Bridging the Gap:
NOAA MAPP’s S2S Prediction Task Force

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When the flap of a butterfly’s wings in Brazil sets off a tornado in Texas.
- Edward Lorenz (1972)

...small differences in the initial positions may lead to enormous differences in the final phenomena. *Prediction becomes impossible.*
- Henri Poincare (1903)
Forecast Gap at Weeks-to-Months

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

NOAA CPO image
Forecast Gap at Weeks-to-Months

- **WEATHER EVENTS**
- **S2S EXTREMES**
- **SEASONAL OUTLOOKS**

Prediction lead time:
- **Prediction skill**
  - Higher
  - Lower
  - Hours
  - 2 weeks
  - 1 month
  - 3 months
  - 12 months

Adapted from: tri.columbia.edu/news/qa-subseasonal-prediction-project
Forecast Gap at Weeks-to-Months

Adapted from: tri.columbia.edu/news/ga-subseasonal-prediction-project
Forecast Gap at Weeks-to-Months
MAPP S2S Prediction Task Force

Bridge the gap in prediction skill and products between traditional weather and seasonal lead times

• 59+ scientists
• 14 projects + SubX
MAPP S2S Prediction Task Force

- connecting scientists by holding monthly teleconferences; most work is conducted remotely
- facilitating collaboration: data sets, methodologies, results, strong ties with the International S2S project
- products: technical reports, review articles, journal special collections and
- supported mainly through the MAPP FY16 S2S research competition
- MAPP Program management facilitates Task Force activities with Task Force leads
To bridge the S2S gap for extreme weather we must understand processes on longer timescales
S2S PREDICTION TASK FORCE

KEY MODEL DATA
- INTERNATIONAL S2S PROJECT
- SUBX
- NMME

MODEL RESOLUTION
MODEL PHYSICS
MODEL FORECAST SETUP
MULTI-MODEL STRATEGY
Task Force: Key Questions

**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?
## Task Force: Key Questions

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ongoing research by Paul Dirmeyer (George Mason University/COLA) & Trent Ford (Southern Illinois University)
MAPP Awards: NA16OAR4310066, NA16OAR4310095
Predicting Heatwaves & Drought

ongoing research by Paul Dirmeyer (George Mason University/COLA) & Trent Ford (Southern Illinois University)
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Duration of Skill of NCEP CFSv2 Forecasts of Extreme Heat

Deterministic Validation Based on CPC
Poisson Validation Based on CPC

variable time-weighting for seamless forecasting
current research by Judith Perlwitz (NOAA/ESRL), Jadwiga Richter (NCAR), Lantao Sun (NOAA/ESRL)
Better Representation of the Stratosphere

- 30-level (low-top) and 46-level (stratosphere resolving) CESM1
- Ran 1999-2015 hindcast set using SubX protocol, 10 ensemble members
- Data submitted to IRI/SubX

**Improved predictability of the stratosphere**

**January surface circulation forecast looks more like reanalysis at S2S lead times**

*Current research by Judith Perlwitz (NOAA/ESRL), Jadwiga Richter (NCAR), Lantao Sun (NOAA/ESRL)*
current research by Elizabeth Barnes, Eric Maloney, Cory Baggett & Bryan Mundhenk (CSU); MAPP Award: NA16OAR4310064
Can we forecast atmospheric rivers on S2S timescales?
The Madden-Julian Oscillation (MJO) as a source of predictability
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Madden-Julian Oscillation and mid-latitude impacts

MJO phase 4

OLR data for Jan-Mar MJO events from 1979-2016

Compared to average

couldier skies
clearer skies

NGAA Climate.gov
Data: NCEP/NCEI
The Madden-Julian Oscillation (MJO) as a source of predictability
The Madden-Julian Oscillation (MJO) as a source of predictability

Madden-Julian Oscillation and mid-latitude impacts

MJO phase 6

OLR data for Jan-Mar MJO events from 1979-2016

Compared to average

dreadier skies
clearer skies

increased AR activity
diverted storm track
decreased AR activity

NOAA Climate.gov
Data: NCEP/NCEI
The Madden-Julian Oscillation (MJO) as a source of predictability
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Madden-Julian Oscillation and mid-latitude impacts

MJO phase 8

OLR data for Jan-Mar MJO events from 1979-2016

Compared to average

cloudier skies

clearer skies

NOAA Climate.gov
Data: NCEP/NCEI
The Madden-Julian Oscillation (MJO) as a source of predictability

Madden-Julian Oscillation and mid-latitude impacts
MJO phase 8

Rossby-wave

OLR data for Jan-Mar MJO events from 1979-2016

Compared to average

cloudier skies
clearer skies

NOAA Climate.gov
Data: NCEP/NCEI

200 hPa geopotential height anomaly
MERRA; made by Kai-Chih Tseng

CSU

Elizabeth A. Barnes
The Quasi-Biennial Oscillation (QBO) as a source of predictability
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Stratospheric circulation variability

- **WEST**
- **EAST**
- 31 miles
- Stratosphere
- Westward wind movement
- Troposphere
- Equator

NOAA Climate.gov
Skill in Atmospheric River Forecasts over the Pacific Northwest

Baggett et al. (GRL, 2017)
Composites of 7-day average activity
ERA-Interim

QBO: winds from **east**
Dec. 17, 1979

QBO: winds from **west**
Dec. 6, 2009

current research by Elizabeth Barnes, Eric Maloney, Cory Baggett & Bryan Mundhenk (CSU); MAPP Award: NA16OAR4310064
Skill in Atmospheric River Forecasts over the Pacific Northwest

prediction skill 30+ days ahead of time using a statistical model based solely on the MJO & QBO

Mundhenk et al. (NPJ Climate, 2018) forecasts for 5-day average activity
MERRA-2

Baggett et al. (GRL, 2017) Composites of 7-day average activity
ERA-Interim

Heidke Skill Score
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Heidke Skill Score

HSS, Decreased AR Activity
HSS, Increased AR Activity
Skill in Atmospheric River Forecasts over the Pacific Northwest

QBO: winds from east

QBO: winds from west

MJO Phase

lead time (weeks)

Composites of 7-day average activity
ERA-Interim

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CSU

Elizabeth A. Barnes
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The Subseasonal eXperiment (SubX)

By the Numbers...

- **7** Global Models
- **17** Years of Retrospective Forecasts
- **1** Year of Real-time Forecasts
- **3-4** Week guidance for CPC Outlooks

Real-time Multi-model Forecasts

[Maps of North America showing temperature anomalies]

IRI Data Library

- Forecast & Hindcast data publicly available


Skill Evaluation

[Charts showing correlation of temperature anomalies]

http://cola.gmu.edu/kpeigon/subx

slide by Kathy Pegion (GMU)
Looking South: tropical clouds and rain
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Looking **South**: tropical clouds and rain
Looking South: tropical clouds and rain
Looking South: tropical clouds and rain
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Madden-Julian Oscillation and mid-latitude impacts

MJO phase 2

OLR data for Jan-Mar MJO events from 1979-2016

Compared to average

cldier skies
clearer skies
Where should we look to bridge the gap?
Looking North: Arctic polar vortex

path of Superstorm Sandy largely determined by a persistent high pressure over the Atlantic

ongoing research led by Andrea Lang (University of Albany)
ongoing research led by Jason Furtado (University of Oklahoma)