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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 rational 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 ($\sim 50\text{ km}$ 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 WWWeb-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)

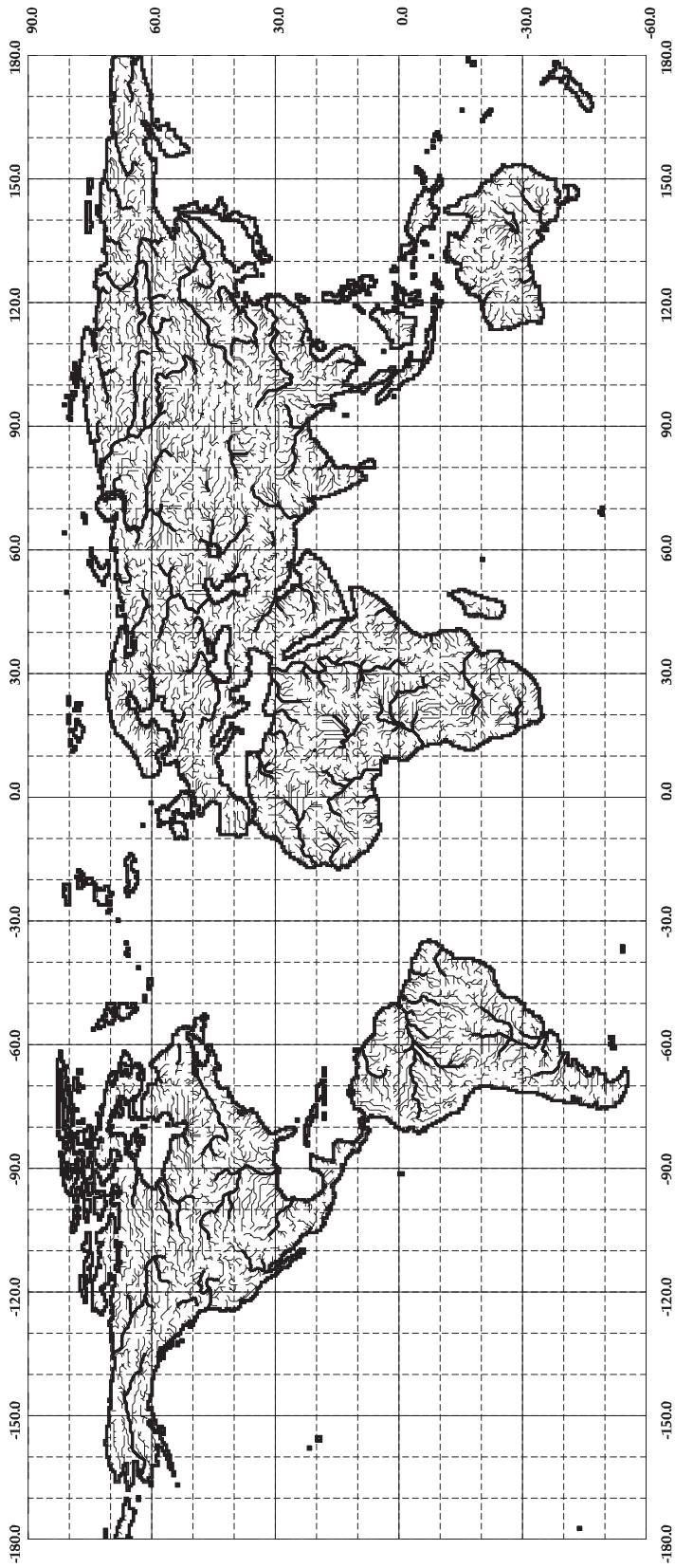


Figure 1: Simulated Topological Networks at 30-minute resolution. A partial inventory is given representing only second or higher order STN-30p rivers segments (using Strahler system).

GRDC Selected Discharge Gauging Stations

1347 Sites

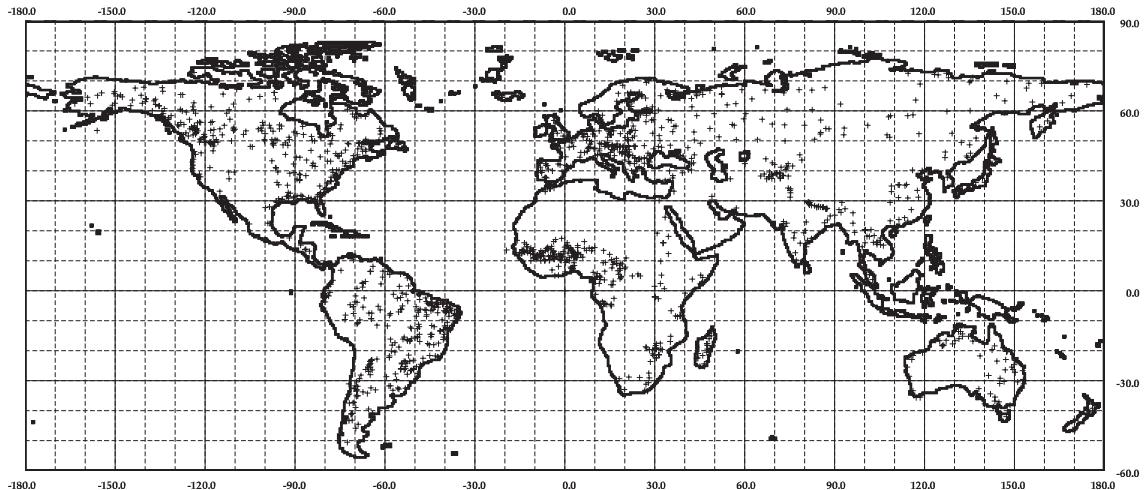


Figure 2: GRDC selected discharge gauging stations.

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 than 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.

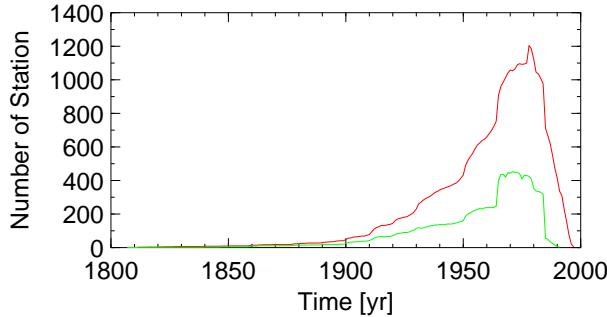


Figure 3: Number of operating stations over time in GRDC and UNESCO/UNH RivDIS V1.0 data sets.

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

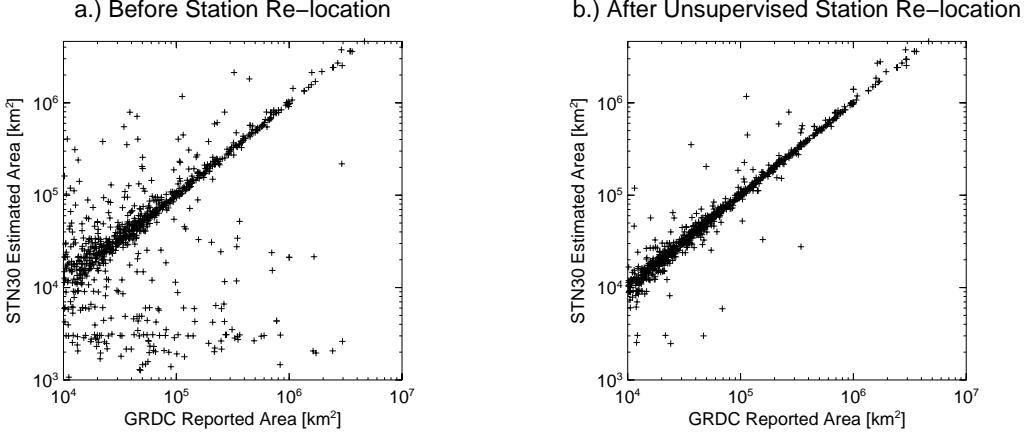


Figure 4: Comparison of GRDC reported catchment areas to STN-30p simulated subbasin areas at the Original and Re-located GRDC gauging sites (using automated unsupervised re-location).

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

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

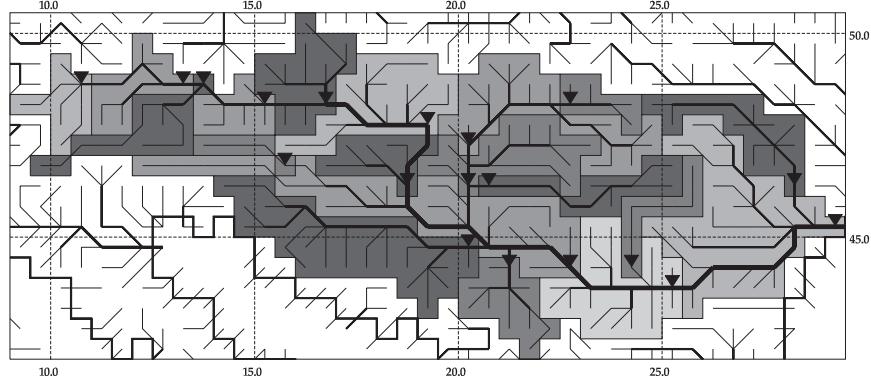


Figure 5: Inter-station areas in the Danube basin.

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, $\sim 13,000 \text{ mm/yr}$ runoff, Manicore, on Rio Madeira $\sim 6000 \text{ mm/yr}$ 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 $67 \times 10^6 \text{ km}^2$, i.e. more than 50% of the $133 \times 10^6 \text{ km}^2$ continental land mass in STN-30p (which does not include Antarctica, the glaciariized portion of Greenland and the Canadian Arctic Archipelago). If we consider only the actively discharging $93 \times 10^6 \text{ km}^2$ 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 $25,000 \text{ km}^2$. Therefore the discharge gauging stations should partition the STN-30p domain into inter-station regions of $25,000 \text{ km}^2$ 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

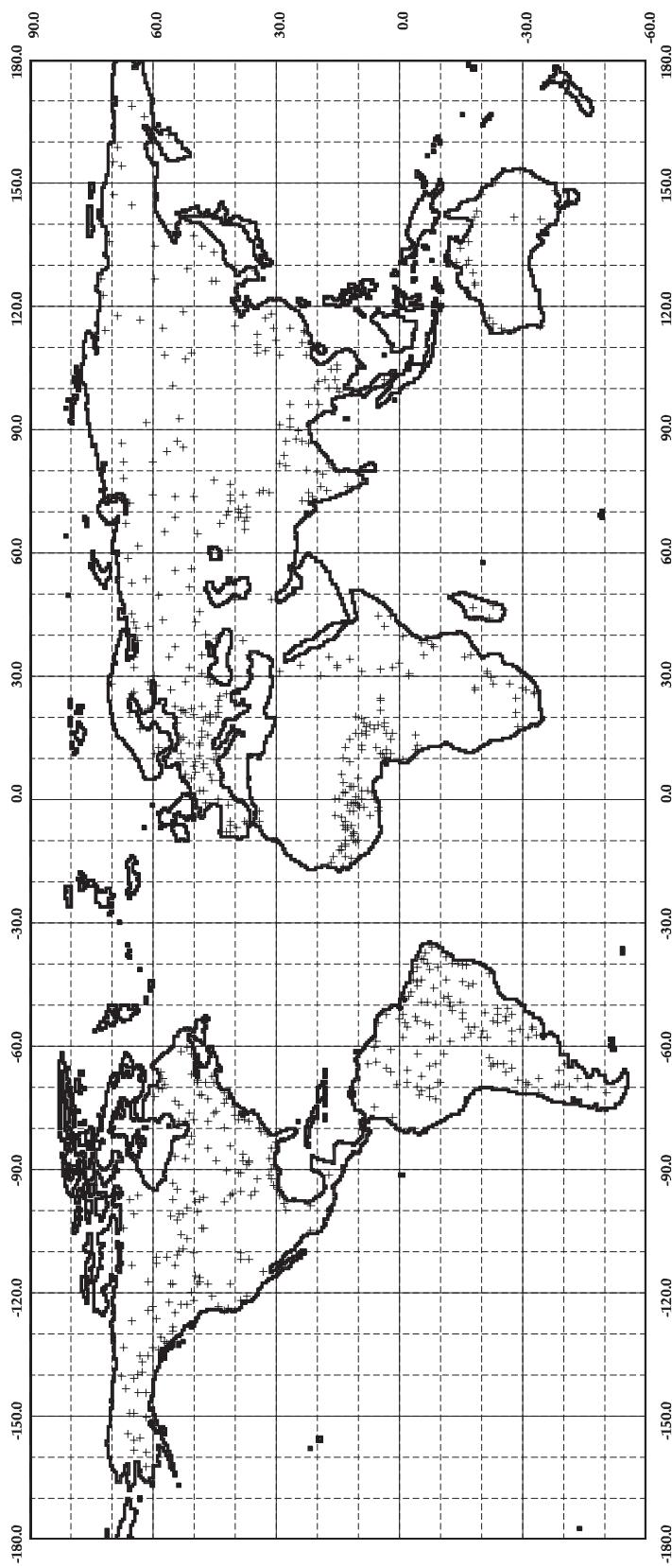


Figure 6: The 663 "Best" discharge gauging stations used in the present study.

Discharge Monitored Regions

-- Inter-station Areas --

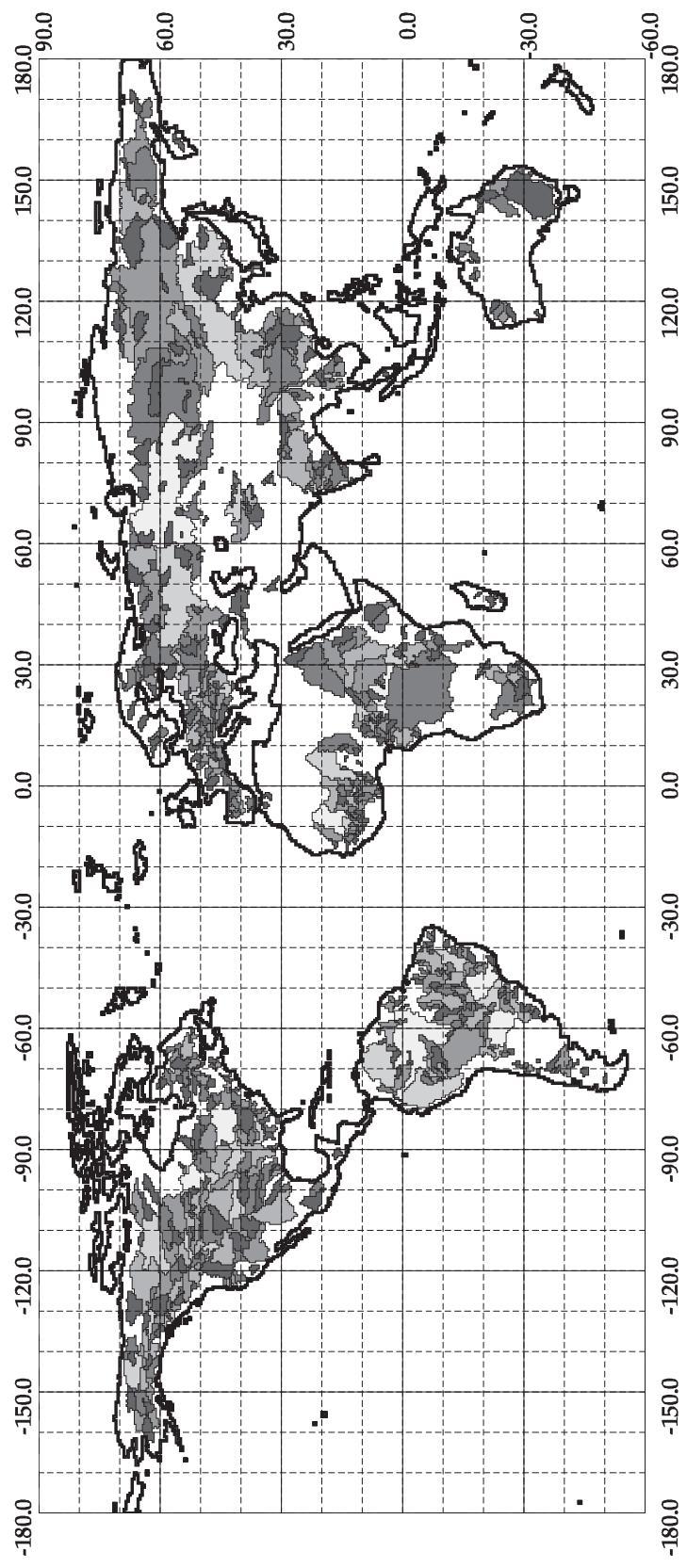


Figure 7: Continental land mass monitored by the selected GRDC stations.

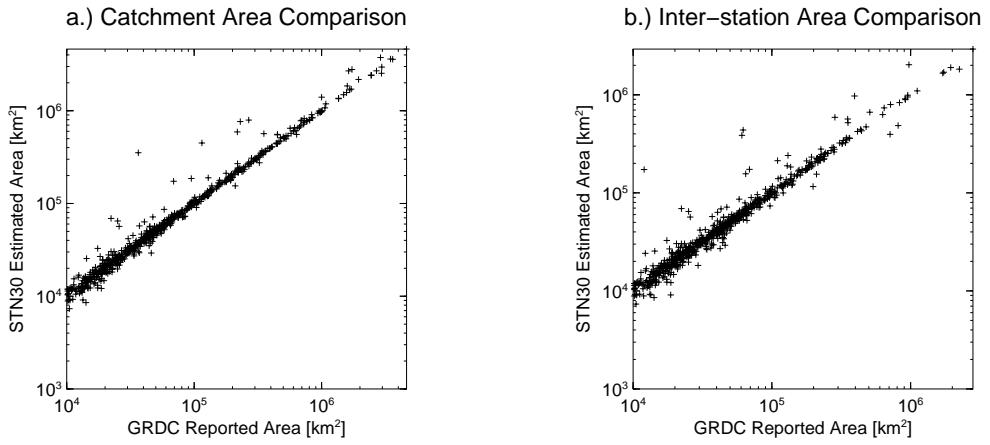


Figure 8: Comparison of GRDC-reported catchment and inter-station areas to those represented by STN-30p.

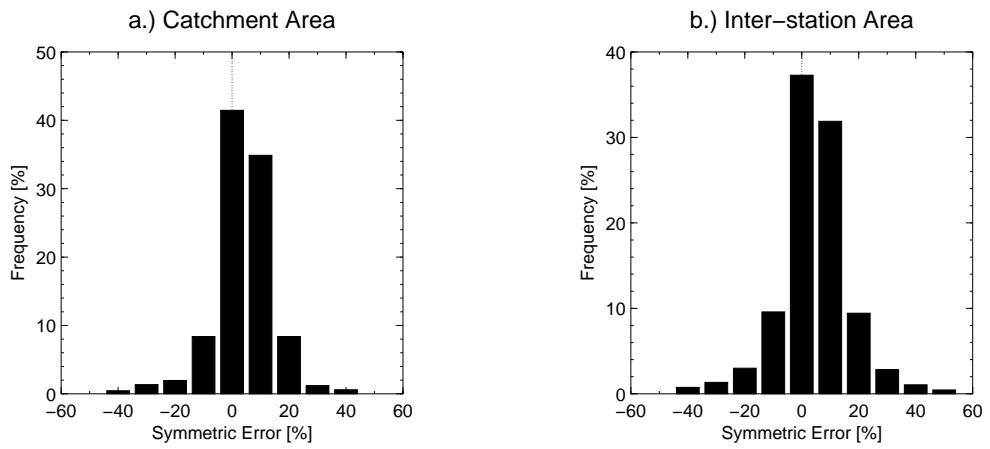


Figure 9: Frequency distribution of Symmetric Error for catchment and inter-station area comparison.

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 ($3600\text{s/hr} * 24\text{hr/day} * 30\text{day/mo} * 1\text{m/s} \simeq 2500\text{ km}$ 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

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

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

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

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

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

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°]. 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 overlayed 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

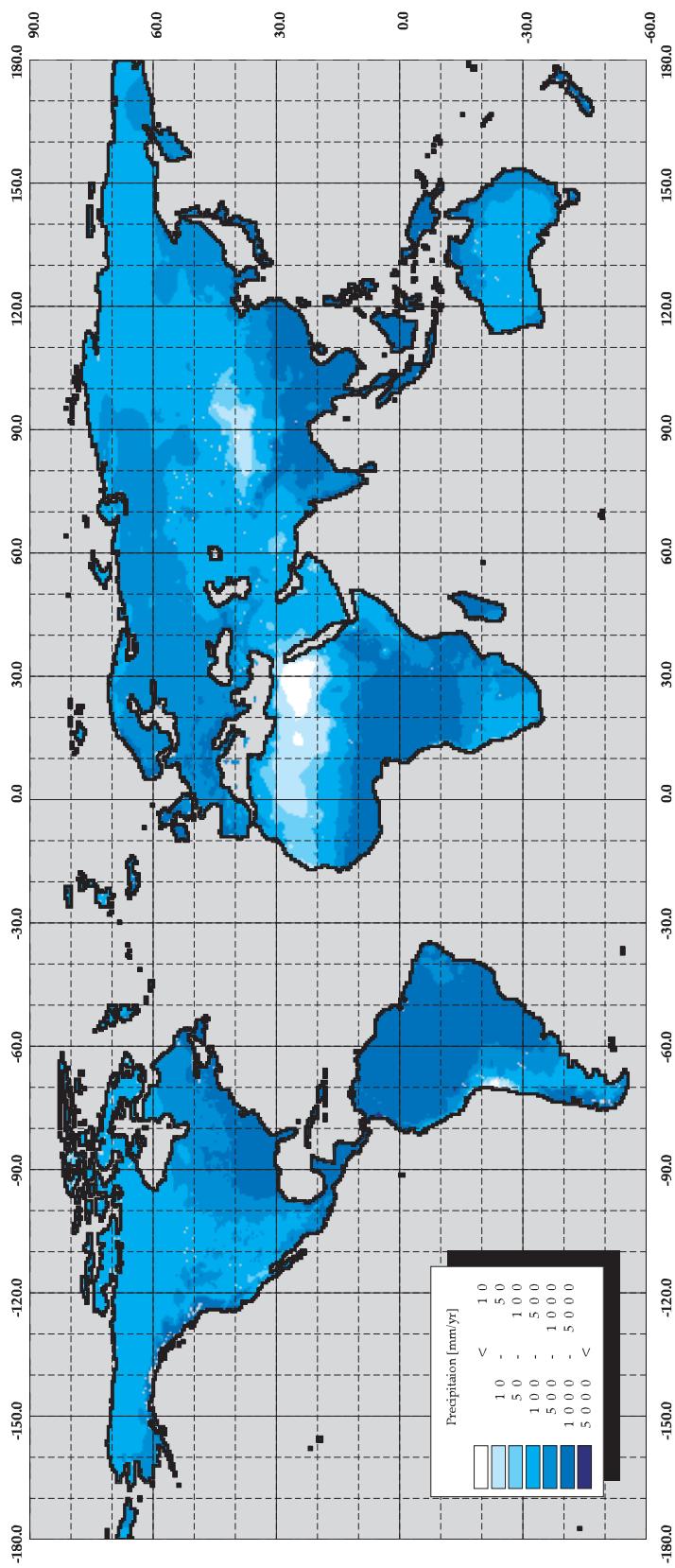


Figure 10: Willmott and Matsuura (1998) mean annual precipitation.

WBM-Simulated Mean Annual Runoff

30-minute spatial resolution

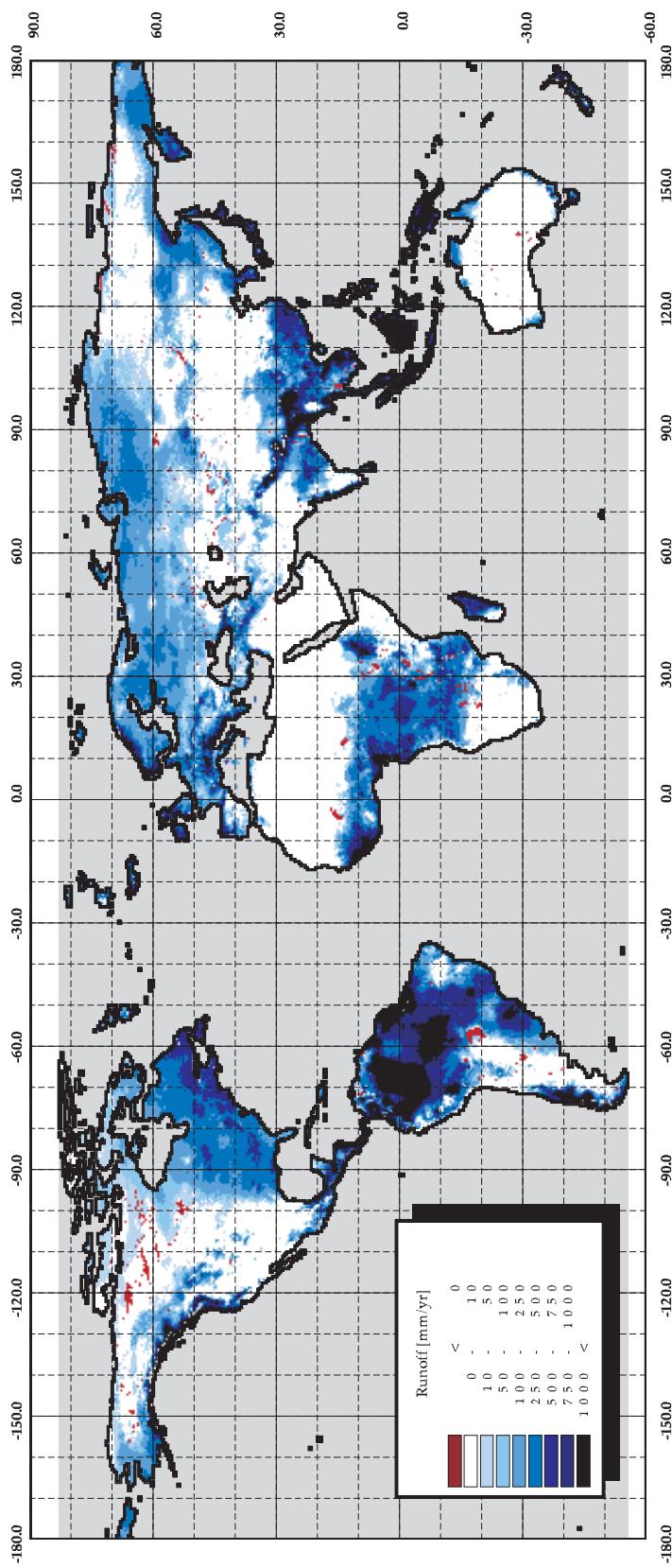


Figure 11: Water Balance Model simulated runoff.

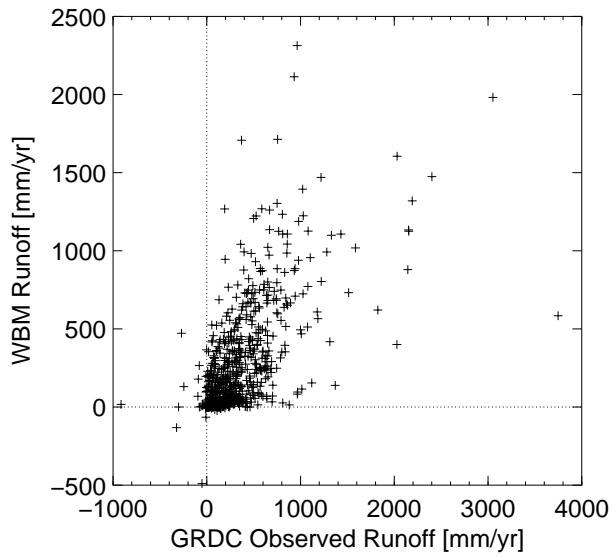


Figure 12: Comparison of observed and simulated sub-basin runoffs.

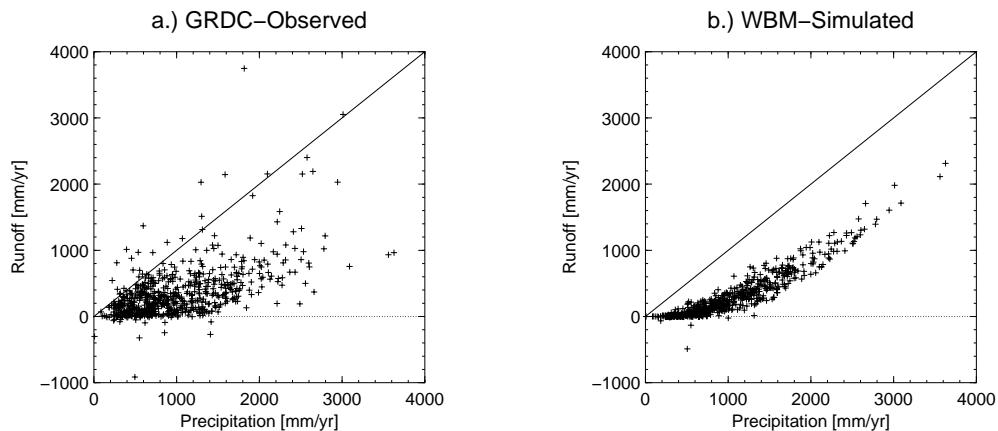


Figure 13: Comparison of Observed precipitation to observed and WBM simulated runoff.

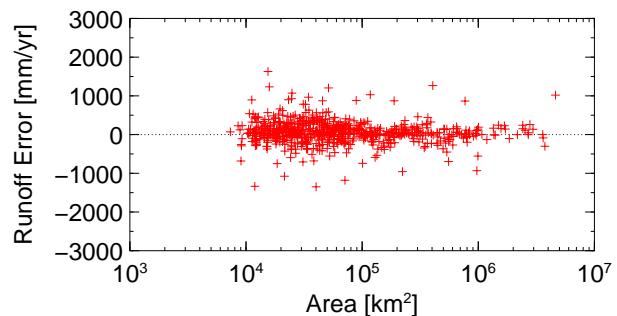


Figure 14: WBM Runoff Error by Catchment Area.

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:

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

where

- \bar{R}_{oi} - Mean annual observed inter-station runoff [L/T]
- \bar{Q}_{oi} - Mean annual inter-station discharge [L^3/T]
- A_{si} - Inter-station area [L^2]

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

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

where

- \bar{R}_{wi} - Mean annual water balance runoff [L/T]
- R_{wbm} - Local annual water balance runoff [L/T]

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

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

The corrected runoff then becomes:

GRDC Observed Mean Annual Runoff

30-minute spatial resolution

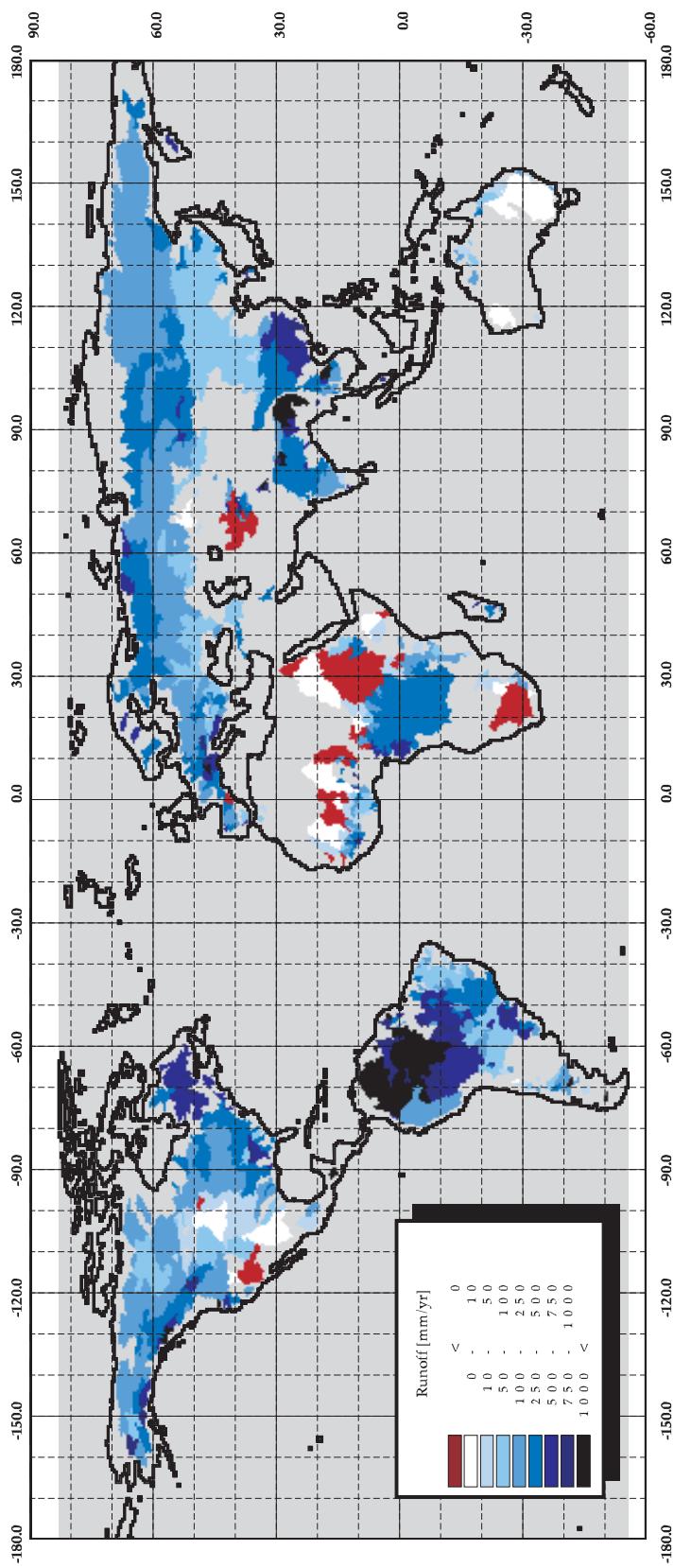


Figure 15: Observed Annual Runoff uniformly distributed along inter-station regions.

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

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

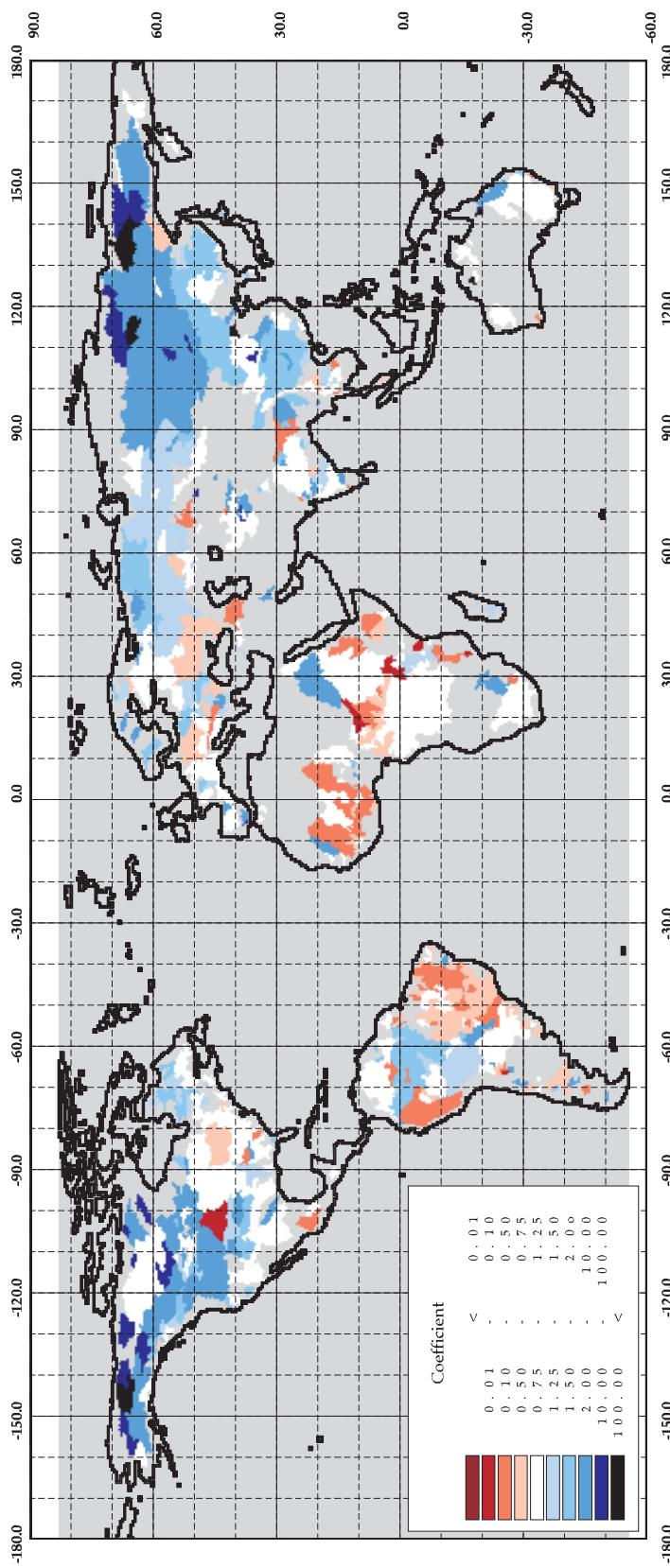


Figure 16: Mean annual runoff correction coefficients.

Composite Mean Annual Runoff

30-minute spatial resolution

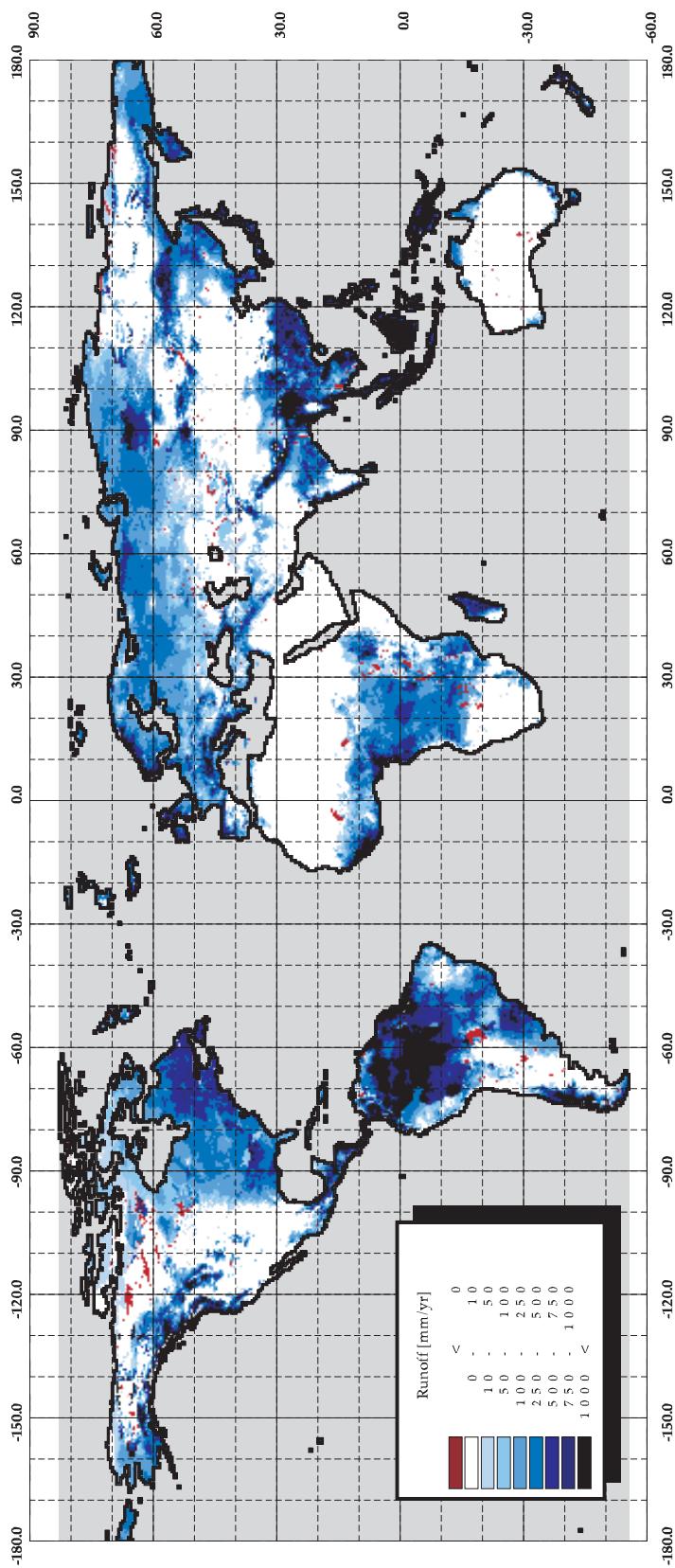


Figure 17: Mean annual combined runoff. Values < 1.0 indicate underestimate and > 1.0 indicate overestimate by WBM

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
Endorheic 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-glacierized 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

$$\omega = \frac{R}{P} \quad (15)$$

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

$$P = \frac{1}{\omega} R \quad (16)$$

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 simulate 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

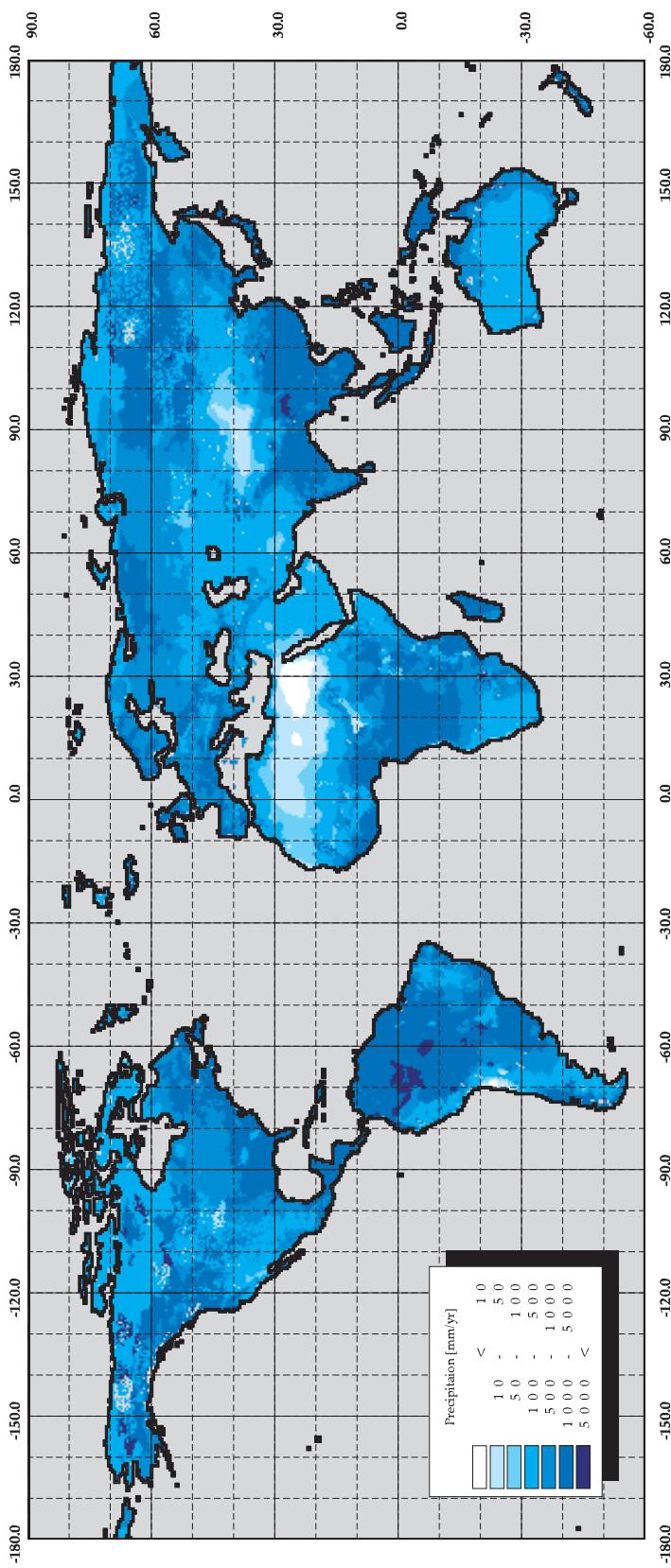


Figure 18: Corrected precipitation field based on discharge observation.

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 ~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:

<code>g_basin</code>	- Basin grid with basin attributes
<code>g_celllength</code>	- Grid cell length [km] grid
<code>g_cumularea</code>	- Upstream catchment area [km^2] grid
<code>g_distmouth</code>	- Distance [km] to mouth of river defined as the confluence with equal or higher order stream
<code>g_distocean</code>	- Distance [km] to the outlet of river basins
<code>g_network</code>	- Flow-direction grid
<code>g_order</code>	- Strahler stream order grid
<code>c_basin</code>	- Basin polygon coverage with the same basin attributes as the basin grid
<code>c_network</code>	- 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:

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

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

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

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

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

GRDC Code	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	ID	Station	Next	Discharge [m ³ /s]		GRDC	STN-30p	GRDC	STN-30p
			Mean	Min					
2180800	Huayuankou				Huanghe(Yellow River)				
141	0	1438.0	447.2	3130.5	Huang He	730036	823531	42167	43083
2181400	Gongtan				Wujiang				
142	143	1142.4	331.7	2573.0	Chang Jiang	58300	52125	58300	52125
2181600	Yichang				Changjiang				
143	144	14185.4	8117.5	22973.3	Chang Jiang	1010000	1003478	951700	951354
2181800	Hankou				Changjiang				
144	146	23301.2	10954.2	37733.3	Chang Jiang	1488036	1489373	436636	444459
2181850	Jian				Ganjiang				
145	146	1670.1	662.3	3428.3	Chang Jiang	56200	61204	56200	61204
2181900	Datong				Changjiang (Yangtze)				
146	0	28811.4	16369.2	47508.3	Chang Jiang	1705383	1712673	161147	162095
2181950	Bengbu				Huaihe				
147	0	863.6	30.8	3833.0	Huai	121330	116778	121330	116778
2182100	Ankang				Hanjiang				
148	144	655.1	137.5	2021.2	Chang Jiang	41400	41436	41400	41436
2186500	Nanning				Yujiang				
149	150	1304.0	374.8	3098.5	Zhujiang	75500	76744	75500	76744
2186800	Wuzhou 3				Xijiang				
150	0	6964.9	2207.7	16465.0	Zhujiang	329705	329344	254205	252600
2186900	Hengshi				Beijiang				
151	0	1092.2	299.9	2819.6	Dongjiang	34013	31079	8688	2840
2186950	Boluo				Dongjiang				
152	151	754.7	242.4	1870.5	Dongjiang	25325	28239	25325	28239
2260100	Hkamti				Chindwin				
153	0	2407.1	1240.2	4022.2	Irrawaddy	27420	24867	27420	24867
2260500	Sagaing				Irrawaddy				
154	0	8024.5	5458.1	10951.6	Irrawaddy	117900	117452	117900	117452
2261500	Toungoo				Sittang				
155	0	299.2	161.8	504.2	Sittang	14660	14520	14660	14520
2423500	Ahvaz				Karun				
156	0	575.4	267.8	1427.6	Karun	60769	60138	60769	60138
2469050	Luang Prabang				Mekong				
157	243	3625.4	2228.9	5095.7	Mekong	268000	278692	79000	86915
2469260	Pakse				Mekong				
158	0	9001.0	6465.2	12514.2	Mekong	545000	536010	50000	41570
2548400	Chisapani				Karnali River				
159	170	1353.0	226.8	2257.3	Ganges	42890	45887	21650	21733
2548450	Benighat				Karnali River				
160	159	612.5	357.6	958.2	Ganges	21240	24154	21240	24154
2549500	Devghat				Narayani River				
161	170	1559.9	1048.4	2566.8	Ganges	31100	32521	31100	32521
2550200	Turkeghat				Arun River				
162	170	420.7	302.1	573.0	Ganges	28200	29902	28200	29902
2557100	Ishikari-Ohashi				Ishikari				
163	0	467.2	146.4	901.8	GHAASBasin1057	12697	11221	12697	11221
2651100	Bahadurabad				Brahmaputra				
164	0	21260.9	13660.1	28732.0	Ganges	636130	554542	198360	116081
2677100	Indogyo				Han				
165	0	525.5	127.9	1673.3	Han	25046	19652	25046	19652
2694510	Samnangjin				Nagdong				
166	0	289.9	54.5	777.2	Nag Dong	22916	20006	22916	20006
2836100	Baramula Br.				Jhelum				
167	0	221.4	93.5	388.2	Indus	12494	12776	12494	12776
2837100	Akhnoor				Chenab				
168	0	796.6	534.0	1157.6	Indus	22681	23296	22681	23296
2839100	Mandi Plain				Beas				
169	0	497.3	247.5	811.6	Indus	18274	20886	18274	20886
2846800	Farakka				Ganga				
170	0	12037.3	6133.0	18667.9	Ganges	935000	941428	832810	833118
2851250	Mathanguri				Manas				
171	164	1223.9	497.0	2311.7	Ganges	32770	32764	32770	32764
2851300	Pandu				Brahmaputra				
172	164	18099.5	10512.2	28251.2	Ganges	405000	405697	251809	252712
2853050	Ahmedabad				Sabarmati				
173	0	32.6	1.6	124.2	Rabarmati	12950	11274	12950	11274
2853150	Sevalia				Mahi				
174	0	382.6	28.4	1672.0	Mahi	33670	28465	33670	28465
2853200	Garudeshwar				Narmada				
175	0	1216.2	202.9	3097.9	Narmada	89345	94020	72769	76936

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

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

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

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

GRDC Code	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	ID	Station	Discharge [m ³ /s]			GRDC	STN-30p	GRDC	STN-30p
			Next Mean	Min	Max				
3629790	Tres Marias				Rio Sao Manoel				
316	314	3978.1	2940.8	5200.2	Amazon	137485	154833	137485	154833
3630050	Altamira				Xingu				
317	0	8670.1	4976.7	14308.4	Amazon	446570	448086	322743	322365
3630120	Pedra do o				Rio Iriri				
318	317	2614.7	1045.2	4233.7	Amazon	123827	125721	37837	46161
3630150	Laranjeiras				Rio Iriri				
319	318	1234.8	639.1	2079.0	Amazon	65187	58138	65187	58138
3630215	Boca do Inferno				Rio Curua				
320	318	129.4	4.6	391.2	Amazon	20803	21422	20803	21422
3630300	Arapari				Rio Maicuru				
321	0	115.2	12.5	294.7	Amazon	17072	18546	17072	18546
3631100	Sao Francisco				Rio Jari				
322	0	1004.1	281.7	1790.5	Amazon	51343	52541	20398	21638
3631210	Fazenda Paquira				Rio Paru de Este				
323	322	489.6	100.1	952.0	Amazon	30945	30903	30945	30903
3649014	Colonia Dos Americanos				Rio Das Almas				
324	327	335.4	162.8	612.5	Tocantins	18282	26841	18282	26841
3649211	Jacinto				Rio Santa Terezinha				
325	330	187.7	62.0	374.2	Tocantins	13811	12048	13811	12048
3649240	Fazenda Lobeira				Rio Manuel Alves				
326	327	207.0	79.8	488.0	Tocantins	14462	15138	14462	15138
3649250	Porto Nacional				Tocantins				
327	334	2245.5	856.9	5180.8	Tocantins	175360	174391	142616	132411
3649412	Araguaiana				Rio Araguaia				
328	329	915.7	458.8	1523.5	Tocantins	50930	56324	50930	56324
3649414	Fazenda Telesforo				Rio Araguaia				
329	330	1482.4	515.5	2404.5	Tocantins	131600	134108	80670	77785
3649416	Conceicao do Araguaia				Rio Araguaia				
330	331	4857.9	9.9	9053.4	Tocantins	320290	315378	119533	112369
3649418	Xambioa				Rio Araguaia				
331	334	5507.8	2218.8	8984.4	Tocantins	364496	364358	44206	48980
3649614	Toriqueje				Rio Das Mortes				
332	333	344.7	204.0	535.4	Tocantins	17850	17887	17850	17887
3649619	Santo Antonio do Leverger				Rio Das Mortes				
333	330	867.5	391.6	1411.2	Tocantins	55346	56853	37496	38966
3649900	Itupiranga				Tocantins				
334	0	11363.6	5875.0	18813.9	Tocantins	727900	743944	188044	205196
3650150	Badajos				Rio Capim				
335	0	555.4	233.0	786.8	GHAASBasin180	38178	37016	38178	37016
3650202	Alto Bonito				Rio Gurupi				
336	0	480.9	115.7	835.8	Gurupi	31850	33923	31850	33923
3650335	Bacabal				Rio Mearim				
337	0	111.2	55.5	237.2	Mearim	25500	24630	25500	24630
3650355	Caxias				Rio Itapecuru				
338	339	80.3	37.3	181.1	GHAASBasin198	31750	33809	31750	33809
3650359	Cantanhede				Rio Itapecuru				
339	0	252.5	73.4	722.8	GHAASBasin198	50800	52295	19050	18486
3650385	Nina Rodrigues				Rio Munim				
340	0	150.7	40.6	362.1	GHAASBasin198	12350	12338	12350	12338
3650460	Santa Cruz do Piaui				Rio Itam				
341	342	12.7	0.1	85.8	Parnaiba	17500	12273	17500	12273
3650481	Luzilandia				Rio Parnaiba				
342	0	846.3	427.0	2043.2	Parnaiba	322823	330977	279323	291250
3650488	Fazenda Paracati				Rio Parnaiba				
343	342	203.4	143.3	297.1	Parnaiba	26000	27454	26000	27454
3650525	Sobral				Rio Acaraú				
344	0	56.3	0.0	308.2	GHAASBasin596	11160	9244	11160	9244
3650634	Morada Nova II				Rio Banabuiú				
345	0	52.9	0.5	422.0	GHAASBasin192	17900	18467	17900	18467
3650645	Iguatu				Rio Jaguaripe				
346	347	29.5	0.0	289.8	GHAASBasin192	21770	18419	21770	18419
3650649	Peixe Gordo				Rio Jaguaripe				
347	0	116.7	0.4	593.7	GHAASBasin192	48200	42986	26430	24567
3650750	Jardim de Piranhas				Rio Piranhas				
348	0	78.6	1.5	403.1	GHAASBasin369	22875	27628	22875	27628
3650885	Ponte Da Batalha				Rio Paraíba				
349	0	33.8	0.7	172.1	GHAASBasin433	19244	24511	19244	24511
3651309	Varzea Da Palma				Rio Das Velhas				
350	354	296.2	87.6	682.4	Sao Francisco	25940	26317	25940	26317

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

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

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			Mean	Min						
4146110		Klamath, Calif.			Klamath					
421	0	521.5	98.3	1505.2	Klamath	31339	32197	31339	32197	
4146280		Sacramento, Calif.			Sacramento					
422	0	683.7	195.1	1462.4	Sacramento	60886	58907	60886	58907	
4146360		Vernalis, Calif.			San Joaquin					
423	0	158.2	11.8	660.8	Sacramento	35058	39596	35058	39596	
4147010		West Enfield, Me.			Penobscot					
424	0	339.6	135.8	897.7	Penobscot	17275	17237	17275	17237	
4147380		Lowell, Mass.			Merrimack					
425	0	231.5	83.6	506.2	Merrimack	12005	11239	12005	11239	
4147460		Thompsonville, Conn.			Connecticut					
426	0	470.1	170.3	1234.0	Connecticut	25022	22383	25022	22383	
4147500		Green Island, N.Y.			Hudson					
427	0	388.9	144.9	856.2	Hudson	20953	24767	20953	24767	
4147600		Trenton, N.J.			Delaware					
428	0	333.6	95.6	979.0	Delaware	17560	16214	17560	16214	
4147700		Harrisburg, Pa.			Susquehanna					
429	0	974.1	221.8	3194.8	Susquehanna	62419	65000	62419	65000	
4147900		Washington, D.C.			Potomac					
430	0	312.7	66.3	1068.0	Potomac	29940	33598	29940	33598	
4148050		Richmond, Va.			James					
431	0	202.2	35.6	588.3	James	17503	17110	17503	17110	
4148090		Roanoke Rapids, N.C.			Roanoke					
432	0	223.4	78.3	550.5	Roanoke	21782	22259	21782	22259	
4148300		Pee Dee, S.C.			Pee Dee					
433	0	282.7	90.9	833.4	Pee Dee	22870	25164	22870	25164	
4148550		Pineville, S.C.			Santee					
434	0	66.7	13.4	328.4	Santee	38073	38004	38073	38004	
4148720		Doctortown, Ga.			Altamaha					
435	0	392.6	105.5	1156.2	Savannah	35224	35905	35224	35905	
4149120		Bogalusa, La.			Pearl					
436	0	282.2	61.9	895.4	Pearl	17172	18285	17172	18285	
4149300		Merrill, Miss.			Pascagoula					
437	0	285.3	56.9	957.8	GHAASBasin785	17094	15814	17094	15814	
4149400		Claiborne, Ala.			Alabama					
438	0	943.4	275.8	2574.6	Alabama	56895	54164	56895	54164	
4149630		Chattahoochee, Fla.			Apalachicola					
439	0	638.4	242.8	1647.9	Appalachicola	44548	44163	44548	44163	
4149780		Branford, Fla.			Suwannee					
440	0	217.6	64.2	512.0	Suwannee	20409	18569	20409	18569	
4150280		Mathis, Tex.			Nueces					
441	0	24.7	1.8	191.2	Nueces	43149	43269	43149	43269	
4150500		Richmond, Tex.			Brazos					
442	0	199.4	23.8	679.9	Colorado (Texas)	116568	118467	116568	118467	
4150600		Romaylor, Tex.			Trinity					
443	0	206.1	18.4	717.7	Trinity	44512	47549	44512	47549	
4150680		Evadale, Tex.			Neches					
444	0	146.2	20.6	432.8	Neches	20593	21196	20593	21196	
4150700		Rulif, Tex.			Sabine					
445	0	207.4	27.9	565.2	Sabine	24162	23585	24162	23585	
4151800		Laredo, Tex.			Rio Grande					
446	0	114.8	8.6	542.3	Rio Grande (US)	352178	566451	352178	566451	
4152100		Yuma, Ariz.			Colorado					
447	0	20.5	13.0	29.2	Colorado (Ari)	629100	608155	339538	324612	
4152450		Lees Ferry, Ariz.			Colorado					
448	447	463.7	40.2	1315.9	Colorado (Ari)	289562	283543	184408	180698	
4152550		Green River, Utah			Green					
449	448	177.0	68.4	364.5	Colorado (Ari)	105154	102845	105154	102845	
4203050		Old Crow			Porcupine River					
450	389	319.4	78.8	610.7	Yukon	55400	54958	55400	54958	
4203150		Mayo			Stewart River					
451	452	382.2	187.4	653.0	Yukon	31598	34470	31598	34470	
4203200		Dawson			Yukon River					
452	391	2160.0	1573.7	2874.3	Yukon	264000	264496	82441	86300	
4203250		above White River			Yukon River					
453	452	1186.5	723.4	1865.2	Yukon	149961	143725	39840	36506	
4203500		Pelly Crossing			Pelly River					
454	453	370.5	188.2	576.1	Yukon	49000	47306	49000	47306	
4203770		near Teslin			Teslin River					
455	453	302.7	143.1	503.3	Yukon	30300	30724	30300	30724	

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4203900		above Frank Creek			Yukon River					
456	453	316.4	205.9	444.4	Yukon	30821	29190	30821	29190	
4204050		above Butterfly Creek			Stikine					
457	459	631.0	414.8	917.3	Stikine	36000	34503	6700	6598	
4204100		Telegraph Creek			Stikine					
458	457	396.8	241.2	621.8	Stikine	29300	27905	29300	27905	
4204900		near Wrangell			Stikine					
459	0	1603.9	1055.0	2514.4	Stikine	51593	51316	15593	16813	
4205600		near Tulsequah			Taku					
460	0	264.8	153.8	452.9	Taku	15500	16106	15500	16106	
4206100		above Shumal Creek			Nass					
461	0	774.8	461.2	1420.5	Nass	19200	20608	19200	20608	
4206250		Usk			Seena					
462	0	900.3	487.4	1846.8	GHA ASBasin261	42200	40322	42200	40322	
4207150		near Fort St. James			Stuart River					
463	465	132.2	70.5	234.6	Fraser	14600	12378	14600	12378	
4207305		below Big Creek			Chilcotin					
464	467	97.0	66.5	147.9	Fraser	19300	19138	19300	19138	
4207310		Marguerite			Fraser River					
465	467	1477.6	834.9	2387.3	Fraser	114000	111710	99400	99332	
4207830		McLure			North Thompson					
466	467	433.5	263.9	685.8	Fraser	19600	19621	19600	19621	
4207900		Hope			Fraser River					
467	0	2718.1	1594.0	4739.2	Fraser	217000	229432	64100	78964	
4208025		Arctic Red River			Mackenzie River					
468	0	9118.7	6289.6	12594.8	Mackenzie	1660000	1678481	90000	108883	
4208150		Norman Wells			Mackenzie River					
469	468	8324.0	6025.0	11162.2	Mackenzie	1570000	1569598	344600	346739	
4208220		above Clausen Creek			South Nahanni River					
470	469	408.2	266.6	915.9	Mackenzie	33400	33223	33400	33223	
4208270		Lower Crossing			Liard River					
471	472	1144.0	662.1	1831.8	Mackenzie	104000	103458	104000	103458	
4208280		Fort Liard			Liard River					
472	469	1878.5	1184.4	3034.9	Mackenzie	222000	219420	118000	115962	
4208300		near Fort Providence			Mackenzie River					
473	469	4384.6	3233.1	5647.5	Mackenzie	970000	970216	364000	359594	
4208400		Fitzgerald			Slave River					
474	473	3409.1	1969.7	5412.5	Mackenzie	606000	610621	180000	174941	
4208450		Peace Point			Peace River					
475	474	1934.9	840.8	3454.8	Mackenzie	293000	294429	107000	99959	
4208550		Hudson Hope			Peace River					
476	477	1071.1	146.2	2353.3	Mackenzie	70200	72214	70200	72214	
4208630		Peace River			Peace River					
477	475	1763.8	676.6	3700.0	Mackenzie	186000	194470	65500	72171	
4208640		Watino			Smoky River					
478	477	354.2	159.9	754.4	Mackenzie	50300	50085	50300	50085	
4208730		below McMurray			Athabasca River					
479	474	668.7	396.8	1071.3	Mackenzie	133000	141252	58400	63403	
4208870		Athabasca			Athabasca River					
480	479	437.8	230.0	929.3	Mackenzie	74600	77848	74600	77848	
4209400		Point Lake Outlet			Coppermine River					
481	0	106.4	56.1	173.8	Coppermine	19300	19779	19300	19779	
4209600		near The mouth			Ellice River					
482	0	82.6	19.5	171.3	Ellice	16900	18378	16900	18378	
4209805		above Hermann River			Back					
483	0	488.2	204.0	969.2	Back	93900	93513	93900	93513	
4213250		Medicine Hat			South Saskatchewan					
484	487	199.6	40.8	629.9	Nelson	56500	55199	56500	55199	
4213290		near Unwin			Battle					
485	488	8.8	0.7	49.1	Nelson	25900	26239	25900	26239	
4213300		near Deer Creek			North Saskatchewan					
486	488	208.6	124.8	396.2	Nelson	57000	55614	57000	55614	
4213400		Saskatoon			South Saskatchewan					
487	490	263.3	37.2	880.4	Nelson	141000	140246	84500	85047	
4213440		Prince Albert			North Saskatchewan					
488	490	242.6	88.0	732.4	Nelson	131000	130413	48100	48561	
4213510		Turnberry			Carrot River					
489	490	18.0	3.8	48.8	Nelson	12600	10793	12600	10793	
4213550		The Pas			Saskatchewan River					
490	496	591.1	303.2	1046.8	Nelson	347000	334978	62400	53527	

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

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4243410	526	Centrale de Chute-A-La-Savane	634.1	390.8	936.9	Peribonca St. Lawrence	26900	25443	26900	25443
4243600	527	Centrale de Chute-Aux-Outardes	0	391.1	252.2	Aux Outardes St. Lawrence	18900	19556	18900	19556
4243610	528	Centrale McCormick	868.6	315.6	1667.4	Manicouagan St. Lawrence	45800	46157	45800	46157
4243800	529	above Qnslr Bridge	0	457.9	252.5	Moisie Moisie	19000	17266	19000	17266
4244050	530	en amont de la Riviere Hamelin	0	345.8	194.4	Arnaud Arnaud	26900	31144	26900	31144
4244100	531	en aval de la Riviere Paladeau	0	623.4	290.2	Aux Feuilles Aux Feuilles	41700	40871	41700	40871
4244150	532	pres de la Riviere Koksoak	0	628.9	243.3	Aux Melezes Koksoak	42700	42729	42700	42729
4244180	533	Chute de la Pyrite	0	1584.7	576.7	Caniapiscau Koksoak	86800	85199	86800	85199
4244200	534	pres de L'embouchure	0	535.3	203.2	A la Baleine A la Baleine	29800	29037	29800	29037
4244250	535	Aux Chutes Helen	0	746.4	411.8	George George	35200	37461	35200	37461
4244500	536	above Upper Muskrat Falls	0	1861.3	893.8	Churchill River Churchill (Atlantic)	92500	99457	92500	99457
4244640	537	pres de L'embouchure	0	348.5	195.7	Natashquan Natashquan	16000	19137	16000	19137
4244660	538	en amont de la Riviere Netagamiou	0	490.8	234.8	du Petit Mecatina Petit Mecatina	19100	20753	19100	20753
4356100	539	el Capomal	0	290.7	107.0	Santiago Grande de Santiago	128943	189027	128943	189027
4358300	540	Las Adjuntas	0	481.0	166.7	Panuco Panuco	58115	86315	58115	86315
4362600	541	Boca del Cerro	0	1646.4	163.1	Usumacinta Usumacinta	50743	50458	50743	50458
5101200	542	Clare	0	329.6	2.8	Burdekin Burdekin	129660	121214	129660	121214
5101301	543	The Gap	0	163.0	0.1	Fitzroy Fitzroy East	135860	135648	135860	135648
5109170	544	Rockfields	0	43.7	0.4	Gilbert River Gilbert	11800	11682	11800	11682
5109200	545	Koolatah	0	385.2	17.4	Mitchell River GHAASBasin387	46050	29210	46050	29210
5202044	546	Lilydale (Newbold Crossing)	0	117.2	1.9	Clarence River GHAASBasin674	16690	18932	16690	18932
5202101	547	Belmore Bridge (Maitland)	0	31.6	0.6	Hunter River GHAASBasin930	17476	13129	17476	13129
5204268	548	Lock 9 Upper	0	256.9	22.2	Murray Murray	991000	972414	394700	972414
5224500	549	Temerloh	0	551.8	219.9	Pahang Pahang	19000	21579	19000	21579
5302229	550	Jarramond	0	51.6	3.5	Snowy River GHAASBasin960	13421	12352	13421	12352
5410100	551	Callamurra	0	61.0	0.0	Cooper Creek Great Artesian Basin	230000	232556	230000	232556
5606100	552	Darradup	0	20.2	2.7	Blackwood River GHAASBasin632	20500	20622	20500	20622
5607100	553	Emu Springs	0	5.1	0.0	Murchison River Murchinson	82300	71730	82300	71730
5607200	554	Nune Mile Bridge	0	21.8	0.0	Gascoyne River Gascoyne	73400	78453	73400	78453
5607400	555	Nanutarra	0	18.5	0.0	Ashburton River Ashburton	70200	76444	70200	76444
5607450	556	Jimbegnyinoo Pool	0	7.7	0.0	Fortescue River Fortesque	48900	57023	48900	57023
5608023	557	Dimond Gorge	558	70.8	1.2	Fitzroy River Fitzroy West	16800	20525	16800	20525
5608024	558	Fitzroy Crossing	0	188.2	0.0	Fitzroy Fitzroy West	45300	50014	28500	29489
5608095	559	Old Ord Homestead	0	51.9	0.0	Ord Ord	19600	14704	19600	14704
5708110	560	Coolibah Homestead	0	97.2	1.3	Victoria River Victoria	44900	55926	44900	55926

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

GRDC Code	Station Name				RiverName	Area [km ²]		Inter-Stn Area [km ²]				
	Next ID	Station	Mean	Discharge m ³ /s Min	Max	STN	Basin Name	GRDC	STN-30p	GRDC	STN-30p	
6348800	Pontelagoscuro				Po				70091	78362	28061	30524
596	0	1514.6	505.8	3745.0	Po							
6421500	Borgharen				Maas				21300	27899	21300	27899
597	0	246.1	34.2	714.4	Meuse							
6442500	Nagymaros				Danube(Duna)				183533	182903	52195	51417
598	599	2346.0	1093.6	4929.4	Danube							
6442600	Mohacs				Danube				209064	206123	25531	23220
599	619	2401.3	1096.2	4588.8	Danube							
6444100	Szeged				Tisza				138408	142313	33146	42144
600	619	829.3	200.2	2446.7	Danube							
6444110	Mako				Maros				30149	29946	30149	29946
601	600	168.8	0.9	508.1	Danube							
6444200	Szolnok				Tisza				75113	70223	59830	55834
602	600	595.9	180.4	1376.6	Danube							
6444600	Csenger				Szamos				15283	14389	15283	14389
603	602	124.2	28.8	410.6	Danube							
6457010	Gozdowice				Odra				109729	110663	56347	52021
604	0	546.6	201.6	2853.2	Odra							
6457100	Slubice				Odra				53382	58642	53382	58642
605	604	351.8	116.0	2319.1	Odra							
6458010	Tczew				Wisla				194376	180583	48538	46752
606	0	1041.7	345.6	2954.7	Wisla							
6458450	Szczucin				Wisla				23901	27797	23901	27797
607	608	248.1	21.6	2225.8	Wisla							
6458500	Warszawa				Wisla				84857	72881	44253	31124
608	606	561.2	168.3	1515.0	Wisla							
6458550	Wyszkow				Bug				39119	40627	39119	40627
609	606	145.8	35.2	555.0	Wisla							
6458600	Radomysl				San				16703	13960	16703	13960
610	608	132.7	30.9	453.1	Wisla							
6458810	Ostroleka				Narew				21862	20323	21862	20323
611	606	110.9	42.6	309.8	Wisla							
6545800	Sremska Mitrovica				Sava				87966	85461	87966	85461
612	619	1609.1	524.9	3655.0	Danube							
6546610	Gornja Radgona				Mura				10197	10512	10197	10512
613	619	155.6	78.5	315.2	Danube							
6547500	Lubicevsky Most				Velika Morava				34345	31465	34345	31465
614	619	240.3	55.4	663.5	Danube							
6691650	Misis				Ceyhan				20466	24391	20466	24391
615	0	222.4	85.6	454.4	Seyhan							
6695200	Keban				Firat(Euphrates)				63835	64684	63835	64684
616	0	663.3	295.4	1341.2	Shatt el Arab							
6730500	Polmak				Tana				14005	14035	14005	14035
617	0	165.7	59.5	408.9	GHAASBasin895							
6731400	Langnes				Gloma				40221	42784	40221	42784
618	0	672.1	274.8	1494.4	Glama							
6742200	Orsova (1971:drobata-Turnu Severin)				Danube				576232	570835	96252	94961
619	623	5456.5	2424.2	10986.7	Danube							
6742450	Stoenesti				Olt				22683	19470	22683	19470
620	623	161.3	58.8	365.4	Danube							
6742700	Lungoci				Siret				36036	37530	36036	37530
621	622	171.6	58.3	529.1	Danube							
6742900	Ceatal Izmail				Danube				807000	788002	120624	99899
622	0	6488.3	2845.6	11631.6	Danube							
6842700	Svistov				Danube				650340	650574	51425	60268
623	622	6152.2	2709.2	10640.0	Danube							
6854100	Kalsinkosi				Kokemjenjoki				26025	26312	26025	26312
624	0	219.9	58.7	556.0	Kokemaenjoki							
6854500	near The mouth				Oulujoiki				22900	21244	22900	21244
625	0	255.0	100.0	454.1	Oulujoiki							
6854600	near The mouth				Siurnanjoki				14315	25491	14315	25491
626	0	171.0	55.2	398.7	Oulujoiki							
6854700	near The mouth				Kenijoki				50900	50179	50900	50179
627	0	562.1	240.5	1264.2	Kemijoki							
628	0	280.3	81.4	598.1	Kymijoki				36305	35932	36305	35932
629	644	592.7	243.0	1079.9	Vuoksi				61061	60690	61061	60690
6865500	Tainionkoski				Neva							
630	0	113.3	20.2	272.0	Evros				19693	18360	19693	18360

GRDC Code	Station Name				RiverName STN Basin Name	Area [km ²]		Inter-Stn Area [km ²]	
	ID	Station	Next	Discharge [m ³ /s]		GRDC	STN-30p	GRDC	STN-30p
			Mean	Min					
6935050	Basel(St. Alban)				Rhein				
631	587	1106.1	619.5	1749.8	Rhine	35929	35691	18304	16826
6935300	Untersiggenthal				Aare				
632	631	558.1	296.2	977.2	Rhine	17625	18865	17625	18865
6939050	Chancy				Rhone				
633	571	341.6	177.5	536.8	Rhone	10299	10688	10299	10688
6970100	Porog				Onega				
634	0	513.1	235.5	1026.6	Onega	55770	56600	55770	56600
6970250	Ust-Pinega				Severnaya Dvina				
635	0	3331.5	1178.8	7920.8	Dvina	348000	357844	271600	289297
6970270	Filaievskaya				Vaga				
636	635	110.8	31.4	295.7	Dvina	13200	13523	13200	13523
6970400	Kulogory				Pinega				
637	635	367.8	217.2	722.9	Dvina	36700	30246	36700	30246
6970500	Malonisogorskaya				Mezen				
638	0	649.3	279.3	1365.2	Mezen	56400	56522	56400	56522
6970650	Ust-Tsilma				Pechora				
639	641	3404.8	1197.5	6981.2	Pechora	248000	233553	193300	184523
6970680	Malaya Kushba				Vytchegda				
640	635	258.1	110.2	572.2	Dvina	26500	24778	26500	24778
6970710	Oksino				Pechora				
641	0	4515.1	2367.0	7272.1	Pechora	312000	301599	64000	68045
6970850	Adzva				Usa				
642	639	993.2	356.7	2029.0	Pechora	54700	49031	54700	49031
6972350	Narva (Hep)				Narva				
643	0	379.2	187.2	754.9	Narva	56000	58230	56000	58230
6972430	Novosaratovka				Neva				
644	0	2504.1	1290.5	3764.2	Neva	281000	279904	219939	219214
6972800	Yushkozero				Kem				
645	0	198.5	105.8	347.8	Kem	19800	22391	19800	22391
6972810	Putkinskaya Ges				Kem				
646	0	297.5	166.0	494.0	GHAASBasin509	27700	26001	27700	26001
6973300	Daugavpils				Western Dvina (Daugava)				
647	0	390.8	191.4	850.8	Daugava	64500	62897	64500	62897
6974150	Smalininkai				Neman				
648	0	538.3	222.6	1536.8	Nemanus	81200	79440	81200	79440
6975080	Staritsa				Volga				
649	654	153.7	38.4	494.3	Volga	21100	22347	21100	22347
6975140	Kaluga				Oka				
650	654	292.1	73.7	972.5	Volga	54900	51003	54900	51003
6975500	Makariev				Unzha				
651	654	168.7	41.1	462.8	Volga	18500	17640	18500	17640
6976200	Kirov				Viatka				
652	654	373.6	105.9	829.5	Volga	48300	52825	48300	52825
6976450	Ufa				Belaya				
653	654	338.7	9.5	1449.1	Volga	100000	108083	100000	108083
6977100	Volgograd Power Plant				Volga				
654	0	8087.1	3146.7	16125.0	Volga	1360000	1348501	1117200	1096604
6978250	Razdorskaya				Don				
655	0	790.3	185.4	2657.7	Don	378000	391664	344300	364451
6978500	Archedinskaya				Medveditsa				
656	655	51.8	15.5	134.8	Don	33700	27213	33700	27213
6979500	Mozyr				Pripyat				
657	660	454.9	161.7	1209.2	Dnepr	101000	116685	101000	116685
6979600	Chernigov				Desna				
658	660	321.1	87.3	1086.4	Dnepr	81400	84721	81400	84721
6980300	Aleksandrovka				Southern Bug				
659	0	110.3	40.1	284.2	Bug	46200	46326	46200	46326
6980800	Dniepr Power Plant				Dniepr				
660	0	1483.7	479.5	3211.7	Dnepr	463000	463075	280600	261670
6981800	Bendery				Dniestr				
661	0	376.6	143.8	823.9	Dnestr	66100	67739	66100	67739
6983350	Tikhovsky				Kuban				
662	0	317.2	141.6	638.7	Kuban	48100	50794	48100	50794
6990700	Surra				Kura				
663	0	550.9	204.7	1173.3	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`, `wmb_ro##.grd` and `cmp_ro##.grd`). The format of ARC/INFO grid is the same as described 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
```

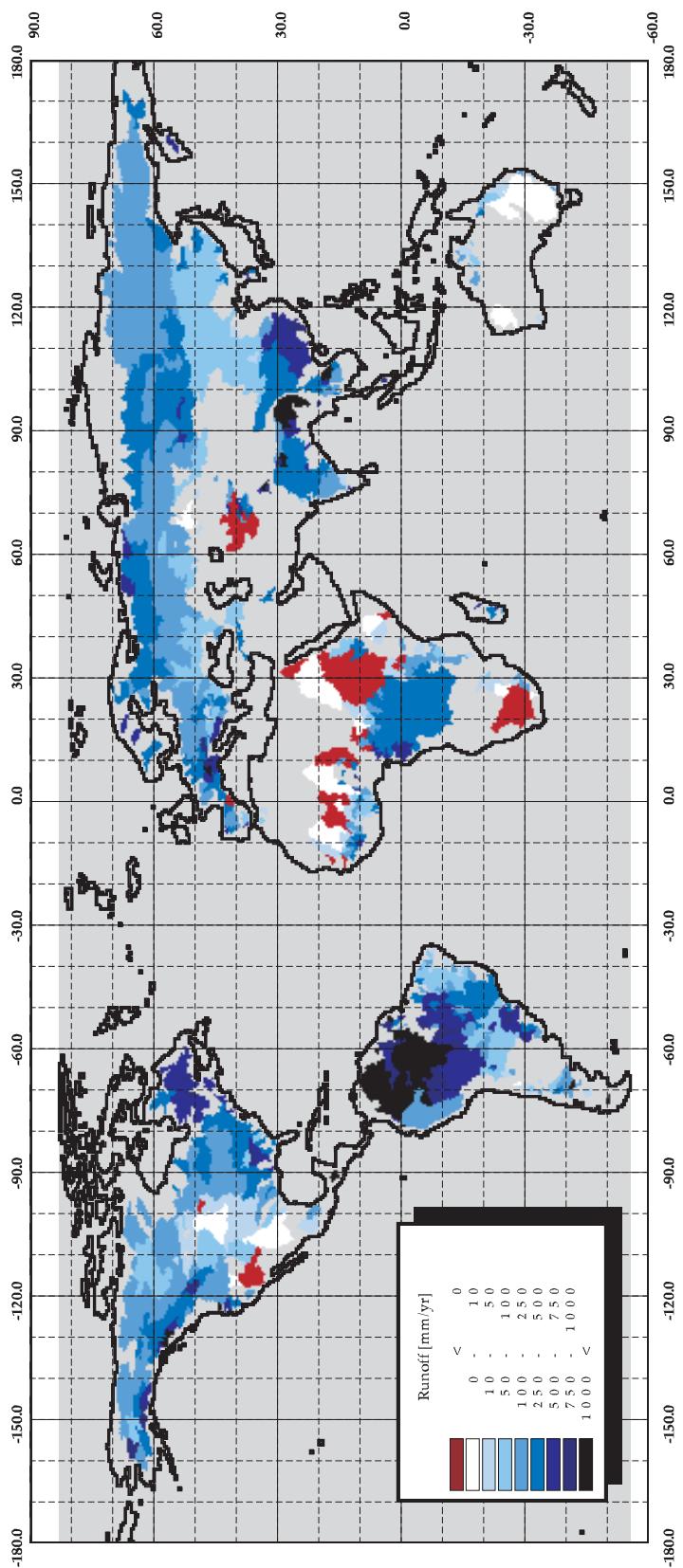
ncols	-	number of columns
nrows	-	number of rows
xllcorner	-	horizontal coordinate of the lower left corner
yllcorner	-	vertical coordinate of the lower left corner
cellsize	-	cell size
NODATA	-	missing data value

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

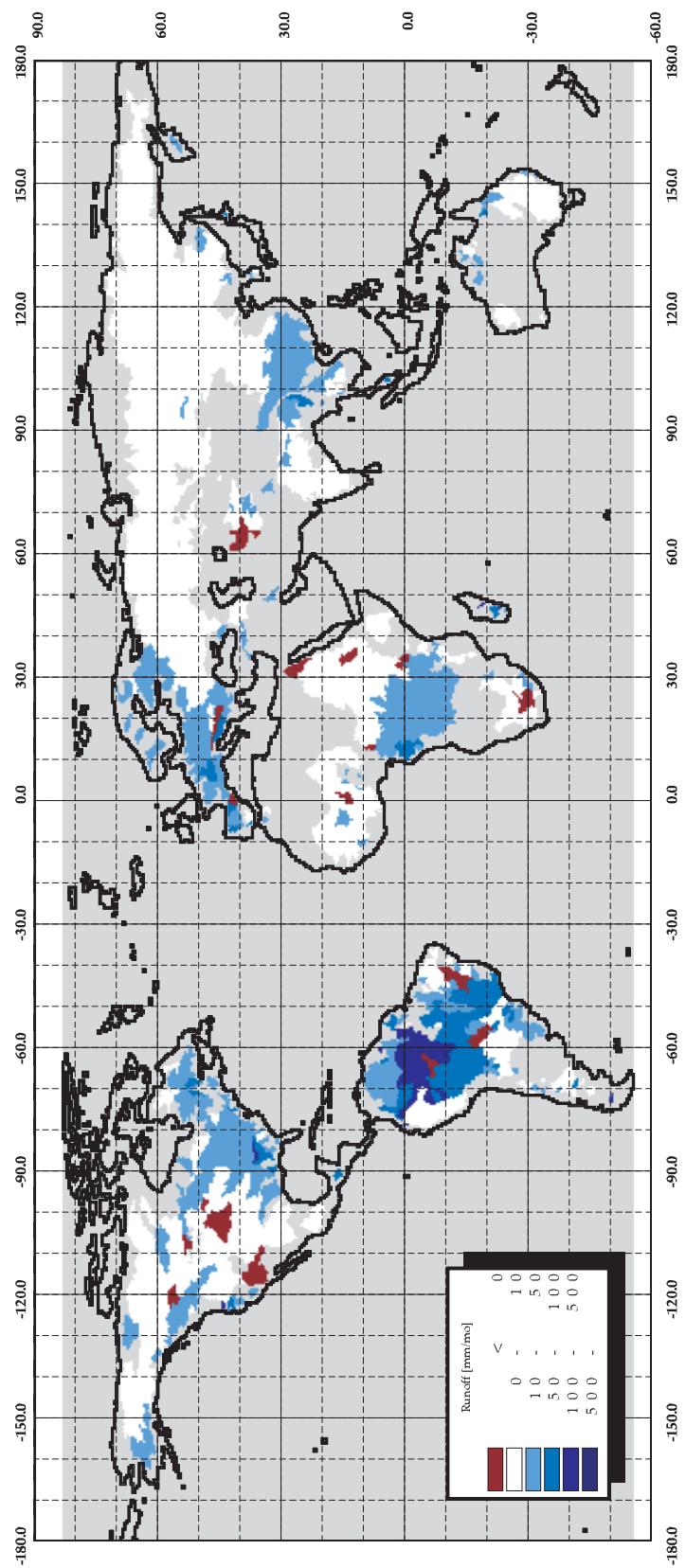
GRDC Observed Mean Annual Runoff

30-minute spatial resolution



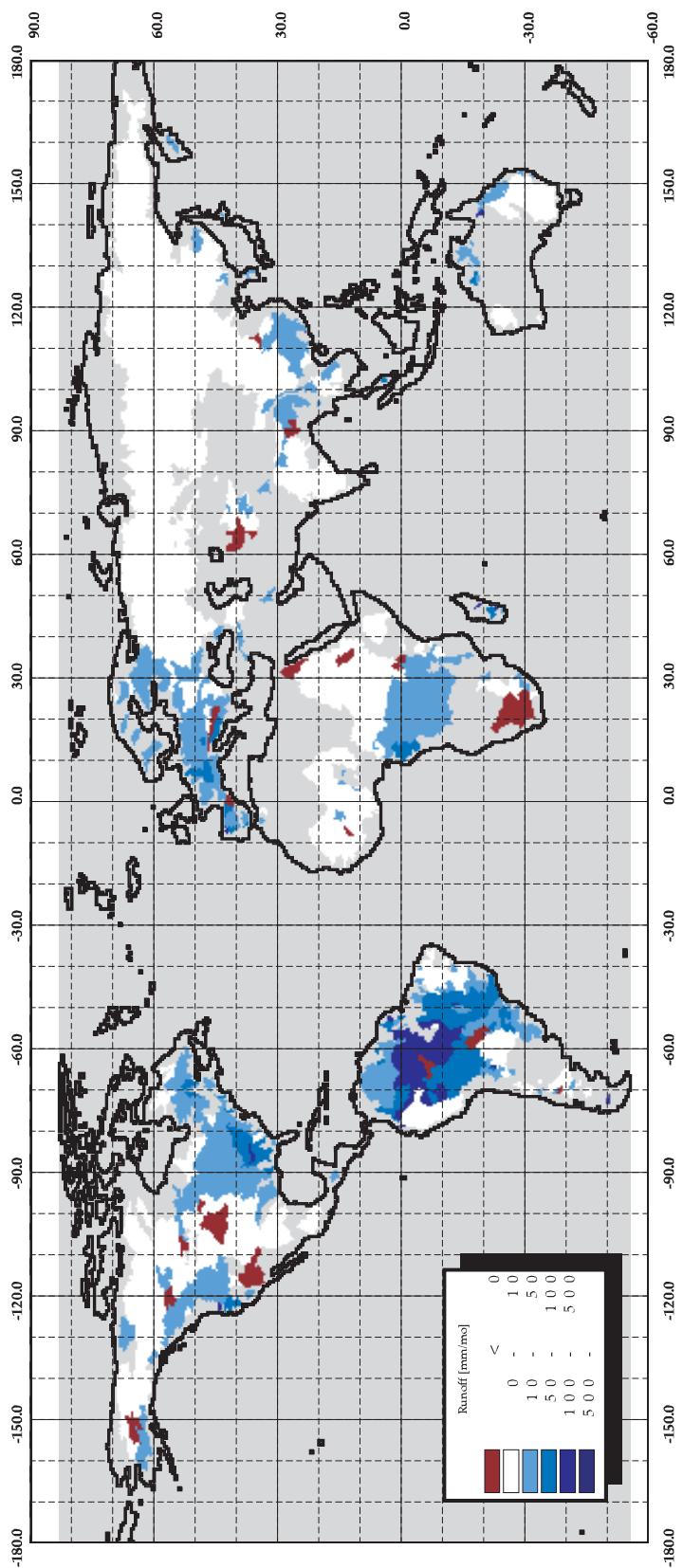
GRDC-Observed January Runoff

30-minute spatial resolution



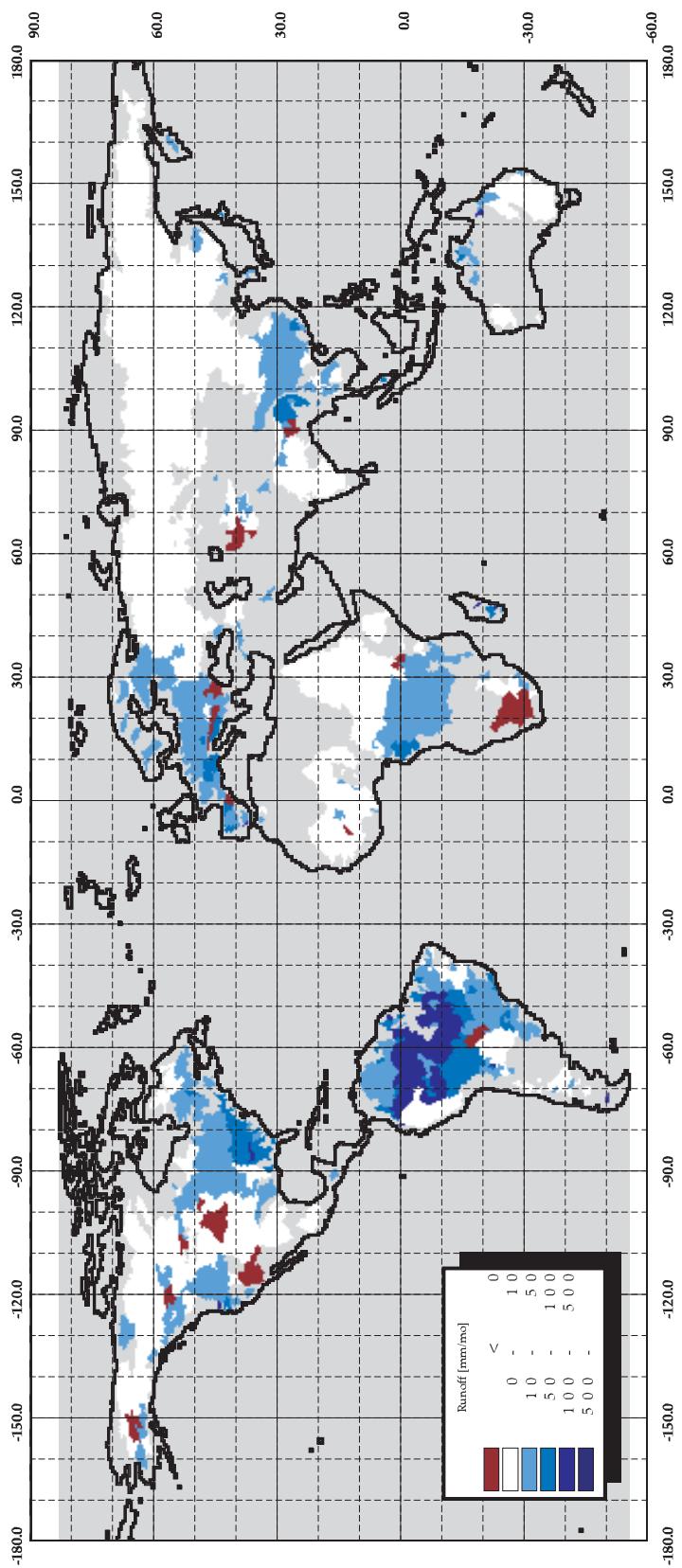
GRDC-Observed February Runoff

30-minute spatial resolution



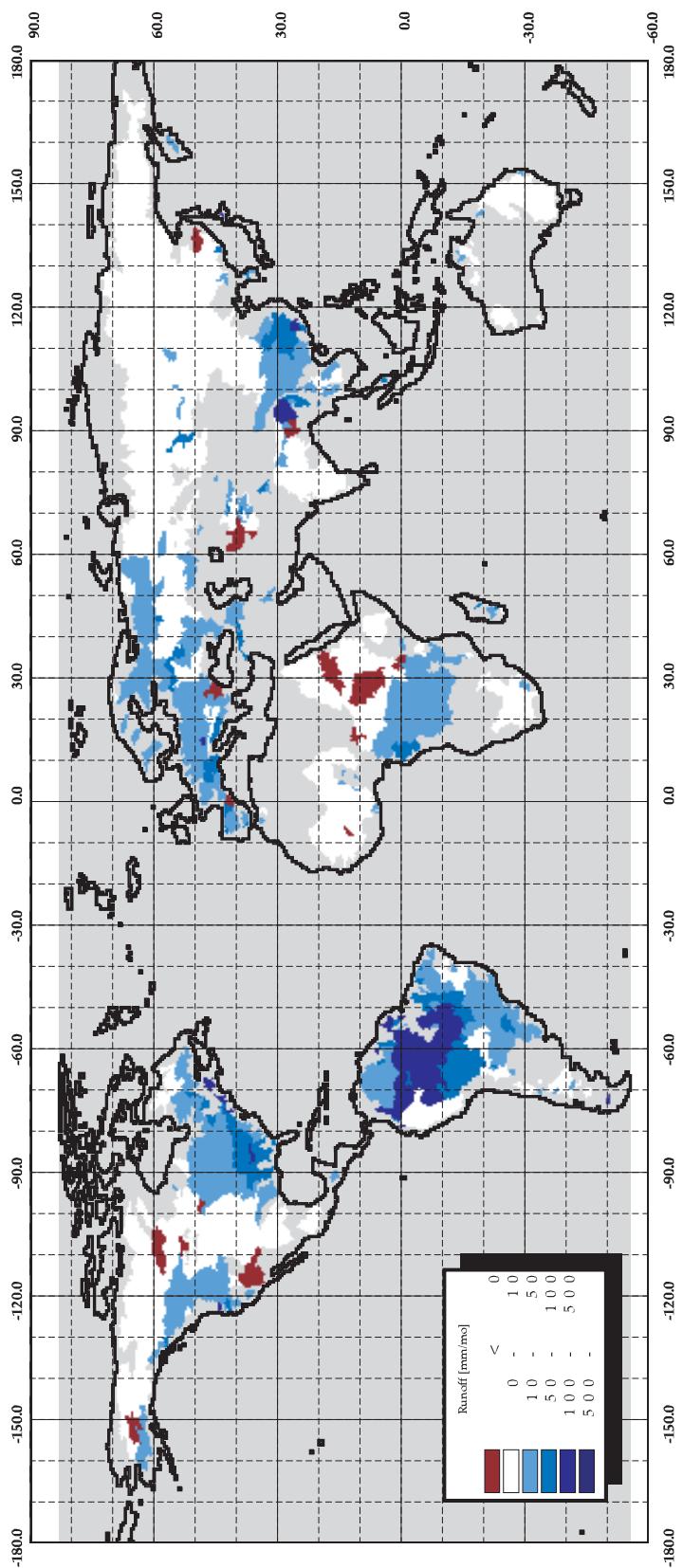
GRDC-Observed March Runoff

30-minute spatial resolution



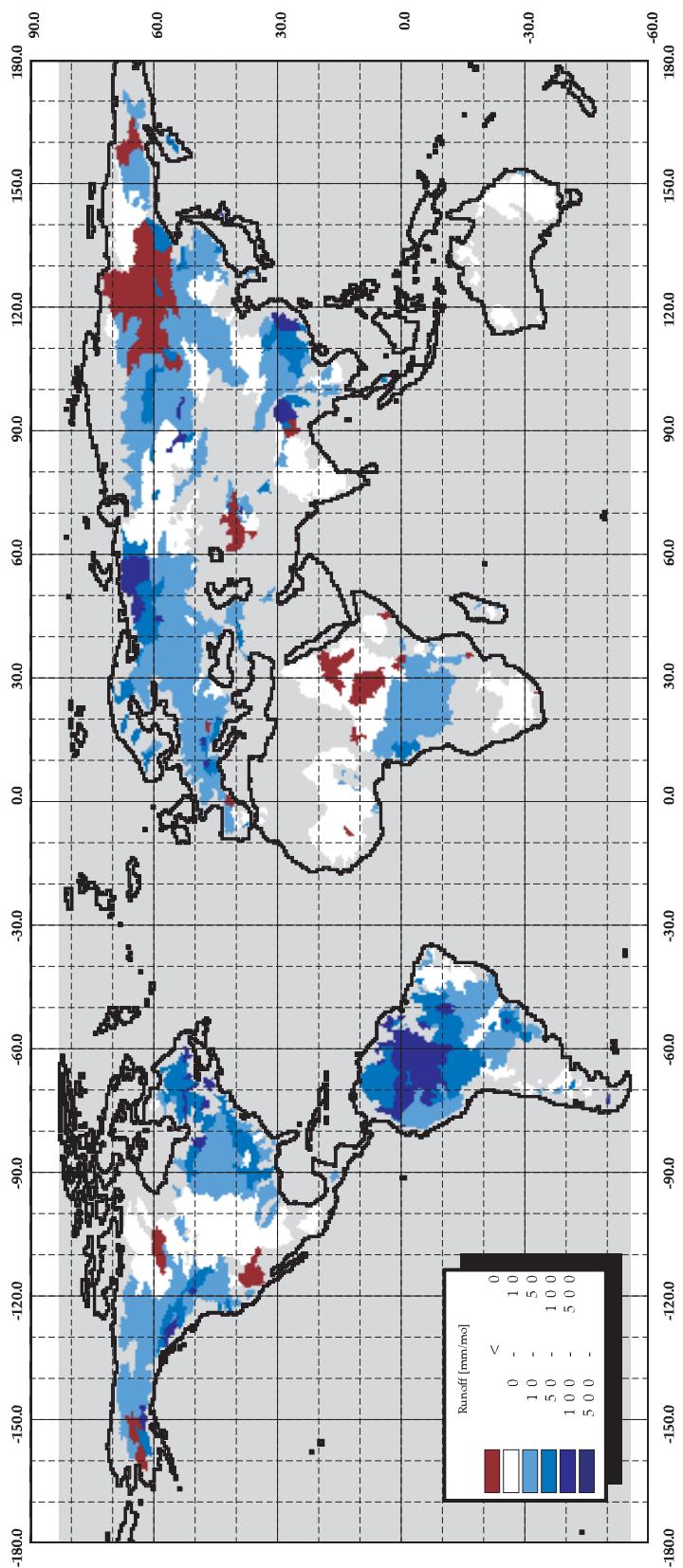
GRDC-Observed April Runoff

30-minute spatial resolution



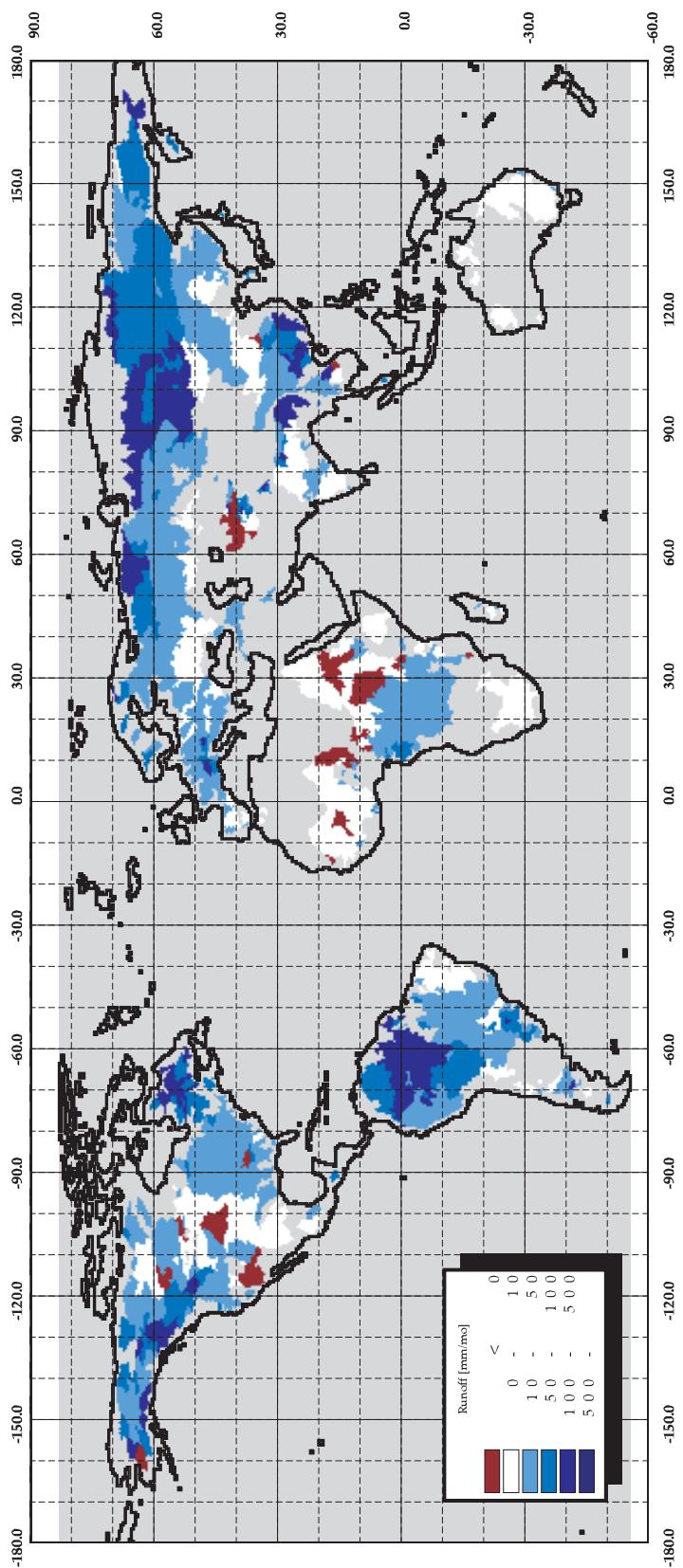
GRDC-Observed May Runoff

30-minute spatial resolution



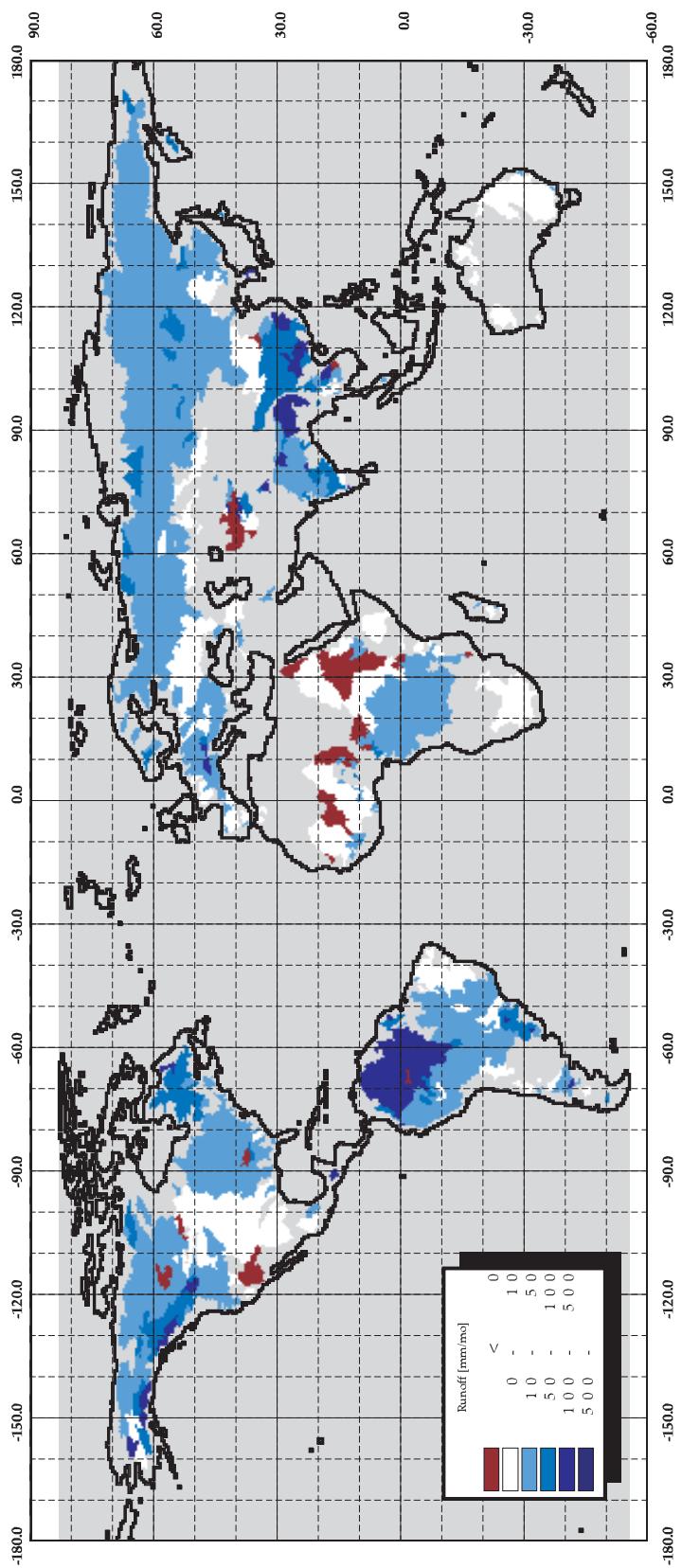
GRDC-Observed June Runoff

30-minute spatial resolution



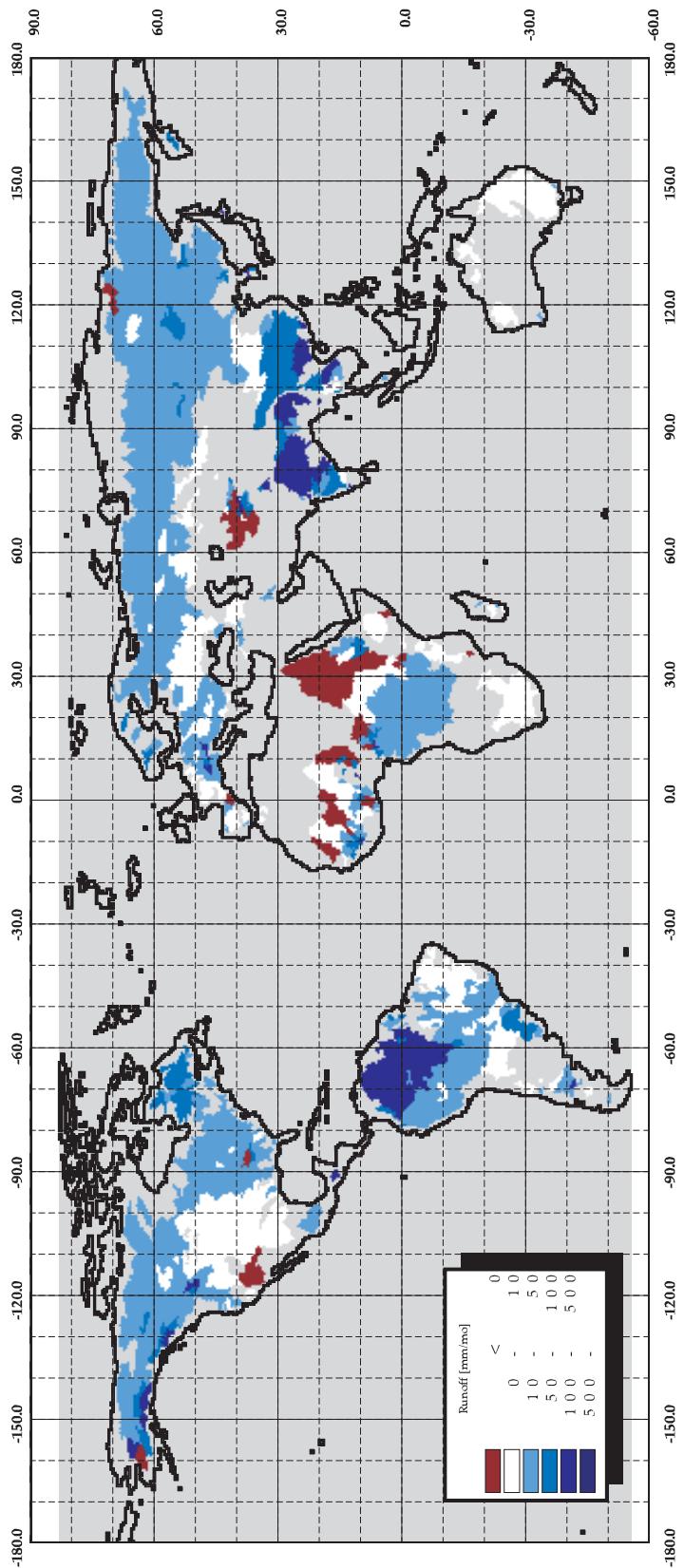
GRDC-Observed July Runoff

30-minute spatial resolution



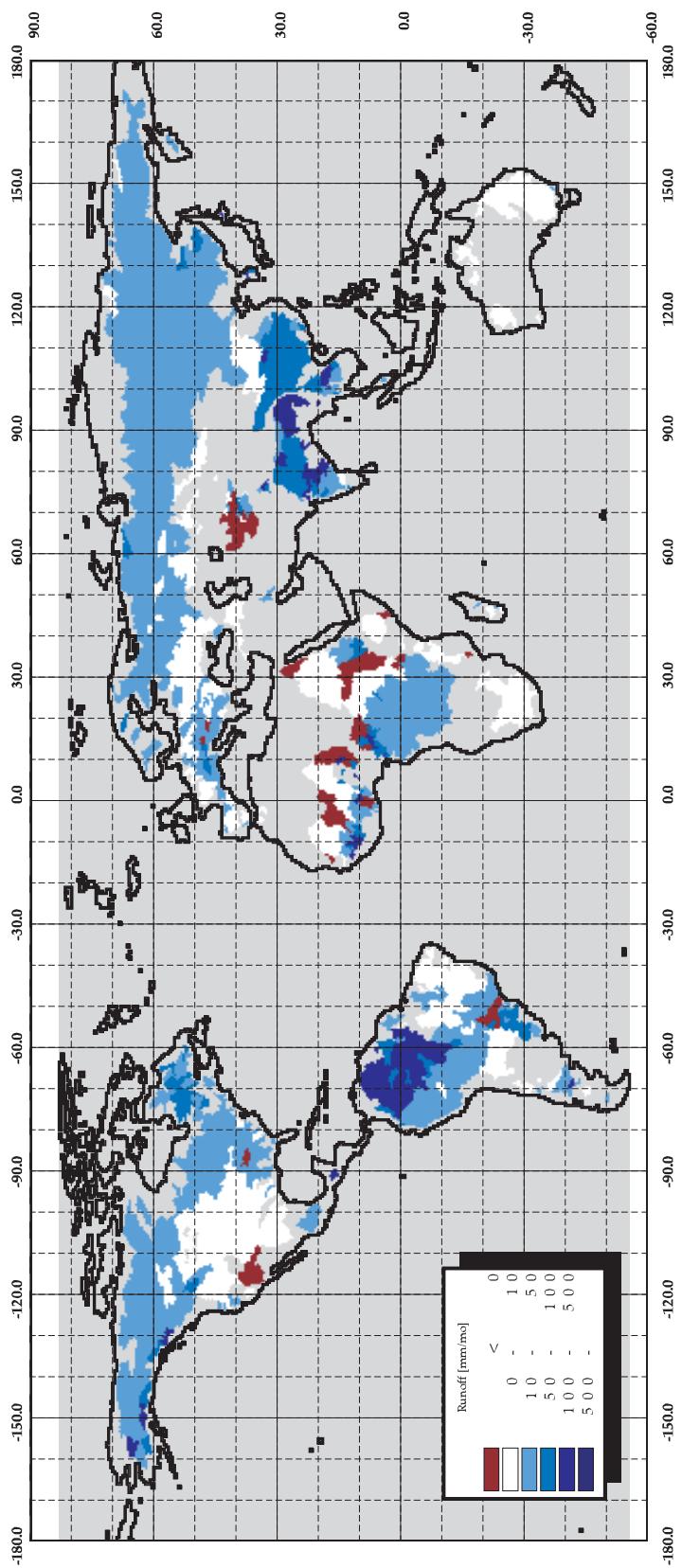
GRDC-Observed August Runoff

30-minute spatial resolution



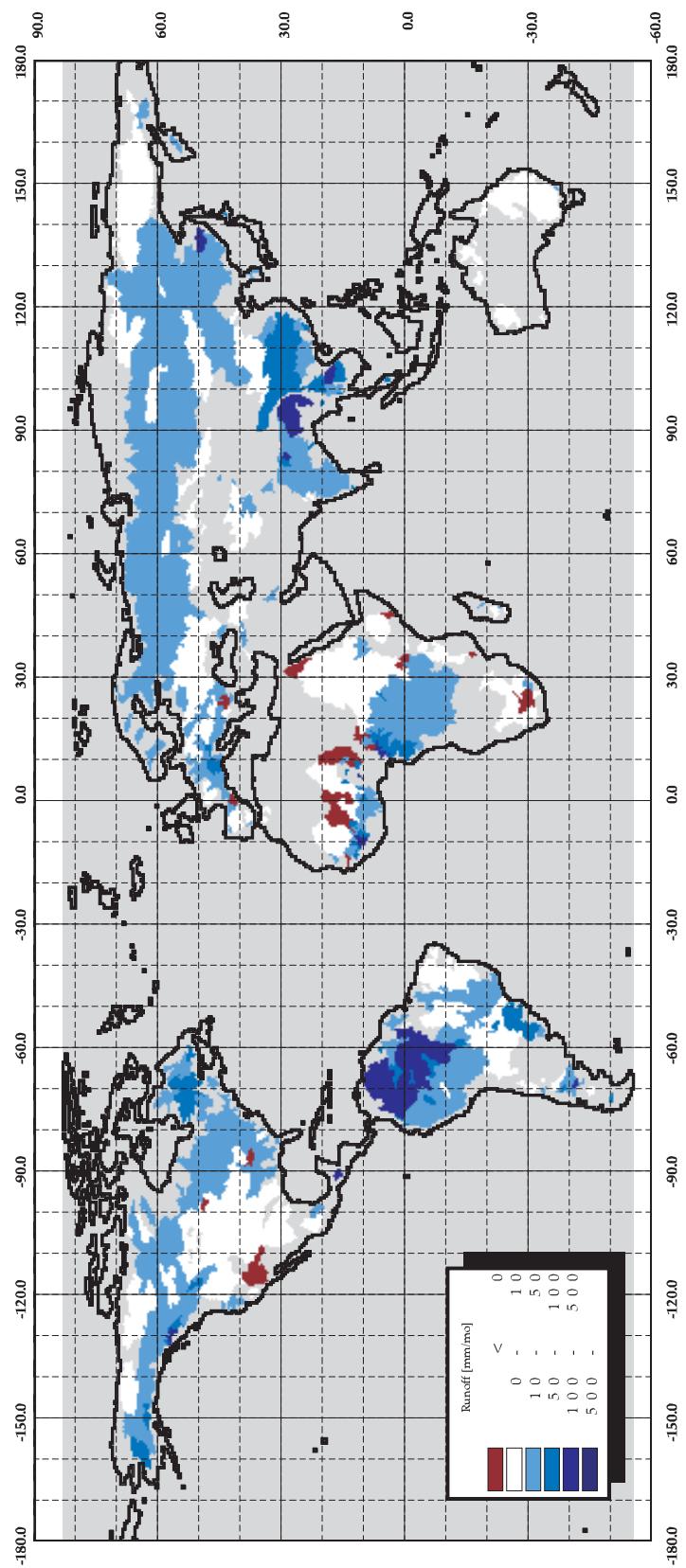
GRDC-Observed September Runoff

30-minute spatial resolution



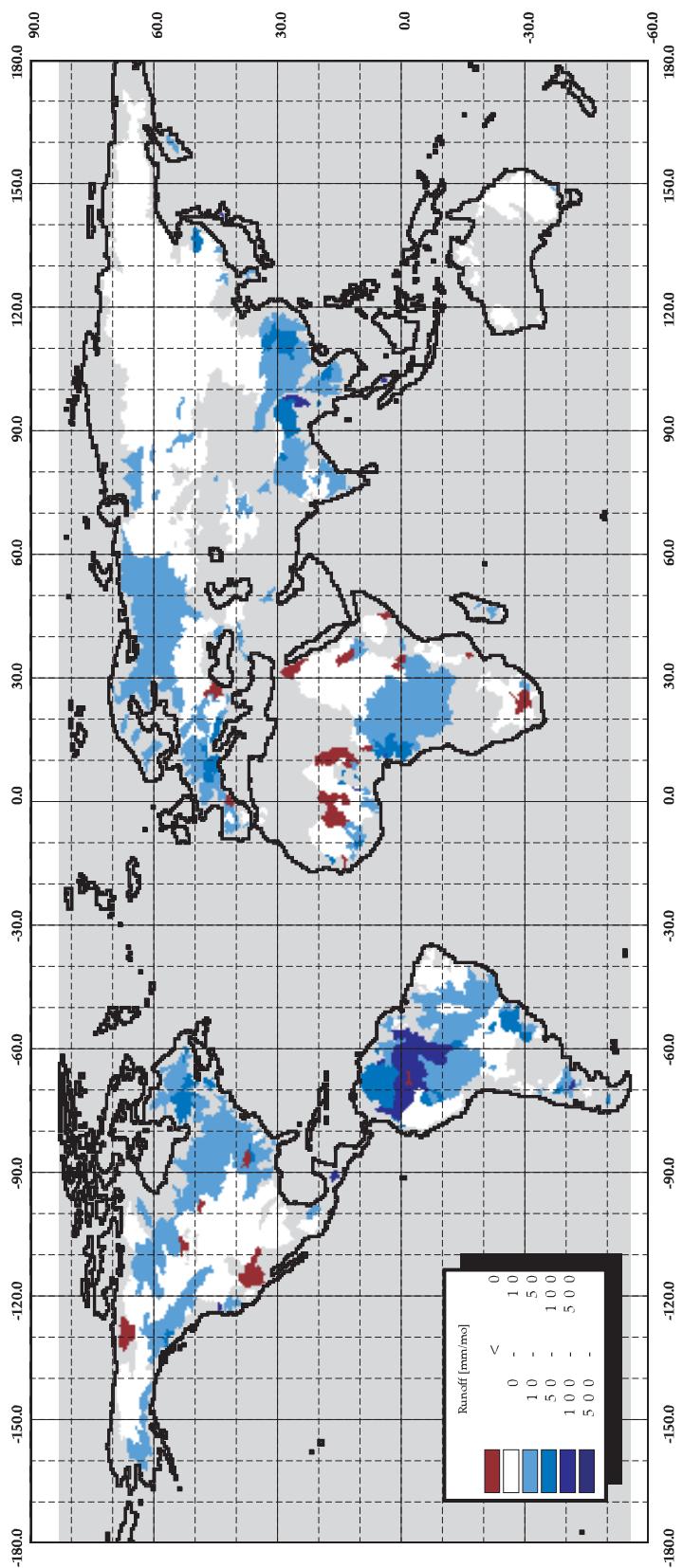
GRDC-Observed October Runoff

30-minute spatial resolution



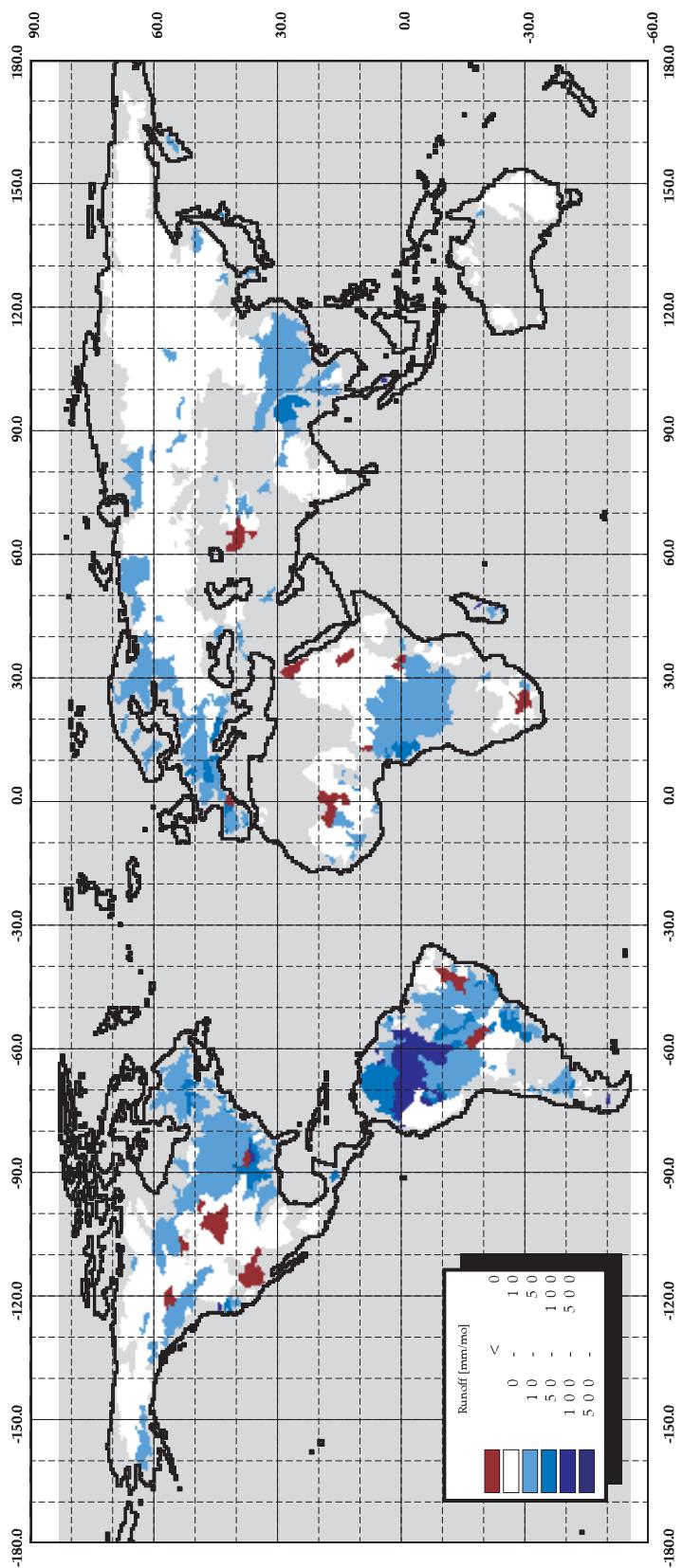
GRDC-Observed November Runoff

30-minute spatial resolution



GRDC-Observed December Runoff

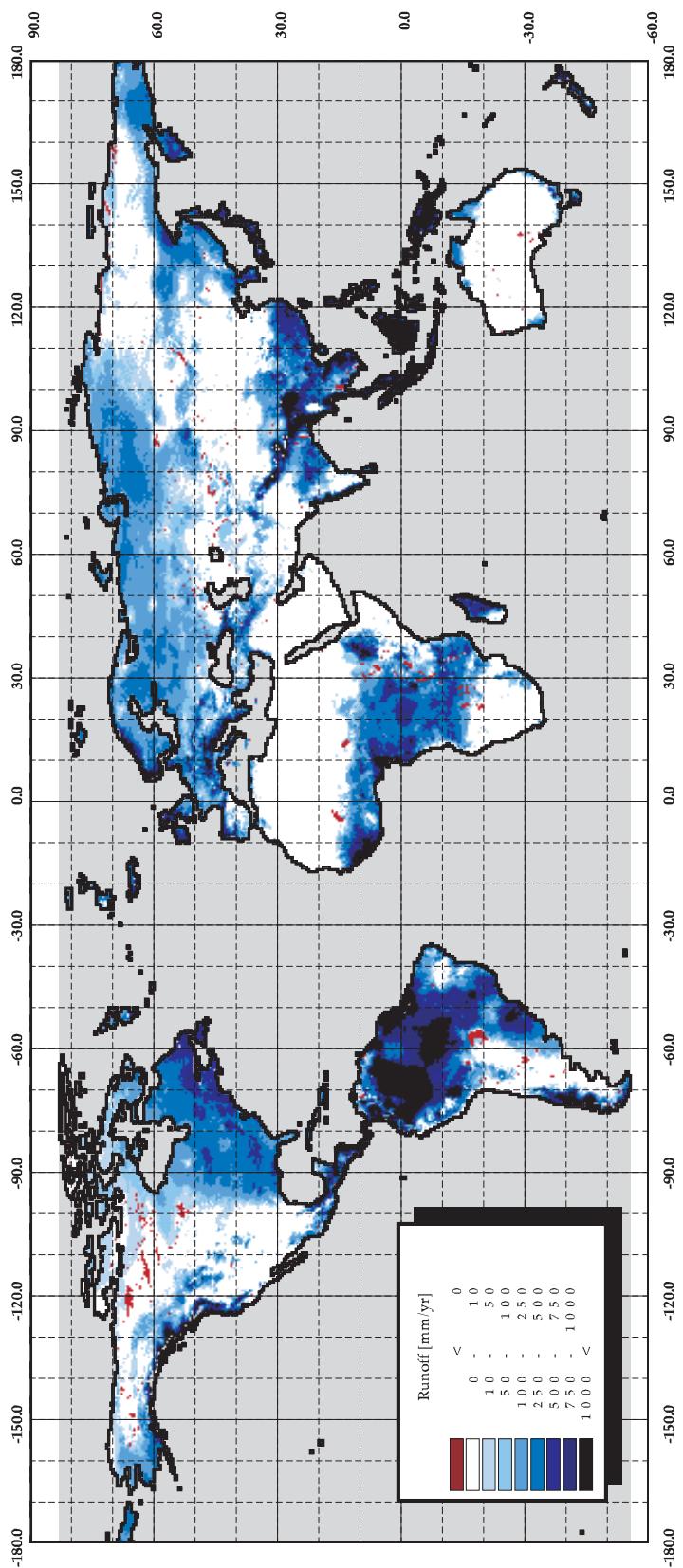
30-minute spatial resolution



G Appendix: WBM Simulated Annual and Monthly Runoff Fields

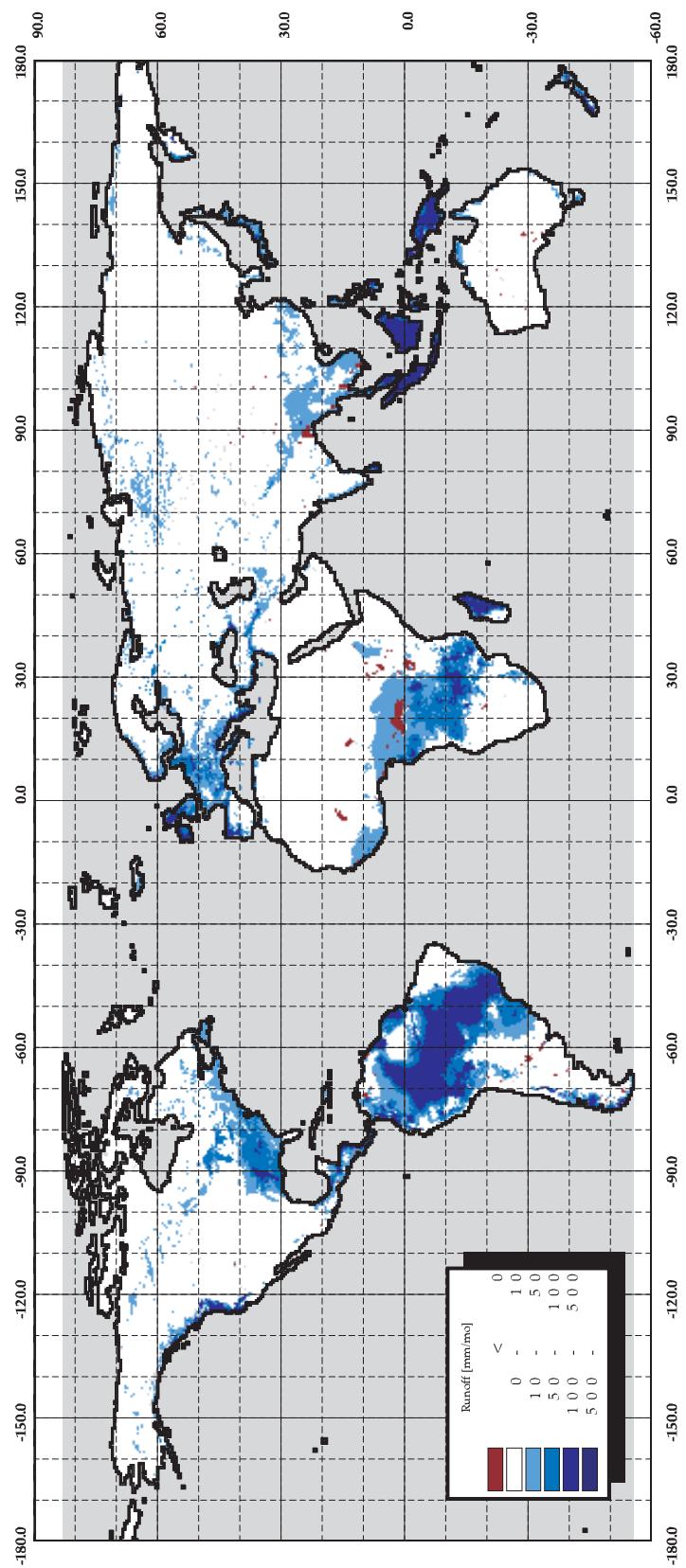
WBM-Simulated Mean Annual Runoff

30-minute spatial resolution



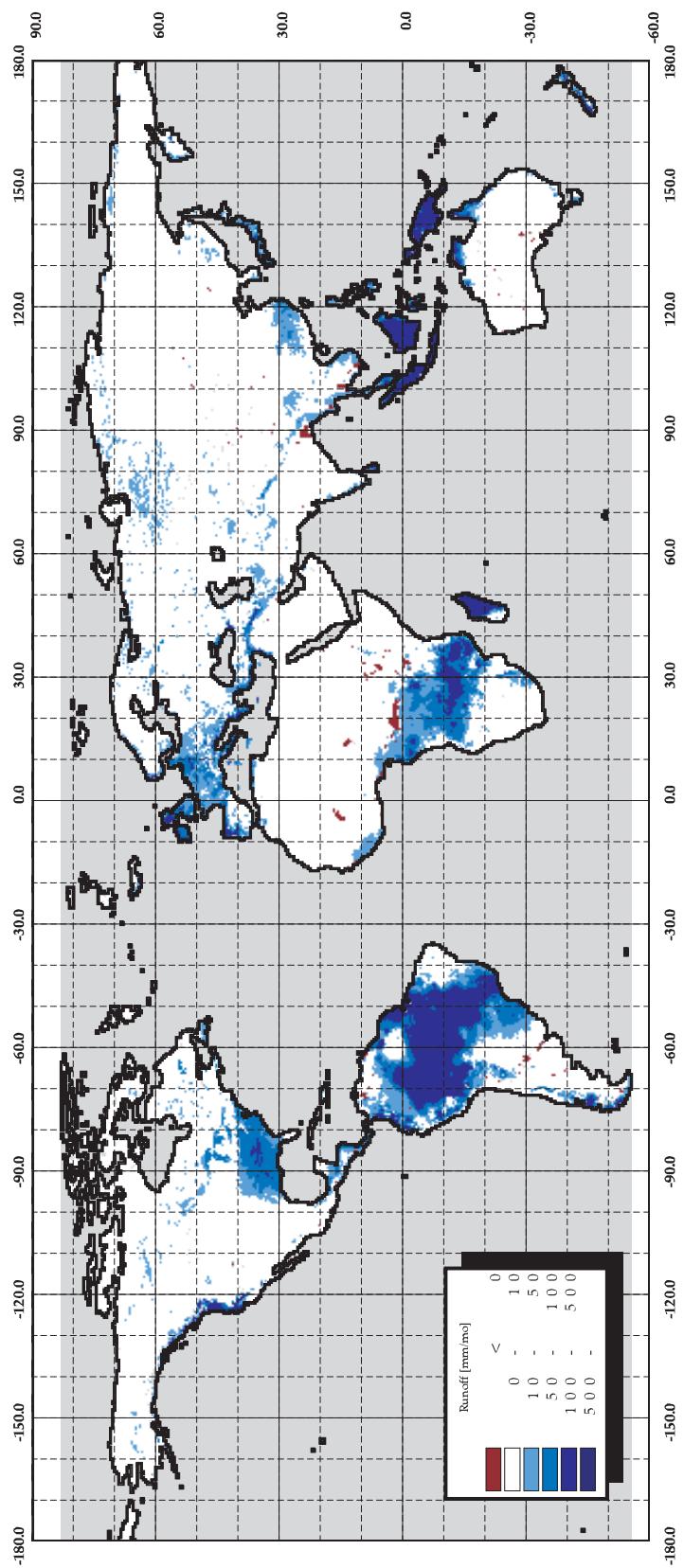
WBM-Simulated January Runoff

30-minute spatial resolution



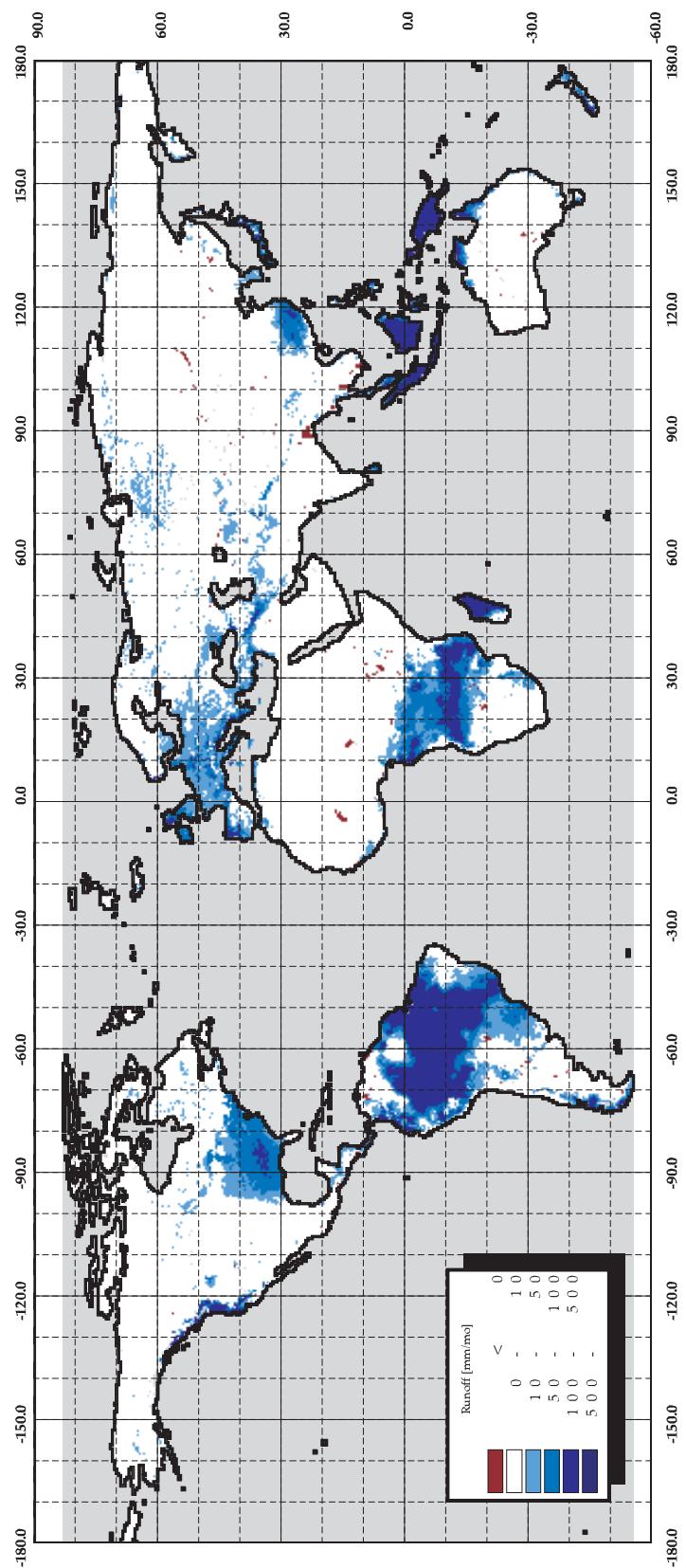
WBM-Simulated February Runoff

30-minute spatial resolution



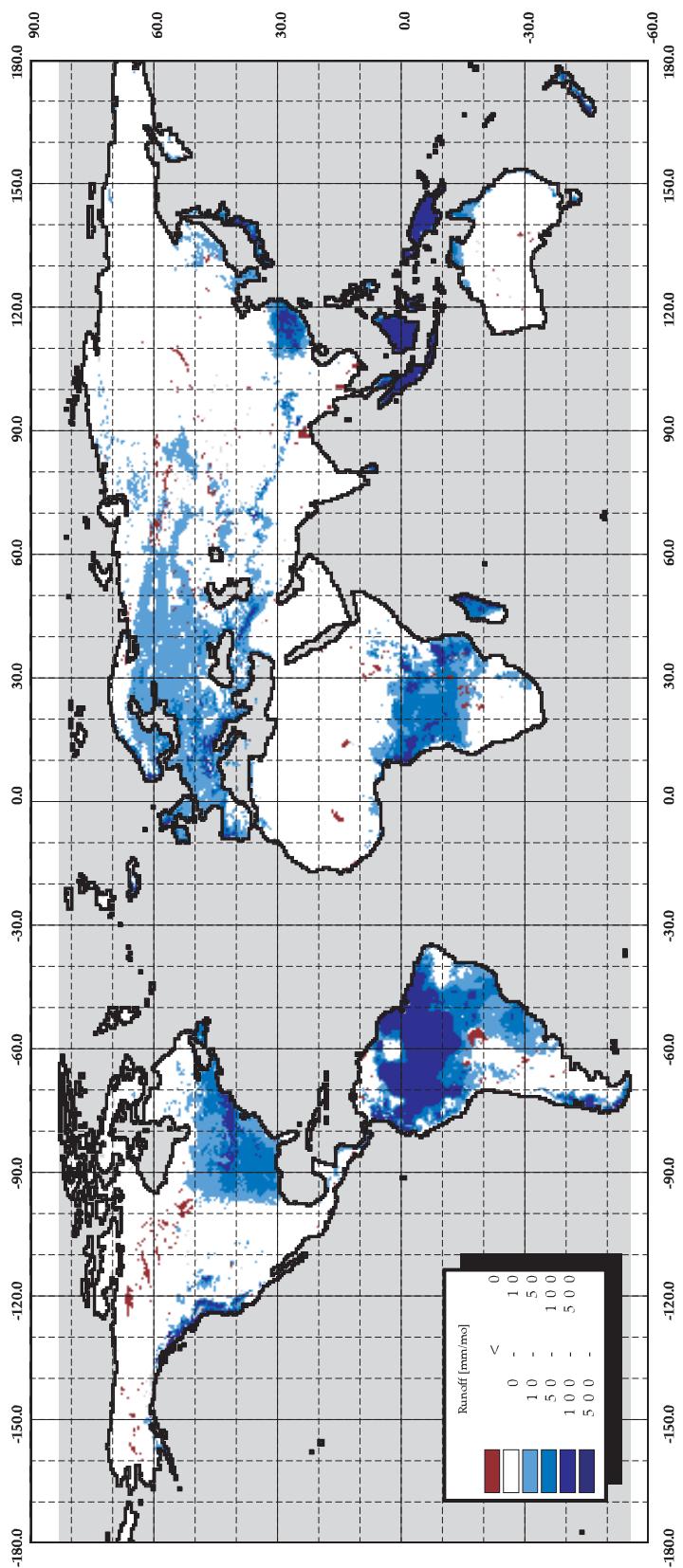
WBM-Simulated March Runoff

30-minute spatial resolution



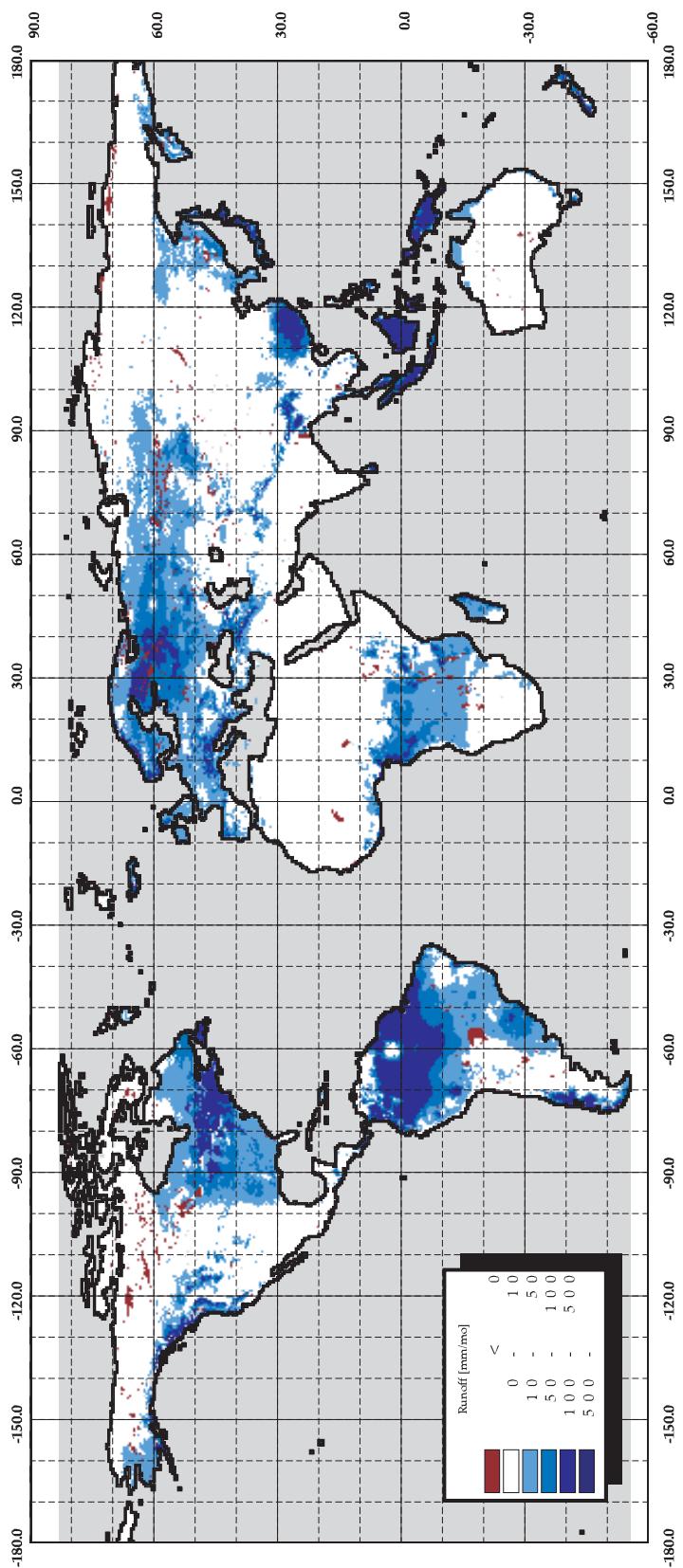
WBM-Simulated April Runoff

30-minute spatial resolution



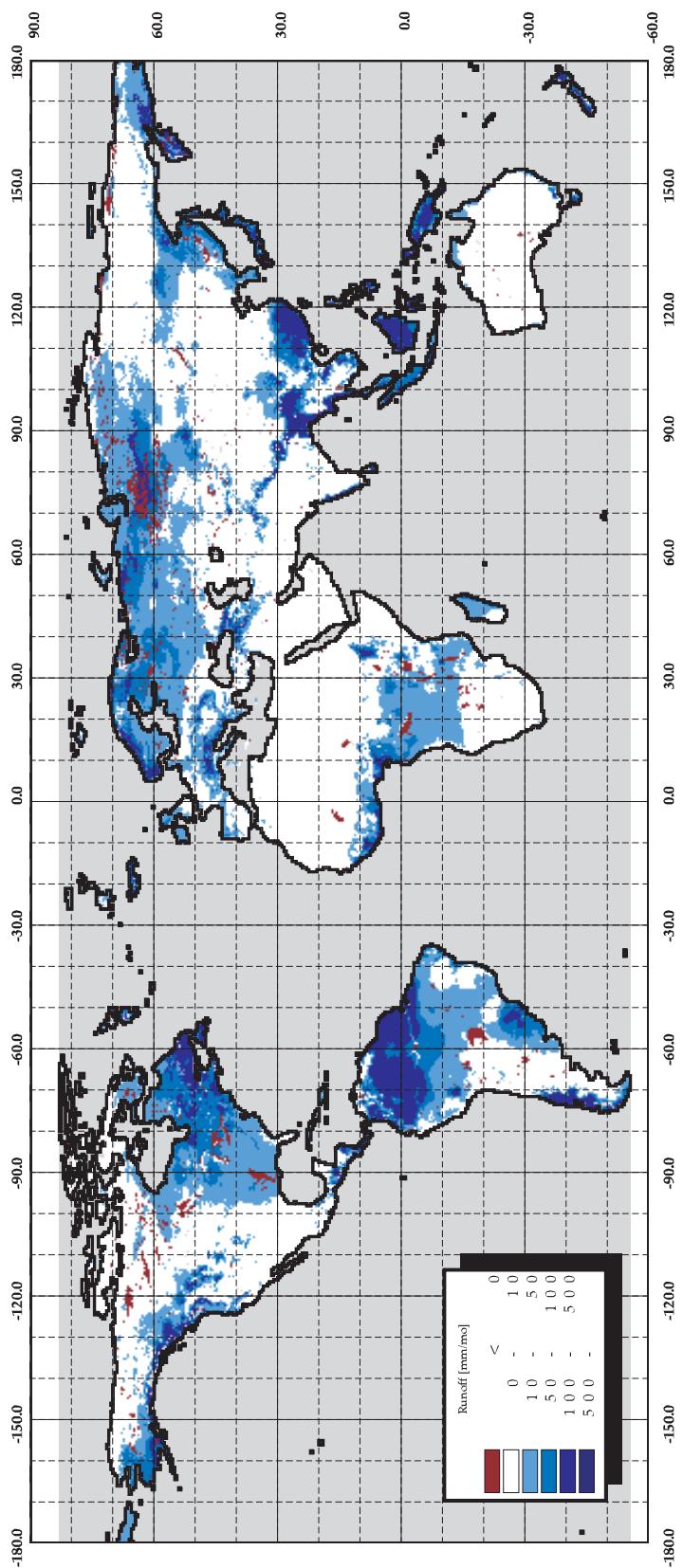
WBM-Simulated May Runoff

30-minute spatial resolution



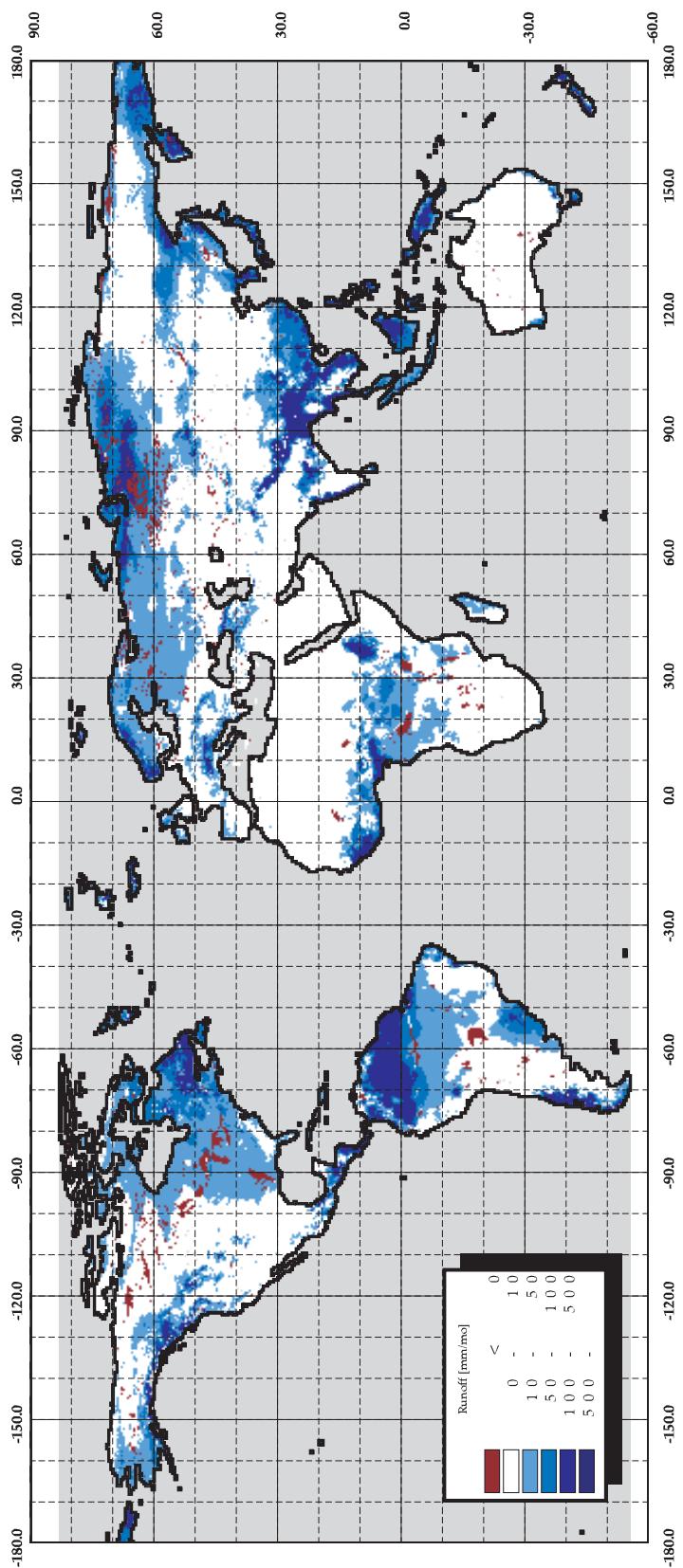
WBM-Simulated June Runoff

30-minute spatial resolution



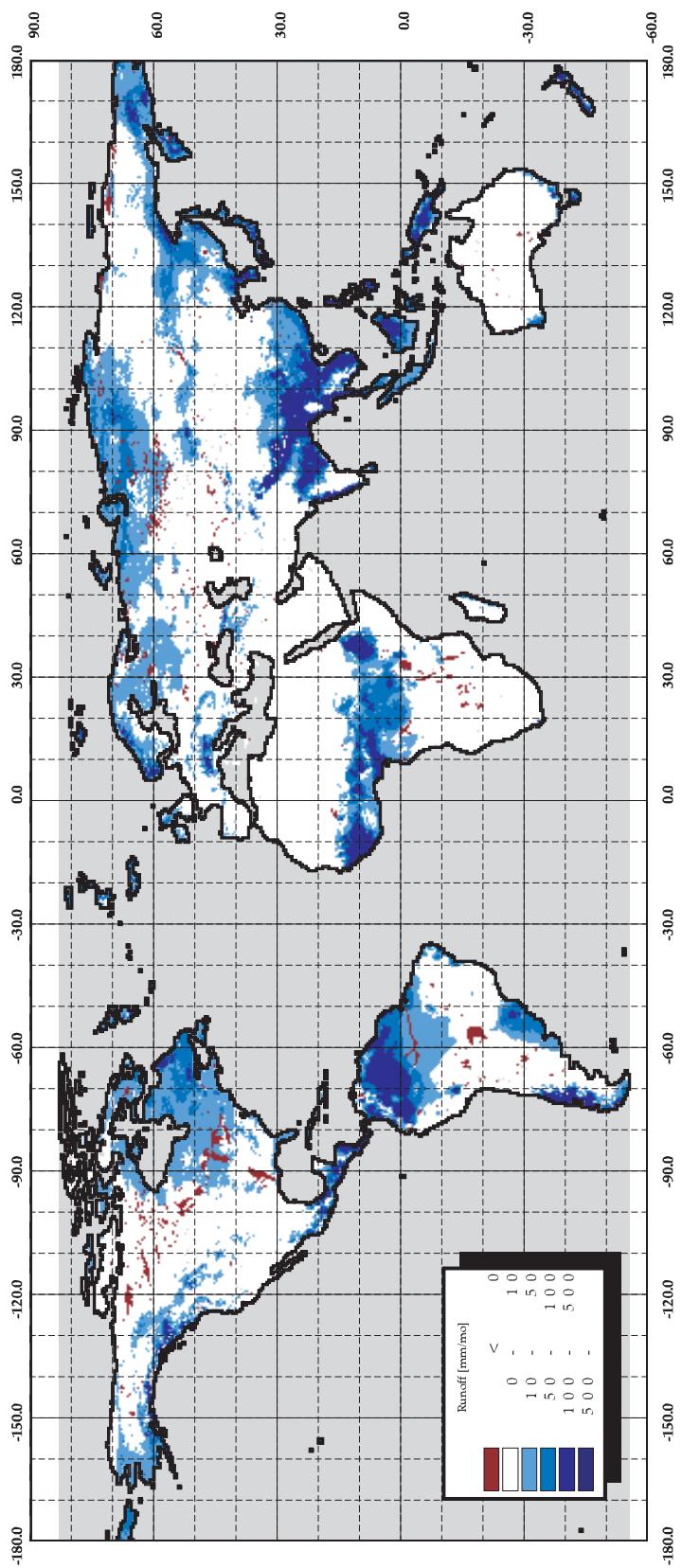
WBM-Simulated July Runoff

30-minute spatial resolution



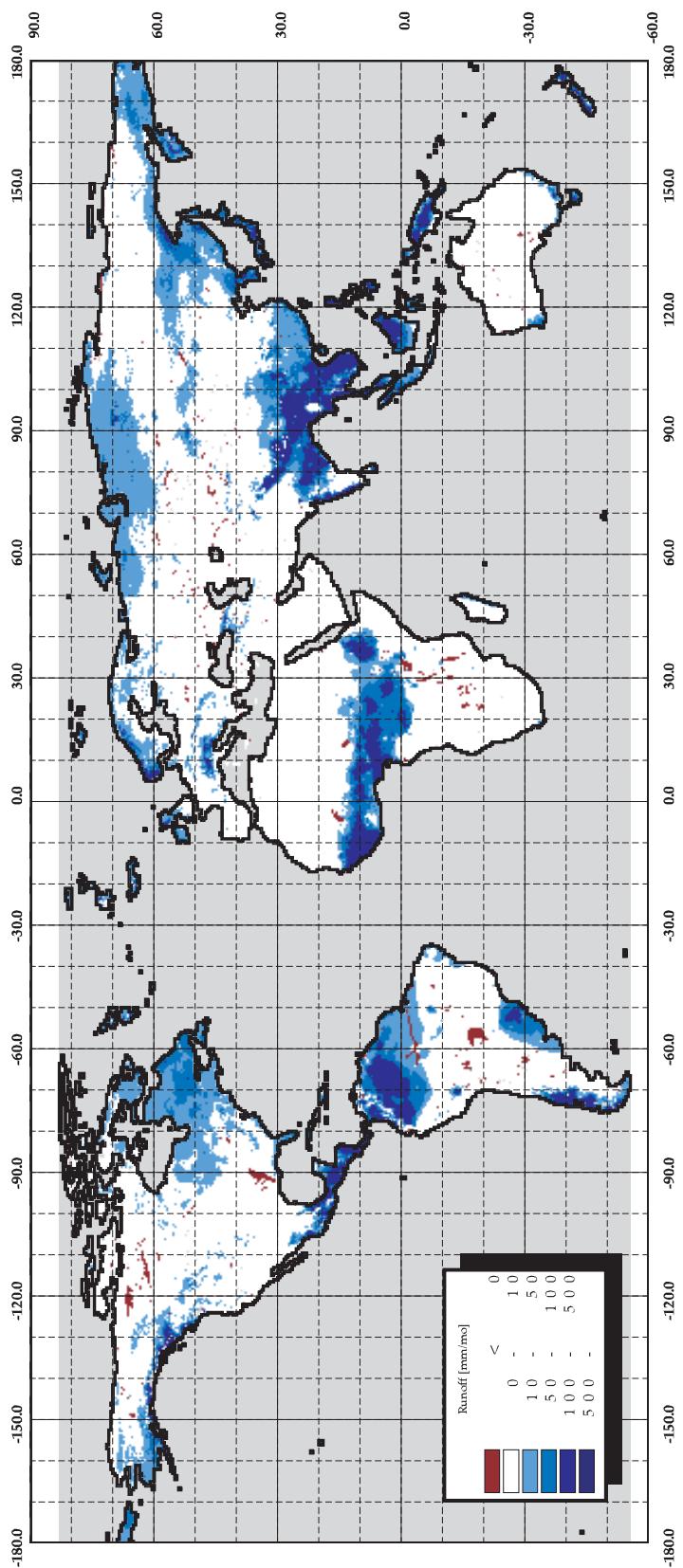
WBM-Simulated August Runoff

30-minute spatial resolution



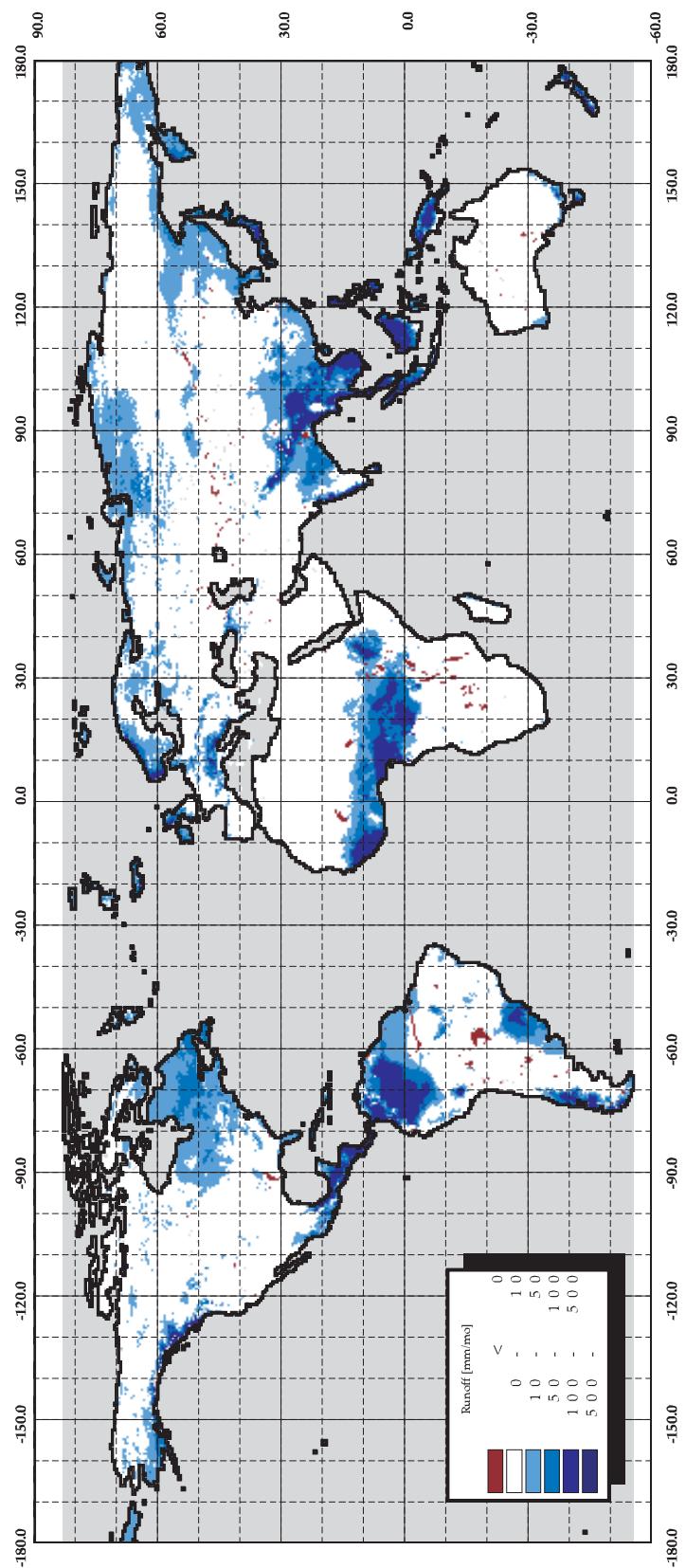
WBM-Simulated September Runoff

30-minute spatial resolution



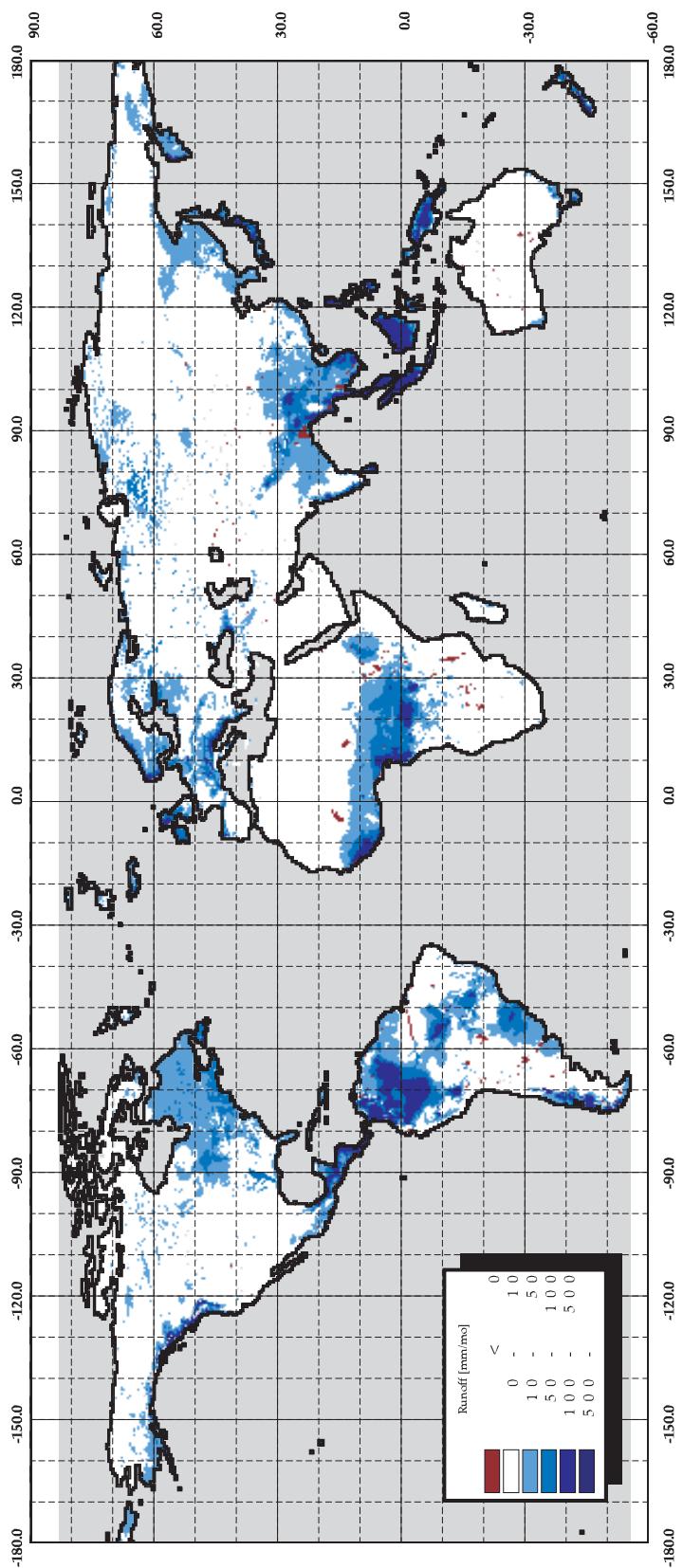
WBM-Simulated October Runoff

30-minute spatial resolution



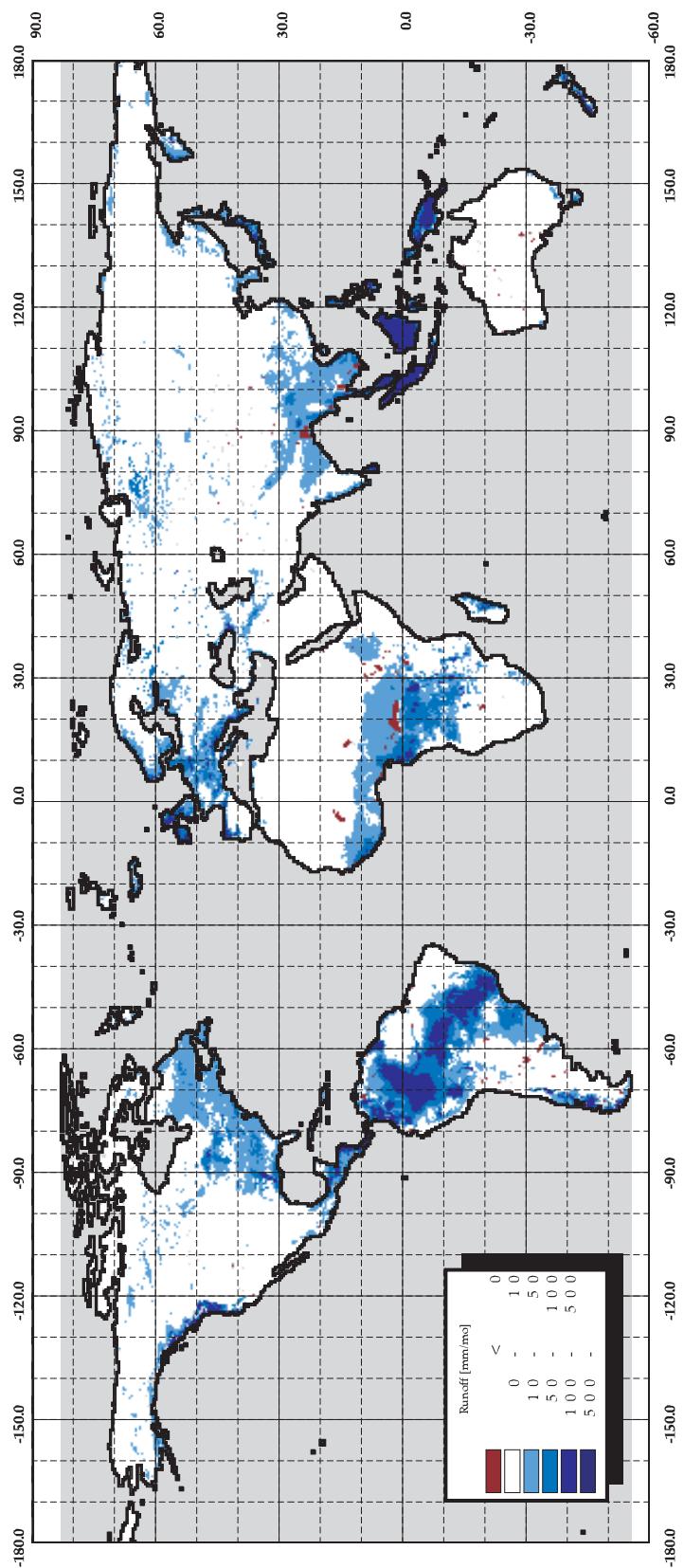
WBM-Simulated November Runoff

30-minute spatial resolution



WBM-Simulated December Runoff

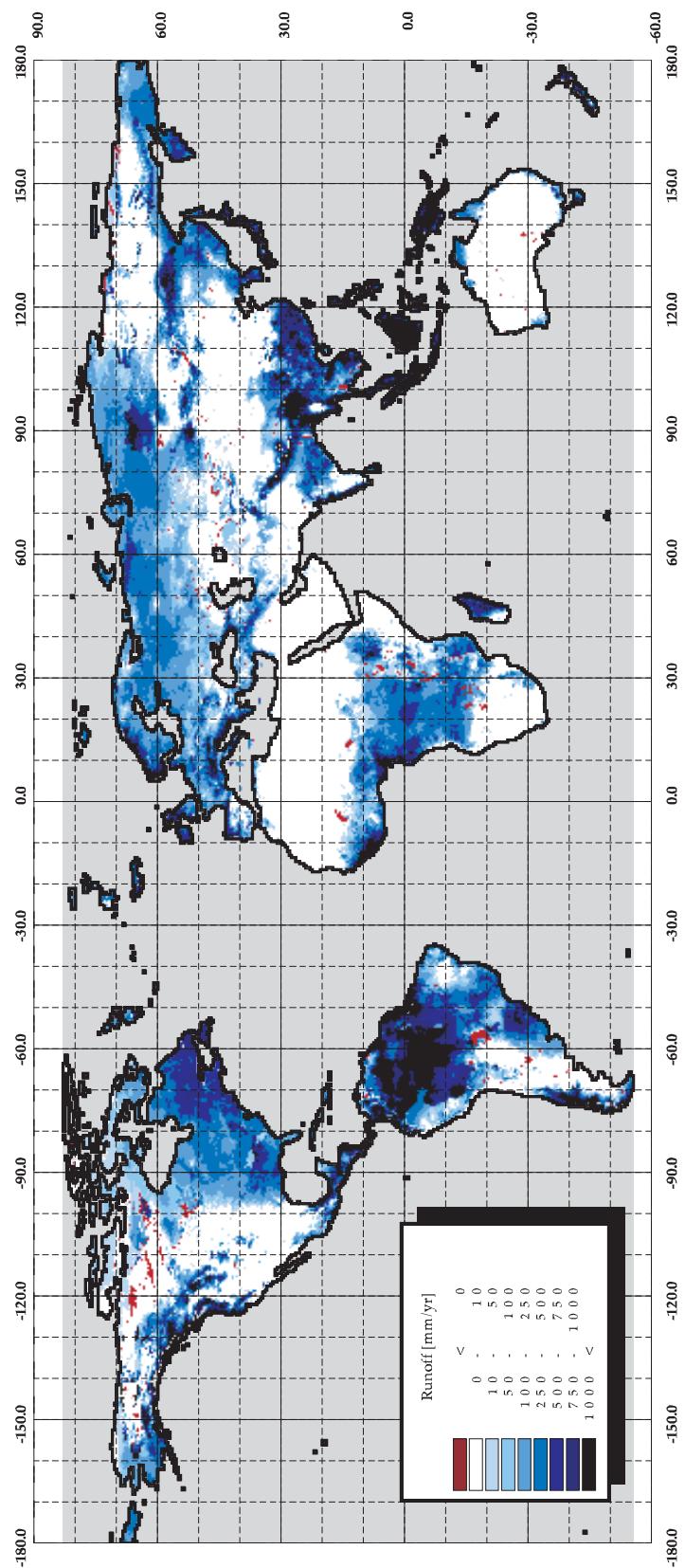
30-minute spatial resolution



H Appendix: UNH-GRDC Composite Monthly Runoff Fields

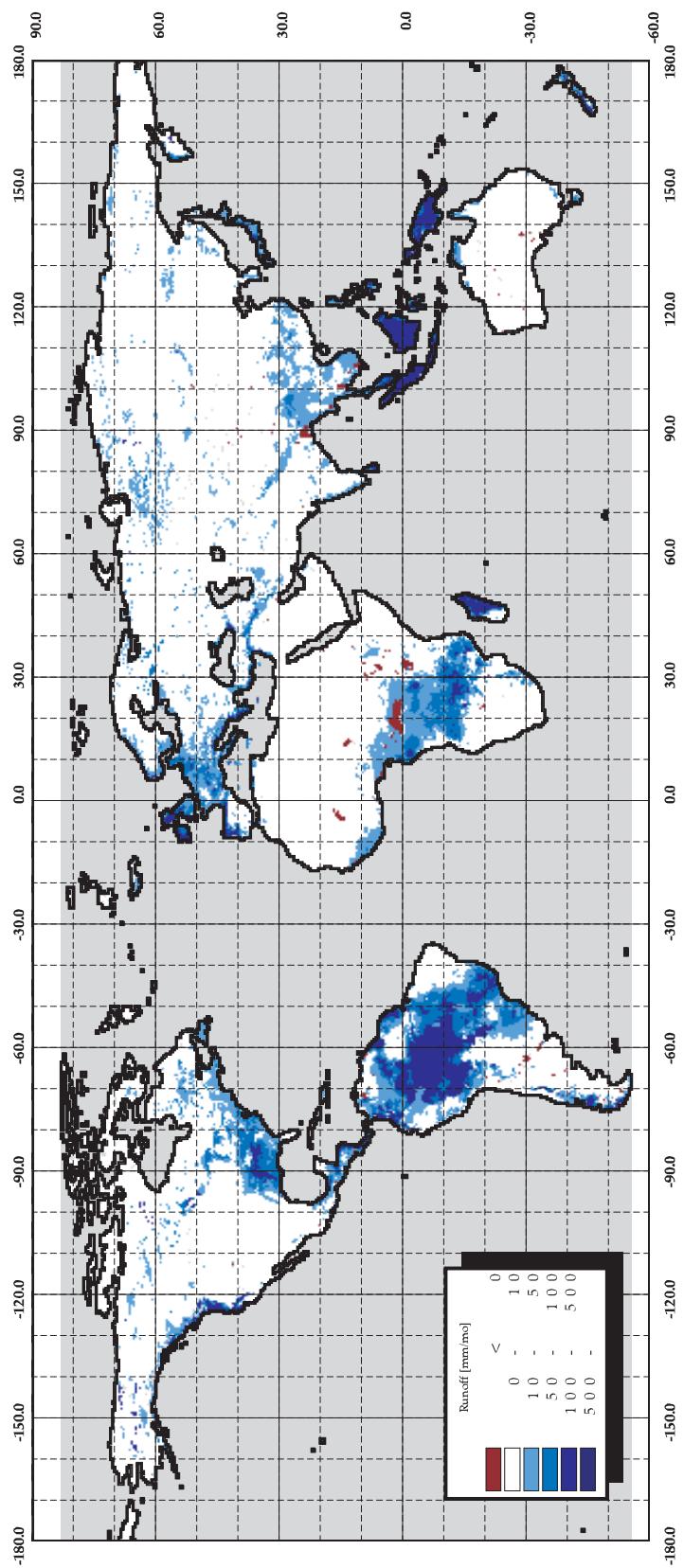
Composite Mean Annual Runoff

30-minute spatial resolution



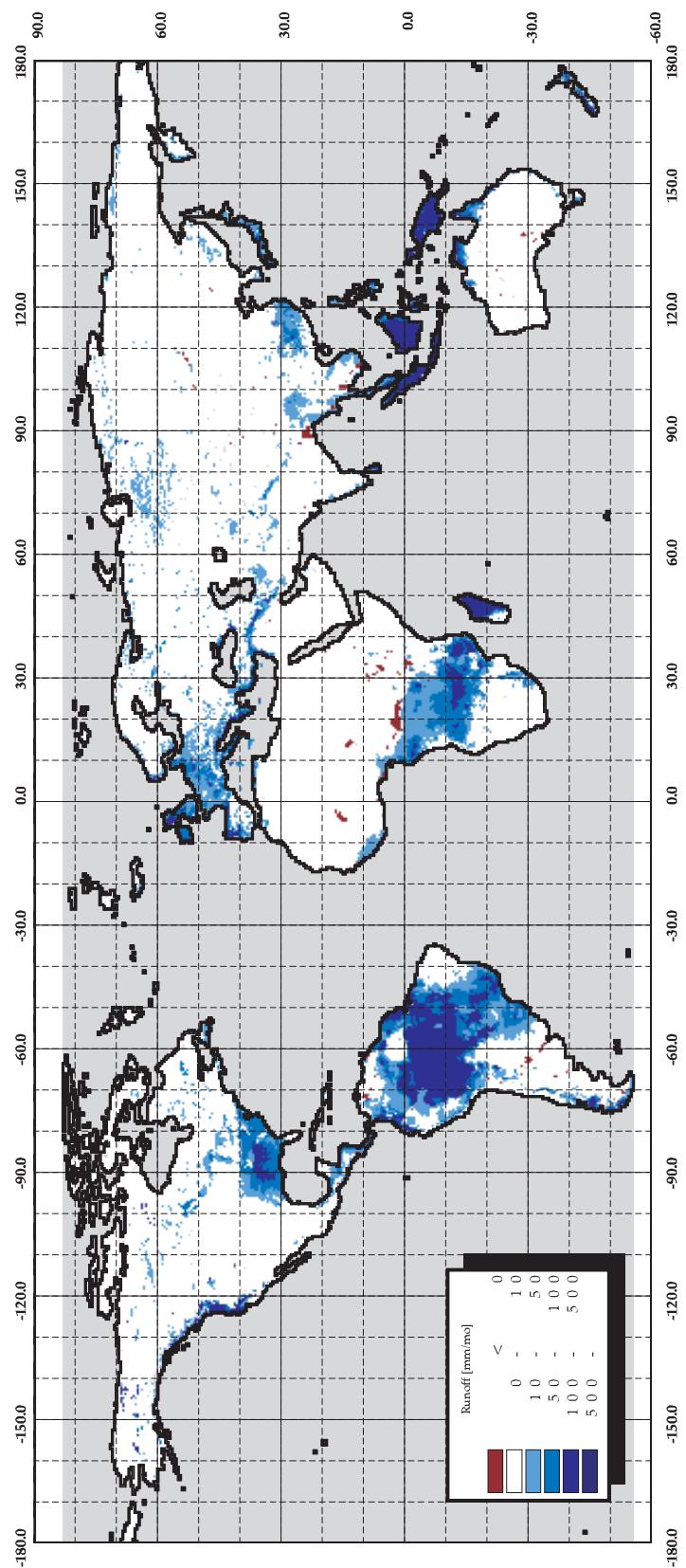
Composite January Runoff

30-minute spatial resolution



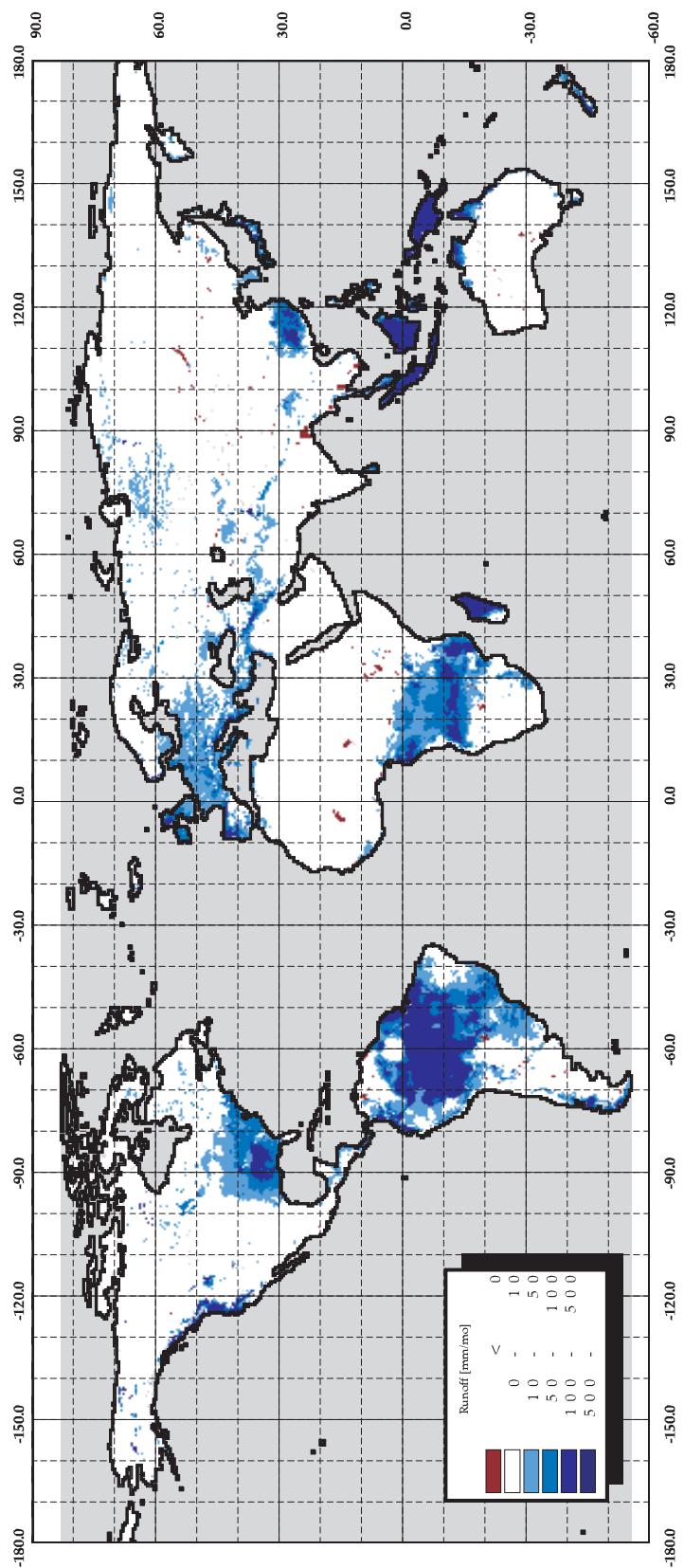
Composite February Runoff

30-minute spatial resolution



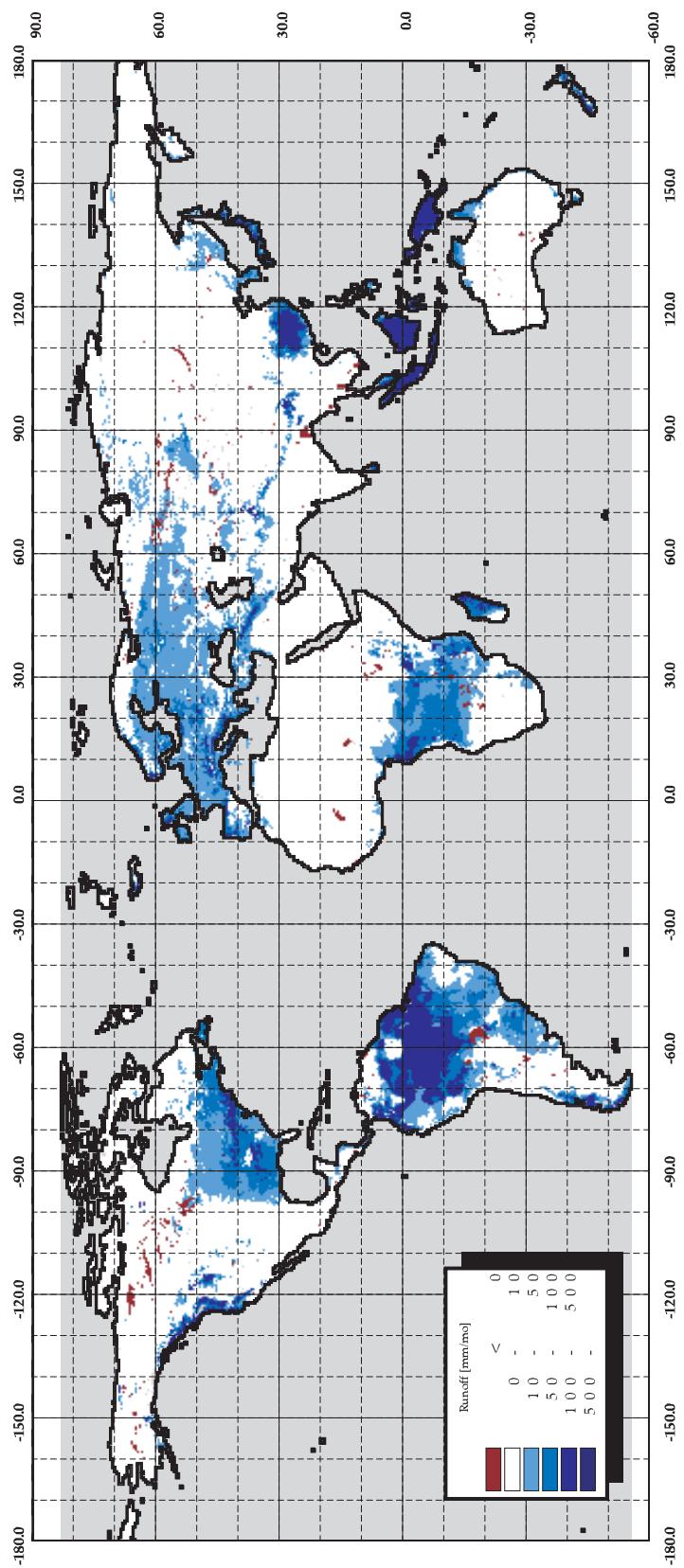
Composite March Runoff

30-minute spatial resolution



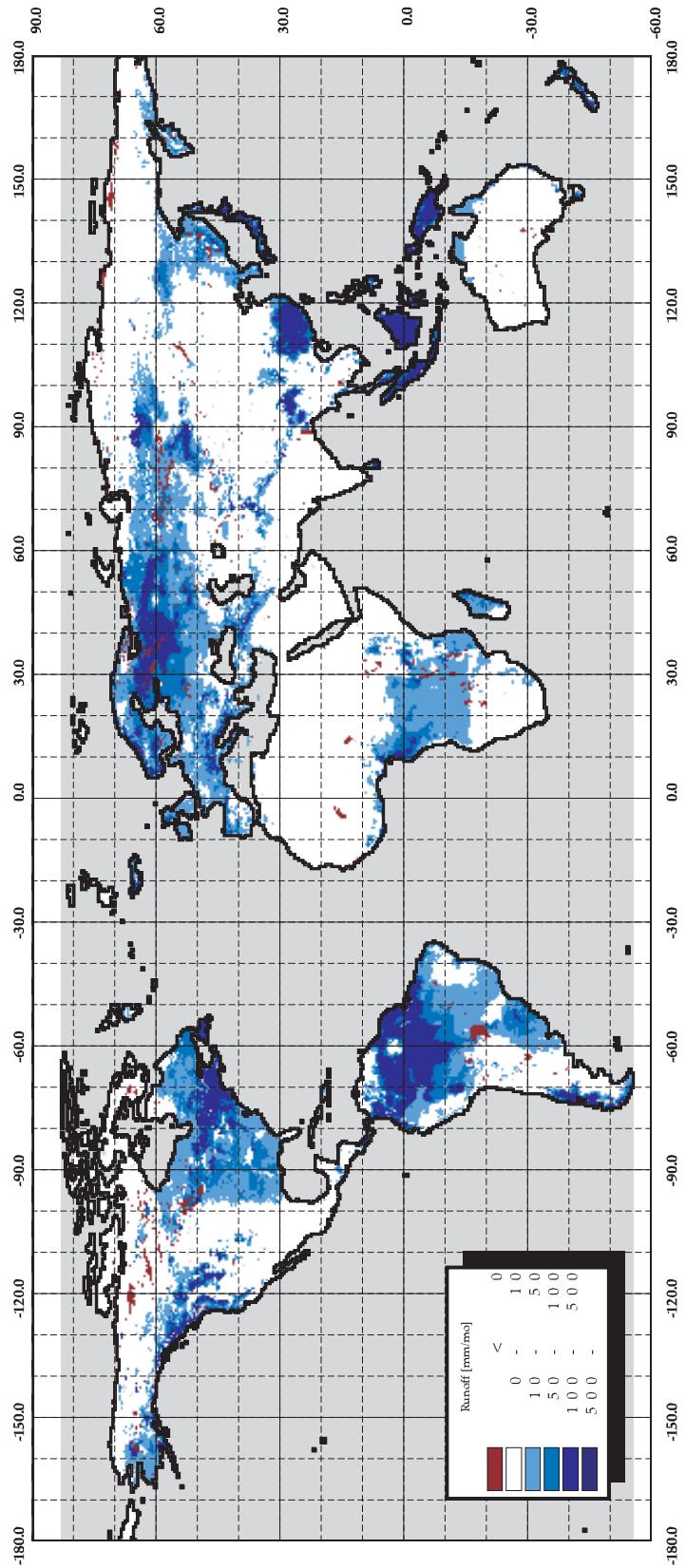
Composite April Runoff

30-minute spatial resolution



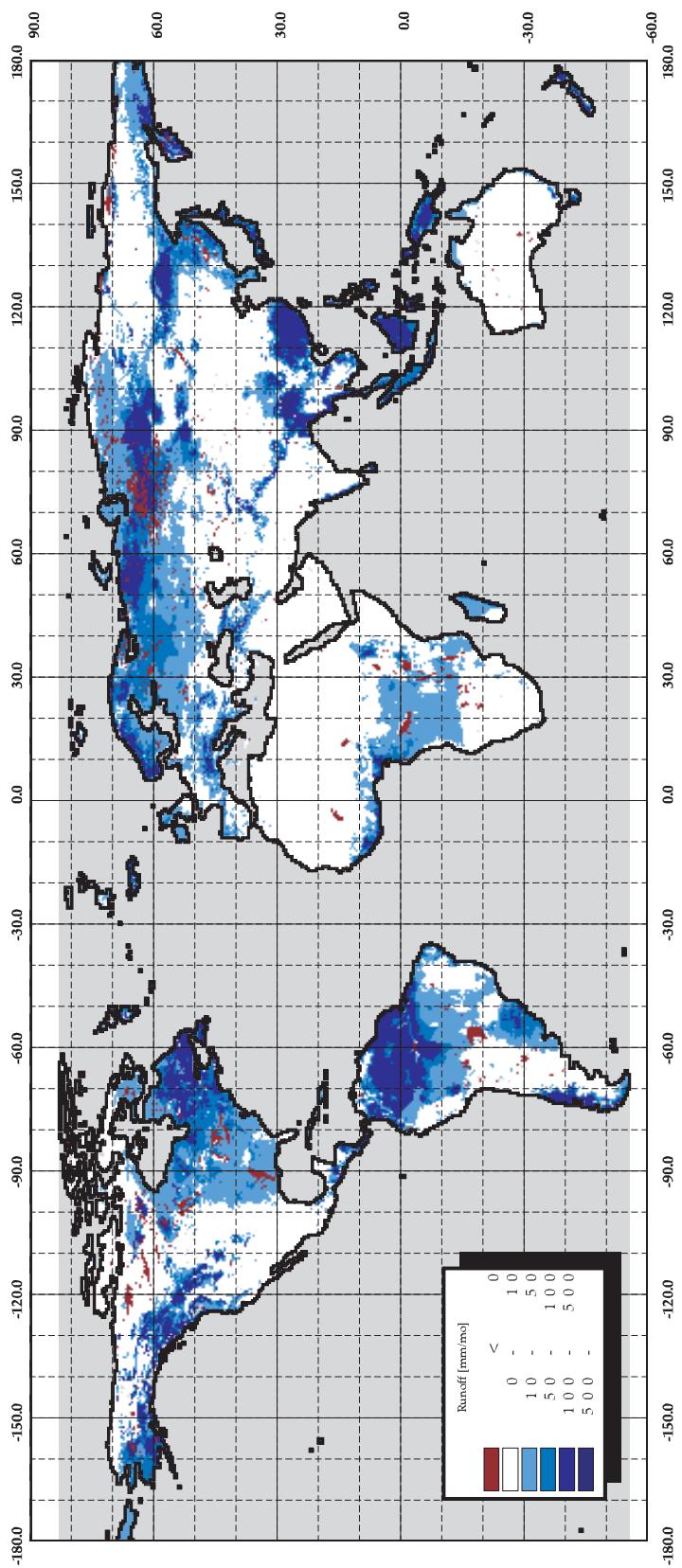
Composite May Runoff

30-minute spatial resolution



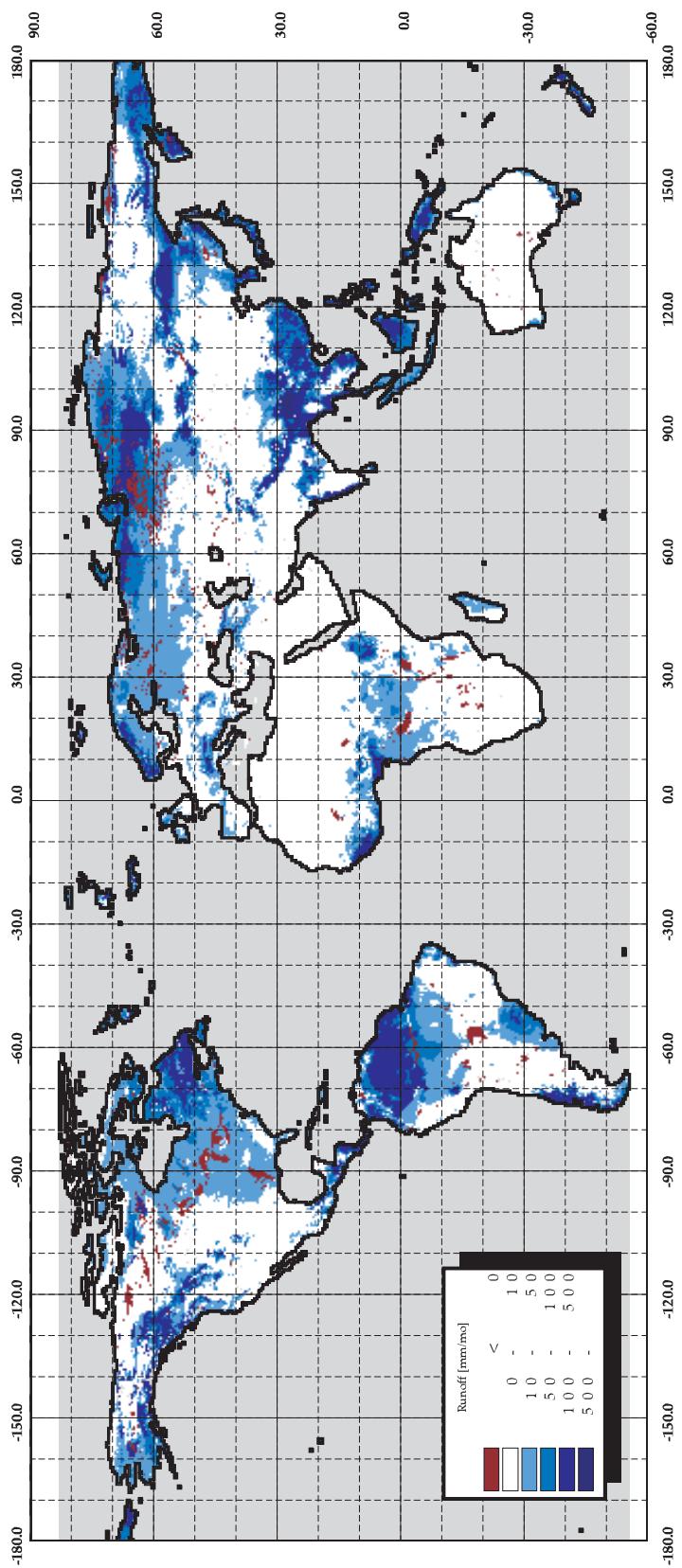
Composite June Runoff

30-minute spatial resolution



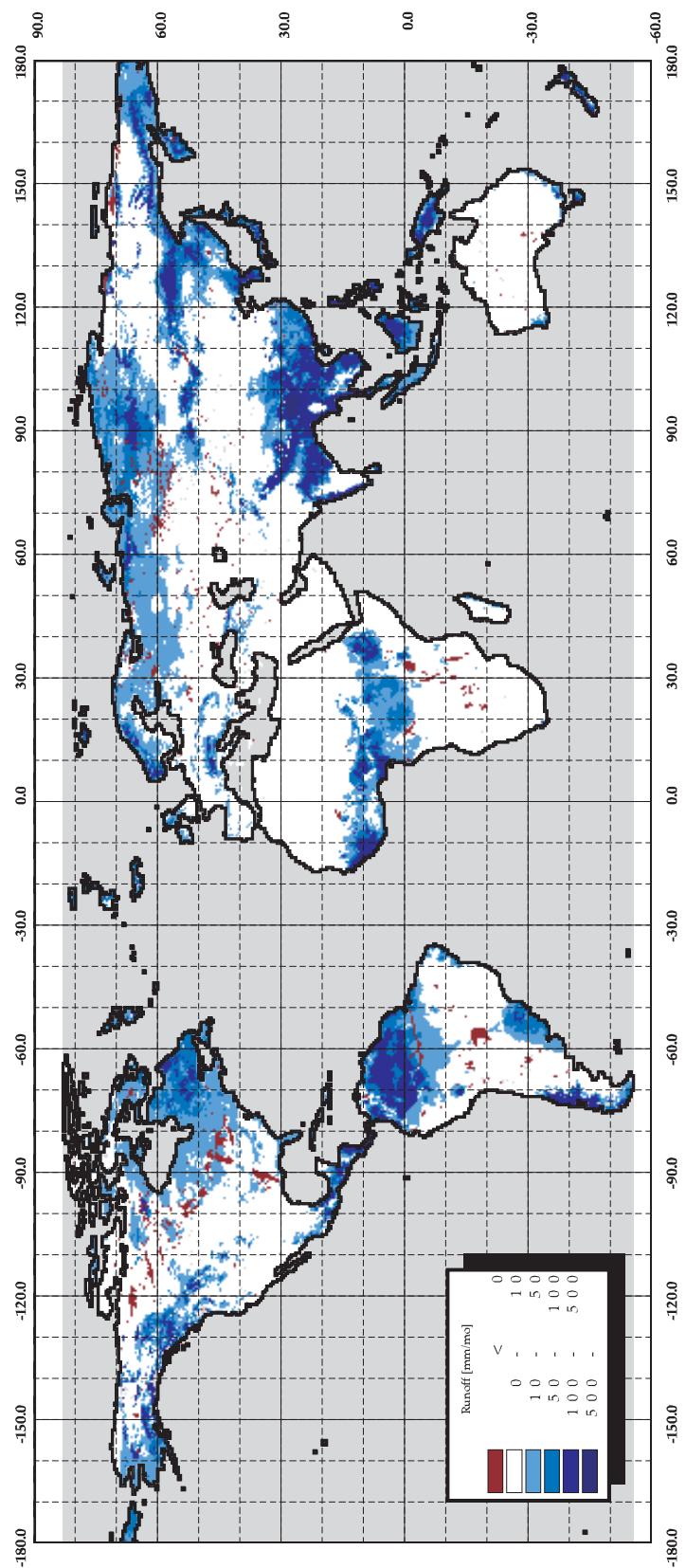
Composite July Runoff

30-minute spatial resolution



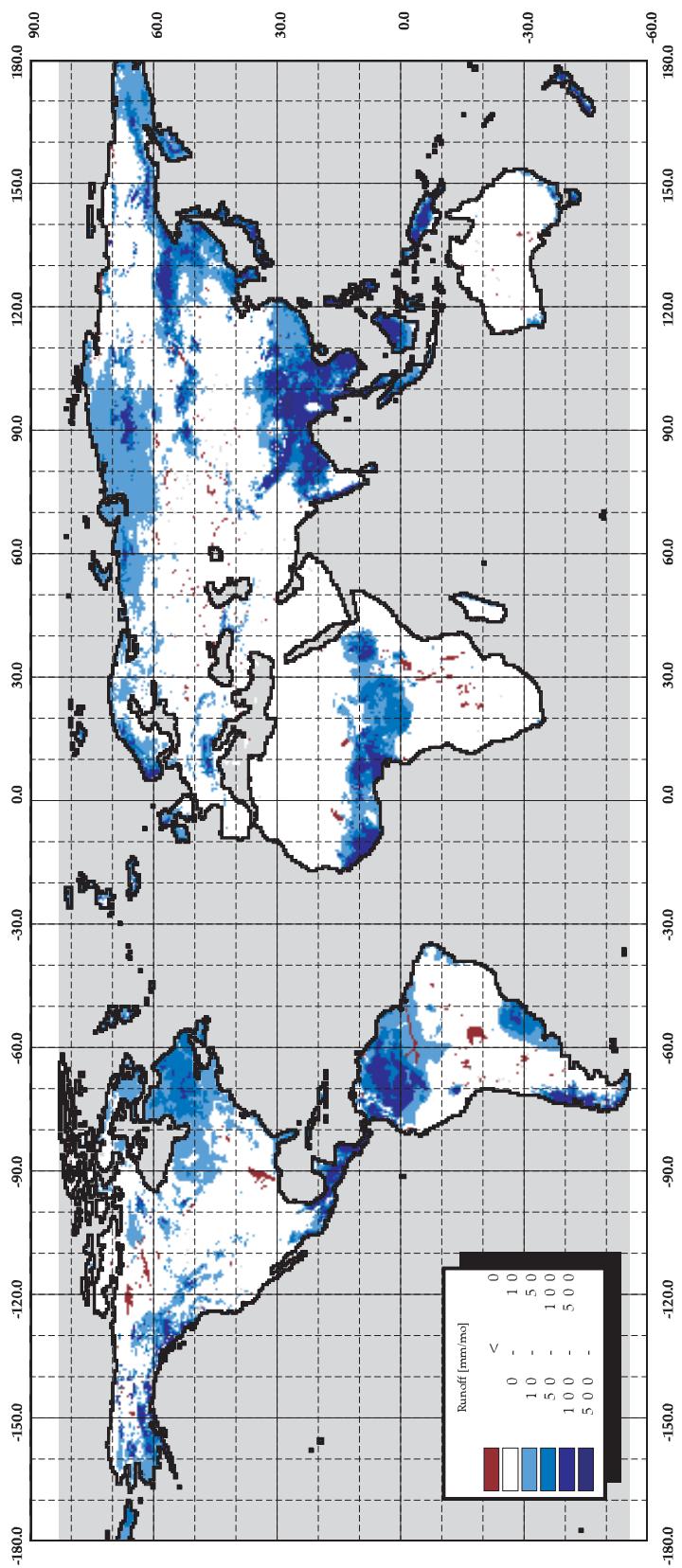
Composite August Runoff

30-minute spatial resolution



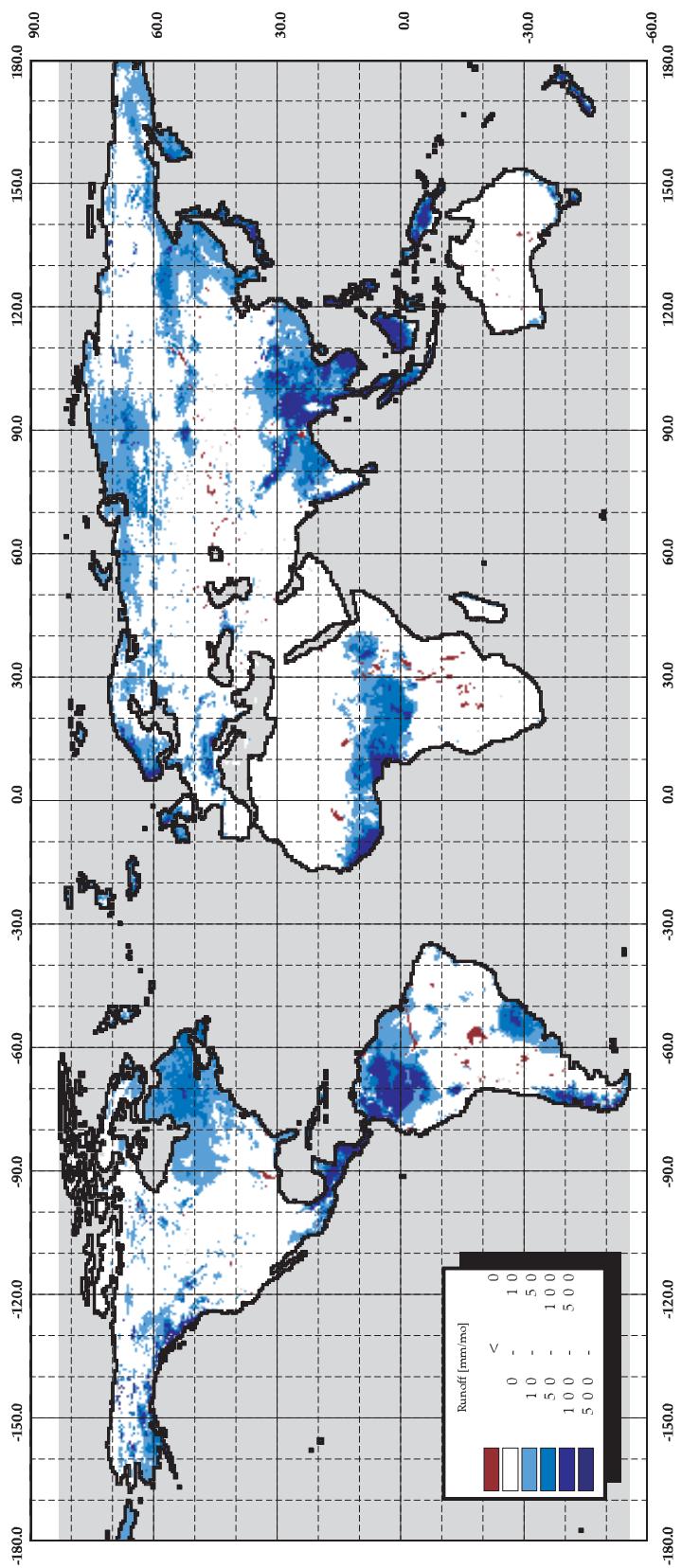
Composite September Runoff

30-minute spatial resolution



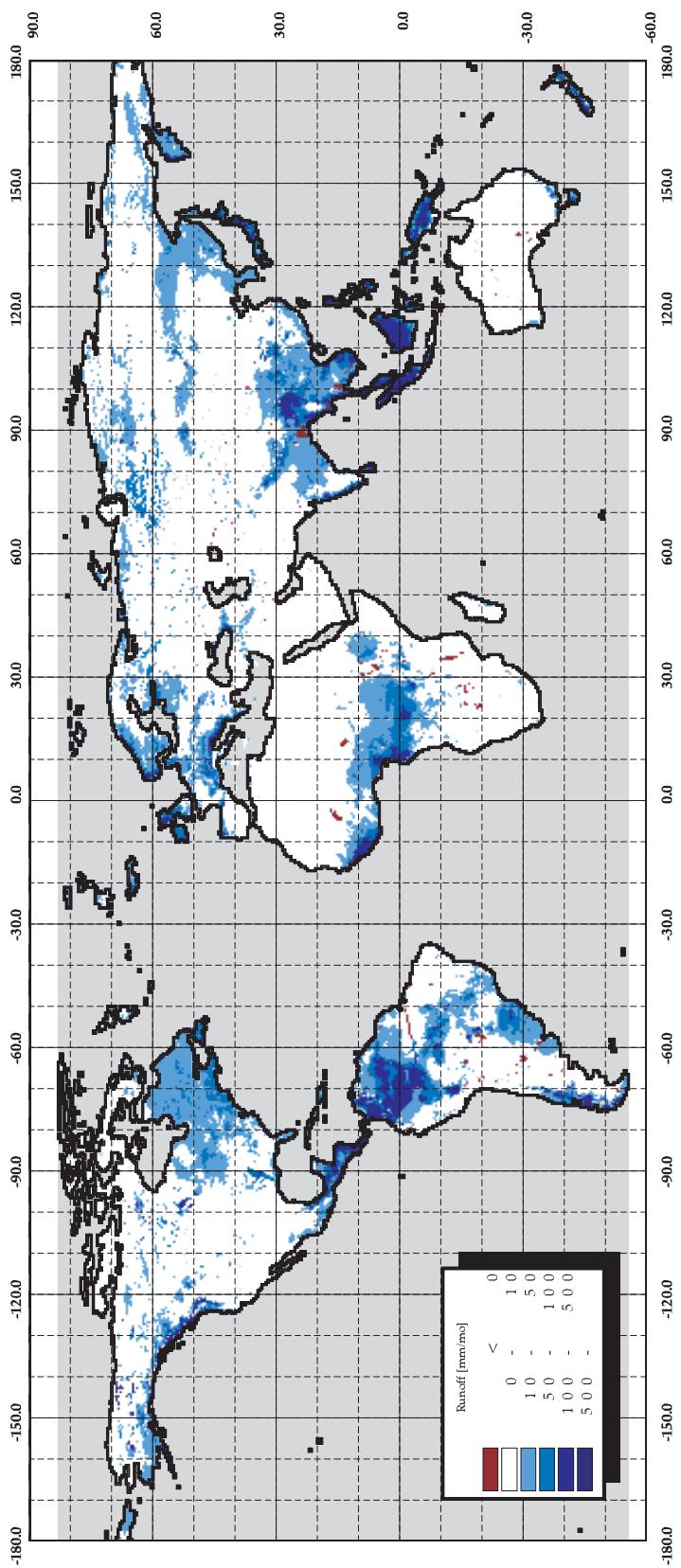
Composite October Runoff

30-minute spatial resolution



Composite November Runoff

30-minute spatial resolution



Composite December Runoff

30-minute spatial resolution

