RAIN COMPENSATION ALGORITHM USING ADAPTIVE LINEAR PREDICTION

Edgar Satorius

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY

JPL
• RAIN COMPENSATION ALGORITHM IMPLEMENTS DATA RATE CHANGES (BETWEEN 2.4, 4.8 AND 9.6 kbps) TO COMPENSATE FOR PATH ATTENUATIONS BETWEEN ACTS AND BOTH THE MOBIL (MT) AND FIXED (FT) TERMINALS

• BEACON SIGNALS AT 20 AND 27 GHZ CAN BE UTILIZED TO DETERMINE BOTH UP AND DOWNLINK PATH ATTENUATIONS BETWEEN ACTS AND THE FT -- HOWEVER, ONLY PILOT SIGNAL AT 19 GHZ IS AVAILABLE FOR ESTIMATING PATH ATTENUATIONS BETWEEN ACTS AND THE MT
SUMMARY OF AMT-RCA

- PURPOSE: CONTROL DATA RATES IN FORWARD OR RETURN LINKS

- INPUTS: ESTIMATES OF UPLINK RAIN ATTENUATION, AU, AND DOWNLINK ATTENUATION, AD

- METHOD:
  
  (1) COMPUTE OVERALL FORWARD (OR RETURN) RECEIVED CNR:

  \[
  (C/No)t = \frac{1}{[AU/(C/No)u] + [AD/(C/No)d]}
  \]

  where: \((C/No)u,d\) = clear-sky uplink(u)/downlink(d) received CNR

  (2) THRESHOLD \((C/No)t\) TO DETERMINE DATA RATE:

  ![Graph showing data rate thresholds]

  - SOURCES OF ERROR: EXTRAPOLATIONS OF ATTENUATION IN
    FREQUENCY (20/30 GHz) AND TIME (≈ 1-2 sec)
EMPIRICAL BASIS FOR REDUCING ATTENUATION EXTRAPOLATION ERRORS


• SAMPLE OBSERVATIONS -- PREDICTING 30 GHz ATTENUATION 1 SEC AHEAD:

<table>
<thead>
<tr>
<th>Method</th>
<th>RMS Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRC Scaling</td>
<td>0.66 dB</td>
</tr>
<tr>
<td>Current 30 GHz data</td>
<td>0.48 dB</td>
</tr>
<tr>
<td>20 predicting 30</td>
<td>0.55 dB</td>
</tr>
<tr>
<td>30 predicting 30</td>
<td>0.39 dB</td>
</tr>
</tbody>
</table>

Notes:

1. Data set obtained from heavy rain event on 6 Nov 1990 (0000-0100 UT)
2. Both 15-th order FIR linear prediction and 1-st order IIR linear prediction filters examined with comparable results
3. Prediction filter coefficients obtained by least squares fit to this data set -- also applied to other data sets with good results

• TENTATIVE CONCLUSIONS:

1. 0.66-0.48 = 0.18 dB of 0.27 dB improvement due to frequency extrapolation errors
2. 0.48-0.39 = 0.09 dB due to time extrapolation (prediction) -- possibly even better results could be obtained if prediction coefficients are estimated adaptively ???
3. For AMT-RCA at the MT, we must use 20/30 GHz frequency scaling -- but possibly adaptive prediction (20 predicting 20 + scaling) could improve RCA performance ??
CANDIDATE ADAPTIVE 1-POLE PREDICTION FILTER
FOR APPLICATION TO AMT-RCA (at the MI)

\[ y(n) = \alpha(n) y_0(n-1) + \beta(n) A_{20}(n) \]

Predicting current 20 GHz using k-sample delayed data \( y_0(n) \)

Update IIR prediction filter coefficients (LMS algorithm)

To AMT-RCA

Prediction 20 GHz data k-samples into the future

\[ z(n) = A_{20}(n+k) \]