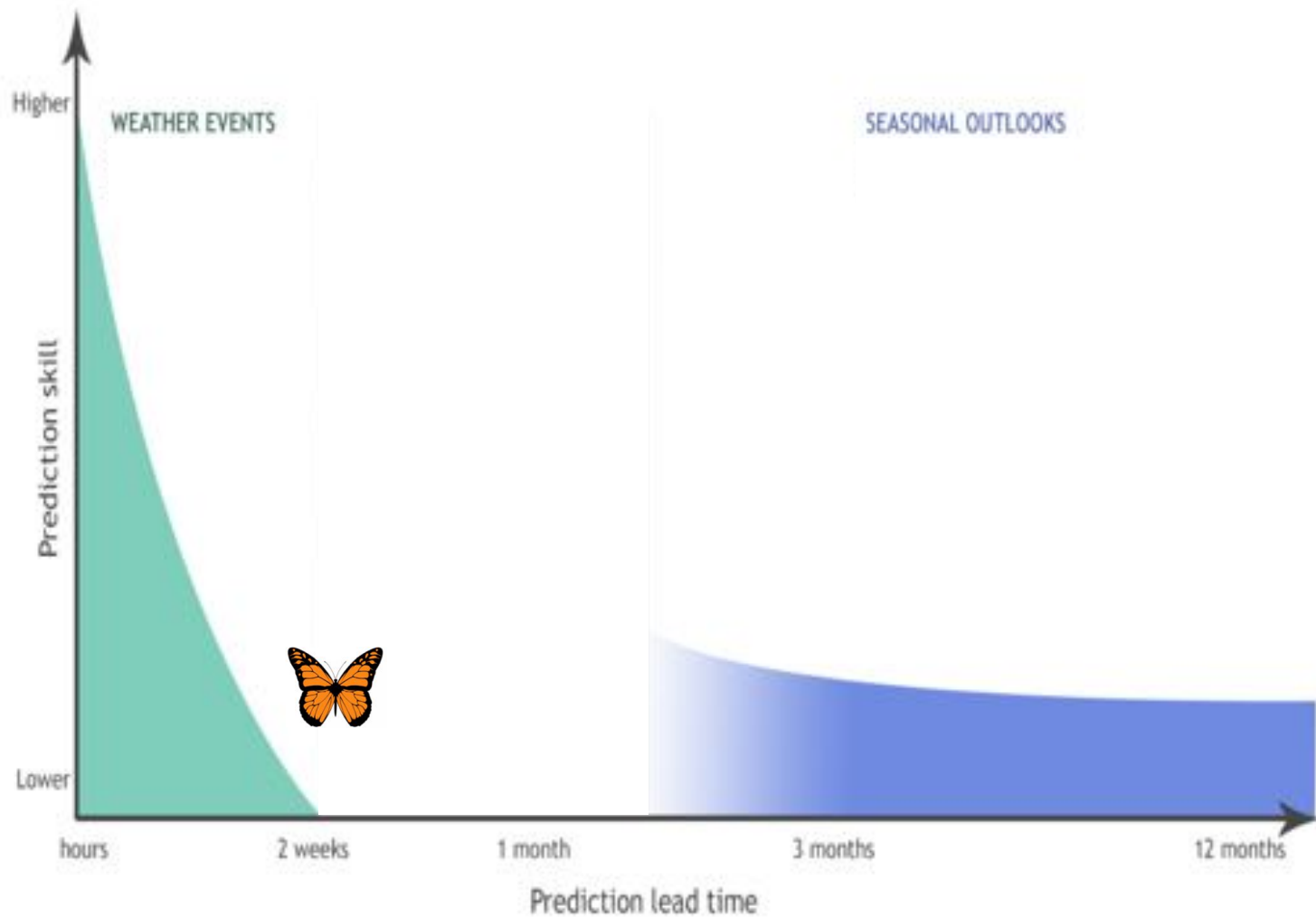# S2S Research Opportunities

Annarita Mariotti, NOAA/OAR Climate Program Office

Contributors: Heather Archambault, GFDL, Tom Hamill, ESRL, Mike Patterson, US CLIVAR
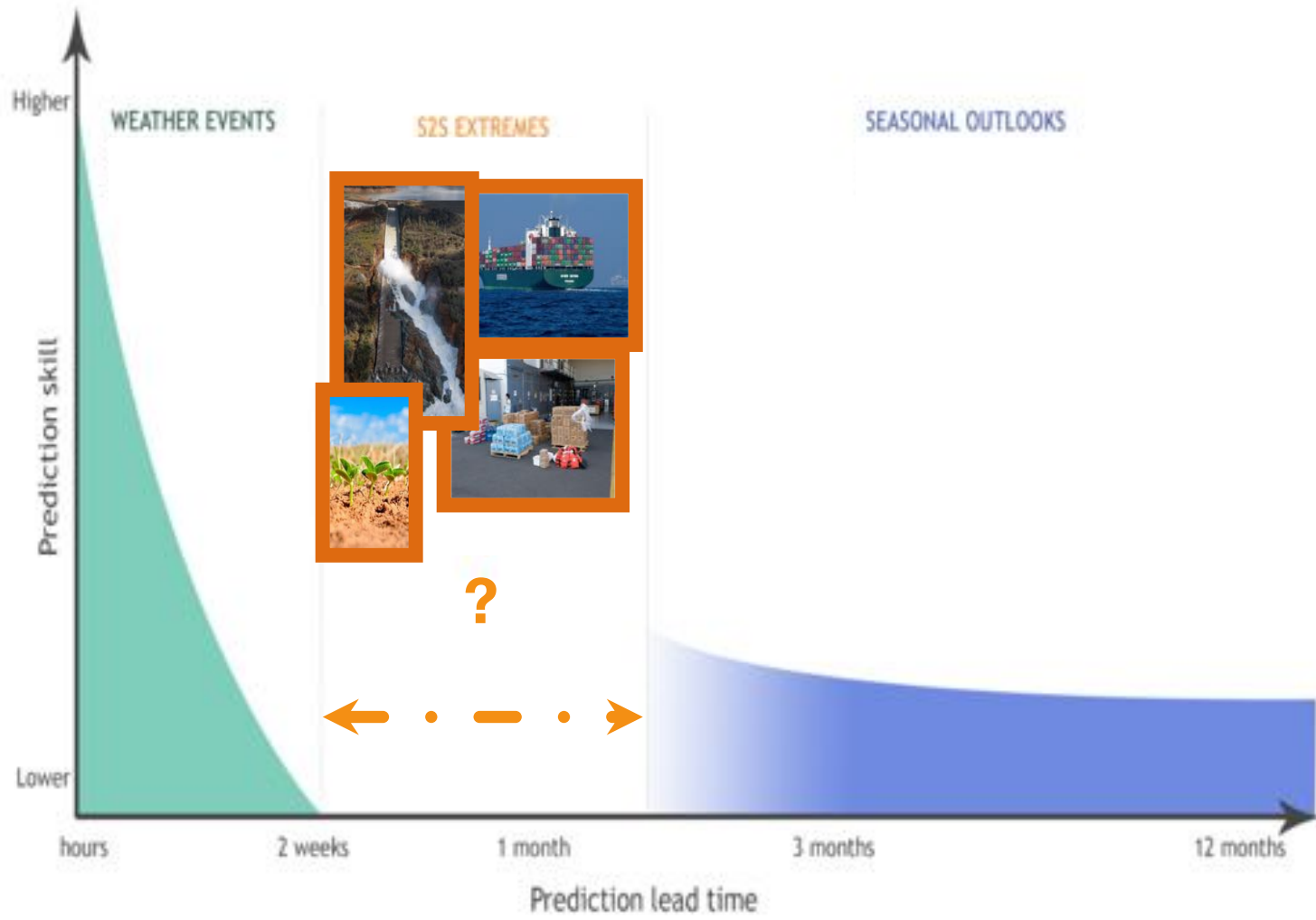
MAPP
Modeling, Analysis,
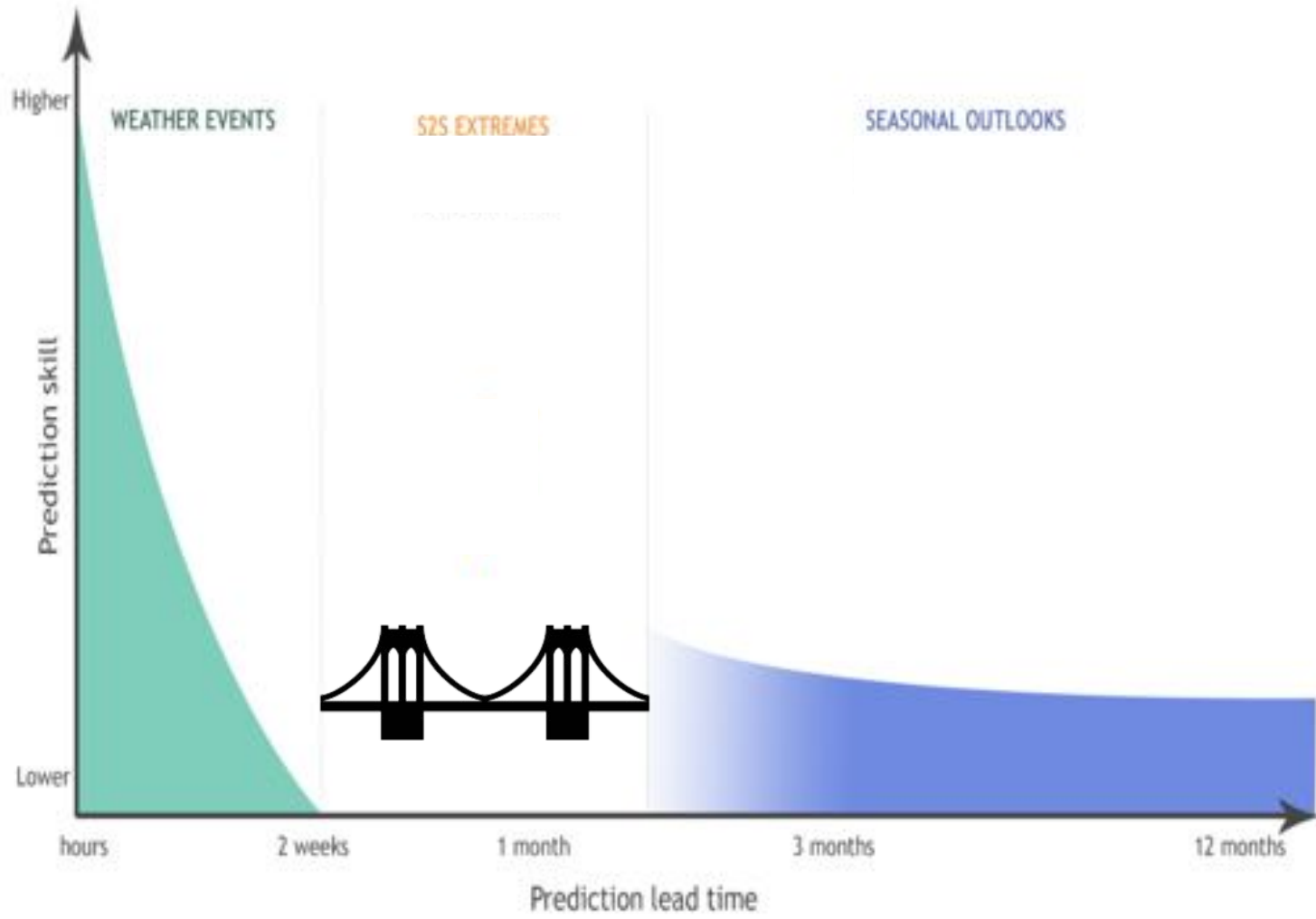Predictions, and Projections

NOAA CPO image

Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

NOAA CPO image

Forecast Gap at Weeks-to-Months

Adapted from: iri.columbia.edu/news/qa-subseasonal-prediction-project

S2S PREDICTION TASK FORCE

MAPP

EXTRATROPICAL CYCLONES

BLOCKING

HEAT WAVES

TROPICAL CYCLONES

ATMOSPHERIC RIVERS
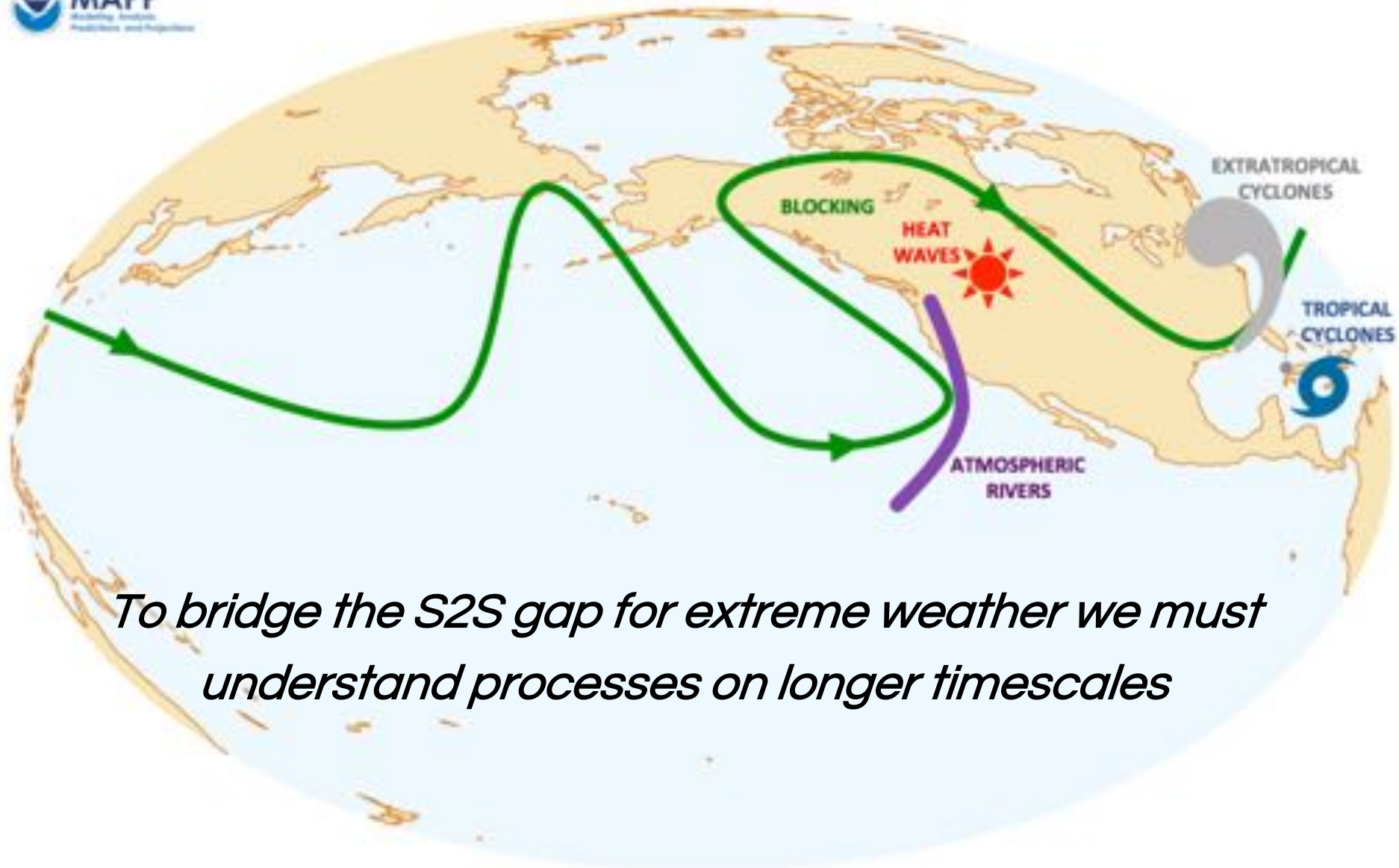
To bridge the S2S gap for extreme weather we must understand processes on longer timescales

Courtesy of Libby Barnes and Cory Baggett

S2S PREDICTION TASK FORCE

MAPP

MJO
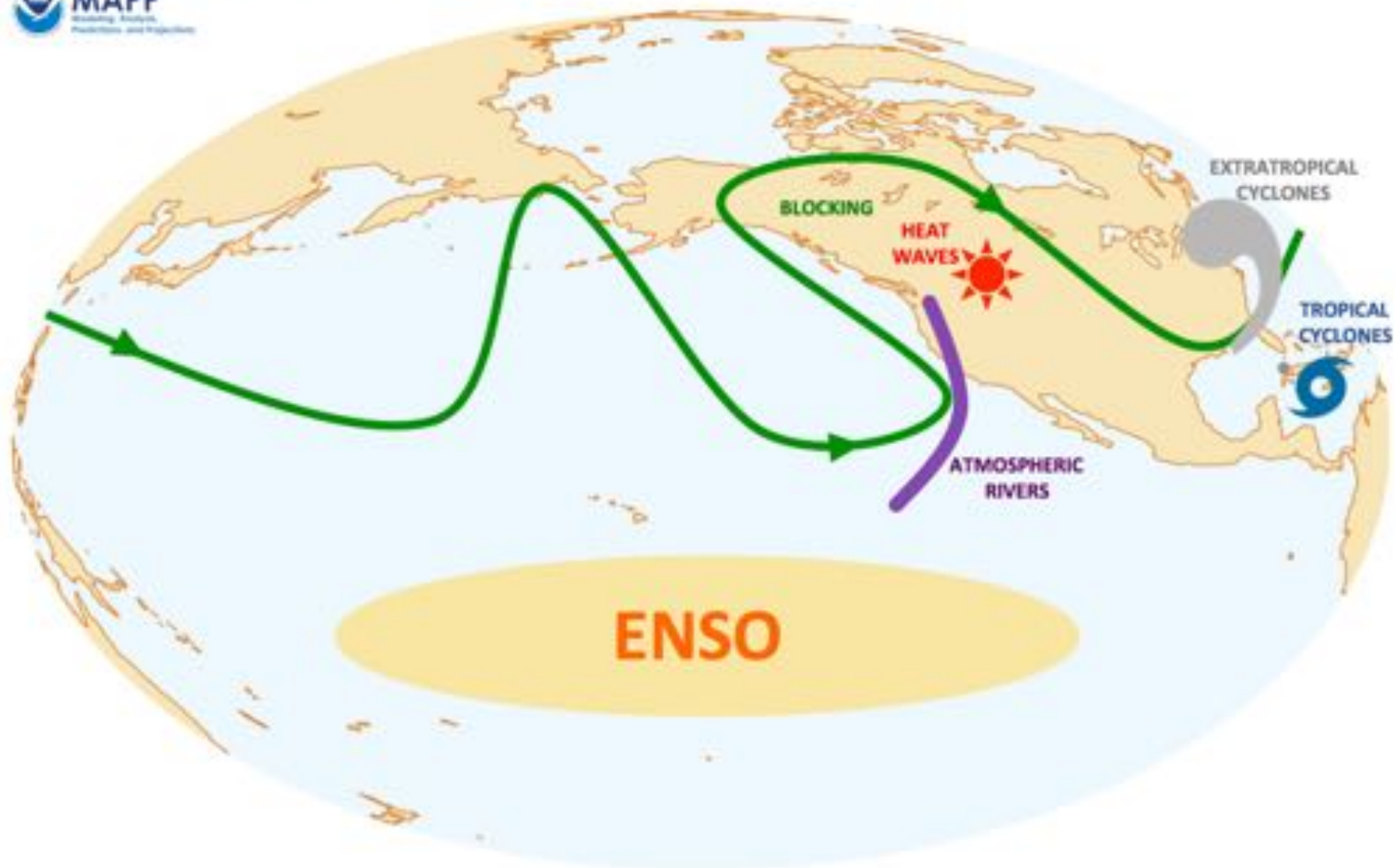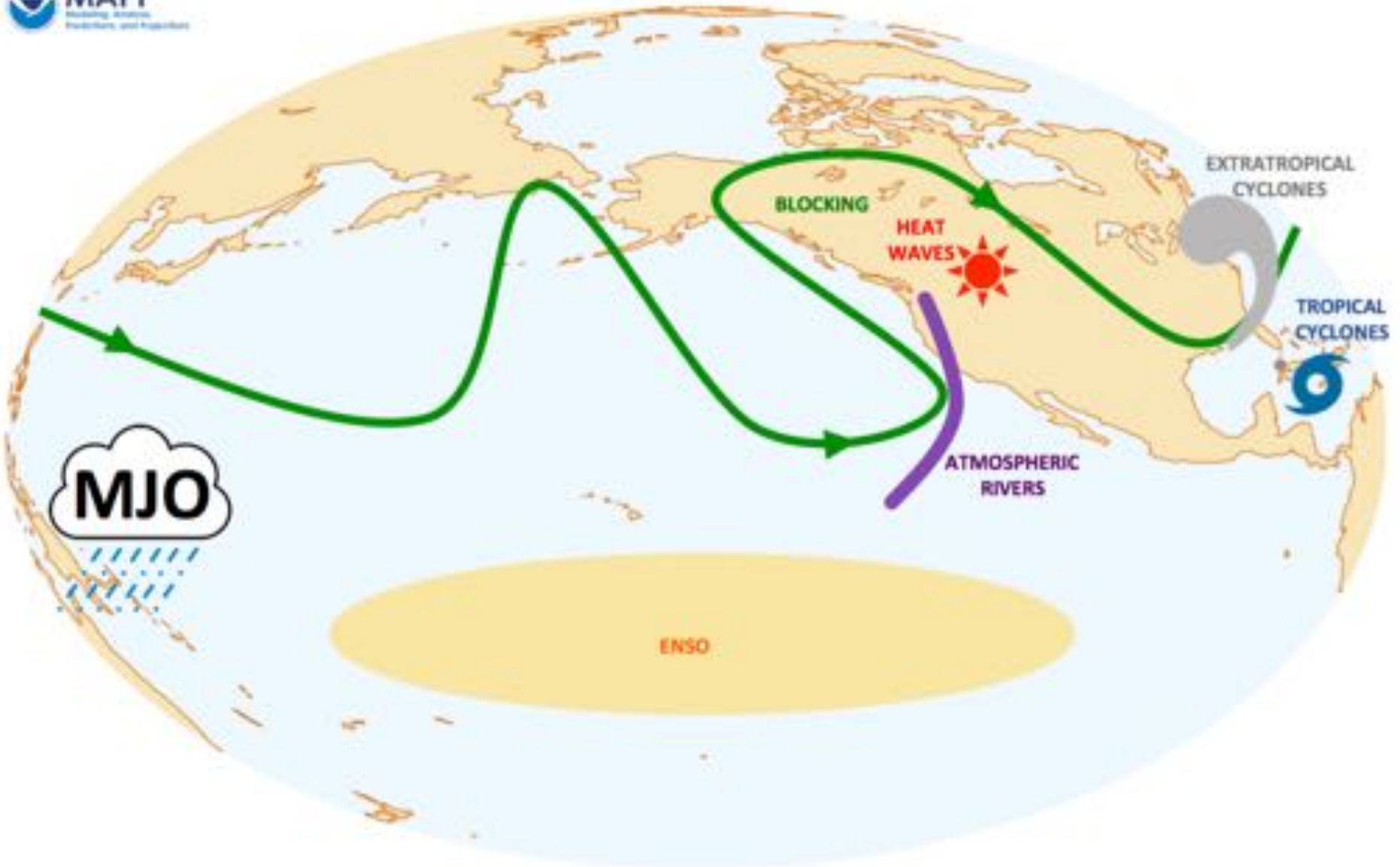
ENSO

BLOCKING

HEAT WAVES

ATMOSPHERIC RIVERS

EXTRATROPICAL CYCLONES

TROPICAL CYCLONES

courtesy of Paul Dirmeyer (GMU/COLA)

S2S PREDICTION TASK FORCE

MAPP
Modeling, Analysis,
Predictions and Projections
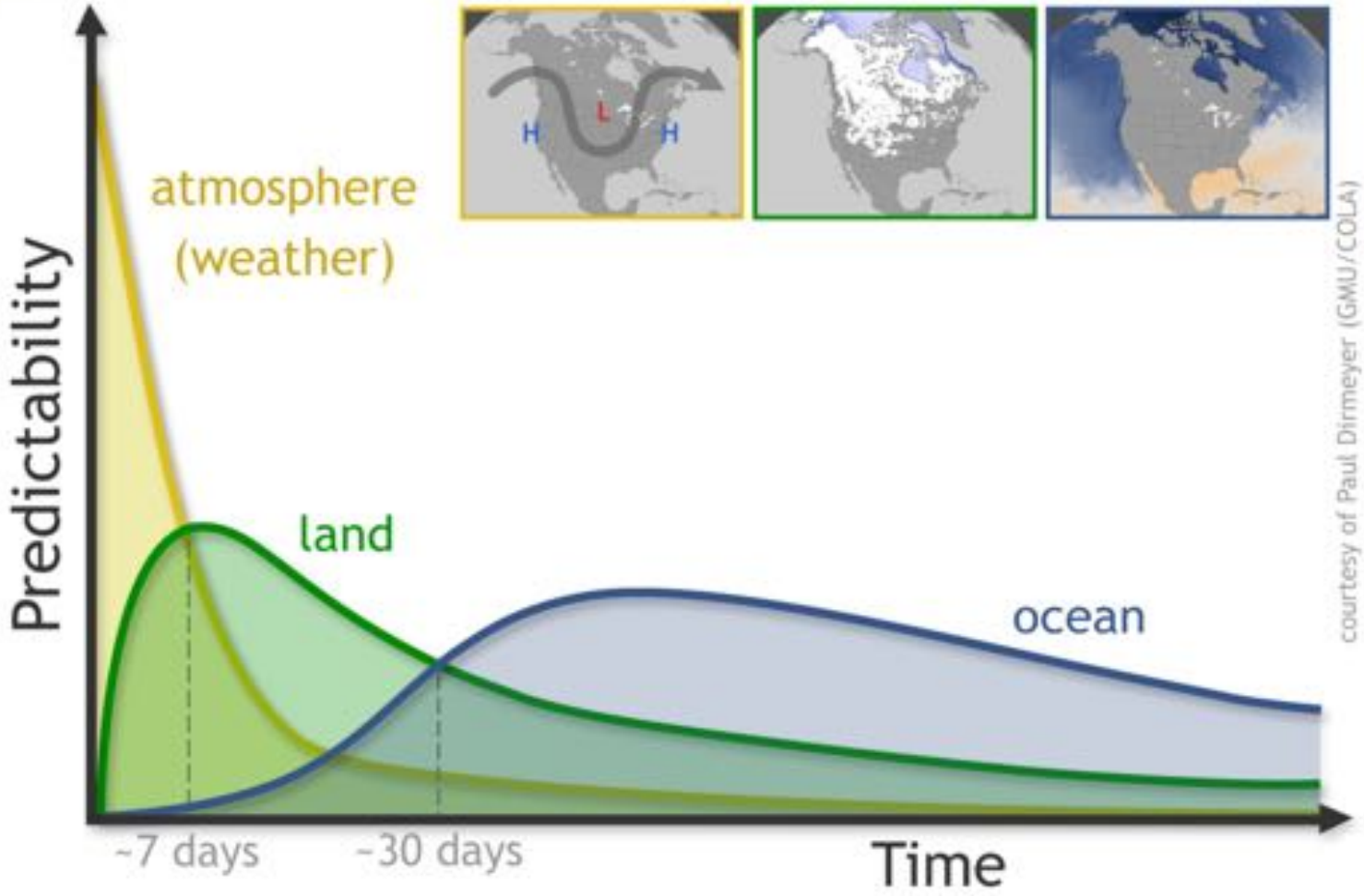
KEY MODEL DATA
- INTERNATIONAL S2S PROJECT
- SUBX
- NMME

STRATOSPHERIC POLAR VORTEX

NAO

WAVE ACTIVITY FLUX

EXTRATROPICAL CYCLONES

MESOSCALE SST VARIABILITY

BLOCKING

HEAT WAVES

TROPICAL CYCLONES

STORM TRACKS

ROSSBY WAVE BREAKING

LAND SURFACE MEMORY

ATMOSPHERIC RIVERS

MJO CONVECTION

AIR-SEA COUPLING

MARITIME CONTINENT BARRIER

OCEANIC FEEDBACKS

ENSO

MODEL RESOLUTION
MODEL PHYSICS
MODEL FORECAST SETUP
MULTI-MODEL STRATEGY

SKILL
PREDICTABILITY
VERIFICATION
PRODUCTS
LINEAR INVERSE MODEL

- Bad news: it's a complex puzzle to solve, it will take time and resources to do it..

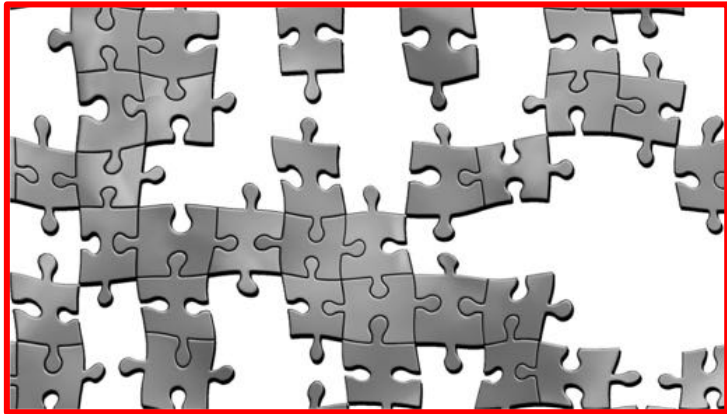- Good news: there is a community of scientists that is in place to help us find the major pieces = research opportunities

Key Questions: Processes and Physics

- What are the dominant physical sources of S2S predictability, and how well are these sources simulated and predicted?
- How do tropical/extra-tropical and stratosphere/troposphere connections influence S2S prediction?

Key Questions: Approaches to S2S Prediction

- What indices/metrics best describe extreme weather phenomena relevant to S2S prediction given the limitations in available model and observed variables?
- How can we seamlessly treat the transition from an atmospheric initial value forecast problem to a boundary value forecast problem across subseasonal (1-4 week) timescales, in terms of forecast products and their validation?
- To what extent can S2S prediction skill be enhanced by statistical post-processing (i.e., model output statistics) for various applications?
- How can single- and multi-model ensembles be best exploited for S2S prediction?

Key Questions: Evaluating and Improving Models for S2S Prediction

- What is the relative importance of model resolution, physics parameterizations and forecast initialization for prediction skill of phenomena on S2S timescales?
- How well do models represent interactions between the tropics and extratropics, troposphere and stratosphere, ocean and atmosphere, land and atmosphere, and between S2S and other timescales?
- What are the main sources of model systematic errors on S2S timescales?

As part of the WWRP/WCRP S2S Prediction Project

Research foci of the S2S Prediction Project Phase-II (2018-2023), involving both the weather and climate communities, are key research opportunities

New S2S research foci

MJO prediction and Teleconnections: MJO impacts on high impact weather in the tropics/subtropics and potential for S2S skill; MJO tropical-extratropical teleconnections and extratropical predictive skill

Land Initialization and Configuration: impact of the observing system on land initialization and S2S forecasts; representation of coupled land/atmosphere processes in S2S models; contribution of land surface states to extremes

Ocean and Sea Ice Initialization and Configuration: role of ocean-atmosphere coupling in S2S variability & S2S model representation; current capabilities of S2S sea ice process simulation, prediction, and sensitivity to initial state; predictability of sub-seasonal marine variability (eg relevant to fisheries & coral bleaching)

Ensemble Generation: impact of burst and lagged ensemble & relative importance of random and systematic errors on forecast spread; potential benefits of stochastic parameterization; benchmark of spread-error relationship

Atmospheric Composition: impact of prognostic aerosols on S2S forecasts; level of complexity needed; predictability of aerosols (e.g. dust) & potential forecast value for applications

Stratosphere: role of vertical coupling, stratospheric systematic errors, and impact of quality of stratospheric initial conditions
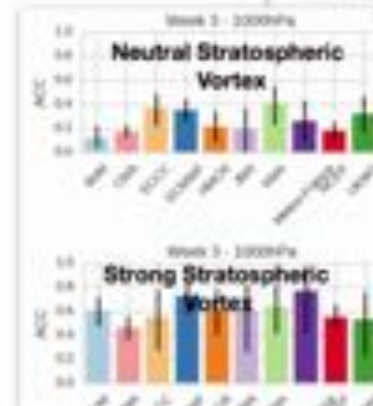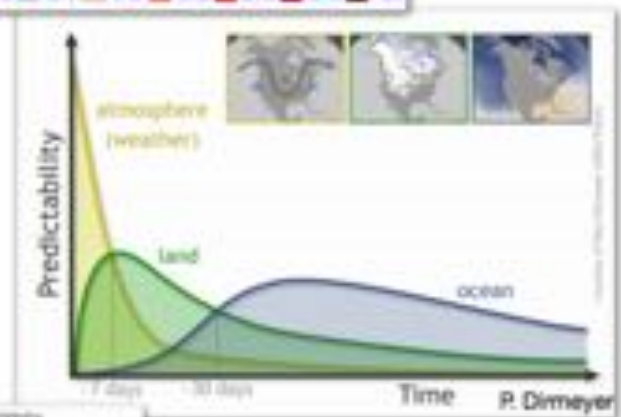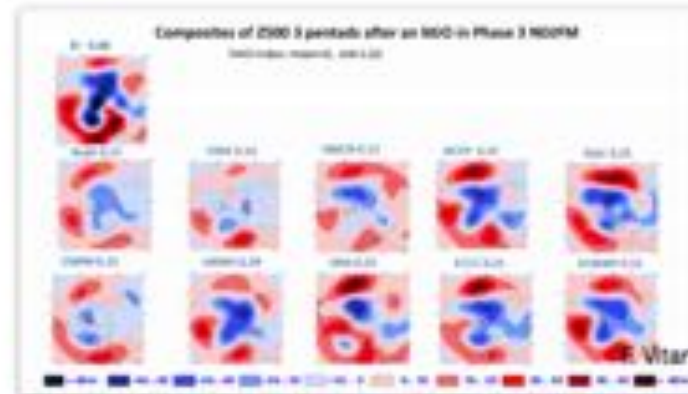
Courtesy of Andy Robertson, S2S Prediction Project co-chair

More broadly, the World Weather Research Program (WWRP) and World Climate Research Program (WCRP) have projects/programs that identify relevant research opportunities

- CLIVAR, GEWEX, WGSIP, SPARC, Polar Prediction, High Impact Weather..

US CLIVAR
Climate Variability and Predictability Program

- Nationally, the US CLIVAR program promotes process studies and research activities key to S2S:
  - better measure, understand, and model the role of ocean-atmosphere interactions that underpin S2S predictability
  - develop and evaluate S2S predictions and better quantify uncertainties
  - collaborate with research and operational communities that produce and use S2S information
- US Global Change Research Program (USGCRP) climate programs and their communities are key contributors to US CLIVAR and the National ESPC

International Conferences on Subseasonal to Decadal Prediction

17-21 September 2018 | NCAR, Boulder, CO, USA

https://www.wcrp-climate.org/s2s-s2d-2018-home

16 March 2018: Deadline for submissions and applications for financial support

- Focus on S2S prediction of select events relevant to the US
  - E.g. the 2015-2016 El Nino, atmospheric river activity, extreme heat waves..
  - Real-time pilot activities, retrospective/long term context, process/mechanistic studies..
  - Bring together research and application/operations communities
- Develop the interdisciplinary capacity for making predictions of disruptive events (volcano/ nuclear/ oil spill, etc.).
- Develop capacity for seamless S2S predictions to be used across application areas (next slide..)

Research questions regarding design of a next-generation seamless prediction system

Model design?
- ➤ Coupling physical component models
- ➤ Initialization approach
- ➤ Resolution (granularity)
- ➤ Ensemble size
- ➤ Computational time

User needs?
- ➤ Who will use this data?
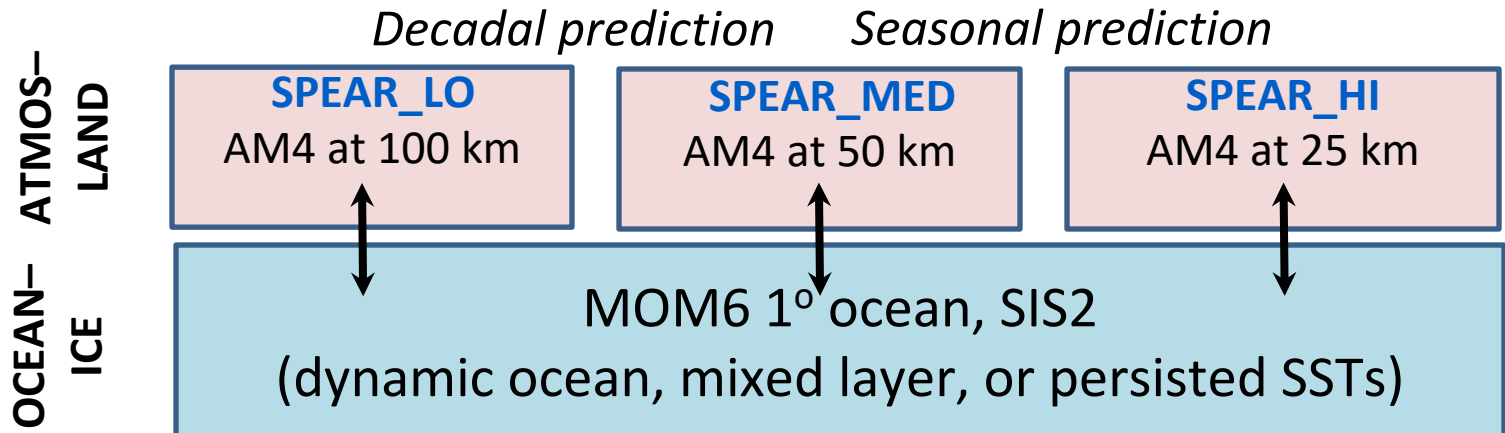- ➤ Scientific needs vs. societal applications

Seamlessness
- ➤ Used across time scales and by different sets of users

NOAA/GFDL's next-gen system, SPEAR, will be used for various S2S research questions: e.g., role of improved initialization in extending precip. prediction skill; prediction skill of winter storminess, hurricane tracks, sea ice extent

GFDL SPEAR design

Courtesy T. Delworth

ATMOS–LAND

Decadal prediction   *Seasonal prediction*

| SPEAR_LO AM4 at 100 km | SPEAR_MED AM4 at 50 km | SPEAR_HI AM4 at 25 km |

OCEAN–ICE

MOM6 1° ocean, SIS2
(dynamic ocean, mixed layer, or persisted SSTs)

Take home messages

Important research questions currently being addressed the MAPP S2S Prediction Task Force

For the next 5 years, research opportunities outlined by the broad WWRP/WCRP scientific community as part the S2S Prediction Project.

Nationally, there are S2S opportunities as part of US CLIVAR

There are specific opportunities at the research - application interface

The overarching opportunity is for the weather and climate research communities/programs to continue to work together for optimal progress

Held Feb 21, 2018

Go on-line for presentations and recordings.

MAPP Webinar Series: Subseasonal to Seasonal Prediction: Research Efforts and Broader Perspective

16 February 2018   Number of views: 357
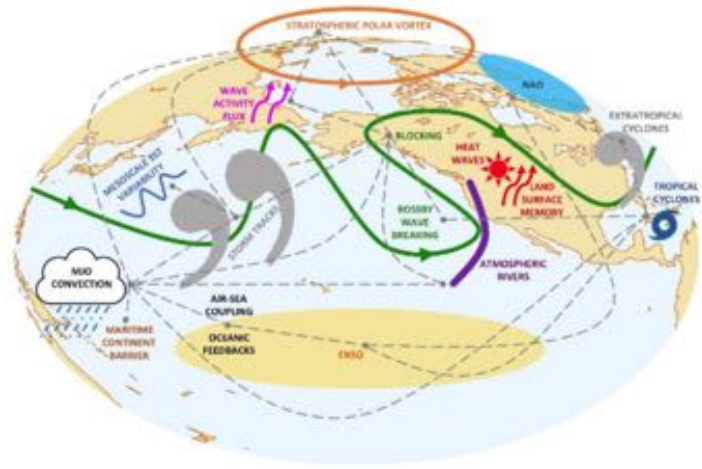
Event date: 2/21/2018 12:00 PM - 2:00 PM

Image Credit: Cory Baggett, Colorado State University and MAPP S2S Task Force

The NOAA CPO Modeling, Analysis, Predictions, and Projections (MAPP) program hosted a webinar on the topic of Subseasonal to Seasonal Prediction: Research Efforts and Broader Perspective on Wednesday, February 21, 2018.

Michael Rixen (WMO/World Climate Research Programme) and Paolo Ruti (WMO/World Weather Research Programme): *The Subseasonal to Seasonal (S2S) Prediction Project*

Michael Ventrice (The Weather Company): *The Weather Company (Energy Team) And NOAA Data*

Elizabeth Barnes (Colorado State University): *Bridging the Gap: NOAA MAPP's S2S Prediction Task Force*

Andrew Robertson (Columbia University): *Update on the WWRP/WCRP S2S Project and linkages with MAPP S2S Task Force*

Ben Kirtman (University of Miami): *SubX Multi-Model Predictability and Prediction Experiment*