------------------

   res@xyLineColors          = (/"black","black"/)     ; Set the line colors.

   res@xyLineThicknesses     = (/3.0,3.0/)

   res@xyDashPatterns        = (/0,0/) ; 0- solid, 1-dash.

; --------------------- marker -----------------------------------------------

   res@xyMarkLineModes = (/"Markers","Lines"/)

   res@xyMarkers       = (/4,4/)

;           ;  4 - circle,  5- corss , 6-square ,7 - triangle

;           ;  0 - none  ,  1- dot   , 2 - plus ,3 - asterisk

;           ;  9 - lingxi,  12 -star , 14 - dotted cirle , 16 - full cirlce

   res@xyMarkerColors   = (/"red","red"/)            ; Marker color string

   res@xyMarkerSizeF    = (/0.02,0.02,0.01,0.02,0.02,0.02/)  ;default is 0.01

;

; ---------------this is the values of X axis-------------------------------------------------

   x = new(n\_new,float)

    do i = 1,n\_new

      x(i-1) = (i)\*1.

    end do

;----------------define the figure size and select fields----------------------------------

   res@gsnDraw   = False

   res@gsnFrame  = False ; Don't advance the frame.

   res@vpWidthF  = 4.0      ;the default are all 0.6\*0.6. We make it wider and lower now

   res@vpHeightF = 0.55

    plot = new(6,graphic)

;--------statistical metrics-----

   CC       = new(19,float)

   RMSE     = new(19,float)

   NSE      = new(19,float)

   ;RB      = new(19,float)

;-----------Begin for every river-------------------------------------------------------------

 ;  ----river5--

   river = 5

   res@trYMaxF                = 1.2

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/Noah\_data/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(0,:)

   simu       = tavg(1,:)

   ;RB(river) = model\_rb(n,simu,obs)

  ;  NSE(river) = model\_nse(n,simu,obs)

   res@gsnLeftString = "05 Ohio"

   res@gsnLeftStringFontHeightF = 0.07

    ;res@txFontThicknessF = 2.0

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

    ; res@gsnRightStringFontHeightF = 0.07

    ;res@txFontThicknessF = 2.0

    res@tmXBLabelsOn = True

   plot(0) = gsn\_csm\_xy(wks,x,tavg,res)

   ;----river6--

   delete(res@pmLegendDisplayMode)

   river = 6

   res@trYMaxF                = 1.0

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/Noah\_data/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)                                  ;1982-2008

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(0,:)

   simu       = tavg(1,:)

   ;RB(river) = model\_rb(n,simu,obs)

   ; print(simu)

   ;print(obs)

  ;  NSE(river) = model\_nse(n,simu,obs)

   res@gsnLeftString = "06 Tennessee"

      res@gsnLeftStringFontHeightF = 0.07

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

    ; res@gsnRightStringFontHeightF = 0.07

     res@tmXBLabelsOn = False

   plot(1) = gsn\_csm\_xy(wks,x,tavg,res)

   ;----river7--

   delete(res@pmLegendDisplayMode)

   river = 7

   res@trYMaxF                = 1.0

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/Noah\_data/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)                                  ;1982-2008

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(0,:)

   simu       = tavg(1,:)

   ;RB(river) = model\_rb(n,simu,obs)

  ;  NSE(river) = model\_nse(n\_new-1,simu,obs)

   res@gsnLeftString = "07 Upper Mississippi"

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

    res@gsnLeftStringFontHeightF = 0.07

    ; res@gsnRightStringFontHeightF = 0.07

     res@tmXBLabelsOn = False

   plot(2)    = gsn\_csm\_xy(wks,x,tavg,res)

   ;----river8--

   delete(res@pmLegendDisplayMode)

   river = 8

   res@trYMaxF                = 1.0

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/Noah\_data/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)                                  ;1982-2008

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(0,:)

   simu       = tavg(1,:)

   ;RB(river) = model\_rb(n,simu,obs)

  ;  NSE(river) = model\_nse(n\_new-1,simu,obs)

   res@gsnLeftString = "08 Lower Mississippi"

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

       res@gsnLeftStringFontHeightF = 0.07

    ; res@gsnRightStringFontHeightF =0.07

     res@tmXBLabelsOn = False

   plot(3)    = gsn\_csm\_xy(wks,x,tavg,res)

   ;----river10--

   delete(res@pmLegendDisplayMode)

   river = 10

   res@trYMaxF                = 1.0

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)                                  ;1982-2008

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(0,:)

   simu       = tavg(1,:)

   ;RB(river) = model\_rb(n,simu,obs)

  ;  NSE(river) = model\_nse(n\_new-1,simu,obs)

   res@gsnLeftString = "10 Missouri"

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

      res@gsnLeftStringFontHeightF = 0.07

    ; res@gsnRightStringFontHeightF = 0.07

     res@tmXBLabelsOn = False

   plot(4)      = gsn\_csm\_xy(wks,x,tavg,res)

;----river11--

delete(res@pmLegendDisplayMode)

   river = 11

   res@trYMaxF                = 1.0

   res@tmYLTickSpacingF       = 0.2

   tavg      =new((/2,n\_new/),float)

   MP\_q       = new(n,float)

   MP\_q       = avg\_sim("/Noah\_data/results/exp1/daily/",field1,river)

   obs\_q      = avg\_obs("/SMAP\_L3\_regrid/2015-2019/",field2,river)

   tavg(0,:)  = obs\_q(0:n\_new-1)                           ;get the obs from 1982-2008=27yr=324

   tavg(1,:)  = MP\_q(0:n\_new-1)

   print(tavg)                                 ;1982-2008

   printVarSummary(tavg)

   printMinMax(tavg,1)

  ;  CC(river)  = escorc(tavg(0,:),tavg(1,:))        ;R

  ;  RMSE(river)= dim\_rmsd(tavg(0,:),tavg(1,:))      ;RMSE

   obs        = tavg(1,:)

   simu       = tavg(0,:)

   ;RB(river) = model\_rb(n,simu,obs)

  ;  NSE(river) = model\_nse(n\_new-1,simu,obs)

   res@gsnLeftString = "11 Arkansas-White-Red"

    ; res@gsnRightString = "r ="+ sprintf("%4.2f",CC(river))+", "+"RMSE ="+sprintf("%4.2f",RMSE(river))+", "+"NSE ="+sprintf("%4.2f",NSE(river))

      res@gsnLeftStringFontHeightF = 0.07

    ; res@gsnRightStringFontHeightF = 0.07

    res@tmXBLabelsOn = True

     plot(5)  = gsn\_csm\_xy(wks,x,tavg,res)

;panel plot initialization

  pres                        = True

  pres@gsnMaximize            = True

pres@gsnPanelLeft  = 0.1

pres@gsnPanelFigureStrings= (/"a)","b)","c)","d)","e)","f)" /) ; add strings to panel

  pres@amJust   = "TopLeft"

  pres@gsnPanelFigureStringsFontHeightF = 0.015

  pres@gsnPanelFigureStringsPerimOn = False

;Create another set of text resources for overall axis labels

        txres3               = True

        txres3@txAngleF      = 90.          ; Rotate string clockwise

        txres3@txFontHeightF = 0.017

        gsn\_text\_ndc(wks,"Soil Moisture (mm)",0.09,0.5,txres3)  ; add the common left y-axis label

        gsn\_panel(wks,plot,(/6,1/),pres)

 frame(wks)

end