J158-001 **Room: 202** **Time: May 14 9:00-9:18**

Climate model simulations on the effect of large-scale orography on climate

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The role of large-scale orography on climate is investigated by a series of coupled ocean-atmosphere general circulation model (AOGCM) experiments. We used eight different mountain heights: 0% (no mountain), 20%, 40%, 60%, 80%, 100% (control run), 120%, and 140%. Land-sea distribution is the same for all experiments and all mountains in the world are uniformly varied. Systematic changes in precipitation and circulation fields as well as sea surface temperature (SST) are obtained with progressive mountain uplift. A north-south jump of the 500 hPa zonal wind axis around the longitude of the Tibetan plateau is found with mountain height higher than 60% between the winter and summer season. On the other hand the jet axis stayed in the northward position all the year round in the experiments with lower mountains. Summertime precipitation is confined in the deep tropics around 10N in the no-mountain (M0) case, but it moves inland on the Asian continent with mountain uplift. Associated with this, an intensification of the Pacific subtropical anticyclone and trade winds is found. The Baiu-like precipitation belt in East Asia clearly appeared at mountains higher than 60%. Surface wind distribution over the Indian Ocean and the Maritime Continent region drastically changed by mountain uplift. Summertime southwesterly monsoon flow does not cover the northernmost Arabian Sea region so that upwelling is inactive all the year round when mountain is lower than 40%. Changes in potential vegetation are also investigated using BIOME4 model. It is found that desert area is the largest in the no-mountain case and decreases in its area extent with mountain uplift. The western Pacific warm pool and ENSO also systematically changed. When the mountain height is low, a warm pool is located over the central Pacific due to weak trade winds in the Pacific. The model ENSO is strongest, its frequency is longest and is most periodic in the no mountain run. The model ENSO becomes weaker, shorter and less periodic when the mountain height increases. Strengthening the mean state trade winds and narrowing meridional extent of equatorial wind and ocean response by mountain uplift would be responsible for ENSO modulation.