Introducing Human Influences in Land-Surface models at NCEP

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"Including Water Management in Large Scale Models"
Centre National de la Recherche Scientifique (CNRS)
Gif-sur-Yvette, France, 28-30 September 2016
Traditionally, from the perspective of Numerical Weather Prediction (NWP) and (coupled atmosphere-ocean-land-ice) Climate Modeling, a land-surface model provides quantities as boundary conditions:

- **Surface energy budget** (sensible & latent turbulent heat fluxes, ground heat flux, emitted longwave and reflected shortwave radiation)
- **Surface water budget** (including groundwater)
- **Surface momentum exchange**

*Human influences must be accounted for in these as part of urban regions, and for management of water, e.g. for agricultural uses & flood control.*
• We must more properly represent & close the (surface) energy budget and water budget (hydrological cycle) to provide surface boundary conditions in weather and climate models as they expand their role in more fully-coupled Earth System models.

• It’s a careful “bookkeeping” job for energy, water, and momentum, including the human influence on these quantities.
Proper land initial conditions (e.g. via remote sensing), and improved land model physics parameterizations, including human influences.

Realtime greenness should reflect human impact

Land-cover change/deforestation

Urban areas/model

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Basins where water is managed, river "fragmentation" and regulation. 48% of world's river volume moderately or severely affected by dams today, would nearly double if all dams planned or under construction are completed in the future.

Aquifers: local/shallow, complex, major groundwater (left), and groundwater re-charge rate from very low to very high (right).

Water use stress

- Minimal use
- Moderate stress
- Stress
- No stress
- High stress

www.feow.org/maps/threat/surface_water_abstraction_stress_to_rivers

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• Jarvis-Stewart “big-leaf” canopy conductance; canopy interception; direct soil evap; soil hydraulics/thermodynamics, including veg. effect on thermal conductivity; patchy/fractional snow cover effect on surface fluxes; snowpack density/snow water equivalent; freeze/thaw soil physics.

- **Urban effects on heat, water, momentum.**
- **Irrigation land-use type.**
- **No other explicit effects of water management.**
- **Noah-MP: includes groundwater.**

**Unified NCEP-NCAR Noah Land Model**

- Noah for NWP & seasonal prediction, coupled with NCEP short-range NAM, medium-range GFS, seasonal CFS, and HWRF, uncoupled NLDAS & GLDAS, etc.

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Terrestrial Water in Noah LSM: Current Capabilities

Irrigated gridboxes or subgrid tiles, Urban regions

- Urban land-use (one vegetation type) & small vegetation fraction, “adjusted” hydraulic/thermal properties to approximate an urban heat island. **But no explicit accounting in water budget.**

- Irrigation land-use type as an option in Noah LSM; soil moisture held at field capacity. **But no explicit accounting in water budget.**
Terrestrial Water in Noah LSM: Current Capabilities
National Water Model: Noah-MP+WRF-Hydro; no management

Video Unavailable
Including Water Management in Large Scale Models

CNRS, Gif-sur-Yvette, France, 28-30 September 2016

- Proper initial conditions (e.g. via remote sensing) with land data assimilation, and improved land model physics parameterizations, to include human influences. Compare with in situ measurements/studies.

NESDIS Soil Moisture Operational Product System (SMOPS): Blended Microwave.


Surface Water Ocean Topography (SWOT): Terrestrial Surface Water.

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Summary

In a fully-coupled *Earth System*, land models must include human impact on heat, moisture/water, and momentum budgets (e.g. water management, urban regions), where land models provide boundary conditions for *Weather & Climate* models with connections to:

- **Hydrology**: soil moisture & ground water/water tables, irrigation and groundwater extraction, water quality, streamflow and river discharge to oceans, drought/flood, lakes/reservoirs.

- **Biogeochemical cycles**: application to ecosystems, both terrestrial & marine, dynamic vegetation and biomass, carbon budgets, etc, including *Air Quality*: interaction with boundary-layer, biogenic emissions, VOC, dust/aerosols, etc.

Rely on remote sensing & land data assimilation systems. More constraints/less degrees of freedom, i.e. must simultaneously close energy & water budgets, BGC cycles, etc.

*We need to get the right answers for the right reasons!*
Local Land-Atmosphere Interactions

- incoming solar
- wind
- moisture flux
- canopy conductance
- soil moisture
- soil temperature
- soil heat flux
- reflected solar albedo
- radiation
- surface layer & ABL
- land-surface processes

- above-ABL dryness
- cloud cover
- precipitation
- entrainment
- turbulence
- temperature
- emission
- reflected solar
- incoming solar
- positive feedback for C3 & C4 plants, negative feedback for CAM plants
- *negative feedback above optimal temperature

Feedbacks:
- positive
- negative 12/50
Hierarchical Model Parameterization Development
Simple-to-More Complex

- **Simulators**
  - Radiation
  - Clouds & convection
  - Microphysics
  - Boundary-Layer
  - Surface-layer
  - Land-Hydrology
  - Sea-ice
  - Ocean, Waves

- **Interaction tests**
- **Column tests**
- **Limited-area**
- **Regional & Global**

- **Simulators**: test submodel parameterizations at **process level**, e.g. radiation-only, land-only, ...
- Testbed data sets to develop, drive & validate submodels: **observations, models, idealized, with “benchmarks” before adopting changes.**
- **Submodel interactions, with benchmarks.**
- Full columns, **with benchmarks.**
- Limited-area/3-D (convection) **with benchmarks.**
- Regional & global NWP & seasonal climate, **with benchmarks.**

- **More efficient** model development, community engagement, R2O/O2R & computer usage.

E.g. WCRP/GEWEX activities!
Including Water Management in Large Scale Models

Uh oh! These surface fluxes don’t look so good.

...and you’re also going to need a land-atmosphere interaction alignment.

GLOBAL MODELERS: But how much will this cost to fix?!

Well... at least several more funding cycles.

Ugh! Look at the Hydrology & WATER MANAGEMENT in this thing!