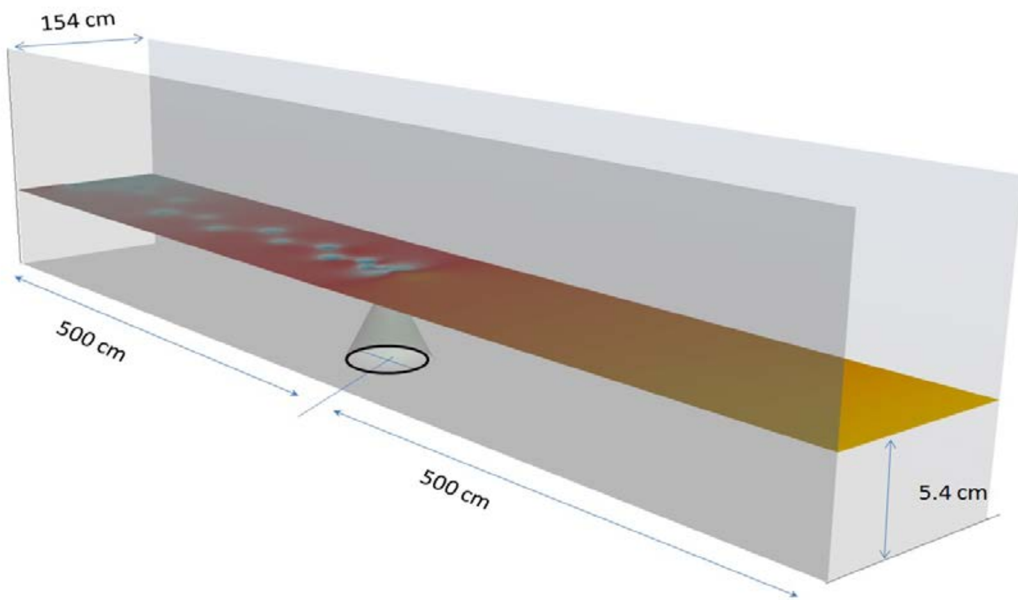
ATFM-V2 (Alaska Tsunami Forecast Model) – National Tsunami Warning Center
B. Knight – NTHMP CURRENT BENCHMARKS 1-2 Feb 9, 2015

Model description:

- 2D Depth averaged formulation
- Non-linear Shallow Water equations of motion
- Hydrostatic
  - there is a non-hydrostatic version running in “test mode”
- Finite difference solution technique for U, V, & Sea Level.
  - PDEs formulated in spherical coordinates
- Basic upwind-downwind formulation for velocity advection
  - piecewise linear reconstruction of the velocity field under development
- Finite Volume treatment for the continuity equation
- 2-way subgrid nesting to achieve high resolution where needed
- Inundation scheme based on VOF[1] (Volume of Fluid) methods

Benchmark problem # 1 – *run with 1 cm x 1 cm grid*



Inflow condition: $U_{inlet} = U_o\left(1 - e^{-t/\tau}\right)$ with $Uo = .115\frac{m}{s}$ and $T = 5\ s$

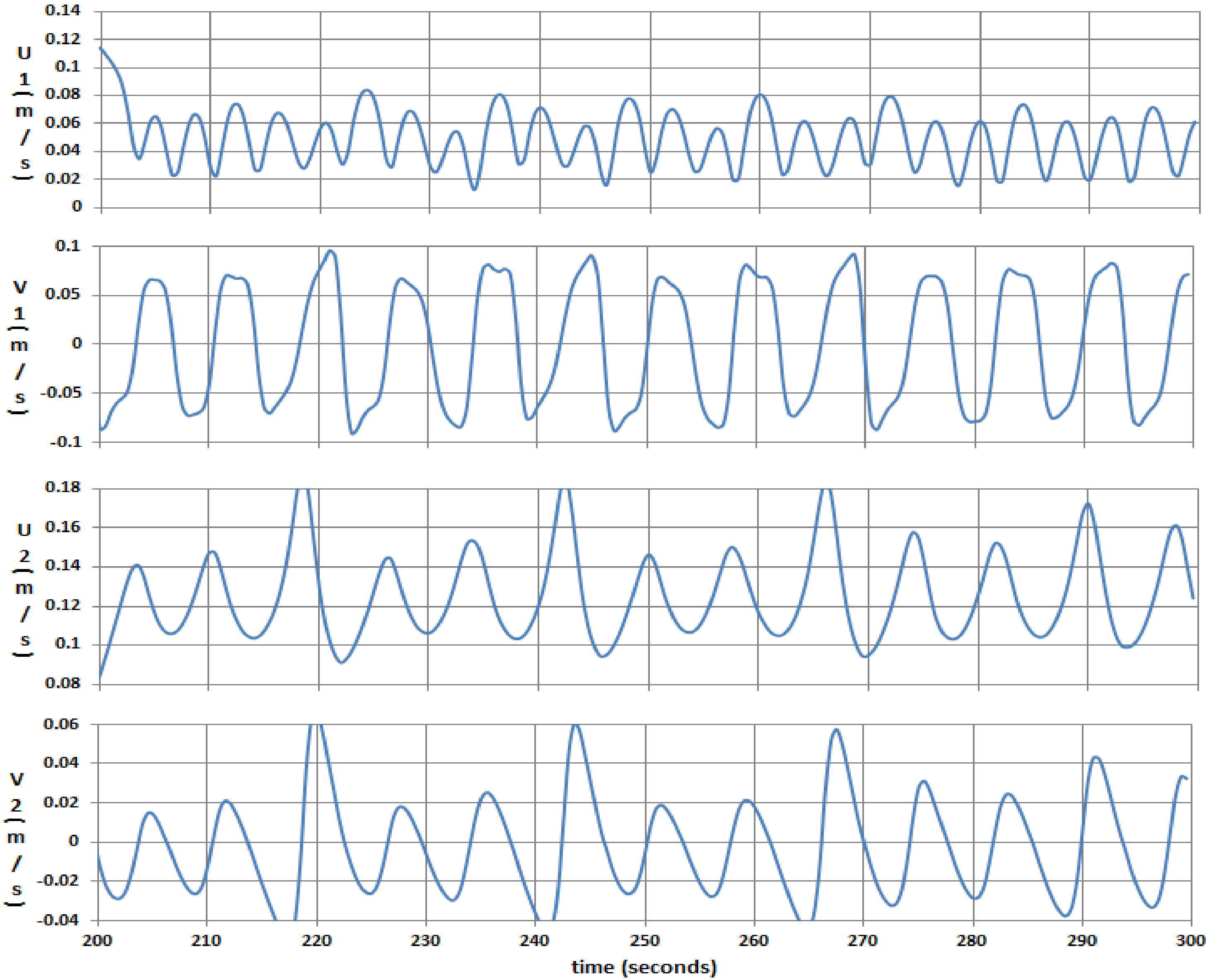
Outflow condition: $\eta = (U - U_{inlet})\sqrt{\frac{D}{G}}$ with $D = .054m$

Parameter space investigated:
Manning's "n" from .008 to .02 s/ m $^{1/3}$
Horizontal friction ν from $1x10^{-6}$ to $4x10^{-5}$ m^2/s

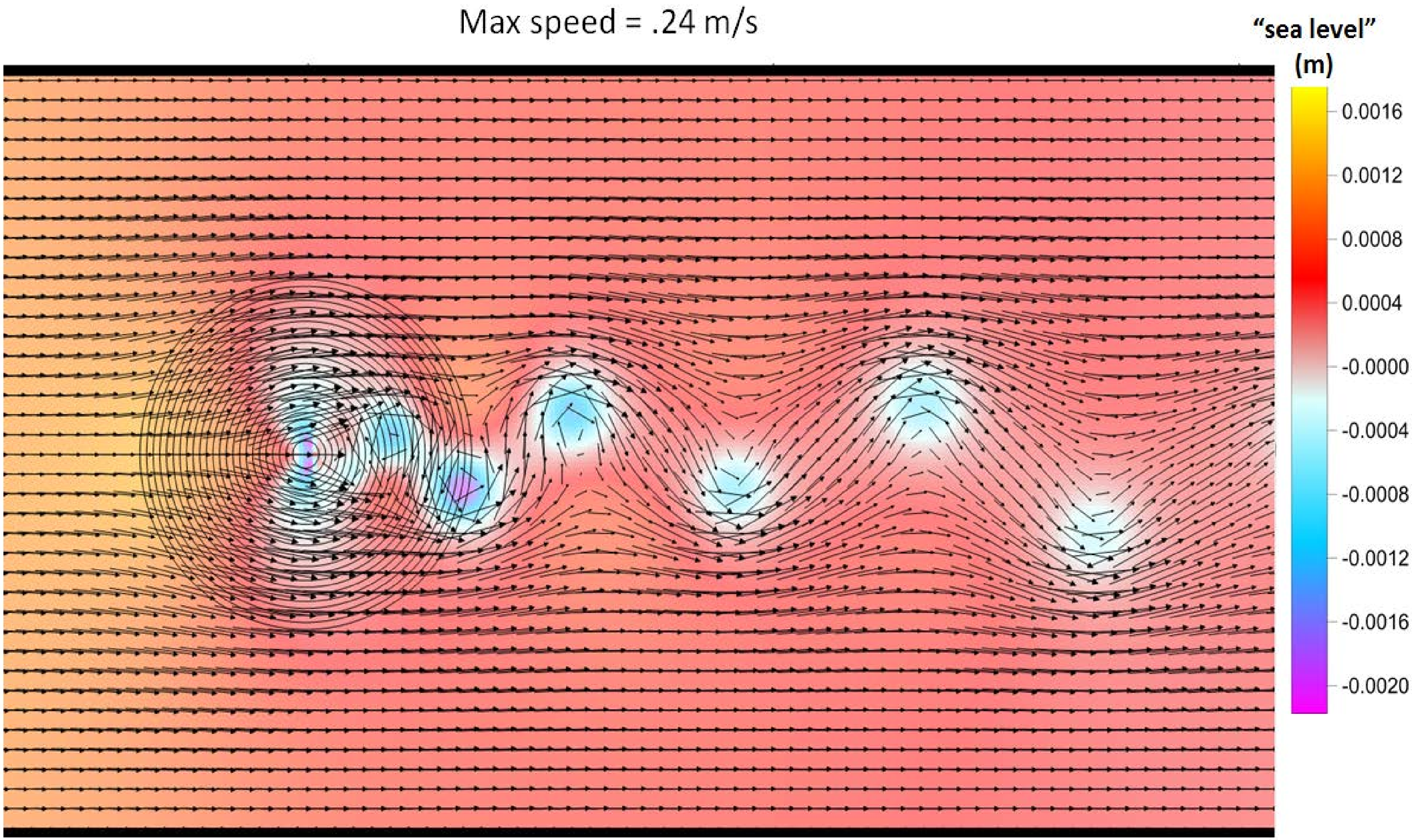
No vortex shedding was seen with the original upwind-downwind scheme. Ever!   However….

Advection treated in the manner of VanLeer[2], with U & V represented as piecewise linear functions across the mesh, did produce reasonable results (next slide).

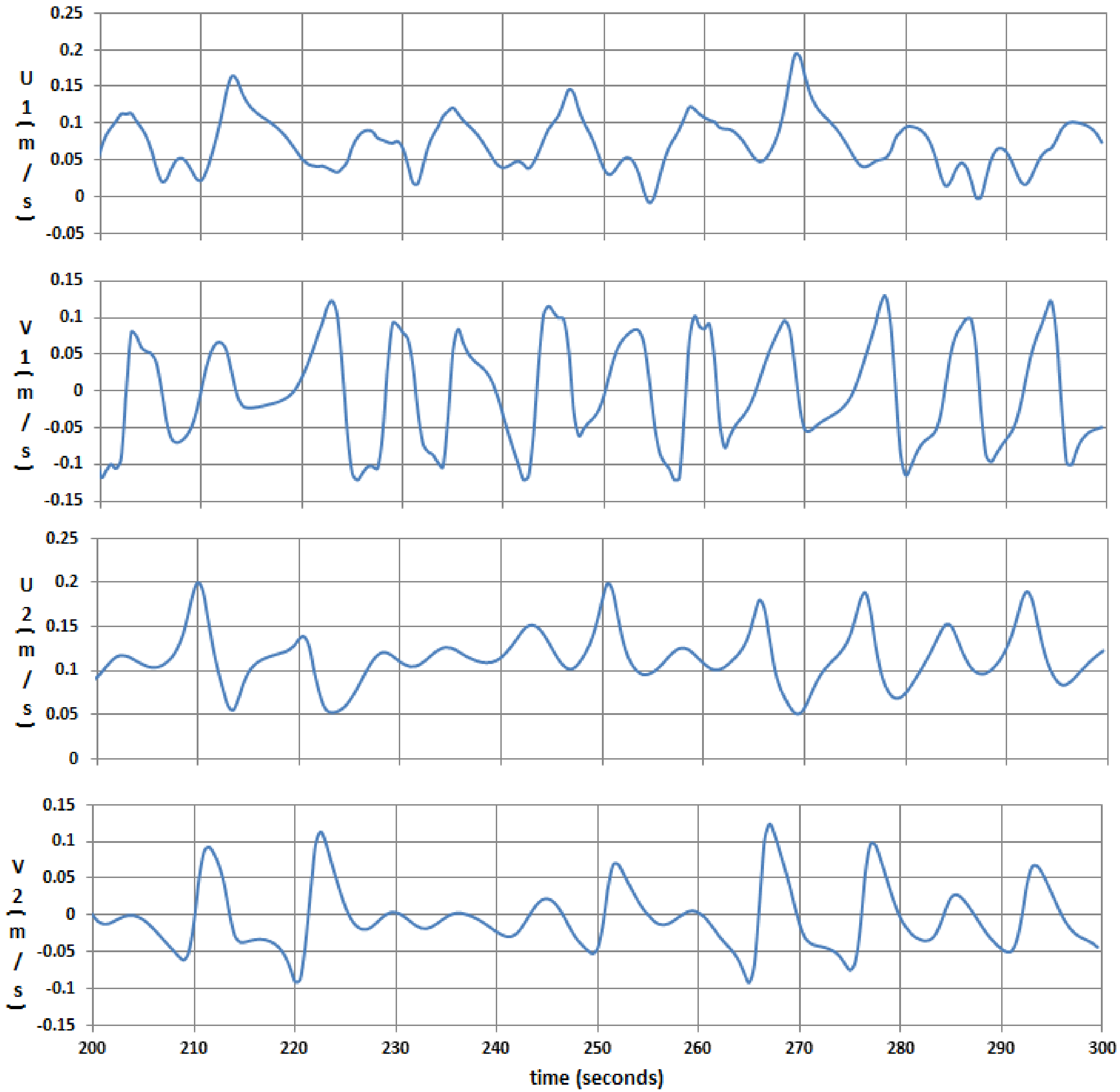
OPTIMIZED model velocity components at points 1, 2 – based on VanLeer, Manning "n" value of 0.015 and horizontal viscosity of $5x10^{-6}$ m^2/s



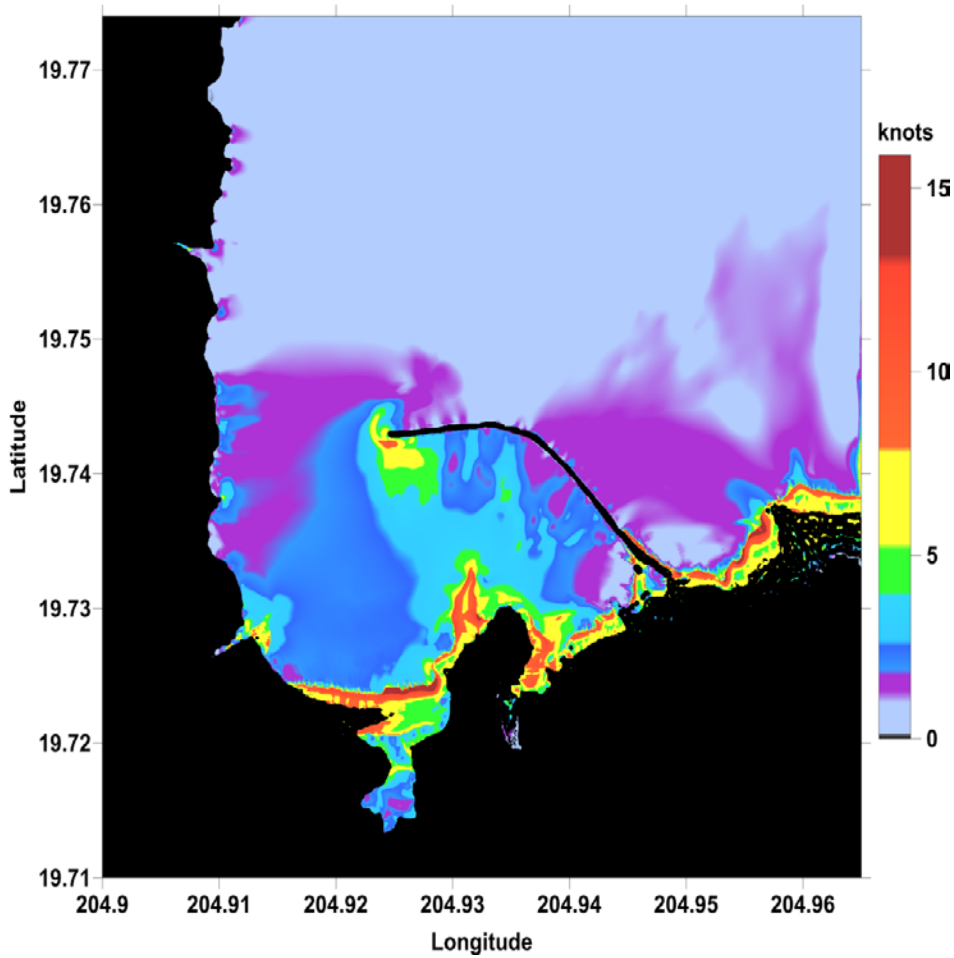
OPTIMIZED model: velocity vectors at t = 150 s
False color for “sea level”. “Guyot” is to the left



inviscid result – taking that to mean no horizontal friction in the model, but keeping Manning's n = .01



Benchmark problem # 2 (max current map below)

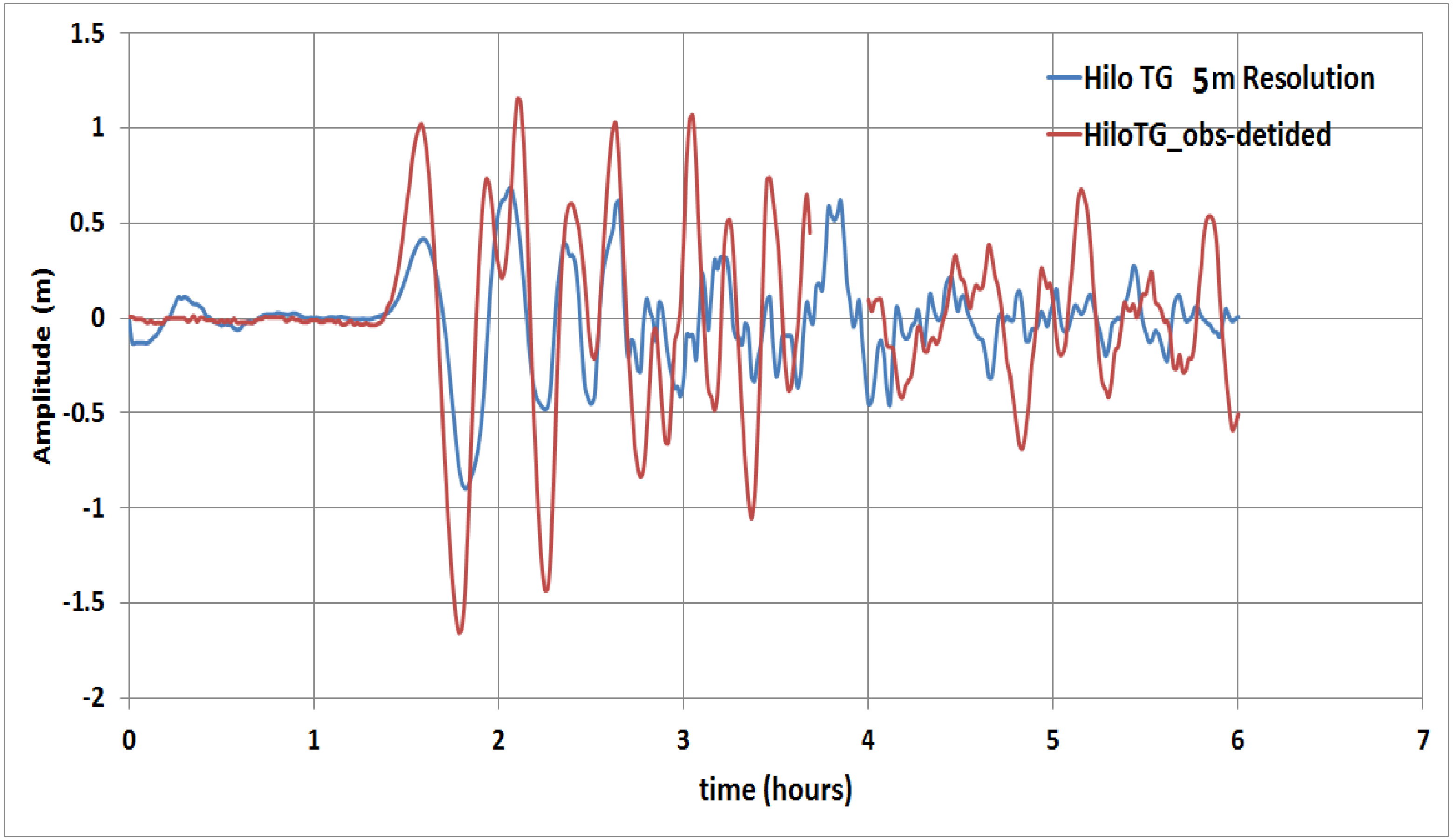


The original ATFM upwind-downwind advection scheme was used. Unlike benchmark # 1, plausible results were obtained with the simpler upwind/downwind treatment.

The model was driven along the northern edge of the domain with data from “SE.dat”.

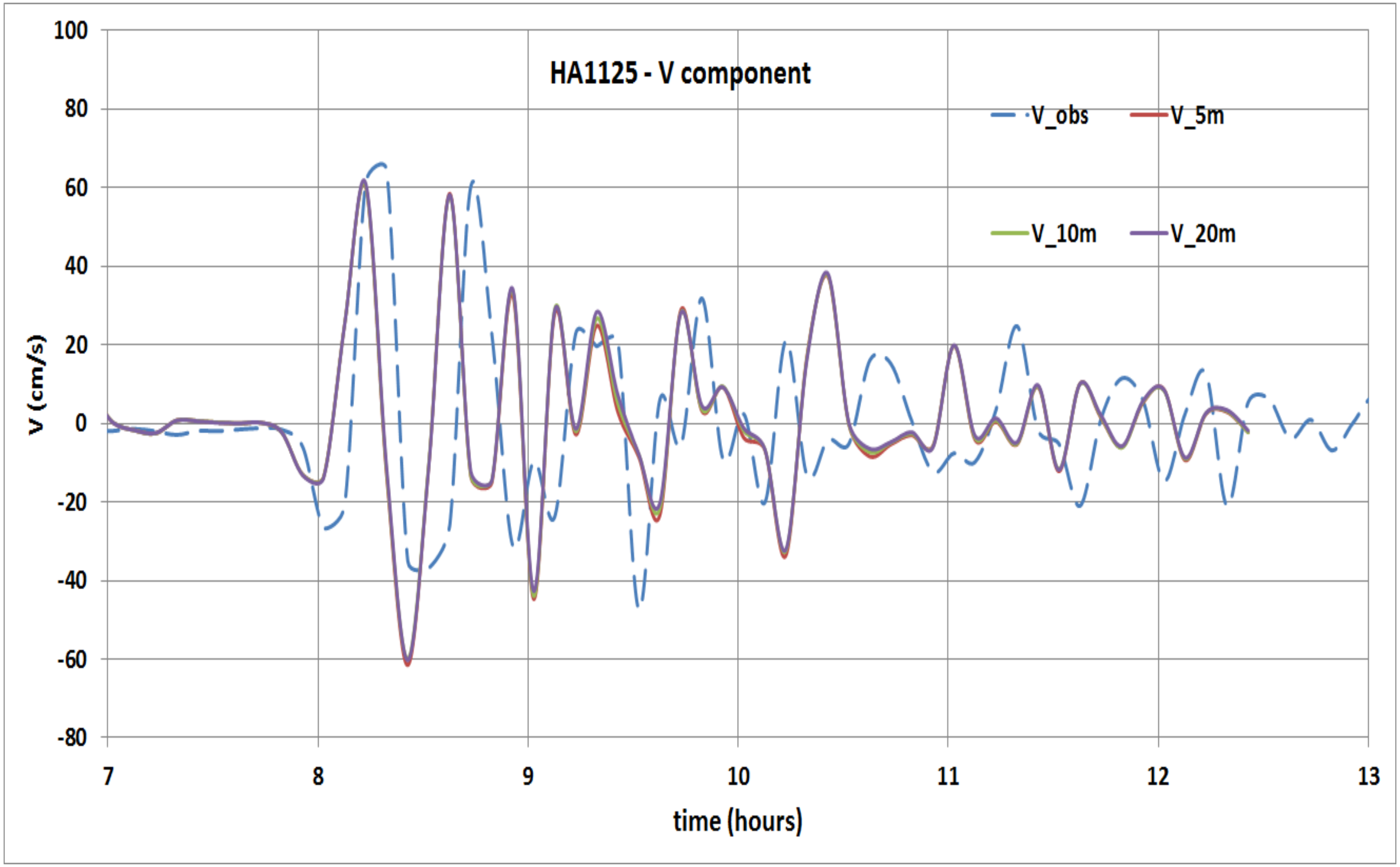
Manning’s “n” was set at 0.025 and horizontal friction to 0.

Although the forecast marigram at the control point was close to the published result, the Hilo TG forecast was low

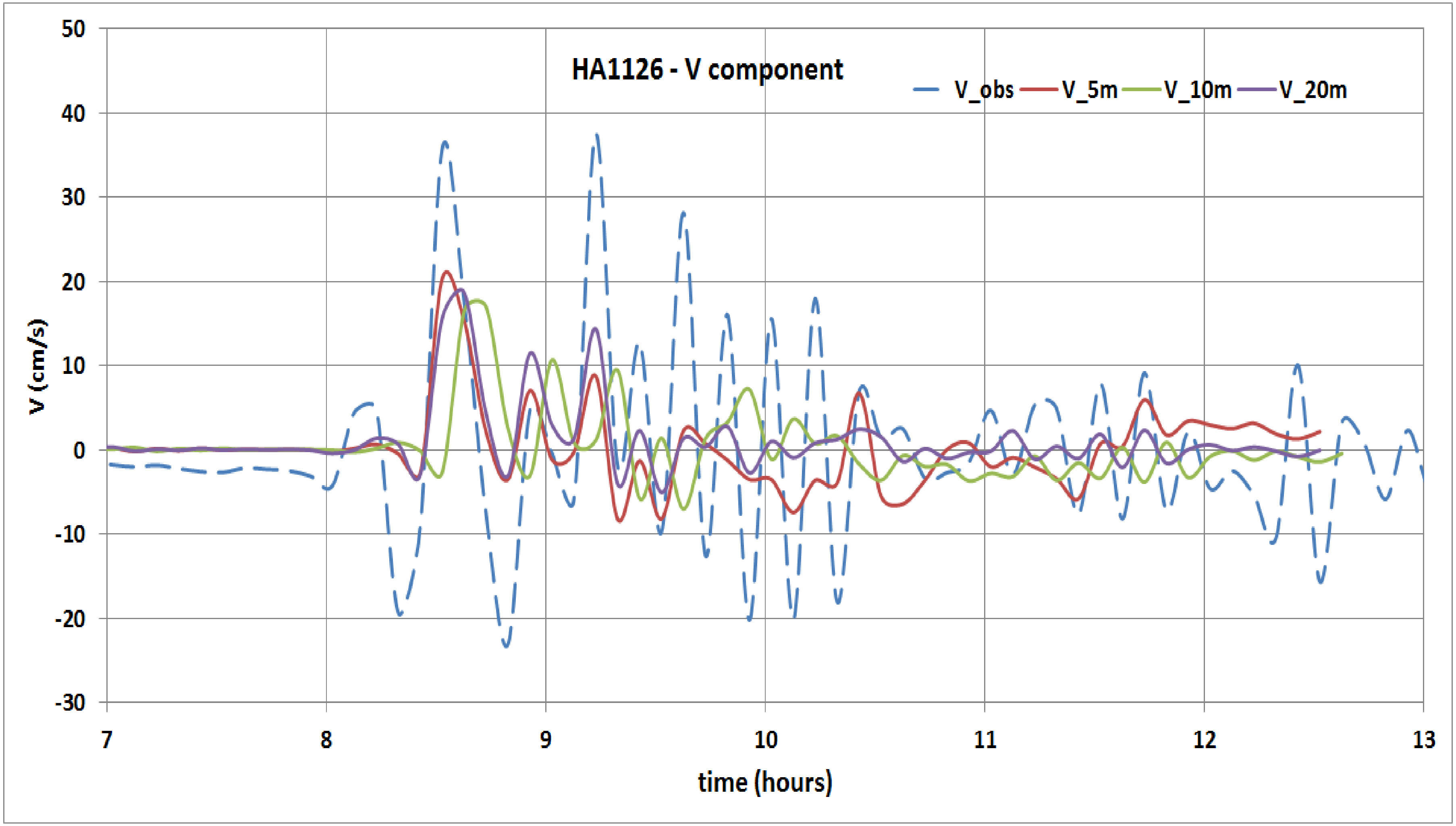


The computed velocity data was averaged to produce the equivalent of 6 minute samples – although it is unclear what the correct averaging approach should be here

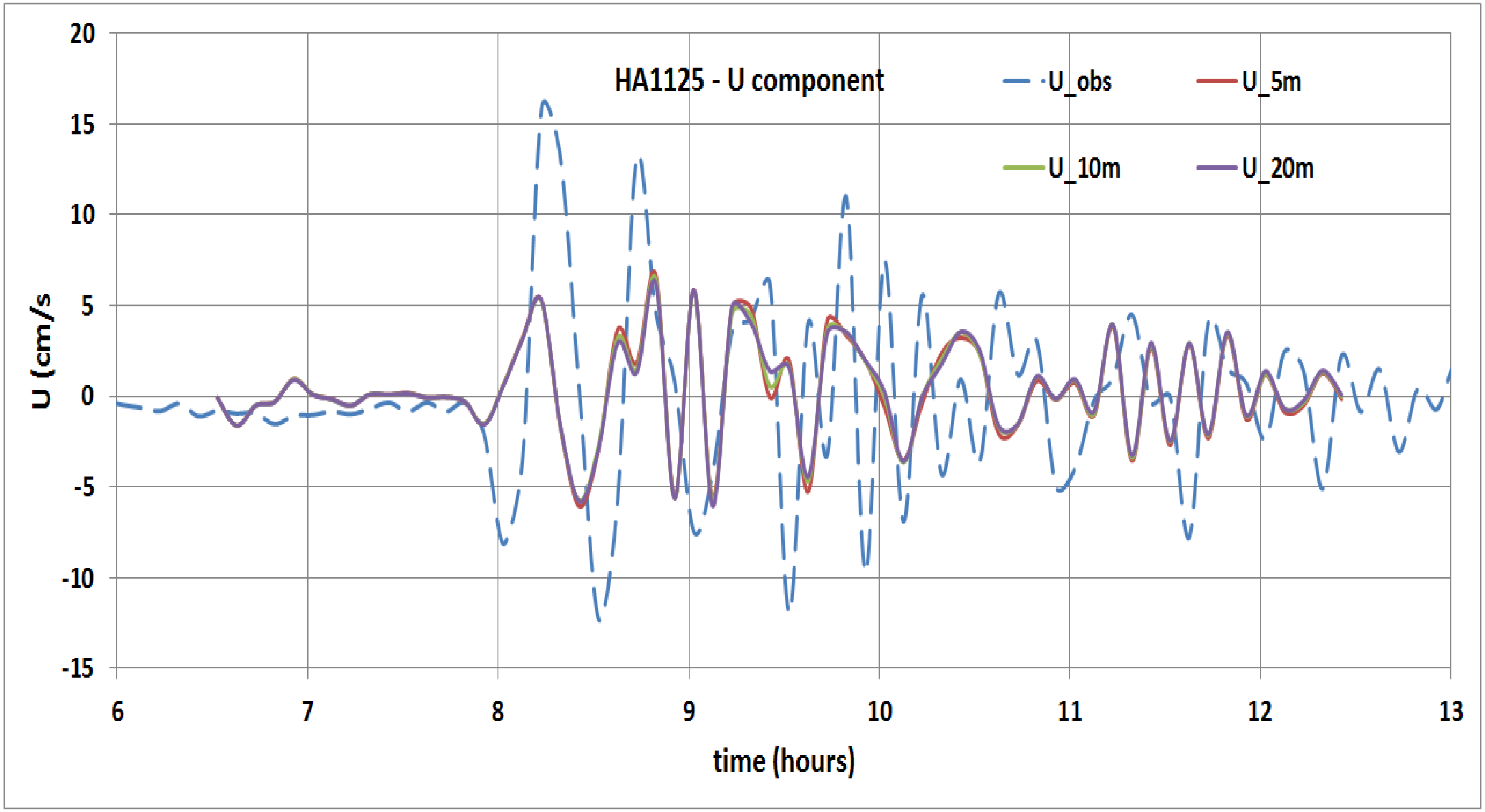
HA1125 – V component (detided dashed line)



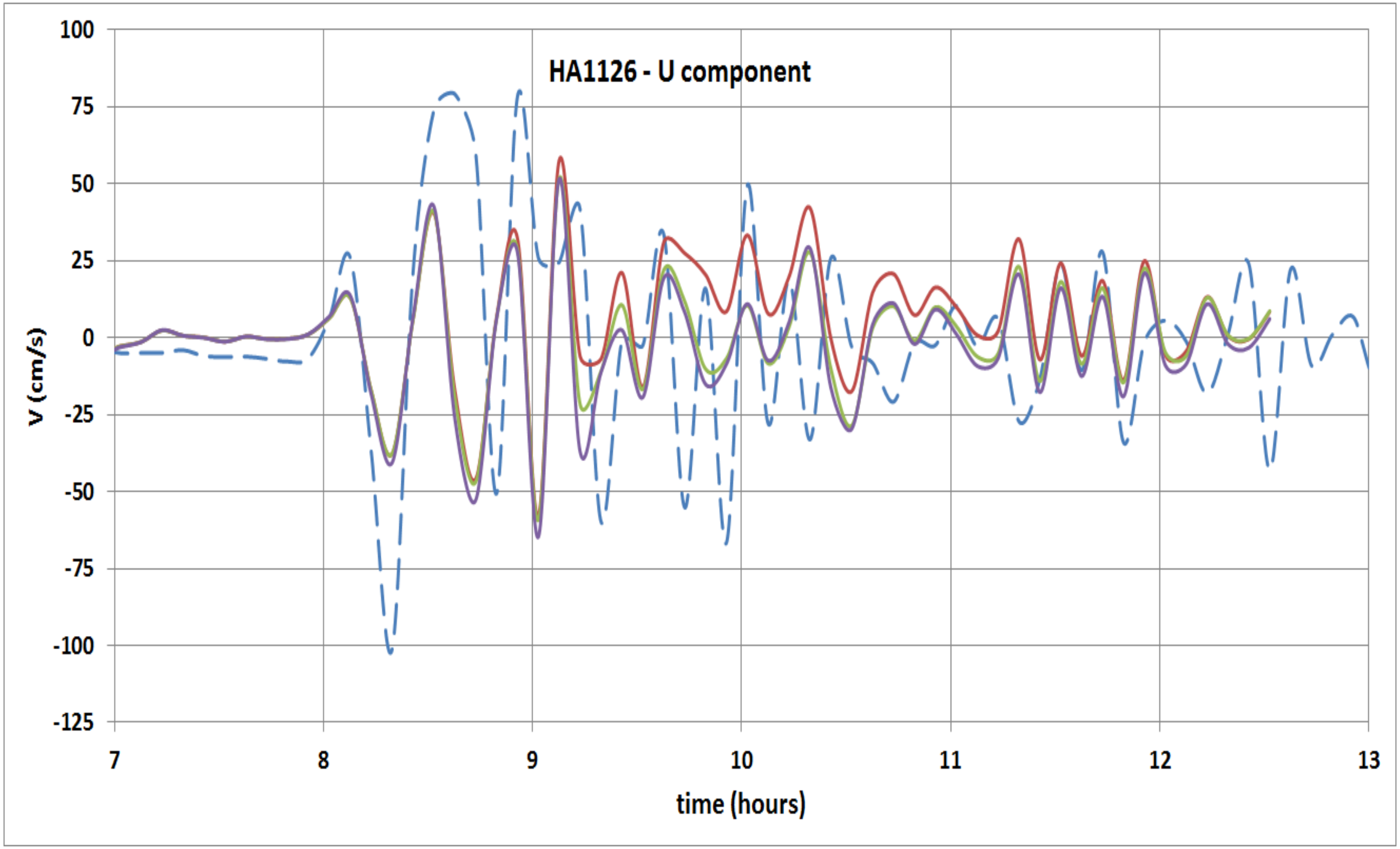
HA1126 – V component (detided dashed line)



HA1125 U component (detided dashed line)



HA1126 – U component (detided dashed line)



Summary

Result for Benchmark problem 1 show the need for higher order schemes.

The extreme sensitivity of results to small variations in model parameters makes me wonder how useful anything other than a qualitative comparison will be.

With the exception of HA1125 (V component) the results from the ATFM in benchmark problem 2 were disappointing. The model should be rerun with the more accurate piecewise linear method used for problem # 1.

In the future, a better statement of appropriate velocity averaging will be helpful.

[1]Hirt, C.W., Nichols, B.D., 1981: Volume of Fluid (VOF) Method for the Dynamics of Free Boundaries, Journal of Comp. Phys. 39 pp 201-225

[2]VanLeer, B. 1977, Towards the Ultimate Conservative Difference Scheme IV-A New Approach to Numerical Convection: Journal of Comp. Phys. 23 pp 276-299