

Demo case GIRAgua Recharge

Use of iMOD for numerical modelling and analysis of artificial recharge scenarios in Chile

iMOD User day - November 2021

Betsy Romero, Marta Faneca, Frans Roelofsen, Corine ten Velden

Components

- **GIRAgua project**
- **iMOD use**
- **Using MODFLOW 6**
- **Solid Tool**
- **Results - Conclusion**
- **Experiences**

GIRAgua Recarga project

Using iMOD for Aquifer Storage and Recovery (ASR) evaluation: infiltration ponds and infiltration wells systems.

Current situation

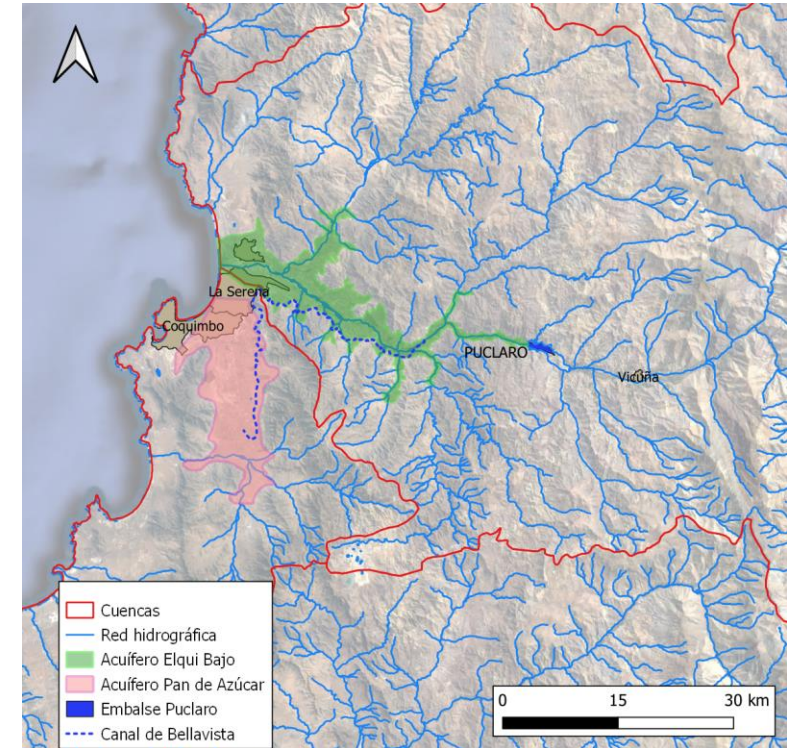
- Long periods of water scarcity
- Decreases in the levels of some aquifers that do not recover during rainy seasons.
- Water demand exceeds supply in dry periods.

Objective:

- Identify whether application of artificial aquifer recharge systems could be one of the solutions to increase water availability.

Study area:

Pan de Azúcar and Elqui Bajo aquifers (Chile)



iMOD

iMOD 5

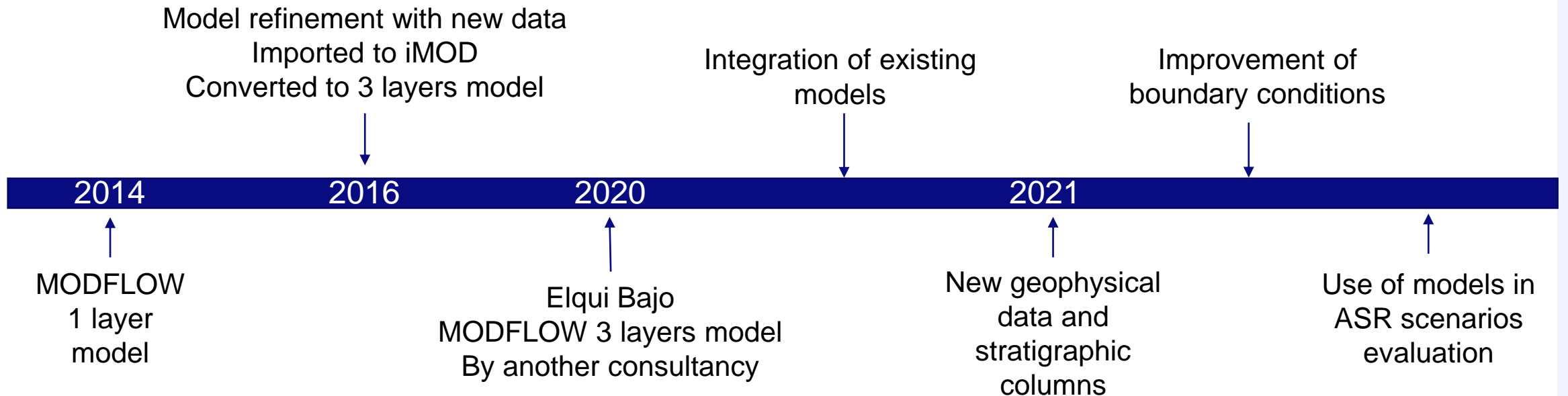
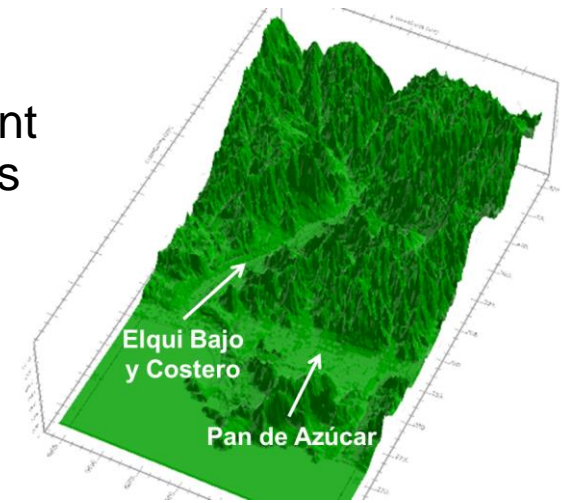
- iMOD5 GUI
 - Visualization
 - iMOD batch
- Calculation software
 - iMODFLOW (with MetaSWAP)
 - iMOD-WQ
 - MODFLOW 6 executable
 - MODFLOW 6 and MetaSWAP *.dll
 - iMOD coupler (imod_coupler)

iMOD Suite 2022.01

- New iMOD Viewer
 - QGIS plugin
 - 3D viewer
- Calculation software
 - MODFLOW 6 executable
 - MODFLOW 6 and MetaSWAP *.dll
 - iMOD coupler (imod_coupler)
- iMOD-python
 - Pre- and postprocessing
 - Model conversion (regular and irregular grids in MODFLOW 6)
 - Supports iMOD5 file formats (idf, ipf, prj)

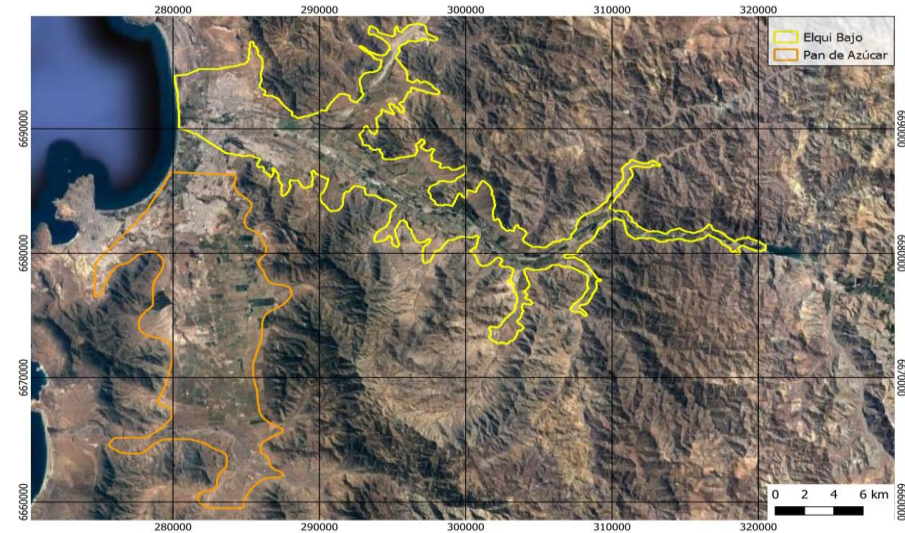
iMOD use

Development
of 2 models



iMOD use

- Easy model conversion
 - From other GUI platforms into iMOD
- Use of imod-python
 - Conversion of new input data (shp, rasters, boreholes, extraction wells)
 - Postprocessing
- Geological modelling
 - Using iMOD Solid tool
- Quick model run
 - Few minutes for 50x50m grid and 40 years simulation
- Calibration
 - Steady state and transient
- Use of MODFLOW 6



```
stages = {
    'alto'      : ['20030101', 20],
    'normal'    : ['20060901', 5],
    'bajo'      : ['20070901', 3.5],
    'muy_bajo' : ['20110801', 0]
} # 'tipo de evento': ['fecha en yyyymmdd', threshold]

# Packages .....
import imod, pandas, os, datetime, shutil

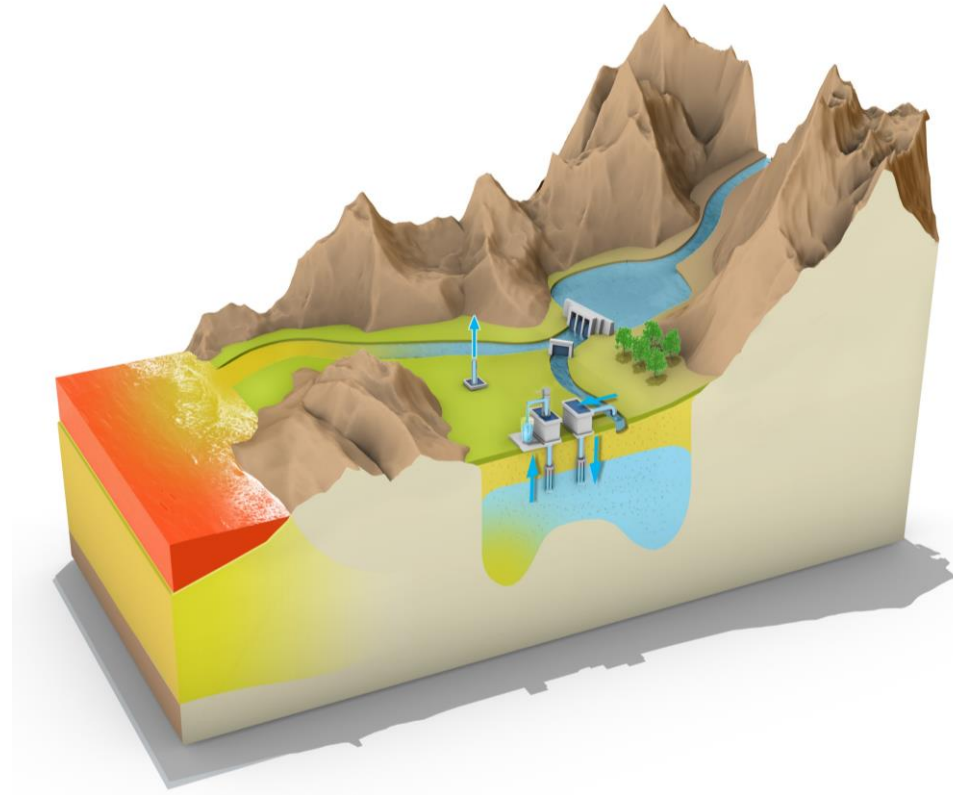
# Processing ...
## Setting discharge timeseries
data = pandas.read_excel(q_xls_file, sheet_name='wflow', headers=None) # Opening input data file
data.columns = ['Fecha', 'Q_m3s', 'Drop'] # Setting headers
data.Fecha = data.Fecha.str.split('_', expand=True)[0] # Splitting 'Fecha' column by '_' and keeping date info only
data.Fecha = pandas.to_datetime(data.Fecha) # Converting date numerical type to datetime format
data.set_index('Fecha', inplace=True) # Setting column 'Fecha' as index
data = data[(data.index >= datetime.datetime(2010,1,1)) & (data.index <= datetime.datetime(2020,12,31))] # Framing timeframe

## Identifying correspondent river idf
for row,col in data.iterrows():
    idx = 0
    for stage in stages.keys():
        if (col['Q_m3s'] >= stages[stage][1] and (idx==0)):
            idx += 1
            in_file = riv_idf.replace('<DATE>', stages[stage][0])
            out_file = os.path.join(out_dir, 'RIO_STAGE_'+str(row).split(' ')[0].replace('-', ''))+'.idf')
            shutil.copy(in_file, out_file)

print('Done!')
```

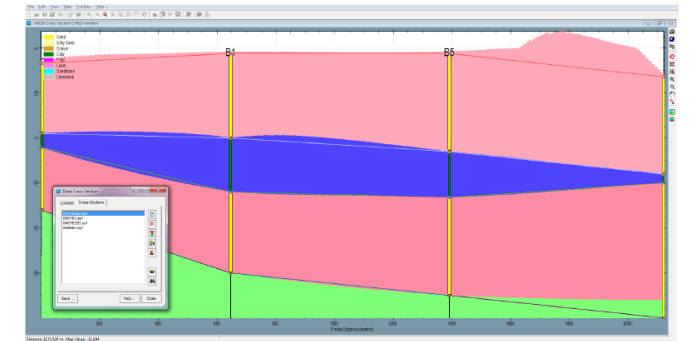
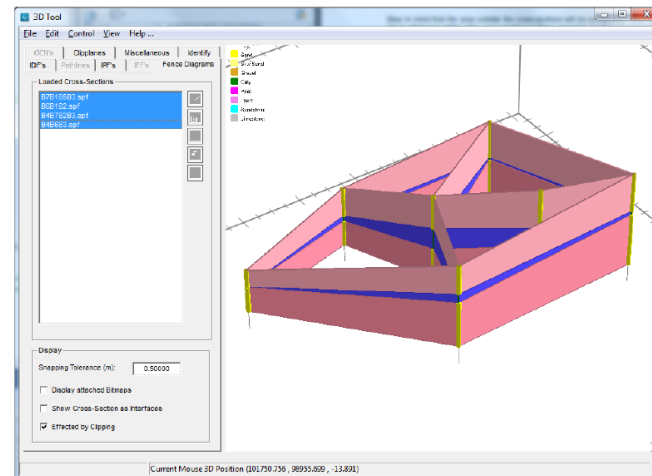
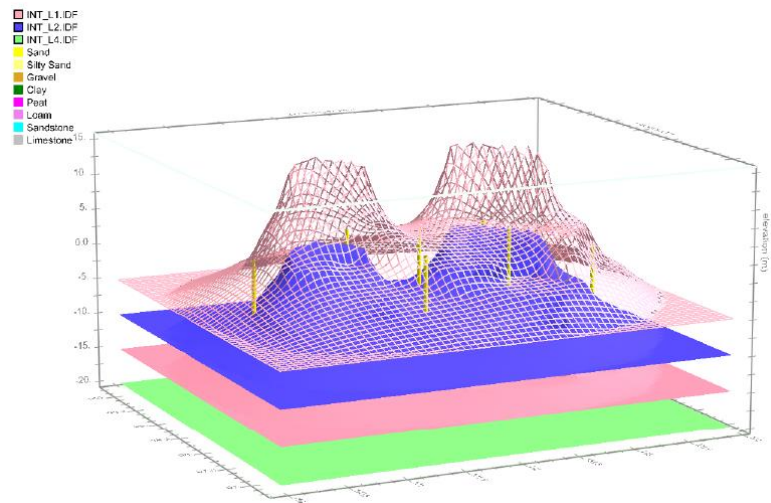
Using MODFLOW 6

- Conversion of MF2005 project file to MODFLOW 6 using iMOD tools
- Possibility of using multiple recharge systems:
 - Diffuse recharge (from wflow model Deltares), irrigation, leaking from channels, infiltration ponds
- Layers with zero thickness
- Unconfined aquifer conditions
- From Quasi 3D model to fully 3D model



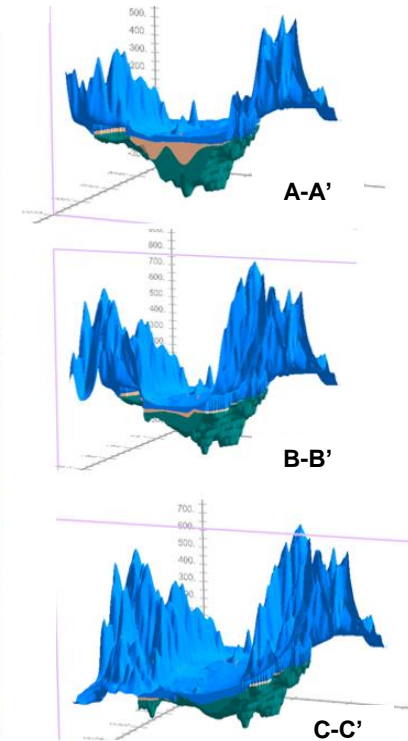
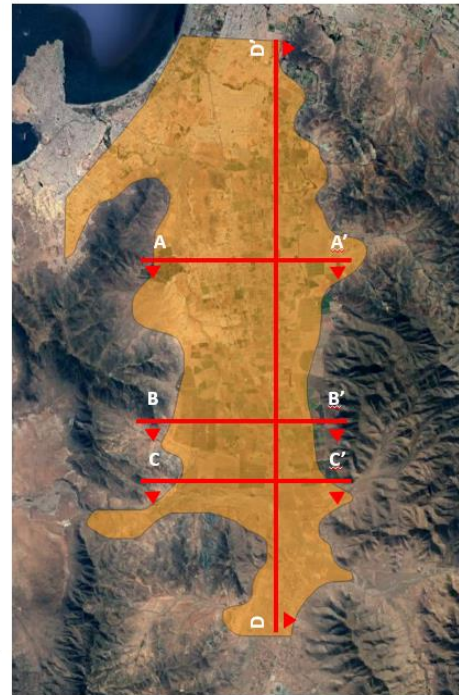
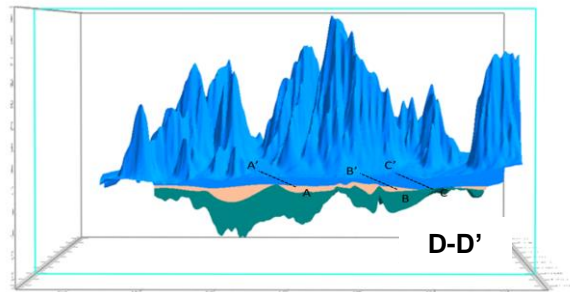
Solid tool

iMOD tool to create a 3-D representation of the subsurface where interfaces with different lithology and/or sediments can be distinguished.



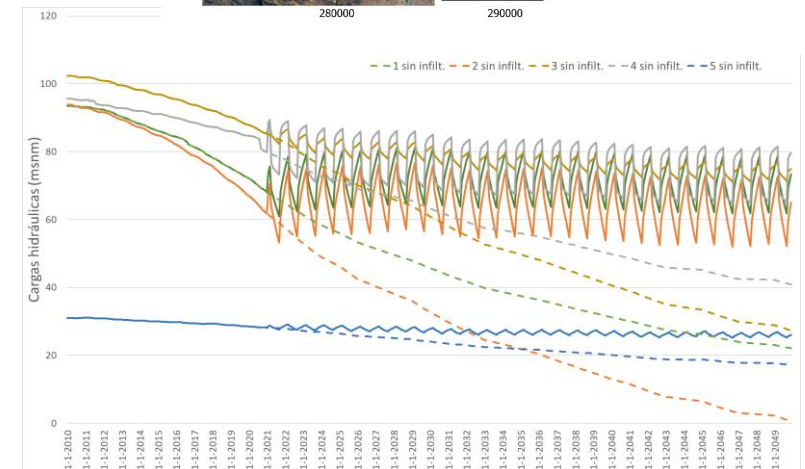
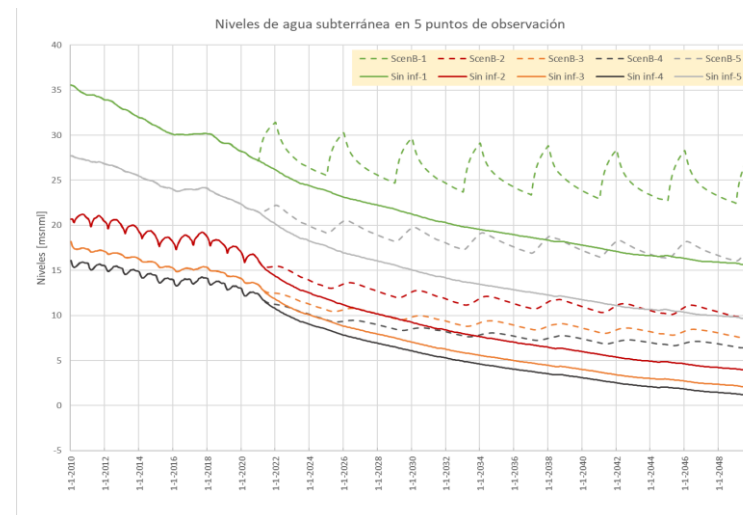
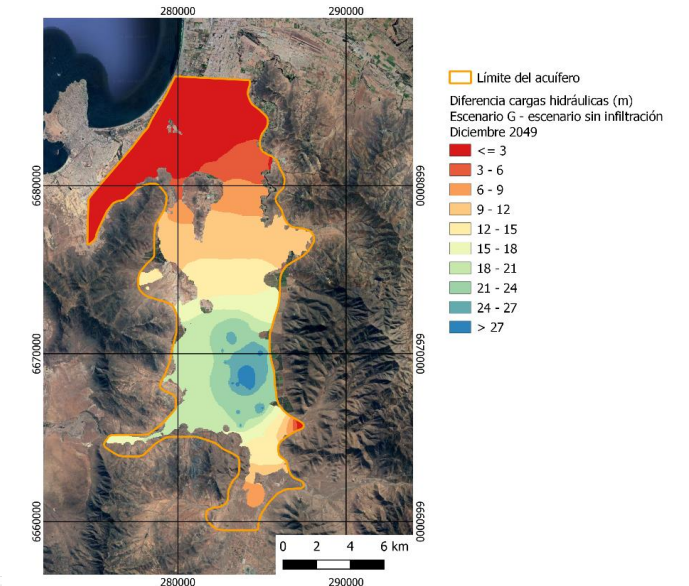
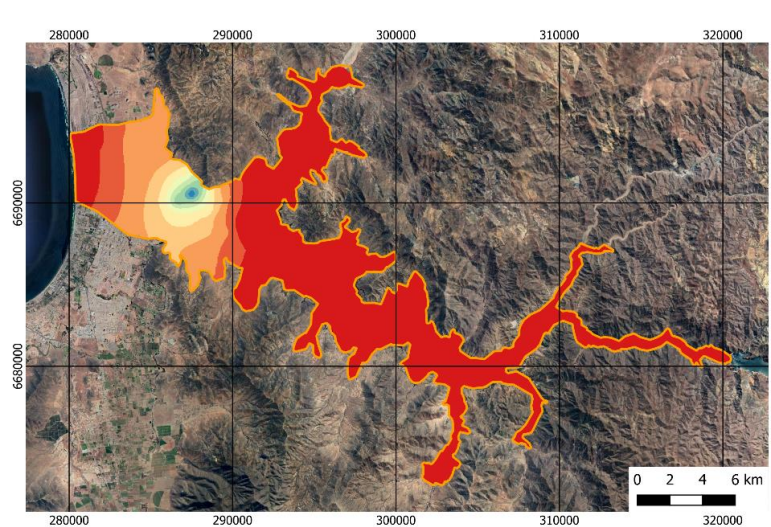
Use of iMOD Solid tool to create geological layers

Based on several geological profiles information.



Conclusion: Possibility of using ASR for stabilizing groundwater levels and ensuring future water supply

6 different ASR scenarios until 2049



Experiences

- Conversion of model files from other platforms to iMOD
 - A bit difficult when having a rotated grid
- Easy model run from iMOD 5 files to MODFLOW 6
- MODFLOW 6:
 - More options for model setup
- Use of Solid Tool
 - Good visualization

Experiences

- Easy creation of input data using imod-python tools:
 - Monthly varying data for wells, river stages, recharge rates for ~40 years
- Scripting very helpful in the process of analysis and understanding the model:
 - Easily re-run and adapting the model
- In the future: Use of MODFLOW 6 for nested gridding in infiltration areas

Questions to Betsy Romero



EXTRA: iMOD 5 manual and tutorials are available
in Spanish! (check iMOD website)