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Tropical-Extratropical Interactions associated with Asia-Australian Monsoon

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Introduction

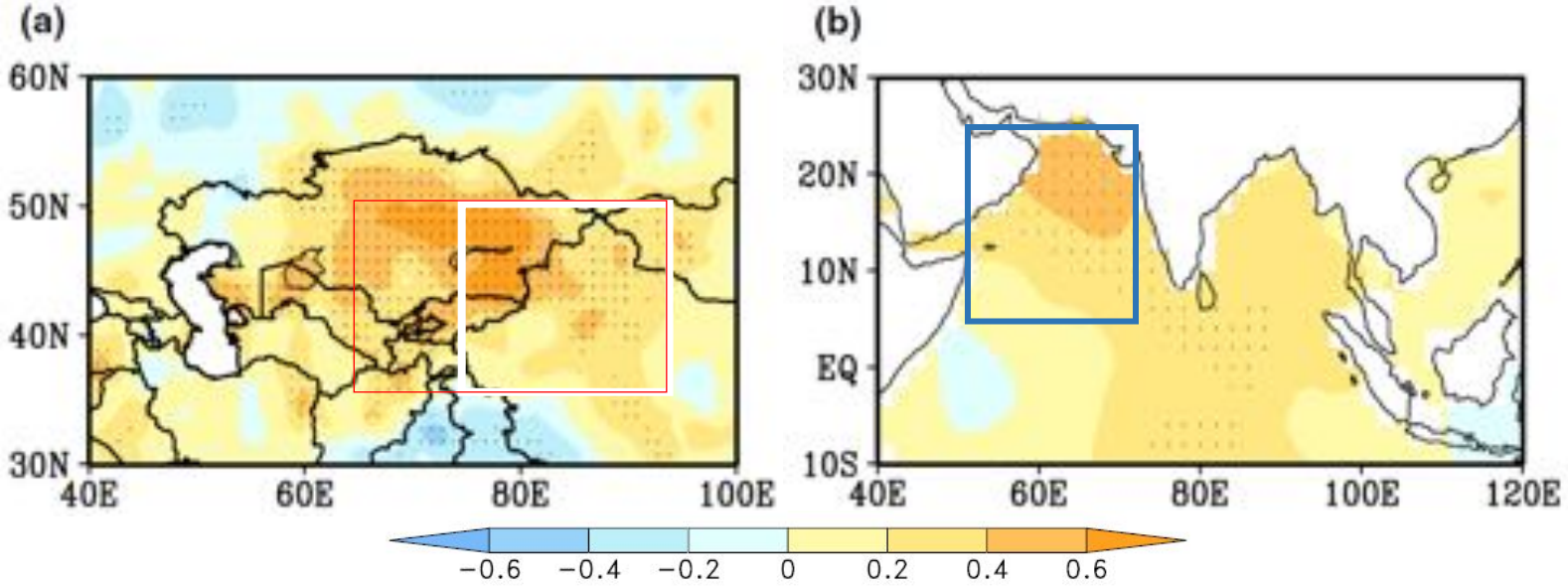
Recent studies (Zhao et al. 2014, J. Climate; Zhao and Zhang 2016, Climate Dynamics) investigated the linkage between summer rainfall in Central Asia and tropical Indian monsoon and Indian Ocean SST warming

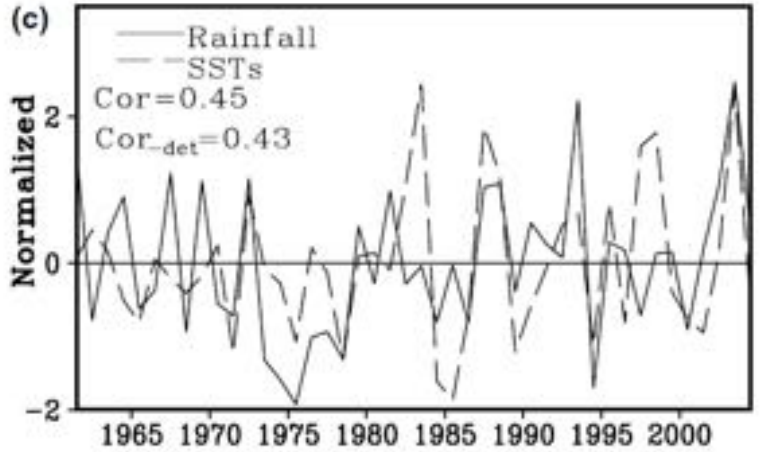
Introduction

(a) Rainfall averaged over white BOX correlated to everywhere shows that summer rainfall over Central Asia is fairly homogenous and strongly positive

(b) Rainfall over Central Asia (red BOX in (a)) is correlated to Indian Ocean SST in summer

(c) IAV of summer Rainfall (red box) and SST (blue BOX)

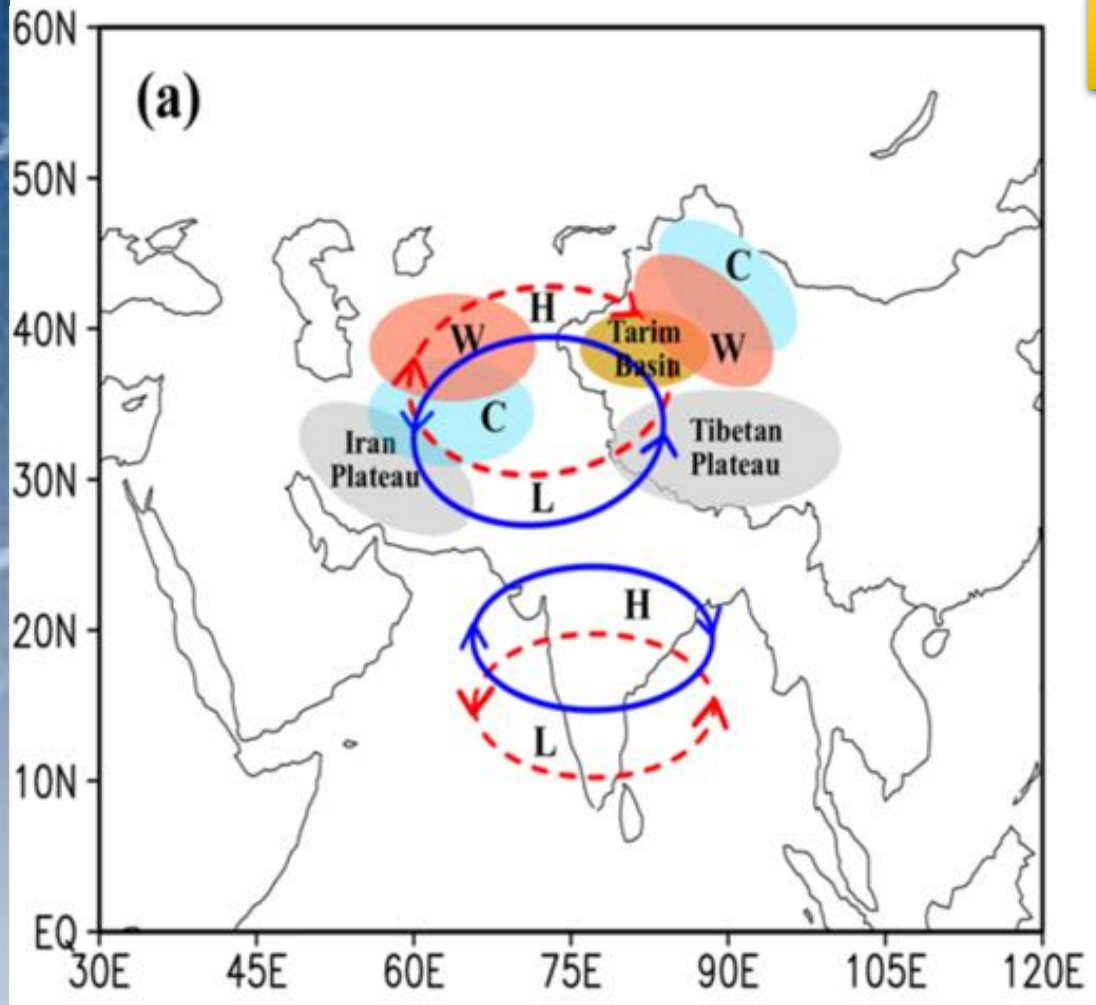




Linkage between IO SST's and Central Asia rainfall on IA and Dec time scales from OBSERVATIONS

From Zhao and Zhang 2016, Climate Dynamics

Pathways of IO SST influence to CA rainfall



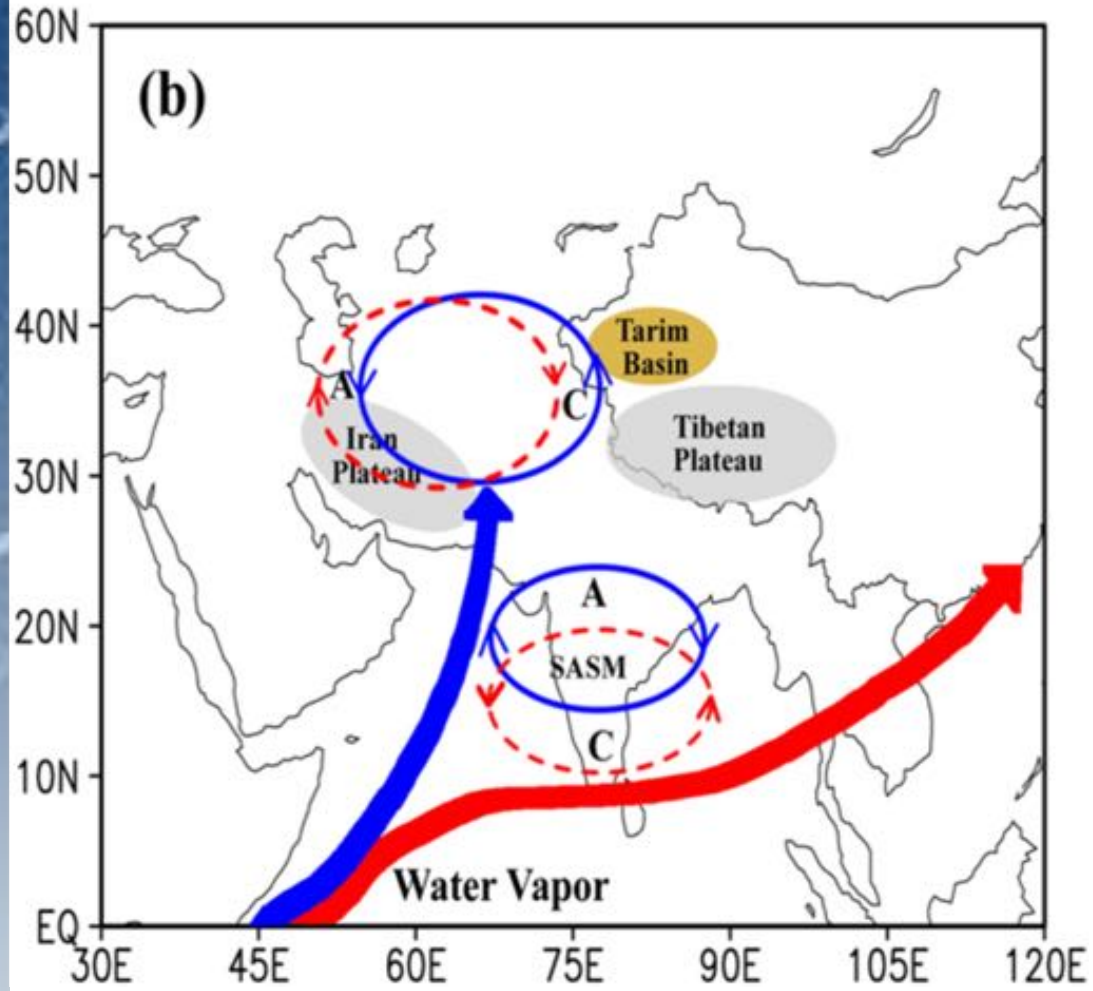
1. DYNAMICAL pathway

- Significant atmospheric circulation responses to SST anomalies in IO
- Warm IO SST's → stronger cyclonic circulation → enhanced low-level convergence → strengthened upward motion in in tropical IO region
- Linking to strong anti-cyclonic flow anomaly north - like a descending branch of the ascending flow from tropical IO

SST's are the 'driving force' for the atmospheric dynamics

Modulation of position and intensity of SAH in tropopause with significant impact on climate in CA

Pathways of IO SST influence to CA rainfall



2. MOISTURE pathway

- Significant enhancement of southerly flow into the CA region associated with two branches: SW (Arabian Sea) and SE (across Indian sub-continent)
- Transport of moisture through valleys between Iran and Tibetan Plateaus towards CA

So how is this tropical-extra tropical teleconnection (Desert-Monsoon TC) – simulated in our GCM (UK UM)?

Especially, given the systematic biases in tropical rainfall simulations

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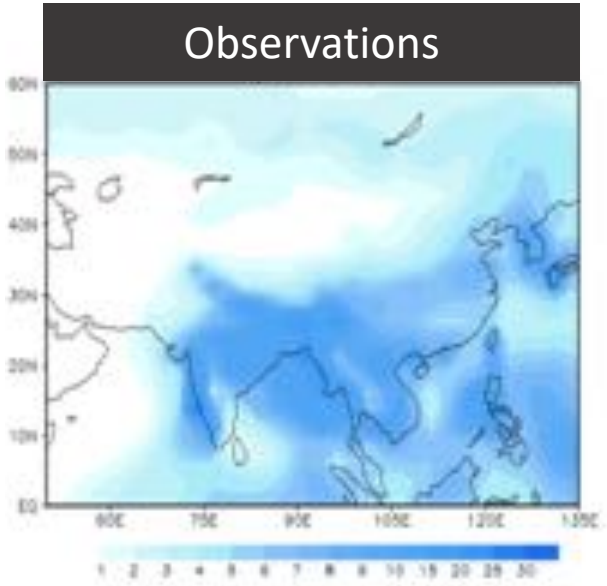
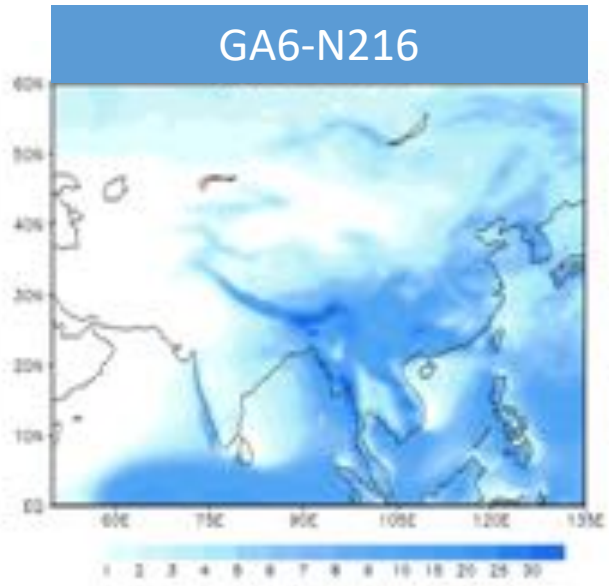
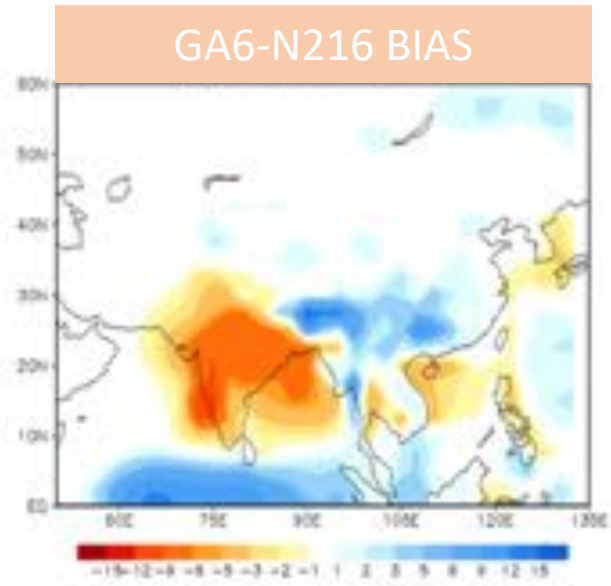
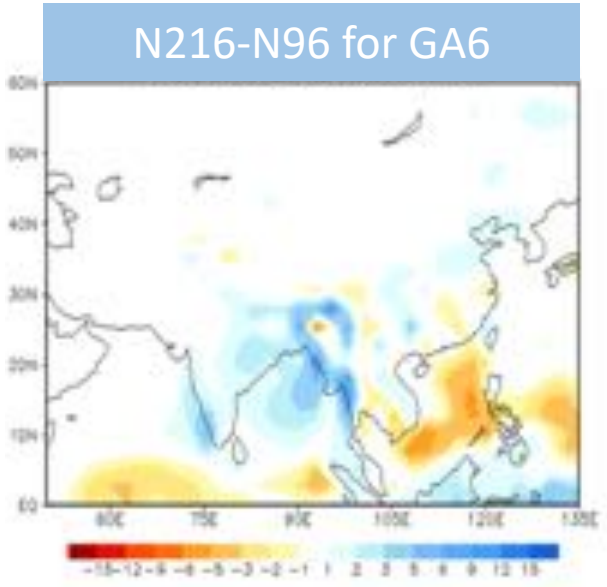
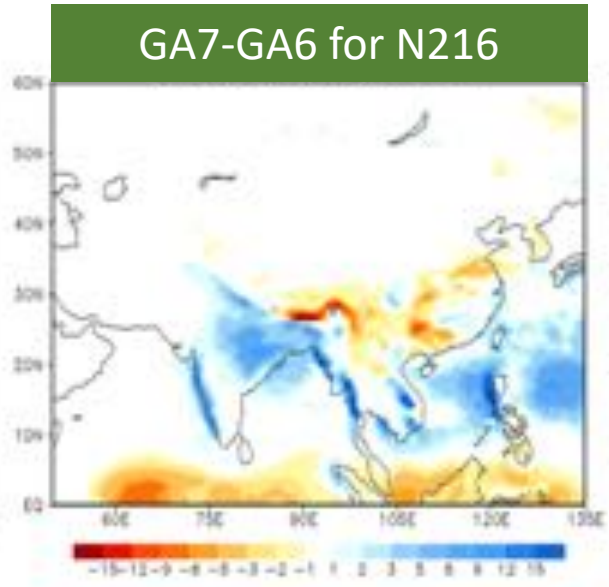
Rainfall biases in UM Model family for JULY

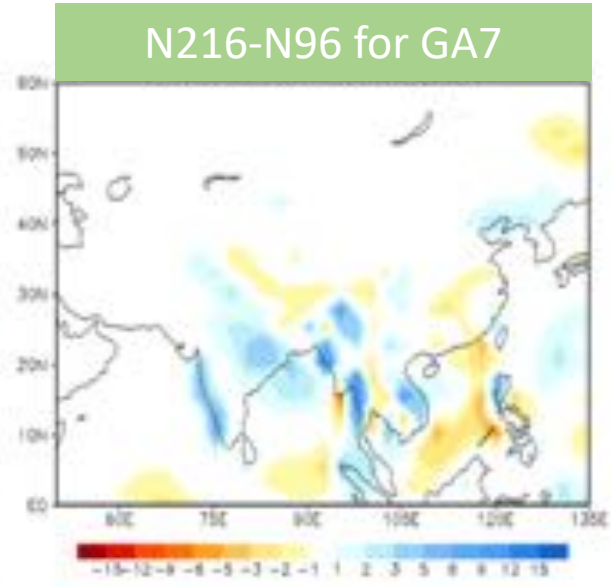




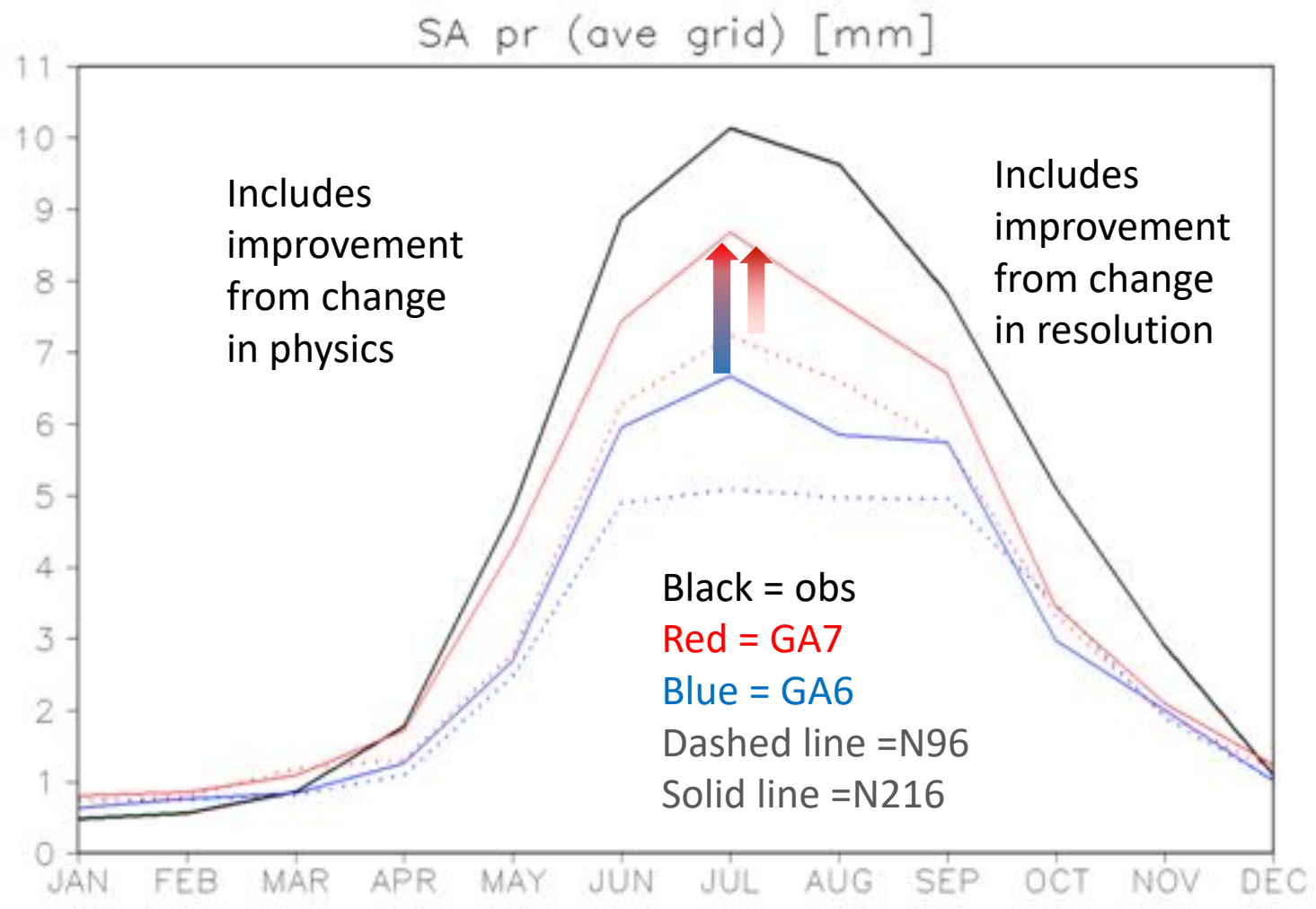








Rainfall bias in UM Model family for JULY



So how does this reflect on the tropical-extra tropical teleconnection, e.g. the Desert-Monsoon TC?

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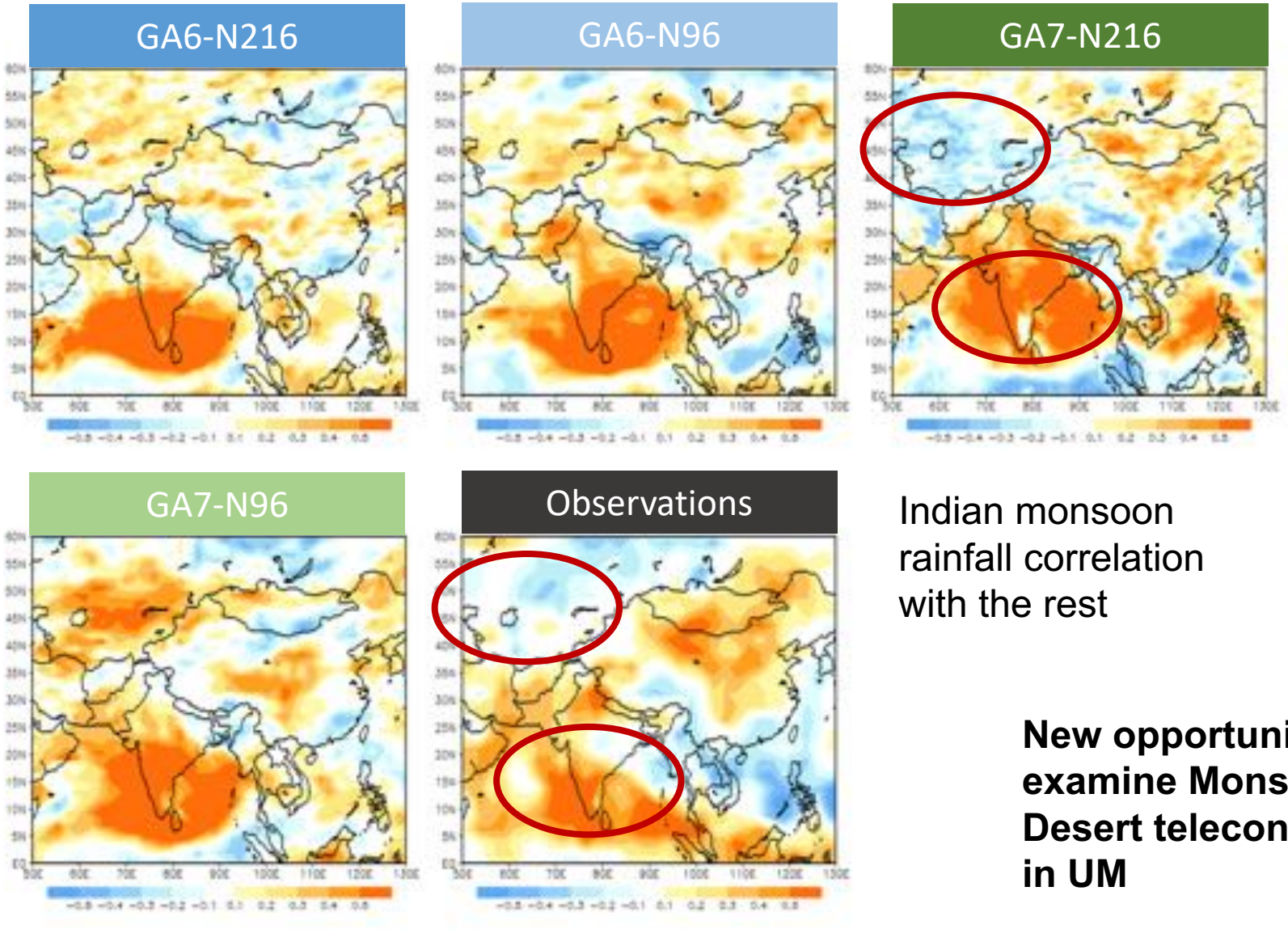
Monsoon – Desert teleconnection in UM



Indian monsoon rainfall correlation with the rest

New opportunity to re-examine Monsoon-Desert teleconnection in UM

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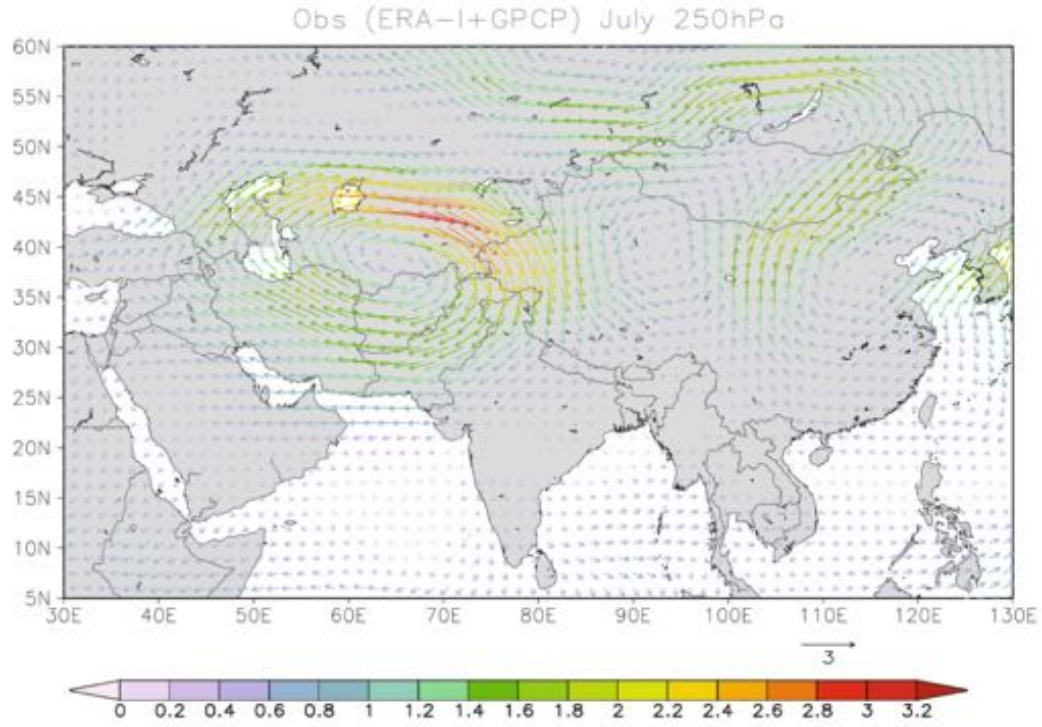
Observed circulation correlations (250hPa)

ERA-I + GPCP; July; 250hPa



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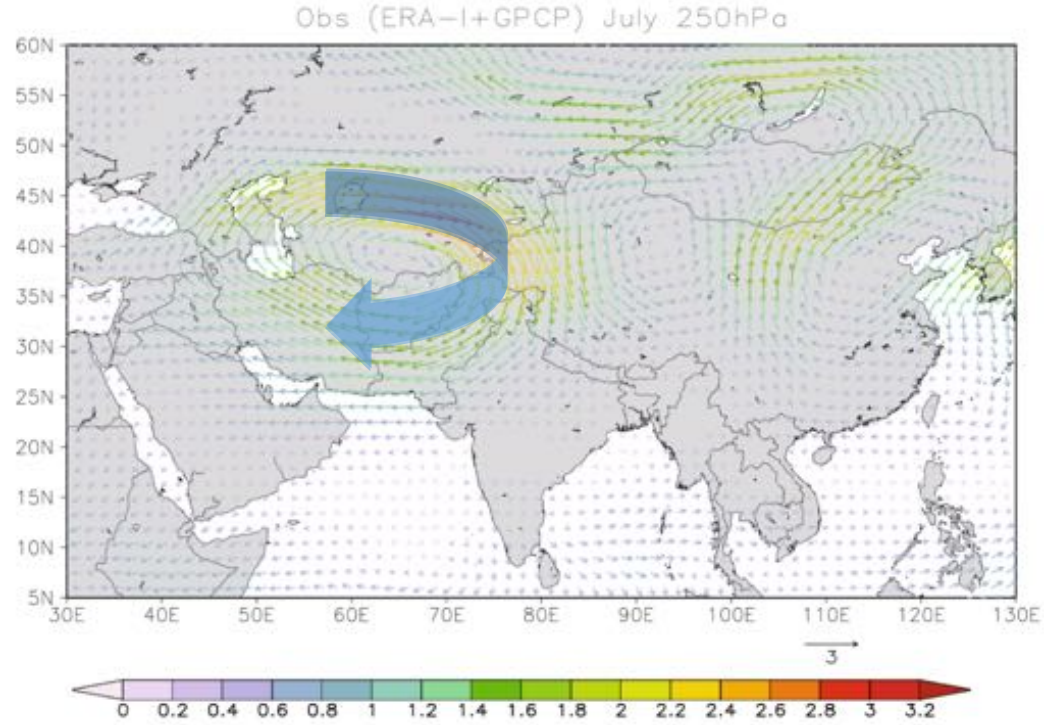

Indian Monsoon rainfall (60E-90E, 10N-25N) correlated with 250hPa Winds

→ High correlation with Gill-type response in OBS

→ Significant upper level circulation across central Asia associated with Indian Monsoon rainfall

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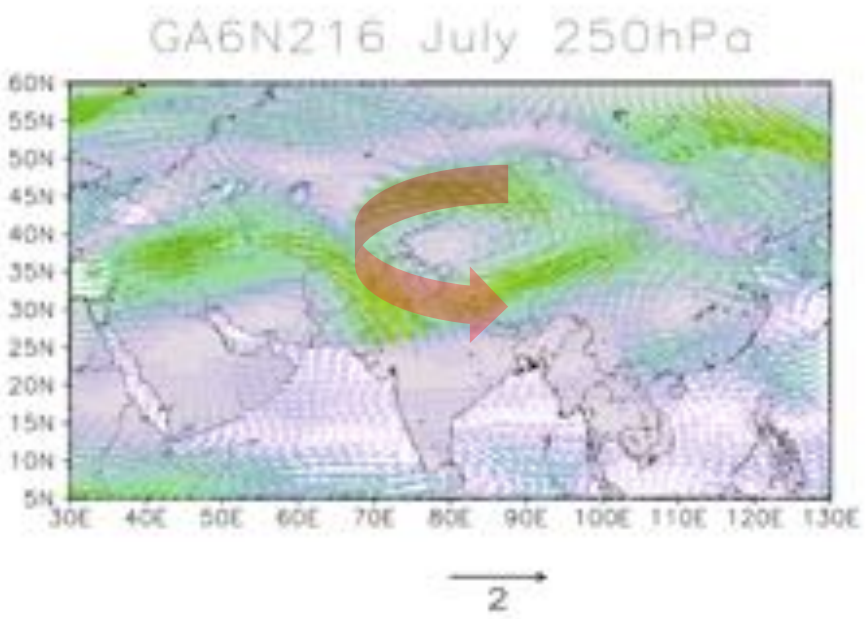
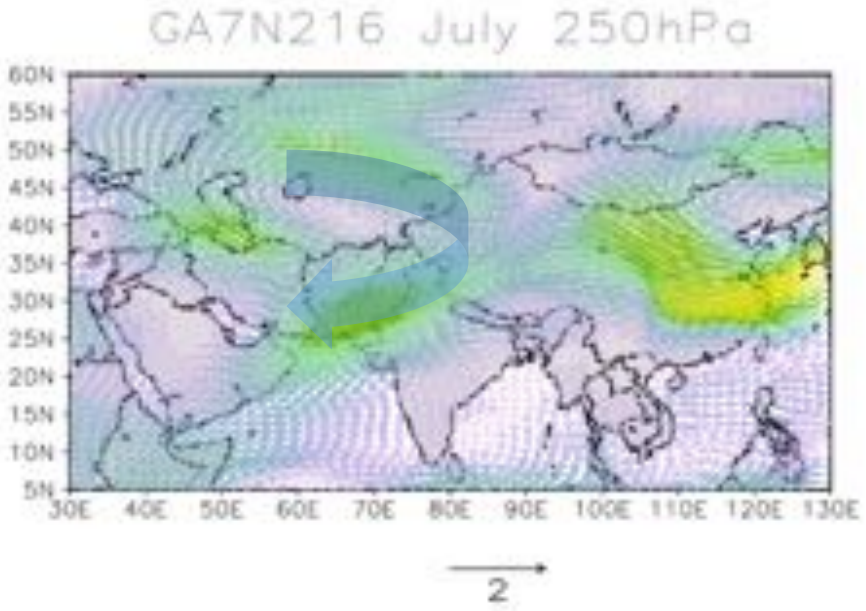
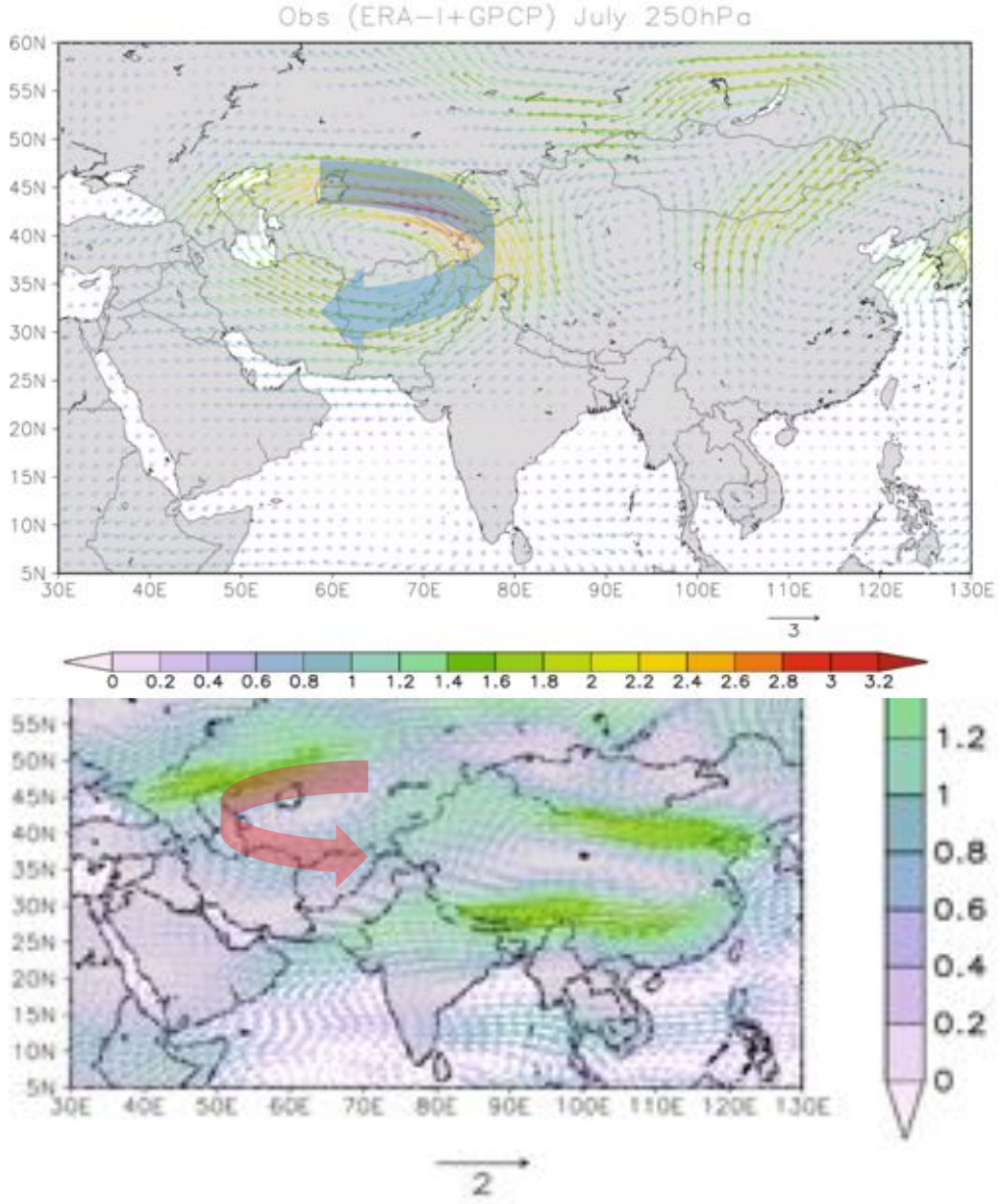
UM Model circulation anomaly







Possible reason for GA7 improvements

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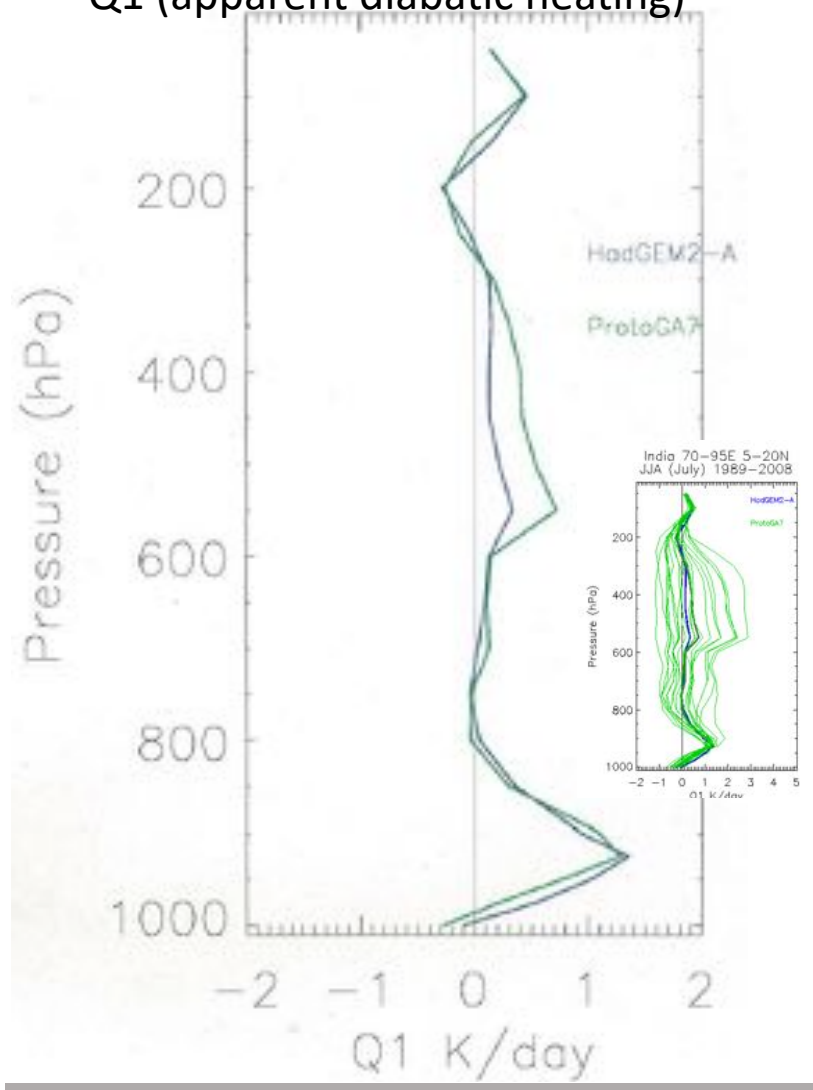
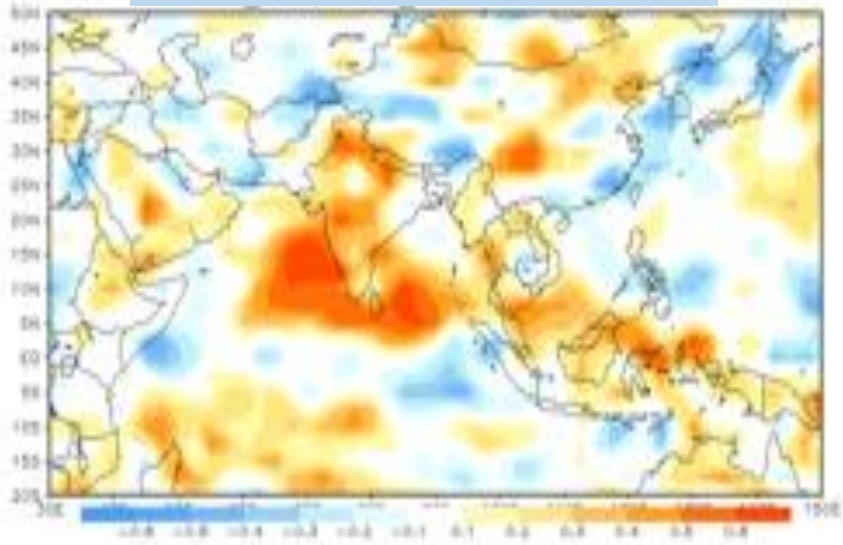
Tropical Diabatic Heating in GA7 and GA6

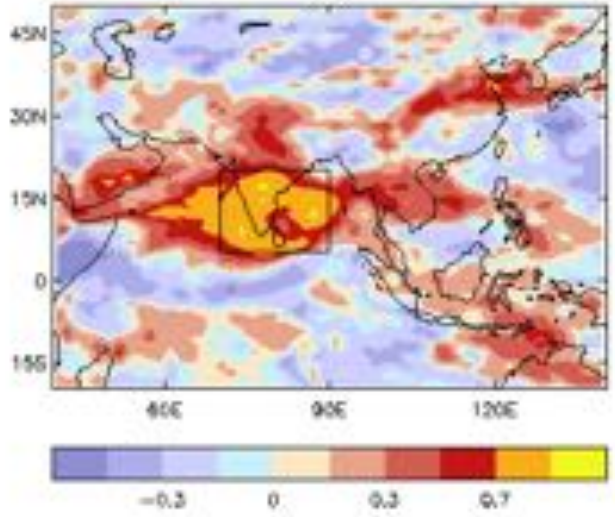
Q1 (apparent diabatic heating)



OBS cor(Pr~heat@400hPa)

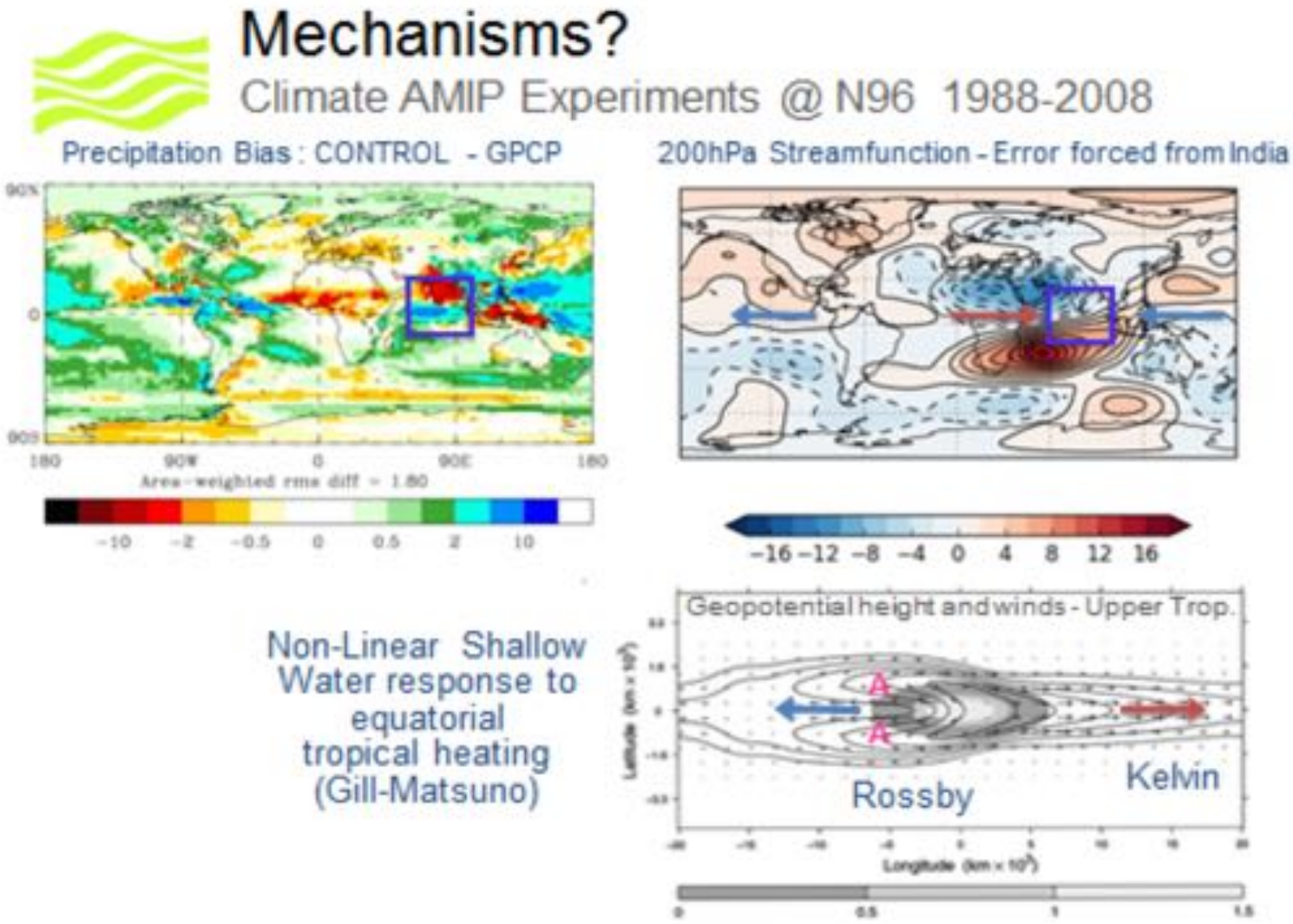


ProtoGA7 cor(Pr~heat@400hPa)



Diabetic heating intensity is almost doubled over Indian monsoon region in ~GA7 (G. Martin)

Leading to a Gill-type response in UM when nudged



Courtesy: Sean Milton

Summary

- Extratropical-tropical teleconnections between tropical IO and Central Asia are shown in observations
- Monsoon diabatic heating is the 'driving force' for the atmospheric dynamics
- Moisture originated from tropics associated with Indian Monsoon is important for rainfall variations in CA.
- Improved topical monsoon representation in the UM leads to more realistic rainfall teleconnections between tropics and extratropics

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UM Model circulation anomaly