Effects of upper-level background wind bias on Rossby waveguides, Rossby wave source hotspots, and predictability of the Silk Road pattern

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The Silk Road pattern (SRP) is a leading mode of atmospheric circulation over mid-latitude Eurasia during boreal summer. Its temporal phase is known to be unpredictable in many climate models. Previous studies have not reached a clear consensus on the role of sea surface temperature (SST) associated with SRP. To investigate role of SST on SRP formation, we begin by comparing reanalysis with seasonal hindcast experiments of the Pusan National University coupled climate model.

Although SRP cannot be predicted temporally, the ensemble runs show potential predictability in SRP related to tropical Pacific SST. While reanalysis SRP is associated with North Atlantic SST anomalies, hindcast SRP is associated with tropical Pacific SST anomalies similar to El-Nino Southern Oscillation (ENSO). To explain the different SST associations, we propose two jet biases in the climate model which may affect Rossby wave propagation. Bias in North Atlantic jet exit results in a discontinuous waveguide from North Atlantic to Asia, which may hinder propagation of waves associated with North Atlantic SST to trigger SRP. In addition, bias in subtropical western Pacific westerlies reduces the evanescent region between subtropical western Pacific and Asian jet, which may favour westward dispersion of zonally elongated waves associated with ENSO SST to trigger SRP. Therefore, we propose that the role of SST on SRP can be substantially changed depending on fidelity of model upper-level background winds.

To investigate more quantitatively the roles of waveguides and the Rossby wave sources (RWS), we perform wave-making experiments using an idealised barotropic model prescribed with two different upper-level background winds, namely from reanalysis and from climate model. By comparing with result using reanalysis background winds, the preferred forcing locations - RWS hotspots - of SRP are identified from all the RWS associated with SRP in reanalysis. In addition to
previously identified hotspots from the literature, a new hotspot in central North Pacific is discovered which can force SRP by westward dispersion of zonally elongated Rossby wave.

Wave-making result using climate model background winds reveals that the upper-level wind bias changes the RWS hotspots locations of SRP. Experimental result is consistent with theoretical analysis of waveguide bias, and support our conclusion that the relationship between SRP and SST can be substantially changed depending on model background winds bias. The impact of our study is that this sensitivity of SRP hotspots to background winds may reduce seasonal forecast skill of SRP in models with background winds bias.