The MOPEX 2004 French database: main hydrological and morphological characteristics

N. CHAHINIAN[1,2], T. MATHEVET[1,3], F. HABETS[4] & V. ANDRÉASSIAN[1]

1 *Hydrology group, Cemagref Antony, Parc Tourvoie BP 44, F-92163 Antony cedex, France*
nanee.chahinian@agrocampus-rennes.fr

2 *Now at: Institut de Recherche pour le Développement(IRD), UMR HydroSciences–Université Montpellier II, Case Courrier MSE, Place Eugène Bataillon,F- 34095 Montpellier cedex 5, France*

3 *Now at: EDF-DTG, BP 41, F-38040 Grenoble cedex, France*

4 *Météo-France, 42, avenue G. Coriolis, F-31057 Toulouse cedex 1, France*

Abstract The MOPEX 2004 workshop was held in Paris in July 2004. As for former workshops, the participants were asked to test their models and explore new parameter estimation strategies using the common databases. However, for this workshop a new series of 40 French catchments was added to the existing MOPEX database. The new data consists of hourly estimates of hydrometric data as well as information on land surface characteristics. This paper presents and analyses the contents of the Paris workshop database.

Key words database; MOPEX; parameter estimation; rainfall–runoff modelling

INTRODUCTION

Since its launch in 1996, the Model Parameter Estimation Experiment, MOPEX, was aimed at the development of a comprehensive database containing many years of historical hydrometeorological time series and land surface characteristics data. The database thus compiled is available to the hydrological community and serves as a common base for model and parameterization inter-comparison experiments.

In the previous experiments (Birmingham, 1999; Arizona 2002; Sapporo, 2003), the database included daily measurements of precipitation and runoff (Duan *et al.*, 2006). For the 2004 workshop a new selection of 40 French catchments, with both daily and hourly meteorological data, was added to the MOPEX database pool. As in previous workshops, the participants were asked to run their models and simulate runoff series. However, as part of the IAHS's PUB decade (Predictions on Ungauged Basins) participants were asked to further explore alternative ways to estimate parameters without using runoff data for model calibration. This paper is a synthesis of the French database information.

The database

The database was put together especially for the MOPEX 2004 workshop. All the selected catchments satisfy the number of raingauge *vs* area criterion set by Schaake *et al.* (2000), i.e. a minimum of two raingauges for catchments with an area <50 km^2 and an increasing number of gauges with area, to reach nine raingauges for catchments with an area >6000 km^2.

In addition to hourly and daily hydrometric data, the database contains information on the catchments' elevation, land use and soil type. The files are available in digital format both as ASCII files and as ArcView coverages.

Catchment location

The database is composed of 40 French catchments scattered all around continental France (Fig. 1) covering the full range of climatic conditions encountered in France. Special care was taken to avoid catchments with significant snow cover/contribution and flow regulation structures. The catchment contours and the river network were digitized from the 1/25 000 topographic analogue maps produced by the National Geographic Institute. The digitized river network hence corresponds to the "blue lines" found on these maps.

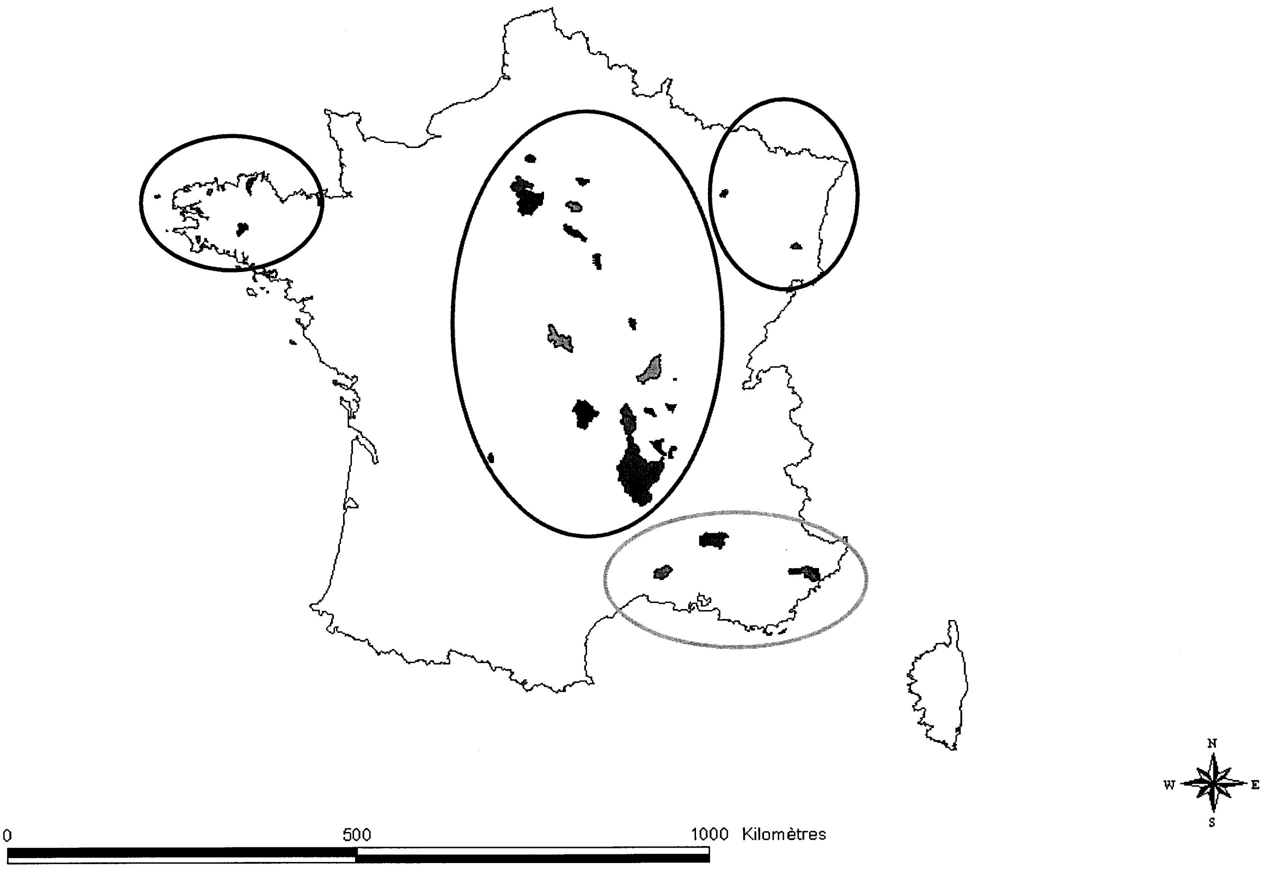

Fig. 1 Simulated and observed hydrographs for VIC model.

Two of the selected catchments (A1522020, A5723010) are located in the Alsace region of eastern France with a semi-continental climate, i.e. with harsh winters and hot summers. Four catchments (J2034010, J3024010, J4124420, J4712010) are located in Brittany, western France under oceanic-humid climatic conditions. Seven

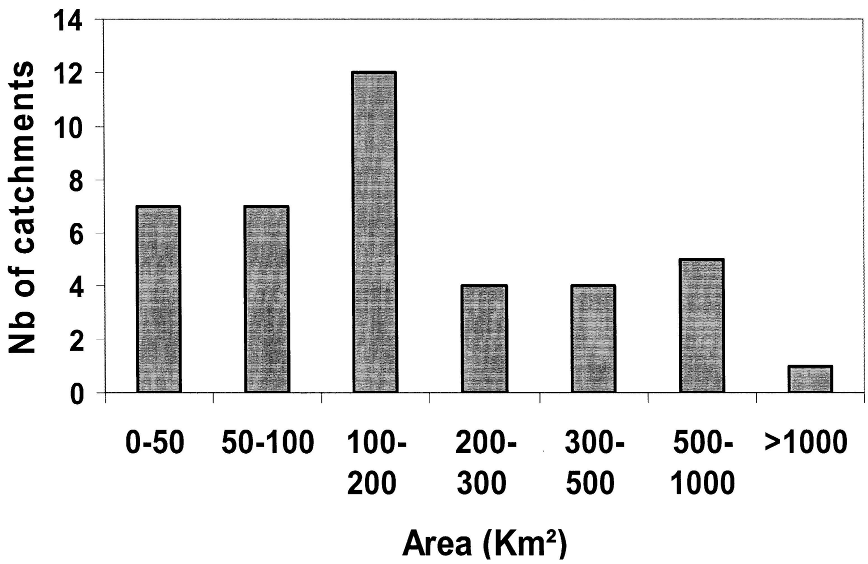

Fig. 2 Catchment area distribution.

catchments (V6035010, V6052010, X2414030, Y3514020, Y5615010, Y5615030 and Y5625020) are located in southern France, near the Mediterranean Sea where the winters are mild and the summers hot. The remaining 27 catchments are sited in the Parisian area and in central France i.e. they have an intermediate climate with cold winters and hot summers.

Catchment size varies between 11 km^2 for the smallest (La Denante at Davayé) and 3234 km^2 (La Loire at Bas en Basset). The mean area is 297 km^2 (Fig. 2), with 30 catchments having an area smaller than 291 km^2.

Elevation

The elevation data was derived from a Digital Elevation Model with 75-m resolution (Table 2). The minimal elevation values range between 5 m (J2034010) and 1010 m (X2414030) while maximum elevation ranges between 121 m (J3024010) and 1900 m (V6052010). The catchment with the highest span is the Loup at Villeneuve-Loubet (5615030) with 1750 m. Six out of the seven Mediterranean catchments have a higher span than the median, whereas all four Breton catchments have a lower span than the median. These two groups have very contrasted characteristics and performances and it would be interesting to see how the model parameters will try to account for and translate this variability.

Hydrological data

The hydrological data consisted of climatic data provided by Météo-France and runoff data provided through the Banque Hydro database. The climatic data consists of hourly estimates of evapotranspiration, downward solar and infrared radiation, specific air

Table 1 Catchment list and characteristics.

Level	Code	Name	Area (km²)	Instantaneous peak discharge-maximum value ever recorded ($m^3 s^{-1}$)*	Median of annual discharge ($m^3 s^{-1}$)*	Mean annual rainfall 1995–2002 (mm $year^{-1}$)	Mean annual evapo-transpiration 1995–2002 (mm $year^{-1}$)
3C	J3024010	Le Guillec à Trézilidé	43	12	0.67	1014	686
	V6035010	Le Toulourenc à Malaucène	150	81	1.32	1059	1081
	Y5615030	Le Loup à Villeneuve-Loubet	279	228	4.47	1159	1120
12C	A1522020	La Lauch à Guebwiller	68	41	1.65	1665	735
	H2001020	L'Yonne à Corancy	98	45	2.89	1299	742
	H3613020	Le Lunain à Épisy	252	12	0.74	808	736
	H5723011	L'Orgeval à Boissy-le-Châtel	104	33	0.63	804	753
	J2034010	Le Guindy à Plouguiel	125	27	1.21	960	710
	J4124420	La Rivière de Pont-l'Abbé à Plonéour-Lanvern	32	4	0.53	1236	719
	K0744010	L'Anzon à Débats-Rivière-d'Orpra	181	72	2.54	980	727
	K0753210	Le Lignon du Forez à Boën	371	285	5.70	1012	727
	Y3514020	Le Vistre à Bernis	291	43	2.11	847	1161
40C	A5723010	L'Ingressin à Toul	54	10	0.44	881	666
	H2513110	Le Tholon à Champvallon	131	18	0.86	824	761
	H3613010	Le Lunain à Paley	163	18	0.56	818	736
	H3923010	Le ru d'Ancoeur à Blandy	181	24	0.59	780	753
	H4252010	L'Orge à Morsang-sur-Orge	922	41	3.96	720	707
	H7853010	Le Sausseron à Nesles-la-Vallée	101	3	0.56	763	726
	H7913030	La Mauldre à Aulnay-sur-Mauldre	369	29	2.15	711	685
	J4712010	L'Éllé au Faouët	142	59	2.75	1192	729
	K0100020	La Loire à Goudet	432	1600	5.70	1395	773
	K0253020	La Borne occidentale à Espaly-Saint-Marcel	375	261	3.66	840	773
	K0550010	La Loire à Bas-en-Basset	3234	3500	38.60	979	784
	K0614010	Le Furan à Andrézieux-Bouthéon	178	142	2.54	849	773
	K0813020	L'Aix à Saint-Germain-Laval	193	195	3.02	988	727
	K0974010	Le Gand à Neaux	85	58	0.90	798	727
	K1173210	L'Arconce à Montceaux-l'Étoile	599	147	5.77	890	794
	K2724210	L'Artière à Clermont-Ferrand	49	9	0.27	955	825
	K2783010	La Morge à Maringues	713	103	4.29	862	825
	K5623010	L'Auron au Pondy	199	30	0.98	783	733
	K5653010	L'Auron à Bourges	585	84	3.77	801	786
	P3245010	Le Mayne à Saint-Cyr-la-Roche	49	23	0.70	1166	771
	U4305410	La Denante à Davayé	11	8	0.13	872	792
	U4525210	Le Morgon à Villefranche-sur-Saône	68	18	0.49	828	749
	V3315010	La Valencize à Chavanay	36	17	0.36	851	735
	V3517010	Le Ternay à Savas	25	16	0.34	867	735
	V6052010	L'Ouvèze à Vaison-la-Romaine	585	1000	6.07	990	1081
	X2414030	L'Artuby à la Bastide	91	104	1.04	1241	1267
	Y5615010	Le Loup à Tourrettes-sur-Loup	206	147	3.67	1226	1120
	Y5625020	La Cagne à Cagnes-sur-Mer	95	160	0.82	1059	1120

(*) Record length is variable. The longest time series available in "Banque Hydro" is retained.

Table 2 Synthesis of elevation data.

Catchment	Elevation (m)				
	Minimum	Maximum	Mean	1st quantile	3rd quantile
A1522020	299	1408	782	547	1014
A5723010	213	421	303	246	358
H2001020	335	900	594	506	672
H2513110	90	322	176	137	212
H3613010	86	201	149	135	159
H3613020	55	201	134	124	152
H3923010	67	146	115	107	124
H4252010	40	180	132	102	160
H5723011	77	185	148	140	157
H7853010	40	216	107	88	126
H7913030	24	187	124	104	149
J2034010	5	300	83	61	98
J3024010	33	121	87	77	97
J4124420	20	156	85	62	105
J4712010	79	302	197	180	212
K0100020	765	1602	1174	1101	1255
K0253020	631	1281	951	878	1024
K0550010	440	1720	967	843	1098
K0614010	362	1307	661	513	752
K0744010	405	1344	758	654	841
K0753210	387	1628	866	678	1039
K0813020	372	1183	745	634	848
K0974010	355	886	569	483	647
K1173210	245	760	357	320	389
K2724210	341	1018	613	433	788
K2783010	291	1458	526	336	674
K5623010	168	313	212	196	226
K5653010	133	313	191	170	210
P3245010	117	445	279	196	360
U4305410	195	483	314	249	375
U4525210	169	797	327	257	374
V3315010	191	1355	639	446	806
V3517010	505	1391	893	736	1043
V6035010	315	1876	838	652	989
V6052010	180	1900	695	456	884
X2414030	1010	1640	1192	1095	1262
Y3514020	20	213	81	48	108
Y5615010	130	1760	1050	890	1242
Y5615030	10	1760	827	349	1180
Y5625020	10	1688	597	240	939

humidity, air temperature and wind speed. They are extrapolated over each catchment with Météo-France's SAFRAN code (Durand *et al.*, 1993), hence a single set of average climatic variables are given for each catchment. The hydrometric data consists of hourly and daily estimates of runoff depth at each catchment outlet.

Table 1 and Figs 3 and 4 indicate that the database is indeed representative of the hydrological regimes encountered in France. Figure 3 shows a rough linear trend

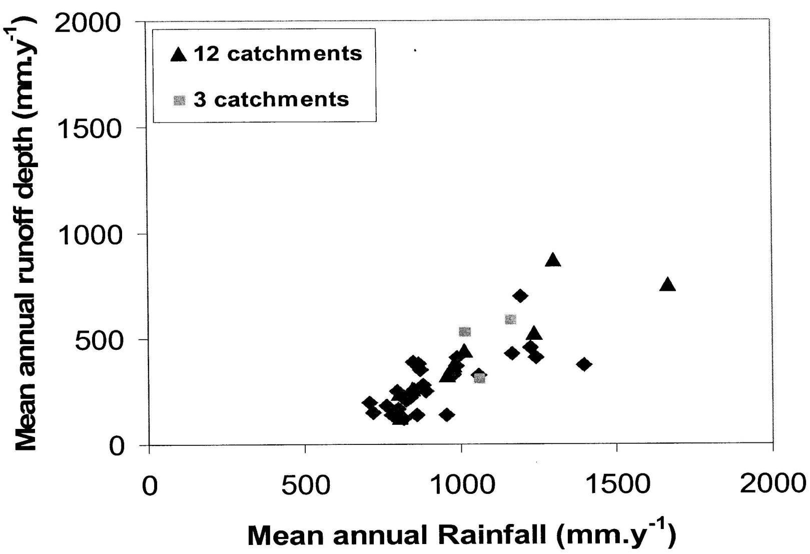

Fig. 3 Mean yearly rainfall *vs* runoff.

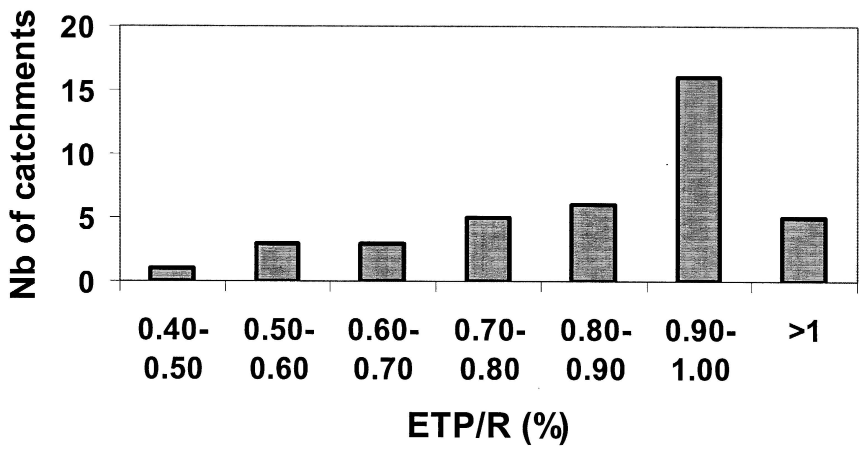

Fig. 4 Mean yearly aridity index distribution.

between the average annual rainfall and runoff depth. Analysis of the catchments' rainfall and runoff data over the 1995–2002 period indicates that the catchment receiving the least amount of rain is the Mauldre at Aulnay-sur-Mauldre (H7913030) with 711 mm year^{-1} whereas the wettest catchment is the Lauch at Guebwiller (A1522020) with 1665 mm year^{-1}. The mean annual evapotranspiration varies between 666 mm year^{-1} for the Ingressin at Toul (A5723010) and 1267 mm year^{-1} for the Artuby at La Bastide (X2414030). Not surprizingly, the highest evapotranspiration values are reported for the Mediterranean catchments.

Table 1 also indicates that the catchment producing the highest amount of runoff is the Yonne at Corancy (H2001020). The driest catchment in terms of runoff depth is the Lunain at Paley (H3613010). The mean runoff yield over the study period varies between 14% and 67%, with a mean value of 33%. Thus the selected catchments have moderate runoff coefficients with only 11 catchments transforming more than 40% of the mean rainfall input into runoff (Fig. 5).

Table 1 and Fig. 6 also present the long-term behaviour of these catchments, as reported in the Banque Hydro database. Figure 6 indicates that the highest value of peak discharge recorded for the majority of catchments does not exceed 25 $m^3 s^{-1}$. The highest values of peak discharge were recorded for the Loire at Bas en Basset (K0550010) and Goudet (K0100020). The third highest value is reported for the Ouvèze at Vaison la Romaine (V6052010). The Ouvèze is a tributary of the Rhone, the fastest of French rivers, and the largest tributary of the Mediterranean after the Nile. The peak discharge value reported corresponds to the 1992 flood.

Land use

Land-use percentages were calculated using the Corine Land Cover inventory (EEA, 1995), which is a homogeneous European land use database. The information is based

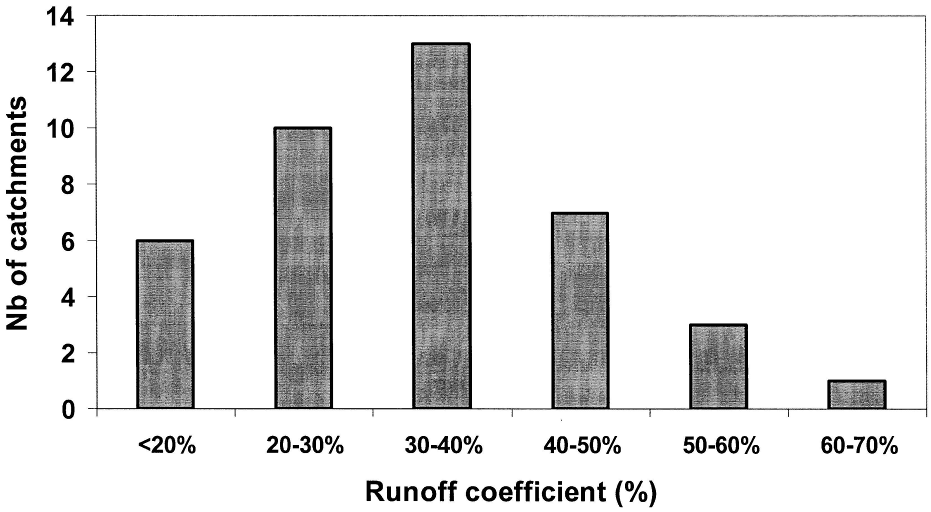

Fig. 5 Mean yearly runoff coefficient.

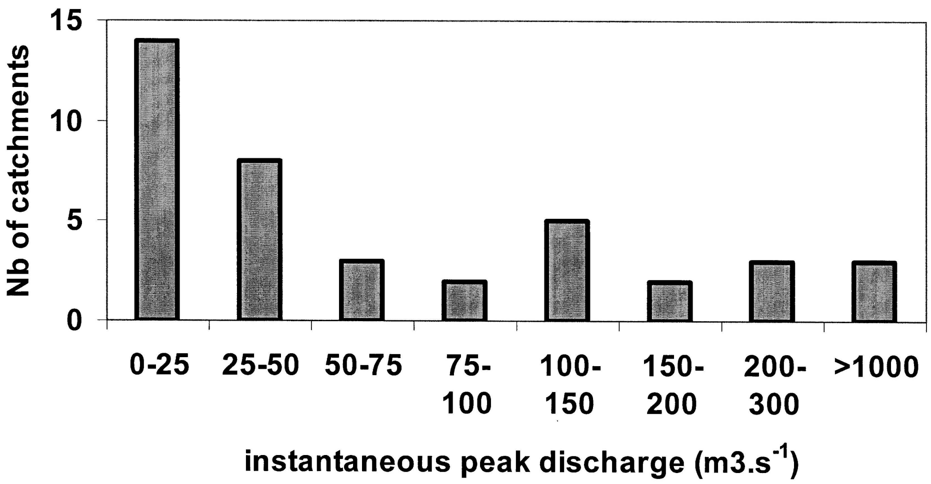

Fig. 6 Peak discharge distribution.

Table 3 Synthesis of main land use classes.

Catchment code	Urban fabric (%)	Indus-trial or comm ercial units (%)	Non irrigated arable land (%)	Vineyards and olive groves (%)	Fruit trees and berry plantations (%)	Pastures	Complex cultivation patterns (%)	Land principally occupied by agriculture, with significant area of natural vegetation (%)	Broad leaved forest (%)	Coniferous forest (%)	Mixed forest (%)	Natural grassland (%)	Moors and heath lands (%)	Sclero-phylous vegetation (%)	Trans-itional wood land-scrub (%)	Total (%)
A1522020	4	0	1	0	0	5	2	0	17	25	35	5	5	0	0	99
A5723010	4	3	11	0	0	9	7	7	51	2	4	0	1	0	0	100
H2001020	1	0	0	0	0	27	5	4	18	36	9	0	0	0	0	100
H2513110	1	0	59	0	0	2	11	5	21	0	1	0	0	0	0	100
H3613010	1	0	74	0	0	1	2	4	18	0	0	0	0	0	0	100
H3613020	1	0	70	0	0	1	2	3	22	0	1	0	0	0	0	100
H3923010	2	1	63	0	0	0	1	0	31	0	0	0	0	0	0	99
H4252010	14	2	49	0	0	0	0	0	28	3	1	0	0	0	0	97
H5723011	0	0	81	0	0	0	2	0	17	0	0	0	0	0	0	100
H7853010	3	0	75	0	0	0	1	1	21	0	0	0	0	0	0	100
H7913030	15	2	54	0	1	1	0	0	21	0	2	0	0	0	1	96
J2034010	1	0	43	0	0	1	35	17	3	0	0	0	0	0	0	100
J3024010	4	0	38	0	0	9	35	13	1	0	0	0	1	0	0	100
J4124420	1	0	16	0	0	10	51	15	7	0	0	0	0	0	0	100
J4712010	1	0	10	0	0	15	36	19	9	1	1	1	4	0	1	98
K0100020	0	0	0	0	0	26	8	5	8	25	5	15	5	0	2	99
K0253020	1	0	3	0	0	32	30	8	1	22	2	0	0	0	0	100
K0550010	1	0	1	0	0	33	15	8	2	26	7	3	2	0	1	99

Table 3 *(cont.)*

K0614010	14	9	0	0	0	30	10	8	8	12	3	0	0	0	0	95
K0744010	1	0	0	0	0	36	1	7	4	33	14	1	1	0	4	100
K0753210	1	0	0	0	0	31	1	6	4	33	10	4	4	0	5	100
K0813020	1	0	0	0	0	45	3	5	3	31	10	0	1	0	1	100
K0974010	3	0	1	0	0	54	16	10	4	5	6	0	0	0	0	100
K1173210	0	0	0	0	0	70	8	4	9	7	2	0	0	0	0	100
K2724210	23	3	1	0	0	18	14	16	4	1	10	0	6	0	1	98
K2783010	7	1	30	0	0	14	18	8	13	3	2	0	2	0	0	99
K5623010	0	0	32	0	0	53	2	4	9	0	0	0	0	0	0	100
K5653010	1	0	46	0	0	26	1	3	22	0	1	0	0	0	0	100
P3245010	1	0	1	0	4	23	38	10	21	3	1	0	0	0	0	100
U4305410	1	0	0	40	0	8	34	7	6	0	1	0	0	0	4	100
U4525210	11	1	0	36	0	6	30	6	9	0	0	0	0	0	0	100
V3315010	3	0	0	2	1	12	19	8	23	23	7	0	1	0	0	100
V3517010	1	0	0	0	0	32	5	5	6	37	11	0	1	0	2	100
V6035010	0	0	3	0	0	0	4	5	36	3	12	3	19	1	9	95
V6052010	1	0	2	6	0	0	10	6	26	13	11	1	12	4	5	97
X2414030	0	0	10	0	0	12	2	2	0	57	0	11	0	0	2	98
Y3514020	5	1	5	46	7	0	1	0	9	0	0	0	3	5	13	95
Y5615010	1	0	0	0	0	2	1	2	16	13	1	51	0	1	8	96
Y5615030	7	0	1	0	0	1	1	1	14	16	6	38	1	4	6	97
Y5625020	24	0	2	0	0	1	1	1	14	2	12	40	0	0	0	97

on Landsat MS and Spot XS satellite images which were later combined with aerial photographs, and topographic and forest maps by the French National Institute for the Environment (IFN) and the National Geographical Institute (IGN). The end product is a set of 1/100 000 scale digital maps with a 3-level nomenclature. The three levels are aggregated such that there are 5 classes in the first level, 15 in the second and 44 in the last. This level has the most detailed information. Table 3 summarizes the main land use classes, i.e. those occupying >5% of total area of the catchment, encountered on the 40 catchments selected for this study. The catchments retained for this study are not affected directly by urban activities. Pastures, non-irrigated arable land and coniferous forest cover the greatest areas when considering all the catchments (Fig. 7).

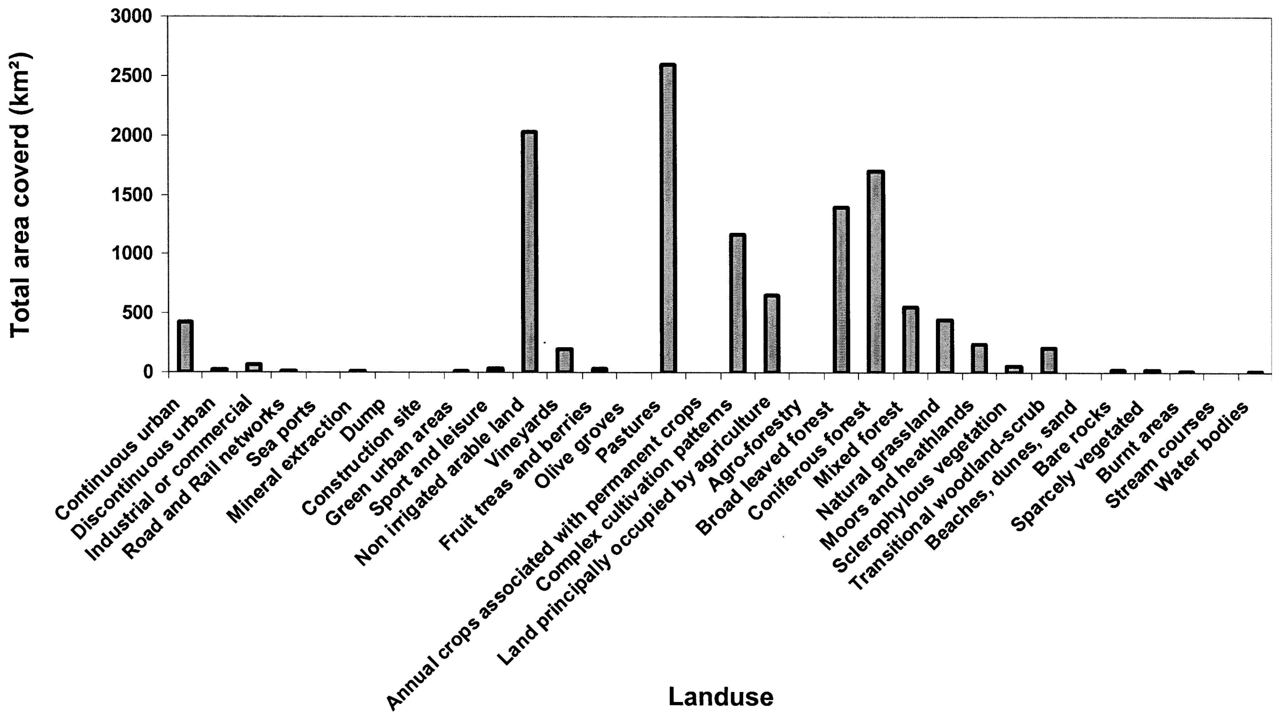

Fig. 7 Land use distribution.

Soil

The soil data consist of texture data derived from the 1/1 000 000 digital soil map compiled by the French National Institute for Agricultural Research (Dupuis, 1967; INRA, 2005). The maps are in vector form and correspond to five broadly defined texture classes. Although the data represented at this scale is rather crude, it is the only scale for which homogeneous and continuous soil information is available for the whole of continental France.

Each soil unit is organized into Soil Cartographic Units (SCU); this is the smallest geographic entity represented for a given scale. A SCU often groups several Soil Typological Units (STU). A STU is the smallest semantic entity according to a predefined nomenclature. At the 1/1 000 000 scale it is impossible to locate and delimit them. However, the SCUs are entities that can be localized in space and are composed of well-identified STUs.

Table 4 Minimum, maximum and median of land-use percentages.

Land use	Minimum percentage covered (%)	Maximum percentage of catchment area covered (%)	Median (%)
Urban fabric	0.1	24.1	1.2
Industrial or commercial units	0.0	9.1	0.0
Non irrigated arable land	0.0	80.6	3.0
Vineyards and olive groves	0.0	45.7	0.0
Fruit trees and berry plantations	0.0	6.9	0.0
Pastures	0.0	69.6	12.0
Complex cultivation patterns	0.1	50.8	4.9
Land principally occupied by agriculture, with significant area of natural vegetation	0.0	19.3	5.1
Broad leaved forest	0.0	51.5	9.1
Coniferous forest	0.0	57.0	3.1
Mixed forest	0.0	34.7	1.6
Natural grassland	0.0	50.9	0.0
Moors and heathlands	0.0	18.6	0.1
Sclerophylous vegetation	0.0	5.3	0.0
Transitional woodland-scrub	0.0	13.2	0.3

Table 5 Soil texture classification (Dupuis, 1967).

Texture	Composition
Coarse	Clay < 18% and sand > 65%
Moderate	18% < Clay < 35% and Sand > 15% or Clay < 18% and 15% < Sand < 65%
Moderately fine	Clay < 35% and Sand < 15%
Fine	35% < Clay < 60%
Very fine	Clay > 60 %

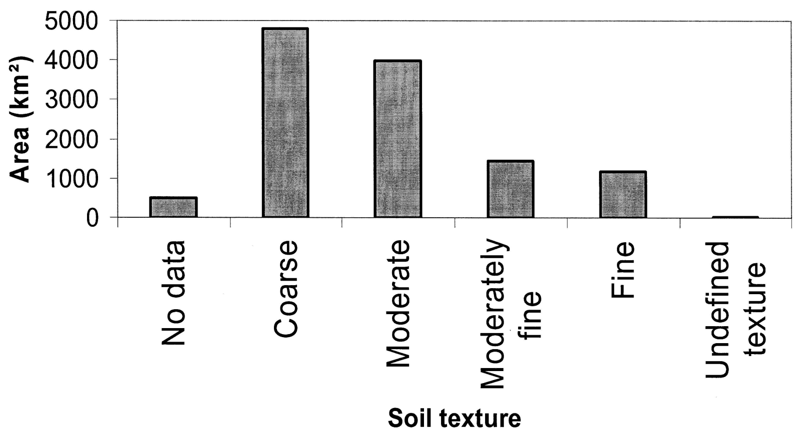

Fig. 8 Soil texture distribution.

Hence, the authors advise caution while using these maps, given the fact that "*the 1/100 000 scale limits the representation of the variability… The database should be used for projects effectively corresponding to the 1/1 000 000 scale i.e. for regional or national projects requiring a global reasoning on large landscape units*" (INRA, 2005). The texture defined on the maps corresponds to five classes, coarse, moderate, moderately fine, fine and very fine. Given the spatial resolution of the maps, the class limits are not determined precisely (Table 5). Determining a soil type or inferring soil hydrodynamic properties based on the data provided is not a straightforward process.

The two most represented texture classes are the coarse and moderate textures. The "moderately fine" class is the least represented while the "very fine" class is totally absent (Fig. 8).

CONCLUSION

A specific database containing both hourly and daily hydrometric and morphological data was compiled specially for the MOPEX 2004 workshop in Paris.

Although every effort has been made to ensure data quality, in some instances we were forced to use coarse resolution maps to produce a homogenous database. With the growing efforts into soil mapping, these problems should be easily overcome.

Acknowledgements The MOPEX workshop organization funds were provided by Cemagref's International Relations' department. The authors would like to thank Météo-France, the French Ministry of the Environment (Banque Hydro), Cemagref and ENGREF for hosting the 2004 workshop.

REFERENCES

Banque HYDRO (2004) Banque de données pour l'hydrométrie et l'hydrologie. http://hydro.rnde.tm.fr/.

Duan, Q., Schaake, J., Andréssian, V. *et al*. (2006) Model Parameter Estimation Experiment (MOPEX): An overview of science strategy and major results from the second and third workshops. *J. Hydrol.* **320,** 3–17.

Dupuis J. (1967) *Carte pédologique de la France* à 1/1 000 000. Editions INRA, France.

Durand, Y., Brun, E., Mérindol, L., Guyomarc'h, G., Lesaffre, B. & Martin E. (1993) A meteorological estimation of relevant parameters for snow schemes used with atmospheric models. *Ann. Glaciol.* **18**, 65–71.

European Environmental Agency (1995) *Corine Landcover*. EEA Report. Commission of the European Communities.

INRA (2005) http://gissol.orleans.inra.fr/programme/bdgsf/tarifs.php.

Schaake, J., Duan, Q., Smith, M. & Koren, V. (2000) Criteria to select basins for hydrologic model development and testing. Conference on Hydrology, AMS, Long Beach, California, USA.