Trends in Groundwater Observation Data and Implications

Dr Ahmed Hadidi

Senior Lecturer

German University of Technology in Oman

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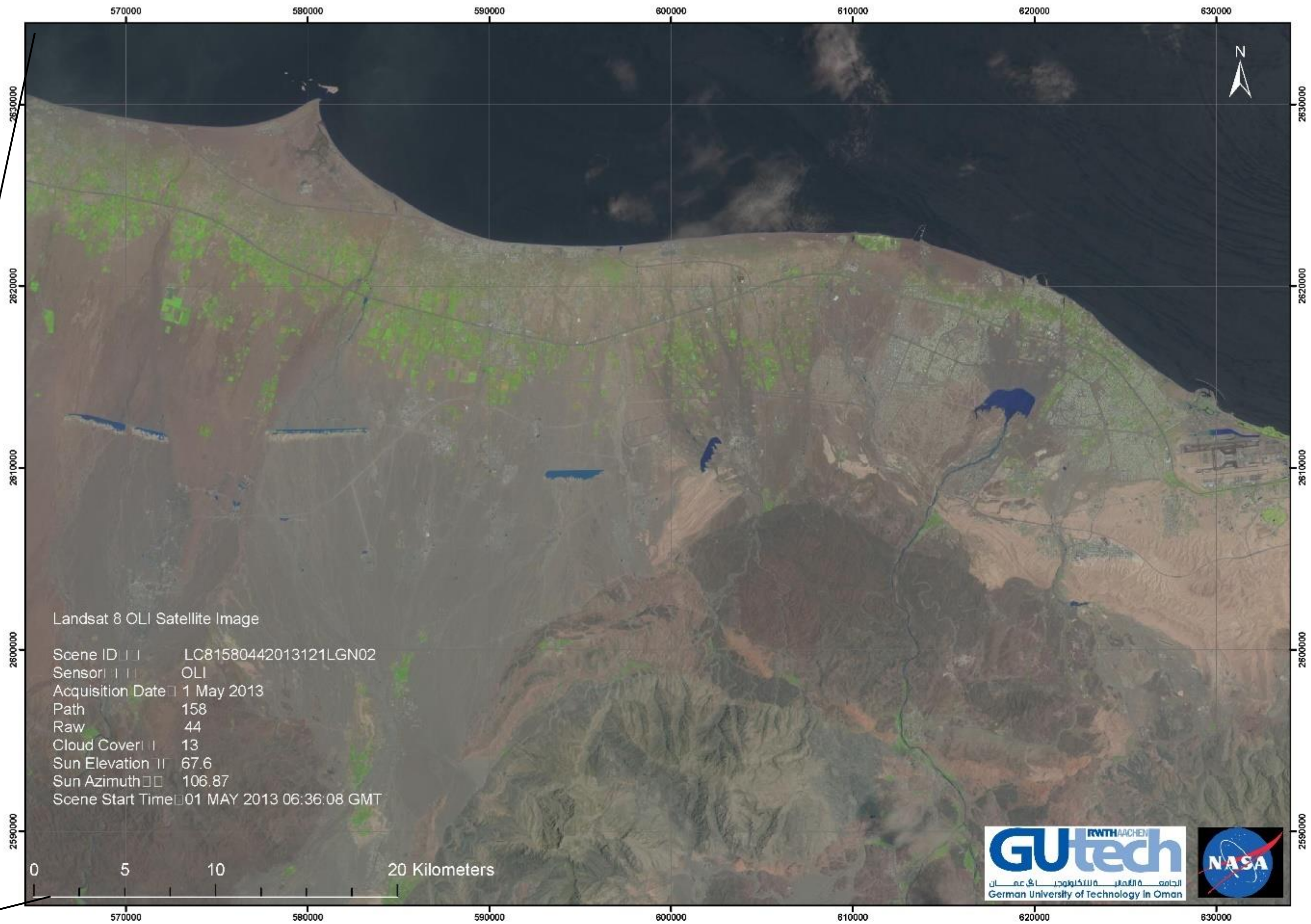
Introduction

- Batinah plain in the North of the Sultanate of Oman is undergoing several severe changes
- These changes includes:
  - Growing population
  - Urbanization
  - Industrial activities
  - Increasing of the cultivated area
- This development stresses the water resources in Batinah plain, mainly alluvial aquifer
- Governmental authorities in Oman constructed 46 recharge dams since 1970

Google maps ™



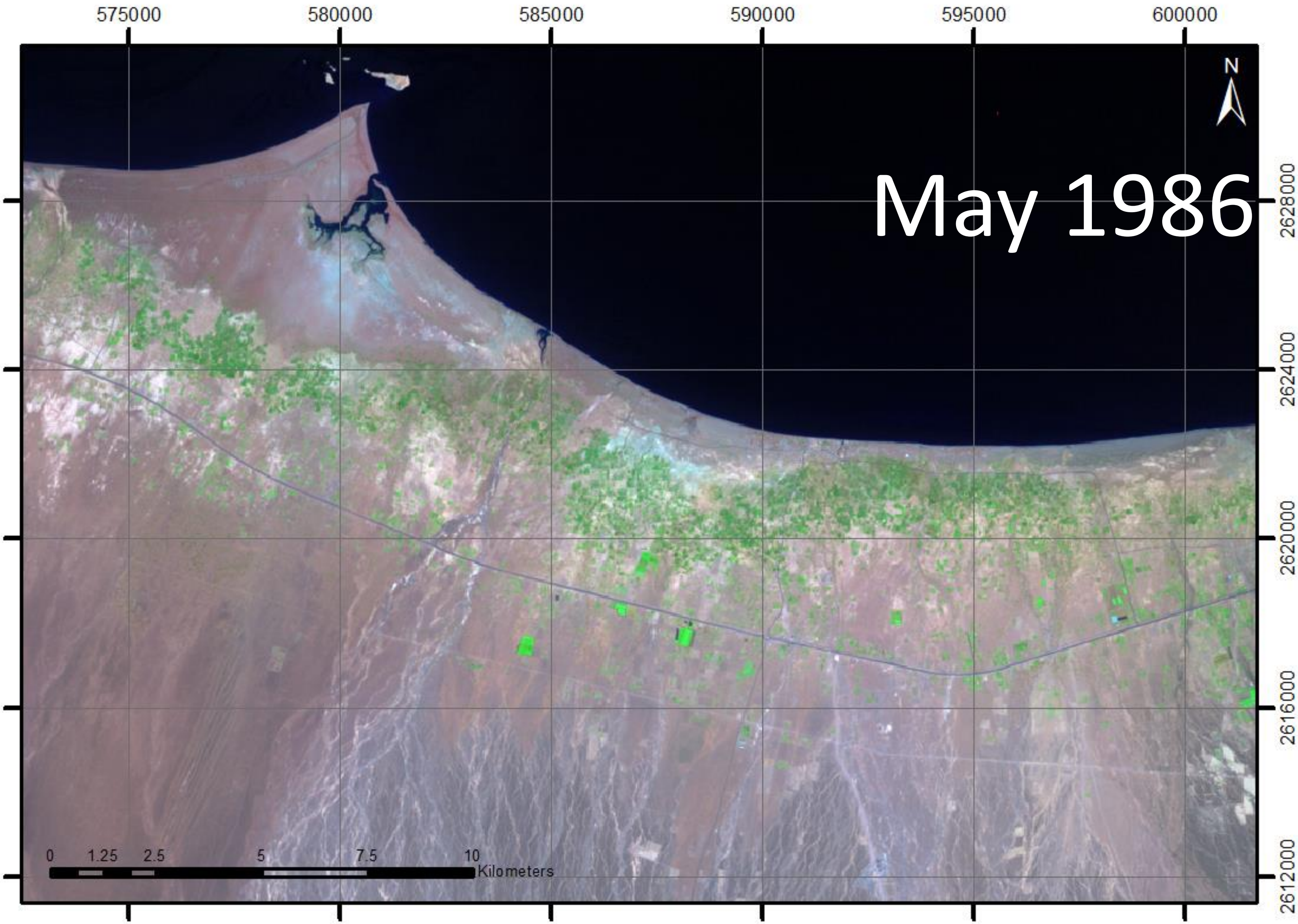
Landsat 8 OLI satellite image acquired 1 May 2013

Geology of Batinah Plain

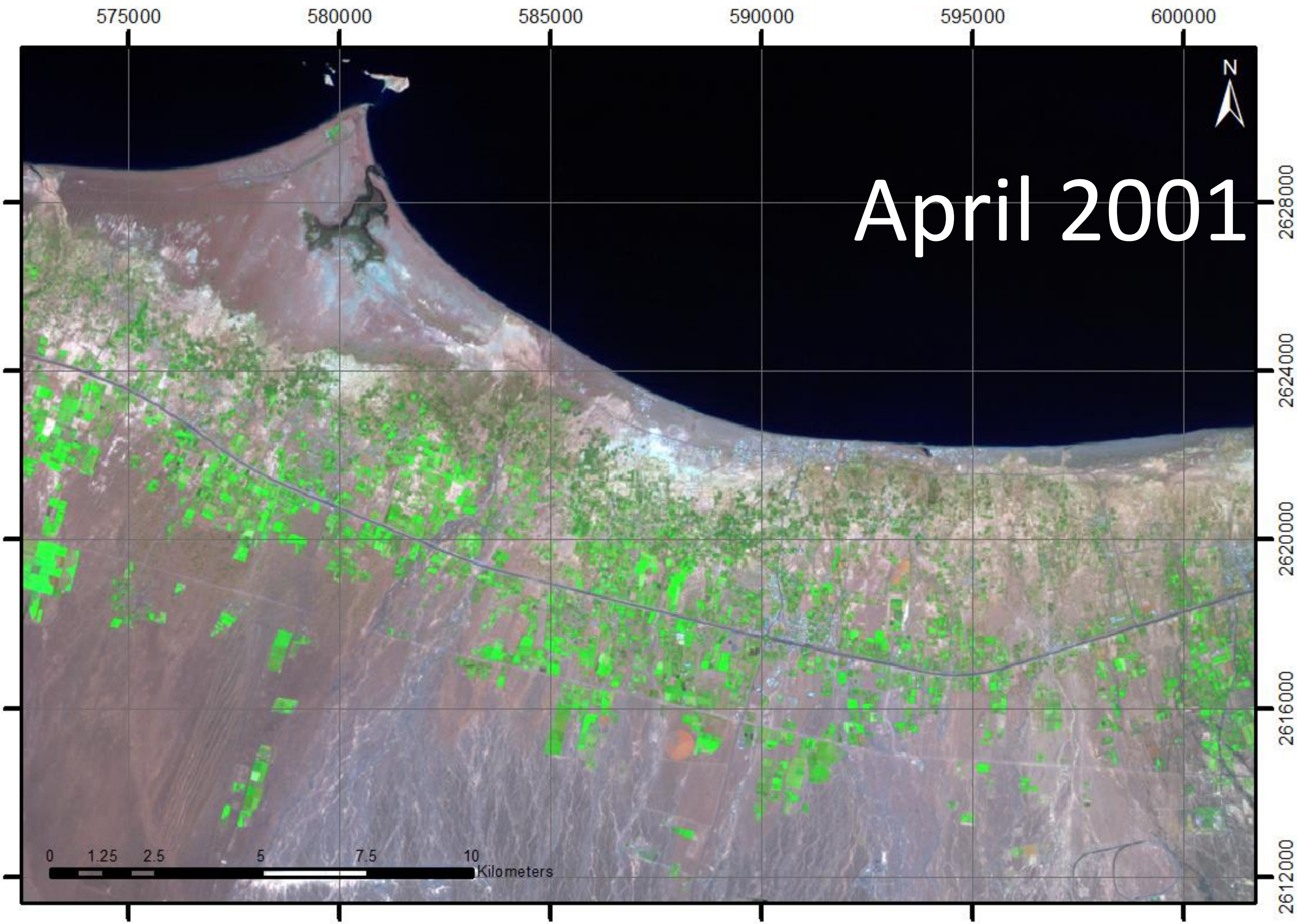
- The Alluvium deposits in Batina plain was originated from the erosion of Hajar mountain in the South
- Two major clastic deposits are distinguished in Batina plain:
  - Ancient alluvium (Tertiary age)
  - sub-Recent/Recent alluvium
- They are unconformably underlined by consolidated bed rock basically composed of Tertiary carbonates and marl
- Dune and sand sheets are the best outcrops supporting direct rainfall infiltration

Hydrogeology of Al Batinah

- The estimated hydraulic conductivity of the ancient alluvium ranges between 0.2 and 5 m/d
- sub-recent and recent alluvium shows values between 5 and 30 m/d
- Annual rainfall at Seeb airport 80 mm/year
- most of the events occur over Northern Oman mountains (330mm/year)
- sea water intrusion affected wide area next to the Batina coast



575000
580000
585000
590000
595000
600000
N
May 1986
2628000
2624000
2620000
2616000
2612000
0 1.25 2.5 5 7.5 10
Kilometers


575000
580000
585000
590000
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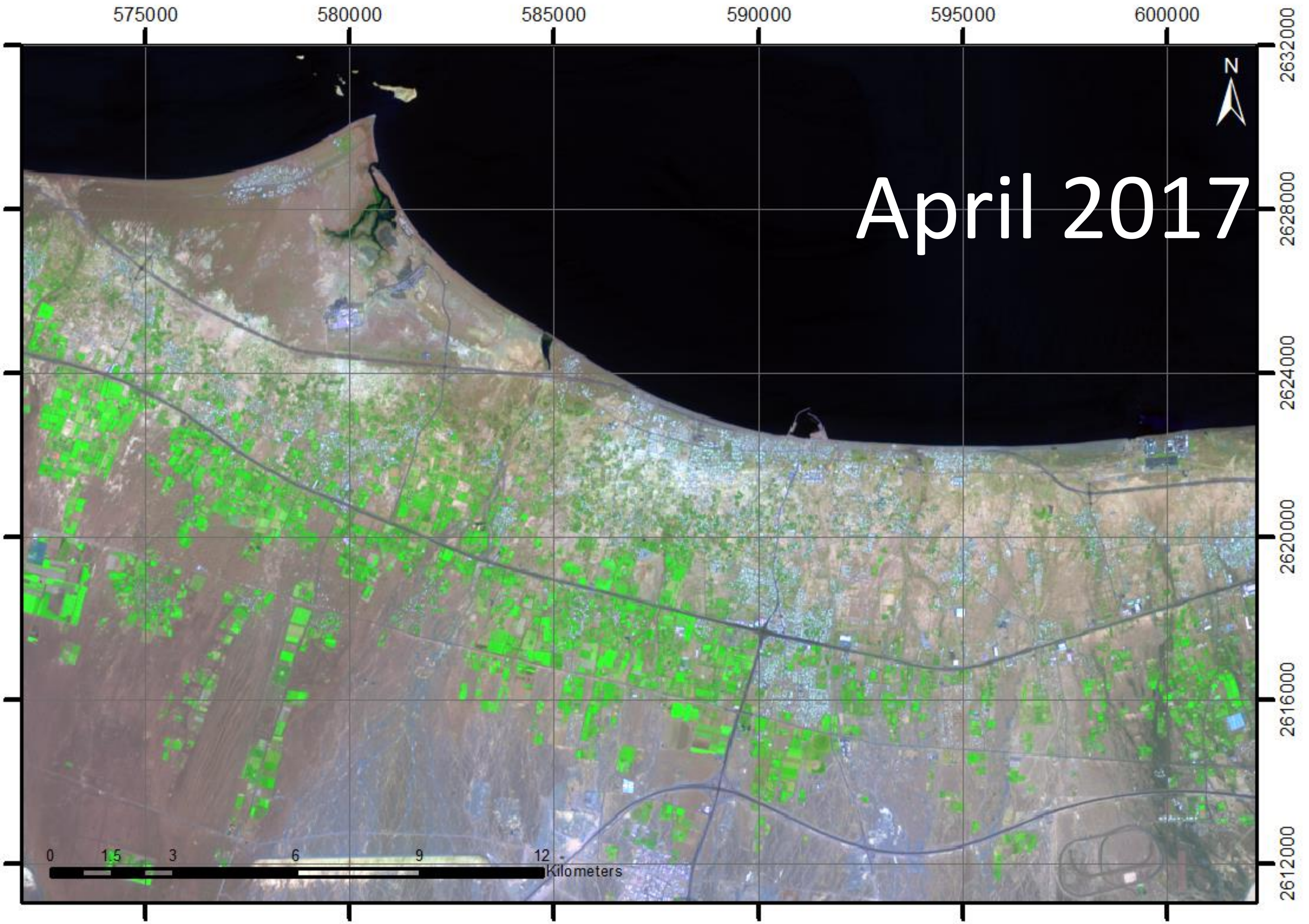
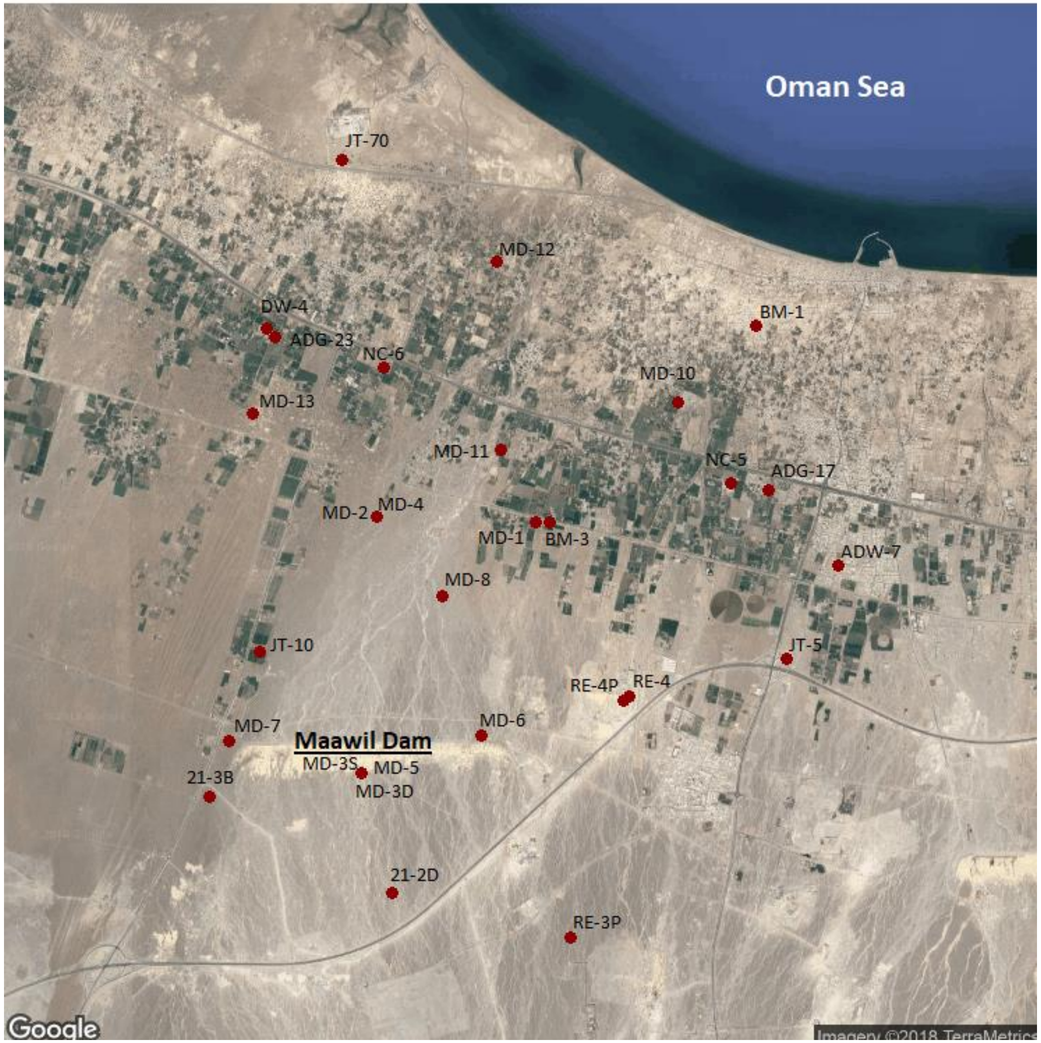
2616000
2612000
N
April 2001
0 1.25 2.5 5 7.5 10
Kilometers


575000
580000
585000
590000
595000
600000
2632000
2628000
2624000
2620000
2616000
2612000
N
April 2017
0 1.5 3 6 9 12
Kilometers

Available data

- data-set consists of water table measurements in 29 water wells, in Maawil catchment, South Batinah
- observations started by 1973 for some wells
- A recharge dam was constructed in Wadi pathway on 1991

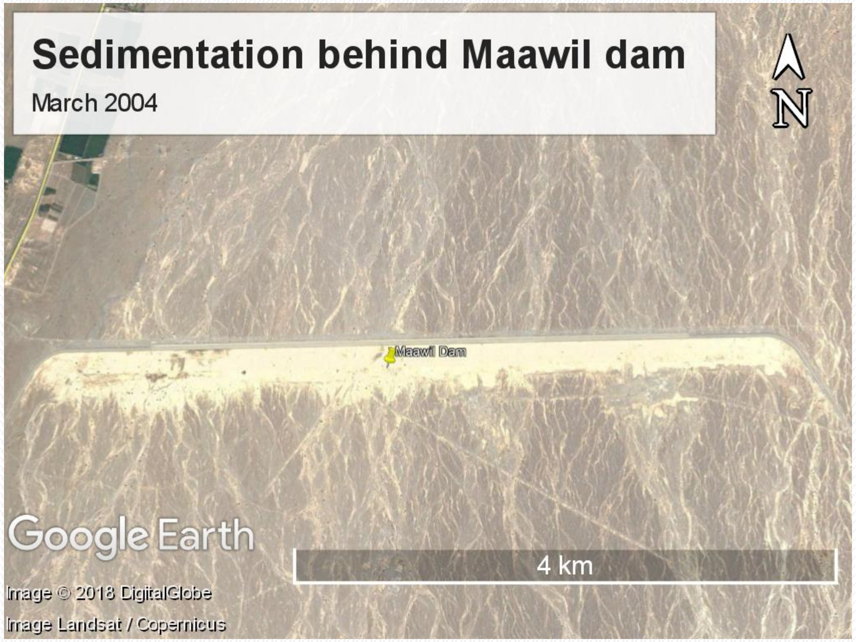


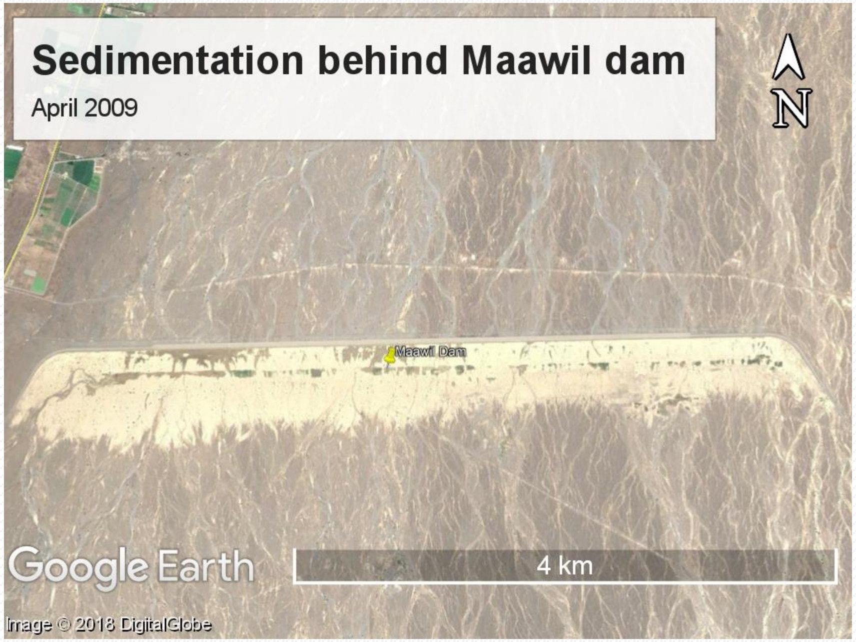
Well	Start observation		Start w.t.[1] (m)	End observation		End w.t.[1] (m)	Date to fall below NN	Number of outliers
	Month	Year		Month	Year			
21-2D	03	1993	78.71	10	2016	82.52	-	24
21-3D	04	1993	59.96	10	2016	66.76	24/09/2005	5
ADG17	07	1973	15.95	02	2018	24.54	14/04/1984	3
ADG23	05	1973	13.21	01	2015	25.98	21/01/1984	4
ADW7	01	1976	26.33	03	2018	34.14	04/10/1986	2
BM1	01	1984	4.64	02	2018	9.47	b.o.*	13
BM3	04	1984	22.56	03	2018	33.93	07/06/1992	5
DW4	12	1975	12.63	02	2018	25.36	29/06/1987	2
JT5	06	1973	51.05	03	2018	59.88	07/06/1992	9
JT10	04	1973	42.14	03	2018	54.71	16/09/2002	10
JT70	02	1974	2.66	08	2013	9.66	19/06/1982	33
MD1	02	1989	23.88	03	2018	33.80	b.o.*	0
MD2	02	1989	28.28	03	2018	39.23	24/10/1992	3
MD3D	02	1989	59.36	01	2018	68.56	25/02/2001	6
MD3S	02	1989	59.29	01	2018	68.60	25/02/2001	11
MD4	02	1989	28.27	03	2018	39.24	15/11/1992	3
MD5	02	1989	59.09	01	2018	68.39	31/03/2001	9
MD6	04	1991	53.24	01	2018	62.66	28/02/1994	3
MD7	10	1991	53.84	01	2018	64.20	29/10/2001	2
MD8	12	1991	33.44	03	2018	42.88	17/01/1993	7
MD10	01	1996	15.55	02	2018	19.36	b.o.*	0
MD11	12	1993	19.39	02	2018	27.41	b.o.*	3
MD12	04	1996	12.01	02	2018	17.18	b.o.*	0
MD13	04	1996	25.37	03	2018	34.32	10/1999**	5
NC5	06	1984	15.73	02	2018	23.11	23/04/1986	3
NC6	06	1984	15.18	02	2018	27.20	04/09/1988	5
RE3P	10	1989	87.43	01	2018	95.52	28/10/2002	2
RE4	06	1985	44.40	03	2018	53.53	12/07/1993	7
RE4P	10	1989	45.88	03	2018	53.76	13/06/1993	13

Available data

(Ministry of Regional Municipalities and Water Resources)

Maawil dam


Sedimentation behind Maawil dam
March 2004
N
Maawil Dam
Google Earth
4 km
Image © 2018 DigitalGlobe
Image Landsat / Copernicus


Sedimentation behind Maawil dam
April 2009
N
Maawil Dam
Google Earth
4 km
Image © 2018 DigitalGlobe

Time series analysis

Statistics Package R

Seasonal decomposition (local polynomial regression fitting)

$$Y(t) = S(t) + T(t) + E(t)$$

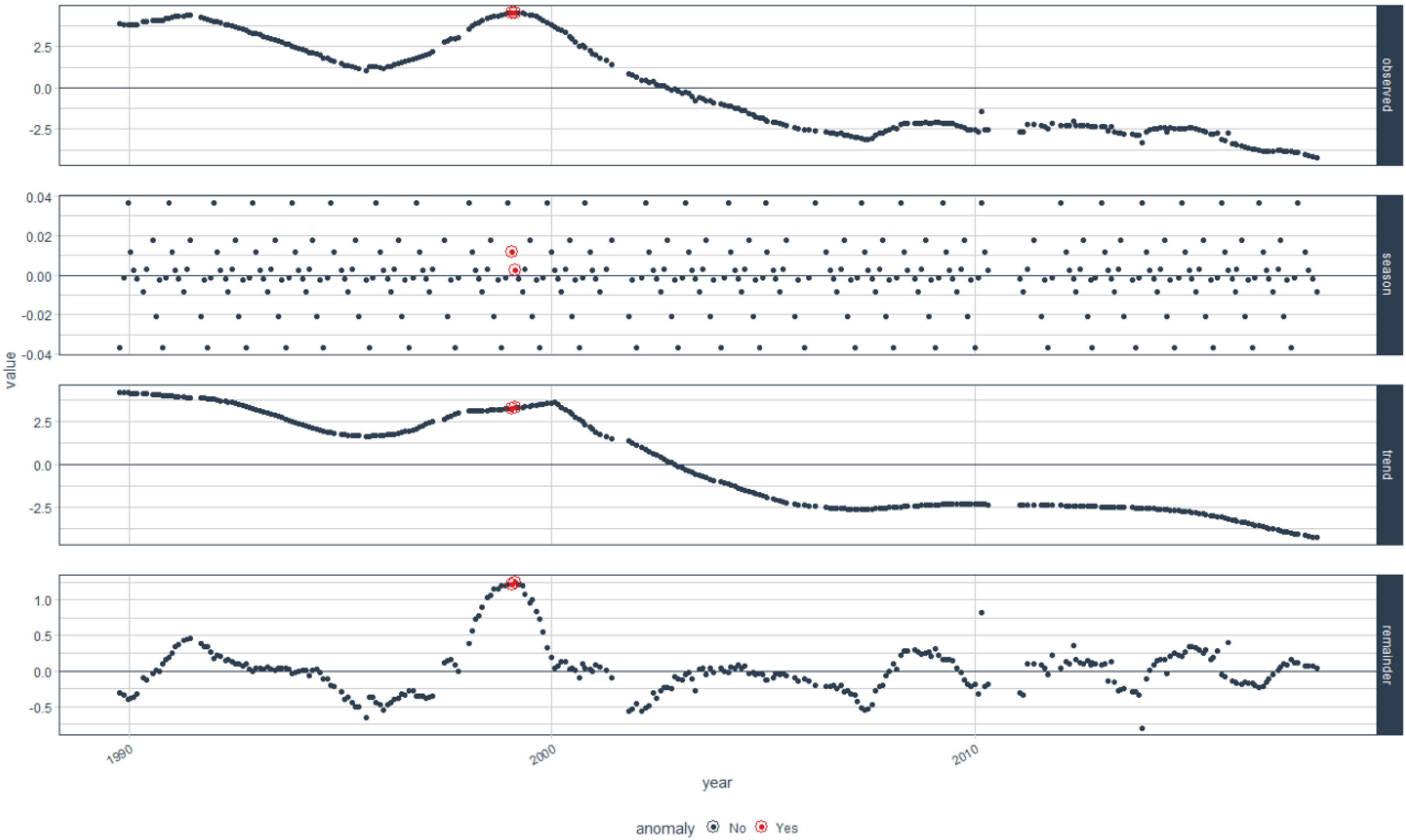
- Observed $Y(t)$
- Seasonality $S(t)$
- Trend $T(t)$
- Remainder $E(t)$
- Outlier (anomaly) detection by IQR* method

*Inner Quartile Range

Results

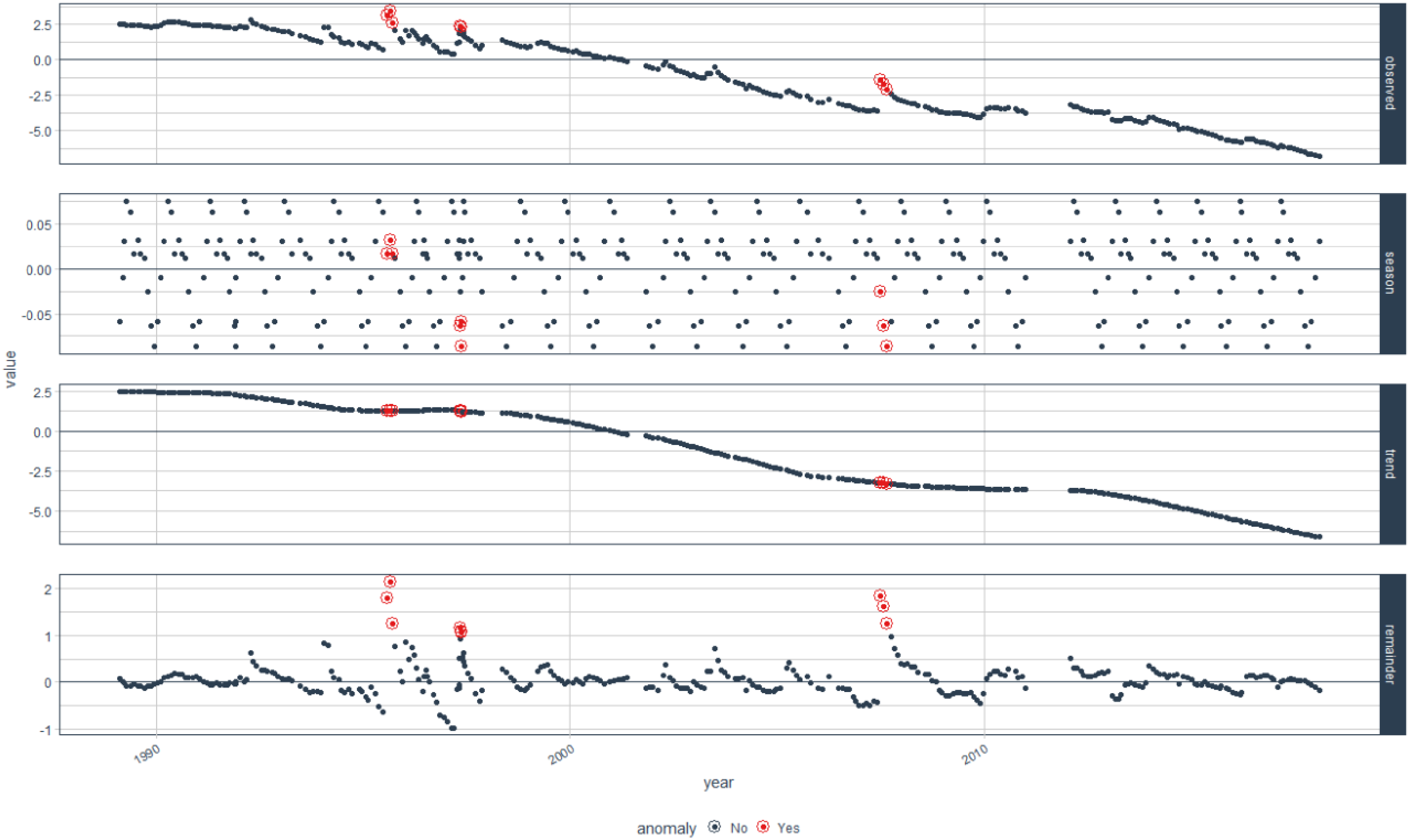
- Different groundwater trends identified in the observed wells
- These trends are classified into 6 different groups

Group 1



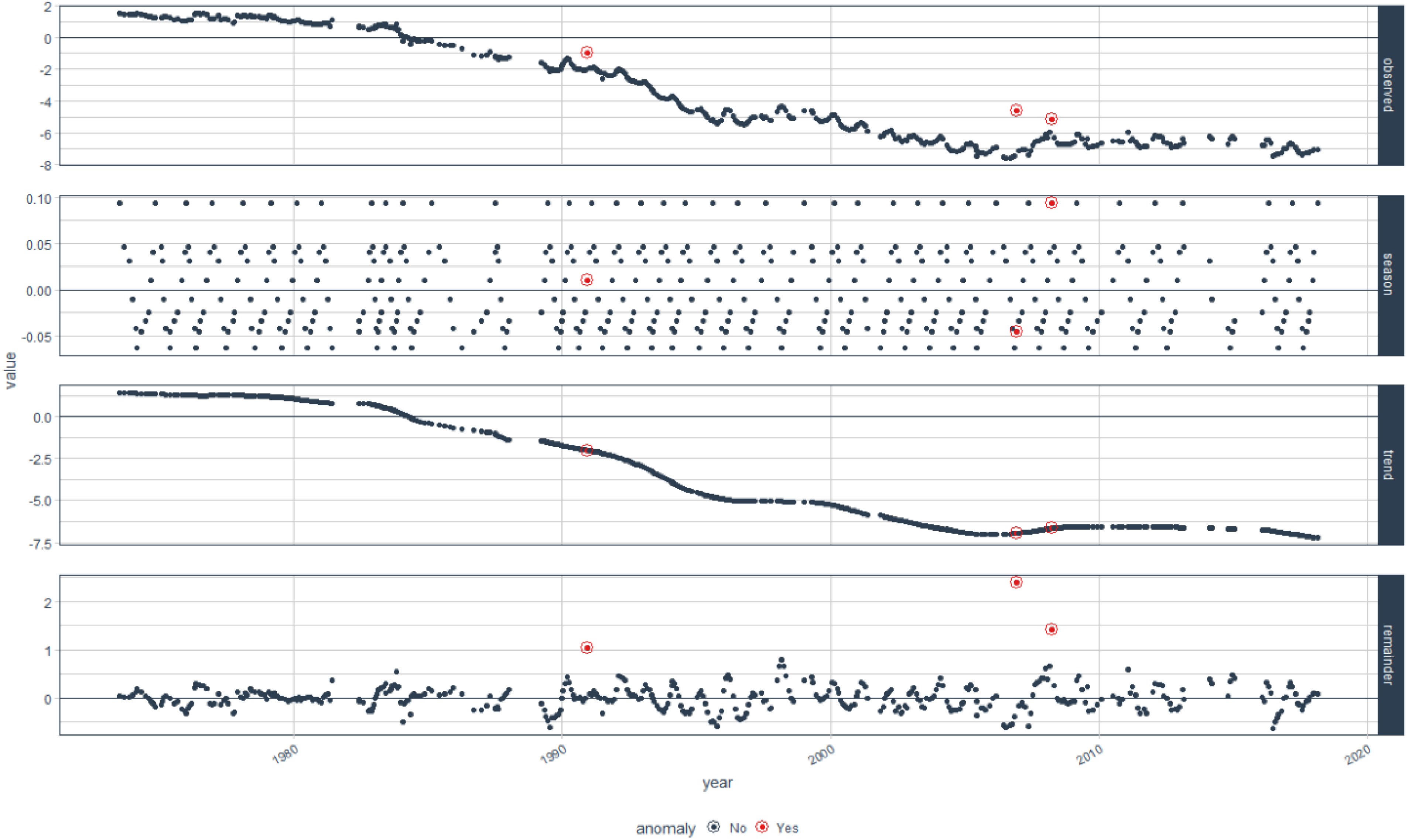
observed
season
trend
remainder
value
year
1990
2000
2010
anomaly
No
Yes

Group 2

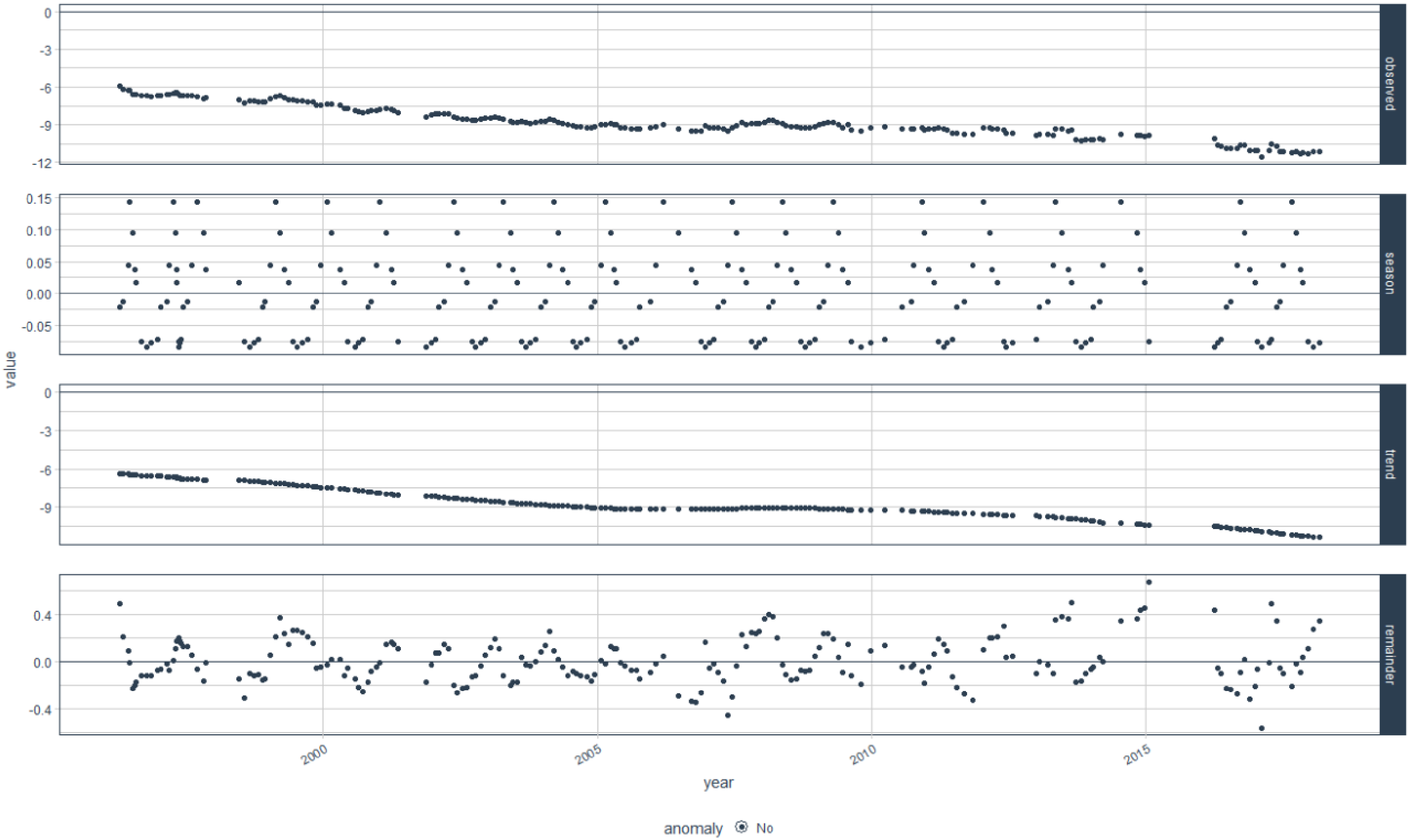


2.5
0.0
-2.5
-5.0
observed
0.05
0.00
-0.05
season
value
2.5
0.0
-2.5
-5.0
trend
2
1
0
-1
remainder
1990
2000
2010
year
anomaly
No
Yes

Group 3

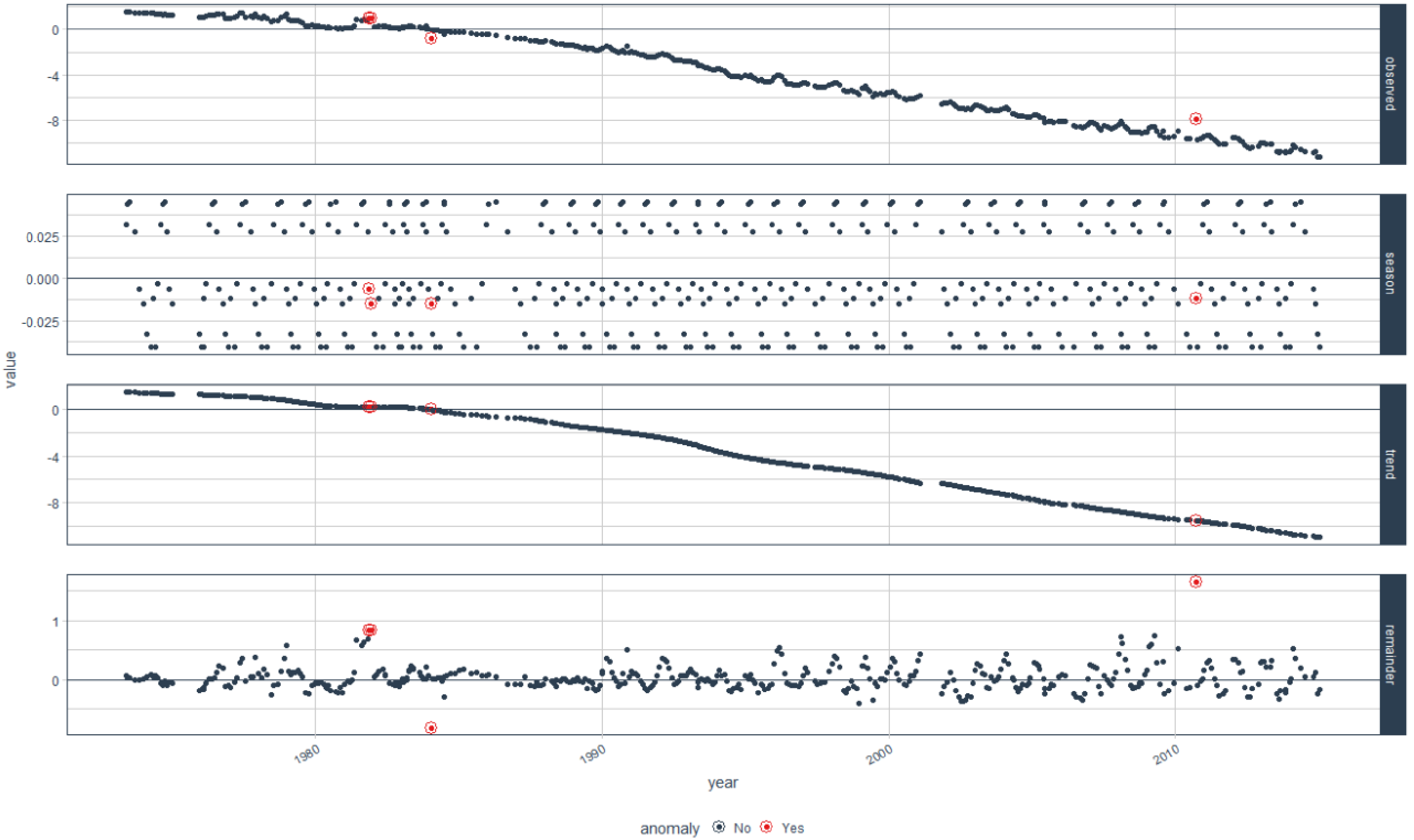

observed
season
trend
remainder
value
year
1980
1990
2000
2010
2020
2
0
-2
-4
-6
-8
0.10
0.05
0.00
-0.05
0.0
-2.5
-5.0
-7.5
1
anomaly
No
Yes

Group 4



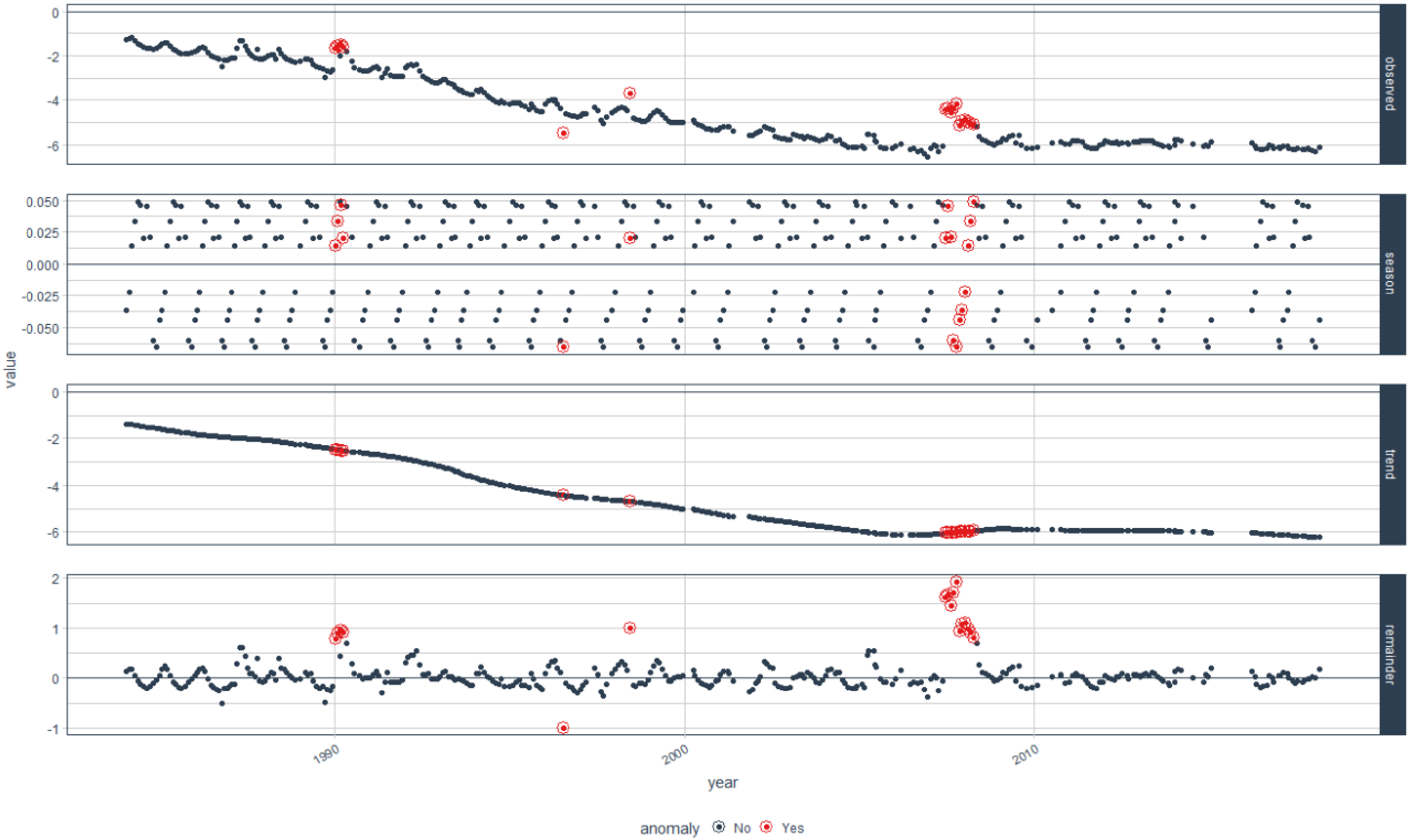
value
observed
season
trend
remainder
0
-3
-6
-9
-12
0.15
0.10
0.05
0.00
-0.05
0.4
0.0
-0.4
2000
2005
2010
2015
year
anomaly
No

Group 5

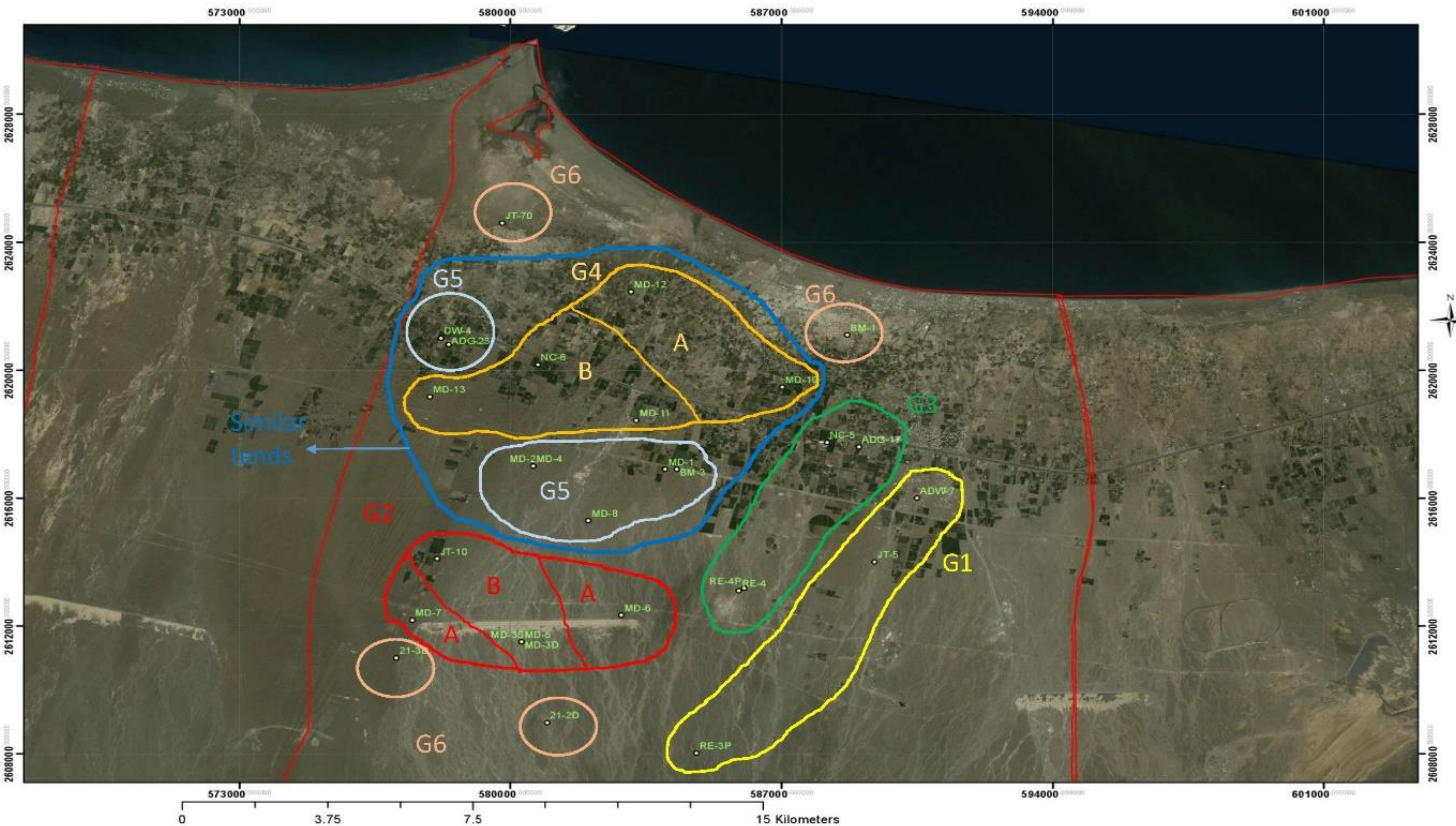


observed
season
trend
remainder
value
0
-4
-8
0.025
0.000
-0.025
1
1980
1990
2000
2010
year
anomaly
No
Yes

Group 6


observed
season
trend
remainder
value
year
1990
2000
2010
anomaly No Yes

Groups spatial distribution



Conclusion

- This work shows the possibility of making successful water-table-changes trend analysis of alluvial aquifer in arid region using statistical analysis
- Recharge dams with design used in Oman are effective on alluvial fans and it increase storage in the shallow aquifer
- Integral management of recharge dam is necessary to improve its efficiency - this includes fine sediments removal
- Local rainfall affects the aquifers where the outcrop is mostly sand dunes and sand sheets, i.e. homogenous clastics

Credits and Acknowledgements

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