Limits and Sources of Predictability – Seasonal to Multidecadal Scale

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On progressively longer scales predictability arising from:

- Lower boundary (ocean, ice, land/vegetation)
- Changing external forcing (ghgs and aerosols)

Key issues:

- What is inherent predictability for: ocean, sea ice, land, radiative forcing
  - each may have different timescales and processes
  - upper ocean versus deep ocean, wind-driven, buoyancy driven
  - soil hydrology and vegetation feedback
  - ability to project changes in external forcing (emissions and feedbacks)
- What is our ability to observe each component (ocean, land-vegetation, sea ice, biogeochemistry)
- What is our ability to inject observations into model to optimize predictions?
- Model bias and drift

Major Pathways – Seasonal to Multidecadal

Statistical models (past as predictor of future)

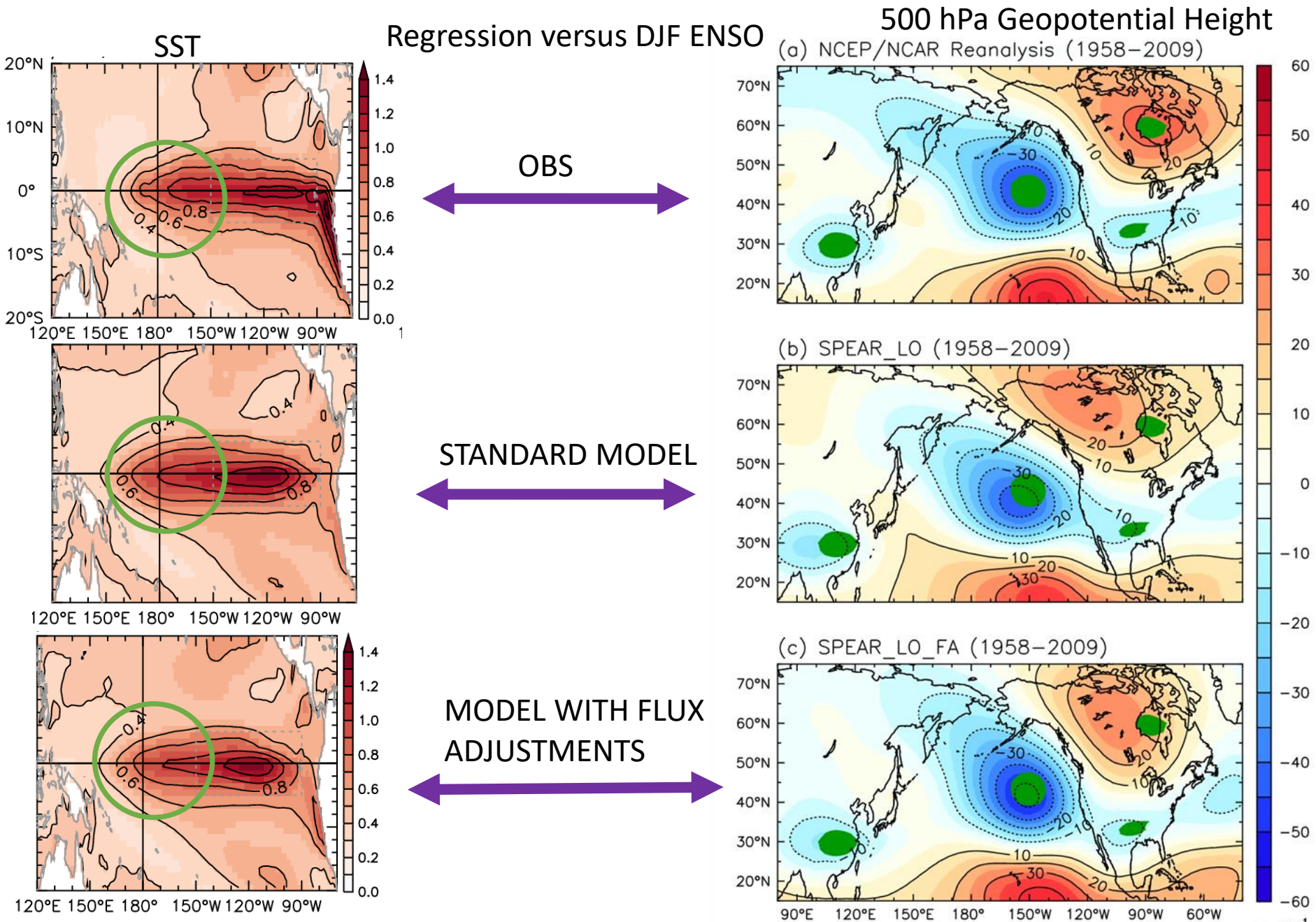
- Benefits - very computationally affordable, flexible, skillful
- New techniques (machine learning, etc) building off older statistical predictions
- Important benchmark for, and complement to, dynamical models
- Concerns - less physical, unknown suitability for changing climate

Dynamical models

- combination of physics/chemistry based understanding translated through numerical techniques to make predictions from observed state

- Benefits - based on fluid dynamics, physics, chemistry; potentially tightly linked across timescales (“seamless”)
- Concerns - computational challenges, difficulties at small scale, model biases

In parallel with fundamental advancements, artificial bias reduction techniques may yield useful insights



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Adjustments significantly increase winter temperature prediction skill

Opportunities – Seasonal to Multidecadal

Near term

- New generation of statistical models (machine learning, analogs, etc); improved predictive skill from such efforts is beneficial on its own, and serves as useful benchmark/complement for dynamical models

Recent examples include:
Ding et al., 2018, J Climate, 2018
Switanek et al., 2020

- Artificial means to reduce model biases to investigate predictive skill

- Improved representation and projection of short-lived radiative drivers

Near and longer term

- Improve representation of physical processes in models ("Motherhood statement")
- Reduce model drift
- Strategic focus on critical observations
- Improve initialization
- Progressively higher resolution is a necessary step for models →

- Unified modeling across scales has distinct advantages

Pascale et al., 2020, PNAS
Increasing risk of another Cape Town "Day Zero" drought in the 21st century
Uses GFDL SPEAR Seasonal to Multidecadal Prediction and Projection system.