Dust Storms over the Arabian Peninsula: Sources, Transport, Site Visit, Health, and Rehabilitation

Dr. Ali Al-Hemoud, Ph.D., CIH, CSP
Environment & Life Sciences Center
Kuwait Institute for Scientific Research

Contents

1. Dust Storms over the Arabian Peninsula (2010 – 2018)
2. Dust source areas affecting Kuwait (2007 – 2018)
3. Diurnal variation of dust storms
4. Health studies – PM_{10} and $PM_{2.5}$
5. Source rehabilitation

Methodology

1. High resolution MODIS Aqua and Terra 250 m/pxl
2. NOAA HYSPLIT backward trajectories
3. Soil sampling from ‘hot spot’ in Iraq
4. WHO AirQ^{+} model

Dust Definitions

Aeolian dust is characterized (in Kuwait, see next slide for other definitions) using combinations of wind speed and visibility into three types:

1. Dust Storms (visibility ≤1,000 m and wind speed ≥8 m/s)
2. Rising or blowing dust (visibility ≥1,000 m and wind speed ≥8 m/s)
3. Suspended or dust haze (visibility ≤5,000 m and wind speed ≤8 m/s)

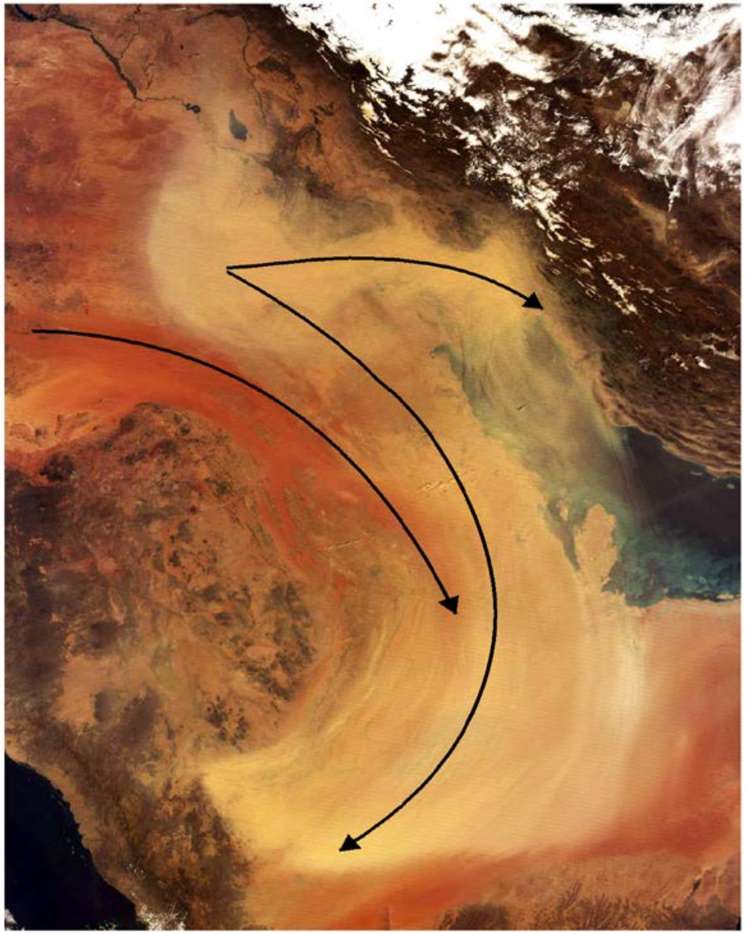
Dust storms are further subdivided into three categories:

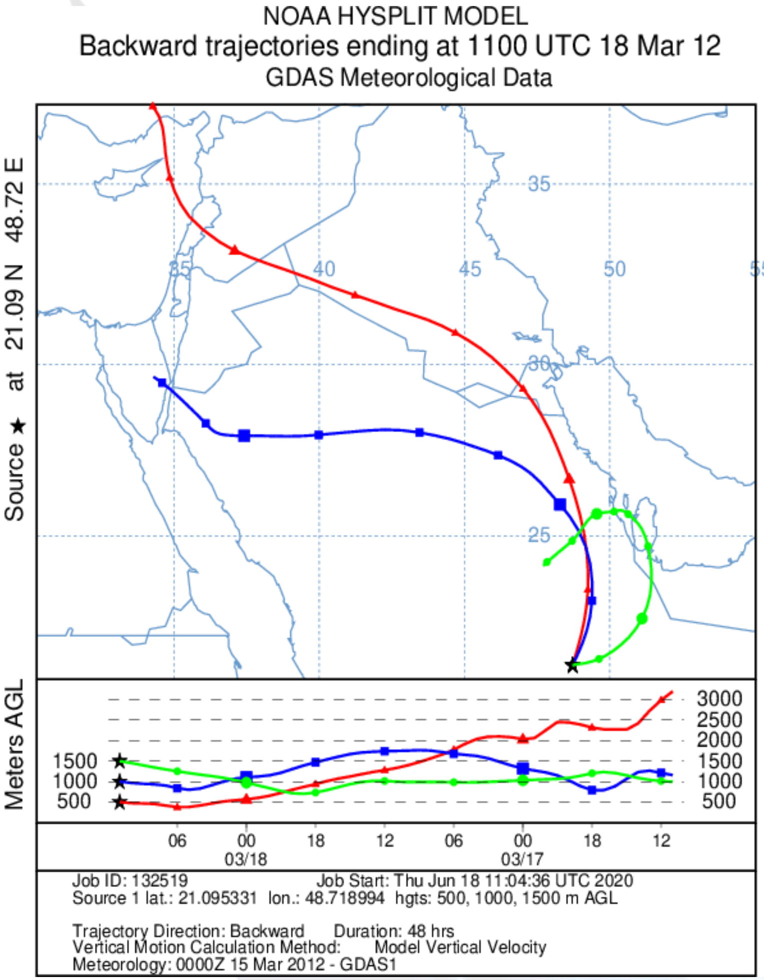
1. Severe dust storm (visibility: 0-200 m)
2. Moderate dust storm (visibility: 200-600 m)
3. Minimum dust storm (visibility: 600-1,000 m).

Dust Definitions

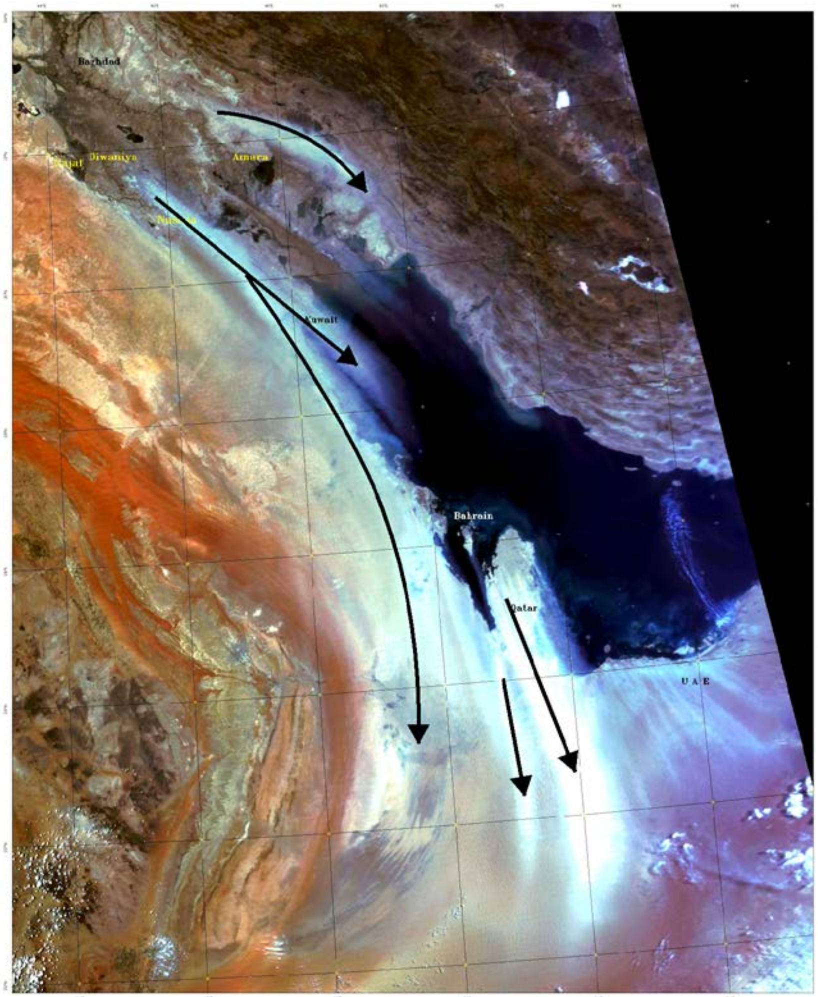
	Visibility (m)	Wind Speed (m/s)	PM_{10} (μg/m³)	Source
Dusty air (DA)	> 2000	–	50–200	Hoffmann et al., 2008a,b
Light dust storm (DS1)	< 2000	–	200–500	
Dust storm (DS2)	< 1000	> 17	500–2000	
Strong dust storm (DS3)	< 200	> 20	2000–5000	
Serious strong DS (DS4)	< 50	> 25	> 5000	
Dust storm	The result of turbulent winds raising large quantities of dust into the air and reducing visibility to less than 1000 m.			McTainsh and Pitblado, 1987
Blowing Dust	Raised by winds to moderate heights above the ground reducing visibility at eye level (1.8 m), but not to less than 1000 m.			
Dust Haze	Produced by dust particles in suspended transport which have been raised from the ground by a dust storm prior to the time of observation.			
Dust storm or sandstorm	An ensemble of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind.			World International Organizational (WMO) - International Cloud Atlas. https://cloudatlas.wmo.int/en/drifting-and-blowing-dust-or-sand.html
Drifting and blowing dust or sand	An ensemble of particles of dust or sand raised, at or near the observation site, from the ground to small or moderate heights by a sufficiently strong and turbulent wind.			
Dust Haze	A suspension in the air of dust or small sand particles, raised from the ground prior to the time of observation by a dust storm or sandstorm. The dust storm or sandstorm may have occurred either at or near the observation site or far from it.			

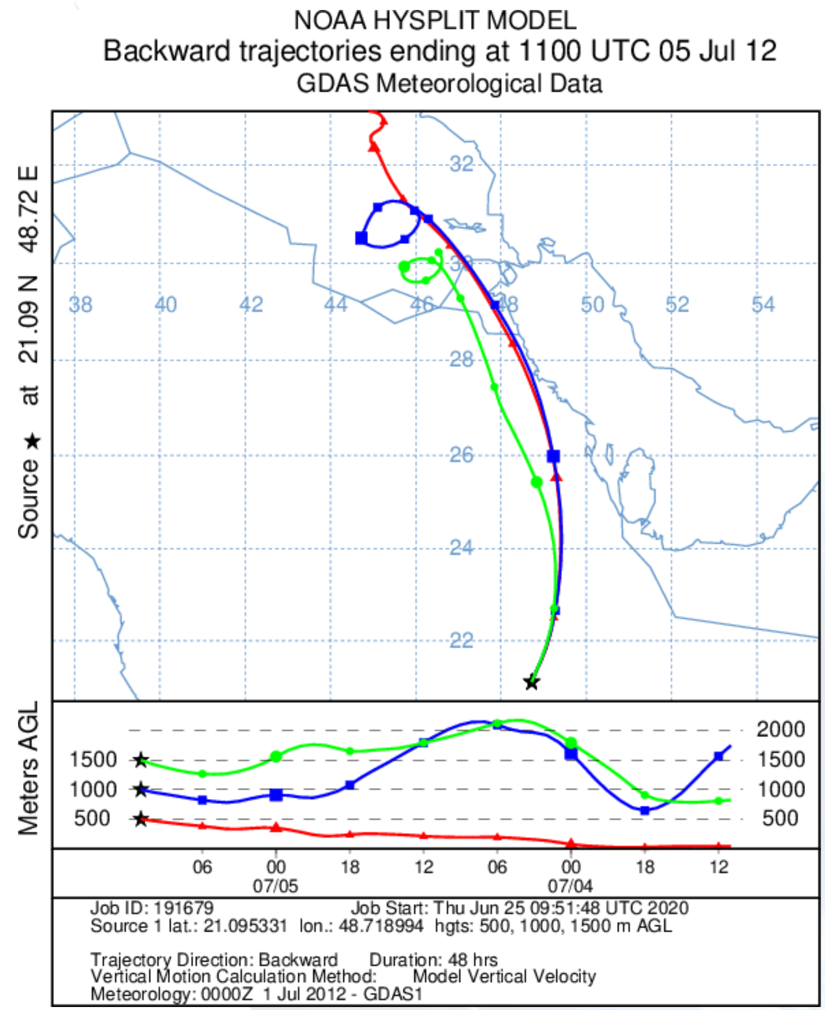
1. Sources and Transport Pathways over Arabian Peninsula





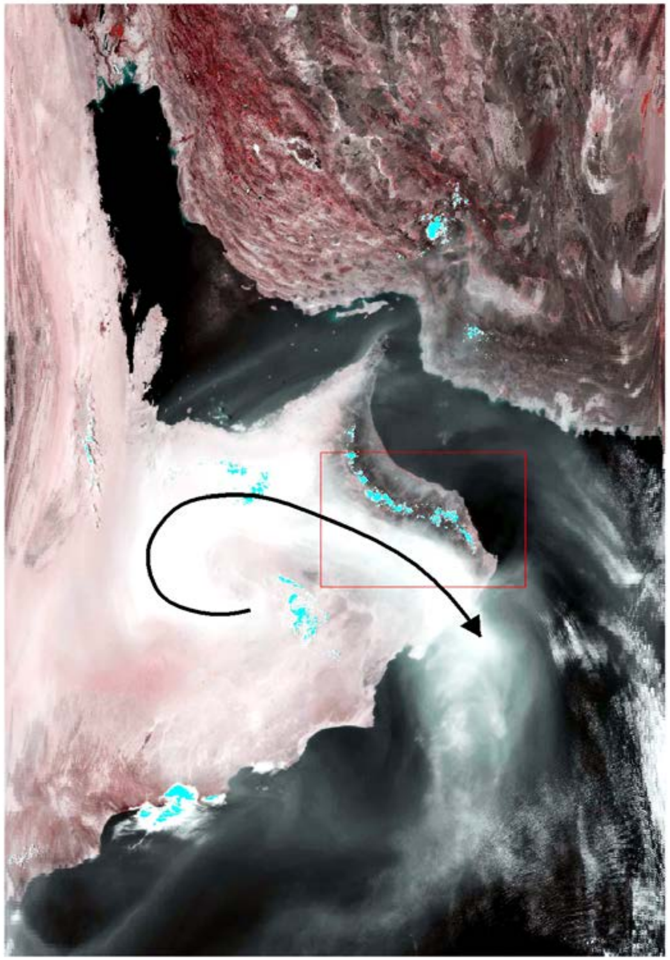
1. Sources and Transport Pathways over Arabian Peninsula

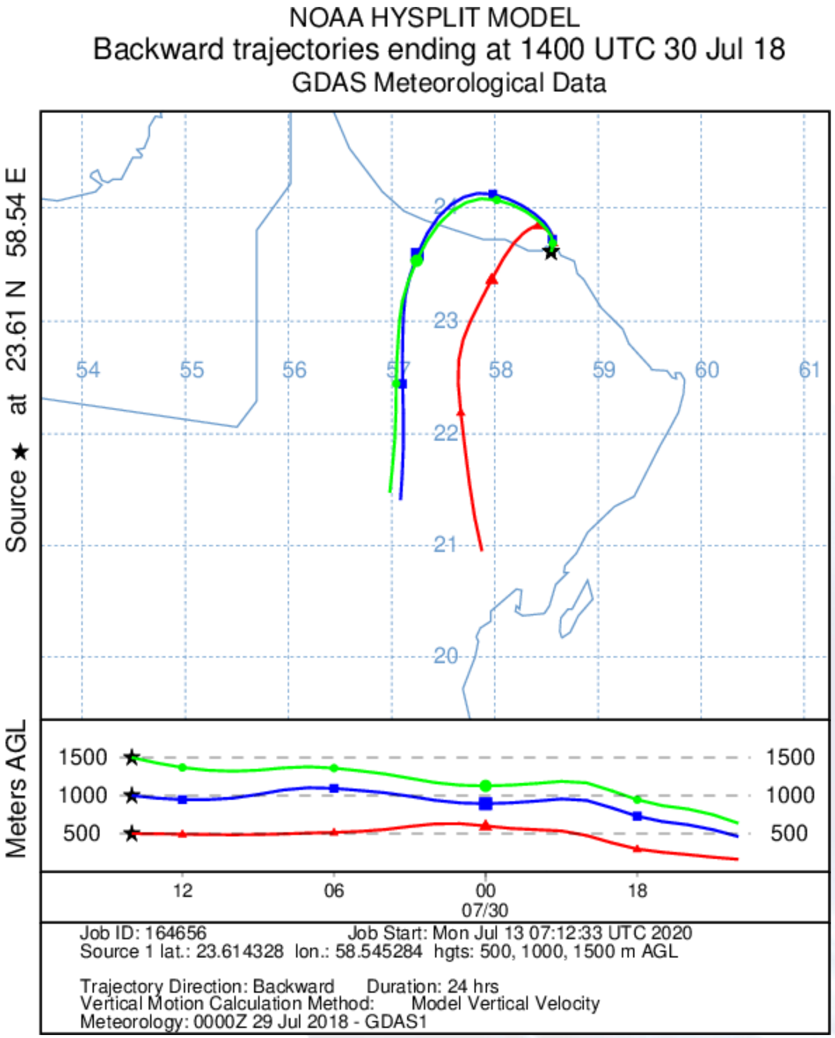




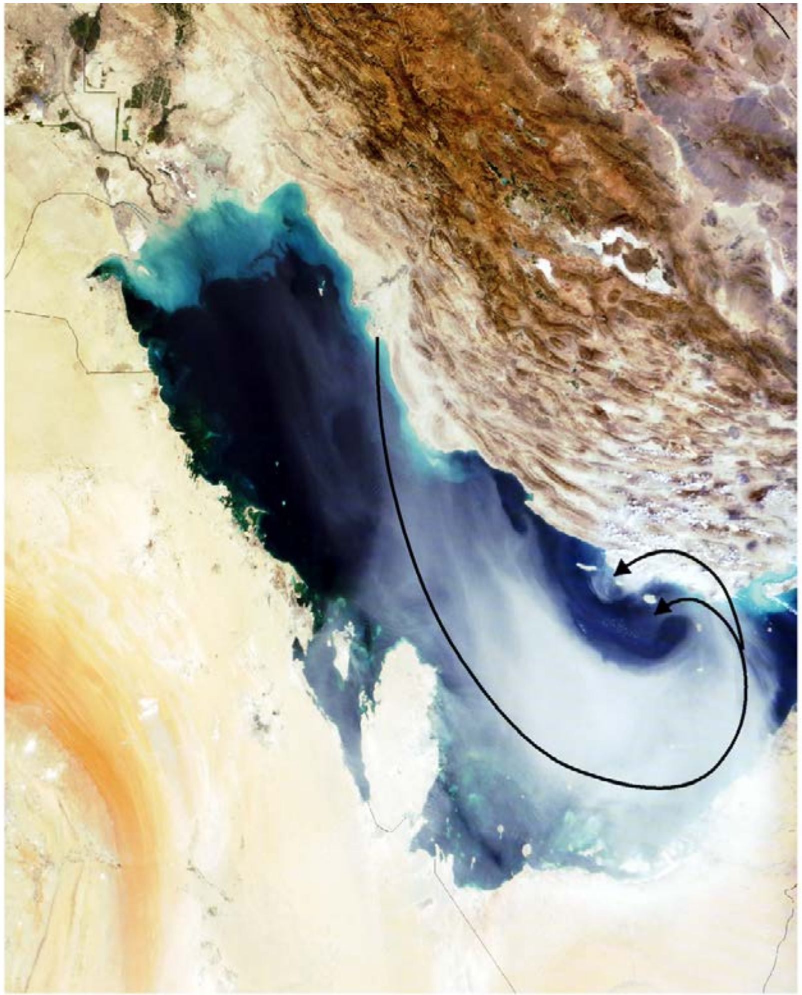
1. Sources and Transport Pathways over Arabian Peninsula

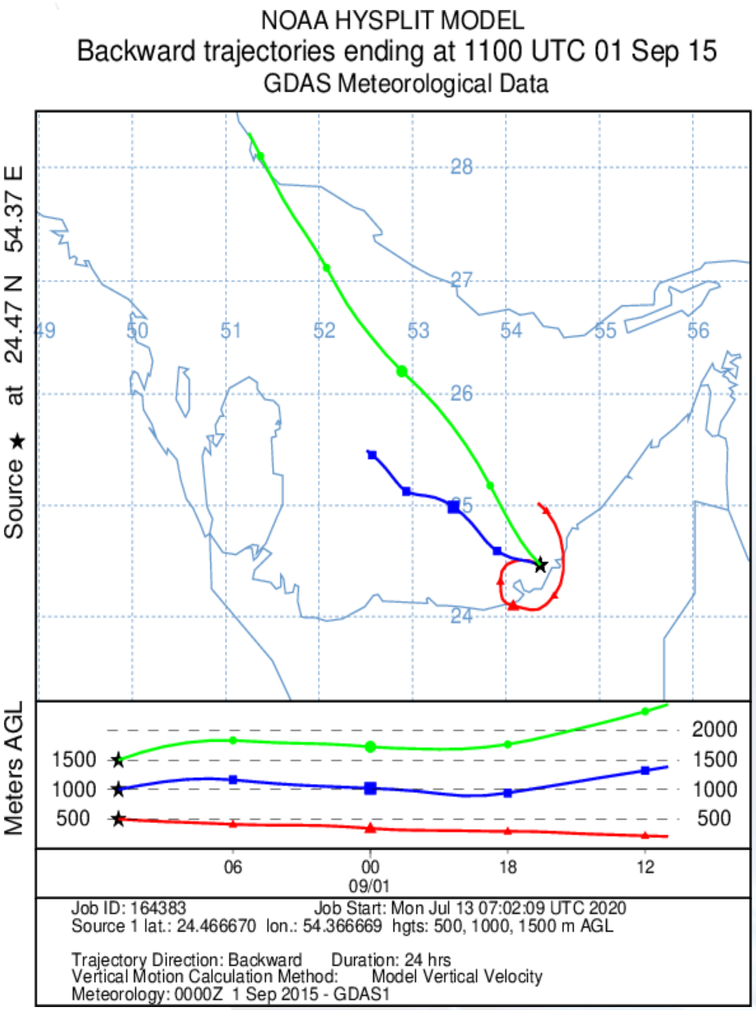
KISR
Kuwait Institute for Scientific Research



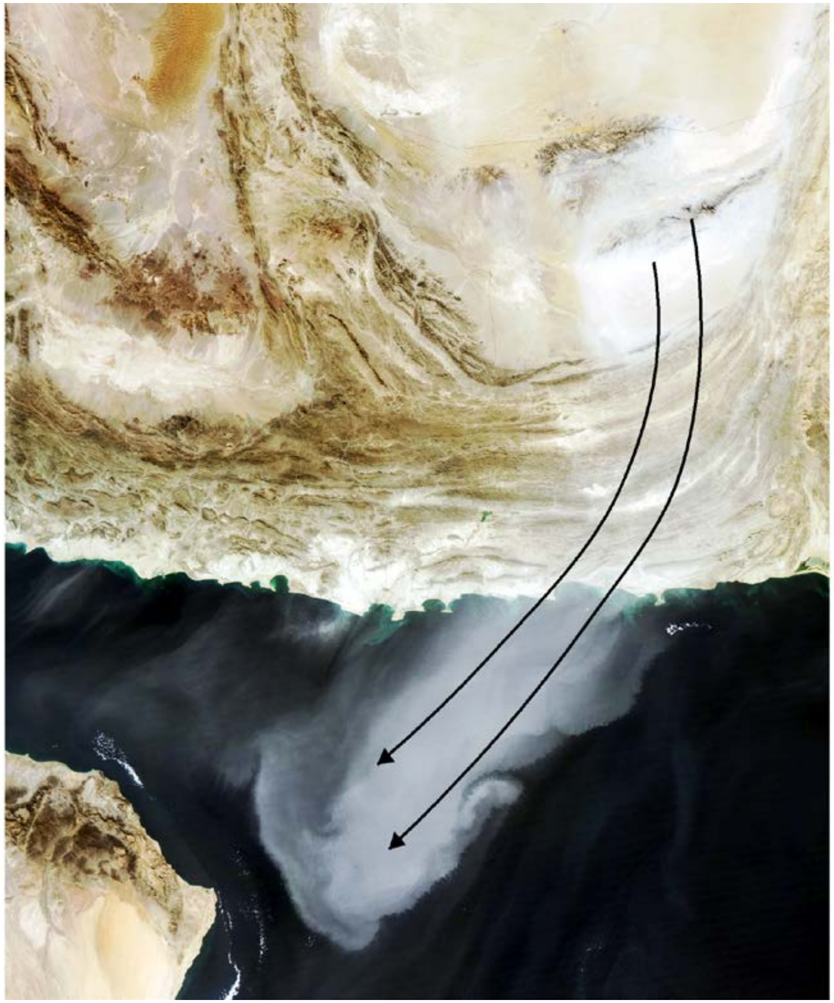


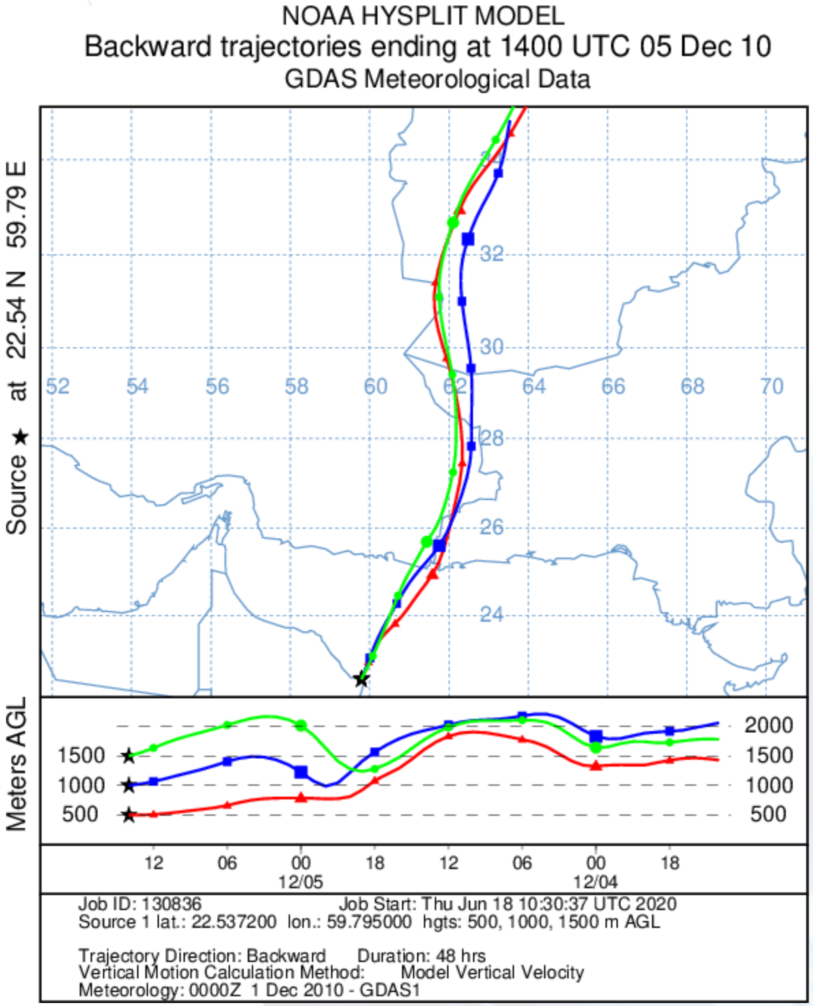
1. Sources and Transport Pathways over Arabian Peninsula



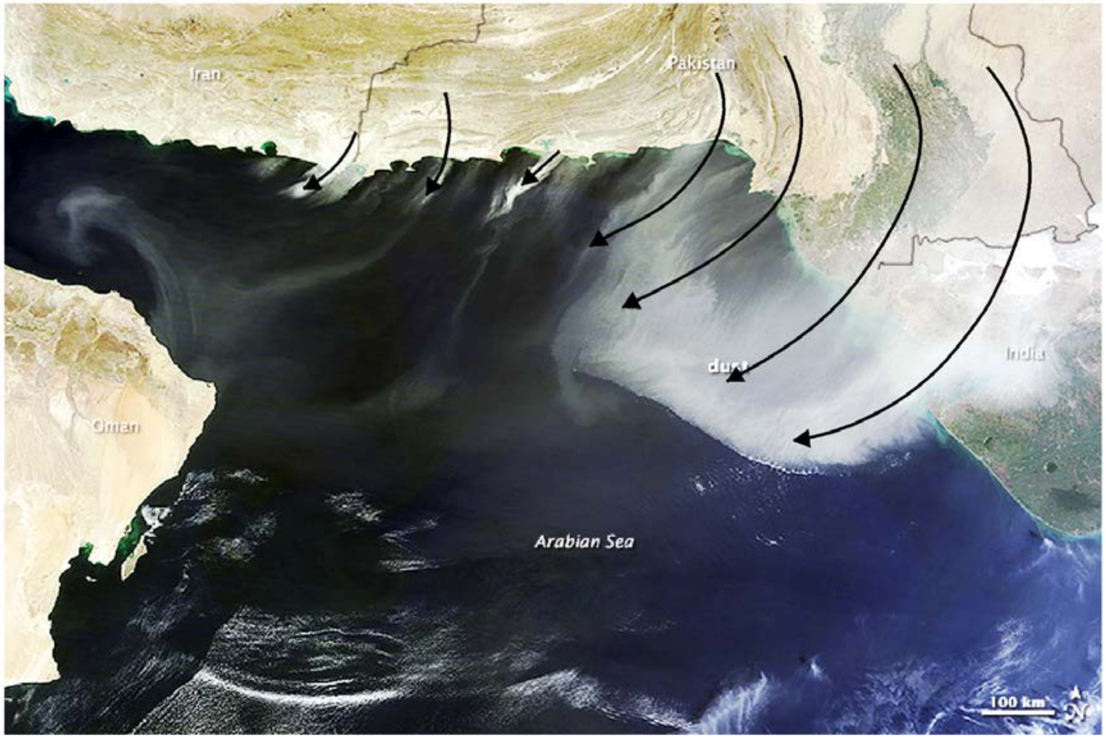


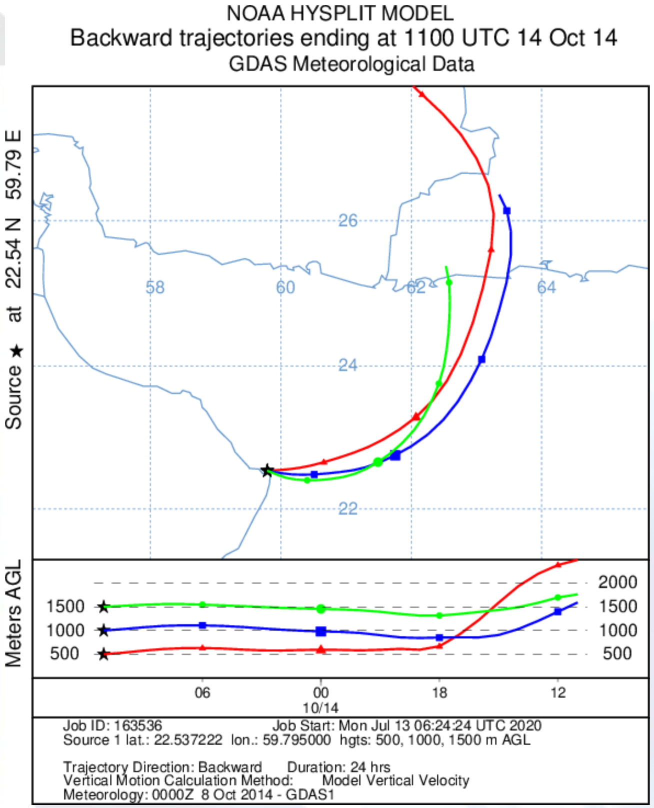
1. Sources and Transport Pathways over Arabian Peninsula



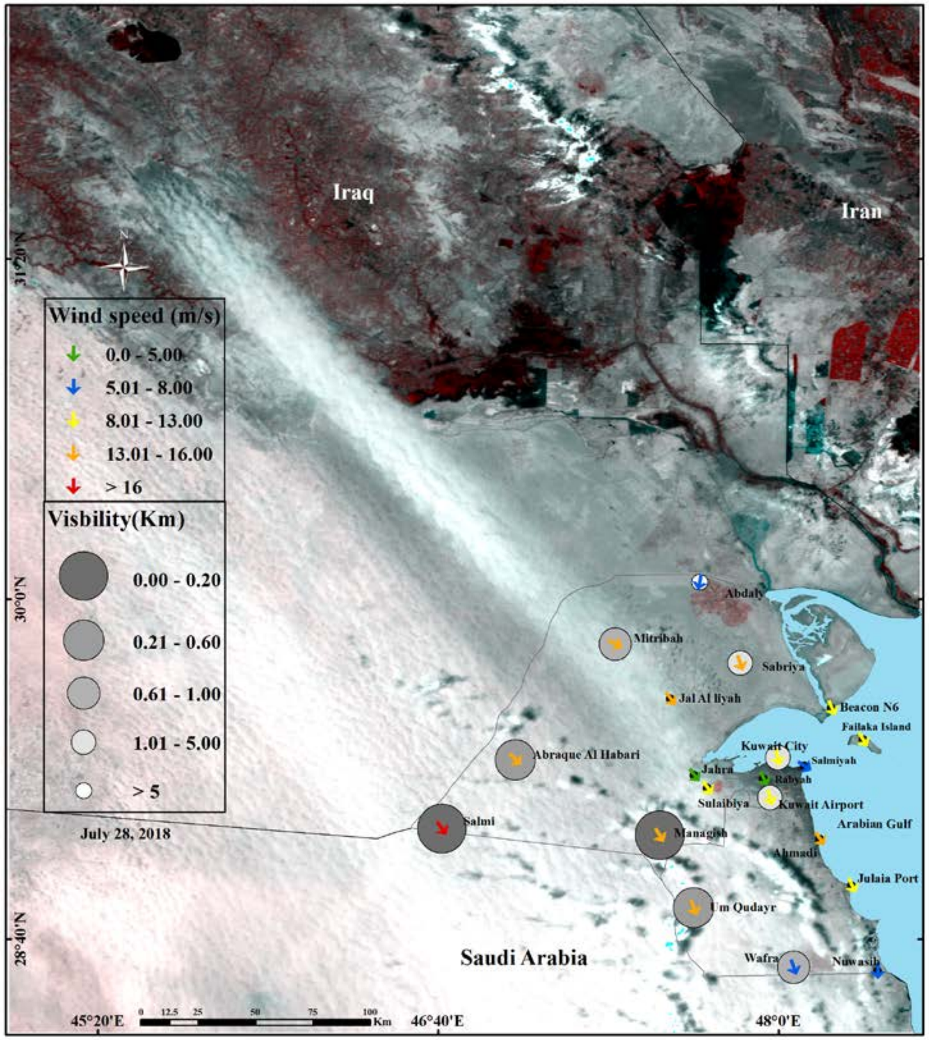


1. Sources and Transport Pathways over Arabian Peninsula

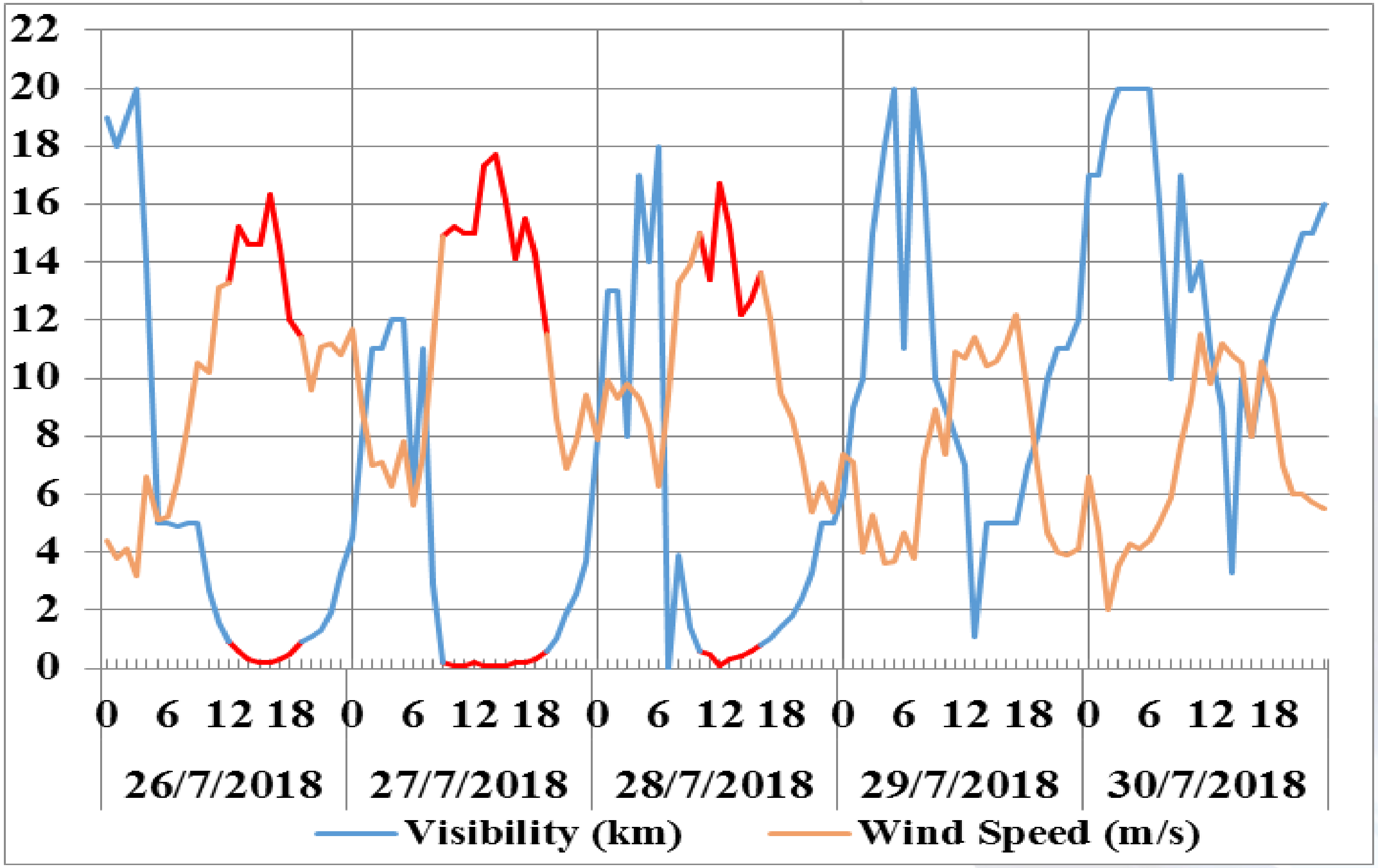




2. Sources and Transport Pathways over Kuwait

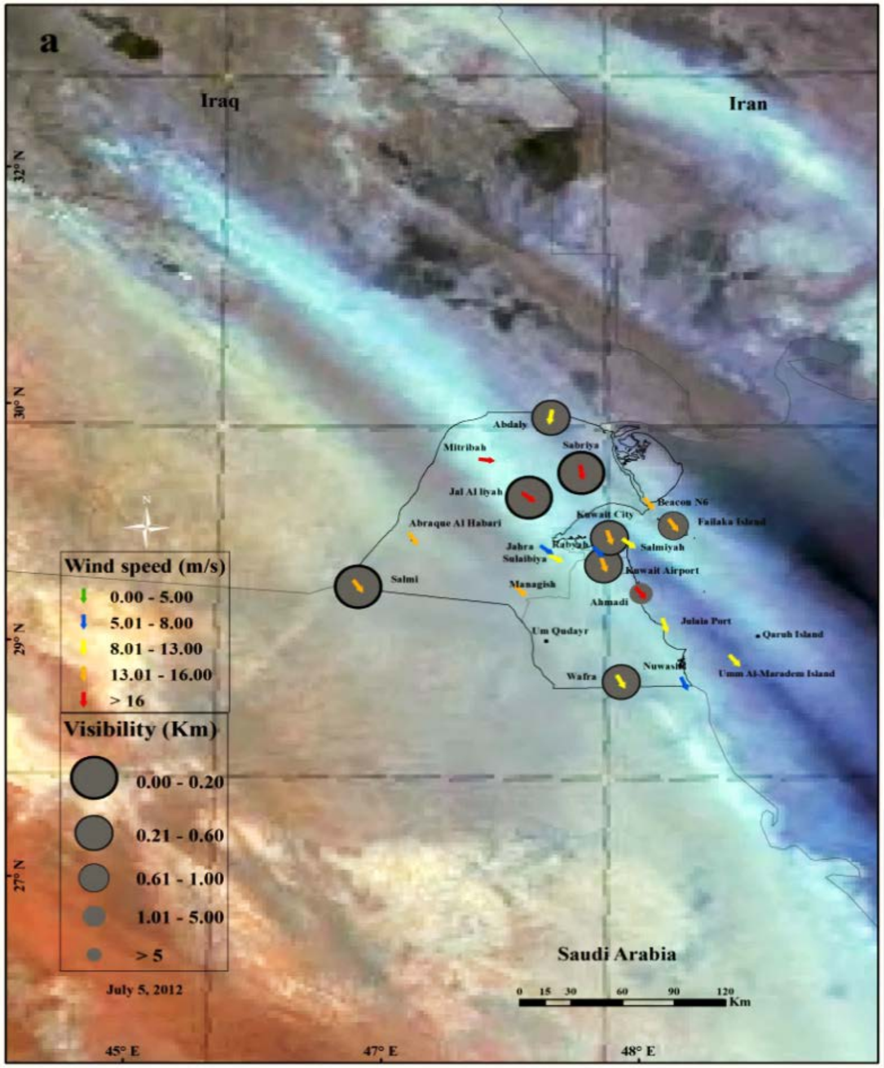


2. Sources and Transport Pathways over Kuwait

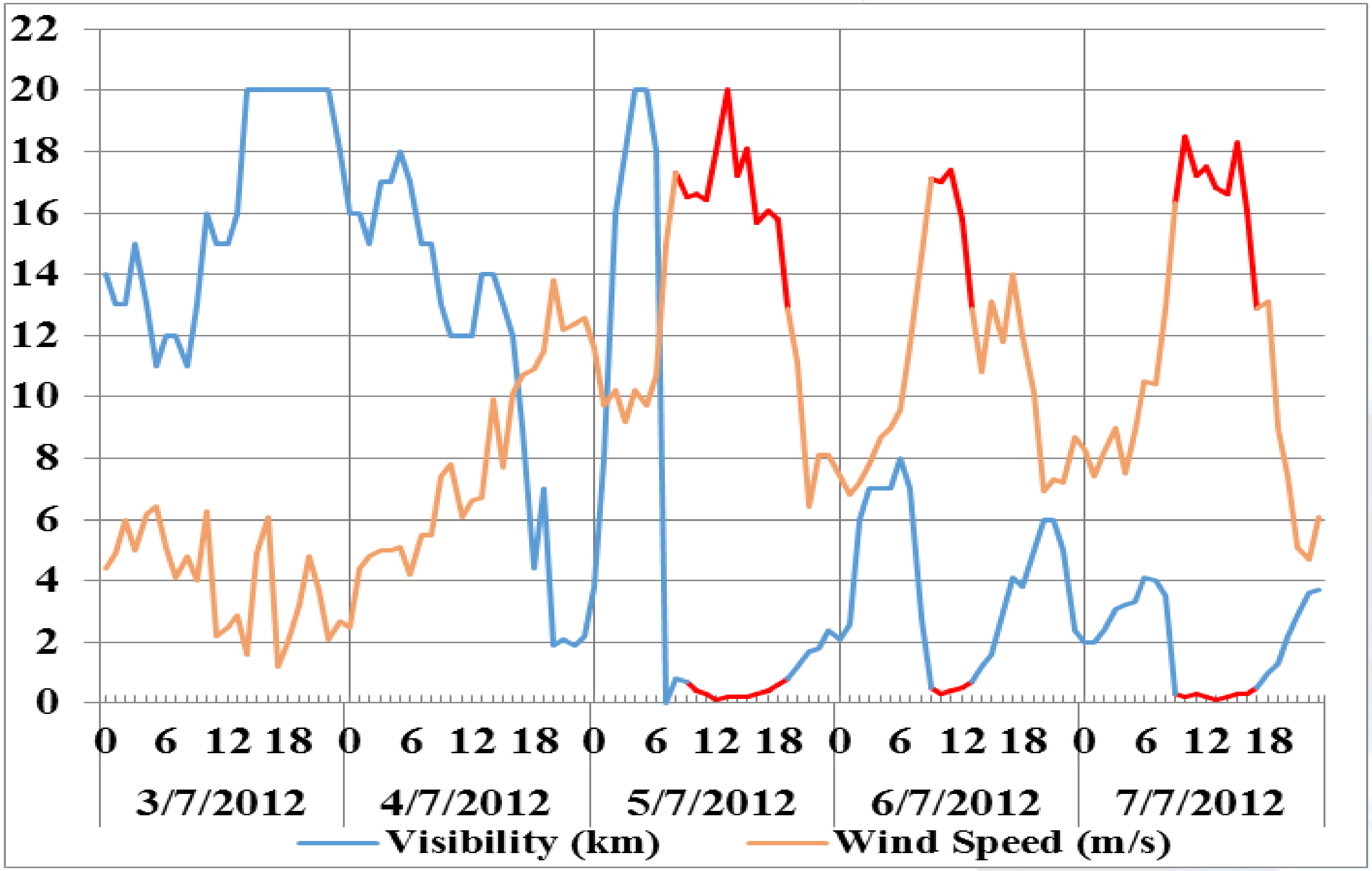


Salmi, Kuwait (26-30 July 2018)

2. Sources and Transport Pathways over Kuwait

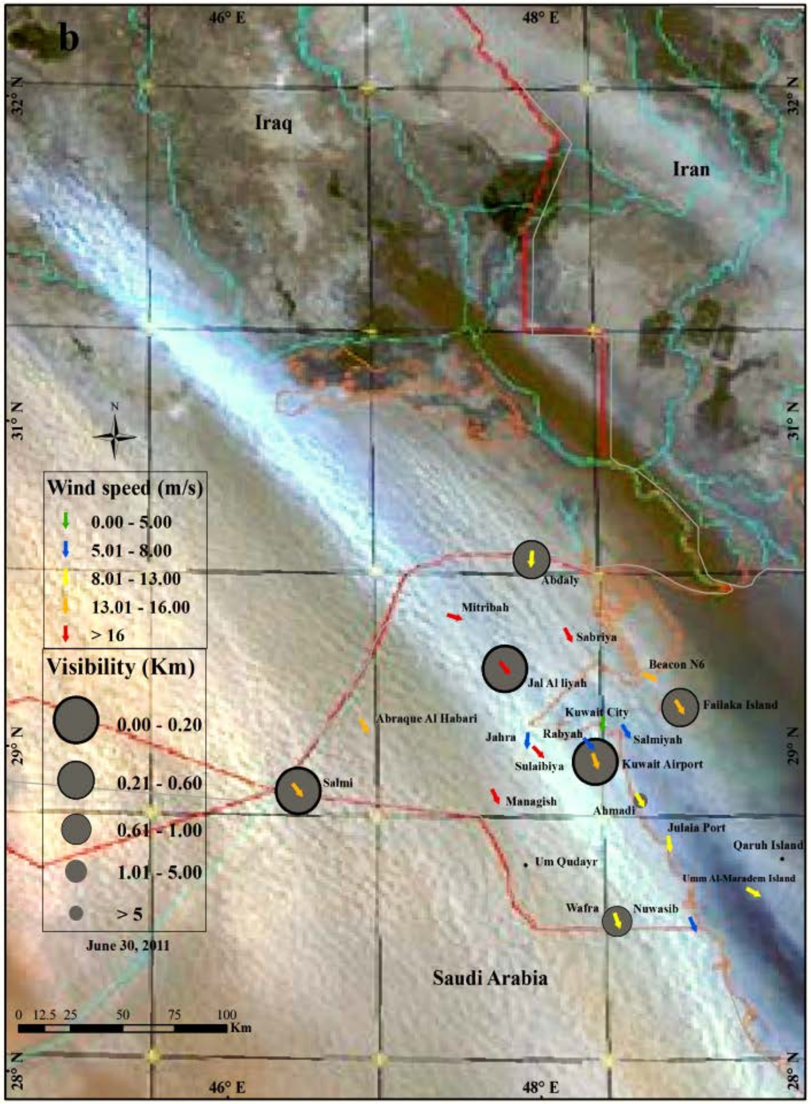


2. Sources and Transport Pathways over Kuwait

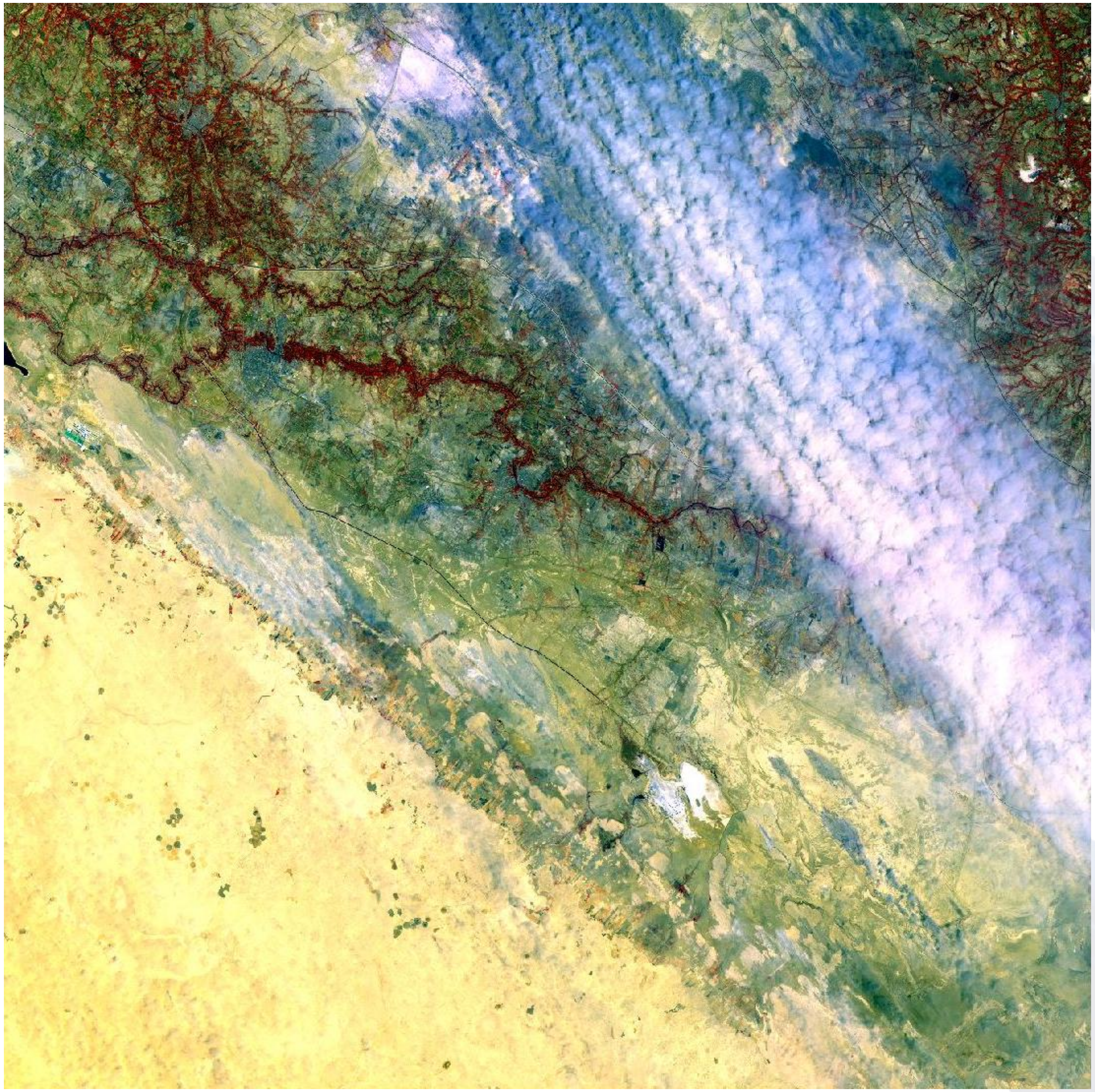


Jal Al liyah, Kuwait (3-7 July 2012)

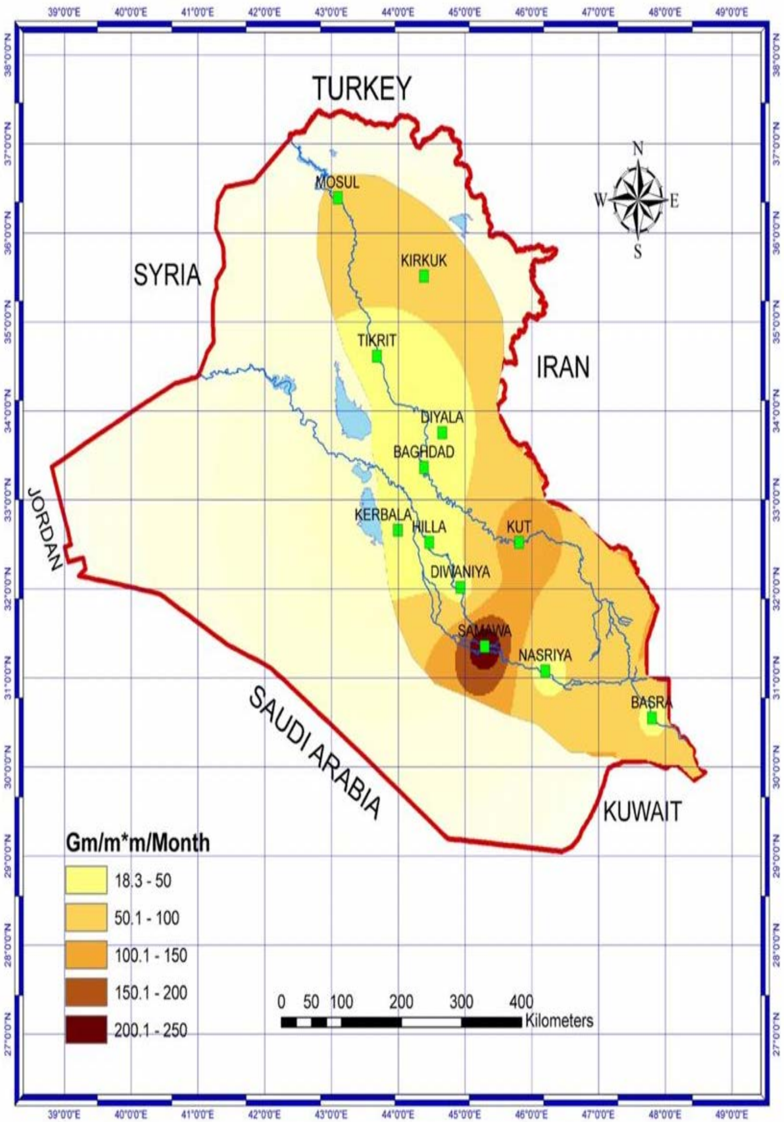
2. Sources and Transport Pathways over Kuwait



2. Sources and Transport Pathways over Kuwait



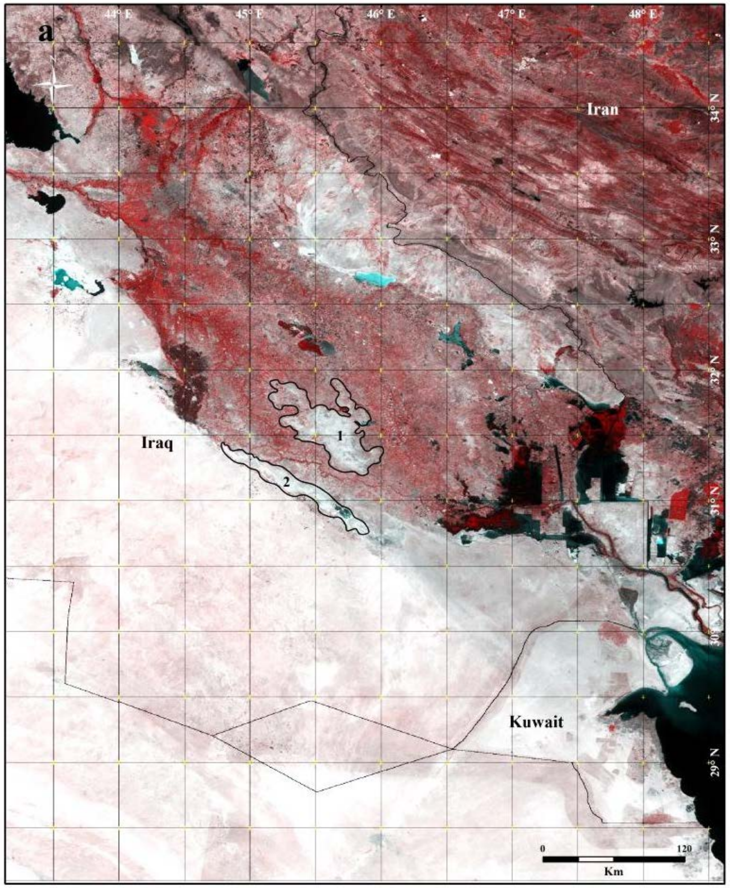
Site visit and sample collection

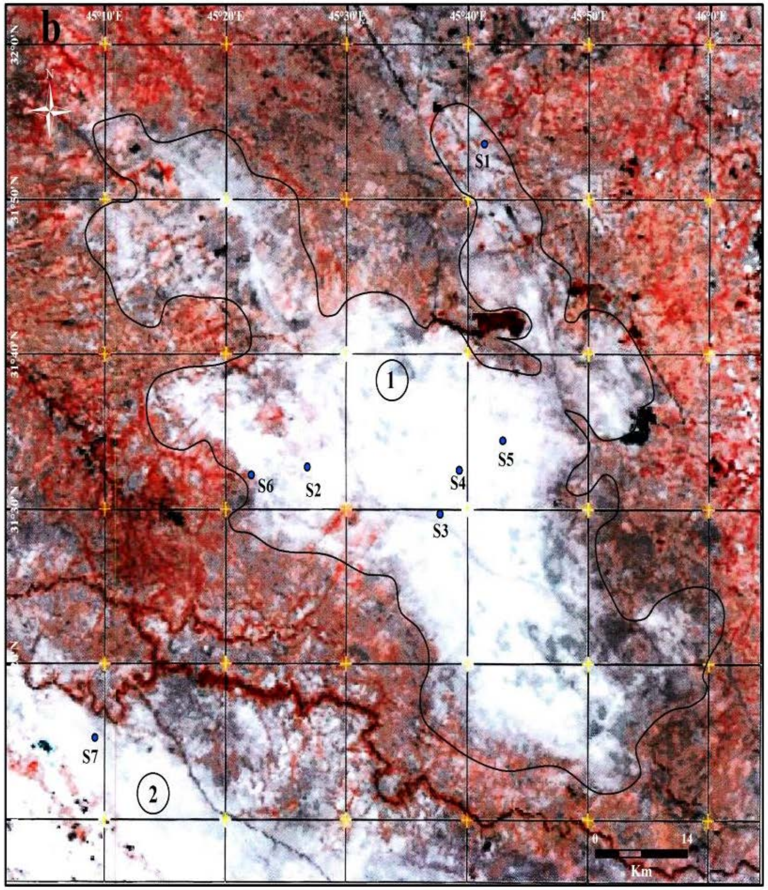


Site visit and sample collection

Site visit and sample collection

Site visit and sample collection





‘Dust Storm Trajectory’ publications

KISR
Kuwait Institute for Scientific Research

Science of the Total Environment 710 (2020) 136291

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Sand and dust storm trajectories from Iraq Mesopotamian flood plain to Kuwait

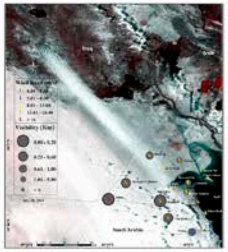
Ali Al-Hemoud [a,*], Ali Al-Dousari [a], Hassan Al-Dashti [b], Peter Petrov [a], Abeer Al-Saleh [a], Sarhan Al-Khafaji [c], Weam Behbehani [d], Jing Li [e], Petros Koutrakis [e]

[a] Crisis and Decision Support Program, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait
[b] Meteorology Department, Directorate General of Civil Aviation, P.O. Box 35, 32001 Hawalli, Kuwait
[c] Geography Department, Al Muthanna University, Samawah, Iraq
[d] Techno-Economics Division, Kuwait Institute for Scientific Research, Kuwait
[e] Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston 02115, USA

HIGHLIGHTS

- Severe sand and dust storm (SDS) trajectories traveled from the source and crossed over three countries.
- The use of high spatial resolution MODIS Aqua and Terra satellite images is important to delineate the SDS sources.
- Suspended dust was sustained for two days following the severe dust storms.
- Understanding the genesis of the dust storms is critical to mitigation efforts.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 20 August 2019
Received in revised form 25 November 2019
Accepted 21 December 2019
Available online 26 December 2019

Editor: Pavlos Kassomenos

Keywords:
Dust storms
Mesopotamia
Sand dunes
Iraq
Kuwait

ABSTRACT

Although Kuwait is greatly impacted by sand and dust storms (SDS) from Southern Iraq, to date little is known about the nature of these storms. Kuwait is vulnerable to SDS trajectories from the middle Euphrates region, specifically, from two "hot spot" areas (Al-Batha and Mamlahat Al-Samawah) of 4550 km^2 located 250 km from its northern border. This study explores the transboundary SDS jets originating from Southern Iraq using Moderate Resolution Imaging Spectroradiometer (MODIS) images obtained from Aqua and Terra satellites over a twelve-year period (2007–2018). Furthermore, an analysis of a 5-day diurnal variation (two days prior, the day of the SDS occurrence, and two days after) explored the hourly patterns of visibility and wind speed, as well as grain size distribution of soil samples to better understand grain size compositions and sediment transport mechanisms. Satellite images confirmed that dust storm jets originated from the "hot spot" in southern Iraq and spread over Kuwait and extended to neighboring Arab Gulf countries as far as Bahrain (900 km) and Qatar (1200 km). In general, the highest wind speed and lowest visibility values were recorded in Northern of Kuwait, with suspended dust sustained for two days following the dust storm. The largest silt and clay fractions (grains ≤63 μm) were identified at the center and west Sabkha region of the "hot spot" area. Very fine sand particles

* Corresponding author.
E-mail address: ahomood@kisr.edu.kw (A. Al-Hemoud).

https://doi.org/10.1016/j.scitotenv.2019.136291

‘Dust Storm Trajectory’ publications

KISR
Kuwait Institute for Scientific Research

Atmospheric Research 212 (2018) 158–171

Contents lists available at ScienceDirect

Atmospheric Research

journal homepage: www.elsevier.com/locate/atmosres

Dust storms backward Trajectories' and source identification over Kuwait

Mohamed F. Yassin[a,*], Sarah K. Almutairi[b], Ali Al-Hemoud[a]

[a] Environment & Life Sciences Center, Kuwait Institute for Research and Science, Kuwait
[b] College for Graduate Student, Kuwait University, Kuwait

A R T I C L E I N F O

Keywords:
Atmospheric conditions
Backward trajectories
Dust storms
HYSPLIT model
MODIS satellite

A B S T R A C T

Dust storms (DS) are considered a common environmental phenomenon in numerous countries of the world, especially in the arid and semi-arid regions. DS causes a significant impact on human health, climate, the environment and many associated socioeconomic factors. The main goal of this study is to assess the sources of DS in the State of Kuwait. The present study investigates DS over Kuwait using the backward trajectories' simulation with MODIS satellite observations at various latitudes (1000, 3000, 5000 m) during the four seasons; winter, spring, summer, and fall. The trajectories' simulation was modeled using the HYSPLIT model to create the seasonal climatologic of air parcel trajectories. The meteorological data (e.g., visibility, wind speed, wind direction, temperature, and humidity) were collected during a 12-year period from 2000 to 2012. Daily trajectories were computed backward for five days from a central origin at several altitudes above the ground surface. The variability of the DS was analyzed daily, monthly, seasonally and annually. A case study on 25 March 2011 and two cases from each season were selected for analysis. The results showed that the HYSPLIT model was consistent with the MODIS satellite images. The sources of DS were identified from both the Sahara Desert and the Arabian Desert. Furthermore, there is a significant influence of the atmospheric conditions on the DS sources. The most influential parameter was visibility, from the west and the northwest direction. The present work provides evidence and suggestions for the origins of DS and is expected to help in establishing guidelines for public protection against dust particles and provides significant information to the concerned officials to take proper actions.

1. Introduction

Dust storms (DS) are natural phenomena that arise globally with meteorological properties of gusty wind and occur when strong pressure gradients change through dry arid or semi-arid districts where loose sands are more prevalent, especially in the Middle East, Southwestern United States, Northern China, and Saharan desert. Essential conditions on the occurrence of DS include immense dust or sand sources, strong surface winds, and unstable atmosphere. DS cause problems environmental, economic, climate and human health problems, e.g., air quality, damage to crops and reduced soil fertility, reduction of solar radiation, and damage to telecommunications and mechanical systems (Al-Hemoud et al., 2017). DS also cause a decrease in visibility that limits various activities such as air and sea navigation movement and increases traffic accidents. Dense and intense DS can reduce the visibility to be near-zero in and near source regions. There are three main classifications for DS according to the reduced visibility: (a) Blowing dust - the horizontal visibility is less than 11 km; (b) DS - the horizontal visibility is less than 1000 m; and (c) Severe dust - horizontal visibility is less than 200 m. Suspended dust particles can rise by strong winds thousands of meters upward and downwind. Arid and semi-arid districts, approximating the boundaries of deserts occupied almost 20% of the earth's surface. Many factors make an area affected by DS, e.g., soil type, topography, climate and weather conditions.

Numerous previous studies have been conducted to identify DS transport and trajectories over different regions of the world, e.g., Prospero et al., 2002; Kutiel and Furman, 2003; Xiaodong et al., 2004; Lin et al., 2004, 2007; Kaskaoutis et al., 2008; Dementeva et al., 2008; Baddock et al., 2009; Yasunari and Yamazaki, 2009. Review studies (Yu et al., 2010) examined Asian DS activity from 1995 to 2006 and the associated atmospheric circulation using SYNOP and NCEP/NCAR reanalysis atmospheric data. Observations showed that the Gobi desert is the most common birthplace for severe dust in Asia, accounting for approximately 58% of total dust events, followed by about 32% from the Taklamakan Desert and nearly 10% from the Loess Plateau. DS from East and non-East Asian sources to Hong Kong over the period from 1996 to 2007 (76 dusty days) were studied by Lee et al. (2010). Results revealed that 73 out of the 76 DS events (96%) involved non-East Asian

* Corresponding author.
E-mail address: mohamed_f_yassin@hotmail.com (M.F. Yassin).

https://doi.org/10.1016/j.atmosres.2018.05.020
Received 8 February 2018; Received in revised form 7 May 2018; Accepted 8 May 2018
Available online 26 May 2018
0169-8095/

3. Dust Storms Impact on Kuwait

3. Dust Storms Impact on Kuwait

3. Dust Storms Impact on Kuwait

Al-Raudhatain oil field (Aug 2008)

3. Dust Storms Impact on Kuwait

Wafra oil field (Sept 2018)

3. Dust Storms Impact on Kuwait

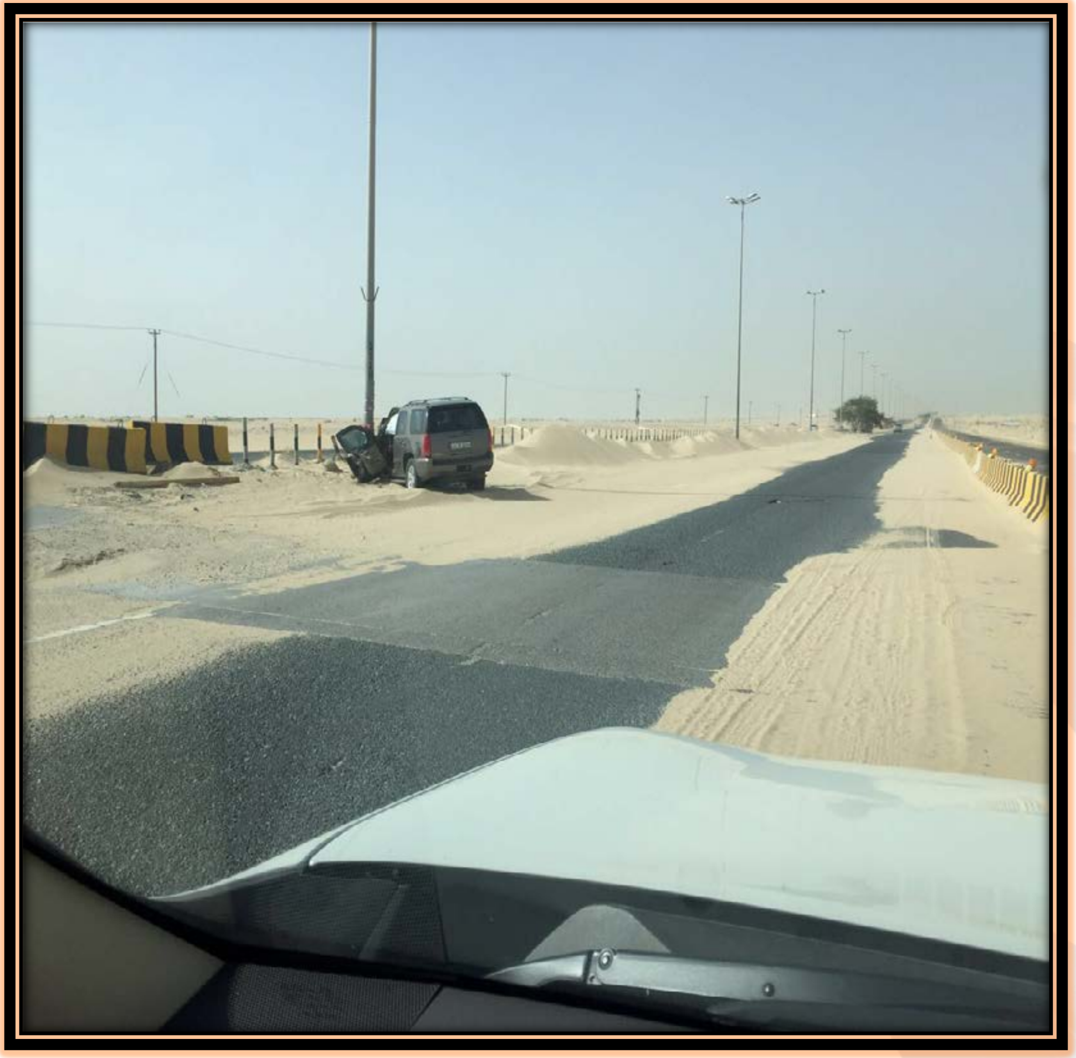
Minagish oil field (July 2008)

3. Dust Storms Impact on Kuwait

3. Dust Storms Impact on Kuwait

Wafra Road (June 2015)

3. Dust Storms Impact on Kuwait



Wafra - Mina Abdallah Road (June 2017)

'Impact' Publication

KISR
Kuwait Institute for Scientific Research

sustainability

MDPI

Article

Economic Impact and Risk Assessment of Sand and Dust Storms (SDS) on the Oil and Gas Industry in Kuwait

Ali Al-Hemoud [1,*], Ali Al-Dousari [1], Raafat Misak [1], Mane Al-Sudairawi [1], Adil Naseeb [2], Hassan Al-Dashti [3] and Noor Al-Dousari [1]

1 Crisis and Decision Support Program, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885, Safat 13109, Kuwait; adousari@kisr.edu.kw (A.A.-D.); rmisak@kisr.edu.kw (R.M.); msudrawi@kisr.edu.kw (M.A.-S.); ndousari@kisr.edu.kw (N.A.-D.)

2 Techno-Economics Division, Kuwait Institute for Scientific Research, Safat 13109, Kuwait; ajnaseeb@kisr.edu.kw

3 Meteorology Department, Directorate General of Civil Aviation, P.O. Box 35, Hawalli 32001, Kuwait; h.dashti@met.gov.kw

* Correspondence: ahomood@kisr.edu.kw

Received: 12 December 2018; Accepted: 27 December 2018; Published: 3 January 2019

check for updates

Abstract: There is a lack of published research on the economic effect and the risk associated with sand and dust storms (SDS) worldwide. The objectives of this study are to estimate the economic impact of SDS on the oil and gas industry in Kuwait, to estimate a risk index for each loss, and to recommend a sustainable system for the mitigation of the damaging effects and economic losses of infrastructures. Hot spots of wind erosion, wind corridors, and dust frequency and severity formed the basis to locate the most susceptible oil and gas fields and operations. Ten sectors with potential loss vulnerabilities were evaluated: exploration, drilling, production, gas, marine, soil remediation, project management, water handling, maintenance, and research and development. Sand encroachment, although not a sector per se, was also considered. The results indicate that sand, and to lesser extent dust, are damaging and costly to the oil and gas infrastructure of Kuwait, with an economic cost estimation of US$9.36 million, a total of 5159 nonproductive lost hours, and 347,310 m^3 of annual sand removal. A risk assessment identified three sectors with the highest risk indices (RI): drilling (RI = 25), project management (RI = 20), and maintenance (RI = 16). Sand encroachment also constituted a high risk (RI = 25). Mitigation of sand storms using a hybrid biological–mechanical system was shown to be cost-effective with an equivalent saving of 4.6 years of sand encroachment. The hazard implications of sand storm events continue to be a major concern for policy-makers given their detrimental economic impacts, and require that government officials wisely allocate investment budgets to effectively control and mitigate their damaging effects.

Keywords: Dust storms; wind erosion; economic impact; oil and gas; risk assessment; Kuwait

1. Introduction

1.1. Sand and Dust Storms: Definition, Sources, and Trajectories

Sand and dust storms (SDSs) are the result of wind erosion by either natural or anthropogenic factors. Dust storms are formally defined by the World Meteorological Organization (WMO) as the result of surface winds raising large quantities of dust into the air and reducing visibility at eye level to less than 1000 m [1]. There is no strict distinction between the definitions of sand versus dust storms [2]. However,

Sustainability 2019, *11*, 200; doi:10.3390/su11010200 www.mdpi.com/journal/sustainability

4. Health Impact – WHO AirQ+

- Estimating the BOD and DALYs associated with exposure to:
  - $PM_{2.5}$
  - PM_{10}
  - O_3
  - NO_2

Mortality, All Causes	• Long-term exposure • Short-term exposure
Specific-Cause Mortality	• IHD, Stroke • Lung cancer • COPD, ALRI
Hospital Admissions	• Respiratory • CVD

4. Health Impact – WHO AirQ+

- Over a span of a four-year period (2014-2017), the annual $PM_{2.5}$ concentration levels ranged from 38.0 μg/m^3 to 75.2 μg/m^3
- Higher $PM_{2.5}$ levels recorded during rush hours (early morning and early evening), weekends (particularly Saturdays), and summer (i.e., August and September)
- $PM_{2.5}$: Highest number of excess cases and attributable proportions of premature mortalities were related to ischemic heart disease and stroke
- $PM_{2.5}$: Respiratory diseases showed a higher number of excess cases and attributable proportions than cardiovascular diseases
- ELR showed that 30- and 65-year-old persons would gain 2.34 years and 1.93 years, respectively if the current $PM_{2.5}$ exposure levels were reduced to the WHO interim targets (IT-1 = 35 μg/m^3)
- Newborns and 1-year old children may live 79.81 and 78.94 years, respectively with an increase in average life expectancy of 2.65 years if the WHO PM_{10} interim targets were met (IT-1 = 70 μg/m3)

Health publications

KISR
Kuwait Institute for Scientific Research

Environmental Research 179 (2019) 108730

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

ELSEVIER

Exposure levels of air pollution ($PM_{2.5}$) and associated health risk in Kuwait

Ali Al-Hemoud[a,*], Janvier Gasana[b], Abdullah Al-Dabbous[a], Abdullah Alajeel[c], Ahmad Al-Shatti[c], Weam Behbehani[d], Mariam Malak[a]

[a] *Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109, Safat, Kuwait*
[b] *Faculty of Public Health, Kuwait University, P.O. Box 24923, 13110, Safat, Kuwait*
[c] *Ministry of Health, P.O. Box 5, 13001, Shuwaikh, Kuwait*
[d] *Techno-Economics Division, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109, Safat, Kuwait*

A R T I C L E   I N F O

Keywords:
Fine particles
Diurnal variation
Mortality and morbidity rates
$PM_{2.5}$ exposure
Kuwait

A B S T R A C T

It is well established that respiratory and cardiovascular mortality and morbidity rates are associated with poor air quality as measured by high concentrations of fine particulate matter such as $PM_{2.5}$ parameters. Since such information is lacking for the State of Kuwait, this study examined the exposure levels of $PM_{2.5}$ and the associated health risk as evaluated by five mortality measures embodied in ischemic heart disease, stroke, lung cancer, chronic obstructive pulmonary disease and acute lower respiratory infection as well as two morbidity outcomes related to both cardiovascular and respiratory diseases. The measurement models utilized in this investigation followed the WHO guidelines. Over a span of a four-year period (2014–2017), the annual $PM_{2.5}$ concentration levels ranged from 38.0 μg/m³ to 75.2 μg/m³. In general, exposure levels tended to fluctuate throughout the day with the higher levels recorded during rush hours (early morning and early evening), weekends (particularly Saturdays), and summer (i.e., August and September). The highest number of excess cases and attributable proportions of premature mortalities were related to ischemic heart disease and stroke at 352 (95% CI 275–426) and 70.8% (95% CI 39.7–85.2), respectively. In general, respiratory diseases showed a higher number of excess cases and attributable proportions than cardiovascular diseases. Relative to other findings on the global stage, the results emanating from Kuwait are emerging on the higher side. The study outcomes suggest that control strategies are in dire need to bend the pollution levels in Kuwait.

1. Introduction

Outdoor air pollution is estimated to account for approximately 1.5% of total world mortality and 2% of all cardiopulmonary diseases (Ezzati et al., 2002, 2004; Ostro et al., 1999). Only one in every ten people lives in communities that comply with the World Health Organization (WHO) air quality guidelines. One in nine deaths is attributed to air pollution, accounting for three million deaths annually (WHO, 2016). Estimating the burden of disease (BOD) associated with air pollution is based on current concentrations of particulate matter (PM) measured as either 'inhalable particles' PM_{10} (with an aerodynamic diameter of less than 10 μm) or 'fine inhalable particles' $PM_{2.5}$ (with an aerodynamic diameter of less than 2.5 μm). $PM_{2.5}$ represents a larger health threat than PM_{10} since its very fine particles are more likely to be deposited deep into the lungs (Cifuentes et al., 2000; Schwartz et al., 1999). It has been estimated that 3.24 million deaths worldwide were attributed to $PM_{2.5}$ exposure (Lim et al., 2012) with 70% of the cases accounting for non-communicable diseases (Landrigan et al., 2017).

Early studies associating mortality rates with fine particles were conducted by Dockery et al. (1993) and Pope et al. (1995), and were validated by Krewski et al. (2005). Schwartz et al. (1996) indicated that a 10 μg/m³ increase in two-day mean $PM_{2.5}$ was associated with a 1.5% increase in total daily mortality. Pope et al. (2002) reported that each 10 μg/m³ increase in $PM_{2.5}$ was associated with a 4% increase in all-cause mortality. Many recent epidemiological studies have reported an association between elevated $PM_{2.5}$ concentrations and detrimental health effects, including total mortality (Brunekreef et al., 2009; Pope and Dockery, 2006; Shi et al., 2016; Zanobetti and Schwartz, 2009), lung cancer mortality (Hamra et al., 2014), cardiovascular mortality including stroke (Lepeule et al., 2012; Lipsett et al., 2011), hospital admissions due to respiratory diseases (Al-Hemoud et al., 2018a; Xing et al., 2016), cardiovascular diseases (Dabass et al., 2016; Franklin et al., 2015; Puett et al., 2009), and childhood acute bronchitis (Hertz-Picciotto et al., 2007; Karr et al., 2009). Other recent studies have reported associations between ambient $PM_{2.5}$ and low birth weight in newborns (Ibrahimou et al., 2014; WHO, 2013; Wu et al., 2018) and

* Corresponding author.
E-mail address: ahomood@kisr.edu.kw (A. Al-Hemoud).

https://doi.org/10.1016/j.envres.2019.108730
Received 26 June 2019; Received in revised form 28 August 2019; Accepted 5 September 2019
Available online 18 September 2019

Health publications

Kuwait Institute for Scientific Research

International Journal of *Environmental Research and Public Health*

MDPI

Article

Disability Adjusted Life Years (DALYs) in Terms of Years of Life Lost (YLL) Due to Premature Adult Mortalities and Postneonatal Infant Mortalities Attributed to $PM_{2.5}$ and PM_{10} Exposures in Kuwait

Ali Al-Hemoud [1,*], Janvier Gasana [2], Abdullah N. Al-Dabbous [1], Ahmad Al-Shatti [3] and Ahmad Al-Khayat [4]

1. Crisis Decision Support Program, Environment and Life Sciences Research Center, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait; adabbous@kisr.edu.kw
2. Faculty of Public Health, Health Sciences Center, Kuwait University, P.O. Box 24923, 13110 Hawalli, Kuwait; janvier.gasana@HSC.EDU.KW
3. Occupational Health Department, Kuwait Ministry of Health, P.O. Box 51360, 53454 Riqqa, Kuwait; ahmad.alshatti2011@yahoo.com
4. Techno-Economics Division, Kuwait Institute for Scientific Research, P.O. Box 24885, 13109 Safat, Kuwait; akhayat@kisr.edu.kw

* Correspondence: ahomood@kisr.edu.kw; Tel.: +09-652-498-9464

Received: 9 October 2018; Accepted: 17 November 2018; Published: 21 November 2018

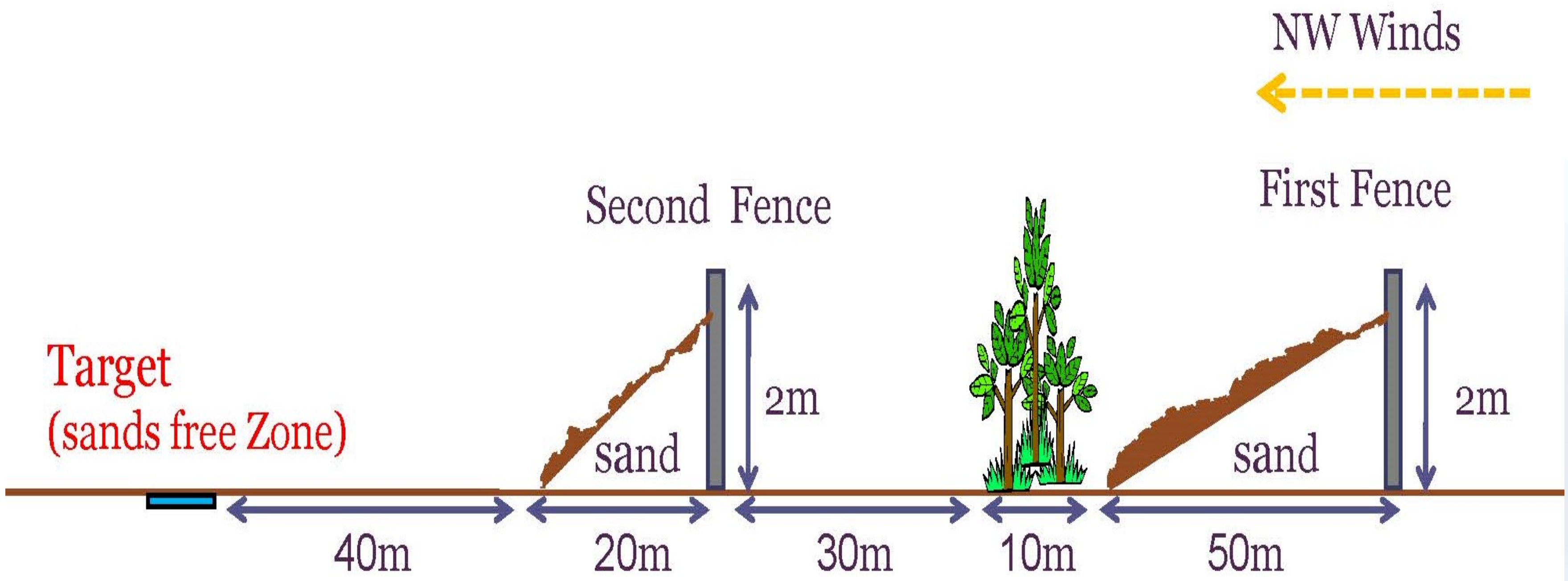
check for updates

Abstract: Ambient air pollution in terms of fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}) has been shown to increase adult and infant mortalities. Most studies have estimated the risk of mortalities through attributable proportions and number of excess cases with no reference to the time lost due to premature mortalities. Disability adjusted life years (DALYs) are necessary to measure the health impact of Ambient particulate matter (PM) over time. In this study, we used life-tables for three years (2014–2016) to estimate the years of life lost (YLL), a main component of DALYs, for adult mortalities (age 30+ years) and postneonatal infant mortalities (age 28+ days–1 year) associated with $PM_{2.5}$ exposure and PM_{10} exposure, respectively. The annual average of $PM_{2.5}$ and PM_{10} concentrations were recorded as 87.9 $\mu g/m^3$ and 167.5 $\mu g/m^3$, which are 8 times greater than the World Health Organization (WHO) air quality guidelines of 10 $\mu g/m^3$ and 20 $\mu g/m^3$, respectively. Results indicated a total of 252.18 (95% CI: 170.69–322.92) YLL for all ages with an increase of 27,474.61 (95% CI: 18,483.02–35,370.58) YLL over 10 years. The expected life remaining (ELR) calculations showed that 30- and 65-year-old persons would gain 2.34 years and 1.93 years, respectively if the current $PM_{2.5}$ exposure levels were reduced to the WHO interim targets (IT-1 = 35 $\mu g/m^3$). Newborns and 1-year old children may live 79.81 and 78.94 years, respectively with an increase in average life expectancy of 2.65 years if the WHO PM_{10} interim targets were met (IT-1 = 70 $\mu g/m^3$). Sensitivity analyses for YLL were carried out for the years 2015, 2025, and 2045 and showed that the years of life would increase significantly for age groups between 30 and 85. Life expectancy, especially for the elderly ($\geq$60 years), would increase at higher rates if $PM_{2.5}$ levels were reduced further. This study can be helpful for the assessment of poor air quality represented by $PM_{2.5}$ and PM_{10} exposures in causing premature adult mortalities and postneonatal infant mortalities in developing countries with high ambient air pollution. Information in this article adds insights to the sustainable development goals (SDG 3.9.1 and 11.6.2) related to the reduction of mortality rates attributed to ambient air levels of coarse and fine particulate matter.

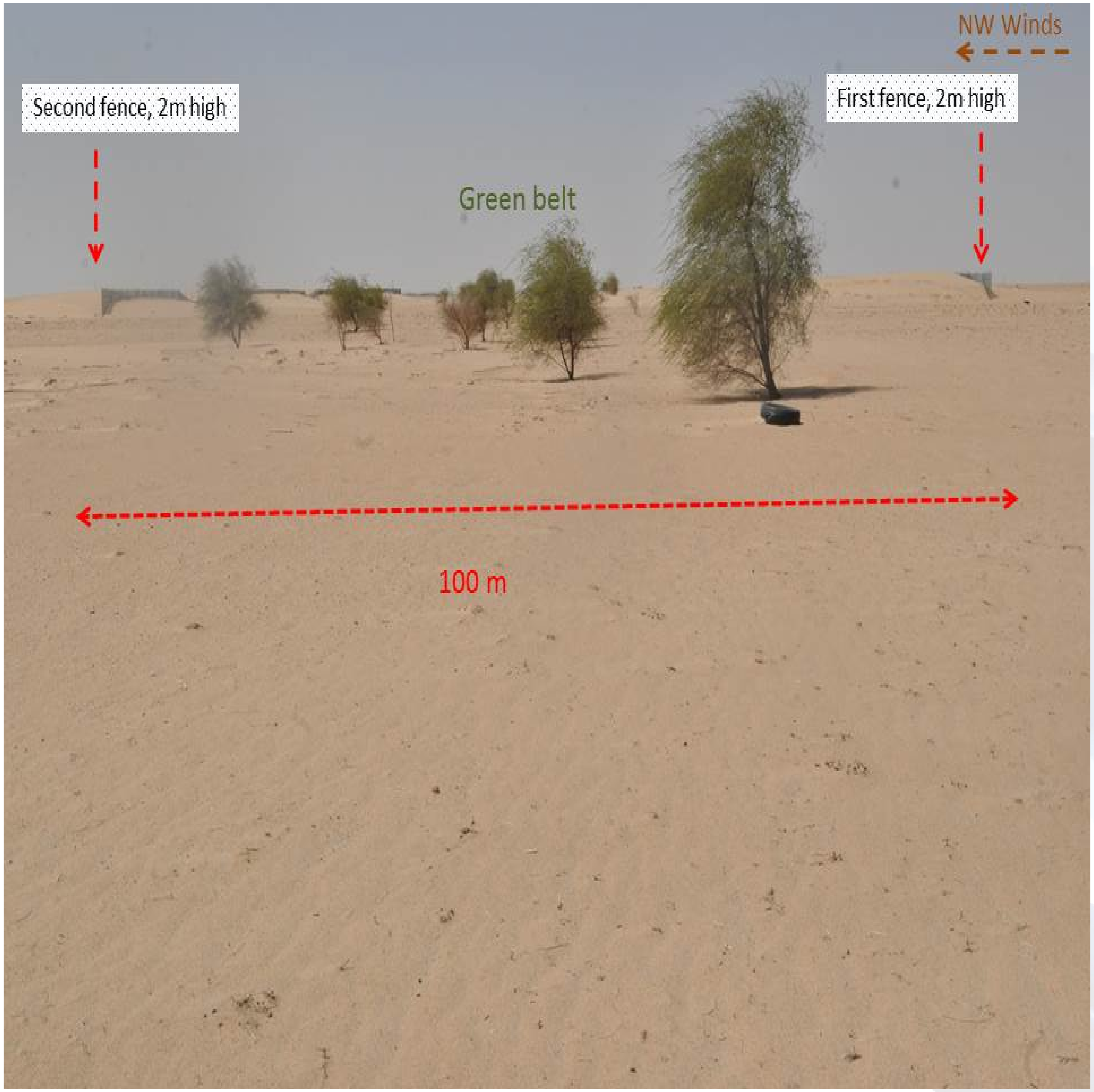
Keywords: AirQ+; burden of disease (BOD); DALYs; $PM_{2.5}$; postneonatal mortality; YLD; YLL

Int. J. Environ. Res. Public Health **2018**, *15*, 2609; doi:10.3390/ijerph15112609 www.mdpi.com/journal/ijerph

Dust Storm Mitigation



Dust Storm Mitigation



Dust Storm Mitigation

Dust Storm Mitigation

KISR
Kuwait Institute for Scientific Research

Dust Storm Mitigation

Dust Storm Mitigation

Dust Storm Mitigation

Dust Storm Mitigation

KISR
Kuwait Institute for Scientific Research

Dust Storm Mitigation

KISR
Kuwait Institute for Scientific Research

Dust Storm Mitigation

Dust Storm Mitigation

KISR
Kuwait Institute for Scientific Research

Dust Storm Mitigation

KISR
Kuwait Institute for Scientific Research

Success

KISR
Kuwait Institute for Scientific Research

Success

Success

Success

Success

KISR
Kuwait Institute for Scientific Research

Success

شكرا