NOAH Land-surface Model & WRF

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Noah Land-Surface Model

- Stand-alone, uncoupled, 1-D column version
- Simulates soil moisture (both liquid and frozen), soil temperature, skin temperature, snowpack depth, snowpack water equivalent (and hence snowpack density), canopy water content, and the energy flux and water flux terms of the surface energy balance and surface water balance

Noah Land-Surface Model

- Main steps of the MAIN program:
  - read in control file (model configuration, site characteristics, and initial conditions)
  - open output file unit numbers
  - invoke time-step loop
  - read atmospheric forcing data and change its sign and units as expected by SFLX
  - interpolate monthly-mean surface greenness and albedo to julian day of time step
  - assign downward solar and longwave radiation from input forcing
  - calculate actual and saturated specific humidity from input atmospheric forcing
  - assign wind speed from input forcing
  - invoke LSM physics (CALL SFLX) to update state variables / sfc fluxes over one time step
  - write simulation output data each time step to four output files

Noah Land-Surface Model

- **Logic Tree:**
  - READCNTL: read control file (including LSM initial conditions and site characteristics)
  - ----------- Begin optional Multi-year Spin-Up Loop: if invoked by control file -------------
  - ------------------------------------- Begin: Time Step Loop -----------------------------------
  - READBND : read atmospheric forcing data (and observed validation variables)
  - MONTH-D: interpolate monthly albedo and veg greenness to current julian day
  - -- JULDATE: determine julian day for current time
  - QDATAP: calculate actual and saturated specific humidity
  - -- E (function) calculate vapor pressure
  - DQSDT (function): slope of sat specific humidity wrt air temp (needed in PENMAN)
  - -- DQS (function) intermediate value for routine dqsdt
  - **SFLX**: call to family of physics routines (see Sec 4.2) **** key call ****
  - PRTDAILY: write daily total values to output file 1 (once a day only)
  - PRTHYDF: write LSM water related variables to output file 2 (every time step)
  - PRTHMF: write LSM energy related variables to output file 3 (every time step)
  - PRTBND: write out input atmospheric forcing to output file 4 (every time step)
  - ----------------------------- End: Time Step Loop ---
  - ----------------------End: Optional Multi-year Spin-Up Loop------------------------------
  - STOP 0

Noah Land-Surface Model

- **SFLX**:

In using SFLX in a coupled atmospheric model, the output arguments needed from SFLX are:

- ETA - latent heat flux
- H - sensible heat flux
- T1 - skin temperature (from which to calculate upward longwave radiation)
- ALBEDO - (including snowpack effects) for calculating upward solar radiation

Noah Land-Surface Model

- **SFLX logic Tree**:
  - REDPRM -- set land-surface parameters
  - -- set soil-type dependent parameters
  - -- set veg-type dependent parameters
  - -- set other land-surface parameters
  - SNO_NEW – update snow depth and snow density to account for new snowfall
  - SNFRAC – determine snow cover fraction
  - ALCALC – determine surface albedo (including snow cover fraction)
  - TDFCND – compute soil thermal diffusivity
  - SNOWZo – compute snow roughness length (currently a null/no effect process)
  - **SFCDIF -- calculate surface exchange coefficient for heat/moisture**
  - PENMAN – compute potential evaporation
  - **CANRES – compute canopy resistance**

Noah Land-Surface Model

- **SFLX logic Tree (cont)**:

  - **NOPAC** – this path invoked if ZERO snowpack on ground and zero snowfall (frozen precip)

    -- surface skin temperature updated via surface energy balance

    - **SMFLX** – compute a) surface water fluxes and b) layer soil moisture update
    - **SHFLX** – compute a) ground heat flux and b) layer soil temperature update
  - **SNOPAC –** this path invoked if NONZERO snowpack on ground and/or NONZERO snowfall
    - surface skin temperature updated via surface energy balance
    - new patchy snow cover treatment in above
    - snowmelt computed if thermal and available energy conditions warrant

    - **SMFLX** – see above
    - **SHFLX** – see above

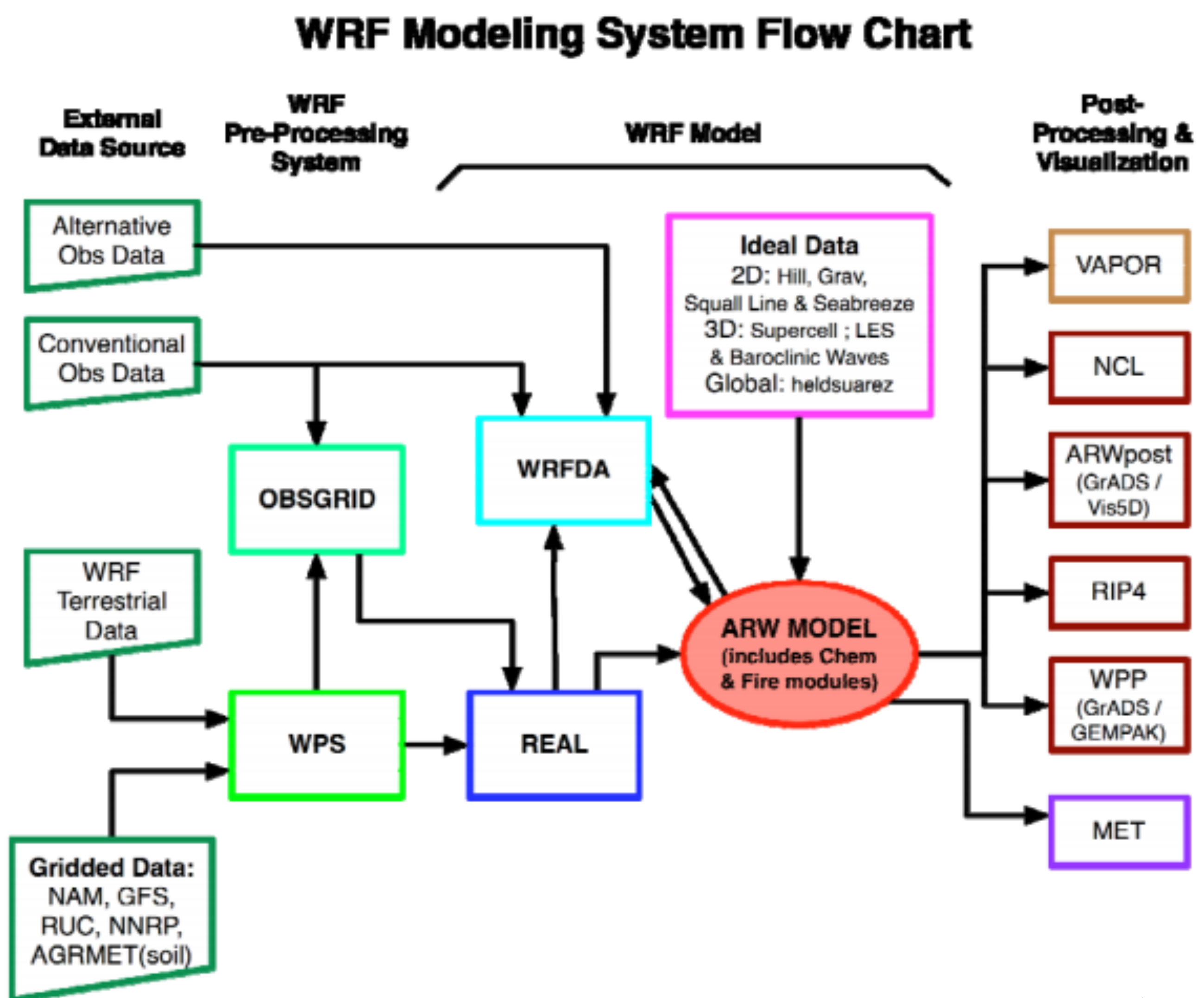
      SNOWPACK – update snow depth and snow density owing to snow compaction

Noah Land-Surface Model

- SFCDIF:
  - SFCDIF (Z, Z0, T1V, TH2V, SFCSPD,CZIL, CM, CH)
  - Calculate surface layer exchange coefficients via iterative process --- Based on CHEN ET AL (1997, BLM)
  - CM & CH are technically conductances.

WRF

- The ARW is suitable for use in a broad range:
  - Idealized simulations (e.g. LES, convection, baroclinic waves)
  - Parameterization research
  - Data assimilation research
  - Forecast research
  - Real-time NWP
  - Hurricane research
  - Regional climate research
  - Coupled-model applications



By ARWUserGuide V3

WRF

- WRF modeling system consists of these major programs:
  - The WRF Preprocessing System (WPS)
  - WRF- Var
  - ARW solver
  - Post-processing & Visualization tools

WPS

- is used primarily for real-data simulation:
  - Defining simulation domains;
  - Interpolating terrestrial data (such as terrain, landuse, and soil types) to the simulation domain;
  - Degribbing and interpolating meteorological data from another model to this simulation domain

WRF-DA

- can be used to ingest observations into the interpolated analyses created by WPS

- can also be used to update WRF model's initial condition when WRF model is run in cycling mode

ARW Solver

- This is the key component of the modeling system, which is composed of several initialization programs for idealized, and real-data simulation, and the numerical integration program

- It contains full physics options for land-surface, planetary boundary layer, atmospheric and surface radiation, microphysics and cumulus convection

ARW surface physics

- Surface Layer Schemes
  - MM5 similarity theory: uses stability functions from Paulson (1970), Dyer and Hicks (1970) and Webb (1970)
  - Eta Similarity theory: based on Monin-obukhov theory
  - PX similarity theory: in the form of a quasi-laminar boundary layer resistance accounting for differences in the diffusivity of heat, water vapor, and trace chemical species

ARW surface physics

- LSM: lower boundary condition for PBL
  - 5-layer thermal diffusion
  - Noah LSM
  - Rapid Update Cycle (RUC) Model LSM
  - Pleim-Xiu LSM
  - Urban Canopy Model (run as an option with the Noah)
  - Ocean Mixed-Layer Model

ARW surface physics

- PBL:

  responsible for vertical sub-grid-scale fluxes due to eddy transports in the whole atmospheric column, not just the boundary layer

  - Medium Range Forecast Model PBL
  - Yonsei University (YSU) PBL
  - Melloro-Yamada-Janjic(MYJ) PBL
  - Asymmetric Convective Model 2 (ACM2) PBL