Appendix 1 : Modifications to the CERF structure within CERF2-HadUK.

As described within the science report there has been an effort to try to capture a number of features which are recognised within the observed flow records. These include the occurrence of small runoff events within the summer, which can be present when there are soil moisture deficits (SMDs) within the catchment, and the capturing the delayed recovery of flows following persistent droughts. Note that neither of these have a significant impact on the measures of fit which are used to assess the performance of the rainfall-runoff model.

For this analysis the CERF model structure used in the provision of flows in Qube (2019 – 2024), referred to as CERF 2019, is compared with the revised structure, referred to as CERF2-HadUK.

Capturing small summer events

During dry periods when soil moisture deficits can be significant there can be small rainfall events which still result in higher flows in the river. Capturing these within the rainfall-runoff model, or not, has little impact on the measures of fit (since they are largely at low flows and represent small differences in flows) but ideally the rainfall-runoff model should be able to capture these events satisfactorily.

Within CERF 2019 a 'bypass' function was introduced where, for specific HRUs, a percentage of runoff 'bypassed' the loss module allowing runoff even when SMDs are present.

Within the CERF2-HadUK model, a distribution soil moisture store is used to allow effective precipitation to occur even where large soil moisture deficits may have built up. This was calibrated via the pareto variable, b, where the resulting value is a compromise between providing too much or too little response in different catchments and conditions.

More than 30 catchments; either permeable or where the actual precipitation/potential evaporation ratio (AE/PE) was low (which would indicate a predisposition to significant soil moisture deficits) were assessed. Flow records for these indicate that, in general, the difference between the distribution or bypass models is minimal, with little difference between the two approaches in most of the examples examined. The soil distribution model will generally provide a lower response during periods of low flow than the bypass function. Depending on the catchment characteristics, this can result in either the soil moisture store model being not responsive enough, or the bypass function being too responsive.

Within regionalised modelling, decisions on parameterisation and model forms are often compromises to capture the aspects that are important for a particular modelling process, relative to the variability that is found within the gauged dataset for similar catchment types. In this case it was decided, on balance, to take the soil moisture distribution store model forward with the pareto variable set to 0.5.

The difference between the bypass model in CERF 2019 and the distribution model in CERF2-HadUK are presented for a selection of catchments in Figure 1 to Figure 8. The catchments were selected due to having significant dry periods during 1976 and/or 1983.

Catchments where the responses are similar are presented in Figure 1 and Figure 2. These are catchments in which the bypass is not activated and the differences between the two soil moisture accounting methods are not significant.

Catchments where the bypass function is active are presented within Figure 3 to Figure 6. For most of these, the bypass function is slightly too responsive to rainfall events (since it is independent of current soil moisture conditions).

Catchments where the difference between the loss models can be identified tend to indicate that the soil distribution store is too unresponsive, and are presented within Figure 7 and Figure 8.

Although an exhaustive search was not implemented, there were no catchments identified where the soil distribution stored was too responsive relative to the observed flows.

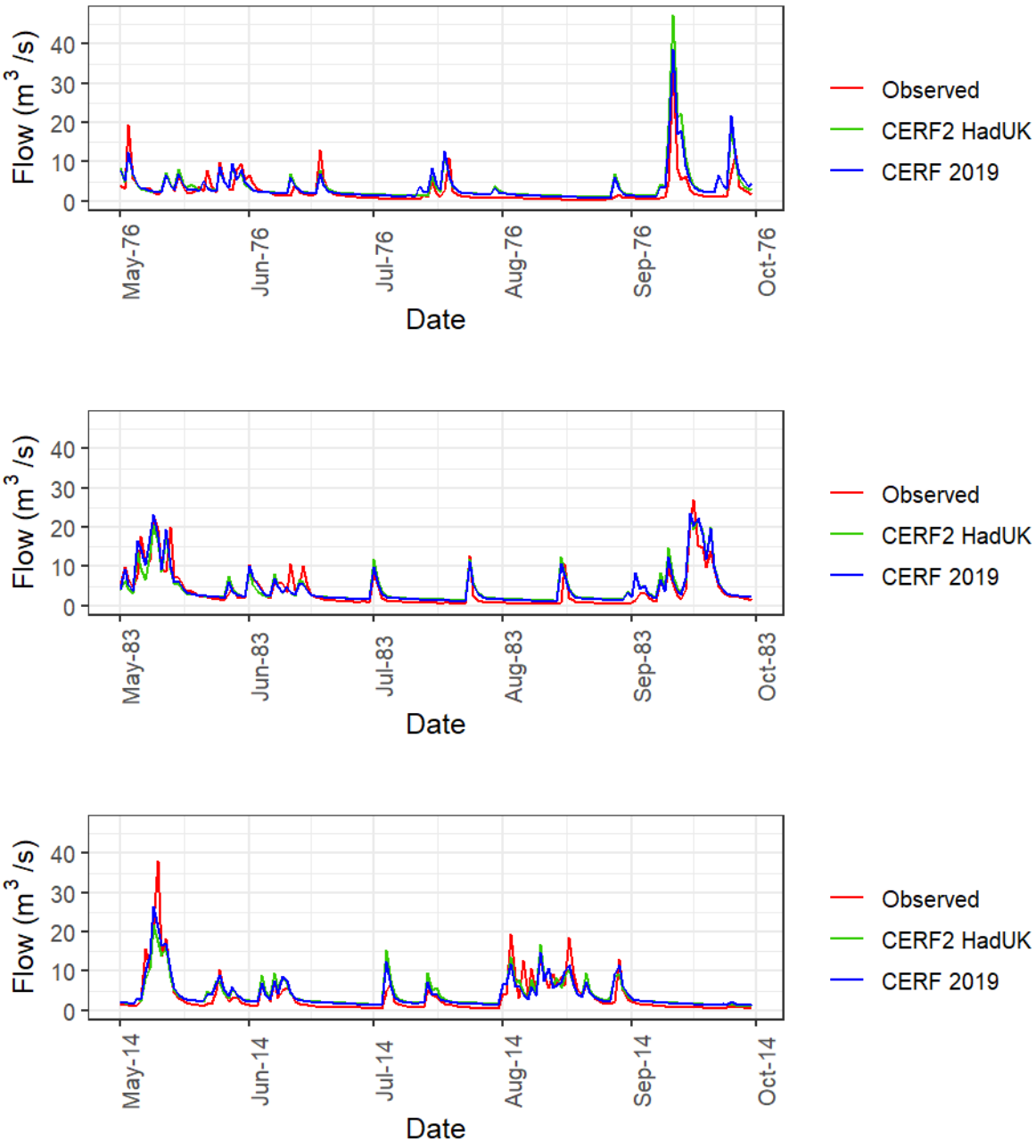

Figure 1. Times series of flows for 72011 for the years 1976, 1983 and 2014. An example catchment where both models perform similarly during summer months.

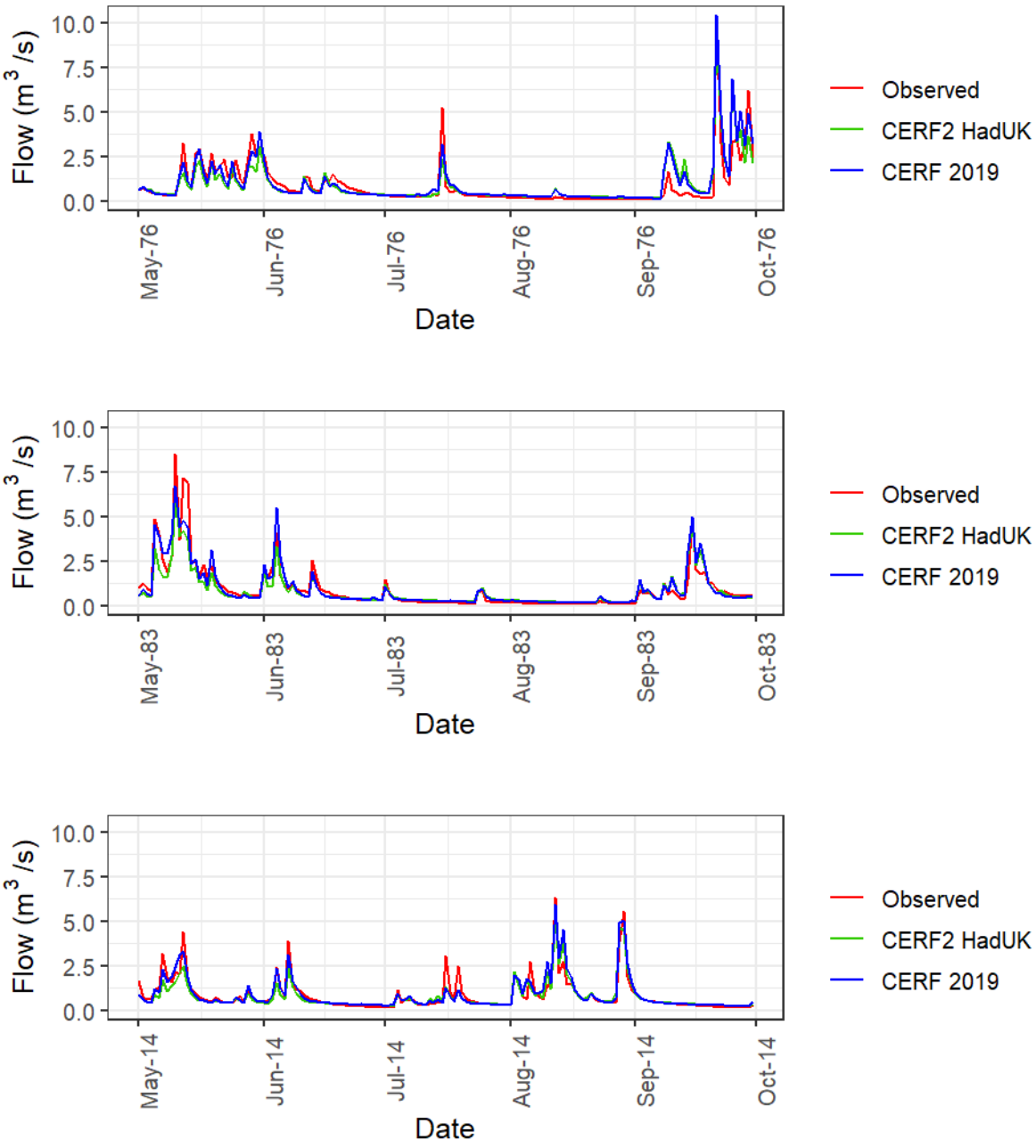

Figure 2. Times series of flows for 21017 for the years 1976, 1983 and 2014. An example catchment where both models perform similarly during summer months.

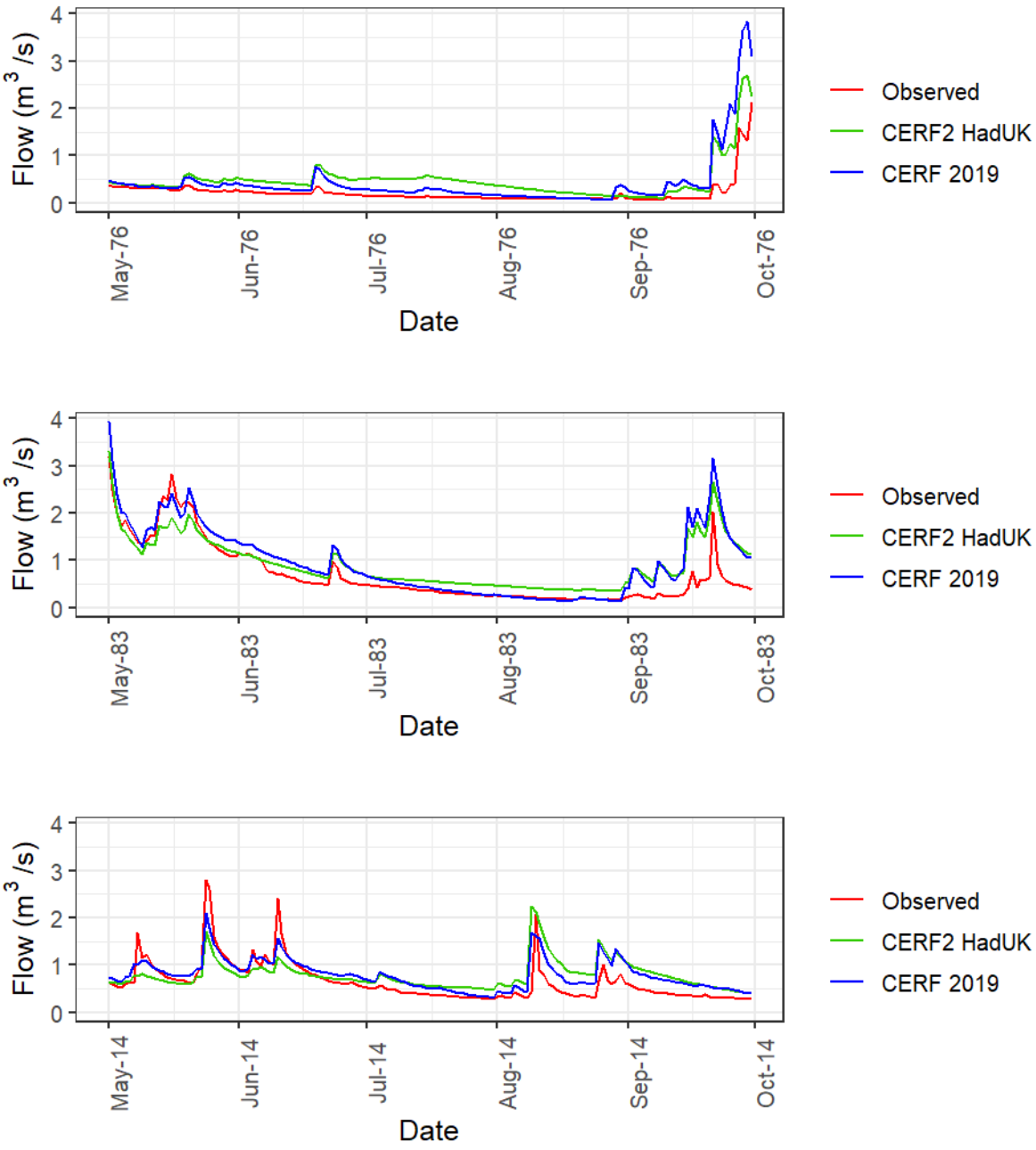

Figure 3. Times series of flows for 58011 for the years 1976, 1983 and 2014. An example catchment where the bypass model can be too responsive during dry periods. This catchment is dominated by HOST4 with HOST2 subdominant.

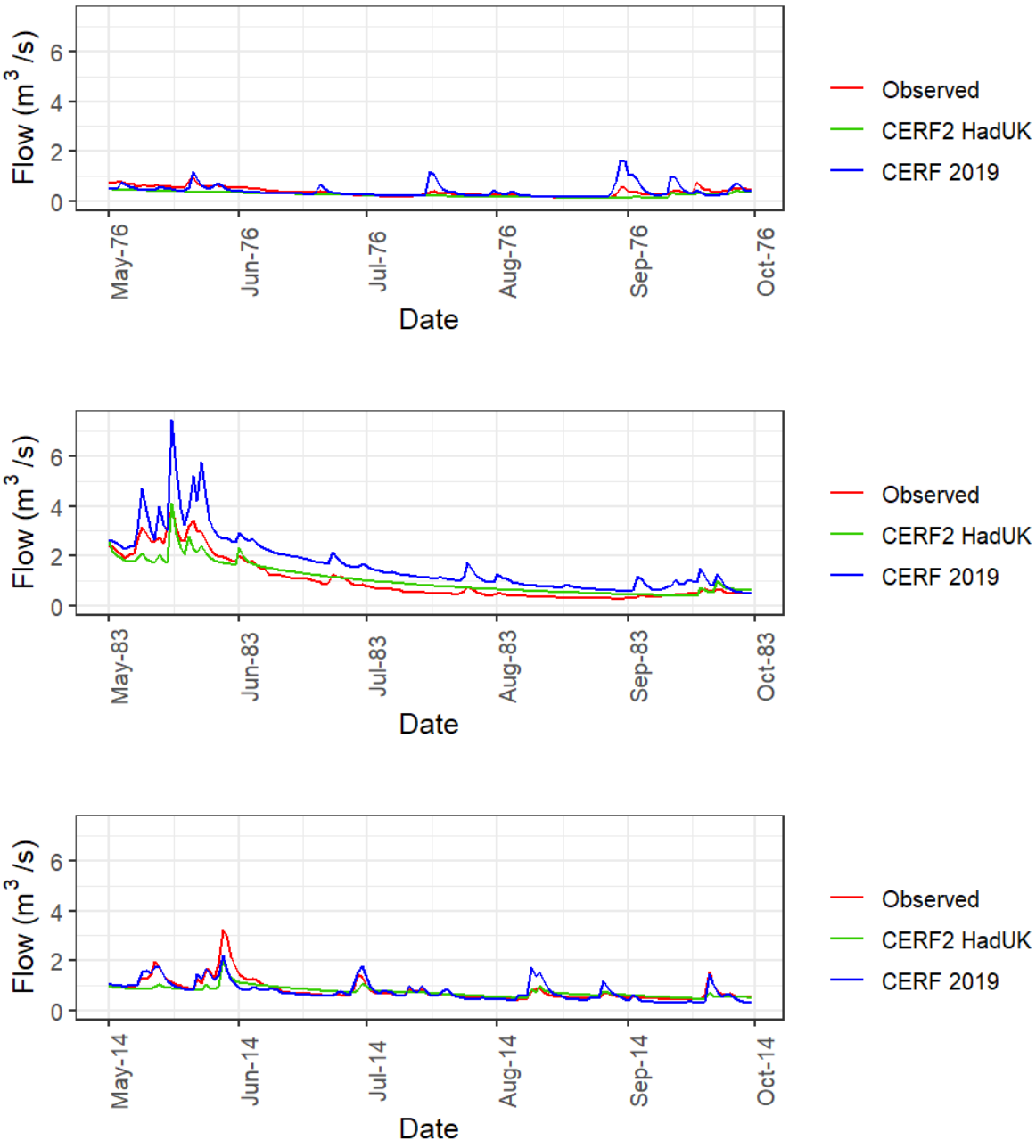

Figure 4. Times series of flows for 33044 for the years 1976, 1983 and 2014. This is an example where the bypass model can be too responsive during dry periods. This is a chalk dominated catchment.

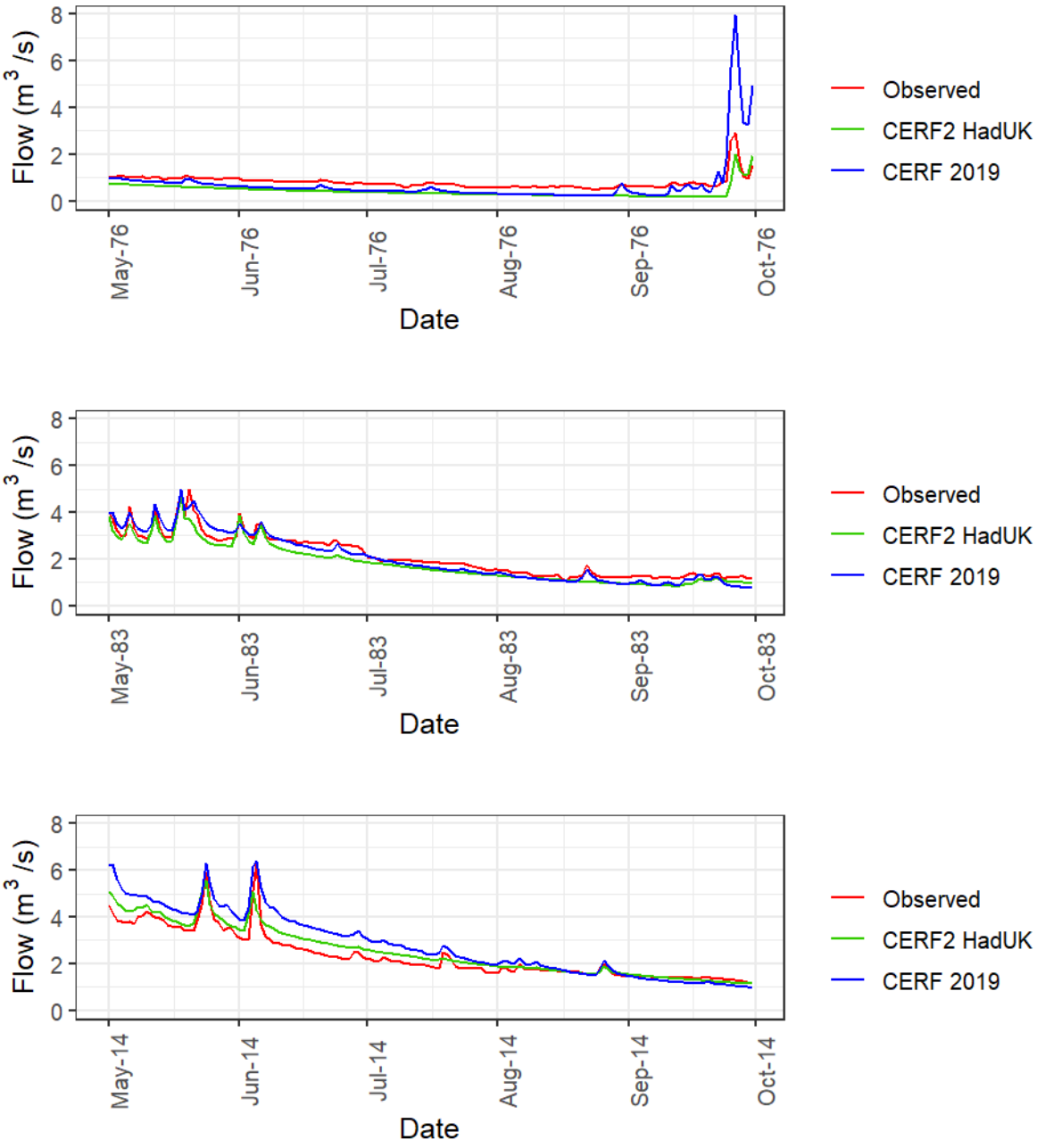

Figure 5. Times series of flows for 43006 for the years 1976, 1983 and 2014. An example catchment where the bypass model can be too responsive during dry periods. This is a chalk dominated catchment.

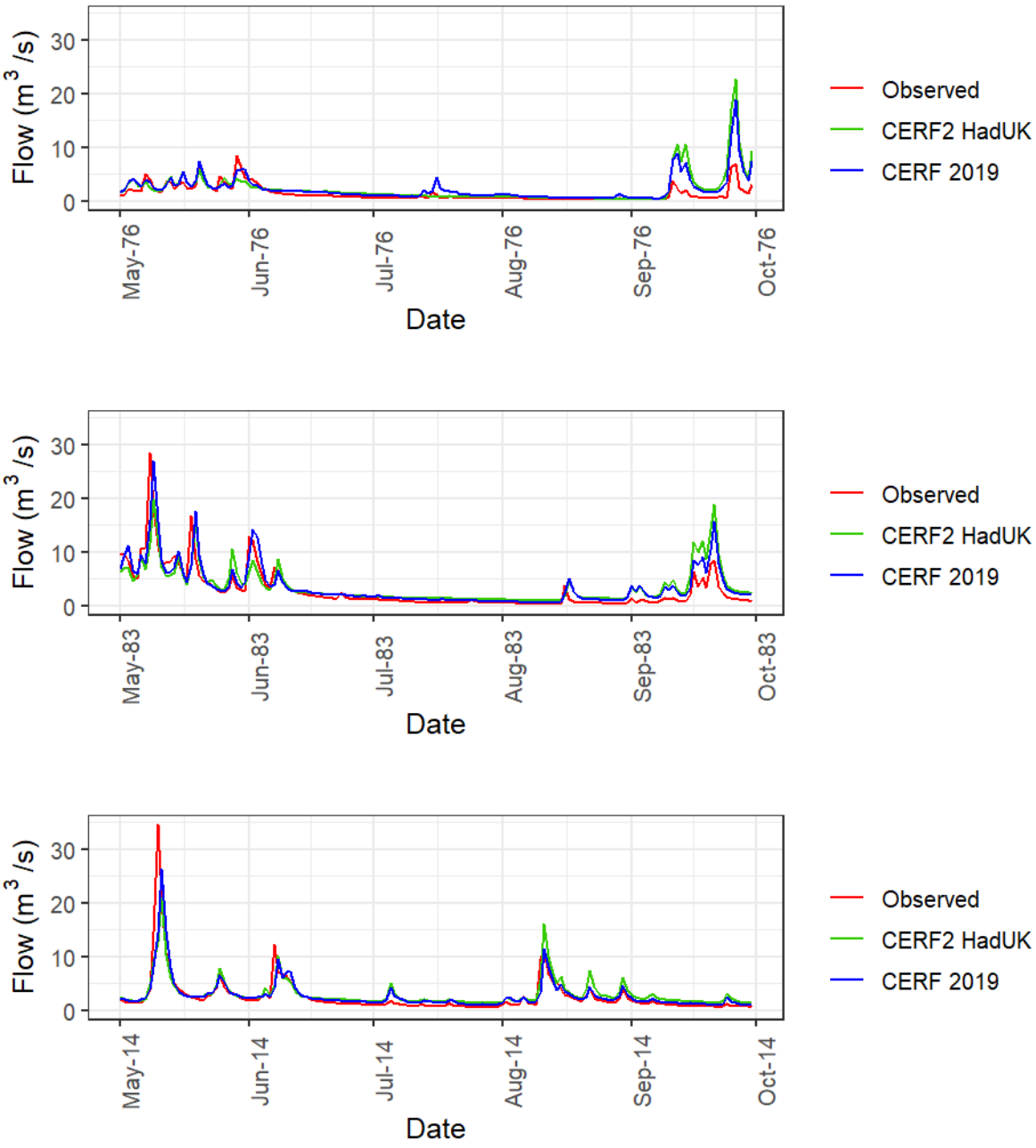

Figure 6. Times series of flows for 27035 for the years 1976, 1983 and 2014. An example catchment where the bypass model can be too responsive during dry periods.

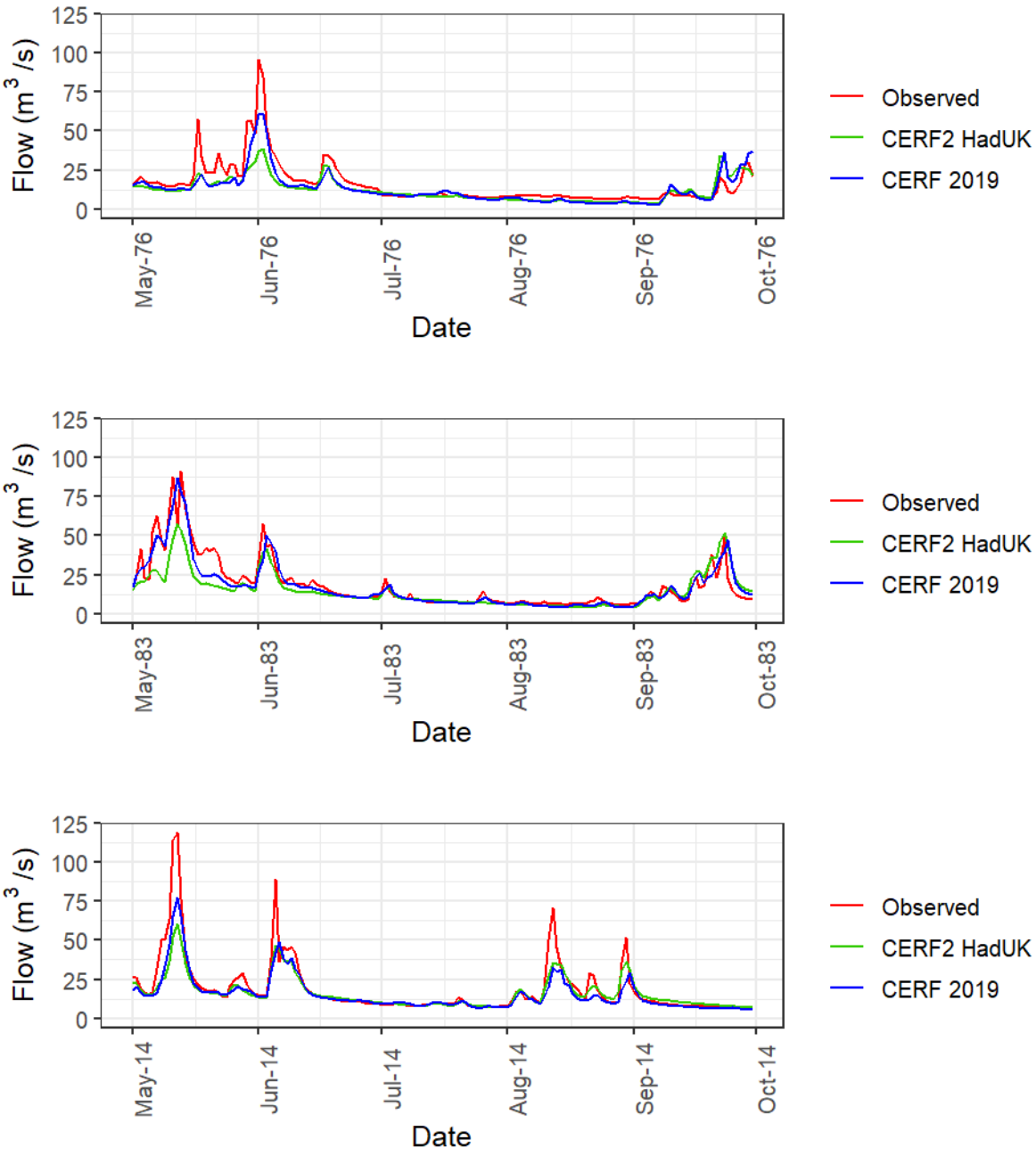

Figure 7. Times series of flows for 84005 for the years 1976, 1983 and 2014. An example catchment where the soil distribution model may not be responsive enough during dry periods.

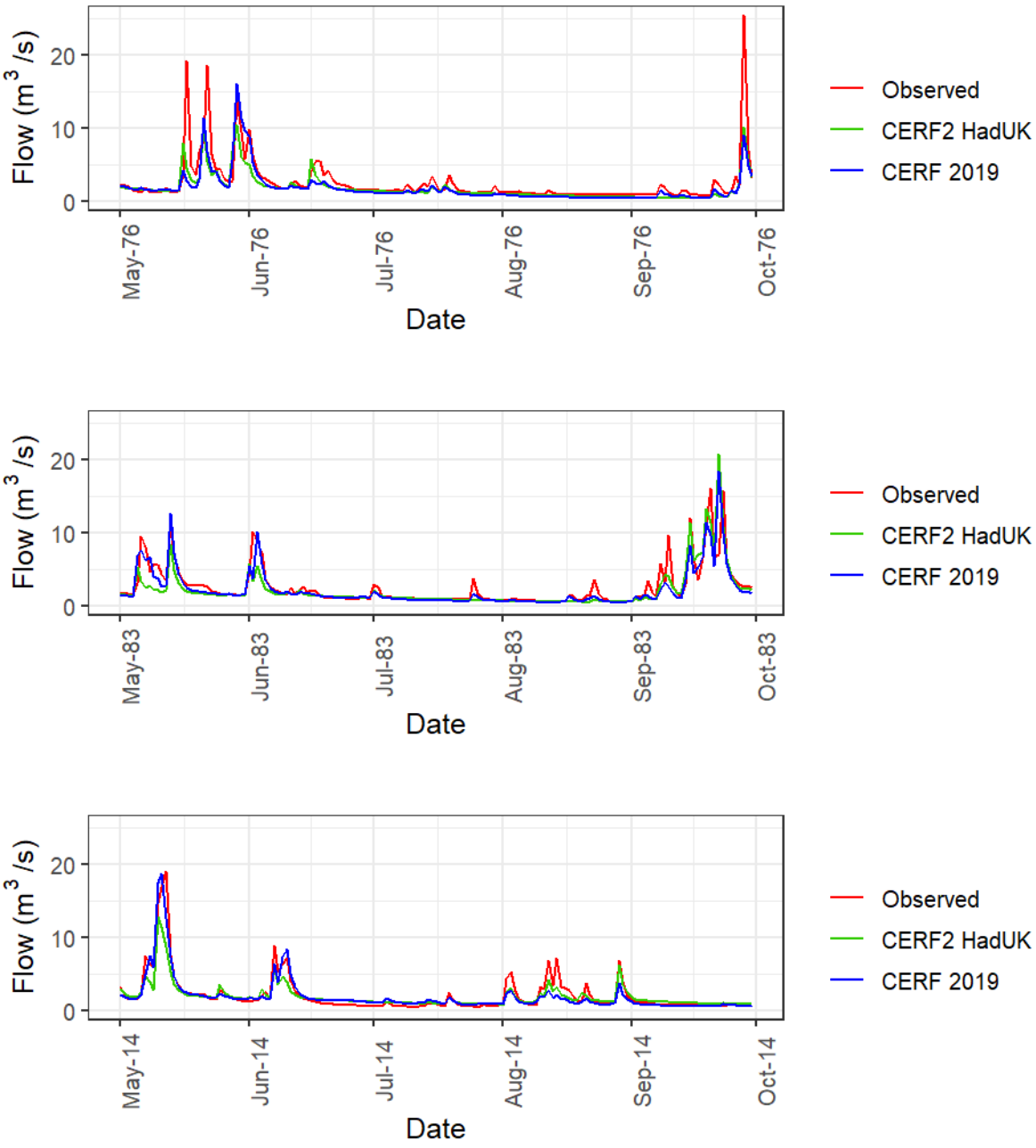

Figure 8. Times series of flows for 84012 for the years 1976, 1983 and 2014. An example catchment where the soil distribution model may not be responsive enough during dry periods.

Capturing drought events

As described previously, it can be very difficult to model extreme events within a regionalised rainfall-runoff model. This can be particularly true for drought periods. Whilst the extremity of the 1976 drought varies spatially across the UK, it is used as a benchmark drought in many regions. Therefore, this section presents an assessment of how CERF2-HadUK captures the 1976 drought event.

When assessing the differences between the observed and modelled flow time series one feature that can be seen is that the modelled flows tend to 'recover' more quickly than the observed flows i.e. low flows dominate for longer within the observed flows with recovery occurring later in the year. When the modelled soil moisture deficits are assessed alongside the flows, it can be seen that the soil moisture deficits frequently reach the 'maximum' threshold during the drought period. During the recovery period, these soil moisture deficits recover quicker within the model compared to the observed flow records.

It is hypothesised that greater soil moisture deficits can build up during drought periods, compared to those found in 'normal' years. This could be addressed in the model by increasing the depth for which soil moisture deficits can build up within a particular catchment, i.e. increasing TAW. However, implementing this would adversely impact the water balance within more typical years.

To allow deficits to build up in years with prolonged periods of low rainfall, without adversely impacting more typical years, a minimum actual evaporation/potential evaporation ratio has been introduced. This means that additional soil moisture deficits can build up beyond the threshold, but these deficits are only reached in extreme years.

This is illustrated in Figure 9 to Figure 17, which present the soil moisture deficit and the modelled and observed flows for a selection of catchments, along with the modelled flows if a minimum value of AE/PE is set. In order for the impacts to be seen clearly results using values of 0.1 and 0.4 are presented. For station 33044 the optimum value of AE/PE is also presented, which was found to be 0.3.

Note that the CERF2-HadUK flow results presented here are not the final results as further calibration was completed following assessment of the AE/PE.

Figure 9 to Figure 17 illustrate that during drought events it is common for maximum soil moisture deficits to be reached. The time series presented indicate that by setting a relatively high value of the AE/PE minimum the recovery from the drought can be slowed. However, if the value is too high then it can restrict the responsiveness to small summer events and may also impact on the more 'normal' years summer water balances and the autumn recovery of flows. Testing of various AE/PE ratios was completed and an optimum value of 0.3 was obtained, as presented within Figure 17 for 33044.

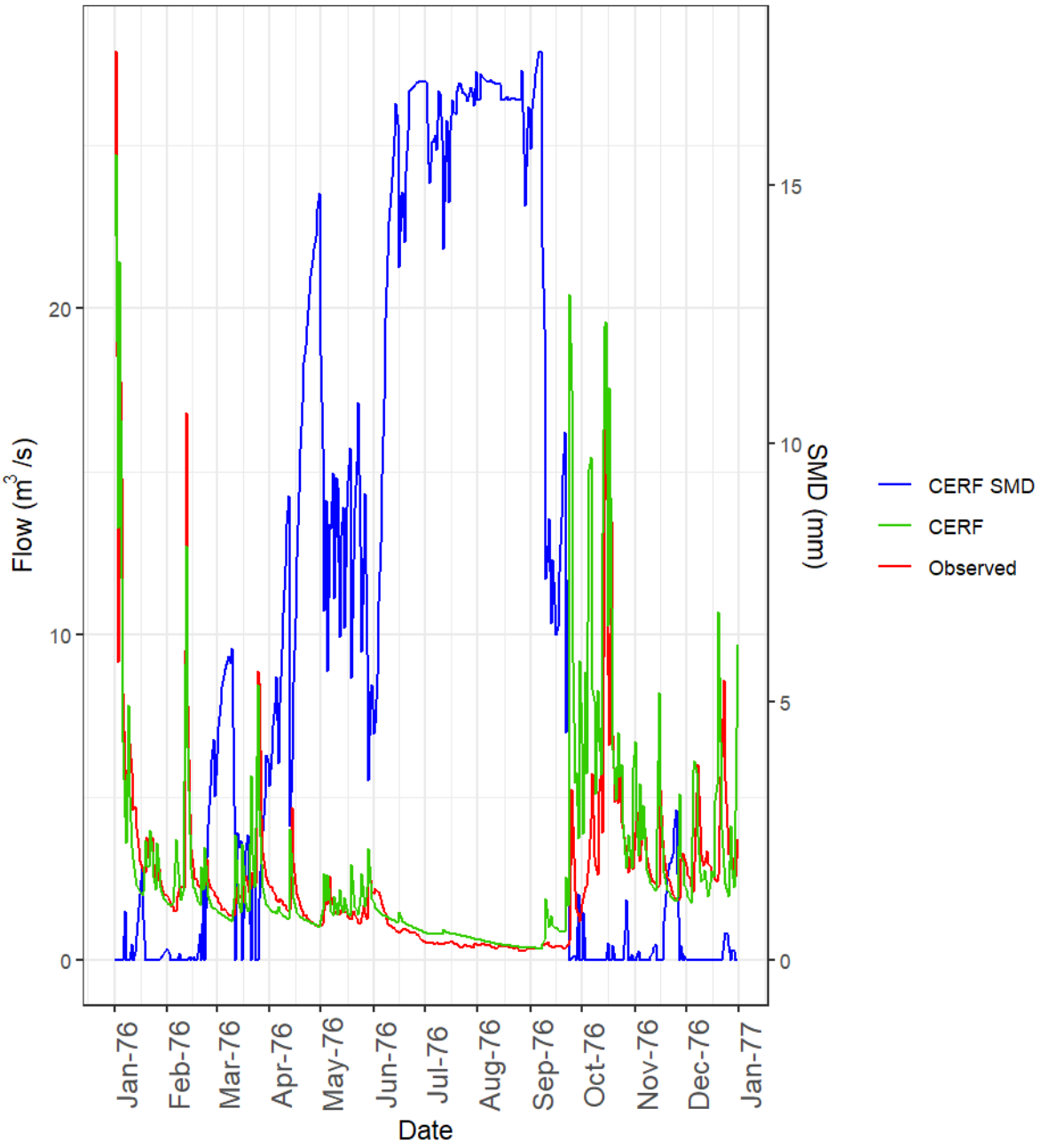

Figure 9. Time series of flows for 28031 and the modelled soil moisture deficits (SMD) for 1976.

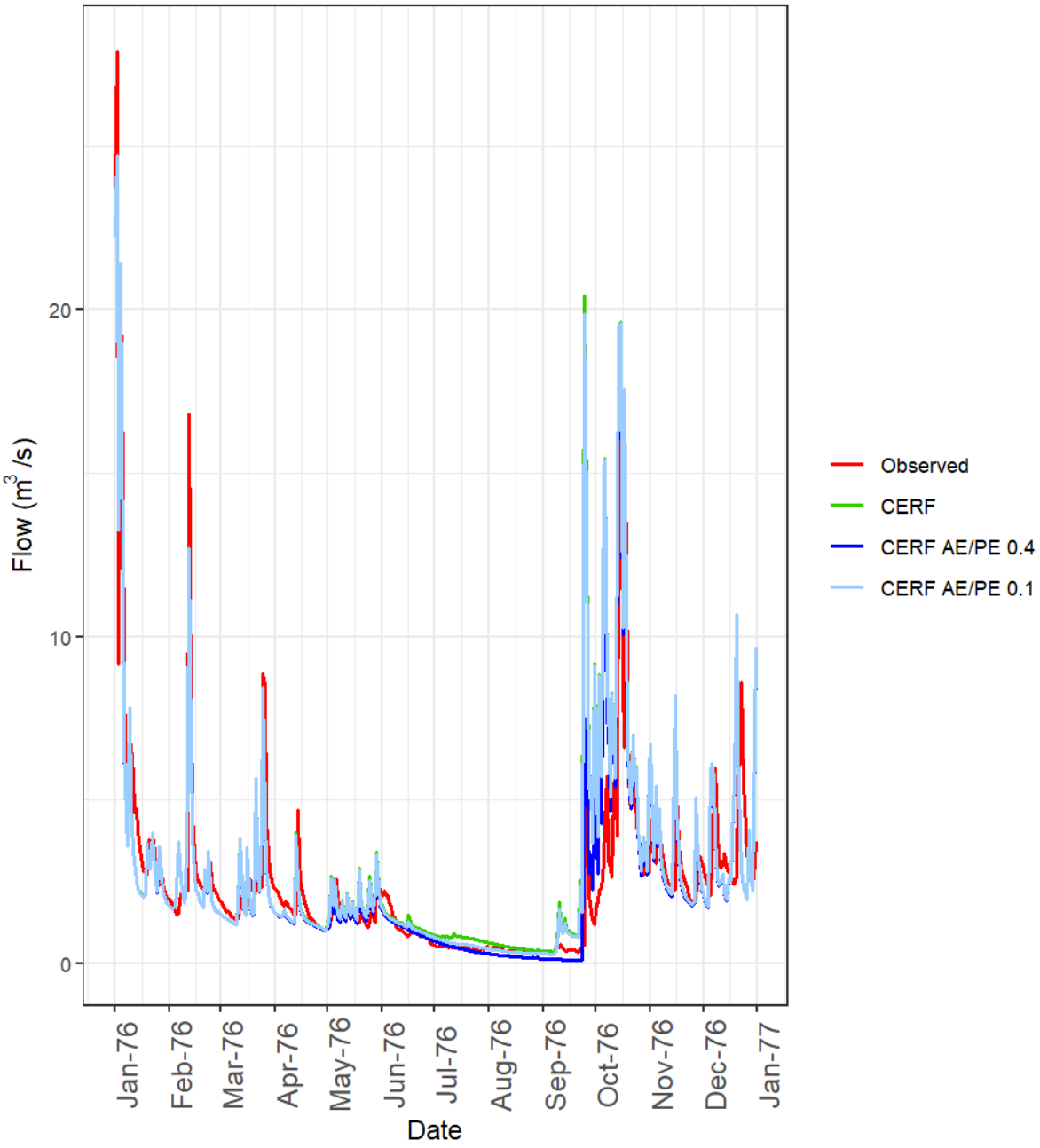

Figure 10. Time series of flows for 28031 for 1976 presenting the difference between the baseline model and setting a minimum AE/PE ratio.

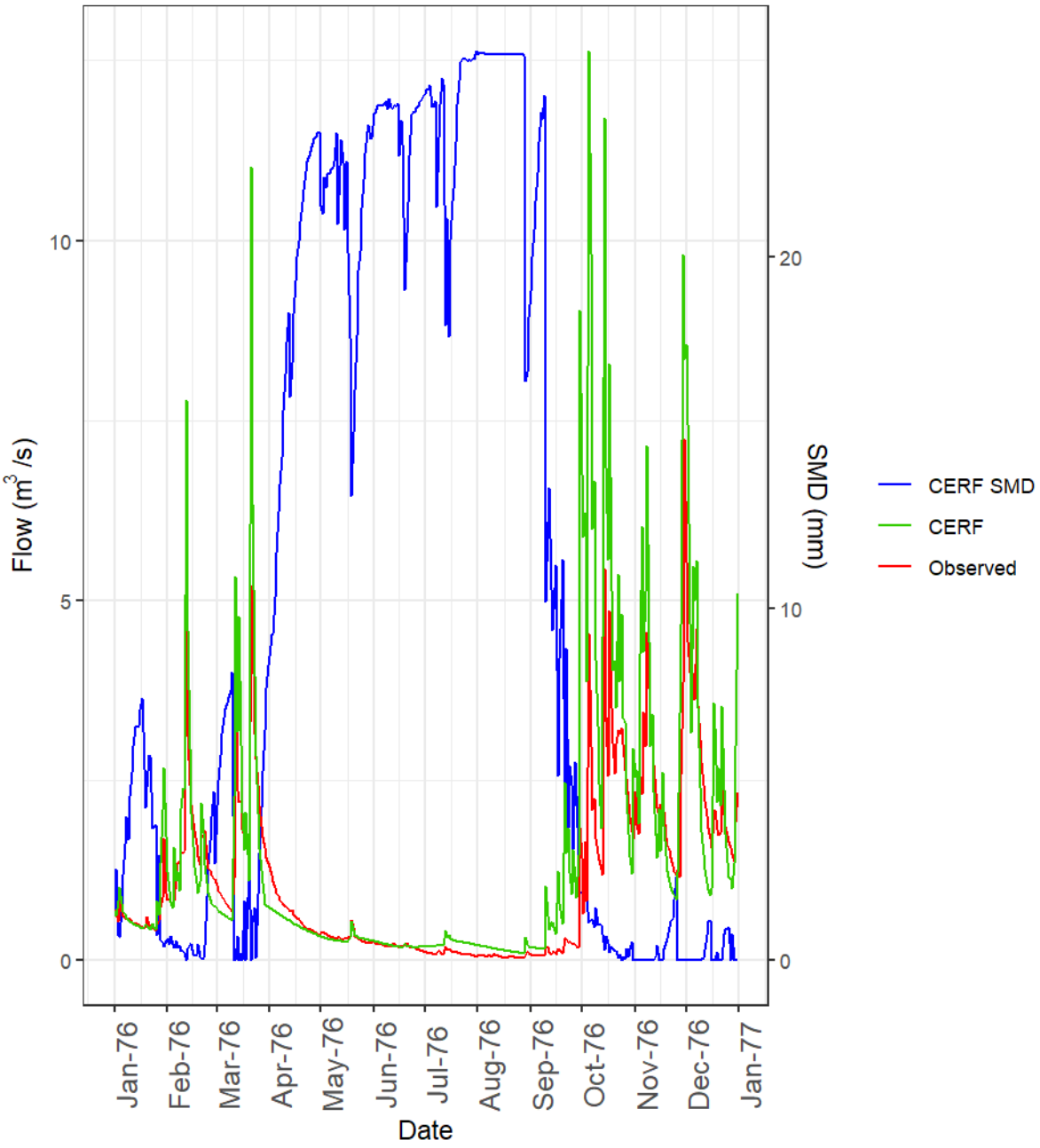

Figure 11. Time series of flows for 47007 and the modelled soil moisture deficits (SMD) for 1976.

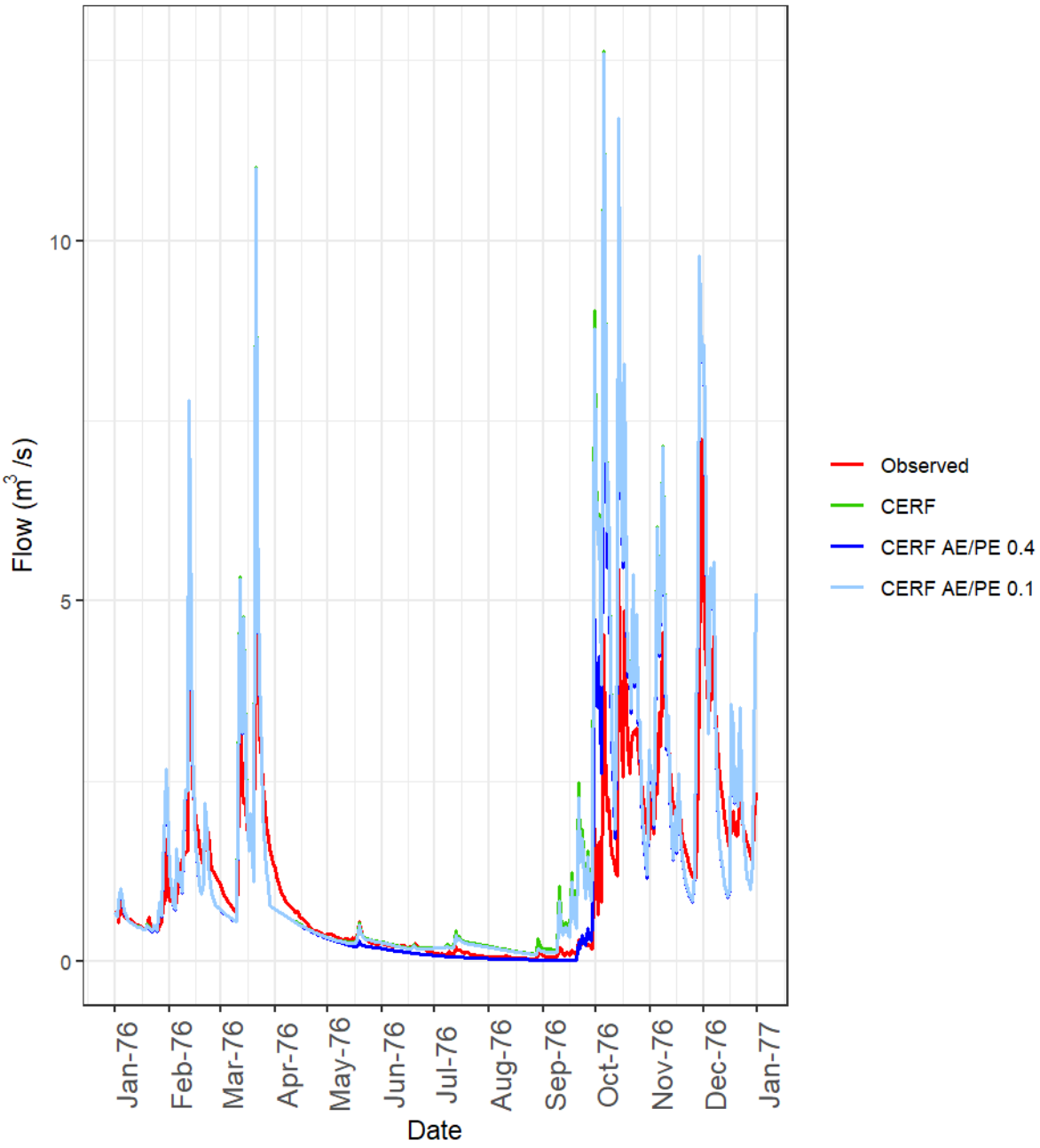

Figure 12. Time series of flows for 47007 for 1976 presenting the difference between the baseline model and setting a minimum AE/PE ratio.

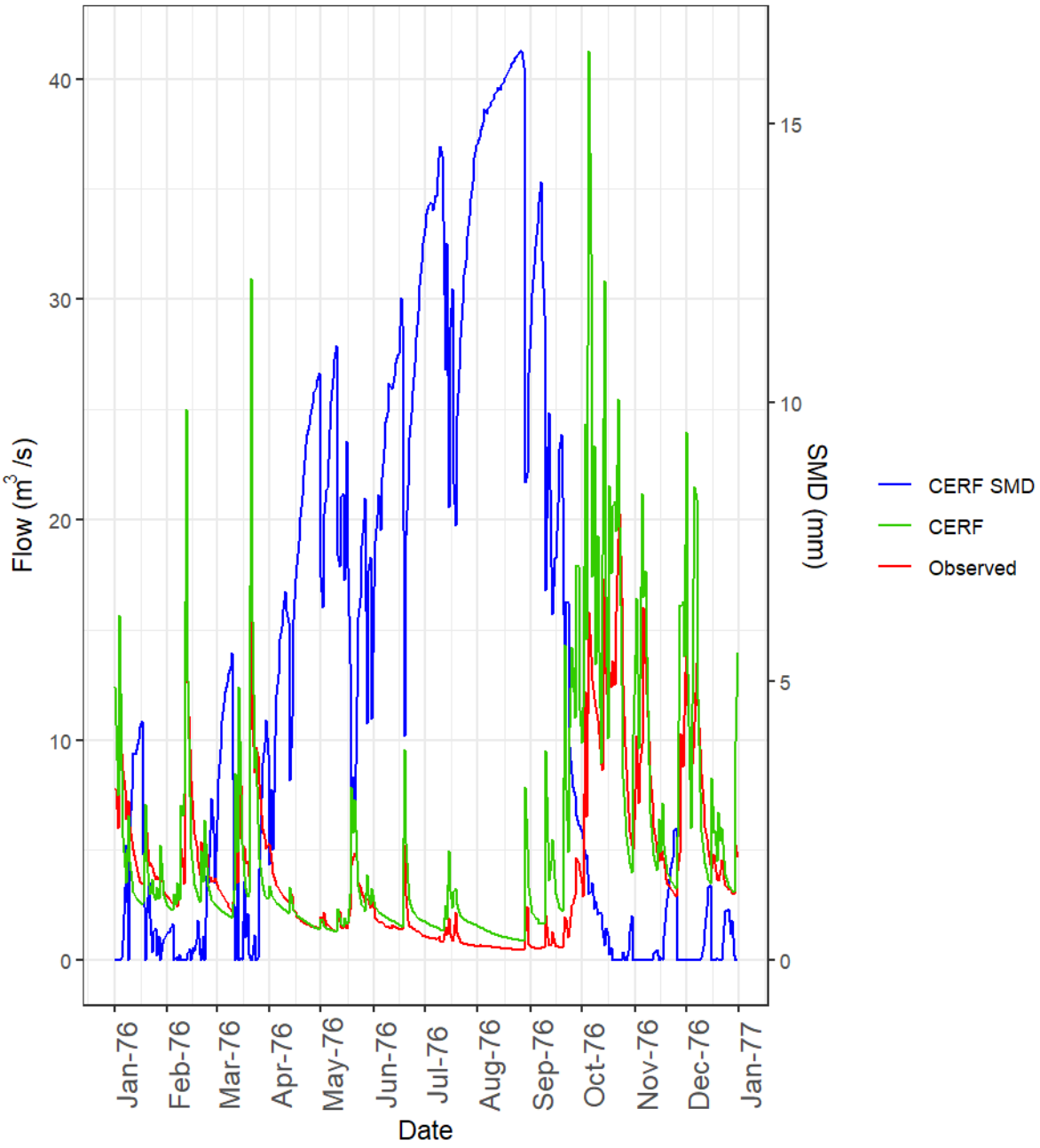

Figure 13. Time series of flows for 47007 and the modelled soil moisture deficits (SMD) for 1976

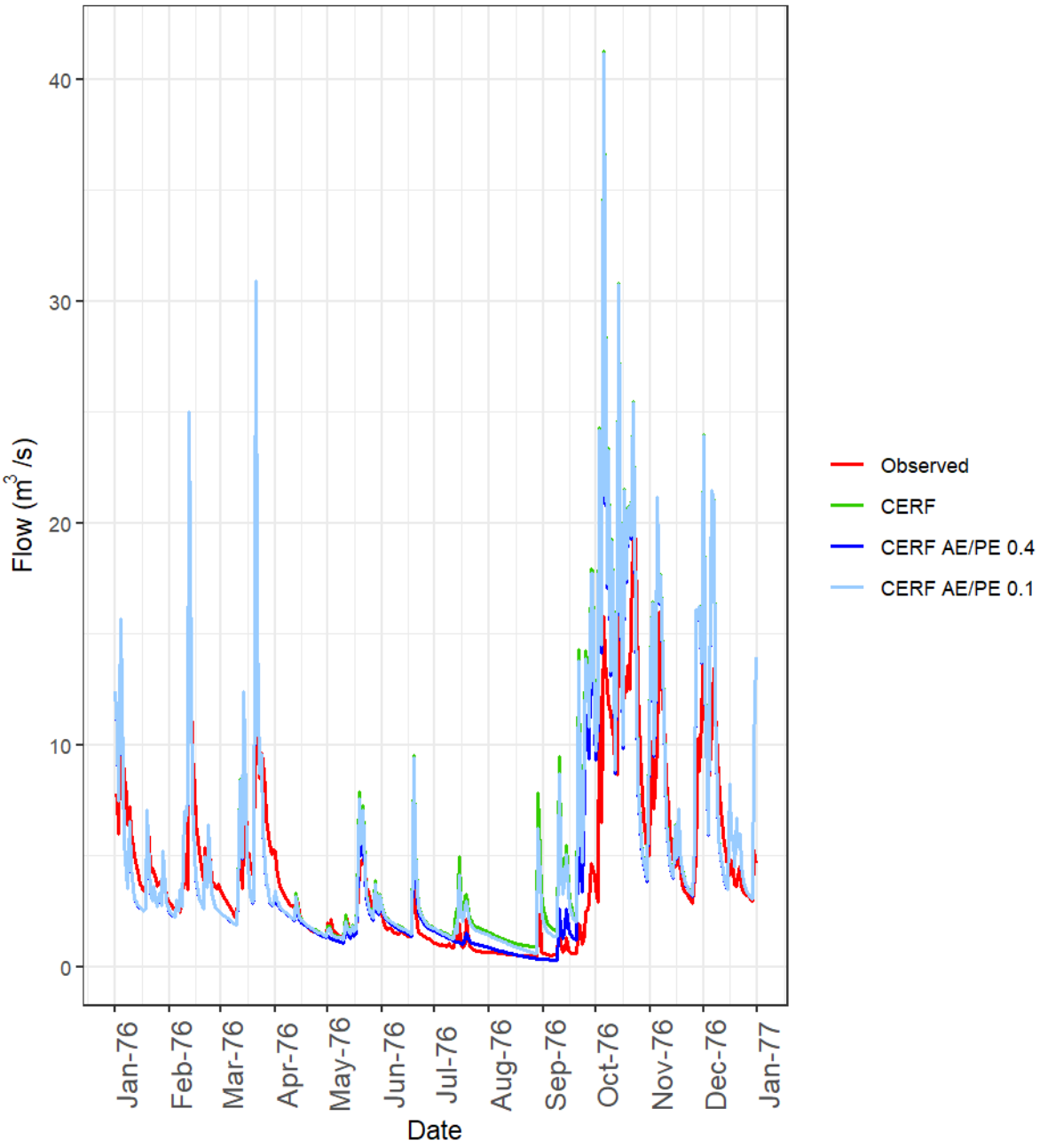

Figure 14. Time series of flows for 58001 for 1976 presenting the difference between the baseline model and setting a minimum AE/PE ratio.

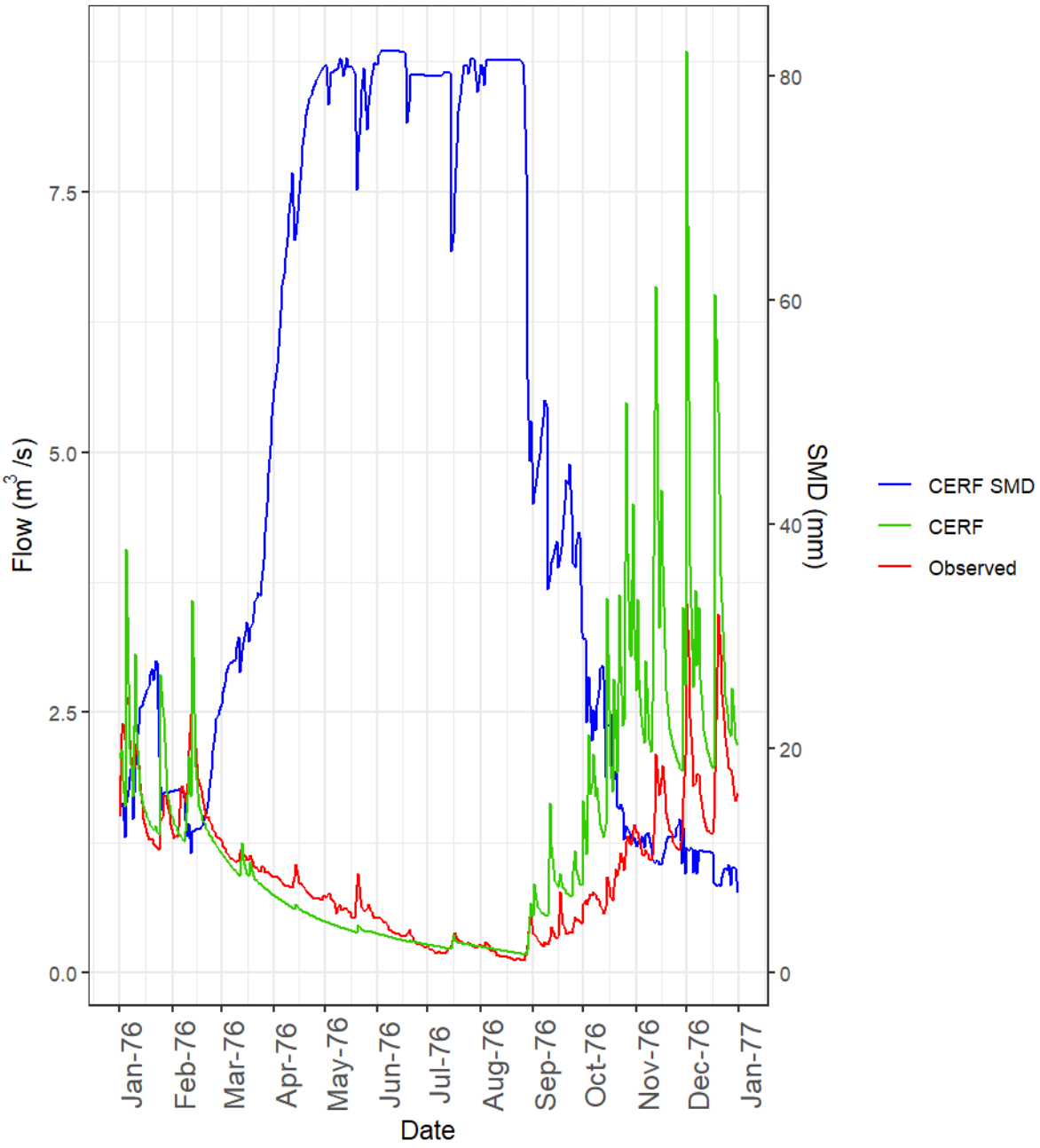

Figure 15. Time series of flows for 33044 and the modelled soil moisture deficits (SMD) for 1976.

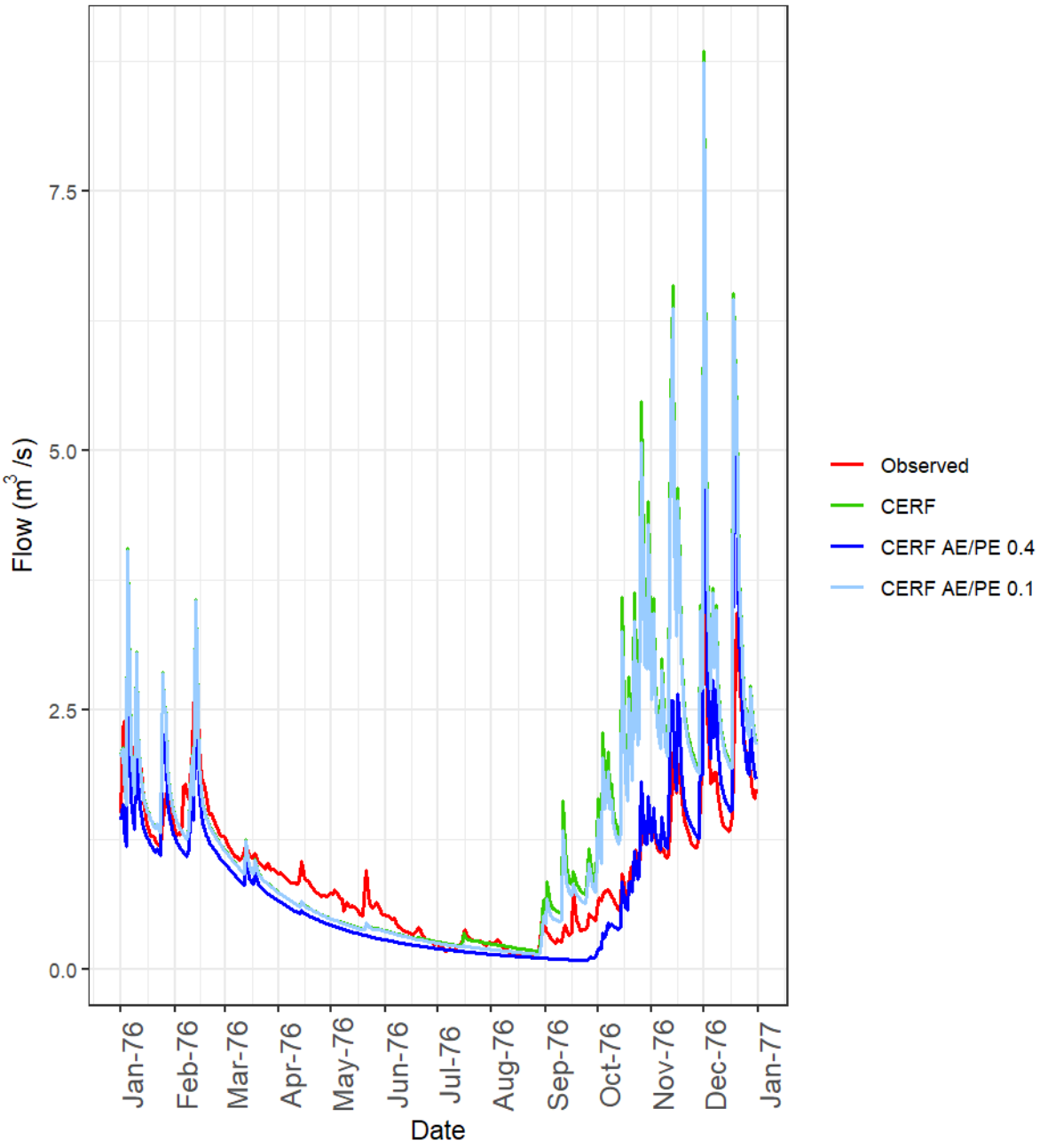

Figure 16. Time series of flows for 33044 for 1976 presenting the difference between the baseline model and setting a minimum AE/PE ratio.

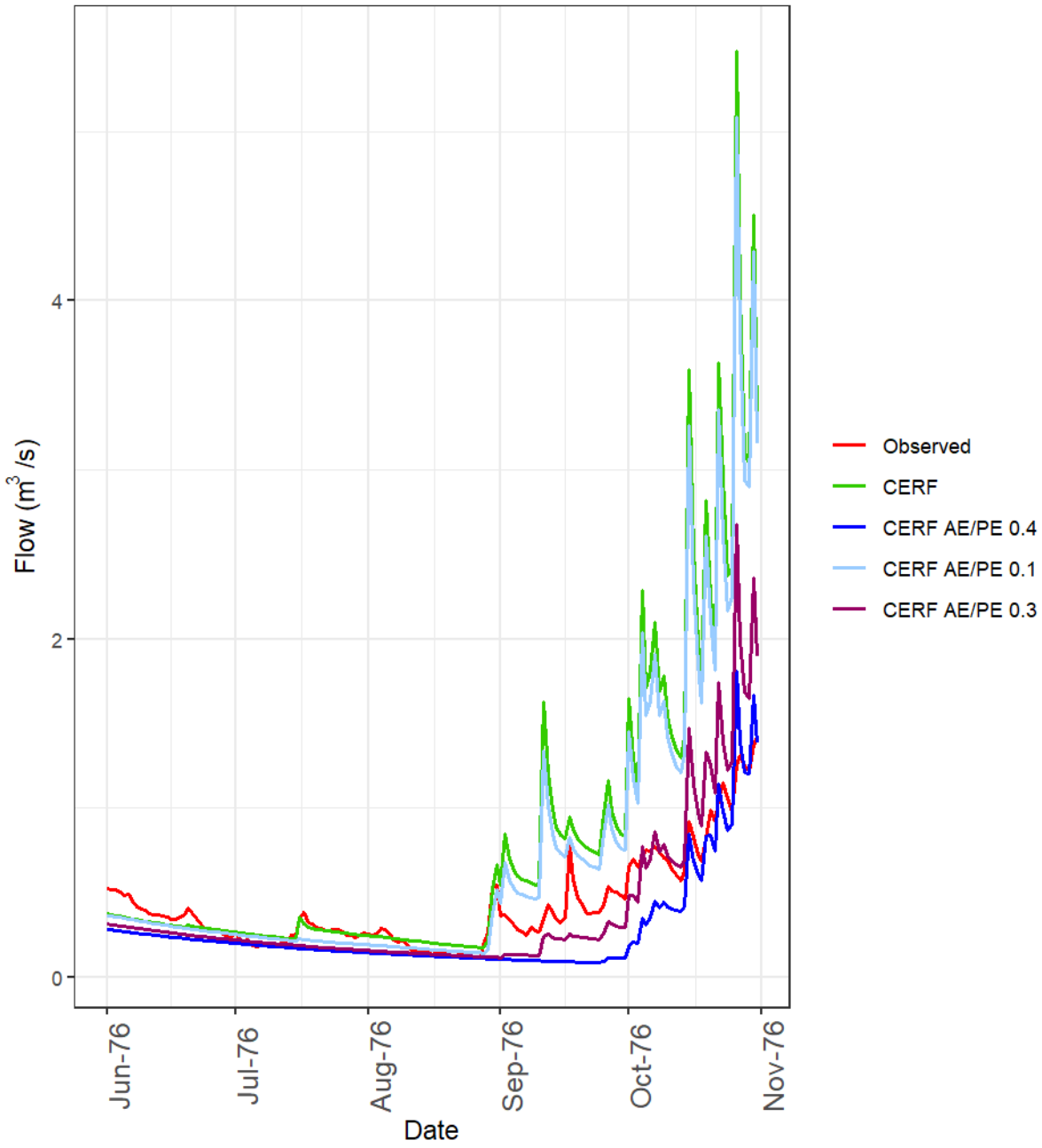

Figure 17. Time series of flows for 33044 for summer 1976 presenting the difference between the baseline model and setting a minimum AE/PE ratio, together with the final AE/PE of 0.3.

Conclusion

The model structure that was therefore taken forward for full calibration included both the soil moisture distribution for the loss model and the implementation of a minimum AE/PE value.

Appendix 2: Gauging stations used within the CERF2-HadUK development dataset.

Gauging Station NRFA ID	Name	Within ROI Dataset	Added as in Benchmark Dataset	Added as has forest as dominant or sub dominant
1001	Wick at Tarroul	Y		
2002	Brora at Bruachrobie		Y	
3003	Oykel at Easter Turnaig	Y		
4003	Alness at Alness	Y		
4005	Meig at Glenmeanie	Y		
6011	Tarff at Ardachy Bridge	Y		
7001	Findhorn at Shenachie	Y		
7002	Findhorn at Forres	Y		
7003	Lossie at Sheriffmills			Y
7004	Nairn at Firhall	Y		
7005	Divie at Dunphail	Y		
7009	Mosset Burn at Wardend Bridge	Y		
8001	Spey at Aberlour	Y		
8004	Avon at Delnashaugh	Y		
8006	Spey at Boat o Brig	Y		
8009	Dulnain at Balnaan Bridge	Y		
8013	Feshie at Feshie Bridge	Y		
9001	Deveron at Avochie	Y		
9002	Deveron at Muiresk	Y		
9003	Isla at Grange	Y		
9004	Bogie at Redcraig	Y		
9005	Allt Deveron at Cabrach	Y		
10002	Ugie at Inverugie	Y		
10003	Ythan at Ellon	Y		
11001	Don at Parkhill	Y		
11002	Don at Haughton	Y		
11003	Don at Bridge of Alford	Y		
11004	Urie at Pitcaple	Y		
12001	Dee at Woodend	Y		
12002	Dee at Park	Y		
12003	Dee at Polhollick	Y		
12005	Muick at Invermuick	Y		
12006	Gairn at Invergairn	Y		
12007	Dee at Mar Lodge	Y		
12008	Feugh at Heugh Head	Y		
13001	Bervie at Inverbervie	Y		
13002	Luther Water at Luther Bridge	Y		
13004	Prosen Water at Prosen Bridge	Y		
13005	Lunan Water at Kirkton Mill	Y		
13007	North Esk at Logie Mill	Y		
13008	South Esk at Brechin	Y		
13009	West Water at Dalhouse Bridge	Y		
13012	South Esk at Gella Bridge	Y		
14001	Eden at Kemback	Y		
14002	Dighty Water at Balmossie Mill	Y		
15008	Dean Water at Cookston	Y		
15014	Ardle at Kindrogan	Y		
15023	Braan at Hermitage	Y		
15024	Dochart at Killin	Y		
15025	Ericht at Craighall	Y		
15039	Tilt at Marble Lodge	Y		
16003	Ruchill Water at Cultybraggan	Y		
16007	Ruthven Water at Aberuthven	Y		
17003	Bonny Water at Bonnybridge	Y		

Gauging Station NRFA ID	Name	Within ROI Dataset	Added as in Benchmark Dataset	Added as has forest as dominant or sub dominant
17004	Ore at Balfour Mains	Y		
17005	Avon at Polmonthill	Y		
17015	North Queich at Lathro	Y		
17016	Lochty Burn at Whinnyhall	Y		
18001	Allan Water at Kinbuck	Y		
18005	Allan Water at Bridge of Allan	Y		
18010	Forth at Gargunnock	Y		
18013	Black Devon at Fauld Mill	Y		
18020	Loch Ard Burn at Duchray			Y
18021	Loch Ard Burn at Elrig			Y
19002	Almond at Almond Weir	Y		
19004	North Esk at Dalmore Weir	Y		
19006	Water of Leith at Murrayfield	Y		
19007	Esk at Musselburgh	Y		
19017	Gogar Burn at Turnhouse	Y		
19020	Almond at Whitburn	Y		
20001	Tyne at East Linton	Y		
20003	Tyne at Spilmersford	Y		
20005	Birns Water at Saltoun Hall	Y		
20007	Gifford Water at Lennoxlove	Y		
21003	Tweed at Peebles	Y		
21005	Tweed at Lyne Ford	Y		
21006	Tweed at Boleside	Y		
21008	Teviot at Ormiston Mill	Y		
21009	Tweed at Norham	Y		
21012	Teviot at Hawick	Y		
21013	Gala Water at Galashiels	Y		
21015	Leader Water at Earlston	Y		
21016	Eye Water at Eyemouth Mill	Y		
21017	Ettrick Water at Brockhoperig	Y		
21018	Lyne Water at Lyne Station	Y		
21019	Manor Water at Cademuir	Y		
21021	Tweed at Sprouston	Y		
21022	Whiteadder Water at Hutton Castle	Y		
21023	Leet Water at Coldstream	Y		
21024	Jed Water at Jedburgh	Y		
21026	Tima Water at Deephope	Y		
21027	Blackadder Water at Mouth Bridge	Y		
21031	Till at Etal	Y		
21032	Glen at Kirknewton	Y		
21035	Till at Heaton Mill	Y		
22001	Coquet at Morwick	Y		
22002	Coquet at Bygate	Y		
22003	Usway Burn at Shillmoor	Y		
22004	Aln at Hawkhill	Y		
22007	Wansbeck at Mitford	Y		
22008	Alwin at Clennell	Y		
22009	Coquet at Rothbury	Y		
23004	South Tyne at Haydon Bridge	Y		
23006	South Tyne at Featherstone	Y		
23008	Rede at Rede Bridge	Y		
23009	South Tyne at Alston	Y		
23010	Tarset Burn at Greenhaugh	Y		
23011	Kielder Burn at Kielder	Y		
23014	North Tyne at Kielder temporary	Y		
23018	Ouse Burn at Woolsington	Y		
24002	Gaunless at Bishop Auckland	Y		
24003	Wear at Stanhope	Y		
24004	Bedburn Beck at Bedburn	Y		
24006	Rookhope Burn at Eastgate	Y		

Gauging Station NRFA ID	Name	Within ROI Dataset	Added as in Benchmark Dataset	Added as has forest as dominant or sub dominant
24007	Browney at Lanchester	Y		
24008	Wear at Witton Park	Y		
25003	Trout Beck at Moor House	Y		
25005	Leven at Leven Bridge	Y		
25006	Greta at Rutherford Bridge	Y		
25007	Clow Beck at Croft	Y		
25011	Langdon Beck at Langdon	Y		
25012	Harwood Beck at Harwood	Y		
25019	Leven at Easby	Y		
25020	Skerne at Preston le Skerne	Y		
26003	Foston Beck at Foston Mill		Y	
27007	Ure at Westwick	Y		
27024	Swale at Richmond	Y		
27034	Ure at Kilgram Bridge	Y		
27035	Aire at Kildwick Bridge	Y		
27041	Derwent at Buttercrambe	Y		
27042	Dove at Kirkby Mills	Y		
27047	Snaizeholme Beck at Low Houses	Y		
27049	Rye at Ness	Y		
27050		Y		
27051	Crimple at Burn Bridge	Y		
27054	Hodge Beck at Cherry Farm	Y		
27055	Rye at Broadway Foot	Y		
27057	Seven at Normanby	Y		
27071	Swale at Crakehill	Y		
27075	Bedale Beck at Leeming	Y		
27083	Foss at Huntington	Y		
27084	Eastburn Beck at Crosshills	Y		
27085	Cod Beck at Dalton Bridge	Y		
27090	Swale at Catterick Bridge	Y		
28008	Dove at Rocester Weir	Y		
28018	Dove at Marston on Dove	Y		
28025	Sence at Ratcliffe Culey	Y		
28030	Black Brook at Onebarrow	Y		
28031	Manifold at Ilam	Y		
28033	Dove at Hollinsclough	Y		
28038	Manifold at Hulme End	Y		
28041	Hamps at Waterhouses	Y		
28046	Dove at Izaak Walton	Y		
28055	Ecclesbourne at Duffield	Y		
28070	Burbage Brook at Burbage	Y		
29003	Lud at Louth		Y	
29009	Ancholme at Toft Newton		Y	
30002	Barlings Eau at Langworth Bridge	Y		
30004	Lymn at Partney Mill		Y	
30012	Stainfield Beck at Cream Poke Farm	Y		
30015	Cringle Brook at Stoke Rochford	Y		
30018	Honington Beck at Honington	Y		
30033	Brant at Brant Broughton	Y		
31010	Chater at Fosters Bridge	Y		
31016	North Brook at Empingham	Y		
31025	Gwash South Arm at Manton	Y		
32003	Harpers Brook at Old Mill Bridge	Y		
32004	Ise Brook at Harrowden	Y		
33013	Sapiston at Rectory Bridge	Y		
33018	Tove at Cappenham Bridge	Y		
33019	Thet at Melford Bridge		Y	
33029	Stringside at Whitebridge		Y	
33044	Thet at Bridgham	Y		
33063	Little Ouse at Knettishall	Y		

Gauging Station NRFA ID	Name	Within ROI Dataset	Added as in Benchmark Dataset	Added as has forest as dominant or sub dominant
34011	Wensum at Fakenham	Y		
34014	Wensum at Swanton Morley Total	Y		
34018	Stiffkey at Warham	Y		
35008	Gipping at Stowmarket	Y		
36002	Glem at Glemsford	Y		
36003	Box at Polstead	Y		
36007	Belchamp Brook at Bardfield Bridge	Y		
36009	Brett at Cockfield		Y	
36010	Bumpstead Brook at Broad Green		Y	
37005	Colne at Lexden		Y	
37008	Chelmer at Springfield	Y		
37011	Chelmer at Churchend	Y		
37014	Roding at High Ongar	Y		
37020	Chelmer at Felsted	Y		
38026	Pincey Brook at Sheering Hall		Y	
39006	Windrush at Newbridge	Y		
39016	Kennet at Theale	Y		
39019	Lambourn at Shaw	Y		
39020	Coln at Bibury	Y		
39025	Enborne at Brimpton	Y		
39034	Evenlode at Cassington Mill	Y		
39076	Windrush at Worsham	Y		
39090	Cole at Inglesham	Y		
39103	Kennet at Newbury	Y		
39105	Thame at Wheatley	Y		
39110	Coln at Fairford	Y		
39141	Wey at Guildford	Y		
40005	Beult at Stilebridge	Y		
40011	Great Stour at Horton	Y		
40017	Dudwell at Burwash	Y		
40023	East Stour at South Willesborough	Y		
41001	Nunningham Stream at Tilley Bridge	Y		
41011	Rother at Iping Mill	Y		
41013	Huggletts Stream at Henley Bridge	Y		
41016	Cuckmere at Cowbeech	Y		
41022	Lod at Halfway Bridge	Y		
41025	Loxwood Stream at Drungewick	Y		
41026	Cockhaise Brook at Holywell	Y		
41027	Rother at Princes Marsh		Y	
41028	Chess Stream at Chess Bridge	Y		
41029	Bull at Lealands	Y		
41035	North at Brookhurst	Y		
42003	Lymington at Brockenhurst	Y		
42004	Test at Broadlands	Y		
42012	Anton at Fullerton	Y		
42014	Blackwater at Ower	Y		
42024	Test at Chilbolton Total	Y		
43003	Avon at East Mills Total	Y		
43005	Avon at Amesbury	Y		
43006	Nadder at Wilton	Y		
43014	East Avon at Upavon East	Y		
44011	Asker at Bridport East Bridge	Y		
45001	Exe at Thorverton	Y		
45002	Exe at Stoodleigh	Y		
45003	Culm at Woodmill	Y		
45004	Axe at Whitford	Y		
45005	Otter at Dotton	Y		
45008	Otter at Fenny Bridges	Y		
45011	Barle at Brushford	Y		
45012	Creedy at Cowley	Y		

Gauging Station NRFA ID	Name	Within ROI Dataset	Added as in Benchmark Dataset	Added as has forest as dominant or sub dominant
45013	Tale at Fairmile	Y		
46002	Teign at Preston	Y		
46003	Dart at Austins Bridge	Y		
46005	East Dart at Bellever	Y		
46006	Erme at Ermington	Y		
47001	Tamar at Gunnislake	Y		
47004	Lynher at Pillaton Mill	Y		
47005	Ottery at Werrington Park	Y		
47007	Yealm at Puslinch	Y		
47008	Thrushel at Tinhay	Y		
47009	Tiddy at Tideford	Y		
47014	Walkham at Horrabridge	Y		
47015	Tavy at Ludbrook	Y		
47016	Lumburn at Lumburn Bridge	Y		
47018	Thrushel at Hayne Bridge	Y		
47019	Tamar at Polson Bridge	Y		
47020	Inny at Bealsmill	Y		
48003	Fal at Tregony	Y		
48004	Warleggan at Trengoffe	Y		
48005	Kenwyn at Truro	Y		
48010	Seaton at Trebrownbridge	Y		
49001	Camel at Denby	Y		
49002	Hayle at St Erth	Y		
49004	Gannel at Gwills	Y		
50001	Taw at Umberleigh	Y		
50002	Torridge at Torrington	Y		
50003	Taw at Sticklepath	Y		
50006	Mole at Woodleigh	Y		
50007	Taw at Taw Bridge	Y		
50008	Lew at Gribbleford Bridge	Y		
50009	Lew at Norley Bridge	Y		
50010	Torridge at Rockhay Bridge	Y		
50012	Yeo at Veraby	Y		
51001	Doniford Stream at Swill Bridge	Y		
51003	Washford at Beggearn Huish	Y		
52003	Halsewater at Halsewater	Y		
52004	Isle at Ashford Mill	Y		
52005	Tone at Bishops Hull	Y		
52007	Parrett at Chiselborough	Y		
52010	Brue at Lovington	Y		
52016	Currypool Stream at Currypool Farm	Y		
52025	Hillfarrance Brook at Milverton	Y		
53005	Midford Brook at Midford	Y		
53006	Frome (Bristol) at Frenchay	Y		
53008	Avon at Great Somerford		Y	
53009	Wellow Brook at Wellow	Y		
53013	Marden at Stanley	Y		
53017	Boyd at Bitton	Y		
53025	Mells at Vallis	Y		
53028	By Brook at Middlehill	Y		
54008	Teme at Tenbury	Y		
54012	Tern at Walcot	Y		
54016	Roden at Rodington	Y		
54018	Rea Brook at Hookagate	Y		
54020	Perry at Yeaton	Y		
54022	Severn at Plynlimon flume	Y		
54025	Dulas at Rhos-y-pentref	Y		
54027	Frome at Ebley Mill	Y		
54029	Teme at Knightsford Bridge	Y		
54034	Dowles Brook at Oak Cottage	Y		

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54036	Isbourne at Hinton on the Green	Y		
54038	Tanat at Llanyblodwel	Y		
54041	Tern at Eaton upon Tern	Y		
54052	Bailey Brook at Ternhill	Y		
54084	Cannop Brook at Parkend			Y
54085	Cannop Brook at Cannop Cross			Y
54088	Little Avon at Berkeley Kennels	Y		
54090	Tanllwyth at Tanllwyth Flume			Y
54098	Cam at Cambridge	Y		
54099	Coley Brook at Coley Mill	Y		
55003	Lugg at Lugwardine	Y		
55004	Irfon at Abernant	Y		
55008	Wye at Cefn Brwyn		Y	
55011	Ithon at Llandewi	Y		
55012	Irfon at Cilmery	Y		
55013	Arrow at Titley Mill	Y		
55014	Lugg at Byton	Y		
55016	Ithon at Disserth	Y		
55017	Chwefru at Carreg-y-wen	Y		
55018	Frome at Yarkhill	Y		
55021	Lugg at Butts Bridge	Y		
55022	Trothy at Mitchel Troy	Y		
55025	Llynfi at Three Cocks	Y		
55026	Wye at Ddol Farm	Y		
55028	Frome at Bishops Frome	Y		
55029	Monnow at Grosmont	Y		
55034	Cyff at Cyff flume		Y	
56002	Ebbw at Rhiwderin	Y		
56003	Honddu at The Forge Brecon	Y		
56005	Lwyd at Ponthir	Y		
56007	Senni at Pont-Hen-Hafod	Y		
56013	Yscir at Pont-Ar-Yscir	Y		
56015	Olway Brook at Olway Inn	Y		
56019	Ebbw at Aberbeeg	Y		
57004	Cynon at Abercynon	Y		
57008	Rhymney at Llanedeyrn	Y		
58001	Ogmore at Bridgend	Y		
58005	Ogmore at Brynmenyn	Y		
58007	Llynfi at Coytrahen	Y		
58008	Dulais at Cilfrew	Y		
58010	Hepste at Esgair Carnau	Y		
58011	Thaw at Gigman Bridge	Y		
58012	Afan at Marcroft Weir	Y		
59001	Tawe at Ynystanglws	Y		
59002	Loughor at Tir-y-dail	Y		
60002	Cothi at Felin Mynachdy	Y		
60003	Taf at Clog-y-Fran	Y		
60004	Dewi Fawr at Glasfryn Ford	Y		
60005	Bran at Llandovery	Y		
60006	Gwili at Glangwili	Y		
60009	Sawdde at Felin-y-cwm	Y		
60012	Twrch at Ddol Las	Y		
61001	Western Cleddau at Prendergast Mill	Y		
61003	Gwaun at Cilrhedyn Bridge	Y		
62001	Teifi at Glanteifi	Y		
62002	Teifi at Llanfair	Y		
63001	Ystwyth at Pont Llolwyn	Y		
63003	Wyre at Llanrhystud	Y		
63004	Ystwyth at Cwm Ystwyth	Y		
64001	Dyfi at Dyfi Bridge	Y		

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64002	Dysynni at Pont-y-Garth	Y		
64004	Twymyn at Cemmaes Road	Y		
65001	Glaslyn at Beddgelert	Y		
65005	Erch at Pencaenewydd	Y		
65006	Seiont at Peblic Mill	Y		
65007	Dwyfor at Garndolbenmaen	Y		
65008	Peris at Nant Peris	Y		
65014	Colwyn at Hafod Wydr	Y		
66004	Wheeler at Bodfari		Y	
66005	Clwyd at Ruthin Weir	Y		
66011	Conwy at Cwmlanerch	Y		
66012	Lledr at Pont Gethin	Y		
67005	Ceiriog at Brynkinalt Weir	Y		
67010	Gelyn at Cynefail	Y		
67013	Hirnant at Plas Rhiwedog	Y		
67018	Dee at New Inn	Y		
67025	Clywedog at Bowling Bank	Y		
67028	Ceidiog at Llandrillo	Y		
68001	Weaver at Ashbrook	Y		
68003	Dane at Rudheath	Y		
68004	Wistaston Brook at Marshfield Bridge	Y		
68005	Weaver at Audlem	Y		
68044	Dane at Hug Bridge	Y		
69042	Ding Brook at Naden Reservoir	Y		
71001	Ribble at Samlesbury		Y	
71004	Calder at Whalley Weir		Y	
71006	Ribble at Henthorn	Y		
71008	Hodder at Hodder Place	Y		
71009	Ribble at New Jumbles Rock	Y		
71011	Ribble at Arnford	Y		
72003	Hindburn at Wray	Y		
72004	Lune at Caton	Y		
72005	Lune at Killington	Y		
72007	Brock at upstream of A6	Y		
72009	Wenning at Wennington	Y		
72011	Rawthey at Brigflatts	Y		
72014	Conder at Galgate	Y		
72015	Lune at Lunes Bridge	Y		
73003	Kent at Burneside	Y		
73005	Kent at Sedgwick	Y		
73006	Cunsey Beck at Eel House Bridge	Y		
73009	Sprint at Sprint Mill	Y		
73011	Mint at Mint Bridge	Y		
73013	Rothay at Miller Bridge House	Y		
73014	Brathay at Jeffy Knotts	Y		
73015	Keer at High Keer Weir	Y		
74001	Duddon at Duddon Hall	Y		
74005	Ehen at Braystones	Y		
74006	Calder at Calder Hall	Y		
74007	Esk at Cropple How	Y		
75007	Glenderamackin at Threlkeld	Y		
75017	Ellen at Bullgill	Y		
76005	Eden at Temple Sowerby	Y		
76008	Irthing at Greenholme	Y		
76010	Petteril at Harraby Green	Y		
76011	Coal Burn at Coalburn			Y
76014	Eden at Kirkby Stephen	Y		
77002	Esk at Canonbie	Y		
77003	Liddel Water at Rowanburnfoot	Y		
77004	Kirtle Water at Mossknowe	Y		

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78003	Annan at Brydekirk	Y		
78004	Kinnel Water at Redhall	Y		
78005	Kinnel Water at Bridgemuir	Y		
78006	Annan at Woodfoot	Y		
79002	Nith at Friars Carse	Y		
79003	Nith at Hall Bridge	Y		
79004	Scar Water at Capenoch	Y		
79005	Cluden Water at Fiddlers Ford	Y		
79006	Nith at Drumlanrig	Y		
80001	Urr at Dalbeattie	Y		
80005	Dargall Lane at Loch Dee	Y		
81002	Cree at Newton Stewart	Y		
81004	Bladnoch at Low Malzie	Y		
81005	Piltanton Burn at Barsolus	Y		
81006	Water of Minnoch at Minnoch Bridge	Y		
81007	Water of Fleet at Rusko	Y		
82001	Girvan at Robstone	Y		
82003	Stinchar at Balnowlart	Y		
83003	Ayr at Catrine	Y		
83004	Lugar Water at Langholm	Y		
83005	Irvine at Shewalton	Y		
83006	Ayr at Mainholm	Y		
83007	Lugton Water at Eglinton Castle	Y		
83008	Annick Water at Dreghorn	Y		
83009	Garnock at Kilwinning	Y		
83010	Irvine at Newmilns	Y		
83011	Ayr at Wellwood	Y		
83013	Irvine at Glenfield	Y		
84003	Clyde at Hazelbank	Y		
84004	Clyde at Sills of Clyde	Y		
84005	Clyde at Blairston	Y		
84012	White Cart Water at Hawkhead	Y		
84013	Clyde at Daldowie	Y		
84014	Avon Water at Fairholm	Y		
84015	Kelvin at Dryfield	Y		
84018	Clyde at Tulliford Mill	Y		
84020	Glazert Water at Milton of Campsie	Y		
84022	Duneaton at Maidencots	Y		
84026	Allander Water at Milngavie	Y		
84029	Cander Water at Candermill	Y		
84037	Douglas Water at Happendon	Y		
85002	Endrick Water at Gaidrew	Y		
85003	Falloch at Glen Falloch		Y	
85004	Luss Water at Luss	Y		
89002	Linne nam Beathach at Victoria Bridge	Y		
89003	Orchy at Glen Orchy	Y		
89004	Strae at Glen Strae	Y		
89005	Lochy at Inverlochy	Y		
89008	Eas Daimh at Eas Daimh	Y		
89009	Eas a' Ghaill at Succoth	Y		
90003	Nevis at Claggan	Y		
92002	Allt Coire nan Con at Polloch	Y		
93001	Carron at New Kelso		Y	
96001	Halladale at Halladale	Y		
96003	Strathy at Strathy Bridge	Y		
101002	Medina at Shide	Y		
102001	Cefni at Bodffordd	Y		
105001	Snizort at Skeabost	Y		