Effects of Mesoscale Circulations in Soil Moisture Over the Desert of Kuwait

Hussain Alsarraf[1], Hala Aljassar[2]

Chair, Department of Math & Natural Sciences, American University of Kuwait

Physics Department, Kuwait University

Abstract

Feedbacks between soil moisture and mesoscale circulation are important for understanding soil moisture variability in the desert regions in summertime. The wind mesoscale circulation over Kuwait plays an important role to changes in soil moisture in the desert. This paper presents three summer common atmospheric dynamics over kuwait linking wind circulation to soil moisture, based land surface soil moisture observation, and the European Centre for Medium-range Weather Forecasts ECMWF reanalysis (ERA-Interim) model. The results show that strong pressure gradient will lead into strong northerly wind over Kuwait, which are favored on the downwind side of dry surfaces, The weak synoptic force over Kuwait in summer will lead into inland easterly gulf light humid winds, consistent with forcing by a mesoscale circulation. Overall, By demonstrating the significance of wind circulations in driving the soil moisture, the study shows that soil moisture increase during summertime is a likely caused by mesoscale circulation

1.Introduction

The two case studies will be investigated to illustrate the character of the winds and soil moisture in the region under different synoptic regimes. The illustration of changes of large-scale pressure gradient and the resulting changes in the existing wind direction affecting the soil moisture in Kuwait will be carried out in this paper. The Shamal wind is supported by the presence of large-scale pressure gradient. The occasional breakdowns of this pressure distributions results in sea breeze circulation formed in the near coast region and extending up to inland.

2.Material and methods

The reanalysis ECMWF model uses its forecast models and data assimilation systems to reanalyze archived data for the atmospheric, and land surface. The comparison between the observation data from an automatic weather station located in the middle of Kuwait desert area (29.190990°/47.144865°), and the simulations of the reanalysis European Centre for Medium-Range Weather Forecasts, (ECWMF) model the ERA-Interim will be studied and investigated two case studies in this research.
The data assimilation system used to produce ERA-Interim is based from 1979 continuously updated in real time. The system includes a 4-dimensional vibrational analysis with a 6-hour analysis window. The spatial resolution of the data set is approximately 80 km (T255 spectral) on 60 vertical levels from the surface up to 0.1 hPa. In this study the 0.12 degree resolution is simulated to compare with desert weather stations in Kuwait; Managish (29.0667, 47.5333), Jal Aliyaah (29.6124, 47.5767), Abraque Alhabari (29.3703, 46.9686).

3.Synoptic Force

- The first case on 28th Aug 2015, experiences a strong pressure gradient. The pressure gradient force is the force that causes the wind to blow, more closely a space isobar corresponds to greater force as equation 1, 2 present the components of this force

$$\frac{fx\,PG}{m} = -\frac{1}{\rho}\frac{\Delta P}{\Delta X} \qquad (1)$$

$$\frac{fx\,PG}{m} = -\frac{1}{\rho}\frac{\Delta P}{\Delta y} \qquad (2)$$

Where the ΔP is the change of pressure gradient a cross-distance ΔX or Δy, and the ρ is air density. The negative sign explain the force act from high to low pressure.

- The second case to be considered is 4th August 2015 depicts the effect of weak synoptic forcing in the local area , contrast in the land and water temperature creates a mesoscale circulation.

The moisture advection equation (3) in which the V is the horizontal wind vectors, and the *pm* is density of water vapor.

$$Adv(pm) = -V.\nabla pm \qquad (3)$$

The horizontal transfer of water vapor by the wind plays a huge role on increasing soil moisture over the coastal areas and affecting the soil moisture in desert areas in Kuwait

The advection of dew point *(Td)* itself can be thought as moisture advection (4)

$$Adv(Td) = -V.\nabla Td \qquad (4)$$

4.Observation

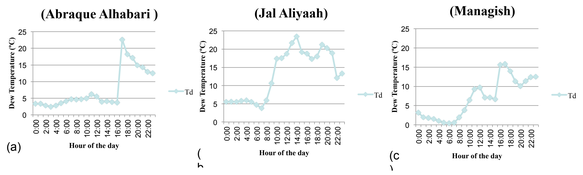
4.1 Dew Point Temperature

The diurnal cycle of the dew point is important to illustrate the exchange between the dew point and soil moisture, the mesoscale circulation can effect the diurnal cycle of the dew point.

Dew point temperature for 4th of August 2015

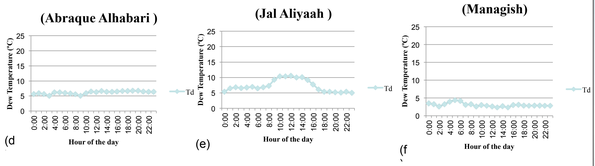
.

(a) Abraque Alhabari (29.3703, 46.9686). (b) Jal Aliyaah (29.6124, 47.5767), (c) Abraque Alhabari (29.3703, 46.9686.



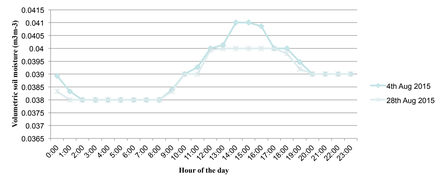
Dew point temperature for 28th of August 2015.

(a) Abraque Alhabari (29.3703, 46.9686). (b) Jal Aliyaah (29.6124, 47.5767), (c) Abraque Alhabari (29.3703, 46.9686).



4.2 Volumetric Soil Moisture

In the 4rd Aug 2015 this case because of the wind direction changes from northwesterly to south easterly due to the sea breeze, the impact of this wind direction is seen in the (Figure 8) for the 4rd Aug 2016 data. The soil moisture on this day is higher than the 28rd Aug 2015 because of Northwesterly dry wind flow due to the pressure gradient over the region on 28rd Aug 2015. The max soil moisture recorded for 4th Aug 2015 is 0.041 m3m-3 from 12:00 to 14:00 local time, and for the 28th Aug 2015 is 0.04 m3m-3 from 12:00 to 16:00 local time

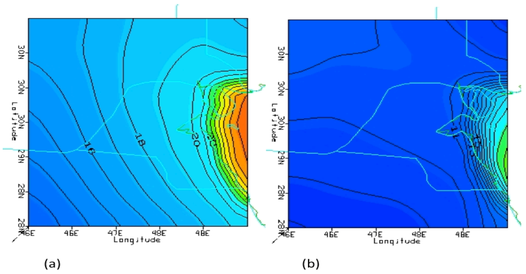


5.ECWMF

The ECWMF reanalysis ERA-Interim/Land, near-surface were used to force the latest version of the HTESSEL land-surface model (Hydrology-Tiled ECMWF Scheme for Surface Exchanges over Land).

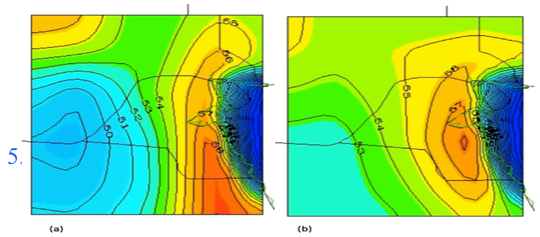
5.1 Model Dew Point Temperature

Dew Point Temprature (ECMWF) 12:00 UTC, (a) 4th August 2015, (b) 28th August 2015



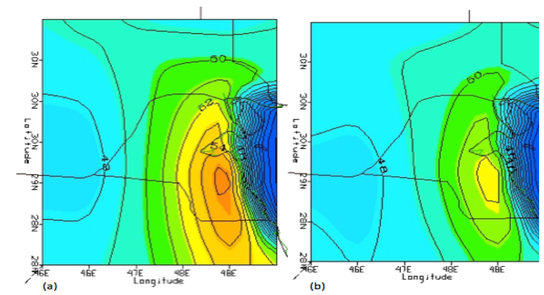
5.2 Model Skin Temperature

Skin Temprature (ECMWF) 12:00 UTC, (a) 4th August 2015, (b) 28th August 2015



5.3 Model Soil Temperature

Soil Temperature (ECMWF) 12:00 UTC, (a) 4th August 2015, (b) 28th August 2015



Conclusion

The two cases illustrated associated with strong pressure gradient over the region and weak pressure gradient that led to mesoscale circulation which effected the soil moisture over the desert.