FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

European Commission

ict4water.eu

Open Workshop
1st FREEWAT User and Developers International Workshop

September 21st 2017

IDAEA. CID - CSIC

16 Jordi Girona. 08034 Barcelona

Bremerhaven Case Study

Groundwater under climate change

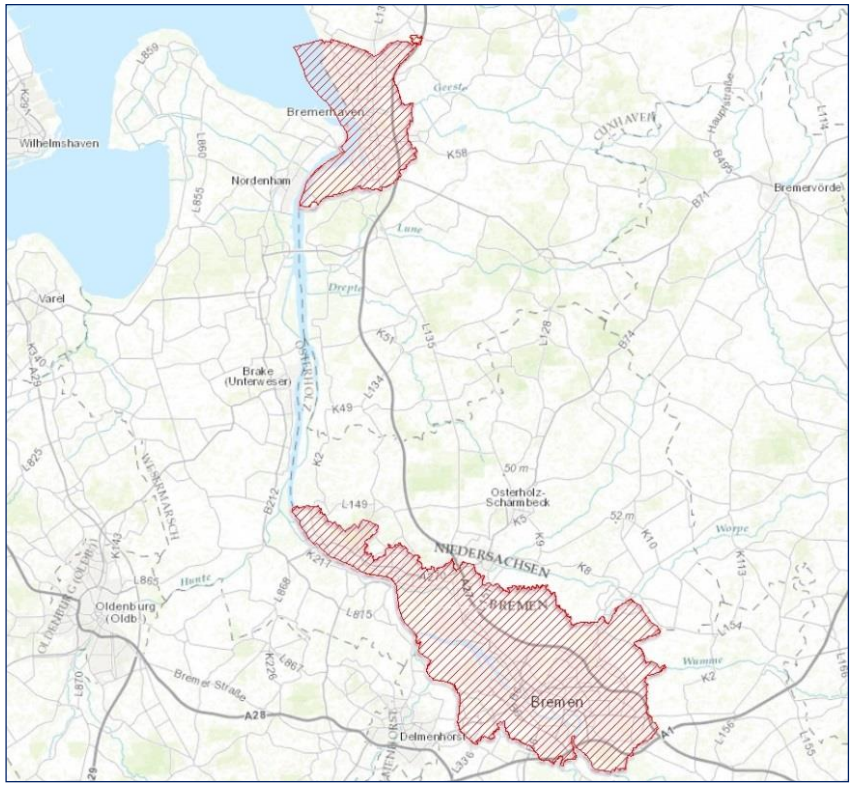
Björn Panteleit, Sven Jensen

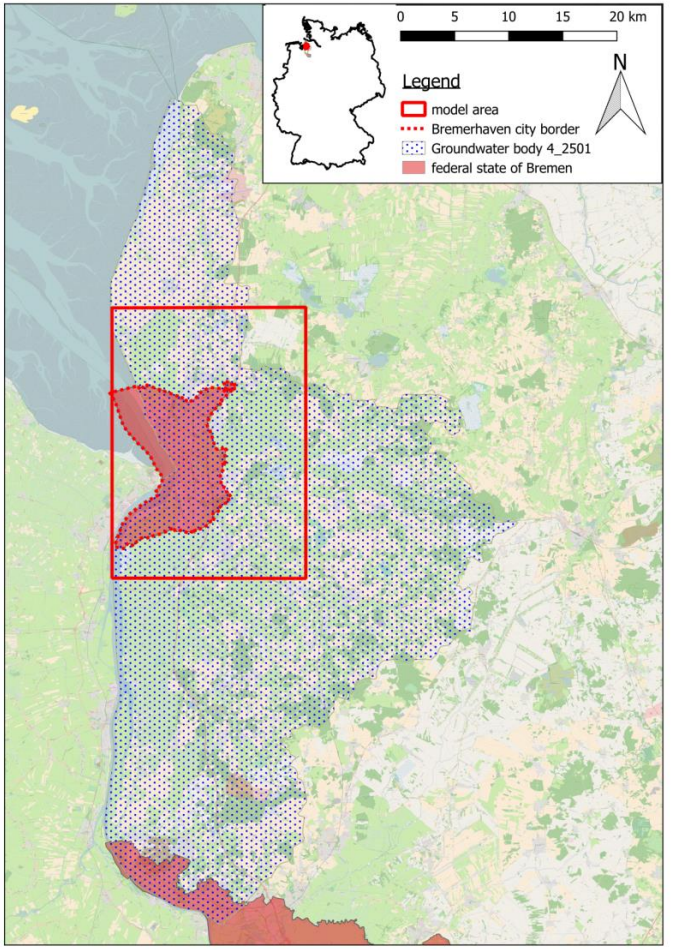
EIP Water Online Market Place
Matchmaking for water Innovation
MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

Universität Bremen
Geologischer Dienst für Bremen GDfB

50 anys
idaea
CSIC CID
CELEBRAR INNOVAR DEBATRE
CENTRE D'INVESTIGACIÓ I DESENVOLUPAMENT

Where, What ?





Aim: Management tool for the sustainable groundwater management under changing climatic conditions

FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

ict4water.eu

European Commission

EIP Water Online Market Place
Matchmaking for water Innovation
MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

idaea CSIC CID CELEBRAR INNOVAR DEBATRE

Universität Bremen
Geologischer Dienst für Bremen
GDfB

Method - overview

Structural based hydraulic modelling

-> flow model is based on a structural model

Modflow

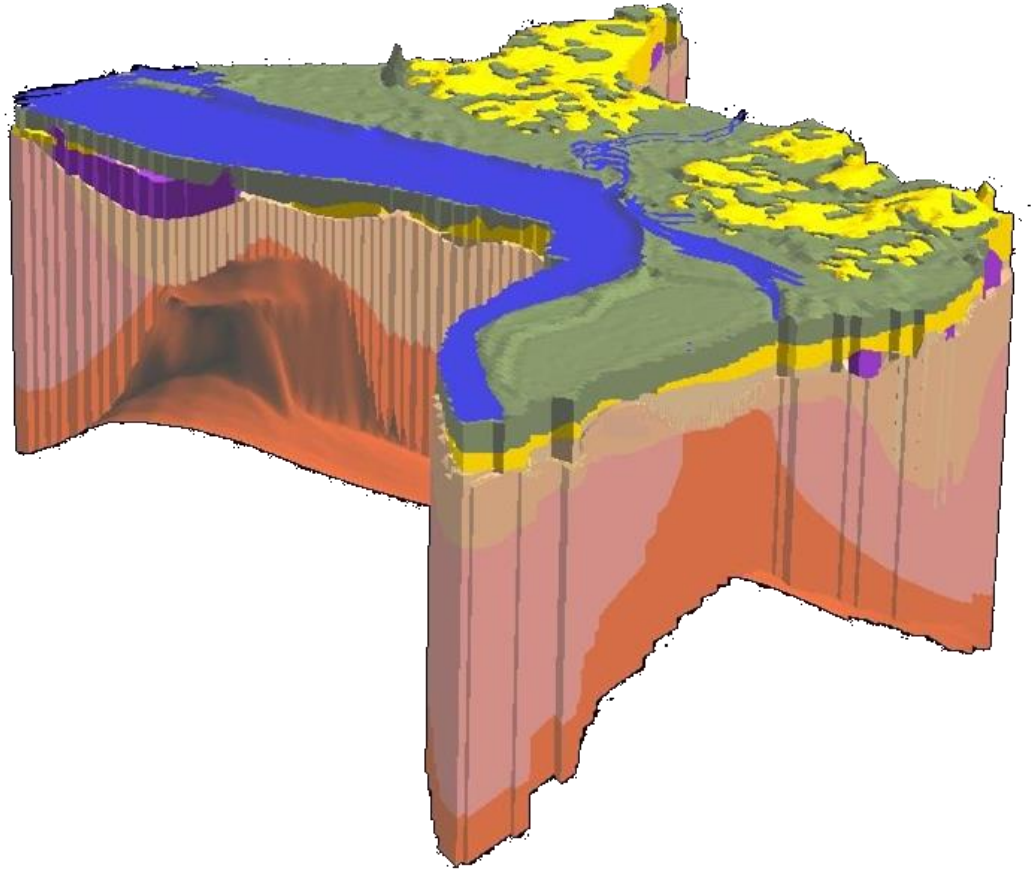
FREEWAT

-> no classical calibration by local variation of transmissivities

=> regional flow model

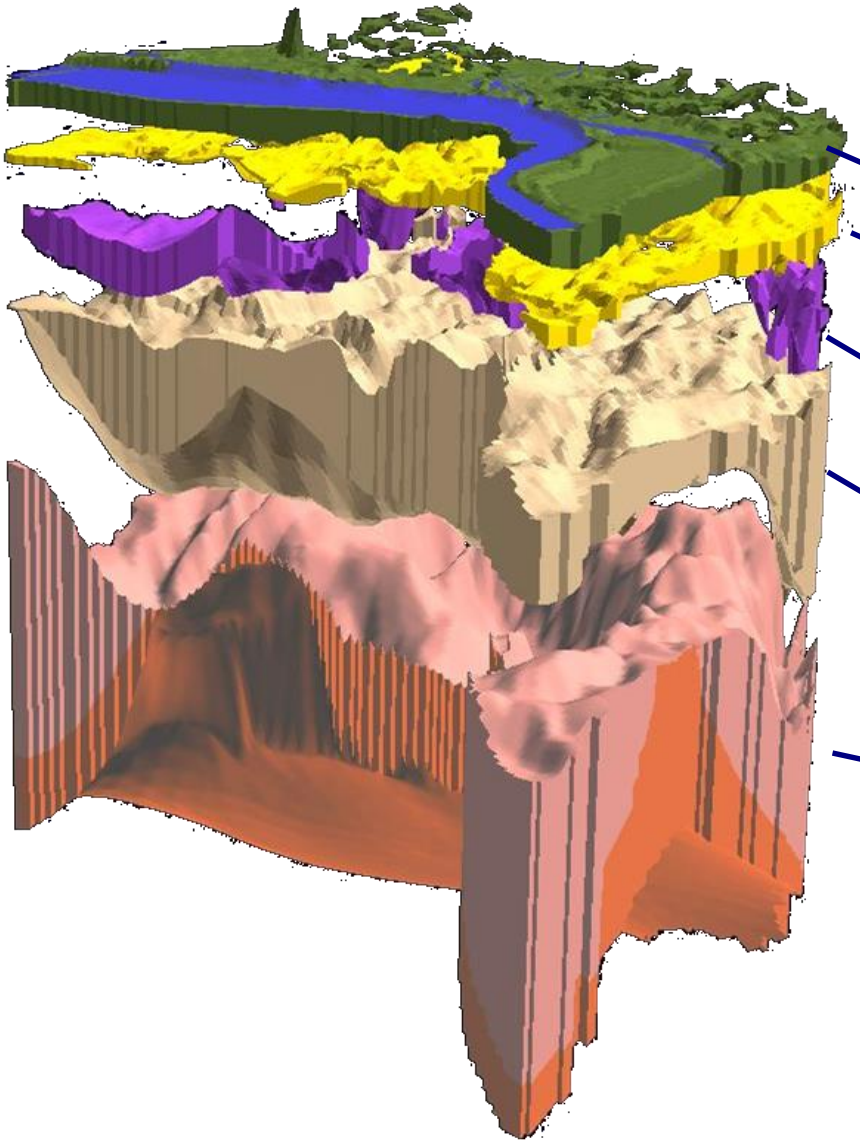
>> refinements for local models
>> detail models as voxel models

Structural Model



Quaternary aquifer system

Structural Model



Quaternary aquifer system

Holocene clay

Glacigene sand & till

Glacigene clay

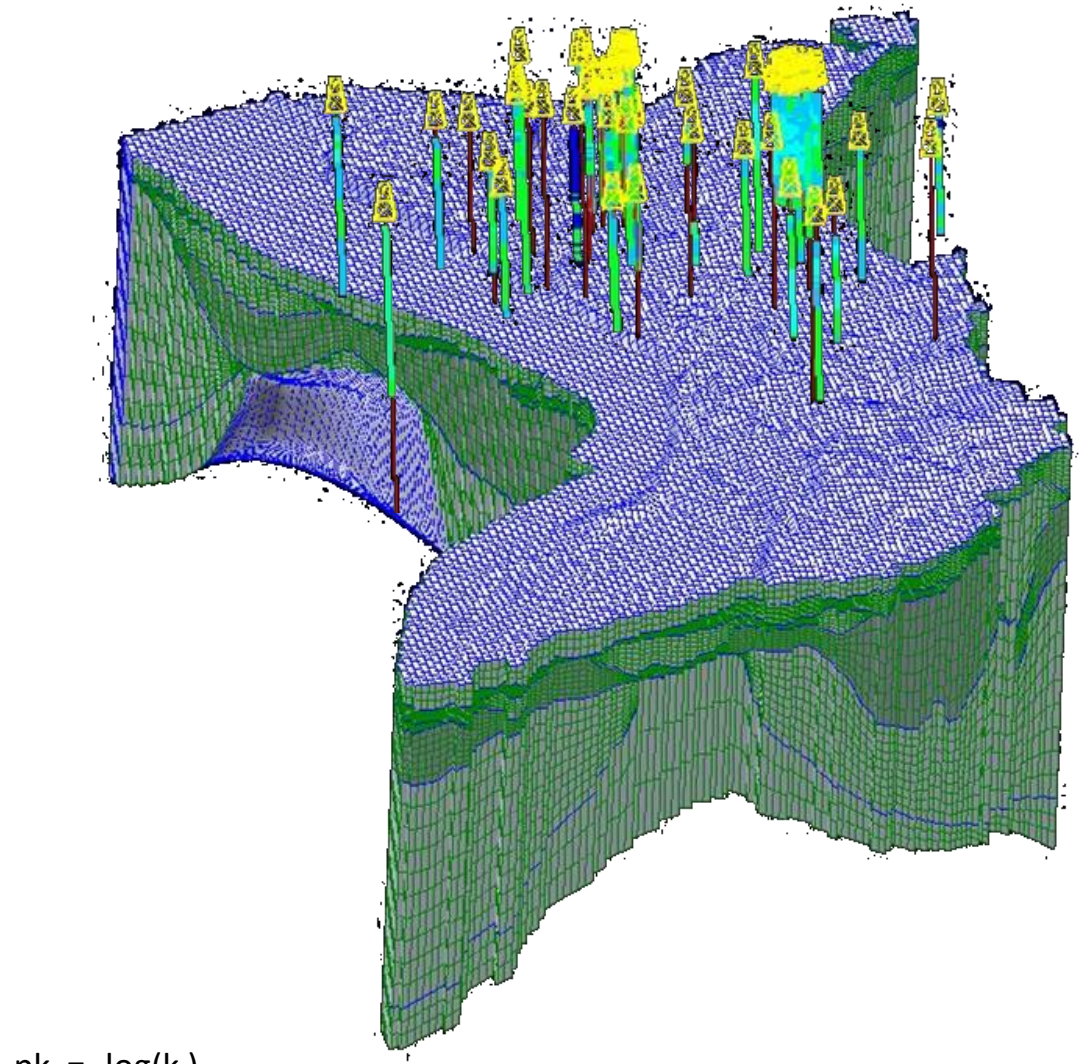
Glacigene sand & till

Tertiary marine fine sand / silt

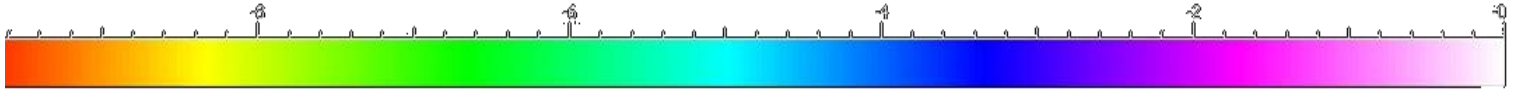
Structural Model

Model Element	Name of Horizon / Unit	Depth of Horizons [mNN] min	max
pimary data horizon	ground level	-1,3	25,6
modelled horizon	base Holocene	-24,2	10,7
modelled horizon	base Saalian	-57,4	-1,3
modelled horizon	base Lauenburger unit	-145	-3,2
modelled horizon	base Quaternary	-244	-15,6
modelled horizon	base middle Miocene	-298	-48,6
modelled horizon	base Miocene	-373	-59,0

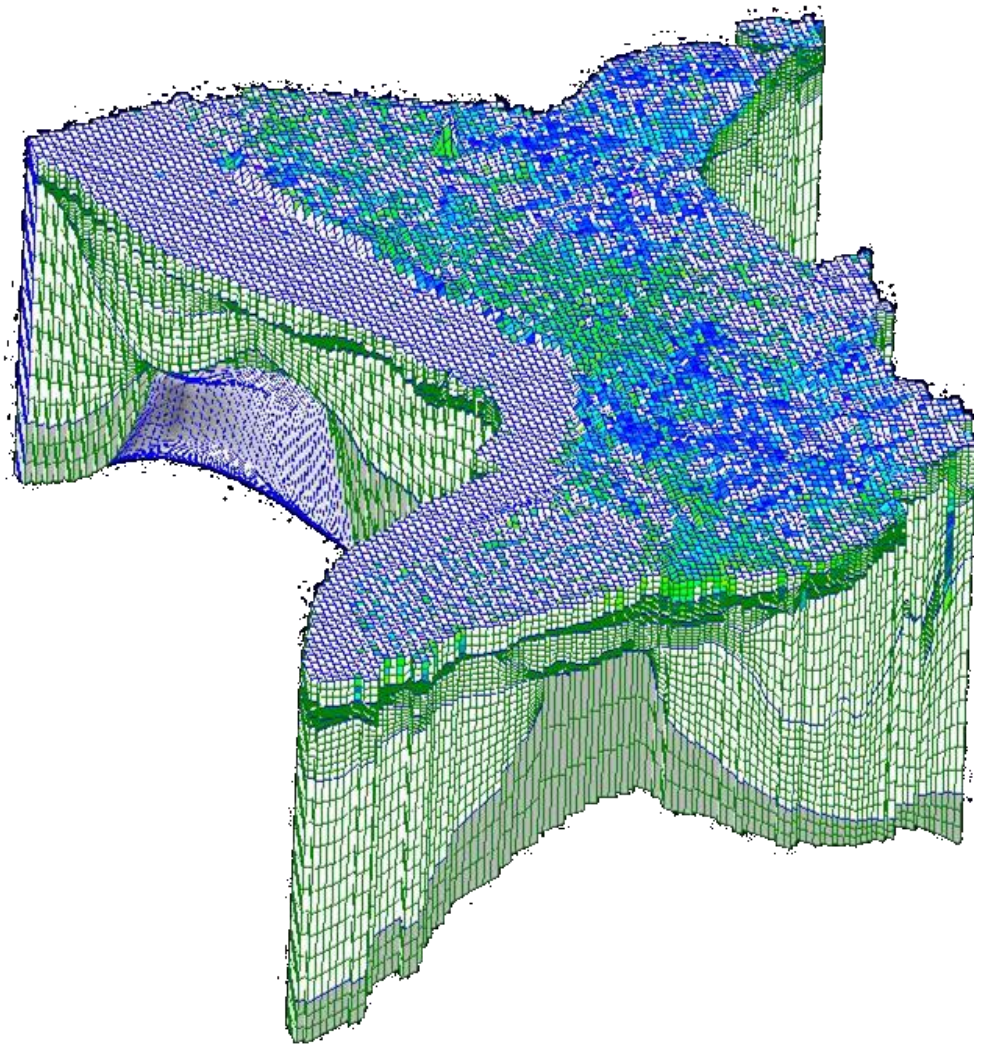
Parameterisation of the Model



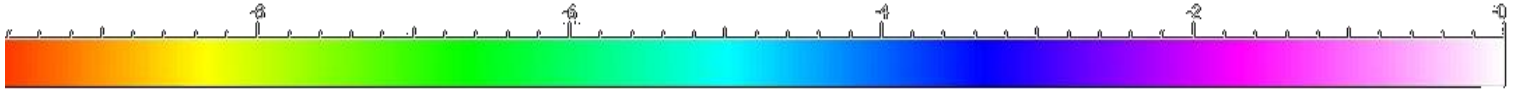
$pk_f = -\log(k_f)$



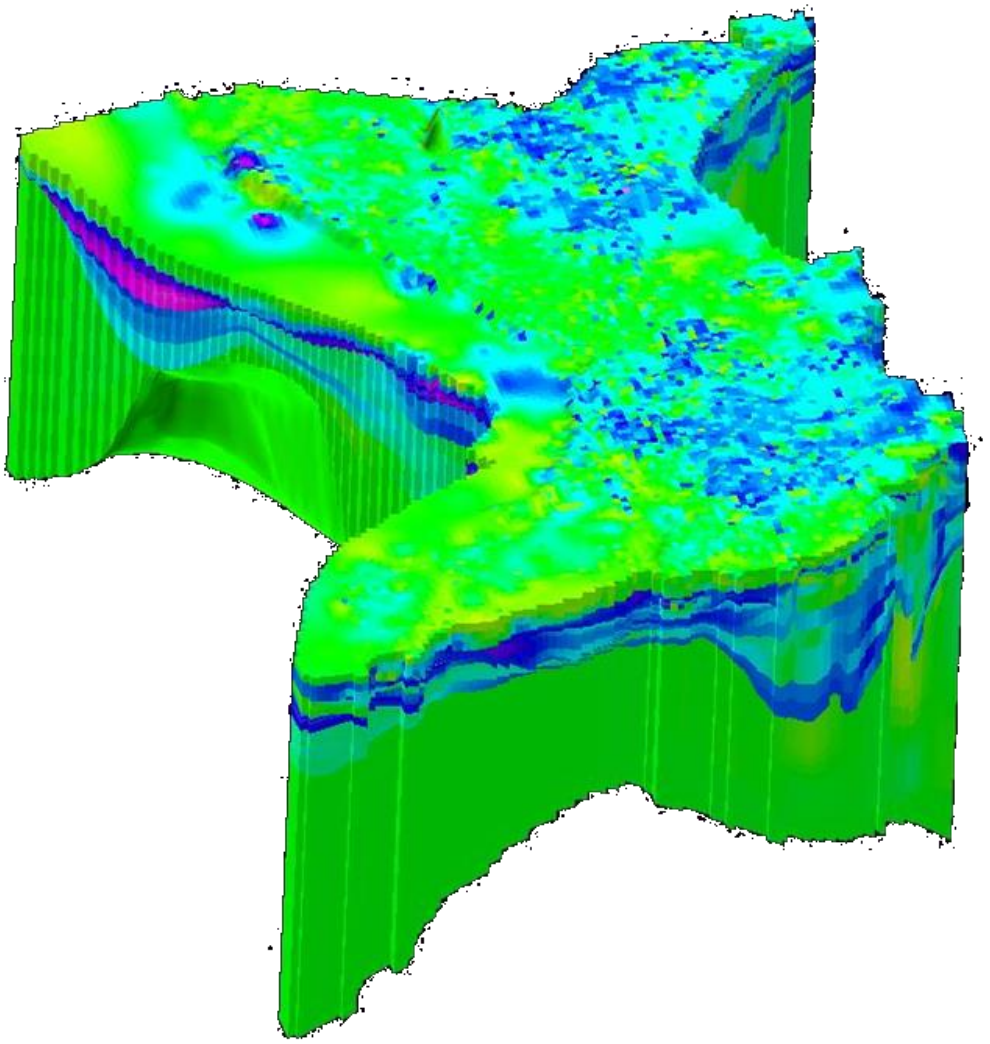
Parameterisation of the Model



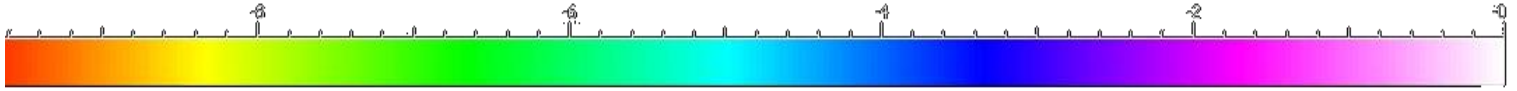
$pk_f = -\log(k_f)$



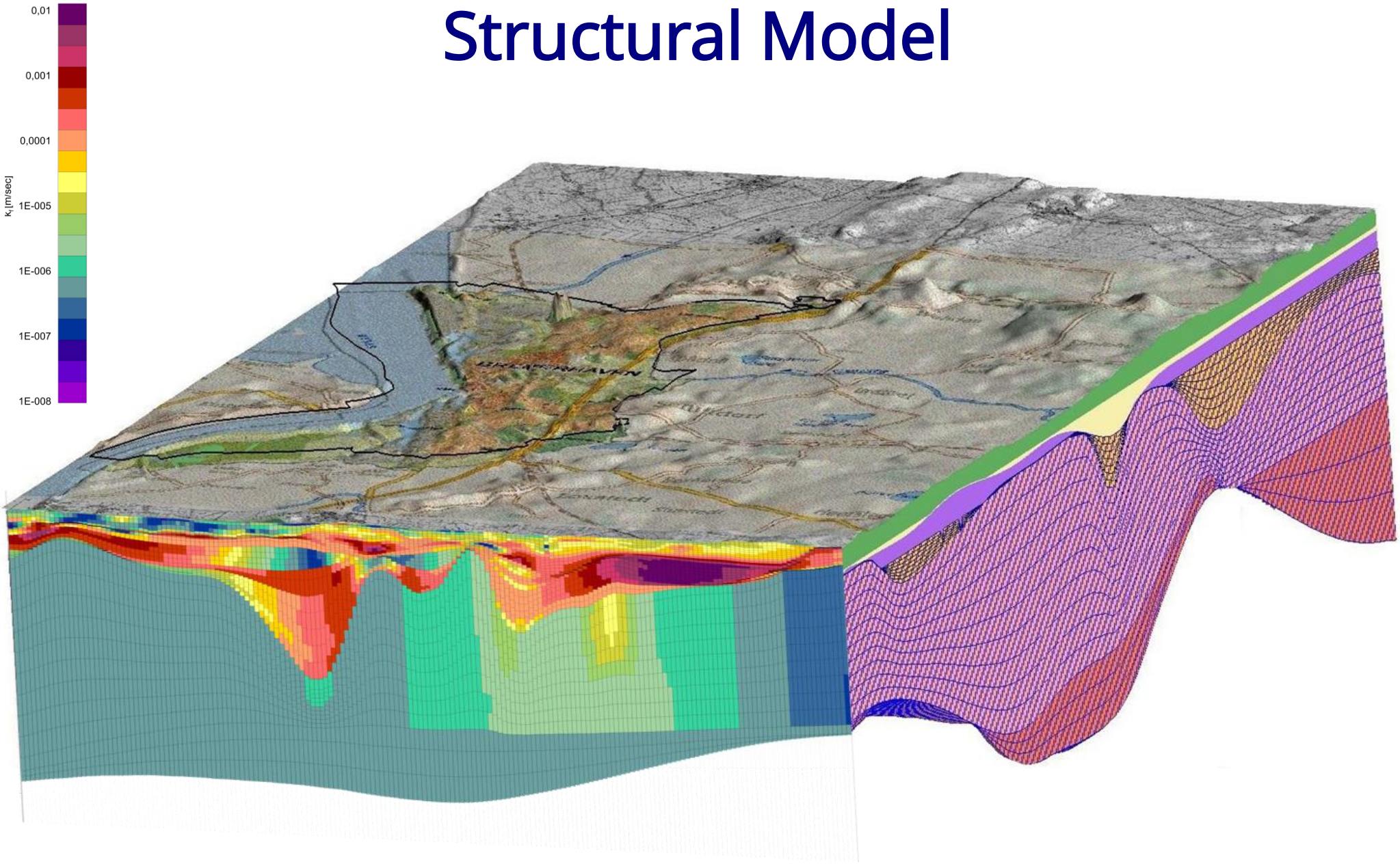
Parameterisation of the Model



$pk_f = -\log(k_f)$



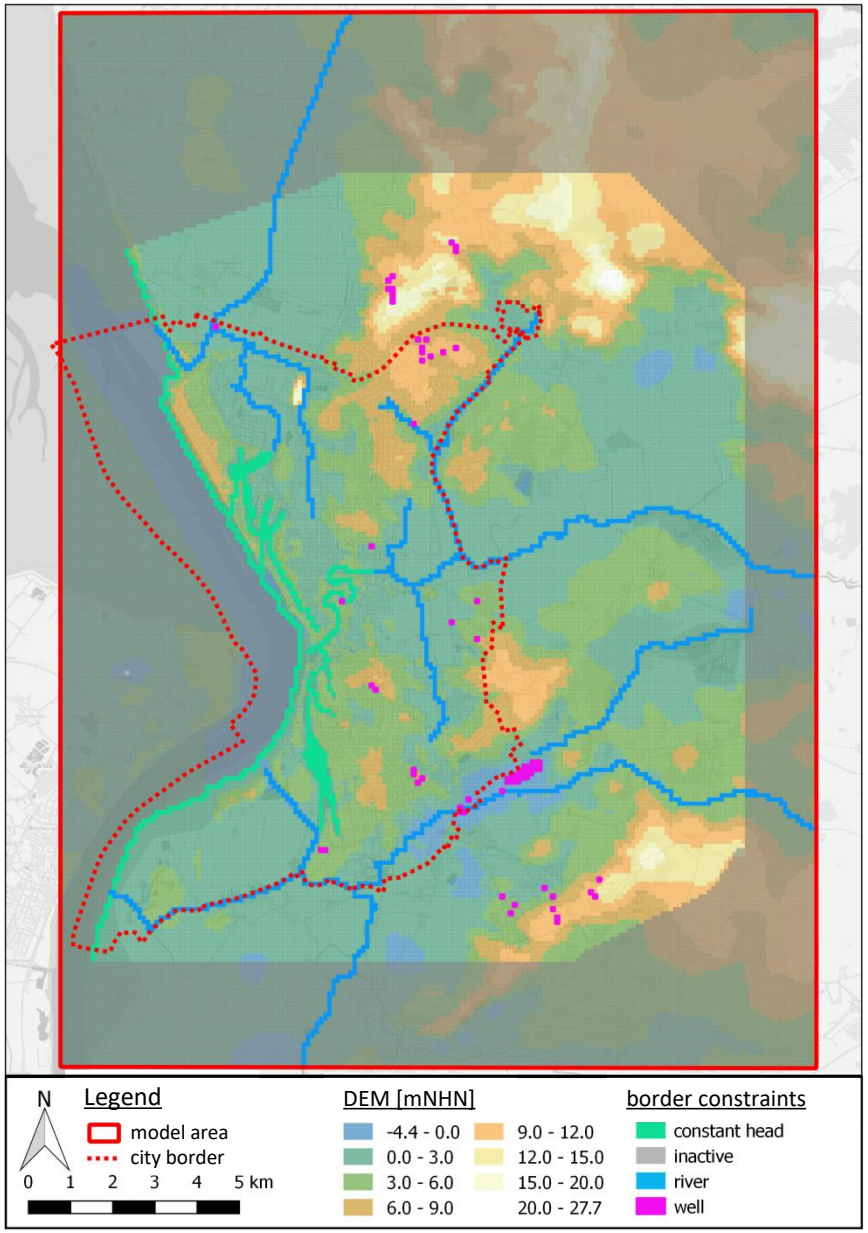
Structural Model



Model Area


WREMEN
LEHE
MITTE
Bremerhaven
Schiffdorf
FISCHEREIHAFEN
WULSDORF
BREMEN
NIEDERSACHSEN
Bilder © 2017 Google,TerraMetrics,Data SIO, NOAA, U.S. Navy, NGA, GEBCO,DigitalGlobe,GeoBasis-DE/BKG,Landsat / Copernicus,IBCAO,Kartendaten © 2017 GeoBasis-DE/BKG (©2009),Google
Deutschland

Model Setup



area:	25 x 17,9 km
cell size:	100 m
active cells:	34865
Layers:	38
	-> 1324870 cells

Boundaries:

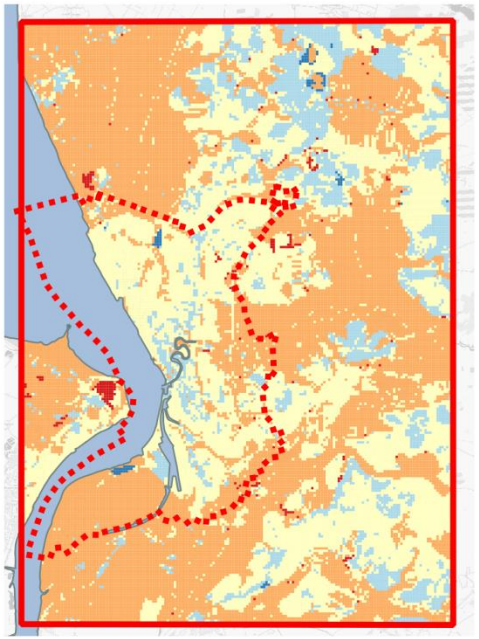
West :	Constant head
Others:	No Flow

78 wells (some multilayer)
1 lake as 30 well cells

13 rivers

Climate Variations

2010



Legend

model area

city border

Groundwater recharge [mm/year]

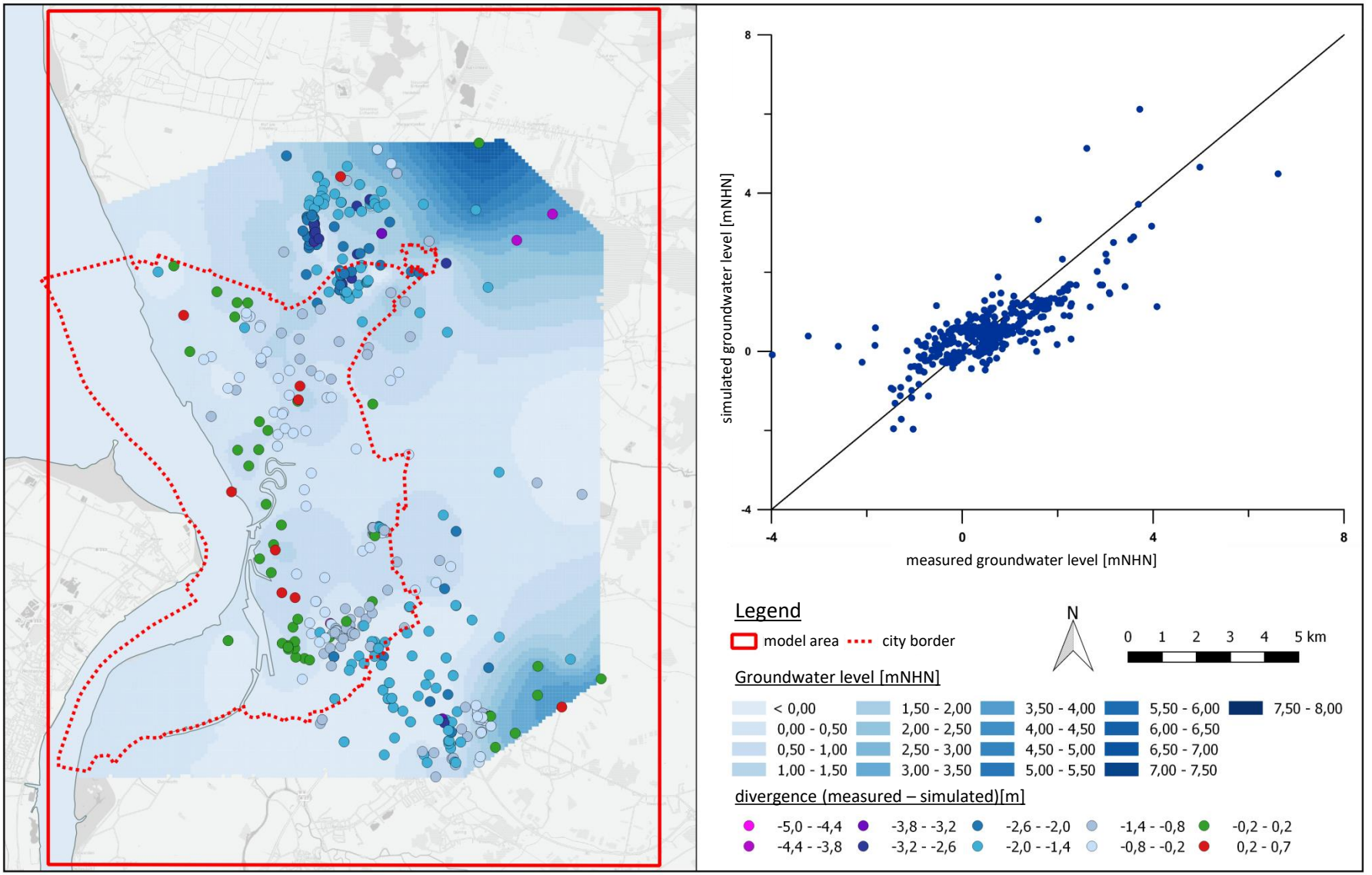
< 25 | 25 - 150 | 150 - 300 | 300 - 450 | 450 - 650

0 5 10 15 20 km

N

year	2010	2040	2070	2100
mean gw recharge	150 mm/y	147 mm/y	105 mm/y	62 mm/y
total gw recharge / year	34.974 Mio m³	34.274 Mio m³	24.481 Mio m³	14.456 Mio m³
sealevel	0,00 mNHN	0,18 mNHN	0,45 mNHN	0,78 mNHN

Calibration results



FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

ict4water.eu

European Commission

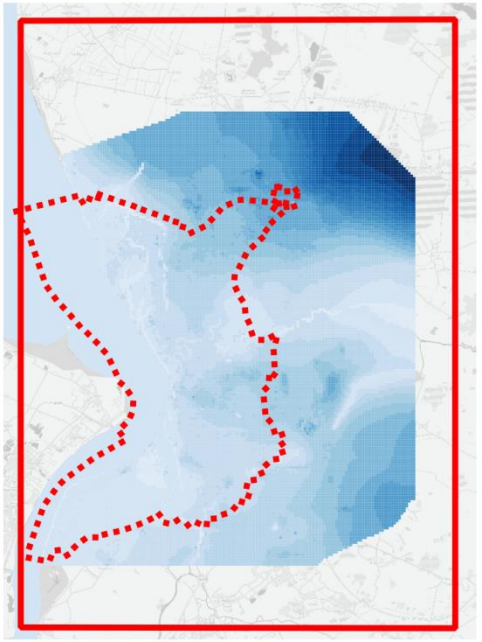
EIP Water Online Market Place
Matchmaking for water Innovation
MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

idaea aCID CSIC CELEBRAR INNOVAR DEBATRE

Universität Bremen
Geologischer Dienst für Bremen GDfB

Climate impact on groundwater

2010



N

Legend

model area

city border

0 5 10 15 km

Groundwater level [mNHN]

< 0,00	1,00 - 1,50	2,50 - 3,00	4,00 - 4,50	5,50 - 6,00	7,00 - 7,50
0,00 - 0,50	1,50 - 2,00	3,00 - 3,50	4,50 - 5,00	6,00 - 6,50	7,50 - 8,00
0.50 - 1.00	2.00 - 2.50	3.50 - 4.00	5.00 - 5.50	6.50 - 7.00	

Climate impact on groundwater

FREEWAT
Free and Open Source Software Tools for Water Resource Management
EU HORIZON 2020 Project

ict4water.eu

European Commission

EIP Water Online Market Place
Matchmaking for water Innovation
MAR Solutions - Managed Aquifer Recharge Strategies and Actions (AG128)

idaea aCID CSIC CELEBRAR INNOVAR DEBATRE

Universität Bremen
Geologischer Dienst für Bremen GDfB