TERRAIN

4

4 TERRAIN

4.1 Purpose

The program that begins any complete forecast simulation in MM5 modeling system is TERRAIN (Fig. 1.1). This program horizontally interpolates (or analyzes) the regular *latitude-longitude* terrain elevation, and vegetation (land use) onto the chosen mesoscale domains (see Fig. 4.1). If the land-surface model (LSM) will be used in the MM5 model, additional fields such as soil types, vegetation fraction, and annual deep soil temperature will also be generated.

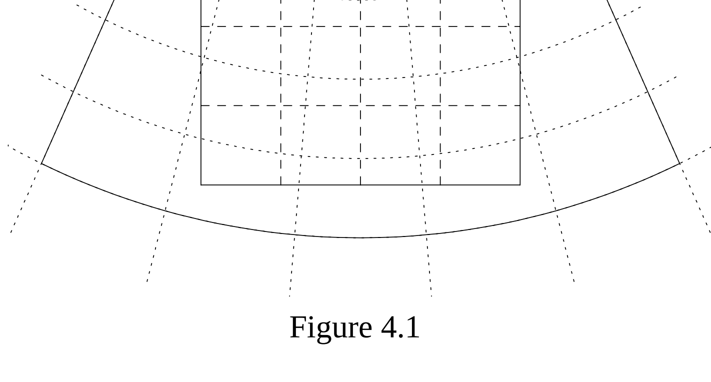

Figure 4.1

4.1.1 Tasks of TERRAIN

There are essentially two tasks the program TERRAIN performs:

1. Set up mesoscale domains: coarse and fine grids (except for moving nests);
2. Produce terrestrial data fields for all of the mesoscale domains, which will first be used by

REGRID, and later by MM5 (optionally) and NESTDOWN. The program also computes a few constant fields required by the modeling system: latitude and longitude, map scale factors, and Coriolis parameter.

4.1.2 Overview of TERRAIN

The TERRAIN program is composed of four parts (Fig. 4.2):

1. Source data input;
2. Interpolation from lat/long source data to mesoscale grid;
3. Nest interface adjustment and feed back; and
4. Output terrain elevation, land use and other terrestrial data in MM5 format.

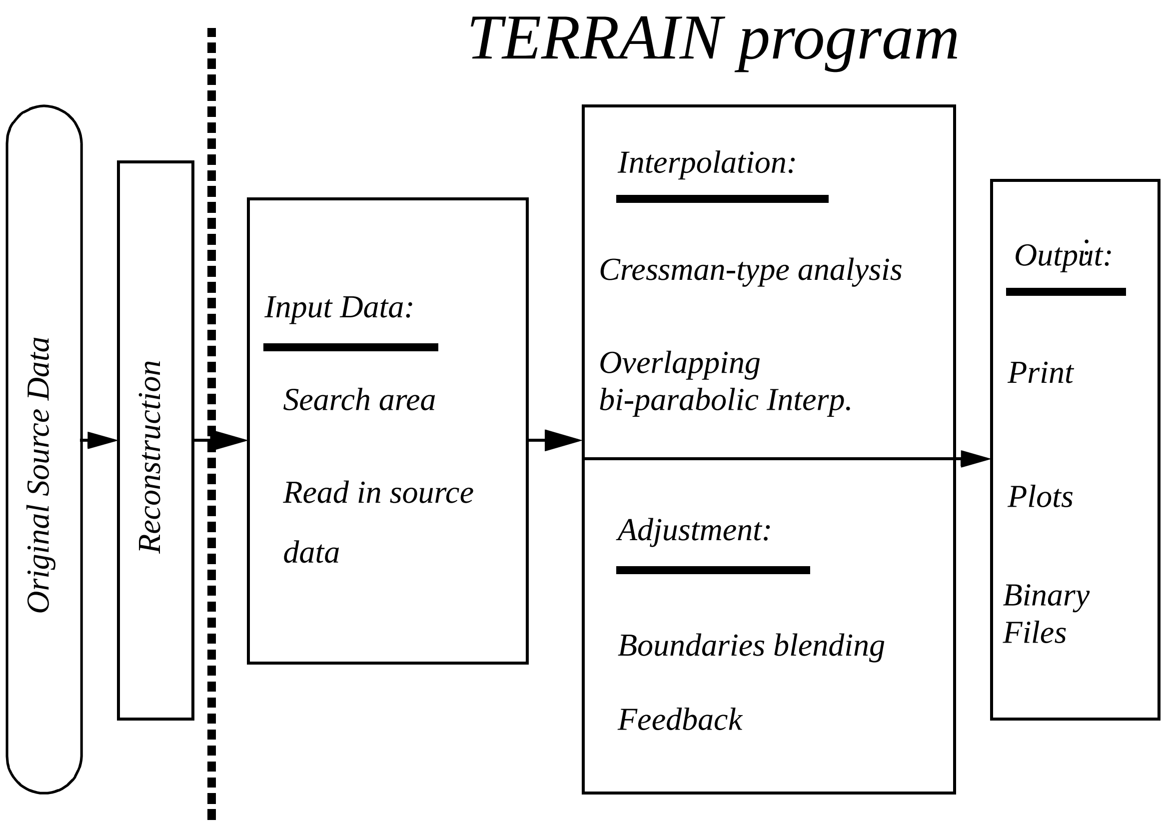

Figure 4.2

4.2 Input Data

4.2.1 Source Data

The data available as input to the program TERRAIN include terrain elevation, landuse/vegetation, land-water mask, soil types, vegetation fraction and deep soil temperature. Most data are available at six resolutions: 1 degree, 30, 10, 5 and 2 minutes, and 30 seconds. Here is the list of available data:

1. Elevation data at six resolutions from USGS: 1-degree, 30-, 10-, 5-, 2-minutes (5 files) and 30-second (33 tiles directly from USGS). All lower resolution data (1 degree to 2 minutes) are created from the 30 seconds USGS data.

2. Three types of source vegetation/land-use data available:

   (a) 13-category, global coverage with the resolution of 1-degree, 30- and 10-minute (3 files);
   (b) 17-category, North-American coverage with the resolution of 1-degree, 30-, 10-, 5-, 2-minutes and 30 seconds (6 files);
   (c) 25-category, global coverage with the resolution of 1-degree, 30-, 10-, 5-, 2-minutes and 30-seconds (6 files; all lower resolution data are created from 30 sec data from USGS version 2 land cover data).

3. Two types of land-water mask data:

   (a) 17-category, North-American coverage with the resolution of 1-degree, 30-, 10-, 5-, 2-minutes and 30seconds (6 files);
   (b) 25-category, global coverage with the resolution of 1-degree, 30-, 10-, 5-, 2-minutes and 30-seconds (6 files).

4. For LSM option in MM5, the soil, vegetation fraction, and annual deep soil temperature are needed. The source data files are:

   (a) 17-category, six resolutions of global soil data (6 files);
   (b) 12 monthly, 10-minute, global vegetation fraction data (1 file);
   (c) 1-degree, global annual deep soil temperature (1 file).

More description of the data is available in section 4.2.3.

4.2.2 Data Format

Since the original data come from different sources, they have different formats and layouts. These data sets are translated to a standard format which is used by the TERRAIN program. The data arrangement and format in the reformatted data file are as follows,

- Latitude by latitude from north to south in one latitude, the data points are arranged from west to east, usually starting from 0 degree longitude (or dateline).
- Two-characters arrays are used to store the elevation and deep soil temperature data (the maximum value $< 2^{15}$, or 32768) (Fig. 4.3), and 1-character array to store all other data (values < 100) (Fig. 4.4).
- All source data files are direct-access, which makes data reading efficient.
- All data are assumed to be valid at the center of a grid box. Hence there are 360x180 data points for 1-degree data, and (360x2)x(180x2) for 30-minute data, and (360x120)x(180x120) data points for the 30-second data, and so on.

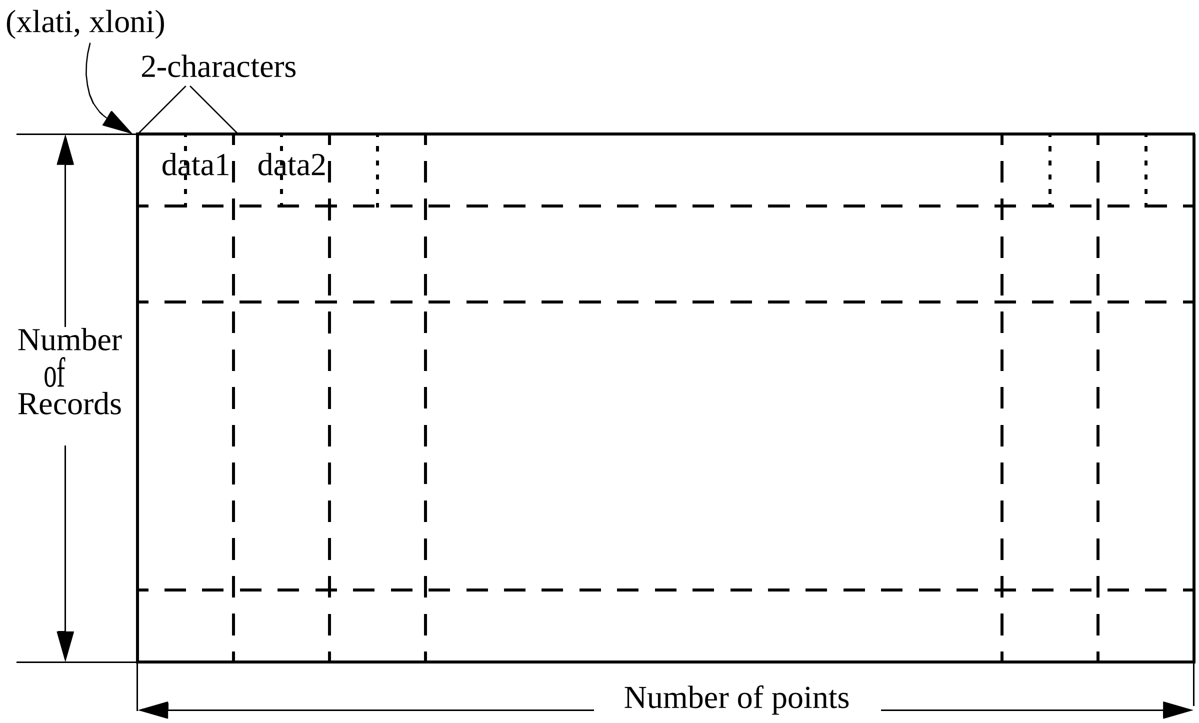

Figure 4.3

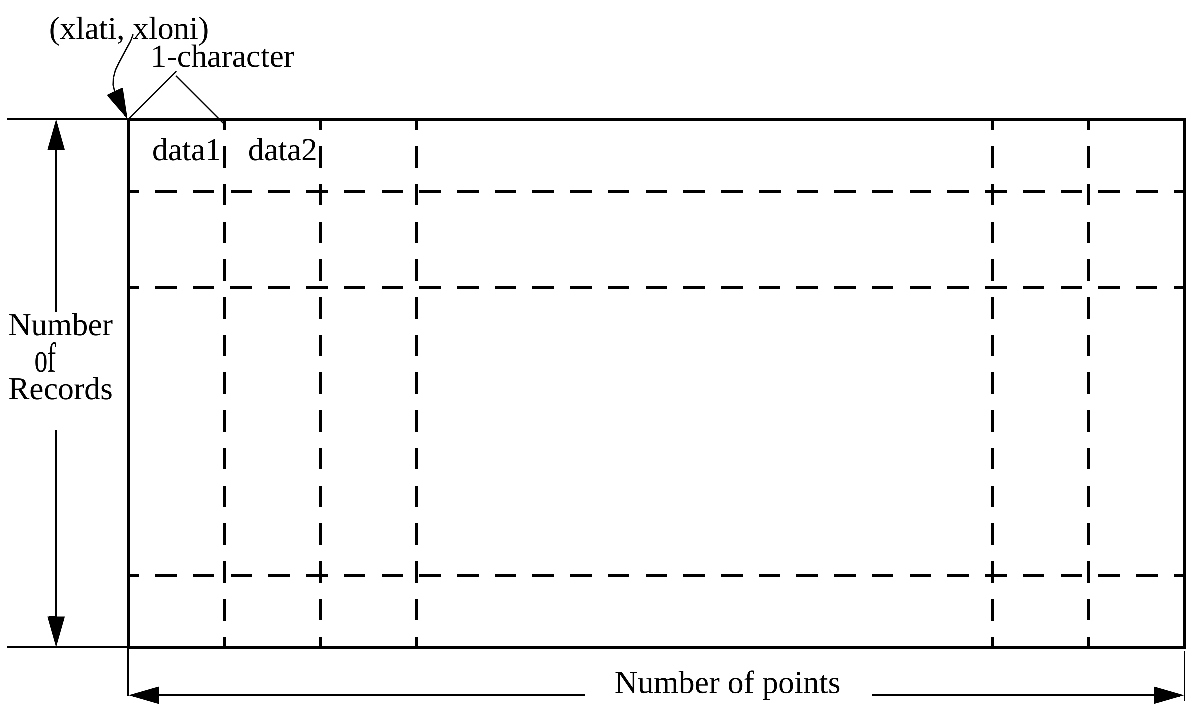

Figure 4.4

4.2.3 Input Data Sources and File Sizes

- **Elevation:**

Table 4.1a Terrain Height Data

Resolution	Data source*	Coverage	Size(bytes)
1 deg. (111.0 km)	USGS	Global	129,600
30 min. (55.0 km)	USGS	Global	518,400
10 min. (18.5 km)	USGS	Global	4,665,600
5 min. (9.25 km)	USGS	Global	18,662,400
2 min. (3.70 km)	USGS	Global	116,640,000
Tiled 30 sec. (0.925 km)**	GTOPO30 by U.S. Geological Survey's EROS Data Center in late 1996	Global (33 tiles: 40^o lon. x 50^o lat. or 60^o lon. x 30^o lat.)	57,600,000 or 51,840,000 for each of tiles
30 sec. (0.925 km)	USGS	Global***	1,866,240,000

* Except for the tiled 30 sec. data (GTOPO30), the data reconstruction from original source data was completed separately prior to TERRAIN. All lower resolution elevation datasets are created from the USGS global 30 second dataset since Version 3.4.

** For details of the GTOPO30 data, see *http://www.scd.ucar.edu/dss/datasets/ds758.0.html*. The tiled 30 seconds elevation data are available from the USGS EROS Data Center's anonymous ftp site *edcftp.cr.usgs.gov* under directory: */pub/data/gtopo30/global*

*** This single tile global 30 second file is available through request to mesouser, or on MSS: /MESOUSER/MM5V3/DATA/SINGLE-TILE-GLOBAL-30S-ELEVATION.gz.

The data reconstruction for the 30 second data is included in the *ftp30s.csh* which is used by the TERRAIN job deck. The reconstructing procedure contains three steps:

(1) determine which tiles of the elevation data are needed based on the information in namelist (*data_area.exe*);
(2) fetch the data from ftp site (or MSS if one runs at NCAR) (*dem_read*);
(3) reconstruct data in TERRAIN standard input format from the tiled data and provide the necessary information to TERRAIN (*rdem.exe*).

The outputs are *new_30sdata*, and *new_30sdata_info*, located in *Data/* directory.

- **Vegetation/Land-use**

(1) Global 13-category data from PSU/NCAR tape

Table 4.1b PSU/NCAR Land-use Data

Resolution	Data source	Coverage	Size(bytes)
1 deg. (111.0 km)	PSU/NCAR	Global	842,400
30 min. (55.0 km)	PSU/NCAR	Global	3,369,600
10 min. (18.5 km)	PSU/NCAR	Global	30,326,400

The 13 categories are listed in Table 4.2a. The data are represented by 13 numbers of percentages for the 13 categories at each of lat/lon grid points.

(2) North-American 17-category data used by Simple Biosphere (SiB) model (from USGS)

Table 4.1c 17-category SiB Vegetation Data

Resolution	Data source	Coverage	Size(bytes)
1 deg. (111.0 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	183,600
30 min. (55.0 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	734,400
10 min. (18.5 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	6,609,600
5 min. (9.25 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	26,438,400
2 min. (3.70 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	165,240,000
30 sec. (0.925 km)	Simple Biosphere model	0^o-90^oN, 60^o-180^oW	155,520,000

The 17 categories are listed in Table 4.2b. The 30-sec data are represented by one category-ID number at each of lat/lon grid point. The low resolution (1-deg, 30-, 10-, 5- and 2-min) data are derived from 30-sec data, and are represented by 17 numbers of percentages for the 17 categories at each of lat/lon grid points.

(3) Global 25-category data from U.S. Geological Survey (USGS)

Table 4.1d 25-category USGS Vegetation Data

Resolution	Data source	Coverage	Size(bytes)
1 deg. (111.0 km)	USGS	Global	1,620,000
30 min. (55.0 km)	USGS	Global	6,480,000
10 min. (18.5 km)	USGS	Global	58,320,000
5 min. (9.25 km)	USGS	Global	233,280,000
2 min. (3.70 km)	USGS	Global	1,458,000,000
30 sec. (0.925 km)	USGS	Global	933,120,000

The 25 categories are listed in Table 4.2c. The 30-sec data are represented by one category-ID number at each of lat/lon grid point. The low resolution (1-deg, 30-, 10-, 5- and 2-min) data are derived from 30-sec data, and are represented by 25 numbers of percentages for the 25 categories at each of lat/lon grid points.

- **Land-water mask**

(1) North-American Land-water mask files derived from SiB Vegetation data

Table 4.1e SiB Land-Water Mask Data

Resolution	Data source	Coverage	Size(bytes)
1 deg. (111.0 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	10,800
30 min. (55.0 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	43,200
10 min. (18.5 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	388,800
5 min. (9.25 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	1,555,200
2 min. (3.70 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	9,720,000
30 sec. (0.925 km)	SiB Vegetation	0^{o}-90^{o}N, 60^{o}-180^{o}W	155,520,000

The SiB land-water mask data files are derived from SiB vegetation data files. At each of lat/lon grid points, there is one number indicating the land (1), water (0), or missing data (-1) at that point.

(2) Global Land-water mask files derived from USGS Vegetation data

Table 4.1f USGS Land-Water Mask Data

Resolution	Data source	Coverage	Size(bytes)
1 deg. (111.0 km)	USGS Vegetation	Global	64,800
30 min. (55.0 km)	USGS Vegetation	Global	259,200
10 min. (18.5 km)	USGS Vegetation	Global	2,332,800
5 min. (9.25 km)	USGS Vegetation	Global	9,331,200
2 min. (3.70 km)	USGS Vegetation	Global	58,320,000
30 sec. (0.925 km)	USGS Vegetation	Global	933,120,000

The land-water mask data files are derived from USGS vegetation data files. At each of lat/lon grid points, there is one number indicating the land (1), water (0), or missing data (-1) at that point.

- **Soil**

Table 4.1g Global 17-category Soil Data

Resolution	Data source*	Coverage	Size(bytes)
1 deg. (111.0 km)	FAO+STATSGO	Global	1,101,600
30 min. (55.0 km)	FAO+STATSGO	Global	4,406,400
10 min. (18.5 km)	FAO+STATSGO	Global	39,657,600
5 min. (9.25 km)	FAO+STATSGO	Global	158,630,400
2 min. (3.70 km)	FAO+STATSGO	Global	991,440,000
30 sec. (0.925 km)	FAO+STATSGO	Global	933,120,000

The 17-Category Global Soil data files are generated by

(1) Global 5-minutes United Nation FAO soil data are converted to the 17-category data, same as STATSGO data (available since V3.5);
(2) North-American STATSGO 30-sec soil data
(3) Global high resolution soil data are produced from 5-min FAO data;
(4) North-American low resolution (1-deg, 30-, 10-, 5 -and 2-min) soil data are derived from the 30-sec North-American soil data;
(5) FAO and STATSGO data are combined for each of the resolutions.
(6) Both top soil layer (0 - 30 cm) and bottom soil layer (30 - 100 cm) data are provided. Obtaining a particular dataset can be set in *terrain.deck*.

The 17 categories are listed in Table 4.2d. Similar to the vegetation data, the 30-sec data are represented by one category-ID number at each of lat/lon grid point, and the low resolution (1-deg, 30-, 10-, 5- and 2-min) data are represented by 17 numbers of percentages for the 17 categories at each of lat/lon grid points.

- **Vegetation fraction**

Table 4.1h Global Monthly Vegetation Fraction Data

Resolution	Data source	Coverage*	Size(bytes)
10 min. (18.5 km)	AVHRR	Global	27,993,600

The original 10-min vegetation fraction data contained 12 percentage-values for 12 months at each of lat/lon grid points, but covered only from 55^{o}S to 75^{o}N. To make the data file have global coverage, a zero value of vegetation fraction was assigned over the high latitude area.

- **Soil temperature**

Table 4.1i Global Annual Deep Soil Temperature Data

Resolution*	Data source	Coverage*	Size(bytes)
1 deg. (111.0 km)	ECMWF analysis	Global	129,600

The resolution of the 1-deg annual deep soil temperature data is rather low. For some of grid points located at small islands in the ocean, it is unable to obtain the deep soil temperature value by interpolation based on this source dataset. In this case, an annual deep soil temperature, *Tg*, will be assigned based on the latitude of the point, φ:

$$T_g = C_0 + C_1 \sin(A) + C_2 \cos(A)$$

where

$$A = 0.5 \times 3.1415926 \times \frac{(89.5 - \varphi)}{89.5}$$

and $C_0 = 242.06$, $C_1 = 59.736$, $C_2 = 1.9445$.

4.2.4 Data Information

If a user has a different source data, the data must be translated to the above standard format and a direct-access file. In addition, the following information should be provided to the TERRAIN pro gram through a DATA statement in setup.F or in vs_data.incl, and paramesv.incl.

- Number of categories
- ID number of water category
- Data resolution in degree
- Initial latitude and longitude
- Total number of records (latitudes)
- The number of data points (longitudes) in a latitude
- File name to be linked to the Fortran unit number

Note: (1) If your own data contain missing data, you must provide the missing-value and modify the interpolation subroutine INTERP or ANAL2 for processing missing-values.
(2) For plotting the map of vegetation and soil, one may need to modify the existing color tables, especially if the number of categories have been changed.

4.2.5 Lists of Landuse/Vegetation and Soil Categories

Table 4.2a Description of 13-category (PSU/NCAR) land-use categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April).

Landuse Integer Identification	Landuse Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm^{-2} k^{-1} s$^{-1/2}$)	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Urban land	18	18	5	10	88	88	50	50	0.03	0.03
2	Agriculture	17	23	30	60	92	92	15	5	0.04	0.04
3	Range-grassland	19	23	15	30	92	92	12	10	0.03	0.04
4	Deciduous forest	16	17	30	60	93	93	50	50	0.04	0.05
5	Coniferous forest	12	12	30	60	95	95	50	50	0.04	0.05
6	Mixed forest and wet land	14	14	35	70	95	95	40	40	0.05	0.06
7	Water	8	8	100	100	98	98	.01	.01	0.06	0.06
8	Marsh or wet land	14	14	50	75	95	95	20	20	0.06	0.06
9	Desert	25	25	2	5	85	85	10	10	0.02	0.02
10	Tundra	15	70	50	90	92	92	10	10	0.05	0.05
11	Permanent ice	80	82	95	95	95	95	0.01	0.01	0.05	0.05
12	Tropical or sub tropical forest	12	12	50	50	95	95	50	50	0.05	0.05
13	Savannah	20	20	15	15	92	92	15	15	0.03	0.03

Table 4.2b Description of 17-category (SiB) vegetation categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April).

Vegetation Integer Identification	Vegetation Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm^{-2} k^{-1} s$^{-1/2}$)	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Evergrn. Broadlf.	12	12	50	50	95	95	50	50	0.05	0.05
2	Broadlf, Decids.	16	17	30	60	93	93	50	50	0.04	0.05
3	Decids. Evergrn.	14	14	35	70	95	95	40	40	0.05	0.06
4	Evergrn. Needlf.	12	12	30	60	95	95	50	50	0.04	0.05
5	Decids. Needlf.	16	17	30	60	93	93	50	50	0.04	0.05
6	Grnd. Tree Shrb.	20	20	15	15	92	92	15	15	0.03	0.03
7	Ground only	19	23	15	30	92	92	12	10	0.03	0.04
8	Broadlf. Shrb.P.G.	19	23	15	30	92	92	12	10	0.03	0.04
9	Broadlf. Shrb.B.S.	19	23	15	30	92	92	12	10	0.03	0.04
10	Grndcvr. DT. Shrb	15	70	50	90	92	92	10	10	0.05	0.05
11	Bare Soil	25	25	2	5	85	85	10	10	0.02	0.02
12	Agricltr. or C3 Grs	17	23	30	60	92	92	15	5	0.04	0.04
13	Perst. Wetland	14	14	50	75	95	95	20	20	0.06	0.06
14	Dry Coast Cmplx	19	23	15	30	92	92	12	10	0.03	0.04
15	Water	8	8	100	100	98	98	.01	.01	0.06	0.06
16	Ice cap & Glacier	80	82	95	95	95	95	5	5	0.05	0.05
17	No data										

Table 4.2c Description of 25-category (USGS) vegetation categories and physical parameters for N.H. summer (15 April - 15 October) and winter (15 October - 15 April).

Vegetation Integer Identification	Vegetation Description	Albedo(%)		Moisture Avail. (%)		Emissivity (% at 9 μ m)		Roughness Length (cm)		Thermal Inertia (cal cm^{-2} k^{-1} s$^{-1/2}$)	
		Sum	Win	Sum	Win	Sum	Win	Sum	Win	Sum	Win
1	Urban	15	15	10	10	88	88	80	80	0.03	0.03
2	Drylnd Crop. Past.	17	23	30	60	98.5	92	15	5	0.04	0.04
3	Irrg. Crop. Past.	18	23	50	50	98.5	92	15	5	0.04	0.04
4	Mix. Dry/Irrg.C.P.	18	23	25	50	98.5	92	15	5	0.04	0.04
5	Crop./Grs. Mosaic	18	23	25	40	99	92	14	5	0.04	0.04
6	Crop./Wood Mosc	16	20	35	60	98.5	93	20	20	0.04	0.04
7	Grassland	19	23	15	30	98.5	92	12	10	0.03	0.04
8	Shrubland	22	25	10	20	88	88	10	10	0.03	0.04
9	Mix Shrb./Grs.	20	24	15	25	90	90	11	10	0.03	0.04
10	Savanna	20	20	15	15	92	92	15	15	0.03	0.03
11	Decids. Broadlf.	16	17	30	60	93	93	50	50	0.04	0.05
12	Decids. Needlf.	14	15	30	60	94	93	50	50	0.04	0.05
13	Evergrn. Braodlf.	12	12	50	50	95	95	50	50	0.05	0.05
14	Evergrn. Needlf.	12	12	30	60	95	95	50	50	0.04	0.05
15	Mixed Forest	13	14	30	60	94	94	50	50	0.04	0.06
16	Water Bodies	8	8	100	100	98	98	.01	.01	0.06	0.06
17	Herb. Wetland	14	14	60	75	95	95	20	20	0.06	0.06
18	Wooded wetland	14	14	35	70	95	95	40	40	0.05	0.06
19	Bar. Sparse Veg.	25	25	2	5	85	85	10	10	0.02	0.02
20	Herb. Tundra	15	60	50	90	92	92	10	10	0.05	0.05
21	Wooden Tundra	15	50	50	90	93	93	30	30	0.05	0.05
22	Mixed Tundra	15	55	50	90	92	92	15	15	0.05	0.05
23	Bare Grnd. Tundra	25	70	2	95	85	95	10	5	0.02	0.05
24	Snow or Ice	55	70	95	95	95	95	5	5	0.05	0.05
25	No data										

Table 4.2d Description of 17-category Soil categories and physical parameters

Soil Integer Identification	Soil Description	Max moisture content	Reference soil moisture	Wilting point soil moisture	Air dry moist content limits	Saturation soil potential	Saturation Soil conductivity (10^{-6})	B parameter	Saturation soil diffusivity (10^{-6})	Soil diffu./ condu. coef.
1	Sand	0.339	0.236	0.010	0.010	0.069	1.07	2.79	0.608	- 0.472
2	Loamy Sand	0.421	0.283	0.028	0.028	0.036	14.10	4.26	5.14	- 1.044
3	Sandy Loam	0.434	0.312	0.047	0.047	0.141	5.23	4.74	8.05	- 0.569
4	Silt Loam	0.476	0.360	0.084	0.084	0.759	2.81	5.33	23.9	0.162
5	Silt	0.476	0.360	0.084	0.084	0.759	2.81	5.33	23.9	0.162
6	Loam	0.439	0.329	0.066	0.066	0.355	3.38	5.25	14.3	- 0.327
7	Sandy Clay Loam	0.404	0.314	0.067	0.067	0.135	4.45	6.66	9.90	- 1.491
8	Silty Clay Loam	0.464	0.387	0.120	0.120	0.617	2.04	8.72	23.7	- 1.118
9	Clay Loam	0.465	0.382	0.103	0.103	0.263	2.45	8.17	11.3	- 1.297
10	Sandy Clay	0.406	0.338	0.100	0.100	0.098	7.22	10.73	18.7	- 3.209
11	Silty Clay	0.468	0.404	0.126	0.126	0.324	1.34	10.39	9.64	- 1.916
12	Clay	0.468	0.412	0.138	0.138	0.468	0.974	11.55	11.2	- 2.138
13	Organic Materials	0.439	0.329	0.066	0.066	0.355	3.38	5.25	14.3	- 0.327
14	Water	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	Bedrock	0.200	0.108	0.006	0.006	0.069	141.0	2.79	136.0	- 1.111
16	Other	0.421	0.283	0.028	0.028	0.036	14.10	4.26	5.14	- 1.044
17	No data									

4.3 Defining Mesoscale Domains

There are a number of key parameters a user must specify in order to define mesoscale domains. These are:

- Map projection: three types are available:
  - Lambert conformal
  - Polar stereographic
  - Mercator

- Coarse domain parameters:
  - Central latitude and longitude
  - Expanded domain information (useful for objective analysis)
  - Domain size (number of grid points in each direction: IX is in Y direction)
  - Grid distance in km

- Nested domain parameters:
  - Location of grid point (1,1) in its mother domain
  - Mother domain ID
  - Domain size (number of grid points in each direction)
  - Grid distance in km (must have a ratio of 3-to-1 for 2-way runs)

The latitudes and longitudes of mesoscale grids should be in the range of

$$-90° \le \varphi \le 90° \qquad (4.1)$$

$$-180° \le \lambda \le 180° \qquad (4.2)$$

There are some restrictions in defining a nest in the program:

- A nest domain must start and end at a coarse domain grid point whether it is a one-way or two-way nest. This means that for a two-way nest, the number of grid points in the nest must satisfy (number of nest grid points - 1)/3 is an integer.

- A nest must be at least 5 coarse grid points away from the coarse domain boundary. This is necessary to ensure enough data points are available when the coarse-to-fine grid data interpolation is performed for the nest interface adjustment (see below).

- TERRAIN program cannot be used to generate overlapping nests. Overlapping nests and moving nests can only be dealt with in the MM5 model, which gets the data for the nests from interpolation of the coarse domain data (see Fig. 4.5).

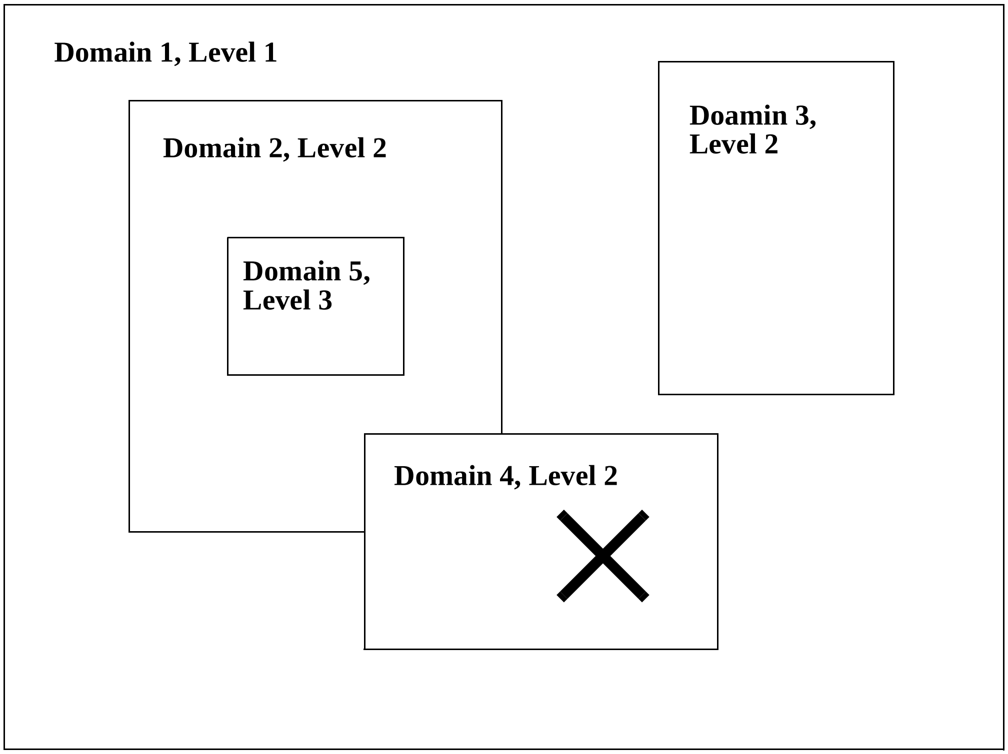

Figure 4.5

The mesoscale domain information specified by a user in the namelist is used to set up a *search area* for reading and storing input data in memory. Using this information, the program calculates the maximum and minimum latitude/longitude for the search area. The formulas to calculate the latitude/longitude (λ, ϕ) from mesoscale grid indices (I, J) and vice versa for different map projections can be found in the documentation "Terrain and Land Use for the Fifth-Generation Penn State/NCAR Mesoscale Modeling System (MM5): Program TERRAIN", page 10-17.

- In most situations, determination of the search area is a straightforward job.

- In case of domain across the dateline, the longitudes at some of the points must have a conversion prior to the calculation

$$\lambda = \lambda - 360° \qquad (4.3)$$

- In case of poles inside the domain, determination of the *search area* is more complicated. User may refer to page 22-25 of the documentation of TERRAIN program (Guo and Chen 1994).

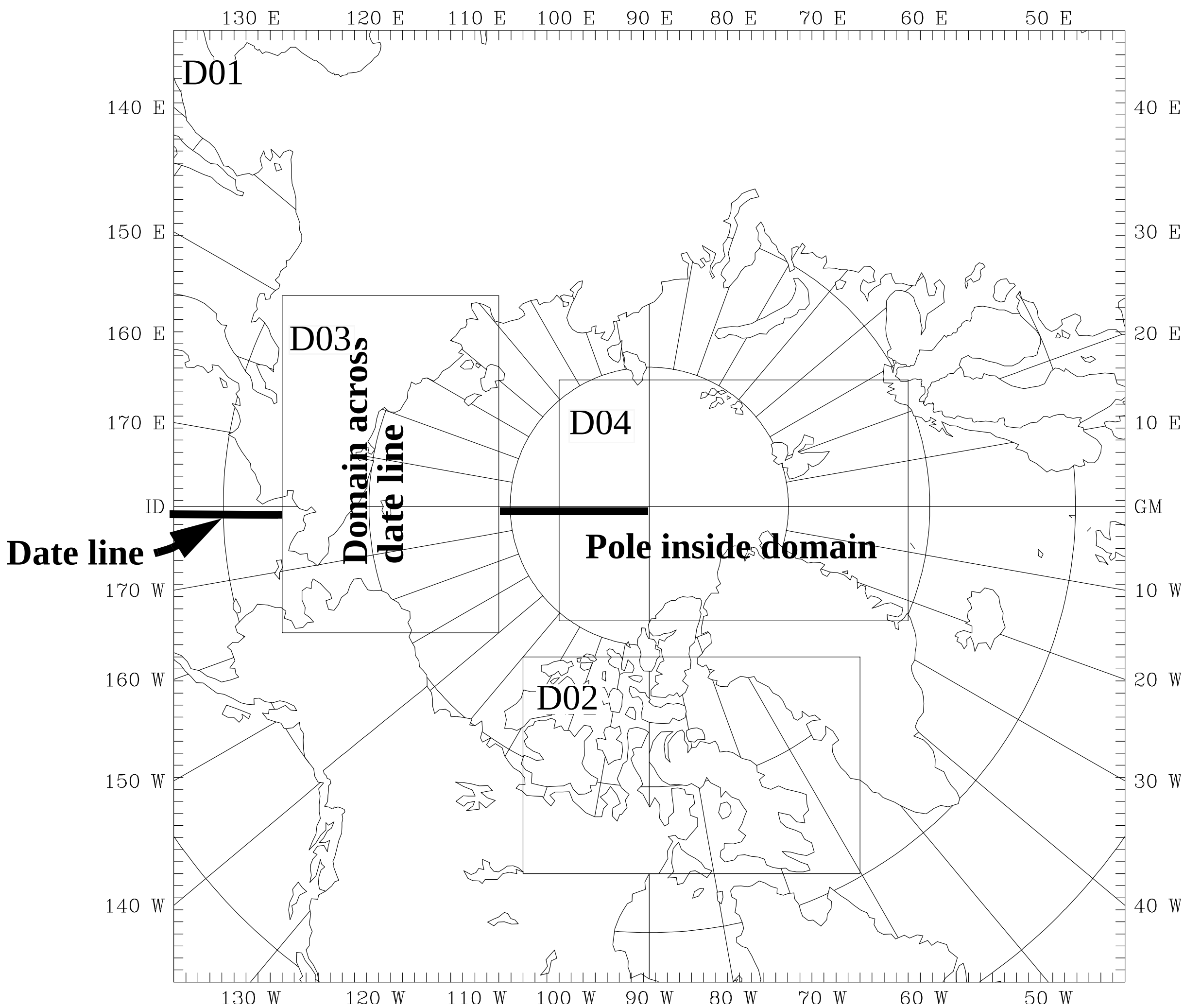
130 E
120 E
110 E
100 E
90 E
80 E
70 E
60 E
50 E
140 E
150 E
160 E
170 E
ID
170 W
160 W
150 W
140 W
40 E
30 E
20 E
10 E
GM
10 W
20 W
30 W
40 W
130 W
120 W
110 W
100 W
90 W
80 W
70 W
60 W
50 W
D01
D02
D03
D04
Domain across date line
Date line
Pole inside domain

Figure 4.6

4.4 Interpolation

4.4.1 Overlapping parabolic interpolation

- Used for terrain height, vegetation/land use, soil, vegetation fraction, and deep soil temperature
- Spherical (latitude-longitude) coordinate for input data is assumed
- 16-point, 2-dimensional parabolic fit (see page 81-82 of Guo and Chen 1994)

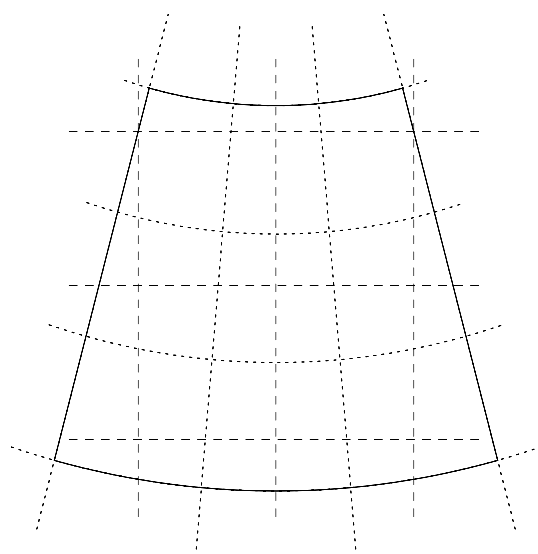

Figure 4.7 16-point, 2-dimension parabolic interpolation

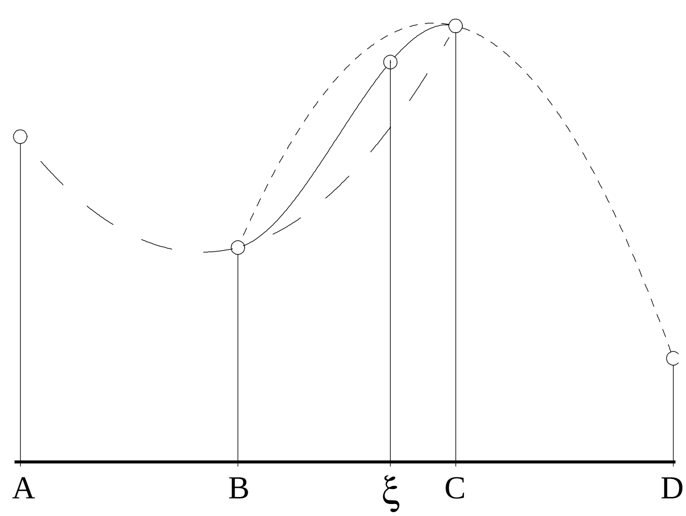

Figure 4.8 One-dimension overlapping parabolic interpolation

There are 3 types of vegetation/land-use data with different number of categories (N = 13, 17 or 25, see Table 4.1b, 4.1c, and 4.1d) and one type of soil data with 17 categories (Table 4.1g) available. At each data point, there are N numbers of percentage values for the N categories in the source data with 1-deg, 30-, 10-, 5- and 2-min resolution. The overlapping parabolic interpolation method is applied to obtain the percentages for each vegetation/land-use or soil categories at the mesoscale grid. If the water coverage (category 7, 15, or 16 for 13-, 17-, 25-category vegetation/land-use data, respectively, and category 14 for 17-category soil data) is more than 50% at the point, the category with the maximum percentage (water) will be assigned to that point. If the water coverage is less than 50%, the category with the maximum percentage excluding the water will be assigned to that point.

When the 30-sec vegetation/land-use and soil source data are used, the overlapping parabolic interpolation method cannot be applied to obtain the percentages at the mesoscale grids because the source data are represented by the category ID numbers. Another algorithm was developed to calculate the percentages at the mesoscale grids. The same rule used for the lower resolution data above was also used to determine the dominant category at each of the mesoscale grid points.

The overlapping parabolic interpolation method is also applied to obtain values of the monthly vegetation fraction and annual deep soil temperature at the mesoscale grid points. For the vegetation fraction, there are 12 monthly values of percentages assigned to each of the mesoscale grid points, and for the annual deep soil temperature, there is one value at each grid point.

Because the resolution of the deep soil temperature data is rather low (1-deg), its value at some ‘land points’ cannot be obtained from the interpolation procedure. To remedy this problem, the following two steps are taken:

(1) A weighted averaged value from the neighbor points is assigned to those points.
(2) If the temperature still cannot be found for the small isolated islands, a latitude-based value from the formula in section 4.2.3 is assigned to the point.

After the mesoscale fields of the terrain elevation, vegetation/land-use, soil, and vegetation fraction are produced, the land-water mask data, or EZFUDGE function (just for elevation) are used to correct the land/water boundaries.

The input vegetation/land-use and soil data to TERRAIN are the percentage values (1-deg, 30-, 10-, 5- and 2-min data) or ID numbers (30-sec data) for the N categories on the latitude/longitude grid. The output from TERRAIN is the dominant category ID number on the mesoscale grid. In the MM5 model without LSM, the dominant vegetation/land-use category ID number will be translated to the physical parameters of the surface characteristics, such as albedo, moisture availability, emissivity, roughness length, and thermal inertia, etc., as shown in Tables 4.2a-c for the three types of landuse data (which are provided in the MM5/Run/LANDUSE.TBL file). For the LSM option in MM5, given the dominant category ID numbers of vegetation and soil, the land properties are defined in the model. A vegetation fraction field is derived based on the model time and monthly vegetation fraction fields (which is assumed to be valid in the middle of each month) from TERRAIN.

4.4.2 Cressman-type objective analysis

- Used for terrain elevation only
- No first guess field is used
- Only single-pass scan is performed

The weighting function is defined as

$$W_s = \begin{cases} \dfrac{R^2 - r_s^2}{R^2 + r_s^2} & r_s \le R \\ 0 & r_s > R \end{cases} \tag{4.4}$$

$$r_s^2 = (I - I_{obs})^2 + (J - J_{obs})^2 \tag{4.5}$$

$$HT(I, J) = \frac{\sum_{s=1}^{SN} W_s \times ht_s}{\sum_{s=1}^{SN} W_s} \tag{4.6}$$

In the TERRAIN program, both of the overlapping parabolic interpolation and Cressman-type objective analysis methods are available as the interpolation options for terrain elevation. No systematic comparison with these two methods is performed. They are kept in the current program for historical reason (they are from TERRAIN program of MM4 modeling system). In general, a large radius of influence will give a smoother results (with less terrain gradient). When a small radius of influence is used. it may cause “no data available” error for certain grid boxes if a lower resolution dataset is used. It is recommended that a user should choose the source dataset with the resolution comparable to the grid distance of the given domain.

4.5 Adjustment

When MM5 is applied for a multiple-nest simulation, each of the nest domains obtains their lateral boundary condition from their mother domain during the integration, and feeds the results back to the mother domain in the two-way nested application. After the terrain height, land-use and other terrestrial files are produced for each domain, the following procedure must be completed to make the terrain height, land-use and other terrestrial fields consistent between the domains:

- reset the nested domain boundary values for both 1-way and 2-way applications, and
- feed the nest domain information back to the mother domain for 2-way application

4.5.1 Reset the nested domain boundary values

For both 1-way and 2-way nests, these steps are taken to reset nest boundary values:

1. Interpolate the mother domain's terrain heights to the nest grid by using the monotonic interpolation scheme (ratio=3), or bi-parabolic interpolation scheme (ratio≠3).

2. For rows and columns 1 to 3 (2-way) or 1 to 4 (one-way) along the nest domain boundaries, terrain heights are replaced with mother domain's values.

3. For rows and columns 4 to 6 (2-way) or 5 to 7 (one-way), blending the nest domain's values with mother domain's values.

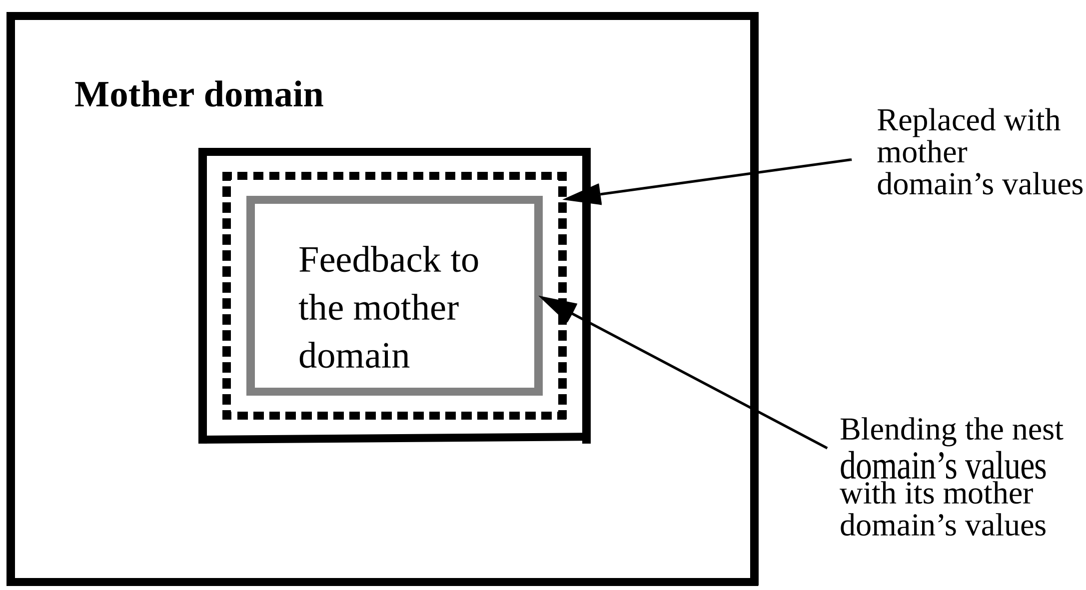

Figure 4.8

User must leave enough space (at least 5 grid-points) between the nest's boundary and its mother domain's boundary so that the (high-order) interpolation can be applied. If there is not enough space between the boundaries, the program will stop and issue a warning message.

4.5.2 Feedback

The interior values of terrain, land-use and other terrestrial fields in a nest-domain are used to overwrite the mother domain values for the two-way nest application. This is necessary to ensure that at the coinciding grid points between the nests, the terrestrial values are identical for all the domains. This is done from the finest nest domain down to the coarsest domain.

4.6 Fudging function

4.6.1 Water body correction

- **Based on land-water mask data files**

If a user chooses to use the 24-category land-use data (VEGTYPE = 1), or to process the LSM data (LSMDATA = .T.), or not to use EZFUDGE function (IFEZFUG = .FALSE.; all namelist-controlled options), the land-water mask files generated based on the vegetation data are used to correct the vegetation/land-use, soil categories, vegetation fraction, and the elevation of water bodies. This is recommended as the vegetation data provide fairly accurate representation of land mass, and in most cases (e.g. outside US) have better resolution than map information from NCAR Graphics.

- **Based on the EZMAP from NCAR GRAPHICS**

NCAR Graphics' mapping utility may be used to identify water bodies. The information from a call to ARGTAI can be used to correct the land-use categories and the elevation of water bodies. When the IFEZFUG = .T., the inland spurious lakes can be eliminated, and the terrain heights are also matched with the coastline better. The heights of some of the larger lakes in the US have been defined in the namelist EZFUDGE, a user can define more lakes in this namelist. We recommend that users set IFEZFUG = .T. to correct possible errors from the source land-use data only if VEGTYPE = 1and LSMDATA = FALSE. This is because of data used in NCAR Graphics are rather old, the coastlines for many parts of the world are very coarse and some are even incorrect. Using land-water mask files can make the coastlines more realistic. Using IFEZFUG = .T. may require more computer memory and CPU time.

To skip this EZFUDGE option over special areas, turn the switch IFTFUG on and specify the LAT/LON boxes in the namelist FUDGET.

4.6.2 Land-use fudge

After the TERRAIN program is finished, a user should check the results carefully. Sometime the program does not generate satisfactory land-use categories at some grid points due to errors in the original dataset, or sometimes a user may want to modify the land-use categories in their numerical experiments. TERRAIN provides the user another chance to modify the land-use categories at upto 200 grid points for each domain. In the namelist, the switch IFFUDG = .T. allows a user to fudge the land-use data point by point. The locations (IFUG, JFUG) and land-use values (LNDFUG) are specified in namelist FUDGE. After the namelist variables IFFUG, NDFUG, IFUG, JFUG, LNDFUG are modified, the user needs to run the TERRAIN program again to get the corrected land-use data output.

4.7 Script Variables

ftpdata Switch to indicate whether one wants to ftp data (T) or not (F).

Where30sTer Switch to indicate where tiled global 30-s dataset is. = ftp: ftp data; = directory: data have been ftp'ed, untared, and reside in local directory

users Users from inside NCAR set users = MMM, otherwise set users = Others. This causes the terrain job script to use a different ftp script to ftp data.

BotSoil Uncomment this line to obtain bottom soil layer (30 - 100 cm) data.

4.8 Parameter statement

parame.incl To specify the maximum dimensions (IIMX, JJMX) of any domains (expanded or non expanded).

paramed.incl To specify the maximum dimensions (ITRH, JTRH) of array holding the source data. They depend on source data resolution, and map projection, etc.

4.9 Namelist Options

4.9.1 MAPBG: Map Background Options

PHIC Central latitude of the coarse domain in degrees North; latitudes in SH is negative.

XLONC Central longitude of the coarse domain in degrees East. Longitudes between Greenwich and Dateline is negative.

IEXP Logical flag to use the expanded coarse domain (T) or not (F).

AEXP Approximate expansion (km) of the grid on all sides of the coarse domain.

IPROJ Map projection: 'LAMCON' for Lambert Conformal, 'POLSTR' for Polar Stereographic, and 'MERCAT' for Mercator.

4.9.2 DOMAINS: Domain Setting Options

MAXNES Maximum number of domains. The TERRAIN program allows the maximum number of domains less than or equal to 100.

NESTIX The I(y)-direction dimensions for each of the domains.

NESTJX The J(x)-direction dimensions for each of the domains.

DIS The grid distance for each of the domains in km.

NUMNC The mother domain's ID number for each of the domains. For the coarse domain, always set NUMNC=1.

NESTI The I location in its mother domain of the nest domain's low-left corner ---

point (1,1).

NESTJ The J location in its mother domain of the nest domain's low-left corner --- point (1,1).

RID The radius of influence in unit of grid points used only for Cressman type objective analysis (IFANAL=T).

NTYPE The source terrain height and land-use data type for each of the domains:1=one degree; 2=30 min.; 3=10min.; 4=5 min.; 5=2 min.; 6=30 sec.

NSTTYP To indicate the nest type: 1=one way nest; 2=two way nest.

4.9.3 OPTN: Function Options

IFTER Logical flag to indicate to create terrain height and other terrestrial fields, =T; or map background only, =F.

IFANAL Interpolation method: .T. -- Cressman type objective analysis; .F. -- Overlapping parabolic interpolation.

ISMTHTR To choose smoothing method: 1= 1-2-1 smoother; 2= smoother/desmoother.

IFEZFUG To activate the EZFUDGE function: .T. turns on; .F. is off.

IFFUDG Need to do land-use fudging (T) or not (F).

IFTFUG Need to skip the EZFUDGE function over certain areas (T) or not (F).

IPRINTD Print out the latitude and longitude of the mesoscale grids (T) or not (F).

IPRTHT Print out all processing fields on the mesoscale grids (T) or not (F).

IPRINT = 1: A lot more print output in terrain.print.out. Helpful when error occurs.

FIN Contour interval (meter) of terrain height plots.

TRUELAT1 The first true latitude for the map projection. Default value = 91.0 means the standard values will be used for the projections. True lat/long may only be changed for Lambert-Conformal and Polar Stereographic projections.

TRUELAT2 The second latitude for the map projection. Default value = 91.0 means the standard value will be used for the projections. (Use this for Lambert-Conformal projection only.)

IFILL Plots are color filled (T) or not (F).

LSMDATA Switch to indicate whether to create vegetation, soil, vegetation fraction, and deep soil temperature files for LSM in MM5.

VEGTYPE Switch to indicate which vegetation dataset to use. = 0: use old 13-category dataset; =1: use 24-category USGS dataset; =2: use 16-SiB category dataset.

VSPLOT Switch to indicate whether to plot the dominant vegetation, soil, and vegetation fraction (T) or not (F).

IEXTRA Switch to indicate whether to output and plot the percentage values of vegetation and soil types. Required for ISOIL=3 or Pleim-Xiu LSM option in MM5.

4.9.4 Land-use Fudging Options (used when IFFUDG=T)

IFFUG To indicate which domains need to be fudged (T) or not (F).

NDFUG The number of fudge points for each of the domains. The maximum of NDFUG is 200, that means that user can fudge maximum of 200 points for land-use for each of the domains.

IFUG The I location of the fudge points for each of the domains. IFUG is a 2-dimension array IFUG(200,100), the first index is corresponding to points, and the second index corresponding to domains.

JFUG The J location of the fudge points for each of the domains.

LNDFUG The land-use category of the fudge points for each of the domains.

4.9.5 Skip the EZFUDGE over the boxes (used when IFTFUG=T)

Note: The maximum number of boxes is 10. The user can use STARTLAT(10),..., to specify the boxes over which no EZFUDGE is to be done.

STARTLAT The latitudes of the lower-left corner of the area.

ENDLAT The latitudes of the upper-right corner of the area.

STARTLON The longitudes of the lower-left corner of the area.

ENDLON The longitudes of the upper-right corner of the area

4.9.6 Heights of water bodies

The heights of the water bodies can be specified in the record EZFUDGE in the namelist file as follows. The index in parenthesis refers to a specific water body that can be found in file "ezids" which are known to NCAR Graphics. For the Great Lakes in US, the heights have already been specified. Users can add more water body's surface heights, in meters above sea level only if the water bodies are identifiable in NCAR Graphics.

HTPS(441) = -.001 ; Ocean

HTPS(550) = 183. ; Lake Superior

4.10 How to run TERRAIN

1. Get the source code. The current TERRAIN release resides on NCAR's anonymous ftp site, ftp.ucar.edu:mesouser/MM5V3/TERRAIN.TAR.gz. You may download TERRAIN.TAR.gz to your working directory from the web page, ftp://ftp.ucar.edu/mesouser/MM5V3. Or you can copy it from ~mesouser/MM5V3/TERRAIN.TAR.gz on NCAR's SCD machines.

2. Create the terrain.deck. Uncompress ("`gunzip TERRAIN.TAR.gz`") and untar ("`tar -xvf`

`TERRAIN.TAR`") the file, a directory TERRAIN will be created. Go into the TERRAIN directory, and type "`make terrain.deck`", which creates a cshell script, `terrain.deck`. This deck is created specifically for your computer.

If your system does not have NCAR Graphics, you must modify the "*Makefile*" in the TERRAIN/ directory, set NCARGRAPHICS = NONCARG, and remove the libraries in LOCAL_LIBRARIES line.

Note that the TERRAIN program does not require NCAR Graphics to run, but having it will make life a lot easier because you can see where you have set your domains. Although NCAR Graphics is a licensed software, but part of it has become free to download. See NCAR Graphics Web page for details: *ngwww.ucar.edu*.

3. Edit *terrain.deck*. There are three parts in *terrain.deck* that need to be edited:

(a) Shell variables: ftp, *Where30sTer*, and users. Instructions on how to set these shell variables can be found in *terrain.deck*, or refer to section 4.7 in this chapter.

(b) Parameter statements in *parame.incl* and *paramed.incl* (edit them in the *terrain.deck*): parameters IIMX and JJMX in parame.incl are used to declare the arrays holding the mesoscale gridded data, while parameters ITRH and JTRH in *paramed.incl* are used to declare the arrays holding the input lat/lon data (refer to the instructions in *terrain.deck* or section 4.8 in this chapter).

(c) Records in *terrain.namelist*: MAPBG, DOMAINS, and OPTN.

In case you would like to fudge the land-use, or add more heights of water bodies, the records FUDGE, FUDGET, and EZFUDGE need to be modified. Refer to the instructions in terrain.deck or section 4.9 in this chapter.

4. Run *terrain.deck* by typing "`./terrain.deck`"

TERRAIN needs two kinds of inputs: (a) *terrain.namelist* and (b) data files for elevation, landuse, etc.. The *terrain.namelist* is created from *terrain.deck*, and the necessary data files are obtained from ftp sites based on the types of data user specifies in the namelist. Beware that the minimum size of downloaded data from ftp site is 57 Mb, and it can go up to 362 Mb if one requests the USGS landuse data and land-water mask data. It will require a few Gb of disk space to host 30 sec datasets.

5. Check your output. TERRAIN has three kinds of output:

(a) A log file from compilation: *make.terrain.out*, and a print file from running the program: *terrain.print.out*.

Check *make.terrain.out* to see if compilation is successful.
Check *terrain.print.out* to see if the program runs successfully.
When the TERRAIN job is successful, you should get a message

"== NORMAL TERMINATION OF TERRAIN PROGRAM =="

at the end of the *terrain.print.out* file. If the TERRAIN job failed, you can also find error messages and look for clues in this file.

(b) A plot file, *TER.PLT* (or *gmeta*), if NCAR Graphics is used (type *idt* TER.PLT to view);

Because the TERRAIN is the first component of MM5 modeling system and it produces constant fields used in the model, we use NCAR Graphics in the program to produce plots for users to check the output carefully.

When LSMDATA = FALSE, there are 7 frames plotted for each of the domains: map background, color and black/white terrain height, land-use (vegetation), mesh, schematic raob station map, a map showing the rest of the nests (6 frames only for the finest domain without the last map).

When LSMDATA = TRUE, there are additional 15 frames plotted: deep soil temperature, soil category, 12 monthly vegetation fraction percentages, land-water mask.

When IEXTRA = TRUE, more frames will be plotted.

(c) Binary files, TERRAIN_DOMAIN1, TERRAIN_DOMAIN2, ...;

These are the terrestrial data files for each of the mesoscale domains used by REGRID, MM5 or NESTDOWN. You may check the size of each of the files to make sure the files were created correctly (not having a zero size).

Useful ‘make’ commands:

```
make clean
```

If you are going to recompile, it is best to type ‘`make clean`’ first. It will remove all generated files (which include object files and executables).

```
make dataclean
```

This command removes downloaded data in Data/ directory, and Data30s/ directory itself.

4.11 TERRAIN Didn’t Work: What Went Wrong?

If the TERRAIN job fails, check to see if one of the following is a possibility:

- First, make sure the compilation is successful. Check if the following executables are produced:

  `terrain.exe` - main terrain executable
  `rdnml` - utility to read namelist variables and figure out what data to download
  `data_area.exe` - utility to figure out which 30 sec elevation data tile to download
  `rdem.exe` - utility to read the 30 sec elevation data and reformat it for terrain program

  If they are not generated, check make.terrain.out file for compiler errors. To recompile, type
  `make clean`

and again

```
./terrain.deck
```

- Missing NCAR Graphics environment variable: see if you have included the following line in your .cshrc file:

  setenv NCARG_ROOT /usr/local or **/usr/local/ncarg**

  This is required for making plots using NCAR Graphics.

- Program aborted in subroutine SETUP: most likely you didn't provide the map background information correctly. Check the namelist MAPBG and variables TRUELAT1, TRUELAT2.

- The program stopped abnormally, check the *terrain.print.out* to find the maximum dimensions required. For example, when polar projection specified and the pole inside the domain, the JTRH should be much larger than ITRH, but for other projections, both ITRH and JTRH may be comparable. Also IIMX and JJMX should be the maximum dimensions including the expanded domain.

- "The nest 2 is too close to the boundary of the domain 1 ..." and STOP in subroutine TFUDGE: This means there are not enough grid points between domains' boundaries, change the domain settings (e.g. NESTI and NESTJ), and run the program again.

- The grid size or the dimensions of the nested domain are specified incorrectly (do not match the mother domain). Please check the messages in terrain.print.out to find the correct ones.

- The necessary input data files have not been accessed correctly via ftp. You may check the directories, *Data* and *Data30s*, to see if the necessary source data files are there. Type '*make dataclean*' can remove all data files before one starts again.

- When the constant fields (for example, whole domain located over ocean) are generated, the plotting errors will occurred if IFILL = TRUE. Set IFILL = FALSE or reset your domains.

- If running the TERRAIN job on a CRAY computer, probably a huge memory is required and more CPU time are needed because all integer numbers are represented by a 8-byte word and all operations are done on the 8-byte word. So, if possible, we suggest that users run the TERRAIN job on workstations.

4.12 TERRAIN Files and Unit Numbers

Table 4.3 List of shell names, fortran unit numbers and their description for TERRAIN

Shell name	Unit number	Description
terrain.namelist	fort.15	namelist

Shell name	Unit number	Description
*.tbl	fort.17	the tables used for plotting
ezids	fort.18	area ID file used by ezmap
raobsta.ieee	fort.19	Global RAOB station list
LNDNAME(1), (2), (3)	fort.20, 22, 24	1-deg, 30-, and 10-min source land-use file
TERNAME(1), (2), (3), (4), (5)	fort.21, 23, 25, 27,29	1-deg, 30-, 10-, 5- and 2-min source terrain file
new_30sdata	fort.31	30 seconds source terrain file
TERRAIN_DOMAIN*n*	fort.7(*n-1)*	TERRAIN output files for domain ID *n*
LWNAME(1), (2), (3), (4), (5), (6)	fort.32, 33, 34, 35,36,37	1-deg, 30-, 10-, 5-, 2-min, and 30-sec land-water mask file
VGNAME(1), (2), (3), (4), (5), (6)	fort.38,39,40, 41,42,43	1-deg, 30-, 10-, 5-, 2-min, and 30-sec vegetation file
SONAME(1), (2), (3), (4), (5), (6)	fort.44,45,46, 47,48,49	1-deg, 30-, 10-, 5-, 2-min, and 30-sec soil file
VFNAME	fort.50	12 monthly 10-min vegetation fraction file
TSNAME	fort.51	1-deg annual deep soil temp. file
new_30sdata_info	fort.97	global 30 sec. elevation data information

4.13 TERRAIN tar File

The terrain.tar file contains the following files and directories

CHANGES	Description of changes to Terrain program
Data/	Data directory
Makefile	Makefile to create terrain.deck and executable
README	General information about the Terrain directory
Templates/	Job deck and tables directory
con.tbl	Table file for terrain height plot
confi.tbl	Table file for color terrain height plot
confiP.tbl	Table file for vegetation fraction percentages plots
confiT.tbl	Table file for deep soil temperature plot
ezids	File for NCAR Graphics geographic area identifier
lsco.tbl	Table file for soil category plot
luco.tbl	Table file for old land-use plot
lvc1.tbl	Table file for SiB vegetation category plot
lvc2.tbl	Table file for USGS vegetation category plot
map.tbl	Table file for plots
maparea.tbl	Table file for plots

mapfi.tbl	Table file for plots
raobsta.ieee	Radiosonde locations for plot
src/	Terrain source code

In the directory *src/*,

paramesv0.incl and *vs_data0.incl* are the parameters and data statements for SiB data.
paramesv1.incl and *vs_data2.incl* are the parameters and data statements for USGS data.

In the *Data/* directory, namelists for USGS and SiB input files are present. These namelists will be cat'ed to terrain namelist file during the run. Also present in the directory are the ftp scripts to ftp general terrain data from NCAR ftp site and 30 second USGS terrain dataset from USGS ftp site. These ftp scripts may be run separately from the Terrain program to obtain data.

If users have their own vegetation, soil data with different definitions, these parameter and data statement files must be created as well as the corresponding color tables for plots.

4.14 terrain.deck

```
#!/bin/csh -f
# terrain.csh
#
set echo
#
#   Set this if you would like to ftp terrain data
#
set ftpdata = true
#set ftpdata = false
#
#   Set the following for ftp'ing 30 sec elevation data from USGS ftp site
#
set Where30sTer = ftp
#set Where30sTer = /your-data-directory
if ( $Where30sTer == ftp) then
#
#    Use this if you are ftping from other places
#
#    set users = Others
#
#    Use this if you are ftping from inside NCAR
#
     set users = MMM
else
     set users =
endif
#
#    Uncomment the following line if using the 30-100 cm layer soil file
#
# set BotSoil
#
# --------------------------------------------------------------
#          1. Set up parameter statements
# --------------------------------------------------------------
#
cat > src/parame.incl.tmp << EOF
C      IIMX,JJMX are the maximum size of the domains, NSIZE = IIMX*JJMX
       PARAMETER (IIMX = 100, JJMX = 100, NSIZE = IIMX*JJMX)
EOF
cat > src/paramed.incl.tmp << EOF
C      ITRH,JTRH are the maximum size of the terrain data.
C      NOBT = ITRH*JTRH, here assuming
C      ITRH= 270 ( 45 deg. in north-south direction, 10 min. resolution)
C      JTRH= 450 ( 75 deg. in north-south direction, 10 min. resolution)
C  NOTE:
C      IF USING GLOBAL 30SEC ELEVATION DATASET FROM USGS, NEED TO SET
C      BOTH ITRH AND JTRH BIG. TRY THE COMMENTED PARAMETER LINE FIRST.
C      THIS WILL REQUIRE APPROXI 0.9 GB MEMORY ON A 32-BIT IEEE MACHINE.
C      AN ESTIMATE OF THE DIMENSION SIZE CAN BE MADE FROM Data30s/rdem.out
C      AFTER THE FIRST JOB FAILS. USE (XMAXLAT-XMINLAT)*120 TO ESTIMATE
C      ITRH, AND (XMAXLON-XMINLON)*120 TO ESTIMATE JTRH.
C
       PARAMETER (ITRH =  500, JTRH =  500, NOBT = ITRH*JTRH)
C      PARAMETER (ITRH = 1500, JTRH = 1800, NOBT = ITRH*JTRH)
EOF
#
# --------------------------------------------------------------
#          2. Set up NAMELIST
# --------------------------------------------------------------
#
if ( -e terrain.namelist ) rm terrain.namelist
cat > terrain.namelist << EOF
 &MAPBG
 PHIC  =   36.0,       ; CENTRAL LATITUDE (minus for southern hemesphere)
 XLONC =  -85.0,       ; CENTRAL LONGITUDE (minus for western hemesphere)
 IEXP  =    .F.,       ; .T. EXPANDED COARSE DOMAIN, .F. NOT EXPANDED.
                       ; USEFUL IF RUNNING RAWINS/little_r
 AEXP  =   360.,       ; APPROX EXPANSION (KM)
 IPROJ = 'LAMCON',     ; LAMBERT-CONFORMAL MAP PROJECTION
 ;IPROJ = 'POLSTR',    ; POLAR STEREOGRAPHIC MAP PROJECTION
```

```
;IPROJ = 'MERCAT',   ; MERCATOR MAP PROJECTION
&END
&DOMAINS
;
MAXNES =    2,       ; NUMBER OF DOMAINS TO PROCESS
NESTIX =   35,   49,  136,  181,  211, 221,  ; GRID DIMENSIONS IN Y DIRECTION
NESTJX =   41,   52,  181,  196,  211, 221,  ; GRID DIMENSIONS IN X DIRECTION
DIS    =  90.,  30.,   9.,  3.0,  1.0, 1.0,  ; GRID DISTANCE
NUMNC  =    1,    1,    2,    3,    4,   5,  ; MOTHER DOMAIN ID
NESTI  =    1,   10,   28,   35,   45,  50,  ; LOWER LEFT I OF NEST IN MOTHER DOMAIN
NESTJ  =    1,   17,   25,   65,   55,  50,  ; LOWER LEFT J OF NEST IN MOTHER DOMAIN
RID    =  1.5,  1.5,  1.5,  3.1,  2.3,  2.3, ; RADIUS OF INFLUENCE IN GRID UNITS (IFANAL=T)
NTYPE  =    2,    3,    4,    6,    6,   6,  ; INPUT DATA RESOLUTION
;
;      1:  1 deg (~111 km) global terrain and landuse
;      2: 30 min ( ~56 km) global terrain and landuse
;      3: 10 min ( ~19 km) global terrain and landuse
;      4;  5 min (  ~9 km) global terrain and landuse
;      5;  2 min (  ~4 km) global terrain and landuse
;      6; 30 sec ( ~.9 km) global terrain and landuse
;
NSTTYP=     1,    2,    2,    2,    2,   2,  ;  1 -- ONE WAY NEST, 2 -- TWO WAY NEST
&END
&OPTN
IFTER   = .TRUE.,    ; .T.-- TERRAIN,  .F.-- PLOT DOMAIN MAPS ONLY
IFANAL  = .F.,       ; .T.-- OBJECTIVE ANALYSIS, .F.-- INTERPOLATION
ISMTHTR =  2 ,       ;  1: 1-2-1 smoother, 2: two pass smoother/desmoother
IFEZFUG = .F.,      ; .T. USE NCAR GRAPHICS EZMAP WATER BODY INFO TO FUDGE THE LAND USE
                     ; .F. USE LANDWATER MASK DATA
IFTFUG  = .F.,       ; .T. DON'T DO EZFUDGE WITHIN THE USER-SPECIFIED
;                      LAT/LON BOXES, need to define namelist fudget
IFFUDG  = .F.,       ; .T. POINT-BY-POINT FUDGING OF LANDUSE,
                     ;  need to define namelist fudge
IPRNTD  = .F.,       ; PRINT OUT LAT. AND LON. ON THE MESH
IPRTHT  = .F.,       ; PRINT OUT ALL PROCESSING FIELDS ON THE MESH
IPRINT  =  0,        ; = 1: A LOT MORE PRINT OUTPUT IN terrain.print.out
FIN     = 100., 100., 100., 100., 100., 100., ; CONTOUR INTERVAL (meter) FOR TERRAIN
  HEIGHT PLOT
;TRUELAT1=91.,       ; TRUE LATITUDE 1
;TRUELAT2=91.,       ; TRUE LATITUDE 2, use this if IPROJ='LAMCON'
IFILL   = .TRUE.,    ; .TRUE. --- color filled plots
LSMDATA = .FALSE.,   ; .TRUE. --- Create the data for LSM
VEGTYPE = 1,        ; LANDUSE DATA TYPE: =0: old 13 cat; =1: 24 cat USGS; =2: 16 cat SiB
VSPLOT  = .TRUE.,    ; .TRUE. --- plot Vege., Soil, Vege. Frc. percentages.
IEXTRA  = .FALSE.,   ; .TRUE. --- Create extra data for Pleim-Xiu LSM
&END
&FUDGE
; USE ONLY IF IFFUDG = .T., POINT-BY-POINT FUDGING OF LANDUSE,
; IFFUG FOR EACH OF THE NESTS: .F. NO FUDGING, .T. FUDGING
IFFUG   = .F.,.F.,    ; FUDGE FLAGS
; NDFUG : THE NUMBER OF FUDGING POINTS FOR EACH OF NESTS
NDFUG   = 0,0,
; LOCATION (I,J) AND LANDUSE VALUES FOR EACH OF THE NESTS
; NOTE: REGARDLESS OF IFFUG AND NDFUG, 200 VALUES MUST BE GIVEN FOR
;       EACH NEST, OR ELSE THE INDEXING WILL GET MESSED UP
; The example below is for two domains. Add more for domain 3 and up
;       if needed. Do not remove 0 values for domain 1 and/or 2 even
;       they are not used.
;
IFUG(1,1)=  200*0,    ; I location for fudge points in domain 1
IFUG(1,2)=  200*0,    ; I location for fudge points in domain 2
JFUG(1,1)=  200*0,    ; J location for fudge points in domain 1
JFUG(1,2)=  200*0,    ; J location for fudge points in domain 2
LNDFUG(1,1)= 200*0,   ; land-use value at fudge points for domain 1
LNDFUG(1,2)= 200*0,   ; land-use value at fudge points for domain 2
&END
&FUDGET
; USE ONLY IF IFTFUG=.T., WHICH MEANS TERRAIN WON'T DO EZFUDGE WITHIN
;    THE USER-SPECIFIED LAT/LON BOXES.  THIS OPTION IS USED WHEN THERE
;    ARE INLAND BODIES OF WATER THAT ARE DEFINED IN THE LAND USE
;    DATA SET BUT NOT IN THE EZMAP DATA SET.  THIS OPTION PREVENTS
;    THOSE BODIES OF WATER FROM BEING WIPED OUT BY EZFUDGE
NFUGBOX = 2             ;  NUMBER OF SUBDOMAINS IN WHICH TO
;                          TURN OFF EZMAP LAND USE FUDGING
```

```
 STARTLAT=45.0,44.0,     ;  LATITUDES OF LOWER-LEFT CORNERS OF SUBDOMAINS
 ENDLAT  =46.5,45.0,     ;  LATITUDES OF UPPER-RIGHT CORNERS OF SUBDOMAINS
 STARTLON=-95.0,-79.8,   ;  LONGITUDES OF LOWER-LEFT CORNERS OF SUBDOMAINS
 ENDLON  =-92.6,-78.5,   ;  LONGITUDES OF UPPER-RIGHT CORNERS OF SUBDOMAINS
 &END
 &EZFUDGE
 ; USE ONLY IF IFEZFUG=.T., WHICH TURNS ON EZMAP WATER BODY FUDGING OF LANDUSE.
 ; USERS: FEEL FREE TO ADD ANY MORE LAKE SURFACE HEIGHTS THAT YOU'LL NEED.
 ; HTPS IS THE HEIGHT IN METERS AND THE INDEX OF HTPS CORRESPONDS TO THE ID
 ; OF THE 'PS' AREA IN THE FILE ezmap_area_ids.
 ;
 HTPS(441) =  -.001   ; Oceans  --  Do NOT change this one
 HTPS(550) =  183.    ; Lake Superior
 HTPS(587) =  177.    ; Lakes Michigan and Huron
 HTPS(618) =  176.    ; Lake St. Clair
 HTPS(613) =  174.    ; Lake Erie
 HTPS(645) =   75.    ; Lake Ontario
 HTPS(480) = 1897.    ; Lake Tahoe
 HTPS(500) = 1281.    ; Great Salt Lake
 &END
EOF
#
# ----------------------------------------------------------------------------
#
#                 END OF USER MODIFICATION
#
# ----------------------------------------------------------------------------
#
#     Check to see if recompilation is needed
#       Need to make here so that rdnml may be used
#
cd src
../Templates/incldiff.sh parame.incl.tmp parame.incl
../Templates/incldiff.sh paramed.incl.tmp paramed.incl
cd ..
make >& make.terrain.out
#
#     Create a namelist without comments
#
sed -f Templates/no_comment.sed terrain.namelist | grep "[A-Z,a-z]" > terlif.tmp
mv terlif.tmp terrain.namelist
#
#     Set default script variables
#
set LandUse = OLD
#
set DataType = `src/rdnml < terrain.namelist`
echo $DataType
#
if ( $DataType[4] == 1 ) set IfProcData
if ( $DataType[4] == 0 ) set ftpdata = false
if ( $DataType[5] == 1 ) set LandUse = USGS
if ( $DataType[5] == 2 ) set LandUse = SiB
if ( $DataType[3] == 1 ) set IfUsgsTopo
#
#       reset LandUse if BotSoil is set
#             -- use bottome soil files
#
if ( $?BotSoil ) set LandUse = USGS2
#
#      link to Fortran units
#
set ForUnit = fort.
rm ${ForUnit}1* ${ForUnit}2* ${ForUnit}4*
#
if ( $LandUse == OLD ) cat Data/namelist.usgsdata >> terrain.namelist
if ( $LandUse == USGS ) cat Data/namelist.usgsdata  >> terrain.namelist
if ( $LandUse == USGS2 ) cat Data/namelist.usgsdata2 >> terrain.namelist
if ( $LandUse == SiB ) cat Data/namelist.sibdata  >> terrain.namelist
cat > endnml << EOF
 &END
EOF
cat endnml >> terrain.namelist
rm endnml
```

```
#
   ln -s  terrain.namelist      ${ForUnit}15
   ln -s  ezids                 ${ForUnit}18
   ln -s  raobsta.ieee          ${ForUnit}16
# ----------------------------------------------------------------------
#
#     Update parameter statements for vegetation dataset
#       (may require partial recompilation)
#
if ( $LandUse == SiB ) then

   cp src/paramesv0.incl src/paramesv.incl.tmp
   ./Templates/incldiff.sh src/paramesv.incl.tmp src/paramesv.incl
   cp src/vs_data0.incl  src/vs_data.incl.tmp
   ./Templates/incldiff.sh src/vs_data.incl.tmp src/vs_data.incl
   make >& make2.print.out

else if ( $LandUse == USGS ) then

   cp src/paramesv1.incl src/paramesv.incl.tmp
   ./Templates/incldiff.sh src/paramesv.incl.tmp src/paramesv.incl
   cp src/vs_data2.incl  src/vs_data.incl.tmp
   ./Templates/incldiff.sh src/vs_data.incl.tmp src/vs_data.incl
   make >& make2.print.out

endif
# ----------------------------------------------------------------------
#
#     should I ftp the data?
#
if ( $ftpdata == true && $?BotSoil ) then
# ftp other data plus bottom soil data
   echo 'about to start ftping'
   cp Data/ftp2.csh ftp.csh
   chmod +x ftp.csh
   ./ftp.csh >& ftp.out
# rm ftp.csh ftp.out
else
# ftp other data plus top soil data
   echo 'about to start ftping'
   cp Data/ftp.csh ftp.csh
   chmod +x ftp.csh
   ./ftp.csh >& ftp.out
# rm ftp.csh ftp.out
endif
#
if ( $?IfUsgsTopo && $IfProcData ) then
   echo 'about to start ftping 30 sec tiled elevation data from USGS'
   cp Data/ftp30s.csh .
   chmod +x ftp30s.csh
   ./ftp30s.csh $Where30sTer $users >& ftp30s.out
# rm ftp30s.csh ftp30s.out
endif
# ----------------------------------------------------------------------
#
#      Execute terrain
#
unlimit
date
./terrain.exe >&! terrain.print.out
#
rm ${ForUnit}*
```