Accelerating Progress in S2S Prediction Capabilities by Improving Subgrid-Scale Parameterizations in the UFS

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Background

- For practical reasons, most model physics development takes place for systems run on timescales of global weather (< 2 weeks), or even shorter: not as much at S2S+ timescales

- Paradigm shift (at least at operational centers): consolidate modeling systems (dynamical cores, and subgrid-scale physics) to run across many timescales – “minutes-to-millenia”

- Leverage paradigm shift to look at model physics at subseasonal timescales

Project goals

- Use “one-at-a-time” tests that swap parameterizations of convection, microphysics, and PBL to examine impact of these schemes on coupled UFS subseasonal runs
- Leverage ongoing coupled UFS development at EMC (they run “Experiment 1”):

Experiment #	Experiment Name	Convection	Boundary Layer	Microphysics
1	UFS_P5	SASAS	EDMF	GFDL
2	GF	**GF**	EDMF	GFDL
3	MYNN	SASAS	**MYNN**	GFDL
4	Thompson	SASAS	EDMF	**Thompson**

- GF, MYNN, and Thompson schemes are developed by NOAA/GSL, NCAR, and other partners primarily for use in high-resolution short-range NWP
- Comparing Experiment 1 to 2, 3, or 4 gives insight into impacts of convection/PBL/microphysics, **accelerating S2S physics development**

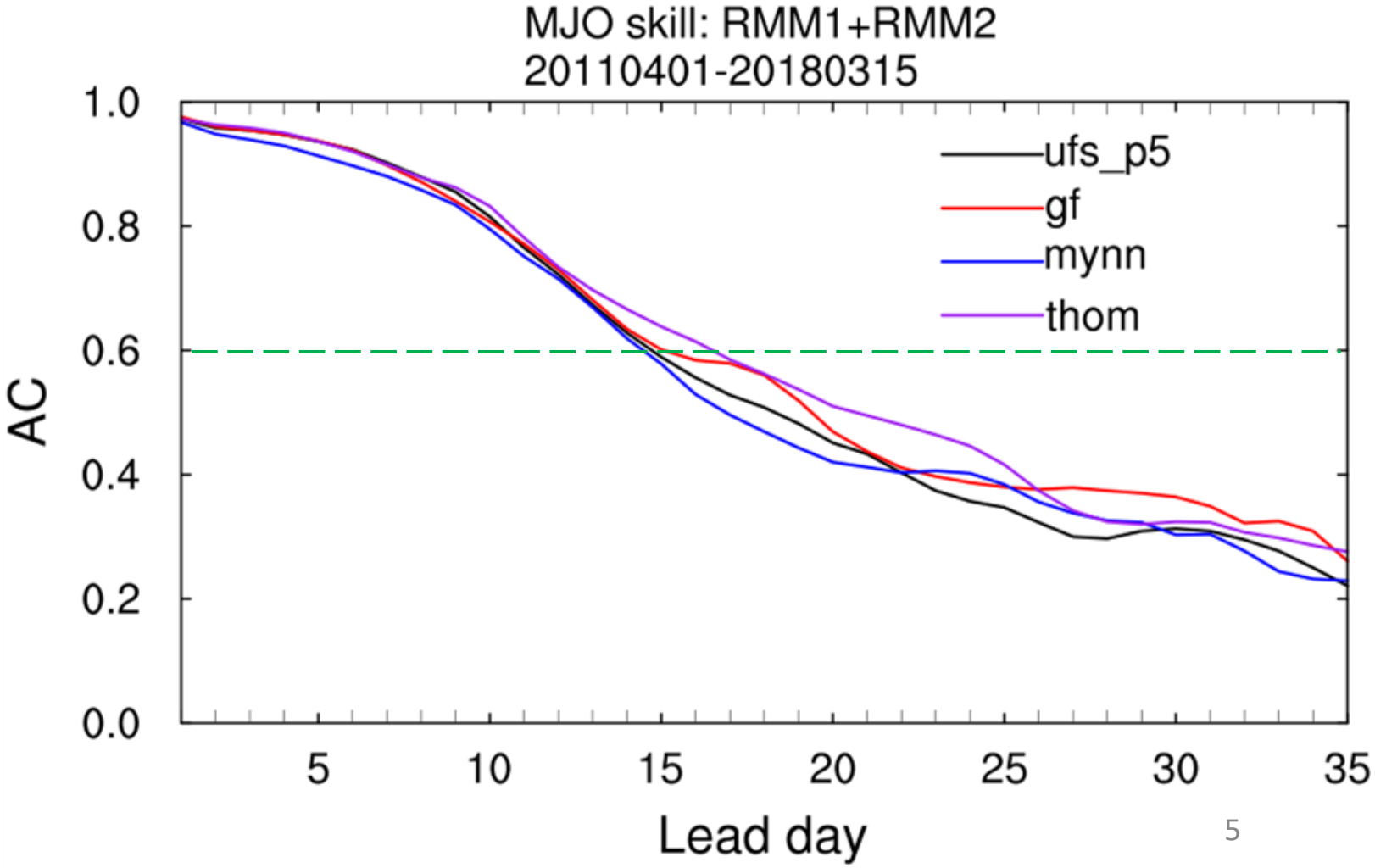
Experimental design

- Run 3 additional sets of experiments (see previous slide). Follow EMC's "Prototype 5" protocol for each experiment:
  - Initialize 1st and 15th of every month from 1 April 2011 through 15 March 2018 (**168 cases**)
  - C384 (~25 km) resolution, 64 vertical layers: daily 1x1 output on isobaric & surface levels
  - 35-day runs
  - CMEPS mediator used to couple the following models:
    - FV3 atmosphere
    - MOM6 ocean
    - CICE6 sea ice
    - WW3 wave

- Note: Currently rerunning all experiments (Experiment 1 baseline is now Prototype 7.0 from EMC)

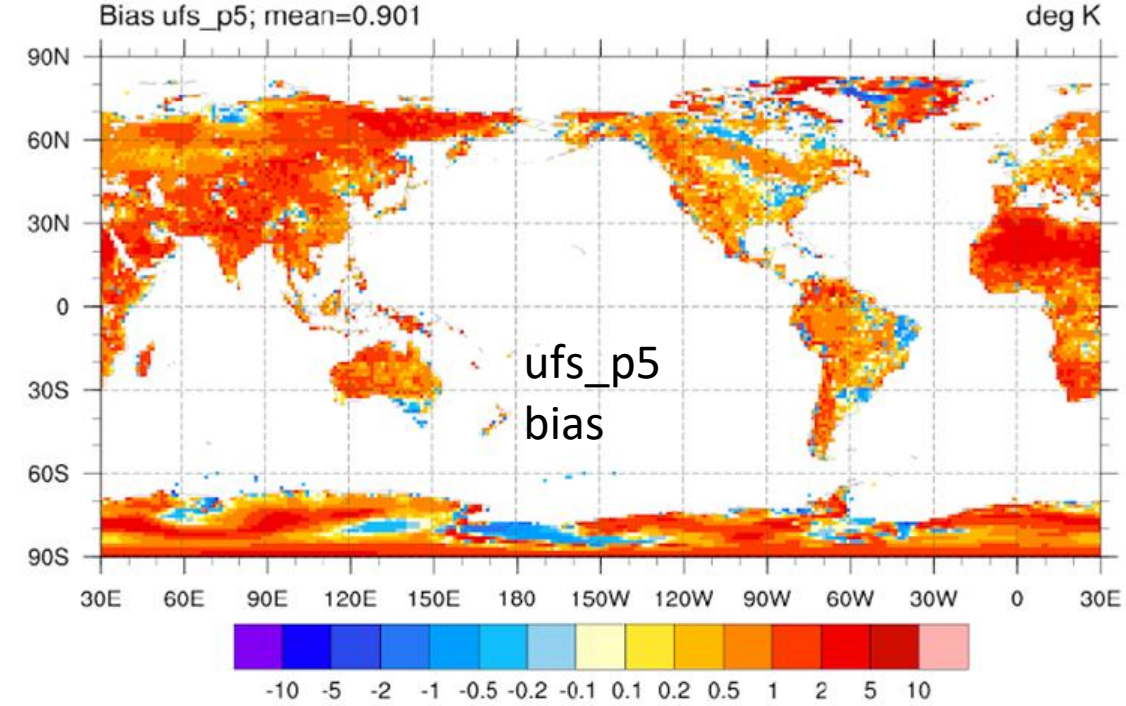
RMM skill score

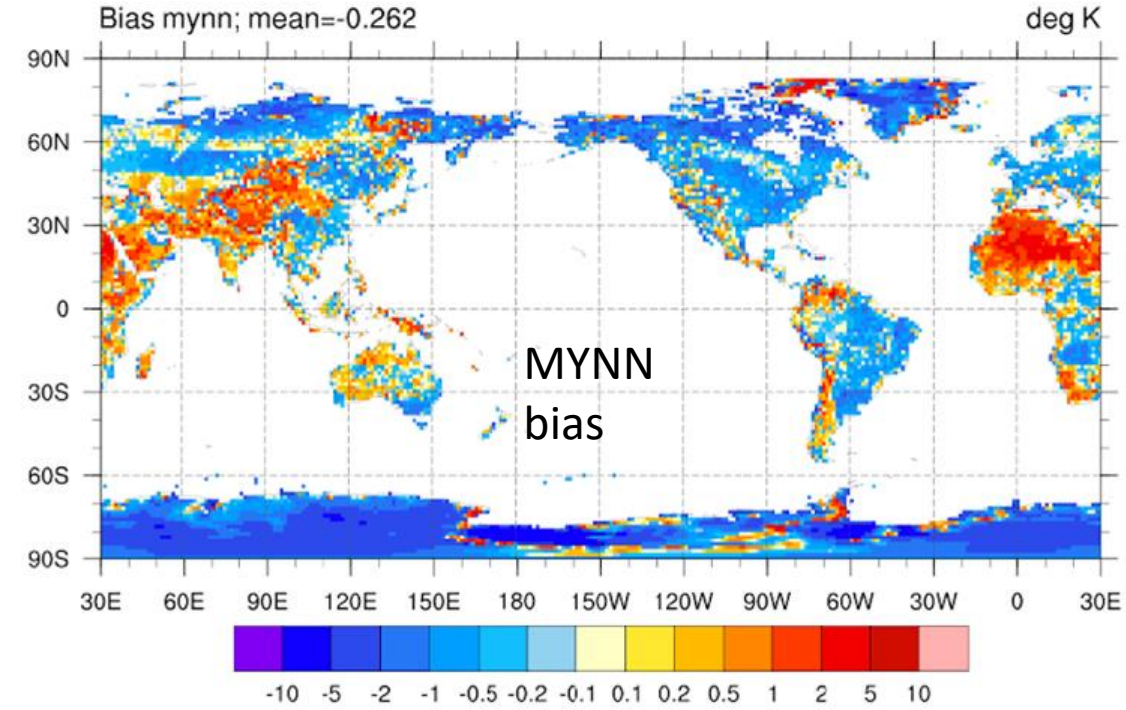
- Control (“ufs_p5”) never has the highest RMM skill score
- Using score of 0.6 as a threshold, Thompson experiment is skillful out to 16 days (**year round**); others skillful to 14-15 days
- Still need to look at various teleconnections: RMM skill is meaningless if relationship between tropics and mid-latitudes is wrong

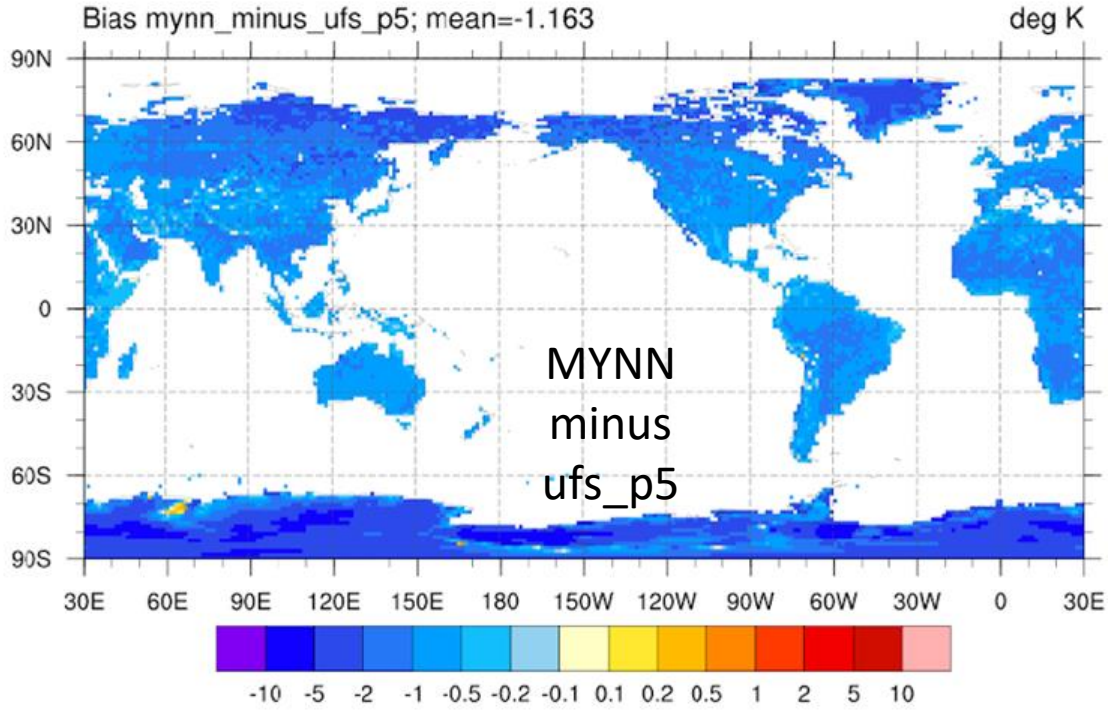


Week **1** T2m bias (vs. CFSR)

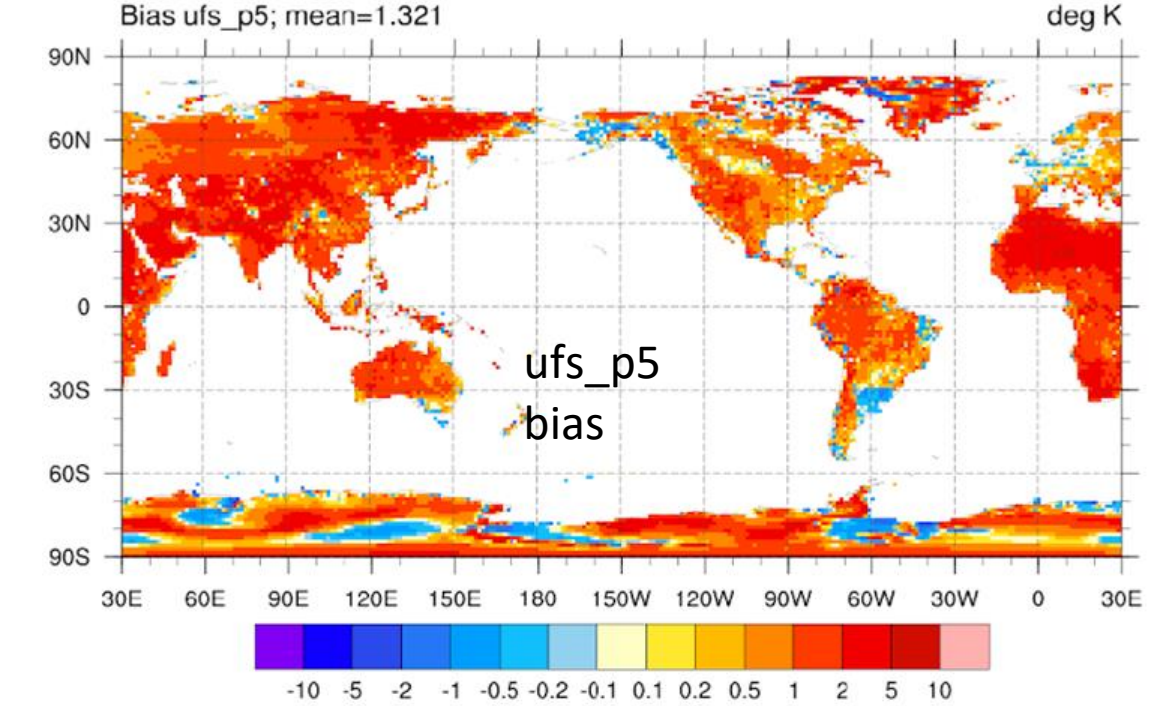
- Land biases (left), ufs_p5 vs. MYNN
- Systematic cooling in MYNN relative to ufs_p5 (bottom right)



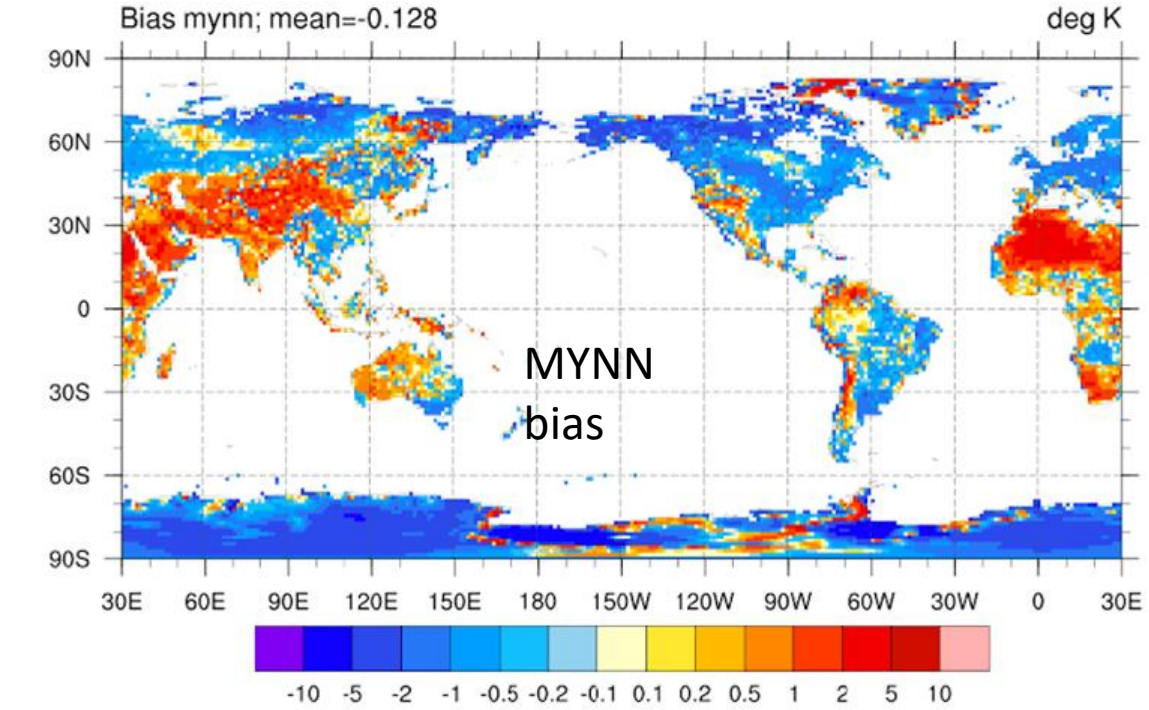


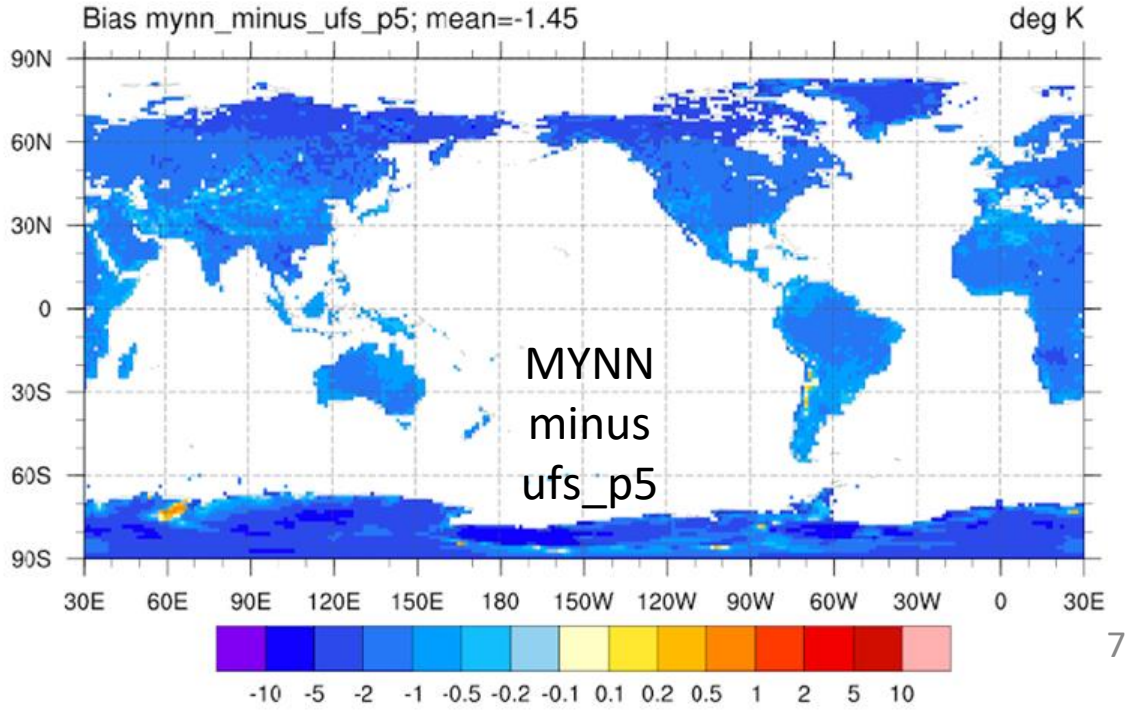


Weeks **3-4** T2m bias (vs. CFSR)



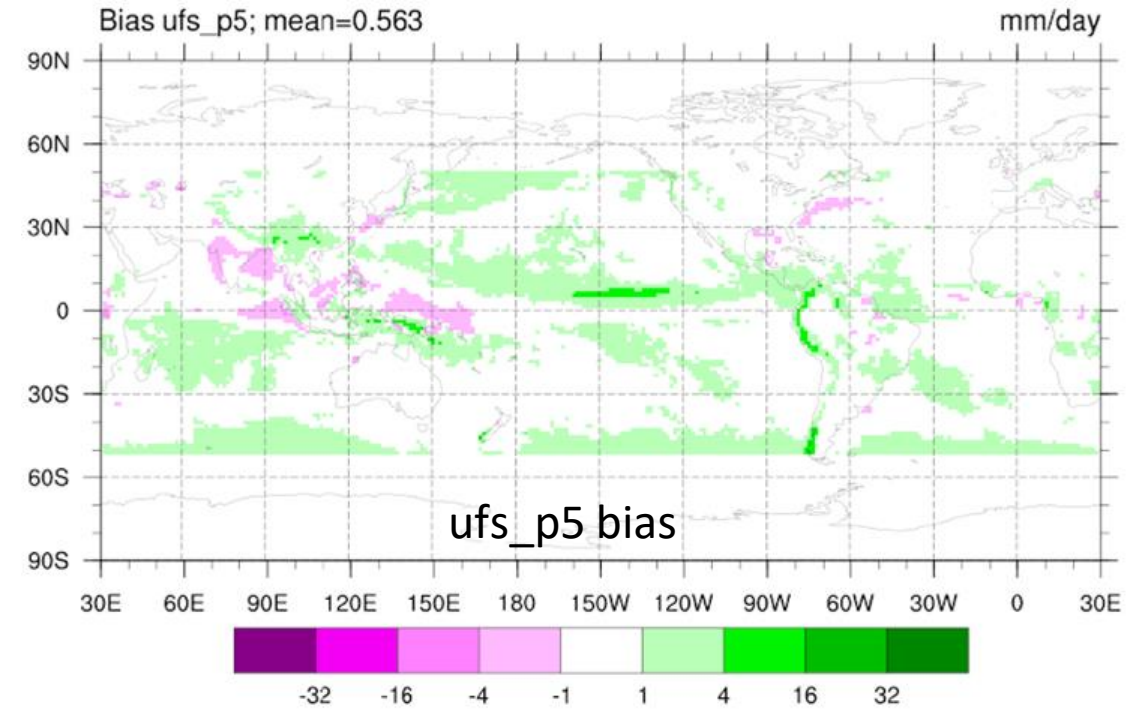
- Land biases (left), ufs_p5 vs. MYNN
- **Patterns extremely similar to week 1!**
- Systematic cooling in MYNN relative to ufs_p5 (bottor right)



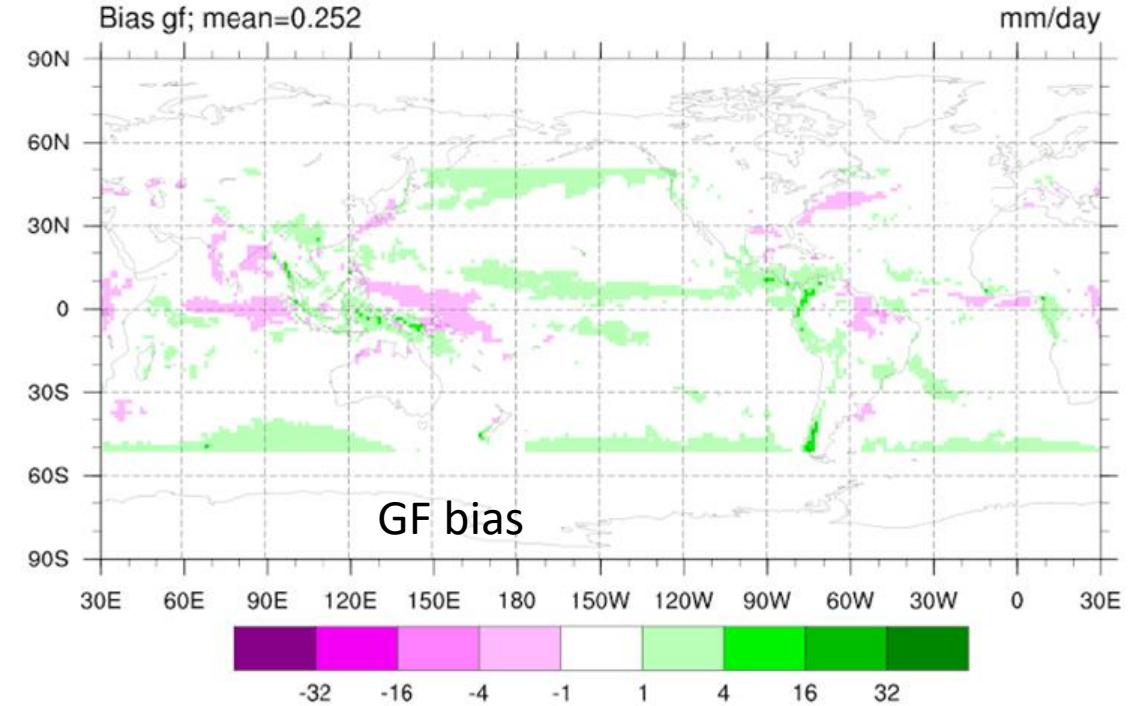


Weeks **3-4** QPF bias (vs. TRMM)

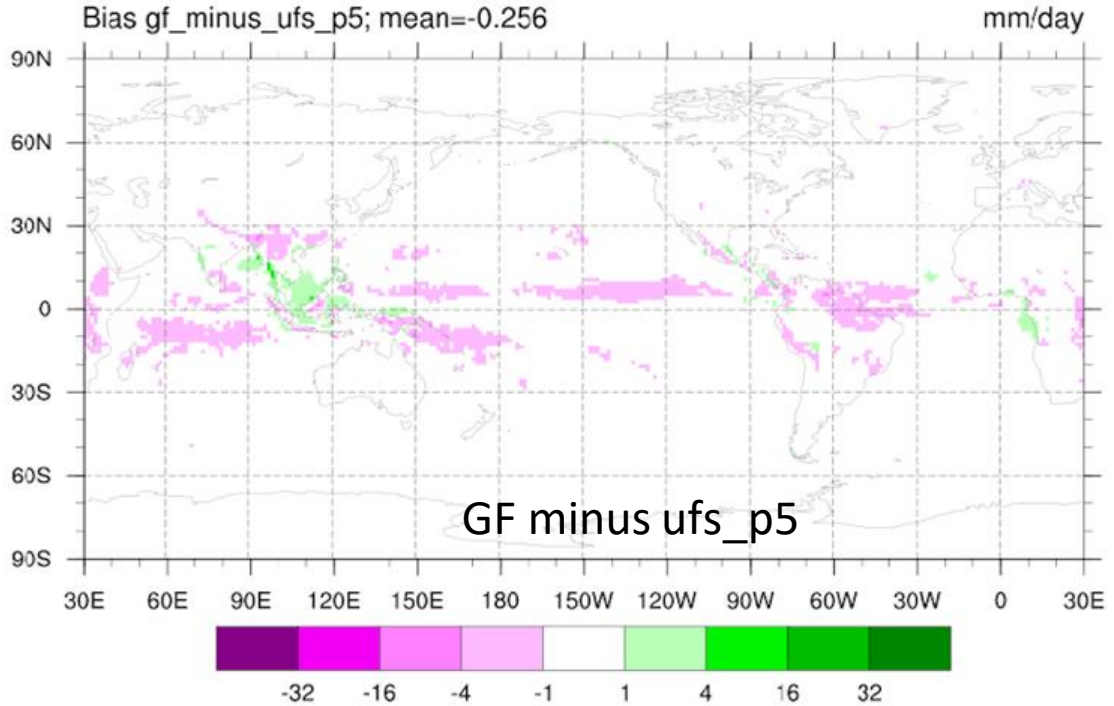
- ufs_p5 vs. GF
- **GF has smaller mean bias than ufs_p5**
- Systematic drying in GF relative to ufs_p5 (bottom right)



ufs_p5 bias

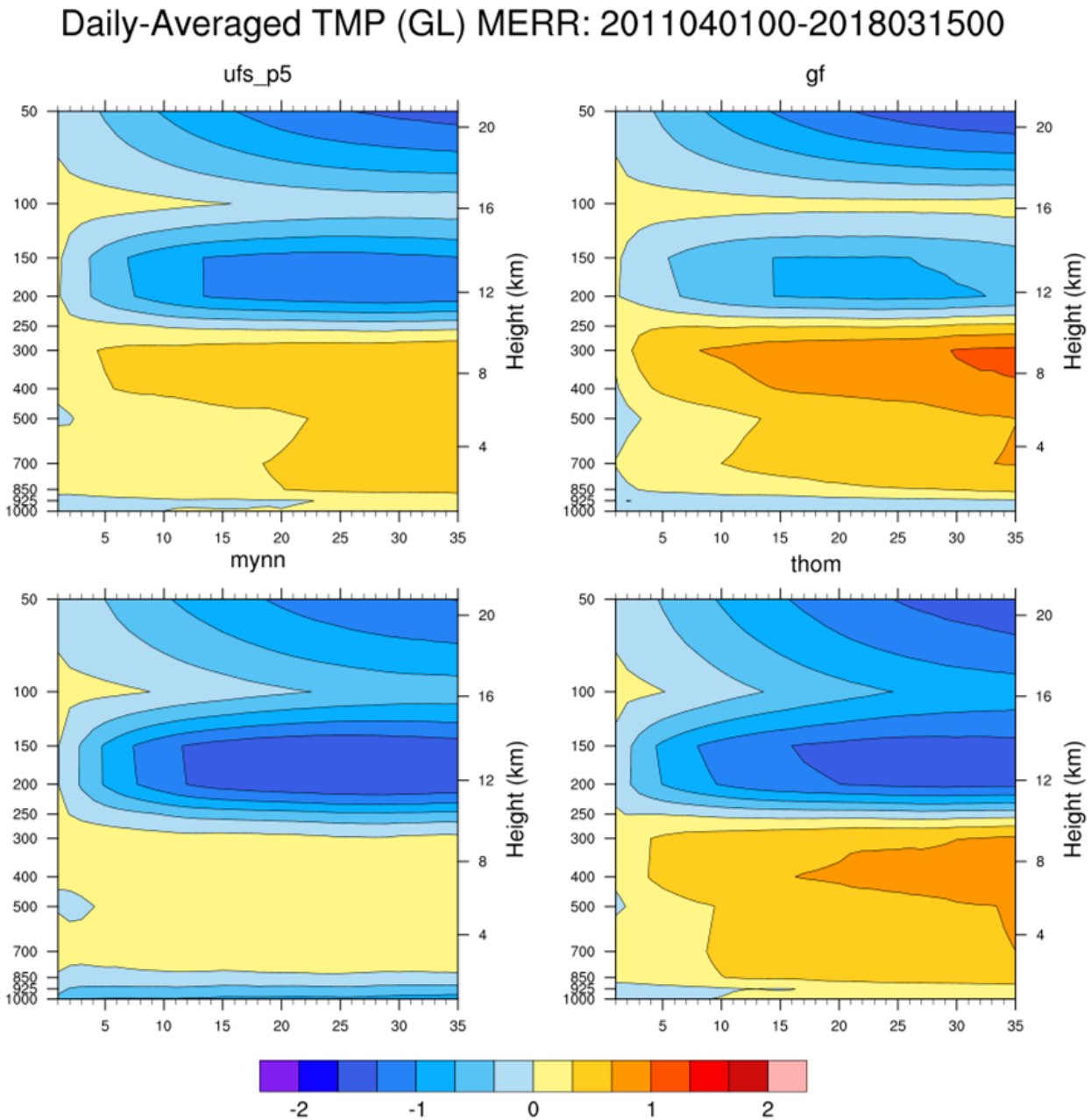


GF bias



GF minus ufs_p5

Global temperature bias evolution (vs. CFSR)

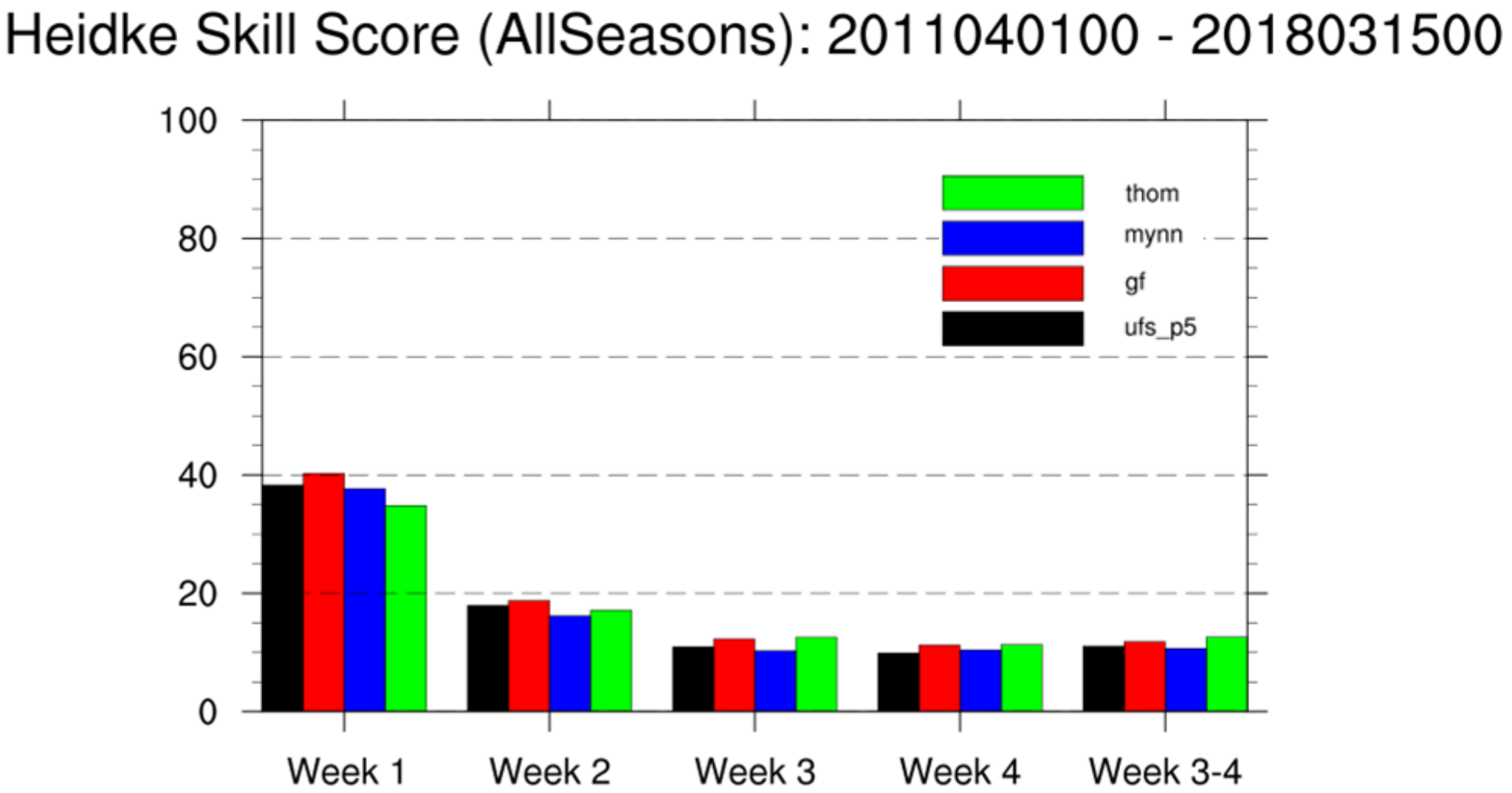


- Troposphere warms with time; opposite in stratosphere

- Implication: Could potentially look at **bias evolution** in first ~14 days to get a sense of biases in weeks 3-4. This could allow for **shorter runs to guide some S2S physics development**

CONUS Heidke Skill Scores for **QPF**

- Aggregated over all CONUS and over all seasons:
  - GF best for weeks 1-2; Thompson slightly better weeks 3,4,3+4



Summary

- Swapping in alternative physics shows promise in subseasonal forecast performance (skill scores, bias)
- "First-order" tuning may not require 35-d runs (potential to tune based on shorter runs)
  - But "second-order" impacts (e.g., impact of convection on T2m) can't take this shortcut
- Skill scores for MJO (and for Z500, not shown) are quite similar across all 4 experiments: why?
  - Coincidence or compensating errors?
  - Do **multiple** physics schemes need to be changed at once to see a bigger impact?
- Future work: Quantify bias evolution over time