Detecting Silent Data Corruption through Data Dynamic Monitoring for Scientific Applications

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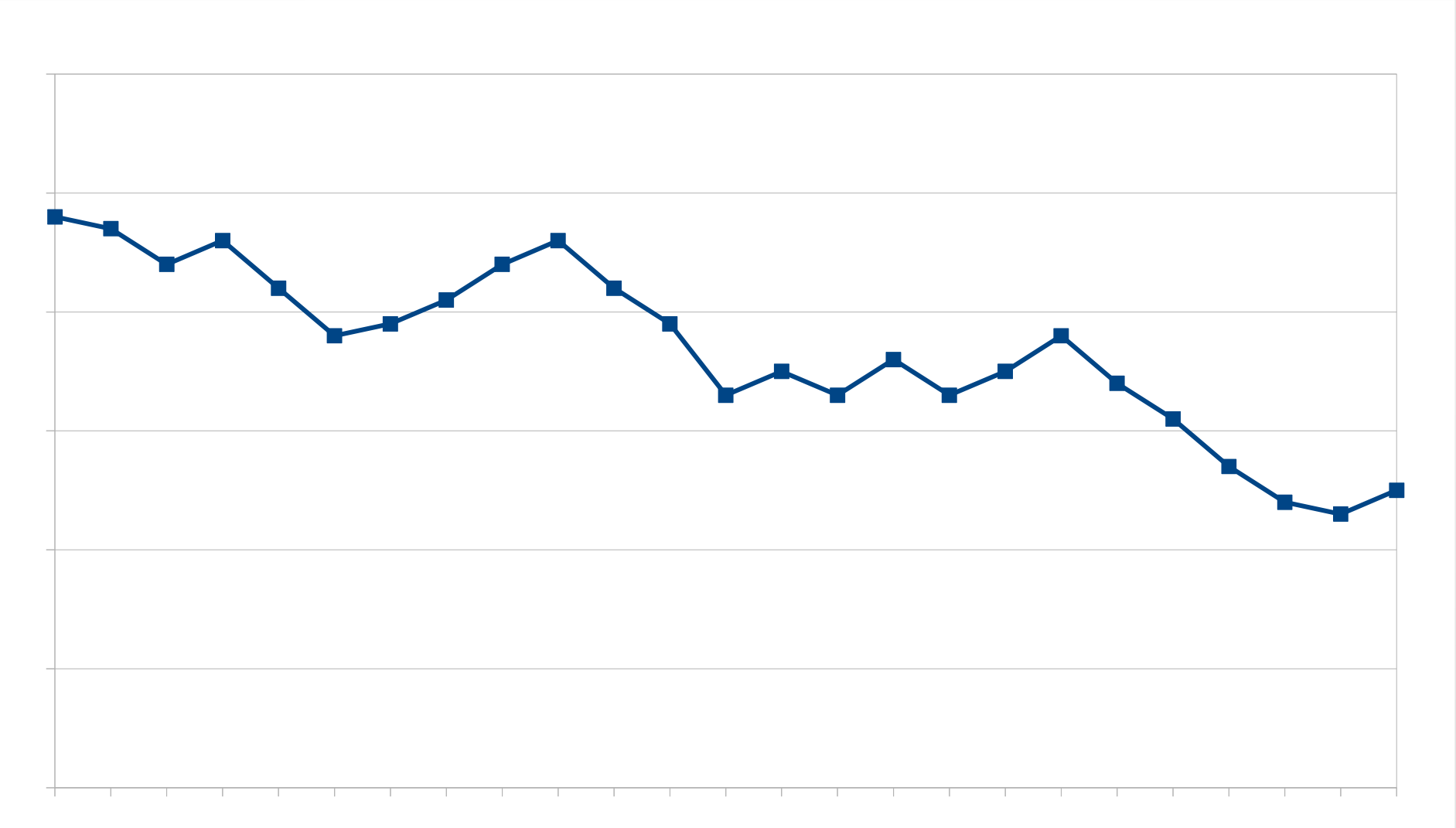
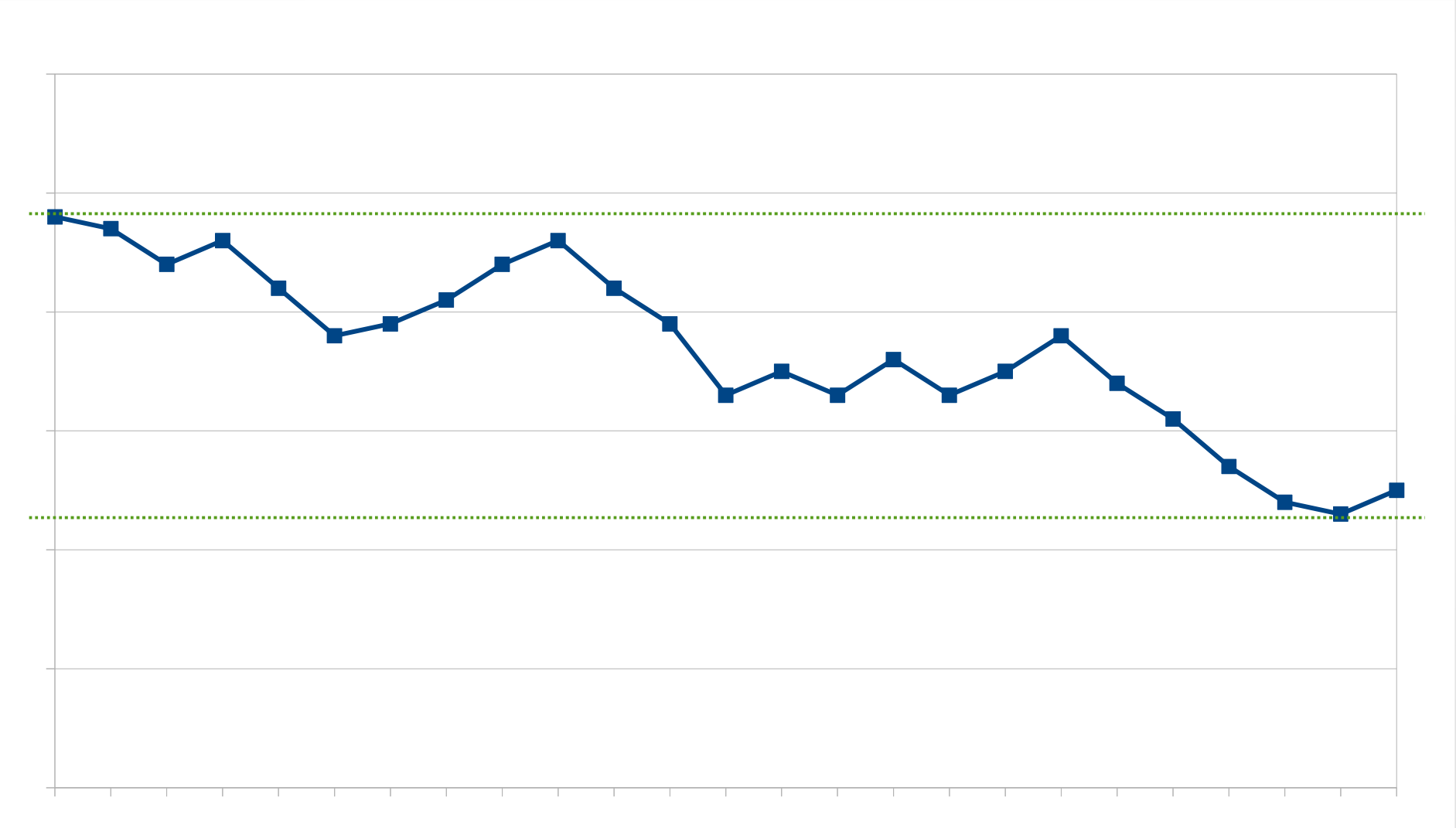
Silent Data Corruption

```
Original : 0000110000101111101010010010101001010000110011001100101110001100010010 00
Bit flip : 1000110010101111001010011010101001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0100110001101111111010010110101001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0010110000001111100010010000101001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0001110000111111101110010011101001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0000010000100111101000010010001001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0000100000101011101011010010111001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0000111000101110110101011001010001010000110011001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101110101010000010101101010001110011001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111001010011010101011010000010011001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111111010010110101000010000100011001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111100010010000101001110000111011001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111101110010011101001010000001101110011001011100011000100 10 : Detected = 0
Bit flip : 0000110000101111101000010010001001011000110001001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111101011010010111001010100110010001100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111101010110010100001010010110011101100101110001100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101101010001110011011100101010001100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101011010000010011000100101100001100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101000010000100011001000101111001100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101001110000111011001110101110101100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101001010000001101110011011011100111100010 10 : Detected = 0
Bit flip : 0000110000101111101010010010101001011000110001001100001110000100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101001010100110010001100111110000100010010 00 : Detected = 0
Bit flip : 0000110000101111101010010010101001010010110011101100100110001110010010 00 : Detected = 0
```

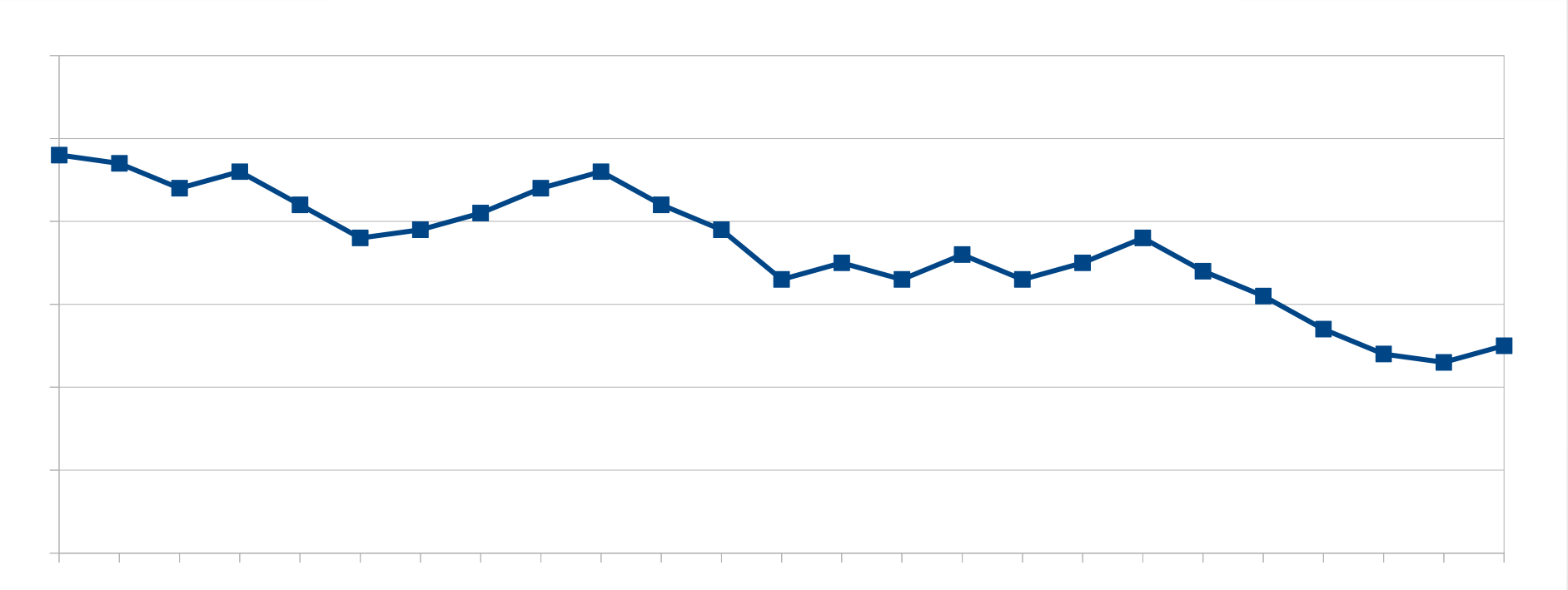
Data Dynamics Monitoring

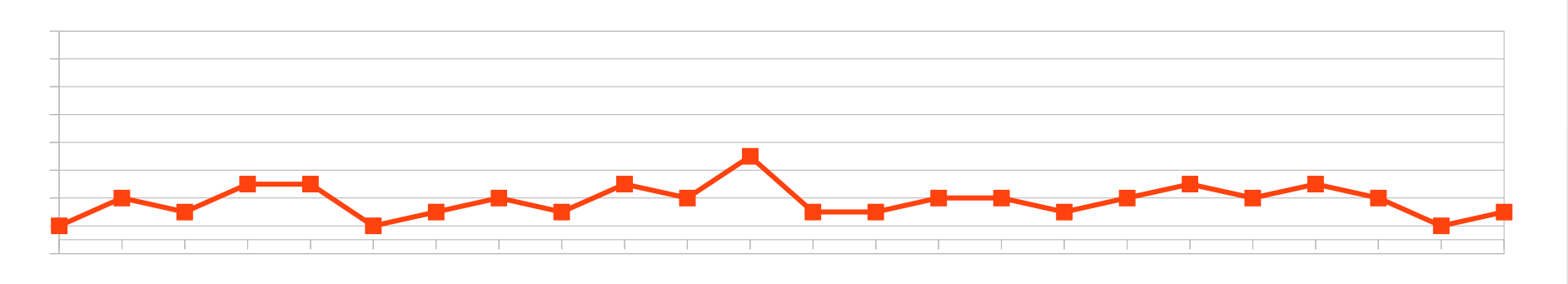


Data Dynamics Monitoring

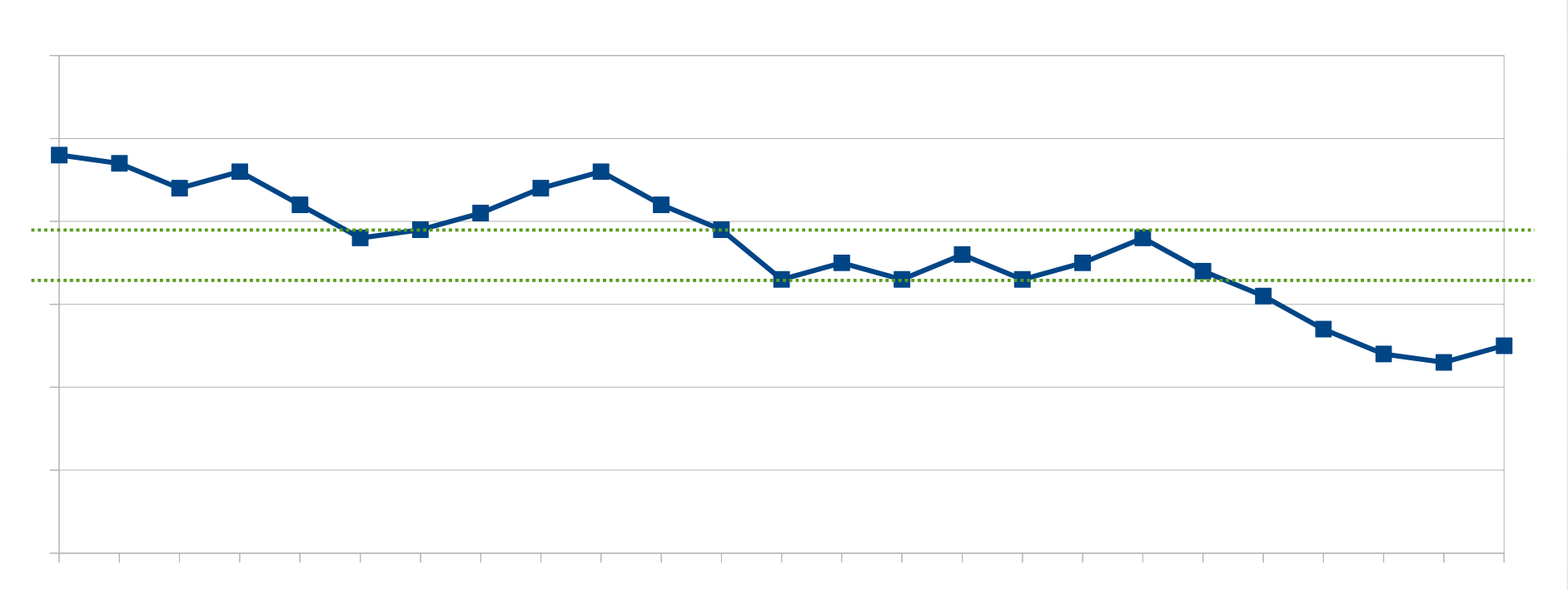


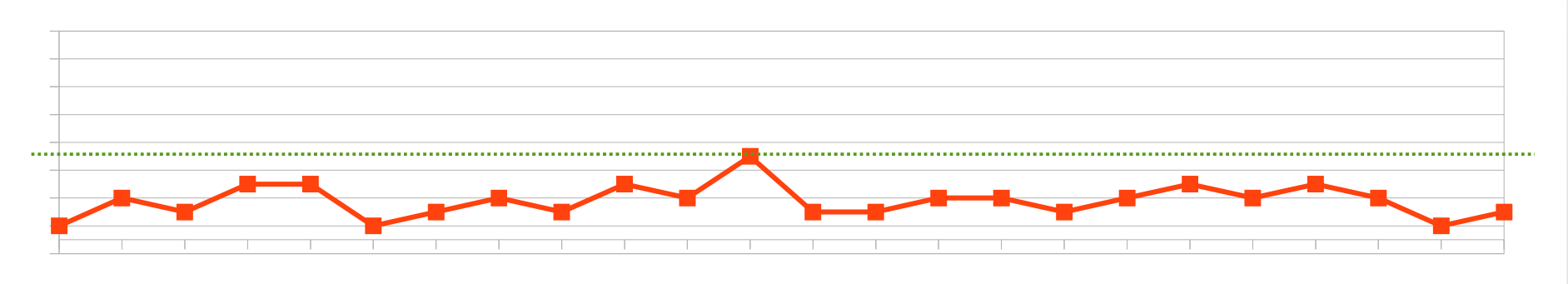
Data Dynamics Monitoring



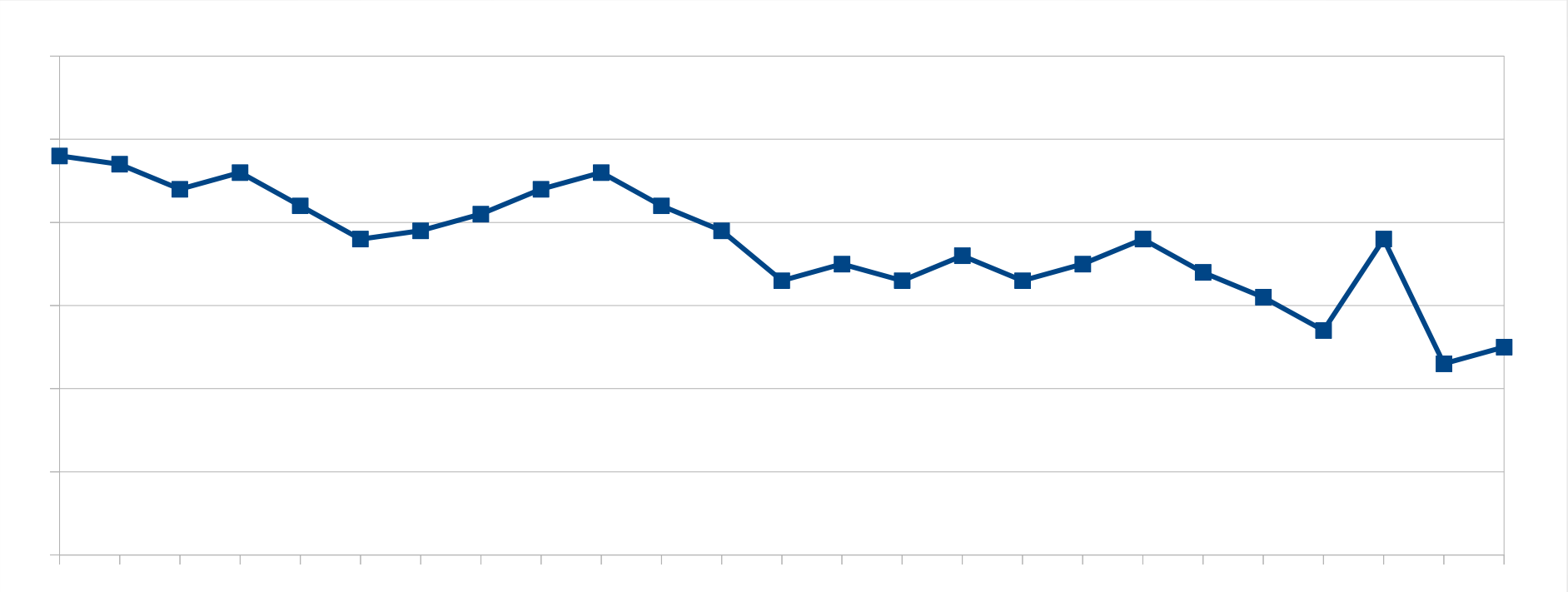


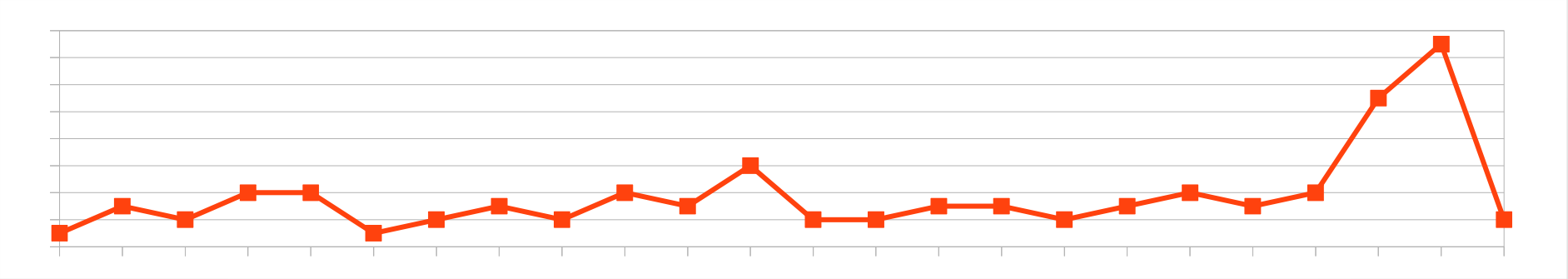
Data Dynamics Monitoring



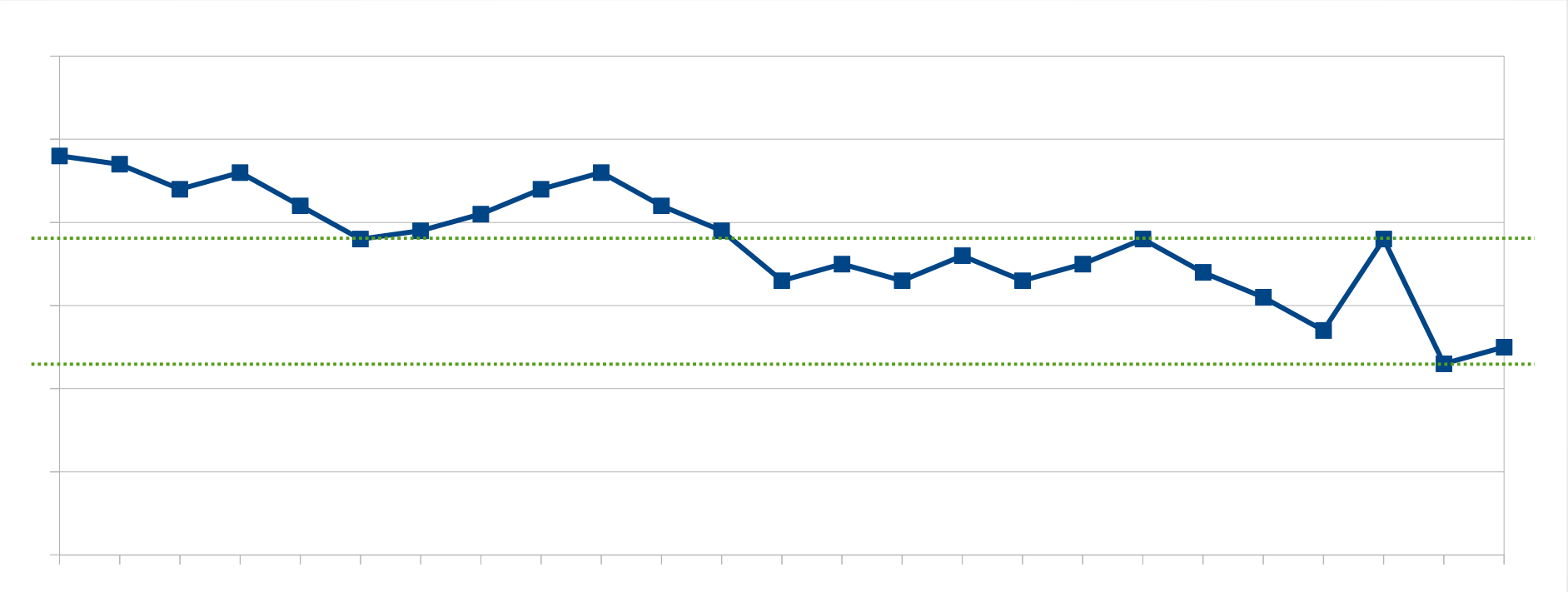


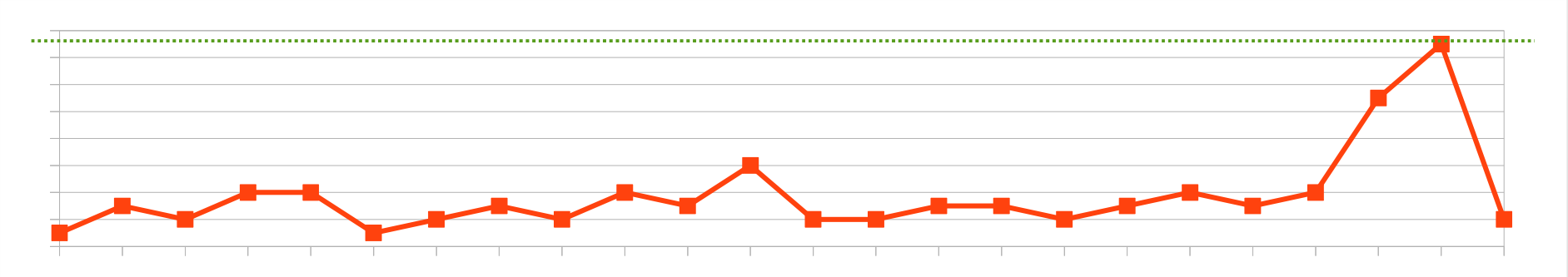
Data Dynamics Monitoring





Data Dynamics Monitoring



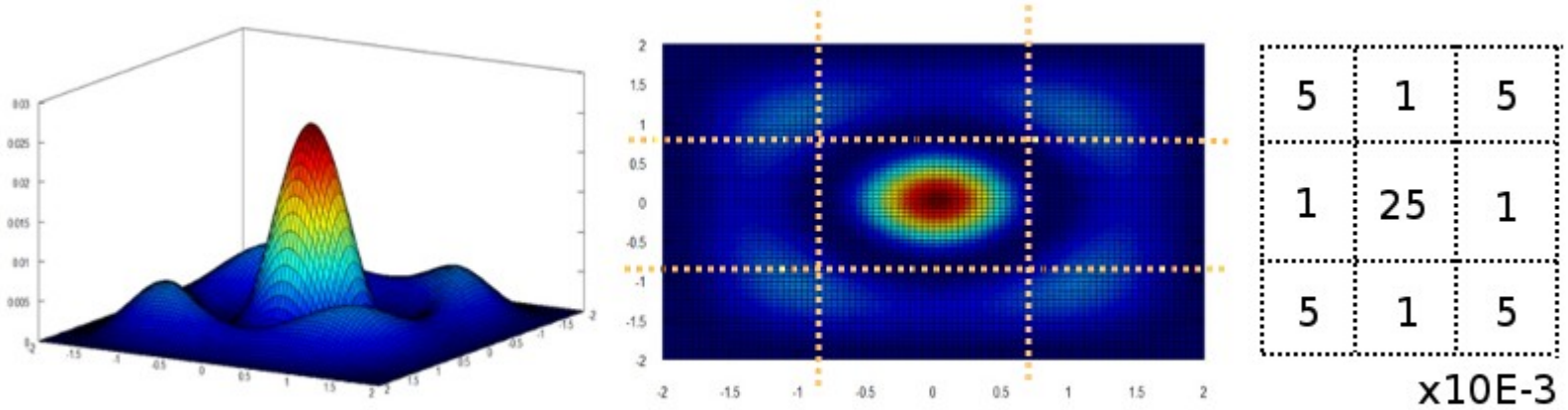


DADYMO API

```
function MAIN (argc, **argv)
    loadGridData(gridT, vectorU, ...)
    DADYMOprotect(gridT, 3D, type, dimX, dimY, dimZ)
    DADYMOprotect(vectorU, 1D, type, dimX)
        for i ← 0..Steps do
            kernel1(gridT, vectorU, ...)
            kernel2(gridT, vectorU, ...)
            if (DADYMOcheck() == DETECTION) then
                if (MassConservationTest() == DETECTION)
                then    RollbackLastCkpt()
                else    DADYMOfakeDetect()
                end if
            end if
        end for
 end function
```

Localized Data Monitoring

- More parallelism => Better detection.
- Higher resolution => Better detection.
- Mesh refinement => Better detection.

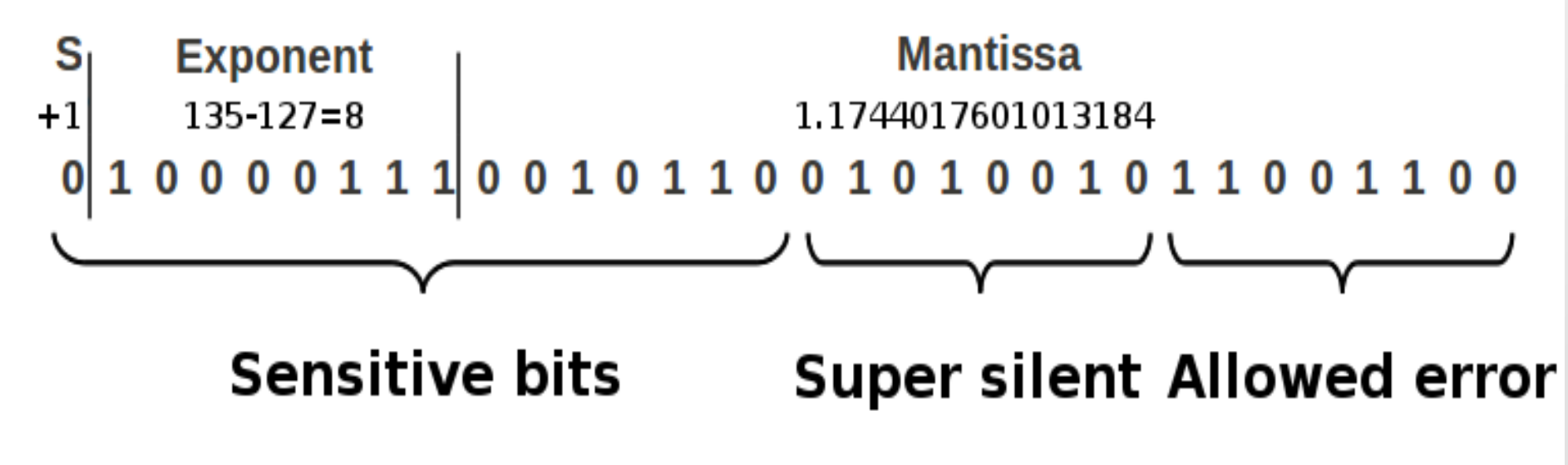


DADYMO Sensitivity Example

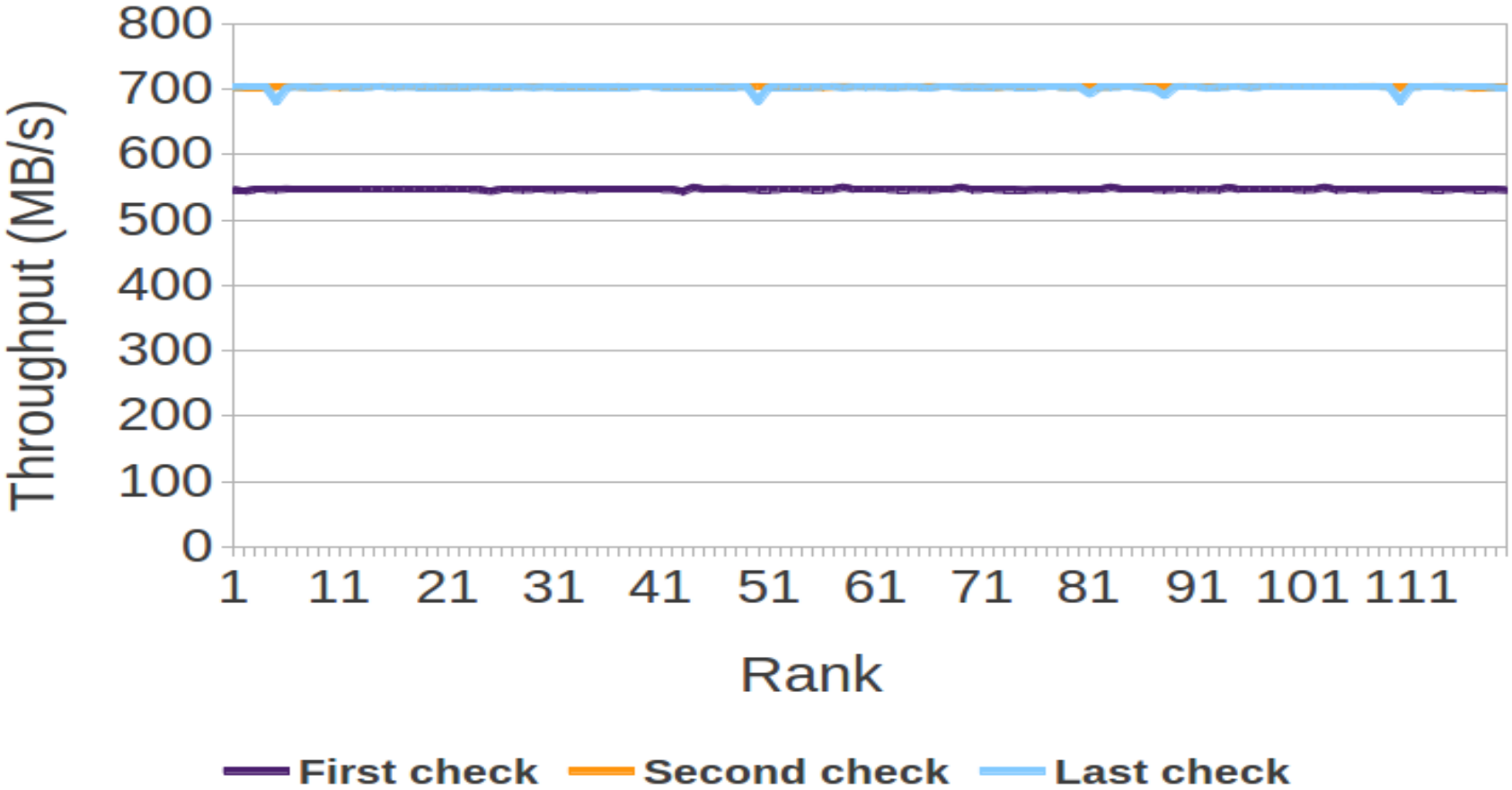
3D structured mesh: Temperature

Maximum difference: 01.00 Kelvin

Target cell value: 300.64685 Kelvin



SDC Detection Performance



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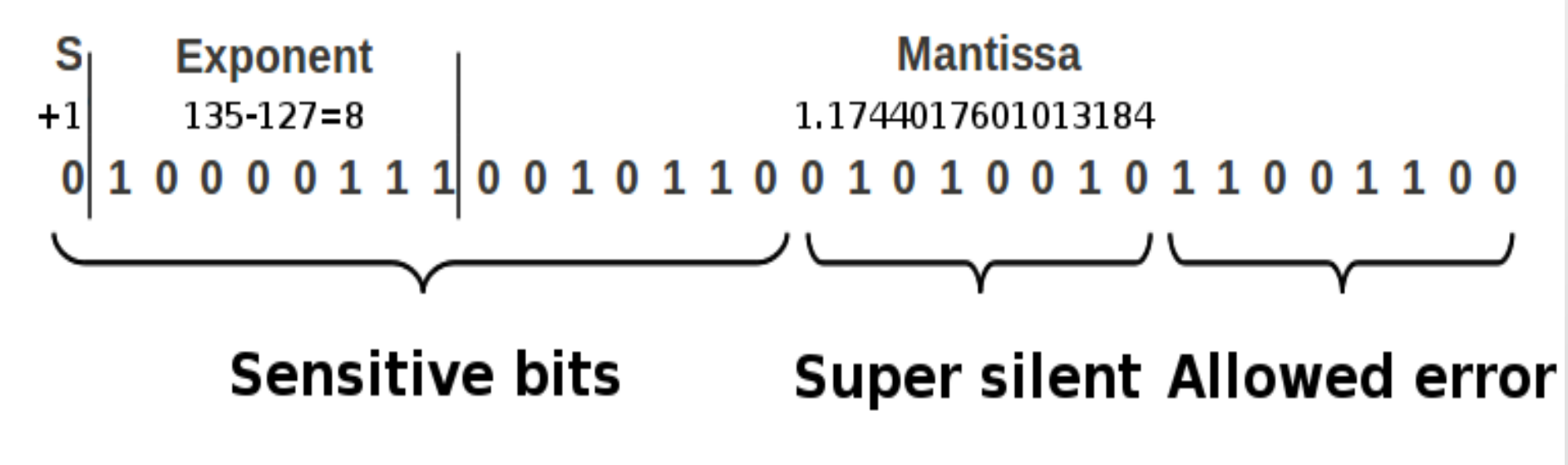
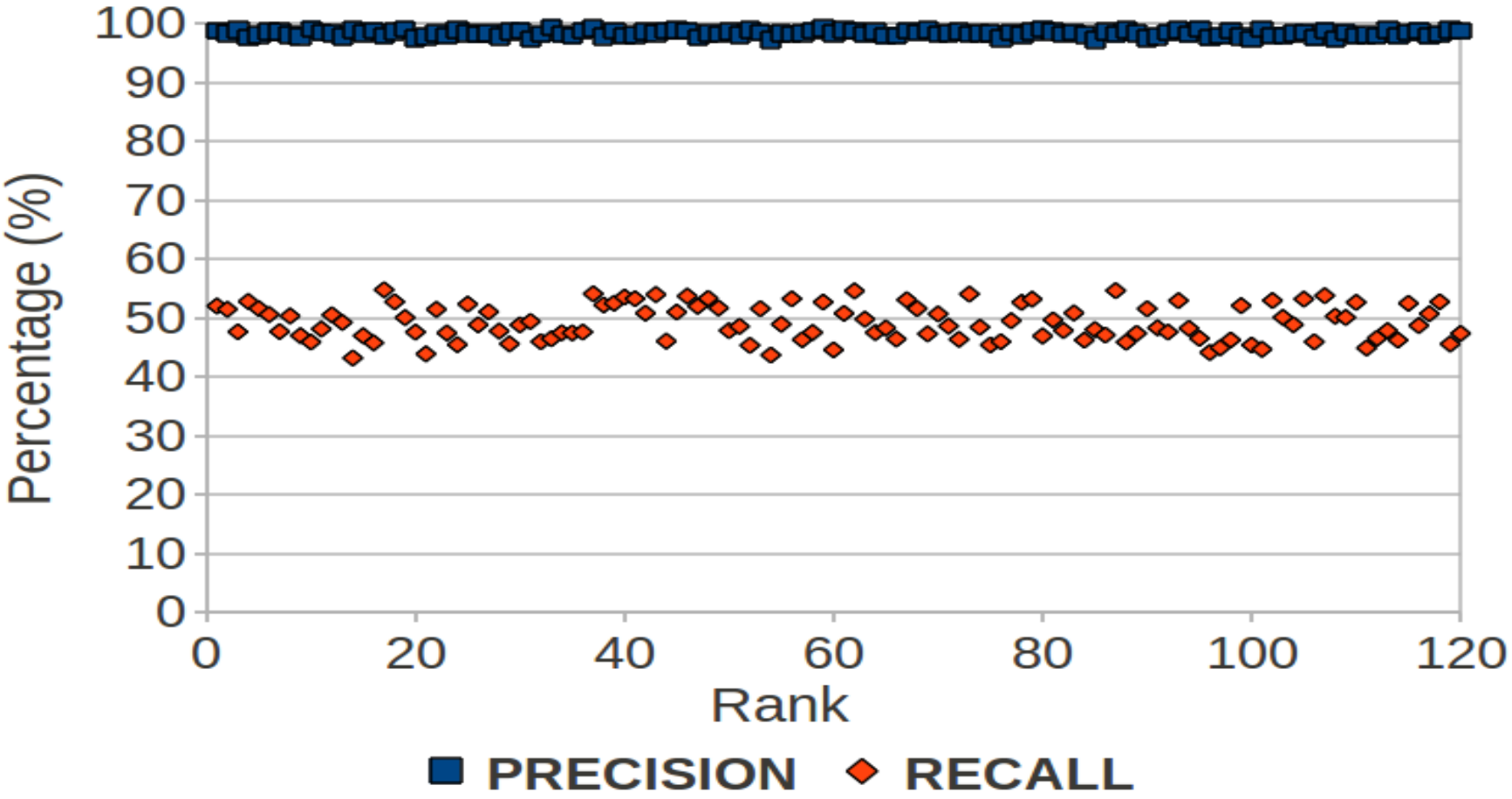
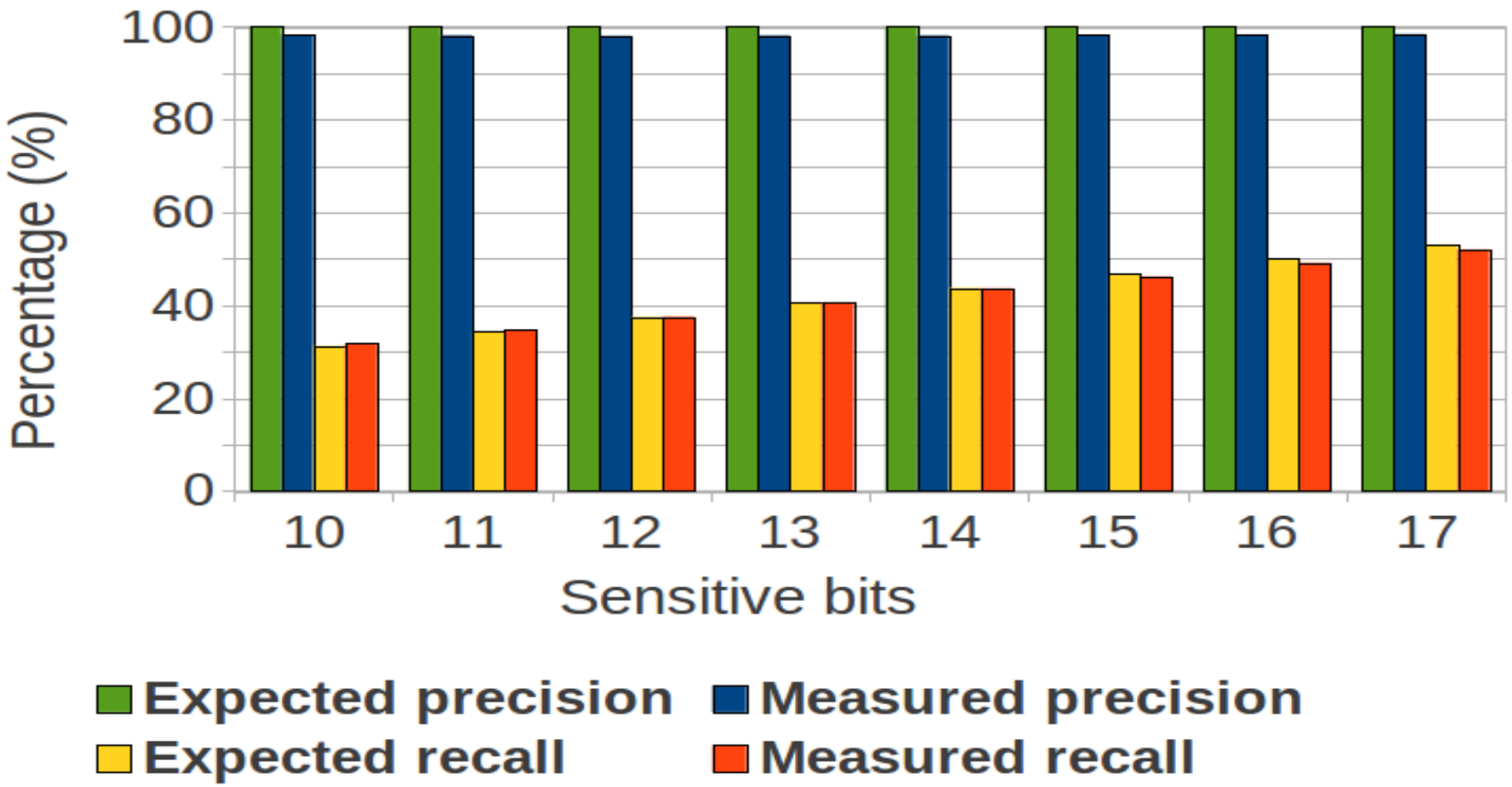


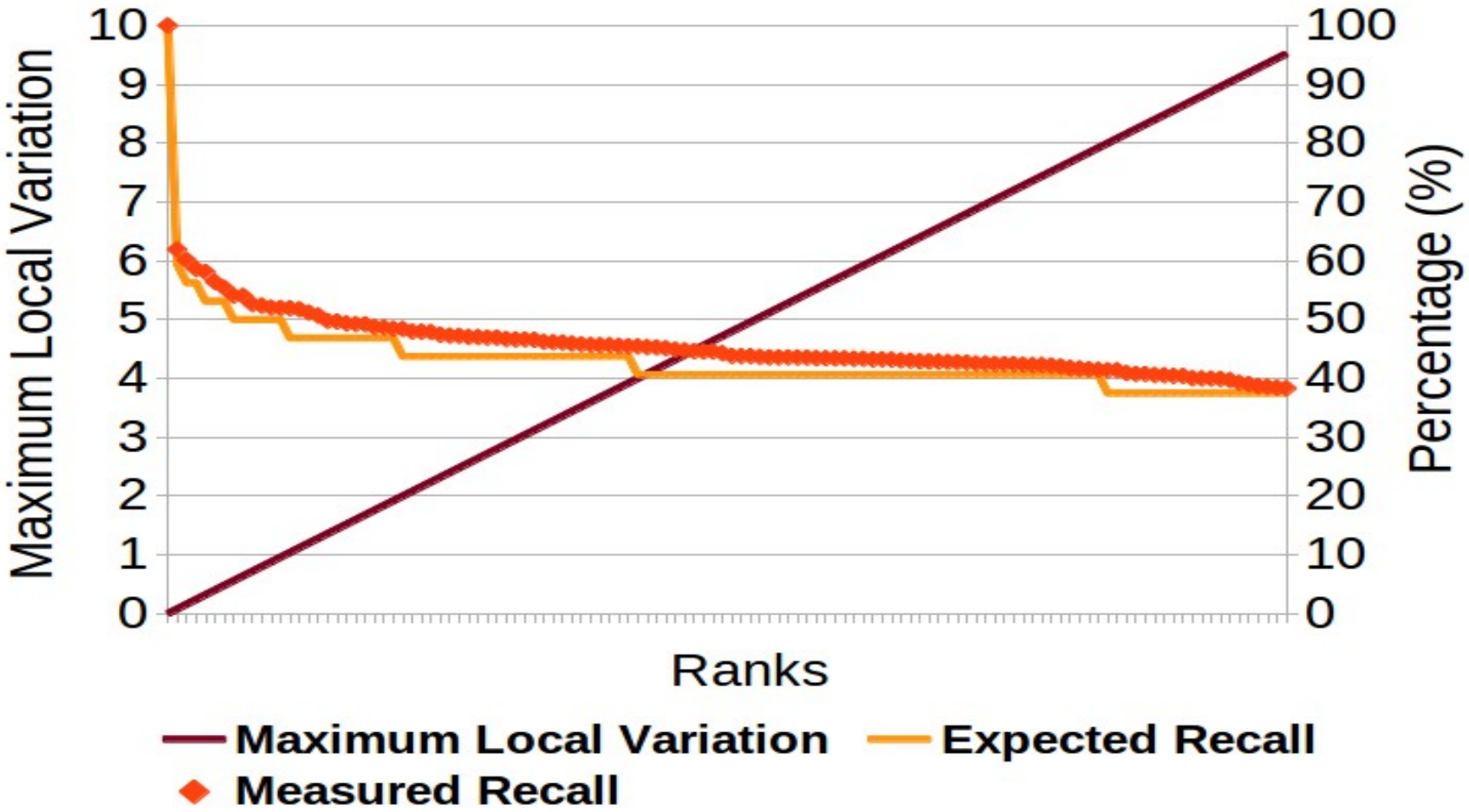
SDC Detection Recall Granularity



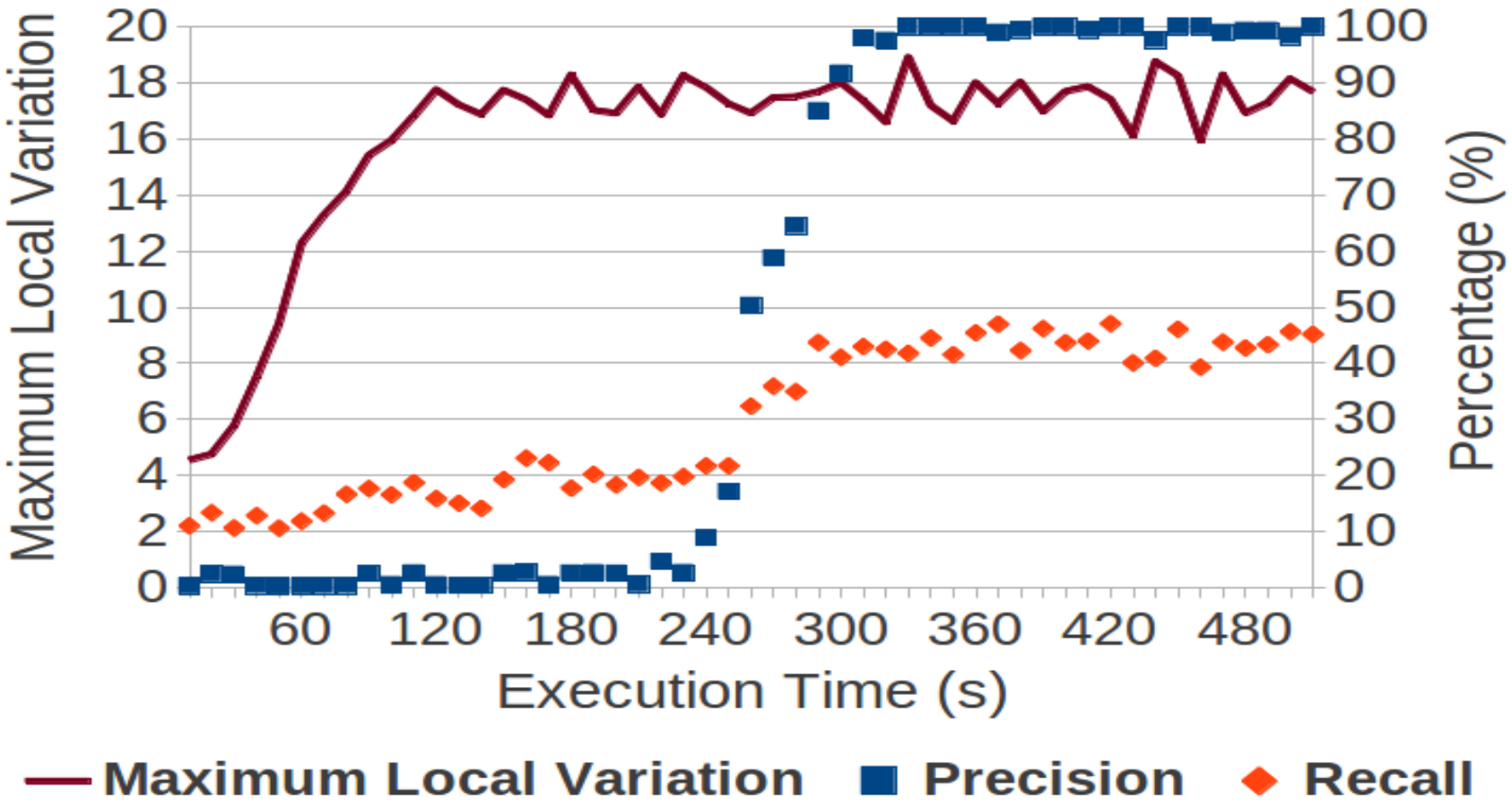
SDC Detection Accuracy



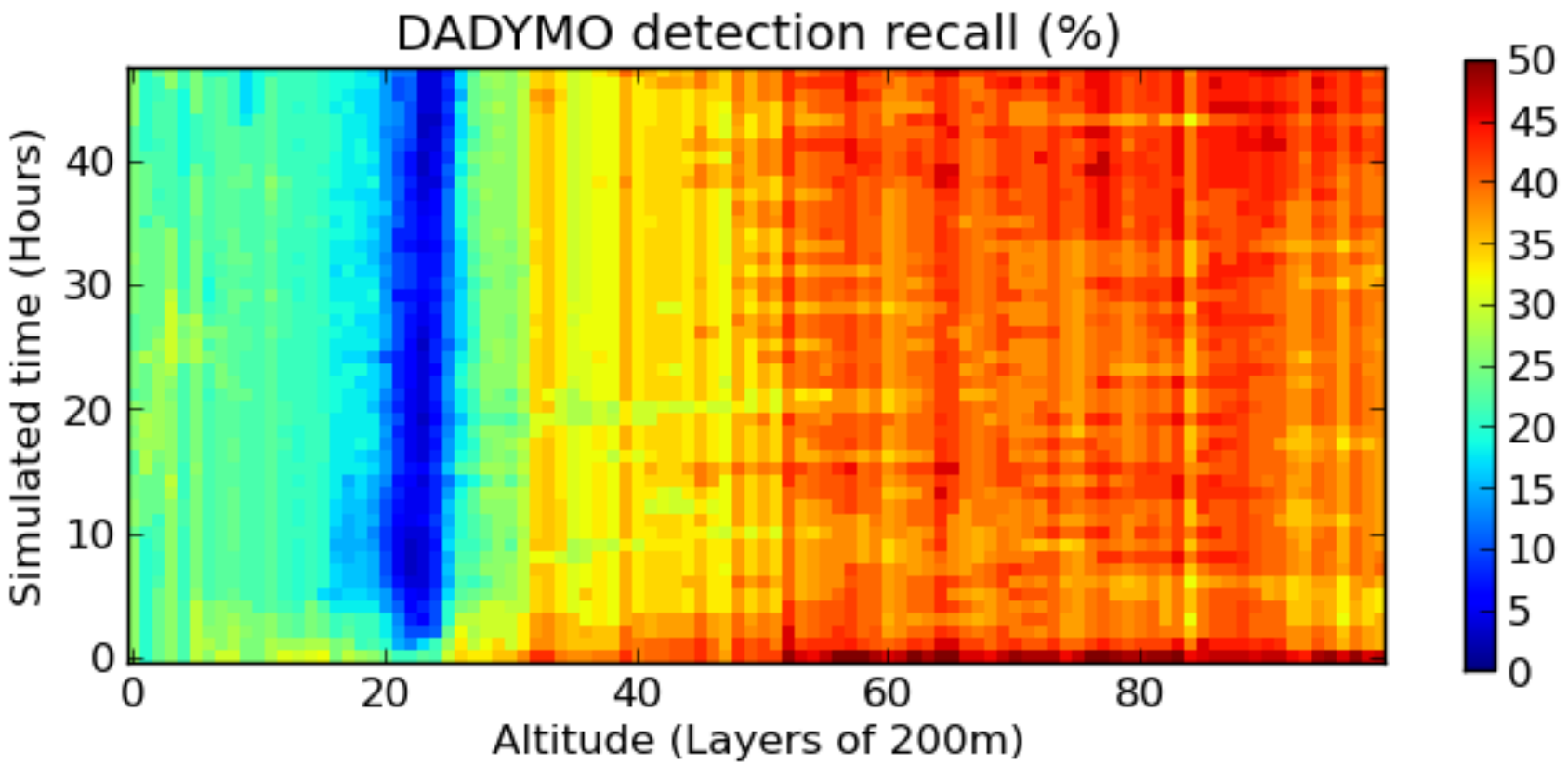
SDC Detection Recall Granularity



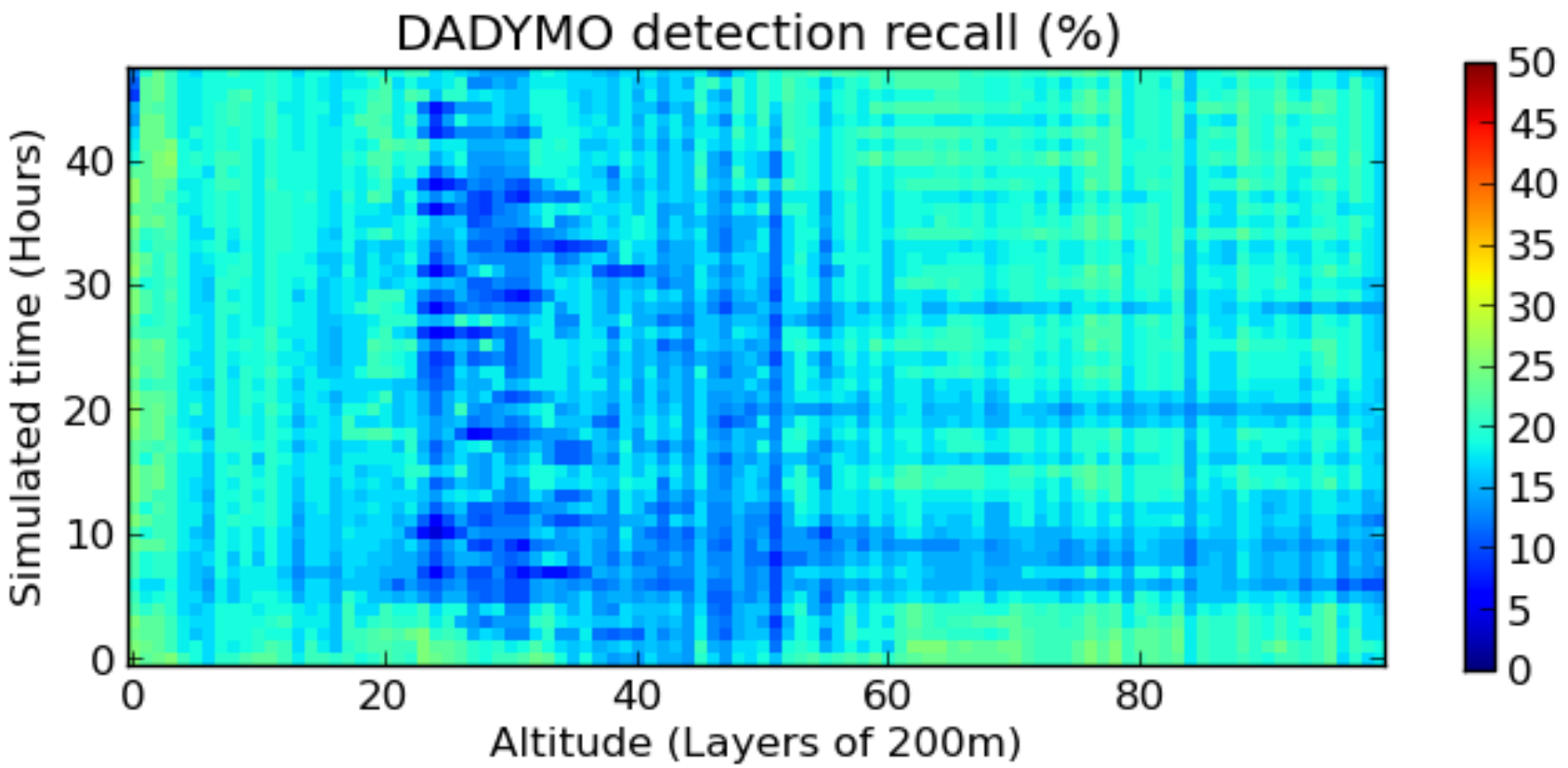
SDC Detection on dynamic datasets



SDC Detection Recall (Temperature)



SDC Detection Recall (Pressure)



Limitations

- “Non-smooth” datasets.
- One-directional learning.
- Limited sensitivity.