Post-processing Tools (1): NCL *(WRF-ARW Only)*

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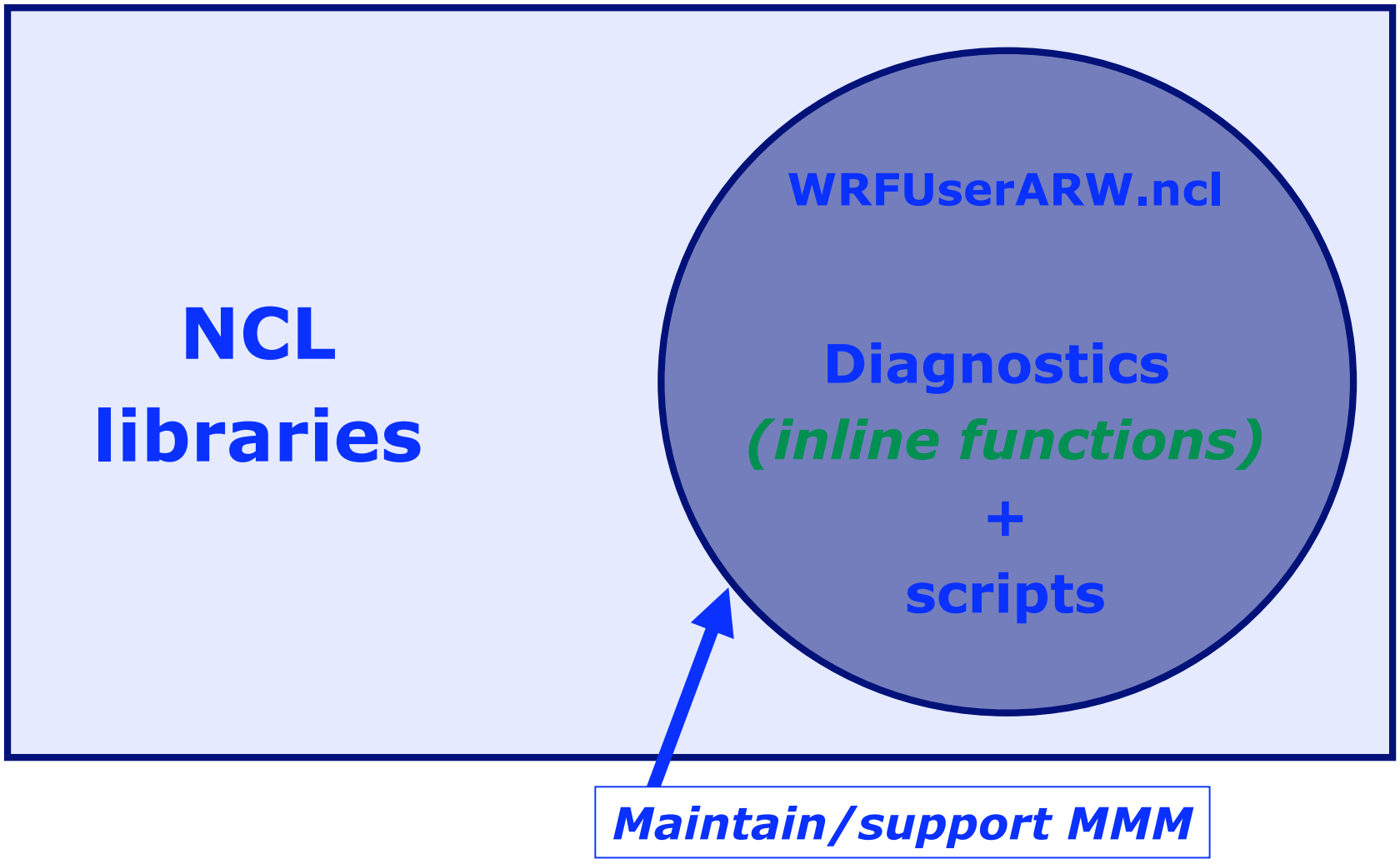
NCL

- **NCAR Command Language**
- ***http://www.ncl.ucar.edu***
- **Read WRF-ARW data directly**
- **Generate a number of graphical plots**
  - *Horizontal, cross-section, skewT, meteogram, panel*

NCL & WRF *(July 2007 - ncl v4.3.1)*



Download NCL

- ***http://www.ncl.ucar.edu/Download***
  - Fill out short registration form *(there is a short waiting period)*
  - Read and agree to OSI-based license
  - Download binaries
- **NCARG_ROOT environment variable**
  - *setenv NCARG_ROOT /usr/local/ncl*
- ***NCL version 4.3.1 or 5.0.0***
  - *Get new WRFUserARW.ncl from MMM site*

Home Directory → ~/.hluresfile ← Very Important

- **Required by NCL libraries**
- **Must be in your "~/" directory** ***(home directory)***
- **Control**
  - color table ; font
  - white/black background
  - size of plot
  - control characters

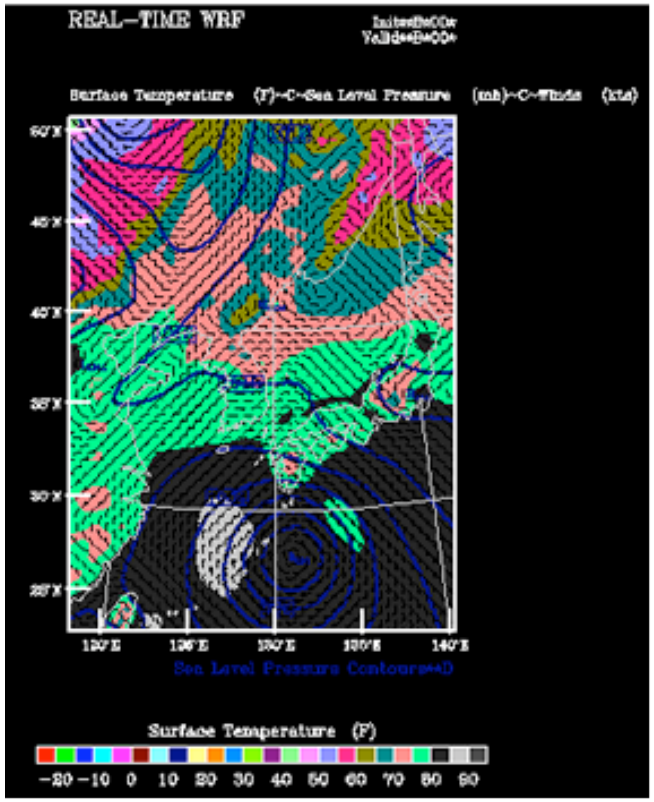
- ***http://www.ncl.ucar.edu/Document/Graphics/hlures.shtml***

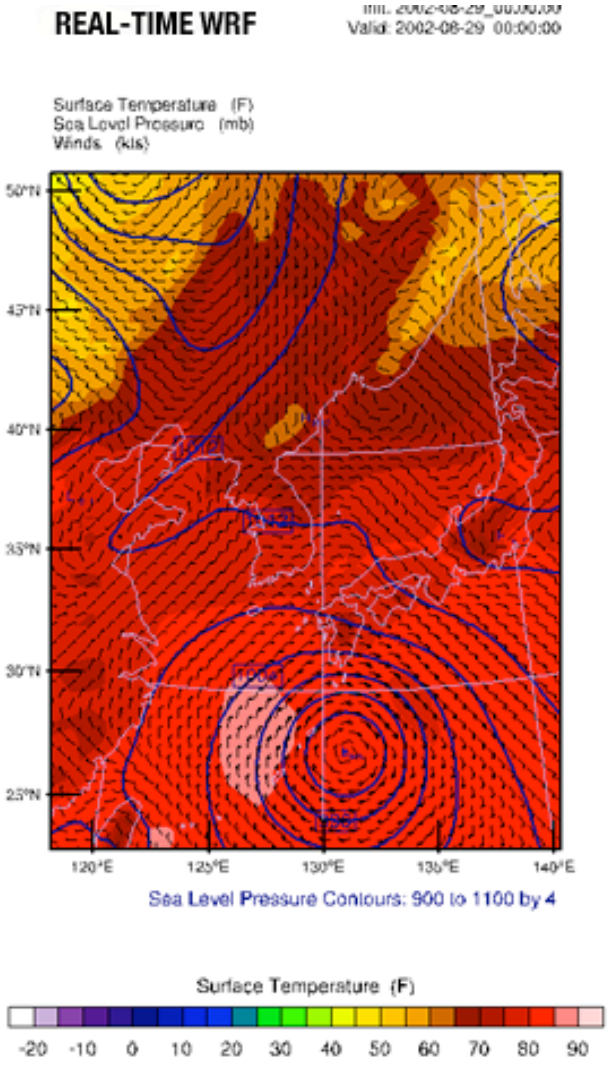
~/.hluresfile

```
*wkColorMap              : BlAqGrYeOrReVi200
*wkBackgroundColor       : white
*wkForegroundColor       : black
*FuncCode                : ~
*TextFuncCode            : ~
*Font                    : helvetica
*wkWidth                 : 900
*wkHeight                : 900
```

http://www.mmm.ucar.edu/wrf/OnLineTutorial/Graphics/NCL/.hluresfile

~/.hluresfile


REAL-TIME WRF
Surface Temperature (F)~C~Sea Level Pressure (mb)~C~Winds (kts)
60°N
45°N
40°N
35°N
30°N
25°N
120°E
125°E
130°E
135°E
140°E
Sea Level Pressure Contours:900 to 1100 by 4
Surface Temperature (F)
-20 -10 0 10 20 30 40 50 60 70 80 90

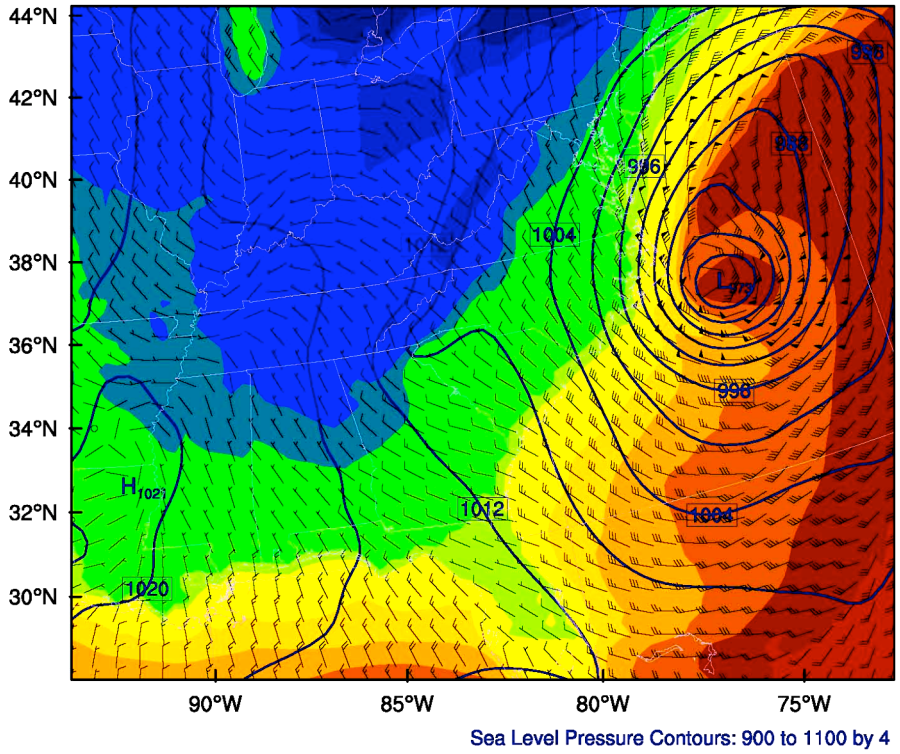

REAL-TIME WRF
Valid: 2002-08-29 00:00:00
Surface Temperature (F)
Sea Level Pressure (mb)
Winds (kts)
50°N
45°N
40°N
35°N
30°N
25°N
120°E
125°E
130°E
135°E
140°E
Sea Level Pressure Contours: 900 to 1100 by 4
Surface Temperature (F)
-20 -10 0 10 20 30 40 50 60 70 80 90

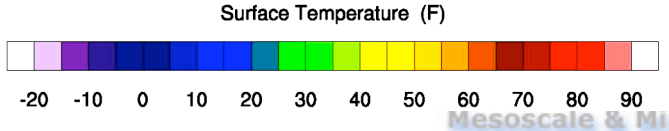
Generate Plots

- **Generate a script**
- **Run NCL to generate plots**
- **A good start - OnLine Tutorial**
  - ***http://www.mmm.ucar.edu/wrf/OnLineTutorial/Graphics/NCL/index.html***
  - Contain sample scripts

Creating a Plot

Surface Temperature (F)
Sea Level Pressure (mb)
Winds (kts)





Creating a Plot : NCL script

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/wrf/WRFUserARW.ncl"

begin

  ; Open graphical output
  ; Open input file(s)

  ; Read variables

  ; Set up plot resources & Create plots
  ; Output graphics

end
```

Creating a Plot : NCL script

```
begin

; Open graphical output
 wks = gsn_open_wks("x11","wrfout")        ; x11, ps, pdf

; Open input file
 a = addfile("wrfout_d01_2000-01-24_12:00:00.nc","r")

 ; Set up plot resources
 res = True                          ; contour / vector resources
 res@MainTitle = "REAL-TIME WRF"           ; Main title
 res@Footer = False                      ; Set Footers off

 pltres = True                         ; Plotting resources
 mpres = True                             ; Map resources
```

Not part of file name, but needs to be added inside the ncl script

Creating a Plot : NCL script

Function from: WRFUserARW.ncl

Function will call NCL diagnostics if needed

```
; Read variables

slp = wrf_user_getvar(a,"slp",5)
tc2 = wrf_user_getvar(a,"T2",5)
      tf2 = 1.8 * (tc2-273.16) + 32.
      tf2@description = "Surface Temperature"
      tf2@units = "F"
u10 = wrf_user_getvar(a,"U10",5)
v10 = wrf_user_getvar(a,"V10",5)
      u10 = u10*1.94386
      v10 = v10*1.94386
      u10@units = "kts"
      v10@units = "kts"
```

Diagnostics:

uvmet, ua, va, wa, pressure, z, th, tk, tc, td, td2, slp, rh

Creating a Plot : NCL script

```
; Create plots
 opts_psl                          = res
 opts_psl@cnLineColor              = "NavyBlue"
 c_slp = wrf_contour(a,wks,slp,opts_psl)

 opts_tc                           = res
 opts_tc@cnFillOn                  = True
 c_tc = wrf_contour(a,wks,tf2,opts_tc)

 opts_vct                          = res
 opts_vct@FieldTitle               = "Wind"
 opts_vct@NumVectors               = 47
 vec = wrf_vector(a,wks,u10,v10,opts_vct)

 plot = wrf_map_overlays(a, wks, \
        (/c_tc,c_slp,vec/),pltres, mpres)

end
```

Creating a Plot : NCL script

- **Create a script**
  - *wrf_real.ncl*
- **Set NCARG_ROOT environment variable:**
  - *setenv NCARG_ROOT /usr/local/ncl*
- **Ensure you have an ~/.hluresfile file**
- **Run NCL script**
  - *ncl wrf_real.ncl*

Special WRF Functions

- **wrf_user_getvar**
  Get fields from input file
  Calculate diagnostics *(currently only for wrfout files)*
  uvmet, ua, va, wa, pressure, z, th, tk, tc, td, td2, slp, rh

- **wrf_user_list_times**
  Get list if times available in input file

- **wrf_contour / wrf_vector**
  Create line/shaded & vector plots

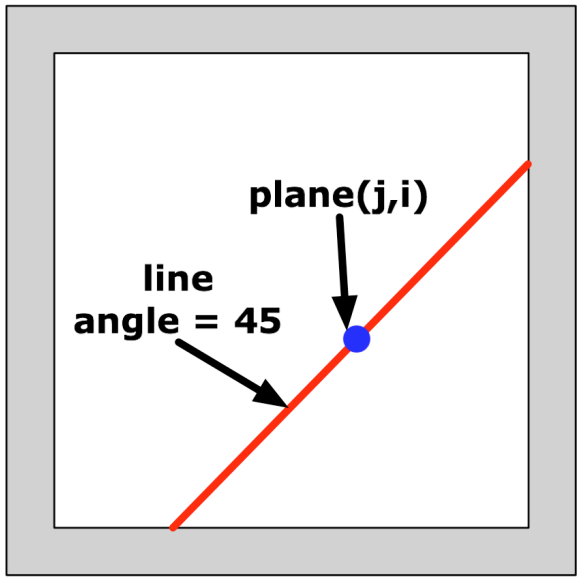
- **wrf_map_overlays / wrf_overlays**
  Overlay plots created with *wrf_contour* and *wrf_vector*

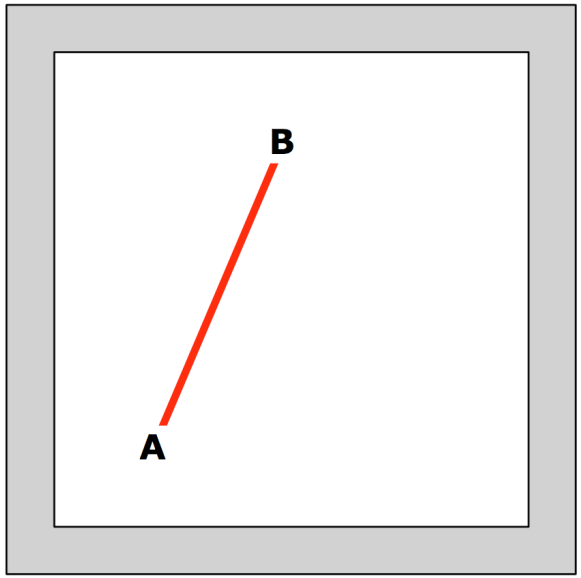
- **wrf_user_latlon_to_ij (nc_file, lats, lons)**
  Find closest ij to a given lat/lon location

Special WRF Functions

- **wrf_user_intrp3d**
  Interpolate horizontally to a given pressure or height level
  Interpolate vertically *(pressure/height),* along a given line

- **wrf_user_intrp2d**
  Interpolate along a given line

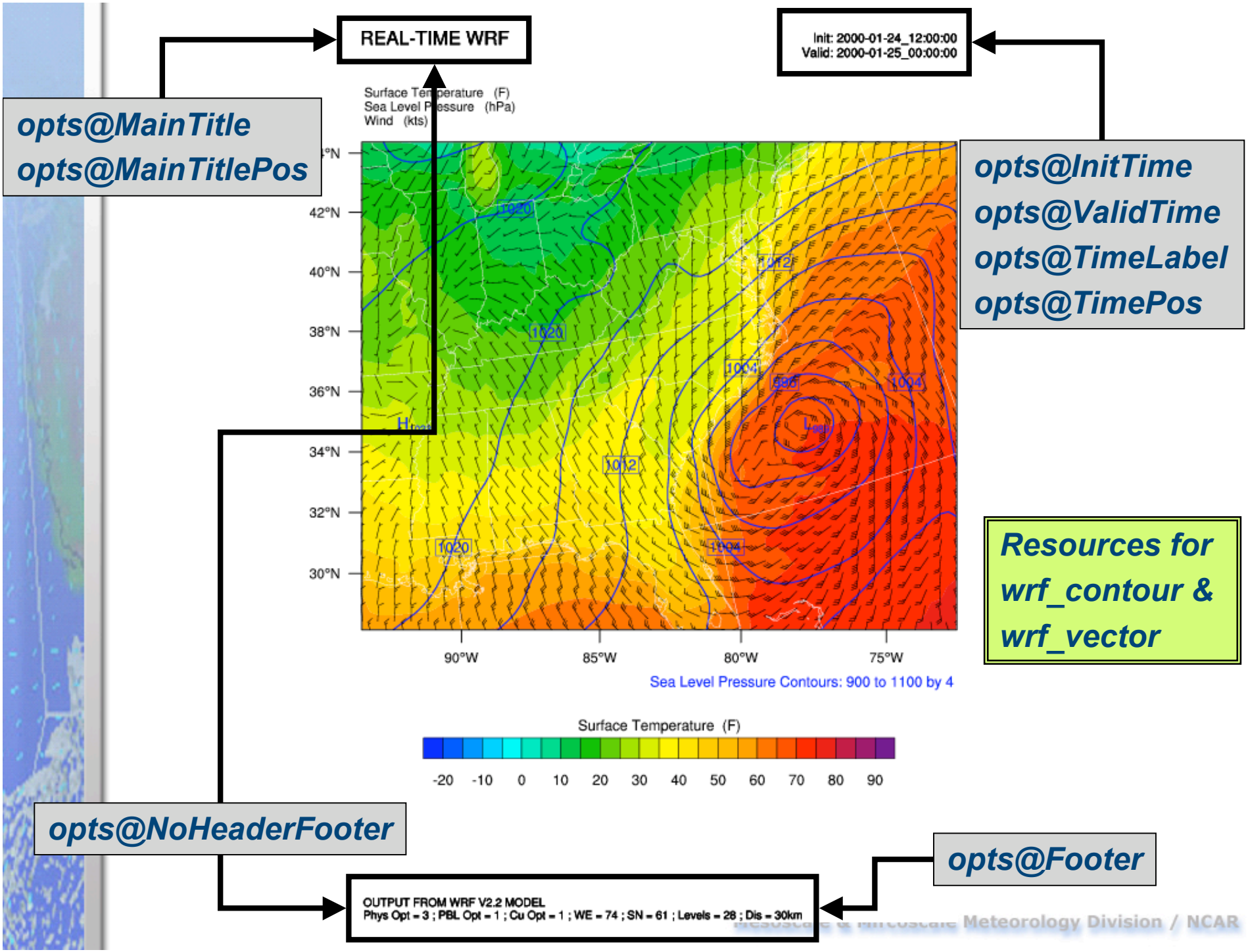


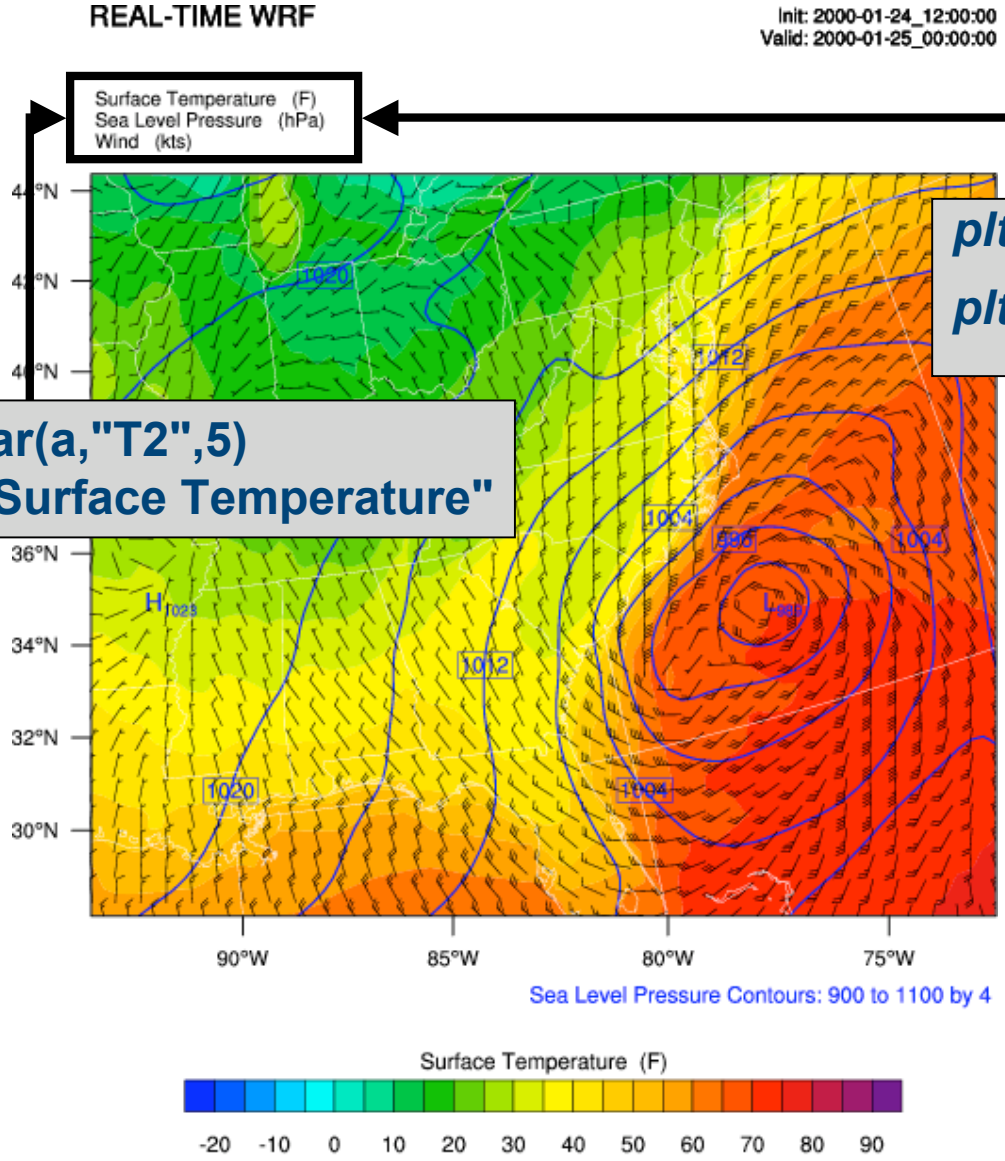


Resources

- **The special WRF functions have unique resources:**
  http://www.mmm.ucar.edu/wrf/OnLineTutorial/Graphics/NCL/NCL_functions.htm

- **All general NCL resources can also be used to control the plot:**
  http://www.ncl.ucar.edu/Document/Graphics/Resources


REAL-TIME WRF
Init: 2000-01-24_12:00:00
Valid: 2000-01-25_00:00:00
opts@MainTitle
opts@MainTitlePos
opts@InitTime
opts@ValidTime
opts@TimeLabel
opts@TimePos
Surface Temperature (F)
Sea Level Pressure (hPa)
Wind (kts)
42°N
40°N
38°N
36°N
34°N
32°N
30°N
90°W
85°W
80°W
75°W
1020
1012
1004
996
Sea Level Pressure Contours: 900 to 1100 by 4
Surface Temperature (F)
-20 -10 0 10 20 30 40 50 60 70 80 90
Resources for wrf_contour & wrf_vector
opts@NoHeaderFooter
opts@Footer
OUTPUT FROM WRF V2.2 MODEL
Phys Opt = 3 ; PBL Opt = 1 ; Cu Opt = 1 ; WE = 74 ; SN = 61 ; Levels = 28 ; Dis = 30km



t2 = wrf_user_getvar(a,"T2",5)
t2@description = "Surface Temperature"

pltres@NoTitles
pltres@CommonTitle

Resources for wrf_overlay

Adding FORTRAN code

- **Can link NCL to existing FORTRAN code**
- **Easiest to deal with F77 code**
- **Code must contain special *NCL START* and *END* markers**
- **Must create a shared object library from these routines in order for NCL to recognize the code.**

myTK.f

```
subroutine compute_tk (tk,pressure,theta, nx, ny, nz)
  implicit none
  integer nx,ny,nz
  real    pi, tk(nx,ny,nz)
  real    pressure(nx,ny,nz), theta(nx,ny,nz)


  integer i,j,k

  do k=1,nz
    do j=1,ny
    do i=1,nx
       pi=(pressure(i,j,k) / 1000.)**(287./1004.)
       tk(i,j,k) = pi*theta(i,j,k)
    enddo
    enddo
  enddo

  end
```

myTK.f

```
C NCLFORTSTART
      subroutine compute_tk (tk,pressure,theta, nx, ny, nz)
        implicit none
        integer nx,ny,nz
        real    pi, tk(nx,ny,nz)
        real    pressure(nx,ny,nz), theta(nx,ny,nz)
C NCLEND

        integer i,j,k

        do k=1,nz
          do j=1,ny
          do i=1,nx
             pi=(pressure(i,j,k) / 1000.)**(287./1004.)
             tk(i,j,k) = pi*theta(i,j,k)
          enddo
          enddo
        enddo

        end
```

myTK.so

WRAPIT myTK.f

setenv NCARG_ROOT */usr/local/ncl*

/usr/local/ncl/bin/WRAPIT myTK.f

cp /usr/local/ncl/bin/WRAPIT .

edit your copy

./WRAPIT myTK.f

myTK.so - use in NCL script

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/wrf/WRFUserARW.ncl"
external myTK "./myTK.so"

begin

      t = wrf_user_getvar(a,"T",5)
      t = t + 300
      p = wrf_user_getvar(a,"pressure",5)

      dim = dimsizes(t)
      tk = new( (/ dim(0), dim(1), dim(2) /), float)

      myTK :: compute_tk (tk,p,t,dim(2),dim(1),dim(0))

end
```

FORTRAN 90 code

- **Can use simple FORTRAN 90 code**

- **Your FORTRAN 90 program may not contain any of the following features:**
  - pointers or structures as arguments,
  - missing/optional arguments,
  - keyword arguments, or
  - recursive procedure.

FORTRAN 90 code

myTK.f90

```
subroutine compute_tk (tk, pres, theta, nx, ny, nz)
  implicit none
  integer :: nx,ny,nz, i, j, k
  real (nx,ny,nz) :: tk, pres, theta, pi

  pi(:,:,:)=(pres(:,:,:)/1000.)**(287./1004.)
  tk(i,j,k) = pi(:,:,:)*theta(i,j,k)

end subroutine compute_tk
```

FORTRAN 90 code

myTK.f90

```
subroutine compute_tk (tk, pres, theta, nx, ny, nz)
  implicit none
  integer :: nx,ny,nz, i, j, k
  real (nx,ny,nz) :: tk, pres, theta, pi

  pi(:,:,:)=(pres(:,:,:)/1000.)**(287./1004.)
  tk(i,j,k) = pi(:,:,:)*theta(i,j,k)

end subroutine compute_tk
```

myTK90.stub

```
C NCLFORTSTART
  subroutine compute_tk (tk, pres, theta, nx, ny, nz)
  implicit none
  integer nx,ny,nz
  real    tk(nx,ny,nz)
  real    pres(nx,ny,nz), theta(nx,ny,nz)
C NCLEND
```

myTK90.so

WRAPIT myTK90.stub myTK.f90

setenv NCARG_ROOT */usr/local/ncl*
/usr/local/ncl/bin/WRAPIT myTK.f
cp /usr/local/ncl/bin/WRAPIT . *edit your copy - link to a f90 compiler* ./WRAPIT myTK.f

myTK90.so - use in NCL script

```
load "$NCARG_ROOT/lib/ncarg/nclscripts/csm/gsn_code.ncl"
load "$NCARG_ROOT/lib/ncarg/nclscripts/wrf/WRFUserARW.ncl"
external myTK90 "./myTK90.so"

begin

    t = wrf_user_getvar(a,"T",5)
    t = t + 300
    p = wrf_user_getvar(a,"pressure",5)

    dim = dimsizes(t)
    tk = new( (/ dim(0), dim(1), dim(2) /), float)

    myTK90 :: compute_tk(tk,p,t,dim(2),dim(1),dim(0))

end
```