Shallow water landslide-generated tsunami wave modeling: FBSlide

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What one would expect from a hydrostatic model

- Fast results, easy to introduce different approaches
- Acceptable for coastal areas, which is important for practical needs
- Poor-to-inacceptable for deep water

Case 2

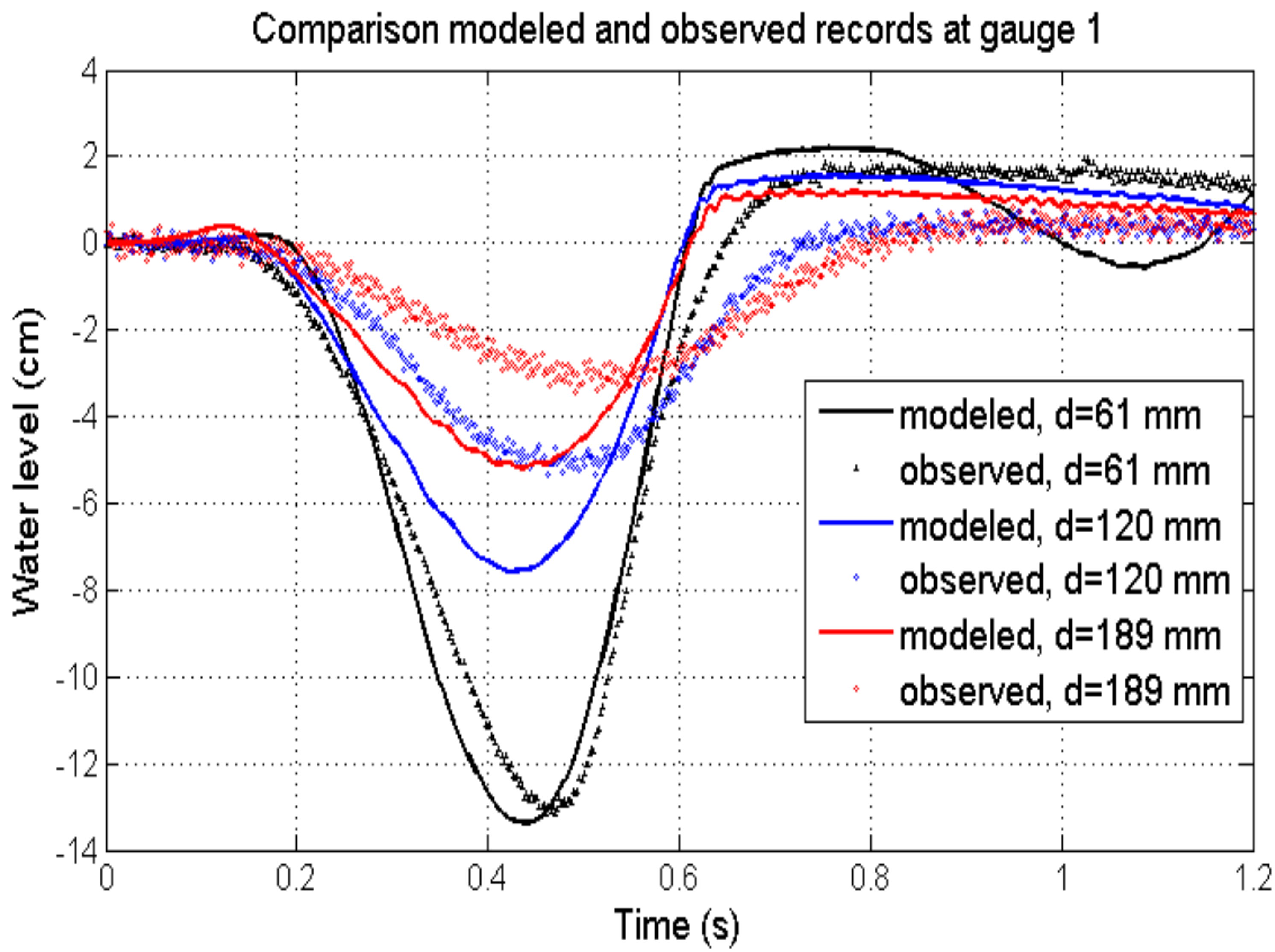
- Slide density exceeds 2.0 g/cm^3; reduced gravity is more than g/2, whereby Proudman resonance is possible for submarine landslides
- Wave celerity: $c^2=gh$; slide speed: $v^2=2g'\Delta h$,
- Froude Number: Fr can be ~1
- Short wavelengths compared to water depth, so that non-hydrostatic effects are important
- Nonlinearity of waves is not important

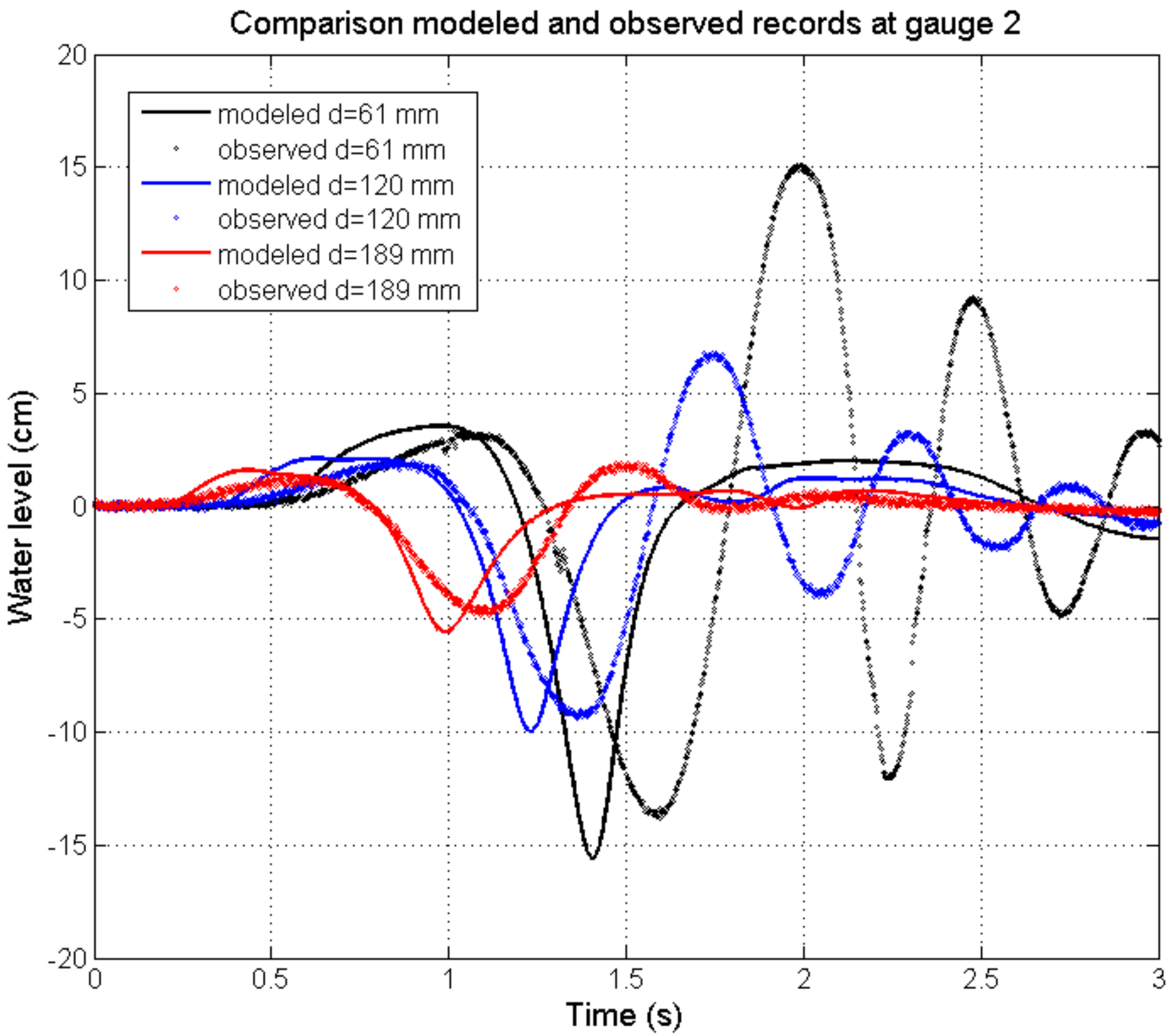
Case 2

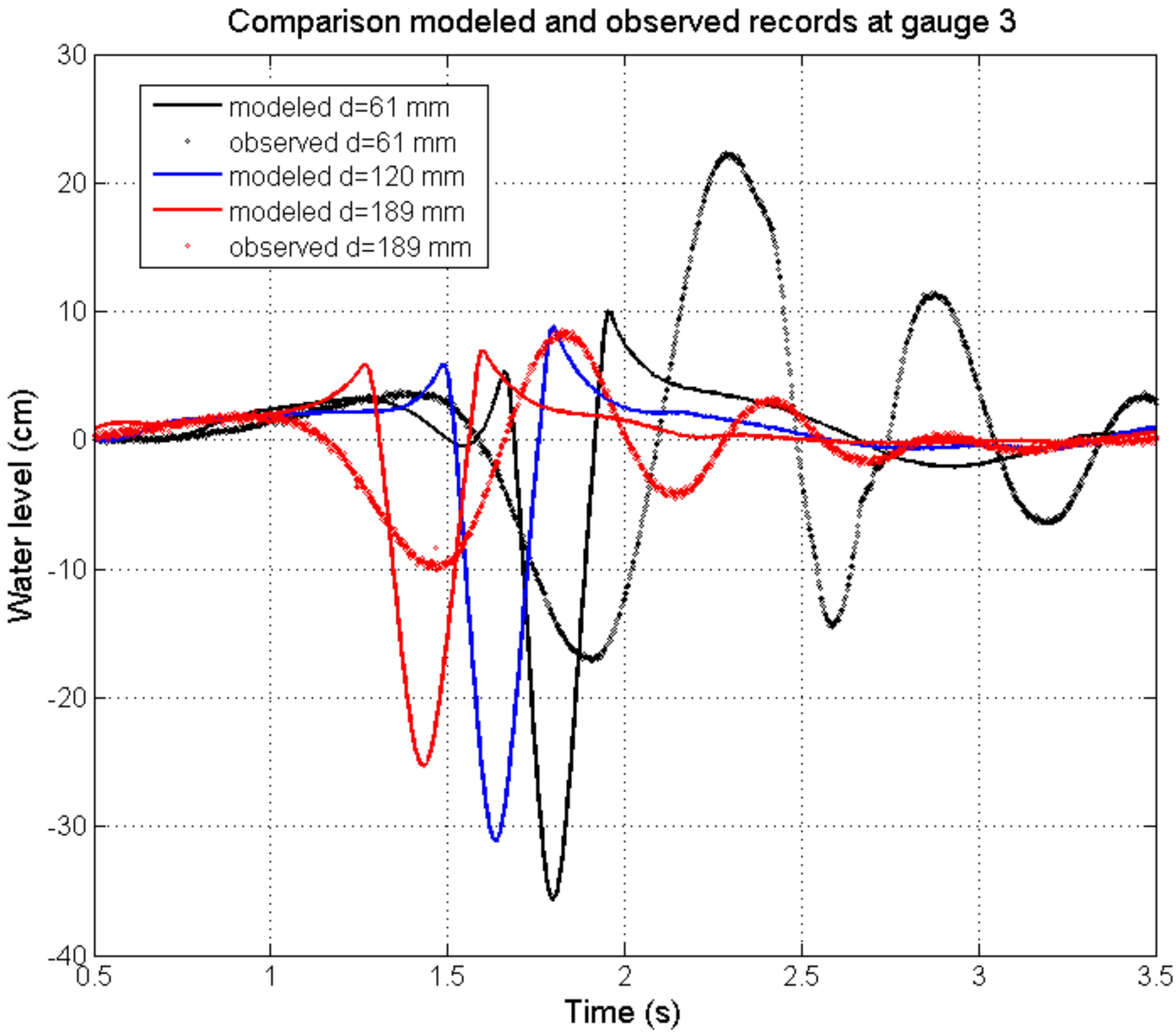
- In an ideal world, the slide acceleration is *a=g'sin(a)* = 1.4 m^2/s
- The measured acceleration is about 1.2 m^2/s
- With a larger volume slide, the theoretical acceleration will be the same as measured: No ability to reduce acceleration using added-mass, friction, etc.

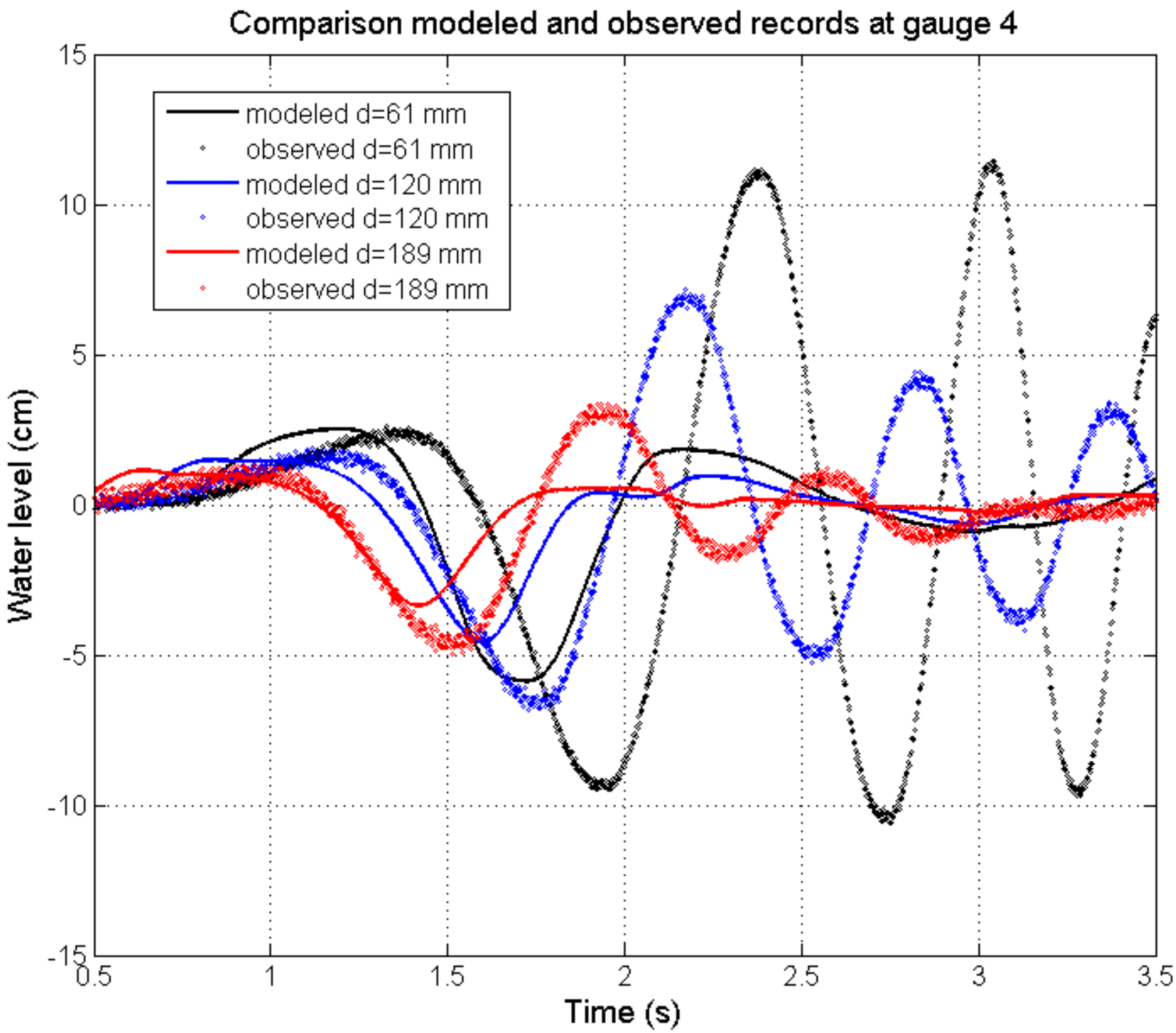
Proudman solution: When the slide movement is at sub-resonance speed, U<c, the steady solution consists of a trough at the surface:

$$\eta = -\frac{U^2}{c^2 - U^2}$$


Comparison modeled and observed records at gauge 1
Water level (cm)
Time (s)
4
2
0
-2
-4
-6
-8
-10
-12
-14
0
0.2
0.4
0.6
0.8
1
1.2
modeled, d=61 mm
observed, d=61 mm
modeled, d=120 mm
observed, d=120 mm
modeled, d=189 mm
observed, d=189 mm


Comparison modeled and observed records at gauge 2
modeled d=61 mm
observed d=61 mm
modeled d=120 mm
observed d=120 mm
modeled d=189 mm
observed d=189 mm
Water level (cm)
Time (s)
20
15
10
5
0
-5
-10
-15
-20
0
0.5
1
1.5
2
2.5
3


Comparison modeled and observed records at gauge 3
modeled d=61 mm
observed d=61 mm
modeled d=120 mm
modeled d=189 mm
observed d=189 mm
Water level (cm)
Time (s)
30
20
10
0
-10
-20
-30
-40
0.5
1
1.5
2
2.5
3
3.5


Comparison modeled and observed records at gauge 4
modeled d=61 mm
observed d=61 mm
modeled d=120 mm
observed d=120 mm
modeled d=189 mm
observed d=189 mm
Water level (cm)
Time (s)
15
10
5
0
-5
-10
-15
0.5
1
1.5
2
2.5
3
3.5

Conclusions

- You get what you pay for: The results are the expected results!
- The forced solution differs considerably between hydrostatic and non-hydrostatic models; in hydrostatic models, resonance is too high
- Hydrostatic models overestimate wave heights in deep water by a factor of ~2
- In specific experiments for which runup is very small, a sudden stop of the slide will increase runup many times!
- Added-mass: Not important for benchmarking but ... may be important for water movement
- Quadratic skin friction: important feedback for water