Assessment of CFSv2 terrestrial hydrologic processes

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CFSv2 Evaluation Workshop
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CFSv2 and CFSR issues related to land hydrology and comparisons over land

1. Comparisons of CFSv2 and NMME skill over land. This is critical for driving seasonal hydrologic forecast systems.

2. Areas predicted under drought (CFSR)

3. Seasonal Hydrologic Forecasting system and drought forecasting (CFSv1 and CFSv2).

4. Land-atmospheric coupling over the SE US

5. Hydrologic processes related to snow predictions. CFSv2 uses Noah 2.7 as its LSM while EMC runs Noah 2.8 in their NLDAS system.

6. Hydrologic sensitivity of Noah 2.7 compared to other LSM. Implications for basin discharge forecasts due to precipitation and temperature errors as well as using CFSv2 for decadal and long-term projections (e.g. COLA).
Covariance Matrix: T2M correlation (198201-200912, w/o seasonality)

Month-1 fcst

Month-2 fcst
### Covariance Matrix: PR correlation (198201-200912, w/o seasonality)

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**Month-1 fcst**

**Month-2 fcst**
1 Month Temperature (significant at 95%)

Model

Correlation (Pearson)
1 Month Precipitation (significant at 95%)

Model

Correlation (Pearson)
Change in skill score over equally weighted NMME for month-1 forecast averaged during Aug-Mar

T2M

PR
Time Series of **Soil Moisture Percentiles and Area in Drought**: GLOBAL
Time Series of **Soil Moisture Percentiles and Area in Drought**: USA

**USA mean soil moisture percentile 1979–2010**

**USA extent of drought 1979–2010**

NLDAS2 MME
20CR
CFS-R
ERA-int
MERRA
Representation of Drought Events

---|---|---|---
NLDAS2 | 20CR | CFS-R | ERA-int
MERRA
Schematic illustration of the seasonal hydrologic ensemble prediction system
Soil moisture percentile in Jan 2008

VIC Off-line (Control) for Jan-08

1 Month Lead

3 Month Lead

ESP CFSv1 CFSv2
Correlation with Predicted Runoff for the first two months over Eastern US

- Cold season is better than warm season.
- Skill decreases dramatically in the second month.
- Due to the effects of initial conditions, CFSv1 and CFSv2 have more obvious improvement for month-2.
### Onset
Forecast of Low flow – Forecast initiated from Avg. flow

### Continuation
Forecast of Low flow – Forecast initiated from Low flow

### Recovery
Forecast of Avg. – Forecast initiated from Low flow

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<th>Month</th>
<th>Probability of Detection</th>
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<td>1 Month</td>
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#### Area Under ROC Skill Score (ESP)

- **ESP**
- **CFSV1**
- **CFSV2**

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<th>Lead Time</th>
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CFSv2 land-atmospheric coupling: Humidity Index – Convective Triggering Potential

No Coupling
(Less than minimum number of points)

Dry Coupling
(Drier than Reference)

Transition
(No Difference from Reference)

Wet Coupling
(Wetter than Reference)
Coupling in the SE tends to last ~25 days in one state. Transition related to atmospheric processes but maintenance is probably has a land component.
Binned evolution of soil moisture and precipitation from dry (red) and wet (blue coupling for off-line (VIC – NLDAS2), CFSR and CFSv2 (month 1). Note that initial SM has little impact on initiation of wet and dry coupling.

Average Soil Moisture and Precipitation for event duration for CFSR (Reanalysis) and CFSF (Forecast).
Bias in monthly mean precipitation with duration of coupling events.

Biased wet under dry coupling

Biased dry under wet coupling
Comparison of Snow Cover Area (%)

CFS-R (12H, 01April)

2005

NLDAS - NOAH (12H, 01April)

2005
Noah 2.7 snow cover prediction problems. Work at UW has shown that snow albedo (aging, etc.), atmospheric stability over snow covered regions and refreezing of melt water are the major problems related to snow processes. In Noah 2.8, the snow albedo correction has been implemented. (work at U Washington by Ben Livneh and Dennis Lettenmaier)

- Negative SWE bias noted in Noah LSM.
- Important for partitioning radiative inputs, fluxes (coupled mode) and capturing soil moisture anomalies and streamflow timing (hydrology).
- Prompted offline testing of various model components
Conclusions

1. CFSv2 is significantly more skillful than CFSv1 and **most** other NMME models (and EUROSIP models – see Yuan and Wood, GRL, 2011).
2. Drought prediction – especially the recovery of drought – is a challenge
3. Land coupling is a challenge, with systematic wet (dry) biases during dry (wet) conditions – a push to the mean.
4. There are still issues related to Noah2.7 with respect to snow processes, climate sensitivity, etc. -- work to do!