

Software Users Guide

FOR THE

Interactive Gridded Analysis Display System

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Table Of Contents

• 1	SCOPE	4
1.1	Introduction.....	4
1.2	System Overview	4
1.3	Document Overview	5
• 2	REFERENCED DOCUMENTS	5
2.1	Project Documents	5
2.2	Web Sites	5
• 3	SOFTWARE SUMMARY	6
3.1	Software application	6
3.1.1	Finding New Weather Model Data.....	18
	Map and Control File Generation	18
3.2	Software inventory.....	18
3.2.1	Directory Structure.....	18
3.3	Software Data Environment.....	24
3.3.1	Structure of Data Directories	24
3.3.2	Directory Description.....	25
• 4	SOFTWARE MAINTENANCE	26
4.1	Creating New Map and Control Files	26
4.1.1	Control Files.....	26
4.1.2	Degribbing Files.....	30
4.1.3	Creating Map Files Using gribmap.....	32
4.2	Troubleshooting Existing Map and Control Files.....	33
4.2.1	Data Problems	33
4.2.2	Log Files	34
• 5	NOTES	34
•	Appendix A – Detailed Description of Control File Variables	35
•	Appendix B – Weather Model Data Locations	41

1 SCOPE

1.1 Introduction

The purpose of this document is to provide a user's guide at a technical level that explains the generation, use, and maintenance of the Interactive Gridded Analysis Display System (IGrADS) software application.

1.2 System Overview

IGrADS is a government developed, user-friendly web-based display tool that interacts with the Grid Analysis and Display System (GrADS), which is an interactive desktop tool used for easy access, manipulation, and visualization of earth science data (binary, GRIB, NetCDF, or HDF- Scientific Data Sets). GrADS has been implemented worldwide on a variety of commonly used operating systems and is freely distributed over the Internet.

GrADS uses a 4-Dimensional data environment: longitude, latitude, vertical level, and time. Data sets are placed within the 4-D space by use of a data descriptor file. GrADS interprets station data as well as gridded data, and the grids may be regular, non-linearly spaced, gaussian, or of variable resolution. Data from different data sets may be graphically overlaid, with correct spatial and time registration. Operations are executed interactively by entering FORTRAN-like expressions at the command line. A rich set of built-in functions are provided, but users may also add their own functions as external routines written in any programming language.

Data may be displayed using a variety of graphical techniques: line and bar graphs, scatter plots, smoothed contours, shaded contours, streamlines, wind vectors, grid boxes, shaded grid boxes, and station model plots. Graphics may be output in PostScript or image formats. GrADS provides geophysically intuitive defaults, but the user has the option to control all aspects of graphics output.

GrADS has a programmable interface (scripting language) that allows for sophisticated analysis and display applications. IGrADS takes user input from the GUI and passes these variables to GrADS scripts via CGI scripts, Korn Shell scripts and C-programs. In combination with map and control files (please see the MAP and CONTROL File Users Guide), a .GM file is produced. This file is converted into a .gif image and is displayed in separate web browser window.

This users guide will be divided into three sections. The first section will deal strictly with the GUI interface. The second section will discuss the underlying "Nuts and Bolts" of IGrADS. The final section will outline troubleshooting techniques commonly used to handle IGrADS issues.

1.3 Document Overview

This document comprises of six sections:

- Scope;
- Referenced documents and websites;
- Software Summary;
- Software Maintenance and Troubleshooting;
- Notes

2 REFERENCED DOCUMENTS

2.1 Project Documents

Map and Control Software Users Manual

2.2 Web Sites

GrADS - <http://grads.iges.org/grads/>

Load Leveler - <https://fred.afwa.af.mil/lldocs/index.html>

3 SOFTWARE SUMMARY

3.1 IGrADS GUI Interface

IGrADS allows remote users to request various weather products using various types of weather model data and user-specific location points. This section will go through each selectable option

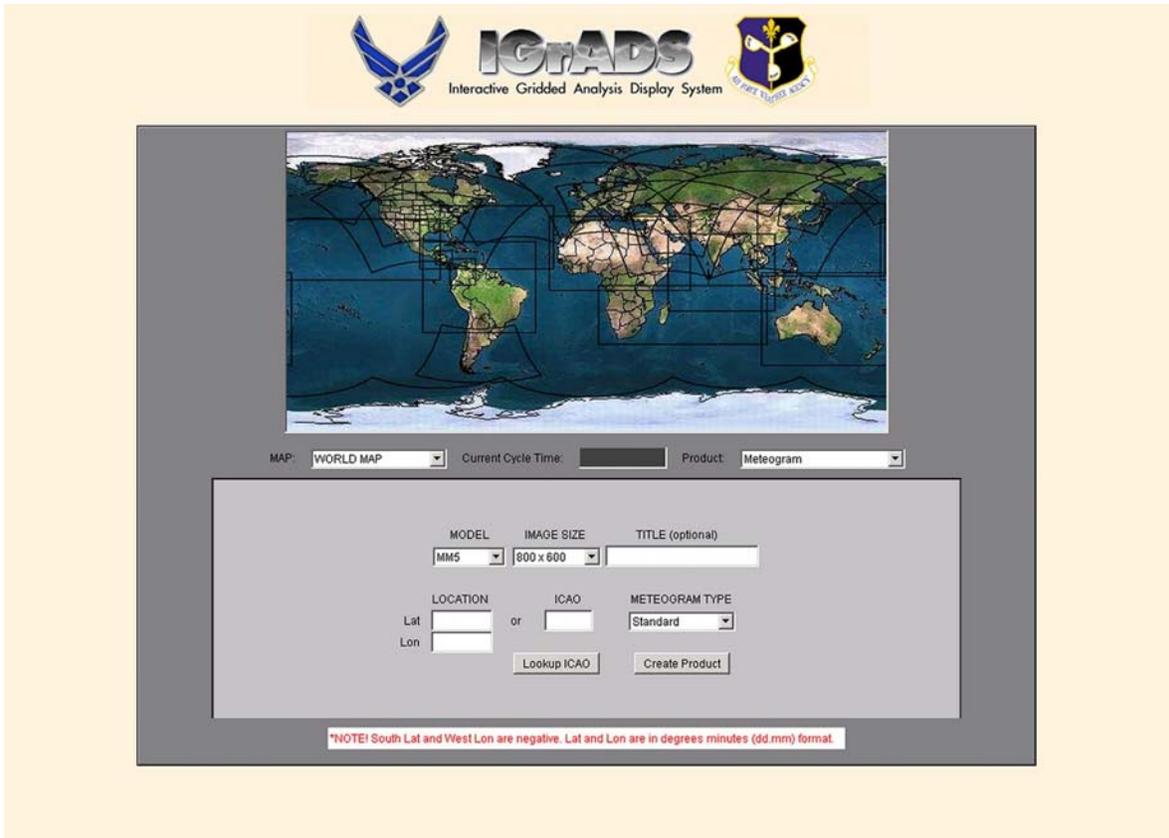


Figure 3-1 IGrADS Introduction

3.1.1 Map Drop-Down Box

The MAP drop-down box lists all of the available theater views in IGrADS. With the exception of WORLD MAP, WORLD MAP #2 and ETA MAP (these are pre-defined theaters), the list displayed in the map drop-down box is dynamically populated by the theaters file located in the /usr/netscape/ns-home/docs directory. The theaters file is generated by a korn shell script called update_Jtheaters.ksh, which uses data from a file called product.list. This file is generated by GTWAPS and is located in the /mnt/gds/global/VISUAL/data/cfg directory. Upon selecting one of the available theaters in the MAP drop-down box, the corresponding image of the selected area is displayed in the IGrADS clickable map area.

Example: Selecting a MAP

Click on the MAP drop-down box

Select **CONUS 45-km**

End Result:

- An image of the Continental United States is displayed in the clickable map area.
- CONUS 45-km is displayed in the MAP drop-down box.



3.1.2 Current Cycle Time Box

The Current Cycle Time box is located in the center of each IGrADS java panel. It displays the current cycle time according to the selected MAP and MODEL in IGrADS. The current cycle time is pulled directly out of the corresponding model's control file. The user cannot alter the value displayed in this box.



3.1.3 Product Drop-Down Box

The following Products can be produced using the IGrADS interface. The models available differ for each product chosen: Meteograms, User Defined Meteograms, Skew-Ts, Vertical and Multiple Cross Sections, Forecast Maps and Alphanumeric Products

❖ **Meteograms**

The screenshot shows a graphical user interface for generating a meteogram. It features several input fields and a dropdown menu. At the top, there are three main sections: 'MODEL' with a dropdown menu showing 'MM5', 'IMAGE SIZE' with a dropdown menu showing '640 x 480', and 'TITLE (optional)' with a text input field. Below these, there are two columns of input fields. The left column is labeled 'LOCATION' and contains 'Lat' and 'Lon' text boxes. The right column is labeled 'ICAO' and contains a text box with 'koff' and a 'Lookup ICAO' button. To the right of the ICAO section is a 'METEGRAM TYPE' dropdown menu that is currently open, displaying a list of options: 'Standard', 'Electro-Optical', 'Army Low-Level', and 'Severe'. The 'Standard' option is highlighted in blue.

- **Description**-A time series of meteorological data for a particular point. The progresses from left to right across the figure and the quantities are plotted either as a line graph, bar graph, or shading.
- **Options**
 - **MODEL** – This option allows the user to select one of the various models that can be used to create a meteogram. The available models are: ADVCLD, COAMPS, ETA, GFS, MM5, NOGAPS, UKMO
 - **IMAGE SIZE** – This option allows the user to change the size of the image. Available sizes: 640 X 480, 800 X 600, 1024 X 768 and 1280 X 1024
 - **TITLE** – This option allows the user to put a “Title” on the created image.
 - **LOCATION**
 - Lat – A box to enter latitude coordinates
 - Lon – A box to enter longitude coordinates

Note: Coordinates can physically entered in or selected by picking point on the clickable map.
 - **ICAO** – See Appendix for description
 - **LOOKUP ICAO** – See **Lookup ICAO** section
 - **METEGRAM TYPE**
 - Standard – **Weekly Task**
 - Electro-Optical – **Weekly Task**
 - Army Low-Level – **Weekly Task**
 - Severe – **Weekly Task**

❖ User-Defined Meteograms

The screenshot shows a web-based interface for creating user-defined meteograms. It includes the following elements:

- MODEL:** A dropdown menu set to "MM5".
- IMAGE SIZE:** A dropdown menu set to "800 x 600".
- LOCATION:** Input fields for "Lat" and "Lon", and an "ICAO" field containing "koff".
- TITLE (optional):** An empty text input field.
- GRAPH SELECTION:** A large dropdown menu with a scrollable list of options: "NONE", "Blank Space", "Absolute Humidity / Lifted Index", "Cloud Cover", "Convective Inhibition / Lid Strength Index", "Hail Size Potential / Precipitable Water", "K Index / Storm Relative Helicity", and "Lifted Index / Energy Helicity Index".
- SIZE:** A dropdown menu.
- Buttons:** "Profile Options", "Lookup ICAO", "Create Product", and "Reset".

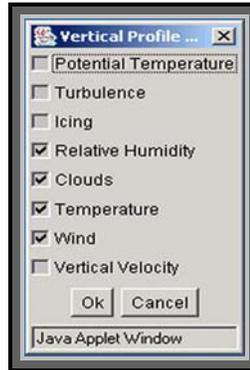
➤ **Description-**A time series of meteorological data for a particular point. The progresses from left to right across the figure and the quantities are plotted either as a line graph, bar graph, or shading.

➤ Options

- **MODEL** – This option allows the user to select one of the various models that can be used to create a user-defined meteogram. The only available model is MM5
- **IMAGE SIZE** – This option allows the user to change the size of the image. Available sizes: 640 X 480, 800 X 600, 1024 X 768 and 1280 X 1024
- **TITLE** – This option allows the user to put a “Title” on the created image.
- **LOCATION**
 - Lat – A box to enter latitude coordinates
 - Lon – A box to enter longitude coordinates

Note: Coordinates can physically entered in or selected by picking point on the clickable map.
- **ICAO** – See Appendix for description
- **LOOKUP ICAO** – See **Lookup ICAO section**
- **VERTICAL PROFILE OPTIONS** – See **Vertical Profile Options section**
- **GRAPH SELECTION** – Weekly Task
- **SIZE** – Weekly Task

❖ VERTICAL PROFILE OPTIONS



- **Description** – An option box available under user-defined meteograms that turns on and off viewable items on created meteogram images.
- **Available Display Options:**
 - **Potential Temperature** – The potential temperature is the temperature an air parcel at a specific pressure level and temperature would have if it were lowered or raised adiabatically to 1000 mb. This is defined by Poisson's equation.
 - **Turbulence** – A state of fluid flow in which the instantaneous velocities exhibit irregular and apparently random fluctuations so that in practice only statistical properties can be recognized and subjected to analysis. Compare laminar flow.
 - **Icing** – The forming or depositing of ice on an object.
 - **Relative Humidity** – This is the ratio of actual vapor pressure to the saturation vapor pressure at a specific temperature.
 - **Clouds** – A visible collection of minute particle matter, such as water droplets and/or ice crystals, in the free air. A cloud forms in the atmosphere as a result of condensation of water vapor. Condensation nuclei, such as in smoke or dust particles, form a surface upon which water vapor can condense.
 - **Temperature** – The temperature is a measure of the internal energy that a substance contains. This measure of the internal energy that a substance contains. This is the most measured quantity in the atmosphere.
 - **Wind** - A result due to the differences in air mass pressures (temperature). The wind blows as a result of nature trying to balance the differences. The larger the differences between air masses, the stronger the wind.
 - **Vertical Velocity** – The rate of upward or downward motion of air passing through a given pressure level.

SkewT's

- **Description-**Vertical sounding of temperature, dew point, and winds based on pressure levels.
- **Available Models-** COAMPS, ETA, GFS, MM5, NOGAPS, UKMO

MODEL		IMAGE SIZE	TITLE (optional)
MM5		800 x 600	
LOCATION		FORECAST HOUR	
Lat		First	10 FEB 12Z (0hr)
Lon		Last	10 FEB 12Z (0hr)
or			
ICAO		Lookup ICAO	Create Product

- **Vertical Cross Sections**

- **Description**-Vertical profile of the atmosphere over a 1 dimensional spatial domain.
- **Available Models**-COAMPS, ETA, GFS, MM5, NOGAPS, UKMO

The screenshot shows a web-based control panel for generating vertical cross-sections. The interface includes the following elements:

- MODEL:** A dropdown menu set to "MM5".
- IMAGE SIZE:** A dropdown menu set to "800x600".
- Path Type:** A dropdown menu with "Great Circle" selected, and a sub-menu showing "Straight" and "Great Circle".
- FCST 1:** A date-time dropdown menu set to "10 FEB 12Z (0hr)".
- Base FL:** A dropdown menu set to "SFC".
- FCST 2:** A date-time dropdown menu set to "10 FEB 12Z (0hr)".
- Top FL:** A dropdown menu set to "500".
- Lon 1, Lat 1, Lat 2, Lon 2:** Input fields for geographic coordinates.
- Start ICAO, End ICAO:** Input fields for International Civil Aviation Organization codes.
- Buttons:** "Profile Options", "Create Product", and "Lookup ICAO".

Vertical Cross Section Panel

The screenshot shows a dialog box titled "Vertical Profile O..." with the following settings:

- Relative Humidity
- Clouds
- Temperature
- Wind
- Potential Temperature
- Vertical Velocity
- Turbulence
- Icing
- Temp Interval: 4
- Potential Interval: 4
- Ok button

Java Applet Window

- **Multiple Cross Sections**
 - **Description**-Vertical profile of the atmosphere over a 1 dimensional spatial domain.
 - **Available Models**-COAMPS, ETA, GFS, MM5, NOGAPS, UKMO

MODEL	IMAGE SIZE	Path Type			
MM5	800x600	Great Circle			
FCST 1	Base FL	Lat 1	Lon 1		Start ICAO
00	SFC				
FCST 2	Top FL	Lat 2	Lon 2	OR	Mid ICAO
00	500				
		Lat 3	Lon 3		End ICAO
Profile Options		Create Product		Lookup ICAO	

Multiple Cross Section Panel

Vertical Profile O...	
<input type="checkbox"/>	Relative Humidity
<input checked="" type="checkbox"/>	Clouds
<input checked="" type="checkbox"/>	Temperature
<input type="checkbox"/>	Wind
<input type="checkbox"/>	Potential Temperature
<input type="checkbox"/>	Vertical Velocity
<input type="checkbox"/>	Turbulence
<input type="checkbox"/>	Icing
4	Temp Interval
4	Potential Interval
OK	
Java Applet Window	

1. Vertical Cross Sections

- Multiple Cross Sections

A screenshot of a Java Applet window titled "Vertical Profile D...". The window contains a list of meteorological variables with checkboxes and two dropdown menus. The "Clouds" and "Temperature" checkboxes are checked. The "Temp Interval" and "Potential Interval" dropdown menus are both set to "4". An "Ok" button is located at the bottom of the dialog.

<input type="checkbox"/>	Relative Humidity
<input checked="" type="checkbox"/>	Clouds
<input checked="" type="checkbox"/>	Temperature
<input type="checkbox"/>	Wind
<input type="checkbox"/>	Potential Temperature
<input type="checkbox"/>	Vertical Velocity
<input type="checkbox"/>	Turbulence
<input type="checkbox"/>	Icing
4	Temp Interval
4	Potential Interval

Ok

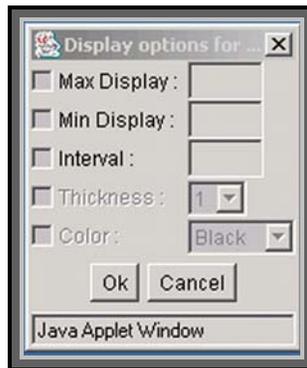
Java Applet Window

- **Forecast Maps**

- **Description**-2 dimensional representation of weather model data over a user defined geographical location. The data can be displayed as either color filled or contours. Each model has a different set of available parameters
- **Available Models**- COAMPS, DCF, ETA, GFS, MM5, NOGAPS, UKMO

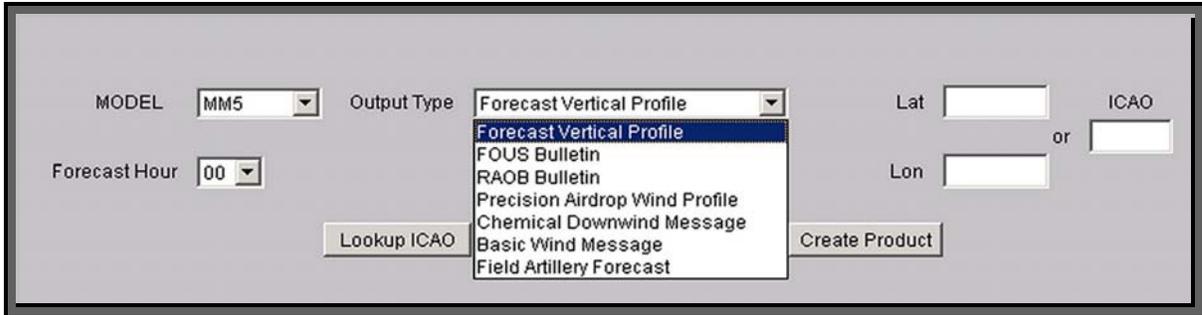
MODEL	IMAGE SIZE	PARAMETER	LEVEL	DISPLAY	
MM5	800 x 600	1000-500mb Avg RH	Not Applic	Color Filled	Options
		None	Not Applic	Contour Lines	Options
		None	Not Applic	Contour Lines	Options
		None	Not Applic	Contour Lines	Options

FCST HRS	LAT 1	LON 1*
10 FEB 12Z (0hr)	5.0	-129.0
to	LAT 2	LON 2*
10 FEB 12Z (0hr)	49.16	-26.16



- **Alphanumeric Products**

- **Description**-Textual representation of the numerical model formatted into standardized or user proscribed bulletins.
- **Available Models**- COAMPS, GFS, MM5
-



To select a product, click on the patient drop-down box and a list of available products will be displayed (see figure 3-2). Different products require different parameters in order for IGrADS to produce images. Upon the selection of a product, the light grey panel in IGrADS changes.

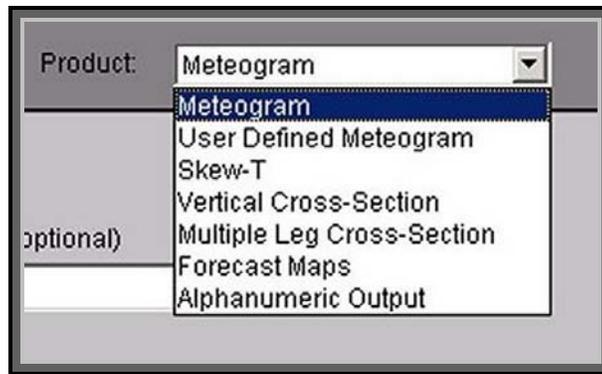


Figure 3-2 IGrADS Product Box



- 3.1.4 Model Drop-Down Box**
- 3.1.5 Image Size Drop-Down Box**
- 3.1.6 Title Text Box**
- 3.1.7 Location Text Boxes**
- 3.1.8 ICAO Text Box and Lookup ICAO Button**
- 3.1.9 Meteogram Type Drop-Down Box**
- 3.1.10 Create Product Button**

3.1.11 Finding New Weather Model Data

The main driver for the Map and Control File Generation Process is a korn shell script (MAPCTL_check_data.ksh) that continually checks for new weather model data, sleeping two minutes between each pass through the designated data directories. For each weather model, a ready flag system is utilized. The script searches for the ready flag in each data directory and compares the file's date/time stamp against a date/time stamp contained in the corresponding ready flag's last cycle file (see detailed description of the last_cycle directory in section 3.3.1), created from the previous run. If the date/time stamps do not match, the data is considered to be new. The new date/time stamp is overwritten into the last cycle file, and a separate process is spawned to produce new Map and Control files for the specific weather model.

3.1.12 Map and Control File Generation

When new data is found, an update script is executed for the specific weather model. Depending on the model, the data-specific script either ensures that all of the data files are present or it will wait for the ready file to be present (see section 4.1.1). The control file is then constructed from a combination of information pulled from the data files and static text files. After the control file is constructed a gribmap utility that came bundled with the GRADS software package is ran against the control file, creating the map file. The Map and Control files are then copied to a common directory for later retrieval by GrADS users.

3.2 Software inventory

3.2.1 Directory Structure

The directory structure used separates the executables files from the data. All scripts, routines, and software applications used in the generation of the Map and Control files are found in the executables Directory path. All data elements, to include static text files, log

files, and any output or bi-product of the Map and Control Files Generation Process are found in the data path.

Directory Description

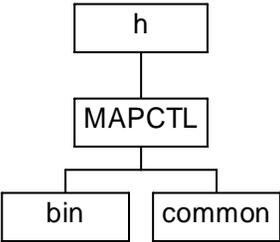


Fig 3.2.1-1

bin	Contains all scripts required to check for new data and update the Map and Control files
common	Contains all COTS and GOTS software utilities and routines used in the creation of Map and Control files.

3.2.1.1 Script Description (/h/MAPCTL/bin)

Note: It is essential for DNXT to have Read and Write (r-w) capability for the following Korn Shell scripts (listed below) because of the operational readiness of the IGrADS software and the 24-hour basis on which it needs to be maintained.

<p>get_grads_files.pl</p>	<p>This script is located in the /appl/igrads/bin directory. It is used to put the latest weather data and the updated Map and Control files into their respective work directories. This script is executed on each enterprise according to the following schedule:</p> <table border="1" data-bbox="711 701 1487 1020"> <tr> <td colspan="2">JAAWIN-U</td> <td rowspan="4"> <ul style="list-style-type: none"> Runs at the top of the top of each hour in the ftpafwin crontab. </td> </tr> <tr> <td>afwin-1</td> <td>afwin-2</td> </tr> <tr> <td>afwinmil-1</td> <td>afwinmil-2</td> </tr> <tr> <td>afwin-test</td> <td></td> </tr> <tr> <td colspan="2">JAAWIN-U dev</td> <td>Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab.</td> </tr> </table> <table border="1" data-bbox="711 1087 1487 1339"> <tr> <td colspan="2">JAAWIN-S</td> <td rowspan="4"> <ul style="list-style-type: none"> Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab. </td> </tr> <tr> <td>safwin-1</td> <td>safwin-2</td> </tr> <tr> <td>safwin-3</td> <td>safwin-4</td> </tr> <tr> <td colspan="2">JAAWIN-S dev</td> </tr> <tr> <td colspan="2">JAAWIN-S dev</td> <td>Runs at the top of the top of each hour in the ftpafwin crontab.</td> </tr> </table> <table border="1" data-bbox="711 1398 1487 1587"> <tr> <td colspan="2">JAAWIN-SCI</td> <td rowspan="4"> <ul style="list-style-type: none"> Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab. </td> </tr> <tr> <td>jsci-1</td> <td>jsci-1</td> </tr> <tr> <td>tweather (dev box)</td> <td></td> </tr> <tr> <td colspan="2"></td> </tr> </table>	JAAWIN-U		<ul style="list-style-type: none"> Runs at the top of the top of each hour in the ftpafwin crontab. 	afwin-1	afwin-2	afwinmil-1	afwinmil-2	afwin-test		JAAWIN-U dev		Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab.	JAAWIN-S		<ul style="list-style-type: none"> Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab. 	safwin-1	safwin-2	safwin-3	safwin-4	JAAWIN-S dev		JAAWIN-S dev		Runs at the top of the top of each hour in the ftpafwin crontab.	JAAWIN-SCI		<ul style="list-style-type: none"> Runs at 0, 15, 30, and 45 minutes each hour in the ftpafwin crontab. 	jsci-1	jsci-1	tweather (dev box)			
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jsci-1	jsci-1																																	
tweather (dev box)																																		
<p>MAPCTL_spinup_grads.ksh</p>	<p>This script is run from the visual account's crontab. It is used to ensure that the MAPCTL_check_data.ksh script is always running. If it finds that it is not running, it will start it up again. This script is executed every 15 minutes.</p>																																	
<p>MAPCTL_check_data.ksh</p>	<p>The main script used to continually check for new data. This</p>																																	

	<p>script runs in an infinite loop, sleeping two minutes between iterations. With each iteration, the script checks for a designated ready flag within the data directory of each weather model. The data/time stamp of the ready flag is compared with the date/time stamp stored in the Last cycle file for the particular model. If the two do not match the data is considered new. The Last cycle flag is updated with the new data/time stamp and a Load Leveler command file, which specifies which update script to run, is built and submitted to the server.</p>
MAPCTL-Update-advclcd.ksh	<p>This is the update script for the ADVCLD weather model data. This script is executed when new data is found for the ADVCLD model. The new control file is built by extracting the current cycle information from the ADVCLD INFO file and combining it with the static text files that describe the grid dimensions and variables for the data.</p>
MAPCTL-Update-dcf.ksh	<p>This is the update script for the Diagnostic Cloud Forecast (DCF) weather model data. This script is executed when new data is found for the DCF model. The control file is built by extracting the current cycle information from the grib data and combining it with static text files that describe the grid dimensions and variables for the data.</p>
MAPCTL-Update-eta.ksh	<p>This is the update script for the ETA weather model data. This script is executed when new data is found for the ETA model. The control file is built by extracting the current cycle information from the grib data and combining it with static text files that describe the grid dimensions and variables for the data.</p>
MAPCTL_update_gfs_1deg.ksh	<p>This is the update script for the GFS 1 degree resolution weather model data. This script is executed when new data is found for the GFS model. The control file is built by extracting the current cycle information from the grib data and combining it with static text files that describe the grid dimensions and variables for the data.</p>
MAPCTL_update_gfs_2p5deg.ksh	<p>This is the update script for the GFS 2.5 resolution degree weather model data. This script is executed when new data is found for the GFS model. The control file is built by extracting the current cycle information from the grib data and combining it with static text files that describe the grid</p>

	dimensions and variables for the data.
MAPCTL_update_ngp.ksh	This is the update script for the NGP weather model data. This script is executed when new data is found for the NGP model. The control file is built by extracting the current cycle information from the grib data and combining it with static text files that describe the grid dimensions and variables for the data.
MAPCTL_update-mm5.ksh	This is the update script for the MM5 weather model data. This script is executed when new data is found for any of the MM5 theaters. The control file is built by running another script called MAPCTL-make-ctl.ksh.
MAPCTL_check_ctl.ksh	This script is called from MAPCTL_update_mm5.ksh and MAPCTL_update_dcf.ksh. Due to the many different window locations, grid resolutions, and projection types found among the various MM5 theaters, this script is used to extract and compile information that is found in static text files and INFO files for all other weather models.
MAPCTL-replace-dset.ksh	This script modifies the dset line in the control file (which points to the data location) after the gribmap utility is executed for the control file.

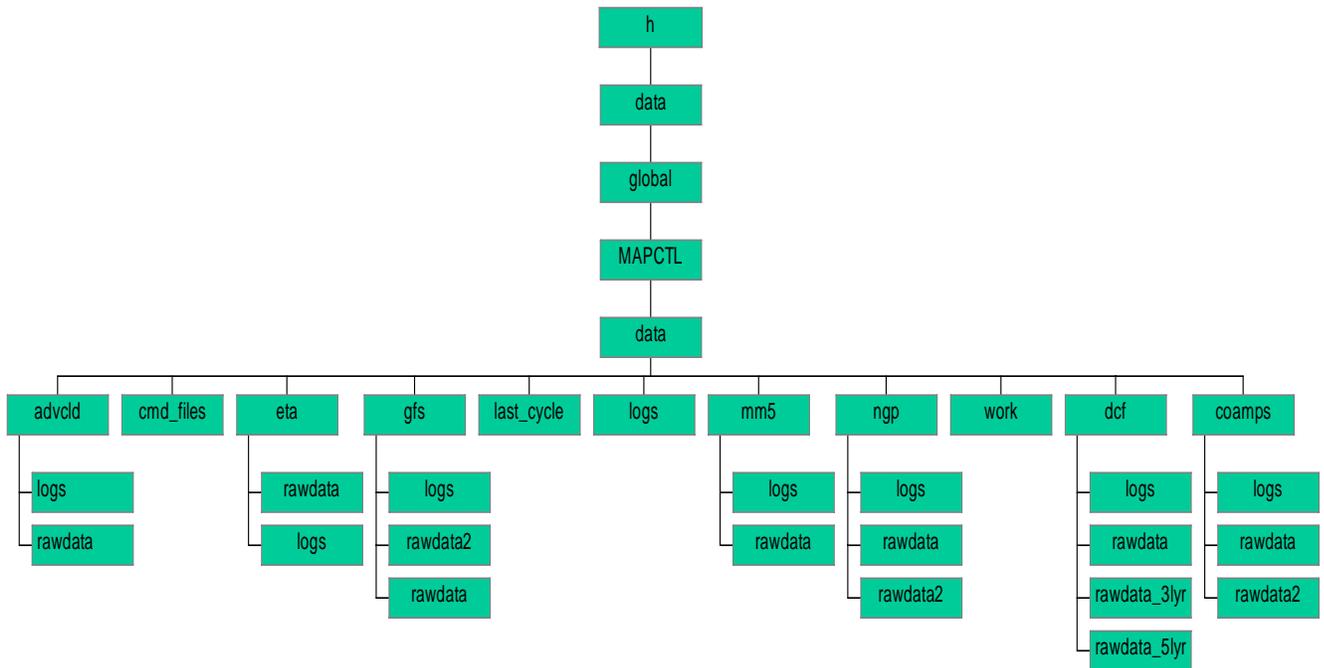
3.2.1.2 COTS Software Utilities and C Routines (/h/MAPCTL/common)

wgrib	Portable grib decoder written by NCEP/NCAR. Used to extract information about the different records within the grib data.
gribmap	GRADS software utility used to map the grib data to the 4 dimensional grid laid out by the control file. The output of this utility is the map file.
pole	A C routine used to find the I,J coordinates of the pole for a Polar Stereographic map projection.

3.3 Software Data Environment

3.3.1 Structure of Data Directories

The Map and Control files use the following data structure



3.3.2 Directory Description

advclcd	Contains all of the static text files used to create the control file for the Advect Cloud (ADVCLD) weather model data. This directory contains a link to the work directory used for the current run. The link is labeled as "current".
../logs	Contains log files for past and current runs of the ADVCLD update script.
../rawdata	Symbolic link to the data directory for ADVCLD model data.
cmd_files	Contains the latest command file used to submit a "Load Leveler" job for each of the model update scripts. Load Leveler is the load balancing software used on the GTWAPS Application Server to split the jobs up between many processors.
eta	Contains all of the static text files used to create the control file for the eta weather model data. This directory contains a link to the work directory used for the current run. The link is labeled as "current."
../logs	Contains log files for past and current runs of the eta update script.
../rawdata	Symbolic link to the data directory for eta model data.
gfs	Contains all of the static text files used to create the control file for the Global Forecast System (GFS) weather model data. This directory contains a link to the work directory used for the current run. The link is labeled as "current."
../logs	Contains log files for past and current runs of the GFS update script.
../rawdata	Symbolic link to the raw data directory for GFS model data.
../rawdata2	Symbolic link to the post-processed data directory for GFS model data.
coamps	Contains all of the static text files used to create the control file for the COAMPS weather model data. This directory contains a link to the work directory used for the current run. The link is labeled as "current."
../logs	Contains log files for past and current runs of the COAMPS

	update script.
../rawdata	Symbolic link to the raw data directory for COAMPS model data.
../rawdata2	Symbolic link to the post-processed data directory for COAMPS model data.
../rawdata	Symbolic link to the data directory for MM5 model data.
ngp	Contains all of the static text files used to create the control file for the Navy Operational Global Analysis and Prediction System (NOGAPS) weather model data. This directory contains a link to the work directory used for the current run. The link is labeled as "current."
../logs	Contains log files for past and current runs of the NOGAPS update script.
../rawdata	Symbolic link to the raw data directory for GFS model data.
../rawdata.2	Symbolic link to the post-processed data directory for NOGAPS model data.
work	Contains all of the working directories for each of the weather models. Each working directory contains symbolic links to files and applications used in the generation of Map and Control files. The finished Map and Control files are also stored in the working directory. A symbolic link is stored within each weather models directory that points to the most current working directory for that particular model.
dcf	Contains all of the static text files used to create the control file for the DCF weather data. This directory contains a link to the work directory used for the current run. The link is labeled as "current."
../logs	Contains log files for past and current runs of the DCF update script.
../rawdata_3lyr	Symbolic link to the 3-layer raw data directory for DCF model data.
../rawdata_5lyr	Symbolic link to the 5-layer raw data directory for DCF model data.

4 SOFTWARE MAINTENANCE

4.1 Creating New Map and Control Files

4.1.1 Control Files

Control files are generated by various scripts (see section 3.2.3 Script Description). These scripts search for new weather data in the respective data directories. Note: data directory paths can be found in the individual .ksh scripts listed in chart 4.1.1-1.

The MAPCTL_check_data.ksh constantly checks for new data and/or ready flags.

If new data is available, the corresponding data script is executed in creating the control and map files. The script checks to see if all of the data has arrived for the particular data set. If the data is incomplete, the process will wait to create the control file until all of the data has arrived.

If the ready flag is available, a comparison is made with the last date/time stamp stored in the last-cycle file to determine if the data is 'NEW'.

NOTE: The MAPCTL_check_data.ksh script checks for new data every 2 minutes in a continuous loop. The update scripts check for complete data sets. Chart 4.1.1-1 outlines those time limits.

MAPCTL_update_advclد.ksh	Waits for grib file. No time limit.
MAPCTL_update_advclد_grib.ksh	3 hours (180 minutes). Checks in 1 min. increments.
MAPCTL_update_avn.ksh	5 hours (300 minutes). Checks in 1 min. increments.
MAPCTL_update_coamps.ksh	1 hour (60 minutes). Checks in 1 min. increments.
MAPCTL_update_avn.ksh	5 hours (300 minutes). Checks in 1 min. increments.
MAPCTL_update_gfs_1deg.ksh	5 hours (300 minutes). Checks in 1 min. increments.
MAPCTL_update_gfs_2p5deg.ksh	5 hours (300 minutes). Checks in 1 min. increments.
MAPCTL_update_mm5.ksh	Waits for ready flag. No time limit
MAPCTL_update_dcf.ksh	Waits for ready flag. No time limit
MAPCTL_update_ngp.ksh	.5 hours (30 minutes). Checks in 1 min. increments.
MAPCTL_update_eta.ksh	5 hours (300 minutes). Checks in 1 min. increments.
MAPCTL_update_mrf.ksh	Waits for ready flag. No time limit

Chart 4.1.1-1 MAPCTL Update Scripts

Once the data set is complete:

1. The MAPCTL_check_data.ksh script calls the update script(s) relating to the new data.
2. The update script uses the application wgrib to pull out the cycle date out of the grib files. (NOTE: Not all data scripts use wgrib. MAPCTL_update_advcl.d.ksh (for example) comes in both grib and flat formats. The flat format is a gridded binary data type and therefore does not use wgrib to get the cycle date. Instead, the script pulls the cycle date out of the ADVCLD16INFO file.)
3. The data script then uses standard text files (aka the “bot”, “top”, & “mid” files) to create the standard control file template (* denotes model type prefix. Ex etabot.txt).
4. Next, the application gribmap is run against the control file to product the map file.
5. The newly created control and map files are copied to the production mount points where they are available to all users.

A control file consists of the following GrADS data descriptor file elements:

DSET	ZDEF
DTYPE	TDEF
INDEX	VARs
TITLE	ENDVARs
UNDEF	FILEHEADER
OPTIONS	THEADER
XDEF	XYHEADER
YDEF	

Note See Appendix A for a detailed description of the control file variables.

#1 – Sample grads control file

```
dset ^model.grb
title "Sample Model Data for GrADS Tutorial"
undef 1e+20
dtype grib
index ^model.gmp
xdef 72 linear 0.000000 5.000000
ydef 46 linear -90.000000 4.000000
zdef 7 levels
1000 850 700 500 300 200 100
tdef 5 linear 0Z2jan1987 1dy
vars 8
ps      0    1, 1, 0, 0 Surface pressure [hPa]
u       7    33,100 Eastward wind [m/s]
v       7    34,100 Northward wind [m/s]
z       7    7,100 Geopotential height [m]
t       7    11,100 Air Temperature [K]
q       7    51,100 Specific humidity [kg/kg]
ts      0    11,105, 2 Surface (2m) air temperature [K]
p       0    59, 1, 0, 0 Total precipitation rate [kg/(m^2*s)]
endvars
```

#2 - Real World Excerpt of an AFWA control file

```
dset /mnt/BMFS/u09/data/grib/mm5/t2/us057g1010t02a0600%f300
dtype grib
options template yrev
index t2amm5.map
undef -9.99E+33
title us057g1010t02a0600%f300
PDEF 192 139 lcc 5.01 -129.00 1 1 60.00 30.00 -96.00 45000.00 45000.00
XDEF 192 LINEAR -165.73 .730
YDEF 139 LINEAR 5.01 .451
zdef 23 levels
1025 1000 975 950 925 900 875 850 800 750 700 650 600 550 500 450 400
350 300 250 200 150 100
tdef 25 linear 06Z26Sep03 3hr
vars 12
DIST 23 7 ,100 Geometric height [m]
TMP 23 11 ,100 Temperature [K]
DPT 23 17 ,100 Dew point temperature [K]
UGRD 23 33 ,100 u wind [m/s]
VGRD 23 34 ,100 v wind [m/s]
DZDT 23 40 ,100 Geometric vertical velocity [m/s]
PVV 23 39 ,100 Pressure vertical velocity [Pa/s]
RH 23 52 ,100 Relative humidity [percent]
PRES 0 1 ,1 ,0 Surface Pressure [Pa]
PMSL 0 2 ,102,0 Pressure reduced to MSL [Pa]
TS995 0 11 ,107,9950 Temperature [K] at Sigma Level .995
T2M 0 11 ,105,2 Temperature [K] at 2m AGL
endvars
```

- NOTE: The number listed next to “vars” must exactly match the number of variables described.

4.1.2 Degribbing Files

WGRIB is a program to manipulate, inventory and decode GRIB files. The program is known to work on machines ranging from 486s to Cray supercomputers. (One fellow even ported it to a 286!) The program is Y2K friendly (NCO Y2K testing procedure).

WGRIB is located in GTWAPS production box Chris (g01n07 / 131.7.238.58) and is located in /h/WXPMET/common/ directory.

Usage: wgrib [output selections] [grib file] [options]

Inventory/diagnostic-output selections	
-s/-v	short/verbose inventory
-V	Diagnostic output (not inventory)
(none)	regular inventory
Options	
-PDS/-PDS10	print PDS in hex/decimal
-GDS/-GDS10	print GDS in hex/decimal
-verf	print forecast verification time
-ncep_opn/-ncep_rean	default T62 NCEP grib table

Decoding GRIB selection	
-d [record number]	decode record number
-p [byte position]	decode record at byte position
-I	decode controlled by stdin (inventory list)
(none)	no decoding
Options	
-text/-ieee/-grib/-bin	convert to text/ieee/grib/bin (default)
-nh/-h	output will have no headers/headers (default)
-H	output will include PDS and GDS (-bin/-ieee only)
-append	append to output file
-o [file]	output file name, 'dump' is default

Example #1: wgrib -v model.grb

Result: This command displays the short inventory stored in model.grb.

```
1:0:D=1987010200:PRES:sfc:kpds=1,1,0:anl:"Pressure [Pa]
2:3396:D=1987010200:UGRD:1000 mb:kpds=33,100,1000:anl:"u wind [m/s]
3:5474:D=1987010200:UGRD:850 mb:kpds=33,100,850:anl:"u wind [m/s]
4:8840:D=1987010200:UGRD:700 mb:kpds=33,100,700:anl:"u wind [m/s]
5:12440:D=1987010200:UGRD:500 mb:kpds=33,100,500:anl:"u wind [m/s]
6:16252:D=1987010200:UGRD:300 mb:kpds=33,100,300:anl:"u wind [m/s]
```

Example #2: wgrib -V model.grb

Result: This command displays the long inventory stored in model.grb.

```
rec 1:0:date 1987010200 PRES kpds5=1 kpds6=1 kpds7=0 levels=(0,0) grid=255 sfc anl: PRES=Pressure [Pa]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data 481.911 1049.91 num bits 8 BDS_Ref 481.911 DecScale 0 BinScale 2

rec 2:3396:date 1987010200 UGRD kpds5=33 kpds6=100 kpds7=1000 levels=(3,232) grid=255 1000 mb anl: bitmap: 1738 undef
UGRD=u wind [m/s]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data -12.9719 20.0281 num bits 8 BDS_Ref -12.9719 DecScale 0 BinScale -2

rec 3:5474:date 1987010200 UGRD kpds5=33 kpds6=100 kpds7=850 levels=(3,82) grid=255 850 mb anl: bitmap: 449 undef
UGRD=u wind [m/s]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data -22.5107 29.7393 num bits 8 BDS_Ref -22.5107 DecScale 0 BinScale -2

rec 4:8840:date 1987010200 UGRD kpds5=33 kpds6=100 kpds7=700 levels=(2,188) grid=255 700 mb anl: bitmap: 216 undef
UGRD=u wind [m/s]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data -19.0453 33.9547 num bits 8 BDS_Ref -19.0453 DecScale 0 BinScale -2

rec 5:12440:date 1987010200 UGRD kpds5=33 kpds6=100 kpds7=500 levels=(1,244) grid=255 500 mb anl: bitmap: 3 undef
UGRD=u wind [m/s]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data -26.0697 50.9303 num bits 8 BDS_Ref -26.0697 DecScale 0 BinScale -1

rec 6:16252:date 1987010200 UGRD kpds5=33 kpds6=100 kpds7=300 levels=(1,44) grid=255 300 mb anl:
UGRD=u wind [m/s]
timerange 0 P1 0 P2 0 TimeU 2 nx 72 ny 46 GDS grid 0 num_in_ave 0 missing 0
center 100 subcenter 2 process 100 Table 128
latlon: lat -90.000000 to 90.000000 by 4.000000 nxny 3312
long 0.000000 to 355.000000 by 5.000000, (72 x 46) scan 2 bdsgrid 1
min/max data -30.2449 73.7551 num bits 8 BDS_Ref -30.2449 DecScale 0 BinScale -1
```

4.1.3 Creating Map Files Using gribmap

The GrADS data descriptor file defines a grid structure into which the data will fit -- it gives "shape" to the data by identifying its spatial dimensions, the number of time steps, and the number of variables.

If the data is in binary format, its structure has already been prescribed. If the data is in GRIB format, no consistent relationship exists between the data and the grid structure defined in the data descriptor file. Hence, the need for the gribmap utility which "maps" between the GRIB data and the GrADS data description.

As gribmap reads each field in the GRIB data file, the parameters for that field (e.g. variable name, vertical level, time) are compared to the information in the data descriptor file until a match is found. The process continues until all the GRIB elements have been "mapped" to their location within the GrADS grid structure.

Usage: gribmap [-i *fname*] [-v] [-t0] [-0] [-fhr] [-sxxx] [-hxxx]

help	Just this help
i	the data descriptor file (.ctl) to map
v	***** VERBOSE OPTION SHOWING DETAILS OF THE MAPPING ***** use THIS !!!
q	quiet mode give no listing except for error
hNNNN	where NNNN is the number of header bytes to look for first GRIB messages (default is 100)
sNNNN	where NNNN is the maximum number of bytes to skip between GRIB messages (default is 1000)
u	update existing gribmap if templated data (options template in the .ctl file)
1	create a machine specific version 1 map
2	create a machine-INDEPENDENT version 2 map (the default for 1.7Beta9a and above
0	ignore the forecast time in the mapping; only use the base time
t0	force match if base time in the GRIB message is the same as base time in the .ctl file
fNNNN	force match for forecast time in hours = NNNNN (e.g., f24 for t=24 h)
e	ignore junk bytes (non GRIB msg) at end of file (e.g., ECMWF GRIB because of blocking)
E	ignore junk bytes in middle and/or end of GRIB file
N	do NOT write the map....
d	internal diagnostics only makes sense to developers (Brian Doty and Mike Fiorino)
m	SPECIAL OPTION for MPI....
hnmcc	SPECIAL OPTION for NCEP (before the name change from NMC)

Example: gribmap -e -i mygrib.ctl

This creates a map file (specified by the index line in mygrib.ctl) but ignores the junk at end.

Another feature was added to map by the GRIB "time-range-indicator" as specified in the .ctl file. This was put in for handling NMC reanalysis data where the time-range-indicator distinguishes between monthly mean variances and means.

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4.2 Troubleshooting Existing Map and Control Files

NOTE: Typically, any problems that concern the Map and Control process are a result of data issues. Data issues are not the responsibility of the Map and Control File Generation Process, however, it must be understood that the method typically used in identifying problems is by using the IGrADS application. IGrADS is a web-based application that is comprised of several different languages, in order to interact with the command-line based GrADS utilities (grads, wgrib, gribmap) and files (.ctl, .map, grb). Knowing this information will help the troubleshooter assist the SDO in tracking down the problem.

4.2.1 Data Problems

1. Log on using the visual account.
2. Check the control files (.ctl) to make sure they are update to the current cycle (Z cycle). To do this, open the control file of the data type and cycle in question and review the tdef line.

```
dset us057g1080g0020000%f300
dtype grib
options template yrev
index mrf4.map
undef -9.99e33
```

- title MRF IC = 00Z Sep 03, 2002

```
xdef 144 linear 0 2.5
ydef 181 linear -90 2.5
zdef 26 levels 1000 975 950 925 900 850 800 750 700 650 600 550 500
tdef 33 linear 00z03sep02 12hr
```

4.2.1-1 Sample Control File

3. Check to make sure all the data has come in. (See Appendix B for data directory listing). If all the data has come in and the Map and Control files **are** up-to-date. Then notify the SDO that it is a data issue.
4. If the Map and Control files **are not** up-to-date. Then it needs to be determined why. Remember, the method as to how the Map and Control files are created (see the information listed above.)
5. Check this key file: MAPCTL_check_data.ksh (Master file). MAPCTL_check_data.ksh will run against the “ready flags” and check the time stamps. If the time stamp is different from the “last cycle” file, it will run the respective update script for that model. Updates run through load leveler.

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Notes

- Load leveler (llq command in UNIX) will check the status of the queue. (visit the web link <https://fred.afwa.af.mil/lldocs/index.html> for a complete set of documentation on load leveler).
- Last cycle files are located /h/data/global/MAPCTL/data/last_cycle
- If a model's CTL files need to be re-ran, remove the corresponding last cycle file will . The MAPCTL_check.ksh script will “think” the theater window has not been processed and create a new last_cycle file (bogus information is written to this new file) for that particular window. The process will then check for the READY and INFO files. If they are present, it will compare the information in the READY file against the information on the related “last_cycle” file. If the information is not equal to each other, a new GrADS process is kicked off.
- Visual Environment Variables
 - i. IMQCONFIGCL=/etc/IMNSearch/dbshelp
 - ii. IMQCONFIGSRV=/etc/IMNSearch
 - iii. CGI_DIRECTORY=/var/docsearch/cgi-bin
 - iv. WXPJET_HOME=/h/WXPJET
 - v. MAPCTL_HOME=/h/MAPCTL
 - vi. MAPCTL_DATA=/h/data/global/MAPCTL/data
 - vii. DOCUMENT_DIRECTORY=/usr/docsearch/html

4.2.2 Log Files

- Look at the log file. There will be links to the current cycle log /h/data/global/MAPCTL/data/[model]/logs
- If data is missing, call the SDO and let him know what data sets are missing, have him call you back once that's done so you can re-run the process.
- If the data is all there and the Map and Control files ran to completion but didn't copy over for some reason, you will have to manually copy them over from the GAS to the BMFS. Map and Control files get copied:
 - from -> /h/data/global/MAPCTL/data/[model]/current*
 - to -> /afwin/u07/data

5 NOTES

None

Appendix A – Detailed Description of Control File Variables

DSET <data_filename>

This entry specifies the filename of the binary data set being described. If data_filename is prefixed with a ^data_filename must include a full path.

For example:

If the data descriptor file is: /data/wx/grads/sa.ctl
and the binary data file is: /data/wx/grads/sa.dat

then the data file name in the data descriptor file can be:

DSET ^sa.dat instead of: DSET /data/wx/grads/sa.dat

As long as the two files are kept together, they may be moved to any directory without changing the entries in the data descriptor file.

DTYPE [station | grib]

This entry specifies the type of data being described. There are only two options: station or grib. If the data type is neither of these, then this entry is omitted completely from the descriptor file and GrADS will assume the data type is gridded binary.

INDEX <filename>

This entry specifies the name of the grib map file. It is required when using the DTYPE grib entry to read grib formatted data. The file is generated by running the external utility gribmap.

TITLE <string>

This entry gives brief description of the contents of the data set. This will be included in the output from a query command, so it is helpful to put meaningful information here.

Here are some examples:

TITLE “Days of Sample Model Output”

TITLE “CEP Reanalysis Jan 1987 thru Jul 1999”

UNDEF <value>

This entry specifies the undefined, or missing, data value. GrADS operations and graphics routines will ignore data with this value from this data set. UNDEF is a required parameter even if there are no undefined data.

For example:

UNDEF -9.99e33

OPTIONS <keyword >

This entry controls various aspects of the way GrADS interprets the raw data file. It replaces the old FORMAT record. The keyword argument may be one or more of the following:

yrev - Indicates that the Y dimension (latitude) in the data file has been written in the reverse order from what GrADS assumes. An important thing to remember is that GrADS still presents the view that the data goes from south to north. The YDEF statement does not change; it still describes the transformation from a grid space going from south to north. The reversal of the Y axis is done as the data is read from the data file.

zrev - Indicates that the Z dimension (pressure) in the data file has been written from top to bottom, rather than from bottom to top as GrADS assumes. The same considerations as noted above for yrev also apply.

template - Indicates that a template for multiple data files is in use. For more information, see the section on Using Templates.

sequential - Indicates that the file was written in sequential unformatted I/O. This keyword may be used with either station or gridded data. If your gridded data is written in sequential format, then each record must be an X-Y varying grid. If you have only one X and one Y dimension in your file, then each record in the file will be one element long (it may not be a good idea to write the file this way).

•

byteswapped - Indicates the binary data file is in reverse byte order from the normal byte order of your machine. Putting this keyword in the OPTIONS record of the descriptor file tells GrADS to swap the byte order as the data is being read. May be used with gridded or station data.

The best way to ensure hardware independence for gridded data is to specify the data's source platform. This allows the data to be used on any type of hardware without having to worry about byte ordering. The following OPTION keywords indicate the actual byte ordering of the data. If the data are already in the correct order, no conversion is performed. These options facilitate moving data files and descriptor files between machines.

big_endian - Indicates the data file contains 32-bit IEEE floats created on a big_endian platform (e.g., sun, sgi and hp). May be used with gridded or station data.

little_endian - Indicates the data file contains 32-bit IEEE floats created on a little_endian platform (e.g., iX86, and dec). May be used with gridded or station data.

cray_32bit_ieee - Indicates the data file contains 32-bit IEEE floats created on a cray. May be used with gridded or station data.

365_day_calendar - Indicates the data file was created with perpetual 365-day years, with no leap years. This is used for some types of model output.

XDEF *<xnum mapping>* *<additional arguments>*

This entry defines the grid point values for the X dimension. The first argument, *xnum*, specifies the number of grid points in the X direction. *xnum* must be an integer ≥ 1 . *mapping* defines the method by which longitudes are assigned to X grid points. There are two options for *mapping*:

LINEAR Linear mapping
LEVELS Longitudes specified individually

The LINEAR mapping method requires two additional arguments: *start* and *increment*. *start* is a floating point value that indicates the longitude at grid point X=1. Negative values indicate western longitudes. *increment* is the spacing between grid point values, given as a positive floating point value.

The LEVELS mapping method requires one additional argument, *value-list*, which explicitly specifies the longitude value for each grid point. *value-list* should contain *xnum* floating point values. It may continue into the next record in the descriptor file, but note that records may not have more than 255 characters. There must be at least 2 levels in *value-list*; otherwise use the LINEAR method.

Here are some examples:

```
XDEF 144 LINEAR 0.0 2.5
XDEF 72 LINEAR 0.0 5.0
XDEF 12 LEVELS 0 30 60 90 120 150 180 210 240 270 300 330
XDEF 12 LEVELS 15 45 75 105 135 165 195 225 255 285 315 345
```

YDEF *<ynum mapping>* *<additional arguments>*

This entry defines the grid point values for the Y dimension. The first argument, *ynum*, specifies the number of grid points in the Y direction. *ynum* must be an integer ≥ 1 . *mapping* defines the method by which latitudes are assigned to Y grid points. There are several options for *mapping*:

LINEAR Linear mapping (see description under xdef definition)
LEVELS Pressure levels specified individually (see description under xdef definition)
GAUST62 Gaussian T62 latitudes
GAUSR15 Gaussian R15 latitudes
GAUSR20 Gaussian R20 latitudes
GAUSR30 Gaussian R30 latitudes
GAUSR40 Gaussian R40 latitudes

The Gaussian (GAUSR) mapping methods require one additional argument: *start*. This argument indicates the first gaussian grid number. If the data span all latitudes, *start* would be 1, indicating the southernmost gaussian grid latitude.

Here are some examples:

```
YDEF 180 LINEAR -90 1.0
```

```
YDEF 18 LEVELS -85 -75 -65 -55 -45 -35 -25 -15 -5 5 15 25 35 45 55 65 75 85
```

```
YDEF 94 GAUST62 1
```

```
YDEF 20 GAUSR40 15
```

The NCEP/NCAR Reanalysis surface variables are on the GAUST62 grid. The final example shows that there are 20 Y dimension values which start at Gaussian Latitude 15 (64.10 south) on the Gaussian R40 grid.

ZDEF *znum mapping <additional arguments>*

This entry defines the grid point values for the Z dimension. The first argument, *znum*, specifies the number of pressure levels. *znum* must be an integer ≥ 1 . *mapping* defines the method by which longitudes are assigned to Z grid points. There are two options for *mapping*:

LINEAR Linear mapping (see description under xdef definition)

LEVELS Pressure levels specified individually (see description under xdef definition)

Here are some examples:

```
ZDEF 10 LINEAR 1000 -100
```

```
ZDEF 7 LEVELS 1000 850 700 500 300 200 100
```

```
ZDEF 17 LEVELS 1000 925 850 700 600 500 400 300 250 200 150 100 70 50 30  
20 10
```

TDEF *tnum LINEAR start increment*

This entry defines the grid point values for the T dimension.

The first argument, *tnum*, specifies the number of time steps. *tnum* must be an integer ≥ 1 .

The method by which times are assigned to T grid points is always LINEAR.

start indicates the initial time value at grid point T=1. *start* must be specified in the GrADS absolute date/time format:

hh:mmZddmmyyyy

where:

hh = hour (two digit integer)

mm = minute (two digit integer)

dd = day (one or two digit integer)

mmm = 3-character month

yyyy = year (may be a two or four digit integer; 2 digits implies a year between 1950 and 2049).

If not specified,

hh defaults to 00

mm defaults to 00

and *dd* defaults to 1.

The month and year must be specified.

No intervening blanks are allowed in the GrADS absolute date/time format.

increment is the spacing between grid point values in the T direction. *increment* must be specified in the GrADS absolute time increment format:

vvkk

where:

vv = an integer number, 1 or 2 digits

kk = mn (minute)

hr (hour)

dy (day)

mo (month)

yr (year)

Here are some examples:

TDEF 60 LINEAR 00Z31dec1999 1mn

TDEF 73 LINEAR 3jan1989 5dy

TDEF 730 LINEAR 00z1jan1990 12hr

TDEF 12 LINEAR 1jan2000 1mo

TDEF 365 LINEAR 12Z1jan1959 1dy

TDEF 40 LINEAR 1jan1950 1yr

VARs *varnum*

variable_record_1

variable_record_2

...

variable_record_*varnum*

ENDVARS

This ensemble of entries describes all the variables contained in the data set. *varnum* indicates the number of variables in the data set and is therefore also equal to the number of variable records that are listed between the VARS and ENDVARS entries. ENDVARS must be the final line of the Grads data descriptor file. Any blank lines after the ENDVARS statement may cause open to fail.

The format of the `variable_records` is as follows:

varname levs units description

varname is a 1-15 character "name" or abbreviation for the variable. *varname* may contain alphabetic and numeric characters but it must start with an alphabetic character (a-z).

levs is an integer that specifies the number of vertical levels the variable contains. *levs* may not exceed *znum* as specified in the `ZDEF` statement. If *levs* is 0, the variable does not correspond to any vertical level. Surface variables (e.g. sea level pressure) have a *levs* value of 0.

The *units* component of the `variable_record` is used for data in GRIB and other special formats. If the data you are describing are not in one of these formats, put a value of 99 here.

description is text description of the variable, max 40 characters.

Here is an example:

```
VARs 4
PS 0 99 Surface Pressure
U 7 99 U-Winds
V 7 99 V-Winds
Z 7 99 Geopotential Heights
ENDVARs
```

NOTE: Failure to match *varnum* with an equal number of listed variables will cause erroneous output from GrADS.

FILEHEADER *length*

This optional entry tells GrADS that your data file has a header record of *length* bytes that precedes the data. GrADS will skip past this header, then treat the remainder of the file as though it were a normal GrADS binary file after that point. This optional descriptor file entry is only valid for GrADS gridded data sets.

THEADER *length*

This optional entry tells GrADS that the data file has a header record of *length* bytes preceding each time block of binary data. This optional descriptor file entry is only valid for GrADS gridded data sets. See the section on structure of a gridded binary data file for more information.

XYHEADER *length*

This optional entry tells GrADS that the data file has a header record of *length* bytes preceding each horizontal grid (XY block) of binary data. This optional descriptor file entry is only valid for GrADS gridded data sets. See the section on structure of a gridded binary data file for more information.

Appendix B – Weather Model Data Locations

Weather Model	ACRONYM	Data Directory (dev)	Server	Mount Point	Mount Point Info
Advect Cloud	ADVCLD	/u09/data/grib/advclcd	BMFS	/mnt/BMFS/	
Coupled Ocean Atmosphere Mesoscale Prediction Systems	COAMPS	/u09/data/grib/coamps/gpost	BMFS	/mnt/BMFS/	
Diagnostic Cloud Forecast	DCF	/u09/data/grib/DCF	BMFS	/mnt/BMFS/	
ETA Scientific Model	ETA	/u09/data/grib/eta	BMFS	/mnt/BMFS/	
Global Forecast System	GFS	/u09/data/grib/avn	BMFS	/mnt/BMFS/	
Global Forecast System (post process)	GFS	/u09/data/grib/gfs_gpost	BMFS	/mnt/BMFS/	
Mesoscale Model Version 5	MM5	/u09/data/grib/mm5	BMFS	/mnt/BMFS/	
Navy Operational Global Analysis and Prediction System	NOGAPS	/h/data/global/GRIBI/data/nogaps	GDS	/mnt/gds/	If using this mnt pt, replace /h/data/global with /mnt/gds/global. Everything else is the same.
Navy Operational Global Analysis and Prediction System (post process)	NOGAPS	/h/data/global/GPOST/data/nogaps	GDS	/mnt/gds/	If using this mnt pt, replace /h/data/global with /mnt/gds/global. Everything else is the same.

Notes:

For an accurate location of the data, you can grab the directory path out of the model's control file.

Useful paths on the unclassified production servers are:

Data directory - /h/data/global/MAPCTL/data/[model]

Raw Data directory - /h/data/global/MAPCTL/data/[model]/rawdata[.2]/ (Note: Not all models have /rawdata.2/ subdirectories.)

These directories contain post processed data.)

Logs - /h/data/global/MAPCTL/data/[model]/logs

Appendix A – GrADS Tutorial

What is it?

This document presents a brief tutorial for Brian Doty's [Grid Analysis and Display System \(GrADS\)](#). The following sample session will give you a feeling for how to use the basic capabilities of GrADS. This sample session takes about 30 minutes to run through.

Tutorial Requirements:

A current version of GrADS running on either a UNIX or Windows platform (note: UNIX is preferred).

The following sample data files (Location: <http://grads.iges.org/grads/gadoc/tutorial.html>)

[model.ctl](#) GrADS descriptor file (0.7 kb)
[model.grb](#) GrADS (GRIB) data file (579 kb)
[model.gmp](#) GrADS gribmap index file (4 kb)

This data file is described by the data descriptor file [model.ctl](#). You may want to look at this file before continuing. The data descriptor file describes the actual data file, which in the case contains 5 days of global grids that are 72 x 46 elements in size.

Please download these 3 files to a local directory before proceeding.

Sample Session

To start up GrADS, enter:

[grads](#)

If grads is not in your current directory, or if it is not in your PATH somewhere, you may need to enter the full pathname, ie:

```
/usr/homes/smith/grads/grads
```

GrADS will prompt you with a landscape vs. portrait question; just press enter. At this point a graphics output window should open on your console. You may wish to move or resize this window. Keep in mind that you will be entering GrADS commands from the window where you first started GrADS -- this window will need to be made the 'active' window and you will not want to entirely cover that window with the graphics output window.

In the text window (where you started grads from), you should now see a prompt:

```
ga-> You will enter GrADS commands at this prompt and see the results displayed in the graphics output window.
```

The first command you will enter is:

[open](#) model.ctl

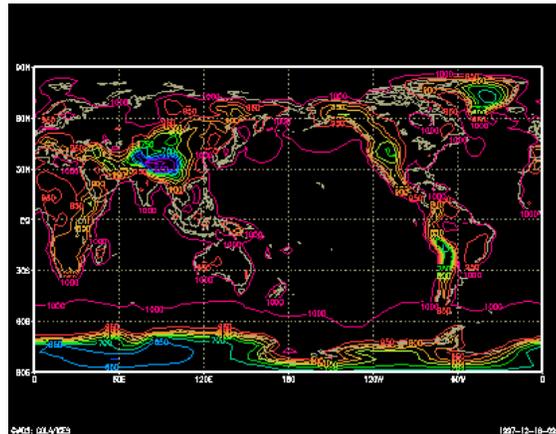
You may want to see what is in this file, so enter:

[query](#) file

One of the available variable is called ps, for surface pressure. We can display this variable by entering:

[d](#) ps

d is short for [display](#). You will note that by default, GrADS will display an X, Y plot at the first time and at the lowest level in the data set.



Now you will enter commands to alter the [dimension environment](#). The [display](#) command (and implicitly, the access, operation, and output of the data) will do things with respect to the current dimension environment. You control the dimension environment with the set command:

- [clear](#) clears the display
- [set lon](#) -90 sets longitude to 90 degrees West
- [set lat](#) 40 sets latitude to 40 degrees North
- [set lev](#) 500 sets level to 500 mb
- [set t](#) 1 sets time to first time step
- [d](#) z displays the variable 'z'

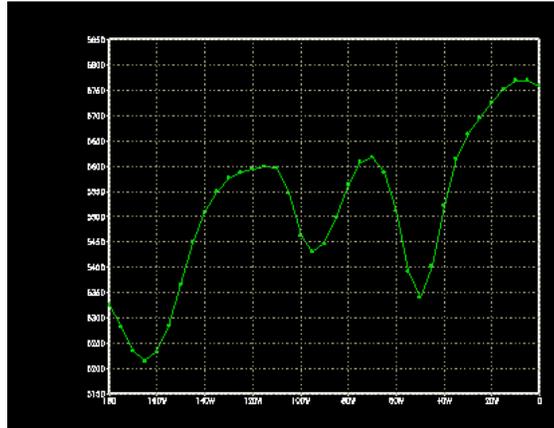
In the above sequence of commands, we have set all four GrADS dimensions to a single value. When we set a dimension to a single value, we say that dimension is "fixed". Since all the dimensions are fixed, when we display a variable we get a single value, in this case the value at the location 90W, 40N, 500mb, and the 1st time in the data set.

If we now enter:

- [set lon](#) -180 0 X is now a varying dimension
- [d](#) z

We have set the X dimension, or longitude, to vary. We have done this by entering two values on the set command. We now have one varying dimension (the other

dimensions are still fixed), and when we display a variable we get a line graph, in this case a graph of 500mb Heights at 40N.



Now enter:

```
clear  
set lat 0 90  
d z
```

We now have two varying dimensions, so by default we get a contour plot. If we have 3 varying dimensions:

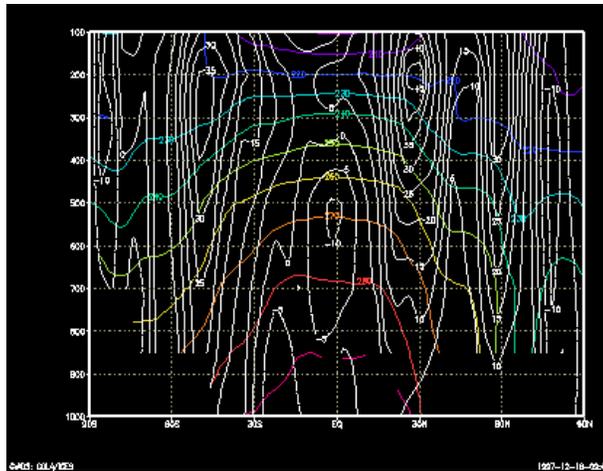
```
c  
set t 1 5  
d z
```

we get an animation sequence, in this case through time.

Now enter:

```
clear  
set lon -90  
set lat -90 90  
set lev 1000 100  
set t 1  
d t  
d u
```

In this case we have set the Y (latitude) and Z (level) dimensions to vary, so we get a vertical cross section. We have also displayed two variables, which simply overlay each other. You may display as many items as you desire overlaid before you enter the [clear](#) command.

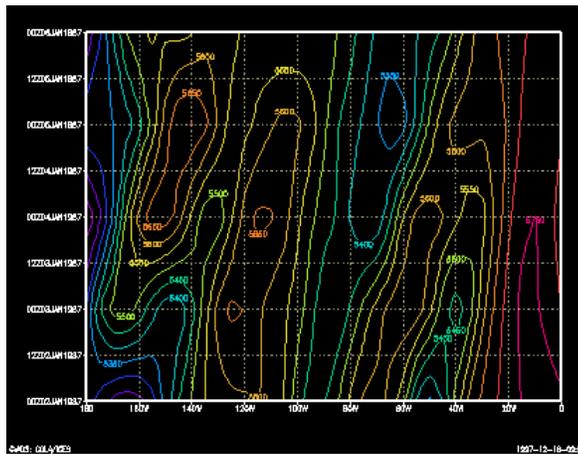


Another example, in this case with X and T varying (Hovmoller plot):

```

c
set lon -180 0
set lat 40
set lev 500
set t 1 5
d z

```



Now that you know how to select the portion of the data set to view, we will move on to the topic of operations on the data. First, set the dimension environment to an Z, Y varying one:

```

clear
set lon -180 0
set lat 0 90
set lev 500
set t 1

```

Now lets say that we want to see the temperature in Fahrenheit instead of Kelvin. We can do the conversion by entering:

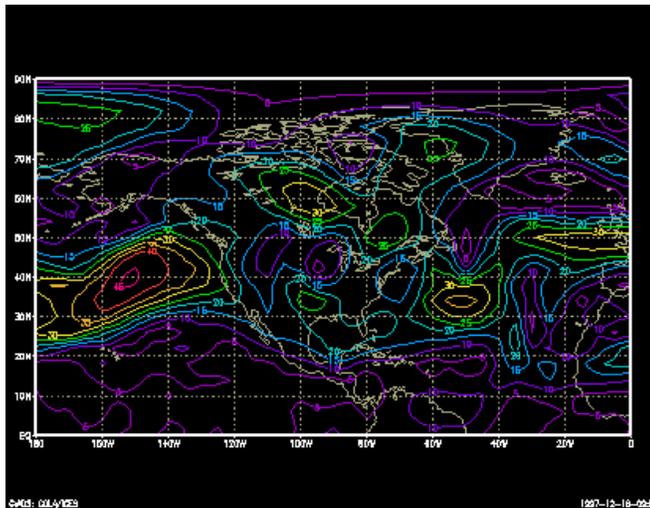
`display (t-273.16)*9/5+32`

Any expression may be entered that involves the standard operators of +, -, *, and /, and which involves operands which may be constants, variables, or functions. An example involving functions:

```
clear
d sqrt(u*u+v*v)
```

to calculate the magnitude of the wind. A function is provided to do this calculation directly:

```
d mag(u,v)
```



Another built in function is the averaging function:

```
clear
d ave(z,t=1,t=5)
```

In this case we calculate the 5 day mean. We can also remove the mean from the current field:

```
d z - ave(z,t=1,t=5)
```

We can also take means over longitude to remove the zonal mean:

```
clear d z-ave(z,x=1,x=72)
d z
```

We can also perform time differencing:

```
clear
d z(t=2)-z(t=1)
```

This computes the change between the two fields over 1 day. We could have also done this calculation using an offset from the current time:

```
d z(t+1) - z
```

The complete specification of a variable name is:

```
name.file(dim +|-|= value, ...)
```

If we had two files open, perhaps one with model output, the other with analyses, we could take the difference between the two fields by entering:

```
display z.2 - z.1
```

Another built in function calculates horizontal relative vorticity via finite differencing:

```
clear  
d hcurl(u,v)
```

Yet another function takes a mass weighted vertical integral:

```
clear  
d vint(ps,q,275)
```

Here we have calculated precipitable water in mm.

Now we will move on to the topic of controlling the graphics output. So far, we have allowed GrADS to chose a default contour interval. We can override this by:

```
clear  
set cint 30  
d z
```

We can also control the contour color by:

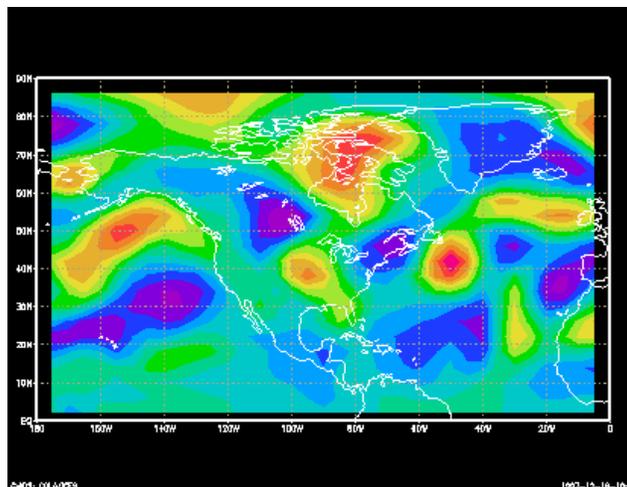
```
clear  
set ccolor 3  
d z
```

We can select alternate ways of displaying the data:

```
clear  
set gxout shaded  
d hcurl(u,v)
```

This is not very smooth; we can apply a cubic smoother by entering:

```
clear  
set csmooth on  
d hcurl(u,v)
```



We can overlay different graphics types:

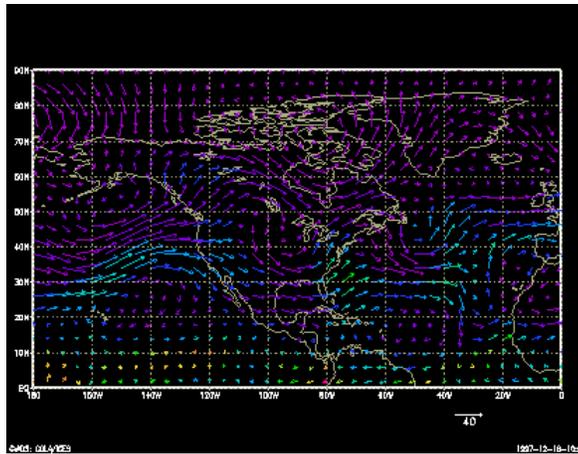
```
set gxout contour  
set ccolor 0  
set cint 30  
d z
```

and we can annotate:

```
draw title 500mb Heights and Vorticity
```

We can view wind vectors:

```
clear  
set gxout vector  
d u;v
```



Here we are displaying two expressions, the first for the U component of the vector; the 2nd the V component of the vector. We can also colorize the vectors by specifying a 3rd field:

```
d u;v;q
```

or maybe:

```
d u;v;hcurl(u,v)
```

You may display pseudo vectors by displaying any field you want:

```
clear  
d mag(u,v) ; q*10000
```

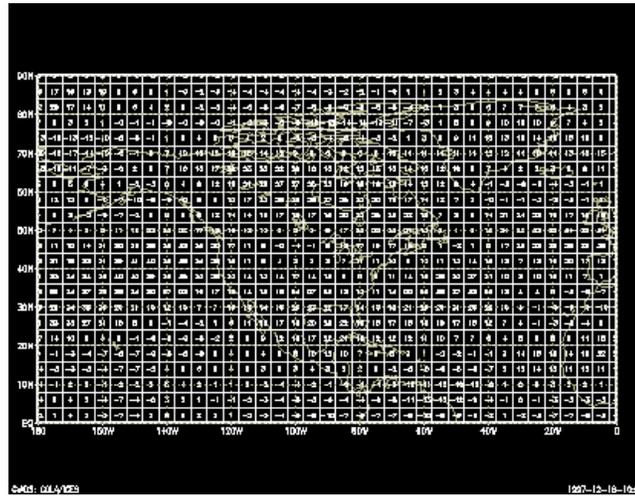
Here the U component is the wind speed; the V component is moisture.

We can also view streamlines (and colorize them):

```
clear  
set gxout stream  
d u;v;hcurl(u,v)
```

Or we can display actual grid point values:

```
clear
set gxout grid
du
```



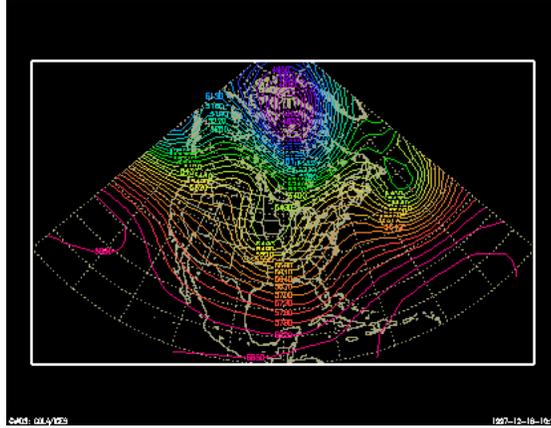
We may wish to alter the map background:

```
clear
set lon -110 -70
set lat 30 45
set mpdset nam
set digsize 0.2
set dignum 2
du
```

To alter the projection:

```
set lon -140 -40
set lat 15 80
set mpvals -120 -75 25 65
set mproj nps
set gxout contour
set cint 30
du
```

In this case, we have told grads to access and operate on data from longitude 140W to 40W, and latitude 15N to 80N. But we have told it to display a polar stereographic plot that contains the region bounded by 120W to 75W and 25N to 65N. The extra plotting area is clipped by the map projection routine.



This concludes the sample session. At this point, you may wish to examine the data set further, or you may want to go through the GrADS documentation and try out the other options described there.

Absolute Humidity

(1) The ratio of the mass of water vapor to the volume occupied by a mixture of water vapor and dry air. (2) Mass of water contained in a unit volume of moist air.

Absolute Vorticity

Vorticity measured relative to a non-rotating reference frame.

CAPE

Convective Available Potential Energy. A measure of the amount of energy available for convection. CAPE is directly related to the maximum potential vertical speed within an updraft; thus, higher values indicate greater potential for severe weather. Observed values in thunderstorm environments often may exceed 1,000 joules per kilogram (j/kg), and in extreme cases may exceed 5,000 j/kg. However, as with other indices or indicators, there are no threshold values above which severe weather becomes imminent. CAPE is represented on a sounding by the area enclosed between the environmental temperature profile and the path of a rising air parcel, over the layer within which the latter is warmer than the former. (This area often is called positive area.) See also CIN and Fig. 6, sounding.

Cloud Cover

Cloud cover is the amount of total sky coverage by clouds.

Clear = less than 10% cloud coverage.

Scattered = more than 10% and less than 60% cloud coverage.

Broken = more than 60% and less than 90% cloud coverage.

Overcast = more than 90% cloud coverage.

Obscured = cannot determine cloud information due to obscuration by precipitation, fog, dust, etc. Sometimes referred to as vertical visibility.

Source: <http://weather.unisys.com/wxp/Appendices/Glossary.html>

Clouds

Cloud Base

For a given cloud or cloud layer, the lowest level in the atmosphere at which the air contains a perceptible quantity of cloud particles.

Cloud Height

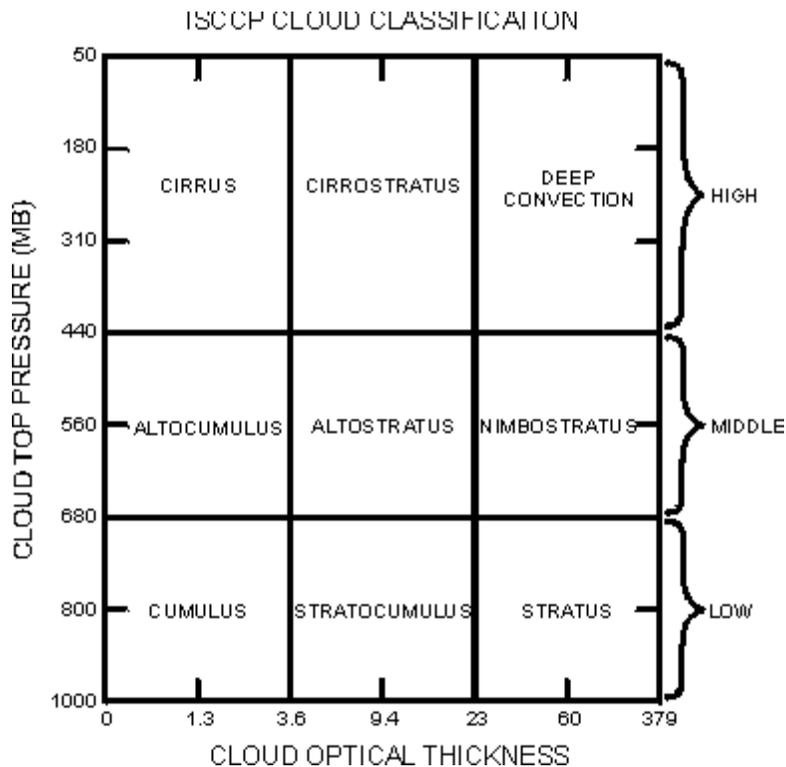
The height of the cloud base above the local terrain.

Cloud Top

For a given cloud or cloud layer, the highest level in the atmosphere at which the air contains a perceptible quantity of cloud particles.

Cloud Types

A value of cloud top pressure and optical thickness is obtained for each cloudy pixel during the daytime. This information can be used to classify different cloud types as shown in the figure. The cloud type names here represent only an approximate climatological relationship between the satellite-measured optical parameters and the classical morphological cloud types. However, a detailed comparison of the satellite and surface-based cloud observations supports this assignment of names.



Layer Cloud Amount - ?

This parameter represents the fractional area covered by clouds as observed from above by satellites. It is estimated by counting the number of satellite fields-of-view (called pixels, about 5 km across for ISCCP) that are determined to be cloudy and dividing by the total number of pixels in a region about 280 km across. Cloud amount for lower-level clouds is only that fraction of the area actually observed to be covered by clouds at that level. This way of determining cloud amount assumes that each cloudy pixel is covered completely by clouds.

Dew Point

The dewpoint is the point at which air, when cooled at a specific pressure and moisture content, reaches the saturation point of water vapor. In other words, when the temperature is lowered, this is the point at which condensation occurs or dew forms.

Dew Point Depression

Dew point depression is the difference in degrees Celsius between the temperature and the dew point.

Energy Helicity Index (or EHI)

An index that incorporates vertical shear and instability, designed for the purpose of forecasting super cell thunderstorms. It is related directly to storm-relative helicity in the lowest 2 km (SRH, in m^2/s^2) and CAPE (in j/kg) as follows:

$$EHI=(CAPE \times SRH)/160,000.$$

Thus, higher values indicate unstable conditions and/or strong vertical shear. Since both parameters are important for severe weather development, higher values generally indicate a greater potential for severe weather. Values of 1 or more are said to indicate a heightened threat of tornadoes; values of 5 or more are rarely observed, and are said to indicate potential for violent tornadoes. However, there are no magic numbers or critical threshold values to confirm or predict the occurrence of tornadoes of a particular intensity.

Hail (Size Potential)

Precipitation that originates in convective clouds, such as cumulonimbus, in the form of balls or irregular pieces of ice, which comes in different shapes and sizes. Hail is considered to have a diameter of 5 millimeter or more; smaller bits of ice are classified as ice pellets, snow pellets, or graupel. Individual lumps are called hailstones. It is reported as "GR" in an observation and on the METAR. Small hail and/or snow pellets is reported as "GS" in an observation and on the METAR.

Heat Index

Heat index is the temperature your body feels when the air temperature is combined with the relative humidity. As humidity increases, the rate of evaporation decreases. Our bodies are cooled by the evaporation of our perspiration. Therefore, if evaporation is slowed, the cooling of our bodies is slowed and we feel warmer.

RH (%)	Temperature (F)															
	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	
90	119	123	128	132	137											
85	115	119	123	127	132	136										
80	112	115	119	123	127	131	135									
75	109	112	115	119	122	126	130	134								
70	106	109	112	115	118	122	125	129	133							
65	103	106	108	111	114	117	121	124	127	131						
60	100	103	105	108	111	114	116	120	123	126	129					
55	98	100	103	105	107	110	113	115	118	121	124	127				
50	96	98	100	102	104	107	109	112	114	117	119	122	125			
45	94	96	98	100	102	104	106	108	110	113	115	118	120	123		
40	92	94	96	97	99	101	103	105	107	109	111	113	116	118	121	
35	91	92	94	95	97	98	100	102	104	106	107	109	112	114	116	
30	89	90	92	93	95	96	98	99	101	102	104	106	108	110	112	

Source: http://www.aws.com/aws_2001/homeland/gloss.html#top

Helicity

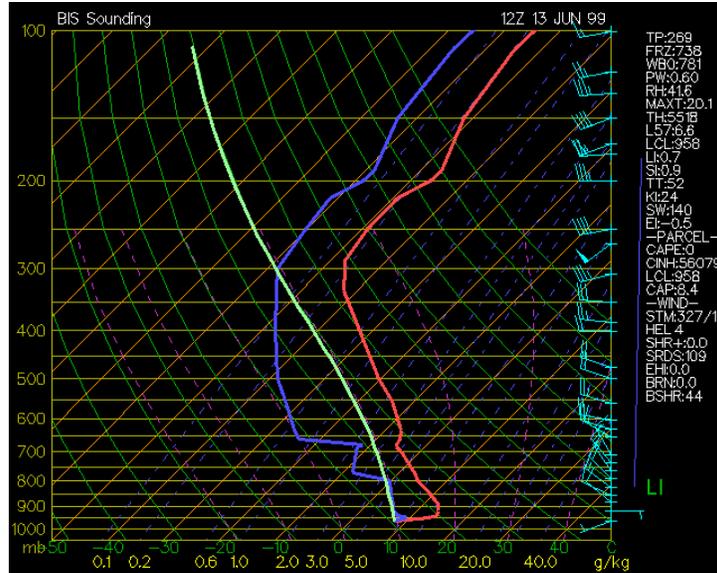
A property of a moving fluid which represents the potential for helical flow (i.e. flow which follows the pattern of a corkscrew) to evolve. Helicity is proportional to the strength of the flow, the amount of vertical wind shear, and the amount of turning in the flow (i.e. vorticity). Atmospheric helicity is computed from the vertical wind profile in the lower part of the atmosphere (usually from the surface up to 3 km), and is measured relative to storm motion. Higher values of helicity (generally, around $150 \text{ m}^2/\text{s}^2$ or more) favor the development of mid-level rotation (i.e. mesocyclones). Extreme values can exceed $600 \text{ m}^2/\text{s}^2$.

K Index

The measure of thunderstorm potential based on the vertical temperature lapse rate, the moisture content of the lower atmosphere and the vertical extent of the moist layer.

Lifted Index (LI)

Lifted index is a measure of the thunderstorm potential which takes into account the low level moisture availability. The LI can be found from looking at a skew-t thermodynamic diagram. The lifted index takes into account low-level moisture. A negative lifted index indicates the possibility of convection. A lifted index less than -6C indicates the possibility of extremely intense convection. To find LI you subtract the temperature of the parcel at 500mb from the environmental temperature at 500mb.



The Lifted Index (LI)

RANGE IN K	COLOR	AMOUNT OF INSTABILITY	THUNDERSTORM PROBABILITY
more than 11	BLUE	Extremely stable conditions	Thunderstorms unlikely
8 to 11	LIGHT BLUE	Very stable conditions	Thunderstorms unlikely
4 to 7	GREEN	Stable conditions	Thunderstorms unlikely
0 to 3	LIGHT GREEN	Mostly stable conditions	Thunderstorm unlikely
-3 to -1	YELLOW	Slightly unstable	Thunderstorms possible
-5 to -4	ORANGE	Unstable	Thunderstorms probable
-7 to -6	RED	Highly unstable	Severe thunderstorms possible
less than -7	VIOLET	Extremely unstable	Violent thunderstorms, tornadoes possible

Source: <http://twister.sbs.ohio-state.edu/severe/liftindex.html>

Lid Strength Index

Measures the ability of the warm air layer between approximately 800 and 900 mb to prevent convection.

Source: <http://meted.ucar.edu/nwp/pcu2/afppp3.htm>

Millibar

A millibar (mb) is a unit of measure for air pressure.

1 millibar is .02953 inches of mercury (Hg).

Average sea level pressure is 1013.2 millibars or 29.92 inches of mercury.

Mesocyclone

A area of rotation of storm size that may often be found on the southwest part of a supercell. Its circulation can be larger than the tornado that may develop within it, but not necessarily. Originally a radar term for a rotation signature that met certain criteria, it is best seen on Doppler radar.

Precipitation Type

Any and all forms of water, liquid or solid, that falls from clouds and reaches the ground. This includes drizzle, freezing drizzle, freezing rain, hail, ice crystals, ice pellets, rain, snow, snow pellets, and snow grains. The amount of fall is usually expressed in inches of liquid water depth of the substance that has fallen at a given point over a specified time period.

Pressure Tendency

This is the change of sea level pressure with time. This is usually reported as a three hour pressure change in millibars.

Relative Humidity

A dimensionless ratio, expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated. Since the latter amount is dependent on temperature, relative humidity is a function of both moisture content and temperature. As such, relative humidity by itself does not directly indicate the actual amount of atmospheric moisture present.

Relative Vorticity

Relative vorticity is the sum of the rotation of the parcel about the axis of the pressure system (curvature) and the rotation of the parcel about its own axis (shear).

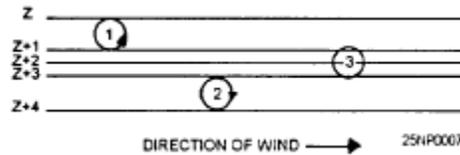


Figure 1-4.-Illustration of vorticity due to the shear effect.

The vorticity of a horizontal current can be broken down into two components, one due to curvature of the streamlines and the other due to shear in the current.

Sea Level Pressure

The sea level pressure is a correction of the station pressure to sea level. This correction takes into account the standard variation of pressure with height and the influence of temperature variations with height on the pressure. The temperature used in the sea level correction is a twelve hour mean, eliminating diurnal effects. Once calculated, horizontal variations of sea level pressure may be compared for location of high and low pressure areas and fronts.

Storm-Relative

Measured relative to a moving thunderstorm, usually referring to winds, wind shear, or helicity.

SWEAT Index

Severe Weather ThrEAT index. A stability index developed by the Air Force which incorporates instability, wind shear, and wind speeds as follows:

$SWEAT = (12 Td_{850}) + (20 [TT - 49]) + (2 f_{850}) + f_{500} + (125 [s + 0.2])$ where

- Td_{850} is the dew point temperature at 850 mb,
- TT is the total-totals index,
- f_{850} is the 850-mb wind speed (in knots),
- f_{500} is the 500-mb wind speed (in knots), and
- s is the sine of the angle between the wind directions at 500 mb and 850 mb (thus representing the directional shear in this layer).

SWEAT values of about 250-300 or more indicate a greater potential for severe weather, but as with all stability indices, there are no magic numbers.

The SWEAT index has the advantage (and disadvantage) of using only mandatory-level data (i.e., 500 mb and 850 mb), but has fallen into relative disuse with the advent of more detailed sounding analysis programs.

Temperature

The temperature is a measure of the internal energy that a substance contains. This measure of the internal energy that a substance contains. This is the most measured quantity in the atmosphere.

Thickness

The thickness of a layer in the atmosphere is proportional to the mean temperature of that whole layer. The layer most often used in meteorology is between 1000 and 500 millibars. There can be different temperature profiles in the lowest layer of the atmosphere with the same 1000-500 millibar thickness value, depending on what is happening above that lowest layer. For example, if the lower levels are warming but higher levels are cooling, the overall mean temperature, the thickness, could remain the same. Likewise, on a sunny day, the amount of incoming solar radiation, affects the temperature right at the earth's surface, without necessarily having much effect on the thickness of the whole layer.

Visibility

The visibility is the maximum distance an object may be seen considering air conditions. Precipitation, fog, haze, pollutants, and suspended dust all contribute to lowering visibility.

Vorticity

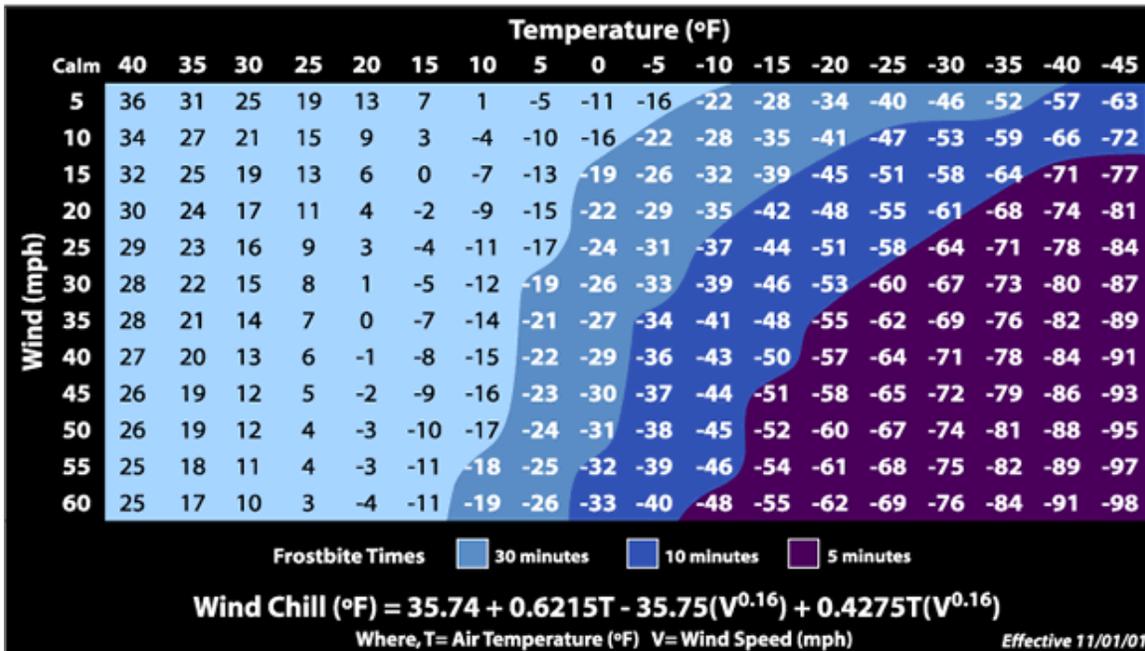
The measurement of the rotation of a small air parcel. It has vorticity when the parcel spins as it moves along its path. Although the axis of the rotation can extend in any direction, meteorologists are primarily concerned with the rotational motion about an axis that is perpendicular to the earth's surface. If it does not spin, it is said to have zero vorticity. In the Northern Hemisphere, the vorticity is positive when the parcel has a counterclockwise, or cyclonic, rotation. It is negative when the parcel has clockwise, or anticyclonic, rotation.

Wind Chill

The wind chill index is the temperature your body feels when the air temperature is combined with the wind speed. The higher the wind speed the faster exposed areas of your body lose heat and the cooler you feel. This is not the actual air temperature.



Wind Chill Chart



Source: http://www.aws.com/aws_2001/homeland/gloss.html

Wind Shear

The rate of wind speed or direction change with distance. Vertical wind shear is the rate of change of the wind with respect to altitude. Horizontal wind shear is the rate of change on a horizontal plane.

Wind Speed

The wind speed is a measure of the average speed of movement of the wind at a specific point. When measured, the value represents an average taken over a couple of minutes.

Wind

Air that flows in relation to the earth's surface, generally horizontally. There are four areas of wind that are measured: direction, speed, character (gusts and squalls), and

shifts. Surface winds are measured by wind vanes and anemometers, while upper level winds are detected through pilot balloons, rawin, or aircraft reports.

MM5 Modeling System Overview

Brief Description

The PSU/NCAR mesoscale model is a limited-area, nonhydrostatic or hydrostatic (Version 2 only), terrain-following sigma-coordinate model designed to simulate or predict mesoscale and regional-scale atmospheric circulation. It has been developed at Penn State and NCAR as a community mesoscale model and is continuously being improved by contributions from users at several universities and government laboratories.

The Fifth-Generation NCAR / Penn State Mesoscale Model (MM5) is the latest in a series that developed from a mesoscale model used by Anthes at Penn State in the early 70's that was later documented by Anthes and Warner (1978). Since that time, it has undergone many changes designed to broaden its usage. These include (i) a multiple-nest capability, (ii) nonhydrostatic dynamics, which allows the model to be used at a few-kilometer scale, (iii) multitasking capability on shared- and distributed-memory machines, (iv) a four-dimensional data-assimilation capability, and (v) more physics options.

The model (known as MM5) is supported by several auxiliary programs, which are referred to collectively as the MM5 modeling system.

A schematic diagram is provided to facilitate discussion of the complete modeling system. It is intended to show the order of the programs and the flow of the data, and to briefly describe their primary functions. Documentation for various programs in the modeling system is available online (see Documents and Publications above).

Terrestrial and isobaric meteorological data are horizontally interpolated (programs TERRAIN and REGRID) from a latitude-longitude mesh to a variable high-resolution domain on either a Mercator, Lambert conformal, or polar stereographic projection. Since the interpolation does not provide mesoscale detail, the interpolated data may be enhanced (program RAWINS or little_r) with observations from the standard network of surface and rawinsonde stations using either a successive-scan Cressman technique or multiquadric scheme. Program INTERPF performs the vertical interpolation from pressure levels to the sigma coordinate system of MM5. Sigma surfaces near the ground closely follow the terrain, and the higher-level sigma surfaces tend to approximate isobaric surfaces. Since the vertical and horizontal resolution and domain size are variable, the modeling package programs employ parameterized dimensions requiring a variable amount of core memory. Some peripheral storage devices are also used.

Since MM5 is a regional model, it requires an initial condition as well as lateral boundary condition to run. To produce lateral boundary condition for a model run, one needs gridded data to cover the entire time period that the model is integrated.

Diagnostic Cloud Forecast

Typically, when forecasters think of cloud cover, they think in terms of cumulative obscuration from the ground up - the clouds are broken at 10,000 feet, for example. Another way to think of cloud cover is through the cumulative obscuration looking down on the clouds from above. Flight operations such as ground surveillance, in-flight refueling, close air support and weapon selection for surgical air strikes all benefit from this type of cloud information. One of the Air Force Weather Agency's core missions is to provide cloud analysis and forecasts of this type.

Accurately forecasting clouds is a challenge. The AFWA Cloud Depiction and Forecast System II produces a World-Wide Merged Cloud Analysis by merging data from five geostationary and up to seven polar-orbiting satellites. It then uses the WWMCA to initialize an Advection Cloud model that produces cloud forecasts out to 48 hours. As the name implies, ADVCLD simply advects, or blows, the clouds around using winds from a global weather forecast model. Clouds can only be generated or dissipated in the model through large-scale ascent or descent of air, respectively. An example of this is given the lack of detailed physics used in the model, it does not produce convective and orographically-forced clouds. As a result, accuracy of the ADVCLD model rapidly declines beyond the 12-hour forecast.

In contrast, numerical weather prediction models, such as the Mesoscale Model 5, include more sophisticated cloud physics but generally are also unable to forecast clouds with sufficient accuracy. Another approach is needed to produce accurate cloud forecasts beyond 12 hours.

The Diagnostic Cloud Forecast application, developed by Air Force Research Lab, produces improved cloud forecasts by combining MM5 output with CDFS II cloud analysis using a technique similar to Model Output Statistics. DCF statistically relates past MM5 output parameters such as relative humidity, winds, cloud water, etc., to WWMCA cloud parameters valid at the same time. Assuming that the statistical relationships do not change significantly from day-to-day, we can use them to generate cloud forecasts from future MM5 output. Computing statistics each day, DCF "learns" or "remembers" cloud trends.

DCF has demonstrated improved skill over cloud forecasts derived from ADVCLD and MM5, but Air Force Weather specialists must understand how to use the output effectively. Real-time subjective verification reveals that DCF provides more accurate cloud structures; however, objective verification has shown only about a five-percent improvement in absolute error beyond the 12-hour forecast. While cloud structures are more accurate, the fine details are highly variable thus contributing to the small decrease in overall error. As forecasters apply DCF, they should keep this in mind.

AFWA is running DCF operationally for a limited set of MM5 domains, but intends to expand its application globally. Currently, DCF is run for the CONUS, Central/South

America, Europe, plus South West and South East Asia MM5 45-km domains out to 72 hours. Output is available through IGrADS on JAAWIN and is input into the Target Acquisition Weapon Software. A version of DCF capable of running on the MM5 15-km domains is in development testing and evaluations, and a version that runs globally with Global Forecast System input is under consideration.

DCF provides a more accurate, long-range cloud forecasting capability to strategic and tactical mission planners. Because DCF is based on MM5, it complements other theater forecasting tools to provide a more complete picture of the operational weather environment.

Source: https://afweather.afwa.af.mil/observer/JUL_AUG_2003/dcf.html
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AFWA Meteorological Models Branch

NOGAPS

The NOGAPS (Navy Operational Global Atmospheric Prediction System) forecast model is a global model that is spectral in the horizontal and energy-conserving finite difference (sigma coordinate) in the vertical. The model top pressure is set at 1 hPa; however, the first velocity and temperature level is approximately 5 hPa. The variables used in dynamic formulations are vorticity and divergence, virtual potential temperature, specific humidity, and terrain pressure.

On 24 June 1998, NOGAPS was upgraded to version 4.0. The primary change was an increase in the number of vertical levels from 18 to 24.

The operational T159L24 NOGAPS (4.0) runs on a CRAY C90 and executes several times each 00-UTC and 12-UTC watch, including a six-day forecast completing approximately five and one-half hours past the synoptic time. NOGAPS currently outputs close to 25,000 gridded fields per day. Products from NOGAPS are distributed to a worldwide customer base. NOGAPS also provides essential and tailored input to many other models, including the Navy's advanced Coupled Ocean-Atmosphere Mesoscale Prediction System (COAMPS), ocean wave model, sea ice model, ocean circulation model, ocean thermodynamics model, tropical cyclone model, aircraft and ship-routing programs, and application programs at both FNMOC (U.S. Navy's Fleet Numerical Meteorology and Oceanography Center) and the Air Force Weather Agency (AFWA).

Along with the GFDL tropical cyclone forecast model and the UK Met Office and Japanese global models, NOGAPS is a primary tropical cyclone forecast tool for forecasters at the Joint Typhoon Warning Center (JTWC) and the National Hurricane Center (NHC).

NOGAPS uses a multi-variate optimal interpolation (MVOI) scheme. This analysis scheme uses multivariate statistical analytical techniques, patterned after the volume method developed by Lorenc (1981) for ECMWF. First implemented operationally at FNMOC in January 1988, NOGAPS has undergone evolution to reach its current configuration. The analysis is performed on the Gaussian grid of the T159L24 global spectral model on the 16 standard pressure levels from 1000 to 10 hPa, inclusive. The maximum number of observations used per volume is 600.

Besides using conventional observations (surface, rawinsonde, pibal, and aircraft), the analysis makes heavy use of various forms of satellite-derived observations. The analysis uses derived soundings from the NOAA and DMSP polar-orbiting satellites as well as DMSP SSM/I total column precipitable water and surface wind speeds. NOGAPS was the first operational model to use SSM/I wind speeds (Goerss and Phoebus 1992). Besides the wind observations derived from the various operational processing centers for the geostationary satellites, NOGAPS also uses high-density multispectral wind observations produced by the University of Wisconsin-Cooperative Institute for Meteorological Satellite Studies (CIMSS).

The NOGAPS model time step begins as 540 seconds, but is dynamically reduced to a shorter time step if stratospheric jets go beyond a designated threshold.

The physics package includes

Bulk-Richardson number-dependent vertical mixing patterned after ECMWF's vertical mixing parameterization

A time-implicit Louis surface flux parameterization

Gravity wave drag

Shallow cumulus mixing of moisture, temperature, and winds

Relaxed Arakawa-Schubert cumulus parameterization

Convective and stratiform cloud parameterization

Harshvardhan solar and longwave radiation

Semi-implicit treatment of gravity wave propagation and Robert time filtering

Source: <http://meted.ucar.edu/nwp/pcu2/nogaps/#top>

COAMPS

The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS™)* is the latest product in a series of mesoscale model developments at the Naval Research Laboratory (NRL) Marine Meteorology Division (MMD). COAMPS represents state-of-the-art analysis (including the Nowcast capability) and short-term (up to 72 hours) forecast tools applicable for any given region of the Earth in both the atmosphere and ocean.

The atmospheric component of COAMPS can be used for real-data or for idealized applications. For the real data applications, the COAMPS analysis can use either global fields from the Navy Operational Global Atmospheric Prediction System (NOGAPS) or the most recent COAMPS forecast as the first-guess. Observations from aircraft, rawinsondes, ships, and satellites are blended with the first-guess fields to generate the current analysis. For idealized experiments, the initial fields are specified using an analytic function and/or empirical data (such as a single sounding) to study the atmosphere in a more controlled and simplified setting. The atmospheric model uses nested grids to achieve high resolution for a given area; it contains parameterizations for subgrid scale mixing, cumulus parameterization, radiation, and explicit moist physics. Examples of mesoscale phenomena to which COAMPS has been applied include mountain waves, land-sea breezes, terrain-induced circulations, tropical cyclones, mesoscale convective systems, coastal rain bands, and frontal systems.

The COAMPS model domain typically covers a limited area over the Earth. The model grid resolution may range from a few hundred kilometers (synoptic scale) to approximately 100 meters. The actual dimensions applied depend on the scale of phenomena that the user is interested in simulating. The model dimensions can be set to produce any rectilinear pattern. In addition, it can be rotated to align with any surface feature, such as the terrain or a coastline. COAMPS can be run with any number of nested grids, with the requirement that the horizontal grid resolution in any mesh be one-third that of the next coarser mesh.

The COAMPS atmospheric system consists of two major components – analysis and forecast. The COAMPS analysis executable is run first to prepare the initial and boundary files used in the forecast model. The COAMPS forecast executable performs time integration of the model numerics and physics. It then outputs prognostic and diagnostic fields in pressure, sigma, or height coordinates. Options for running the analysis and forecast are specified through several Fortran namelists.

Source: <http://www.nrlmry.navy.mil/~coamps/coamps/>

ETA Model

The Meso Eta model is a hydrostatic model with a horizontal grid spacing of approximately 29 km and 50 vertical levels, with layer depths that range from 20 m in the planetary boundary layer to 2 km at 50 mb (Fig. 1). The eta coordinate, defined by Mesinger (1984), was used in order to remove the large errors which are known to occur when computing the horizontal pressure gradient force, as well as the advection and horizontal diffusion, along a steeply sloped coordinate surface, such as the sigma surfaces in the NGM model. This coordinate system makes the eta surfaces quasi-horizontal everywhere as opposed to sigma surfaces which can be steeply sloped. Thus, this model should show marked improvements in areas with widely varying topography such as the Western Region of the NWS. Because the eta coordinate is pressure based and normalized (i.e. quasi-horizontal), it leads to a much simpler solution of the equations of motion in areas such as the pressure gradient force, horizontal advection, and diffusion. The eta coordinate is defined by the relationship:

$$\eta = \left(\frac{p - p_T}{p_{sfc} - p_T} \right) \left[\frac{p_{ref}(z_{sfc}) - p_T}{p_{ref}(0) - p_T} \right]$$

where T refers to the top of the domain (25 mb), sfc is at the model's lower boundary, and ref refers to a reference pressure level that is a function of distance above sea level (Black 1994).

The semi-staggered Arakawa E grid (Arakawa and Lamb 1977) is the basis of the model's horizontal structure. This grid staggers the mass variables and the wind variables and is designed to minimize errors associated with geostrophic adjustment and topographic forcing that occur in other horizontal grid domains. A sample subset of the E grid can be seen in Fig. 2. Each H represents a "mass" variable point (such as temperature or moisture) and each V represents both horizontal components of the wind. The distance "d" is the spacing between adjacent H or adjacent V points, and the magnitude of this distance is commonly used to indicate the model's horizontal resolution, which in this case is approximately 29 km. The E grid lies upon a rotated latitude-longitude framework. This coordinate system is created by simply rotating the earth's entire geographic latitude-longitude grid so as to place the intersection of the equator and the prime meridian (or 0 degrees north and east) over the center of the forecast area, which lies somewhere in north-central Kansas. In doing this, the convergence of the meridians, which occurs as one moves away from the equator towards the poles, is minimized over the forecast area, thus leading to a more uniform and evenly spaced grid. Each grid box consists of a mass point surrounded by four velocity points, all of which lie along parallels and meridians of the rotated latitude-longitude coordinate system.

The model topography is represented as discrete steps whose tops coincide exactly with one of the model's 50 vertical layer interfaces (Black 1994). In determining their elevations, each 29 km horizontal grid box is first divided into 16 subboxes. Mean

elevations for each of these 16 subboxes are calculated from official United States Geological Survey (USGS) topographical data. Using these values, the maximum mean value from each of the four rows and four columns are determined, resulting in eight intermediate terrain values. The mean of these eight values are taken to yield an intermediate value for the step height. Having already determined the height of each model layer interface based on the standard atmosphere and the specified distribution of vertical resolution, the final step elevation is found by moving the mean either up or down to match the closest layer interface in the model domain.

A schematic vertical cross section through the lowest layers of the domain (Fig. 3) illustrates the various aspects of the horizontal and vertical structures in the model. For each model grid box, T represents "mass" variables such as temperature and moisture, while U represents both horizontal components of the wind; ps is the surface pressure.

All velocity points that lie on the edge of a step are given the value of zero and retain it throughout the forecast (these are indicated by the circled U's in Fig. 3). This is called the no-slip condition. Because of this condition, if any grid point in the model lies in a "hole", where it is surrounded by steps of greater elevation, all four surrounding velocity points would be zero. If this is the case, this "hole" is raised to the point where at least one of the surrounding velocities is nonzero. This is necessary to ensure that all grid boxes that are above the model surface have some horizontal divergence to produce vertical advections.

The assimilation procedure for the Meso Eta begins 3 hours prior to the actual start of the forecast model run. At t-3 hours, or at 0000 UTC and 1200 UTC, a first guess is provided by the Global Data Assimilation System (GDAS) using all available data and applied to the Meso Eta coordinate system. The model then integrates for 3 hours which provides the first guess to the new "initial" analyses at 0300 UTC and 1500 UTC which utilize all new available data, comprised of numerous aircraft reports, NEXRAD, profiler, and satellite observations. Finally, the 33 hour forecast is run. By allowing the model to adjust gradually to the analyzed data during the 3-hour preforecast period, the typical spinup problems that tend to occur during the early hours of the actual forecast are significantly reduced. An increase from one to three separate 3-hour spinup cycles starting nine hours prior to the actual start of the forecast model run is envisioned in the future.

The model's boundary data on its single outermost row of points are obtained by direct interpolation from the AVN run of the Global Spectral Model (GSM). At inflow boundary points, all of the prognostic variables are determined by the GSM data, while at outflow points, the velocity components tangential to the boundary are extrapolated from the interior of the integration domain. The values of the second outermost row are a blend of those along the boundary and those in the third row which are part of the true integration domain.

Source: <http://nimbo.wrh.noaa.gov/wrhq/96TAs/TA9606/ta96-06.html>

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