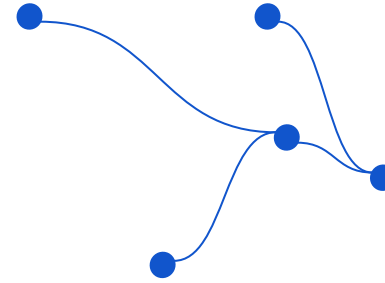


ORCHIDEE DEV - 21/06/2024



# 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, ...

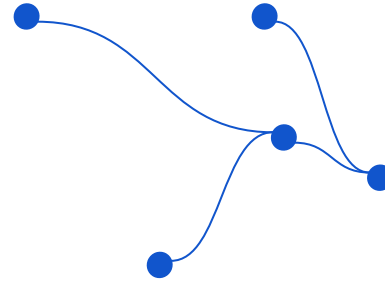
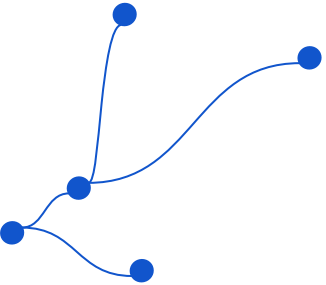
# Some introductions...



Antoine Bierjon  
Research Engineer  
IPSL (45-55 211)

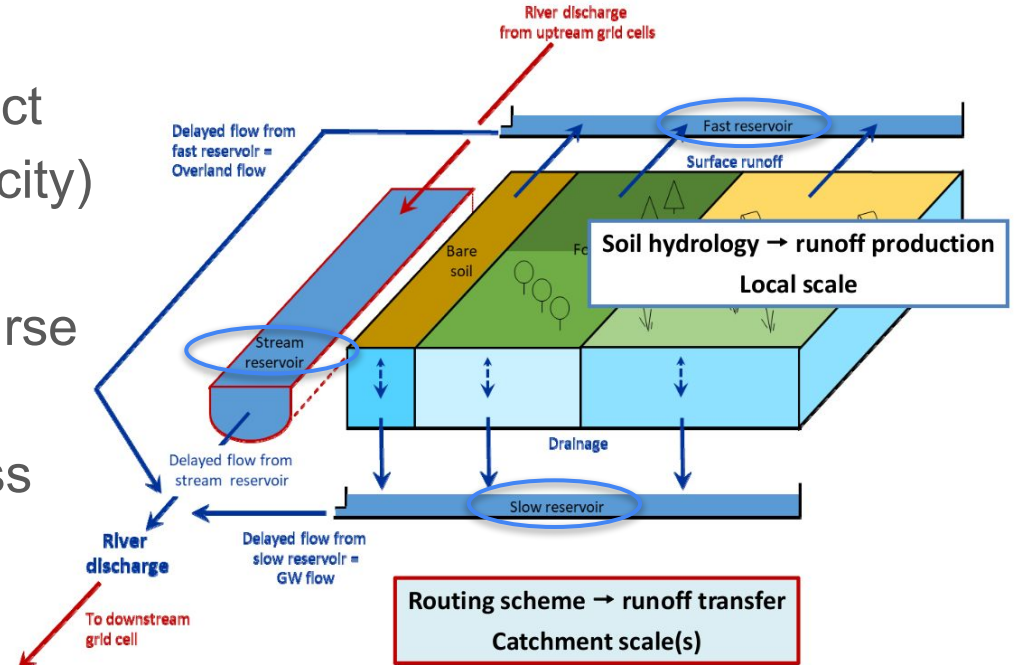


Pierre Tiengou  
PhD student  
METIS (56-55 405B) / LMD



# 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. Ducharme, ORCHIDEE Training](#)

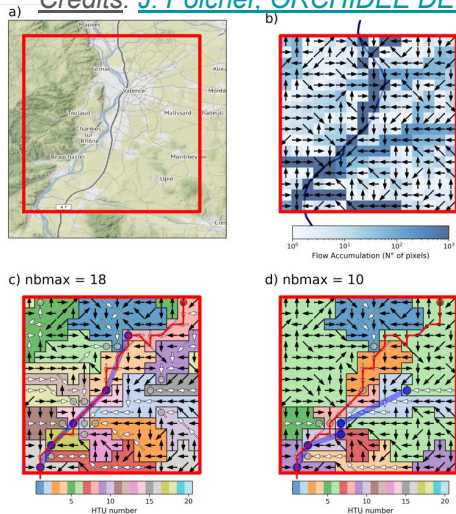
# The routing methods in ORCHIDEE: overview & clarification

CMIP6

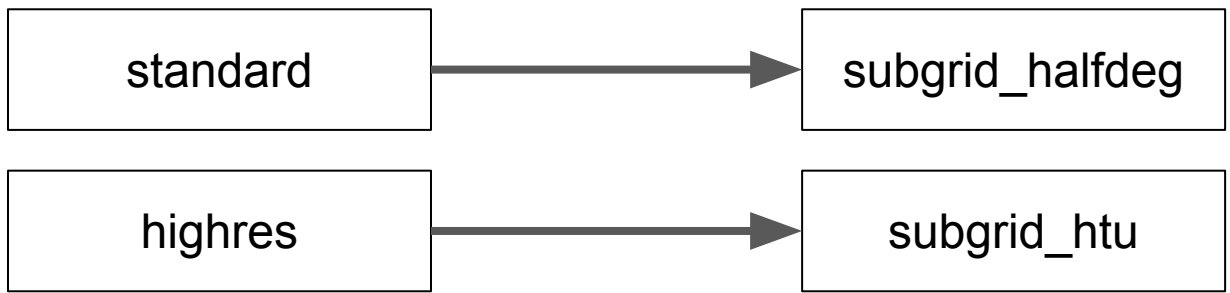
standard

# The routing methods in ORCHIDEE: overview & clarification

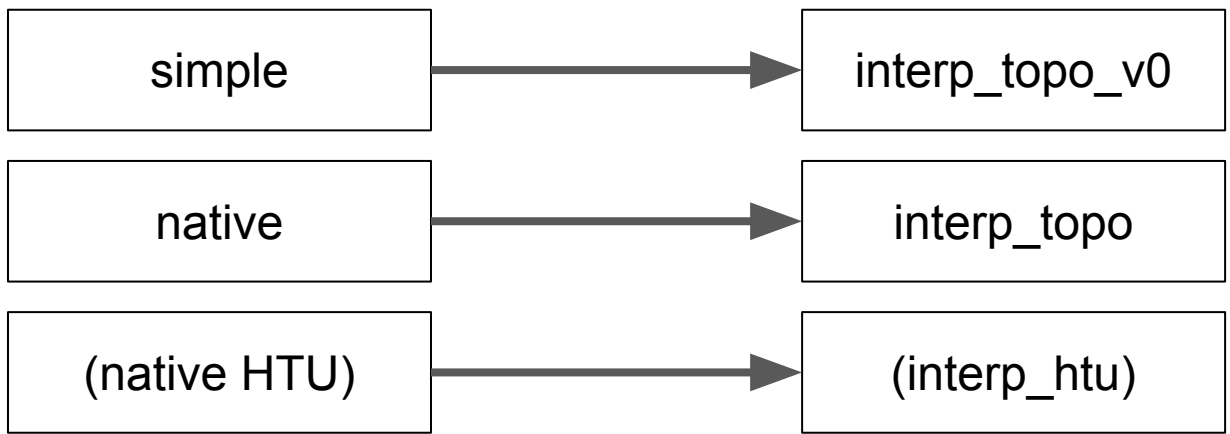
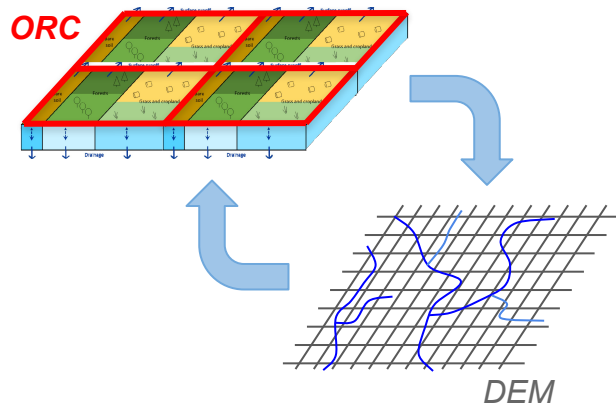
Credits: [J. Polcher](#), [ORCHIDEE DEV](#)



now



\*HTU: Hydrological Transfer Unit



# 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>

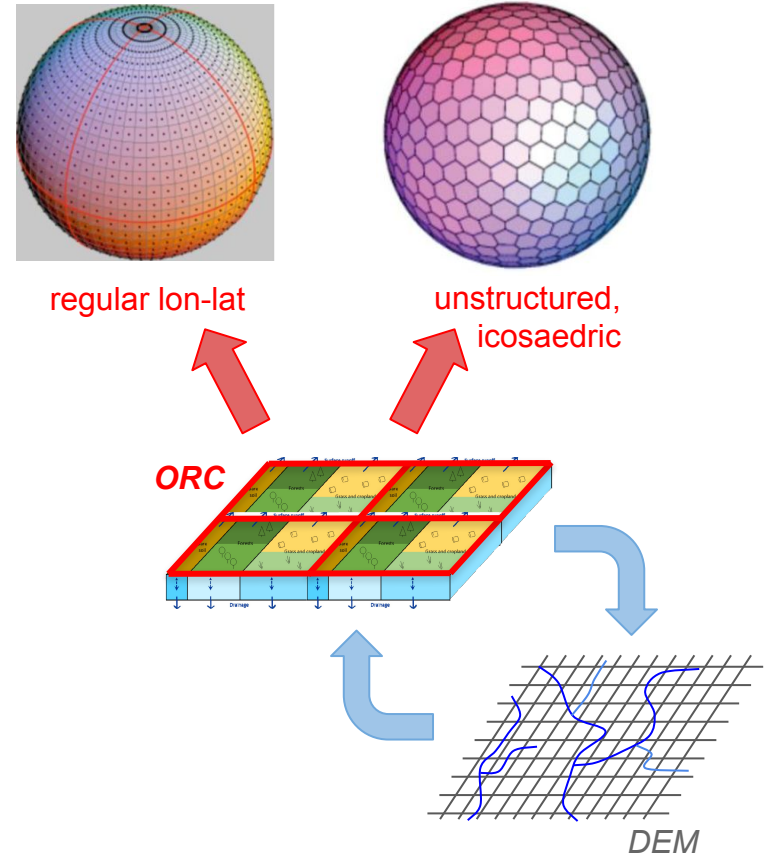
⇒ Tickets to follow : [#842](#) ; [#857](#) ; [#910](#) ; [#955](#) ; [#978](#) ; [#997](#)

⇒ 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)
```

## ORCHIDEE grid

Runoff  
Drainage

Reservoir volumes

xios interpolation

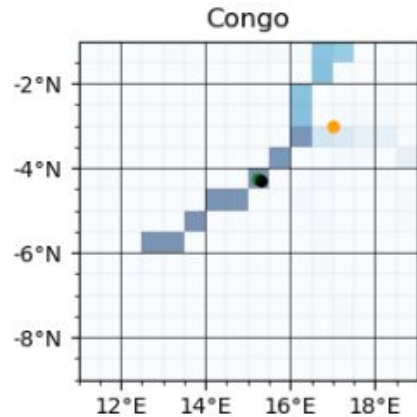
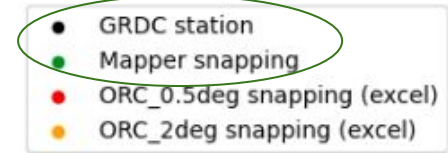
Reservoir volumes  
River discharge

Routing grid (NB : variables end with \_r)

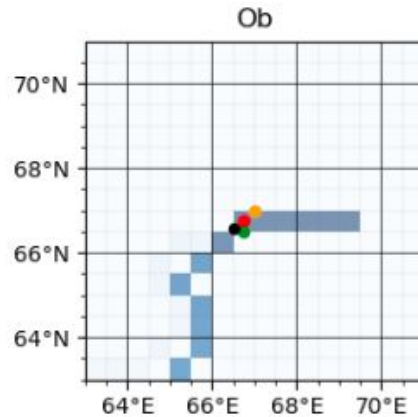
# Routing interp\_topo: getting ready for CMIP7

New routing grid for **hydrographs**

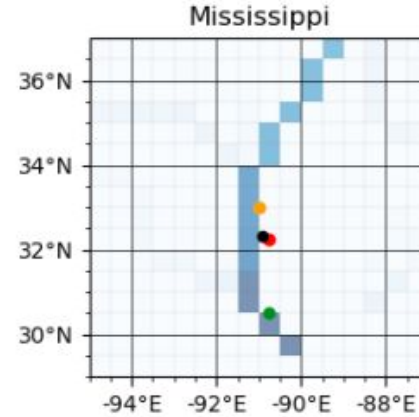
=> How to evaluate routing interp\_topo ?



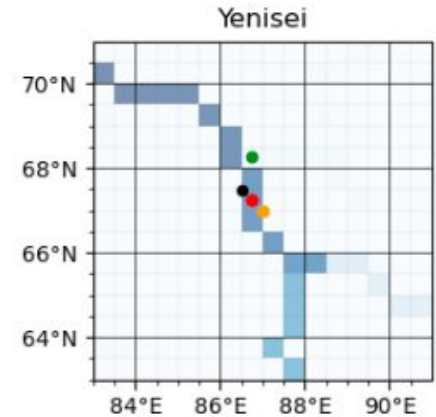
OK



OK?



OK?



Not OK.

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

=> take inspiration from/make use of HydroFiles and RoutingPP ?

([Polcher et al. 2022](#))

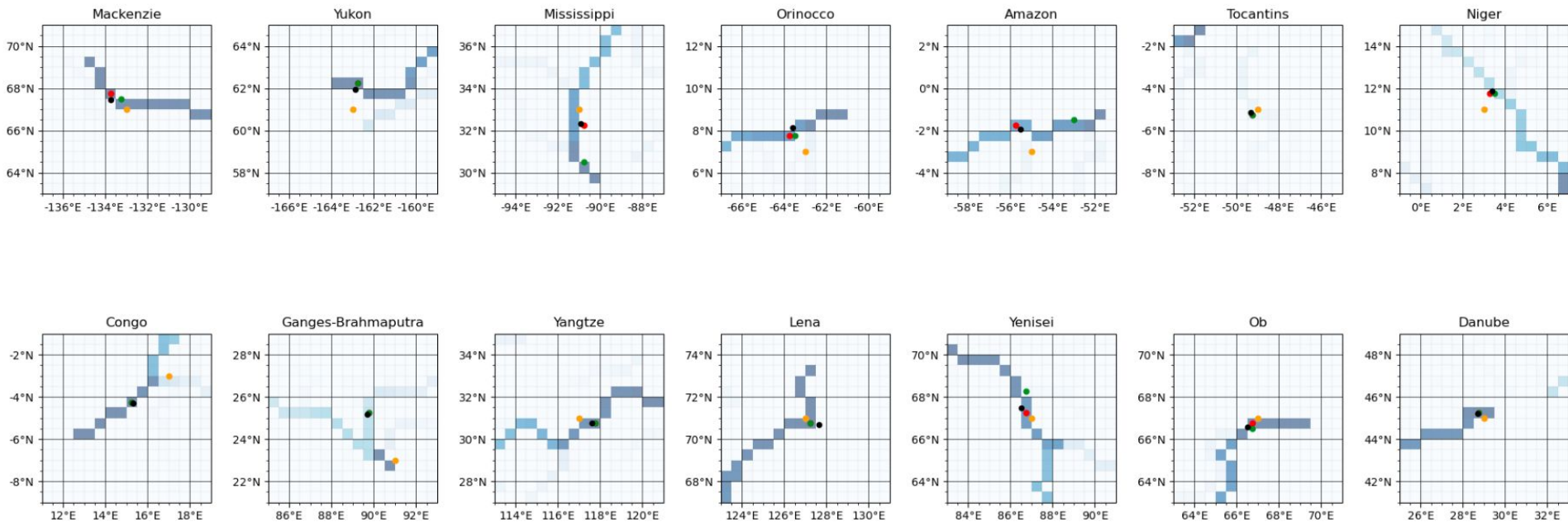
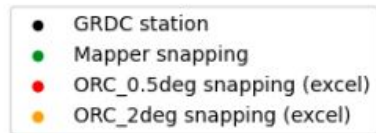
**stations.def**

```
nb_station = 14
station1_id = Arctic Red River
station1_coor = -133.7447 67.4583
station1_prec = 1000000
station1_area = 1660000.0
```

# 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 <sup>-3</sup> day/km] | TCST_FAST [10 <sup>-3</sup> day/km] | TCST_STREAM [10 <sup>-3</sup> 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

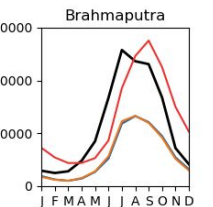
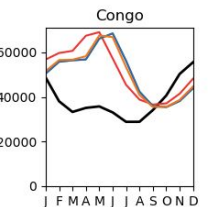
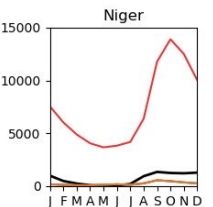
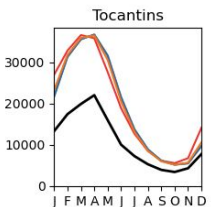
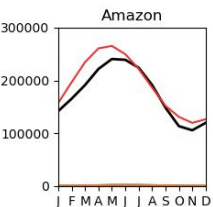
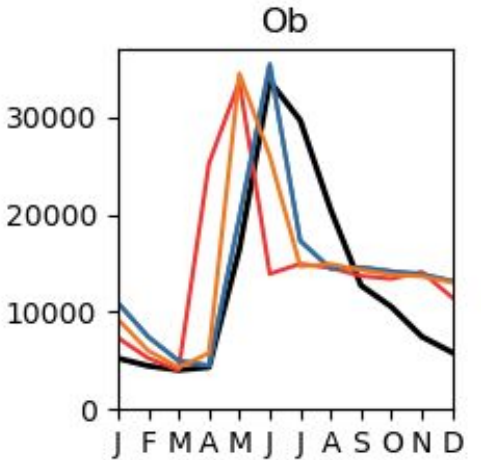
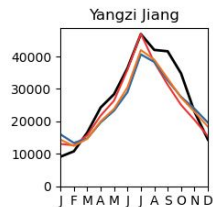
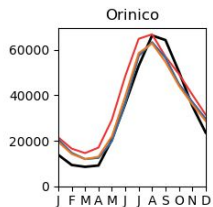
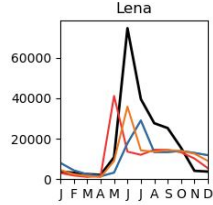
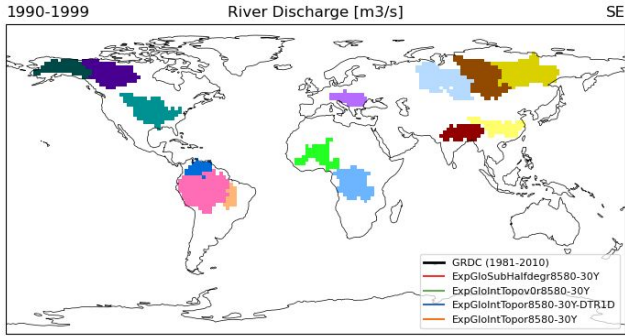
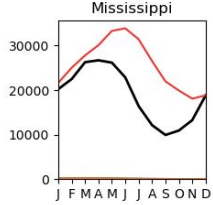
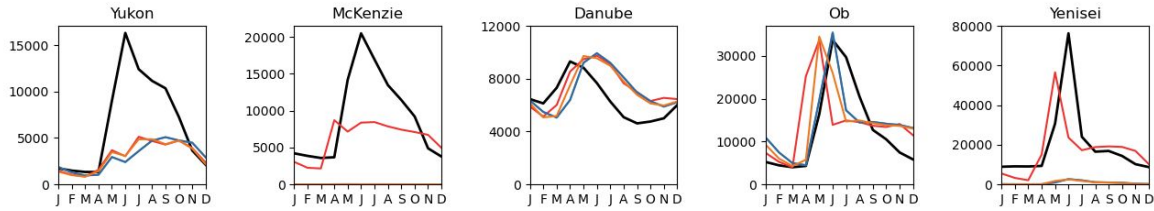
```
SLOW_TCST = 0.025  
FAST_TCST = 0.003  
STREAM_TCST = 0.00024
```

run.def

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

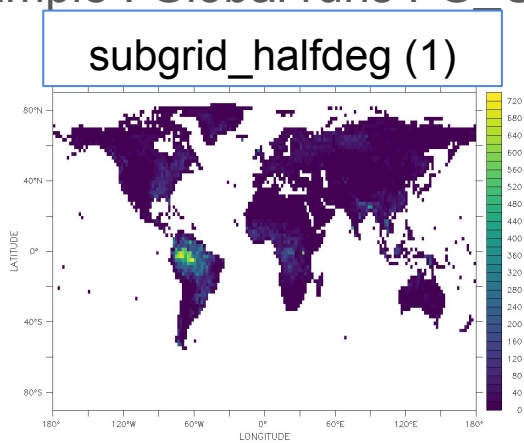
# Routing comparisons

Study example : Global runs FG\_CRUJRA\_HIST (2°x2°) with ORC-trunk, 1970-2000

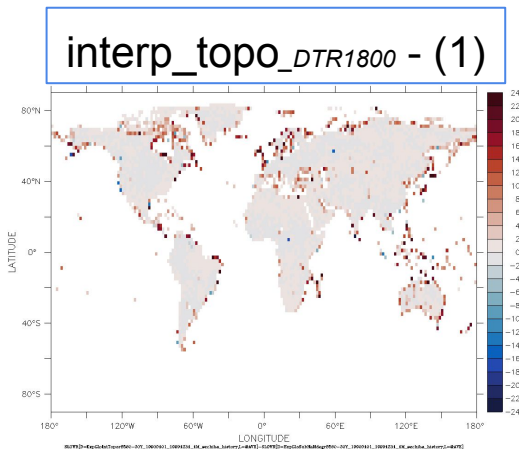
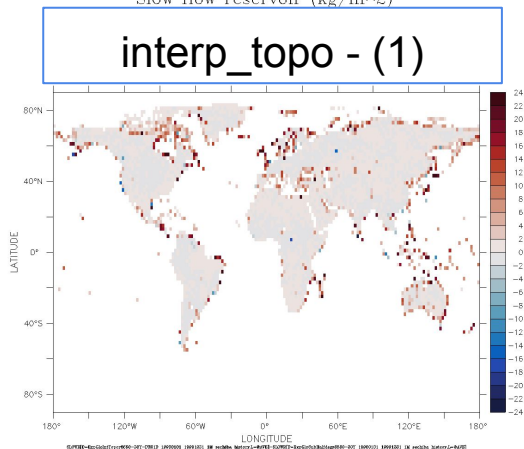
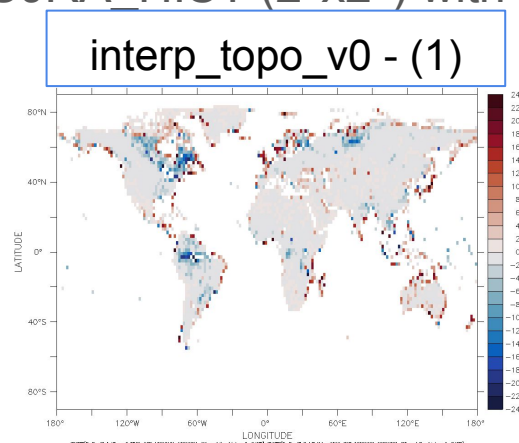


# Routing comparisons

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



Slow flow reservoir (kg/m<sup>2</sup>)



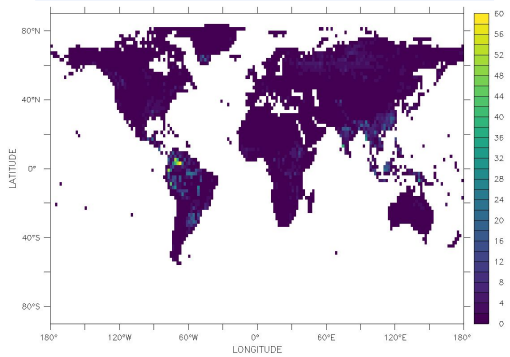
Slow reservoir  
[0-720 kg/m<sup>2</sup>]



# Routing comparisons

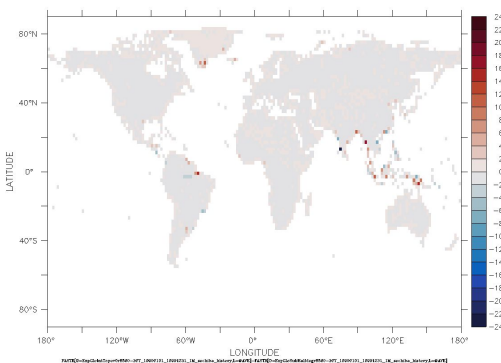
Study example : Global runs FG CRUJRA HIST (2°x2°) with ORC-trunk, 1970-2000

subgrid\_halfdeg (1)

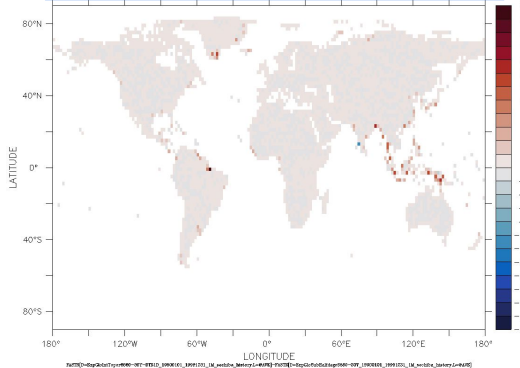


Fast flow reservoir (kg/m^2)

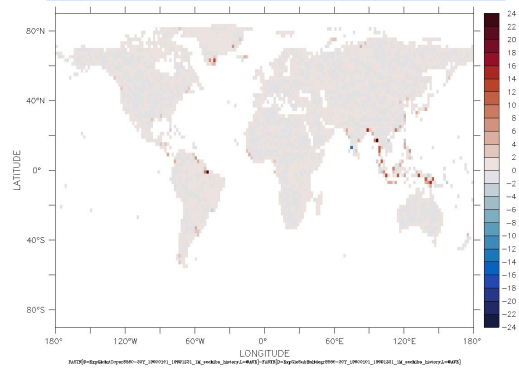
interp\_topo\_v0 - (1)



interp\_topo - (1)



interp\_topo\_DTR1800 - (1)

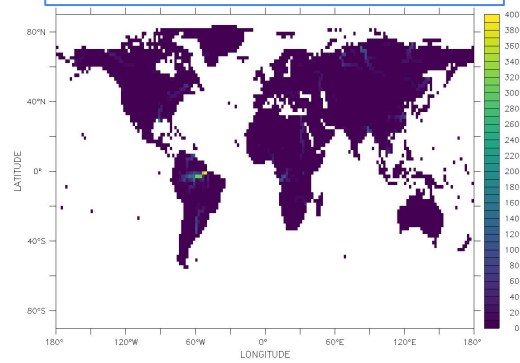


Fast reservoir  
[0-50 kg/m<sup>2</sup>]

# Routing comparisons

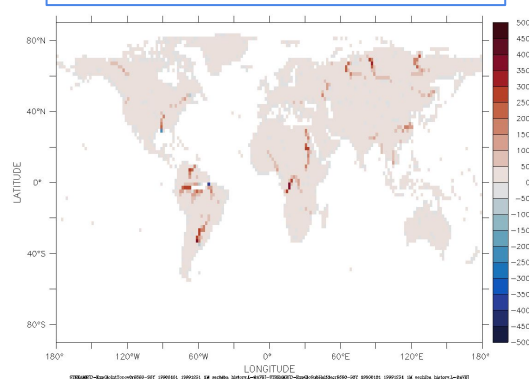
Study example : Global runs FG\_CRUJRA\_HIST (2°x2°) with ORC-trunk, 1970-2000

subgrid\_halfdeg (1)

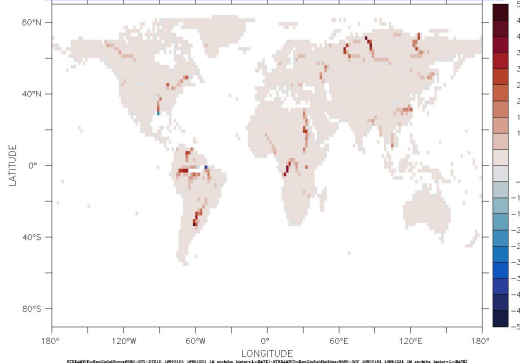


Stream flow reservoir (kg/m<sup>2</sup>)

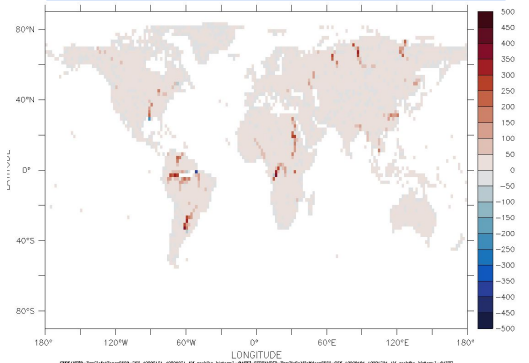
interp\_topo\_v0 - (1)



interp\_topo - (1)



interp\_topo\_DTR1800 - (1)



Stream reservoir  
[0-1500 kg/m<sup>2</sup>]



## 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**

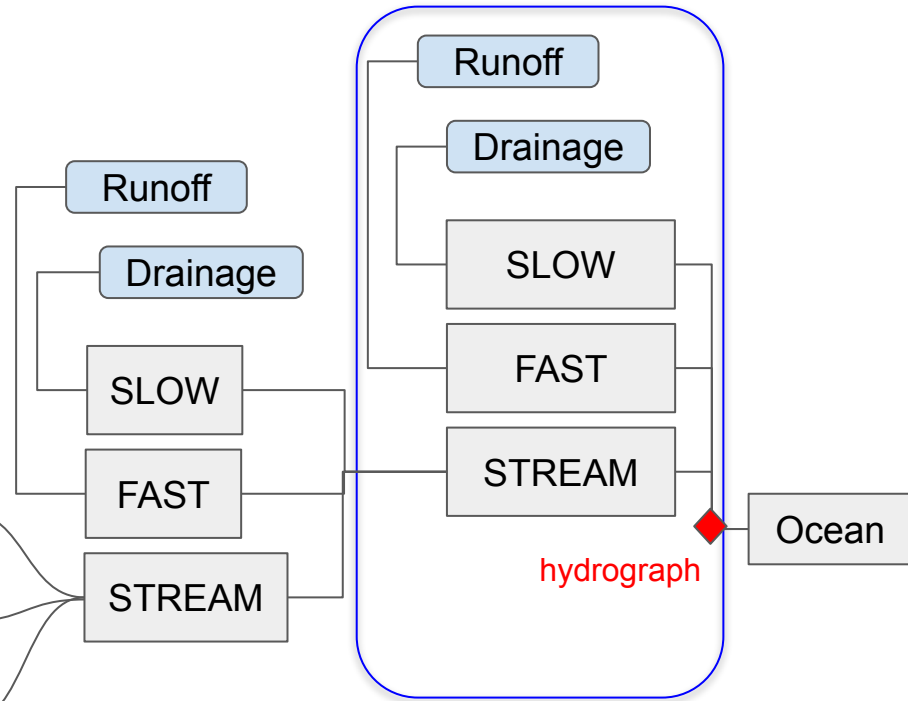
- 1) Offline evaluation : comparison with subgrid\_halfdeg using 0.5° topography
- 2) Offline calibration using MERIT topography : choice of time constants
- 3) Coupling with ICOLMDZ

# 1) Offline evaluation : interp\_topo\_0.5° vs subgrid\_halfdeg

## Development differences

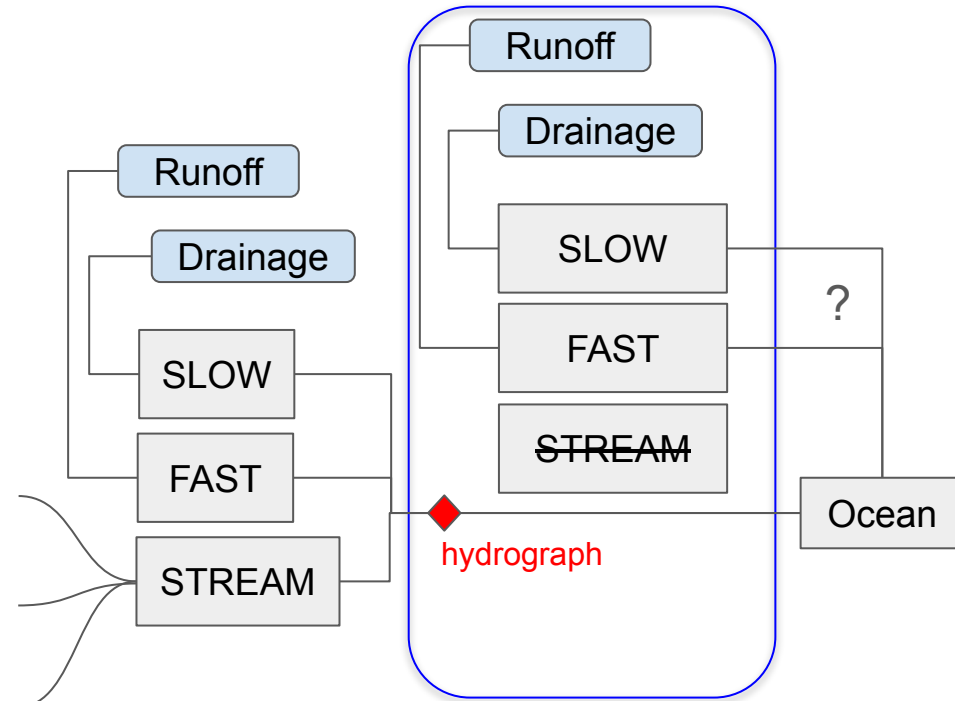
### subgrid\_halfdeg

Last continental point



### interp\_topo

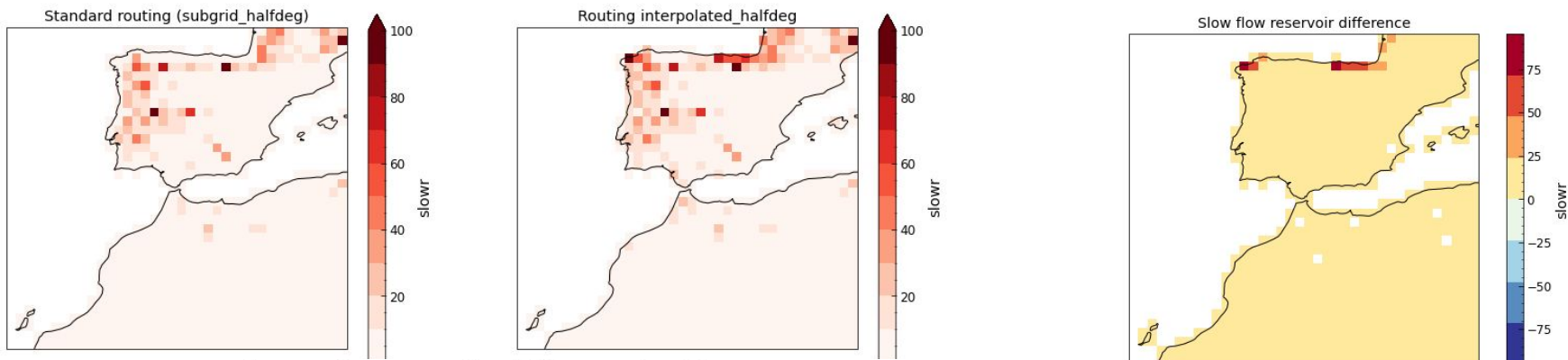
Last continental point



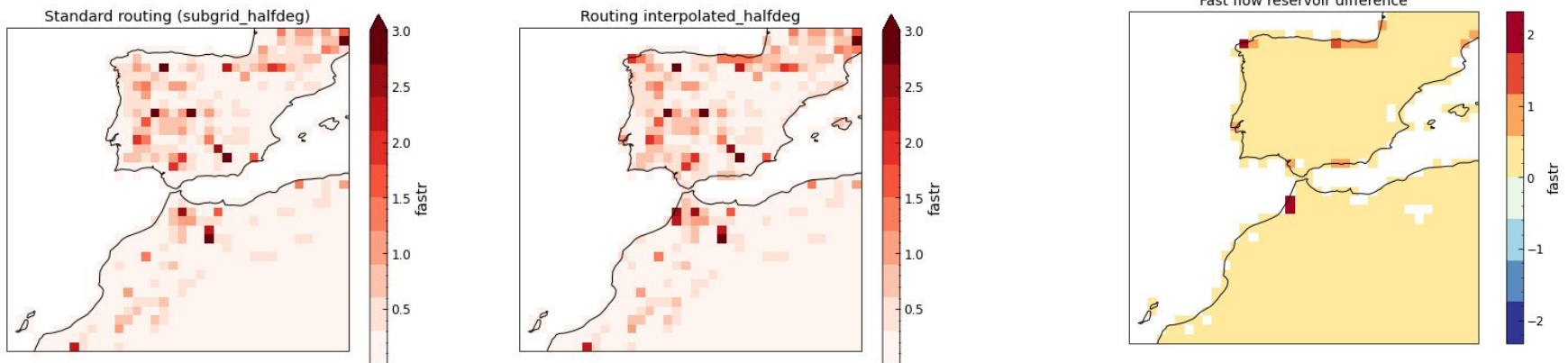
# 1) Offline evaluation : interp\_topo\_0.5° vs subgrid\_halfdeg

## SLOW and FAST : differences on the coastline

Slow flow reservoir average over the period (2003-2012, kg/m<sup>2</sup>)



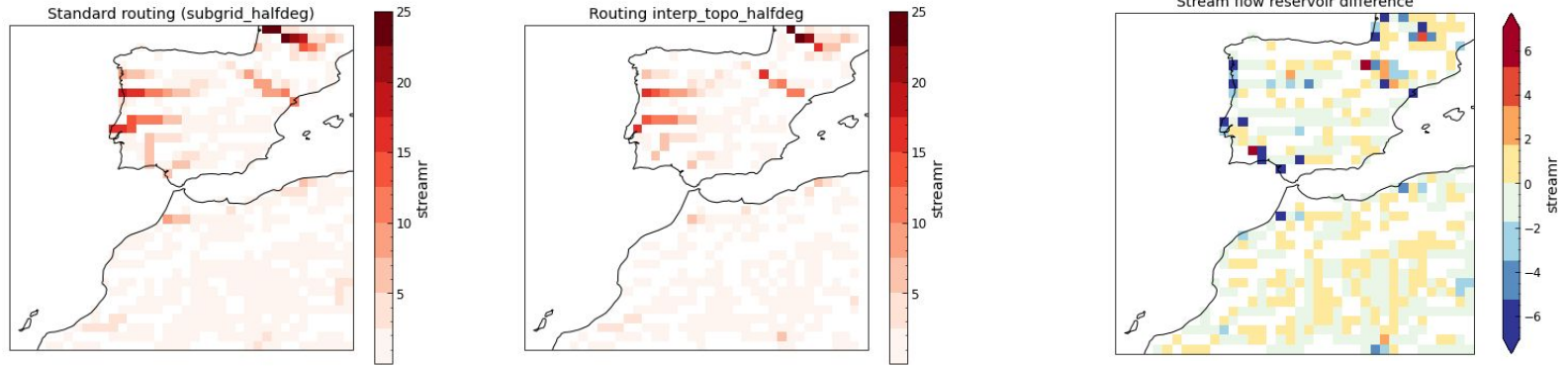
Fast flow reservoir average over the period (2003-2012, kg/m<sup>2</sup>)



# 1) Offline evaluation : interp\_topo\_0.5° vs subgrid\_halfdeg

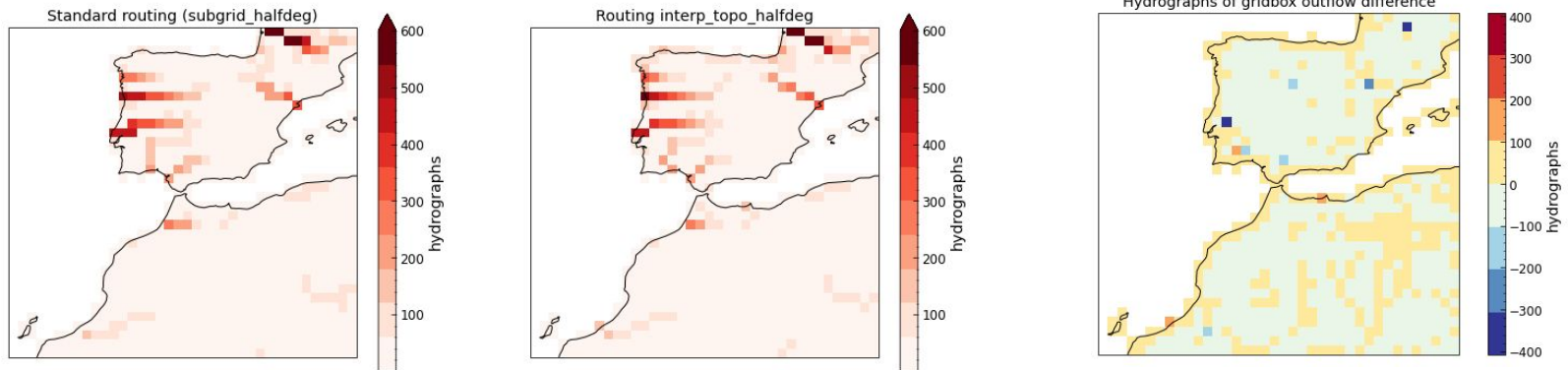
## STREAM : differences on the coastline and on the routing path

Stream flow reservoir average over the period (2003-2012, kg/m<sup>2</sup>)



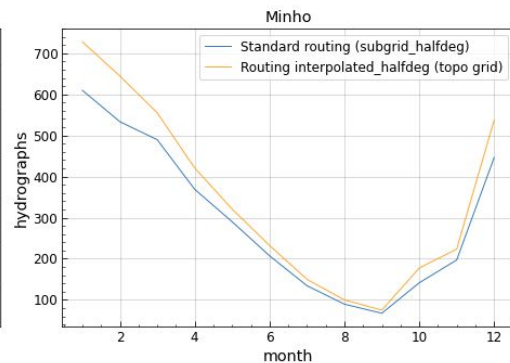
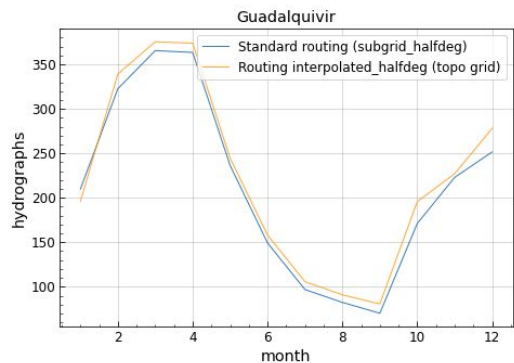
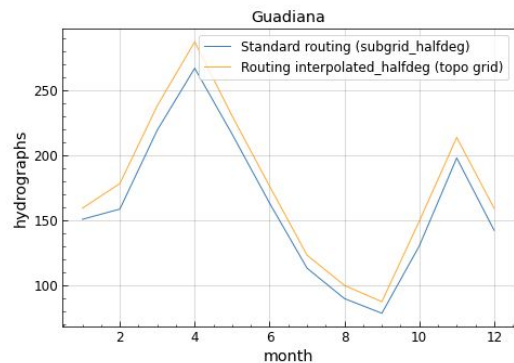
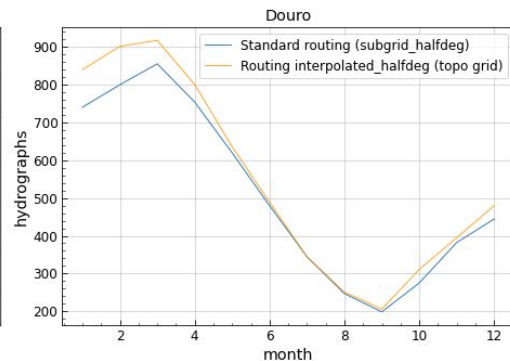
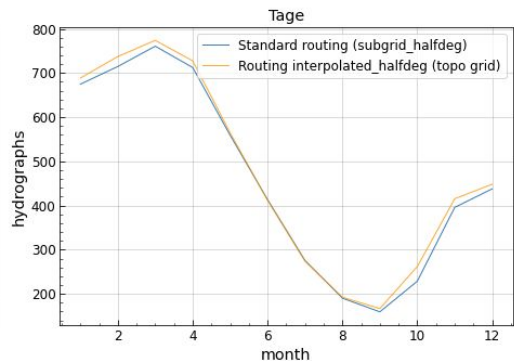
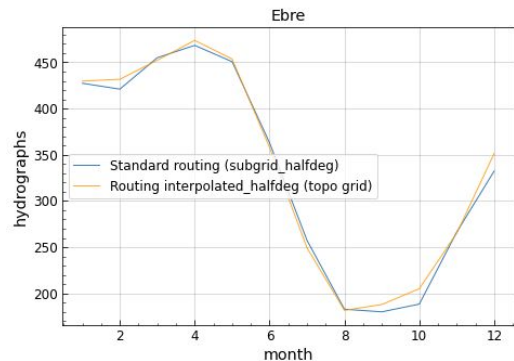
## Hydrographs : differences on the routing path

Hydrographs of gridbox outflow average over the period (2003-2012, m<sup>3</sup>/s)



# 1) Offline evaluation : interp\_topo\_0.5° vs subgrid\_halfdeg

River discharge seasonal cycle (m<sup>3</sup>/s, 2003-2012)



## 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. Rinchioso) | 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      |

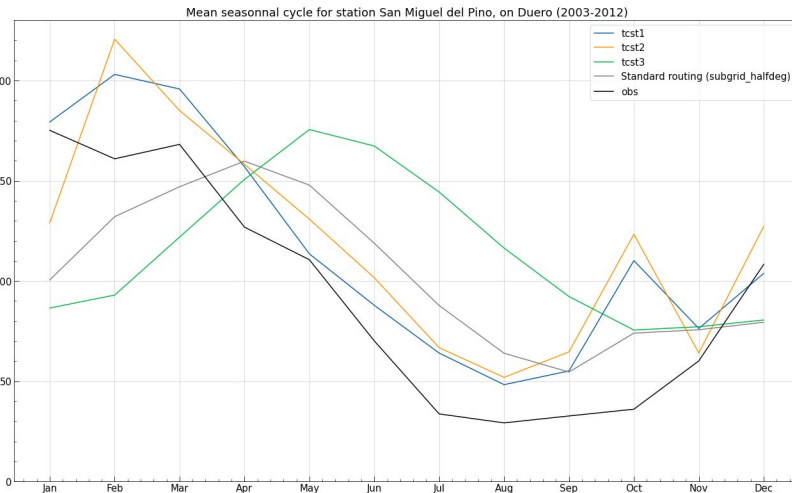
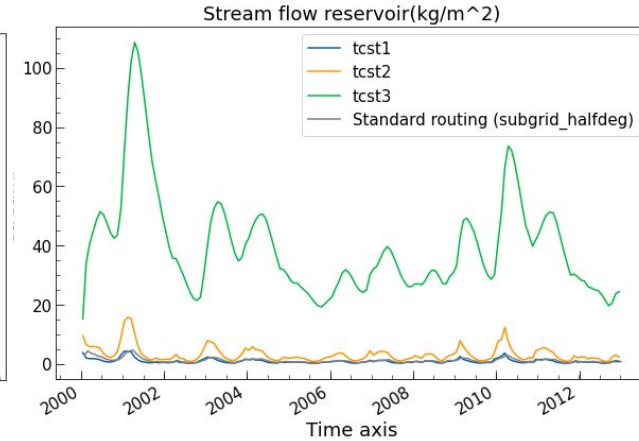
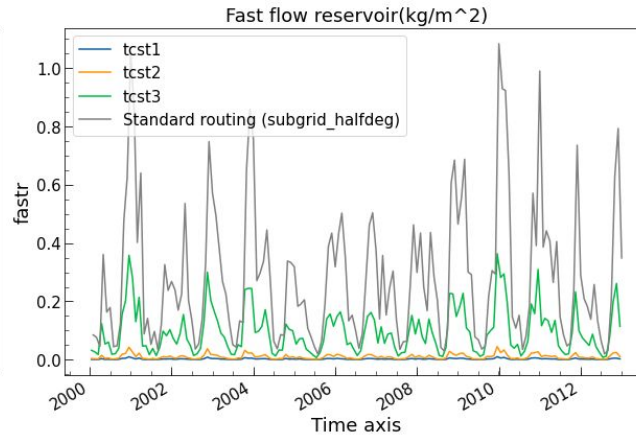
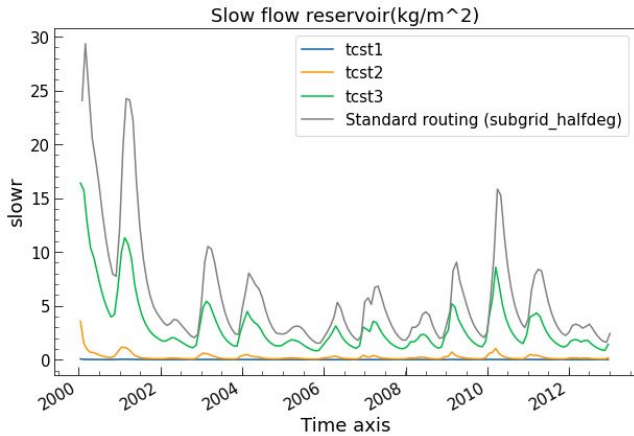
Variables to evaluate

- 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



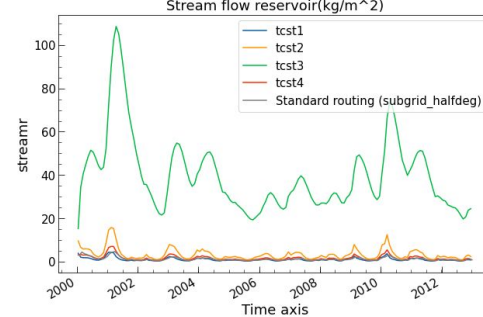
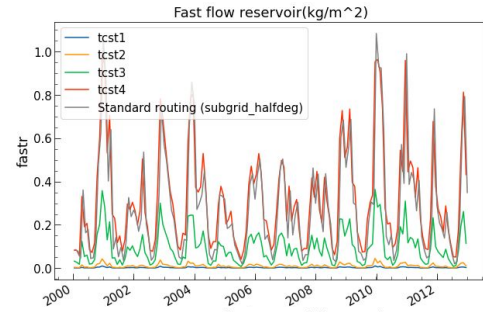
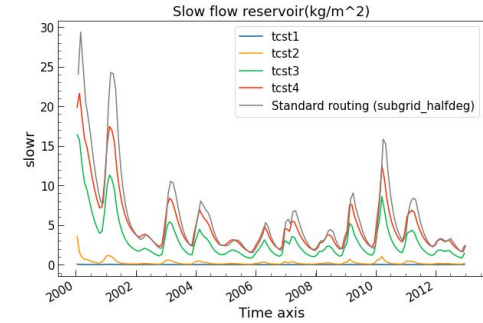
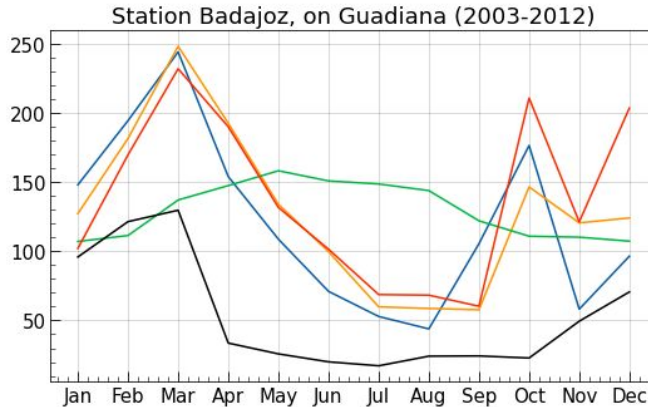
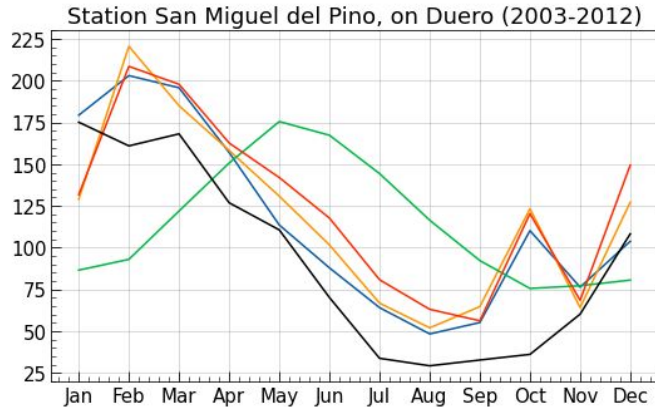
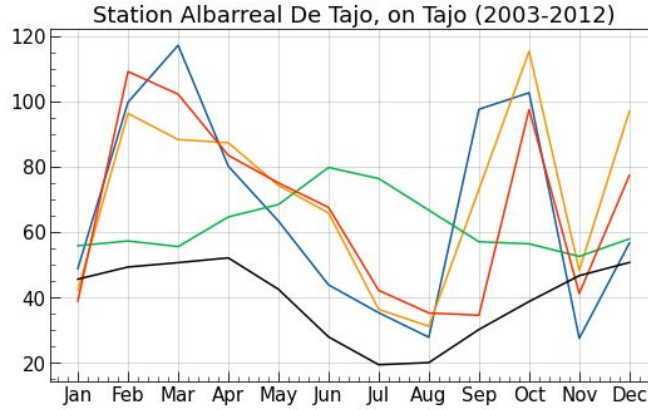
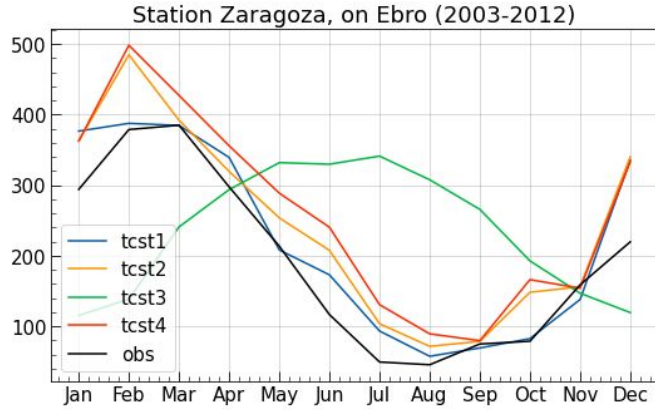
## Reservoir time constants ( $10^{-3}$ day /km)

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



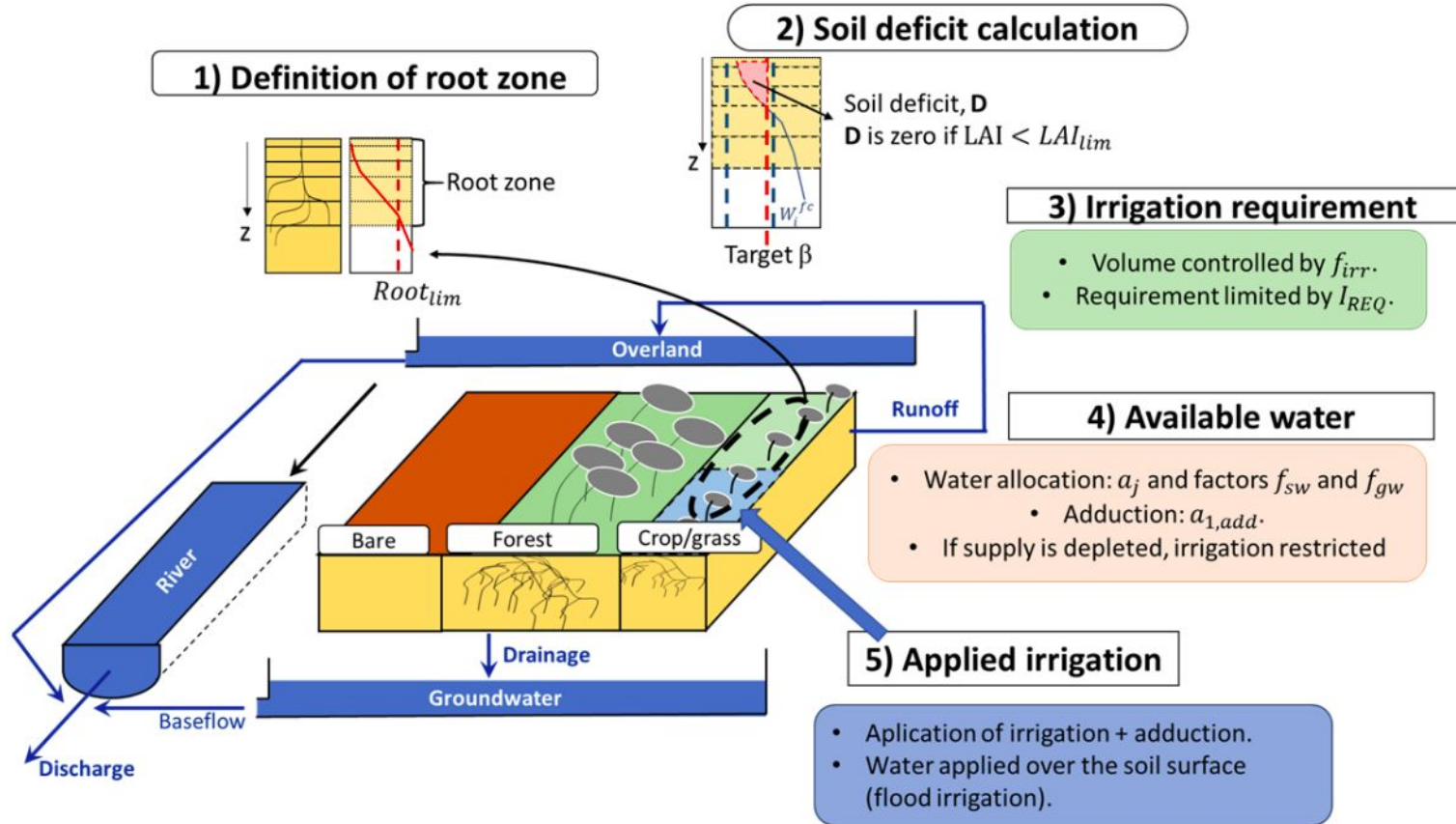
## 2) Offline evaluation and calibration of interp\_topo\_MERIT

Seasonal cycle of river discharge ( $\text{m}^3/\text{s}$ )





# Adaptation of new irrigation ([Arboleda et al. 2024](#)) to routing interp\_topo

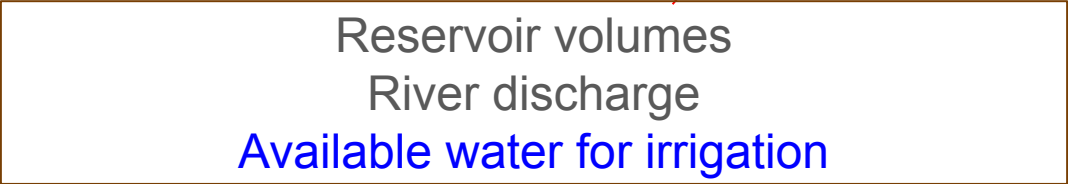


Adaptation of new irrigation ([Arboleda et al. 2024](#)) to routing interp\_topo

ORCHIDEE grid



xios interpolation

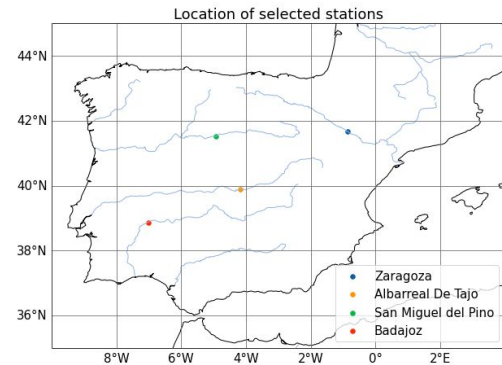
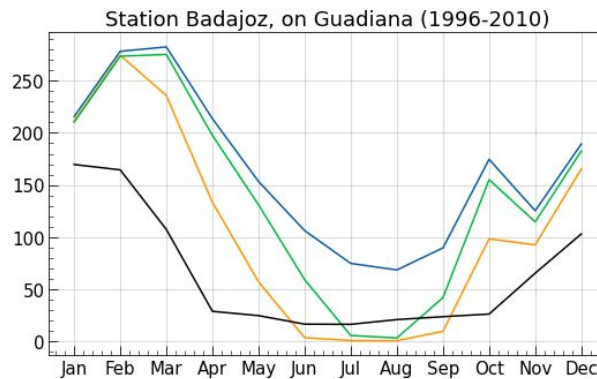
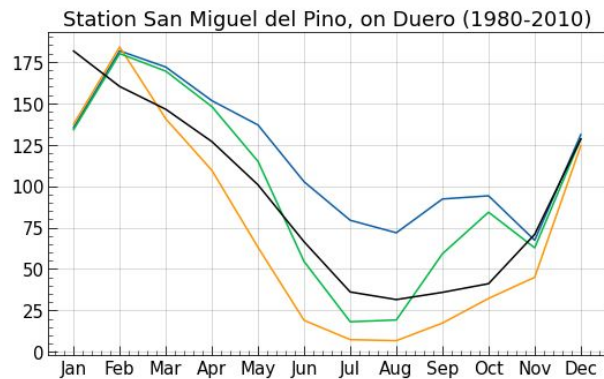
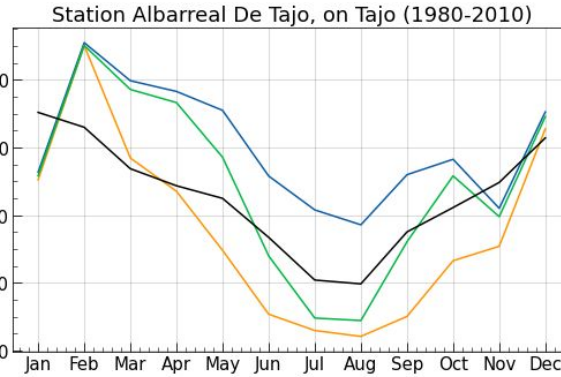
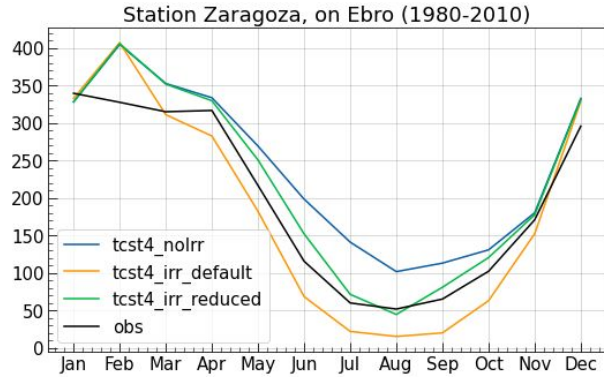


Routing grid (NB : variables end with \_r)

## 2) Offline evaluation and calibration of interp\_topo\_MERIT

### Influence of irrigation

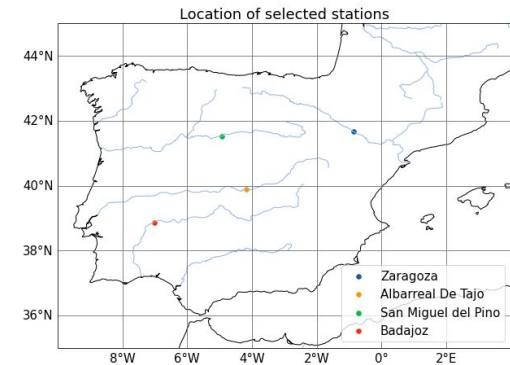
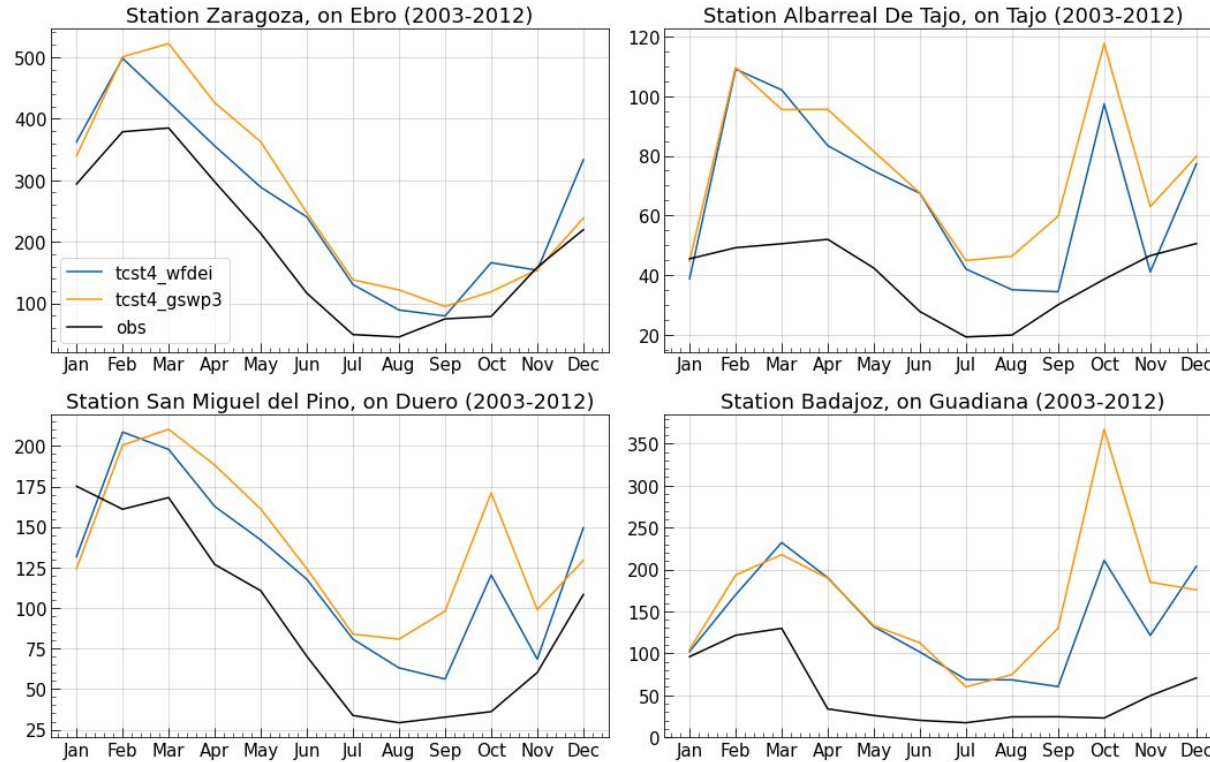
Seasonal cycle of river discharge (m<sup>3</sup>/s)



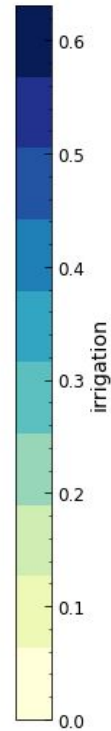
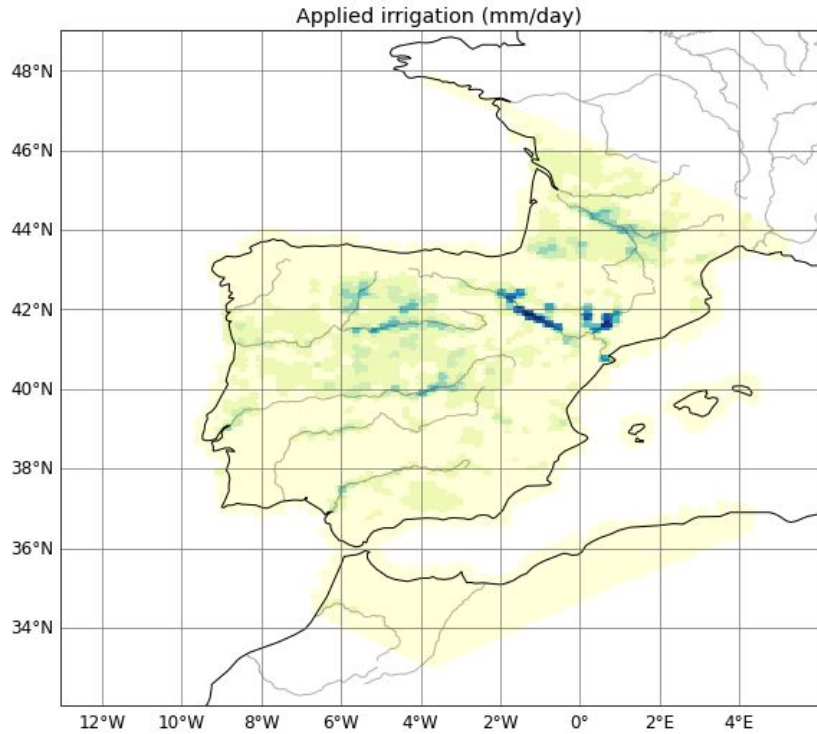
## 2) Offline evaluation and calibration of interp\_topo\_MERIT

### Influence of meteorological forcing

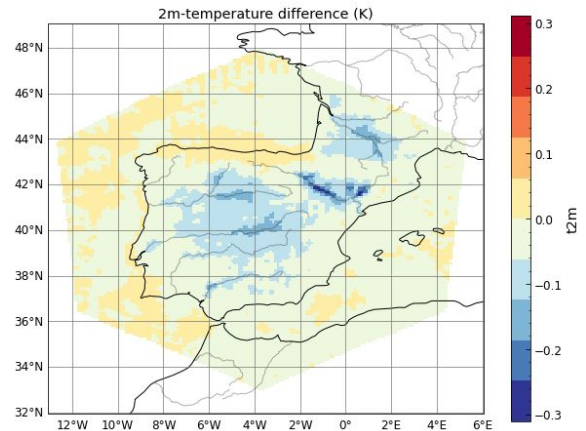
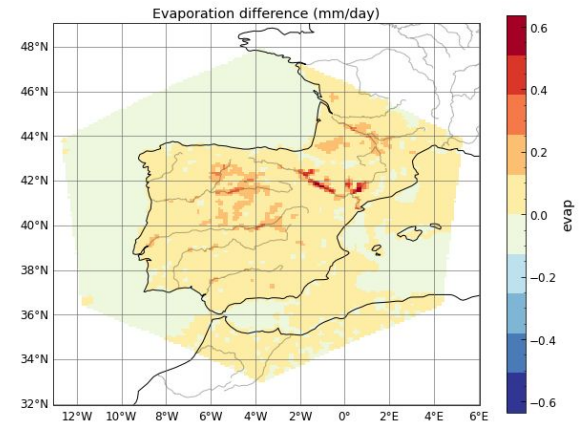
Seasonal cycle of river discharge (m<sup>3</sup>/s)



### 3) Coupled simulations using interp\_topo\_MERIT



### Difference (irr - no\_irr)



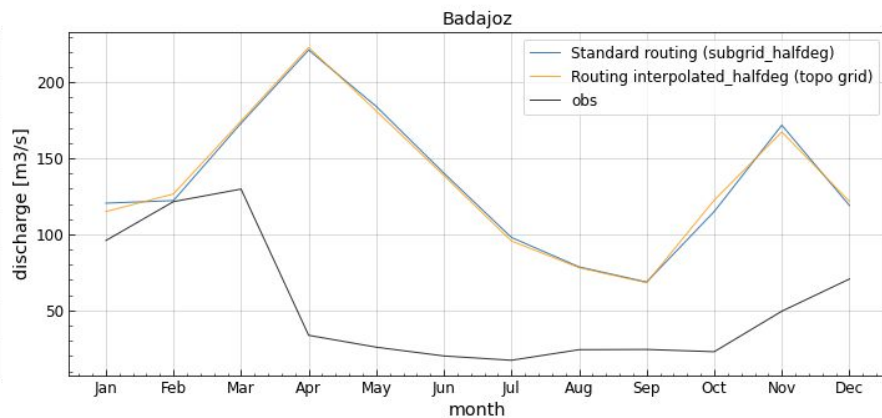
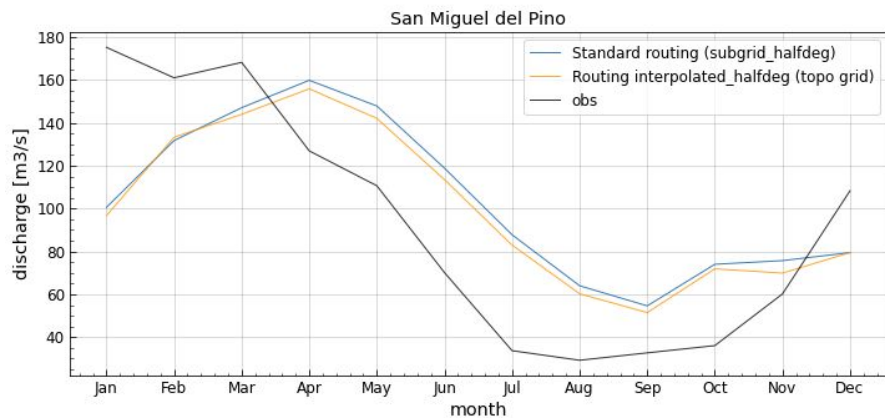
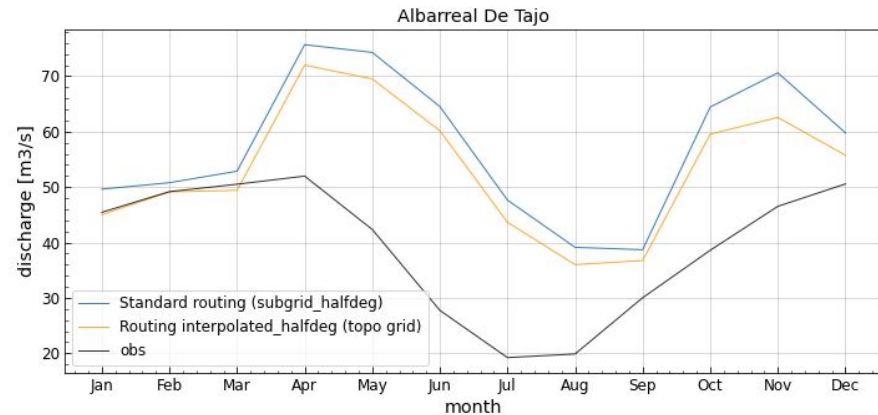
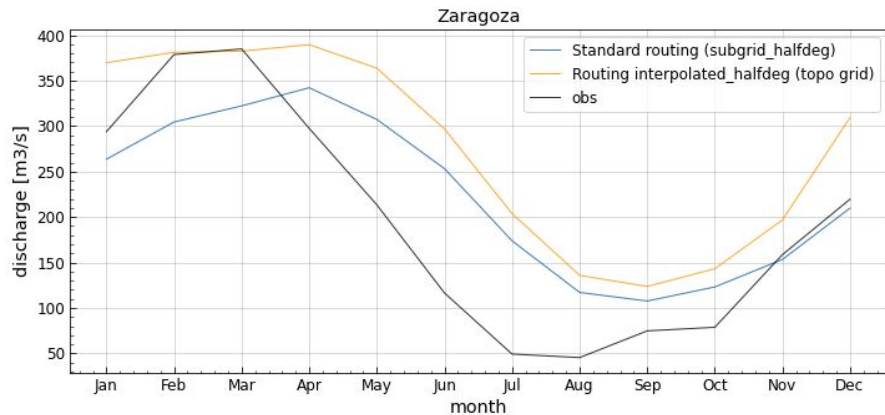
# Thank you for your attention

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[pierre.tiengou@sorbonne-universite.fr](mailto:pierre.tiengou@sorbonne-universite.fr)

# 1) Offline evaluation : interpolated\_topo\_0.5° vs subgrid\_halfdeg

River discharge seasonal cycle (m<sup>3</sup>/s, 2003-2012)





## 2) Offline evaluation and calibration of interpolated\_topo\_MERIT

Impact of RSOIL => Leads to strong overestimation of discharge

Seasonal cycle of river discharge (m<sup>3</sup>/s)

