Cobb SLR Methodology and Application in NBM v4.1

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Snowfall, a subject I love to talk about

- Diagnosing the Snow-Liquid-Ratio (SLR)
 - Gloud/Sub cloud processes
 - Ground processes
 - └→ Cobb Methodology
- Applications
 - ↓ NBM algorithms
 - Gobb Probabilistic Winter Wx Tool
- Verification Approach
 - Areal approach leveraging CoCoRahs estimates/distributions
 - Isolating NWP snow amount forecast errors (QPF, T/Tv, SLR, WS)

Motivation

- Provide improved forecasts of snowfall in support of winter alerts and provision of IDSS.
- Provide a conceptual model through which forecasters can understand and anticipate the snow ratio and its probable evolution over a given forecast event.
- Support the development of the National Blend of Models (NBM)
- Improve ensemble / probabilistic snowfall forecasts



Original Inspiration (2004)

- Wintertime Cloud Microphysics
 of Baumgardt (NOAA/NWS)
- Crosshair approach of
 Waldstreicher (NOAA/NWS)
- Canadian snow ratio decision tree algorithm by Dubè (Met. Services of Canada)



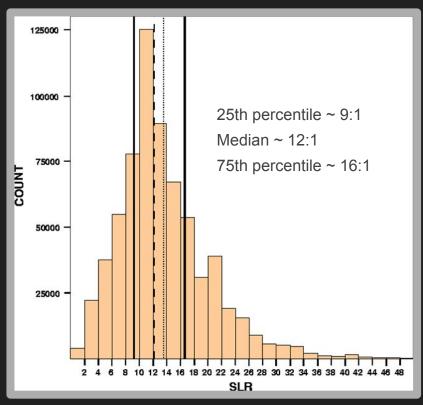
My old house in Presque Isle, ME

What determines the observed Snow Liquid Ratio (SLR)?

The SLR of freshly fallen snow is directly related to its predominant crystalline structure (shape & size of ice crystals)

This structure depends on:

- → In-cloud deposition, accretion, and aggregation f(T, RH, Uvv)
- → Sub-cloud processes such as sublimation, partial melting, aggregation, and refreezing f(T, RH, Uvv)
- → Surface or ground effects of fragmentation, compaction, sublimation, and melting f(T, Tg, RH, Uvv, Wnd, INSOLATION)

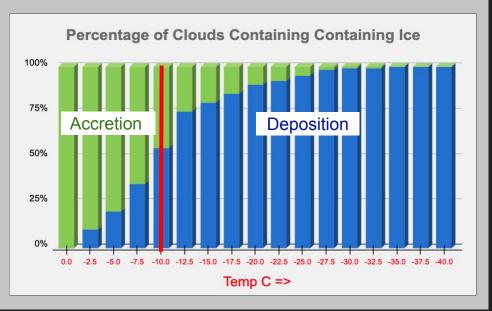


(from Baxter 2005)

Ice Nucleation and Crystal Growth

As a first guess, lack of active ice nuclei at temperatures above -10°C increasingly favor growth via accretion while deposition is favored at colder temperatures.

Silver lodine	-4°C
Copper Sulfide	-7°C
Sea Salt	-8°C
Kaolinite	-9°C
Volcanic Ash	-13°C
Vermiculite	-15°C

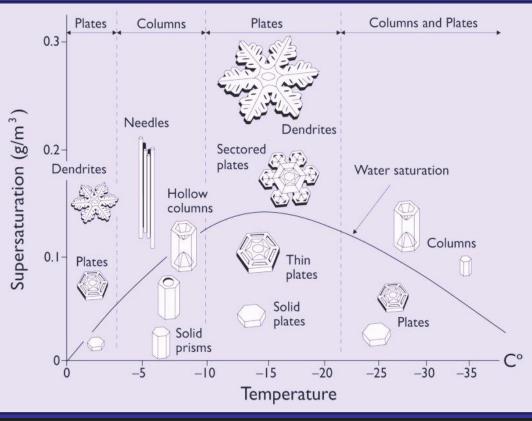


(Adapted from Baumgardt, 1999)

(Adapted from COMET)

Depositional Growth

- Crystal habit is a function of humidity and temperature
- Dendrites (branched plate forms) grow between -12°C and -18°C when RH_W > 100% and are associated with higher SLRs
- Max growth rates are observed around -15°C
- Needles (columnar forms) grow between -4°C and -6°C and may be important in ice multiplication processes

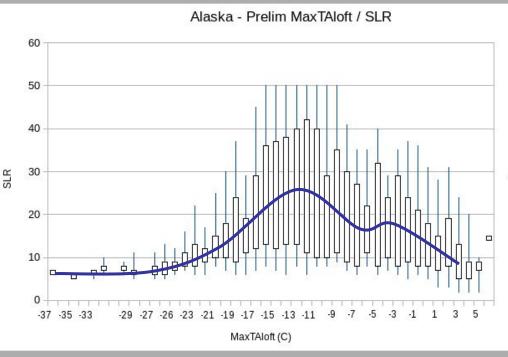


(From Libbrecht, 1999)

Utility of MaxT Aloft as a first Guess - Just Okay?

Based on 1,500 snowfall observations across Alaska with observed wind speeds < 20 mph. Cold ground and low solar elevation minimize effects of surface processes.

- → Relatively low SLRs above 0°C and below -19°C
- → Highest SLR associated with the dendritic growth zone (DGZ) with a secondary max with needles growth near -5°C
- → Largest spread in observed SLRs also associated with dendritic and needle growth



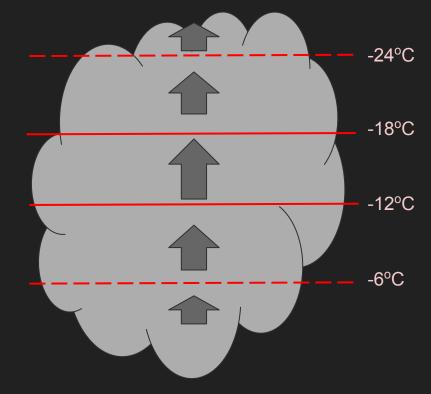
Courtesy Gene Petrescue NWS AK

Observed 30:1 Snow Ratio



Importance of Vertical Motion (Crosshairs Approach)

- Upward vertical velocity (Uvv) maxima along with RH identify precipitation source regions
- Waldstreicher (2001) showed that warning event snowfalls were often associated with the collocation of Uvv maxima with the DGZ
- The colocation inferres greater precipitation efficiency combined with higher SLRs on average
- Lower SLRs were observed when Uvv maxima was below (warmer) than DGZ and lower snowfall amounts overall were associated with Uvv maxima above (colder) than DGZ



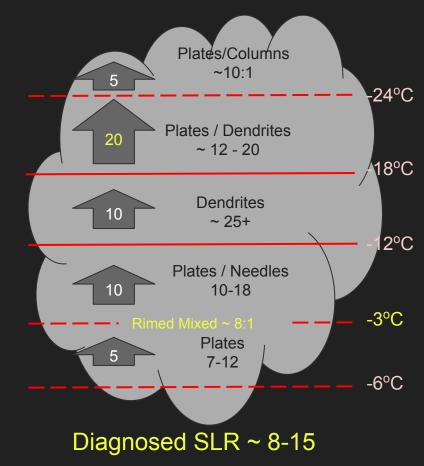
Importance of Vertical Motion (Residence Time)

Terminal Fall V	elocities	A18°C
Cloud Ice	1 - 20 cm/s	1,800 m { 10
Dendrites/Needles	25 - 100 cm/s	-12°C
Mixed aggregates	75 - 125 cm/s	
Rimed, wet, or melting aggregates	100 - 200 cm/s	B18°C
Graupel	150 - 300 cm/s	1,000 m { 30 cm/s 1000
Which scenario will yiel	d a larger resid	lence -12°C

time? (assume a 60 cm/s fall speed)

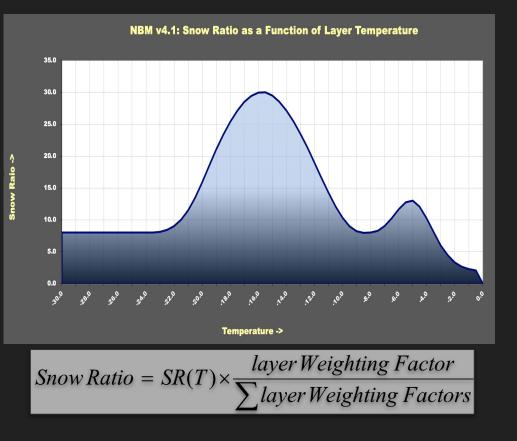
MaxT combined with Crosshair

- Dube (2003) combined the two approaches into a decision tree.
- Approximate SLRs were assigned to discrete temperature range based on expected crystal habit(s)
- First the SLR associated with T of Max Uvv was diagnosed.
- Second the max Uvv was modified by the SLR associated with MaxT
- A colder MaxT along with a Crosshair signature led to higher SLRs
- Overall the Dube approach helps to narrow the range of probable SLRs over using MaxT or snowfall expectations with Crosshair.



Cobb Method

- Generalized the approach of Dube by synthesizing a continuous SLR curve as a function of temperature and successively integrating SLR contribution of each cloud layer.
- Uses a weighting function based on Uvv, RH, and thickness / mass to determine the contribution of each layer
- Results in a "top-down" 2-dimensional continuous SLR diagnosis that can be used to calculate snowfall
- Developed as a Perl script, then AWIPS GFE SmartTool, and presently included in NBM
- Perl script includes P-type diagnosis and surface effects of wind, melting and compaction
- NBM v4.2 code will incorporate melting when Tw > -0.5C.



NBM v4.1 Cobb Method

- Integration from 925 300 mb with vertical resolution of 25 mb with some interpolation depending on NWP dataset
- Incorporate a simple +/- temperature perturbation for calculating layer SLR
- Set downward VV (vertical velocity) to "1" so that saturated layers can still contribute to SLR
- Also a minimum VV of "1" ensures a continuous gridded SLR field
- Use the square root of the VV for VVw (layer VV weight) to limit excessive single layer contribution (primarily a concern w/ CAMS)

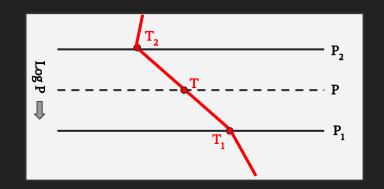
$$SLR = \frac{\sum (SR(T) \times PVVw)}{\sum PVVw} \qquad PVVw = VVw \times RHw \\ RHw = \frac{(RH)^2}{6400} \qquad SR(T) = \left\{ \int_{0}^{0} \int_{0$$

NBM v4.1 Logarithmic Vertical Interpolation for Ensembles

- Applying Cobb to Ensembles (ECMWFe, GEFS, SREF).
 - The vertical resolution of these data sets is limited to mandatory levels for (P, T, and RH). UVV is only available at 700 and 800 mbs for ECMWFe.
 - Logarithmic interpolation is used estimate (P, T, RH, and UVV) at 25 mb intervals between 925 - 300 mb. UVV is assumed to be zero at mandatory levels where it is missing. This interpolation would is the equivalent of picking off data points along a straight line between two temperatures at known levels on a SkewT-LogP diagram

$$\mathbf{y} = \mathbf{y}_{p1} + \left[\frac{y_{p2} - y_{p1}}{\log \frac{P_2}{P_1}}\right] \left[\log \frac{P}{P_1}\right]$$

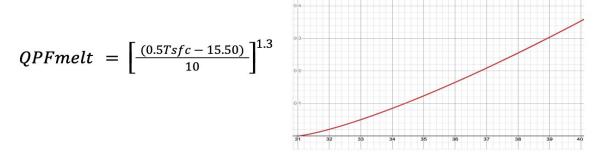
Where y is the variable to interpolate (T, RH, UVV) at level P. P_2 and P_1 are mandatory pressure levels immediately above(below) P where y_2 and y_1 are known.



NBM V4.2 SnowMelt Function for "Warm" Snowfall

Experiment 1: Steps to incorporate SLR correction to account for melting snow:

- Calculate each "cloud base" SLR and blend as previous.
- Calculate potential snow melt for falling snow based on the following equation:



Revise the blended SLR as:

$$SLR_{new} = SLR \times \left[\frac{QPF - QPFmelt}{QPF}\right]$$

If $QPF_{melt} > QPF$ set SLR_{new} to zero, i.e. there will be no snow accumulation.

• Adjust logic to allow for a p-type of snow with temps ≤ 40F.

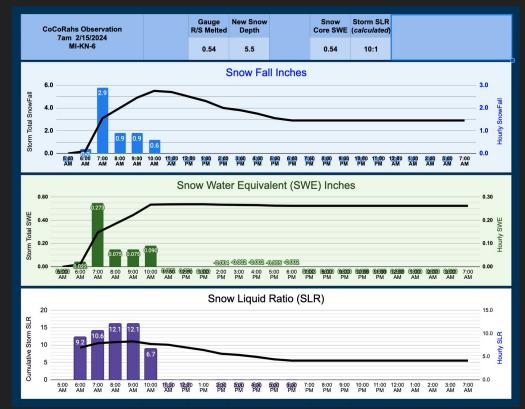
Melting Rates	32F	33F	34F	35F	36F	37F	38F	39F	≥40F
(hourly)	0.02	0.05	0.08	0.12	0.16	0.21	0.26	0.30	0.35

					F	lourl	y Sn	owfa	all Ra	ates	w/ S	Surfa	ce N	lelt F	unc	tion	NBM	v4.′	1					
			(Cloud	SLR =	20:1		Tw 1	Thresh	old =	33F		N	/lelt Fa	ctor =	0		s	ize Fa	ctor =	0			
											Temp	eratu	re (F)											
		30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0		SLR
	0.30	6.0	6.0	6.0	6.0	6.0	6.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	
	0.29	5.8	5.8	5.8	5.8	5.8	5.8	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.29	1 - 2
	0.28	5.6	5.6	5.6	5.6	5.6	5.6	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.28	
	0.27	5.4	5.4	5.4	5.4	5.4	5.4	5.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.27	
	0.26	5.2	5.2	5.2	5.2	5.2	5.2	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.26	3 - 5
	0.25	5.0	5.0	5.0	5.0	5.0	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	
	0.24	4.8	4.8	4.8	4.8	4.8	4.8	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.24	
Ŧ	0.23	4.6	4.6	4.6	4.6	4.6	4.6	4.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.23	6 - 8
Equivalent)	0.22	4.4	4.4	4.4	4.4	4.4	4.4	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.22	
<u>N</u>	0.21	4.2	4.2	4.2	4.2	4.2	4.2	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.21	
dr	0.20	4.0	4.0	4.0	4.0	4.0	4.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.20	9 - 11
	0.19	3.8	3.8	3.8	3.8	3.8	3.8	3.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.19	
ni	0.18	3.6	3.6	3.6	3.6	3.6	3.6	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.18	
. <mark>.</mark>	0.17	3.4	3.4	3.4	3.4	3.4	3.4	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.17	12 - 14
1	0.16	3.2	3.2	3.2	3.2	3.2	3.2	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.16	
ior	0.15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.15	
Precipitation (Liquid	0.14	2.8	2.8	2.8	2.8	2.8	2.8	2.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.14	15 - 17
ipi	0.13	2.6	2.6	2.6	2.6	2.6	2.6	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.13	
Tec	0.12	2.4	2.4	2.4	2.4	2.4	2.4	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	
	0.11	2.2	2.2	2.2	2.2	2.2	2.2	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.11	18 - 20
É.	0.10	2.0	2.0	2.0	2.0	2.0	2.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	
Hourly	0.09	1.8	1.8	1.8	1.8	1.8	1.8	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.09	
-	0.08	1.6	1.6	1.6	1.6	1.6	1.6	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	21 - 23
	0.07	1.4	1.4	1.4	1.4	1.4	1.4	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	
	0.06	1.2	1.2	1.2	1.2	1.2	1.2	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	
	0.05	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	25 - 27
	0.04	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	
	0.03	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	
	0.02	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	27 +
	0.01		0.2	0.2	0.2	0.2	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	
		30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0		
	urly Rate	0.00	0.00	0.00	0.00	0.00	0.00	0.00	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		

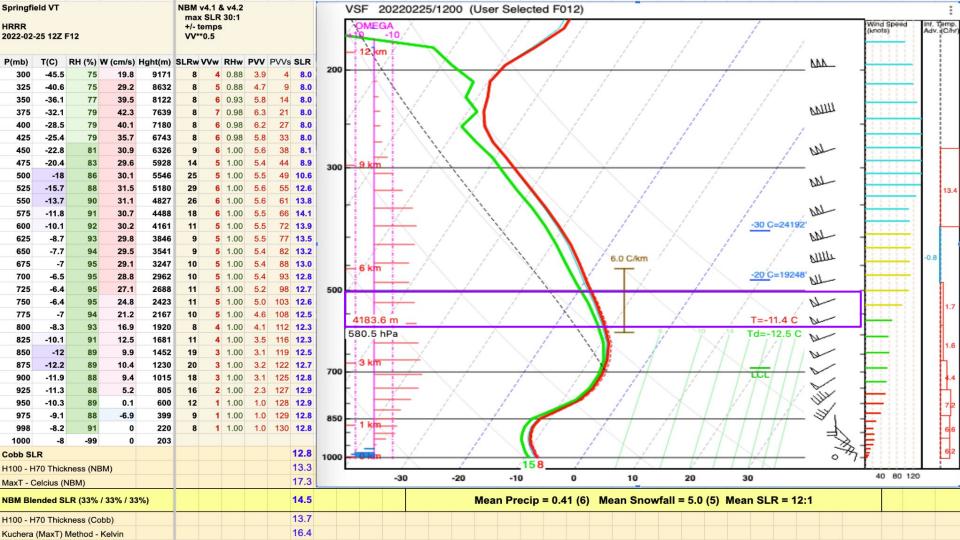
				H	ourly	v Sno	owfal	ll Ra	tes v	v/ Sı	ırfac	e Me	elt Fu	uncti	on P	ropc	bsed	NBN	/I v4 .	.2				
			(Cloud	SLR =	20:1		Tw 1	Thresh	old =	31F		N	lelt Fa	ctor =	15		S	ize Fa	ctor =	1.3			
											Temp	eratur	re (F)											
		30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0		35.0	35.5	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0		SLR
	0.30	6.0	6.0	6.0	5.9	5.8	5.6	5.4	5.2	5.0	4.8	4.5	4.3	4.1	3.8	3.5	3.3	3.0	2.7	2.4	2.1	1.8	0.30	
	0.29	5.8	5.8	5.8	5.7	5.6	5.4	5.2	5.0	4.8	4.6	4.3	4.1	3.9	3.6	3.3	3.1	2.8	2.5	2.2	1.9	1.6	0.29	1 - 2
	0.28	5.6	5.6	5.6	5.5	5.4	5.2	5.0	4.8	4.6	4.4	4.1	3.9	3.7	3.4	3.1	2.9	2.6	2.3	2.0	1.7	1.4	0.28	
	0.27	5.4	5.4	5.4	5.3	5.2	5.0	4.8	4.6	4.4	4.2	3.9	3.7	3.5	3.2	2.9	2.7	2.4	2.1	1.8	1.5	1.2	0.27	
	0.26	5.2	5.2	5.2	5.1	5.0	4.8	4.6	4.4	4.2	4.0	3.7	3.5	3.3	3.0	2.7	2.5	2.2	1.9	1.6	1.3	1.0	0.26	3 - 5
	0.25	5.0	5.0	5.0	4.9	4.8	4.6	4.4	4.2	4.0	3.8	3.5	3.3	3.1	2.8	2.5	2.3	2.0	1.7	1.4	1.1	0.8	0.25	
	0.24	4.8	4.8	4.8	4.7	4.6	4.4	4.2	4.0	3.8	3.6	3.3	3.1	2.9	2.6	2.3	2.1	1.8	1.5	1.2	0.9	0.6	0.24	
nt)	0.23	4.6	4.6	4.6	4.5	4.4	4.2	4.0	3.8	3.6	3.4	3.1	2.9	2.7	2.4	2.1	1.9	1.6	1.3	1.0	0.7	0.4	0.23	6 - 8
Precipitation (Liquid Equivalent)	0.22	4.4	4.4	4.4	4.3	4.2	4.0	3.8	3.6	3.4	3.2	2.9	2.7	2.5	2.2	1.9	1.7	1.4	1.1	0.8	0.5	0.2	0.22	-
, İ	0.21	4.2	4.2	4.2	4.1	4.0	3.8	3.6	3.4	3.2	3.0	2.7	2.5	2.3	2.0	1.7	1.5	1.2	0.9	0.6	0.3	0.0	0.21	0 11
d	0.20	4.0	4.0	4.0	3.9	3.8	3.6	3.4	3.2	3.0	2.8	2.5	2.3	2.1	1.8	1.5	1.3	1.0	0.7	0.4	0.1	0.0	0.20	9 - 11
Ч	0.19	3.8	3.8	3.8	3.7	3.6	3.4	3.2	3.0	2.8	2.6	2.3	2.1	1.9	1.6	1.3	1.1	0.8	0.5	0.2	0.0	0.0	0.19	
qui	0.18	3.6	3.6	3.6	3.5	3.4	3.2	3.0	2.8	2.6	2.4	2.1	1.9	1.7	1.4	1.1	0.9	0.6	0.3	0.0	0.0	0.0	0.18	12 - 14
(Li	0.17 0.16	3.4 3.2	3.4 3.2	3.4 3.2	3.3 3.1	3.2 3.0	3.0 2.8	2.8 2.6	2.6	2.4 2.2	2.2 2.0	1.9 1.7	1.7 1.5	1.5 1.3	1.2 1.0	0.9	0.7	0.4 0.2	0.1	0.0	0.0	0.0	0.17 0.16	12 - 14
u	0.16	3.0	3.0	3.0	2.9	2.8	2.0	2.0	2.4	2.2	1.8	1.7	1.3	1.5	0.8	0.7	0.5	0.0	0.0	0.0	0.0	0.0	0.16	
atic	0.15	2.8	2.8	2.8	2.9	2.6	2.0	2.4	2.2	1.8	1.6	1.3	1.1	0.9	0.6	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.15	15 - 17
pita	0.14	2.6	2.6	2.6	2.5	2.4	2.2	2.0	1.8	1.6	1.4	1.1	0.9	0.7	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.14	
šci	0.12	2.4	2.4	2.4	2.3	2.2	2.0	1.8	1.6	1.4	1.2	0.9	0.7	0.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	
Pr	0.11	2.2	2.2	2.2	2.1	2.0	1.8	1.6	1.4	1.2	1.0	0.7	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	18 - 20
Ņ	0.10	2.0	2.0	2.0	1.9	1.8	1.6	1.4	1.2	1.0	0.8	0.5	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	
Hourly	0.09	1.8	1.8	1.8	1.7	1.6	1.4	1.2	1.0	0.8	0.6	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.09	
Ĩ	0.08	1.6	1.6	1.6	1.5	1.4	1.2	1.0	0.8	0.6	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.08	21 - 23
	0.07	1.4	1.4	1.4	1.3	1.2	1.0	0.8	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.07	
	0.06	1.2	1.2	1.2	1.1	1.0	0.8	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.06	
	0.05	1.0	1.0	1.0	0.9	0.8	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.05	25 - 27
	0.04	0.8	0.8	0.8	0.7	0.6	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.04	
	0.03	0.6	0.6	0.6	0.5	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.03	
	0.02	0.4	0.4	0.4	0.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.02	27 +
	0.01	0.2	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	
		30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0		
	urly Rate	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.15	0.16	0.18	0.19	0.21		

Relating Event SLR to incremental observed SLRs

- While hourly SLRs may vary considerably over an event the event or storm SLR will be reflective of the period with the highest precipitation rates.
- As a first guess then, an individual SLR diagnosis at the time of max precipitation rate will be representative of the overall event SLR.



Aberdee	en, SD. (H	KABR)			NBM V	4.1 8 SLR					KABR 20221214/0000 (User Selected F024) NBM v4.1: Snow Ratio as a Function of Layer Temperature
12-13-20)22 00Z (F	F24) NA	W 3			emps					100 OMEGA ±195 km1
P(mb)	T(C) I	RH (%)	W (cm/s)	Hght(m)	SLRw V	wVv	RHw	PVV	PVVs	SLR	
300	-48.6	27	-3	8982	8	1	0.11	0.1	0	8.0	
325	-45.2	29	-4.1	8452	8	1	0.13	0.1	0	8.0	
350	-41.7	42	-3.9	7954	8	1	0.28	0.3	1	8.0	
375	-37.8	54	-3.7	7483	8	1	0.46	0.5	1	8.0	
400	-33.4	29	-3.5	7034	8	1	0.13	0.1	1	8.0	
425	-29.5	15	-5.5	6605	8	1	0.04	0.0	1	8.0	
450	-26.4	31	-6.4	6195	8	1	0.15	0.2	1	8.0	200 / / / / / / / / / / / / / / / /
475	-23.7	46	-4.8	5802	8	1	0.33	0.3	2	8.0	Temperature >
500	-20.8	31	-1.1	5425	13	1	0.15	0.2	2	8.4	
525	-17.8	31	1.3	5063	26	1	0.15	0.2	2	9.9	
550	-15	49	3.5	4713	29	2	0.38	0.7	3	15.0	
575	-12.5	64	5.6	4375	21	2	0.64	1.5	4	17.2	300 9 km
600	-10.7	81	7	4049	13	3	1.00	2.6	7	15.7	
625	-8.8	95	8.2	3733	9	3	1.00	2.9	10	13.6	
650	-6.2	99	10.1	3428	11	3	1.00	3.2	13	12.9	
675	-4.5	99	11.5	3132	11	3	1.00	3.4	16	12.5	
700	-3.2	98	10.2	2844	7	3	1.00	3.2	19	11.6	Fill i / / / / / / / / / / / / / / / / /
725	-4.4	98	9.8	2567	11	3	1.00	3.1	23	11.5	64m
750	-5.7	99	11.4	2300	12	3	1.00	3.4	26	11.5	
775	-4.9	99	10.1	2043	12	3	1.00	3.2	29	11.5	500
800	-4.9	99	9.8	1793	12	3	1.00	3.1	32	11.5	
825	-5.6	98	7.6	1551	12	3	1.00	2.8	35	11.5	
850	-5.7	99	6.2	1317	12	2	1.00	2.5	37	11.5	
875	-4.8	99	4.4	1089	11	2	1.00	2.1	40	11.5	
925	-2.2	99	1	650	4	1	1.00	1.0	41	11.4	
950	-0.4	96	0	437	2	1	1.00	1.0	42	11.1	
955	-0.1	95	0	396	1	1	1.00	1.0	43	10.9	
1000	2.3	-99	0	26	0	1	1.53	1.5	44	10.5	
					1	1	0.00	0.0	44	10.5	
											1000 31
Cobb SL	R								1	0.5	
H100 - H	70 Thickr	ness (NE	SM)						1	0.5	-50 -40 -30 -20 -10 0 10 20 30 40 50 40 80 120
	Celcius (N									2.3	
NBM Ble	ended SL	R (33%	/ 33% / 33	%)						7.8	Mean Precip = 0.56 (3) Mean Snowfall = 4.5 (3) Mean SLR = 8:1
H100 - H	70 Thickr	ness (Co	bb)						1	0.4	
	(MaxT) M									3.4	



Grand R	apids, N	AI .					& v4.2 30:1				KGRR	202	20240215/1200 (User Selected F012)	
01-28-20	23 12Z ((F16) HRR	R			emps					OME +10	19.	2 Wind Speed Inf. Adv	Temp. . (C/hr)
P(mb)	T(C)	RH (%) V	/ (cm/s)	Hght(m)	SLRw	VVw	RHw	PVV P	VVs SLR			AN		1
300	-56.7	67	19.5	8918	8	4	0.00	0.0	0 0.0		1			1
325	-51.9	64	28.4	8406	8	5	0.00	0.0	0 0.0		1			1
350	-47.5	68	31.5	7921	8	6	0.72	4.1	4 8.0		- /			i i
375	-43.2	72	31.9	7461	8	6	0.81	4.6	9 8.0		1			1
400	-39.3	76	29.7	7022	8	5	0.90	4.9	14 8.0				8.0 C/km	1
425	-35.5	79	25	6604	8	5	0.98	4.9	18 8.0		🗕 6 km	+		h l
450	-32	80	20.4	6204	8	5	1.00	4.5	23 8.0				-30 C=19587'	
475	-28.7	82	19.6	5819	8	4	1.00	4.4	27 8.0			-		
500	-25.7	87	22.9	5449	8	5	1.00	4.8	32 8.0	500		$\langle 1/$		
525	-22.8	91	27.8	5094	9	5	1.00	5.3	37 8.1			X		1°
550	-20.2	95	36.3	4751	15	6	1.00	6.0	43 9.1			4		
575	-17.8	98	44.1	4420	26	7	1.00	6.6	50 11.3		-1 X		<u>-20</u> C=15496'	
600	-15.7	98	50.6	4100	29	7	1.00	7.1	57 13.5			-		
625	-13.8	98	54.9	3791	26	7	1.00	7.4	65 15.0		1			
650	-12.2	98	56.4	3493	20	8	1.00	7.5	72 15.5		7			1.9
675	-10.5	98	54.1	3203	13	7	1.00	7.4	79 15.2					
700	-8.7	99	49.8	2922	9	7	1.00	7.1	87 14.6		- 1			8
725	-6.9	99	39.6	2649	10	6	1.00	6.3	93 14.3		- 3 km			
750	-5.3	99	28.5	2383	12	5	1.00		98 14.2	70				1.6
775	-4.1	99	16.4	2125	10	4	1.00		102 14.0			1		
800	-2.8	99	7	1874	6	3	1.00		105 13.8			4		
825	-1.6	99	1.2	1629	3	1	1.00		106 13.7					1.3
850	-1	98	-2.1	1391	2		1.00		107 13.6		- /			
875	-1	97	-4.6	1160	2	1	1.00		108 13.5		1/1			
900	-1.8	94	-6.5	935	4		1.00		109 13.4	850		-		2.0
925	-2.2	92	-6.9	717	4				110 13.3		- 1 km			n l
950	-1.8	92	-4.4	505	4		1.00		111 13.2		-			4.0
975	-1.1	95	0.1	298	3		1.00		112 13.1					
984	-1	97	0	225	2	1	1.00	1.0	113 13.0		— 0 km			8.0
1000	-0.1	-99	0	96						1000		1	<u>∕ X 301 / X / // × </u> [[]]	13.2
Cobb SL			0						13.0 9.8		- 1	1		
		ness (NB	vi)						7.8		-	-20	0 -10 0 10 20 40 80 120	-
MaxT - C		NBM) LR (33% /	33% / 33	%)	-				10.2				Mean Precip = 0.25 (9) Mean Snowfall = 3.5 (6) Mean SLR = 14:1	
-		5 0.000 M	mini	,					9.5					
		ness (Cob												
Kuchera	(MaxT)	Method - K	elvin						10.0					

IRRER INDERSIGNATION	Grand Ra	pids MI	F			NBM v					KGRR 20220225/0800 (User Selected F008)	
100 43.4 6 12.6 898 8 4 0.01 0.0 0.0 25 40.3 12.6 84.6 8 4 0.0 0.0 0.0 350 37.5 4 11.8 776 8 3 0.0 0.0 0.0 0.0 400 31.0 27.6 8 3 0.0 0.0 0.0 0.0 400 31.0 27.6 8 3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	HRRR 2022-02-2					+/- te VV**(mps D.5				Vindu +10 -11 -15 km	Speed Inf. Temp. Adv. (C/hr)
25 40.3 5 22.6 845. 6 4 0.00 0.0 0.0 357 35.6 3 112 747. 4 1.6 700 0.0 0.0 0.0 375 35.6 3 110.6 705.8 3 0.00 0.0 0.0 0.0 425 32.8 1 10.1 654.7 8 3 0.00 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 </th <th>P(mb)</th> <th>T(C)</th> <th>RH (%) V</th> <th>V (cm/s)</th> <th>Hght(m)</th> <th>SLRw V</th> <th>/Vw R</th> <th>Hw P</th> <th>VV P</th> <th>VVs SLR</th> <th>\mathbf{R}</th> <th></th>	P(mb)	T(C)	RH (%) V	V (cm/s)	Hght(m)	SLRw V	/Vw R	Hw P	VV P	VVs SLR	\mathbf{R}	
395 37.5 4 11.8 744 8 3 0.00 0.0 0 0.0 400 31.9 1 10.6 7073 4 11.8 74.4 0 3 0.00 0.0 0 0.0 400 31.9 1 10.6 7073 4 3 0.00 0.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	300	-43.4	6	12.6	8996	8	4 0	.01	0.0			
77 3.46 3 112 747 3 6 3 0.00 0 0.0 73 3.6 1 10 673 6 3 0.00 0 0.0 73 228 1 10.1 654 8 3 0.00 0 0.0 745 221 30 6.7 6 3 0.0 0.0 0.0 0.0 747 27.1 30 6.7 6 3 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 <	325		5			8	4 0	.00	0.0			
400 319 1 106 701 8 3 000 00 0 00 425 284 1 101 1684 6 3 000 00 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	350	-37.5	4	11.8	7946	8			0.0	0 8.0		
125 228.8 1 101.1 654 8 3 0.00 0 8.0 405 227.1 39 6.7 578 6 3 0.20 0.00 0.80 500 228.6 69 4.6 6416 8 2 0.77 18 2 0.00 18.0 500 22.5 95 3.4 479 11 2 100 12.6 6 4.6 417 2 1.00 18.6 6 6.8 6 4.6 417 2 1.00 2.0 1.6 5.8 6 4.07 1.8 6 8.6 6 6 4.7 7.7 7.7 9.5 3.465 2.2 3.100 3.2 10.0 3.2 10.0 3.2 10.0 3.2 10.0 3.2 2.0 2.0 2.2 7.3 10.0 3.2 2.0 2.0 7.7 7.7 3.0 3.2 2.0 2.0 7.7 7.7 3.0 3.2 2.0 2.0 1.0 3.2 2.0 2.0	375	-34.6	3	11.2	7467	8	3 0	.00	0.0	0 8.0		
422 238 1 1 10.1 6654 8 3 0.00 0 0 6 8.0 476 22.7 1 39 6.7 577 8 3 0.02 0 0 0 8.0 476 27.1 39 6.7 577 8 3 0.24 0 6 1 8.0 500 25.6 6 4.6 5716 8 2 0.074 16 2 8.0 500 25.6 6 4.6 7417 11 2 0.0 18 6 8.8 575 13.1 39 7.8 3764 28 3 100 2.0 8 118 500 16.5 94 6 0 707 29 2 100 2.4 10 15.9 500 16.5 94 6 0 707 29 2 100 2.4 10 15.9 500 16.5 94 6 0 707 29 2 1 00 2.4 10 15.9 500 16.5 94 6 0 707 29 2 1 00 2.4 10 15.9 500 16.5 94 6 0 707 29 2 1 00 2.4 10 15.9 500 16.5 94 6 0 707 29 2 1 00 2.4 10 15.9 500 16.5 95 1.4 2 95 11.2 227 3 100 3.3 2 19.3 500 17.5 95 11.2 227 2 1 3 100 3.3 2 19.3 500 13.5 95 11.2 227 2 1 3 100 3.3 2 19.3 500 13.5 95 11.2 227 2 1 3 100 3.3 2 19.3 500 13.5 95 11.2 227 2 1 3 100 3.3 4 30 17.9 500 13.5 95 11.2 227 2 5 1 100 2.4 10 13.9 500 13.5 95 11.2 227 5 1 100 3.4 30 17.9 500 13.5 95 11.2 227 5 1 100 3.4 30 17.9 500 13.5 95 12.2 128 2.0 5 110 0.24 40 17.9 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 17.9 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 17.9 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 17.9 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 17.9 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 128 2.0 5 10 0.32 4 30 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 12.2 1492 2.7 5 100 3.2 4 40 2.7 500 13.5 95 10.0 2.4 40 2.7 500 13.5 98 0 .2 5.7 13 10 10.0 1.5 5 2.21 500 1.5 8.7 500 1.5 8	400	-31.9	1	10.6		8	3 0	.00	0.0			
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500	-26.7	55	2	5438	8		0.47			8.0	1		1	NY.		1	$\langle \ \rangle$	1	1	1	1	1			
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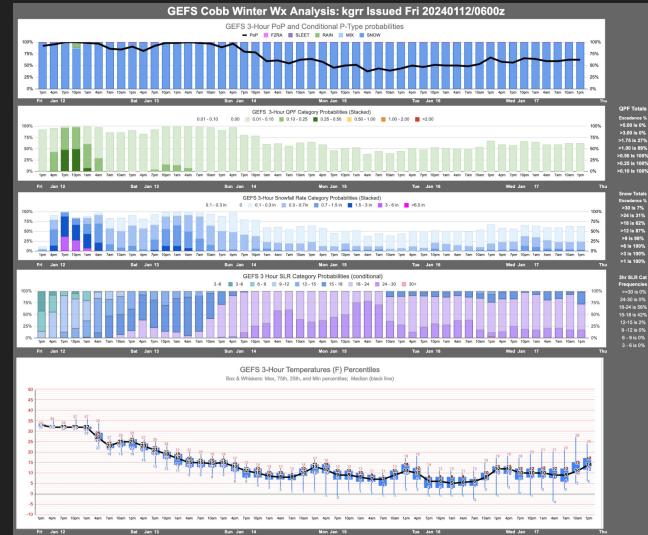
Cobb Winter Wx Tool Applied to Time-Lag GEFS KGRR Forecast from 06/00z Jan 12, 2024

- Utilizes full vertical resolution of BUFR/Bufkit files for GEFS / GFS
- Uses latest GEFS/GFS (32 members) + previous run (T- 6hr) for total of 64 members
- Processing includes Ptype, SLR, SN/IP/ZR accumulations
- Provides a hands-on approach to understanding ensemble probabilities
- Allows isolation of snowfall components (SLR, QPF, Temp, Wind, etc)



KGRR Jan 12, 2024

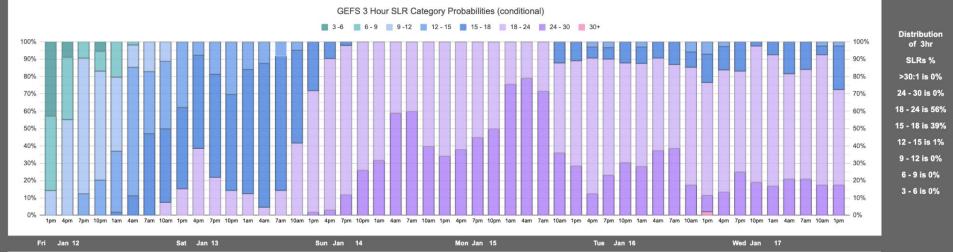
- Significant Winter Wx potential with initial synoptic storm followed by several Days of Lake Effect potential
- Dashboard provides overview of potential through the week



GEFS SLR for kgrr Issued Fri 20240112/0600z

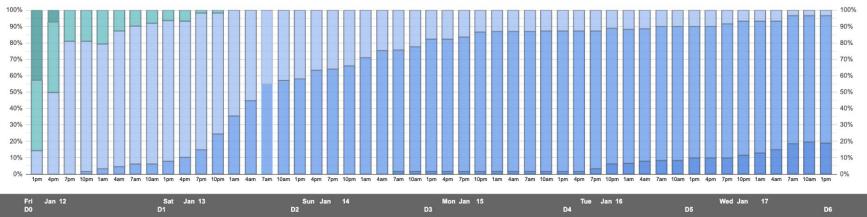
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GEFS Cobb Winter Wx Analysis: kgrr Issued Fri 20240112/0600z



GEFS Cumulative (snow core) SLR Category Probabilities (conditional)

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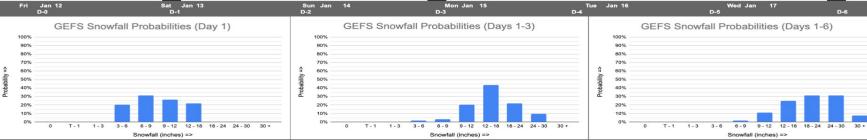


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GEFS P12 GEFS P13			1.0 2.8					0.		2 0			0.6		0.4	0.2		E 0.2	0.2							.2 0.2			.2 0.2	0.2	0.2 0.3	2 0.3	0.3		0.2		0.2 0.4	0.9	0.2			0.2 0		15 24
GEFS P14			1.8				.1 0	.1 0.	.4 0.	0.	2 0.5	0.0	0.3	0.3	0.4	0.2 (0.2 0	.2 0.2	0.2		0.5	0.2	0.2	0.4	J.40 G	.4 0.0	0.0	0.5 0.	0.2	0.2	0.3 0.1	2					.9 0.2				0.5	1.7 1.		14
GEFS P15	0.0	0.9	2.4	2.2		1.0 0	.2	0 0	0.3	2 0.	2 0.2	0.2	0.3	0.5	0.4	0.2 ().2	.0 0.0	6.8			0.0	0.3	0.3	0.2	0.0	0.0	0.0 0.	.3 0.0			0.0			0.0	0.0 0	0.0	0.0		0.3				11
GEFS P16	_		2.4						.5 0.4	.4 0.												0.2	0.2	0.3	C	.3 0.3	0.3	0.3				0.3	0.2	0.2	0.2	0.4 0	.4 0.7	7 0.6	0.2	0.2				18
GEFS P17 GEFS P18	0.0		3.9 1.1				0		1 0	2 0			0.8									0.2	0.2	0.2							0.2 0.3	2 0.2			0.2	02 0	2 02	0.2			0.2	0.2		13 11
GEFS P19	0.0																								0.2 0	.2 0.3	0.3	0.3	0.2		0.3 0.4		0.4		0.0	0.0 0			0.7	0.8	0.2			24
GEFS P20			2.9	2.6	1	1.2 (.3 0	.3 0.	.5 0.	.3 0.4	4 0.6	0.8	0.9	0.5	0.5	0.3 (.4 0	.2 0.2	0.2	0.2	0.5	0.5	0.4	0.4 (0.5 0	.8 0.5					0.1								0.9	0.7	0.7	0.5 0	.4	24
GEFS P21 GEFS P22	1.5	0.7	2.4						0 0				0.2					4 0.5	0.2	0.5	0.4	0.2	0.2	0.2	12 0	0.3	0.2		.2 0.2		0.2 0.1							3 0.4 2 0.5		0.2	0.2	0.2 0	.2	9 32
GEFS P23	1.5	0.7							.0 1.																				.2 0.2									4 0.6		0.2	0.3	0.3 0	.3	32 19
GEFS P24			2.5							2 0.	2 0.5	0.8	0.6	0.5	0.3	0.2 (0.2 0	.2 0.2			0.3	0.5	0.4			0.3				0.2			0.2			0.2 0	.2 0.3	3 0.4	0.2	0.2	0.2			14
GEFS P25	0.0		2.2										1.4					.6 0.4	0.2	0.4		0.3	0.2				0.0	0.3					0.2	0.2	0.2	0.2 0	.2					0.3 0		17
GEFS P26 GEFS P27			1.8										0.5					6 0.4	0.3	0.3	0.3	0.2	0.2	02 (12 0	.3 0.3					0.1	2 0.2	0.2	0.2	0.2	0.2 0	12			0.7		0.2 0		12 25
GEFS P28	0.2		5.4	2.6	3.1	1.0				0.	5 0.8	1.1	1.0	0.5	0.4	0.4 (0.4 0	.2					0.2							0.3								2 0.3		0.0	0.2	0.2 0		22
GEFS P29	0.0		3.6	2.4	6.0	0.2	0	.4 0.	.3 0.4	4 0.	5 1.1	1.4	1.3	1.1	0.7	0.6 (0.6 0	.4 0.5	0.2	0.5	0.2	0.2					0.5	0.5 0.	.3 0.2								0.2	2 1.0		0.0	0.0	0.0 0		21
GEFS P30 GFS-6		0.6	2.8										0.7											0.2 (0.2 0	.2					0.2 0.5	5 0.5	0.4	0.5		0.2	2		0.2	0.4		0.4 0		24 15
GEFS C00-6		1.1																		0.2	0.2	0.2	0.2	0.2	0.3 0	.3 0.3	0.2	0.3	0.2	0.2	0.2 0.1	2 0.2	0.2		0.2		.3			0.9		0.2 0		15 27
GEFS P01-6			3.6	4.3	0.5	0.6 (.1 0	.5 0.	2 0.	2 0.	6 0.4	0.1	0.3	0.3	0.4	0.5 (.6 0	.6 0.6	0.4	0.2	0.2	0.2	0.2	0.2	0.2 0	.2 0.0	0.0	0.3 0.	.2 0.2								.4 0.4	4 0.2				0.4 0		23
GEFS P02-6		0.9						.2 0.	.7 0.:	.3 1.								.2 0.2	0.2	0.2	0.4	0.4	0.4	0.4	0.2 0	.3 0.2	0.3	0.3 0.	.2	0.2						0.2		0.2	0.7	0.2	0.2	0.2 0		22
GEFS P03-6 GEFS P04-6	1010	0.8	1.8 3.6					2 0	3 0	2			0.5					5 0 5	0.5	0.3	0.5	0.3	0.2	0.3		3 0.2	0.3								0.2		.2	4 0.2	0.2					10 27
GEFS P05-6			1.1		0.0								0.9												0	.2	0.5	0.3							0.2	0.4 0		0.2		0.3	1.0	0.2 0		15
GEFS P06-6		0.8				1.3 (.8 0	1.5 0.	.8 0.	.8 1.	4 1.2	1.4	1.0	8.0	0.5	0.4 (0.4 0	.2 0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.4 0	.4 0.3	0.3	0.3 0.					0.2	0.2		0.2 0	.2 0.2					0.		30
GEFS P07-6	0.0		4.1							0.			0.2				0.2		0.0	0.0									0.2		0.2 0.1		0.0	0.0	0.0	0.0	4 05			0.2		4.0		13 22
GEFS P09-6	1000		2.5 7.1																			0.5	0.5	0.5	0.5 0	4 0.4				0.2	0.2 0.4	2 0.1	0.2	0.2	0.2	0.2 0		0.2		0.2	0.0	1.0 0		27
GEFS P10-6		1.0											1.3																									5 0.7		0.2				19
GEFS P11-6	0.6		2.5													0.0		0.0	0.0	0.0	1.0					0.2		0.2 0.	.2 0.2	0.2	0.2 0.1	2 0.2	0.2	0.2				0.0		0.2	0.0	6.6 6		15
GEFS P12-6 GEFS P13-6		0.8											1.0 4.1															0.3	0.2	0.5	0.5 0.8	0.5	0.5	0.3		0.2 0		2 0.5			0.2	0.4 0.		25 33
GEFS P14-6			4.1										0.6									0.2	0.5	0.3	0.2 0	.2 0.3		0.5	0.2	0.5	0.0 0.1	0.0		0.3			1.9		1.4	0.0	0.2	0.2 0.		17
GEFS P15-6).2 0									.4 0.3		0.2		0.1	0.1 0.1	2 0.2	0.5	0.5	0.2	0.2 0	.2	0.4	0.4	0.2	6.6	0.2 0		21
GEFS P16-6																		0 00										0.	.2									0.5	_	1.6	1.3	0.4 0		15
GEFS P17-6 GEFS P18-6		1.1	0.8										0.3							0.7	0.5	0.2	0.2	0.2												0.2 0	.3 0.2	0.5	0.4	0.4	0.5	0.1	- 12	10
GEFS P19-6																									0.4 0	.5 0.4	0.2	0.2 0.	.2 0.0		0.2 0.3	3 0.5	0.2	0.2	0.3	0.5 0	.5 0.3	0.2	0.4	0.0	0.0	0.2 0	.2	22
GEFS P20-6		1.4	2.4	- 9	2.4	2.9 (.9 0	.5 0.	.7 0.:	2 0.	4 0.8	1.1	1.1	0.6	0.1	0.2 (0.2 0	.2 0.2		0.2	_	0.2	0.2												0.2	0.2		0.5	1.6	0.7	0.5	0.2 0		21
GEFS P21-6																													.5 0.5 .2 0.2		0.5 0.5	5 0.3		0.3			.5 0.2	0.3	0.3	0.3	0.0	04 0		32 26
GEFS P23-6	0.2																												.5 0.5		0.5 0.5	5 0.5					.8 0.5	0.9	0.6	0.4	0.2	0.4 0.		31
GEFS P24-6		0.2	2.0	2.3	0.8	0.3 0	.3 0	.5 0.	.3 0.	.5 1.	3 0.8	0.6	0.8	0.6	0.5	0.6 (0.4 0	.2 0.2		0.2	0.2	0.2	0.2	0.2 (0.3 0	.3 0.2	0.5	0.5 0.	.2 0.2	0.2	0.2 0.4	4 0.4	0.5	0.5	0.3	0.3 0	.2 0.6	5 1.1	0.4	0.3		0	.2	22
GEFS P25-6 GEFS P26-6			4.8		0.9																0.5	0.5	0.5	0.2 (0.2 0	.2 0.5	0.5	0.2 0.	.2 0.2									0.2			0.0	0.2 0		25
GEFS P26-6 GEFS P27-6		1.7	3.2										0.6					.5 1.4	0.5	0.2			0.3						0.2	0.2	0.4 0.4	0.2	0.2	0.2	0.2	0.4 0	.4 0.2				0.2	0.2		22 14
GEFS P28-6	0.1	0.8											1.3					.4 0.2		0.3		0.3	0.5	0.3 (0.2 0	.3 0.2	0.4	0.4 0.	.2 0.2	0.2	0.2 0.4	4 0.2	0.2	0.4	0.2	0.2 0	.4 0.6	6 0.7	0.7	0.5	0.3	0.5 0		27
GEFS P29-6	0.0	0.9	3.3	4.7	3.1	1.8 0	.7 0	.5 0.	.5 0.	.3 0.	3 0.5	0.3	0.3	0.3	0.5	0.3 (0.4 0	.5 0.5			.0.0					.0 0.0										0.2 0	.2 0.2	0.0		0.3		0.01 0		21
GEFS P30-6		1.4	3.5	3.0	0.6	1.4 0	.6 0	.2 0.	.3 0.	2 1.	1 2.2	1.0	0.6	0.6	0.2	0.2 (0.2 0	.2		_	_	0.3	0.3	0.2	0.2 0	.4 0.4	_	_	_	_	_	_	_	_	_	_	_	_	0.5	0.5	2.6	0.9 0	.4	24

GEFS Cobb Winter Wx Analysis: kgrr Issued Fri 20240112/0600z



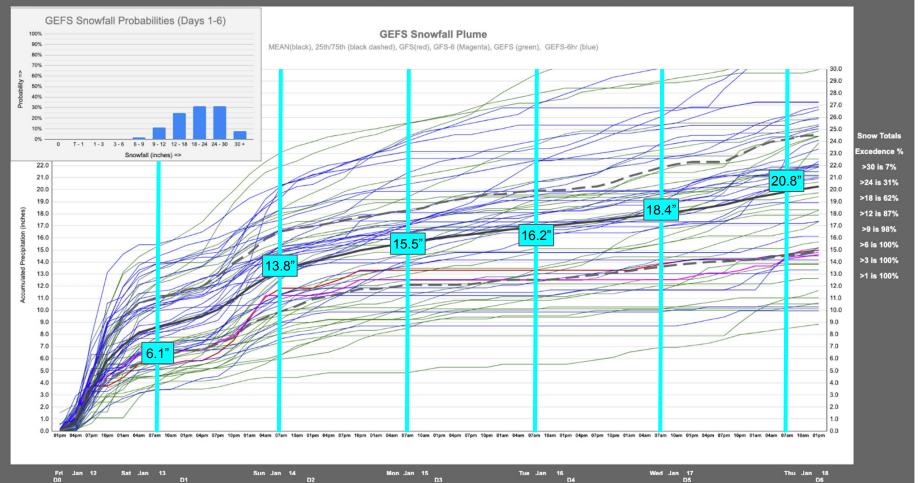
Snow Totals Excedence % >30 is 7% >24 is 31% >18 is 62% >12 is 87% >9 is 98% >6 is 100% >3 is 100%



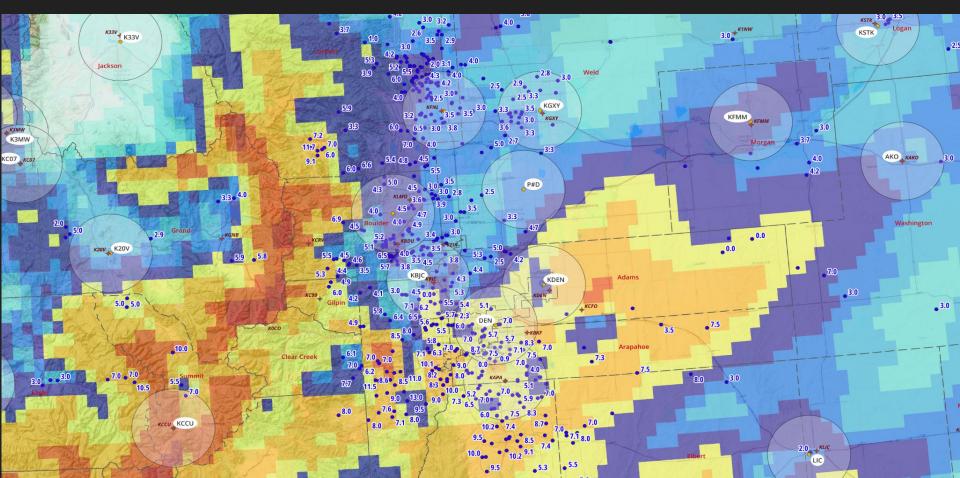
Cobb Winter Wx Tool Applied to Time-Lag GEFS KGRR Forecast from 06/00z Jan 12, 2024

		20240112/0600z			GEFS 3-Hour Sno	wfall Rates for kgrr Issued Fri 20	240112/0600z		
			Fri Jan 10	Sat Jan 12	Sun Jan	14 Mon Jan 15	Tue Jan 16	Wed Jan 17	Thu Stor
Fri Jan 12 Sat	Ja 13 Sun Jan 14 Mon Jan 15	Tue Jan 16 Wed Jan 17	Thu Totals LT 1pr 4pr 7pr 1	10pm 1am 4am 1 m 10am 1pm 4pr 7p	pm 10pm 1am 4am 7am 0am 1pm 4pm	7pm 10pm 1am 4am 7am 10am 1pm 4pm 7pm 10pm 1am	4am 7am 10am 1pm 4pm 7pm 10pm 1am 4a	em 7em 10em 1pm 4pm 7pm 10pm 1em 4	4am 7am 10am 1pm Tota
LI 1pr 4pm /pm 1upm 1am 4am / m 1uam 1pm crs 0.0 0.08 0.35 0.36 0.08 0.08 0.1 0.02	4 n /ph tupm tam kam /am luam tpm kpm /pm tupm tam kam ram tuam tpm kpm /pm tupm tam - 0.04 0.07 0.12 0.11 0.05 0.01 0.02 0.02 0.03	aam zaam tuaam tipm 4pm 7pm tupm taam 4aam 7aam tuaam tipm 4pm 7pm tupm taam 4aam 7aam tua 0.01 0.01 0.01 0.01 0.01	1 0.01 1.34 GEFS COO 0.4 3.0	44 1.7 1.2 0.5 0.3 0.3 02	0.3 0.8 1.1 0.8 0.5 0.2 0.2 0.4	0.2 0.4 0.2 0.2 0.2 0.2 0.2 0.2 0.3	0.3 0.3 0.3 0.2 0.2 0.2 0.2 0.2	0.2 0.2 0.2 0.2 0.2 0.2 0.3	0.2 0.2 22
F5 C00 0.0 0.05 0.27 0.37 0.15 0.09 03 0.02 0.02	01 8.02 8.05 8.08 8.05 8.03 8.01 8.01 8.02 8.01 8.02 8.01 8.01 8.01 8.01 8.01 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.56 GEFS PO1 0.8 1.9	1.9 0.4 0.8 0.1 0.2 0.4 03 1.5 1.7 0.6 0.5 0.7 07	07 1.2 1.8 1.4 1.1 0.9 0.7 0.4 1.8 1.5 2.9 1.8 1.0 0.4 0.4 0.2	0.2 0.2 0.3 0.5 0.2 0.2 0.3 0.3 0.2 0.4 0.3 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.3 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.2 0.3 0.2 0.5 0.5 0.5 0.4 0.2 0.3 0.2 1.3 0.5	0.2 0.7 0.5 23
PSPE2 0.0 0.03 0.06 0.15 0.15 0.05 0.05 0.03 0.04	14 8.18 0.11 8.16 8.18 8.06 8.02 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0	0.01 0.01 0.01 0.01 0.01 0.03 0.03 0.02 0.01 0.01 0.01 0.01 0.01 0.01 0.01	2 0.02 1.60 0EFS Pos 0 1.2 3.1	3.4 1.9 2.0 0.6 0.2 0.5 0.3	0.2 0.6 1.5 0.6 0.5 0.3 00 0.2	0.2 0.4 0.3 0.5 0.5 0.6 0.6 0.4 0.7 0.7 0.5	0.5 0.3 0.5 0.5 0.2 00 00 00	0.2 0.2 0.2 0.0 0.0 0.0 0.0	00 0.3 00 0.2 26
ESP63 0.0 0.12 0.28 0.28 0.16 0.13 0.4 0.01 0.03	02 0.01 0.04 0.09 0.04 0.03 0.02 0.01 0.01 0.02 0.01 0.02 0.03 0.03 0.02 0.03 0.03 0.02 01 0.03 0.08 0.09 0.06 0.05 0.02 0.01 0.01 0.01 0.01 0.01	0.02 0.01 0.02 0.02 0.01 0.01 0.01 0.01	0.01 1.77 0EFS PM 0.6 1.5 2 0.02 1.29 0EFS PM 0.6 2.1	3.8 3.0 1.8 1.9 0.4 0.5 C	0.5 1.2 1.4 1.0 0.8 0.3 0.2 0.9 1.0 1.4 0.8 0.8 0.7 0.6 0.6	0.7 1.5 0.7 0.6 0.7 0.5 0.5 0.4 0.5 0.9 0.9	0.7 0.7 0.5 0.4 0.5 0.3 0.5 0.2	0.2 0.4 0.2 0.4 0.4 0.4 0.4 0.4 0.4 0.4 0.4	0.4 0.5 0.4 0.5 18
75 Pes 0.0 0.07 0.21 0.38 0.27 0.13 06 0.02 0.03	03 0.06 0.07 0.09 0.05 0.05 0.04 0.03 0.03 0.07 0.03 0.03 0.03 0.02 0.02 0.02 0.04 0.04	0.03 0.03 0.02 0.02 0.02 0.01 0.02 0.01 0.01 0.01	2 0.03 2.27 055 94 0.1 25	2.6 1.2 0.7 0.1 0.3 0.3	0.3 0.3 0.6 0.4 0.3 0.2 0.2	0.2 0.2 0.5 0.2 0.2 0.2 0.2 0.2 0.2	0.3 0.5 0.2 0.2 0.2 0.3 0.2	0.2 0.5	0.4 0.2 16
PS P65 0.0 0.02 0.24 0.24 0.1 0.05 01 0.02 PS P67 0.01 0.2 0.16 0.29 0.05 03 0.07 0.01		0.01 0.02 0.01 0.01 0.01 0.01 0.01	1.01 GEFS POR 0.6 3.5	0.6 0.4 0.1 0.1 0.2	0.5 1.0 1.3 1.0 0.8 0.5 0.6 0.8	0.6 0.4 0.4 0.3	0.3 0.3 0.5 0.2 0.4 0.2	0.2 0.5 0.4 0.4 0.4 0.2 0.2 0.2	18
75 Pt6 0.0 0.08 0.32 0.28 0.1 0.03 0.01 0.01	01 0.03 0.07 0.09 0.07 0.05 0.03 0.03 0.04 0.03 0.02 0.02 0.01	0.01 0.01 0.02 0.01 0.02 0.01 0.01 0.02 0.02	1.55 GEF3 Pos 0.7 3.7	25 24 13 03 03 04 04	0.5 1.4 0.8 0.6 0.4 0.3 0.2 0.2	0.2 0.2 0.2 0.4 0.3 0.3 0.5 0.3 0.3 0.3	0.2 0.2 0.2 0.2 0.2	0.3 0.6 0.5 0.2	0.2 0.2 0.2 20
FS P10 0.0 0.16 0.12 0.17 11 0.07 0.03	8.01 8.01 8.01 8.01 8.01 8.01 8.01 8.02 8.03 8.02 8.01 8.01 8.02 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 0.92 GEFS P11 0 1.5 3.8	1.8 1.5 1.4 0.5 0.1 0.2 0.4	0.3 0.8 1.0 0.8 0.5 0.2 0.5 0.2	00 te 00 00 0.2 0.2 0.2 0.2 0.0 0.0 0.3	0.3 0.3 0.2 0.2 0.2 0.2 0.2 0.2	00 00 03 00 00 0.2 0.4 0.7	0.5 0.4 0.2 0.2 21
PS PH 0.0 0.14 0.32 0.16 0.16 0.11 0.03 0.01 0.01 PS PH2 0.0 0.12 0.12 0.29 0.12 0.11 0.02 0.01	02 0.02 0.05 0.05 0.03 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.51 GEFS P12 1.0 1.0 1 0.02 1.18 GEFS P13 0.5 2.8	2.6 1.2 1.4 0.3 0.2 2.6 1.3 0.5 0.7 0.7 0.4 03	0.2 0.4 0.6 0.3 0.2 0.2 0.8 0.9 0.6 0.5 0.5 0.4 0.3 0.2	0.2 0.4 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.2 0.3 0.2 0.2 0.2 0.2 0.2 0.3 0 0.6 0.5 0.2	0.3 0.2 0.4 0.9 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.2 0.2 0.4 15
FEP13 0.0 0.06 0.32 0.33 0.13 0.05 06 0.06 0.03	102 0.05 0.04 0.03 0.03 0.02 0.02 0.01 0.02 0.01 0.01 0.01 0.02 0.03 0.02 0.02 0.02 0.03	0.83 0.82 0.81 0.81 0.81 0.81 0.81 0.81 0.91 0.91 0.92 0.	6 0.05 1.80 GEFS P14 1.3 1.8	28 0.7 0.5 0.1 0.1 0.3	0.2 0.5 0.7 0.3 0.3 0.1 0.2 0.2	0.2 0.2 0.2 0.2	0.2 0.2 0.3 0.2	0.4 0.6 0.5 0.2 0.2	14
275 P15 0.0 0.1 0.24 0.22 0.03 0.09 02	101 6.01 6.01 6.01 6.03 6.03 6.01 6.01 6.01 6.01 6.01	0.01 0.01 0.01 0.01 0.01	0.91 0253 24	1.4 0.1 0.1 0.1 0.5 C 4	0.5 0.8 0.9 0.8 0.8 0.7 0.6 0.4	0.5 0.6 0.5 0.2 0.2 0.2 0.2 0.3 0.3 0.3 0.3	0.3 0.3 0.3	0.2 0.2 0.2 0.4 0.4 0.7 0.6 0.2	0.2 18
75 P16 0.0 0.07 0.24 0.18 0.01 0.01 0.01 0.03	002 0.03 0.06 0.06 0.05 0.05 0.04 0.03 0.02 0.02 0.03 0.02 0.01 0.01 0.01 0.01 0.01 0.01 0.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.02 0.02	1.27 GEF3 P17 0.4 3.9	28 0.4 0.2 0.1	0.2 0.7 0.8 0.5 0.2 00 0.2	0.2 0.2 0.7 0.5 0.3 0.6 0.6 0.6 0.6 0.6 0.6	02 02 02 02 02 02		0.0 0.2 0.2 0.0 13
PSP10 0.0 0.02 0.11 0.18 0.1 0.05 01 0.02 0.01	01 8.01 8.02 8.01 8.01 8.02 8.05 8.02 8.02 8.02 8.01 8.01 8.01 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	0.85 GEFS P19 0.4 32	1.2 1.6 3.1 1.7 1.3 0.3 0.5	1.1 1.1 0.8 0.3 0.5 0.2 0.2 0.2	0.2 0.2 0.2 0.3 0.2 0.2 0.5 0.5 0.2 0.2 0.3	0.3 0.3 0.2 0.2 0.3 0.5 0.5	0.4 0.1 0.1 0.1 0.1 0.7	0.8 0.2 00 00 24
55 P30 0.0 0.00 0.27 0.20 0.16 0.22 0.0 0.1 0.02 F5 P20 0.0 0.03 0.24 0.33 0.65 0.09 0.2 0.02 0.03	02 0.02 0.04 0.05 0.05 0.03 0.07 0.07 0.07 0.07 0.07 0.07 0.07		2 0.02 1.68 GEFS P28 0.1 2.9 2.4	2.6 1.2 0.3 0.3 0.5 0.3	0.4 0.6 0.8 0.9 0.5 0.5 0.3 0.4 0.2 0.3 0.3 0.2 0.2 0.2 0.2	0.2 0.2 0.2 0.2 0.5 0.5 0.4 0.4 0.5 0.8 0.5 0.2 0.2 0.2 0.3	0.2 0.2 0.2 0.4 0	0.3 0.2 0.2 0.1 0.3 0.8 1.5 0.9 0.2 0.2 0.2 0.2 0.3 0.4 0.2	0.7 0.7 0.5 0.4 24
75 P21 0.24 0.11 0.01 0.07 02 0.01	8.01 8.02 8.02 8.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	0.01 0.01 0.01 0.01 0.02 0.01 0.01 0.01	1 0.01 0.75 0EF3 P22 1. 0.7 1.6	28 25 18 12 08 08 10	2.2 2.0 1.4 1.1 0.5 0.4 0.6 0.5	0.4 0.5 0.3 0.5 0.4 0.2 0.2 0.2 0.2 0.2 0.3	0.3 0.2 0.2 0.5 0.2 0.2 0.3	0.3 0.2 0.2 0.2 0.2 0.5 0.3	0.2 0.3 0.2 0.2 32
75 P23 0.0 0.13 0.26 0.03 0.03 04 0.02	0.01 0.02 0.02 0.03 0.04 0.03 0.03 0.03 0.02 0.02 0.02 0.02 0.02	0.01 0.01 0.01 0.02 0.02 0.04 0.05 0.04 0.03 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.29 GEF3 P24 0.6 2.5	21 0.0 0.3 0.4 0.3 0.9 0.2 0.4 0.4 0.2 0.2 0.2	0.2 0.4 0.4 0.5 0.8 0.6 0.5 0.8 0.2 0.2 0.5 0.8 0.6 0.5 0.3 0.2 0.2 0.2	0.4 0.4 0.5 0.5 0.5 0.4 0.4 0.4 0.2 0.5 0.2 0.2 0.2 0.3 0.5 0.4 0.2 0.3 0.3		0.5 0.2 0.2 0.2 0.2 0.4 0.6 0.2 0.2 0.2 0.2 0.2 0.3 0.4 0.2	0.3 0.2 0.3 0.3 19 0.2 0.2 14
P3 P24 0.0 0.07 0.23 0.09 0.03 0.03 0.0 0.01 0.01 P3 P25 0.0 0.07 0.2 0.11 0.03 0.05 03 0.04 0.05	01 0.01 0.03 0.06 0.04 0.03 0.02 0.01 0.01 0.01 0.01 0.01 0.02 0.02	0.01 0.01 0.01 0.01 0.01 0.01 0.02 0.02	0.97 GEFS P25 0.6 2.2 1 0.03 1.30 GEFS P25 0.1 1.9	0.6 0.3 0.5 0.7 02	0.3 0.8 1.4 1.4 1.3 1.2 0.5 0.8	0.6 0.4 0.2 0.4 00 0.3 0.2 00 00 00	00 0.3 00 00 00 00 00 00 0	0.2 0.2 0.2 0.2 0.2 11 10	0.3 0.3 0.6 17
51 P25 0.0 0.03 0.18 0.15 0.07 0.04 0.02	01 8.02 8.04 8.04 8.03 8.02 8.01 8.01 8.01	0.06 0.05 0.03 0.02 0.	1 0.02 0.88 GEFS P27 0.6 3.5	3.7 1.8 2.9 1.8 0.4 0.8 0.5	0.5 0.8 0.8 0.5 0.5 0.2 0.4 0.6	0.6 0.4 0.3 0.3 0.3 0.2 0.2 0.2 0.2 0.3 0.3	00 00 00 00 00 00 0.2 0.2 0	0.2 0.2 0.2 0.2 0.2 0.0 0.5	0.3 0.3 0.2 0.3 25
25 227 CL CLO CLO C12 C14 C16 C22 LC C12 CLC		0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.02 1.74 0EFS P28 0 1.8 5.4 3.6	2.6 3.1 1.0 2.4 0.2 0.4 0.3 0.4	0.5 0.8 1.1 1.0 0.5 0.4 0.4 0.4 0.4 0.5 1.1 1.4 1.3 1.1 0.7 0.6 0.6	0.2 0.2 0.2 0.2 0.2 0.0 0.0 0.0 0.0	0.3		0.2 0.2 0.4 22
75 P23 0.0 0.01 0.33 0.27 0.01 0.02 0.03 0.02 (112) 0.08 0.25 0.29 0.17 0.07 04 0.02 0.05	02 0.03 0.08 0.09 0.08 0.07 0.04 0.03 0.03 0.02 0.02 0.01 0.02 0.01 0.01 0.01 0.01	0.02 0.02 0.01 0.01 0.01 0.01 0.01 0.01	1.46 GEFS P30 0.6 2.8	3.2 2.0 1.0 0.6 0.3 0.9 0.5	1.2 1.2 0.9 0.7 0.6 0.5 0.4 0.4	0.4 0.5 0.2 0.2 0.2 0.2 0.2	0.2 0.5 0.5	0.4 0.5 0.4 0.2 0.2 0.2	0.4 0.6 0.4 0.4 24
0754 0.0 0.14 0.29 0.15 0.68 0.07 01 0.02	0.04 0.04 0.09 0.12 0.03 0.01 0.01 0.02 0.03	0.01 0.01 0.01 0.02 0.03 0.	1 0.01 1.31 GEFS C00-4 1.0 32	0.8 1.0 0.3 4.6 3.1 1.4 0.5 0.3 0.3	0.6 0.6 1.4 2.0 0.2 0.2 0.3 1.1 0.8 0.8 0.6 0.2 0.2 0.4	0.5 0.7 0.4 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.3 0.3 0.3	0.2 0.3 0.2 0.2 0.2 0.2 0.2 0.2	0.3 0.3 0.2 0.4	0.6 0.2 0.2 15
FS C104 0.0 0.1 0.29 0.42 0.26 0.1 0.3 0.02 0.02 FS PV-4 0.0 0.12 0.37 0.39 0.65 0.65 01 0.04 0.01	62 6.62 6.67 6.05 6.05 6.04 6.01 6.01 6.02 6.02 6.01 6.01 6.01 6.01 6.01 6.01 6.01 6.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.02 1.91 0EFS P014 0. 1.1 3.5 2 0.02 1.72 0FES P014 0. 1.1 3.5	43 0.5 0.6 0.1 0.5 0.2 02	0.6 0.4 0.1 0.3 0.3 0.4 0.5 0.6	0.6 0.6 0.4 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.3 0.2 0.2 0.2 0.2 0.2	0.2 0.7 1.0 0.4 0.4 0.2 0.2	0.4 0.2 0.4 0.4 23
SP824 0.0 0.1 0.34 0.28 0.16 0.05 0.5 0.01 0.05	102 8.07 8.03 8.04 8.03 8.02 8.01 8.01 8.01 8.01 8.01 8.01 8.01 8.02 8.02 8.02 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.67 GEFS PO24 0.8 1.8	1.5 0.9 1.6 0.3	0.2 1.0 0.5 0.6 0.3 0.4 0.2	0.2 0.2 0.2 0.2 0.4 0.4 0.4 0.4 0.2 0.3 0.2		0.2 0.2 0.2	0.2 0.2 0.2 0.2 22
F3 Pre-5 0.0 0.08 0.33 0.52 0.65 0.15 0.4 0.61 0.62	101 8.02 8.17 8.18 8.07 8.03 8.02 8.02 8.02 8.02 8.02 8.01 0.02 8.01 0.01 0.01 0.01 0.01	0.01 0.0 20.0 20.0 10.0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0.92 GEFS POL4 0.7 3.6 1.93 GEFS POL4 0.7 3.6	62 0.6 2.0 0.7 0.2 0.3 02	0.3 26 20 1.1 0.5 0.4 0.4	0.5 0.5 0.5 0.3 0.5 0.3 0.2 0.3 0.3 0.2	0.3	0.2 0.4 0.4 0.4 0.2 0.2	27
F3 PN54 0.0 0.29 0.2 0.16 0.09 0.4 0.09 0.04	02 8.01 8.03 8.08 8.06 8.05 8.02 8.02 8.02 8.01 8.01 8.01 8.01 8.01 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.37 GETS P364 0.8 3.4	5.7 3.2 1.3 0.8 0.5 0.8 0.5	1.4 1.2 1.4 1.0 0.8 0.5 0.4 0.4	0.2 0.2 0.2 0.2 0.2 0.2 0.3 0.3 0.4 0.4 0.3	0.3 0.3 0.3 0.3	0.2 0.2 0.2 0.2 0.2 0.2	0.3 0.2 0.2 15
FS PN74 0.8 0.84 0.34 0.48 0.87 0.84 0.81 0.81	0.01 0.01 0.01 0.01 0.01	0.01 0.01 0.01 0.01	1.18 0273 P014 0.2 41	43 08 05 0.1 0.2	0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	A2 A2 A2 A2	0.2 0.2 0.2 0.1 0	0.2 0.2 0.2 0.2 0.4 0.5 0.4 0.4	0.2 0.2 13
55 F06-4 0.0 0.07 0.23 0.38 0.22 0.09 1.02 0.02 F5 F06-4 0.0 0.08 0.59 0.41 0.17 0.06 0.02 0.02	02 0.02 0.03 0.06 0.04 0.05 0.02 0.02 0.01 0.01 0.01 0.01 0.01 02 0.05 0.07 0.06 0.04 0.03 0.02 0.02 0.03 0.03 0.02 0.02 0.02	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	5 0.04 1.64 GEFS POS-6 0.7 7.1	53 1.5 0.8 0.3 0.3 04	0.5 1.1 0.9 0.6 0.5 0.3 0.3 0.5	0.6 0.4 0.5 0.5 0.5 0.5 0.5 0.5 0.4 0.4	15 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.	0.0 0.0 0.0 0.0 0.0 0.2 0.3	10 10 10 10 27
52934 0.0 0.1 0.2 0.19 0.14 0.06 62 0.02 0.03		0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1.34 GEFS P114 0 0.3 2.5	1.9 2.0 1.1 0.3 0.3 0.5 0.5 1.4 0.7 1.0 0.4 0.2 0.3 0.3	0.5 0.5 1.4 1.3 0.6 0.7 0.2 0.2 0.4 1.3 0.6 0.3 1.0 0.3 0.2	0.4 0.5 0.5 0.5 0.3 0.2	0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.5 0.7 0.2	0.2 00 00 00 15
SP124 0.0 0.11 0.35 0.4 0.15 0.1 0.2 0.04 0.02	12 8.07 0.11 8.07 8.06 8.05 8.08 8.03 8.01 8.01 8.01 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	2 0.01 1.88 GEFS P124 0.8 3.9	44 17 15 0.3 0.6 0.3 03	1.1 1.7 1.1 1.0 0.9 1.4 0.5 0.2	0.2 0.2 0.3 0.2 0.2		0.2 0.2 0.2 0.5 0.4	0.3 0.4 0.2 25
SP134 0.0 0.1 0.24 0.13 0.11 0.08 05 0.02 0.04 SP145 0.0 0.12 0.41 0.24 0.18 0.12 04 0.02 0.01	02 0.07 0.13 0.06 0.24 0.14 0.04 0.03 0.02 0.01 0.01 0.01 0.01 0.01 02 0.06 0.1 0.07 0.04 0.07 0.06 0.03 0.01 0.01 0.01 0.01 0.01 0.01 0.01	0.01 0.01 0.02 0.02 0.03 0.02 0.01 0.01 0.07 0.06 0.07 0.06 0.01 0.	1 0.03 2.06 GEFS P144 0.9 2.8 0.01 1.78 GEFS P144 1.1 4.1	0.1 0.9 0.4 0.3 0.1 0.3	1.0 1.8 1.2 4.1 2.2 0.7 0.6 0.4 0.8 1.5 1.1 0.6 1.2 1.0 0.5 0.2	0.2 0.2 0.2 0.2 0.2 0.2 0.5 0.3 0.2 0.2 0.3	0.3 0.2 0.5 0.5 0.8 0.5	0.2 0.3 0.1 0.1	0.2 0.2 0.6 33
BP154 0.0 0.12 0.19 0.28 0.16 0.08 01 0.02 0.05	03 8.05 8.09 8.07 8.02 8.02 8.03 8.01 8.01 8.01 8.01 8.01 8.01 8.01	0.01 0.01 0.01 0.01 0.01 0.02 0.01 0.01	1 0.01 1.52 GEFS P154 1.1 1.9	29 18 11 12 03 08 05	0.9 1.3 1.0 0.3 0.4 0.5 0.2 0.2	0.2 0.2 0.2 00 00 00 0.3 0.2 0.4 0.3	0.2 0.2 0.1 0.1 0.2 0.2 0	0.5 0.5 0.2 0.2 0.2 0.4 0.4	02 02 02 02 21
21214 0.0 0.17 0.18 0.11 0.05 0.08 0.2 0.02 0.02 219174 0.0 0.12 0.25 0.18 0.1 0.06 0.02 0.02 0.02	01 0.01 0.04 0.06 0.03 0.03 0.02 0.01 01 0.01 0.02 0.02 0.02 0.03 0.02 0.01 0.01 0.01	0.01 0.01 0.01 0.02 0.06 0.	1.0 1.15 000104 1.9 1.7 1.04 0073 P174 1.1 2.2	0.8 0.8 0.3 0.3 0.3 0.2	0.2 0.4 0.3 0.3 0.5 0.3 0.2 0.2	0.2 0.2 44 66 60 49 60 66 0.0 64 55	0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0	00 00 00 0.2 0.3 0.2 0.5	10 13 04 0.2 15
19754 0.0 0.04 0.09 0.1 0.05 0.03 02 0.03	03 8.01 8.06 8.1 8.06 8.04 8.04 8.04 8.03 8.04 8.03 8.03 8.03 8.02 8.01 8.01 8.01		1 1.07 GEFS P18-4 0.2 0.8	10 0.7 0.4 0.3 0.5 04	0.2 0.9 1.8 1.0 0.7 0.7 0.7 0.8	0.6 0.8 0.7 0.7 0.5 0.2 0.2 0.2 0.4 0.5 0.4	A2 A2 A2 A2 A A A2 A3 A5	0.2 0.2 0.3 0.5 0.5 0.3 0.2 0.4	0.4 0.5 0.1 16
12 2224 0.1 0.14 0.24 0.21 0.31 0.24 0.6 0.03 0.05		0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.01	1 0.01 1.84 GEFS P20-4 1.4 2.4	2.4 2.9 1.9 0.5 0.7 02	0.4 0.8 1.1 1.1 0.6 0.1 0.2 0.2	0.2 0.2 0.2 0.2 0.2 0.4 0.5 0.4		0.2 0.2 0.5 1.6	0.7 0.5 0.2 0.2 21
37214 0.0 0.22 0.41 0.22 0.07 0.06 01 0.01 0.03 37224 0.0 0.16 0.25 0.4 0.21 0.13 04 0.03 0.04	102 8.03 8.13 8.14 8.09 8.06 8.03 8.01 8.03 8.02 8.03 8.04 8.02 8.03 8.02 8.01 8.01 8.01 8.01 8.01	0.01 0.03 0.02 0.02 0.02 0.02 0.02 0.01 0.01 0.01	2.07 05/5 9214 2.2 45 2.001 4.92 05/5 9224 15 28	26 08 12 0.2 0.2 0.5 08 44 25 16 06 05 0.5 08	0.5 2.1 2.1 1.4 1.0 0.5 0.2 0.6	0.4 0.6 0.5 0.5 0.8 0.5 0.2 0.2 0.3 0.3 0.2 0.5 1.0 1.0 0.7 0.7 0.4 0.5 0.2 0.2 0.5 0.3		0.3 0.3 0.3 0.5 0.5 0.2 0.3 0.3 0.2 0.2 0.2 0.2	0.3 0.4 0.2 26
15 P23-4 0.0 0.15 0.25 0.23 0.1 0.13 0.7 0.02 0.05	102 8.06 8.1 8.11 8.07 8.06 8.02 8.02 8.03 8.02 8.02 8.01 8.01 8.01 8.02 8.02 8.02 8.04 8.03	0.83 0.83 0.82 0.82 0.82 0.82 0.82 0.82 0.82 0.82	2.20 GEFS P234 0 1.5 28	0.8 0.1 1.5 1.8 0.3 0.6 4	0.8 1.5 1.7 1.0 0.8 0.3 0.4 0.5	0.4 0.4 0.2 0.2 0.4 0.4 0.4 0.4 1.0 0.8	0.8 0.8 0.5 0.5 0.4 0.5 0.5 0.5	0.5 0.5 0.8 1.0 0.8 0.5 0.9 0.6	0.4 0.2 00 00 31
37244 0.0 0.04 0.2 0.23 0.06 0.02 0.0 0.04 0.02 38754 0.0 0.15 0.44 0.31 0.11 0.07 0.02 0.02	03 0.09 0.06 0.04 0.05 0.04 0.03 0.03 0.02 0.01 0.01 0.01 0.01 0.01 0.01 0.01	0.02 0.01 0.01 0.01 0.01 0.02 0.02 0.02	0.01 1.46 0EF3 P244 0.2 2.0 1 0.02 1 05 0EF3 P244 1.5 48		1.3 0.8 0.6 0.8 0.6 0.5 0.6 0.4 0.8 0.6 0.5 1.0 0.7 0.6 0.4 0.4	0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.3 0.3 0.2 0.2 0.5 0.8 0.5 0.5 0.5 0.5 0.2 0.2 0.2 0.5	0.5 0.5 0.2 0.2 0.2 0.2 0.4 0.4 0.5 0.2 0.2 0.2 0.4 0.4 0.5 0.7 0.5 0.2 0.2 0.2 0.4 0.5 0.7 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	0.5 0.5 0.3 0.3 0.2 0.6 1.1 0.4 0.5 0.3 0.5 0.2 0.2	0.3 0.2 22
3 P264 0.5 0.15 0.27 0.22 0.14 0.08 02 0.02 0.06	04 8.02 8.03 8.03 8.04 8.03 8.01 8.01 8.01 8.02 8.06 8.02 8.01	0.01 0.01 0.02 0.02 0.01 0.01 0.01 0.02 0.02	1 1,49 DEF8 P264 1.7 32	2.6 2.0 1.1 0.3 0.3 0.8 0.6	0.3 0.4 0.5 0.6 0.5 0.2 0.2 0.2	0.5 1.4 0.5 0.2	0.2 0.2 0.4 0.4 0.2	0.2 0.2 0.2 0.4 0.4 0.2	0.2 0.2 22
27244 0.0 0.01 0.22 0.28 0.16 0.05 01 0.03 0.02 27244 0.0 0.1 0.18 0.2 0.11 0.06 03 0.01 0.01	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx	0.02 0.03 0.01 0.01 0.01 0.02 0.01 0.01 0.02 0.01 0.01	1.12 0EF8 P214 2.0 2 0.01 1.70 0EF8 P284 0. 0.8 2.0	3.4 2.1 0.7 0.2 0.4 0.4 0.4 2.2 1.7 0.9 0.5 0.1 0.2 0.3	1.2 1.3 0.6 0.3 0.4 0.4 0.2 0.2 0.4 1.7 2.4 1.3 1.0 0.7 0.5 0.6	0.4 0.2 0.3 0.3 0.5 0.3 0.2 0.3 0.2	0.4 0.4 0.2 0.2 0.2 0.2 0.4 0.2	0.2 0.4 0.2 0.2 0.4 0.6 0.7 0.7	0.5 0.3 0.5 0.3 27
5 P294 0.0 0.09 0.3 0.39 0.22 0.11 04 0.03 0.03		0.01 0.01 0.01 0.02 0.01	1.58 GEF3 P294 0.9 3.3	47 31 18 0.7 0.5 0.5 03	0.3 0.5 0.3 0.3 0.3 0.5 0.3 0.4	0.5 0.5 0.2 0.0 0.0 0.0 0.0 0.0 0.0 0.0	60 00 00 0.0 00 0.0 00 0.0	0.0 0.0 0.0 0.2 0.2 0.0 0.2	0.3 0.2 00 00 21
1212 0.0 0.10 0.12 0.3 0.18 0.11 1.14 0.01 0.12	CO1 C.01 C.01 C.01 C.01 C.01 C.01 C.01 C.0	6.03 E.02 E.1 E.	• • • • • • • • • • • • • • • • • • •	3.0 0.6 1.4 0.6 0.2 0.3 0.2	1.1 2.2 1.0 0.6 0.6 0.2 0.2 0.2	0.2 0.3 0.3 0.2 0.2 0.4 0.4		0.5	0.5 2.6 0.9 0.4 24

GEFS Cobb Winter Wx Analysis: kgrr Issued Fri 20240112/0600z

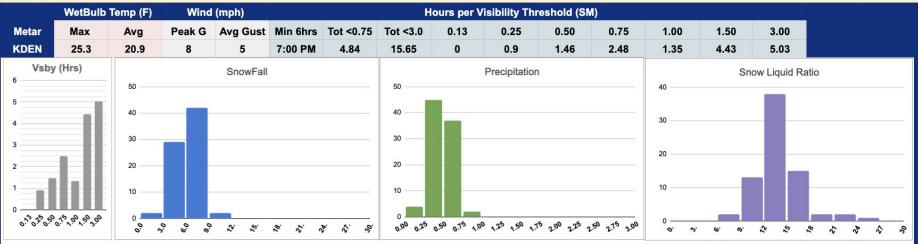


Verification / Validation Efforts



Verification / Validation Efforts

DEN (39.75, -104.87) 2023-10-29



				SnowFall					Precip	itation		Consensus Snow to Liquid Ratio (SLR)						
OBS #	Avg Dist	25%	Median	75% Mean		StdDev	25%	Median	75%	Mean StdDev		25%	Median	75%	Mean	StdDev		
94	16 5.5 6.5		7.5	6.4	1.8	0.41	0.48	0.54	0.47	0.14	12	13	15	14	3			
									SWE SI	now Liquid	Ratio =>	12	14	15	14	3		
<u>Obs</u>									Consensus			ensus			Distance	Obs		
Date	Obs Time	tion Num	ation Nam	<u>10</u>		<u>Ga</u>	uge Catch	Snow	SWE SLR SLR				METAR	BUF ID	<u>(km)</u>	Count		

24HR CoCoRahs Consensus vs Simple NBM Comparison for 12Z 15Mar2023

Deterministic snowfall forecast based on corrected simple blend means for Tw, QPF, and Cloud SLR

	Observed													HREF	⁼ 12Z	14Ma	r2023	3												
	Area Mean Values			Raw Fcst										$((0.5 \cdot x - 15.50))$ 1.3 $((0.5 \cdot x - 15.50))$ 1.3							$\left(\frac{(0.5 \cdot x - 15.75)}{10}\right) 1.3$				$((0.5 \cdot x - 15.75))_{1.3}$					
					Cor Fcst		No Snow Melt			Snow Melt > 33F							/	(-15)												
STN	Twsfc	SN	QPE	SLR	QPF	Twsfc	SN	Bias	ARE	SLR	SN	Bias	ARE	SLR	SN	Bias	ARE	SLR	SN	Bias	ARE	SLR	SN	Bias	ARE	SLR	SN	Bias	ARE	SLR
MEAN								3.10	0.67			0.14	0.32			-1.27	0.28			-0.10	0.26			-0.30	0.26			0.13	0.27	
KODU	31.5	7.6	4.04	7.4	1.07	31.7	12.7			14	9.2			10	7.6			8	9.2			9	9.0			9	9.7			10
KORH	31.5	1.0	1.01	7:1	1.01	31.5	12.2	4.6	0.61	13	9.4	1.8	0.24	10	7.9	0.3	0.04	8	9.2	1.6	0.21	10	9.1	1.5	0.20	10	9.5	1.9	0.25	10
KALB	32.8	6.6	0.93	7:1	0.73	32.4	9.9			14	8.3			12	5.2			7	6.6			10	6.5			9	7.1			10
INALD	52.0	0.0	0.35	7.1	0.93	32.8	12.5	5.9	0.89	15	9.4	2.8	0.42	11	5.6	-1.0	0.15	6	7.8	1.2	0.18	9	7.2	0.6	0.09	8	8.1	1.5	0.23	9
KCON	32.7	11.3	1 10	10:1	0.72	32.3	9.1			14	4.7			8	2.7			4	4.4			7	3.9			6	4.7			8
Keen	52.1	11.5	1.10	10.1	1.10	32.7	13.6	2.3	0.20	14	4.9	-6.4	0.57	6	4.4	-6.9	0.61	5	7.2	-4.1	0.36	8	6.1	-5.2	0.46	7	7.3	-4.0	0.35	8
КМНТ	33.3	11 4	1.39	8:1	1.09	33.1	13.1			14	7.5			8	5.5			6	7.8			8	7.0			8	7.9			8
	00.0				1.39	33.2	16.5	5.1	0.45	15	9.5	-1.9	0.17	8	7.8	-3.6	0.32	7	10.5	-0.9	0.08	9	9.5	-1.9	0.17	8	10.6	-0.8	0.07	9
KBED	33.6	32	1.45	3:1	1.61	33.5	14.7			16	6.6			7	5.2			5	7.2			8	6.7			7	7.4			8
RBEB	00.0	0.2			1.45	33.6	13.2	10.0	3.13	16	5.9	2.7	0.84	7	4.2	1.0	0.31	5	5.9	2.7	0.84	7	5.5	2.3	0.72	6	6.1	2.9	0.91	7
KPWM	32.9	4.8	0.72	6:1	0.88	32.9	10.7			14	7.4			9	5.2			6	6.7			8	6.6			8	7.2			9
					0.72	32.9	8.7	3.9	0.81	14	6.0	1.2	0.25	9	3.7	-1.1	0.23	5	5.0	0.2	0.04	8	5.0	0.2	0.04	7	5.4	0.6	0.13	8
KMPV 28	28.8	11.8	0.72	16:1	0.41	28.7	6.0			15	6.0			15	5.6			14	5.7			14	5.8			14	5.8			14
					0.72	28.8	10.5	-1.3	0.11	15	10.4	-1.4	0.12	15	9.9	-1.9	0.16	14	10.1	-1.7	0.14	14	10.1	-1.7	0.14	14	10.2	-1.6	0.14	15
KRUT	30.3	9.7	0.89	10:1	0.65	29.3	9.1			14	8.9			14	8.0			12	8.2			12	8.4			13	8.5			13
					0.89	30.3	11.8	2.1	0.22	14	10.2	0.5	0.05	12	8.5	-1.2	0.12	9	9.5	-0.2	0.02	11	9.5	-0.2	0.02	11	9.8	0.1	0.01	11
KCEF	33.2	3.3	0.70	5:1	0.54	33.6	6.1			17	2.3			6	1.1			3	1.9			5	1.7			4	2.0			5
					0.70	33.1	8.2	4.9	1.48	15	4.0	0.7	0.21	8	3.0	-0.3	0.09	5	4.2	0.9	0.27	8	3.9	0.6	0.18	7	4.3	1.0	0.30	8
KPSF	29.8	8.2	0.71	9:1	0.86	29.8	12.5			15	11.4			13	9.9			12	10.9			13	11.0			13	11.3			13
					0.71	29.8	10.2	2.0	0.24	15	9.3	1.1	0.13	13	7.7	-0.5	0.06	11	8.6	0.4	0.05	12	8.8	0.6	0.07	13	9.1	0.9	0.11	13
KBTV	32.5	11.2	1.10	12:1	0.58	31.5	8.2	0.0	0.00	15	6.9		0.00	12	5.3	5.0	0.50	9	5.9	10	0.00	10	6.1		0.40	11	6.3		0.00	11
			0.49	9:1	0.84	32.5	11.2	0.0	0.00	16	7.6	-3.6	0.32	10	5.6	-5.6	0.50	7	6.9	-4.3	0.38	9	6.7	-4.5	0.40	9	7.2	-4.0	0.36	10
KBGR	31.9	4.2			0.50	31.1	6.2	4.0	0.00	13	5.9	0.4	0.40	12	4.6	4.5	0.00	9	5.2	0.0	0.44	11	5.5	0.0	0.44	11	5.6	0.0	0.07	11
101001					0.49	31.9	5.8 5.9	1.6	0.38	13	4.6	0.4	0.10	10	2.7	-1.5	0.36	6	3.6 4.0	-0.6	0.14	8	3.6	-0.6	0.14	8	3.9	-0.3	0.07	9
KUCA/ KRME	31.3	6.5	0.55	12:1	0.44	32.7		4.0	0.40	14	4.9	10	0.45	12	3.2	0.0	0.05			0.0	0.00		4.0	07	0.44	•	4.3	0.0	0.40	10
				3 16:1	0.55	31.3	7.7	1.2	0.18	14	7.5	1.0	0.15	14	6.8	0.3	0.05	12	7.1	0.6	0.09	13	7.2	0.7	0.11	13	7.3	0.8	0.12	13
KITH	24.5	5.3	0.33		0.72	24.8	12.0 5.5	0.2	0.04	17 17	12.0 5.5	0.2	0.04	17 17	12.0 5.5	0.2	0.04	17	12.0 5.5	0.2	0.04	17 17	12.0 5.5	0.2	0.04	17 17	12.0	0.2	0.04	17
					0.33 0.38	24.5	5.5	0.2	0.04	17		0.2	0.04	17		0.2	0.04	17 11	5.5 4.9	0.2	0.04	17	5.5	0.2	0.04	17	5.5 5.3	0.2	0.04	17 14
KSYR	30.6	7.5	0.81	10:1	0.38	30.6 30.7	12.1	4.6	0.61	15	5.6 12.1	4.6	0.61	15	4.4	3.2	0.43	13	4.9	3.8	0.51	13	5.2	4.1	0.55	14	5.3	4.2	0.56	14
					0.62	34.9	5.0	4.0	0.01	18	1.4	4.0	0.01	3	0.5	0.2	0.43	13	1.0	3.0	0.01	2	0.9	4.1	0.00	2	1.1	4.2	0.00	2
KHFD	35.4	1.8	0.56	4:1	0.62			2.5	1 20	23		-1.5	0.83	3	0.5	-1.7	0.94	0		14	0.79	2		-1.5	0.83	2		-1.3	0.72	1
					0.56	35.4	4.3	2.5	1.39	23	0.3	-1.5	0.83		0.1	-1.7	0.94	0	0.4	-1.4	0.78		0.3	-1.5	0.83	1	0.5	-1.3	0.72	1

Current / Future Work

- Complete verification of past two seasons
- Investigating incorporation of a Rime Factor
- Diagnose snow size distribution (mass) to improve wet snow vs sleet/rain discrimination
- Improve surface/ground effects of wind, solar insolation, and warm ground temperatures
- Develop ensemble probability graphics to include RRFSe, SREF, and HREF

Thank You

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