FEH changes for Peak Flows V13

Overview of changes based on current methods and descriptors

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Issue number 1
2024-08-29

UK Centre for Ecology & Hydrology

Contents

1. Executive Summary

This report serves as an appendix to the Peak Flows V13 release notes (https://nrfa.ceh.ac.uk/sites/default/files/Note_on_version_13_FINAL.pdf), expanding on the differences between Version 12.1 and Version 13 in the context of FEH methods: single-site analysis, donor adjustment to *QMED* estimates, and pooled flood frequency estimates (Robson and Reed, 1999; Kjeldsen et al., 2008). This includes an analysis of the new data at a selection of approximately 1500 ungauged locations across Great Britain.

It does not include or discuss the new catchment descriptors: $FARL_{2015}$, $SAAR_{9120}$, $URBEXT_{2015}$, $BFIHOST19_{SCALED}$. These will be discussed in a separate report, available through the FEH Web Service.

Overall, there were some small changes across the UK in growth curves and pooling-groups due to longer records on average, a small number of new stations and the reclassifying of a small number of stations as “Suitable for Pooling”. Single-site analysis was typically impacted most by new peak flow values above AMAX3, or the inclusion or rejection of a large number of AMAX values as part of the period of record review.

The ungauged locations selected are representative of the gridded river network across Great Britain (covering all combinations of *AREA*, $BFIHOST19$, *SAAR*, *FARL* and *FPEXT*), and as such predominantly consists of very small catchments, unlike the NRFA Peak Flow dataset. This leads to very different patterns in the differences between the results using V12.1 and V13 as potential donors and pooling-group members on the ungauged dataset. This is to be expected.

2. Differences in catchment descriptors

2.1.1 Between V12.1 and V13, there were no unexpected changes found in FEH catchment descriptors. Stations 6003 and 43014 have had corrections applied; see V13 release notes for explanations. As such, there are essentially no changes in the catchment-descriptor estimates of *QMED*, or any urban adjustments.

3. Differences in single-site analysis

This section documents changes in single-site (not Enhanced single-site) analysis of FEH statistics.

Between V12.1 and V13, most stations gained one extra year of record (as expected), though a small number of stations had some periods excluded or un-excluded from AMAX analysis due to a period of record review or similar. These are documented in the main NRFA V13 release note (https://nrfa.ceh.ac.uk/sites/default/files/Note_on_version_13_FINAL.pdf).

3.1 Changes in record length

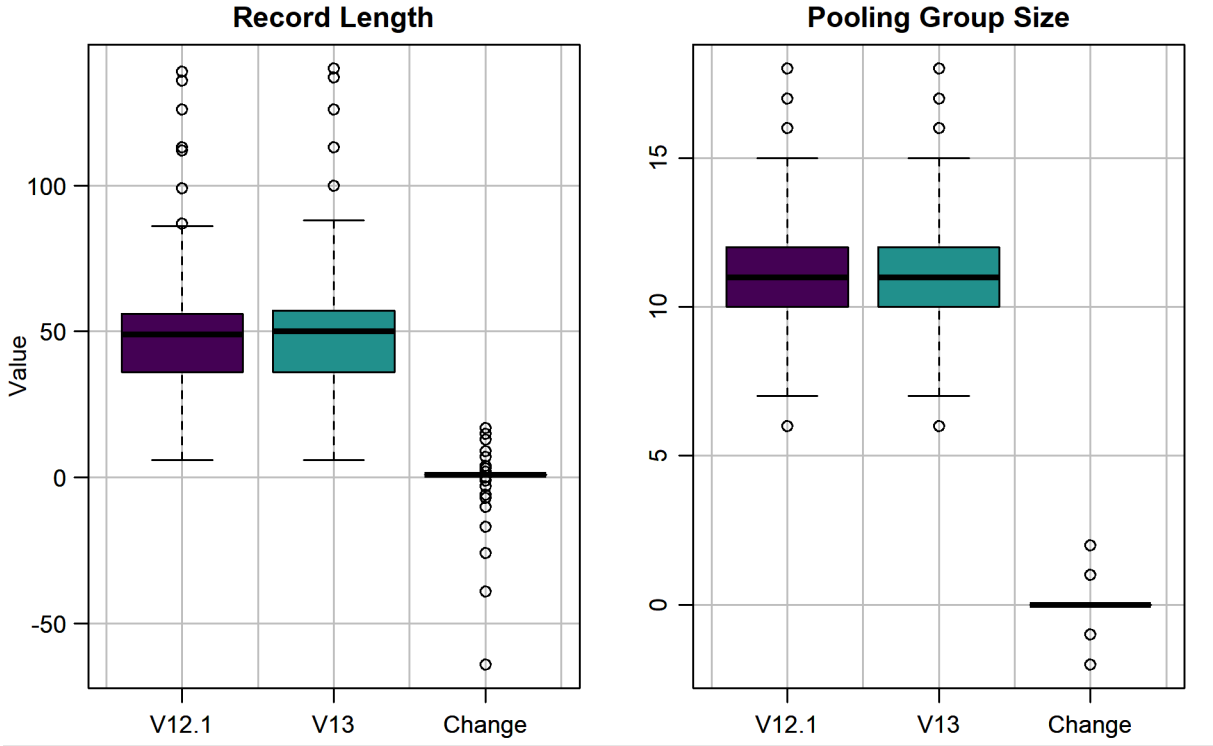

Figure 1: Boxplots showing percentage change in record length and pooling-group size, split by NRFA version.

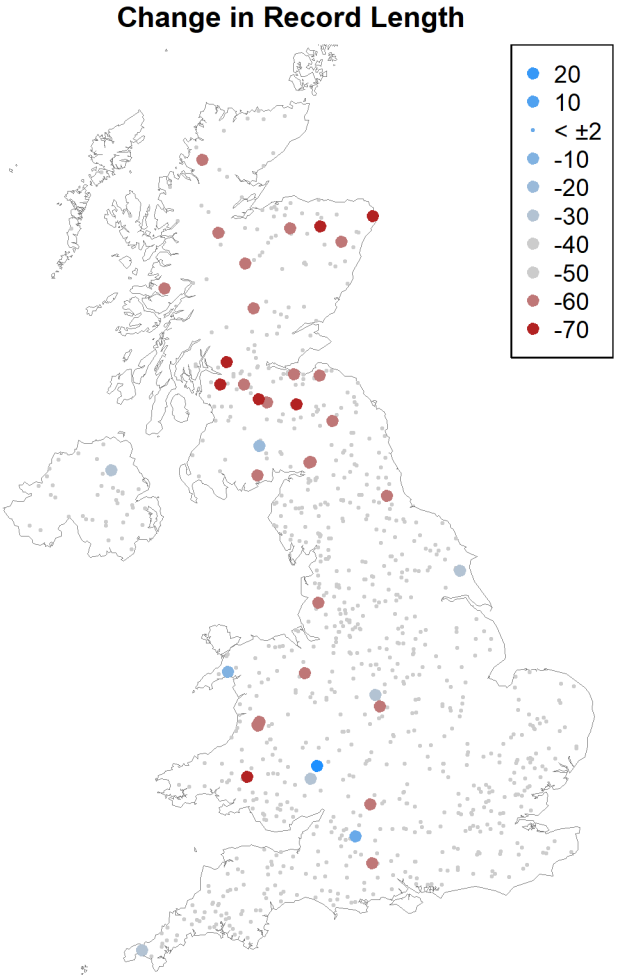

Figure 2: Change in record length across NRFA stations.

3.2 Changes in gauged *QMED*

See Figure 3 for changes in gauged *QMED* between V12.1 and V13. Specific changes (greater than 10%) are shown in Figure 5.

Apart from at stations 6003 and 43014, there were no changes in $QMED_{CD}$, the estimate of *QMED* derived from catchment descriptors, because there were no other changes in the underlying datasets from which the catchment descriptors were derived. These two corrections were due to changes in previous releases.

3.3 Changes in gauged (single-site) growth curve

The following figures show changes in the FEH growth curve, X_T, which is equal to the flood frequency curve, Q_T, divided by *QMED*, based just on the scale and shape parameters of the fitted GLO distribution. They are linked by $Q_T = QMED \times X_T$.

Changes in the growth curve are shown summarised in boxplots in Figure 3 and illustrated spatially (for changes above 10%) in Figure 4.

The gauged changes in growth curve are mostly down to notable new AMAX values (above AMAX3) which can affect the tails of the distribution, as well as rejections or introductions of periods of station records. Thirdly, rating changes enacted on the whole AMAX series can lead to notable changes in the flood frequency curve, especially if flow derivations increase in the upper tail under the new rating. These major changes are justified in the main NRFA V13 release note.

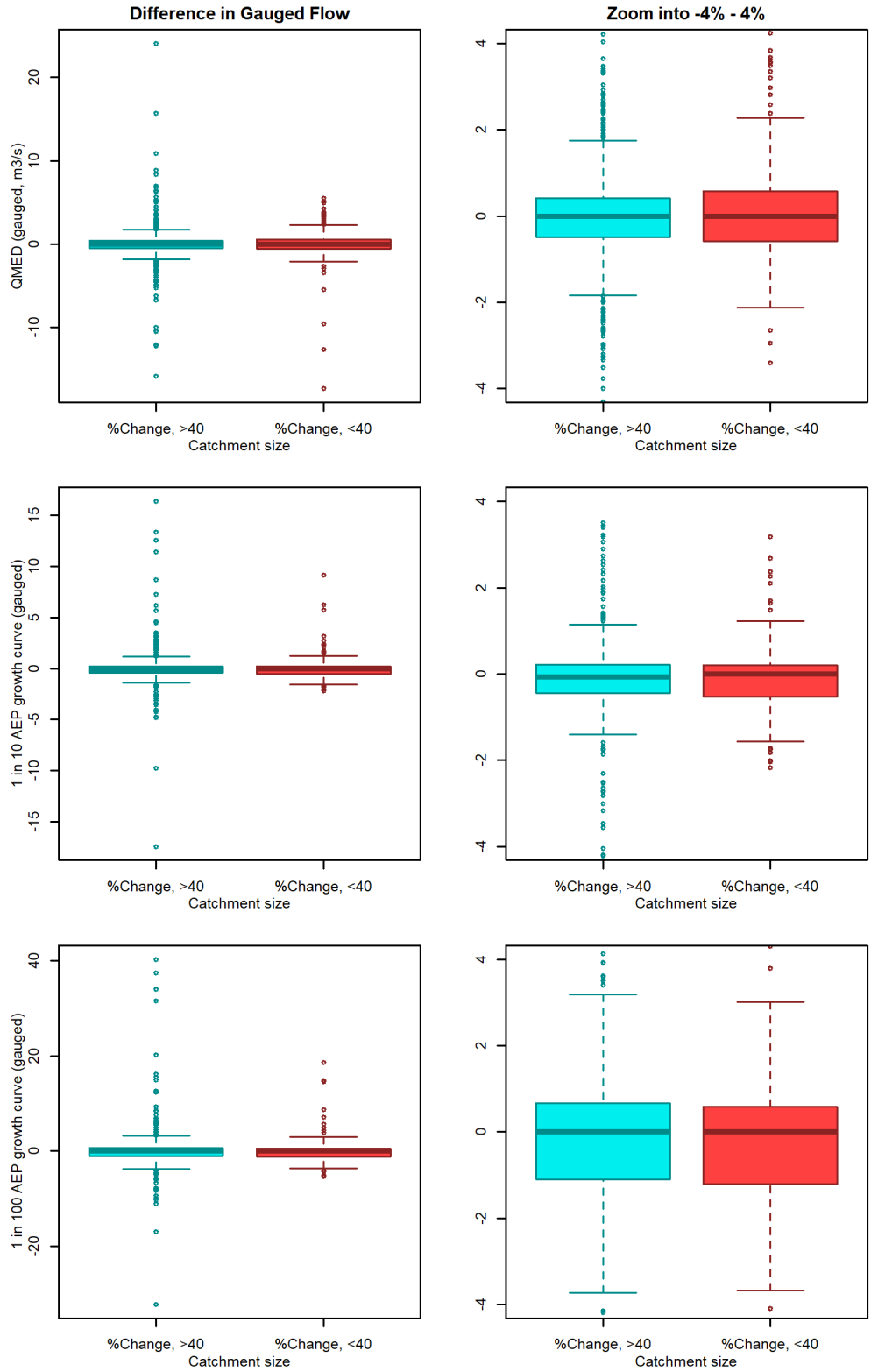

Figure 3: Box plots of differences in gauged *QMED* and growth curves, split by catchment size (Small < 40 km^2). Right column is close-up of left.

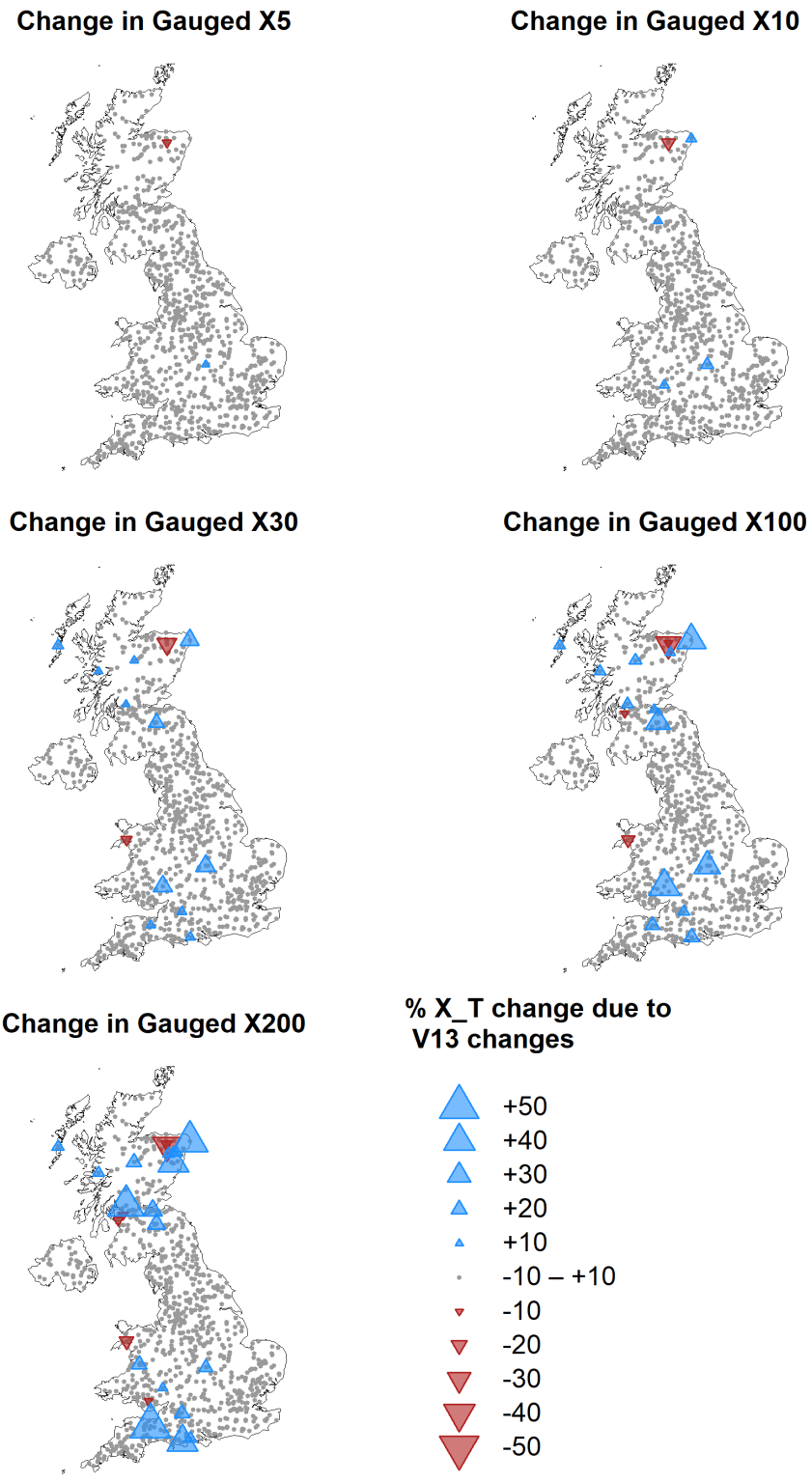

Figure 4: Changed in gauged (single-site) estimates of flood frequency growth curves at NRFA stations.

3.4 Changes in flood frequency curve

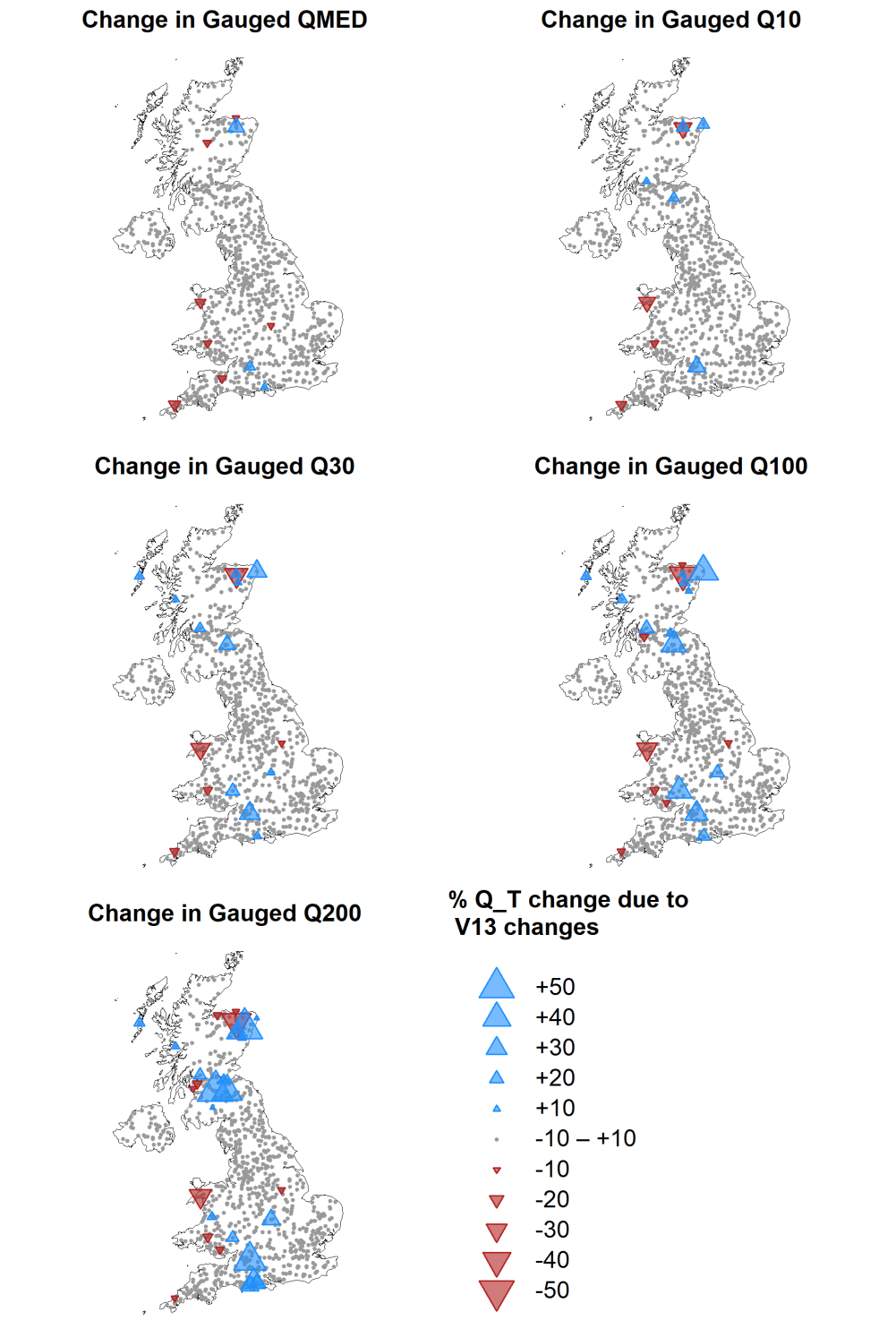

Figure 5: Changed in gauged (single-site) estimates of flood frequency return levels at NRFA stations.

Changes in flood frequency exceeding 10% can be seen across the network in Figure 5.

Big changes in the gauged flood frequency curves are all a combination of the changes already documented with regards to changes in gauged *QMED* and changes in the growth curve. There is no obvious spatial pattern of compounding changes in both *QMED* and X_T.

4. Differences in Donor adjustment

Donor-adjustment, as developed in WINFAP 5.1 and Kjeldsen *et al.* (2014), uses the six nearest "suitable for *QMED*" stations to improve the $QMED_{CD}$ estimate assuming spatially consistent errors between gauged *QMED* and $QMED_{CD}$. In this report, selected donors are those chosen as default in WINFAP 5.1 without adjustment.

The main changes between donor-adjusted *QMED* at NRFA stations are due to two stations being downgraded from "Suitable for *QMED*", the addition of 13 new "Suitable for pooling" stations, and changes in gauged *QMED* at existing stations.

In the ungauged network, the predominantly small catchments lead to overall small changes in donor-adjusted *QMED*. There were no changes above 10% in donor-adjusted *QMED* for the ungauged dataset

4.1 Changes in donor-adjusted *QMED*

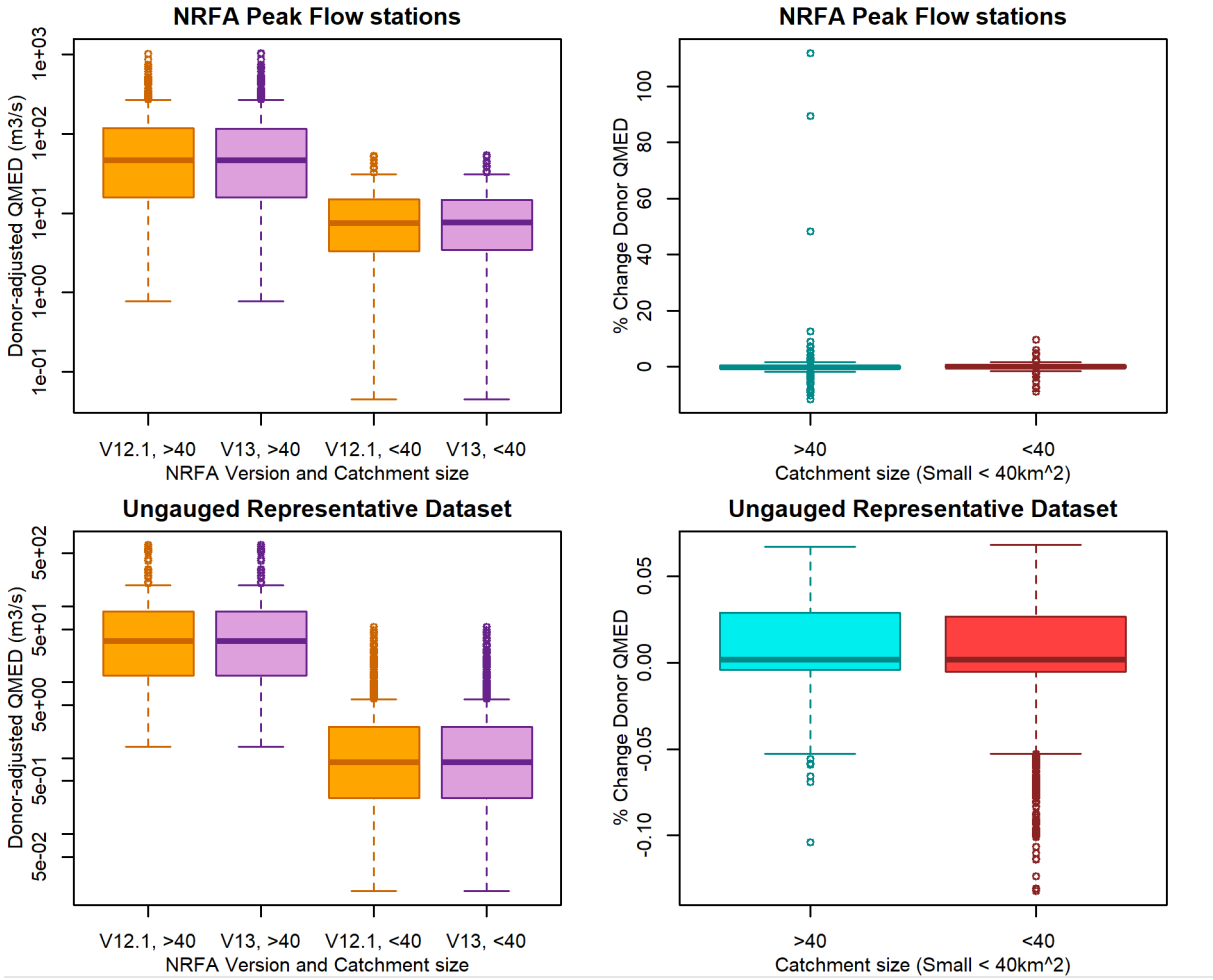

Figure 6: Boxplots highlighting differences between donor-adjusted *QMED* in NRFA stations and ungauged locations.

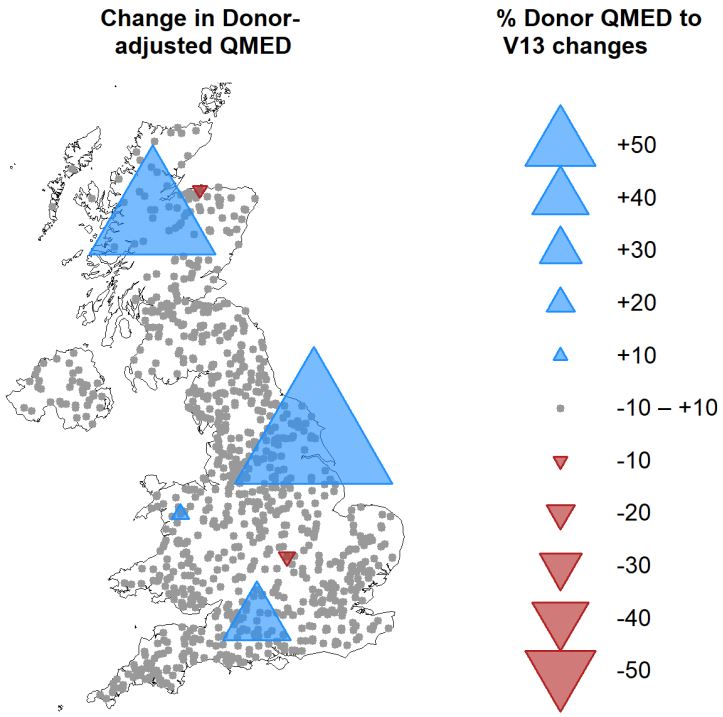

Figure 7: Changes in donor-adjusted *QMED* at NRFA stations, highlighting changes greater than 10%.

5. Differences in pooled flood frequency

Pooling uses hydrologically similar catchments to generate a set of at least 500 station-years, which is used to generate weighted average estimates of *L*-moment ratios for calculating return levels. The FEH approach uses the Generalised Logistic distribution to estimate return levels of specified exceedance probabilities.

In the following, default pooling-groups are used as derived in WINFAP 5.1 (Wallingford HydroSolutions, 2024), which includes the Small Catchments refinement to pooling.

Nearly all major changes in pooled flood frequency at NRFA stations are due to the addition of 8 new stations which are “Suitable for Pooling”, including 7009 (Mosset Burn at Wardend Bridge) and 7012 (Lossie at Ballachraggen) which now occur in several pooling-groups. These two in particular are small catchments (28.3 km^2 and 31.6 km^2), which typically pool together with other small catchments. Some stations experienced changes in pooled estimates due to a reduction in pooling-group size as a result of increased average record length.

5.1 Changes in pooling-groups

Table 1 to Table 4 show the ten most common pooled stations in V12.1 and in V13 for the NRFA stations and for the ungauged dataset. Because, even with the small catchments update (Vesuviano et al., 2024), there are very few small catchments in the NRFA dataset, all of the most commonly used stations are small, as are two of the newly "Suitable for pooling" stations, 7009 and 7012. This is even more true in the ungauged dataset, which leads to a very small variability in the pooling-groups for the smallest catchments. To look beyond this, Table 2 shows the most common pooling-group members for larger NRFA catchments (above 40 km^2), and Table 4 shows this for the ungauged dataset.

All the tables also indicate where stations have been added (New to V13), removed, closed (but kept in V13), or changed in FEH suitability.

The changes between the most common pooling-group members are either due to the addition of new NRFA small catchments, or to the overall increase in average record length leading to small adjustments of pooling-group size.

Table 1: Most commonly "pooled" stations in V12.1 and V13 for NRFA stations. Small refers to a catchment of area less than 40km^2.

V12.1	% pools	notes	V13	% pools	notes
28058	4.80	Small	7012	4.89	Small, New in V13
56002	4.80	Not small	41020	4.78	Small
7011	4.80	Small	56002	4.78	Not small
41020	4.69	Small	19014	4.67	Small, New in V13
26014	4.58	Small	7009	4.67	Small, New in V13
49004	4.58	Small	7011	4.67	Small
39086	4.47	Small	28058	4.56	Small
49003	4.47	Small	26014	4.34	Small
206006	4.25	Small	49004	4.34	Small
28041	4.25	Small	206006	4.23	Small
43029	4.25	Not small	39086	4.23	Small
58006	4.25	Not small	58006	4.23	Not small
25011	4.14	Small	49003	4.13	Small
44013	4.14	Small	28041	4.02	Small
53017	4.14	Not small	46007	4.02	Not small
55004	4.14	Not small	55004	4.02	Not small
72007	4.14	Small	84020	4.02	Not small
73011	4.14	Not small	25011	3.91	Small
76014	4.14	Not small	28040	3.91	Not small
84020	4.14	Not small	48001	3.91	Small
27081	4.03	Small	49002	3.91	Not small
28040	4.03	Not small	53017	3.91	Not small
39089	4.03	Not small	72007	3.91	Small
48001	4.03	Small	76014	3.91	Not small
57014	4.03	Not small	27081	3.80	Small

Table 2: Most commonly "pooled" stations in V12.1 and V13 for NRFA stations with area above 40 km^2.

V12.1	% pools	notes	V13	% pools	notes
56002	4.90		56002	5.66	
28058	4.65		58006	5.01	
41020	4.52		55004	4.76	
49003	4.52		28040	4.63	
206006	4.26		76014	4.63	
43029	4.26		39042	4.50	
58006	4.26		57014	4.37	
7011	4.26		73011	4.37	
25011	4.13		25006	4.24	
84020	4.13		27086	4.24	
27086	4.00		58005	4.24	
28040	4.00		28035	4.11	New in V13
39086	4.00		83010	4.11	
49004	4.00		84020	4.11	
57014	4.00		42006	3.98	
58007	4.00		47024	3.98	
26003	3.87		63001	3.98	
26014	3.87		73017	3.98	
46007	3.87		26003	3.86	
48001	3.87		48011	3.86	
49002	3.87		49001	3.86	
30006	3.74		58007	3.73	
33032	3.74		8013	3.73	
39089	3.74		81003	3.73	

47021	3.74		22006	3.60	

Table 3: List of most commonly "pooled" stations in V12.1 and V13 for ungauged locations.

V12.1	% pools		V13	% pools	
45816	68.49		45816	67.28	
76011	65.56		76011	65.18	
27051	63.20		27051	63.20	
28033	61.80		28033	58.10	
27073	58.10		27073	58.04	
25019	56.51		25019	55.87	
49005	54.21		49005	52.93	
26016	52.87		23018	52.36	
23018	52.55		26016	50.45	
27010	51.15		27010	48.28	
47022	46.49		68021	46.11	
68021	46.24		47022	43.56	
69047	44.13		39055	41.71	
39055	42.47		25011	38.52	
84035	41.26		84035	38.52	
25011	39.92		69047	36.10	
44008	37.05		27081	34.82	
27081	35.71		44008	33.99	
30013	32.02		30013	28.44	
71003	28.38	Closed	71003	28.00	Closed
206006	28.06		206006	27.87	
25003	26.21		25003	26.08	
106002	24.74		106002	24.55	
36010	21.81		36010	20.66	

91802	18.11		91802	17.67	

Table 4: List of most commonly "pooled" stations in V12.1 and V13 for ungauged locations with catchment area above 40 km^2.

V12.1	% pools	notes	V13	% pools	notes
33032	7.96		33032	7.96	
26013	6.97		30006	6.97	
30006	6.97		48012	6.97	
33050	6.97		57014	6.97	
57014	6.97		26003	6.47	
28040	6.47		26013	6.47	
34005	6.47		26015	6.47	New in V13
42006	6.47		28040	6.47	
48012	6.47		33050	6.47	
6012	6.47		58006	6.47	
83010	6.47		6012	6.47	
26003	5.97		83010	6.47	
33029	5.97		33029	5.97	
36003	5.97		34005	5.97	
39042	5.97		36003	5.97	
43029	5.97		39042	5.97	
53026	5.97		43029	5.97	
58006	5.97		53026	5.97	
23017	5.47		33031	5.47	
25006	5.47		42006	5.47	
33031	5.47		45008	5.47	
36004	5.47		55004	5.47	
55004	5.47		69032	5.47	

69032	5.47		73017	5.47	
73011	5.47		17001	4.98	

5.2 Changes in pooled growth curves

Figure 8 and Figure 9 show changes in pooled growth curve (and donor-adjusted *QMED* for reference) for the NRFA stations (Figure 8) and the ungauged dataset (Figure 9). The overall differences between versions V12.1 and V13 are very small due to the overall consistency between the two datasets. Figure 10 shows large changes in pooled growth curves for NRFA stations (differences above 10%). Figure 11 shows the same for ungauged catchments. The biggest differences are only seen for the more extreme growth curve values, incurred due to very large AMAX values (above AMAX3) at a small number of stations across the network, highlighted in the main NRFA V13 release note. These large values only impact the upper tail of the flood frequency distribution.

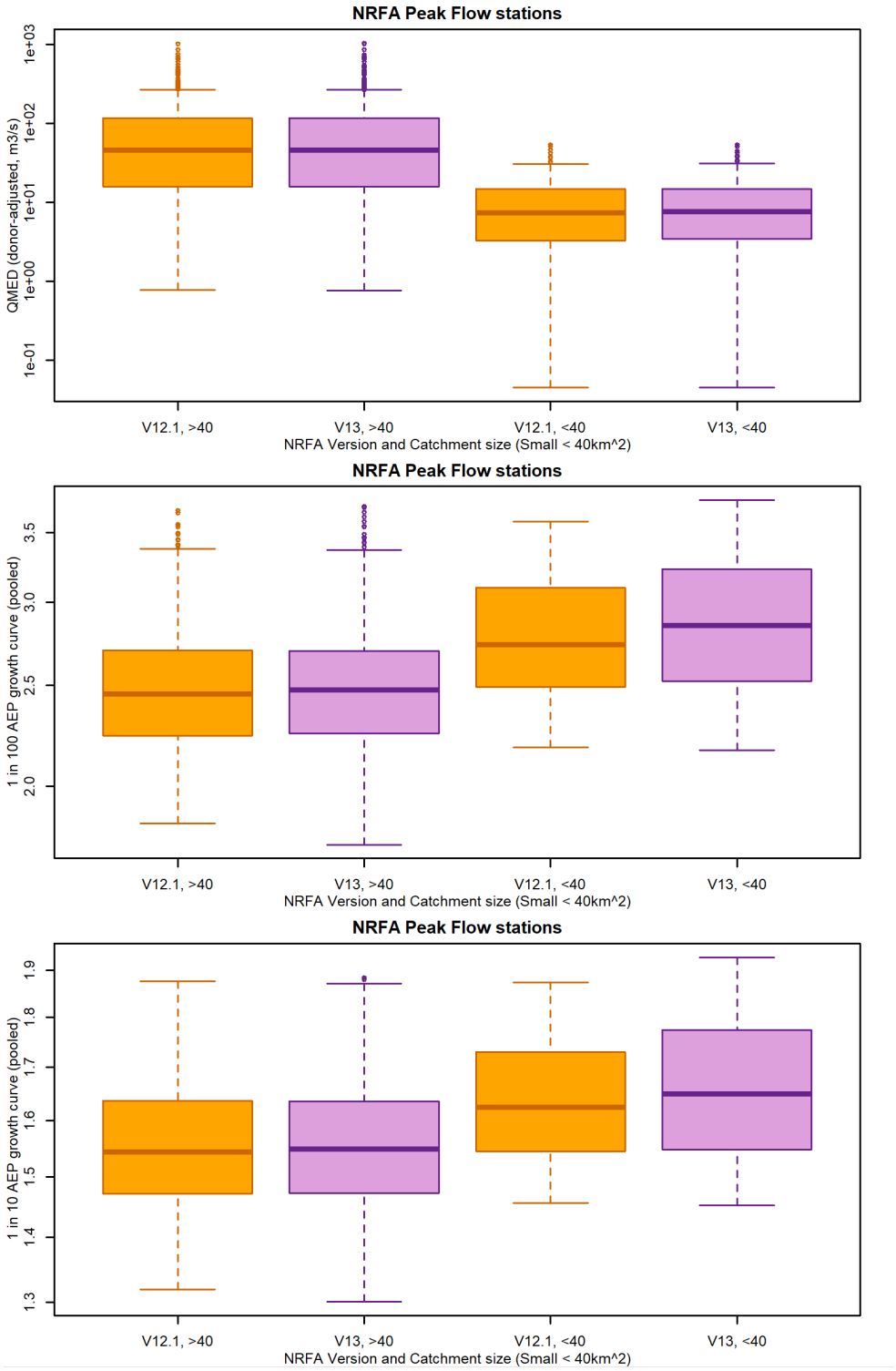

Figure 8: Boxplots of changes in pooled flood frequency growth curves between NRFA Peak Flow versions for NRFA stations, split by catchment size (Small < 40 km^2).

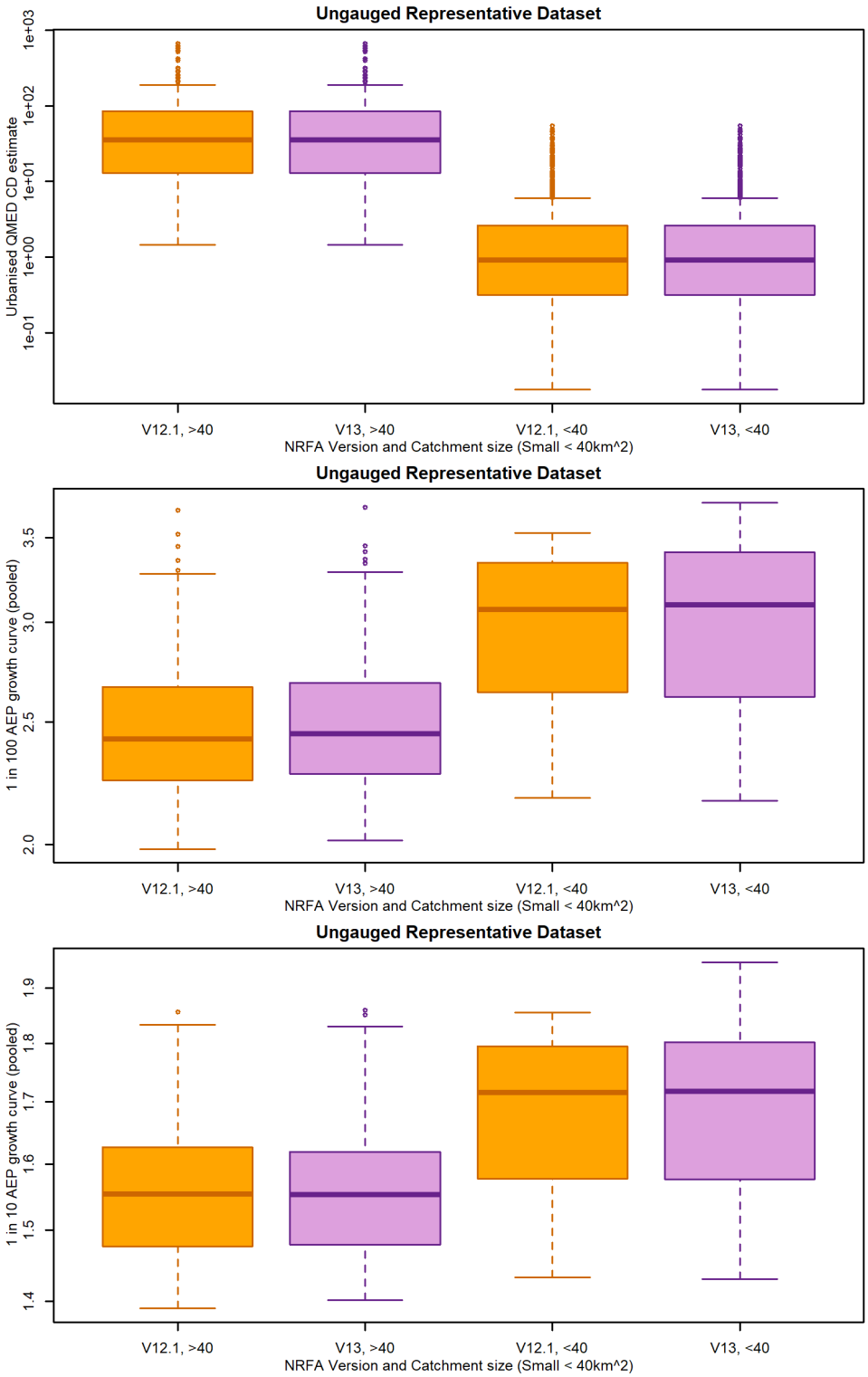

Figure 9: Boxplots of changes in pooled flood frequency growth curves between NRFA Peak Flow versions for ungauged locations, split by catchment size (Small < 40 km^2).

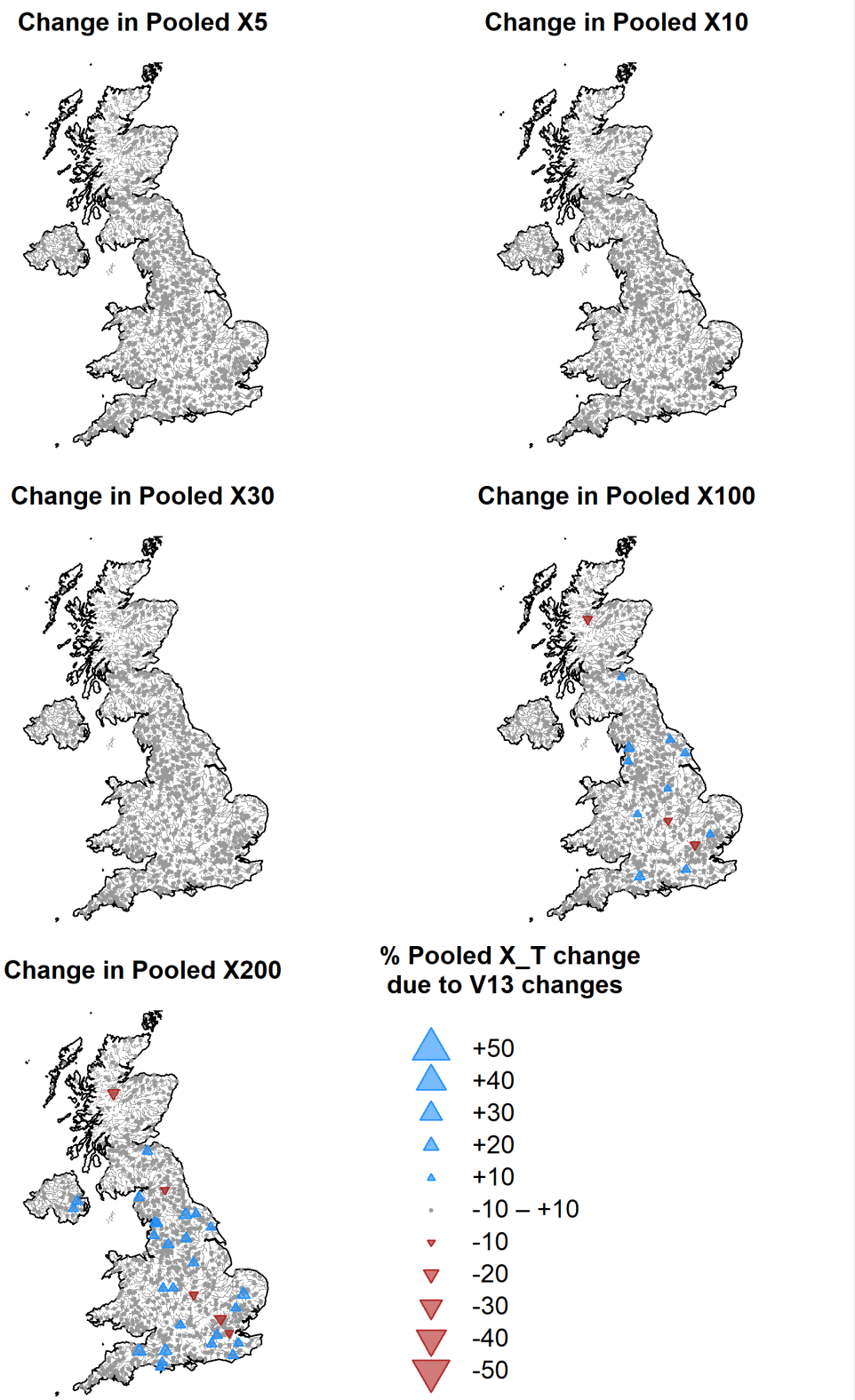

Figure 10: Changed in pooled estimates of flood frequency growth curves at NRFA stations.

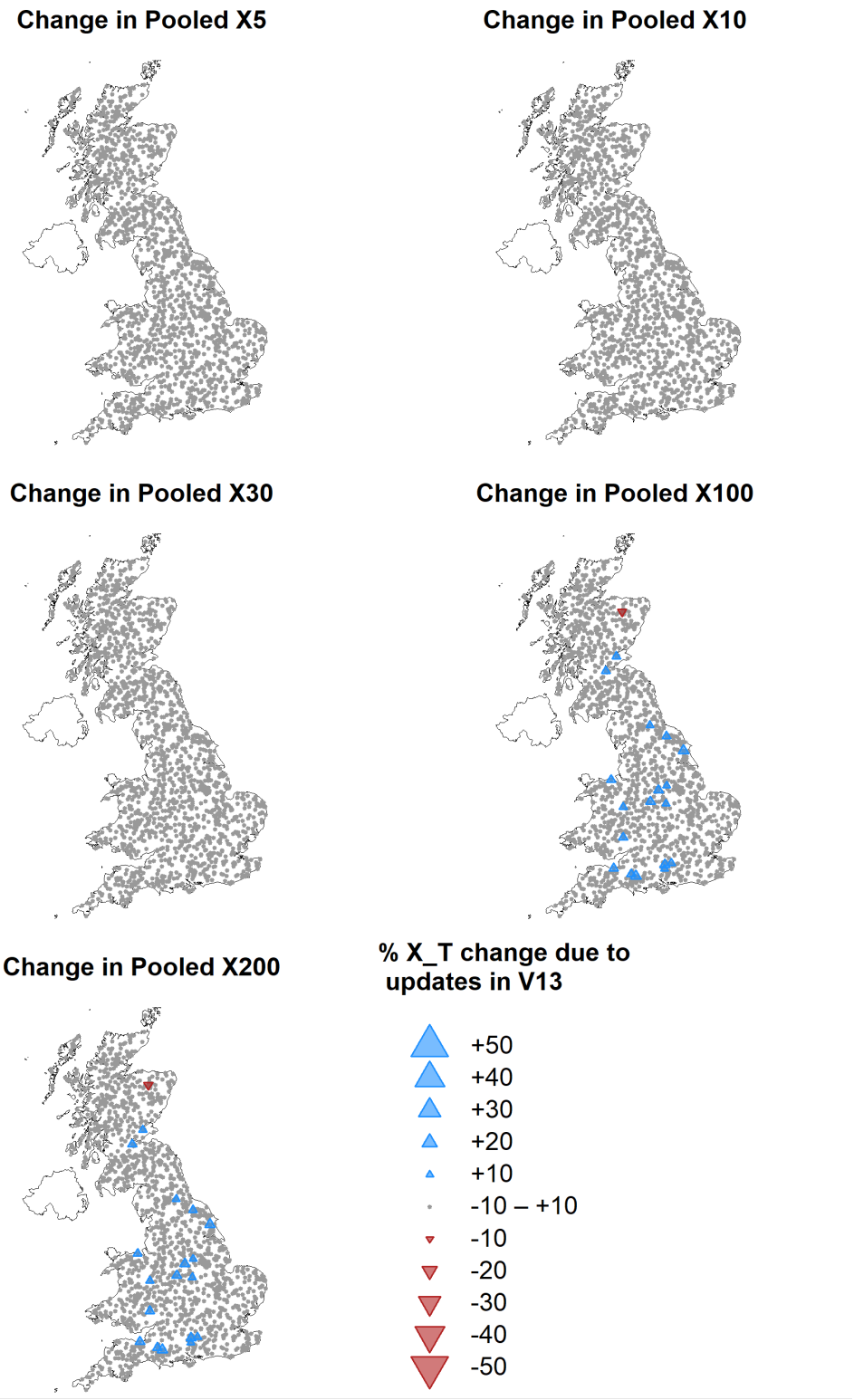

Figure 11: Changed in pooled estimates of flood frequency growth curves at ungauged locations.

5.3 Changes in flood frequency curves

Figure 12 and Figure 13 show changes in pooled return levels (Q_T) (and donor-adjusted *QMED* for reference) for the NRFA stations (Figure 12) and the ungauged dataset (Figure 13). The overall differences between versions V12.1 and V13 are very small due to the overall high similarity between the two datasets. Figure 14 shows large changes in pooled return levels for NRFA stations (differences above 10%). Figure 15 shows the same for ungauged catchments. The patterns fit with the previous sections regarding the different effects of the growth curve and the estimates of *QMED*.

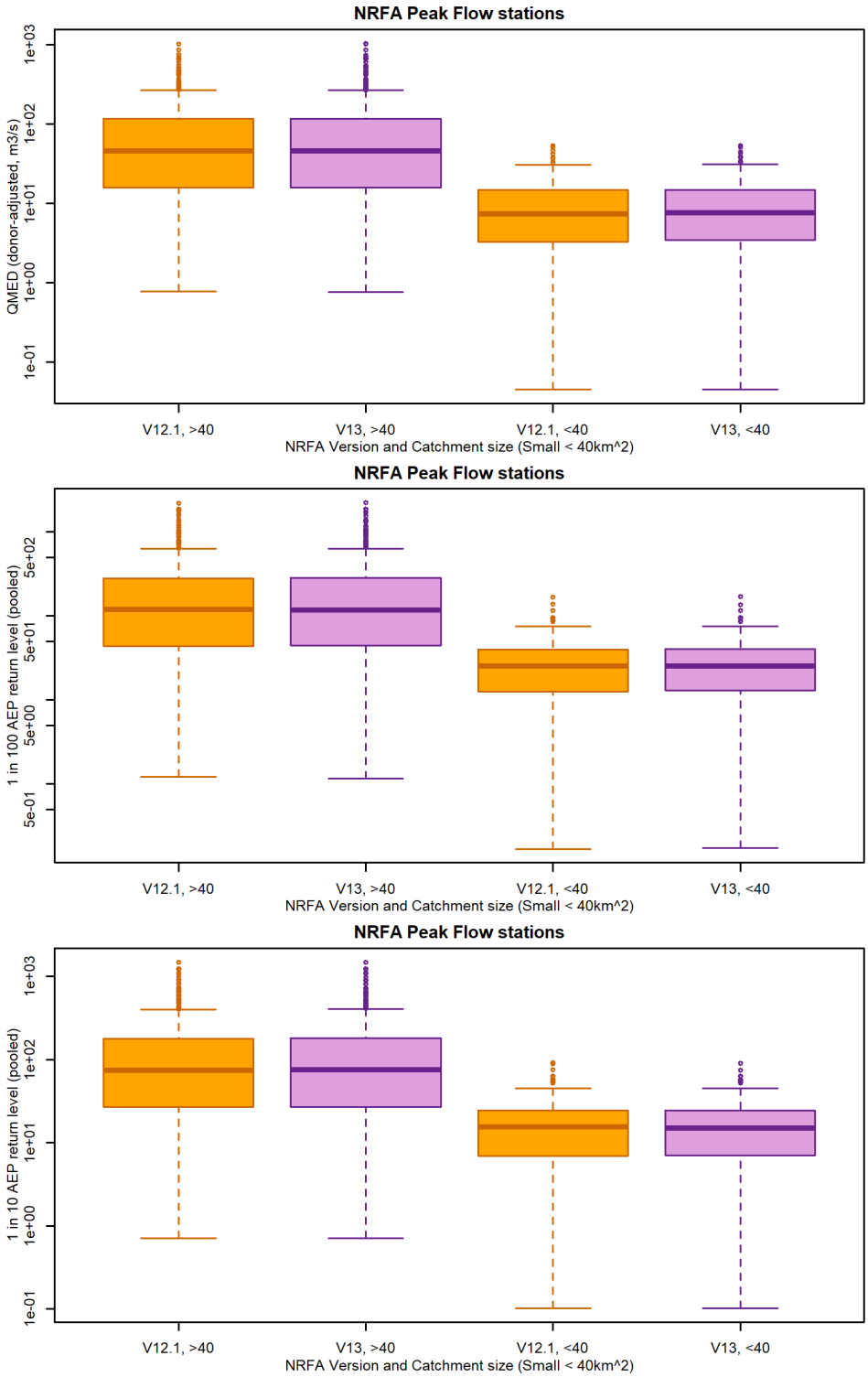

Figure 12: Boxplots of changes in pooled flood frequency return levels between NRFA Peak Flow versions for NRFA stations, split by catchment size (Small < 40 km^2).

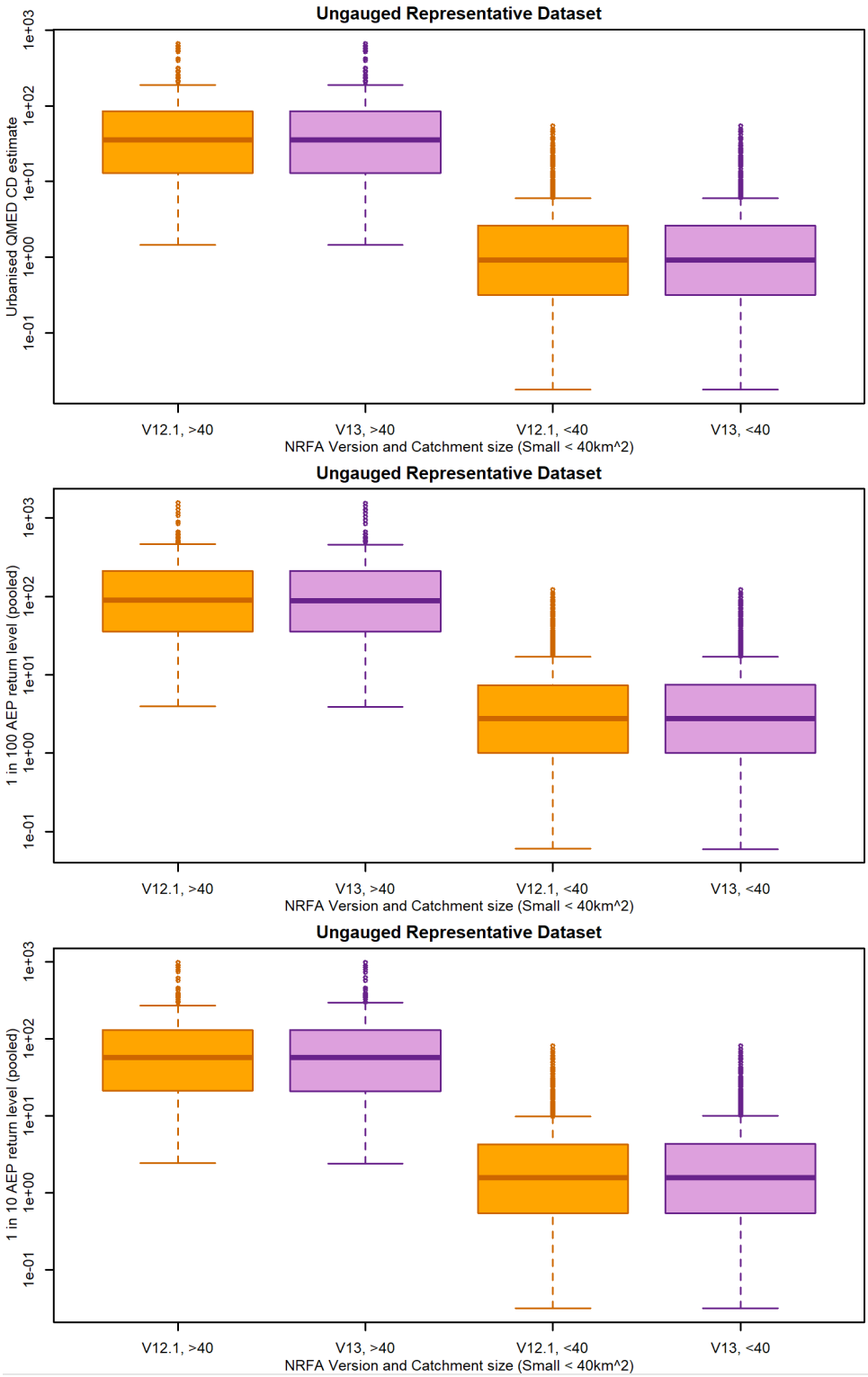

Figure 13: Boxplots of changes in pooled flood frequency return levels between NRFA Peak Flow versions for ungauged locations, split by catchment size (Small < 40 km^2).

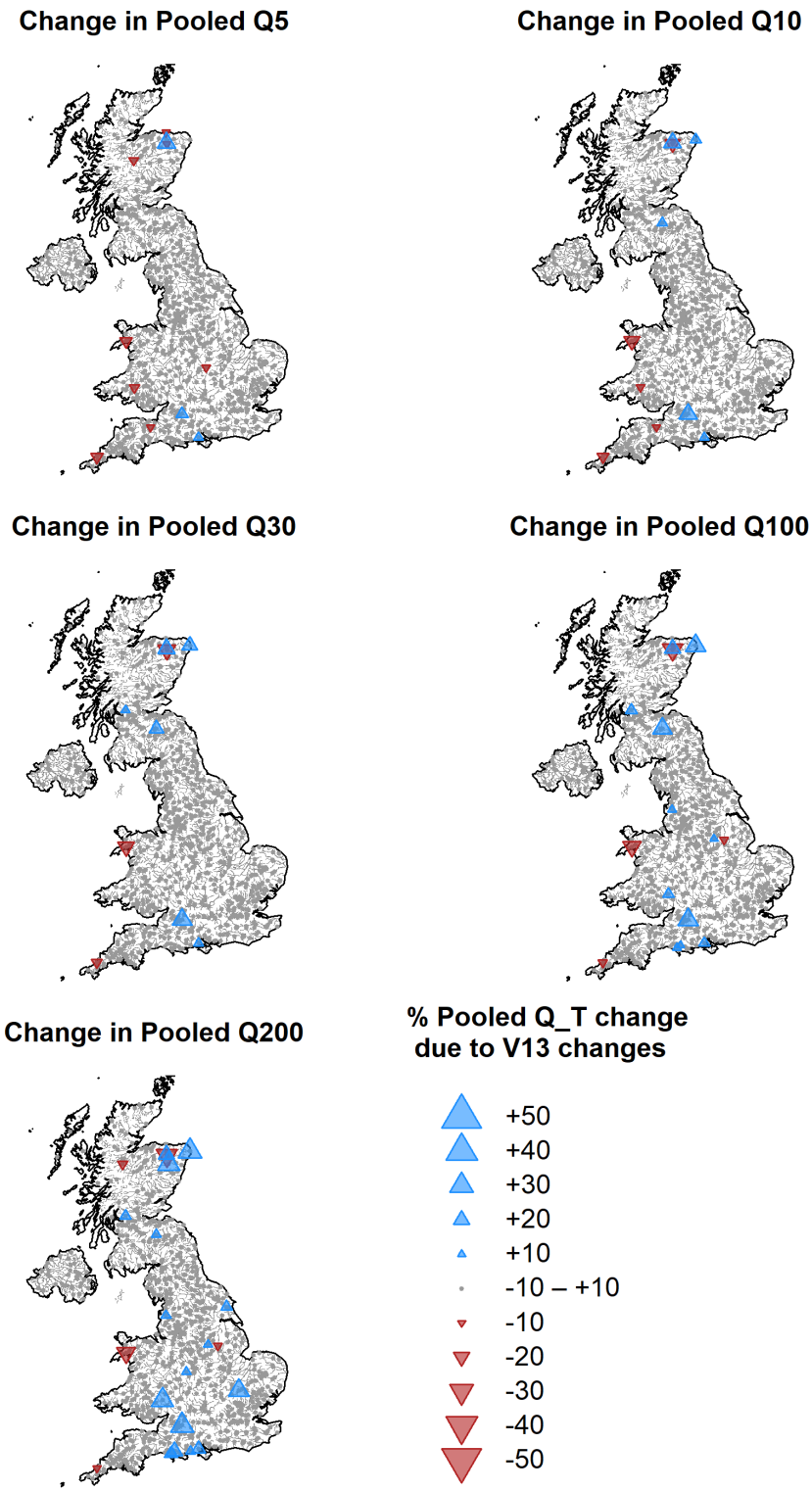

Figure 14: Changes in pooled estimates of flood frequency return levels at NRFA stations.

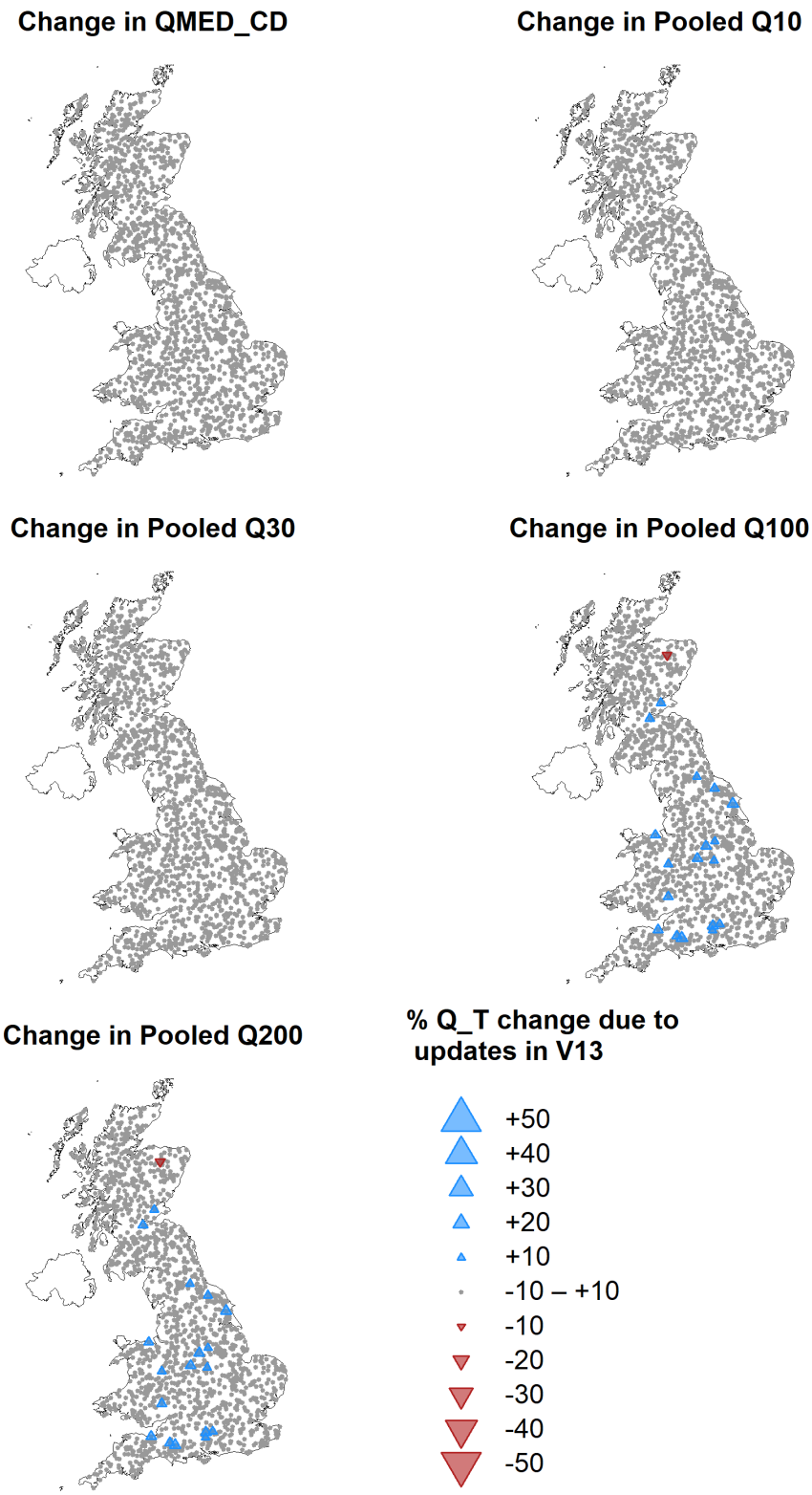

Figure 15: Changed in pooled estimates of flood frequency return levels at ungauged locations.

6. Conclusions

Overall, there were no unexpected or inexplicable changes between the two datasets in terms of flood frequency estimation, with a small number of large changes in the 10-year and 100-year return levels at places that either experienced large AMAX events, or had pooling-group members that experienced such events.

As mentioned above, this report does not include discussion of new catchment descriptors and 'FEH' methods. These will be discussed in detail in subsequent reports available online.

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Distribution of catchment descriptors in ungauged dataset

Although this report does not go into the derivation of the ungauged dataset in-depth (can be requested from the FEH team), Figure 16 shows the distribution several catchment descriptors for the ungauged representative dataset drawn from the IHDTM river network in Great Britain.

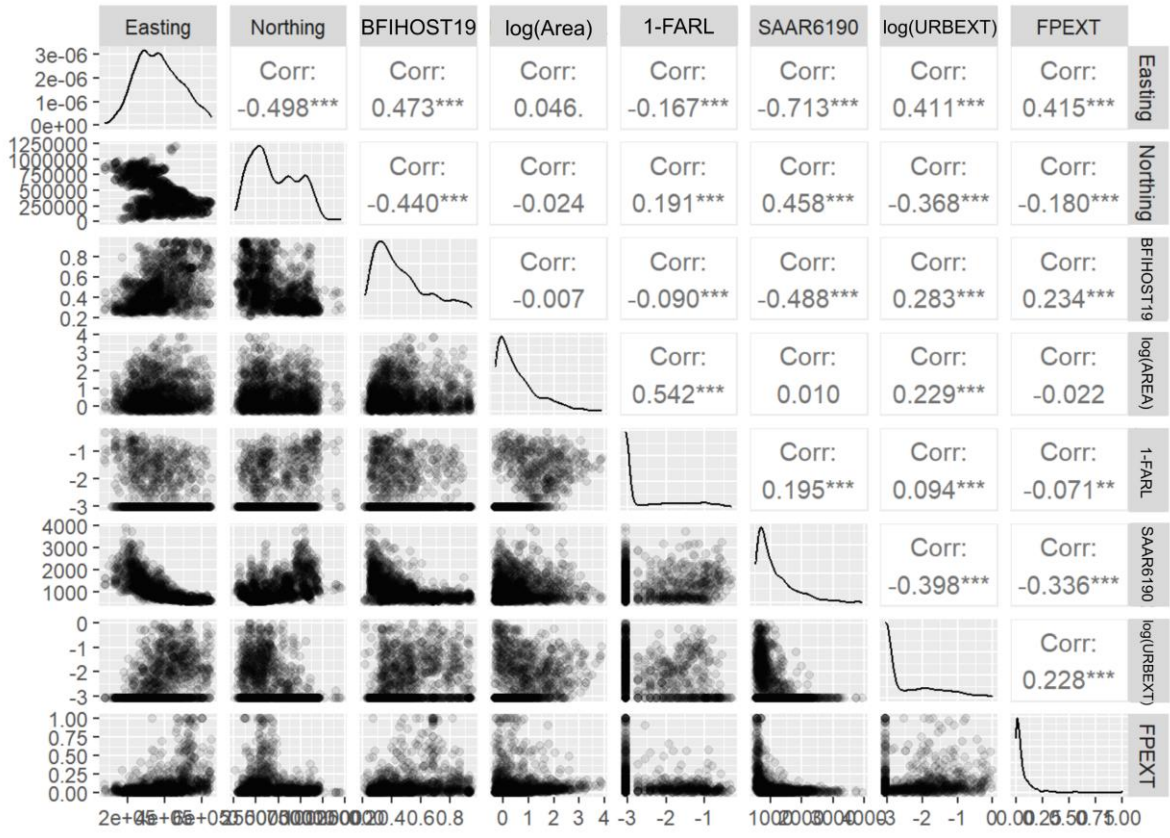

Figure 16: Distribution of catchment descriptors across the IHDTM river network in Great Britain.

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