



**The Abdus Salam  
International Centre for Theoretical Physics**



**1968-33**

**Conference on Teleconnections in the Atmosphere and Oceans**

*17 - 20 November 2008*

**Examining teleconnections generated by Indian ocean convection by modifying  
diabatic heating in a GCM**

BARLOW Mathew  
*University of Massachusetts Lowell  
Dept. of Environmental, Earth and Atmospheric Sciences  
One University Ave., MA 01854 Lowell  
U.S.A.*

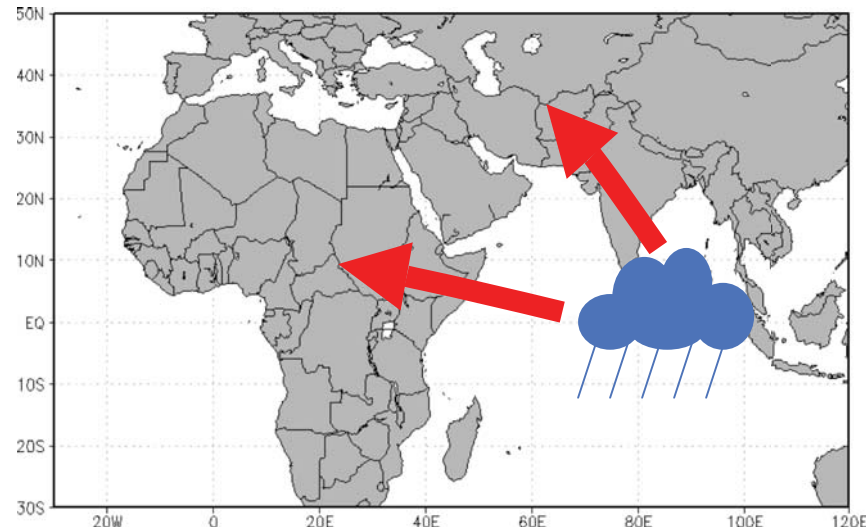


# **Examining teleconnections generated by Indian ocean convection by modifying diabatic heating in a GCM**

**Matt Barlow**

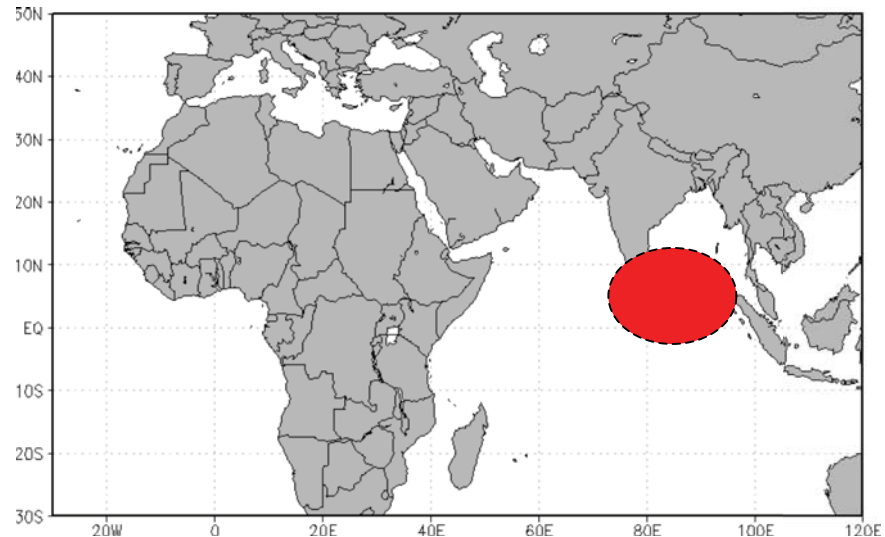
*University of Massachusetts Lowell*

## Two Teleconnections



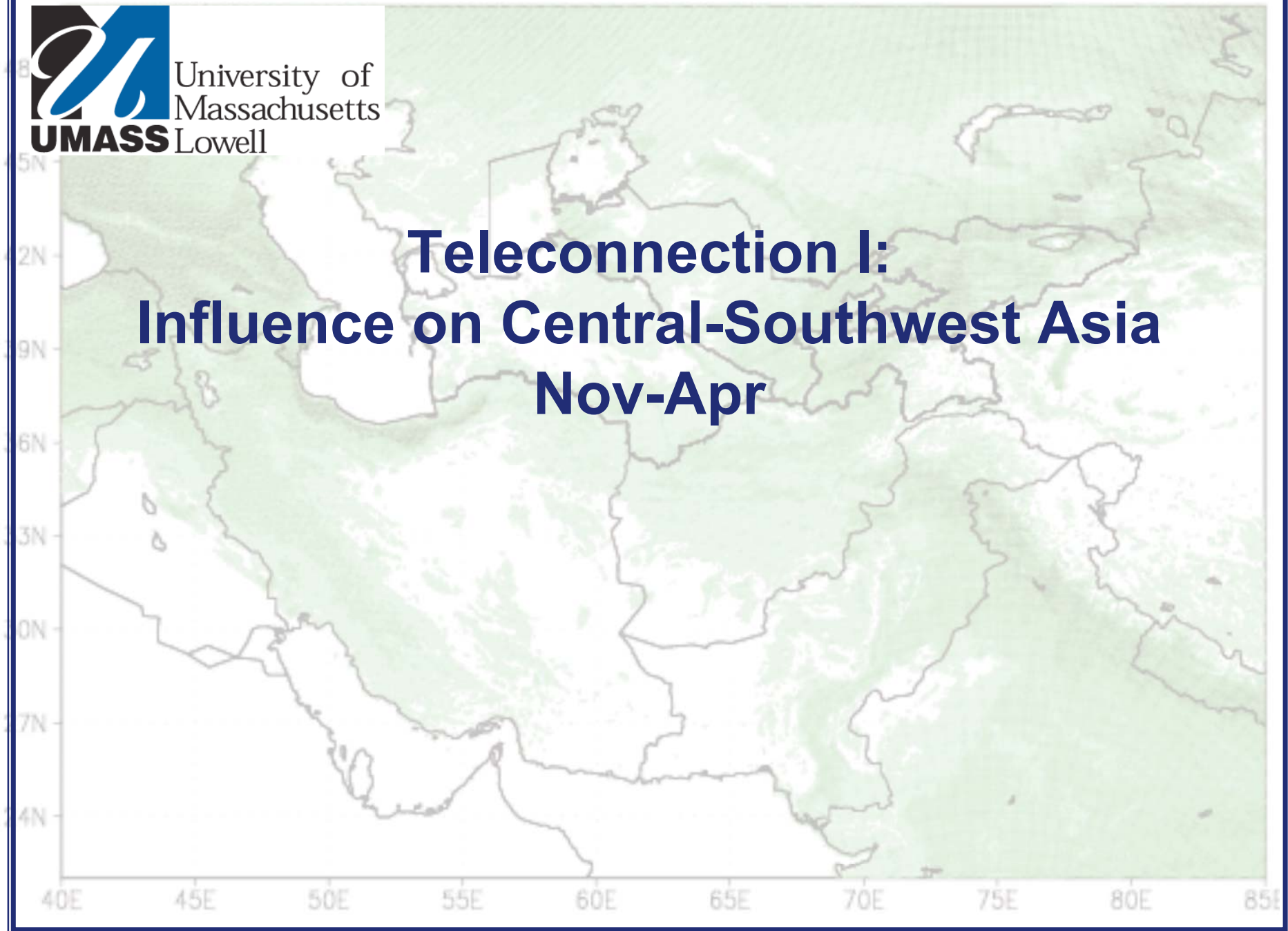
Influence of Indian Ocean  
convection on Southwest Asia  
and on Africa

## One Technique



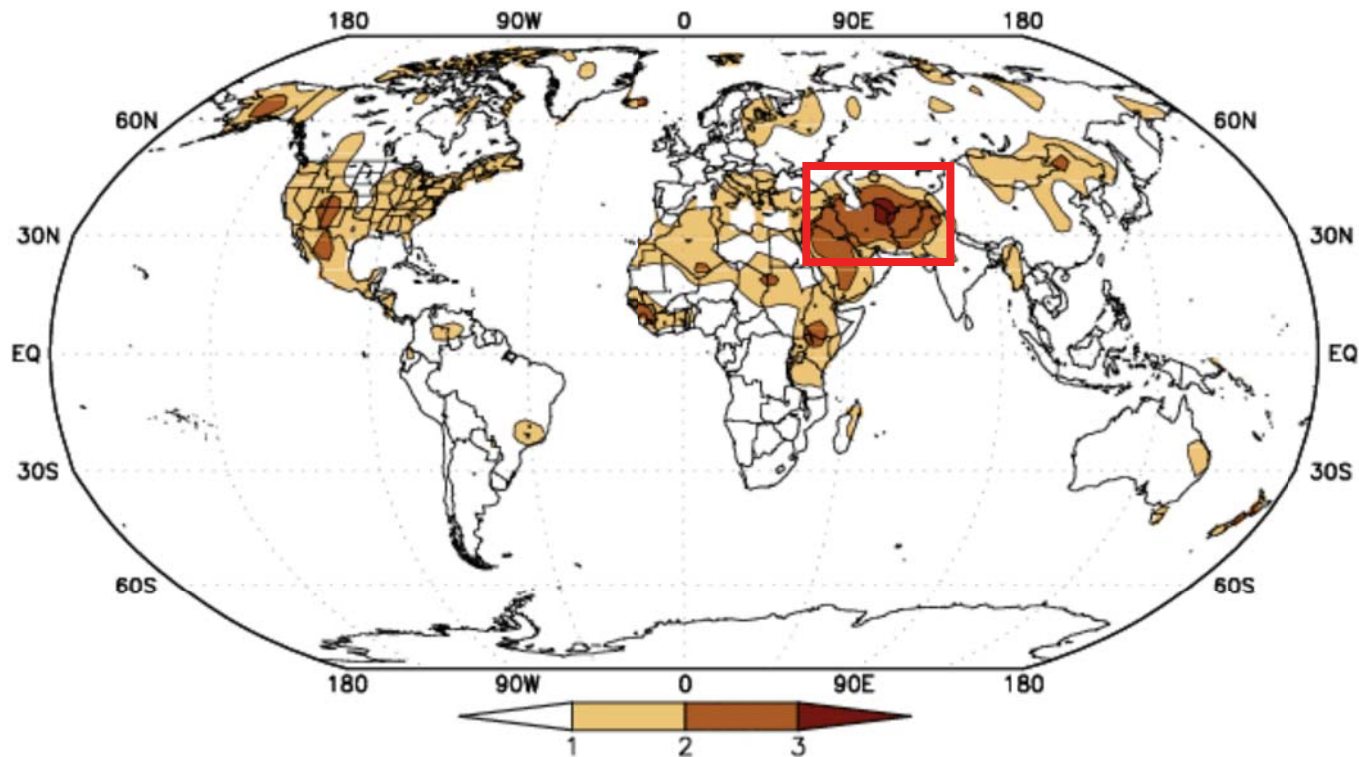
Add diabatic heating to NCAR  
CAM 3.1 -- similar to classical  
linear modeling, but use of a  
GCM allows fully nonlinear  
response with explicitly resolved  
precipitation

# Teleconnection I: Influence on Central-Southwest Asia Nov-Apr



# Why worry about Central-Southwest Asia?

## Severe Drought, 1998-2001



Number of consecutive years the precipitation deficit was in the lowest fifth of the record.

Agrawala et al. (2001), Barlow et al. (2002), Barlow et al. (2006)

## Selected Drought Impacts

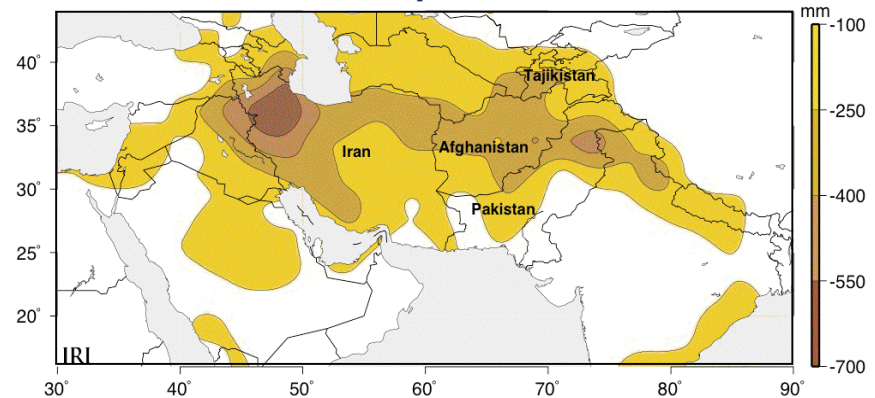
The severity and spatial extent of the drought—the worst drought in the region for the last 50-100 years—resulted in exceptionally severe impacts across a wide range of sectors. **More than 60 million people were affected, with economic losses in the billions of dollars.** Several aspects of the drought's impacts will be felt for decades and the drought still continues in southern areas of the region. A partial list of impacts includes:

**Health:** Large increases in the incidence of polio, cholera, diphtheria, typhoid, and tuberculosis were reported, particularly in refugee camps (drought refugees + no water for sanitation).

**Agriculture:** In 2001, half of Tajikistan's grain crops failed. In Afghanistan, rain-fed crops failed completely in many regions and irrigated crops were drastically reduced (no water for irrigation). In Pakistan's Balochistan province, the cropping areas were reduced by 45% from 1999-2003.

**Livestock:** In Iran, an estimated 100,000 head of livestock died in 2000.

**Deficit in Precipitation, 1998-2001**



**Water resources:** National water reserves were down by 45% in Iran by July 2001.

**Environment:** The internationally-recognized Sistan wetland, home to more than 150 species of waterfowl, including 8 globally-threatened species, was almost completely desiccated. Much of the vegetation died or was collected for fuel, contributing to erosion and significant movement of sand.

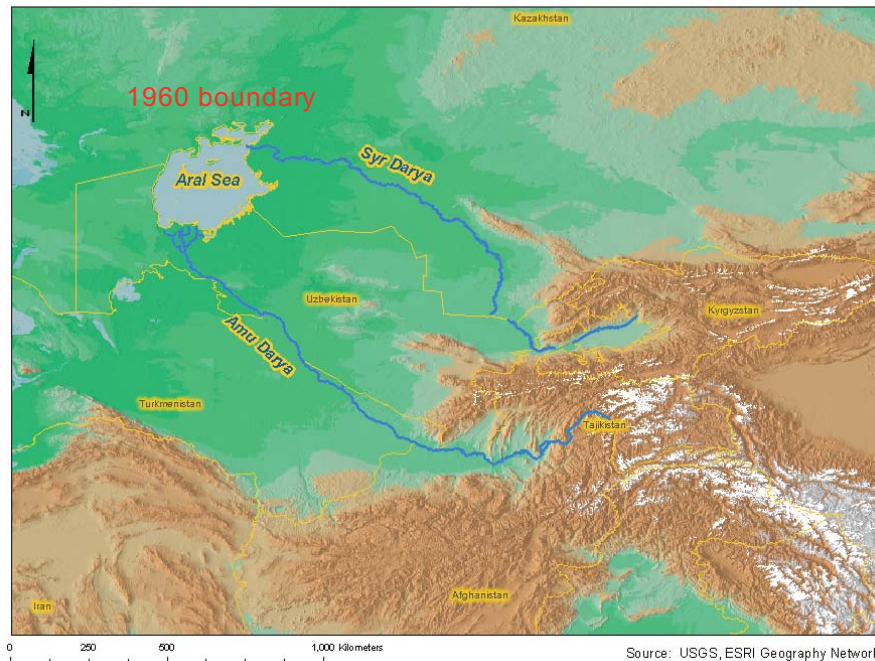
**Economics:** During the first two years of drought in Afghanistan, household debt doubled and assets decreased by half.

Agrawala et al. (2001), Barlow et al. (2006)

# Primary hydro input to shrinking Aral Sea

## Primary Rivers

Amu Darya and Syr Darya



## Shrinking Aral Sea

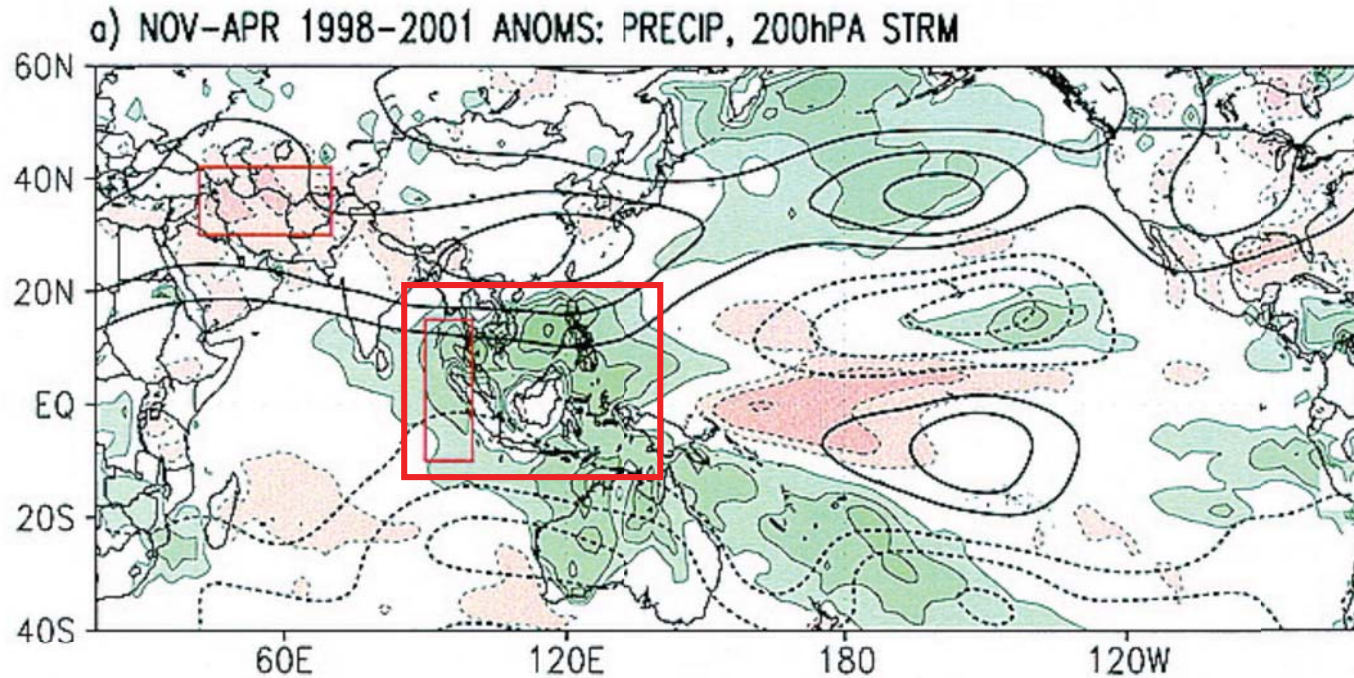


Orlovsky and Orlovsky (2002)

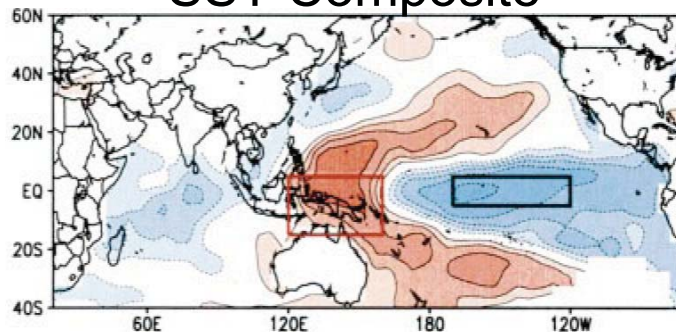
Due to massive irrigation  
withdrawals from Amu Darya  
and Syr Darya

# Why look at the Indian Ocean convection?

## 1998-2001 La Nina



### SST Composite



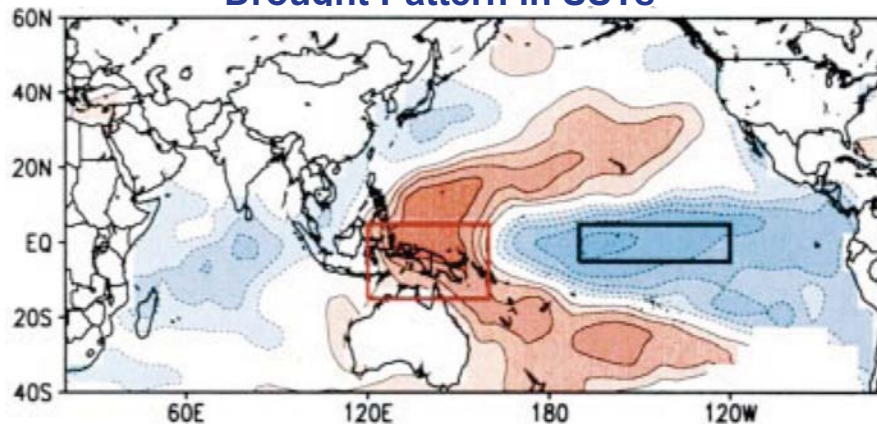
Compositing shows  
precip & winds typical  
of La Nina + warm  
west Pacific

Barlow et al. (2002)

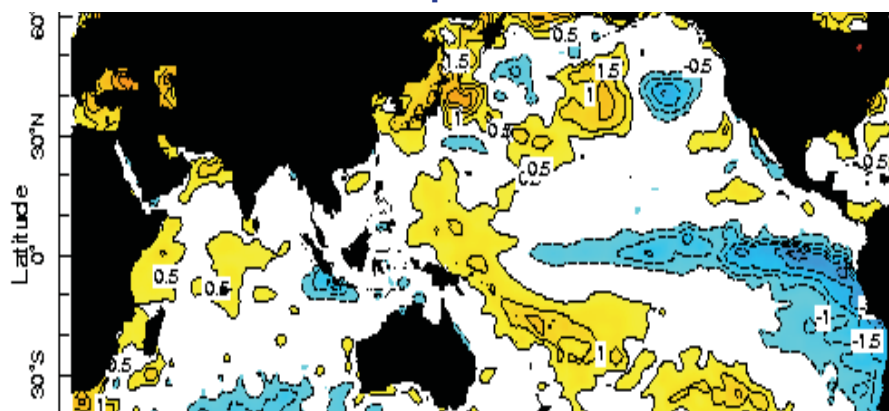


# Past is Prologue: Last Winter

### Drought Pattern in SSTs

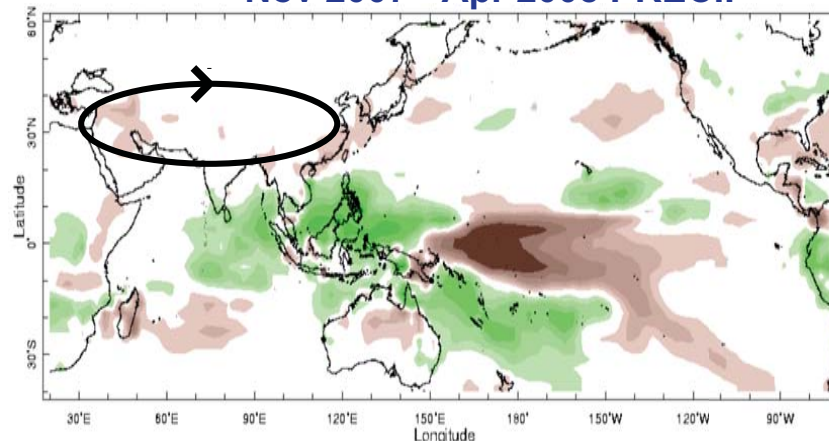


### Sep 2007

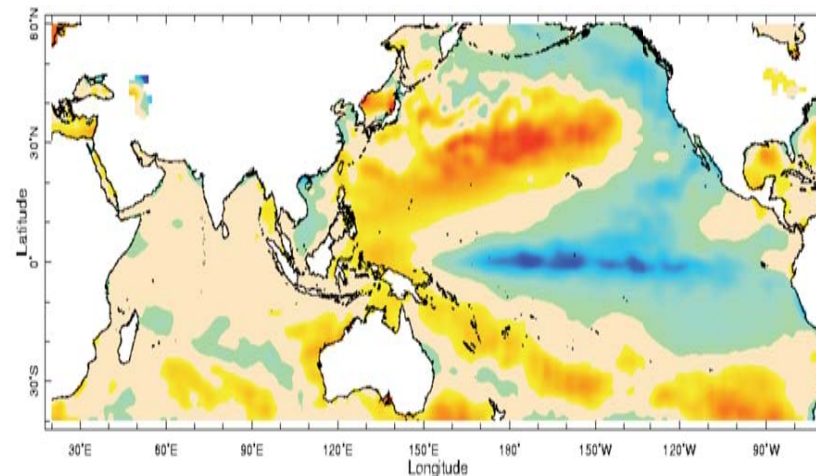


From a talk in Oct 2007

### Nov 2007 - Apr 2008 PRECIP



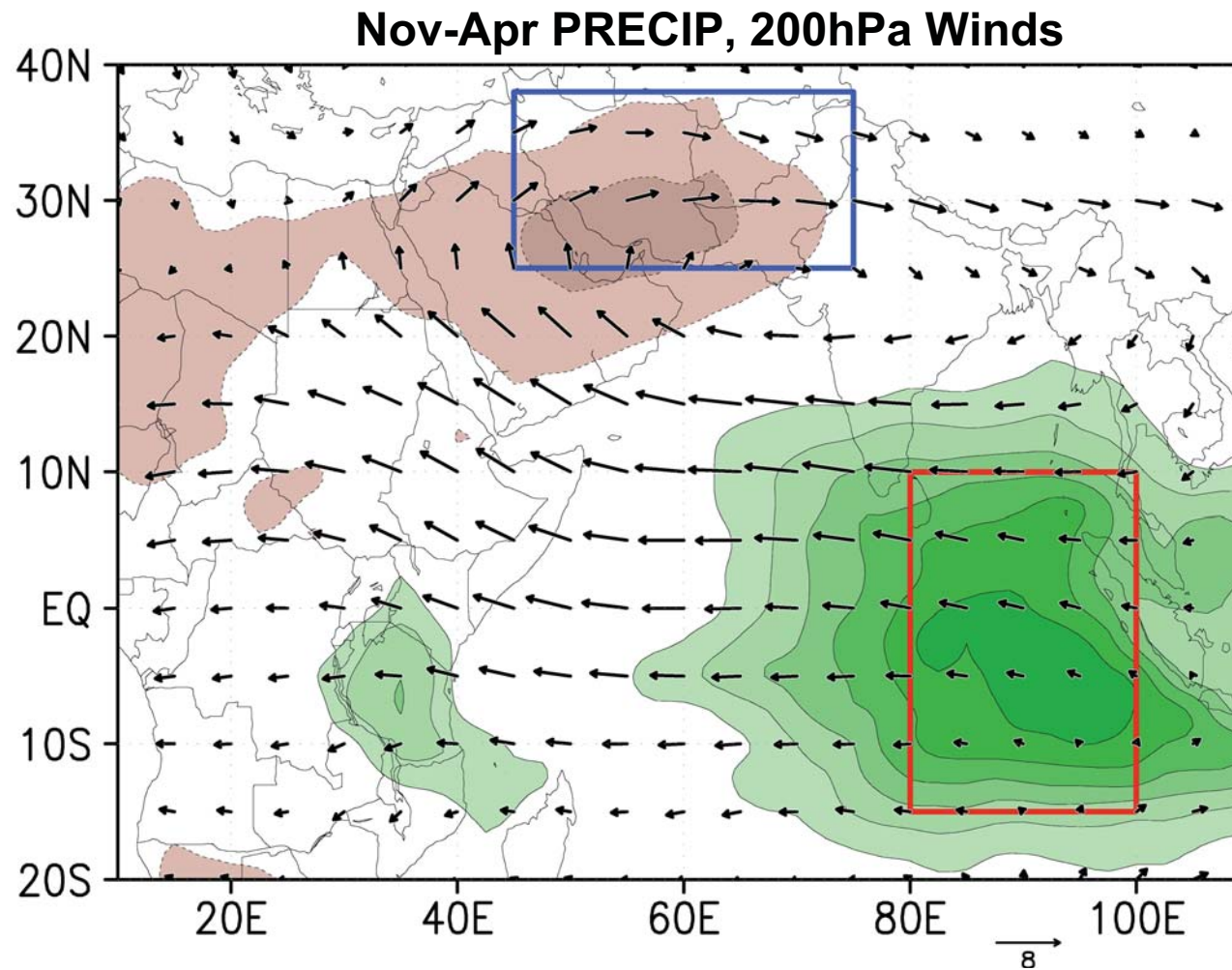
### Nov 2007 - Apr 2008 SST



### Last Winter

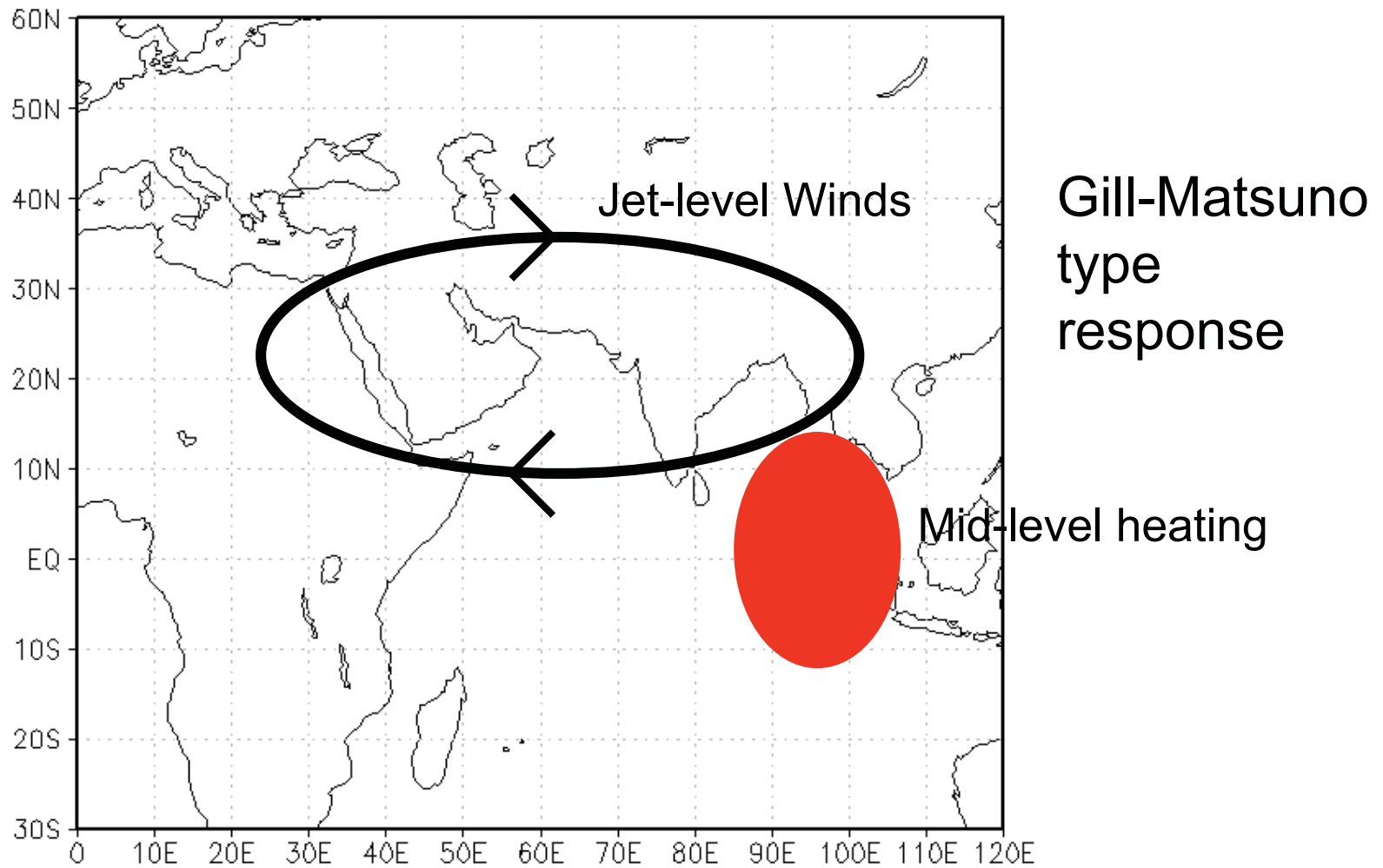
Shakespeare (1610), Hoell et al. (in prep)

## And don't forget the Madden Julian Oscillation (MJO)

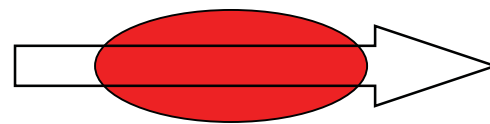
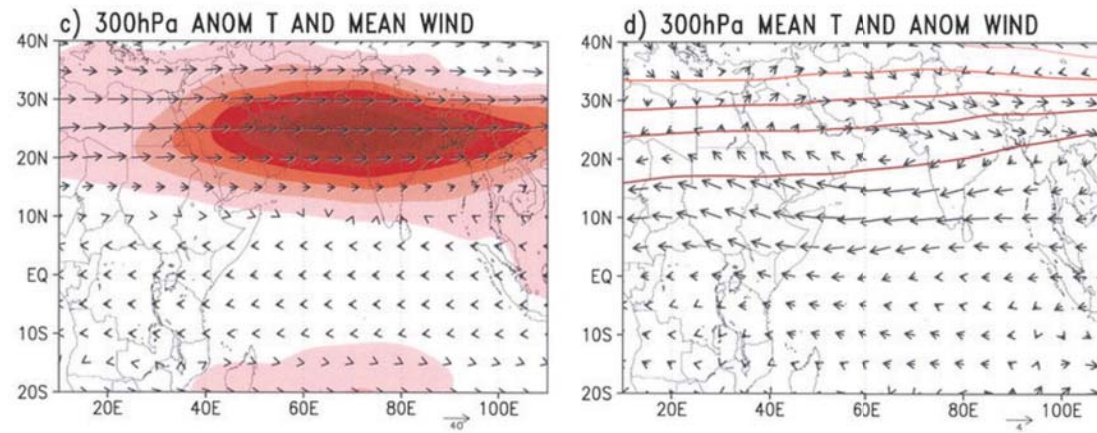


Barlow et al. (2005)

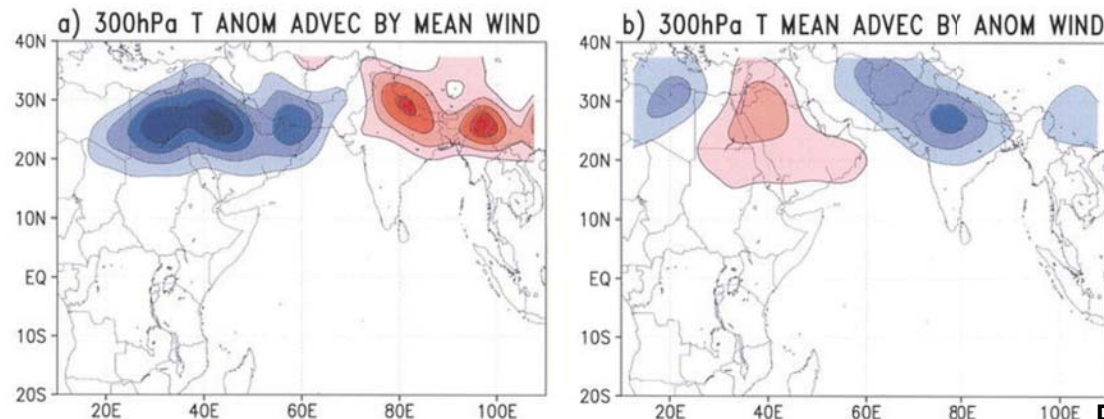
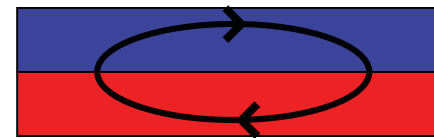
# Common Feature



# Proposed Dynamics: Thermodynamic Interaction of Rossby Wave and Westerlies → Subsidence (cf. Rodwell-Hoskins Desert Monsoon Hypothesis)



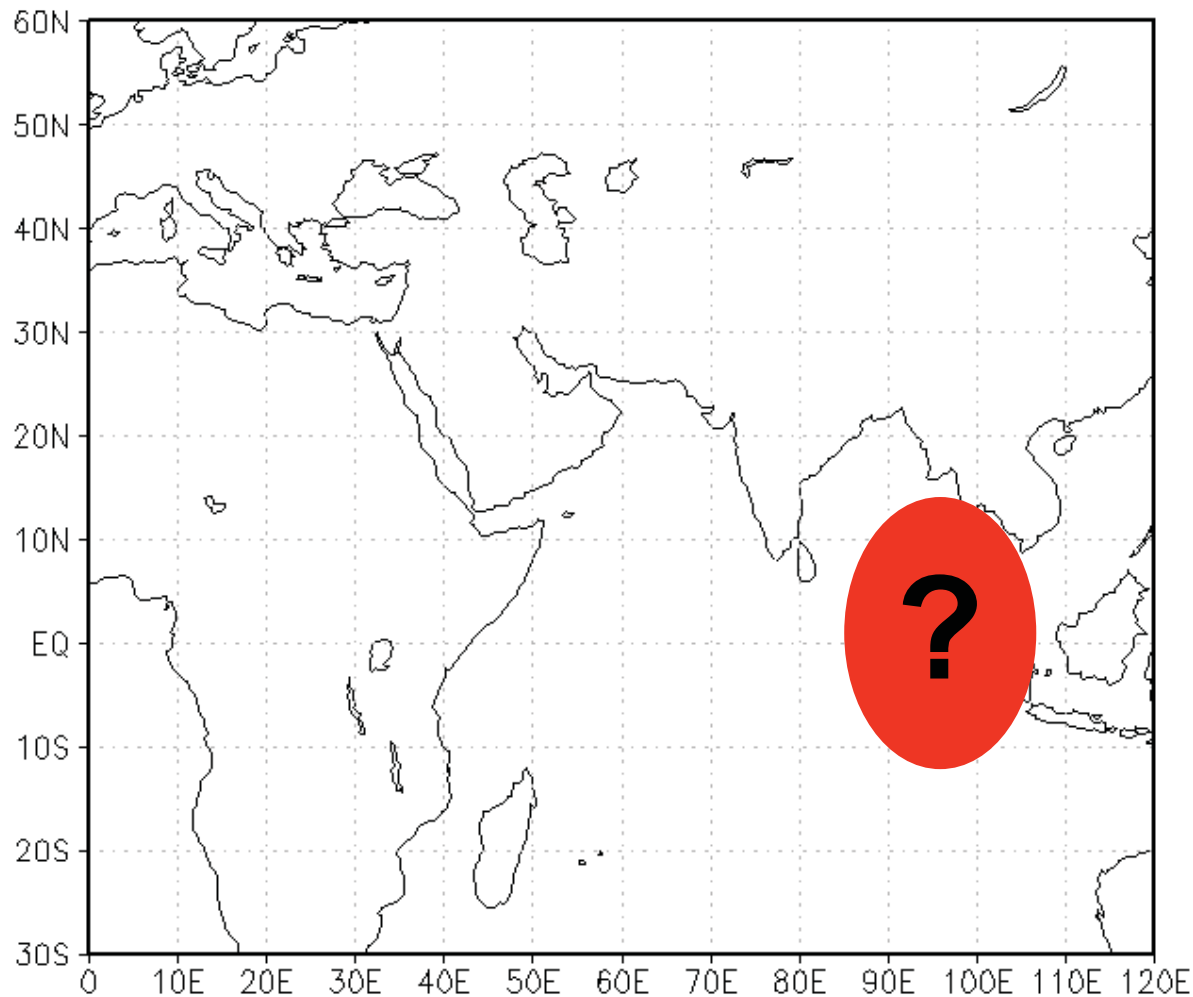
Isentropic Downgliding



Barlow et al. (2005)

**But ...**

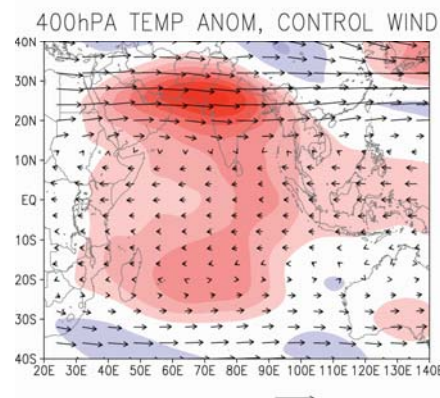
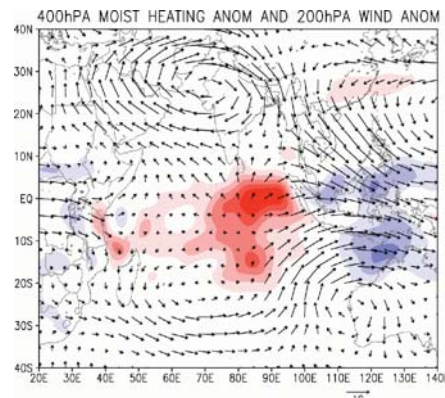
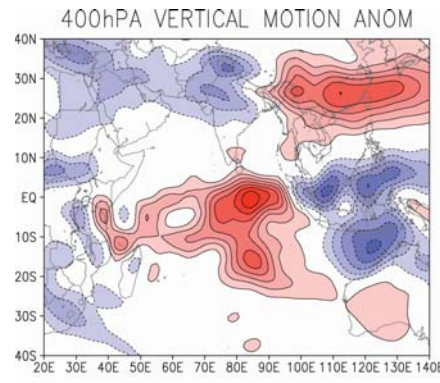
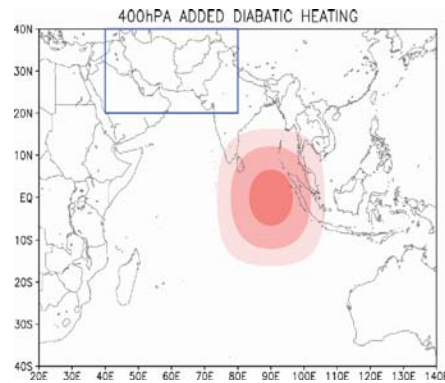
**Lot's of other things going on, even in composites, how can we focus in on one small area of convection?**



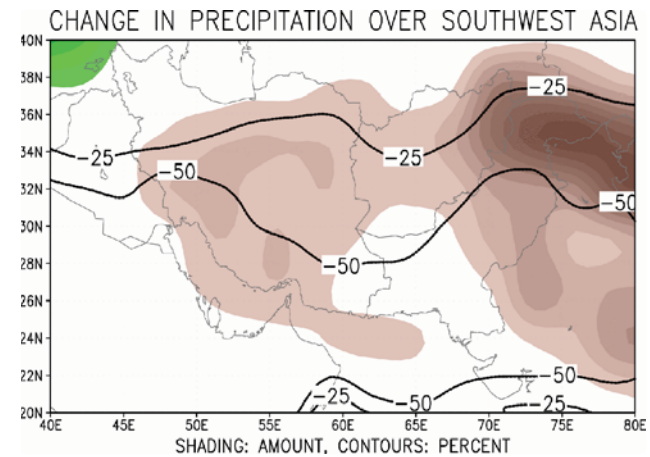
... by adding heating in that region in the CAM,  
and letting the model otherwise evolve freely ...

Local feedback enhances heating, wind response still Gil-Matsunol-like, and accompanied by thermodynamically-driven subsidence and suppressed rainfall over SW Asia

### ADDED HEATING



### Andy Hoell's Research

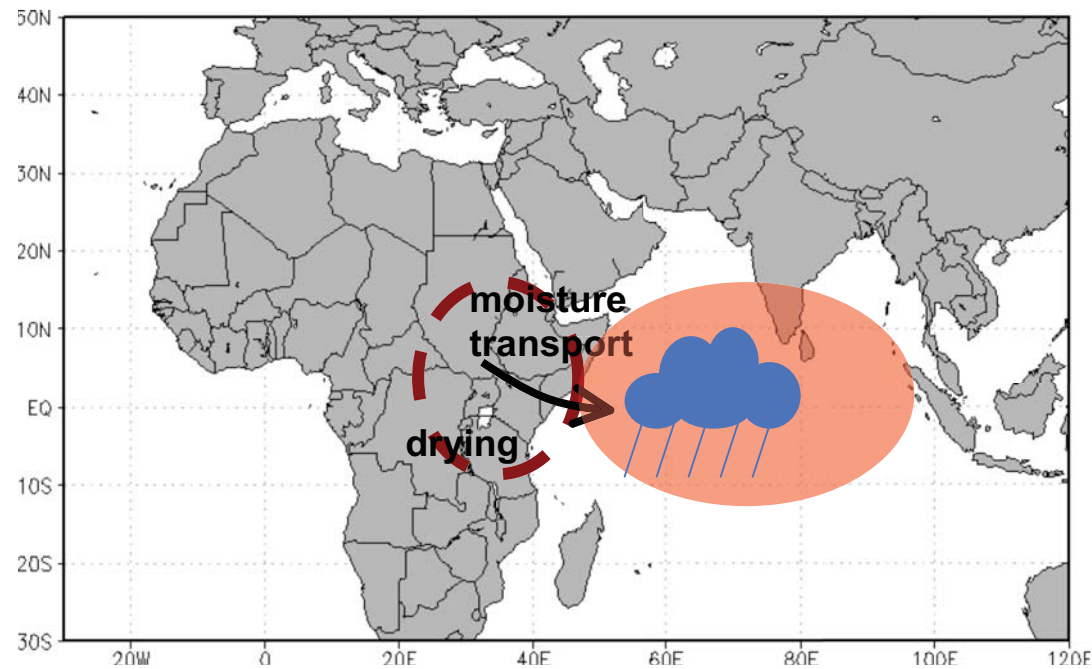


Barlow et al. (2007), Hoell et al. (in prep)



## **Teleconnection II: Influence on Africa**

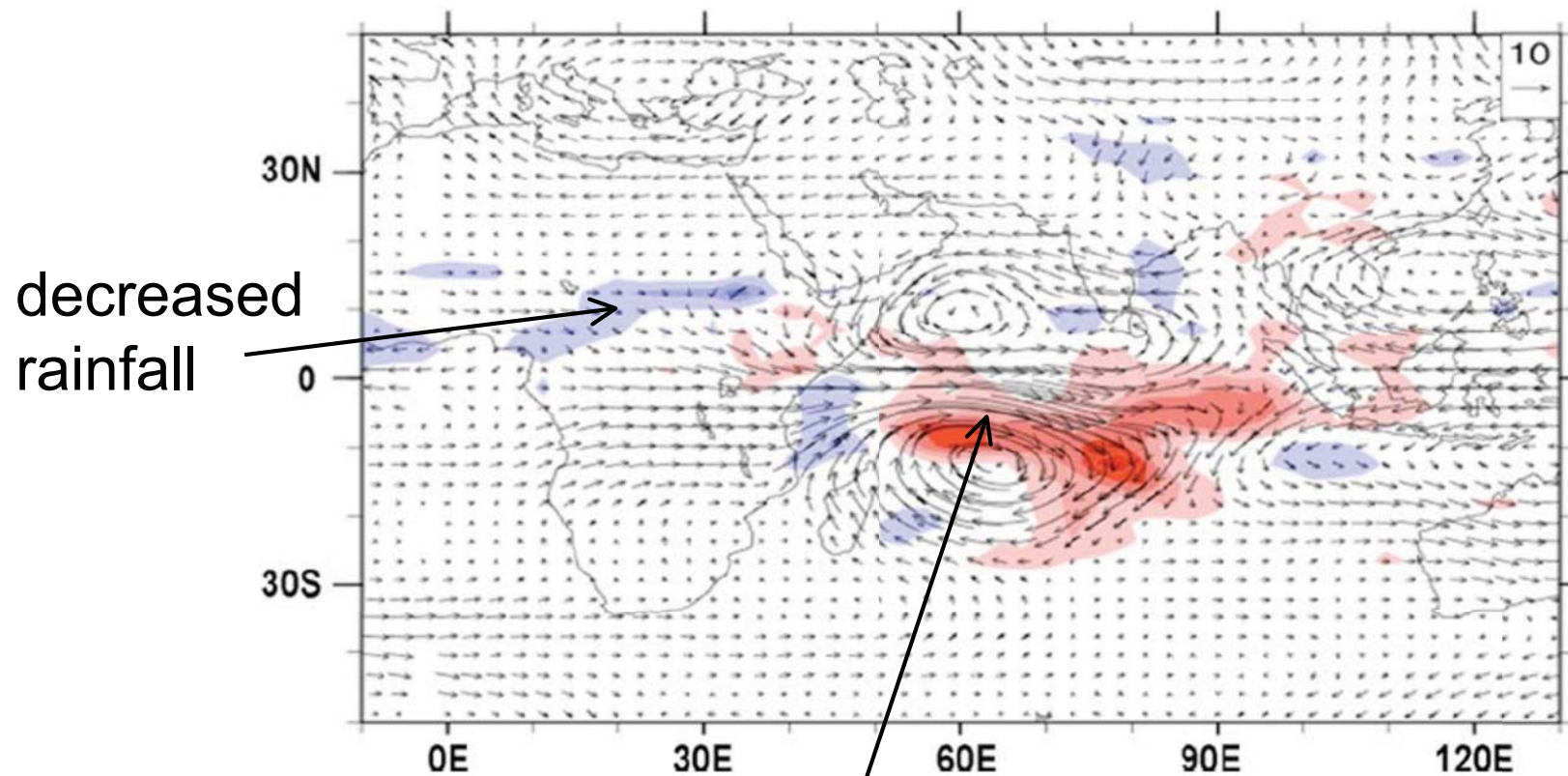
**Hypothesis:**  
**Warming Indian Ocean**  
→ **Greater oceanic convection**  
→ **Greater low-level flow into convection**  
→ **Less rain over continent**





# GCM Results

## Moisture Transport and Precipitation



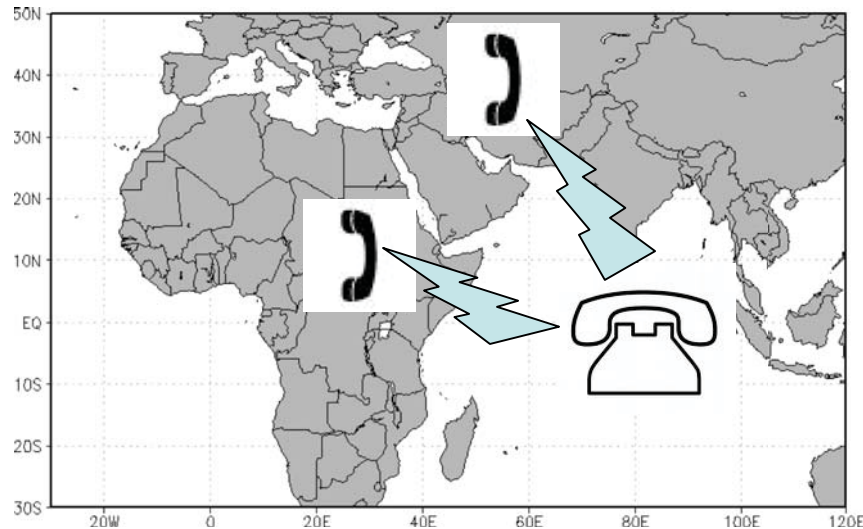
**PLAUSIBLE**

added heating

Funk et al. (2008)

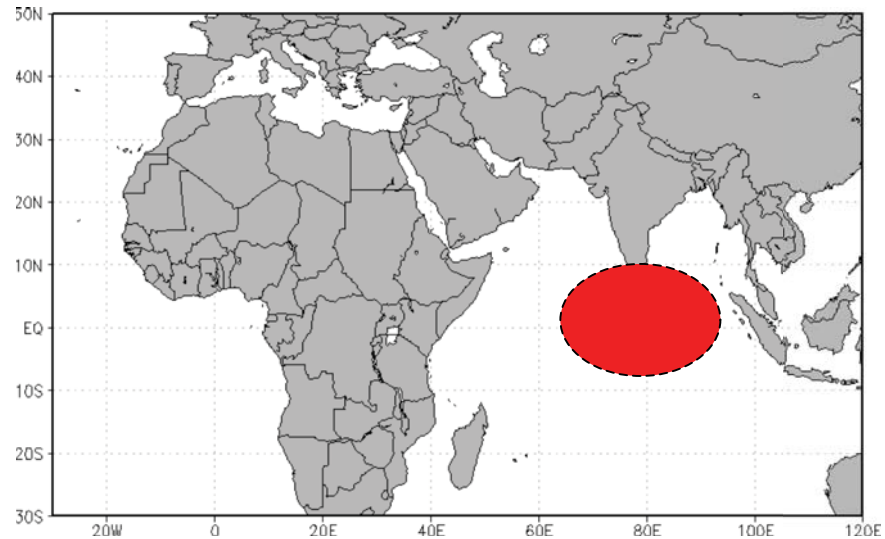
# Summary

## Two Teleconnections



Two different dynamical mechanisms for teleconnections

## One Technique

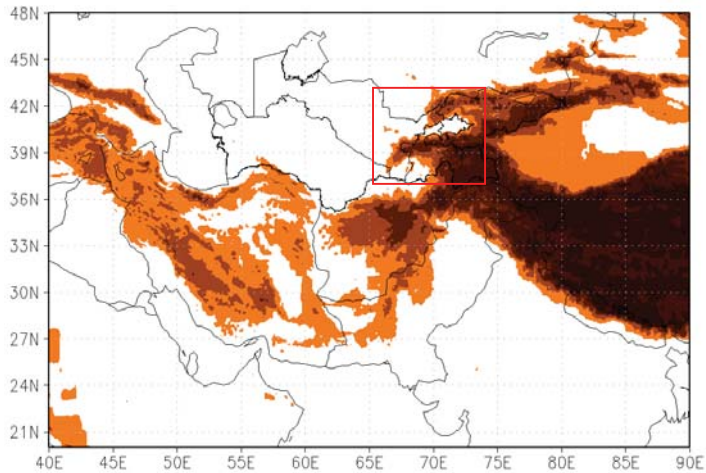


Modified GCM approach useful for explicitly modeling response in terms of moist dynamics and precipitation

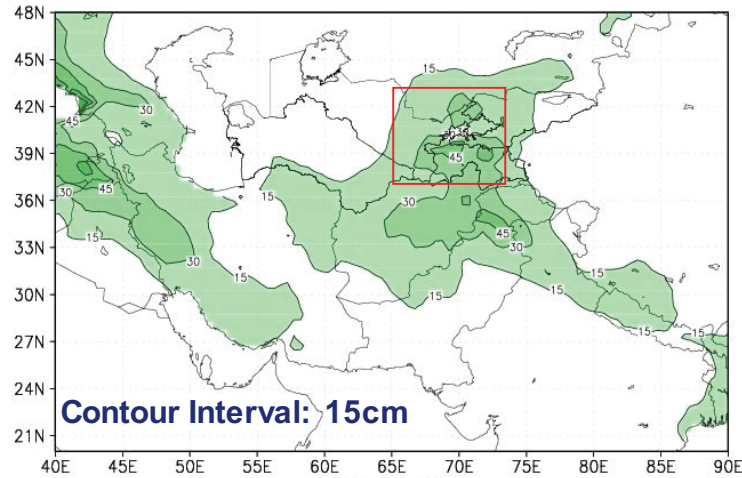
**Ongoing: Refining GCM approach, comparison with linear modeling, African work**

# Background: Climate of Central-Southwest Asia

## Topography (km)

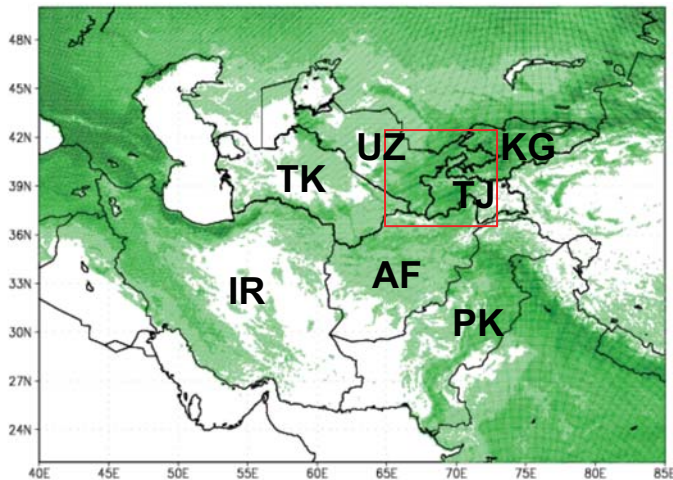


## Avg Nov-Apr Precipitation



Little precipitation during growing season -- snowmelt is providing much of the water for growth.

## Apr-Aug Vegetation (NDVI)



## Avg May-Oct Precipitation

