Table 1. Summary of remote sensing techniques for soil moisture measurements [Engman and Gurney, 1991; Moran et al., 2004; Wang and Qu, 2009].

Spectrum domain	Physical processes	Primary information	Merits	Demerits
Optical – visible, near infrared, short-wave infrared (0.4 – 2.5 μm)	It is related to surface soil moisture as a function of spectral absorption features; for bare soil, drier soil generally has higher soil reflectance	Soil reflectance	High spatial resolution Wide coverage Multiple satellites available	Limited surface penetration (~ 1 mm) Limited capability of passing through cloud, and attenuated by Earth's atmosphere Infrequent revisit time Many other noise sources Strongly perturbed by meteorological conditions and vegetation coverage Physical processes not well understood
Thermal infrared (3.5 – 14 μm)	Soil moisture can increase both specific heat and thermal conductivity of the soil, hence soil temperature varies; for bare soil, fluctuations in land surface temperature are mainly affected by the variations of surface soil moisture	Land surface temperature	High spatial resolution Wide coverage Multiple satellites available Physical processes well understood	Limited surface penetration (~ 1 mm) Limited capability of passing through cloud and attenuated by Earth's atmosphere Infrequent revisit time Strongly perturbed by meteorological conditions and vegetation coverage
Microwave: passive (1– 30 cm)	Microwave emissivity is related to soil moisture at Earth surface, due to the large dielectric constant difference between dry soil (< 5) and water (~ 80); for bare soil, wetter soil normally shows lower brightness temperature (i.e., less emissivity)	Brightness temperature Dielectric properties	Wide coverage Multiple satellites recently available Low atmospheric noise Moderate surface penetration (up to 5 cm) Physical processes well understood	Low spatial resolution (~ 30 km) Perturbed mainly by surface roughness, vegetation coverage and incidence angle
Microwave: active (1– 30 cm)	Based on the empirical relationships that relate the radar measured backscattering coefficient to volumetric soil moisture, which is linked to the dielectric constant difference between dry soil and water; for bare soil, wetter surface soil has higher backscattering coefficient	Backscattering coefficient Dielectric properties	High spatial resolution Multiple satellites recently available Low atmospheric noise Moderate surface penetration (up to 5 cm) Physical processes well understood	Limited swath width Perturbed mainly by surface roughness, vegetation coverage and incidence angle

Table 2. The XAJ model parameters used in the Pontiac catchment.

Symbol	Model parameters	Unit	Optimal value	Range
Runoff generating parameters				
K	Ratio of evapotranspiration	[-]	0.56	0.10-1.20
WUM	The capacity of areal mean tension water storage in the upper layer	mm	46.96	30-50
WLM	The capacity of areal mean tension water storage in the lower layer	mm	39.08	20-150
WDM	The capacity of areal mean tension water storage in the deep layer	mm	30.11	30-400
IMP	Percentage of impervious and saturated areas in the catchment	%	0.00	0.00-0.10
B	Exponential parameter with a single parabolic curve, which represents the non-uniformity of the spatial distribution of the soil moisture storage capacity over the catchment	[-]	0.70	0.10-0.90
C	Coefficient of the deep layer that depends on the proportion of the catchment area covered by vegetation with deep roots	[-]	0.49	0.10-0.70
Routing parameters				
SM	Areal mean free water capacity of the surface soil layer, which represents the maximum possible deficit of free water storage	mm	31.48	10-50
KG	Outflow coefficient of the free water storage to groundwater relationship	[-]	0.10	0.10-0.70
KSS	Outflow coefficient of the free water storage to interflow relationship	[-]	0.19	0.10-0.70
KKG	Recession constant of the groundwater storage	[-]	0.31	0.01-0.99
KKSS	Recession constant of the lower interflow storage	[-]	0.01	0.01-0.99
CS	Recession constant in the lag and route method for routing through the channel system within each sub-catchment	[-]	0.26	0.10-0.70
EX	Exponent of the free water capacity curve influencing the development of the saturated area	[-]	1.93	1.10-2.00
L	Lag in time	[-]	0.00	0.00-6.00
V	Parameter of the Muskingum method	m/s	0.43	0.40-1.20
dX	Parameter of the Muskingum method	[-]	0.18	0.00-0.40

Table 3. The definitions of the four states of the soil moisture. Note: 'water' refers to liquid water only (water vapour is not considered).

States	Definition
Saturation	Soil pores are filled with water
Field capacity	A measure of soil water holding capacity such that any excess water will not be held for a very long time by soil particles (e.g., 50% of soil pores are filled with water, mainly depends on soil properties and catchment conditions)
Wilting point	The minimal point of soil moisture for the vegetation to survive (e.g., 20% of soil pores are filled with water), and its value is highly related to vegetation cover
Total dryness	Soil pores do not contain any liquid water