ROBIN

Reference observatory of basins for international hydrological climate change detection

Network Criteria

The aim of Reference Hydrological Networks (RHNs) is to observe the effect of variations in climate on hydrology (Stahl et al., 2010). To do this RHNs need to be defined based on catchments with stable conditions which have as little human influence as possible, and which are gauged by stations producing reliable streamflow data. This is to prevent spurious trends resulting from human impacts (e.g., abstractions/withdrawals, reservoir operations) or poor-quality data (e.g., step changes due to instrument changes) (Whitfield et al., 2012).

The ROBIN project aims to develop a global RHN network. While RHNs are well established in many countries (e.g., see Whitfield et al. 2012, Burn et al. 2012), in many, others' efforts to establish RHNs are at early stages, or have not commenced. Members of the ROBIN Network have already led some efforts to establish networks of RHN catchments, or at least RHN-like catchments, across international boundaries (e.g., Stahl et al. 2010; Hodgkins et al. 2017). In such ventures, it has often proved difficult to develop a suitable set of criteria for inclusion of sites – not least because there are very different definitions of what constitutes a 'natural' catchment and 'good quality data' between (and even within) countries. In some parts of the world RHNs can be based on truly 'pristine' unaltered catchments, whereas in a majority of localities, some degree of human disturbance must be tolerated. Moreover, there is always a trade-off between having exacting RHN criteria, which by definition, results in a limited number of sites and ensuring good coverage and representativeness of the network.

Within ROBIN we aim to balance the need for near-natural catchments against network density, and therefore propose an inclusive two-level approach to gauging stations within the ROBIN Network.

Data from Level 1 gauging stations would be directed towards analysis of extreme flows (both high and low) where the highest quality and most complete data from 'pristine' catchments (or as close to this as possible) is required. Data from Level 2 gauging stations would be used for analysis of less sensitive hydrological variables such as monthly, seasonal or annual mean flows and water balances.

The two levels are intended to give a more flexible approach to balance the requirements of robust data analysis with good coverage of global geographies and hydrological regimes. In the case of Level 1 criteria, they are heavily influenced by those used in the Low Flows Study (Hodgkins et al., in prep).

ROBIN Network Criteria Summary

The ROBIN Network Criteria is summarised below, and the four elements that make up the criteria are explored further below this:

- Catchment development and artificial influences
- Data quality
- Record length
- Missing data

The criteria are in many ways qualitative in their nature which allows for a degree of flexibility in station inclusion, and we accept that compromise may be required to ensure there is a geographically representative network for the globe. The local knowledge of the ROBIN Partners is key to ensuring the network is representative and the inclusion of stations is appropriate.

ROBIN Network Criteria Summary

Level 1 Network	**Level 2 Network**
Largely free from human disturbances such as urbanisation (≤ 10% of the catchment), river engineering and water abstractions. Modest net impact of all influences on low flows and high flows and any impacts stable over time. No known major changes in land use likely to impact streamflow regime.	Fairly free from human disturbances such as urbanisation (≤ 20% of the catchment), river engineering and water abstractions. Modest net impact of all influences on monthly and annual flows and any impacts stable over time.
Very high-quality daily mean river flow data capable of reliably representing high and low flows. Appropriate metadata.	High to fair quality daily mean river flow data capable of reliably representing monthly average flow conditions with appropriate metadata.
Record length of at least 40 years	Record length of at least 20 years – countries are welcome to flag catchments that are close to making the 20 year record.
No data gaps longer than three years.	

Catchment Development and Artificial Influences

To detect climate-driven trends we need to analyse river basins that are undisturbed by human impacts. Ideally catchments should be pristine but can be considered 'near natural' if reasonably free from human disturbances such as urbanisation, river engineering and water abstractions and therefore represent a natural flow regime such that the effects of climate-driven changes in river flow can be discerned from the noise of more direct human influences.

In many RHN initiatives, including the UK Benchmark Network, a pragmatic approach has been taken where some degree of influence is tolerated, provided that the river approximates a natural regime – influences should still be modest, have a limited net impact on flows (water abstractions and returns, e.g. sewage treatment discharges, can be tolerated provided the *net* effect is modest) and ideally any influences should be stable over time (Harrigan et al., 2018). Recognising the challenges of finding stations that are suitably natural across the flow range, the UK has adopted 'sub-networks' of the RHN suitable for analysing high and average flows but not low flows (and vice versa) for example.

Hence, for ROBIN, the impact of catchment development and artificial influences on the catchment should be minimal or at least stable although this should be based on judgement and local expertise. We acknowledge definitions of near-natural are likely to differ country-to-country and to some extent that there is a limitation of the number of catchments that could be called legitimately pristine due to them being situated in or near populated areas. We propose different criteria for the two levels, with Level 1 being the closest to approximating 'pristine' conditions and analogous to previous international efforts (Hodgkins et al. 2017; Hodgkins in prep). Level 1 is designed to enable the analysis of extremes including low and high flows, whereas Level 2 the analysis of variables such as monthly and annual averages.

Catchment Development and Artificial Influences Criteria	
Level 1 Network	**Level 2 Network**
Largely free from human disturbances such as urbanisation (≤ 10% of the catchment), river engineering and water abstractions. Modest net impact of all influences on low flows and high flows and any impacts stable over time. No known major changes in land use likely to impact streamflow regime.	Fairly free from human disturbances such as urbanisation (≤ 20% of the catchment), river engineering and water abstractions. Modest net impact of all influences on monthly and annual flows and any impacts stable over time.

Data Quality

Ideally, only stations that are considered to record high quality, fit-for-purpose streamflow data and adequate metadata should be considered for inclusion in the ROBIN Network. Stations should also have homogeneous time series, i.e., there should not be major step-changes resulting from changes to gauging structures or instrumentation. Definitions of data quality is different in different countries (or regions within) depending on their circumstances and it is important to recognise that historical elements of records may reduce quality but still provide utility by allowing much longer record lengths. Assessment of data quality should be based on judgement and local expertise. A flexible approach to this is required within ROBIN. The two levels listed below have different criteria for data quality depending on the type of analysis each level is intended to support.

Data Quality Criteria	
Level 1 Network	**Level 2 Network**
Very high quality daily mean river flow data capable of reliably representing high and low flows and appropriate metadata.	High to fair quality daily mean river flow data capable of reliably representing monthly average flow conditions with appropriate metadata.

Record Length

Flow record lengths should be as long as possible so that decadal variability can be distinguished from longer term trends. Record length is critical in the detection of trends in hydrological variables, and it has been shown in many studies that the results of trend analysis are dependent on the chosen period, which can have a significant impact on trend magnitude and direction (Dixon et al., 2006; Hannaford et al., 2013).

In trend analyses, study periods are usually selected to represent a trade-off between record length and network density. Within ROBIN we support the use of the longest river flow datasets that are available but recognise the need for a sufficient number of stations to be included in the network.

We propose any ROBIN station should have a minimum record length of 20 years (Level 2 Network), however for use in the Level 1 Network the record length must be of more than 40 years.

Record Length Criteria	
Level 1 Network	**Level 2 Network**
Record length of at least 40 years.	Record length of at least 20 years – countries are welcome to flag catchments that are close to making the 20 year record.

Missing Data

Missing values can lead to biased results in statistical and hydrological analyses and therefore within ROBIN, to conduct a robust analysis of river flow data, missing data should be kept to a minimum. Therefore, we propose that stations with data gaps no longer than a three year period would be acceptable for the ROBIN network and this criterion is applicable to both levels. A percentage is chosen to reflect a wide range of record lengths meaning a set number of years may not be appropriate.

Missing Data Criteria
Level 1 and 2 Network
No data gaps longer than three years.

References

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