

Real-time Refinement of ECMWF Subseasonal Forecast Confidence

June 2020

Dr. Jan F. Dutton, CEO
Prescient Weather



World Climate Service

If you knew then what we knew then ...

Founded in 2009

- 11-year history of CropProphet
- 16-year history of World Climate Service
- Significant R&D funding from U.S. government Small Business Innovation Research grants (SBIRs) focused on weather and climate risk



Company:
Product development
focused

Products	CropProphet	World Climate Service	ClimBiz
Content	Crop Yield Prediction	S2S Tools and Forecasts	Climate Change Risk
Decision	Crop Marketing/Trading	Impact on energy consumption/production	Likely impact on business

Objective: Create quantitative guidance for weather and climate related decisions based on the best science and information available.

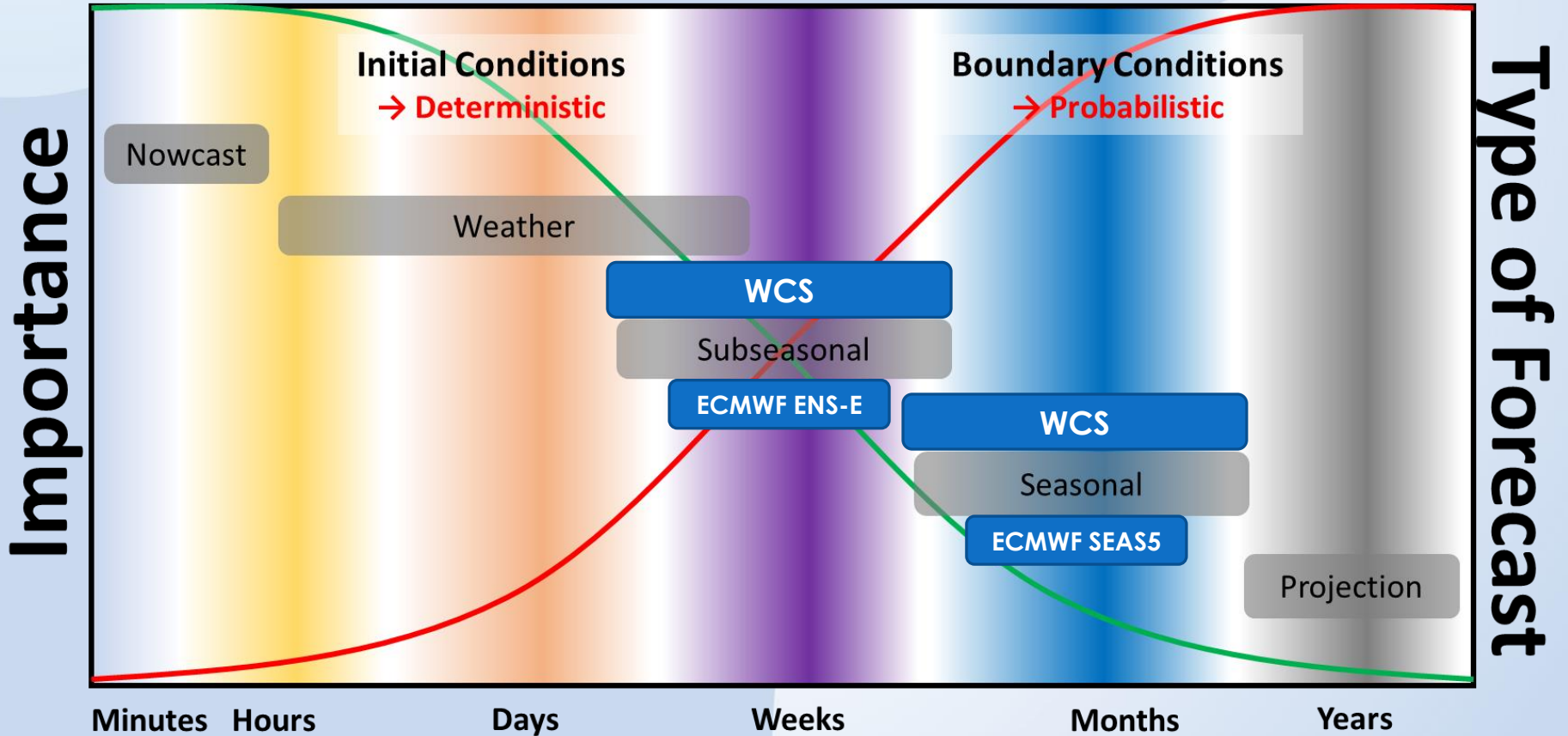
Ethos: Conduct business with integrity, innovation, credibility, and transparency.



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Weather/Climate Timescales



← Time Scale of Prediction →

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WCS S2S Forecasting Philosophy

- A toolset to enable weekly, monthly, and seasonal forecast preparation and communication
- Enable risk analysis by providing **multiple independent prediction methods**
 - Calibrated dynamical ensemble model forecasts (including ECWMF ENS/SEAS5)
 - Statistical forecasts
 - Analog forecasts augmented by human insight/experience
- Emphasize **forecast confidence** and **probabilities**

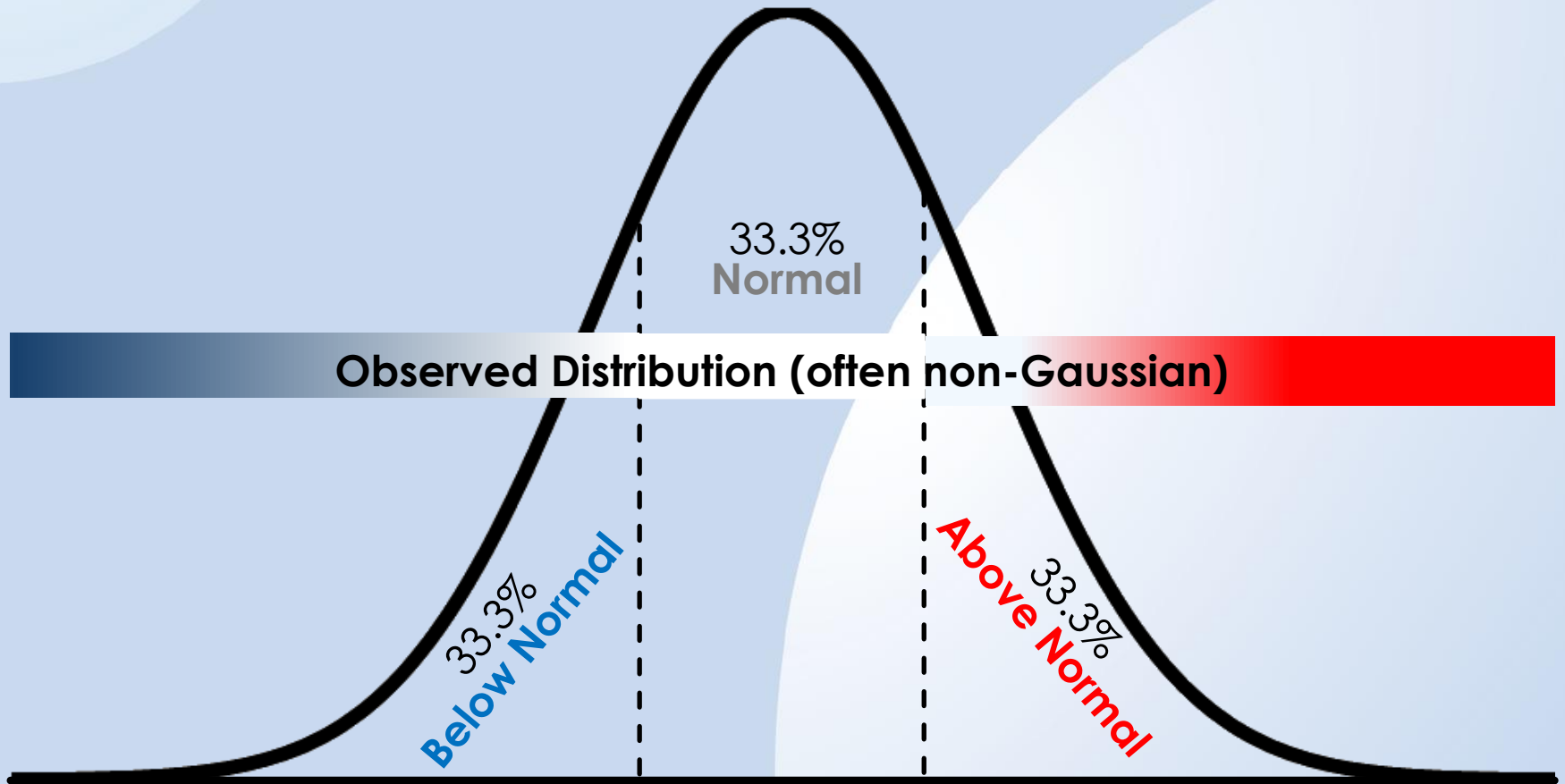


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Climate Distribution

Seasonal forecasts have traditionally predicted tercile probabilities



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Forecast Application

Long lead forecasts focus on shifts in the distribution

If observation falls within predicted tercile it's "correct"

X

If observation falls outside predicted tercile it's "incorrect"

X

50% Chance
Below Normal

33.3%
Below Normal

50% Chance
Normal/Above Normal

33.3%
Above Normal

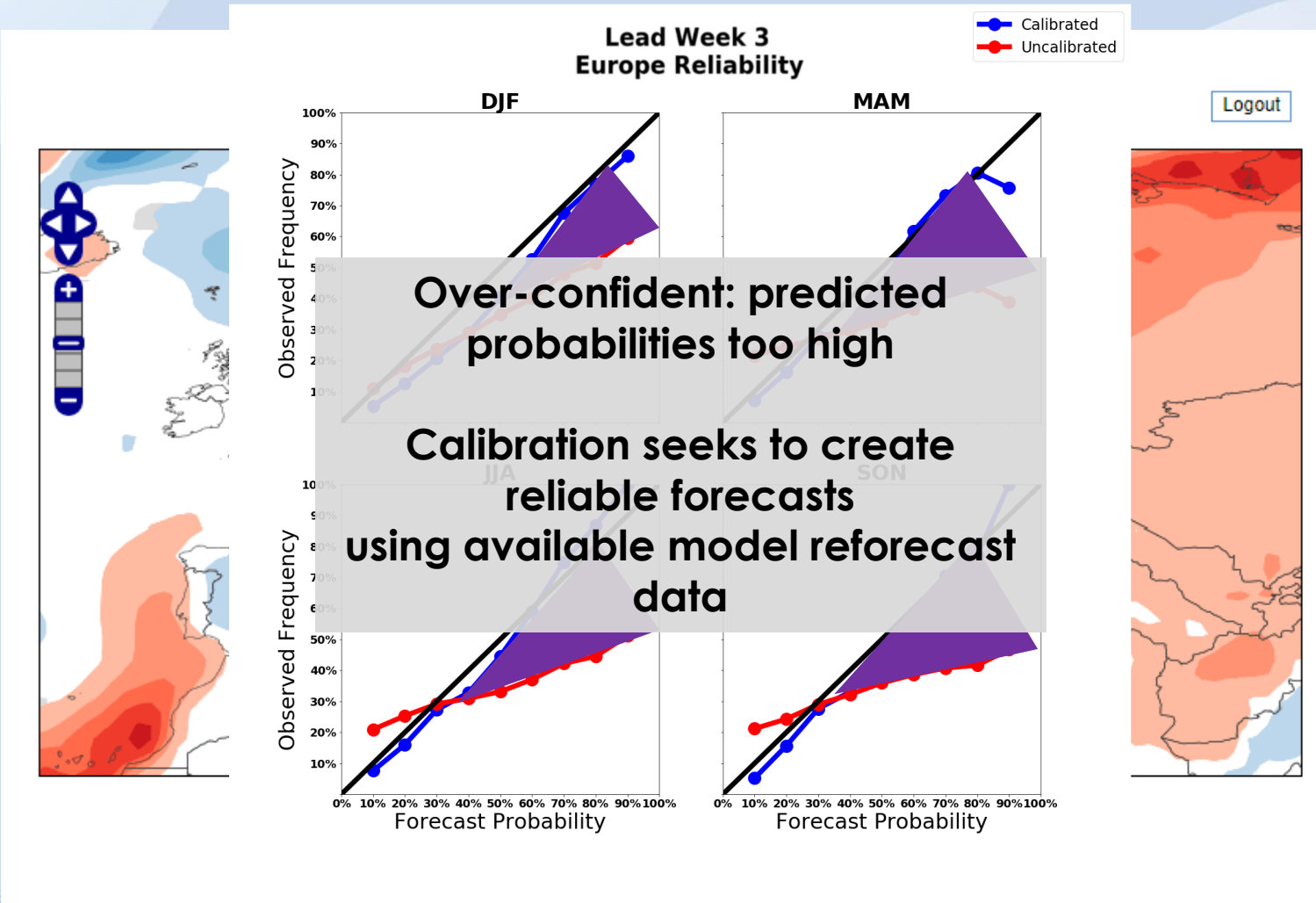


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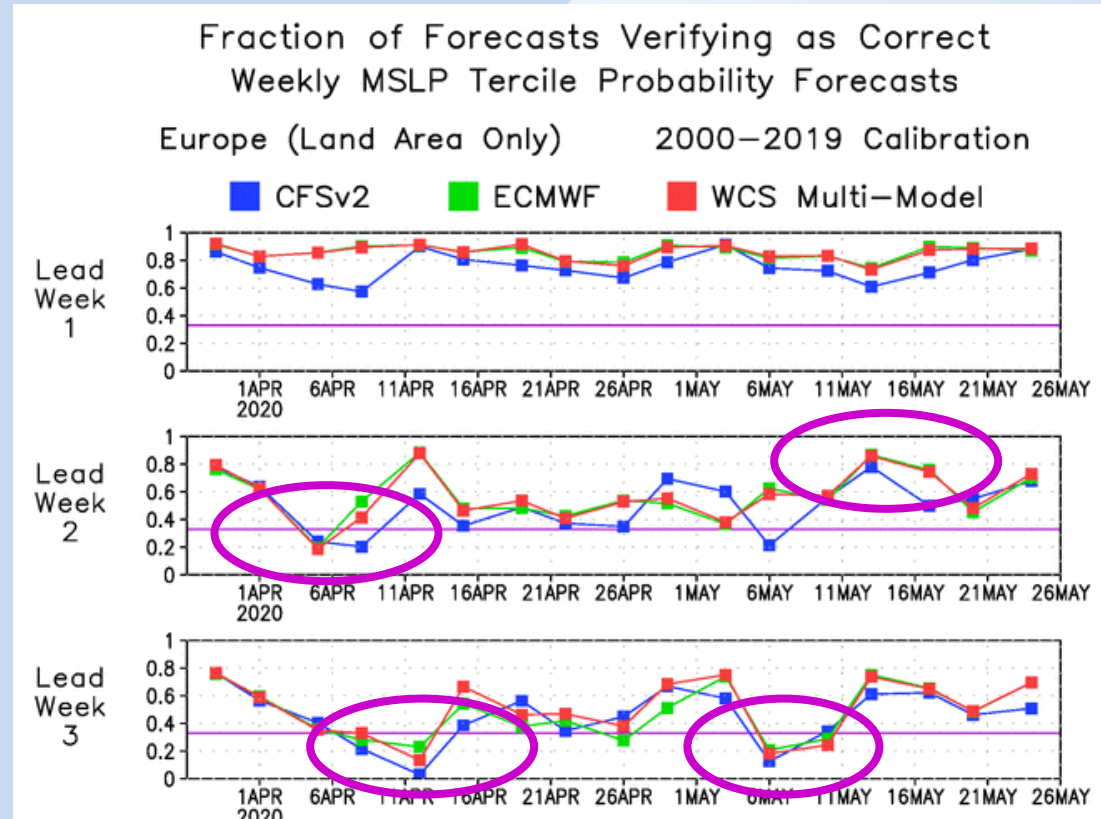
Example Forecast

Calibrated ECMWF "Week Three" Forecast



Forecaster Challenge

- Weekly predictability, on average, is low
- Time variant skill: windows of opportunity?
- When can the forecast be trusted?



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Forecast Rodeo



WATER
PRIZE COMPETITION CENTER

\$800,000 in prize \$\$\$!

Saddle up for the Sub-Seasonal Climate Forecast Rodeo!

March 2, 2016 Forecast



usbr.gov/research/challenges

Competition Sponsor: **RECLAMATION**
Managing Water in the West

Competition Partners:



- US Bureau of Reclamation
- Announced in 2017
- Western US Domain
- Provide week 3&4/week 5&6 temperature and precipitation anomaly forecasts
- Every week for 1 Year



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Contest Results

- WCS/Prescient Weather (prwx) submitted a simple calibrated ensemble forecast

Team	Week 3-4 Temp	Week 5-6 Temp	Week 3-4 Precip	Week 5-6 Precip	Average
prwx	0.2265	0.2026	0.1711	0.1208	0.1803
bgzimmerman	0.2855	0.2357	-0.0221	0.0773	0.1441
StillLearning	0.2170	0.2044	0.0227	0.0941	0.1346
lupoa13	0.0895	0.1675	0.1246	0.0931	0.1187
CFSv2	0.1589	0.2192	0.0713	0.0227	0.1180
Salient	-0.1365	-0.0900	0.2144	0.2162	0.0510
asanteko2000	0.0909	0.0897	-0.0612	-0.0879	0.0079
DampedPersistence	0.1952	-0.0762	-0.1463	-0.1613	-0.0472



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Results Detail

Click on a team's name to see the full stats about that particular team.

Weeks 3&4 Temperature

Team	Newest Score	Average Score ▼
bgzimmerman	-0.0994	0.2855
prwx	-0.1821	0.2265
StillLearning	0.029	0.217
DampedPersistence	-0.0794	0.1952
CFSv2	-0.3997	0.1589
asanteko2000	-0.1117	0.0909
lupoa13	-0.2187	0.0895
Salient	0.05	-0.1365

Weeks 5&6 Temperature

Team	Newest Score	Average Score ▼
bgzimmerman	-0.4472	0.2357
CFSv2	0.5267	0.2192
StillLearning	0.1436	0.2044
prwx	0.3105	0.2026
lupoa13	-0.5854	0.1675
asanteko2000	-0.1046	0.0897
DampedPersistence	0.1084	-0.0762
Salient	-0.8229	-0.09

Weeks 3&4 Precipitation

Team	Newest Score	Average Score ▼
Salient	0.7758	0.2144
prwx	0.0921	0.1711
lupoa13	-0.1367	0.1246
CFSv2	0.1837	0.0713
StillLearning	0.7987	0.0227
bgzimmerman	0.1087	-0.0221
asanteko2000	-0.7981	-0.0612
DampedPersistence	-0.7996	-0.1463

Weeks 5&6 Precipitation

Team	Newest Score	Average Score ▼
Salient	0.5897	0.2162
prwx	0.0995	0.1208
StillLearning	0.5816	0.0941
lupoa13	0.0916	0.0931
bgzimmerman	0.303	0.0773
CFSv2	0.0692	0.0227
asanteko2000	-0.5561	-0.0879
DampedPersistence	-0.4375	-0.1613

Who is “bgzimmerman?”



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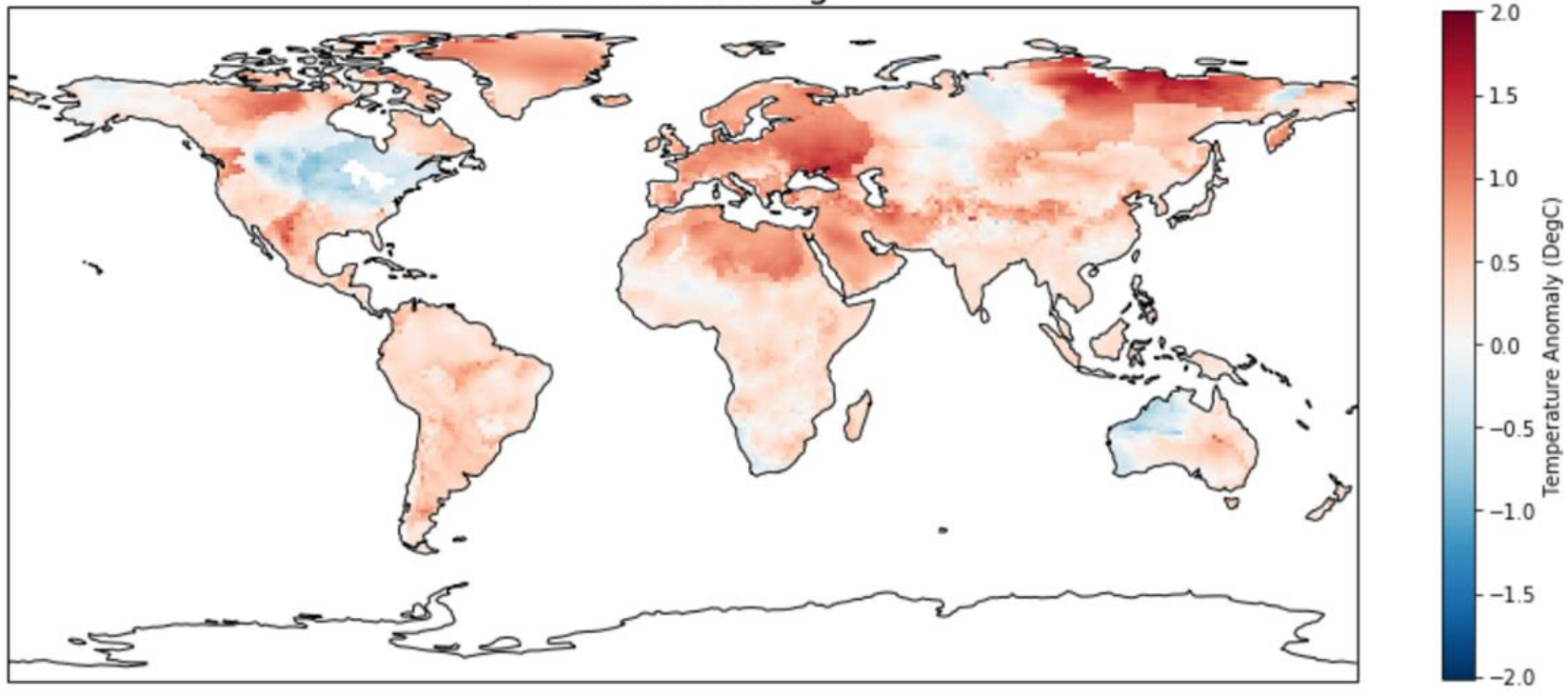
Sub-R Statistical Model Methodology

- Cluster the predictand (i.e. T2M) to reduce dimensionality and capture regional variability on the weekly timescale.
- Optimize out-of-sample accuracy by searching through a variety of antecedent global variables (SST, SLP, H500, T2M) from one week to two months prior.
- Condition on climate indices such as ENSO to enhance predictability.



Expanded to Global Forecasting

Global SubR Week 3 Forecast
Init: 2010-06-01
Ensemble Average

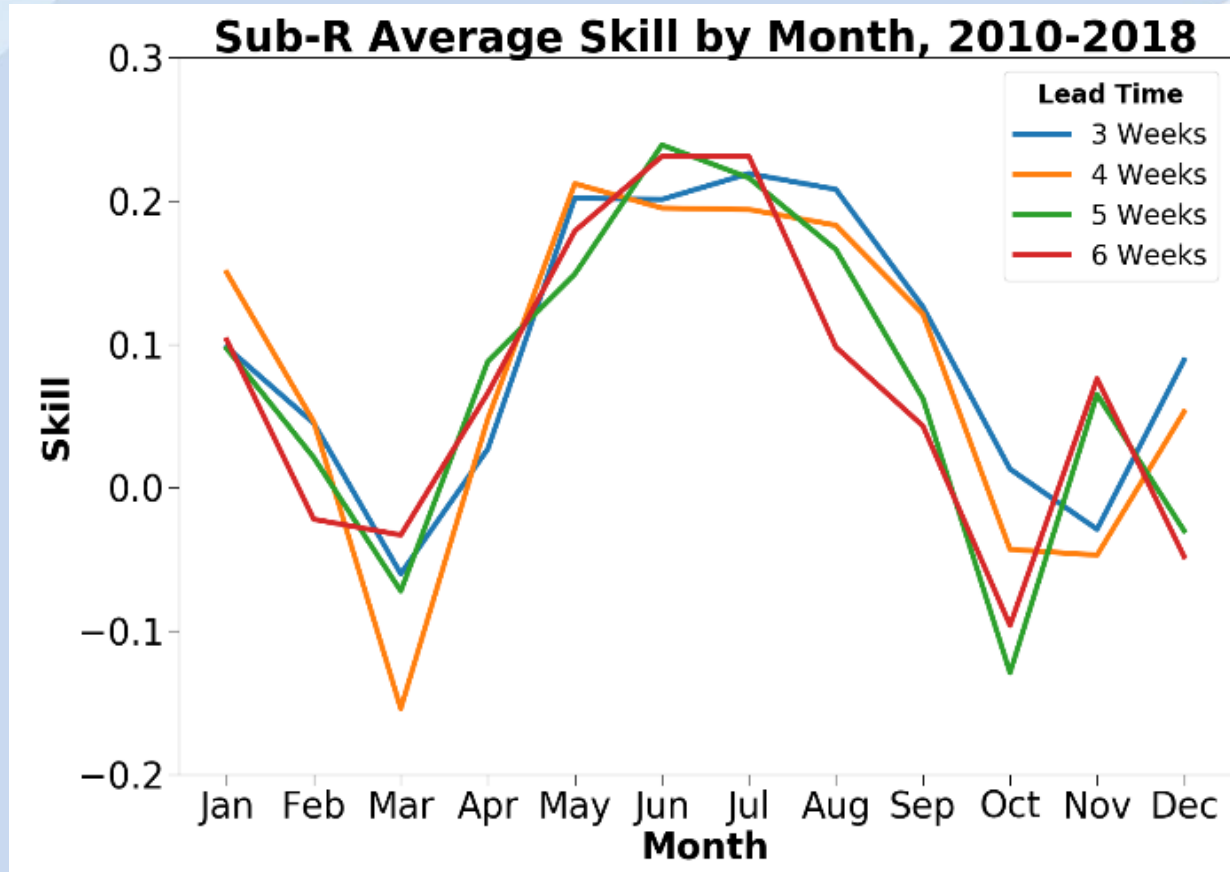


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Sub-R Performance

9-year Hindcast – Out of Sample Results for Temperature



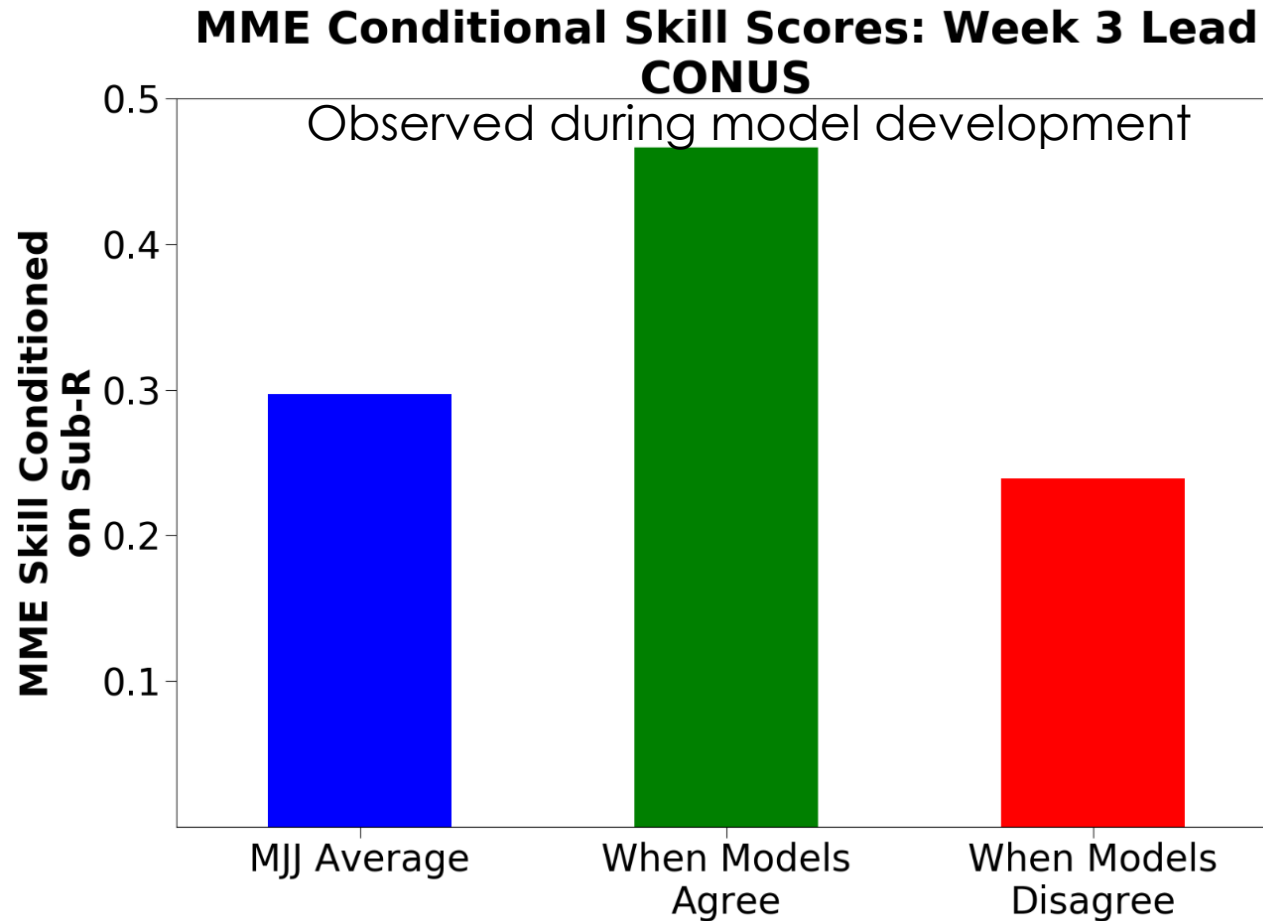
Anomaly Correlations between forecasts and observations



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During Model Development



Agreement measured using land-only anomaly correlation of forecasted anomaly from both statistical & dynamical models

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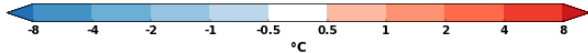
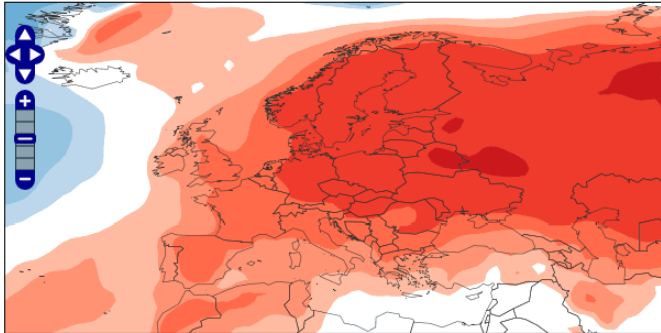
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Forecast Agreement

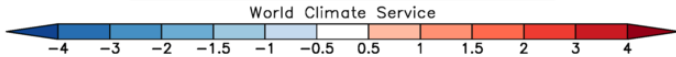
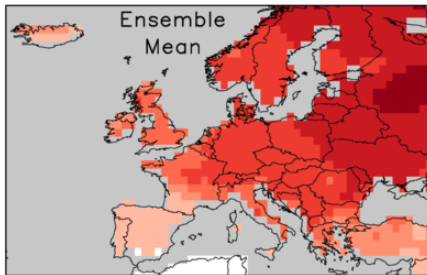
Anomaly Correlation

Agree

ECMWF T2m Ensemble Mean Anomaly (°C)
Week 3 Forecast Valid 13 Feb 2020 - 19 Feb 2020
Initialized 30Jan2020 2000-2018 Climatology

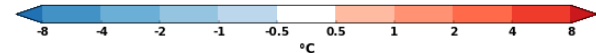
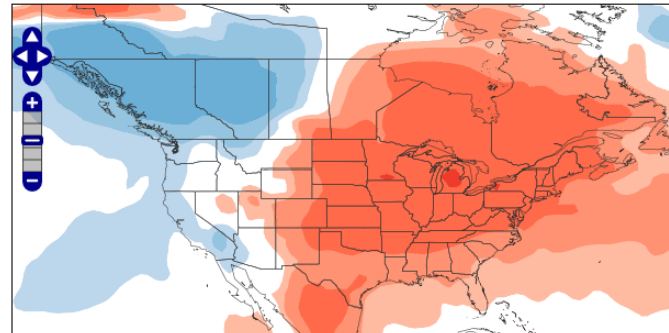


Sub-R Predicted Temperature Anomaly (°C)
Week 3: 7 Days Ending 19FEB2020
Initialized 30JAN2020 2000-2018 Climatology

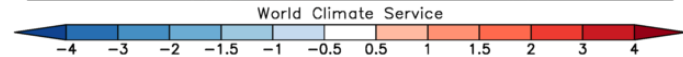
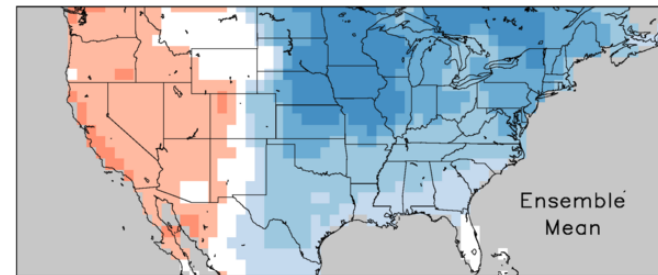


Disagree

ECMWF T2m Ensemble Mean Anomaly (°C)
Week 3 Forecast Valid 16 Mar 2020 - 22 Mar 2020
Initialized 02Mar2020 2000-2018 Climatology



Sub-R Predicted Temperature Anomaly (°C)
Week 3: 7 Days Ending 22MAR2020
Initialized 02MAR2020 2000-2018 Climatology



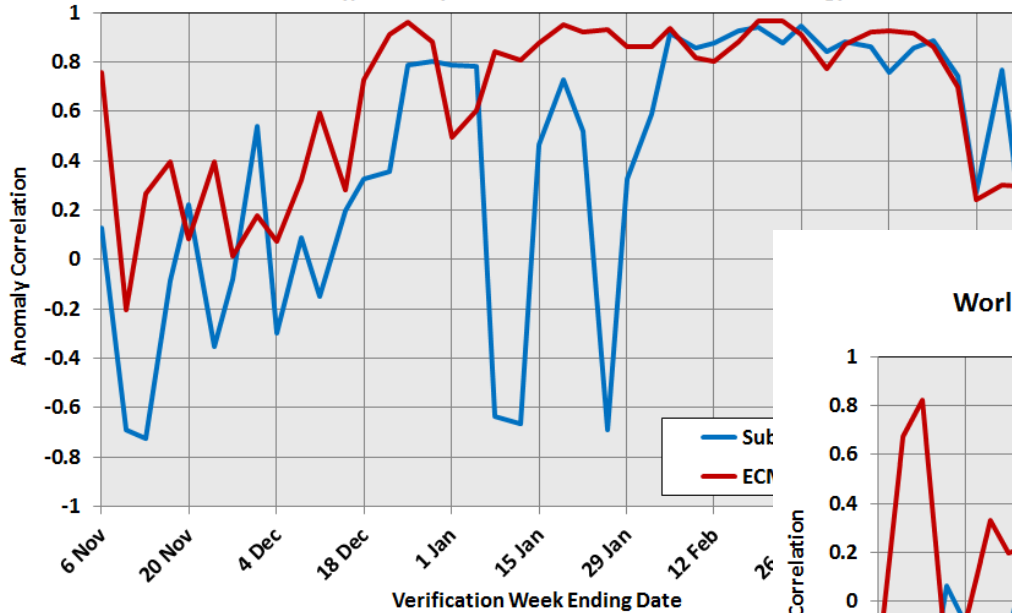
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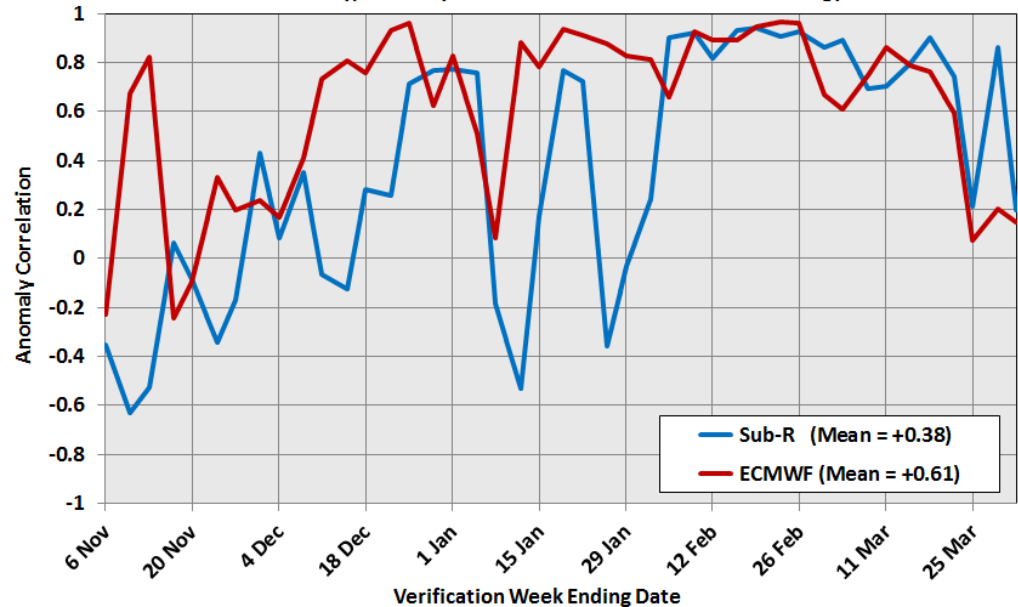
Winter 2020 Forecasts

Europe

Europe Week 3 Temperature Anomaly Correlation
World Climate Service Sub-R versus ECMWF: Winter 2019-2020
Monday/Thursday Initializations 2000-2018 Climatology



Europe Week 4 Temperature Anomaly Correlation
World Climate Service Sub-R versus ECMWF: Winter 2019-2020
Monday/Thursday Initializations 2000-2018 Climatology



Summary Skill Score Performance

Europe

Lead Sub-R ECWFMF

Week 3	0.39	0.65
Week 4	0.38	0.61



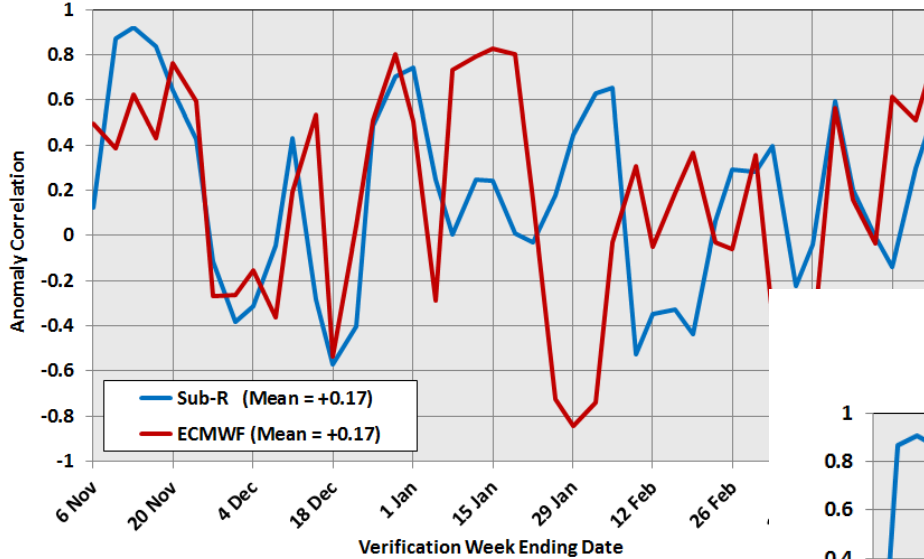
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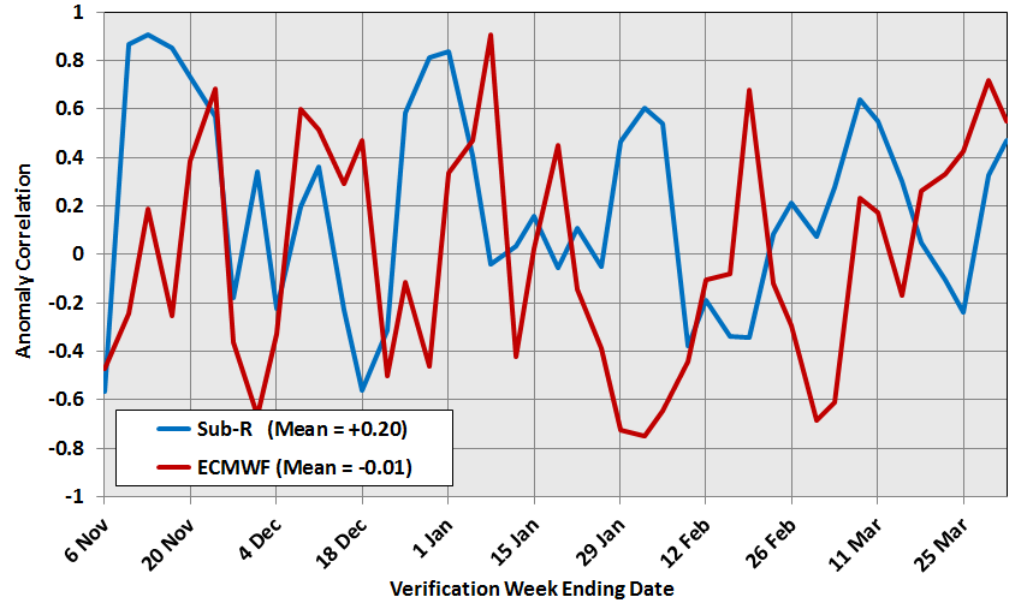
Winter 2020 Forecasts

United States

CONUS Week 3 Temperature Anomaly Correlation
World Climate Service Sub-R versus ECMWF: Winter 2019-2020
Monday/Thursday Initializations 2000-2018 Climatology



CONUS Week 4 Temperature Anomaly Correlation
World Climate Service Sub-R versus ECMWF: Winter 2019-2020
Monday/Thursday Initializations 2000-2018 Climatology



Summary Skill Score Performance

CONUS

Lead	Sub-R	ECMWF
Week 3	0.17	0.17
Week 4	0.20	-0.01



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Winter '19/'20

2m Temperature Anomaly Correlation Forecasts Verifying in Nov 2019 - Mar 2020

CONUS Week 3

	Sub-R	ECMWF
All Forecasts	0.17	0.17
Agree	0.24	0.26
Disagree	0.10	0.08

Europe Week 3

	Sub-R	ECMWF
All Forecasts	0.39	0.65
Agree	0.73	0.77
Disagree	0.02	0.51

East Asia Week 3

	Sub-R	ECMWF
All Forecasts	0.30	0.55
Agree	0.54	0.64
Disagree	0.05	0.45

2m Temperature Anomaly Correlation Forecasts Verifying in Nov 2019 - Mar 2020

CONUS Week 4

	Sub-R	ECMWF
All Forecasts	0.20	-0.01
Agree	0.22	0.18
Disagree	0.16	-0.21

Europe Week 4

	Sub-R	ECMWF
All Forecasts	0.38	0.61
Agree	0.68	0.70
Disagree	0.09	0.55

East Asia Week 4

	Sub-R	ECMWF
All Forecasts	0.28	0.43
Agree	0.49	0.58
Disagree	0.09	0.29



Summary

- Subseasonal forecasts have a low skill baseline, but skill variations over time are large.
- A major forecasting challenge is trying to identify windows of predictability.
- Winter '19/'20 ECMWF mid-latitude forecast skill was higher when forecasts agreed with an independent statistical model.
- World Climate Service users now have a tool to refine confidence in dynamical model subseasonal forecasts.



Thank You!

<https://www.worldclimateservice.com>

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