

HYTEC

3D Reactive Transport Simulation

Production Optimization Scenarios (KATCO)

Antoine COLLET¹, Askar KHAIRULDIN², Gwenaële PETIT¹,
Vincent LAGNEAU³, Olivier REGNAULT²

¹ ORANO, 125, avenue de Paris, 92320 Châtillon, France

² KATCO JV LLP, Esil district, 48 Sauran Street, Congress Office BC, Nur-Sultan

³ MINES ParisTech, PSL Research University, Centre de Géosciences, Fontainebleau, France

Almaty - 07/11/2019



01

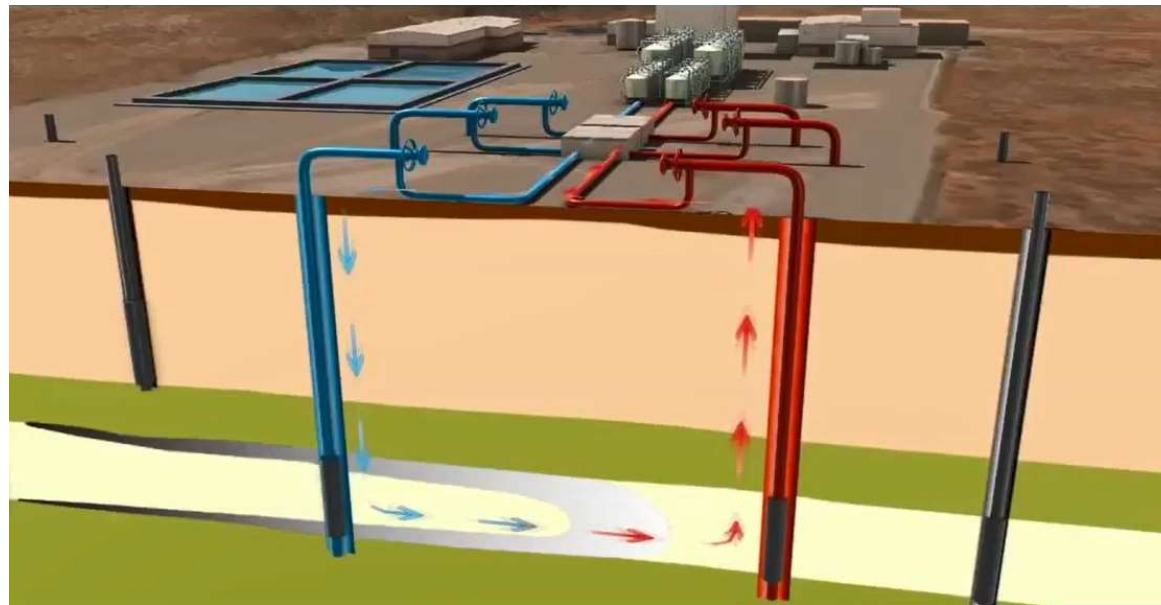
**In Situ Recovery (ISR)
and reactive
transportation with
HYTEC**



ISR challenges

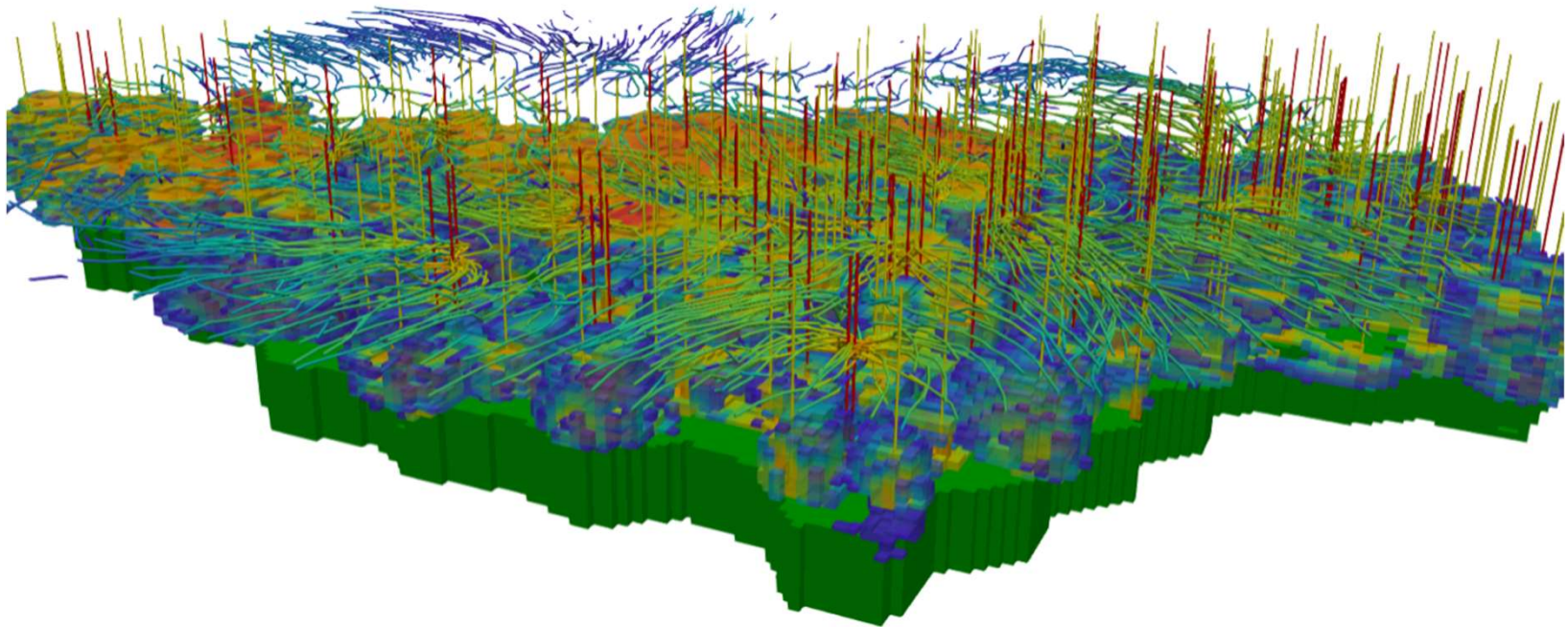
In ISR the miner never sees the deposit

- **Very hard to forecast the reservoir behavior**
- **Impossibility to know what has really been recovered**



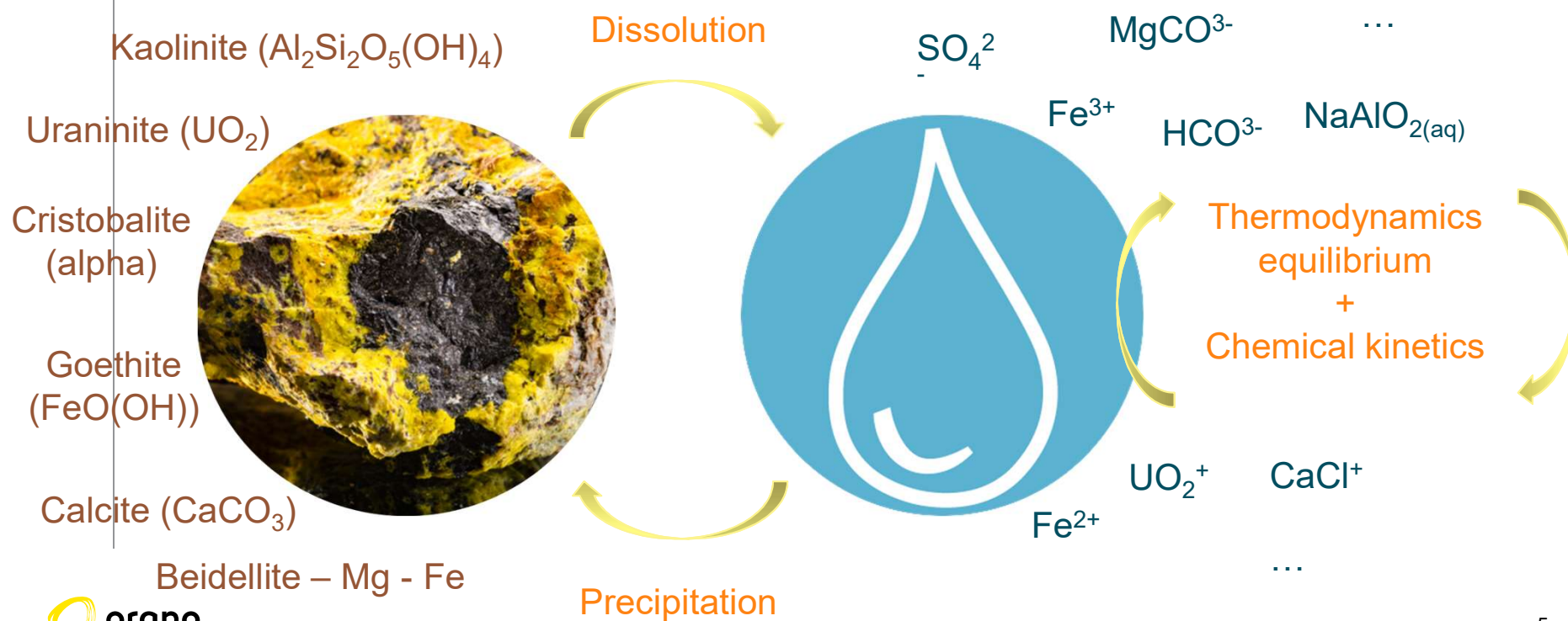
HYTEC double approach

1 – Reservoir hydrodynamics

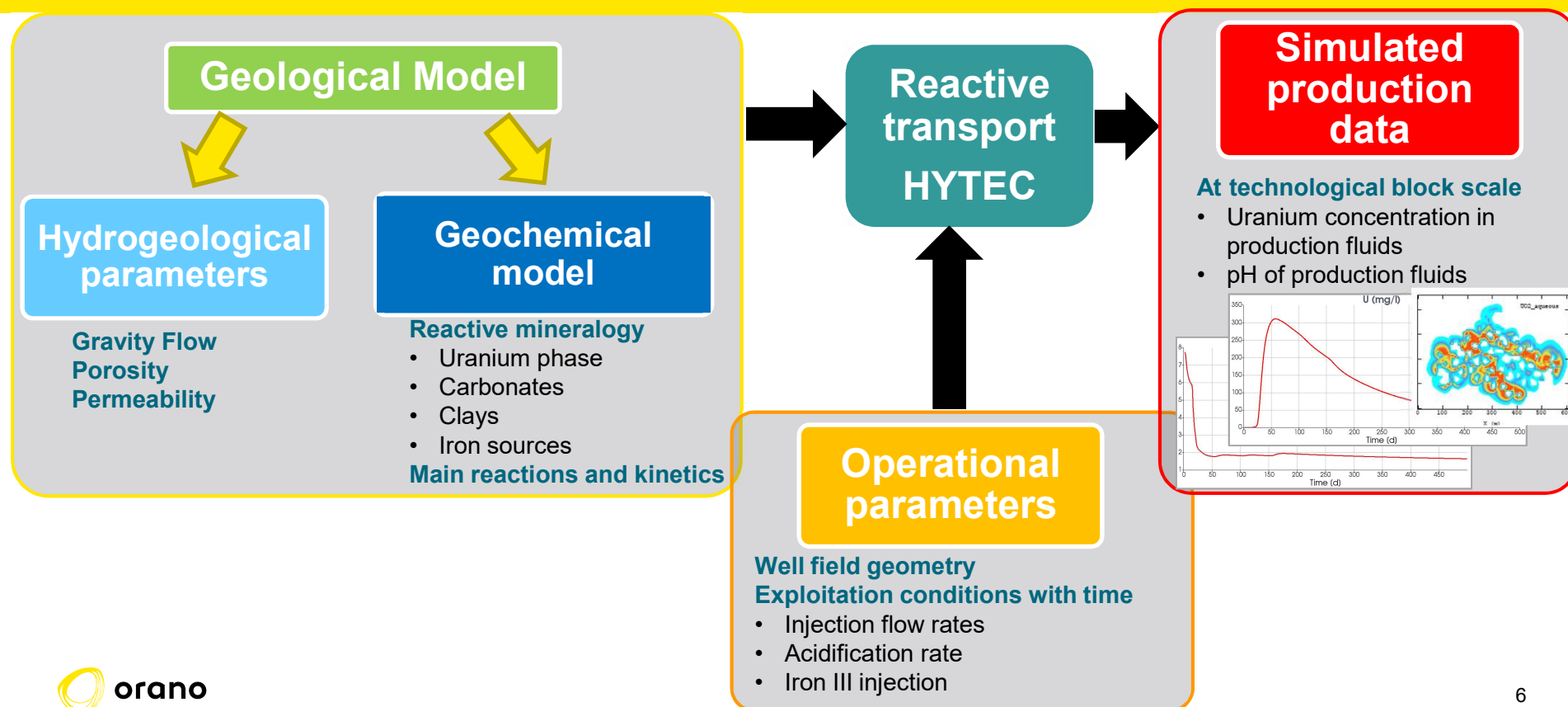


HYTEC double approach

2 – Chemical reactions between mineral and aqueous phases

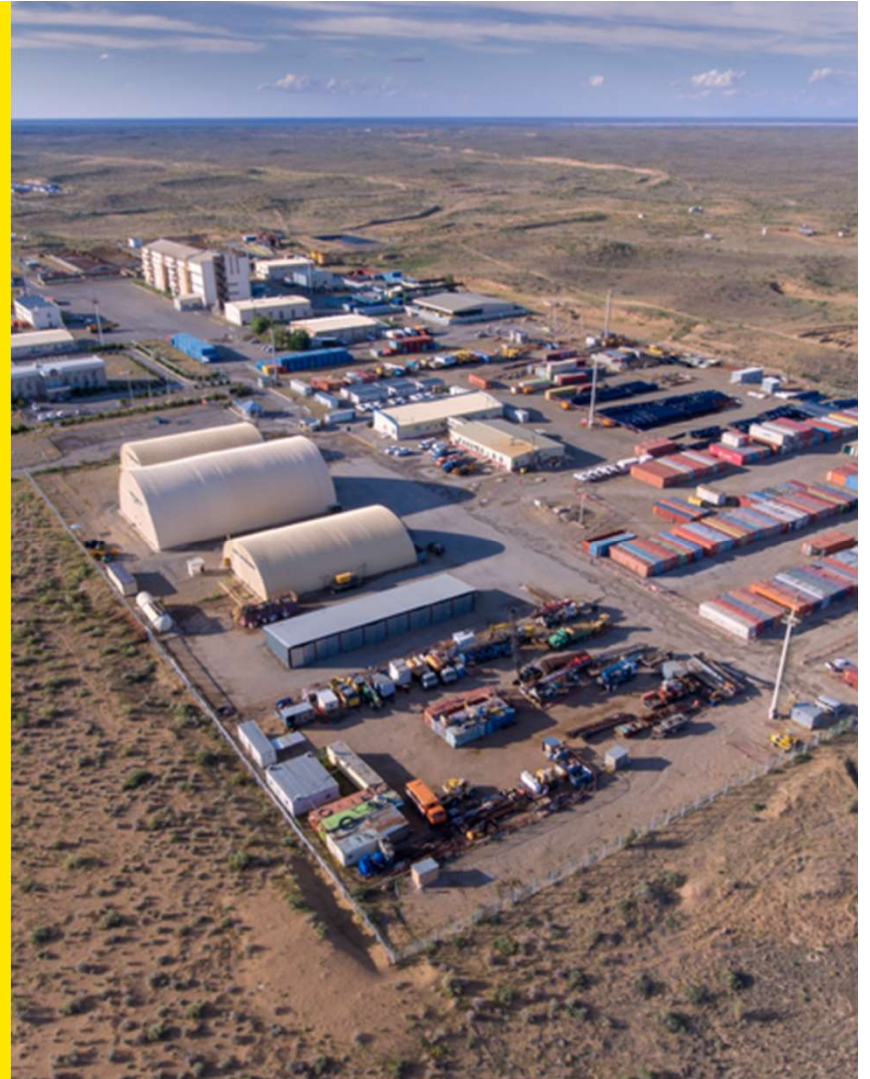


An integrated 3D modeling workflow

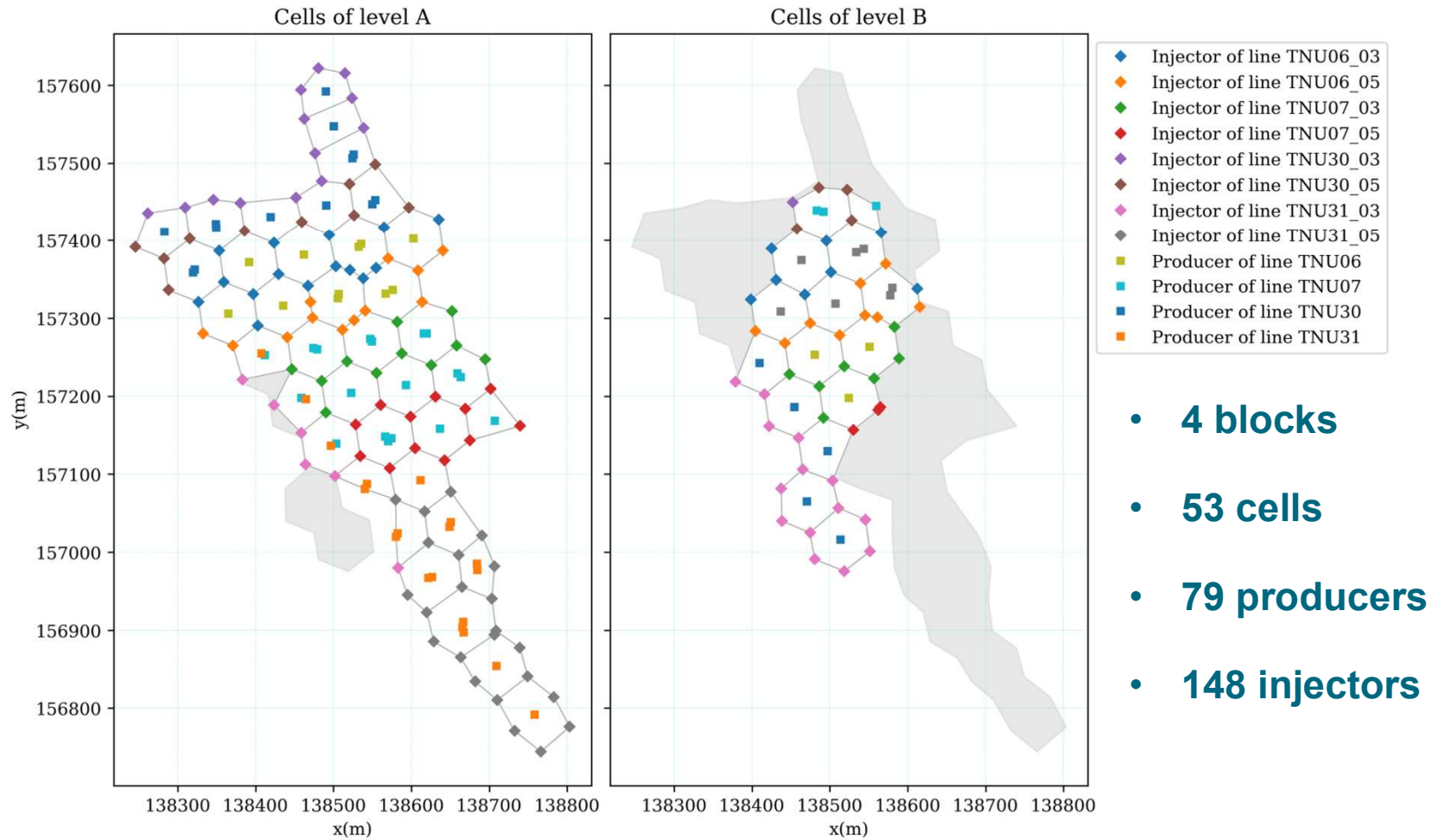


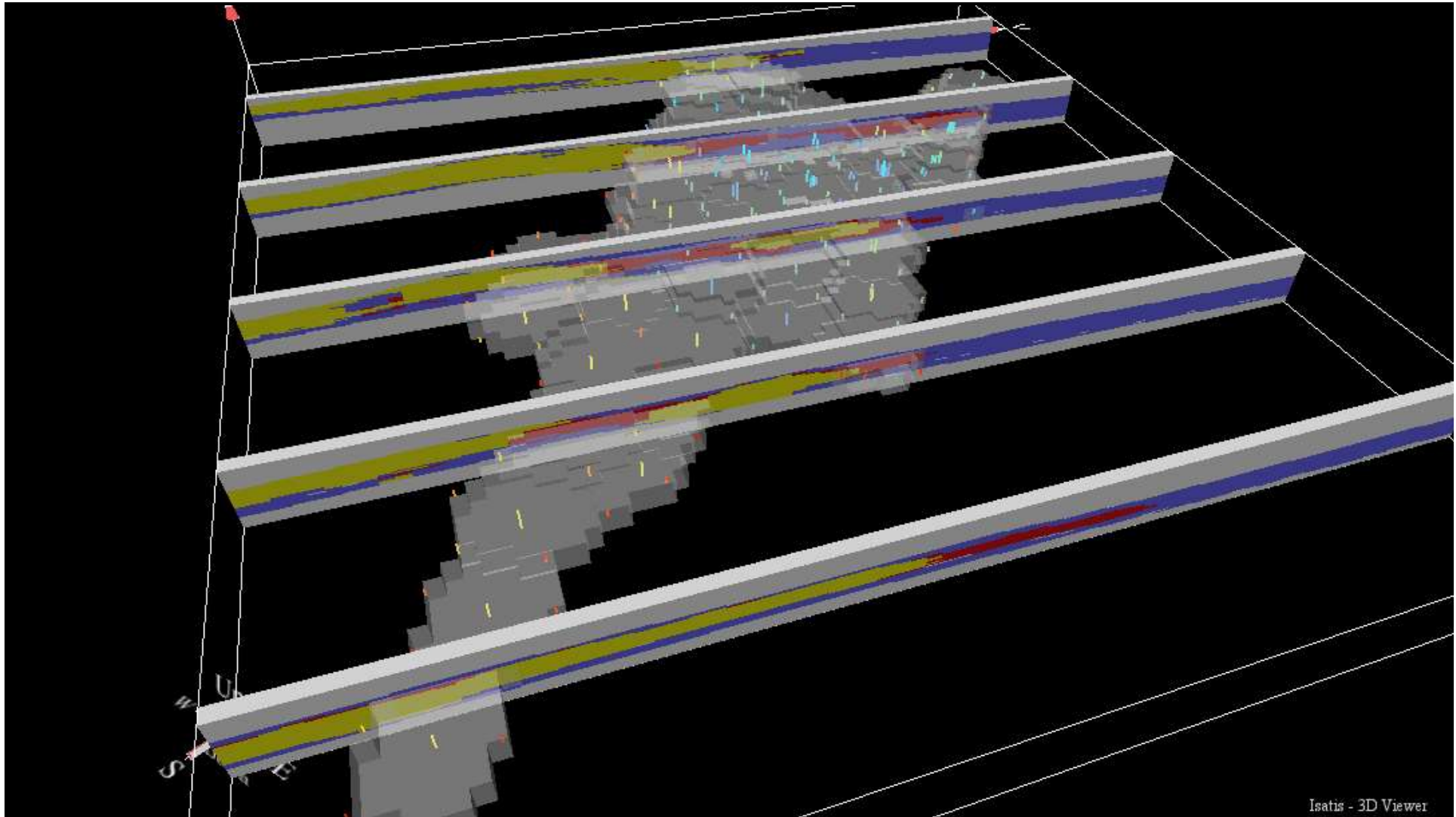
02

**Studied area:
TNU06-07-30-31**

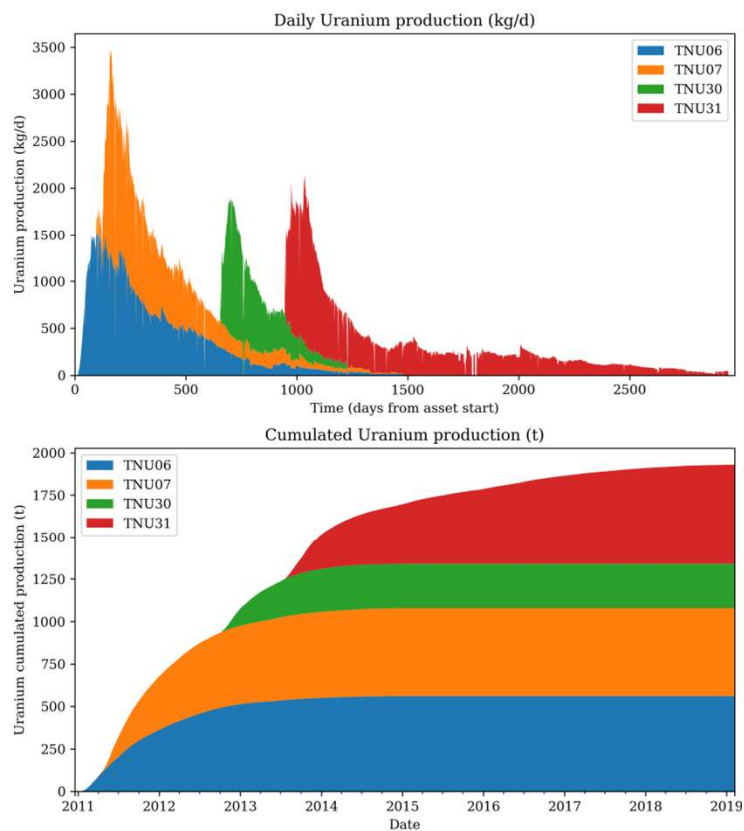


Map of the technological wells and associated lines

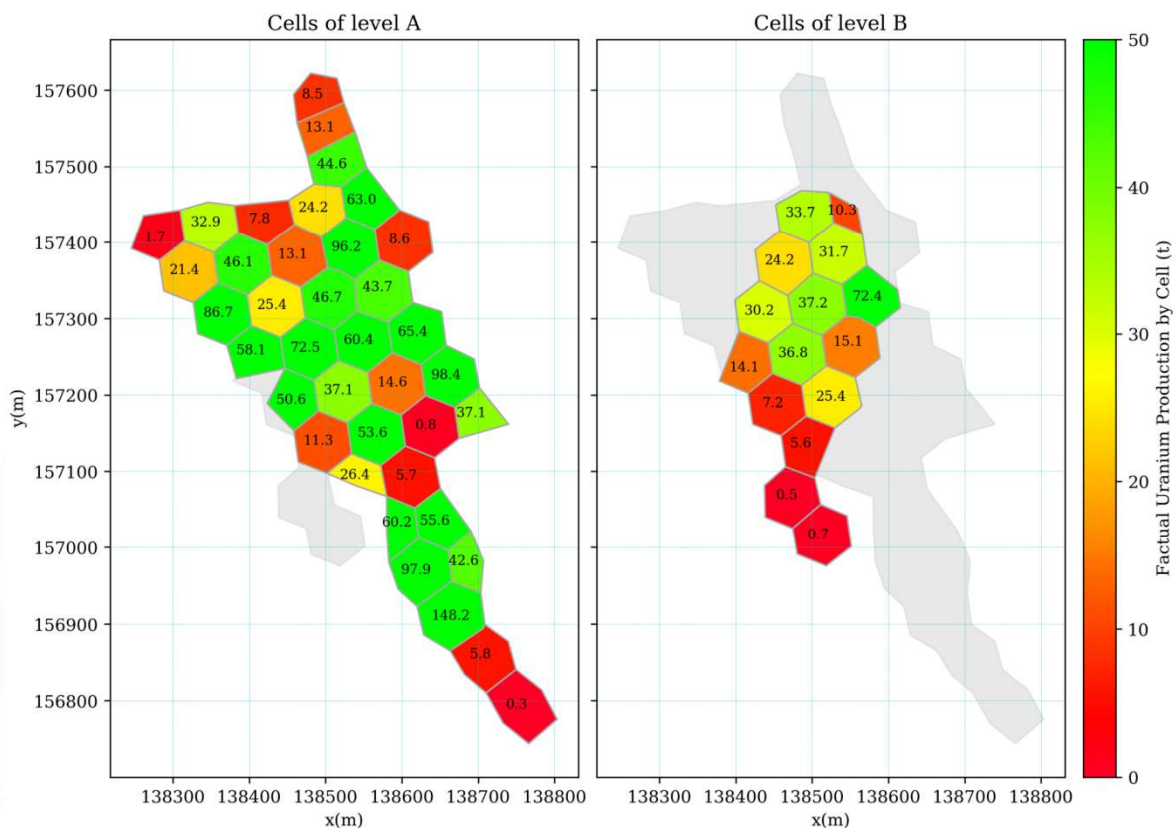




Factual production of the Technological Zone TNU06_07_30_31_1000mg

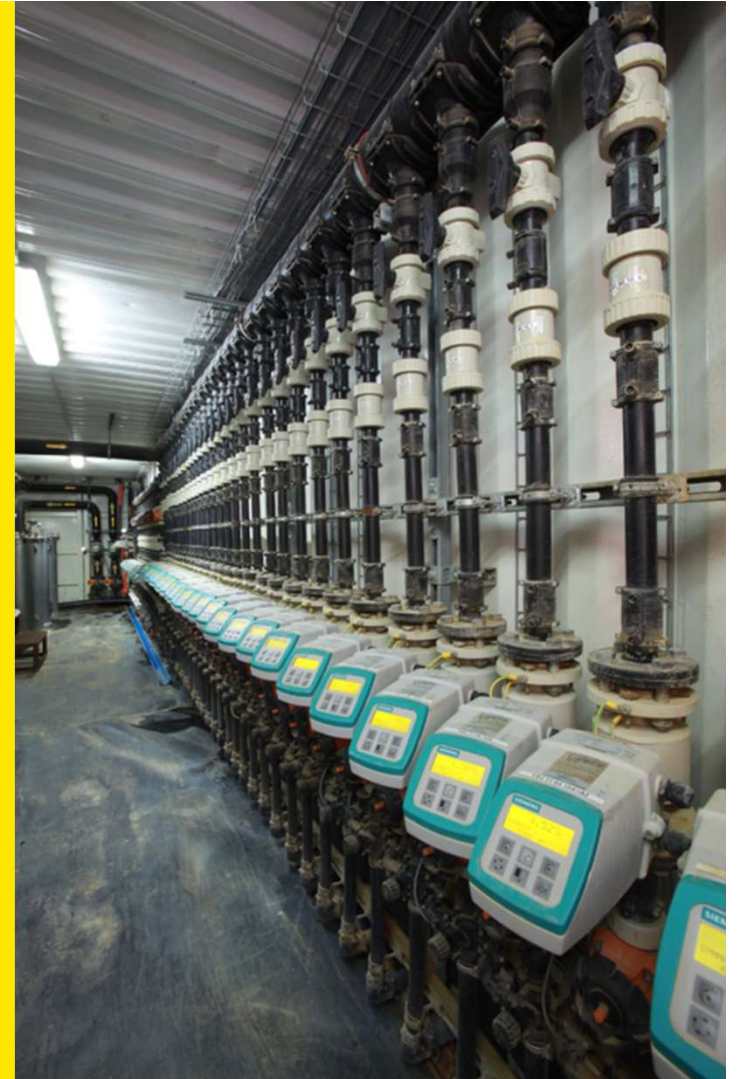


Factual Uranium Production by Cell (t)



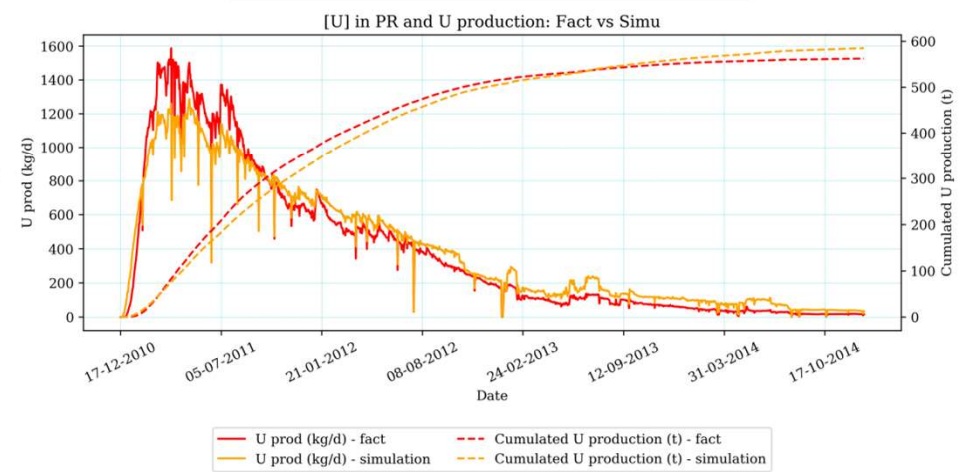
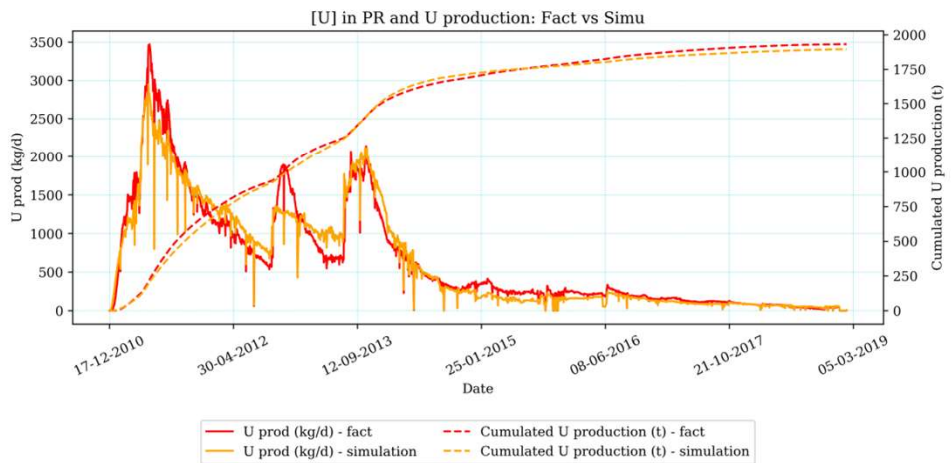
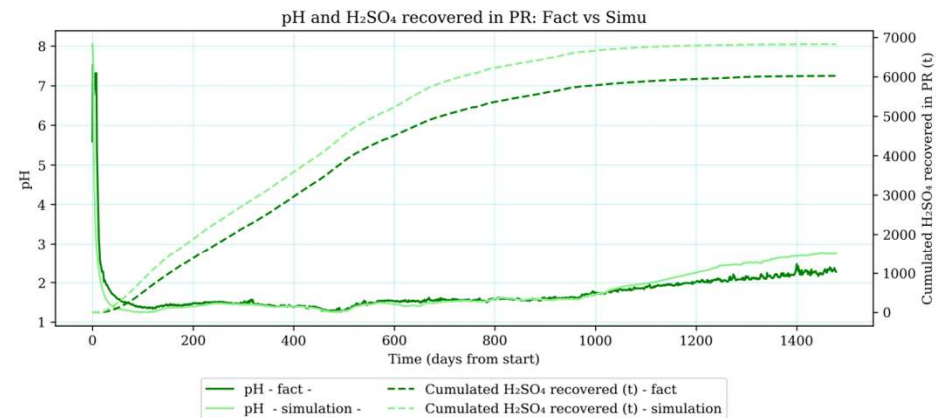
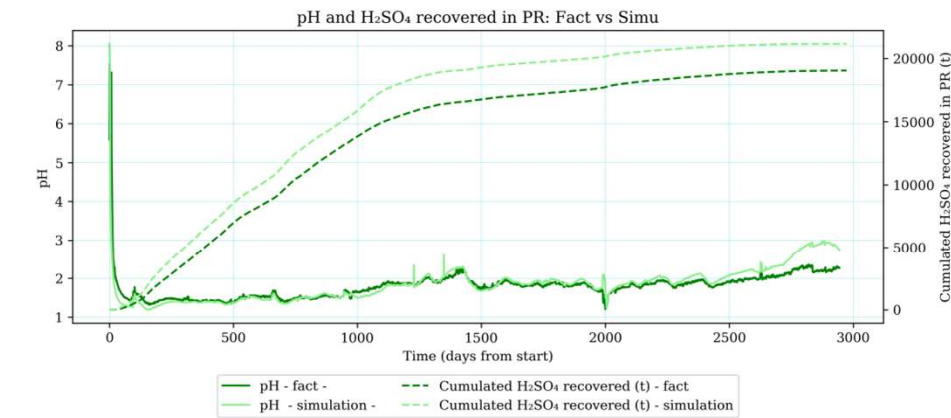
03

History Matching (2010-2019)

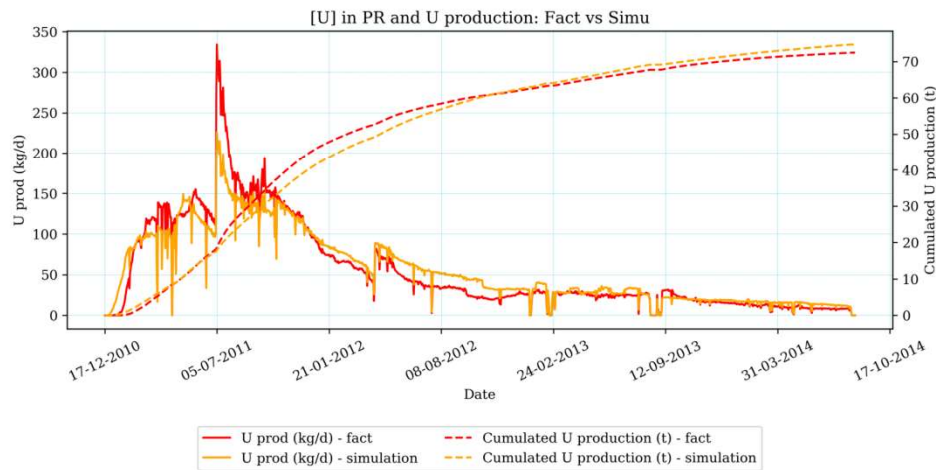
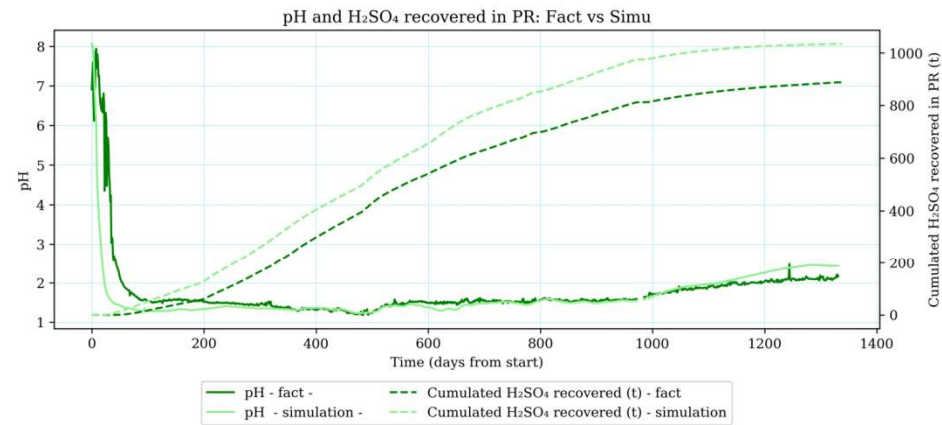


History matching results of the Technological Zone TNU06_07_30_31_1000mg

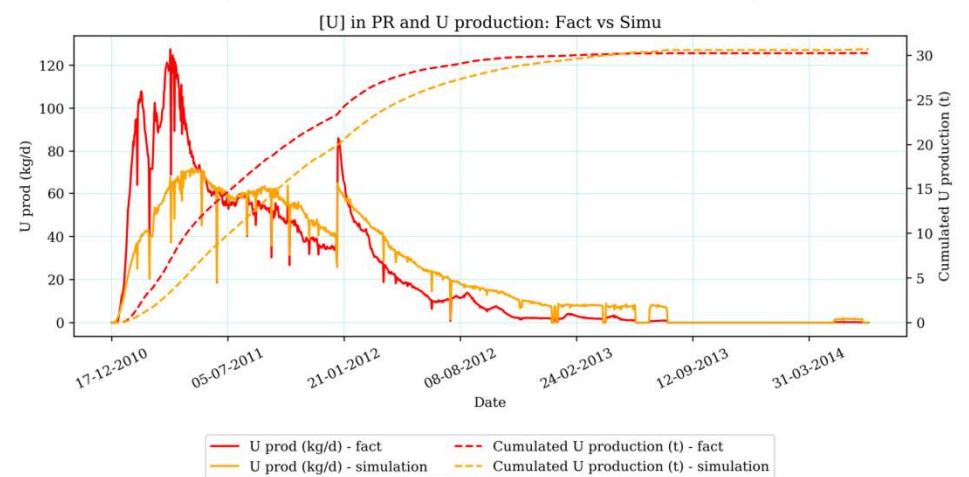
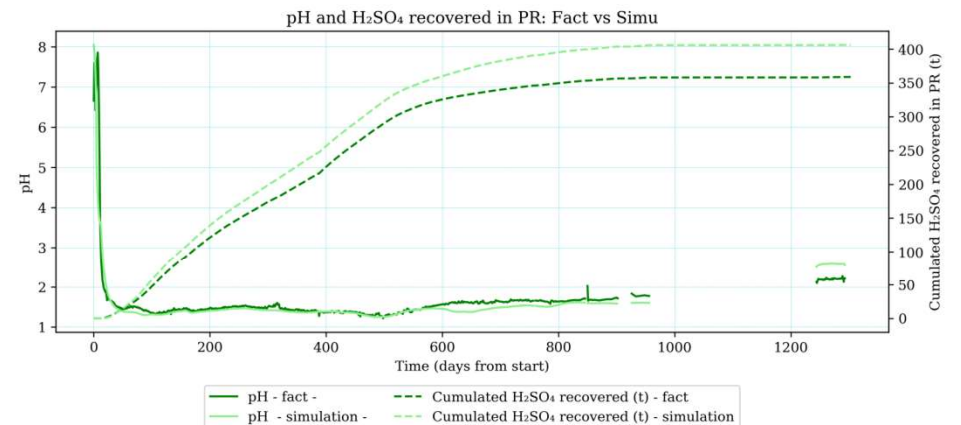
History matching results of the Technological Block TNU06



History matching results of the Tehcnological Cell TNU06_04_08_B_

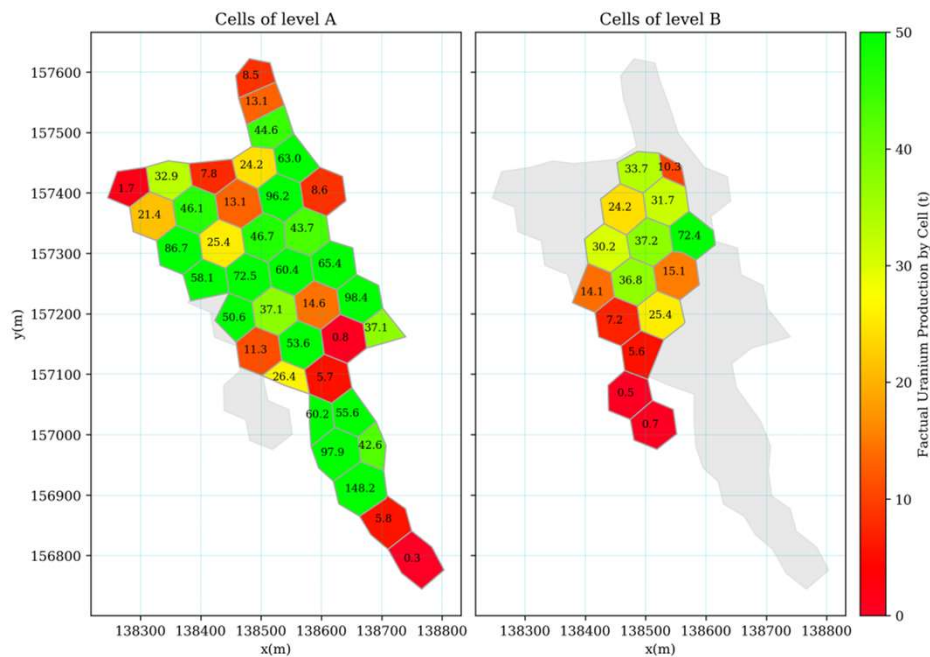


History matching results of the Producer TNU06_04_04_B_

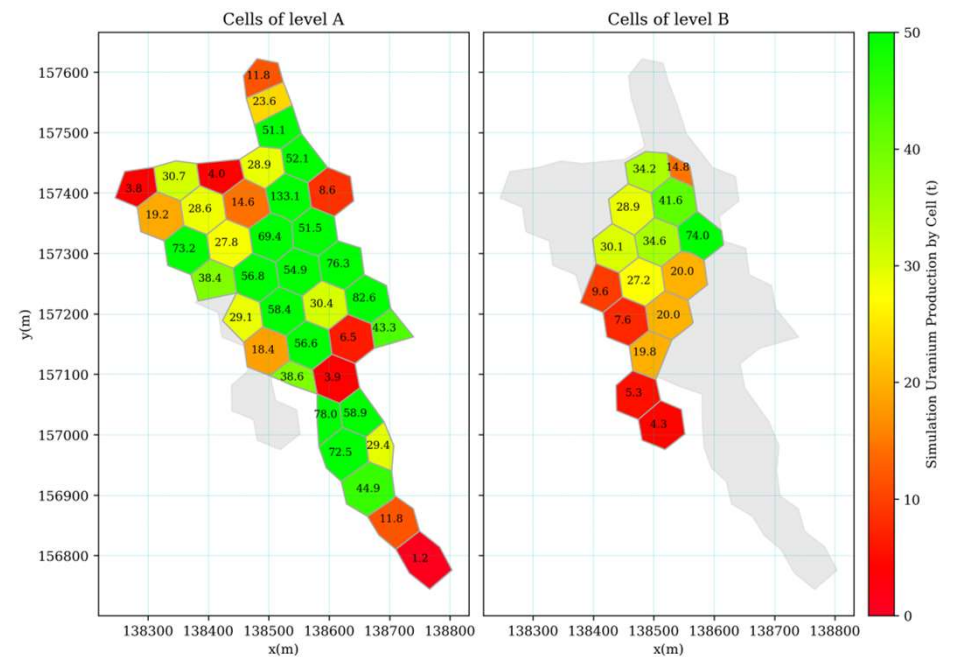


A fair match at the cell scale

Factual Uranium Production by Cell (t)

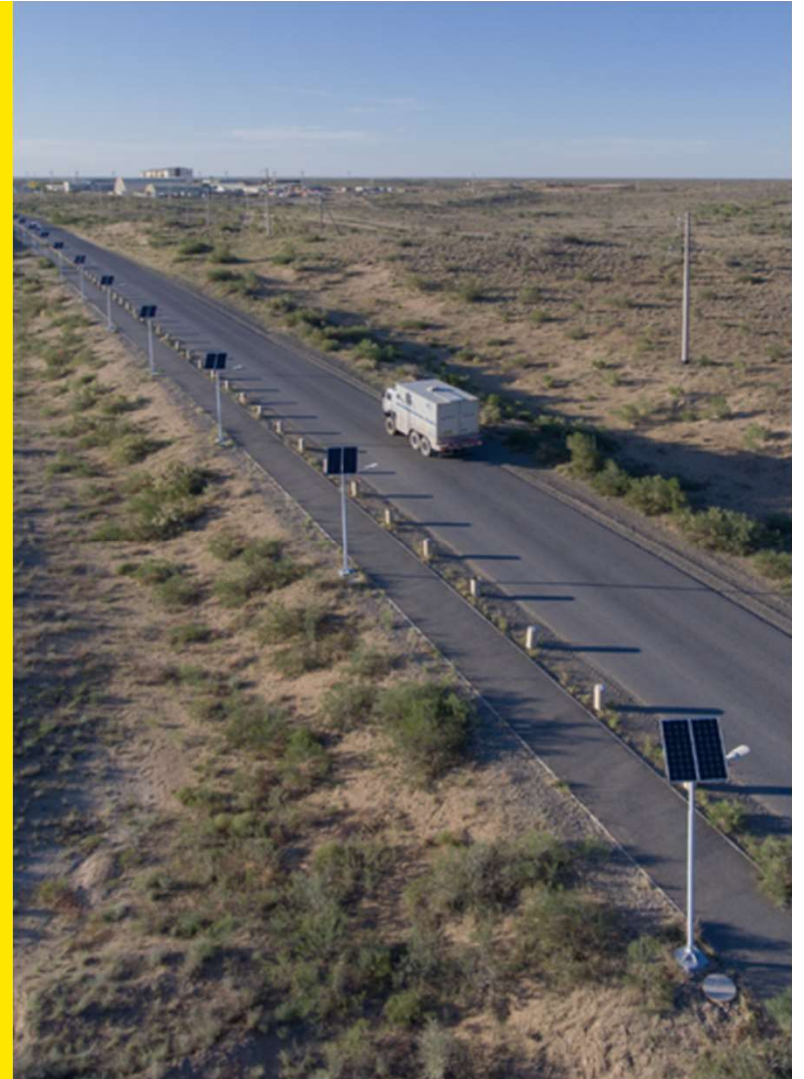


Simulation Uranium Production by Cell (t)



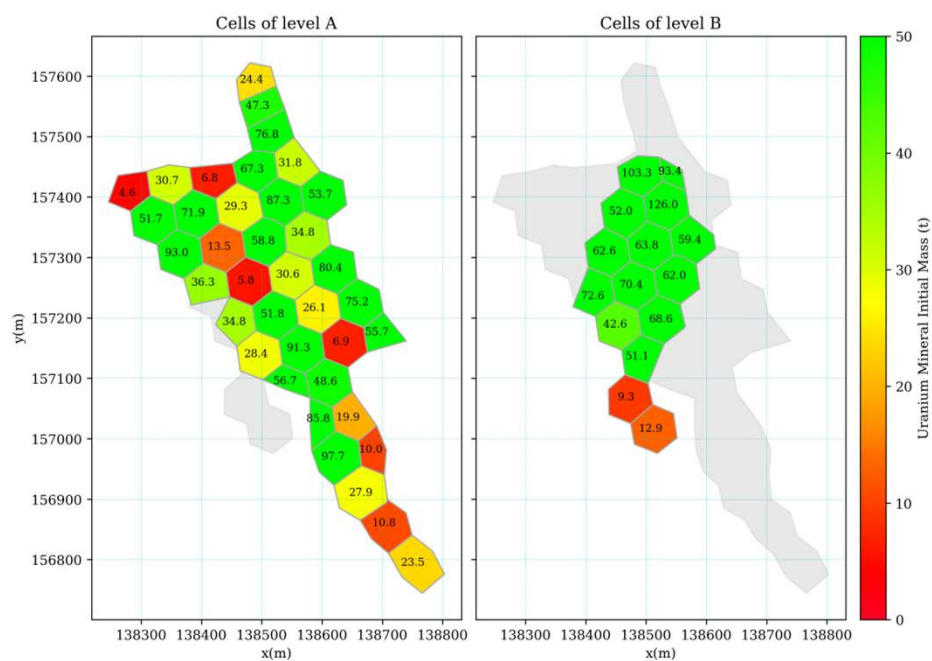
04

Forecast scenarios (2019-2021)

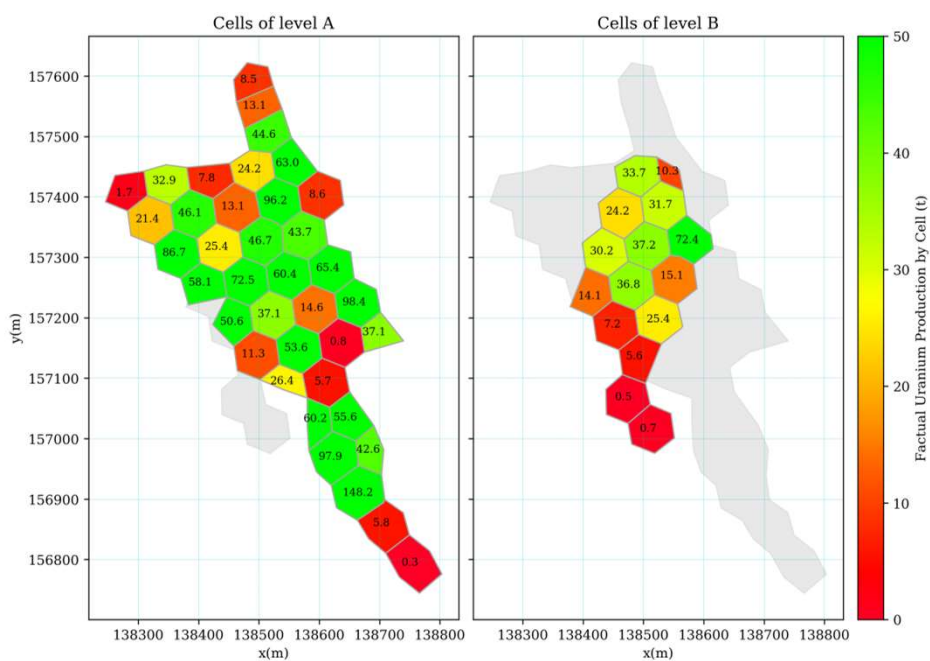


Uranium: location vs. production

Uranium Mineral Initial Mass (t)

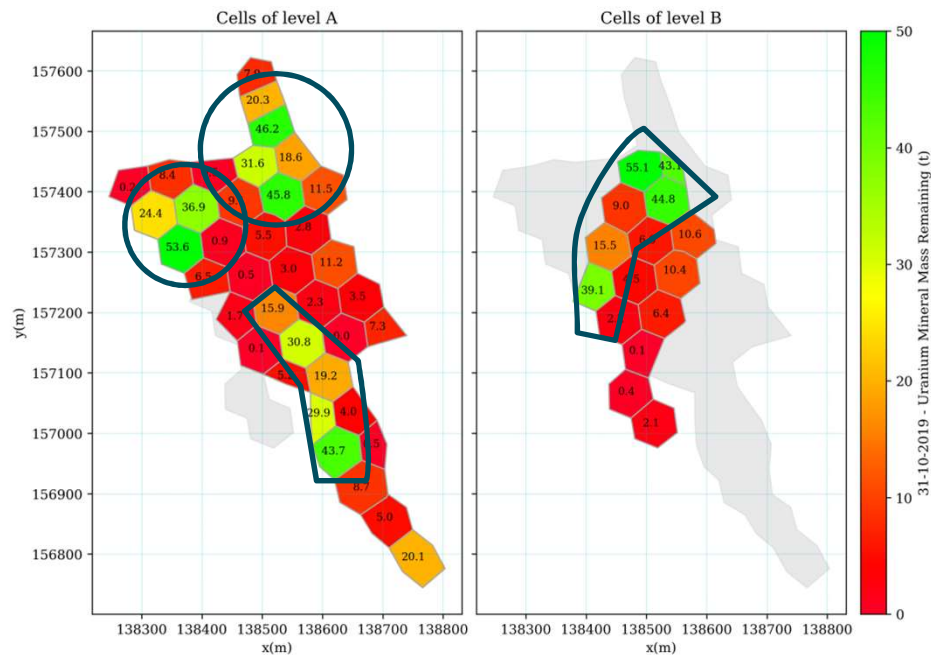


Factual Uranium Production by Cell (t)



Looking for the best design

31-10-2019 - Uranium Mineral Mass Remaining (t)



- **Capacity constraints**

- ~ 20 cells
- ~ 250 m³/h

- **What criteria ?**

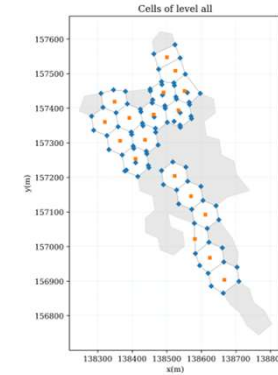
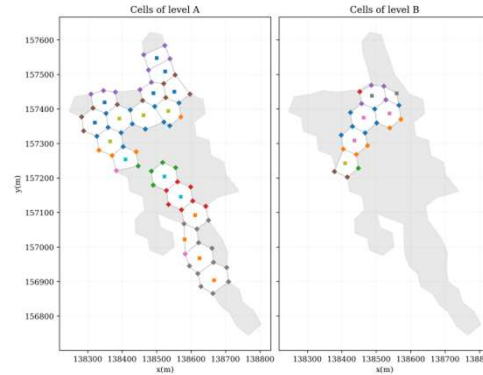
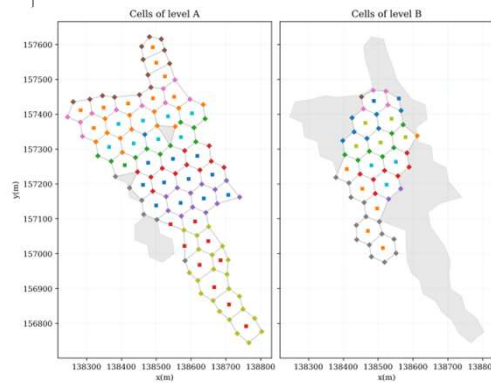
- **Last [U]**
- **Remaining reserves**
- **Simulated production**
- **Global [U] simulated**
- **NPV (KZT)**

Design based on simulation results

S1) Simulation
of all cells

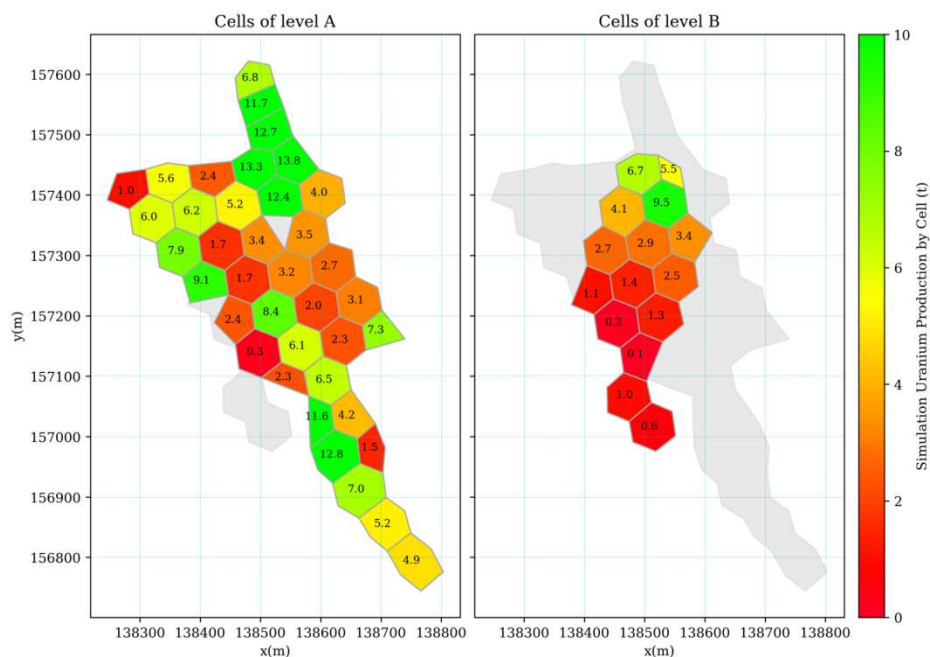
S2) Simulation
of best cells only

S3) Optimization
of the scenario



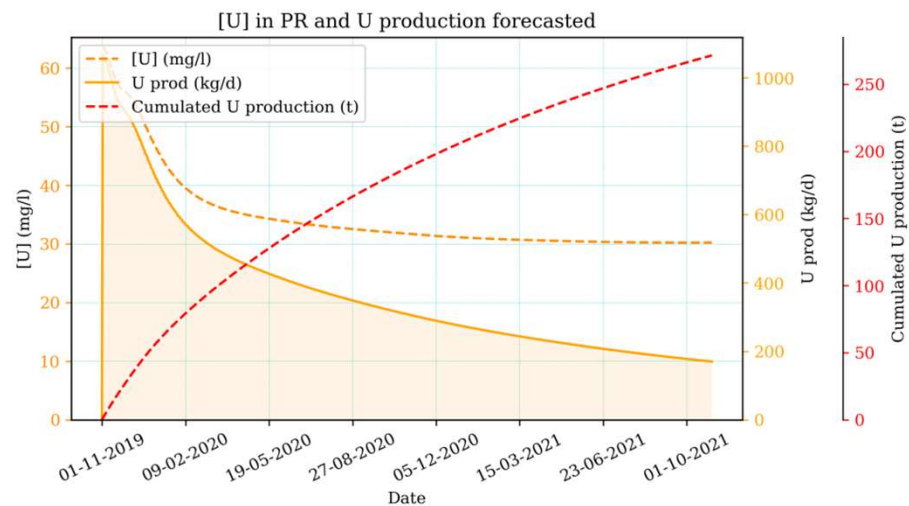
S1: All cells forecasted

Simulation Uranium Production by Cell (t)

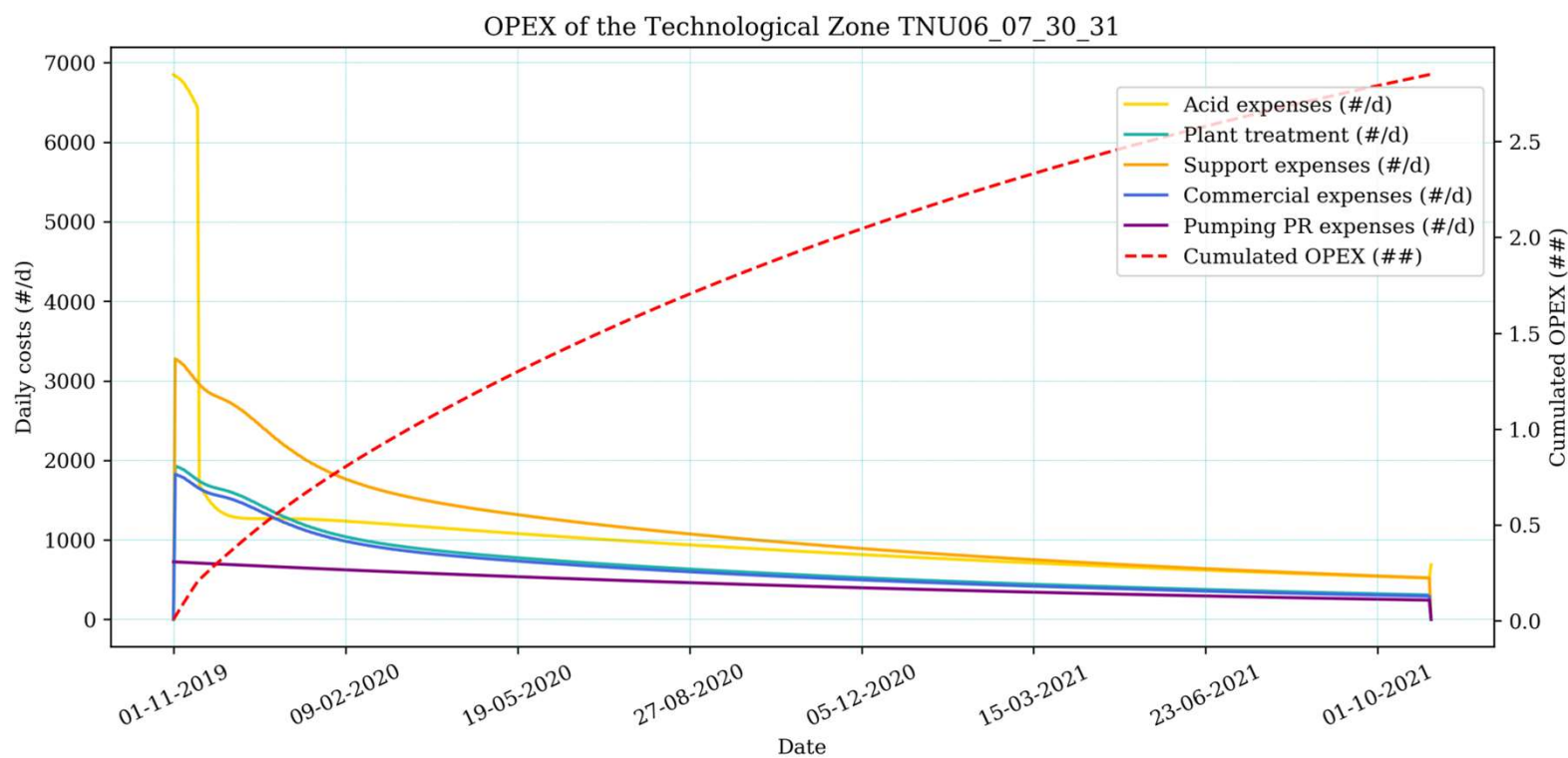


• After 2 years with 53 cells:

- > 250 t of U produced
- < 30 [U] (mg/l) → too low

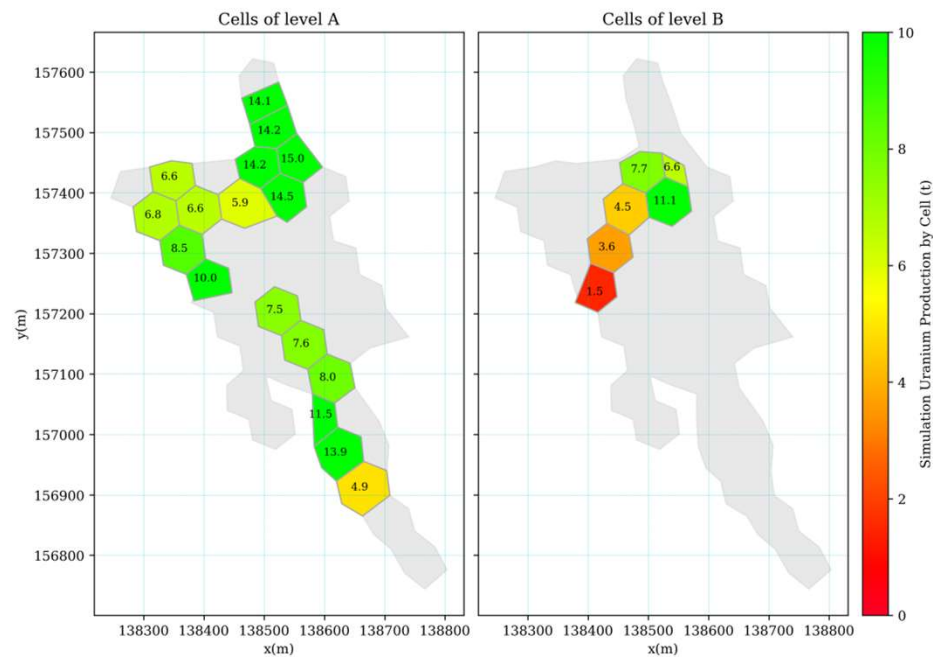


S1: All cells forecasted

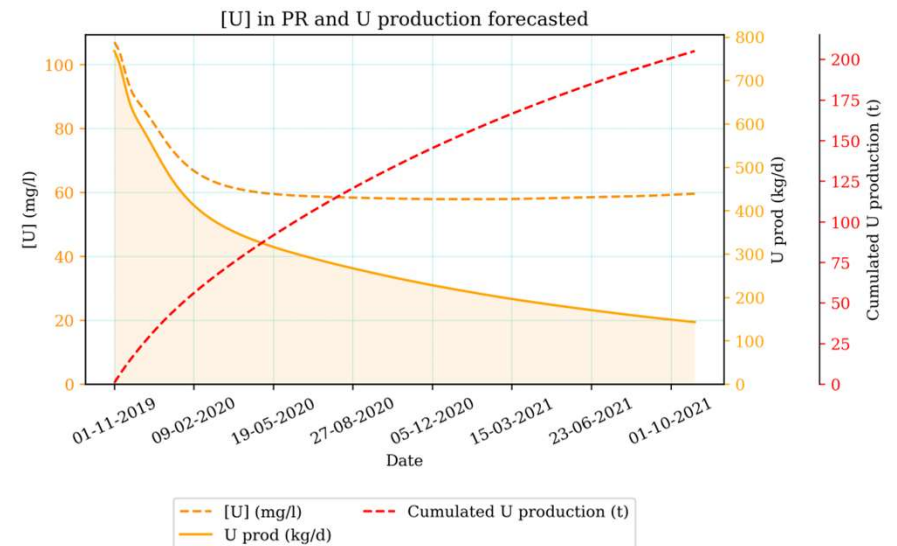


S2: 23 best cells kept

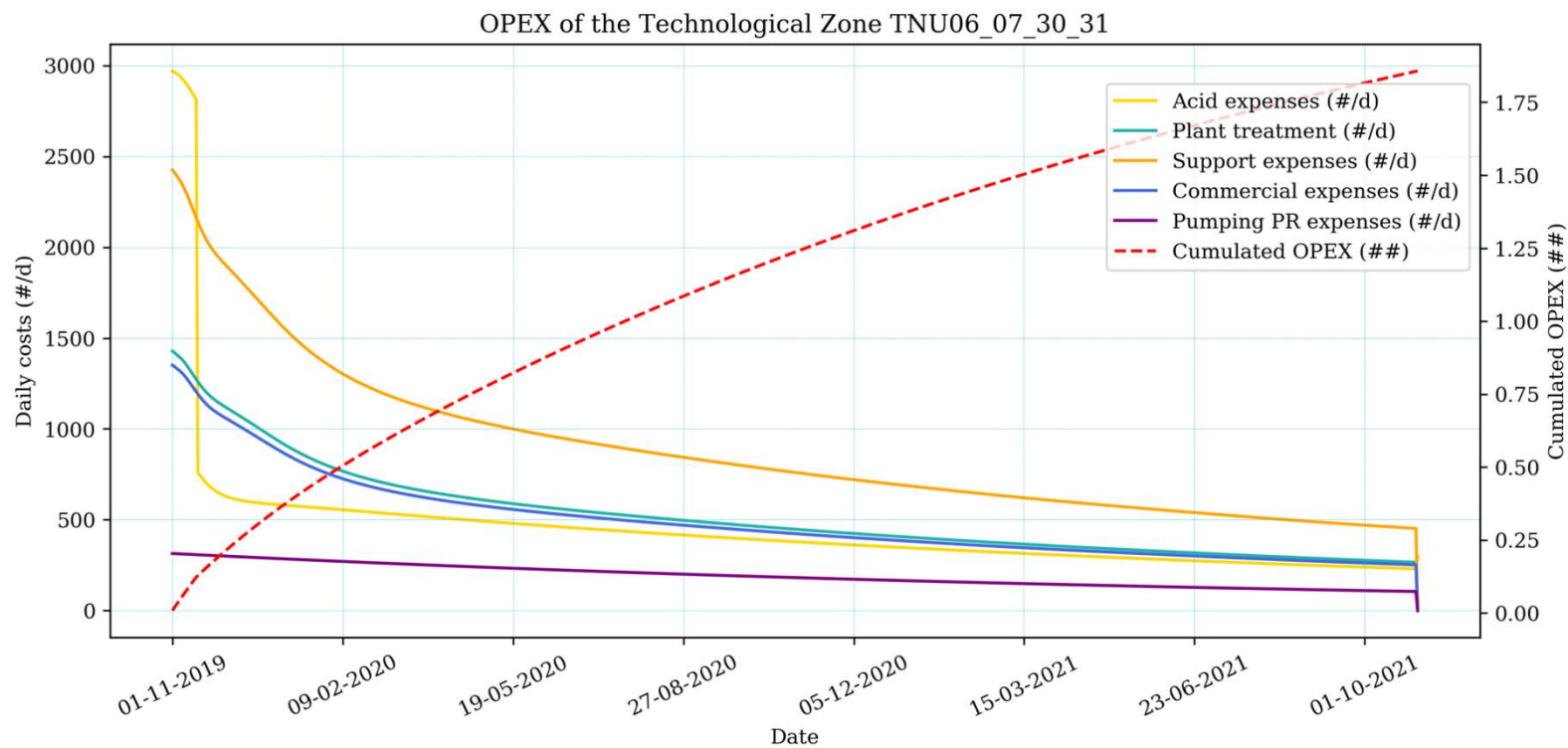
Simulation Uranium Production by Cell (t)



- After 2 years with 23 cells:
 - > 200 t of U produced
 - ~ 60 [U] (mg/l) → good concentration

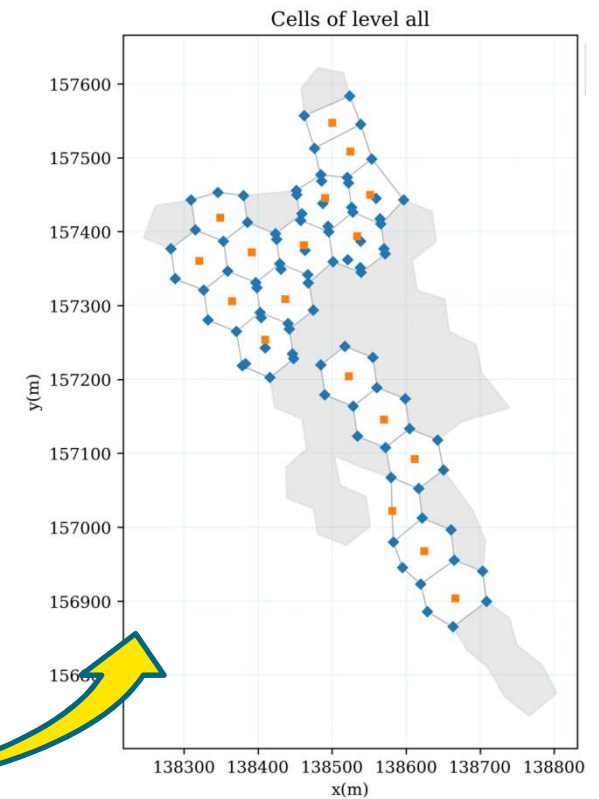
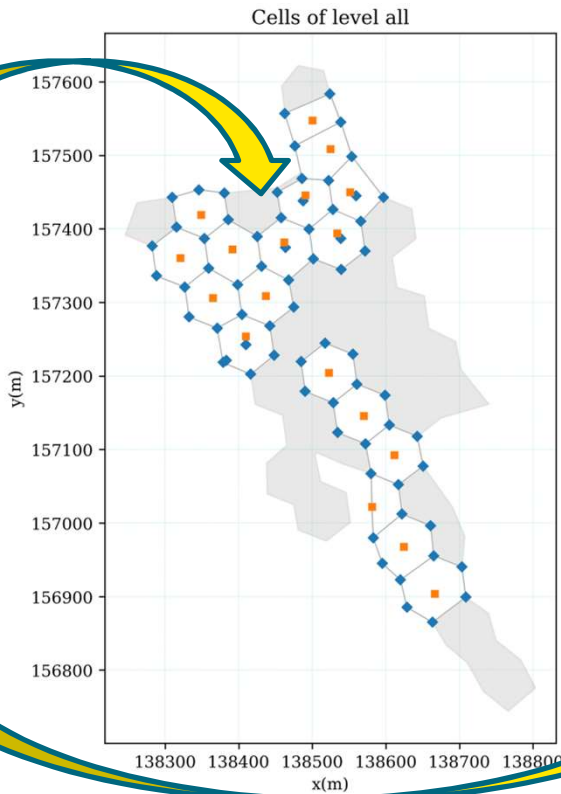
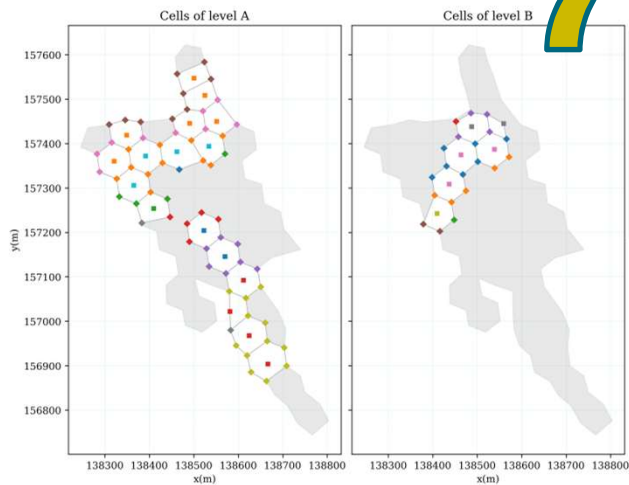


S2: 23 best cells kept



S3: Optimization examples

S3-1: Keep only level B producers as injectors

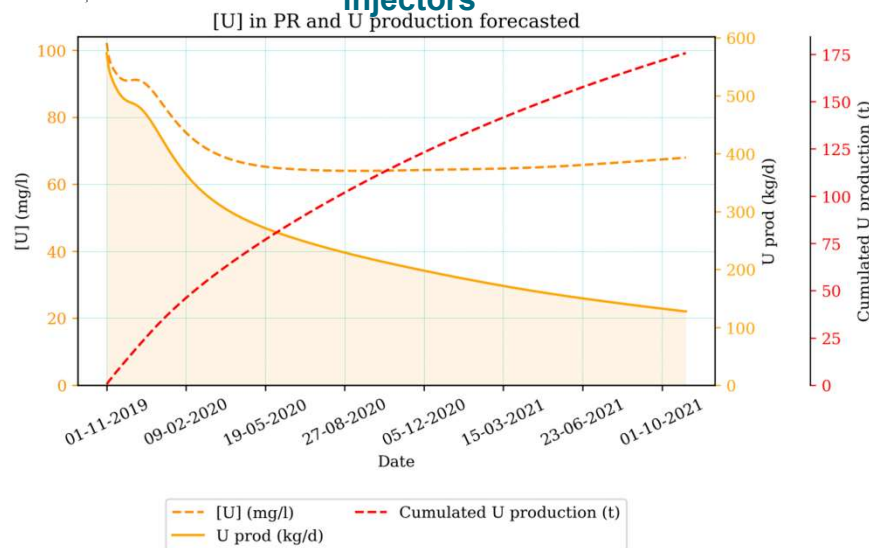


S3-2: Transform all level B as injectors

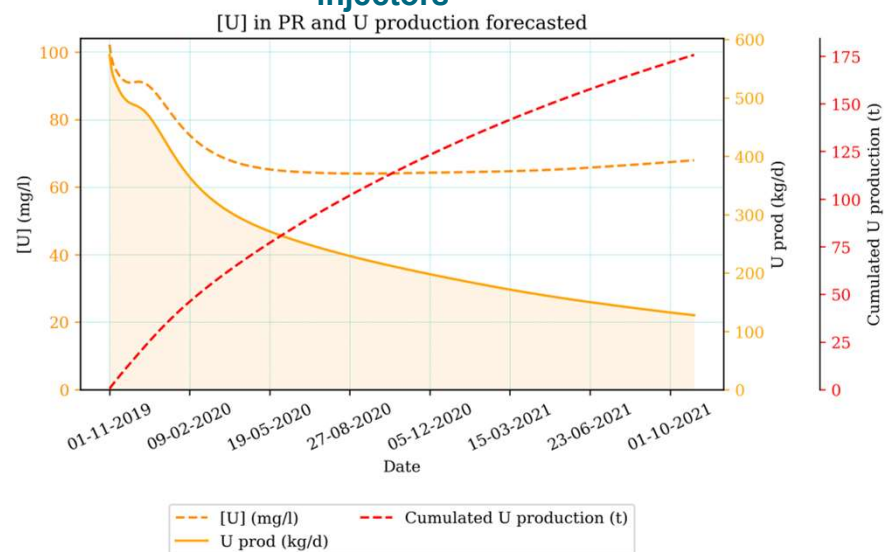
S3: Optimization examples

- After 2 years with 18 cells:
- > 175 t of U produced and > 65 [U] (mg/l) → good concentration

S3-1: Keep only level B producers as injectors

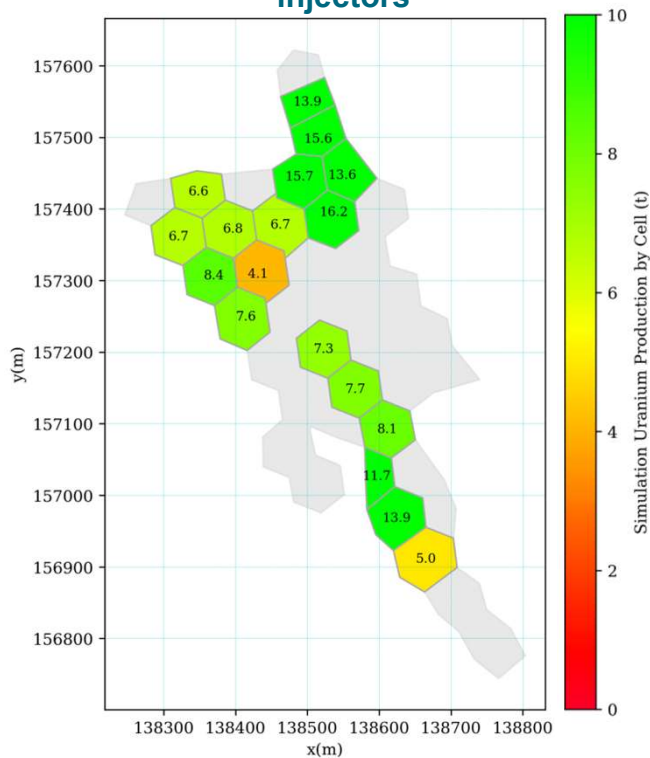


S3-2: Transform all level B as injectors

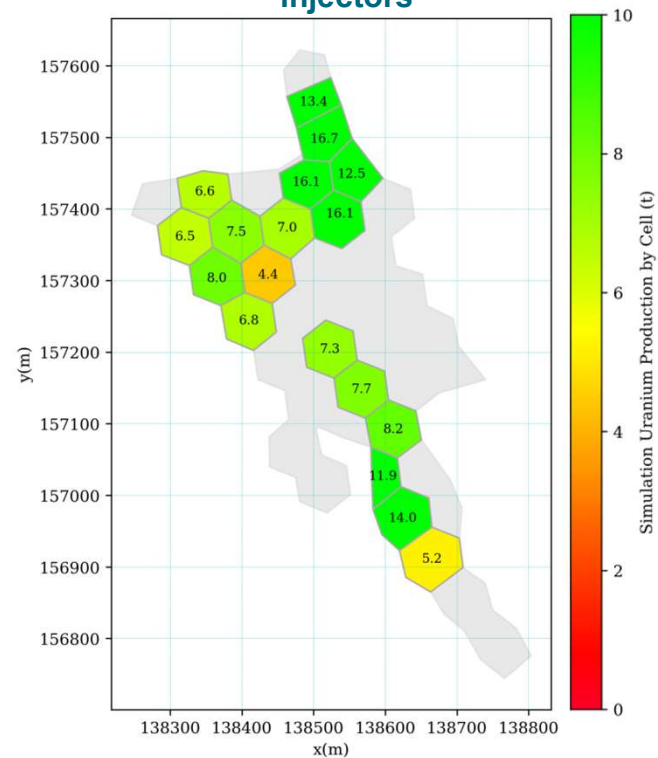


S3: Optimization examples

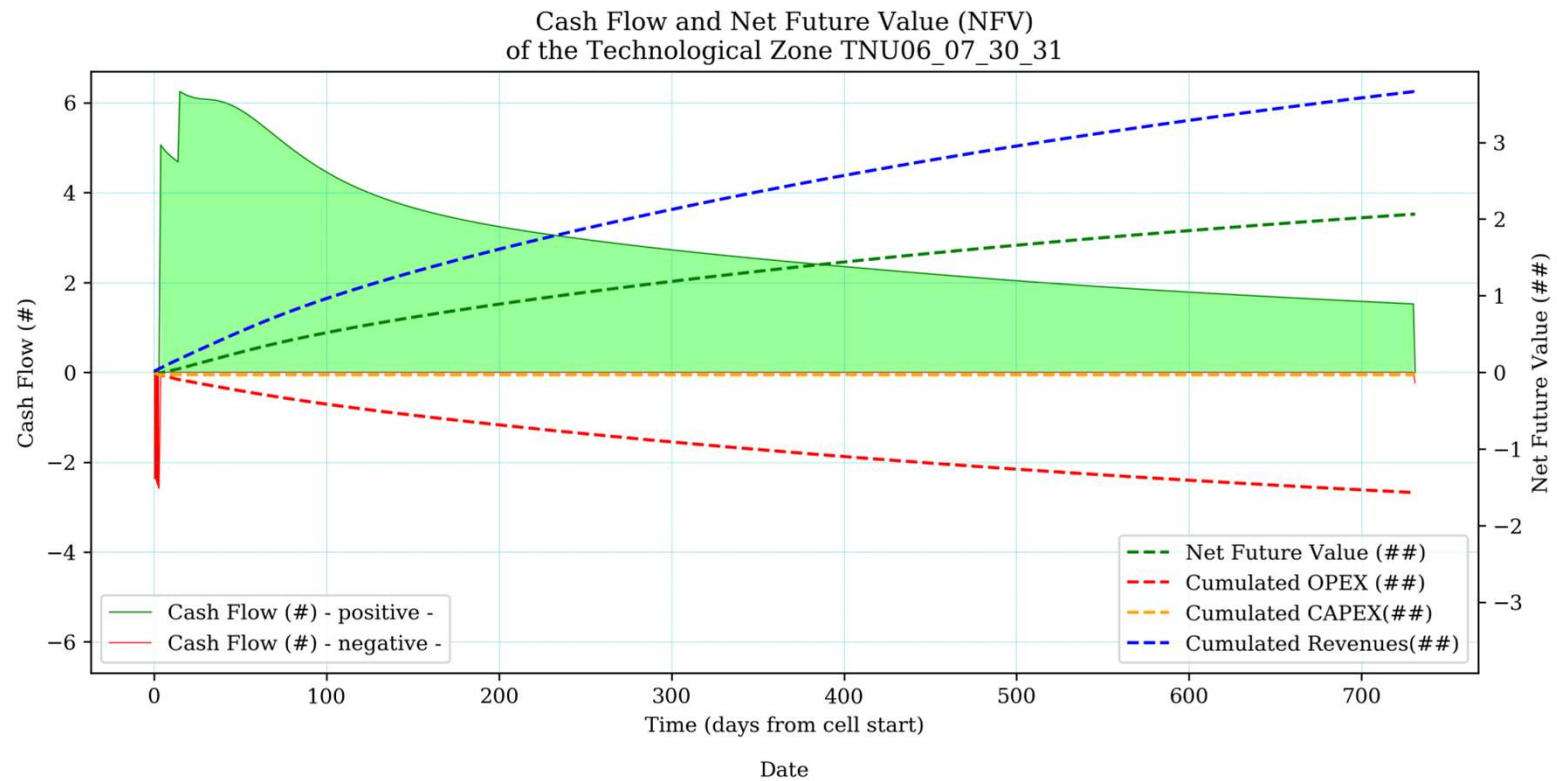
S3-1: Keep only level B producers as injectors



S3-2: Transform all level B as injectors



S3: Optimization examples



Conclusions

- **Complete approach**
 - **Geology + reserves**
 - **Operational parameters**
- **Hytec reliability**
 - **Long history (10 y)**
 - **Several main events (4 blocks)**
 - **Cell scale**
 - **Multi-levels**
- **Short term optimization suited**
 - **Well scale**
 - **Producer → injector**
 - **Investigate gravity effects**
- **Allow scenarios economic analysis**
 - **U production**
 - **Acid consumption**
- **Powerful decision helper tool when used multi-step**
 - **Where the uranium remains**
 - **Base case scenario**
 - **Respect of the technical constraints**
 - **Local optimization at the well scale**
 - **Usage complementary criteria ([U], production, NPV, ...)**



orano

Giving nuclear energy its full value