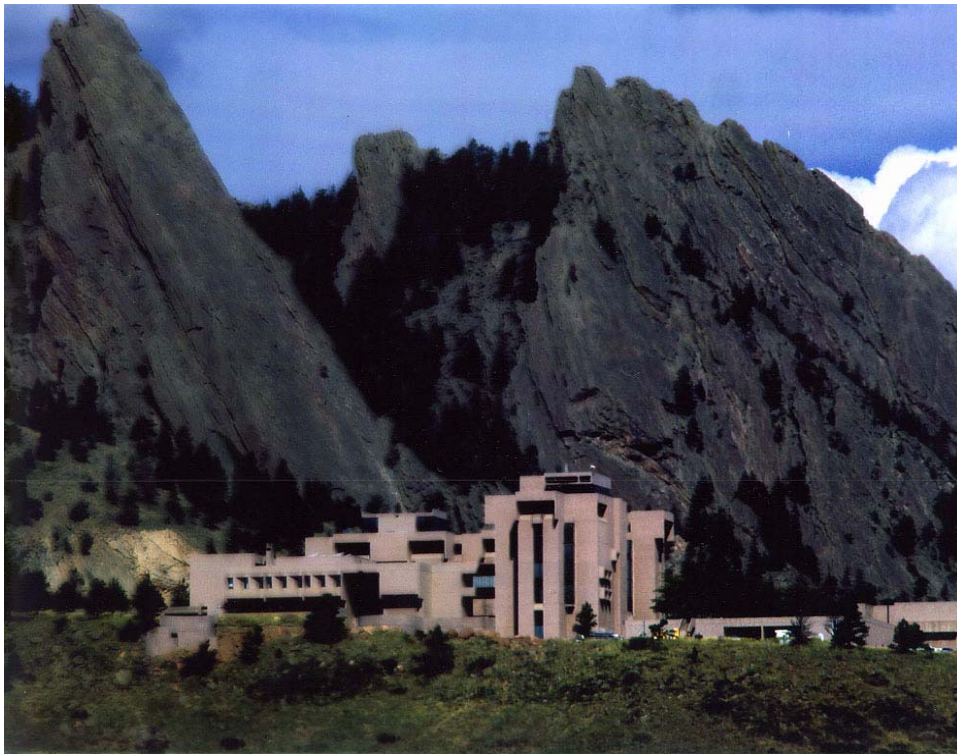


# CDF Forecasts: Generation and Verification



**Wes Wilson**  
**Sept. 2003**

# Overview

- **Comments on Classical Skill Statistics**
- **CDF Forecasts**
- **Statistical Decision Theory**
- **Application: CDF forecasts for SF Marine Stratus**



# Skill Scores for Deterministic Forecasts

Scoring Contingency Table

FORECAST	OBSERVATION			
		T	F	
	Y	A	B	$M_Y$
	N	C	D	$M_N$
		$M_T$	$M_F$	$M$

T: Event happens  
 F: Event does not happen  
 Y: Forecast "YES"  
 N: Forecast "NO"

Conditional Probability Contingency Table

FORECAST	OBSERVATION			
		T	F	
	Y	$P(Y T) P(T)$	$P(Y F) P(F)$	$P(Y)$
	N	$P(N T) P(T)$	$P(N F) P(F)$	$P(N)$
	$P(T)$	$P(F)$	1	

Two Interpretations:  
 1. Sample estimates  
 2. Intrinsic statistics



# Skill Statistics for Deterministic Forecasts

- $PSS = P(Y|T) - P(Y|F)$  reflects total benefit
- $LR = P(Y|T) / P(Y|F)$  reflects Benefit-per-Action

**PSS Flat Spot:**  $.9 - .3 = .7 - .1 = .6$

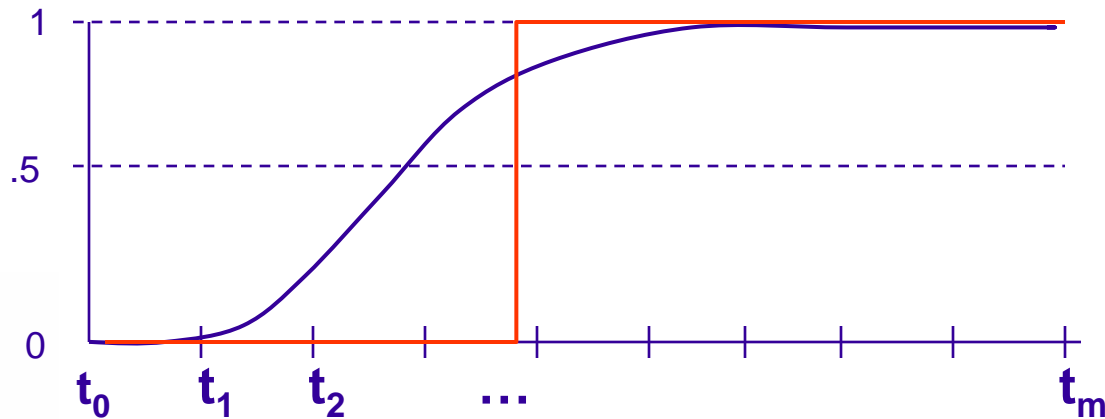
**Different LR:**  $.9/.3 = 3$  &  $.7/.1 = 7$

**Strategy: Maximize LR constrained by “Maintain PSS”**



# Intro: CDF Forecasts

- **Setting:**
  - Dichotomous outcomes (T or F ) for N trials
  - Nested categories whose union fills the outcome space  $\{[t_0, t_1], [t_0, t_2], \dots, [t_0, t_m]\}$  with  $t_1 < t_2 < \dots < t_m$
  - Probability Forecast :  $p_k(T_i)$  for the i-th trial, k-th Category
- **CDF Forecast: A forecast of probabilities for the i-th trial, for all categories**



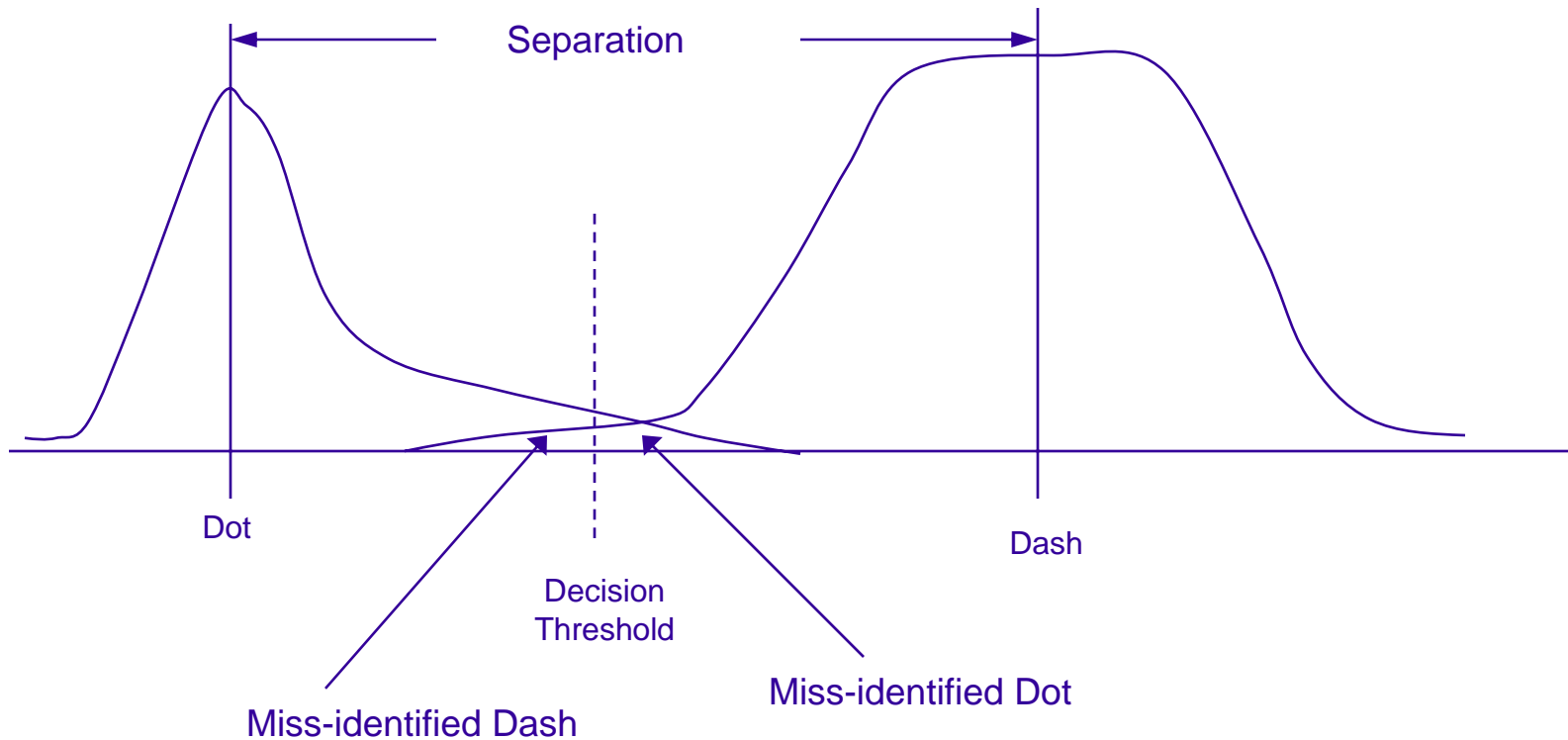
# Skill Statistics for CDF Forecasts

- **Brier Score:**  $(1/N) \sum (p_i - o_i)^2$  (Mn.Sq.Error)  
= Reliability + Resolution +  $P(T) * P(F)$
- **For each Category:**
  - Define  $P(Y|T)$  to be the mean probability forecasted when T
  - Define  $P(Y|F)$  to be the mean probability forecasted when F
  - Define  $PSS = P(Y|T) - P(Y|F)$  (Pierce skill for Prob. Fcst.)
- **In the limit as a forecast becomes confident,**  
**CDF PSS  $\rightarrow$  Deterministic PSS**



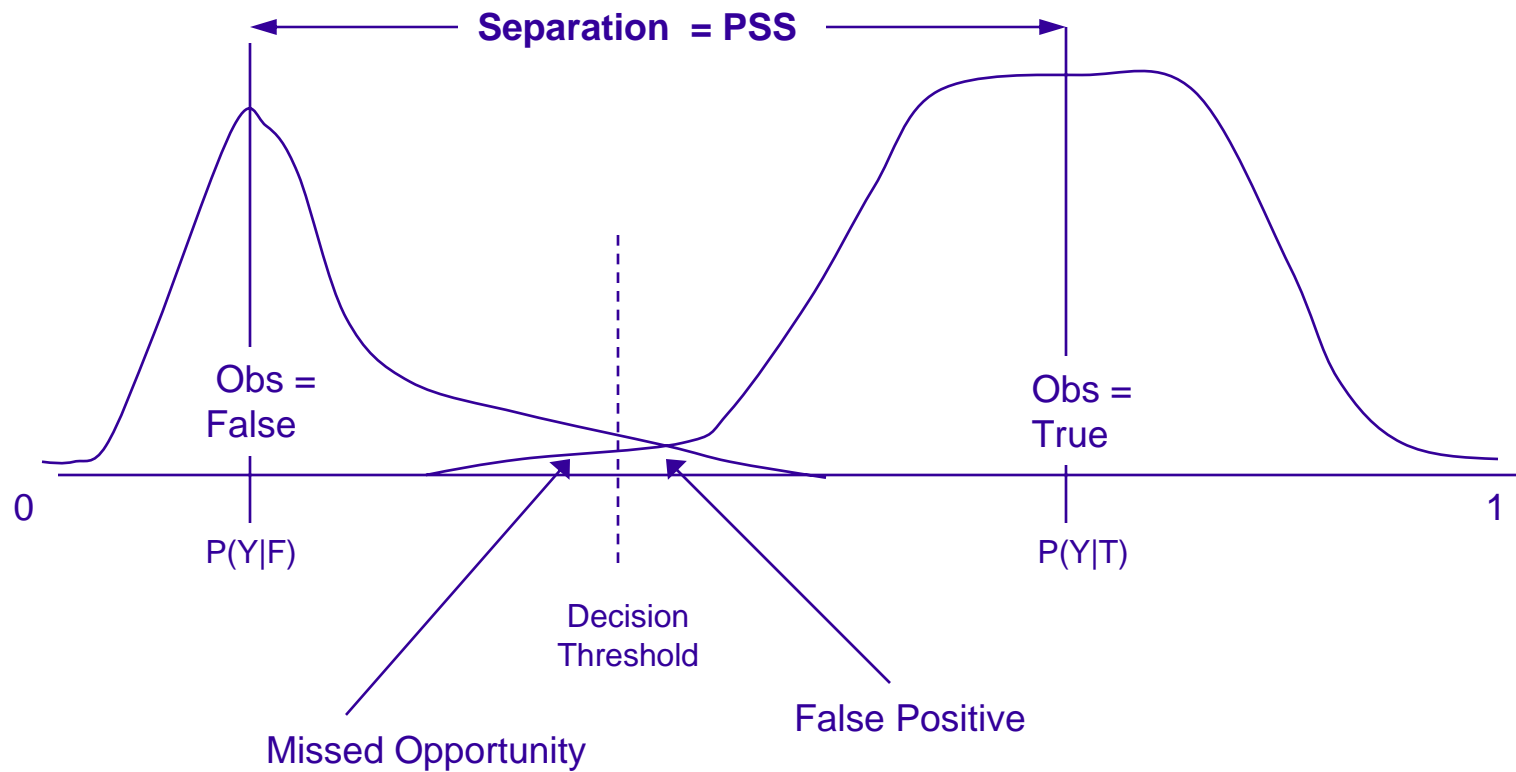
# Decision Theory - Historical

Stream of signals: Dots and Dashes- Discrimination by Length



# Decision Theory – Probability Forecasts

Stream of Trials: Decisions based on the Probability of events



**Discrimination by Magnitude of the Probability**

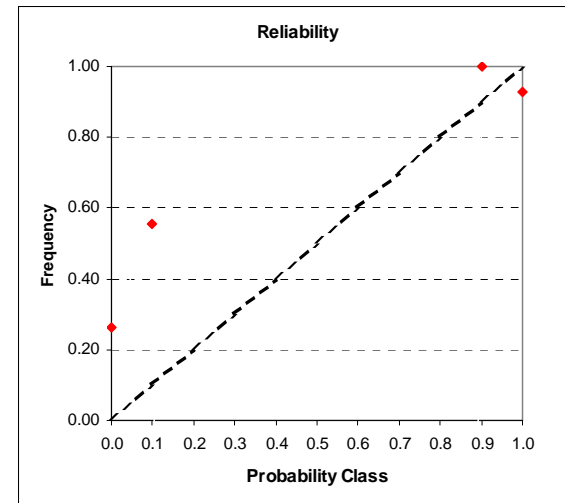
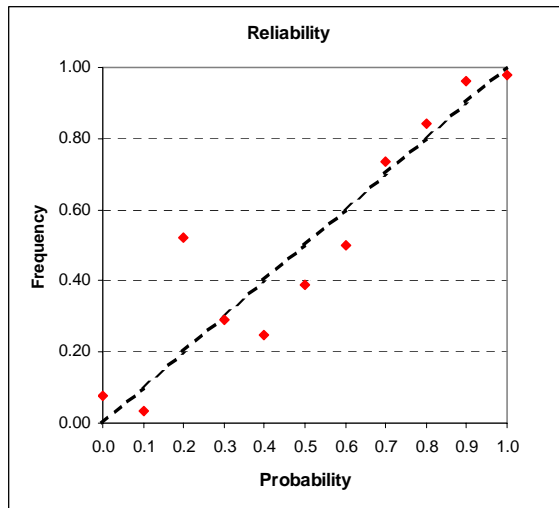
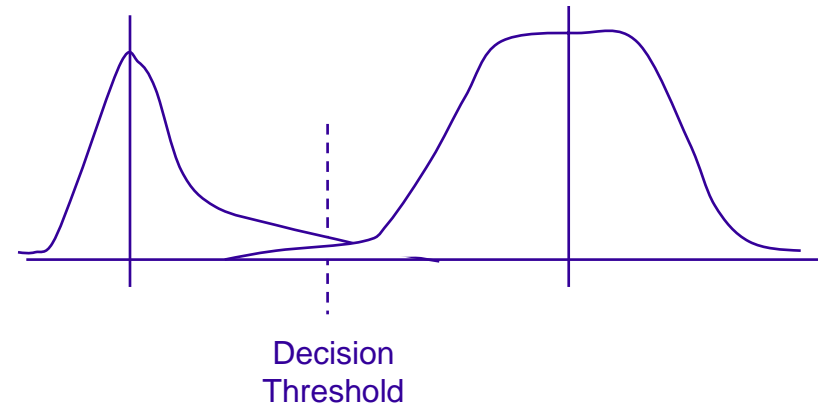
**Discriminant = # sigma's to partition equally**



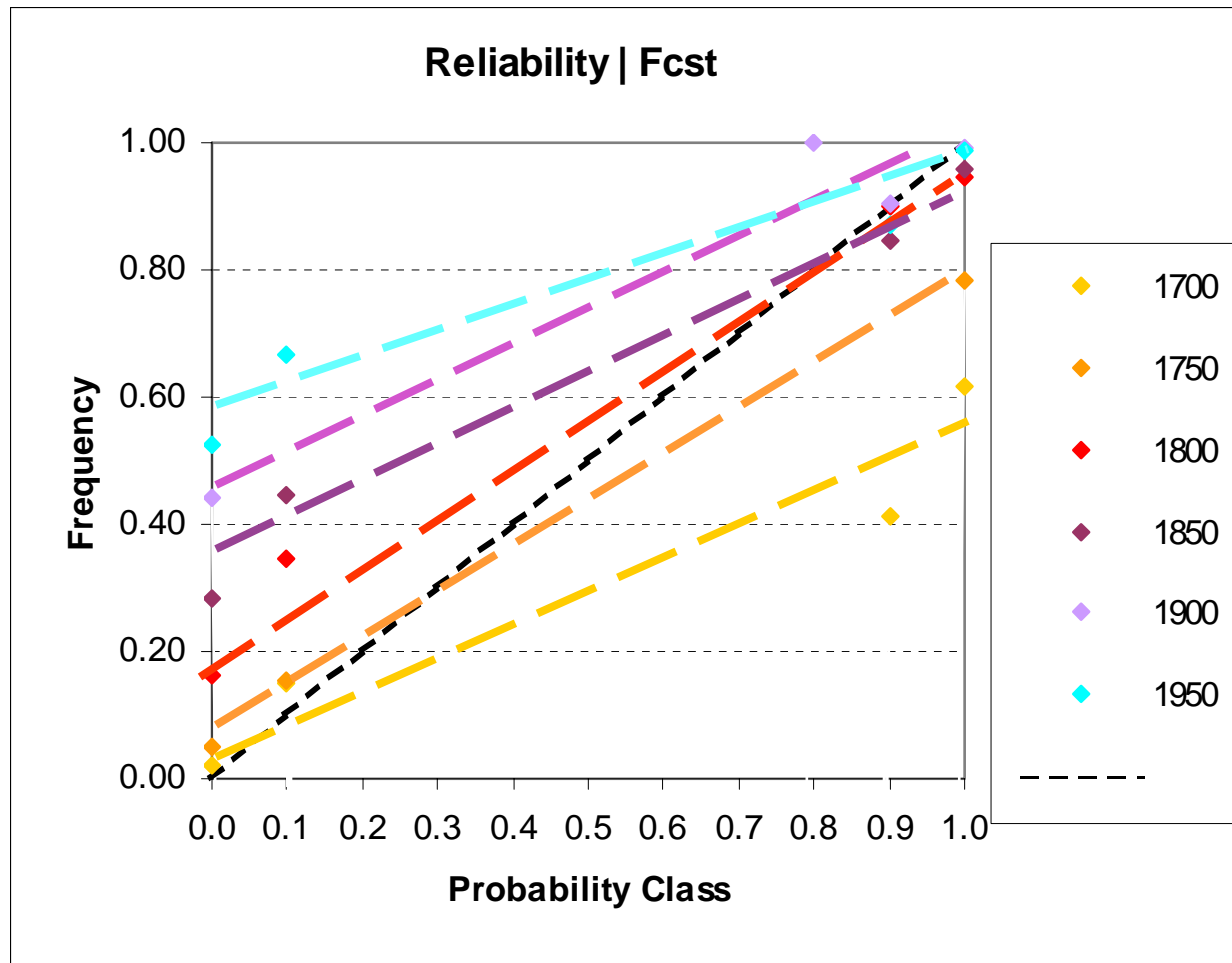


# Reliability

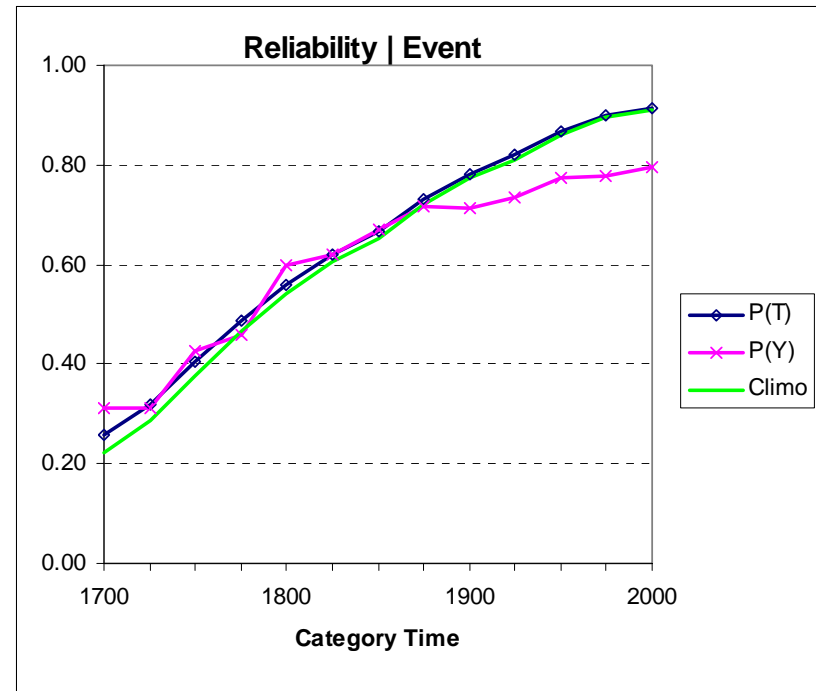
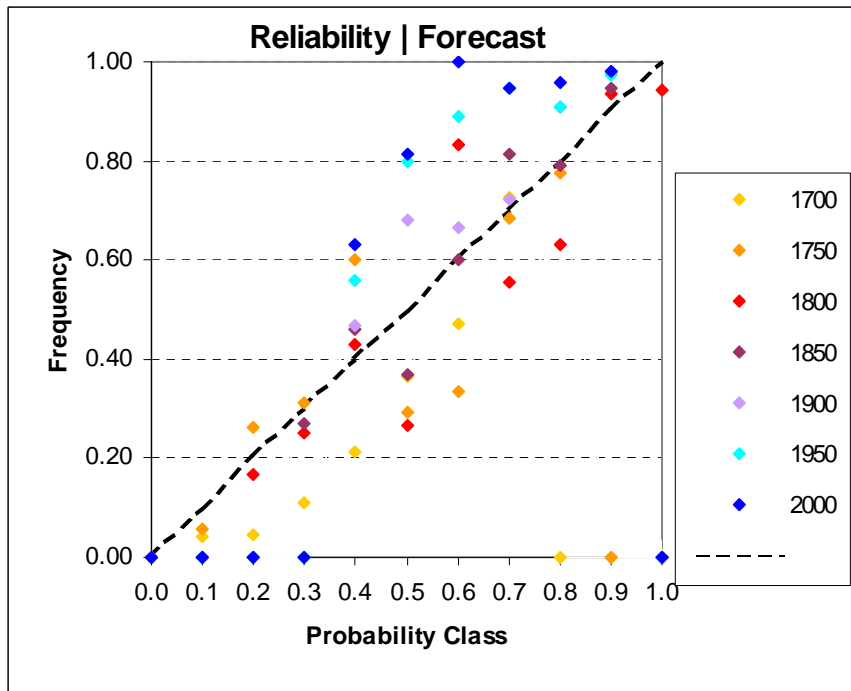
- Bin data to (k) Probability Classes
- Frequency of Occurrence vs. Fcst
- Discriminating forecast should have small counts in the middle classes
- Numerical estimation of mid-class frequencies may be problematic



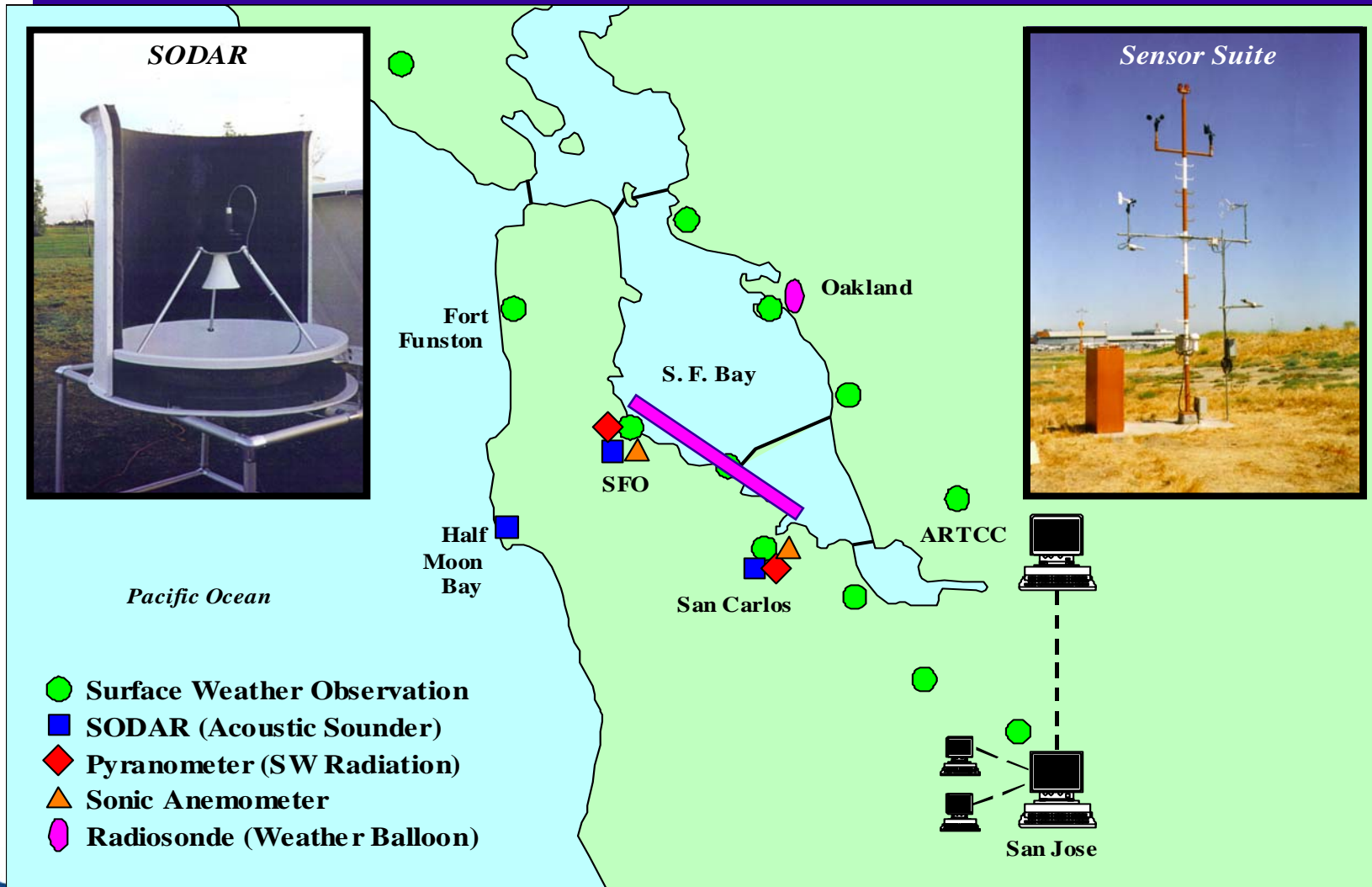
# Reliability & Linear Calibration



# Two Notions of Reliability

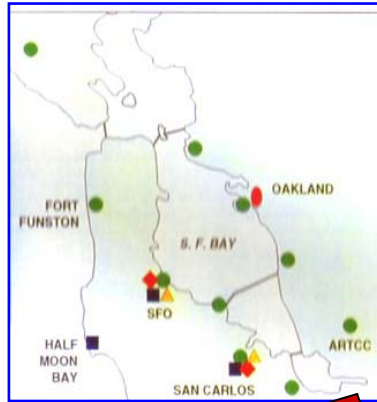


# SFO Problem

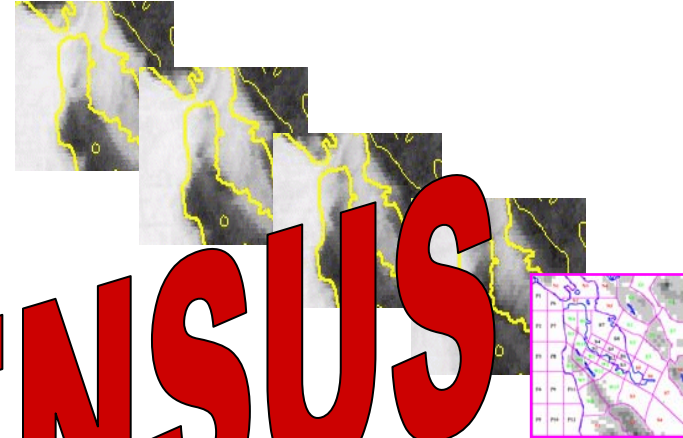


# Forecast Algorithms

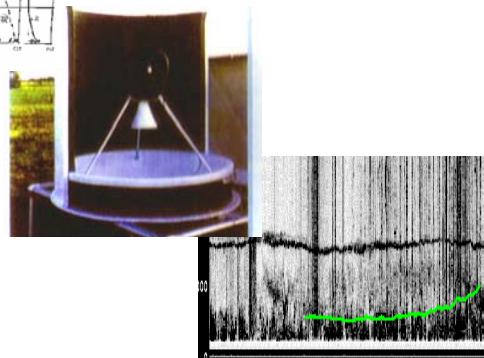
Regional Stat. Fcst Model



Satellite Stat. Fcst Model



**CONSENSUS**

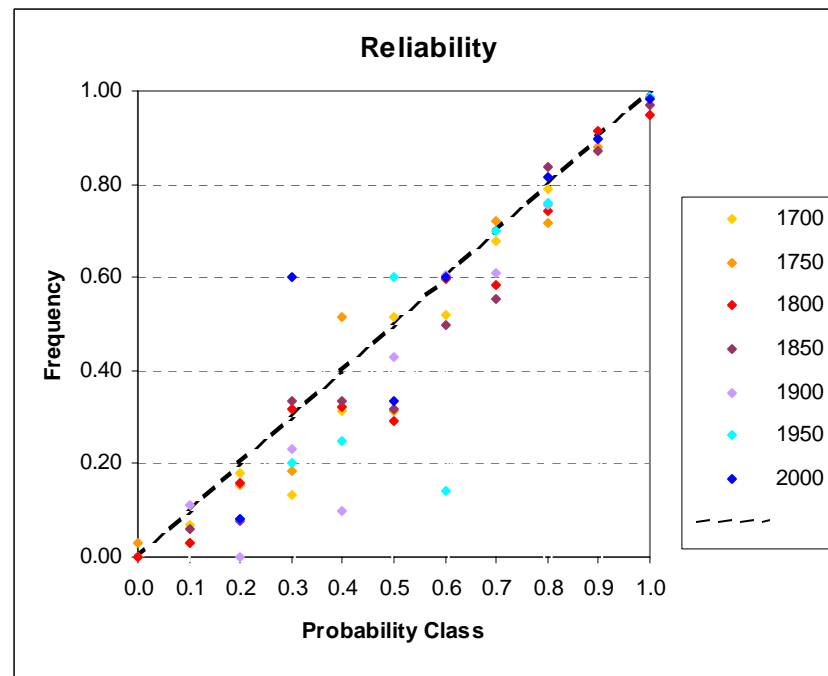


# Generating CDF forecasts

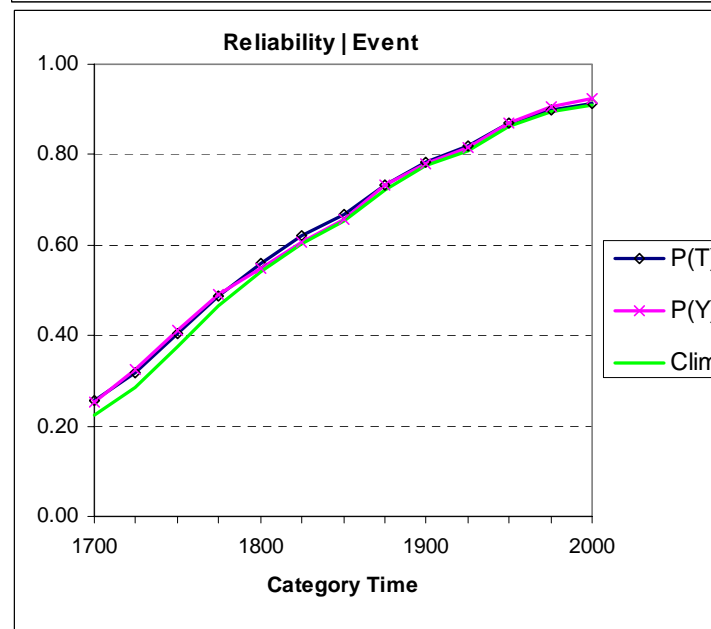
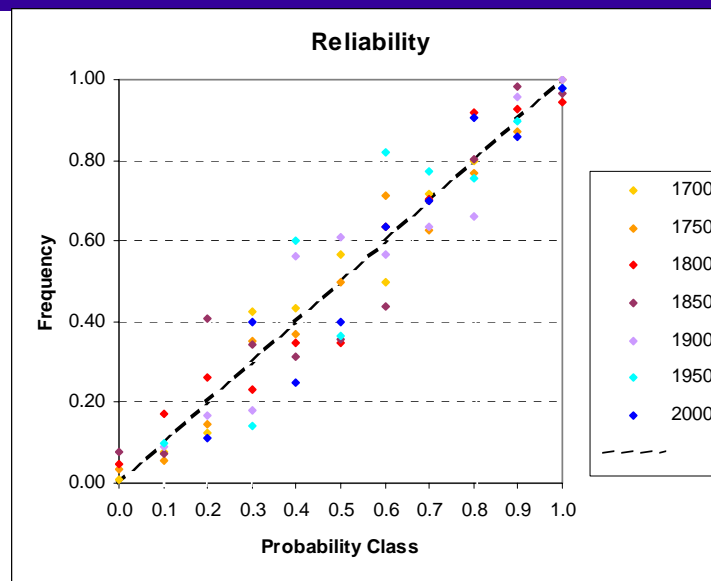
- **Goal: Build models that forecast PDF's for each of the SFO Marine Stratus Forecasts for CDM TM models (13z, 15z, 16z, 17z, 18z)**
- **Climo: Historical Model Performance**
- **Optimize Five Objective Functions**
  - **BS, MLE, PSS, LR|PSS, RL&PSS**
    - 15 min. Nested Categories
    - Predictors: SFO deterministic forecasts LSF, RSF, SSF, CF
    - Develop a Forecast Model for the probability that the event will occur in each category
    - Obs: Times that SFO initiated Side-by approaches



# 15z Climo Forecast



# 15z BS Forecast



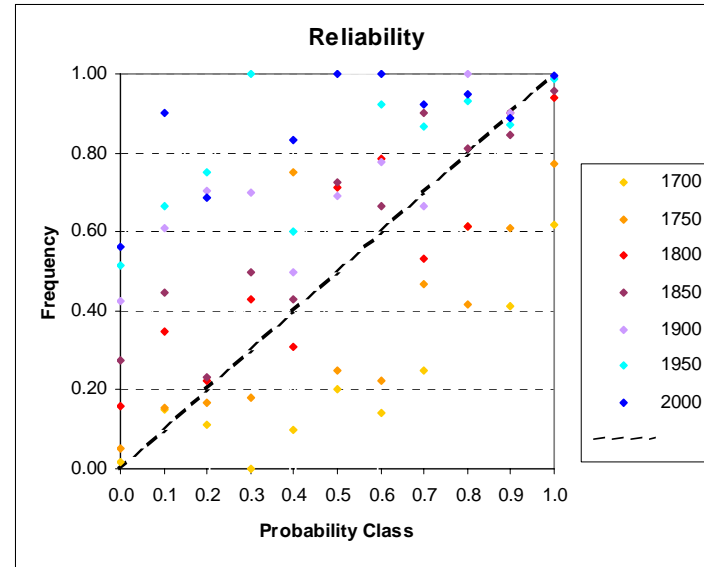
**Rel\_F 0.06**  
**Rel\_E 0.01**  
**avgPSS 0.40**



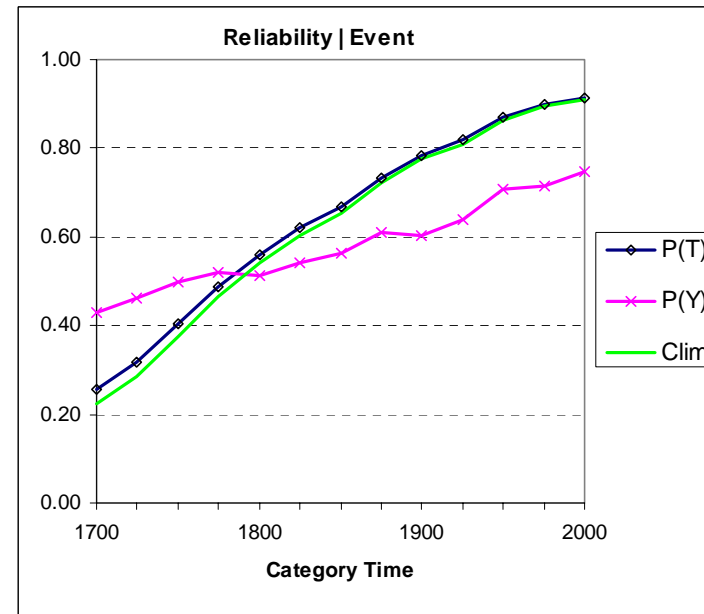
**NCAR**



# 15z PSS Forecast

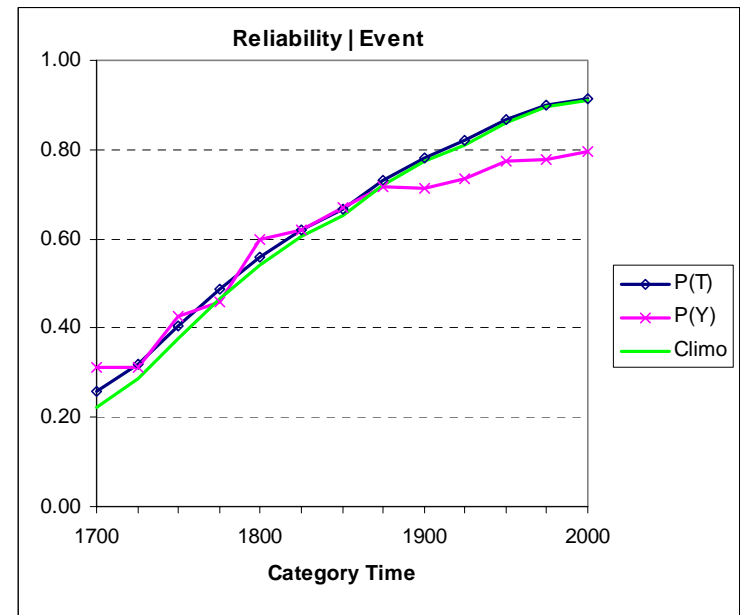
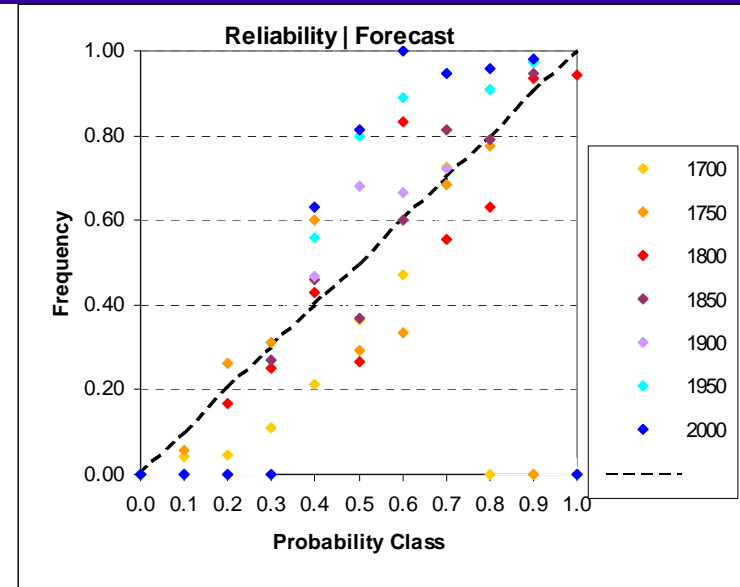
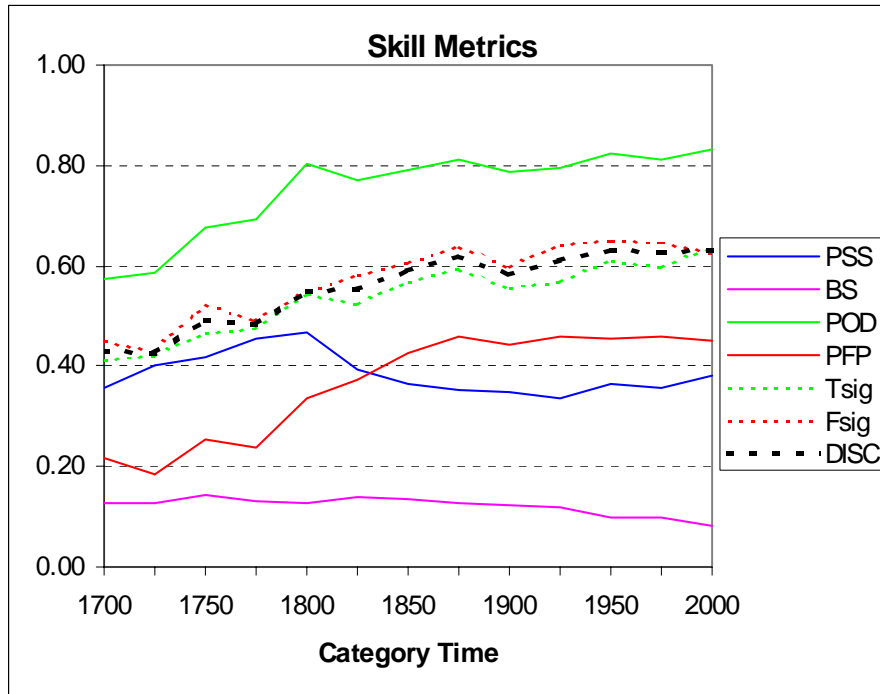


**Rel\_F**     **0.23**  
**Rel\_E**     **0.14**  
**avgPSS**    **0.60**



**NCAR**

# 15z PSS-cal Forecast



**Rel\_F**      **0.10**  
**Rel\_E**      **0.07**  
**avgPSS**     **0.38**

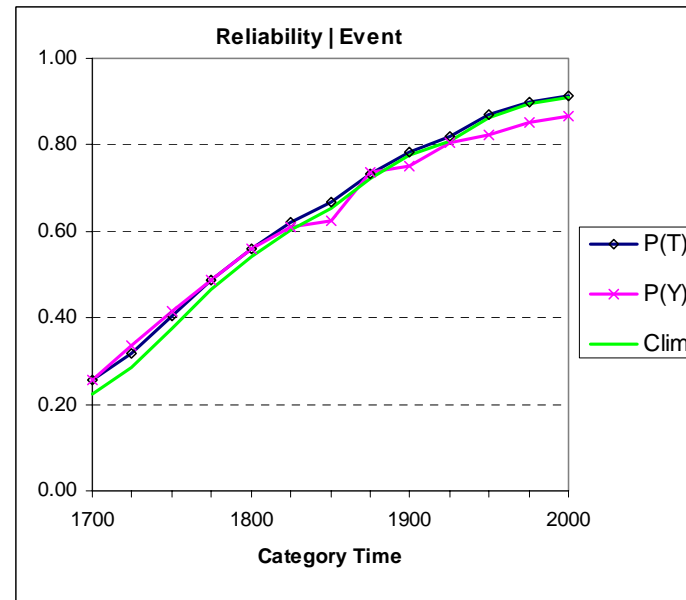
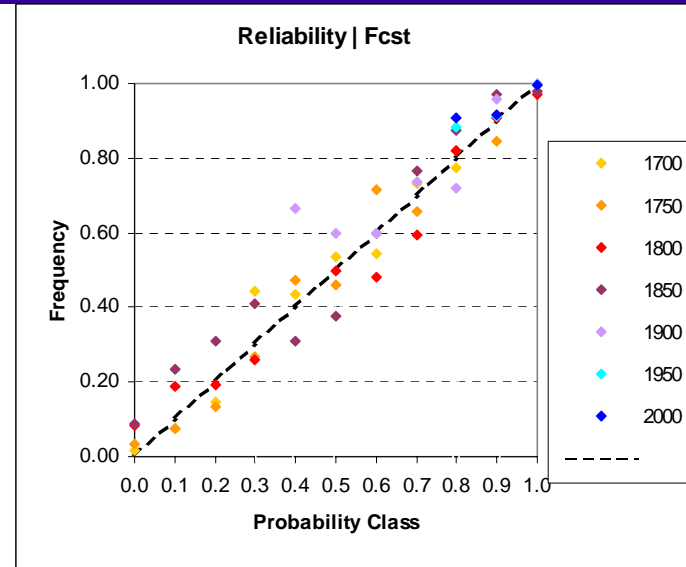


**NCAR**

# 15z PSS&RL Forecast



**Rel\_F 0.06**  
**Rel\_E 0.03**  
**avgPSS 0.43**



# Forecast Comparisons

15z	DET	DETC	CLIMO	BS	PSS	PSSc	PSS&RL
PSS	0.51	0.31	0.38	0.40	0.60	0.38	0.43
sqrtREL	0.42	0.24	0.22	0.24	0.48	0.32	0.24
16z							
PSS	0.54	0.35	0.39	0.45	0.59	0.41	0.48
sqrtREL	0.41	0.22	0.22	0.22	0.40	0.32	0.24
17z							
PSS	0.55	0.34	0.40	0.43	0.56	0.43	0.43
sqrtREL	0.40	0.22	0.20	0.24	0.32	0.28	0.22
18z							
PSS	0.53	0.32	0.34	0.35	0.54	0.35	0.40
sqrtREL	0.41	0.22	0.14	0.24	0.32	0.24	0.28



# Summary

- **We have developed several viable methods for generating CDF forecasts**
- **The deterministic forecasts developed by the SFO Marine Stratus project are useful predictors for modeling CDF forecasts**
- **Some CDF forecasts have much better Pierce Skill than the deterministic Consensus forecasts**
- **There is a trade-off between PSS and Reliability**



# What's Next?

- Understand PSS/Rel balance
- Tune forecasts to needs of TM models
- CDF forecasts for other Airports & CDM Needs
  - SFO forecasts from Met. Data
  - Other airports:
    - Convert deterministic Forecasts to CDF's
    - Forecasts from archived NWS data

