Investigating the Structure of Summer Atmospheric Circulation over Southwest Asia

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1. Introduction

- Atmospheric circulation over South-west Asia (SWA) has a complex structure during the boreal summer. A combination of regional to large-scale anticyclones in middle and upper troposphere controls the weather and climate over the area. The mechanisms which governing on the formation and maintenance of these anticyclones are different and can act at scales that vary from local to large scales. While in upper troposphere the events control by monsoon circulation, in middle and lower troposphere a local to regional scale surface forcing including forcing from high plateaus is the main factor to control the weather and climate over the SWA.

2. Data

- The NCEP/NCAR daily reanalysis dataset (Kalnay *et al.* 1996) for a 61-year period (1948-2008) are used to study the summer atmospheric circulation. In this research, the geopotential height, temperature, Outgoing Longwave Radiation (OLR), zonal and meridonal wind components are the variables that obtained from NCEP/NCAR daily dataset and horizontal divergence field, divergent wind, relative vorticity and diabatic heating were calculated using the same dataset.

3. Length of Summer

- Three regional indices including Physical index, Subtropical Jet index, and Dynamical index were designated to determine the start time, ending time and the length of summer season as well as to study the intensity of the atmospheric circulation over SWA. The above-mentioned indices provided the possibility of assessing different aspects of the summer circulation (Figs. 1 and 2). Physical index is based on a primary work by Floehn (1957) which developed by Goswami and Xavier (2005) and Xavier *et al.* (2007) as a Monsoon Index (Fig. 1).

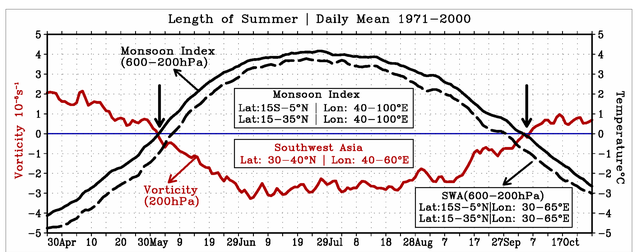
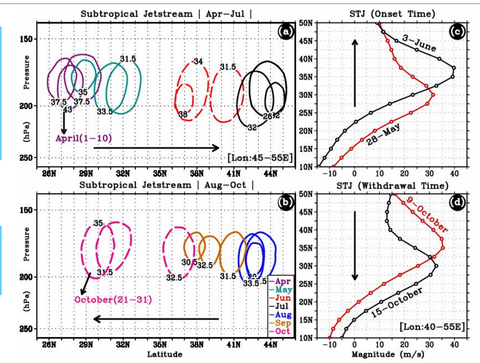


Fig. 1. Length of summer over SWA and South Asia. (Dynamical index: solid red line, Physical index: black dash line and Monsoon index, black solid line).

Fig. 2. Subtropical Jet Index.

(a) and (c) North-ward jump of Subtropical Jet stream over SWA. Beginning of summer.

(b) and (d) South-ward jump of Subtropical Jet Stream over SWA. End of summer.



4. Large –Scale Circulation

- The results show that the monsoon circulation over south-southeast Asia is the main factor in which controlling the large-scale summer circulation over SWA. The onset of Asian monsoon is associated with the formation of a permanent westward flow in the upper troposphere (Fig. 3). The sinks of energy over the SWA and east of the Mediterranean Sea are corresponding maximum convergence and subsidence locations of the westward flow. Maintenance of the large-scale subsidence creates a transverse meridional gradient in the temperature field; therefore, the meridional large-scale circulation is changed and this in turn creates a transverse Hadley circulation over the SWA.

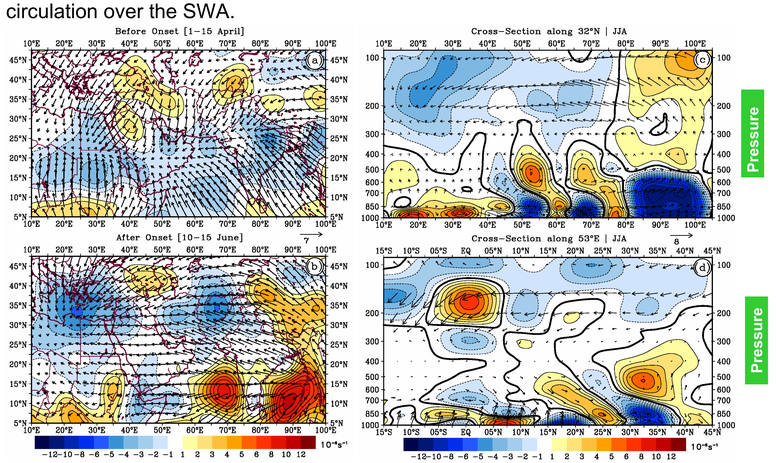


Fig. 3. Horizontal Divergence field (shaded) and divergent wind at 200 hPa before (a) and after (b) Monsoon Onset. Zonal and Meridional cross-sections for JJA.

5. Regional-Scale circulation

- The surface heat forcing has the main role in the formation and maintenance of regional-scale atmospheric circulation in middle and lower troposphere. The vertical heat advection induced by the existence of an elevated heat source in western Iran (Zagros Mountains) has the main effect on the formation of a thermally-driven anticyclonic circulation in mid-troposphere (Fig.4),(Zarrin *et al.* 2008; 2010; 2011).

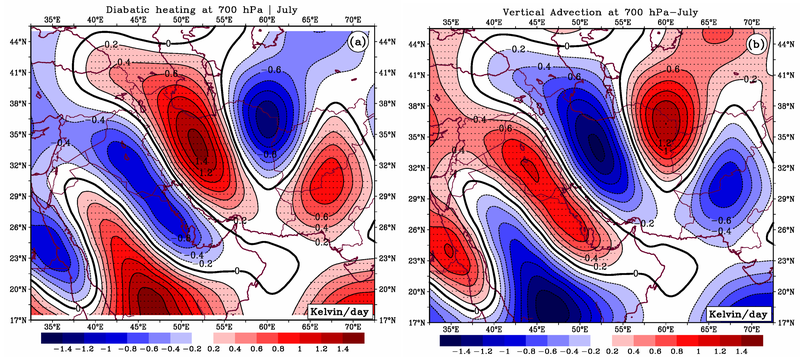
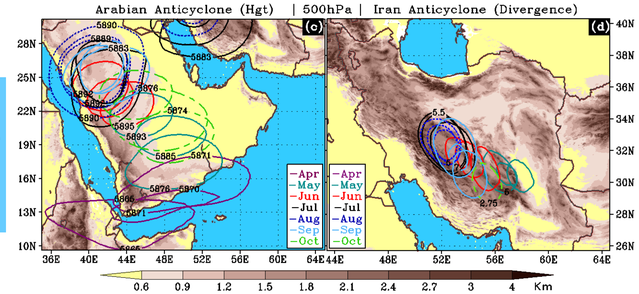


Fig. 4. (a) Total heating and (b) Vertical advection over SWA at 700 hPa.

Fig. 4. Anticyclones in Mid-troposphere. (c) Arabian anticyclone. (d) Iran anticyclone.



6. Summary

- It is found that the summer length has been considerably reduced in the recent two decades. The early ending of the summer can be physically related to the early ending of the transverse gradient in meridional temperature field during the 2-3 recent decades. The research also indicated that shortening of the summer and weakening of the atmospheric circulation over SWA has a relationship with the variability of summer monsoon circulation.

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