

TNO's perspective on dutch subsurface information for GEO-ELEC: a geological survey and national geo-energy research perspective

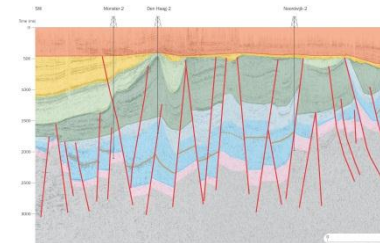
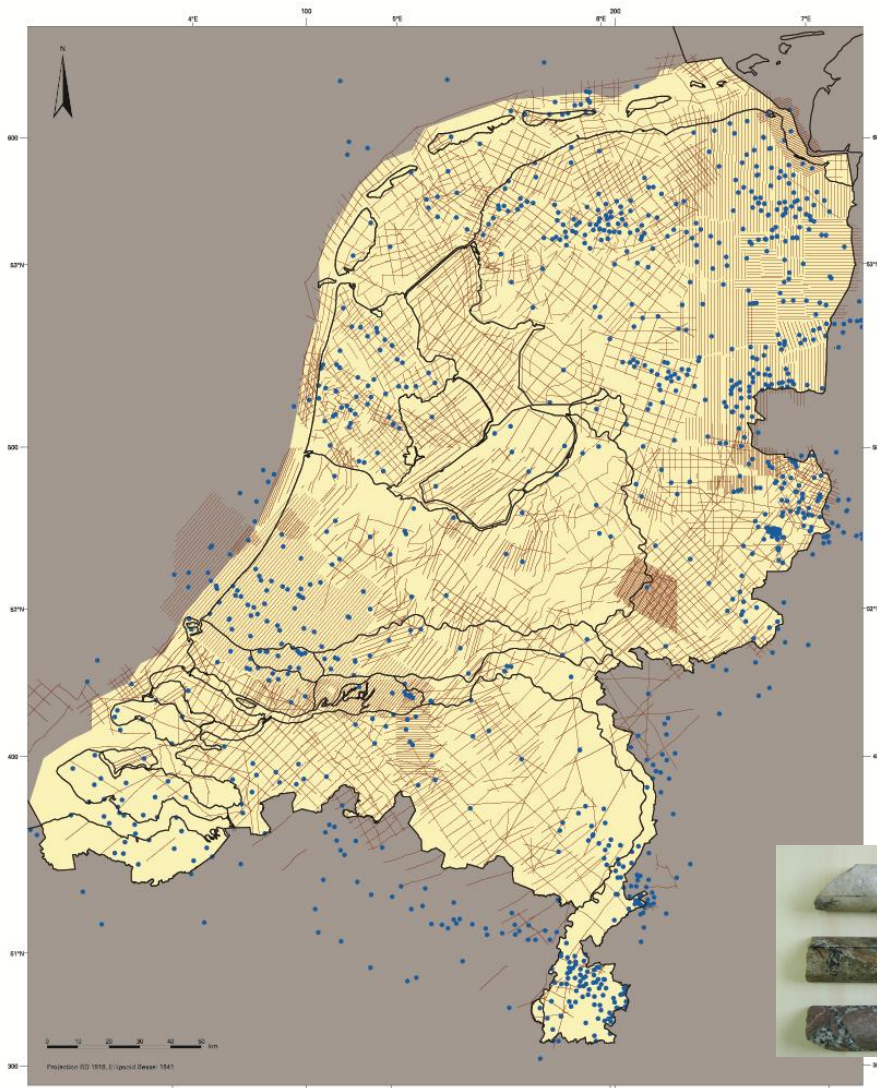
› Jan-Diederik van Wees



Outline

- › General Data availability
- › Play types
 - › Mesozoic Aquifers, currently target for direct heat – information system ThermoGIS
 - › Deep temperature, active faults, characterization of ‘paleozoic rocks

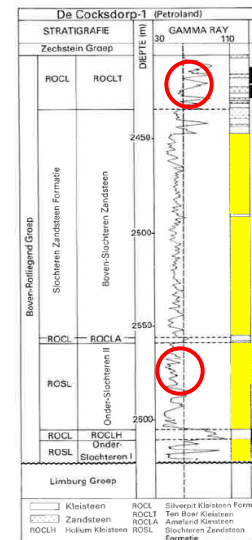
Dutch database: over 50 billion Euro of data



Well & Seismic Data

Wells: 5876

Seismic: 72.000 km



Log data

Gamma ray

Sonic

Resistivity

Neutron, etc



Petrophysics

Cores: 100 km

Poro/permeability: 60.000 measurements (300.000 total)

www.NLOG.nl



OG
NL Olie- en
Gasportaal

- ☐ Boreholes
- ☐ Seismic surveys
- ☐ Fields
- ☐ Production
- ☐ Infrastructure
- ☐ Licences
- ☐ Publications and Data sets
- ☐ Legislation
- ☐ Administrative procedures
- ☐ Fees, taxes and state participation
- ☐ Seismicity and subsidence
- ☐ Contacts
- ☐ [Links](#)
- ☐ [Home](#)
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-  (In het Nederlands)



Ministerie van Economische Zaken,
Landbouw en Innovatie

TNO innovation for life

Welcome to the NL Oil and Gas Portal

This site provides information about oil and gas exploration and production in the Netherlands and the Dutch sector of the North Sea continental shelf.

It aims to help users access information furnished by the Dutch government in an easy, comprehensible fashion.

This site was produced at the request of the Dutch Ministry of Economic Affairs, Agriculture and Innovation and is being managed by TNO, *Geological Survey of the Netherlands*.

Recent changes

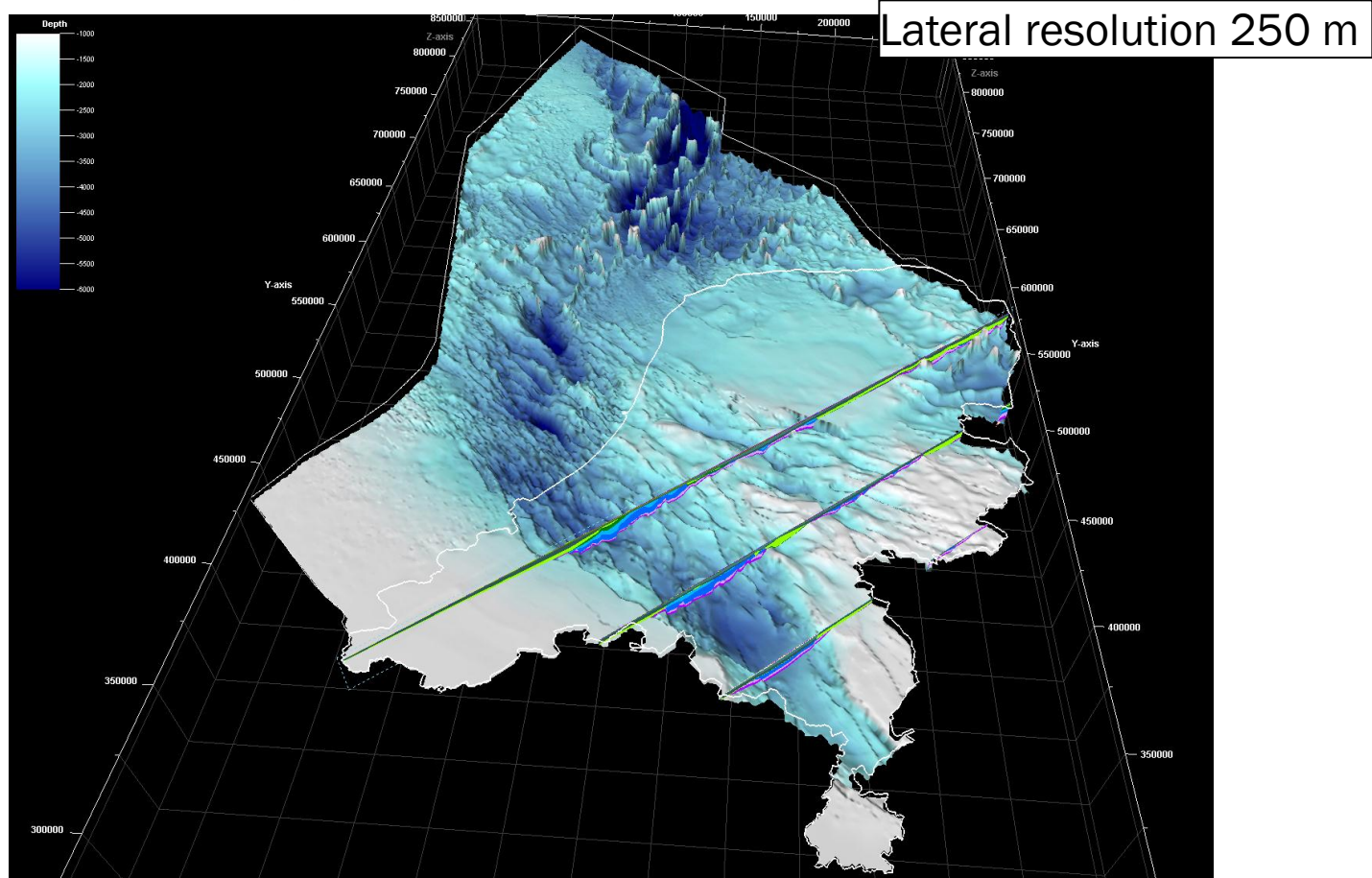
We keep this site continually up-to-date. Click [here](#) for an overview of recent changes.

Other topics

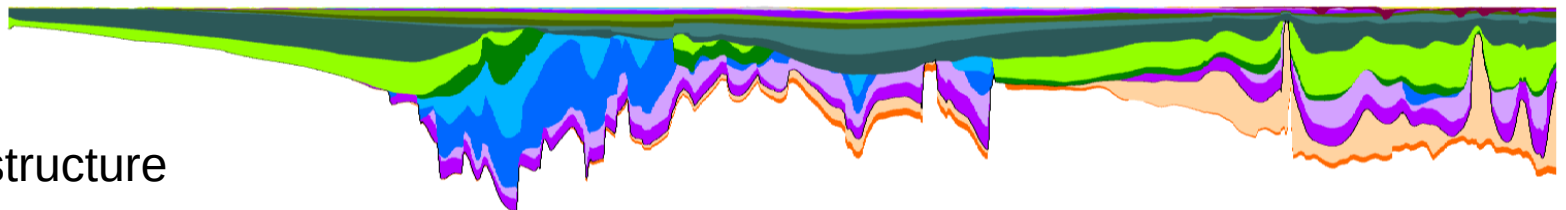
- [Salt production](#)
- Underground gas storage
- [Geothermal Energy](#)
- [Geological storage of CO2](#)

- All kinds of well data & seismic data accessible and free to download

Seismic interpretation



Mesozoic structure



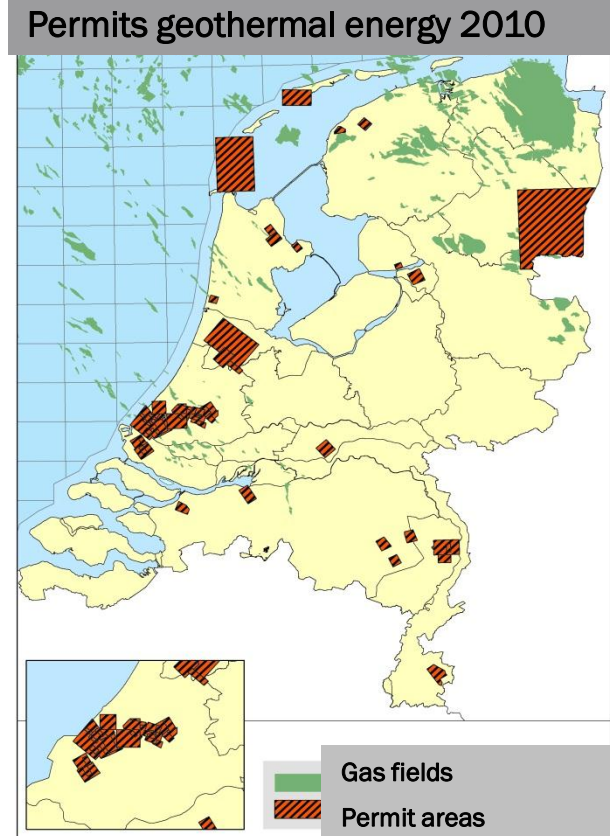
Reasons to develop ThermoGIS

Interest is booming

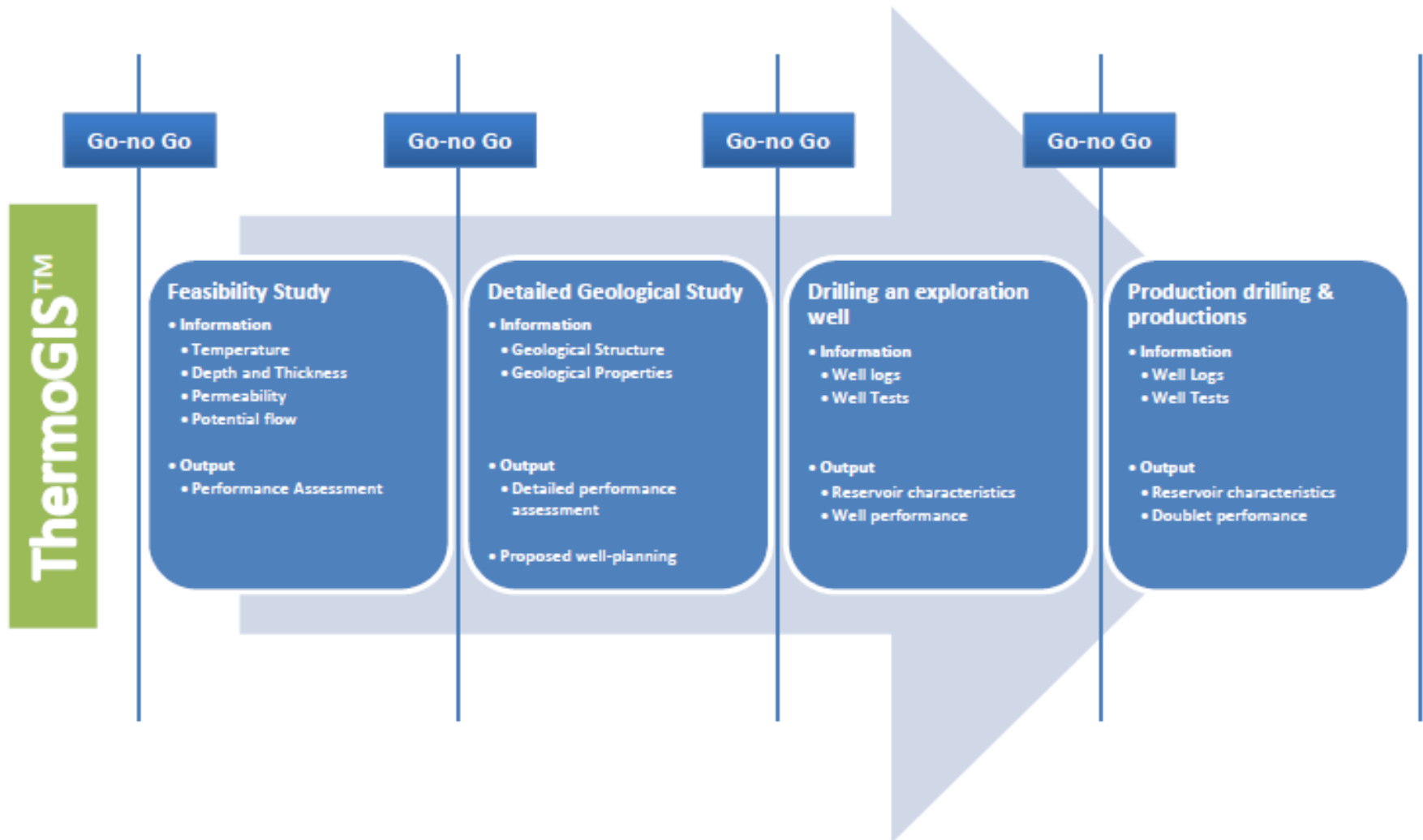


Currently over 100 permits granted

- › Geological properties and uncertainties
- › Independent analysis and information
- › Overview potential areas and 'hot spots'
- › Performance assessment
- › Quickscan
- › Realization of market opportunities



General development scheme



ThermoGIS - project on aquifers

Bonte et al., 2012

Comprehends:

3D mapping reservoirs (aquifers)

- › Depth, thickness and temperature → Temperature
- › (Thickness) porosity, permeability
- › Uncertainties
- › Potential energy

Pluymaekers et al., 2012

Development ThermoGIS application

- › Visualisation map
- › Performance assessment tool
- › Economic assessment tool

Van Wees et al., 2012

Kramers et al., 2012

Potential estimates – for specific application areas

Geothermal direct heat Application	Min. Production Temperature	Min. production depth@ 30 °C/km	Re-injection temperature	Load factor	Heat demand/yr
Greenhouse 	45°C	1200m	25°C	60%	12x10 ³ GJ/ha
Spatial 	65°C	1900m	40°C	60%	25GJ/house

Doublet performance

$$E \text{ [MWth]} = Q \cdot \Delta T \cdot C_p$$

Flow-rate Q

$$Q = \frac{\Delta p}{\mu \left(\ln \left(\frac{L}{r_w} \right) - S \right)}$$

Permeability X thickness $2\pi kH$

Viscosity μ

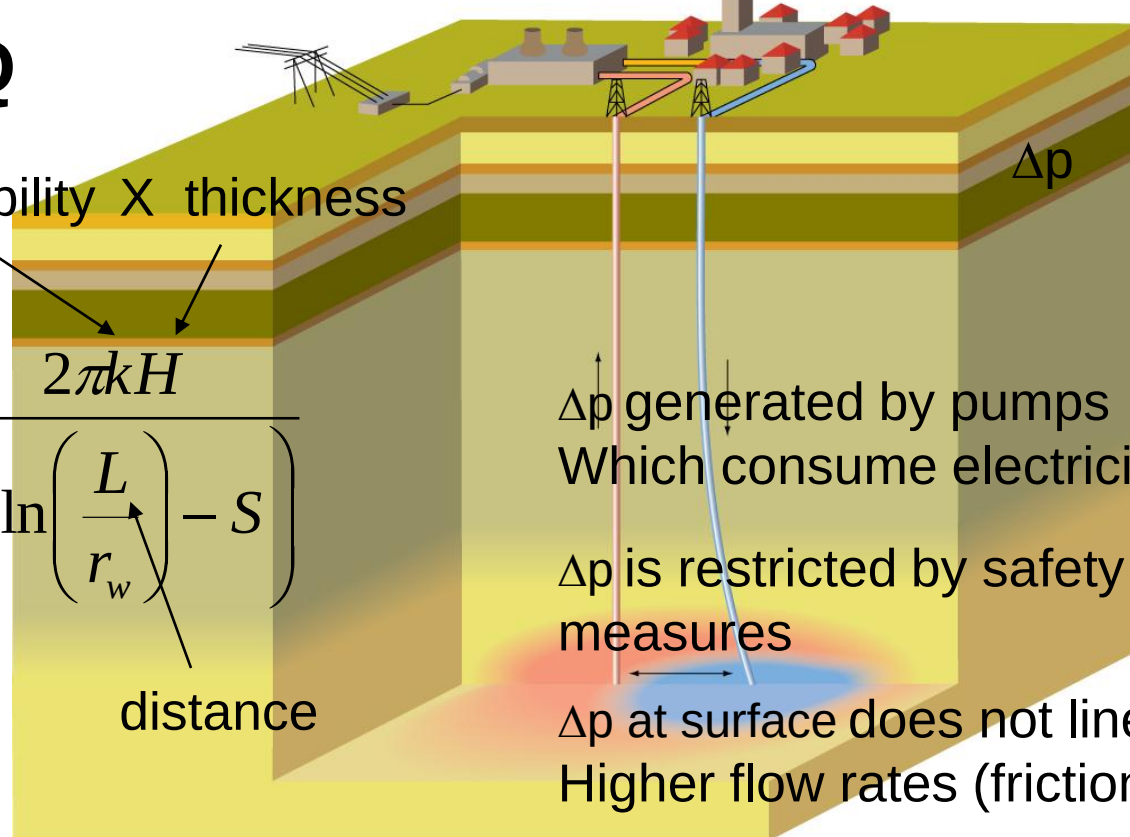
distance L

well radius r_w

skin effect S

$T_p = 70^\circ \text{C}$

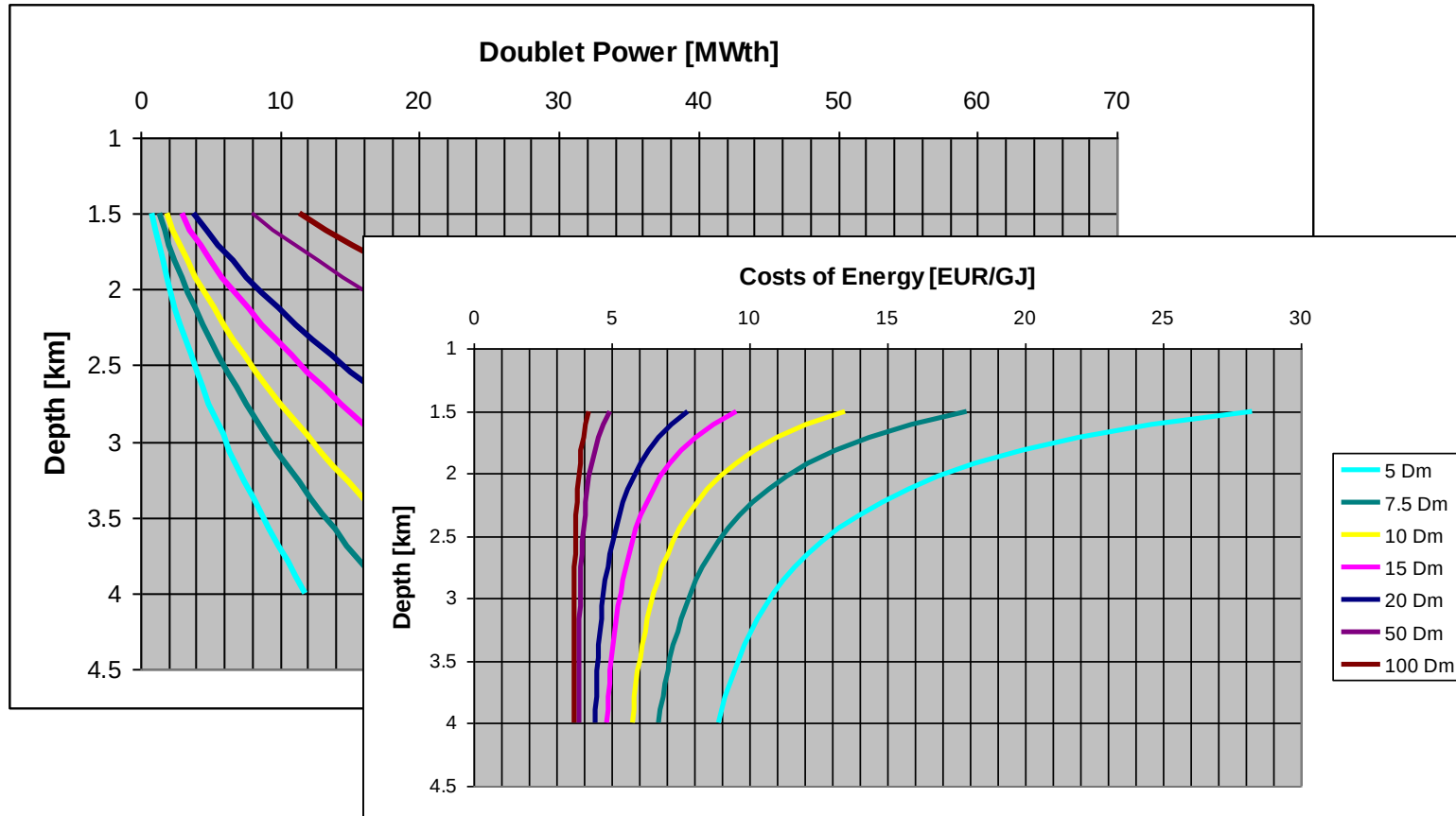
$T_i = 25^\circ \text{C}$



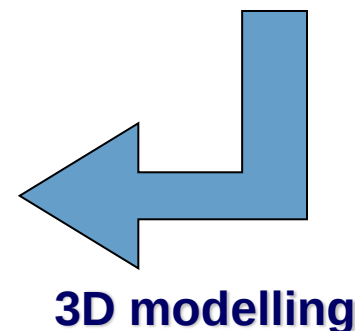
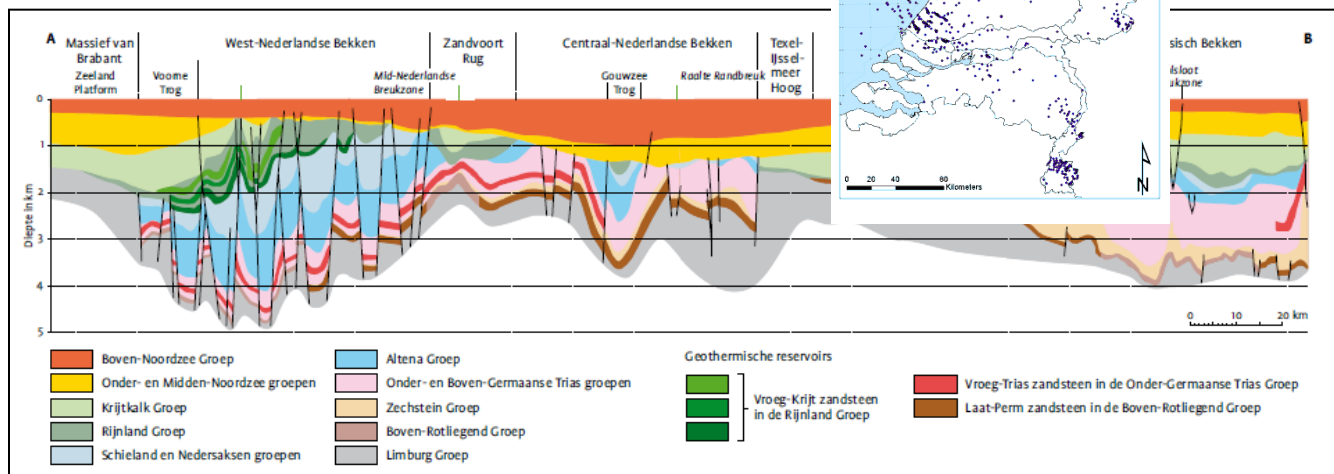
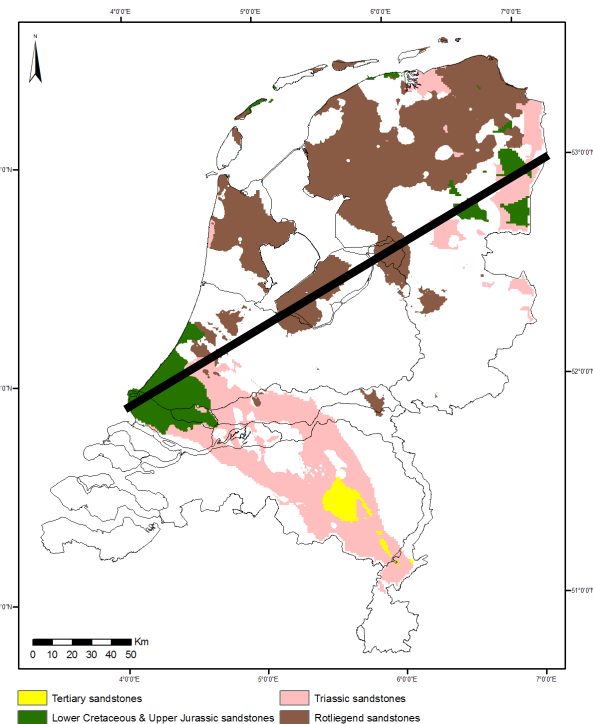
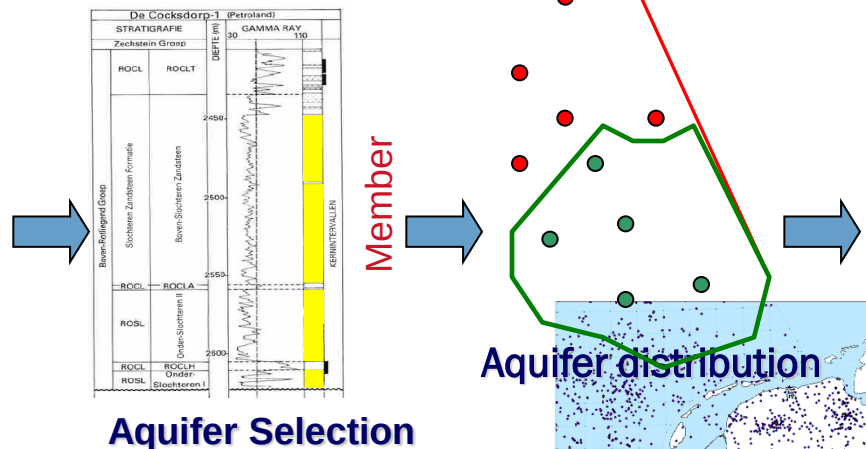
Sensitivity to transmissivity (kH)

$T_{\text{greenhouse}} = 45$
 $T_{\text{return}} = 25$

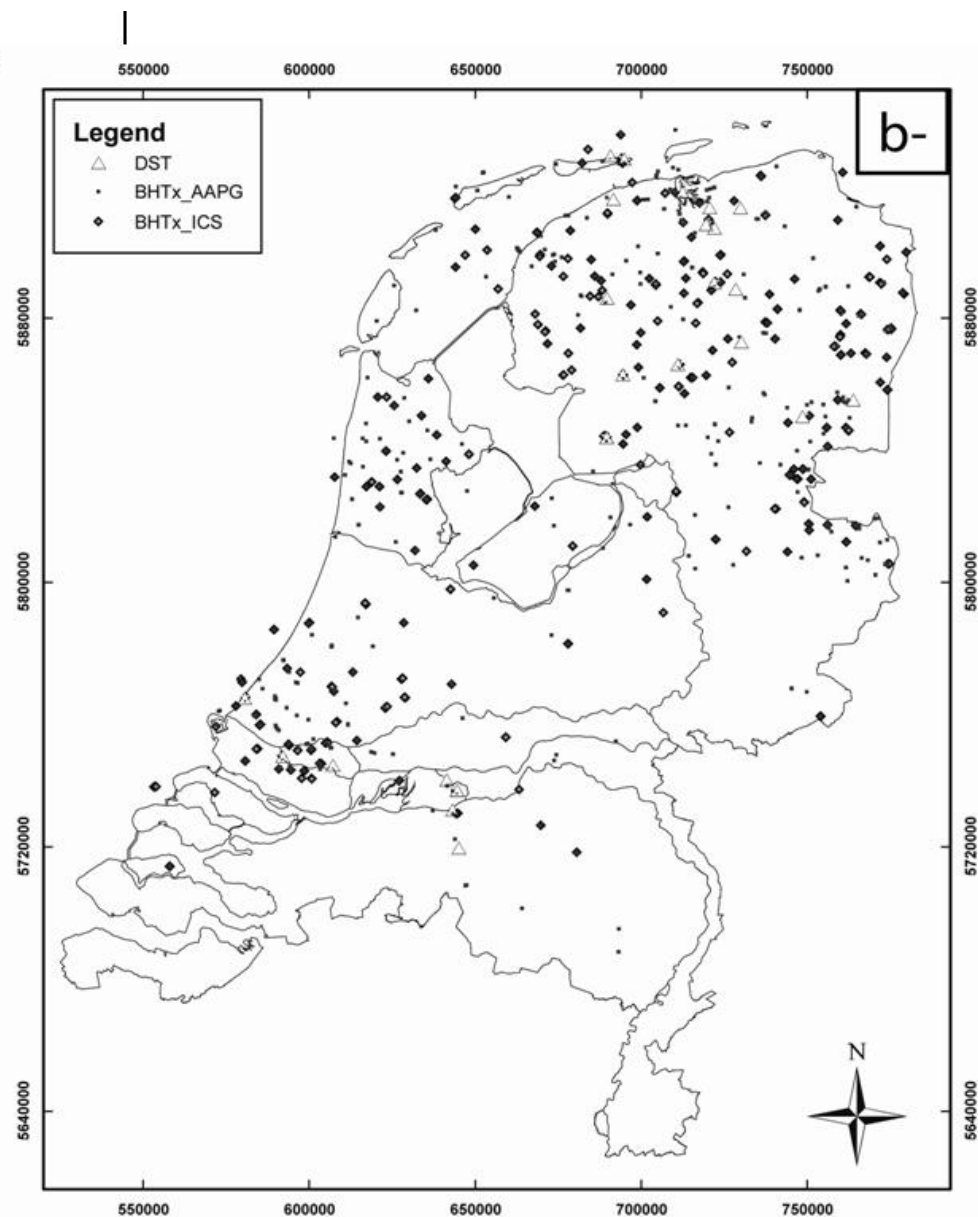
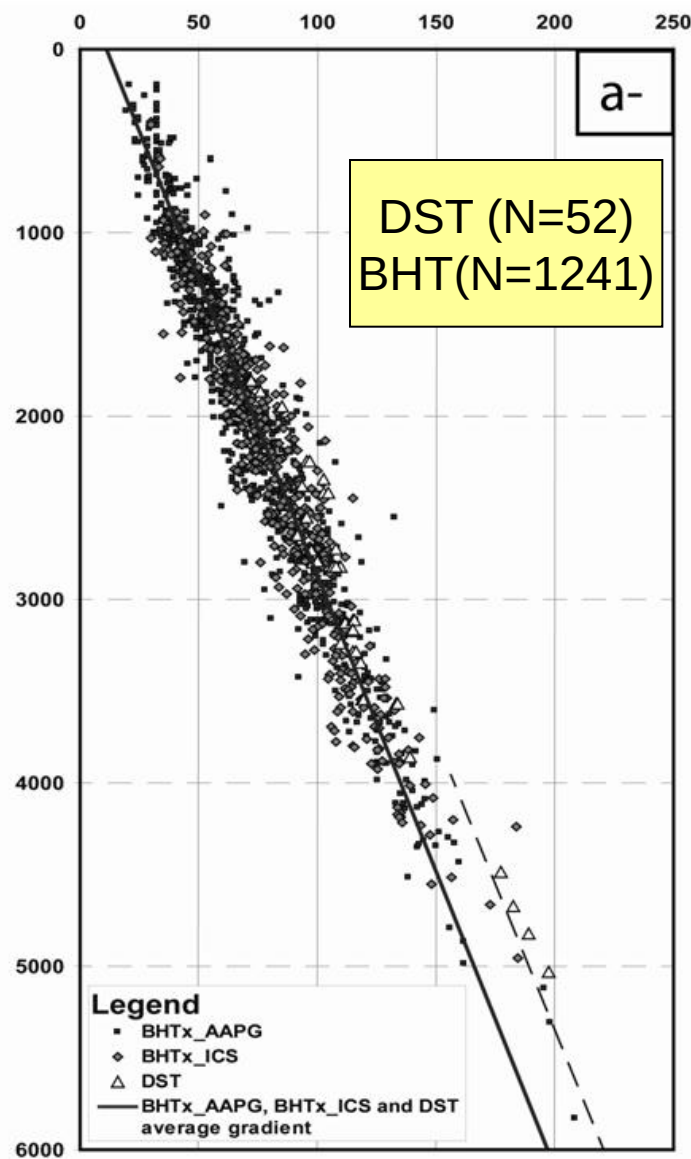
$T_g = 30\text{C/km}$



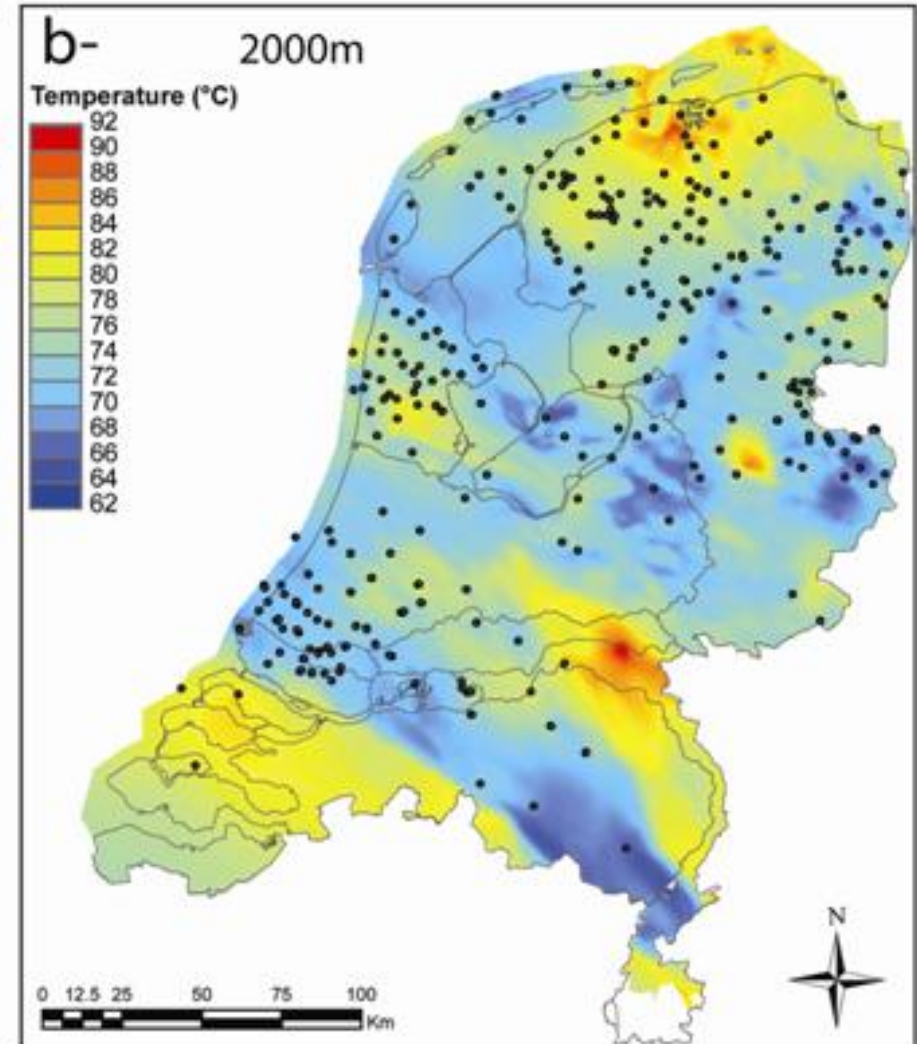
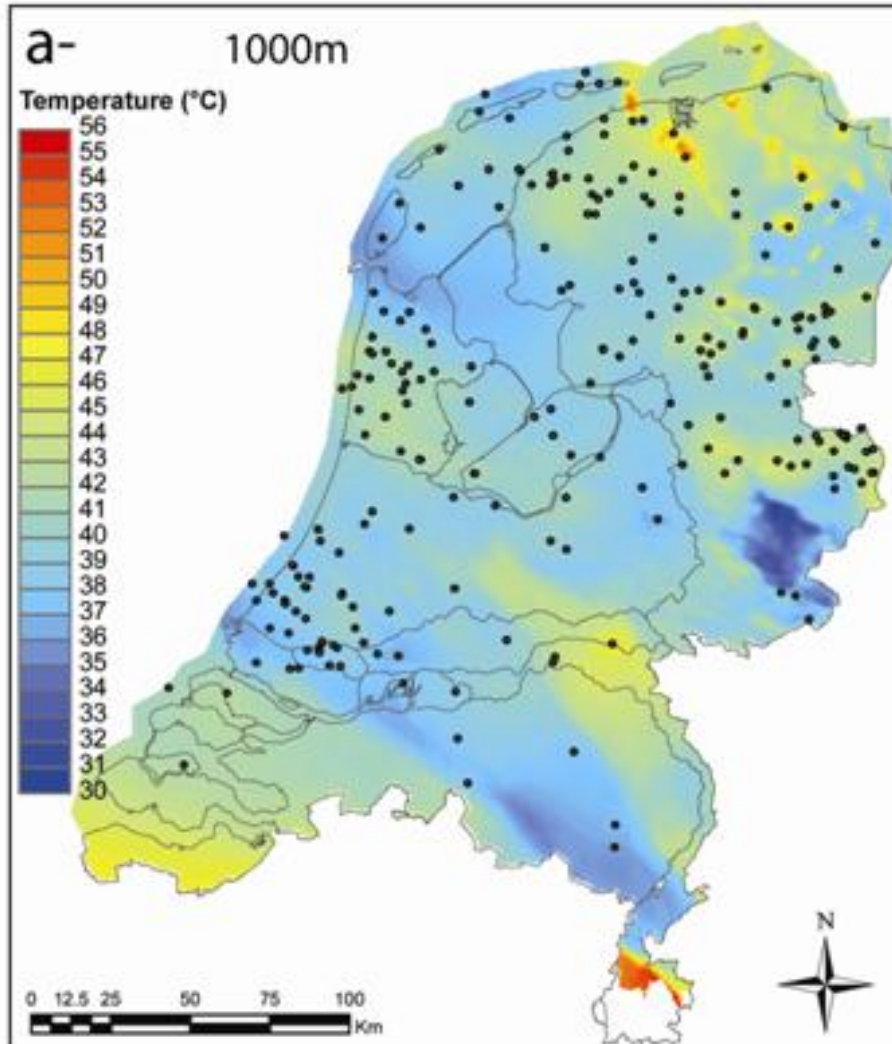
Aquifer depth and thickness mappi



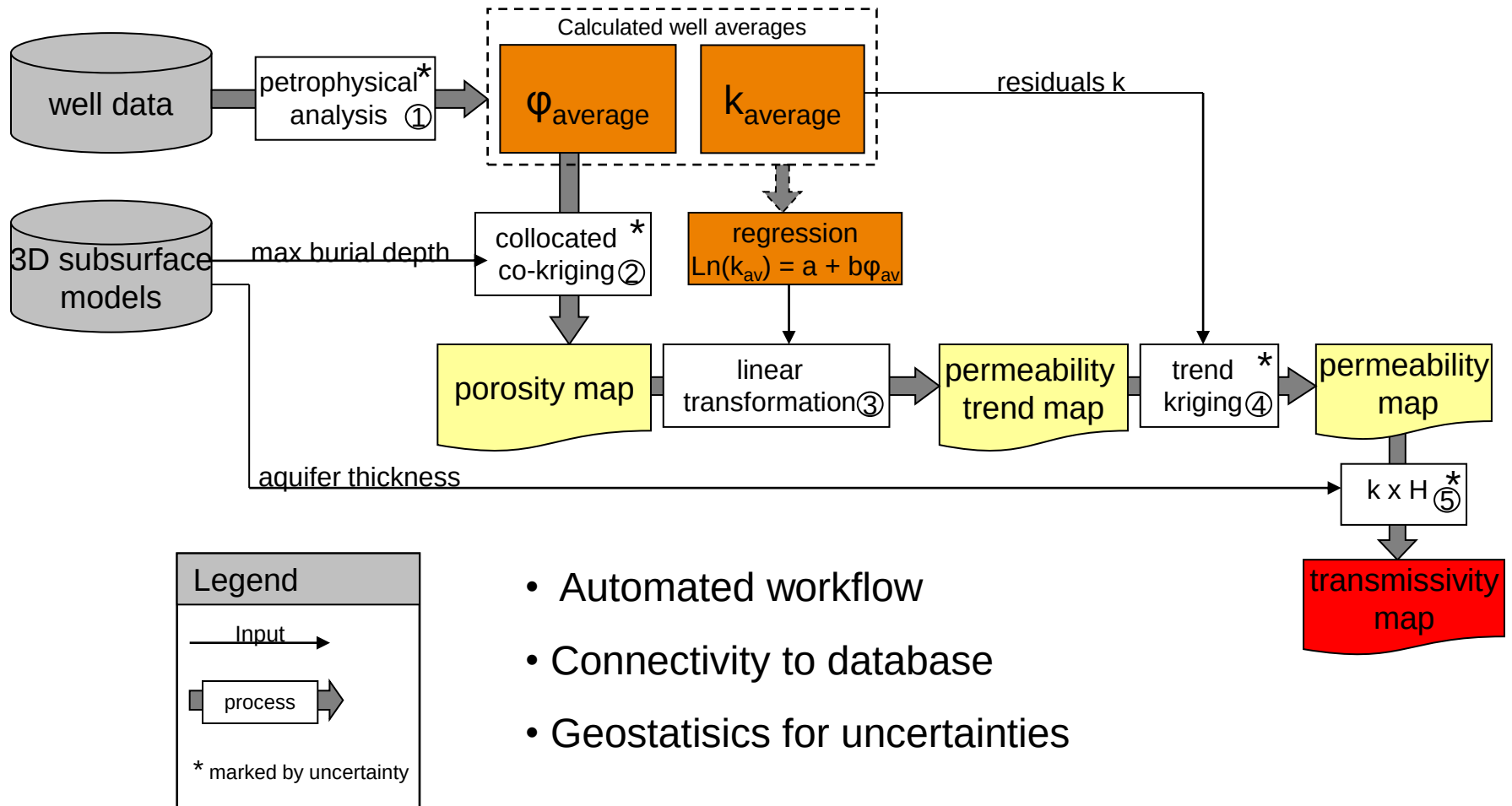
3D modelling

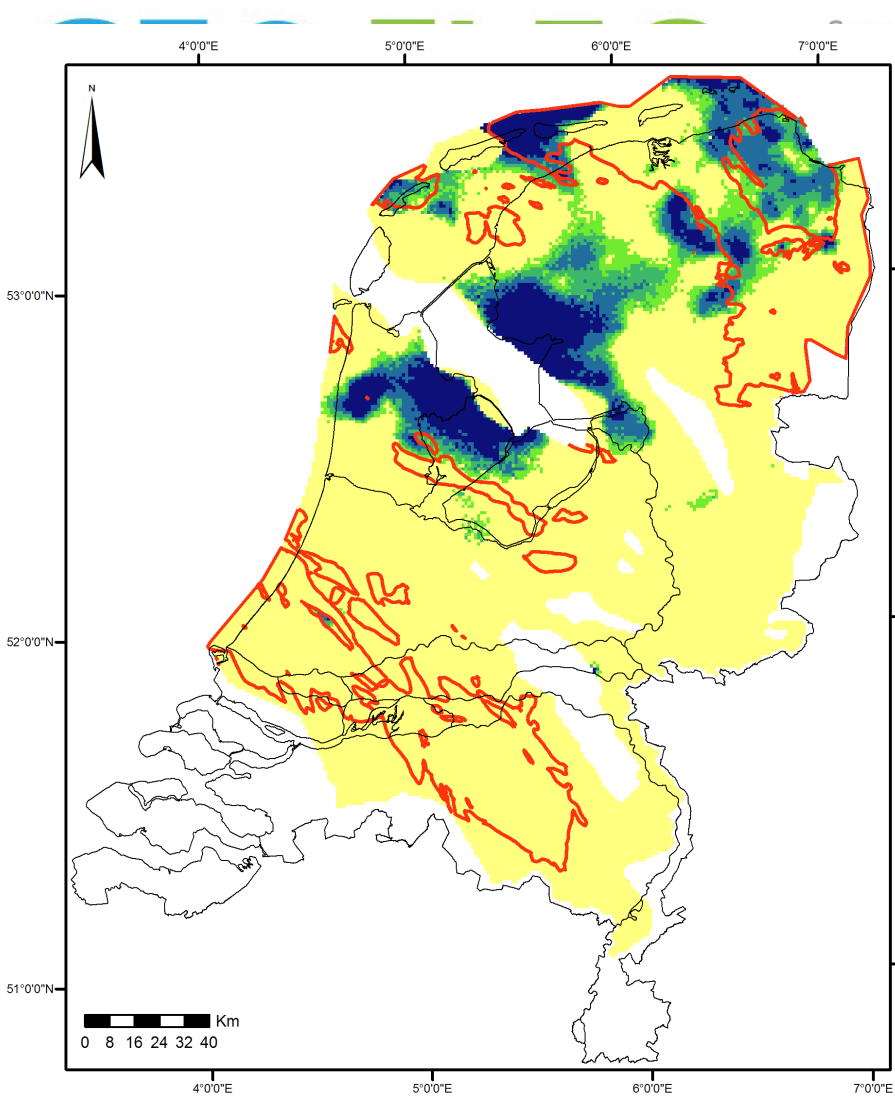


Results - temperature (1)

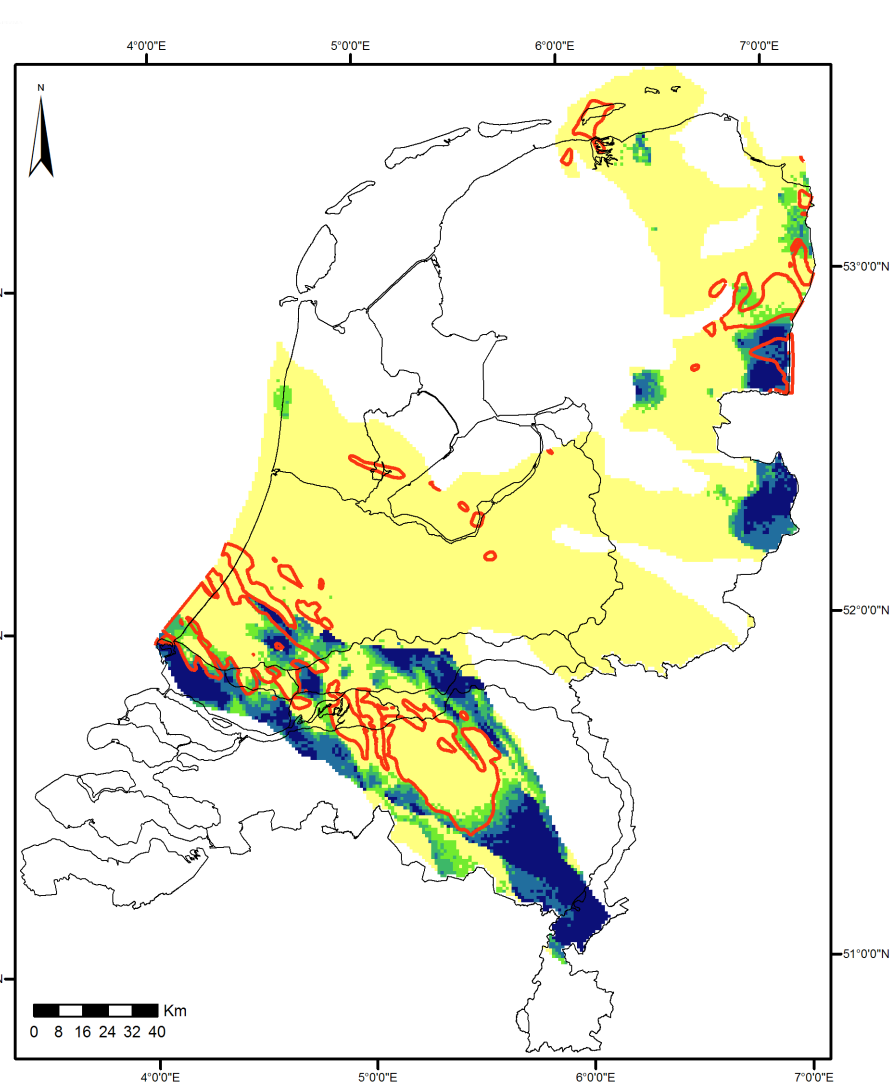
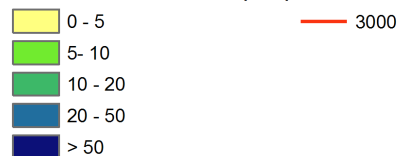


- Automated workflow
- Connectivity to database
- Geostatistics for uncertainties

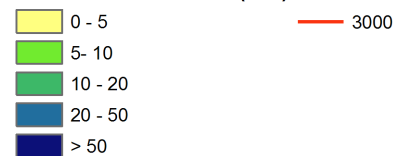




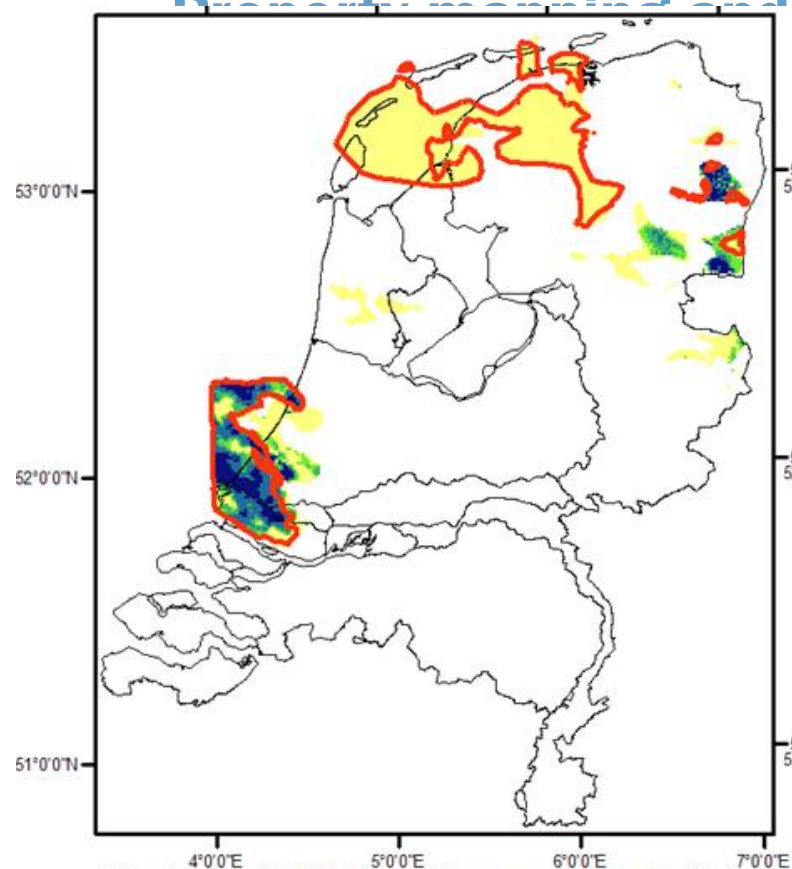
RO-stacked kH - P50 (Dm) Reservoir Depth (m)



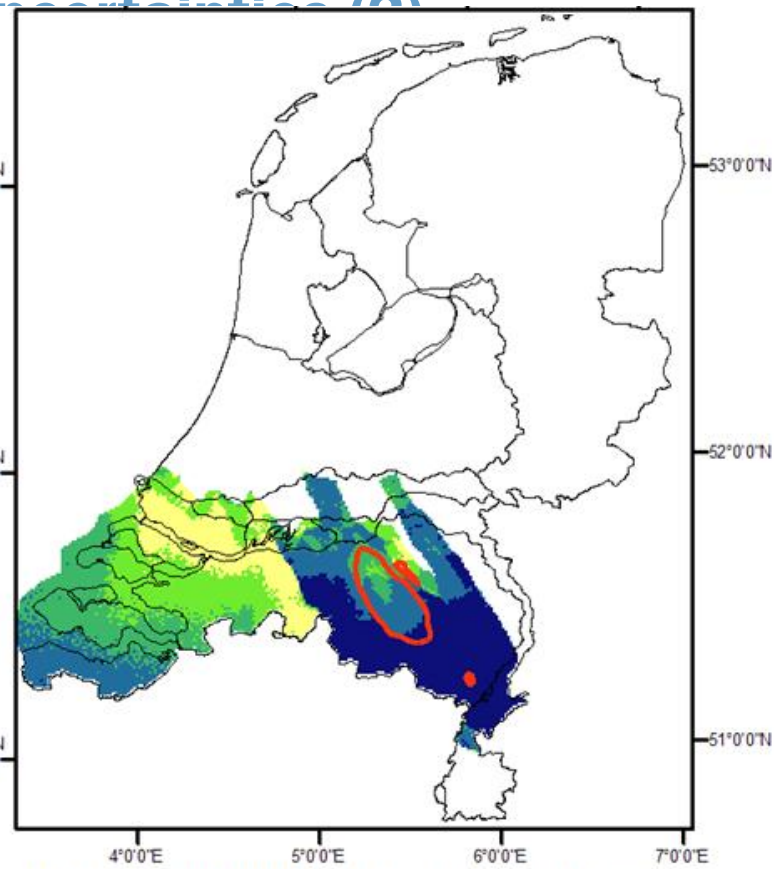
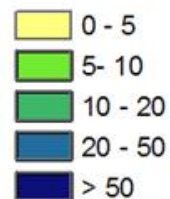
TR-stacked kH - P50 (Dm) Reservoir Depth (m)



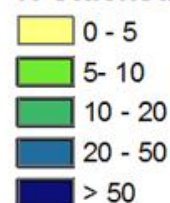
Deep-sea mapping and interpretation (2)



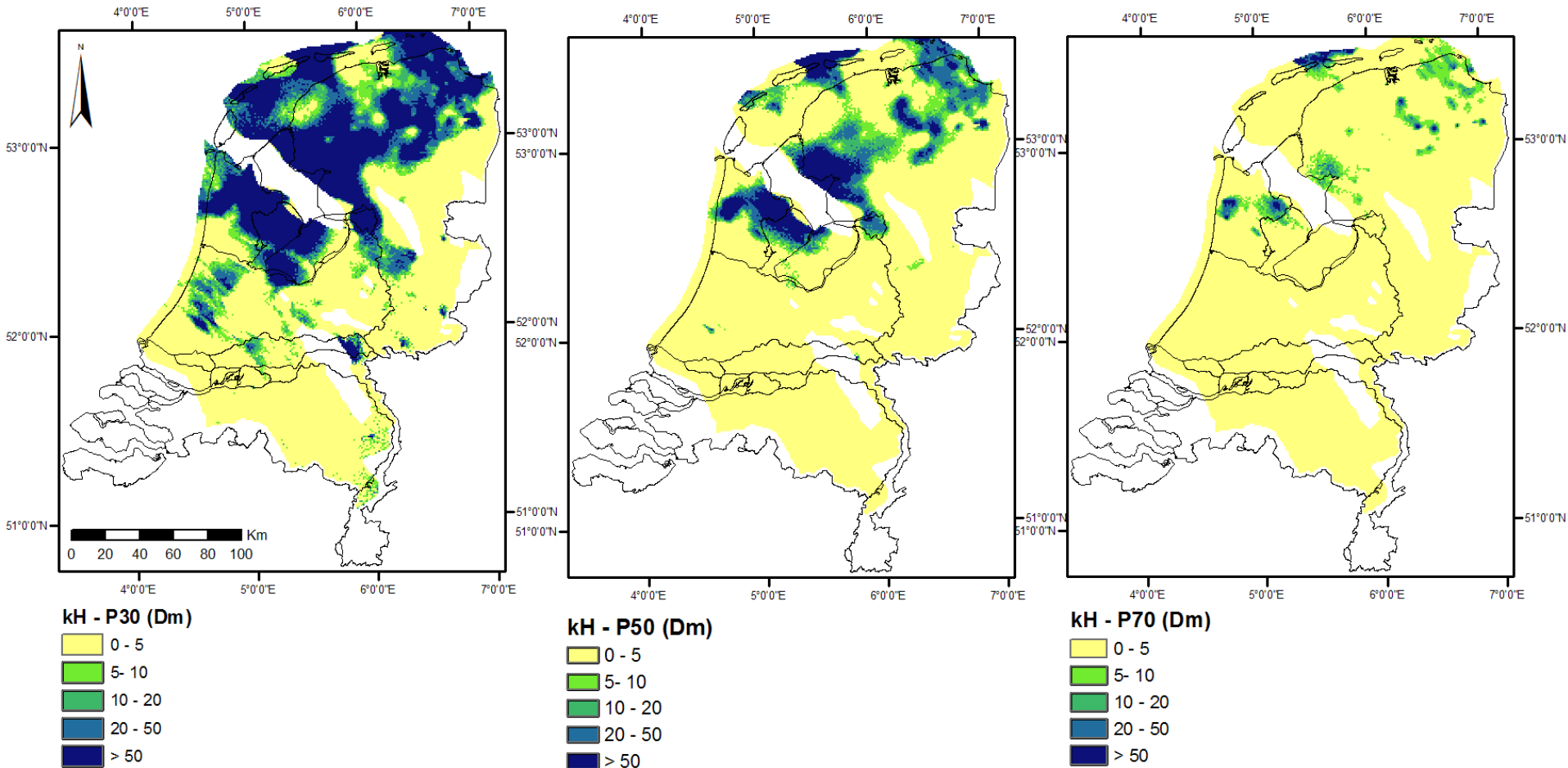
JK-stacked P50 (Dm) Reservoir depth (m)



N-stacked P50 (Dm) Reservoir depth (m)

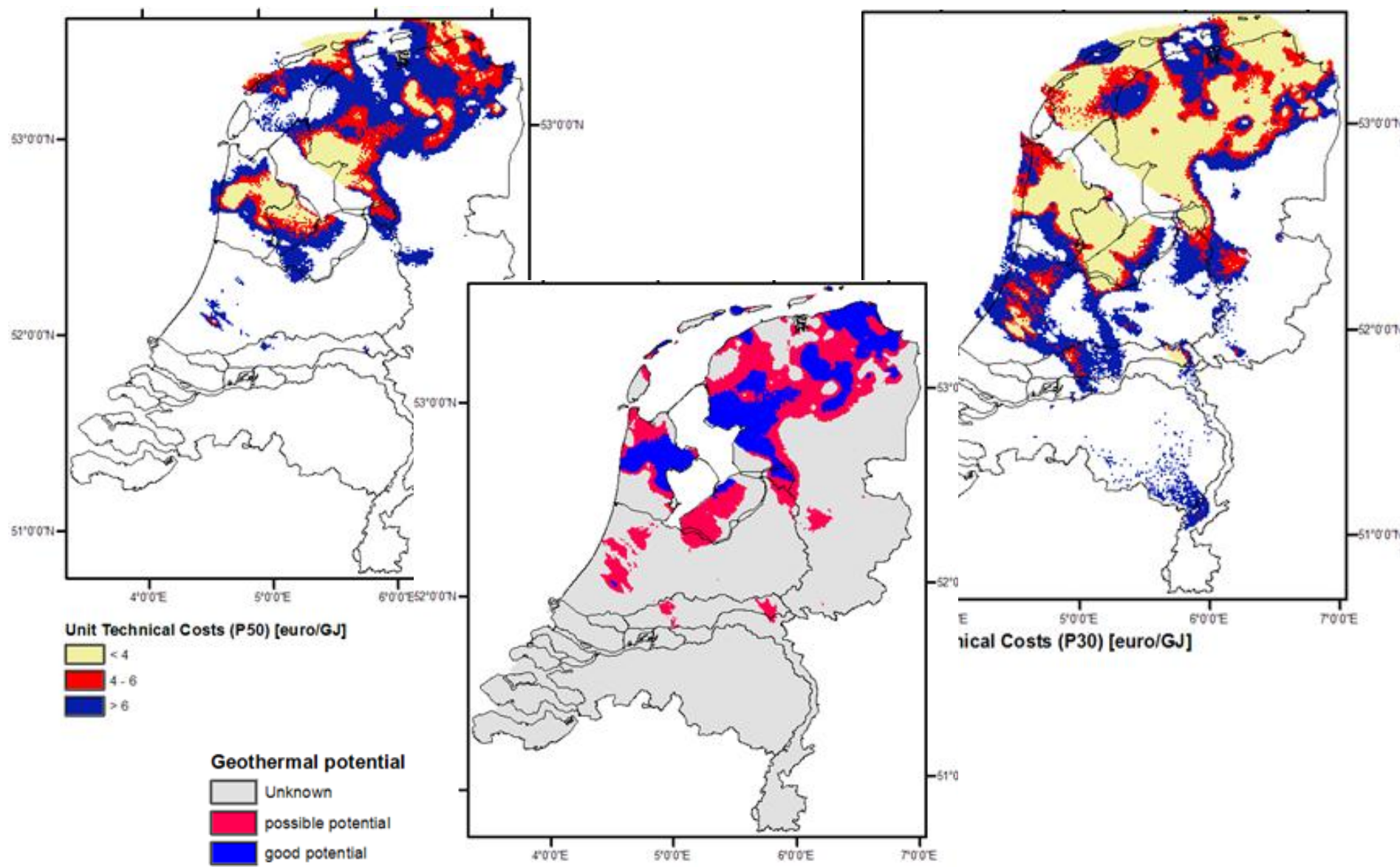


Property mapping and uncertainties (3)

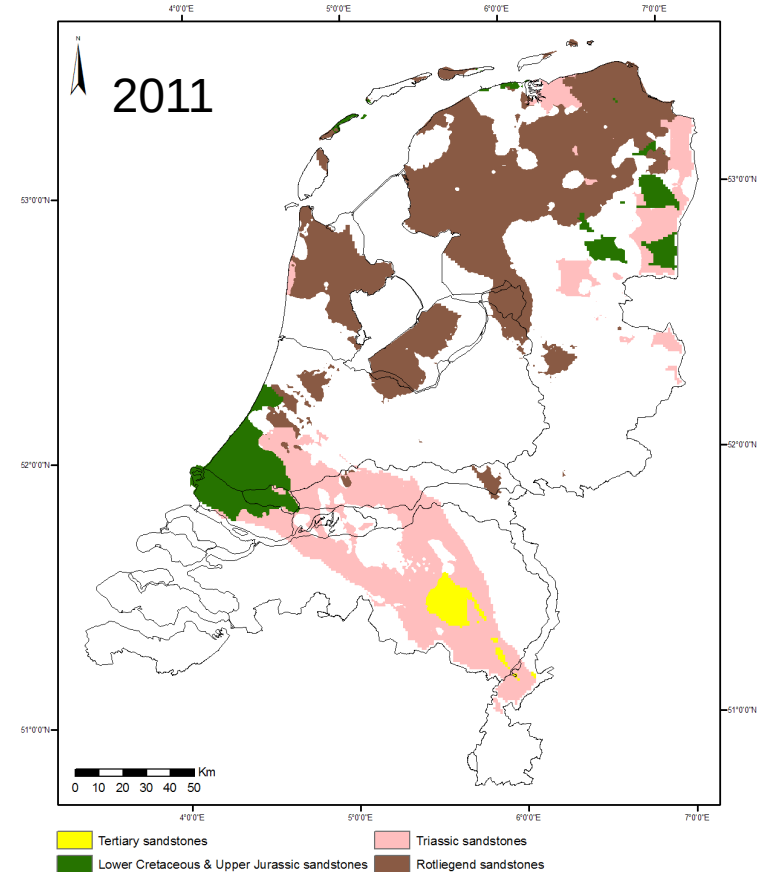
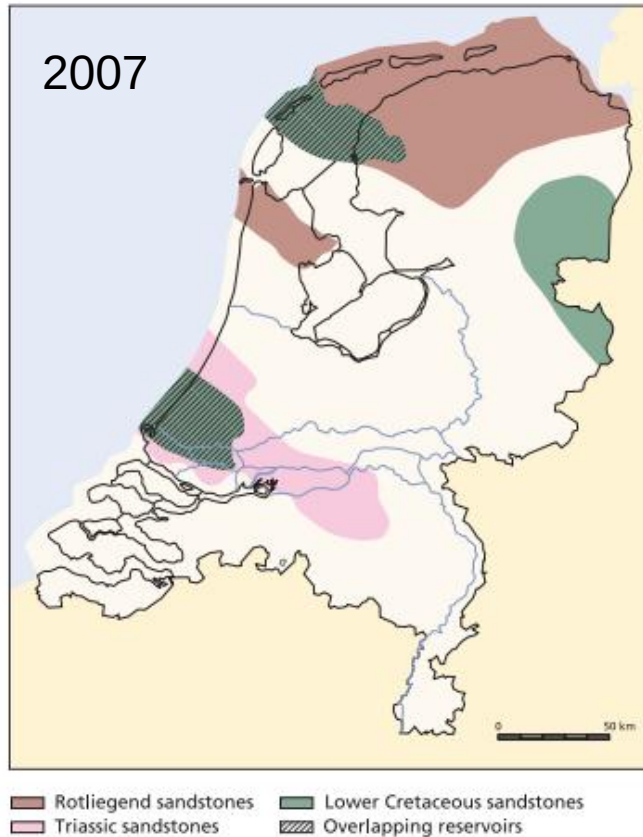


Rotliegendes aquifer

Potential Map



potential map vs earlier assessments



Mapped stratigraphic areas

White: insufficient amount of data or other stratigraphic units (like Carboniferous)

Introductie pagina

Selecteer een kaart

Toepassing: Kaart:

Meer informatie over deze kaart

[Informatie](#)

Selecteer aanvullende gegevens

- ☐ Geothermische boringen
- ☐ Geothermische vergunningen
- ☐ Oorsturing gebieden
- ☐ Olie en gas velden

Zoek adres

Adres: [Zoek](#)

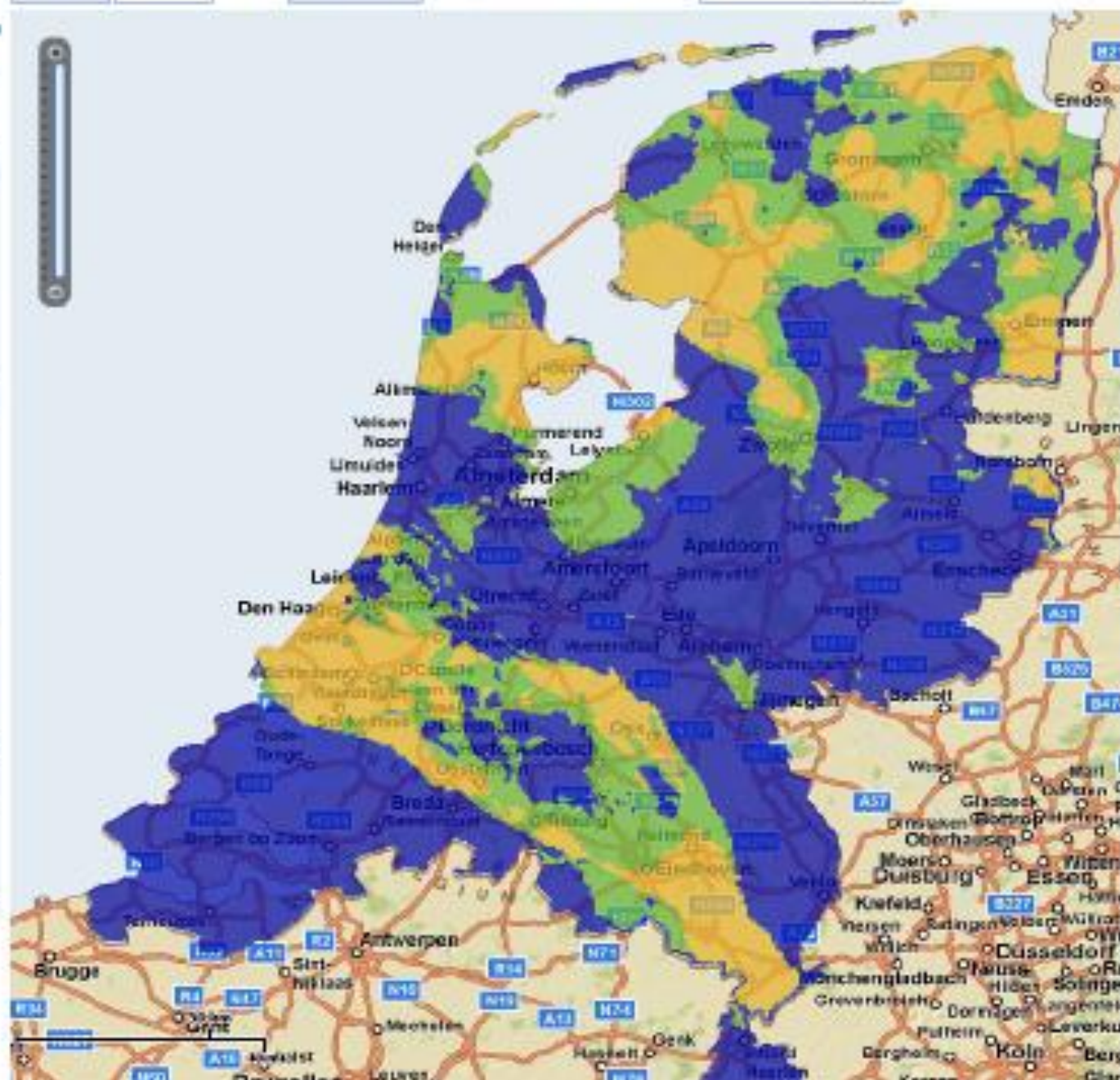
Legenda - Geothermische Potentie [-]

- onbekend
- mogelijke potentie
- goede potentie

Kaart

Satelliet

ThermoGIS

Transparantie ☐[Disclaimer \(PDF\)](#)

Kaart

Satelliet

ThermoGIS

Transparantie



Disclaimer [PDF]

Introductie pagina

Selecteer een Kaart

Toepassing: KassenKaart: Geothermische Potentie

Meer informatie over deze kaart

[Informatie](#)

Selecteer additionele gegevens

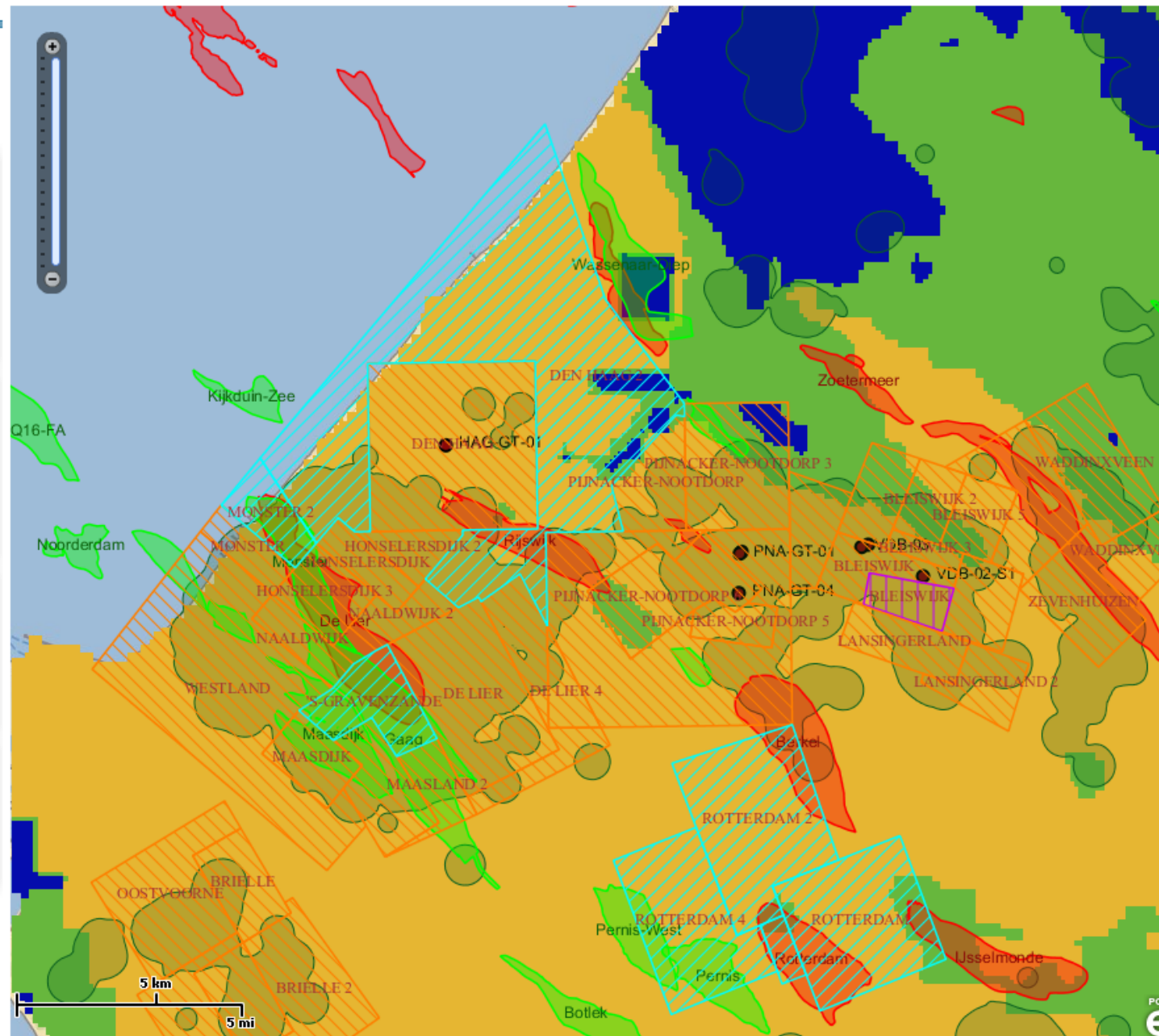
- ☒ Geothermische boringen
- ☒ Geothermische vergunningen
- ☒ Glastuinbouw gebieden
- ☒ Olie en gas velden

Zoek adres

Adres [Zoek](#)

Legenda - Geothermische Potentie [-]

- onbekend
- mogelijke potentie
- goede potentie



Main points Aquifers

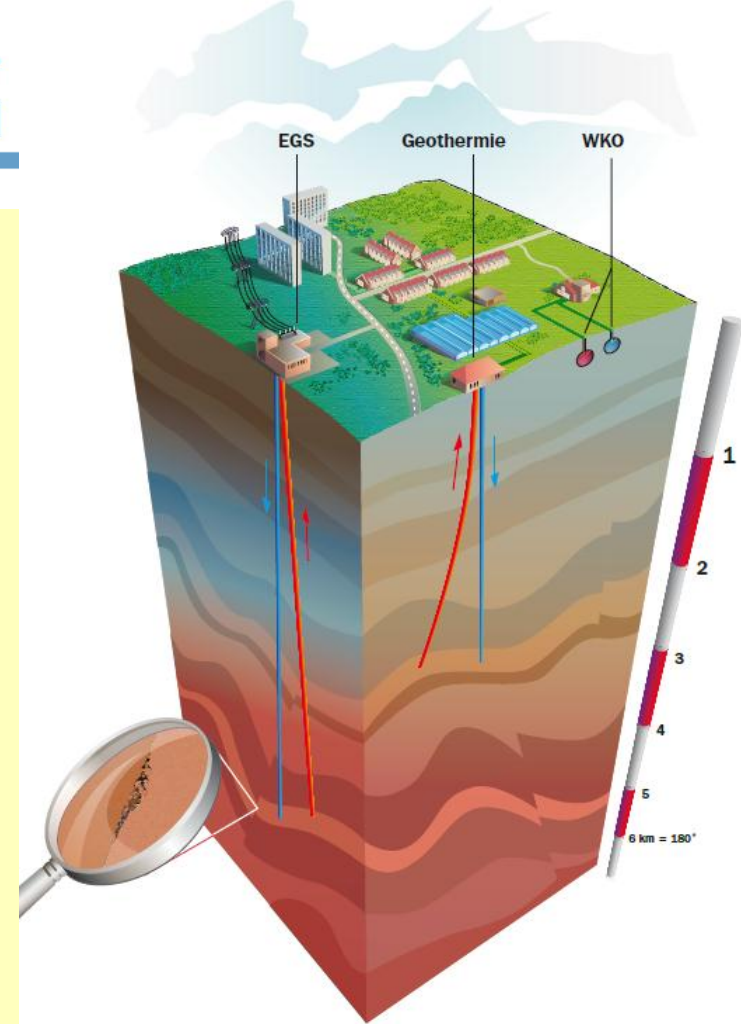
- › Free access to oil and gas data excellent stepping stone for geothermal exploration and information systems
- › Over 15 aquifers mapped, stacked in 4 groups
 - › Rotliegendes, Triassic, Jurassic-Cretaceous, Tertiary
 - › Technical potential ca 85,000 PetaJoules, almost equivalent to heating value of giant groningen gas-field
- › web-based information system split for different stakeholders
 - › Basic version, not showing subsurface information
 - › Expert version

Geothermal electricity resource assessment

- › Vision on EGS development (IF-Technology,TNO,KEMA)
- › Proposal for National Research Program on geothermal energy
- › Pilot project feasibility studies
- › TNO National geological survey: Ongoing mapping activities

Diepe geothermie Nationaal Onderzoek Programma Geothermie (NOPG)

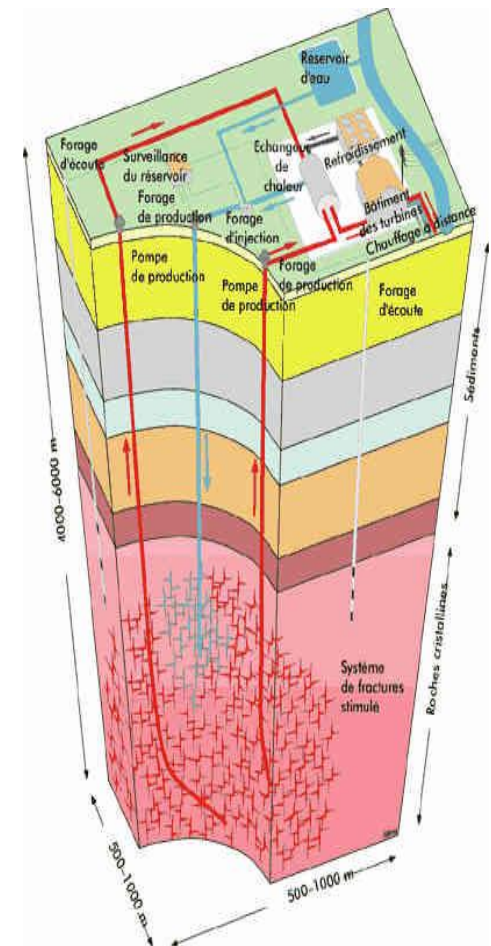
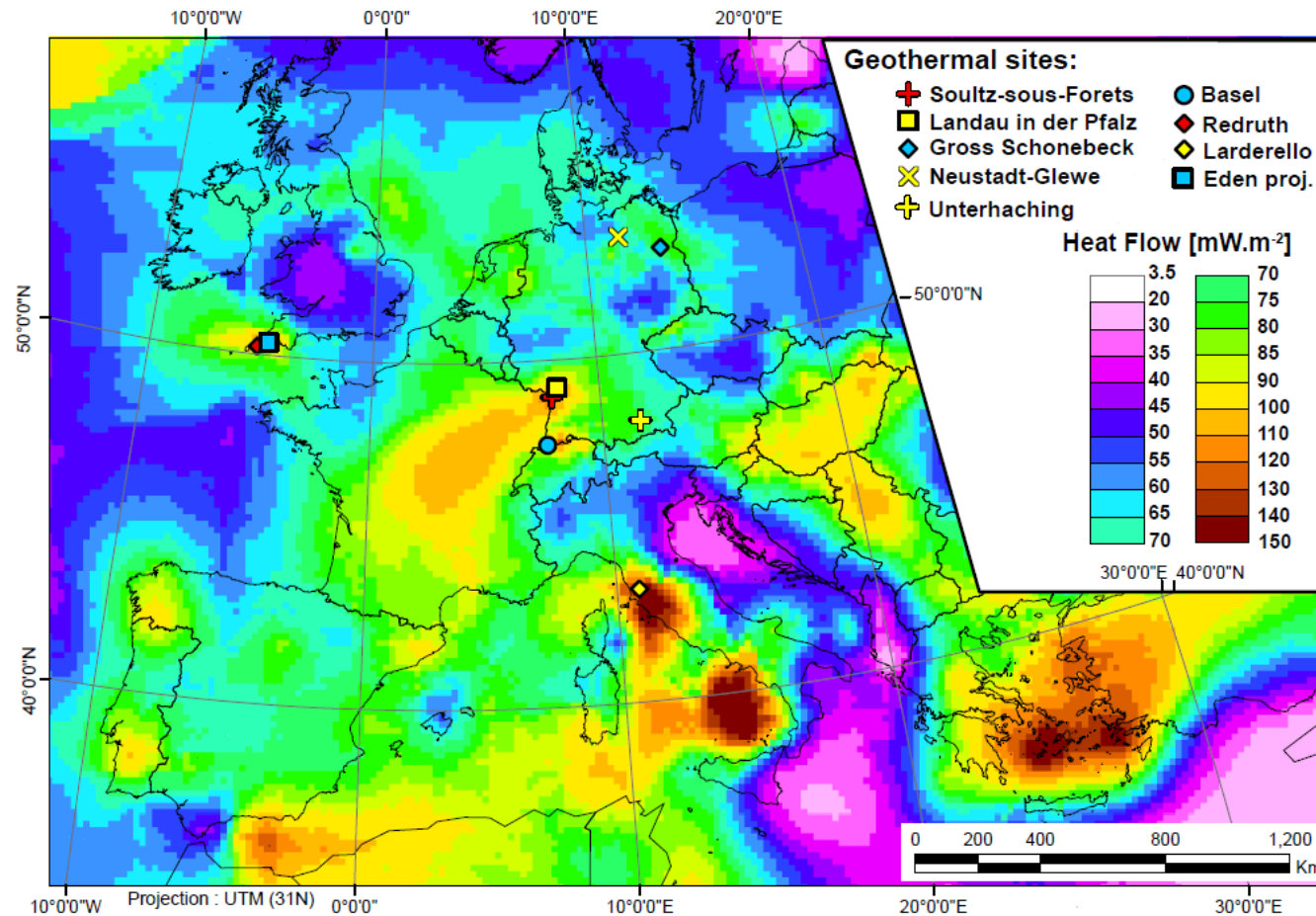
Breed inzetbare goedkope duurzame energie



Universiteit Utrecht



Engineered Geothermal Systems - EGS



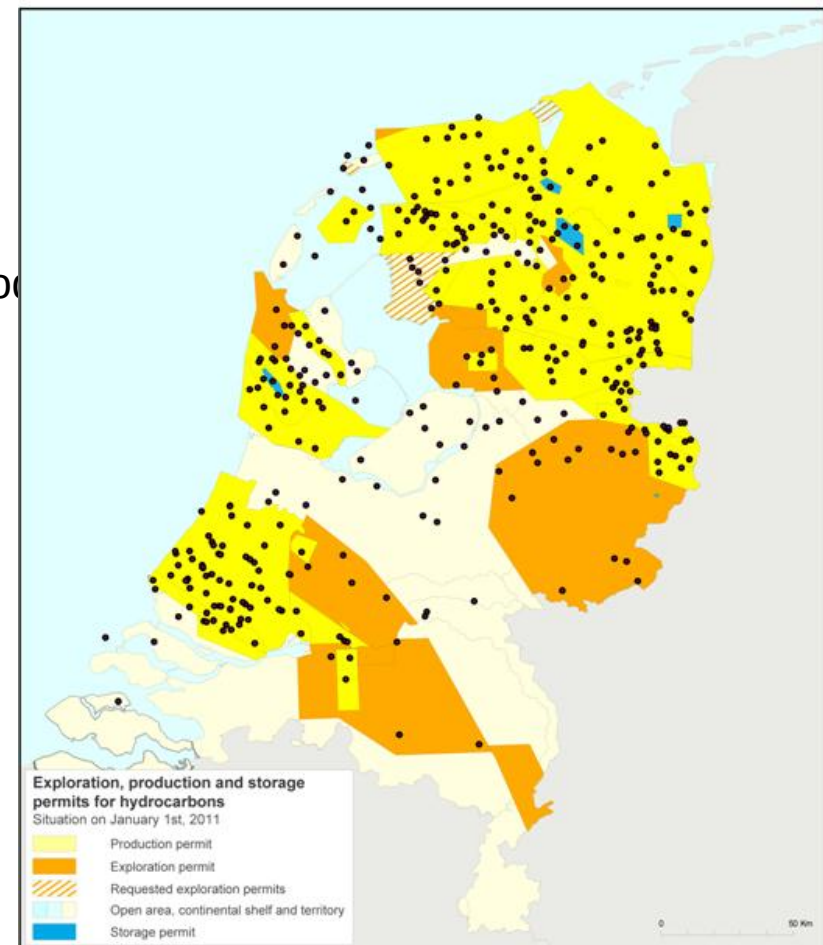
Cloetingh et al. 2010 (Earth-Science Reviews)

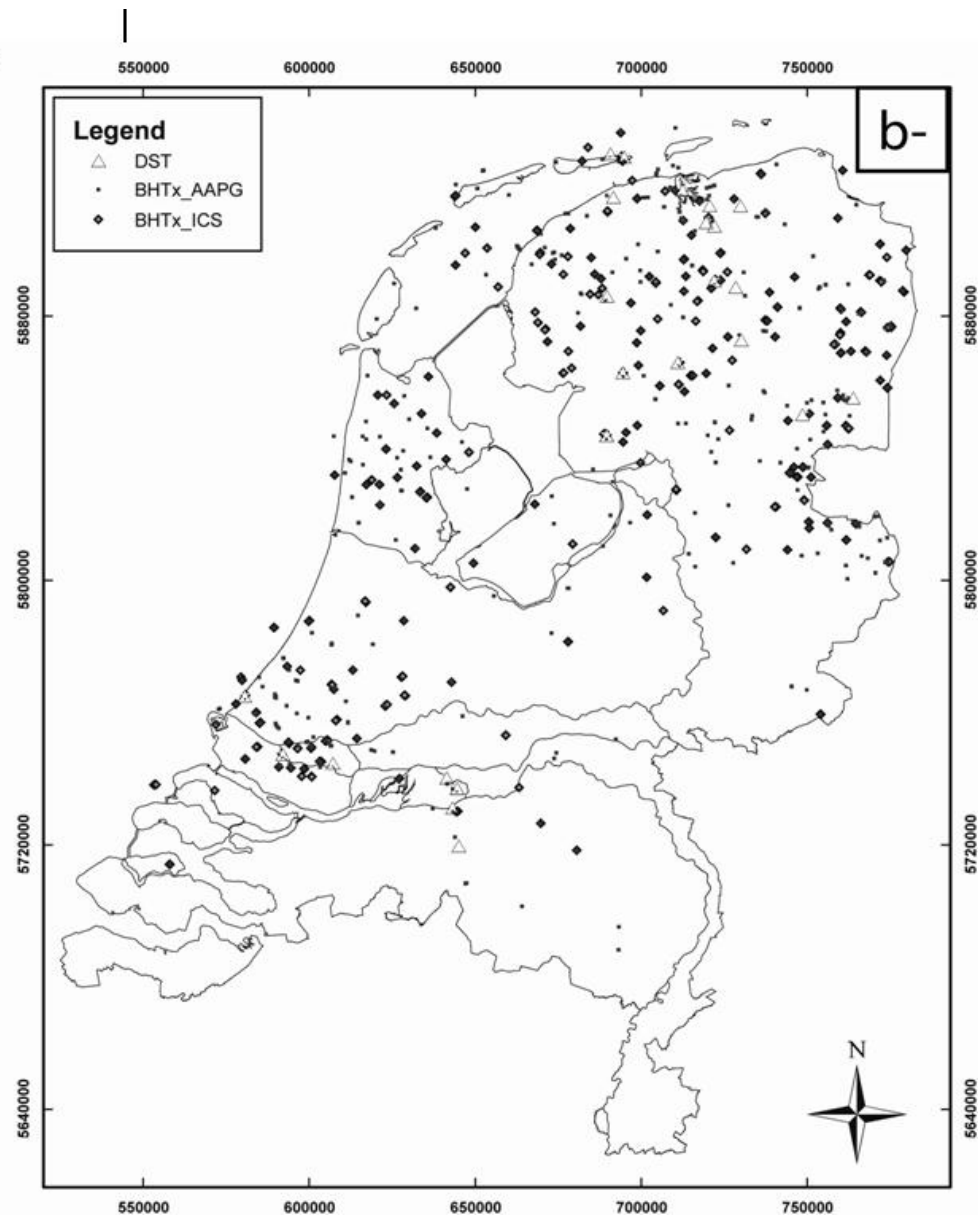
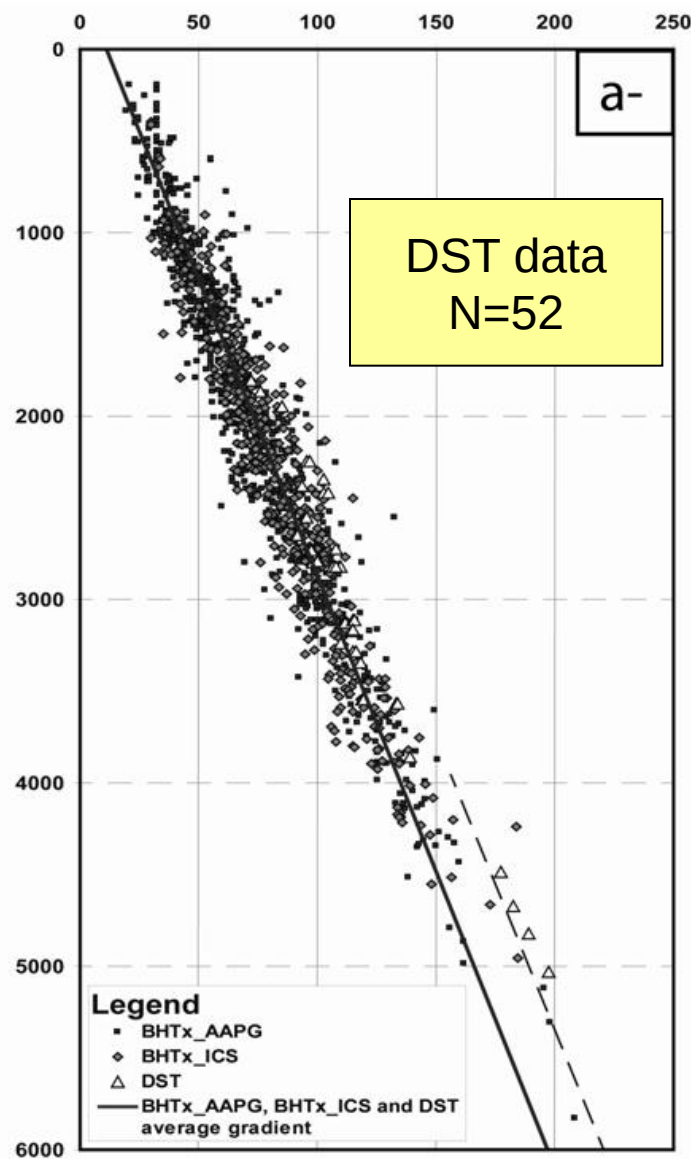
BHT data (n=1241)

- › ICS (n=412)
 - › Initial Cylindrical source
 - › Used to correct simpler AAPG method
- › AAPG + AAPGcorrected (n=829)

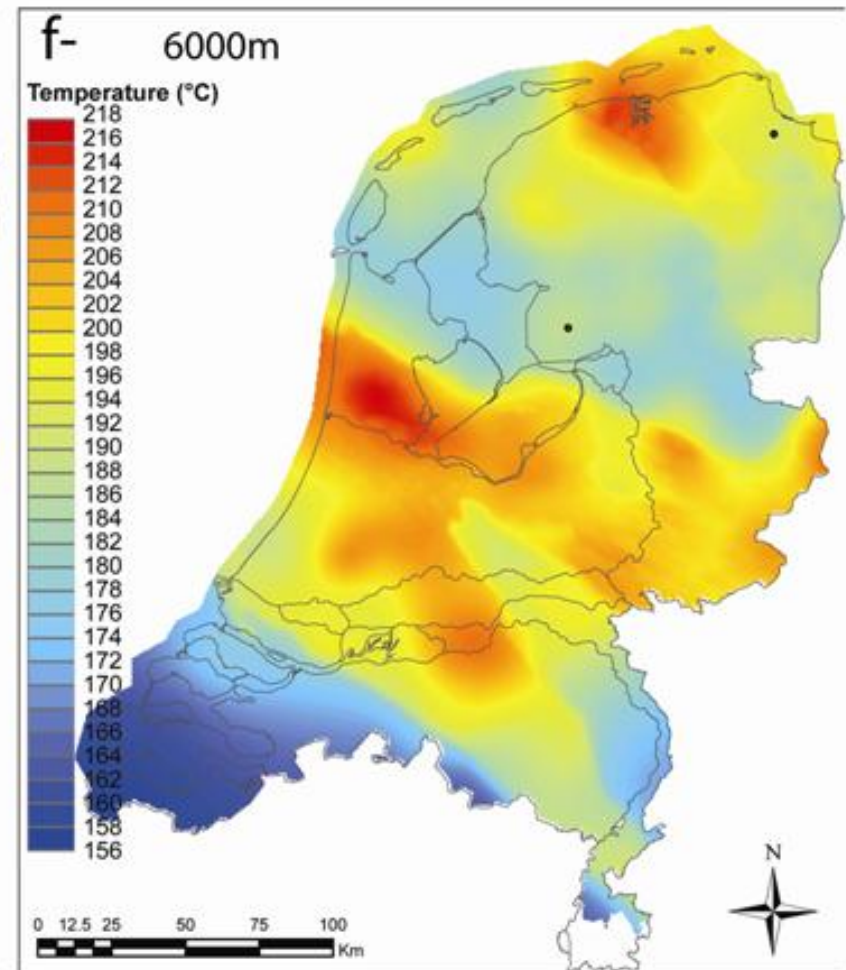
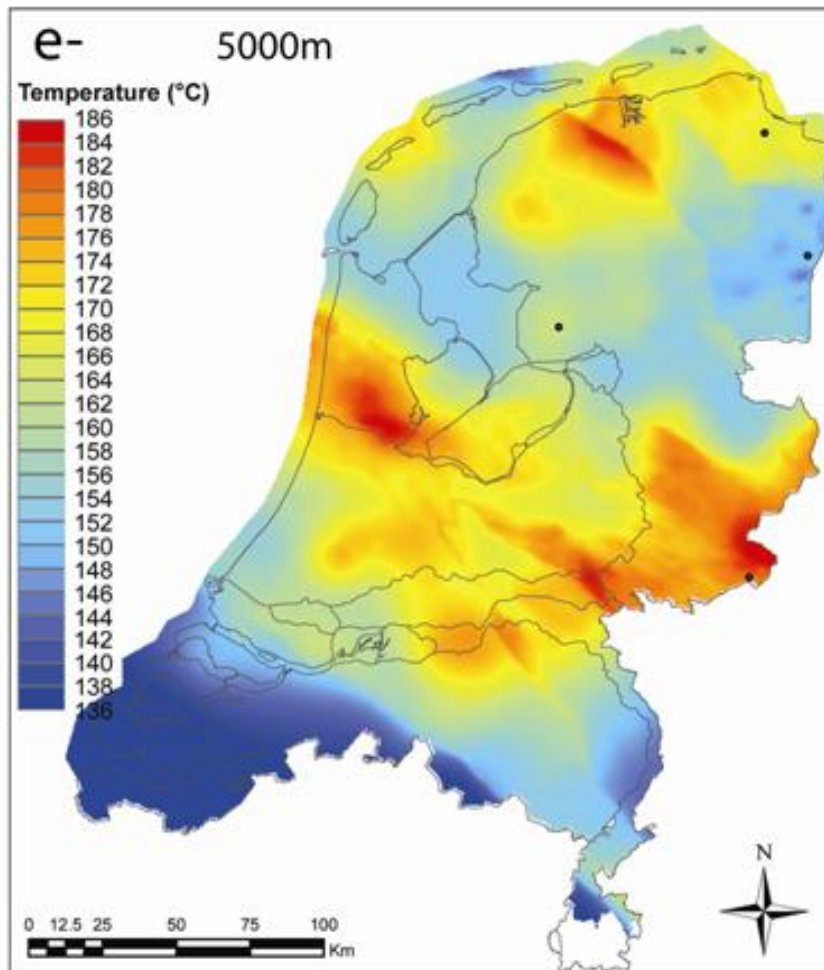
For comparison
DST much less (n=52)

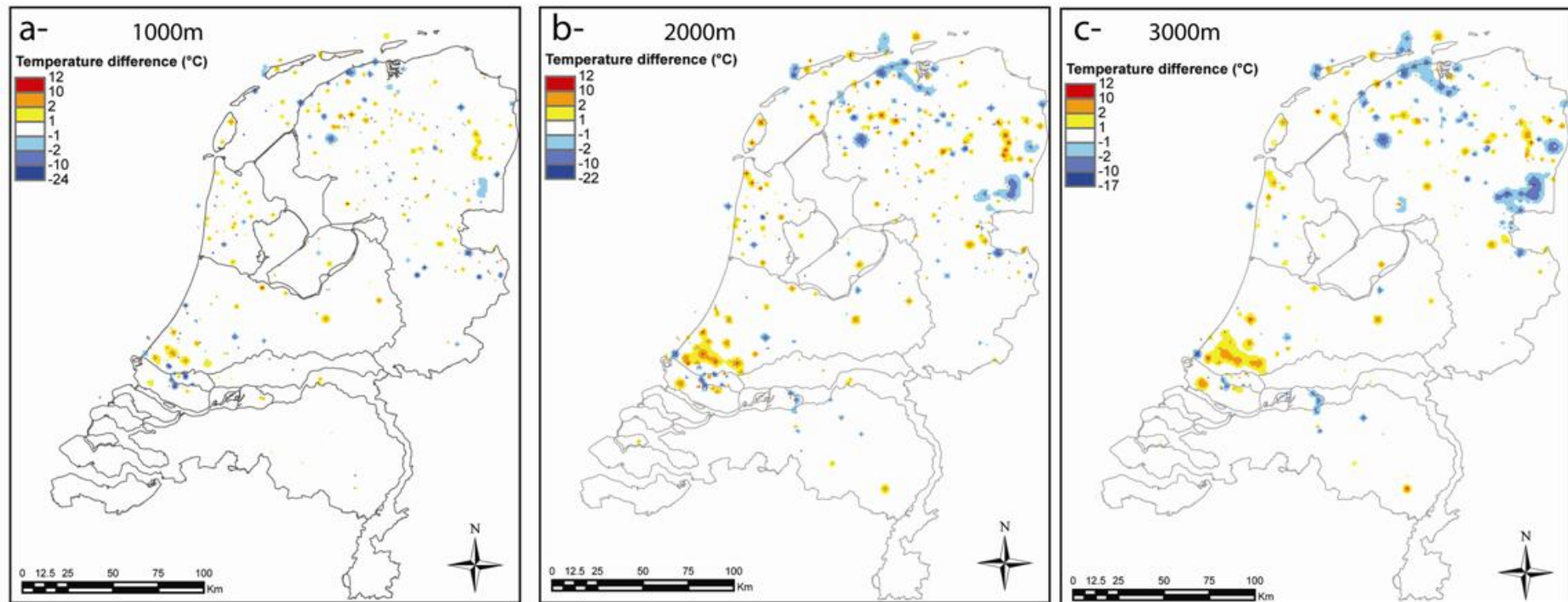
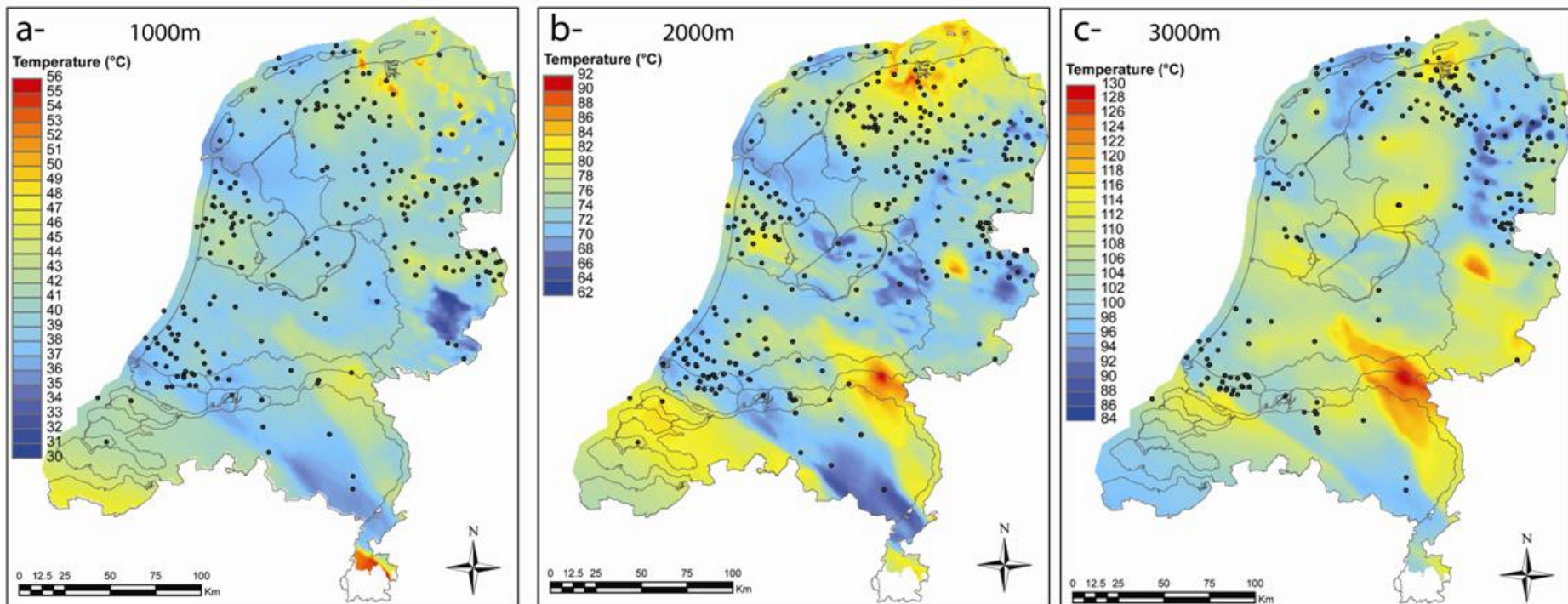
BHT wells and E&P licenses



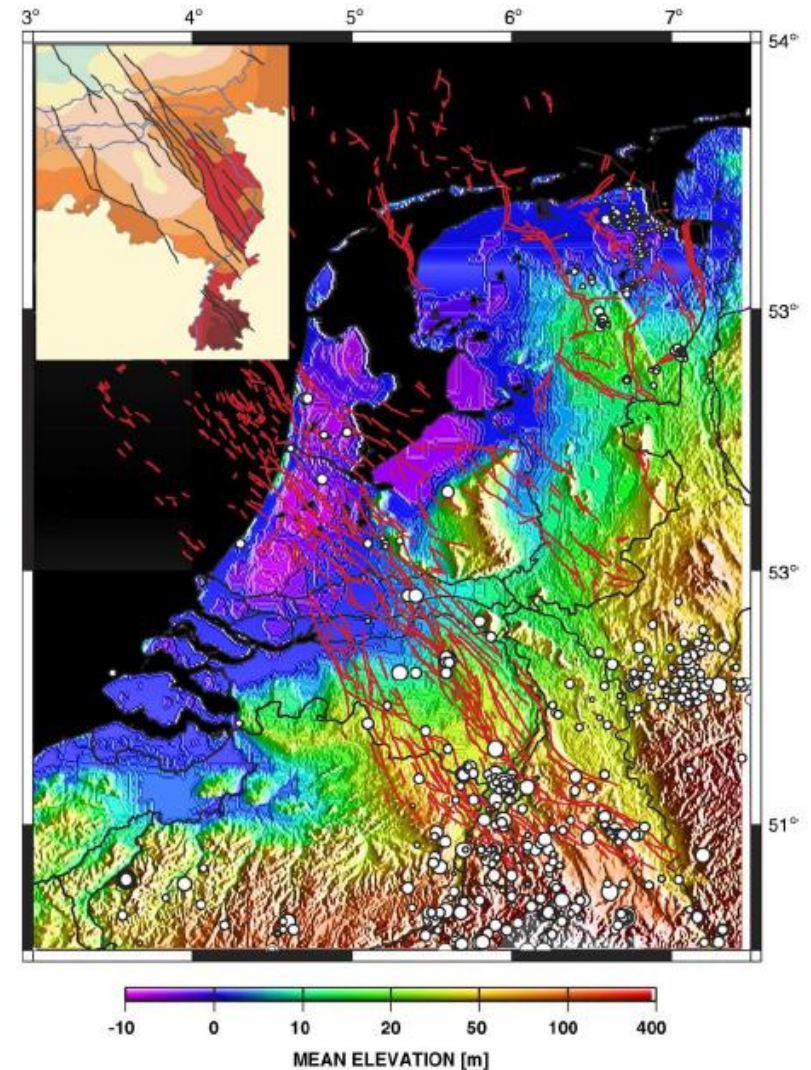
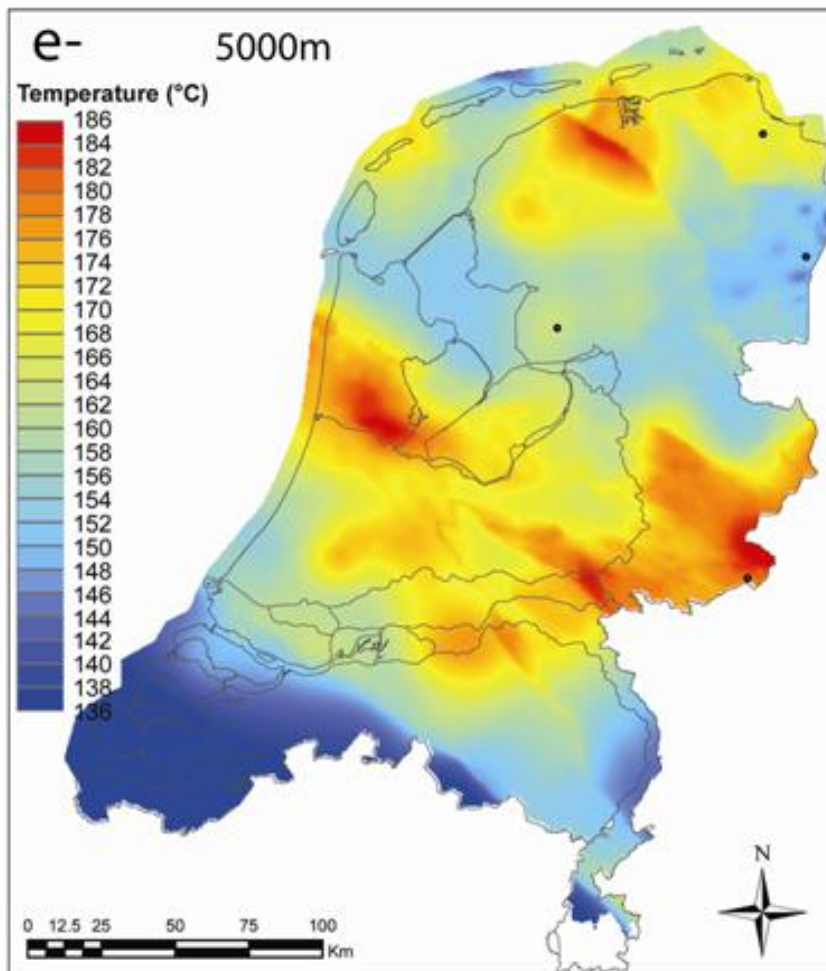


Results - temperature (3)

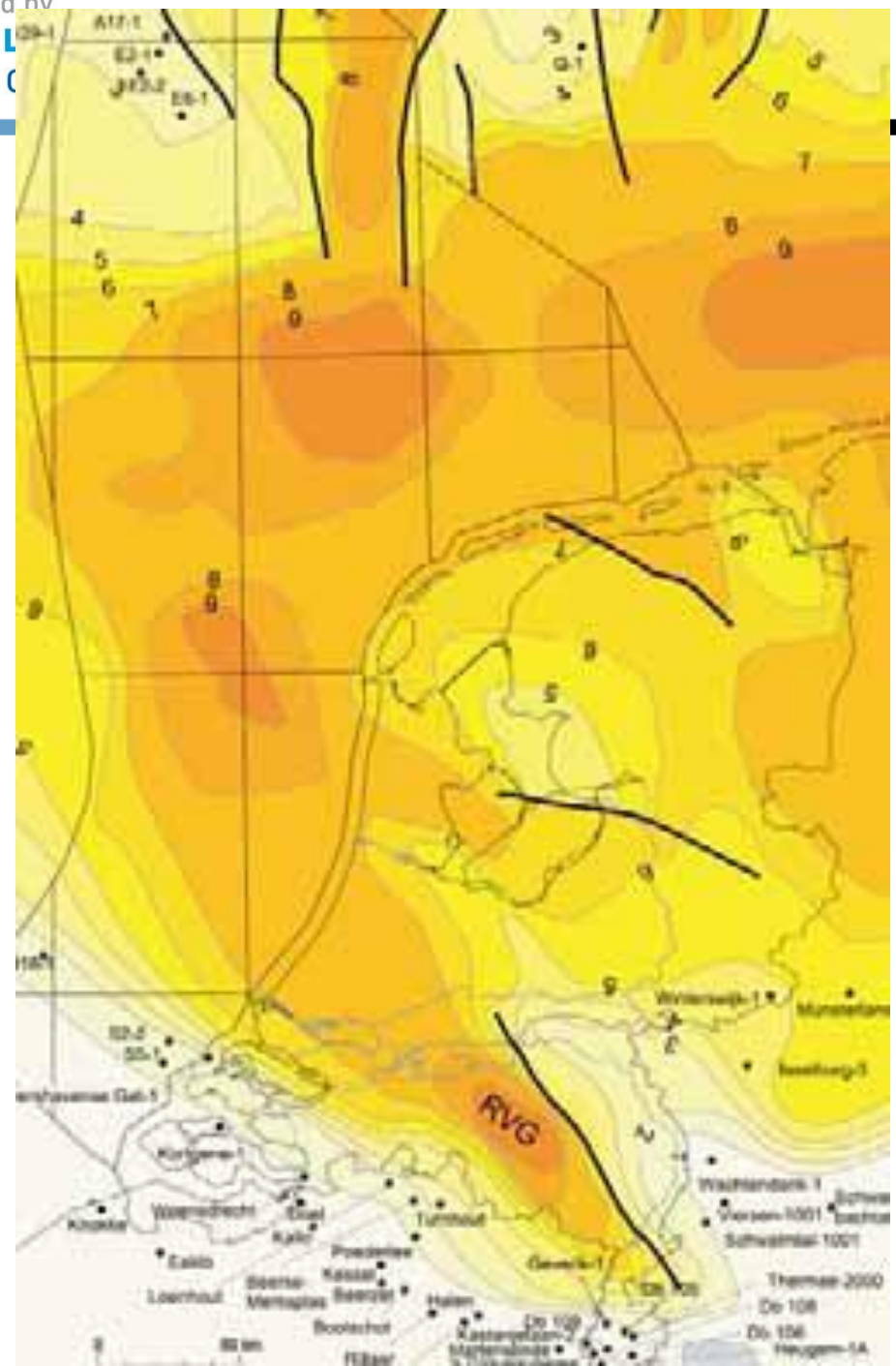


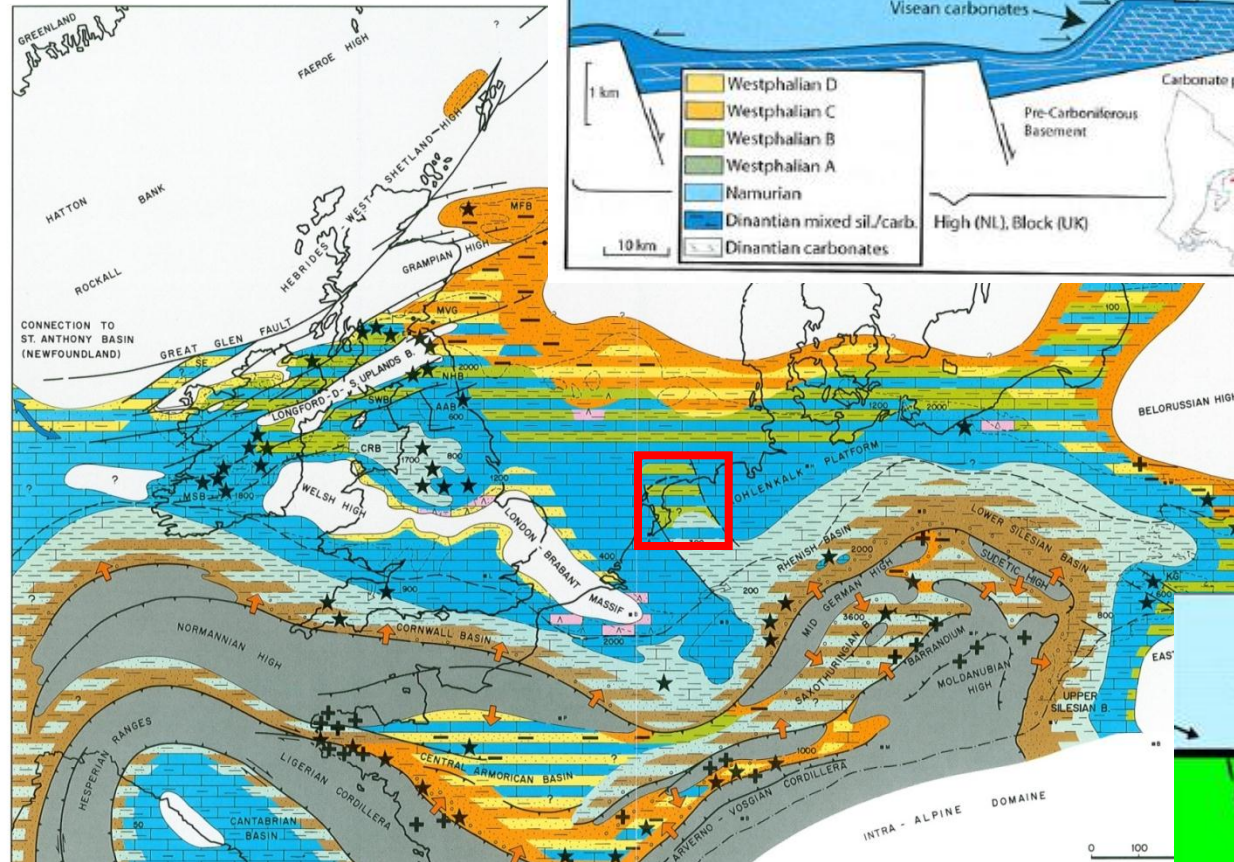


Implications for EGS

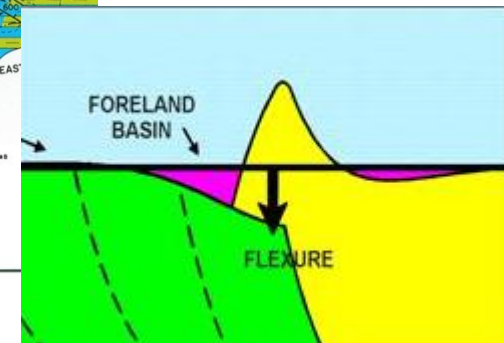
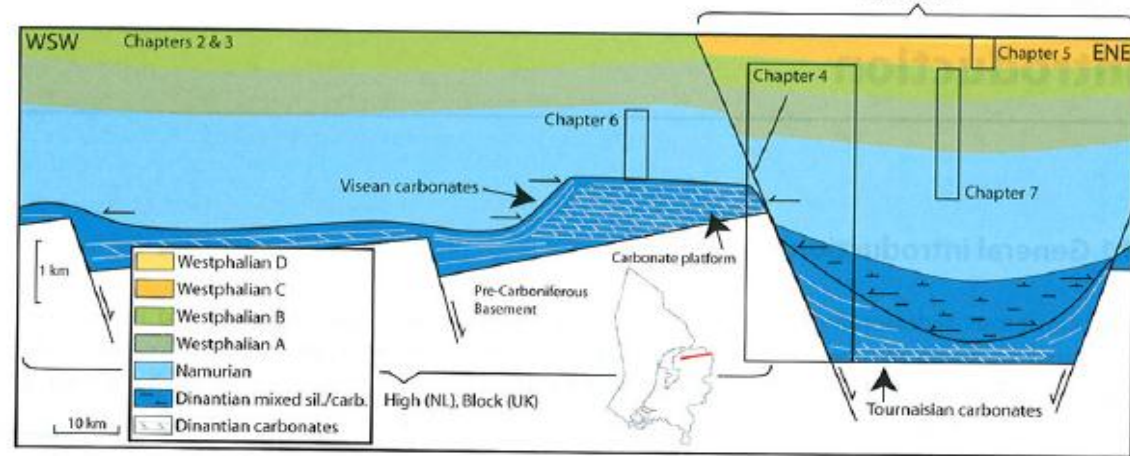


To be updated by mapping

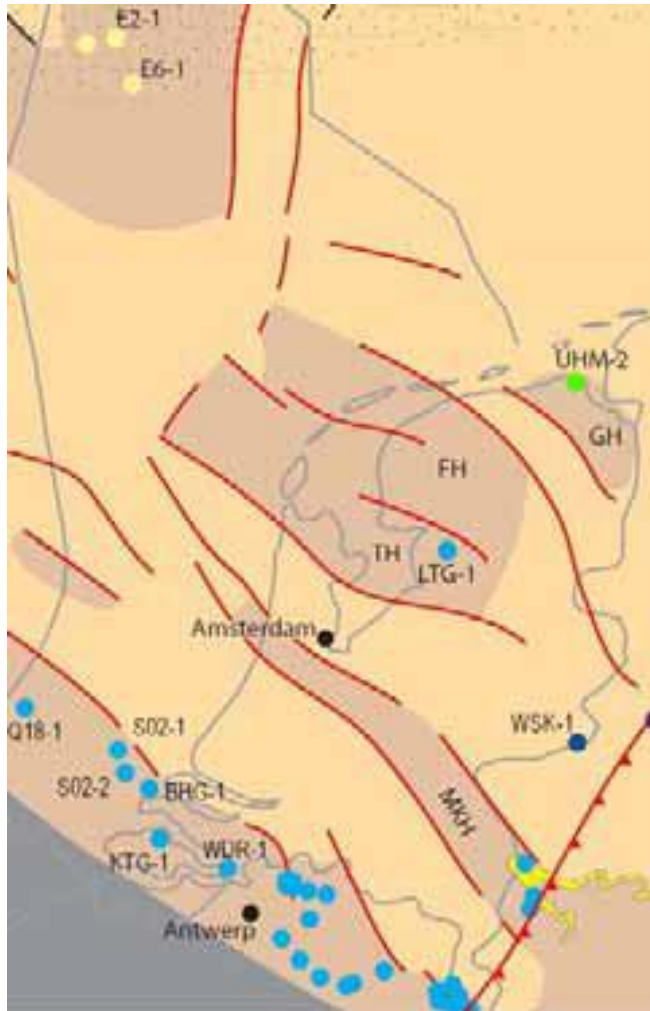




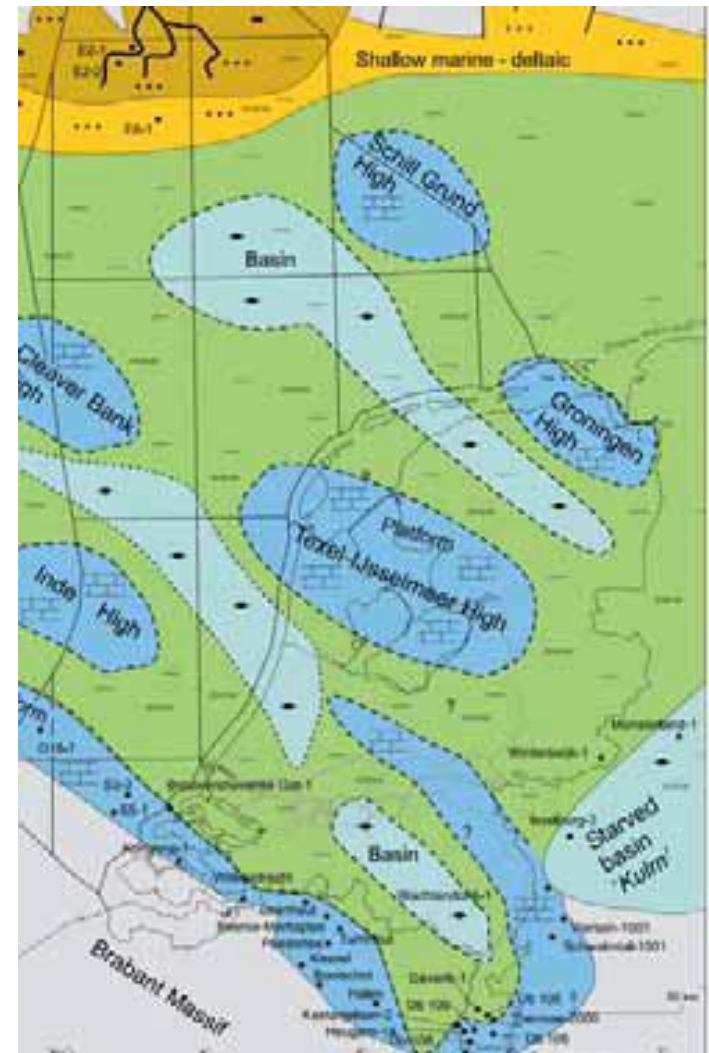
Dinantian (Ziegler, 1990)



Regional studies – VARISCAN BASIN DEVELOPMENT

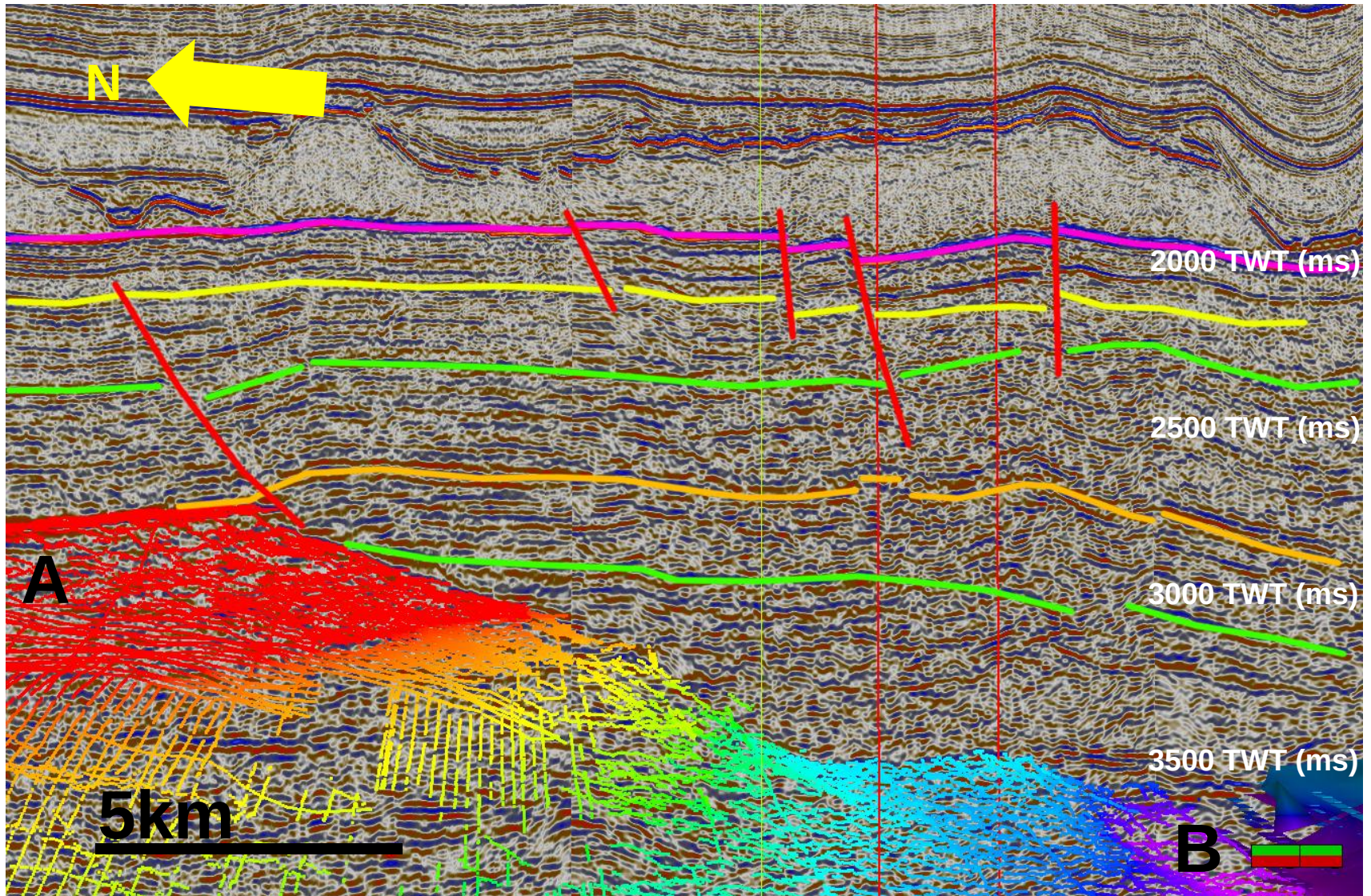


Southern Permian Basin Atlas,
Kombrink et al., 2010



Geluk et al., 2007

Carboniferous Carbonate Platforms



October 10, 2011

Susanne Nelskamp
Estimation of erosion

Carboniferous platforms

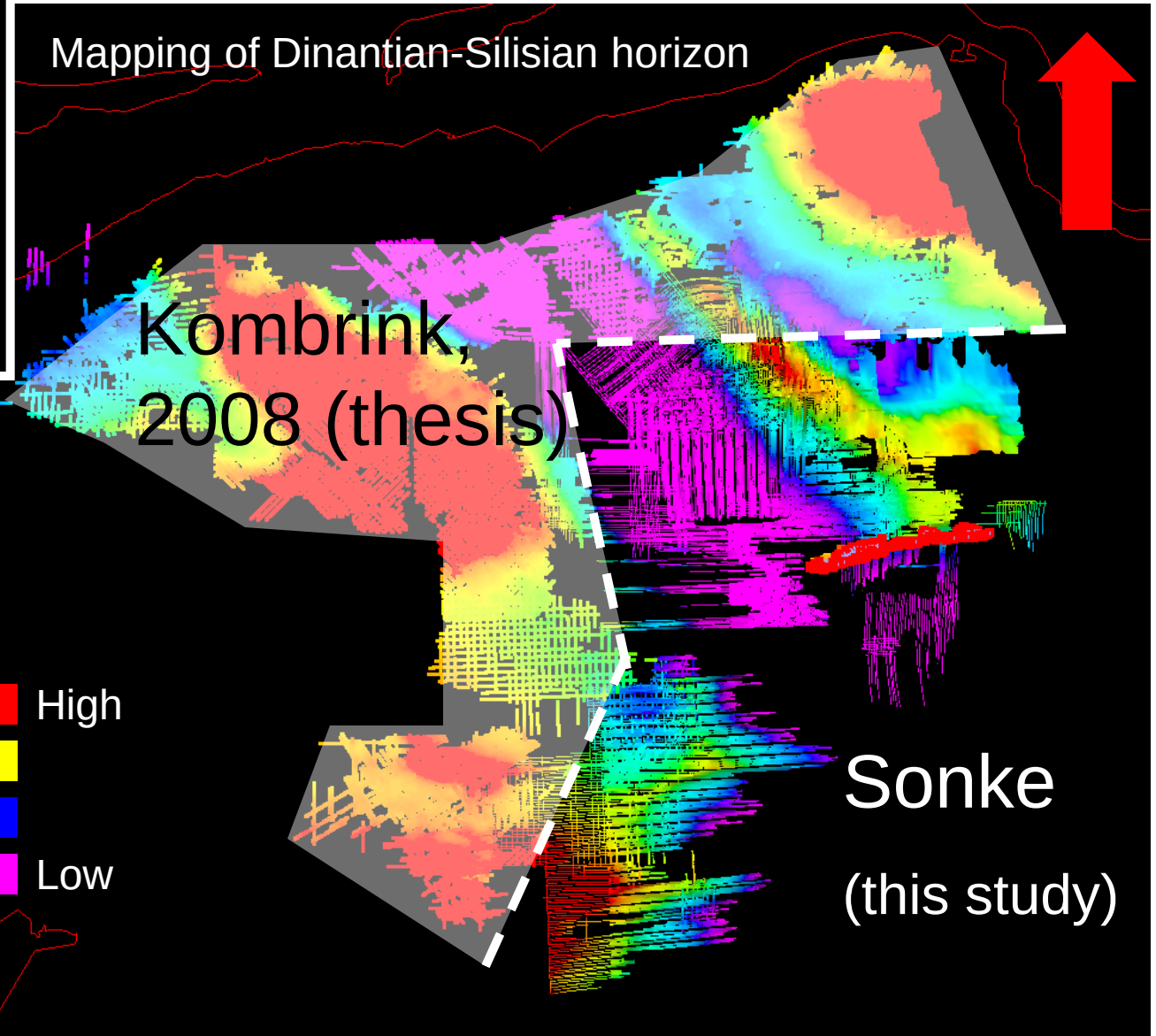
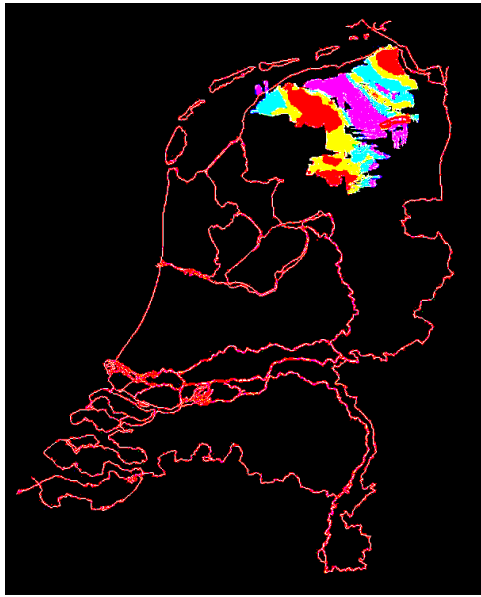
Mapping of Dinantian-Silisian horizon

Kombrink,
2008 (thesis)

Sonke
(this study)



Estimation of erosion



fe

Kasimo-
vian

Moscovian

Bashkirian

Serpukhovian

Visean

Dinantian

Ivorian

Krevyakinian	Silesian	Westphalian	Carboniferous
Myachkovian		(D) Asturian	Deserian
Podolskian		(C) Bolsovian	Avalonian
Kashirian		(B) Duckmantian	
Vereian		(A) Langsettian	
Melekessian		Yeadonian	
Cheremshankian		Marsdenian	
Prikamian		Kinderscoutian	
Severokeltmenian		Alportian	
Krasnopolyan		Chokierian	
Voznesenian			
Zapaltyubian	Namurian	Arnsbergian	
Protvian			
Steshevian		Pendleian	Chadrian
Tarusian			
Venevian	Visean	Wanantian	
Mikhailovian		Asbian	Brigantian
Aleksinian			
Tulian		Holkerian	
Bobrikian		Arun-dian	
Radaevkian		Molini-acian	
Kosvian			
		Ivorian	

October 10, 2018

Summary

- › Mesozoic Clastic Aquifers well mapped → UR locally in excess of 1%
- › Temperature data and model
- › Active faults
- › Paleozoic Carbonates (platforms) proposed as target in various pilot projects