Air Quality Forecast Evaluation

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As part of **NOAA's Strategic Plan -**

the Agency will be expanding from
meteorological prediction to environmental prediction.

As a result, NOAA has launched a major new initiative:

Chemical Weather Forecasting
"Early Start" Research Plan.

The goal of this research is to provide an:

"operational national air quality forecasting system",

which will be achieved through a collaborative effort:

other federal agencies (e.g. EPA)
universities (e.g. UNH)
private sector (e.g. MCNC)

As part of *Task 2* of the:

Chemical Weather Forecasting “Early Start” Research Plan,

ARL-RTP has been asked to:

1) develop an evaluation protocol and
2) apply this protocol to several “air quality” forecast models:

MM5-”on-line” chemical model
NOAA’s Forecast Systems Laboratory

MM5-SMOKE-MAQSIP model
MCNC’s Environmental Programs Division

MM5-CAMX model
SUNY’s Atmospheric Science Research Center

These air quality forecast models provide twice-daily, 36-hr forecasts:

- Maximum 1-h and 8-h ozone concentrations
- 1 July – 30 September 2001 (*Summer 2002*)
- Eastern United States

  Texas (Houston)

  North Carolina (Charlotte)

  East Tennessee

  New Hampshire (Boston)

In developing the protocol for this operational evaluation,

ARL-RTP will utilize ozone data:

EPA's AIRS (state and local)
NOAA's AIRMAP and ETOS

Because of the significant influence of meteorology has on the quality of the ozone forecast, MM5 will also be evaluated using standard observations:

Surface and Upper-air

Model predictions will be extracted from the grid cells that contain observational data

Two Forecast / Evaluation Types

Discrete Forecasts [Observed] *vs* [Forecast]

Category Forecasts

Two Category
Exceedance
Non-Exceedance

a	b
c	d

Four Category
Good
Moderate
Unhealthy for Sensitive
Unhealthy

k	l	m	n
o	p	q	r
s	t	u	v
w	x	y	z

Evaluation of Discrete Forecasts

Accuracy (A) Average "closeness" between forecast and observations.

$$A = \frac{1}{N}\sum_{1}^{N} |f - o|$$

Bias (B) Indicates average over- or under-prediction of the forecast.

$$B = \frac{1}{N}\sum_{1}^{N} (f - o)$$

Evaluation of Discrete Forecasts

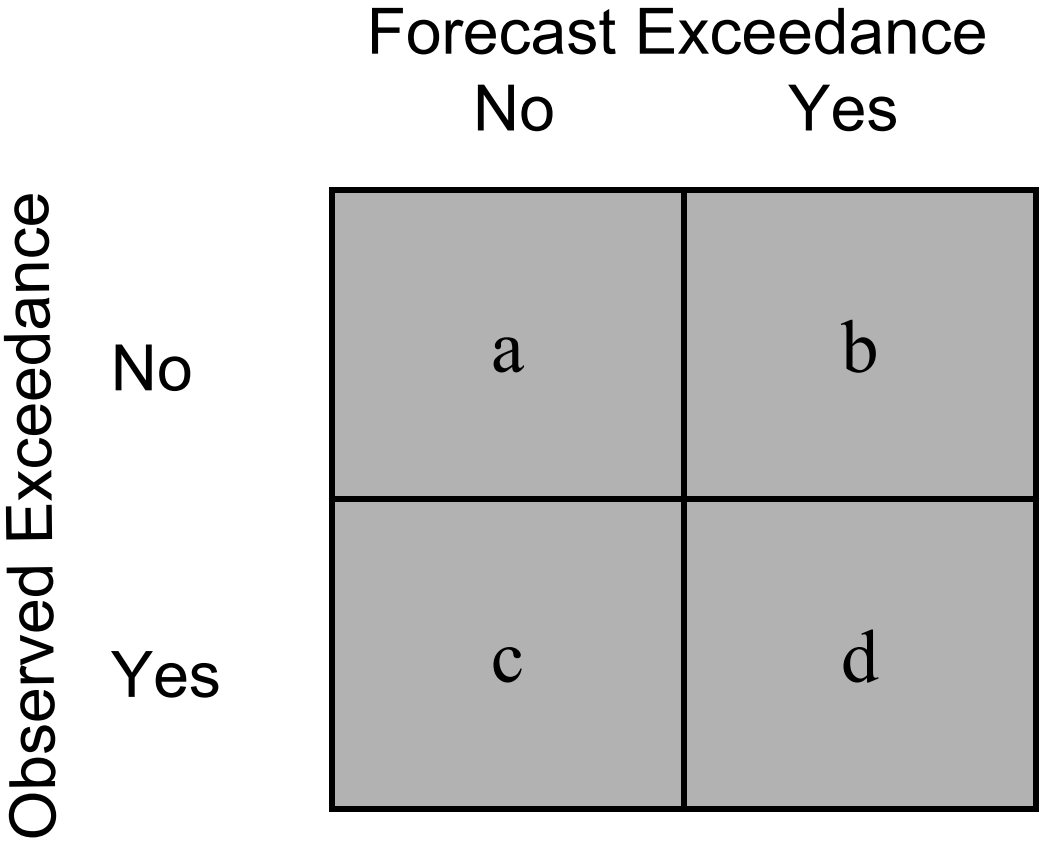
Skill Score (SS) Percentage improvement of a forecast with respect to a reference forecast (i.e.climatology)

$$SS = \left[1 - \frac{A}{A_{ref}}\right] 100$$

Correlation (r) A measure of the relationship between forecast and observations.

$$r = \frac{\frac{1}{N}\left(\sum_{j=1}^{N}\left(f_j - \mu_f\right)\left(o_j - \mu_o\right)\right)}{\sqrt{\frac{N\sum_{j=1}^{N} f_j^2 - \left(\sum_{j=1}^{N} f_j\right)^2}{N(N-1)}}\sqrt{\frac{N\sum_{j=1}^{N} o_j^2 - \left(\sum_{j=1}^{N} o_j\right)^2}{N(N-1)}}}$$

Two Category Forecast



Evaluation of Two Category Forecasts

a	b
c	d

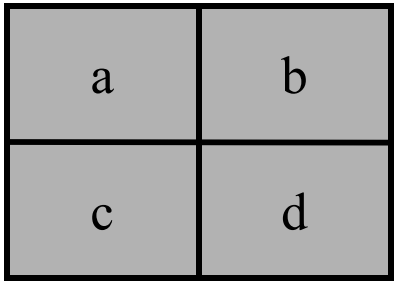
Accuracy (A) Percent of forecasts that correctly predict event or non-event.

$$A = \left(\frac{a + d}{N} \right) 100$$

Bias (B) Indicates if forecasts are under-predicted (false negatives) or over-predicted (false positives)

$$B = \frac{b + d}{c + d}$$

Evaluation of Two Category Forecasts



False Alarm Rate (FAR)

Percent of times a forecast of high ozone did not occur

$$FAR = \left(\frac{b}{b+d} \right) 100$$

Critical Success Index (CSI)

How well the high ozone events were predicted

$$CSI = \left(\frac{d}{b+c+d} \right) 100$$

Evaluation of Two Category Forecasts

a	b
c	d

Probability of Detection (POD) Ability to predict high ozone events

$$POD = \left(\frac{d}{c + d} \right) 100$$

Skill Score (SS) Percentage improvement of a forecast with respect to a reference forecast (i.e.,persistence).

$$SS = \left(\frac{1 - A}{A_{ref}} \right) 100$$

Evaluation of Four Category Forecast

Forecast

Observed	Good	Moderate	Unhealthy Sensitive	Unhealthy
Good	k	l	m	n
Moderate	o	p	q	r
Unhealthy Sensitive	s	t	u	v
Unhealthy	w	x	y	z

The purpose of ARL-RTP's research is twofold:

- Develop an evaluation protocol for the air quality forecast models
  - determine which metrics are best
  - refine, streamline and "standardize" the evaluation procedure

2) Evaluate existing air quality forecast models
  - refine the models being used for forecasting
  - focus research on critical areas needing improvement

Help NOAA in their overall goal of providing:

operational national air quality forecasting system

Schedule

Meteorological/chemical observations database preparation	Spring 2002
Forecast evaluation protocol development	Summer 2002
Forecast evaluation report	Autumn 2002

UCAR Postdoctoral Fellowship

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