SEACLIM - WP3
A Method to Generate Runoff Data Fields for Downscaling Simulations

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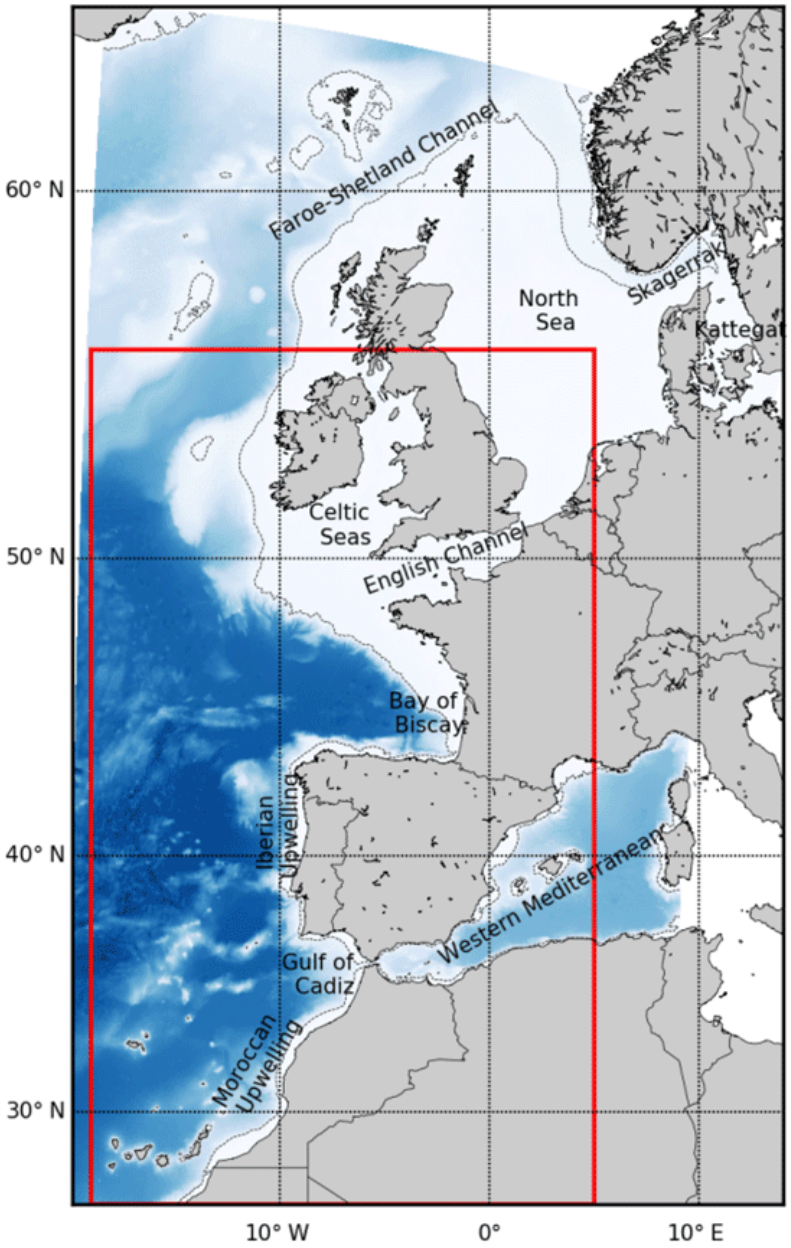
September 17, 2025

Outline

1. The Problem
2. Rerouting Runoff from Climate Models
3. Bias Correction of the Re-Routed Runoff



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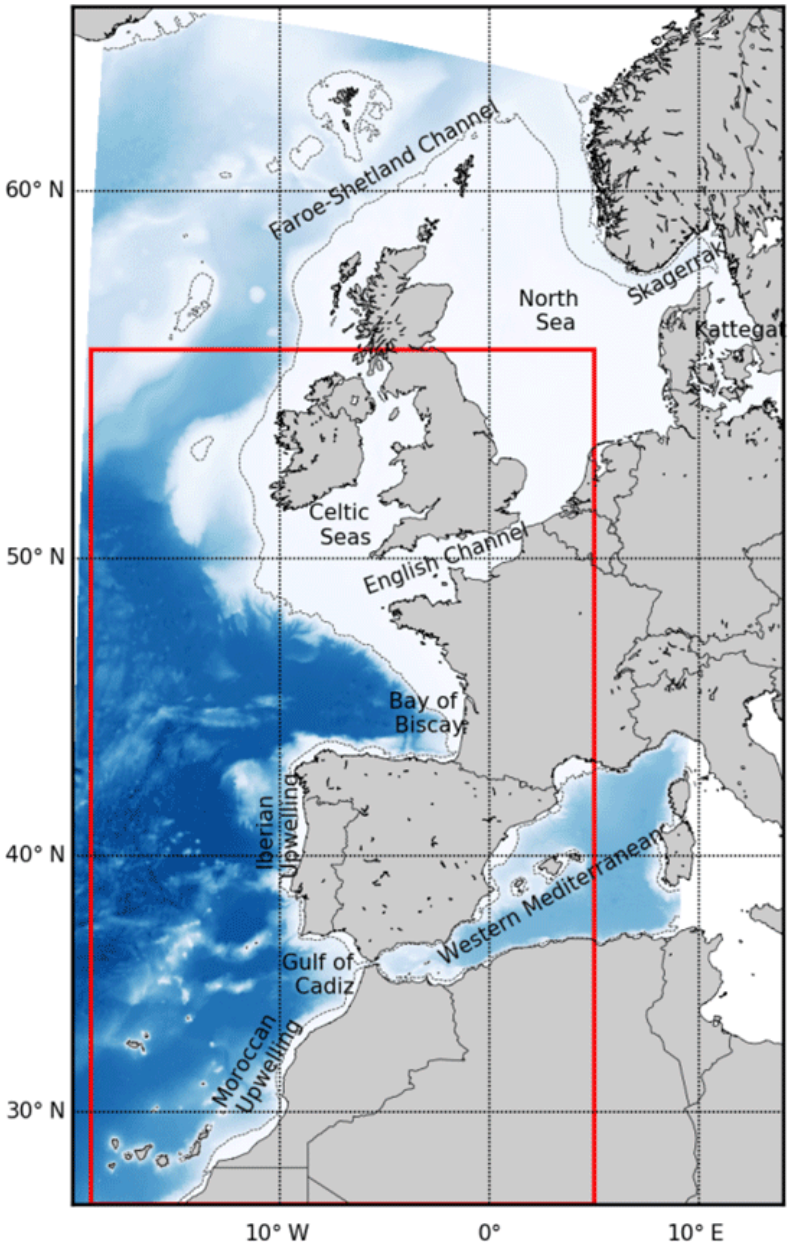

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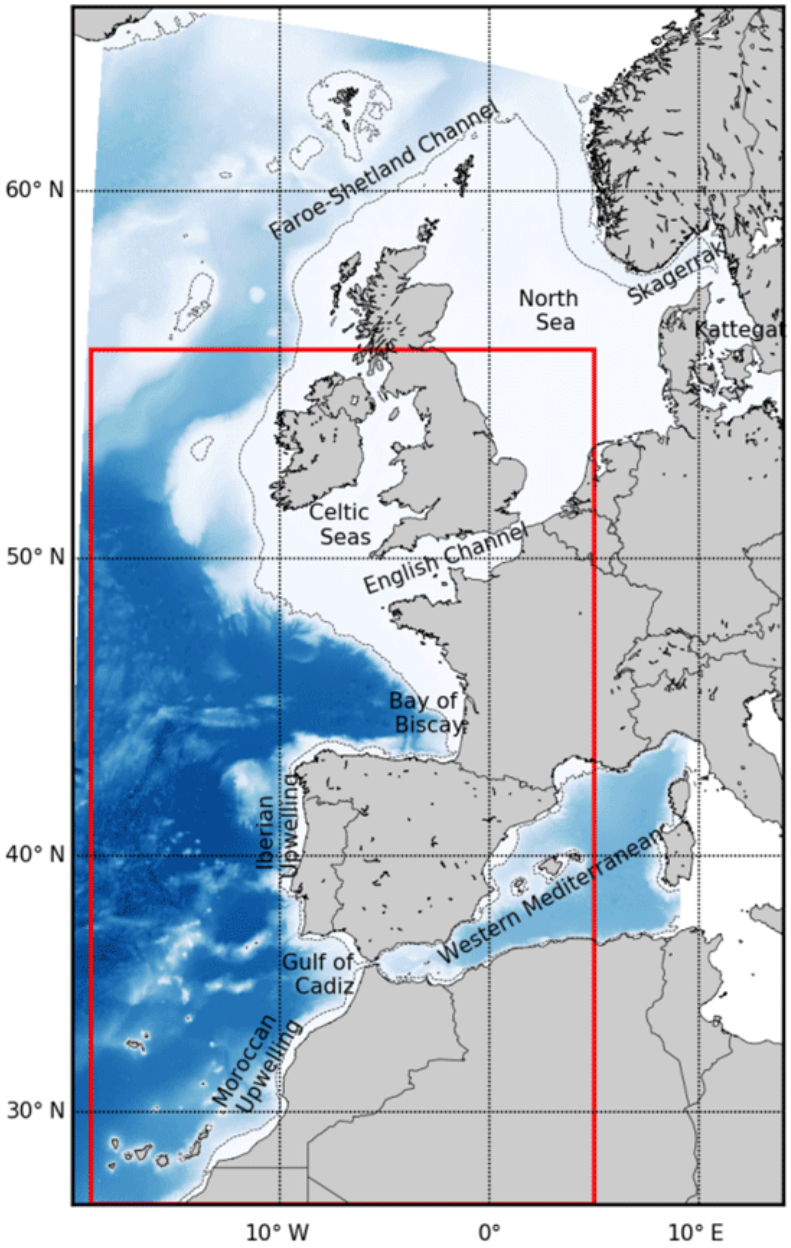
- But such fields would require running a regional hydrology model with the same atmospheric forcing as the ocean model (costly and complicated)



- We want to have runoff datafields for regional ocean downscaling
- But such fields would require running a regional hydrology model with the same atmospheric forcing as the ocean model (costly and complicated)
- Is there another way ?
- The entire concept is based on the fact hindcast simulations are tuned and work, with a reference runoff (usually a climatology)

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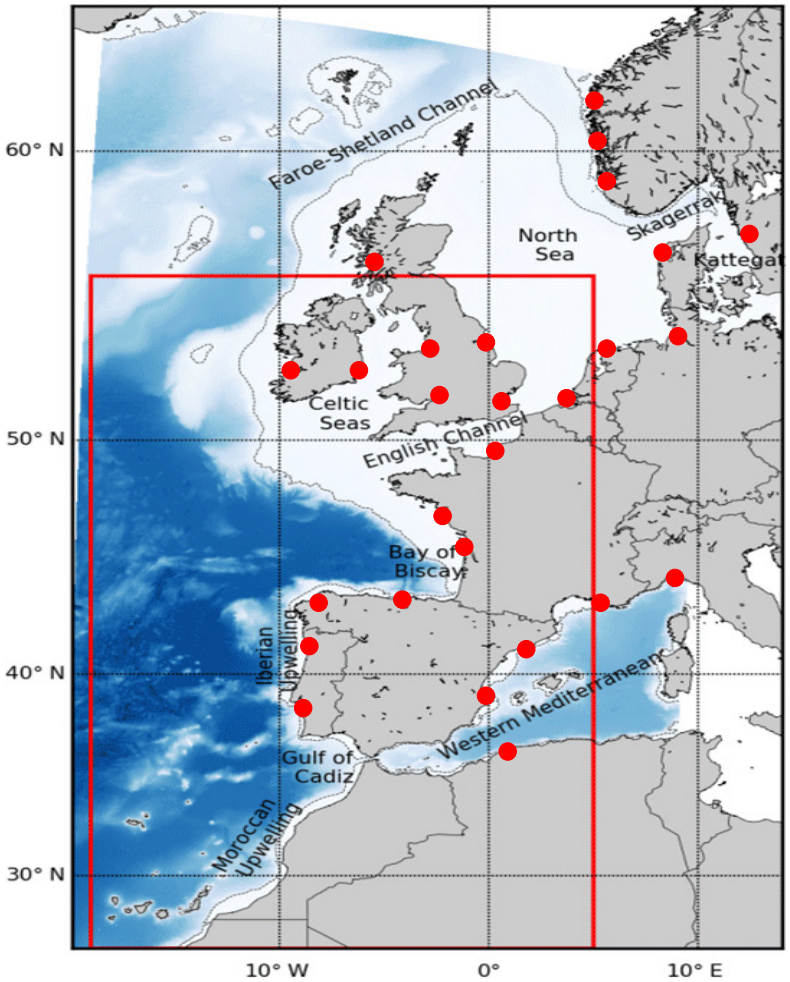

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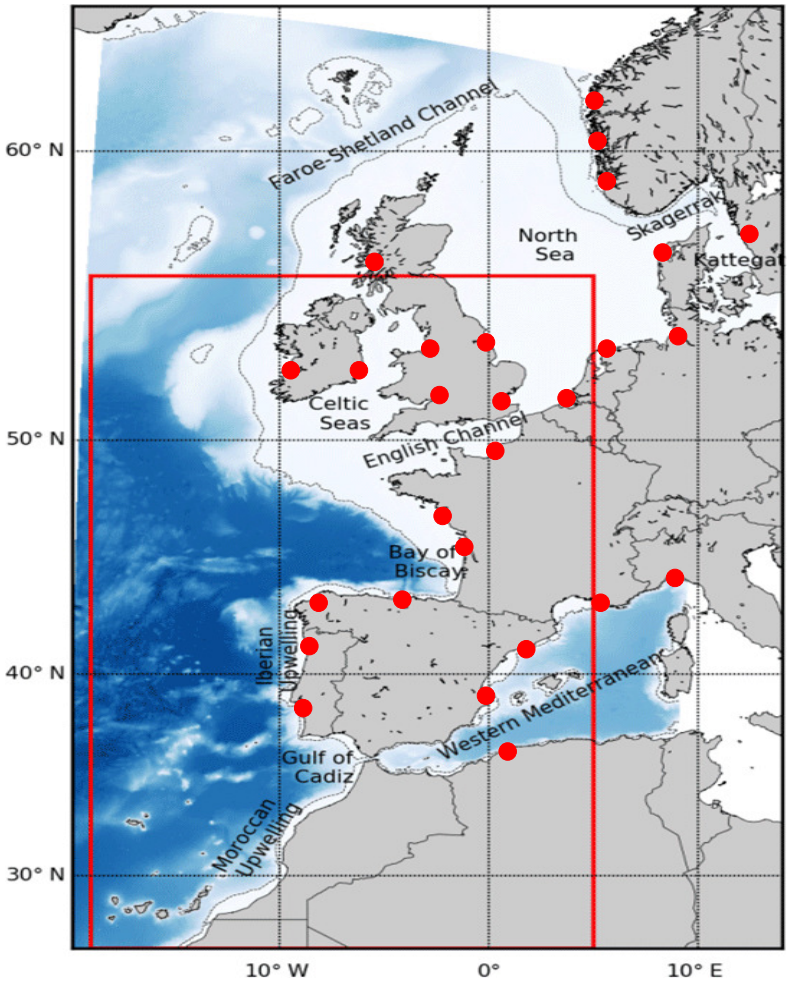

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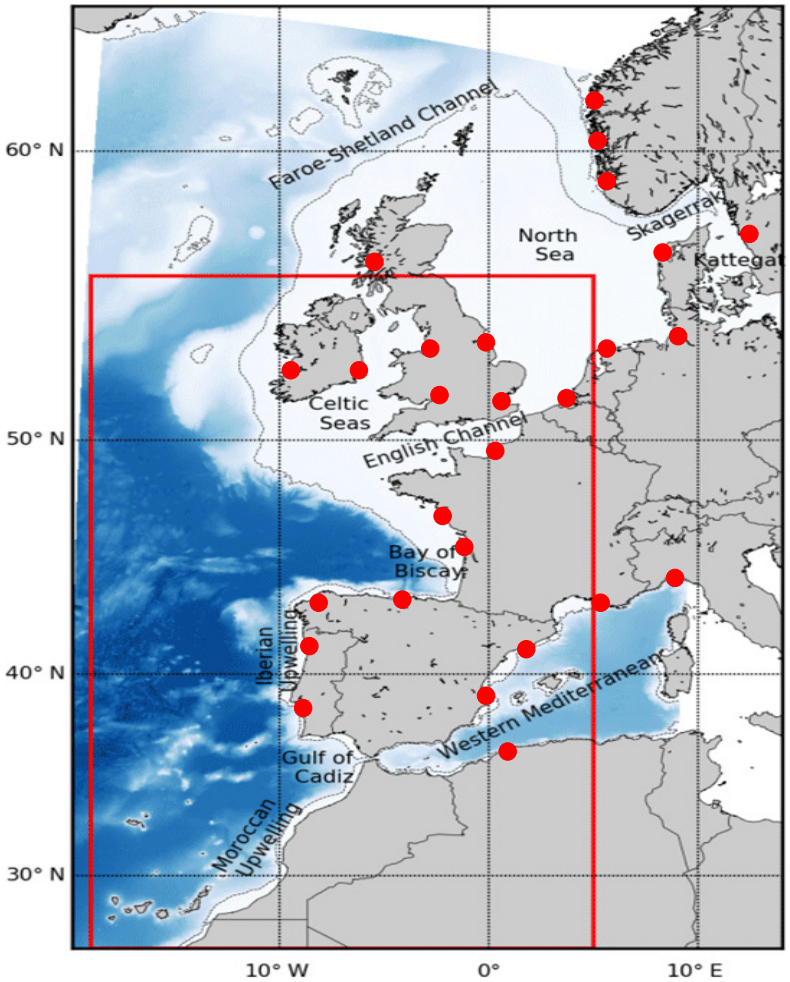

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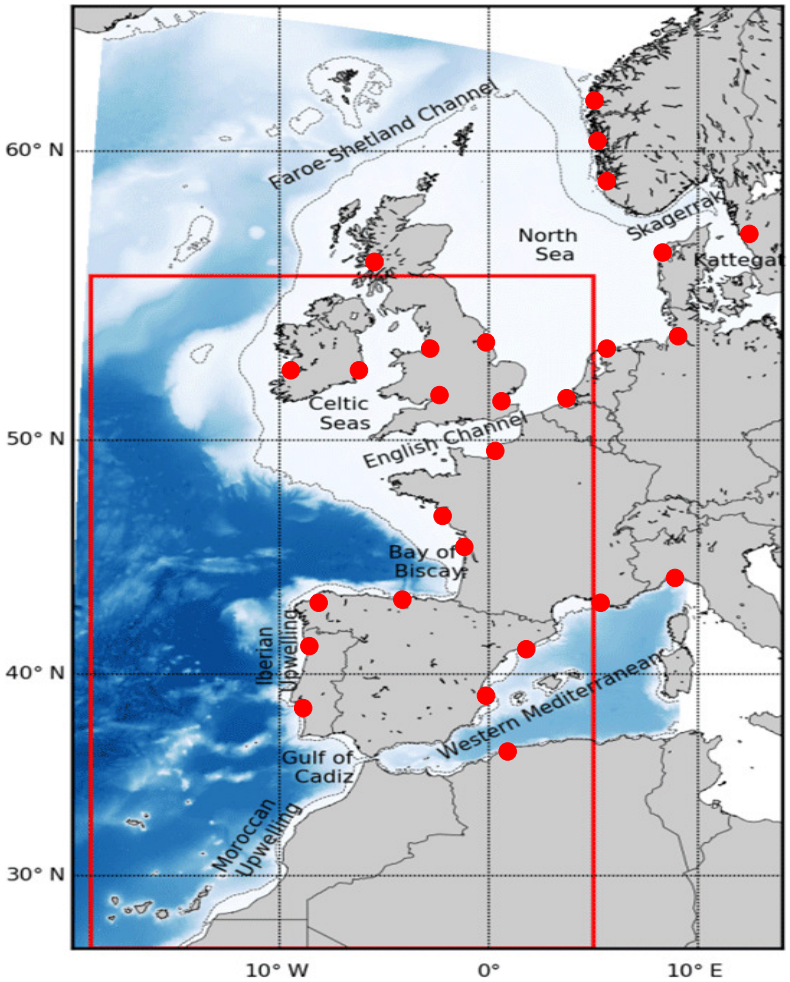

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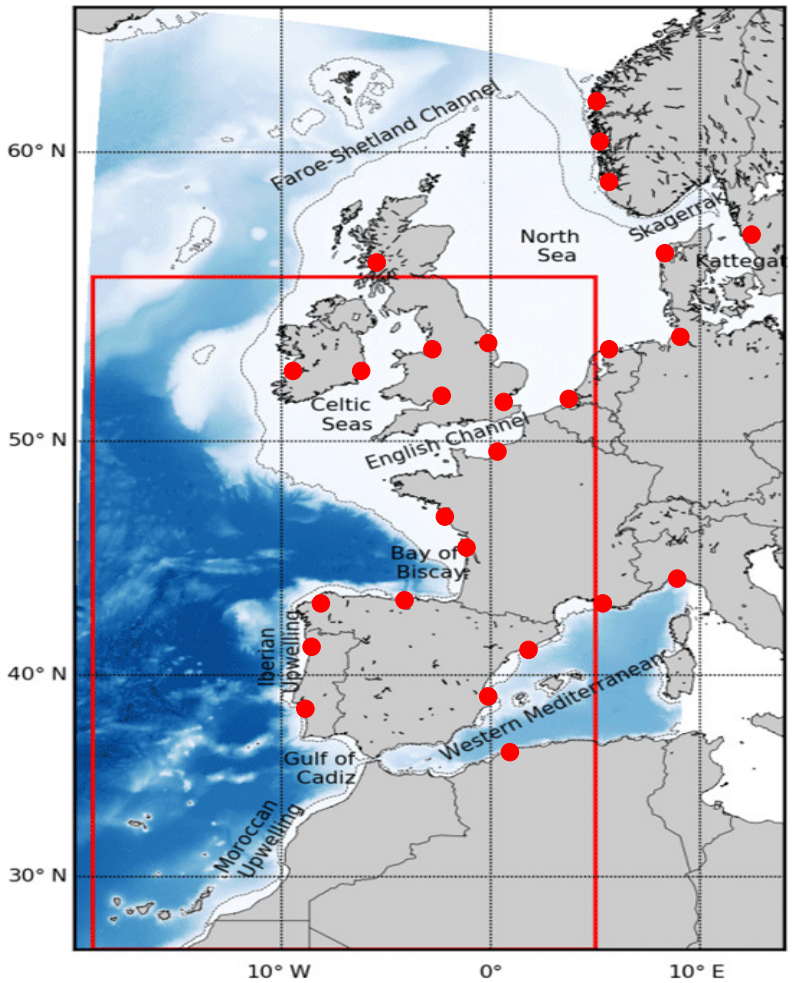
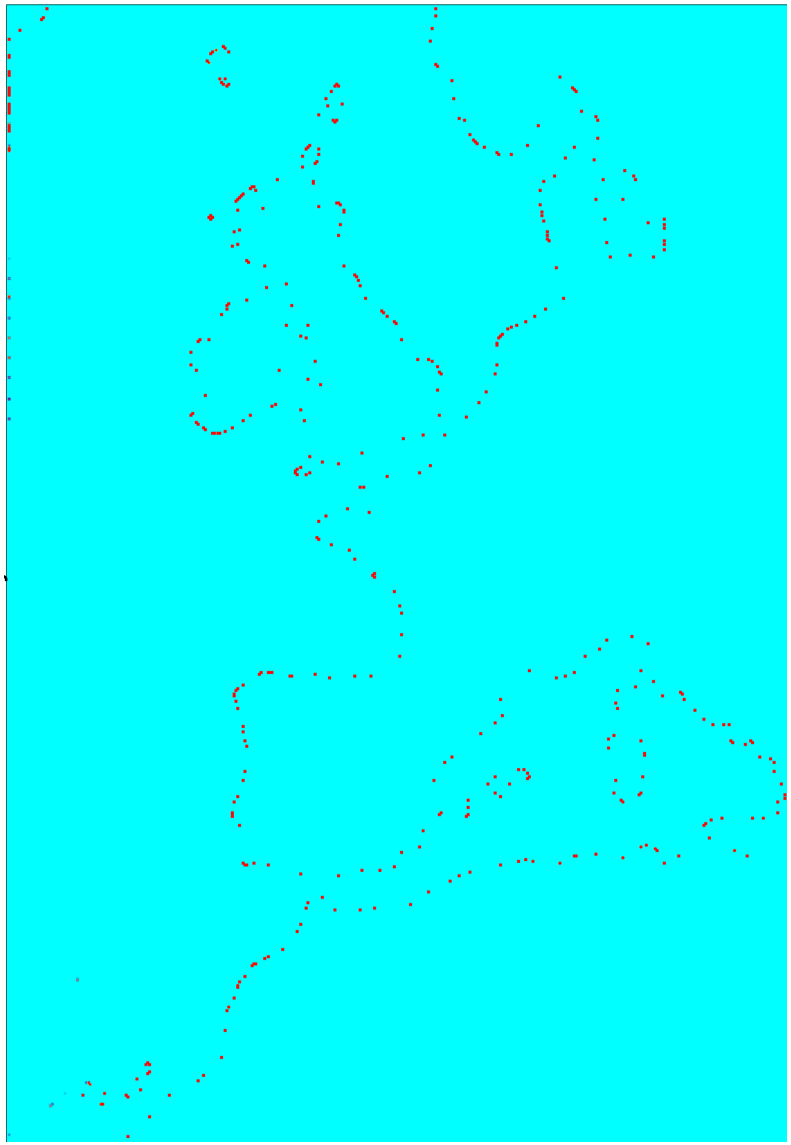
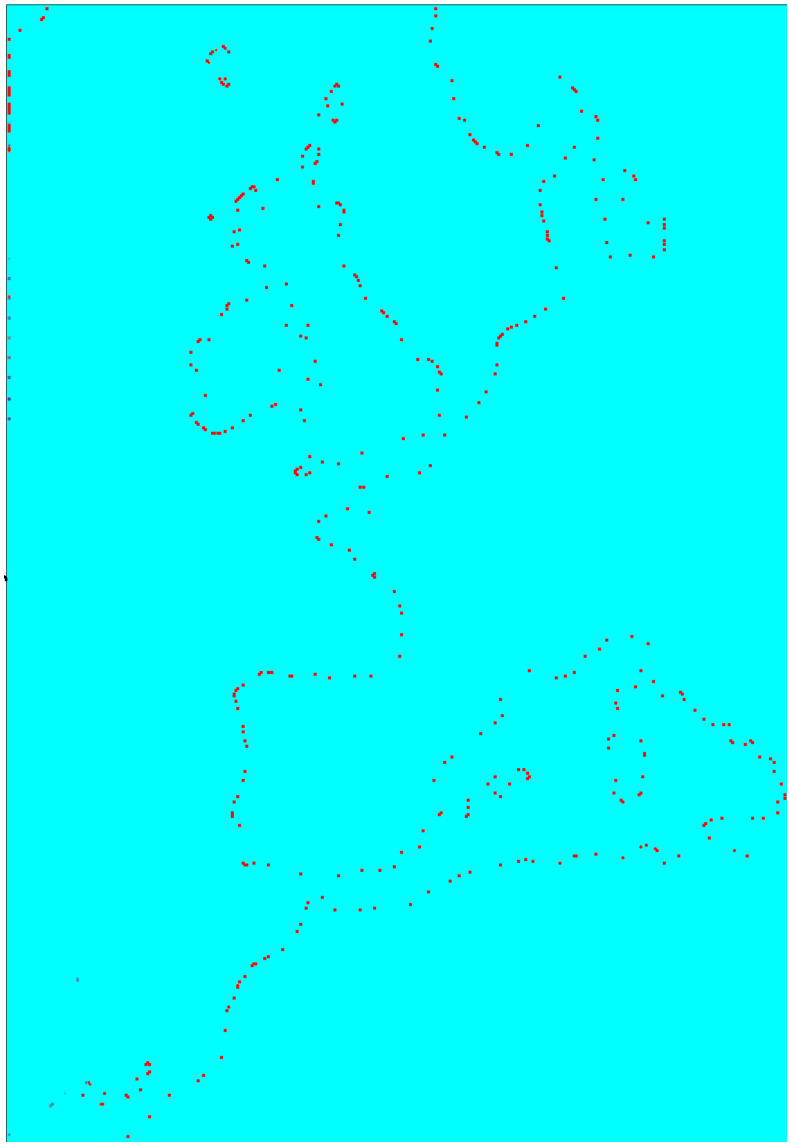
- But we can extract the runoff of the regional area and re-route it


60° N
50° N
40° N
30° N
10° W
0°
10° E
Faroe-Shetland Channel
North Sea
Skagerrak
Kattegat
Celtic Seas
English Channel
Bay of Biscay
Iberian Upwelling
Western Mediterranean
Gulf of Cadiz
Moroccan Upwelling





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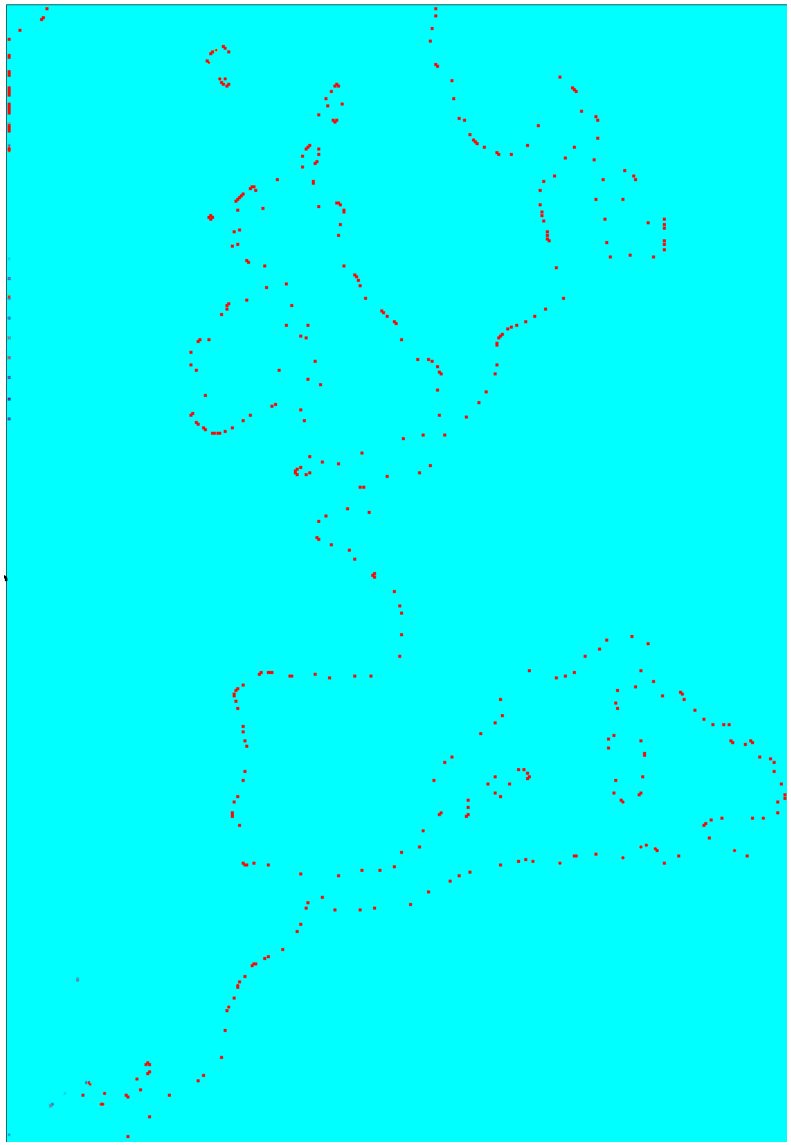

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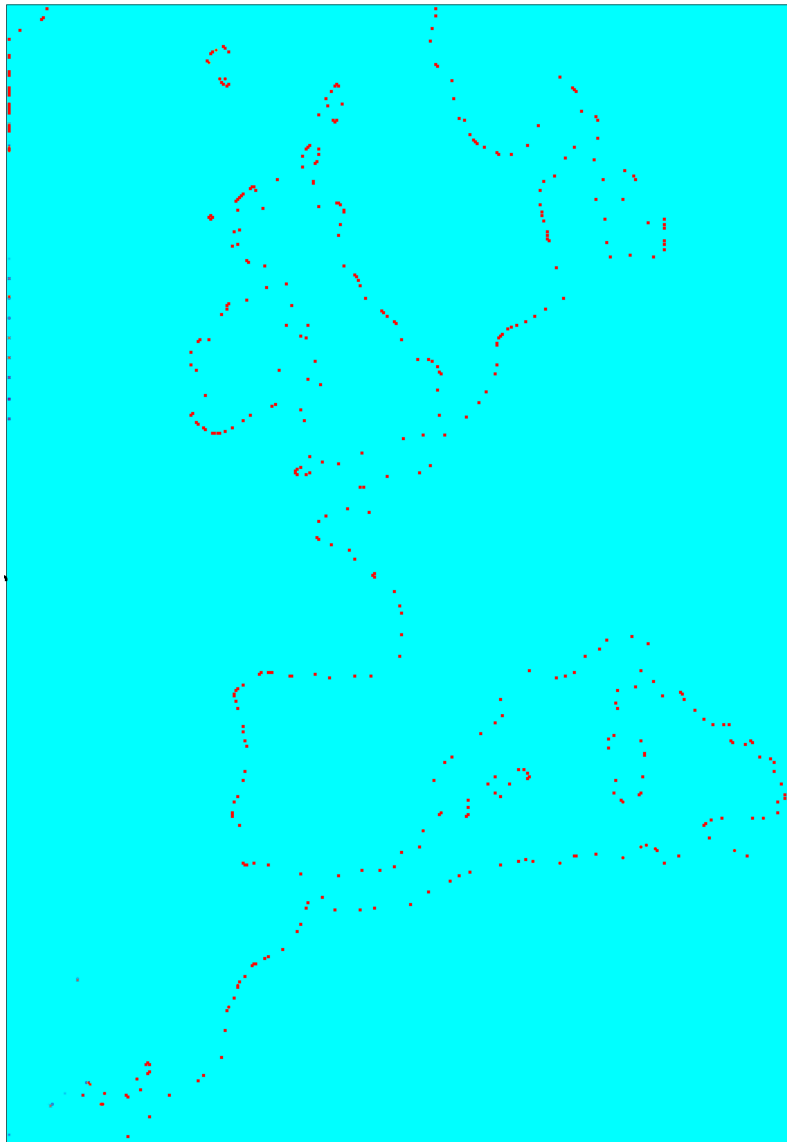

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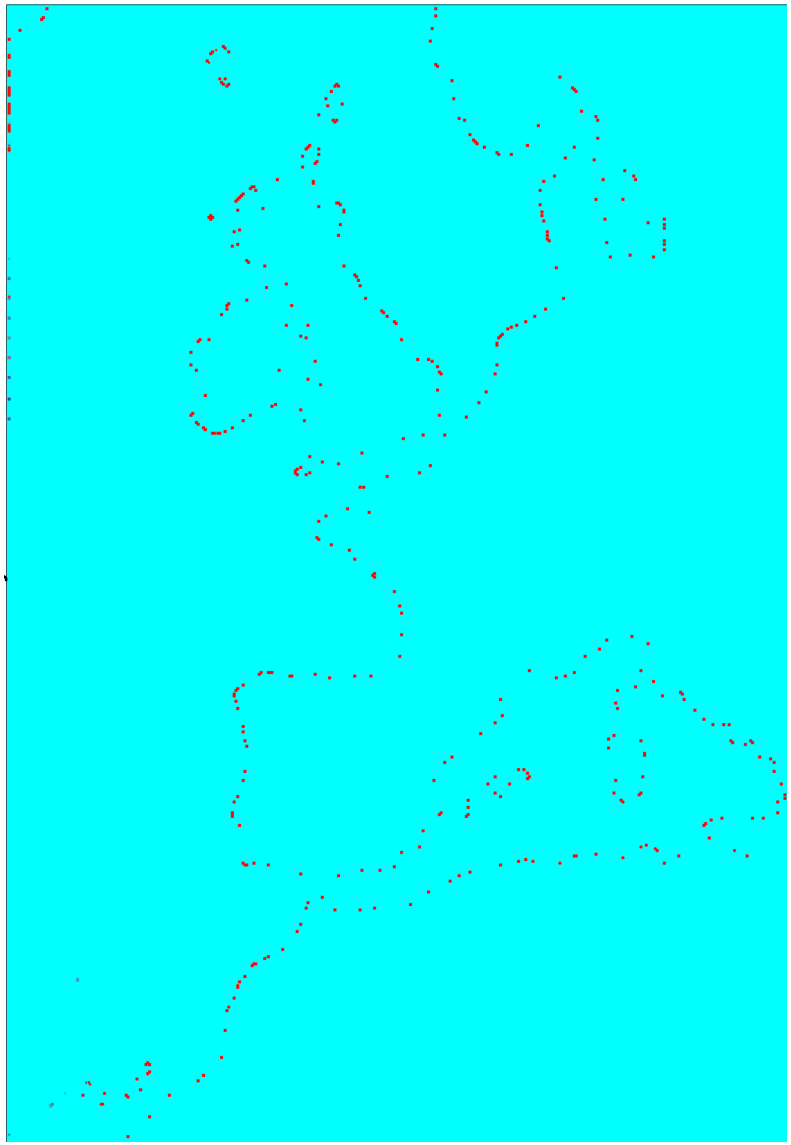

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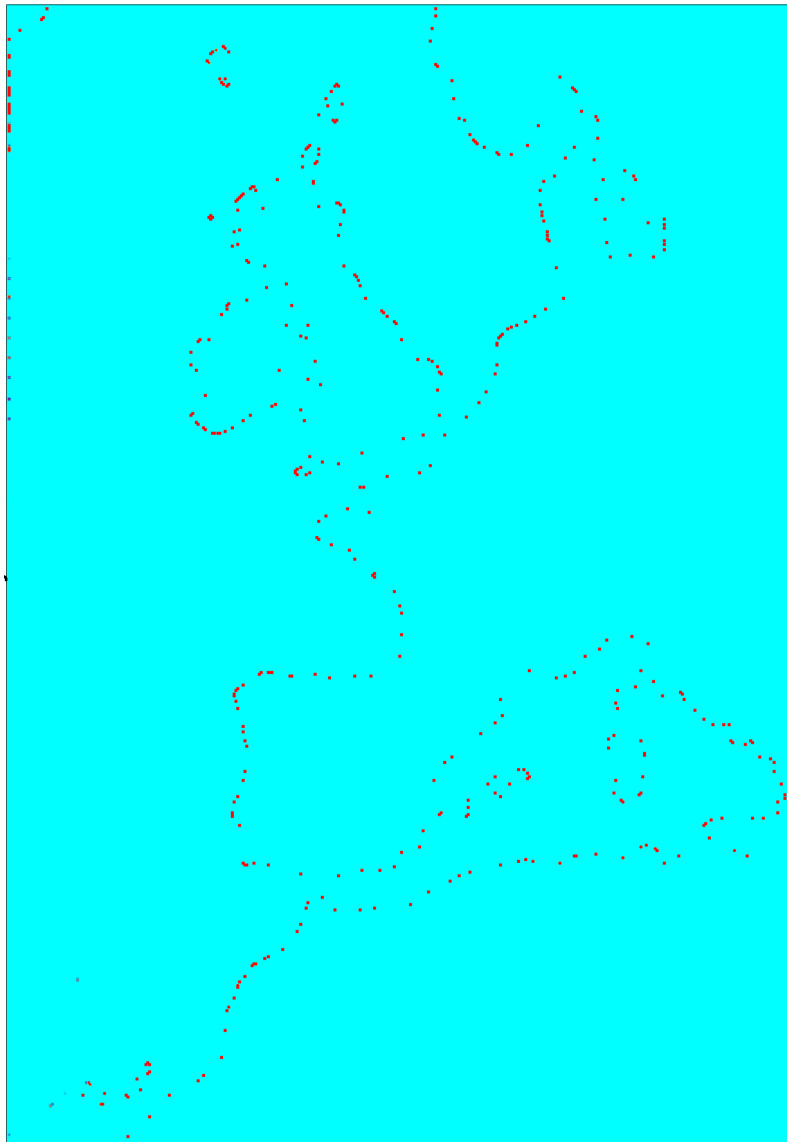

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- Can we apply a bias correction ?

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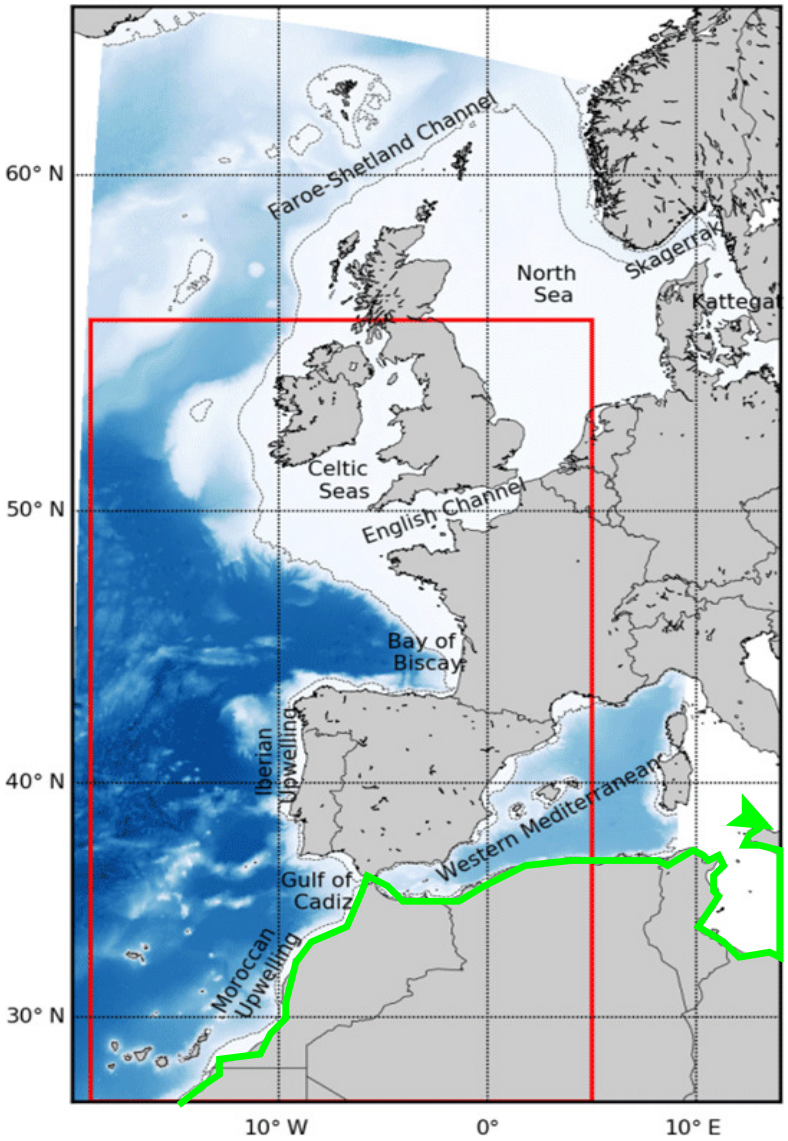

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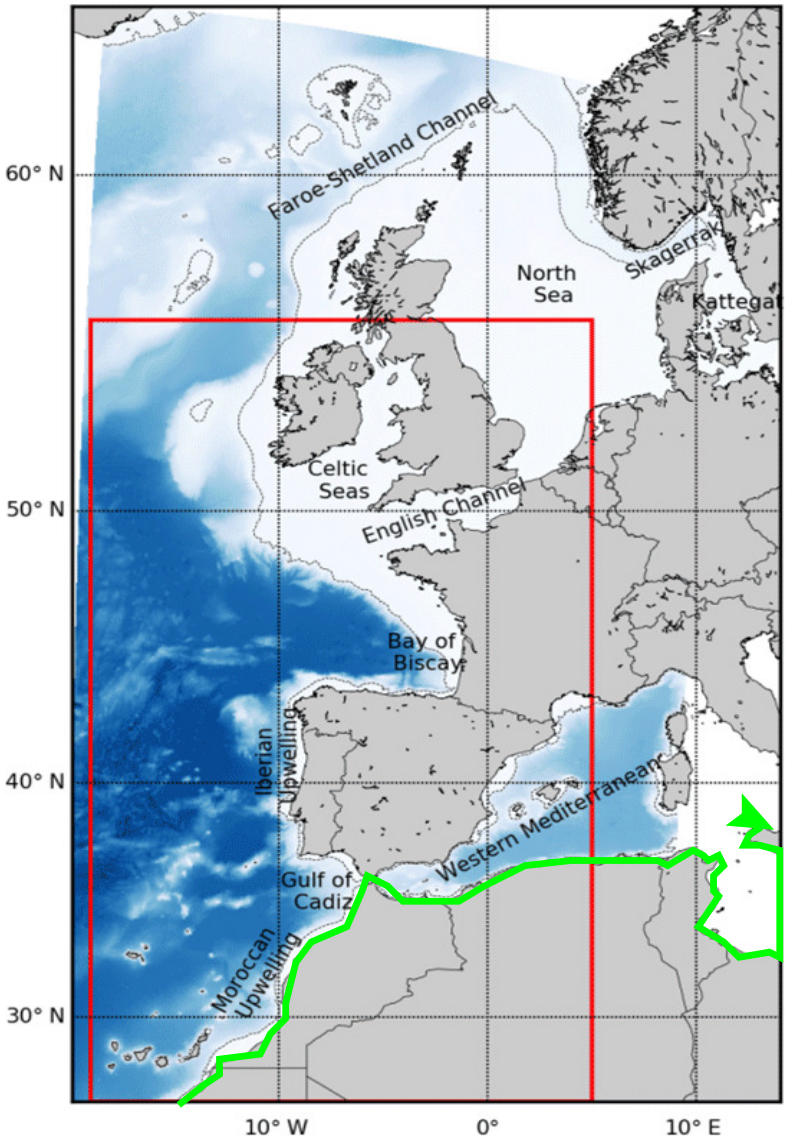

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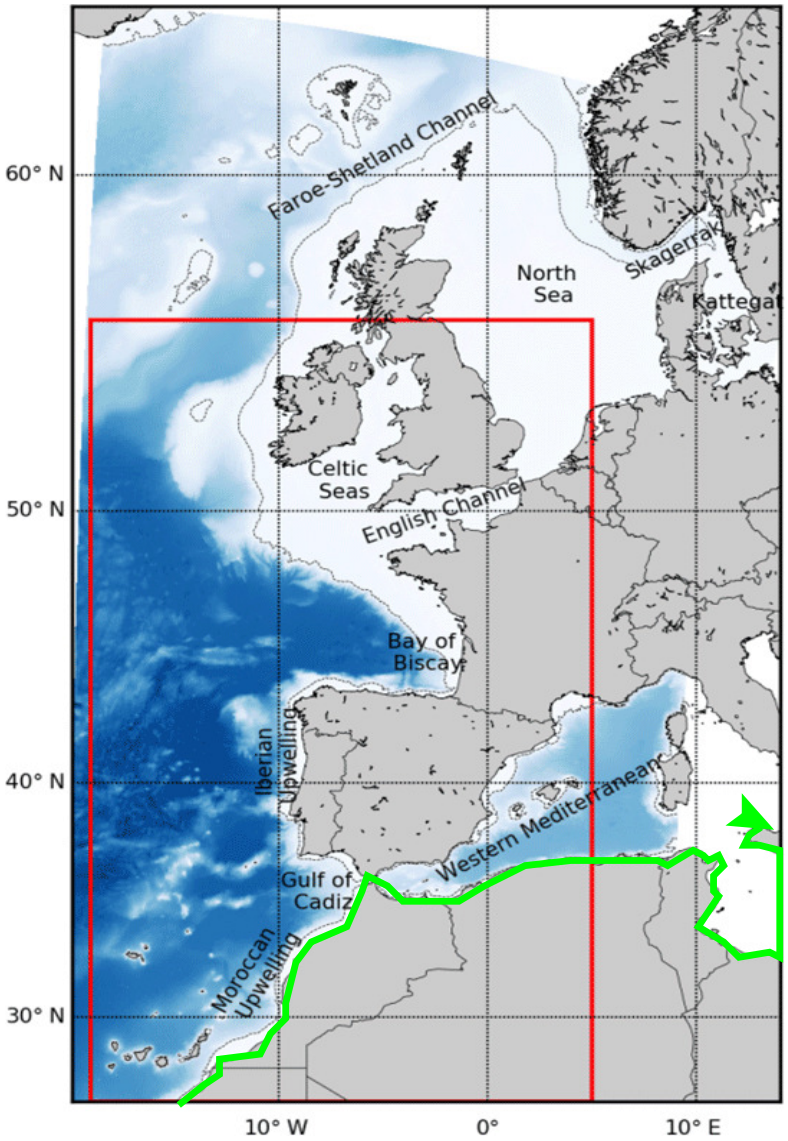

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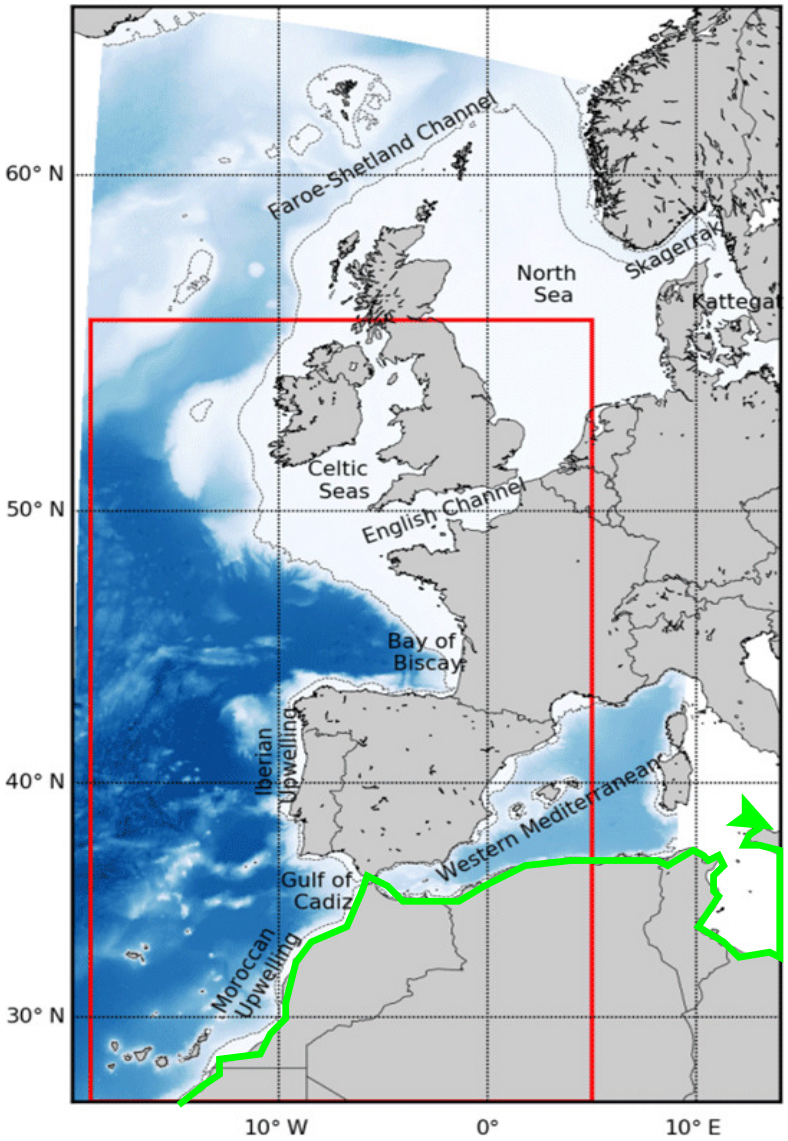

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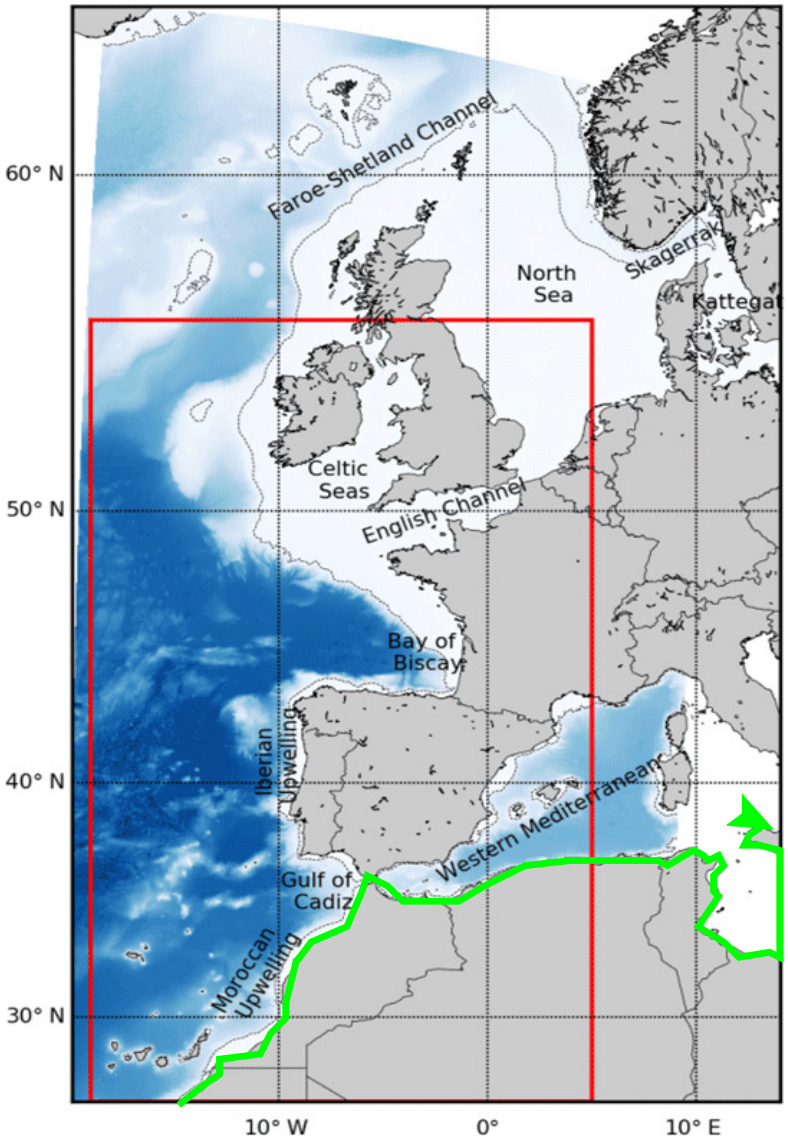

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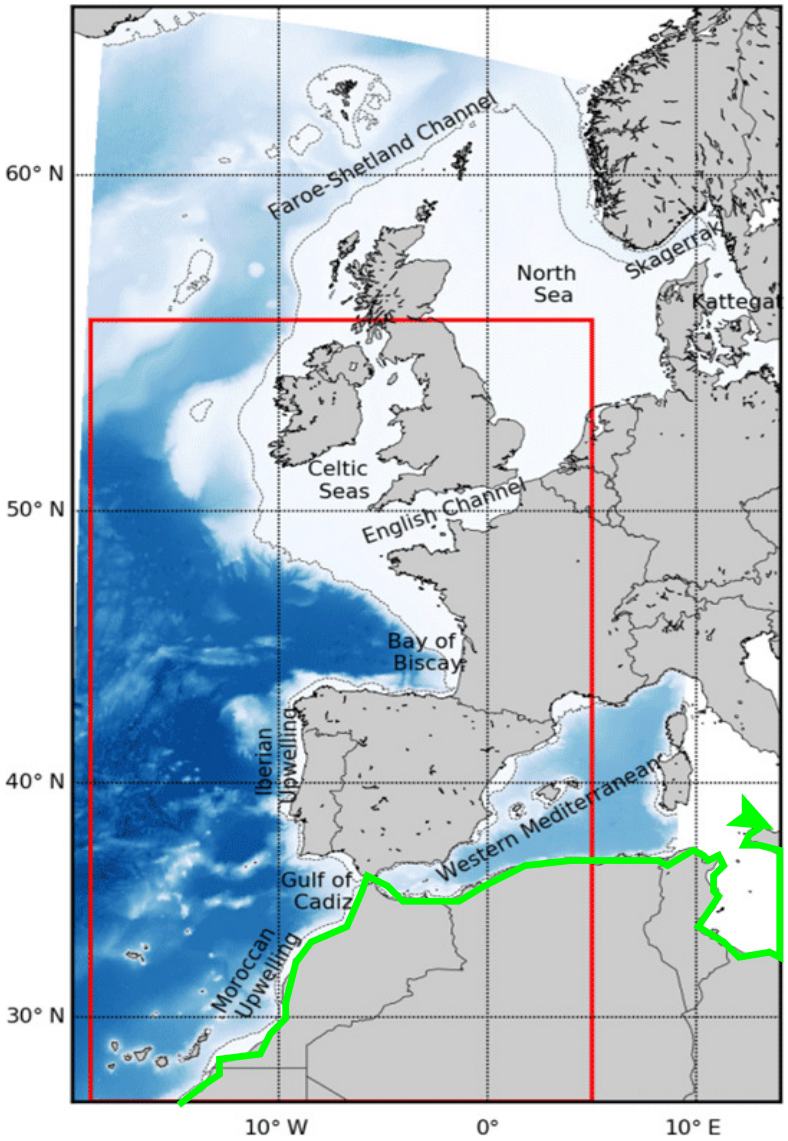
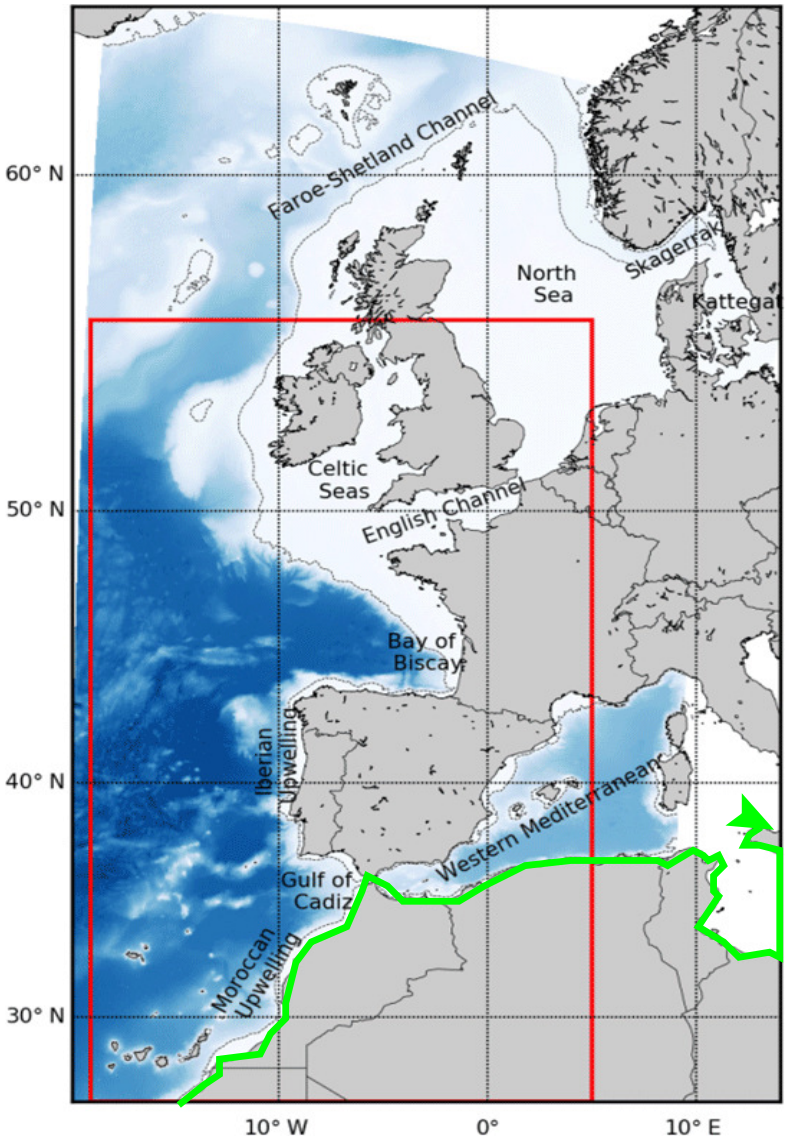
- Further, a river can arrive at a given grid point in the climate model and in another in a reference
- We need a geometry that allows a comparison



- We move along the coast of the IBI grid, until all coastal grid points are counted



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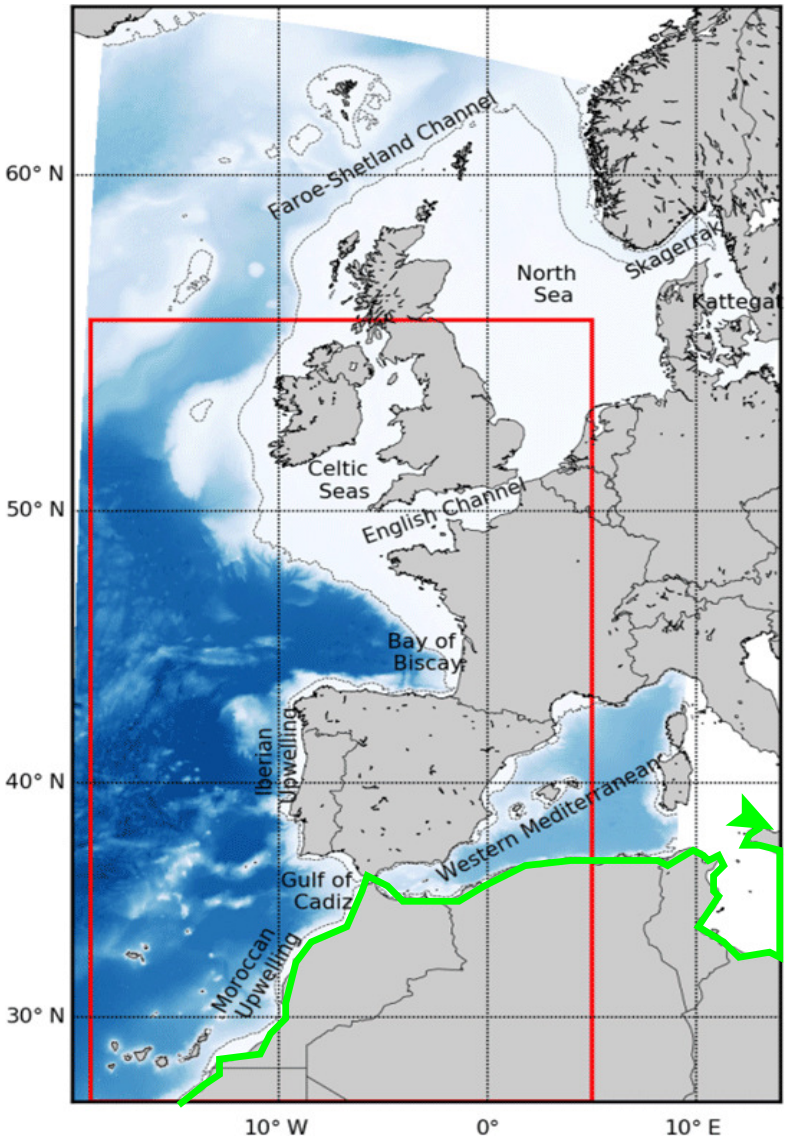

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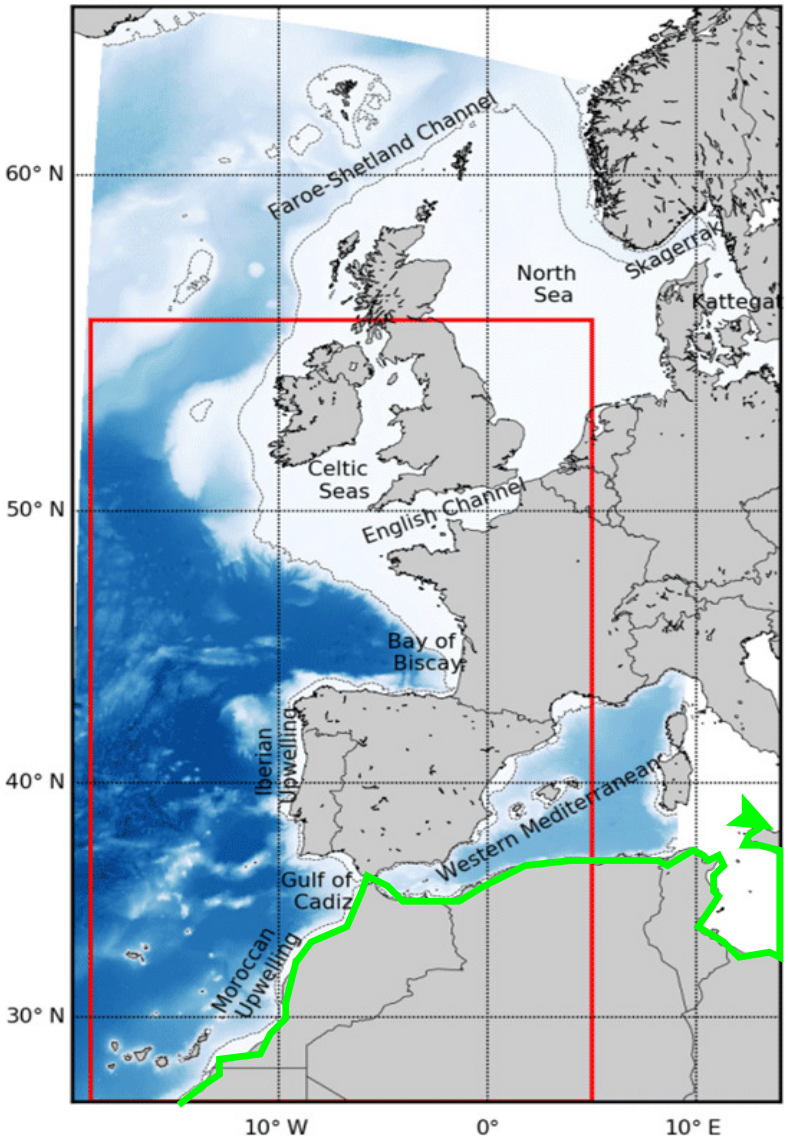
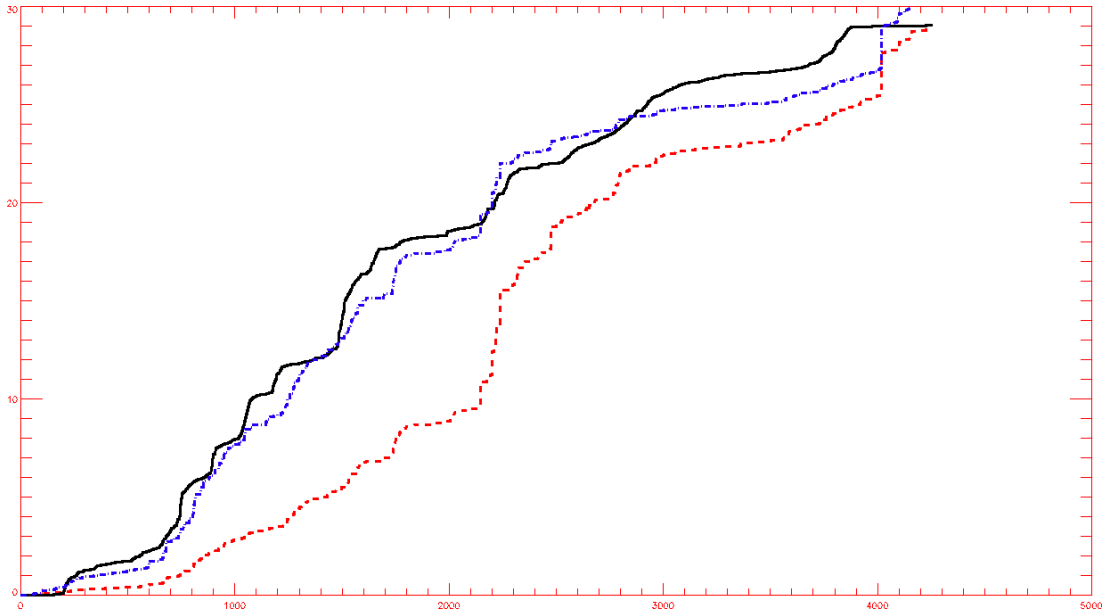
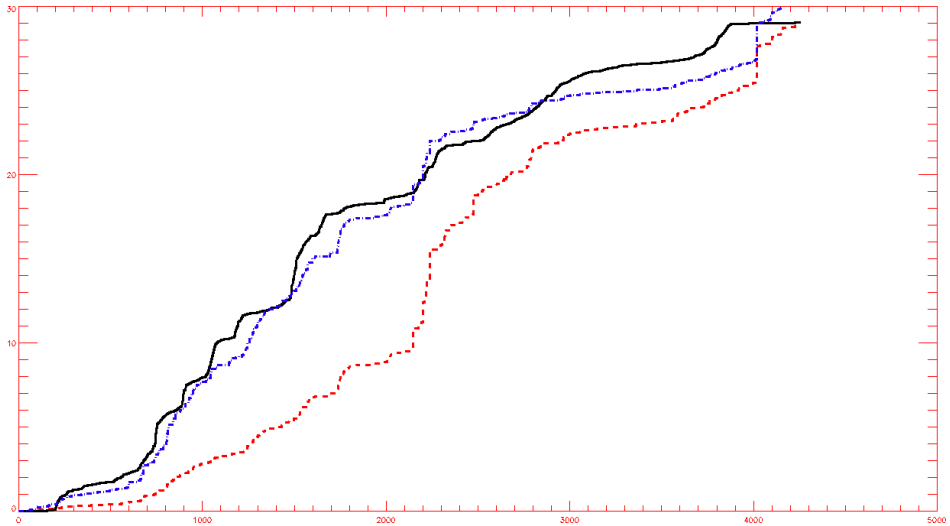


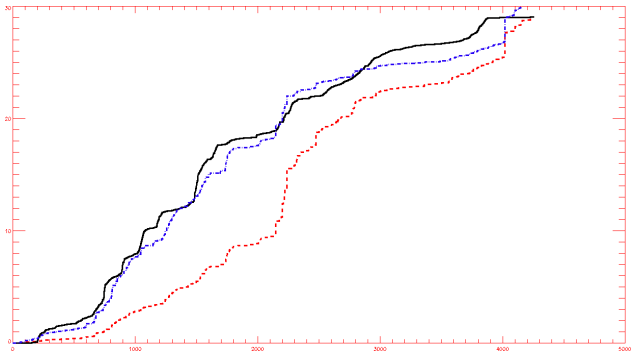
- We move along the coast of the IBI grid, until all coastal grid points are counted
- This gives us a pointer of the "numerical coast"
- The starting point of this pointer, is chosen as a physical geographical corner of the domain
- We cumulate runoff along this pathway, for mean values of the historical period for climate model runoff, and reference (Dai & Trenberth)



- One can now compare the reference runoff (black) and the re-routed NorESM runoff (red)



$$x(i) = nor_{runoff}(i)/max(nor_{runoff})$$
$$y(i) = ref_{runoff}(i)/max(ref_{runoff})$$



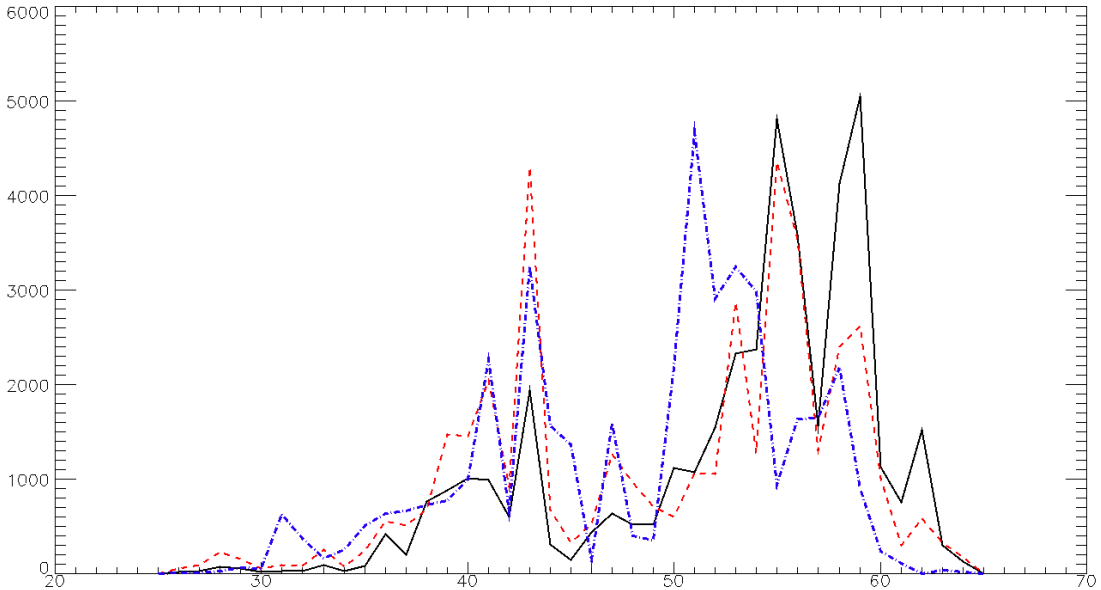
$$
\begin{aligned}
x(i) &= nor_{runoff}(i)/max(nor_{runoff}) \\
y(i) &= ref_{runoff}(i)/max(ref_{runoff}) \\
y(i) &= a_3x^3(i) + a_2x^2(i) + a_1x(i) + a_0
\end{aligned}
$$

$$A = \begin{pmatrix} x_0^3 & x_0^2 & x_0 & 1 \\ x_1^3 & x_1^2 & x_1 & 1 \\ \vdots & \vdots & \vdots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ x_n^3 & x_n^2 & x_n & 1 \end{pmatrix}$$

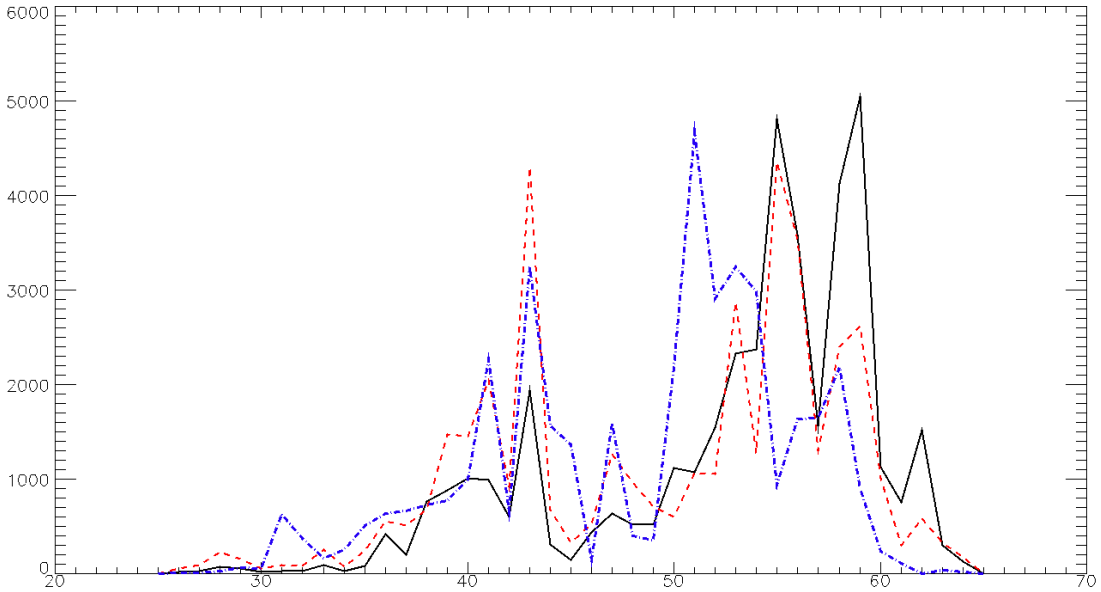
$$
\begin{aligned}
Y &= A \begin{pmatrix} a_3 \\ a_2 \\ a_1 \\ a_0 \end{pmatrix} \\
A^t Y &= A^t A \\
\begin{pmatrix} a_3 \\ a_2 \\ a_1 \\ a_0 \end{pmatrix} &= (A^t A)^{-1} A^t Y
\end{aligned}
$$

$$\begin{pmatrix} a_3 \\ a_2 \\ a_1 \\ a_0 \end{pmatrix}$$

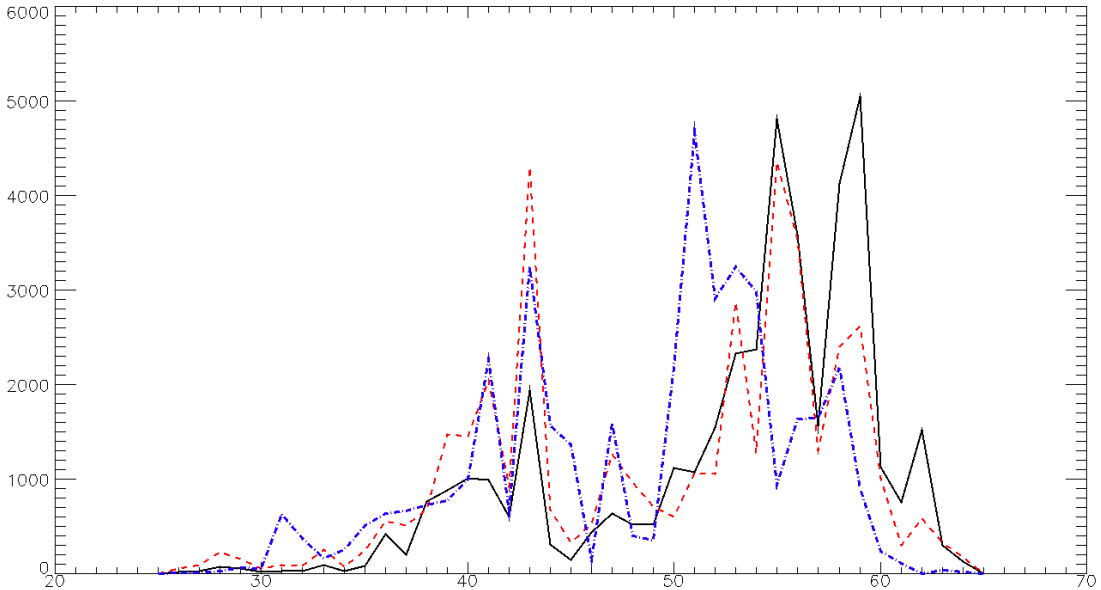
- The assumption is that this set of polynomial coefficients is valid, regardless of seasonal or inter-annual variability
- It works rather nicely since it (almost) keeps the monotonicity of the cumulated runoff distribution
- At the very end, a constant factor is applied
- All this tuning is made during the historical time period, and extended to the projections



- Runoff against latitude



- Runoff against latitude
- Black: NorESM, Red: Corrected-NorESM, Blue: Reference IBI hindcast runoff



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- The correction pushes the NorESM runoff distribution towards the reference one