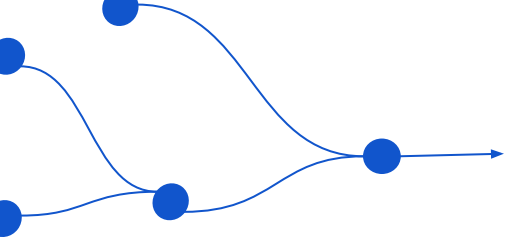
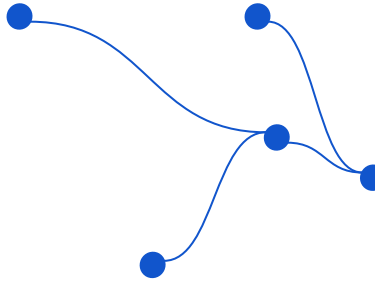


ORCHIDEE DEV - 21/06/2024



Water routing for CMIP7 ORCHIDEE

technical update and studies examples

Antoine Bierjon (IPSL) & Pierre Tiengou (METIS/LMD)

… as well as : Yann Meurdesoif, Agnès Ducharne, Josefine Ghattas, Jan Polcher, Pedro Arboleda, Frédérique Cheruy, …

Some introductions…

Antoine Bierjon
Research Engineer
IPSL (45-55 211)

Pierre Tiengou
PhD student
METIS (56-55 405B) / LMD

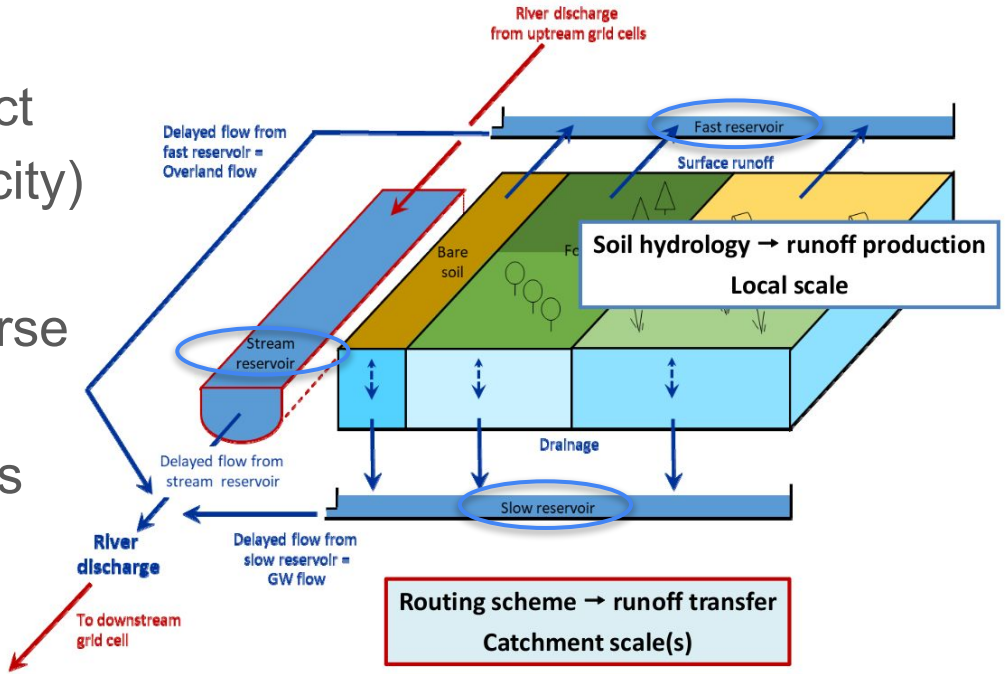
Routing ?

- Computational scheme to predict the behaviour (magnitude, velocity) of a flood wave with time (hydrograph) along a water course

- Lateral transport of runoff across continents

- Enables water cycle closure

- But also many more things !



Credits: A. Ducharne, ORCHIDEE Training

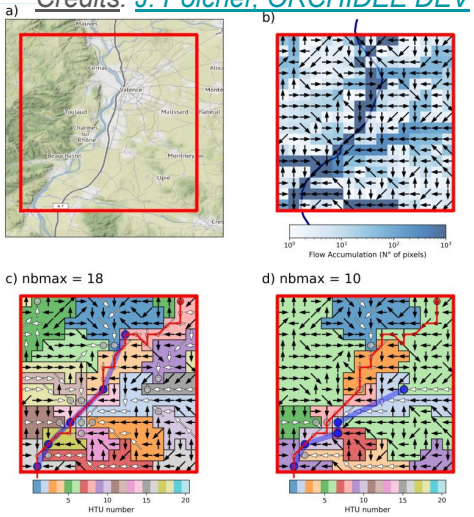
The routing methods in ORCHIDEE: overview & clarification

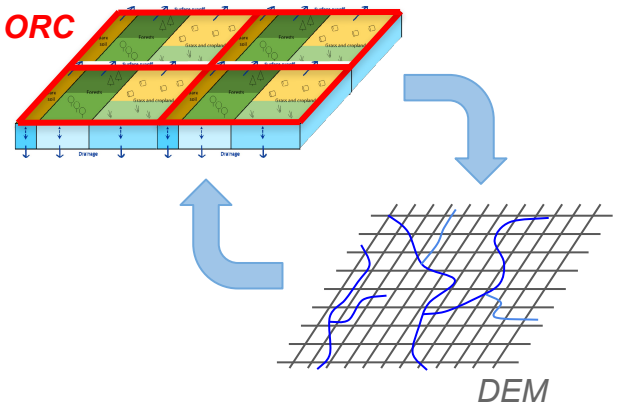
CMIP6

standard

The routing methods in ORCHIDEE: overview & clarification

Credits: J. Polcher, ORCHIDEE DEV





now

standard	subgrid_halfdeg
highres	subgrid_htu

**HTU: Hydrological Transfer Unit*

simple	interp_topo_v0
native	interp_topo
(native HTU)	(interp_htu)

The routing methods in ORCHIDEE: overview & clarification

⇒ Renaming of the routing methods to be done very soon !

(old flags ROUTING will still be recognized)

⇒ New documentation to come on the wiki on :

- how to activate the different routing methods

- what processes can be activated with the different routing methods
  (table due to evolve)

Previous ROUTING flag	New ROUTING flag	Can run with Irrigation	Can run with Flood Plains	Can run with Lakes	Can run with Water Temperature
standard	subgrid_halfdeg	old & new	old only	no	no
highres	subgrid_htu	old & new	old & new	yes	yes
simple	interp_topo_v0	old only	old only?	no	no
native	interp_topo	old & new	old only?	no	no
(native htu	interp_htu	no	no	no	no)

follow ticket #997
for more info !

The routing methods in ORCHIDEE: overview & clarification

⇒ (Old) documentation already existing on the wiki :

- *https://forge.ipsl.fr/orchidee/wiki/DevelopmentActivities/ORCHIDEE-routage*
- *https://forge.ipsl.fr/orchidee/wiki/Documentation/Ancillary*
- *https://forge.ipsl.fr/orchidee/wiki/Documentation/UserGuide/RoutageSimple*
- *https://forge.ipsl.fr/orchidee/wiki/Documentation/UserGuide/RoutageHighres*
- *https://forge.ipsl.fr/orchidee/wiki/GroupActivities/Meetings/Developer*

⇒ Tickets to follow : *#842* ; *#857* ; *#910* ; *#955* ; *#978* ; *#997*

⇒ Other resources :

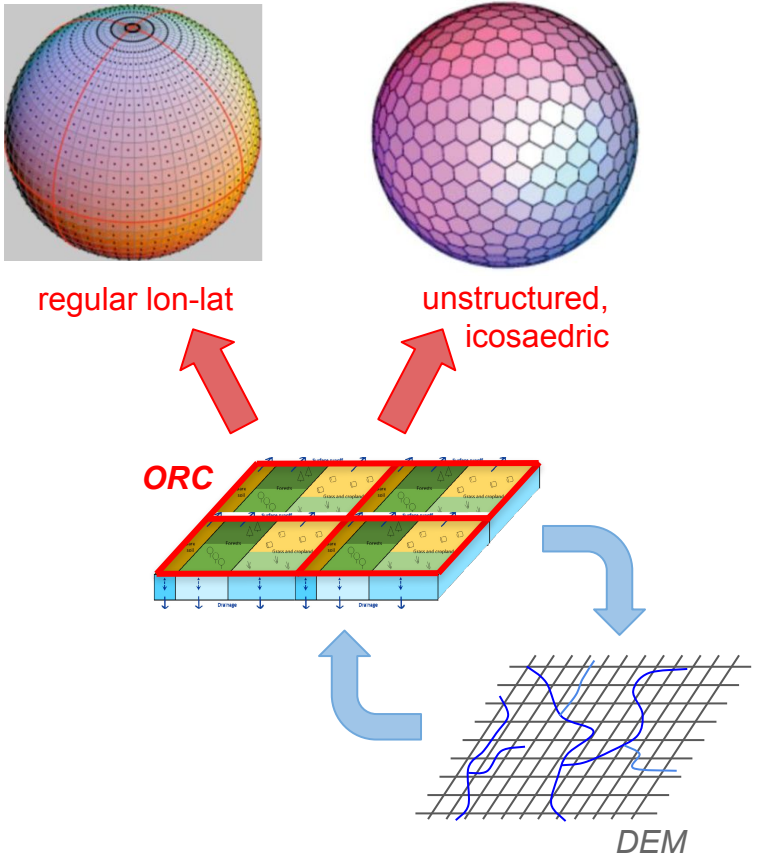
- *wiki page* of project HydroFiles
- *wiki page* of project Routing-PP

Routing interp_topo: getting ready for CMIP7

- More robust rewriting by Y. Meurdesoif of current trunk default routing “interp_topo_v0”
- Works with any ORCHIDEE grid type, any resolutions
- Interpolations as conservative as possible

⇒ Implemented in trunk and ORC2.2

⇒ Experiment configs adapted in the trunk
(default is still “interp_topo_v0”)



Routing interp_topo: getting ready for CMIP7

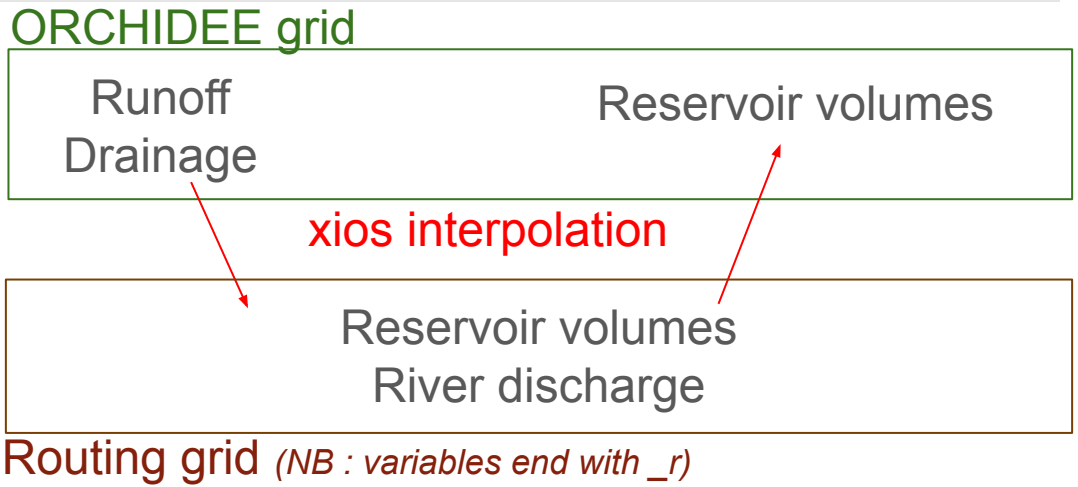
sechiba.card

```
# Choice for routing scheme. Set ROUTING below to have following parameters set in orchidee.def :
# ROUTING=standard   => in orchidee.def RIVER_ROUTING=y and ROUTING_METHOD=standard
# ROUTING=highres    => in orchidee.def RIVER_ROUTING=y and ROUTING_METHOD=highres
# ROUTING=simple     => in orchidee.def RIVER_ROUTING=y and ROUTING_METHOD=simple
# ROUTING=native     => in orchidee.def RIVER_ROUTING=y and ROUTING_METHOD=native (note: routing_simple.nc is used also for this case)
# ROUTING=off        => in orchidee.def RIVER_ROUTING=n
ROUTING=native
```

```
[BoundaryFiles]
List= (${R_IN}/SRF/PFTMAPS/CMIP6/ESA-LUH2v2/historical/15PFT.v2023.1/PFTmap_${year}.nc, PFTmap.nc)
ListNonDel= (${R_IN}/SRF/ROUTING/routing_simple.nc, .)
```

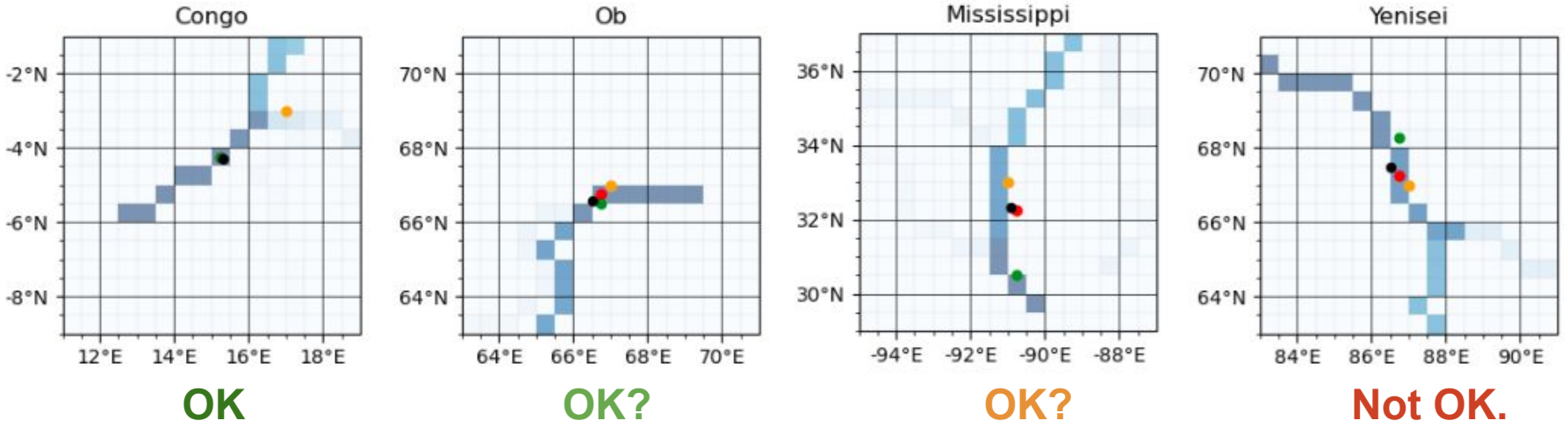
```
[RestartFiles]
List=   (sechiba_rest_out.nc, sechiba_rest.nc, sechiba_rest_in.nc), \
        (routing_restart.nc, routing_restart.nc, routing_start.nc, OPTIONAL)
```

```
[OutputFiles]
List=    ...,\
         (diag_routing.nc,   ${R_OUT_SRF_O_D}/${PREFIX}_1D_sechiba_routing.nc, NONE),\
         (diag_routing_r.nc, ${R_OUT_SRF_O_D}/${PREFIX}_1D_sechiba_routing_r.nc, NONE)
```



Routing interp_topo: getting ready for CMIP7

New routing grid for **hydrographs**
=> How to evaluate routing interp_topo ?



OK **OK?** **OK?** **Not OK.**

⇒ automatic stations snapping (I:stations.def / O:stations.nc) ?
→ implemented but still some work to do… (+ add basin mask)

stations.def

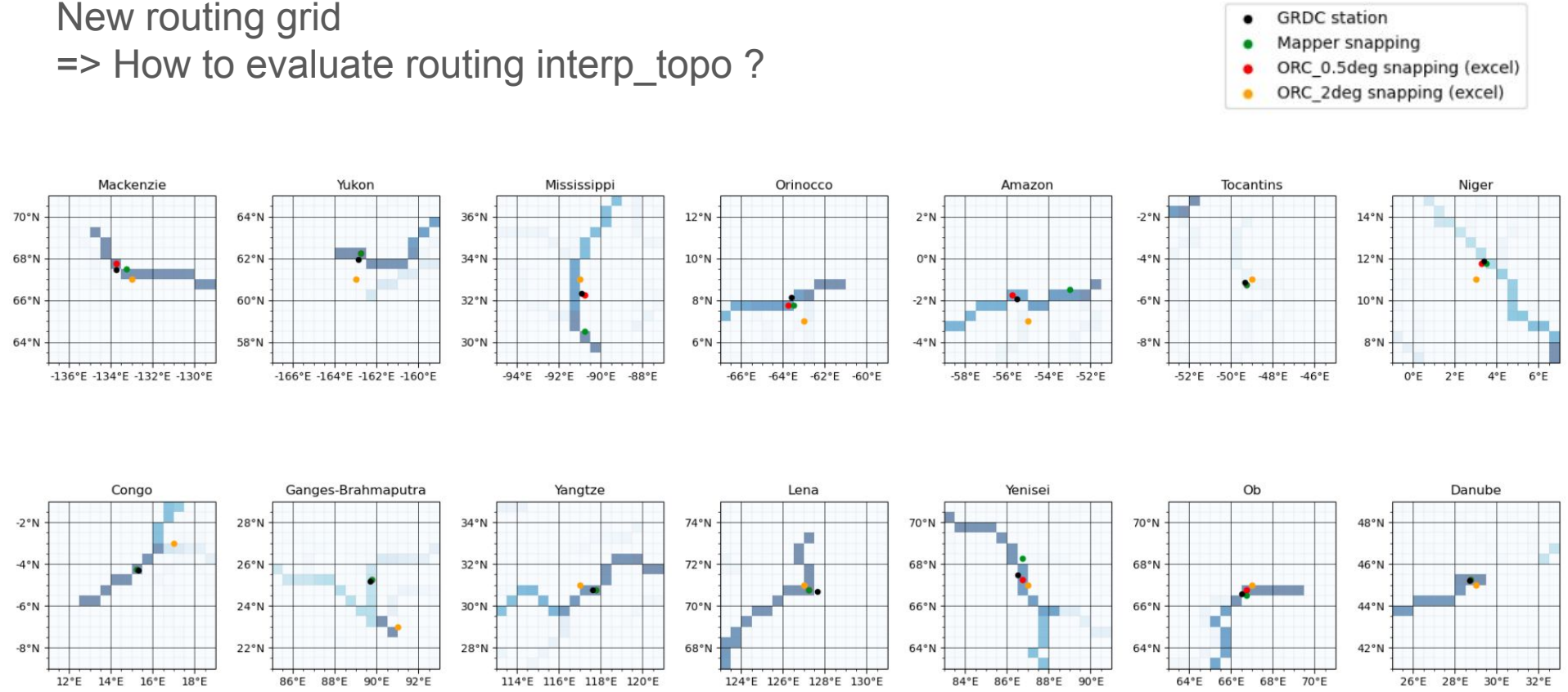
```
nb_station =  14

station1_id =  Arctic Red River
station1_coor =  -133.7447 67.4583
station1_prec = 1000000
station1_area =  1660000.0
```

⇒ take inspiration from/make use of HydroFiles and RoutingPP ?
(*Polcher et al. 2022*)

Routing interp_topo: getting ready for CMIP7

New routing grid
=> How to evaluate routing interp_topo ?



Routing comparisons

Study example : Global runs FG_CRUJRA_HIST (2°x2°) with ORC-trunk, 1970-2000

New ROUTING flag	Routing grid resolution	DT_ROUTING [s]	TCST_SLOW [10^{-3} day/km]	TCST_FAST [10^{-3} day/km]	TCST_STREAM [10^{-3} day/km]
subgrid_halfdeg	(0.5° (def))	86400 (def)	25 (def)	3 (def)	0.24 (def)
interp_topo_v0	0.5° (def)	86400 (def)	25 (def)	3 (def)	0.24 (def)
interp_topo	0.5° (def)	86400 (def)	25	3	0.24
interp_topo	0.5° (def)	1800	25	3	0.24

```
routing_file_type = standard
```
run.def

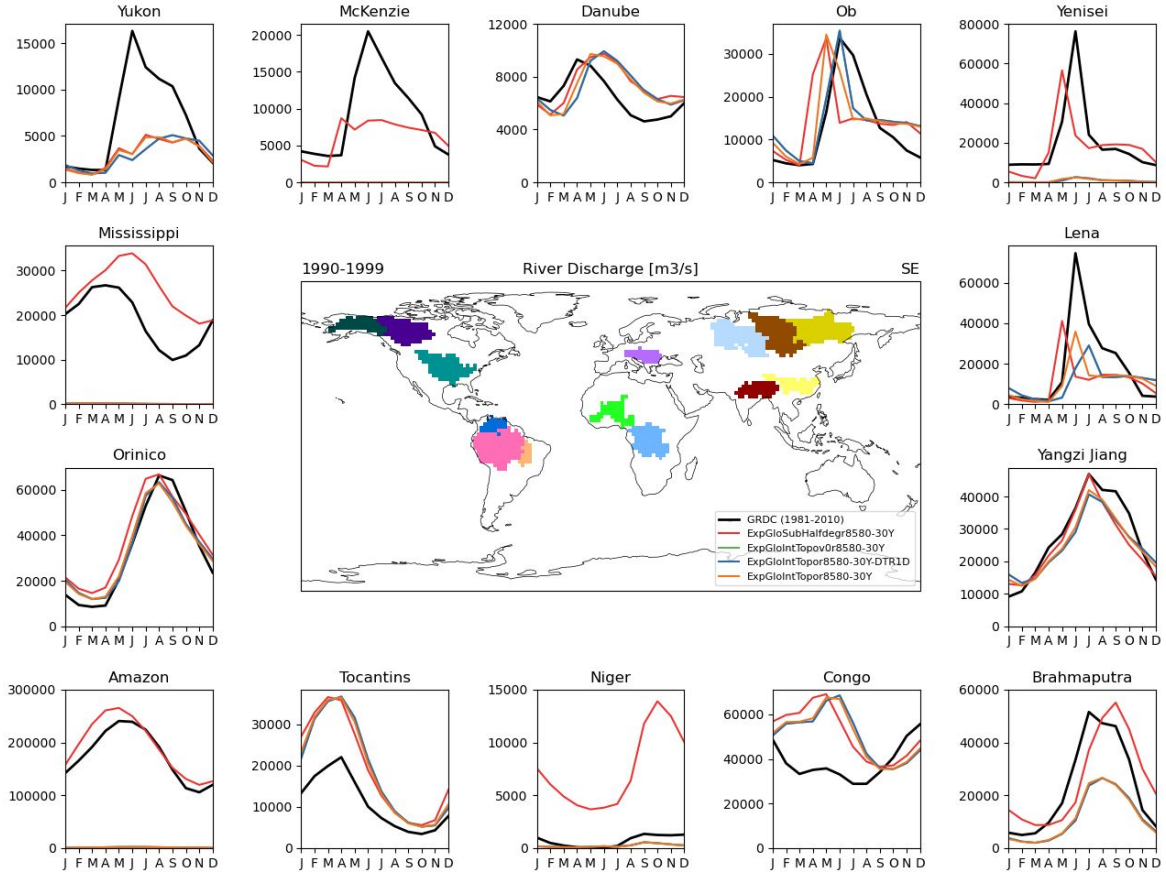
=DT_SECHIBA

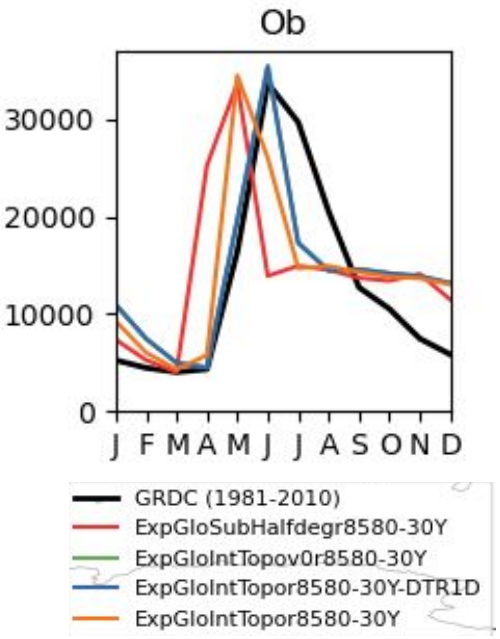
```
SLOW_TCST = 0.025
FAST_TCST = 0.003
STREAM_TCST = 0.00024
```
run.def

/!\ Reservoir time constants written in [day / km] in run.def for interp_topo

Routing comparisons

Study example : Global runs FG_CRUJRA_HIST (2°x2°) with ORC-trunk, 1970-2000

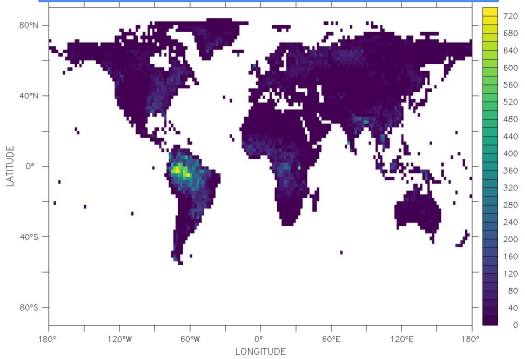




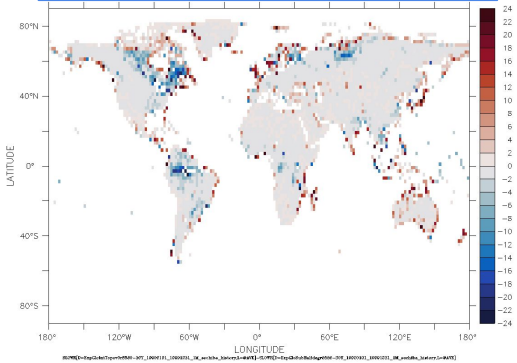
Routing comparisons

Study example : Global runs FG_CRUJRA_HIST (2°x2°) with ORC-trunk, 1970-2000

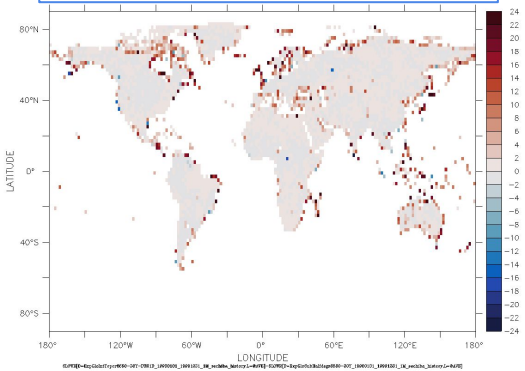
subgrid_halfdeg (1)



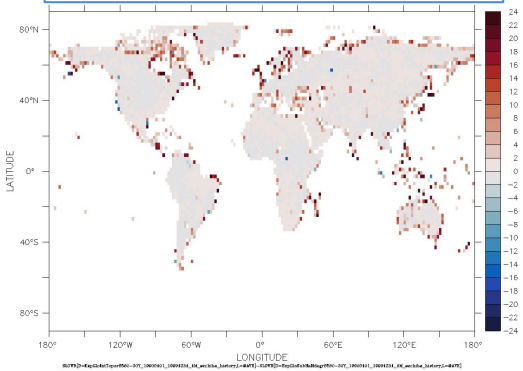
interp_topo_v0 - (1)



interp_topo - (1)



interp_topo_*DTR1800* - (1)

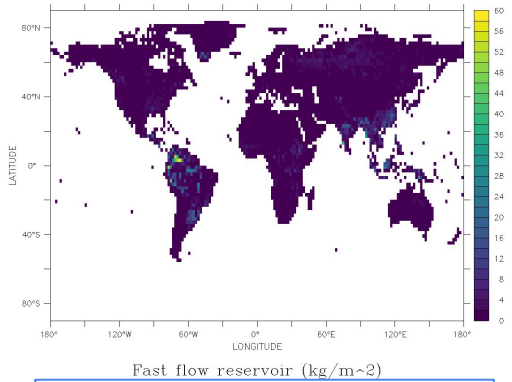


Slow reservoir
[0-720 kg/m²]

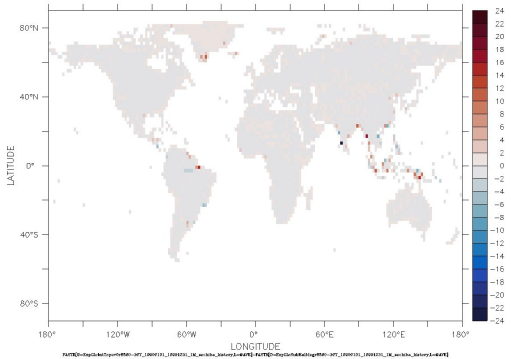
Routing comparisons

Study example : Global runs FG_CRUJRA_HIST (2°x2°) with ORC-trunk, 1970-2000

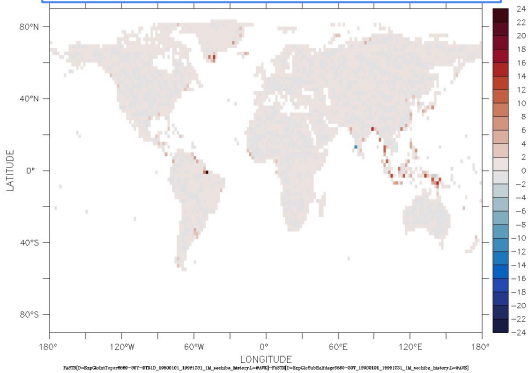
subgrid_halfdeg (1)



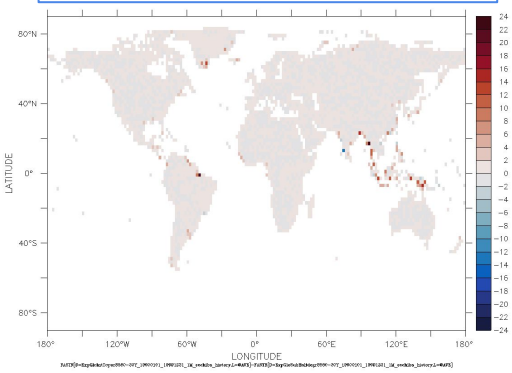
interp_topo_v0 - (1)



interp_topo - (1)



interp_topo_*DTR1800* - (1)

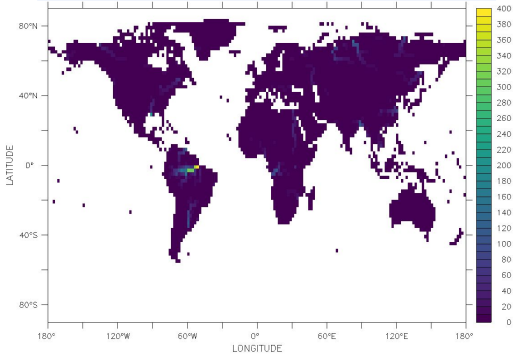


Fast reservoir
[0-50 kg/m²]

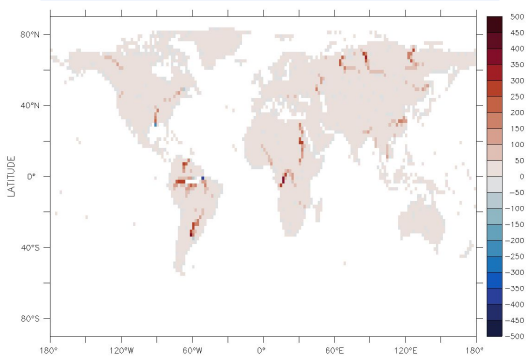
Routing comparisons

Study example : Global runs FG_CRUJRA_HIST (2°x2°) with ORC-trunk, 1970-2000

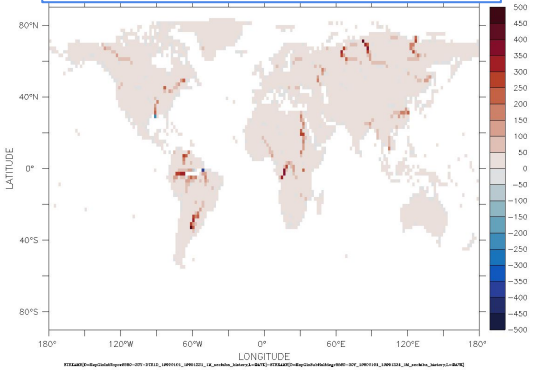
subgrid_halfdeg (1)



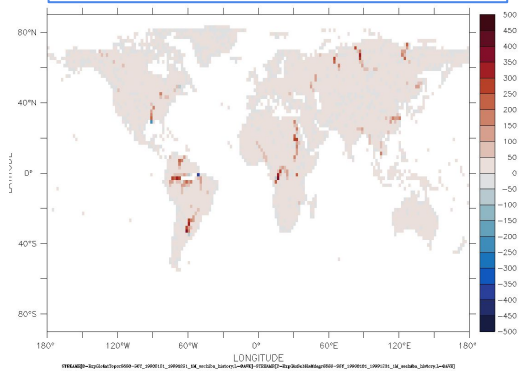
interp_topo_v0 - (1)



interp_topo - (1)



interp_topo_*DTR1800* - (1)



Stream reservoir
[0-1500 kg/m²]

Study example : Regional impacts of irrigation in Spain with ORC2.2

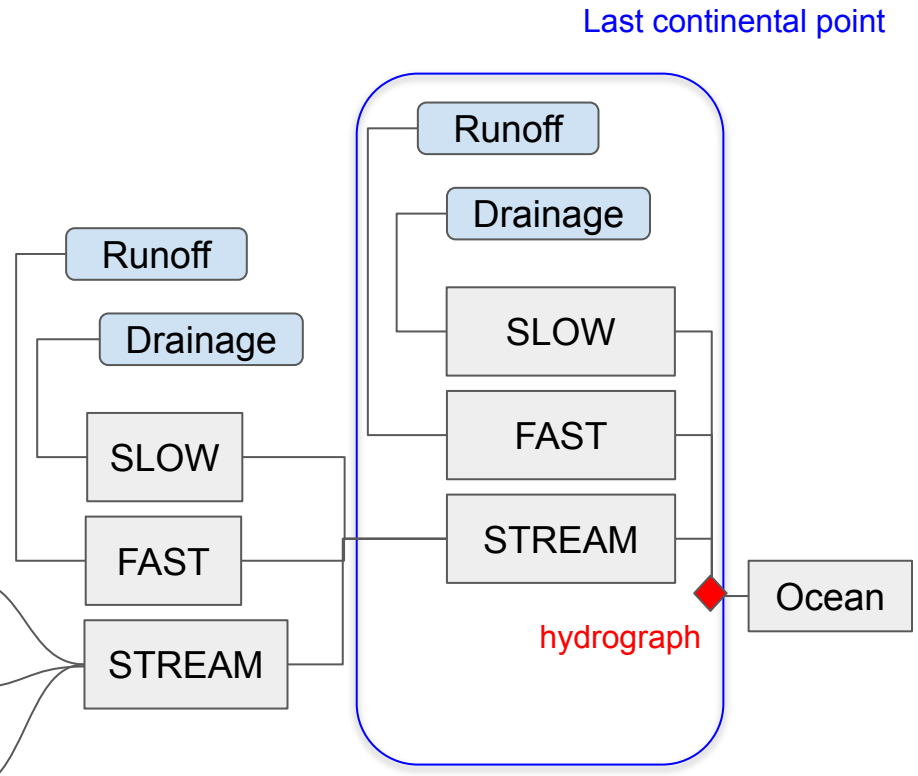
Objective :
Study the impacts of simulated irrigation in coupled simulations using the ICOLMDZOR Limited Area Model configuration.
Requires using river routing with DYNAMICO, at high resolutions
=> **interp_topo** with **MERIT 2km topography**

1) Offline evaluation : comparison with subgrid_halfdeg using 0.5° topography
2) Offline calibration using MERIT topography : choice of time constants
3) Coupling with ICOLMDZ

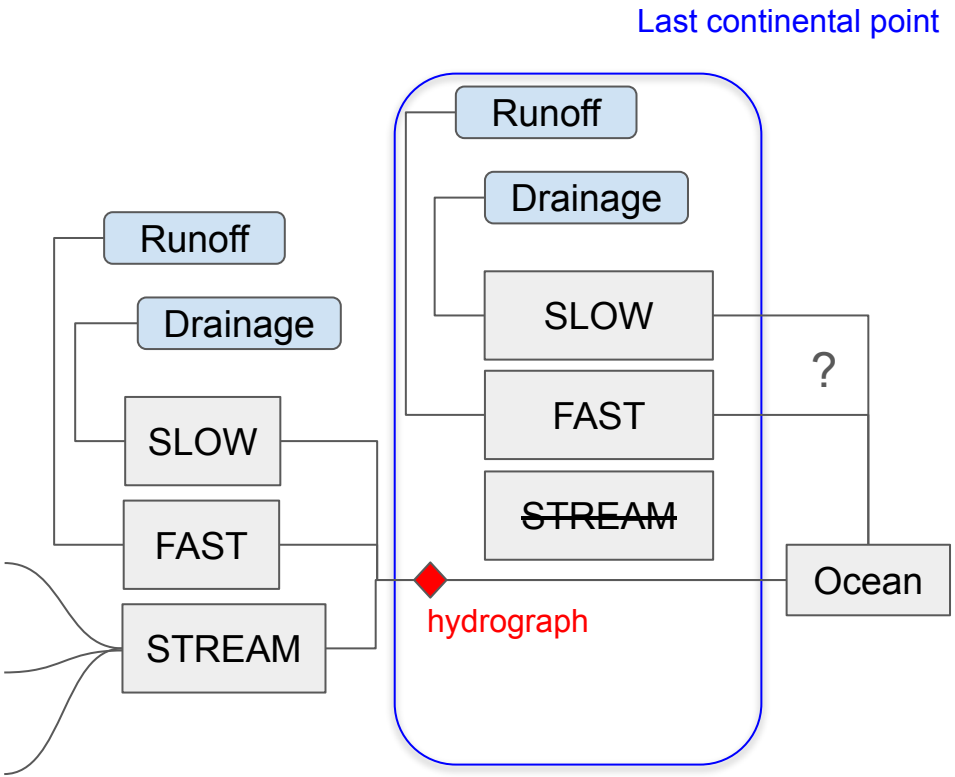
1) Offline evaluation : interp_**topo_0.5°** vs subgrid_halfdeg

Development differences

subgrid_halfdeg

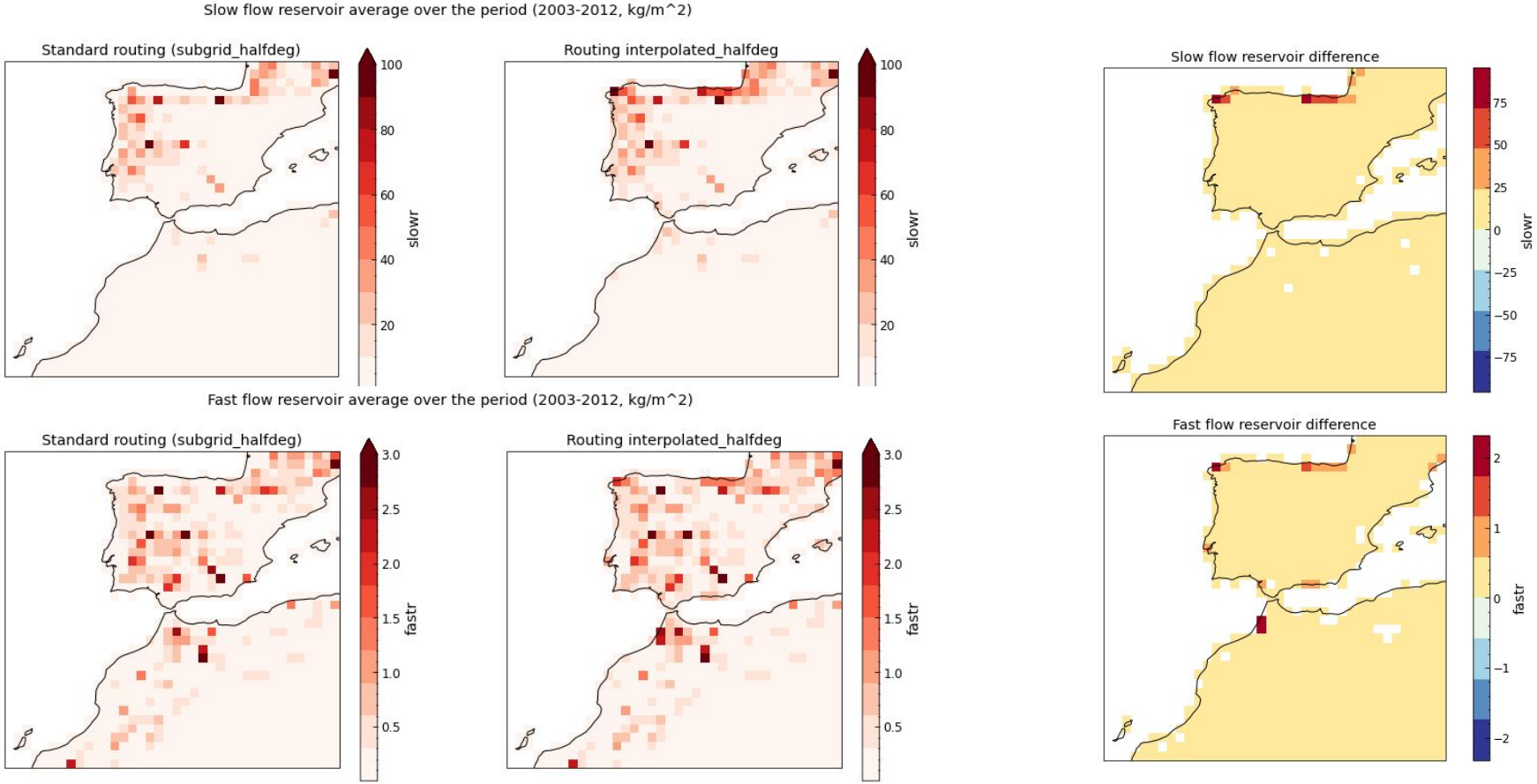


interp_topo



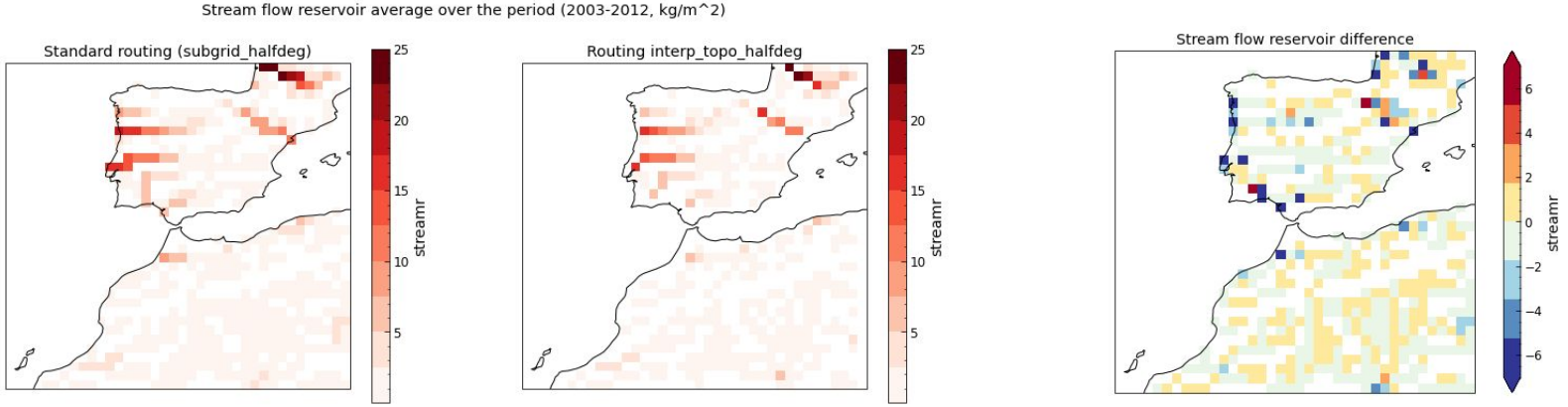
1) Offline evaluation : interp_**topo_0.5°** vs subgrid_halfdeg

SLOW and FAST : differences on the coastline

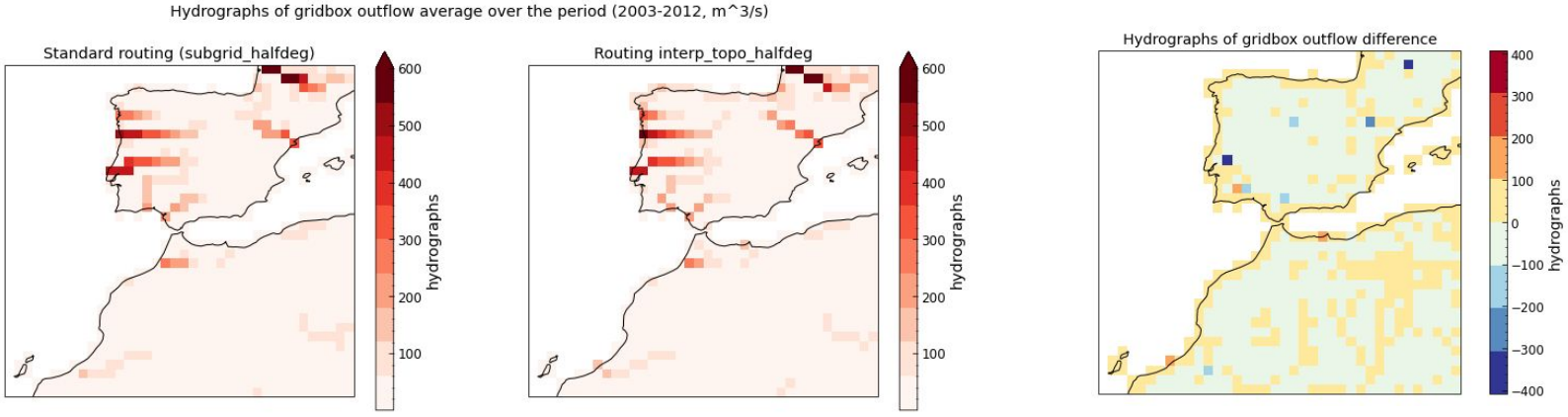


1) Offline evaluation : interp_**topo_0.5°** vs subgrid_halfdeg

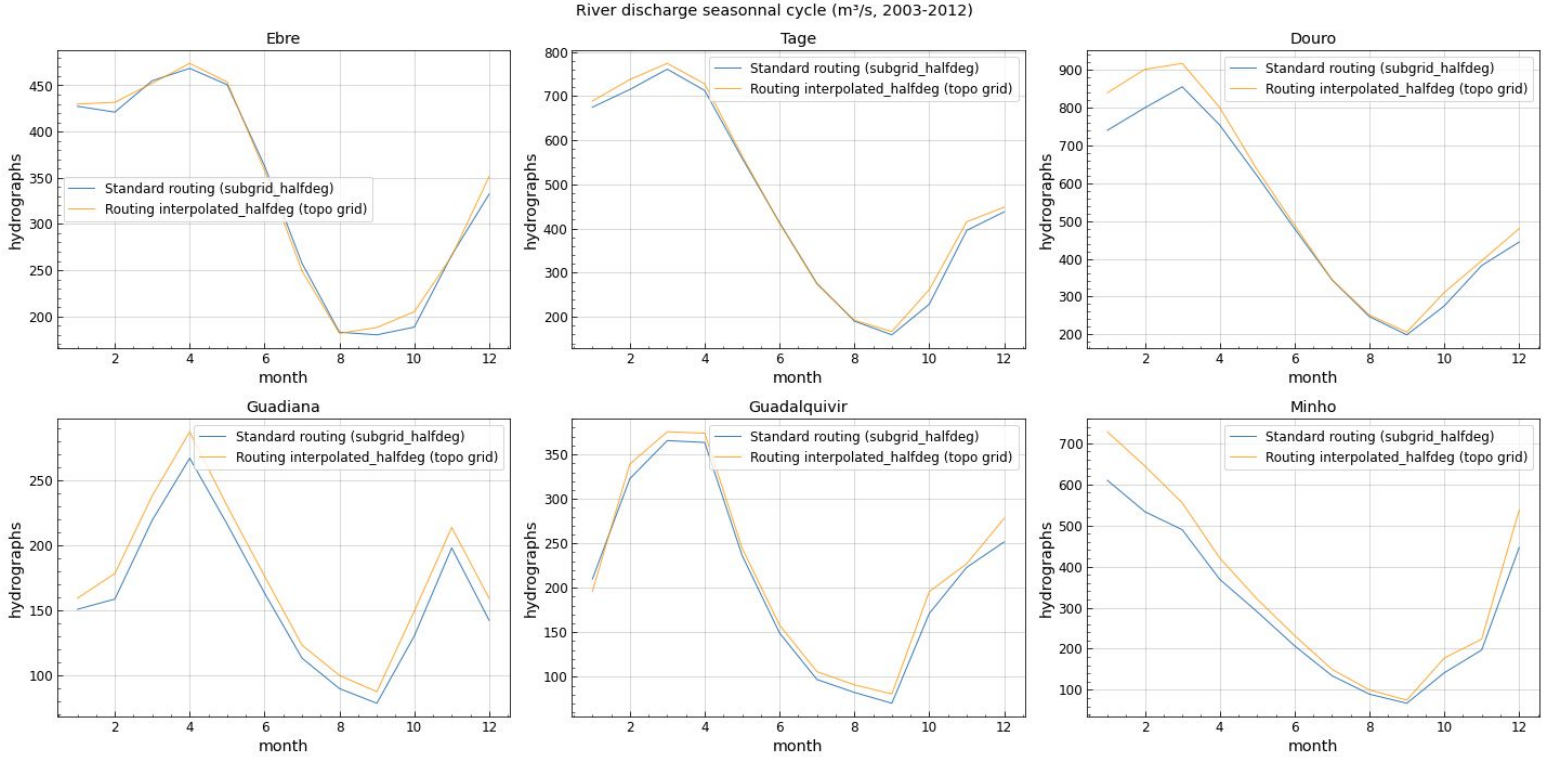
STREAM : differences on the coastline and on the routing path



Hydrographs : differences on the routing path



1) Offline evaluation : interp_**topo_0.5°** vs subgrid_halfdeg



2) Offline evaluation and calibration of interp_**topo_MERIT**

MERIT : different topography, ~2km resolution

Reservoir time constants (10^{-3} day/km)

3 "reference" options

	SLOW	FAST	STREAM
Y.Meurdesoif + D.Kiliç	1.2	0.9	0.03
Subgrid_halfdeg (standard)	25	3	0.24
Subgrid_HTU (L. Rinchiuso)	600	80	6.3

3 initial experiments

	SLOW	FAST	STREAM
TCST1	3	0.3	0.03
TCST2	30	3	0.3
TCST3	300	30	3

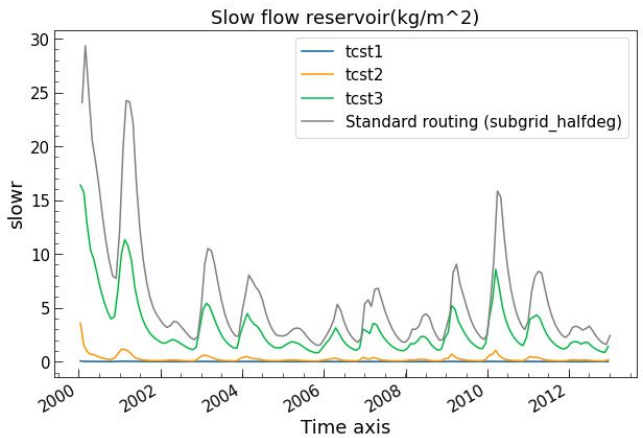
Variables to evaluate

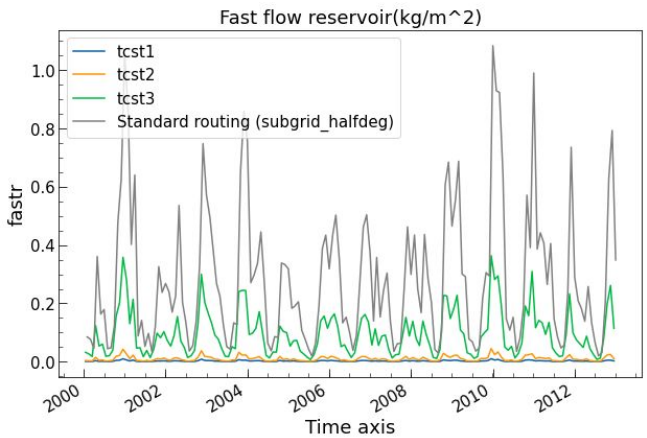
- Reservoir volumes
- River discharge

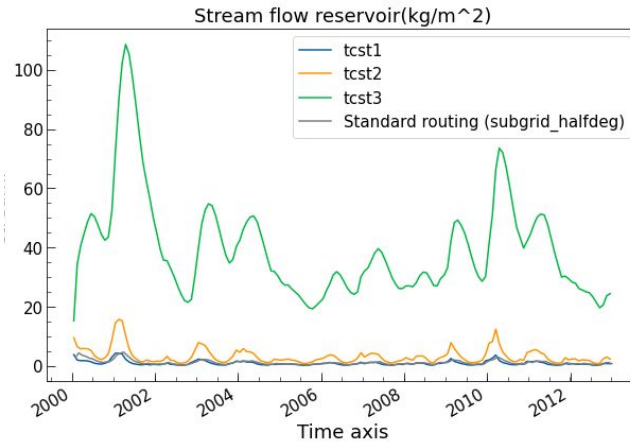
Other factors considered

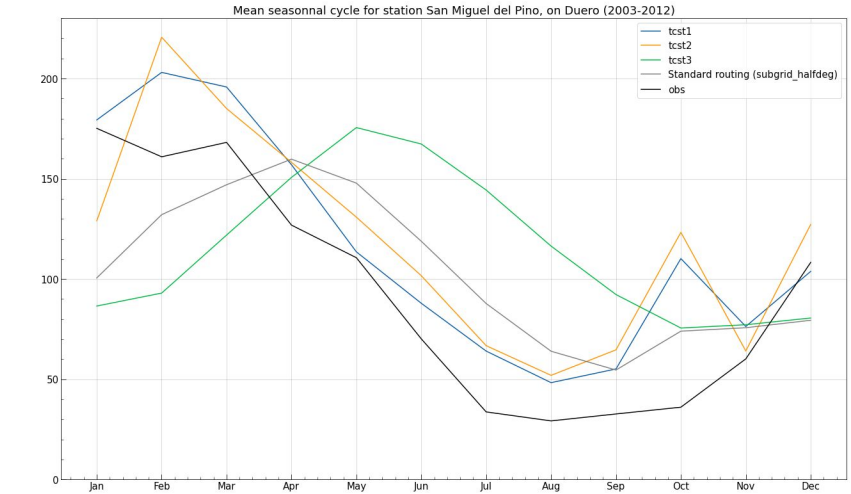
- Forcing (WFDEI vs GSWP3)
- Irrigation (noIrr, Irr_0.9, Irr_0.6)

2) Offline evaluation and calibration of interp_**topo_MERIT**





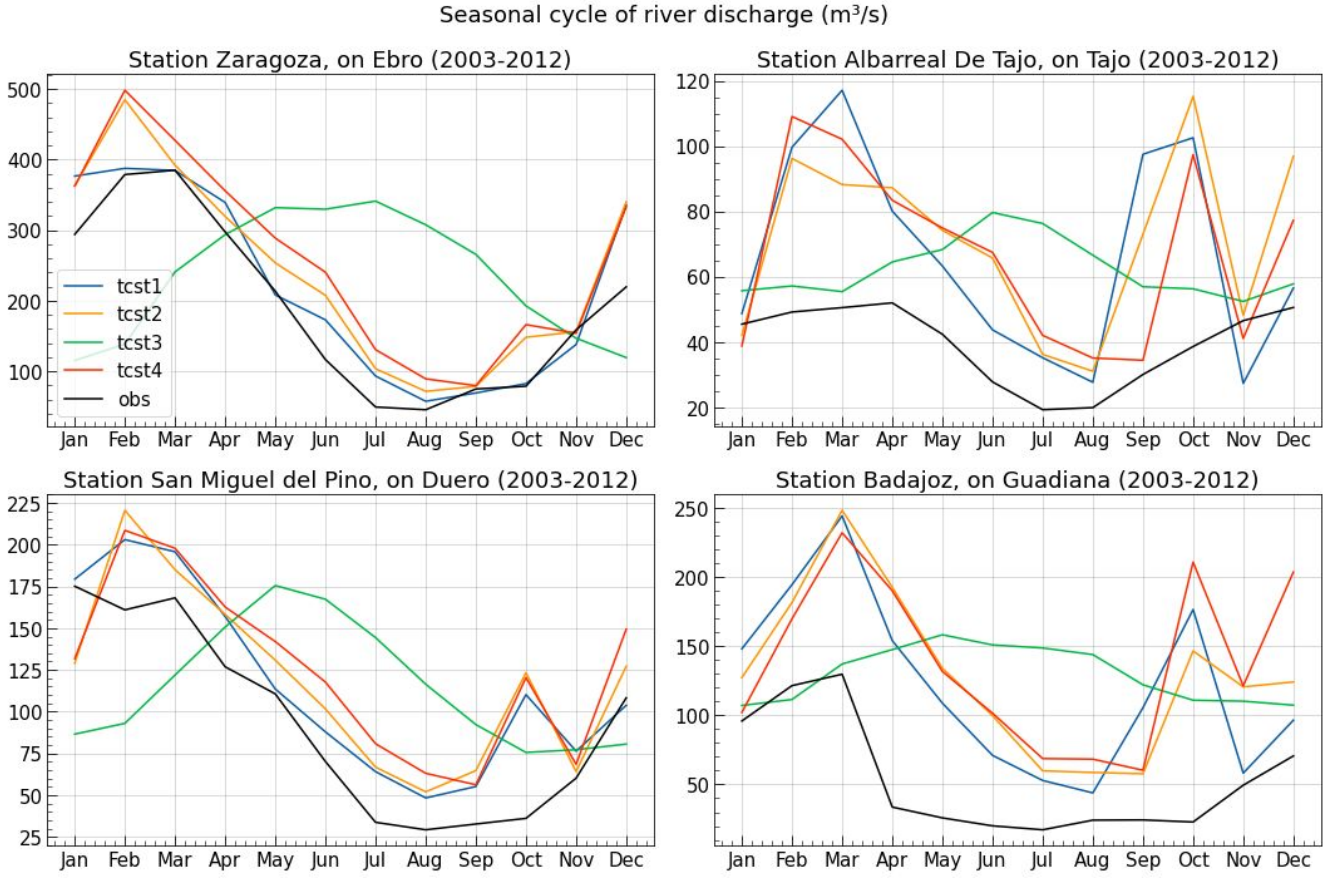


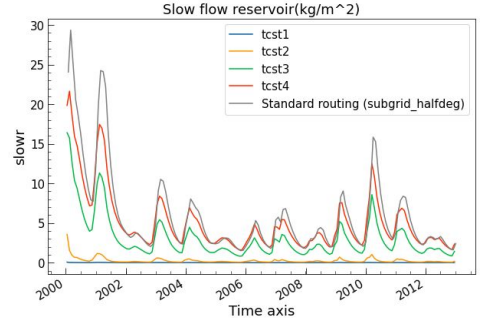


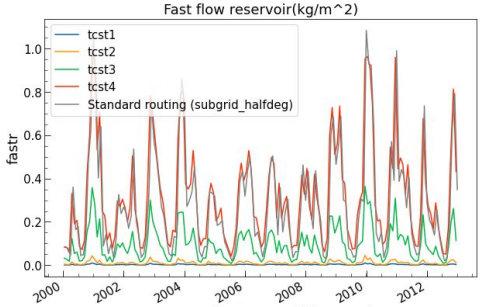
Reservoir time constants (10^{-3}day /km)

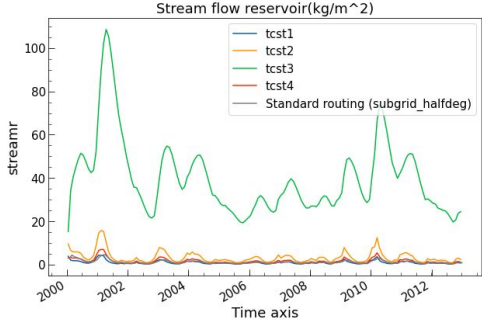
	SLOW	FAST	STREAM
TCST1	3	0.3	0.03
TCST2	30	3	0.3
TCST3	300	30	3
TCST4	700	100	0.1

2) Offline evaluation and calibration of interp_**topo_MERIT**

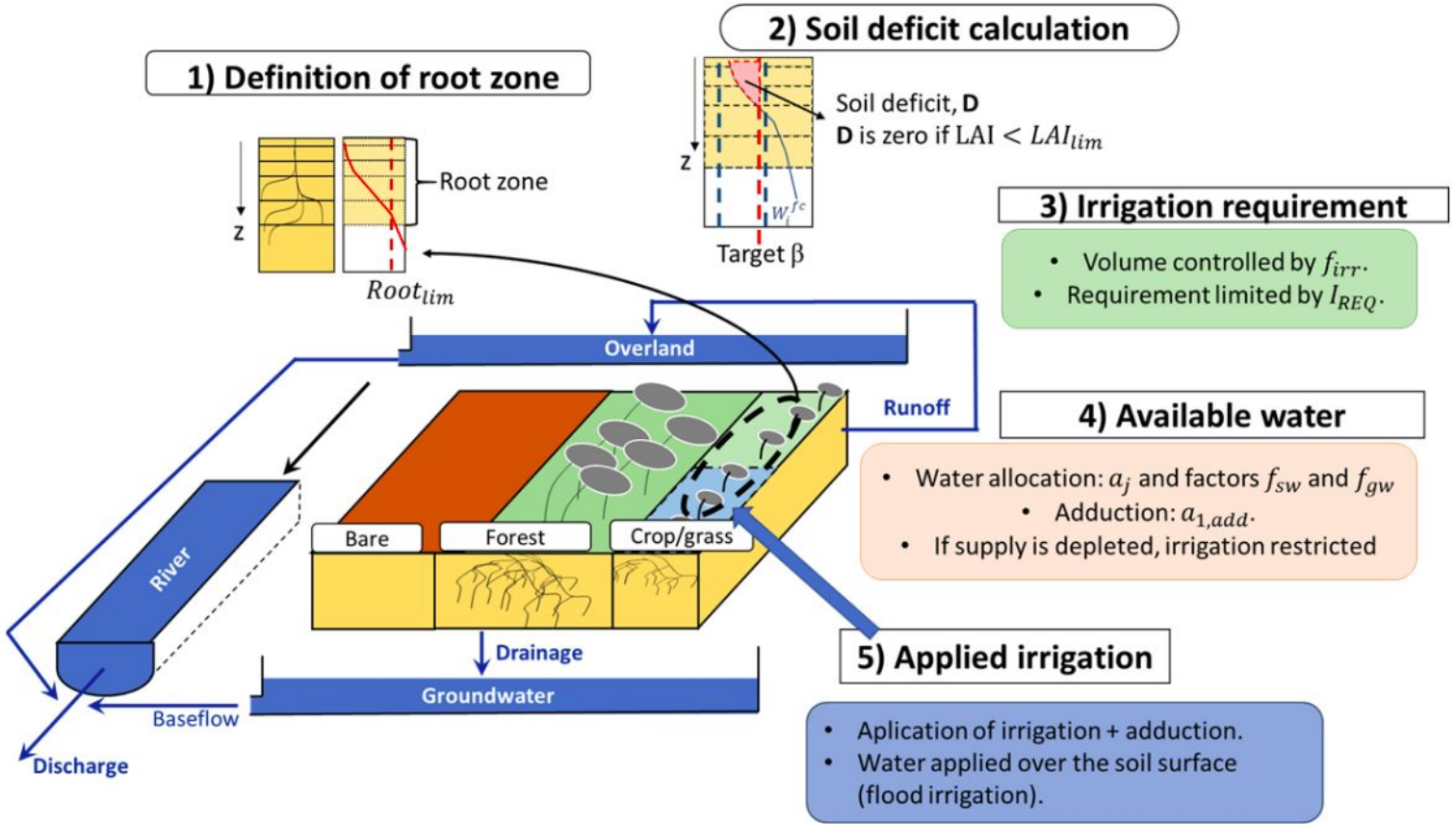




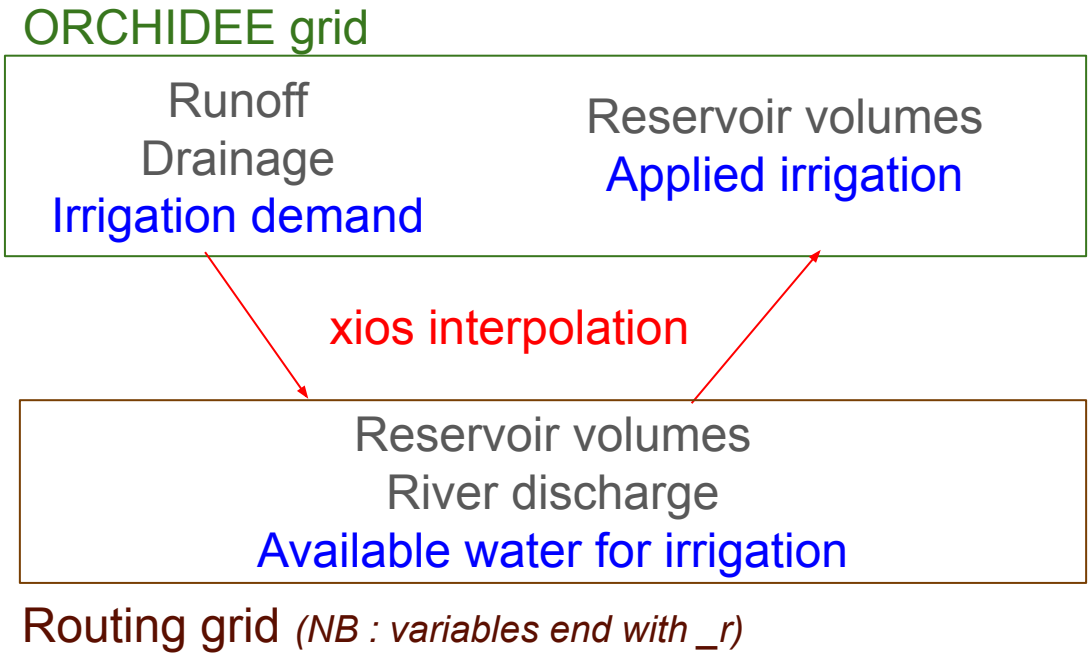




Adaptation of new irrigation (*Arboleda et al. 2024*) to routing interp_topo

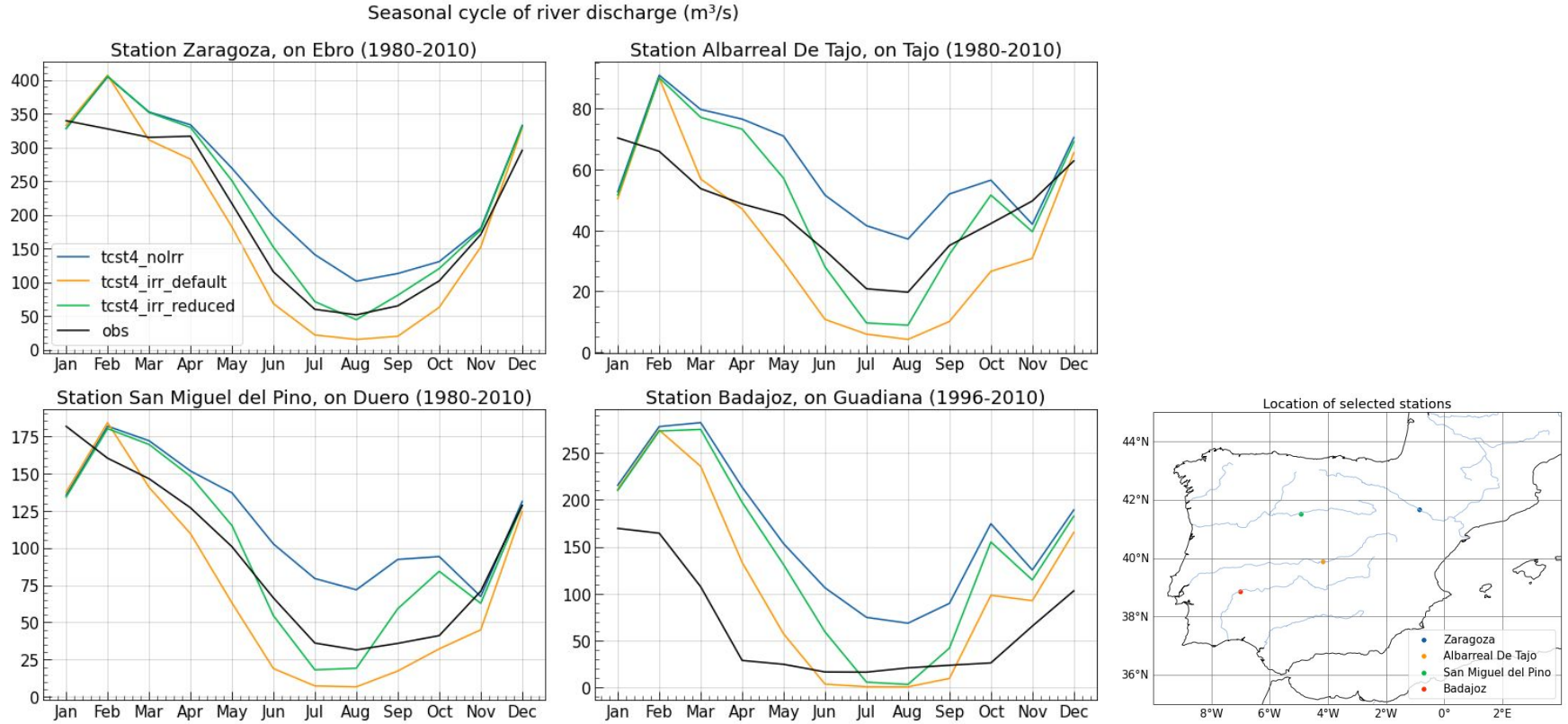


Adaptation of new irrigation (*Arboleda et al. 2024*) to routing interp_topo



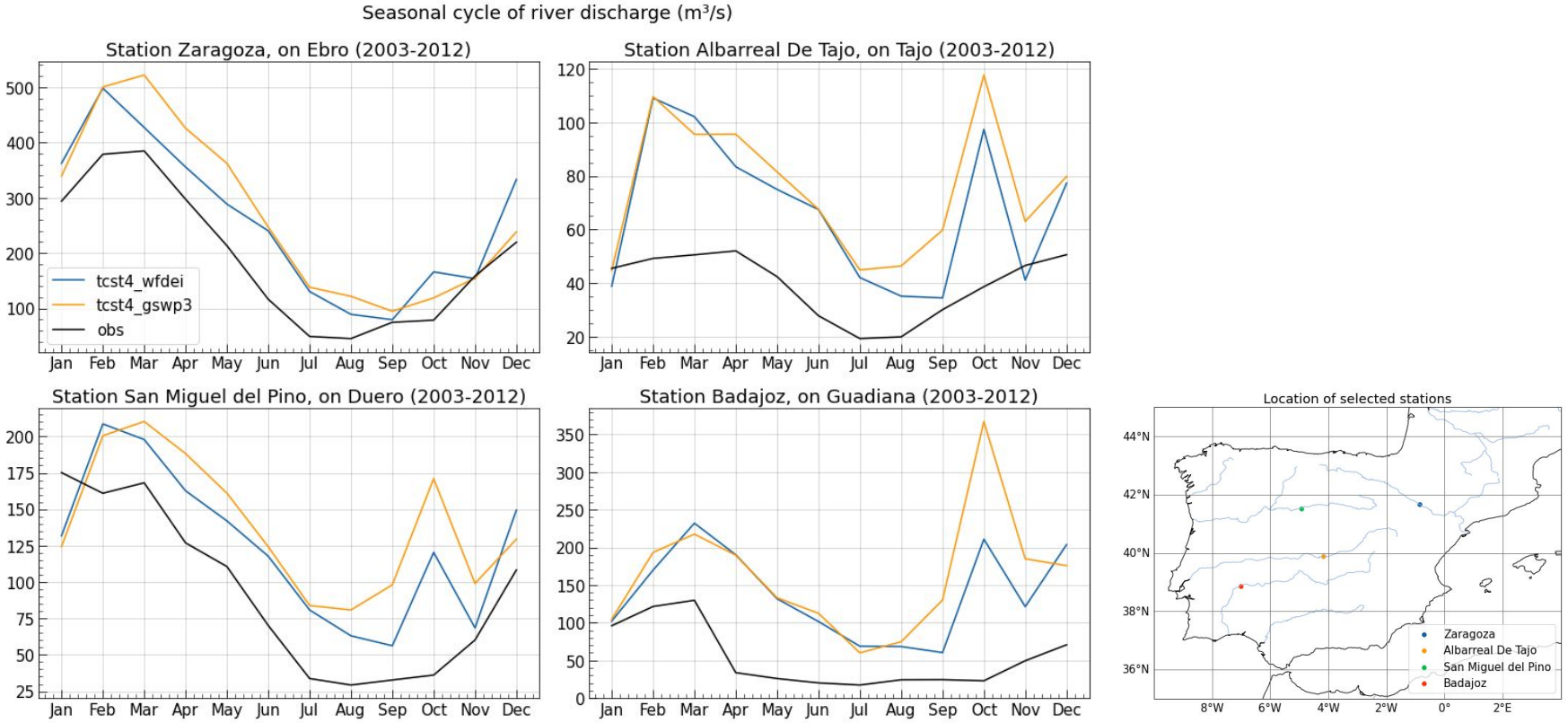
2) Offline evaluation and calibration of interp_**topo_MERIT**

Influence of irrigation

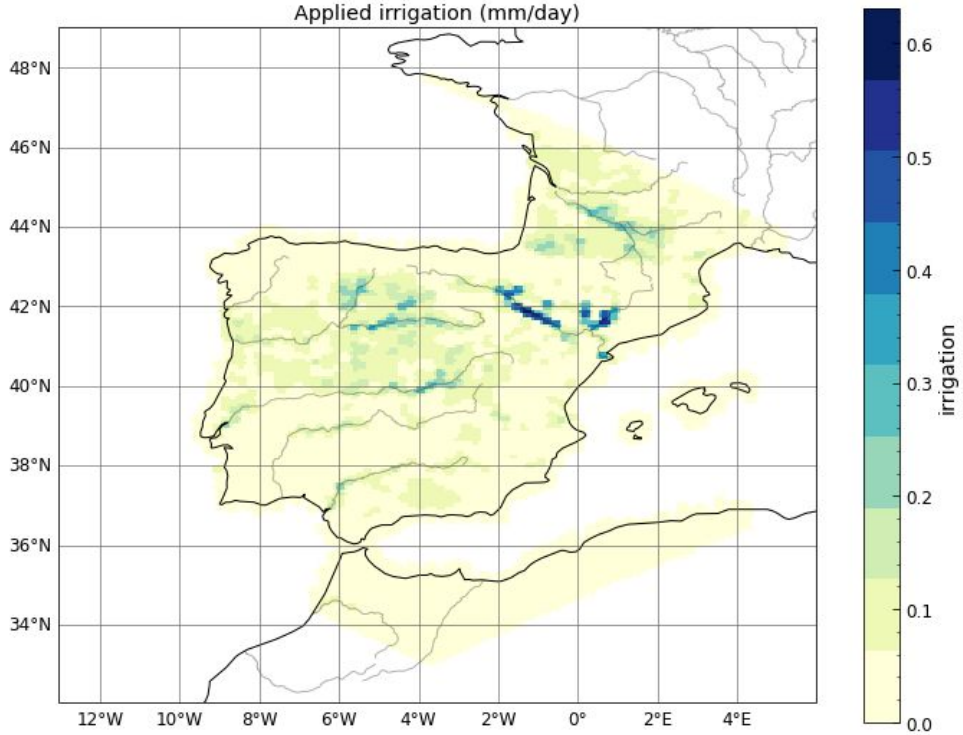


2) Offline evaluation and calibration of interp_**topo_MERIT**

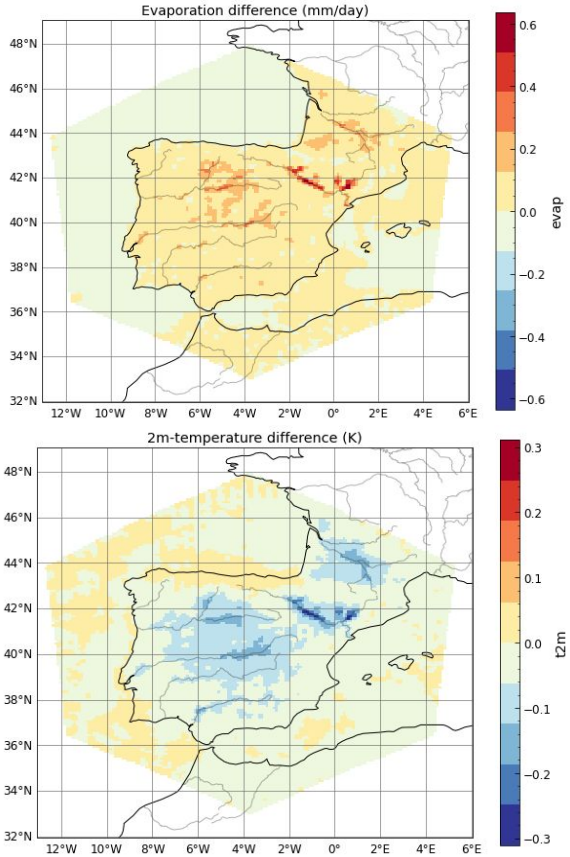
Influence of meteorological forcing



3) Coupled simulations using interp_**topo_MERIT**



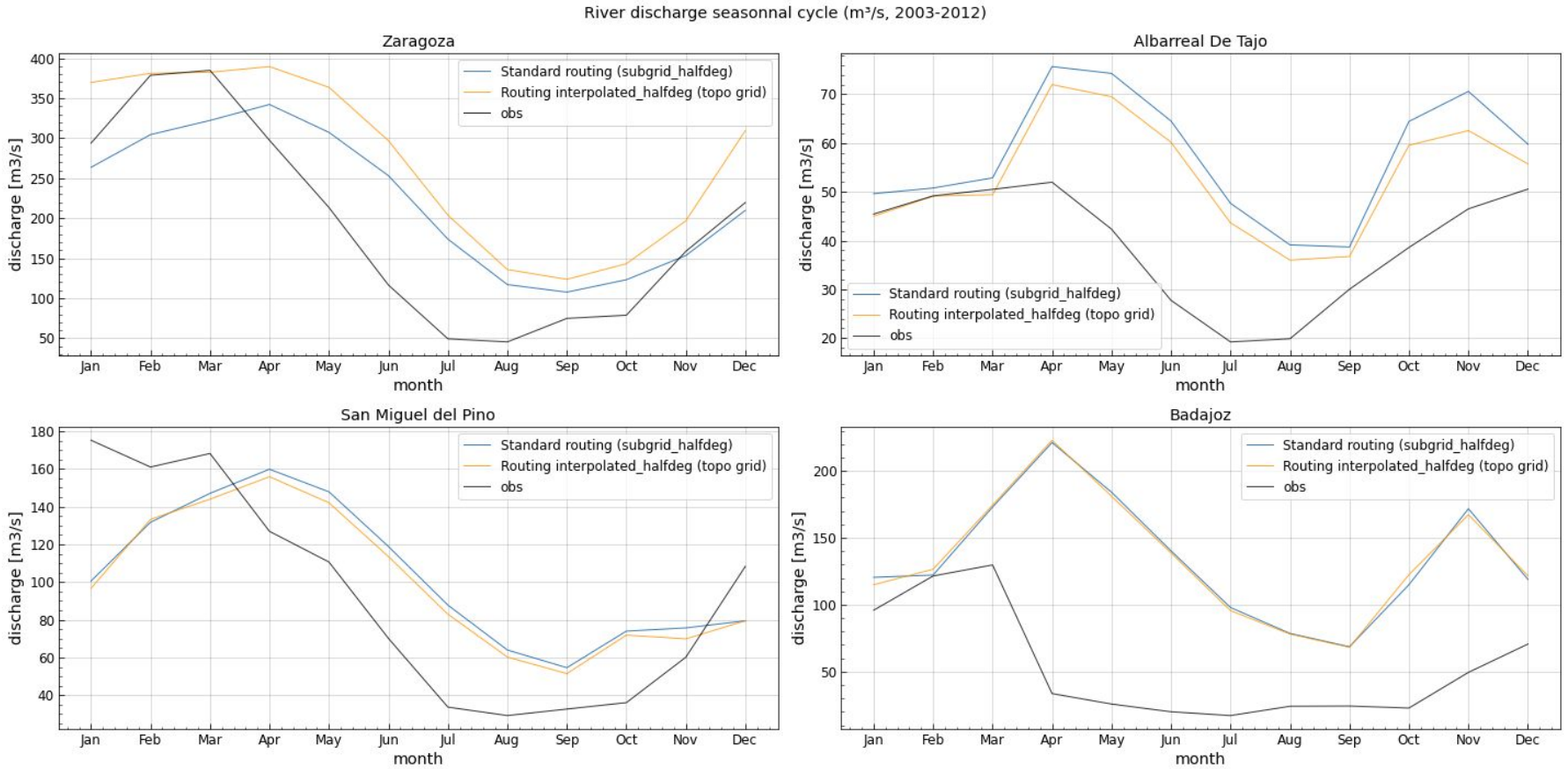
Difference (irr - no_irr)



Thank you for your attention

abierjon@ipsl.fr
pierre.tiengou@sorbonne-universite.fr

1) Offline evaluation : interpolated_**topo_0.5°** vs subgrid_halfdeg



2) Offline evaluation and calibration of interpolated_**topo_MERIT**

Impact of RSOIL => Leads to strong overestimation of discharge