Interactions and Teleconnections between Midlatitudes and Tropics
A WWRP/WCRP/ S2S sub-project

Science Plan

November, 2015

Broad Objectives:

Better understand sub-seasonal tropical-extratropical interaction pathways

Identify periods and regions of increased predictability ("forecasts of opportunity")

Improve subseasonal-to-seasonal forecasts of weather and climate for applications

The important role of large scale tropical diabatic heating fluctuations on intra-seasonal time scales as a forcing mechanism for extra-tropical circulation changes has been well recognized. While the existence of teleconnections from tropical heating and SST variability has been well documented, there are still fundamental questions regarding the underlying mechanisms. Can we understand mid-latitude teleconnections from the fluctuating tropical heating as time-lagged stationary wave responses to the heating, or does time-dependent wave interference play a role in the response? Is the excitation of fundamental modes of barotropic instability an important player? What is the role of synoptic–scale transients? On shorter time scales, intense tropical storm related heating can impact the low-frequency extra-tropical circulation fluctuations, as seen in the boreal winter of 2014. One of the broad objectives of this sub-project is to gain a better understanding of the fundamental process of tropical - extra-tropical interaction on sub-seasonal time scales.

Tropical convection itself may be excited and/or maintained by extra-tropical influences which are not well understood. The current state of knowledge suggests that the impact seems to be mostly associated with the initiation of tropical convection, whereas the significance of extratropical forcing on organizing tropical convection on intraseasonal time scales is less understood. Can impinging extratropical waves modulate tropical convection? What is the role of PV streamers? What regions favor the propagation of extratropical signal into the tropics? Does extratropical excitation have a significant impact on the entire life cycle of intraseasonal oscillations in the tropics?

Based on this understanding, we seek to identify periods and regions for which these interactions yield the potential to extend predictability of mid-latitude circulation and weather beyond the canonical two-week limit. Such enhanced predictability may arise from, e.g., observed tropical convection indicating a developing intra-seasonal oscillation, from intense tropical storms, or from particular mid-latitude configurations likely to trigger tropical convection. In order

to translate this potential predictability to better long-range forecasts, model errors in simulating the broad range of interactions between the tropics and extra-tropics need to be identified and corrected.

Research Priorities

Understand physical mechanisms of tropical – extratropical interaction

Assess the physical mechanisms and robustness of mid-latitude circulation and weather responses to the spectrum of three-dimensional tropical diabatic heating on all subseasonal time scales, from tropical cyclones to the boreal winter and summer ISO. Identify mechanisms of extra-tropical forcing of tropical convection and circulation on all subseasonal time scales.

Develop new comprehensive estimates of tropical heating

Synthesize available satellite radiance and radar measurements with modern reanalysis products to produce four-dimensional estimates of tropical heating.

Mechanistic numerical experiments to assess mechanisms and potential predictability

Carry out a broad array of numerical experiments with tropical diabatic heating estimates to further refine understanding of mechanisms. Use state-of-the art models with the (observed) tropical heating embedded to assess potential predictability of mid-latitude weather and circulation. (It is not expected that all groups will be able to perform such experiments.)

Development of down-scaling and error correction methods for applications.

Identify the main errors associated with teleconnections, especially those associated with extratropical response to tropical forcing. Develop postprocessing techniques to correct systematic teleconnection related model errors.

Scientific Questions

Fundamental mechanisms of tropical forcing

What are the fundamental mechanisms of mid- and high-latitude responses to tropical heating at all subseasonal time scales; where and when are such responses robust (season, location, relationship to ENSO)? What is the role of the background circulation (basic state)? Do air-sea fluxes and SST feedbacks provide the boundary forcing for tropics-midlatitude interactions? How are tropically initiated intraseasonal oscillations maintained against the higher dissipation rates in midlatitudes? What explains the hemispheric asymmetry of the responses to tropical forcing?

Sensitivity to tropical heating characteristics

What aspects of intra-seasonal heating arising from tropical convection are most important for forcing extra-tropical responses? What is the sensitivity to vertical and horizontal structure and to temporal evolution of the heating, and why? Does the strength of tropical heating affect the amplitude of midlatitude Rossby waves? Does the seasonal variability of the mean meridional circulation have an impact on the tropics-midlatitude feedbacks on the sub-seasonal scale? Does tropical forcing amplify the intrinsic extratropical intraseasonal variability or excite new perturbations?

Systematic extra-tropical forcing of the tropics

What are the systematic aspects and mechanisms of extra-tropical initiation and maintenance of organized tropical convection? In what conditions the dynamical subtropical barrier act as a valve?

Interaction of intense storms with the polar vortex

How do intense mid-latitude storms and poleward propagating tropical storms interact with the polar vortex and alter the annular modes on sub-seasonal time scales?

Existence of coherent global or hemispheric intra-seasonal modes

To what extent are the dominant tropical and extra-tropical intra-seasonal oscillations connected: are they both aspects of a global or hemispheric oscillation? What determines the properties of such a mode? Do the oscillations have a multi-scale structure?

<u>Modeling Issues</u>

Role of air-sea coupling and convective parameterizations in forecast skill of tropical intra-seasonal oscillations

Methodologies for "implanting" observed estimates of tropical heating in models for mechanistic and potential predictability studies

Role of resolution and ensemble size

Role of basic state (climatology) errors in simulation of tropical – extra-tropical pathways

The relative importance of tropical SST variability versus organized convective heating

Implementation

The objectives of the science plan will be implemented on two time scales. On a shorter time scale they will benefit from being executed within the framework of a coordinated program, and on longer time-scale they will evolve independently and interweave as progress in research reaches the stage of transfer to applications.

An intense international program of one year, the Year of Tropics-Midlatitude Interactions and Teleconnections (YTMIT), should be implemented. This program is designed to foster relationships between research, forecasting, and stakeholder communities, and will facilitate the sharing of common interests to explore the links between the tropics and midlatitudes. The international program will include an integrated observations component (using existing products of Global Observing System, reanalyses), an operational forecast and reforecast component (using the S2S and NMME databases), an applications component, and a research component aligned with the research priorities of this science plan and WCRP mission. The research component will consist of a combination of theoretical, diagnostic, and modeling studies and will be focused on understanding the physical nature of the tropics-midlatitude interactions and teleconnections and their potential as sources of predictability.

Collaboration with other WMO projects, and S2S subprojects such as WCRP Working Group on Seasonal to Interannual Prediction (WGSIP), MJOTF-S2S Joint Project on MJO and Maritime Continent Interactions, S2S sub-project on extreme weather, and the S2S sub-project on verification.