Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

Lake Mendocino Forecast-Informed Reservoir Operations (FIRO) June, 27-29, 2016 Workshop Scripps Institution of Oceanography Southwest Fisheries Service Center

CW3E-FIRO: Task 3 Forecast Verification

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Outline

- Task 3 Overview
- Forecast Verification
  - Purpose of verification
  - Experimental skill curves and “certainty” calculation
    - December 2012 example

FIRO Task 3

- Evaluate past weather and streamflow forecast lead times and accuracy - *6-hour QPF and Streamflow forecasts (120 hours)*
  - National Weather Service (NWS)
  - California-Nevada River Forecast Center (CNRFC)
- Evaluate past hydrologic forecasts
  - U.S. Army Corps of Engineers (USACE)
    - Engineering Research and Development Center (ERDC)
- Evaluate past reservoir operations
  - Sonoma County Water Agency and USACE
- **FIRO work plan: 4.1, 4.4, 5.1, 8.1**

Wide range of collaboration – Spring Board Approach

- Communication and collaboration
  - Data, Rob Hartman and CNRFC team
  - Task 2, Dave Reynolds
  - Task 3, Brian Kawzenuk and Julie Kalansky
  - Many fantastic discussions with Marchia V. Bond and Matt McPherson, among others (USACE)
  - FIRO Viability Assessment Committee feedback and perspective

Why verify forecast data?

- Determine the accuracy of a forecast

$$Mean\ Square\ Error\ (MSE) = \frac{1}{N}\sum_{i=1}^{N}(y^{(i)} - \hat{y}^{(i)})^2$$

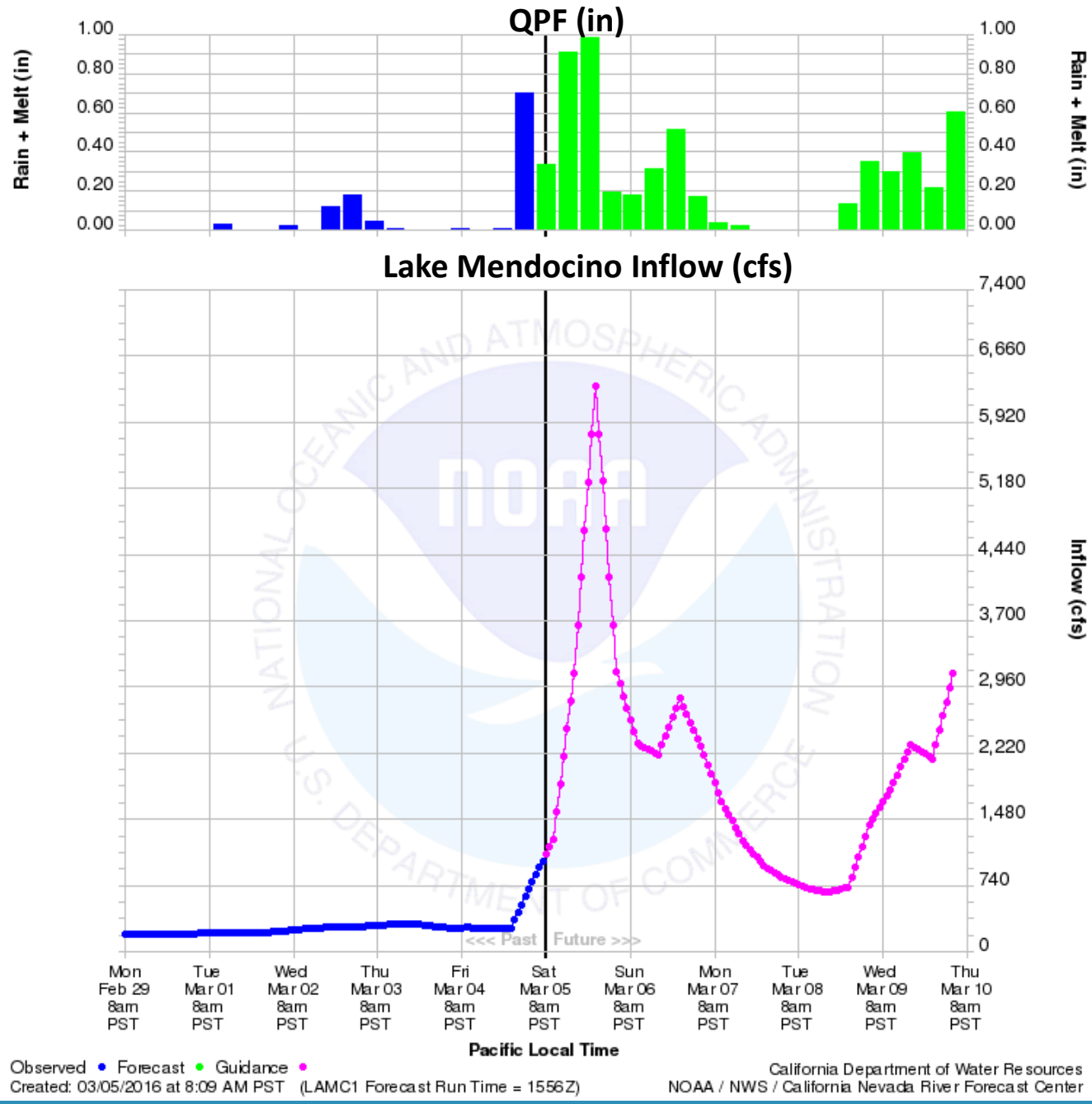
$y^{(i)}$= ith observation
$\hat{y}^{(i)}$= ith forecast
N = number of forecast

- Extreme events?
  - Quantiles (i.e., percentiles)
  - Verify the top 5% of all events
- 2x2 Contingency Table (for a forecast)
  - Hits, misses, false alarms, correct negatives

- We want to provide USACE with **"actionable information"** for use in FIRO

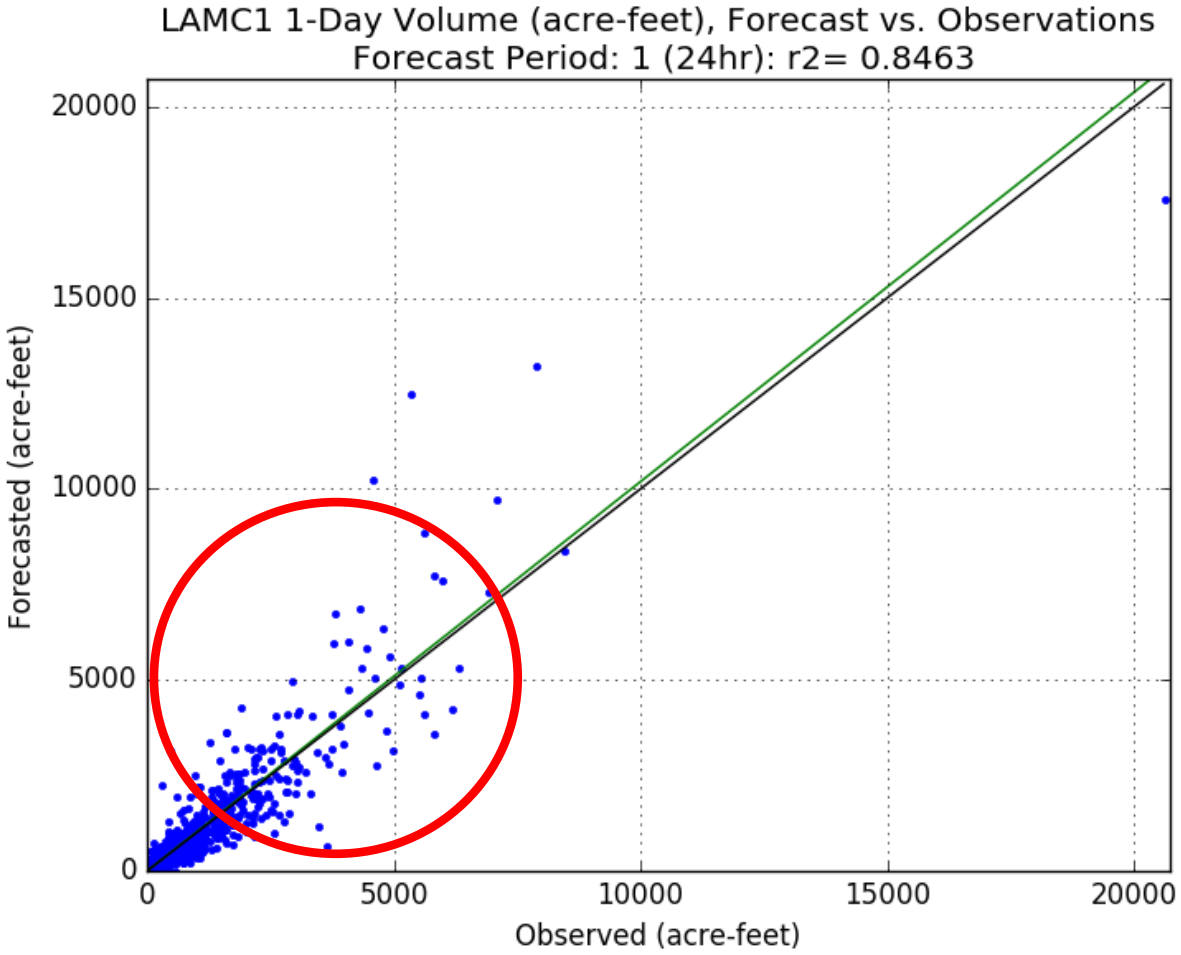
CNRFC Forecasts – Inflow

- Issued twice a day
- 6hr forecasts for 5 days (120 hours)
  - 20 (6 hour) forecasts
- Lake Mendocino
  - 12/1/2005 to 12/1/2015 (inflow)
- **24 hour volumes (acre-feet)**
  - **Aggregate to 1 day (24 hour) volumes**
  - **How much volume is expected to come into the reservoir?**

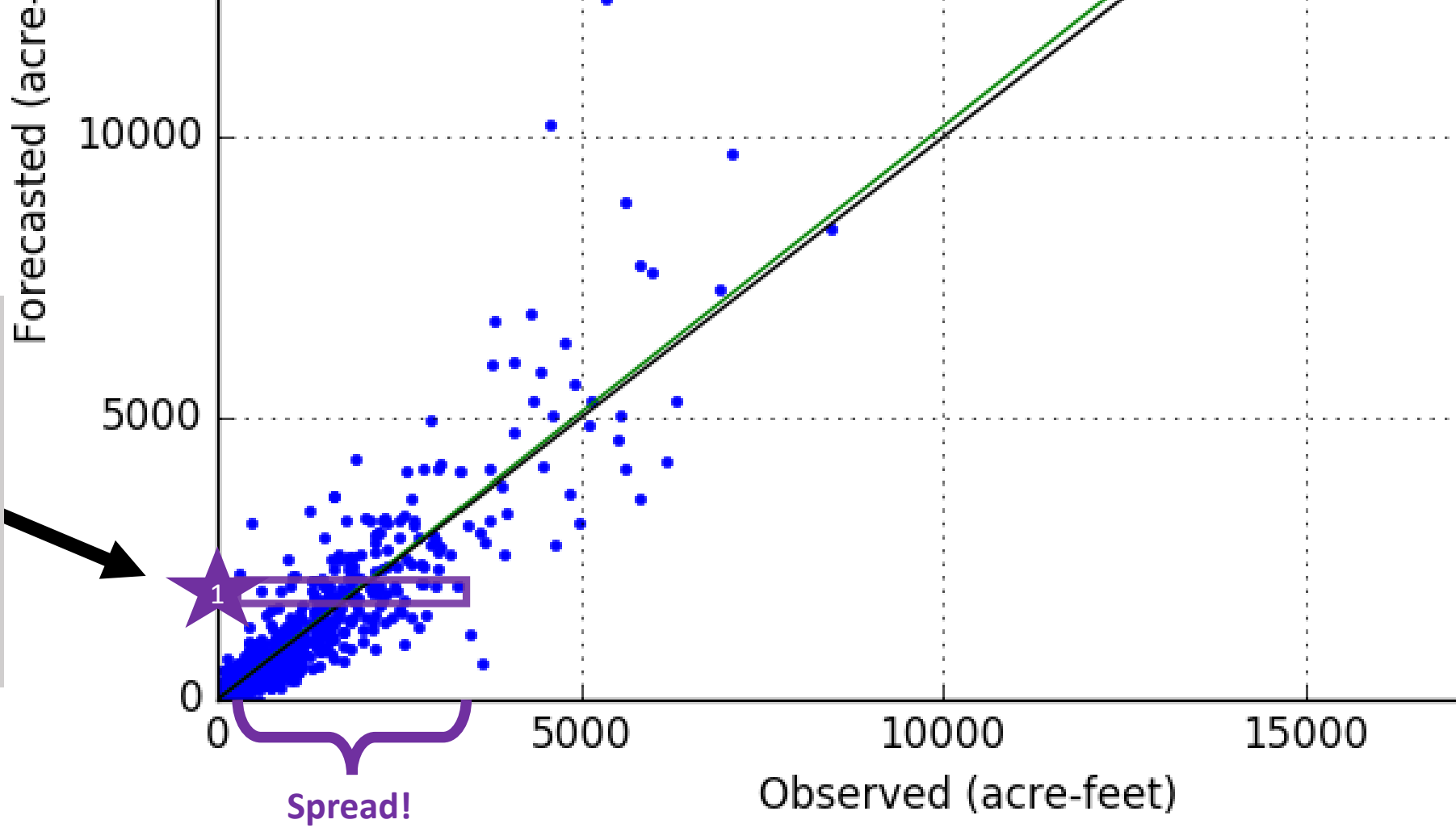


CNRFC Forecasts: 1-day (24 hour) Volume

- Quantify the difference between forecasts and observations.



What if I provide you with a 24 hour volumetric inflow forecast of 1400 acre-feet ending on day 1?

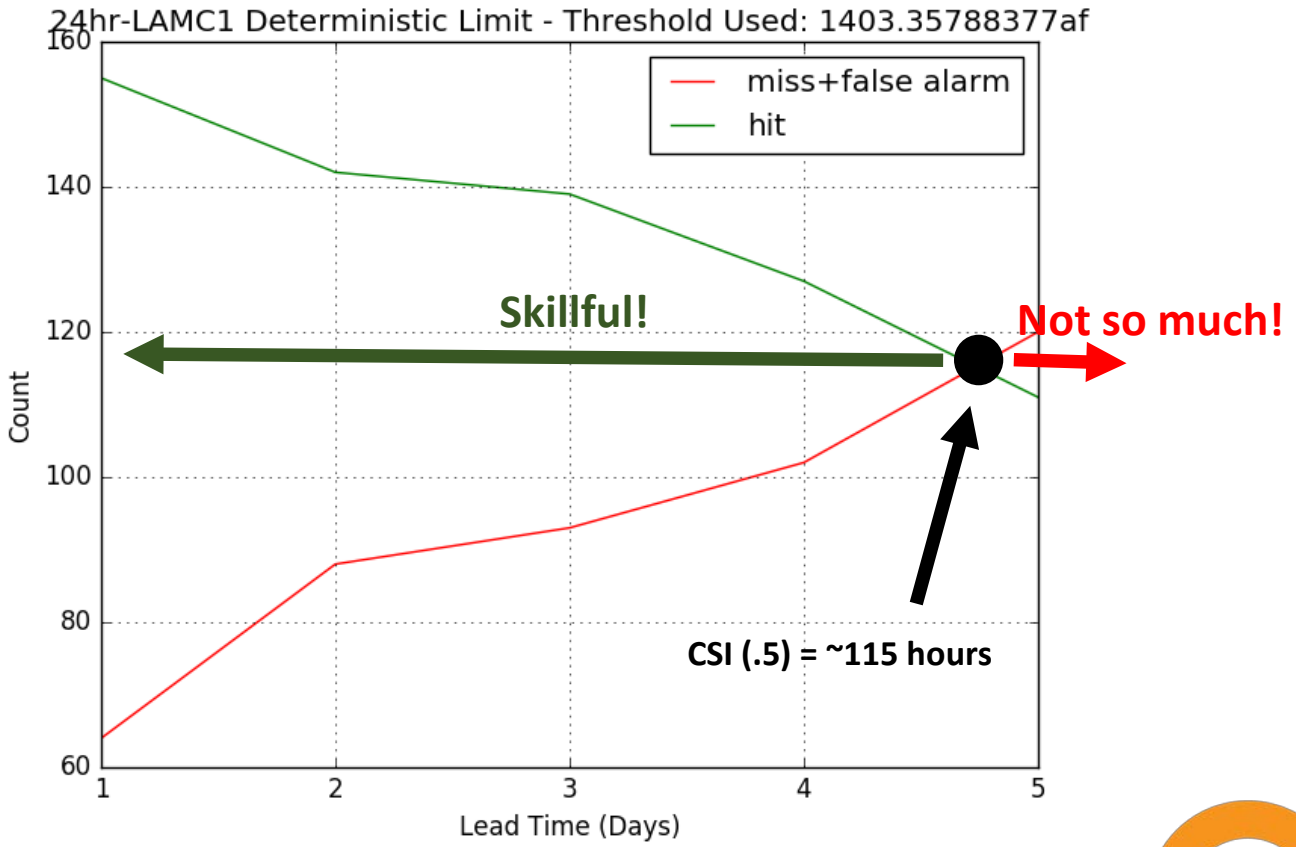


What is the length of time into the forecast in which it is more likely to be correct than incorrect?

Contingency Table

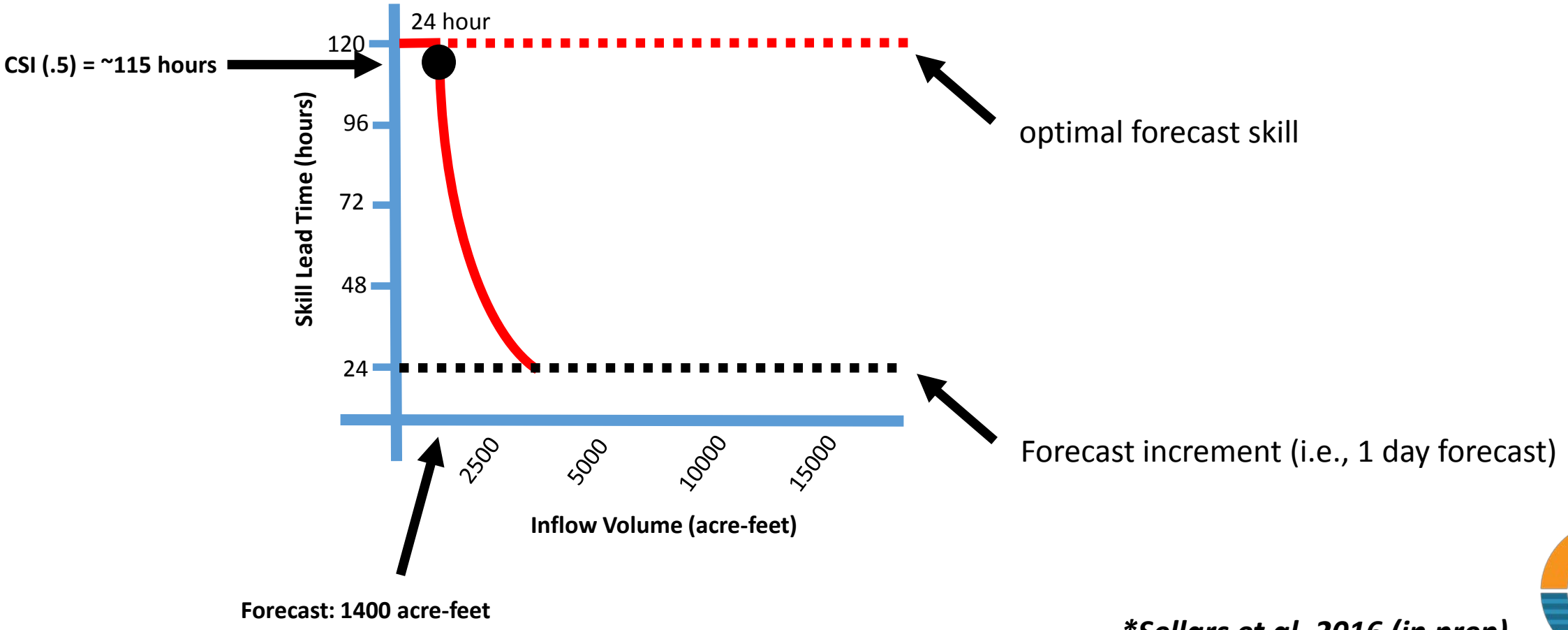
		Observed: yes	Observed: no	Total
Forecast	yes	*hits*	*false alarms*	*forecast yes*
	no	*misses*	*correct negatives*	*forecast no*
Total		*observed yes*	*observed no*	*total*

What is the forecast value you want to verify?
***1400 acre-feet in 24 hours**



Critical Success Index (CSI) = .5 → hits = misses + false alarms, "skillful" lead time
***Stephenson et al., 2010**

Example:"Forecast **Skill** Curve"

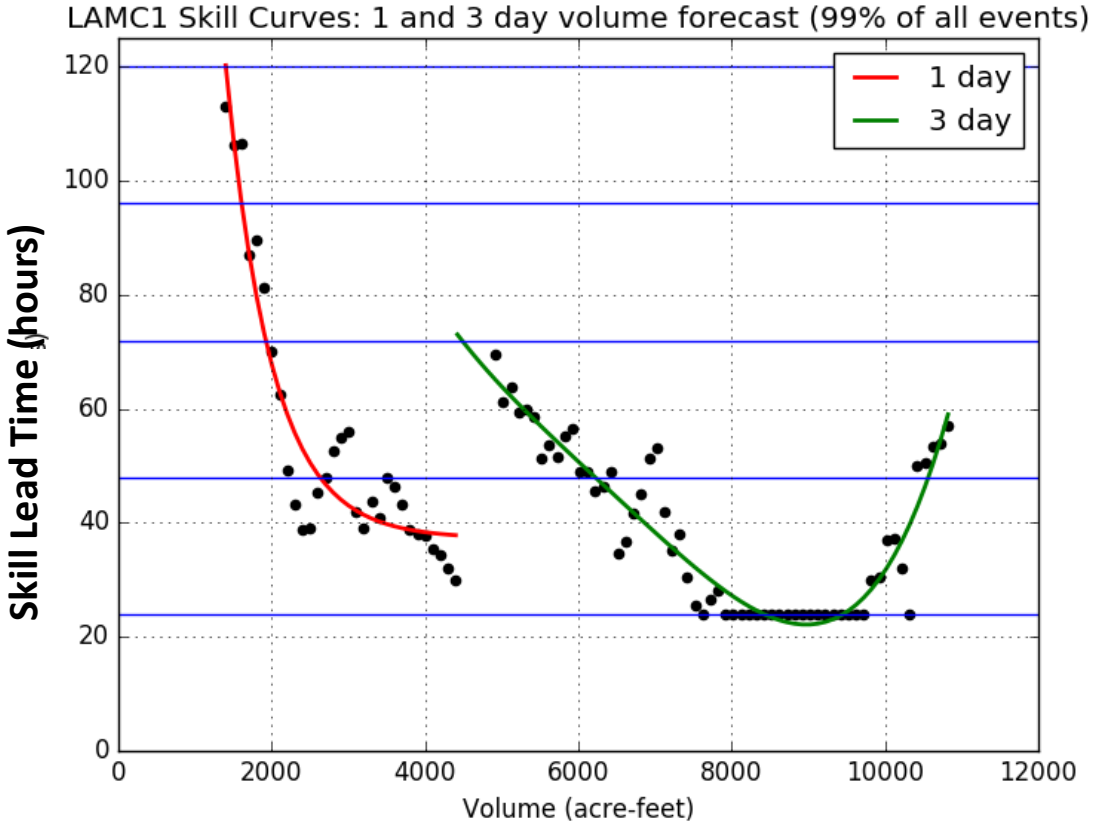


***Sellars et al. 2016 (in prep)**

Forecast **Skill** Curves (Volume)

What is the length of time into the forecast in which the forecast is more likely to be correct than incorrect?

CNFRC Inflow Volume (acre-feet) (LAMC1)



***Historical forecast data provided by the CNRFC**

****Sellars et al. 2016 (in prep)***

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Example: Step by step (Inflow Volume)

- Aggregate to 24 hour volumes (acre-feet)
- 12Z forecast - One day volumes (acre-feet)
  - 1000af/ 1000af/ 1000af/ 4000af/ 2000af/
- Given this forecast, what is the historical forecast certainty?

Example: Forecast **Skill** Curve

Skills Hours - Forecast Hours ~ certainty

<u>12Z Forecast Volumes:</u>

1 **24hr: 1000af Skill = 120hr**

120hr – 24hr = 96hr

2 **48hr: 1000af Skill = 120hr**

120hr – 48hr = 72hr

3 **72hr: 1000af Skill = 120hr**

120hr – 72hr = 48hr

4 **96hr: 4000af Skill = 38hr**

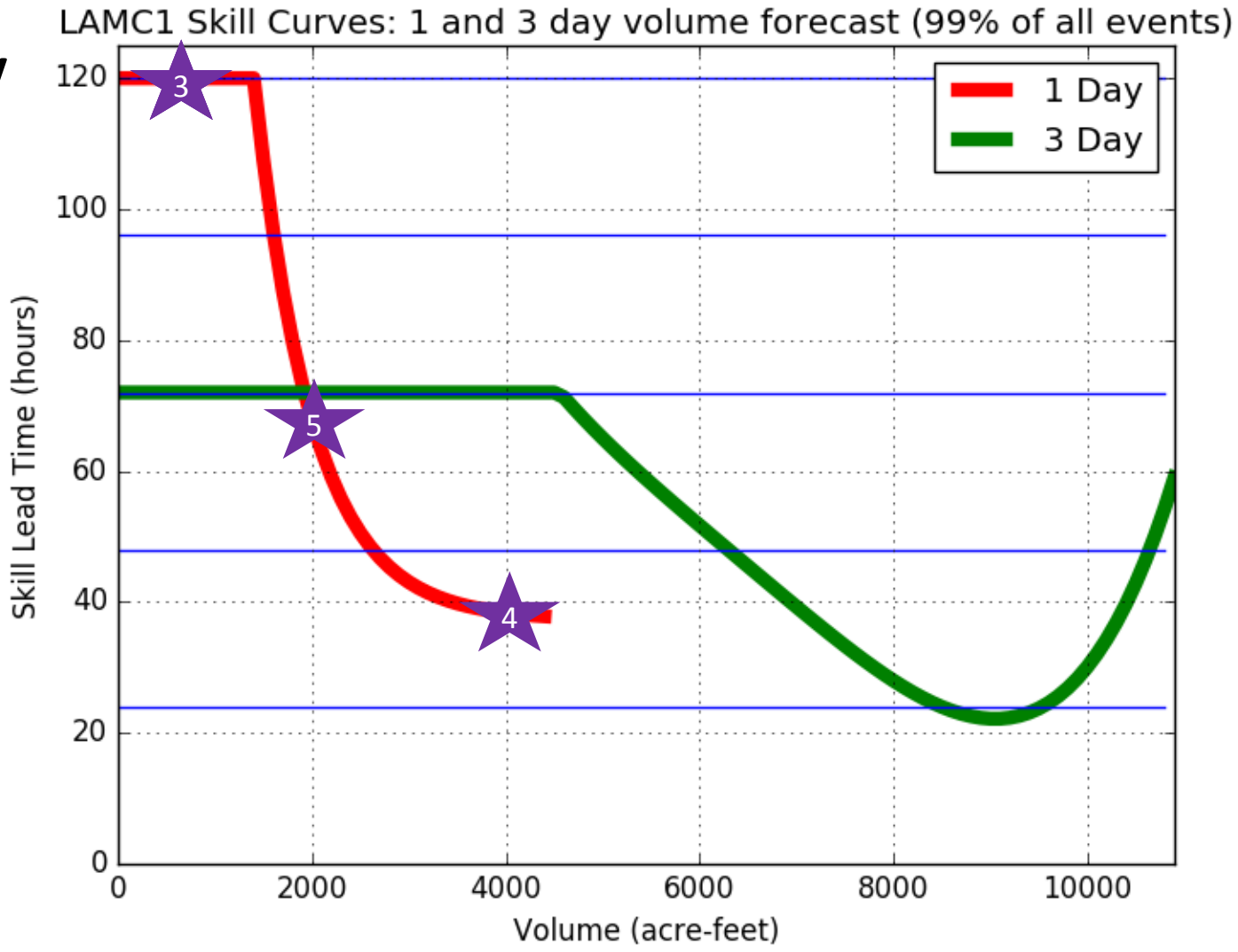
38hr – 96hr = -58

5 **120hr: 2000af Skill = 68hr**

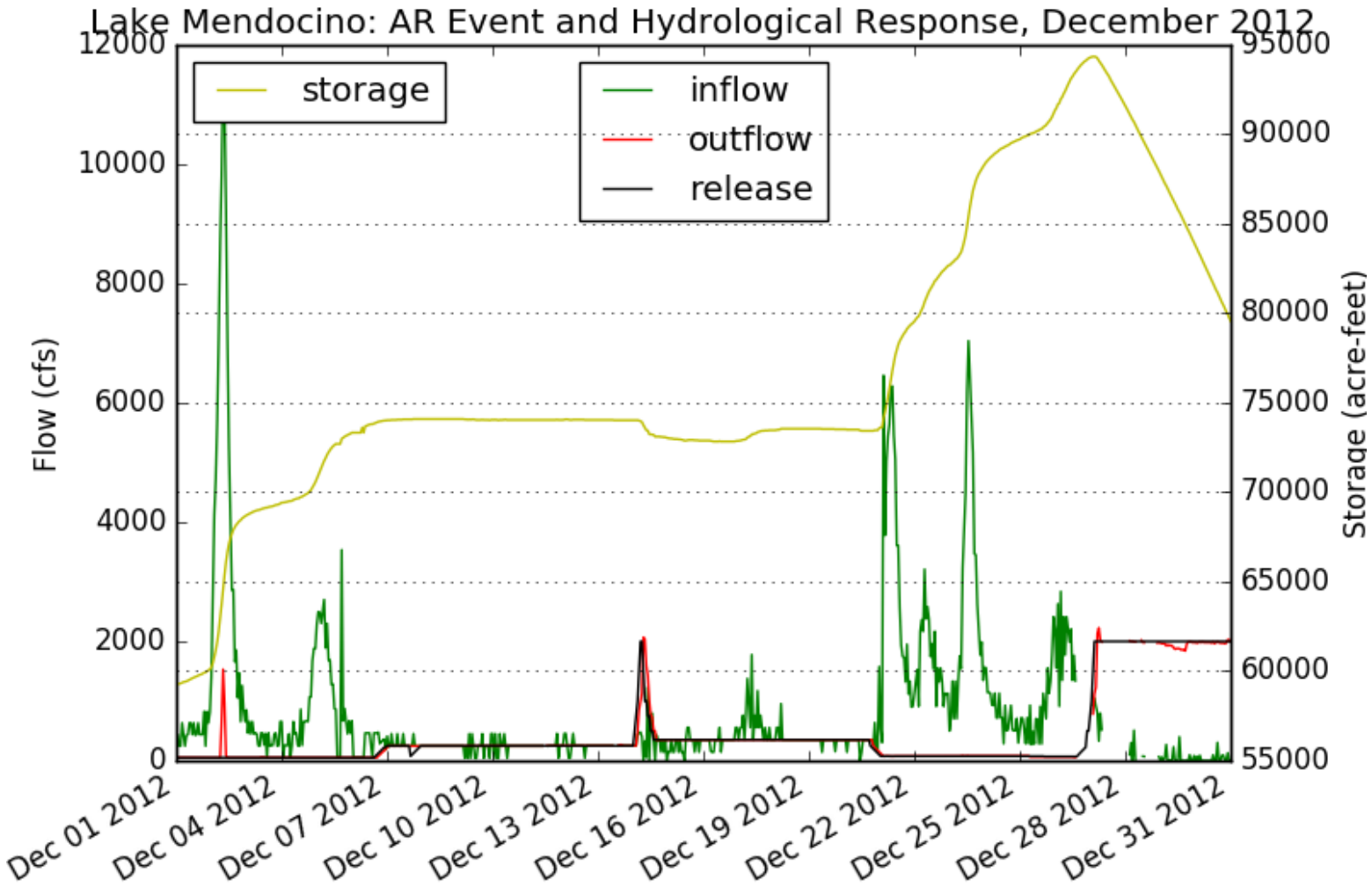
68hr – 120hr = -52

Certainty measure, range 0 to 1

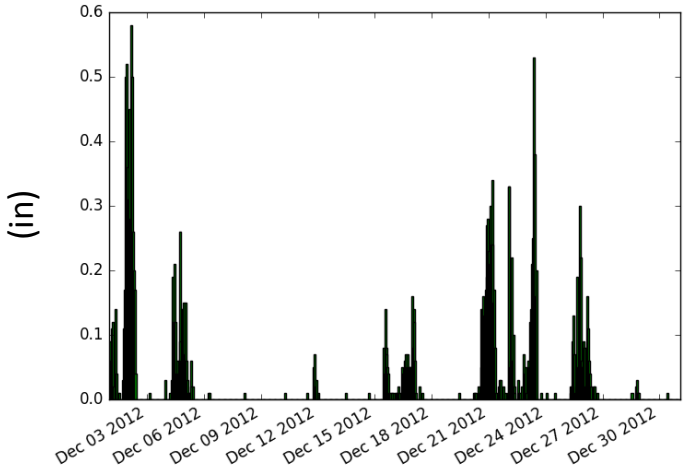
Optimal score: = 0



December 2012 Case Study



Precipitation (inches)



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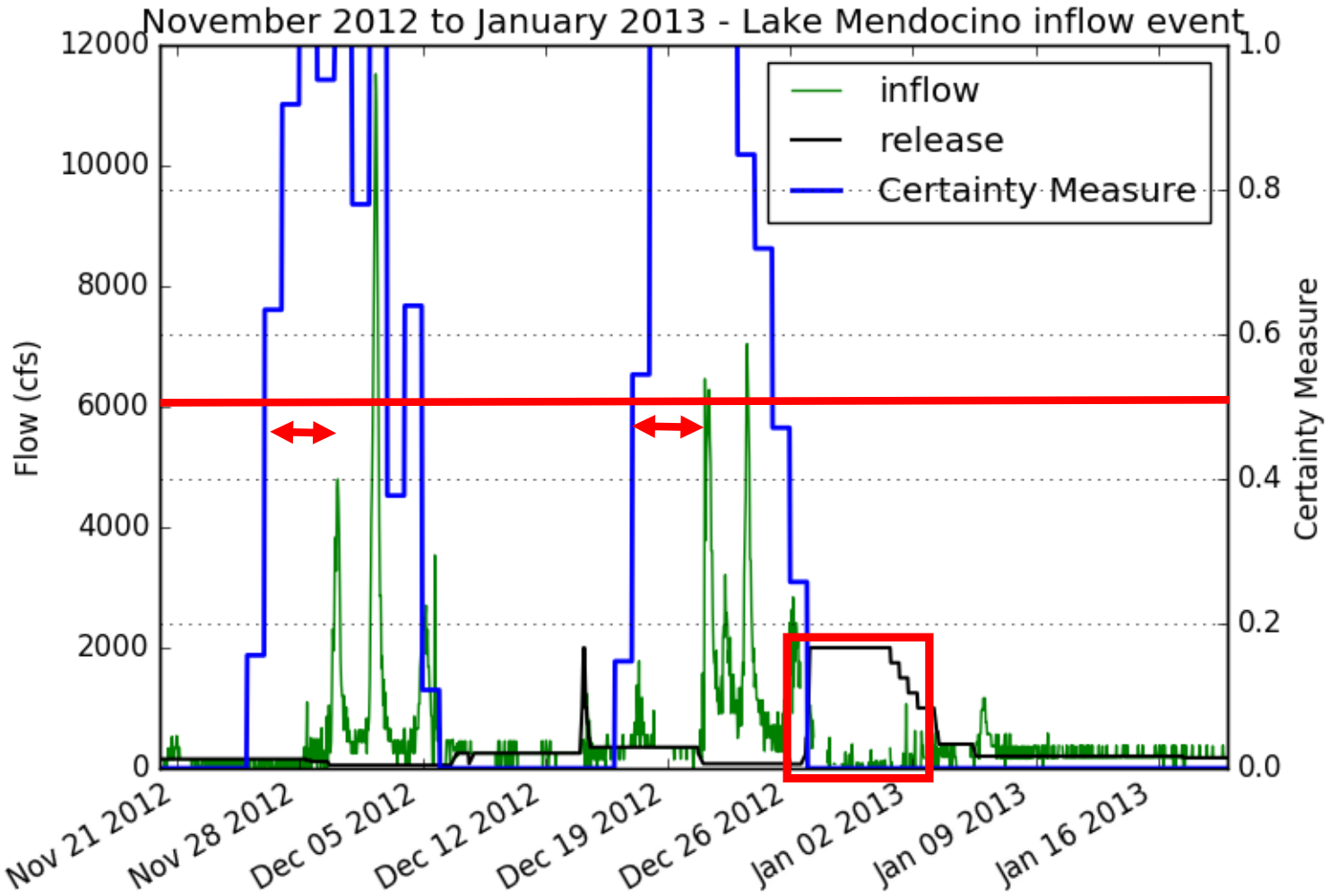
Results



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Summary

- Provided forecast skill assessment and actionable information based on the certainty (or lack)
  - Can look up **<u>any</u>** forecast in the context of historical forecast skill
    - Skill can be defined based on operator/basin/type of storm
  - Precipitation has also been assessed (not shown)
  - Showed an example from December 2012

- Transferability
- "certainty" criteria can optimized for each operator/basin
- Next steps: Decision support tool development

Thank you!

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Example: Forecast **Skill** Curve

Skills Hours - Forecast Hours ~ certainty

<u>12Z Forecast Volumes:</u>

1 **24hr: 1000af Skill = 120hr**

120hr – 24hr = 96hr

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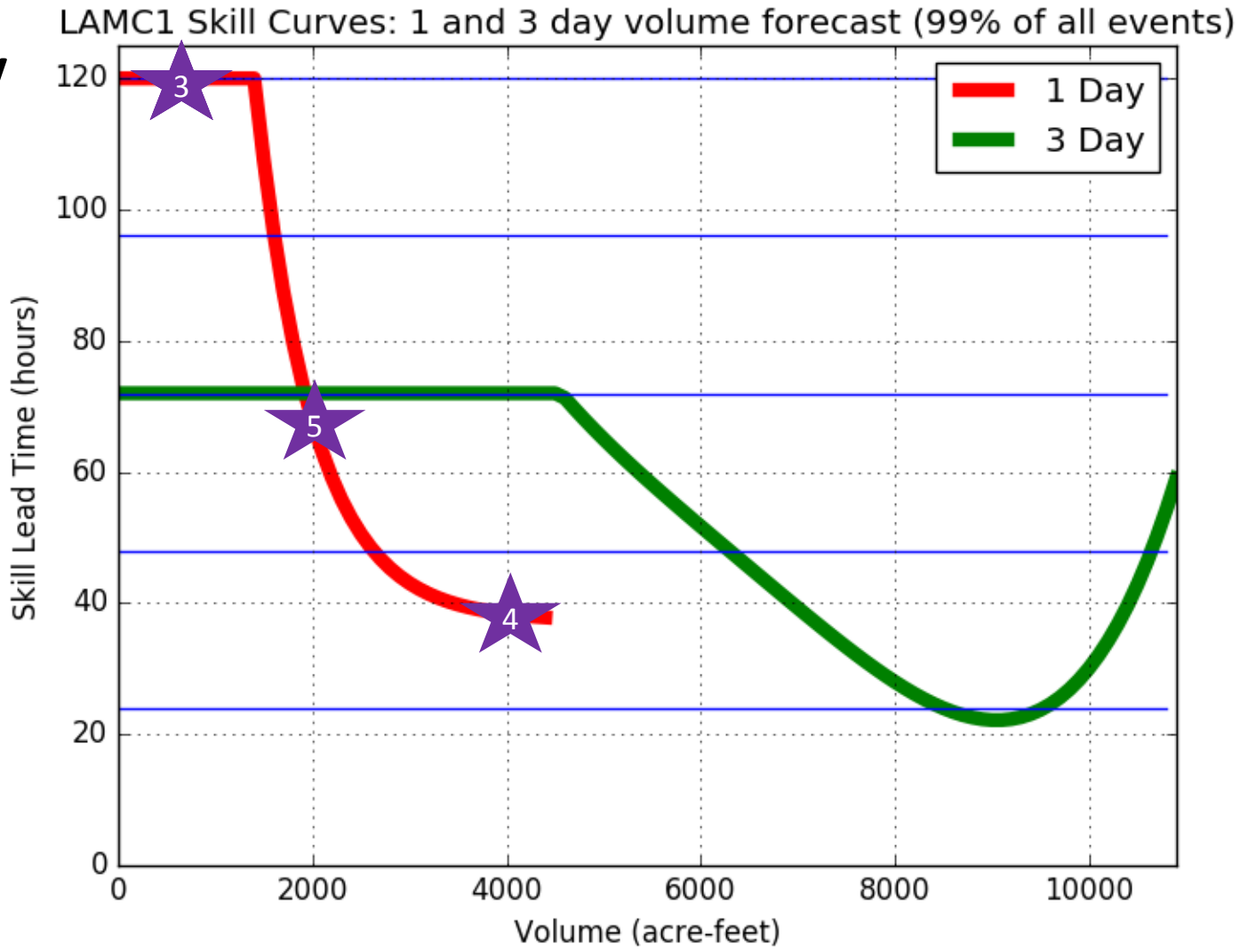
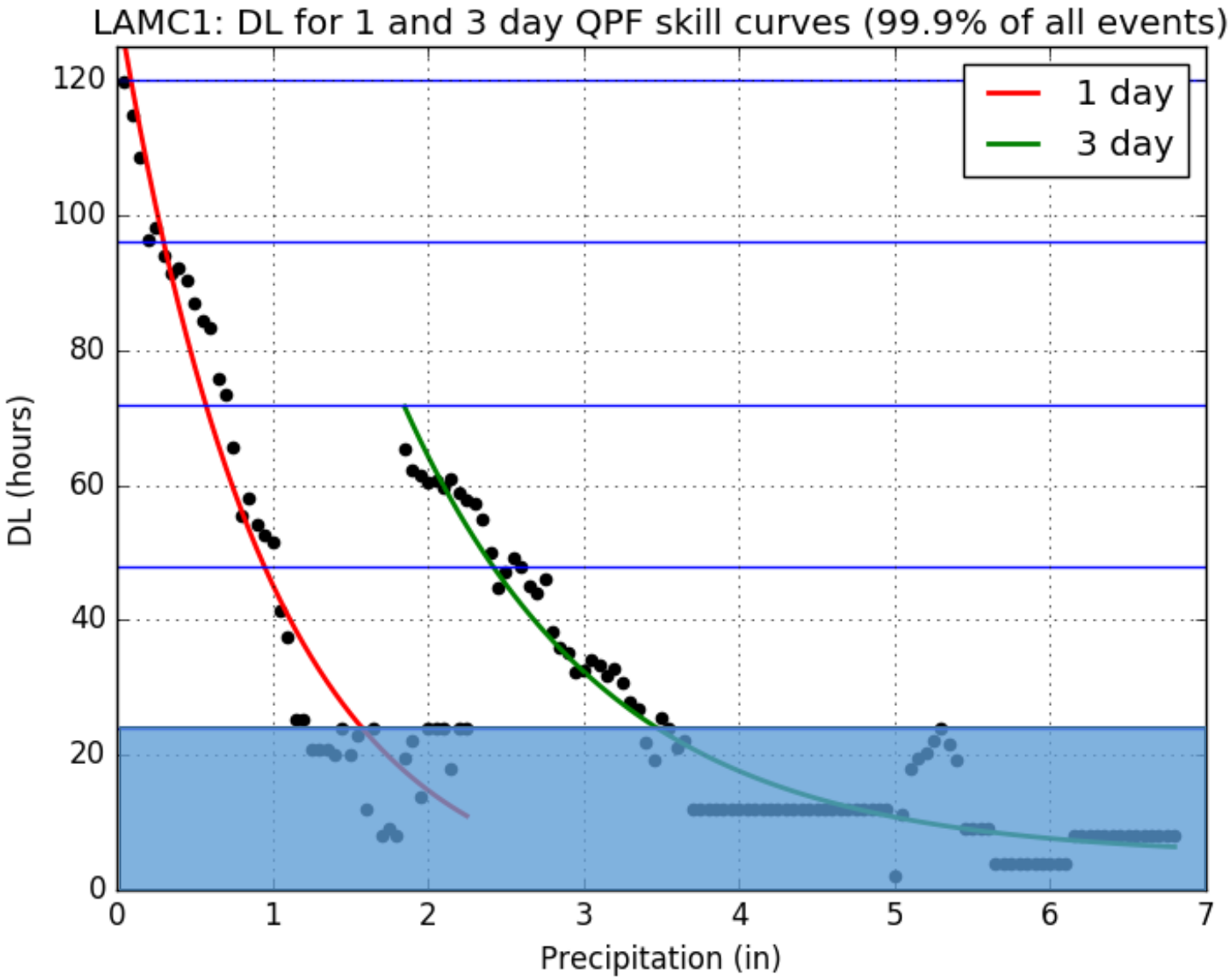
Forecast certainty ~
96+72+72-58-52 = 130/240 = **.54**



Actionable Risk

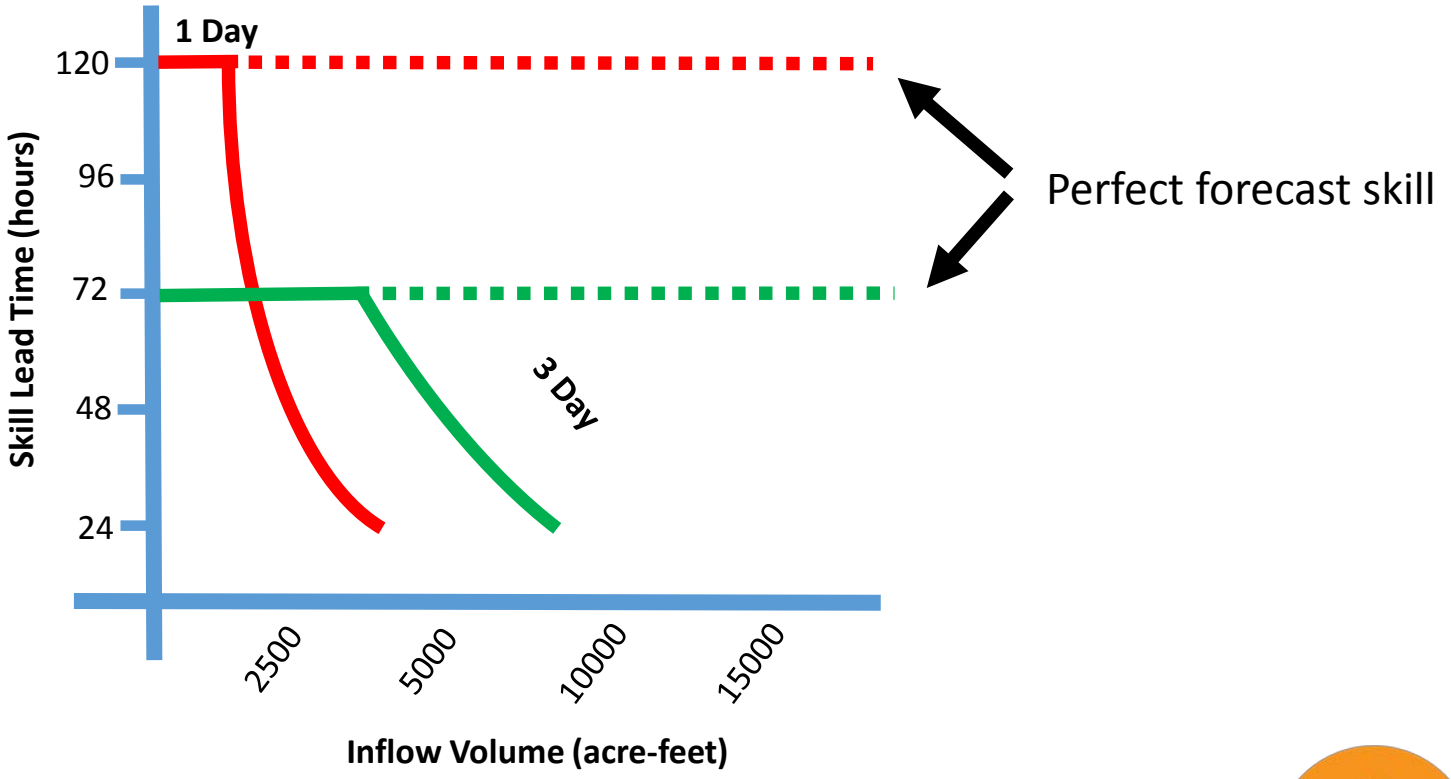
- "Actionable Risk Theory"
  - Recently motivated by terrorism.
- "process of exchanging information among interested parties about the nature, magnitude, significance, or control of a risk" - Covello (1992)

QPF


LAMC1: DL for 1 and 3 day QPF skill curves (99.9% of all events)
1 day
3 day
DL (hours)
Precipitation (in)
0
20
40
60
80
100
120
0
1
2
3
4
5
6
7

Forecast **Skill** Curve

Forecast Uncertainty =
96+72+72-58-52 = 130/240 = **.54**



Sellars et al. 2016 (in prep)