

# 1<sup>st</sup> FSCC Soil Physical Ring Test 2009

Action C1-Soil-3(FI)



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<http://fsc.inbo.be>

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# Sample preparation of the artificial ring test sample



- Homogenisation by quartering
- Sieved at 1 cm to overcome heterogeneity caused by stoniness
- $30 \times 5 = 150$  sample rings: about 20 ring per tray
- All trays filled in the same way and compressed at 120 bar

# Variation of the bulk density in the homogeneity test

| volcc<br>TrayN. | 100<br>1 | 180<br>1 | 300<br>1 | 100<br>2 | 300<br>2 | 100<br>3 | 300<br>3 | 100<br>4 | 300<br>4 |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| Min             | 1304     | 1331     | 1354     | 1367     | 1364     | 1351     | 1382     | 1333     | 1384     |
| 1st Qu.         | 1371     | 1341     | 1379     | 1380     | 1368     | 1380     | 1388     | 1374     | 1433     |
| Mean            | 1407     | 1368     | 1402     | 1396     | 1403     | 1430     | 1404     | 1399     | 1437     |
| Median          | 1433     | 1369     | 1386     | 1390     | 1396     | 1415     | 1414     | 1384     | 1437     |
| 3rd Qu.         | 1451     | 1388     | 1426     | 1402     | 1432     | 1456     | 1417     | 1441     | 1447     |
| Max             | 1466     | 1418     | 1473     | 1439     | 1457     | 1551     | 1418     | 1464     | 1484     |
| Total N         | 11       | 7        | 6        | 5        | 5        | 5        | 5        | 5        | 5        |
| Std Dev.        | 53.41    | 32.19    | 44.28    | 27.32    | 40.19    | 77.90    | 17.42    | 52.78    | 35.75    |
| CV              | 3.80     | 2.35     | 3.16     | 1.96     | 2.86     | 5.45     | 1.24     | 3.77     | 2.49     |

# Damage to the samples due to transport

2009

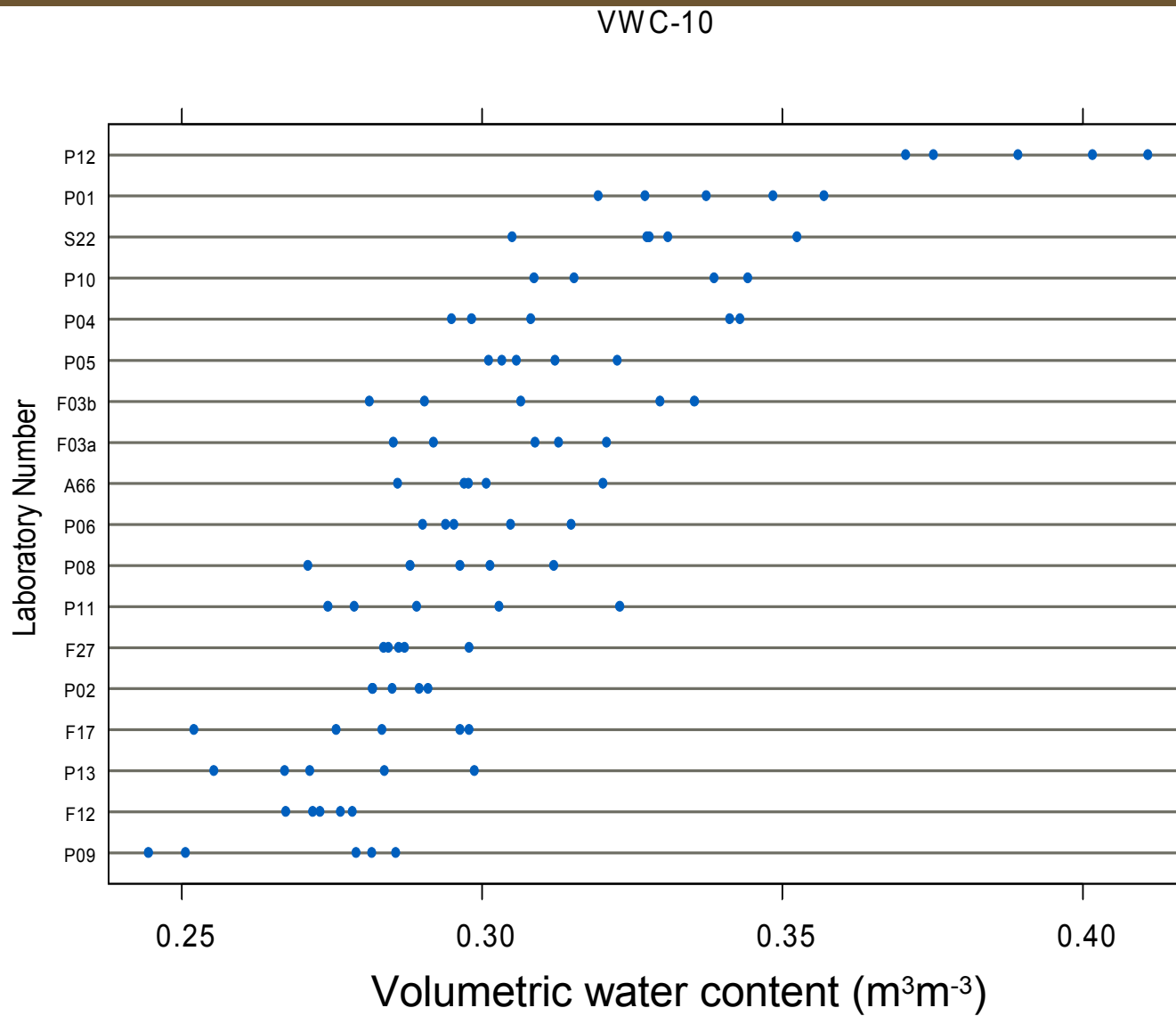


# Participation

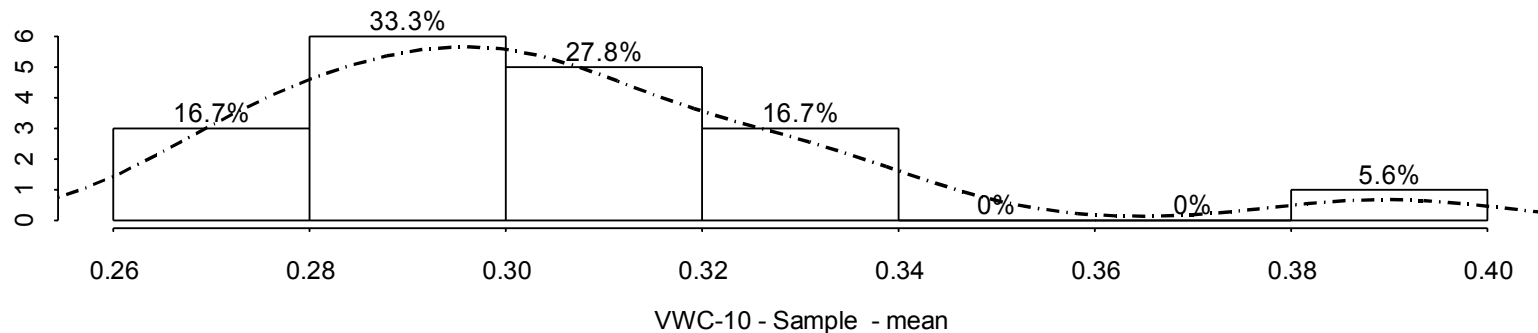
- Registration by 27 labs
- Results submitted by 23 labs
- 3 labs with 2 sets of rings (F03, F15 and F14)
- F15b reported as only lab at – 50 kPa = pF 2.7 => not included in stat. analysis

| N° reported data     | Parameter |       |       |        |        |           |         |         |          |       |                            |
|----------------------|-----------|-------|-------|--------|--------|-----------|---------|---------|----------|-------|----------------------------|
| LabID                | VWC-0     | VWC-1 | VWC-5 | VWC-10 | VWC-33 | VWC-50    | VWC-100 | VWC-250 | VWC-1500 | dryBD | Total N° submitted results |
| Mand./Opt./Not asked | M         | M     | M     | O      | M      | Not asked | O       | O       | M        | M     |                            |
| A66                  | 5         | 5     | 5     | 5      | 5      |           | 5       |         | 5        | 5     | 40                         |
| F03a                 | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| F03b                 | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| F10                  | 5         | 5     | 5     |        | 5      |           |         | 5       | 5        | 5     | 35                         |
| F12                  | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| F15a                 |           | 5     | 5     |        | 5      |           |         |         |          | 5     | 20                         |
| F15b                 |           |       |       |        |        | 5         |         |         |          |       | 5                          |
| F17                  | 5         | 5     | 5     | 5      | 5      |           |         |         | 5        | 5     | 35                         |
| F23                  | 5         | 5     | 5     |        | 5      |           |         |         | 4        | 5     | 29                         |
| F27                  | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| P01                  | 5         | 5     | 5     | 5      | 5      |           |         |         | 5        | 5     | 35                         |
| P02                  | 5         | 5     | 5     | 5      | 5      |           | 5       |         | 3        | 5     | 38                         |
| P04                  | 5         | 5     | 5     | 5      | 5      |           | 5       |         | 5        | 5     | 40                         |
| P05                  | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| P06                  | 5         | 5     | 5     | 5      | 5      |           | 5       | 3       | 5        | 5     | 43                         |
| P08                  | 5         | 5     | 5     | 5      | 5      |           |         |         | 5        | 5     | 35                         |
| P09                  | 5         | 5     | 5     | 5      | 5      |           | 5       |         | 5        | 5     | 40                         |
| P10                  | 4         | 4     | 4     | 4      | 4      |           | 4       | 4       | 4        | 4     | 36                         |
| P11                  | 5         | 5     | 5     | 5      | 5      |           | 3       | 3       | 3        | 5     | 39                         |
| P12                  | 5         | 5     | 5     | 5      | 5      |           |         | 5       | 5        | 5     | 40                         |
| P13                  | 5         | 5     | 5     | 5      | 5      |           | 5       |         | 5        | 5     | 40                         |
| P14a                 | 5         | 5     | 5     |        |        |           |         |         | 5        | 5     | 25                         |
| P14b                 |           |       |       |        | 5      |           | 5       | 5       | 5        | 5     | 25                         |
| S01                  | 5         | 5     | 5     |        | 5      |           | 5       |         | 5        | 5     | 35                         |
| S04                  | 5         | 5     | 5     |        | 5      |           |         |         | 5        | 5     | 30                         |
| S22                  | 5         | 5     | 5     | 5      | 5      |           | 5       | 5       | 5        | 5     | 45                         |
| Total N° data sets   | 23        | 24    | 24    | 18     | 24     | 1         | 16      | 12      | 24       | 25    | 935                        |

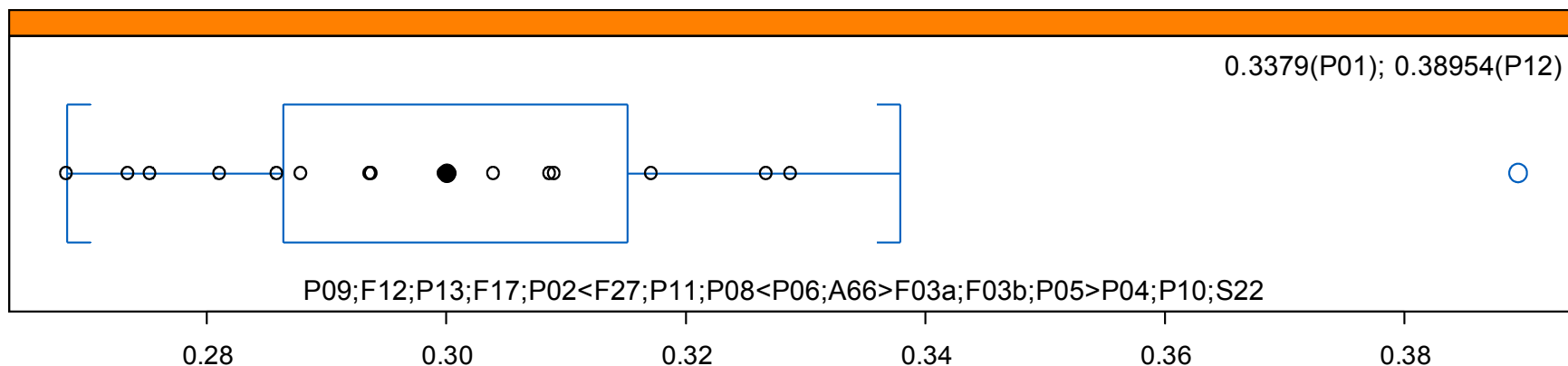
# Exploratory data analysis



# Histogram and boxplot of the mean VWC at – 10 kPa



N: 18 NA: 0 Z: 0 E: 0 U: 18  
a: 0.3045342 m: 0.30012 s: 0.02889388

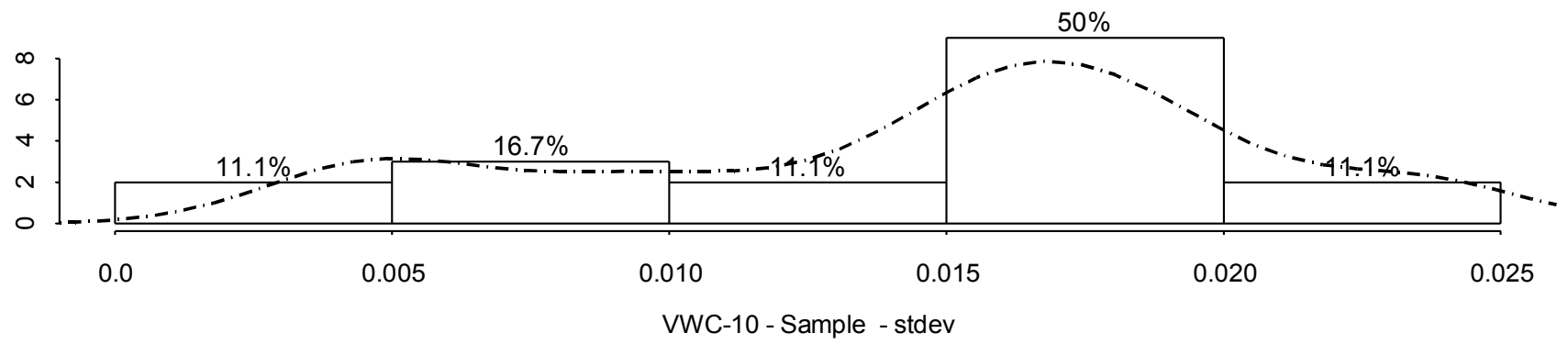


0.3379(P01); 0.38954(P12)

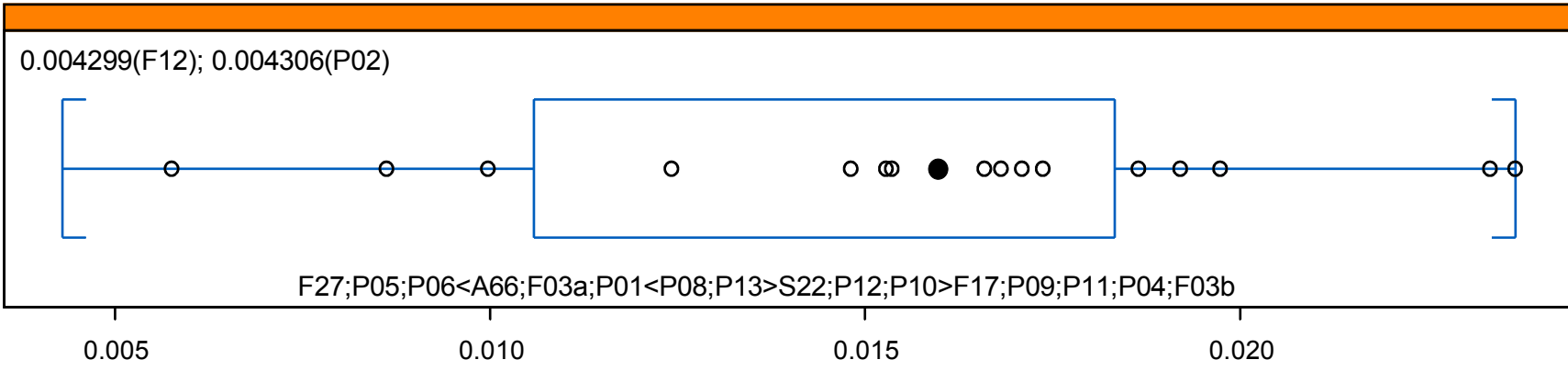


# Histogram and boxplot of the standard deviations of the VWC at- 10 kPa

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N: 18 NA: 0 Z: 0 E: 0 U: 18  
a: 0.01463 m: 0.01598 s: 0.005935



O: 2,0 / U: 18



# Statistical data analysis

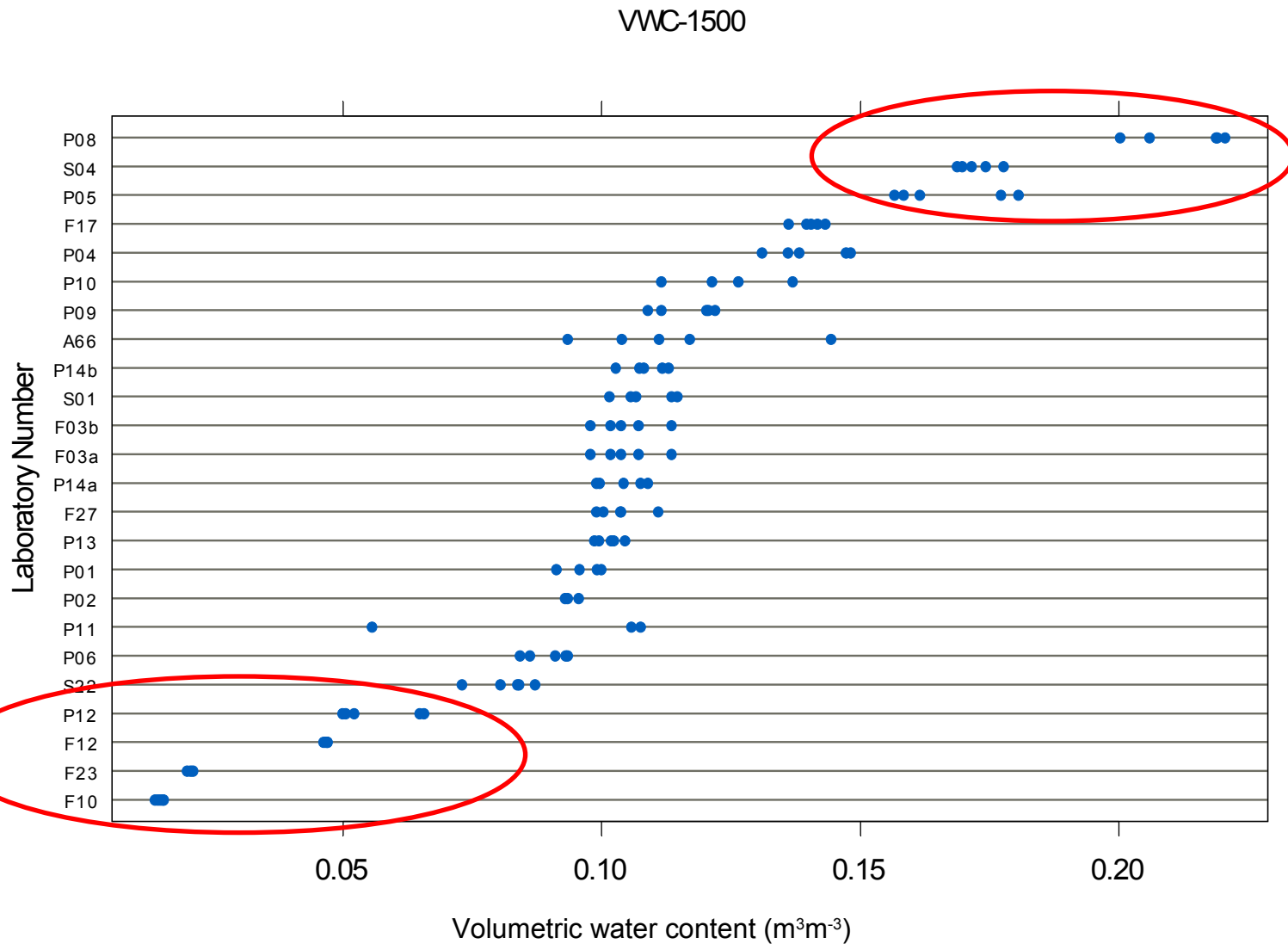
| Parameter | Units                           | M/O | Excluded labs | Step | Tot N° results | N° Labs | General cleaned mean | CV    |
|-----------|---------------------------------|-----|---------------|------|----------------|---------|----------------------|-------|
| VWC0      | m <sup>3</sup> .m <sup>-3</sup> | M   | hkP12         | 2    | 109            | 22      | 0.43                 | 6.42  |
| VWC-1     | m <sup>3</sup> .m <sup>-3</sup> | M   | hP12          | 2    | 114            | 23      | 0.38                 | 7.46  |
| VWC-5     | m <sup>3</sup> .m <sup>-3</sup> | M   | hP12          | 2    | 114            | 23      | 0.34                 | 9.54  |
| VWC-10    | m <sup>3</sup> .m <sup>-3</sup> | O   | hP12          | 2    | 84             | 17      | 0.30                 | 8.18  |
| VWC-33    | m <sup>3</sup> .m <sup>-3</sup> | M   | hP12          | 2    | 114            | 23      | 0.25                 | 8.68  |
| VWC-100   | m <sup>3</sup> .m <sup>-3</sup> | O   | kP11;kP02     | 3    | 69             | 14      | 0.20                 | 10.03 |
| VWC-250   | m <sup>3</sup> .m <sup>-3</sup> | O   | kP11          | 2    | 52             | 11      | 0.15                 | 19.12 |
| VWC-1500  | m <sup>3</sup> .m <sup>-3</sup> | M   | kP11;kA66     | 3    | 106            | 22      | 0.11                 | 42.32 |
| dryBD     | kg.m <sup>-3</sup>              | M   |               | 1    | 124            | 25      | 1431                 | 4.53  |

# % of variation between and within the labs

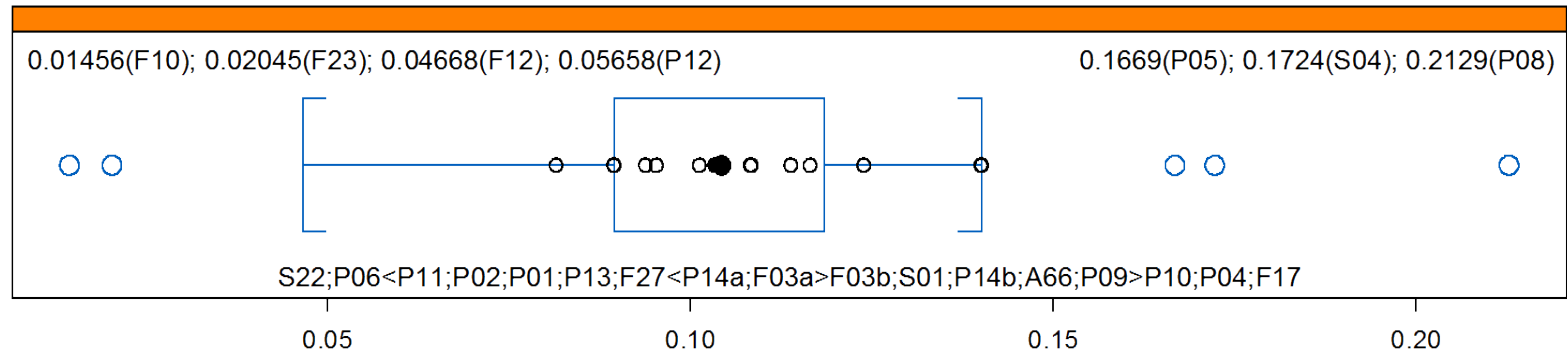
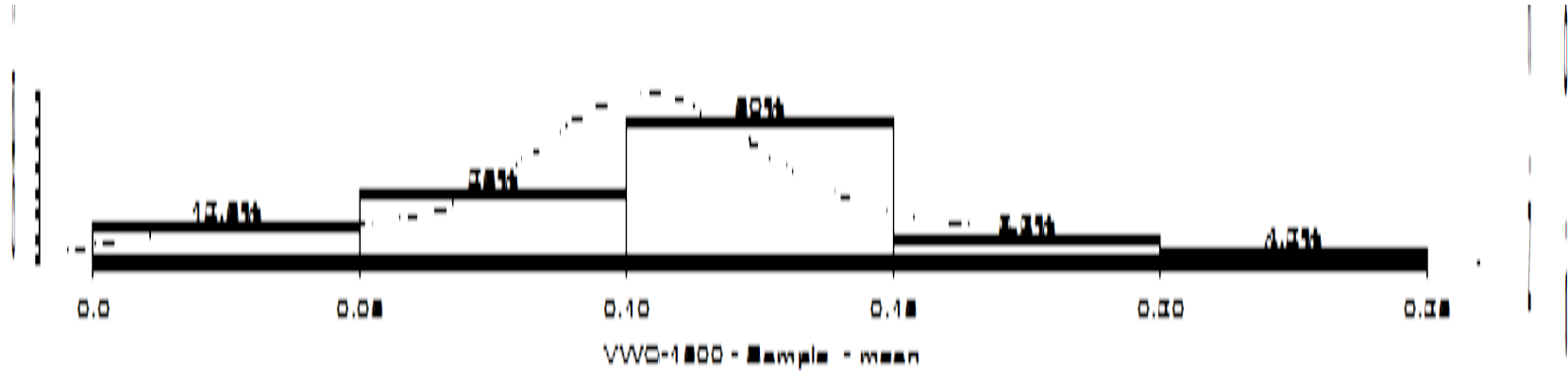
| Parameter | CV(%) | % Between lab variance | % Within lab variance |
|-----------|-------|------------------------|-----------------------|
| VWC0      | 6.4   | 77                     | 23                    |
| VWC-1     | 7.5   | 78                     | 22                    |
| VWC-5     | 9.5   | 73                     | 27                    |
| VWC-10    | 8.2   | 59                     | 41                    |
| VWC-33    | 8.7   | 80                     | 20                    |
| VWC-100   | 10.0  | 83                     | 17                    |
| VWC-250   | 19.1  | 90                     | 10                    |
| VWC-1500  | 42.3  | 98                     | 2                     |
| dryBD     | 4.5   | 36                     | 64                    |

- Most of the variance due to between lab differences, except for dry BD
  - Sample had homogeneous BD
  - High potential to improve comparability between labs for VWC at – 250 and – 1500 kPa
  - Benefit of one central laboratory mainly for high suction/pressure levels

# Dot plot of the VWC at – 1500 kPa



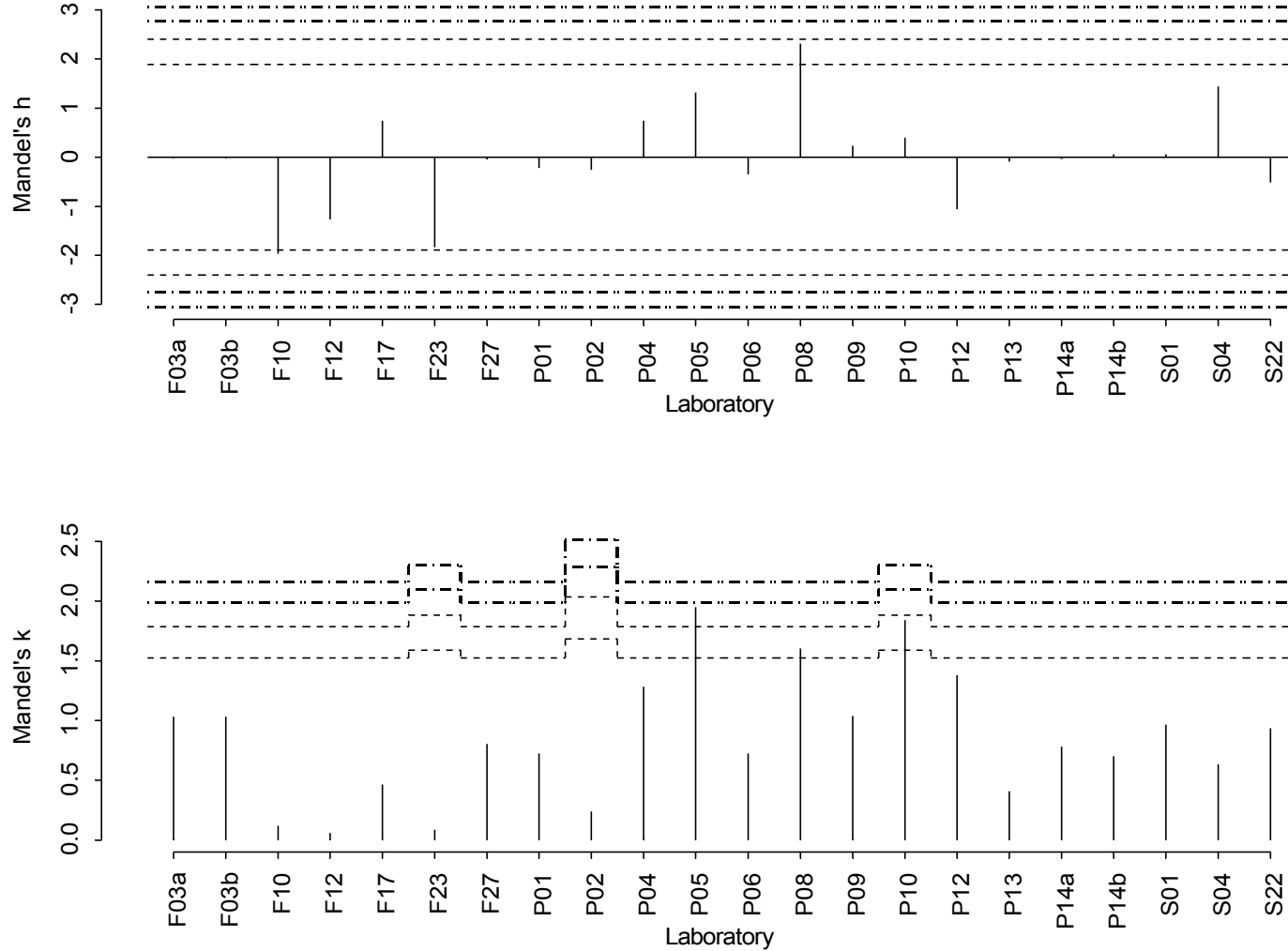
# Histogram and dotplot of the mean VWC at – 1500 kPa



O: 4,3 / U: 24

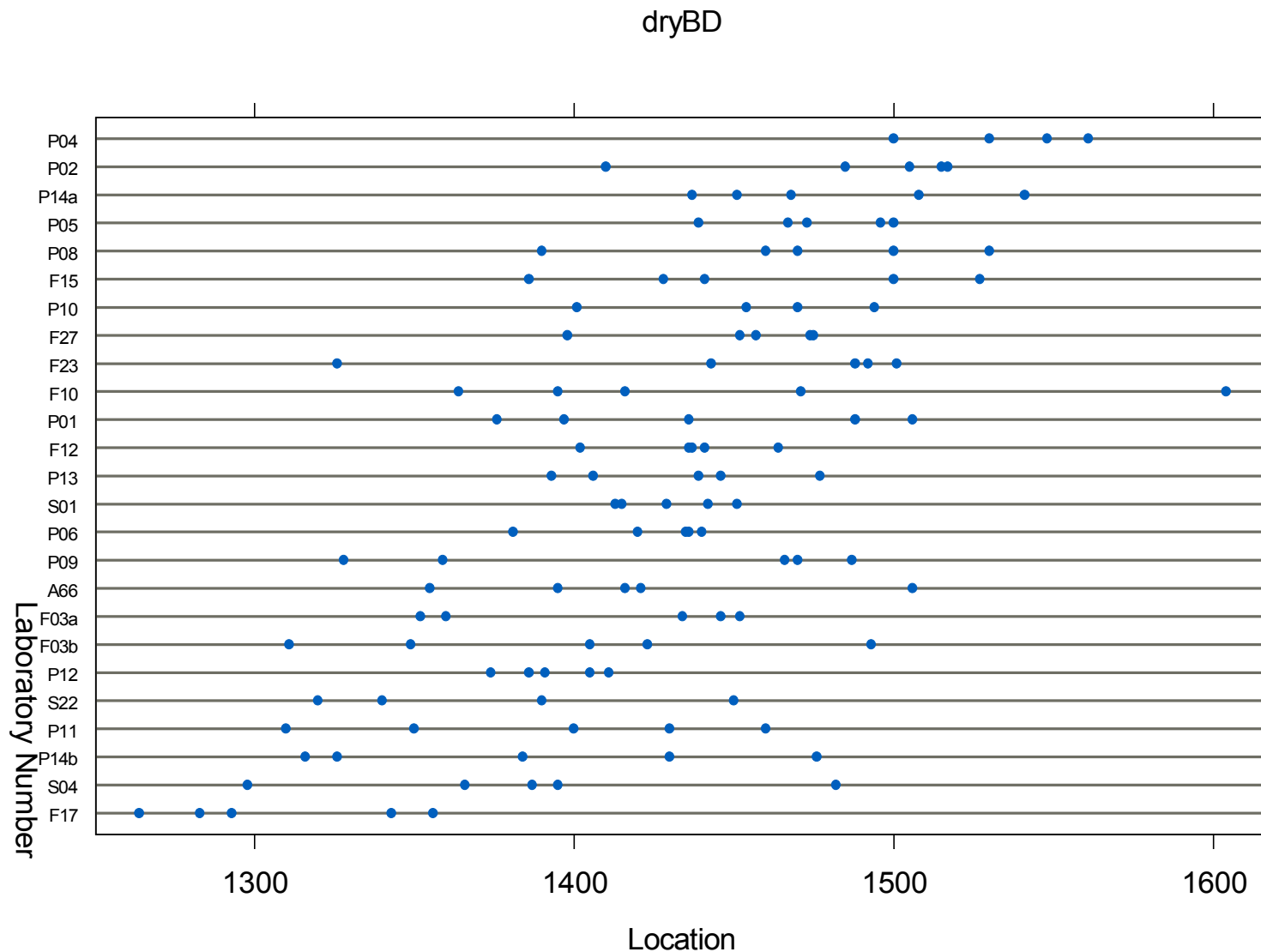
# Mandel's h and k plots of the VWC at – 1500 kPa

VWC-1500  
Step:3; Nlab:22; Mgen:0.1057; Fval:312.2; Pval:0; sRep:0.005761; sLab:0.04631; sRpr:0.04667; CV:44.16

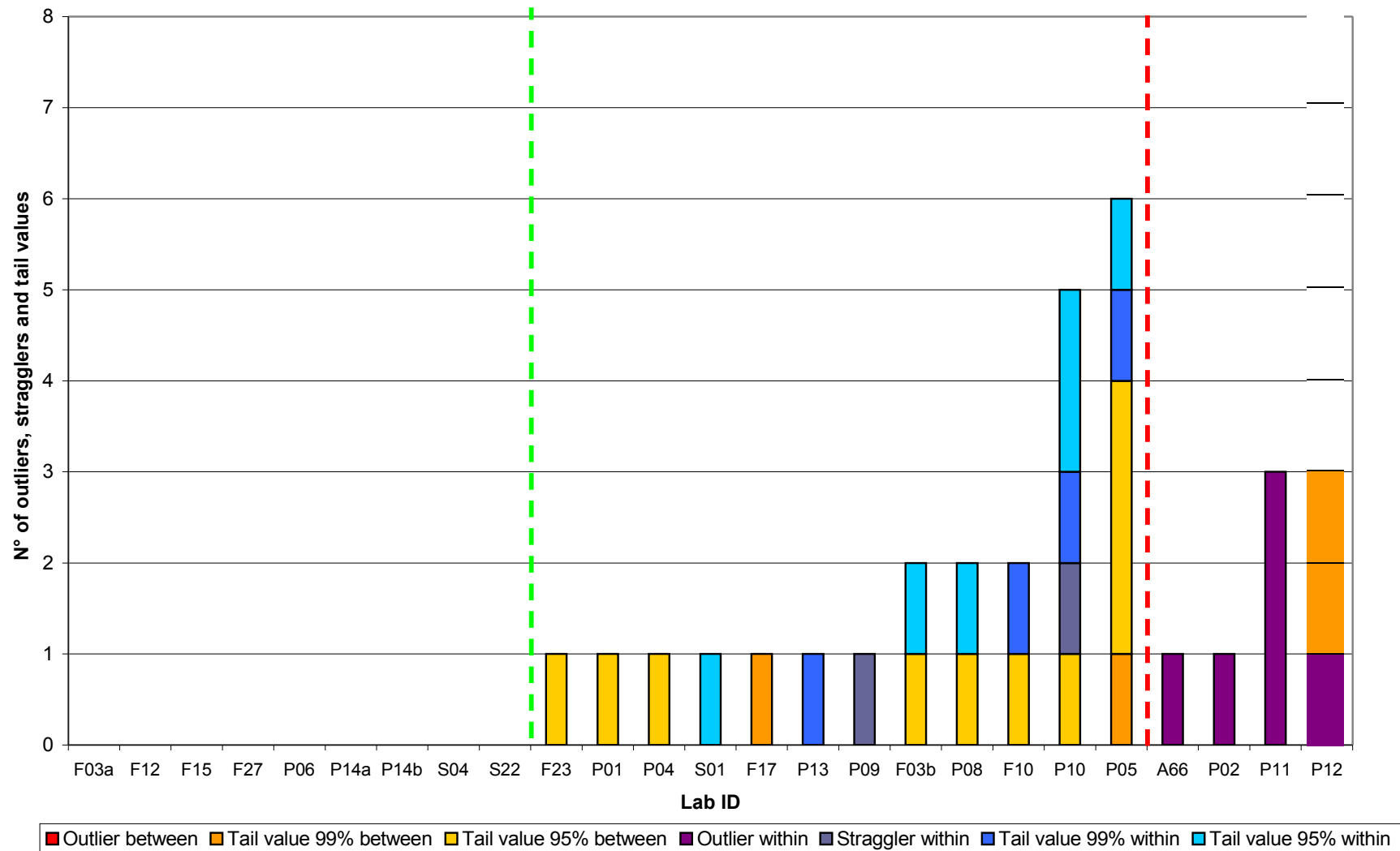


E: kP11;kA66

# Variation of the dry bulk density in the ring test



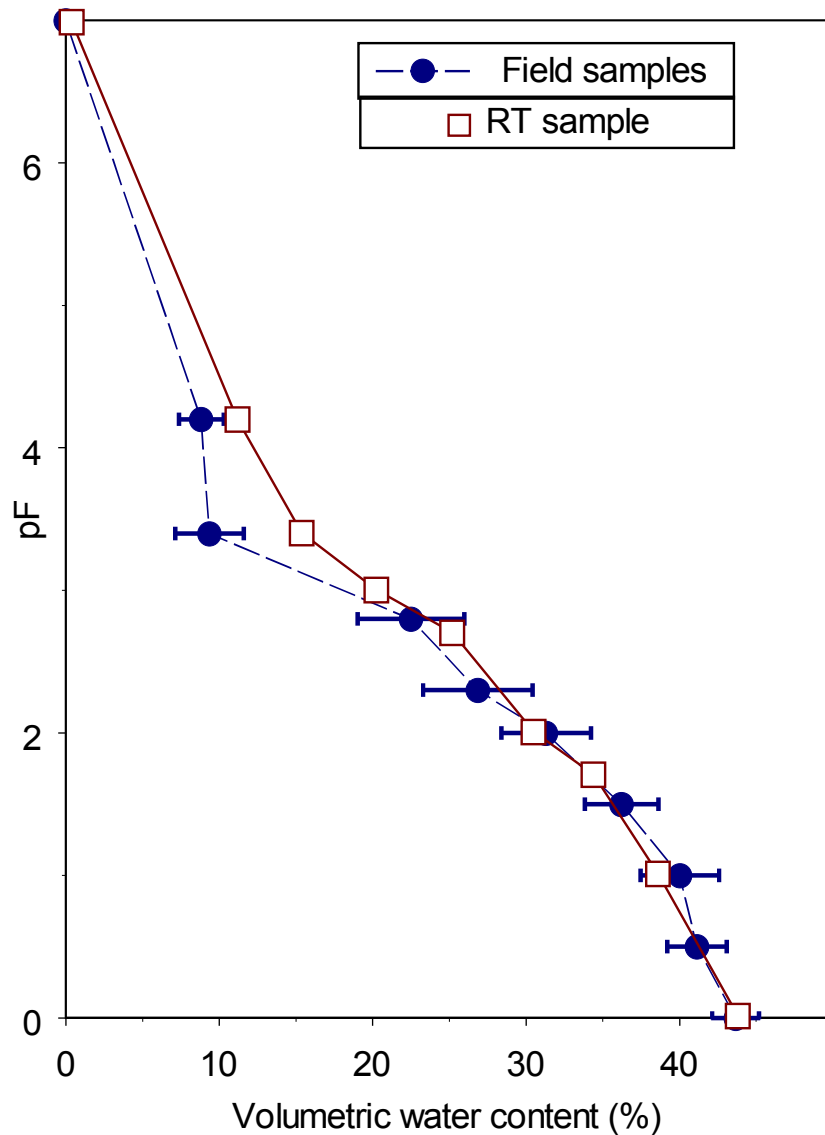
# Ranking of the labs



# Statistical data analysis: after corrections by lab P12

| Parameter | Units                     | M/O | Exluded labs | Tot N° results | N° labs | General cleaned mean | CV    |
|-----------|---------------------------|-----|--------------|----------------|---------|----------------------|-------|
| VWC0      | $\text{m}^3\text{m}^{-3}$ | M   | kP12         | 109            | 22      | 0.4316               | 6.42  |
| VWC-1     | $\text{m}^3\text{m}^{-3}$ | M   |              | 119            | 24      | 0.3787               | 7.44  |
| VWC-5     | $\text{m}^3\text{m}^{-3}$ | M   |              | 119            | 24      | 0.3373               | 9.44  |
| VWC-10    | $\text{m}^3\text{m}^{-3}$ | O   |              | 89             | 18      | 0.2957               | 9.49  |
| VWC-33    | $\text{m}^3\text{m}^{-3}$ | M   |              | 119            | 24      | 0.2450               | 9.17  |
| VWC-100   | $\text{m}^3\text{m}^{-3}$ | O   | kP11;kP02    | 69             | 14      | 0.1974               | 10.03 |
| VWC-250   | $\text{m}^3\text{m}^{-3}$ | O   | kP11         | 52             | 11      | 0.1449               | 25.37 |
| VWC-1500  | $\text{m}^3\text{m}^{-3}$ | M   | kP11;kA66    | 106            | 22      | 0.1057               | 44.16 |
| dryBD     | $\text{kg m}^{-3}$        | M   |              | 124            | 25      | 1431                 | 4.53  |

# Soil Water Retention Characteristic



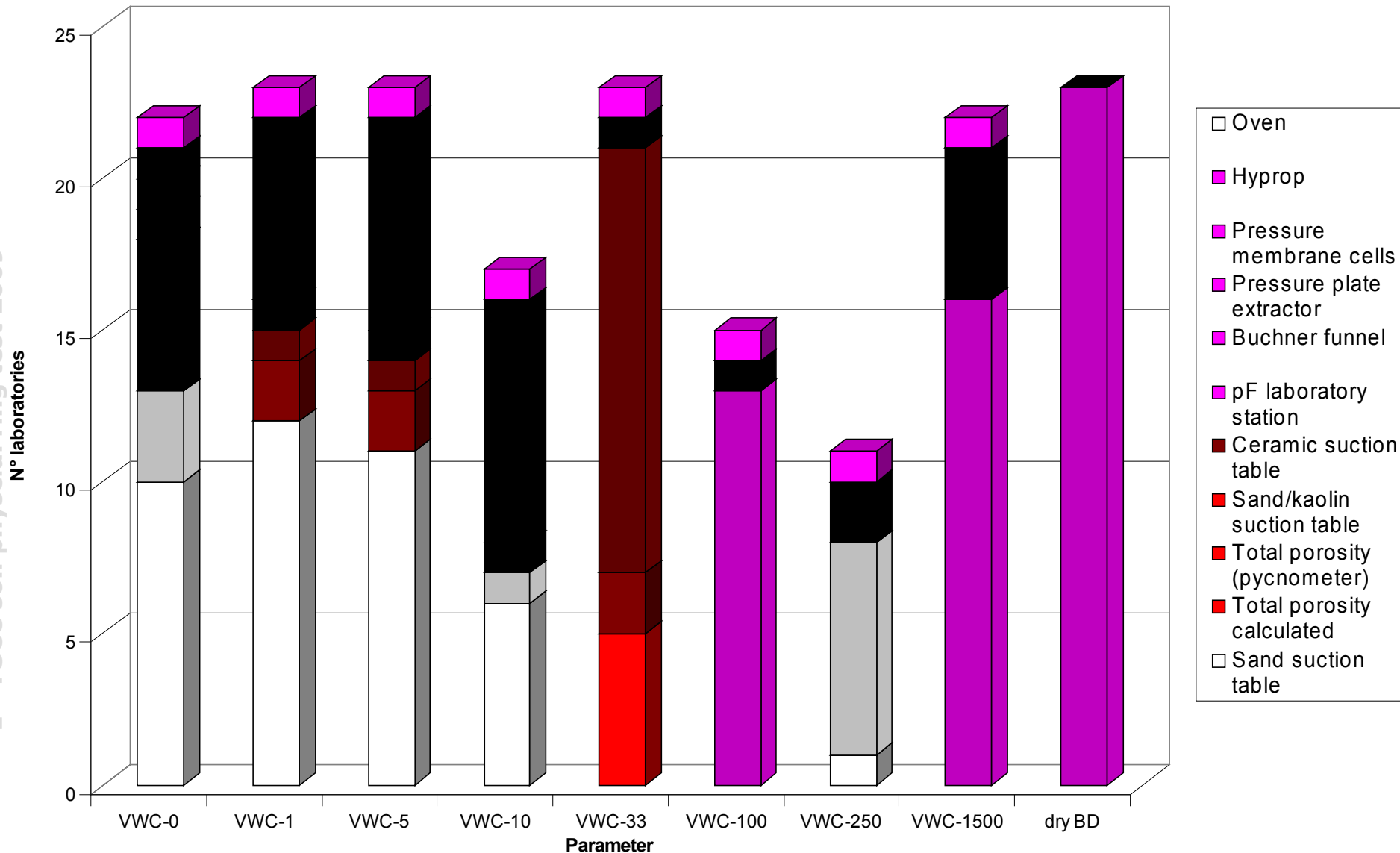
## Bulk Density ( $\text{kg m}^{-3}$ )

| Sample            | Mean | St. dev |
|-------------------|------|---------|
| Natural Bw hor.   | 1301 | 48      |
| Artificial sample | 1431 | 65      |

- Good fit between both curves
- At pF 3.4 and 4.2 higher VWC in artificial sample

# Applied methods and instruments

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# pF station with ceramic plate



# Conclusions

- Good comparability amongst the labs:
  - 6 of the 9 variables:  $CV < 10 \%$
- At -250 and -1500 kPa clear need to improve
- Is the statistical approach appropriate?
  - E.g. VWC at - 1500 kPa: no exclusion based on between-lab variance while very high variability amongst labs
  - Criticism: MANOVA, repeated measures
- Absolutely necessary for the FutMon database to measure the volumetric water content at predefined pressure heads
  - E.g. Lab P12
- Hyprop instrument:
  - No significant differences
  - Accepted but not promoted:
    - No measurement at 4.2 kPa which is very important
    - Time efficiency

## More information?

- Ring test reports and graphs can be downloaded from the FSCC homepage [FSCC.inbo.be](http://www.fsc.inbo.be)
  - Soil physical ring test (<http://www.inbo.be/content/page.asp?pid=ringtest>)
  - 6<sup>th</sup> FSCC Interlaboratory Comparisons and previous ones ([http://www.inbo.be/content/page.asp?pid=EN\\_MON\\_FSCC\\_compa](http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_compa))
  - FSCC soil reference material ([http://www.inbo.be/content/page.asp?pid=EN\\_MON\\_FSCC\\_soil\\_re](http://www.inbo.be/content/page.asp?pid=EN_MON_FSCC_soil_re))

# Thank you for your attention



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Soil Moisture Workshop, Freising, 25-26 March, 2009

<http://fsc.inbo.be>