**Program to compute verification scores for weather forecasts. See https://github.com/WFRT/verif/wiki for how to format input files.**

**INSTALLATION:**

**Download source code from the Github repository above and install from source (When in doubt, consult the README.rst file)**

**Steps**

**Installing on Ubuntu**

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\*\*Prerequisites\*\*

Verif requires a pip installation and Python 3. The python package "cartopy" is optional, but provides

a background map when verification scores are plotted on a map. To install Cartopy, with its GEOS and

PROJ4 dependencies, do the following:

sudo apt-get update

sudo apt-get install libgeos-dev libproj-dev

sudo pip3 install cartopy

\*\*Installing using pip\*\*

After this, the easiest is to install the lastest version of Verif using pip:

sudo pip install verif

Verif should then be accessible by typing ``verif`` on the command-line. If you do not have sudo-rights, then install verif as follows:

pip install verif --user

This will create the executable ``~/.local/bin/verif``. Add this to your PATH environment variable if necessary (i.e add ``export PATH=$PATH:~/.local/bin`` to ``~/.bashrc``).

**\*\*Installing from source\*\***

Alternatively, to install from source, download the source code of the latest version: https://github.com/WFRT/verif/releases/. Unzip the file and navigate into the extracted folder.

Then install Verif by executing the following inside the extracted folder:

sudo pip install -r requirements.txt

sudo python setup.py install

This will create the executable ``/usr/local/bin/verif``. Add ``/usr/local/bin`` to your PATH environment

variable if necessary. If you do not have sudo privileges do:

pip install -r requirements.txt --user

python setup.py install --user

This will create the executable ``~/.local/bin/verif``. Add ``~/.local/bin`` to your PATH environment variable.

**Utilization of Verif**

Arguments:

files One or more verification files in NetCDF or text format (see 'File Formats' below). The file format is autodetected.

-m metric Which verification metric to use? See 'Metrics' below.

--config file Read further arguments from this file. This flag can appear multiple times.

--list-times Prints what times are available in the files

--list-dates Like --list-times but in YYYYMMDD HH:MM:SS format

--list-locations Prints what locations are available in the files

--list-quantiles Prints what quantiles are available in the files

--list-thresholds Prints what thresholds are available in the files

--version Prints what version of verif this is

**Dimensions and subset:**

(Note: vectors can be entered using commas, or MATLAB syntax i.e 3:5 is 3,4,5 and 3:2:7 is 3,5,7)

-d dates A vector of dates in YYYYMMDD format, e.g. 20130101:20130201.

-elevrange range Limit the verification to locations within minelev,maxelev.

-l locations Limit the verification to these location IDs.

-lx locations Remove these locations from the verification. This happens after -l, -latrange, -lonrange, and -elevrange has been applied.

-latrange range Limit the verification to locations within minlat,maxlat.

-lonrange range Limit the verification to locations within minlon,maxlon.

-o leadtimes Limit the verification to these leadtimes (in hours).

-obsrange range Limit the verification to this range of observation values.

-r thresholds Compute scores using these thresholds (only used by some metrics).

-q quantiles Compute scores using these quantiles (only used by some metrics).

-t times A vector of unix timestamps. Only allow these times.

-tod timeofdays A vector of hours of day, e.g. 0:12. Only allow times with these hour of the day.

-x dim Plot this dimension on the x-axis: time, leadtime, year, month, week, day, timeofday, dayofyear, monthofyear, location, elev, lat, lon, threshold, leadtimeday, or no. Not supported by all metrics. If not specified, then a default is used based on the metric. 'location' refers to the location id. 'leadtimeday' aggregates leadtimes into whole forecast days. 'no' collapses all dimensions and computes one value.

**Data manipulation:**

-acc Accumulated values along the x-axis. Does not work for 'Special diagams.'

-agg type Aggregation type: 'absmean', 'count', 'iqr', 'max', 'mean', 'meanabs', 'median', 'min', 'range', 'std', 'sum', 'variance', or a number between 0 and 1. Some metrics computes a value for each value on the x-axis. Which function should be used to do the aggregation? Default is 'mean'. Only supported by some metrics. A number between 0 and 1 returns a specific quantile (e.g. 0.5 is the median).

-b type One of 'below' (< x), 'below=' (<= x), '=within' (<= x <), 'within' (< x <), 'within=' (< x <=), '=within=' (<= x<=), 'above' (> x), or 'above=' (>= x). For threshold plots (ets, hit, within, etc) 'below/above' computes frequency below/above the threshold, and 'within' computes the frequency between consecutive thresholds.

-c file File containing climatology data. Subtract all forecasts and obs with climatology values.

-C file File containing climatology data. Divide all forecasts and obs by climatology values.

-fcst field What variable should be used as the forecast? 'obs', 'fcst' (default), threshold:<threshold>, quantile:<quantile>, 'pit', or the name of any other field in the input files.

-hist Plot values as histogram. Only works for any field that can be specified with -fcst.

-obs field What variable should be used as the observation? See -fcst.

-sort Plot values sorted. Only works for any field than can be specified with -fcst.

-T value Aggregate observations and forecasts across this many leadtimes.

**Plotting options:**

-a Annotate graph by labeling each data point. Not supported by all metrics.

-aspect ratio Force the aspect ratio of the plot. A value greater than 1will stretch out the y-axis.

-bottom value Bottom boundary location for saved figure [range 0-1]

-clabel text Custom colorbar label

-clim limits Force colorbar limits to the two values lower,upper. Only used in combination with -type map.

-cmap colormap Use this colormap when possible (e.g. jet, inferno, RdBu).

Only used in combination with -type map.

-dpi value Resolution of image in dots per inch (default 100)

-gc color Color for grid lines. e.g red,[0.3,0,0],0.3.

-gs style Line styles for gri, such as -, --, or :.

-gw width Line width for grid

-f file Save image to this filename

-fs size Set figure size width,height (in inches). Default 8x6.

-labfs size Font size for axis labels

-lc colors Comma-separated list of line colors, such as red,[0.3,0,0],0.3. Colors are repeated if there are more lines than colors.

-left value Left boundary location for saved figure [range 0-1]

-leg titles Comma-separated list of legend titles. Use '\_' to represent space.

-legfs size Font size for legend. Set to 0 to hide legend.

-legloc loc Where should the legend be placed? Locations such as 'best', 'upper\_left', 'lower\_right', 'center'. Use underscore when using two words.

-ls styles Comma-separated list of line styles, such as -,--. Styles are repeated if there are more lines than styles.

-lw width Comma-separated list of line widths

-maptype type One of 'simple', 'sat', or 'topo'. 'simple' shows a basic ocean/lakes/land map, 'sat' shows a satellite image, and 'topo' a topographical map. Only relevant when '-type map' has been selected.

-ma markers Comma-separated list of markers (e.g. o,\*,x)

-ms size Comma-separated list of marker sizes

-nogrid Turn the grid on the plot off

-nomargin Remove margins (whitespace) in the plot

-obsleg Name to put in legend for observations (if applicable)

-right value Right boundary location for saved figure [range 0-1]. Must be greater than -left.

-simple Make a simpler plot, without extra lines, subplots, etc.

-sp Show a line indicating the perfect score

-tickfs size Font size for axis ticks

-title text Custom title to chart top

-titlefs size Font size for title.

-top value Top boundary location for saved figure [range 0-1]. Must be greater than -bottom.

-type type One of 'plot' (default), 'text', 'csv', 'map', 'rank', 'maprank', 'impact', or 'mapimpact'.

-xlabel text Custom x-axis label

-xlim limits Force x-axis limits to the two values lower,upper

-xlog Use a logarithmic x-axis

-xrot value Rotation angle for x-axis labels

-xticks ticks A vector of values to put ticks on the x-axis

-xticklabels labs A comma-separated list of labels for the x-axis ticks

-ylabel text Custom y-axis label

-ylim limits Force y-axis limits to the two values lower,upper

-ylog Use a logarithmic y-axis

-yrot value Rotation angle for y-axis labels

-yticks ticks A vector of values to put ticks on the y-axis

-yticklabels labs A comma-separated list of labels for the y-axis ticks

**Metrics (-m):**

(For a full description of a metric, run verif -m <metric>)

**Deterministic:**

alphaindex Alpha index

bias Bias (forecast - observation)

cmae Cube-root mean absolute cubic error

corr Correlation between observations and forecasts

derror Distribution error

diff Difference in aggregated statistics (agg(forecast) - agg(observation))

dmb Degree of mass balance (obs/fcst)

ef Exceedance fraction: fraction of times that forecasts > observations

fcst Forecasted value

kendallcorr Kendall correlation between observations and forecasts

leps Linear error in probability space

mae Mean absolute error

mbias Multiplicative bias (fcst/obs)

nsec Nash-Sutcliffe efficiency coefficient

obs Observed value

rankcorr Rank correlation between observations and forecasts

ratio Ratio of aggregated statistics (agg(forecast) / agg(observation))

rmse Root mean squared error

rmsf Root mean squared factor

stderror Standard error (i.e. RMSE if forecast had no bias)

within The percentage of forecasts within some error bound. Use -r to specify error bounds

**Threshold:**

a Hit

b False alarm

baserate Base rate: Fraction of observations (a + c)

biasfreq Bias frequency (number of fcsts / number of obs)

c Miss

d Correct rejection

dscore Generalized discrimination score

edi Extremal dependency index

eds Extreme dependency score

ets Equitable threat score

fa False alarm rate

far False alarm ratio

fcstrate Fractions of forecasts (a + b)

hit Hit rate (a.k.a. probability of detection)

hss Heidke skill score

kss Hanssen-Kuiper skill score

lor Log odds ratio

miss Miss rate

n Total cases

or Odds ratio

pc Proportion correct

sedi Symmetric extremal dependency index

seds Symmetric extreme dependency score

threat Threat score

yulesq Yule's Q (Odds ratio skill score)

**Probabilistic:**

bs Brier score

bsrel Brier score, reliability term

bsres Brier score, resolution term

bss Brier skill score

bssrel Brier skill score, reliability term

bssres Brier skill score, resolution term

bsunc Brier score, uncertainty term

ign0 Ignorance of the binary probability based on threshold

marginalratio Ratio of marginal probability of obs to marginal probability of fcst. Use -r to specify thresholds.

pit Verifying PIT-value (CDF at observation)

pithistdev PIT histogram deviation factor (actual deviation / expected deviation)

pithistshape Second derivative of the PIT histogram. Negative means U-shaped.

pithistslope Average slope of the PIT histogram. Positive mean too many obs in the higher ranks.

quantile Mean value of a quantile forecast. Use -q to set quantile.

quantilecoverage Fraction of observations contained within quantile interval. Use -q to set quantiles, and -b to set interval definition.

quantilescore Quantile score. Use -q to set which quantiles to use, and -b to set interval definition.

spherical Spherical probabilistic scoring rule for binary events

spread Spread between two quantiles. Use -q to set which quantiles to use.

threshold Mean value of threshold forecast. Use -r to set threshold.

**Special diagrams:**

against Plots the forecasts for each pair of input files against each other. Colours indicate which input file had the best forecast (but only if the difference is more than 10% of the standard deviation of the observation).

autocorr Plots error auto-correlation as a function of distance.

Use -x to specify axis to find auto-correlations for: -x location gives correlation between all pairs of locations; -x time gives between all pairs of forecast initializations; Similarly for -x leadtime, -x lat, -x lon, -x elev.

autocov Plots error auto-covariance as a function of distance. Use -x to specify axis to find auto-correlations for: -x location gives correlation between all pairs of locations; -x time gives between all pairs of forecast initializations; Similarly for -x leadtime, -x lat, -x lon, -x elev.

change Forecast skill (MAE) as a function of change in obs from previous forecast run

cond Plots forecasts as a function of obs (use -r to specify bin-edges)

discrimination Discrimination diagram for a certain threshold (-r)

droc Plots the receiver operating characteristics curve for the deterministic forecast for a single threshold. Uses different forecast thresholds to create points.

droc0 Same as DRoc, except don't use different forecast thresholds: Use the same threshold for forecast and obs.

economicvalue Economic value diagram for a single threshold (-r). Shows what fraction of costs/loses can be reduced by the forecast relative to using climatology.

error Decomposition of RMSE into systematic and unsystematic components

freq Frequency of obs and forecasts

fss Plots the fractions skill score for different spatial scales. Use -r to specify a threshold, -b to define the event, and '-x leadtime' to specify temporal FSS.

igncontrib Binary Ignorance contribution diagram for a single threshold (-r). Shows how much each probability issued contributes to the total ignorance.

invreliability Reliability diagram for a certain quantile (-q)

marginal Show marginal distribution for different thresholds

meteo Plot a meteogram, with deterministic forecast, all quantile lines available (use -q to select a subset of quantiles), and observations. This makes most sense to use for a single location and forecast initialization time. If multiple dates and locations are used, then the average is used.

obsfcst Plot observations and forecasts performance

Categorical performance diagram showing POD, FAR, bias, and Threat score. Also shows the scores the forecasts would attain by using different forecast thresholds (turn off using -simple)

pithist Histogram of PIT values. Use -r to specify bins.

qq Quantile-quantile plot of obs vs forecasts

reliability Reliability diagram for a certain threshold (-r)

roc Plots the receiver operating characteristics curve for a single threshold (-r)

scatter Scatter plot of forecasts vs obs and lines showing quantiles of obs given forecast (use -r to specify)

spreadskill Spread/skill plot showing RMSE of ensemble mean as a function of ensemble spread (use -r to specify spread thresholds and -q to specify a lower and upper quantile to represent spread)

taylor Taylor diagram showing correlation and forecast standard deviation. Use '-x none' to collapse all data showing only one point. Otherwise, the whole graph is normalized by the standard deviation of the observations.

timeseries Plot observations and forecasts as a time series (i.e. by concatenating all leadtimes). '-x <dimension>' has no effect, as it is always shown by date.