Large wetlands representation in SWAT+: The case of the Pantanal in the Paraguay River Basin

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Hydrologic components in floodplains

Floodplains and channels are connected

Flooding (If Vbankfull < Vin: Overbank)

Evaporation + seepage

Floodplain – Channel representation in SWAT+

Overbank volume calculation

When the water volume in the channel surpasses its capacity, additional water will flow onto the floodplain area

$$V_{ob} = \frac{1}{2} \times \frac{(peakrate - vel_{bf}) \times vel_{bf}}{peakrate \times l_{base}}$$

Implementing the floodplain-channel interaction

- Deliniate floodplains.
- Set the HRUs within the floodplains as wetlands.
- Connect the floodplain LSUs to the channel (chan-surf.lin file).
- Use DT to control wetland release.
- Parametisation of wetland paramaters.

```
hydrology.wet: written by SWAT+ editor v2.3.3 on 2024-03-05 13:49 for SWAT+ rev.60.5.7
name                hru_ps        dp_ps        hru_es        dp_es           k         evap
hydwet0066         0.10000     800.00000      0.25000    30000.00000     0.01000     0.00000
hydwet0074         0.10000     800.00000      0.25000     1500.00000     0.00000     0.00000
hydwet0330         0.10000     800.00000      0.25000     1500.00000     0.00000     0.00000
hydwet0352         0.10000     800.00000      0.25000     1500.00000     0.00000     0.00000
hydwet0353         0.10000     800.00000      0.25000     1500.00000     0.00000     0.00000
```


Emergency spillway

Principal spillway

Volume to emergency spillway

dp_es

Volume to principal spillway

dp_ps

Volume of permanent storage

Paraguay River Basin case

Studied Area

1. Watershed discretized into 305 sub-basins; 607 LSUs, and 6225 HRUs.
2. Simulated area: 631,300 km²
3. Average PCP: 1140 mm
4. Average Streamflow: 5500 m3/s.
5. Average temperature between 18 and 22 °C.
6. Very flat topography: presence of the Pantanal.
7. Simulation period 1987-2020 (3 years warm up)
8. Floodplain delimitation: slope position method.

Pantanal: a complex system

1. Largest tropical wetland in the world (140,000 km2)
2. The water dynamics regulates the landscape, vegetation dynamics, and biogeochemical procesees.
3. Flood waves flowing along the pantanal are strongly dampened because of the water spilling over the main channel that inundates the floodplain.
4. Flood wave propagates along hundreds of kilometers of the main channel and interacts with other floodplains.

Monthly mean (1990-2020) rainfall and streamflow

Hydrologic Gauge	NSE	Pbias	COR	KGE
Caceres	0.72	0.51	0.85	0.84
Porto Murtinho	0.47	-6.11	0.71	0.55
Asuncion (outlet)	0.56	-8.94	0.79	0.57

Floodplain Storage

- Simulated annual storage average 1.24×10^{10} m^3

- 61% of the surface runoff flows through the pantanal.

- Total Water Storage in greater than the streamflow during the first months.

Average floodplain Water Storage and discharge at the outlet

Floodplain effect shifts and reduces peak flow

Comparison SWAT+ floodplain effect vs SWAT+ with no floodplain effect

Conclusion

- The simulated results ranged from satisfactory to good, physical processes are well simulated.

- The discretization of the watershed into LSUs and the inclusion the floodplain effect improved the simulation of discharge.

- New model outputs were added, including the total water stored in wetlands, LSUs, and HRUs.

- Maximum water storage occurs between March and April, with the annual average storage of water in the floodplain being approximately 1.24×10^{10} m^3

- Approximately 61% of the surface water travels along the floodplain before reaching the outlet, highliting the importance on regulating the flooding.

- Results suggest that SWAT+ is capable of satisfactorily representing the hydrology of the Paraguay River Basin.

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Thank you! Merci! Gracias! ありがとう!

Questions?

```
chan-surf.lin:  Channel Floodplain      Linkage
  305
NUMB     NAME    NSPU     OBTYP    OBTYP_N0
1        cha001  1        ru       1
2        cha002  1        ru       3
3        cha003  1        ru       5
4        cha004  1        ru       7
5        cha005  1        ru       9
6        cha006  1        ru       11
7        cha007  1        ru       13
```

Upland-Floodplain pairs

Routing unit number

```
rout_unit.con: written by SWAT+ editor v2.3.3 on 2024-03-05 13:49 for SWAT+ rev.60.5.7
     id  name              gis_id       area        lat          lon         elev      rtu
      1  rtu0011              11    2600.00000   -24.64054   -57.17290    62.14423        1
      2  rtu0012              12   48875.00000   -24.60115   -57.07905    68.93964        2
      3  rtu0021              21   12475.00000   -24.40817   -57.17317    64.65531        3
      4  rtu0022              22  155950.00000   -24.40775   -56.99078    94.74463        4
```

Routing unit 2 is the upland: sends water to routing unit 1 (floodplain)

```
obj_id    hyd_typ        frac
   1        tot     1.00000     aqu     606     rhg     1.00000
   1        sur     0.95000      ru       1     sur     0.05000      ru       1    lat    1.00000     aqu    607    rhg    1.00000
   2        tot     1.00000     aqu     604     rhg     1.00000
   2        sur     0.93000      ru       3     sur     0.07000      ru       3    lat    1.00000     aqu    605    rhg    1.00000
```

Channel ID

Parameter	Description	Final Value
flo_min	Threshold required for return flow to occur (meters)	10.0
sp_yld	Ratio of the volume of water drained by gravity (fraction)	0.15
alpha	Baseflow recession constant (days)	0.007
revap_min	Threshold depth of water in the shallow aquifer for evap to occur	0.02
revap_co	Groundwater revap coefficient	0.01
fpn	Floodplain roughness coefficient	0.07
dp_ps	Wetland's depth to the principal spillway (meters)	0.8
dp_es	Wetland's depth to the emergency spillway (meters)	from 1.5 to 3.0
deep_seep	Deep aquifer percolation fraction	0.001

Codes.bsn
i_fpwet = 0 (no floodplain effect)
i_fpwet = 2 (floodplain effect)

Comparison SWAT+ floodplain effect vs SWAT+ with no floodplain effect