AN AUTOMATED PROCEDURE FOR SWAT-LUD TO BE APPLIED AT THE CATCHMENT SCALE.

SWAT 2015
PULA / SARDINIA / ITALY

Gregory ESPITALIER NOEL, Xiaoling SUN, Sabine SAUVAGE, José-Miguel SANCHEZ-PEREZ

Outlines

1. The **Landscape Units Darcy** model (**LUD**)
2. The LUD implementation in SWAT
3. The LUD model validation

For more (denitrification, etc) see Xiaoling SUN presentation this afternoon!

The Landscape Units Darcy (LUD) model

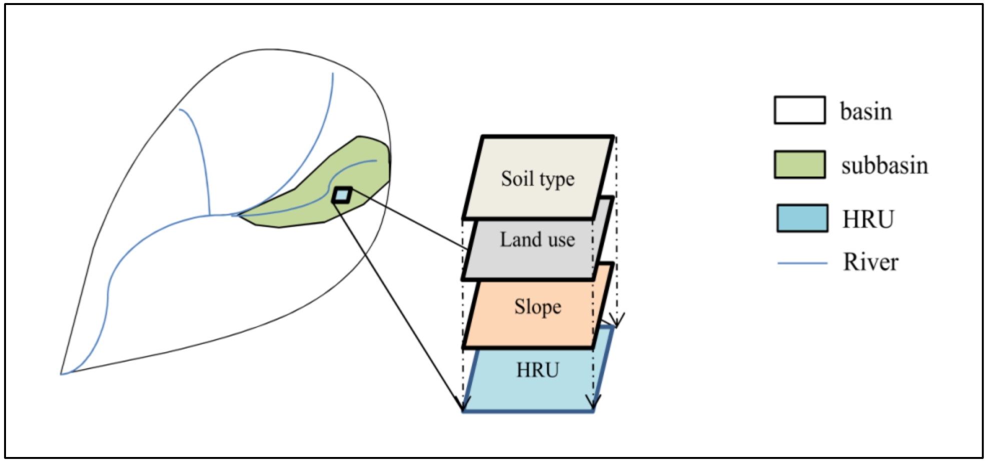
What is an **LUD**?

What are the model **parameters**?

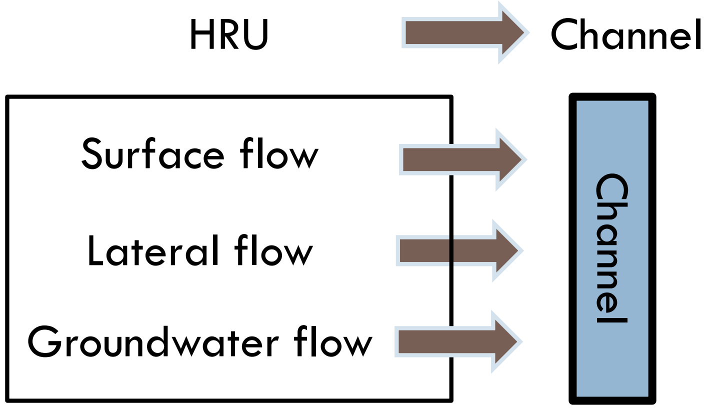
How to find **values** for these parameters?

SWAT model

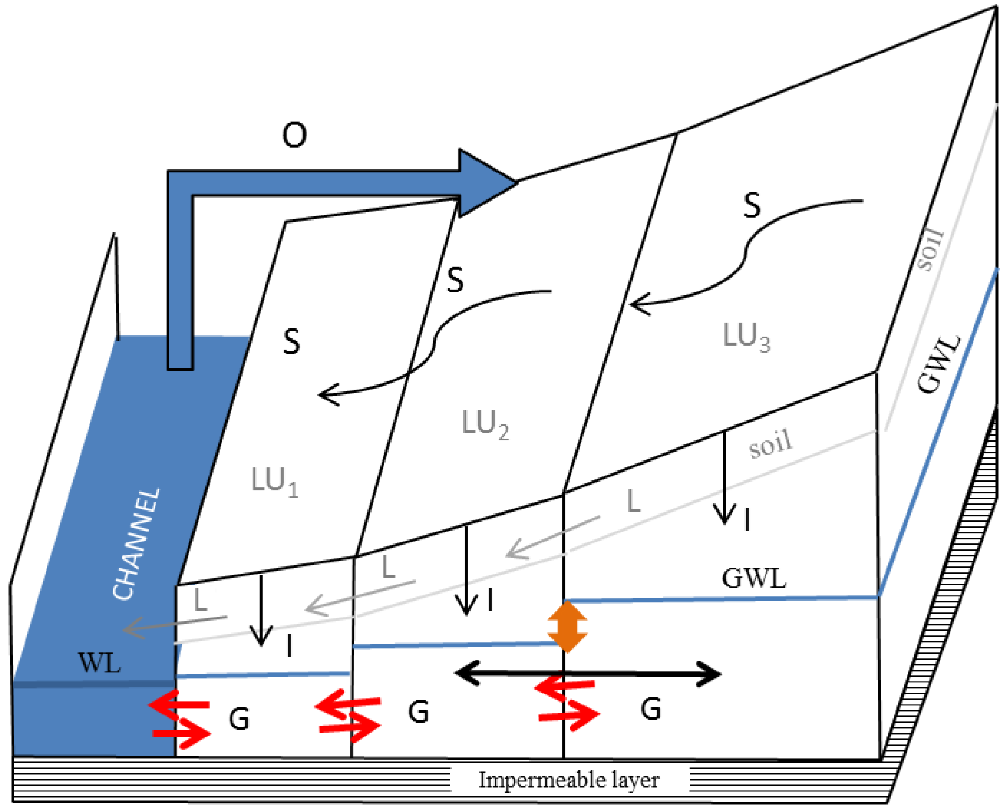
Reminder: HRU



Flow direction

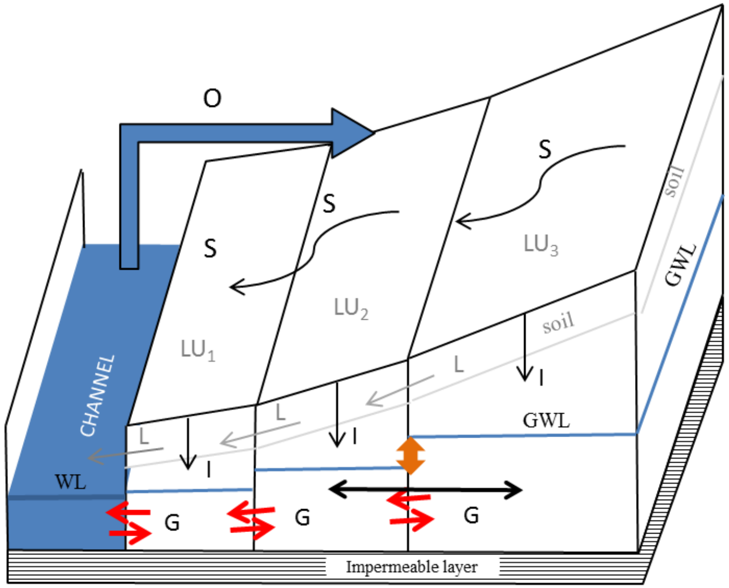


Surface water to Groundwater is not simulated in SWAT



Landscape Unit model (from Volk et al. 2007)

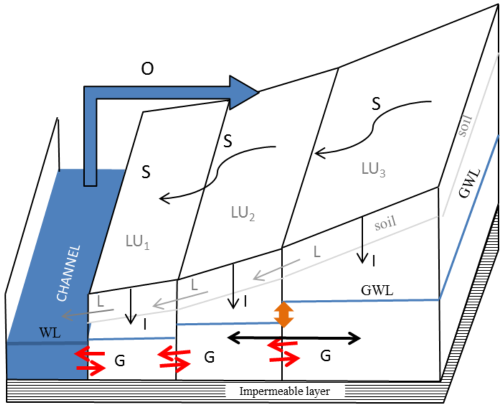
- River to alluvial aquifer water exchanges,
- Flooding water infiltrating the LUs,



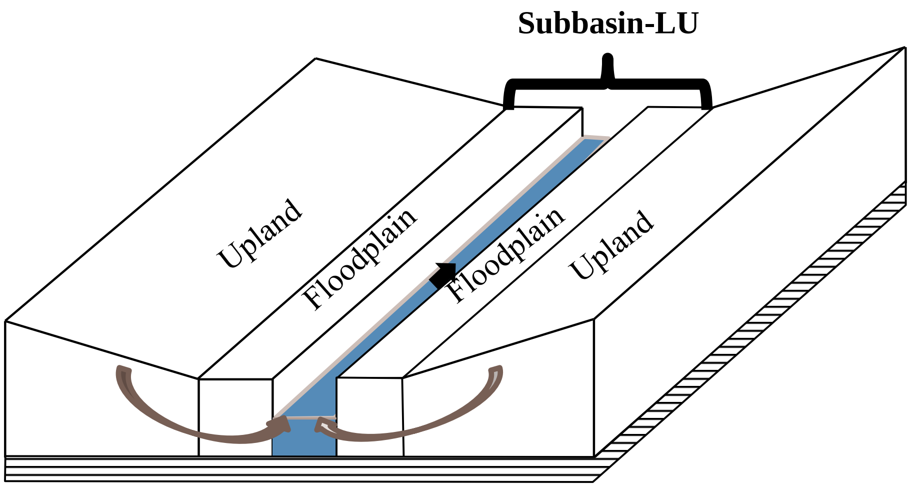
- LUD1: annual flooding area
- LUD2: 2 to 5 years flooding area
- LUD3: 10+ years flooding area

Landscape Unit model

- River to alluvial aquifer water exchanges,
- Flooding water infiltrating the LUs,

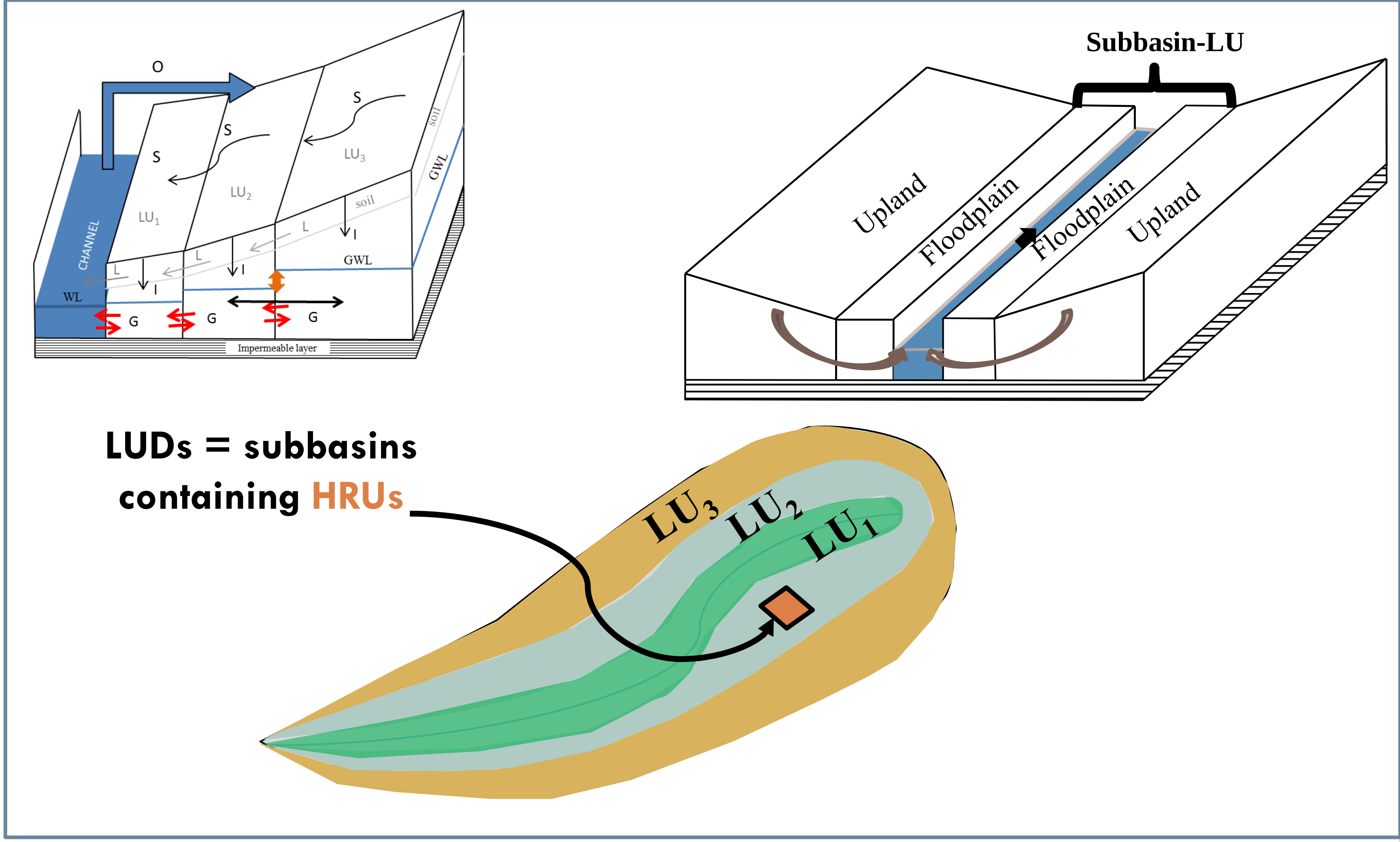


LUDs = subbasin containing HRUs



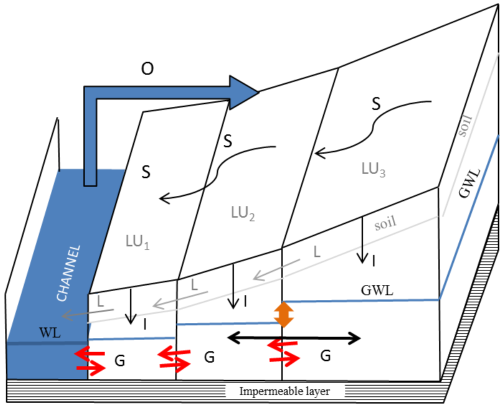
Landscape Unit model

- River to alluvial aquifer water exchanges,
- Flooding water infiltrating the LUs,
- **At the alluvial plain scale.**

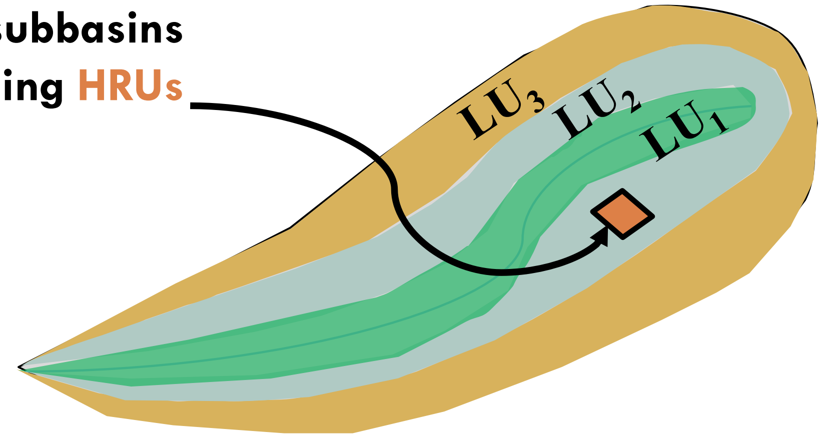


Landscape Unit model

- River to alluvial aquifer water exchanges,
- Flooding water infiltrating the Lus,
- At the floodplain scale.



LUs = subbasins containing HRUs

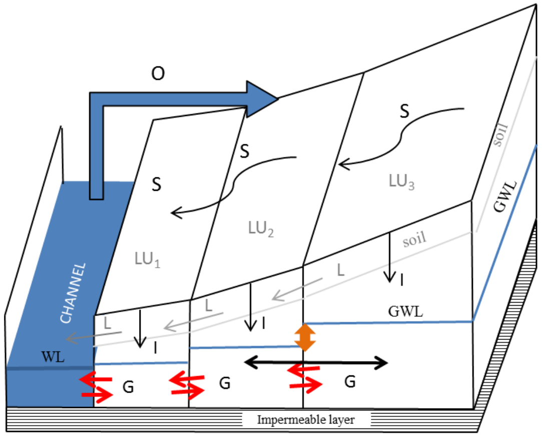


Channel ⟺ Landscape Unit ⟺ Contained HRUs

Landscape Unit model

- River to alluvial aquifer water exchanges,
- Flooding water infiltrating the Lus,
- At the floodplain scale.

Landscape Units geometry



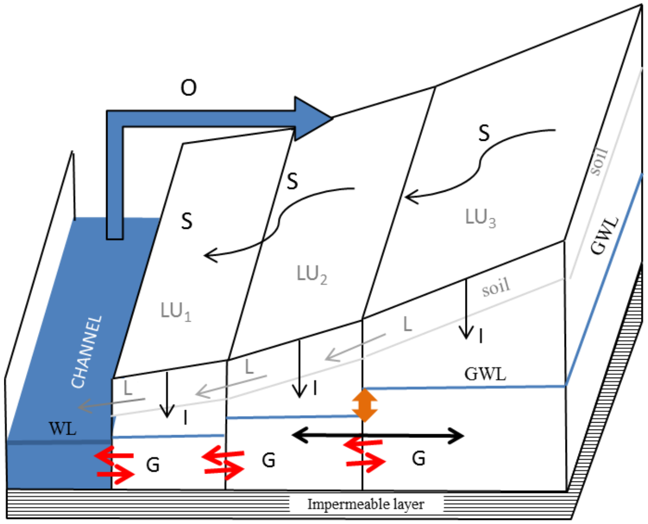
LUD geometric parameters

Parameter	Unit	Description	Hypothesis
l	meters	LUD's length along the river	= channel's length
S_para	m/m	LUD's slope parallel to the channel	= channel's slope
S_perp	m/m	LUD's slope perpendicular to the channel	• LUD1 = channel's slope x 2 • LUD2 = channel's slope x 5 • LUD3 = channel's slope x 10
A	m^2	LUD's surface	• LUD1 = 10% alluvial surface • LUD2 = 20% alluvial surface • LUD3 = 70% alluvial surface
L	meters	LUD's width	• A / l
h	meters	LUD's mean height to the surface	Channel depth + (L x S_perp) / 2

River / Alluvial aquifer interface

Darcy's equation (1856):

$$Q = K \times A \times \frac{\Delta H}{D}$$



Parameter	Unit	Description	Value
K	$m.d^{-1}$	Hydraulic conductivity	• LUD1 = 300 • LUD2 = 200 • LUD3 =100
A	m^2	Area of interface	h x l
D	m	Distance between the middle of two consecutive reservoirs	$L_{LUD\_i}/2 + L_{LUD\_k}/2$
ΔH	m	Difference of water levels	$gw_{height\_i} - gw_{height\_k}$

River / Alluvial aquifer processes

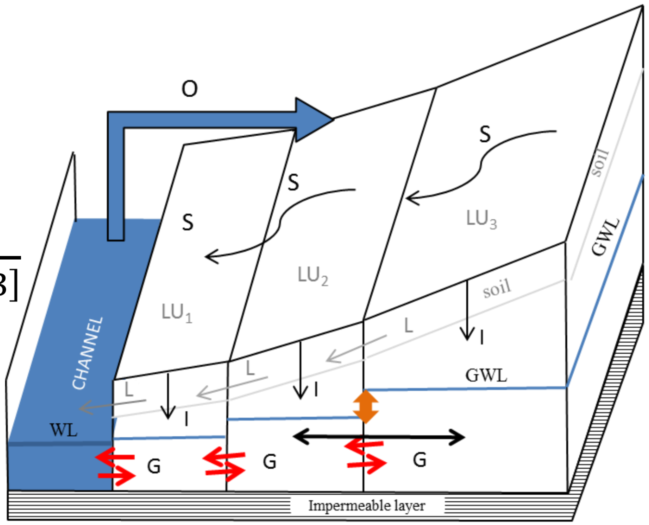
Denitrification:

Nitrate consume rate:

$$R_{NO3} = -0.8(\rho\frac{1-\varphi}{\varphi}.k_{POC}[POC].\frac{10^6}{M_C}+k_{DOC}[DOC]).\frac{[NO3]}{k_{NO3}+[NO3]}$$

DOC consume rate: $R_{DOC} = -k_{DOC}[DOC]$

POC consume rate: $R_{POC} = -k_{POC}[POC]$



Parameters	Units	Description
φ	-	Sediment porosity
ρ	kg.dm^{-3}	Dry sediment density
k_{POC}	d^{-1}	Mineralisation rate constant of POC
k_{DOC}	d^{-1}	Mineralisation rate constant of DOC
k_{NO3}	µM	Half-saturation for nitrate limitation

For more (denitrification, etc) see Xiaoling SUN presentation this afternoon!

The LUD implementation in SWAT

Where do **changes** occurs in the source code?

How to **automatically** construct LUDs?

How to **populate** LUDs with **HRUs**?

G-MOD

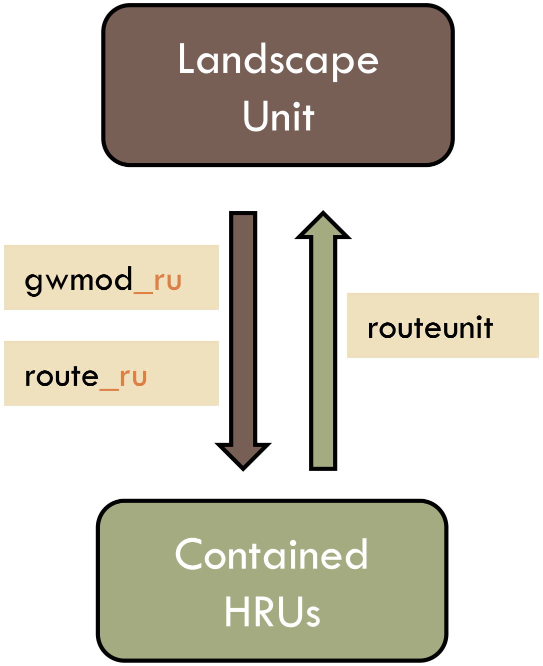
LUD implementation in SWAT

Several subroutines **specific to LUD model**:

- routeunit :
  - Groundwater and nitrate sum from HRUs to LUDs,
- routels :
  - No groundwater flow between landscape units (now done in route_ru).

Several subroutines **added**:

- route_ru :
  - DOC / nitrate masses and concentrations in LUD groundwater,
  - Nitrate from soil to groundwater with infiltrated flood water,
  - Darcy equation,
  - Nitrate and DOC exchanges between LUDs.
- rtday_ru :
  - flooding,
  - Infiltration.
- rchinit_ru,
- rtout_ru,
- gwmod_ru : groundwater volume and height in each HRU from correponding LUD (without flood water),
- gw_no3_ru : nitrate content in groundwater for each HRU,
- denit_gw : denitrification in each LUD.



G-MOD

SWAT LUD: project creation

generate_landscape_unit.f90

Reading parameters from old SWAT project:
- **.fig,**
- **.sub,**
- **.hru,**
- **.sol**

→

Computing all LUD parameters:
- **Length,**
- **Slope,**
- **Conductivity, Surface,**
- **Width,**
- **Mean depth.**

→

- **Rearranging subbasins and HRUs to fit the LUD model.**
- **Compute new subbasin's and HRU's surfaces.**

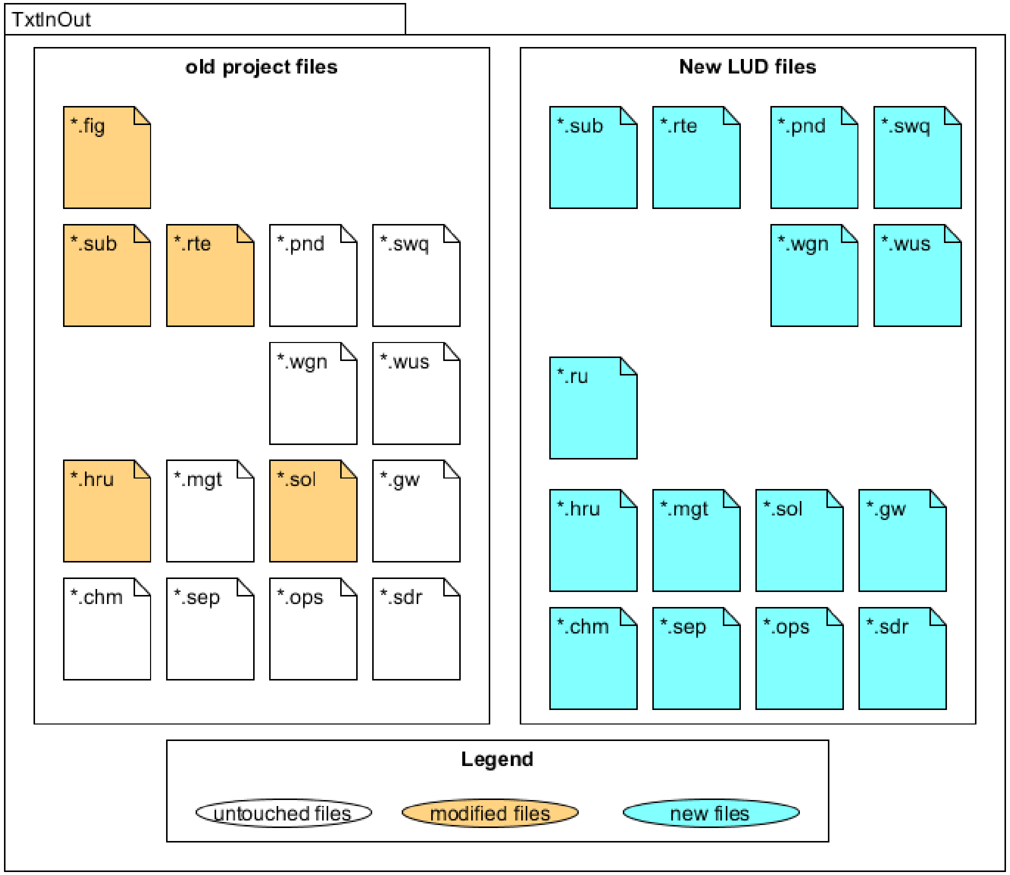
→

Rewriting needed files:
- **Old subbasins whithout alluvial aquifer,**
- **Old subbasins with alluvial aquifers**
- **New LUD subbasins with new HRUs**
- **figfile**

Will be implemented in **ARCSWAT**

SWAT LUD: file structure

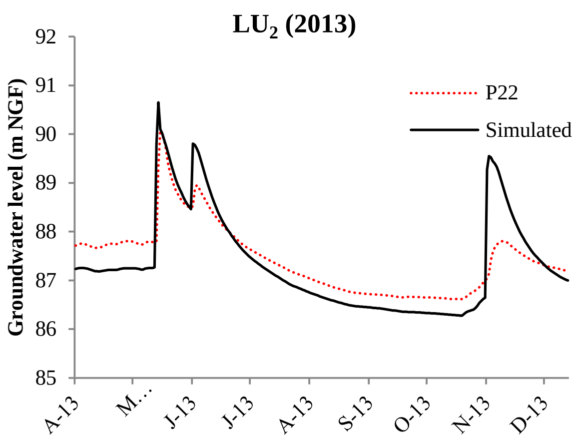
Untouched, modified and added input files in a SWAT LUD project compared to a standard SWAT project.

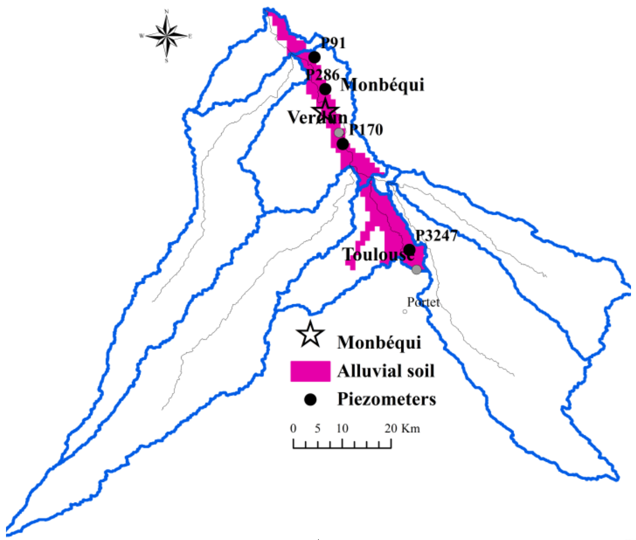


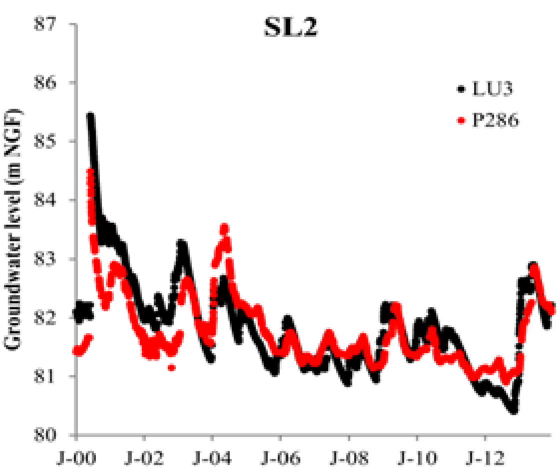
LUD approach validation

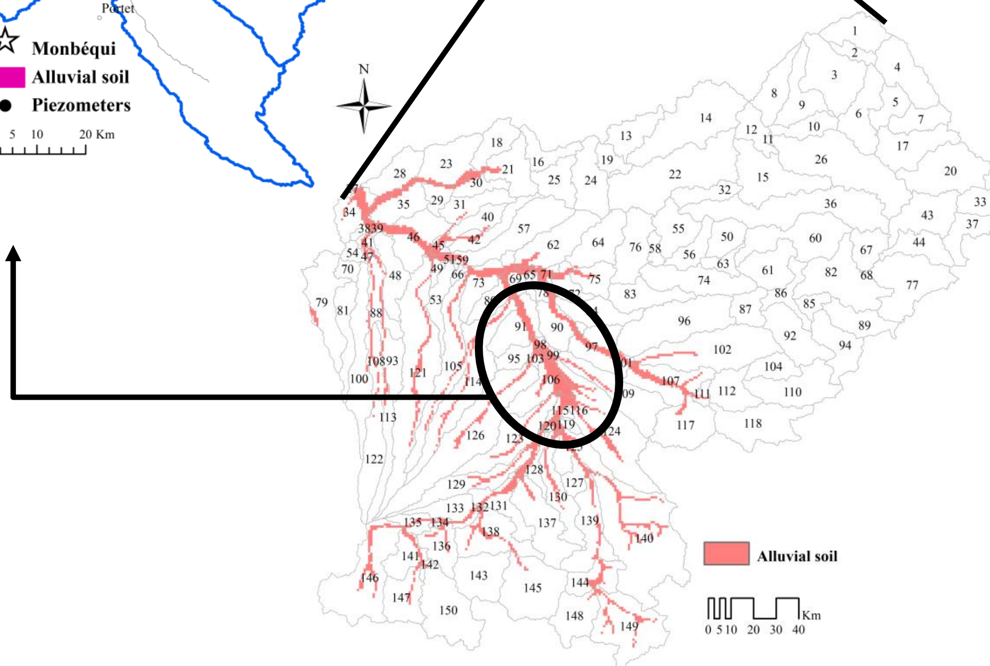
How well does the model works?

First LUD results





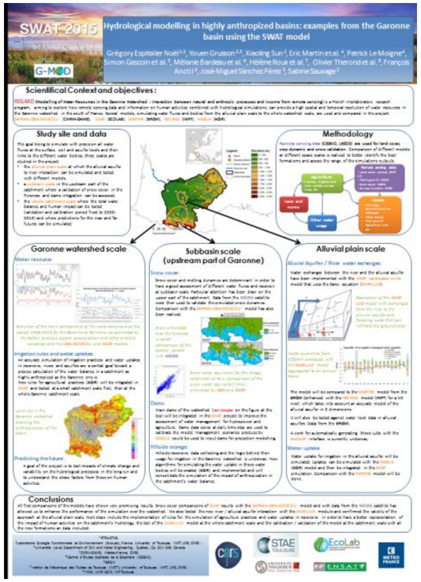




For more (denitrification, etc) see Xiaoling SUN presentation this afternoon!

Conclusions & Perspectives

- Model validated at:
  - Meander scale (Monbequi)
  - Alluvial plain scale
  - Subbasin scale
- Against:
  - Water levels
  - nitrate

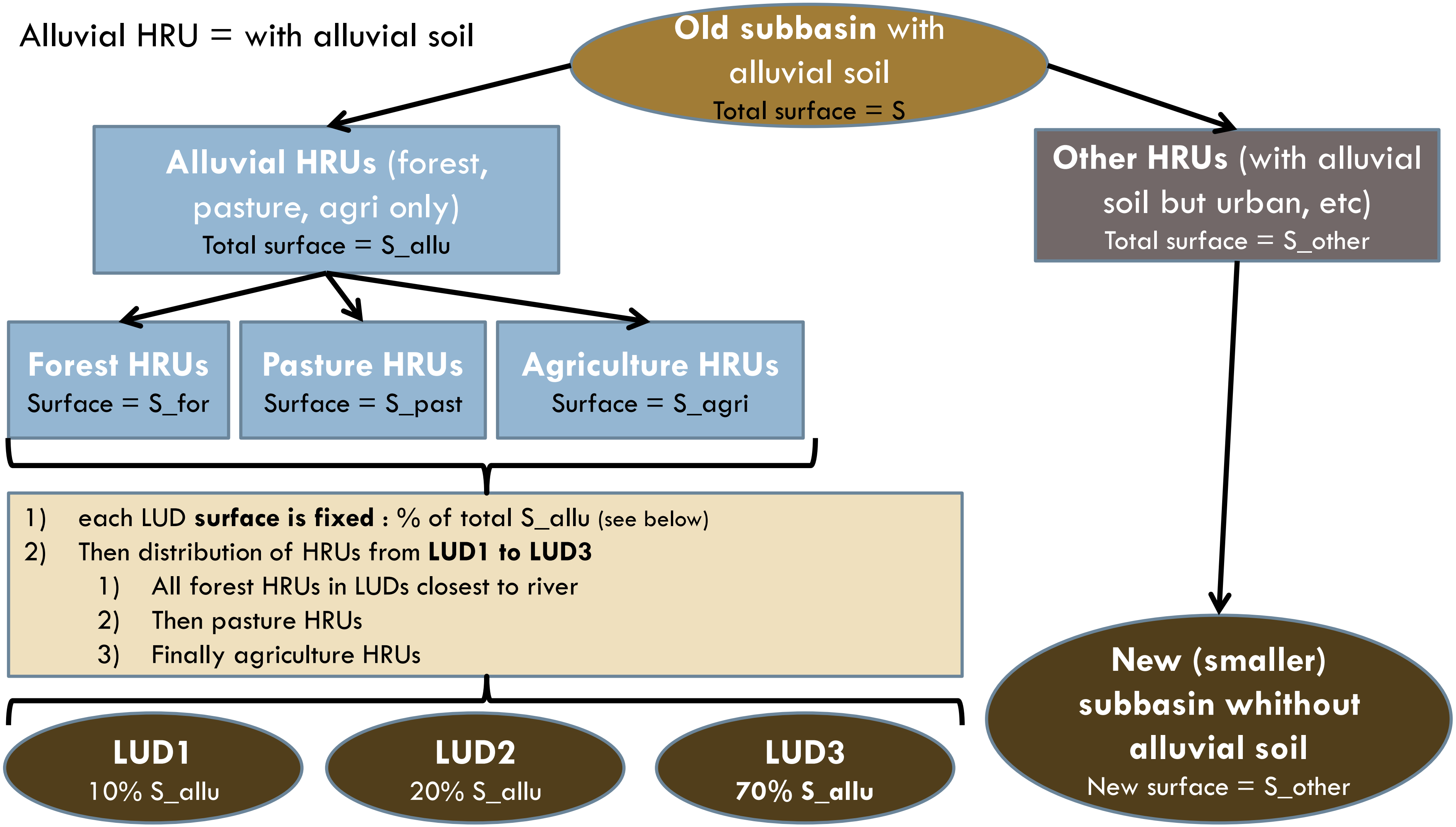


Come and see the poster!

- Create LUD project from ArcSWAT
- Include river sinuosity in hydraulic conductivity parameter
- Calculate LUD's area from flooded areas
- Calculate mean depth from aquifer geometry

SWAT LUD: alluvial HRUs redistribution

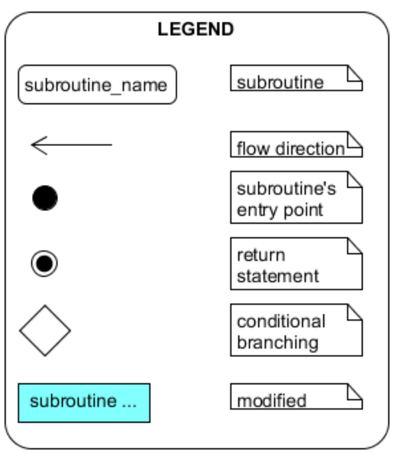
Alluvial HRU = with alluvial soil

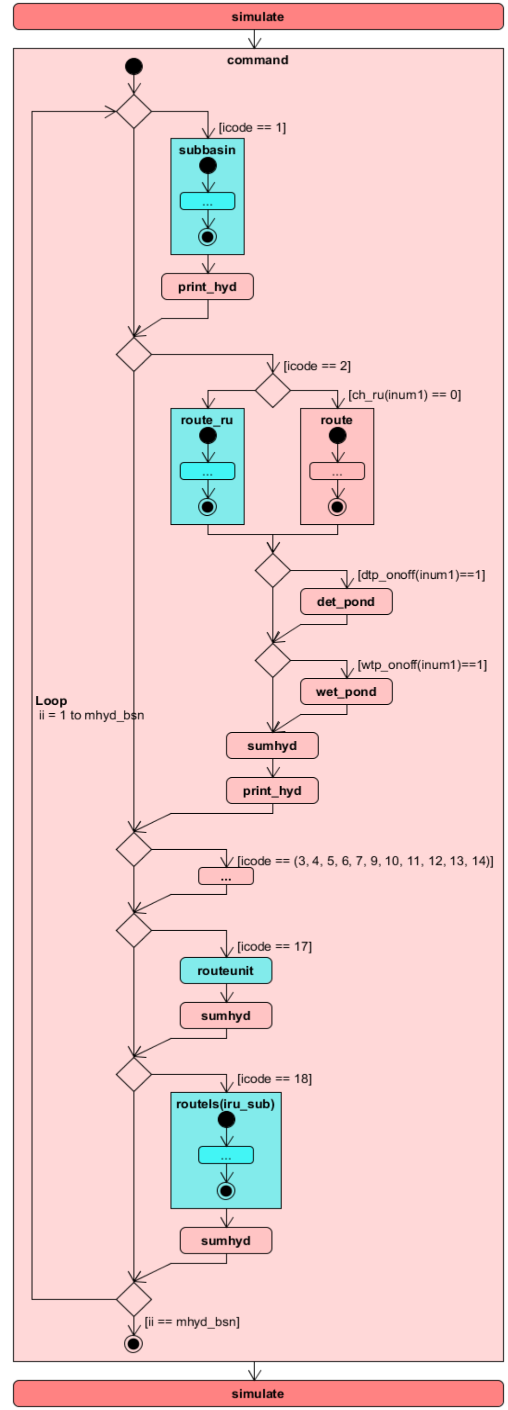


LUD implementation

Modifications **(CYAN)** to the **command** subroutine (executing the figfile).

The diagram shows the execution flow of the subroutine from top to bottom.

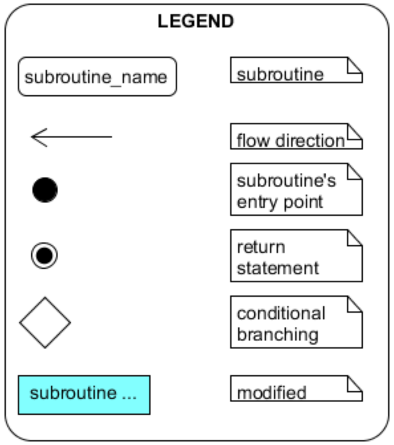


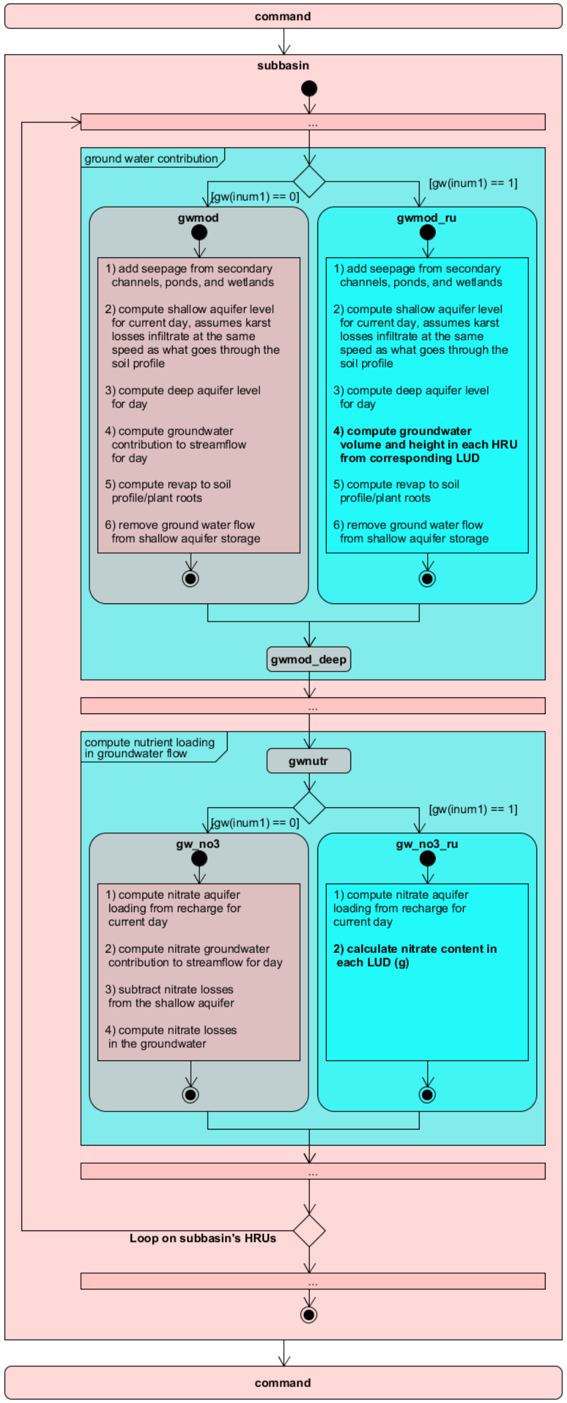


LUD implementation

Modifications (**CYAN and BOLD**) to the **subbasin** subroutine.

The diagram shows the execution flow of the subroutine from top to bottom.

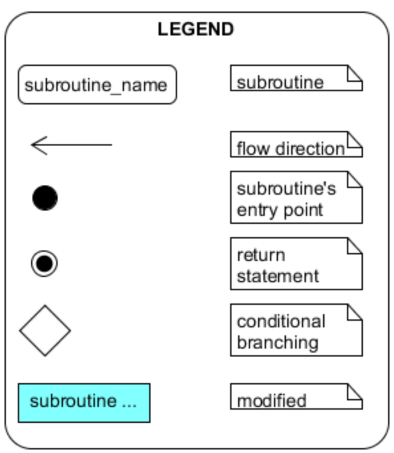


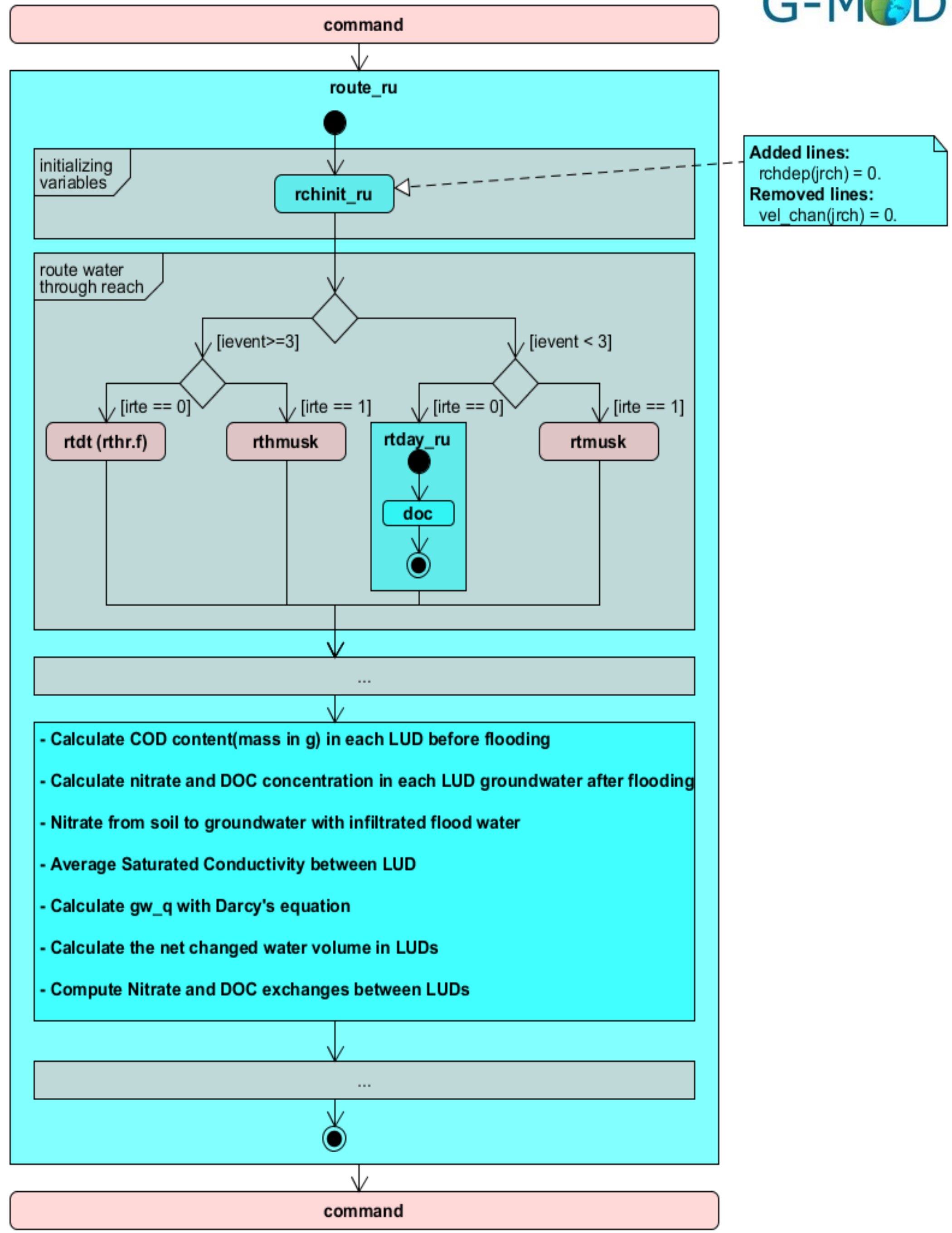


LUD implementation

Modifications **(CYAN)** to the **route_ru** subroutine.

The diagram shows the execution flow of the subroutine from top to bottom.





LUD implementation

Added **route_ru** subroutine with modifications in bold compared to the route subroutine.

The diagram shows the execution flow of the subroutine from top to bottom.