



Activities surrounding the Year of Tropics-Midlatitude Interactions and Teleconnections

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&

Members of S2S/Teleconnection

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Outline



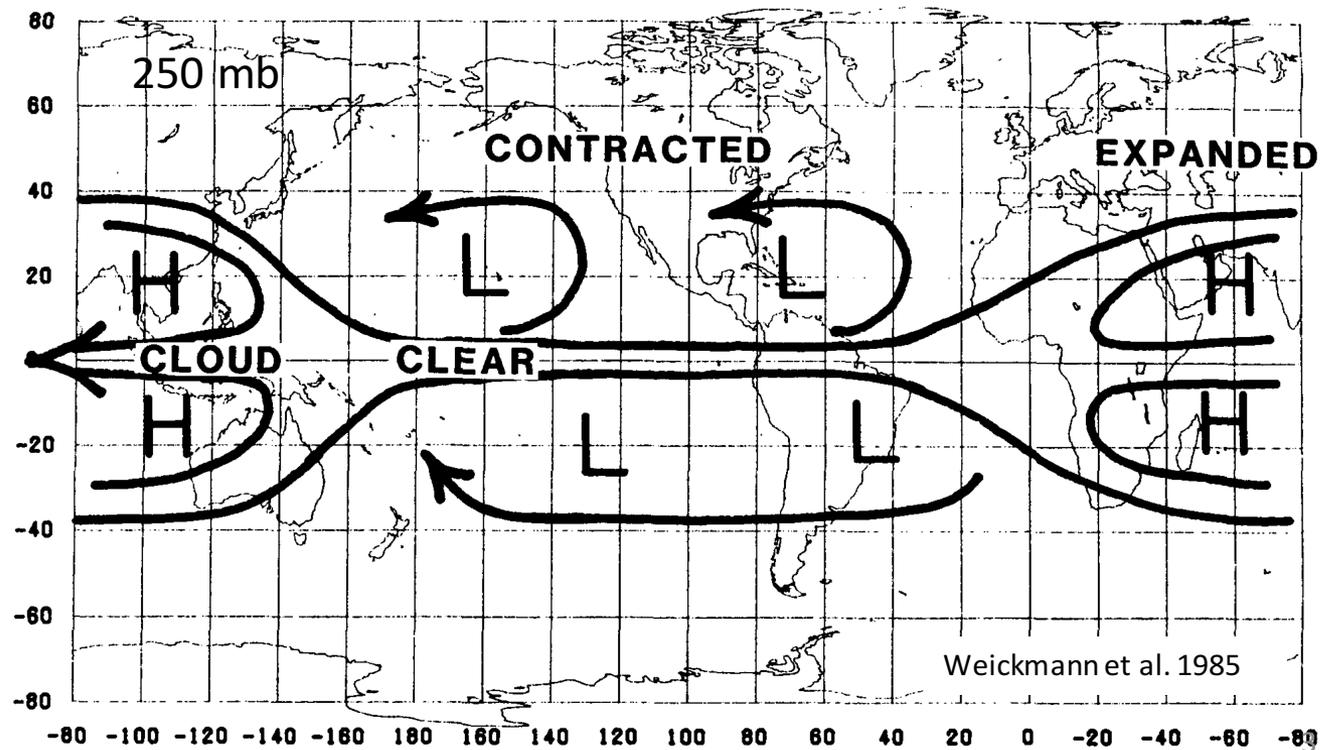
- Overview of the current knowledge and challenges of the teleconnections on the sub-seasonal to seasonal timescales
- Presentation of the Virtual Field Campaign, the Year of Tropics-Midlatitudes Interactions and Teleconnections, YTMIT
- Ongoing activities

Observations

The influence of Tropics onto NH Midlatitudes

Weickmann 1983; Liebmann and Hartman 1994; Weickmann et al. 1985; Lau and Phillips 1986; Knutson and Weickmann 1987

After satellite data became available



Overview

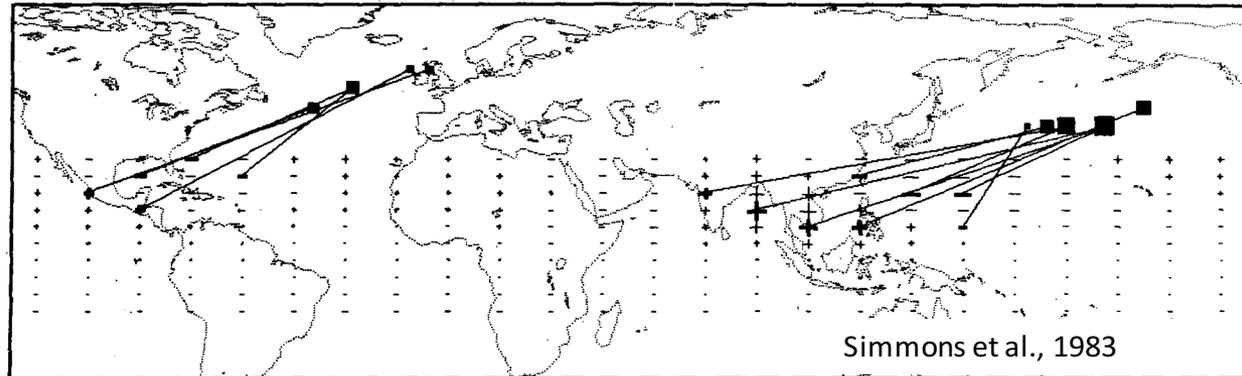
The virtual field
campaign

Ongoing
activities

Theoretical/Modeling Studies

The influence of Tropics onto Midlatitudes

Opsteegh and Van den Dool 1980; Hoskins and Karoly 1981; Webster 1981; Simmons et al. 1983; Branstator 1985



- A tropical disturbance will excite stationary Rossby waves with the ability to influence the midlatitudes only if the zonal scale of the perturbation is smaller than a critical value; the critical wavenumber depends on the local conditions (westerlies).
- Perturbations over the northeastern Pacific are *excited* by tropical forcing located over Southeast Asia and tropical western Pacific
- The Atlantic perturbations are *excited* by the tropical forcing located to the southwest

Overview

The virtual field campaign

Ongoing activities

Theoretical/Modeling Studies

The influence of Tropics onto Midlatitudes

Overview

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Ongoing
activities

Sardeshmukh and Hoskins 1988

- The midlatitude perturbations are associated with the fast growing mode of baroclinic instability of the tropics
- The atmospheric anomalies in the extra-tropics have an equivalent barotropic structure
- The variability of the midlatitude large-scale flow due to tropical forcing is dominated by a 28-72 day oscillation

Observations

The influence of Tropics onto Midlatitudes

Ferranti et al. 1990; Gill and Mo 1991a,b; Higgins and Mo 1997; Mathews and Kiladis 1999

Overview

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Ongoing
activities

- Variability of the climate patterns of midlatitudes, such as NAO and PNA is linked to the convective activity in the tropics
- In the Northern Hemisphere, there are two modes of oscillation with periods of about 48 and 23 days
- North Pacific circulation anomalies develop one to two weeks after the appearance of anomalous convection over the tropical Pacific

Theoretical/Modeling Studies

The influence of Tropics onto Midlatitudes

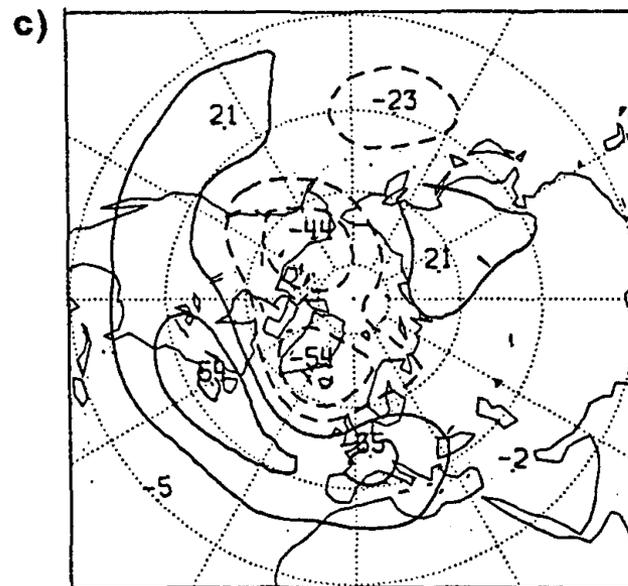
Overview

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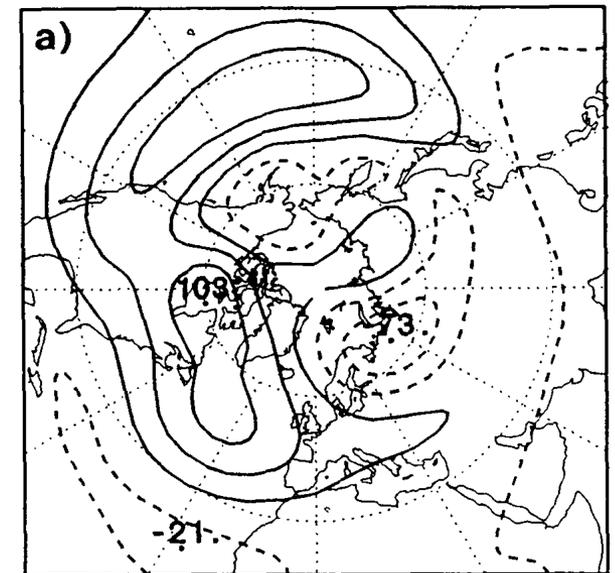
Ongoing
activities

Ferranti et al. 1990

Observations



**Barotropic model
forced by realistic OLR heating**



500 hPa Geopotential Height

The role of barotropic instability: Simmons, Wallace, Branstator, 1983

Modeling Studies

The influence of Tropics onto Midlatitudes in GCMs

Overview

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Ongoing
activities

Higgins and Schubert 1996; Hsu 1996

- GCM simulations tend to reproduce the observed relationships between tropical anomalous convection and midlatitude circulation anomalies during boreal winter
- GCM simulations also show differences from observation, resulting especially from the model inability to reproduce the observed location of the tropical heating anomalies

Observations

The influence of Tropics onto Midlatitudes

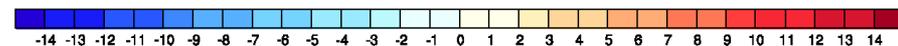
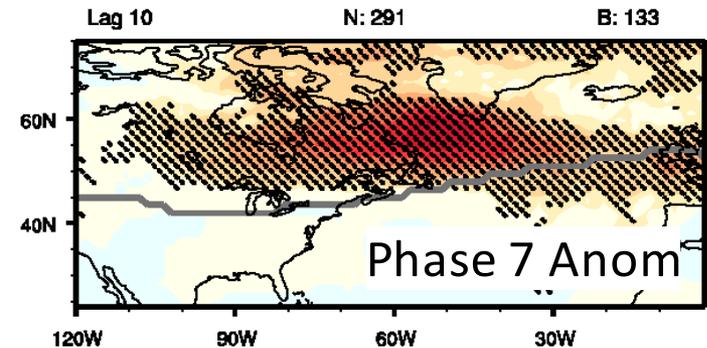
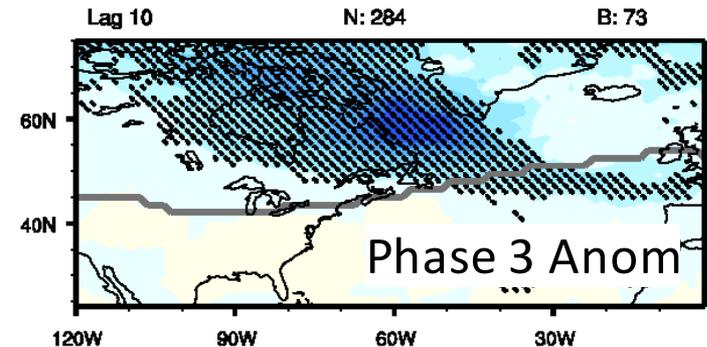
Cassou 2008; Deng and Jiang 2011; Lee and Lim 2012; Grise et al. 2013; Frederiksen and Lin 2013; Lin 2014; Henderson et al. 2015

Overview

The virtual field campaign

Ongoing activities

- MJO strongly modulate the North Atlantic blocking frequency
- Following MJO phase 3, the probability of blocking over the North Atlantic is halved
- Following MJO phase 7, the frequency of blocking over the North Atlantic doubles



Observations

The influence of Tropics onto Midlatitudes

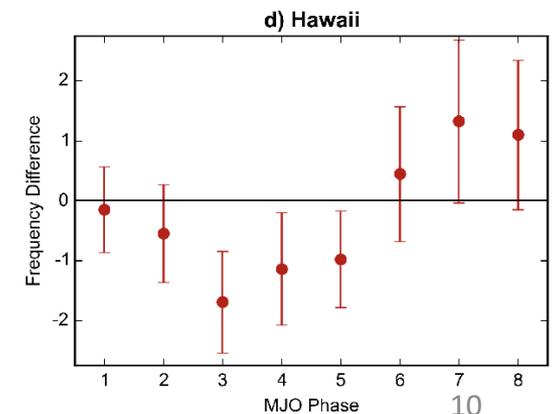
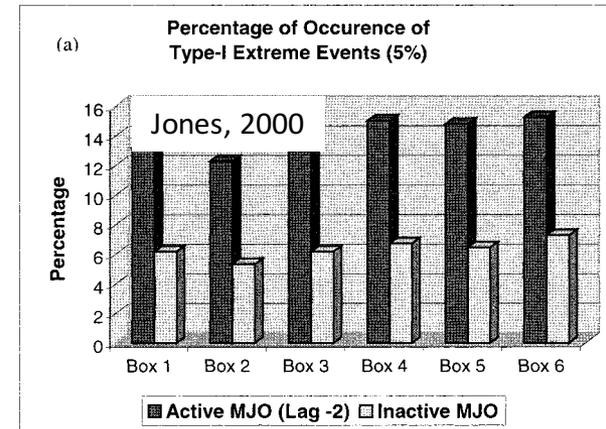
Overview

The virtual field campaign

Ongoing activities

Mo and Higgins 1998; Jones 2000; Bond and Vecchi 2003; Jeong 2005; He et al. 2011; Zhou et al. 2012; Payne and Magnusdottir 2014; Mundhenk et al. 2016

- Winter extreme precipitation events over U.S. West Coast and below-average SAT are favored by MJO in phase 2
- MJO modulates the extreme precipitation along the U.S. West Coast associated with atmospheric rivers



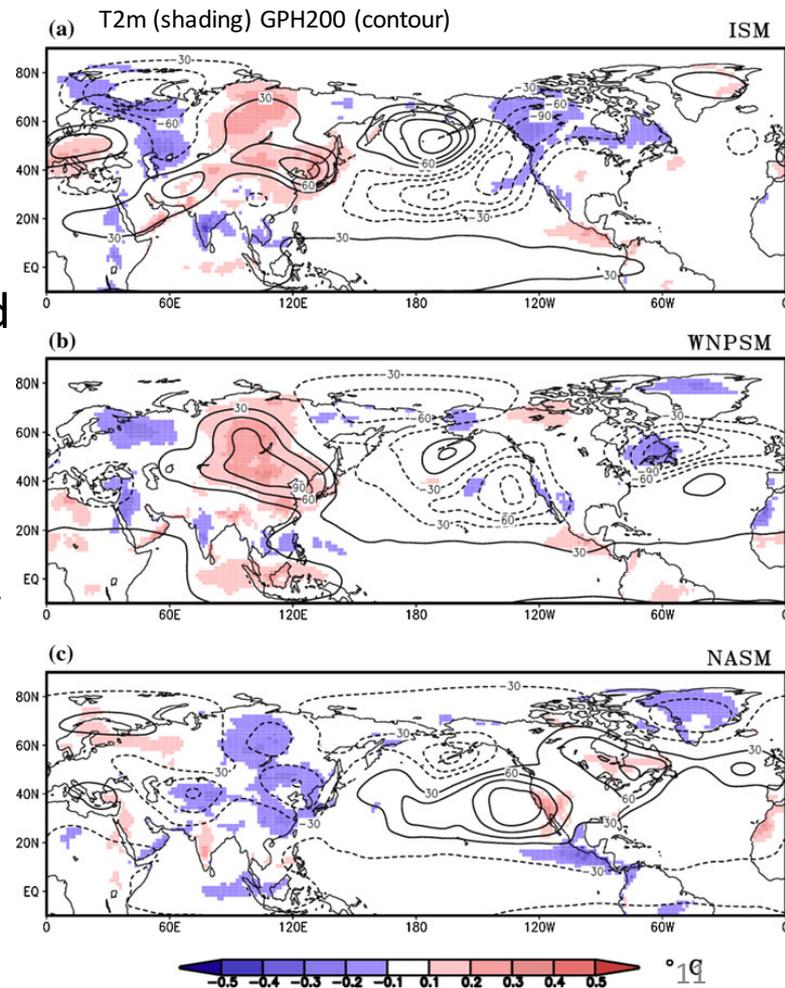
Mundhenk, Barnes, Maloney 2016

Observations

The influence of Tropics onto Midlatitudes

Moon et al. 2013

- During the active phase of ISM, WNPSM, and NASM extra-tropical circulation and surface temperature anomalies develop.
- BSISO teleconnections show both quasi-stationary and eastward propagation characteristics



Overview

The virtual field campaign

Ongoing activities

Modeling Studies

The influence of Tropics onto Midlatitudes

Overview

The virtual field
campaign

Ongoing
activities

Blade and Hartmann 1995; Mathews et al. 2004; Branstator 2014; Straus et al. 2015

- Extra-tropical response is sensitive to the phase speed of the forcing
- The tropical convection outflow anomalies lead to Rossby waves, which then interact with the midlatitude mean flow and in preferred locations extract energy from the mean flow, in a manner similar to that of unstable barotropic modes
- The midlatitude response to the MJO depends on the history of heating and cooling and is not just a response to heating at some longitude with some lag
- Short pulses of tropical heating also affect the midlatitudes and the effect persists for more than two weeks

Forecasting

The influence of Tropics onto Midlatitudes in Forecasts

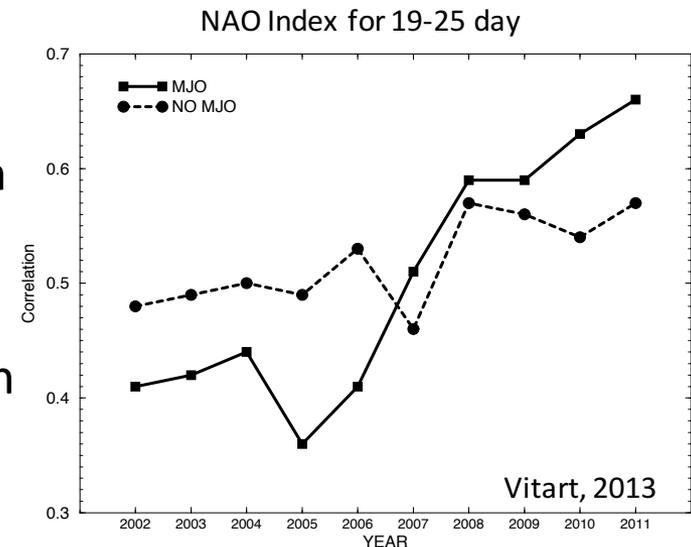
Feranti et al. 1990; Waliser et al. 2003; Vitart and Molteni 2010; Riddle et al. 2013; Vitart 2013; Molteni et al. 2015;

Overview

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Ongoing activities

- Skillful extended-range forecasts are associated with small errors in the simulation of tropical heating
- MJO has significant impact on the midlatitude forecast especially for days 19-25

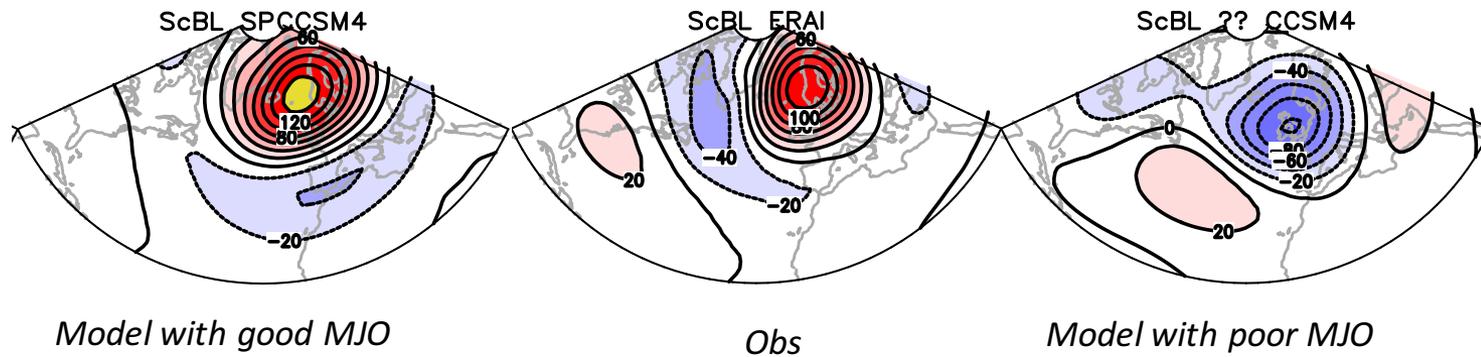


MJO model forecast improved after 2007

The influence of Tropics onto Midlatitudes in Forecasts

Overview

Stan and Straus, 2016



The virtual field campaign

Ongoing activities

- Deficient representation of eastward propagating organized convection in the tropics leads to large errors in the forecast of midlatitude weather patterns

Remaining Challenges

Overview

The virtual field
campaign

Discussions

- What are the mechanisms underlying the teleconnection on intraseasonal time scales?
- What aspects of intra-seasonal heating arising from tropical convection are most important for forcing extra-tropical responses?
- What are the geographical regions where tropical forcings are most effective in exciting extra-tropical circulation anomalies and what are the characteristics of these regions?
- How and why do the baroclinic atmospheric anomalies in the tropics transition to barotropic anomalies by the time their influences manifest in the extra-tropics?

Remaining Challenges

Overview

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campaign

Ongoing
activities

- What is the limit of predictability of mid-latitude disturbances forced by the tropical forcing?
- Do we have enough observations to describe the tropical forcing?
- Do air-sea fluxes and SST feedbacks provide the boundary-forcing for telconnections?
- What is the role of resolution and /or ensemble size on the forecast skill of teleconnections?
- What is the relative importance of tropical SST variability versus organized convective heating?

Sub-seasonal to Seasonal (S2S) Prediction Project

Sub-Projects

Teleconnections

Madden-Julian Oscillation

Monsoons

Africa

Extremes

Verification and Products

Research Issues

- Predictability
- Teleconnection
- O-A Coupling
- Scale interactions
- Physical processes

Modelling Issues

- Initialisation
- Ensemble generation
- Resolution
- O-A Coupling
- Systematic errors
- Multi-model combination

Needs & Applications

Liaison with SERA
(Working Group on Societal and Economic Research Applications)

S2S Database

S2S Teleconnection Sub-project

Members

- Jorgen Frederiksen (CSIRO)
- Hai Lin (EC Canada) and Cristiana Stan *Co-Chairs*
- Eric Maloney (CSU) and Steven Woolnough (U Reading)– *Liaison to the MJO sub-project*
- Franco Molteni (ECMWF)
- Andrew Robertson (IRI) – *Liaison to WGSIP*
- Courtney Schumacher (Texas A&M University)
- David Straus (George Mason University)

Overview

The virtual field
campaign

Ongoing
activities



Year of Tropics-Midlatitude Interactions and Teleconnections

Description

- Intense coordinated effort involving existing observational data, forecasts and applications, diagnostics, theory and modeling experiments

Mission

- Foster relationships between research, forecasting, and stakeholder communities, and facilitate the sharing of common interests to explore the links between the tropics and midlatitudes for a better prediction skill at intraseasonal time scales

Research Questions

- Are mid-latitude teleconnections from the fluctuating tropical heating fundamentally just time-lagged stationary wave responses to heating, or does time-dependent wave interference play a role?
- Why are the North Atlantic weather regimes so influenced by MJO-related heating in the distant Indian and Pacific Oceans?
- What is the role of synoptic-scale transients?
- Is the impact of extra-tropical forcing associated primarily with the initiation of tropical convection, or can it organize tropical convection of intraseasonal time scale?
- What is the role of PV streamers?

YTMIT

mid 2017-mid 2019

Virtual

Field

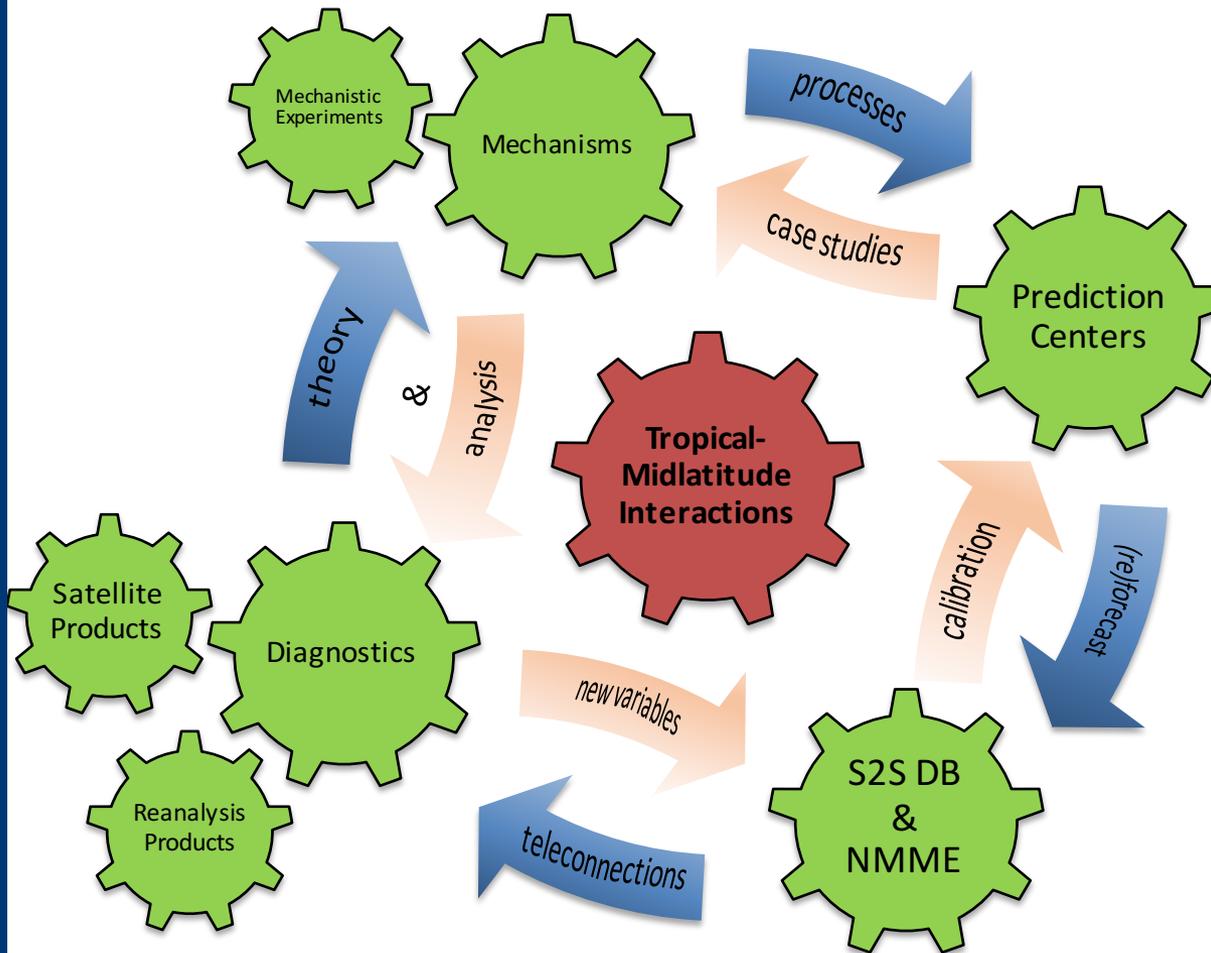
Campaign



Better
understand
and predict
sub-seasonal
tropical-
extratropical
interaction
pathways



Year of Tropics-Midlatitude Interactions and Teleconnections



YTMIT
mid 2017-mid 2019

**Virtual
Field
Campaign**



Better understand and predict sub-seasonal tropical-extratropical interaction pathways



Resources Needed

Overview

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Ongoing
activities

- Support for fundamental research
- Satellite and reanalysis products
- Computational resources for numerical experiments with multiple state-of-the-art CGMs
- Equipment for storage and public access to data
 - Prototype of a National Data Library?
- Support for K-12 education and outreach activities
- Support for team meetings and project coordination

Ongoing Activities

Overview

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Ongoing
activities

- **Review paper** to be submitted to Review of Geophysics

- **Workshops:**

Title: *Large-Scale Intra-Seasonal Diabatic Heating Variability in the Tropics and Monsoon Regions: Multi-Scale Interactions and Teleconnections*

Date: June, 6-7, 2016

Venue: George Mason University

Sponsor: ONR

Title: Systematic Error

Date: June 19-23, 2017

Venue: Montreal, Canada

Sponsor: WGNE

- **AGU Fall Meeting 2016 Session** (proposed)

- **ICTP School** (proposed)

Date: 2017

Sponsors: ICTP, WWRP/WCRP/S2S