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A study of orographic convection over the Hajar mountains in Northern Oman

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Background: The Hajar Mountain range is a key factor in inducing a significant amount of rainfall during summer months. These steep mountains have peaks of approximately 10,000 feet, and run parallel to the coast of Gulf of Oman. Convective clouds form over the mountains creating a regular occurrence of showers and thunderstorms over a limited area in northern Oman. The active weather is generally of short duration, quite intense and is occasionally accompanied by hail and strong downdrafts. In addition to orographic forcing, the synoptic pattern shows that the advection of moisture and large scale lifting are important factors in determining wet days from dry days. The most important source of moisture is a tropical monsoonal flow from the south-western parts of the Arabian Sea. In order to understand this orographic convection, various observational data was collected during June/July 2004. Simultaneously, a meso-scale non-hydrostatic model with a horizontal resolution of 2 km was used to simulate the orographic convection. The model was initialised with a single morning profile. Results and analysis from the field observations and preliminary model results are presented.

Discussion: The aim is to present two cases (dry and wet). In the dry-case, streamlines (produced by the Oman regional model) show that the dry north-westerlies converge (over the mountains) with the sea-breeze (setting rather late) from the Gulf of Oman. The streamlines pattern is confirmed by the sodar observations (at Nizwa) showing northwesterly winds. In the wet-case, the sea-breeze converges with moisture flow advected from the Arabian Sea. This flow was also confirmed by sodar observations. Surface observations of dew-point temperature and wind speed and direction for Adam station and for Seeb station are also in agreement with the streamlines and the sodar winds. Examining various case studies indicated that the position of the heat low and its depth determine the direction and type of winds that converge over the mountains.

A dry desert air (even when flowing over the Arabian Gulf) will lead to moist convection being suppressed, whereas moist air advected from the Arabian Sea will enhance moist convection. Moisture advection from the Arabian Sea in a column of at least 1km in depth is required for proper convection. The stronger the flow from the Arabian Sea and the deeper the column of the moist air, the heavier the precipitation. Early results from the anelastic model show that the model is able to simulate cloud development, but it underestimates the total precipitation amount. The model also shows that clouds develop over the mountain peaks and dissipate as they move west, which agrees well with radar and satellite imagery.

Conclusions:- 1. Sea-breeze, orographic forcing, and most importantly, moisture advection (and the depth of the moist column), and convergence are key factors in convective cloud development over the Hajar Mountains. 2. The position of the thermal low and its depth determines whether the flow towards the mountains is dry desert air or moist air from the Arabian Sea. 3. The model demonstrated its ability to simulate the convergence of winds and cloud (development and movement) well, but underestimated the total rainfall intensity.