# Appendix C: How to Use Noah Land-Surface Model Option

Since Version 3.6, the Oregon State University / NCEP Eta Land-Surface Model (OSU LSM) in MM5 (Chen and Dudhia 1999) has been replaced by an updated version of the model, known as the Noah LSM, which includes many improvements from NCEP, NCAR, AFWA and UCLA. Like the OSU LSM, using the Noah LSM option in MM5 requires additional inputs to initialize the model.

## C.1 Noah LSM Requirements in Pre-Processing Programs

To use the Noah LSM option, the MM5 model requires several additional input fields. The Version 3 *TERRAIN* program provides an annual-mean deep soil temperature adjusted to model terrain elevation, a monthly climatological vegetation fraction, dominant soil type, and dominant vegetation type in each grid cell. All of the inputs to the *TERRAIN* program are provided by mesouser.

The *REGRID* program provides soil moisture, soil temperature at various depths, water-equivalent snow depth, sea ice, and optionally canopy moisture and soil water content. These additional fields are currently available from the NCEP/NCAR Reanalysis (NNRP, 2.5 degree resolution over past 40 more years), NCEP's global Final Analyses (FNL, 1.0 degree resolution since Sept 1999) and the Eta AWIP analyses (for the Continental US only, about 40 km resolution since May 1995). These datasets are archived at NCAR. The additional soil data are also available in real-time from NCEP's ftp site from Eta and AVN model outputs (*ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/*), or from AFWA-produced AGRMET data *(http://www.mmm.ucar.edu/mm5/doc.html)*. These input data are illustrated in Fig. C-1.

Two additional types of input can be ingested in the *REGRID/regridder* program as well: 1-degree global maximum snow albedo, and 0.15-degree monthly climatological (snow-free) albedo. The recommendation is to use the maximum snow albedo (which is used in the Noah LSM to limit values of albedo when snow is present), and use the climatological albedo with caution (for example, one may want to only use this field when the grid size is above the data resolution which is about 16 km). These two datasets are provided by mesouser. The maximum snow albedo data are provided in *REGRID* tar file (*REGRID/regridder/*ALMX_FILE), and one can obtain monthly albedo from:

*ftp://ftp.ucar.edu/mesouser/MM5V3/REGRID_DATA/MONTHLY_ALBEDO.TAR.gz*

or on MSS:

*/MESOUSER/DATASETS/REGRID/MONTHLY_ALBEDO.TAR.gz*

All LSM fields are passed along in programs *RAWINS/LITTLE_R* and *INTERPF.*

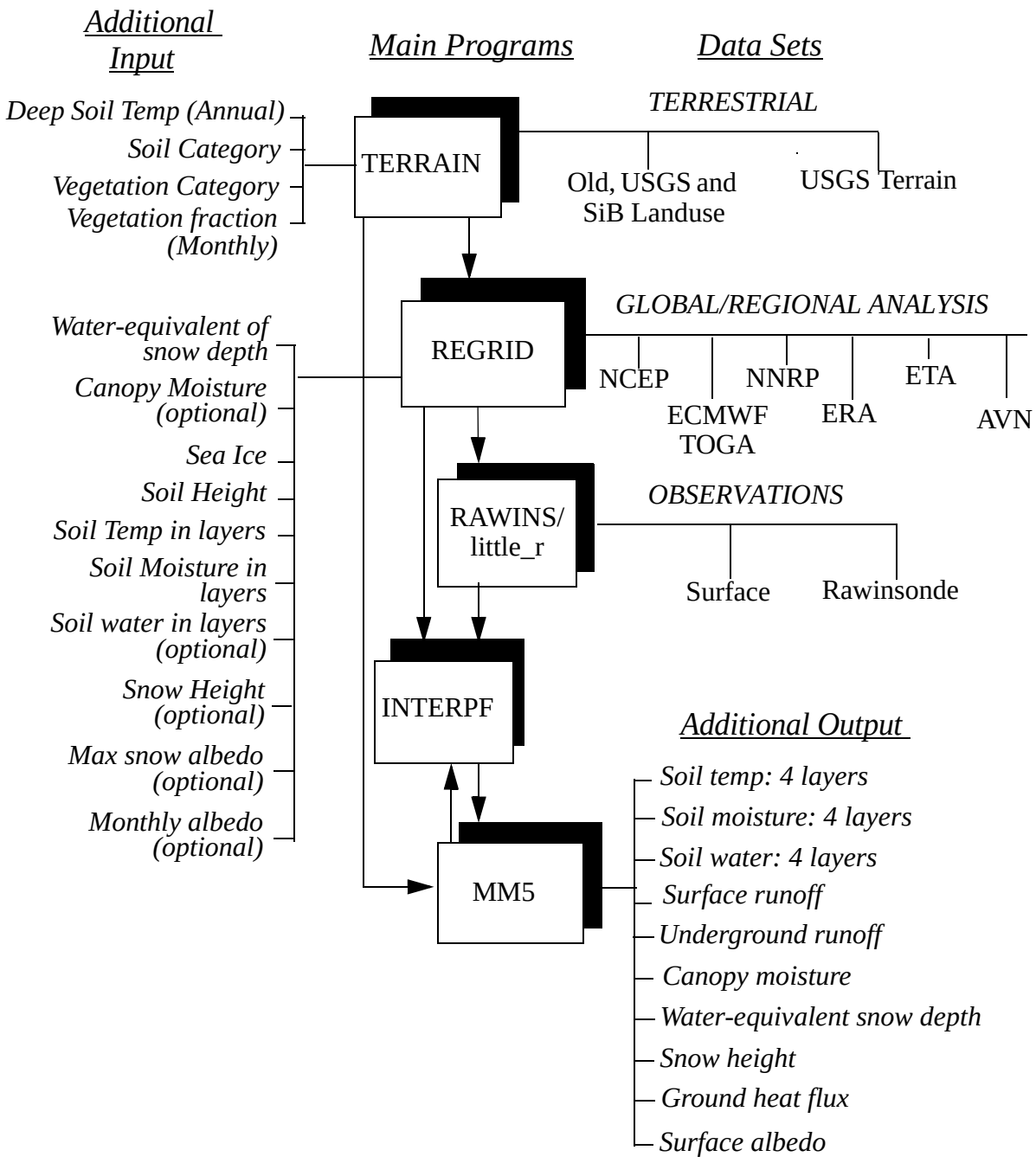


Fig C-1 The MM5 Version 3 modeling system flow chart with input data to and output data from Noah LSM shown.

## C.2 How to Set Program Switches to Run Noah LSM

### Terrain -

In *terrain.deck,* set namelist variable

```
LSMDATA = .T.,
```

and select values 1 or 2 for VEGTYPE. e.g.,

```
VEGTYPE = 1,
```

(In V3.3 or earlier *terrain.deck,* select

```
set NewLandUseOnly = FALSE
 set LandSurface = TRUE
```

and either

```
set VegType = USGS
```

or

```
set VegType = SiB
```

The rest of the *terrain.deck* is the same.)

Note that SiB data is only available over North America, but these categories correspond to those used in the Eta model's operational LSM. However, either set can be used in MM5's version of the Noah LSM. Also, note that the SiB classification lacks an 'urban' category.

These setups will make use of the terrestrial datasets to create the following additional fields on the model grid in the *TERRAIN* output:

1. *VEGFRCnn* (nn=1,12): vegetation fraction monthly climatology
2. *TEMPGRD*: annual mean ground temp adjusted to model terrain elevation
3. *SOILINDX*: dominant soil type (currently 30" over US, 5-minutes elsewhere)

Note, for soil types, one may choose either soil type data over top layer (0 - 30 cm), or bottom layer (30 - 100 cm). Selecting the bottom soil data can be done by uncommenting the script variable *BotSoil* near the top of *terrain.deck*. A comparison of top and bottom soil types over the continental US may be found online at *http://www.mmm.ucar.edu/mm5/mm5v3/new-soil.html*.

### REGRID -

The datasets that have the required additional fields to run Noah LSM in MM5 are Eta (AWIP or Eta212 grid), NNRP and NCEP's FNL data archived at NCAR (DSS609.2, DSS090.0, and DSS083.2, respectively). Real-time data from NCEP's Eta and AVN can also be used.

To get the NNRP data from NCAR archive, use either *get_nnrp.deck.ibm* for batch IBM job, or

*get_nnrp.csh* for running interactively from *pregrid/nnrp* directory.

To get the FNL data from NCAR archive, go to *http://dss.ucar.edu/datasets/ds083.2/inventories/*, and download individual files as needed, or use the *get_fnl.deck* script to download multiple files.

To get NCAR archived AWIP data, use the *get_awip.deck* script, or to download the files manually, follow the instructions below.
(Note that the Eta dataset only covers Continental US. It starts May 1995, and may have missing periods):

1. Use Web browser to go to

*ftp://ncardata.ucar.edu/datasets/ds609.2/inventories/eta.inv*

and find out which Gxxxxx file contains the time period of your interest. Should get both 3Danal and SFanal files.

2. On NCAR's computer, type the following to get the dataset in non-cos-blocked format:

```
msread -fBI Gxxxxx /DSS/Gxxxxx
```

(You may then ftp this file back to your local workstation to do the rest. Note though these files are very BIG in size: the 3Danal file is about 1Gb each, and SFanal is about 250 mb. If ftping big files is a problem, do steps 3 and 4 on IBM, and ftp the files after step 4.)

3. Type the following to obtain all files listed in the Gxxxxx file:

```
tar tvf Gxxxxx > tar.list
```

Or find out the file names from

*ftp://ncardata.ucar.edu/datasets/ds609.2/inventories/TARLIST*

and click on the appropriate tarlist file.

4. Extract the tm00 files to use by typing, using G40001 (containing upperair data) and G40006 (containing surface data) files as an example:

```
tar -xvf G40001 9706_3Danal/97062400.AWIP3D00.tm00
```
and
```
tar -xvf G40006 9706_SFanal/97062400.AWIPSF00.tm00
```

Repeat the last two commands several times to obtain all time periods. The tm00 files are to be used by *pregrid* program. (If one wants to use other tmXX files, please refer to the DSS document at *http://dss.ucar.edu/datasets/ds609.2/docs/awip212.html*.) The extracted file for each time period is considerably smaller in file size: about 5 Mb each for upperair data and 1.2 Mb for surface data. You can ftp each file back to your workstation, or tar them up and then ftp the file back. Note, if you would like to run *REGRID* on NCAR's IBM using AWIP dataset, you can either run the job interactively if your domain size is not too big (IBM allows for 32 Mb of memory for interactive job only), or you can modify the deck to extract the files only.

In *pregrid.csh* make sure you have either Eta (AWIP or Eta212 grid), or NNRP, or FNL data for the relevant dates, set *SRCSOIL* to either *$SRC3D* or different input files, and:

```
set VTSOIL = ../grib.misc/Vtable.AWIPSOIL
```

or

```
set VTSOIL = ../grib.misc/Vtable.NNRPSOIL
```

or

```
set VTSOIL = ../grib.misc/Vtable.AVNSOIL
```

For snow data, you will need to set *SRCSNOW* for input files and use one of the *Vtable* file for *VTSNOW* (*Vtable.AWIPSNOW,* or *Vtable.NNRPSNOW,* or *Vtable.AVNSNOW*).

If you have other LSM data, check the *Vtables* above to see which fields that may be used. The fields added to the standard meteorological fields by setting *SRCSOIL* (and *SRCSNOW*) are:

1. *SOILTnnn*: Soil temp at various depths (nnn are in cm; unit: K)
2. *SOILMnnn*: Soil moisture at various depths (nnn are in cm; unit: fraction)
3. *SOILHGT*: Analysis surface elevation, used in *REGRID* to adjust soil temp (unit: m)
4. *WEASD*: Water-equivalent snow depth (optional but highly desirable; unit: kg m{-2})
5. *SEAICE*: Sea-ice mask (optional but highly desirable; 0 or 1)
6. *SOILWnnn*: Soil water (optional and currently from AGRMET only; unit: m3/m3)

where *nnn* is equal to 010, 040, 100 and 200 (10, 40, 100 and 200 cm, respectively) for various datasets we support. Among these fields, only the soil temperature, soil moisture, and soil height fields are required by the Noah LSM option. But we recommend that fields *WEASD* and *SEAICE* are made available. If your LSM data contain fields at levels other than those listed, you can still use them. For example, you may get soil temperature at 10 and 200 cm only, or perhaps at other levels, you can modify *Vtable* to extract these fields. When you run MM5, you can use the namelist options *ISTLYR* and *ISMLYR* (available since V3-2) to define where your data are (see below).

Since V3.6, *REGRID* may ingest AGRMET LSM data. This dataset is produced by AFWA, and made available to MM5 users since October 2002 (with two months delay in real-time). The data are archived at NCAR on MSS: /MESOUSER/DATASETS/AGRMET/. *Vtables* for this dataset are provided in *REGRID/pregrid/grib.misc*/Vtable.AGRMETxxxx. Soil temperature, moisture, water, landsea mask and soil height fields are extracted from this dataset. One may use this dataset in combination with other three-dimensional meteorological input.

In *regridder*, do not use *sst_to_ice_threshold* in the namelist.input, i.e. do not turn sea water into land ice. Use the *SEAICE* field in the input instead.

## MM5 -

To use the Noah LSM option, set *ISOIL=2* in *configure.user* prior to compilation. *IBLTYP=4* or *5* (the Eta or MRF PBL) must be used for now. They are the only ones coupled to the LSM.

If you have ingested climatological albedo fields from *REGRID*, you may choose to use or not use them in MM5. Set the following namelist variables to .FALSE. if you don't want to use them in the model:

```
RDMAXALB = .FALSE.,
RDBRDALB = .FALSE.,
```

We generally recommend that one uses the climatological maximum snow albedo only.

To use input soil temperature and moisture one must add the input levels to the namelist variables *ISTLYR* and *ISMLYR* in the namelist *LPARAM* section. For example,

```
ISTLYR = 10,200,0,0,
ISMLYR = 10,200,0,0,
```

This shows that the input soil temperature and moisture only comes in at 10 and 200 cm levels.

Or for input coming in at levels 10,40,100 and 200 cm, one will set,

```
ISTLYR = 10,40,100,200,
ISMLYR = 10,40,100,200,
```

Other common layers found in ECMWF models are 7, 28, 199, 255 cm. Inputting these layers in the model can be done by setting,

```
ISTLYR = 7,28,100,255,
ISMLYR = 7,28,100,255,
```

Note that one can only input up to 4 levels of soil temperature and moisture.

The prediction levels in current MM5/Noah LSM are 5, 25, 70, and 150 cm and are bounded between surface and 300 cm below. The climatological deep soil temperature generated in program *TERRAIN* is used as the lower boundary condition for the Noah LSM, while open-boundary condition is used for soil moisture and soil water.

Additional Noah LSM prognostic outputs from MM5 are:

1. *SOIL Tn* (n=1,4): The soil temp at all 4 soil levels, unit K;
2. *SOIL Mn* (n=1,4): The soil moisture at all 4 soil levels, unit $m^3/m^3$;
3. *SOIL Wn* (n=1,4): The soil water at all 4 soil levels, unit $m^3/m^3$;
4. *CANOPYM*: Canopy moisture, unit m;
5. *SNOWH*: Snow height, unit m;
6. *WEASD*: Water equivalent snow depth, unit mm;
7. *SFCRNOFF*: Surface runoff accumulation, unit mm;
8. *UGDRNOFF*: Underground runoff accumulation, unit mm;
9. *GRNFLX*: Ground head flux, unit W $m^{-2}$;
10. *ALB*: Albedo, unit fraction.

**Note 1**: If using NNRP soil moisture, you may want to check *init.F* and *initnest.F*, where there is a correction for some known biases in soil moisture. Comment out GOTO 1001, and GOTO 2001 in those routines respectively, if you want to use this correction.

**Note 2**: If you want diagnostic LSM prints at a gridpoint, change the line in surfce.F (SURFCE.284) to NOOUT=1 and edit the IF statements determining where and how often to output data.

**Note 3**: When using *NESTDOWN* to generate input files for a one-way nested run, again make sure that one doesn't use the *sst_to_ice_threshold* option, and check interpolated fields (especially those of masked fields: e.g. sea ice, snow height, soil water, and other LSM fields) carefully.