

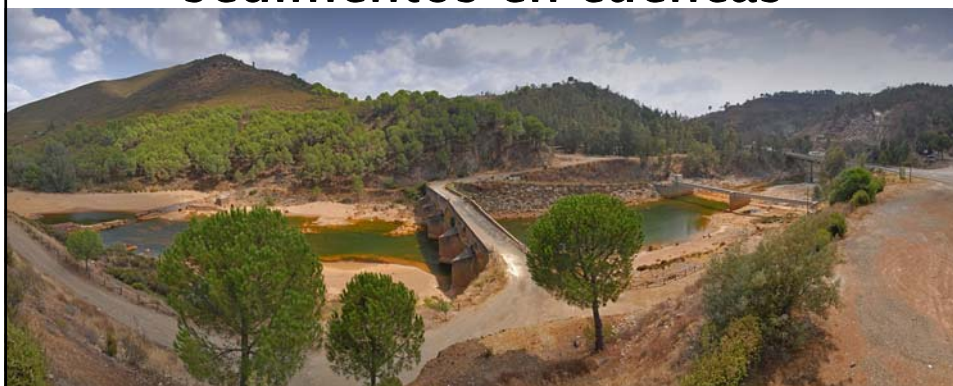


II ENCUESTRO SOBRE RESTAURACIÓN HIDROLÓGICO-
FORESTAL UVA-UCAV



2016

Manejo del programa SWAT para la emisión de sedimentos en cuencas



SWAT

¿QUE ES SWAT?

S = Soil
&
W = Water
A = Assessment
T = Tool

Herramienta de evaluación de suelo y agua

Dr. Jeff Arnold en 1990 (ARS)

SWAT**¿QUE ES SWAT?**

Software de modelización y predicción:

- Impacto que tiene el manejo del suelo sobre:
 - El ciclo hidrológico
 - La producción de sedimento
 - La difusión de sustancias químicas
- Impacto que tiene los tratamientos culturales del suelo sobre la calidad del agua.

En cuencas grandes

SWAT**¿QUE ES SWAT?**

¿Porque es un modelo de amplia difusión?:

- Trabaja con cuencas hidrográficas complejas
- Es un modelo con base física
- Es eficiente a nivel computacional
- Usa los registros de entrada reales
- Apoyado por la comunidad científica = más desarrollo

SWAT**¿QUE ES SWAT?**

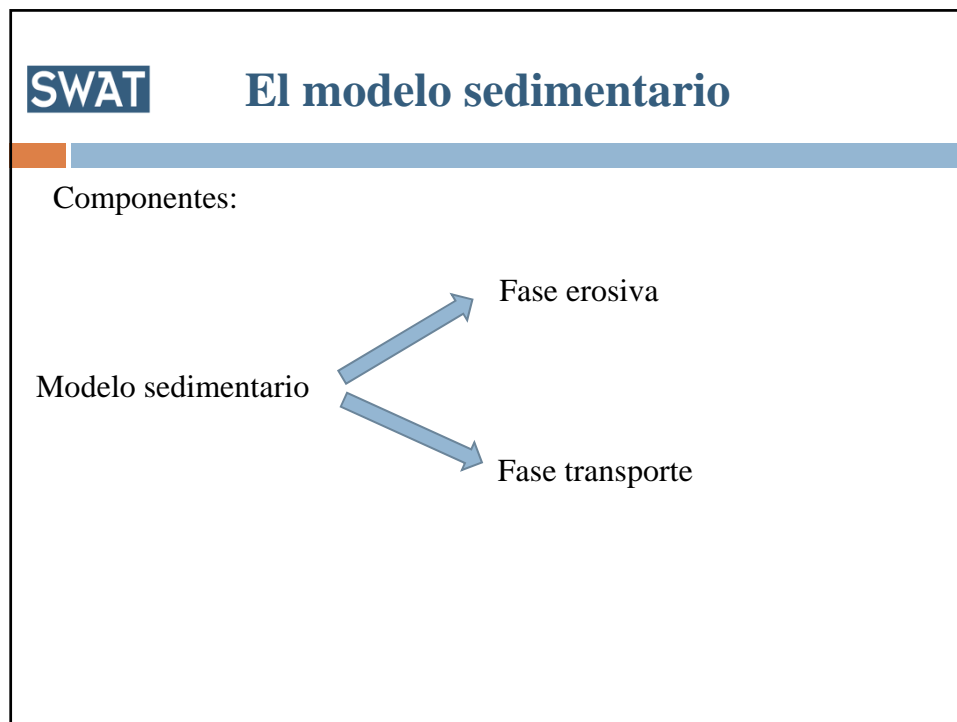
SWAT se compone de submodelos o módulos:

- Hidrológico
- Sedimentario
- Crecimiento de cultivos
- Ciclo de nutrientes
- Dinámica de pesticidas
- Gestión agrícola

SWAT**El modelado**

El modelado con SWAT requiere de 6 pasos:

- Delimitación de la cuenca y subcuencas
- Definición de las HRU
- Incorporación de los datos climáticos
- Edición de los datos de entrada del modelo
- Simulación
- Calibración y validación



SWAT El modelo sedimentario

Fase erosiva:

MUSLE (William, 1972):

$$sed = 11.8 \cdot (Q_{surf} \cdot q_{peak} \cdot area_{hru})^{0.56} \cdot K_{USLE} \cdot C_{USLE} \cdot P_{USLE} \cdot LS_{USLE} \cdot CFRG$$

Caudal punta (Método racional):

$$q_{peak} = \frac{C \cdot i \cdot Area}{3.6}$$

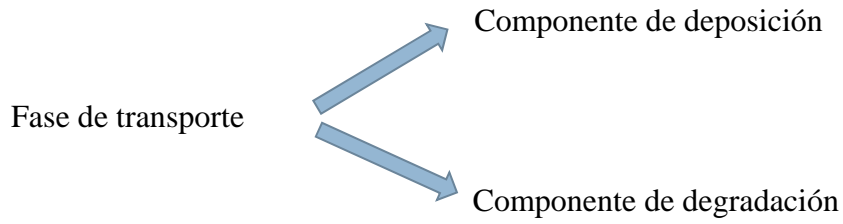
Factor C diario:

$$C_{USLE} = \exp(\ln(0.8) - \ln(C_{USLE,m})) \cdot \exp[-0.00115 \cdot rsd_{surf}] + \ln[C_{USLE,m}]$$

SWAT

El modelo sedimentario

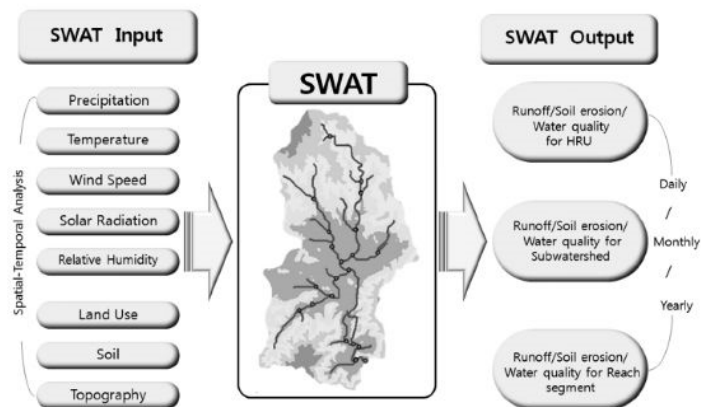
Fase transporte:

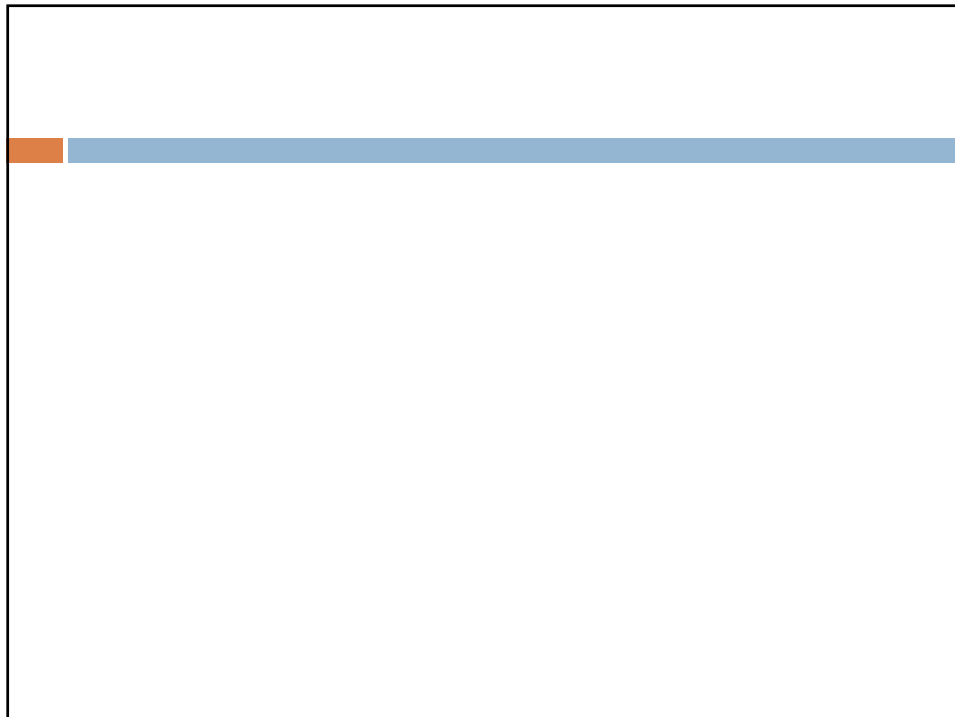
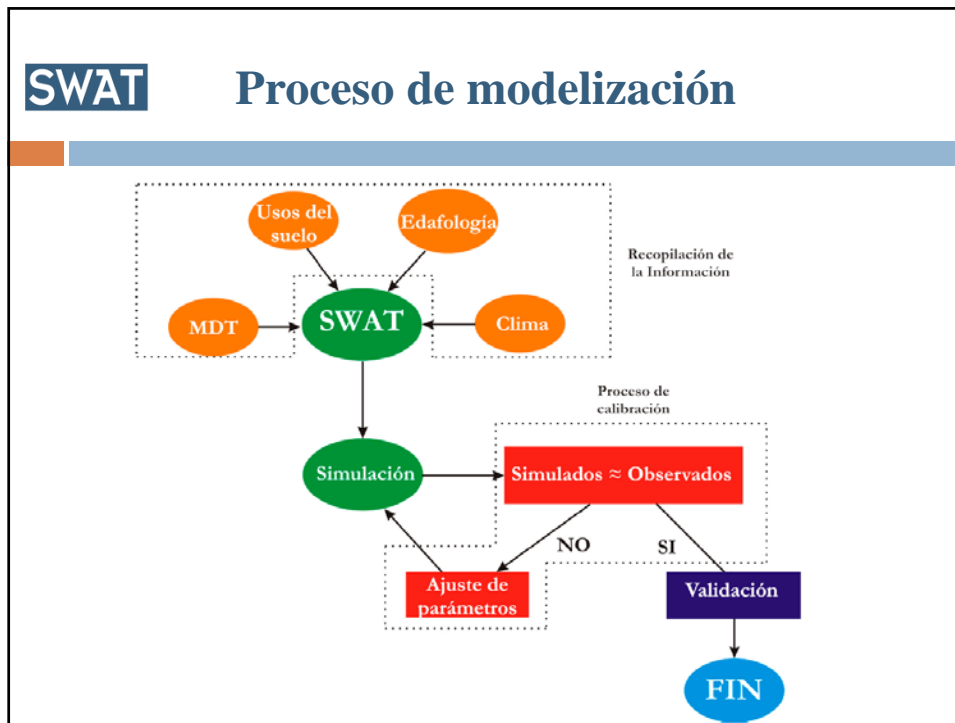


$$S_{OUT} = S_{IN} - S_D + D_T$$

SWAT

Entradas y salidas





SWAT

Salida de SWAT

sub	YEAR	MCN	AREA(KM2)	PRECIP(mm)	SNOWMELT	PET(mm)	ET(mm)	STFLOW	PERC(%)
sub	1977	1	11.95	29.048	0	47.566	18.688	115.937	0
sub	1977	1	11.94	29.132	0	47.707	18.744	115.411	0
sub	1977	1	14.13	29.358	0	48.079	18.887	115.393	0
sub	1977	1	23.54	29.327	0	48.023	18.868	115.42	0
sub	1977	1	32.14	28.796	0	47.153	18.526	115.403	0
sub	1977	1	4.86	29.367	0	48.114	18.126	116.778	0
sub	1977	1	26.79	29.153	0	47.706	18.15	115.938	0
sub	1977	1	40.07	29.268	0.3	49.554	19.161	115.1	0
sub	1977	1	45.28	29.271	0.3	49.569	19.034	114.345	0
sub	1977	1	18.59	29.38	0.3	49.766	18.327	129.265	0
sub	1977	1	92.84	29.107	0.3	47.186	17.242	116.908	0
sub	1977	1	16.7	29.163	0.3	49.41	19.25	150.556	0
sub	1977	1	39.68	29.227	0.3	49.531	18.54	141.709	0
sub	1977	1	18.74	29.286	0.3	49.791	21.555	166.342	0
sub	1977	1	31.79	29.368	0.3	49.578	18.028	125.917	0
sub	1977	1	15.79	29.334	0.3	53.831	27.582	251.524	0
sub	1977	2	13.95	43.483	0	73.931	32.842	146.729	0
sub	1977	2	11.94	43.593	0	74.149	32.947	146.829	0
sub	1977	2	34.13	43.948	0	74.722	33.134	146.697	0
sub	1977	2	23.54	43.899	0	74.64	33.167	146.867	0
sub	1977	2	32.14	43.067	0	73.287	32.56	146.791	0
sub	1977	2	4.86	43.943	0	74.773	29.244	144.605	0
sub	1977	2	26.79	43.626	0	74.22	30.343	145.2	0
sub	1977	2	40.07	43.791	0	75.456	32.908	146.756	0
sub	1977	2	45.28	43.812	0	75.462	32.536	146.18	0
sub	1977	2	18.59	43.961	0	75.778	27.918	141.048	0
sub	1977	2	92.84	43.555	0	73.02	32.738	144.469	0
sub	1977	2	16.7	43.642	0	75.23	33.07	162.206	0
sub	1977	2	39.68	43.742	0	75.409	29.841	134.746	0
sub	1977	2	18.74	43.835	0	77.677	33.314	179.136	0
sub	1977	2	31.79	43.807	0	75.49	27.208	141.492	0
sub	1977	2	15.79	43.591	0	82.817	42.815	266.3	0
sub	1977	3	13.95	51.53	0	136.334	50.96	144.625	0
sub	1977	3	11.94	51.679	0	137.236	51.129	144.777	0
sub	1977	3	34.13	52.081	0	136.292	51.5	144.544	0

SWAT

Salida de SWAT

SWAT May 20 2015 VER 2015/Rev 637
 General Input/Output section (File, Ctrl):
 6/14/2016 12:00:00 am ARCCIS-SWAT Interface av

Number of years to run: 2
 Area of watershed: 486.830 km2

SWAT May 20 2015 VER 2015/Rev 637
 General Input/Output section (File, Ctrl):
 6/14/2016 12:00:00 am ARCCIS-SWAT Interface av

Annual summary for watershed in year 1 of simulation

UNIT	PREC	SURF	LATO	PERCO	TILE	SW	ET	PET	WATER	SED	NO3	NO3	NO3	NO3	ORGANIC	N	P	P
TIME	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
1	29.70	0.19	0.07	0.00	0.00	0.00	146.10	18.37	74.89	0.31	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	41.80	1.95	0.00	0.00	0.00	28.81	15.79	29.368	52.19	0.02	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00
3	107.70	24.42	0.18	0.00	1.44	0.00	171.00	36.15	142.78	24.77	1.15	0.02	0.00	0.11	11.01	2.89	0.02	0.29
4	197.10	71.92	0.00	1.21	0.01	0.00	198.00	95.34	181.18	82.57	0.00	0.00	0.00	0.71	49.09	1.30	0.02	0.14
5	111.80	0.00	0.13	2.09	0.35	0.00	81.34	130.30	213.13	14.09	0.00	0.00	0.00	0.01	1.44	0.02	0.00	0.00
6	493.00	197.82	0.18	0.00	0.00	0.00	44.44	11.94	42.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	18.00	0.00	0.04	0.07	0.05	0.00	31.80	64.21	181.20	11.34	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	112.60	11.15	0.26	0.00	0.00	0.00	50.80	84.21	181.20	11.34	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	151.00	134.14	0.24	0.11	0.76	0.00	275.11	98.49	191.79	147.03	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.11
10	146.40	7.80	0.23	1.82	1.43	0.00	189.11	33.69	87.50	11.73	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.02
11	112.80	32.64	0.22	2.48	1.42	0.00	227.64	23.46	34.79	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06

1977 1160.80 288.11 1.87 8.52 27.23 0.00 227.64 737.44 1647.09 299.00 2.50 0.18 0.01 3.40 81.43 3.73 0.05 0.71 0.0

SWAT May 20 2015 VER 2015/Rev 637
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Annual summary for watershed in year 2 of simulation

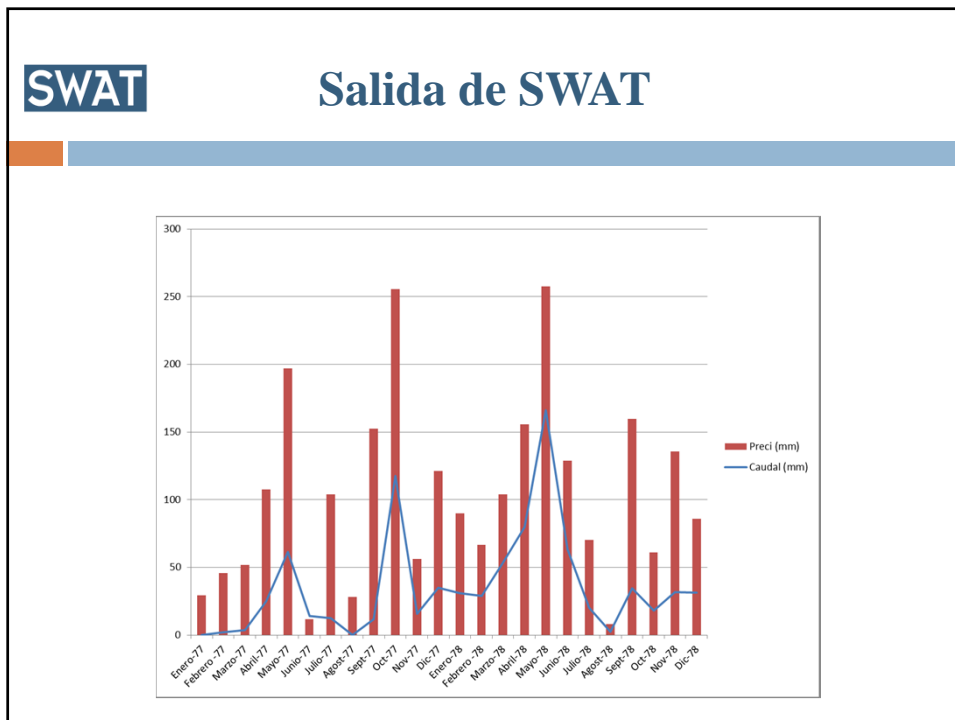
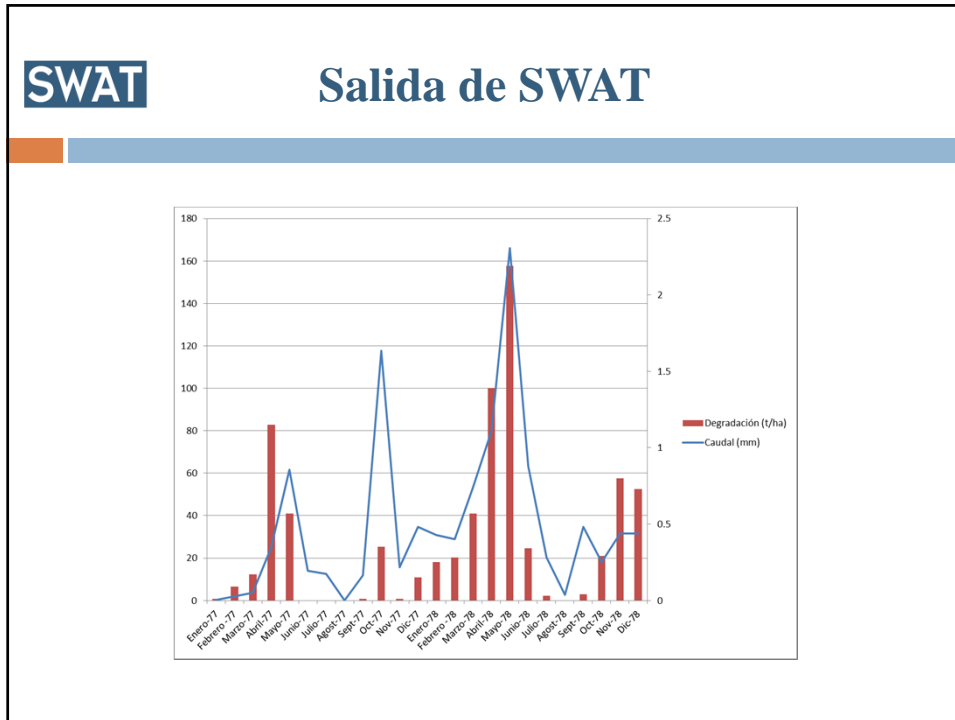
UNIT	PREC	SURF	LATO	PERCO	TILE	SW	ET	PET	WATER	SED	NO3	NO3	NO3	NO3	ORGANIC	N	P	P
TIME	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)
1	49.80	26.90	0.17	0.42	2.71	0.00	231.13	21.74	80.84	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	103.90	17.29	0.13	5.40	24.32	0.00	231.99	38.21	121.59	29.18	0.17	0.02	0.00	2.09	0.00	0.00	0.00	0.00
3	102.00	8.51	0.18	7.91	15.08	0.00	214.29	38.21	121.59	29.18	0.17	0.02	0.00	0.00	0.00	0.00	0.00	0.00
4	237.40	136.47	0.19	21.80	54.48	0.00	214.14	88.42	142.45	168.28	2.19	0.14	0.00	0.41	1.41	4.90	0.02	0.41
5	139.70	12.15	0.27	79.43	1.00	0.00	255.08	125.34	154.31	61.11	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	70.40	8.52	0.17	10.15	0.03	0.00	194.31	110.50	217.08	20.16	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01
7	8.20	0.02	0.04	0.08	0.10	0.00	135.70	74.20	136.31	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	145.00	16.45	0.17	0.98	1.19	0.00	162.79	89.10	118.01	18.09	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	151.00	134.14	0.24	0.11	0.76	0.00	275.11	98.49	191.79	147.03	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	146.40	7.80	0.23	1.82	1.43	0.00	189.11	33.69	87.50	11.73	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.02
11	112.80	32.64	0.22	2.48	1.42	0.00	227.64	23.46	34.79	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.06

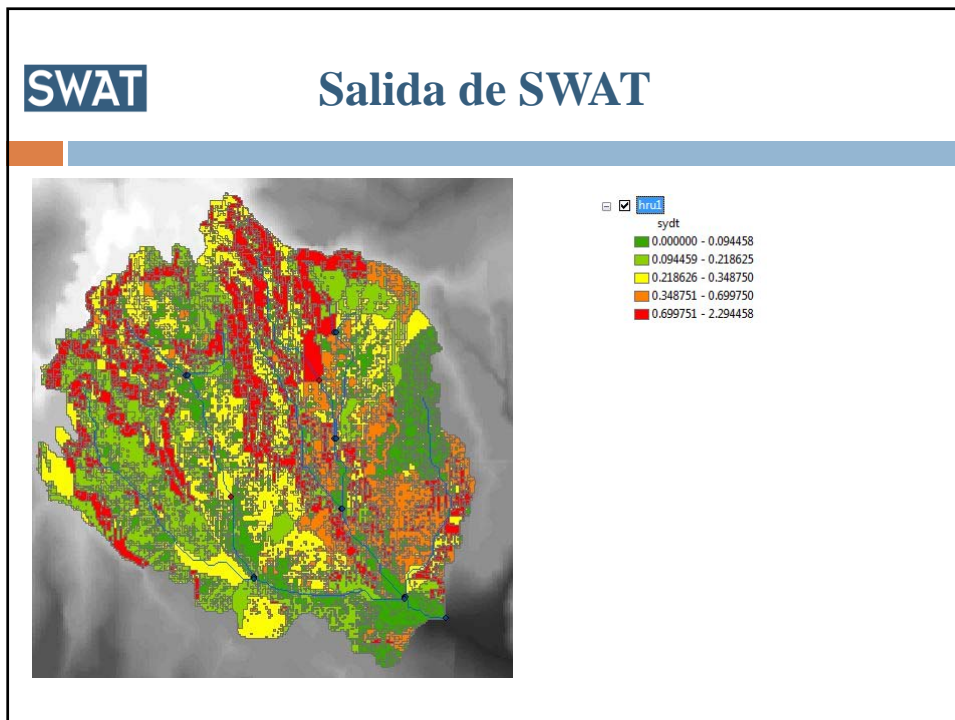
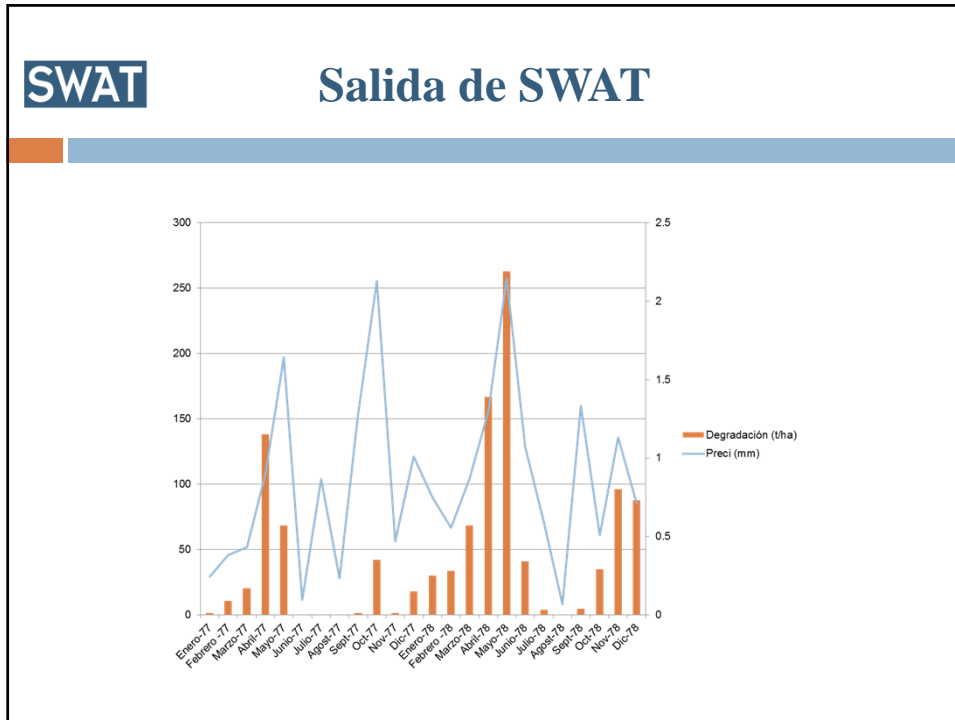
1978 1133.00 432.22 2.04 118.09 184.08 0.00 226.34 715.67 1537.44 561.46 6.91 0.28 0.00 7.66 8.28 14.82 0.08 2.83 0.0

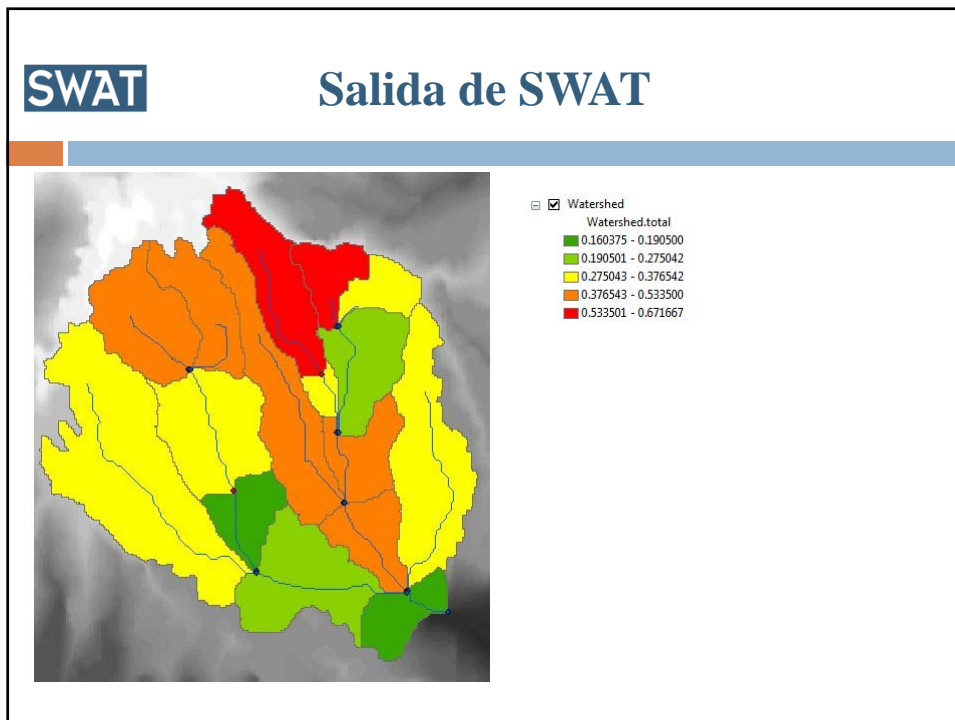
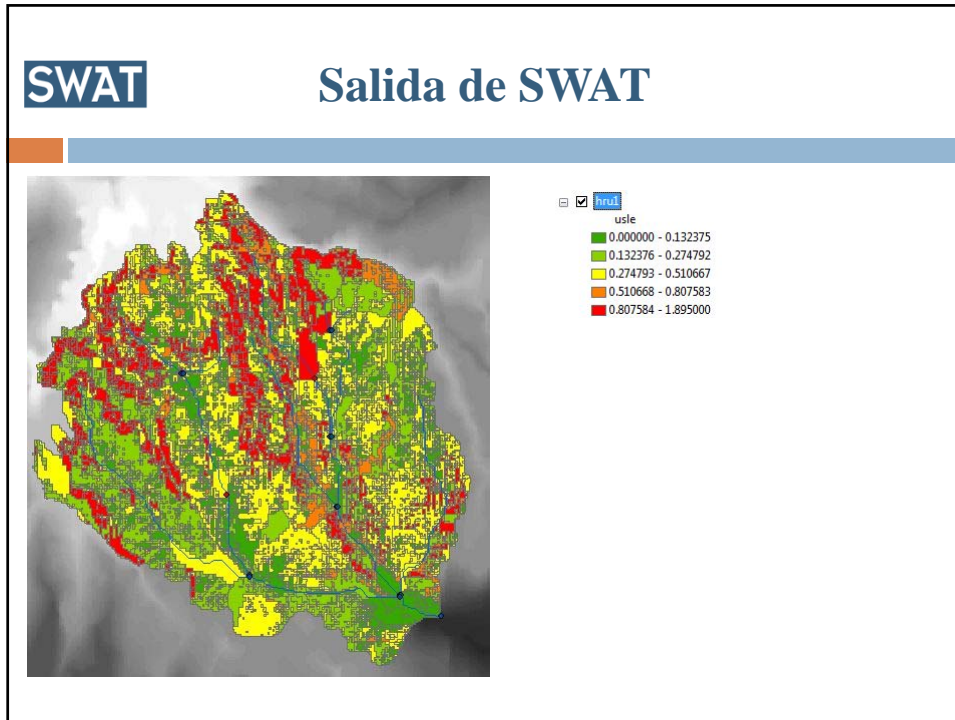
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FINAL VALUES

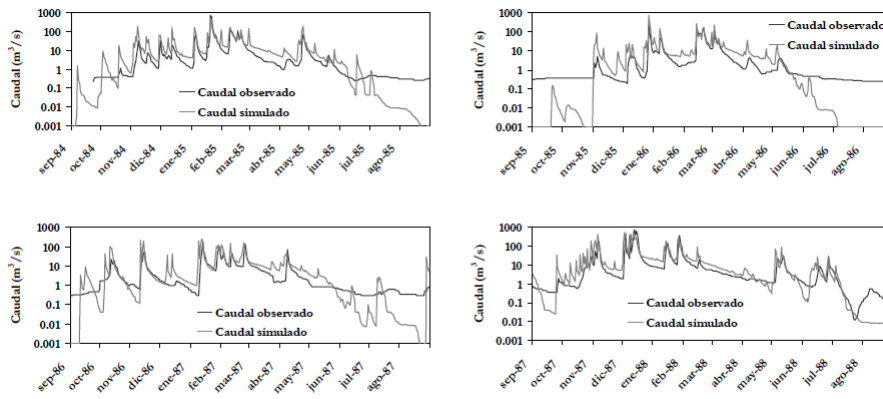
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 General Input/Output section (File, Ctrl):





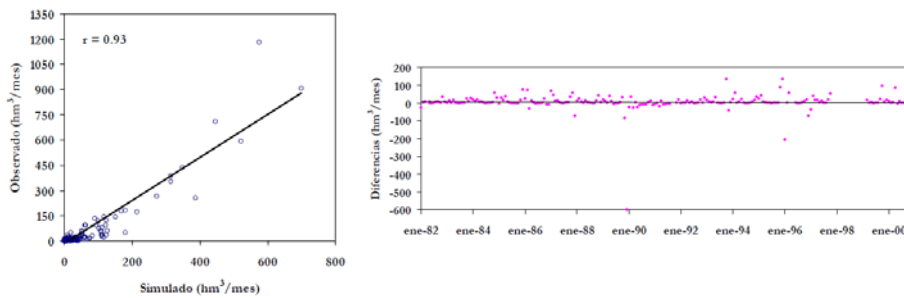


SWAT Ejemplo con Calibración- Validación



Calibración con SWAT-CUP = Análisis de sensibilidad

SWAT Ejemplo con Calibración - Validación



Calibración con SWAT-CUP = Análisis de sensibilidad

SWAT Ejemplo con Calibración - Validación

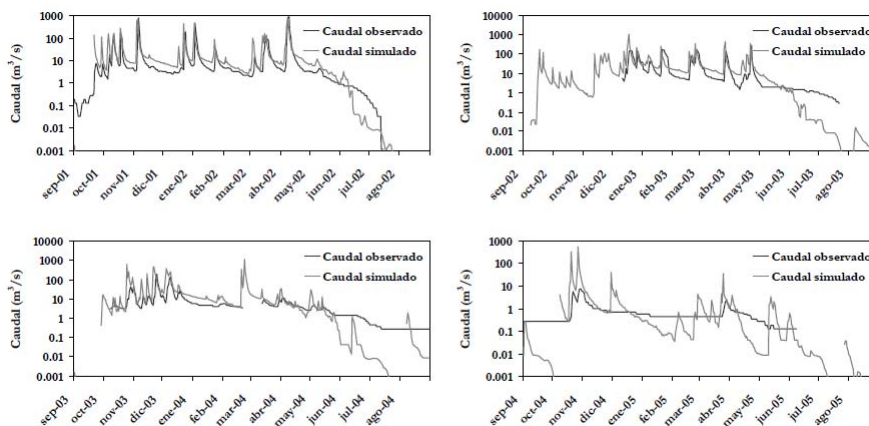
Odiel.

Variable	Subcuencas:	Subcuencas:	Subcuencas:	Resto de subcuencas
	1, 2, 6, 9, 14 y 21	41, 42, 43, 46, 50 y 51	45 y 47	
ALPHA_BF	0.2	1	0.02	0.95
GW_REVAP	0.055	0.1055	0.02	0.02
SHALLST	-	0	0	-
GWQMN	150	292.5	0	423
REVAPMN	30	442.5	0	383
GW_DELAY	41	0.025	0	0.27
RCHRG_DP	-	0.2	0	0
CN2	-25%	-30%	-30%	-
ESCO	-	0.01	0.01	0.31
SOL_AWC	20%	+ 0.04 ud.	+ 0.04 ud.	-

Reajuste de parámetros del modelo

SWAT Ejemplo con Calibración - Validación

Validación con algunos años reservados



SWAT Ejemplo con Calibración - Validación

Estadísticos de validación

del río Odiel.

Índice	Diario	Mensual
Coefficiente de correlación de Pearson (r)	0.76	0.87
Coefficiente de eficiencia de Nash y Sutcliffe (NSE)	0.57	0.70
Error cuadrático medio (RMS, m ³ /s)	42.37	24.28
Desviación del volumen de escorrentía (DV)	1.10	1.10