INTEGRATION OF A LANDSCAPE SEDIMENT DEPOSITION ROUTINE INTO SWAT MODEL

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Outline

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Introduction

- **Sediment delivery** from hillslopes to the rivers is spatially **variable**;

- This may cause long-term **delays** between initial erosion and the related sediment yield at the watershed outlet.

- The concept of **sediment transport capacity** of overland flow is often applied to the **modeling of watershed erosion**.

Introduction

SOIL AND WATER ASSESSMENT TOOL (SWAT)

- **Watershed scale model** that has been applied to watersheds throughout the world (Arnold and Fohrer, 2005; Gassman et al., 2007) - the impact of land management practices on water, sediment and agricultural chemical yields (Neitsch et al., 2005).

- **Sediment yield**: uses the MUSLE equation (Williams, 1975) for calculating sediment yield in each HRU.

- **Aim:** to account for **sediment movement across the watersheds slopes.**

- SWAT routines were carefully examined and some **improvements** in the **sediment routines** were proposed.

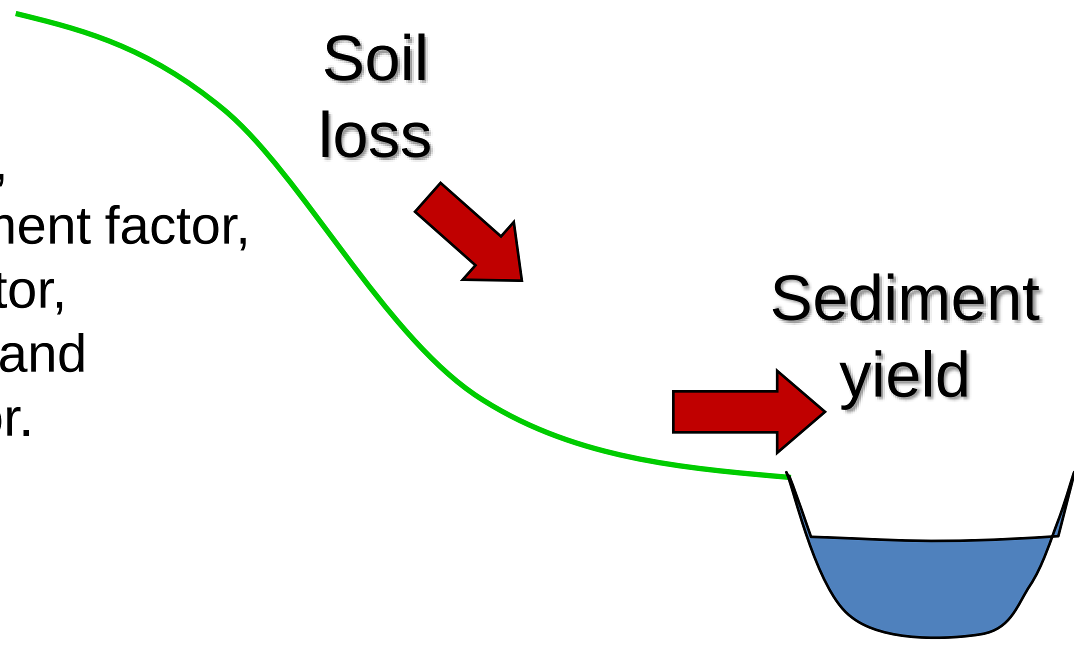
SWAT sediment routine

Erosion and Sediment Yield:

- MUSLE (Modified Universal Soil Loss Equation) (Williams, 1975) :

$$sed = 11{,}8.(Q_{sup}.q_p.area_{hru})^{0{,}56} K.C.P.LS.CRFG$$

where :
sed is the sediment yield on a given day,
Q_{sup} is the surface runoff volume,
q_p is the peak runoff rate,
$area_{hru}$ is the area of the HRU,
K is the USLE soil erodibility factor,
C is the USLE cover and management factor,
P is the USLE support practice factor,
LS is the USLE topographic factor and
CFRG is the coarse fragment factor.



Landscape Transport Capacity

Sediment transport capacity of overland flow:

- Rustomji and Prosser (2001):

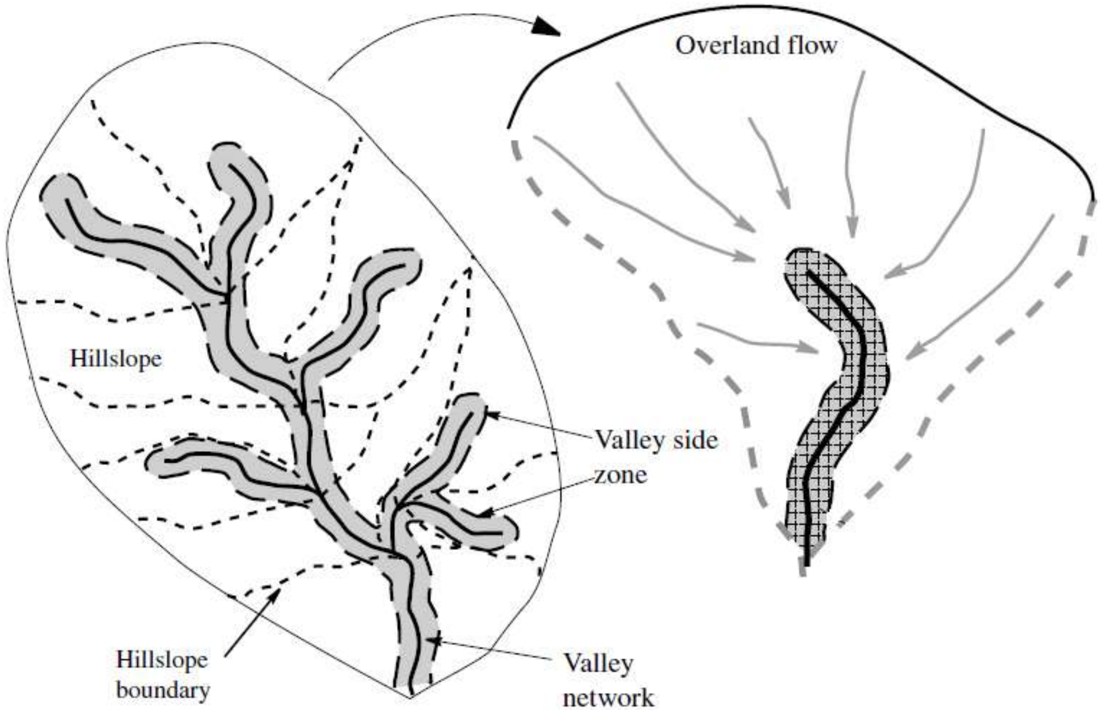
$$TC = k_1 k_2 a^{1.4} s^{1.4}$$

a = hillslope area per unit width of contour
k_1, k_2 = parameters

Van Rompaey *et al.* (2001):

[illegible]

TC = landscape transport capacity
ktc =transport capacity coefficient,
R = rainfall erosivity factor ,
K = soil erodibility factor
LS = slope and slope length factor,
s = slope gradient



Source: Adapted from Rustomji & Prosser (2001)

Landscape Transport Capacity

Landscape transport capacity (Verstraeten, 2006):

$$TC = ktc \times R \times K \times a^{1.4} \times S^{1.4}$$

TC: landscape transport capacity;

ktc: transport capacity parameter;

R: rainfall erosivity factor;

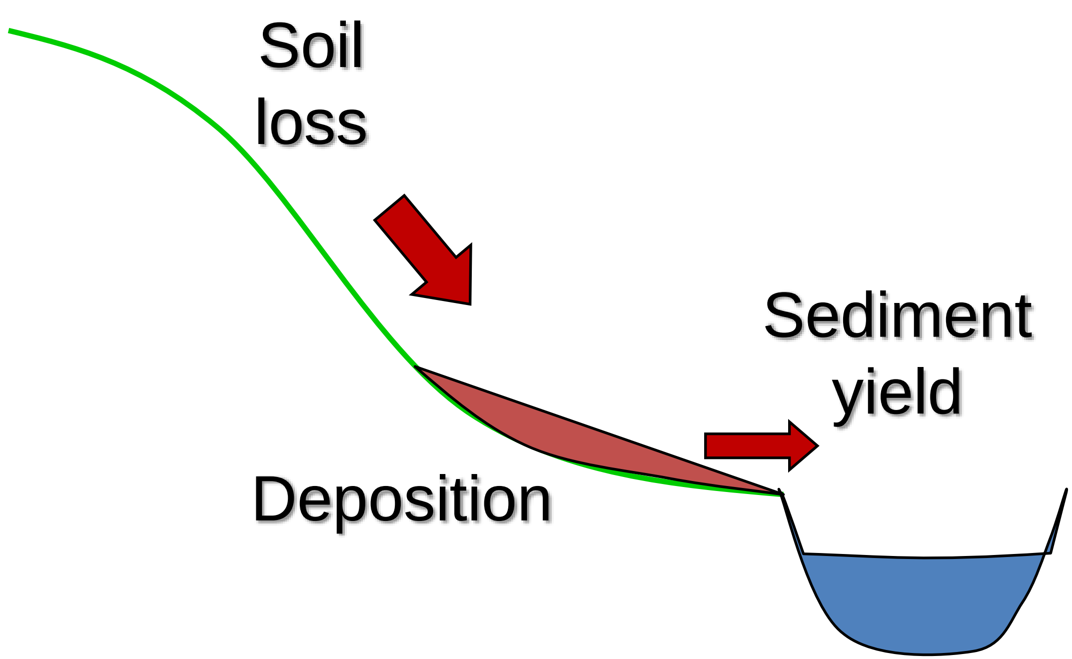
K: soil erodibility factor;

a: unit hillslope area;

S: slope.

$$a = \frac{total\_hillslope\_area}{(2 \times valley\_length)}$$

$$S = \frac{\sum_{i=1}^{n} \cos slope}{n}$$



Landscape Transport Capacity

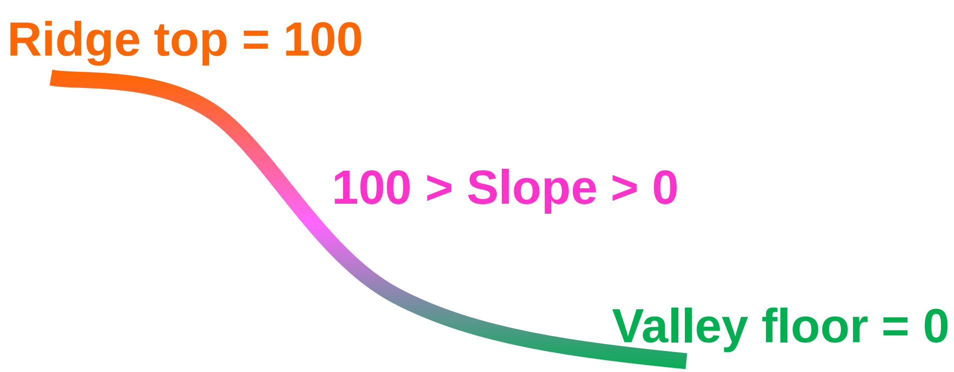
Landscape delineation routine (Volk et al., 2007):

• Slope position = relative position between ridge top (divide) and valley floor (floodplain);

• First step: filling sinks and leveling peaks;

• Downhill and “uphill” flow accumulation values > specified limits are used to identify valleys and ridges.

• Slope position is calculated as the elevation of each cell relative to the elevation of the valley the cell flows down to and the ridge it flows up to.



• This is presented as a ratio, ranging from 0 (valley floor) to 100 (ridge top).

• Hillslope areas are represented by the values between these two ranges.

Landscape Transport Capacity

Main/Simulate/Command/Subbasin

...Surface/Ysed: Predicts **daily soil loss** with **MUSLE**.

HRU

...Subbasin/Latsed: Calculates sediment contributed in **lateral** flow.

...Subbasin/Surfstor: Stores and **lags** sediment in surface runoff.

sedyld (j) (ton)

SUBBASIN

*...Subbasin/**Virtual**:* Summarizes data for subbasins:

-Sum HRU results for **subbasin** (ton):

sub_sedy(sb) = sub_sedy(sb) + sedyld(j)

...Readfig/Readsub: reads data from the HRU/subbasin input file.

```
!! Landscape Transport Capacity
call read_ltc
      l_harea(i) = l_harea(i) / (2 * l_vleng(i))
      l_qs(i) = l_ktc(i) * l_k1(i) * l_k2(i) * l_harea(i) ** l_beta(i)      &
     &                              * l_vslope(i) ** l_gama(i)
```

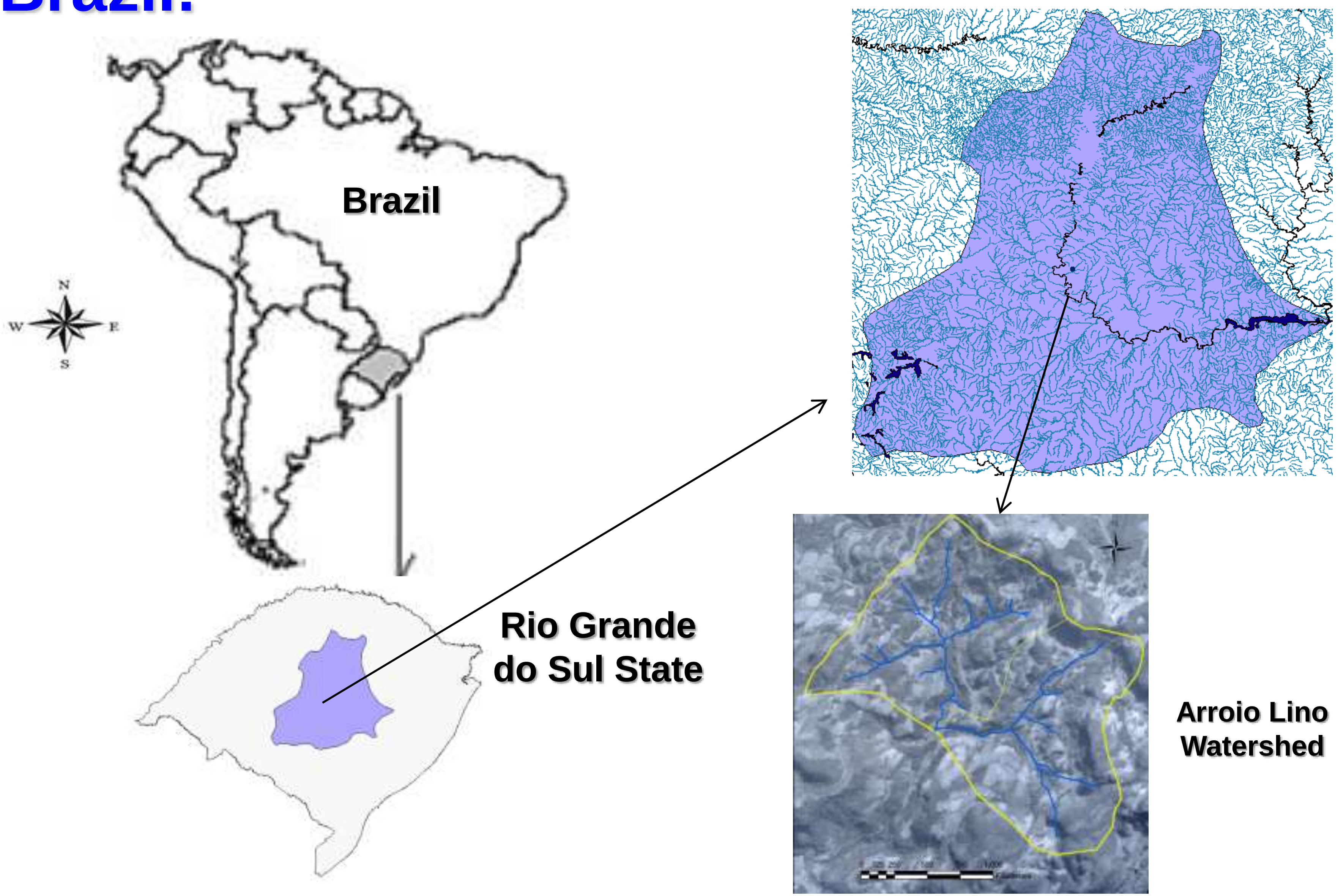
sedyld (sb) (ton)

CHANNEL

Main/Simulate/Route: Simulates channel routing.

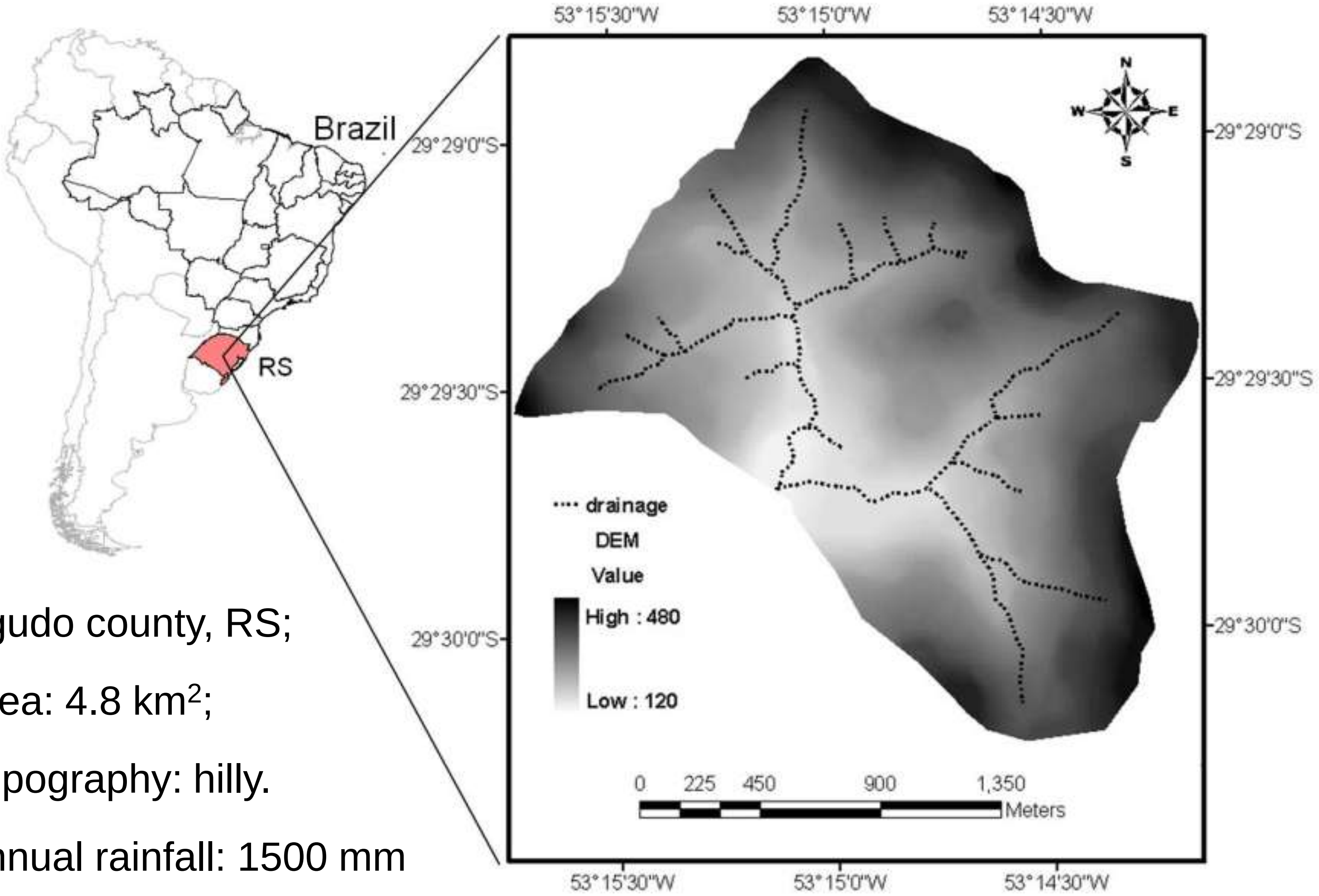
Study area

Brazil:



Study area

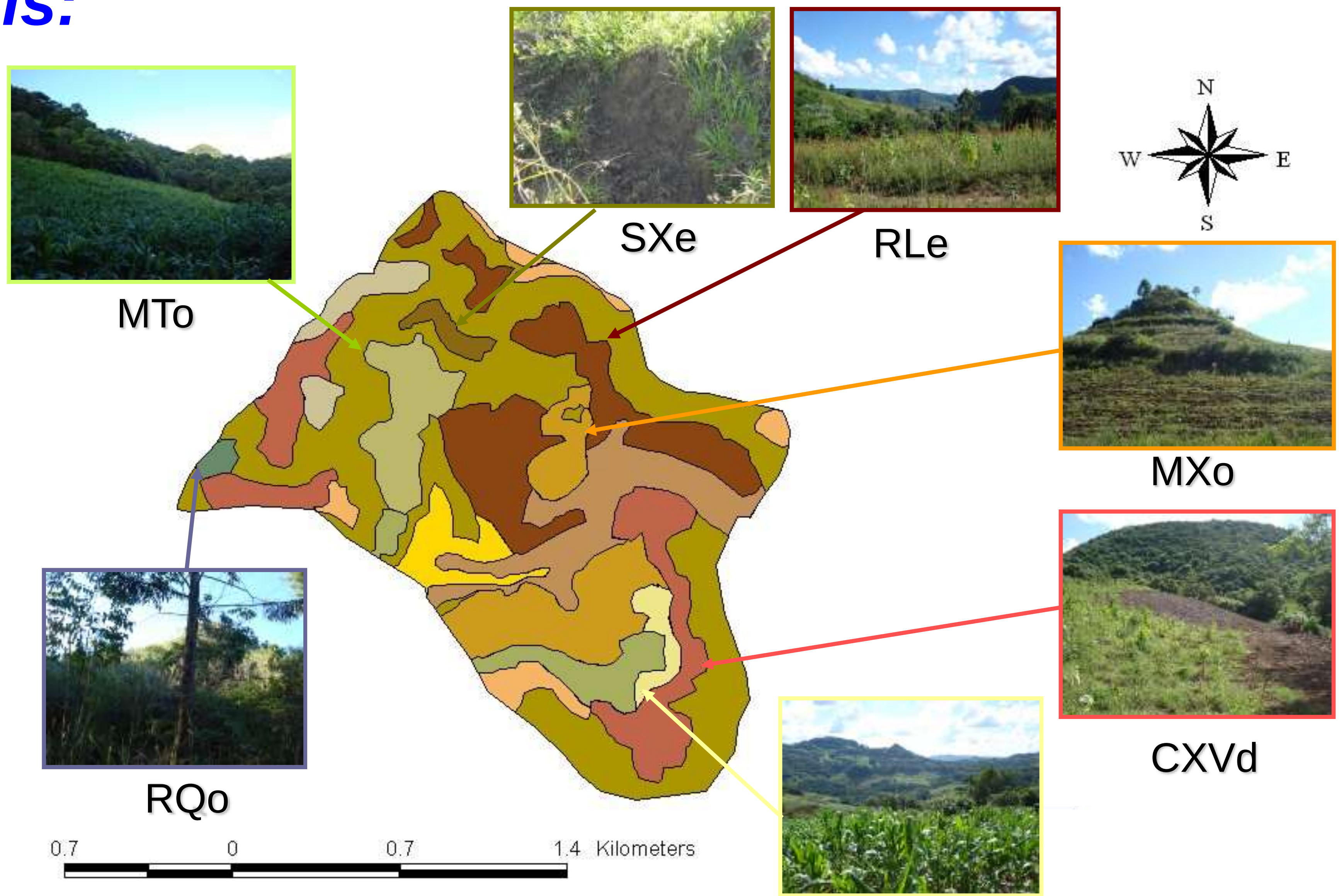
Arroio Lino watershed:



- Agudo county, RS;
- Area: 4.8 km^2;
- Topography: hilly.
- Annual rainfall: 1500 mm

Study area

Soils:



Source: Dalmolin et al. (2004), EMBRAPA (2006)

Land use and sediment yield:

Shallow and stony soils

+

Steeper slopes

+

Vegetation removal
Intensive agriculture

Erosive processes

Sediment delivery ?

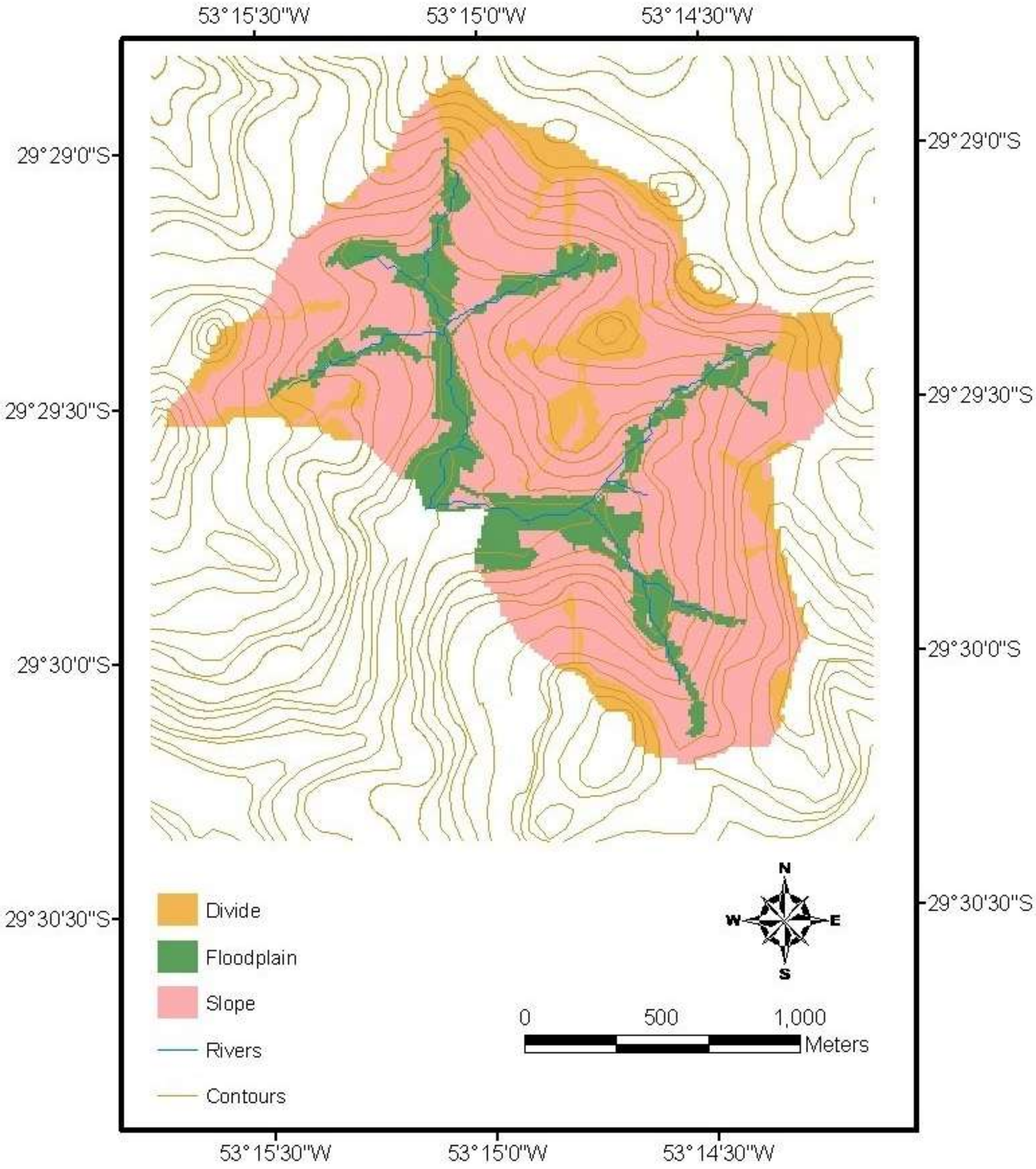
Sediment Yield

Source: Sequinatto (2007), pictures: Kaiser, D.R.; Pellegrini, A.

Model Results

Landscape units of Arroio Lino watershed:

Landscape delineation routine (Volk et al., 2007)



Model Results

Prediction of hillslope sediment delivery for the Arroio Lino Watershed:

Subbasin	TC (t ha^{-1})	TC (t)	SY_MUSLE (t ha^{-1})	SY_MUSLE (t)	SY (t ha^{-1})	SY (t)	DEP (t ha^{-1})	DEP (t)
1	2.45	44.51	37.02	673.21	2.45	44.51	34.57	628.69
2	23.87	585.65	53.34	1308.56	23.87	585.65	29.47	722.89
3	0.58	1.98	13.28	45.35	0.58	1.98	12.71	43.37
4	40	1670.8	70.57	2947.75	40	1670.8	30.57	1276.95
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
18	2.38	14.92	45.19	283.03	2.38	14.92	42.81	268.11
19	3.07	55.85	54.69	993.64	3.07	55.85	51.62	937.82
20	31.05	490.21	45.17	712.95	31.05	490.21	14.11	222.75
21	14.52	428.36	43.49	1282.82	14.52	428.36	28.97	854.47
Total	21.84	6710.4	49.52	15217	19.7	6054.17	28.33	9162.83

TC = Landscape transport capacity

SY = predicted by MUSLE

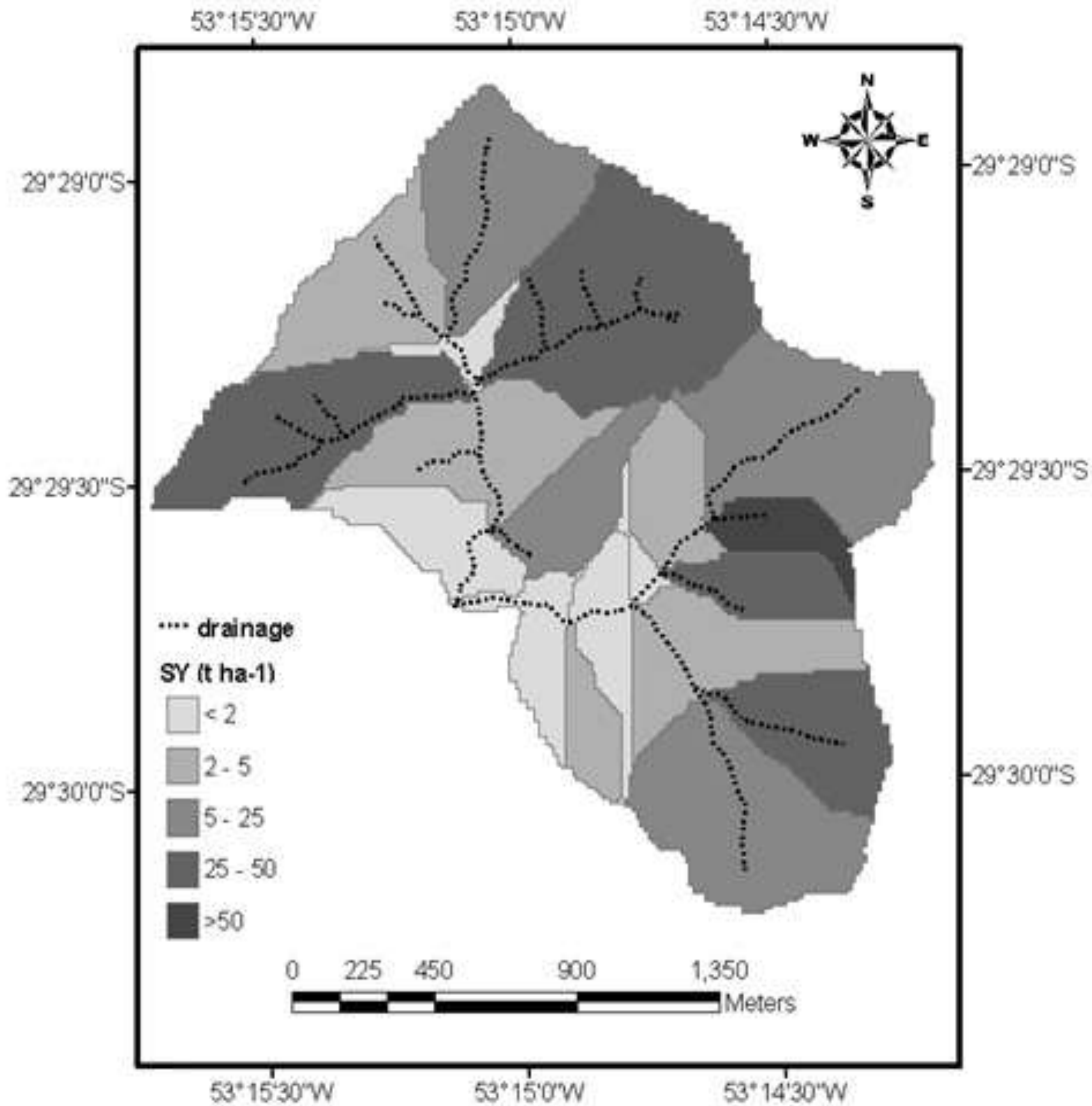
SY <= TC

DEP = Deposition

Model Results

Spatial distribution of sediment delivery:

- **Sediment delivery** from hillslopes = 19.70 t/ha year.
- **Total soil loss** = 49.53 t/ha year.
- **Deposition**: 60% of the mobilized soil.



Conclusions

- Attempt to include the **sediment transport capacity** description in the source code of the SWAT model version 2009.

- **Modified model** provided reasonable simulations of **sediment transport across the landscape positions**.

- Application demonstrates the **applicability** of the model to simulate sediment yield in watersheds with **steep slopes**.

Future work

- **Calibration** of the **transport capacity parameters (ktc)** is a very important issue of SWAT sediment routine that has yet to be adequately solved, so further research is needed to address the uncertainties involved.

- **Further work** is still needed to more broadly test the model in areas with others topography configuration and land uses.

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