

Check Complementary Filter

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The new filter function

Janine has recoded the filter function to eliminate a bias present in the earlier version. This note is a test of how the filter works, using a TREX flight segment processed with the old filter and with the new filter. Janine has saved these files in /net/work/dev/jaa/nimbus, in directories before_changes and butter, the latter implementing the changes recommended on Aug 2014. Here is her record of the changes that she made:

```
dvy[FeedBack]      += (1.-fctrf[FeedBack])\  
                    *(filter((double)(gvns-vns),zf[FeedBack][0])-dvy[FeedBack]);  
dvx[FeedBack]      += (1.-fctrf[FeedBack])\  
                    *(filter((double)(gvew-vew),zf[FeedBack][1])-dvx[FeedBack]);  
dlat[FeedBack]     = glat - alat;  
dlon[FeedBack]     = glon - alon;
```

and I [Janine] coded the new filter function as:

```
if (firstTime[FeedBack])  
{  
    bfb[0] = 1.42056081706421e-07;  
    bfb[1] = 4.26168245119263e-07;  
    bfb[2] = 4.26168245119263e-07;  
    bfb[3] = 1.42056081706421e-07;  
    bfa[0] = 1.0;  
    bfa[1] = -2.97905614466461;  
    bfa[2] = 2.95833103772367;  
    bfa[3] = -0.97927375661041;  
  
    firstTime[FeedBack] = false;  
}  
  
xf = (bfb[0] * x + bfb[1] * zf[1] + bfb[2]*zf[2] + bfb[3]*zf[3]  
      - (bfa[1]*zf[4] + bfa[2]*zf[5] + bfa[3]*zf[6]));
```

```

/* Store terms for the next call. */
zf [3] = zf [2];
zf [2] = zf [1];
zf [1] = x;
zf [6] = zf [5];
zf [5] = zf [4];
zf [4] = xf;

return(xf);

```

Original Processing

Figure 1 shows the measurements processed using the standard code and also, in red, my calculation of what I would expect, obtained using an R-based Butterworth filter. I have applied the same exponential-update factor, 0.995, as used in Janine's processing. For the interval from 1:40:00 to 1:55:00, the mean difference between VNS and GGVNS is -0.749 and that between VEW and GGVEW is -0.387 . For the original corrected measurements (VNSC and VEWC), the corresponding differences were 0.107 and 0.037. The bias estimated in the old filter was about 11%, so it would be expected that the latter difference would be about 11% of the former and of opposite sign. The results thus reflect the expected bias well: If the correction applied by the filter is 11% too great, the resulting differences from this effect alone would be 0.09 and 0.05, close to the observed values. These are then the errors that the revised filter function should remove.

The new filter

Figure 2 shows the corresponding measurements processed using the revised filter code as listed at the beginning of this document. Also shown in red and overplotted by green is my calculation using R and so completely independent. For the same time interval as for the original processing, the mean differences in this revised processing were, for the original measurements, the same as before, as they should be: $\langle \text{VNS-GGVNS} \rangle = -0.749$ and $\langle \text{VEW-GGVEW} \rangle = -0.387$. For the corrected measurements VNSC and VEWC, the corresponding differences were -0.125 and -0.255 . These are not improved from the original values but at least have the sign expected if they arise from the delayed response of the filter. The differences I get by calculating with an R-based filter with time constant of 600 s are -0.125 and -0.255 , which are exactly the same. Figure 2 shows that the two results are indistinguishable. The differences over the time period selected are less than $1. \times 10^{-5}$ for both mean and standard deviation for both components.

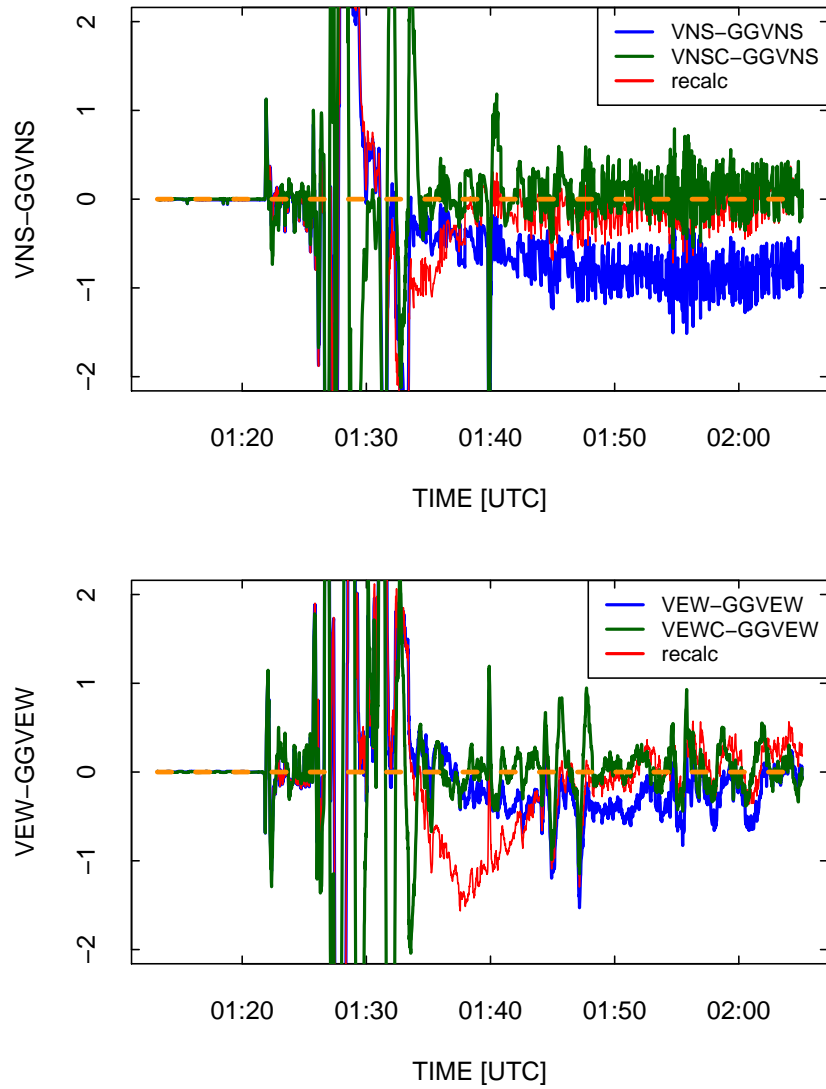


Figure 1: Original processing for a selected TREX flight. Top: Differences between VNS, VNSC, and recalculated VNSC; bottom: Similar difference for the EW component of groundspeed.

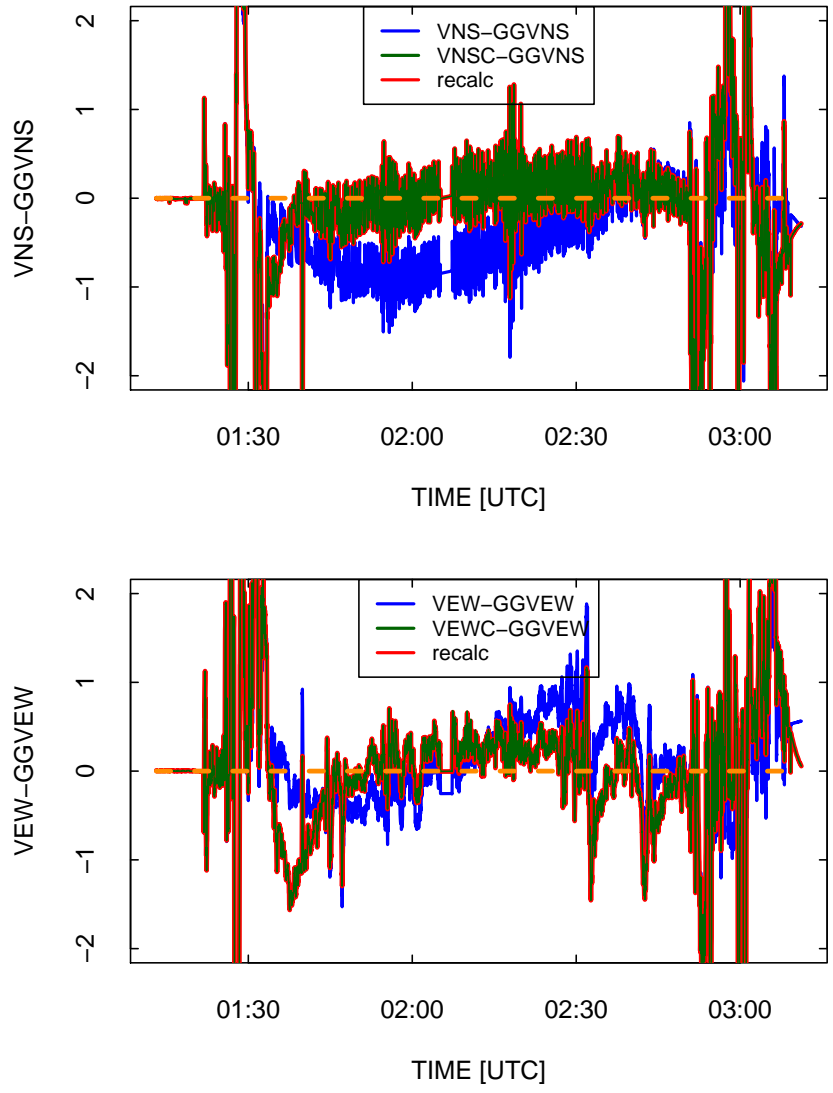


Figure 2: Revised processing of the same flight shown in Fig. 1, with the new filter function. The 'recalc' red line is plotted triple-width vs single-width for the green line, and the green line is plotted over the red, so both can be visible. If they are equal, the green should appear centered in the red.

Conclusion

The filter is implemented as I had suggested and produces results essentially identical to those I get using an R script. However, the mean offset in both sets of results is a little larger than I would expect. This arises from the exponential update factor; the offsets are smaller if that update is suppressed. To some extent, that factor is a remnant from times when GPS reception was much less reliable and was needed to avoid problems when GPS reception is lost. I need to reconsider if a different compromise for the exponential factor is appropriate. For example, a factor of 0.95 reduces the offset by more than a factor of 2 and so might be a better compromise. I'll revise this note once I look into the exponential-update factor more.