Short-term climate extremes: prediction skill and predictability

Emily J. Becker[1], Huug van den Dool[1], and Malaquias Peña[2]

1: Climate Prediction Center (NOAA/NWS/NCEP),

2: IMSG at Environmental Modeling Center (NOAA/NWS/NCEP)

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How well can we currently predict short-term climate extremes?

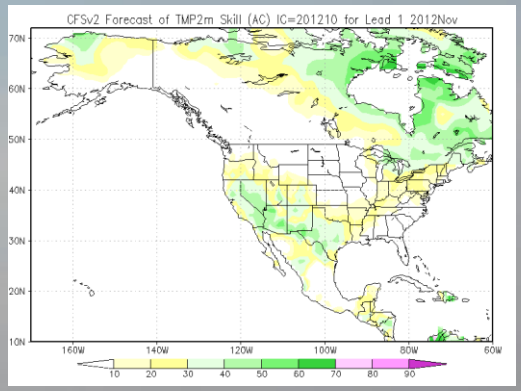
- Short-term climate extremes (STCE): monthly or seasonal means well above or below the mean, at leads of 1 – 8 months.
- Present-day prediction skill and predictability
- 2-meter surface temperature and precip. rate over North and South America; sea-surface temperature in Niño 3.4 region and Atlantic hurricane main development region (MDR)

Forecasts and Observations

- Climate Forecast System version 2 ensemble mean reforecasts
  - 9-month leads, 1982-2010
  - all 12 initial months
  - regridded to resolution 1° x 1° (Saha et al. 2012)
- Tmp2m: GHCN+CAMS, regridded to 1° x 1° (Fan and van den Dool 2008)
- Precipitation rate: CPC global Unified Rain-Gauge Database, regridded to 1° x 1° (P. Xie et al. 2010).
- Sea-surface temperature: OI-2 (Reynolds et al. 2002), native resolution is 1° x 1°.

Methods

- Systematic error correction to remove model bias: model climatology is removed, and replaced with climatology from observations
- Cross-validation: “CV3RE”
- Verification measures:
  - Anomaly correlation (AC)
  - Root-mean-square error (RMSE)
- AC and RMSE are area-averaged over North America, South America (tmp2m and prate) and Niño3.4 and MDR regions (SST).



The definition of extreme

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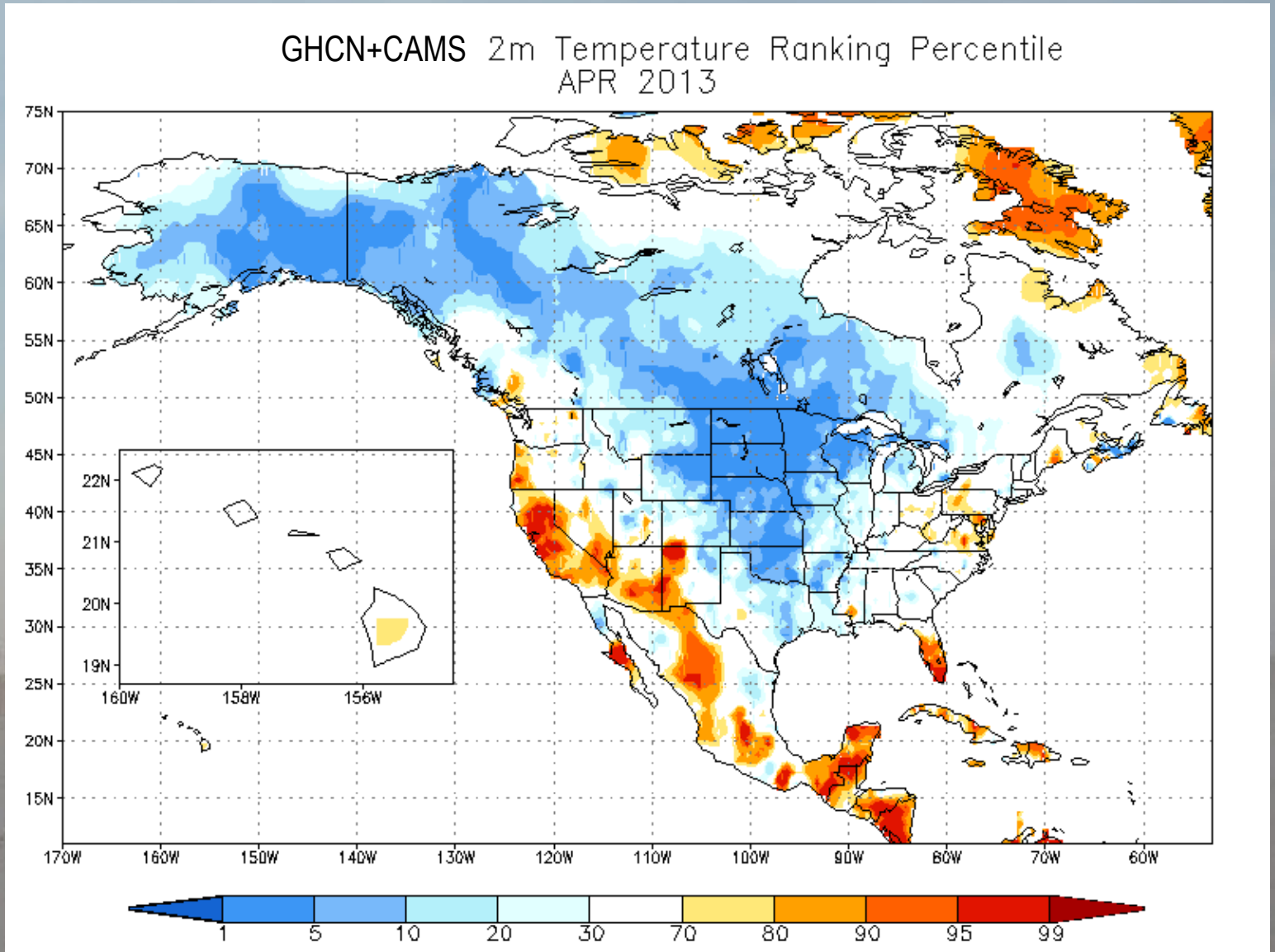
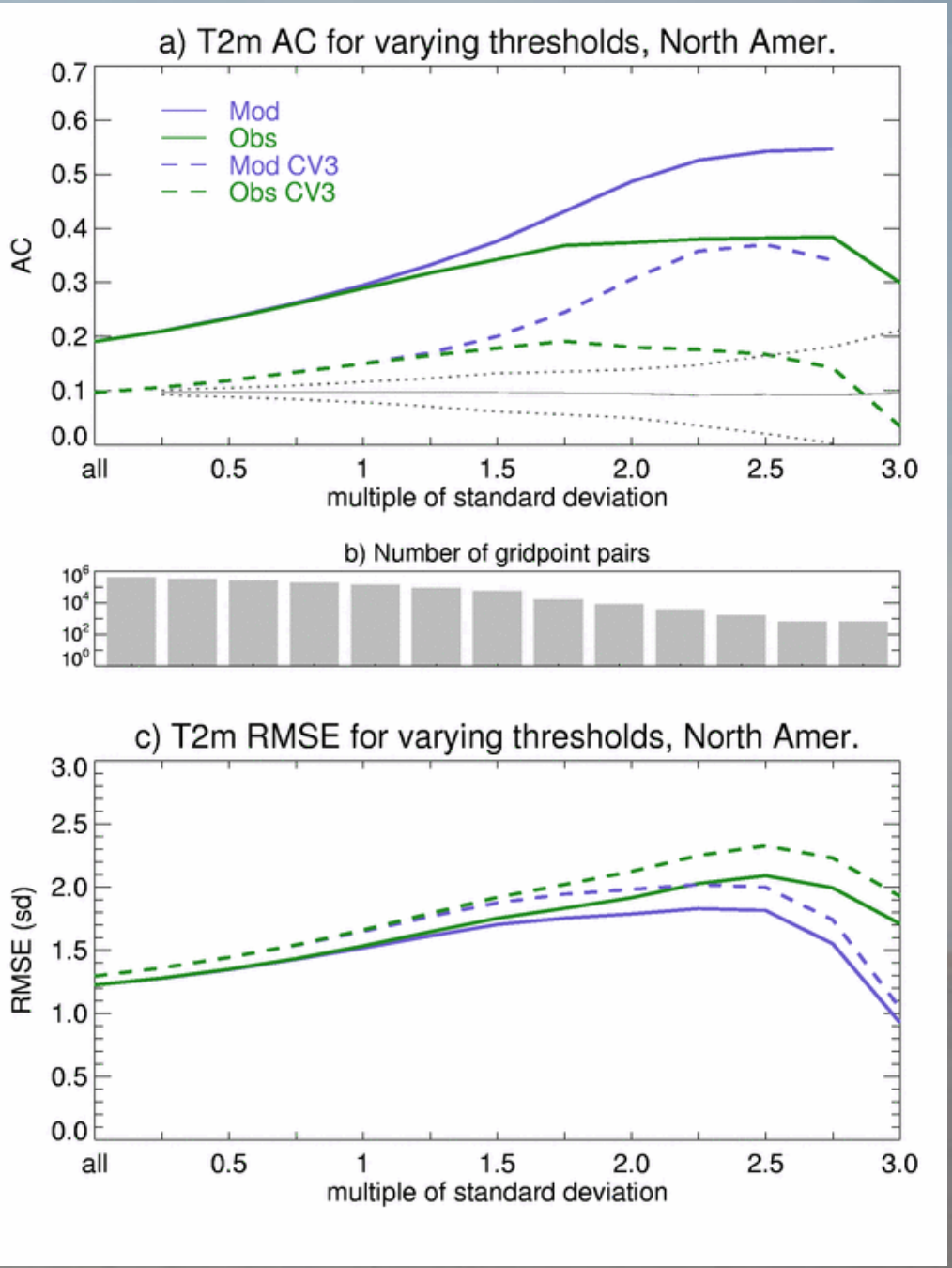


The definition of extreme

- Gridpoint monthly mean anomaly above/below +/- 1.645 standard deviations
  - Approximately equivalent to 5^{th}/95^{th} percentiles.
  - Other definitions were tested, with similar skill findings.
- Two scenarios:
  - Extreme is forecast: did it come true?
  - Extreme was observed: was it forecast?

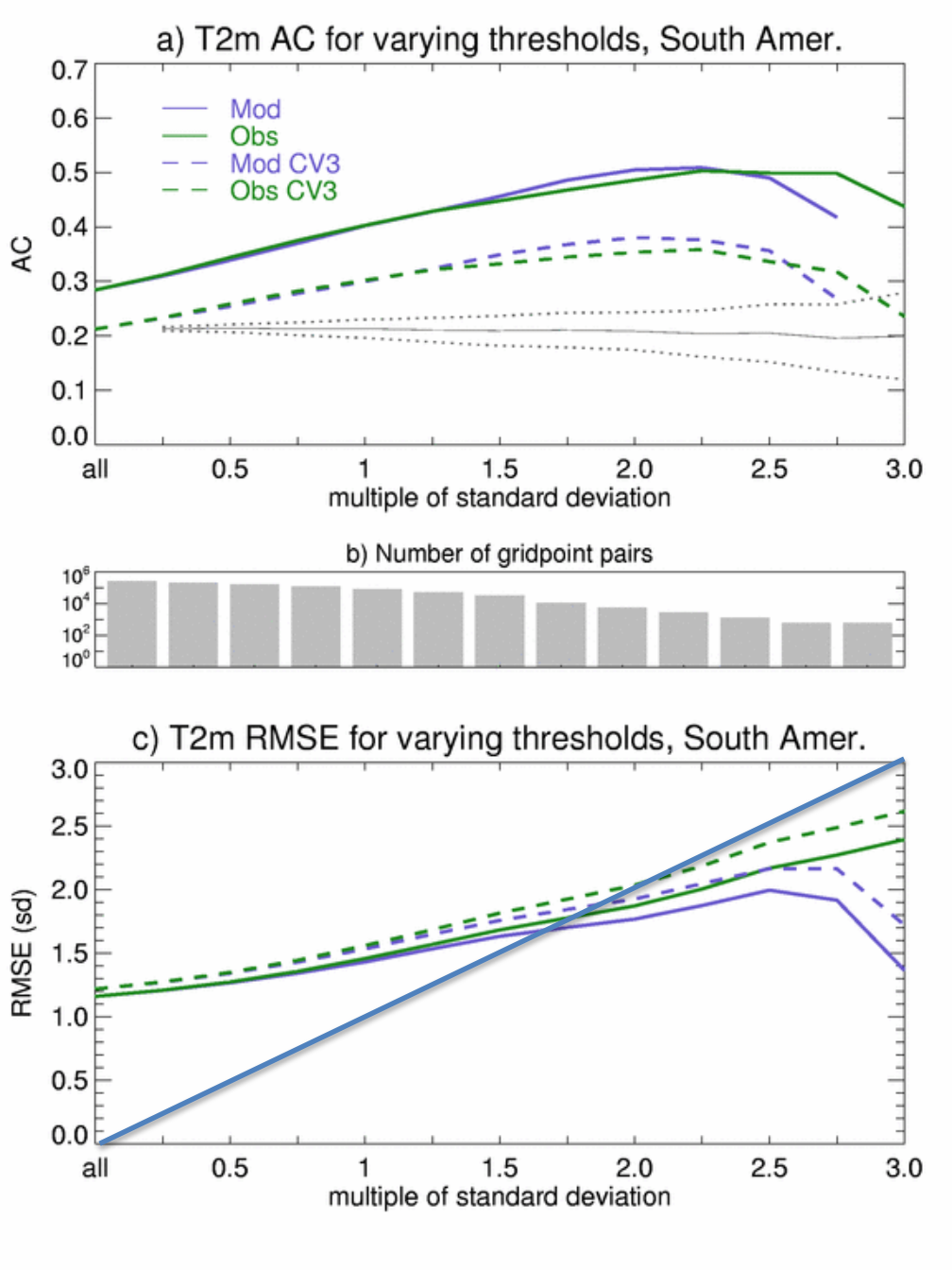
Tmp2m: North Amer.

- Sliding scale ranging from “all cases” included to 3.0xSD.
- “Mod” = skill assessed for cases where an extreme was forecast
- “Obs” = skill when an extreme was observed
- Permutation tests of 1,000 random subsets



Tmp2m: South Amer.

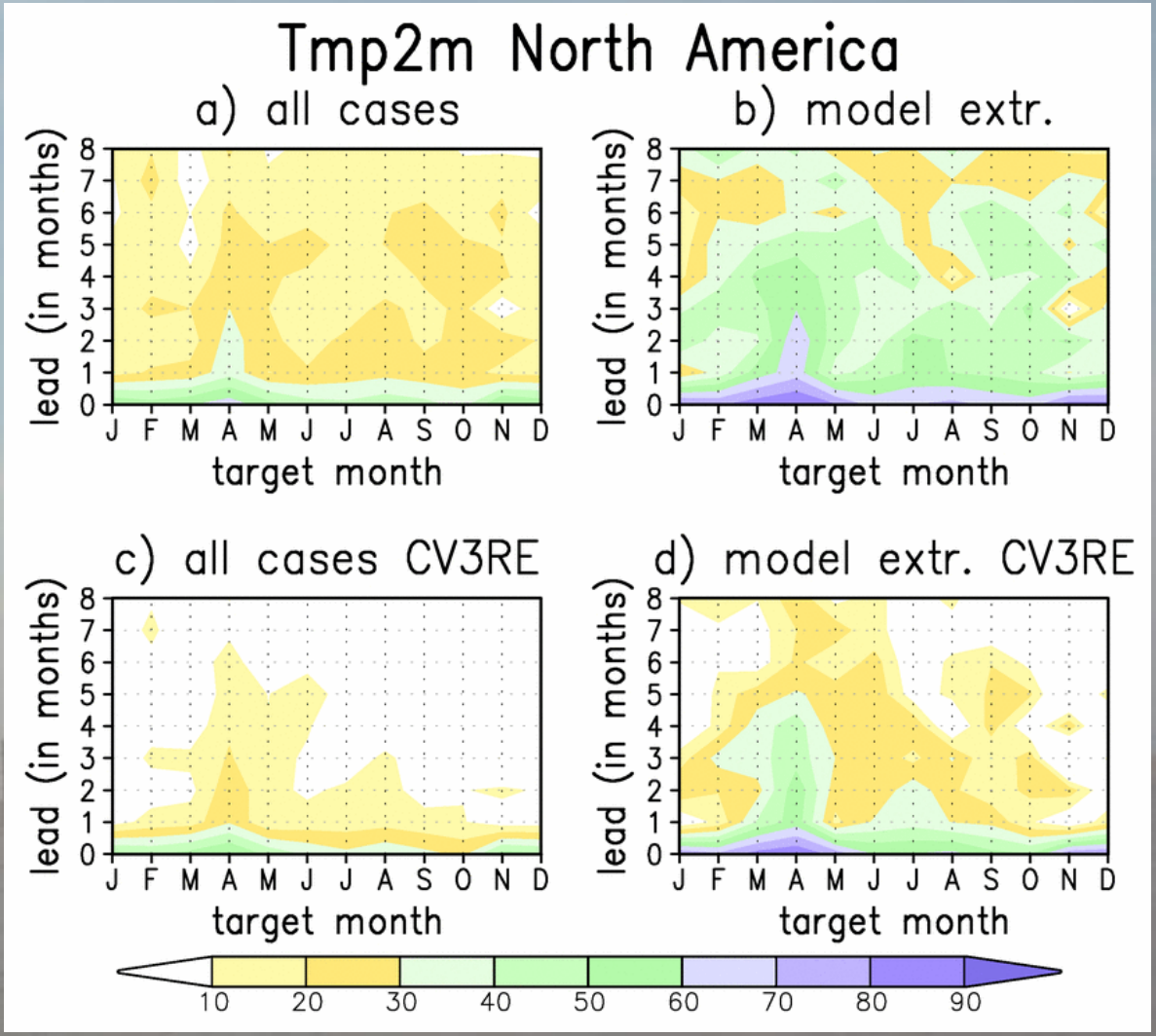
T2m skill is higher in South America than North America



Tmp2m: North Amer.

- Skill is often a function more of target than lead

- STCE defined here by +/- 1.645 std. dev. threshold



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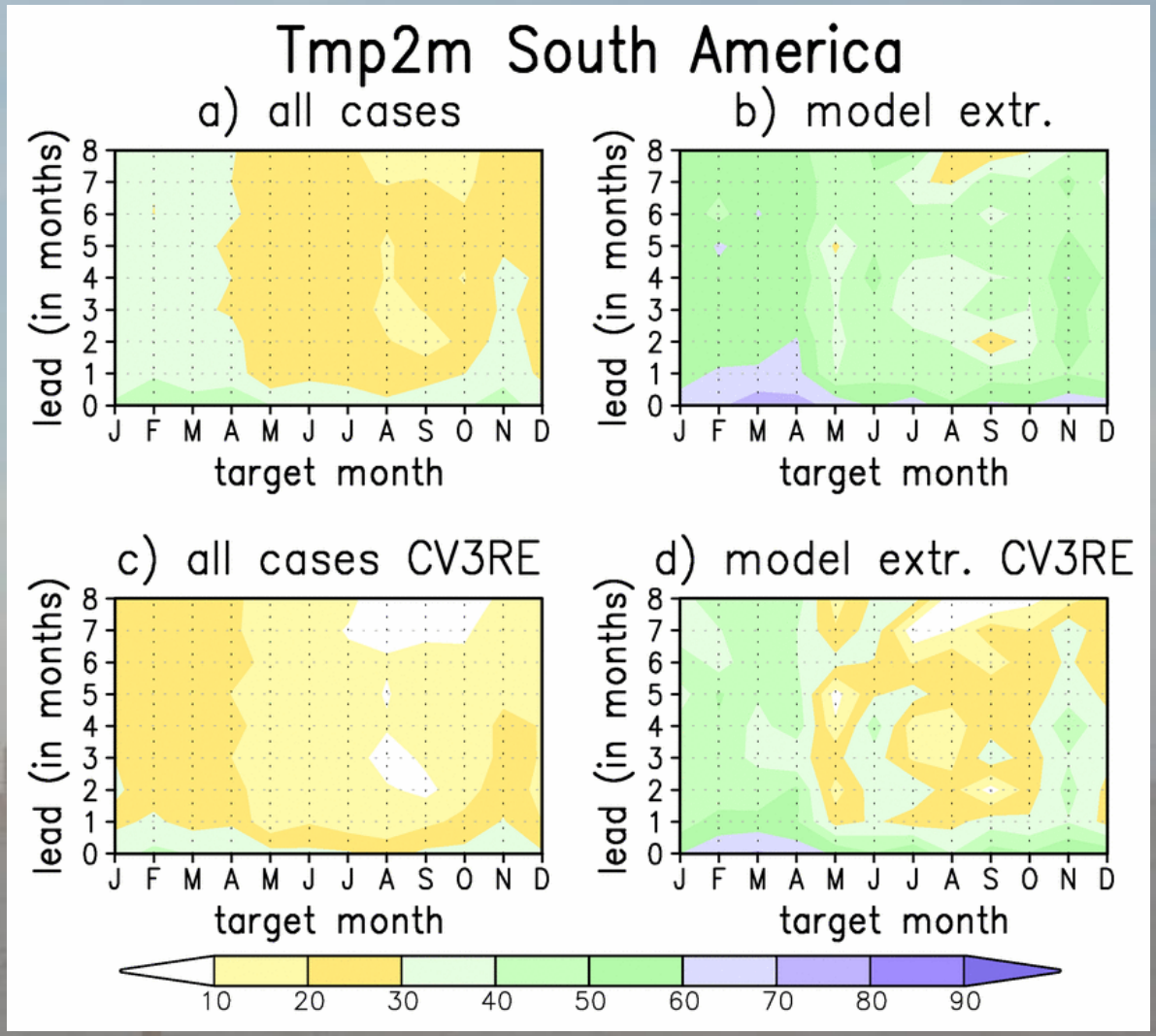
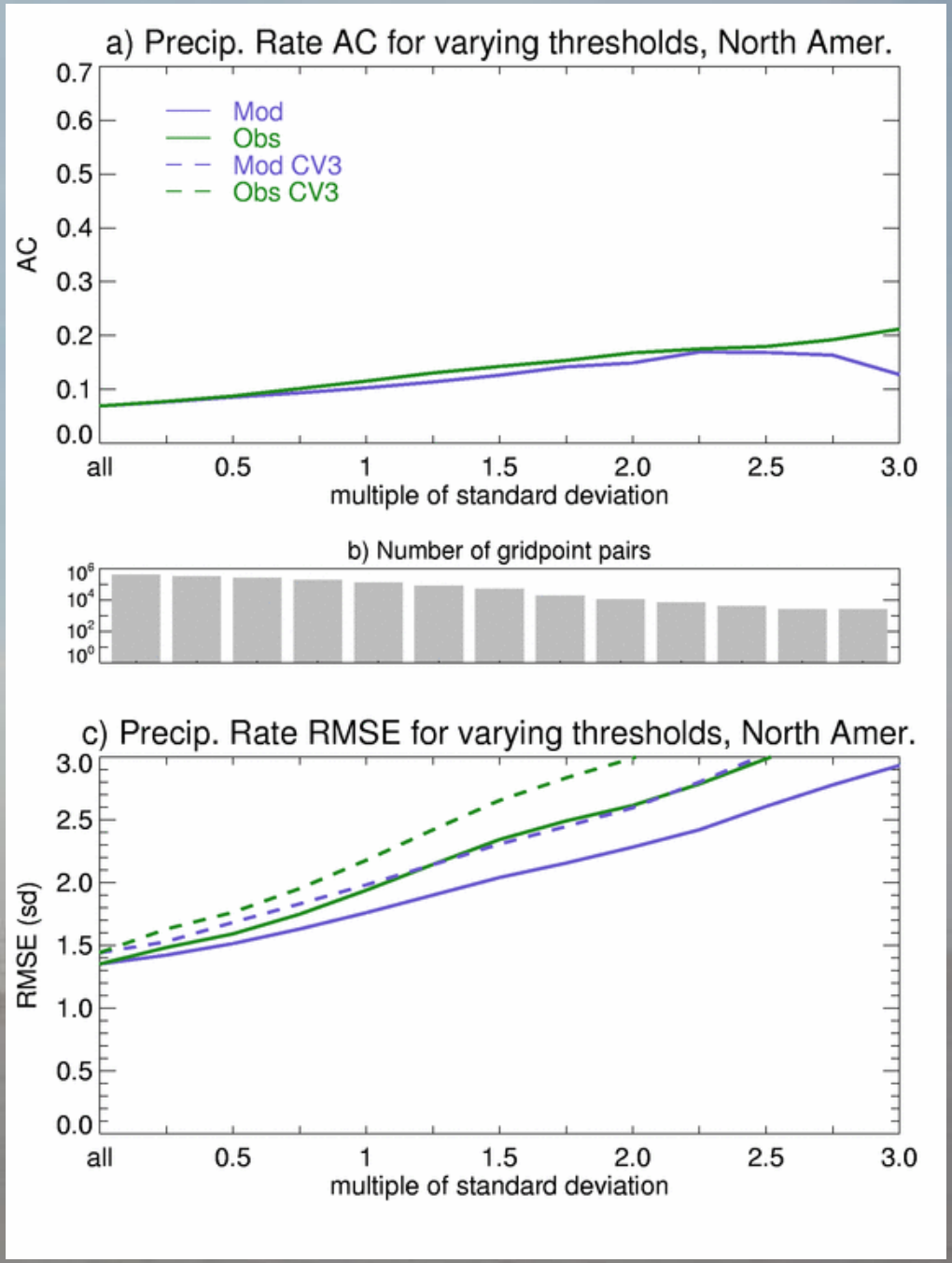
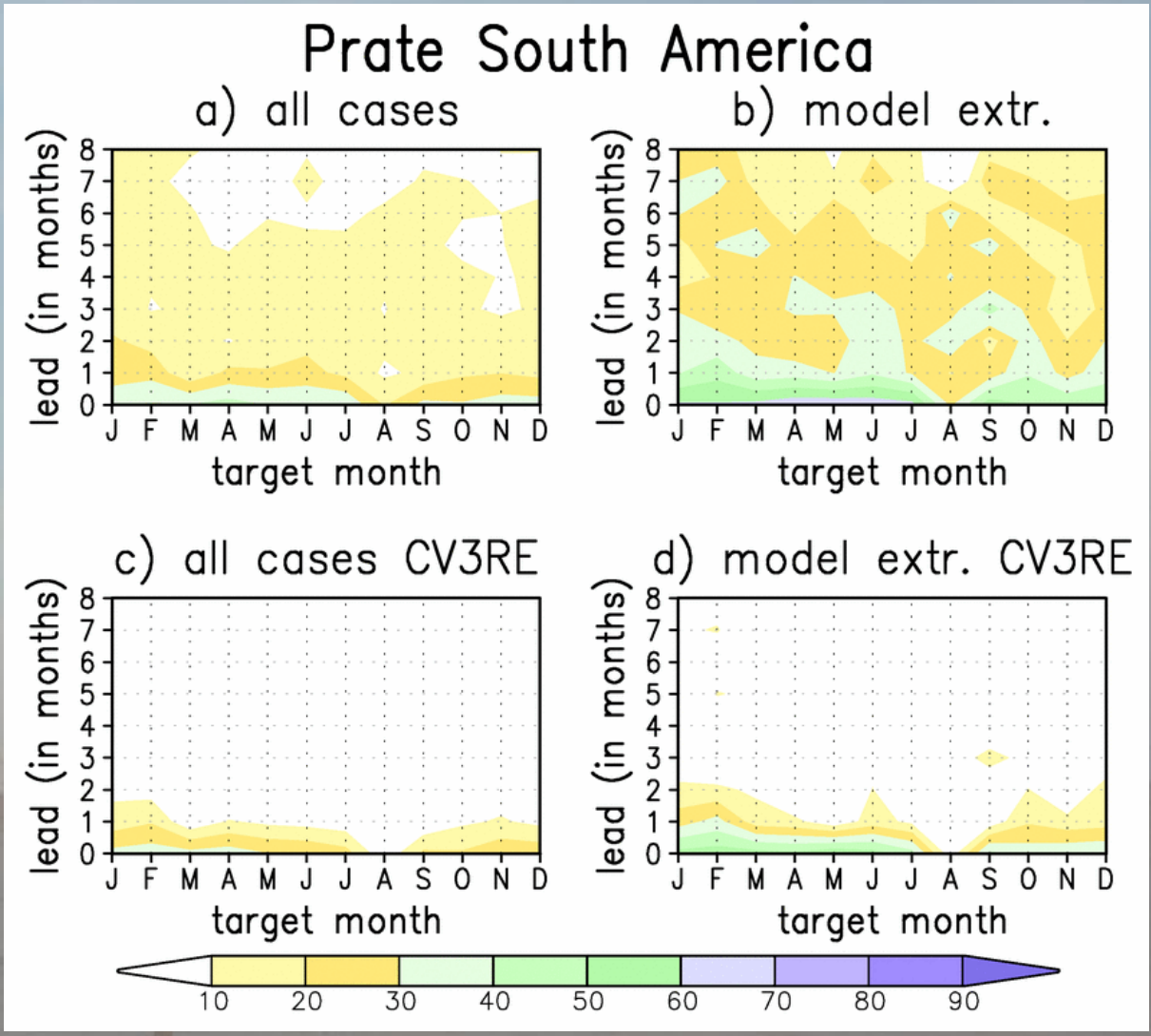


Prate: NA

- Precipitation is very difficult to forecast!
- Cross-validation affects lower scores the most, and leaves us with near-zero scores for precipitation rate

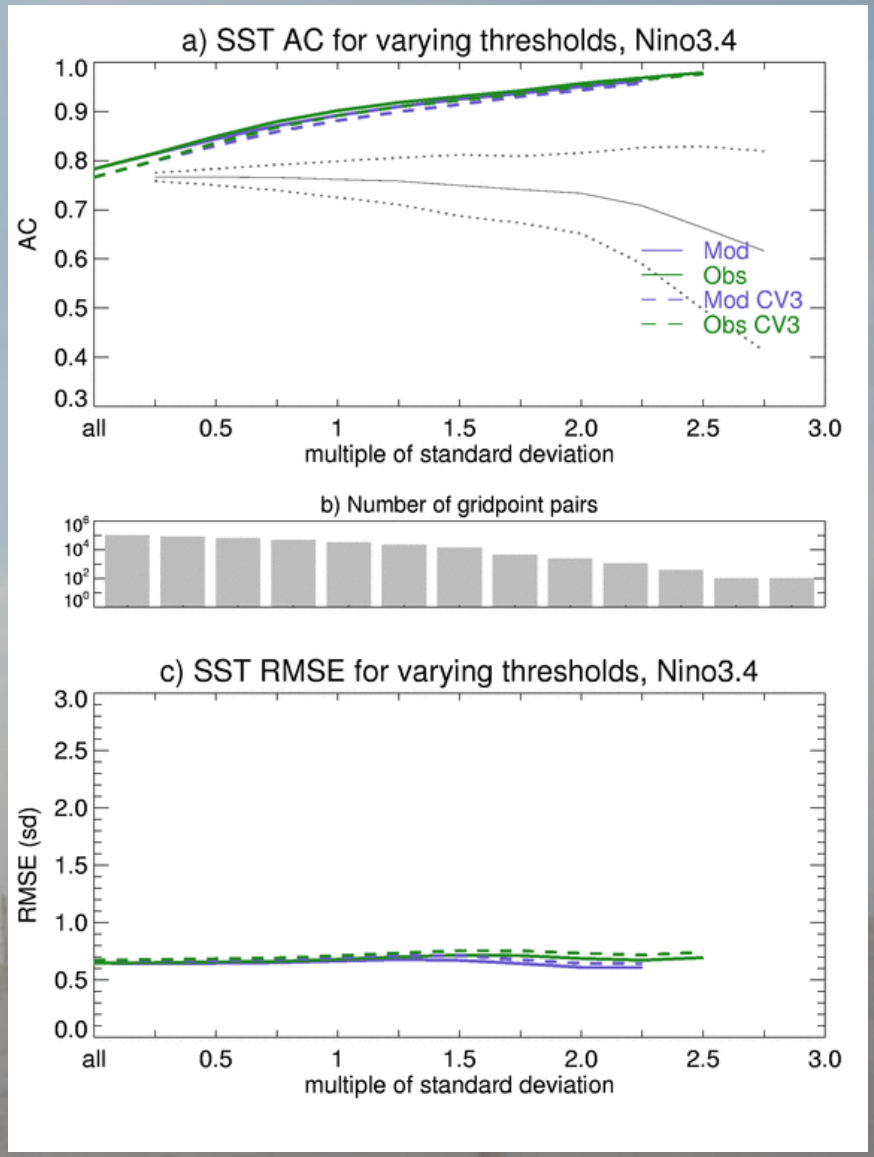


Precipitation rate: South Amer.



SST: Niño3.4 Region

- Higher skill scores are not noticeably reduced by CV
- RMSE is essentially flat with increase in threshold defining extreme



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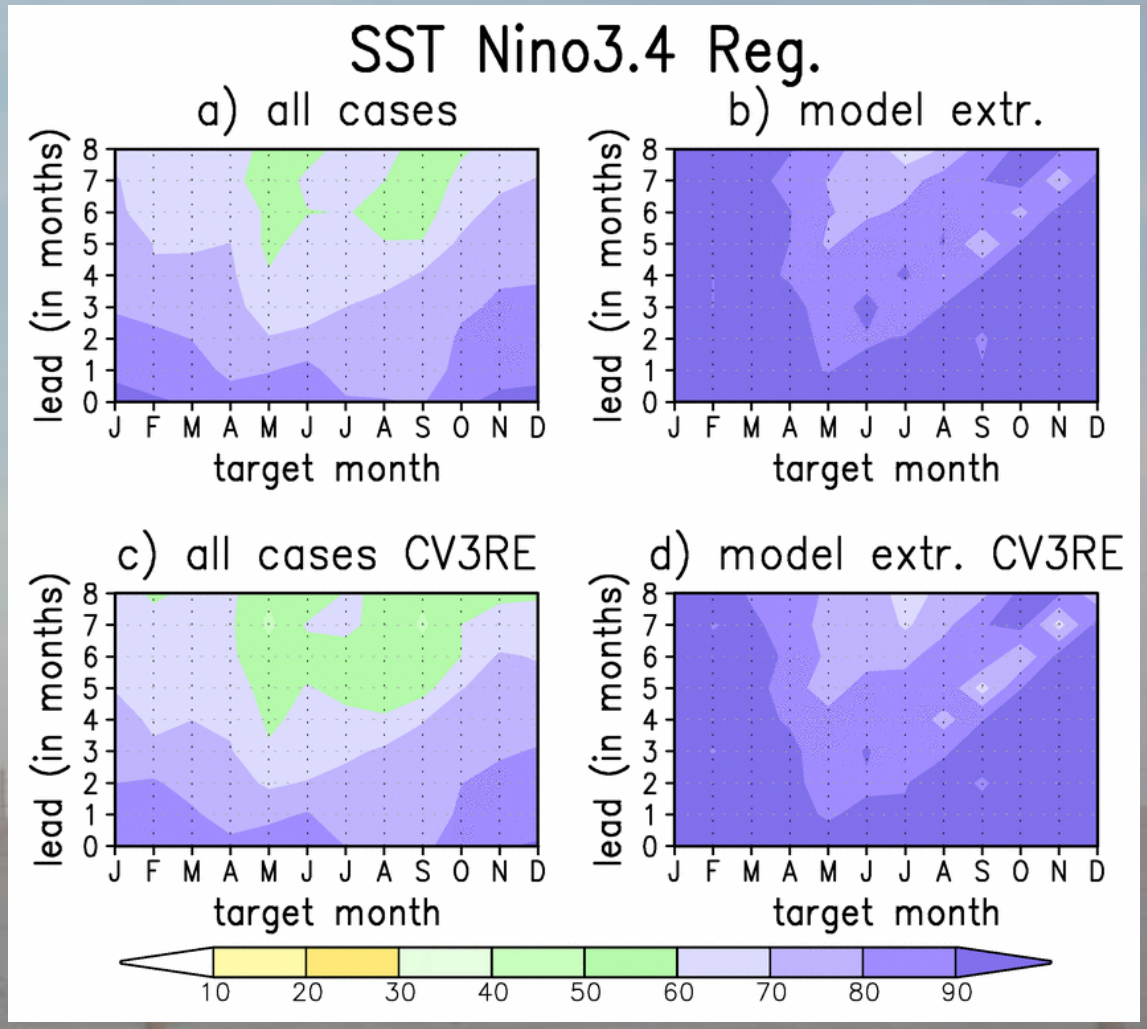
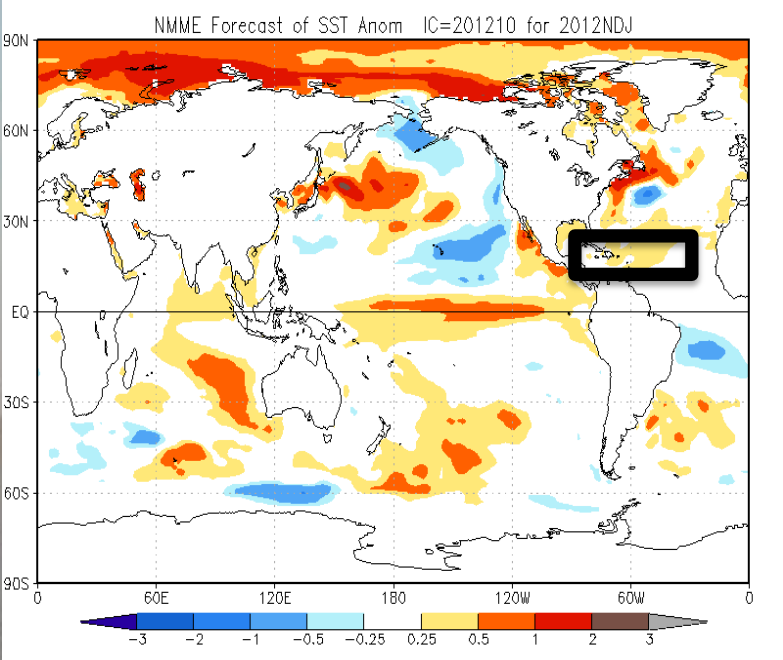
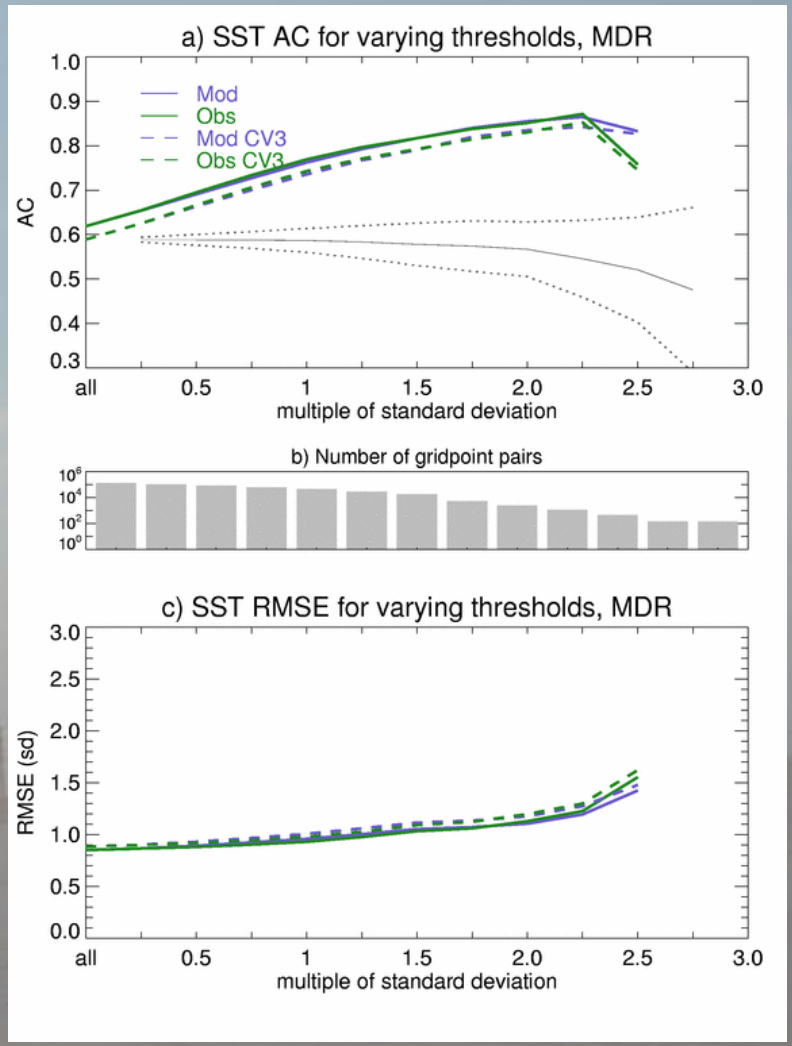


SST: Atlantic hurricane dev. region

SSTs in this region are important for hurricane forecasting





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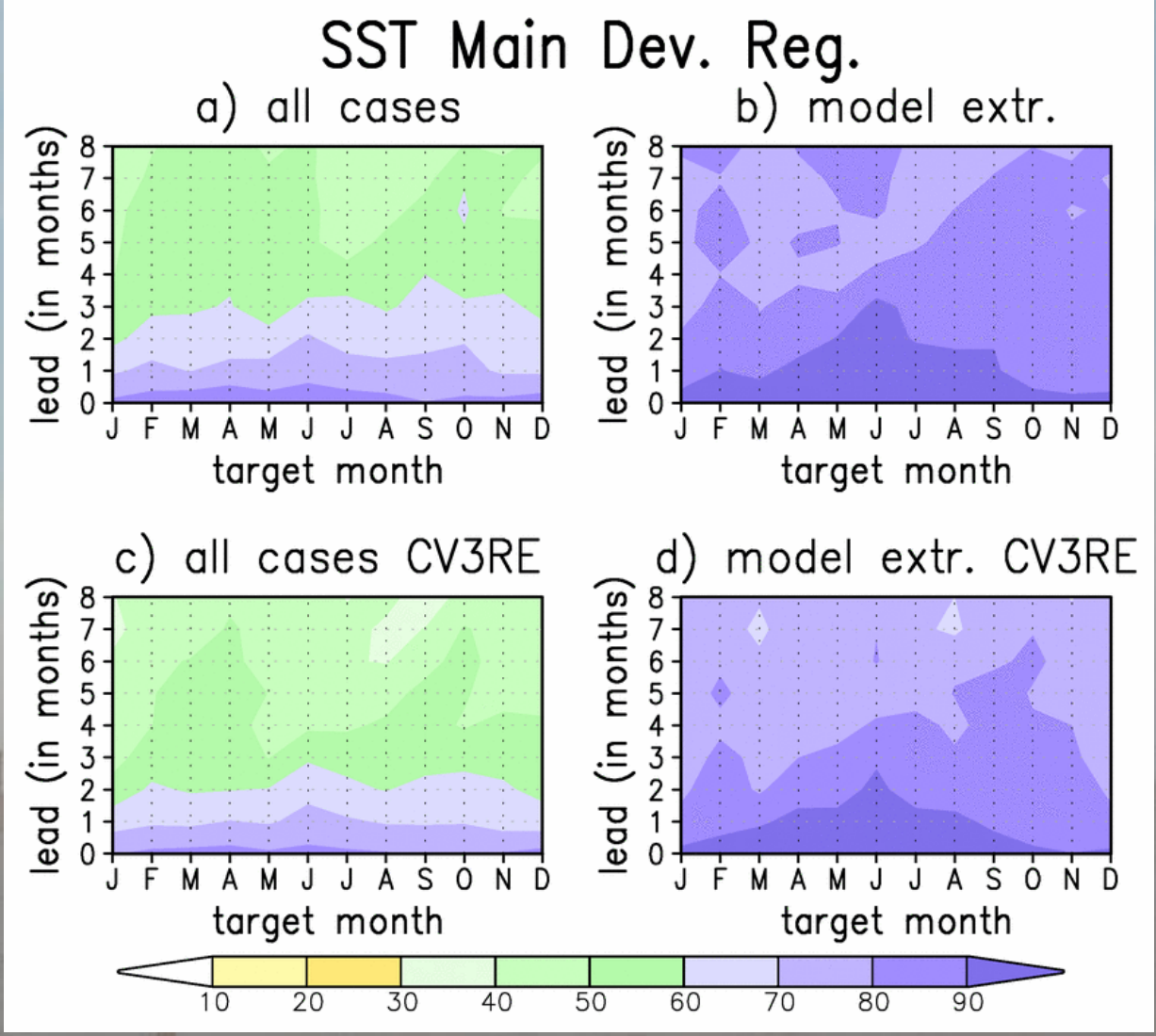
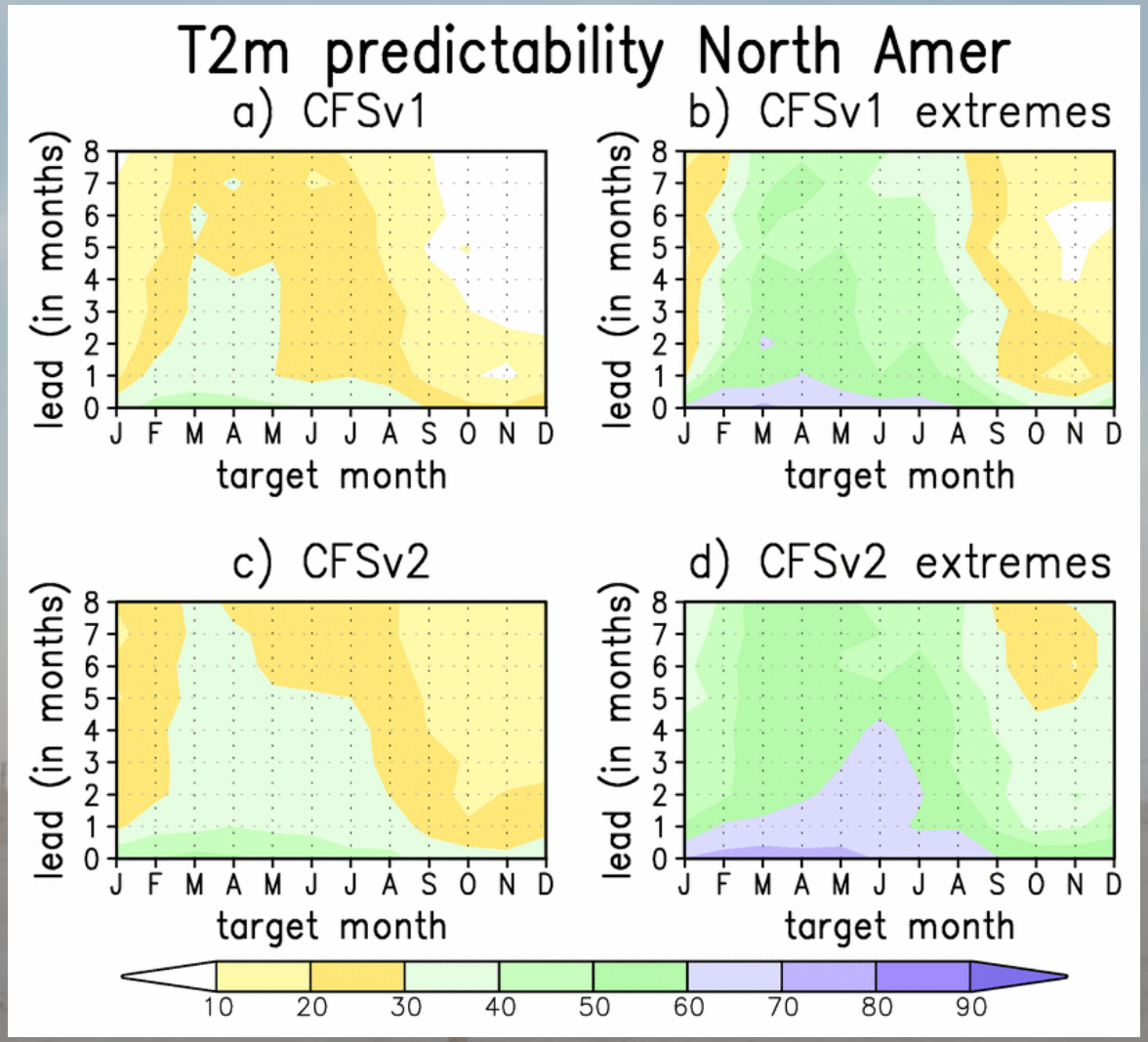
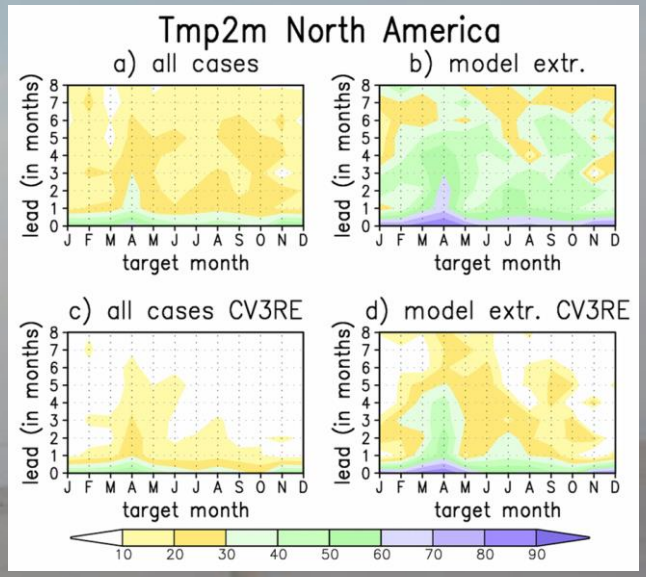


Potential predictability

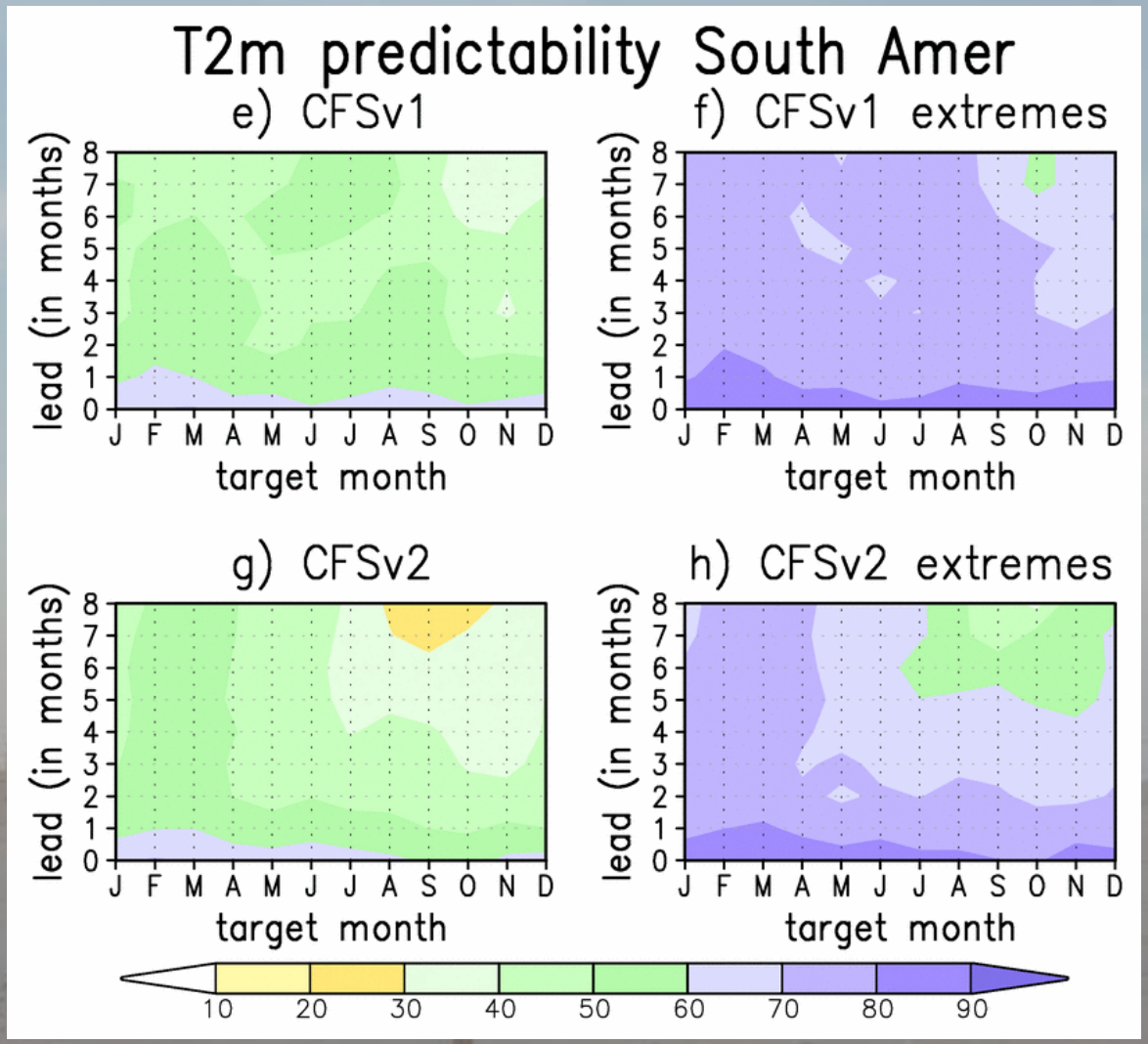
- Test how well the model predicts itself, under “perfect model” assumption.
- Take one member from the ensemble of N members, verify “prediction” of ensemble mean of N-1 members against this member
- Employ both CFSv1 and CFSv2, as (ideally) the predictability should not depend on the model.

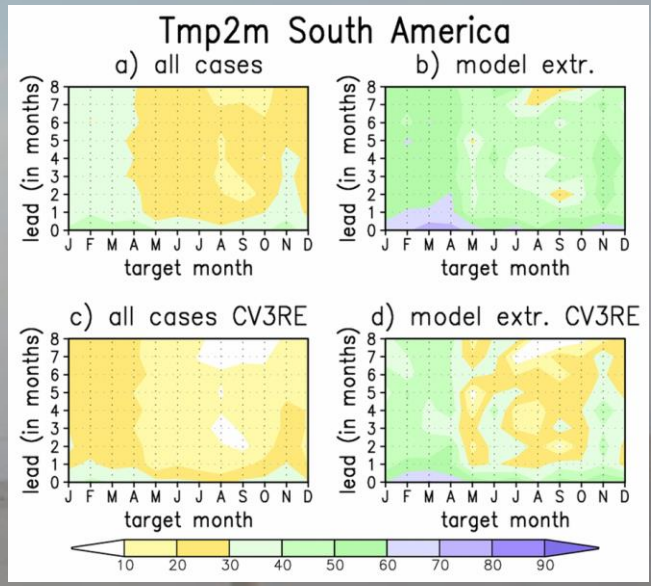
Tmp2m predictability, North Amer.



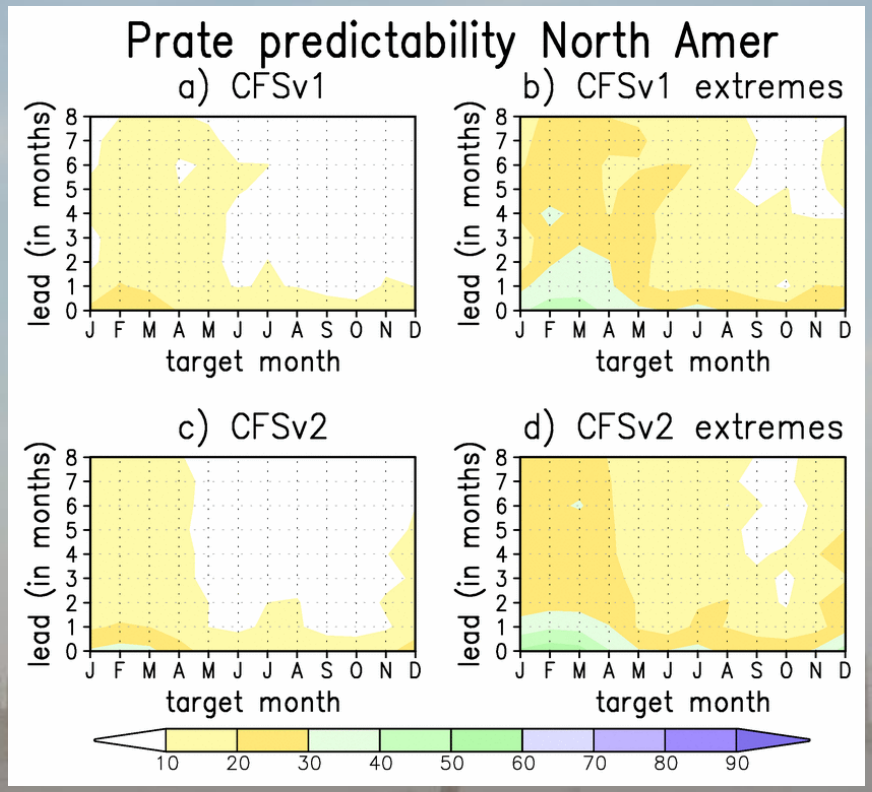


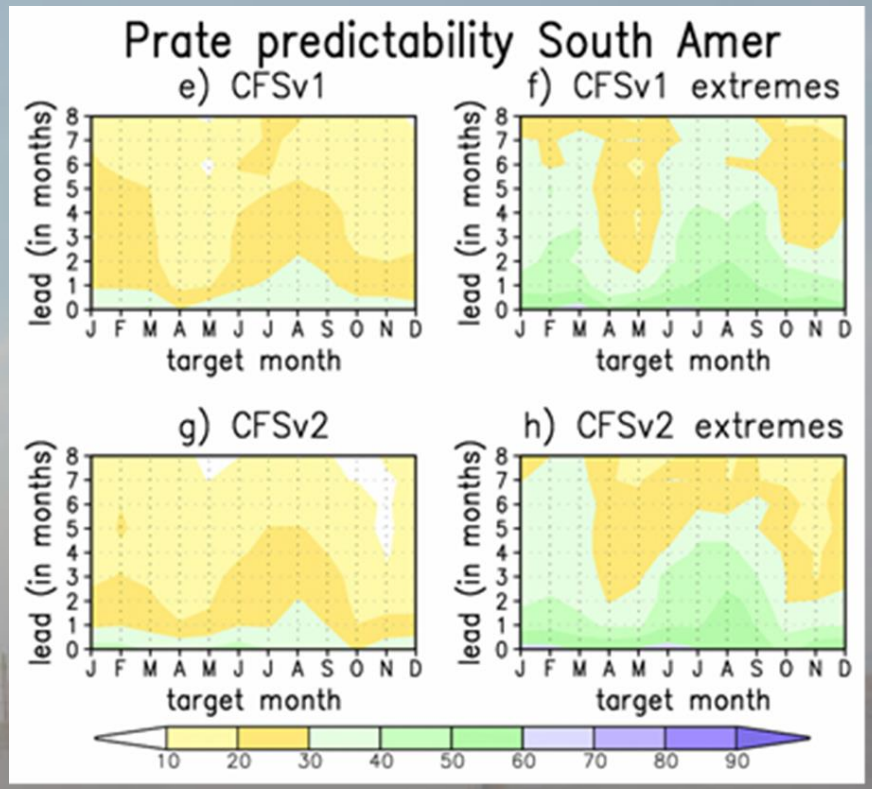
Tmp2m predictability, South Amer.



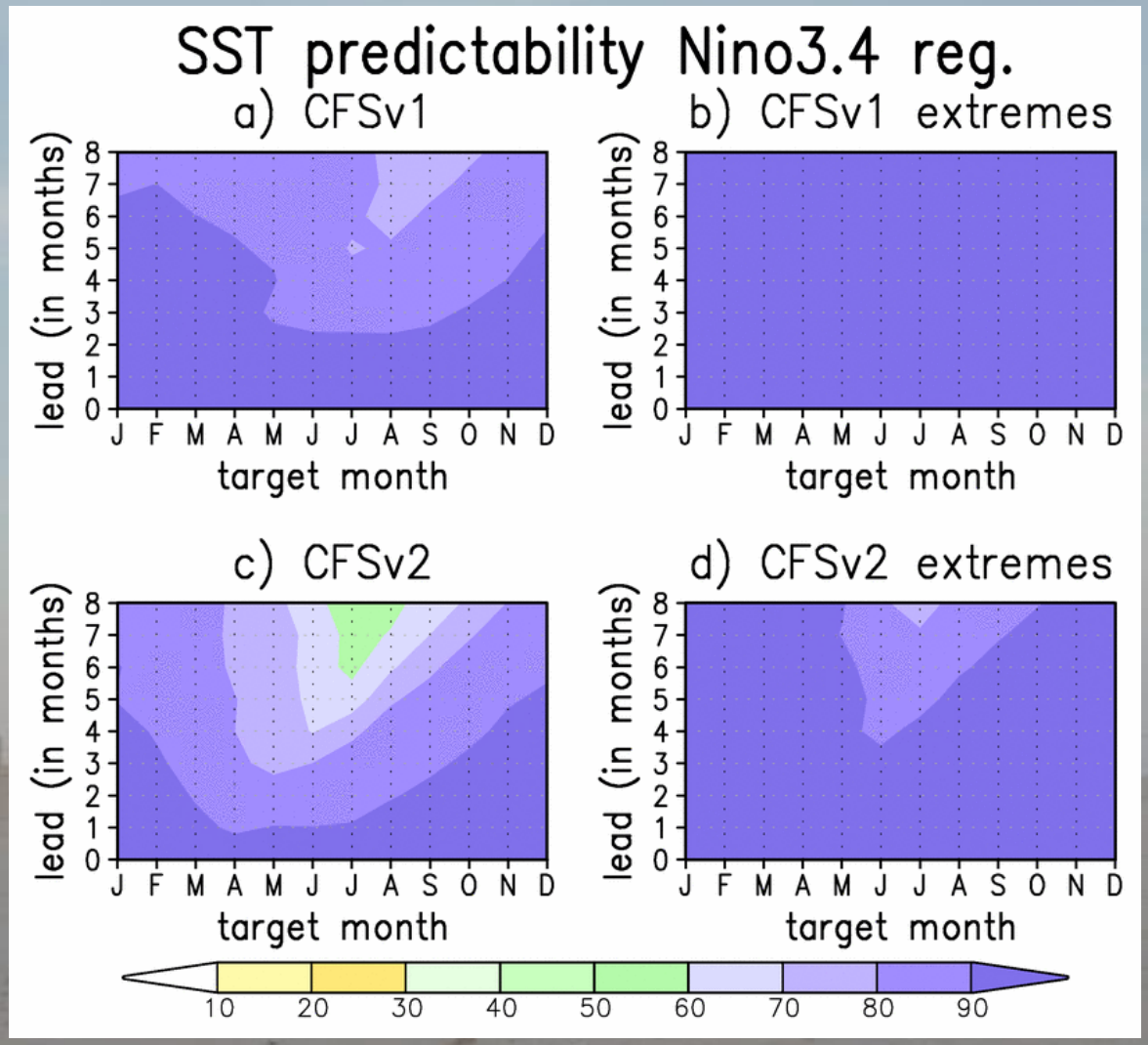


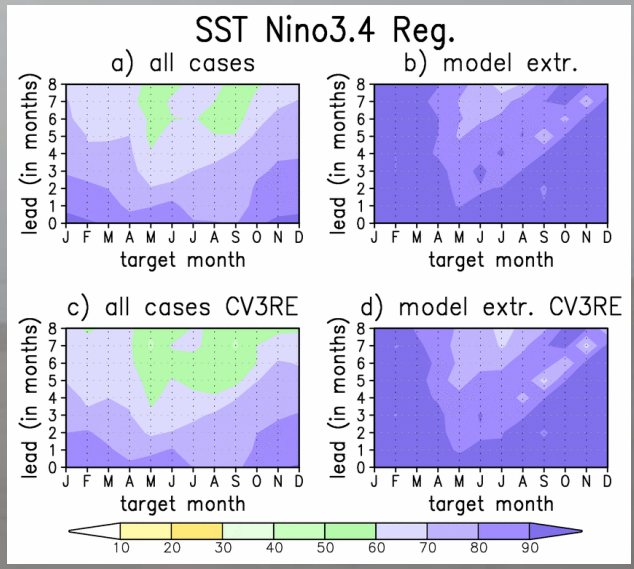
Potential predictability: precip rate



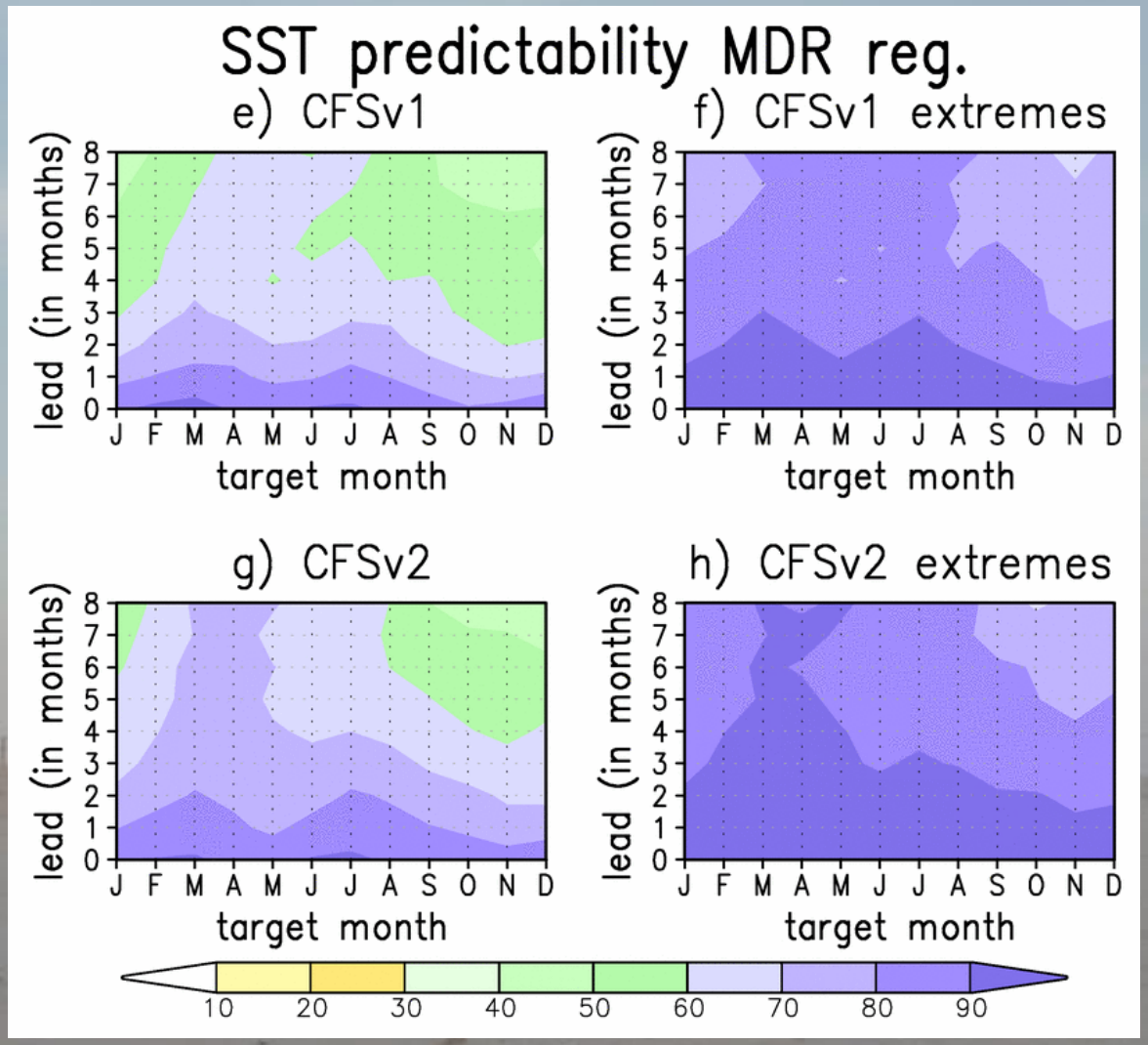


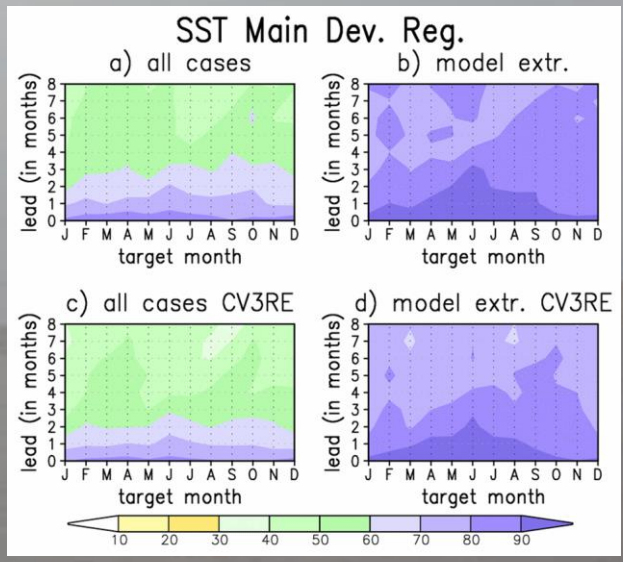
Potential predictability: SST in Niño3.4





Potential predictability: SST in MDR





Summary (1/2)

- Assessed model forecast skill of short-term climate extremes (STCE) in 2 m temperature, precipitation rate, and sea surface temperature using CFSv2, 1982-2010.
- Anomaly correlations for STCEs are routinely higher than for “all cases”.
- RMSE, which can be considered as noise in a signal-to-noise ratio such as the AC, grows more slowly than the threshold: the signal grows despite increased noise.

Summary (2/2)

- Cross-validation leads to lower ACs. ACs that are already low are affected the most: precipitation ACs are reduced to near zero, while SST ACs are largely unaffected.
- Highest potential predictability for T2m in the first half of the year (both So. and No. Amer.)
- Target months with higher predictability tend to have higher forecast skill, but forecast skill is generally lower than its potential.

References

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