Climatological study of south foehn in Japan: Dynamic, thermodynamic, or hybrid/scrambling type?

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Japanese society takes a greater interest in the foehn phenomenon because it updated Japan's maximum temperature record in 2007 and 2018 (Takane and Kusaka 2011, Nishi and Kusaka 2019). Recent increase in heat stroke patient and damage to rice in paddy-fields also helped to grow the people's concern about the foehn phenomenon. Most of the foehn phenomenon in Japan is considered to be the thermodynamic (diabetic process) type with precipitation and latent heating because textbooks mainly introduce this type. However, is it true?

A purpose of the present study is to have a climatological understanding of the types of foehn in Japan. Our study area is the Toyama plain where is located in the coastal region of the Sea of Japan. It is worth mentioning that the Toyama plain is a high frequency place of the southerly foehn wind, according to our preliminary analysis.

We first extracted foehn days and then found that 19% of the hot days (20% tile) at Toyama city in the past 10 years were caused by foehn phenomenon. Additionally, we investigated surface weather chart on foehn events and found that the foehn phenomenon tends to occur under the synoptic conditions with extratropical cyclone over the Sea of Japan (77% of total foehn events), anticyclone over the Pacific Ocean (12%), tropical cyclone around Japan (5%), and stationary front over Japan (5%). Last, the foehn events were classified into the thermodynamic (diabatic process) type with precipitation, dynamic (adiabatic decent) type without precipitation, and hybrid/scrambling type with precipitation (Takane et al. 2015, Miltenberger et al. 2016). The thermodynamic, dynamic, and hybrid/scrambling type occupy 3%, 82%, and 14%, respectively. Surprisingly, most of the south foehn in Japan are the dynamic type. Numerical simulations with the WRF model and backward trajectory analysis for many foehn cases supported this findings.