River basin budgets from ERA40

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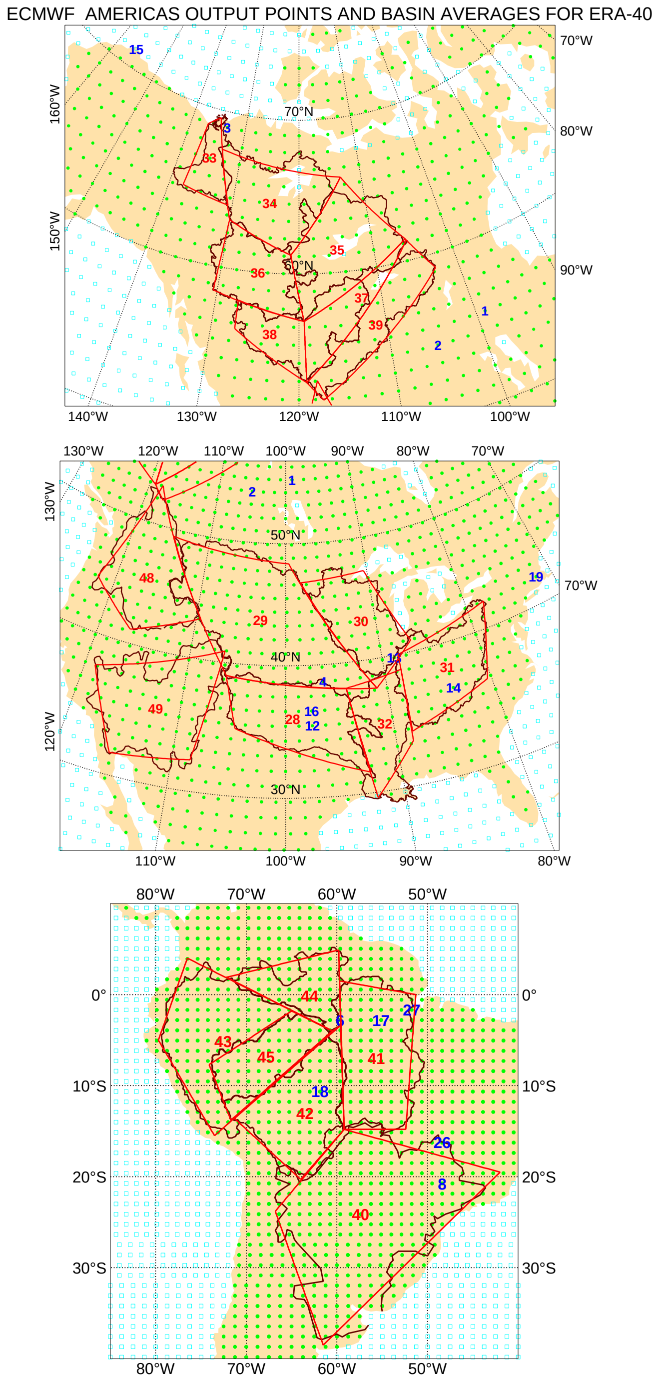

In this paper hourly river basin-scale budgets are analyzed from ERA40 for the Mississippi, Mackenzie and Amazon rivers for 1990-1992. For the Mississippi comparisons are made with ERA15 and basin averaged observations. For the Mackenzie, comparisons are made with MAGS data

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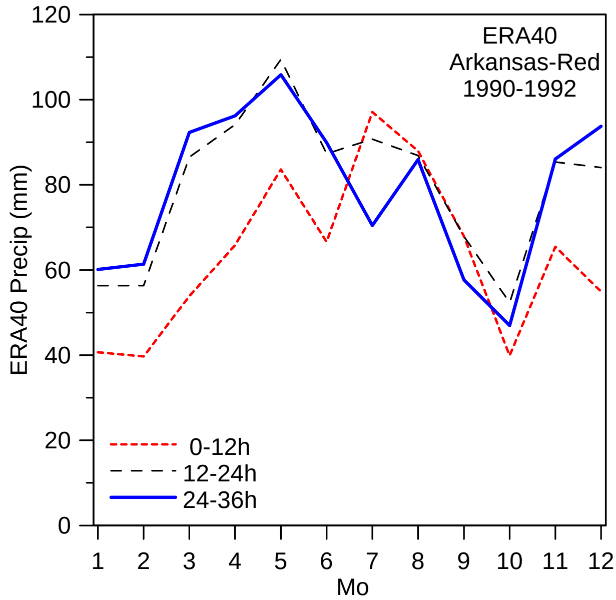
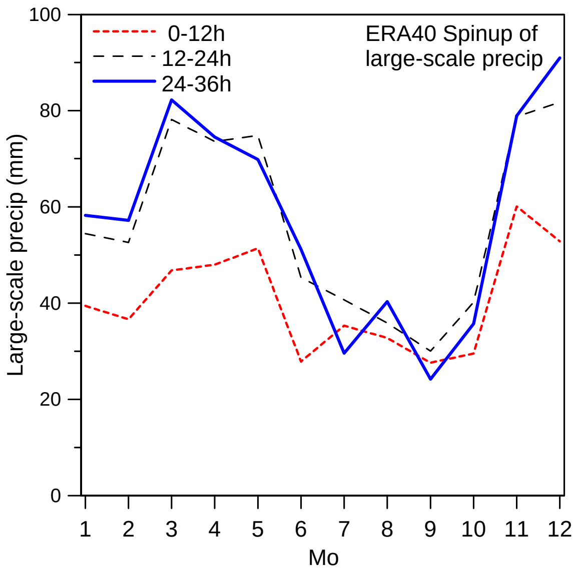
ERA40 AMERICAS RIVER BASINS

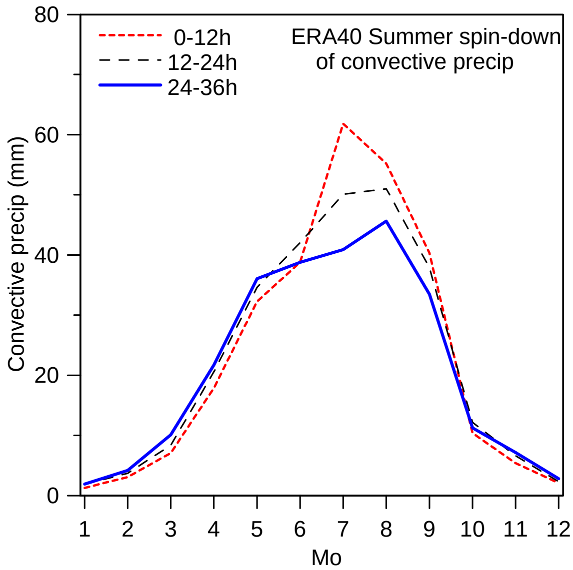
Index #	MISSISSIPPI	LS Mask
28	Red-Arkansas	1
29	Missouri	1
30	Upper Mississippi	1
31	Ohio	1
32	Lower Mississippi/Tennessee	1
	MACKENZIE	1
33	Peel/Delta	1
34	Great Bear Lake sub-basin	0.964
35	Great Slave Lake sub-basin	0.968
36	Liard	1
37	Peace (East)	1
38	Peace (West)	1
39	Athabasca	1
40	RIO DE LA PLATA	1
	AMAZON	
41	Xingu/Tapajos/Trombetas/Uatuma	1
42	Madiera	1
43	Solimoes	1
44	Negro	1
45	Purus	1

[Also: Columbia and Colorado in NA]

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



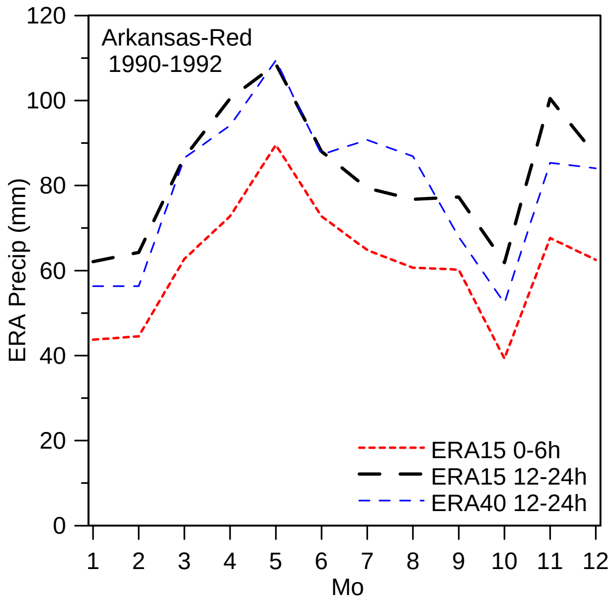


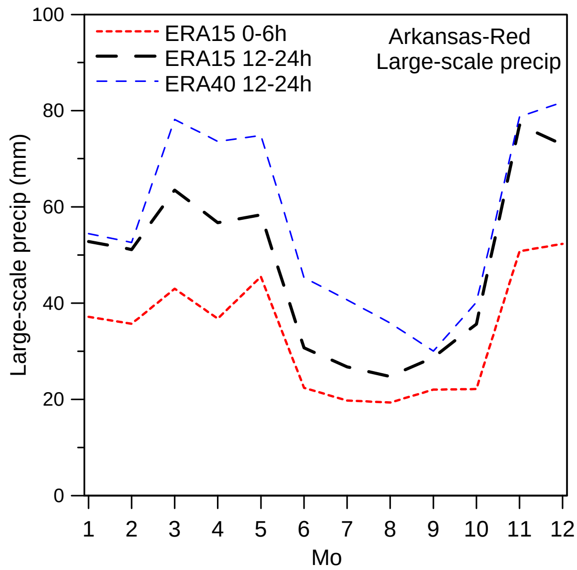


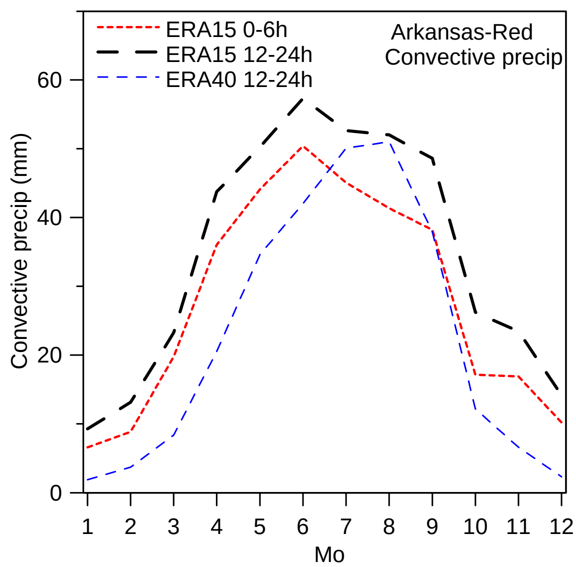
Large-scale precipitation spin-up
Months 11- 4 ERA40
0-12: 12-24: 24-36h
1 : 1.48 : 1.56

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





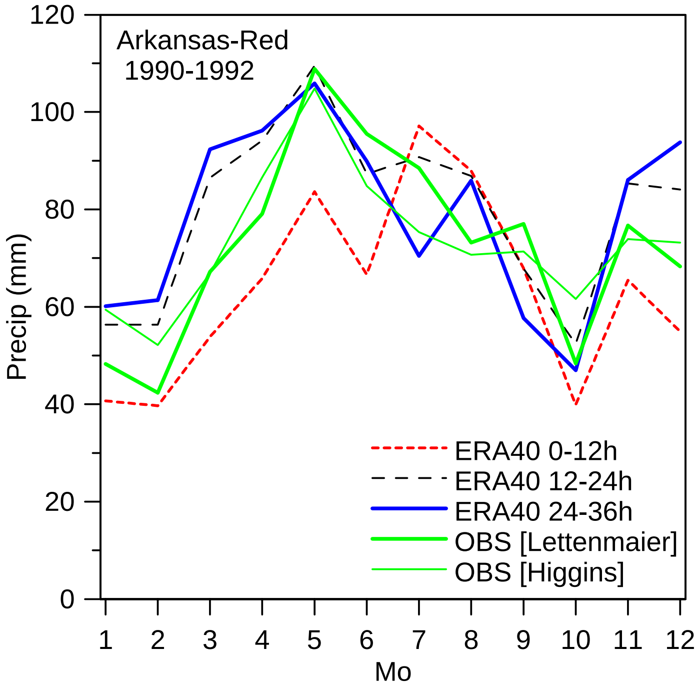


Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.42

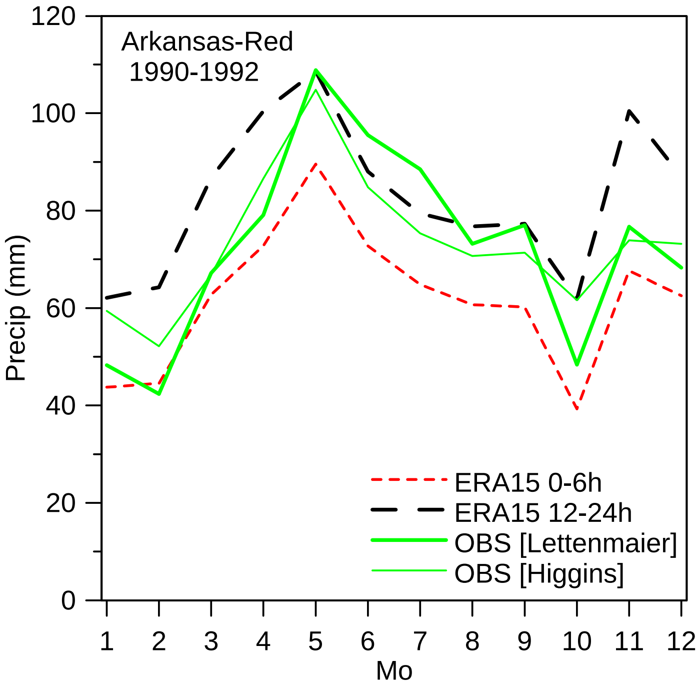
Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.24

COMPARISON WITH OBSERVATIONS.

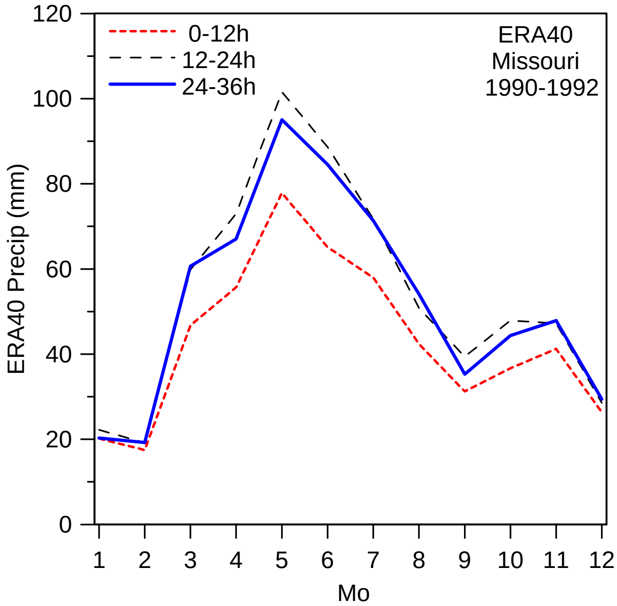
ERA40
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages

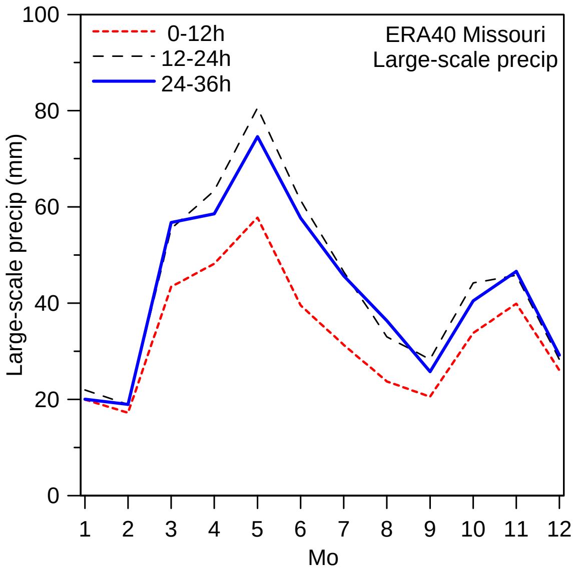


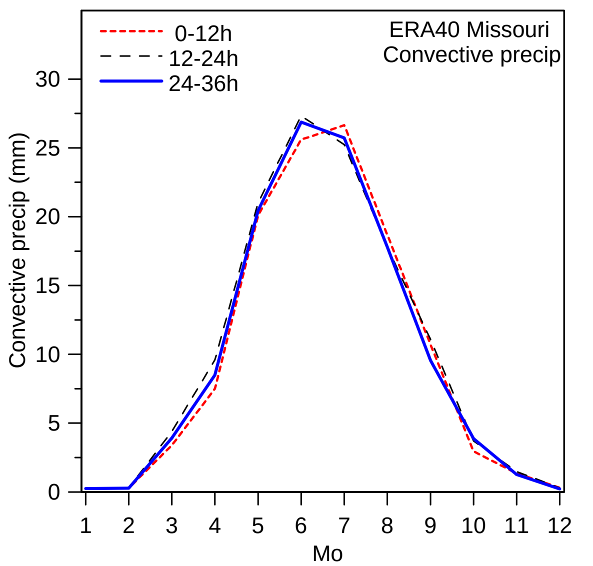
ERA15
BASIN PRECIPITATION
Arkansas-Red rivers
1990-1992 monthly averages



ERA40
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages



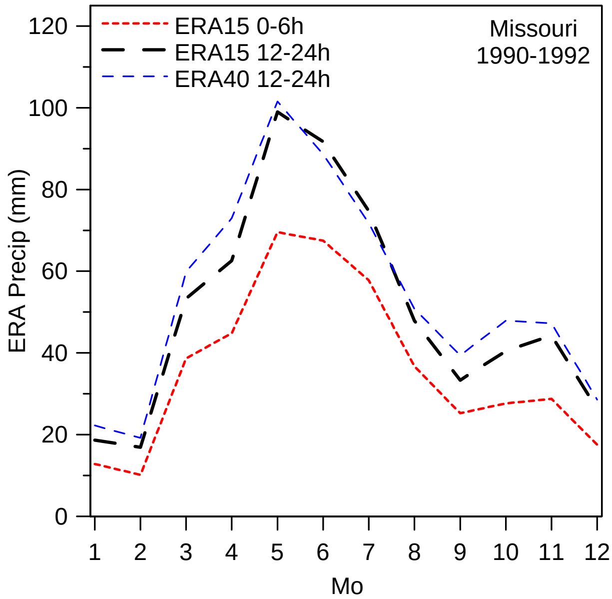


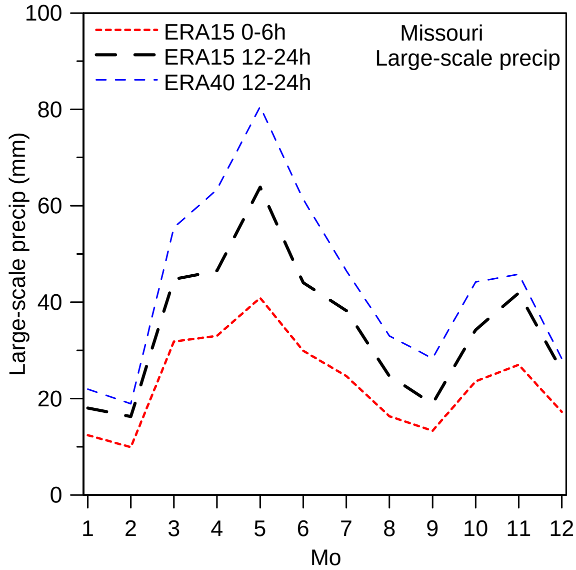


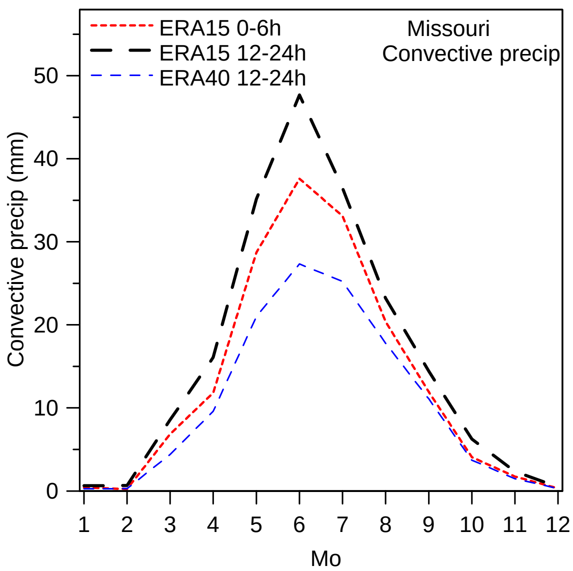
Large-scale precipitation spin-up
Months 11- 4 ERA40
0-12: 12-24: 24-36h
1 : 1.20 : 1.18

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





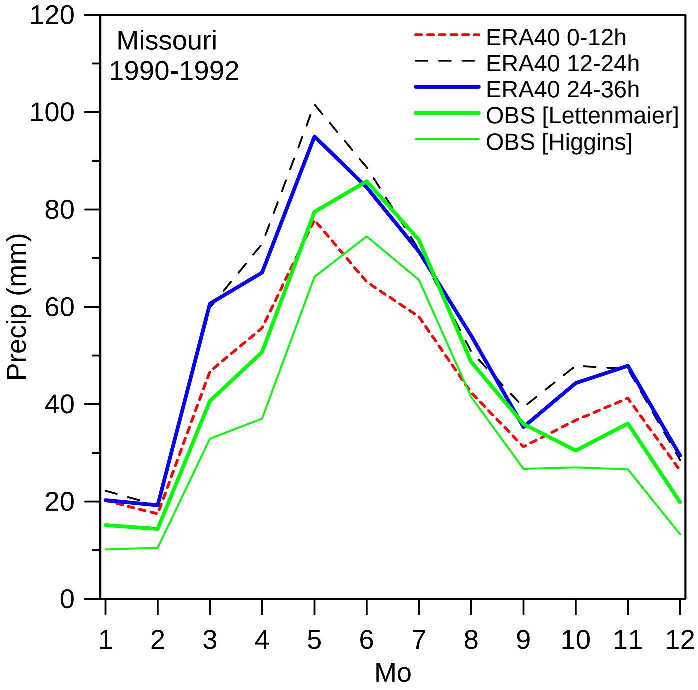


Large-scale precipitation spin-up
ERA15
0-12: 12-24
1 : 1.49

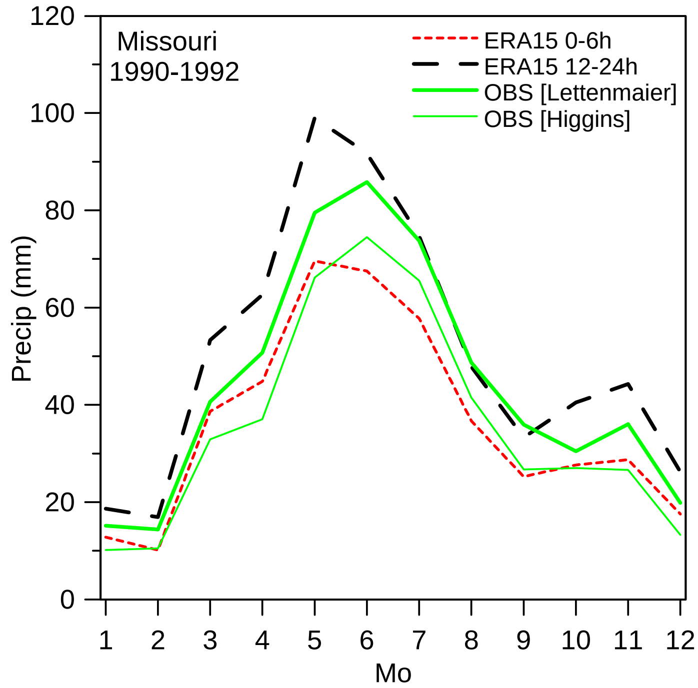
Convective precipitation spin-up
ERA15
0-12: 12-24
1 : 1.22

COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages

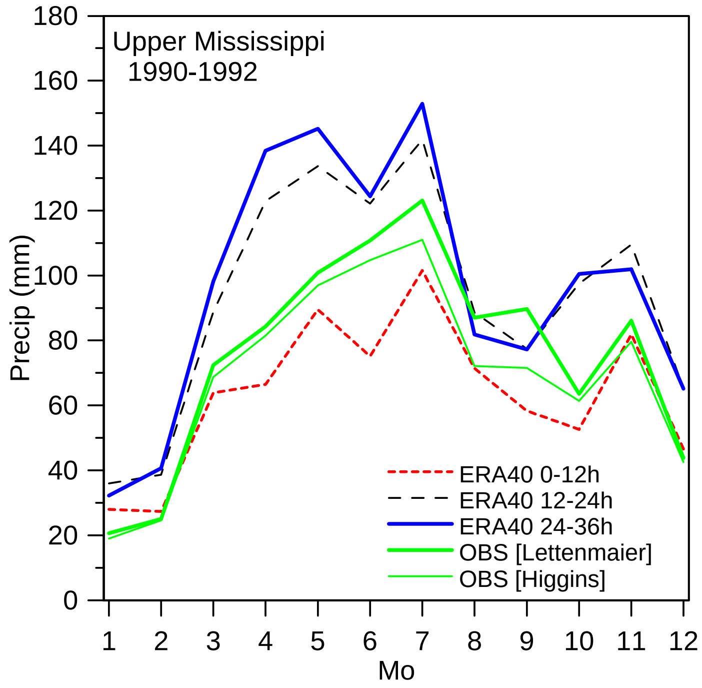


ERA15
BASIN PRECIPITATION
Missouri River
1990-1992 monthly averages

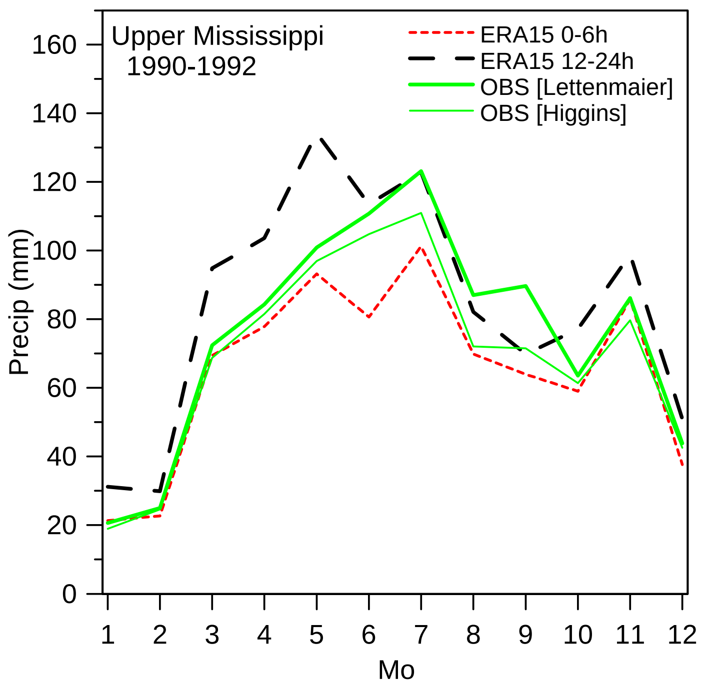


COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages

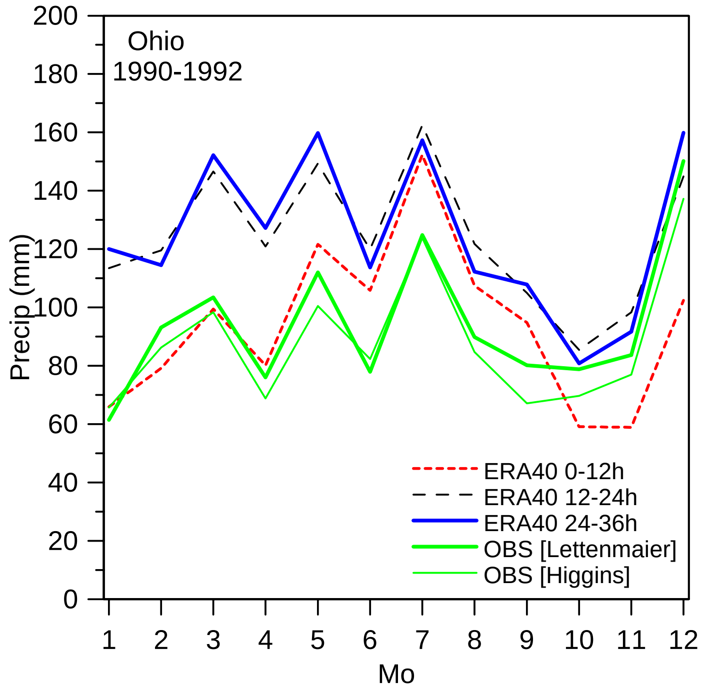


ERA15
BASIN PRECIPITATION
Upper Mississippi River
1990-1992 monthly averages

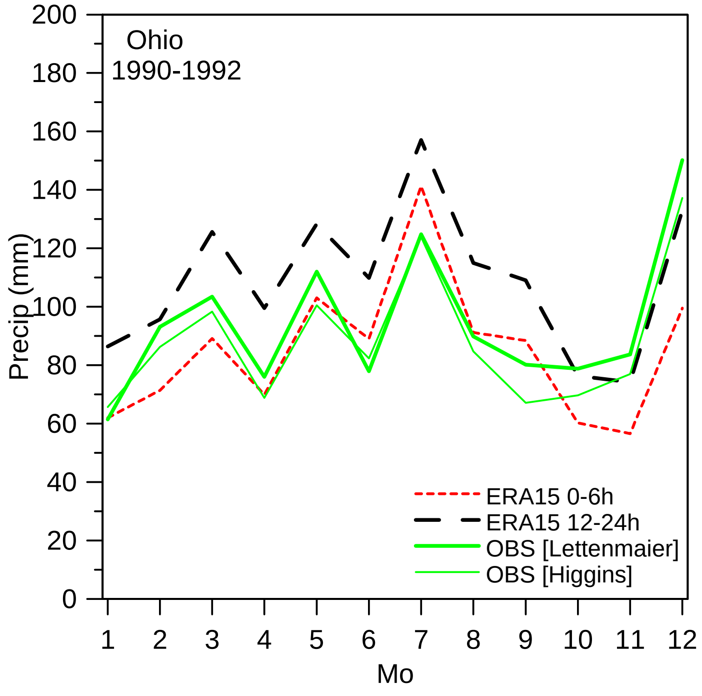


COMPARISON WITH OBSERVATIONS.

ERA40
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages

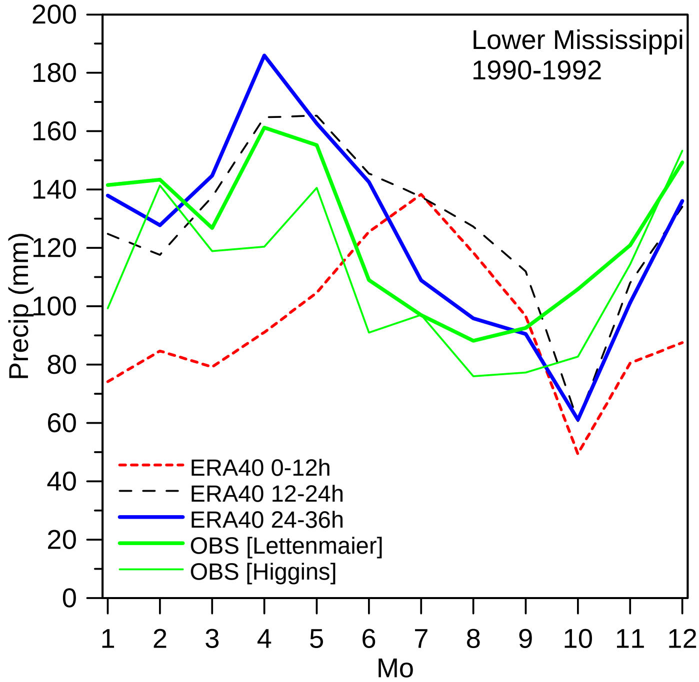


ERA15
BASIN PRECIPITATION
Ohio River
1990-1992 monthly averages

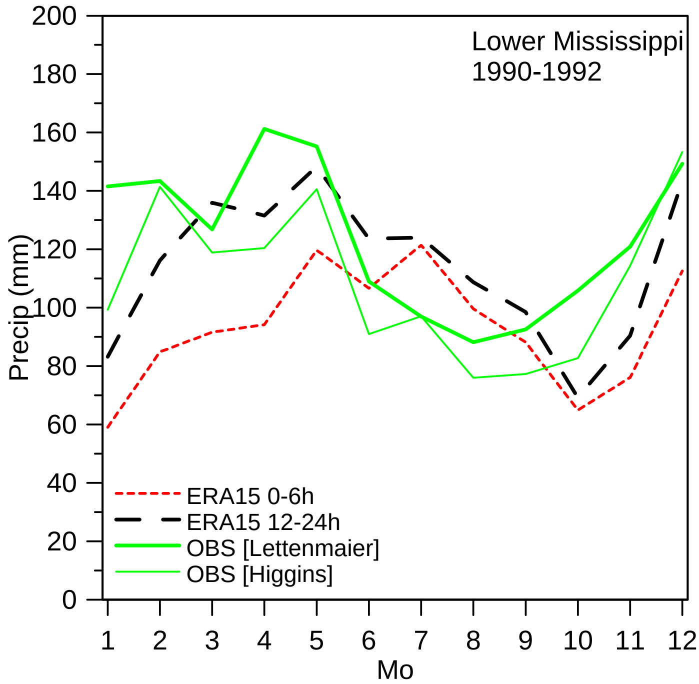


COMPARISON WITH OBSERVATIONS.

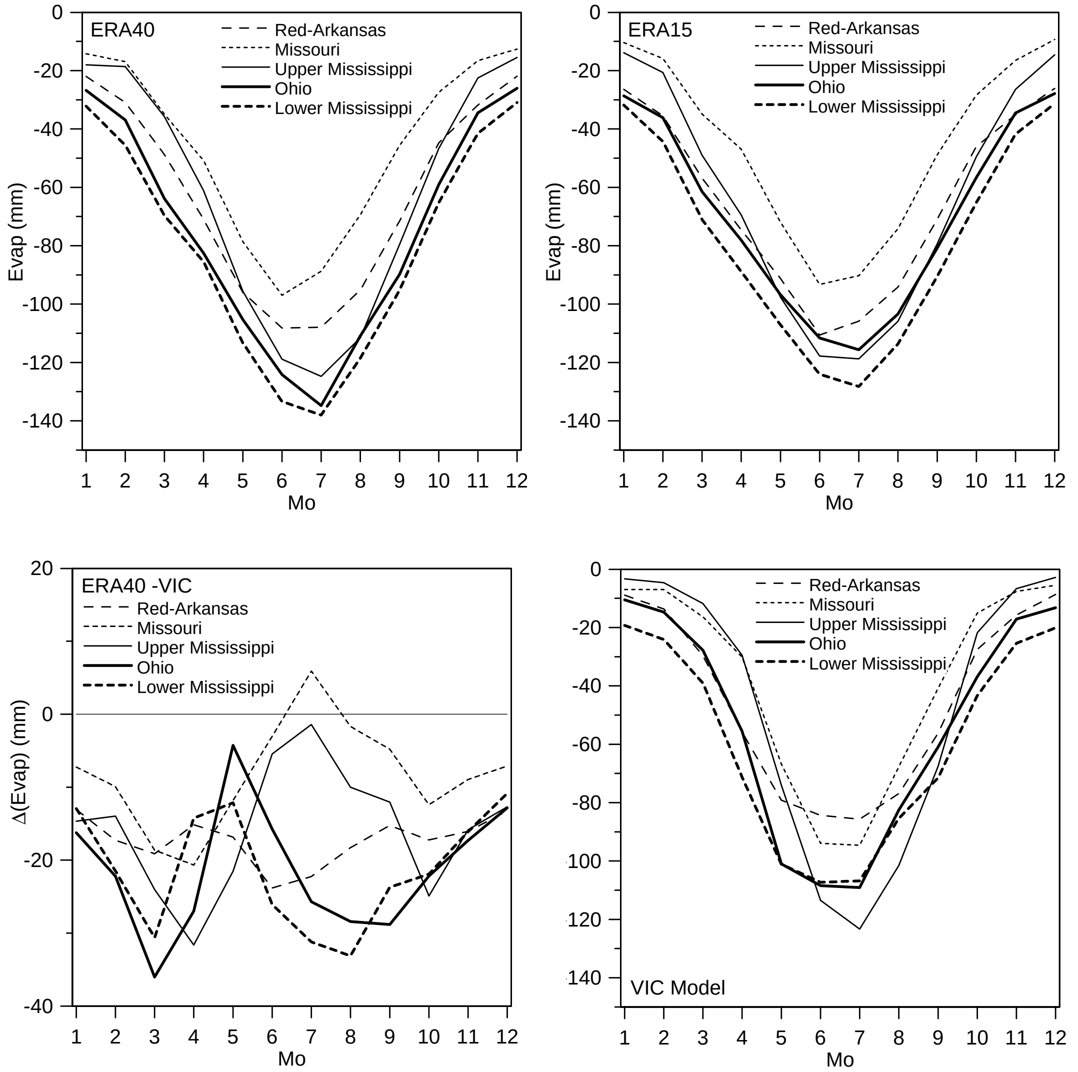
ERA40
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages



ERA15
BASIN PRECIPITATION
Lower Mississippi River
1990-1992 monthly averages



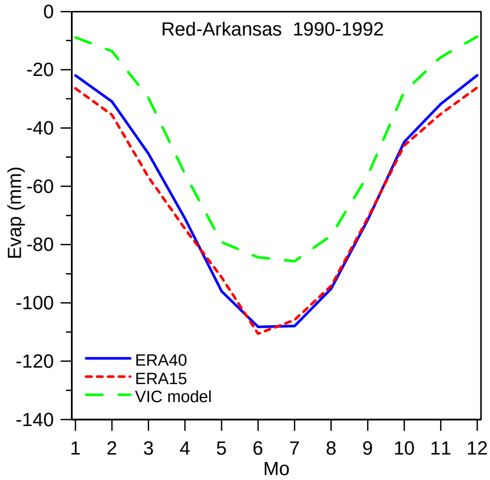
EVAPORATION FOR MISSISSIPPI

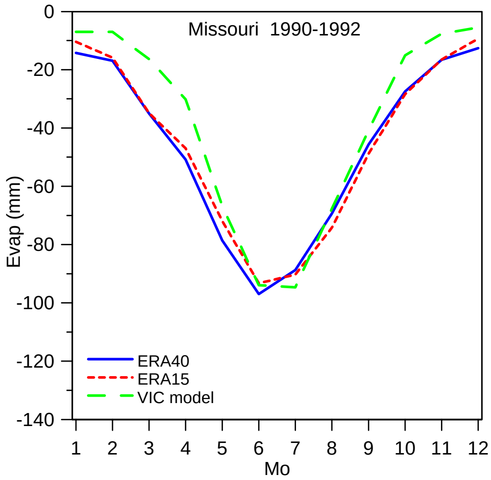


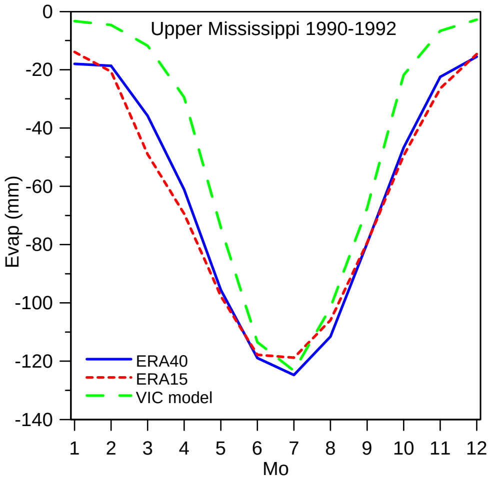
ERA40 -VIC **VIC model** [Maurer et al, 2001]

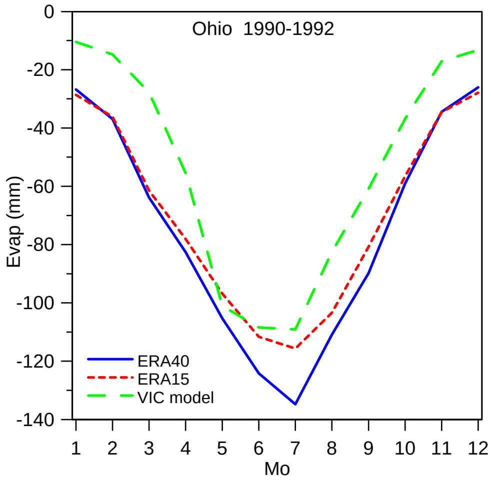
ERA40 evaporation generally higher than VIC model estimate. Note peaks in Δ(Evap) in growing season which shift in phase from south to north, which suggest model needs vegetation seasonality.

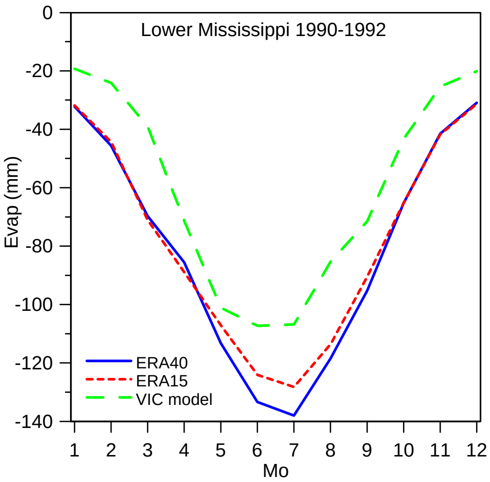
EVAPORATION BY BASIN









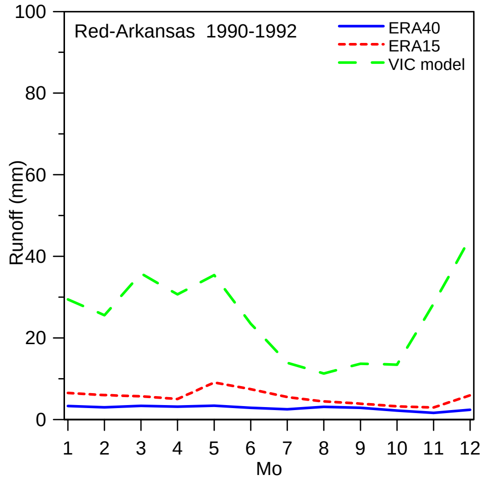


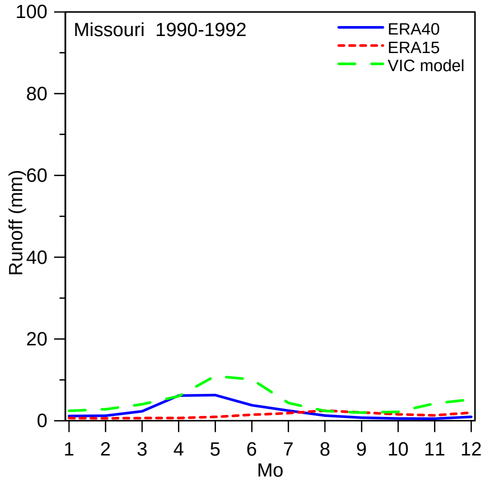
ERA Evaporation high in winter

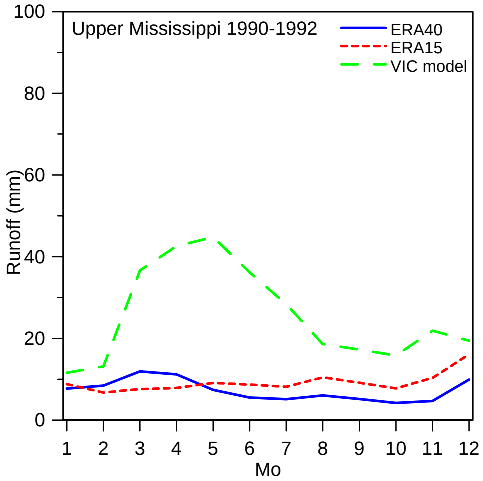
ERA >VIC in summer except for north

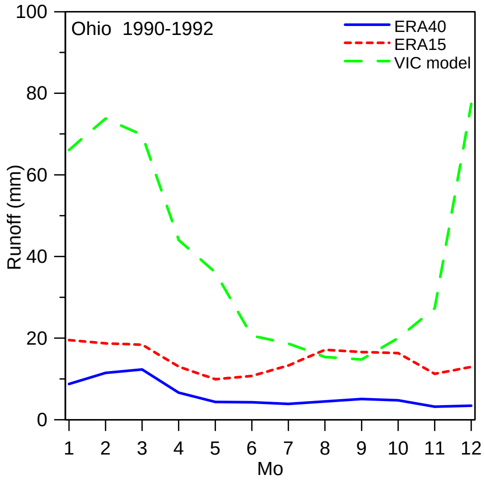
ERA40 >ERA15 in south and east, but not in west and north

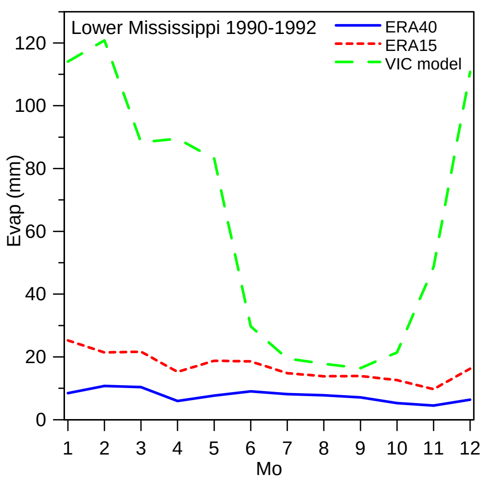
RUNOFF BY BASIN









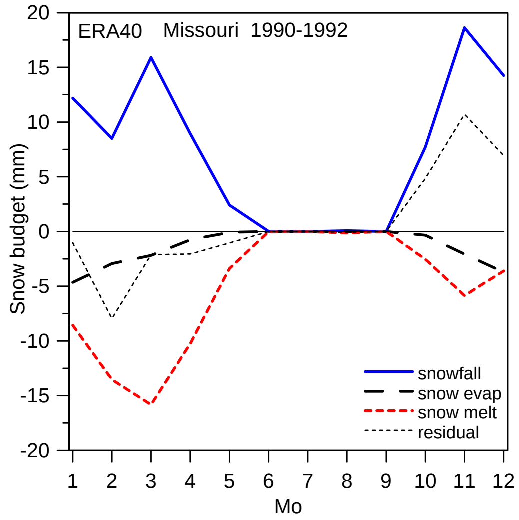


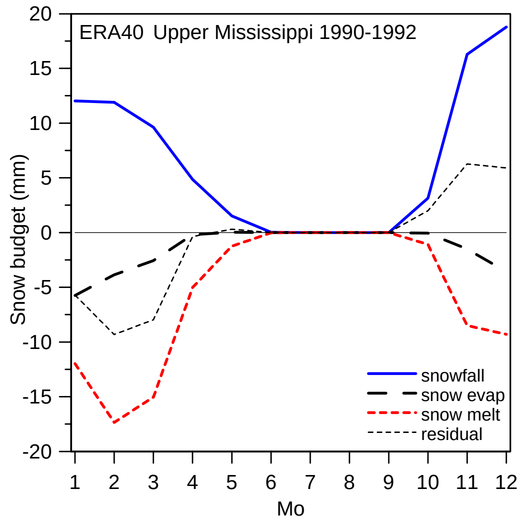
ERA Runoff low << VIC especially in winter

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

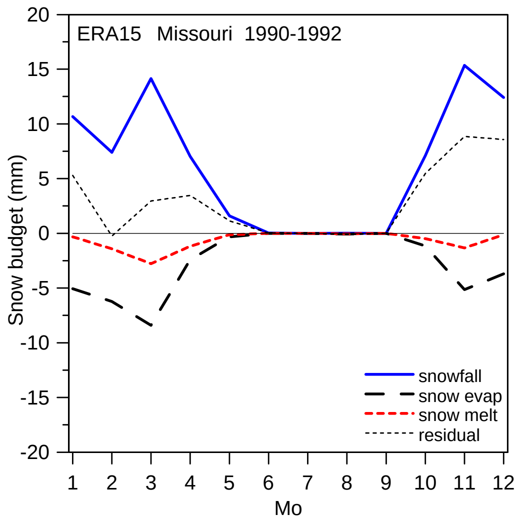
SNOW BUDGET

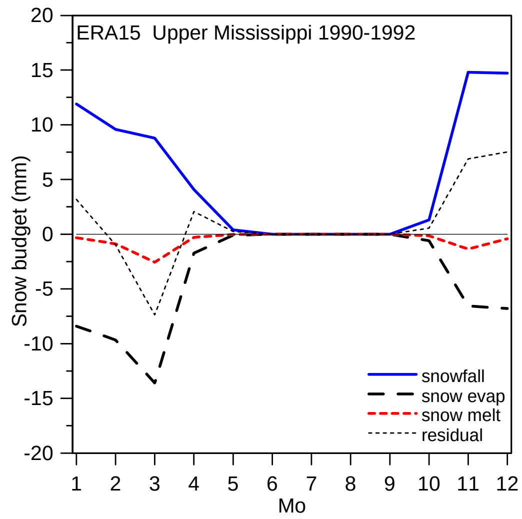
Missouri　　　　　　Upper Mississippi





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

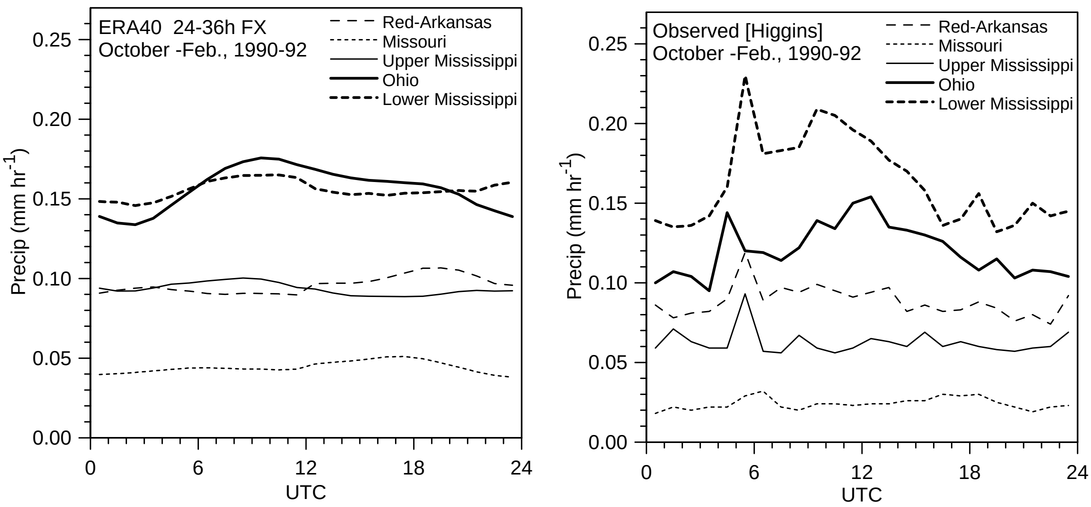




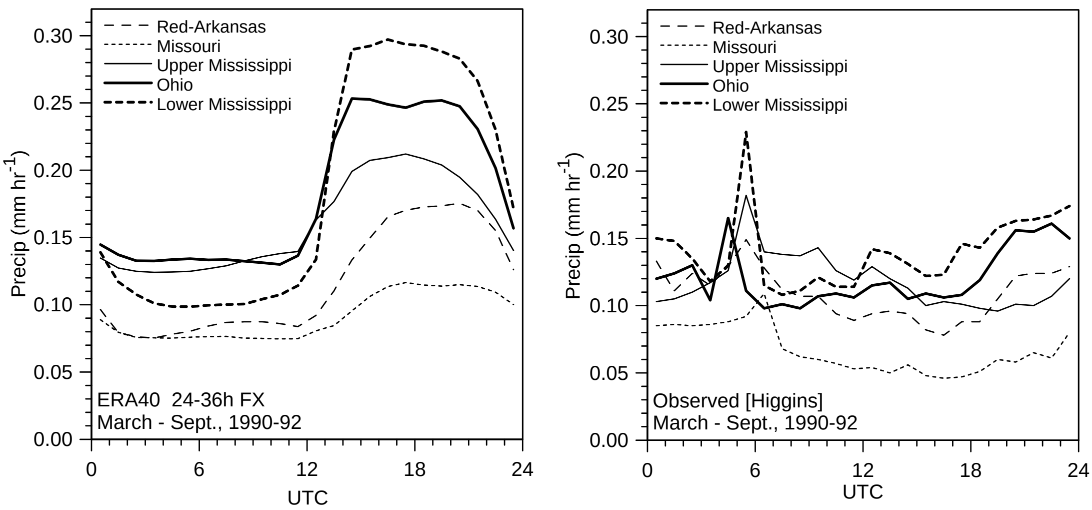
ERA15 Snow evaporation > snowmelt
Seasonal residual larger [12-24h FX]

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.

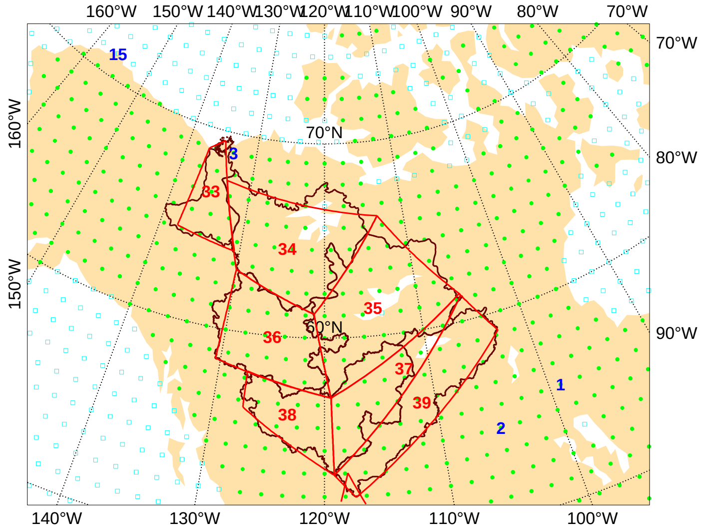
Ratio of 1990-92 ERA precipitation to 'VIC' observations

[Maurer et al., 2001 for Mississippi]

Basin	Prec.[VIC] (mm)	E40 0-12	E40 12-24	E40 24-36	E15 0-6	E15 12-24
28	873	.874	1.096	1.084	.849	1.137
29	531	.977	1.224	1.185	.823	1.147
30	907	.841	1.237	1.277	.863	1.111
31	1131	.996	1.315	1.323	.907	1.158
32	1490	.758	1.030	1.004	.750	.921
Avg		*0.89*	*1.18*	*1.17*	*0.84*	*1.09*

Mackenzie River Basins

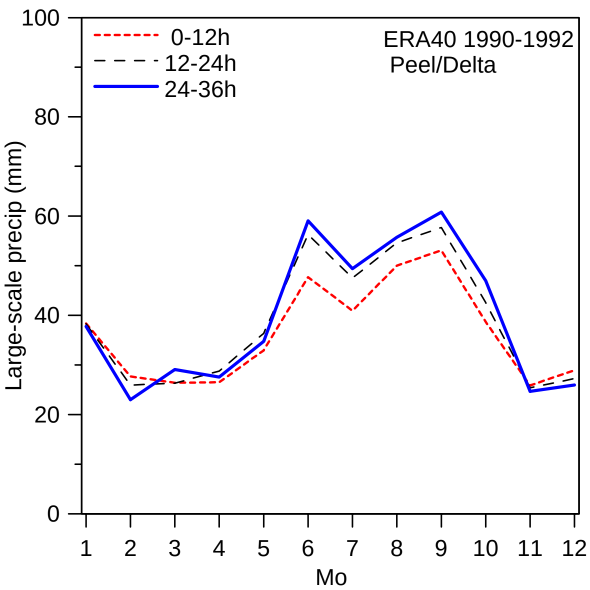
33	Peel/Delta
34	Great Bear Lake
35	Great Slave Lake
36	Liard
37	Peace (East)
38	Peace (West)
39	Athabasca

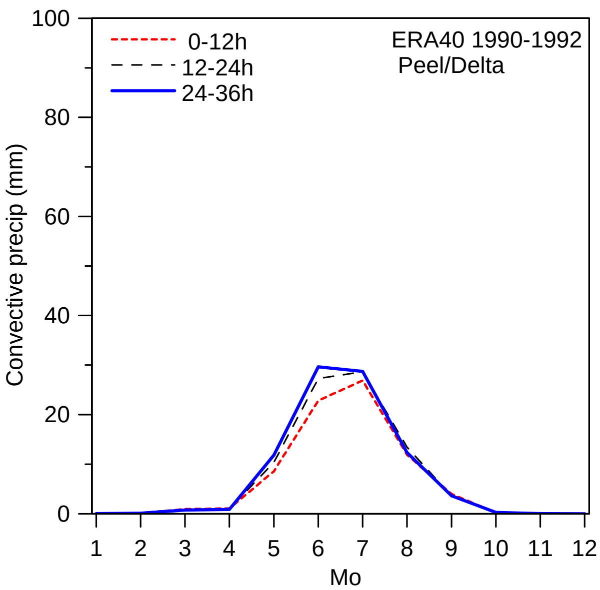


Verification data from the MAGS project [Paul Louie, AES, Canada]

Test of model at high latitudes: frozen physics

Peel/Delta (#33)

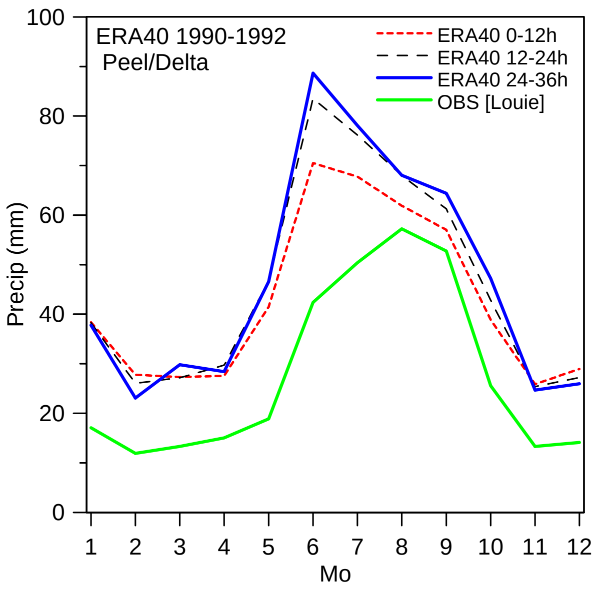




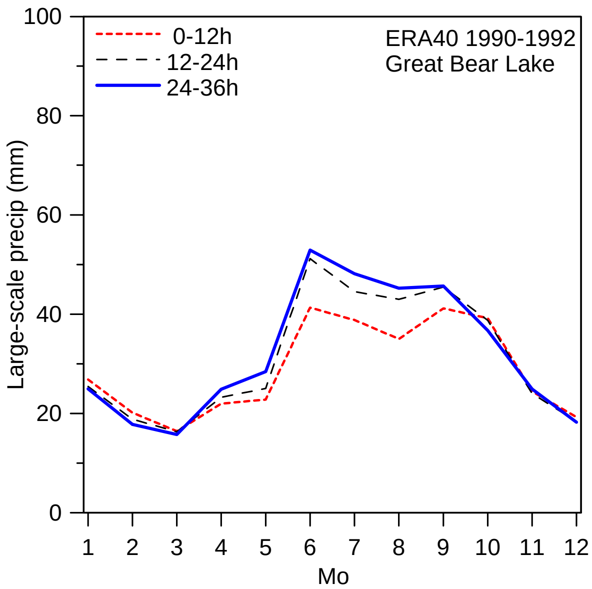
Spinup small at 24-36h

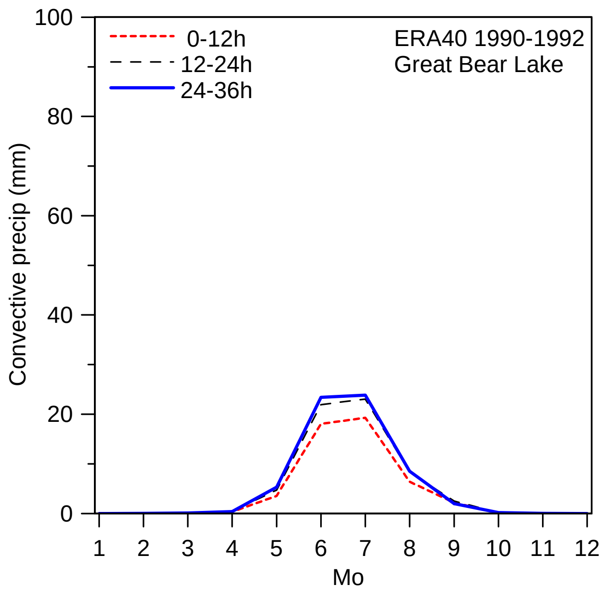
LSP	CP
1.09	1.15

ERA40 > Observations especially June, July when convective



Great Bear Lake (#34)

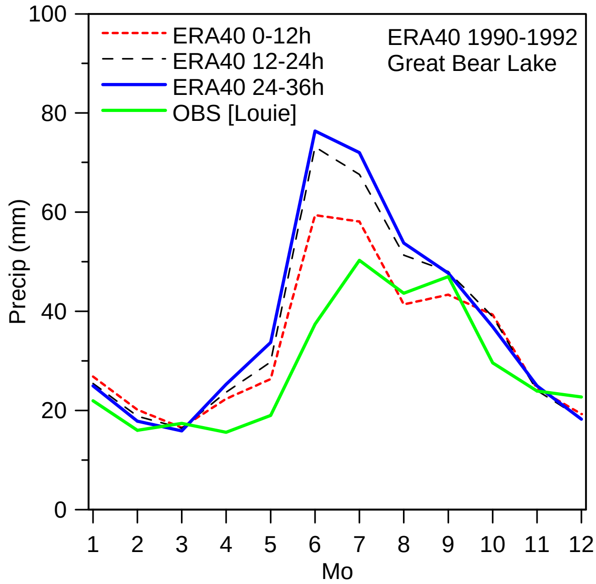




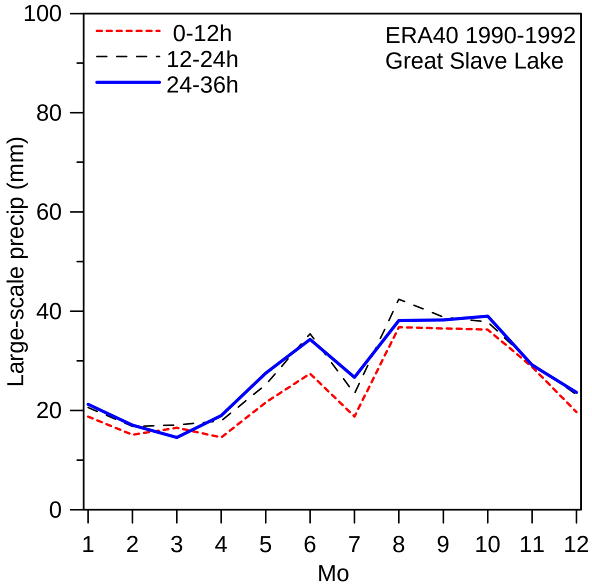
Spinup small at 24-36h

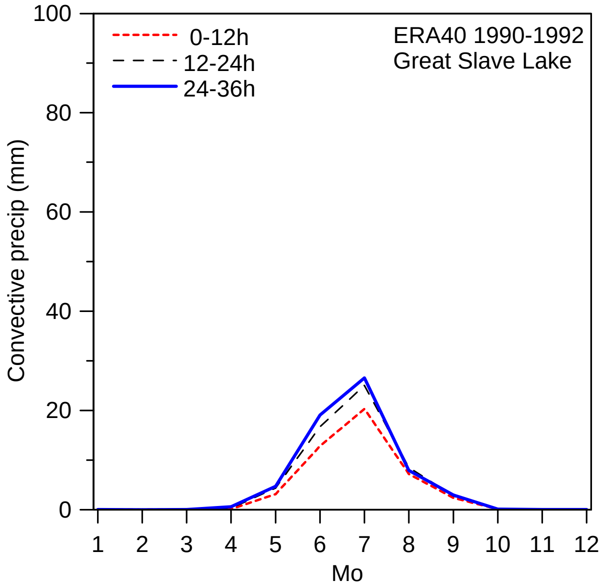
LSP	CP
1.10	1.27

ERA40 > Observations especially June, July when convective, but not September



Great Slave Lake (#35)

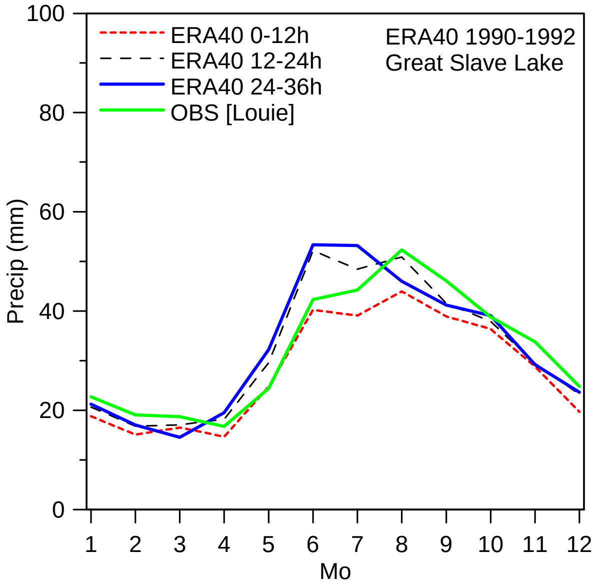




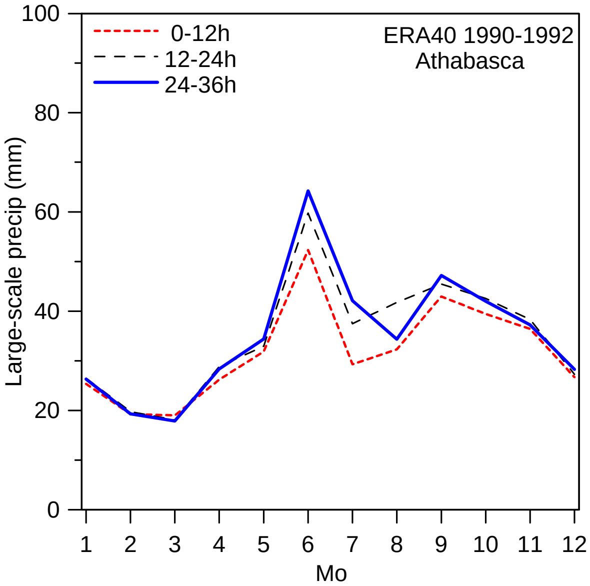
Spinup at 24-36h

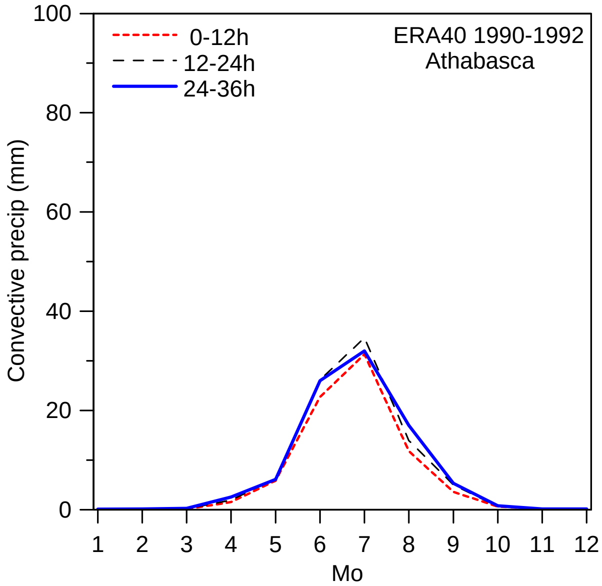
LSP	CP
1.13	1.34

ERA40
> Observations June, July
< Observations Aug., Sept.



Athabasca (#39)

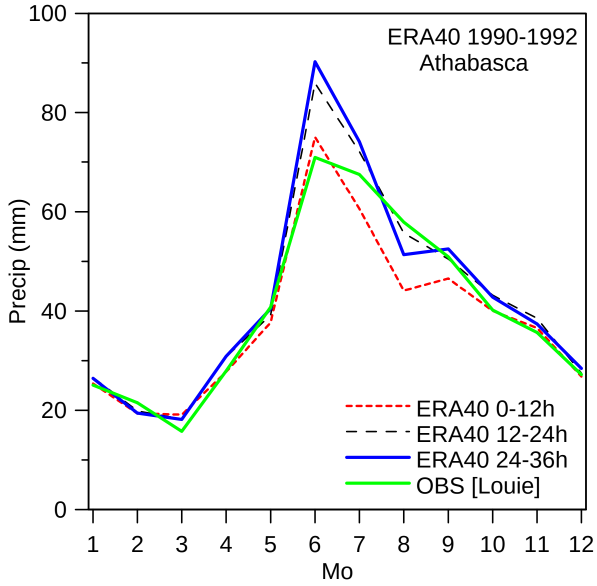




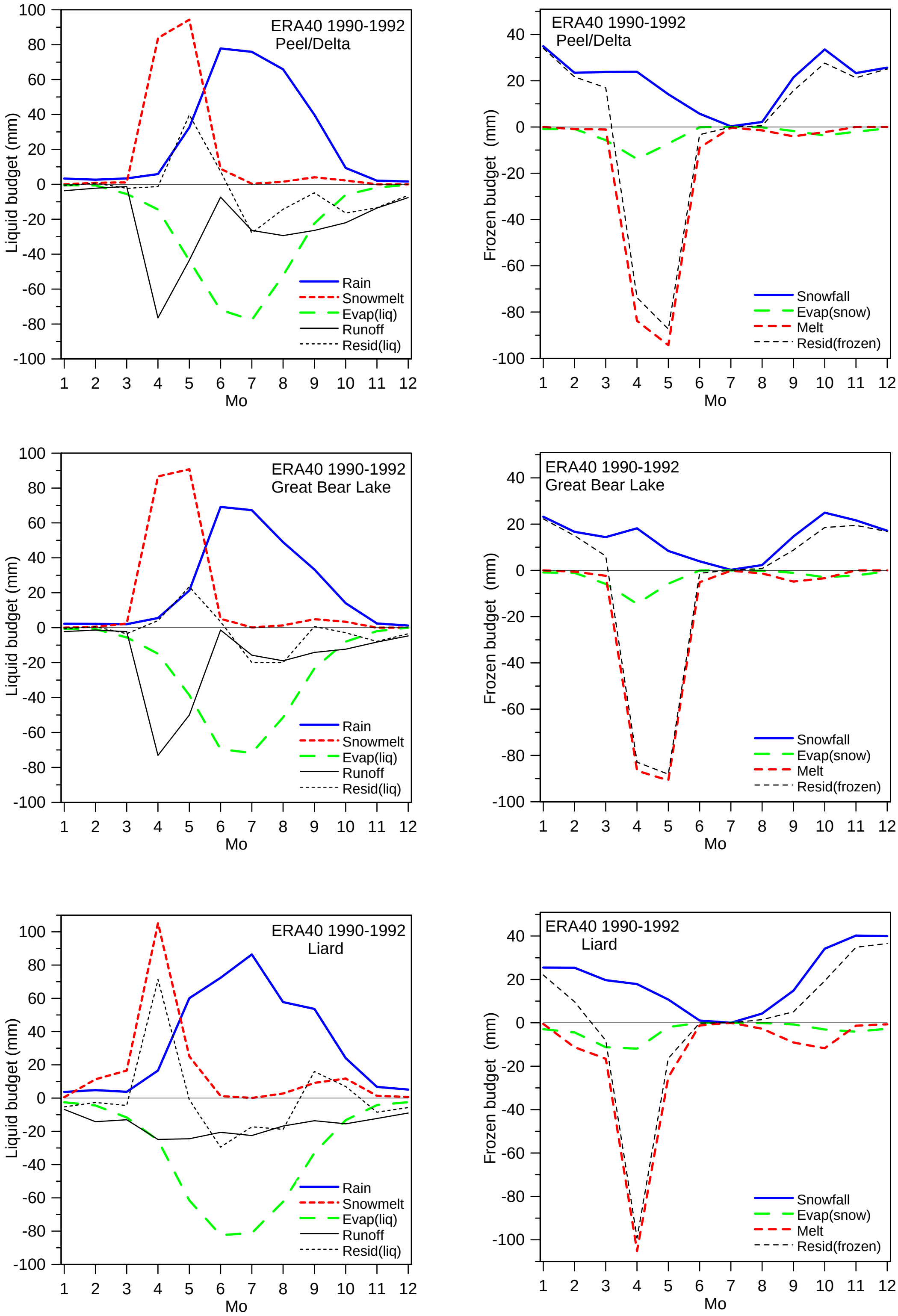
Spinup small at 24-36h

LSP	CP
1.11	1.16

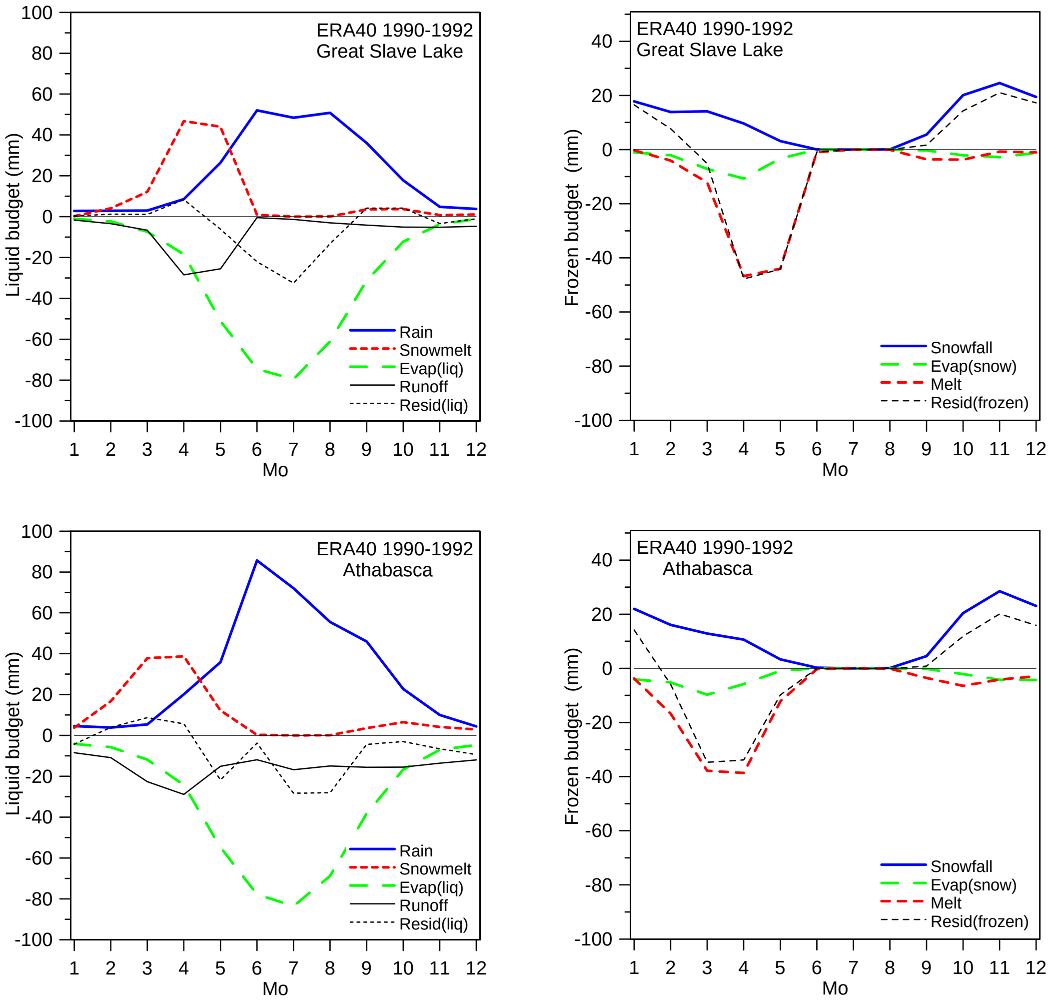
ERA40 > Observations
in June, July; less in August



Liquid and frozen budgets for the Mackenzie: 1990-1992 mean



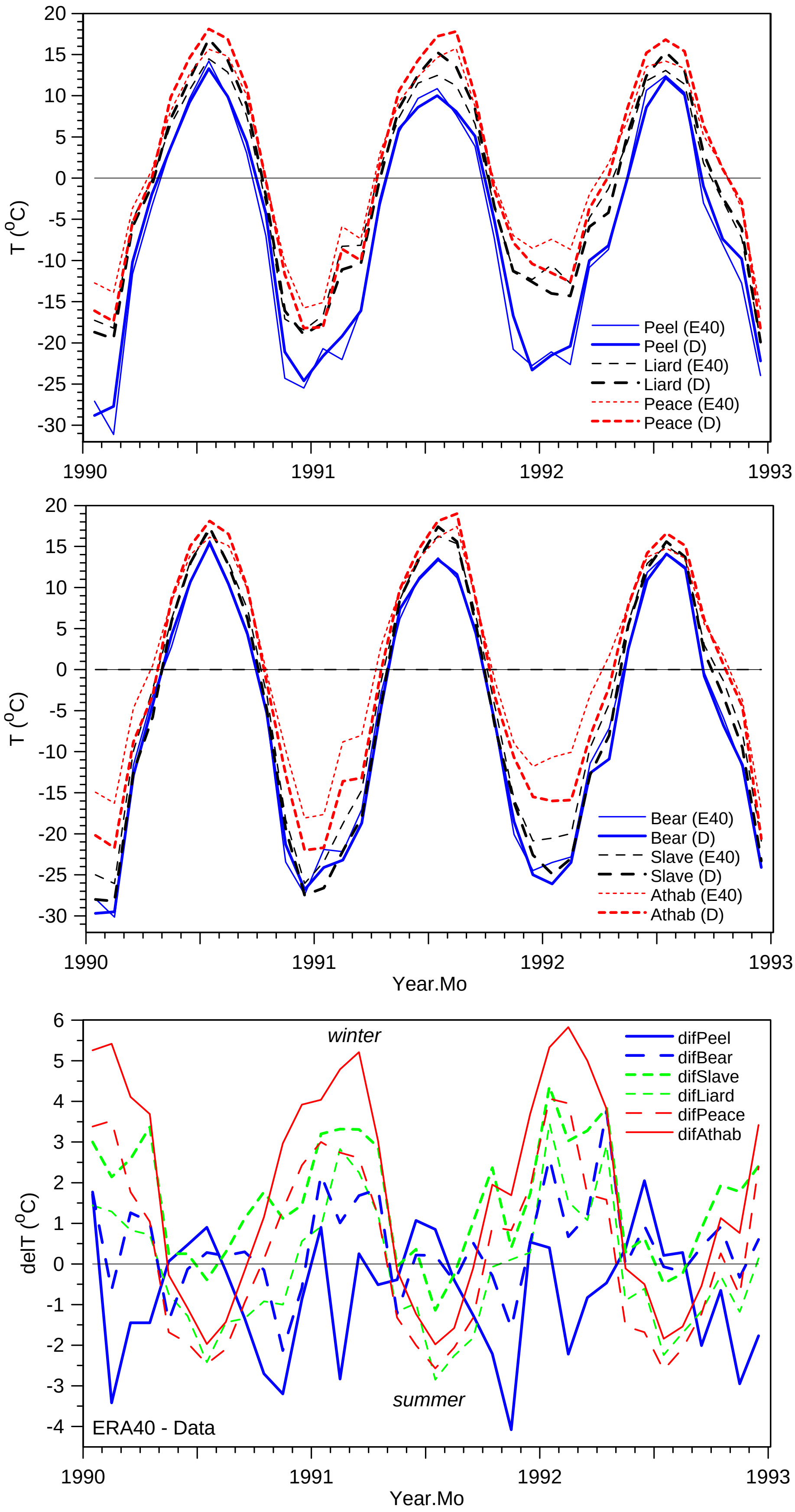
Western mountainous basins of Mackenzie with strong spring melt and runoff



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]

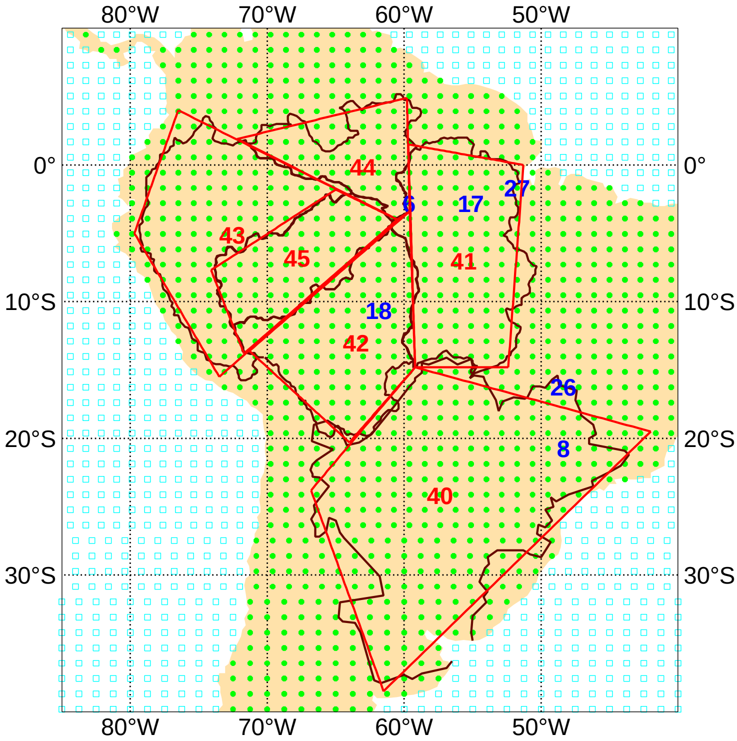
2) ERA40 precipitation generally > MAGS observations [from Louie]
    especially in June, July, but not in August, September
    Suggests there may be problems with model convective precip in June, July

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

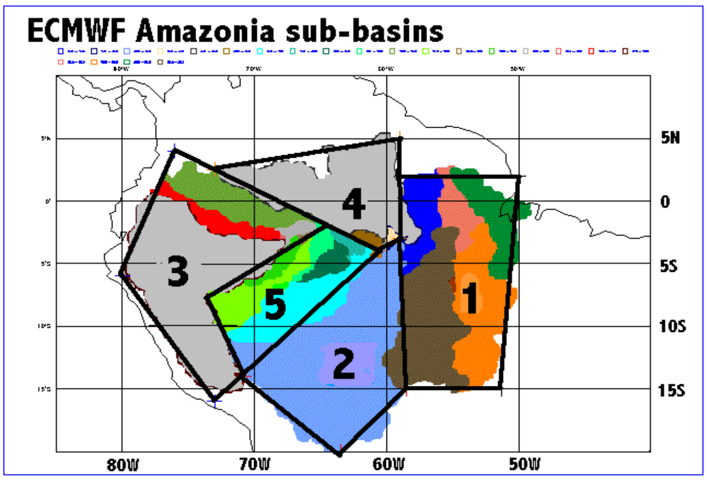
Basins as implemented for S. America showing ERA40 grid, including 5 sub-basins for the Amazon and the Rio de la Plata



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

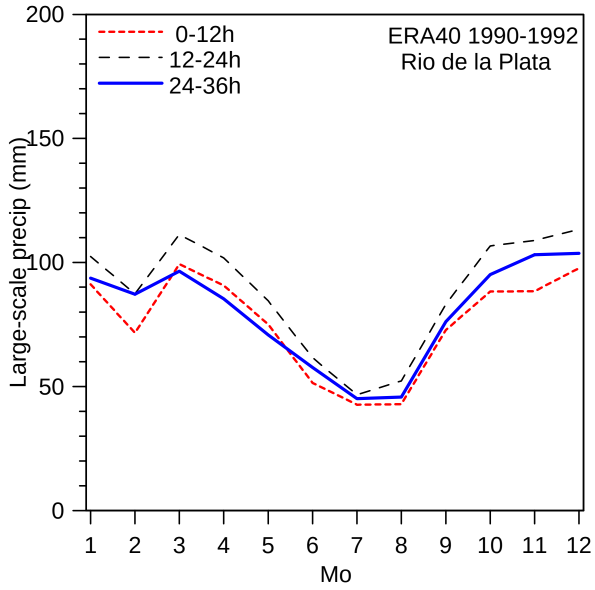
[Amazon basin coordinates based on file from Brad Newton (see below); Rio de la Plata basin definition from Hugo Berberry]

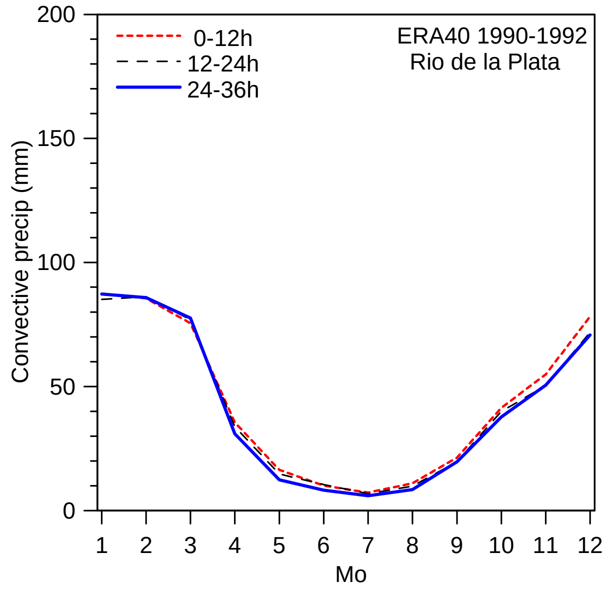
Original schematic (1999) of proposed basins superimposed on file from Brad Newton

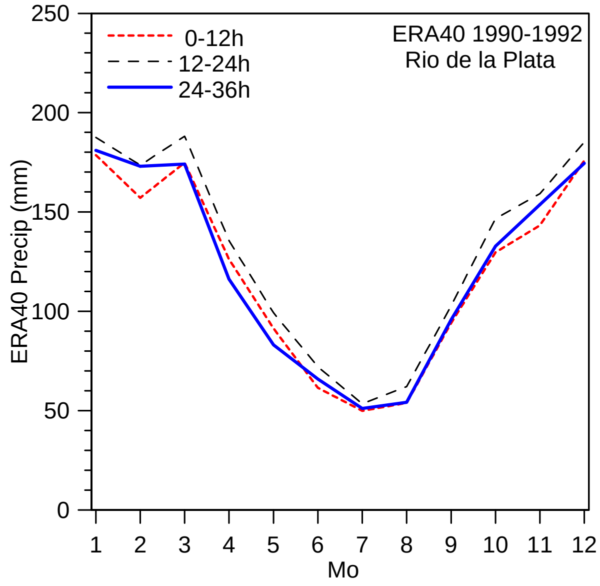


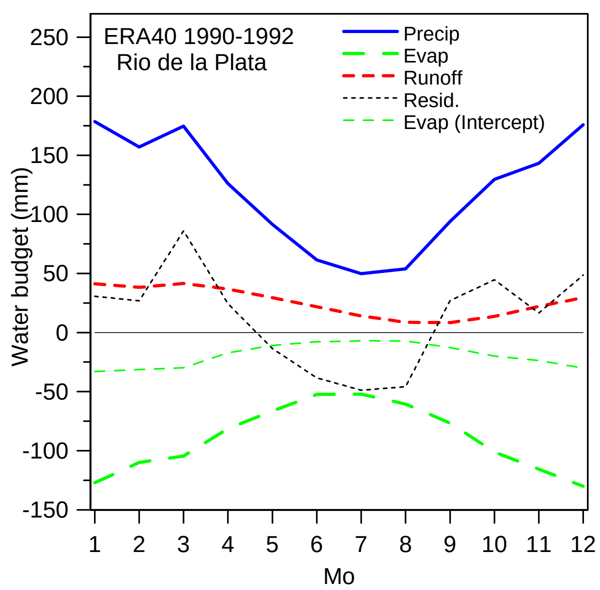
Some *preliminary* results from ERA40 (T-159, L60) follow, showing monthly precipitation from 0-12, 12-24, 24-36 hr forecasts, run from analysis cycle [averages for 1990-1992], and hydrologic budget.

Rio de la Plata (#40)



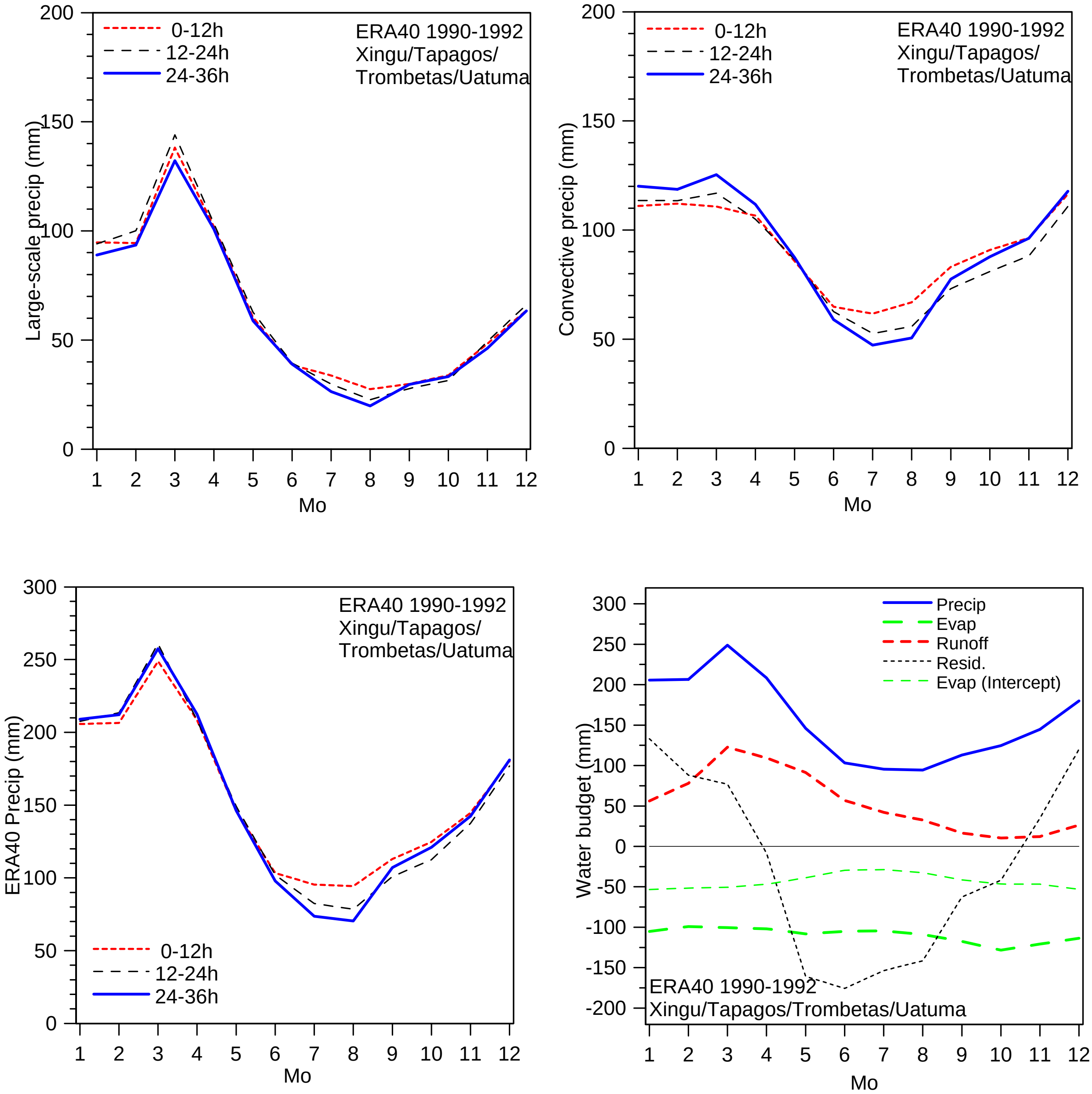






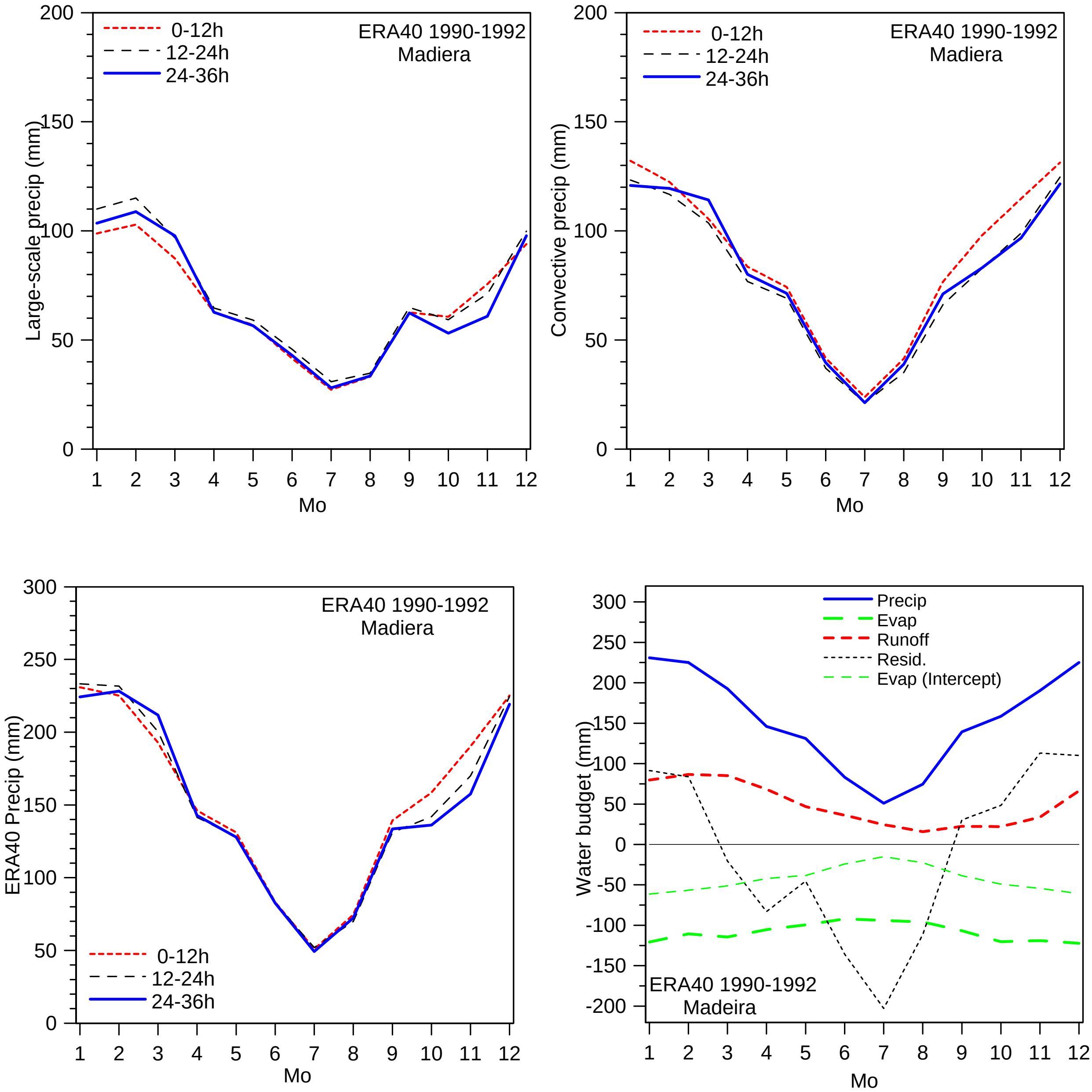
Spinup small; seasonal cycle of precipitation & evaporation

Xingu/Tapagos/Trombetas/Uatuma (#41)



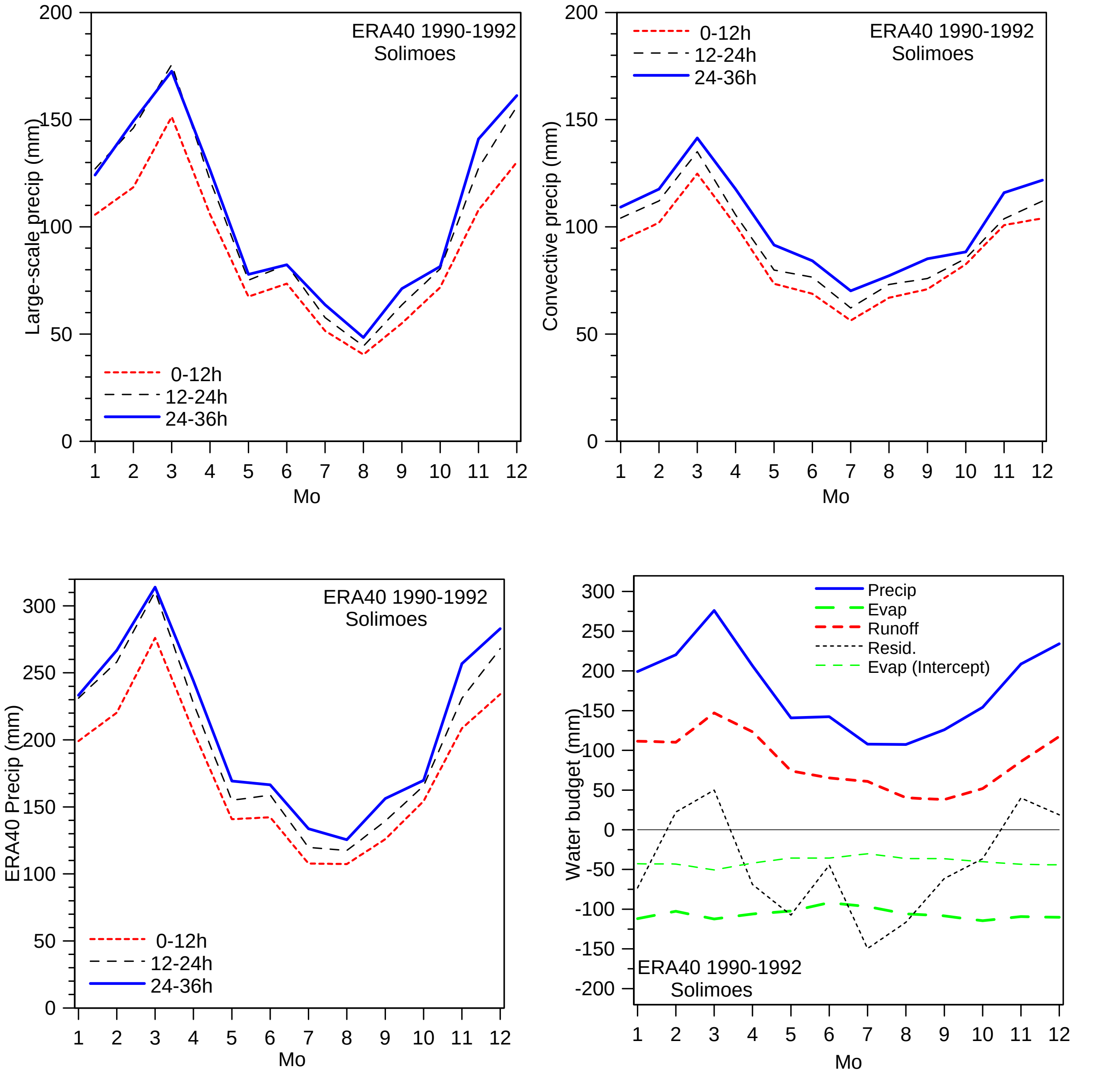
Small spinup in wet season: Small spindown in dry season
Little seasonal cycle of evaporation

Madiera (#42)



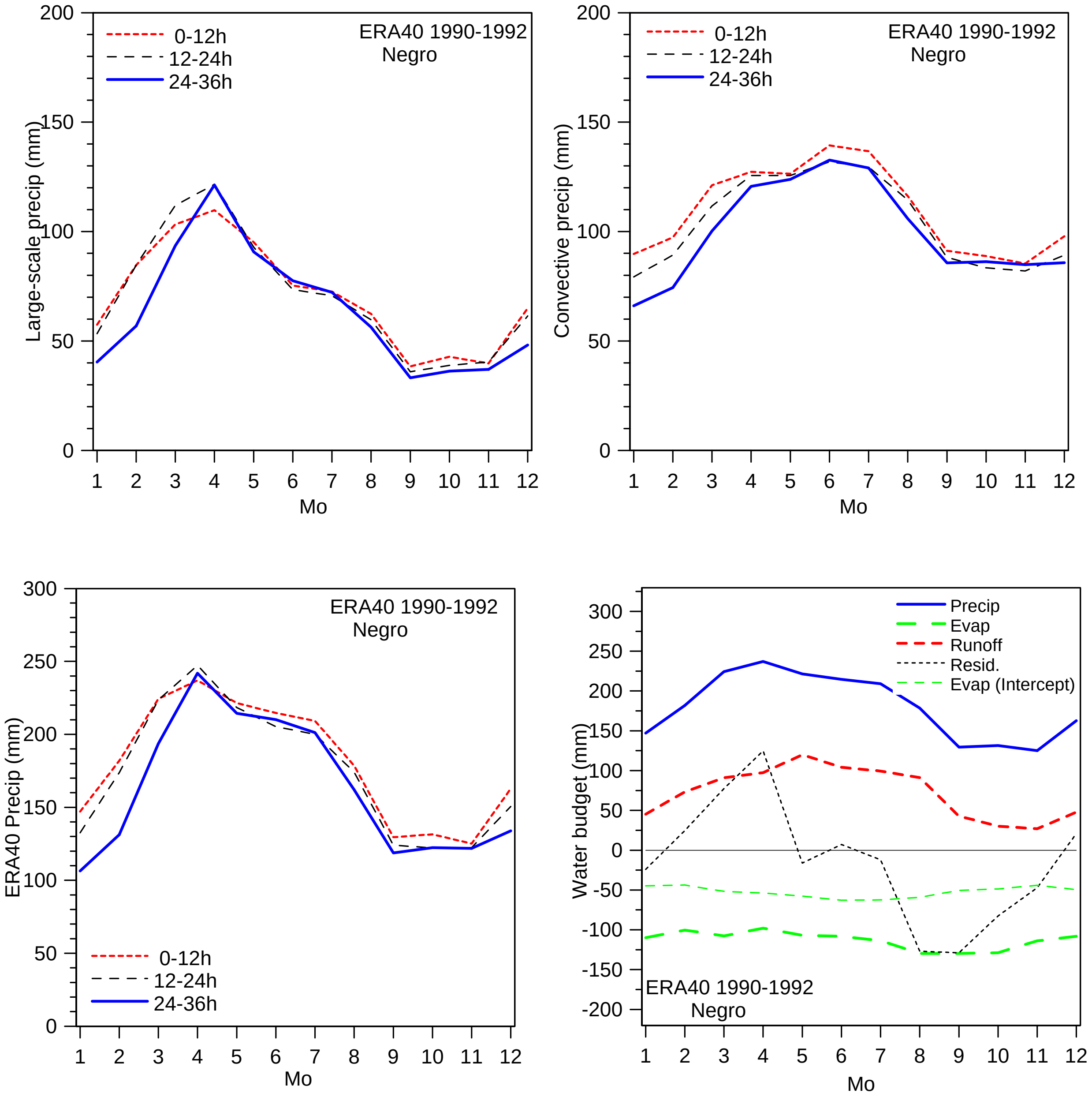
Spinup small; strong seasonal cycle

Solimoes (#43)



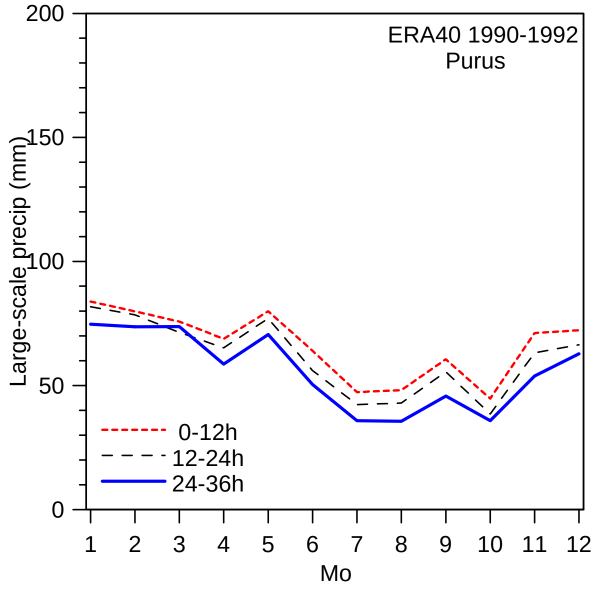
Spinup of 12-19% is largest of any in Amazon and differs from nested #45; highest rainfall and runoff ; seasonal cycle of evaporation weak

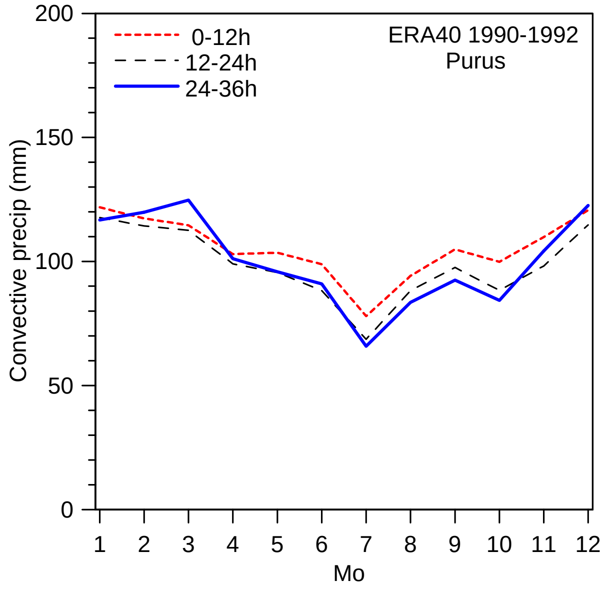
Negro (#44)

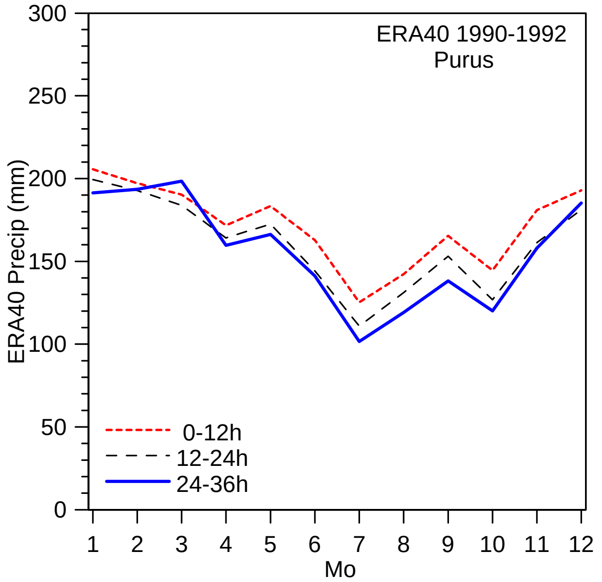


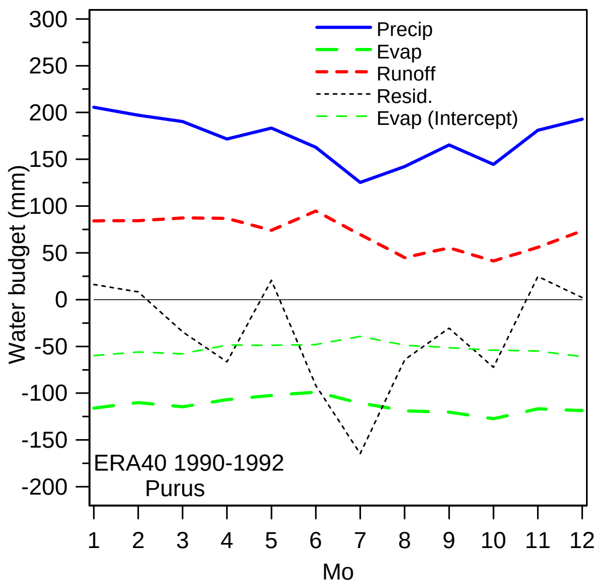
Small Spindown; later rainfall and runoff maximum; seasonal cycle of evaporation very weak

Purus (#45)





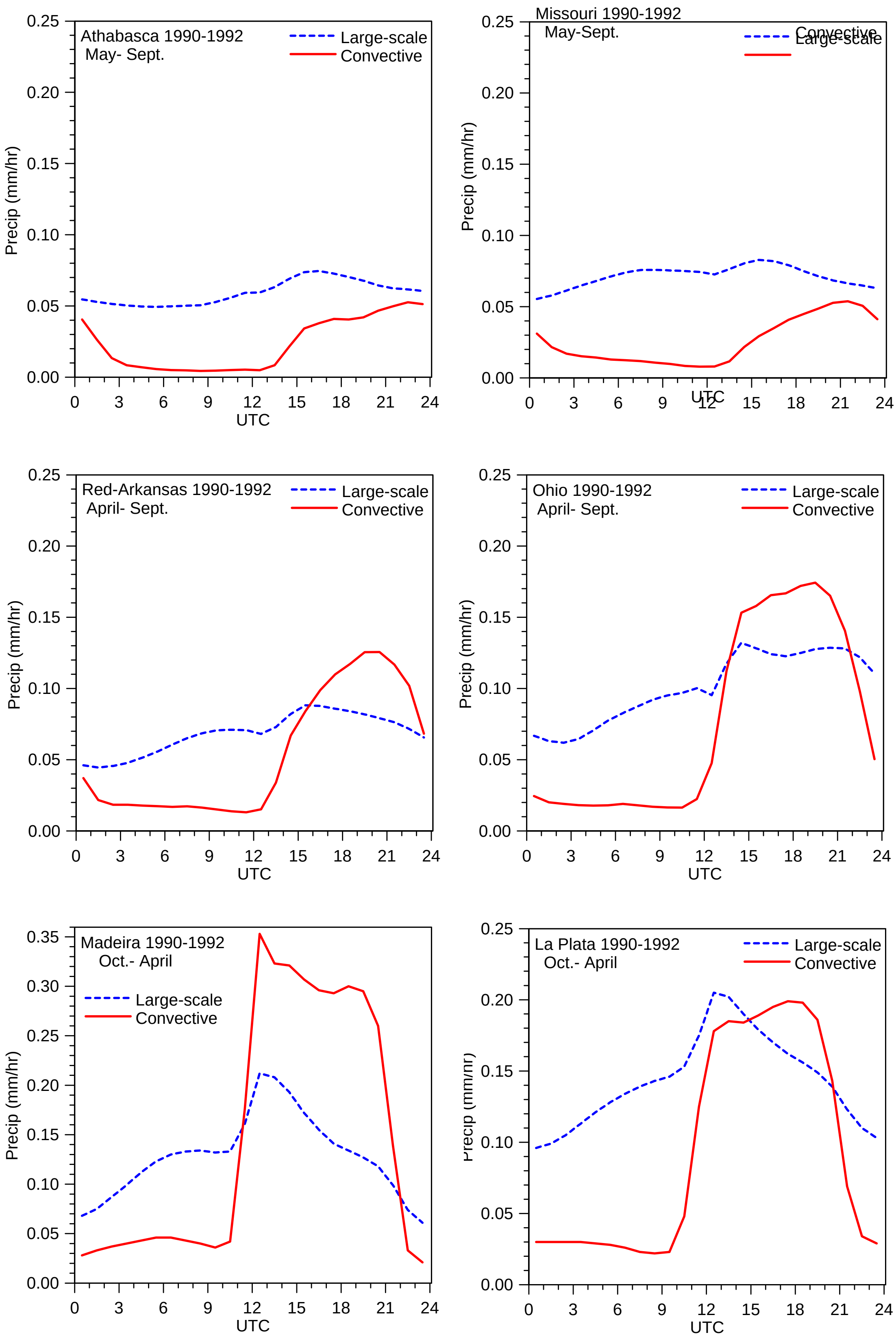




Small Spindown; weakest seasonal cycle
Note nested in #43, which has different spinup. Effect of Andes?

Diurnal cycle of convective and large-scale precipitation

[12-24FX]



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

Basin	Precip (mm) 0-12 h	Ratio 12-24	Ratio 24-36	L-S Precip. 12-24	L-S Precip. 24-36	Convective 12-24	Convective 24-36
40	1436	1.09	1.01	1.16	1.05	.96	.94
41	1871	.98	.98	1.01	.96	.96	.99
42	1848	.98	.97	1.06	1.00	.91	.94
43	2123	1.12	1.19	1.17	1.21	1.08	1.17
44	2163	.97	.91	1.0	.90	.95	.91
45	2062	.93	.91	.93	.84	.93	.95

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]