

**Methodology for
PRISM SNOTEL Spatial QC System**

Last Revised: 27 May 2014

Christopher Daly, Matthew Doggett, and Joseph Smith

PRISM Climate Group/NACSE

An effective method for determining the validity of a daily station observation is to estimate a range of possible values for that observation using nearby station data, and assess the consistency of the observation with that estimated valid range. To this end, SNOTEL spatial QC (SPQC) uses a point version of PRISM, called ASSAY, to estimate a valid range of data for SNOTEL station locations. ASSAY is run each day on TMAX (maximum temperature), TMIN (minimum temperature), and IP (incremental precipitation). Station precipitation data are also screened for validity using comparisons with radar analyses. The ASSAY estimates serve as replacement values for observations failing SPQC.

Summary

Station data that pass single-station QC (SSQC) and PROF (profile QC) are eligible to enter SPQC. SPQC is divided into two parts: RadarQC and ASSAYQC. A summary of each is provided below. Data passing SPQC are then eligible to enter multi-sensor QC (MSQC).

RadarQC (Precipitation only)

RadarQC runs a check comparing Stage IV NEXRAD radar analysis against observed station IP. The Stage IV analysis is a national radar mosaic with artifacts removed, and locally adjusted with station data. Only areas east of -105 longitude are subject to RadarQC, as that corresponds with the area of greatest radar influence without terrain interference. RadarQC is flagged false (bad) if the Stage IV analysis indicates substantial precipitation and the station observation does not, or vice-versa. Because of the longitude restriction, few SNOTEL stations are subject to RadarQC.

Observations that fail RadarQC are not precluded from entering the ASSAYQC section (below).

ASSAYQC

Station observations are processed through ASSAYQC iteratively, where each pass removes stations that were evaluated as suspect (howlers). Normally, this requires about 3-5 passes until no further howlers are identified. These results are then checked for “flip-flop” cases. A flip-flop situation occurs when two stations are identified as bad and both have maximum influence on the

other. The station that causes the largest scatter in the ASSAY regression function becomes the station flagged as bad. Finally, the results of ASSAYQC are inserted into the database. Stations that pass receive a confidence probability (CP) value of 100 and those that fail receive a CP value of 0.

ASSAYQC for IP, TMAX, and TMIN is performed using climatologically-aided interpolation (CAI), where PRISM 1981-2010 monthly normal maps are used as predictor grids. Additionally, Stage IIun and Stage IV NEXRAD radar data are used as predictor grids for IP. The Stage IIun radar analysis is a raw radar mosaic without artifacts removed, and is bias-corrected with station data only in an areal-average sense around each radar installation. ASSAYQC with Stage IIun is used to prepare the set of stations used by PRISM for Stage IIun mapping, which generates diagnostic statistics for the “besting” process, where decisions are made as to which predictor grid has the most explanatory power (radar or CAI). Stage IIun is used instead of Stage IV for this purpose, because station data are not yet assimilated, and therefore do not skew the performance statistics when compared to the station data. The stations rejected as part of ASSAYQC/Stage IIun are not kept or used for other processing or evaluation. When ASSAYQC is completed, there are two spatial evaluation flags kept for final analysis: spqc_cai (CAI predictor) and spqc_radar (Stage IV predictor).

The final determination to keep/reject an observation occurs by evaluating each of the three QC flags: radar_qc (from RadarQC) and the two QC flags set in the ASSAYQC process above (spqc_cai, and spqc_radar). The observation is accepted if:

(radar_qc IS TRUE OR radar_qc IS NULL) AND (spqc_radar IS TRUE OR (spqc_radar IS NULL AND spqc_cai IS TRUE))

Process Details

1. Perform RadarQC check (cai_ppt only).
 - a. Program: radar_clean_rma (compiled FORTRAN in \$PRISM/src)
 - b. Method
 - i. Run radar_clean_rma using Stage IV radar data to compare with station data. This is done only once during the initial CAI QC run.
 - ii. Only areas east of -105 longitude are evaluated for radarqc. Western US is not checked.
 - iii. Set radar_qc FALSE (bad station. Flag value 12) on the following conditions:
 1. Dry radar/Wet station. Radar==0 and Obs> 2.54mm (Summer::Apr-Oct) 6.35mm (Winter)
 2. Wet radar/Dry station. Radar>2.54mm and Obs==0.
2. Fetch data from database
 - a. Data are retrieved such that only ssqc flag is checked.
 - b. (ppt only) --winterraws is enabled which means winter RAWs data are included.

3. Run ASSAYQC.
 - a. Programs: master_qc_rma.pl, run_assayqc_rma.pl, assayqc_mpp_rma.pl, process_qc_rma.pl, flip_flop_rma.pl
 - b. Method
 - i. Iterate over several passes, usually 3-5, running ASSAY_qc each time.
 - ii. Each pass ‘removes’ observations from subsequent ones until no more howlers are found. ASSAY parameter descriptions and values are listed in Tables 1 and 2.
 - iii. Results of ASSAY_qc are collected into ‘cut’ files that contains details of “howler” stations.
 - iv. “Flip flop” cases are evaluated.
4. Update database
 - a. Program: insert_qc_db_rma.pl
 - b. Method
 - i. spqc flag reset to NULL for the given QC date
 - ii. ASSAYQC records are deleted from the spat_assoc table
 - iii. ‘cut’ files are scanned
 - iv. Insert records into <var>_spat_assoc table with spatid/cp value set to 0 for stations in howler list. Stations passing QC have CP value of 100.
NOTE. There is a problem here where only --baselayer=radar is checked, not ‘st2un’ or ‘st4’. May be holdover from before we started using both st2 and st4 radar. This affected all daily qc from 20121101 to present. RadarQC overwrote spqc results.
5. Set spqc flag
 - a. Program: set_spqc.pl
 - b. Method
 - i. Updates the spatial QC (spqc) flags based on their spatial QC test results, or single-station and/or radar QC results. This script sets the spqc flags for observations based on their cp value in the spat_assoc table, or their ssqc and/or radar_qc flags if the observation is acceptable for spatial QC.
 - ii. CP threshold is currently set to 50. CP>50 returns spqc flag =TRUE otherwise =FALSE.
6. Collect ASSAY estimates to use as replacement values for SNOTEL stations.
 - a. Program: ASSAY_predict.pl
 - b. Method
 - i. Export QCd station data. Only data passing ssqc and spqc are used.
 - ii. Run ASSAY for isubset=1 with SNOTEL stations flagged (*)
 - iii. Run ASSAY for isubset=3 with missing SNOTEL stations flagged (*)
 - iv. Insert/update ASSAY predictions into alt_daily table.

Table 1. ASSAYQC input parameter descriptions.

Parameter	Name	Description
Resmod	Climatology residual multiplier	Threshold for number of maximum number of standard deviations the observation can differ from the ASSAY prediction
Resmod_max	Maximum climatology residual multiplier	Resmod can be adjusted for coastal proximity, up to Resmod_max; mainly for TMAX and TMIN
Resmod2	PRISM multiplier	Multiplier on Resmod if ASSAY regression function is noisy (high residual standard deviation)
Resmod_close	Closest station multiplier	Multiplier on Resmod is ASSAY prediction is poor
Dist	Cutoff distance (km)	Distance from the target station to the nearest station, beyond which ASSAY predictions are considered poor and observation is not evaluated
Elev	Cutoff elevation difference (m)	Elevation difference from the target station to the nearest station, beyond which ASSAY predictions are considered poor and observation is not evaluated
Prox_diff	Coastal proximity difference	Coastal proximity difference from the target station to the nearest station, beyond which ASSAY predictions are considered poor and observation is not evaluated
Prox_thresh	Coastal proximity threshold for scaling	If target grid cell is closer to the coastline than Prox_thresh, adjust Resmod accordingly
Resdiff_max	Maximum residual outlier detector (mm, K*10)	If coastal proximity difference > Prox_diff, reject observation if $\text{abs}(\text{abs}(\text{Pred}-\text{Obs})-\text{Resmod}) > \text{Resdiff_max} * \text{STDEV}(\min(\text{Pred}, \text{Obs}))$

Table 2. ASSAYQC input parameter values.

Parameter	IP	TMAX	TMIN
Resmod	1.59	2.28	2.28
Resmod_max	1.59	2.736	2.736
Resmod2	1.19	1.19	1.19
Resmod_close	1.4	0.0	0.0
Dist	100 km	1000 km	1000 km
Elev	500 m	5000 m	5000 m
Prox_diff	10	West: 500 (Summer), 1000 (Winter) Cent/East: 5 (Summer), 10 (Winter)	West: 1000 Cent/East: 10 (Summer), 5 (Winter)
Prox_thresh	(same as prox_diff)	(same as prox_diff)	(same as prox_diff)
Resdiff_max	150	50	50

Future work

1. In a single pass of ASSAY_QC, it is possible that two stations are both flagged as bad, and one station is the highest weighted predictor to the other, but this is not a flip-flop case. We need to add the ability to “put back” a station that was flagged bad when the highest weighted predictor was also flagged bad at the same time.
2. Radar_qc currently uses a fixed -105 longitude for determining when to use radar. We need to utilize the radar_mask that was developed for the besting process to get cleaner representation of where radar is being utilized.
3. ASSAY QC is currently parameterized for monthly operation. In the future, optimum parameter values for daily operation should be established.
4. In the long term, we plan to resurrect the previous SNOTEL QC methodology that used relationships among stations, rather than ASSAY predictions, and calculated performance statistics on the estimates. The idea will be to develop a hybrid QC system that integrates the two systems, and executes a “besting” process where results from the best-performing system are used

ASSAY Control File Settings

Maxrad1/2 Maxrad_step	Radius of Influence	Lower, upper, and interval values of radius within which ASSAY searches for valid stations. ASSAY makes repeated cross-validation analyses with Radius of Influence values that vary incrementally within the range bounded by the Starting and Ending values. A common method for narrowing down optimal parameter values is to initially set the ranges and increments to relatively large values (to keep the number of combinations manageable), then successively narrow the search using ever smaller ranges and increments.
Minsta1/2 Minsta_step	Minimum Number of Stations on Facet	lower, upper, and interval values for minimum number of stations desired on facet in the regression calculations. ASSAY makes repeated cross-validation analyses with Minimum Number of Stations on Facet values that vary incrementally within the range bounded by the Starting and Ending values. A common method for narrowing down optimal parameter values is to initially set the ranges and increments to relatively large values (to keep the number of combinations manageable), then successively narrow the search using ever smaller ranges and increments.
Isubfac1/2 Isubfac_step	Minimum Number of Stations on Regression	lower, upper, and interval values for minimum number of stations desired in each regression calculation. ASSAY makes repeated cross-validation analyses with Minimum Number of Stations in Regression values that vary incrementally within the range bounded by the Starting and Ending values. A common method for narrowing down optimal parameter values is to initially set the ranges and increments to relatively large values (to keep the number of combinations manageable), then successively narrow the search using ever smaller ranges and increments.
Stat_thresh1/2 Idry1/2 Istep_dry Iwet1/2 Istep_wet	Wet/Dry Statistics	Controls calculation of wet/dry statistics in the ASSAY .sum file. Used in ppt results only.