Organization of Course

INTRODUCTION

1. Course overview

2. Air Toxics overview

3. HYSPLIT overview

HYSPLIT Theory and Practice

4. **Meteorology**

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6. Concentrations / Deposition

7. HYSPLIT-SV for
   semivolatiles (e.g, PCDD/F)

8. HYSPLIT-HG for mercury

Overall Project Issues & Examples

9. Emissions Inventories

10. Source-Receptor Post-
    Processing

11. Source-Attribution for Deposition

12. Model Evaluation

13. Model Intercomparison

14. Collaboration Possibilities

Meteorological Data
Introduction

- HYSPLIT requires at a minimum, u,v,w,T, P_{sfc} (RH or Q optional) in 3 dimensions

- Meteorological data are specially formatted to minimize execution time

    - Compressed binary
    - Fields are written at each level for one time period, then repeated as needed in time

- All forecast data currently available in HYSPLIT menus originates from NOAA's National Centers for Environmental Prediction (NCEP)

- Forecast or Analysis
    - Registration is required to run HYSPLIT dispersion with forecast data
    - Data is available globally and regionally over North America

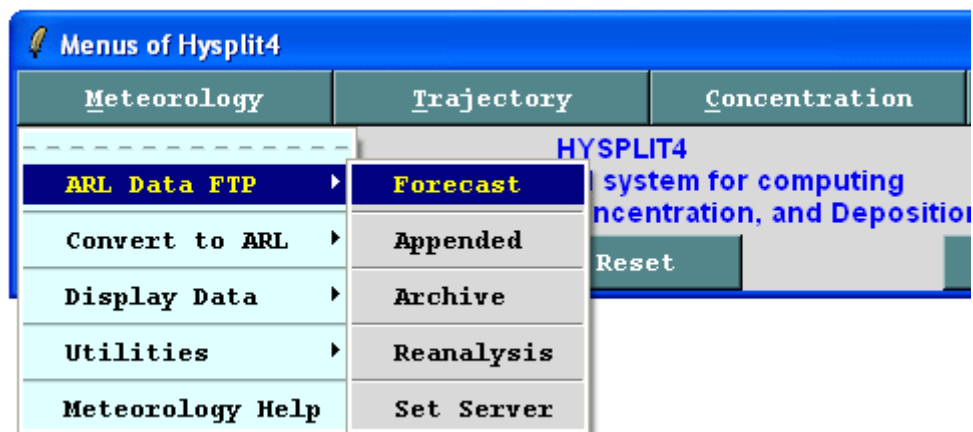- PC HYSPLIT downloads data directly from NOAA ARL servers; options are available to switch to other FTP servers

Meteorological Data

- **<u>Forecast</u> Meteorological Data:**
  - North American Meso (**NAM**)
  - Rapid Update Cycle (**RUC**)
  - Global Forecast System (**GFS**)

- **<u>Analysis</u> Meteorological Data:**
  - North American Meso (**NAM**)
  - NAM Data Assimilation System (**NDAS**, formerly **EDAS**)
  - Global Data Assimilation System (**GDAS**, formerly **FNL**)
  - Global **Reanalysis**

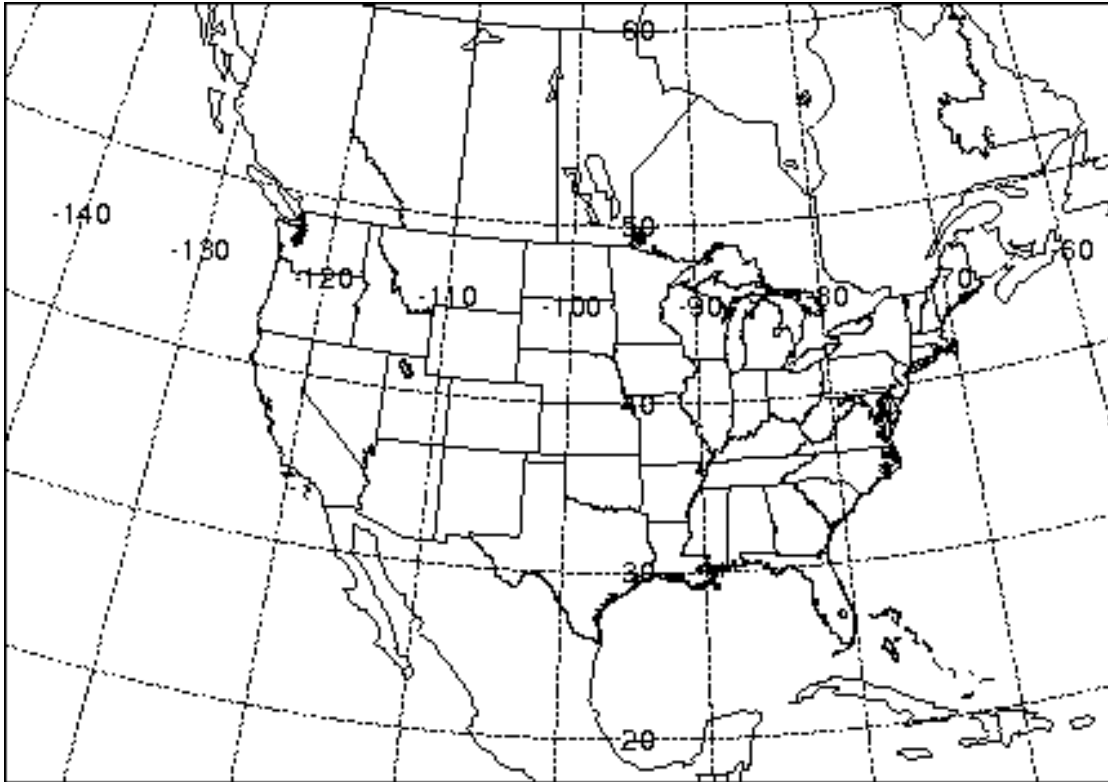For more information, see the following websites:

http://www.arl.noaa.gov/READYmetdata.php

http://www.arl.noaa.gov/archives.php

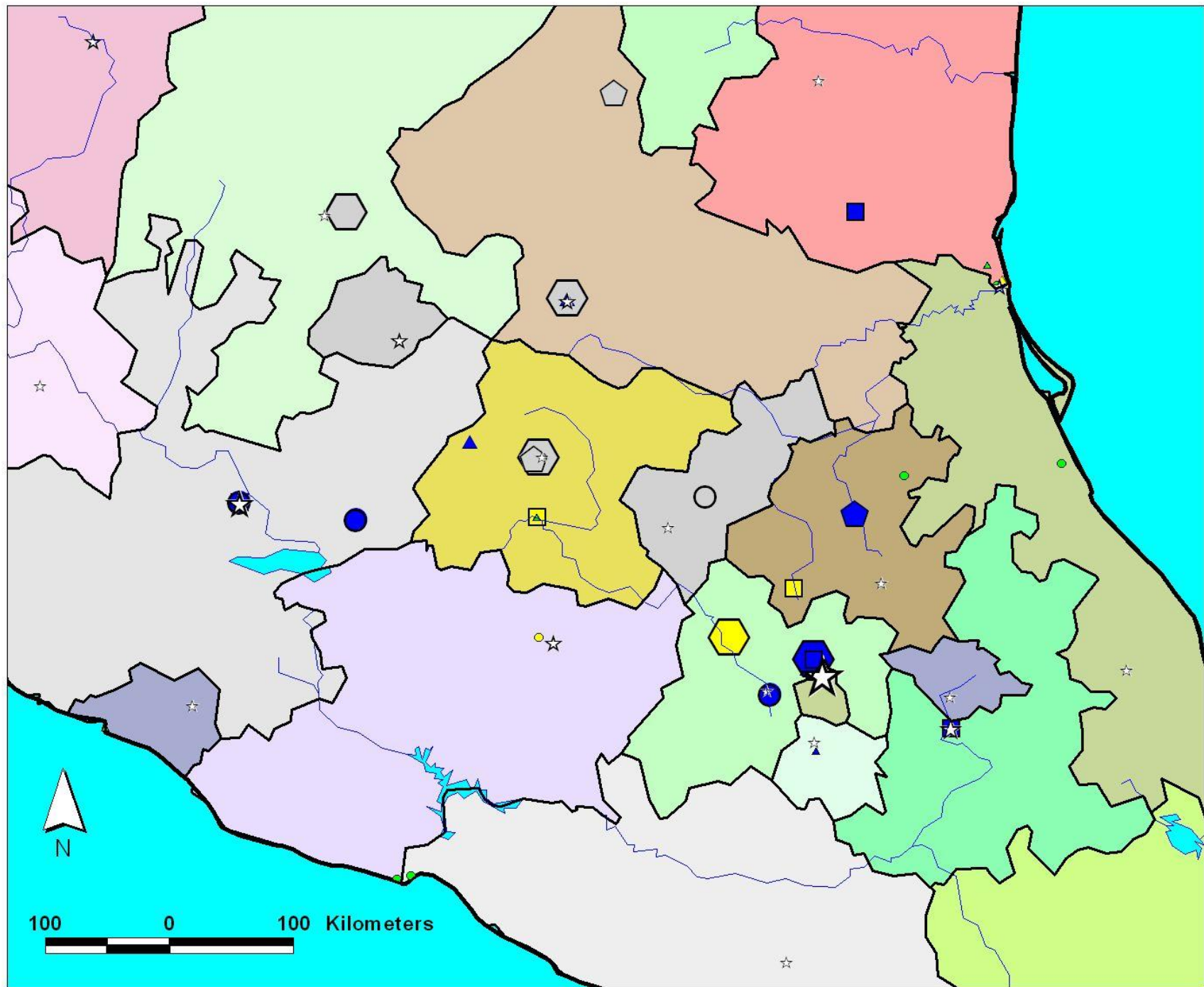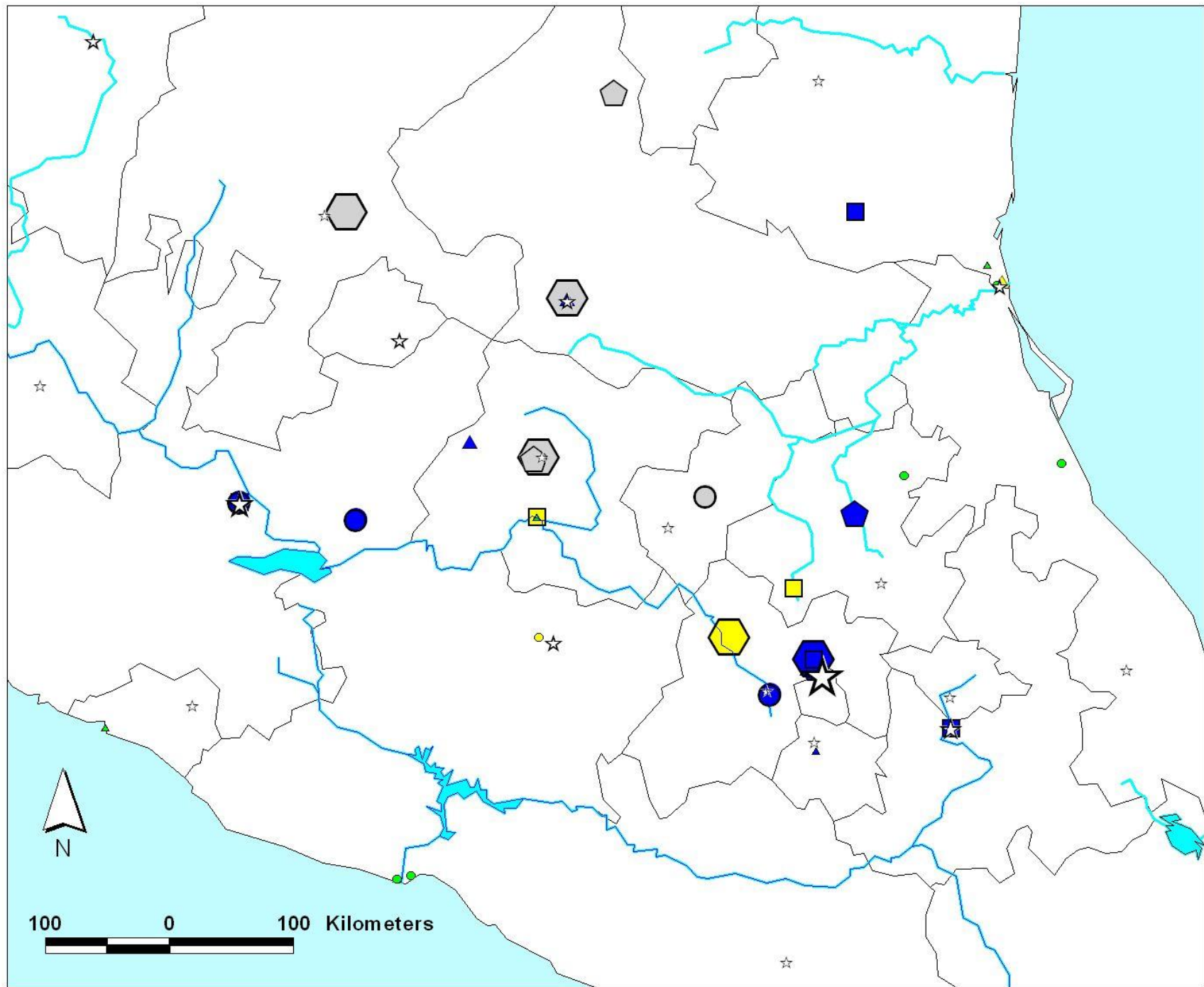http://www.nco.ncep.noaa.gov/pmb/products/

Regional Met Data Sets

Example: EDAS 40km data set

EDAS 40km Grid

ftp://arlftp.arlhq.noaa.gov/pub/archives/edas40/edas.aug08.001

ftp://arlftp.arlhq.noaa.gov/pub/archives/edas40/edas.aug08.002

N

100   0   100 Kilometers

N

100   0   100 Kilometers

N

100   0   100   Kilometers

500   0   500 Kilometers

N
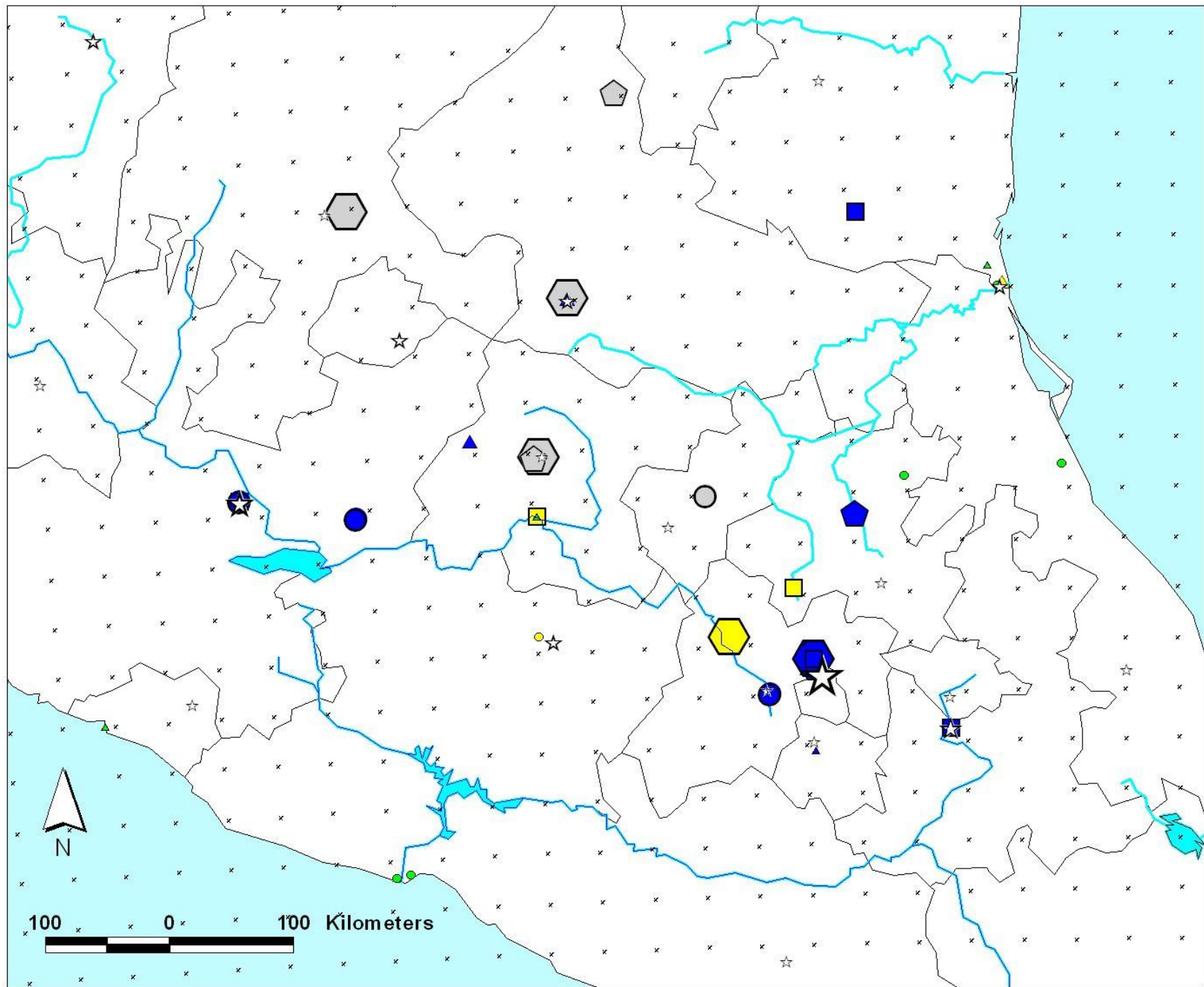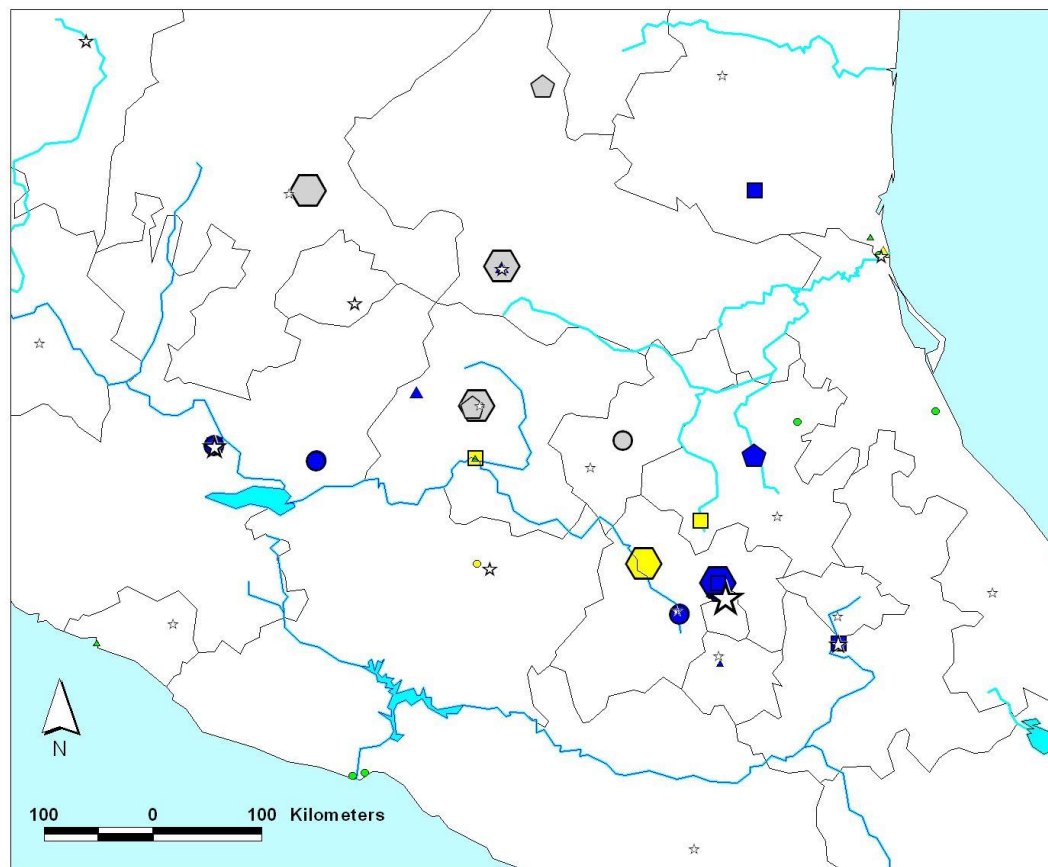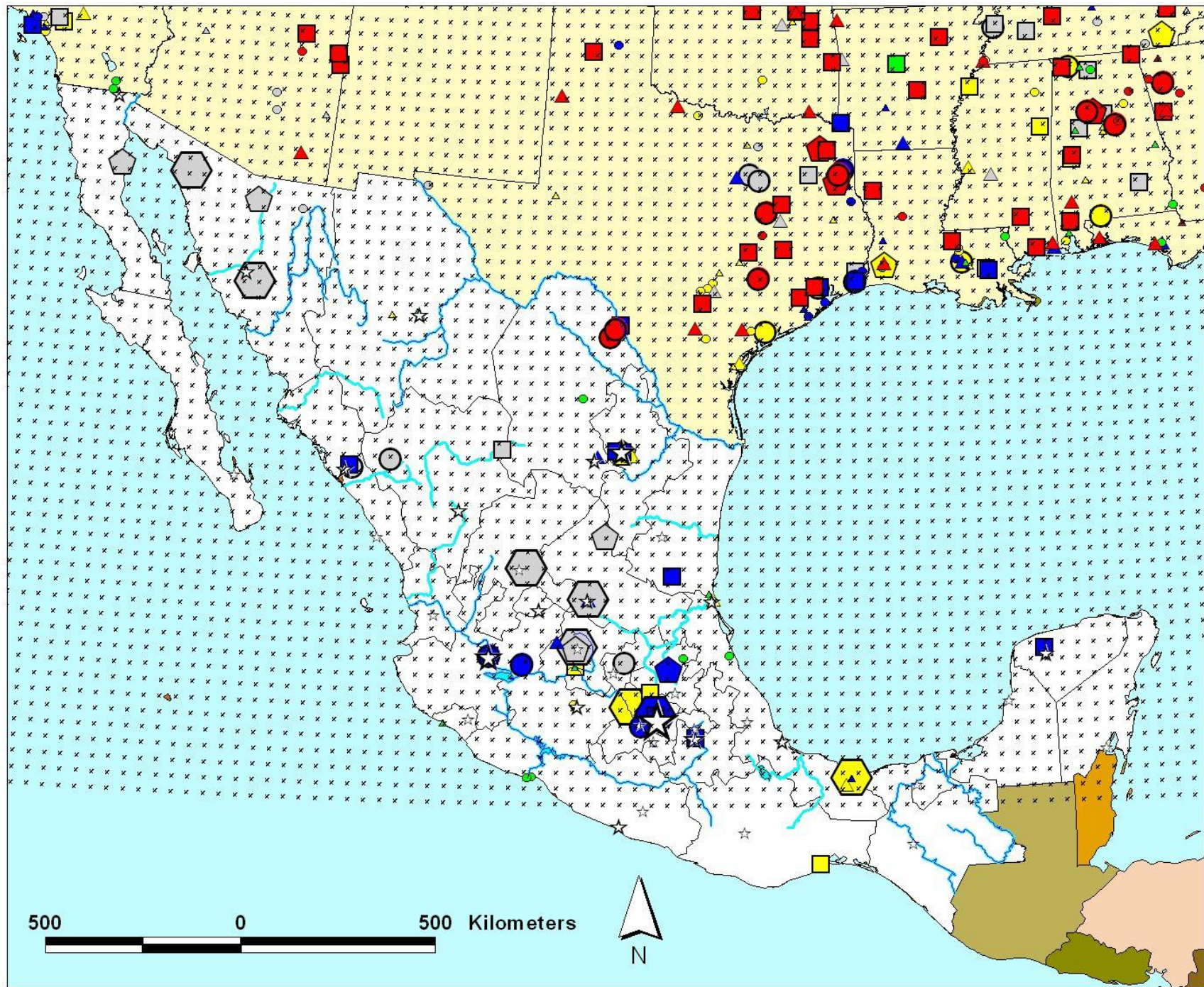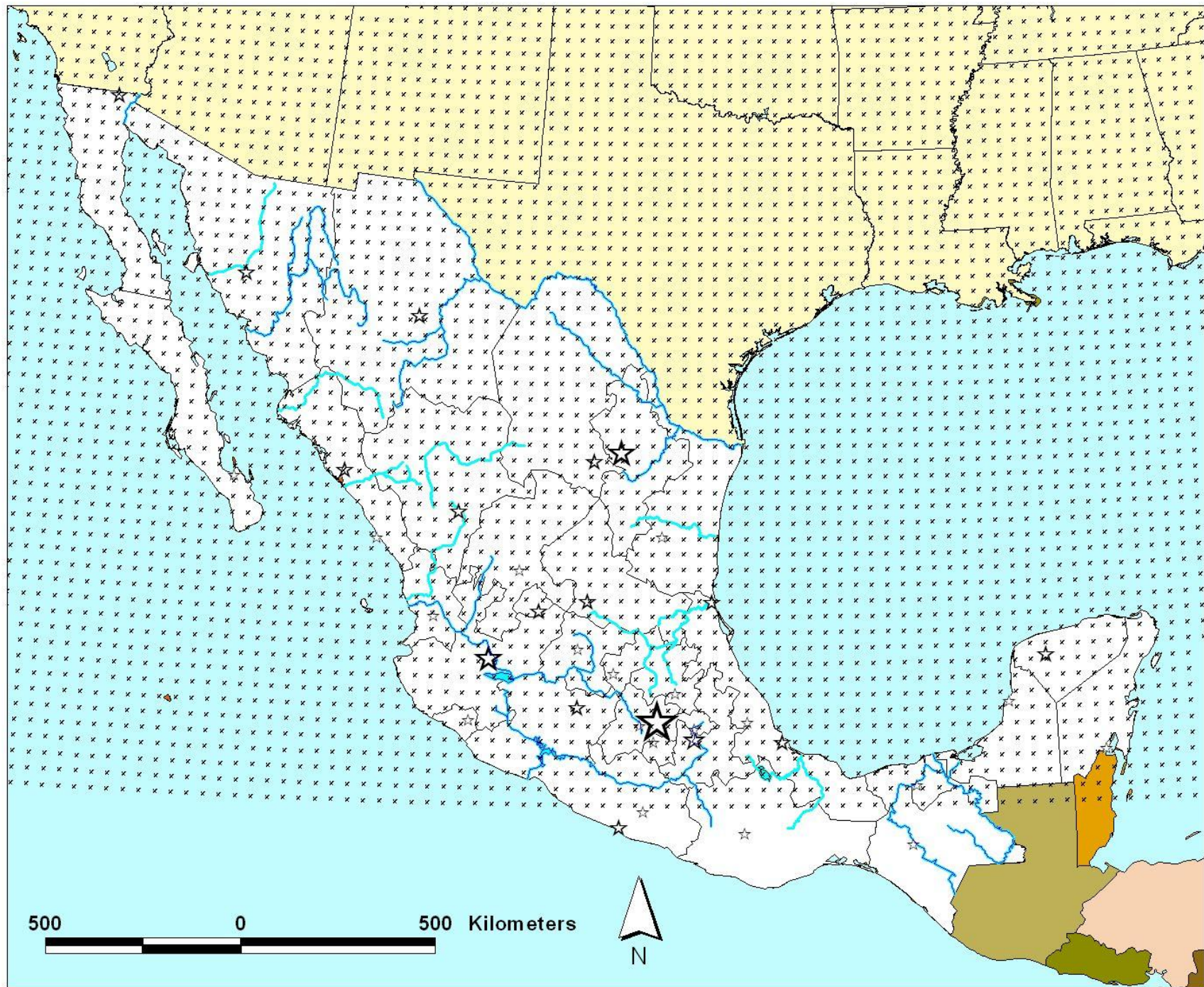
Global Met Data Sets

Example:

NCEP/NCAR
Reanalysis Data Archive

Meteorological Data

- **Global Reanalysis Meteorological Data:**
  - Global coverage from 1948 to ~present
  - NCEP & NCAR reran GFS for the past
  - Used primarily for running events prior to model data availability
    - reanalysis – 2.5 degree (~277 km), 6 hrly, pressure levels, archive

Global reanalysis

File Edit View History Bookmarks Tools Help

ftp://arlftp.arlhq.noaa.gov/pub/archives/reanalysis/

Google

NOAA web mail   credit cards   on-line publications   software   NOAA stuff   personal   GIS training and other   top stub checks

UltraEdit   Web Search   Wikipedia   84°F

Index of ftp://arlftp.arlhq.noaa.gov/pub/archives/reanalysis/

Up to higher level directory

Name	Size	Last Modified	
README.TXT	5 KB	4/7/2008	12:00:00 AM
RP194801.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194802.gbl	112469 KB	9/26/2003	12:00:00 AM
RP194803.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194804.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194805.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194806.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194807.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194808.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194809.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194810.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194811.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194812.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194901.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194902.gbl	108591 KB	9/26/2003	12:00:00 AM
RP194903.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194904.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194905.gbl	120226 KB	9/26/2003	12:00:00 AM
RP194906.gbl	116348 KB	9/26/2003	12:00:00 AM
RP194907.gbl	120226 KB	9/26/2003	12:00:00 AM

Done

Meteorological Data

- **NAM Meteorological Data:**
  - Regional forecast model – used in most HYSPLIT model runs over U.S.
  - Updated every 6 hours
    - namf – CONUS, 12 km, 3 hrly, pressure levels, 48h forecast
    - namf40 – CONUS, 40 km, 3 hrly, pressure levels, 84h forecast
    - namakf – Alaska, 45 km, 3 hrly, pressure levels, 36h forecast
    - namsf.XXtile – 4 U.S. quadrants, 12 km, 1 hrly, sigma levels, 48h forecast
    - namsf.AK – Alaska,12 km, 1 hrly, sigma levels, 48h forecast
    - namsf.HI – Hawaii, 12 km, 1 hrly, sigma levels, 48h forecast
    - Nam12/NAMs – CONUS, 12 km, 3 hrly, P & S levels, daily archive of forecasts
    - NDAS (EDAS) – 40 km (80km <2004), 3 hrly, pressure, archive (analysis + forecast)
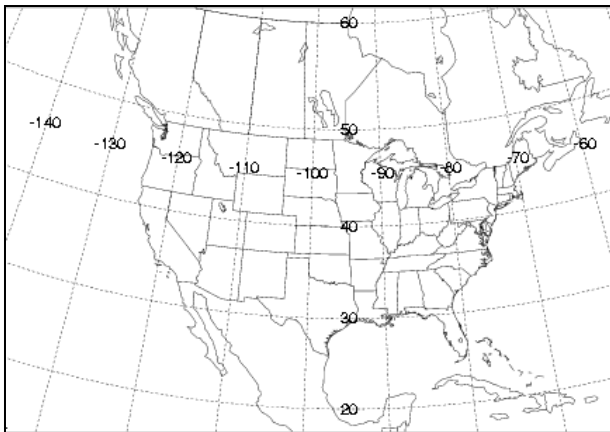
NAM 12 km   Alaska 45 km

Supplement
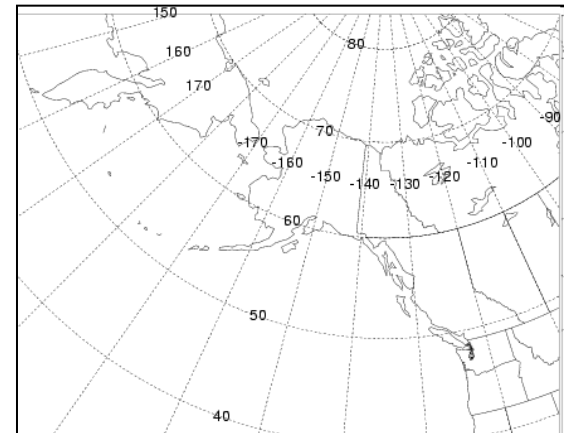
Meteorological Data

RUC Meteorological Data:

- Rapid Update Cycle forecast model – useful for rapidly changing conditions
- Incorporates radar, satellite, aircraft, surface, upper-air observations
- Updated every 3 hours
  - ruc – CONUS, 20 km, 1 hrly, pressure levels, 12h forecast
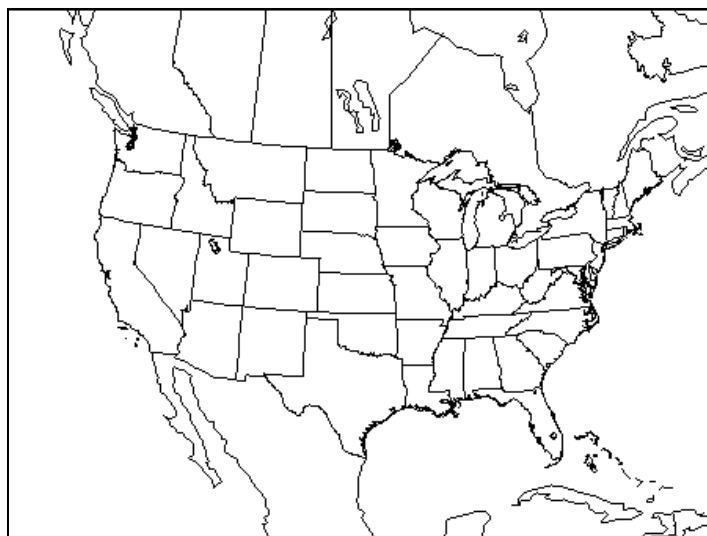
RUC 20 km

Meteorological Data

- **GFS Meteorological Data:**
  - Global Forecast System model – Global coverage
  - Updated every 6 hours
    - gfsf – 1 degree (~111 km), 3 hrly, pressure levels, 180h forecast
    - gfslrf – 2.5 degree (~277km), 12 hrly, pressure levels, 180-384 forecast hours
    - GDAS (>12/2004) – 1 degree, 3 hrly, pressure levels, archive (analysis + forecasts)
    - GDAS (>8/2007) – 0.5 degree, 3 hrly, hybrid levels, archive (analysis + forecasts)
    - FNL (1997-2006) – 191 km, 6 hrly, pressure levels, archive (analysis + forecast)

GFS

Data Requirements

File characteristics and projection

HYSPLIT requires that meteorological data fields be:

- projected on a conformal map projection (Polar Stereographic, Lambert, or Mercator) or a regular latitude-longitude grid,
- organized with one record per variable per level and all records must have the same record length,
- written in a forward time sequence.

More details on the format and packing of the meteorological data can be found in the HYSPLIT User's Guide.

The **\exec** directory contains several command line programs (**chk_data.exe**, **chk_rec.exe**) that can be used to analyze a HYSPLIT compatible meteorological data file. **chk_file.exe** has been incorporated into a HYSPLIT GUI under the **Meteorology** / **Display Data** menu.
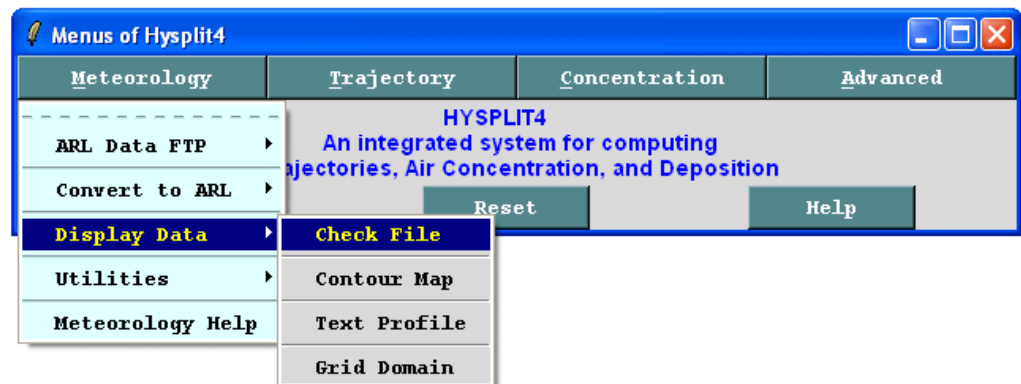
Forecast Data Access

Forecast Data

Forecast meteorological data, already been converted from standard GRIB format to the HYSPLIT compatible format, can be conveniently downloaded using the **ARL Data FTP** and **Forecas**t submenus of the **Meteorology** menu. The user can download the most recent four forecast runs (cycles), except for the RUC model, which is available eight times per day.

All meteorological data are retrieved by default from the Air Resources Laboratory's FTP server (gus.arlhq.noaa.gov). The submenu option **Set Server** allows the user to change to an alternate ARL FTP server (arlftp.arlhq.noaa.gov), to a backup NOAA NCEP operational FTP server (ftpprd.ncep.noaa.gov) or to user-specified FTP server and directory containing HYSPLIT compatible meteorological files.

PC-HYSPLIT WORKSHOP
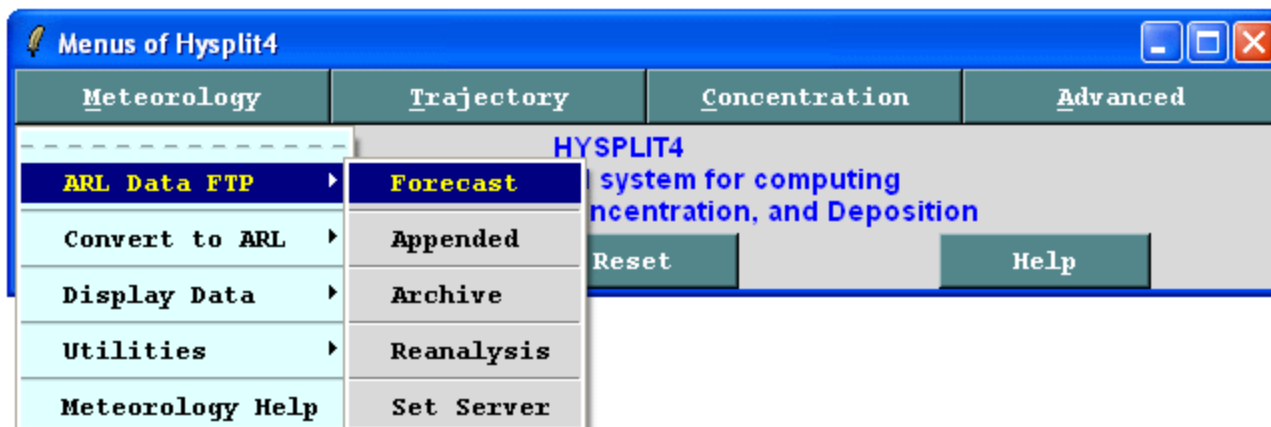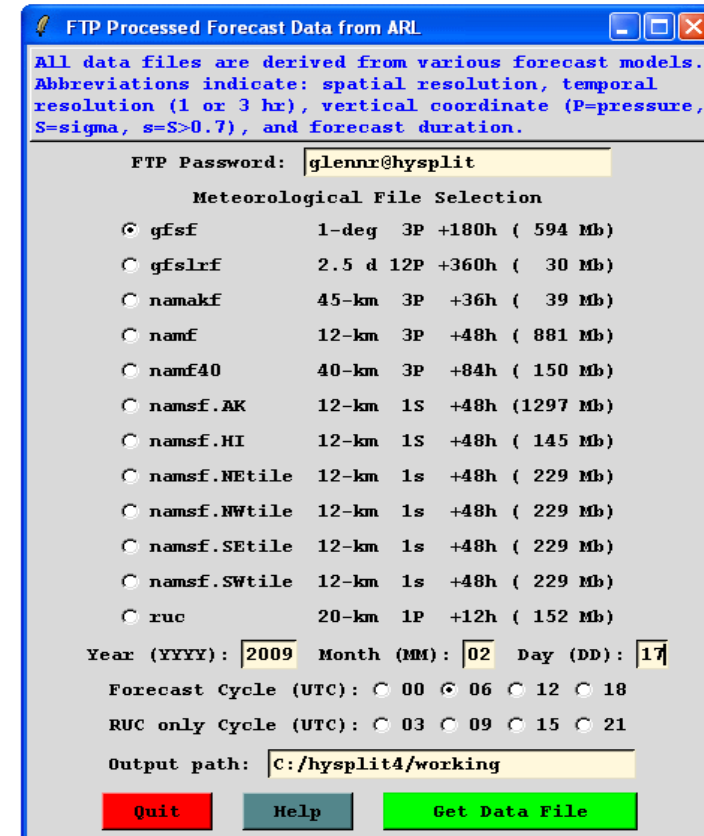
Forecast Data Access

Processed Forecast Data

The forecast data on the ARL server covers 4 domains:

– <u>North America</u>
  * **NAM** (North American Mesoscale - 12 and 40 km),
  * **NAM** (12 km sigma in four tiles – NE, SE, SW, NW)
  * **RUC** (Rapid Update Cycle - 20 km)
– <u>Alaska</u>
  * **NAM** (12 km sigma level and 45 km pressure level data)
– <u>Hawaii</u>
  * **NAM** (12 km sigma level data)
– <u>Global latitude-longitude grids</u>
  * **GFSF** - 1 degree, 3 hourly to +180 hours,
  * **GFSLR** - 2.5 degree, 12 hourly from +180 to +360 hours.

Prior to selecting **Get Data File**, a valid Email address should be entered into the password field. The latest forecast cycle will be downloaded by default. A percent complete message will appear indicating the FTP is in progress. Another message will appear when the FTP process is complete. More information on the forecast meteorological data can be found on the READY website.

Analysis Data Access

Analysis Data FTP

There are 3 options under the **ARL Data FTP** menu tab for retrieving analysis meteorological data in HYSPLIT compatible format from the ARL FTP server.

- **Appended** – a 48 hour pseudo-analysis consisting of the 0 hour initialization and short-time (+3 or +1,+2,+3,+4,+5 hour) forecasts from the last seven forecast cycles) of the NAM (45 km Alaska, 12 and 40 km CONUS), RUC and GFS
- **Archive** - longer term archives (discussed in more detail on the next slide)
- **Reanalysis** - access to monthly 2.5 degree NCAR/NCEP files from 1948 to end of last year
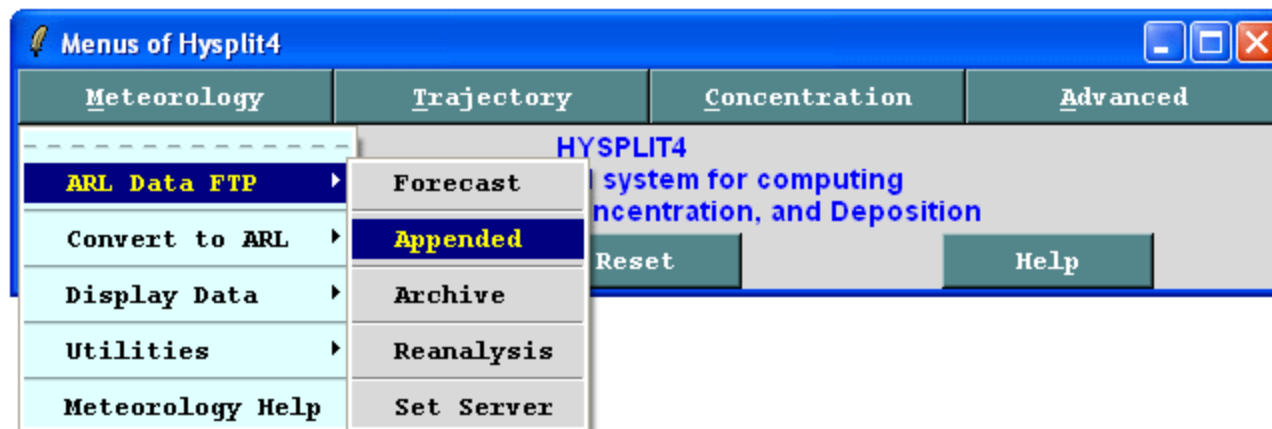
Analysis Data Access

Archive

The following archive data are currently available:

- The **EDAS** (now called **NDAS**) is available on a reduced resolution (80 km) grid over the US prior to January 2004. Thereafter, it is available at 40 km horizontal resolution.
- The **NAMs** and **NAM12** are 12 km pseudo-analyses over the US on sigma and pressure levels, respectively, made from daily forecast files.
- The **FNL** global archive pressure level data are on northern and southern hemispheric grids at 6 hour intervals (replaced by **GDAS** in 2006).
- The **GDAS** global archive data are available on two grids (both 3 hrly); 1.0 degree, pressure levels, and 0.5 degree, sigma levels

The **EDAS** and **FNL** files are selected according the to year and half-month (**001** for days 1 to 15 and **002** for days 16 to the end of the month). The 1 degree **GDAS** files are weekly with the week of the month represented by the numbers 1 to 5. The 0.5 degree **GDAS** and **NAM** archives are downloaded as a daily files.

There are a lot of powerful tools available in the HYSPLIT modeling system to display meteorological data

We aren't going to go into much detail here, but here are a few examples…

Data Requirements

Running **Check File** prompts the user for the location of a HYSPLIT compatible dataset. (Note: its best to store all HYSPLIT compatible data sets in a directory whose name does not contain spaces as these can sometimes confuse the TCL scripts).

Meteorological Data Information

Program to summarize the contents of a HYSPLIT compatible meteorological data file. The summary output is written to a text file: chkfile.txt. Displaying results for very large data sets may take a few minutes. All records are listed!

Set File Name of ARL format Data

C:/hysplit4/working   hysplit.t12z.namf40

Quit   Help   Run File Program

SIMULATION LOG

METEOROLOGICAL DATA LISTING ...
 Enter meteorological directory ...
 Enter meteorological file name ...

```
     File start time:    9    2   17   12    0
     File ending time:   9    2   21    0    0

Last record number : 6235
Record length bytes:   23915
Meteo data model    :  NAM
 Grid size x,y,z    :  185  129   27
Vertical coordinate:    2
First forecast hour:    0
Last forecast hour :   84
Records per time    :  215
Minutes between     :  180

  Pole pnt lat/lon :   90.0000     0.0000
  Reference lat/lon:   35.0000   -95.0000
 Grid size (km)    :   40.0000
 Orientation       :    0.0000
 Tang Lat / Cone   :   25.0000
  Synch pnt x,y    :    1.0000     1.0000
  Synch pnt lat/lon:   12.1900 -133.4600

  Lower left corner:   12.1900 -133.4600
Upper right corner:   57.2899  -49.3865
  Tangent point x,y:  321.8001  100.7176
```

Exit

A sample of section 1 of the full output from **Check File** (**chk_file.exe**) is shown (right) for the 40 km NAM forecast file from February 17, 2009, 1200 UTC. (Note: the source code for **chk_file** can be found in **\examples\source** and can be used to develop other programs that need to read the meteorological data).
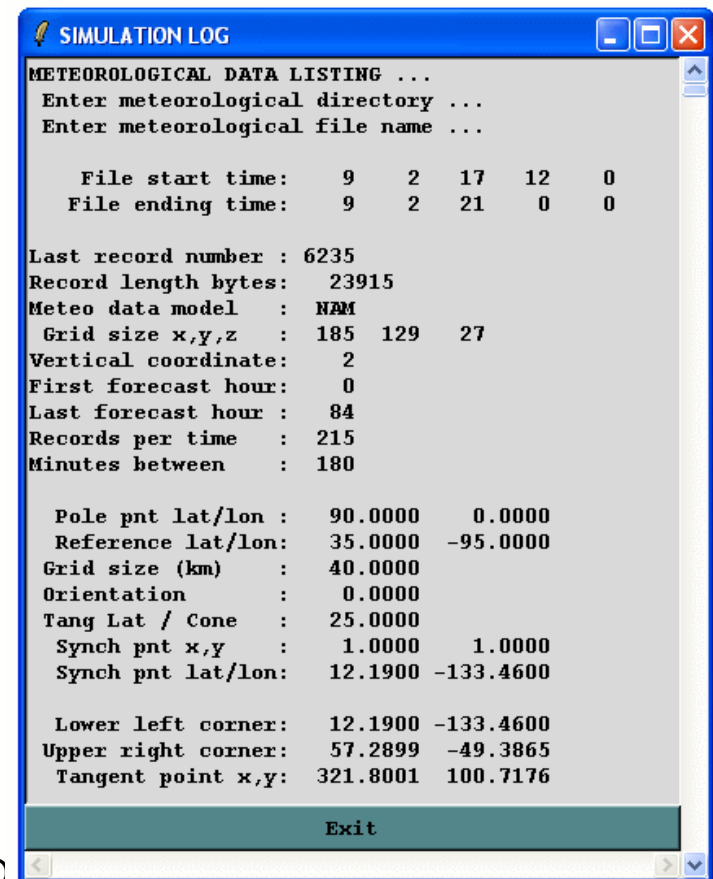
Display Data Menu

There are four options under the **Display Data** menu tab:
- **Check File** - display information about meteorological data set (discussed previously),
- **Contour Map** - contour and map meteorological data fields,
- **Text Profile** - a vertical profile text listing of all meteorological variables at a selected point,
- **Grid Domain** - a map of the spatial domain of the meteorological data grid.

PC-HYSPLIT WORKSHOP
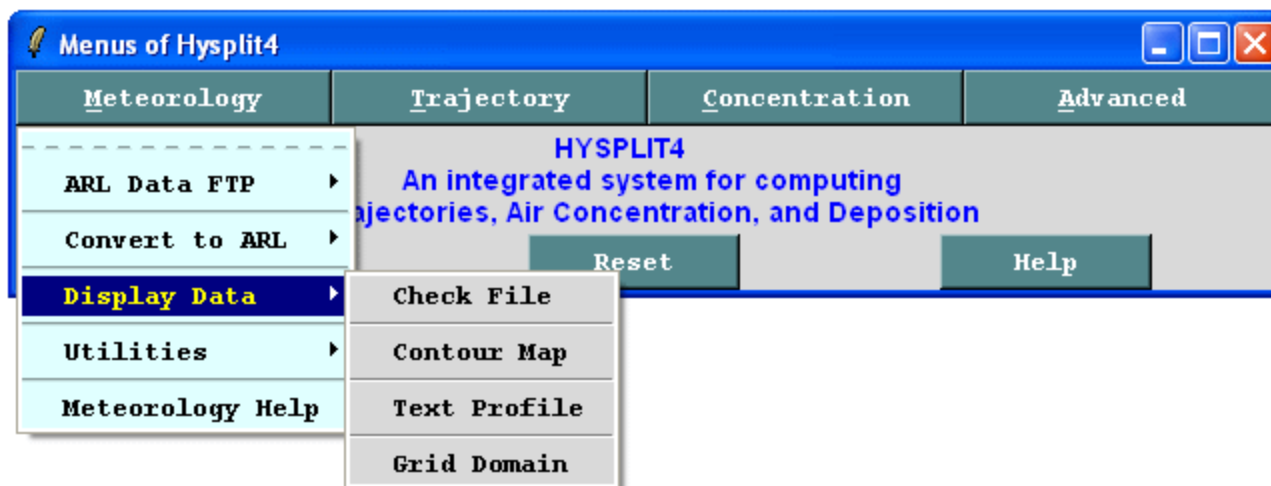
Meteorological Grid Domain

Grid Domain

- **Grid Domain** creates a Postscript graphic of the meteorological data set domain, which can be useful to determine the area covered by a data set.

- The domain can be displayed by selecting a meteorological data file. In the example below, the 40 km lambert-conformal projection of the NAM model was chosen. (keep data files in a directory without spaces in the name).

- For this example, every fourth grid point is displayed (set the **grid point plotting interval** to 4) and latitude-longitude lines are drawn every 5 degrees (set **lat-lon interval** to 5).
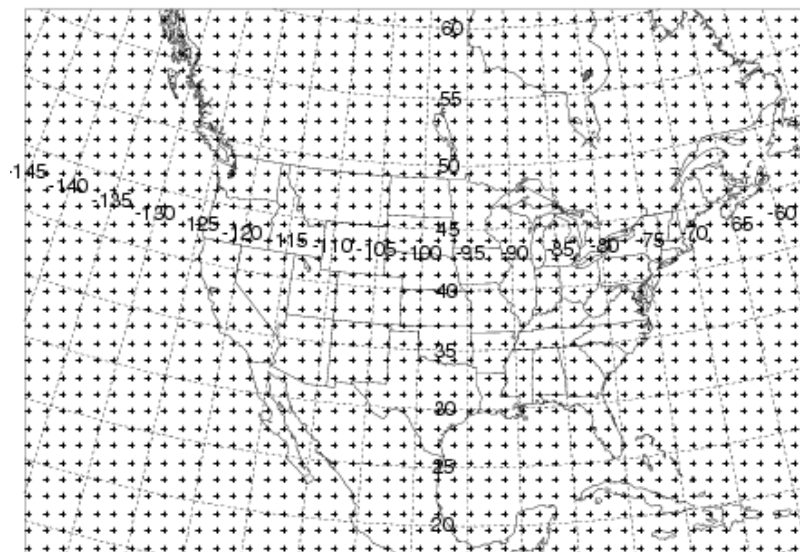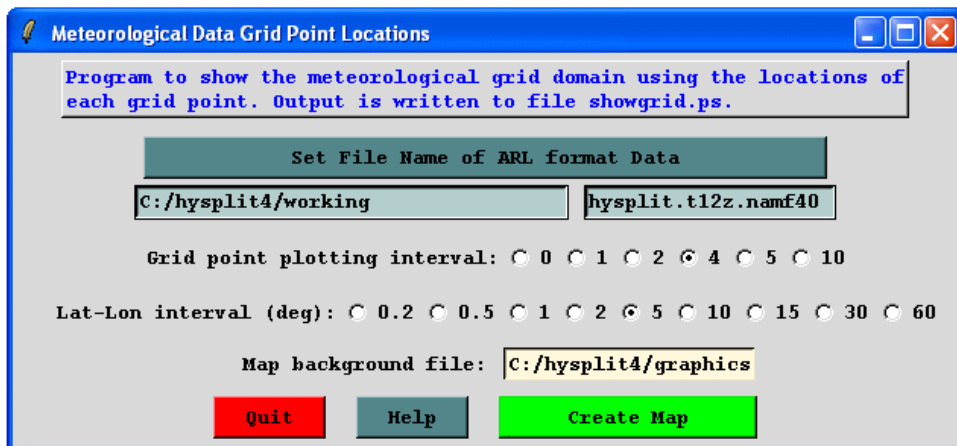
Convert PostScript

Under the **Meteorology**, **Trajectory**, and **Concentration** menus there is a submenu item called **Utilities**. Utility programs that are specific to each main menu reside in this submenu. In every **Utilities** sub-menu there is a program called **Convert Postscript** that can be used to convert the Postscript graphic into other graphic formats such as gif, jpg, bmp, etc.

The **Convert Postscript** menu will display the last created Postscript filename. If this is not the desired graphic to convert, it should be replaced with the appropriate name. The output file extension (gif, jpg, bmp, etc) represents the conversion format. The conversion process uses *Ghostscript* to read the Postscript file and *ImageMagick* to convert that file to a variety of other supported formats (conversion to gif is the default). The slider bar determines the size of the output graphic in pixels per inch. The checkboxes permit the creation of a multiframe animation in one file or multiple output files if the "Frames" option has been checked. The "Crop" option eliminates the white space around the graphic. However this option may produce inconsistent results in conjunction with the animation feature.

32
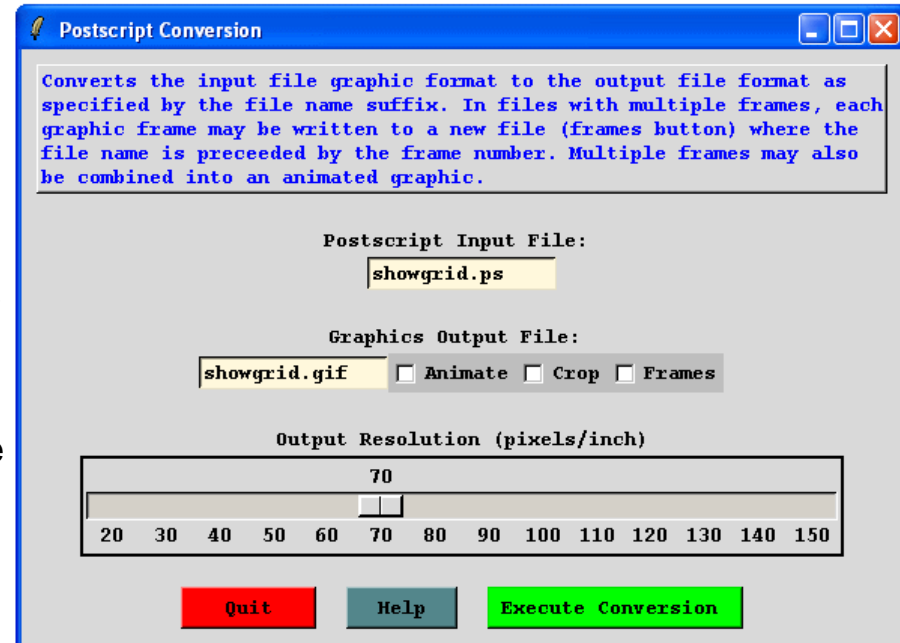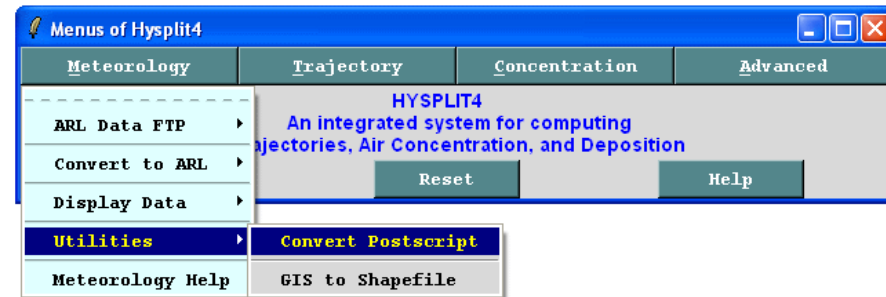
Vertical Meteorological Profile

The **Text Profile** program creates a simple text based listing of the meteorological data vertical profile at a selected latitude-longitude point. In this example (right), the NAM 40km data set was selected with default values for offset and increment (zeros indicate that only the first time period is displayed). The profile location was chosen at 40N, 90W. The polar default option will display the wind as a direction and speed, whereas the vector option will display the wind components u & v.

The data are shown for the nearest grid point location (no temporal or spatial interpolation). The location grid index (I,J) is indicated in parenthesis next to the lat-lon position. The first row shows the surface variables. Subsequent rows show the upper-level data, in this case by pressure level. The leftmost columns show the data directly from the file, while on the right side ambient temperatures have been converted to potential temperature and wind components have been rotated from the native grid to true compass direction. The leftmost coordinate is pressure as taken from the index (INDX) record. In other coordinate systems the program computes a height. This program can be useful in validating the data when investigating a problem with a HYSPLIT calculation.

PC-HYSPLIT WORKSHOP

Meteorological Data Data Profile

Displays a text meteorological data profile (file:profile.txt) for an ARL formatted data set. Defaults (zeros) to grid center location for the first time period.

Set File Name of ARL format Data

C:/hysplit4/working   hysplit.t12z.namf40

Wind Display: ○ Vector ◉ Polar

Time offset (hrs): ◉ 0 ○ 2 ○ 3 ○ 6 ○ 12 ○ 24 ○ 48

Time increment (hrs): ◉ 0 ○ 1 ○ 2 ○ 3 ○ 6 ○ 12 ○ 24

Profile Location   Lat: 40.0   Lon: -90.0

Quit   Help   Run PROFILE

SIMULATION LOG

```
METEOROLOGICAL PROFILE LISTING ...
Meteorological Profile: hysplit.t12z.namf40
File start time :  9  2 17 12  0
File ending time:  9  2 21  0  0


Profile Time:     9  2 17 12  0
Profile Location:    40.00  -90.00  (116, 63)

        MSLP   TMPS  TPP3  CPP3  SOLT  SOLW  T02M  RH2M  U10M  V10M  P10M
  VSBY  RGHS   LCLD  MCLD  HCLD  TCLD  DSWF  WTMP  CAPE  CINH  LISD  LIB4


   996  1020   -2.1     0     0   272   680  -1.5  76.1  -1.1   6.1   272

        UWND   VWND  HGTS  TEMP  WWND  RELH  TKEN          TPOT  WDIR  WSPD
        m/s    m/s          oC  mb/h     %                  oK   deg   m/s
  1000  -1.2    5.3   155 -0.92     0  76.9   1.3         272.2 169.7   5.5
   975  0.23   12.3   356  -2.0   1.1  77.9   1.2         273.1 183.2  12.3
   950   6.7   15.7   564  0.48   1.5  56.9  0.38         277.7 205.2  17.0
   925  10.1   11.3   779   2.5     0  47.8  0.20         281.9 223.9  15.1
   900  11.2    6.9  1000   2.4  -2.3  51.8  0.20         284.0 240.5  13.2
   875  11.2    4.4  1227  0.99  -3.1  55.6  0.20         284.8 250.6  12.0
   850  10.7    4.5  1459 -0.46  -4.6  55.0  0.20         285.7 249.5  11.6
   825  10.5    5.4  1697  -1.4  -4.2  49.0  0.20         287.2 244.8  11.8
   800  11.4    6.8  1942  -1.9  -3.9  45.0  0.21         289.2 241.4  13.3
   775  13.3    7.8  2194  -2.4  -4.0  44.0  0.20         291.3 241.7  15.4
   750  15.5    7.7  2454  -3.2  -3.9  48.0     0         293.2 245.7  17.3
   725  16.7    6.4  2722  -3.6  -3.8  51.0  0.20         295.5 251.2  17.9
   700  16.9    4.0  2998  -4.5  -1.6  39.0     0         297.5 258.8  17.4
   650  16.6   0.28  3578  -7.9   1.7  16.0  0.20         300.0 271.2  16.6
   600  17.7   -1.6  4194 -12.3   2.1  16.0  0.20         301.9 277.2  17.8
   550  22.1   -2.0  4852 -17.5   1.7  30.0  0.20         303.3 277.3  22.2
   500  26.1   -2.5  5556 -23.4   1.3  72.0  0.20         304.5 277.6  26.2
   450  27.5   -3.2  6318 -28.9   1.6  76.0  0.20         306.9 278.8  27.7
   400  35.2   -3.3  7151 -34.0  -1.6  86.0  0.20         310.8 277.5  35.3
   350  41.5   -4.8  8073 -40.7  -1.0  87.8  0.20         313.9 278.7  41.7
   300  45.7   -6.7  9104 -47.8 -0.63  54.3  0.20         318.0 280.5  46.2
   250  51.9  -10.7 10288 -55.0   2.9  39.8  0.20         324.3 283.7  53.0
   200  59.7  -12.2 11693 -57.2   3.6  18.9  0.20         342.3 283.7  60.9
   150  50.6  -15.0 13521 -56.3     0   3.7  0.20         373.1 288.6  52.8
   100  30.3   -8.8 16059 -61.8  -1.4   1.9  0.20         408.4 288.3  31.6
    50  12.7   -6.0 20345 -60.6 -0.68   2.0  0.20         500.8 297.4  14.1
```

Exit

Contour Meteorological Data

Contour Map

– Creates a Postscript graphic of a meteorological variable on a horizontal map.

– In this example (right) the NAM 40 km data set was chosen with default values for **Time offset** and **Time increment**. (Zeros indicate only the first time period is to be displayed.)

– Zeros for **Map center** location sets the default map to be the center of the data grid; (40N, 90W in this example).

– Negative values for the **Contour maximum** and **Delta** force the automatic contour scaling.

– Not all possible meteorological variables are shown, nor may a data file contain all the variables in the selection list. More options are available from the command line version of the program called *display.exe*.

– In this example, wind velocity vectors were plotted for data level 2 (1000 hPA).

– Velocity vectors are shown at every grid point over the domain selected for display; in this case a map with a **Radius** of 5 degrees latitude.

– The "10" in parenthesis after the variable symbol "VECT" indicates that the maximum wind speed vector on the map was 10 m/s.
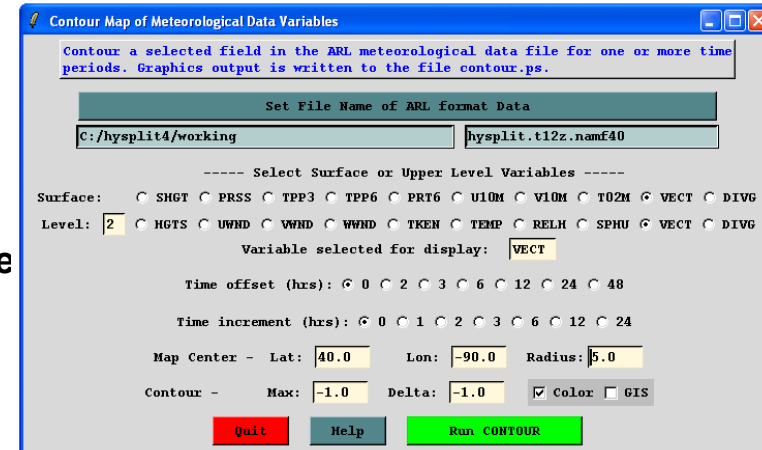
NOAA AIR RESOURCES LABORATORY
Valid Time (UTC): 09/02/17/12
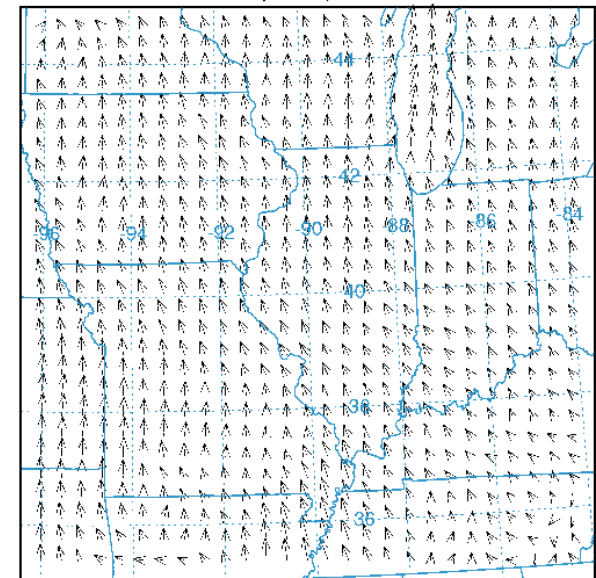
VECT (10) AT HEIGHT: 1000.000

PC-HYSPLIT WORKSHOP

Additional Information about Meteorological Data and HYSPLIT

Data Requirements

Meteorological Variables

– A <u>unique 4-character string </u>identifies meteorological variables.

– Minimum requirements to run the model are the U and V wind components (*UWND*, *VWND*), ambient temperature (*TEMP*), height (*HGTS*) of the data level (if on pressure coordinates), and the surface pressure (*PRSS*).

– A sample extract of section 2 of the **chk_file** program is shown below for the NAM 40 km dataset for levels between the surface and 925 hPa.

```
Index    Level  #    Variable listing and checksum values.....
  5      925.0000   7   UWND  35  VWND  75  HGTS 204  TEMP  24  WWND 238  RELH 222 TKEN  25
  4      950.0000   7   UWND 162  VWND  65   HGTS 219  TEMP 184  WWND 254  RELH  43 TKEN  174
  3      975.0000   7   UWND 107   VWND 157  HGTS 139  TEMP  57  WWND 244  RELH   5 TKEN  49
  2     1000.0000   7   UWND 237   VWND 191  HGTS 192  TEMP 209  WWND 193  RELH  30 TKEN 135
  1        0.0000  32   MSLP  41   TMPS 232  TPP3 180    CPP3 180 SOLT  28   SOLW  136
                        T02M 118   RH2M  87   U10M  28   V10M 253  P10M 217  PRSS 195
                        WESD 172 CSNO 118   CICE 180  CFZR 180 CRAI 118    LHTF    3
                        SHTF 165  USTR  87  VSBY 227  RGHS  97 LCLD  83  MCLD 234
                        HCLD   8   TCLD 176  DSWF 166 WTMP   1 CAPE 203  CINH  144
                        LISD 116   LIB4  191
```

Data Requirements

Data Records

- Each data record is composed of a 50 byte ASCII header portion, describing the data packing, followed by the packed data of length (I*J bytes).
- One-byte per element "difference packing" is used for all data fields.
- The first data record (*INDX*) of each time period contains information on the variables, levels, grid, and checksums to follow.
- An extract of the final section from *chk_file* is shown below for the NAM 40 km data set.

#	YYMMDDHHFHLLGG	FLD	EXP	PRECISION	VAR(1,1)
1	9 21712 0 018	INDX	0	0.0000000E+00	0.0000000E+00
2	9 21712 0 018	MSLP	4	0.6299213E-01	0.1014420E+04
3	9 21712 0 018	TMPS	5	0.1259843E+00	0.2988067E+03
4	9 21712 0 018	TPP3	1	0.7874016E-02	0.0000000E+00
5	9 21712 0 018	CPP3	1	0.7874016E-02	0.0000000E+00
6	9 21712 0 018	SOLT	5	0.1259843E+00	0.2730887E+03
7	9 21712 0 018	SOLW	10	0.4031496E+01	0.1000000E+04
8	9 21712 0 018	T02M	4	0.6299213E-01	0.2977927E+03
9	9 21712 0 018	RH2M	6	0.2519685E+00	0.8214149E+02
10	9 21712 0 018	U10M	3	0.3149606E-01	-0.9052811E+01
11	9 21712 0 018	V10M	4	0.6299213E-01	-0.2805954E+01
12	9 21712 0 018	P10M	4	0.6299213E-01	0.2964305E+03
13	9 21712 0 018	PRSS	8	0.1007874E+01	0.1014287E+04
14	9 21712 0 018	WESD	9	0.2015748E+01	0.0000000E+00
15	9 21712 0 018	CSNO	1	0.7874016E-02	0.0000000E+00
16	9 21712 0 018	CICE	1	0.7874016E-02	0.0000000E+00
17	9 21712 0 018	CFZR	1	0.7874016E-02	0.0000000E+00
18	9 21712 0 018	CRAI	1	0.7874016E-02	0.0000000E+00
19	9 21712 0 018	LHTF	10	0.4031496E+01	0.1704460E+03
20	9 21712 0 018	SHTF	9	0.2015748E+01	0.1664436E+02
21	9 21712 0 018	USTR	0	0.3937008E-02	0.3633987E+00
22	9 21712 0 018	VSBY	15	0.1290079E+03	0.2403518E+05
23	9 21712 0 018	RGHS	2	0.1574803E-01	0.2000000E-02
24	9 21712 0 018	LCLD	7	0.5039370E+00	0.1000000E+02

Definitions:

YYMMDDHH = date/time (UTC)

FH   = forecast hour

LL   = vertical level

GG   = grid number

FLD   = field label

EXP   = scaling exponent

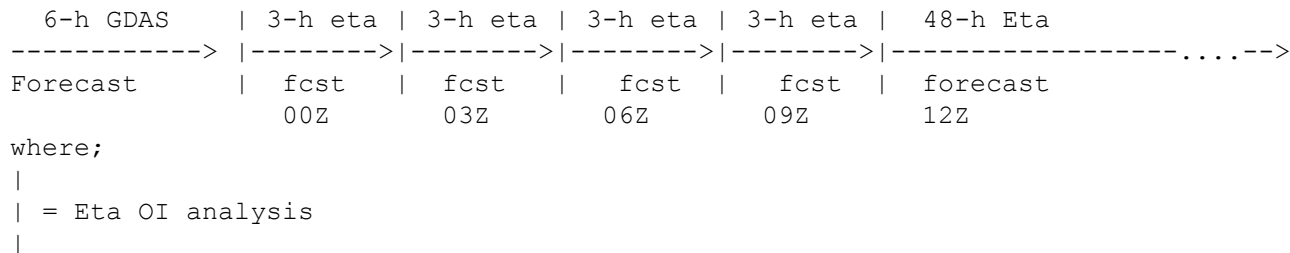PREC   = precision of packed data

VAR(1,1) = data value at (1,1)

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EDAS ARCHIVE OVERVIEW

The National Weather Service's National Centers for Environmental Prediction (NCEP) runs a series of computer analyses and forecasts operationally. One of the operational systems is the EDAS (Eta Data Assimilation System), covering the U.S. Addition current information on this model can be found on NCEP's website (http://www.nco.ncep.noaa.gov/pmb/products/). At NOAA's Air Resources Laboratory (ARL), NCEP model data are used for air quality transport and dispersion modeling. ARL archives both EDAS and FNL data using a 1-byte packing routine. Both archives contain basic fields such as the u- and v-wind components, temperature, and humidity. However, the archives differ from each other because of the horizontal and vertical resolution, as well as in the specific fields, provided by NCEP.

ORIGIN OF THE DATA The 3-hourly archive data come from NCEP's EDAS. (Note: information here may not be up to date. Check the NCEP website for current information.) The EDAS was implemented into the operational early Eta model runs during 1995. The EDAS is an intermittent assimilation system consisting of successive 3-h Eta model forecasts and Optimum Interpolation (OI) analyses for a pre-forecast period (12-h for the early Eta) on a 38 level, 48 km grid. A 6-h forecast from the GDAS is used to to start the assimilation at 12-h prior to model start time. The following is a schematic for the 12Z cycle

```
  6-h GDAS      | 3-h eta | 3-h eta | 3-h eta | 3-h eta |  48-h Eta
------------> |-------->|-------->|-------->|-------->|------------------....-->
Forecast     |  fcst   |  fcst   |  fcst   |  fcst   |  forecast
                00Z       03Z       06Z       09Z       12Z
where;
|
| = Eta OI analysis
|
```

The 3-h analysis updates allow for the use of high frequency observations, such as wind profiler, NEXRAD, and aircraft data. ARL saves the successive 3-hour analyses, twice each day to produce a continuous data archive. Some fields such as precipitation and surface fluxes are not available in the analysis files, therefore these are taken from the successive 3-hour forecast files. The 48 km data are interpolated to a 40 km, Lambert Conformal Grid, covering the continental United States.

ARL PROCESSING The ARL archiving program produces a 3 hourly, 40 km dataset on pressure surfaces. In addition, 14 gridpoints on the western end of the model domain and 10 gridpoints on the northern end of the domain are removed to reduce the size of the semi-monthly files (currently at about 627 Mbytes). The data are put into semi-monthly files and made available online at ARL=s server (ftp://www.arl.noaa.gov/pub/archives/edas40/) for easy access via ftp.

DATA DESCRIPTION The archive data file contains the data in synoptic time sequence, without any missing records (missing data is represented by nulls and the forecast hour is set to negative 1). Therefore it is possible to position randomly to any point within a data file. Each file contains data for approximately two weeks: days one through 15, and 16 through the end of the month. At each time period, an index record is always the first record, followed by surface data, and then all data in each pressure level from the ground up. EDAS data are available in the files called edas.mmmyy.00#, where mmm is the month (e.g. jul) and yy is the year (97) and 00# refer to:

00#=001 - days 1-15 of the month
00#=002 - rest of the month

http://www.arl.noaa.gov/edas40.php

NCEP/NCAR Reanalysis Data Archive (Revised: 26 September 2003)

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Overview -

The NCEP/NCAR Reanalysis Project is a joint project between the National
Centers for Environmental Prediction (NCEP, formerly "NMC") and the National
Center for Atmospheric Research (NCAR). The goal of this joint effort is to
produce new atmospheric analyses using historical data (1948 onwards) and as
well to produce analyses of the current atmospheric state (Climate Data
Assimilation System, CDAS). Until recently, the meteorological community has
had to use analyses that supported the real-time weather forecasting. These
analyses are very inhomogeneous in time as there have been big improvements in
the data assimilation systems. The quality and utility of the re-analyses
should be superior to NCEP's original analyses because:

* a state-of-the-art data assimilation is used
* more observations are used
* quality control has been improved
* the model/data assimilation procedure remains unchanged during the project
* many more fields are being saved
* global (some older analyses were hemispheric)
* better vertical resolution (stratosphere)

More information about the reanalysis project and data are available from
several sources:

http://wesley.wwb.noaa.gov/reanalysis.html
http://www.cdc.noaa.gov/cdc/data.nmc.reanalysis.html

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Availability -

A subset of this data is available from ARL in a format suitable for transport
and dispersion calculations using HYSPLIT through READY by selecting
"Reanalysis" in the meteorological data set selection pull-down menu.

The archive is updated on this site once per year at the end of the year.

The directory contains data files with the following syntax:

R{S|P}{YEAR}{MONTH}.{gbl|tbd}

Where R indicates "Reanalysis", S or P indicates that the data are on Sigma or
Pressure surfaces, YEAR is a four digit year, and MONTH is a two digit month.
The file suffix identifies the projection as either the 2.5 degree global
latitude-longitude projection (gbl), or a regional conformal map projection.
Other regional projections are "to be determined (tbd)" later. The projection
details are encoded in the file's index record and are processed by HYSPLIT
during trajectory or dispersion computations.

The sigma level data were obtained from NCEP's internal spectral coefficient
archive. The pressure level data were obtained from the NOAA-CIRES Climate
Diagnostics Center, Boulder, Colorado, USA.

```
Additional Data Set Details

  Pressure Level Data

        2.5 degree latitude-longitude global grid
        144x73 points from 90N-90S, 0E-357.5E
        1/1/1948 - present with output every 6 hours
        Levels (hPa): 1000,925,850,700,600,500,400,300,250,200,
                  150,100,70,50,30,20,10
        Surface or near the surface (.995 sigma level) winds and temperature
        Precipitation

        Model Type:              LAT-LON
        Vert Coord:               2
        Numb X pt:              144
        Numb Y pt:               73
        Numb Levels:             18
        Sfc Variables:            5 PRSS T02M U10M V10M TPP6
        Upper Levels:             6 HGTS TEMP UWND VWND WWND RELH
```

Additional Data Set Details

Sigma Level Data (CONUS extract for the DATEM archive, not available)

       The spectral coefficients on 28 model sigma surfaces were processed
       to obtain required fields 4 per day on a global Gaussian grid of
       1.875 degree resolution. A regional sub-grid covering the continental
       US and Canada was extracted.

       Current USA spatial domain: 21.9N 127.5W to 60.0N 52.5W
       Output every 6 hours
       Levels: .995,.982,.964,.943,.916,.884,.846,.801,.751,.694,.633,
           .568,.502,.436,.372,.312,.258,.210,.168,.133,.103,.078,
           .058,.042,.029,.018,.010,.003

MODEL TYPE:	MERCATOR
VERT COORD:	1
POLE LAT:	21.904
POLE LON:	-127.5
REF LAT:	21.904
REF LON:	-127.5
REF GRID:	136.5
ORIENTATION:	0.
CONE ANGLE:	0.
SYNC X:	1.
SYNC Y:	1.
SYNC LAT:	21.904
SYNC LON:	-127.5
NUMB X:	57
NUMB Y:	41
NUMB LEVELS:	29
SFC VARIABLES:	01 PRSS
UPPER LEVELS:	05 TEMP SPHU UWND VWND WWND

All of these datasets contain basic fields such as the u- and v-wind components, temperature, and humidity. However, the archives differ from each other because of the horizontal and vertical resolution, as well as in the specific fields provided by NCEP. All fields were selected by ARL according to what is most relevant for transport and dispersion studies and disk space limitations.
Data Packing Format

NCEP typically saves their model output in GRIB format. However, at ARL the data are reprocessed and stored in a 1-byte packing algorithm. This 1- byte packing is a bit more compact than GRIB and can be directly used on a variety of computing platforms with direct access I/O.

The data array is packed and stored into one byte characters. To preserve as much data precision as possible the difference between the values at grid points is saved and packed rather than the actual values. The grid is then reconstructed by adding the differences between grid values starting with the first value, which is stored in unpacked ASCII form in the header record. To illustrate the process, assume that a grid of real data, R, of dimensions i,j is given by the example below.

```
1,j       2,j        ....   i-1,j      i,j
1,j-1     2,j-1      ....   i-1,j-1    i,j-1
....      ....       ....   ....       ....
1,2       2,2        ....   i-1,2      i,2
1,1       2,1        ....   i-1,1      i,1
```

The packed value, P, is then given by

$$P_{i,j} = (R_{i,j} - R_{i-1,j}) * (2^{**(7-N)}),$$

where the scaling exponent

$$N = \ln dR_{max} / \ln 2 .$$

The value of dRmax is the maximum difference between any two adjacent grid points for the entire array. It is computed from the differences along each i index holding j constant. The difference at index (1,j) is computed from index (1,j-1), and at 1,1 the difference is always zero. The packed values are one byte unsigned integers, where values from 0 to 126 represent -127 to -1, 127 represents zero, and values of 128 to 254 represent 1 to 127. Each record length is then equal in bytes to the number of array elements plus 50 bytes for the header label information. The 50 byte label field precedes each packed data field and contains the following ASCII data:

Field	Format	Description
Year	I2	Greenwich date for which data valid
Month	I2	"
Day	I2	"
Hour	I2	"
Forecast*	I2	Hours forecast, zero for analysis
Level	I2	Level from the surface up (see Table 3)
Grid	I2	Grid identification (see Table 1)
Variable	A4	Variable label (see Table 2)
Exponent	I4	Scaling exponent needed for unpacking
Precision	E14.7	Precision of unpacked data
Value 1,1	E14.7	Unpacked data value at grid point 1,1

*Forecast hour is -1 for missing data.