River basin budgets from ERA40

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In this paper hourly river basin-scale budgets are analyzed from ERA40 for the Mississippi, Mackenzie and Amazon rivers for 1990-1992. For the Mississippi comparisons are made with ERA15 and basin averaged observations. For the Mackenzie, comparisons are made with MAGS data.

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## ERA40 AMERICAS RIVER BASINS

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[Also: Columbia and Colorado in NA]
ERA40
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages

Large-scale precipitation spin-up
Months 11-4 ERA40
0-12: 12-24: 24-36h
1 : 1.48 : 1.56

Convective precipitation spin-down
Months 6-9 ERA40
0-12: 12-24: 24-36h
1 : 0.92 : 0.81
ERA15
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages

Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.42

Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.24
COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages

ERA15
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages
**ERA40**

**BASIN PRECIPITATION**

**Missouri River**

**1990-1992 monthly averages**

Large-scale precipitation spin-up

- Months 11-4 ERA40
- 0-12: 12-24: 24-36h
- 1 : 1.20 : 1.18

Convective precipitation spin-down

- Months 6-9 ERA40
- 0-12: 12-24: 24-36h
- 1 : 1 : 0.98
ERA15
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages

Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.49

Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.22
COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages

ERA15
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages
ERA40
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages

Large-scale precipitation spin-up
Months 11-4 ERA40
0-12: 12-24: 24-36h
1 : 1.48 : 1.53

Convective precipitation spin-down
Months 7-9 ERA40
0-12: 12-24: 24-36h
1 : 0.91 : 0.85
ERA15
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages

Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.36

Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.17
COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages

ERA15
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages
ERA40
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages

Large-scale precipitation spin-up
Months 11-4 ERA40
0-12: 12-24: 24-36h
1 : 1.56 : 1.61

Convective precipitation spin-down
Months 6-9 ERA40
0-12: 12-24: 24-36h
1 : 0.98 : 0.83
ERA15
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages

Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.32

Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.21
COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages

ERA15
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages
ERA40
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages

Large-scale precipitation spin-up
Months 11-4 ERA40
0-12: 12-24: 24-36h
1 : 1.62 : 1.73

Convective precipitation spin-down
Months 6-9 ERA40
0-12: 12-24: 24-36h
1 : 0.99 : 0.76
ERA15
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages

Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.32

Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.12
COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages

ERA15
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages
ERA40 - VIC  

ERA40 evaporation generally higher than VIC model estimate. Note peaks in $\Delta$(Evap) in growing season which shift in phase from south to north, which suggest model needs vegetation seasonality.

VIC model [Maurer et al, 2001]
ERA  Evaporation high in winter
ERA >VIC in summer except for north
ERA40 >ERA15 in south and east, but not in west and north
RUNOFF BY BASIN

ERA Runoff low << VIC especially in winter

ERA40 < ERA15 except when ERA40 has surface runoff over frozen ground
SNOW BUDGET

Missouri

Upper Mississippi

ERA40 Snowmelt > snow evaporation
Seasonal residual small [24-36h FX]

ERA15 Snow evaporation > snowmelt
Seasonal residual larger [12-24h FX]
DIURNAL CYCLE OF PRECIPITATION

Cool season (Large-scale Precipitation)

Warm Season (Convective Precipitation)

Unrealistic diurnal cycle: Convective peaks near local noon
Conclusions – Mississippi basin

1) ERA40 precipitation spinup differs from ERA15
   Both have spinup of large-scale precipitation
   ERA40 has generally spin-down of convective precip.
   ERA40 has generally a different partition, with more large scale
   precip. than ERA15

2) ERA40 has generally more total precipitation than ERA15, especially
   in the east and south-east.

3) Evaporation in ERA40 >ERA15 in south and southeast, and greater
   than VIC model estimate in mid-summer in south and east.
   Peaks in Δ(Evap) between ERA40 and VIC estimate in growing
   season, shift in phase from south to north, which suggests model
   needs vegetation seasonality.

4) ERA40 runoff is generally less than smaller than ERA15, which was
   less than observed, especially in winter and spring.

5) ERA40 snow budget is better than ERA15, with less snow
   evaporation and more snowmelt.

6) ERA40 diurnal cycle of precipitation, with a morning or noon
   maximum is still in error [as in ERA15] : data has evening and
   night-time peaks in precipitation.
**Ratio of 1990-92 ERA precipitation to ‘VIC’ observations**  
[Maurer et al., 2001 for Mississippi]

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<thead>
<tr>
<th>Basin</th>
<th>Prec.[VIC] (mm)</th>
<th>E40 0-12</th>
<th>E40 12-24</th>
<th>E40 24-36</th>
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**Mackenzie River Basins**

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<table>
<thead>
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<tbody>
<tr>
<td>33</td>
<td>Peel/Delta</td>
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<tr>
<td>34</td>
<td>Great Bear Lake</td>
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<tr>
<td>35</td>
<td>Great Slave Lake</td>
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<td>36</td>
<td>Liard</td>
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<td>38</td>
<td>Peace (West)</td>
</tr>
<tr>
<td>39</td>
<td>Athabasca</td>
</tr>
</tbody>
</table>

**Verification data from the MAGS project**
[Paul Louie, AES, Canada]

**Test of model at high latitudes: frozen physics**
Peel/Delta (#33)

Spinup small at 24-36h
LSP CP
1.09 1.15

ERA40 > Observations especially June, July when convective
Great Bear Lake (#34)

Spinup small at 24-36h
LSP CP
1.10 1.27

ERA40 > Observations especially June, July when convective, but not September
Great Slave Lake (#35)

Spinup at 24-36h
LSP CP
1.13 1.34

ERA40
> Observations June, July
Liard (#36)

Spinup at 24-36h
LSP CP
1.18 1.50

ERA40 > Observations
Peace (#37 & 38)

Spinup at 24-36h
LSP CP
1.16 1.40

ERA40 > Observations except Aug., Sept
**Athabasca (#39)**

Spinup small at 24-36h

LSP CP

1.11 1.16

ERA40 > Observations in June, July; less in August
Western mountainous basins of Mackenzie with strong spring melt and runoff
Eastern Mackenzie basins with less dramatic spring melt and runoff
Comparison of monthly mean basin temperatures

Compared with monthly mean data [Louie], ERA40 is warm in winter, cool in summer [except far north]
Conclusions – Mackenzie River

1) ERA40 precipitation spinup differs from the Mississippi
   Large-scale is +9-18% at 24-36 hr [much smaller than Mississippi]
   Convective is +15-50% at 24-36 hr [but note convective precip is smaller]

2) ERA40 precipitation generally > MAGS observations [from Louie]
   especially in June, July, but not in August, September
   Suggests there may be problems with model convective precip in
   June, July

3) Liquid and frozen budgets improved
   Spring melt gives runoff peak [too early]
   Snow evaporation reduced

4) ERA40 monthly mean temperatures warmer in winter and cooler in
   summer than observed [except in far north]
ERA40 basin averages for S. America. Alan Betts and Pedro Viterbo

Basins as implemented for S. America showing ERA40 grid, including 5 sub-basins for the Amazon and the Rio de la Plata

# 40  Rio de la Plata
# 41  Amazon: Xingu + Tapajoz+ Trombetas+Uatuma
# 42  Amazon: Madeira River
# 43  Amazon: Solimoes
# 44  Amazon: Negro
# 45  Amazon: Purus

[Amazon basin coordinates based on file from Brad Newton (see below); Rio de la Plata basin definition from Hugo Berberry]

Original schematic (1999) of proposed basins superimposed on file from Brad Newton

Some *preliminary* results from ERA40 (T-159, L60) follow, showing monthly precipitation from 0-12, 12-24, 24-36 hr forecasts, run from analysis cycle [averages for 1990-1992], and hydrologic budget.
Rio de la Plata (#40)

Spinup small; seasonal cycle of precipitation & evaporation
Xingu/Tapagos/Trombetas/Uatuma (#41)

Small spinup in wet season: Small spindown in dry season
Little seasonal cycle of evaporation
Madiera (#42)

Spinup small; strong seasonal cycle
Solimoes (#43)

Spinup of 12-19% is largest of any in Amazon and differs from nested #45; highest rainfall and runoff; seasonal cycle of evaporation weak
Negro (#44)

Small Spindown; later rainfall and runoff maximum; seasonal cycle of evaporation very weak
Purus (#45)

Small Spindown; weakest seasonal cycle
Note nested in #43, which has different spinup. Effect of Andes?
Diurnal cycle of convective and large-scale precipitation

Tendency for precipitation peaks a few hours after sunrise
Conclusions – South America

1) No basin-scale verification data as yet: there is point LBA data

2) Tropical spinup differs from Mid-lats: generally small

Spinup of S. American basins

<table>
<thead>
<tr>
<th>Basin</th>
<th>Precip (mm) 0-12 h</th>
<th>Ratio 12-24</th>
<th>Ratio 24-36</th>
<th>L-S Precip. 12-24</th>
<th>Convective 12-24</th>
<th>Convective 24-36</th>
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3) Seasonal cycle for evaporation for most Amazon basins small, even if large annual cycle in precipitation [not looked yet at nudging].

4) ERA40 has diurnal cycle precipitation error, with 1200UTC maximum

   [see also Rondônia gauge networks for LBA]