Description

Utility ADJUST is used to adjust simulated values based on available
observations.

Any combination of observed instantaneous discharge, mean discharge
and pool elevation can be used. The results from a run using the
ADJUST Utility consist of adjusted time series for use in subsequent
Operations and adjusted carryover which should provide a better
starting point for forecast runs on succeeding days. All adjustments
terminate at the last period with observed data. After the last
observed data further adjusted values are simulated using the last
period with adjusted carryover as a starting point.

Different adjustment procedures are used depending on what observed
data are available. Seven different combinations of observed data
are possible:

    1. only observed instantaneous discharges (outflows)
    2. only observed mean discharges (outflows)
    3. only observed pool elevations
    4. both observed instantaneous discharges and observed mean
        discharges
    5. both observed instantaneous discharges and observed pool
        elevations
    6. both observed pool elevations and observed mean discharges
    7. all three types of observed data

The following symbols will be used throughout this section:

    O = observed (including predicted)
    S = simulated
    A = adjusted

For example OQO, SQO and AQO represent observed instantaneous
discharge, simulated instantaneous discharge and adjusted
instantaneous discharge respectively.

The adjustment procedure for each observed data combination is as
follows:

    1. Only observed instantaneous discharges, OQO [OBSQO].

        A. Generate adjusted instantaneous discharges, AQO [ADJQO]
            from observed instantaneous discharges, OQO and simulated
            instantaneous discharges, SQO.

            a) AQO = OQO whenever observed data are available

            b) If observed data are missing AQO values between
                observations are generated by interpolation or by
                blending depending on a user specified blending number.

Interpolation can be based on differences [CFACTOR DIFF] or ratios [CFACTOR RATIO] between observed data and simulated results. If the number of missing OQO data values = m and the user specified blending number = k [BLEND] then:

- o   if $m+1 \leq k$ use interpolation:

    Differences:

    $$\Delta Q_o = OQO_o - SQO_o' \qquad \Delta Q_{m+1} - SQO_{m+1}$$

    $$AQO_i = SQO_i + \Delta Q_o + (\Delta_{m+1} - \Delta Q_o*[i/(m+1)])$$

    Ratios:

    $$\Delta Q_o = OQO_o/SQO_o' \qquad \Delta Q_{m+1} = OQO_{m+1}/SQO_{m+1}$$

    $$AQO_i = SQO_i * [\Delta Q_o + (\Delta Q_{m+1} - \Delta Q_o)*i/(m+1)]$$

- o   If $m+1 > k$ use forward blending first then apply backward blending:

    Forward blending:

    $$AQO_1' = SQO_1 + (OQO_o - SQO_o)*(k-i)/k$$

    $$i = 1 \text{ to } k$$

    $$AQO_j' = SQO_j \qquad j = k+1, k+2 \text{ to } m$$

    Backward blending:

    $$AQO_i' = AQO_i \qquad i = 1 \text{ to } (m-k)$$

    $$AQO_j' = AQO_j + (OQO_{m+1} - SQO_{m+1})*(j-m+k-1)/k$$

    $$j = (m-k+1), (m-k+2) \text{ to } m$$

B. Generate adjusted mean discharges, AQOM [ADJQOM], from adjusted instantaneous discharges, AQO.

$$AQOM_i = (AQO_{i-1} + AQO_i)/2$$

$$i = 1 \text{ to last observed data period}$$

C. Generate adjusted pool elevations, AH [ADJH] and adjusted storage, AV[ADJS], from adjusted mean discharges, AQOM, using continuity and the reservoir elevation versus storage curve, $H = v(V)$.

$$AV_o = SV_o$$

$$AV_i = AV_{i-1} + (QIM_i - AQOM_i) * data\_time\_interval$$

$$AH_i = v(AV_i)$$

i = 1 to last observed data period

2. Only observed mean discharges, OQOM [OBSQOM].

    A. Generate mean daily discharges, MDQ, from observed mean discharges, OQOM. If any observed data are missing in a day then the mean daily discharge for that day is treated as missing.

$$MDQ = \left(\sum_{I=1}^{nobs} OQOM_i \right) / nobs$$

    nobs = number of observed mean discharges in a day

    B. Generate adjusted instantaneous discharges, AQO [ADJQO], by adjusting simulated instantaneous discharges, SQO, while conserving mean daily volume, MDQ, from Step A.

    The adjustment process is carried out by an iterative procedure over the entire time series for each iteration. The procedure presented herein is typical for any single day in the entire time series except the first and the last days. Special treatments are needed on these two days.

    The adjustment process started with computing the adjusted daily flow as follows:

$$SMDQ = \sum_{i=2}^{n+1} 0.5 * (SQO_{i-1} + SQO_i)$$

    n = 24 / data_time_interval

    i = 1 is at the beginning of the day (also equal to the end of previous day)

    i = n+1 is at the end of the day

    Using the computed daily flow then the instantaneous discharges are adjusted as follows:

    QMIDP = (SQO_{n+1} * MDQ/SMDQ) from previous day

    $QMIDP = (SQO_{n+1} * MDQ/SMDQ)$ from previous day

    $QMIDN = (SQO_1 * MDQ/SMDQ)$ from next day

    $AQO_1 = 0.5 * (QMIDP + SQO_1 * MDQ/SMDQ)$

    $AQO_i = SQO_i * MDQ/SMDQ$

    i = 2 to n

    $ADQ_{n+1} = 0.5 * (SQO_{n+1} * MDQ/SMDQ + QMIDN)$

    The results of the adjustment are then evaluated using the

error between SMDQ and MDQ

$$ERR = |(SMDQ - MDQ)/MDQ|$$

If the error, ERR, is less than 0.025 then the adjustment process is complete. Otherwise set $SQO_i = AQO_i$ and repeat the adjusting process.

If MDQ is missing, no daily flow volume conservation is possible then:

$$AQO_i = 0.5 * (QMIDP + SQO_1)$$

$$AQO_i = SQO_i \qquad i = 2 \text{ to } n$$

$$AQO_{n+1} = 0.5 * (SQO_{n+1} + QMIDN)$$

For the first day no adjustments from previous day are possible. The value at the beginning of the first day is set to the carryover value.

$$AQO_1 = CARRYOVER$$

The rest of the adjustment procedures are the same as for the intermediate days.

For the last day, no adjustments from the next day are possible. The value at the end of the last day can only be adjusted based on the volume ratio from the current day.

$$AQO_{n+1} = SQO_{n+1} * MDQ/SMDQ$$

The rest of the adjustment procedures are the same as for the intermediate days.

C. Generate adjusted mean discharges, AQOM [ADJQOM], from adjusted instantaneous discharges, AQO.

a) If observed mean discharges are missing

$$AQOM_i = (AQO_{i-1} + AQO_i)/2$$

$$i = 1 \text{ to last observed data period}$$

b) AQOM = OQOM whenever observed data are available

D. Generate adjusted pool elevations, AH [ADJH] and adjusted storages, AV[ADJS], using adjusted mean discharges, the continuity equation and the pool elevation versus storage curve, $H = v(V)$.

$$AV_o = SV_o$$

$$AV_i = AV_{i-1} + (QIM_i - AQOM_i) * \text{data\_time\_interval}$$

$$AH_i = v(AV_i)$$

i = 1 to last observed data period

3. Only observed pool elevations, OH [OBSH].

    A. Generate adjusted storages, AV[ADJS], from observed pool
        elevations and the reservoir elevation versus storage
        curve, V = h(H).

        a) AV = h(OH) whenever observed data are available.

        b) If observed data are missing, pool storages are
            interpolated by linearly distributing differences
            between simulated storages and two adjacent adjusted
            storages computed from Step a.

            $DV_{m+1} = OV_{m+1} - SV_{m+1}$

            $DV_o = OV_o - SV_o$

            $AV_1 = SV_i + DV_o + (DV_{m+1} - DV_o)* i/(m+1)$

            i = 1 to m

            m = number of missing data time intervals

    B. Generate adjusted pool elevations, AH [ADJH], using pool
        storages from Step A and the reservoir elevation versus
        storage curve.

        $AH_i = v(AV_i)$

        i = 1 to last observed data period

    C. Generate adjusted mean discharges, AQOM [ADJQOM], using
        pool storages from Step A and the continuity equation:

        $AQOM_i = QIM_i - (AV_i - AV_{i-1})/data\_time\_interval$

        i = 1 to last observed data period

    D. Generate mean daily discharges, MDQ, from adjusted mean
        discharges, AQOM:

        $$MDQ = \left(\sum_{I=1}^{n} AQOM_i \right) /n$$

        n = 24 / data_time_interval

    E. Generate adjusted instantaneous discharges, AQO [ADJQO], by
        adjusting simulated instantaneous discharges, SQO, while
        conserving mean daily discharges, MDQ, from Step D.

        The adjustment process is carried out by an iterative
        procedure over the entire time series for each iteration.
        The procedure presented herein is typical for any single

day in the entire time series, except the first and the last days. Special treatments are needed on these two days.

The adjustment process started with computing the adjusted daily flow as follows:

$$SMDQ = \sum_{i=2}^{n+1} 0.5 * (SQO_{i-1} + SQO_i)$$

$n = 24 / data\_time\_interval$

$i = 1$ is at the beginning of the day (also equal to the end of the previous day)

$i = n+1$ is at the end of the day

Using the computed daily flow then the instantaneous discharges are adjusted as follows:

$QMIDP = (SQO_{n+1} * MDQ/SMDQ)$ from previous day

$QMIDN = (SQO_1 * MDQ/SMDQ)$ from next day

$AQO_1 = 0.5 * (QMIDP + SQO_1 * MDQ/SMDQ)$

$AQO_i = SQO_i * MDQ/SMDQ$

$i = 2$ to n

$AQO_{n+1} = 0.5 * (SQO_{n+1} * MDQ/SMDQ + QMIDN)$

The results of the adjustment are then evaluated using the error between SMDQ and MDQ:

$ERR = |(SMDQ - MDQ)/MDQ|$

If the error, ERR, is less than 0.025 then the adjustment process is complete. Otherwise set $SQO_i = AQO_i$ and repeat the adjusting process.

For the first day, no adjustments from previous day are possible. The value at the beginning of the first day is set to the carryover value:

$AQO_1 = CARRYOVER$

The rest of the adjustment procedures are the same as for the intermediate days.

For the last day no adjustments from next day are possible. The value at the end of the last day can only be adjusted based on the volume ratio from the current day:

$AQO_{n+1} = SQO_{n+1} * MDQ/SMDQ$

The rest of the adjustment procedures are the same as for the intermediate days.

4. Both observed instantaneous discharges, OQO [OBSQO] and observed mean discharges, OQOM [OBSQOM].

   A. Generate initial adjusted instantaneous discharges, AQO', from observed instantaneous discharges, OQO, using procedure described in 1A.

   B. Generate mean daily discharges, MDQ, from observed mean discharges, OQOM, using procedure described in 2A.

   C. Generate final adjusted instantaneous discharges, AQO [ADJQO], by readjusting the adjusted instantaneous discharges, AQO', from Step A while conserving mean daily discharge, MDQ, from Step B.

      The adjustment process is carried out by an iterative procedure over the entire time series for each iteration. The procedure presented herein is typical for any single day in the entire time series, except the first and the last days. Special treatments are needed on these two days.

      The adjustment process started with computing the adjusted daily flow as follows:

$$SMDQ = \sum_{i=2}^{n+1} 0.5 * (AQO'_{i-1} + AQO'_i)$$

      $n = 24\ /\ data\_time\_interval$

      $i = 1$ is at the beginning of the day (also equal to the end of previous day)

      $i = n+1$ is at the end of the day

   Using the computed daily flow then the instantaneous discharges are adjusted as follows:

      $QMIDP = (AQO_{n+1} * MDQ/SMDQ)$ from previous day

      $QMIDN = (AQO'_1 * MDQ/SMDQ)$ from next day

      $AQO_1 = 0.5 * (QMIDP + AQO'_1 * MDQ/SMDQ)$

      $AQO_i = AQO'_i * MDQ/SMDQ$

      $i = 2$ to n

      $AQO'_{n+1} = 0.5 * (AQO_{n+1} * MDQ/SMDQ + QMIDN)$

   If the observed instantaneous discharge, OQO_i, is available then:

$$AQO_i = OQO_i$$

The results of the adjustments are then evaluated using the error between SMDQ and MDQ:

$$ERR = |(SMDQ - MDQ)/MDQ|$$

If the error, ERR, is less than 0.025 then the adjustment process is complete. Otherwise set $AQO'_i = AQO_i$ and repeat the adjusting process.

If the error remains larger than 0.025 after 15 iterations then the observed instantaneous discharges will be ignored and the adjustment process is repeated. A new set of adjusted instantaneous discharges is obtained that conserve the daily flow volume within the specified tolerance.

If MDQ is missing no daily flow volume conservation is possible then:

$$AQO_1 = 0.5 * (QMIDP + AQO'_1)$$

$$AQO_i = AQO'_i \quad i = 2 \text{ to } n$$

$$AQO_{n+1} = 0.5 * (AQO'_{n+1} + QMIDN)$$

Again if the observed instantaneous discharge, OQO_i, is available it will be used:

$$AQO_i = OQO_i$$

For the first day no adjustments from previous day are possible. The value at the beginning of the first day is set to the carryover value:

$$AQO_i = CARRYOVER$$

The rest of the adjustment procedures are the same as for the intermediate days.

For the last day no adjustments from next day are possible. The value at the end of the last day can only be adjusted based on the volume ratio from the current day:

$$AQO_{n+1} = AQO'_{n+1} * MDQ/SMDQ$$

The rest of the adjustment procedures are the same as for the intermediate days.

D. Generate adjusted mean discharges. AQOM [ADJQOM], from adjusted instantaneous discharges, AQO.

a) If observed mean discharges are missing:

$$AQOM_i = (AQO_{i-1} + AQO_i)/2$$

i = 1 to last observed data period

    b) AQOM = OQOM whenever observed data are available

E. Generate adjusted pool elevations, AH [ADJH] and adjusted storages, AV[ADJS], using adjusted mean discharges, the continuity equation and the pool elevation versus storage curve, H = v(V).

$AV_o = SV_o$

$AV_i = AV_{i-1} + (QIM_i - AQOM_i) * data\_time\_interval$

$AH_i = v(AV_i)$

i = 1 to last observed data period

5. Both observed instantaneous discharges, OQO [OBSQO] and observed pool elevations, OH [OHSH].

A. Generate initial adjusted instantaneous discharges, AQO', from observed instantaneous discharges, OQO, using procedure described in 1A.

B. Generate adjusted storages, AV[ADJS], adjusted pool elevation,
AH [ADHH], adjusted mean discharges, AQOM [ADJQOM] and mean daily discharges using procedures described in 3A, 3B, 3C and 3D.

C. Generate final adjusted instantaneous discharges, AQO [ADJQO], by readjusting the adjusted instantaneous discharges, AQO', from Step A, while conserving mean daily discharges, MDQ, from Step B.

The adjustment process is carried out by an iterative procedure over the entire time series for each iteration. The procedure presented herein is typical for any single day in the entire time series, except the first and the last days. Special treatments are needed on these two days.

The adjustment process started with computing the adjusted daily flow as follows:

$$SMDQ = \sum_{i=2}^{n+1} 0.5 * (AQO'_{i-1} + AQO'_i)$$

n = 24 / data_time_interval

i = 1 is at the beginning of the day (also equal to the end of previous day)

i = n+1 is at the end of the day

Using the computed daily flow then the instantaneous discharges are adjusted as follows:

$$QMIDP = (AQO'_{n+1} * MDQ/SMDQ) \text{ from previous day}$$

$$QMIDN = (AQO'_1 * MDQ/SMDQ) \text{ from next day}$$

$$AQO_1 = 0.5 * (QMIDP + AQO'_1 * MDQ/SMDQ)$$

$$AQO_i = AQO'_i * MDQ/SMDQ$$

$$i = 2 \text{ to } n$$

$$AQO'_{n+1} = 0.5 * (AQO_{n+1} * MDQ/SMDQ + QMIDN)$$

If the observed instantaneous discharge, OQO_i, is available then:

$$AQO_i = OQO_i$$

The results of the adjustments are then evaluated using the error between SMDQ and MDQ:

$$ERR = |(SMDQ - MDQ)/MDQ|$$

If the error, ERR, is less than 0.025 then the adjustment process is complete. Otherwise set $AQO'_i = AQO_i$ and repeat the adjusting process.

If the error remains larger than 0.025 after 15 iterations then the observed instantaneous discharges will be ignored and the adjustment process is repeated. A new set of adjusted instantaneous discharges is obtained that conserve the daily flow volume within the specified tolerance.

For the first day no adjustments from previous day are possible. The value at the beginning of the first day is set to the carryover value:

$$AQO_i = CARRYOVER$$

The rest of the adjustment procedures are the same as for the intermediate days.

For the last day, no adjustments from next day are possible. The value at the end of the last day can only be adjusted based on the volume ratio from the current day:

$$AQO_{n+1} = AQO'_{n+1} * MDQ/SMDQ$$

The rest of the adjustment procedures are the same as for the intermediate days.

D. Readjust adjusted mean discharges, AQOM [ADJQOM] using observed instantaneous discharges. If two consecutive observed instantaneous discharges are available then:

$$AQOM_i = (OQO_{i-1} + OQO_i)/2$$

6. Both observed pool elevations, OH [OBSH] and observed mean discharges, OQOM [OBSQOM].

    A. Compute adjusted storages, AV[ADJS], from observed pool elevations, OH and the reservoir elevation versus storage curve, $V = h(H)$:

        $AV = h(OH)$ whenever observed data are available

    B. If observed pool elevations, OH, are missing for some period but observed mean discharges, OQOM, are available continuously for some period then compute adjusted storage from observed mean discharge and the continuity equation.

        a) If observed pool elevation exists at start of the period:

$$AV_o = OV_o$$

$$AV_1 = AV_{i-1} + (QIM_i - OQOM_i) * data\_time\_interval$$

$$i = 1 \text{ to number of continuous OQOM available}$$

        b) If observed pool elevation exists at the end of the period:

$$AV_{m+1} = OV_{m+1}$$

$$AV_i = AV_{i+1} - (QIM_i - OQOM_i) * data\_time\_interval$$

$$i = n \text{ to } 1 \text{ (number of continuous OQOM available)}$$

    C. If both observed pool elevations, OH and observed mean discharges, OQOM, are missing for some period then generate adjusted storage by linearly distributing differences between two adjacent storages computed from Steps A and B:

$$DV_{m+1} = OV_{m+1} - SV_{m+1}$$

$$DV_o = AV_o - SV_o$$

$$AV_i = SV_i + DV_o + (DV_{m+1} - DV_o) * i/(m+1)$$

$$i = 1 \text{ to } m$$

$$m = \text{number of missing data values}$$

    D. Generate adjusted pool elevations, AH [ADJH], using pool storage from Step C and the reservoir elevation versus storage curve as in 3B.

    E. a) If observed mean discharges are missing, generate adjusted mean discharges, AQOM [ADJQOM], using procedure 3C.

b) AQOM = OQOM whenever observed data are available.

F. Generate adjusted instantaneous discharges, AQO [ADJQO],
    conserving mean daily discharges, MDQ, derived from AQOM
    [ADJQOM] computed in E using 3D.

    The adjustment process is carried out by an iterative
    procedure over the entire time series for each iteration.
    The procedure presented herein is typical for any single
    day in the entire time series, except the first and the
    last days. Special treatments are needed on these two
    days.

    The adjustment process started with computing the adjusted
    daily flow as follows:

$$SMDQ = \sum_{i=2}^{n+1} 0.5 * (AQO'_{i-1} + AQO'_{i})$$

    n = 24 / data_time_interval

    i = 1 is at the beginning of the day (also equal to the
           end of previous day)

    i = n+1 is at the end of the day

    Using the computed daily flow then the instantaneous
    discharges are adjusted as follows:

    $QMIDP = (AQO'_{n+1} * MDQ/SMDQ)$ from previous day

    $QMIDN = (AQO'_{1} * MDQ/SMDQ)$ from next day

    $AQO_{1} = 0.5 * (QMIDP + AQO'_{1} * MDQ/SMDQ)$

    $AQO_{i} = AQO'_{i} * MDQ/SMDQ$

        i = 2 to n

    $AQO'_{n+1} = 0.5 * (AQO_{n+1} * MDQ/SMDQ + QMIDN)$

    The results of the adjustments are then evaluated using the
    error between SMDQ and MDQ:

    $ERR = |(SMDQ - MDQ)/MDQ|$

    If the error, ERR, is less than 0.025 then the adjustment
    process is complete. Otherwise set $AQO'_{i} = AQO_{i}$ and repeat
    the adjusting process.

    If MDQ is missing, no daily flow volume conservation is
    possible then:

    $AQO_{1} = 0.5 * (QMIDP + AQO'_{1})$

$$AQO_i = AQO'_i \quad i = 2 \text{ to } n$$

$$AQO_{n+1} = 0.5 * (AQO'_{n+1} + QMIDN)$$

For the first day no adjustments from previous day are possible. The value at the beginning of the first day is set to the carryover value:

$$AQO_i = CARRYOVER$$

The rest of the adjustment procedures are the same as for the intermediate days.

For the last day, no adjustments from next day are possible. The value at the end of the last day can only be adjusted based on the volume ratio from the current day:

$$AQO_{n+1} = AQO'_{n+1} * MDQ/SMDQ$$

The rest of the adjustment procedures are the same as for the intermediate days.

7. All three types of observed time series.

   A. Generate initial adjusted instantaneous discharges, AQO', from observed instantaneous discharges, OQO, using procedures described in 1A.

   B. Generate adjusted storages, AV[ADJS], from observed pool elevations, OH and observed mean discharges, OQOM, using procedures described in 6A, 6B and 6C.

   C. Generate adjusted pool elevations, AH [ADJH], adjusted mean discharges, AQOM [ADJQOM] and mean daily discharges, MDQ, using procedures described in 6D, 6E and 3D.

   D. Generate final adjusted instantaneous discharges, AQO [ADJQO], by readjusting the adjusted instantaneous discharges, AQO', from Step A, while conserving mean daily discharges, MDQ, from Step C, using procedures described in 5C.

   E. Generate adjusted mean discharges, AQOM [ADJQOM], from adjusted instantaneous discharges, AQO.

      a) If observed mean discharges are missing:

         $$AQOM_i = (AQO_{i-1} + AQO_i)/2$$

         i = 1 to last observed data period

      b) AQOM = OQOM whenever observed data are available

   F. Generate adjusted pool elevations, AH [ADJH] and adjusted storages, AV[ADJS], using adjusted mean discharges, the continuity equation and the pool elevation versus storage

curve, $H = v(V)$.

$$AV_o = SV_o$$

$$AV_i = AV_{i-1} + (QIM_i - AQOM_i) * data\_time\_interval$$

$$AH_i = v(AV_i)$$

$$i = 1 \text{ to last observed data period}$$