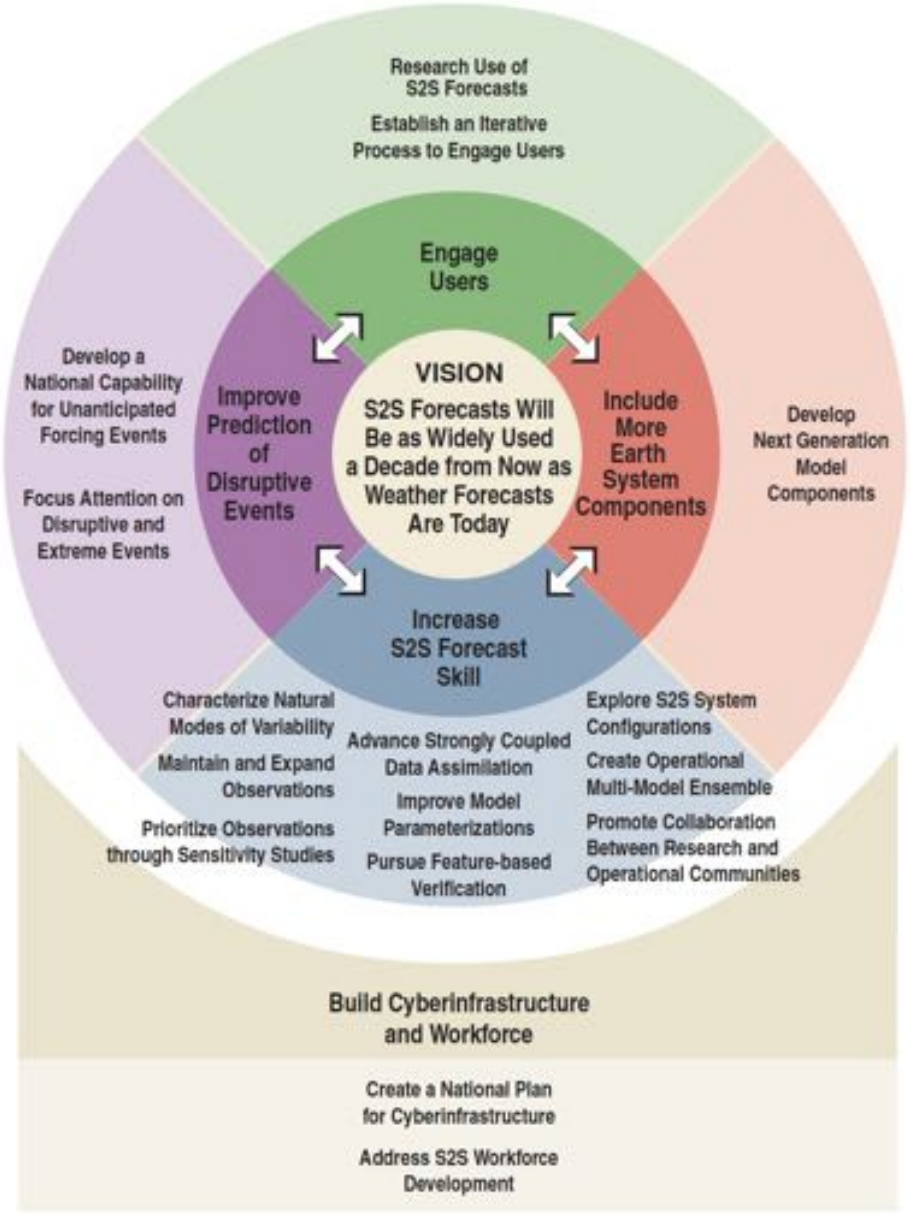
Research Opportunities for Advancing S2S Forecast

Chidong Zhang (NOAA PMEL) and *Robert Hallberg* (NOAA GFDL)



Knowledge

Predictability

Tools

Observations

Data Assimilation

Numerical Models

Forecast Products

Post-Processing

MME

Deliveries

Information Dissemination

Users

S2S Predictability

Ocean
- **Sea ice**
- **Upper-ocean heat content**
- **Eddies**
- **ENSO, IOD, …..**

Land
- **Soil moisture**
- **Vegetation**
- **Snow caps**

Slow Modes
- **ENSO**
- **MJO**
- **QBO**
- **SSW**

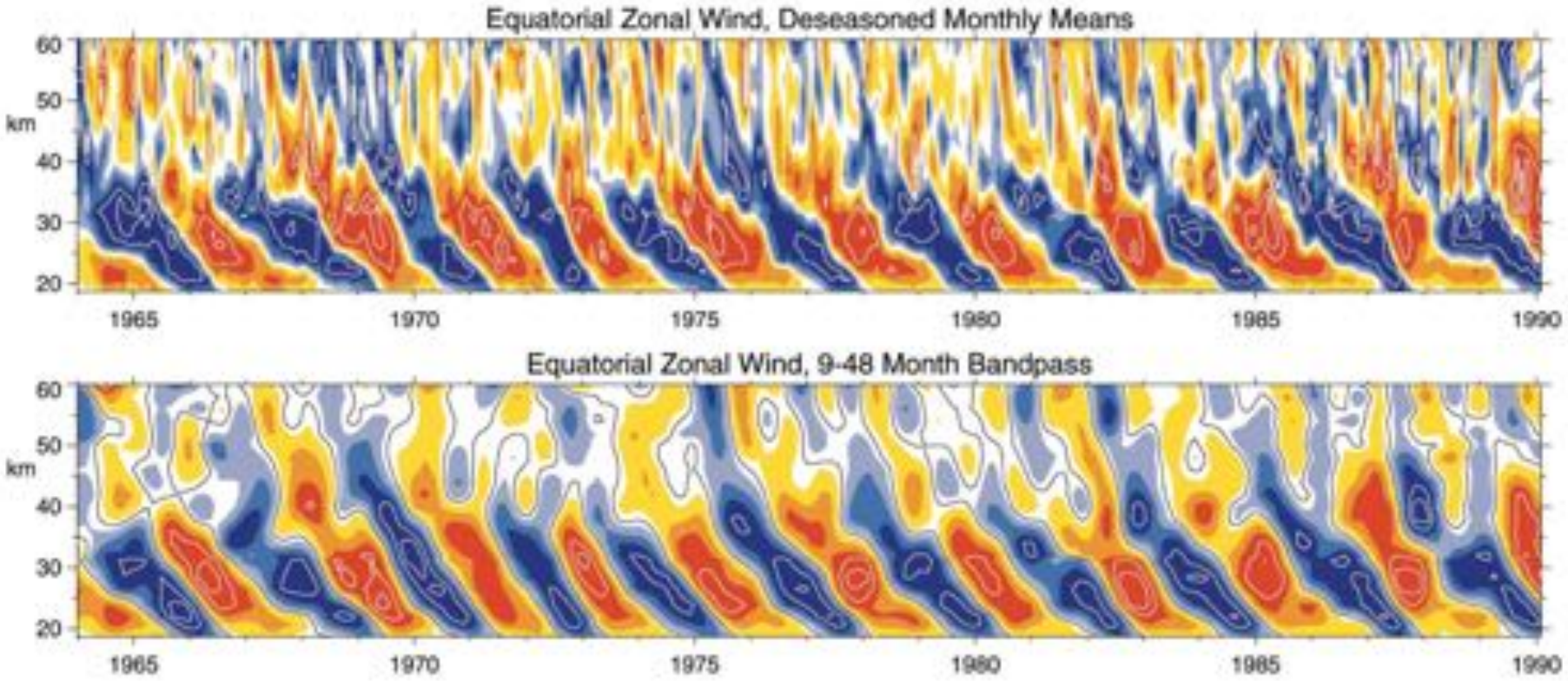
Observing System

Process studies

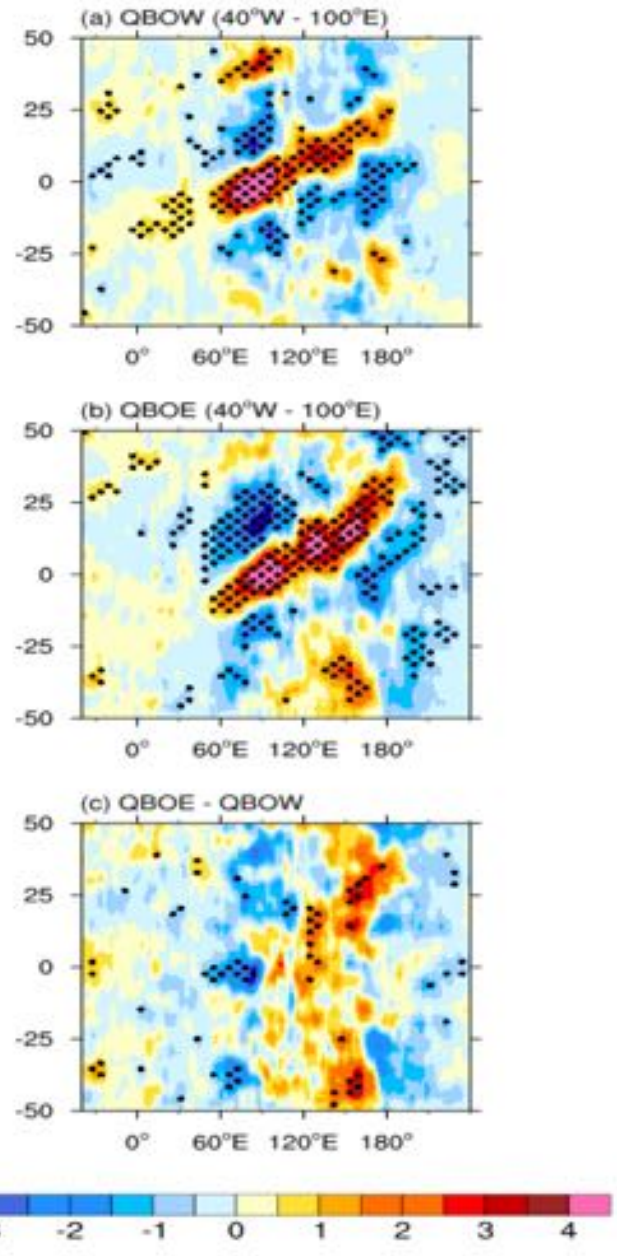
Model Configuration

Global Impact of the MJO on High-Impact Weather

Stratospheric Quasi-Biennial Oscillation



MJO



How should S2S forecast models be configured to capture this combined sources of predictability?

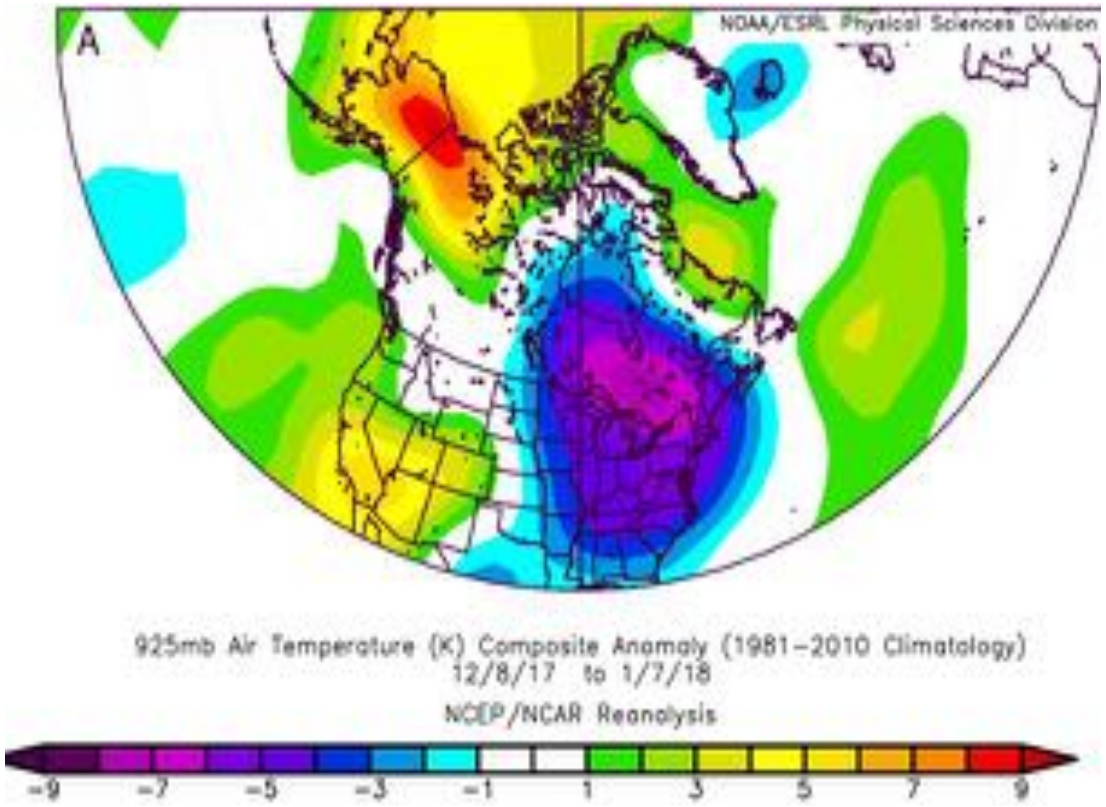
Initial Conditions
Data Assimilation

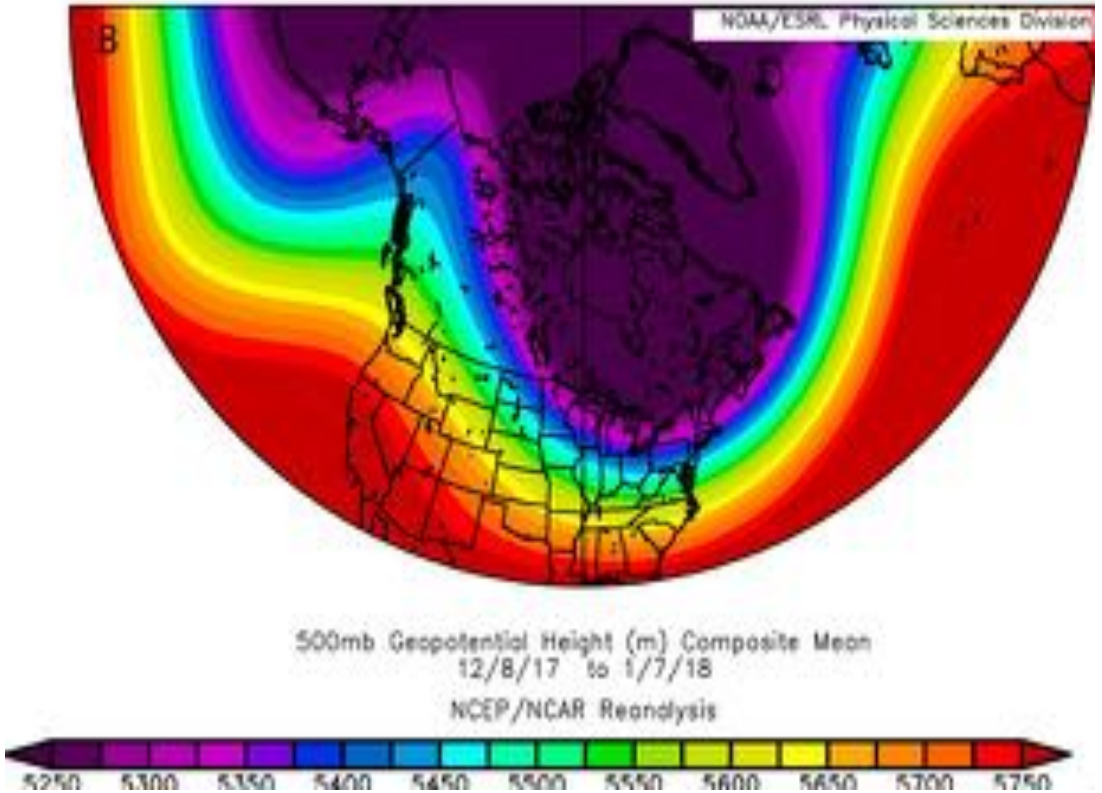
Model/Product Development
- **Parameterization**
- **Validation & Verification**
- **Post-processing**

Observations

- **in situ *vs.* satellites**
- **sustained obs vs. process studies**
- **temporal *vs.* spatial coverage**
- **fixed *vs.* mobile**
- **conventional *vs.* new technologies**
- **public *vs.* private**

Warm temperatures over Alaska (left) help reinforce wavy tropospheric jet stream (right) and prolong eastern US cold temperatures (December 2017)





Overland and Wang 2018

Arctic Sea Ice:

- A major potential source of S2S predictability
- Very low model reproduction and prediction skills
- Huge data void

How may advanced observing technology help?


Credit: Saildrone, Inc.


Credit: Eric Rehm /takuvik

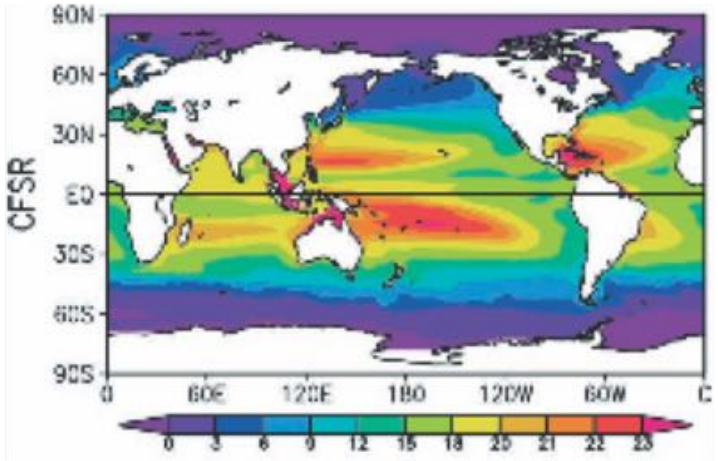
Forecast Models

- **Coupled *vs.* Uncoupled**
- **(air-sea-land-ice) (air quality, algae bloom, fisheries, fire)**
- **Complexity *vs.* ensemble size**
- **Deterministic *vs.* probalistic**
- **Resolving *vs.* parameterizing**
- **Global cloud-resolving *vs.* regional downscaling**

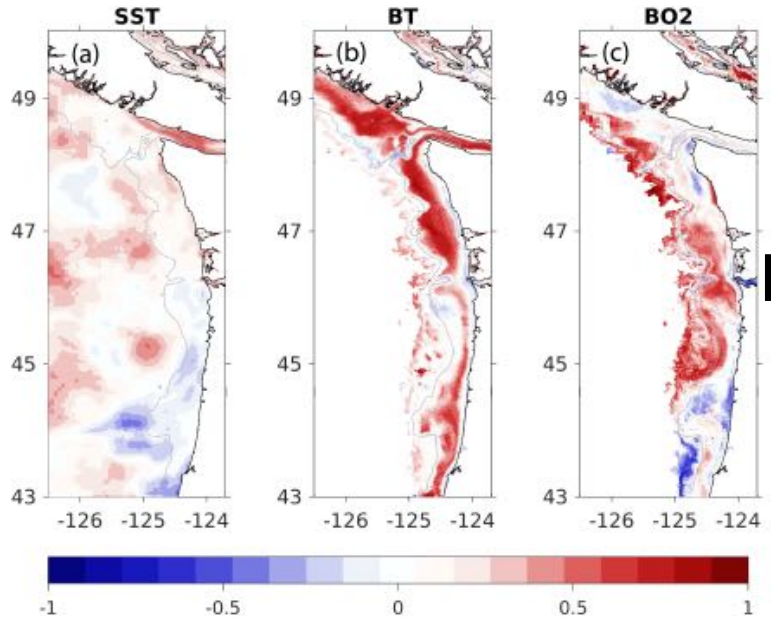
- **Atmosphere**
  - Aerosol
  - Chemistry
  - Pollen
  - Lightning
  - → **Fire Models**
- **Land**
  - Soil moisture
  - Vegetation
  - Snow cap
  - Glacier
  - River routing/runoff
  - Surface/underground water storage
  - → **Hydrology Models**, **Water Models**
  - Freshwater fish habitat
- **Ocean**
  - Waves
  - Storm surges
  - Nutrients
  - Algae
  - Fishes
  - → **Ecosystem Models**
- **Sea Ice**
  - Thickness
  - Melt ponds
  - Waves
  - Aerosol
  - Blowing snow

→ **Ecosystem Models**

JISAO's Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE): Ocean conditions for the marine ecosystem are predictable on S2S timescales



Downscaled ocean conditions (temperature, salinity) from CFS on S2S timescales (2-4 month) for variables relevant to management decisions for fisheries, protected species and ecosystem health.



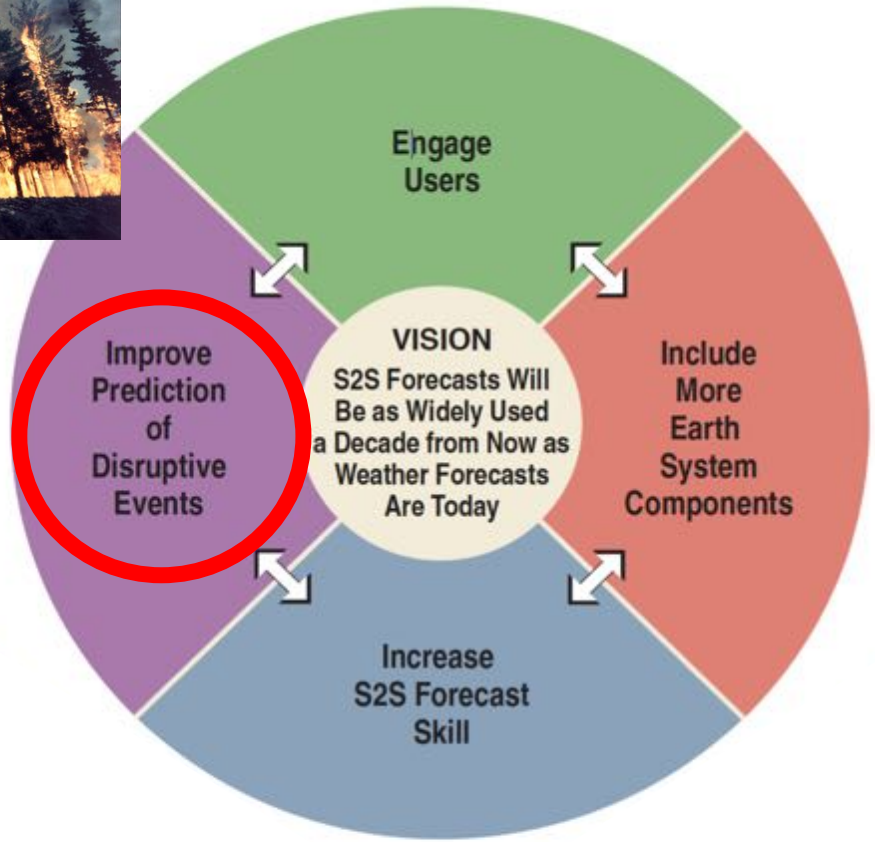
- **Calculate chlorophyll, nitrate, oxygen, pH, aragonite sat. state (Siedlecki et al. 2016)**

=> predict sardine habitat (Kaplan et al. 2016)

- **Calculate ocean acidification specific indices for crab, shellfish, pteropods, and hake habitat**

=> Decisions on opening and quota of commercial fishing season

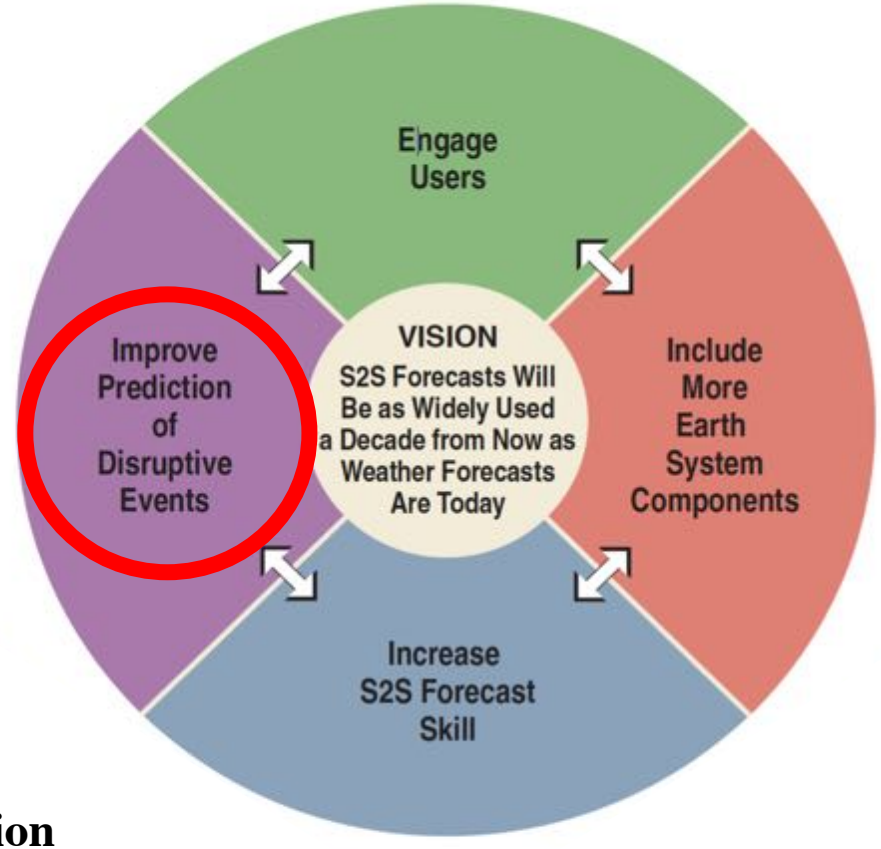
Anticipated Disruptive Events: S2S Forecast Targets



Issues:

- **Predictability (window of opportunities)**
- **Probabilistic forecast, uncertainties, and verification**

Unanticipated Disruptive Events: Forecast Their Consequences on S2S Timescales



Issues:

- **Special forecast systems**
- **Collection and QC of data for initial conditions, monitoring and verification**
- **Special data assimilation package**
- **Special forecast products**
- **Dissemination of forecast to designated users**

Critical Steps in the S2S Prediction "Pipeline"

Predictability

Observations

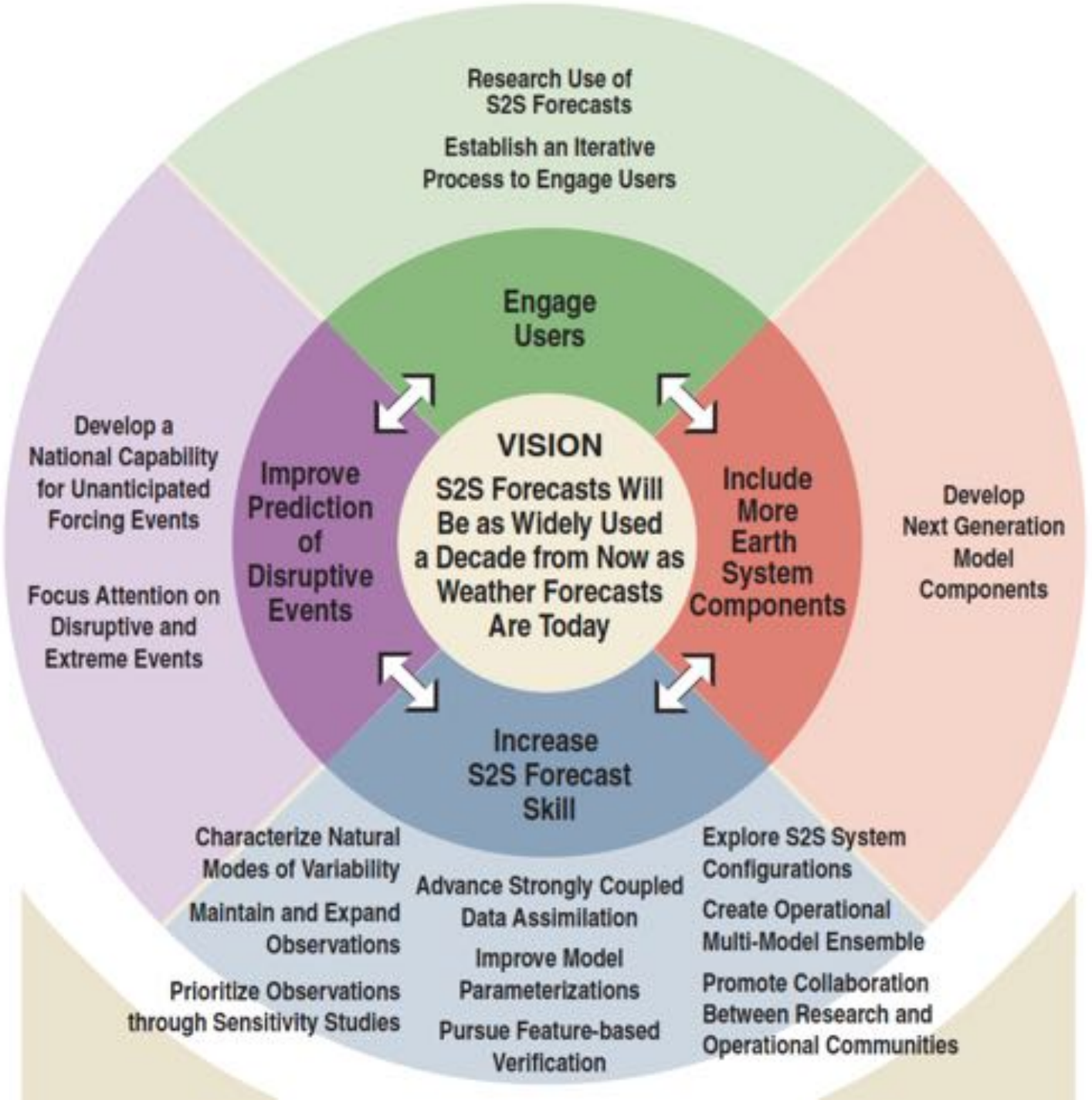
Data Assimilation

Numerical Models

Forecast Products

Information Dissemination

Users



International S2S NOAA MAPP S2S Task Force

NGGPS

Predictability √ √

Observations

Data Assimilation √

Numerical Models √ √

Forecast Products √ √ √

Information Dissemination

Users