Key Points from Today's Sessions

- Optimizing Observations to Explore Predictability
- A Holistic Earth Modeling Framework
- A New Research Framework for Practicable Earth System Predictability

Optimizing Observations to Explore Predictability

- To advance predictive skill, expand observing systems and support process studies
  - Observing system: in situ plus satellite observations provide boundary, initial conditions and model verification.
  - Process studies: probing episodic turbulent processes (things we don't yet know how to parameterize)
- Identifying which observational objectives to optimize → Doing the right science
  - E.g., reducing short-term verification error, differentiating between different hypotheses, improving a decision
  - Sustained and careful engagements with decision-makers to identify mission-oriented research challenges
- Designing obs systems that navigate trade-offs across divergent applications/objectives → Doing the science right
  - include the importance that models play in designing observation systems, feedback loop between models and observations
- Gaps in our current observing network
  - E.g., temporal and spatial coverage for fires
- Opportunities to better leverage existing data
  - Existing networks (e.g., agricultural obs along gradients of urban development); paleo data; low-quality, high-volume info (e.g., pressure data from cell phone users)
- Need to include non-geophysical aspects of our science
  - Societal impacts and decision info hidden behind privacy walls
  - Not well instrumented to observed impacts of weather and climate
- Opportunities from explosion in autonomous observing, satellites, partnerships with commercial sector, nontraditional observations (e.g., cell phone data), combining obs data and models
- FAIR - findable, accessible, interoperable and reusable

A Holistic Earth Modeling Framework

- The emergence of predictability studies in the Earth System Model community needs to be nurtured and greatly expanded, with better, more routine links between S2S forecasting and ESM modeling efforts
- Modeling progress needs multi-disciplinary teams of observationalists, modelers, software engineers, computational scientists and data analysts → way to make progress on process knowledge, statistical and machine learning methods, etc.
- Interoperability of data and models
  - Lots of information needs to flow between different components of predictions systems
  - Synergy and R&D needs of coupling observational systems, data assimilation of model initialization, and predictability studies with ESM models
- Hindcasts, coupled data assimilation are critical to understand where models are good or bad, sources of error growth
- Hierarchy of modeling systems → models are built for a purpose!
  - Unified framework requires co-design, creates opportunities for efficiencies
- Model biases are limiting our ability to understand Earth system predictability
  - Higher resolution could be a game changer, especially resolving moist convection and eddy resolving ocean models
- Tradeoffs between complexity, ensemble size, resolution
  - Depends on the problem at hand; Large ensembles particularly critical for predicting low probability, high impact events
- Biogeochemical, biological, and human processes provide important feedbacks and should be included in models to improve predictability, including on shorter timescales
  - Wildfires, dust, human emissions, vegetation, irrigation, crops, etc.
- Stakeholder involvement – to identify what to predict, and to provide useful data inputs

A New Research Framework for Practicable Earth System Predictability

- Explore a more formal application of systems engineering to our Earth system prediction (ESP) enterprise.
  - need to account for the complexities associated with the relevant and rapidly evolving science, tools and technology, and inter-agency and enterprise landscapes, when making judicious choices about how to advance ESP, and the significant societal benefits associated with it.
- Need to have an ability to execute the overall vision and plans, to achieve the whole rather than the sum of the parts.
  - Agencies empowered to surrender some of their narrower focus in the interest of prioritizing the collective objective → build the sandbox together.
  - Coordinating office or body?
- To do interdisciplinary research in this arena, it is important to
  - Have open accessible, well-documents and publicized community datasets
  - Identify clearly defined shared goals, framed around big problems
- Create opportunities and motivation to attract the best and brightest
  - If we want to decompartmentalize communities, we need the opportunities that achieve that
  - If we want to develop and maintain an effective workforce, people need be excited about the problems and to feel like they are part of something important and well-supported
- Possible next steps
  - Assemble a Tiger Team with SoS expertise to help guide our road mapping and prioritizations to advance ESP
  - Utilize cooperative institutes, FFRDCs, and similar mechanisms

Next Steps

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Thank you,
Be well!