The origin and mechanism of winter depressions over Saudi Arabia

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Outline

- Brief climatological overview (Chakraborty et al. 2004)
- Interannual variability of moisture flux (Chakraborty et al. 2004)
- Winter time transients and analysis of G-ANAL (JMA)
- Preliminary results from MM5 simulations
- Future work
Fig. 1. (a) Diagram showing the adjacent seas of Saudi Arabia along with topography, (b) The domain of selected regions studied in this paper (Area I: over Red Sea; Area II: over Abha; Area III: over Arabian Sea and Area IV: over Mediterranean Sea) and (c) a map of climatological precipitation (in mm) from Xie-Arkin over Saudi Arabia.
Semi-annual rainfall signal

Monthly average rainfall

Rainfall (mm)

Xie-Aarkin
Willmott
Abha

Month

Behera et al. 2004
Seasonal Variability

Monthly net moisture flux

- Moisture Flux: -0.5 to 3
- Month: JAN FEB MAR APR MAY JUN JULY AUG SEP OCT NOV DEC JAN

Graph showing the monthly net moisture flux for two domains: ABCD and EFGH.
Interannual Variability
Interannual Variability

ENSO

IOD

IOD + ENSO
850 hPa MOISTURE FLUX ANOMALIES (SEPTEMBER – OCTOBER)

DIVERGENT COMPONENT

IOD_EXP1

IOD_EXP2

ROTATIONAL COMPONENT

IOD_EXP1

IOD_EXP2

ENSO_EXP

ENSO_EXP
Seasonal Variability

Monthly net moisture flux

Why?
Precipitation from winter disturbances

Mujumdar et. al. 2004)
850 hPa Geo-potential anomalies
Moisture flux anomalies
Type-1
Type-2
Type-2
Type-3
Type-3
G-ANAL
(JMA, 1.25X1.25)
(6 years: 1999 – 2004)
500 hPa Geopotential Height and Rainfall Animations – Note the influence of propagating western disturbances on the rainfall variability over Saudi Arabia.
Vorticity Budget (900hPa)

\[
\frac{\partial \zeta}{\partial t} = -\mathbf{V}_h \cdot \nabla_h (\zeta + f) - \omega \frac{\partial \zeta}{\partial p} - (\zeta + f) \nabla_h \cdot \mathbf{V}_h + \hat{k} \cdot \left( \nabla h \times \nabla_h \right) + D_{\zeta}
\]

- **Horizontal Advection**
- **Vertical Advection**
- **Stretching**
- **Tilting**
- **Advection**
- **Frictional**

* Contributes mainly to shift the vorticity pattern towards the direction of movement.
* Plays the dominant role to form this type of disturbances.
MM5 Simulation

• MM_run1 (90km resolution)
• MM_run2 (30km resolution)

Simple ice physics, Kuo cumulus scheme,
Bulk PBL fluxes, no multi layer soil
temperature model, no shallow convection
MM_run1 (72hr)
MM_run2 (36hr)
MM_run2 (72hr)
Conclusions

• Semi-annual signal for moisture flux.

• Interannual variability of moisture flux due to tropical climatic signals like IOD and ENSO.

• Winter transients triggers Arabian Cyclone (??).

• Stretching and horizontal advection terms are the major contributors to the vorticity dynamics of the cyclone. Vertical advection and tilting terms are relatively weak.

• The horizontal advection term contributes mainly to shift the vorticity pattern toward the direction of the movement of the disturbance and does not contribute to amplify the vorticity.

• The stretching term plays the dominant role for this type of disturbance development.

• The distribution of horizontal advection term simply represents the fact that the vortex is advected by the north-westerly wind.
Future Work

- Details structure and their classifications.

- In order to understand the mechanism of development and propagation, high resolution MM5 sensitivity study for all kinds of disturbances by switching on-off (a) condensational heating, (b) surface sensible heat flux and (c) surface latent heat flux.

- How they are related to NAO, IOD and ENSO?
Thank you

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