

### **Benefits of Long-Range Forecast Calibration**

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### **World Climate Service**

### For reference: Not part of presentation

10:00 - 10:15	Networking Break
10:15 – 11:45	Commercial Forecast Providers and Products   Presentations by commercial providers of S2S forecast products   Type of forecasts (e.g., time scales, parameters, resolution) produced   What methods are used to produce them?   What is the relative role of public sector foundational products versus in-house methods?   Where is the added value relative to public products (e.g., improved accuracy, customization)?   What are the energy-related applications?   How is skill measured?   What feedback has been received from clients?   What is the view of providers on future S2S research priorities?



### **World Climate Service**

#### 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



**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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### **Climate Distribution**

Seasonal forecasts have traditionally predicted tercile probabilities



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### **Forecast Application**



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### **Model-Based Forecasts**

### Subseasonal: Week 1-6



#### Calibrated Forecasts of Average over time period for:

- 2m Temperature
- 10 m wind speed
- solar radiation

## Seasonal: Month 1-6 + seasons

MME





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### What is Calibration?

A two-step process applied to ensemble dynamical model forecasts that uses reforecast data to:

- 1) Correct model biases, and
- 2) Adjust ensemble variances to increase reliability

#### **Reliability**:

An event forecasted with a specific probability should occur at that frequency

i.e., above normal temperatures should occur 70% of the time when the forecast is 70% chance of above normal temperatures



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### **WMO Recommendation**

Guidance on Verification of Operational Seasonal Climate Forecasts

2018 edition



METEOROLOGICAL ORGANIZATION

WMO-No. 1220

#### 4.2.5 **Detailed diagnostics**

The procedures recommended thus far have provided only minimal diagnostic information. For more detailed information on forecast quality, reliability diagrams are recommended. These diagrams provide useful indications of most of the important attributes of forecast quality that were described in section 3.2.1. Reliability diagrams are based on a diagnosis of probabilistic forecasts for a predefined set of events, and so can be constructed for each of the categories

It's possible to analyze a long-list of forecast verification statistics that measures the "academic" performance of the model.



Stephan Rasp @raspstephan · Aug 12

5) In academia, forecast skill reigns supreme. In the real world, wx/climate forecasts are only one component in very messy decision making processes. Having impact isn't as simple as building a better model. We (researchers) should put more effort in talking to end users.

We think it's important to focus on: 1)Reliability (i.e., uncertainty) 2)Understandable skill (i.e., tercile fraction correct) 3)All available sources of skill (i.e., analogs)



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### **Analogs Have Value Too**

2) Find Analog Years

# S Month Averaged Arctic Oscillation: Top 10 Years

#### 1) Find forecast of Climate Indices



M

Ensemt Mean Forecast AO Index

Nominal Initialization Date: 1 NOV 2022

	DEC 2022	JAN 2023	FEB 2023	MAR 2023	APR 2023
lulti-Model Mean	-0.02	+0.17	+0.34	+0.40	+0.11
ECMWF	+0.12	+0.18	+0.32	+0.32	+0.25
UKMO	-0.08	+0.11	+0.43	+0.49	+0.43
CFSv2	+0.18	+0.28	+0.50	+0.92	-0.02
JMA	-0.33	+0.21	+0.27	+0.16	-0.12
Météo-France	+0.06	+0.20	+0.33	+0.44	+0.14
СМСС	-0.14	+0.17	+0.20	+0.43	+0.23
DWD	-0.14	-0.01	+0.49	+0.31	+0.15
ECCC	+0.15	+0.22	+0.19	+0.11	-0.21

-3.0 -2.0 -1.5 -1.0 -0.5 0.0 +0.5 +1.0 +1.5 +2.0 +3.0 Index Definition: First EOF of Monthly MSLP Over 20-90N Highlighted Months Have Statistically Significant Skill (N=24 p=0.05)

Generated using Copernicus Climate Change Service information 2022

#### 3) Composite Those Years

Percent of Years Having Above-Normal JAN-MAR 100m Wind Speed 1973 1989 1990 1992 1993 1997 2002 2015 2017 2020



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### **Example Forecast**

Calibrated ECMWF "Week Three" Forecast



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### **Forecast Evaluation**

Skill Score: Tercile Fraction Correct (TCF)

- Track the dominant probability
- Track the resulting observation category
- Calculate the fraction of forecasts verifying correctly

	Forecast			Observed			
_	Below	Normal	Above	Below	Normal	Above	Correct?
Fcst 1	15%	25%	60%	—	—	1	1
Fcst 2	20%	30%	50%	—	1	—	0
Fcst 3	20%	35%	45%	—	—	1	1
Fcst 4	15%	25%	60%	1	—	—	0
			Fraction Correct			0.5	



### **Benefits of Calibration**



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### Forecast of Opportunity

Wall Street Journal Jan 11, 2021

Week 4

#### Cold Snap Sparks Record Rise in Natural Gas Prices in Asia

Traders are struggling to secure enough vessels to transport LNG from the U.S. Gulf Coast to Asia in time to meet rampant demand



Observed T2m Anomaly (CFSR, °C) Observed 7 Jan 2021 - 13 Jan 2021 2001-2020 Climatology -1 -0.5 0.5

°C

### O Probabilities enable evaluation of risk

50 60 70 80 90 80 70 60 60 70 80 90 90 80 70 60 Above

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### **Seasonal Forecast Calibration**



#### Winter Temperature Forecasts



### Calibration is great, but . . .

How do I get a power forecast from a calibrated forecast?



https://www.hindawi.com/journals/jen/2016/8519785/fig2/

Non-linear power curve makes it difficult to translate a weekly/monthly average wind speed to a power estimate.



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### Solutions

#### #1: Bias Correct Model Forecast to Local Observations



### **Benefits of Calibration**

- Calibration relates probability to forecast confidence, allowing estimation of risk.
- The skill of long-range forecasts, while post-processing dependent, is generally dependent on the models being used.
- The ensembles contain uncertainty information but must be calibrated for maximum reliability.
- If the deterministic skill scores are needed, they should be from a properly calibrated forecast system.

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### Thank You!

### https://www.worldclimateservice.com

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### Weather/Climate Timescales





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