Supplement of

Optimizing a backscatter forward operator using Sentinel-1 data over irrigated land

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**Supplementary Material**

*Table S1:* The UMD-AVHRR 14 classes (Map code) classification (on the left) was used to reclassify the 23 classes-based PROBA-V LC map. On the right side of the table the PROBA-V land uses are displayed, together with the map codes for each land use. Additionally, the number of pixels, related to each class are shown, together with the UMD-AVHRR reclassification map code.

| UMD-AVHRR LC classification | PROBA-V LC classification (23 classes)-100 m spatial resolution |
|-----------------------------|---------------------------------------------------------------|
| Land use                    | Map code | Land use                              | Map code | Number of pixels in the study area | UMD-AVHRR reclassification |
| Evergreen needle leaf forest | 1        | Evergreen needle leaf closed forest    | 111      | 1382                               | 1                           |
| Evergreen broad leaf forest | 2        | Deciduous needle leaf closed forest    | 113      | 0                                  | /                           |
| Deciduous needle leaf forest | 3        | Evergreen broad leaf closed forest     | 112      | 0                                  | /                           |
| Deciduous broad leaf open forest | 4   | Deciduous broad leaf closed forest     | 114      | 409941                             | 4                           |
| Mixed forest                | 5        | Mixed closest forest                  | 115      | 165                                | 5                           |
| Woodland                    | 6        | Unknown closest forest type            | 116      | 55558                              | 5                           |
| Wooded grassland            | 7        | Evergreen needle leaf open forest      | 121      | 1                                  | 1                           |
| Closed shrubland            | 8        | Deciduous needle leaf open forest      | 123      | 0                                  | /                           |
| Open shrubland              | 9        | Evergreen broad leaf open forest       | 122      | 0                                  | /                           |
| Grassland                   | 10       | Deciduous broad leaf open forest       | 124      | 14678                              | 4                           |
| Cropland                    | 11       | Mixed open forest                      | 125      | 0                                  | /                           |
| Bare ground                 | 12       | Unknown open forest type               | 126      | 192883                             | 5                           |
| Upland                      | 13       | Shrubland                              | 20       | 44105                              | 9                           |
| Water                       | 14       | Herbaceous vegetation                  | 30       | 52007                              | 10                          |
|                           |          | Herbaceous wetland                     | 90       | 4151                               | 10                          |
|                           |          | Moss & lichens                         | 100      | 0                                  | /                           |
|                           |          | Bare/sparse vegetation                 | 60       | 0                                  | /                           |
|                           |          | Cropland                               | 40       | 1434823                            | 11                          |
|                           |          | Urban built up                         | 50       | 242714                             | 13                          |
|                           |          | Snow & ice                             | 70       | 0                                  | /                           |
|                           |          | Permanent water bodies                 | 80       | 17798                              | 14                          |
|                           |          | Ocean                                  | 200      | 0                                  | /                           |
|                           |          | No input data available                | 0        | 0                                  | /                           |
Figure S1: 1-km ESDAC root depth data; available at https://esdac.jrc.ec.europa.eu/content/european-soil-database-derived-data

Figure S2: Maps of temporal Pearson-R between biweekly values of SSM from Noah-MP: a) Natural run and SMAP L2; b) Irrigation run and SMAP L2; d) Natural run and ASCAT; e) Irrigation run and ASCAT. Maps of the Pearson-R differences display the grid-based difference between: c) map b and map a; f) map e and map d. The reference period is April 2015-December 2019.
Figure S3. Maps of RMSE between SSM from Noah-MP and satellite retrievals: a) Natural run and SMAP L2; b) Irrigation run and SMAP L2; c) Natural run and ASCAT; d) Irrigation run and ASCAT.
Figure S4: Maps of: a) A parameter, b) B parameter, c) C parameter, and d) D parameter for the J-VV Natural calibration experiment; e) A parameter; f) B parameter; g) C parameter; and h) D parameter for the J-VV Irrigation calibration experiment; i) A parameter, j) B parameter, k) C parameter, and l) D parameter for the J-VH Natural calibration experiment; m) A parameter, n) B parameter, o) C parameter, and p) D parameter for the J-VH Irrigation calibration experiment
Figure S5: Maps of: a) A parameter, b) B parameter, c) C parameter, and d) D parameter for the KGE-VV Natural calibration experiment; e) A parameter; f) B parameter; g) C parameter; and h) D parameter for the KGE-VV Irrigation calibration experiment; i) A parameter, j) B parameter, k) C parameter, and l) D parameter for the KGE-VH Natural calibration experiment; m) A parameter, n) B parameter, o) C parameter, and p) D parameter for the KGE-VH Irrigation calibration experiment.