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Global Composite Runoff Fields on Observed River Discharge and Simulated Water Balances

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Global, Composite Runoff Fields Based on Observed River Discharge and Simulated Water Balances

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Abstract

The present report demonstrates the potential of combining observed river discharge information with climate-driven Water Balance Model in order to develop composite runoff fields which are consistent with observed discharges. Such combined runoff fields preserve the accuracy of the discharge measurements and simultaneously the spatial and temporal distribution of simulated runoff, thereby providing the “best estimate” of terrestrial runoff over large domains.

The method applied in this study utilize a gridded river network at 30-minute spatial resolution to represent the riverine flow pathways and to link the continental land mass to river channels. Selected gauging stations from the Global Runoff Data Centre data archive were co-registered to a simulated topological network (STN-30p) developed at University of New Hampshire. Inter-station regions between gauging stations along STN-30p network were identified. Inter-station discharge and runoff were calculated to compare observed runoff with outputs from water balance model (WBM) simulation. Correction coefficients based on the ratio of observed and simulated runoff for inter-station areas were calculated and applied against simulated runoff to create composite runoff fields.

The resulting composite runoff fields (UNH-GRDC Composite Runoff Fields V1.0) are released along with the present report to the scientific community. Besides the final product, intermediate data sets, such as station attributes and long-term monthly regimes of the selected gauging stations, the simulated topological network (STN-30p), STN-30p derived attributes for the selected stations and gridded fields of the inter-station regions along STN-30p are also released.

The present study also demonstrates some applications of the composite runoff fields. Besides calculating regional statistics of the continental runoff distribution, the study assessed the monitored portion of the continental land mass and discharge. A potential approach in using the composite runoff fields to develop corrected precipitation fields is also presented.

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Introduction

Spatially-distributed runoff estimates are normally based on water balances using climate data such as precipitation, air temperature, vapor pressure, wind speed, etc. (depending on the complexity of the evaporation function used in the water balance model). The potential errors in the observed precipitation - widely recognized in the climate research community [34] - considerably limit the expected accuracy of the runoff estimates based on climate variables.

The rationale to validate components of the hydrological cycle against observed runoff is discharge can be measured more accurately than other components of the land-based energy and water cycles with perhaps the exemption of temperature [14]. The accuracy of river discharge measurements are in the range of 10-20% which is much higher than what can be achieved in measuring precipitation [11]. Climate models at present do not adequately recognize drainage basin processes and the lateral runoff at the continental scale. Available observed runoff data sets have not yet been adequately used in model calibration and validation, which is one of the reasons, why present climate models show marked discrepancies between observed and modeled runoff [8]. More recently, atmospheric scientists have realized the value of river discharge data as a source of information for calibrating and validating climate models [10], [23].

Even though, discharge is an accurate measure of the integrated terrestrial runoff, it does not give information on the spatial distribution of the runoff within the watershed. Disaggregation of the river discharge signal is necessary when spatially distributed runoff information is needed. Early works of Baumgartner and Reichel (1975) and Korzoun et. al. (1977) estimated global runoff using manual techniques to develop spatially distributed runoff fields on the annual basis [1], [13].

The Global Runoff Data Centre¹ (GRDC) and Institute for the Study of Earth Ocean and Space, University of New Hampshire, Durham, USA have teamed to develop methods and data products allowing for the re-distribution of observed global river discharge data from GRDC data archives along grid-based, simulated river networks at 30-minute (~ 50 km at the equator) spatial resolution developed at UNH. The products of this initial joint effort are gridded monthly mean composite runoff fields (UNH-GRDC Composite Runoff Fields V1.0) on a 30-minute global grid, but the intermediate data sets, such as the simulated river network and the co-registered discharge gauging stations data, will also be released to the global research community.

The disaggregation techniques implemented within the present report distribute observed discharge data over a simulated river network by incorporating global water balance model runoff estimates developed at UNH [29], [27], [33], [32] to provide information on the spatial and temporal distribution of runoff. The merging of water balance model runoff with re-distributed observed discharge offers at present the best estimate of the geography of terrestrial runoff where the amount of runoff is constrained by observed discharge while at the same time the spatial distribution of water balance is preserved.

¹GRDC operates under the auspices of the World Meteorological Organization (WMO) and is hosted by the Federal Institute of Hydrology (BfG) in Koblenz, Germany.

1 Geographic Co-Registration of Simulated River Network and Gauged River Flows

The key element to re-distribute gauge-based discharge data across the terrestrial surface is to co-register individual discharge observation stations to a simulated river network. The Global Simulated Topological Network at 30-minute spatial resolution (STN-30p) [29] and allied river-based geographical information system (Global Hydrological Archive and Analysis System, GHAAS) developed at UNH were used in the present context.

1.1 Key features of the Global Simulated Topological Network

The Simulated Topological Network (*Figure 1*) at a 30 *minute* grid cell resolution organizes the $\sim 60,000$ half degree continental land cells into 6152 river basins with sizes ranging from a few hundred km^2 to $5.8 \times 10^6 km^2$. Out of the 6152 river basins represented in STN-30p, 1123 have more than 10,000 km^2 catchment area (~ 5 cells) which could be considered as the smallest catchment area that a 50 *km* network potentially can represent. Our experience with STN-30p [29] shows, that typically river basins with $\geq 25,000 km^2$ can be represented accurately with STN-30p.

The Simulated Topological Network is not simply a flow direction grid at 30-minute resolution, but a set of derived data sets, which makes the representation of river systems more comprehensive. First, every river segment (grid cell with flow direction) has a set of attributes such as basin identifier, upstream catchment area, main-stem length, distance to receiving endpoint downstream, stream order using Strahler's system [24], etc. Furthermore, the attribute table associated with individual river segments is sorted by basin identifier and catchment area. The management of the river segment attributes adds significant overhead compared to simply managing the flow directions, but offers substantial improvement in network analysis, since the attribute information is stored instead of being re-generated every time when needed. Sorting the attribute information is particularly useful in flow accumulation procedures. A detailed description of STN-30p data structures is given in Appendix A.

Beside the river segment attributes, STN-30p maintains information at the river basin level (e.g. basin name, basin area, main-stem length, Strahler stream order, etc.). A total of 397 basins (out of the 1123 basins with more than 10,000 km^2 catchment area) were named by co-registering STN-30p to the GEMS/GLORI (Global Register of River Inputs) data base [19]. Appendix B gives the list of named STN-30p basins with STN-30p derived attributes.

1.2 GRDC Discharge Gauging Station Data Set

GRDC collects and maintains a large set of river discharge data with global coverage. A WWW-based catalog of available data and a user desk assist users to select discharge data for a variety of research purposes. Access to the database is regulated by GRDC's Policy Guidelines for the Dissemination of Data and Costing of Services [7]. The GRDC's discharge data set has the advantage over publicly available global data sets (such as UNESCO/UNH RivDIS [31], [28], [30]) of having continuous updates for many of its stations.

Potential Simulated Topological Networks (STN-30p)

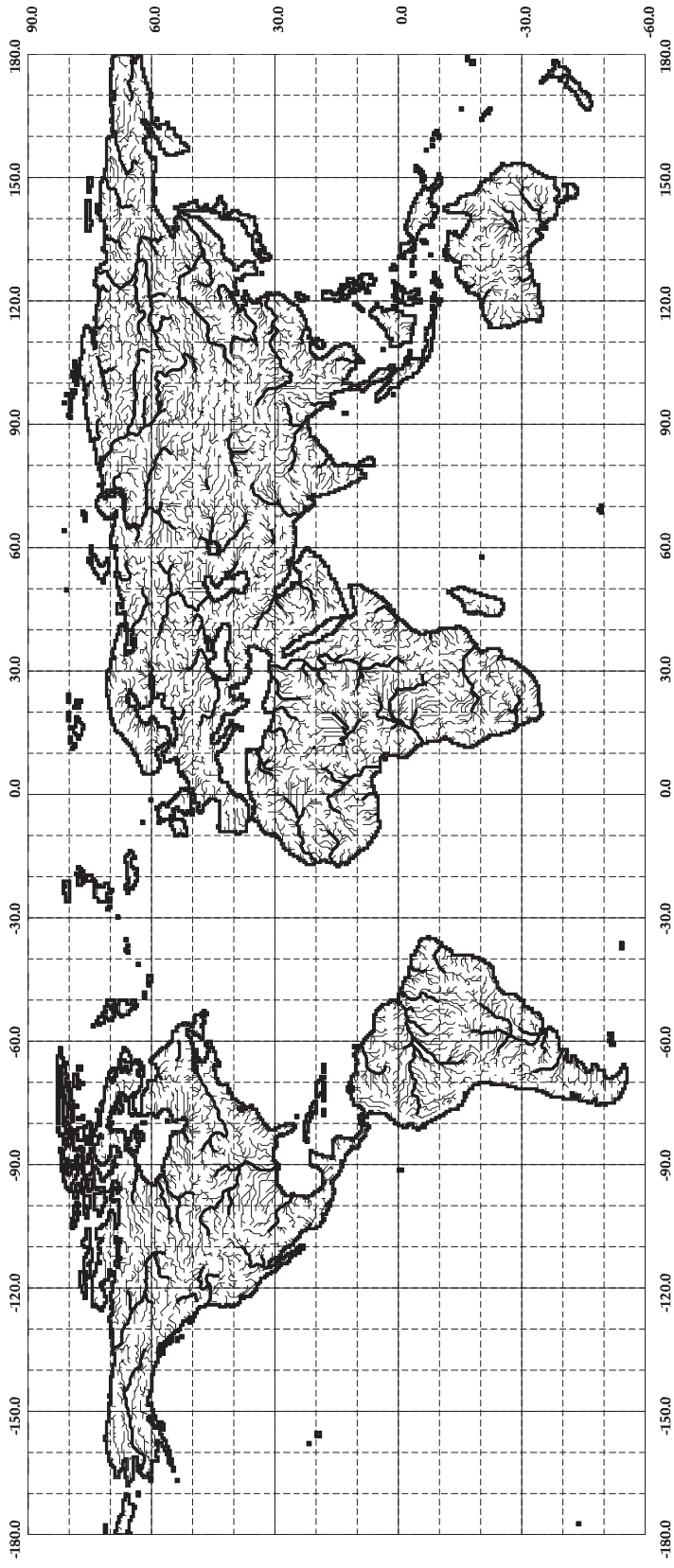


Figure 1: Simulated Topological Networks at 30-minute resolution. A partial inventory is given representing only second or higher order STN-30p rivers segments (using Strahler system).

GRDC Selected Discharge Gauging Stations

1347 Sites

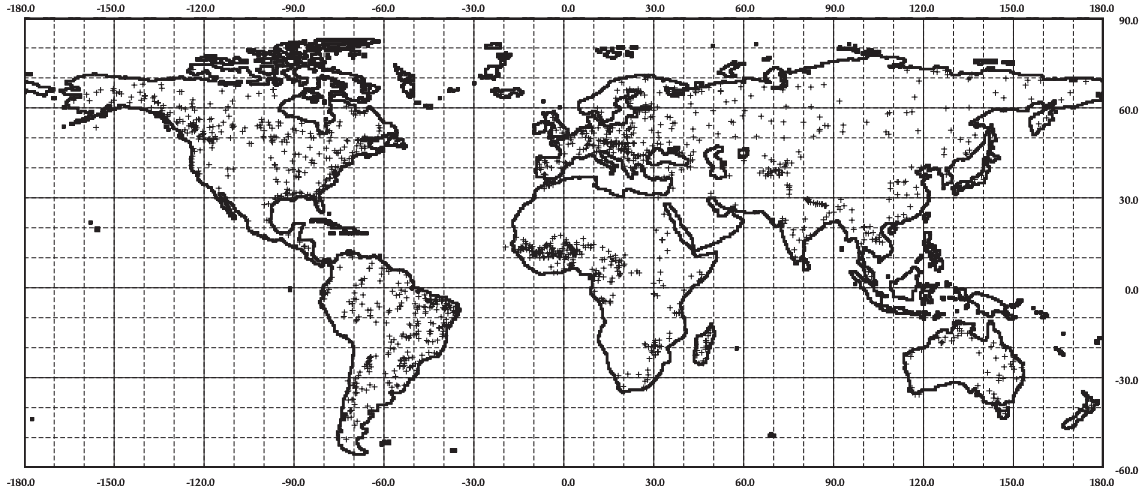


Figure 2: GRDC selected discharge gauging stations.

As an important part of its activities, GRDC is providing analyses and data products for release to the global research community. The release of two datasets on CD-ROM is planned for March 1999. The CD-ROM provides long-term monthly discharge of 198 gauging stations close to mouth of rivers draining into the world oceans in addition to percentile graphs and flow accumulation curves; another data set consists of long term monthly discharge from 1,348 gauging stations with tributaries larger than 2500 km^2 and time series exceeding 12 years with less the 10 % missing data (*Figure 2*). Both data sets also contain maximum and minimum values from these stations.

Figure 3 shows the number of operating stations throughout the observational record in a similar subset (≥ 12 years of record, $\geq 2500 \text{ km}^2$ catchment area) of UNESCO/UNH RivDIS data set vs. the GRDC 1348 selected sites. This demonstrates the improvement in time series coverage in the GRDC data set compared to publicly available data sets.

Since the average grid cell area in STN-30p is around 2250 km^2 and a single grid cell cannot be expected to represent basin catchment areas realistically, the 1348 GRDC stations were further reduced in number for the present study by selecting 861 candidate stations with more than $10,000 \text{ km}^2$ catchment area. This catchment size is still below the $25,000 \text{ km}^2$ limit that STN-30p can resolve reliably, but retains some smaller sites, which may still work well for predicting spatially distributed runoff within our 30-minute resolution framework.

Since the aim of the present study was to develop climatologically-averaged monthly runoff fields, the mean monthly discharge time series associated with the discharge gauging stations were averaged over the time period of the observation records. Unfortunately, the time period of the observation varies station by station [9], therefore the resulting monthly discharge regimes are not fully consistent.

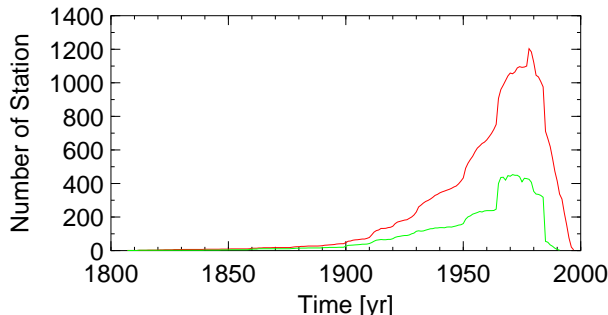


Figure 3: Number of operating stations over time in GRDC and UNESCO/UNH RivDIS V1.0 data sets.

1.3 Co-registering Discharge Gauging Stations to STN-30p

The most important step in the development of disaggregated runoff fields is the proper co-registration of discharge gauging sites to a simulated river network which allows the inter-comparison of simulated to reported catchment area associated with each station. STN-30p (V5.12), documented in Vörösmarty et al [29] was used in the present work. This data set has been validated against several independent atlases and station-based attribute sources, such as the UNH edition of the UNESCO global selected discharge series [31], and R-ArcticNet, a pan-Arctic discharge data set including station data from Russian, Canadian and US monitoring archives representing the Arctic region [15]. The GRDC stations were geo-registered to locations on STN-30p which maintained consistent catchment area attributes.

Considering STN-30p simulated vs. GRDC-reported catchment areas at the gauging stations, we note STN-30p’s tendency to overestimate catchment areas [29]. This is due to the fact that STN-30p represents potential routing (i.e. the river networks that would be formed if sufficient runoff were available to produce discharge everywhere), while GRDC-reported catchment area represent the contributing upstream area only.

In addition to displaying and visually inspecting the one-to-one correspondence between reported and simulated catchment areas, normalized errors were computed for each station. One common approach to computing normalized error is

$$\varepsilon_c = \frac{X_{sim} - X_{obs}}{X_{obs}} 100\% \quad (1)$$

- ε_c - classic normalized error [%]
- X_{sim} - simulated value
- X_{obs} - observed value

However, equation 1 has the disadvantage of being asymmetric, since its lower limit is -100% while its upper limit is $+\infty\%$. A symmetric normalized error term was introduced and given as

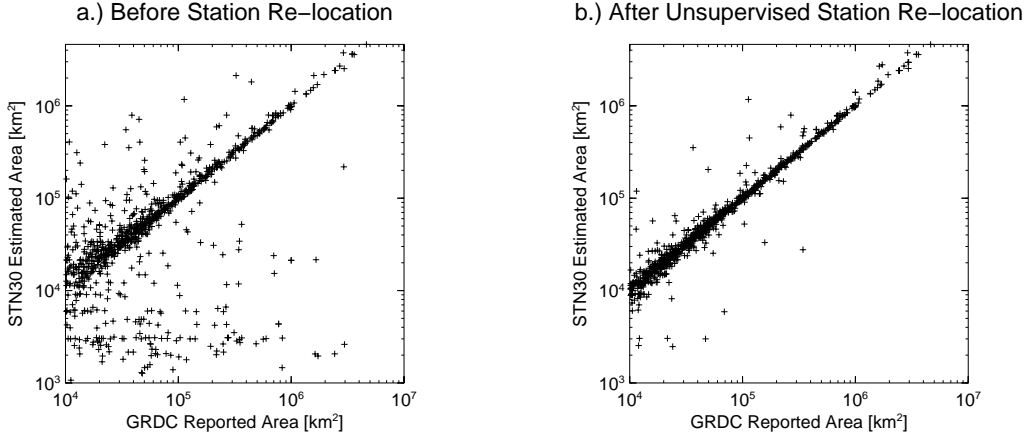


Figure 4: Comparison of GRDC reported catchment areas to STN-30p simulated subbasin areas at the Original and Re-located GRDC gauging sites (using automated unsupervised re-location).

$$\varepsilon_{sym} = \frac{X_{sim} - X_{obs}}{\max(X_{obs}, X_{sim})} 100\% \quad (2)$$

The first step in co-registering gauging stations to the STN-30p simulated network was to assign STN-30p grid cells to GRDC gauging stations. This yielded many inconsistencies in terms of reported and STN-30p derived catchment area (*Figure 4a*). We then applied an automated search algorithm that positioned sites within neighboring STN-30p grids that yielded a best match to GRDC-reported catchment area (*Figure 4b*). This apparent improvement proves the good performance of the STN-30p network and robustness of the unsupervised relocation procedure.

After automatic re-location, every site with symmetric error $\varepsilon_{sym} > 15\%$ was individually inspected to identify whether the significant difference in reported area and the STN-30p area was due to station positioning error, STN-30p routing error or error in the GRDC-reported longitude/latitude or catchment area. Sites where the reported and simulated area differences could not be resolved were removed from the selection when a sufficient number of stations in the neighborhood was available. Some stations, which had substantially different reported and STN-30p areas were kept in the data set when their observed long term mean annual discharges were consistent with the neighboring stations. For example, Upington (Zaire) on the Orange River has ~ 10 times larger area in STN-30p than recorded by GRDC, but its discharge is consistent with upstream and downstream neighboring stations.

Co-registration of gauging stations to STN-30p is not only important as an opportunity to validate STN-30p performance and identify potential errors in the discharge station attributes but allows the derivation of a station network topology. The station network topology is defined by a single attribute specifying the next nearest downstream gauging station. The use of a 30-minute gridded network has some limitation in defining station topology since the terms “upstream” and “downstream” are ambiguous when more than one

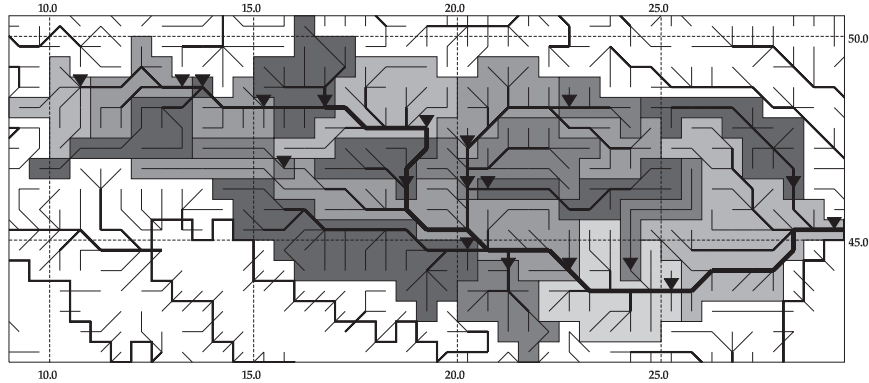


Figure 5: Inter-station areas in the Danube basin.

station shares the same grid-cell. The station data set was screened for multiple stations falling into the same STN-30p grid cell. Stations sharing the same STN-30p cell were either moved to a neighboring grid cell or removed from the analysis. In such situations, the station with the longer and more complete time series was kept. When the length and the quality of the time series were identical, the one with the more contemporary time series was retained. Furthermore, the correspondence of GRDC-recorded and simulated catchment areas was also considered when rejecting or retaining stations.

The co-registered station network and the STN-30p define inter-station regions between gauging stations (*Figure 5*). The station network topology allows the calculation of inter-station areas between gauging stations. The inter-station areas can be calculated both from the GRDC-recorded and the STN-30p estimated catchment areas. As stated earlier STN-30p can reliably represent catchment areas $\geq 25,000 \text{ km}^2$ [29] and occasionally $10,000 \text{ km}^2$ - $25,000 \text{ km}^2$. This is true for inter-station areas as well. Further screening of the gauging station subset was necessary to identify sites which were too close to each other based on the $10,000 \text{ km}^2$ criterion. Similar criteria (better discharge record, better match with simulated catchment area, etc.) to resolve multiple instances of stations falling into the same grid cells were applied here as well. We also considered if improvements could be made by moving sites up or down along the STN-30p network. In such cases the station locations were re-assigned manually.

Further sub-setting of the discharge gauging stations was based on calculated inter-station runoff. Inter-station runoff was calculated based on the long-term mean annual discharge (long-term mean inter-station discharge divided by the inter-station area). Inter-station runoff values were checked for extreme values. One typical extreme situation was the occurrence of negative inter-station runoff (as a result of decreasing observed discharge in the downstream direction). This situation is not without precedent especially in arid regions (e.g. Nile, Niger, etc.). However, it can also reflect errors in the observed discharge database. For instance, there is decreasing discharge between Mohács (the last Danubian station in Hungary) and Bogojevo, the next downstream gauging station on the Danube in the former Yugoslavia. Hydrologists at the Vízgazdálkodási Tudományos Kutató Központ (Water Resources Research Center, VITUKI), Budapest, Hungary, recognize that their dis-

charge rating curves consistently yield higher discharge than those used by the hydrological services of the former Yugoslavia. According to GRDC, a similar situation exists on the Rhein River, where German and Dutch discharge measurements are not fully consistent.

Consistency of the inter-station and the upstream runoff was also checked. For example, two major Brazilian stations (Ipiranga Velho on the Rio Ica, $\sim 13,000$ mm/yr runoff, Manicore, on Rio Madeira ~ 6000 mm/yr runoff) were removed from the discharge station data set because of unrealistically high discharge values. Assuming river basins are exposed to similar climate, wide differences between the inter-station and sub-basin-wide runoff could be indication of errors in the discharge data set, but it is often difficult to judge whether the dramatic difference is in fact unrealistic.

This sub-setting and screening were done manually, with the help of special software called RiverGIS which is part of the Global Hydrological Archive and Analysis System (GHAAS) developed at UNH. RiverGIS is GIS software specially designed for processing river-based spatial data sets. It is a complement to other general purpose GIS software such as ARC/INFO. RiverGIS has some unique functionality geared toward reducing the time-consuming tasks such as manual editing of gridded river networks, comparison of gauging station attributes to STN-30p and delineating inter-station areas. RiverGIS can handle various types of spatial data sets (point, arc, polygon, discrete/continuous grids) both on Cartesian coordinate systems and Geographical (spherical) coordinate systems.

The final selection yielded 663 sites (*Figure 6* and *7*). Appendix D gives the list of the selected stations with GRDC catalog and STN-30p derived attributes. *Figure 8* demonstrates the highly consistent correspondence between GRDC-reported and simulated catchment and inter-station areas. The catchment and inter-station area comparisons show 7.5 and 11% absolute error with 2% and 3% bias respectively. The positive bias is due to the STN-30p tendency mentioned earlier to overestimate catchment areas. *Figure 9* shows the frequency distribution of the symmetric error in comparing reported and STN-30p estimated catchment and inter-station areas.

1.4 Spatial Distribution of the Selected Gauging Stations

The first measure of representativeness of the selected gauging stations is the proportion of continental land mass monitored by these sites. This can be determined by selecting the non-nested (or most downstream) gauging sites (with no further stations downstream) and comparing their catchment area to the continental land mass. The total upstream area of the 298 most downstream stations (*Figure 7*) on the STN-30p network is 67×10^6 km², i.e. more than 50% of the 133×10^6 km² continental land mass in STN-30p (which does not include Antarctica, the glacierized portion of Greenland and the Canadian Arctic Archipelago). If we consider only the actively discharging 93×10^6 km² portion of STN-30p simulated networks, this data set represents (72%) coverage.

As stated in Section 1.1, the 30-minute STN-30p does not always accurately represent catchment areas smaller than 25,000 km². Therefore the discharge gauging stations should partition the STN-30p domain into inter-station regions of 25,000 km² in area or larger. However, these areas should not be too large since (a) modestly sized inter-station regions will preserve important spatial distribution of runoff, and (b) discharge delays within inter-station regions can be neglected. *Table 1* shows the distribution of mean river routing distances within the tributaries of the non-nested stations and the inter-station regions of

"Best" Discharge Gauging Stations

663 Sites

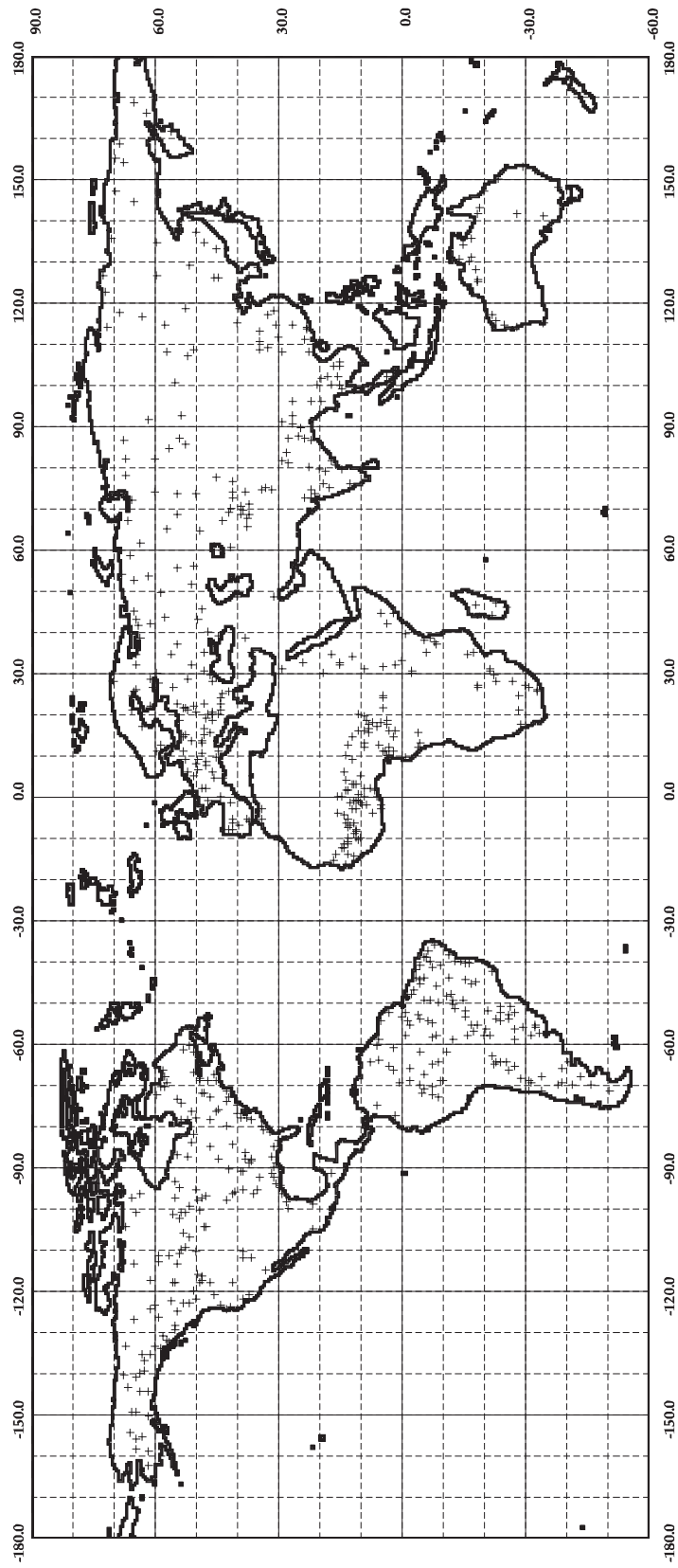


Figure 6: The 663 "Best" discharge gauging stations used in the present study.

Discharge Monitored Regions

-- Inter-station Areas --

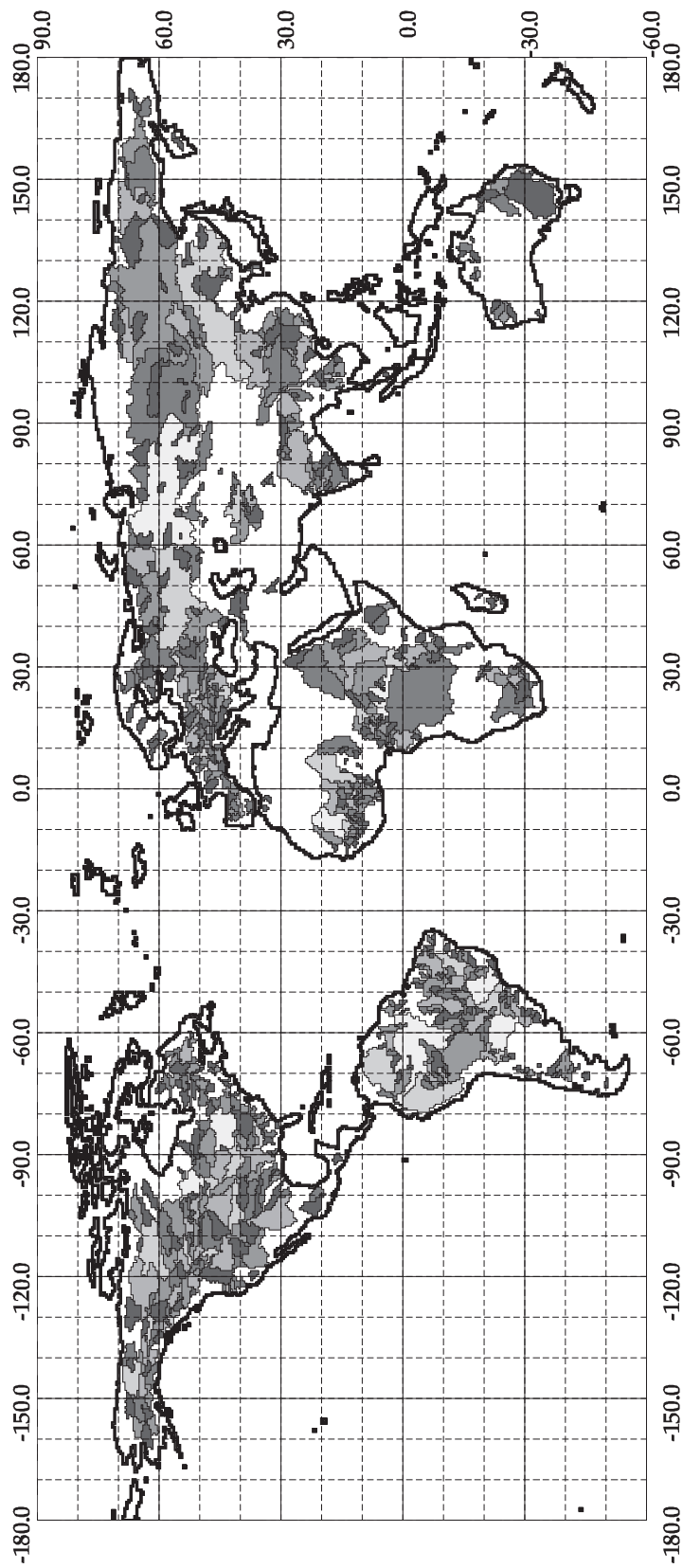


Figure 7: Continental land mass monitored by the selected GRDC stations.

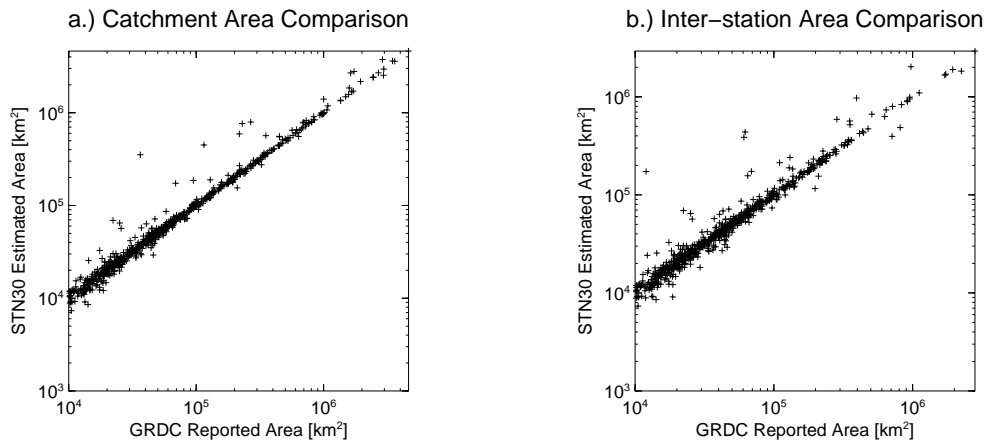


Figure 8: Comparison of GRDC-reported catchment and inter-station areas to those represented by STN-30p.

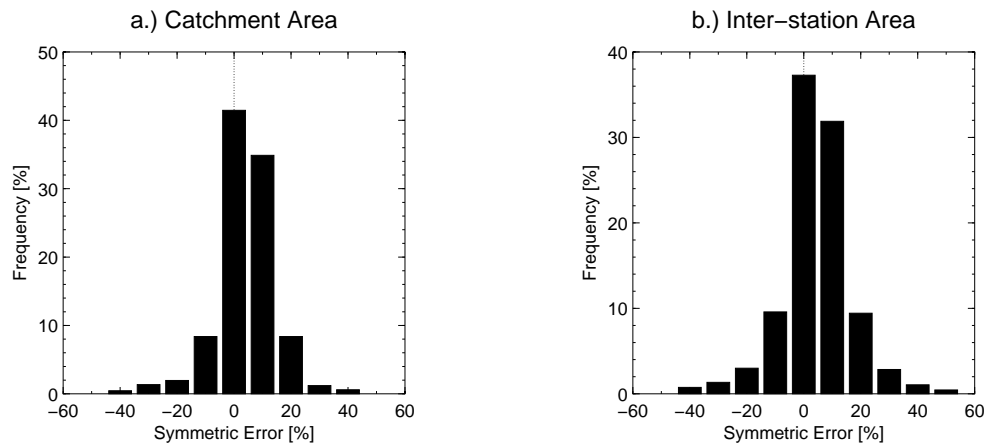


Figure 9: Frequency distribution of Symmetric Error for catchment and inter-station area comparison.

the final subset. However, the extremely long distances are not fully eliminated by using more stations, but the number of inter-station sub-basins with long routing distance is reduced.

Table 1: Distribution of mean river routing distances within monitored regions.

Mean Distance [km]	Non-nested Stations		All (n=663) Stations	
	# of Stations	Percent	# of Stations	Percent
< 100	47	15.8	115	17.4
100 - 1000	231	77.5	537	81.0
1000 - 2000	16	5.4	9	1.4
2000 - 5000	4	1.3	2	0.3
Total	298		663	

Travel time delays along river networks can be estimated by assuming uniform river flow velocity. If we assume average river flow velocity of 1 m/s , then a parcel of water can travel ($3600s/hr * 24hr/day * 30day/mo * 1m/s \simeq$) 2500 km in a month. This means, the monthly inter-station runoff can be estimated from inter-station discharge (expressed as a difference between the discharge measured upstream and the discharge measured at the station) if the maximum travel distance within the inter-station area is significantly less than 2500 km . In this case the inter-station discharge is dominated by the timing of the inter-station runoff and the time delays in discharge traveling along the river systems can be considered negligible in the context of our study.

A distance of 2500 km is long in terms of river networks. The 30-minute STN-30p shows that approximately 90 % of the continental land mass is within 2500 km distance from river mouth along simulated river routes [29]. However STN-30p lengths tend to be shorter than real river lengths, since fine-scale river sinuosity is not considered but this difference is not substantial for most rivers [29]. This suggests that discharge regimes at longer time steps (typically monthly) are dominated by the runoff regime for the major portion of the land mass. This is true for all of the smaller river basins and significant portions of the large rivers. But time delays in the large river networks are not negligible since most of the top 50 river basins have main-stems longer than 2500 km . In the case of large rivers, it is important to partition the basins into smaller inter-station regions where the travel times are negligible on a monthly time scale.

2 Distribution of Continental Runoff

2.1 Estimating Continental Runoff with a Water Balance Model (WBM)

As the First Symposium in Scale Problems in Hydrology in 1982 pointed out, the main problem in hydrology is not the horizontal routing of water, but how much water to route [2]. Estimates of continental runoff can be based on water balance calculations or discharge gauging records.

2.1.1 Water Balance Calculation

Water balance calculations rely on climate variables such as precipitation, air temperature, etc. The first soil moisture budget was given by Thornthwaite's formula [25], [34] as

$$R = P - E - \frac{\partial W}{\partial t} \quad (3)$$

where

$$\begin{aligned} \frac{\partial W}{\partial t} & \text{ - change in soil moisture [mm/day]} \\ P & \text{ - rate of precipitation [mm/day]} \\ E & \text{ - rate of evapotranspiration [mm/day]} \\ R & \text{ - rate of surplus water (runoff and/or recharge) [mm/day]} \end{aligned}$$

The first relatively simple procedure for estimating land-surface evaporation was proposed by Thornthwaite [25], [26]. He introduced the concept of *potential evapotranspiration* (PET) as an upper limit to evapotranspiration in given atmospheric conditions when the evapotranspiration is not limited by water stress. Thornthwaite formulated the soil moisture budget given by equation 3, and proposed to express evapotranspiration as a function of available soil moisture and the rates of precipitation and potential evapotranspiration [34]:

$$E = \begin{cases} P + \beta (W, W^*) [E_0 (T, h) - P], & P < E_0 (T, h) \\ E_0 (T, h) & P \geq E_0 (T, h) \end{cases} \quad (4)$$

where

$$\begin{aligned} T & \text{ - daily average air temperature [}^\circ\text{C]} \\ h & \text{ - duration of the daylight [hour]} \\ E_0 (T, h) & \text{ - potential evapotranspiration [mm/day]} \\ W, W^* & \text{ - soil moisture and soil moisture storage capacity [mm]} \\ \beta (W, W^*) & \text{ - function that relates actual to potential evaporation or,} \\ & \text{ more specifically } [(E - P) / (E_0 - P)] \text{ to } W/W^* \end{aligned}$$

Numerous methods have been proposed to calculate potential evapotranspiration since Thornthwaite published his concept. Federer et al [6] gave a summary of the most frequently used methods. Vörösmarty et. al. studied the impact of the choice of PET method on water-balance estimates [27] and concluded that it had more importance in wet regions, where evapotranspiration is not limited by the availability of water (i.e. $E = E_0$),

than in dry regions where the soil moisture (W) approaches the wilting point (W_0), the $\beta(W, W^*)$ function approaches 0:

$$\lim_{W \rightarrow W_0} \beta(W, W^*) = 0 \quad (5)$$

and the evaporation becomes limited by the precipitation (i.e. $E = P$) [27]. Applying different PET methods on 679 US watersheds Vörösmarty found Hamon’s formula [12] to give the least bias among the “reference crop” methods which are designed to represent a generic land-cover (typically a short, complete green plant cover, employed in experimental plot studies with dry leaf surfaces and “well-watered” soil) [6].

Vörösmarty et. al. applied a variant of the Thornthwaite soil moisture budget as a Water Balance Model (WBM) [27], [32] at continental and global scales. They expressed soil-moisture change ($\frac{\partial W}{\partial t}$) as a function of the soil-moisture (W), the soil’s water holding capacity (W_c), potential evaporation (E_0), precipitation (P_a) available for soil re-charge as rainfall and any snow-melt:

$$\frac{\partial W}{\partial t} = \begin{cases} g(W)(E_0 - P_a) & P_a < E_0 \\ P_a - E_0 & 0 < P_a - E_0 < W_c - W \\ W_c - W & W_c - W < P_a - E_0 \end{cases} \quad (6)$$

where $g(W)$ is a unit-less soil drying function given as

$$g(W) = \frac{1 - e^{\left(\frac{-\alpha W}{W_c}\right)}}{1 - e^{-\alpha}} \quad (7)$$

with α an empirical constant. Evaporation becomes:

$$E = \begin{cases} P_a - \frac{\partial W}{\partial t} & P_a < E_0 \\ E_0 & E_0 < P_a \end{cases} \quad (8)$$

Recent modifications to WBM use quasi-daily time steps to reduce the temporal aggregation bias arising from the use of monthly climatic variables. Monthly precipitation is divided into daily wetting events by applying a probability function based on Rastetter et al. [22]. Precipitation is considered snow when the monthly temperature is below $-1 [C^o]$. Snowmelt is a prescribed function of temperature and elevation as given by Vörösmarty et. al. [32], [27]. Runoff is formed either as snowmelt or when the surplus from the difference between precipitation and evaporation ($P - E$) exceeds soil moisture deficit ($W_c - W$).

WBM maintains a simple runoff detention pool (D_r) to represent the runoff delay caused by water transport through groundwater before it enters river channels. The runoff detention pool dynamics is expressed with the following differential equation:

$$\frac{dD_r}{dt} = (1 - \gamma) R - \beta D_r \quad (9)$$

where R is the soil moisture budget runoff from equation 3 and γ and β are empirical constants. The river runoff (R_r) then becomes:

$$R_r = \gamma R + \beta D_r \quad (10)$$

2.1.2 Applying WBM in the Present Study

The Water Balance Model was used to generate a spatial distribution of monthly mean runoff at 30-minute (longitude x latitude) spatial resolution for the global land mass. The current version of WBM is highly modular, allowing for the assembly of water balance calculation schemes from various components such as different potential evapotranspiration functions or different implementations of the core water balance module (e.g. with or without permafrost). For the present study, the WBM was applied using Hamon’s [12] temperature-based potential evaporation function. Using more sophisticated canopy dependent functions would have required not only more parameterization of the canopy-related parameters, but additional climate variables such as net radiation, vapor pressure and wind speed with unknown error characteristics. By choosing a temperature-based potential evaporation function, the water balance calculation requires only air temperature, precipitation, land cover and soil information, all available globally at the target resolution of this study and with a well-established record in Earth System analysis.

Contemporary land cover classification was assembled by combining Terrestrial Ecosystem Model (TEM) [18] “potential” vegetation overlaid with cultivated areas from Olson’s land-use classification [20]. The TEM/Olson composite vegetation was re-mapped to eight cover types (conifer forest, broad-leaf forest, savannah / shrub-land, grassland, tundra / non-forested wetland, cultivation, desert, open water) which were found to have characteristic evapotranspiration properties [6]. Dominant soil type and texture were from the FAO/UNESCO soil data bank [5]. Land cover classification and dominant soil types were combined to estimate rooting depth and water holding capacity as given by Vörösmarty et. al. [33]. Topographic data were from the ETOPO5 [3] global elevation data set. Climatologically-averaged monthly air temperature and precipitation were from Willmott and Matsuura (*Figure 10*). This data set is a descendent of Legates and Willmott [16], [17] climate fields and was made available to us through an ongoing collaboration.

WBM mean annual runoff is shown on *Figure 11* as an example. *Figure 12* shows the comparison of observed and simulated mean annual runoff averaged over the sub-basins of the selected stations. The spread, and the magnitude of differences look discouraging in terms of WBM performance, but comparing mean annual observed and simulated runoff to annual precipitation (*Figure 13*) suggest that the error in the WBM calculation comes from the precipitation data. WBM Runoff is consistent with the precipitation data used as a driving variable unlike the observed runoff which shows a wide spread and little relationship to observed precipitation. Observed runoff often exceeds the precipitation, which demonstrates a very obvious inconsistency between the two data sets.

Considering the WBM runoff error distribution by catchment area (*Figure 14*) shows WBM performance is significantly better for large basins. The uncertainties in the precipitation distribution show little bias over larger domains, therefore the WBM-based approach can be successfully used to estimate large scale runoff, but it cannot always resolve accurately the distribution of runoff over the terrestrial surface given the apparent problems in the climate fields.

Willmott and Matsuura (1998) Mean Annual Precipitation

30-minute spatial resolution

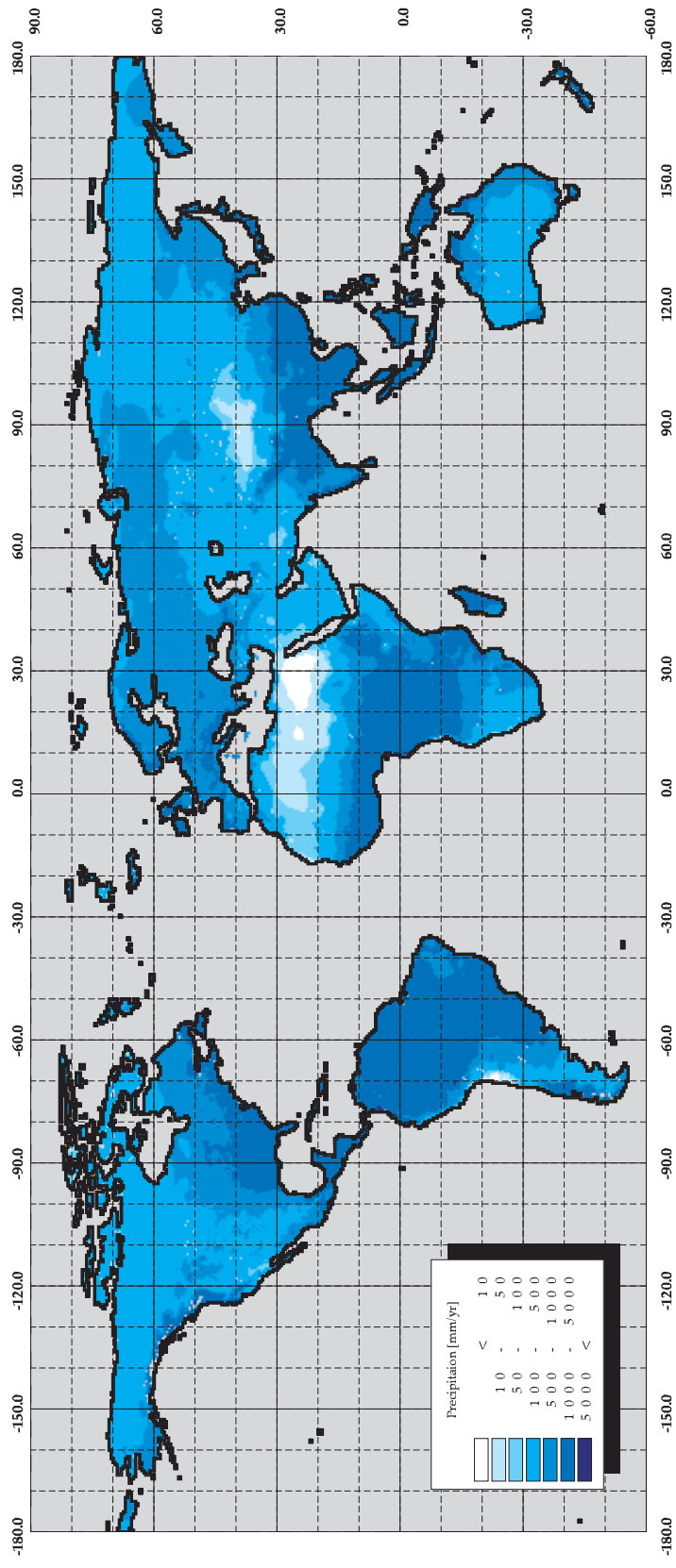


Figure 10: Willmott and Matsuura (1998) mean annual precipitation.

WBM-Simulated Mean Annual Runoff

30-minute spatial resolution

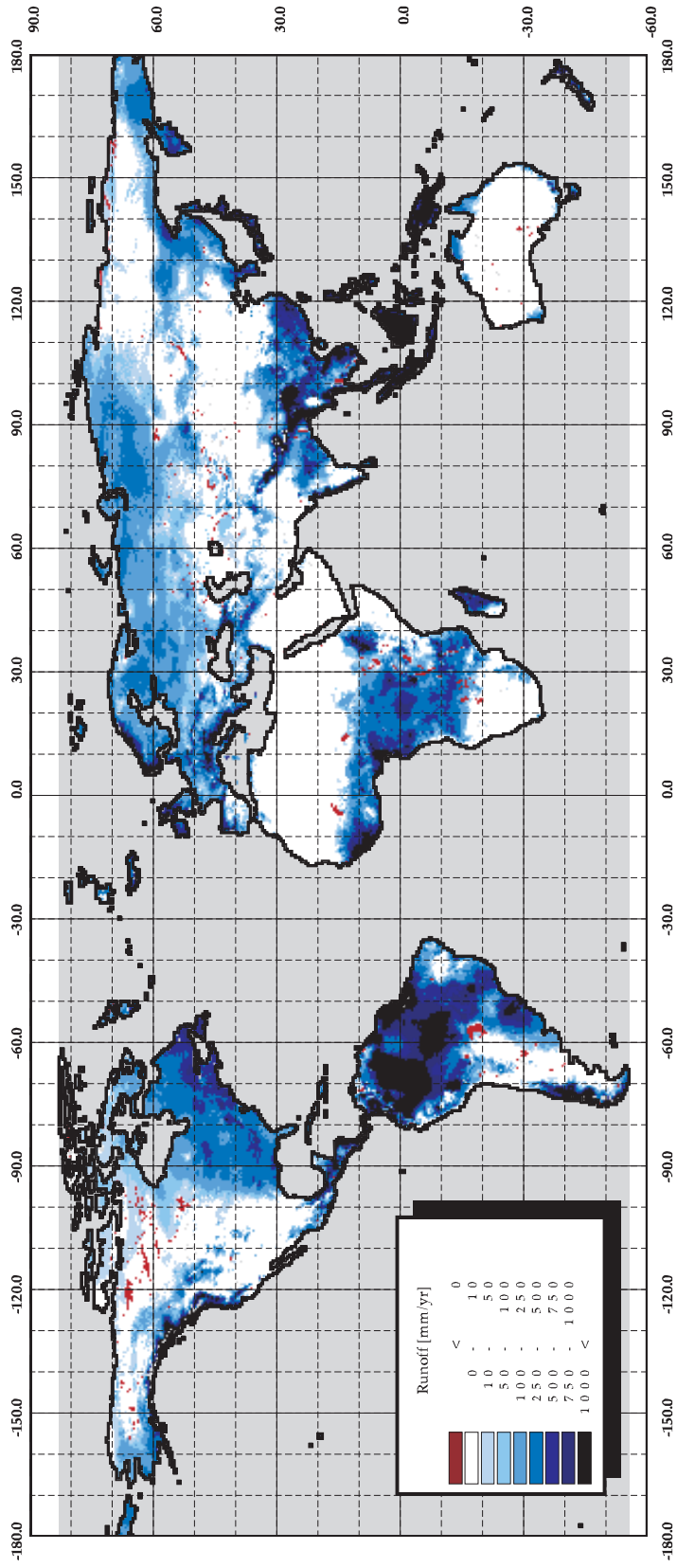


Figure 11: Water Balance Model simulated runoff.

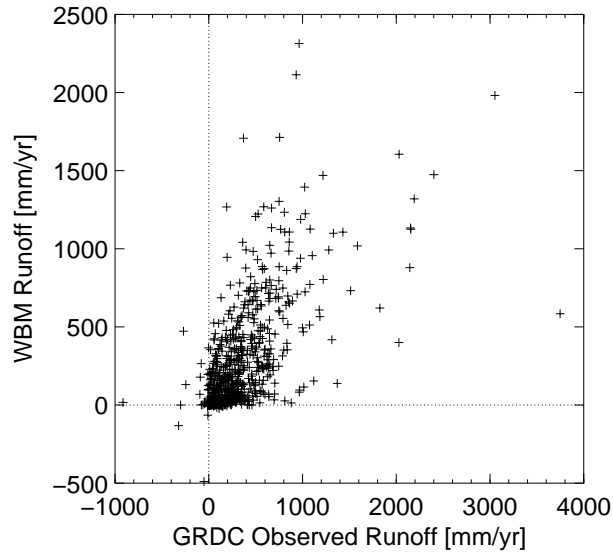


Figure 12: Comparison of observed and simulated sub-basin runoffs.

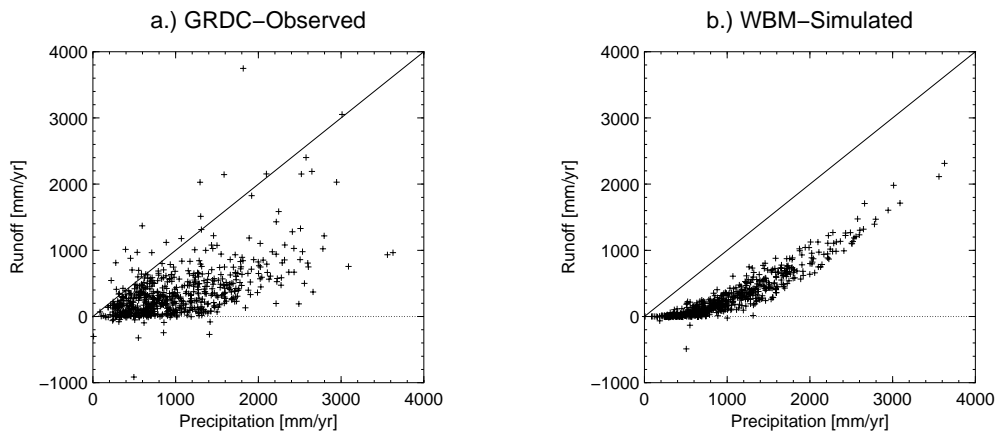


Figure 13: Comparison of Observed precipitation to observed and WBM simulated runoff.

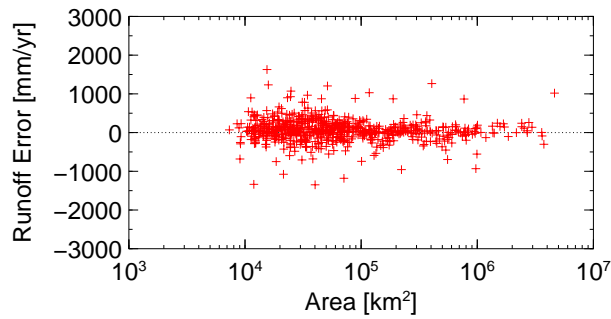


Figure 14: WBM Runoff Error by Catchment Area.

2.2 Creating Composite Runoff Fields

Creating observed runoff fields from observed discharge is ambiguous. As stated earlier, observed discharge is an aggregate signal of terrestrial runoff and spatial disaggregation of discharge requires additional knowledge about the spatial distribution of runoff and the potential time delays along flow pathways. Lacking this information, the only possibility is to assume a uniform spatial distribution and no time delays, i.e. distribute the observed inter-station runoff uniformly over the inter-station areas (*Figure 15*). The observed monthly runoff fields based on this assumption are presented in Appendix F. Note the rather “patchy” pattern of runoff.

As stated above, simulated runoff represents the best potential method of estimating the spatial and temporal pattern of continental runoff, but it is often inherently biased due to inaccuracies in the climate forcings (precipitation in particular). The combination of the two sources of information (observed discharge and simulated runoff) to estimate continental runoff has the possibility of yielding the most reliable assessment at present.

One method to combine water-balance runoff and discharge gauging station data is to use tributaries and inter-station regions of the individual gauging stations in the context of a topological network, and to calculate mean modeled runoff for the defined regions. The simulated mean runoff can be compared to observed runoff over the same domains to calculate a set of correction coefficients for each distinct inter-station area. Assuming there is no substantial year-to-year water storage, the correction coefficients can be calculated on an annual basis to eliminate the impact of travel time delays.

This procedure can be formalized as follows. The mean observed inter-station runoff for inter-station region i can be expressed as:

$$\overline{R}_{oi} = \frac{\overline{Q}_{oi}}{A_{si}} \quad (11)$$

where

$$\begin{aligned} \overline{R}_{oi} & - \text{Mean annual observed inter-station runoff [L/T]} \\ \overline{Q}_{oi} & - \text{Mean annual inter-station discharge [L}^3\text{/T]} \\ A_{si} & - \text{Inter-station area [L}^2\text{]} \end{aligned}$$

The mean water balance runoff in the inter-station region i becomes:

$$\overline{R}_{wi} = \frac{\oint^{A_{si}} R_{wbm} dA}{A_{si}} \quad (12)$$

where

$$\begin{aligned} \overline{R}_{wi} & - \text{Mean annual water balance runoff [L/T]} \\ \overline{R}_{wbm} & - \text{Local annual water balance runoff [L/T]} \end{aligned}$$

Water balance runoff correction coefficient ξ_{si} for inter-station area A_{si} can be calculated as:

$$\xi_{si} = \frac{\overline{R}_{oi}}{\overline{R}_{wi}} \quad (13)$$

The corrected runoff then becomes:

GRDC Observed Mean Annual Runoff

30-minute spatial resolution

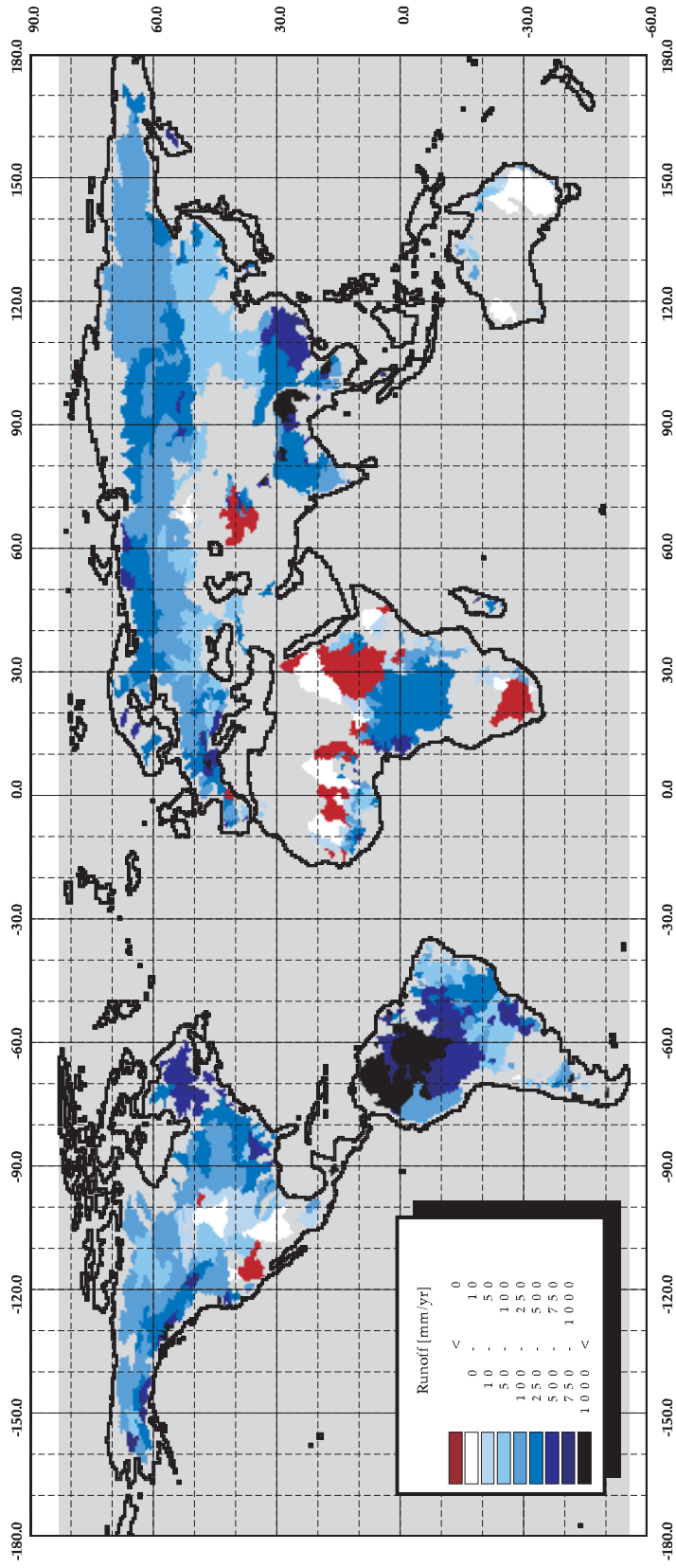


Figure 15: Observed Annual Runoff uniformly distributed along inter-station regions.

$$R_c = \xi_{si} R_{wbm} \quad (14)$$

The water balance runoff correction coefficient (ξ_{si}) can be calculated on an annual basis (i.e. as a time series of annual correction coefficients) or on a long-term annual mean basis. The runoff correction coefficients were calculated for only those inter-station regions where both the observed and the WBM predicted annual runoff was positive.

The runoff correction coefficient (ξ_{si}) can be viewed as a measure of WBM error. Figure 16 shows interesting pattern in terms of water balance error. When the runoff correction coefficient $\xi_{si} < 1$ WBM over-estimates runoff when $\xi_{si} > 1$ represents under-estimation of runoff. According to Figure 16 WBM has a tendency to over-estimate runoff in the tropics with the exception of some portions of the Amazon, while it under-estimates runoff in most of the Arctic basins such as the Ob, Yenisei, Lena, Mackenzie, etc. This is inherent from the precipitation data (Figure 10)

The annual composite runoff field is shown on Figure 17. Monthly composite fields are presented in Appendix H.

WBM Runoff Correction Coefficients

30-minute spatial resolution

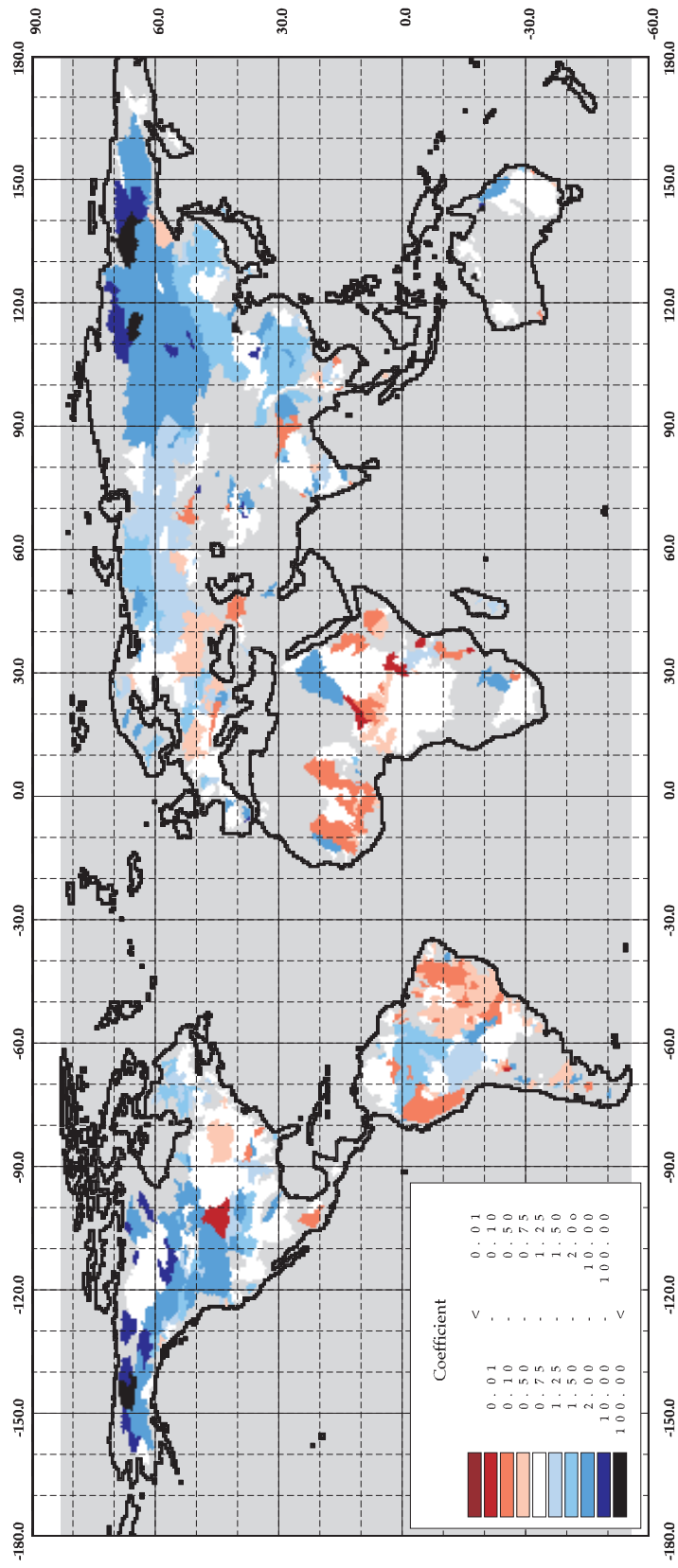


Figure 16: Mean annual runoff correction coefficients.

Composite Mean Annual Runoff

30-minute spatial resolution

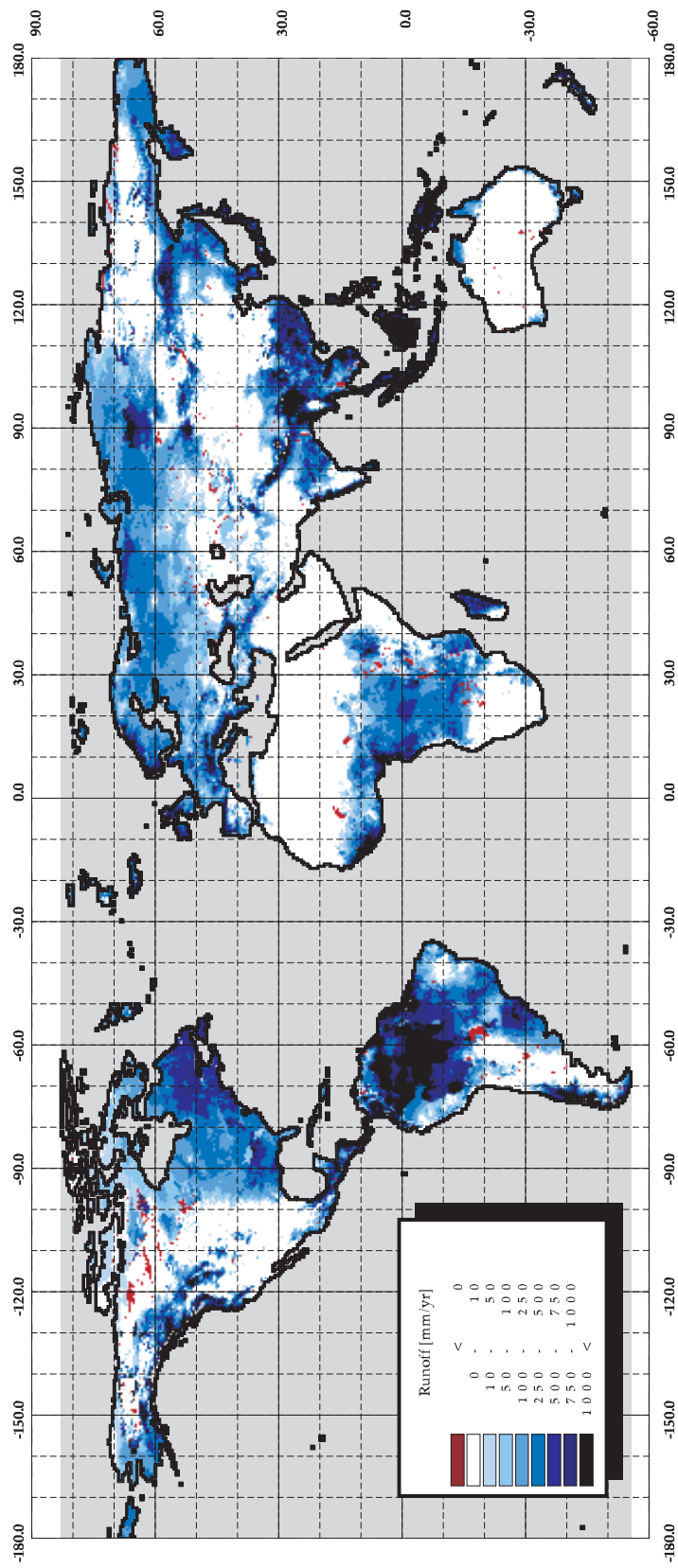


Figure 17: Mean annual combined runoff. Values < 1.0 indicate underestimate and > 1.0 indicate overestimate by WBM

3 Some Applications of the Composite Runoff Fields

Spatially distributed runoff fields have numerous applications ranging from calibrating and validating the soil vegetation atmosphere transfer (SVAT) component of atmospheric models, to providing sustainable water supply estimates in water resource assessments. The scope of the present work has focused on the development of composite runoff fields. We now demonstrate the potential of such a data set by describing some simple applications.

3.1 Characterizing the Distribution of Continental Runoff

One important application of the composite runoff fields is to derive information on the spatial distribution of terrestrial runoff that can be compared to earlier estimates. By putting the runoff fields into the STN-30p context, various statistics and summaries by regions such as continents and receiving water bodies can be calculated (*Table 2*).

Table 2: Distribution of terrestrial runoff [mm/yr] by continents and receiving water bodies.

	Africa	Asia	Australasia	Europe	North America	South America	By Oceans
Arctic Ocean		184		351	79		173
Atlantic Ocean	213			326	279	671	402
Black and Mediterranean Seas	43	137		230			102
Indian Ocean	150	362	38				225
Pacific Ocean		540	456		351	676	498
Endorheic Basins	53	36	0	157	179	108	54
By Continents	143	303	84	268	255	652	290

Table 3: Comparison of Continental Runoff [mm/yr] Estimates.

	Korzoun	GRDC	UNH/GRDC
Africa	153	283	143
Asia	324	288	303
Australasia	280	N/A	84
Europe	283	233	268
North America	339	170	255
South America	685	771	652

Comparing the regional runoff summaries to earlier estimates (such as Korzoun’s Atlas of World Water Balance[13] and GRDC’s current estimate [8]) the degree of agreement varies (*Table 3*). Generally, GRDC and the UNH/GRDC composite shows good agreement in well monitored regions such as Asia, Europe which is not a surprise since these estimates were based on the same discharge data set. The disagreement between the two estimates is higher in dryer regions. Since the GRDC estimate assumes similar runoff in the monitored and un-monitored portions of the continental land-mass, it has the tendency to over-estimate in dry regions like Africa and Australia where the lack of discharge monitoring stations is not only a result of a sparse population, but also the large areas without river networks. UNH/GRDC and Korzoun show better agreement where the disagreement between GRDC and UNH/GRDC is higher (i.e. Africa and South America). Australasia as defined by STN-30p is not really comparable to the other estimates due to the differences in the delineation of the region. The combination of Oceania and Australia as Australasia indeed is questionable inspite of typical cartographic practices. Oceania and Australia have very distinct hydrological characteristics, therefore it would be more appropriate to consider Oceania as part of South-East Asia.

Table 4: Distribution of discharge [km^3/yr] by continents and receiving water bodies.

	Africa	Asia	Australasia	Europe	North America	South America	Total ^a
Arctic Ocean		2067		535	345		2947
Atlantic Ocean	2916			1119	3488	10829	18357
Black and Mediterranean Seas	350	112		707			1169
Indian Ocean	997	3601	193				4802
Pacific Ocean		7266	518		2547	791	11127
Endrorheic Basins	211	368	0	311	97		1075
Total	4474	13414	712	2673	6478	11708	39476

^aIncludes island within major oceans not accounted by continent

Similar to runoff, the discharge by regions can be estimated (*Table 4*). The composite runoff field derived summaries tends to be lower than Korzoun’s [13] and Baumgartner’s [1] estimates (*Table 5*). Some differences might be due to the different delineation of ocean catchments. Furthermore, Korzoun’s estimate includes groundwater flow to ocean, which could be significant in some regions. In general, both Korzoun’s and Baumgartner’s estimate of the continental total discharge flux to ocean is higher than that of the composite runoff field derived in this study.

Table 5: Comparison of continental discharge to oceans [km^3/yr] estimates.

	Korzoun	Baumgartner	UNH/GRDC
Arctic Ocean	5200	2600	2947
Atlantic Ocean	20800	19300	18357
Indian Ocean	6100	5600	4802
Pacific Ocean	14800	12200	11127

3.2 Spatial Coverage of Monitored Discharge

Considering the discharges by region (*Table 4*) and at the non-nested (most downstream) gauging stations within those regions, the percentage of monitored discharge can be assessed (*Table 6*).

Table 6: Percentage of monitored discharge by continents and receiving water bodies.

	Africa	Asia	Australasia	Europe	North America	South America	By Oceans
Arctic Ocean		84.5		57.0	89.6		80.1
Atlantic Ocean	57.3			44.4	53.3	81.0	69.6
Black and Mediterranean Seas	11.4	6.3		59.6			40.1
Indian Ocean	10.8	47.7	23.5				38.9
Pacific Ocean		27.2	4.2		28.2	5.7	24.8
Land	16.0	19.6	0	87.6	57	3.4	40.8
By Continents	41.3	41.2	9.7	55.9	45.4	75.4	52.4

This information by itself can be misleading in terms of the monitoring station coverage, but still it is useful to understand how well the discharge from the continental land mass is monitored in different regions. Using the most downstream station may create the false impression of good data coverage. A good example is South America and particularly the Amazon, which is not an exceptionally well monitored river system, but since the last discharge gauging station at Obidos monitors much of the discharge to ocean from the Amazon basin, and the Amazon delivers a significant fraction of the continental discharge to ocean, South America has an apparently high percentage of monitored discharge.

3.3 Considering Global Continental Discharge Estimates

The global and the continental river discharge estimates published in the scientific literature vary considerably (36,400 [13]; 38,800 [4]; 39,700 [1]; 40,700 [21]; 42,700 [8] km^3/yr). These

differences are partly due to the differences in the set of discharge gauging stations used for the analysis (e.g. GRDC used 198 stations with a total of $52.3 \times 10^6 km^2$ catchment area measuring $18,000 km^3/yr$ discharge, while this report was based on 298 stations with $67 \times 10^6 km^2$ catchment area monitoring $20,700 km^3/yr$ discharge).

Beside the differences in selecting discharge gauging stations, the assumption in extrapolating the measured runoff to un-monitored regions may vary. The simplest approach is to assume similar runoff on the monitored and non monitored portion of the continental land mass. Considering the $133 \times 10^6 km^2$ of total area of the non-glaciarized land-mass this assumption would result in $(20,700 [km^3/yr] \times 133 [10^6 km^2] / 67 [10^6 km^2]) = 41,000 km^3/yr$ annual discharge. Although this approach could be reasonable for some parts of the globe, it fails to recognize the fact that a large portion of the un-monitored regions are actually dry (and there is no river water to monitor). A next approach considers the $93 \times 10^6 km^2$ of actively flowing continental land-mass and assumes the same average runoff as on the observed portion yielding $(20,700 [km^3/yr] \times 93 [10^6 km^2] / 67 [10^6 km^2]) = 28,700 km^3/yr$ annual discharge. This estimate is much lower than any current other estimate published, but the only possibility to increase this number is to assume higher mean runoff on the un-monitored but flowing regions than the observed in the monitored river basins. This finding suggests that the un-monitored but actively flowing portion of the continental land-mass is probably wetter than the monitored average. It is unlikely however that those regions are significantly wetter than the monitored land-mass, therefore lower global river discharge estimates are likely to be more accurate.

The composite runoff fields developed within the present study capture the higher wetness by applying Water Balance Model runoff estimates in the un-monitored regions. The global total discharge estimate of $39,476 km^3/yr$ agrees with several earlier estimates like Baumgartner [1], and L’Vovich [4].

3.4 Simple Precipitation Correction Procedure

Since discharge measurements are typically more accurate than precipitation fields, it would be desirable to develop new techniques, which could incorporate discharge measurements into the estimation of distributed precipitation. A simple approach would be to apply an inverse calculation based on spatially (and temporally) distributed precipitation-runoff (similar to rainfall-runoff) coefficients ω given as

$$\omega = \frac{R}{P} \tag{15}$$

where

- ω - Runoff coefficient
- R - Runoff
- P - Precipitation

The traditional use of runoff coefficients (which represents the fraction of the precipitation forming runoff) is to estimate runoff $R = \omega P$ based on precipitation data in order to forecast discharge. The inverse use of runoff coefficient

$$P = \frac{1}{\omega} R \tag{16}$$

could be used to estimate precipitation from runoff data. This formula can be used only when $\omega \neq 0$, i.e. when the runoff $R \neq 0$. As it was shown in Section 1.3, observed inter-station discharge in regions can be negative when the discharge is decreasing due to river water feeding the groundwater or human water consumption. Since neither negative runoff nor negative precipitation is possible, equation 16 cannot be used when $R \leq 0$.

Traditionally ω is calculated from observed precipitation P and runoff R by equation (15). As was shown in Section 2.1.2, observed precipitation and runoff are often inconsistent, furthermore, the goal of estimating ω is to calculate precipitation based on runoff measurements. A possible approach to estimate spatially (and temporally) distributed ω is to simulated runoff and observed precipitation to compute $\omega_{wbm} = \frac{R_{wbm}}{P}$. As shown in Section 2.1.2, WBM is consistent in terms of reducing precipitation to estimate runoff through its estimate of soil water and groundwater dynamics and evapotranspiration. It is therefore a reasonable assumption to expect WBM to represent the runoff/precipitation ratio somewhat realistically.

Using this assumption, an annual precipitation field was created by calculating WBM runoff coefficient ω_{wbm} on a long-term mean annual basis and applying the ω_{wbm} to the combined mean annual runoff field. The resulting precipitation field represents a combination of our best runoff fields with Willmott and Matsuura (1998) climatological annual precipitation [*Figure 18*](#).

Observed Runoff Corrected Mean Annual Precipitation

30-minute spatial resolution

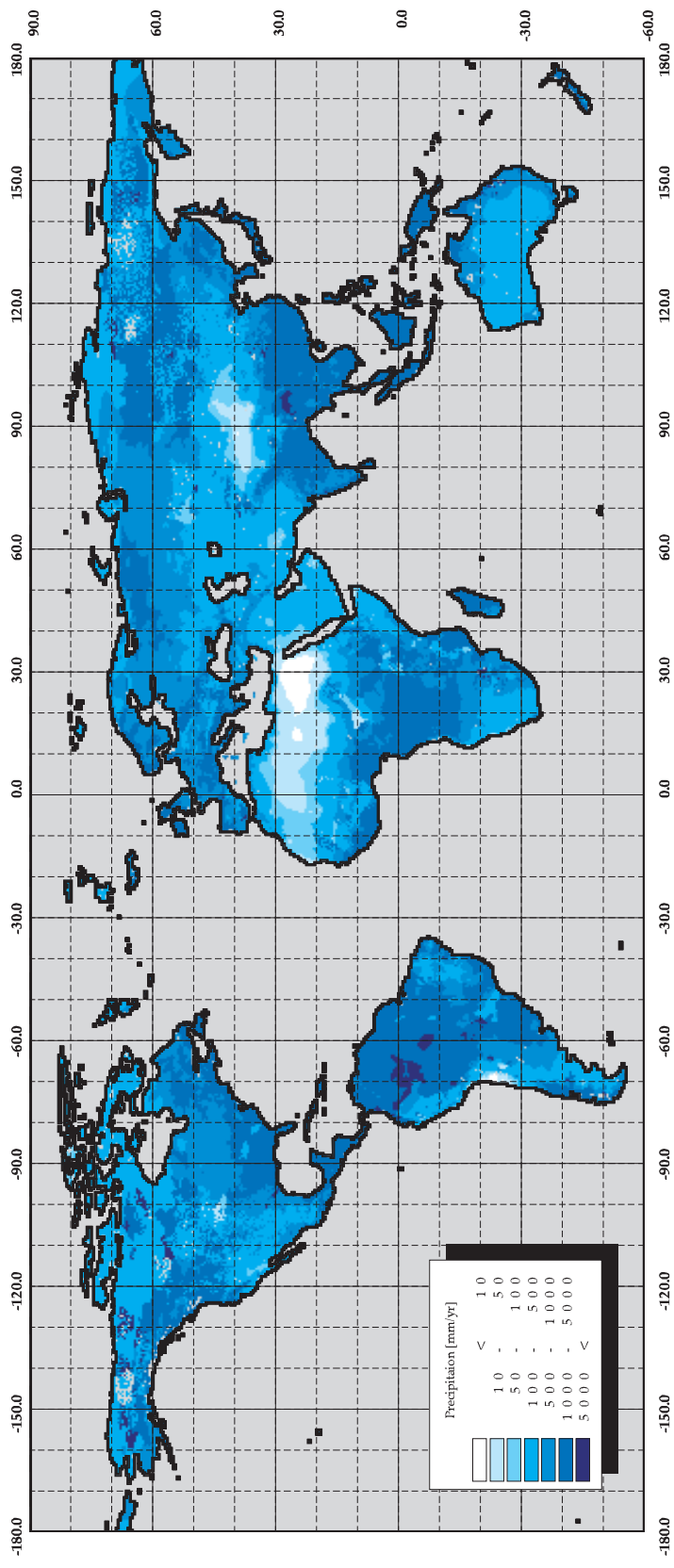


Figure 18: Corrected precipitation field based on discharge observation.

4 Conclusions and Summary

River discharge data represents the most accurate information about terrestrial water cycle, but this information has not been uniformly adopted in Earth Systems studies, such as GCMs or terrestrial productivity models. With the advent of GIS technology and emerging global GIS data sets such as Digital Elevation Models (DEM) and corresponding simulated river routings, the linkage between observed river discharge at individual stations and spatially-distributed fields of runoff can be established. This capability also offers new opportunities to improve the estimates of climate variables such as precipitation and evaporation by closing the water budget at the discharge gauging stations.

This report demonstrates a potential approach to establish a linkage between the spatially distributed runoff and river discharge observation networks. The best available global river discharge data set from GRDC was coupled with a state-of-the-art simulated river network developed by UNH. This exercise demonstrates the difficulties and advantages of linking different geographical data sets. By linking GRDC station data to STN-30p, numerous inconsistencies were found between the two data sets. These inconsistencies were due to either the insufficient resolution of the 30-minute routing or errors in the linked data sets. Linking the two data sets, helped to identify potential problems and often provided information on how to correct the errors discovered.

The coupled discharge gauging station and simulated river networks (which are expected to be important contributions to geo-scientists by themselves) allowed the blending of observed runoff over inter-station regions with simulated water balance estimates driven by long-term mean monthly climate data. By combining observed runoff over inter-station regions with spatially-distributed runoff, spatially distributed runoff fields on long-term mean monthly, seasonal, and annual basis were created. The composite runoff fields are constrained by discharge observations but preserve the spatial and temporal distribution of runoff according to the water balance simulation and are therefore likely to be the most accurate spatially-distributed runoff fields available today.

The composite runoff fields offer the opportunity to analyze the water balance distribution by regions. As an example, some statistics by continents and by receiving water bodies were presented to demonstrate a potential use of the new runoff data set. A further potential of the composite runoff fields is to identify problematic regions represented by current precipitation data sets and to ultimately improve those estimates. A simple approach to correct precipitation estimates by using composite runoff fields and water balance model-derived runoff coefficients was presented. This approach is apparently robust and realistic enough for global analysis using monthly time steps and 30-minute spatial resolution. Although more sophisticated methods will likely be needed at finer spatial and temporal resolutions, the basic concept of combining observed precipitation and discharges with water balance modeling techniques and simulated flow routing appears to provide great potential.

Besides development of the composite runoff fields, the present work also allowed an evaluation of the spatial coverage of present-day discharge observation networks. Roughly 50% of the continental land mass representing $\sim 52\%$ of the discharge are now monitored.

The present report demonstrates the potential of using discharge gauging data in developing runoff surfaces to calibrate and validate Earth System Models. The authors of the

present work are fully convinced that discharge data should be routinely collected as part of a global hydro-meteorological monitoring network. The establishment of a core discharge station network with potential real time reporting would allow significant improvement in our capacity to quantitatively describe the global water cycle.

The developed runoff fields are intended to be the first in a series of data products representing the water cycle components. The next product is planned to be a distributed discharge field along the STN-30p network, which will incorporate the present runoff fields and apply a special discharge interpolation algorithm. Future products will be developed on the basis of innovative techniques to incorporate discharge observations into Earth System modeling.

Further work to identify poorly-monitored regions and the addition of new discharge gauging stations in those regions will be necessary [8]. We would like to present this report as a call for establishing a synoptic discharge gauging station network as complementary part of the WMO World Weather Watch (WWW) program and the regional implementation of WMO's World Hydrological Cycle Observing System (WHYCOS). The proposed discharge station network is likely to be more cost effective than the substantial increase in traditional precipitation networks which would be necessary to otherwise significantly improve upon the existing observational networks for precipitation at global scale.

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A Appendix: STN-30p Data Structures

The global Simulated Topological Network at 30-minute spatial resolution (STN-30p) represents rivers as a set of spatial and tabular data layers derived from a 30-minute flow-direction grid. These data layers are available on the accompanying CD-ROM as ARC/INFO coverages and ASCII interchange files. The ARC/INFO coverages are located in the `./arc/w_stn30-5.12` workspace while the ASCII files are in `./ascii/stn30-5.12` directory. The ARC/INFO coverages are:

- `g_basin` - Basin grid with basin attributes
- `g_celllength` - Grid cell length [*km*] grid
- `g_cumularea` - Upstream catchment area [*km*²] grid
- `g_distmouth` - Distance [*km*] to mouth of river defined as the confluence with equal or higher order stream
- `g_distocean` - Distance [*km*] to the outlet of river basins
- `g_network` - Flow-direction grid
- `g_order` - Strahler stream order grid
- `c_basin` - Basin polygon coverage with the same basin attributes as the basin grid
- `c_network` - Arc/point coverage representing river segments and basin mouths

`g_basin` grid, `c_basin` polygons and `c_network` points have the following STN-30p derived attributes additional to the default ARC/INFO attributes:

- `BASINNAME` - Basin Name (GHAASBasin#### or real basin name from GEMS/GLORI)
- `BASINORDER` - Strahler stream order at mouth
- `COLOR` - Optimized color (7 - 11) to display basins
- `BASINLENGTH` - Mainstem length [*km*]
- `BASINAREA` - Basin area [*km*²]
- `CONTINENTNAME` - Continent name
- `SEANAME` - Name of the recipient sea
- `OCEANNAME` - Name of the recipient ocean

The flow direction grid is given as the standard ARC/INFO representation of the 8 flow direction grid using the following encoding scheme:

32	64	128
16		1
8	4	2

`c_network` arc/line coverage has the following arc attributes besides the point attributes listed before:

BASINNAME	- Basin name
ORDER	- Strahler stream order
BASINID	- Integer basin identifier
BASINCELLS	- Number of 30-minute cells upstream
TRAVEL	- Number of cells downstream
CELLAREA	- Cell area [km^2]
SUBBASINLENGTH	- Mainstem length [km] upstream
SUBBASINAREA	- Upstream area [km^2]
DISTTOMOUTH	- Distance [km] to river mouth defined as confluence with equal or higher order stream
DISTTOOCEAN	- Distance [km] to the outlet of river basins
CELLLENGTH	- Length [km] of 30 minute river segment

The ASCII data are organized in the `./ascii` directory similarly to the ARC/INFO coverages:

basin.grd	- Basin grid with basin attributes
celllength.grd	- Grid cell length [km] grid
cumularea.grd	- Upstream catchment area [km^2] grid
distmouth.grd	- Distance [km] to river mouth defined as confluence with equal or higher order stream
distocean.grd	- Distance [km] to the outlet of river basins
network.grd	- Flow-direction grid
order.grd	- Strahler stream order grid
basins.txt	- Basin attribute table
cells.txt	- Cell attribute table

The grids were exported as ARC/INFO ASCII grid, which has six lines header followed by the actual cell values row by row:

```
ncols 720
nrows 300
xllcorner -180
yllcorner -60
cellsize 0.5
NODATA_value -9999
```

where

ncols	- number of columns
nrows	- number of rows
xllcorner	- horizontal coordinate of the lower left corner
yllcorner	- vertical coordinate of the lower left corner
cellsize	- cell size
NODATA_value	- missing data value

The attribute tables are tab-delimited, strings in quotes and the first line contains field names.

B Appendix: List of Named River Basins in STN-30p

Name	Order	Length [km]	Area [km ²]	Continent	Ocean
Amazon	6	5853804	4327	South America	Atlantic Ocean
Nile	5	3826122	5909	Africa	Mediterranean Sea
Zaire	5	3698803	4339	Africa	Atlantic Ocean
Mississippi	5	3202959	4185	North America	Atlantic Ocean
Amur	5	2902864	5061	Asia	Pacific Ocean
Parana	5	2661392	2748	South America	Atlantic Ocean
Yenisei	5	2582221	4803	Asia	Arctic Ocean
Ob	5	2570130	3977	Asia	Arctic Ocean
Lena	6	2417937	4387	Asia	Arctic Ocean
Niger	5	2240019	3401	Africa	Atlantic Ocean
Zambezi	5	1988756	2541	Africa	Indian Ocean
Chang Jiang	5	1794242	4734	Asia	Pacific Ocean
Mackenzie	5	1712738	3679	North America	Arctic Ocean
Ganges	5	1628404	2221	Asia	Indian Ocean
Chari	5	1571536	1733	Africa	Land
Volga	5	1463315	2785	Europe	Land
St. Lawrence	5	1266642	3175	North America	Atlantic Ocean
Indus	5	1143101	2382	Asia	Indian Ocean
Syr-Darya	5	1070230	1615	Asia	Land
Nelson	5	1047386	2045	North America	Atlantic Ocean
Orinoco	4	1039362	1970	South America	Atlantic Ocean
Murray	5	1031512	1767	Australia	Indian Ocean
Great Artesian Basin	5	977516	1045	Australia	Land
Shatt el Arab	4	967341	2200	Asia	Indian Ocean
Orange	5	943577	1840	Africa	Atlantic Ocean
Huang He	5	893627	4168	Asia	Pacific Ocean
Yukon	5	852029	2716	North America	Pacific Ocean
Senegal	4	847273	1680	Africa	Atlantic Ocean
Jubba	5	816054	1699	Africa	Indian Ocean
Colorado (Ari)	5	807573	1808	North America	Pacific Ocean
Rio Grande (US)	4	804792	2219	North America	Atlantic Ocean
Danube	4	788002	2222	Europe	Black Sea
Mekong	4	773728	3977	Asia	Pacific Ocean
Tocantins	4	768616	2234	South America	Atlantic Ocean
Tarim	5	732728	1227	Asia	Land
Columbia	5	724025	1791	North America	Pacific Ocean
Kolyma	4	665674	2091	Asia	Arctic Ocean
Sao Francisco	4	615148	2212	South America	Atlantic Ocean
Amu-Darya	4	612314	1976	Asia	Land
Dnepr	4	508839	1544	Europe	Black Sea
Don	5	423038	1401	Europe	Black Sea
Colorado (Arg)	4	421798	1750	South America	Atlantic Ocean
Limpopo	4	420337	1316	Africa	Indian Ocean
Zhujiang	4	408528	1696	Asia	Pacific Ocean
Irrawaddy	4	405963	1781	Asia	Indian Ocean
Volta	4	398071	1301	Africa	Atlantic Ocean
Farah	4	385230	1053	Asia	Land
Khatanga	5	371417	1048	Asia	Arctic Ocean
Dvina	5	367123	1441	Europe	Arctic Ocean
Uruguay	4	355505	1424	South America	Atlantic Ocean
Qarqan	4	351254	1216	Asia	Land
Parnaiba	4	330977	1192	South America	Atlantic Ocean
Indigirka	5	323710	1379	Asia	Arctic Ocean
Churchill (Hud)	4	315986	1813	North America	Atlantic Ocean
Godavari	4	311575	950	Asia	Indian Ocean
Pur - Taz	4	306961	1238	Asia	Arctic Ocean
Pechora	4	301599	1417	Europe	Arctic Ocean
Baker	4	299165	1299	North America	Atlantic Ocean
Ural	3	296283	1411	Asia	Land
Neva	5	284506	911	Europe	Atlantic Ocean
Liao	4	274053	1094	Asia	Pacific Ocean
Salween	3	273362	2576	Asia	Indian Ocean
Jordan	3	268914	1068	Asia	Mediterranean Sea
Magdalena	3	251743	1271	South America	Atlantic Ocean
Krishna	3	251684	1091	Asia	Indian Ocean
Salado	4	251460	1229	South America	Atlantic Ocean
Fraser	4	245452	1072	North America	Pacific Ocean
Hai Ho	4	245410	587	Asia	Pacific Ocean
Huai	4	244293	854	Asia	Pacific Ocean
Yana	4	235457	1004	Asia	Arctic Ocean
Kura	4	218906	796	Europe	Land
Olenek	4	212044	1623	Asia	Arctic Ocean
Ogooue	3	210155	815	Africa	Atlantic Ocean
Taymyr	4	204446	965	Australia	Indian Ocean
Negro Arg	4	197542	1112	South America	Atlantic Ocean
Chubut	4	196710	961	South America	Atlantic Ocean
Sacramento	4	192563	927	North America	Pacific Ocean
Fitzroy West	4	192439	965	Australia	Indian Ocean
Grande de Santiago	4	191899	776	North America	Pacific Ocean
Rufiji	4	186759	809	Africa	Indian Ocean
Wisla	4	180583	901	Europe	Atlantic Ocean

Name	Order	Length [km]	Area [km ²]	Continent	Ocean
Hong	3	170903	976	Asia	Pacific Ocean
Swan-Avon	4	166000	762	Australia	Indian Ocean
Rhine	3	165059	1018	Europe	Atlantic Ocean
Cuanza	3	163832	1027	Africa	Atlantic Ocean
Roviuna	3	154171	828	Africa	Indian Ocean
Essequibo	3	150769	736	South America	Atlantic Ocean
Elbe	3	148530	877	Europe	Atlantic Ocean
Koksoak	4	142888	861	North America	Atlantic Ocean
Chao Phraya	3	141830	710	Asia	Pacific Ocean
Brahmani	3	141207	866	Asia	Indian Ocean
Pyasina	4	139062	1139	Asia	Arctic Ocean
Fitzroy East	3	138489	637	Australia	Pacific Ocean
Albany	4	132800	953	North America	Atlantic Ocean
Sanaga	3	129212	803	Africa	Atlantic Ocean
Brazos (Tex)	3	125040	1261	North America	Atlantic Ocean
Alabama	3	124158	620	North America	Atlantic Ocean
Balsas	3	122987	706	North America	Pacific Ocean
Burdekin	3	121214	573	Australia	Pacific Ocean
Colorado (Texas)	3	121178	1047	North America	Atlantic Ocean
Odra	3	119846	663	Europe	Atlantic Ocean
Loire	3	118282	839	Europe	Atlantic Ocean
Galana	3	117369	962	Africa	Indian Ocean
Kuskowin	3	115809	888	North America	Pacific Ocean
Moose	3	114729	577	North America	Atlantic Ocean
Narmada	2	114088	1098	Asia	Indian Ocean
Flinders	3	110341	767	Australia	Indian Ocean
Kizil Irmak	3	109687	675	Asia	Black Sea
Save	3	107293	771	Africa	Indian Ocean
Roper	3	107214	427	Australia	Indian Ocean
Churchill (Atlantic)	4	106898	799	North America	Atlantic Ocean
Victoria	3	106413	659	Australia	Indian Ocean
Back	3	106037	951	North America	Arctic Ocean
Bandama	4	104088	692	Africa	Atlantic Ocean
Severn (Can)	3	104062	804	North America	Atlantic Ocean
Po	3	102183	500	Europe	Mediterranean Sea
Rhone	3	99298	637	Europe	Mediterranean Sea
Tana (Ken)	2	98896	671	Africa	Indian Ocean
La Grande	3	98876	622	North America	Atlantic Ocean
Cunene	3	98117	828	Africa	Atlantic Ocean
Douro	3	97109	555	Europe	Atlantic Ocean
Nemanus	3	95298	734	Europe	Atlantic Ocean
Anabar	4	94023	769	Asia	Arctic Ocean
Hayes	3	94019	633	North America	Atlantic Ocean
Mearim	3	92402	592	South America	Atlantic Ocean
Panuco	3	92037	490	North America	Atlantic Ocean
Doce	3	90357	727	South America	Atlantic Ocean
Gasgoyne	3	89660	784	Australia	Indian Ocean
Ashburton	3	84996	632	Australia	Indian Ocean
Peel	3	84059	776	North America	Arctic Ocean
Daugava	2	83416	812	Europe	Atlantic Ocean
Ebro	3	82841	553	Europe	Mediterranean Sea
Comoe	3	82408	813	Africa	Atlantic Ocean
Jacui	3	80764	458	South America	Atlantic Ocean
Kapuas	3	80368	569	Asia	Pacific Ocean
Penzhina	3	78794	625	Asia	Pacific Ocean
Cauweri	3	78680	627	Asia	Indian Ocean
Mamberamo	3	77145	592	Asia	Pacific Ocean
Sepik	3	77048	569	Asia	Pacific Ocean
Sassandra	2	76626	569	Africa	Atlantic Ocean
Nottaway	3	74326	591	North America	Atlantic Ocean
Barito	2	74155	579	Asia	Pacific Ocean
Seine	3	73472	451	Europe	Atlantic Ocean
Tejo	3	73363	766	Europe	Atlantic Ocean
Gambia	3	72190	745	Africa	Atlantic Ocean
Susquehanna	3	72147	514	North America	Atlantic Ocean
Dnestr	2	71995	867	Europe	Black Sea
Murchinson	3	71730	670	Australia	Indian Ocean
Deseado	2	71638	725	South America	Atlantic Ocean
Mitchell	3	71158	556	Australia	Indian Ocean
Mahakam	3	71093	569	Asia	Pacific Ocean
Pangani	3	70887	457	Africa	Indian Ocean
Bug	3	69228	699	Europe	Black Sea
Usumacinta	3	68130	525	North America	Atlantic Ocean
Jequitinhonha	2	68016	683	South America	Atlantic Ocean
Corantijn	3	67877	569	South America	Atlantic Ocean
Fuchun Jiang	3	67212	439	Asia	Pacific Ocean
Copper	3	67204	504	North America	Pacific Ocean
Tapti	2	66331	594	Asia	Indian Ocean
Menjiang	3	66246	360	Asia	Pacific Ocean
Karun	3	65465	704	Asia	Indian Ocean
Mezen	3	65459	718	Europe	Arctic Ocean

Name	Order	Length [km]	Area [km ²]	Continent	Ocean
Guadiana	2	65021	766	Europe	Atlantic Ocean
Maroni	3	64789	445	South America	Atlantic Ocean
Uda	3	64511	388	Asia	Pacific Ocean
Kuban	2	63890	648	Europe	Black Sea
Colville	3	63433	659	North America	Arctic Ocean
Thaane	3	63428	669	North America	Atlantic Ocean
Alazeya	3	63152	657	Asia	Arctic Ocean
Paraba do Sul	3	63001	663	South America	Atlantic Ocean
Fortesque	3	62775	712	Australia	Indian Ocean
Winisk	3	62119	665	North America	Atlantic Ocean
Ikopa	3	61893	530	Africa	Indian Ocean
Gilbert	3	61779	491	Australia	Indian Ocean
Kouilou	3	61707	481	Africa	Atlantic Ocean
Fly	2	61413	678	Asia	Pacific Ocean
Mangoky	3	60263	486	Africa	Indian Ocean
Damodar	3	59662	562	Asia	Indian Ocean
Onega	3	59359	525	Europe	Arctic Ocean
Moulouya	3	59263	391	Africa	Mediterranean Sea
Ord	3	59094	482	Australia	Indian Ocean
Narva	3	58230	520	Europe	Atlantic Ocean
Seal	3	58051	476	North America	Atlantic Ocean
Cheliff	3	57982	549	Africa	Mediterranean Sea
Garonne	3	57980	484	Europe	Atlantic Ocean
Rupert	3	57814	647	North America	Atlantic Ocean
Brahmani	3	57358	551	Asia	Indian Ocean
Sakarya	3	57055	506	Asia	Black Sea
Gourits	3	56945	295	Africa	Atlantic Ocean
Sittang	2	55667	518	Asia	Indian Ocean
Rajang	3	55604	491	Asia	Pacific Ocean
Evros	3	55096	415	Europe	Mediterranean Sea
Appalachicola	2	54830	697	North America	Atlantic Ocean
Attawapiskat	2	54646	736	North America	Atlantic Ocean
Lurio	2	53949	556	Africa	Indian Ocean
Daly	2	53948	574	Australia	Indian Ocean
Penner	3	53909	479	Asia	Indian Ocean
Guadalquivir	2	53722	487	Europe	Atlantic Ocean
Nadym	3	53129	509	Asia	Arctic Ocean
Saint John	2	53027	616	North America	Atlantic Ocean
Cross	3	52257	480	Africa	Atlantic Ocean
Omoloy	3	52096	409	Asia	Arctic Ocean
Oueme	3	51955	444	Africa	Atlantic Ocean
Gota	3	51451	603	Europe	Atlantic Ocean
Nueces	2	51438	529	North America	Atlantic Ocean
Stikine	3	51316	546	North America	Pacific Ocean
Yalu	2	51165	557	Asia	Pacific Ocean
Arnaud	3	51155	446	North America	Atlantic Ocean
Jequinhonha	2	50665	499	South America	Atlantic Ocean
Kamchatka	2	50604	626	Asia	Pacific Ocean
Grijalva	2	50315	517	North America	Atlantic Ocean
Kemijoki	3	50179	444	Europe	Atlantic Ocean
Olifants	3	50067	249	Africa	Atlantic Ocean
Tsiribihina	3	49467	390	Africa	Indian Ocean
Coppermine	3	49435	690	North America	Arctic Ocean
Kovda	3	47858	405	Europe	Arctic Ocean
Trinity	3	47549	477	North America	Atlantic Ocean
Glama	3	47456	490	Europe	Atlantic Ocean
Luan	3	46497	612	Asia	Pacific Ocean
Leichhardt	3	46470	507	Australia	Indian Ocean
Gurupi	2	46280	569	South America	Atlantic Ocean
GR Baleine	3	45900	543	North America	Atlantic Ocean
Aux Feuilles	2	45728	517	North America	Atlantic Ocean
Weser	3	45629	457	Europe	Atlantic Ocean
Yesil	3	44792	364	Asia	Black Sea
Incomati	2	44722	486	Africa	Indian Ocean
Pungoe	3	43932	390	Africa	Indian Ocean
Meuse	2	43336	565	Europe	Atlantic Ocean
Eastmain	2	43314	639	North America	Atlantic Ocean
Araguari	3	43265	435	South America	Atlantic Ocean
Hudson	3	43252	486	North America	Atlantic Ocean
Kobuk	3	42460	463	North America	Arctic Ocean
Altamaha	2	41580	449	North America	Atlantic Ocean
Mand	2	40768	417	Asia	Indian Ocean
Santee	2	40590	446	North America	Atlantic Ocean
Hari	2	40169	435	Asia	Pacific Ocean
Wami	2	39943	489	Africa	Indian Ocean
San Juan	3	39433	375	North America	Atlantic Ocean
George	2	39064	546	North America	Atlantic Ocean
Omoloy	3	38531	464	Asia	Arctic Ocean
Potomac	3	38419	297	North America	Atlantic Ocean
Sebou	3	38402	321	Africa	Atlantic Ocean
Anderson	2	37848	674	North America	Arctic Ocean

Name	Order	Length [km]	Area [km ²]	Continent	Ocean
Guayas	2	37084	370	South America	Pacific Ocean
Gamtoos	2	36381	358	Africa	Indian Ocean
Grande-Matagalpa	2	36138	348	North America	Atlantic Ocean
Kymijoki	3	35932	433	Europe	Atlantic Ocean
Savannah	2	35905	457	North America	Atlantic Ocean
Burnside	3	35498	473	North America	Arctic Ocean
Nushagak	3	35396	497	North America	Pacific Ocean
Roanoke	2	34756	509	North America	Atlantic Ocean
Topnionjoki	3	34638	454	Europe	Atlantic Ocean
Ceyhan	2	34201	400	Asia	Mediterranean Sea
Great Fish	2	34071	393	Africa	Indian Ocean
Dongjiang	2	33930	388	Asia	Pacific Ocean
Oum Er Rbia	2	33928	431	Africa	Atlantic Ocean
Pahang	2	33924	324	Asia	Pacific Ocean
Purari	2	33773	379	Asia	Pacific Ocean
Atrato	2	33756	434	South America	Atlantic Ocean
Fuerte	2	33136	503	North America	Pacific Ocean
Mae Klong	3	32914	399	Asia	Pacific Ocean
Noatak	2	32524	501	North America	Arctic Ocean
A la Baleine	3	32313	396	North America	Atlantic Ocean
Amgerman	3	32205	436	Europe	Atlantic Ocean
Klamath	2	32197	318	North America	Pacific Ocean
Harricana	3	32016	420	North America	Atlantic Ocean
Connecticut	2	31536	497	North America	Atlantic Ocean
Great Kei	2	31472	321	Africa	Indian Ocean
Oyapok	2	30869	291	South America	Atlantic Ocean
Burnett	2	30673	336	Australia	Pacific Ocean
Kem	2	30254	345	Europe	Arctic Ocean
Messalo	2	30148	528	Africa	Indian Ocean
Dalalven	2	29902	507	Europe	Atlantic Ocean
Patuca	3	29893	373	North America	Atlantic Ocean
Ulua	3	29886	266	North America	Atlantic Ocean
Ume-Vindealven	2	29862	500	Europe	Atlantic Ocean
Licungo	3	29691	321	Africa	Indian Ocean
Papaloapan	3	29481	265	North America	Atlantic Ocean
Attawapiskat	2	29354	393	North America	Atlantic Ocean
Lulealven	3	29037	428	Europe	Atlantic Ocean
Sabine	2	28939	564	North America	Atlantic Ocean
Hunter	3	28700	213	Australia	Pacific Ocean
Povuntnituk	3	28650	368	North America	Atlantic Ocean
Tuloma	2	28586	359	Europe	Arctic Ocean
Mahi	3	28465	378	Asia	Indian Ocean
Onilahy	2	28370	380	Africa	Indian Ocean
Rabarmati	2	28346	373	Asia	Indian Ocean
Coroch	2	28030	307	Europe	Black Sea
Inderagiri	2	27820	357	Asia	Pacific Ocean
Kokemaenjoki	3	27799	318	Europe	Atlantic Ocean
Ntem	2	27797	356	Africa	Atlantic Ocean
Asi	2	27735	329	Asia	Mediterranean Sea
Pee Dee	2	27735	455	North America	Atlantic Ocean
Mono	2	27568	412	Africa	Atlantic Ocean
Maputo	2	27543	347	Africa	Indian Ocean
Medjerda	2	27438	349	Africa	Mediterranean Sea
Broadback	2	27361	411	North America	Atlantic Ocean
Saint John's	2	26956	307	North America	Atlantic Ocean
Coco	2	26952	370	North America	Atlantic Ocean
Motagua	2	26863	393	North America	Atlantic Ocean
Cagayan	2	26600	299	Asia	Pacific Ocean
Petit Mecatina	2	26579	442	North America	Atlantic Ocean
Dordogne	2	26192	401	Europe	Atlantic Ocean
Buzi	2	26166	257	Africa	Indian Ocean
Alsek	2	25887	441	North America	Pacific Ocean
Santa Cruz	2	25759	441	South America	Atlantic Ocean
Oulujoki	2	25491	315	Europe	Atlantic Ocean
Hanjiang	2	25365	262	Asia	Pacific Ocean
Oulujoki	2	25249	338	Europe	Atlantic Ocean
Nyanga	2	24704	324	Africa	Atlantic Ocean
Nyong	2	24685	402	Africa	Atlantic Ocean
Ramu	2	24619	402	Asia	Pacific Ocean
Cavally	2	24602	379	Africa	Atlantic Ocean
Pra	2	24588	245	Africa	Atlantic Ocean
Buyuk Menderes	2	24392	334	Asia	Mediterranean Sea
Seyhan	2	24391	379	Asia	Mediterranean Sea
Nass	2	24176	438	North America	Pacific Ocean
Ponnaiyar	2	24154	374	Asia	Indian Ocean
Suwannee	2	23923	294	North America	Atlantic Ocean
Sofia	2	23779	287	Africa	Indian Ocean
Pearl	2	23612	489	North America	Atlantic Ocean
Natashquan	2	23070	356	North America	Atlantic Ocean
Baker (Chile)	2	23002	284	South America	Pacific Ocean
Subamarekha	2	22837	354	Asia	Indian Ocean

Name	Order	Length [km]	Area [km ²]	Continent	Ocean
Amguema	2	22613	269	Asia	Arctic Ocean
James	2	22031	391	North America	Atlantic Ocean
Segura	2	21898	273	Europe	Mediterranean Sea
Suriname	2	21567	301	South America	Atlantic Ocean
Mazaruni	2	21553	379	South America	Atlantic Ocean
Scheldt	2	21514	347	Europe	Atlantic Ocean
Jucar	2	21510	228	Europe	Mediterranean Sea
Kikori	2	21504	378	Asia	Pacific Ocean
Santa	2	21382	299	South America	Pacific Ocean
Moisie	2	21198	343	North America	Atlantic Ocean
Neches	2	21196	386	North America	Atlantic Ocean
Palar	2	21087	296	Asia	Indian Ocean
Tensift	2	21086	245	Africa	Atlantic Ocean
Delaware	2	20950	459	North America	Land
Strymon	2	20773	389	Europe	Mediterranean Sea
Petite Riviere Baleine	2	20766	251	North America	Atlantic Ocean
Skagit	2	20483	263	North America	Pacific Ocean
Hong	2	20147	284	Asia	Pacific Ocean
Zeroud	2	20133	325	Africa	Mediterranean Sea
Kaladan	2	20056	354	Asia	Indian Ocean
Nag Dong	2	20006	271	Asia	Pacific Ocean
Drammenselva	2	19776	344	Europe	Atlantic Ocean
Kennebec	2	19681	274	North America	Atlantic Ocean
Han	2	19652	221	Asia	Pacific Ocean
Ellice	2	19548	276	North America	Arctic Ocean
Bio Bio	2	19537	327	South America	Pacific Ocean
Penobscot	2	19432	324	North America	Atlantic Ocean
Taku	2	19336	359	North America	Pacific Ocean
Kalix	2	19200	456	Europe	Atlantic Ocean
Patsjoki	2	19097	259	Europe	Land
Simav	2	19030	252	Asia	Land
Ljungan	2	18902	367	Europe	Atlantic Ocean
Guadalupe	2	18866	399	North America	Atlantic Ocean
Sous	2	18665	225	Africa	Atlantic Ocean
Perak	2	18479	268	Asia	Indian Ocean
Mindanao	2	18398	244	Asia	Pacific Ocean
Tugur	2	18387	260	Asia	Pacific Ocean
Minho	2	18251	275	Europe	Atlantic Ocean
Pregolya	2	18017	280	Europe	Atlantic Ocean
Maipo	2	18007	267	South America	Pacific Ocean
Skelleftalv	2	17971	440	Europe	Atlantic Ocean
Breede	2	17932	220	Africa	Atlantic Ocean
Sepik	3	17860	285	North America	Arctic Ocean
Rapel	2	17841	236	South America	Pacific Ocean
Tone	2	17402	217	Asia	Pacific Ocean
Itata	2	17338	286	South America	Pacific Ocean
Thames	2	17330	270	Europe	Atlantic Ocean
Aksu	2	17159	255	Asia	Mediterranean Sea
Waikato	2	17009	282	Oceania	Pacific Ocean
Trent	2	16968	256	Europe	Atlantic Ocean
Mandrare	2	16866	237	Africa	Indian Ocean
Gediz	2	16859	260	Asia	Mediterranean Sea
Axios	2	16463	280	Europe	Mediterranean Sea
Pitalven	2	16333	375	Europe	Atlantic Ocean
Abitibi	2	15813	309	North America	Atlantic Ocean
Indalsalven	2	15689	328	Europe	Atlantic Ocean
Clutha	2	15195	259	Oceania	Pacific Ocean
Maule	2	15037	234	South America	Pacific Ocean
Chowan	2	14861	303	North America	Atlantic Ocean
Shinano	2	14812	253	Asia	Pacific Ocean
Eel	2	14208	252	North America	Pacific Ocean
Romaine	2	13586	233	North America	Atlantic Ocean
Merrimack	2	13509	262	North America	Atlantic Ocean
Adour	2	13454	189	Europe	Atlantic Ocean
Saint Augustin	2	13354	176	North America	Atlantic Ocean
Gizhiga	2	12810	240	Asia	Pacific Ocean
Luga	2	12806	188	Europe	Atlantic Ocean
Kola	2	10459	307	Europe	Arctic Ocean
Shchuchya	3	10434	230	Asia	Arctic Ocean
Skienelva	2	9367	243	Europe	Atlantic Ocean
Thjorsa	1	6763	225	Europe	Atlantic Ocean
Olfusa	2	6691	201	Europe	Atlantic Ocean
Guadalquivir	1	2540	72	Africa	Mediterranean Sea

C Appendix: Selected (n = 663) GRDC Discharge Gauging Stations and the STN-30p derived data layers

The station attributes and annual discharge regime of the 663 discharge gauging stations from the GRDC archive (which were used in the present study) are provided on the accompanying CD-ROM in the `./arc/w_stations` workspace as a set of ARC/INFO coverages and in the `./ascii/stations` directory as ASCII files. The ARC/INFO workspace consists of `c_grdc663`, `g_subbasins` grid and `c_subbasins` polygon coverage. `g_subbasins` and `c_subbasins` coverages represent the inter-station regions between the selected discharge gauging stations along the STN-30p network. The additional attributes beside the default ARC/INFO attributes are the same as follows for all three coverages:

STATIONNAME	- Gauging station name
RIVERNAME	- River name according to GRDC Archive
COUNTRY	- Country name
GRDC-AREA	- Reported catchment area [km^2]
STARTMONTH	- Beginning month of observations
STARTYEAR	- Beginning year of observations
ENDMONTH	- Last month of observations
ENDYEAR	- Last year of observations
TIMESERIES	- Time series type (Monthly, "M" or daily, "D")
PERCENTRECORD	- Percent of missing values in GRDC records
CELLID	- STN-30p Cell-id
BASINID	- STN-30p Basin-id
BASINNAME	- STN-30p Basin name
ORDER	- Strahler stream order on STN-30p network at the station
NUMBEROFCELLS	- Number of 30 minute cells upstream
STNMAINSTEMLENGT	- Main-stem length [km] upstream
STNCATCHMENTAREA	- Catchment area [km^2] upstream
NEXTSTATION	- Next gauging station downstream
INTERSTNA	- Inter-station area [km^2] along STN-30p Network

The ASCII files are organized similarly to the ARC/INFO coverages in the `./ascii/stations` directory. `GRDC663.txt` file is a tab-delimited ASCII file (strings in quotes, first line contains field names), containing the 663 record of the selected GRDC stations with the same attributes as given in ARC/INFO format. `subbasins.grd` is an ARC/INFO ASCII grid (as described in Appendix A) containing the record identifiers of the gauging stations.

D Appendix: List of Selected GRDC Discharge Gauging Stations Used in the Present Report with Catalog and STN-30p Derived Attributes

GRDC Code	Station Name				RiverName	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				STN Basin Name	GRDC	STN-30p	GRDC
ID		Mean	Min	Max					
1112200	Gourbassy				Faleme				
1	119	117.4	15.2	319.3	Senegal	15000	15092	15000	15092
1112300	Galougo				Senegal				
2	118	510.0	84.3	1195.2	Senegal	127000	120332	78000	71990
1112320	Oualia				Bakoye				
3	0	141.0	16.6	354.8	Gambia	84400	72190	42400	27017
1112340	Toukoto				Bakoye				
4	2	75.7	9.8	180.8	Senegal	16000	18107	16000	18107
1112350	Dibia				Bafing				
5	2	332.3	63.5	825.1	Senegal	33000	30235	33000	30235
1134050	Selingue				Sankarani				
6	7	286.2	65.2	616.7	Niger	34200	33496	34200	33496
1134100	Koulikoro				Niger				
7	11	1407.3	500.8	2789.5	Niger	120000	121466	15800	18096
1134110	Bougouni				Baoule				
8	9	101.3	15.3	210.8	Niger	15700	15195	15700	15195
1134200	Dioila				Baoule				
9	12	143.4	21.6	412.6	Niger	32500	33336	16800	18142
1134220	Pankourou				Bagoé				
10	12	169.8	23.6	439.0	Niger	31800	33430	31800	33430
1134250	Kirango aval				Niger				
11	13	1290.4	414.7	2471.6	Niger	137000	136517	17000	15050
1134300	Douna				Bani				
12	13	512.6	59.5	1207.2	Niger	101600	102981	37300	36214
1134500	Mopti				Niger				
13	14	1100.6	453.4	1646.9	Niger	281600	308186	43000	68688
1134700	Dire				Niger				
14	15	1003.2	400.2	1622.4	Niger	340000	367900	58400	59715
1134900	Ansongo				Niger				
15	27	914.8	369.7	1471.8	Niger	566000	647527	226000	279627
1147010	Kinshasa				Zaire				
16	0	39535.6	29705.2	55291.2	Zaire	3475000	3615698	2816650	2929069
1159100	Vioolsdrif				Oranje				
17	0	146.0	5.8	656.8	Orange	850530	838168	814074	485823
1159300	Upington				Oranje				
18	17	219.6	66.2	927.3	Orange	36456	352345	-141546	180606
1159500	de Hoop 65				Vaal				
19	18	32.6	0.7	210.4	Orange	121052	123447	82488	76706
1159650	Aliwal Noord				Oranje				
20	18	145.4	8.7	578.7	Orange	37075	29400	37075	29400
1159800	Engelbrechtsdrift				Vaal				
21	19	38.8	4.4	214.4	Orange	38564	46741	38564	46741
1160510	Piggot's Bridge				Groot-Vis				
22	23	5.1	0.0	20.7	Great Fish	23067	23671	23067	23671
1160580	Outspan				Groot-Vis				
23	0	7.6	0.0	42.2	Great Fish	29745	28886	6678	5214
1160880	Mandini				Tugela				
24	0	100.1	10.9	312.5	GHAASBasin444	28920	29901	28920	29901
1196400	Oxenham Ranch				Limpopo				
25	69	27.1	0.0	120.7	Limpopo	98160	107086	98160	107086
1234080	Alcongui				Gorouol				
26	27	8.6	1.3	50.5	Niger	44900	56713	44900	56713
1234150	Niamey				Niger				
27	103	893.1	335.4	1484.4	Niger	700000	791121	89100	86881
1234180	Diongore amont				Goroubi				
28	103	6.1	0.5	21.8	Niger	15350	18102	15350	18102
1237500	Bagara Diffa				Komadougou Yobe				
29	0	14.6	4.0	30.3	Noname (GHAASBasin49)	115000	449161	60850	385981
1259150	Seaka				Senqu				
30	18	117.4	14.0	394.7	Orange	19875	18893	19875	18893
1286660	Mtera				Great Ruaha				
31	32	123.9	18.6	384.1	Rufiji	67950	73280	67950	73280
1286900	Stigler				Rufiji				
32	0	791.8	343.9	2006.9	Rufiji	158200	177570	78850	88901
1287800	Bahi				Bubu				
33	32	5.2	0.0	25.8	Rufiji	11400	15389	11400	15389
1289200	Korogwe				Pangani				
34	0	26.7	9.7	63.3	Pangani	25110	64728	25110	64728
1289450	Dar-Es-Salam-Morogoro Road Bridge				Ruvu				
35	0	64.6	16.1	223.8	GHAASBasin817	15190	15343	15190	15343

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
1308600 36	Dar el Caid 0	20.0	1.1	102.6	Moulouya Moulouya	24422	25806	24422	25806
1309700 37	Azib Soltane 0	56.7	11.7	244.8	Sebou Sebou	17250	17962	17250	17962
1335014 38	Riao 29	249.1	76.8	463.9	Benoue Noname (GHAASBasin49)	30650	32888	30650	32888
1335122 39	Safaie 29	307.2	154.8	497.5	Faro Noname (GHAASBasin49)	23500	30291	23500	30291
1335500 40	Garoua 122	362.9	113.2	767.5	Benoue Niger	64000	61021	64000	61021
1338050 41	Edea 0	1984.7	1170.2	3007.1	Sanaga Sanaga	131520	129212	13220	9252
1338201 42	Betare-Oya 0	175.1	104.7	272.3	Lom Niger	11100	11991	11100	11991
1338252 43	Mantoum 0	320.6	193.2	478.8	Mbam Niger	14700	12143	14700	12143
1338300 44	Goura 41	710.1	404.8	1070.8	Mbam Sanaga	42300	43054	42300	43054
1338400 45	Nachtigal 41	1078.1	582.8	1654.1	Sanaga Sanaga	76000	76906	55610	58478
1338600 46	Mbakaou 45	389.1	120.0	678.0	Djerem Sanaga	20390	18428	20390	18428
1339017 47	Olama 0	226.8	139.7	362.2	Nyong Niger	18510	21248	5100	12137
1339100 48	Dehane 0	446.3	243.0	829.8	Nyong Nyong	26400	24685	26400	24685
1339500 49	Mbalmayo 61	149.4	78.2	255.2	Nyong Zaire	13555	12345	13555	12345
1340500 50	Ngoazik 0	275.5	119.1	580.2	Ntem Ntem	18100	18530	18100	18530
1348152 51	Pana 0	246.2	150.2	367.6	Kadei Niger	20370	17956	20370	17956
1362100 52	el Ekhsase 0	1251.3	1095.2	1438.7	Nile Nile	2900000	3746812	-712000	157881
1362600 53	Aswan Dam 52	2759.8	861.9	5114.2	Nile Nile	3612000	3588931	918000	894447
1389090 54	Bevoay 0	596.6	175.8	1448.8	Mangoky Mangoky	53225	54530	53225	54530
1389470 55	Amboasary 0	60.3	7.1	226.8	Mandrare Mandrare	12435	16866	12435	16866
1389500 56	Antsatrana 0	438.0	149.2	803.2	Ikopa Ikopa	18550	14653	18550	14653
1389600 57	Maroangaty 0	241.9	81.8	546.1	Mananara GHAASBasin883	14160	8542	14160	8542
1428400 58	Aniassue 0	106.1	13.9	271.9	Comoe Comoe	67400	70112	67400	70112
1445100 59	Sounda 0	856.0	482.1	1232.5	Kouilou Kouilou	55010	55542	31625	30860
1445490 60	Loudima 59	379.2	229.5	572.1	Niari Kouilou	23385	24682	23385	24682
1448050 61	Ngbala 62	420.0	209.9	738.4	Dja Zaire	38600	40139	25045	27794
1448100 62	Ouessou 16	1662.4	968.7	2455.0	Sangha Zaire	158350	163481	51450	55566
1472150 63	Paara 98	946.0	453.8	1757.7	Victoria Nile Nile	340000	342767	71000	89634
1472300 64	Owen Reservoir 63	1175.9	879.1	1491.2	Victoria Nile Nile	269000	253133	238800	222254
1491200 65	Kamativi G/w 0	23.3	0.2	143.9	Gwaai Zambezi	38600	37973	17600	20419
1491210 66	Dahlia Control Section 65	7.3	0.0	44.4	Gwaai Zambezi	21000	17554	21000	17554
1495200 67	Tokwe Confluence U/s C/s 0	48.2	0.2	245.9	Lundi Limpopo	17100	17325	17100	17325
1495240 68	Tokwe Confluence D/s C/s 0	66.3	0.0	342.7	Lundi Save	23000	23237	23000	23237
1496500 69	Beitbridge Pumpstation C/s 0	86.5	0.3	594.3	Limpopo Limpopo	196000	207296	97840	100210
1526300 70	Daboasi 0	196.9	44.2	583.9	Pra Pra	22714	24588	22714	24588

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
1530100 71	Alanda 0	143.8	64.7	263.8	Tano GHAASBasin813	15800	15363	15800	15363
1531100 72	Bamboi 77	262.5	76.9	672.2	Black Volta Volta	134200	139548	67660	64050
1531420 73	Yagaba 74	34.9	1.9	119.5	Kulpawn Volta	10600	12172	10600	12172
1531450 74	Nawuni 77	249.1	60.8	476.9	White Volta Volta	92950	102902	19000	24290
1531550 75	Pwalagu 74	125.2	33.8	311.3	White Volta Volta	63350	66440	18660	9106
1531650 76	Nangodi 75	23.1	4.6	57.9	Red Volta Volta	11570	12111	11570	12111
1531700 77	Senchi(Halcrow) 0	1105.6	35.8	4210.5	Volta Volta	394100	394995	108280	94848
1531800 78	Sabari 77	354.0	155.9	676.3	Oti Volta	58670	57698	36390	27396
1537100 79	Ndjamena(Fort Lamy) 0	1059.4	193.9	1933.2	Chari Chari	600000	603275	76300	84974
1537150 80	Bongor 79	491.7	119.9	797.9	Logone Chari	73700	76533	25430	27501
1537180 81	Moundou 80	366.6	121.6	692.2	Logone Chari	33970	33707	33970	33707
1537250 82	Doba 80	127.5	25.6	244.2	Pende Chari	14300	15325	14300	15325
1537300 83	Bouso 79	811.9	204.6	1280.6	Chari Chari	450000	441767	109400	112603
1537450 84	Moissala 83	479.9	162.2	1018.2	Bahr Sara Chari	67600	67541	22900	24525
1537500 85	Sarh(Fort Archambault) 83	266.4	14.9	521.4	Chari Chari	193000	177081	97000	73504
1537800 86	Am-Timan 83	30.6	5.7	63.2	Bahr Azoum Chari	80000	84543	80000	84543
1634400 87	Kouroussa 90	242.4	113.9	452.4	Niger Niger	18000	15205	18000	15205
1634420 88	Baro 90	251.2	107.2	444.9	Niandan Niger	12770	12186	12770	12186
1634600 89	Ouaran 90	181.4	64.2	353.2	Tinkisso Niger	18700	12133	18700	12133
1634650 90	Tiguibery 7	1097.6	542.0	1827.6	Niger Niger	70000	69875	20530	30351
1643100 91	Lambarene 0	4688.7	2891.6	7182.2	Ogooue Ogooue	205000	207065	205000	207065
1662100 92	Dongola 53	2621.9	1004.8	4467.4	Nile Nile	2694000	2694484	711806	395792
1663100 93	Khartoum 92	1512.8	171.2	2875.7	Blue Nile Nile	325000	275123	115000	120132
1663800 94	Roseires Dam 93	1548.4	570.2	2847.4	Blue Nile Nile	210000	154992	210000	154992
1664100 95	Kilo 3 92	358.6	78.3	936.2	Atbara Nile	69000	173580	69000	173580
1673100 96	Mogren 92	897.3	688.6	1149.1	White Nile Nile	1588194	1849988	508194	664792
1673600 97	Malakal 96	938.6	629.8	1786.7	White Nile Nile	1080000	1185196	630000	629315
1673900 98	Mongalla 97	1050.2	444.1	2164.3	Bahr el Jebel Nile	450000	555881	110000	213114
1731400 99	Porga 78	56.3	9.5	136.0	Pendjari Volta	22280	30302	22280	30302
1732100 100	Athieme 0	53.9	0.8	155.1	Mono Mono	21575	24495	21575	24495
1733100 101	Pont de Beterou 102	53.9	0.8	155.1	Oueme Oueme	10326	9144	10326	9144
1733600 102	Bonou 0	170.2	3.7	416.9	Oueme Oueme	46990	45818	36664	36674
1734500 103	Malanville 0	1053.1	440.8	1709.2	Niger Niger	1000000	1399238	284650	590016
1734600 104	Couberi 47	30.8	4.2	101.8	Sofa Niger	13410	9111	13410	9111
1737150 105	Bossangoa 106	219.1	41.0	402.1	Ouham Chari	22800	21519	22800	21519

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
1737210 106	Batangafa 84	311.3	90.2	535.2	Ouham Chari	44700	43016	21900	21498
1737700 107	Golongosso 85	74.3	18.4	134.8	Bahr Aouk Chari	96000	103577	96000	103577
1748500 108	Salo 62	744.9	416.5	1168.4	Sangha Zaire	68300	67776	68300	67776
1749050 109	M'bata 111	320.9	167.9	441.1	Lobaye Zaire	31000	36972	31000	36972
1749080 110	Bossele-Bali 111	90.1	20.0	162.1	M'poko Zaire	10800	12308	10800	12308
1749100 111	Bangui 16	4091.6	1950.7	6837.5	Oubangui Zaire	500000	523148	327300	341793
1749480 112	Kembe 111	447.0	233.2	768.8	Kotto Zaire	78400	79767	78400	79767
1749550 113	Rafai 111	397.1	176.2	652.1	Chinko Zaire	52500	52308	23200	21523
1749600 114	Zemio 113	196.1	77.4	532.8	M'bomou Zaire	29300	30785	29300	30785
1789300 115	Garissa 0	155.4	31.8	599.7	Tana Tana (Ken)	42220	43277	42220	43277
1812100 116	Dagana 0	687.4	255.9	1135.3	Senegal Senegal	268000	793731	38000	29560
1812300 117	Matam 116	761.4	239.5	1689.6	Senegal Senegal	230000	764171	12000	172953
1812500 118	Bakel 117	705.2	170.8	1719.4	Senegal Senegal	218000	591218	62100	437772
1812600 119	Kidira 118	169.9	25.5	481.8	Faleme Senegal	28900	33114	13900	18022
1813200 120	Gouloumbou 3	149.5	48.8	329.7	Gambie Gambia	42000	45172	42000	45172
1815020 121	Saltinho amont 0	305.2	161.4	496.7	Corubal GHAASBasin437	23840	24206	23840	24206
1835800 122	Yola 0	21.9	4.5	58.9	Benue Niger	107000	100781	43000	39760
1870600 123	Kanzenze 124	109.0	67.8	158.7	Nyabarongo Nile	14600	15445	14600	15445
1870800 124	Rusumo 64	224.0	157.8	324.2	Kagera Nile	30200	30879	15600	15434
1878100 125	Afgoi 0	45.9	12.8	87.9	Shebelle Jubba	278000	270030	66200	52426
1878500 126	Belet Uen 125	68.0	17.8	175.4	Shebelle Jubba	211800	217605	211800	217605
1880100 127	Lugh Ganana 0	192.7	43.6	479.0	Juba Jubba	179520	172335	179520	172335
1931370 128	Boromo 129	32.7	3.1	72.0	Mou Houn (Volta Noire) Volta	37140	57323	37140	57323
1931400 129	Dapola 72	101.0	12.2	292.5	Mou Houn (Volta Noire) Volta	66540	75498	29400	18175
1931725 130	Wayen 131	7.3	0.8	27.8	Nakanbe (Volta Blanche) Volta	20880	21050	20880	21050
1931790 131	Bagre 75	33.1	7.2	90.8	Nakanbe (Volta Blanche) Volta	33120	45222	12240	24172
1992700 132	Liwonde 133	471.6	108.7	828.5	Shire Zambezi	130200	123809	130200	123809
1992900 133	Chiromo 0	485.5	109.5	1004.2	Shire Zambezi	149500	147536	19300	23726
2106500 134	Haerbin 200	1204.7	196.6	3562.6	Songhuajiang Amur	391000	394873	346900	354218
2106600 135	Jilin 134	429.6	121.9	1252.6	Songhuajiang Amur	44100	40655	44100	40655
2151100 136	Yangcun 172	916.4	478.3	1740.7	Yaluzangbu Jiang Ganges	153191	152985	153191	152985
2178300 137	Guanting 0	37.5	2.3	150.4	Yongding Hai Ho	42500	49404	42500	49404
2178500 138	Luanxian 0	130.0	16.8	536.1	Luanhe Luan	44100	46497	44100	46497
2180500 139	Zhangjashan 140	60.8	17.2	202.9	Jinghe Huang He	43200	45123	43200	45123
2180710 140	Shanxian 141	1346.7	544.0	2576.0	Huanghe(Yellow River) Huang He	687869	780448	644669	735324

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
2180800 141	Huayuankou 0	1438.0	447.2	3130.5	Huanghe(Yellow River) Huang He	730036	823531	42167	43083
2181400 142	Gongtan 143	1142.4	331.7	2573.0	Wujiang Chang Jiang	58300	52125	58300	52125
2181600 143	Yichang 144	14185.4	8117.5	22973.3	Changjiang Chang Jiang	1010000	1003478	951700	951354
2181800 144	Hankou 146	23301.2	10954.2	37733.3	Changjiang Chang Jiang	1488036	1489373	436636	444459
2181850 145	Jian 146	1670.1	662.3	3428.3	Ganjiang Chang Jiang	56200	61204	56200	61204
2181900 146	Datong 0	28811.4	16369.2	47508.3	Changjiang (Yangtze) Chang Jiang	1705383	1712673	161147	162095
2181950 147	Bengbu 0	863.6	30.8	3833.0	Huaihe Huai	121330	116778	121330	116778
2182100 148	Ankang 144	655.1	137.5	2021.2	Hanjiang Chang Jiang	41400	41436	41400	41436
2186500 149	Nanning 150	1304.0	374.8	3098.5	Yujiang Zhujiang	75500	76744	75500	76744
2186800 150	Wuzhou 3 0	6964.9	2207.7	16465.0	Xijiang Zhujiang	329705	329344	254205	252600
2186900 151	Hengshi 0	1092.2	299.9	2819.6	Beijing Dongjiang	34013	31079	8688	2840
2186950 152	Boluo 151	754.7	242.4	1870.5	Dongjiang Dongjiang	25325	28239	25325	28239
2260100 153	Hkamti 0	2407.1	1240.2	4022.2	Chindwin Irrawaddy	27420	24867	27420	24867
2260500 154	Sagaing 0	8024.5	5458.1	10951.6	Irrawaddy Irrawaddy	117900	117452	117900	117452
2261500 155	Toungoo 0	299.2	161.8	504.2	Sittang Sittang	14660	14520	14660	14520
2423500 156	Ahvaz 0	575.4	267.8	1427.6	Karun Karun	60769	60138	60769	60138
2469050 157	Luang Prabang 243	3625.4	2228.9	5095.7	Mekong Mekong	268000	278692	79000	86915
2469260 158	Pakse 0	9001.0	6465.2	12514.2	Mekong Mekong	545000	536010	50000	41570
2548400 159	Chisapani 170	1353.0	226.8	2257.3	Karnali River Ganges	42890	45887	21650	21733
2548450 160	Benighat 159	612.5	357.6	958.2	Karnali River Ganges	21240	24154	21240	24154
2549500 161	Devghat 170	1559.9	1048.4	2566.8	Narayani River Ganges	31100	32521	31100	32521
2550200 162	Turkeghat 170	420.7	302.1	573.0	Arun River Ganges	28200	29902	28200	29902
2587100 163	Ishikari-Ohashi 0	467.2	146.4	901.8	Ishikari GHAASBasin1057	12697	11221	12697	11221
2651100 164	Bahadurabad 0	21260.9	13660.1	28732.0	Brahmaputra Ganges	636130	554542	198360	116081
2677100 165	Indogyo 0	525.5	127.9	1673.3	Han Han	25046	19652	25046	19652
2694510 166	Samnangjin 0	289.9	54.5	777.2	Nagdong Nag Dong	22916	20006	22916	20006
2836100 167	Baramula Br. 0	221.4	93.5	388.2	Jhelum Indus	12494	12776	12494	12776
2837100 168	Akhnoor 0	796.6	534.0	1157.6	Chenab Indus	22681	23296	22681	23296
2839100 169	Mandi Plain 0	497.3	247.5	811.6	Beas Indus	18274	20886	18274	20886
2846800 170	Farakka 0	12037.3	6133.0	18667.9	Ganga Ganges	935000	941428	832810	833118
2851250 171	Mathanguri 164	1223.9	497.0	2311.7	Manas Ganges	32770	32764	32770	32764
2851300 172	Pandu 164	18099.5	10512.2	28251.2	Brahmaputra Ganges	405000	405697	251809	252712
2853050 173	Ahmedabad 0	32.6	1.6	124.2	Sabarmati Rabarmati	12950	11274	12950	11274
2853150 174	Sevalia 0	382.6	28.4	1672.0	Mahi Mahi	33670	28465	33670	28465
2853200 175	Garudeshwar 0	1216.2	202.9	3097.9	Narmada Narmada	89345	94020	72769	76936

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
2853300 176	Kathore 0	488.9	10.9	2152.3	Tapi Tapti	61575	60569	61575	60569
2853500 177	Jamtara 175	303.8	36.5	1163.8	Narmada Narmada	16576	17084	16576	17084
2854020 178	Kokpara 0	310.2	89.2	713.1	Subarnarekha Subamarekha	15152	17104	15152	17104
2854050 179	Rhondia 0	296.3	7.5	860.7	Damodar Damodar	19220	22603	19220	22603
2854100 180	Takali 181	236.3	43.8	571.0	Bhima Krishna	33916	32250	33916	32250
2854300 181	Vijayawada 0	1641.7	86.3	4976.9	Krishna Krishna	251355	251684	217439	219434
2854500 182	Nellore 0	74.3	4.4	272.2	Penner Penner	53290	53909	53290	53909
2854700 183	Krishnarajasagar 0	168.3	48.4	352.4	Cauvery Cauveri	10600	9051	10600	9051
2856200 184	Dhalegaon 185	126.3	6.4	387.7	Godavari Godavari	30840	31994	30840	31994
2856500 185	Mancherial 187	430.7	50.8	1474.6	Godavari Godavari	102900	105189	72060	73195
2856550 186	Ashti 187	690.1	180.9	1512.5	Wainganga Godavari	50990	51866	50990	51866
2856900 187	Polavaram 0	3038.2	468.1	10393.9	Godavari Godavari	299320	305663	145430	148608
2901200 188	Novy Erokol 0	464.0	195.5	976.6	Anadyr GHAASBasin91	47300	46258	47300	46258
2901300 189	Kamenskoe 0	695.5	264.2	1451.2	Penzhina Penzhina	71600	73037	71600	73037
2902800 190	Kluchi 0	779.0	513.9	1166.7	Kamchatka Kamchatka	45600	45475	45600	45475
2903050 191	Bodaibo 196	1622.4	784.6	3153.4	Vitim Lena	186000	190305	186000	190305
2903080 192	Chabda 196	1300.6	652.5	2452.3	Maya Lena	165000	162522	165000	162522
2903150 193	Saskylakh 0	445.4	20.6	1025.0	Anabar Anabar	78800	79099	78800	79099
2903300 194	Shorokhovo 196	652.5	349.4	1009.5	Kirenga Lena	46500	48329	46500	48329
2903410 195	Tulun 205	149.1	83.6	274.2	Iya Yenisei	14500	14382	14500	14382
2903430 196	Stolb 0	15204.2	8567.0	23126.3	Lena Lena	2460000	2417046	1949000	1898359
2903700 197	Bugurtak 205	775.4	404.4	1422.4	Tuba Yenisei	31800	34816	31800	34816
2906200 198	Sretensk 200	409.2	118.7	1233.2	Shilka Amur	175000	177872	175000	177872
2906500 199	Ust-Ulma 200	654.8	194.1	1611.5	Selemdha Amur	67000	63142	67000	63142
2906700 200	Khabarovsk 202	8474.4	3056.9	16440.0	Amur Amur	1630000	2686517	972600	2028526
2906800 201	Kirovsky 200	222.3	55.4	625.7	Ussuri Amur	24400	22104	24400	22104
2906900 202	Komsomolsk 0	9874.4	4131.3	16963.2	Amur Amur	1730000	2782795	100000	96278
2907400 203	Mostovoy 205	950.6	417.6	1619.0	Selenga Yenisei	440200	446029	414500	422959
2908400 204	Maleta 203	61.6	15.8	172.1	Khilok Yenisei	25700	23070	25700	23070
2909150 205	Igarka 0	18050.0	10037.1	28900.6	Yenisei Yenisei	2440000	2413479	1735500	1700922
2909280 206	Malykai 196	393.9	124.2	899.8	Markha Lena	89600	93685	89600	93685
2909400 207	Kuzmovka 205	1628.9	794.2	3082.9	Podkamennaya Tunguska Yenisei	218000	217331	218000	217331
2910100 208	Ugut 217	151.4	48.8	308.0	Bolshoi Yugan Ob	22100	21941	22100	21941
2910200 209	Napas 217	205.5	76.9	355.6	Tym Ob	24500	22915	24500	22915
2910300 210	Tomsk 217	1047.0	471.7	1958.9	Tom Ob	57000	57736	27200	26295

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
2910470 211	Biysk 217	478.3	162.0	1063.2	Biya Ob	36900	34656	36900	34656
2910490 212	Novokuznetsk 210	650.9	206.4	1463.0	Tom Ob	29800	31441	29800	31441
2911100 213	Omsk 217	734.2	463.8	985.2	Irtish Ob	321000	316015	321000	316015
2911200 214	Petropavlovsk 217	37.4	1.0	115.7	Ishim Ob	118000	118146	118000	118146
2912400 215	Tiumen 217	189.9	30.8	1189.6	Tura Ob	58500	65659	58500	65659
2912550 216	Sosva 217	608.5	193.5	1209.7	Northern Sosva Ob	65200	68905	65200	68905
2912600 217	Salekhard 0	12532.2	6646.7	20690.5	Ob Ob	2949998	2532786	2246798	1826812
2913200 218	Akutkul 0	9.4	0.6	27.8	Kara-Turgay Syr-Darya	14700	14227	14700	14227
2913550 219	Sergipolskoye 0	10.8	0.2	83.7	Nura GHAASBasin189	12300	16040	12300	16040
2914450 220	Ush-Tobe 0	55.4	2.2	139.1	Karatal GHAASBasin73	13200	10939	13200	10939
2916200 221	Tyumen-Aryk 0	541.9	98.2	1241.8	Syr-Darya Syr-Darya	219000	268980	136600	183669
2916500 222	Arys 221	20.8	6.3	89.2	Arys Syr-Darya	13100	13693	13100	13693
2916550 223	Hodjickent 221	218.3	111.6	472.2	Chirchik Syr-Darya	10900	11495	10900	11495
2916850 224	Uch-Kurgan 221	365.2	124.8	737.2	Naryn Syr-Darya	58400	60123	23800	25333
2916860 225	Ust. Kekirim 224	204.7	125.1	329.8	Naryn Syr-Darya	34600	34790	24100	25530
2916890 226	Naryn 225	86.9	43.5	147.1	Naryn Syr-Darya	10500	9261	10500	9261
2917100 227	Chatly 0	1376.2	506.5	2483.9	Amu-Darya Amu-Darya	450000	550123	130800	240877
2917110 228	Kerki 227	1696.1	789.0	3095.8	Amu-Darya Amu-Darya	309000	297328	151300	148745
2917400 229	Manguzar 228	49.9	1.6	166.1	Surkhandarya Amu-Darya	13500	12104	13500	12104
2917450 230	Dupuli 227	155.0	96.8	239.4	Zaravchan Amu-Darya	10200	11918	10200	11918
2917700 231	Khorog 235	103.8	61.0	169.6	Gunt Amu-Darya	13700	14780	13700	14780
2917830 232	Murgab 235	16.2	6.2	31.5	Bartang Amu-Darya	10500	7333	10500	7333
2917900 233	Tutkaul 228	639.2	442.2	896.2	Vakhsh Amu-Darya	31200	31137	11200	12037
2917920 234	Garm 233	329.7	170.7	622.0	Vakhsh Amu-Darya	20000	19099	20000	19099
2917950 235	Niz. Pjandge 228	1012.4	711.3	1425.8	Pjandge Amu-Darya	113000	105343	88800	83230
2919200 236	Kushum 0	296.7	30.1	1075.6	Ural Ural	190000	187003	179000	175205
2919500 237	Aktubinsk 236	14.9	1.8	38.8	Ilek Ural	11000	11798	11000	11798
2964080 238	Sirikit Dam 239	175.7	69.0	431.2	Nan Chao Phraya	13300	14678	13300	14678
2964100 239	Nakhon Sawan 0	646.6	248.2	1224.4	Chao Phraya Chao Phraya	110569	117902	97269	103224
2964999 240	Srinagarind Dam 0	140.0	51.2	326.2	Quae Yai Mae Klong	10880	11915	10880	11915
2969010 241	Chiang Saen 157	2711.1	1717.4	4477.2	Mekong Mekong	189000	191777	189000	191777
2969082 242	Ban Chot 245	50.1	8.5	146.2	Nam Chi Mekong	10200	11886	10200	11886
2969090 243	Nong Khai 244	4083.6	2598.5	5923.1	Mekong Mekong	302000	305079	34000	26387
2969100 244	Mukdahan 158	7949.9	4248.2	12477.3	Mekong Mekong	391000	390302	89000	85224
2969200 245	Ubon 158	615.7	126.3	1574.6	Nam Mun Mekong	104000	104137	93800	92251

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
2998110 246	Ubileynaya 0	1022.4	417.4	2073.4	Yana Yana	224000	234464	224000	234464
2998400 247	Vorontsovo 0	1587.2	677.2	3217.1	Indigirka Indigirka	305000	299735	282700	278200
2998450 248	Andrushkino 0	45.0	7.4	90.0	Alazeja Alazeya	29000	28511	29000	28511
2998500 249	Sredne-Kolymsk 250	2214.7	765.0	5686.2	Kolyma Kolyma	361000	362791	361000	362791
2998510 250	Kolymskaya 0	3109.0	1371.2	6313.6	Kolyma Kolyma	526000	536288	165000	173497
2998600 251	Ala-Chubuk 247	115.9	29.9	261.8	Nera Indigirka	22300	21535	22300	21535
2999200 252	Nadym 0	460.7	216.2	755.6	Nadym Nadym	48000	42948	48000	42948
2999250 253	Sidorovsk 0	1034.5	533.0	1731.8	Taz Pur - Taz	100000	97166	100000	97166
2999500 254	Samburg 0	906.2	461.5	1446.9	Pur Pur - Taz	95100	91603	95100	91603
2999800 255	Buyaga 196	129.0	59.8	284.1	Amga Lena	23900	23846	23900	23846
2999910 256	7.5km Downstream of River Pur 0	999.5	484.3	2066.5	Olenek Olenek	198000	197908	71000	61522
2999920 257	Sukhana 256	717.2	285.5	1547.1	Olenek Olenek	127000	136386	127000	136386
3103500 258	Puerto Berrio 0	2481.0	1605.5	3564.3	Magdalena Magdalena	74410	70913	74410	70913
3142500 259	Pte Pusmeo 0	290.4	135.3	479.4	Patia GHAASBasin687	13147	12360	13147	12360
3178800 260	Panamericana 0	11.7	0.0	68.2	Limari GHAASBasin923	11343	13269	11343	13269
3179200 261	Cabimbao 0	119.3	25.8	318.7	Maipo Maipo	14823	15437	14823	15437
3206630 262	Dos Aguas 0	1876.0	1268.3	2616.5	Caura Orinoco	25000	24635	25000	24635
3206720 263	Puente Angostura 0	30620.8	19134.2	43036.4	Orinoco Orinoco	836000	907313	717170	796117
3206800 264	Tama-Tama 263	1227.0	666.2	1830.1	Orinoco Orinoco	37870	40139	37870	40139
3218100 265	Solano 263	2100.8	1283.9	3110.5	Brazo Casiquiare Orinoco	80960	71057	80960	71057
3264500 266	Posadas 269	12049.9	6559.4	24973.4	Parana Parana	975000	958816	105483	89273
3265005 267	la Punilla 268	6.4	0.0	30.2	Calchaqui Parana	19800	19548	19800	19548
3265100 268	el Arenal 0	19.2	1.1	73.8	Salado Parana	40000	41960	20200	22412
3265300 269	Corrientes 0	16595.2	7583.8	39291.7	Parana Parana	1950000	2172009	353769	518973
3268130 270	Algarrobito (1971: San Telmo) 271	115.8	52.8	214.2	Grande de Tarija Parana	10460	11475	10460	11475
3268150 271	Zanja del Tigre 269	317.5	109.0	830.9	Bermejo Parana	24931	22908	14471	11434
3268270 272	Caimancito (Puente Carretero) 269	98.5	23.4	353.2	San Francisco Parana	25800	56651	25800	56651
3268500 273	la Paz 269	188.1	71.8	409.1	Filcomayo Parana	96000	103995	96000	103995
3274030 274	Tinogasta 0	2.1	1.0	5.6	Abaucan Colorado (Arg)	14000	16351	14000	16351
3274150 275	el Sauce (1967: Embalse Rio Hondo) 0	94.2	5.4	411.7	Dulce Noname (GHAASBasin174)	20200	22071	20200	22071
3275050 276	Pachimoco 0	8.9	3.2	37.2	Jachal Colorado (Arg)	25500	26836	25500	26836
3275100 277	la Puntilla 0	56.1	13.2	238.7	San Juan Colorado (Arg)	25000	26356	25000	26356
3275270 278	Arco del Desaguadero 0	10.9	0.0	84.6	Desaguadero Colorado (Arg)	10212	10311	10212	10311
3275700 279	Buta Ranquil 281	143.9	49.8	312.8	Colorado Negro Arg	15300	12287	15300	12287
3275750 280	Pichi Mahuida 0	130.4	38.5	299.0	Colorado Colorado (Arg)	22300	69068	22300	69068

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
3275800 281	Paso de los Indios 283	311.9	65.2	910.2	Neuquen Negro Arg	30200	29246	14900	16960
3275900 282	Paso Limay 0	746.0	287.6	1632.1	Limay Chubut	26400	23205	26400	23205
3275990 283	Primera Angostura 0	870.1	243.6	1772.7	Negro Negro Arg	95000	185798	64800	156551
3276200 284	Los Altares 0	48.8	16.3	116.1	Chubut Chubut	16400	13601	16400	13601
3276320 285	Vuelta del Senguerr 0	48.9	9.2	124.2	Senguerr Chubut	17500	32739	17500	32739
3276800 286	Charles Fuhr 0	689.8	330.1	1025.5	Santa Cruz Santa Cruz	15550	15875	15550	15875
3308300 287	Apaikwa 0	773.1	350.8	1339.1	Mazaruni Essequibo	14000	15373	14000	15373
3308600 288	Plantain Island 0	2103.5	657.1	3751.1	Essequibo Essequibo	66600	67866	66600	67866
3469050 289	Salto 0	5224.9	1111.7	12277.0	Uruguay Uruguay	244000	243471	160235	151687
3469100 290	Palmar 0	721.6	26.5	3371.2	Negro Uruguay	63000	67709	37189	41480
3469200 291	Paso de la Laguna 290	226.2	32.2	601.8	Tacuarembó Uruguay	14038	15715	14038	15715
3469400 292	Paso Pereira 290	180.1	18.2	643.0	Negro Uruguay	11773	10515	11773	10515
3512400 293	Langa Tabiki 0	1682.3	482.4	3401.1	Maroni Maroni	60930	61713	60930	61713
3514800 294	Maripa 0	835.0	267.5	1617.8	Oyapock Oyapok	25120	21614	25120	21614
3618500 295	Caracarai 313	2926.2	796.2	5423.8	Rio Branco Amazon	124980	123421	124980	123421
3618950 296	Uaracu 313	2387.5	1533.0	3377.9	Rio Uaupes Amazon	40506	37088	40506	37088
3621200 297	Acanauí 313	13914.9	9400.0	18288.2	Rio Japura Amazon	242259	222518	45123	33988
3621400 298	Vila Bittencourt 297	13100.3	8595.4	17596.0	Rio Japura Amazon	197136	188529	197136	188529
3622400 299	Estirao do Repouso 301	2462.6	1480.7	3455.0	Rio Javari Amazon	58107	58417	58107	58417
3622801 300	Seringal do Ituí 301	797.7	466.4	1168.1	Rio Ituí Amazon	19103	24599	19103	24599
3623100 301	Sao Paulo de Olivenca 313	7034.6	4350.8	9951.4	Amazonas (Rio Solimoes) Amazon	990781	992798	913571	909782
3624120 302	Gaviao 313	4765.3	3089.1	6205.4	Rio Jurua Amazon	162000	168447	78513	82875
3624160 303	Cruzeiro do Sul 302	913.3	331.7	1588.5	Rio Jurua Amazon	38537	42802	21956	27555
3624180 304	Taumaturgo 303	412.1	209.7	709.4	Rio Jurua Amazon	16581	15246	16581	15246
3624300 305	Envira 302	1276.9	744.5	1836.3	Rio Tarauaca Amazon	44950	42770	44950	42770
3625150 306	Rio Branco 309	353.6	115.1	660.8	Rio Acre Amazon	22670	18251	22670	18251
3625310 307	Aruma-Jusante 313	10434.6	6860.5	13452.2	Rio Purus Amazon	359853	360991	139502	119834
3625340 308	Labrea 307	5569.6	3814.2	7298.8	Rio Purus Amazon	220351	241157	157185	171116
3625370 309	Seringal Da Caridade 308	1279.0	498.0	2284.7	Rio Purus Amazon	63166	70040	40496	51789
3627040 310	Porto Velho 313	19758.4	12676.0	27381.0	Rio Madeira Amazon	954285	992572	954285	992572
3627408 311	Jiparana (Rondonia) 313	671.6	430.7	949.2	Rio Jiparana Amazon	32606	33301	32606	33301
3628500 312	Estirao Da Angelica 313	727.1	92.0	1609.5	Rio Mapuera Amazon	26040	27819	26040	27819
3629000 313	Obidos 0	176176.7	129280.1	217490.0	Amazonas Amazon	4640300	4622624	1706990	1663668
3629180 314	Barra do Sao Manuel-Jusante 0	8341.7	6541.7	10460.2	Rio Tapajos Amazon	332163	348344	136720	139384
3629380 315	Fontanilhas 314	1425.5	198.2	1777.7	Rio Jurupena Amazon	57958	54127	57958	54127

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	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
3629790 316	Tres Marias 314	3978.1	2940.8	5200.2	Rio Sao Manoel Amazon	137485	154833	137485	154833
3630050 317	Altamira 0	8670.1	4976.7	14308.4	Xingu Amazon	446570	448086	322743	322365
3630120 318	Pedra do o 317	2614.7	1045.2	4233.7	Rio Iriri Amazon	123827	125721	37837	46161
3630150 319	Laranjeiras 318	1234.8	639.1	2079.0	Rio Iriri Amazon	65187	58138	65187	58138
3630215 320	Boca do Inferno 318	129.4	4.6	391.2	Rio Curua Amazon	20803	21422	20803	21422
3630300 321	Arapari 0	115.2	12.5	294.7	Rio Maicuru Amazon	17072	18546	17072	18546
3631100 322	Sao Francisco 0	1004.1	281.7	1790.5	Rio Jari Amazon	51343	52541	20398	21638
3631210 323	Fazenda Paquira 322	489.6	100.1	952.0	Rio Paru de Este Amazon	30945	30903	30945	30903
3649014 324	Colonia Dos Americanos 327	335.4	162.8	612.5	Rio Das Almas Tocantins	18282	26841	18282	26841
3649211 325	Jacinto 330	187.7	62.0	374.2	Rio Santa Tereza Tocantins	13811	12048	13811	12048
3649240 326	Fazenda Lobeira 327	207.0	79.8	488.0	Rio Manuel Alves Tocantins	14462	15138	14462	15138
3649250 327	Porto Nacional 334	2245.5	856.9	5180.8	Tocantins Tocantins	175360	174391	142616	132411
3649412 328	Araguaiana 329	915.7	458.8	1523.5	Rio Araguaia Tocantins	50930	56324	50930	56324
3649414 329	Fazenda Telesforo 330	1482.4	515.5	2404.5	Rio Araguaia Tocantins	131600	134108	80670	77785
3649416 330	Conceicao do Araguaia 331	4857.9	9.9	9053.4	Rio Araguaia Tocantins	320290	315378	119533	112369
3649418 331	Xambioa 334	5507.8	2218.8	8984.4	Rio Araguaia Tocantins	364496	364358	44206	48980
3649614 332	Torriqueje 333	344.7	204.0	535.4	Rio Das Mortes Tocantins	17850	17887	17850	17887
3649619 333	Santo Antonio do Leverger 330	867.5	391.6	1411.2	Rio Das Mortes Tocantins	55346	56853	37496	38966
3649900 334	Itupiranga 0	11363.6	5875.0	18813.9	Tocantins Tocantins	727900	743944	188044	205196
3650150 335	Badajos 0	555.4	233.0	786.8	Rio Capim GHAASBasin180	38178	37016	38178	37016
3650202 336	Alto Bonito 0	480.9	115.7	835.8	Rio Gurupi Gurupi	31850	33923	31850	33923
3650335 337	Bacabal 0	111.2	55.5	237.2	Rio Mearim Mearim	25500	24630	25500	24630
3650355 338	Caxias 339	80.3	37.3	181.1	Rio Itapecuru GHAASBasin198	31750	33809	31750	33809
3650359 339	Cantanhede 0	252.5	73.4	722.8	Rio Itapecuru GHAASBasin198	50800	52295	19050	18486
3650385 340	Nina Rodrigues 0	150.7	40.6	362.1	Rio Munim GHAASBasin198	12350	12338	12350	12338
3650460 341	Santa Cruz do Piaui 342	12.7	0.1	85.8	Rio Itam Parnaiba	17500	12273	17500	12273
3650481 342	Luzilandia 0	846.3	427.0	2043.2	Rio Parnaiba Parnaiba	322823	330977	279323	291250
3650488 343	Fazenda Paracati 342	203.4	143.3	297.1	Rio Parnaiba Parnaiba	26000	27454	26000	27454
3650525 344	Sobral 0	56.3	0.0	308.2	Rio Acarau GHAASBasin596	11160	9244	11160	9244
3650634 345	Morada Nova Ii 0	52.9	0.5	422.0	Rio Banabuiu GHAASBasin192	17900	18467	17900	18467
3650645 346	Iguatu 347	29.5	0.0	289.8	Rio Jaguaribe GHAASBasin192	21770	18419	21770	18419
3650649 347	Peixe Gordo 0	116.7	0.4	593.7	Rio Jaguaribe GHAASBasin192	48200	42986	26430	24567
3650750 348	Jardim de Piranhas 0	78.6	1.5	403.1	Rio Piranhas GHAASBasin369	22875	27628	22875	27628
3650885 349	Ponte Da Batalha 0	33.8	0.7	172.1	Rio Paraiiba GHAASBasin433	19244	24511	19244	24511
3651309 350	Varzea Da Palma 354	296.2	87.6	682.4	Rio Das Velhas Sao Francisco	25940	26317	25940	26317

GRDC Code ID	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]		
	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p	
		Mean	Min	Max						
3651408 351	Porto Alegre	354	439.9	120.8	1015.1	Rio Paracatu Sao Francisco	41709	38385	41709	38385
3651678 352	Boqueirao	353	269.7	195.2	431.3	Rio Grande Sao Francisco	65900	60549	65900	60549
3651800 353	Juazeiro	0	2710.8	1115.3	5951.6	Sao Francisco Sao Francisco	510800	508266	244111	256505
3651805 354	Manga	353	2020.6	710.3	4692.2	Sao Francisco Sao Francisco	200789	191212	133140	126510
3652039 355	Usina Altamira	0	40.9	5.9	142.7	Rio Itapicuru GHAASBasin322	35150	36439	35150	36439
3652130 356	Fazenda Santa-Fe	0	95.9	21.3	229.6	Rio Paraguacu GHAASBasin250	31488	30162	31488	30162
3652220 357	Jequie	0	28.5	0.8	174.3	Rio Contas GHAASBasin308	42245	44968	42245	44968
3652320 358	Mascote	0	77.7	12.4	264.2	Rio Pardo Jequitinhonha	30360	41732	30360	41732
3652450 359	Jacinto	0	408.6	79.2	1238.8	Jequitinhonha Jequitinhonha	62365	62081	62365	62081
3652890 360	Campos-Ponte Municipal	0	841.6	226.6	1950.3	Paraiba do Sul Paraiba do Sul	55083	57259	55083	57259
3662100 361	Uhe Jupia-Jusante-Jju	362	6369.0	2683.6	12378.8	Parana Parana	478000	471509	478000	471509
3663100 362	Guaira	266	8593.8	4268.3	16137.1	Parana Parana	802200	802804	239386	249077
3663650 363	Novo Porto Taquara	362	690.7	216.0	1792.2	Rio Ivai Parana	34432	34383	34432	34383
3663655 364	Porto Paraiso do Norte	362	524.3	114.9	1709.2	Rio Ivai Parana	28427	25321	28427	25321
3663700 365	Jataizinho	362	367.7	65.7	1588.1	Rio Tibaji Parana	21955	22514	21955	22514
3664150 366	Salto Ozorio	367	963.3	208.8	3247.8	Iguacu Parana	46400	50011	22189	22227
3664160 367	Salto Cataratas	266	1418.7	292.7	5568.0	Iguacu Parana	67317	66740	20917	16729
3664802 368	Uniao Da Vitoria	366	423.1	96.0	1677.9	Iguacu Parana	24211	27784	24211	27784
3666050 369	Caceres (Dnpvn)	372	534.3	238.3	951.2	Paraguai Parana	33890	32848	33890	32848
3666200 370	Sao Jeronimo	371	190.7	108.8	315.5	Rio Piquiri Parana	27150	26694	27150	26694
3666400 371	Porto Alegre	372	589.2	409.3	760.3	Rio Cuiaba Parana	102750	106760	75600	80066
3667020 372	Porto Esperanca (Dnos)	373	1813.7	1107.0	3330.8	Paraguai Parana	363500	371254	184360	190852
3667060 373	Porto Murtinho (Fb/dnos)	269	2299.0	833.5	4899.4	Paraguai Parana	474500	510665	111000	139411
3667200 374	Miranda	372	85.0	27.7	198.4	Rio Miranda Parana	15460	14415	15460	14415
3667300 375	Coxim	372	264.1	157.7	483.9	Rio Taquari Parana	27040	26379	27040	26379
3669600 376	Passo Mariano Pinto	289	798.1	109.0	2796.6	Rio Ibicui Uruguay	42498	50787	42498	50787
3669700 377	Marcelino Ramos	289	846.4	127.0	3012.0	Uruguai Uruguay	41267	40998	41267	40998
3844100 378	D.J.Sade	0	994.0	542.1	2008.4	Esmeraldas GHAASBasin796	18800	15456	18800	15456
4102100 379	Crooked Creek, Alas.	0	1111.9	622.5	1937.6	Kuskokwim Kuskowin	80549	78072	50246	47080
4102110 380	Mcgrath	379	381.5	231.0	631.4	Kuskokwim Kuskowin	30303	30993	30303	30993
4102700 381	Chitina, Alas.	0	1050.6	614.1	1589.3	Copper Copper	53354	58189	53354	58189
4102800 382	Susitna Station	0	1400.8	986.7	2172.1	Susitna GHAASBasin321	50246	45580	50246	45580
4103200 383	Pilot Station	0	6346.8	4376.1	8721.7	Yukon Yukon	831390	840586	64390	71605
4103300 384	Kaltag, Alas.	383	6040.2	3732.4	8838.1	Yukon Yukon	767000	768981	47757	51739
4103450 385	Ruby, Alas.	384	4215.5	2690.3	6258.8	Yukon Yukon	670810	666937	96089	89461

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	Next Station	Discharge [m ³ /s]				STN Basin Name	GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max						
4103500 386	Hughes, Alas.	384	381.6	91.7	789.0	Koyukuk Yukon	48433	50305	48433	50305
4103550 387	near Stevens Village	385	3378.3	2413.8	4948.8	Yukon River Yukon	508417	506410	138047	134449
4103600 388	Nenana, Alas.	385	651.9	469.8	941.4	Tanana Yukon	66304	71066	44160	47125
4103700 389	Fort Yukon, Alas.	387	410.5	116.9	783.6	Porcupine River Yukon	76405	76724	21005	21766
4103750 390	Tanacross, Alas.	388	221.1	148.5	301.2	Tanana Yukon	22144	23941	22144	23941
4103800 391	Eagle	387	2359.2	1405.6	3679.2	Yukon River Yukon	293965	295238	29965	30742
4113300 392	Grand Forks, N.D.	495	105.3	12.8	290.2	Red of The North Nelson	77959	75474	77959	75474
4115100 393	Salem, Oreg.	0	688.1	157.7	2224.8	Willamette Columbia	18855	17771	18855	17771
4115200 394	The Dalles, Oreg.	0	5438.1	2289.3	11335.8	Columbia Columbia	613830	656568	193130	232154
4116180 395	Clarkston, Wash.	394	1414.7	619.9	2788.5	Snake River Columbia	267300	270819	267300	270819
4118440 396	Imlay, Nev.	0	11.3	0.6	58.0	Humboldt GHAASBasin214	40663	63381	40663	63381
4118850 397	Juab, Utah	0	8.9	2.0	44.9	Sevier River GHAASBasin590	13261	12121	13261	12121
4119650 398	Clinton, Iowa	399	1466.4	554.1	2716.8	Mississippi Mississippi	221704	227644	221704	227644
4119800 399	Alton, Ill.	416	2895.6	862.1	6919.2	Mississippi Mississippi	444185	440389	222481	212744
4120900 400	Culbertson, Mont.	402	349.2	195.8	596.9	Missouri Mississippi	237133	220207	237133	220207
4120950 401	Sidney, Mont.	402	390.5	177.7	657.4	Yellowstone Mississippi	178977	173162	178977	173162
4121800 402	Yankton, S.D.	404	748.9	269.3	1845.7	Missouri Mississippi	723900	716161	307790	322792
4122600 403	Louisville, Nebr.	404	214.5	74.4	536.5	Platte Mississippi	222222	215978	222222	215978
4122650 404	Nebraska City, Nebr.	406	1179.7	731.8	1960.9	Missouri Mississippi	1061899	1074472	115777	142333
4122700 405	Desoto, Kans.	406	262.9	48.1	866.7	Kansas Mississippi	154768	167148	154768	167148
4122900 406	Hermann, Mo.	416	2307.5	628.6	7079.4	Missouri Mississippi	1357677	1364134	141010	122514
4123050 407	Metropolis, Ill.	416	7450.4	535.6	18925.8	Ohio Mississippi	525770	497409	65778	58857
4123060 408	Paducah, Ky.	407	1857.0	756.8	4014.8	Tennessee Mississippi	104118	90452	104118	90452
4123080 409	Grand River, Ky.	407	1183.8	357.5	2181.1	Cumberland Mississippi	45579	37361	45579	37361
4123130 410	Mount Carmel, Ill.	407	838.0	207.3	1914.2	Wabash Mississippi	74165	76066	74165	76066
4123300 411	Louisville, Ky.	407	3464.7	1157.4	7118.8	Ohio Mississippi	236130	234672	236130	234672
4125500 412	Tulsa, Okla.	414	198.3	25.4	757.2	Arkansas Mississippi	193253	198789	193253	198789
4125550 413	Whitefield, Okla.	414	124.6	11.3	465.2	Canadian Mississippi	123222	123036	123222	123036
4125800 414	Little Rock, Ark.	416	1065.7	41.5	5159.8	Arkansas Mississippi	409453	408872	92978	87047
4126800 415	Alexandria, La.	0	861.2	127.3	3202.8	Red Mississippi	174825	169478	174825	169478
4127800 416	Vicksburg, Miss.	0	17599.8	7448.0	31341.1	Mississippi Mississippi	2964252	2957806	227167	247002
4133200 417	Wrightstown, Wis.	521	126.4	46.8	284.4	Fox River St. Lawrence	16084	17732	16084	17732
4135200 418	Waterville, Ohio	521	158.2	27.2	492.4	Maumee St. Lawrence	16395	16269	16395	16269
4143300 419	Ogdensburg, N.Y.	0	6782.0	4997.5	8264.8	St.Lawrence St. Lawrence	764600	783664	78600	96032
4145900 420	Agness, Oreg.	0	187.7	41.8	499.8	Rogue GHAASBasin1050	10202	11350	10202	11350

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	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p	
		Mean	Min	Max						
4146110 421	Klamath, Calif.	0	521.5	98.3	1505.2	Klamath	31339	32197	31339	32197
4146280 422	Sacramento, Calif.	0	683.7	195.1	1462.4	Sacramento	60886	58907	60886	58907
4146360 423	Vernalis, Calif.	0	158.2	11.8	660.8	San Joaquin	35058	39596	35058	39596
4147010 424	West Enfield, Me.	0	339.6	135.8	897.7	Penobscot	17275	17237	17275	17237
4147380 425	Lowell, Mass.	0	231.5	83.6	506.2	Merrimack	12005	11239	12005	11239
4147460 426	Thompsonville, Conn.	0	470.1	170.3	1234.0	Connecticut	25022	22383	25022	22383
4147500 427	Green Island, N.Y.	0	388.9	144.9	856.2	Hudson	20953	24767	20953	24767
4147600 428	Trenton, N.J.	0	333.6	95.6	979.0	Delaware	17560	16214	17560	16214
4147700 429	Harrisburg, Pa.	0	974.1	221.8	3194.8	Susquehanna	62419	65000	62419	65000
4147900 430	Washington, D.C.	0	312.7	66.3	1068.0	Potomac	29940	33598	29940	33598
4148050 431	Richmond, Va.	0	202.2	35.6	588.3	James	17503	17110	17503	17110
4148090 432	Roanoke Rapids, N.C.	0	223.4	78.3	550.5	Roanoke	21782	22259	21782	22259
4148300 433	Pee Dee, S.C.	0	282.7	90.9	833.4	Pee Dee	22870	25164	22870	25164
4148550 434	Pineville, S.C.	0	66.7	13.4	328.4	Santee	38073	38004	38073	38004
4148720 435	Doctortown, Ga.	0	392.6	105.5	1156.2	Altamaha	35224	35905	35224	35905
4149120 436	Bogalusa, La.	0	282.2	61.9	895.4	Pearl	17172	18285	17172	18285
4149300 437	Merrill, Miss.	0	285.3	56.9	957.8	Pascagoula	17094	15814	17094	15814
4149400 438	Claiborne, Ala.	0	943.4	275.8	2574.6	Alabama	56895	54164	56895	54164
4149630 439	Chattahoochee, Fla.	0	638.4	242.8	1647.9	Apalachicola	44548	44163	44548	44163
4149780 440	Branford, Fla.	0	217.6	64.2	512.0	Suwannee	20409	18569	20409	18569
4150280 441	Mathis, Tex.	0	24.7	1.8	191.2	Nueces	43149	43269	43149	43269
4150500 442	Richmond, Tex.	0	199.4	23.8	679.9	Brazos	116568	118467	116568	118467
4150600 443	Romayor, Tex.	0	206.1	18.4	717.7	Trinity	44512	47549	44512	47549
4150680 444	Evadale, Tex.	0	146.2	20.6	432.8	Neches	20593	21196	20593	21196
4150700 445	Ruliff, Tex.	0	207.4	27.9	565.2	Sabine	24162	23585	24162	23585
4151800 446	Laredo, Tex.	0	114.8	8.6	542.3	Rio Grande	352178	566451	352178	566451
4152100 447	Yuma, Ariz.	0	20.5	13.0	29.2	Colorado	629100	608155	339538	324612
4152450 448	Lees Ferry, Ariz.	447	463.7	40.2	1315.9	Colorado (Ari)	289562	283543	184408	180698
4152550 449	Green River, Utah	448	177.0	68.4	364.5	Green	105154	102845	105154	102845
4203050 450	Old Crow	389	319.4	78.8	610.7	Porcupine River	55400	54958	55400	54958
4203150 451	Mayo	452	382.2	187.4	653.0	Yukon	31598	34470	31598	34470
4203200 452	Dawson	391	2160.0	1573.7	2874.3	Stewart River	264000	264496	82441	86300
4203250 453	above White River	452	1186.5	723.4	1865.2	Yukon River	149961	143725	39840	36506
4203500 454	Pelly Crossing	453	370.5	188.2	576.1	Yukon	49000	47306	49000	47306
4203770 455	near Teslin	453	302.7	143.1	503.3	Teslin River	30300	30724	30300	30724

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	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
4203900 456	above Frank Creek 453	316.4	205.9	444.4	Yukon River Yukon	30821	29190	30821	29190
4204050 457	above Butterfly Creek 459	631.0	414.8	917.3	Stikine Stikine	36000	34503	6700	6598
4204100 458	Telegraph Creek 457	396.8	241.2	621.8	Stikine Stikine	29300	27905	29300	27905
4204900 459	near Wrangell 0	1603.9	1055.0	2514.4	Stikine Stikine	51593	51316	15593	16813
4205600 460	near Tulsequah 0	264.8	153.8	452.9	Taku Taku	15500	16106	15500	16106
4206100 461	above Shumal Creek 0	774.8	461.2	1420.5	Nass Nass	19200	20608	19200	20608
4206250 462	Usk 0	900.3	487.4	1846.8	Skeena GHAASBasin261	42200	40322	42200	40322
4207150 463	near Port St. James 465	132.2	70.5	234.6	Stuart River Fraser	14600	12378	14600	12378
4207305 464	below Big Creek 467	97.0	66.5	147.9	Chilcotin Fraser	19300	19138	19300	19138
4207310 465	Marguerite 467	1477.6	834.9	2387.3	Fraser River Fraser	114000	111710	99400	99332
4207830 466	Mclure 467	433.5	263.9	685.8	North Thompson Fraser	19600	19621	19600	19621
4207900 467	Hope 0	2718.1	1594.0	4739.2	Fraser River Fraser	217000	229432	64100	78964
4208025 468	Arctic Red River 0	9118.7	6289.6	12594.8	Mackenzie River Mackenzie	1660000	1678481	90000	108883
4208150 469	Norman Wells 468	8324.0	6025.0	11162.2	Mackenzie River Mackenzie	1570000	1569598	344600	346739
4208220 470	above Clausen Creek 469	408.2	266.6	915.9	South Nahanni River Mackenzie	33400	33223	33400	33223
4208270 471	Lower Crossing 472	1144.0	662.1	1831.8	Liard River Mackenzie	104000	103458	104000	103458
4208280 472	Fort Liard 469	1878.5	1184.4	3034.9	Liard River Mackenzie	222000	219420	118000	115962
4208300 473	near Fort Providence 469	4384.6	3233.1	5647.5	Mackenzie River Mackenzie	970000	970216	364000	359594
4208400 474	Fitzgerald 473	3409.1	1969.7	5412.5	Slave River Mackenzie	606000	610621	180000	174941
4208450 475	Peace Point 474	1934.9	840.8	3454.8	Peace River Mackenzie	293000	294429	107000	99959
4208550 476	Hudson Hope 477	1071.1	146.2	2353.3	Peace River Mackenzie	70200	72214	70200	72214
4208630 477	Peace River 475	1763.8	676.6	3700.0	Peace River Mackenzie	186000	194470	65500	72171
4208640 478	Watino 477	354.2	159.9	754.4	Smoky River Mackenzie	50300	50085	50300	50085
4208730 479	below McMurray 474	668.7	396.8	1071.3	Athabasca River Mackenzie	133000	141252	58400	63403
4208870 480	Athabasca 479	437.8	230.0	929.3	Athabasca River Mackenzie	74600	77848	74600	77848
4209400 481	Point Lake Outlet 0	106.4	56.1	173.8	Coppermine River Coppermine	19300	19779	19300	19779
4209600 482	near The mouth 0	82.6	19.5	171.3	Ellice River Ellice	16900	18378	16900	18378
4209805 483	above Hermann River 0	488.2	204.0	969.2	Back Back	93900	93513	93900	93513
4213250 484	Medicine Hat 487	199.6	40.8	629.9	South Saskatchewan Nelson	56500	55199	56500	55199
4213290 485	near Unwin 488	8.8	0.7	49.1	Battle Nelson	25900	26239	25900	26239
4213300 486	near Deer Creek 488	208.6	124.8	396.2	North Saskatchewan Nelson	57000	55614	57000	55614
4213400 487	Saskatoon 490	263.3	37.2	880.4	South Saskatchewan Nelson	141000	140246	84500	85047
4213440 488	Prince Albert 490	242.6	88.0	732.4	North Saskatchewan Nelson	131000	130413	48100	48561
4213510 489	Turnberry 490	18.0	3.8	48.8	Carrot River Nelson	12600	10793	12600	10793
4213550 490	The Pas 496	591.1	303.2	1046.8	Saskatchewan River Nelson	347000	334978	62400	53527

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	Next Station	Discharge [m ³ /s]				GRDC	STN-30p	GRDC	STN-30p
		Mean	Min	Max					
4213560 491	near mouth 493	22.4	3.8	53.8	Red Deer River Nelson	14300	13119	14300	13119
4213590 492	Wawanesa 494	10.6	0.0	98.2	Souris Nelson	60300	62550	60300	62550
4213603 493	near Waterhen 496	76.5	9.0	201.2	Waterhen Nelson	55100	47395	40800	34276
4213650 494	Headingley 496	48.2	5.8	211.6	Assiniboine River Nelson	153000	154385	92700	91834
4213680 495	Emerson 496	94.3	5.2	498.8	Red River Nelson	104000	106127	26041	30653
4213710 496	above Bladder Rapids 0	2402.8	1035.1	3558.8	Nelson River Nelson	1000000	974453	214900	202917
4213800 497	Slave Falls 496	838.5	283.3	2049.2	Winnipeg River Nelson	126000	128651	126000	128651
4214050 498	above Beverly Lake 0	237.3	109.1	561.9	Thelon River Baker	65300	65170	65300	65170
4214090 499	above Kazan Falls 0	441.7	206.4	885.4	Kazan River Baker	72300	71906	72300	71906
4214210 500	Cold Lake Reserve 501	22.0	2.8	96.4	Beaver River Churchill (Hud)	14500	14339	14500	14339
4214260 501	above Granville Falls 0	860.3	576.4	1292.4	Churchill River Churchill (Hud)	228000	240626	213500	226287
4214330 502	near Island Lake 503	86.2	32.6	173.7	Island Lake River Hayes	14000	12730	14000	12730
4214350 503	Outlet of Gods Lake 0	163.4	72.2	300.8	Gods Hayes	25900	21628	11900	8898
4214450 504	below Asheweig River Tributary 0	454.0	173.9	874.7	Winisk Winisk	50000	49587	50000	49587
4214480 505	below Attawapiskat Lake 0	261.2	94.7	542.9	Attawapiskat Attawapiskat	24200	24815	24200	24815
4214520 506	near Hat Island 0	940.5	355.4	1798.4	Albany River Albany	118000	119425	118000	119425
4214550 507	Moose River Crossing 0	760.0	319.2	1405.8	Moose Moose	61100	66968	61100	66968
4214650 508	Tete du Lac Soscumica 0	1051.7	597.9	1792.8	Nottaway Nottaway	57500	62550	57500	62550
4214680 509	en aval du Lac Nemiscau 0	864.4	593.2	1218.5	Rupert Rupert	40900	44396	40900	44396
4214700 510	Tete de la Gorge De Basile 0	942.8	526.1	1624.9	Eastmain Eastmain	44300	43314	44300	43314
4214750 511	en amont de la Riviere De Pontois 512	758.7	435.8	1174.7	Grande Riviere La Grande	37000	38341	37000	38341
4214770 512	en aval de la Riviere Acazi 0	1749.5	983.3	2580.2	Grande Riviere La Grande	96300	97049	59300	58707
4214830 513	Sortie du Lac Bienville 0	352.6	211.7	558.3	Grande R. de la Baleine GR Baleine	21000	19404	21000	19404
4215200 514	Birchbank 394	2013.4	935.4	3839.8	Columbia River Columbia	88100	88953	53400	50907
4215220 515	International Boundary 394	771.5	220.1	1651.0	Pend Oreille Columbia	65300	64643	65300	64643
4215320 516	near Copeland 514	455.3	123.6	1653.2	Kootenai Columbia	34700	38047	21100	22359
4215705 517	Wardner 516	208.5	113.3	365.7	Kootenay Columbia	13600	15688	13600	15688
4231200 518	Fort Kent 519	273.5	54.3	712.1	Saint John Saint John	14700	12649	14700	12649
4231600 519	Pokiok 0	727.7	222.3	1943.8	St. John Saint John	38800	37966	24100	25317
4234010 520	Sault Ste. Marie 521	2141.6	1240.8	3229.2	St. Mary's River St. Lawrence	210000	223837	210000	223837
4236010 521	Queenston 419	5826.3	4259.2	7195.8	Niagara River St. Lawrence	686000	687632	443521	429794
4243050 522	la Cave Rapids 523	696.0	428.7	1144.6	Ottawa St. Lawrence	47900	48022	47900	48022
4243100 523	Chats Falls 0	1165.3	437.8	2766.7	Ottawa St. Lawrence	89600	88772	41700	40750
4243300 524	Centrale de Grande-Mere 0	755.8	219.2	2620.1	Saint-Maurice St. Lawrence	42000	37530	42000	37530
4243400 525	Centrale D'isle Maligne 0	1467.4	547.8	3118.3	Saguenay St. Lawrence	73000	75700	46100	50257

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		Mean	Min	Max						
4243410 526	Centrale de Chute-A-La-Savane	525	634.1	390.8	936.9	Peribonca St. Lawrence	26900	25443	26900	25443
4243600 527	Centrale de Chute-Aux-Outardes	0	391.1	25.2	982.5	Aux Outardes St. Lawrence	18900	19556	18900	19556
4243610 528	Centrale McCormick	0	868.6	315.6	1667.4	Manicouagan St. Lawrence	45800	46157	45800	46157
4243800 529	above Qnsr Bridge	0	457.9	252.5	761.5	Moisie Moisie	19000	17266	19000	17266
4244050 530	en amont de la Riviere Hamelin	0	345.8	194.4	564.2	Arnaud Arnaud	26900	31144	26900	31144
4244100 531	en aval de la Riviere Paladeau	0	623.4	290.2	1462.3	Aux Feuilles Aux Feuilles	41700	40871	41700	40871
4244150 532	pres de la Riviere Koksoak	0	628.9	243.3	1156.3	Aux Melezes Koksoak	42700	42729	42700	42729
4244180 533	Chute de la Pyrite	0	1584.7	576.7	2882.9	Caniapiscau Koksoak	86800	85199	86800	85199
4244200 534	pres de L'embouchure	0	535.3	203.2	1064.1	A la Baleine A la Baleine	29800	29037	29800	29037
4244250 535	Aux Chutes Helen	0	746.4	411.8	1331.6	George George	35200	37461	35200	37461
4244500 536	above Upper Muskrat Falls	0	1861.3	893.8	2903.3	Churchill River Churchill (Atlantic)	92500	99457	92500	99457
4244640 537	pres de L'embouchure	0	348.5	195.7	661.2	Natashquan Natashquan	16000	19137	16000	19137
4244660 538	en amont de la Riviere Netagamio	0	490.8	234.8	862.4	du Petit Mecatina Petit Mecatina	19100	20753	19100	20753
4356100 539	el Capomal	0	290.7	107.0	730.4	Santiago Grande de Santiago	128943	189027	128943	189027
4358300 540	Las Adjuntas	0	481.0	166.7	1039.7	Panuco Panuco	58115	86315	58115	86315
4362600 541	Boca del Cerro	0	1646.4	163.1	3119.8	Usumacinta Usumacinta	50743	50458	50743	50458
5101200 542	Clare	0	329.6	2.8	3017.7	Burdekin Burdekin	129660	121214	129660	121214
5101301 543	The Gap	0	163.0	0.1	1649.8	Fitzroy Fitzroy East	135860	135648	135860	135648
5109170 544	Rockfields	0	43.7	0.4	402.6	Gilbert River Gilbert	11800	11682	11800	11682
5109200 545	Koolatah	0	385.2	17.4	1295.9	Mitchell River GHAASBasin387	46050	29210	46050	29210
5202044 546	Lilydale (Newbold Crossing)	0	117.2	1.9	960.3	Clarence River GHAASBasin674	16690	18932	16690	18932
5202101 547	Belmore Bridge (Maitland)	0	31.6	0.6	188.3	Hunter River GHAASBasin930	17476	13129	17476	13129
5204268 548	Lock 9 Upper	0	256.9	22.2	1122.2	Murray Murray	991000	972414	394700	972414
5224500 549	Temerloh	0	551.8	219.9	1418.8	Pahang Pahang	19000	21579	19000	21579
5302229 550	Jarramond	0	51.6	3.5	353.0	Snowy River GHAASBasin960	13421	12352	13421	12352
5410100 551	Callamurra	0	61.0	0.0	791.8	Cooper Creek Great Artesian Basin	230000	232556	230000	232556
5606100 552	Darradup	0	20.2	2.7	92.7	Blackwood River GHAASBasin632	20500	20622	20500	20622
5607100 553	Emu Springs	0	5.1	0.0	64.3	Murchison River Murchinson	82300	71730	82300	71730
5607200 554	Nune Mile Bridge	0	21.8	0.0	312.1	Gascoyne River Gasgoyne	73400	78453	73400	78453
5607400 555	Nanutarra	0	18.5	0.0	193.6	Ashburton River Ashburton	70200	76444	70200	76444
5607450 556	Jimbegnyinoo Pool	0	7.7	0.0	104.6	Fortescue River Fortesque	48900	57023	48900	57023
5608023 557	Dimond Gorge	558	70.8	1.2	409.4	Fitzroy River Fitzroy West	16800	20525	16800	20525
5608024 558	Fitzroy Crossing	0	188.2	0.0	1696.3	Fitzroy Fitzroy West	45300	50014	28500	29489
5608095 559	Old Ord Homestead	0	51.9	0.0	272.1	Ord Ord	19600	14704	19600	14704
5708110 560	Coolibah Homestead	0	97.2	1.3	593.7	Victoria River Victoria	44900	55926	44900	55926

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		Mean	Min	Max					
5708126 561	Victoria Highway 0	34.4	0.6	246.7	West Baines River Victoria	10204	8880	10204	8880
5708145 562	Mount Nancar 0	211.0	19.8	786.0	Daly Daly	47000	38941	47000	38941
5709100 563	Red Rock 0	75.2	1.6	291.1	Roper River Roper	47400	71500	47400	71500
5709110 564	Mim Pump 0	23.9	0.1	140.9	Macarthur River GHAASBasin299	10400	11825	10400	11825
6112090 565	Regua 0	544.0	111.8	1945.9	Douro Douro	91491	90154	28331	23276
6122300 566	Paris 0	268.2	62.3	799.6	Seine Seine	44320	35052	44320	35052
6123100 567	Montjean 0	838.1	170.8	2535.4	Loire Loire	110000	109908	71760	69278
6123300 568	Blois 567	364.0	78.4	1133.8	Loire Loire	38240	40630	38240	40630
6125100 569	Mas-D'agenais 0	610.1	116.2	1717.5	Garonne Garonne	52000	53590	52000	53590
6139100 570	Beaucaire 0	1692.6	600.8	3866.2	Rhone Rhone	95590	99298	45390	46290
6139390 571	la Mulatiere 570	1046.5	352.7	2582.5	Rhone Rhone	50200	53008	39901	42319
6140400 572	Decin 591	303.4	72.7	1143.7	Labe Elbe	51104	45730	51104	45730
6142200 573	Bratislava 598	2047.1	1005.2	4375.4	Danube Danube	131338	131486	35293	36543
6211100 574	Orense 0	232.0	48.5	780.8	Mino Minho	12925	11405	12925	11405
6212400 575	Villachica 576	142.9	27.2	494.8	Duero Douro	41856	41582	41856	41582
6212420 576	Puente Pino 565	279.4	64.0	929.8	Duero Douro	63160	66878	21304	25296
6213600 577	Alcantara 0	235.7	18.7	1178.8	Tajo Tejo	51958	54333	51958	54333
6217100 578	Alcala del Rio 0	316.3	2.3	2026.7	Guadalquivir Guadalquivir	46995	51245	2124	9793
6217110 579	Cantillana 578	117.2	4.8	593.2	Guadalquivir Guadalquivir	44871	41451	44871	41451
6226400 580	Zaragoza 581	615.9	82.8	2160.6	Ebro Ebro	40434	38952	40434	38952
6226800 581	Tortosa 0	483.2	76.7	1523.8	Ebro Ebro	84230	82841	43796	43889
6229500 582	Vaenersborg 0	534.1	196.3	888.0	Vaenern-Goeta Gota	46830	44945	46830	44945
6233650 583	Solleftea 0	489.4	276.5	816.5	Angerman Angerman	30640	30790	30640	30790
6233750 584	Boden Waterworks 0	488.7	277.2	775.1	Lule Lulealven	24490	26522	24490	26522
6242400 585	Stein-Krems 573	1865.6	971.5	3545.0	Danube Danube	96045	94943	19448	18586
6335020 586	Rees 0	2278.4	922.6	4998.2	Rhein Rhine	159680	159424	28851	33059
6335100 587	Kaub 586	1608.3	616.6	3636.9	Rhein Rhine	103729	97892	43800	38234
6335600 588	Rockenau 587	133.5	37.5	390.6	Neckar Rhine	24000	23968	24000	23968
6336050 589	Cochem 586	314.6	70.1	952.3	Mosel Rhine	27100	28473	27100	28473
6337200 590	Intschede 0	316.6	102.2	842.8	Weser Weser	37788	34424	37788	34424
6340110 591	Neu-Darchau 0	783.8	328.8	1606.7	Labe Elbe	131950	131927	80846	86197
6342500 592	Ingolstadt 593	313.7	115.9	659.2	Danube Danube	20001	20583	20001	20583
6342800 593	Hofkirchen 594	634.3	266.6	1444.2	Danube(Donau) Danube	47496	45081	27495	24498
6342900 594	Achleiten 585	1419.4	642.6	2966.7	Danube Danube	76597	76357	29101	31275
6348400 595	Piacenza 596	981.6	338.4	2700.0	Po Po	42030	47838	42030	47838

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		Mean	Min	Max					
6348800 596	Pontelagoscuro 0	1514.6	505.8	3745.0	Po Po	70091	78362	28061	30524
6421500 597	Borgharen 0	246.1	34.2	714.4	Maas Meuse	21300	27899	21300	27899
6442500 598	Nagymaros 599	2346.0	1093.6	4929.4	Danube(Duna) Danube	183533	182903	52195	51417
6442600 599	Mohacs 619	2401.3	1096.2	4588.8	Danube Danube	209064	206123	25531	23220
6444100 600	Szeged 619	829.3	200.2	2446.7	Tisza Danube	138408	142313	33146	42144
6444110 601	Mako 600	168.8	0.9	508.1	Maros Danube	30149	29946	30149	29946
6444200 602	Szolnok 600	595.9	180.4	1376.6	Tisza Danube	75113	70223	59830	55834
6444600 603	Csenger 602	124.2	28.8	410.6	Szamos Danube	15283	14389	15283	14389
6457010 604	Gozdowice 0	546.6	201.6	2853.2	Odra Odra	109729	110663	56347	52021
6457100 605	Slubice 604	351.8	116.0	2319.1	Odra Odra	53382	58642	53382	58642
6458010 606	Tczew 0	1041.7	345.6	2954.7	Wisla Wisla	194376	180583	48538	46752
6458450 607	Szczucin 608	248.1	21.6	2225.8	Wisla Wisla	23901	27797	23901	27797
6458500 608	Warszawa 606	561.2	168.3	1515.0	Wisla Wisla	84857	72881	44253	31124
6458550 609	Wyszkow 606	145.8	35.2	555.0	Bug Wisla	39119	40627	39119	40627
6458600 610	Radomysl 608	132.7	30.9	453.1	San Wisla	16703	13960	16703	13960
6458810 611	Ostroleka 606	110.9	42.6	309.8	Narew Wisla	21862	20323	21862	20323
6545800 612	Sremska Mitrovica 619	1609.1	524.9	3655.0	Sava Danube	87966	85461	87966	85461
6546610 613	Gornja Radgona 619	155.6	78.5	315.2	Mura Danube	10197	10512	10197	10512
6547500 614	Lubicevsky Most 619	240.3	55.4	663.5	Velika Morava Danube	34345	31465	34345	31465
6691650 615	Misis 0	222.4	85.6	454.4	Ceyhan Seyhan	20466	24391	20466	24391
6695200 616	Keban 0	663.3	295.4	1341.2	Firat(Euphrates) Shatt el Arab	63835	64684	63835	64684
6730500 617	Polmak 0	165.7	59.5	408.9	Tana GHAASBasin895	14005	14035	14005	14035
6731400 618	Langnes 0	672.1	274.8	1494.4	Gloma Glama	40221	42784	40221	42784
6742200 619	Orsova (1971:drobata-Turnu Severin) 623	5456.5	2424.2	10986.7	Danube Danube	576232	570835	96252	94961
6742450 620	Stoenesti 623	161.3	58.8	365.4	Olt Danube	22683	19470	22683	19470
6742700 621	Lungoci 622	171.6	58.3	529.1	Siret Danube	36036	37530	36036	37530
6742900 622	Ceatal Izmail 0	6488.3	2845.6	11631.6	Danube Danube	807000	788002	120624	99899
6842700 623	Svistov 622	6152.2	2709.2	10640.0	Danube Danube	650340	650574	51425	60268
6854100 624	Kalsinkosi 0	219.9	58.7	556.0	Kokemjenjoki Kokemaenjoki	26025	26312	26025	26312
6854500 625	near The mouth 0	255.0	100.0	454.1	Oulujoki Oulujoki	22900	21244	22900	21244
6854600 626	near The mouth 0	171.0	55.2	398.7	Siurnanjoki Oulujoki	14315	25491	14315	25491
6854700 627	near The mouth 0	562.1	240.5	1264.2	Kenijoki Kemijoki	50900	50179	50900	50179
6855200 628	Anjala 0	280.3	81.4	598.1	Kymijoki Kymijoki	36305	35932	36305	35932
6855400 629	Tainionkoski 644	592.7	243.0	1079.9	Vuoksi Neva	61061	60690	61061	60690
6865500 630	Harmanli 0	113.3	20.2	272.0	Maritza Evros	19693	18360	19693	18360

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6935050 631	Basel(St.Alban)	587	1106.1	619.5	1749.8	Rhein Rhine	35929	35691	18304	16826
6935300 632	Untersiggenthal	631	558.1	296.2	977.2	Aare Rhine	17625	18865	17625	18865
6939050 633	Chancy	571	341.6	177.5	536.8	Rhone Rhone	10299	10688	10299	10688
6970100 634	Porog	0	513.1	235.5	1026.6	Onega Onega	55770	56600	55770	56600
6970250 635	Ust-Pinega	0	3331.5	1178.8	7920.8	Severnaya Dvina Dvina	348000	357844	271600	289297
6970270 636	Filaievskaya	635	110.8	31.4	295.7	Vaga Dvina	13200	13523	13200	13523
6970400 637	Kulogory	635	367.8	217.2	722.9	Pinega Dvina	36700	30246	36700	30246
6970500 638	Malonisogorskaya	0	649.3	279.3	1365.2	Mezen Mezen	56400	56522	56400	56522
6970650 639	Ust-Tsilma	641	3404.8	1197.5	6981.2	Pechora Pechora	248000	233553	193300	184523
6970680 640	Malaya Kushba	635	258.1	110.2	572.2	Vytchegda Dvina	26500	24778	26500	24778
6970710 641	Oksino	0	4515.1	2367.0	7272.1	Pechora Pechora	312000	301599	64000	68045
6970850 642	Adzva	639	993.2	356.7	2029.0	Usa Pechora	54700	49031	54700	49031
6972350 643	Narva (Hep)	0	379.2	187.2	754.9	Narva Narva	56000	58230	56000	58230
6972430 644	Novosaratovka	0	2504.1	1290.5	3764.2	Neva Neva	281000	279904	219939	219214
6972800 645	Yushkozero	0	198.5	105.8	347.8	Kem Kem	19800	22391	19800	22391
6972810 646	Putkinskaya Ges	0	297.5	166.0	494.0	Kem GHAASBasin509	27700	26001	27700	26001
6973300 647	Daugavpils	0	390.8	191.4	850.8	Western Dvina (Daugava) Daugava	64500	62897	64500	62897
6974150 648	Smalininkai	0	538.3	222.6	1536.8	Neman Nemanus	81200	79440	81200	79440
6975080 649	Staritsa	654	153.7	38.4	494.3	Volga Volga	21100	22347	21100	22347
6975140 650	Kaluga	654	292.1	73.7	972.5	Oka Volga	54900	51003	54900	51003
6975500 651	Makariev	654	168.7	41.1	462.8	Unzha Volga	18500	17640	18500	17640
6976200 652	Kirov	654	373.6	105.9	829.5	Viatka Volga	48300	52825	48300	52825
6976450 653	Ufa	654	338.7	9.5	1449.1	Belaya Volga	100000	108083	100000	108083
6977100 654	Volgograd Power Plant	0	8087.1	3146.7	16125.0	Volga Volga	1360000	1348501	1117200	1096604
6978250 655	Razdorskaya	0	790.3	185.4	2657.7	Don Don	378000	391664	344300	364451
6978500 656	Archedinskaia	655	51.8	15.5	134.8	Medveditsa Don	33700	27213	33700	27213
6979500 657	Mozyr	660	454.9	161.7	1209.2	Pripiat Dnepr	101000	116685	101000	116685
6979600 658	Chernigov	660	321.1	87.3	1086.4	Desna Dnepr	81400	84721	81400	84721
6980300 659	Aleksandrovka	0	110.3	40.1	284.2	Southern Bug Bug	46200	46326	46200	46326
6980800 660	Dniepr Power Plant	0	1483.7	479.5	3211.7	Dniepr Dnepr	463000	463075	280600	261670
6981800 661	Bendery	0	376.6	143.8	823.9	Dniestr Dniestr	66100	67739	66100	67739
6983350 662	Tikhovsky	0	317.2	141.6	638.7	Kuban Kuban	48100	50794	48100	50794
6990700 663	Surra	0	550.9	204.7	1173.3	Kura Kura	178000	211793	178000	211793

E Appendix: Runoff Field Data Structures

Three sets of annual and monthly climatological (1+12 layers per set) runoff fields are included on the accompanying CD-ROM. The sets are observed, WBM-simulated, and composite monthly runoff fields in the `./arc/w_runoff` ARC/INFO workspace and `./ascii/runoff` directory. The grid coverage names are `g_obs_ro01`, `g_obs_ro02`, ..., `g_obs_ro12` and `g_obs_ro`, where the numbered coverages are the monthly values and `g_obs_ro` contains the annual sum of the observed runoffs. The WBM simulated and the composite fields are organized similarly in `g_wbm_ro##` and `g_cmp_ro##` coverages.

The same grid coverages are given as ARC/INFO ASCII grids as well in the `./ascii/runoff` directory using the same naming convention (`obs_ro##.grd`, `wbm_ro##.grd` and `cmp_ro##.grd`). The format of ARC/INFO grid is the same as describe in Appendix A.

```
ncols 720
nrows 300
xllcorner -180
yllcorner -60
cellsize 0.5
NODATA_value -9999
-9999 -9999 -9999-9999 -9999 -9999 -9999 -9999 -9999 ...
```

...

where

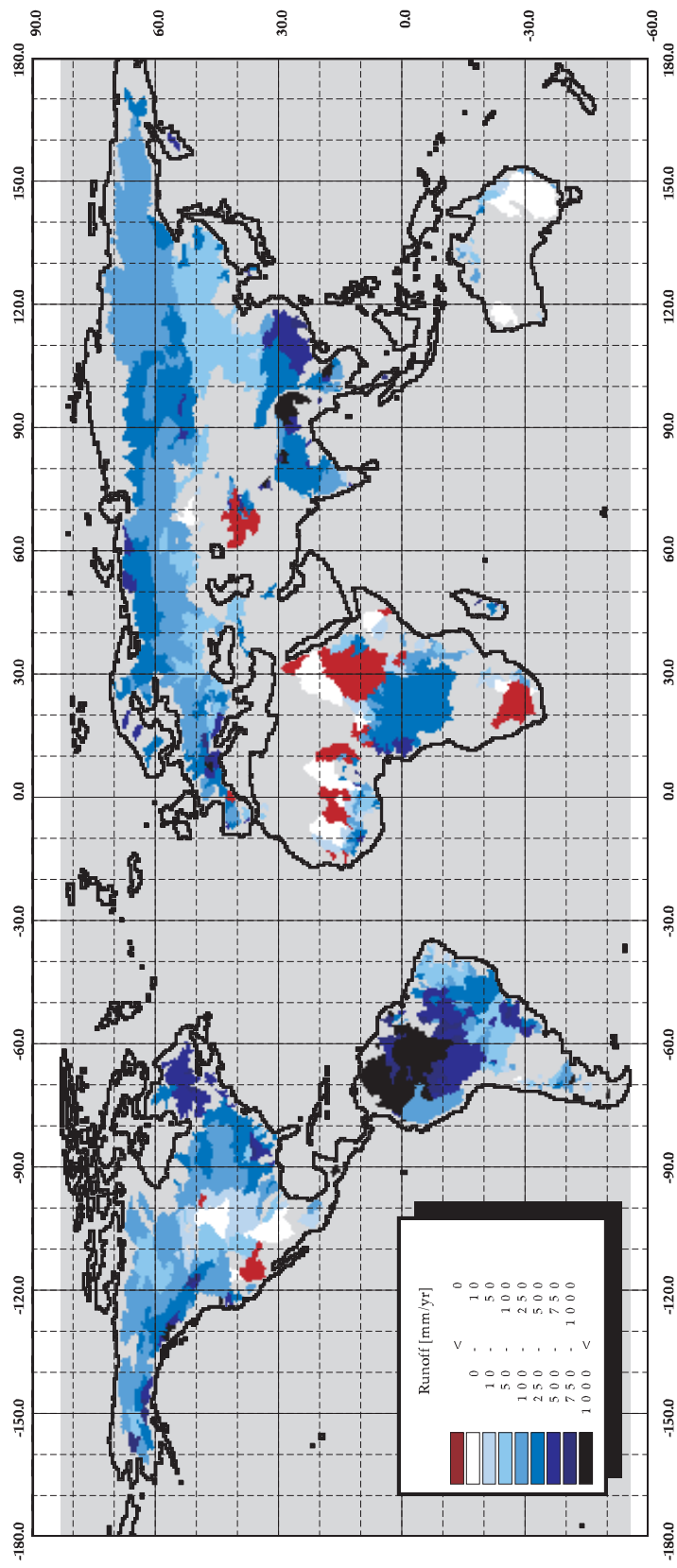
```
ncols      - number of columns
nrows      - number of rows
xllcorner  - horizontal coordinate of the lower left corner
yllcorner  - vertical coordinate of the lower left corner
cellsize   - cell size
NODATA     - missing data value
```

The monthly runoff values are given in *mm/mo* at 30-minute (0.5 *degree*) spatial resolution. The annual values are given in *mm/yr*.

F Appendix: GRDC-Observed Annual and Monthly Runoff Fields

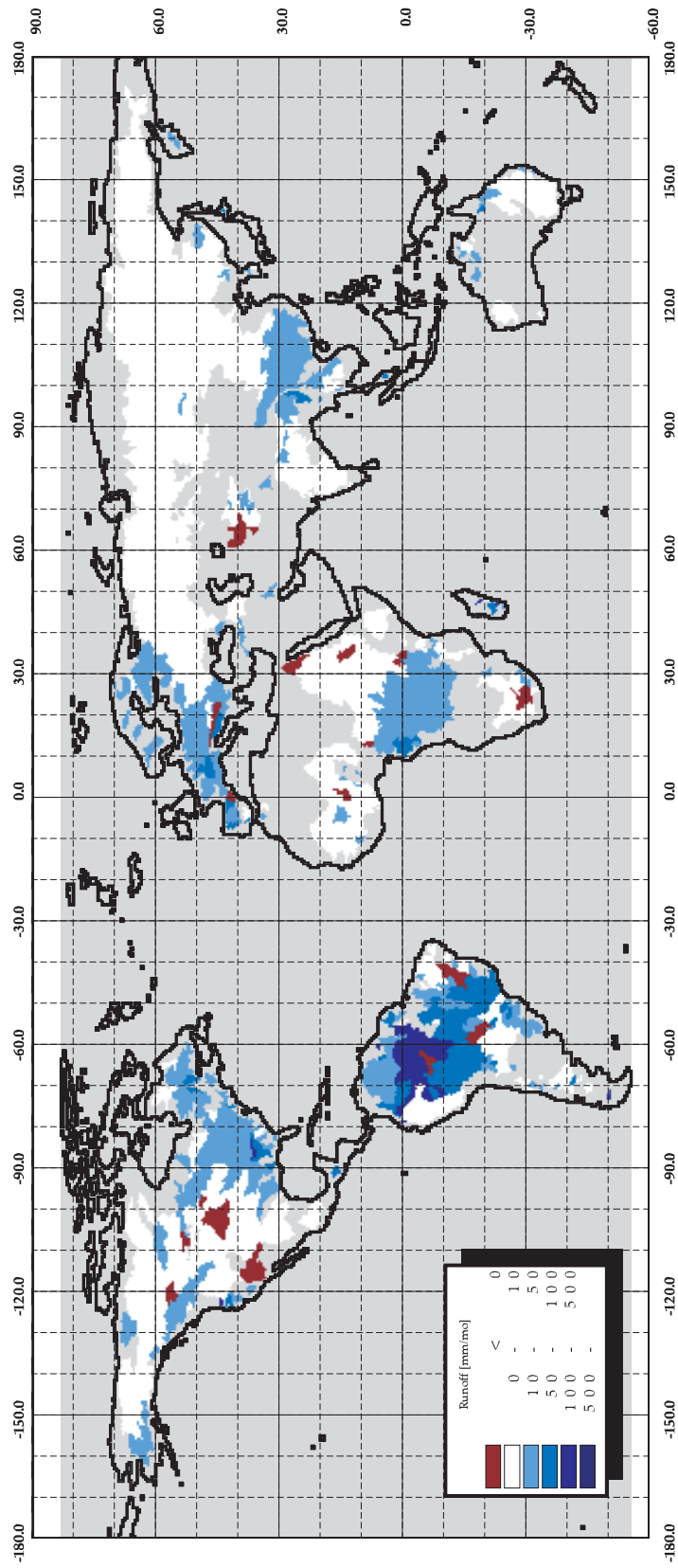
GRDC Observed Mean Annual Runoff

30-minute spatial resolution



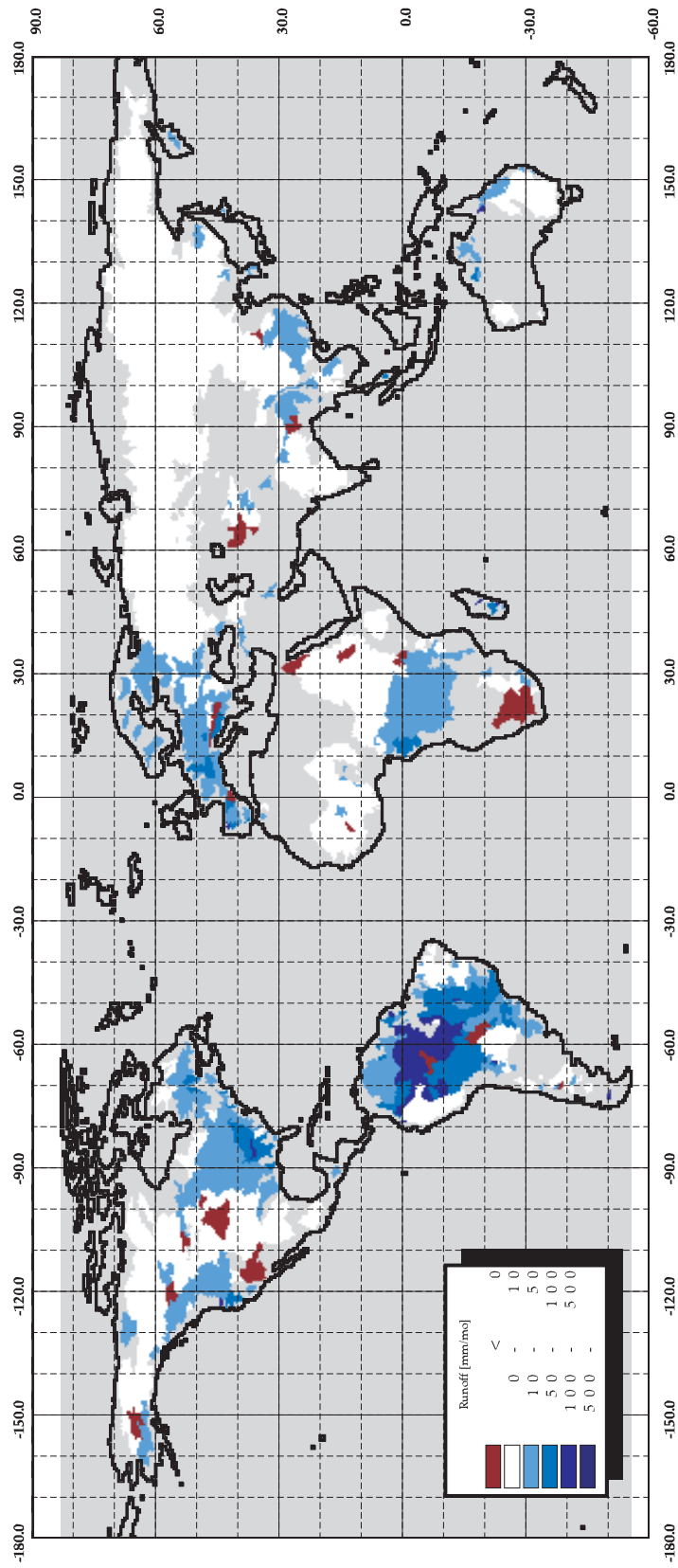
GRDC-Observed January Runoff

30-minute spatial resolution



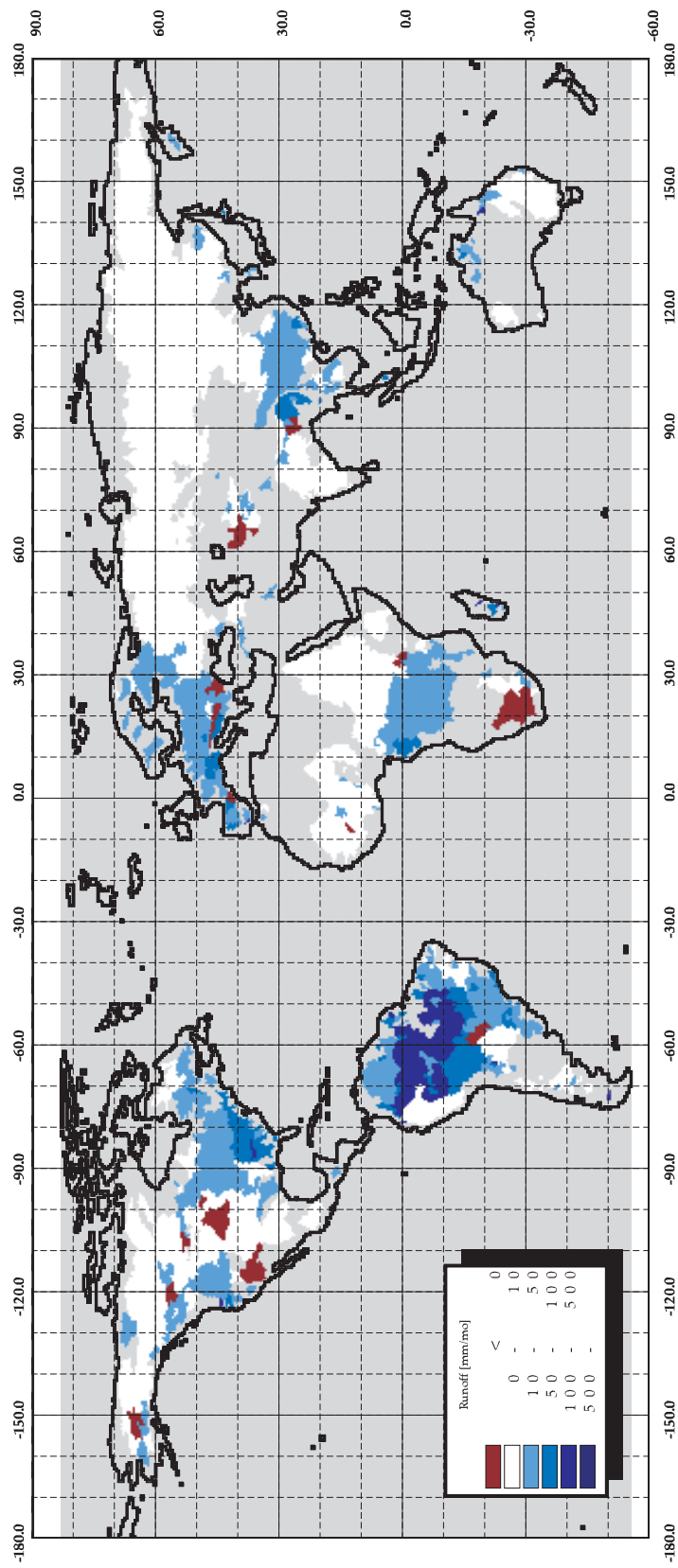
GRDC-Observed February Runoff

30-minute spatial resolution



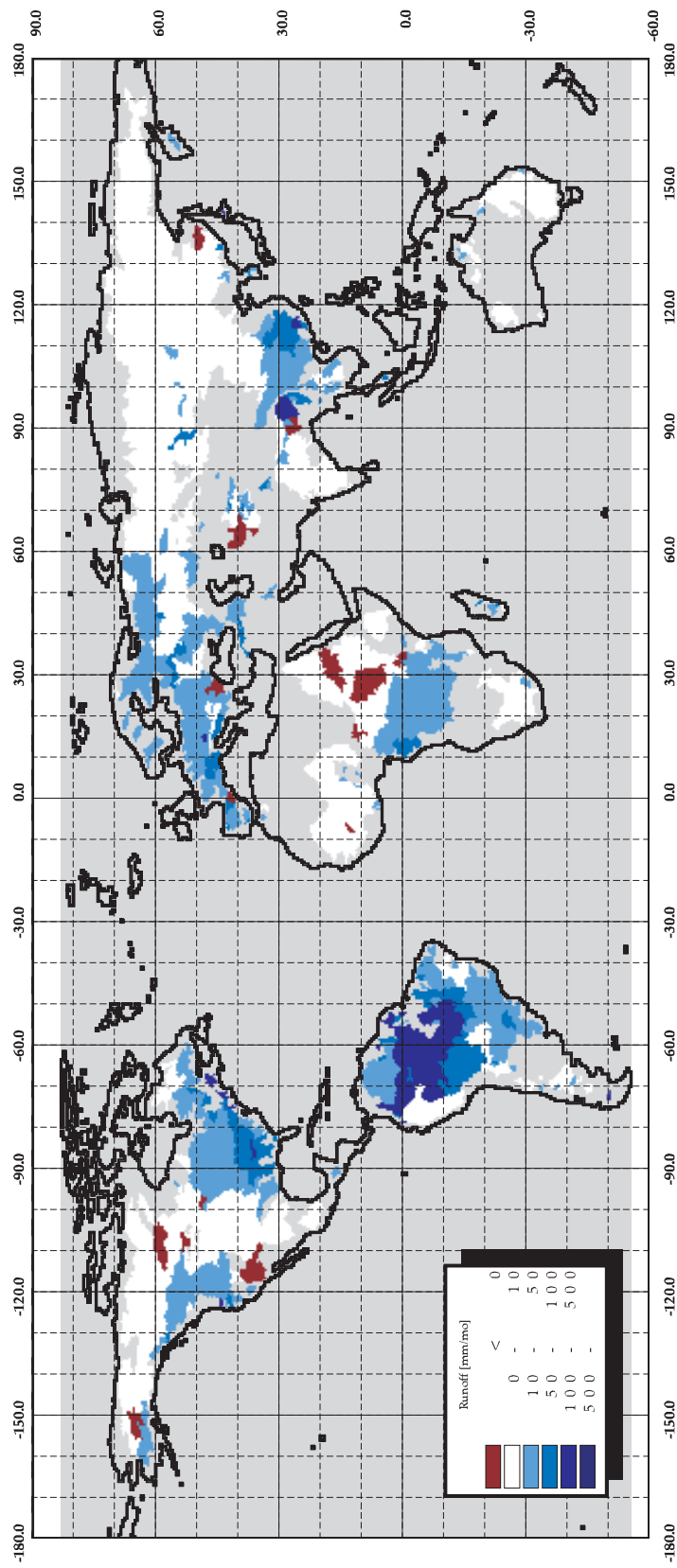
GRDC-Observed March Runoff

30-minute spatial resolution



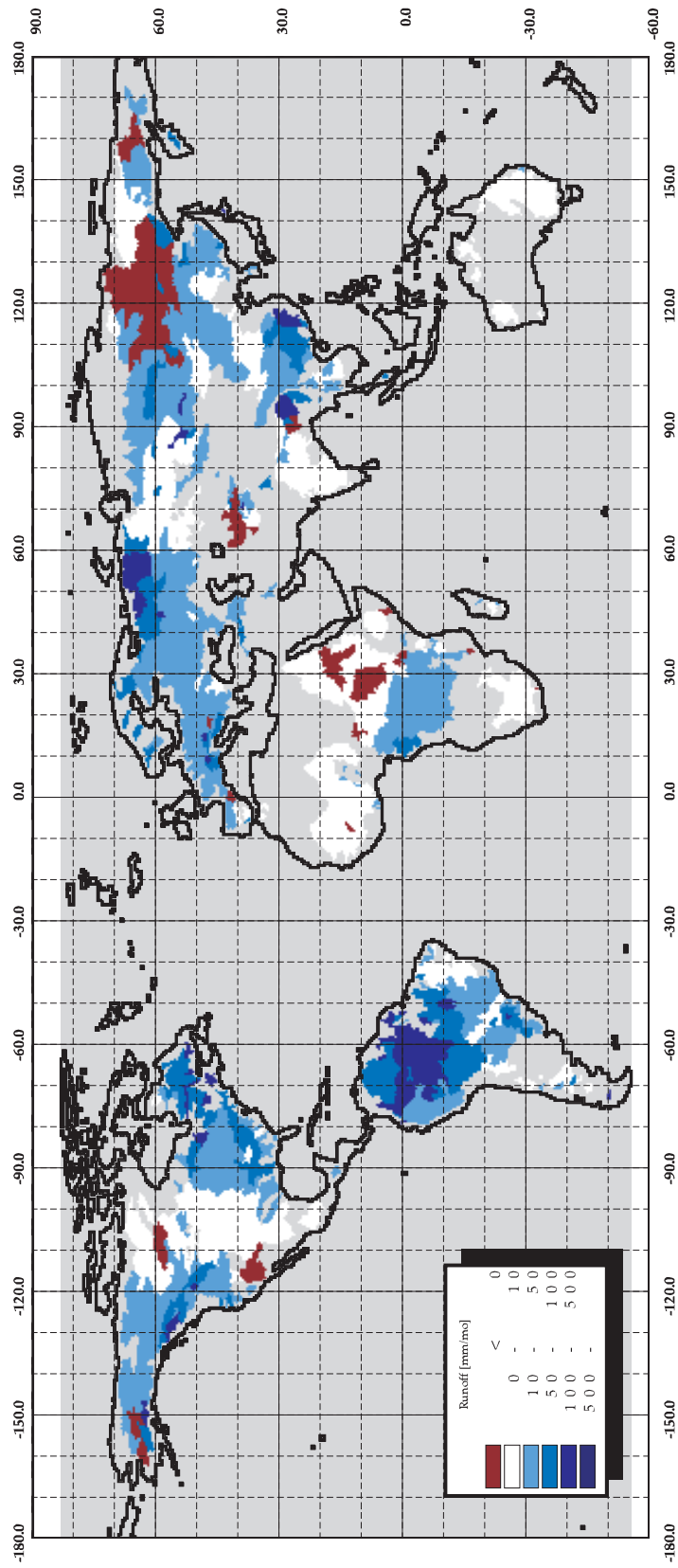
GRDC-Observed April Runoff

30-minute spatial resolution



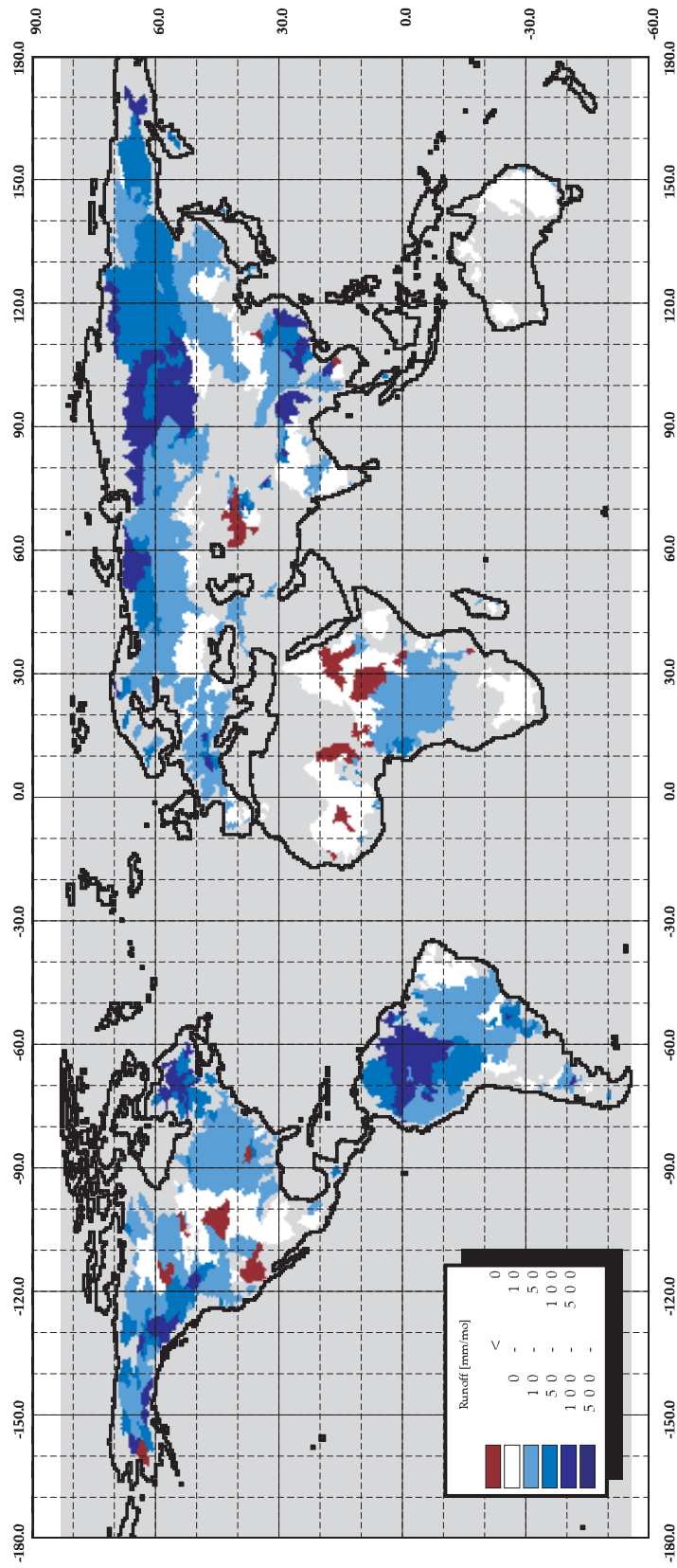
GRDC-Observed May Runoff

30-minute spatial resolution



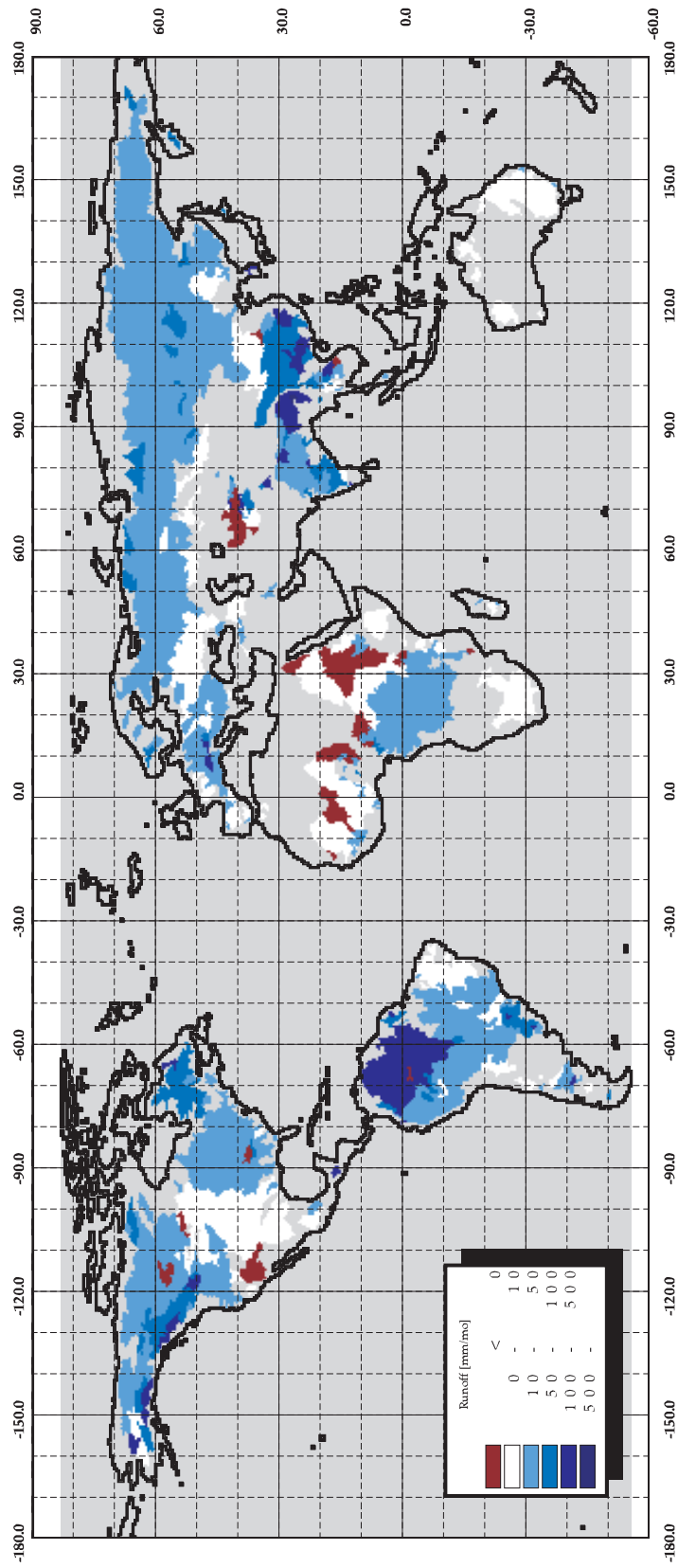
GRDC-Observed June Runoff

30-minute spatial resolution



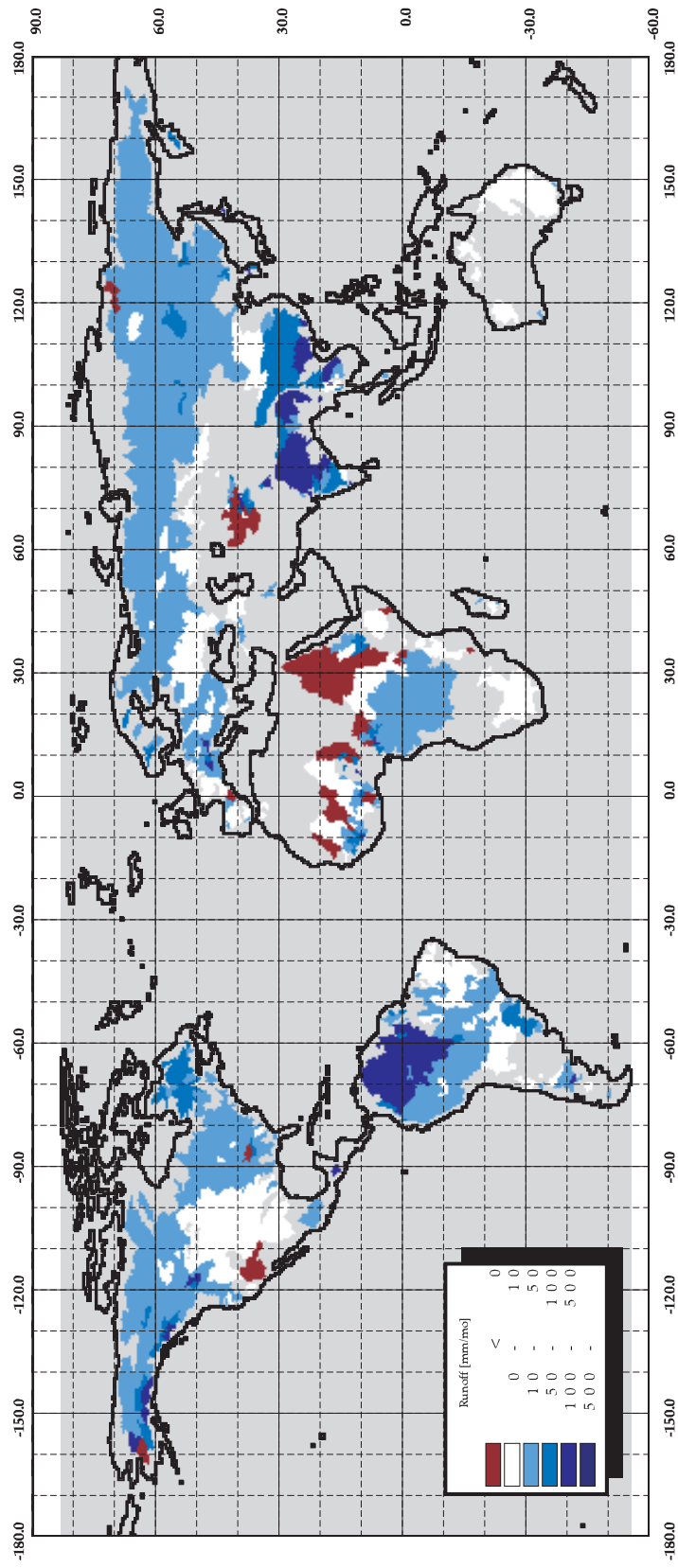
GRDC-Observed July Runoff

30-minute spatial resolution



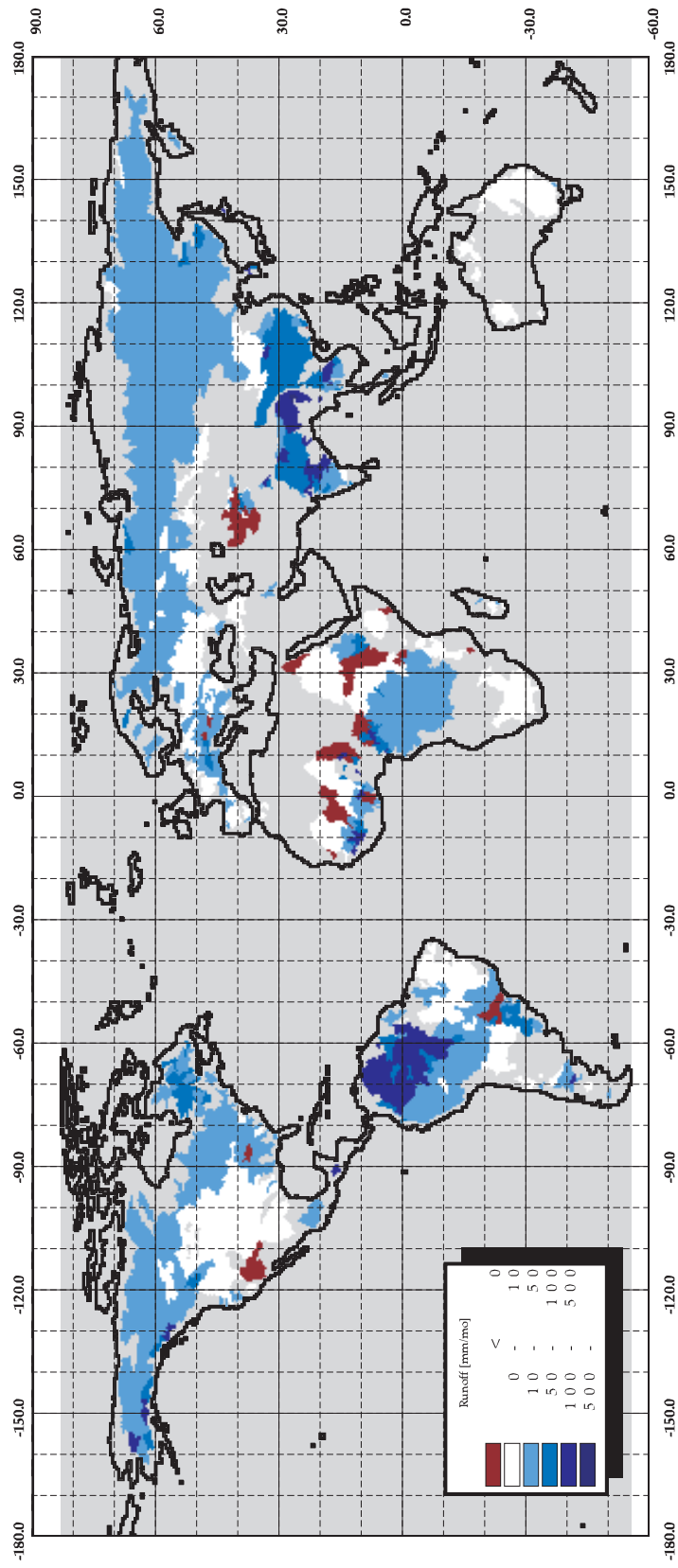
GRDC-Observed August Runoff

30-minute spatial resolution



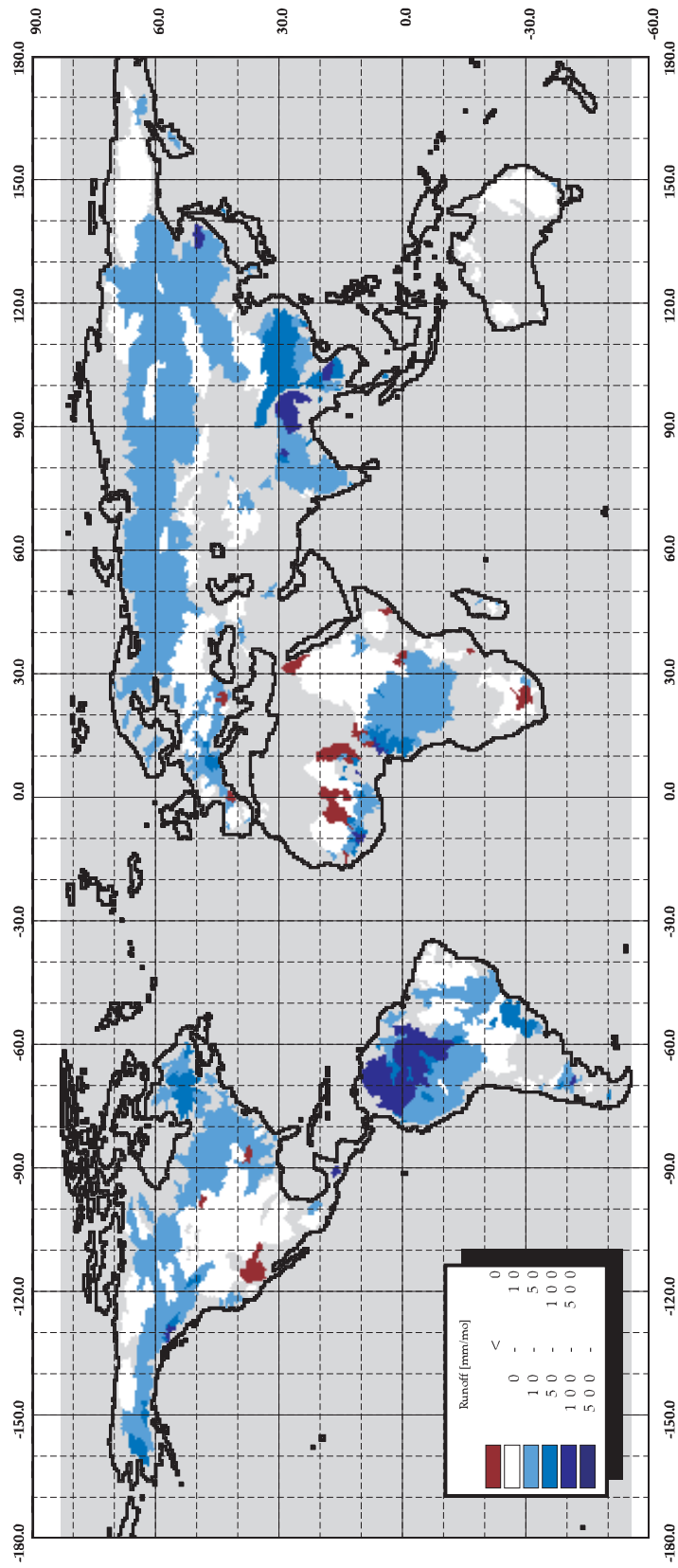
GRDC-Observed September Runoff

30-minute spatial resolution



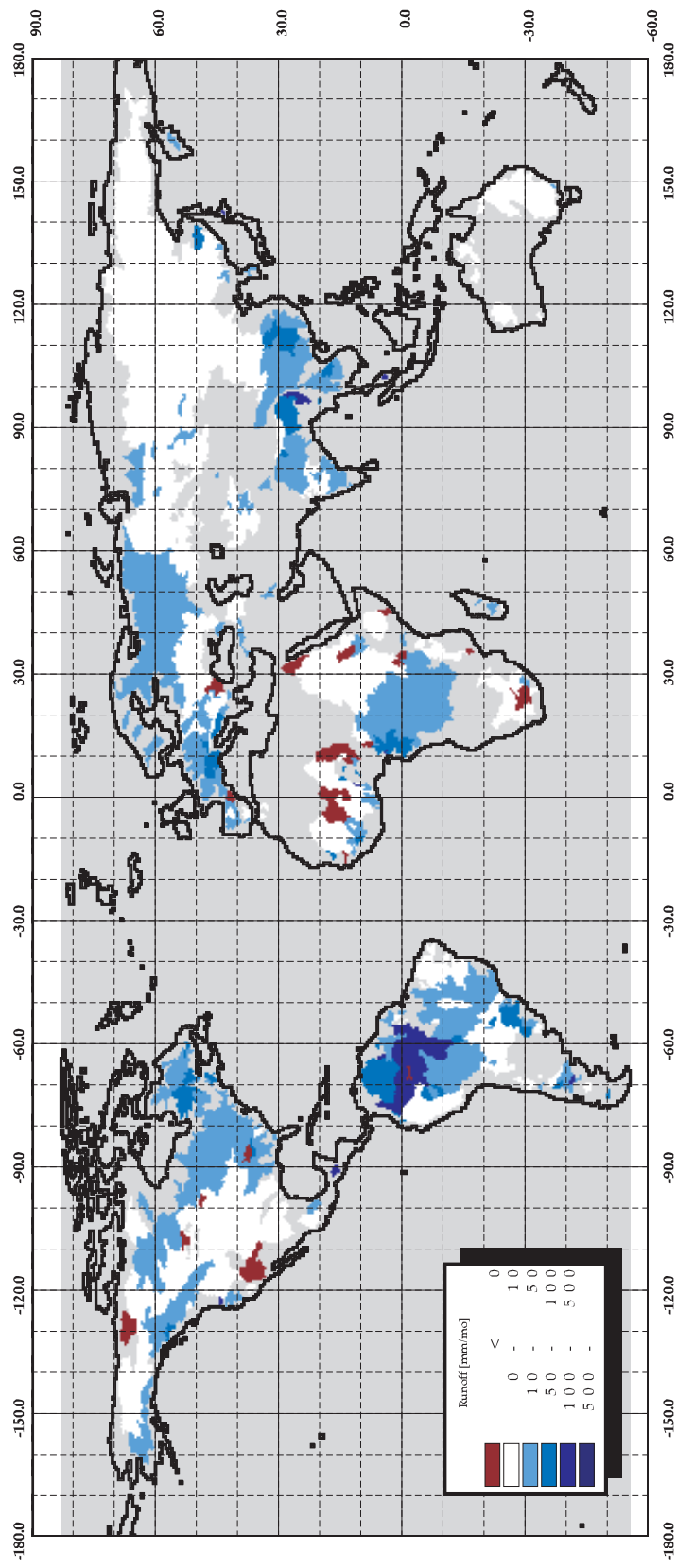
GRDC-Observed October Runoff

30-minute spatial resolution



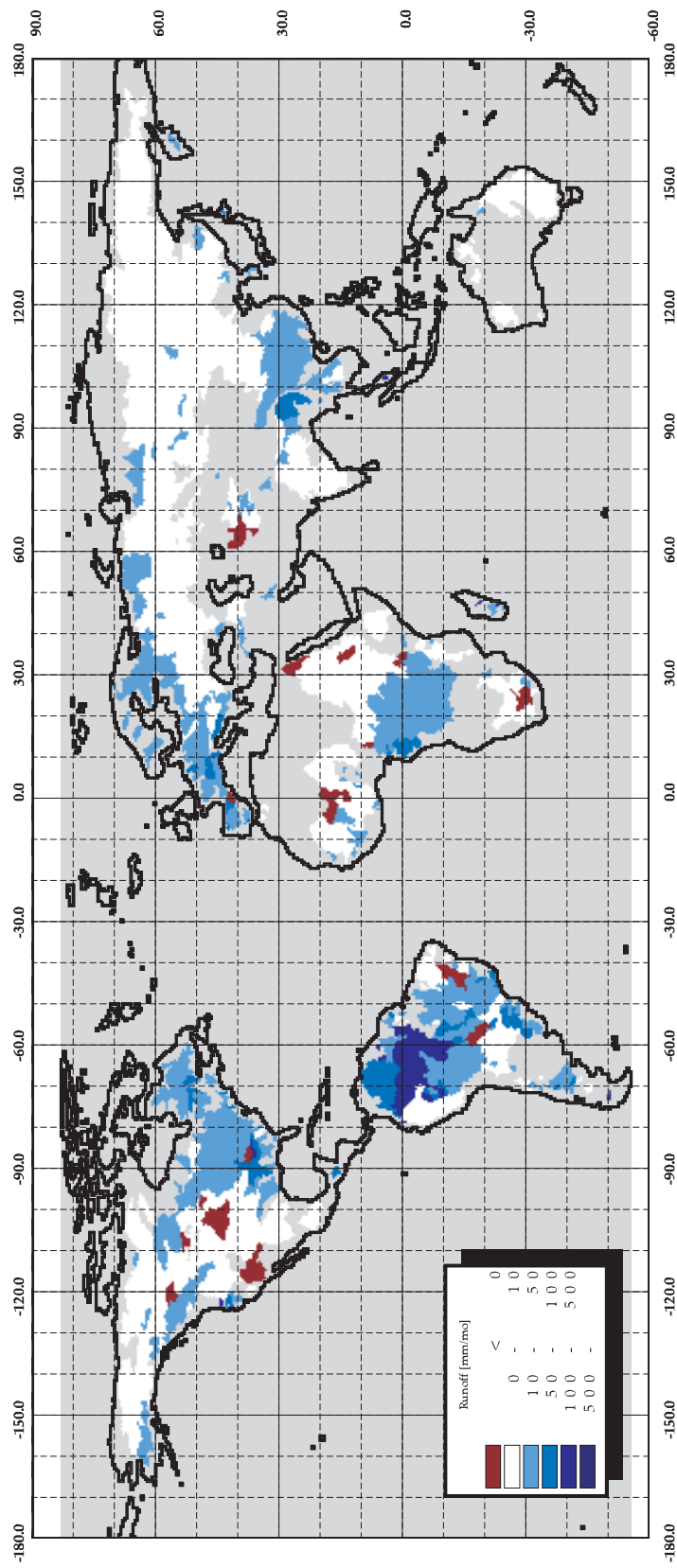
GRDC-Observed November Runoff

30-minute spatial resolution



GRDC-Observed December Runoff

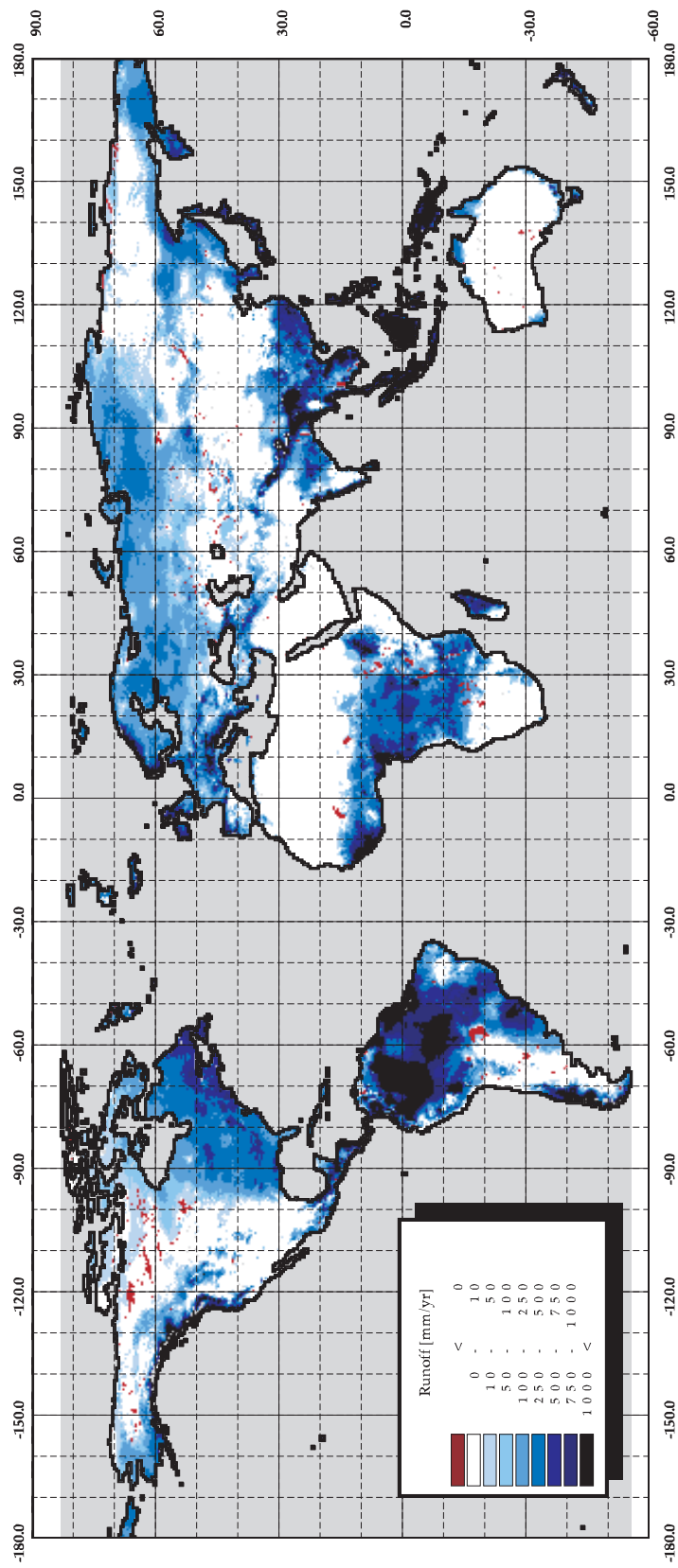
30-minute spatial resolution



**G Appendix: WBM Simulated Annual and Monthly Runoff
Fields**

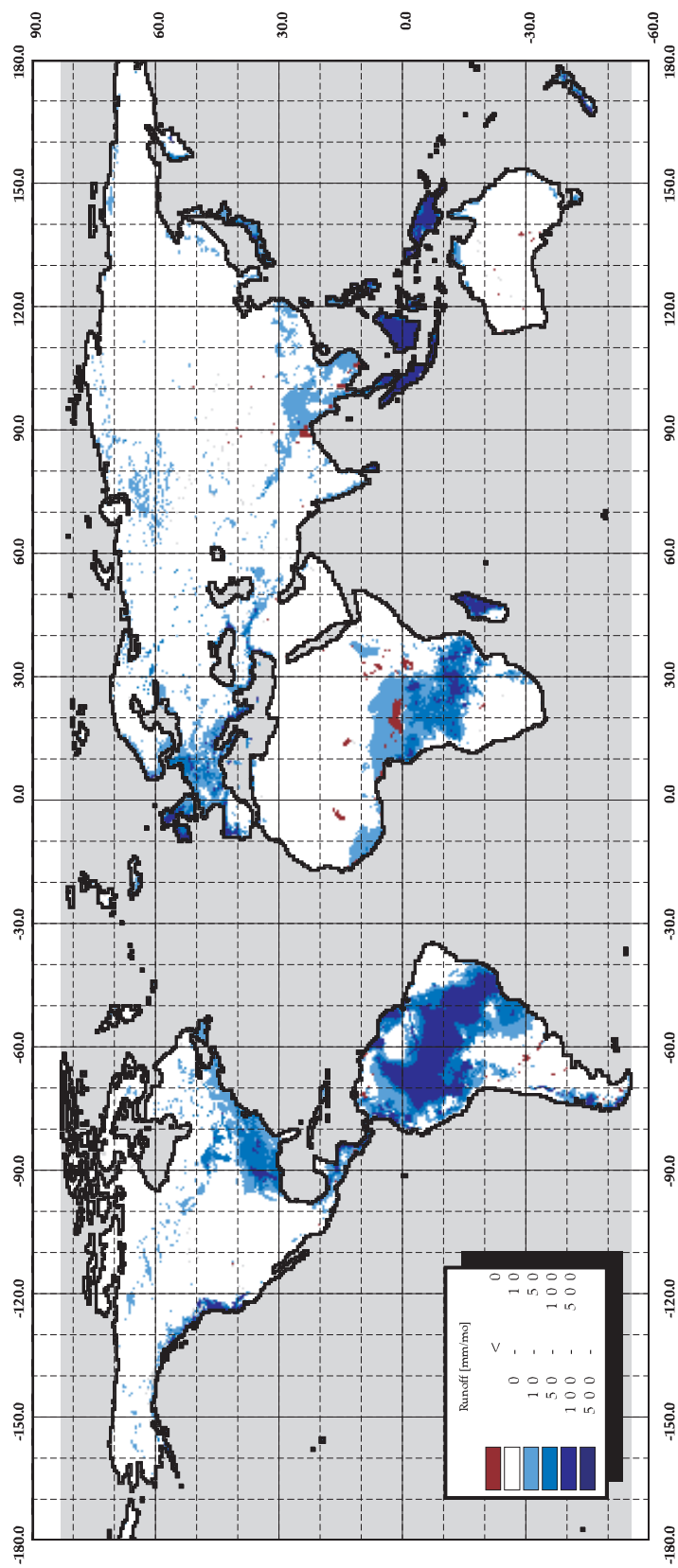
WBM-Simulated Mean Annual Runoff

30-minute spatial resolution



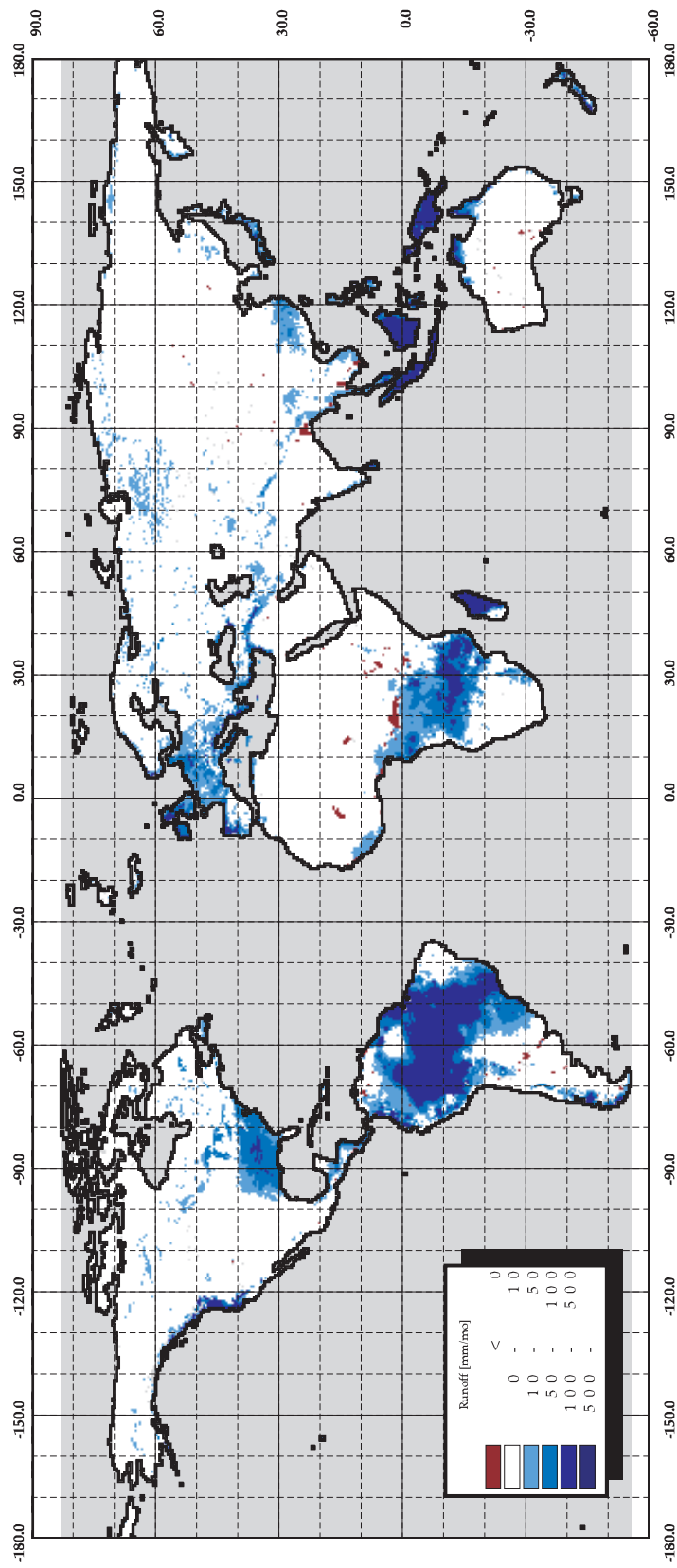
WBM-Simulated January Runoff

30-minute spatial resolution



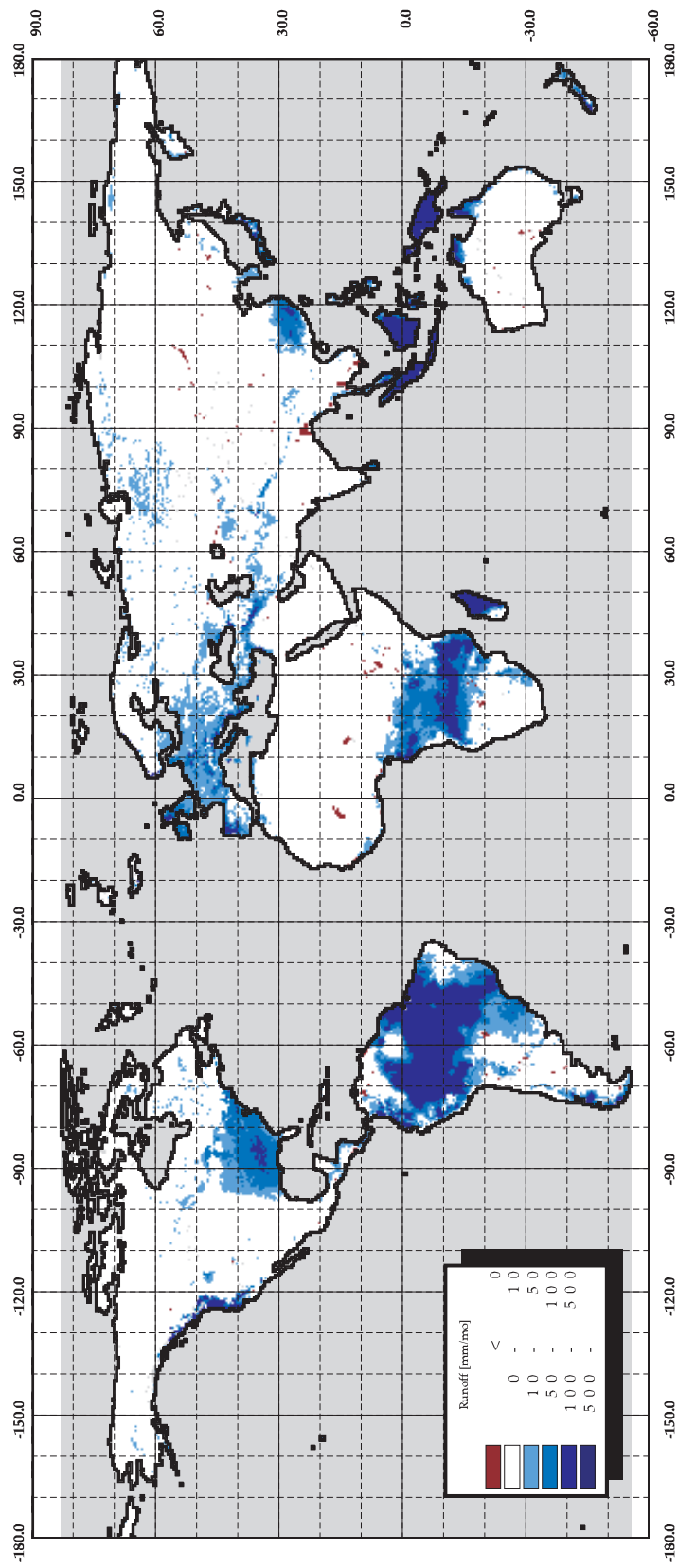
WBM-Simulated February Runoff

30-minute spatial resolution



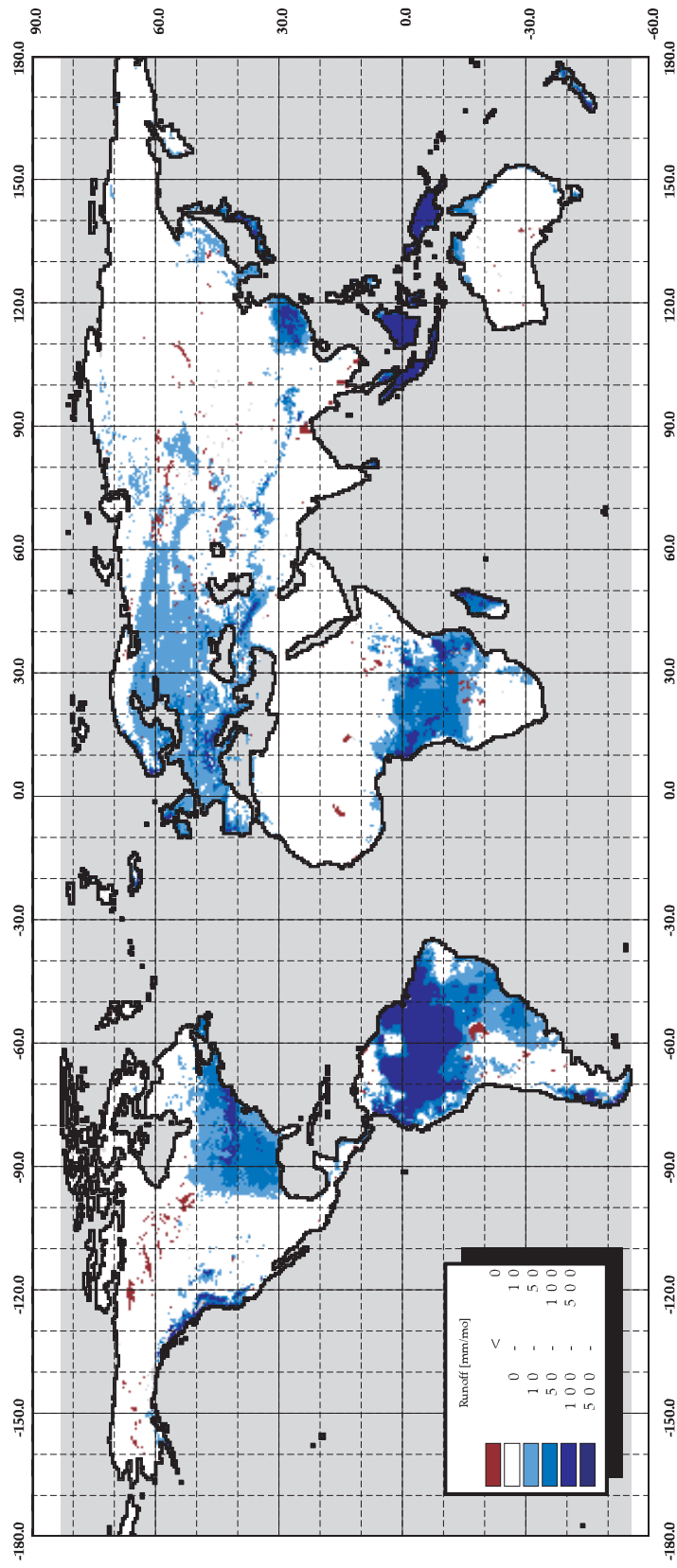
WBM-Simulated March Runoff

30-minute spatial resolution



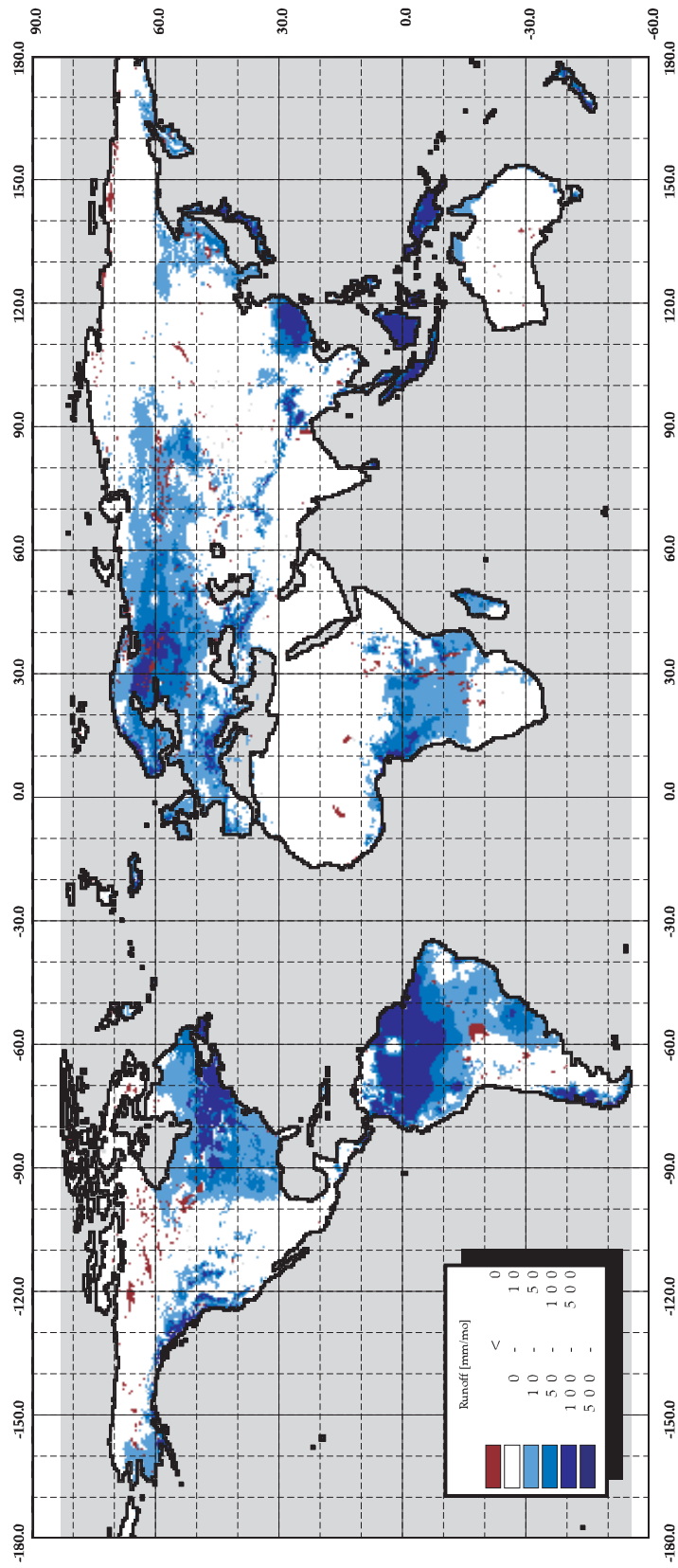
WBM-Simulated April Runoff

30-minute spatial resolution



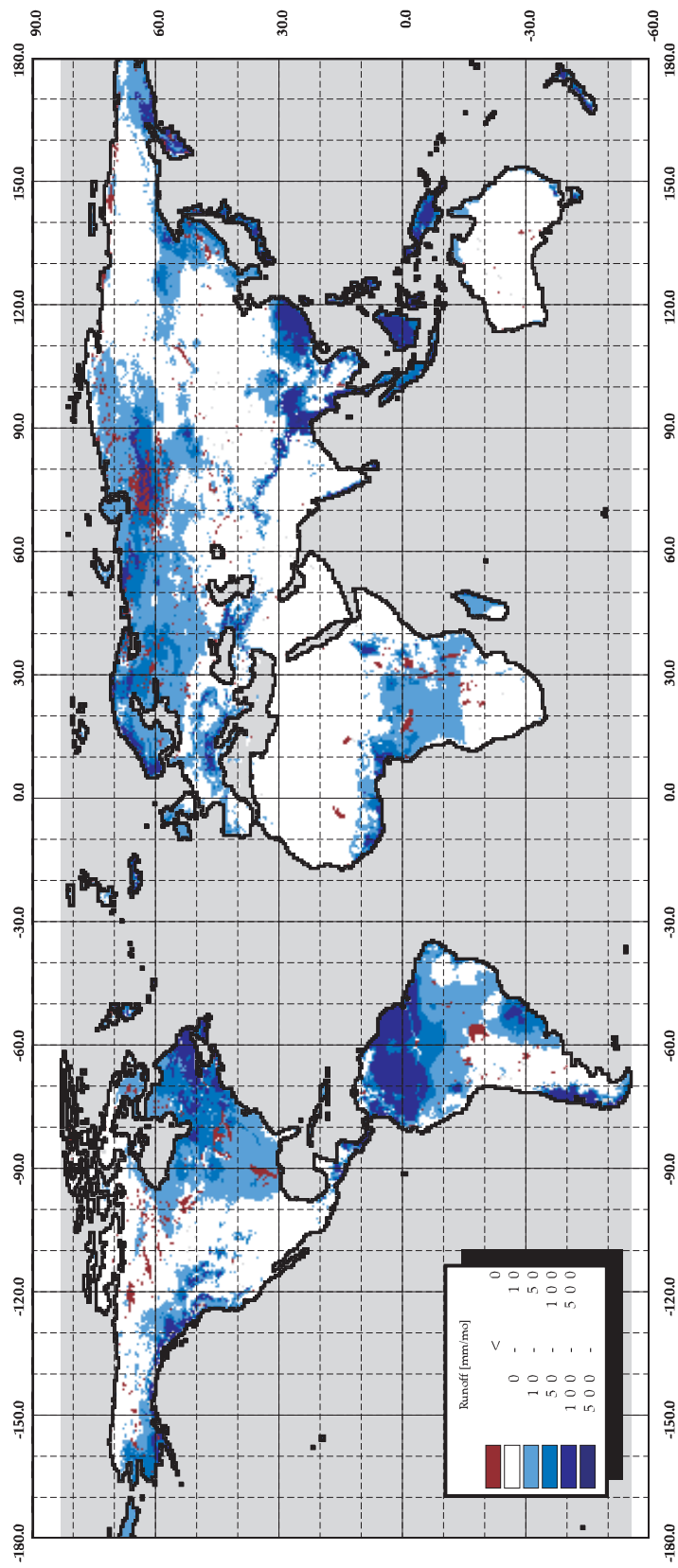
WBM-Simulated May Runoff

30-minute spatial resolution



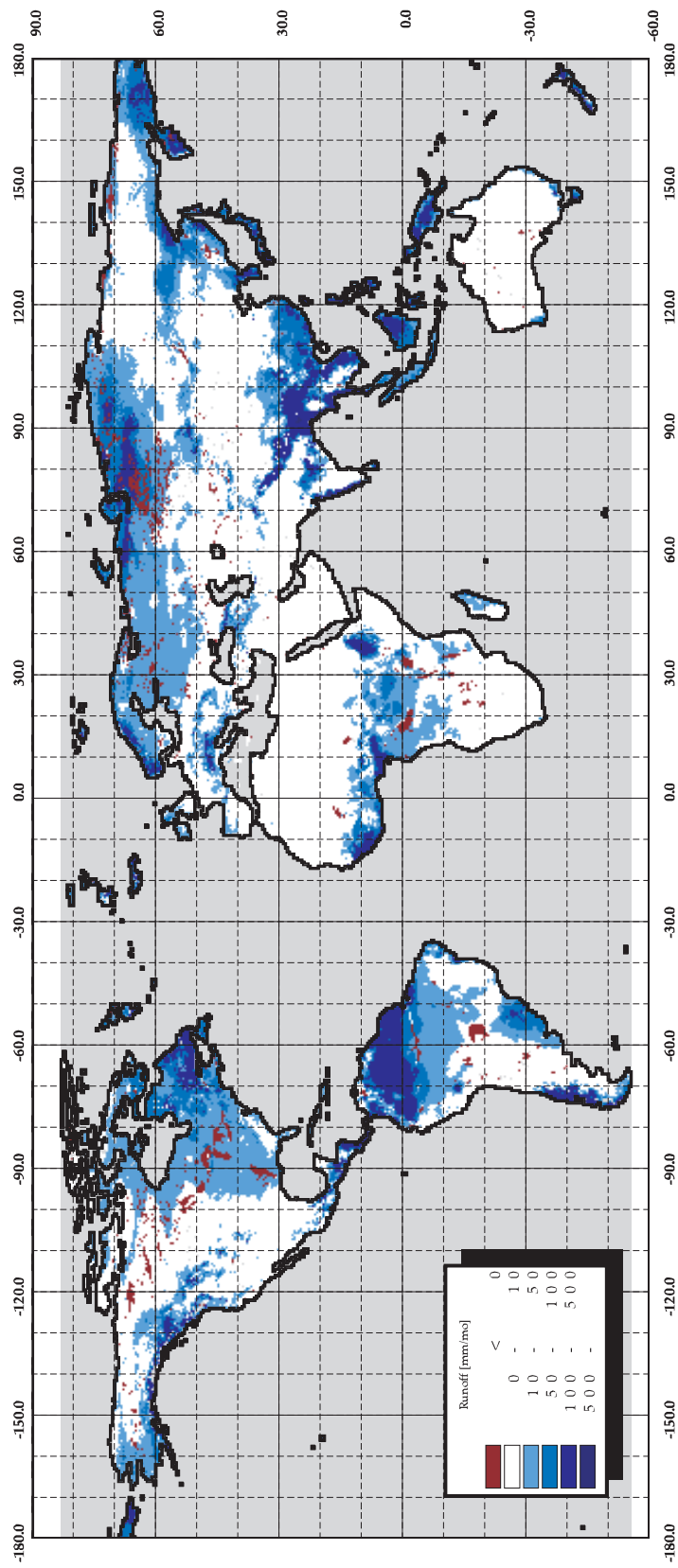
WBM-Simulated June Runoff

30-minute spatial resolution



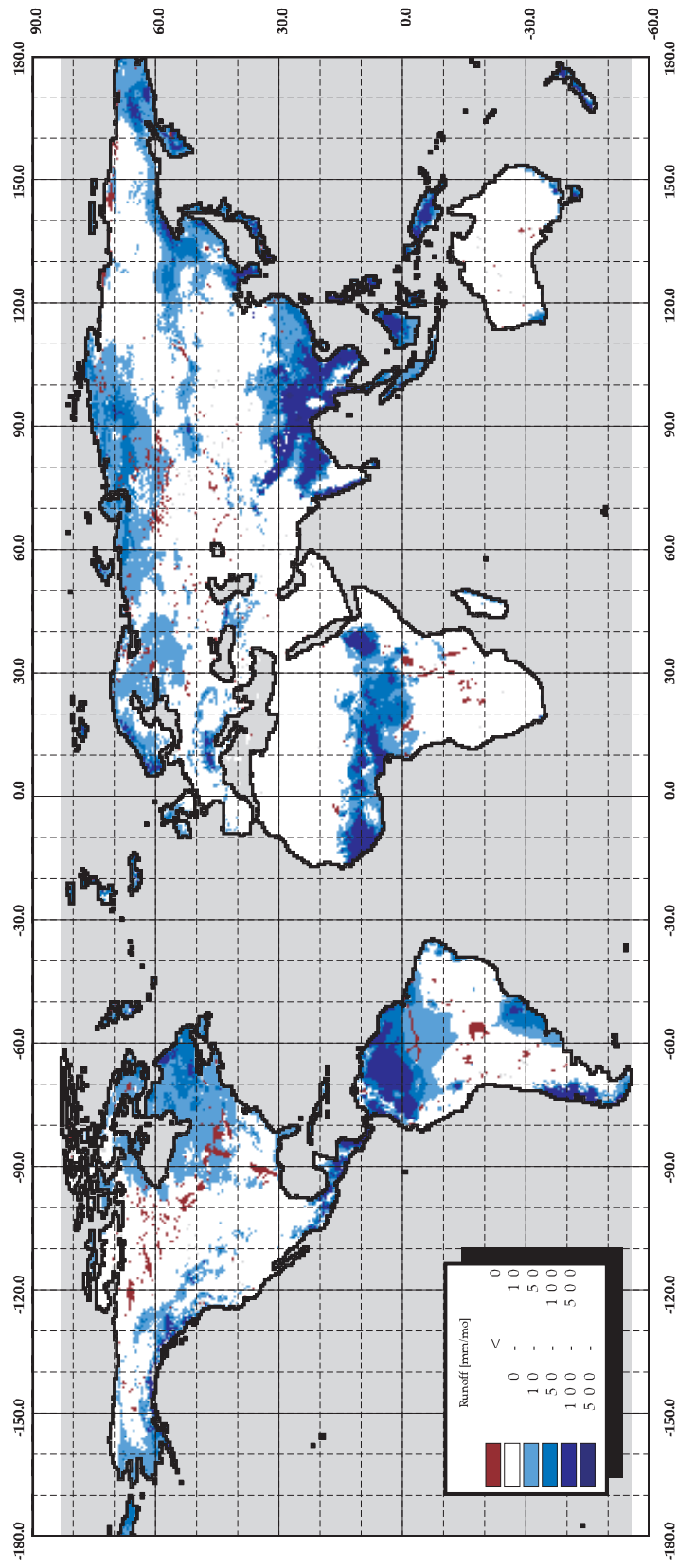
WBM-Simulated July Runoff

30-minute spatial resolution



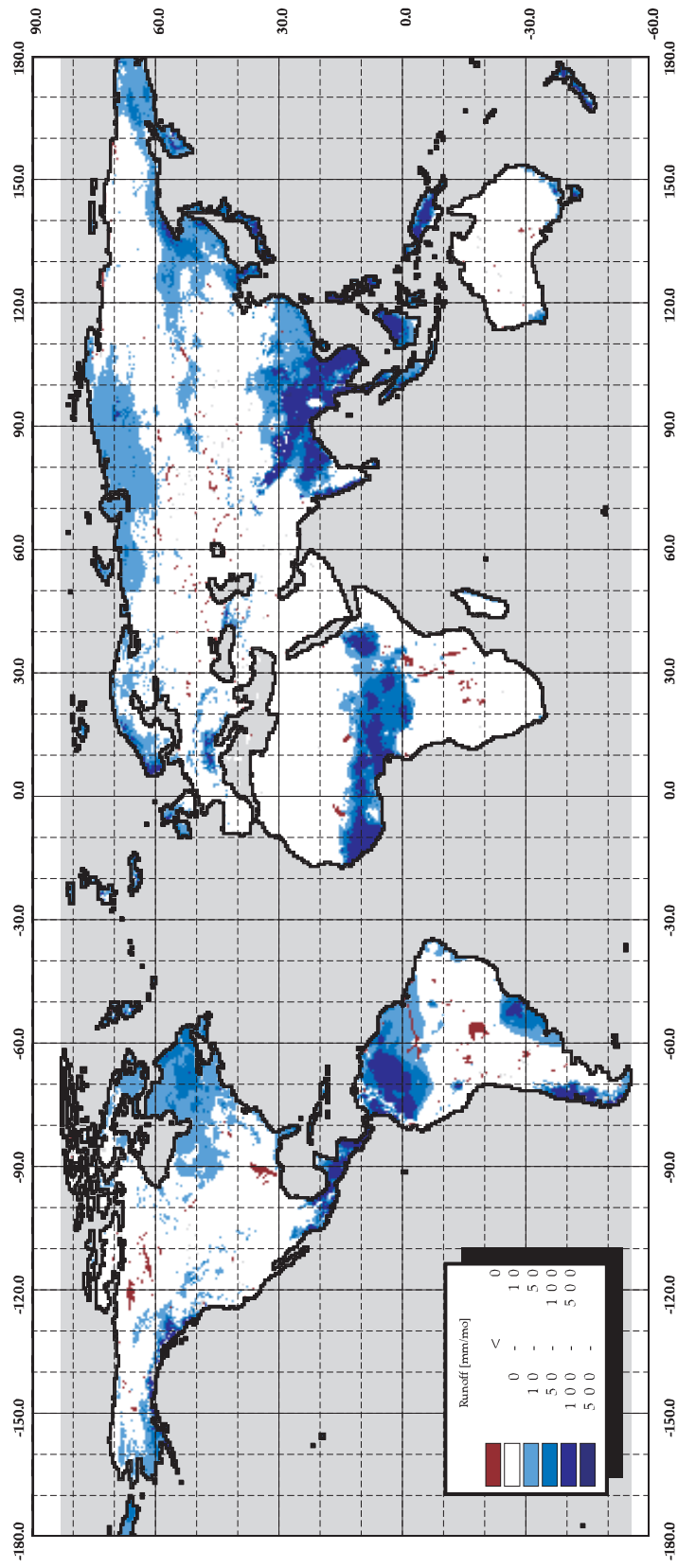
WBM-Simulated August Runoff

30-minute spatial resolution



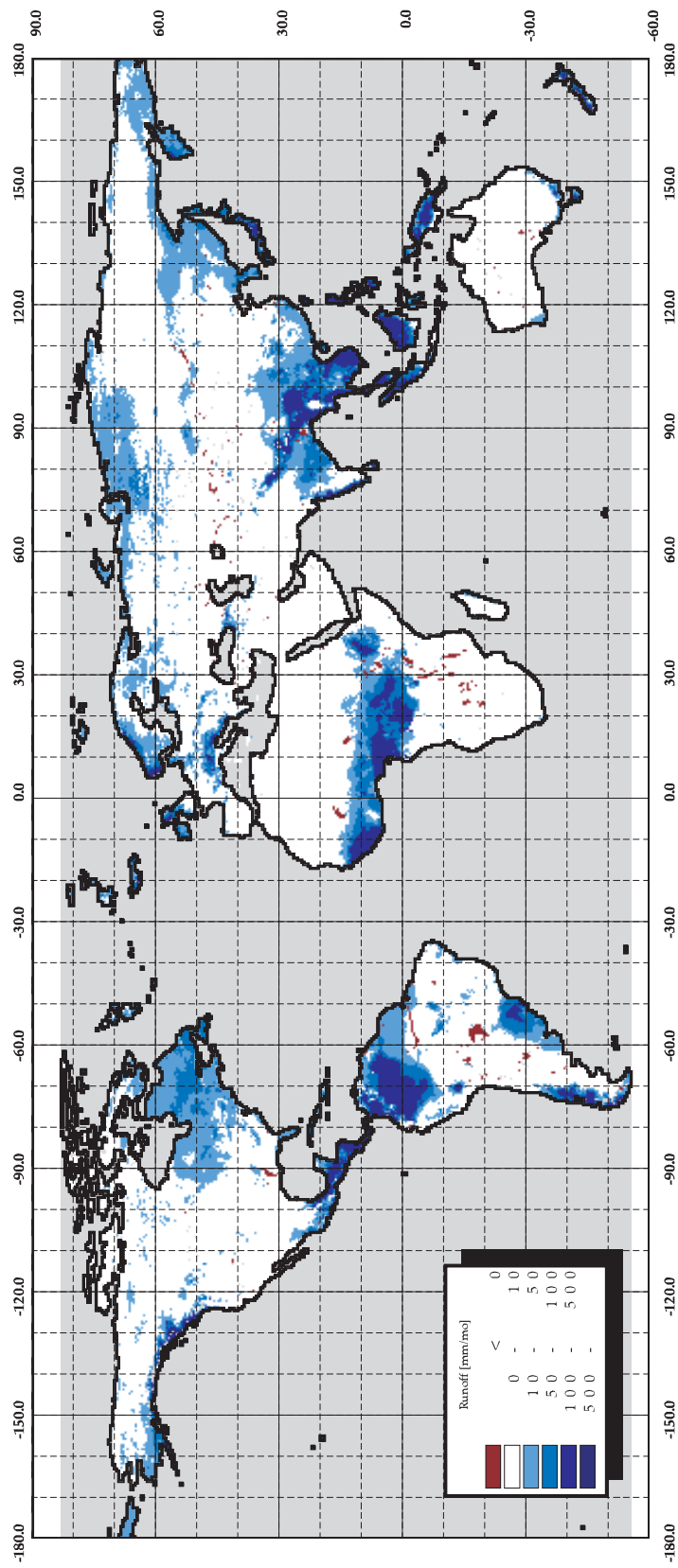
WBM-Simulated September Runoff

30-minute spatial resolution



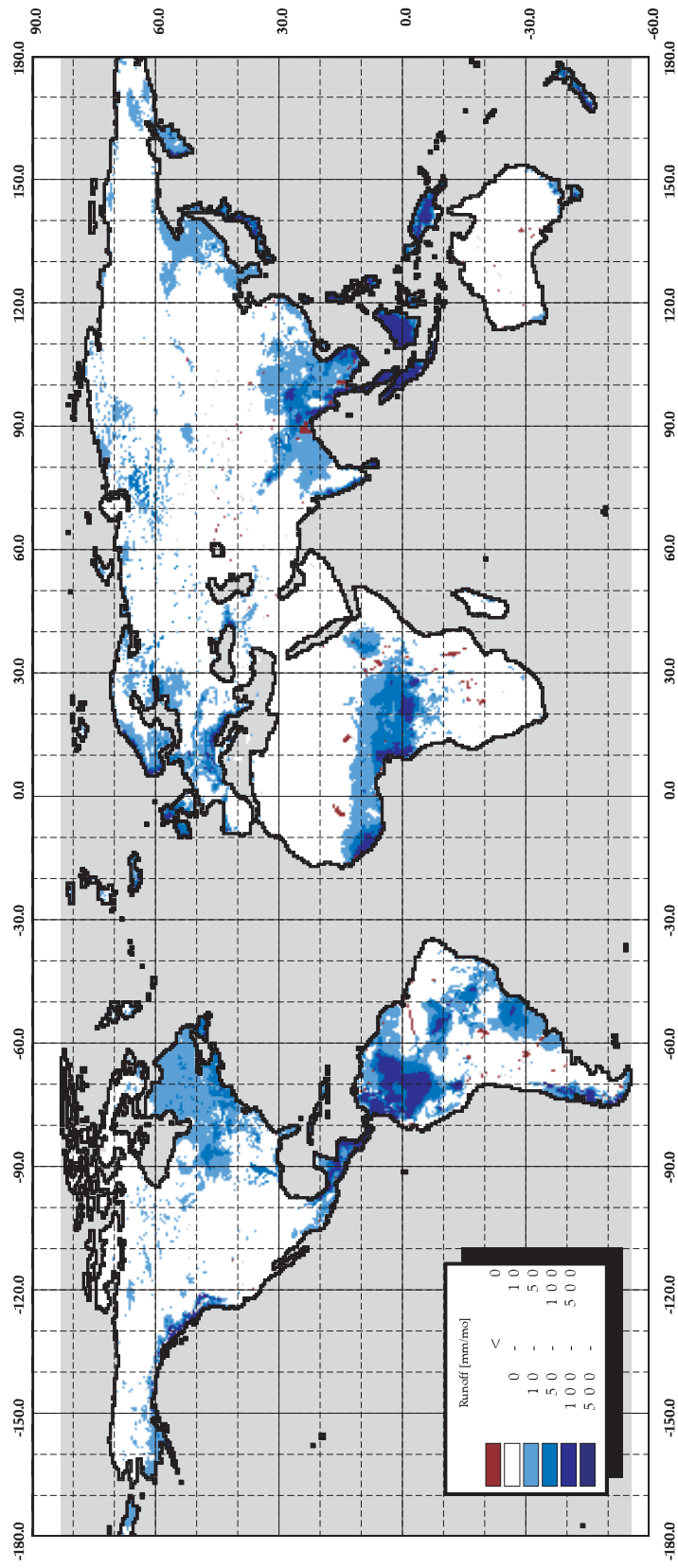
WBM-Simulated October Runoff

30-minute spatial resolution



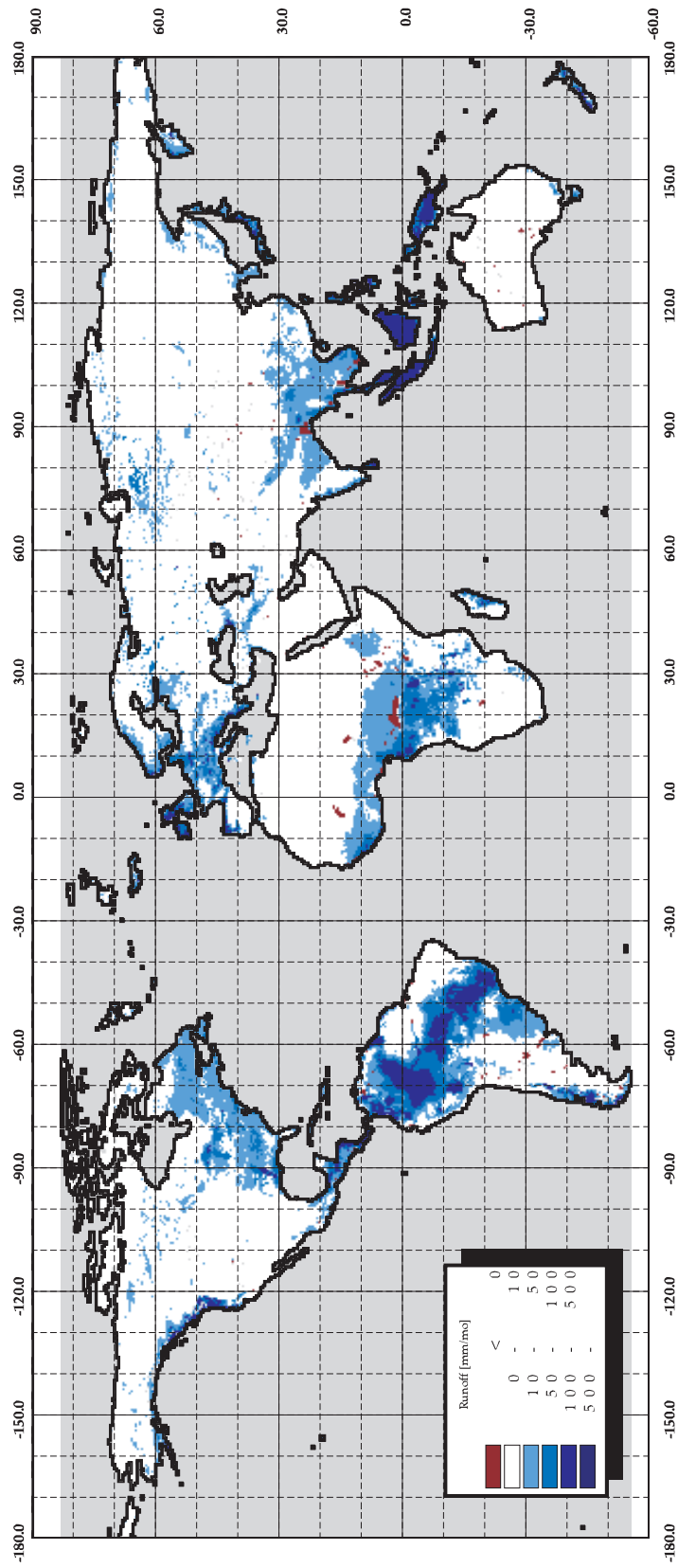
WBM-Simulated November Runoff

30-minute spatial resolution



WBM-Simulated December Runoff

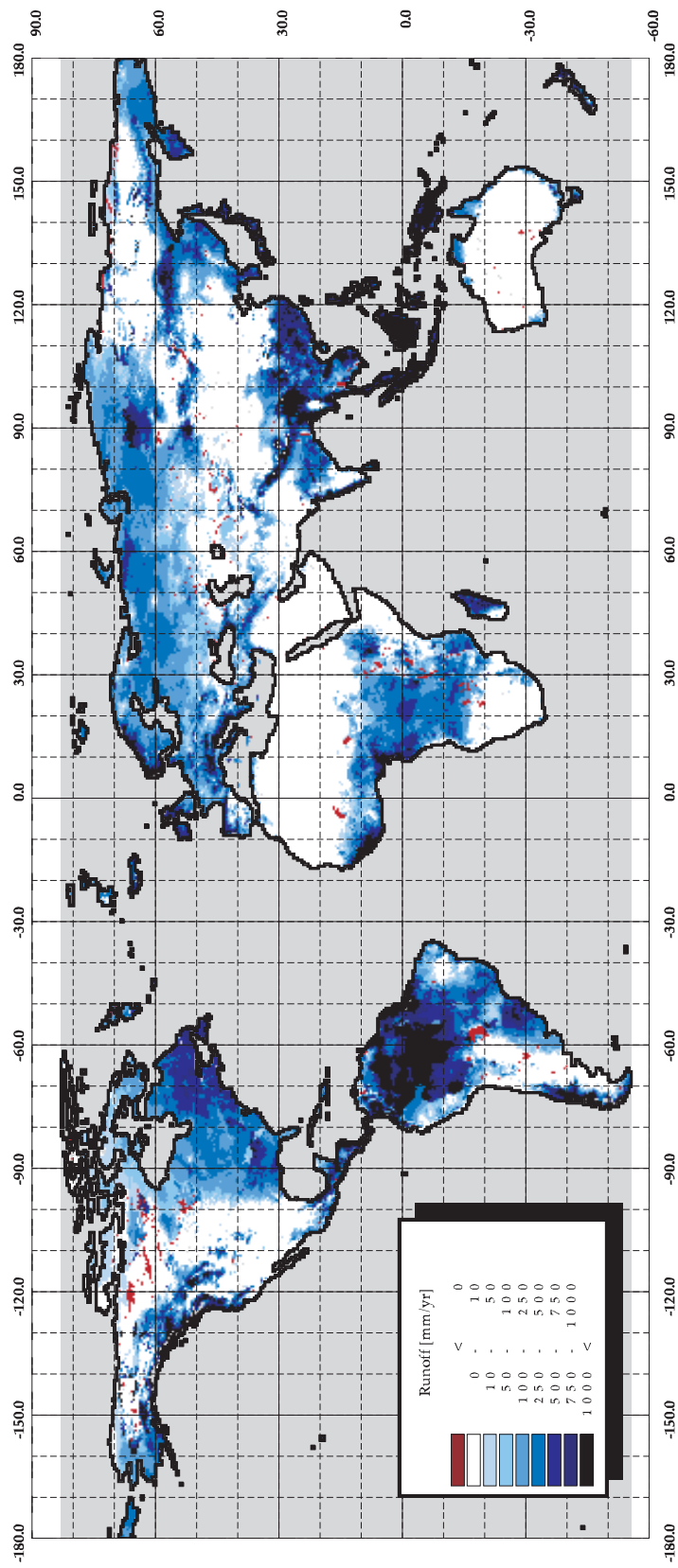
30-minute spatial resolution



H Appendix: UNH-GRDC Composite Monthly Runoff Fields

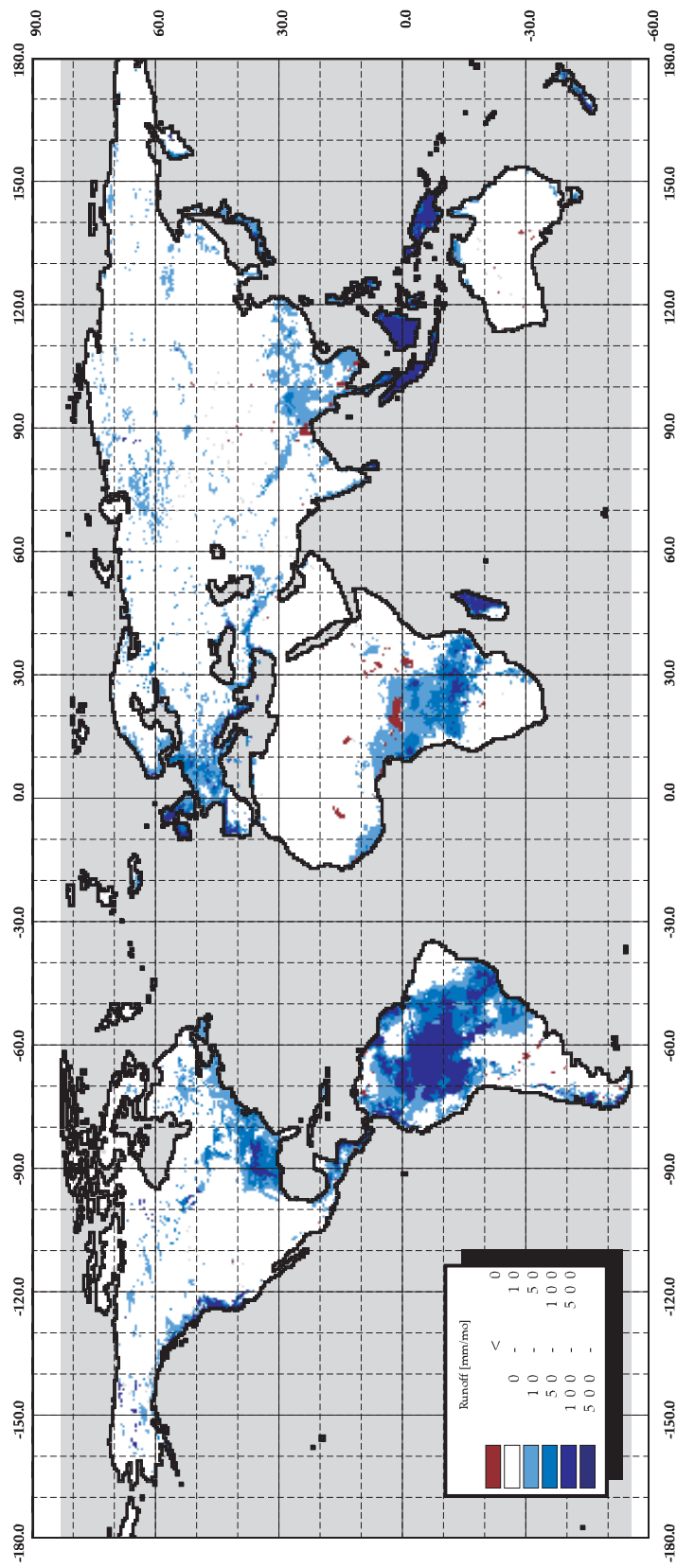
Composite Mean Annual Runoff

30-minute spatial resolution



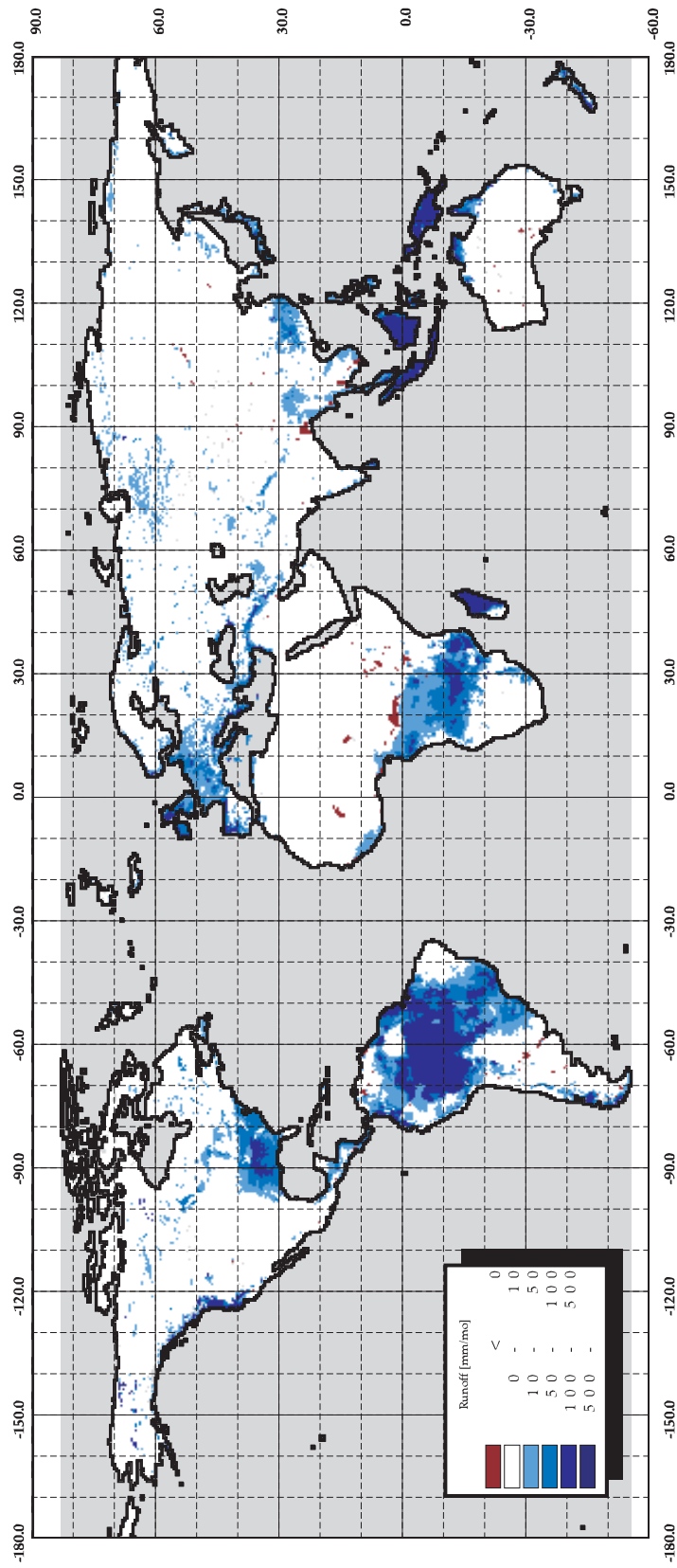
Composite January Runoff

30-minute spatial resolution



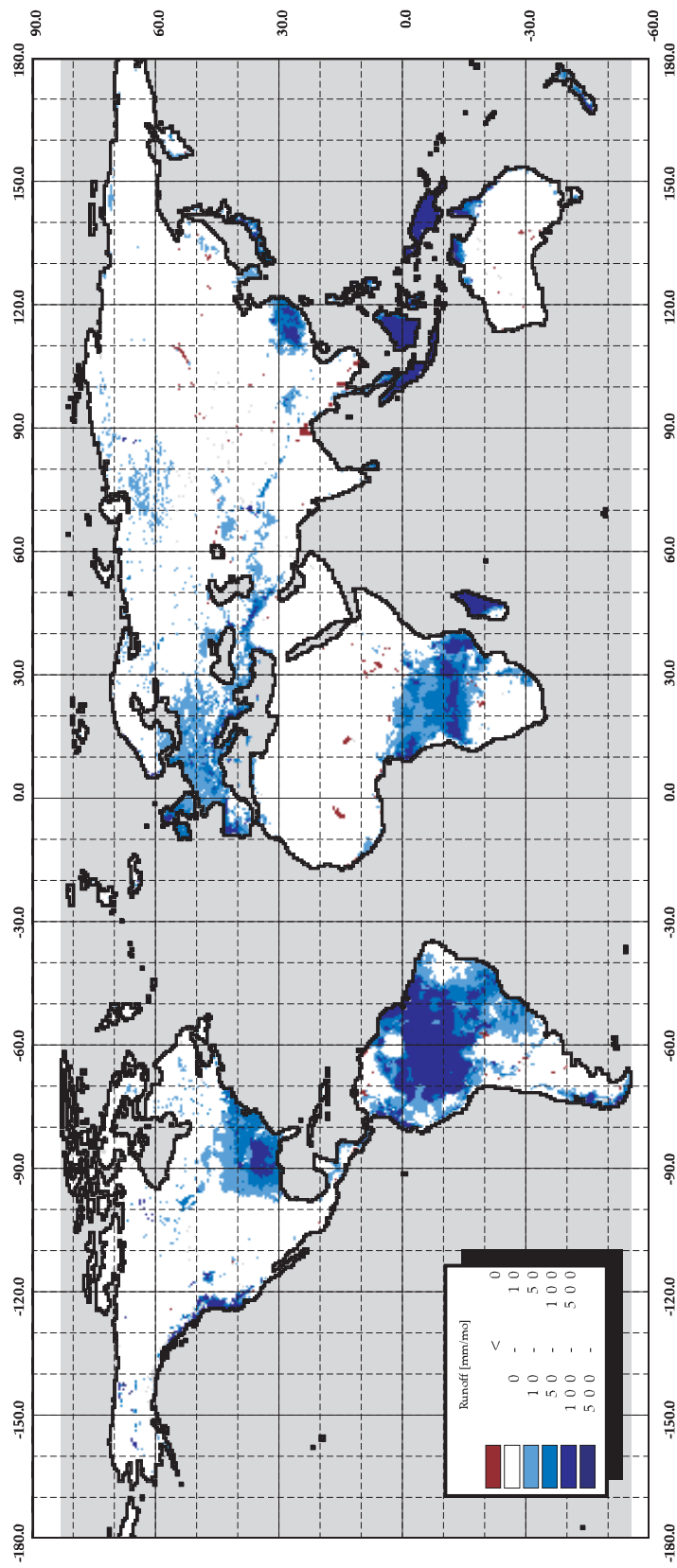
Composite February Runoff

30-minute spatial resolution



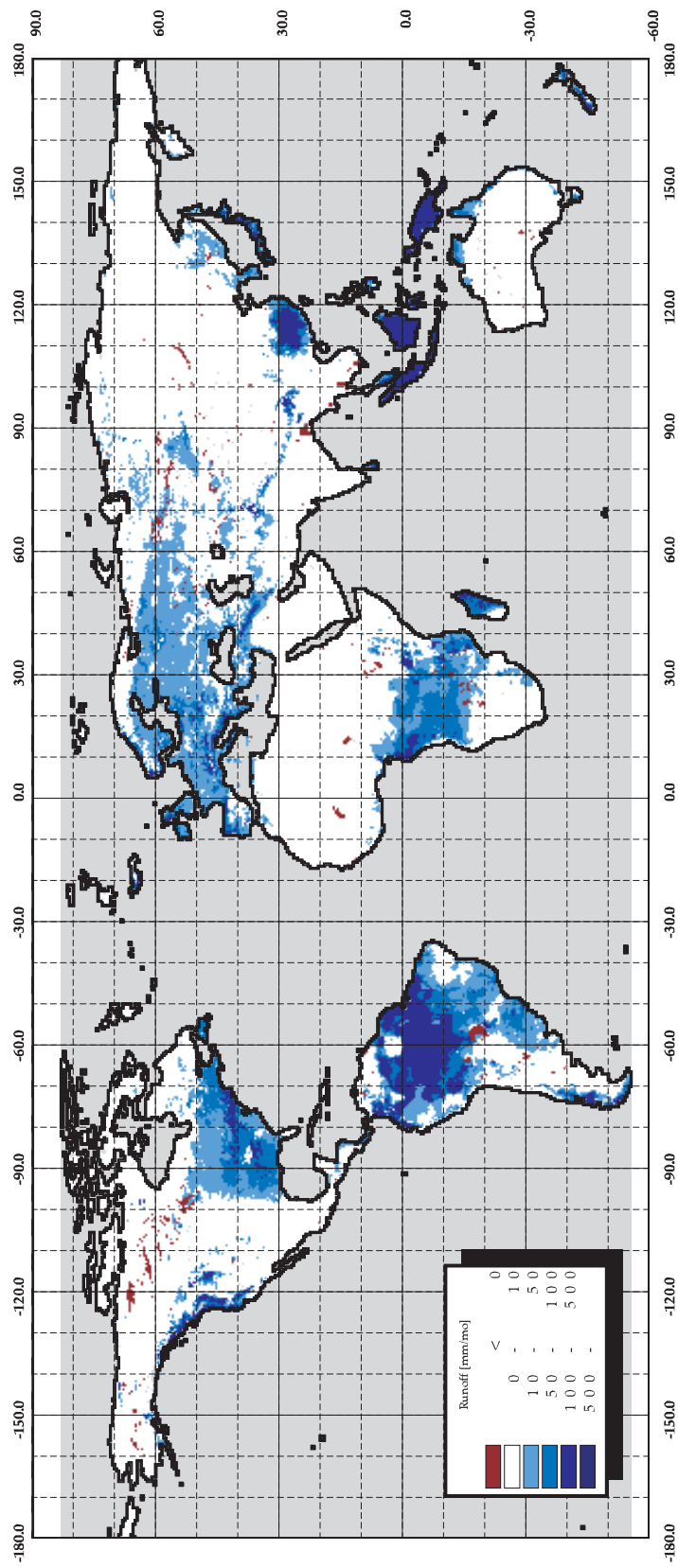
Composite March Runoff

30-minute spatial resolution



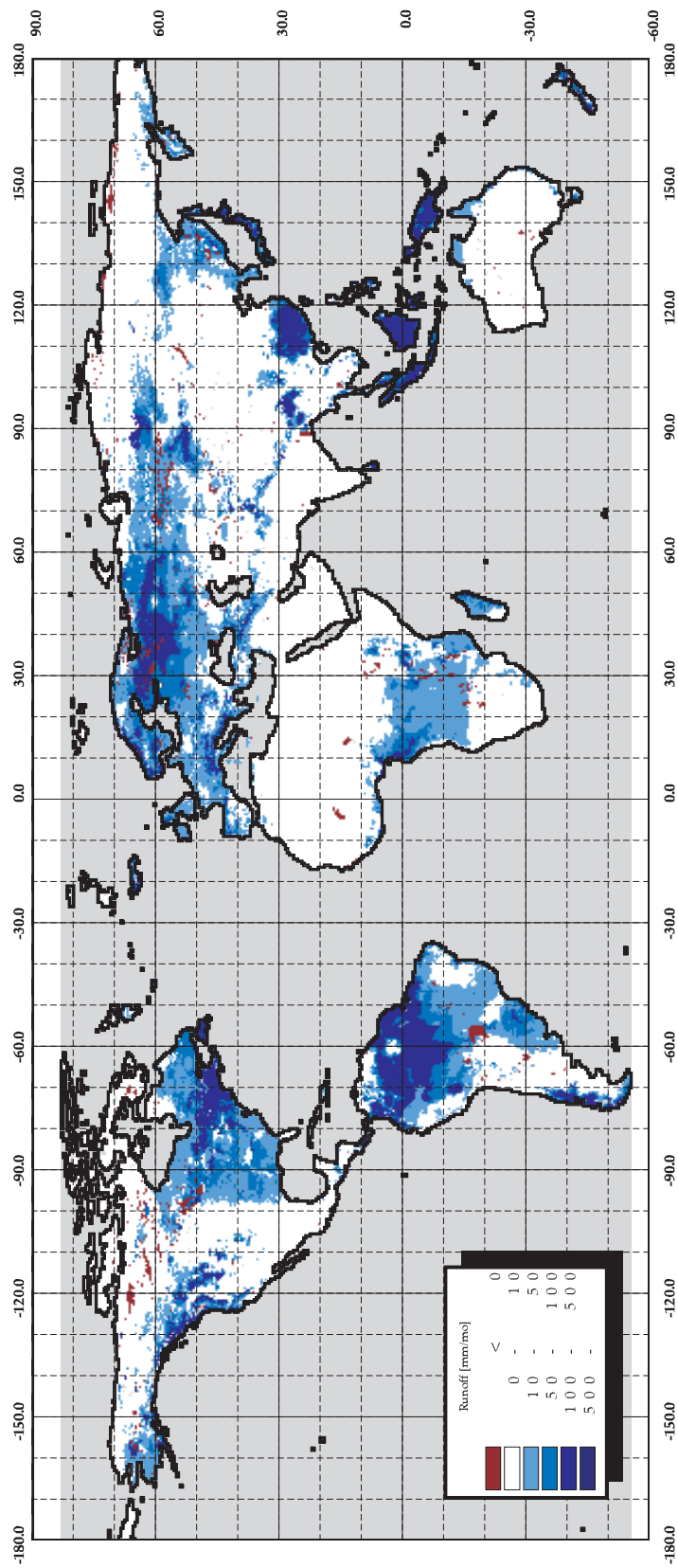
Composite April Runoff

30-minute spatial resolution



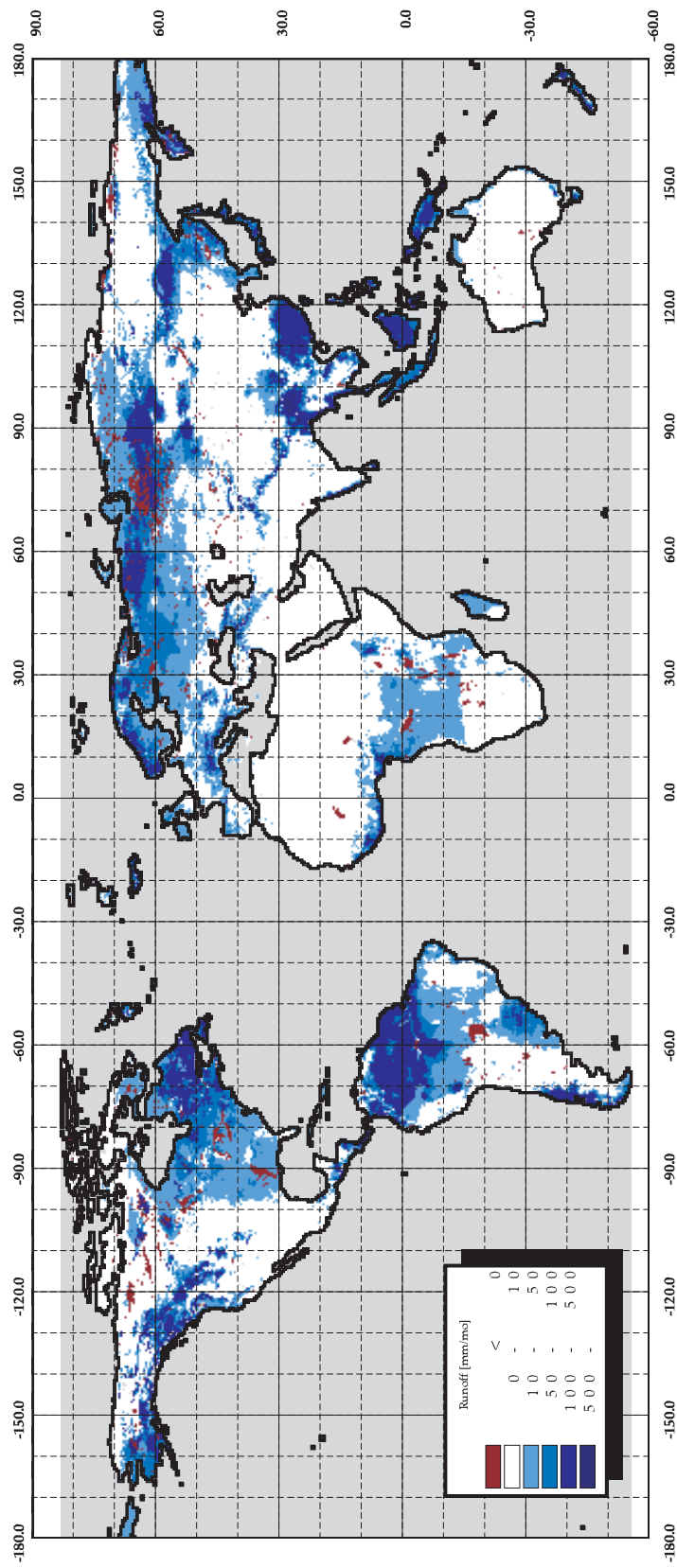
Composite May Runoff

30-minute spatial resolution



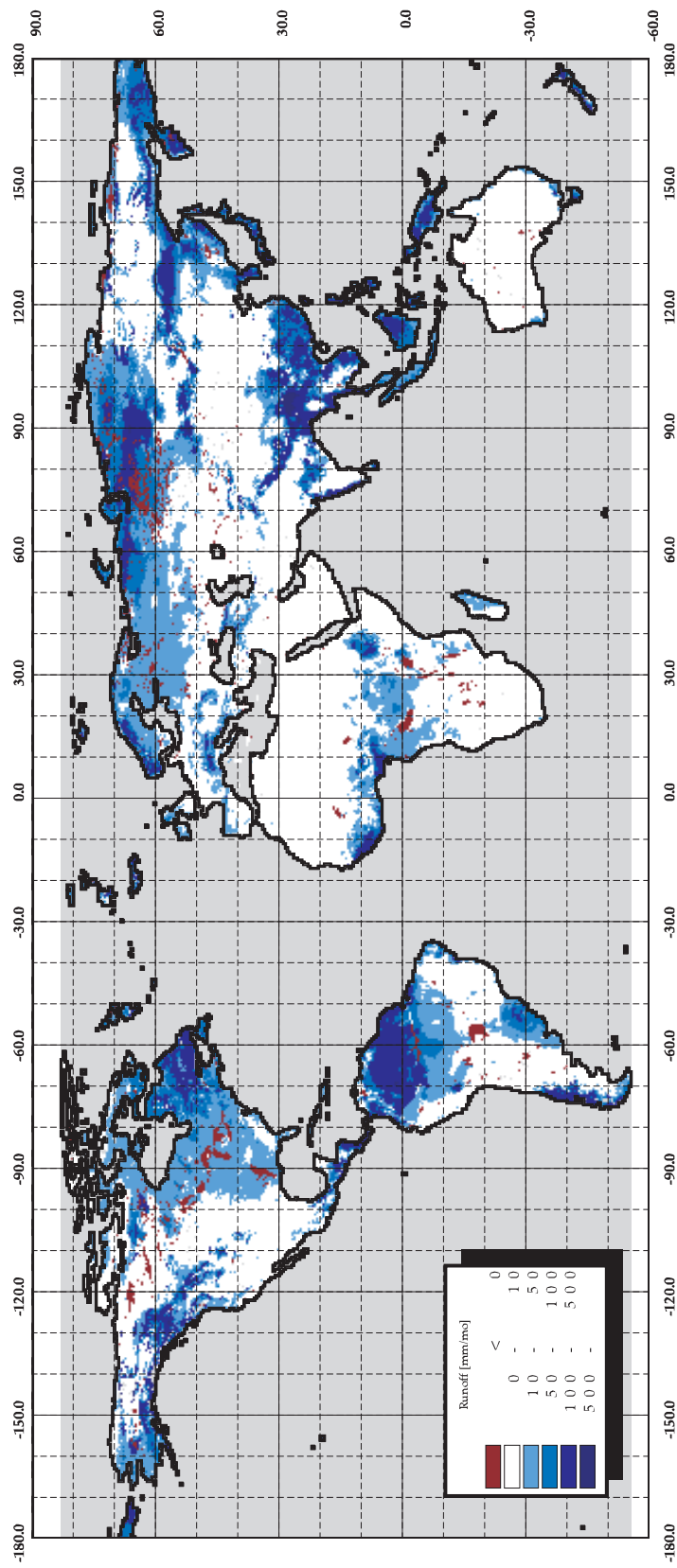
Composite June Runoff

30-minute spatial resolution



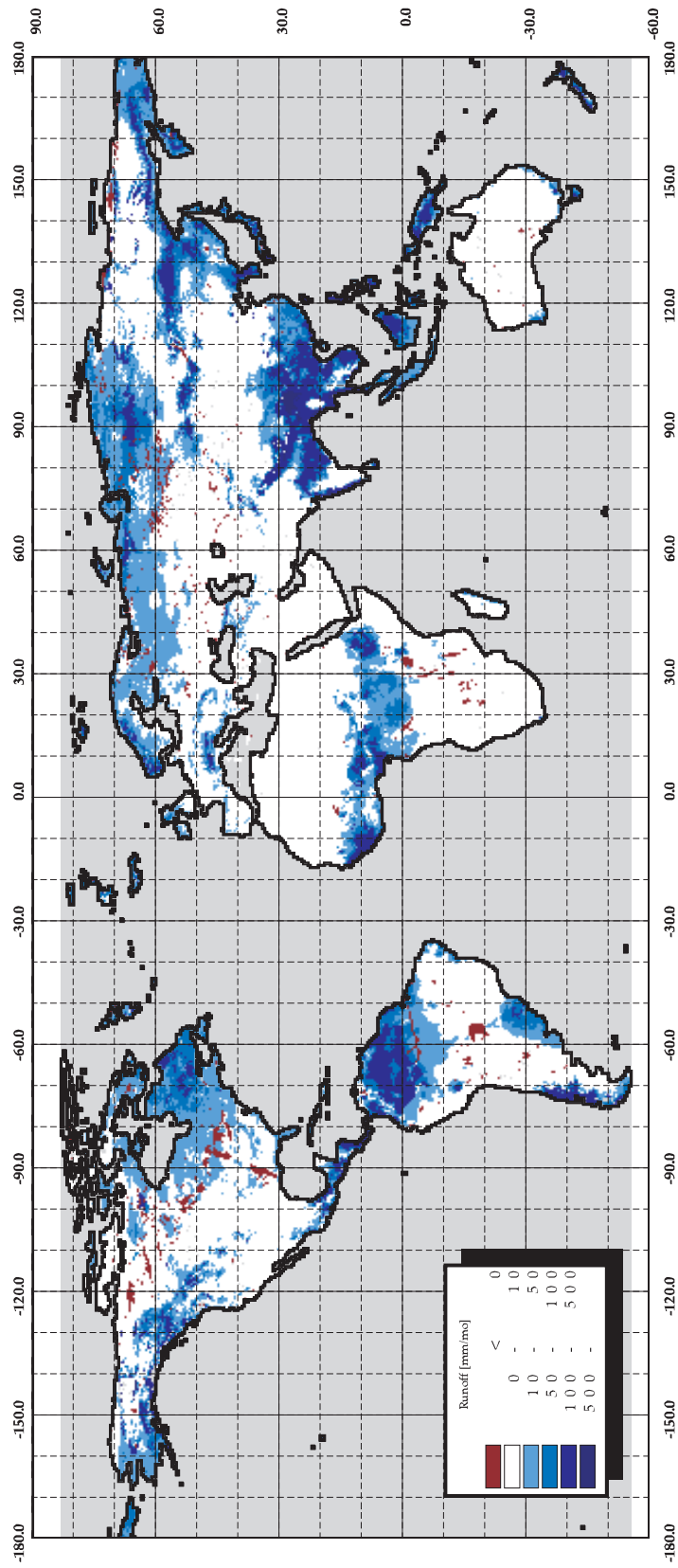
Composite July Runoff

30-minute spatial resolution



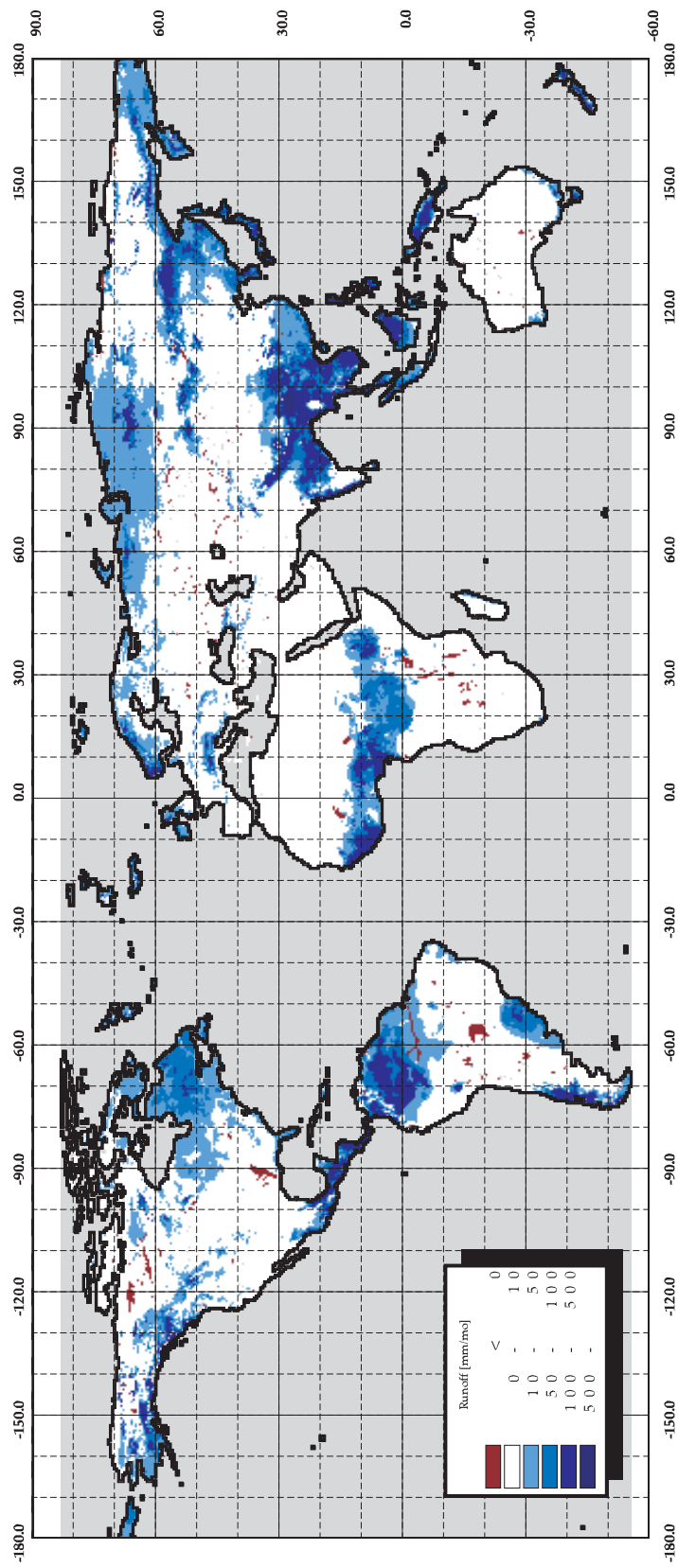
Composite August Runoff

30-minute spatial resolution



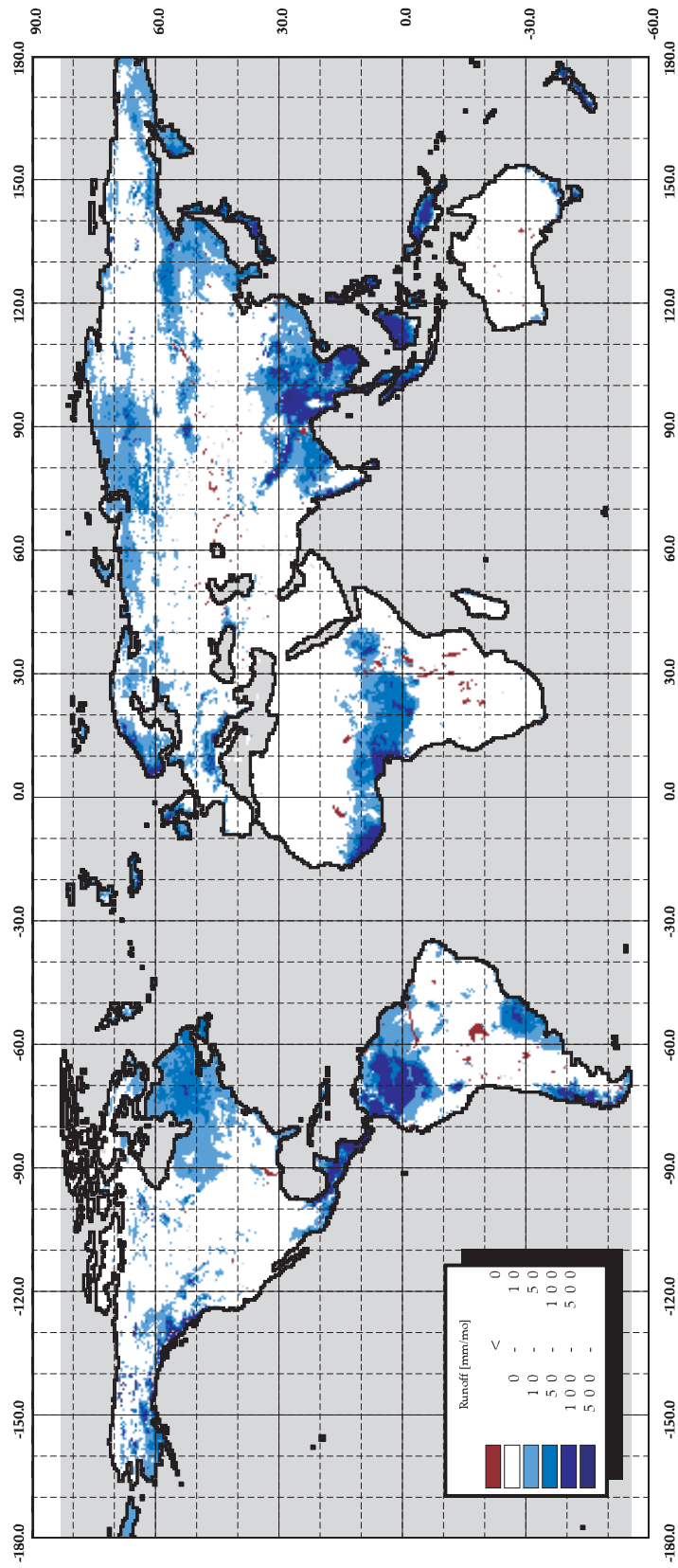
Composite September Runoff

30-minute spatial resolution



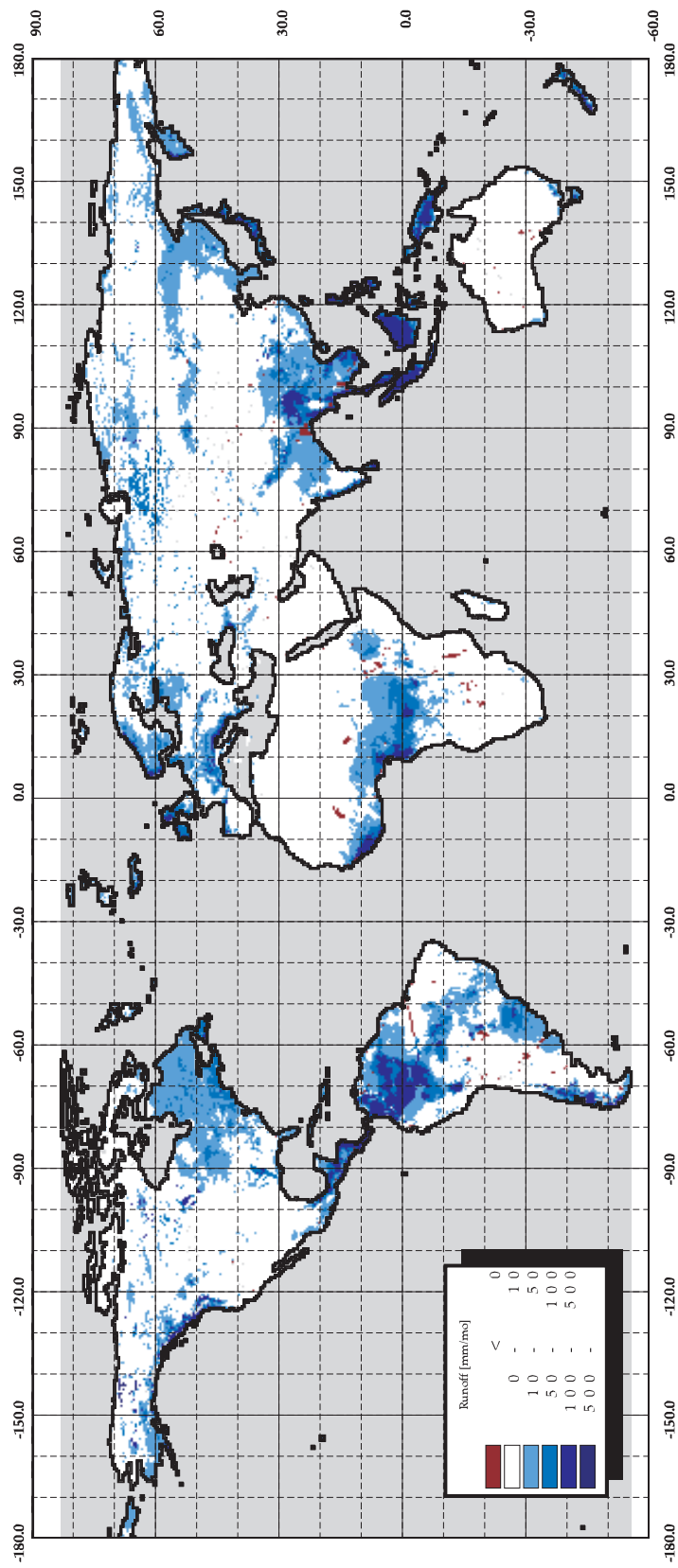
Composite October Runoff

30-minute spatial resolution



Composite November Runoff

30-minute spatial resolution



Composite December Runoff

30-minute spatial resolution

