Release of Upgraded Noah Land Surface Model in WRFV3.1

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Outline:
• Changes implemented for upgraded unified Noah3.1
• Some test results
Changes in a Nutshell
Largest modifications in Noah since 2004

1. Implemented new global 1-km MODIS based land-use and land-cover (LULC) data (NCEP, Boston U.)

2. Created new vegetation parameter tables to accommodate both USGS and MODIS LULC data

3. Added new capabilities for treating time-varying vegetation phenology
   a) Directly import MODIS/AVHRR leaf area index, green vegetation fraction
   b) Scale LAI, albedo, emissivity, and roughness length between its minimum and maximum values using time-varying GVF
Changes in a Nutshell (Conti.)
Largest modifications in Noah since 2004

4. Updated maximum snow albedo based on MODIS data

5. Improved the parameterization of time-varying snow albedo (U. Washington, NCEP)

6. Implemented a multi-layer urban canopy model (Centro de Investigaciones Energeticas, Spain; and Arizona State U.)
## New MODIS LULC

<table>
<thead>
<tr>
<th></th>
<th>USGS (1-km global)</th>
<th>MODIS (1-km global)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data Collection Instrument</strong></td>
<td>AVHRR (Advanced Very High Resolution Radiometer)</td>
<td>MODIS (Moderate resolution Imaging Spectroradiometer)</td>
</tr>
<tr>
<td><strong>Channels</strong></td>
<td>5 channels</td>
<td>15 land surface/vegetation dedicated channels</td>
</tr>
<tr>
<td><strong>Data Provider</strong></td>
<td>USGS</td>
<td>Boston University/NCEP</td>
</tr>
<tr>
<td><strong>Classification Scheme</strong></td>
<td>USGS</td>
<td>Modified IGBP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IGBP used in NPOESS and next-generation NWP models</td>
</tr>
<tr>
<td><strong># of Categories</strong></td>
<td>24</td>
<td>20</td>
</tr>
</tbody>
</table>
MODIS IGBP Landuse Data

• As an option to use instead of USGS landuse
• New dataset is available with the rest of the WRF geographical datasets
• New VEGPARM.TBL, LANDUSE.TBL has entries for both USGS and MODIS
• Hard-coded specific category numbers in Noah have been replaced with flags read from WRF input metadata
  – E.g., ISURBAN is the urban category index
  – IF(VEGTYP==1) is replaced by
  – IF(VEGTYP==ISURBAN) (in module_sf_noahlsm.F)
How to Use (20-category) Modis LU data

• At the WPS stage, namelist.wps
• &geogrid
• For USGS LU
  – geog_data_res = ‘10m’, ‘2m’, ‘30s’

• For Modis LU
  – geog_data_res = ‘modis_30s+10m’, ‘modis_30s+2m’, ‘modis_30s+30s’

• ncdump -h geo_em_d01.nc
• // global attributes:
  MMINLU = "MODIFIED_IGBP_MODIS_NOAH" ;
  – ISWATER = 17 ;
  – ISICE = 15 ;
  – ISURBAN = 13;
Original BU_IGBP 1-km global vegetation class map was developed based on MODIS data by Mark Friedl and his colleagues at Boston University. 3 new classes of tundra has been added by the Land Team EMC/NCEP led by Ken Mitchell.
Landuse map from USGS and MODIS

Vegetation Type (USGS LU)

Vegetation Type (Modis LU)

urban

USGS

Modis
Parameter scaling in time and Option to use 2dLAI (Leaf Area Index) map

- Background emissivity, background $z_0$, background albedo, and LAI can now change between minimum and maximum values depending on the Green Vegetation Fraction.
  - New VEGPARM Table has minimum and maximum Emissivity, $Z_0$, Albedo, and LAI

- Option to use 2d map of LAI
  - LAI field goes into the wrflowbdy file
  - Namelist option \textit{rdlai2d} to use the new map

- Code (contact Mike Barlage) is available as an adjunct to WPS, to put external LAI data from MODIS into a form that the WPS program \textit{metgrid.exe} can ingest
Snow albedo depends on snow age

- **Albedo treatment following Livneh**
  - This is an albedo decay scheme which reflects snow aging (subroutine ALCALC). In this scheme, the modified max snow albedo is calculated based on the time since last snow. This maxsnoalb is used for the calculation of albedo which is based on snow fraction.
  - rdmaxalb switch is added (false: from table, true:2d field)
- **72 hrs simulation starting with 20 Nov 2003, 12Z**
- **3km horizontal resolution (525X490 grid points)**
- **3 Runs with**
  - Control (CTL)
    - Reads the 2-d field of the max snow albedo
  - Control + Max snow albedo from the table
    - Reads the max snow albedo (high res) from the VEGPARM.TBL
  - Livneh’s formulation + Max snow albedo from table
5B.2: IMPROVING SNOW-RELATED PROCESSES IN THE NOAH LAND SURFACE MODEL.
Michael Barlage, Fei Chen, Mukul Tewari, Kyoko Ikeda (NCAR): Talk on 25 June 2009
ALBEDO (CTL Vs LIVNEH)

SNOWH

ALBEDO (CTL)

ALBEDO (LIVNEH)
Release of Multi-layer Urban Canopy Model (BEP)

- New urban namelist.input option sf_urban_physics which replaces the old option ucmcall
- \( \text{sf}_\text{urban}_\text{physics} = 0 \) (Bulk)
  - \( = 1 \) (Single layer (UCM))
  - \( = 2 \) (Multi-layer UCM)* New
- New URBPARM.TBL (has entries for both single and multi-layer UCM)
- BEP works with MYJ (PBL, option 2) and BouLac (PBL, option 8)
Multi-layer UCM (BEP)

- Considers variation in building height and building density of model grid cell.
- Surface Energy balance for roof, wall and road is solved at various levels within the urban canopy.
- Allows for first prognostic model level to be near street level. Near surface variables are determined prognostically.
Multi-Layer UCM in WRF

**namelist.input**

- sf_urban_physics = 1 (Noah UCM)
- sf_urban_physics = 2 (Multi-layer UCM)
- num_urban_layers = number street directions* vertical levels*wall layers

**module_physics_init**

------> CASE (LSMSCHEME) & sf_urban_physics = 1.or.2

urban_param_init: URBPARM.TBL

urban_var_init: fraction cover urban, urban class, T\text{wall}, T\text{road}, T\text{roof}

**module_surface_driver.F**

**module_sf_noahdrv.F**

sf_urban_physics = 1
Module_sf_urban.F

sf_urban_physics = 2
Module_sf_bep.F
Test Results Over Houston Domain

24 hr run starting
25 Aug 2000, 12Z
Landuse: Modis
Domain Size
101X101: domain1
175X157: domain2
220X187: domain3
217X199: domain4
Observations at Wharton and Bayland Park

Obs
Single Layer
Multi-Layer

NCAR
Surface Energy Budget computation

- New array NOAHRES [(in W/m²) is residual of Noah surface energy budget] is added to Registry

\[
\text{NOAHRES} = (\text{SOLNET} + \text{LWDN}) - \text{SHEAT} + \text{SSOIL} \quad \& \\
\& - \text{ETA} - (\text{EMISSI} \times \text{STBOLT} \times (T1^{\ast4})) - \text{FLX1} \quad \& \\
\& - \text{FLX2} - \text{FLX3}
\]

Where:
- Solnet = Net downward solar
- LWDN = Downward Longwave
- SHEAT = Sensible heat flux
- SSOIL = Soil Heat Flux
- ETA = Latent Heat Flux
- EMISSI = Emissivity
- T1 = Skin Temp
- FLX1 = Precip-snow sfc (W m-2)
- FLX2 = Freezing rain latent heat flux (W m-2)
- FLX3 = Phase-change heat flux from snowmelt (W m-2)
HRLDAS June
Noahres (10 June)
Miscellaneous Changes

- Reduction of downward deposition over snow as a function of near-surface bulk Richardson Number
- Latent heat (Ls vs. Lv) weighted by snow-cover fraction for subroutine PENMAN
- 2-timestep iteration for heavy precipitation
- Initialization of FLX3 for shallow-snow cases
- Glacial ice treatment
  - Modifications to better treat surface properties over permanent land ice
Summary

• Upgraded NoahV3.1 is released with WRFV3.1.
• The recent upgrades seems to produce reasonable results.
  – Initial results of ML-UCM vs Single Layer UCM are comparable.
  – Modis Landuse shows more recent development and may be a better alternative to use.