



Land-Hydrology Modeling at NCEP



Michael Ek, Jesse Meng, Rongqian Yang, Helin Wei, Vince Wong, Yulong Xia, Yihua Wu, Weizhong Zheng, Jiarui Dong, and Sid Katz*

National Centers for Environmental Prediction/Environmental Modeling Center (NCEP/EMC)

National Oceanic and Atmospheric Administration/National Weather Service
NOAA Science Center, 5200 Auth Road, Room 207, Suitland, Maryland 20746 USA

*NCEP Climate Prediction Center (CPC)

contact information: michael.ek@noaa.gov



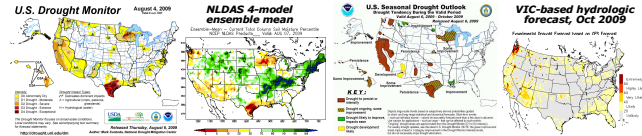
Uncoupled Hydrology

North American Land Data Assimilation System (NLDAS)

- Uncoupled land model simulations: Noah, VIC, Mosaic, SAC.
- 1/8-deg domain over continental US.
- Common surface forcing from hourly North American Regional Reanalysis & disaggregated daily gauge precipitation.
- Output: surface fluxes & hydrological output such as soil moisture, snowpack, & runoff (1979-2008 retrospective mode, 15-year spinup, and 28-year model climatology for each model).
- Uncoupled seasonal hydrological prediction mode uses VIC model driven by 3 sources for seasonal forecast of surface forcing; 20 ensemble members (Bayesian merging) used to generate 1-6 month ensemble seasonal prediction products.
- Cooperative project with NASA/Goddard/Hydrol Sci. Branch (HSB), Princeton Univ., Univ. Washington, NOAA/NWS Office of Hydrologic Development (OHD), sponsored by NOAA/Climate Program Office/Climate Prediction Program for the Americas.
- NLDAS output used by NCEP/CPC for drought monitoring and seasonal prediction, with NLDAS output provided to the National Integrated Drought Info. System (NIDIS, drought.gov).
- NLDAS website: www.emc.ncep.noaa.gov/mmb/nldas

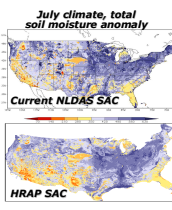
Current real-time monitoring

Seasonal forecasting



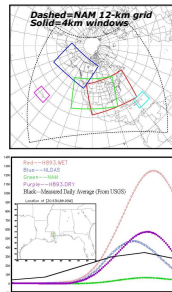
High-resolution hydrologic modeling

- Hydrologic Rainfall Analysis Project (HRAP) 5-km grid using upgraded SAC-HT/SNOW17.
- Downscaled 30-yr NLDAS forcing to HRAP grid used in 30-year retrospective run over continental US (1979 to 2008, 2-step multi-year spin up), with 6-hourly output.
- Hydrological applications, including real-time runs support drought & flood monitoring.
- Cooperative project with OHD; CPPA support.

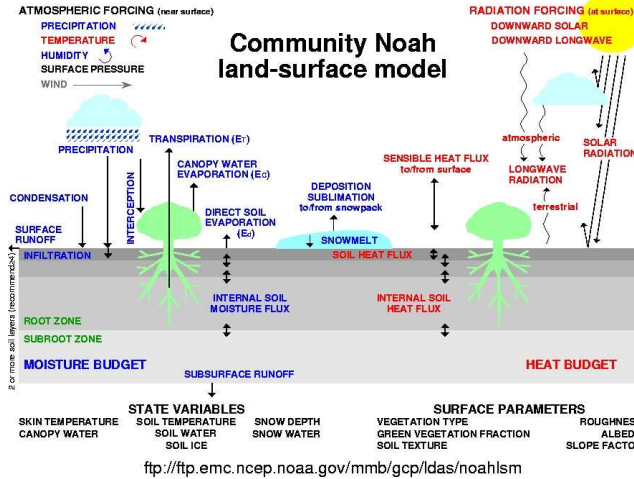


Regional & Hurricane

- NCEP North American Mesoscale (NAM) operational model uses community Weather Forecasting and Research/Non-hydrostatic Mesoscale Model (WRF/NMM), includes the unified NCEP-NCAR version of Noah LSM.
- WRF hurricane configuration (HWRF) with Noah LSM shows no degradation in hurricane track & intensity compared to slab soil model.
- Noah runoff input to river-routing model to produce streamflow, not possible with slab.
- HWRF with NAM ("DRY") soil moisture initial conditions (ICs) shows similar streamflow as operational NAM, better than with (typically "WET") GFS ICs, with NLDAS streamflow best.



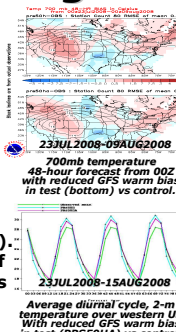
Noah Model Development



- NCAR (F. Chen et al at RAL): NCEP-NCAR unified Noah land surface model (LSM) development for mesoscale Weather Research & Forecasting model (used as NCEP mesoscale NAM).
- Univ. Arizona (X. Zeng et al): surface-layer formulations, snowpack physics and related data sets.
- Univ. Washington (D. Lettenmaier et al) snowpack physics.
- Standardizing Noah LSM in all NCEP modeling systems.
- NASA/Goddard/HSB (C. Peters-Lidard et al): NASA/LIS.
- Univ. Texas (Z.-L. Yang et al): Noah-MP (multi-physics options) with major new components, e.g. multi-layer snowpack, dynamic vegetation, carbon fluxes, and groundwater.
- Land-Hydro website: www.emc.ncep.noaa.gov/mmb/gcip.html

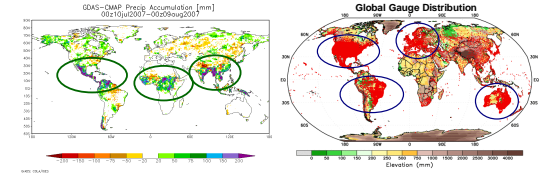
Global Medium-Range

- Global Forecast System (GFS): global forecast model T382L64 (~35-km resolution with 64 levels) runs to 16 days, with surface-layer/Noah LSM providing surface fluxes.
- GFS assumes equal momentum & thermal roughness, resulting in large surface heat exchange coefficients & excess upward (downward) sensible heat flux for unstable (stable) conditions, leading to warm (cold) atmospheric (surface) temperature biases for unstable conditions (e.g. daytime) and the opposite case for stable conditions (e.g. night).
- New momentum & thermal roughness (fct of GVF, via Univ. Arizona) addresses these biases with positive effect in GVF tests, e.g. reduced daytime atmospheric temperature warm bias.



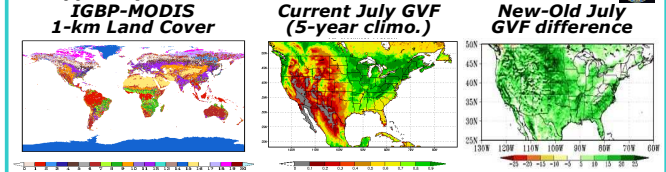
Climate Model & Reanalysis

- NCEP Climate Forecast System (CFS): seasonal forecasts using coupled land-atmos-ocean model (based on GFS/ocean models).
- Land model physics upgraded from OSU to Noah in CFS.
- Noah LSM runs offline using Global Land Data Assimilation System (GLDAS) under NASA Land Information System (LIS).
- Combined use of Noah LSM with GLDAS initial conditions improves summer season CFS/Noah precipitation prediction over continental US, especially for ENSO-neutral years.
- GLDAS/Noah/LIS infrastructure and coupled CFS/Noah implemented in CFS Reanalysis & Reforecast (CFSRR), with obs. precip. forcing; 31-year CFSRR data set to be released 2011.
- Land component research of CFS/CFSRR via CPPA support.



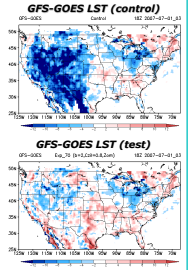
Land Data Sets

- Land-use (vegetation) type and Green Vegetation Fraction (GVF, fractional 0.0-1.0) used to calculate surface moisture flux.
- New 20-class modified IGBP-MODIS land-use (tundra classes added) data set vs. current 24-class USGS data set.
- New weekly 0.144-deg AVHRR/NDVI-based GVF (& companion near real-time GVF) with 24-year climatology vs. current monthly GVF with 5-year climo. generally shows increased GVF.
- Tests in mesoscale NAM model with IGBP-MODIS land-use and new GVF showed reduced near-surface warm/moist biases.
- Support by Joint Center for Satellite Data Assimilation.



Data Assimilation

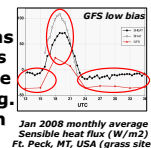
- Gridpoint Statistical Interpolation (GSI) used in NCEP Global & Regional data assimil.
- Due to large daytime cold bias in land skin temperature (LST), most satellite data related surface sensitive channels rejected in the GSI.
- New momentum & thermal roughness (fct of GVF) tests in GFS show greatly reduced arid region LST bias during daytime/warm season.
- New microwave emissivity model (NESDIS) together with better LST results in reduced calculated brightness temperature cold bias (infrared & microwave satellite sensors), so more GSI satellite data use.



GEWEX Projects



- Coordinated Energy & water cycle Observations Project (CEOP): NCEP is providing gridded & time series data sets used e.g. for Noah LSM evaluation and development.



- GEWEX/GLASS/LoCo: Determine "local" land-atmos. coupling metrics, e.g. role of soil moisture.