

Communicating Forecast Uncertainty in Alaska

...

Tools & Techniques For Leveraging Ensemble Forecasts

There will be questions!

As this is an interactive presentation, please join our poll using one of the methods on the right →

You can respond at PollEv.com/davidlevinno072, as long as the activity is active

OR

You can text [DAVIDLEVINNO072](https://www.textnow.com/text/DAVIDLEVINNO072) to [22333](https://www.textnow.com/text/22333) to join the session, then text a response.

It Can Be A Jungle Out There...

- We have had a significant increase in the number of ensemble-based forecast tools in the last few years.
- Each one has its own strengths and weaknesses
- This talk is meant to cover why we would want to leverage these tools as well as a snapshot of how we might use a few of them.
- It is NOT an in-depth look at each tool NOR is it intended as an exhaustive list of best practices
- This will be more of a “quick-guide” :)



But first...we should tackle a more philosophical question...

What is the single most important thing an operational meteorologist does?

Nobody has responded yet.

Hang tight! Responses are coming in.



Our role as meteorologists is not to make good forecasts, but to help people make decisions

Yes! Totally agree!

Partially agree but it makes me a bit uneasy

I feel like I'm supposed to say yes but I don't think I'm on board

Absolutely not! I'm a forecaster not a risk analyst!



Our role as meteorologists is not to make good forecasts, but to help people make decisions

Yes! Totally agree!

0%

Partially agree but it makes me a bit uneasy

0%

I feel like I'm supposed to say yes but I don't think I'm on board

0%

Absolutely not! I'm a forecaster not a risk analyst!

0%



Our role as meteorologists is not to make good forecasts, but to help people make decisions

Yes! Totally agree!

0%

Partially agree but it makes me a bit uneasy

0%

I feel like I'm supposed to say yes but I don't think I'm on board

0%

Absolutely not! I'm a forecaster not a risk analyst!

0%



Weather forecasts possess no intrinsic value. They only acquire value through the ability to influence the decisions made by users of the forecasts.”

[What Is a Good Forecast? An Essay on the Nature of Goodness in Weather Forecasting](#) - Murphy, 1993

It all goes back to decisions!

We are constantly making decisions AND helping others make them..



You're going for a hike with a friend at noon. The night before Google says you're 45 minutes away from the trailhead. You would leave at:

11:15

11:00

10:45

10:30

11:30 because you like to be fashionably late



You're going for a hike with a friend at noon. The night before Google says you're 45 minutes away from the trailhead. You would leave at:

11:15

0%

11:00

0%

10:45

0%

10:30

0%

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0%



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10:45

0%

10:30

0%

11:30 because you like to be fashionably late

0%



You're interviewing at noon for your dream job you have spent your entire career pursuing. The night before, Google says you're 45 minutes away from the interview location. You would leave at what time?

11:15

11:00

10:45

10:30

11:30 because you like to be fashionably late

I'd sleep outside the office to make sure I'm there on time :)



You're interviewing at noon for your dream job you have spent your entire career pursuing. The night before, Google says you're 45 minutes away from the interview location. You would leave at what time?

11:15

0%

11:00

0%

10:45

0%

10:30

0%

11:30 because you like to be fashionably late

0%

I'd sleep outside the office to make sure I'm there on time :)

0%



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10:45

0%

10:30

0%

11:30 because you like to be fashionably late

0%

I'd sleep outside the office to make sure I'm there on time :)

0%



For both the preceding scenarios, I would rather have someone else make that decision for me?

No

Yes

Only for the hiking scenario

Only for the job interview scenario



For both the preceding scenarios, I would rather have someone else make that decision for me?

No



Yes



Only for the hiking scenario



Only for the job interview scenario



For both the preceding scenarios, I would rather have someone else make that decision for me?

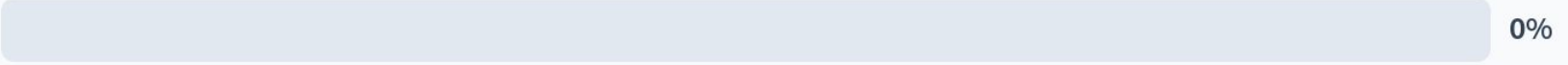
No



Yes



Only for the hiking scenario



Only for the job interview scenario



Both thoroughly understanding (and using) all the tools in our toolbox as well as thoroughly understanding how our partners make decisions is crucial for making our forecasts valuable.



A deterministic answer ("Yes/No") requires deterministic information

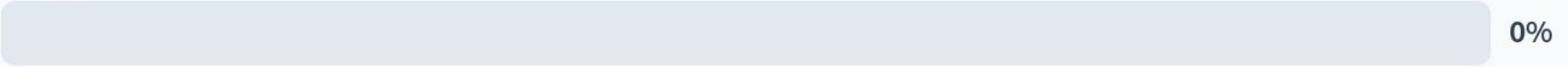
True



False



It depends



We should be making decisions for our partners

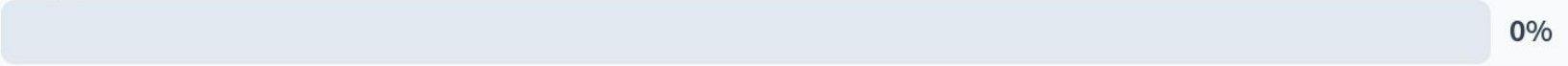
Yes



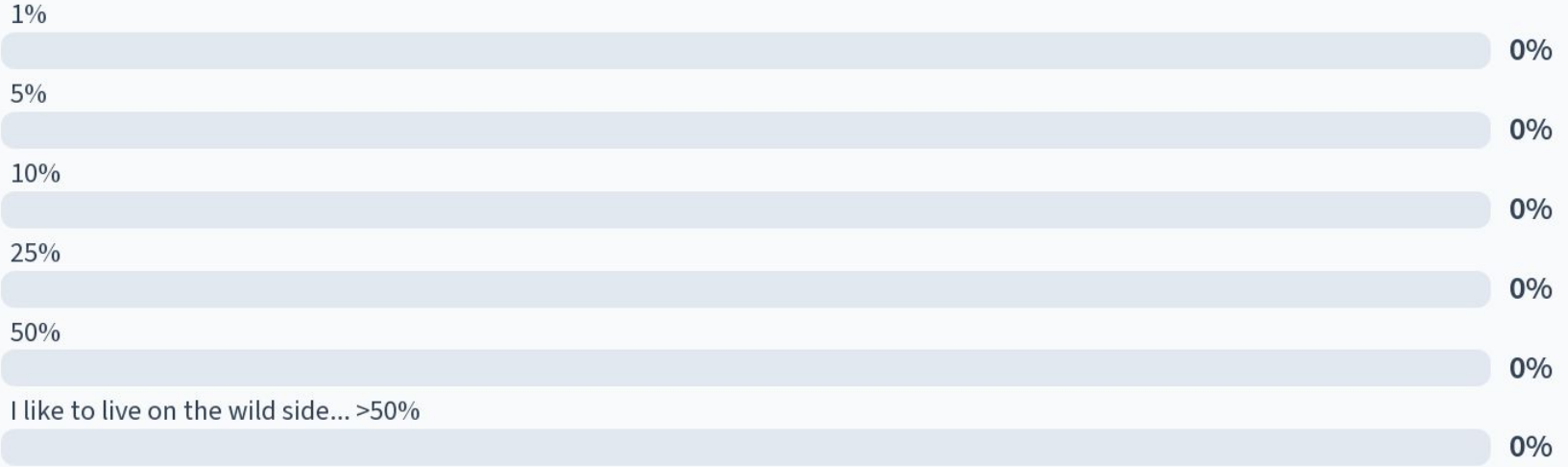
No



It depends



If you booked an airplane ticket and was told there was a chance that the plane would crash, at what confidence level would you cancel your trip?

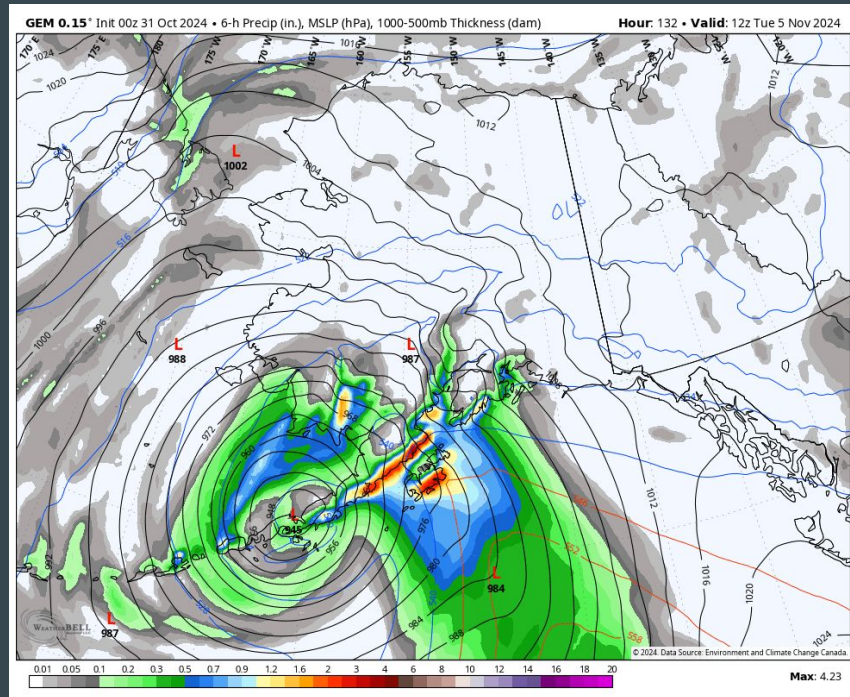
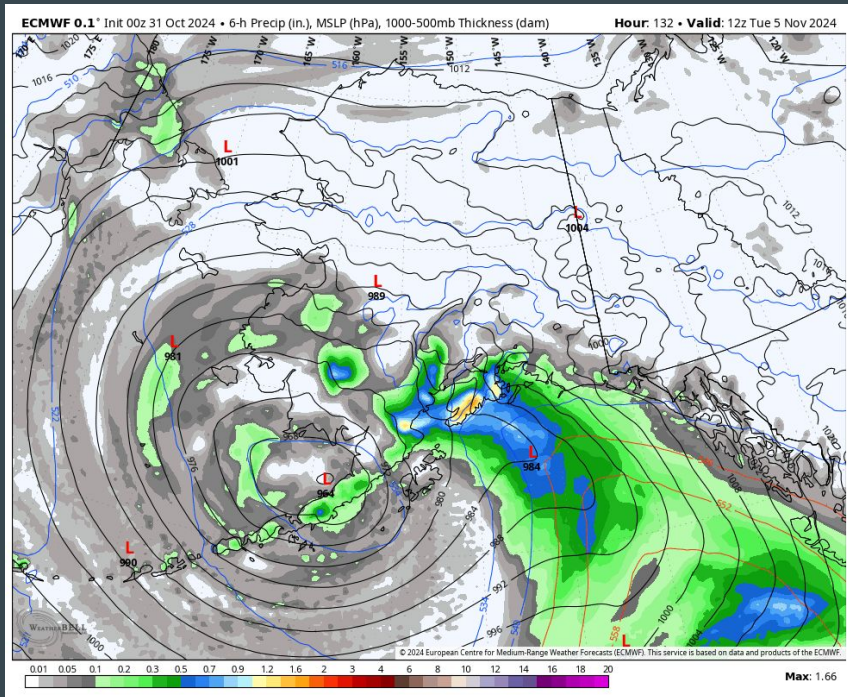


**Enough with the
philosophising...let's dive
into the tools!**

Broad Overview Tools--Cluster Analysis

- Purpose
 - Identify large scale patterns that may produce high impacts (Day 3 and beyond)
 - Utilizes 500mb height fields for pattern analysis
- Data
 - Utilizes Canadian (20 members), European (50 members), and GEFS (30 members) ensemble data
- How do I view it?
 - Best viewing is through DESI (LREF TLE Clustering)
- Training
 - Webinar by Bill Lamberson (WPC) and another training webinar from the Alaska Region Science Share series

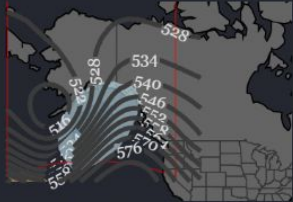
Use Case: Scenarios & Ensemble Support



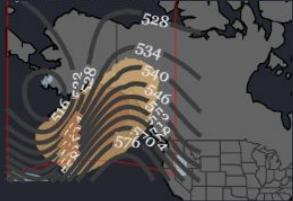
The operational Canadian indicates an intense storm tracking towards the AK Peninsula on Tuesday..while the operational ECMWF shows a storm that is much broader and weaker. How much support does each scenario have? What are the odds? Is the CMC an outlier? Is the EC?

Broad Overview Tools--Cluster Analysis

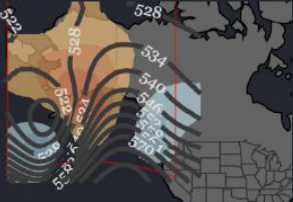
Cluster-1
GEFS: 40% ENS: 36% GEPS: 55% T: 41%



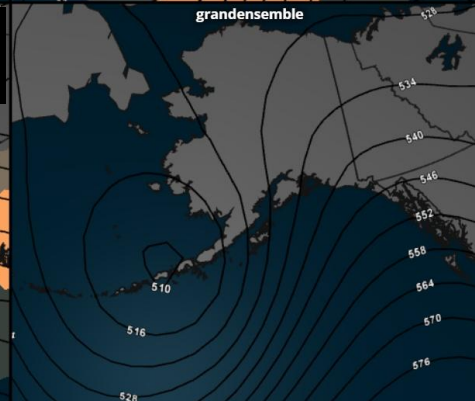
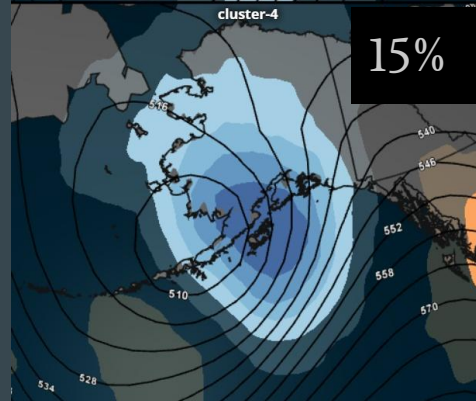
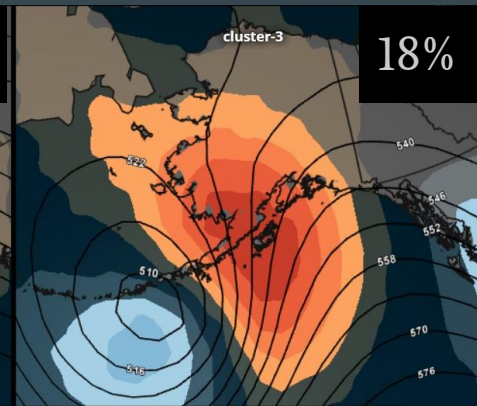
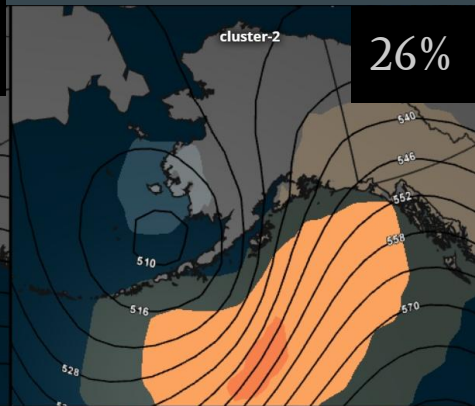
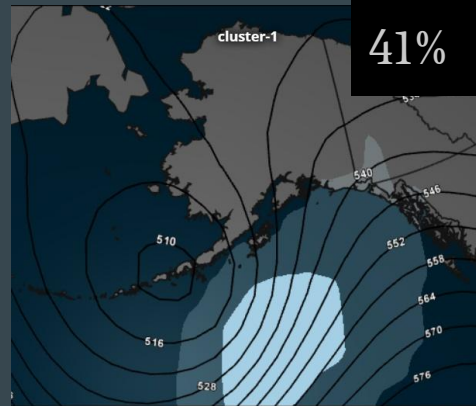
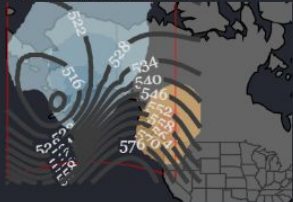
Cluster-2
GEFS: 27% ENS: 36% GEPS: 0% T: 26%



Cluster-3
GEFS: 27% ENS: 14% GEPS: 15% T: 18%



Cluster-4
GEFS: 7% ENS: 14% GEPS: 30% T: 15%



Which height patterns would produce a stronger storm? Which ones would have a higher impact on south central AK?

When I hit the "cluster" toggle in DESI, I'm looking at:

An individual solution from each cluster

An ensemble mean of each cluster

It depends



When I hit the "cluster" toggle in DESI, I'm looking at:

An individual solution from each cluster

0%

An ensemble mean of each cluster

0%

It depends

0%



When I hit the "cluster" toggle in DESI, I'm looking at:

An individual solution from each cluster

0%

An ensemble mean of each cluster

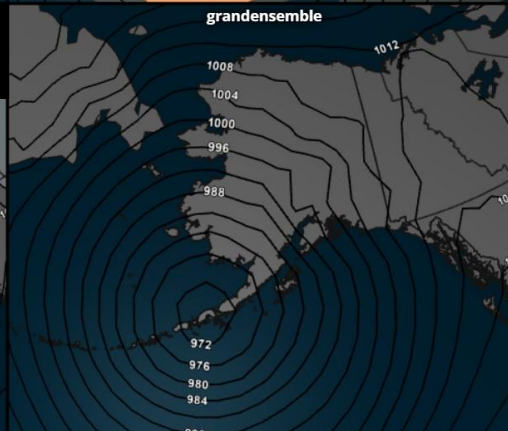
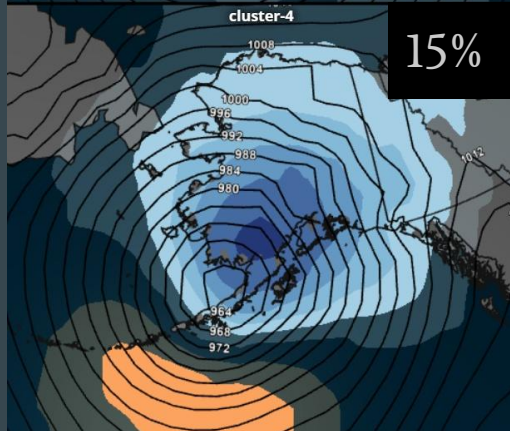
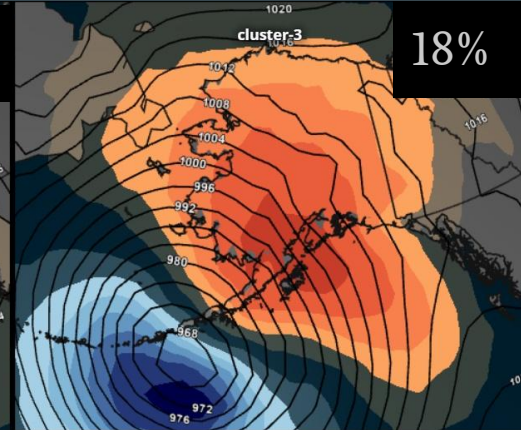
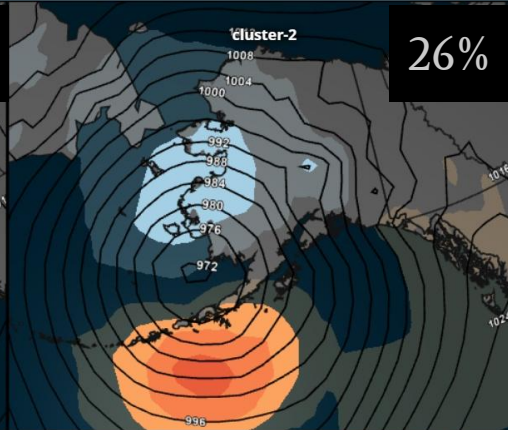
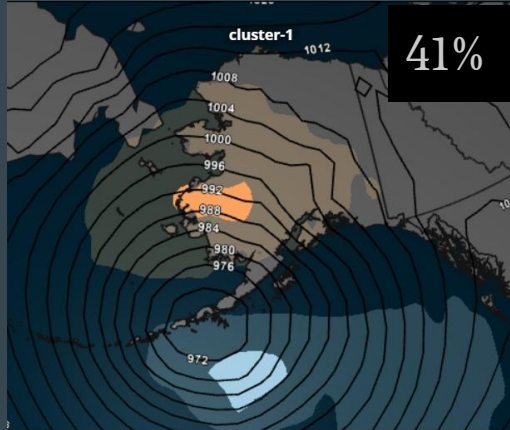
0%

It depends

0%

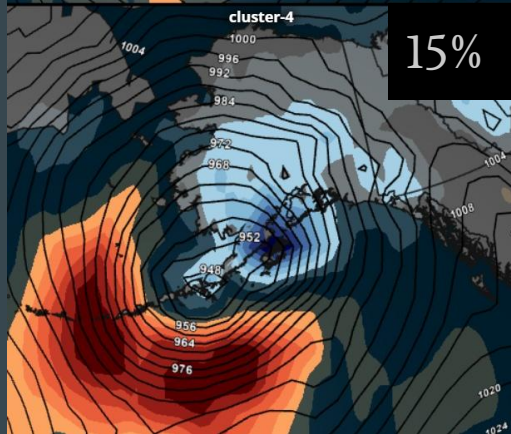
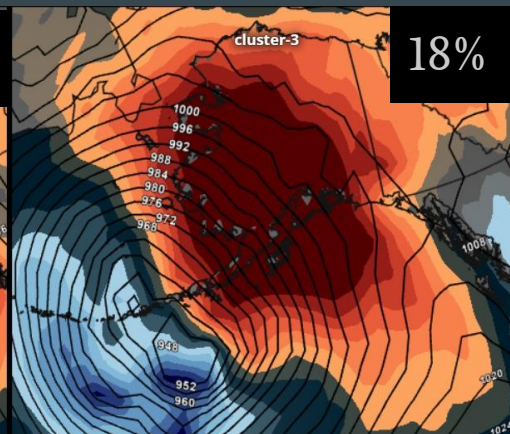
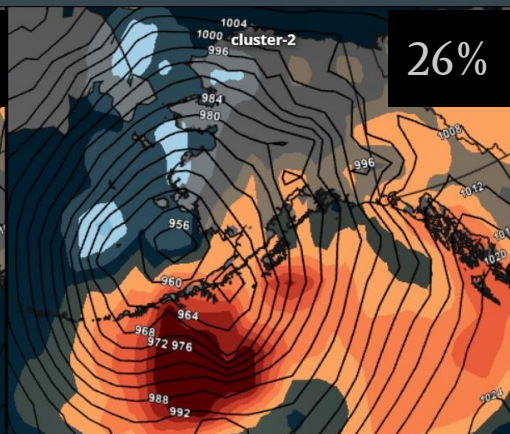
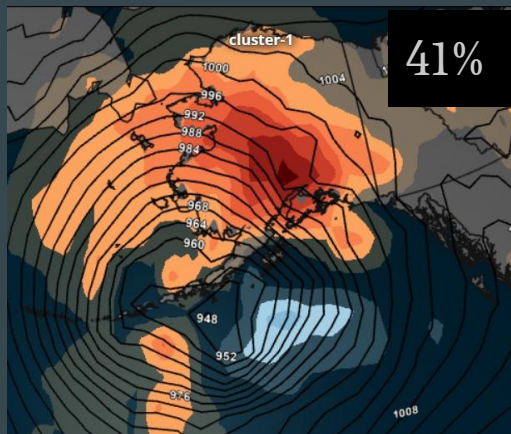


Broad Overview Tools--Cluster Analysis



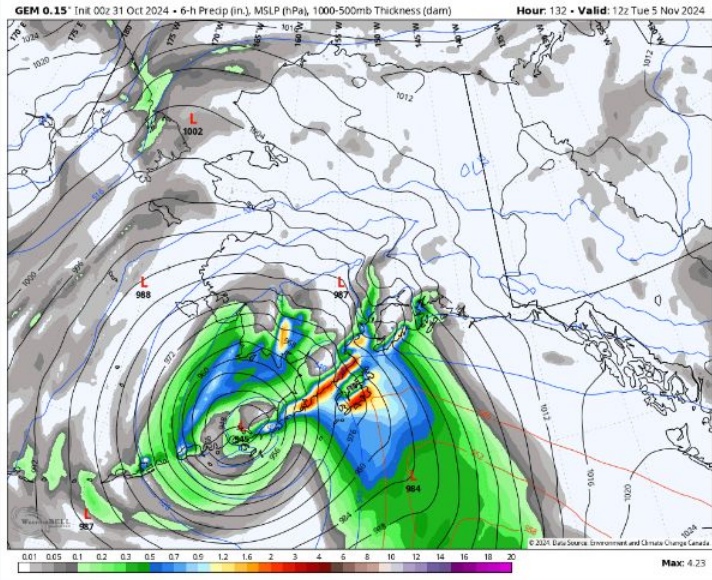
Since these are ensemble means of each cluster, does each cluster produce high end storms? (<950mb)

Broad Overview Tools--Cluster Analysis



Looking at the 5th percentile MSLP can help address that question.

What can we say about the likelihood of the Canadian solution?



A minority of solutions support a <950mb low...

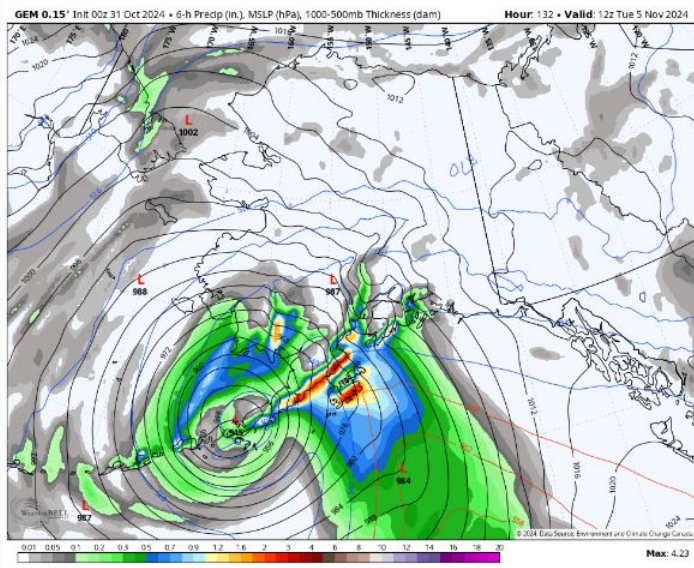
A majority of solutions (clusters 1, 3, 4) have ...

The ECMWF is a better model so I should go w...

The Canadian solution fits my mental model ...



What can we say about the likelihood of the Canadian solution?



A minority of solutions support a <950mb low (clusters 3 and 4)

0%

A majority of solutions (clusters 1, 3, 4) have <950mb lows but significant position differences

0%

The ECMWF is a better model so I should go with cluster 2 (weaker lows)

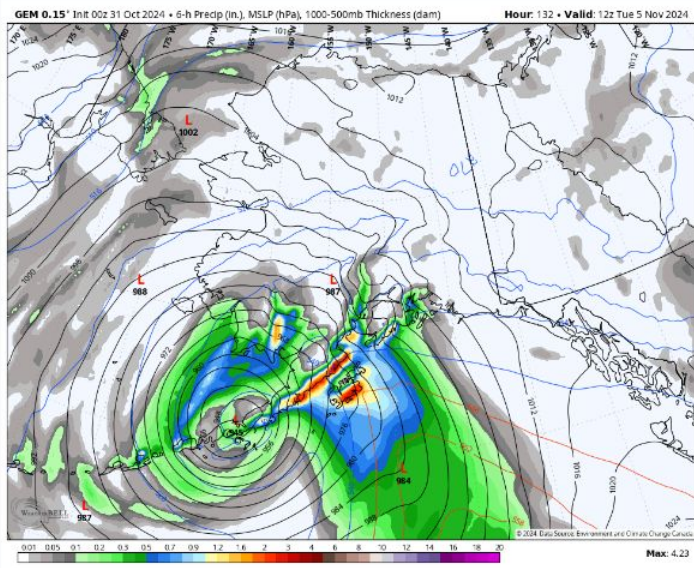
0%

The Canadian solution fits my mental model better so I'll pick cluster 3

0%



What can we say about the likelihood of the Canadian solution?



A minority of solutions support a <950mb low (clusters 3 and 4)

0%

A majority of solutions (clusters 1, 3, 4) have <950mb lows but significant position differences

0%

The ECMWF is a better model so I should go with cluster 2 (weaker lows)

0%

The Canadian solution fits my mental model better so I'll pick cluster 3

0%



Best Practices--Clusters

1. **Know/study your high impact patterns!** Scenario-based messaging doesn't really help if we don't know what the impacts would be!
2. Use cluster analysis to provide added confidence information to potential outlier or high end scenarios
3. Resist the temptation to pick a cluster! Message the impacts and the confidence (how likely)
4. Use for broader patterns and less for detailed mesoscale features that global ensembles struggle with

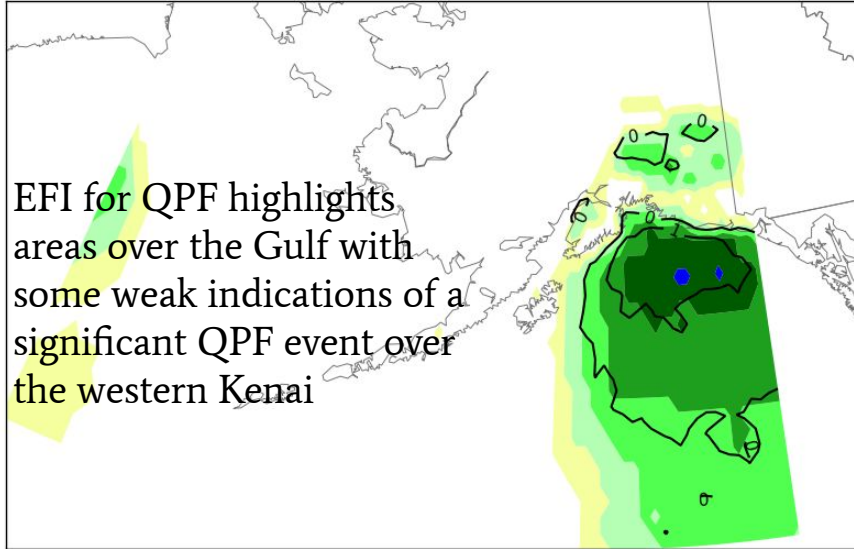
Broad Overview Tools--EFI

- Purpose
 - Puts ensemble forecasts into context (relative to climatology)
 - Tries to account for systemic model biases by comparing to previous model forecasts rather than the actual climatology.
 - Identify where the ECMWF ensemble has members forecasting something unusual
- Data
 - Only ECMWF ensembles (at degraded resolution)
- How do I view it?
 - Plan view using the situational awareness table created by WPC
 - Point view using ECMWF Open Data site--helpful to get trends in EFI and see the whole distribution (actual values)
- Training
 - [Quick training](#) (6 minutes) by Dan Baumgardt (NWS LaCrosse SOO)
 - [In depth training](#) by David Levin
 - From the source using the [ECMWF Forecaster User Guide](#)

Broad Overview Tools--EFI

ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for **QPF**
48-72-h forecast valid

00Z Tue Oct 29 2024 to 00Z Wed Oct 30 2024

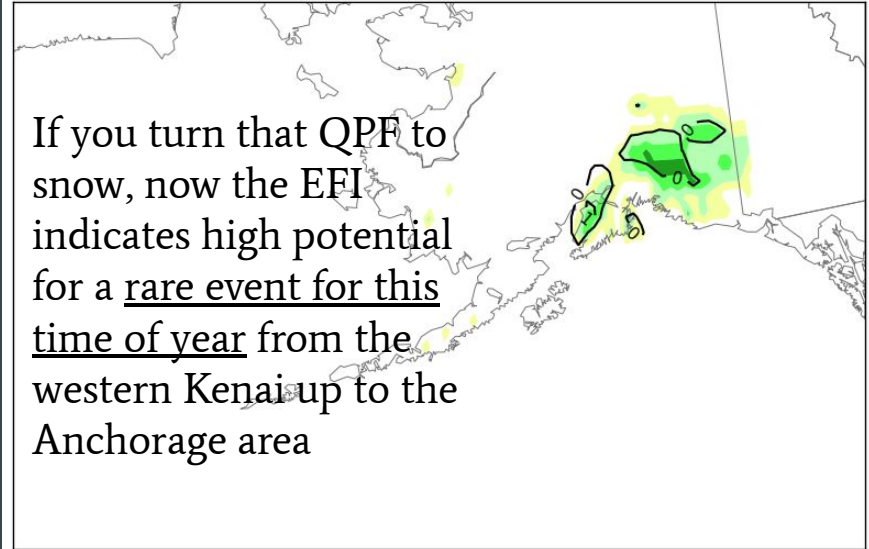


Relative to the ECMWF reforecasts from a 5 week period (2003 - 2024)
centered on the week this forecast was initialized



ECMWF Extreme Forecast Index (shaded)
and Shift of Tails (black contours) for **Snowfall**
48-72-h forecast valid

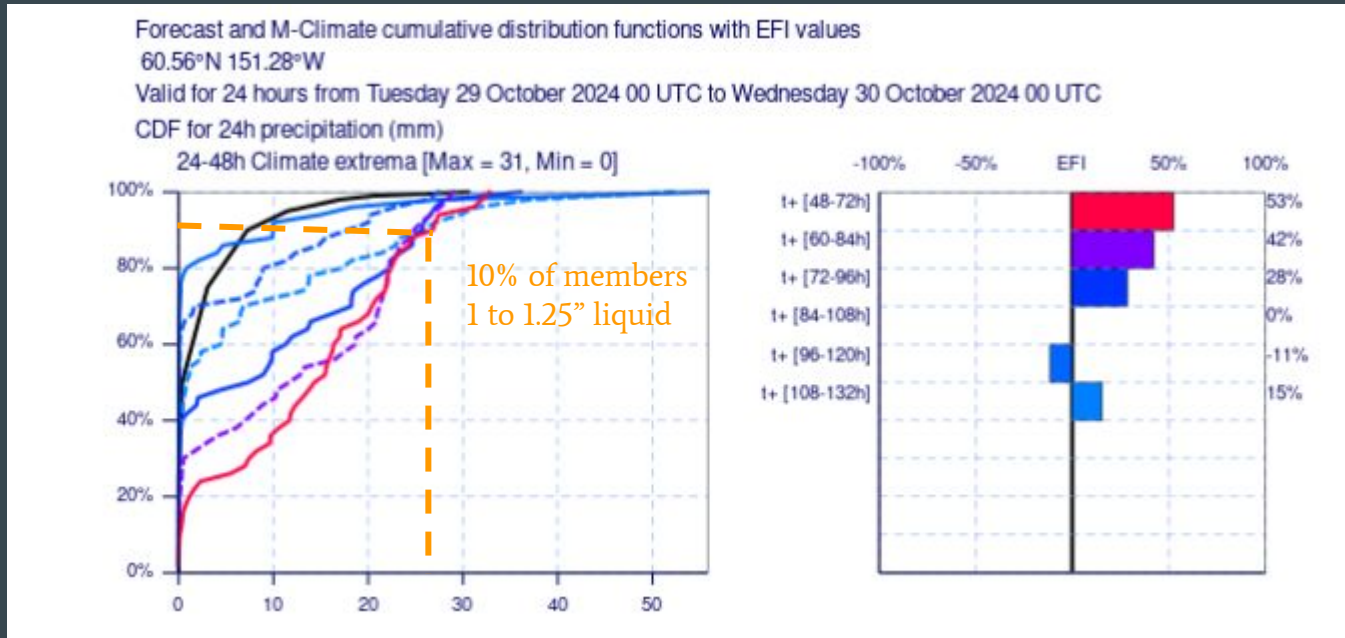
00Z Tue Oct 29 2024 to 00Z Wed Oct 30 2024



Relative to the ECMWF reforecasts from a 5 week period (2003 - 2024)
centered on the week this forecast was initialized



Broad Overview Tools--EFI



AFD Example: *“For Monday afternoon into Tuesday morning, the ECMWF Ensembles are highlighting potential for a high end snowfall event relative to the time of year for the western Kenai northward into the Anchorage area. Looking at Kenai, at least 70% of ensemble members are producing at least 0.5” liquid with the top 10% forecasting 1 to 1.25” liquid equivalent. Assuming this falls in the form of snow this would represent a significant early season snowfall and this event will need to be watched closely.”*

One drawback(s) of using the EFI might be:

It doesn't account for model bias

It leaves out information from other ensemble systems

Extreme forecasts don't always mean impacts

All of the above

Both B and C



One drawback(s) of using the EFI might be:

It doesn't account for model bias

0%

It leaves out information from other ensemble systems

0%

Extreme forecasts don't always mean impacts

0%

All of the above

0%

Both B and C

0%



One drawback(s) of using the EFI might be:

It doesn't account for model bias

0%

It leaves out information from other ensemble systems

0%

Extreme forecasts don't always mean impacts

0%

All of the above

0%

Both B and C

0%



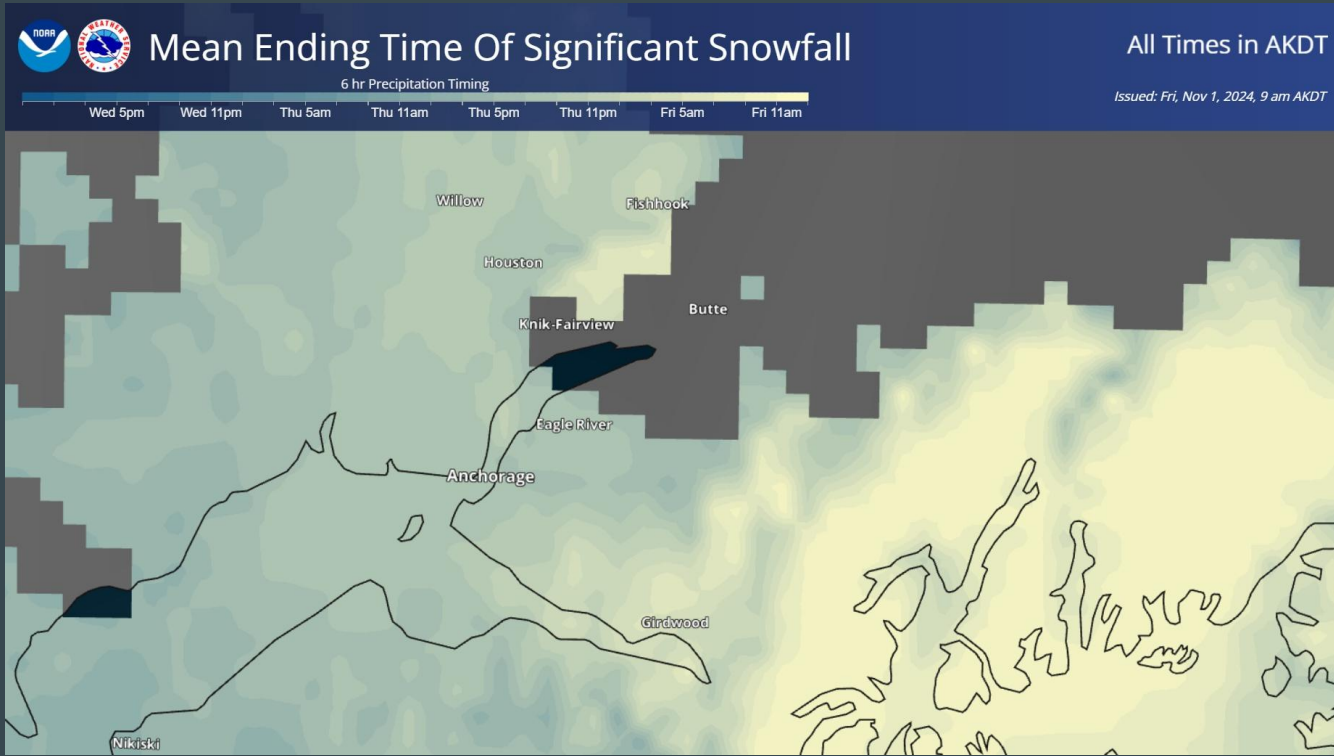
Best Practices--EFI

1. Use for a quick analysis of where the areas of highest impact sensible weather (wind, QPF, snow, temps) are likely to occur...helps to focus your forecast/messaging efforts on areas of concern
2. Use the CDFs in conjunction with the EFI to calibrate yourself to what “extreme” means
3. Keep in mind that you’re only looking at one ensemble system so it might pay confirm with other sources of guidance
4. Pay special attention to areas where there is a high EFI and a shift of tails > 1 as these tend to indicate higher end events.

Local & More Detailed Tools--HREF

- Purpose
 - Provides a summary of most of the high resolution guidance currently available operationally in one place
 - Probabilistic precipitation type
 - Probabilistic liquid equivalent
 - Probabilistic snow (10:1 only) and ice
 - Probabilistic temperatures (and wetbulb)
 - Vertical profiles at any location
 - *Joint probabilities (combinations of wind/temperature and precipitation etc)*
 - *Timing of onset/ending*
- Data
 - 5 different models (HRRR, NSSL WRF, FV3, NamNest, ARW) + a time lagged version of each of these.
- How do I view it?
 - [DESI](#) (HREF Alaska) and the [public version of DESI](#) is the best way to view but some data is available in AWIPS as well
 - Can also find some different fields on [Matt Pyle's EMC site](#)
- Training
 - [In depth look](#) at the HREF by Trevor Alcott

Local & More Detailed Tools--HREF



OR alternatively...When is the most likely time that we should see the heaviest snowfall rates taper off?

The HREF has limitations such as:

It is extremely under-dispersive due to only 10 members

The probabilistic snowfall only uses the Cobb method for SLR

It's easy to take verbatim because its so realistic looking

All of the above

Both A and C

Both A and B



The HREF has limitations such as:

It is extremely under-dispersive due to only 10 members

0%

The probabilistic snowfall only uses the Cobb method for SLR

0%

It's easy to take verbatim because its so realistic looking

0%

All of the above

0%

Both A and C

0%

Both A and B

0%



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0%

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0%

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0%

All of the above

0%

Both A and C

0%

Both A and B

0%



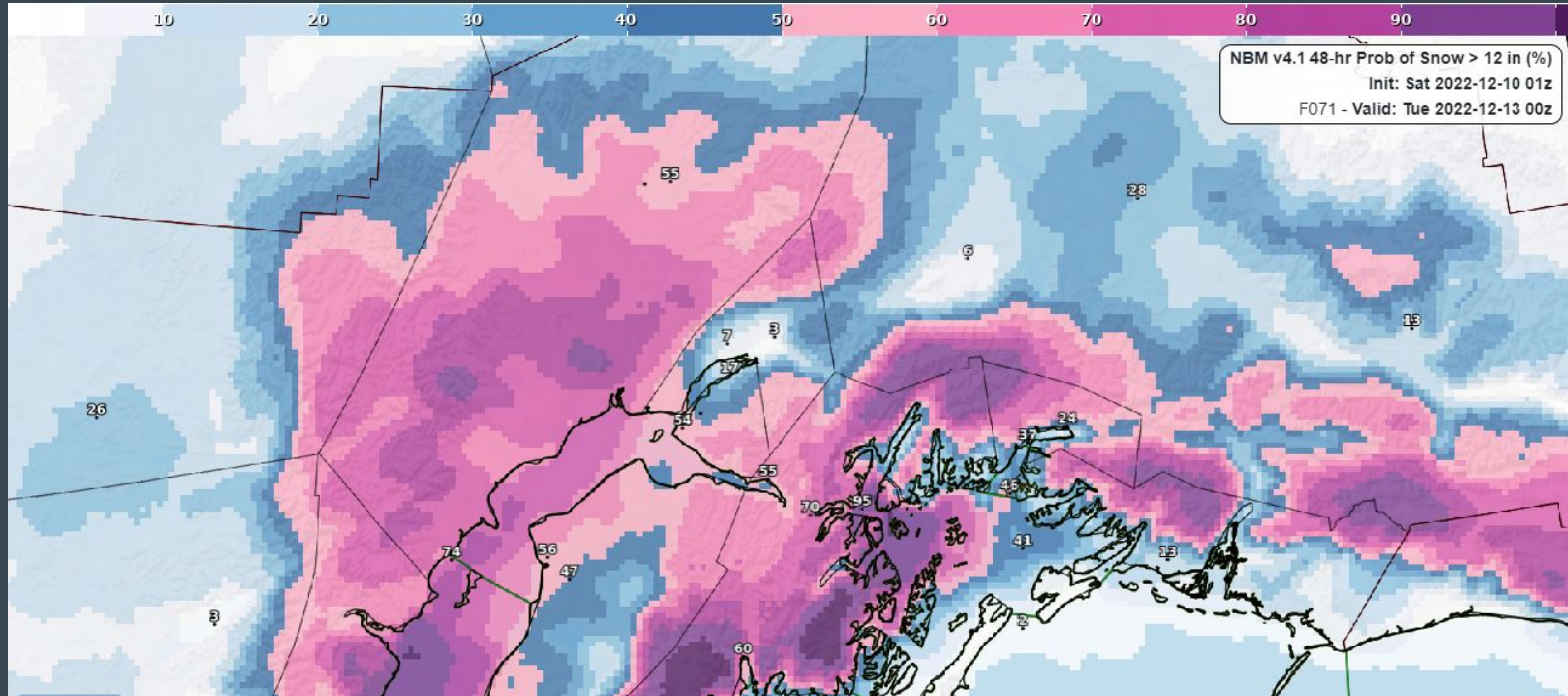
Best Practices--HREF

1. Usually* provides a better look at temperature and precipitation/type distributions in and near complex terrain
2. Use it to get a better understanding of the spread that exists within all available high resolution guidance (as opposed to relying on one high res model...i.e. The HRRR)
3. **Still important to recognize the pattern leading to winter precipitation and mechanisms driving the event...as high resolution models have biases as well*
4. **The HREF only has 5 unique models + 5 time lagged versions so it almost certainly is under-dispersive.*

Local & More Detailed Tools--NBM Probability of Winter Precipitation

- Purpose
 - Comprehensive summary of both global and regional model forecasts of winter precipitation. Helpful to diagnose:
 - Probability of precipitation type
 - Snow-to-liquid ratio
 - Low and high end scenarios (given the above constraints)
- Data
 - 100 operational and ensemble inputs including global ensembles and high resolution models
- How do I view it?
 - [DESI](#) (NBM Alaska)
 - [Whole Story Uncertainty & Probability Viewer](#) (WSUP)
- Training
 - More than you ever want to know can be found in this [comprehensive training slide deck](#) put together by Andy Just
 - I will also be covering this product in depth in next week's [AK Region Science Sharing Webinar](#)

Local & More Detailed Tools--NBM Probability of Winter Precipitation



Given the ptype and SLR uncertainty, how likely is it that Anchorage gets > 12" of snow?

The NBM snow probs can look a lot different than the raw ensemble or HREF snow probs because:

The NBM calculates SLR for each input (not just 10:1)

The NBM downscales/bias corrects the input QPF

The NBM downscales/bias corrects surface wetbulb temps

All of the above

Both A and B



The NBM snow probs can look a lot different than the raw ensemble or HREF snow probs because:

The NBM calculates SLR for each input (not just 10:1)

0%

The NBM downscales/bias corrects the input QPF

0%

The NBM downscales/bias corrects surface wetbulb temps

0%

All of the above

0%

Both A and B

0%



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0%

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0%

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0%

All of the above

0%

Both A and B

0%



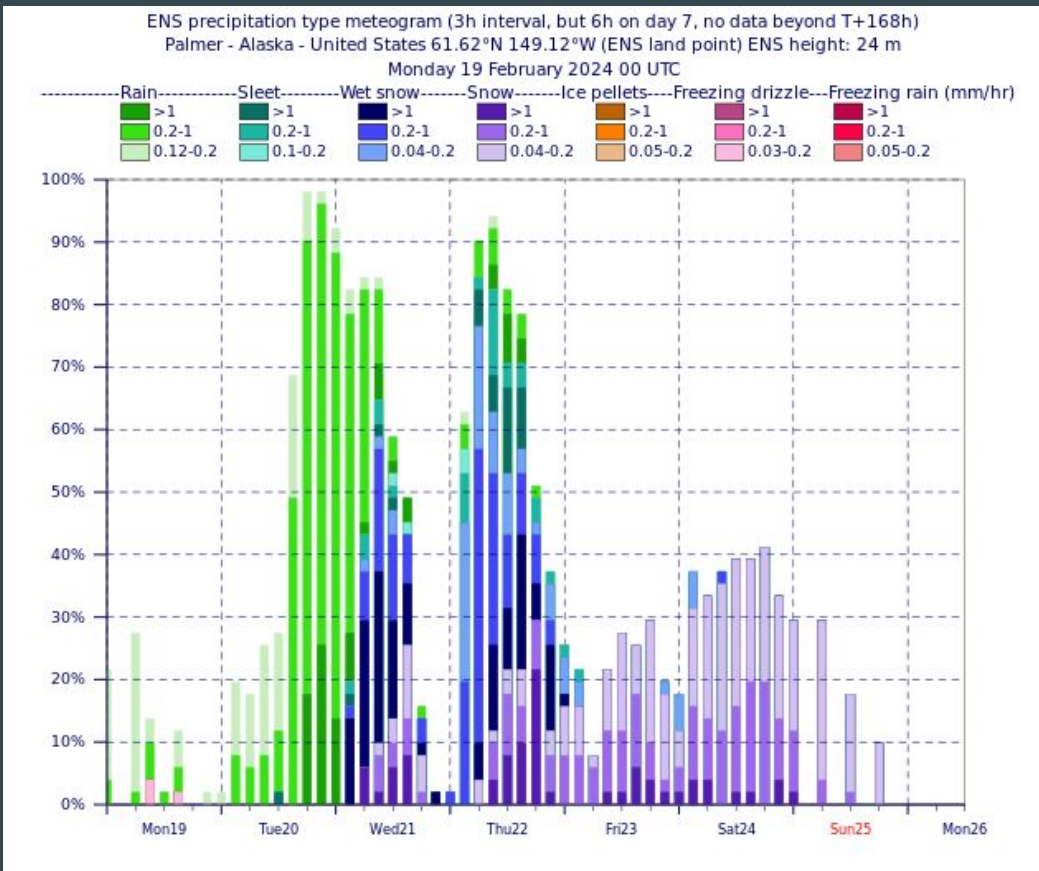
Best Practices--NBM PWPF

1. Use to help you synthesize a lot of uncertainty information (ptype, SLR, QPF etc) into actual probability of snow/ice amounts
2. Useful for identifying areas where there is high/low confidence in ptype or in meeting critical thresholds
3. *Still important to recognize the pattern leading to winter precipitation and mechanisms driving the event...especially to understand where ptype and SLR methodologies may be in error!*
4. *The NBM is much more dispersive than the HREF but also keep in mind that the HREF inputs only account for a very small percentage of the NBM inputs.*

Local & More Detailed Tools--ECMWF Precipitation Type Meteograms

- Purpose
 - Provides an ability to visualize:
 - Time periods of heaviest precipitation intensity
 - Agreement amongst ensemble members
 - Onset and ending times
 - Types of precipitation forecast
- Data
 - Only ECMWF Ensembles (50 members)
- How do I view it?
 - Directly from [ECMWF Open Data](#) site
- Training
 - Directly from the [ECMWF Forecast User Guide](#)

Local & More Detailed Tools--ECMWF Precipitation Type Meteograms



AFD Example: *“Two storms will affect south central AK in rapid succession Tuesday through Thursday. These will be warm storms with rain dominating early Tuesday. By late afternoon Tuesday, enough cooler air will filter in to provide increasing chances (50%) of rain changing to wet snow through the overnight hours before the precipitation ends early Wednesday morning. The next storm will follow close on its heels with precipitation rates increasing rapidly once again by late Wednesday afternoon. The second storm will be slightly cooler and thus higher confidence in wet snow being the primary precipitation type (60-70%). Wet and potentially heavy snow continues Wednesday night before becoming drier and fluffier snow as it ends mid morning Thursday.”*

The ECMWF precipitation type meteograms should **ONLY** be used for timing and **NOT** for actual ptype in complex terrain areas

True

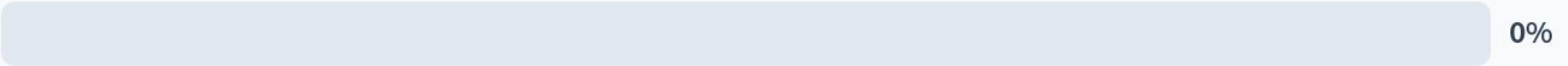
False

It depends



The ECMWF precipitation type meteograms should **ONLY** be used for timing and **NOT** for actual ptype in complex terrain areas

True



0%

False



0%

It depends



0%



The ECMWF precipitation type meteograms should ONLY be used for timing and NOT for actual ptype in complex terrain areas

True



False



It depends



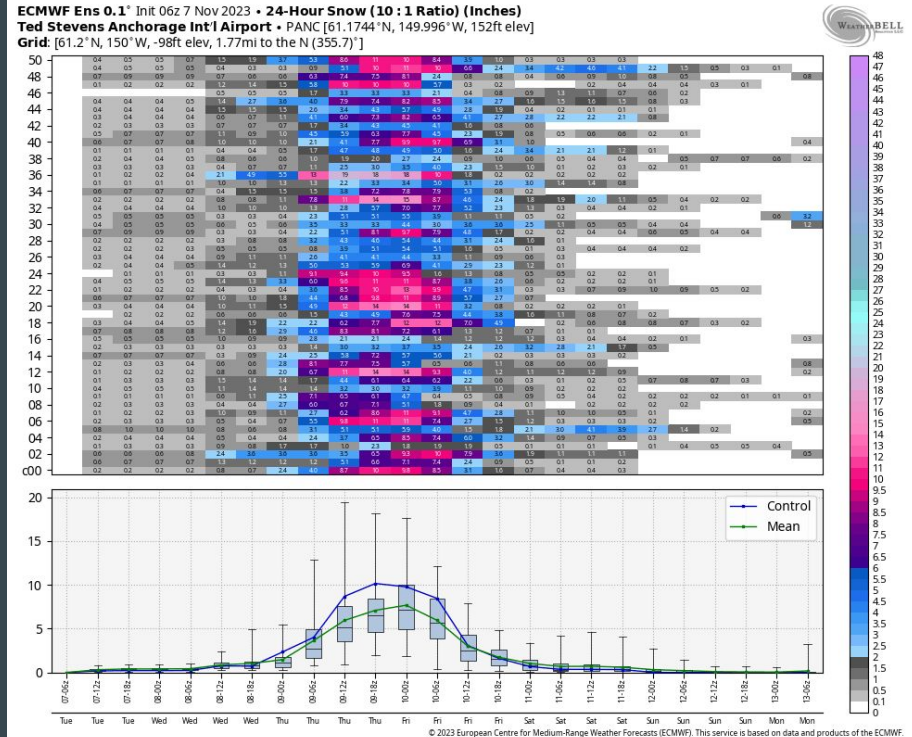
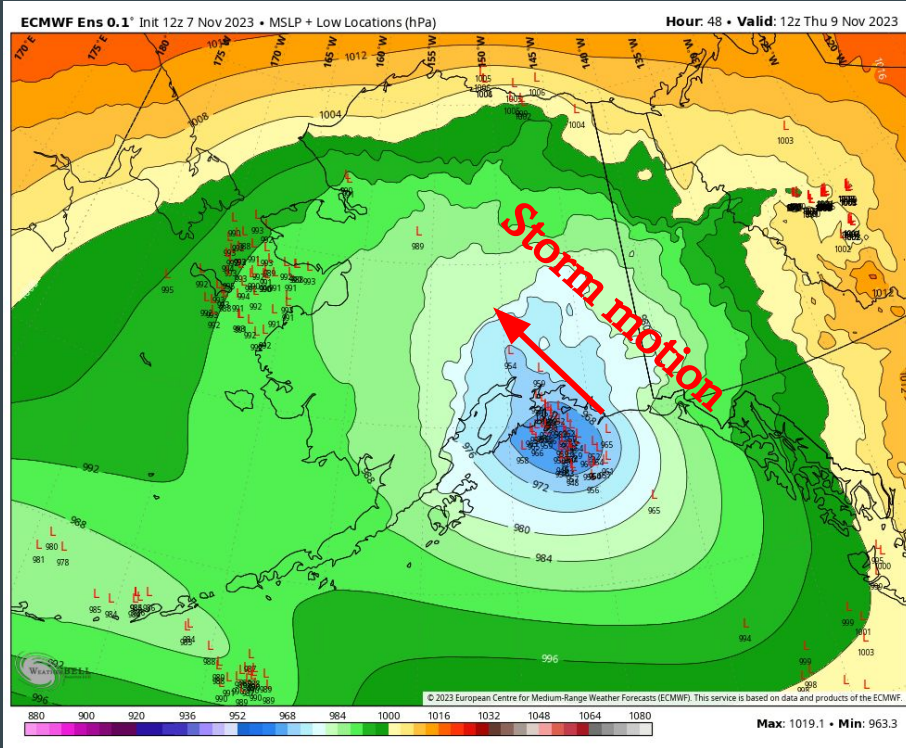
Best Practices--ECMWF Precipitation Type Meteograms

1. Great visual to use when trying to figure out timing of heavier rates or changing characteristics of the precipitation (type etc).
2. 9km effective grid spacing and 50 members makes it a pretty good ensemble for AK
3. Use some caution when looking at raw ptypes and pay attention to the elevation differences between the ensemble terrain and the actual terrain (readout is on chart)
4. It does only use the EC Ensemble...these diagrams don't exist for other ensemble systems.

Local & More Detailed Tools--WxBell Low Locs & Meteograms

- Purpose
 - Low locations provide a snapshot of the spread in storm locations at any point in time
 - Meteograms provide a detailed look at ensemble agreement in:
 - Timing of heaviest precipitation
 - Onset and ending times
 - Spread in expected amounts of liquid precipitation (and 10:1 snowfall)
- Data
 - GEFS (30 members), ECMWF (50 members), CMC (20 members)
- How do I view it?
 - Directly from [WxBell](#) *(Can view the equivalent in DESI but the advantage of WxBell is particularly for the ECMWF...as WxBell has the full 9 km resolution EPS while DESI still uses the degraded resolution EPS)*
- Training
 - You're looking at it!

Local & More Detailed Tools--WxBell Low Locs & Meteograms



How many EC members are forecasting snow as the dominant ptype...assuming a 10:1 ratio what should the range be? Should I assume 10:1?

Best Practices--WxBell Low Locs & Meteograms

1. Use to put ensemble mean MSLP into context (spread and intensity)
2. Use to identify potential high impact outlier scenarios
3. Use to quantify ensemble support for operational solutions
4. Low locations do not = low tracks (time continuity between steps is impossible to determine)
5. Meteograms are from raw ensemble data so take into account resolution in areas of complex topography (use elevation read out on plots)

What is the best tool for forecasting and providing uncertainty information?

The ECMWF EFI



Cluster Analysis



HREF



Your brain



DESI



A Tool By Any Other Name....

- All these tools have great ability to enhance both your internal understanding of uncertainty and how you message it! Both are important!
- No tool is perfect...all have strengths and weaknesses.
- YOU are the expert. Know your meteorology. Know your high impact patterns. Take the time to learn these tools. **It's worth your time!**

Otherwise...

A good tool used improperly can be more dangerous than not having it in the first place!

