Selected options for hydrology

Long-lasting effort (3 years) by A. Ducharne, N. Vuichard, F. Wang, J. Ghattas, M. Guimberteau, A. Tootchi, C. Ottlé, F. Maignan, P. Maugis, J. Polcher, V. Barstrikov, F. Cheruy, B. Guenet, P. Peylin

« Old » features:

- Multi-layer physically-based soil hydrology scheme: HYDROL_CWRR = y
- Vertical discretization: standard with a 2-m soil and 11 « geometrical » layers
- Soil map: Zobler with 3 texture classes

New features:

- Massive debugging leading to excellent water conservation
- The nobio/ice fraction has been excluded from the normal water budget
- Soil freezing is activated (cf. Catherine's talk)
- Soil evaporation has been reduced:
  - Reduced bare soil fraction: frac_bare = veget_max * [1 – exp(-LAI)]
  - Introduction of soil resistance: DO_RSOIL = y
- All water stress factors based on liquid soil moisture (rsoil, humrel, shumdiag, litterhumdiag)
- Routing scheme: no floodplains; modified time constants

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Illustration of important changes:

(1) In coupled and nudged mode (144x142), with the latest configuration (4783):

→ Reference simulation CL5.4783.L6012.v3

https://forge.ipsl.jussieu.fr/orchidee/wiki/ReferenceSimulations/4783

→ 10-year analysis over 2015-2014

- Soil map: Zobler with 3 texture classes
- Massive debugging leading to excellent water conservation
- Introduction of soil resistance: DO_RSOIL = y

(2) In off-line mode, based on reference simulation 4438:

→ with Zobler soil map, rsoil, soil freezing, new albedo

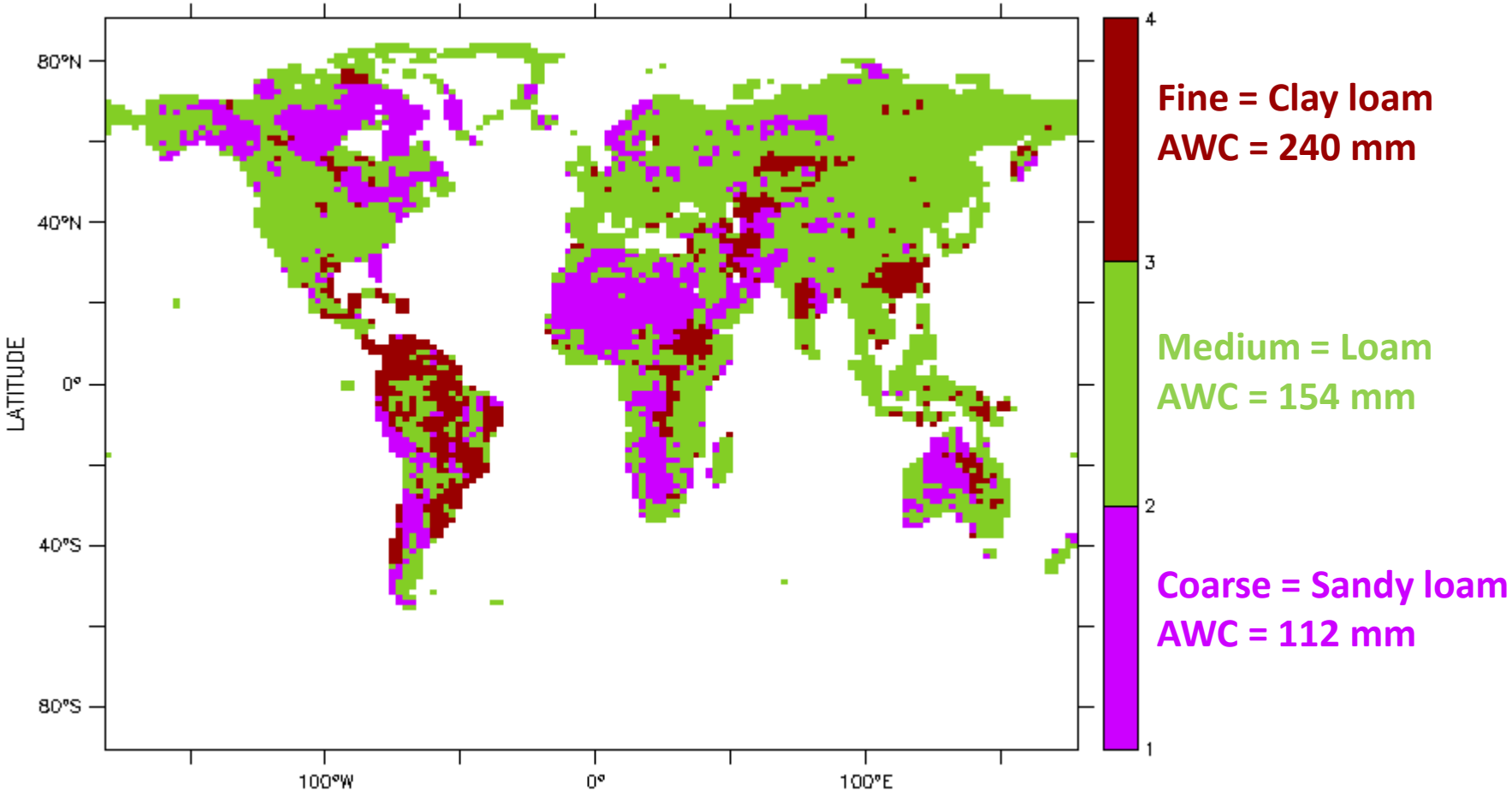
→ without the latest vegetation enhancements; the constant α and n; rsoil=f(θ_{liq})

→ 10 year analysis, with forcing at 2 resolutions: WFDEI at 0.5° vs CRU-NCEP at 2°

- Routing scheme: modified time constants

Soil map of Zobler

From coupled simulation at 144x142



AWC = Available water content = $(\theta_{FC} - \theta_{WP}) * 2000$ [in mm over a 2-m soil]

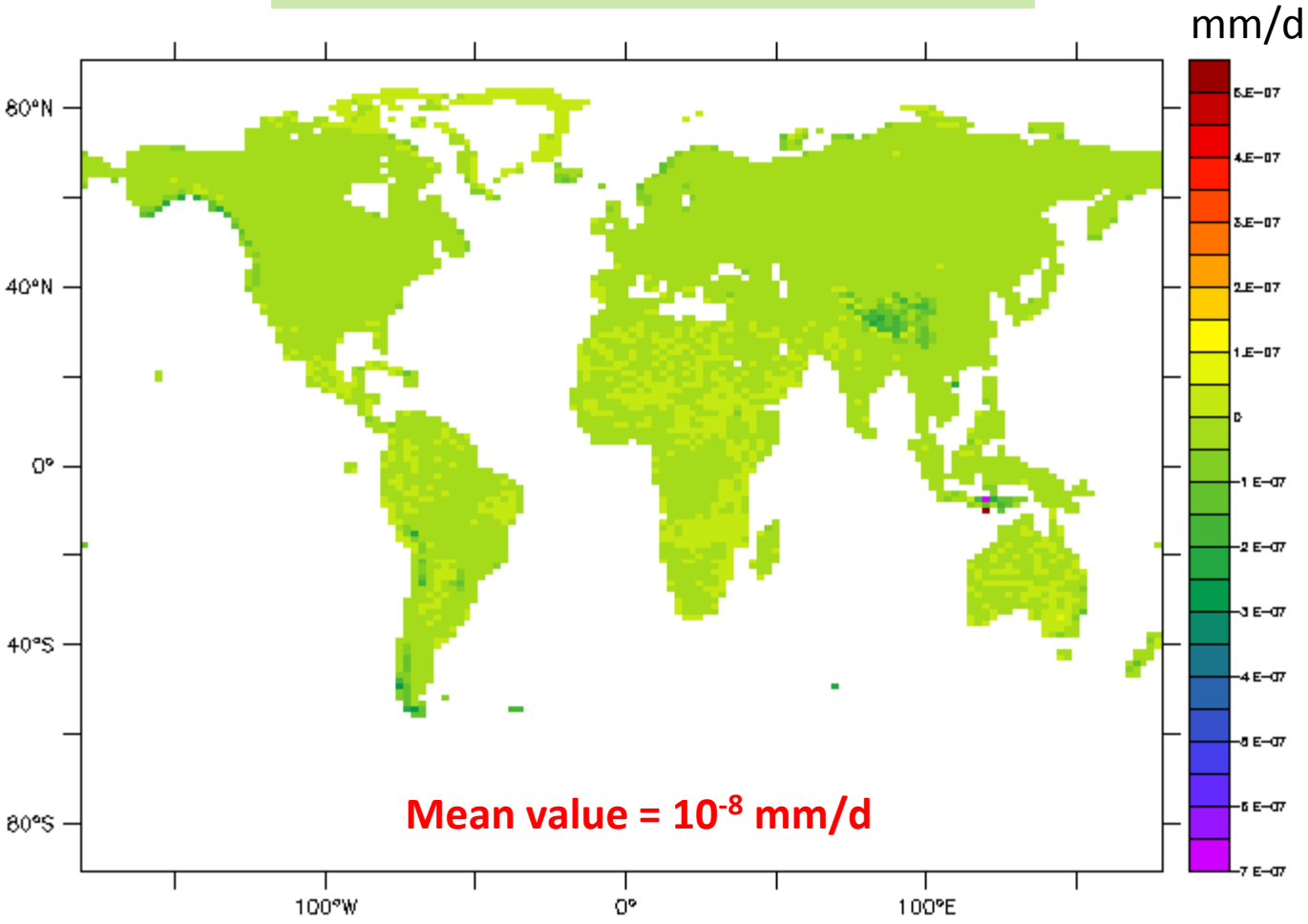
Water conservation

Monitored by TWBR = **Total water budget residu**

Plotted here for the final configuration, coupled and nudged simulation CL5.4783.L6012.v3

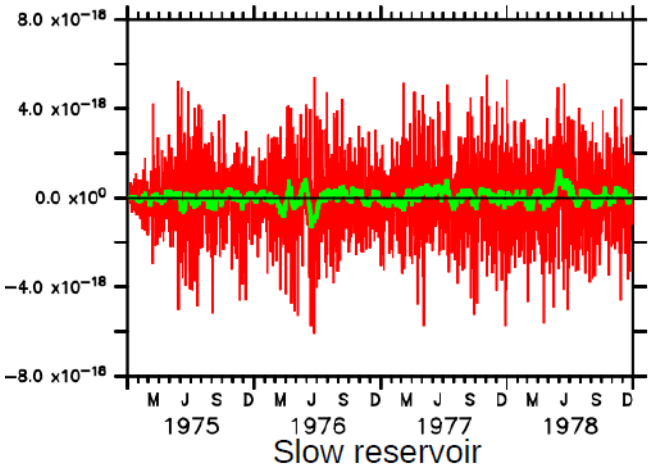
TWBR = dS/dt – (P – E – R)

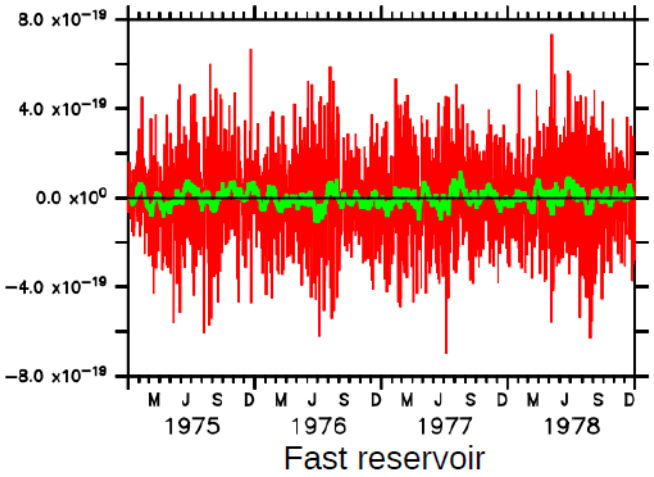
S includes intercepted water and snow



Water conservation

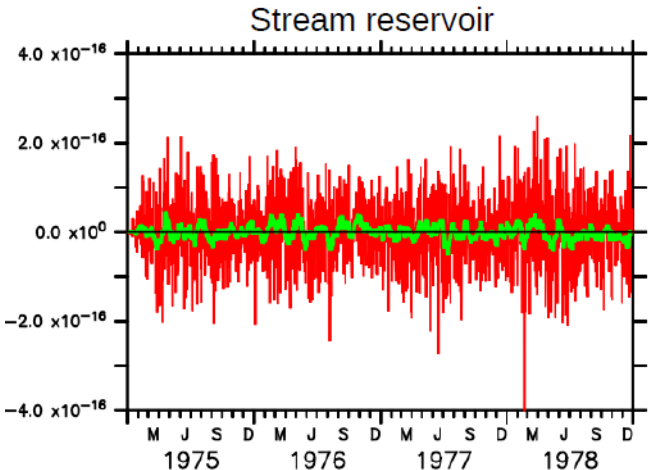
Similar water budget residus for the routing, all exported in the orchidee output via xios
wbr_stream, wbr_fast, wbr_slow, wbr_lakes

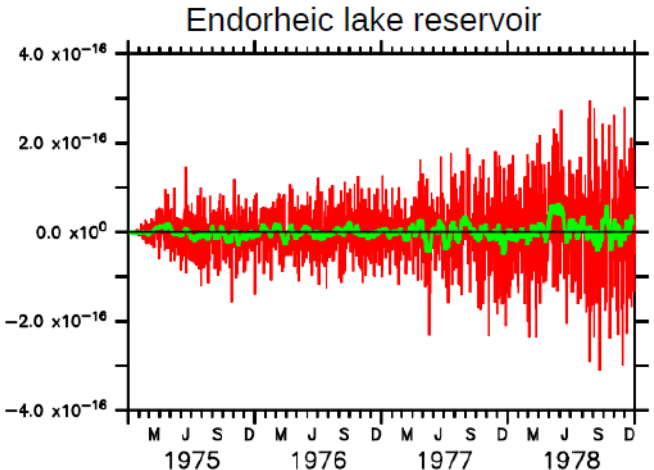




WBR (Water Budget Residual) (mm/d)

(green line = 15days running average)



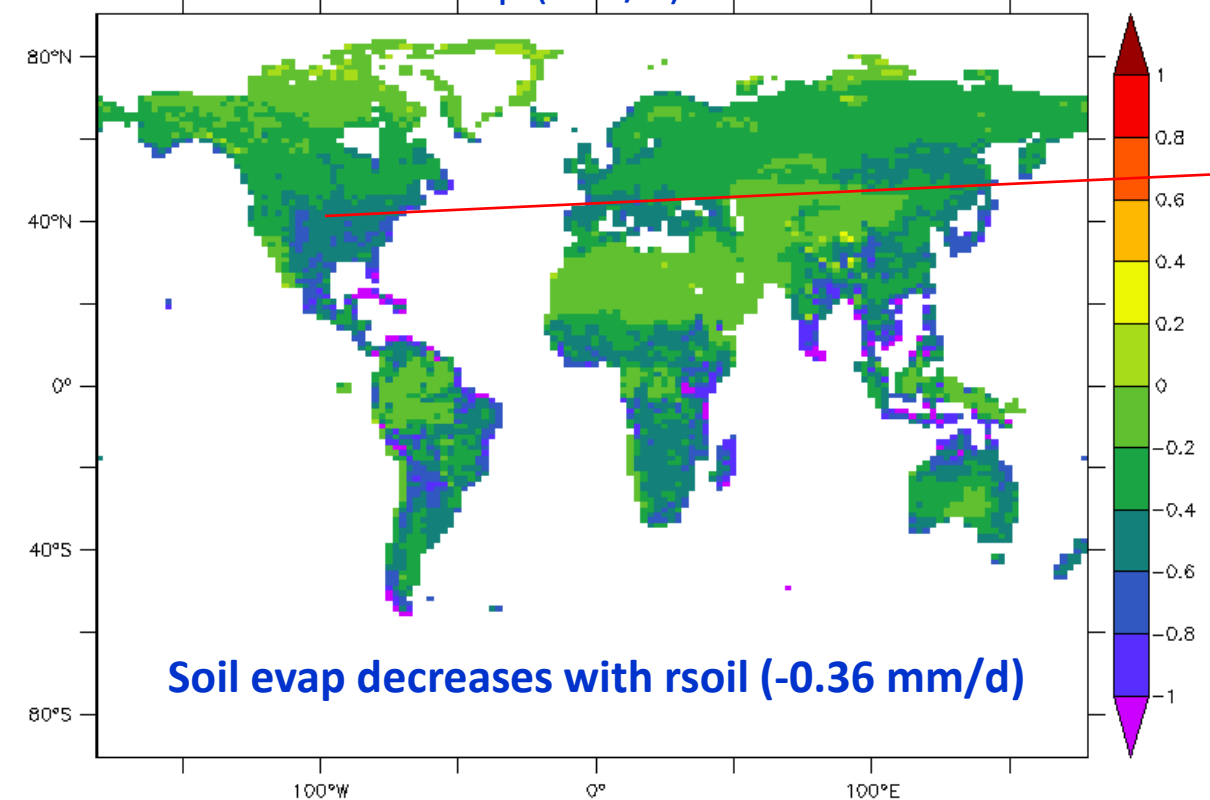


Soil evaporation

Goal: prevent too high soil evaporation, as found in winter over deciduous forests or crops
Solution: introduce a soil resistance increasing with soil moisture (Sellers et al. 1992) based on soil moisture in liquid phase in the top 4 layers (2.5 cm)

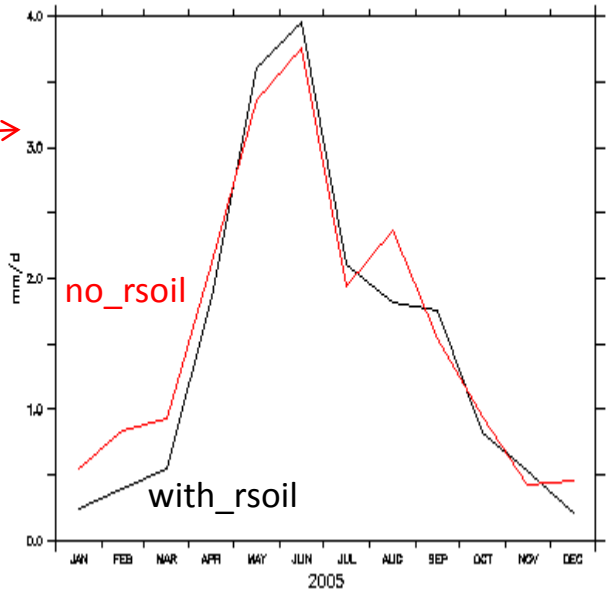
Tested in coupled and nudged mode, over 10 years, based on the final configuration (CL5.4783.L6012.v3)

Difference in soil evap (mm/d): with rsoil - without



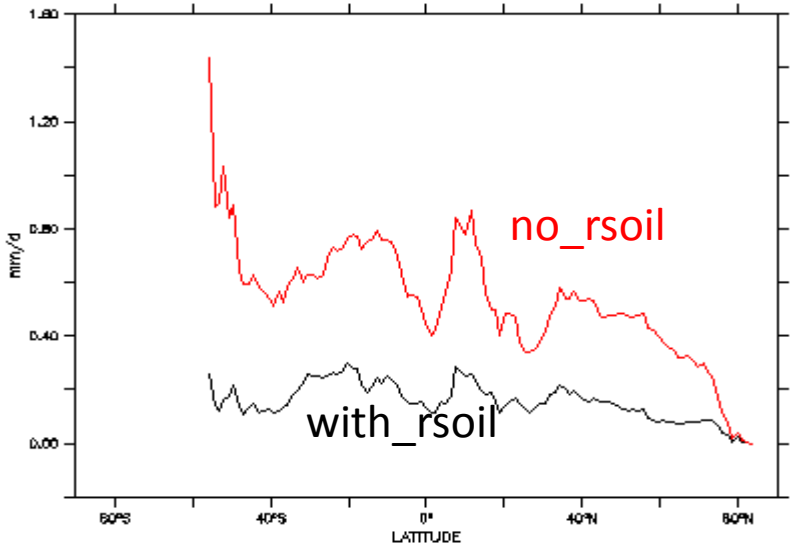
Soil evap decreases with rsoil (-0.36 mm/d)

Etot (mm/d) in the USA

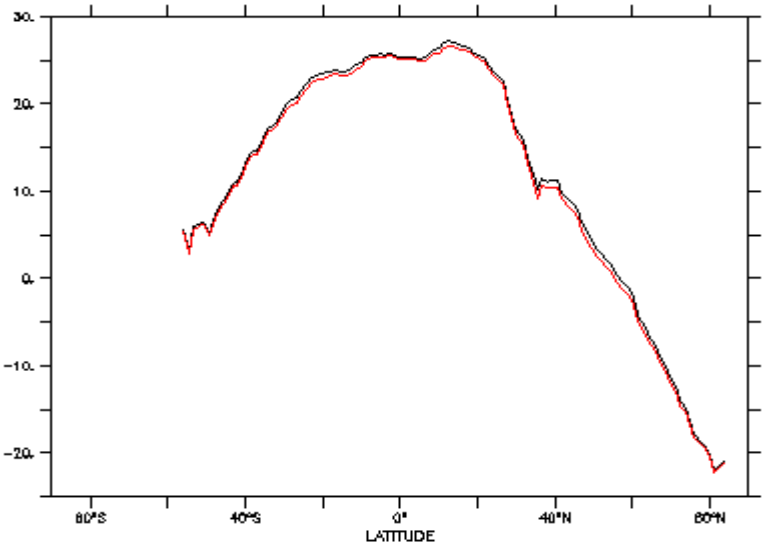


Soil evaporation

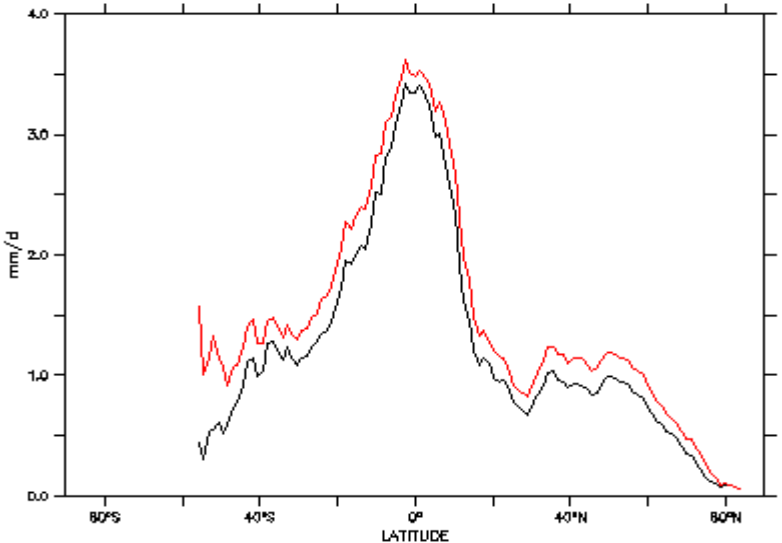
Esoil (Δ = -0.36 mm/d)



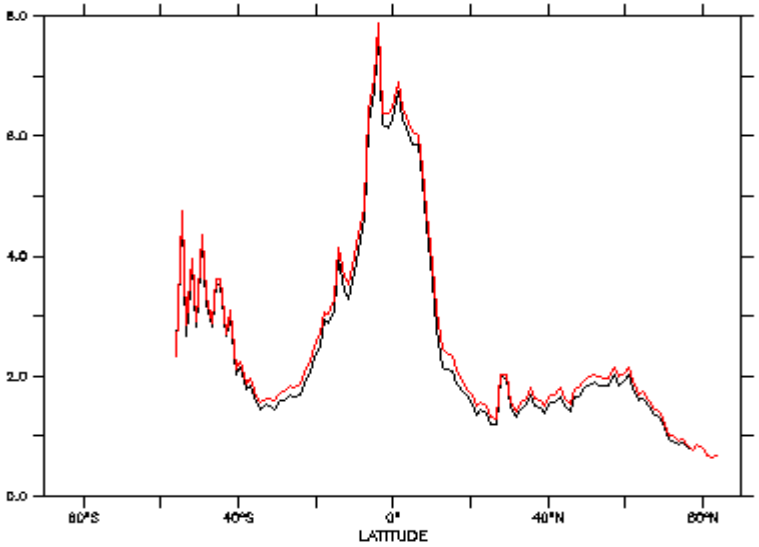
T2m (Δ = +0.58°C)



Etot (Δ = - 0.22 mm/d)



Ptot (Δ = - 0.15 mm/d)

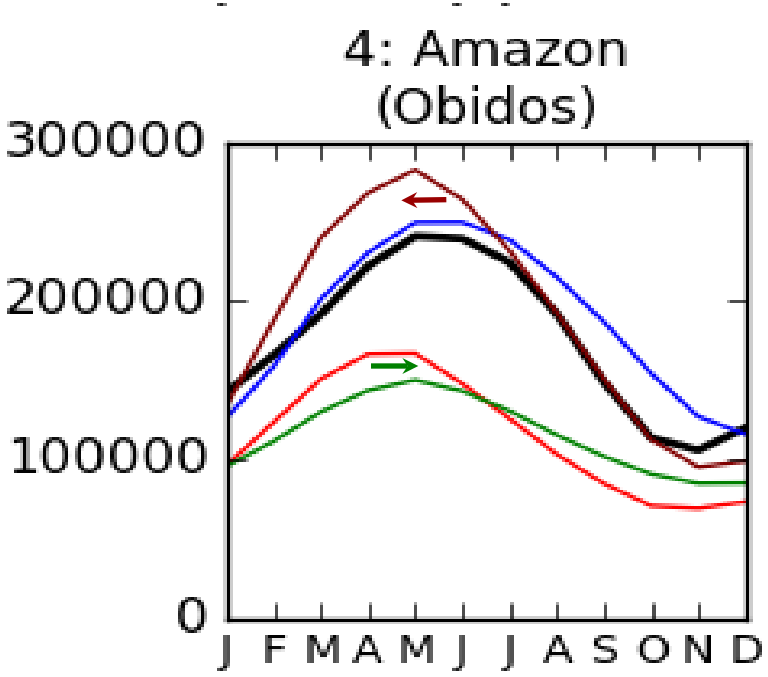


Routing time constants

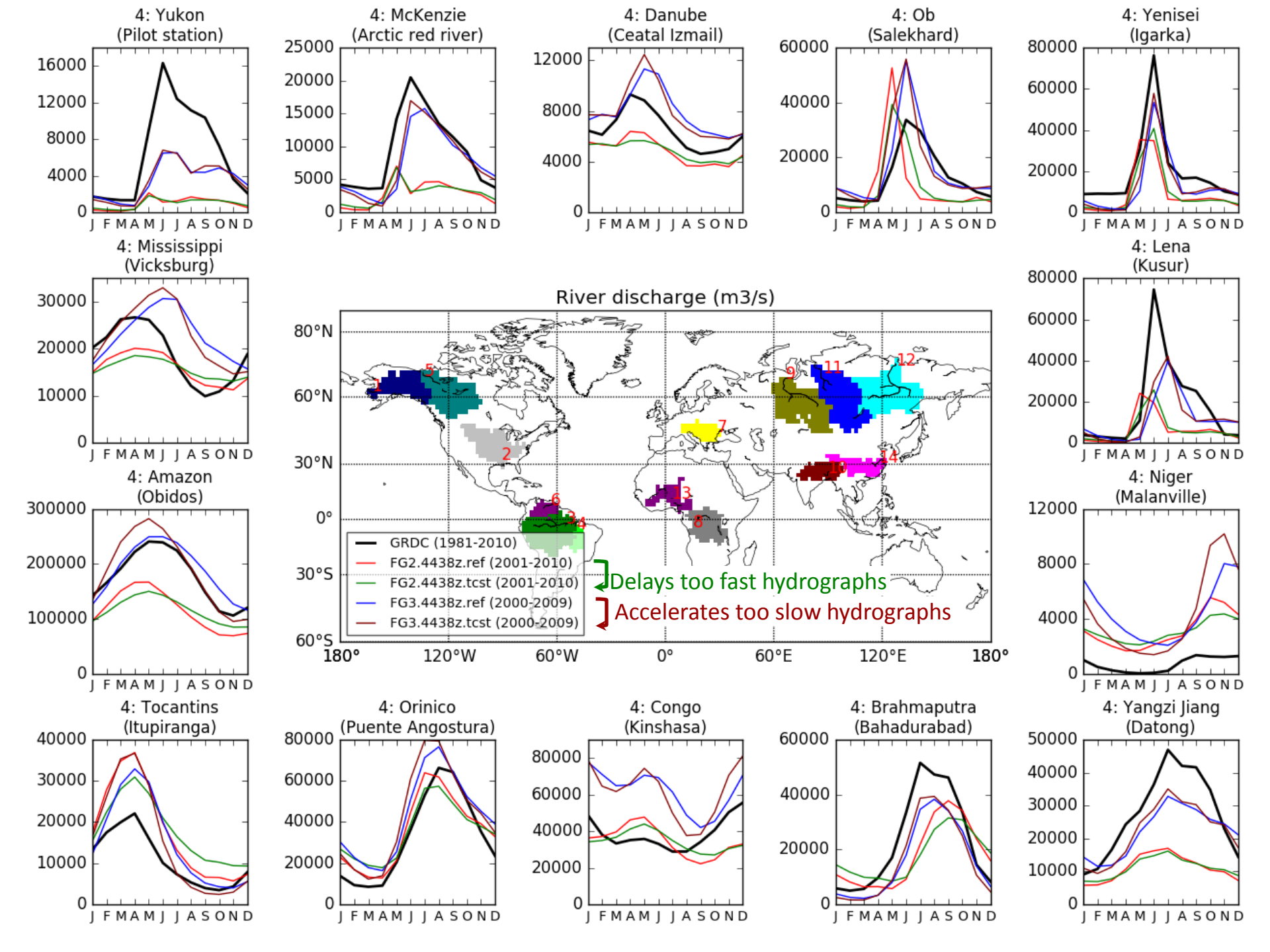
The time constants of the routing scheme correspond to a resolution of 1°
→ Too slow if the resolution gets higher (0.5° like GSWP3)
→ Too fast if the resolution gets coarser (2° or 144x142)

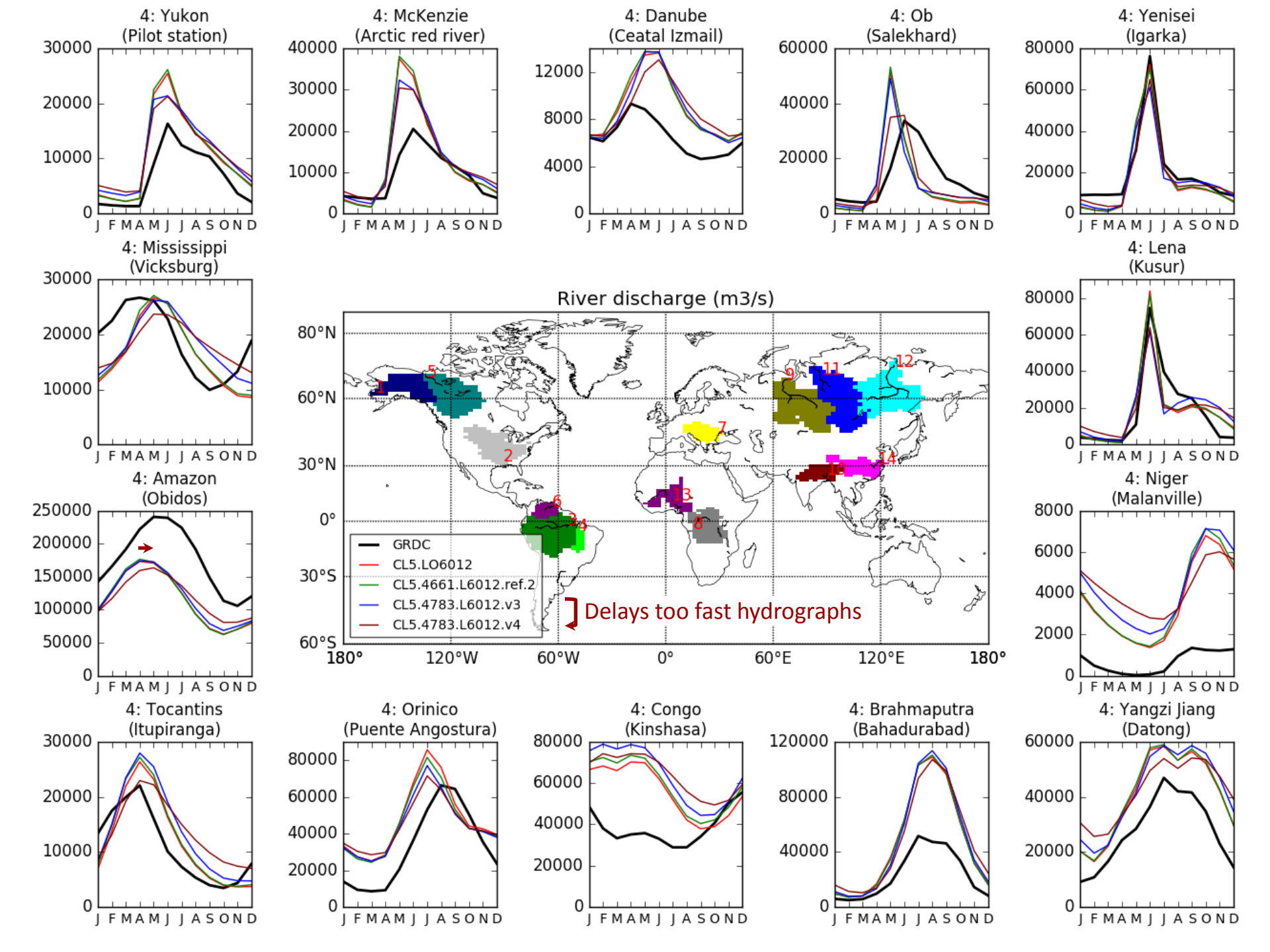
Patch based on externalized time constants : SLOW_TCST, FAST_TCST, STREAM_TCST
→ *0.5 if 0.5°, *2 if 2°, *1.78 if 144x142

Tested in off-line mode (WFDEI at 0.5° vs CRU-NCEP at 2°) over 10 years.



OBS
2° **FG2.std**
FG2.new] Delays too fast hydrographs
0.5° **FG3.std**
FG3.new] Accelerates too slow hydrographs


4: Yukon
(Pilot station)
4: McKenzie
(Arctic red river)
4: Danube
(Ceatal Izmail)
4: Ob
(Salekhard)
4: Yenisei
(Igarka)
4: Mississippi
(Vicksburg)
River discharge (m3/s)
4: Lena
(Kusur)
4: Amazon
(Obidos)
4: Niger
(Malanville)
4: Tocantins
(Itupiranga)
4: Orinico
(Puente Angostura)
4: Congo
(Kinshasa)
4: Brahmaputra
(Bahadurabad)
4: Yangzi Jiang
(Datong)
J F M A M J J A S O N D
80°N
60°N
30°N
0°
30°S
60°S
180°
120°W
60°W
0°
60°E
120°E
180°
GRDC (1981-2010)
FG2.4438z.ref (2001-2010)
FG2.4438z.tcst (2001-2010)
FG3.4438z.ref (2000-2009)
FG3.4438z.tcst (2000-2009)
Delays too fast hydrographs
Accelerates too slow hydrographs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GRDC
CL5.LO6012
CL5.4661.L6012.ref.2
CL5.4783.L6012.v3
CL5.4783.L6012.v4
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