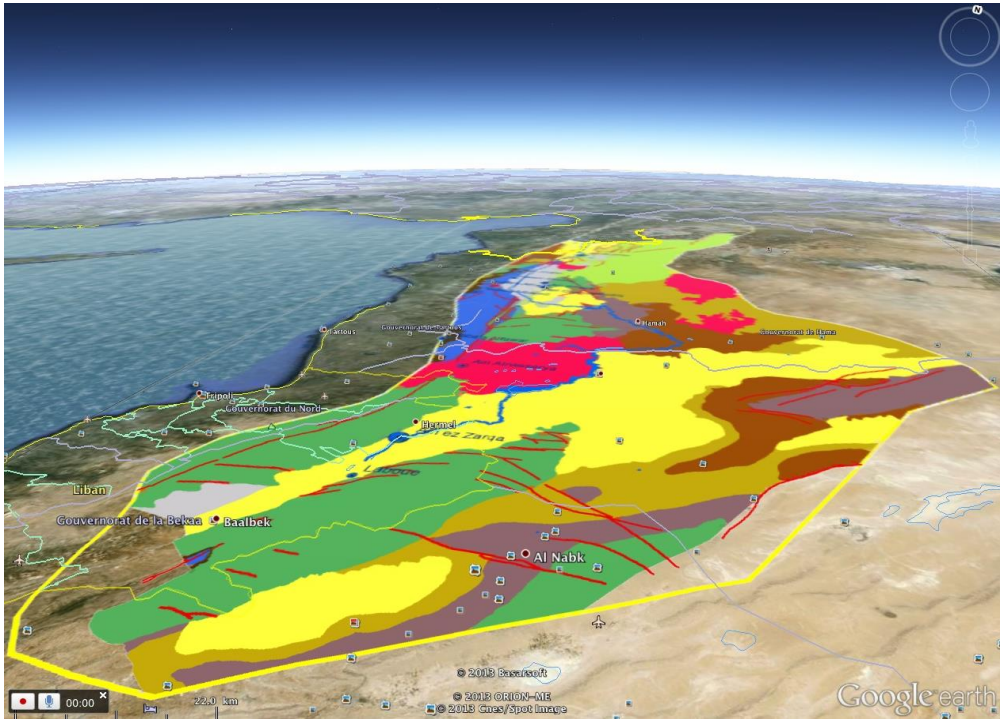
Impacts of intensive exploitation of the Jurassic-Cretaceous aquifer system on the organisation of the subsurface water flows Orontes river basin, Lebanon Syria



Orontes River Basin
Research Program

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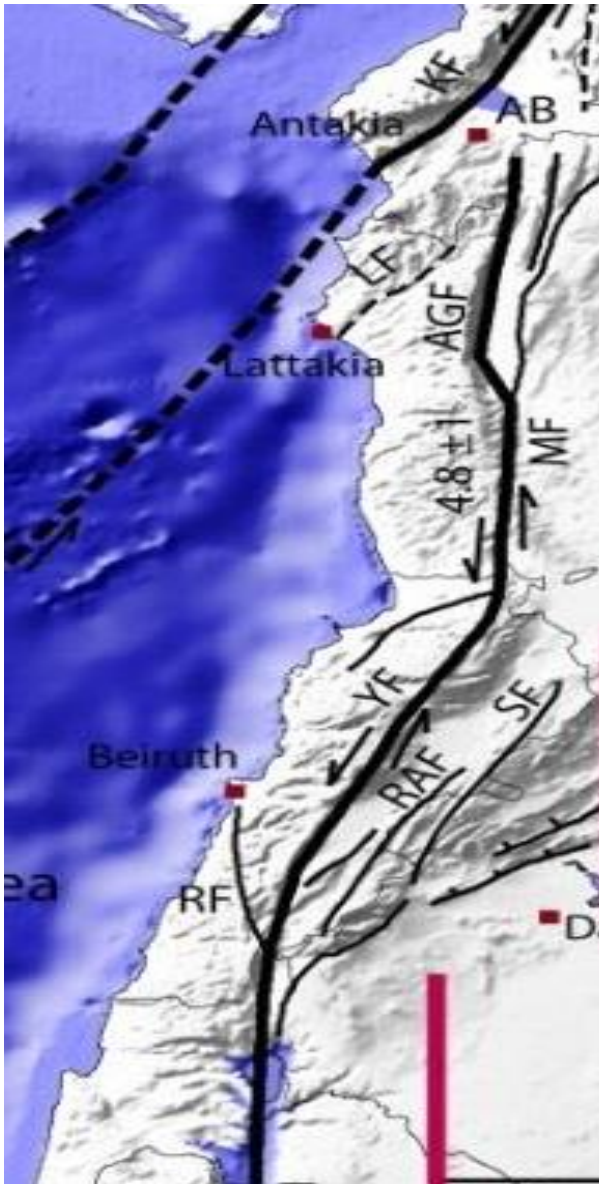
Montpellier, September 2016

Questions:

- Many springs dried out in the 1990s. From where comes the main part of their alimentation?
- Lebanon and Syria border. What about the groundwater flows across it?

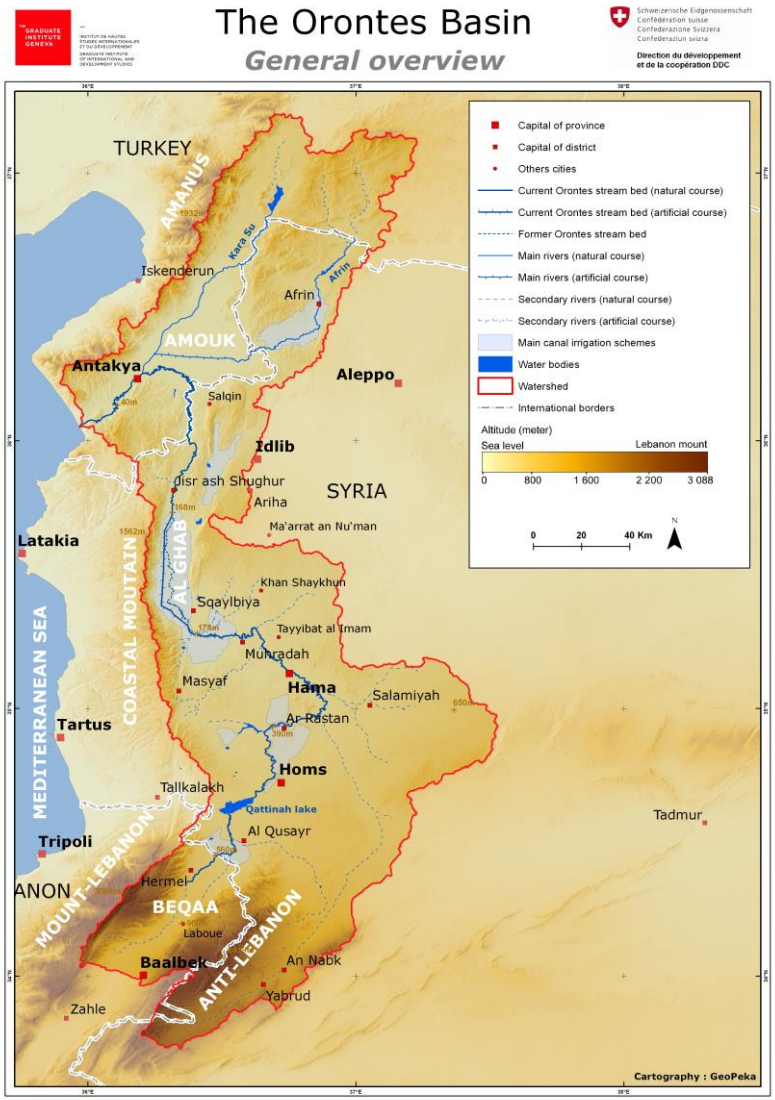


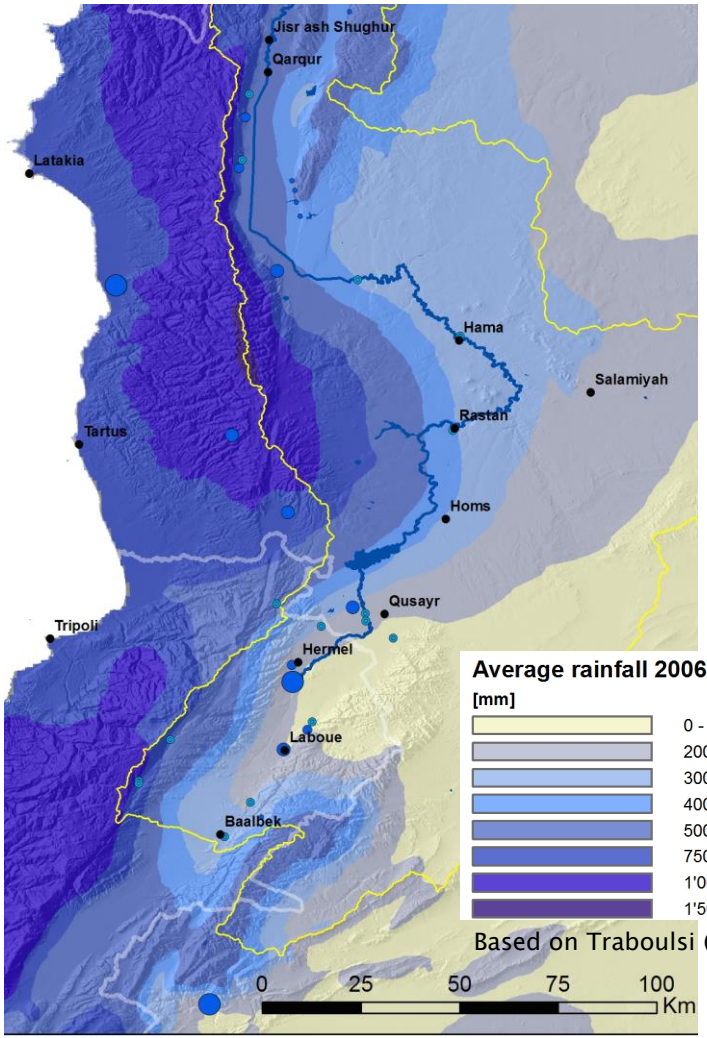
Content:

- Landscape, precipitations & recharge
- Hydrogeological map & cross sections
- Sources, estimated flow in the 1960s and 2000s
- Flow paths in the 1960s and 1990s, reconstitution
- Piezometric map, flow paths, 2006
- Conclusions

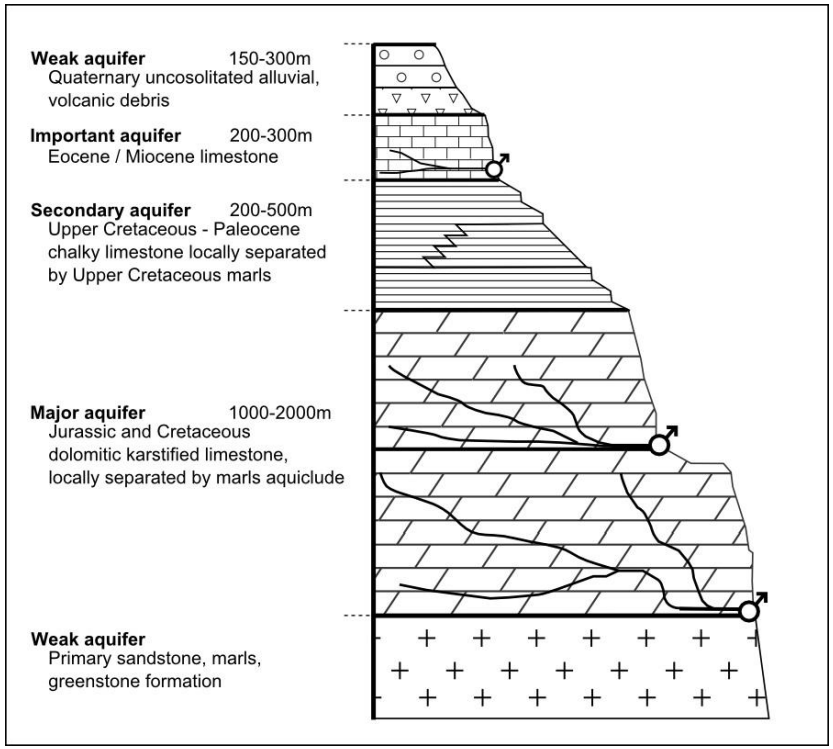
Bekaa, Mount Libanon

Orontes River basin, Syria



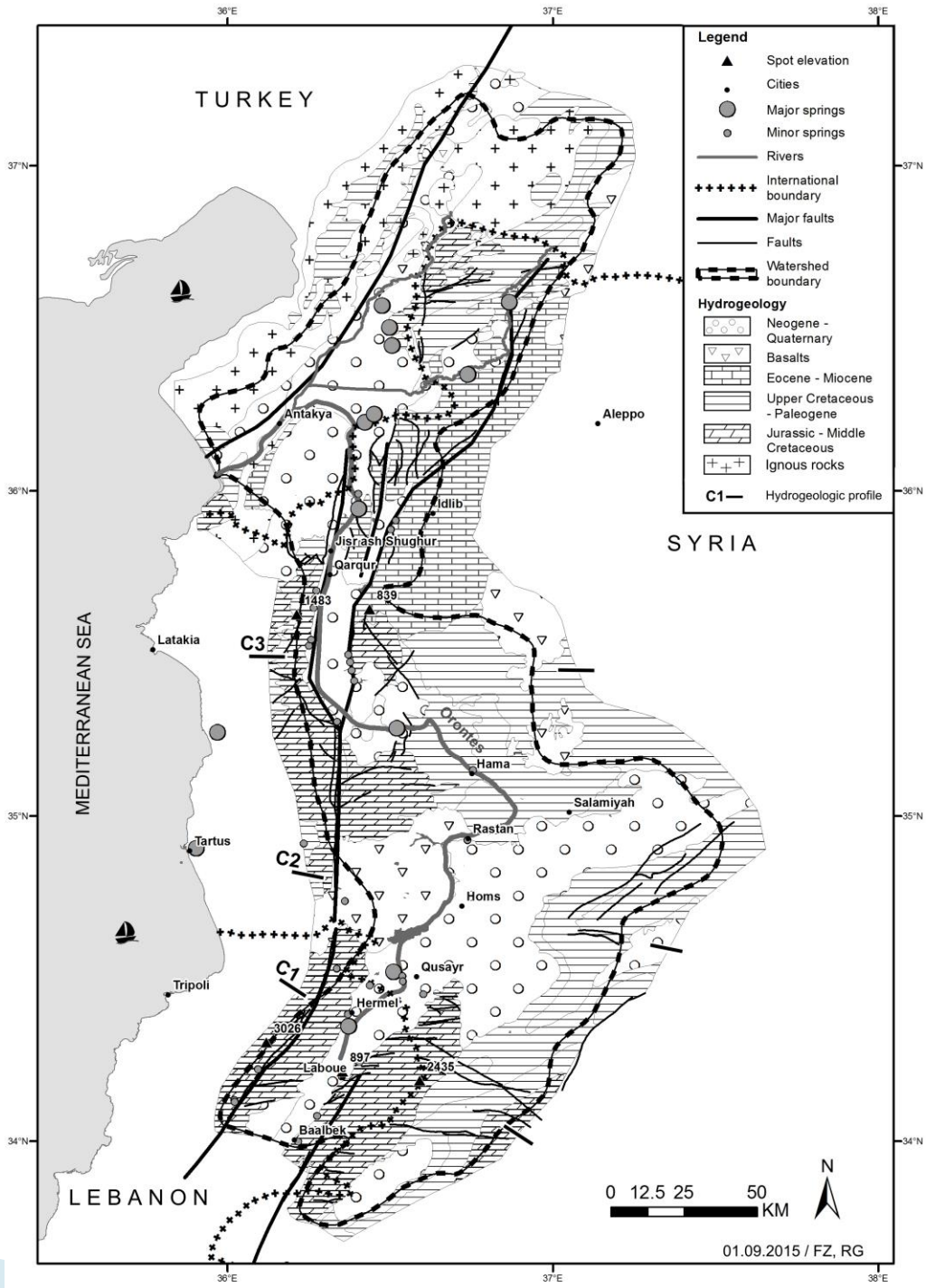


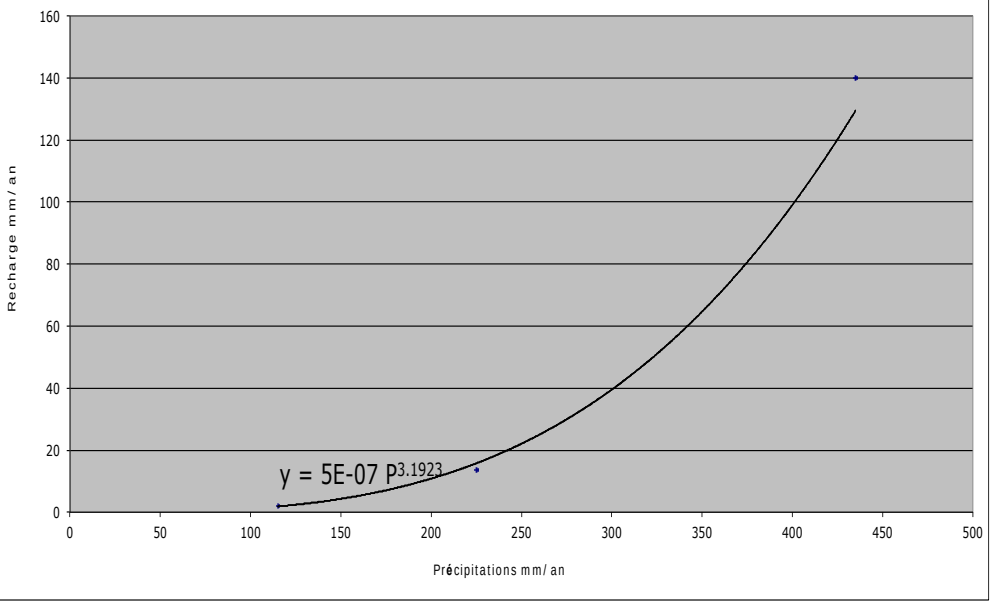
Topography, average annual rainfall (in the 2000s) of the Orontes River basin



Hydro-litho-stratigraphical figure of the Orontes River basin formations

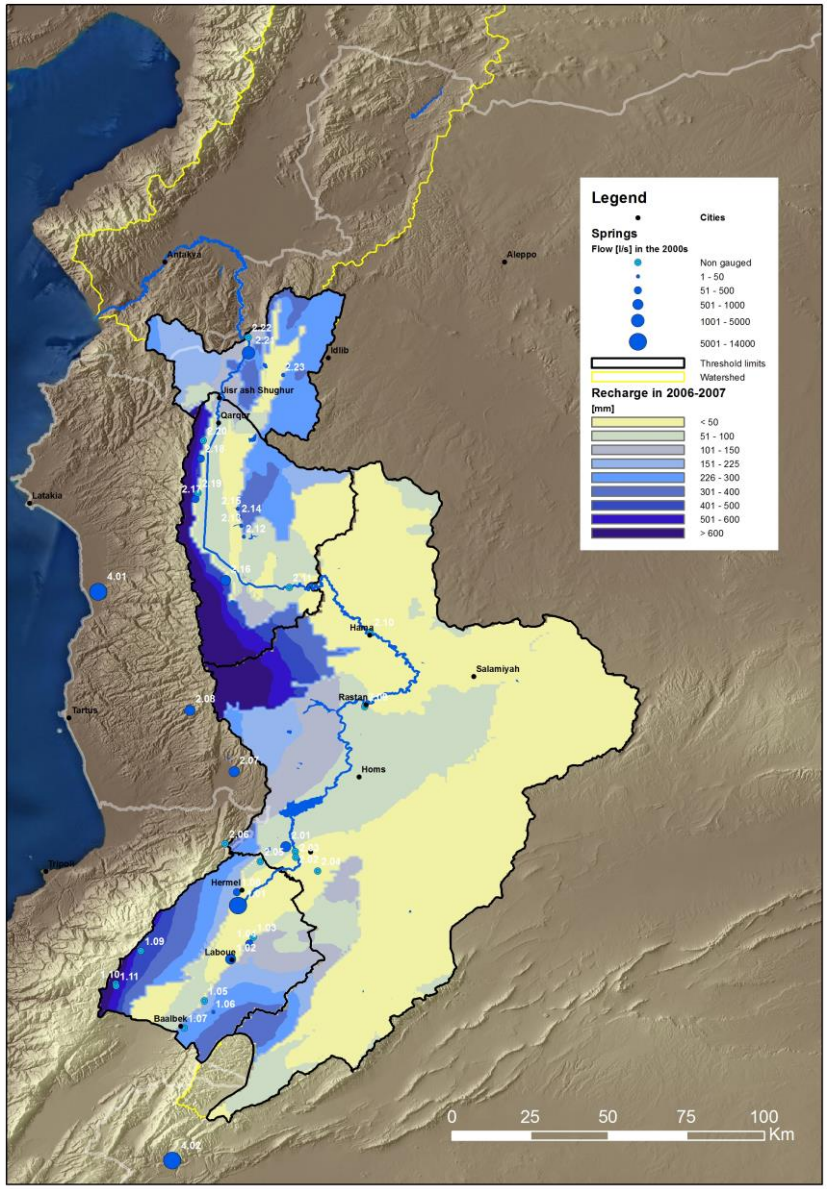
Simplified hydro-geological map of the Orontes River basin





… field observations, Précipitations/Recharge
Salamiah, 2003

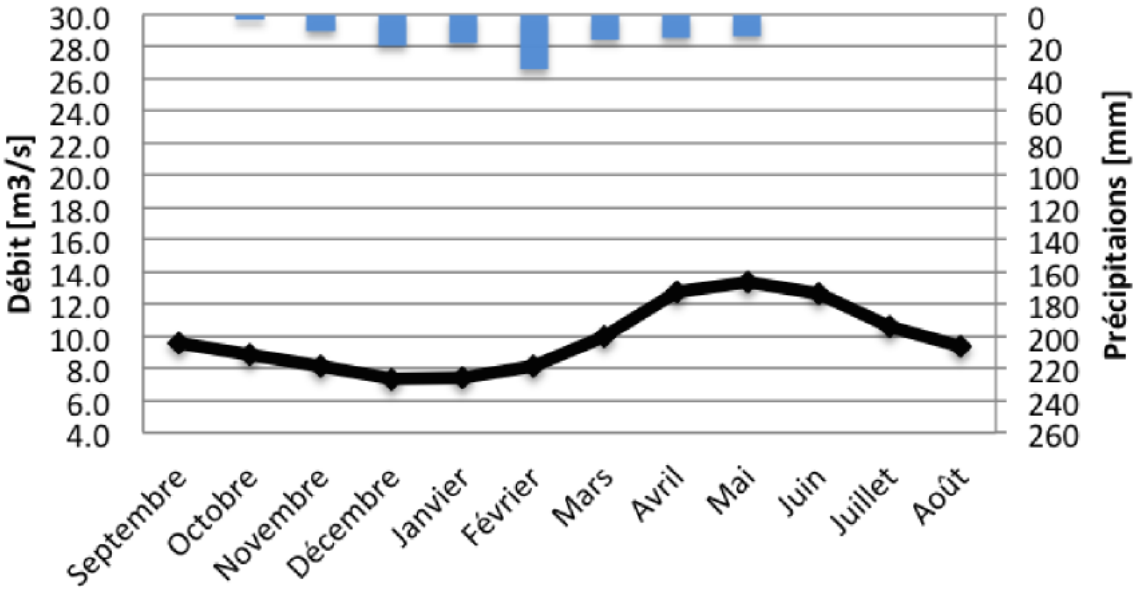
Average recharge
in the Orontes River basin

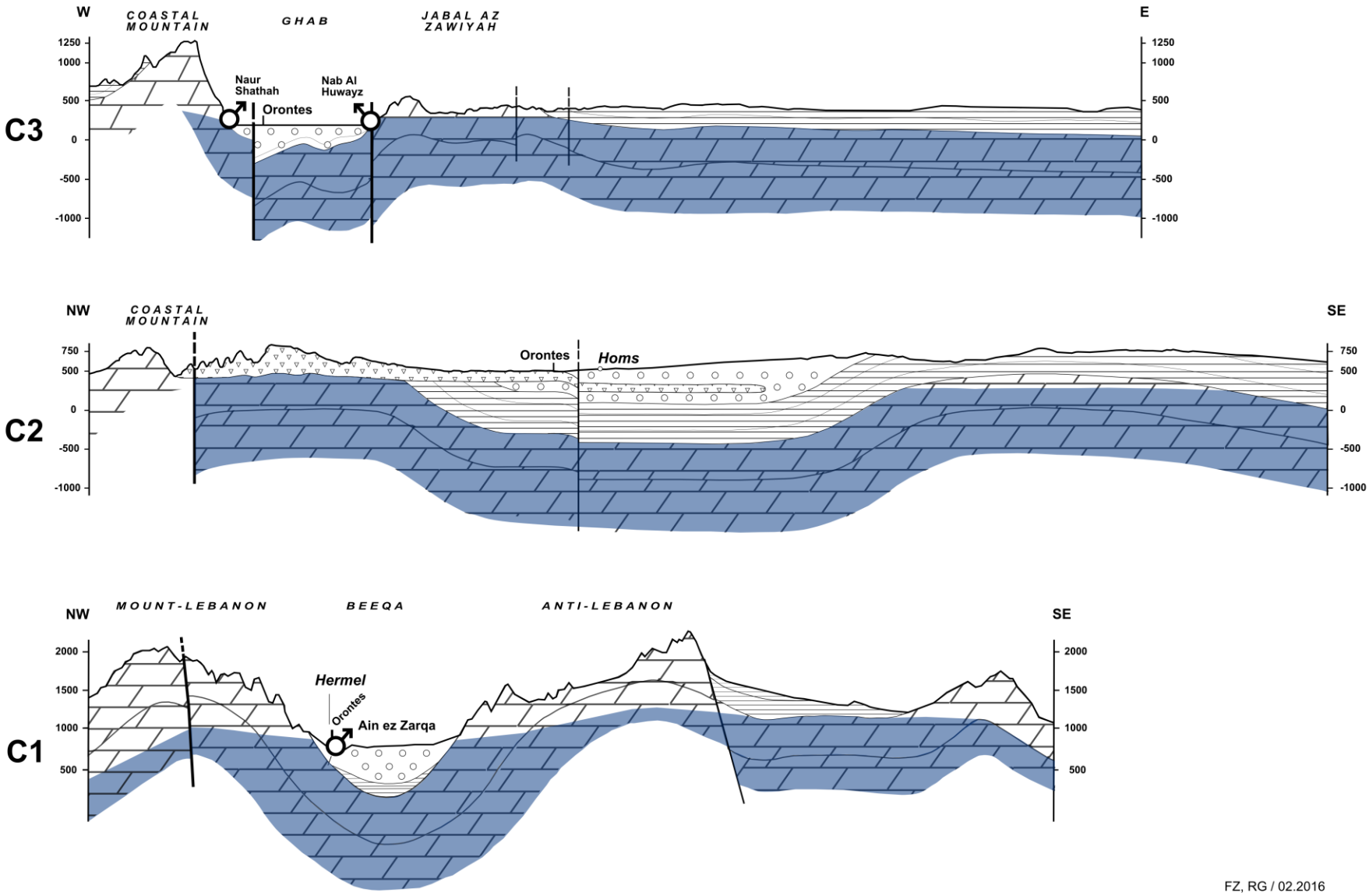


Ayn ez Zarqa spring
(Orontes spring), Lebanon,

…a typical
karstic overflow spring!

Discharge rate Ayn ez Zarqa,
year 1958 -1959, for example





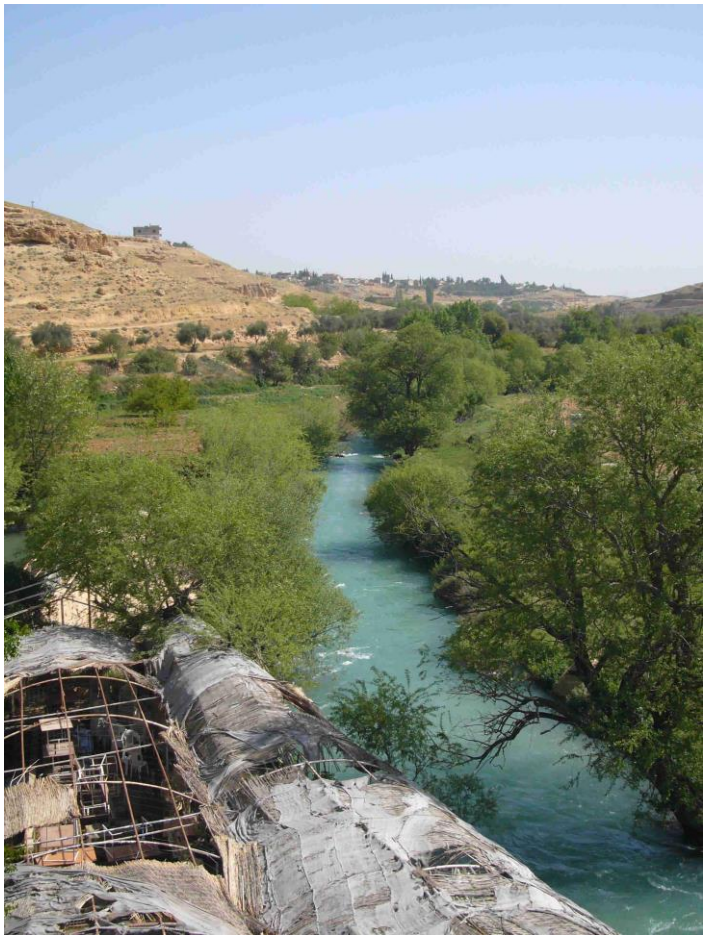
Hydro-geological cross-sections of the Orontes River basin

Pumping test of a new well
in the Salamiah region

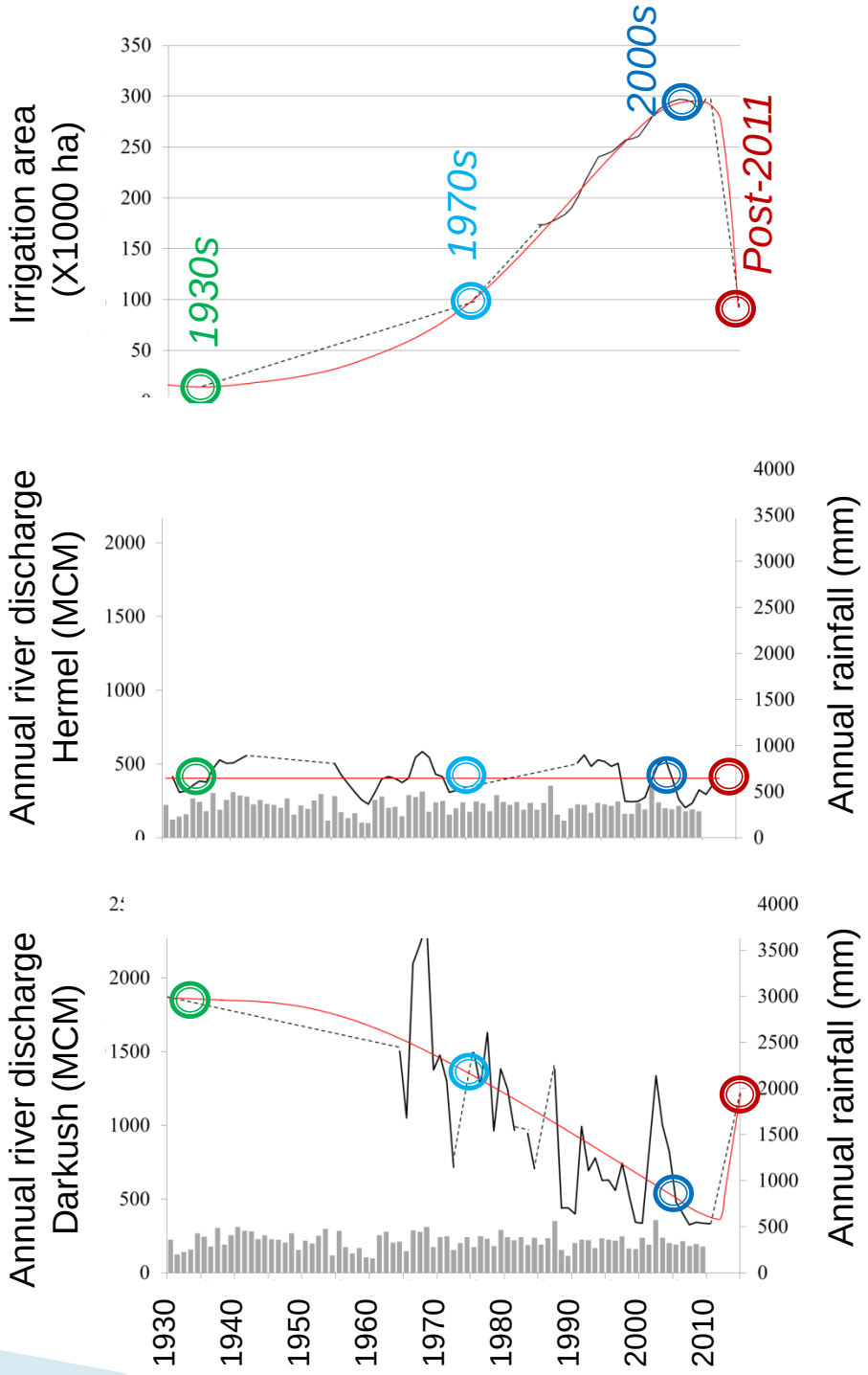
Irrigation Wells & Boreholes (in red)
In the Orontes River basin

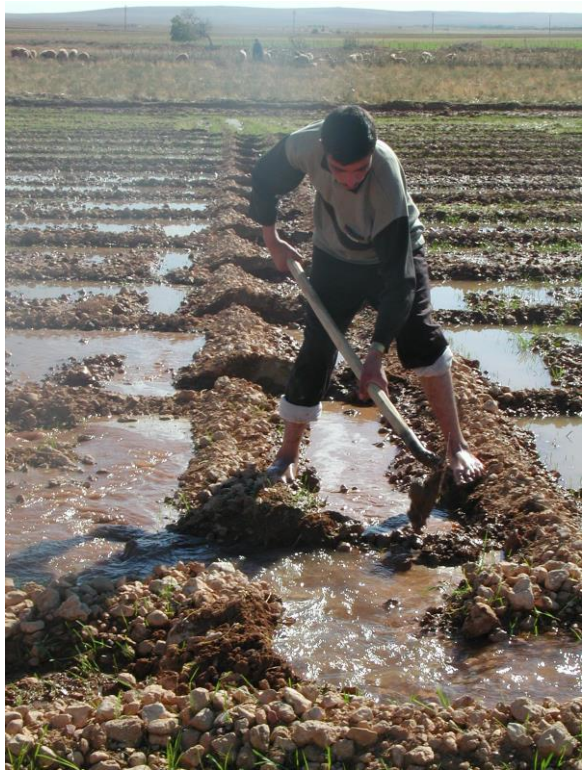
TNO Report, 2008

Changes in irrigated areas And river discharge, 1930 – 2013



Orontes River, Hermel





Main sources or groups of sources	Flow l/s 1960	Flow l/s 1990-2000	Sources	ID
Ayn ez Zarqa	**13 000**	**13 000**	Ayn ez Zarka	1.01
Ayn el Laboue	**1 400**	**700**	Ayn el Laboue	1.02
			Ayn at Tannur	2.01
Ayn at Tannur region	**2 300**	**1 500**	Uyun as Samak	2.02
			Ayn al Damamel	2.03
			Tall al Uyun	2.11
			Ayn Qalat al Madiq	2.12
Al Ghab east region	**13 000**	**virtually zero flow**	Ayn at Taqah, Ash Shariah	2.13
			Nab an Nasiriyah	2.14
			Nab al Huwayz	2.15

Estimated flows of the main springs or group of springs, in the 1960s and in the late 1990s, south and central parts of the basin

What happen regarding the impact of the groundwater (over)exploitation on the discharge rates of the main springs:

After having taken in account:
- the extension of the Jurassic-Cretaceous aquifer all over the upper and middle part of the basin,
- and the impact of the dramatic increase 1990s groundwater exploitation on the different springs…

It became possible to draw empirically different flow paths by taking into account the flow rate of the springs in the 1960s (1930s) and in the 2000s, before and after the (over)exploitation.

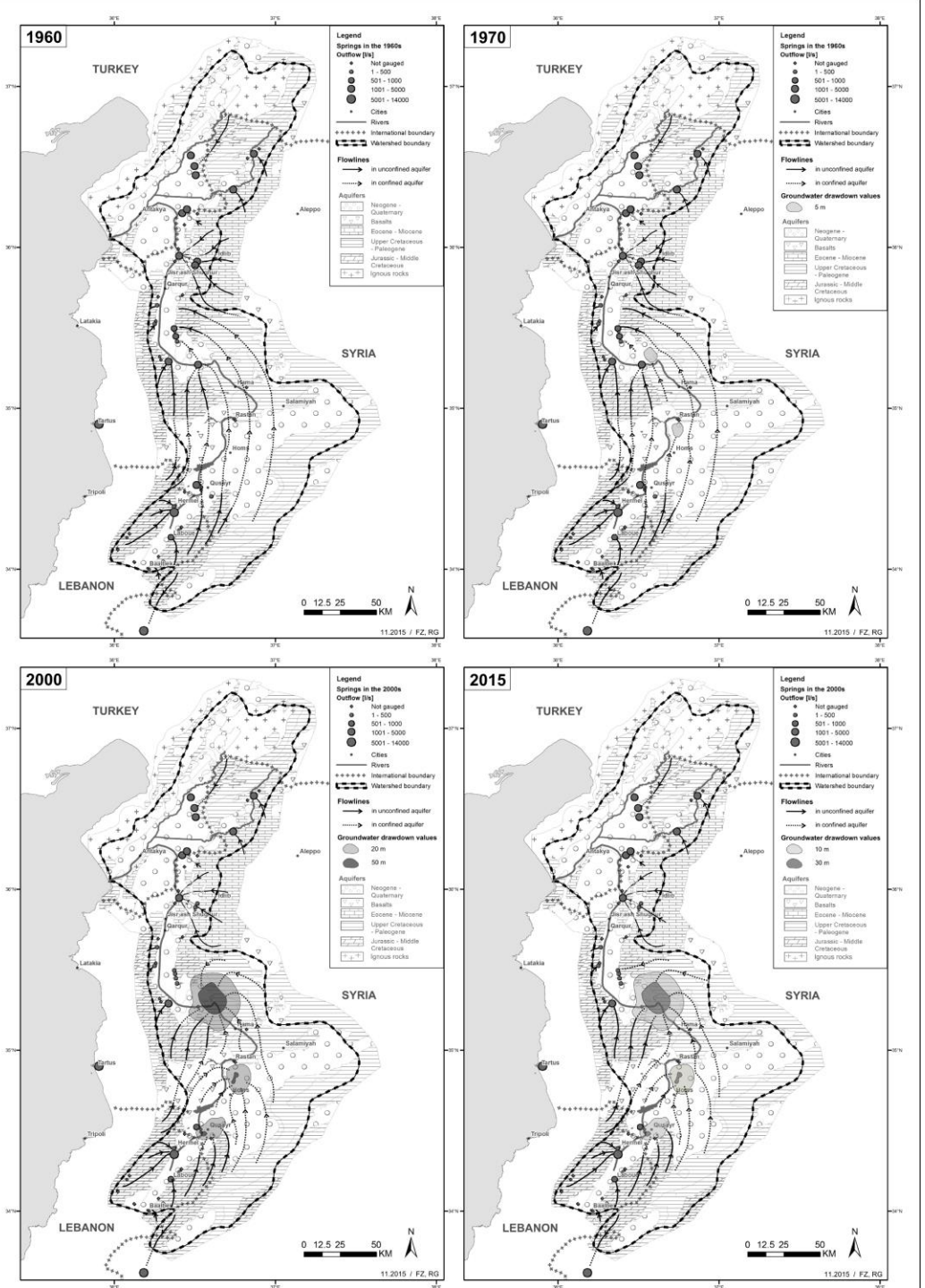
…but that without credible measurement of piezometric levels…

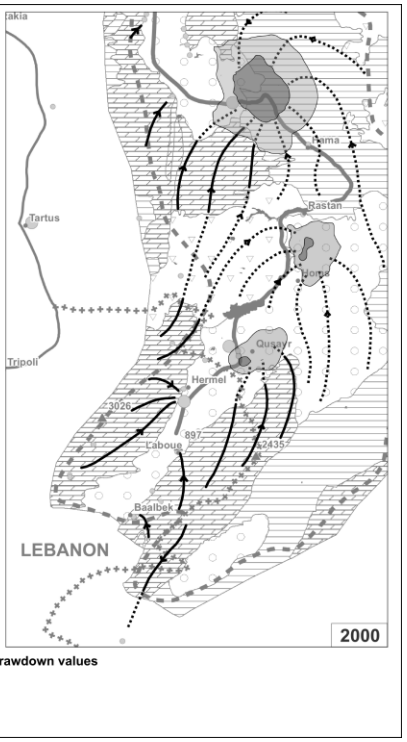
Schematic diagram of the subsurface flow

in the 1960s, 1970s, 2000s and 2015s (right)

	1930s	1970s	2000s	After 2011
IN				
EP_{IN}	2802	2802	2802	2802
D_{IN}	0	0	0	0
F_{IN}	0	0	0	0
IR	5	66	102	46
Total IN	2807	2867	2904	2848
OUT				
D_{OUT}	1850	1250	600	1200
F_{OUT}	50	50	40	55
E	490	131	175	175
C	416	1441	2243	619
Total OUT	2806	2873	3058	2049
ΔS	*0*	*-5*	*-155*	*798*

Water balance, global catchment





Piezometric map of the Jurassic-Cretaceous aquifer, Data from Al-Charideh 2013 paper

2007-2008

How groundwater is taken in account in the Syrian-Lebanon Agreements

- Three agreements have been signed between Lebanon and Syria.
- The agreements defined a fixed amount of 80 million cubic meters allocated to the Lebanon if the river flow exceeds 400 MCM/year at the border
- In fact, in these agreements, the groundwater flow which doesn't supply directly or indirectly the Orontes rivers is attributed to Syria, all over the Lebanese part of the basin
- Moreover, no restriction is mentioned regarding the Syrian exploitation of ground-water in the vicinity of the border even if the hydrogeological situation clearly shows the continuity of the main Jurassic and Cretaceous aquifer between the two countries.
- The last and precise piezometric map, based of Al-Charideh data, show however that the the Syrian exploitation or over exploitation of the groundwater in the region of Qusayr affects already dramatically the

  Lebanon aquifer and that in the future could rapidly increased…

Conclusions

- This paper provides an update of recent issues from the hydrogeology of the Orontes basin
- It shows how over exploitation have dramatically affected the groundwater flow organization
- It mentions how groundwater resources have been taken into account in the Lebanese-Syrian Agreements and how the Syrian over-exploitation affects or could affect in the future the Lebanese aquifers…

…finally, it could provide guidance for recovery planning in the post-conflict transition in Syria, and on the longer term, for the concerted water management in the transboundary Orontes River basin.