MAPP
Modeling, Analysis, Predictions, and Projections

# Process-Oriented Model Diagnosis to Improve Modeling Systems

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# P-O Diagnostics Background

Performance Metrics

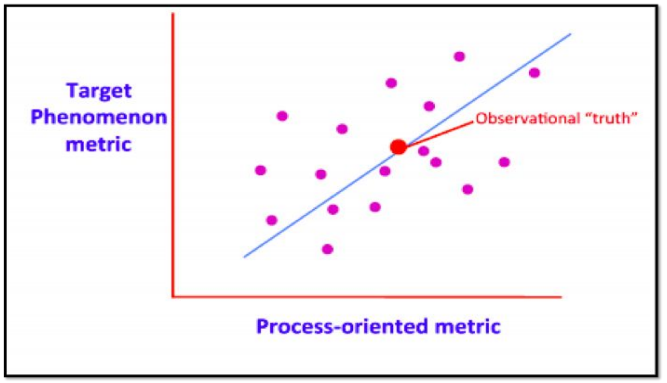
The whether

Process-Oriented Diagnostics

The why

Community evolution toward process diagnostics:

- WGNE Climate Model Metrics Panel
- YOTC MJO Task Force
- ESMValTool effort
- PCMDI Metrics Package
- NOAA/MAPP CMIP5 Task Force
- ...




Process-oriented diagnostics characterize a specific physical process or emergent behavior that is related to the ability to simulate an observed phenomenon.

# MDTF Introduction

In 2014 and 2017, MAPP solicited three-year proposals to:

- Develop process-oriented diagnostics
- Develop and advance a software framework for these diagnostics

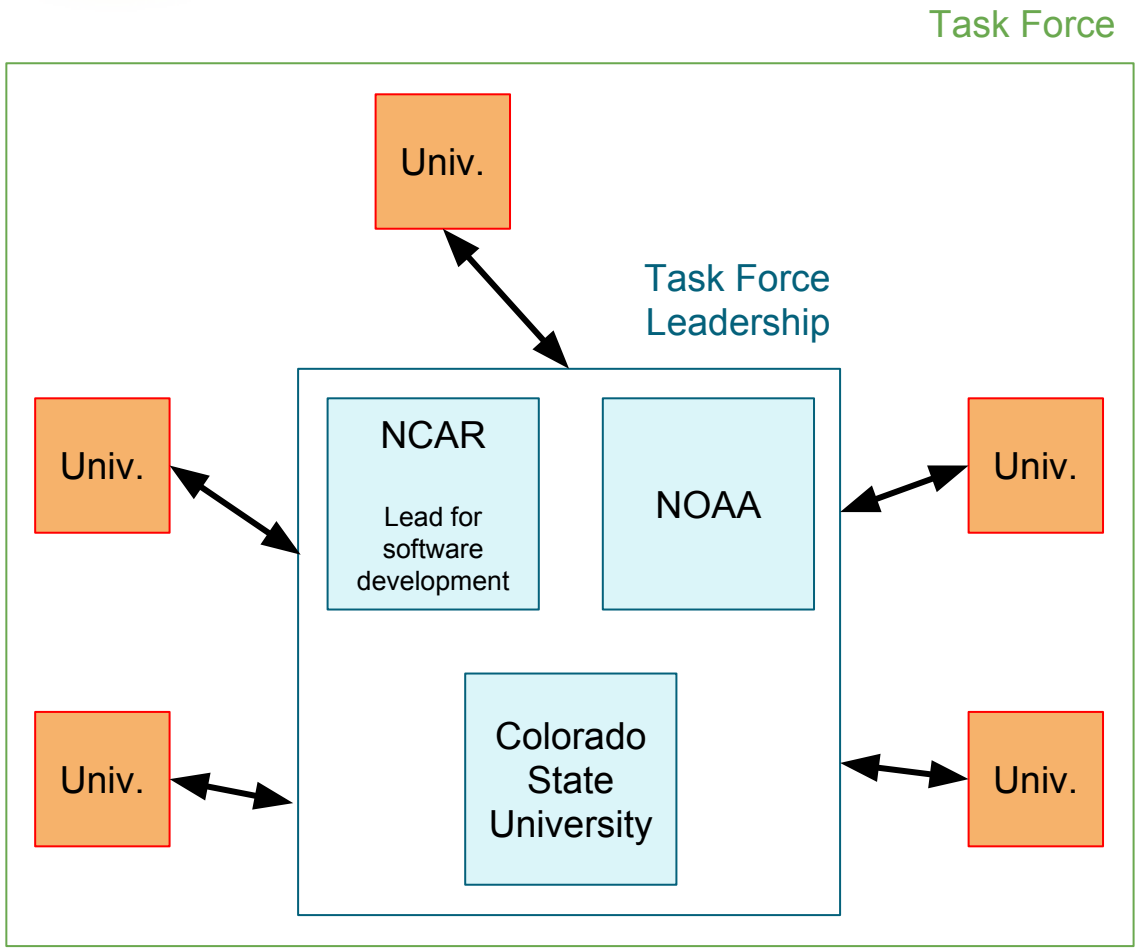
Goals:

- Contribute to next-generation model development at centers
- Leverage CMIP to build development-grade diagnostics
- Link development and evaluation across modeling centers

NCAR
NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

GFDL Geophysical Fluid Dynamics Laboratory

# MDTF Structure




Leadership:
- Develops software
- Supports diagnostic integration
- Develops diagnostics
- Organizes Task Force
- Provides access to development versions of models
- Organizes meetings, sessions, special collection

University Participants:
- Perform Research
- Develop diagnostics
- Integrate and test diagnostics in software package

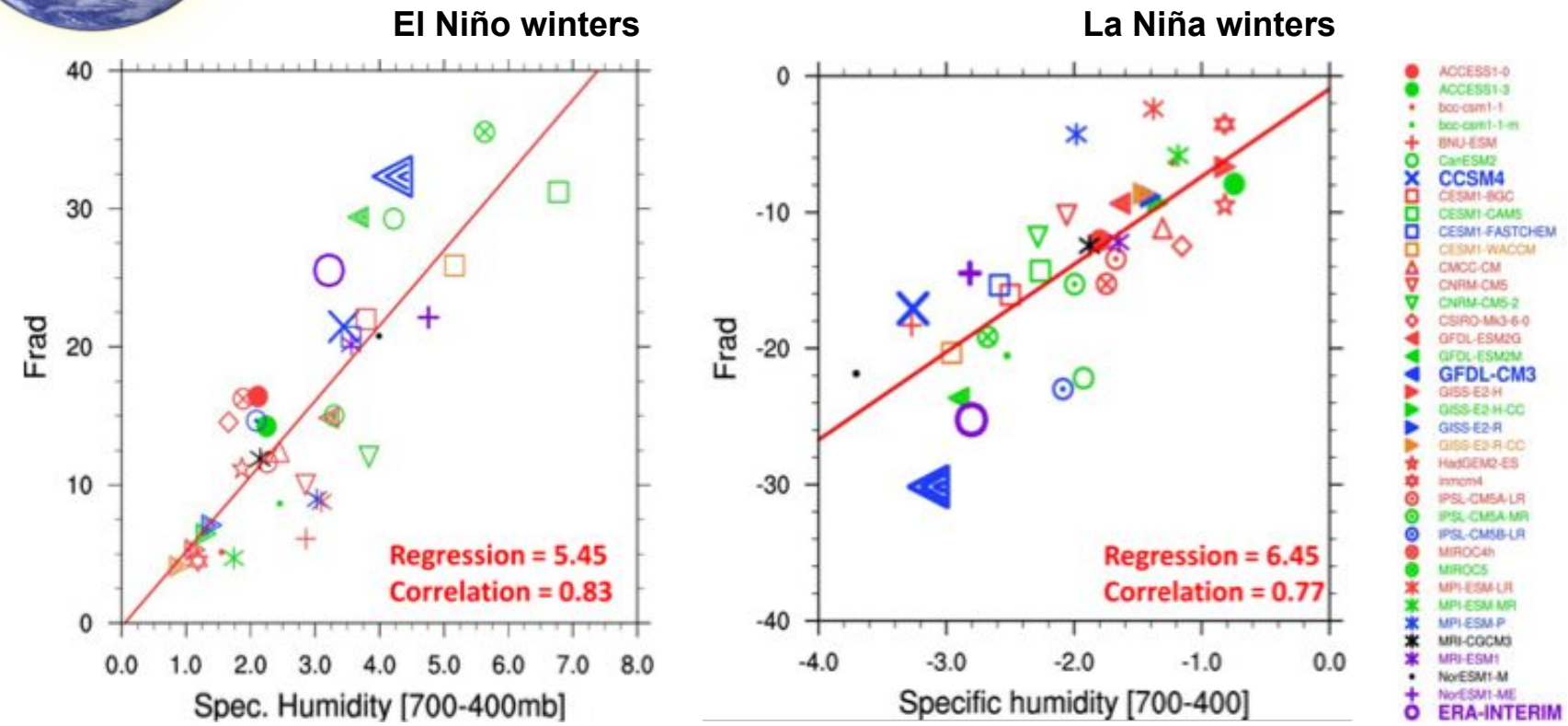
# Projects and Participants

## Diagnostic development areas

- Warm cloud microphysics (K. Suzuki)
- Tropical (S. Camargo) and extratropical (J. Booth) Cyclones
- ENSO teleconnections (H. Annamalai)
- Land/atmosphere coupling (E. Wood)
- MJO (X. Jiang)
- Diurnal cycle (A. Dai)
- AMOC (X. Xu co-support from CVP program)
- Task Force Leadership (Maloney)

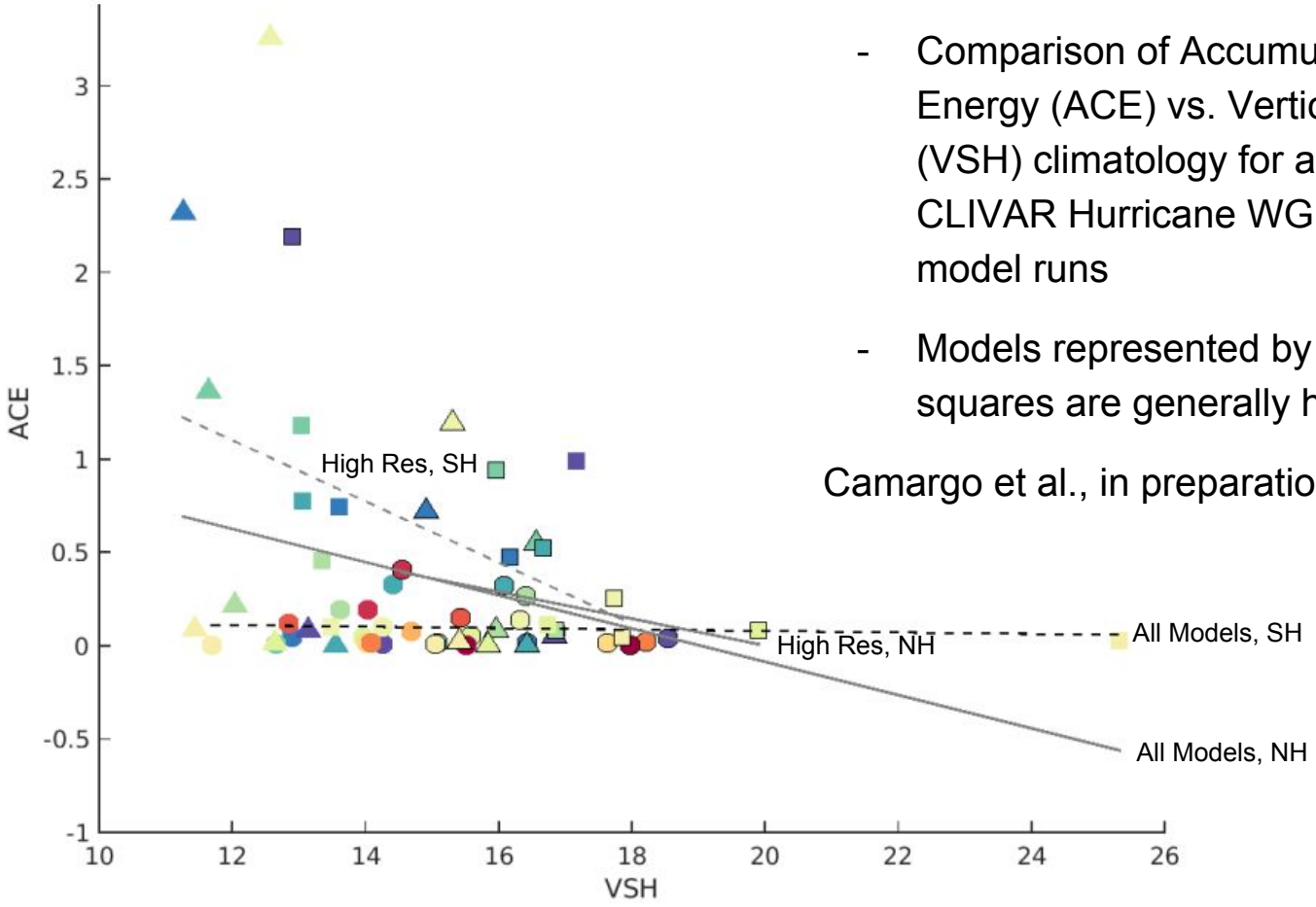
Eric Maloney (Colorado State University; **TF lead**)
Yi Ming (GFDL; **TF co-lead)**
Andrew Gettelman (NCAR; **TF co-lead**)
Aiguo Dai (University at Albany)
Kentaro Suzuki (University of Tokyo)
Huan Guo (GFDL)
Peter Bogenschutz (LLNL)
Xianwen Jing (University of Tokyo)
Suzana Camargo (Columbia University)
Daehyun Kim (University of Washington)
Adam Sobel (Columbia University)
Anthony Del Genio (NASA GISS)
James Booth (City University of New York)
Catherine Naud (Columbia University)
Leo Donner (NOAA GFDL)
Eric Wood (Princeton University)
Zhengzhao Luo (CUNY)
H. Annamalai (University of Hawaii)
Arun Kumar (NOAA CPC)
Xianan Jiang (UCLA)
Ming Zhao (NOAA GFDL)
Yumin Moon (University of Washington)
Shian-Jiann Lin (NOAA GFDL)
Alexis Berg (Princeton University)
Angel Adames (NOAA GFDL)
David Neelin (UCLA)
Junhong Wang (University at Albany)
Xiaobiao Xu (Florida State University)
Molly Basinger (NOAA AOML)
Eric Chassignet (FSU)
Shenfu Dong (NOAA AOML)

# Example 1 (H. Annamalai) ENSO - Atmospheric Biases




- Net radiative flux divergence vs. free tropospheric humidity over central tropical Pacific for Boreal winter.
- Indicator of issues with cloud-radiative and moisture-convection feedbacks in the models manifesting as precipitation biases.

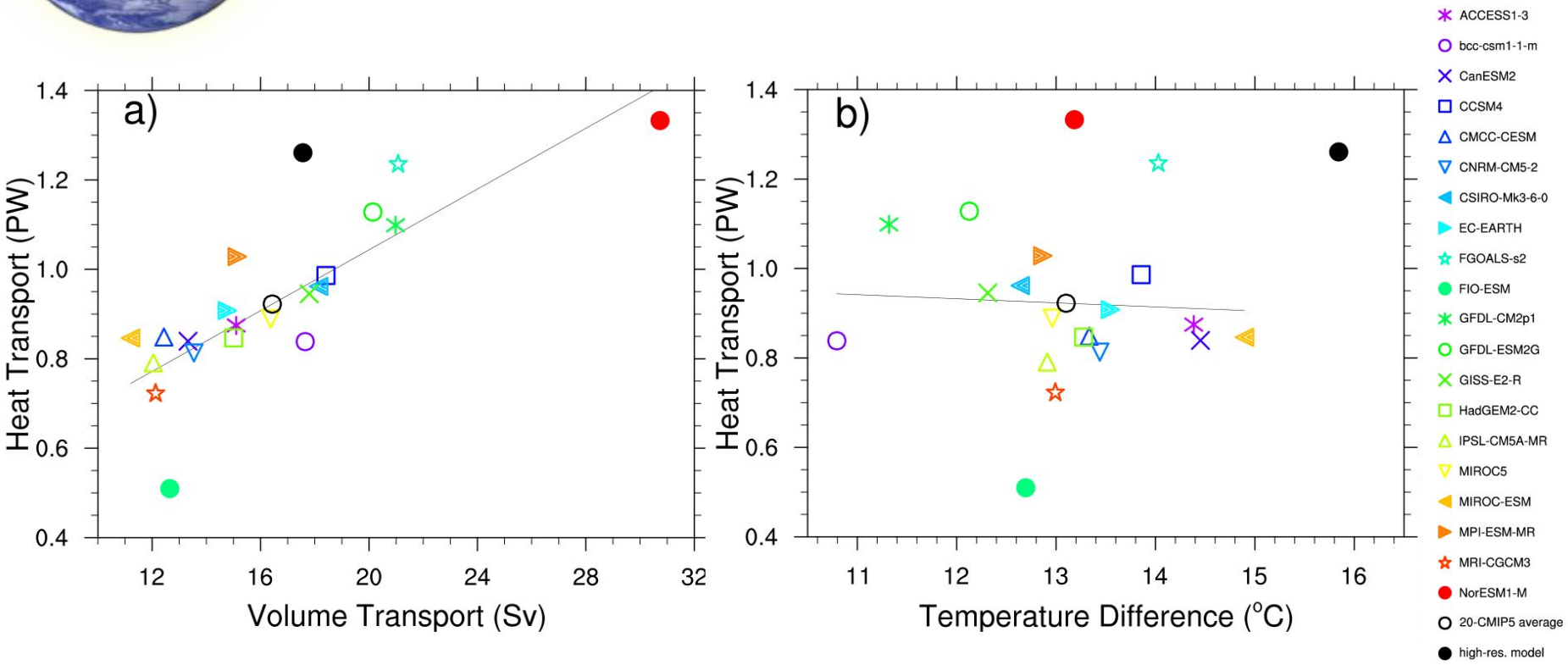
# Example 2 (S. Camargo) Tropical Cyclones




- Comparison of Accumulated Cyclone Energy (ACE) vs. Vertical Wind Shear (VSH) climatology for a selection of CMIP5, CLIVAR Hurricane WG, and experimental model runs
- Models represented by triangles and squares are generally higher resolution

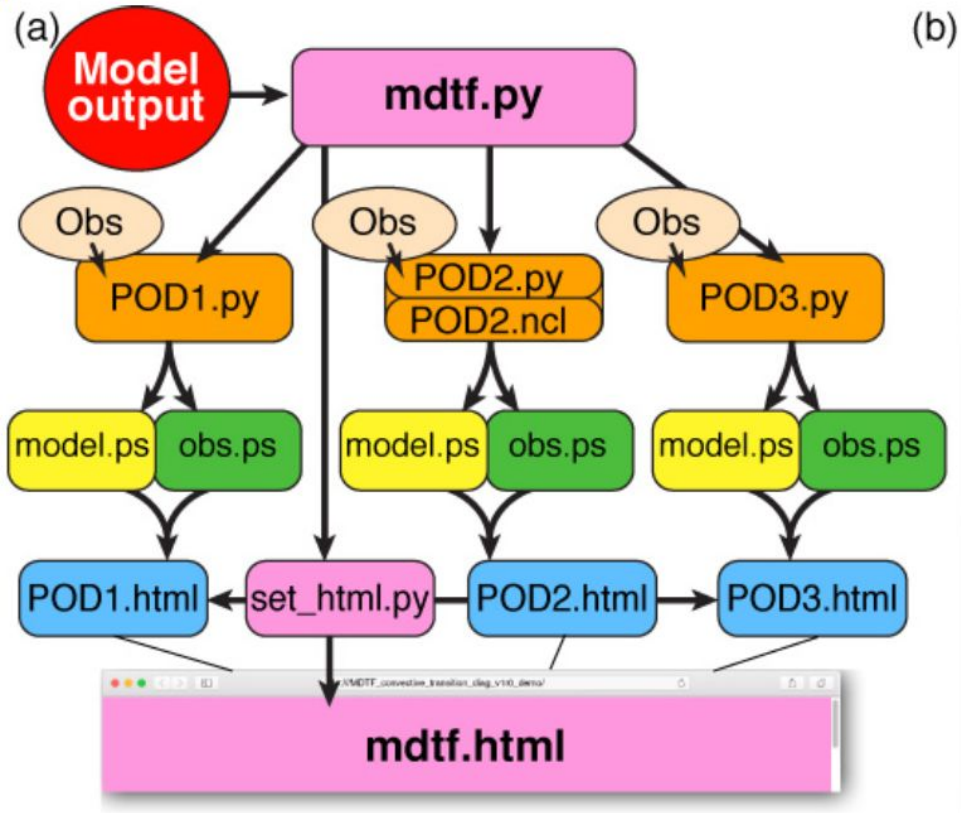
Camargo et al., in preparation

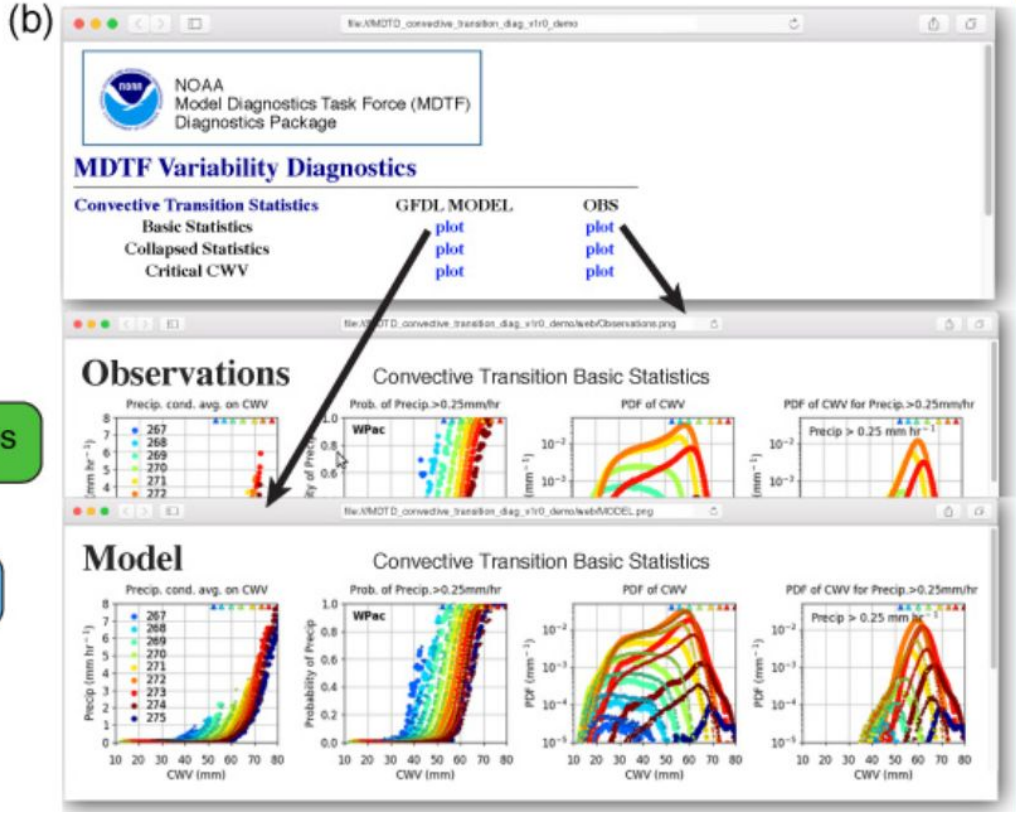
# Example 3 (X. Xu) AMOC




- AMOC Heat Transport is low in CMIP5 models (colored symbols) compared with observations and high-resolution modeling (black dot).
- Volume transport is low in many models (left), and the temperature difference between the upper and lower limbs of the AMOC is too small (right).

# Software Package



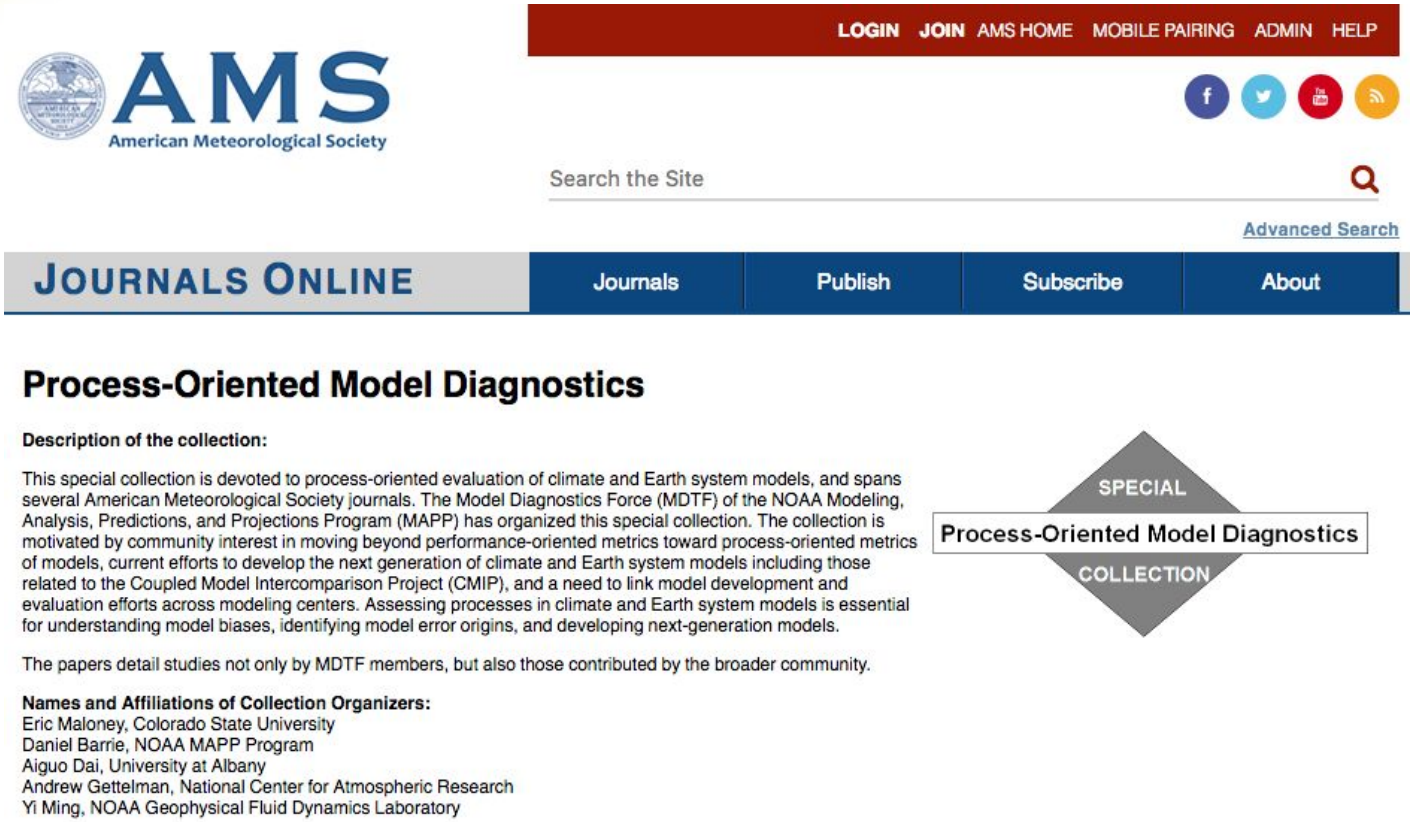



# Software Availability


Software and sample outputs available at:

http://www.cesm.ucar.edu/working_groups/Atmosphere/mdtf-diagnostics-package/

# Special Collection

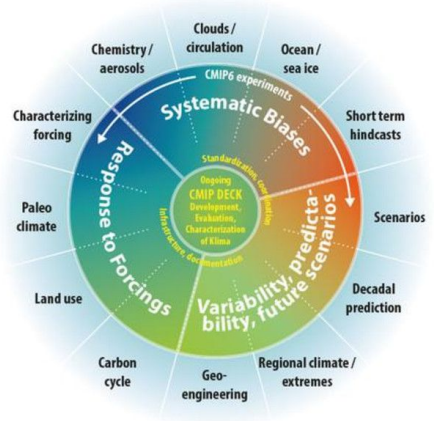



**BAMS overview paper: A framework for process-oriented evaluation of climate and weather forecasting models, Maloney et al., in prep., 2018**

# New MDTF Projects and Participants (2018-2021)

## Diagnostic development areas

- Task Force and assorted diagnostics (Neelin)
- Arctic Sea Ice (Bitz)
- ENSO - Atmospheric dynamics and Energetics (H. Annamalai)
- Lake Effect processes (Notaro)
- TC Genesis and Intensification (Kim)
- North American Monsoon (Wang)
- Pacific Sea Level (Yin)
- RF and Cloud-Circulation Feedbacks (Soden)
- Weather Typing/Extremes (Muñoz)

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Aaron Donohoe (University of Washington)
Allison Wing (Florida State University)
Andrew Robertson (Columbia University)
Ángel Muñoz (Columbia University)
Brian Soden (University of Miami)
Cecilia Bitz (University of Washington)
Daehyun Kim (University of Washington)
Ed Blanchard-Wrigglesworth (University of Washington)
Gabriel Vecchi (Princeton University)
Gill Martin (Hadley Center)
H Annamalai (University of Hawaii)
Jianjun Yin (University of Arizona)
Lucas Harris (NOAA GFDL)
Michael Notaro (University of Wisconsin)
Ming Zhao (NOAA GFDL)
Peter Gleckler (Lawrence Livermore National Laboratory)
Richard Neale (NCAR)
Stephen Griffies (NOAA GFDL)
Suzana Camargo (Columbia University)
Wei Cheng (University of Washington)
Zhuo Wang (University of Illinois)

WCRP CMIP6
World Climate Research Programme

Presenting at S2S Meeting

# Next Steps

- Advance software package
- Process CMIP6 data and build new diagnostics
- Integrate new diagnostics into software package
- Explore development-phase models
- Broaden interactions (new centers, new communities)
- Explore compatibility with other diagnostic packages and efforts

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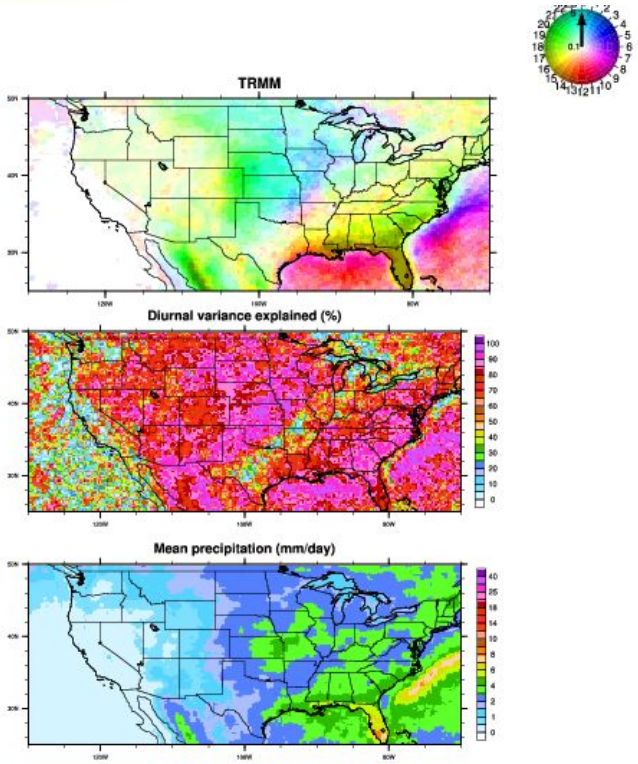
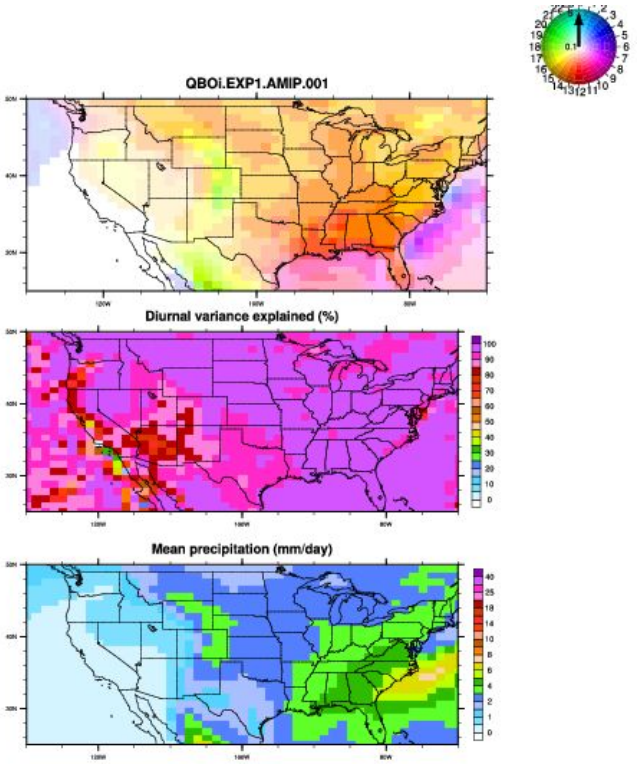
# Diurnal Cycle




- Package includes diurnal cycle plots, after Gervais et al., J. Climate 2014