The Diurnal Variation of the Persian Gulf Summertime Low Level Jet

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Introduction

➢ **Persian Gulf** is near complex terrain with high and steep mountains (e.g. Zagros Mountains in Iran)

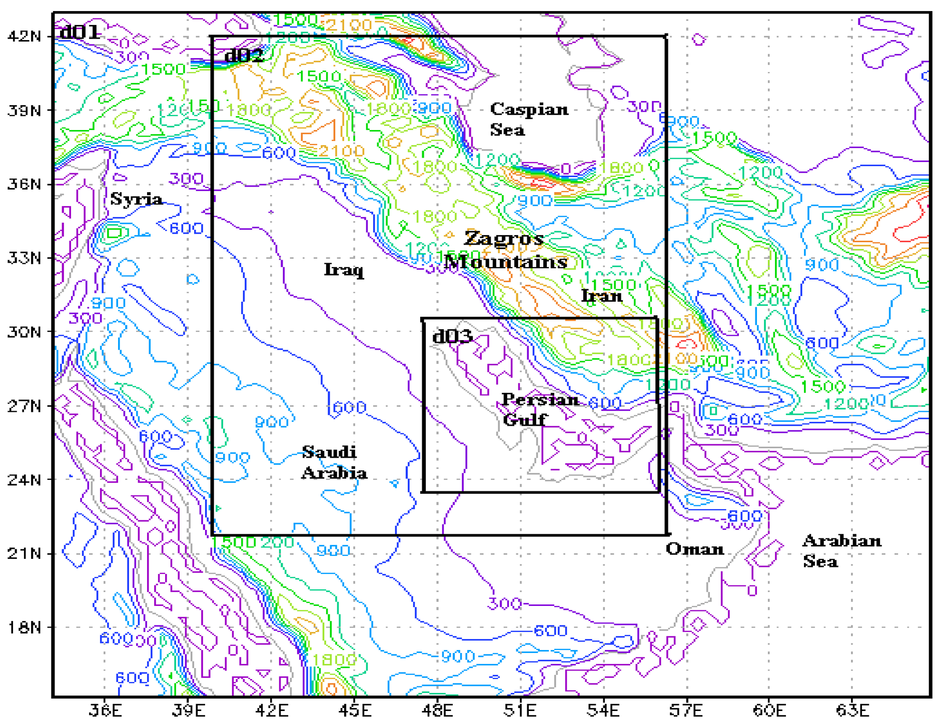

Figure 1: WRF modeling domain: 27 km (d01), 9 km (d02) & 3 km (d03) grid spacing for the control run. Terrain heights are plotted every 300 m.

➢ **Shamal winds**:

- Strong northerly & north-westerly winds.
- Blow during summer (late May – early July) over Iraq & the Persian Gulf.

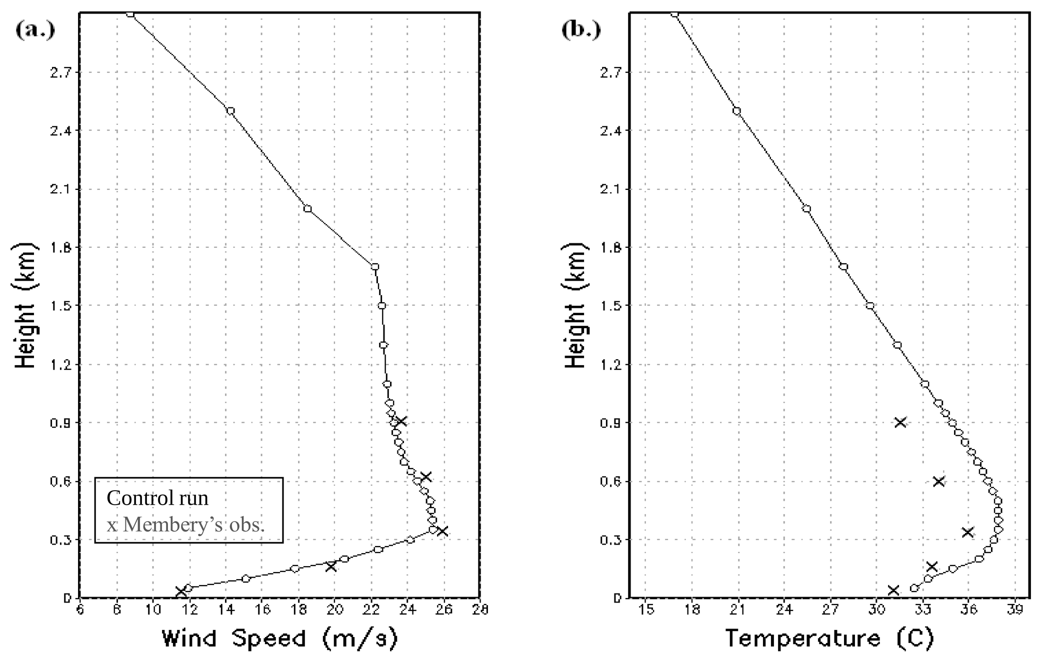

Figure 2: (a.) Wind Speed (m/s) vertical profile up to 3 km AGL over mid-Gulf (lat: 28N, long: 50E) at 22:00 UTC 11 June 1982. (b.) Same as (a.) except temperature (C). Black curve is for the control run, cross points are Membery's (1983) obs.

➢ Nocturnal **low-level jet** (LLJ) profile is developed; wind maximum (27 m/s) at 250 – 500 m AGL (Fig 2(a)).

➢ The **height of the wind maxima** is related to the height and the magnitude of the temperature inversion (Blackadar, 1957).

Motivation

1. Predict the development, intensity, duration & location of Shamal wind events.
2. Evaluate the improvement (if any) of numerical forecasts.
3. Determine the orographic effects on this low-level wind development.
4. Understand & explain the physical mechanisms that produced these low-level wind maxima.

Method

1. Model Overview

➢ **Version 3.2** of the Weather Research and Forecasting (**WRF**) model (Skamarock *et al*., 2008) is used to provide real-time forecasts.

➢ **3 computational domains** (Fig. 1), 1-way nesting & 50 vertical levels are applied.

2. Four sensitivity experiments

1. **Zero** experiment (terrain height over the simulated domain is set equal to zero).
2. **Mountain Slope** experiments (Zagros Mountains are replaced by a Gaussian mountain range with shallow and steep slopes (Fig. 5)).
3. **Land – Sea (LS)** experiment (the water bodies over Persian Gulf are changed into sparsely-vegetated land).

3. Case Study: 11/6/1982 Shamal event

➢ Simulations are conducted from 00:00 UTC 07 June 1982 to 00:00 UTC 14 June 1982. The study period is divided into a **less-extensive** & an **extensive** period.

➢ The initialization and lateral boundary conditions are provided by **ERA-40** re-analysis data. 1*1 degree spatial resolution and temporal resolution of 6h.

Results

➢ The WRF model accurately simulates the LLJ's vertical structure (Fig. 2(a)), location (Fig. 3(a)), nocturnal features and **diurnal variation of the wind speed** (Fig. 4(a)).

➢The Zagros Mountains not only provide a **barrier** for the north-westerly winds but also for the easterly monsoon airflow which maximizes the wind speed (Fig. 4(a)).

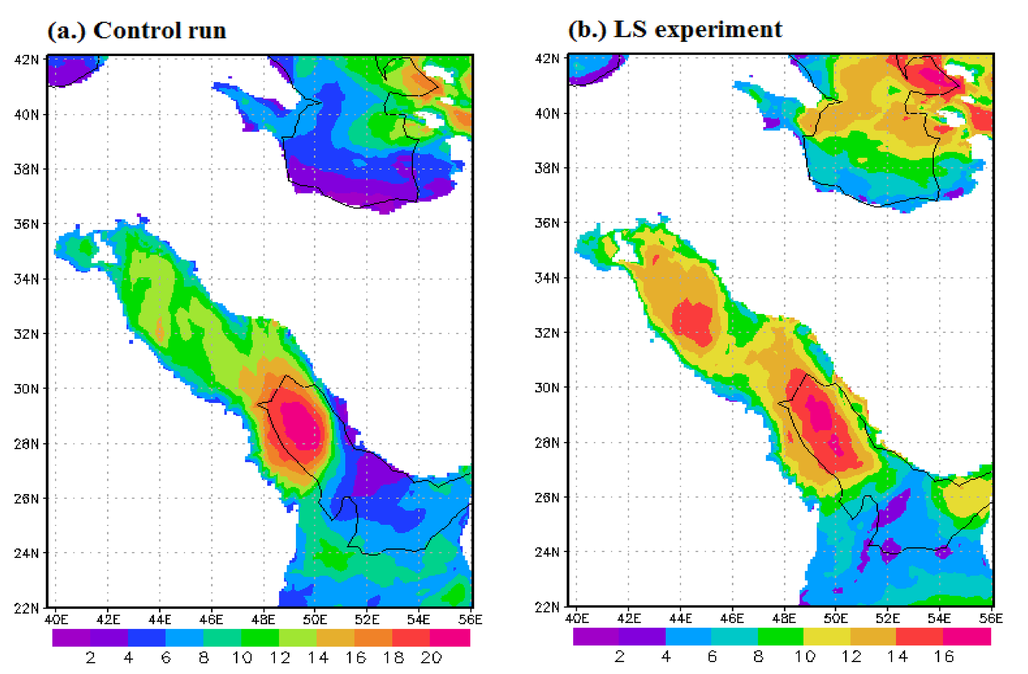

Figure 3: (a) Time average wind speed (m/s) for the less-extensive period at all 22:00 UTC from the control run at 300 m AGL. (b) Same as (a) except LS experiment. Blank regions indicate terrain height above 300 m.

➢ **Strong diurnal cycle of the Shamal wind direction** is observed (Fig. 4(b)).

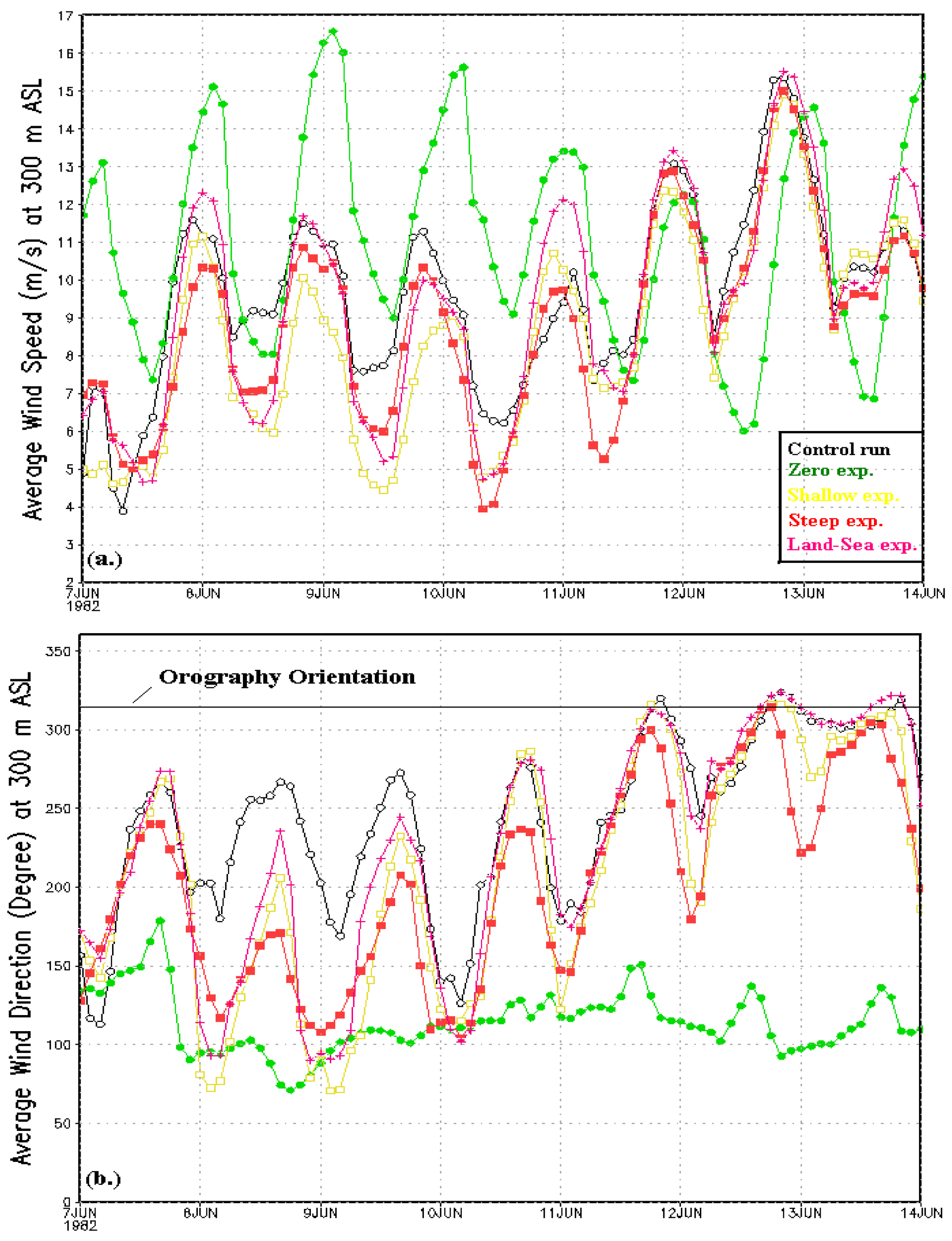

Figure 4: (a) Average wind speed (m/s) time series over the Persian Gulf at 300 m ASL for all the simulation experiments. (b) Same as (a) except wind direction (Degree).

➢The Shamal winds **are positioned parallel** to the Zagros mountains (Fig. 4(b)).

➢ Both shallow and steep slope experiments feature a **jet-like flow** over the Persian Gulf (Fig. 5).

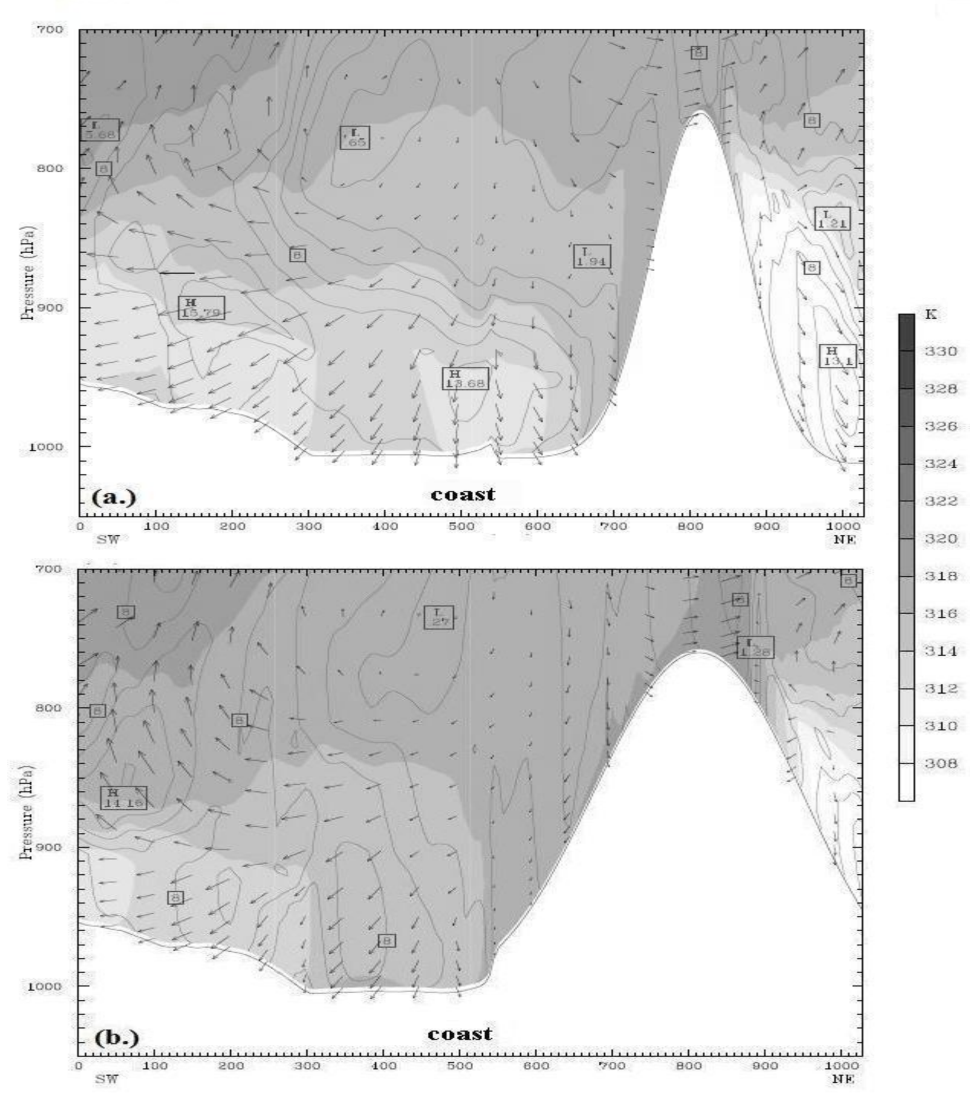

Figure 5: Cross section for the (a) Steep and (b) Shallow experiment at 8:00 UTC 9/6/1982 taken from (x1,y1)=(26.4, 104.5) to (x2,y2)=(97.0,180.0). The shaded contours show the virtual potential temperature (K), the contours are for the wind speed (m/s) and the wind barbs are the horizontal wind vectors.

Conclusions

1. **The wind direction** is to a great extent modulated by the topography (Fig. 4(b)).
2. **The steep** slopes cause larger wind speeds by **stronger horizontal pressure gradients** (Fig. 5(a)).
3. **The shallow** slopes give stronger diurnal varying wind direction due to **larger heating & cooling of the sloping terrain** (Fig. 5(b)).
4. **The land-breeze** & the **lower friction** over the sea increase the intensity of the LLJ over the Gulf (Fig. 3).

References

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