Contents

1. Basin climat computation

Climate attribution is more evident for some basin than for others. For example, the Amazon basin is a simple case with a 90% tropical climate (Fig. S1), while the Mississippi basin (Fig. S2) is 49% continental, 28% arid, and 23% temperate, and the Brahmaputra basin, considered in this study as polar, is actually 48% polar against 40% temperate (Fig. S3). Regarding the Indus Basin, two different gauge stations has been used in order to have a second basin with a polar climate (see Fig. 1).
The definition of the climate over the entire basin could be different.

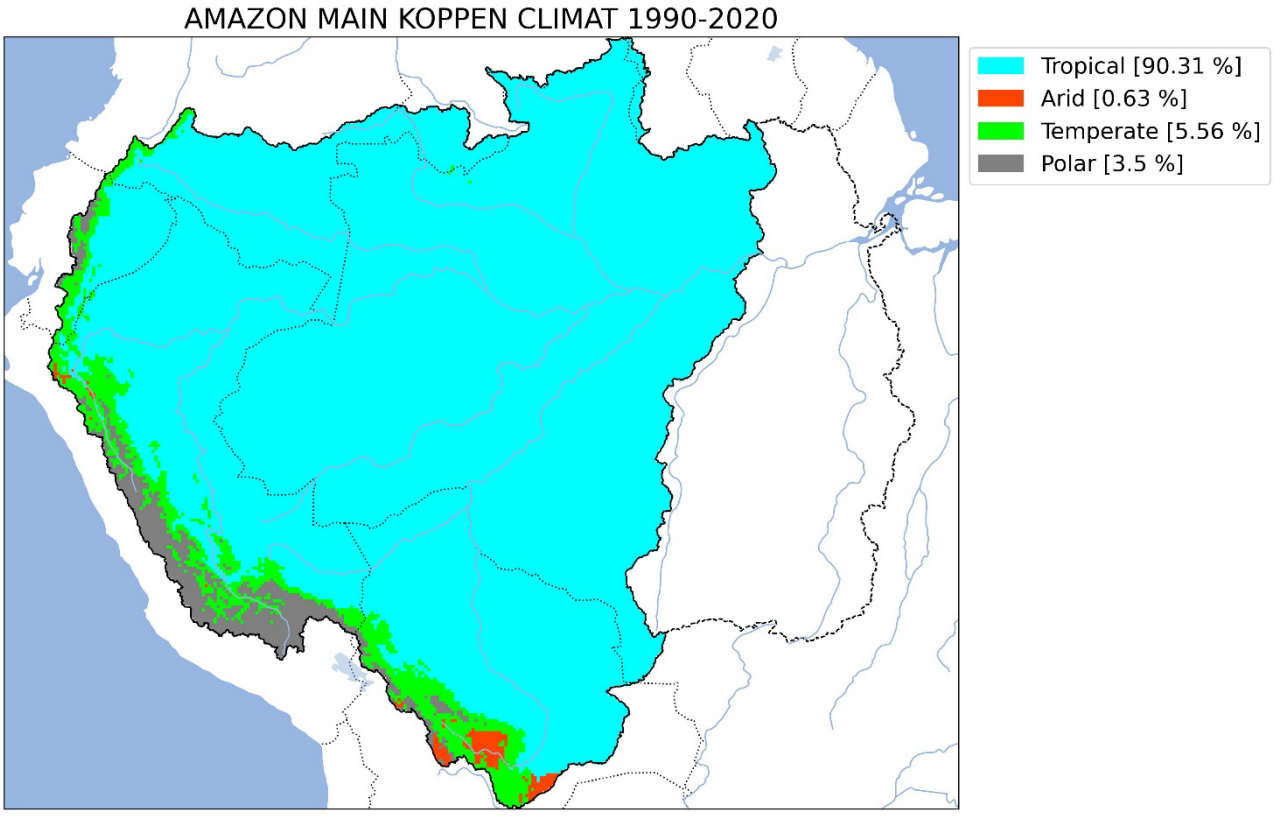

Figure S1 :Amazon climates

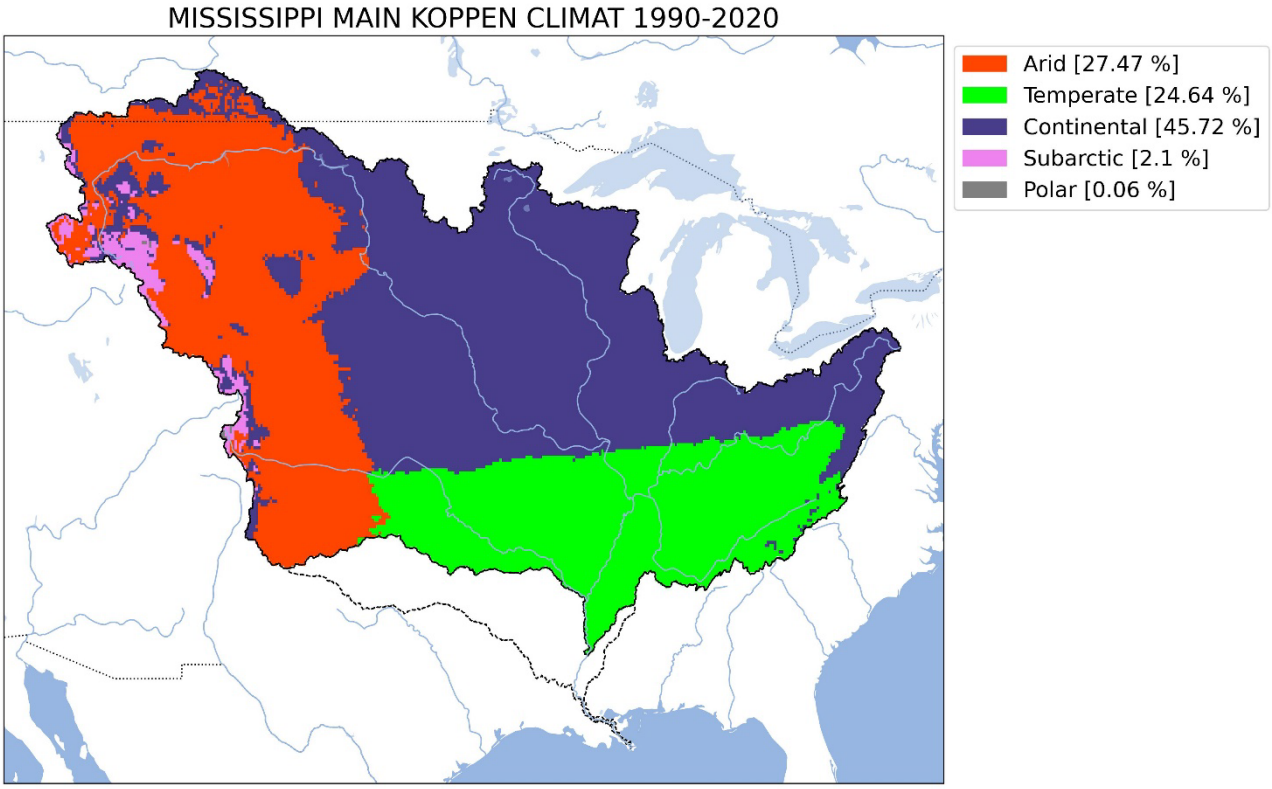

Figure S2 : Mississippi climates

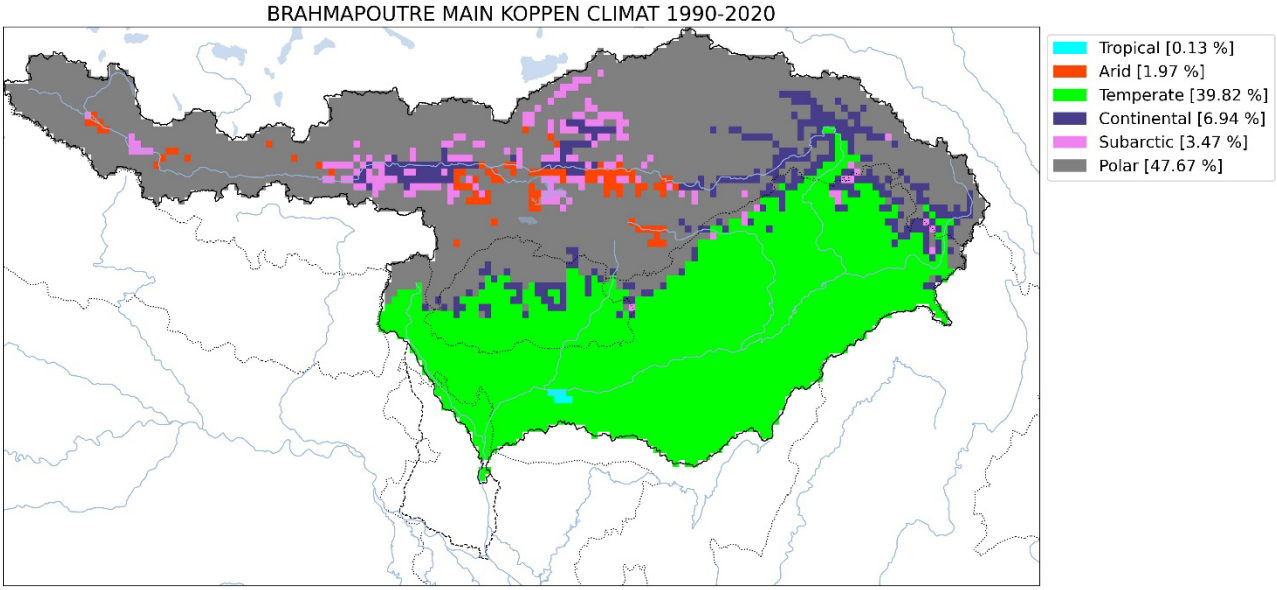

Figure S3 :Brahmaputra climates

2. Sub-mask use example

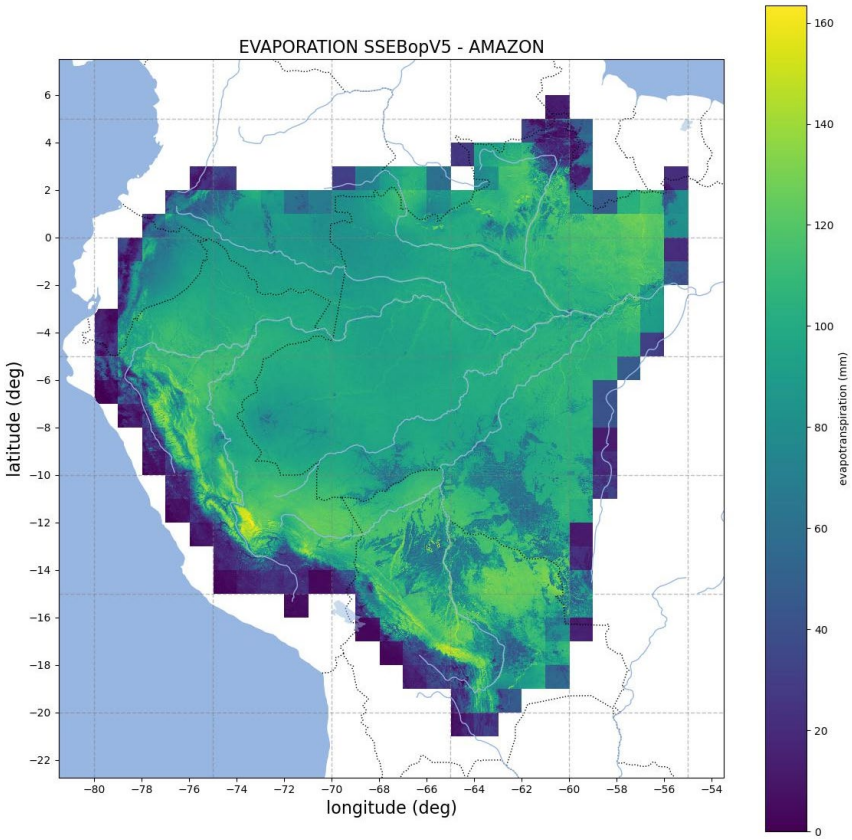

Figure S4 : 1deg subbasin masq on SSEBOP V5 Evapotranspiration

3. Runoff propagation : speed computation and effect

When the results are examined by climate type (Fig. S9 to Fig. S14), a strong heterogeneity in S_{prop} is observed for arid basins. Compared to other climate, there is a fairly homogeneous value of around 0.4 m/s for Sprop on tropical basins, as well as a higher correlation level of 0.9. The routing method has, in particular, a significant positive effect on the Amazon basin with a two-month shift in the flood peak and a homogenous S_{prop} around 0.3 m/s (Fig. S19).
Differences between correlation obtained with S_{prop} and the correlation obtained without routing (i.e., with an infinite propagation speed), show a more significant improvement when S_{prop} is smaller, particularly below 0.5 m/s, especially on subarctic basins (Fig. S15). For some basins, the increase in correlation can be greater than 1, meaning that the discharge peak calculated by simply summing the runoff is significantly offset from the discharge peak observed with OBD (Fig. S16). Even if propagation enables the flood peak dates to align with in situ, the climatologies still do not match (Fig. S16 and S17). GRUN is the model that provides the highest median correlation between climatologies (0.84) while JRA-55 provides the smallest one (0.61) (Fig S8).

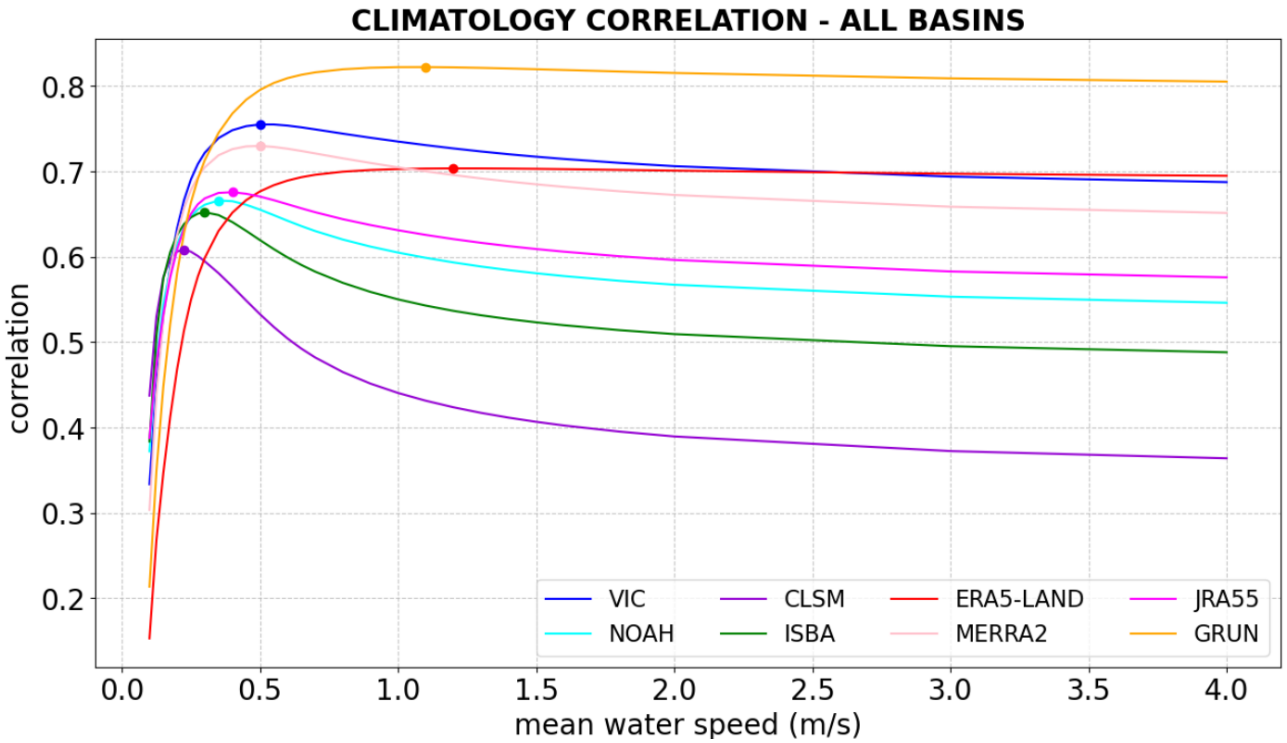

Figure S5: mean correlation vs propagation speed

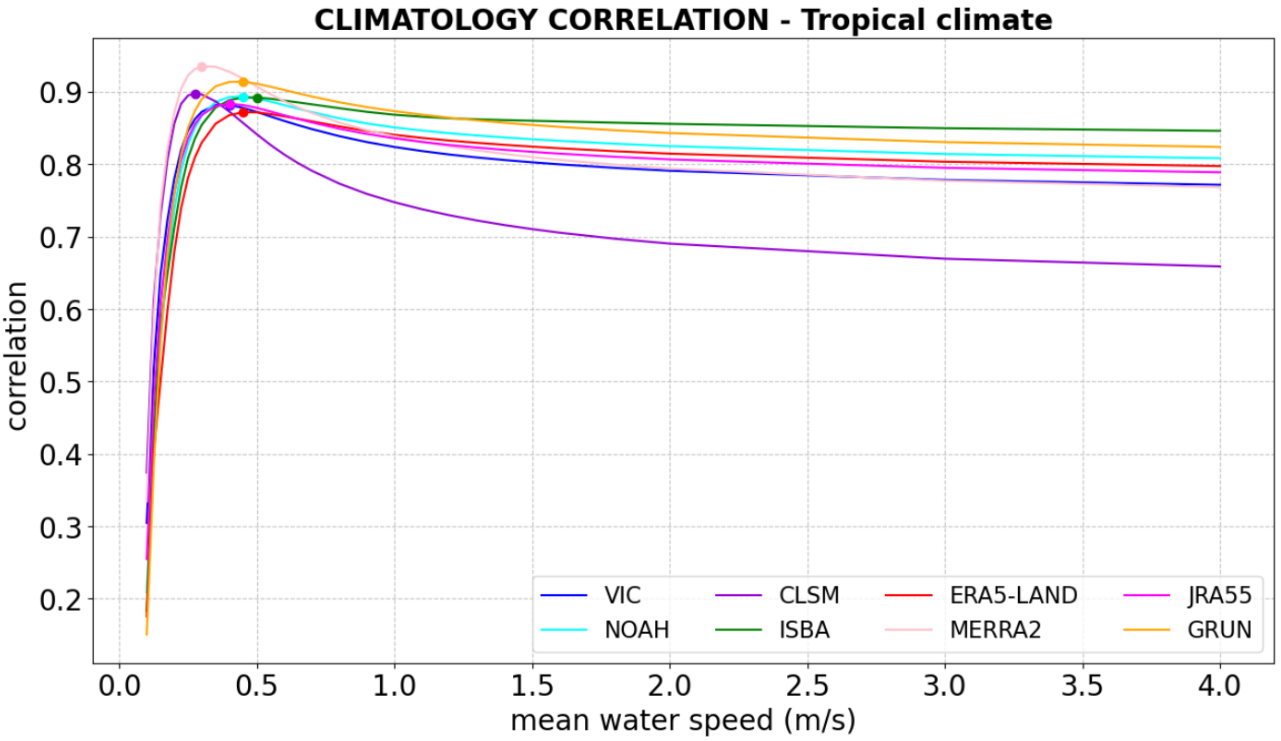

Figure S6: mean correlation vs propagation speed, tropical basins

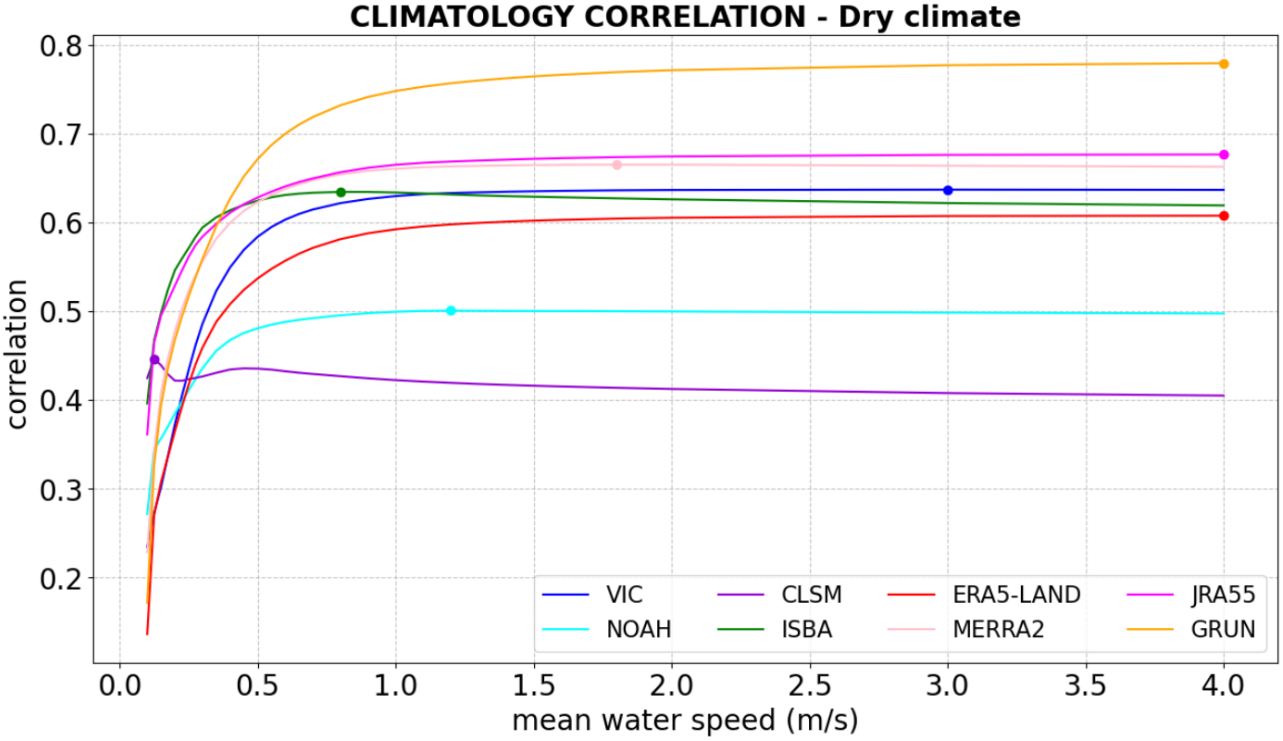

Figure S7: mean correlation vs propagation speed, Arid basins

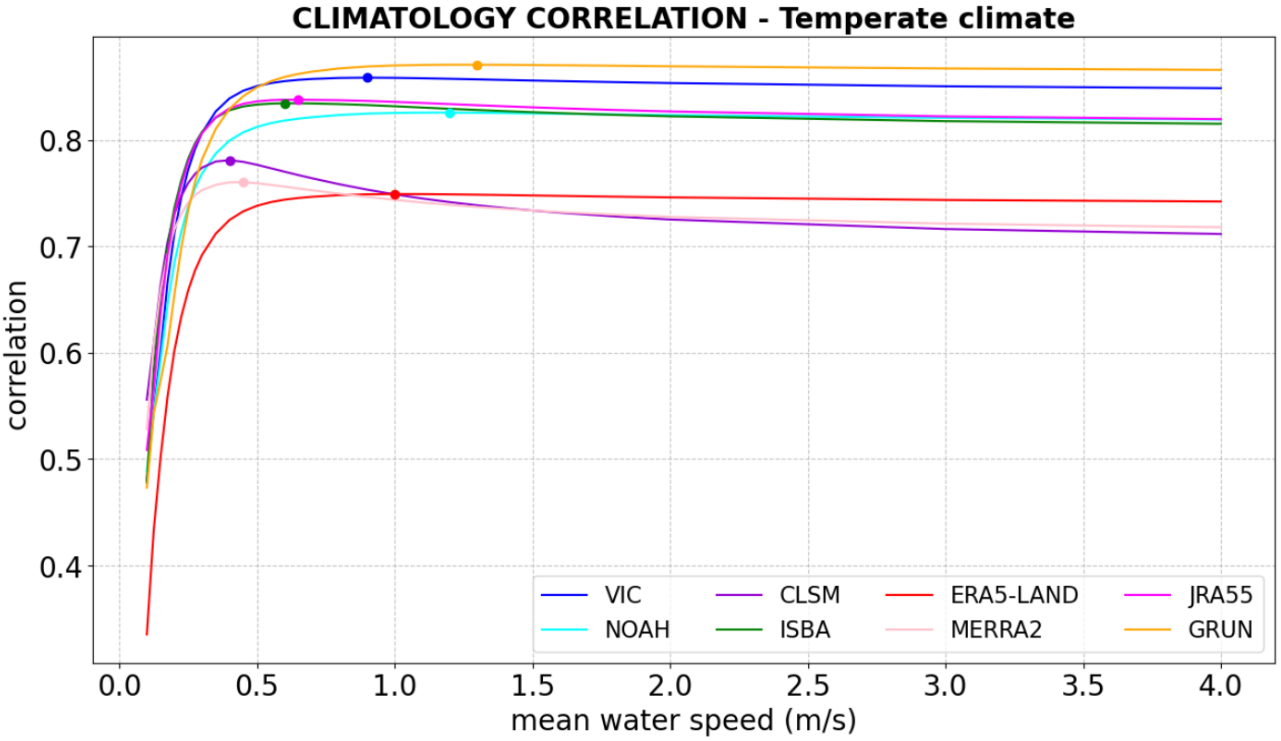

Figure S8: mean correlation vs propagation speed, temperate basins

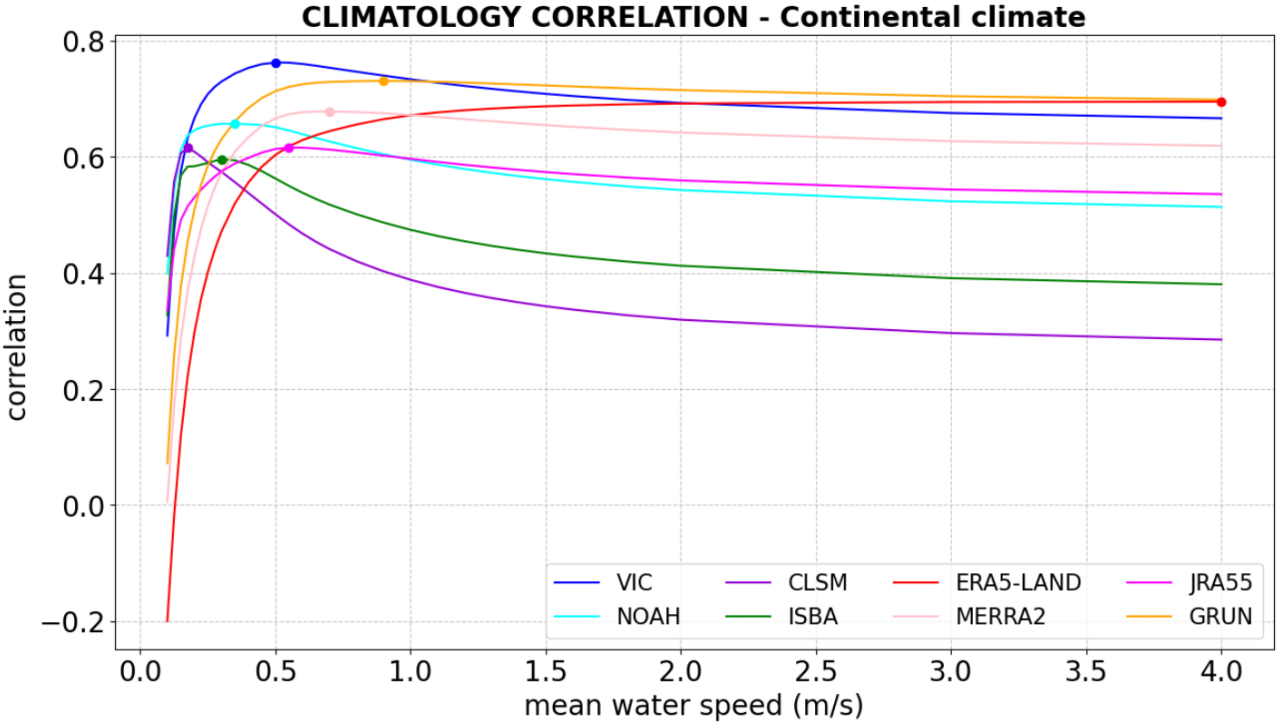

Figure S9: mean correlation vs propagation speed, continental basins

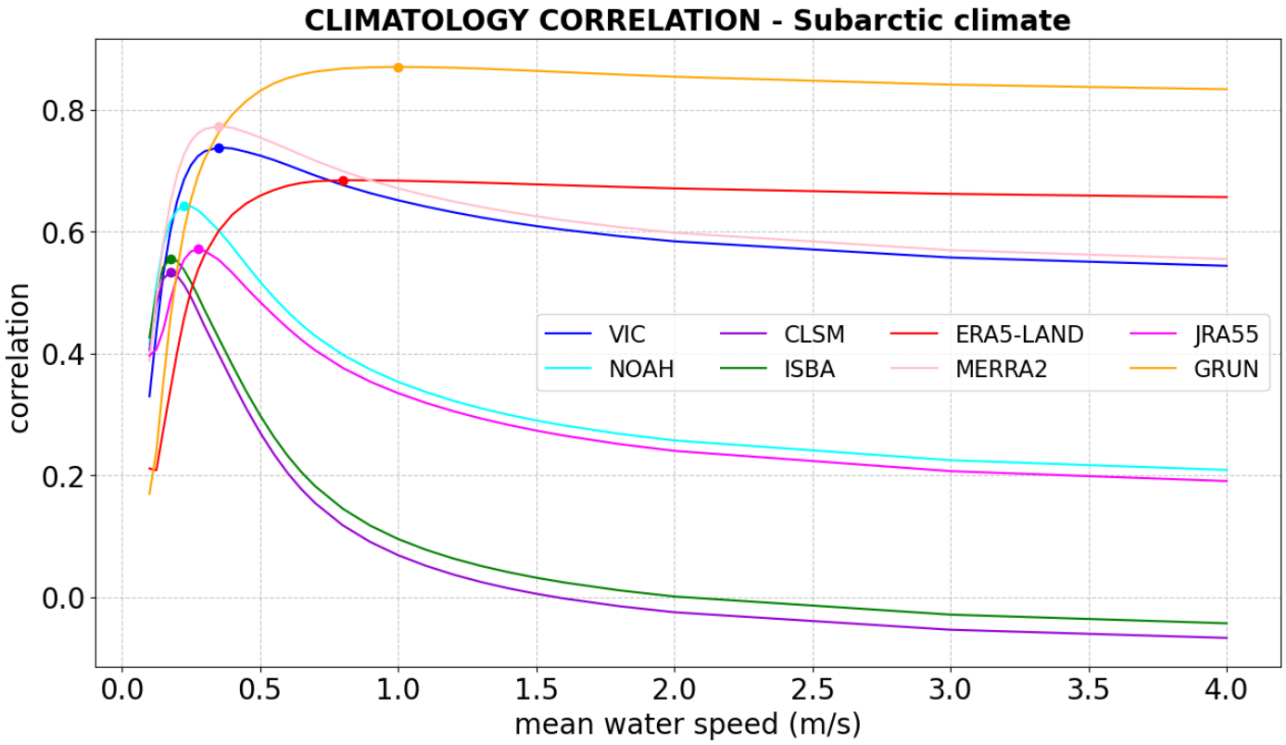

Figure S10: mean correlation vs propagation speed, subarctic basins

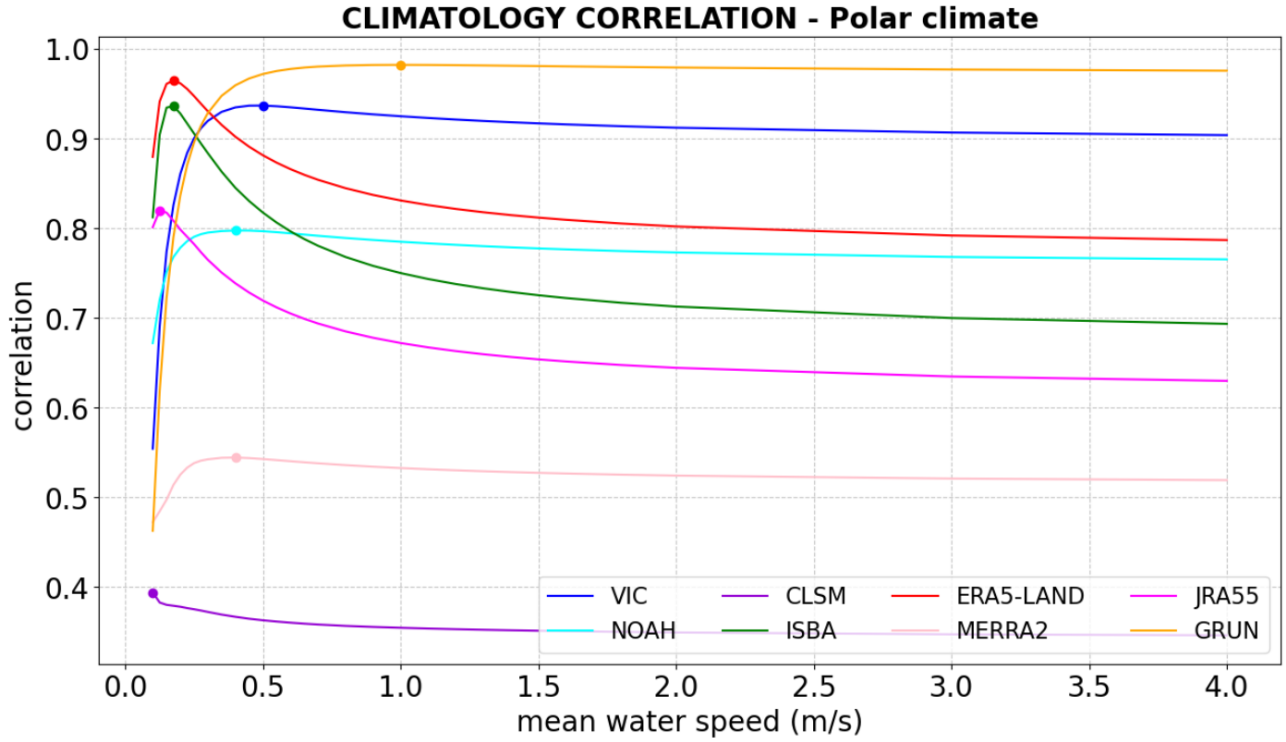

Figure S11: mean correlation vs propagation speed, polar basins

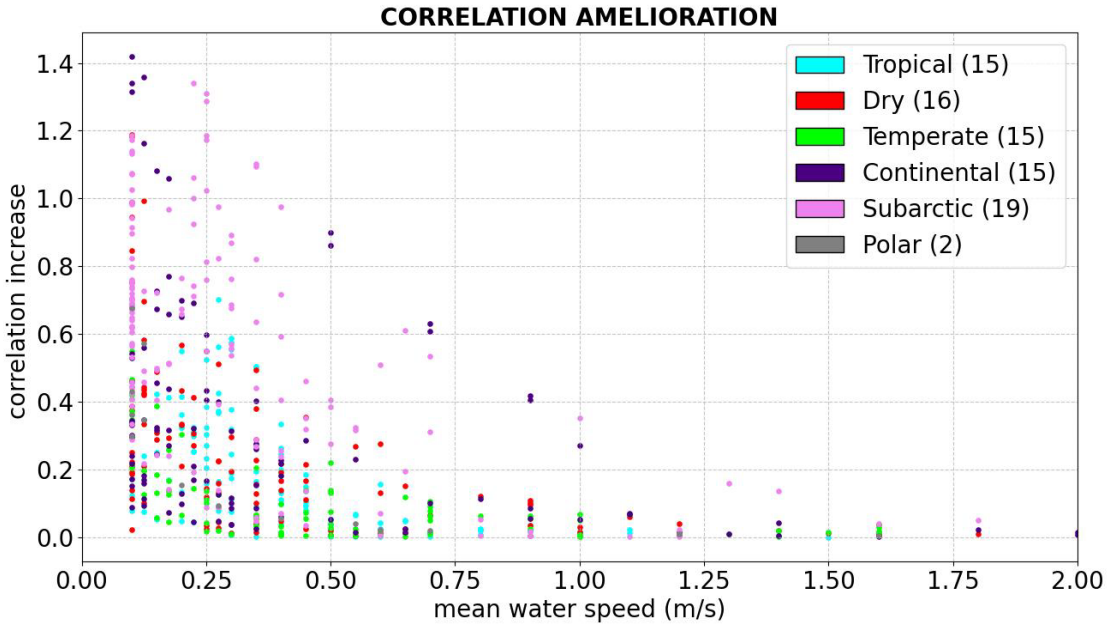

Figure S12: Correlation amelioration vs optimized water propagation speed

4. DTR and DRR discharge evaluation

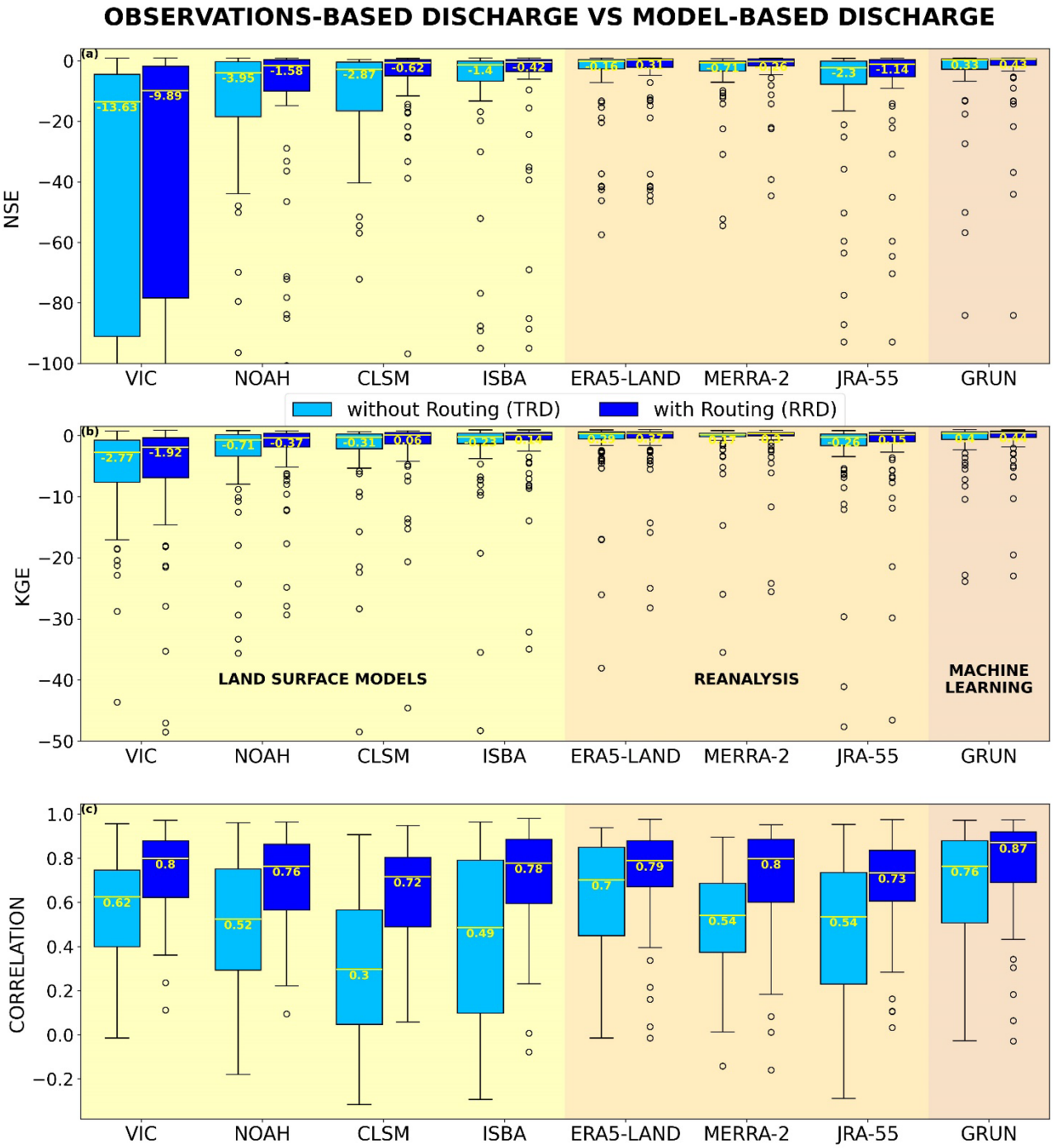

Figure S13 : Evaluation of MDB and effect of the routing on the discharge estimation for tropical basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -100. There is a zoom on the KGE: minimum y axis value is -50

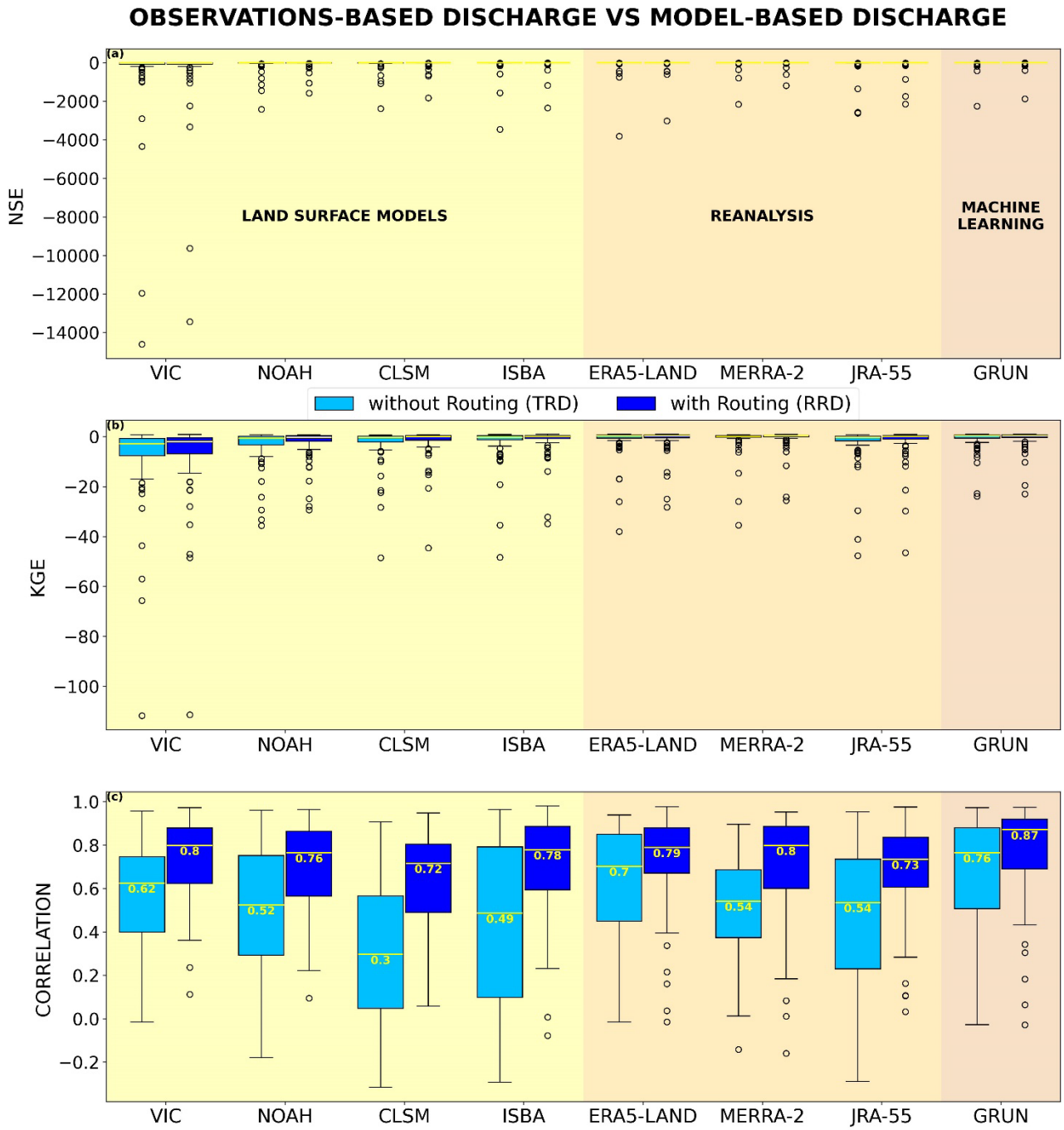

Figure S14 : Evaluation of MDB and effect of the routing on the discharge estimation for tropical basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is no zoom on the NSE figure: There is no a zoom on the KGE figure

5. DTR and DRR discharge evaluation for each climate

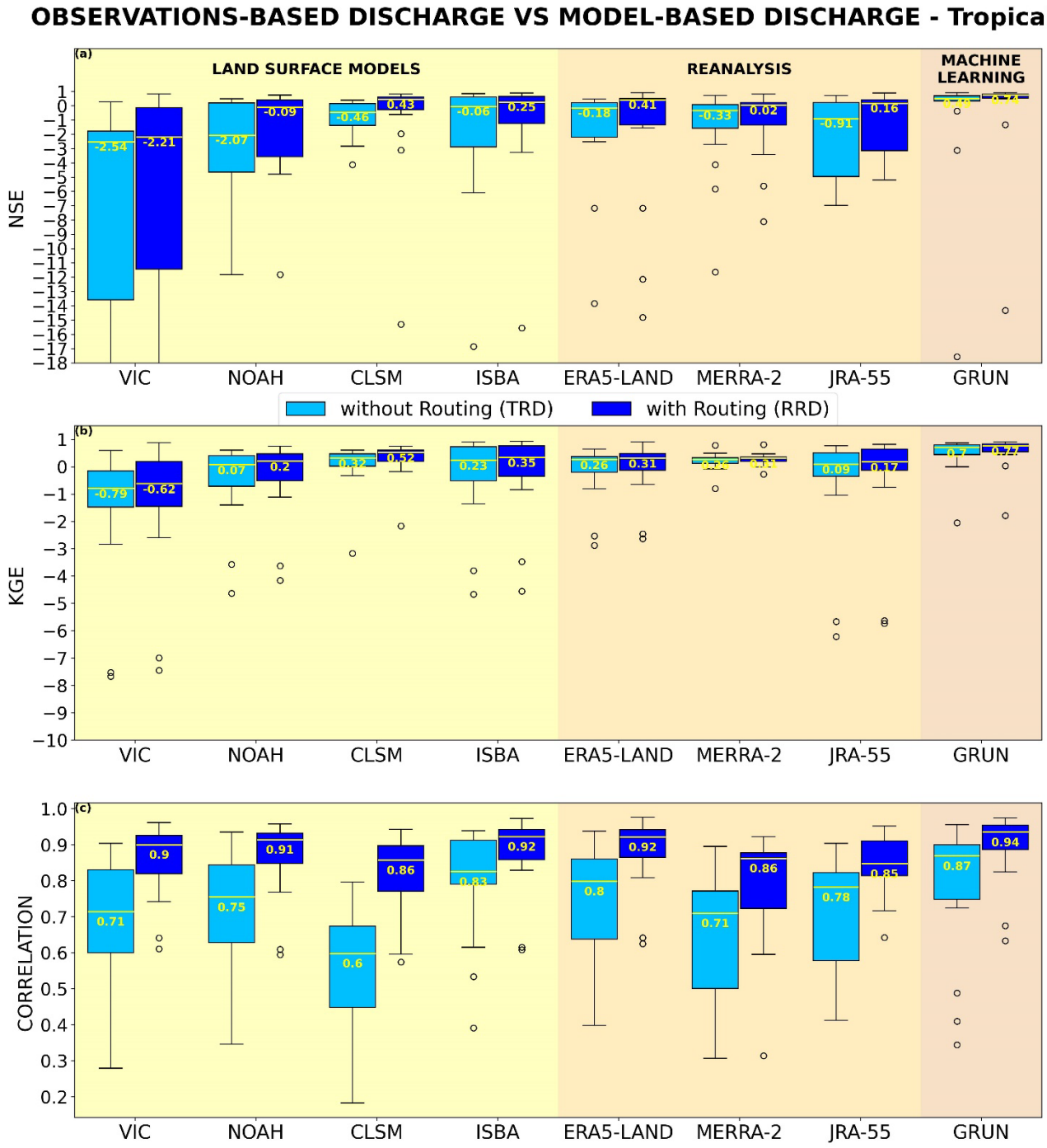

Figure S15: Evaluation of MDB and effect of the routing on the discharge estimation for tropical basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

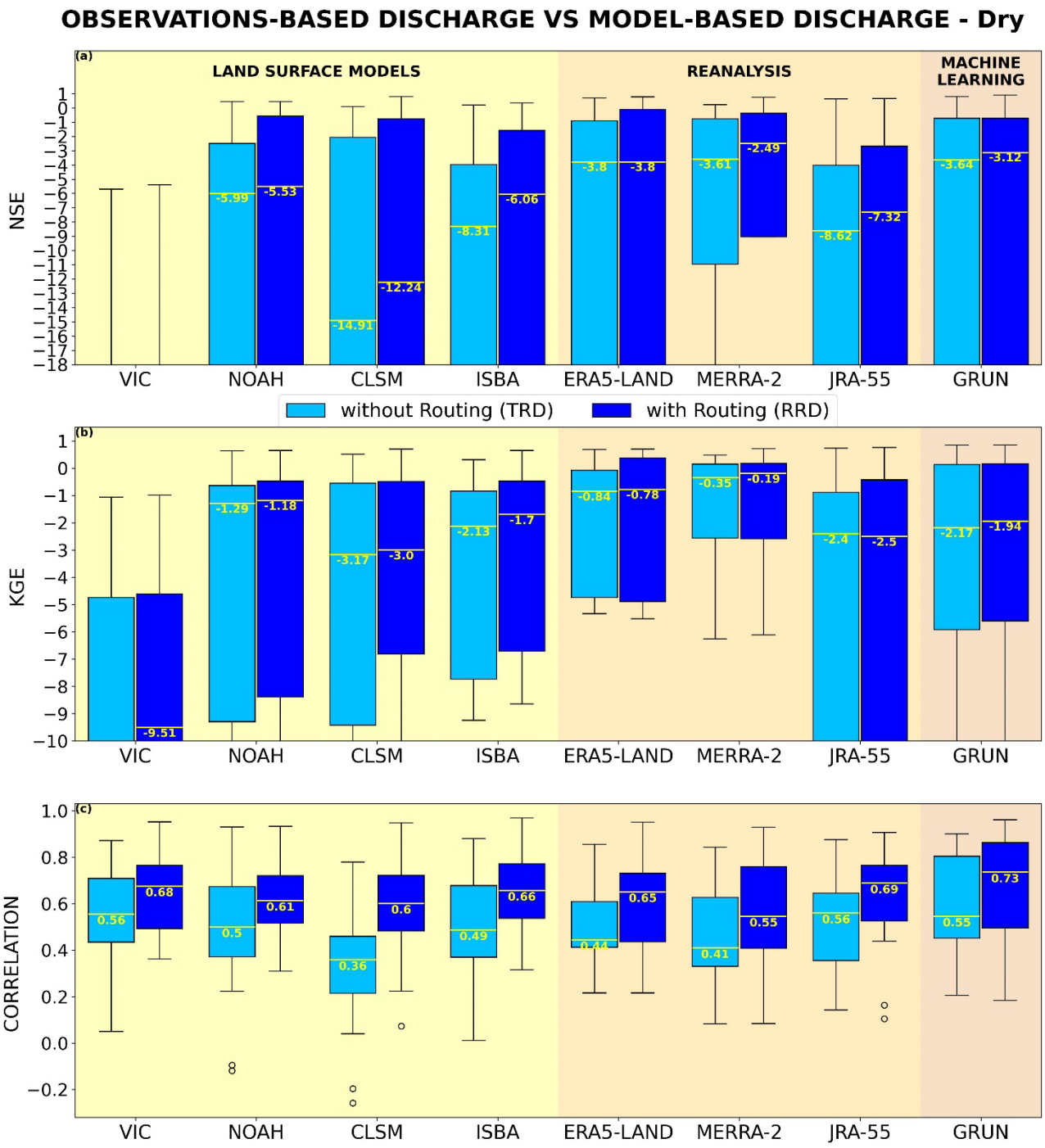

Figure S16: Evaluation of MDB and effect of the routing on the discharge estimation for arid basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

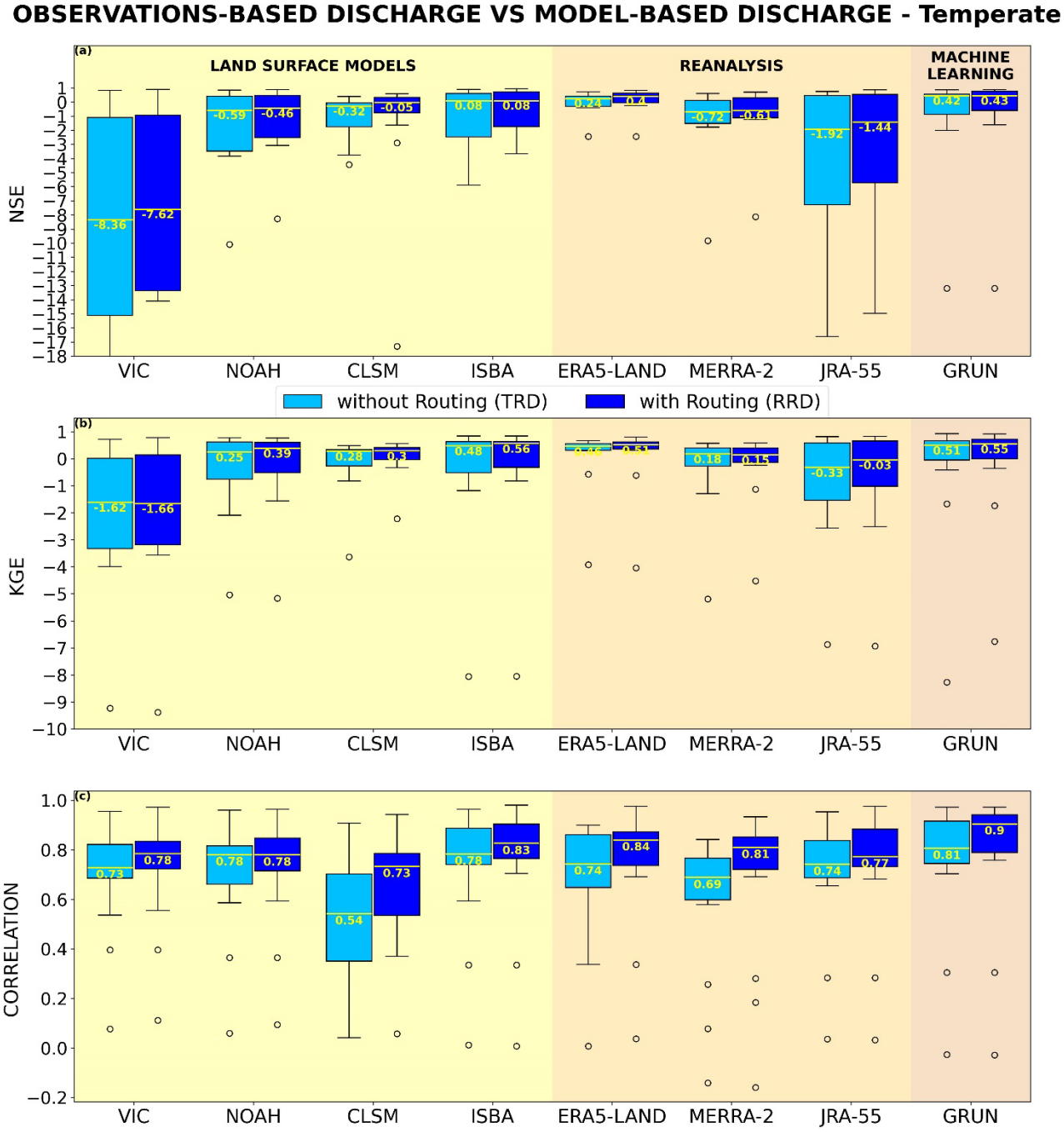

Figure S17: Evaluation of MDB and effect of the routing on the discharge estimation for temperate basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

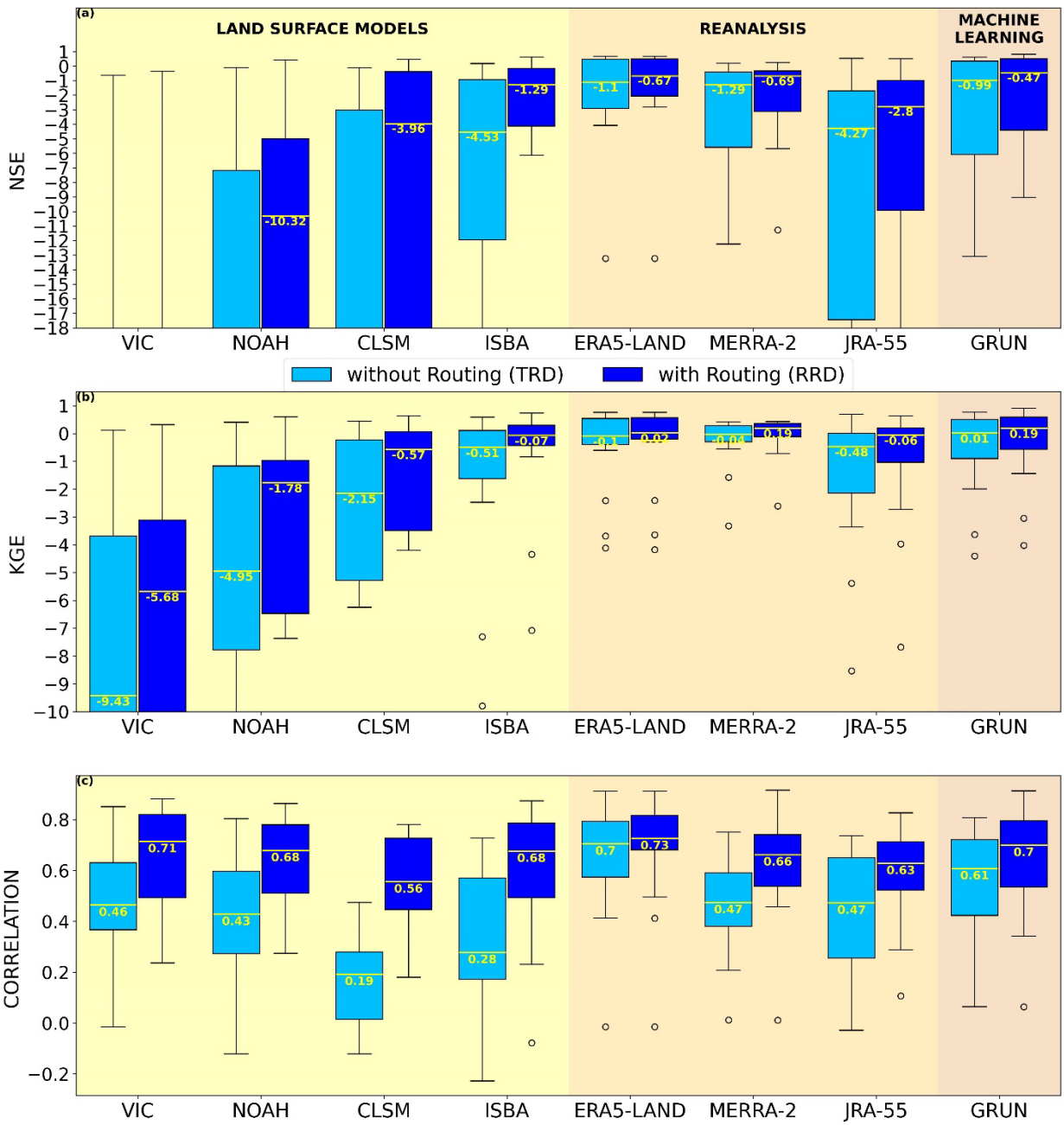

Figure S18: Evaluation of MDB and effect of the routing on the discharge estimation for continental basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

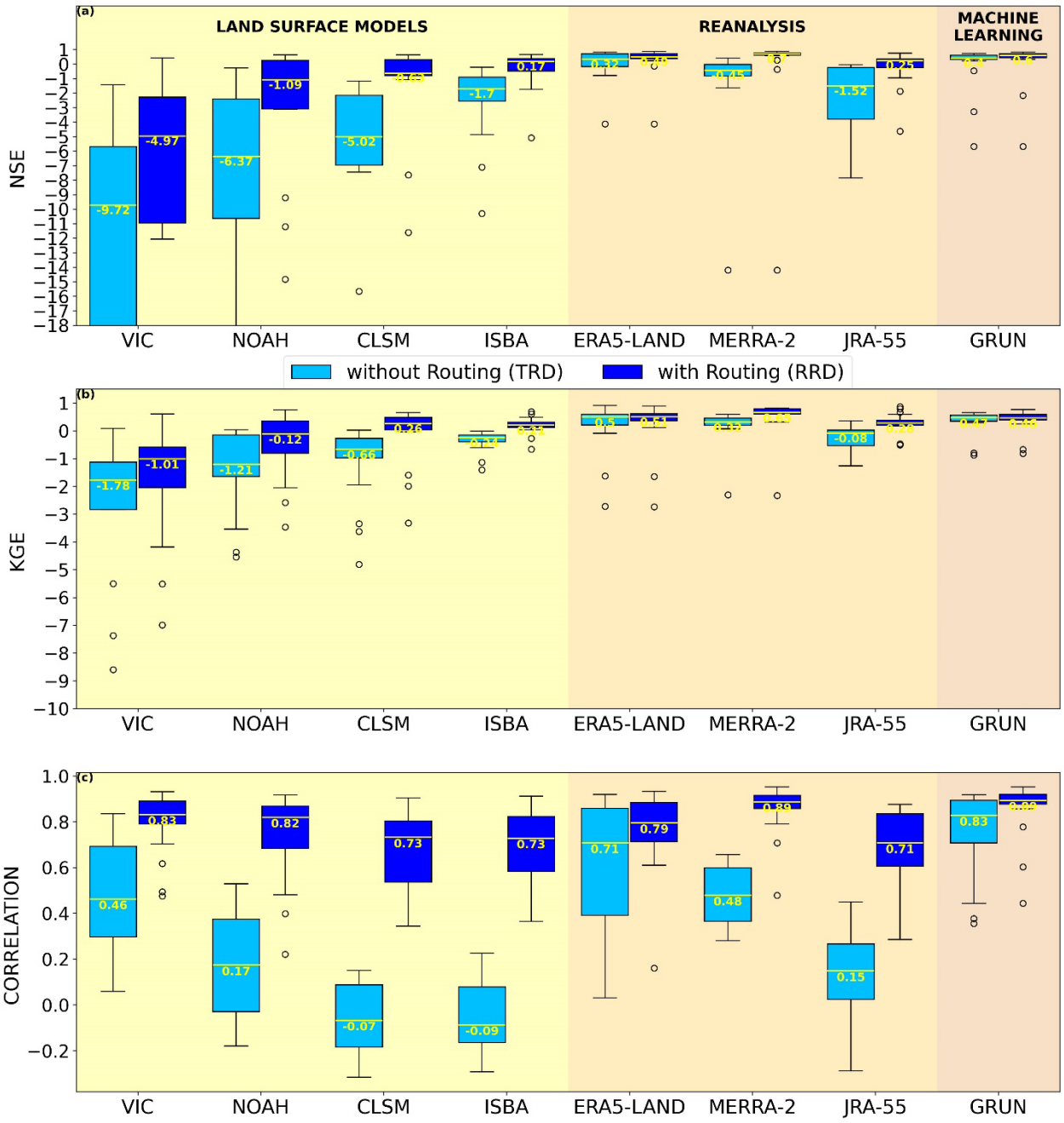

Figure S19: Evaluation of MDB and effect of the routing on the discharge estimation for subarctic basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

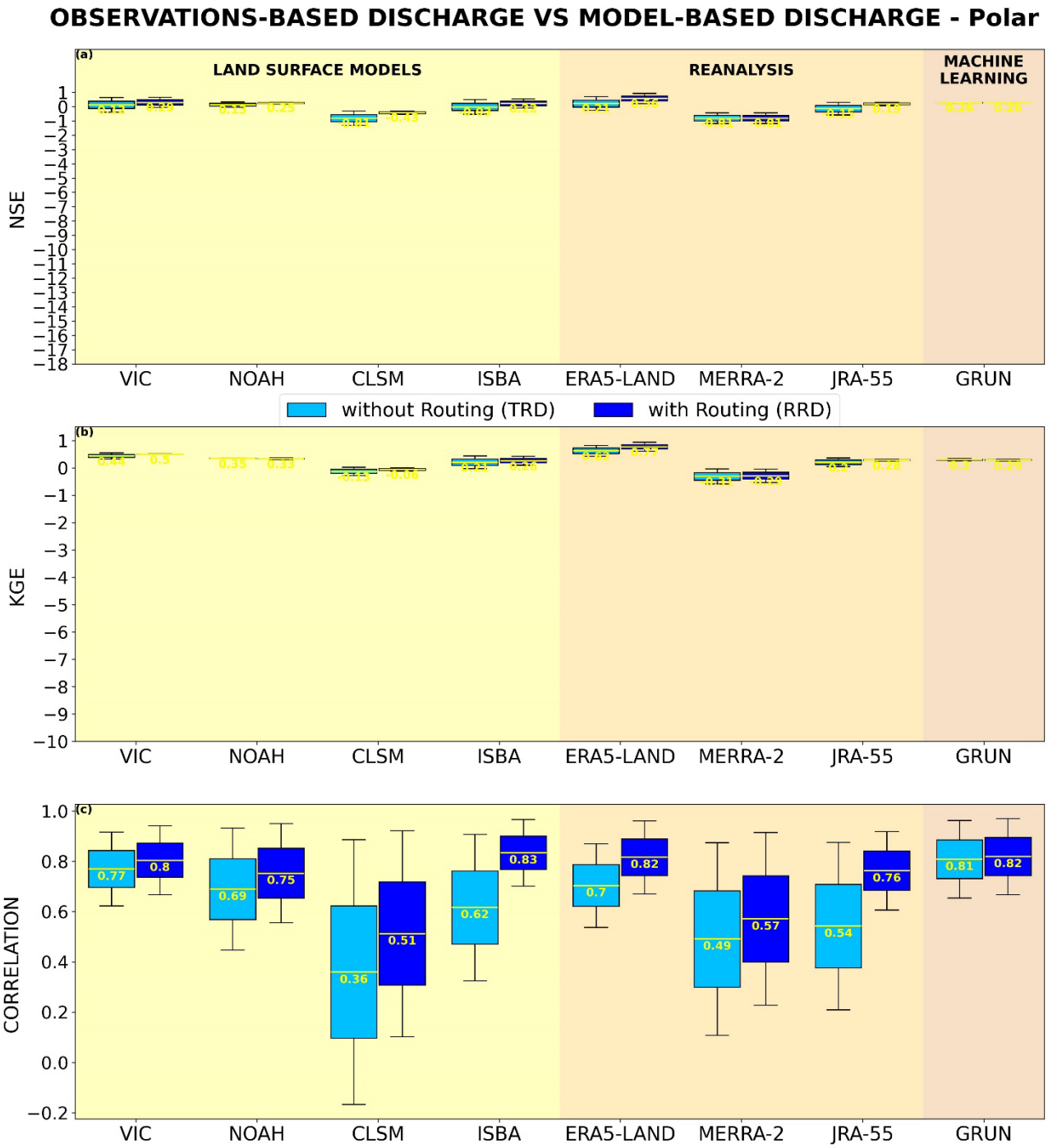

Figure S20: Evaluation of MDB and effect of the routing on the discharge estimation for polar basins. Boxplot of NSEs (a), KGE (b) and correlations (c) for all 82 basins between the observations-based discharge and the two model-based discharge: TRD (light blue) and RRD (blue) discharges. Median values are indicated in yellow. There is a zoom on the NSE figure: minimum y axis value is -18. There is a zoom on the KGE: minimum y axis value is -10

6. WBE and discharge evaluation comparison

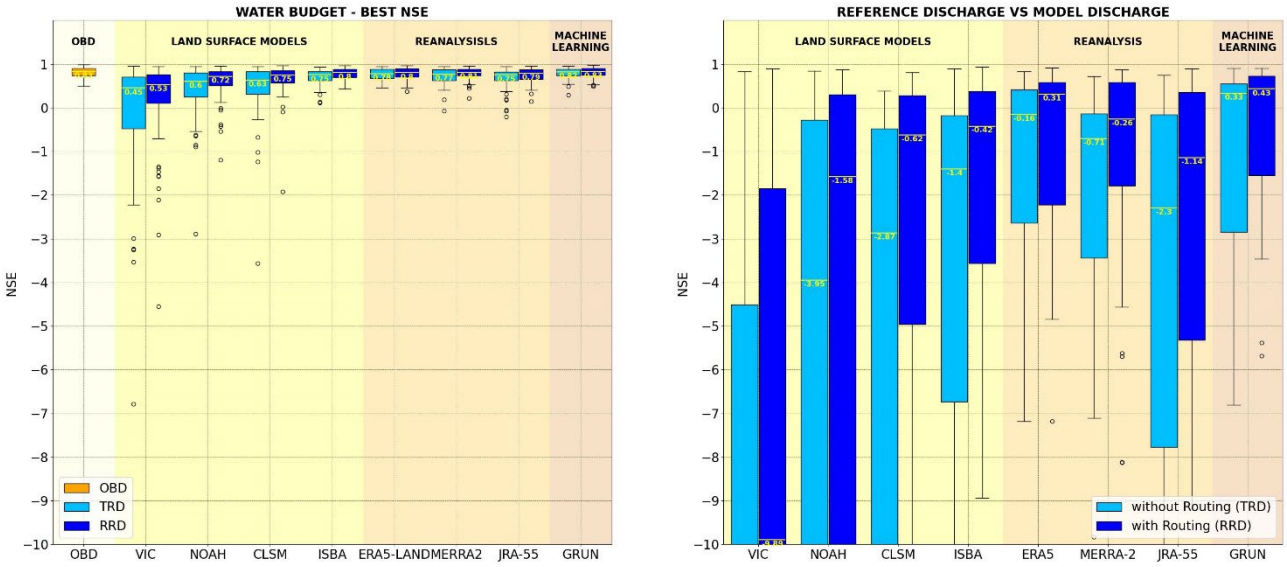

Figure S21 : Water budget closure and MDB evaluation comparison

7. RRD annual volume

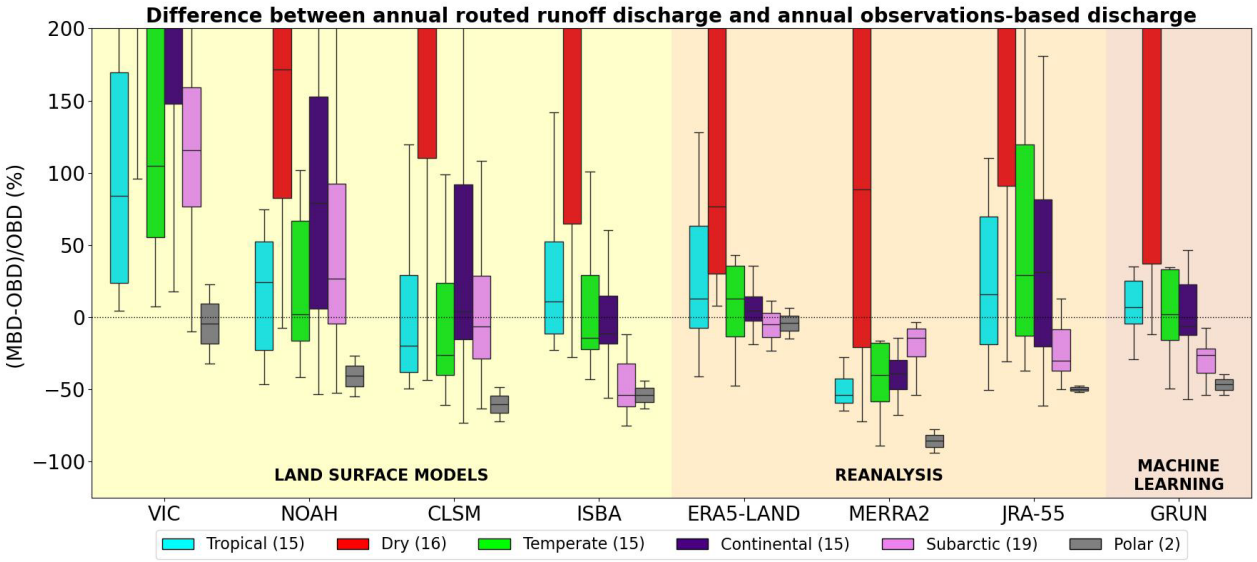

Figure S22 : Percentage of the average annual volume of the RRD compared to that of the OBD: for each climate in the main figure and for all 82 basins in the secondary figure. Median values are indicated in blue on the secondary figure. The black number in the legend corresponds to the number of basins considered for each climate. Y axis zoom between -100 and +200.

8. Number of basins with available discharge

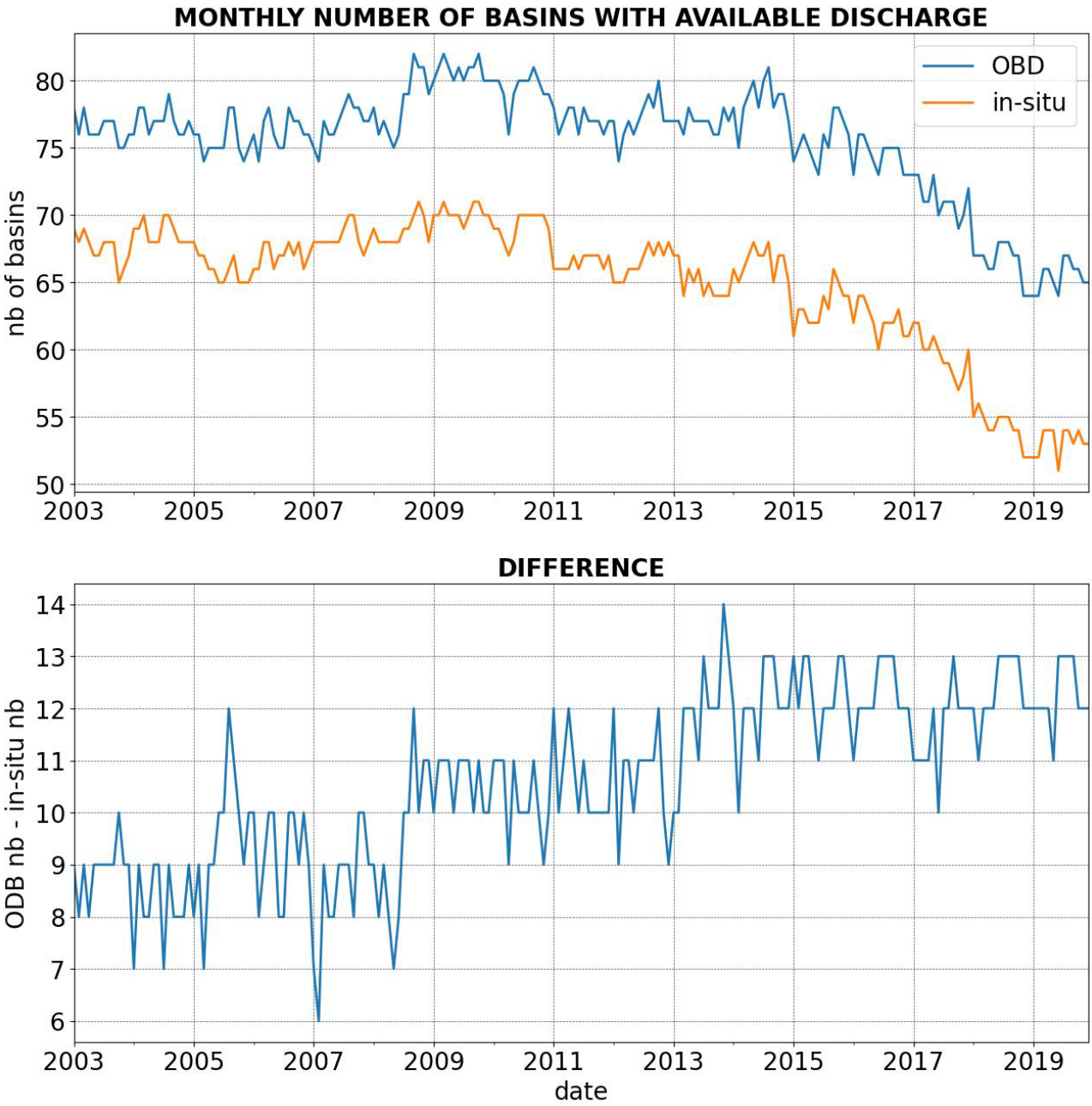

Figure S23: (top) Monthly number of basins with available in situ data (orange) vs monthly number of basins with Observation-Based Discharge data, i.e. in situ + altimetry (blue). (Down) difference between blue and orange curve.

9. RRD correlation

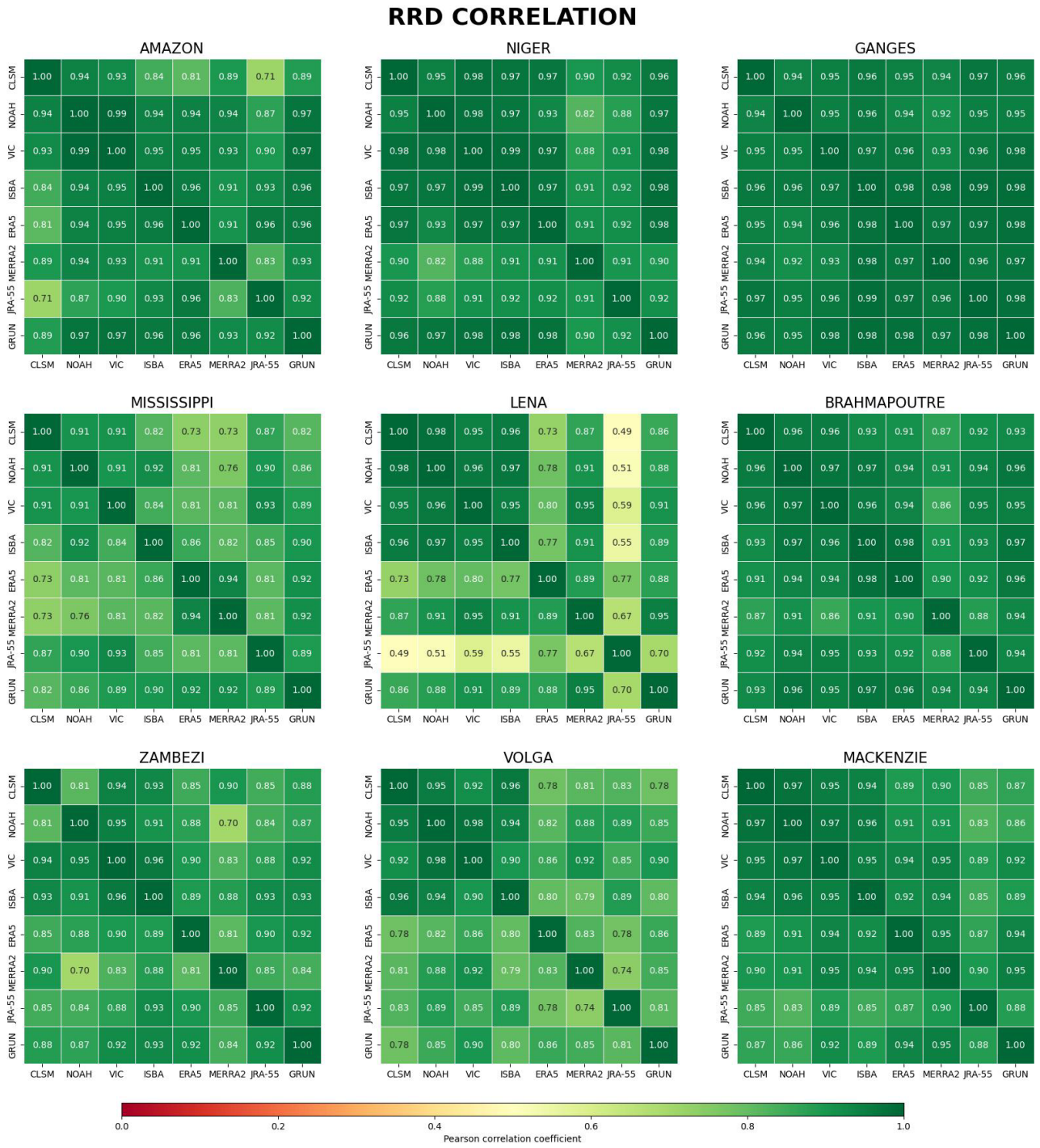

Figure S24: RRD Pearson correlation for Amazon, Niger, Ganges, Mississippi, Lena, Brahmaputra, Zambezi, Volga, and Mackenzie basins