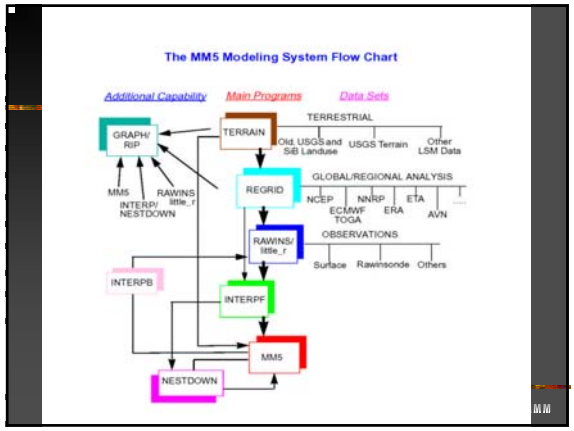
Chapter 4: Terrain

Wei Wang



Topics of Discussion

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

Overview of TERRAIN (page 4-3,4)

- Set up mesoscale domains
- Interpolate regular latitude/longitude terrain and other terrestrial data to mesoscale grids

Overview of TERRAIN (cont)

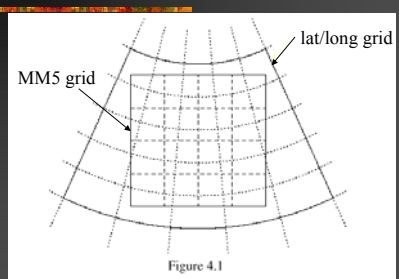


Figure 4.1

Overview of TERRAIN (cont)

The program consists 4 major parts:

1. Reading data for the area of interest
2. Interpolate data to mesoscale domains
3. Adjustment:
   - nest interface blending
   - feedback between domains
4. Output

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 (optional for LSM)
- 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 USGS
- for lower resolutions: 1 degree, 30, 10, 5 and 2 minute resolution, 30 sec data are averaged to these resolutions

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Input Data (cont)

Landuse data:

- old 13-category data (mostly 1 deg resol., except over eastern US)
- USGS 24-category data based on USGS 30 sec landcover data version 2
- SiB 17-category data, also based on USGS

See Tables 4.2a, b, c for complete listing

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Input Data (cont)

Land-water mask data:

- derived from 30 sec USGS vegetation data
- derived from 30 sec SiB vegetation data
- 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
- monthly value only

Deep soil temperature data: for LSM

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

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Input Data (cont)

For vegetation and soil data:

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

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Input Data (cont)

All 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
- 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)
  - 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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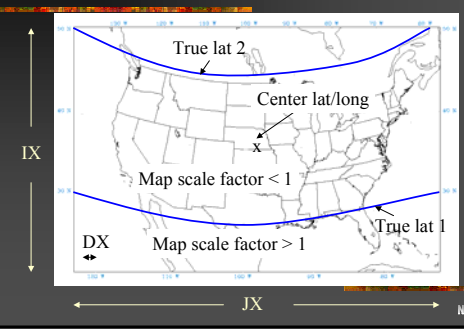
Defining mesoscale domains
(cont)



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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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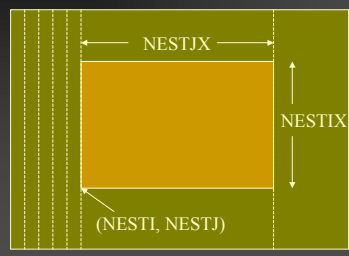
Defining mesoscale domains (cont)

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

Defining mesoscale domains (cont)



Defining mesoscale domains (cont)

- A nest must satisfy certain requirement
  1. 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
  2. A nest domain must start and end at coarse domain grid point
  3. A nest must be at least 5 grid points away from the mother domain boundary
  4. Terrain cannot be use to create overlapping nest

Defining mesoscale domains (cont)

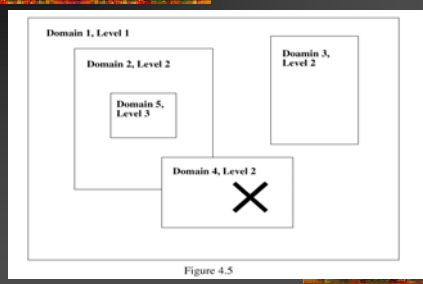


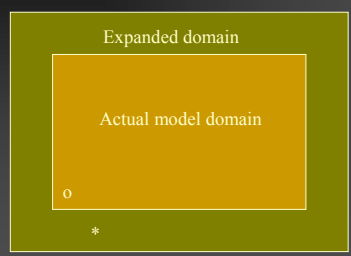
Figure 4.5

Defining mesoscale domains (cont)

- Special case:

  expanded domain option (IEXP, AEXP)
  - useful for objective analysis so that observation just outside mesoscale domain will be used
  - typically 300 km on each side of the domain

Defining mesoscale domains (cont)



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

Interpolation (cont)

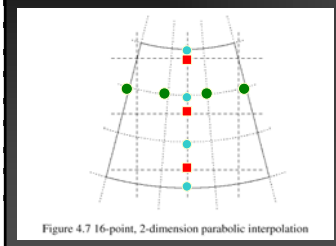


Figure 4.7 16-point, 2-dimension parabolic interpolation

16-point, 2-dimensional parabolic interpolation

Interpolation (cont)

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

Interpolation (cont)

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

Adjustment (pages 4-22, 4-23)

Adjustment between domains is important for two reasons:

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

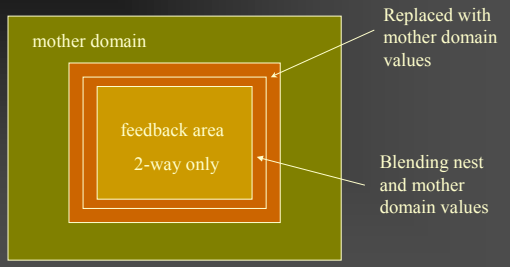
These require that the underlying surface properties are identical at these coincident grid points. Otherwise numerical instability may result.

Adjustment (cont)

Adjustment processes:

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

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

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

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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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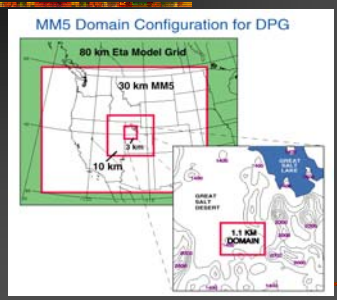
Some considerations on domain configuration (example 1)



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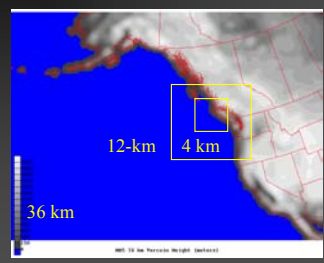
Some considerations on domain configuration (example 2)



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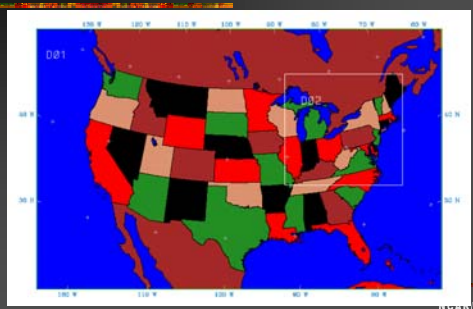
Some considerations on domain configuration (example 3)



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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?

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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`
  to compile and run the program

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What does the job deck do?

- compile terrain program
- ftp data from NCAR's ftp site using ftp scripts ftp.csh and / or ftp30s.csh – according to data types a user chooses in the namelist (NTYPE)
- execute 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 is the domain number, 1, 2, …
- TER.PLT (or gmeta)
  a plot file from NCAR Graphics, very useful to check the output

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What to check if the job fails?

- The log files:
  - *make.terrain.out* file to 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
    data_area.exe: used for 30 sec tiled data
    rdem.exe: used for processing 30 sec tilted data
  - *terrain.print.out* to find possible runtime errors

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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 not correct.

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 4-31)