Organic carbon and nitrate transfers at a watershed scale with the SWAT+ model using landscape units: application to a large watershed in France

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Presented by Clément Fabre
Riparian zones: Powerful water cleaners

\[ 5(\text{CH}_2\text{O}) + 4\text{NO}_3^- + 4\text{H}^+ \rightarrow 5\text{CO}_2 + 2\text{N}_2 + 7\text{H}_2\text{O} \]

Riparian zones impacts on the nitrogen cycle
(Pinay et al., 1998; Sánchez-Pérez et al., 2003; Sun et al., 2015)

Riparian zones:
40% of nitrates consumed by denitrification at a watershed scale
(Seine: Pacsy et al., Garonne: Sun et al., 2015)
Objectives

• Characterize hotspots of denitrification in the alluvial plain of an agricultural catchment

• Quantify the effect of riparian zones on the nitrogen cycle
The Garonne River

- Area: $\approx 55,000$ km$^2$
The Garonne River

- Average discharge: \( \approx 650 \text{ m}^3\text{s}^{-1} \)

- Nitrate concentration: 9.3 mg.L\(^{-1}\)

*Portail Adour-Garonne*
The Garonne River: An agricultural catchment

Legend
- Gauging stations for calibration
- Main streams

Land use type

<table>
<thead>
<tr>
<th>Land use type</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>43 %</td>
</tr>
<tr>
<td>Forest</td>
<td>32 %</td>
</tr>
<tr>
<td>Pasture</td>
<td>16 %</td>
</tr>
</tbody>
</table>
SWAT+ advantages for this study

- Delineation of the floodplain directly in the setup of the project
SWAT + advantages for this study

• 3 methods
SWAT + advantages for this study

• 3 methods
SWAT + advantages for this study

- 3 methods
Alternative: SWAT - LUD

- Landscape Units as in SWAT + with Darcy's law

\[ Q = KA \frac{\Delta H}{L} \]
Alternative: SWAT - LUD

- Landuse and soil dependant
Alternative : SWAT - LUD

- Landuse and soil dependant
Calibration (NSE: 0.58, R²: 0.85, PBIAS: -32.67, RSR: 0.65)

Validation (NSE: 0.54, R²: 0.84, PBIAS: -30.65, RSR: 0.68)

Standard

Calibration (NSE: 0.76, R²: 0.86, PBIAS: -19.99, RSR: 0.49)

Validation (NSE: 0.74, R²: 0.84, PBIAS: -18.15, RSR: 0.51)

LUD

Discharge (m³·s⁻¹)

2001 2003 2005 2007 2009 2011

Simulated discharge

Observations
Calibration (NSE: 0.58, $R^2$: 0.85, PBIAS: -32.67, RSR: 0.65)
Validation (NSE: 0.54, $R^2$: 0.84, PBIAS: -30.65, RSR: 0.68)

Standard

DECREASING

2003 2005 2007 2009 2011

2001 2003 2005 2007 2009 2011

Simulated discharge
Observations

Simulated discharge
Observations

LUD

DECREASING & DELAY
Daily time step

Standard

LUD
Daily time step

Standard

LUD

Calibration (NSE: -1.99, $R^2$: 0.18, PBIAS: -31.85, RSR: 1.73)
Validation (NSE: -1.77, $R^2$: 0.19, PBIAS: -30.37, RSR: 1.66)

Calibration (NSE: -1.98, $R^2$: 0.14, PBIAS: -19.51, RSR: 1.73)
Validation (NSE: -1.70, $R^2$: 0.15, PBIAS: -17.66, RSR: 1.64)
Perspectives: Amazon River

**Standard**

Calibration (NSE: -27.18, R²: 0.26, PBIAS: -75.62, RSR: 5.31)  
Validation (NSE: -38.00, R²: 0.10, PBIAS: -112.78, RSR: 6.25)

**LUD**

Calibration (NSE: -12.00, R²: 0.20, PBIAS: 96.18, RSR: 3.60)  
Validation (NSE: -9.92, R²: 0.05, PBIAS: 95.82, RSR: 3.30)
Perspectives: Amazon River

Standard

Calibration (NSE: -27.18, R^2: 0.26, PBIAS: -75.62, RSR: 5.31)  Validation (NSE: -38.00, R^2: 0.10, PBIAS: -112.78, RSR: 6.25)

LUD

DECREASING & DELAY

Calibration (NSE: -12.00, R^2: 0.20, PBIAS: -30.00, RSR: 4.50)  Validation (NSE: -9.92, R^2: 0.05, PBIAS: 95.82, RSR: 3.30)
Conclusion

• Each model (SWAT, SWAT_LUD, SWAT+) $\rightarrow$ different responses

• Spatially $\rightarrow$ different hotspots

• Different methodologies $\rightarrow$ A whole spectre of the effective alluvial zones
Thank you for your attention