Climate-Dust interaction in the Middle East

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Presented for

"MIDDLE EAST (REGIONAL) DUST SOURCES AND THEIR IMPACTS"

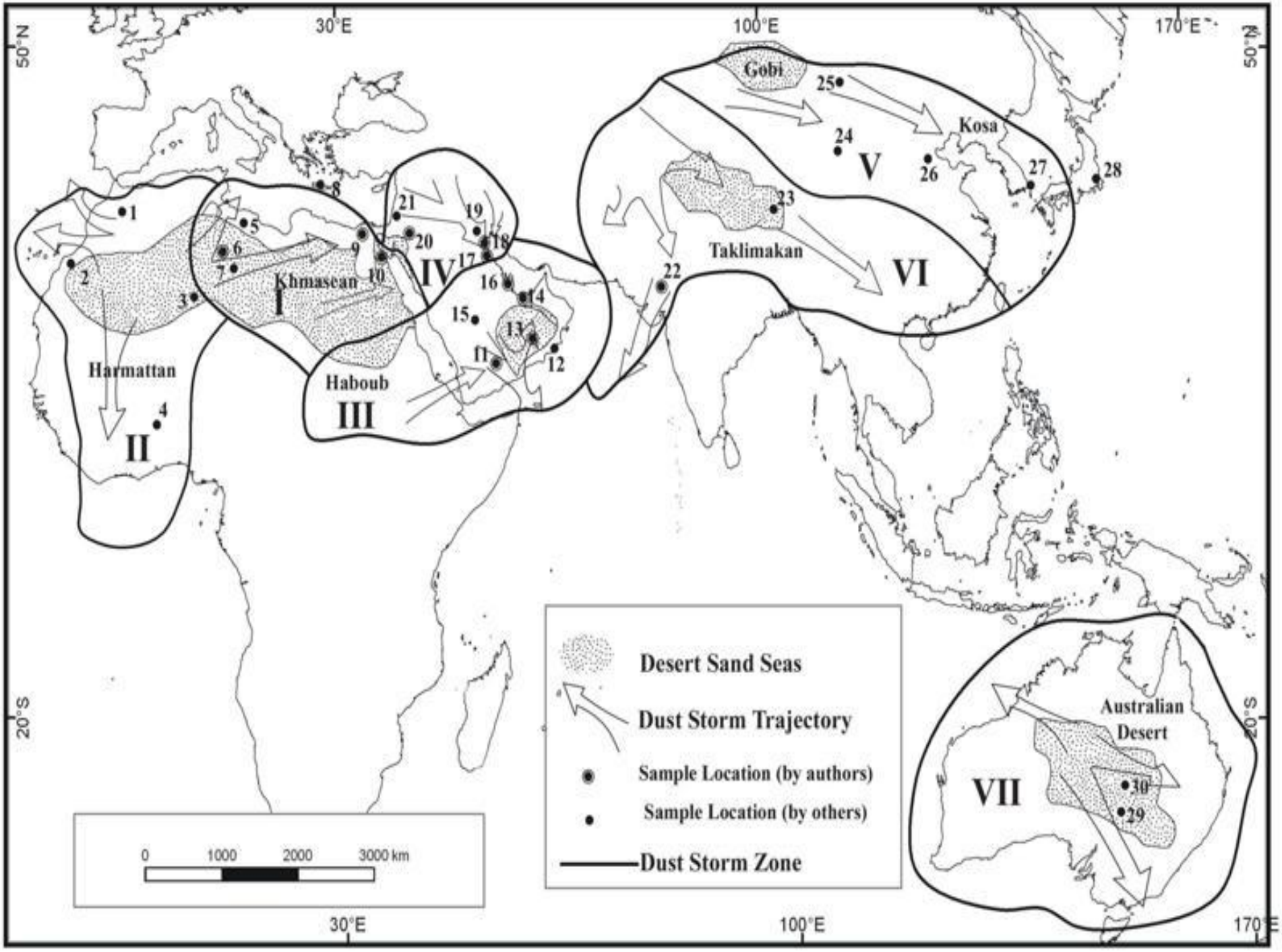
Istanbul, TURKEY

23-25 October 2017

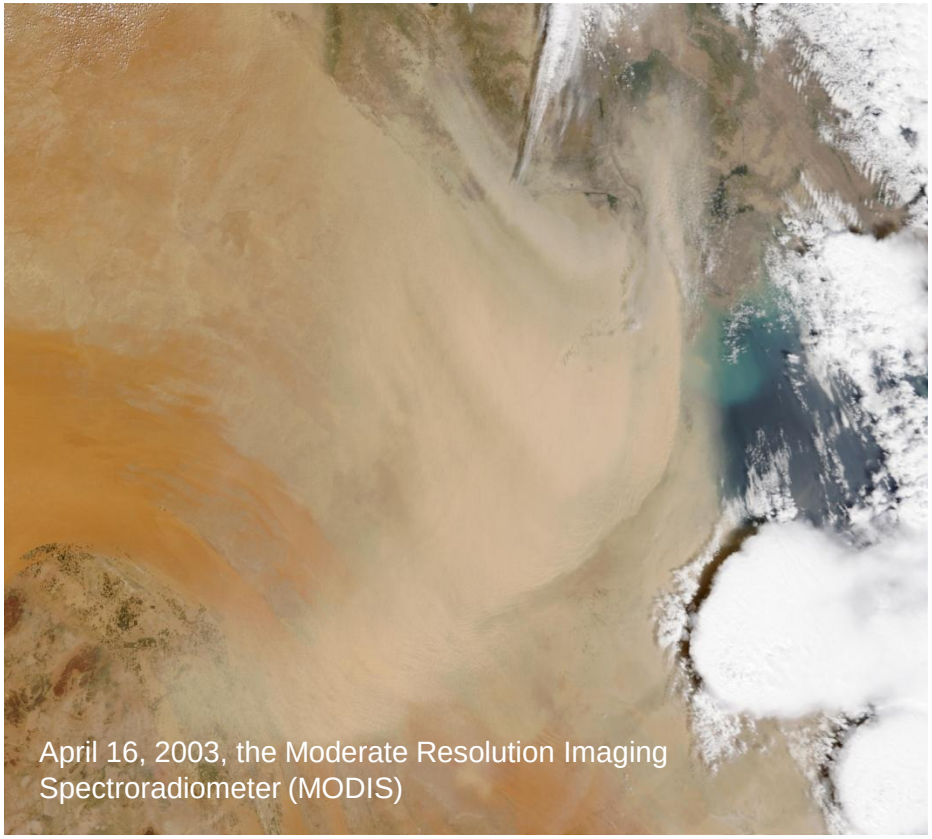
Dust (SDS) is so costly (Kuwait)

- Cost the airport aviation 10,690,800 USD/Year.
- Port (delay for ship and tankers)= 256,700 USD.
- Power plants = 1,087,200 USD.
- Oil Industry plants = 19,192,755 USD.
- Total available cost = 31,414,695 USD/Year.

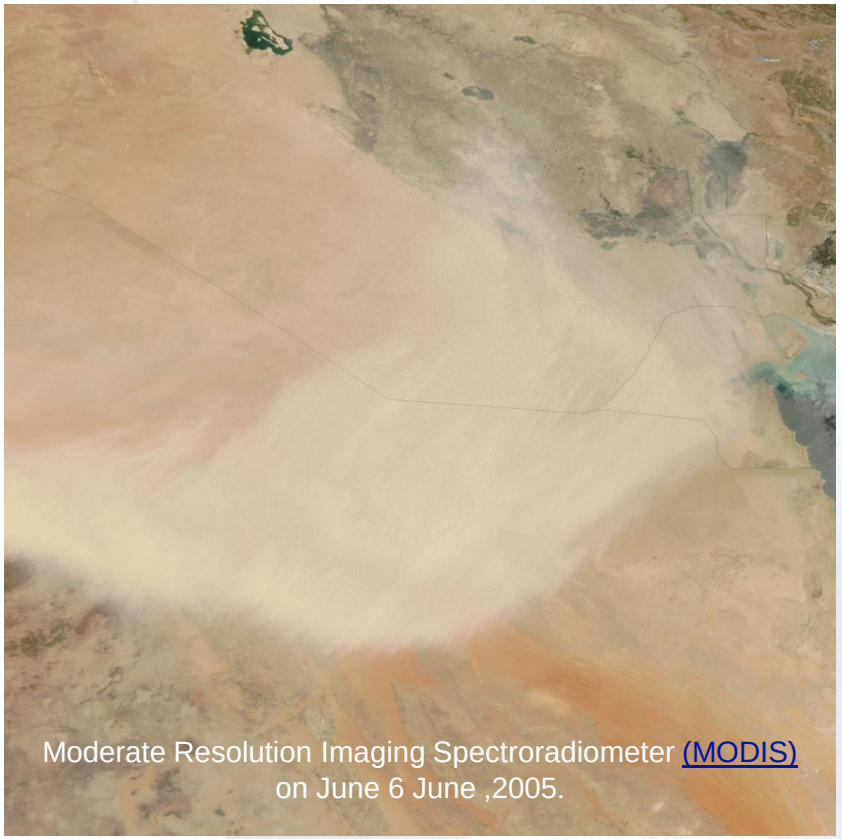
Not including health, agriculture and animal production aspects.


50°N
30°E
100°E
170°E
20°S
Gobi
Kosa
Taklimakan
Khmasean
Harmattan
Haboub
Australian Desert
I
II
III
IV
V
VI
VII
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
Desert Sand Seas
Dust Storm Trajectory
Sample Location (by authors)
Sample Location (by others)
Dust Storm Zone
0
1000
2000
3000 km

Regional Sources of dust



April 16, 2003, the Moderate Resolution Imaging Spectroradiometer (MODIS)



Moderate Resolution Imaging Spectroradiometer (MODIS) on June 6 June ,2005.

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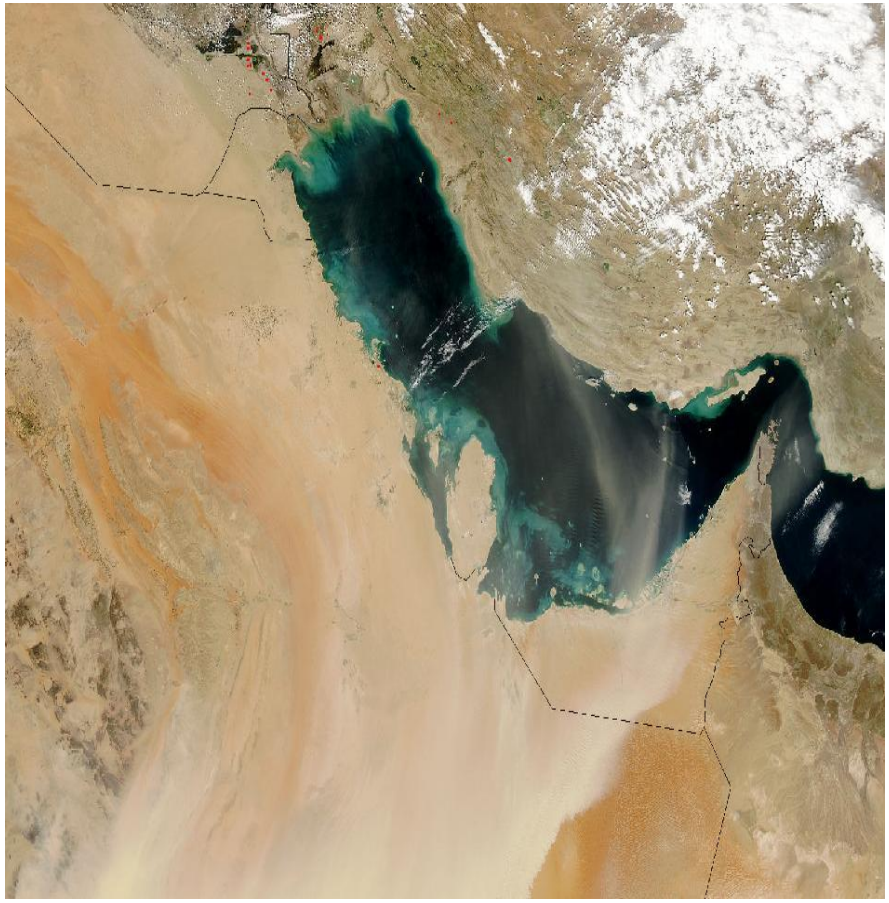
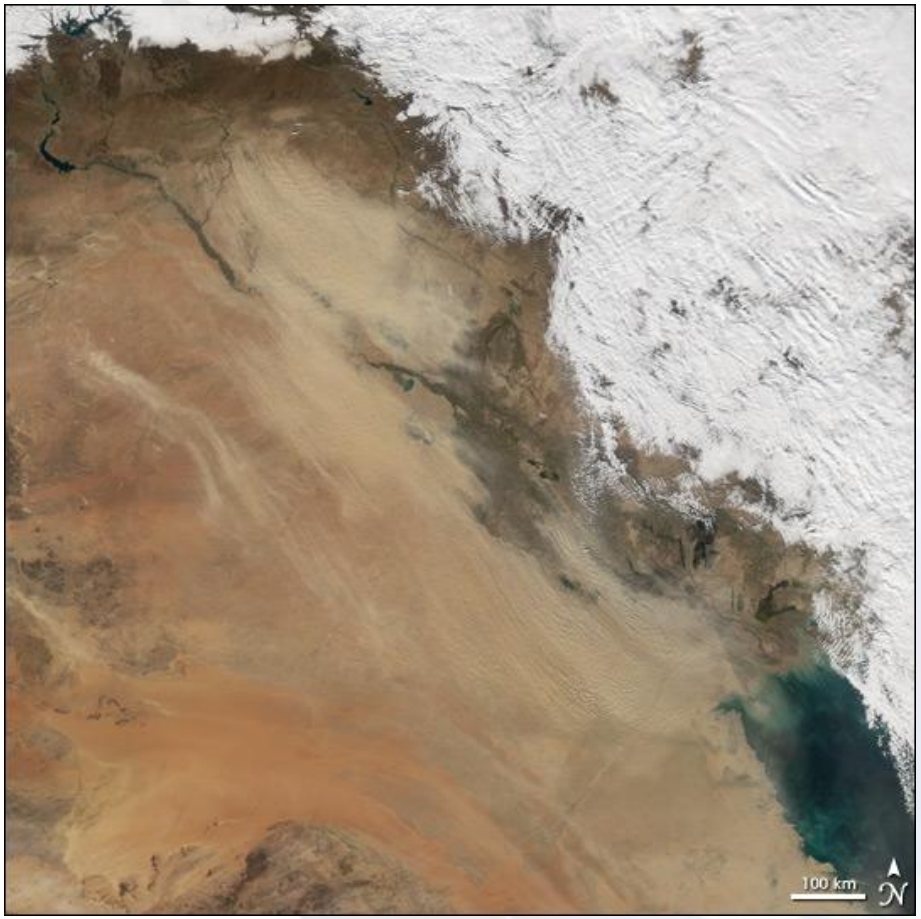
Dust storm Images

NASA captures Aqua satellite, the image a massive dust storm in Saudi Arabia on March 26th2011 .

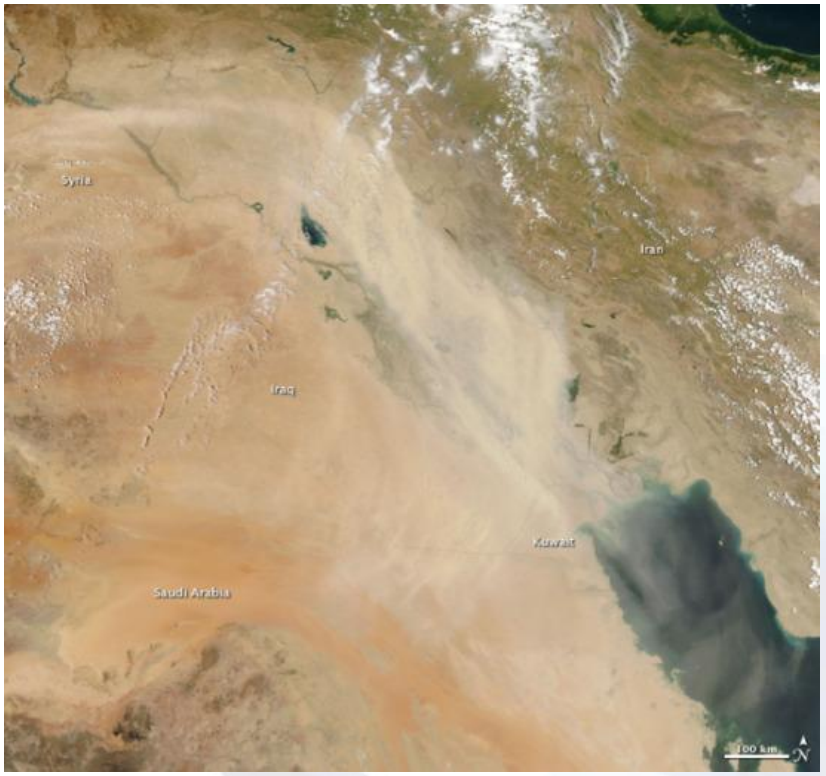


The Moderate Resolution Imaging Spectroradiometer (MODIS) flying onboard the Aqua satellite 21 Jan 2006



August 15, 2009. Moderate Resolution Imaging Spectroradiometer (MODIS) detected fires

7 June 2010 -Aqua satellite.



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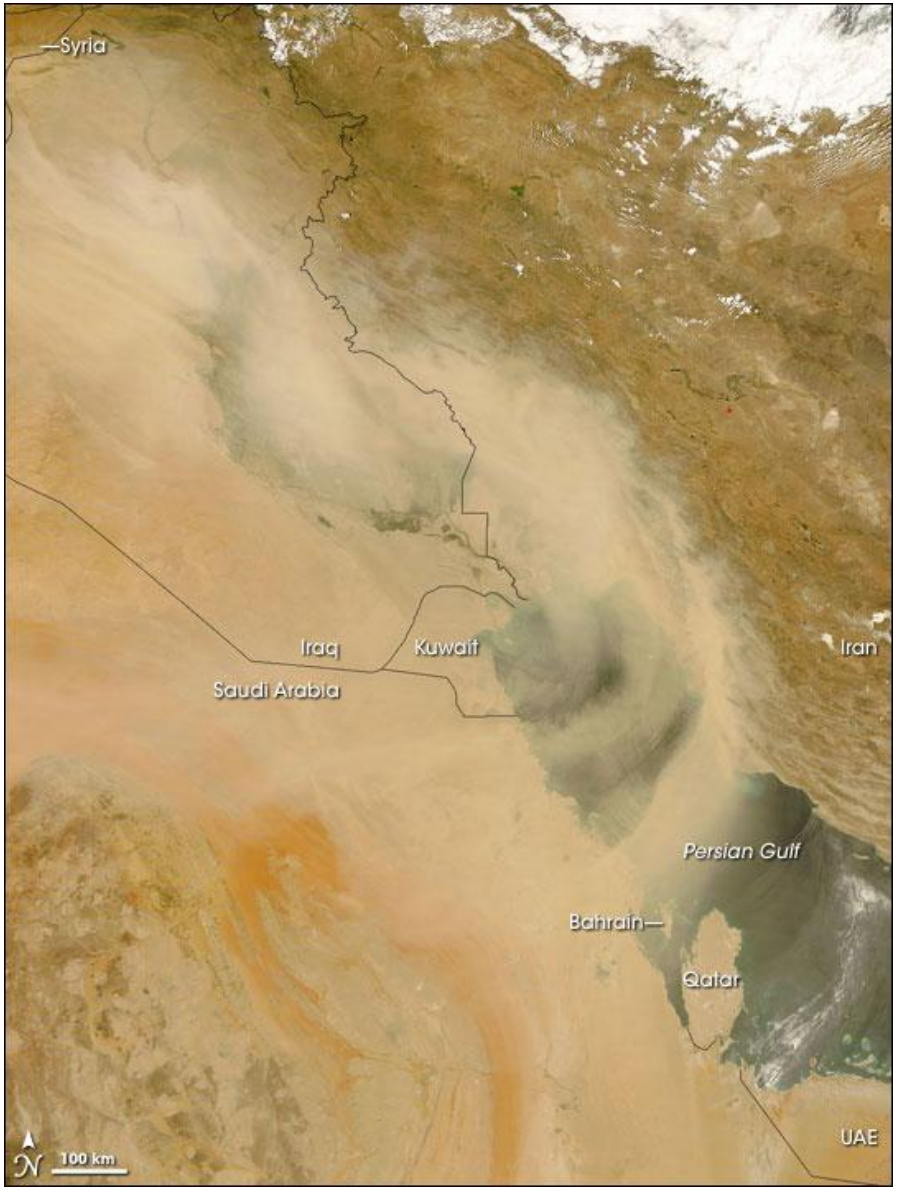

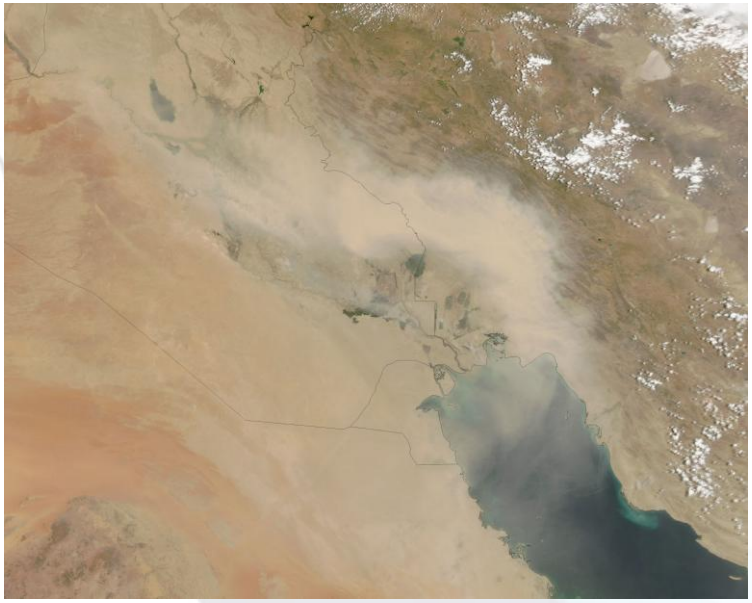

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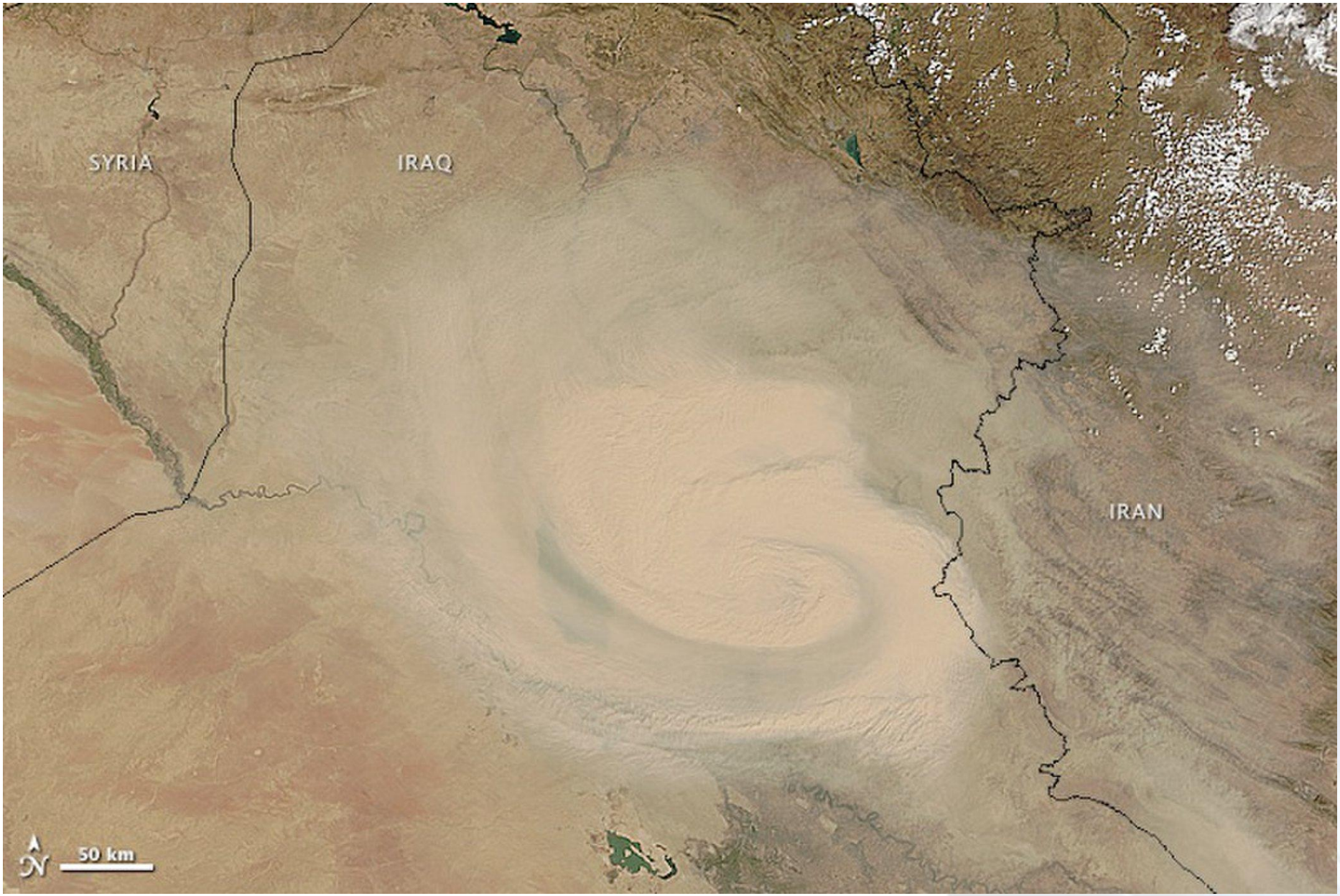
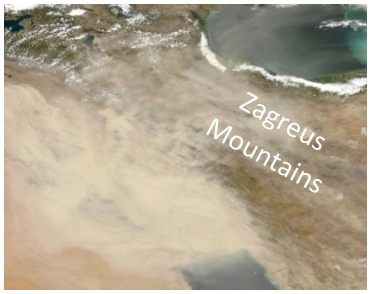


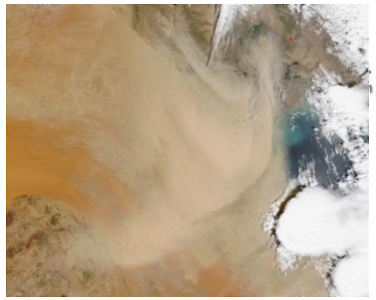
SDS Trajectories types

Classification index of sand and dust storms (SDS) trajectories in the Middle East observed by MODIS images (3 major types and 12 sub types) (Al-Dousari et al., 2017).

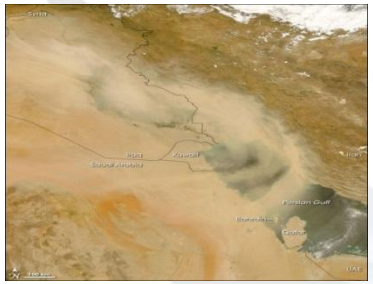


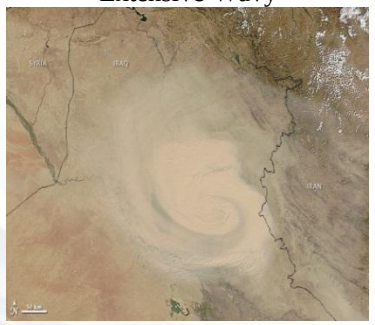
Extensive-Agglomerated–Dense

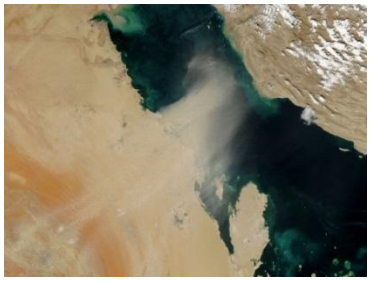
Extensive-Agglomerated–Dispersed


Extensive-Wavy

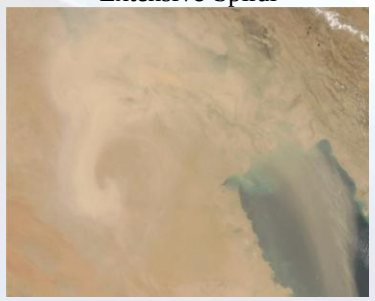

Extensive-Hook–Single head

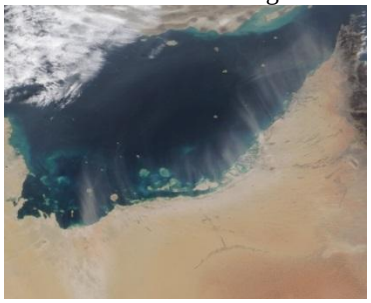

Extensive-Hook–Multiple heads

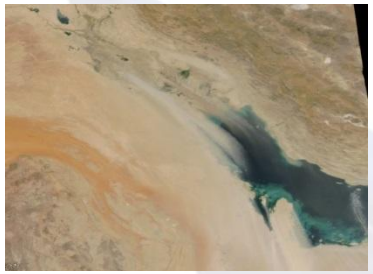

Extensive-Spiral

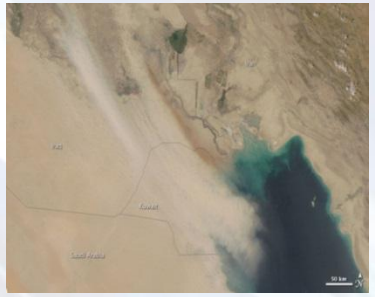

Intermediate-Straight

Intermediate-Curved


Intermediate-Hook


Small-Needle like


Small-Arrow shape-straight


Small-Arrow shape-curved

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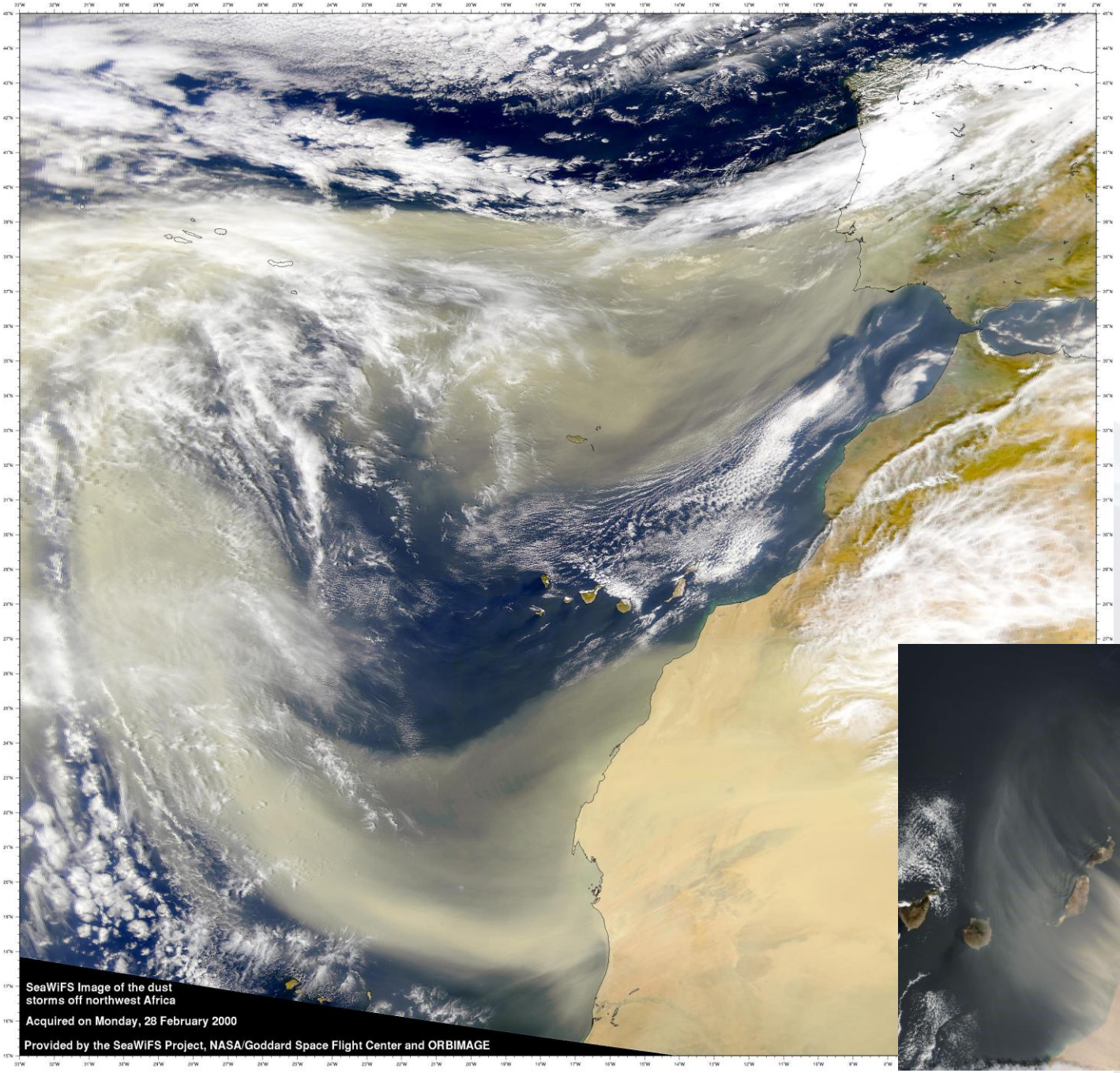
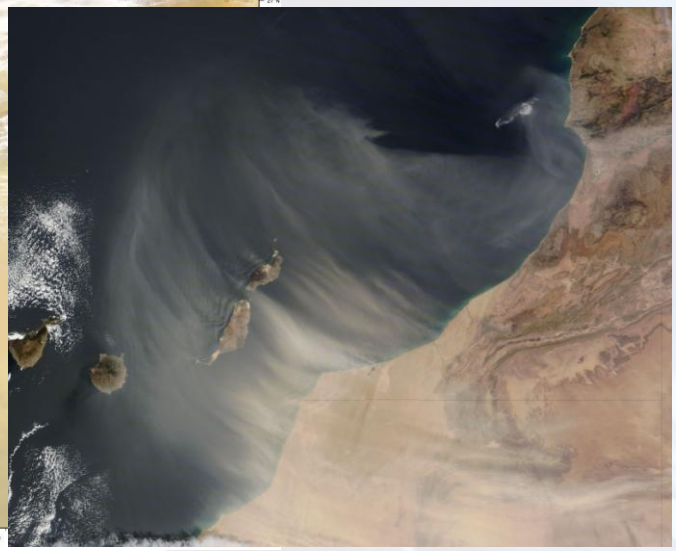
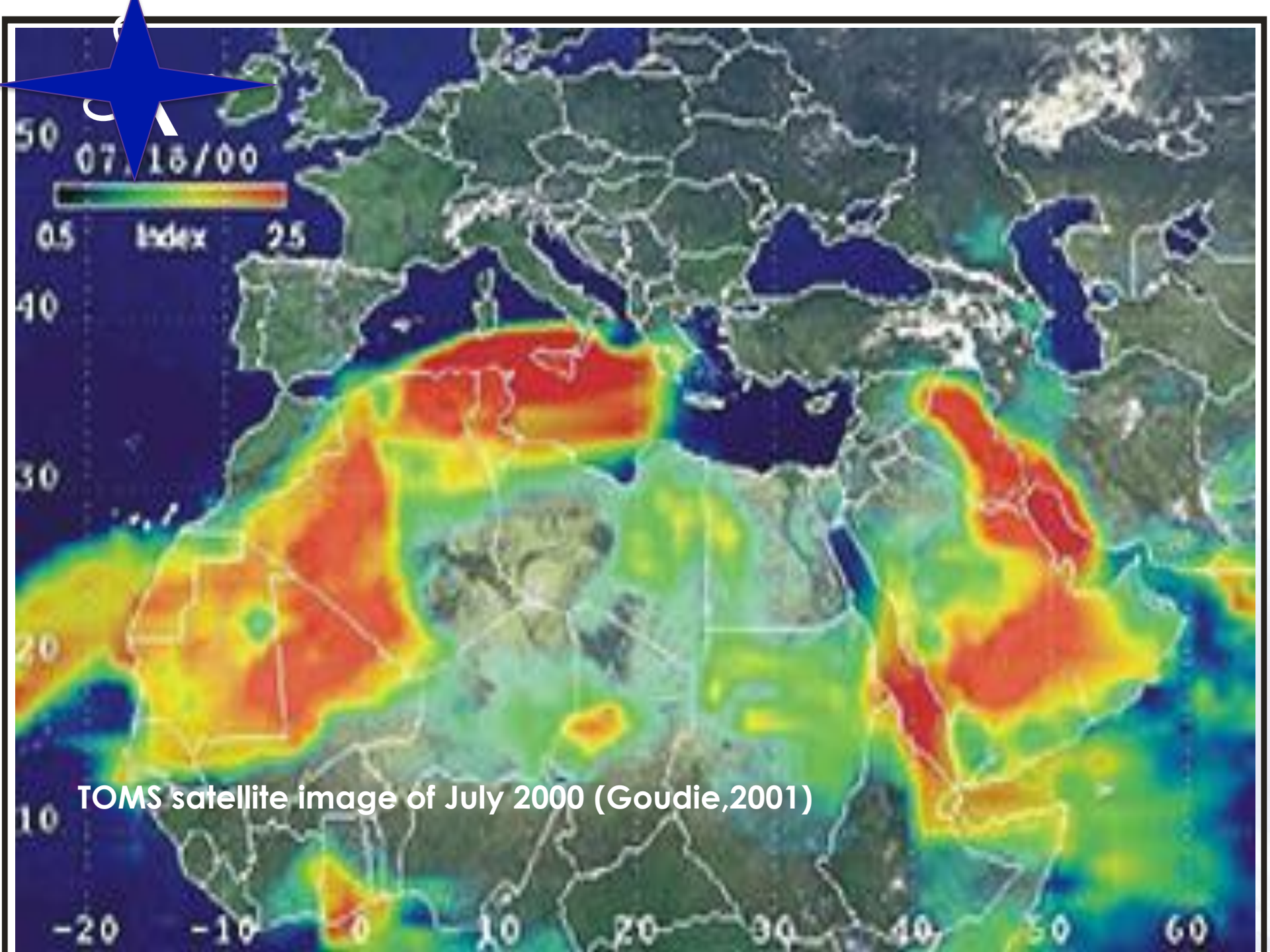


SeaWiFS Image of the dust
storms off northwest Africa

Acquired on Monday, 28 February 2000

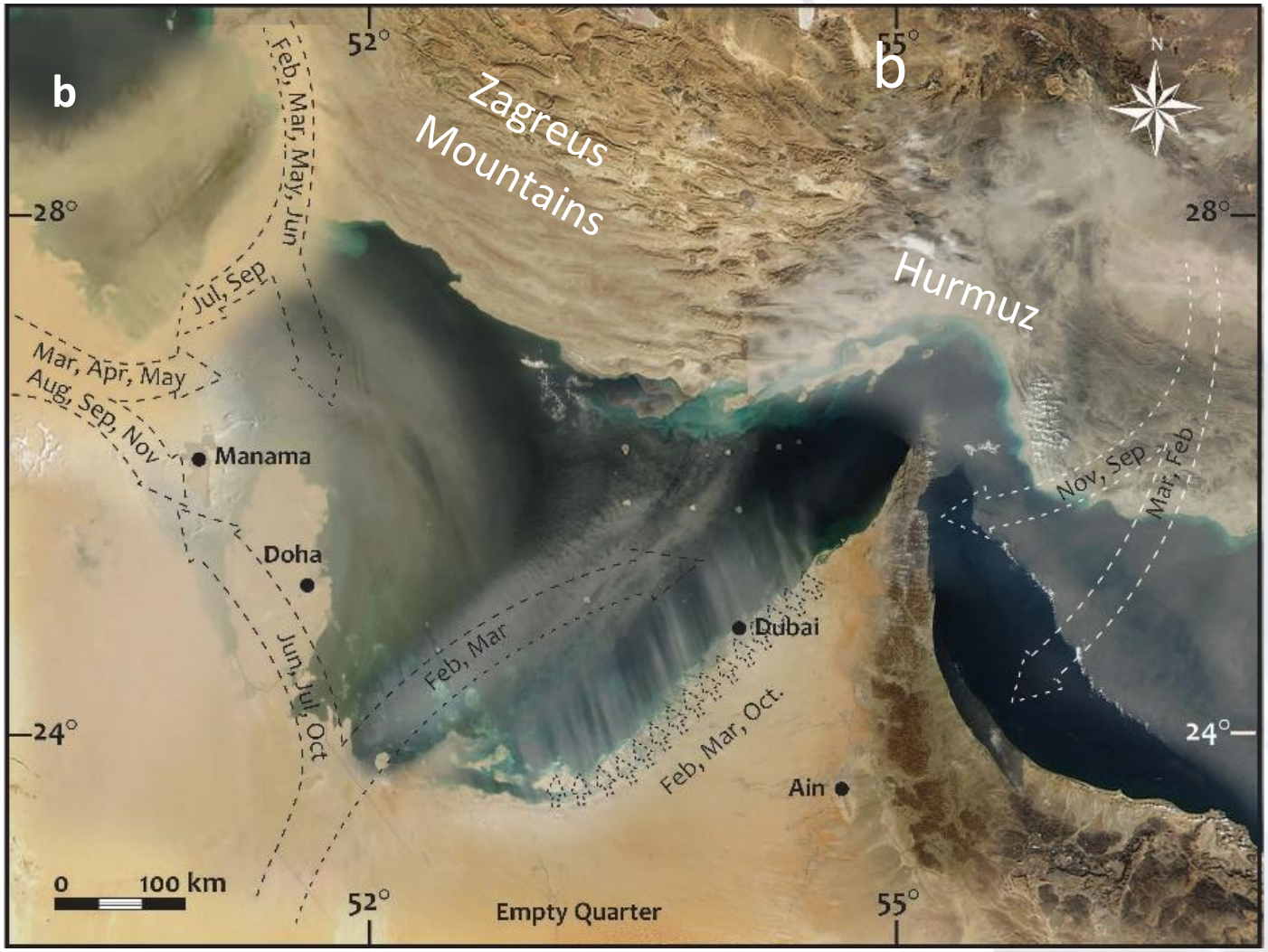
Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE



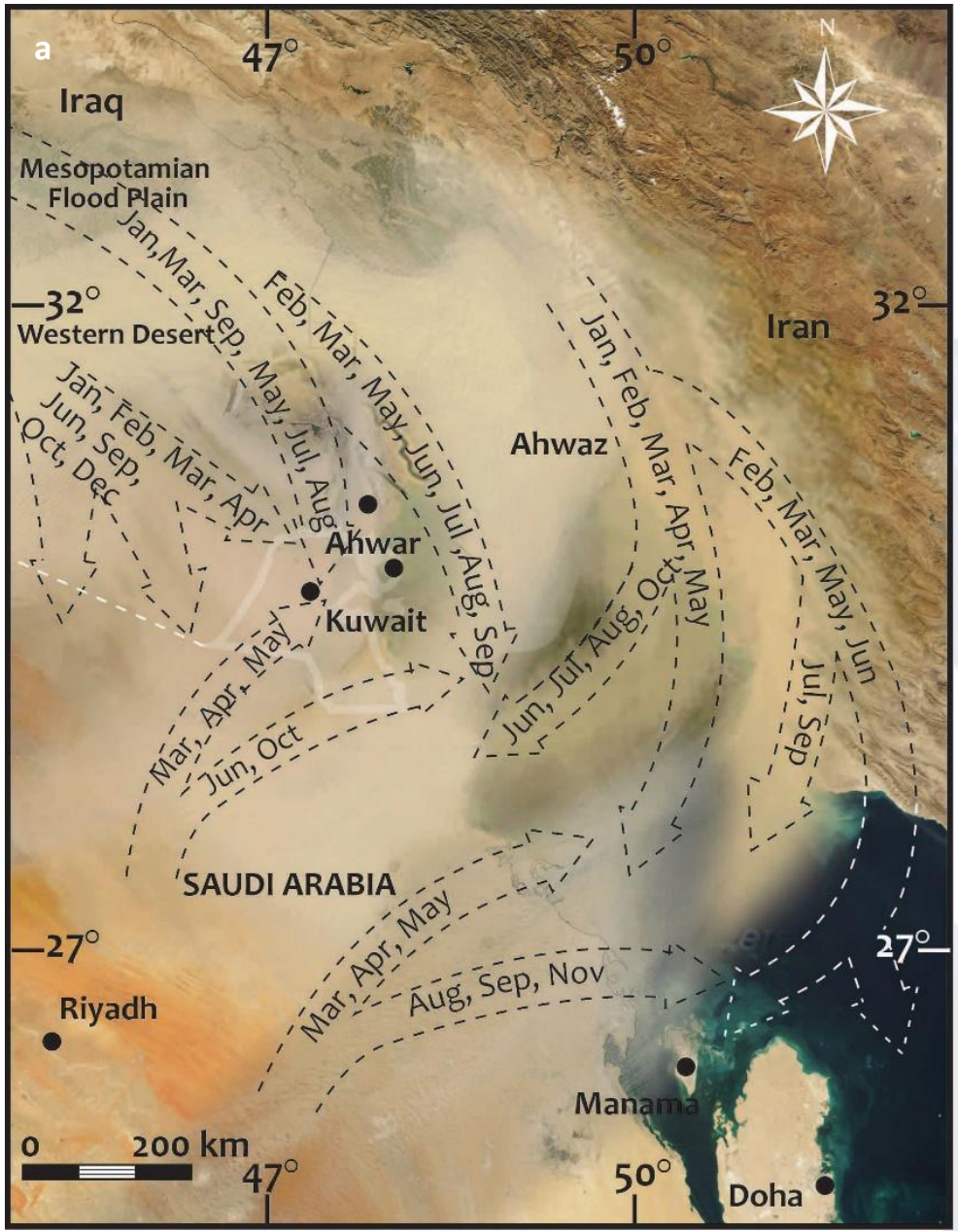


TOMS satellite image of July 2000 (Goudie,2001)

Spatial and temporal distribution for multiple dominant SDS trajectories (2000–2017) superimposed images in Southern Arabian Gulf (b)

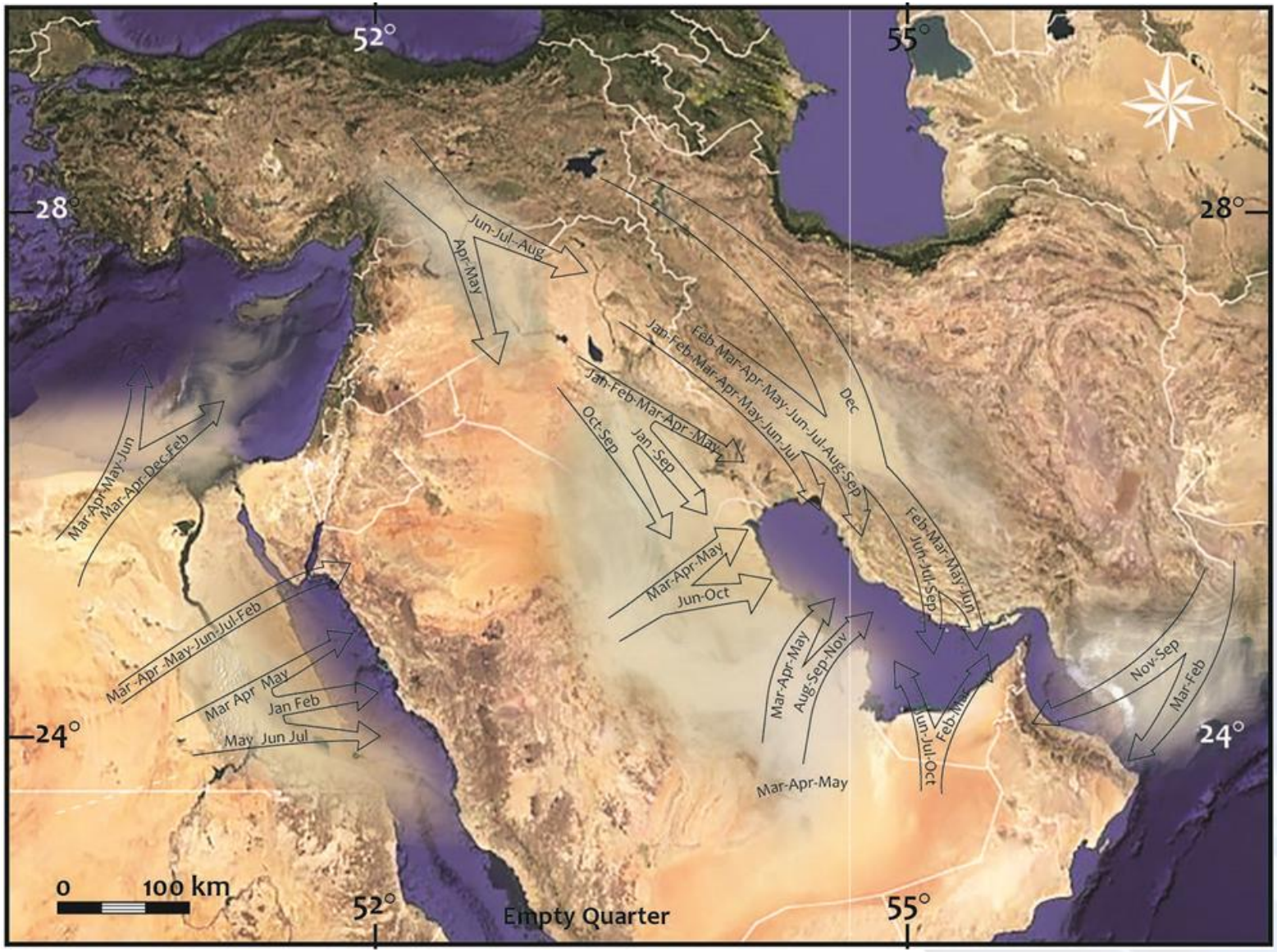


Spatial and temporal distribution for multiple dominant SDS trajectories (2000–2017) superimposed images in northern Arabian Gulf (a)

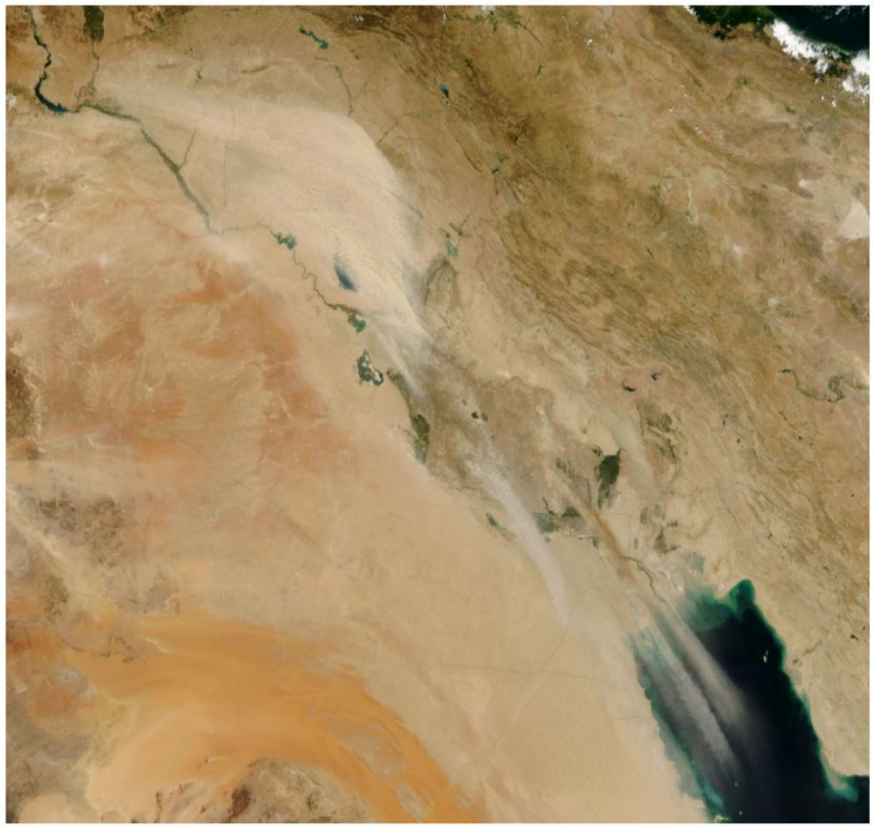


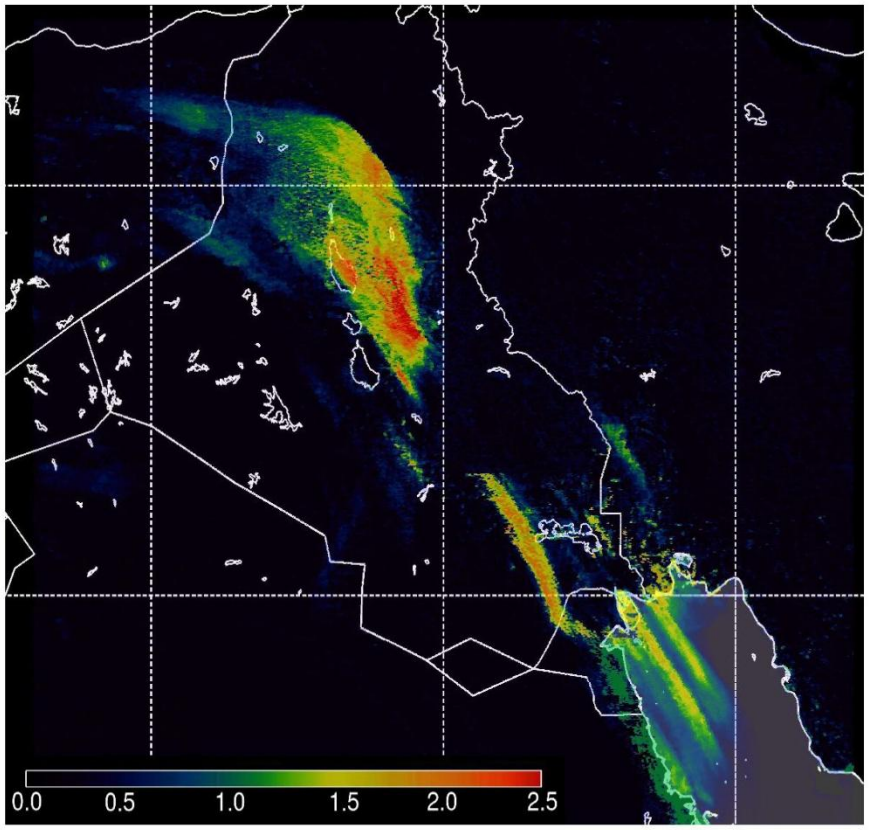

Mesopotamian
Flood Plain
Western
Desert
Ahwar
Kuwait
Iran
ARABIAN GULF
Nufud
Desert
Bahrian
Qatar
Saudi Arabia
Rub khali
Desert
Emirates
50°E
55°E
30°N
25°N
0 50 100 200 300
km

Spatial and temporal distribution for multiple dominant SDS trajectories (2000–2017) superimposed images in the Middle East.



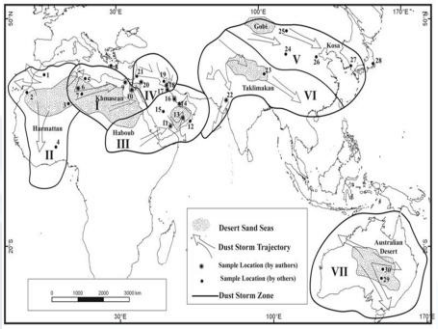
MODIS aerosols distribution map
August 7, 2005





Amount of fallen dust (monthly and annual)

Zone-Location	Political region	Reference	Tons.Km^{-2}.mo^{-1}	Tons.km^{-2}.yr^{1}
Zone I: The western and southern Sahara Desert				
A long Niger River	Mali	McTainsh et al,. 1997	75-858	913-10446
Northern Diarnena	Chad	Maley, 1982	11.83	142
Kano	Nigeria	McTainsh et al,. 1982	11.4-15.1	137-181
Southern Chad	Chad	Maley, 1982	9.08	109
Nouadhibou	Mauritania	Rott, 2001	6.54	80
Smara	Western Sahara	Rott, 2001	9.12	111
Agadir	Morocco	Rott, 2001	9.39	114
Sidi Ifni	Morocco	Rott, 2001	11.88	145
Tan Tan	Morocco	Rott, 2001	14.37	175
Dakhla	Mauritania	Rott, 2001	15.72	191
Boujdour	Western Sahara	Khiri et al, 2004	17.97	219
Zone II: The eastern Sahara Desert				
Libya	Libya	O'Hara et al., 2006	13	155
Negev Desert	Palestine	Singer et al., 2003	4.8-18.1	57-217
Crete	Greece	Pye, 1992	0.83-8.33	10-100
Zone III: Sudan-Ethiopia and southern Arabia				
Fahal	Oman	Badawy et al., 1992	7.4	89
Riyadh	Saudi Arabia	Modaihsh, 1997	32.67	392
Zone IV: Northern Arabia				
Dead Sea	Palestine	Singer et al., 2003	3.71	45
Khur Al-Zubir	Iraq	Khalaf et al., 1980	6.9	75.92
Um Qasr	Iraq	Gharib et al., 1987	17.59	193.47
Kuwait	Kuwait	Present study	22.5	270
Zones V and VI: Gobi and Taklimakan deserts				
Xilingele	Mongolia	Hoffmann et al., 2008	24	292
Shapotou	China	Li et al., 2004	31	372
Tokyo	Japan	MOE, 1993	0.29	3.5
Zone VII: Australia Desert				
Adelaide	Australia	Tiller et al., 1987	0.42-0.83	5-10
Namoi valley	Australia	Cattle et al., 2002	1.4-4.85	16.9-58.2



Trajectory zone	Particle size percentages							Reference
	Sand	V.C.Silt	C.Silt	M.Silt	F.Silt	V.F.Silt	Clay	
Zone I: The western and southern Sahara Desert								
Tripoli-Libya	20	12	17	19	17	8	8	O'Hara et al., 2006
Biougra-Morocco	12	28	22	16	8	8	6	Khiri et al.,2004
Cartagena-Colombia	10	4	18	22	18	12	16	Present study
Arizona-USA	9	26	30	13	8	4	10	Pewe et al.,1981
Average	13	18	22	18	13	8	10	
Zone II: Eastern Sahara Desert								
Tripoli-Libya	20	12	17	19	17	8	8	O'Hara et al., 2006
Cairo-Egypt	10	15	37	21	10	4	3	Present study
Average	15	14	27	20	14	6	6	
Zone III: Sudan-Ethiopia and southern Arabia								
Wadi Dawasir	40	8	21	15	11	2	4	Present study
Ain	97	0	1	1	1	1	0	Present study
Dubai	17	3	14	24	23	10	8	Present study
Average	51	4	12	13	12	4	4	
Zone IV: Northern Arabia								
Amman-Jordan	30	11	30	17	8	2	2	Present study
Um Qasr-Iraq	3	12	20	25	15	5	20	Khalaf et al., 1980
Kuwait	37	22	18	14	7	2	0	Present study
Manamah-Bahrain	12	10	20	11	13	5	28	Present study
Average	21	14	22	17	11	4	13	
Zone V and VI: Gobi and Taklimakan deserts								
Taklimakan-China	70	24	2	1	2	1	0	Nishikawa et al.,2000
Ejin-China	35	18	10	8	5	2	22	Wang et al., 2005
Siberia-Russia	11	31	28	11	7	4	8	Pewe,1981
Average	39	24	13	7	5	2	10	
Zone VII: Australian Desert								
Bald Hill-Australia	9	3	5	5	4	3	70	Cattle et al., 2002
Average	26	14	18	14	10	5	13	
Max	97	31	37	25	23	12	70	
Min	3	0	1	1	1	1	0	

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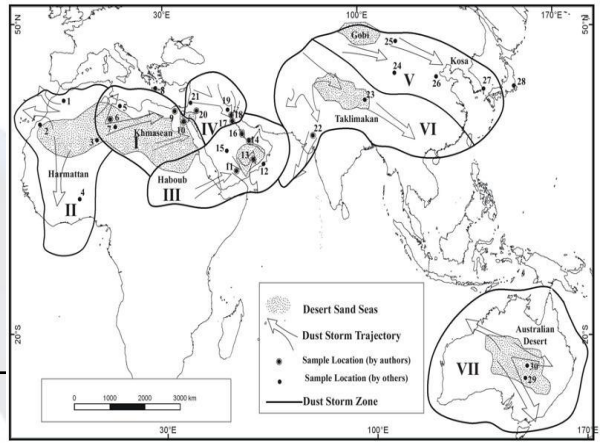
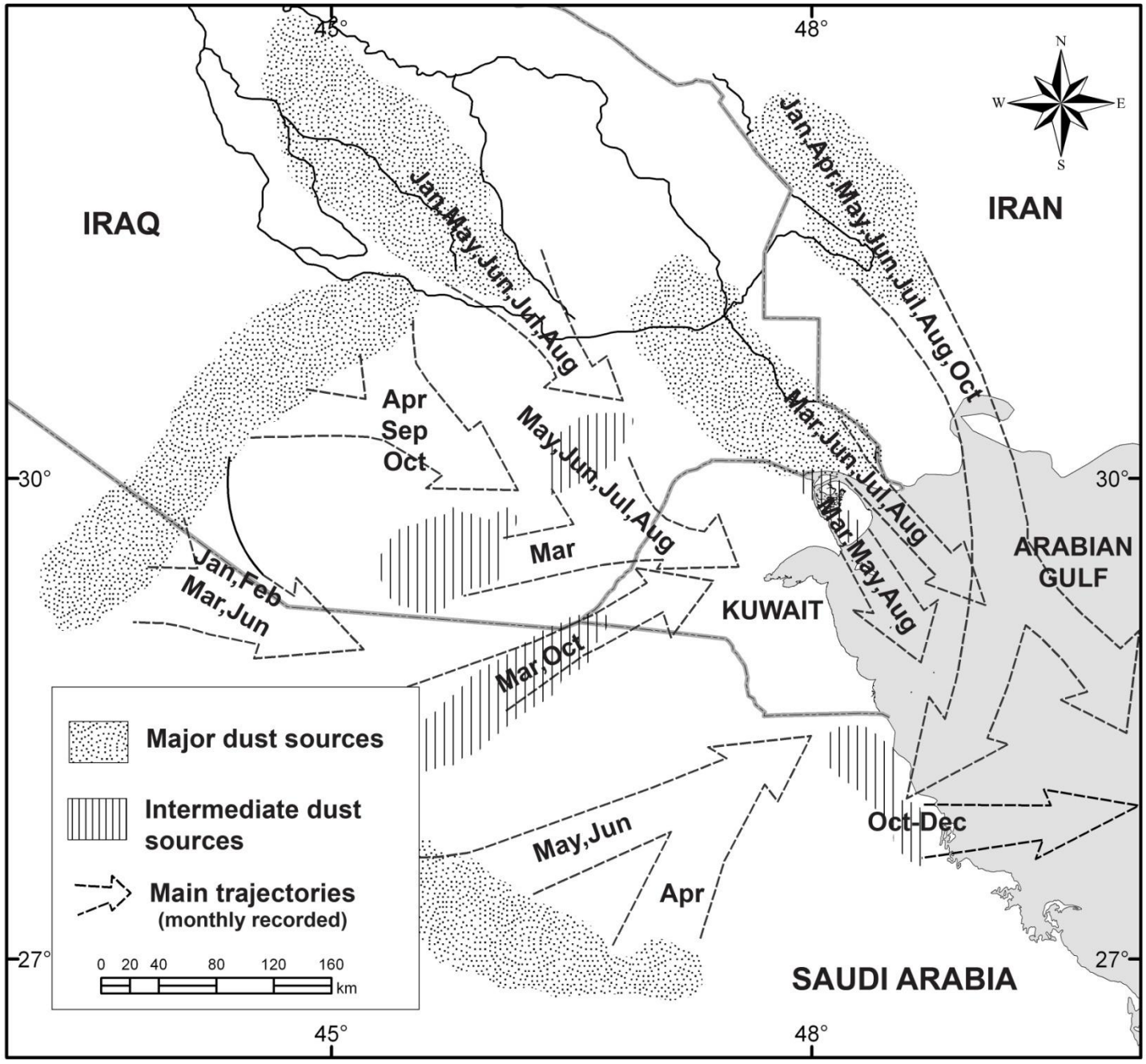
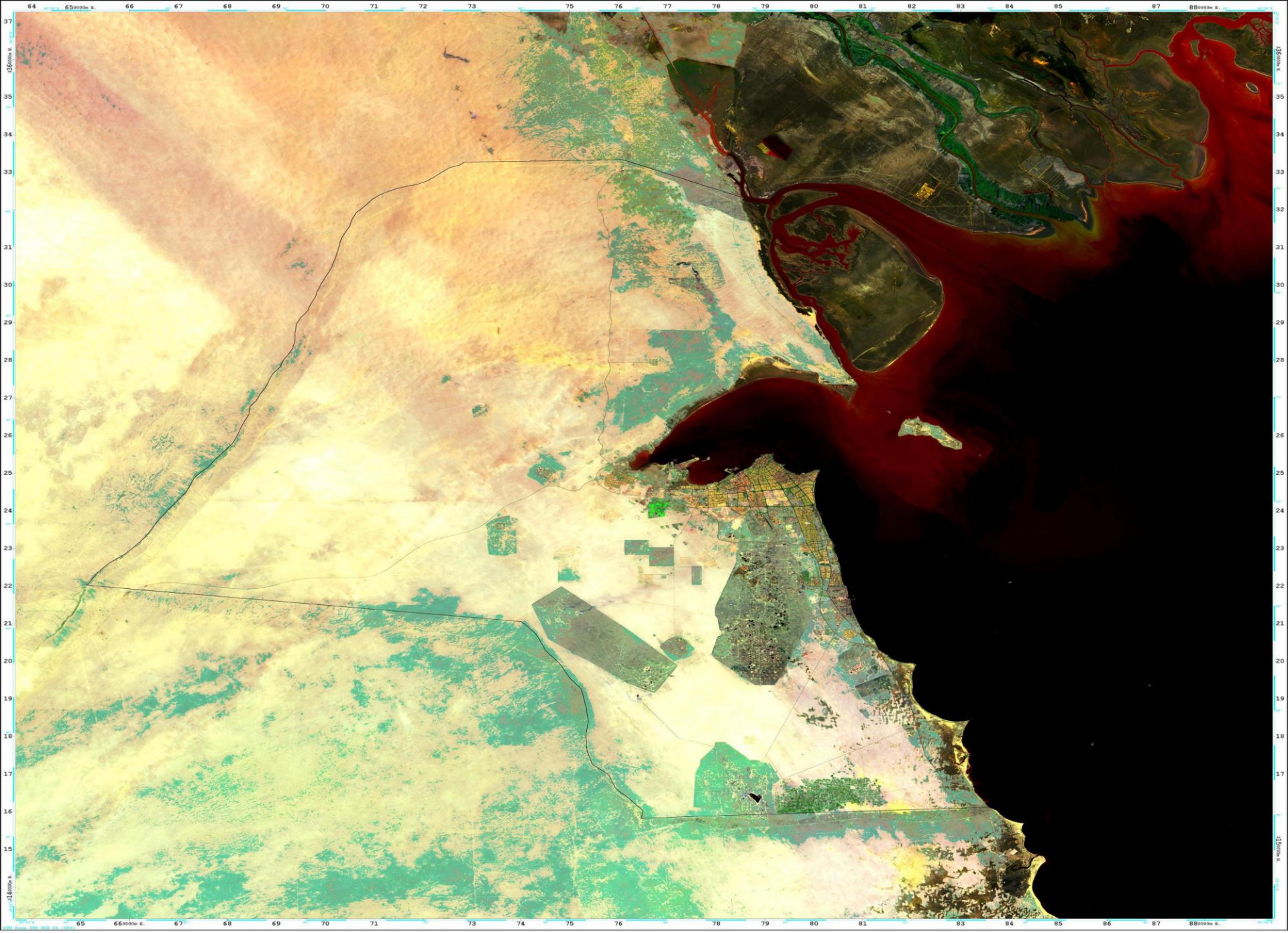
Grain size % of Fallen dust from upwind to downwind




45°
48°
N
W
E
S
IRAQ
IRAN
Jan,May,Jun,Jul,Aug
Jan,Apr,May,Jun,Jul,Aug,Oct
Apr
Sep
Oct
May,Jun,Jul,Aug
Mar,Jun,Jul,Aug
30°
Mar
Mar,May,Aug
ARABIAN
GULF
Jan,Feb
Mar,Jun
KUWAIT
Mar,Oct
Major dust sources
Intermediate dust sources
Main trajectories
(monthly recorded)
0 20 40 80 120 160
km
May,Jun
Oct-Dec
Apr
27°
SAUDI ARABIA
45°
48°



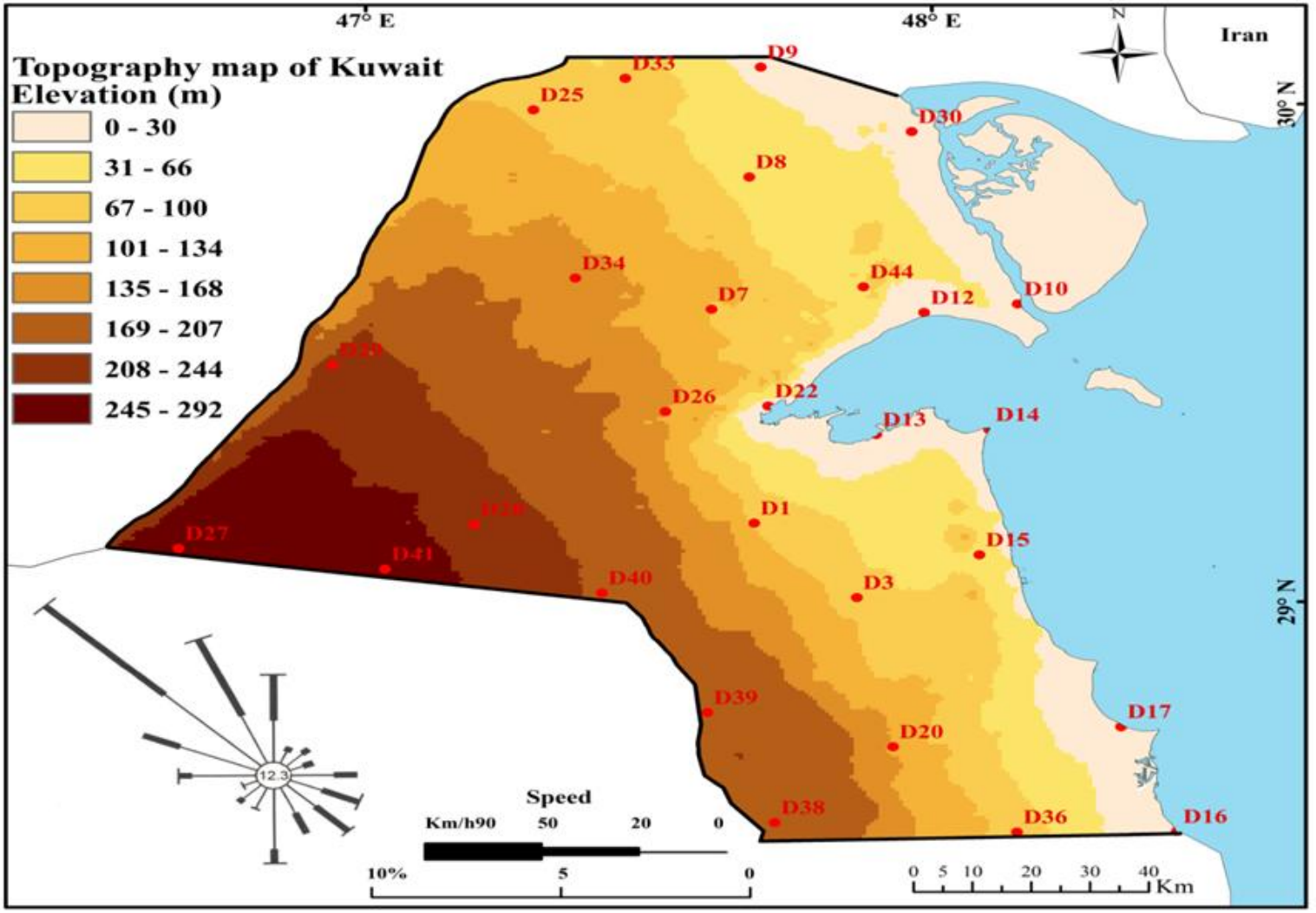
Landsat image of Kuwait in bands 2, 4 and 7 for the year 2003

1:250 000 Scale

Kilometres 10 0 10 20 30

Miles 10 0 10

Dust and pollen traps



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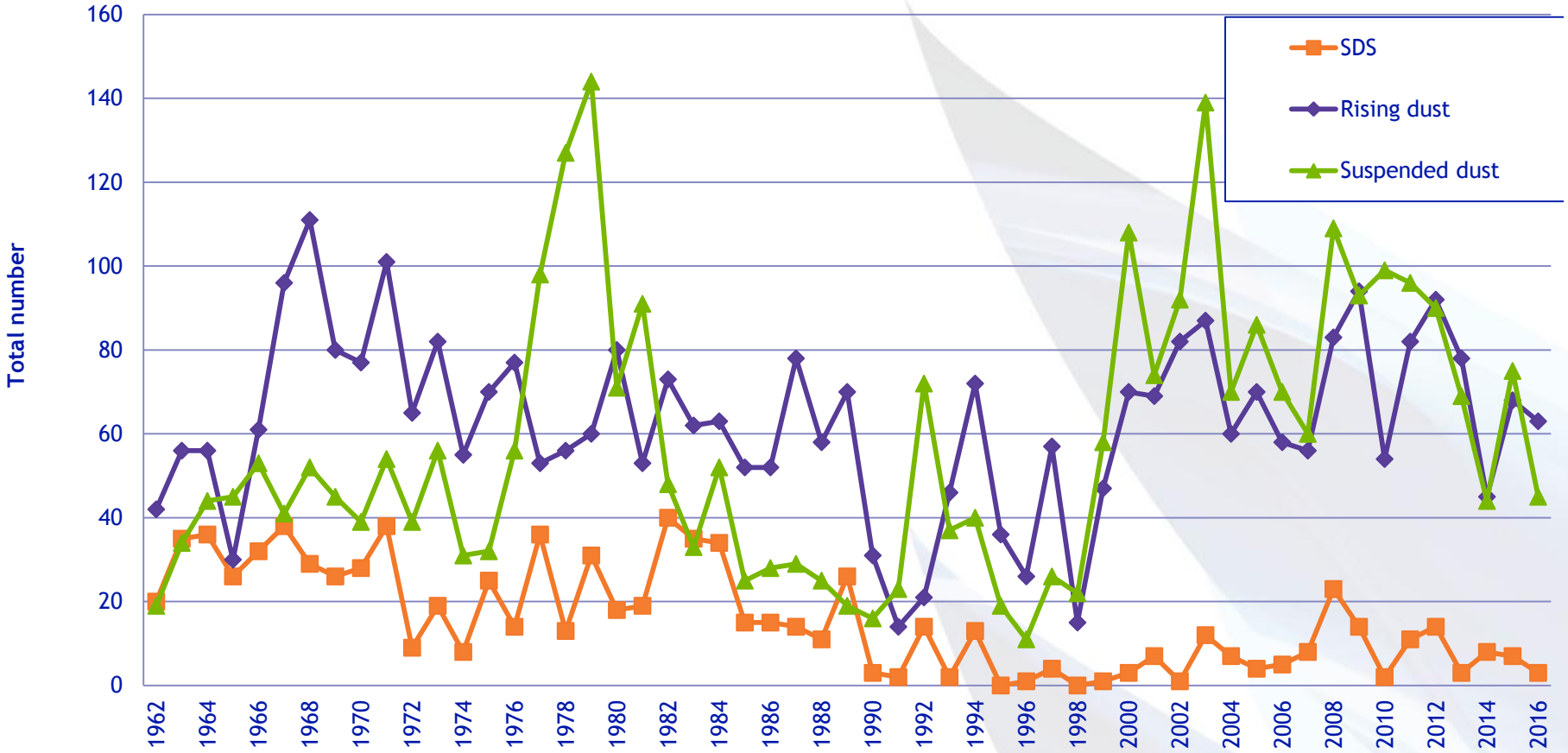

SDS-Kuwait

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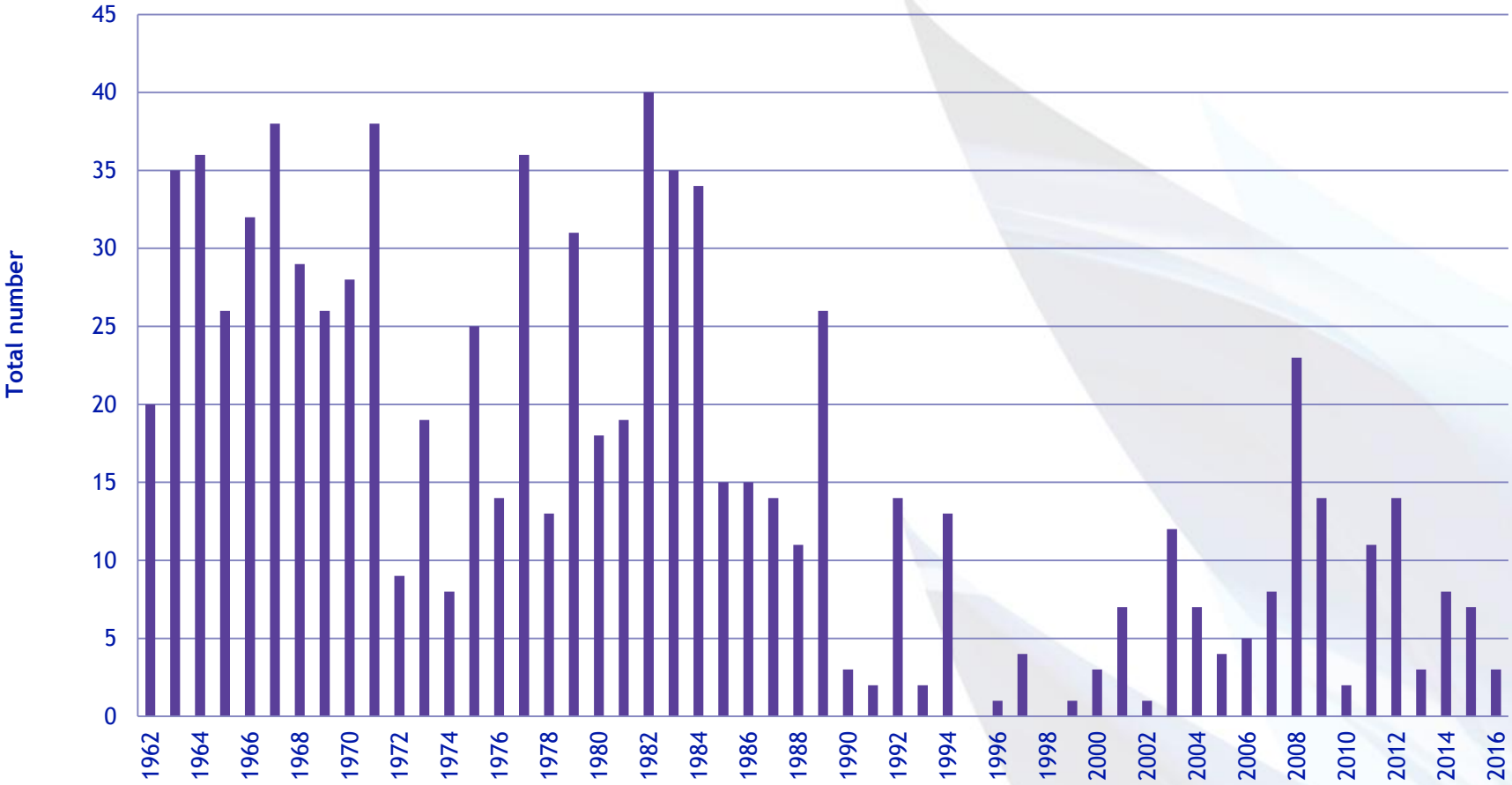
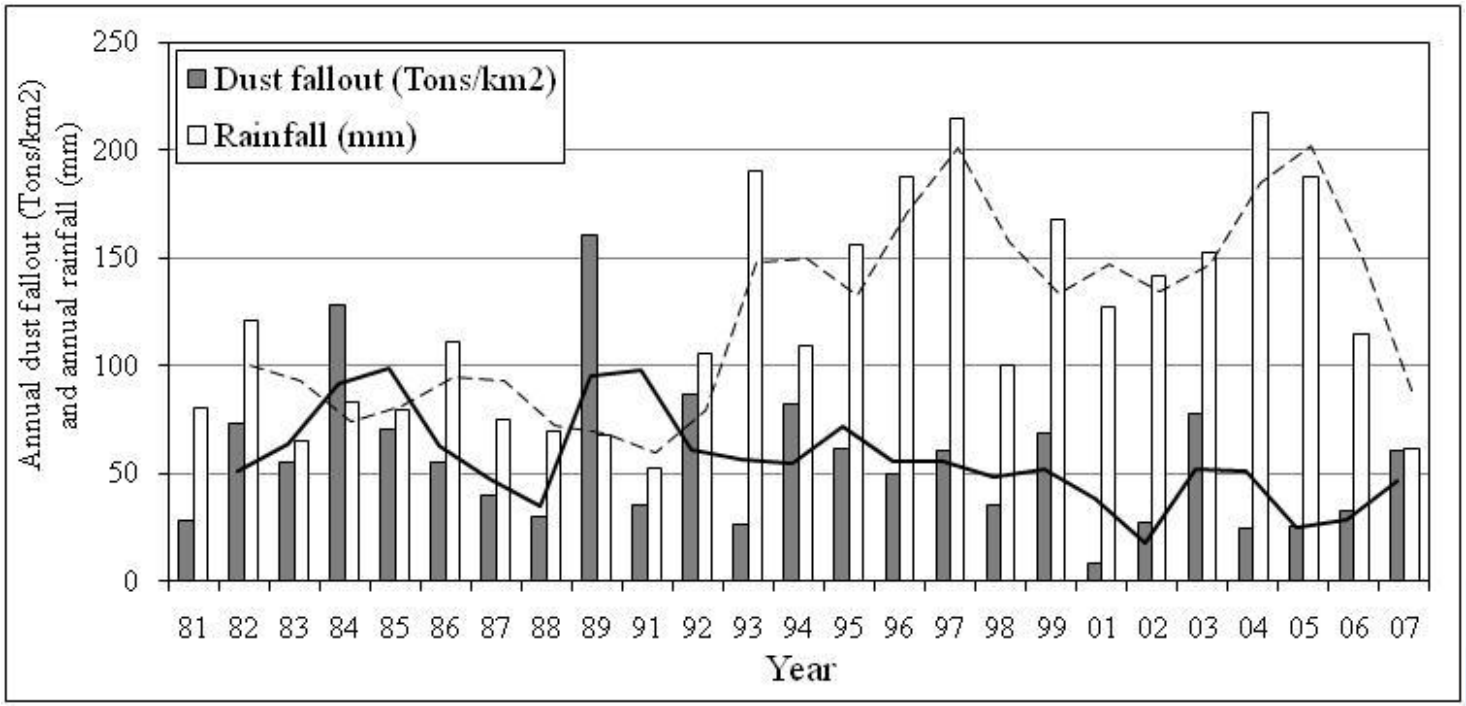
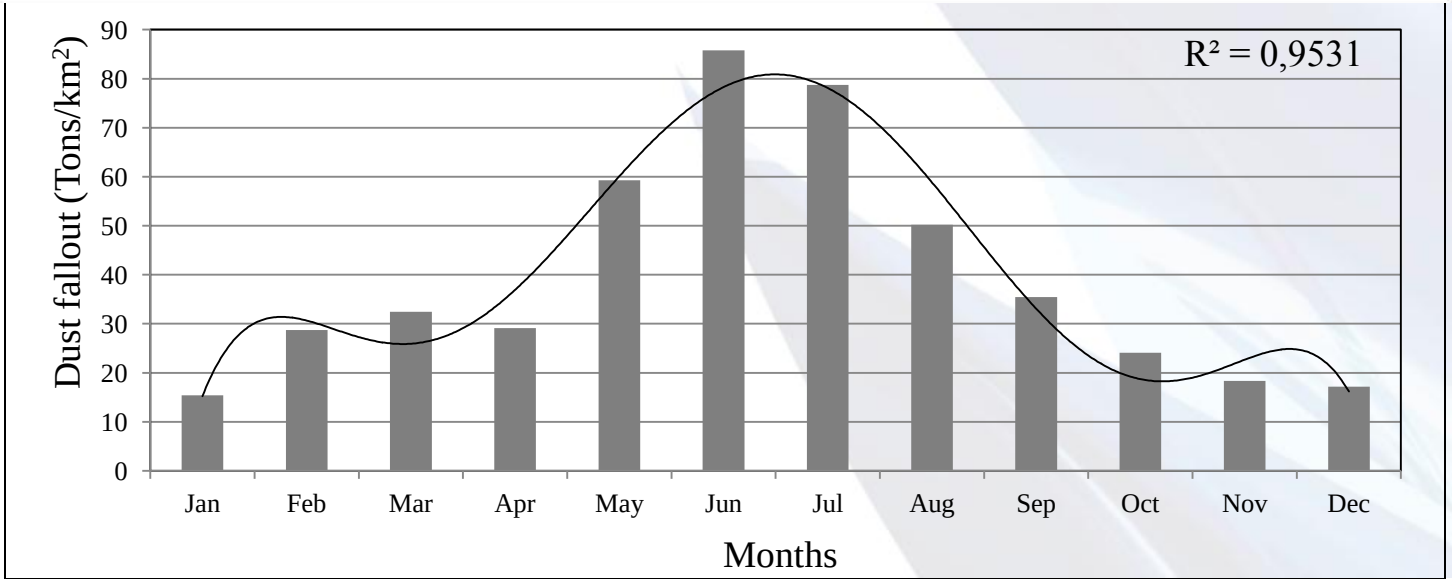


المصدر بتصرف: 1-الهيئة العامة للبيئة (الغبار المتساقط بالشويخ) 2-مطار الكويت الأرصاد الجوية





Mean Number of Days and Hours of Dust Phenomena at Kuwait International Airport (Safar, 1985) (1954-1984)

Month	Dust/Sand Storms		Raising dust		Suspended dust		Haze	
	Days	Hours	Days	Hours	Days	Hours	Days	Hours
January	1.1	4.2	3.7	22.0	3.1	15.4	7.7	47.5
February	1.3	4.7	4.3	35.2	4.4	21.7	7.5	51.2
March	2.1	7.2	6.1	45.7	4.7	38.0	7.6	76.0
April	3.2	11.2	6.1	43.9	5.2	43.8	7.4	81.1
May	4.2	12.7	6.7	51.8	6.2	52.0	7.5	106.3
June	4.8	31.7	10.3	108.3	4.7	56.3	6.4	93.3
July	4.4	31.3	8.4	92.7	5.7	55.1	7.3	94.4
August	2.3	11.2	8.3	75.6	5.2	38.9	8.9	97.4
September	0.6	2.5	5.1	31.4	6.0	25.7	11.3	96.2
October	1.5	4.8	3.6	22.9	5.7	26.2	10.7	79.7
November	0.4	0.9	2.9	14.8	4.0	18.1	10.3	56.0
December	1.1	5.3	3.4	18.3	3.2	14.4	8.8	51.0
Annual Total	27.0	127.7	68.9	562.6	58.1	405.6	101.4	930.1

The average number for dust storm days in the Arabian Gulf (Source: Al-Kulaib, 1990 after modification).

*** Kuwait data from this study from July 2000 to March 2010.**

Station	No. of years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annually Average
Kuwait*	11	0.9	1.2	1.1	3.3	3.7	4.4	4.5	1.9	0.6	1.4	0.3	1.1	21
Bahrain	33	0.1	0.3	0.5	0.6	0.5	1.4	1.5	0.2	0.3	0.0	0.1	0.1	5.6
Doha	15	0.4	0.5	0.7	0.7	0.4	1.7	1.4	0.4	0.4	0.3	0.4	0.1	7.6
Abu Dhabi	6	0.4	0.3	0.6	0.1	0.4	0.4	0.7	0.0	0.0	0.0	0.2	0.7	3.9

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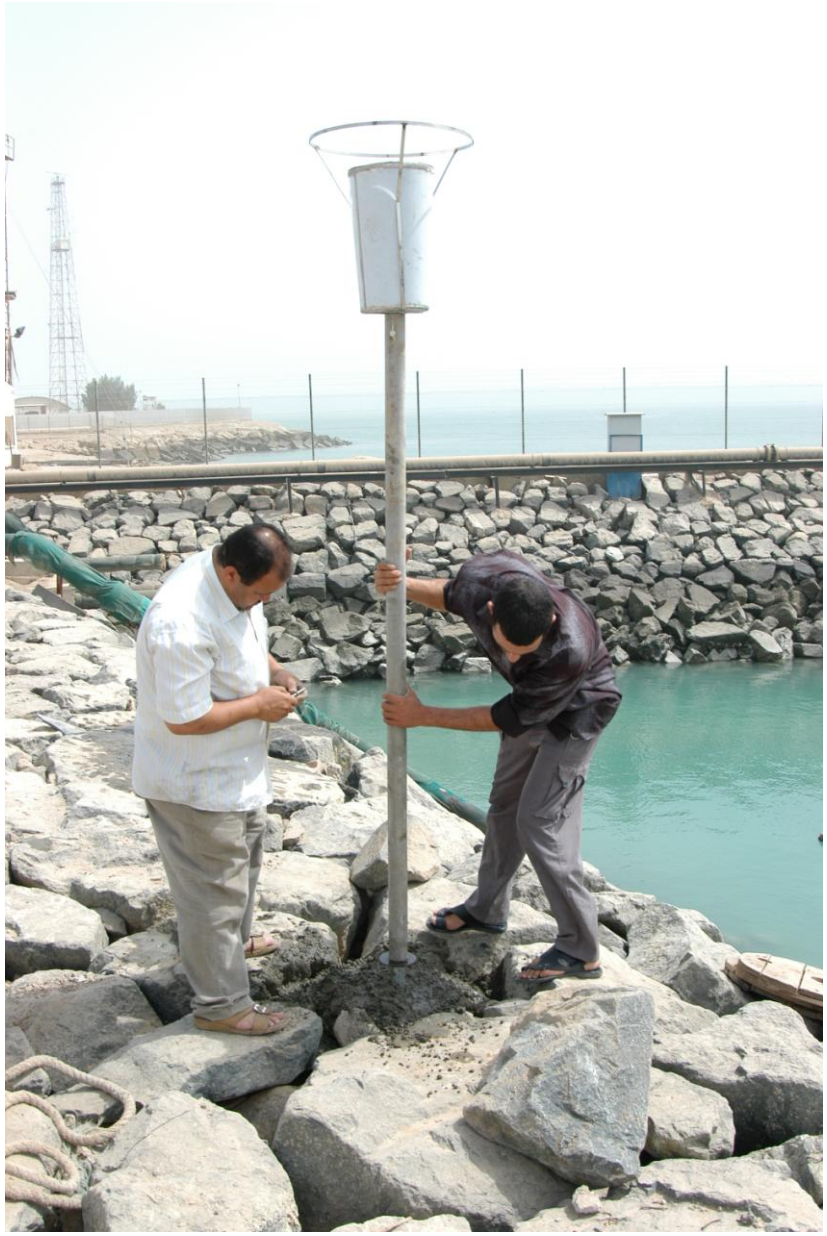
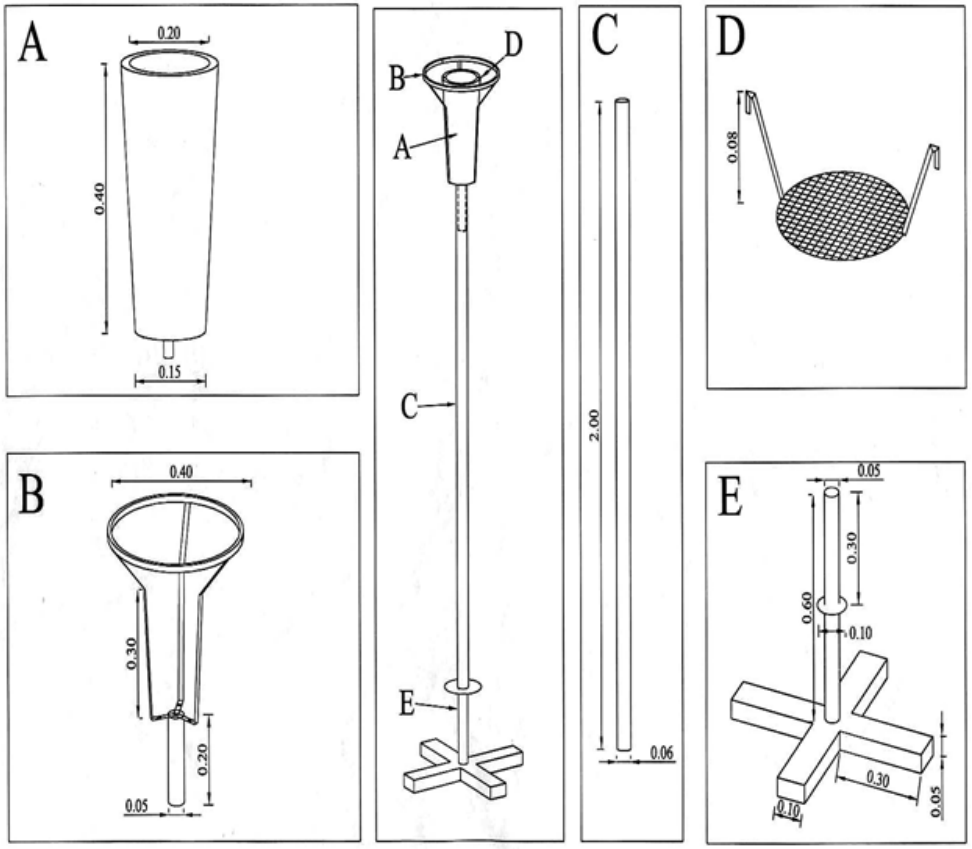


Dust trap



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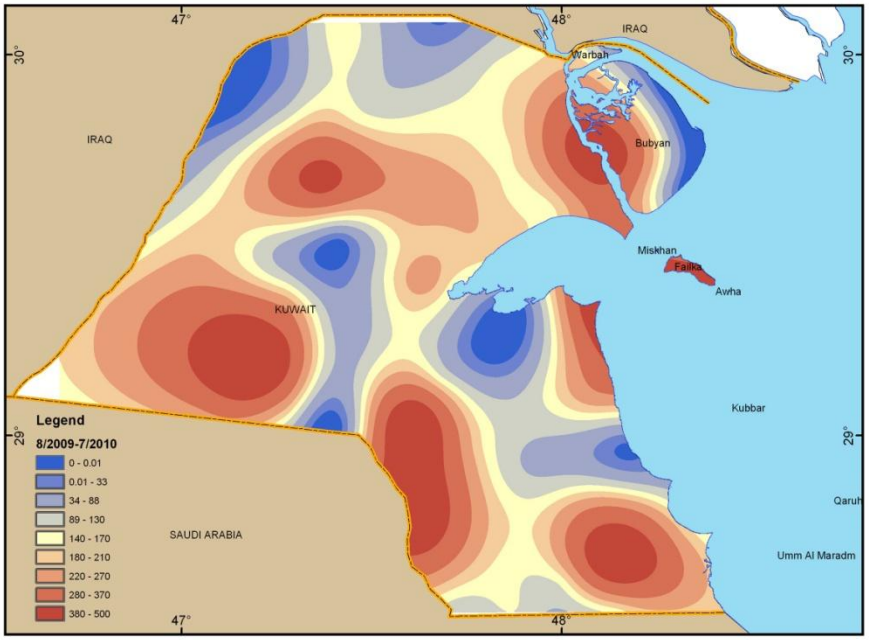
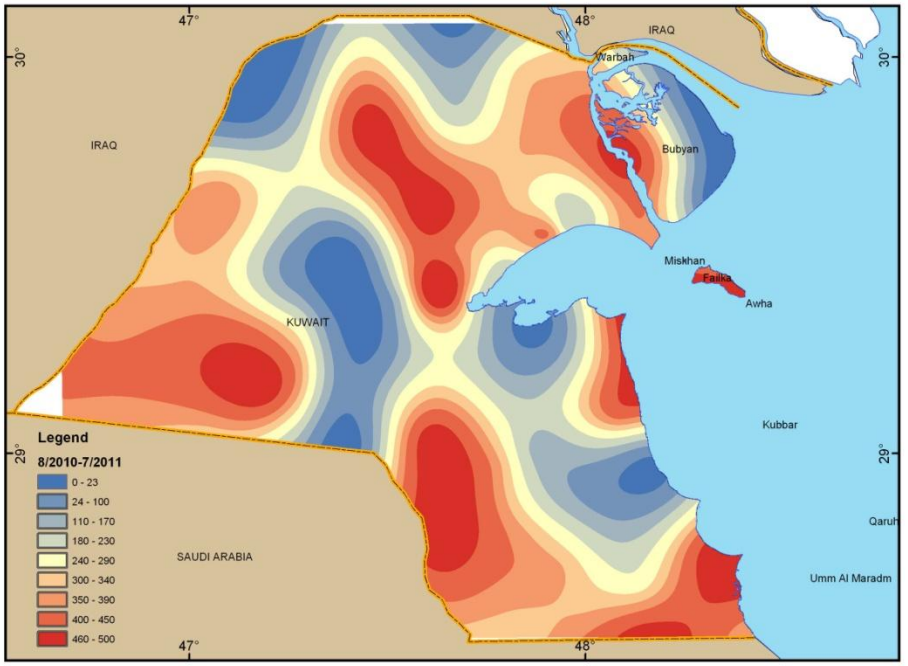
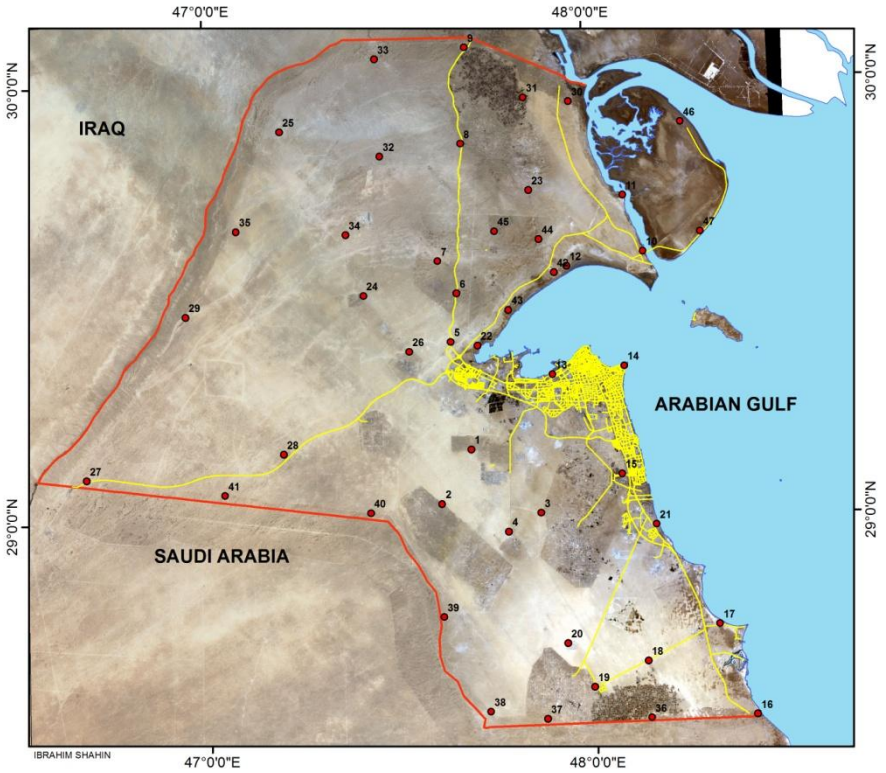
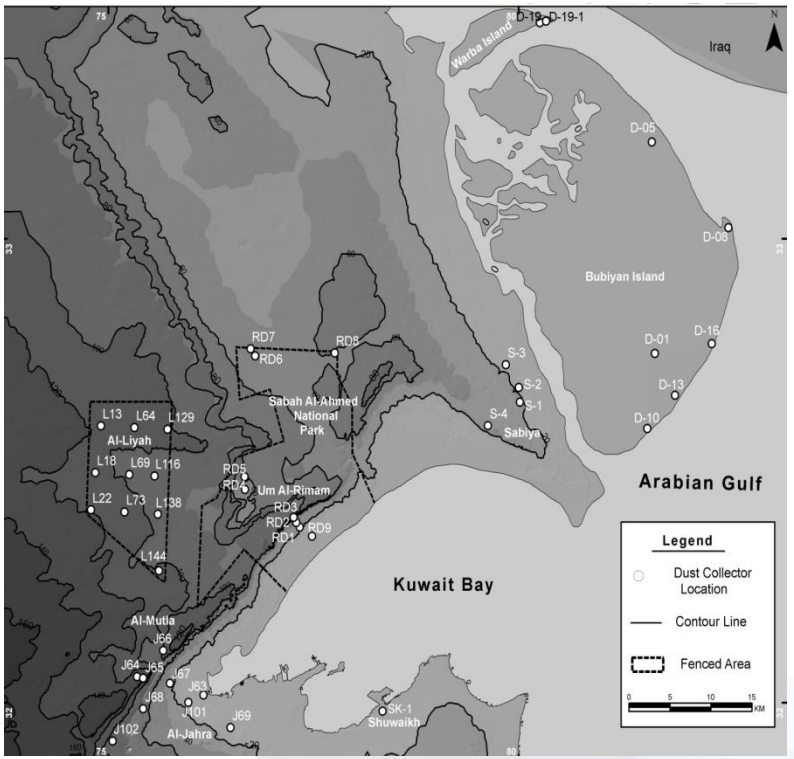
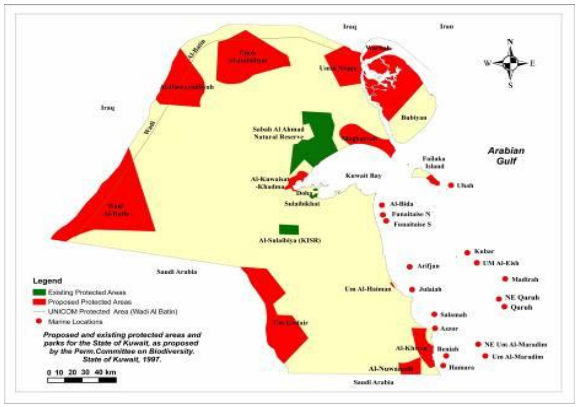
Annual dust comparison between (2009/2010) and (2010/2011)

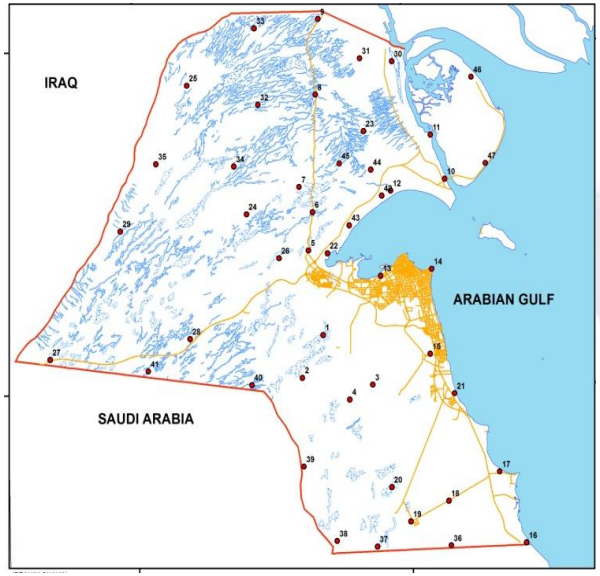


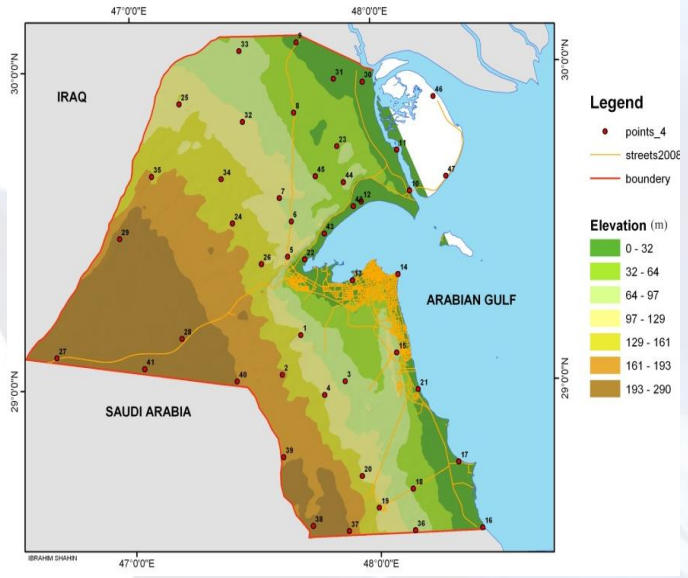



47°0'0"E
48°0'0"E
30°0'0"N
29°0'0"N
IRAQ
SAUDI ARABIA
ARABIAN GULF
IBRAHIM SHAHIN

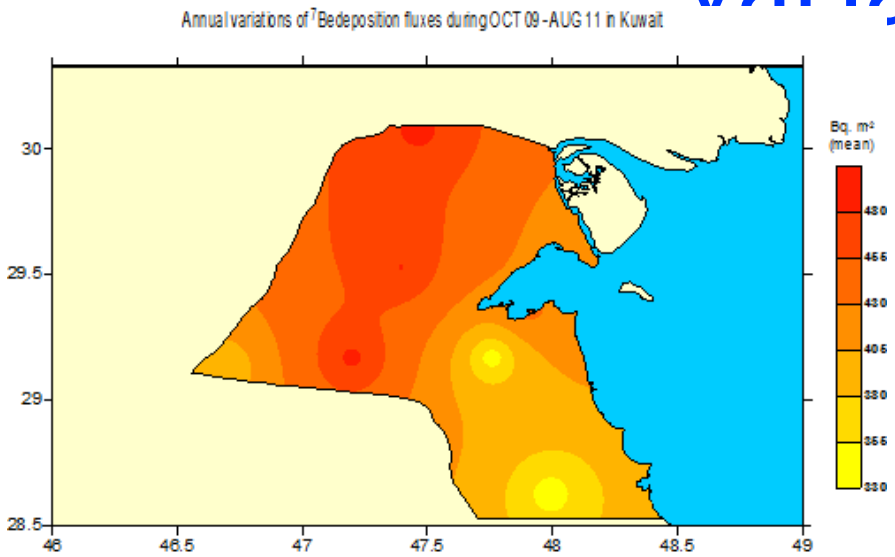

Iraq
Warba Island
Bubiyan Island
Arabian Gulf
Kuwait Bay
Sabah Al-Ahmed National Park
Al-Liyah
Um Al-Rimam
Sabiya
Al-Mutla
Al-Jahra
SK-1
Shuwaikh
Legend
Dust Collector Location
Contour Line
Fenced Area

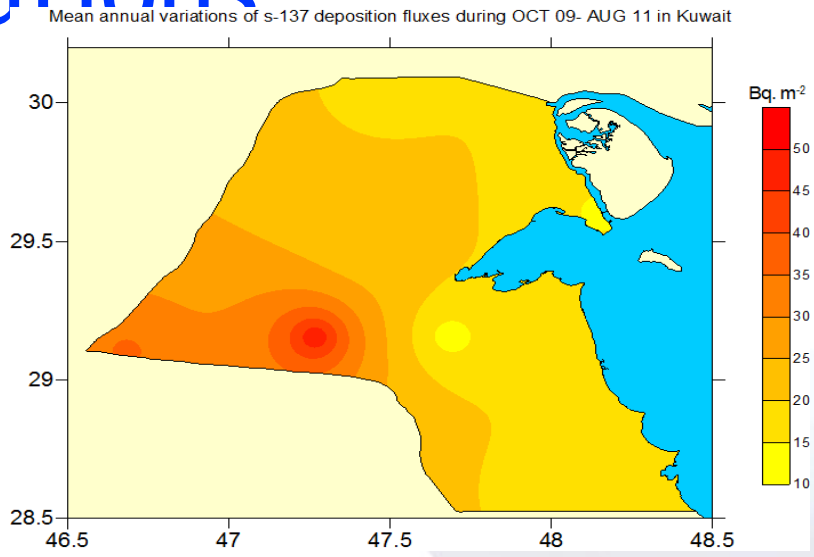

Iraq
Iran
Saudi Arabia
Kuwait Bay
Arabian Gulf
Legend
Existing Protected Areas
Proposed Protected Areas
UNICOM Protected Area (Wadi Al Batin)
Marine Locations
Proposed and existing protected areas and parks for the State of Kuwait, as proposed by the Perm. Committee on Biodiversity. State of Kuwait, 1997.

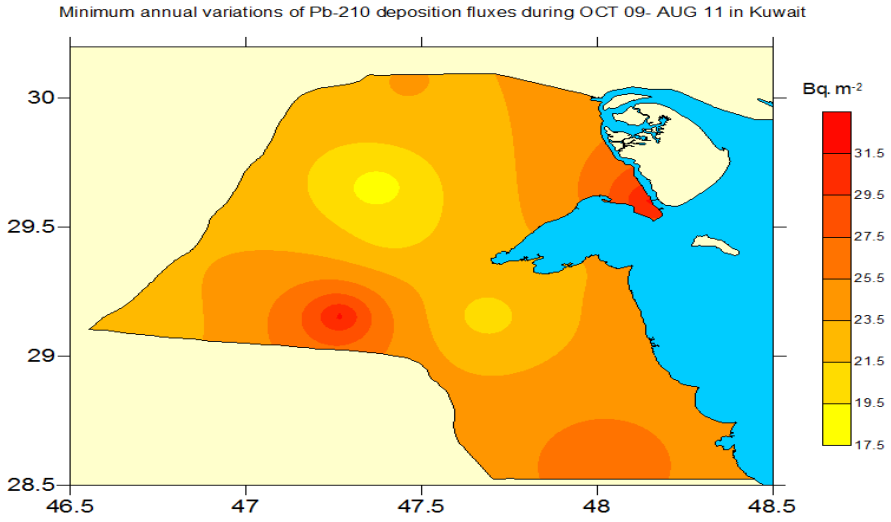

IRAQ
SAUDI ARABIA
ARABIAN GULF

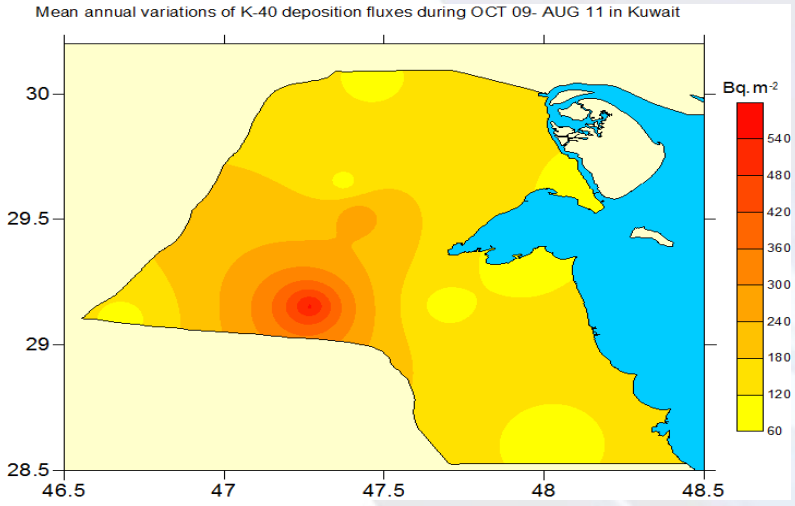

47°0'0"E
48°0'0"E
30°0'0"N
29°0'0"N
IRAQ
SAUDI ARABIA
ARABIAN GULF
IBRAHIM SHAHIN
Legend
points_4
streets2006
boundery
Elevation (m)
0 - 32
32 - 64
64 - 97
97 - 129
129 - 161
161 - 193
193 - 290

^{40}K,Pb-210, Be-7,Cs-137 spatial variations

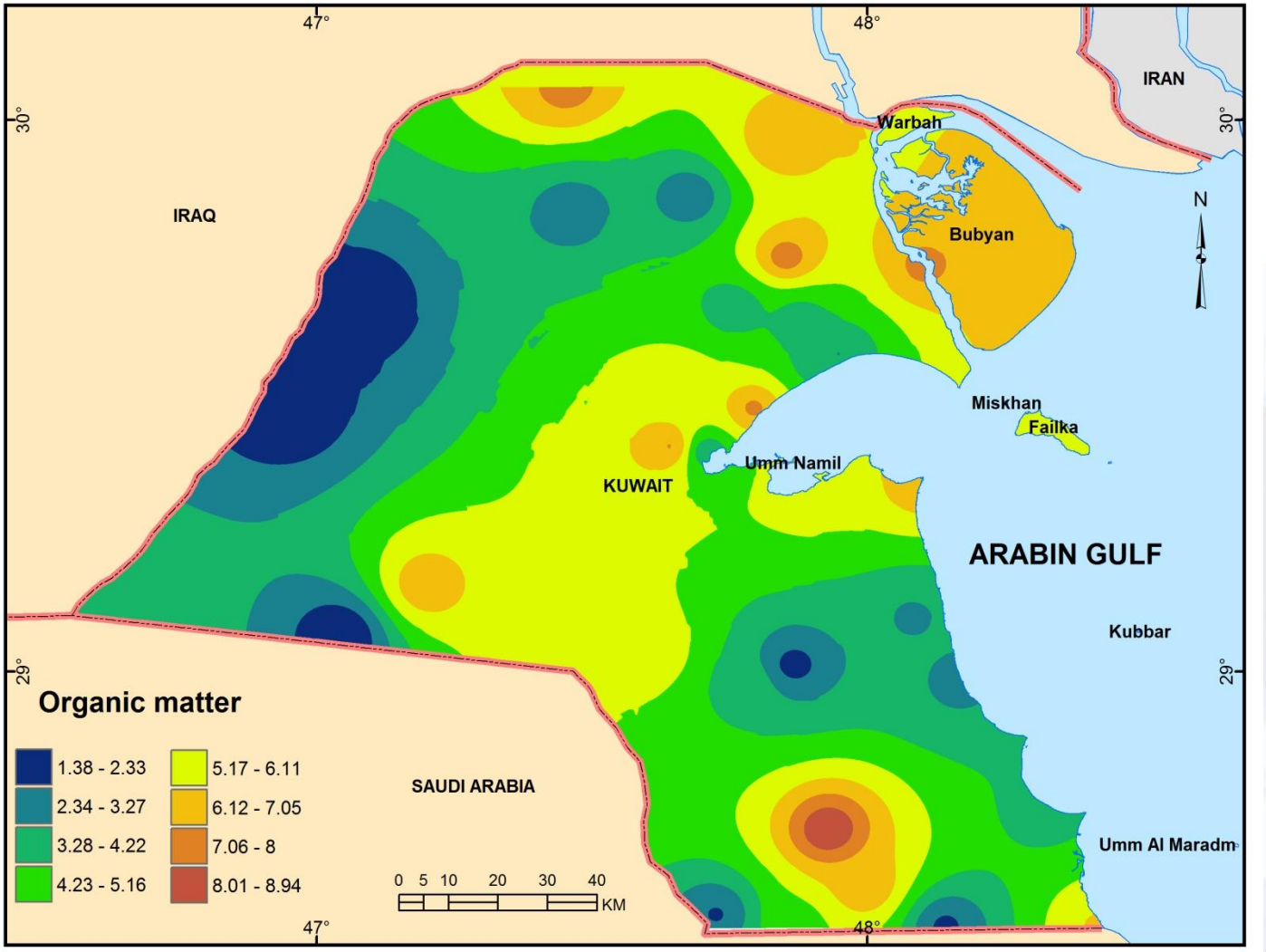




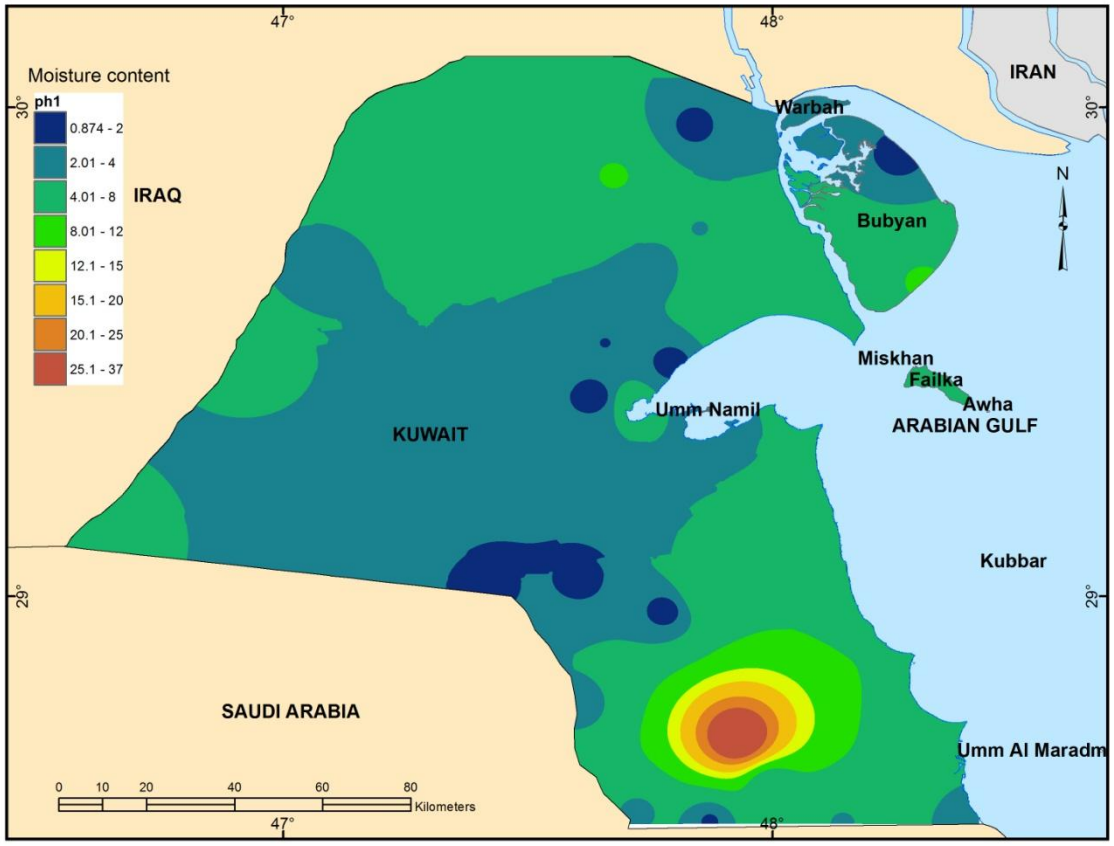




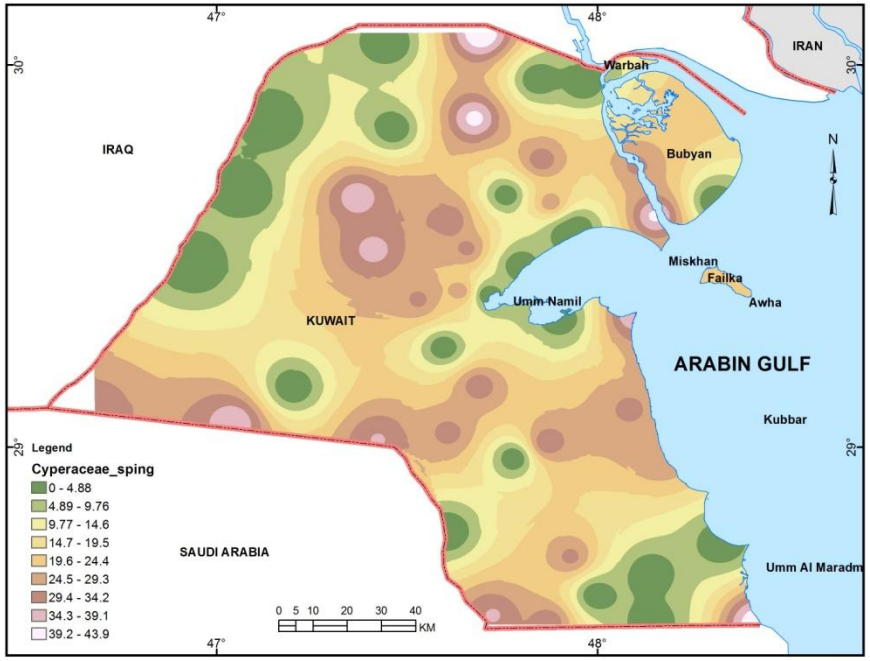
Organic Matter % in dust

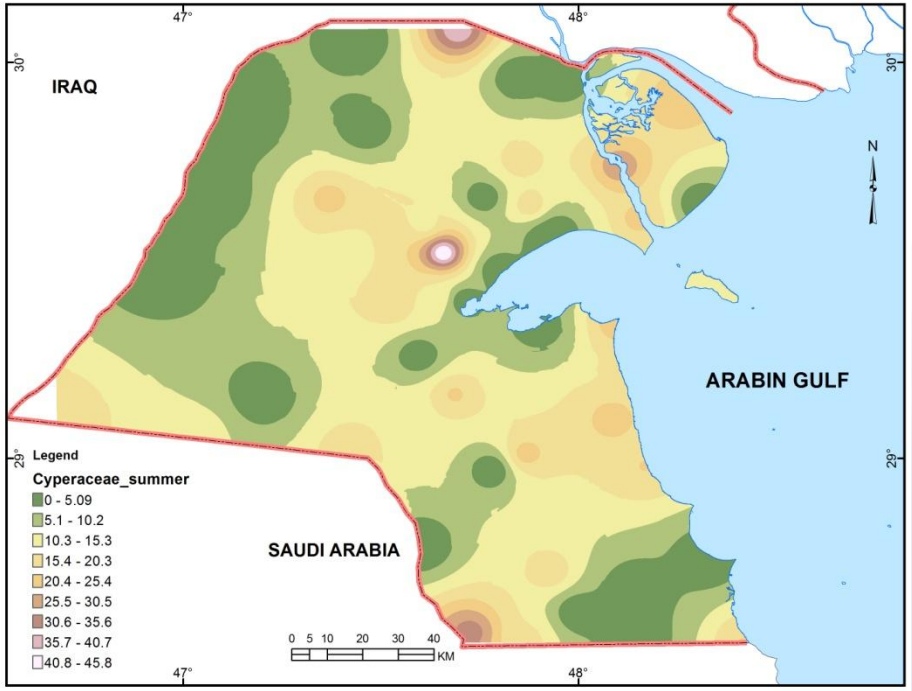


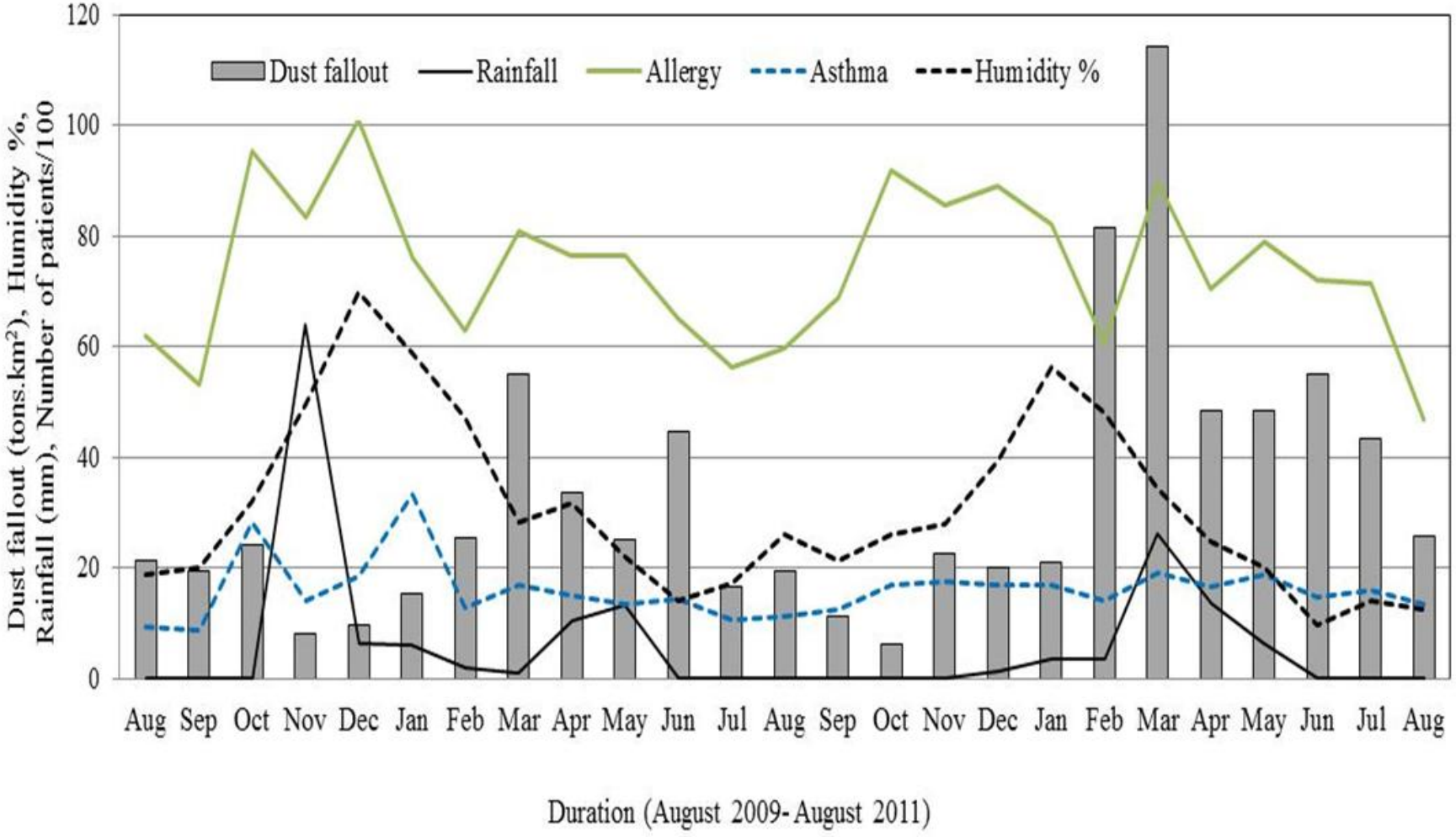
Moisture content in dust



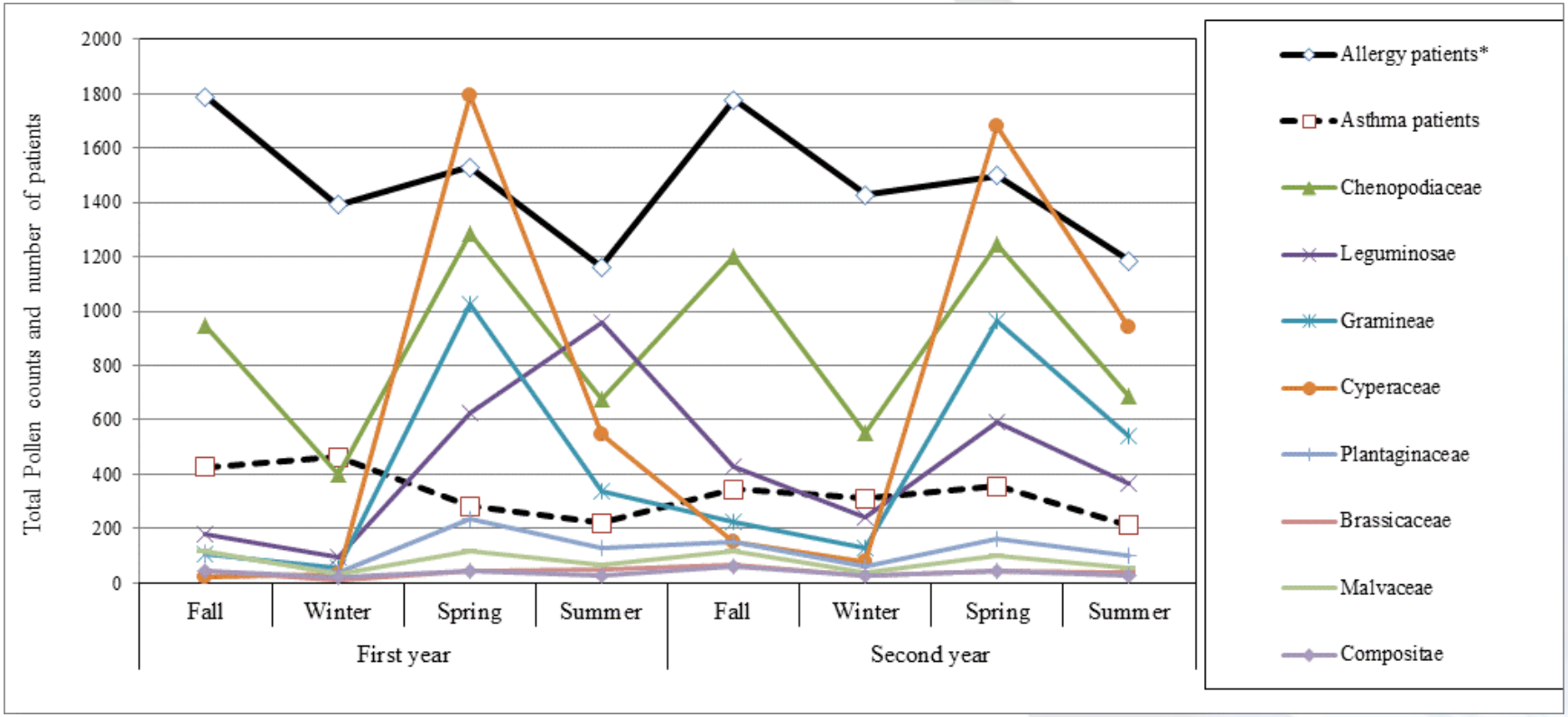
Cyperaceae pollen Winter and summer



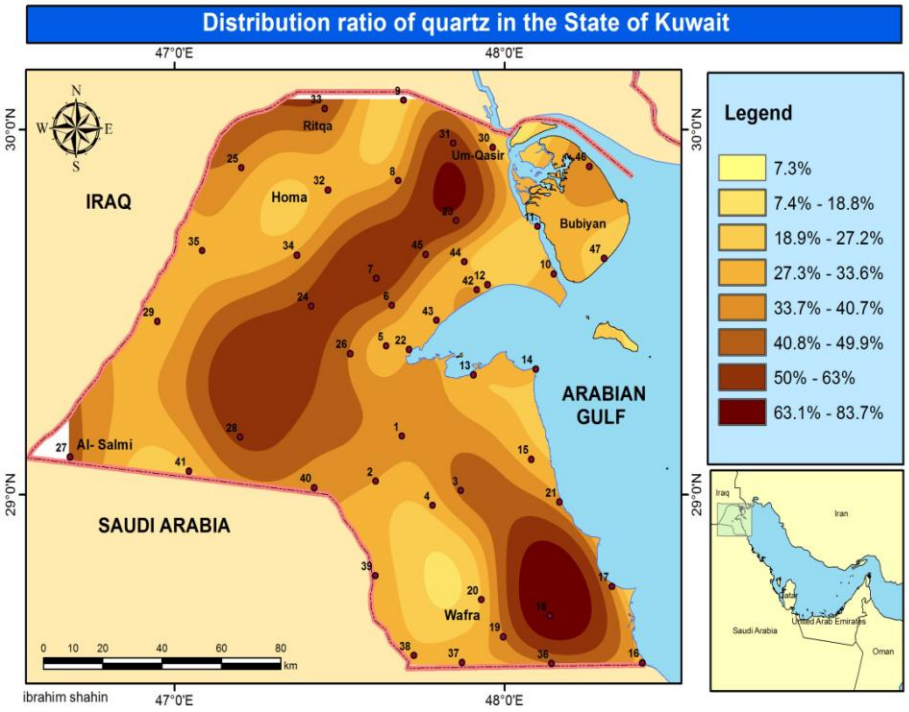


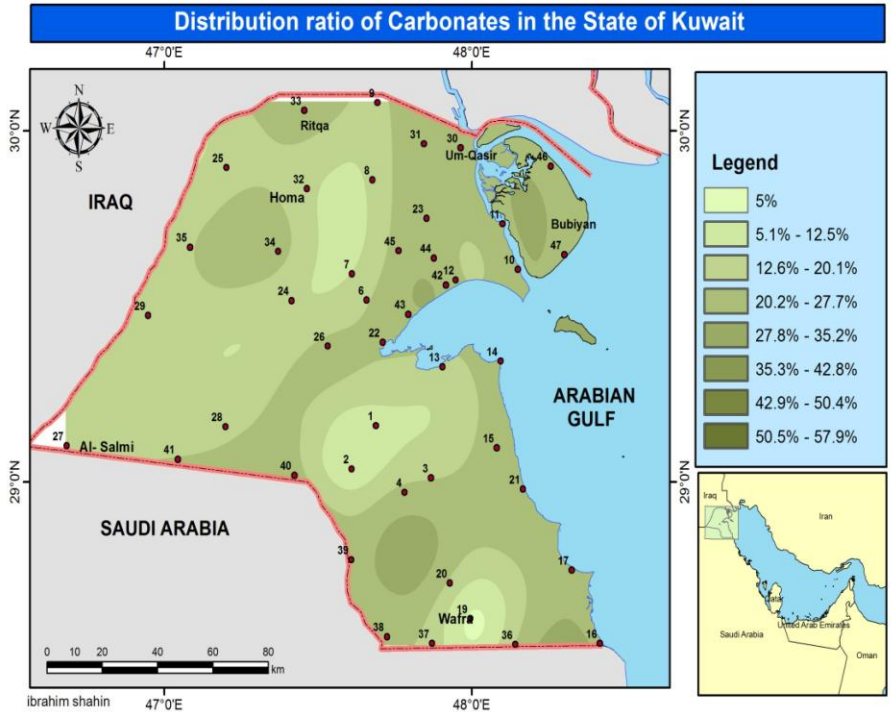

Dust fallout
Rainfall
Allergy
Asthma
Humidity %
Dust fallout (tons.km2), Humidity %, Rainfall (mm), Number of patients/100
120
100
80
60
40
20
0
Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug
Duration (August 2009- August 2011)

Pollen family counts for two years concerning the number of allergy and asthma patients



Mineralogy (Quartz and Carbonates %)





Iron (Fe) in ppm

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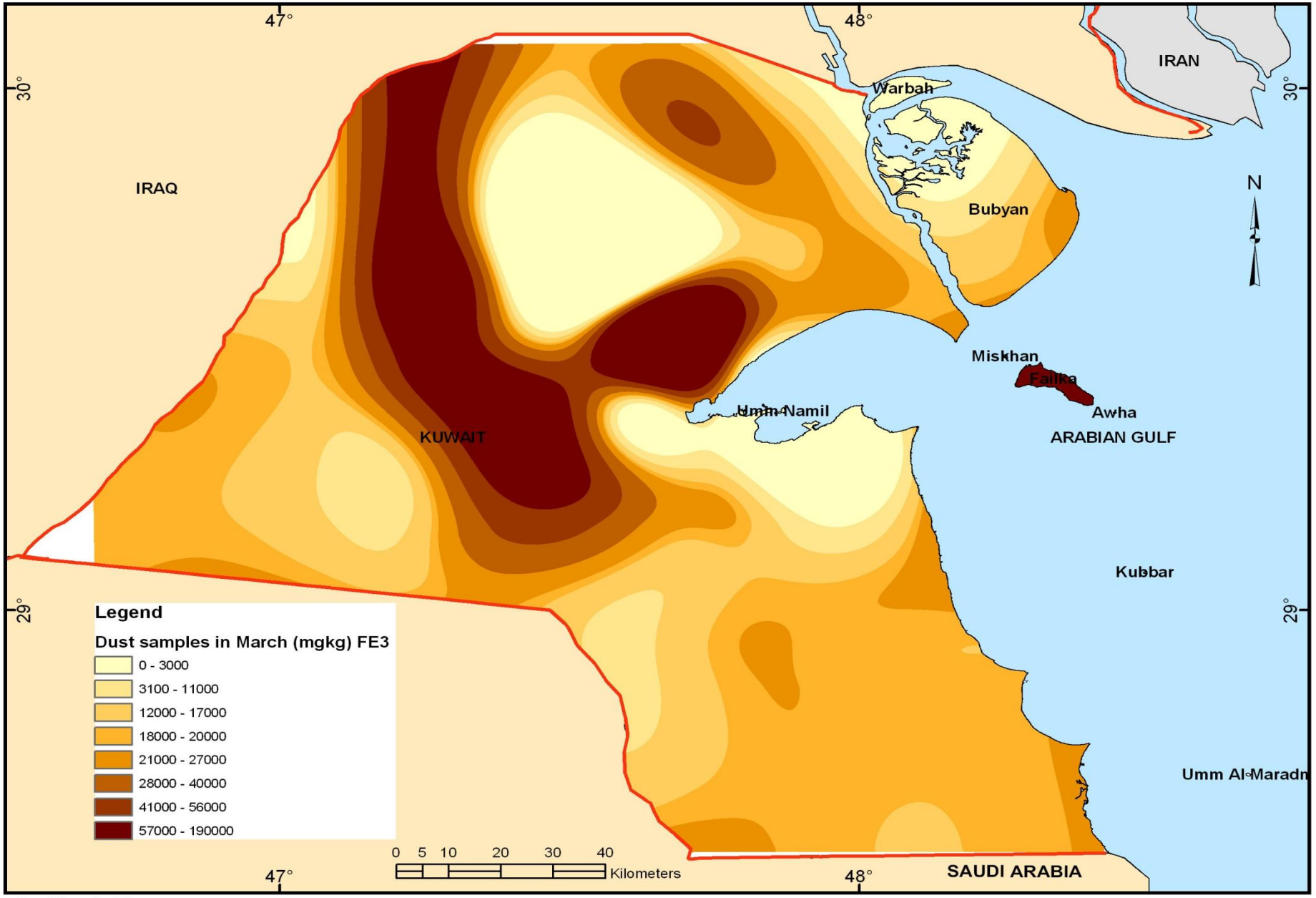
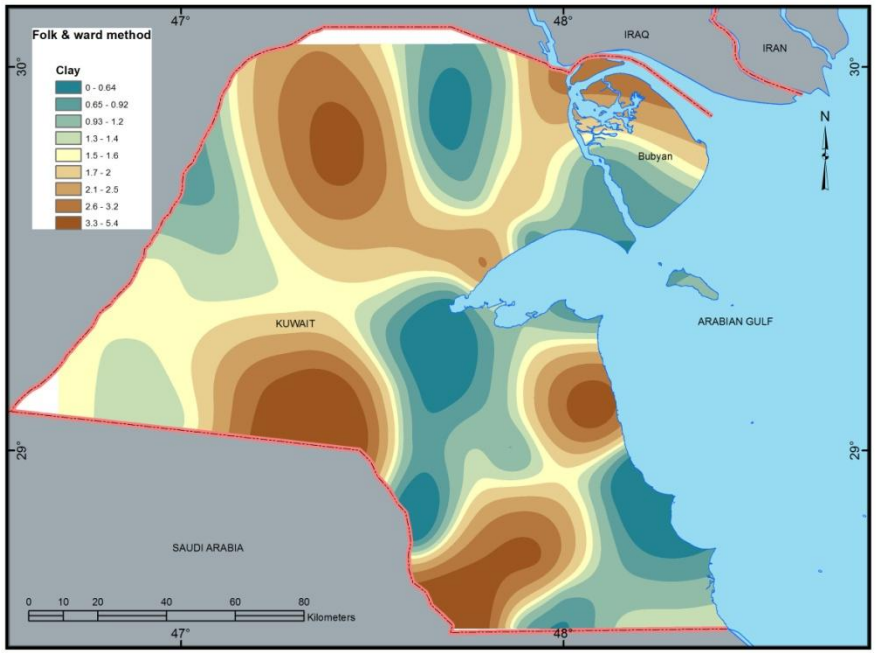
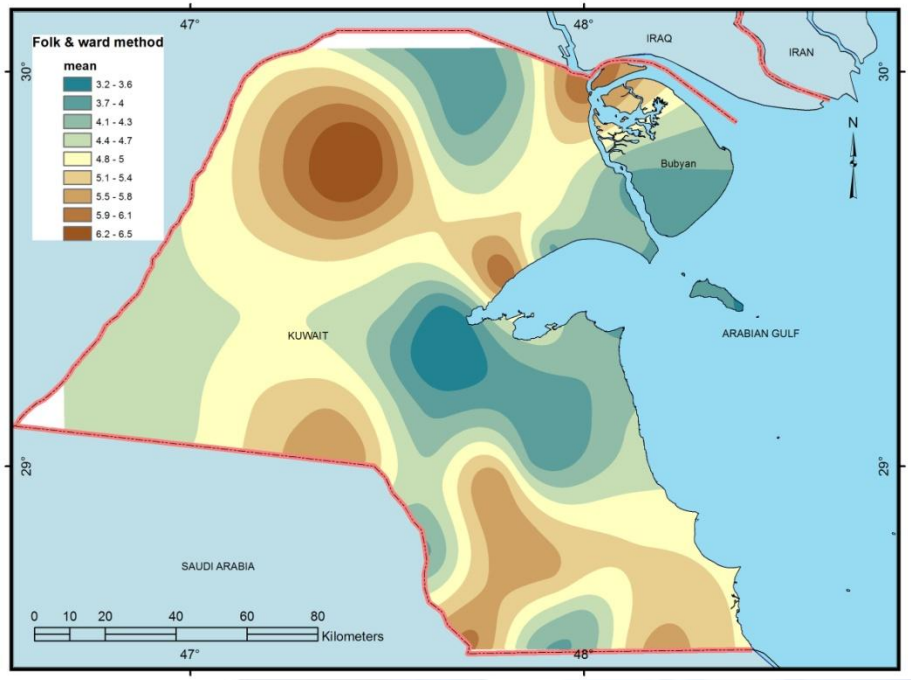
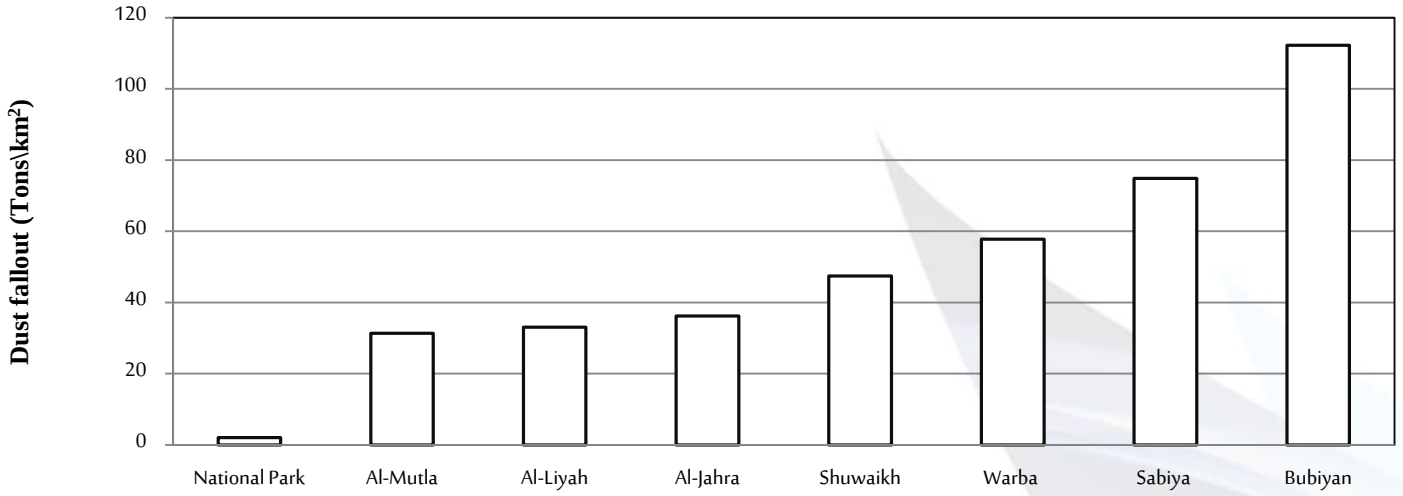


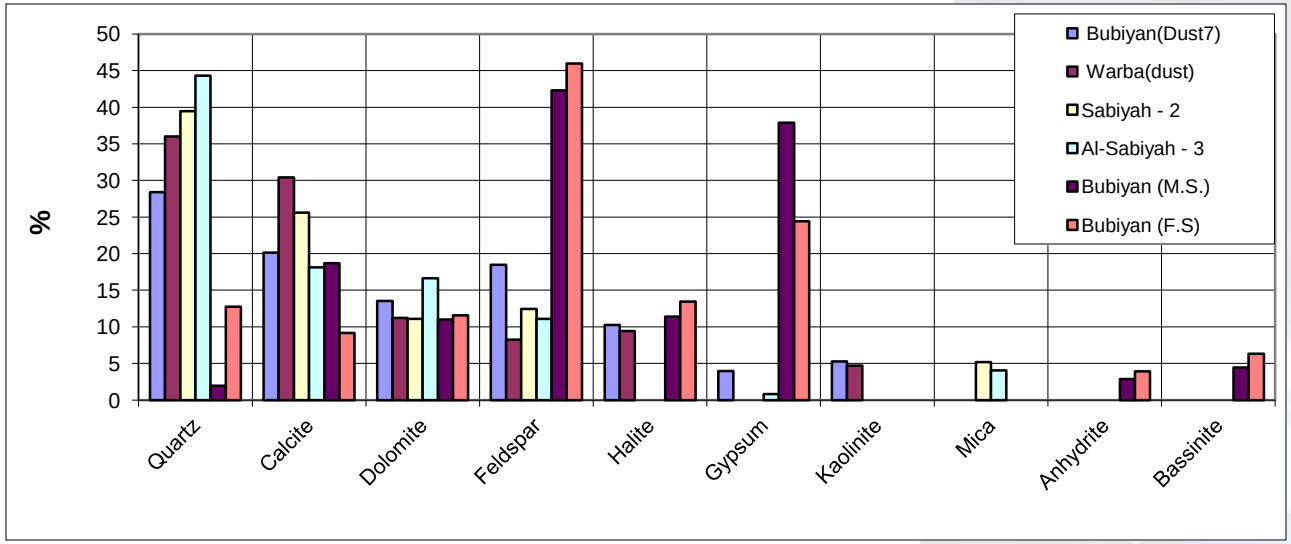
ibrahim shahin

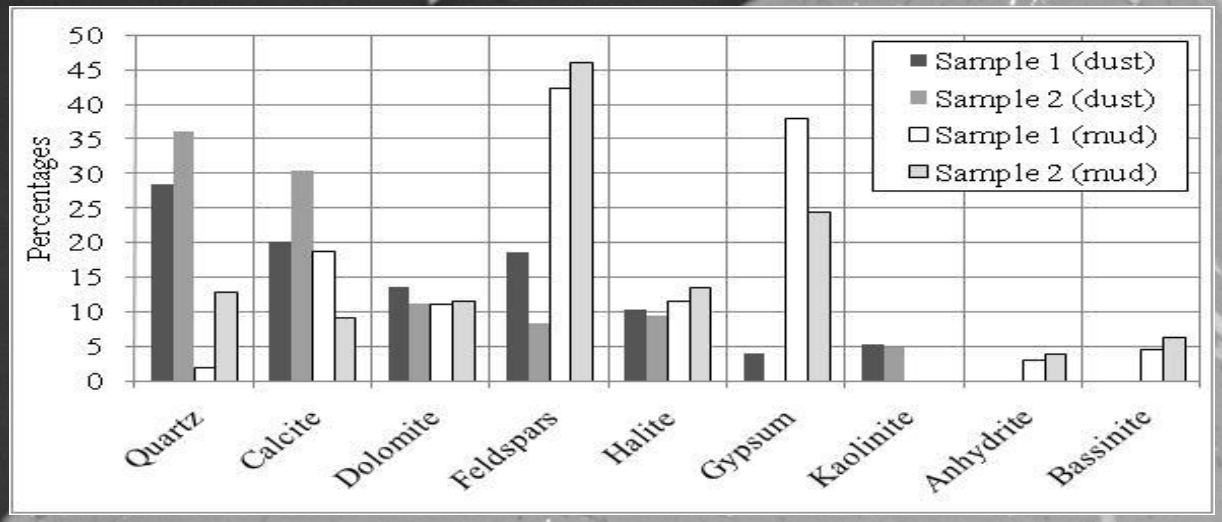
Clay % and mean particle size

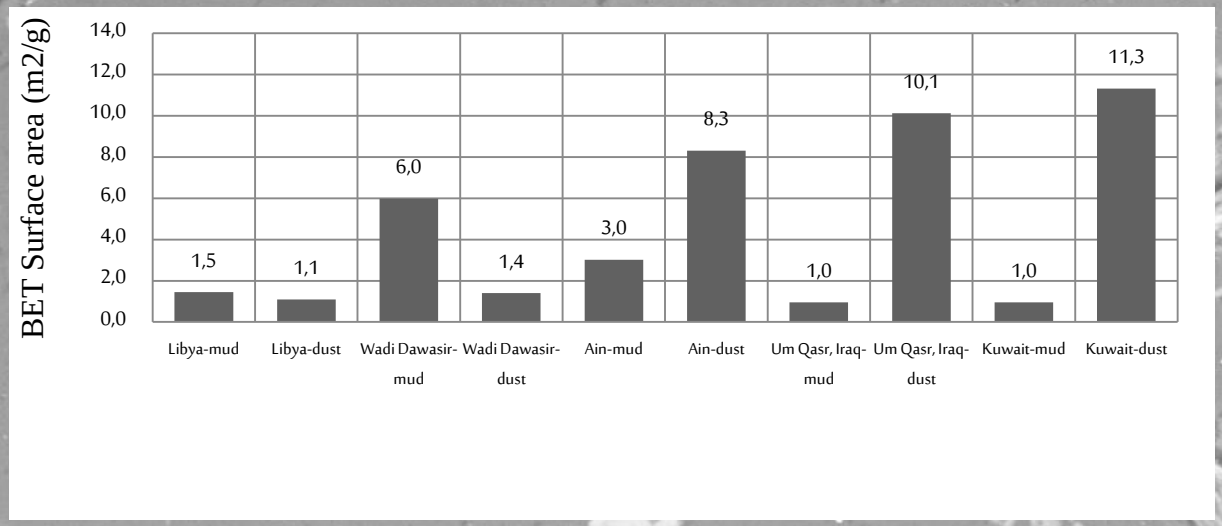





Dust fallout (Tons\km²)
120
100
80
60
40
20
0
National Park
Al-Mutla
Al-Liyah
Al-Jahra
Shuwaikh
Warba
Sabiya
Bubiyan

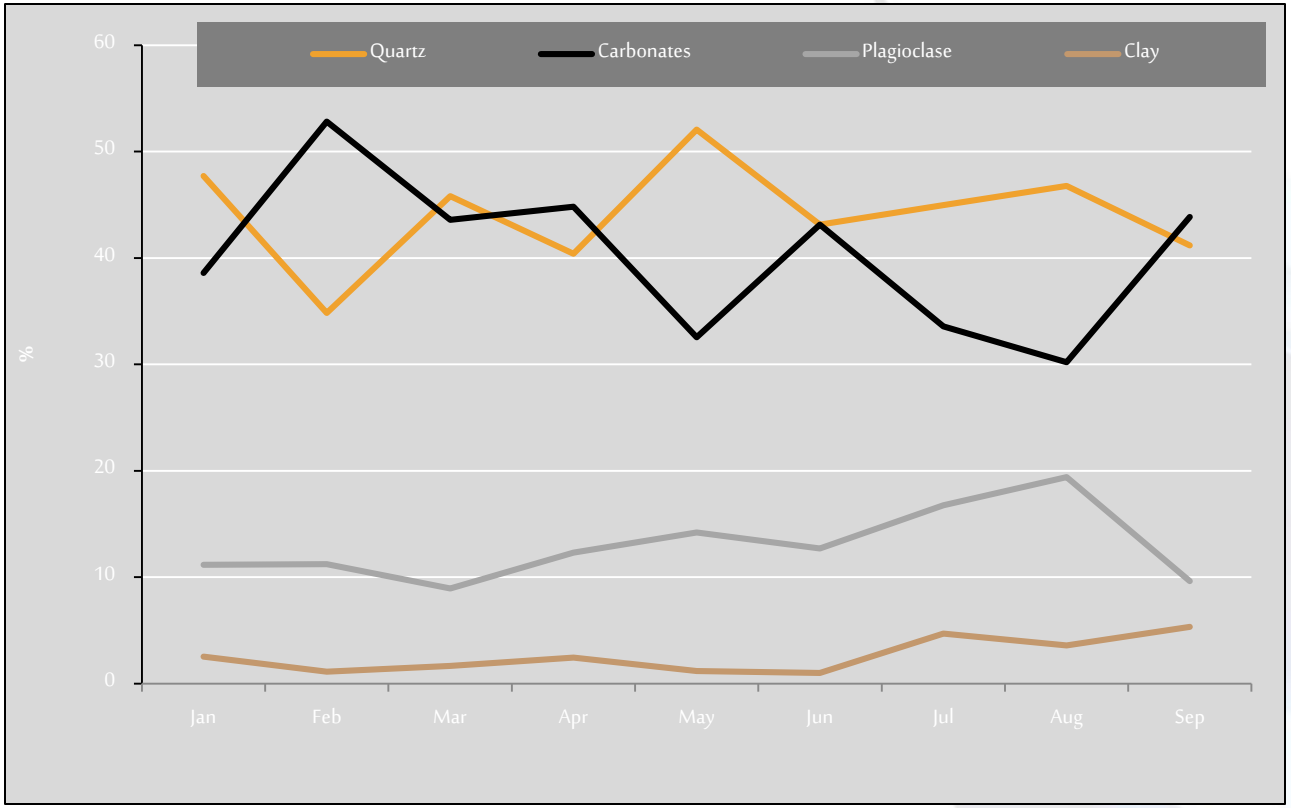

%
50
45
40
35
30
25
20
15
10
5
0
Quartz
Calcite
Dolomite
Feldspar
Halite
Gypsum
Kaolinite
Mica
Anhydrite
Bassinite
Bubiyan(Dust7)
Warba(dust)
Sabiyah - 2
Al-Sabiyah - 3
Bubiyan (M.S.)
Bubiyan (F.S)



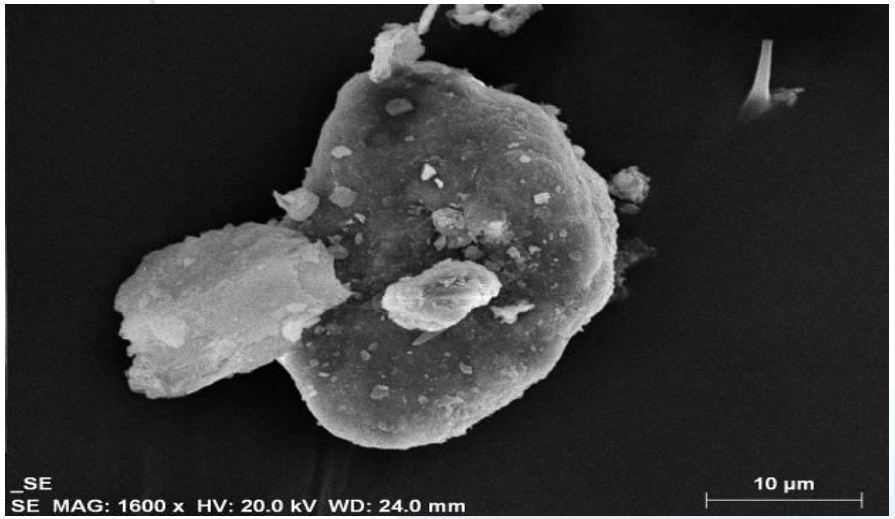


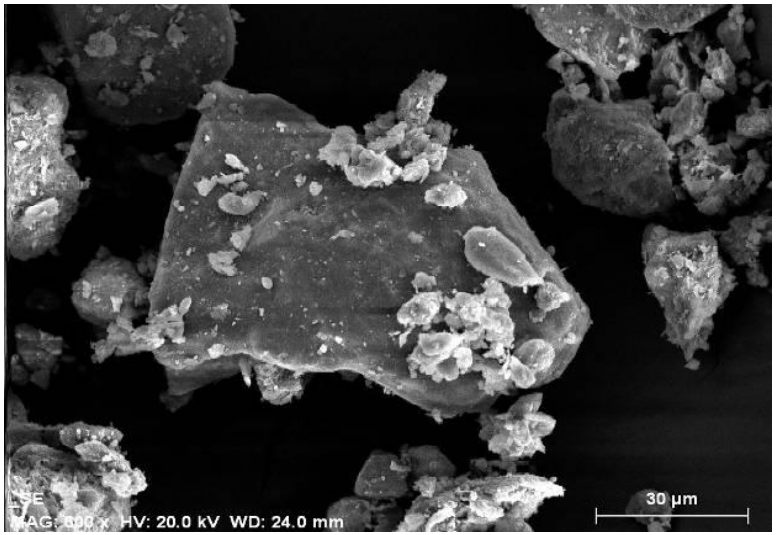
70Pa 10-Jun-02 WD14.3mm 20.0kV x500 100um

Dust Mineralogy



Smooth dust particles within West Rub Al-Khali with dominancy of very coarse silt (a), sub-angular quartz grain with some adhering carbonates particles (b), and 30 µm carbonate particles from Bubiyan with huge number of adhering gypsum and bassanite particles (c &d).





Waba & Bubiyan

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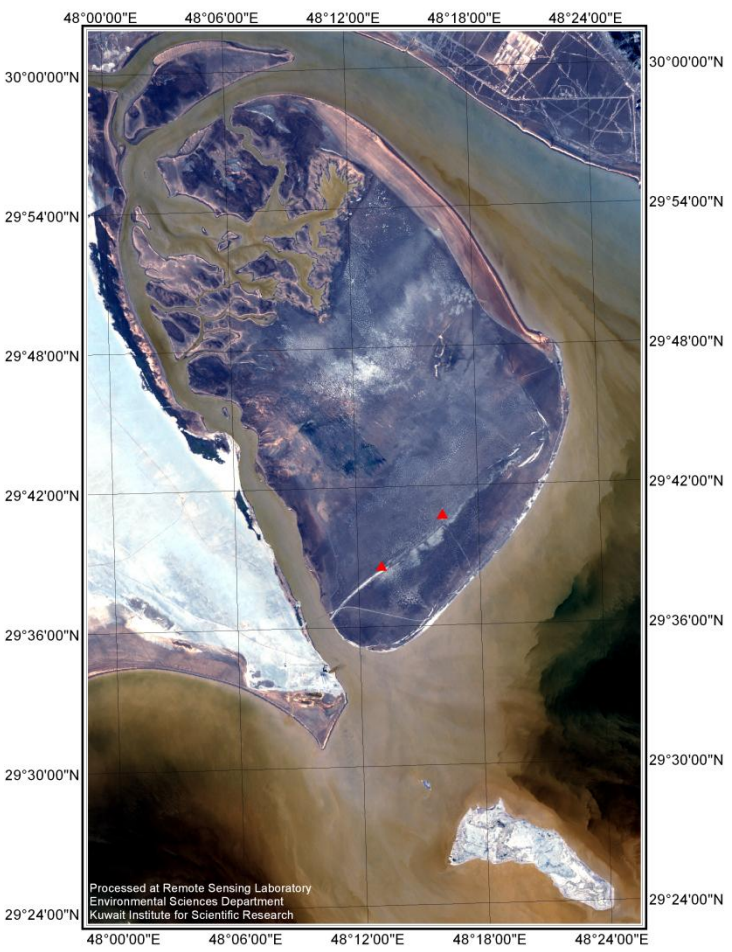
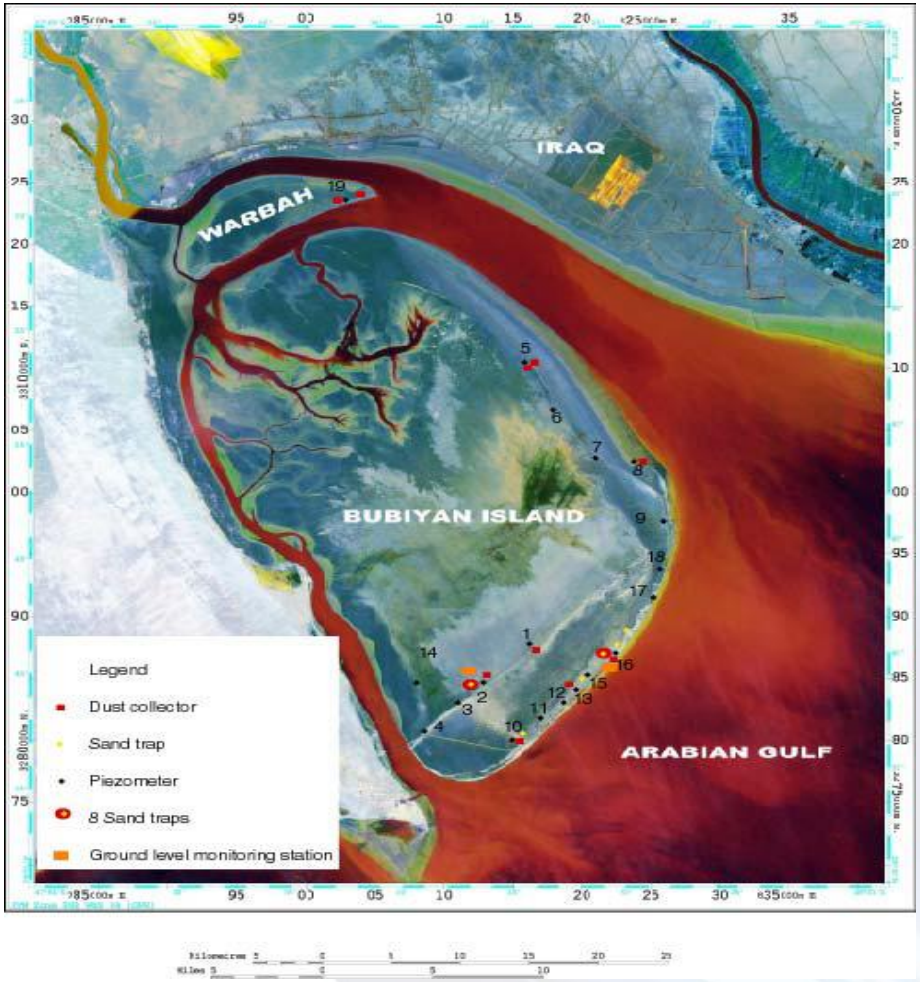
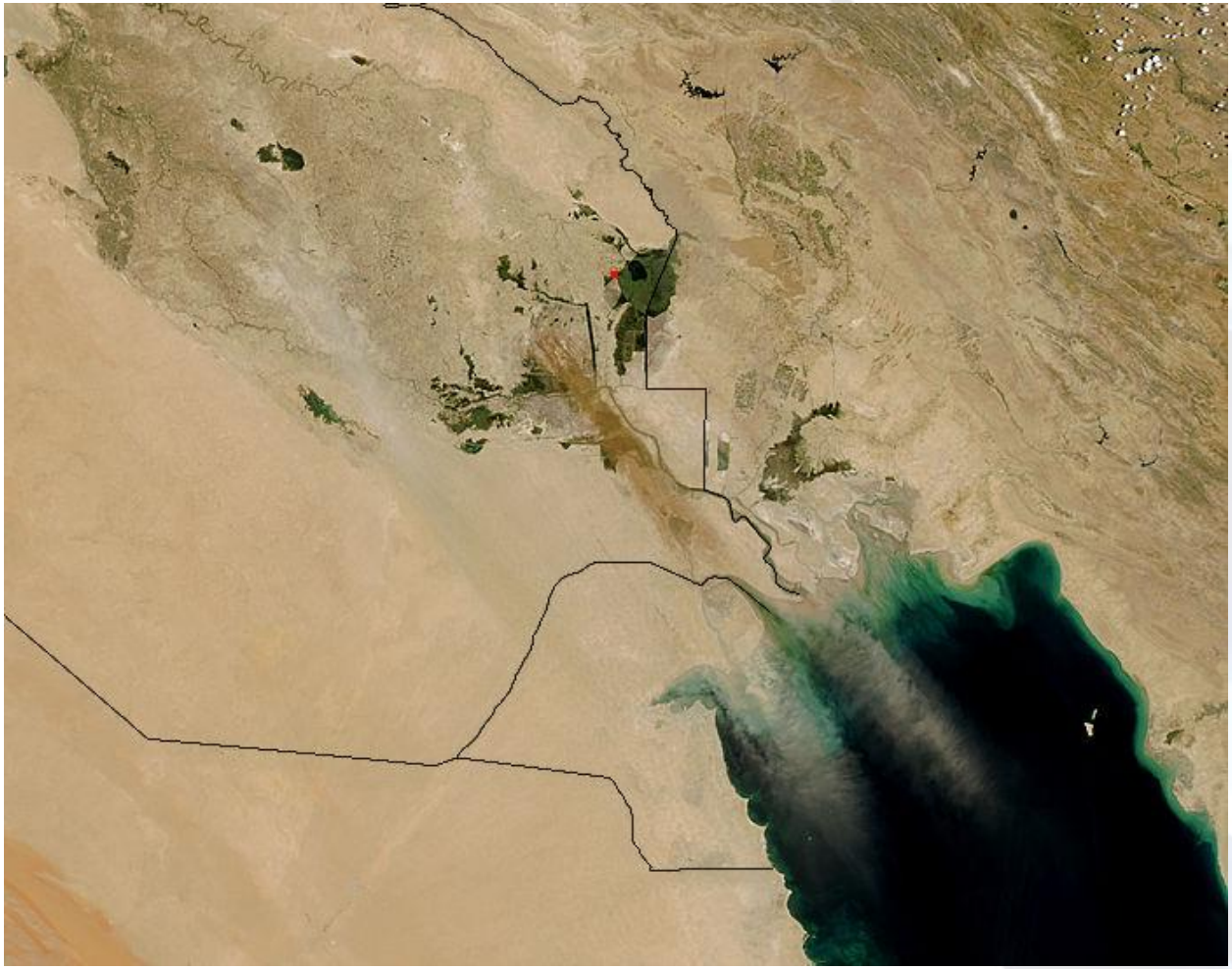


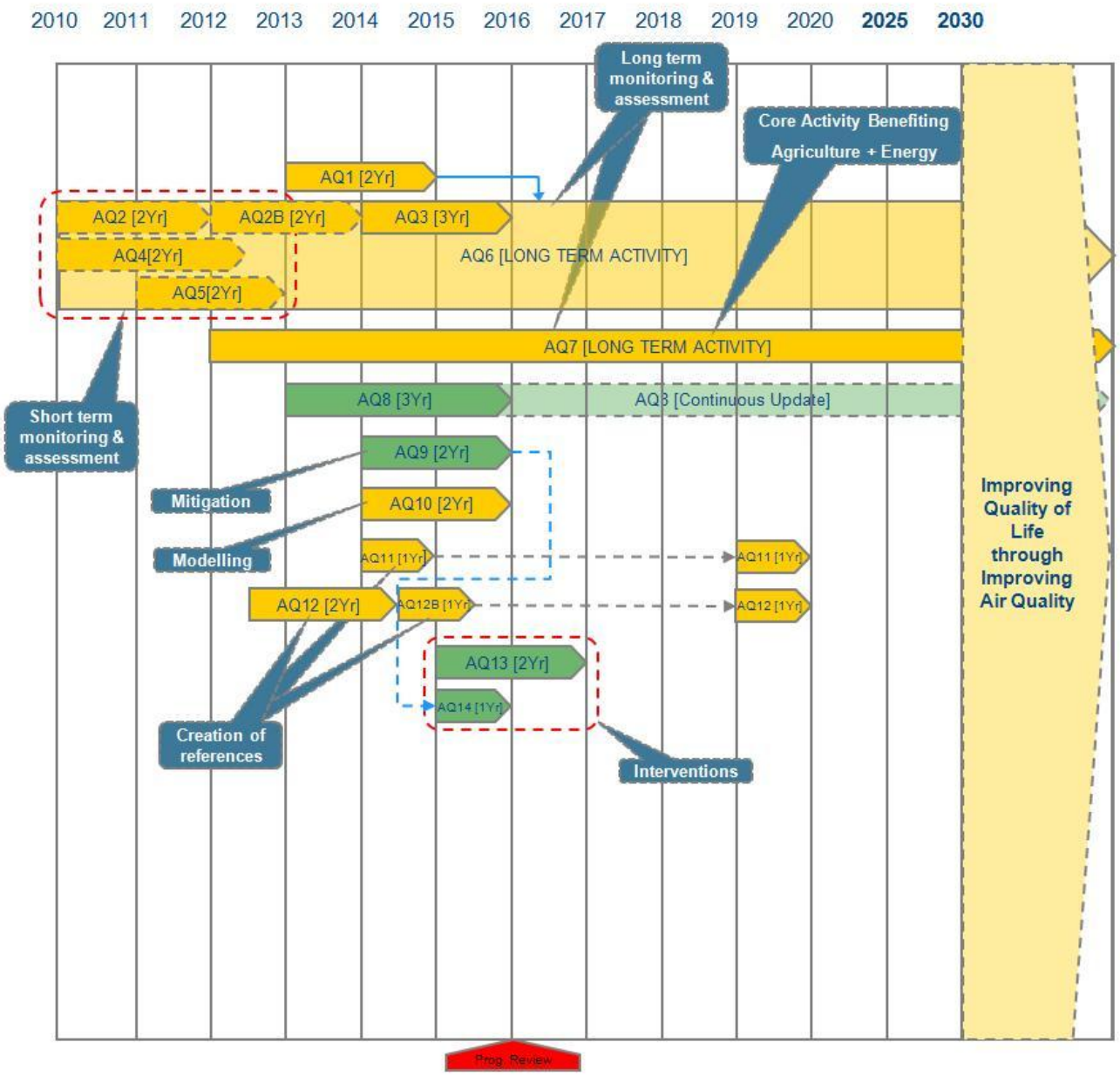


Winds blowing towards southeast picked up dust from the land and carried it out over the Arabian Gulf -Aqua MODIS image from June 18, 2005.



Recommendations

- The plan for controlling dust needs the following items:
  - Preservation of the upwind areas of major Cities and source areas of dust.
  - preservation needs to cover playas, wadis, sabkhas, salt marches and tidal flats.
  - Green belts need to be made in upwind to urban areas in order to reduce the high wind speed.
  - Human awareness is needed (for example by doing friendly environmental camping, presentations based on environmental protection in schools etc.).



AQ1 - Develop a Tailor-Made Air Quality Monitoring & Data Collection System [KEPA's] with QC/QA Measures.

AQ2 - Monitoring & Assessment of Dust Fallout & Associated Pollen within the State of Kuwait (EC063C – KFAS).

AQ2B – Probability and Statistical Analysis of Total Suspended Particulates in Kuwait (EC082K – KFAS).

AQ3 – Allergenic Factors Associated with Airborne Dust in Kuwait.

AQ4 - Assessment of Indoor Organic Pollutants Level in Selected Schools and Hospitals (EC045C – KFAS).

AQ5 - Air Quality Assessment of Ali Sabah Al-Salem Urban Community Phase II (EC084C – KEPA)

AQ6 – Assessment of Air Quality Data.

AQ7 – Monitoring & Assessment of Meteorological Conditions [KNMN].

AQ8 – Developing a Comprehensive Emission Inventory.

AQ9 – Control/Reduction of Emission Levels to Meet Current KEPA Standards (VOCs, NOx & SOx, GHGs) [Options for Change].

AQ10 - Develop Recognised Numerical Models to Predict Pollutants' Dispersion Rates & Pollutants' Short-Long Range Fate in Kuwait.

AQ11 - Creating an Air Quality Baseline Atlas of Kuwait (Based on Collective Measurement & Modelling).

AQ12: Extreme Wind Atlas For Kuwait *(EC078C – KFAS)*

AQ12B - Creating the Meteorological Atlas of Kuwait.

AQ13 – AQ Impact of Master-Plan for Expansion of Power Generation, Water Des. & Petroleum-Related Activities.

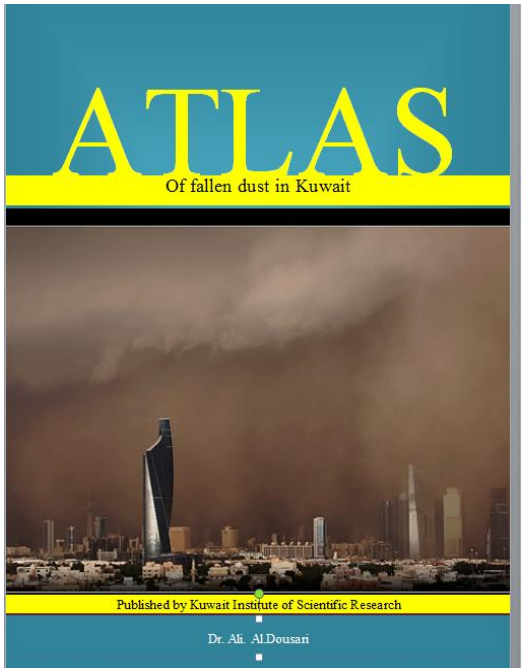
AQ14 – Recommendation for Revising & Updating Kuwaiti Air Quality Regulations and Standards and Help in Developing Appropriate Legislations.

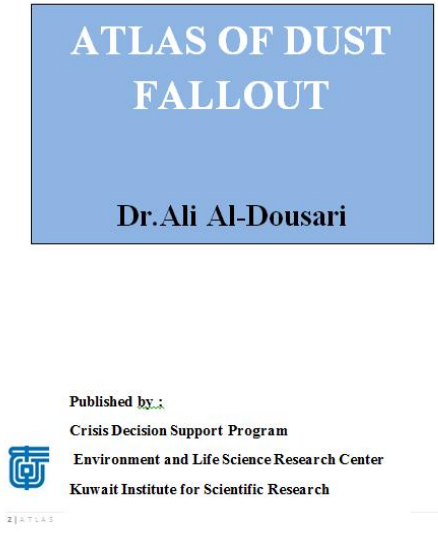
Applied Research

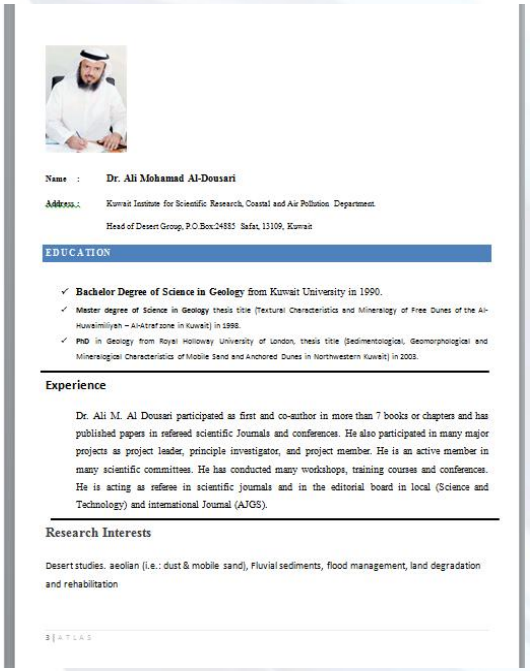
Policy

More Details

Researchgate
https://www.researchgate.net/profile/Ali_Al-Dousari/
Google scholar
http://scholar.google.com/citations?user=R5xJfXMAAAAJ&hl=en&oi=ao








THANK YOU