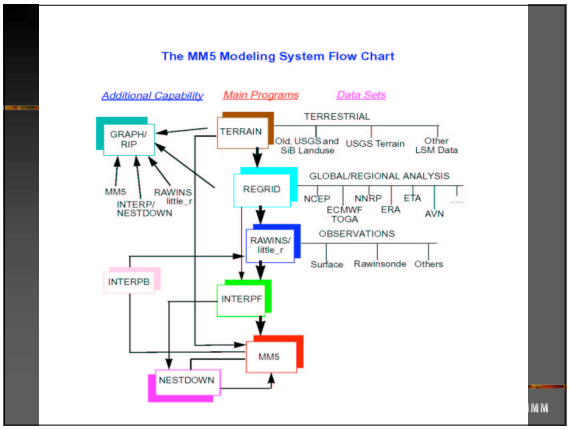
Chapter 4: Terrain

Wei Wang



Topics of Discussion

- Overview of the program
- Input data
- Defining mesoscale domains
- Interpolation
- Adjustment
- Fudging function
- Output
- Some considerations on domain configuration

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Overview of TERRAIN (page 4-3,4)

- Set up mesoscale domains
- Interpolate regular latitude/longitude terrain elevation and other terrestrial data (non time-varying) to mesoscale grids
- Calculate constant fields for the model: latitude / longitude, map scale factor, and Coriolis parameter

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Overview of TERRAIN (cont)

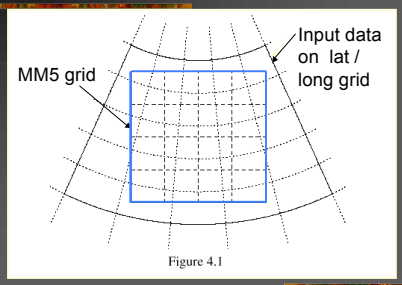

Figure 4.1

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Overview of TERRAIN (cont)

The program consists 4 major parts:

- Reading and storing data for the area of interest
- Interpolate data to mesoscale domains
- Adjustment:
  - nest interface blending
  - feedback between domains
- Output

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Input Data (pages 4-4 – 4-15)

Terrain program processes the following data:

- terrain elevation (basic)
- landuse / vegetation (basic)
- land-water mask (derived from 30 sec vegetation data) (basic)
- soil categories (for Land-Surface Model option in MM5)
- vegetation fraction (optional for LSM)
- deep soil temperature (optional for LSM)

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Input Data (cont)

Terrain/elevation data:

- based on 30 sec (~ 0.9 km) resolution data from USGS
- for lower resolutions: 1 degree, 30, 10, 5 and 2 minute resolutions, 30 sec data are averaged to these resolutions

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Input Data (cont)

Landuse data (three types):

- old 13-category data (mostly 1 deg resol., except over eastern US – rarely used)
- USGS 24-category data based on global USGS 30 second landcover data version 2 (1993)
- SiB 17-category data, also based on USGS (North America coverage only)

See Tables 4.2a, b, c for complete listing

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Input Data (cont)

Land-water mask data (two types):

- derived from 30 sec USGS vegetation data (global coverage)
- derived from 30 sec SiB vegetation data (North America coverage)
- used to define coastlines and other land-water boundaries

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Input Data (cont)

Soil data: for LSM

- merged global 5-minute United Nation/FAO and N. America STATSGO 30 sec data
- 17 categories
- two-layers of soil data provided: 0-30 cm top layer and 30-100 cm bottom layer

See Table 4.2d for complete listing

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Input Data (cont)

Vegetation fraction data: for LSM

- global 10 minutes resolution
- monthly value only

Deep soil temperature data: for LSM

- global 1 degree resolution
- used for lower boundary condition for LSM

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Input Data (cont)

For vegetation and soil data, the input data are provided as

- one value per grid point at 30 sec resolution
- percentage values for each category at other resolutions

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Input Data (cont)

Terrain, landuse, soil and landmask data are provided at six resolutions:

- 1 degree (111 km)
- 30 minutes (55 km)
- 10 minutes (19 km)
- 5 minutes (9 km)
- 2 minutes (3.7 km)
- 30 seconds (0.9 km)

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Input Data (cont)

All data files are in direct-access format:

- Each record contains data from each latitudinal circle from west to east (starting from the dateline for global data)
- There are N number of records in longitudinal direction from north to south

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Defining mesoscale domains
(pages 4-16 – 4-18)

- Coarse domain parameters
  - Projection type (*IPROJ* – namelist option)
  - Central latitude and longitude (*PHIC, XLONG*)
    latitude = {-90, 90}; longitude = {-180, 180}
  - True latitudes (default available) (*TRUELAT1/2*)
  - Domain dimensions (number of grid points in each direction: IX is in Y direction in MM5 (*NESTIX/JX*)
  - Grid distance in km (*DIS*)

The coarse domain will be completely defined by these parameters

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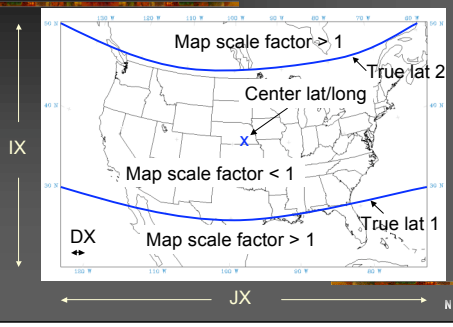
Defining mesoscale domains
(example for a Lambert-Conformal grid)



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Defining mesoscale domains (cont)

- Map projection (*IPROJ*): three available
  - Polar stereographic for high latitudes
  - Lambert conformal for middle latitudes
  - Mercator for low latitudes
- User can choose different true latitude(s) for polar and Lambert conformal projections. Default available.
- The goal is to choose a map projection that gives the minimum distortion of the domain.

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Defining mesoscale domains (cont)

- Nest domain parameters
  - Location of grid point (1,1) in its mother domain (*NESTI, NESTJ* – namelist option)
  - Mother domain ID (*NUMNC*)
  - Domain dimensions (*NESTIX, NESTJX*)
  - Grid distance in km (*DIS*)
  - One-way or two-way nesting (*NSTYPE*)

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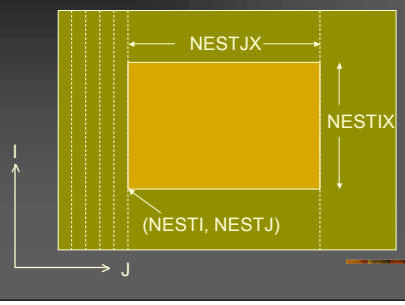
Defining mesoscale domains (cont)



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Defining mesoscale domains (cont)

- A nest must satisfy certain requirements:
  - The ratio of coarse to nest domain grid distances must be an integer (=< 5)
    - if it is a two-way nesting, the ratio must be 3
  - A nest domain must start and end at coarse domain grid point
  - A nest must be at least 5 grid points away from the mother domain boundary
  - Terrain cannot be used to create overlapping nest

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Defining mesoscale domains (cont)

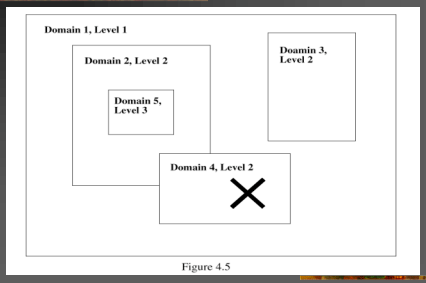

Figure 4.5

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Defining mesoscale domains (cont)

- Special case:

  expanded domain option (*IEXP, AEXP*)
  - useful for objective analysis so that observation just outside mesoscale domain can be used
  - typically 300 km on each side of the domain – the distance is roughly equal to the radiosonde station separation

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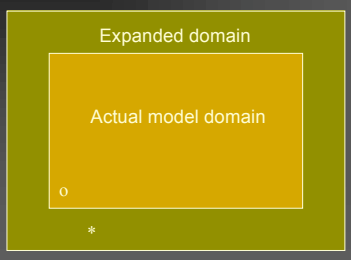
Defining mesoscale domains (cont)



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Interpolation (pages 4-19 – 4-21)

Terrain program interpolates regular lat/long terrestrial data onto mesoscale grids

- Overlapping parabolic interpolation
  - used for terrain height, percentage values for vegetation / landuse and soil, vegetation fraction and deep soil temperature

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Interpolation (cont)

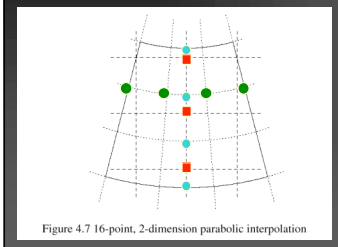

Figure 4.7 16-point, 2-dimension parabolic interpolation

16-point, 2-dimensional parabolic interpolation

- Input data
- MM5 grid data

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Interpolation (cont)

- Dominant type selection
  - used for 30 sec vegetation and soil data

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Interpolation (cont)

- Cressman-type objective analysis
  - used for terrain height only
  - distance weighted
  - single pass
  - large radius of influence gives smoother results

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Adjustment (pages 4-22, 4-23)

Adjustment of terrestrial data between domains is important for two reasons:

- nest boundary conditions are specified from its mother domain in MM5
- nest results are overwritten to coincident coarse domain grids in MM5

These require that the underlying surface properties are identical at these coincident grid points. Otherwise numerical instability may result.

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Adjustment (cont)

Adjustment methods:

- reset the nest domain boundary values for both 1-way and 2-way application from its mother domain values
- overwrite mother domain field with nest domain values for 2-way application

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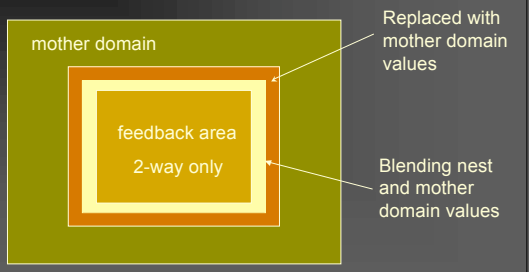
Adjustment (cont)



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Fudging Functions (pages 4-23, 4-24)

Terrain's interpolation procedure can be supplemented by fudging functions

- land-water boundary correction – to correct land-water boundaries, coastlines
- land-use fudge – to replace with user-desired landuse values

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Fudging Functions (cont)

- Two methods to correct land-water boundaries
  - based on land-water mask data (EZFUDGE=F) – works well everywhere
  - based NCAR Graphics map information (EZFUDGE=T) – works well where NCAR map information is good – that is mostly over US

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Output (pages 4-27 – 4-28)

The output files from Terrain are
TERRAIN_DOMAINx (x = 1, 2, 3…)

The following fields on mesoscale domains are in the output files:

- Terrain elevation
- Landuse
- Latitude/longitude values at dot and cross points
- Map scale factors at dot and cross points
- Coriolis parameter

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Output (cont)

If a user chooses to process extra data for LSM option in MM5 (*LSMDATA=.T.*), one will get additional fields:

- dominant soil types
- deep soil temperature
- vegetation fraction for 12 months
- land water mask

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Output (cont)

If one has NCAR Graphics,

- TER.PLT, which contains plots of terrain, landuse, soil data, map of nest, and so on.

Print out file:

- terrain.print.out – log file, useful for looking for runtime errors

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Some considerations on domain configuration

- Keep area of interest away from lateral boundaries
- Consider simulation length versus domain size
- Do not use small but very high resolution domain if the lateral boundary values are provided by a very coarse dataset – consider using nest to go to fine grid from coarse grid

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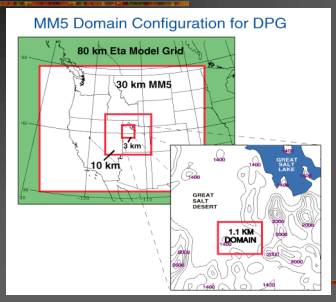
Some considerations on domain configuration (example 1)



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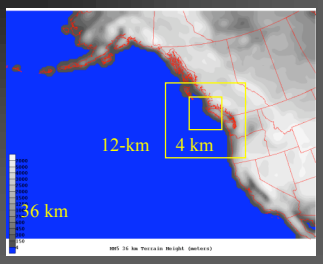
Some considerations on domain configuration (example 2)



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Good reference to read about the effect of lateral boundary conditions in regional models:

Warner, Peterson, and Treaton, 1997: A tutorial on lateral boundary conditions as a basic and potentially serious limitation to the regional numerical weather prediction. BAMS, 78, 2599-2617.

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Chapter 4: Terrain

How to run Terrain?

Wei Wang

How to run TERRAIN

- Pages 4-26 – 4-28
- README file inside TERRAIN tar file

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Step 1:

- Download Terrain program tar file from NCAR's ftp site
- uncompress the file:

```
gunzip TERRAIN.TAR.gz
```

- untar the file:

```
tar -xfv TERRAIN.TAR
```

This will create a directory called *TERRAIN*

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Step 2:

- type

```
make terrain.deck
```

to create a job deck

- edit *terrain.deck* for *parameter* statements and *namelists*
- Use the option *IFTER = .FALSE.* to check domain configuration first

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Step 3:

- Type

```
terrain.deck >& log
```

or

```
./terrain.deck >& log
```

to compile and run the program

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Useful make commands

- To repeat step 3 in previous slide, first type

```
make clean
```

- To remove downloaded data from Data/ directory, type

```
make dataclean
```

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What to edit in the job deck?

- Parameter statements:
  - Compile time option: need to be specified before one compiles the code
- namelist options:
  - Runtime options: can be modified without recompiling the program

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What to edit in the job deck? (cont)

- Parameter statements:
  - *IIMX, JJMX*: maximum dimensions of your domains (including the expanded coarse domain)
  - *ITRH, JTRH*: dimensions for input data. The finer the input data resolution, the larger the dimensions need to be
  - These need not be exact, just big enough

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What to edit in the job deck? (cont)

- Namelist options
  - All sections of MAPBG, DOMAINS, and OPTN (page 4-24 – 4-25)
  - Note that JX indicates X (west-east) direction, and IX indicates Y (south-north) direction.
  - Values from a single column namelist are valid for all domains, values from multiple column namelists are valid one column per domain

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What does the job deck do?

- compiles terrain program
- obtains data via ftp from NCAR's anonymous ftp site using scripts ftp.csh and / or ftp30s.csh – according to the data types a user specifies in the namelist (*NTYPE*)
- executes the program

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Terrain output files

- Two log files:
  - `terrain.print.out`
    output from running the program – useful to look for clues when the program fails
  - `make.terrain.out`
    a log file for compilation
- TERRAIN_DOMAINx (binary files)
  where x denotes the domain ID, e.g. 1, 2, … and the data format conforms to MM5 format
- `TER.PLT` (or `gmeta`)
  a plot file from NCAR Graphics, very useful for checking the domain configuration and output

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What to check if the job fails?

- The log files:
  - ***`make.terrain.out`*** : see if compilation is successful. If it is, one should obtain four executables in the src/ directory:
    `rdnml`: read namelist and decide what data to ftp
    `terrain.exe`: main exe to process terrain data
    `data_area.exe`: used for deciding which 30 sec tiles are required
    `rdem.exe`: used for processing 30 sec tilted data

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What to check if the job fails? (cont)

- ***`terrain.print.out`*** : check to find possible runtime errors

- Turn on namelist option *IPRINT* and this will give you more prints. Can be used to track runtime problems.

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Common Errors:

- Compilation failed due to missing NCAR Graphics library
- Didn't have the complete input data due to ftp error or lacking of disk space – results in reading error when running the program
- Domain or data dimensions are too small for the domain configuration
- Nest specification is incorrect.

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Trouble Shooting:

- If the compilation fails:
  - try repeat the problem by first typing '`make clean`', followed by typing ./terrain.deck again.
  - check path to NCAR Graphics in Makefile
  - check make.terrain.out file for error messages
- If terrain program fails to run:
  - check terrain.print.out file for errors
  - check if data have been ftped correctly – compare data file sizes with those listed in the tables 4.1a – 4.1i.

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Miscellaneous topics

- Common problems (page 4-28)
- Terrain's Fortran unit list (page 4-29)
- What are in Terrain program tar file? (page 4-30)
- `terrain.deck` (page 4-32)

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