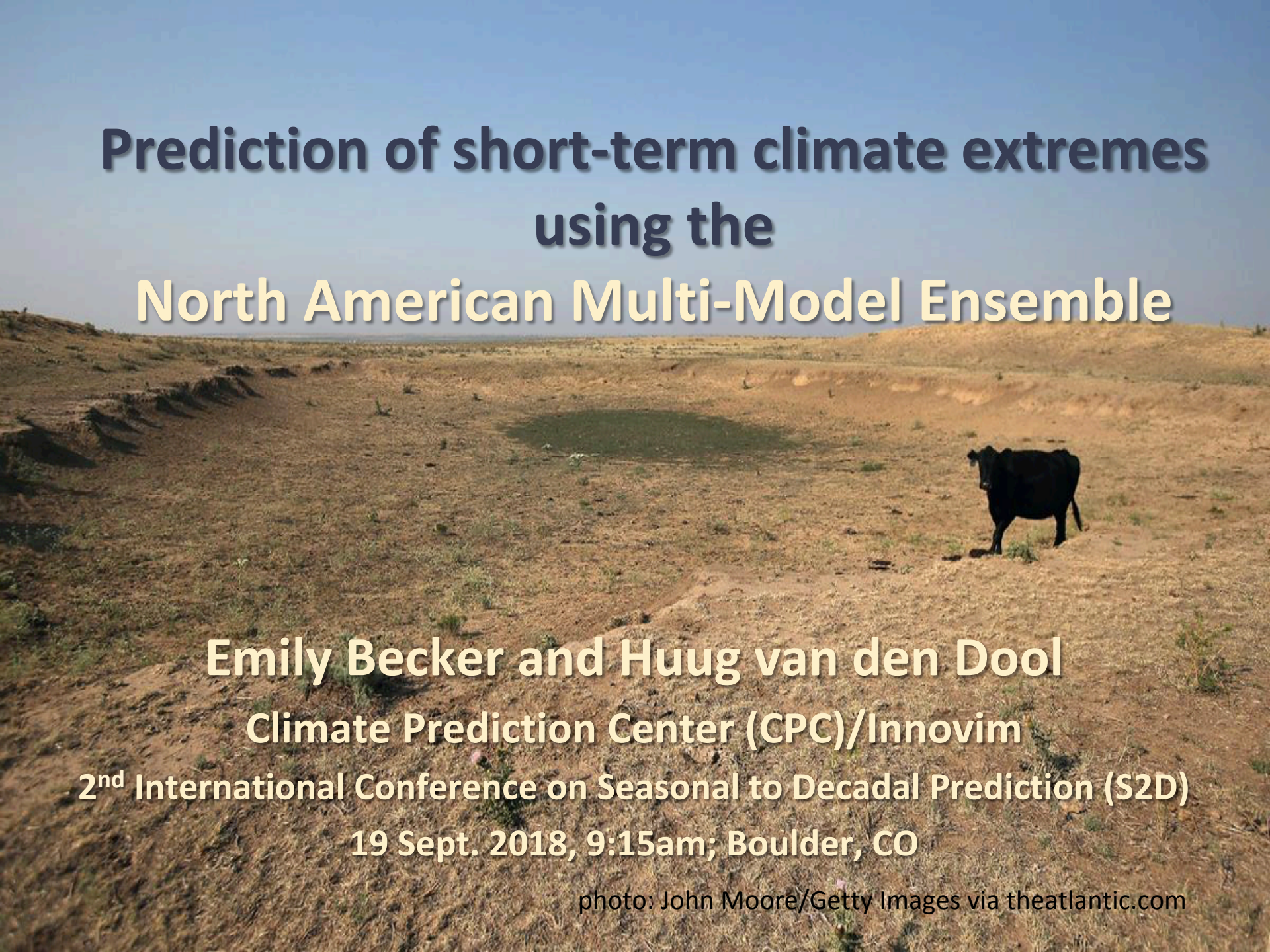
Prediction of short-term climate extremes using the North American Multi-Model Ensemble



Emily Becker and Huug van den Dool

Climate Prediction Center (CPC)/Innovim

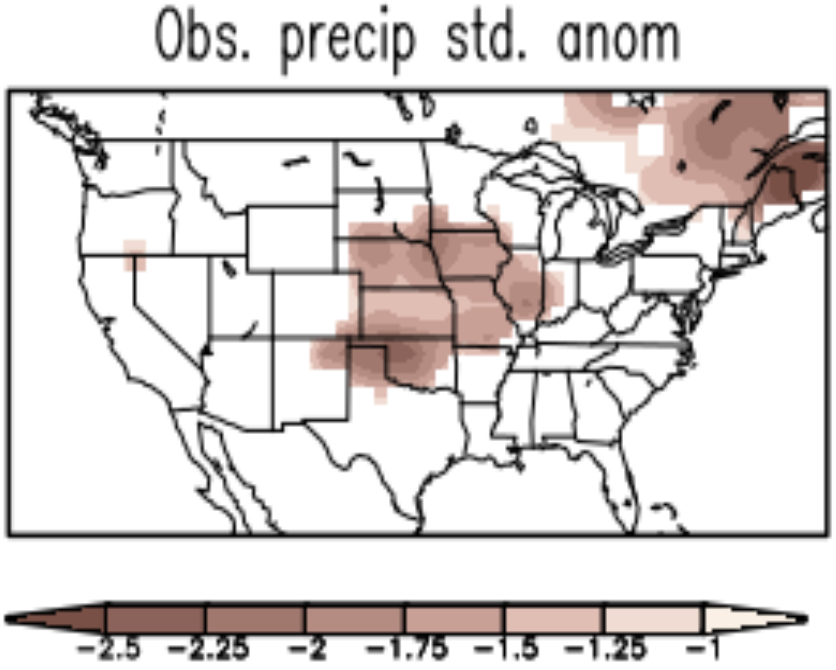
2nd International Conference on Seasonal to Decadal Prediction (S2D)

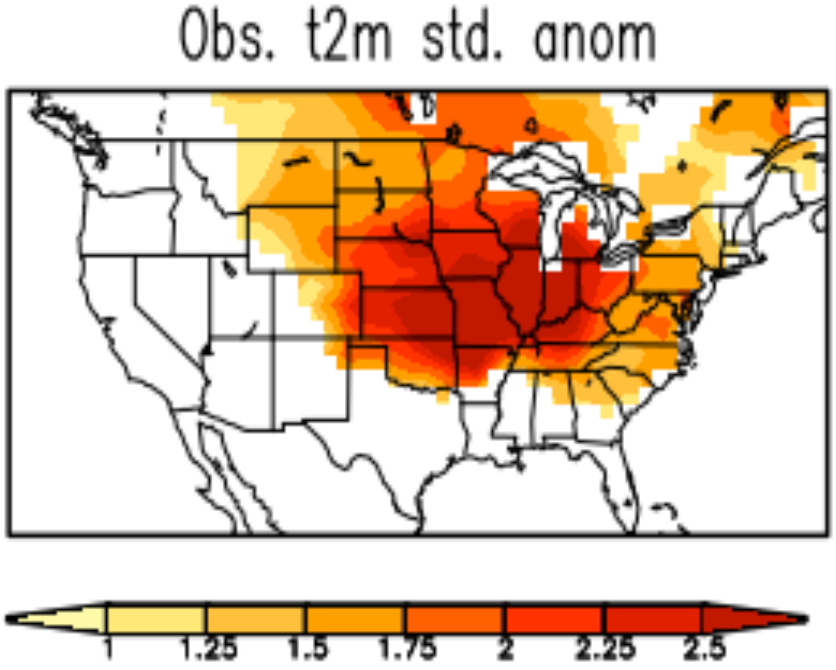
19 Sept. 2018, 9:15am; Boulder, CO

photo: John Moore/Getty Images via theatlantic.com

Early warning systems for climate extremes

July 2012: extreme heat and drought in Midwest caused "flash drought"





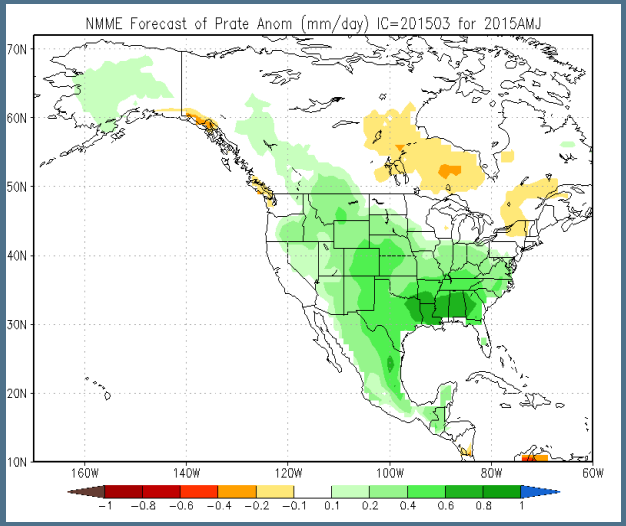
What skill do multi-model forecasts of seasonal extremes have?

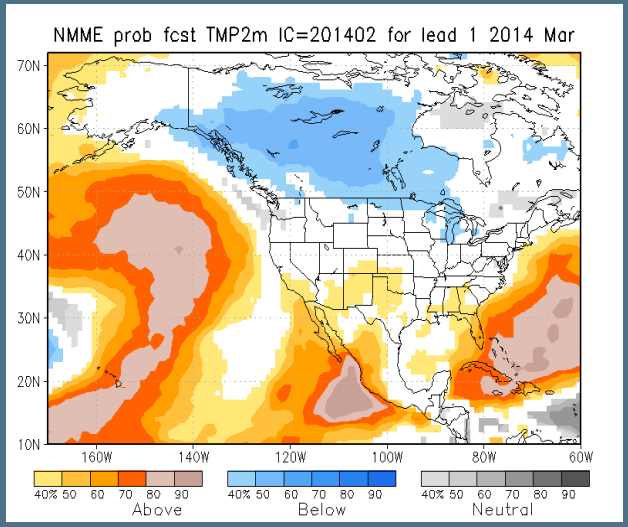
- Precipitation and temperature
- Decile (top 10% of historical record) determined by fitting Gaussian distribution to observations and forecasts from 1982-2017 at each gridpoint
- $+/-1.282\sigma = 90^{th}/10^{th}$ percentiles
- Both high and low extremes
- Forecast verification: there was a forecast for an extreme. Did it come true?
- Deterministic (forecast for a specific anomaly) and probabilistic (probability that the outcome will fall above/below a certain threshold)

NMME

The North American Multi-Model Ensemble

- NMME (North American Multi-Model Ensemble) is an unprecedented MME system intended to improve intra-seasonal to interannual (ISI) operational predictions through integration of leading US and Canadian climate models.
- Seasonal forecasting guidance available monthly, following CPC operational schedule since Aug. 2011.
- All participating models strictly follow the same protocol.
- All data (hindcast and forecast) is archived and available to the public.





http://www.cpc.ncep.noaa.gov/products/NMME

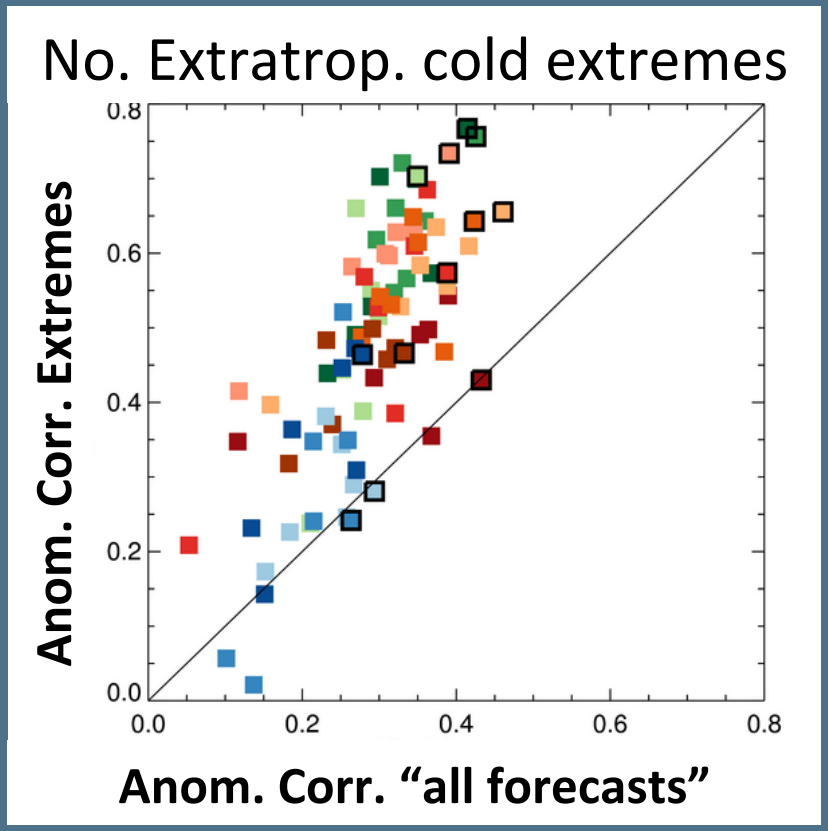
Assessment of deterministic forecasts: forecasts for a specific anomaly

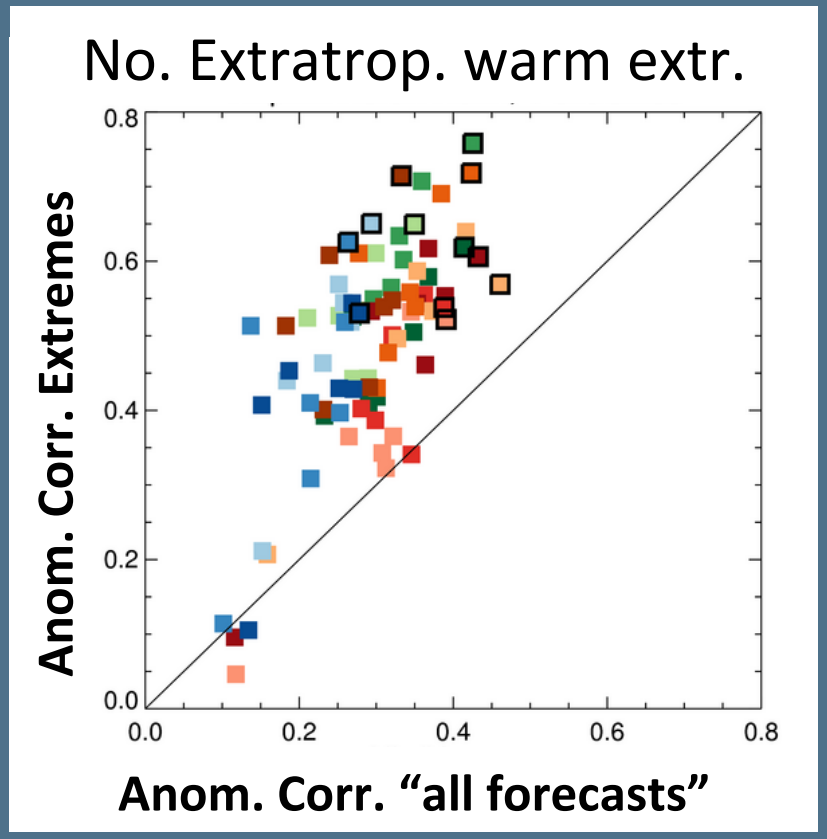
- 7-model multi-model ensemble mean with equal weights per model
- Corrected for bias in the mean using cross-validated 1982-2017 forecasts
- Deterministic skill metrics:
  - Anomaly correlation
  - Symmetric Extremal Dependence Index (SEDI)
    - Based on contingency table
    - Non-degenerate for rare events
    - Normalizes hit rate using false alarm rate

	Obs Y	Obs N
Fcst Y	a	b
Fcst N	c	d

photo: John Moore/Getty Images via theatlantic.com

Forecasts for extremes have higher anomaly correlation than forecasts for “all events”





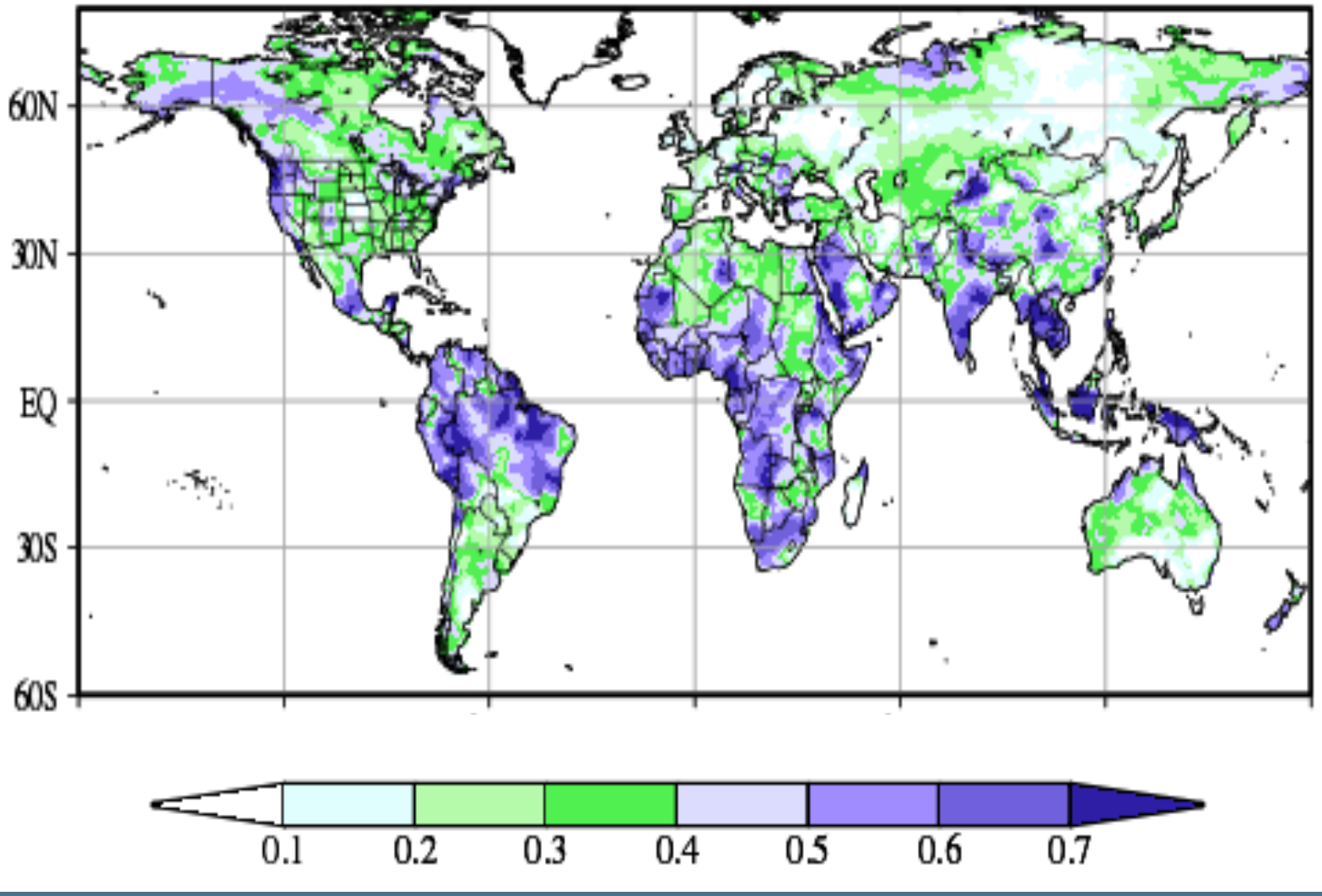
- Each square is one model, one season, area-aggreg
- Black outline squares are multi-model ens.

- Colors indicate season
- ”extremes” = subsample; “all fcsts” = entire sample

Becker et al. 2013; Becker, E. 2017

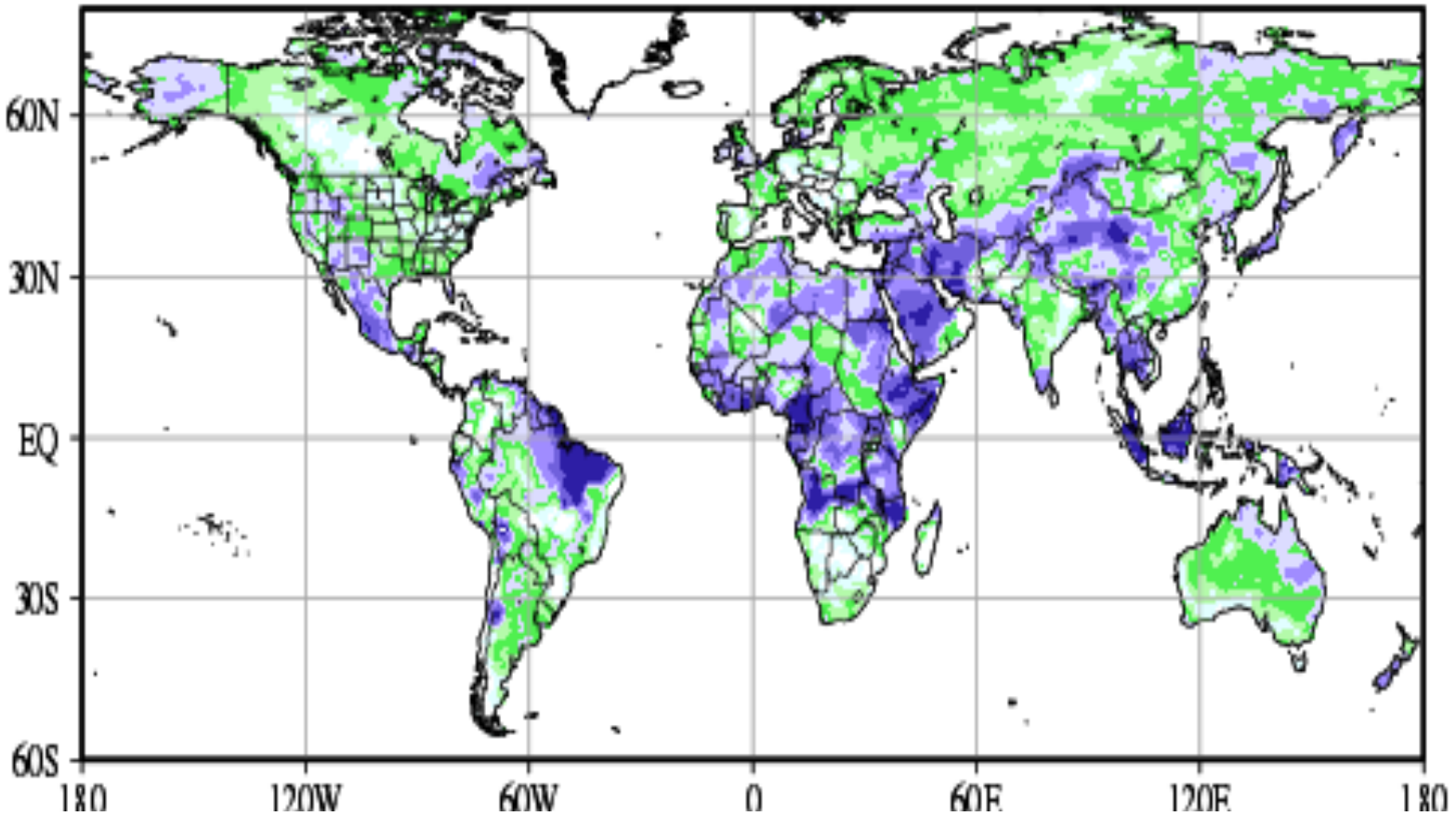
SEDI 2m temperature warm extremes

A) 1-month lead 12-seas aggregate



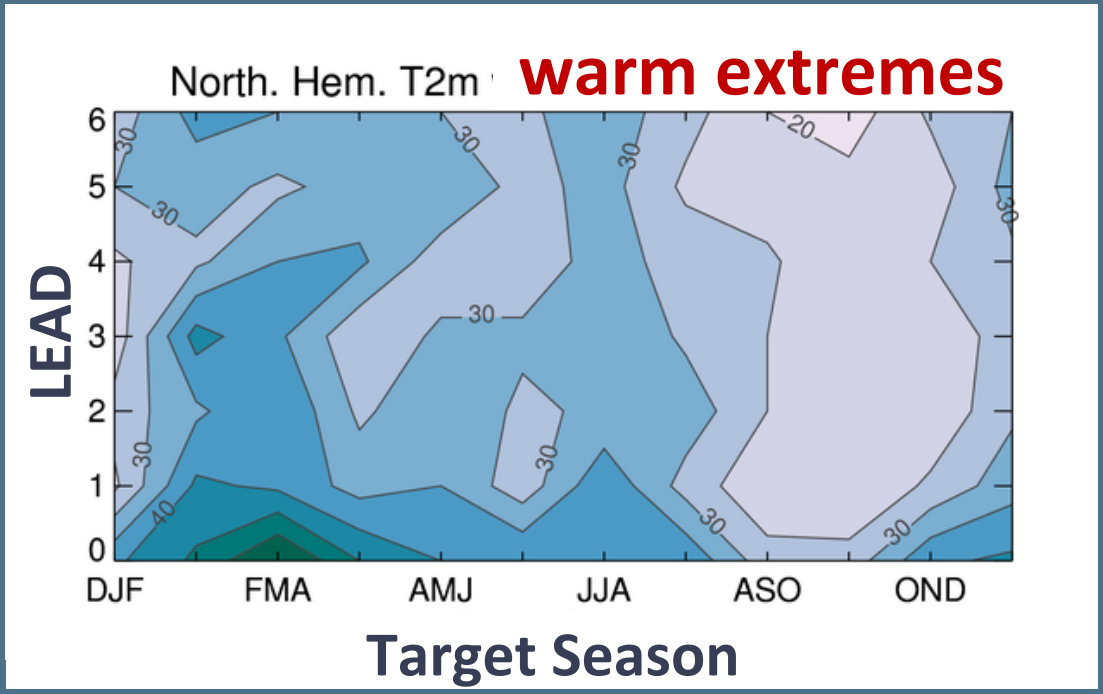
SEDI 2m temperature cool extremes

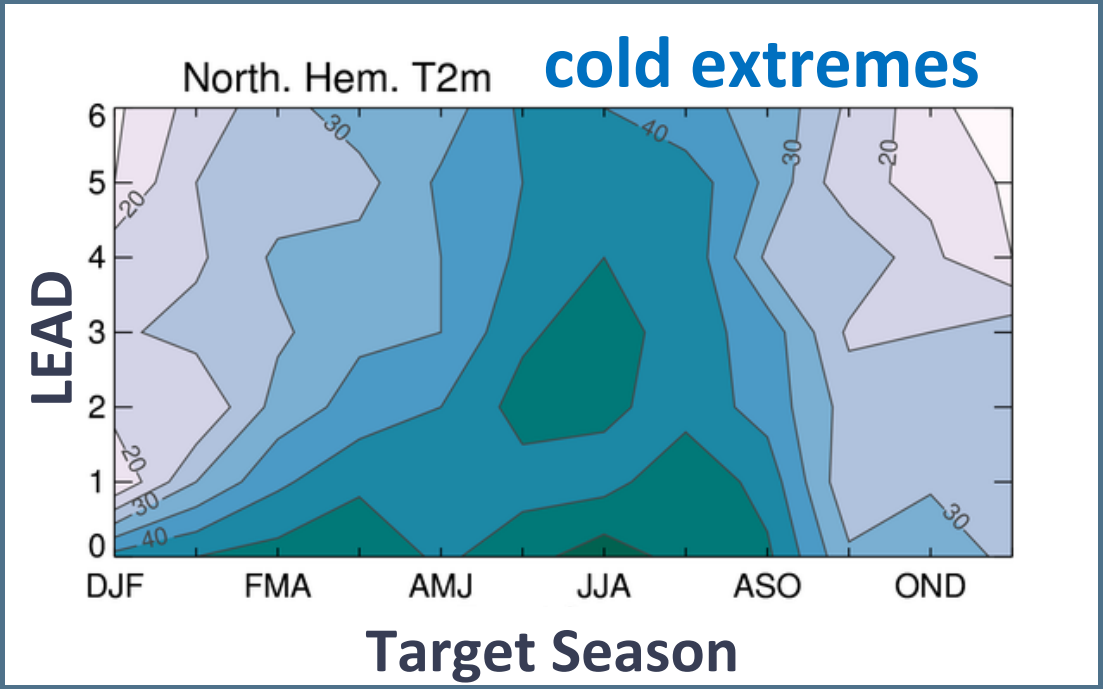
A) 1-month lead 12-seas aggregate



Northern extratropics T2m extremes

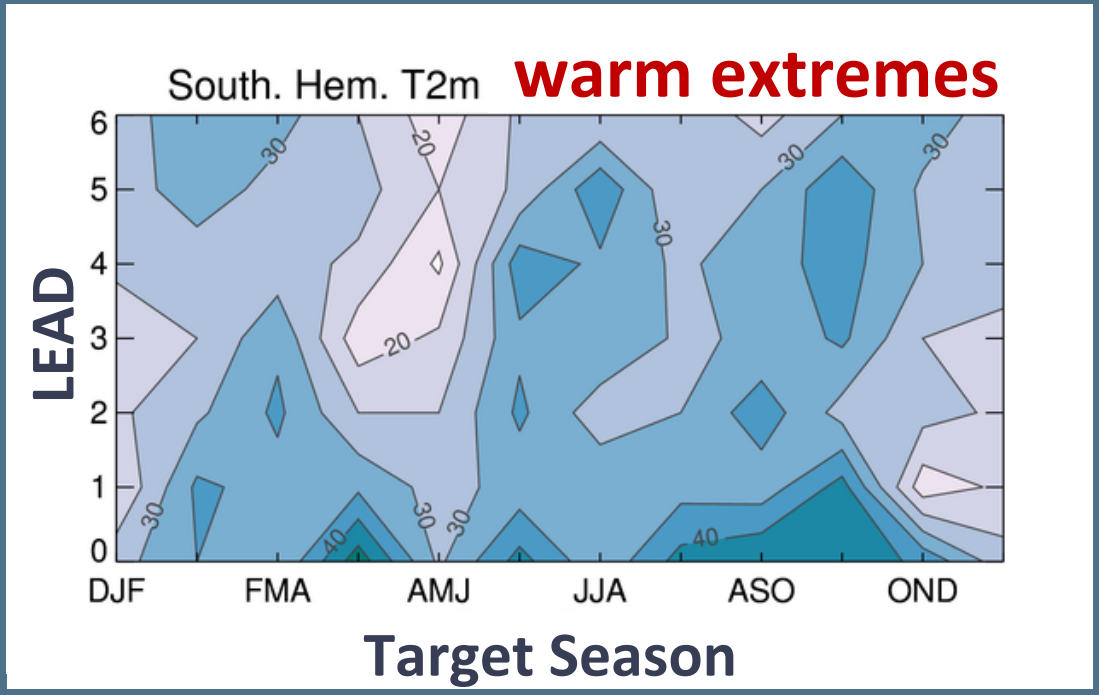
- SEDI*100
- area-aggregated over all land grid points 23N-75N
- “extremes” are top and bottom 10%ile
- Seasonal dependence very different between positive and negative extremes
- “cold” extremes during summer—the extremely nice?

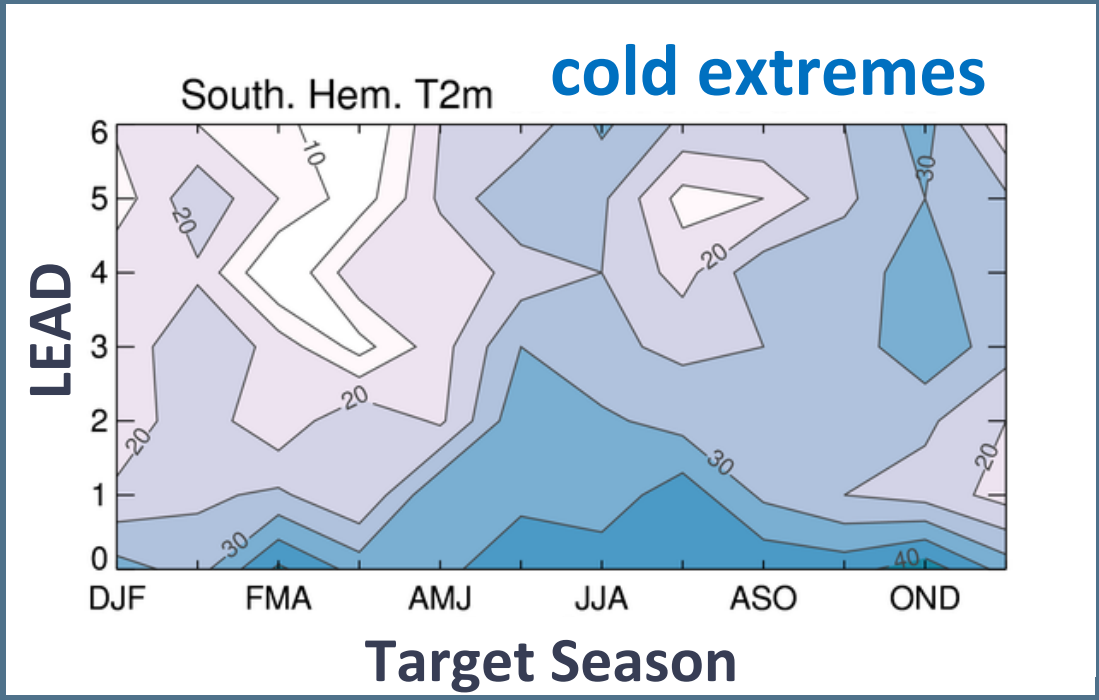




Southern extratropics T2m extremes

- SEDI*100
- area-aggregated over all land grid points 75S-23S
- Warm extremes during winter/ spring
- Lower skill for cold extremes after lead-1

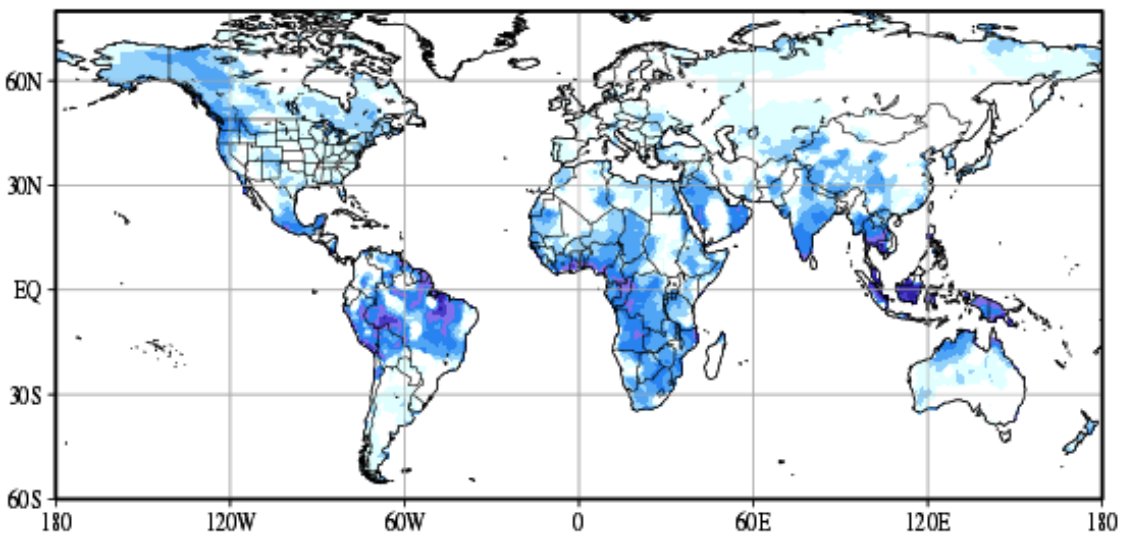


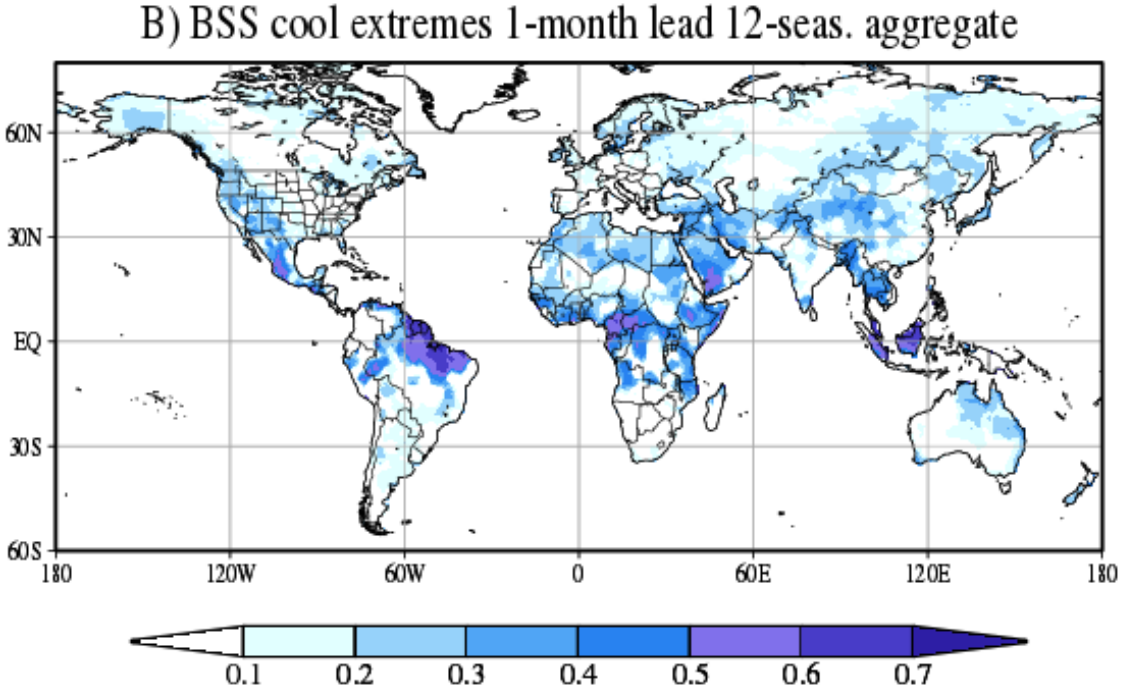


Assessment of probabilistic forecasts: probability that outcome will fall into upper/lower decile

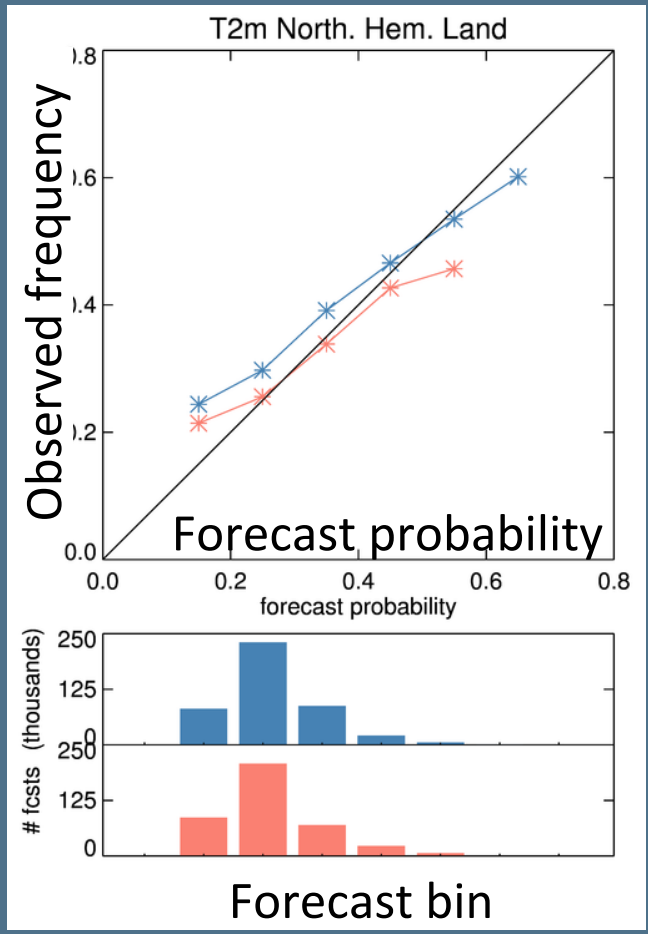
- Simple “count” forecast construction
- Corrected for bias in the mean and variance using cross-validated 1982-2017 forecasts
- Probabilistic skill metric and forecast quality assessment:
  - Brier skill score (BSS)
  - Reliability diagram

photo: John Moore/Getty Images via theatlantic.com

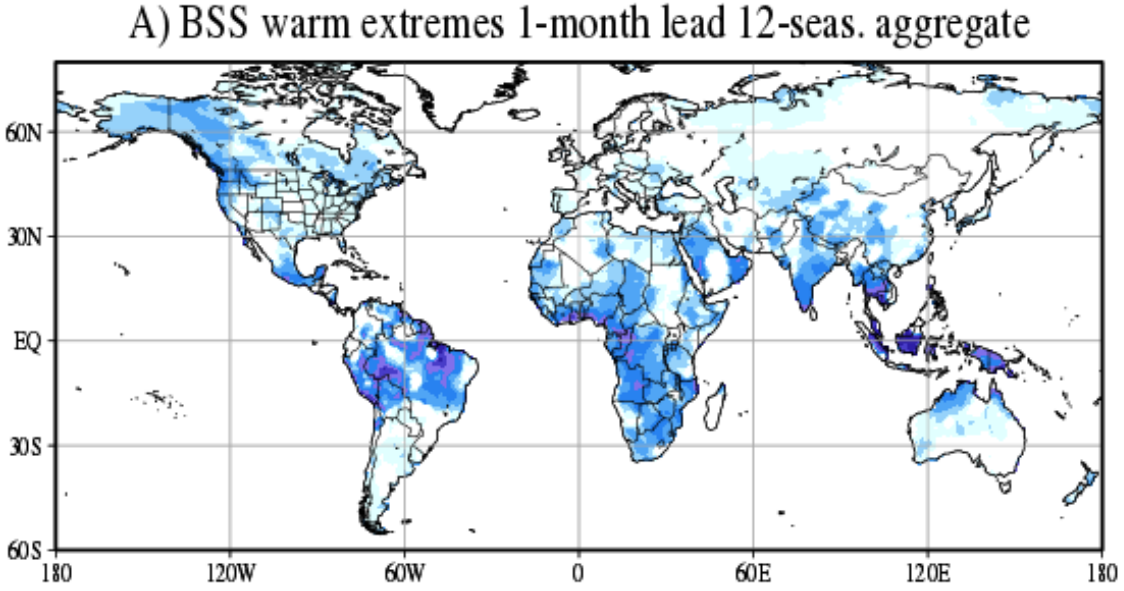


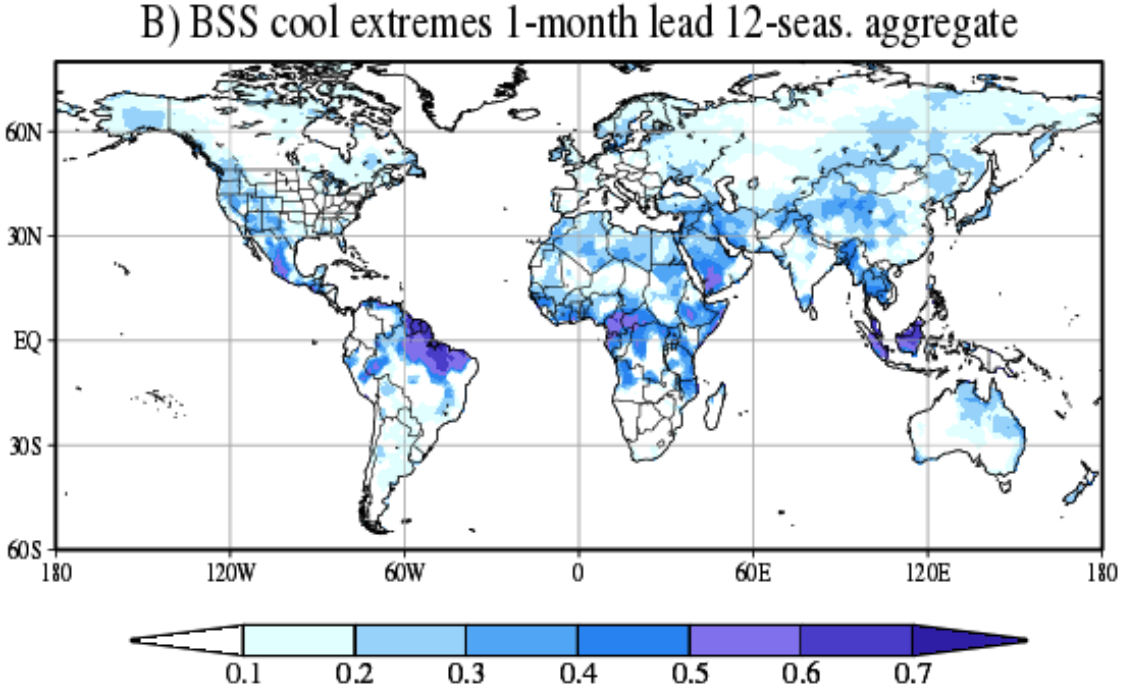


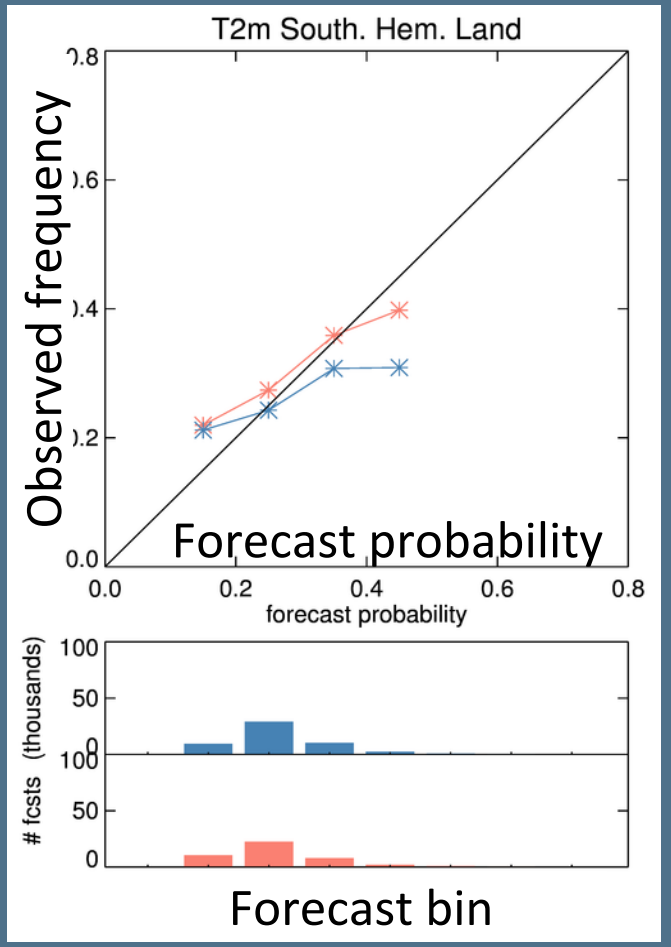
T2m BSS & Northern extratropics reliability



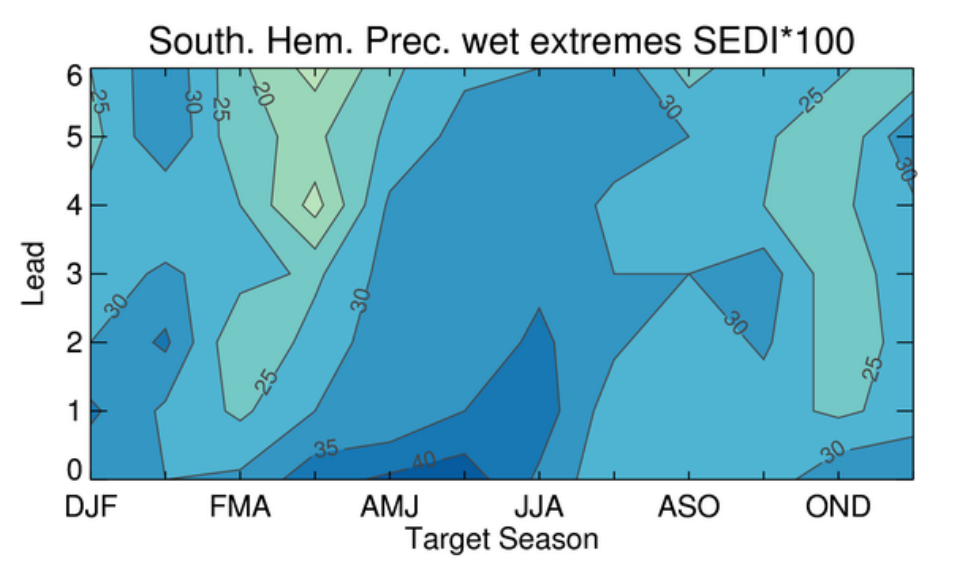
T2m BSS & Southern extratropics reliability

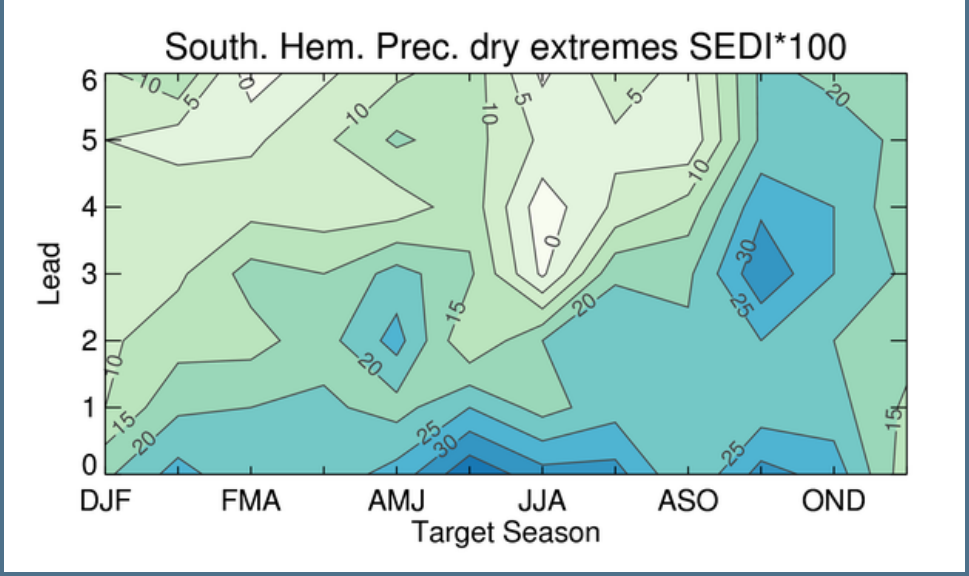


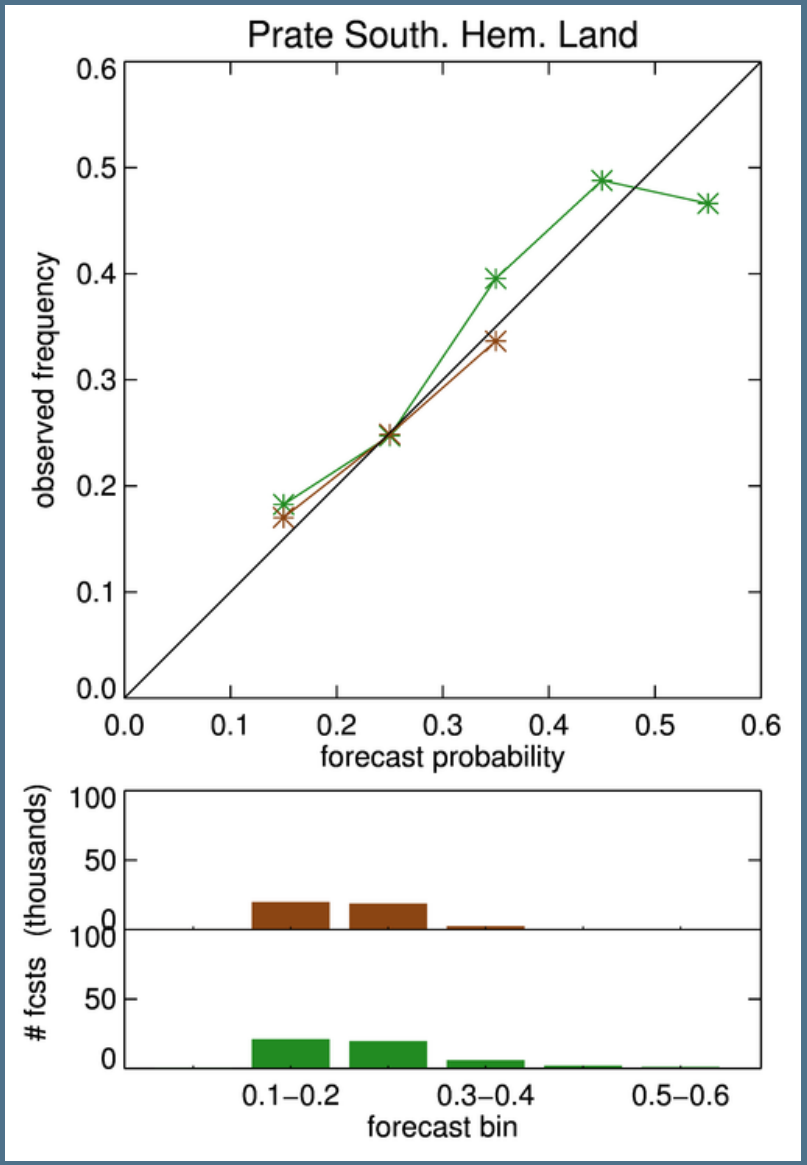




Southern extratropics **precipitation**







Summary & Comment

- Potential for a seasonal extremes forecast tool based on NMME for temperature
- Any official outlook would require substantial R&D, including social science input
  - Threshold probability?
- Precipitation extremes will need some creativity to find skill. However, an outlook for extremes could be issued infrequently and still be useful
- Specific temp. or precip. thresholds…?
- Relationship between temperature and precipitation…?

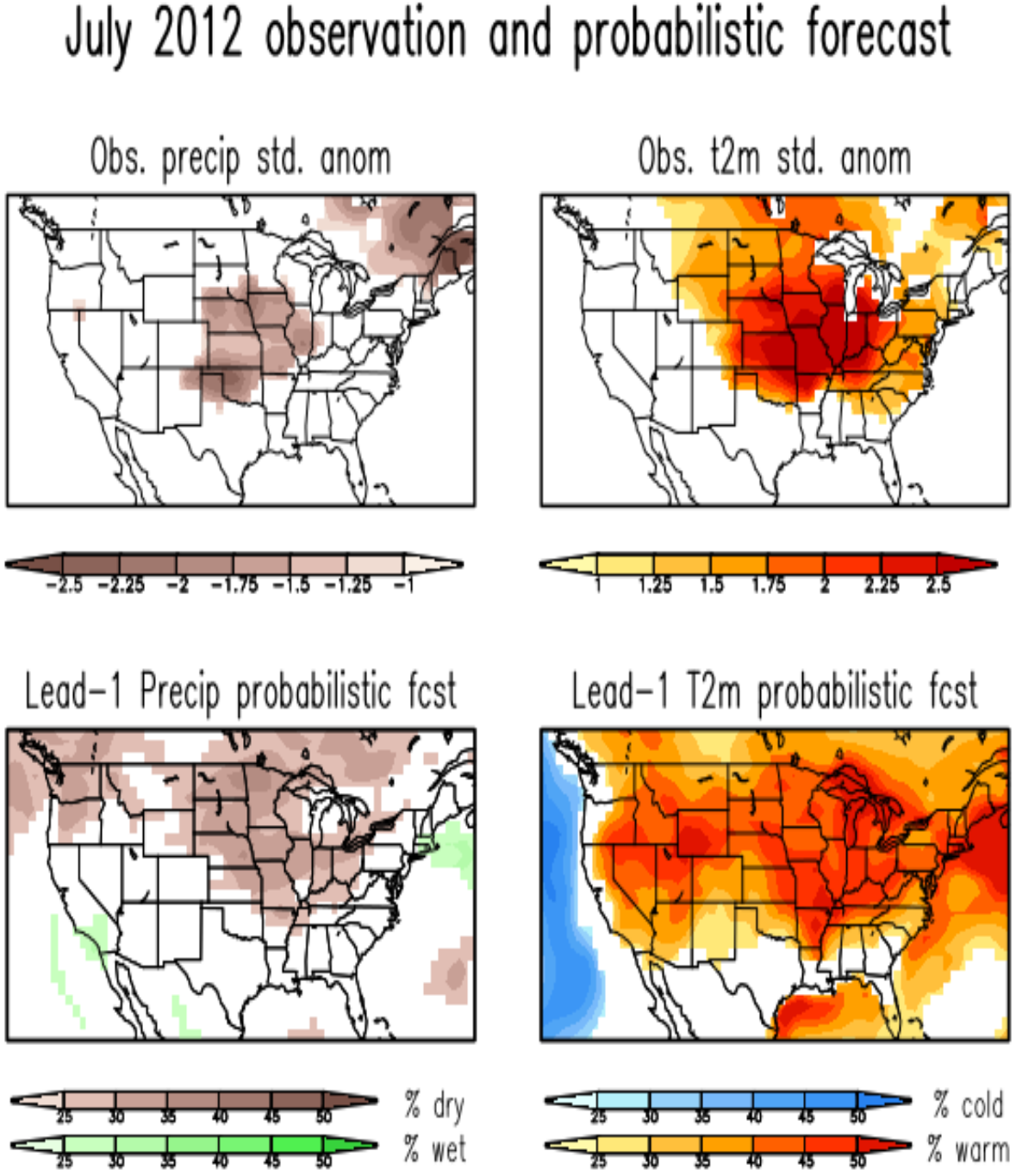
photo: John Moore/Getty Images via theatlantic.com

July 2012 example

- Short-term climate extreme:

  $> 1\ \sigma$ or $< -\sigma$

- NMME prediction Jul 2012 midwest:
  - >30% probability of extreme dry
  - 40-50% probability of extreme warm
- NMME spatial coverage is high



SEDI score

- Symmetric Extremal Dependence Index (Ferro and Stevenson 2011)
- Non-degenerate for rare events
- Normalizes hit rate using false alarm rate

	Obs Y	Obs N
Fcst Y	a	b
Fcst N	c	d

- Hit Rate = a/(a+c)
- False Alarm Rate = b/(b+d)
- SEDI = 0.2 indicates forecast is 20% better than a random forecast, etc.