Evaluating NOAA Climate Forecast System Subseasonal Forecasts

Nicholas Weber[1] and Clifford Mass[1]

[1] Department of Atmospheric Sciences, University of Washington

Motivation

- Subseasonal (weekly to monthly) numerical prediction is challenging because these time scales:
  - Are beyond the theoretical limit of predictability provided by ICs
  - Are too short to be dominated by the slowly evolving (and more predictable) BCs, e.g., sea surface temperature (SST)
- Such forecasts are important for water resource management, renewable energy production, and minimizing the societal impact of extreme events
- **Project Goal:** assess the average predictive skill of the U.S. operational extended model—the Climate Forecast System version 2 (CFSv2)—at multiple time scales.
  - How does skill evolve with lead time?
  - What are the important mean state biases?
  - How does the nature of simulated tropical convection change with lead time, and might this be tied to the limitations of global forecast skill?

Data and Methods

- Model: CFSv2
  - Fully coupled T126 (~0.937º) resolution
- Reforecast dataset: 1982-2008
  - 9-month runs only: 4-member ensemble mean every 5 days (1951 forecasts total)

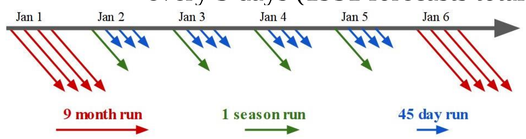


Figure 1. CFSv2 reforecast configuration

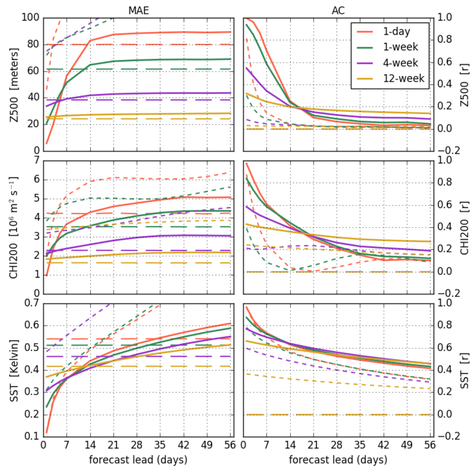
- Verification: CFSR (GDAS)
- Parameters: 500 hPa geopotential height (**Z500**), 200 hPa velocity potential (**CHI200**), and **SST**
- Error/skill metrics: mean absolute error (**MAE**), anomaly correlation coefficient (**AC**), and **bias**

* 1982-2008 bias was removed from the reforecasts

Acknowledgements

- This research was supported by NOAA Grant NA15NWS4680023.
- CFSv2 and CFSR data are made available by NCEP.

CFSv2 Skill



- Errors saturate within **2-3 weeks** for Z500 and CHI200 forecasts
- Skill over climatology is limited to lead times < 2 weeks
- SST forecasts remain skillful for **much longer**
- Persistence forecasts are generally inferior to dynamical forecasts at all lead times and temporal scales

Figure 2. Spatially averaged MAE and AC versus lead time for NH mid-latitude Z500, tropical CHI200, and tropical SST. Solid lines are the CFSv2 9-month reforecasts, broad dashed lines are CFSR climatology, and short dashed lines are persistence forecasts.

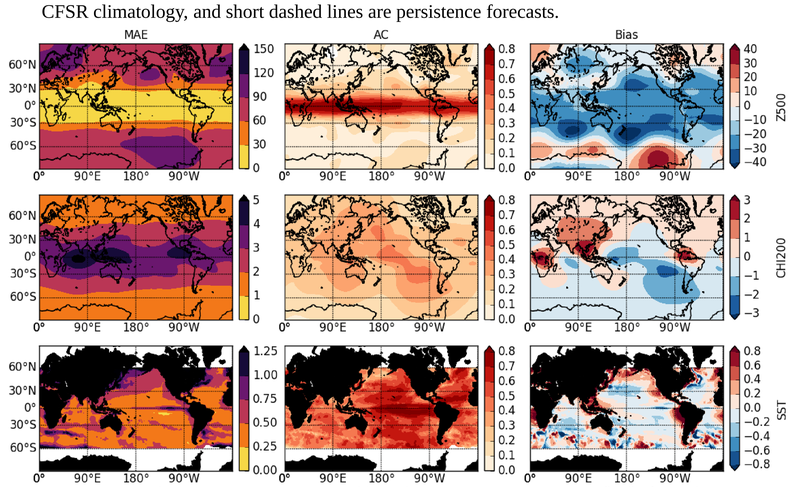


Figure 3. Week-4 CFSv2 MAE, AC, and bias for Z500 (m), CHI200 (10^6 m^2 s^{-1}), and SST (K).

- Spatial error patterns are robust across temporal scales and leads
- **Too little (much) convection over tropical land (ocean)**
- ENSO events have a marked impact on both tropical and extratropical forecast skill

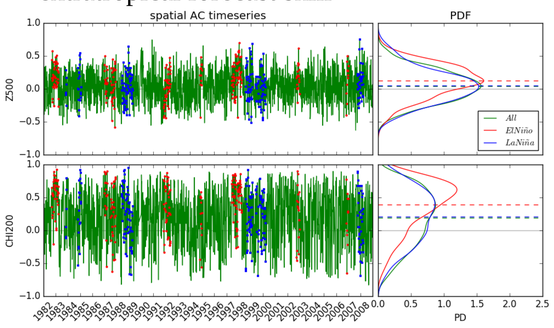


Figure 4. Spatial AC time series and corresponding PDFs for week-4 CFSv2 NH mid-latitude Z500 and tropical CHI200. Green represents all reforecasts and red (blue) represents only those initialized during El Niño (La Niña) events.

Simulated Tropical Convection

Why do we care?

- If the convection in the tropics is not properly simulated, then the associated teleconnections will be missed, undermining global forecast skill at all time scales

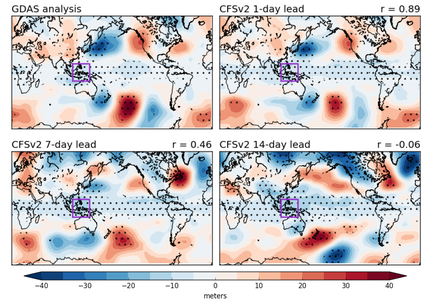


Figure 5. Weekly DJF Z500 anomalies composited about Maritime Continent convective events (OLR anomaly < 1 sigma) at a lag of 7 days.

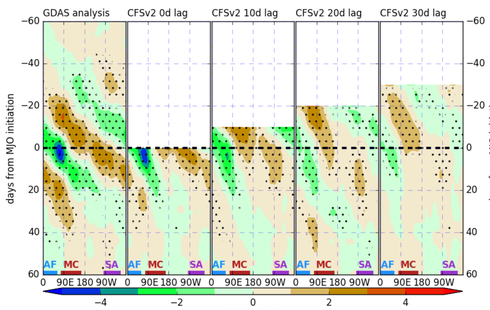


Figure 6. Meridionally averaged (10ºS to 10ºN) weekly CHI200 composited about MJO onset dates.

- The Madden-Julian Oscillation (MJO) is the primary mode of tropical intraseasonal variability
- The signal is barely present at lead times longer than 20 days
- Even at short leads, the **phase speed is too slow**
- At long leads, the model fails to produce distinct MJO and Kelvin wave peaks
- Too much power at **low frequencies**

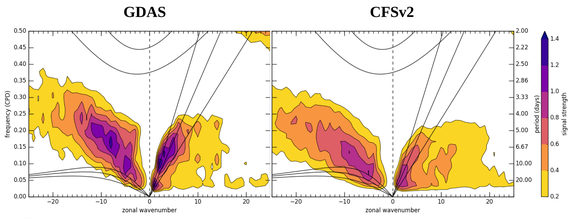


Figure 7. Space-time power spectrum signal strength (relative to background noise) for the analyses (left) and the last 90 days of the CFSv2 9-month reforecasts (right).

Conclusions

- On average, subseasonal and seasonal forecasts exhibit **limited skill** over climatological forecasts
- Spatial patterns of skill and bias are robust across lead time and temporal scale; the **biases in CHI200** develop the most quickly
- Simulating tropical convection is important for global forecast fidelity. CFSv2 has trouble predicting the MJO at long leads times and exhibits the common “Maritime Continent Barrier” issue.
- The model produces **more stationary convection** at long lead times.