A precious resource: irrigation water requirement of golf courses

Micah Woods

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Chief Scientist | Asian Turfgrass Center
www.asianturfgrass.com

1. Why might we want to know?

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2. How can we figure it out?

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3. What happens if I change locations?

1. Why might we want to know?
2. How can we figure it out?
3. What happens if I change locations?
4. Or change grasses, soil, or the way I manage?

Why might we want to know?

With no water, grass stops growing

Hua Hin, May 2010

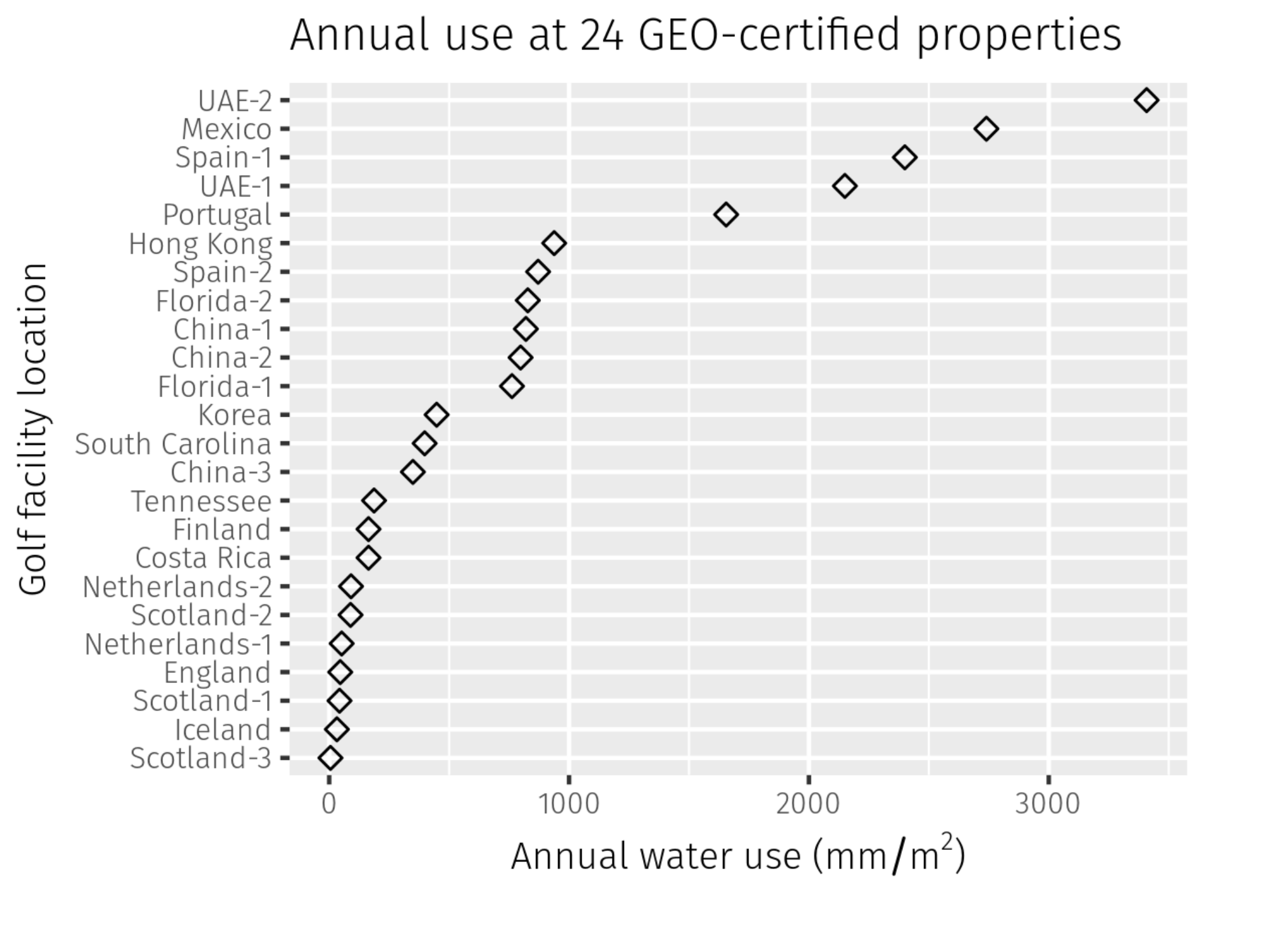
Grass survival, playability, business?

The R&A say “water is a precious resource and golf courses should only use what is absolutely necessary.”

The USGA say “it is essential for everyone involved in the game to strive to conserve and protect the world’s most vital resource.”

Cost: water, irrigation system, and energy

How can we figure it out?


Annual use at 24 GEO-certified properties
Golf facility location
UAE-2
Mexico
Spain-1
UAE-1
Portugal
Hong Kong
Spain-2
Florida-2
China-1
China-2
Florida-1
Korea
South Carolina
China-3
Tennessee
Finland
Costa Rica
Netherlands-2
Scotland-2
Netherlands-1
England
Scotland-1
Iceland
Scotland-3
0
1000
2000
3000
Annual water use (mm/m²)

Water budget, calculated monthly

How to Develop a Water Budget for Your Golf Course

A science-based approach for estimating landscape water requirements.

BY PATRICK J. GROSS AND CHRISTOPHER HARTWIGER

Can you answer three basic questions about water use at your golf facility?

- How much water does your golf facility need each year to keep the turf healthy?
- Does your golf facility use water efficiently?
- Can you prove it?

If you are unable to answer any of these questions, a water budget is just what you need.

Whether the issue is water use or finances, managers have long known that efficiently managing resources requires measuring the use and consumption of those resources. Once consumption is measured, objective decisions can be made to influence behavior and outcomes. These same principles can be applied to developing a water budget for a golf facility. The water budget establishes a benchmark for golf course water requirements that can be compared to actual water use, ultimately confirming if water is being used efficiently or if changes in management strategy are needed. This article will introduce the concept of a water budget, define the terms that make up a water budget, and provide the reader with step-by-step instructions to create a water budget using the USGA Water Budget Calculator Tool.

How much water does your golf course need? Creating a water budget will help answer this question.

Creating a water budget is an important step toward making sure that every drop of irrigation water counts.

THE WATER BUDGET FORMULA

The formula used by many water agencies to calculate a water budget is:

Estimated Water Use =
[(ET$_o$ – K$_r$) x R$_f$] x LA x 27,154

To understand this formula and how it works, let's begin by quickly reviewing the basic information needed to complete the formula.

Gross & Hartwiger, *Green Section Record*, 1 April 2016

The water budget equation

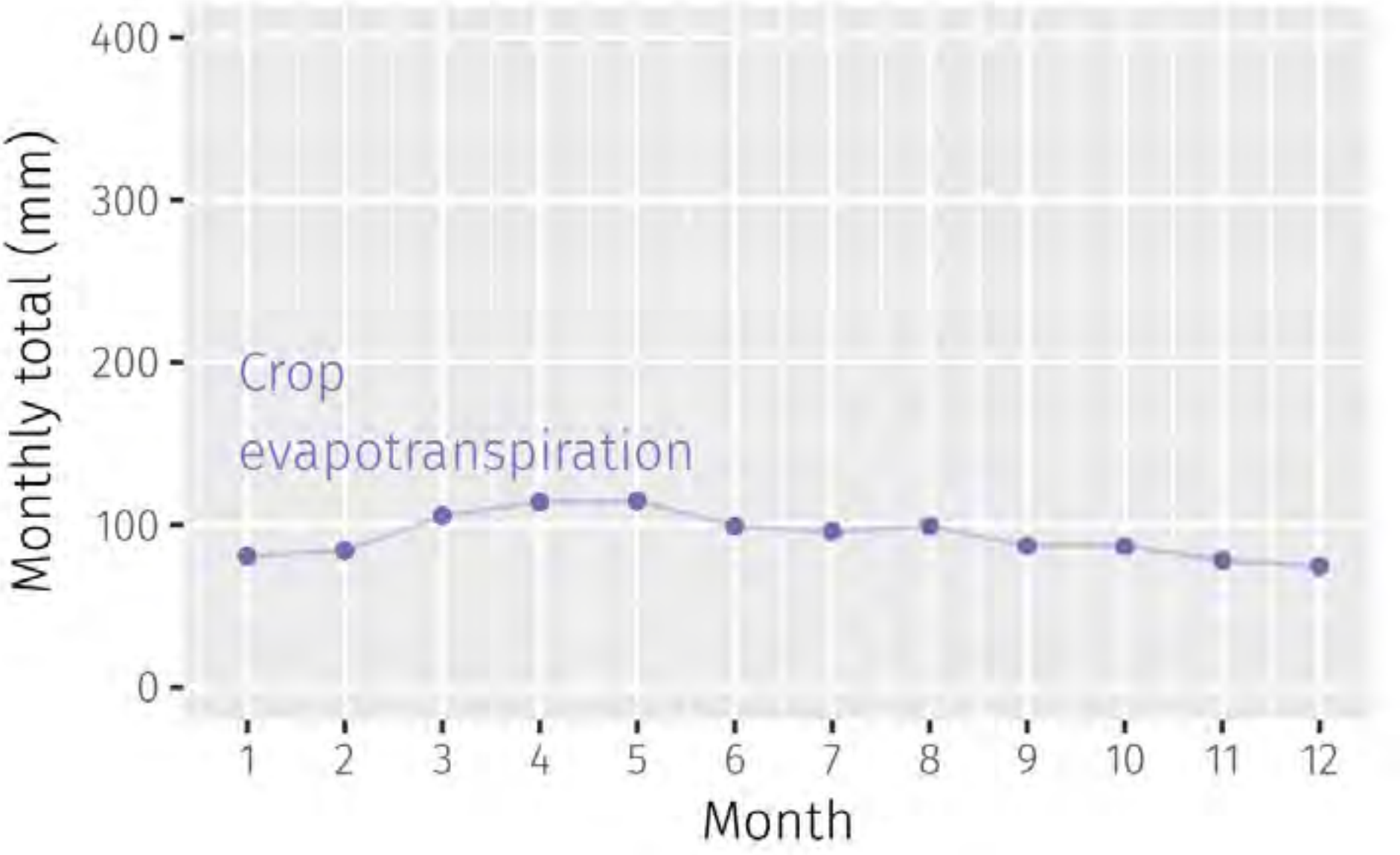
$$\frac{ET_c - P_{eff}}{DU_{LQ}} = IrrReq$$

ET_c is the crop evapotranspiration in mm
P_{eff} is the effective precipitation in mm
DU_{LQ} is the distribution uniformity of the irrigation system
$IrrReq$ is the irrigation requirement in mm

The estimate of grass water use is evapotranspiration (ET).

Manila climatological normals

K_c = 0.7, DU_{LQ} = 0.75



Manila climatological normals

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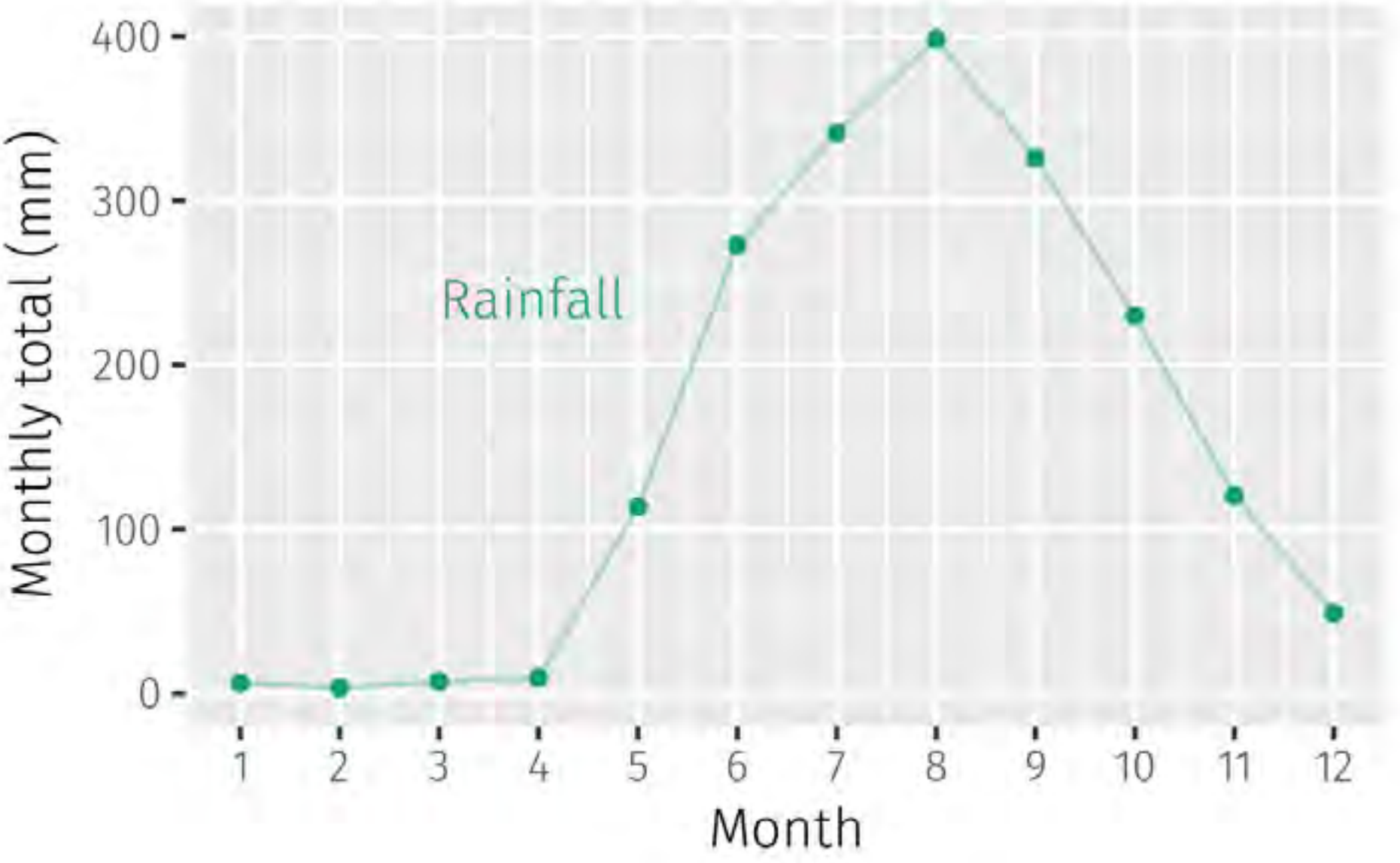

Manila climatological normals

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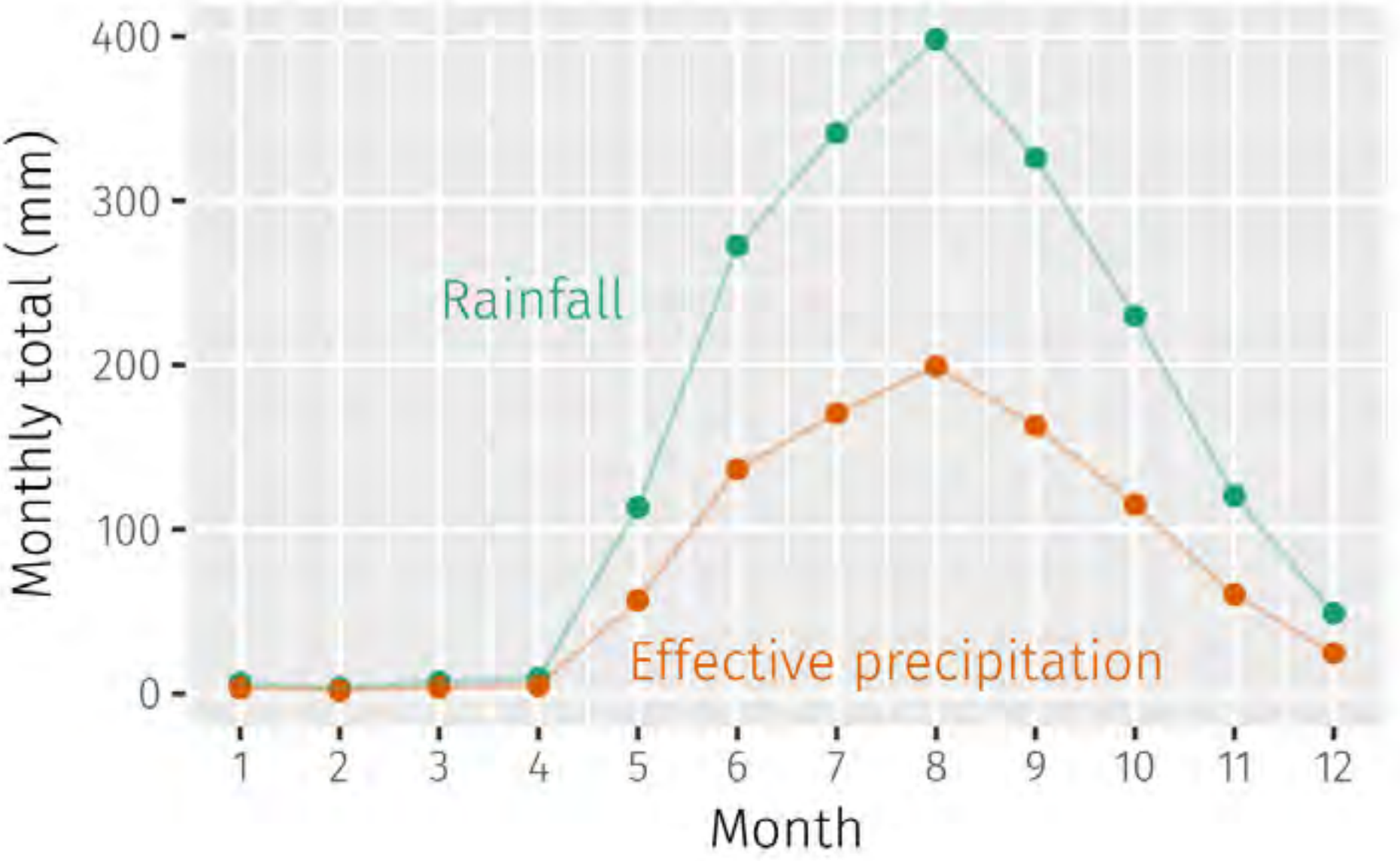
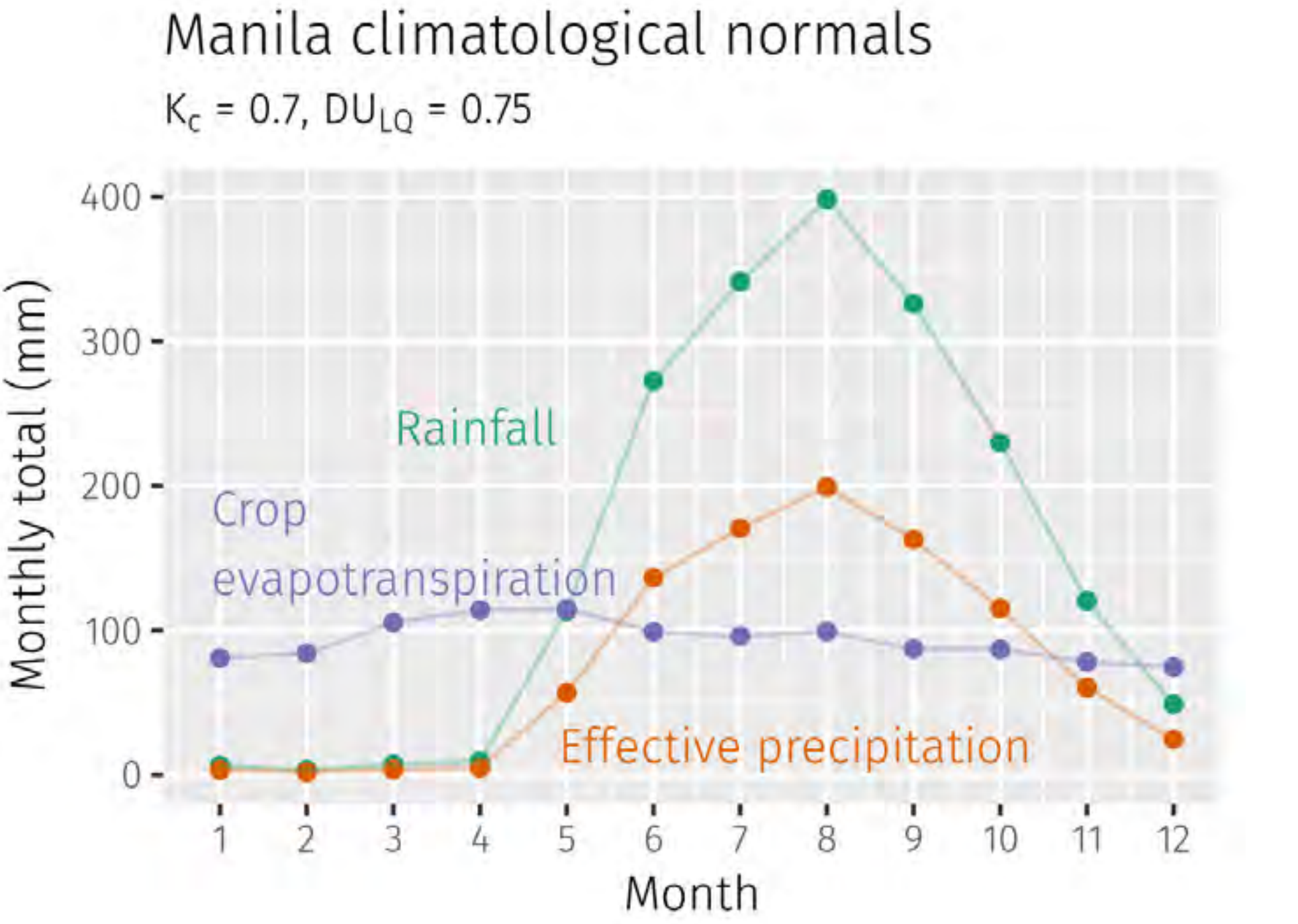
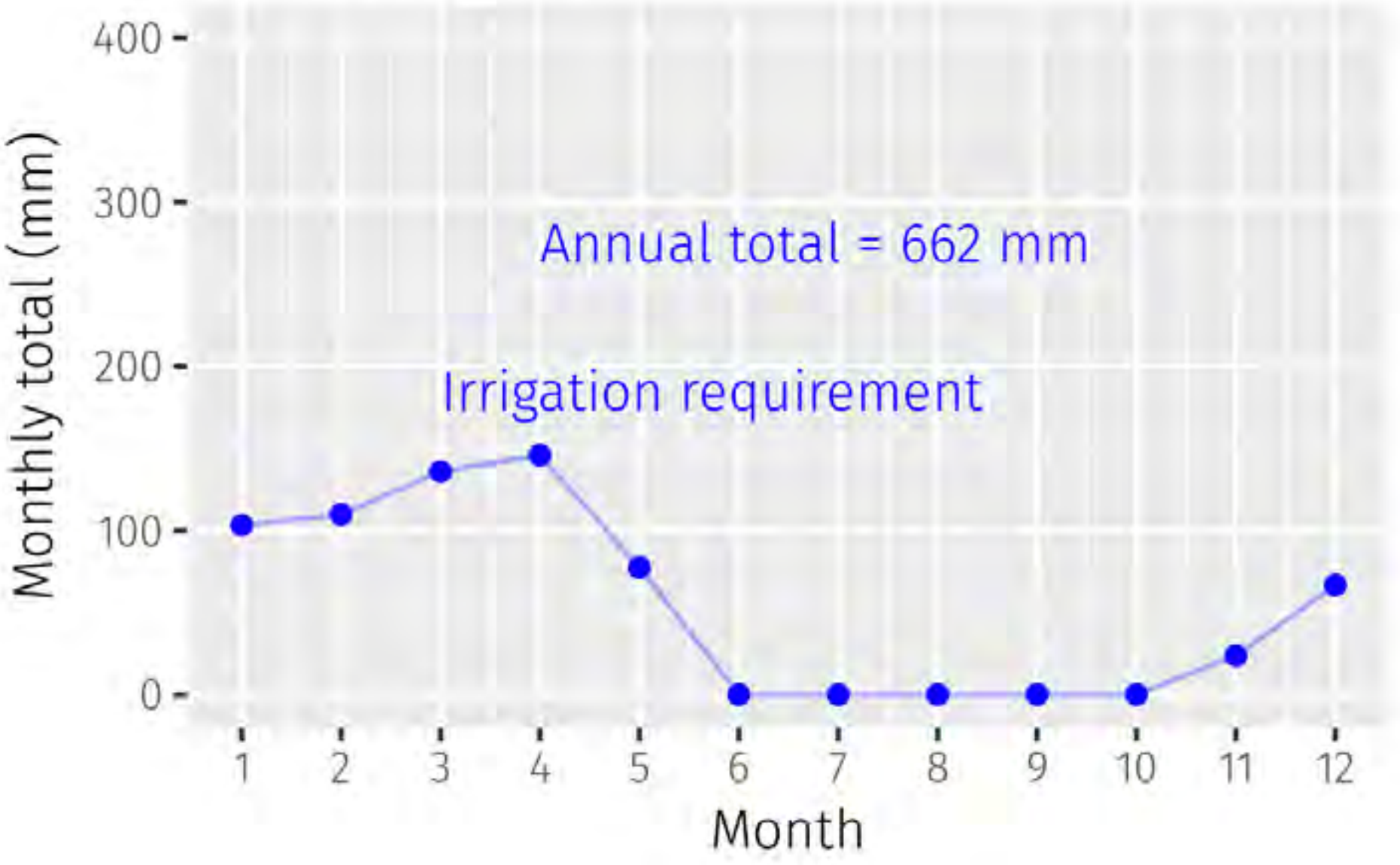


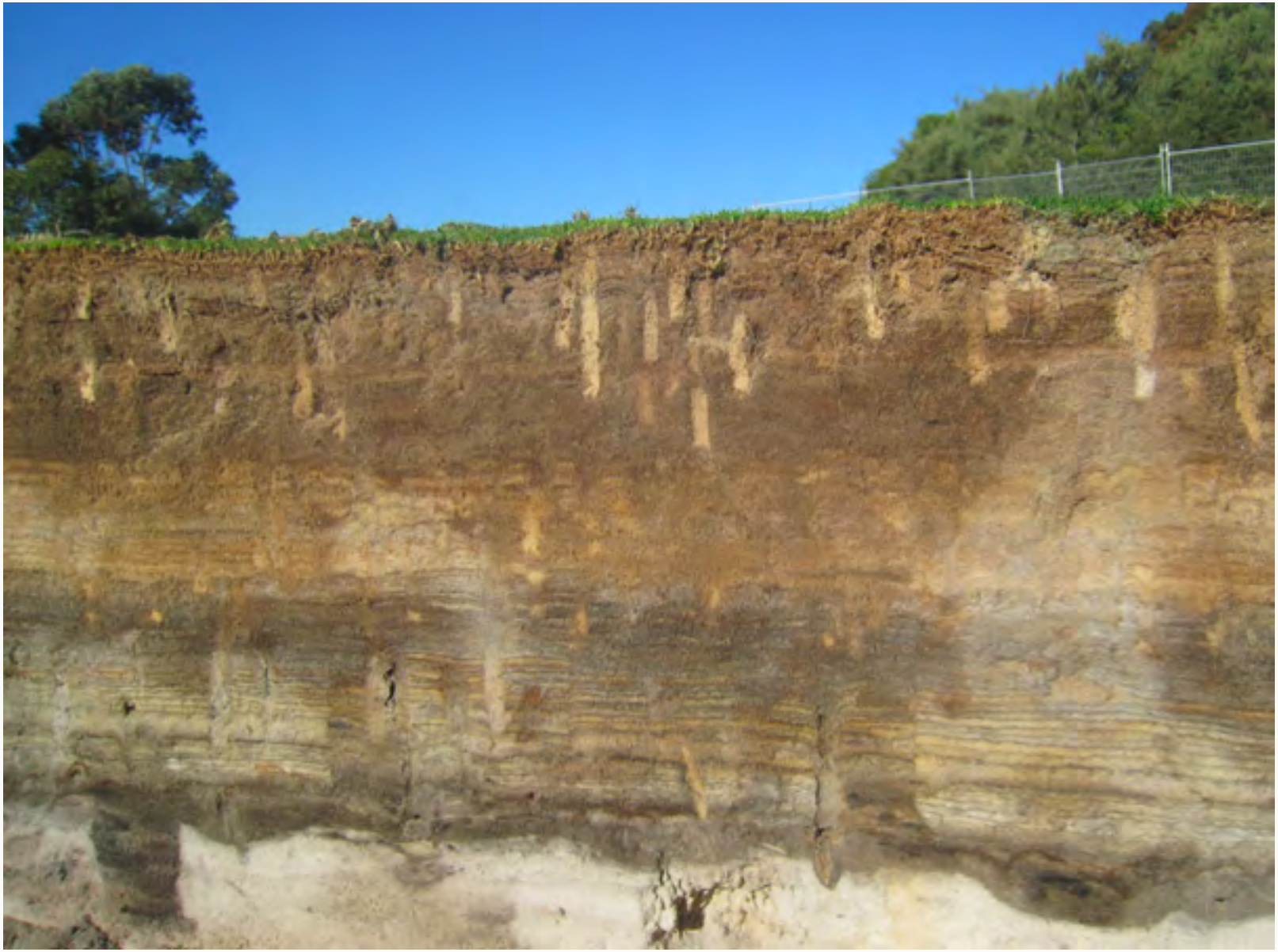

Manila climatological normals
K_c = 0.7, DU_{LQ} = 0.75
Monthly total (mm)
400
300
200
100
0
Rainfall
Crop evapotranspiration
Effective precipitation
1
2
3
4
5
6
7
8
9
10
11
12
Month

Manila climatological normals

K_c = 0.7, DU_{LQ} = 0.75

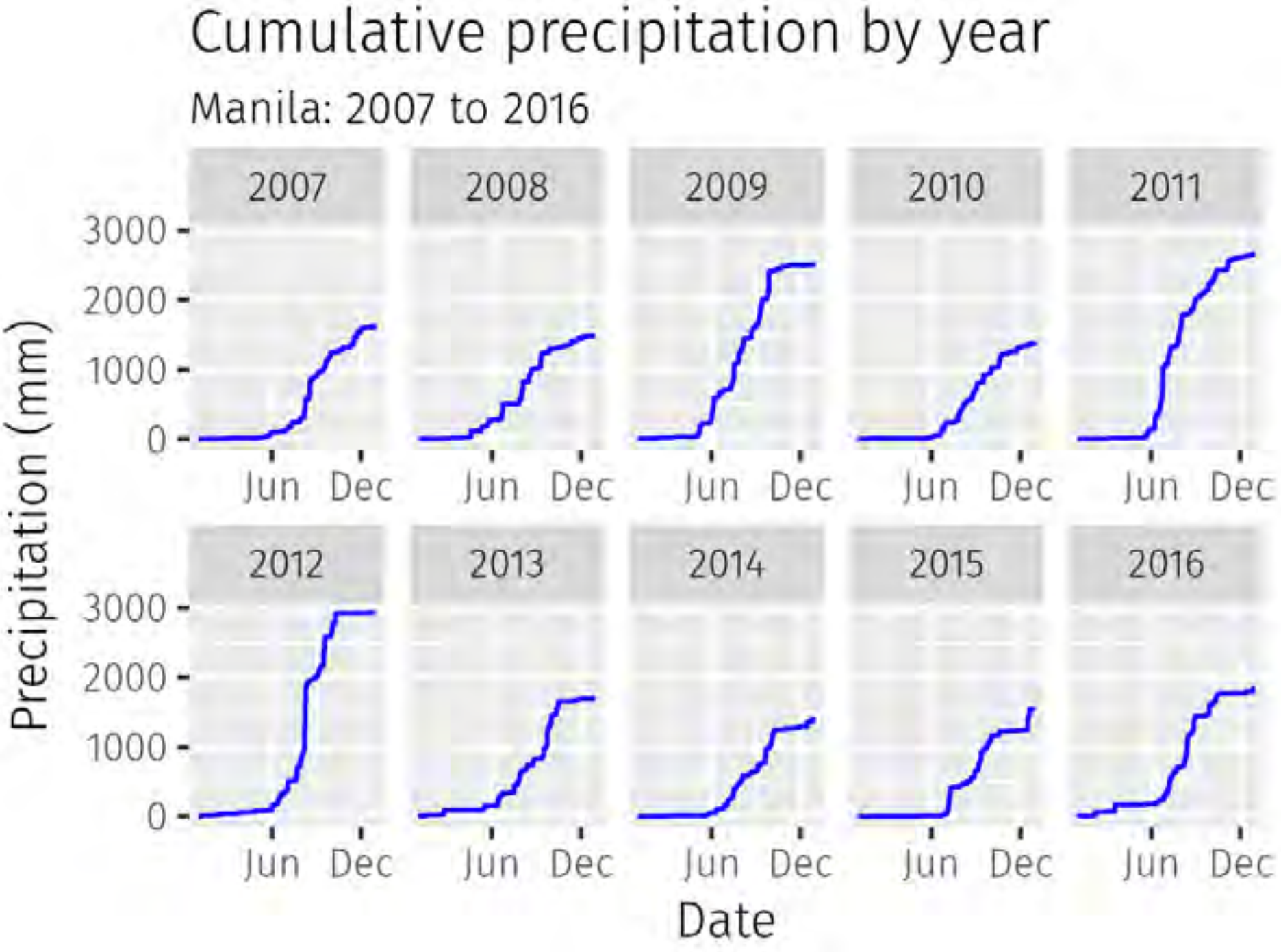


What about the rootzone?

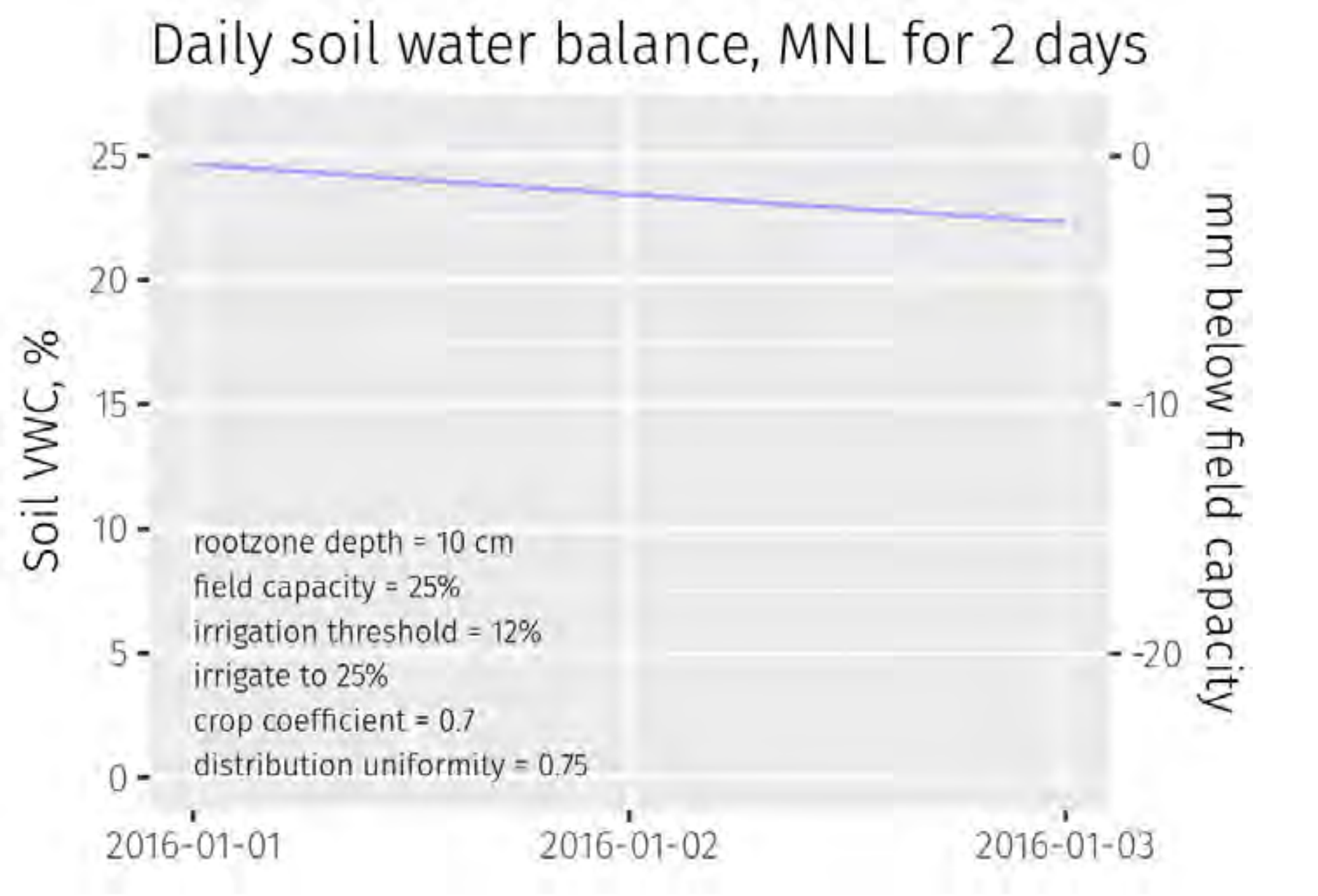


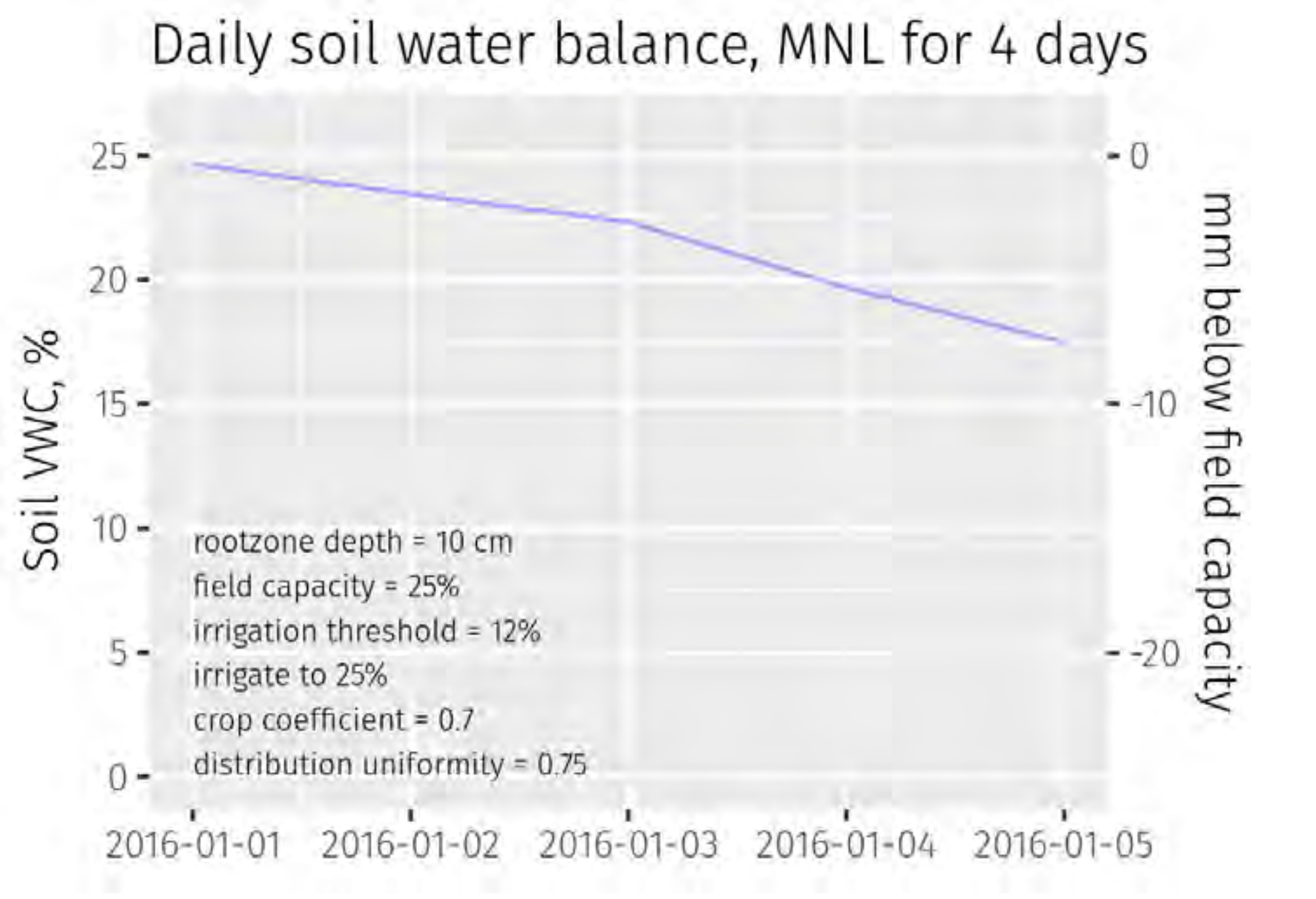
What about the weather?

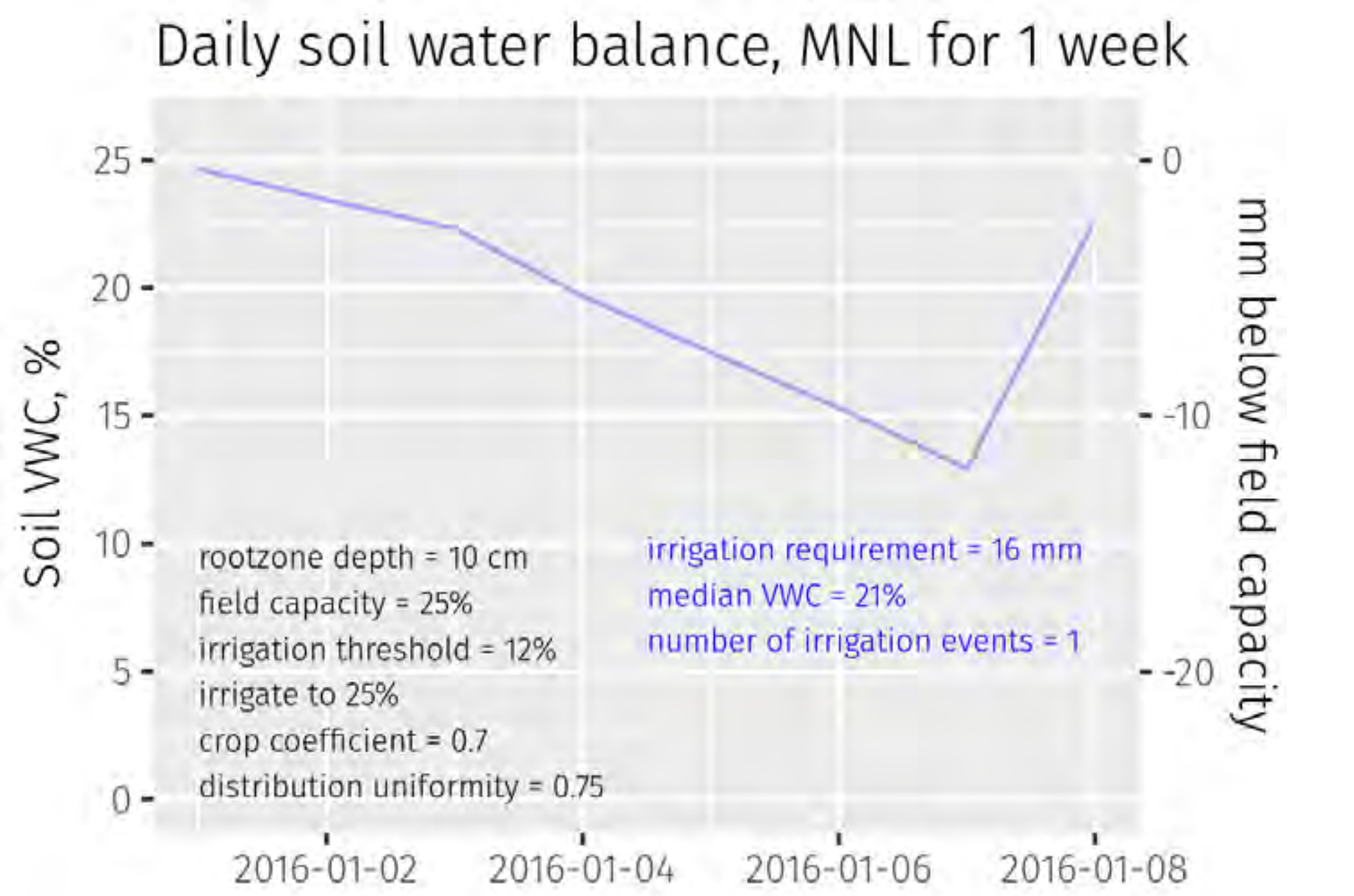
Cavite, 13 August 2014

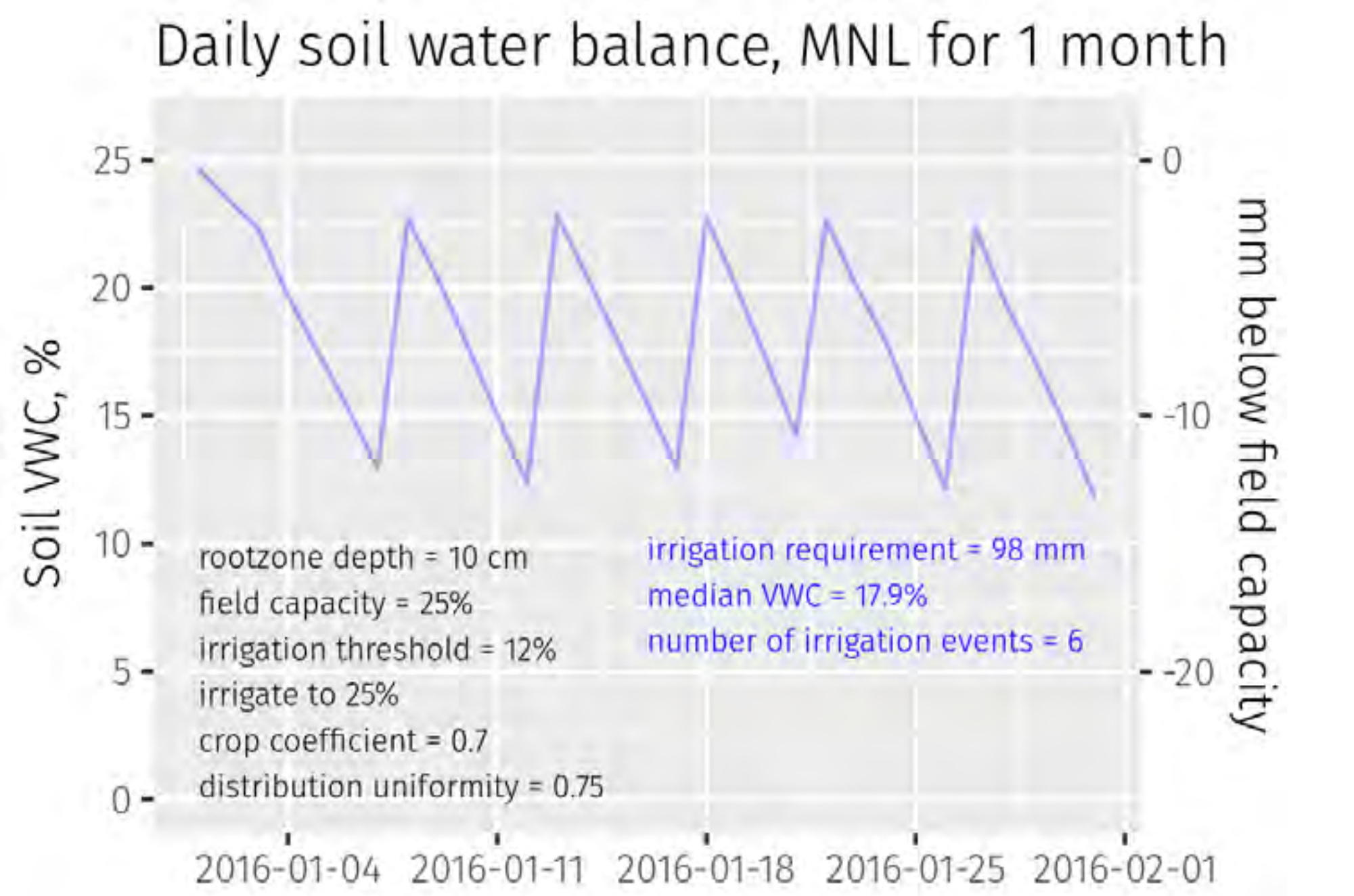

Cumulative precipitation by year
Manila: 2007 to 2016
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
3000
2000
1000
0
Jun
Dec
Precipitation (mm)
Date

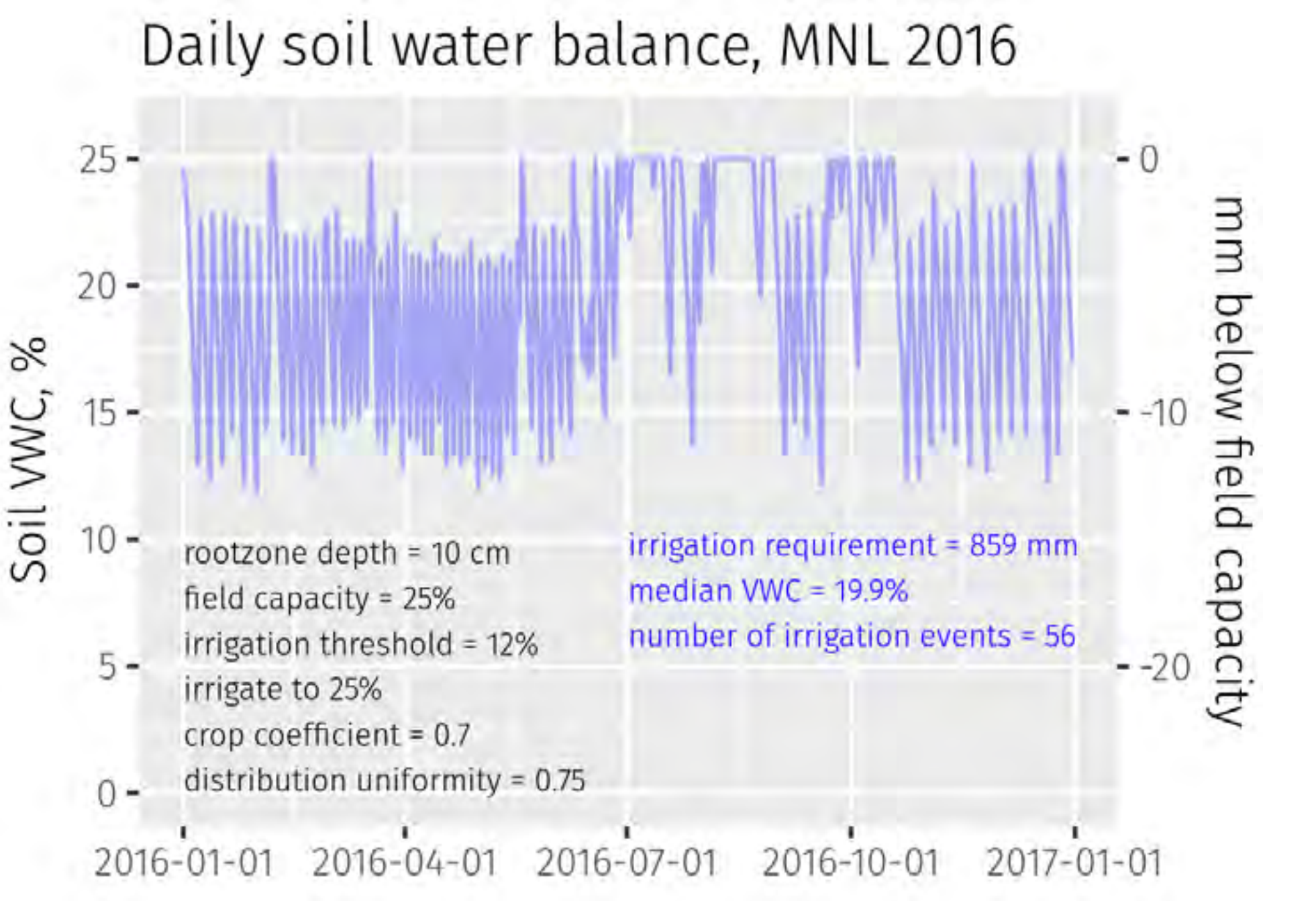
Precipitation data from stations in the Philippines


Daily soil water balance, MNL for 2 days
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
2016-01-01
2016-01-02
2016-01-03


Daily soil water balance, MNL for 4 days
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
2016-01-01
2016-01-02
2016-01-03
2016-01-04
2016-01-05


Daily soil water balance, MNL for 1 week
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 16 mm
median VWC = 21%
number of irrigation events = 1
2016-01-02
2016-01-04
2016-01-06
2016-01-08


Daily soil water balance, MNL for 1 month
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
-0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 98 mm
median VWC = 17.9%
number of irrigation events = 6
2016-01-04
2016-01-11
2016-01-18
2016-01-25
2016-02-01

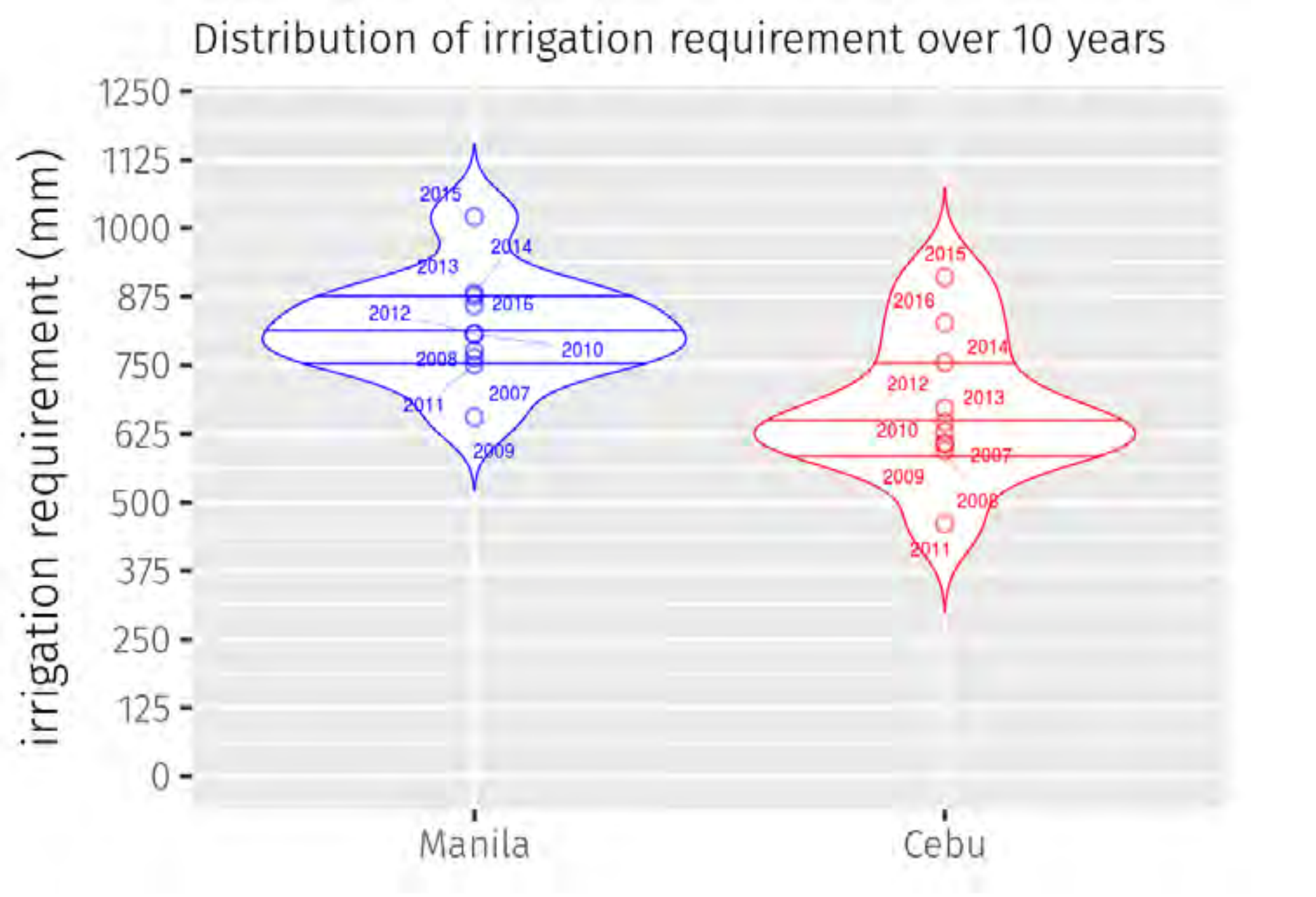

Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 859 mm
median VWC = 19.9%
number of irrigation events = 56
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01


10 years at MNL with those "rules"
irrigation requirement (mm)
1000
750
500
250
0
764
777
656
807
751
807
876
881
1021
859
662 mm water budget prediction
2008
2010
2012
2014
2016
Year

What happens if I change locations?

Irrigation requirement at Cebu


10 years at MNL and CEB
irrigation requirement (mm)
1000
750
500
250
0
Manila
Cebu
764
777
656
807
751
807
876
881
1021
859
609
594
606
629
461
671
646
755
911
827
511 mm water budget prediction
2008
2010
2012
2014
2016
Year


Distribution of irrigation requirement over 10 years
irrigation requirement (mm)
1250
1125
1000
875
750
625
500
375
250
125
0
2015
2014
2013
2016
2012
2010
2008
2007
2011
2009
2015
2016
2014
2012
2013
2010
2007
2009
2008
2011
Manila
Cebu

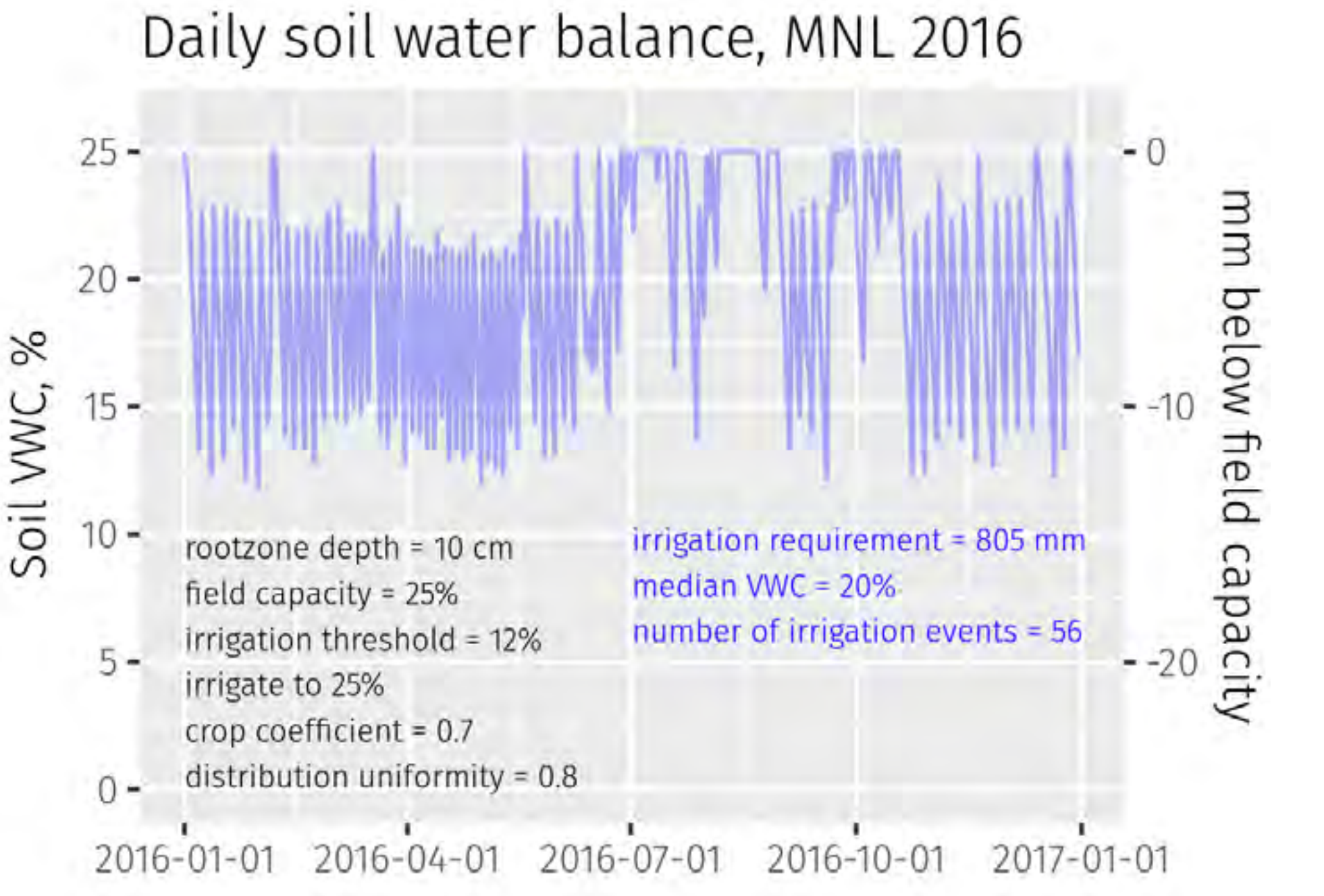
What happens if I change grasses, soil, or the way I manage?

With the irrigation “rules” shown previously, the irrigation water requirement at Manila in 2016 was 859 mm.

Changing the irrigation “rules”

DU_{LQ} from 0.75 to 0.8

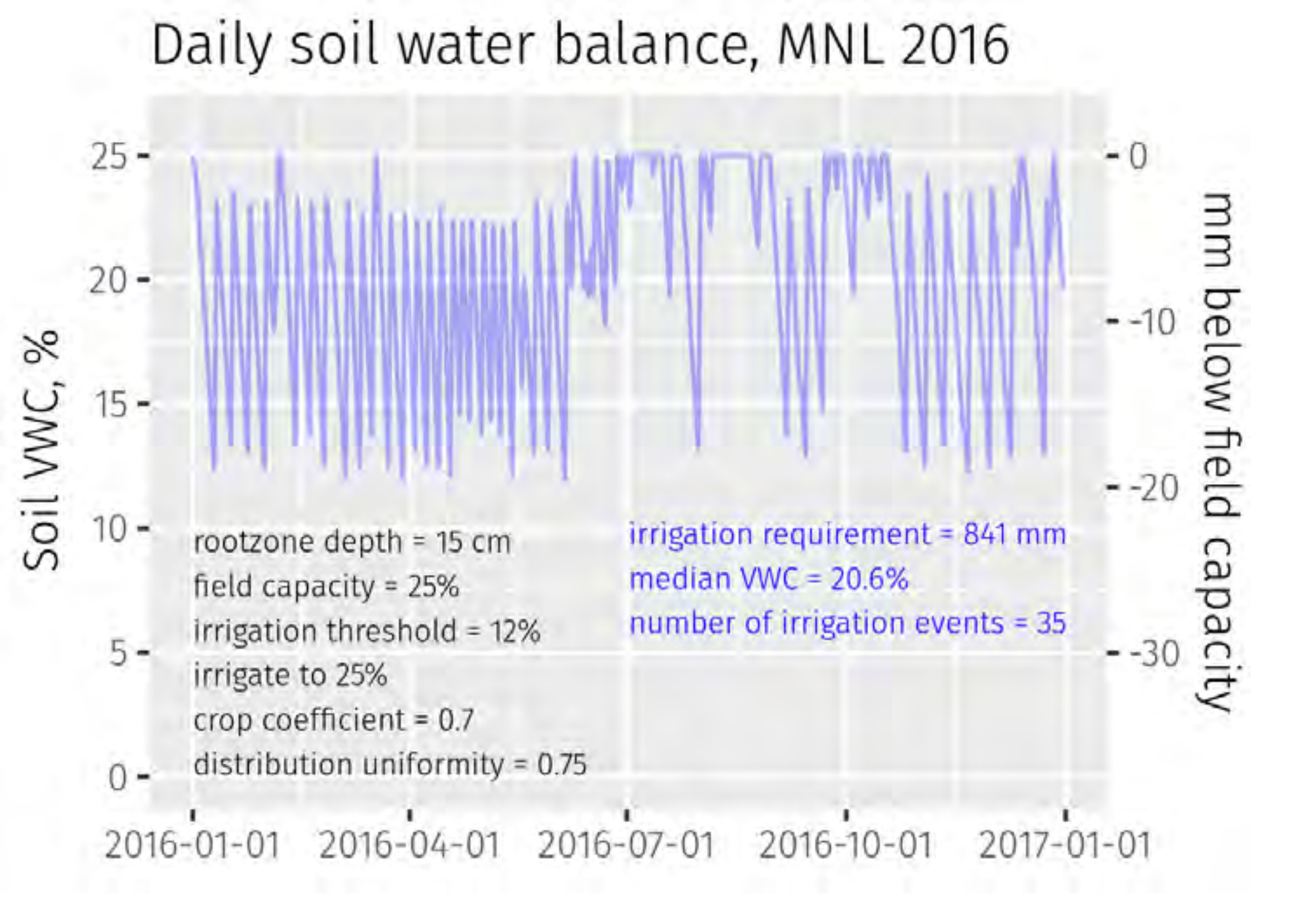
This will reduce water use by applying the water more evenly across the land area.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.8
irrigation requirement = 805 mm
median VWC = 20%
number of irrigation events = 56
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Rootzone depth from 10 to 15 cm

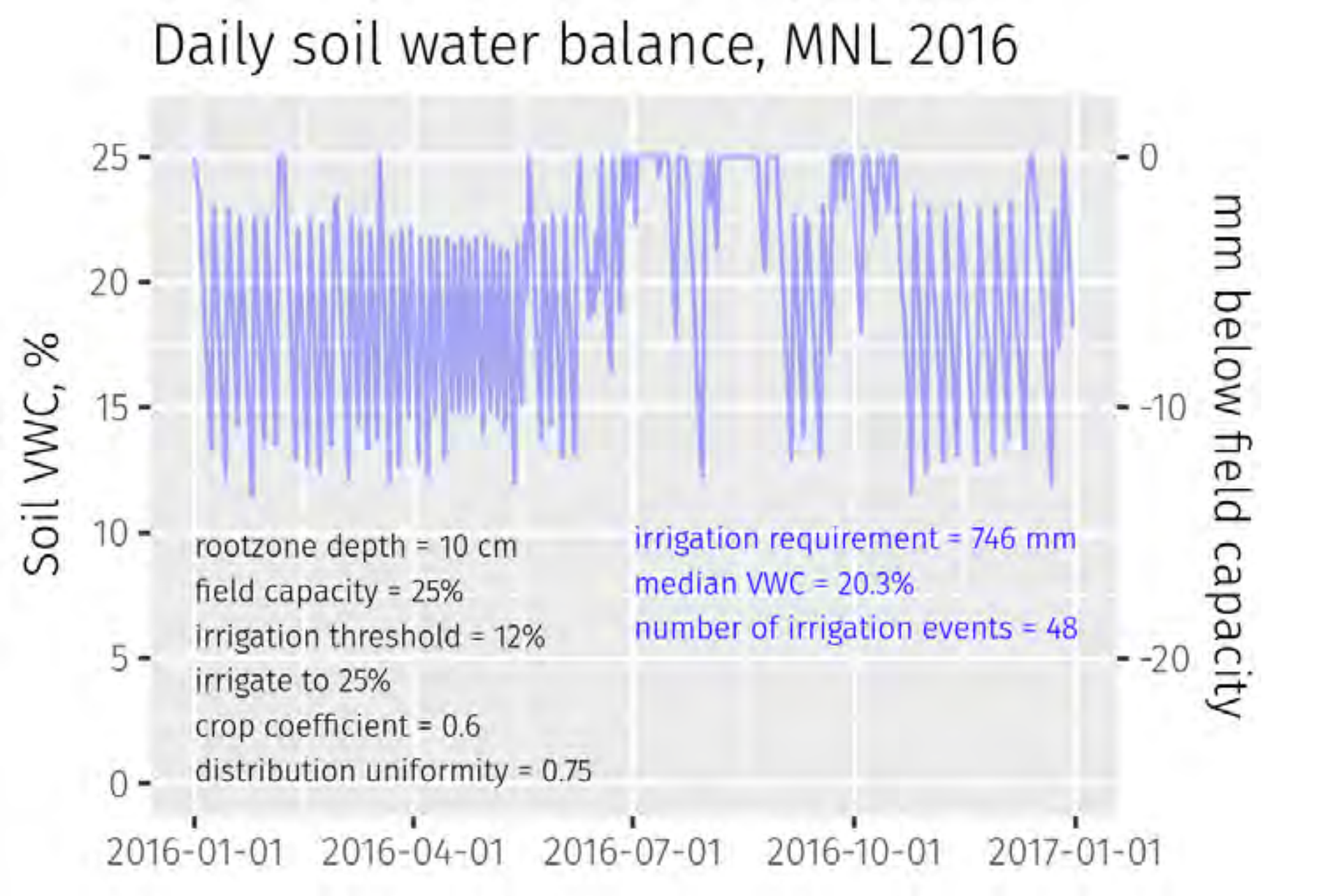
This will increase the *effective precipitation*.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
-30
rootzone depth = 15 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 841 mm
median VWC = 20.6%
number of irrigation events = 35
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Change K_c from 0.7 to 0.6

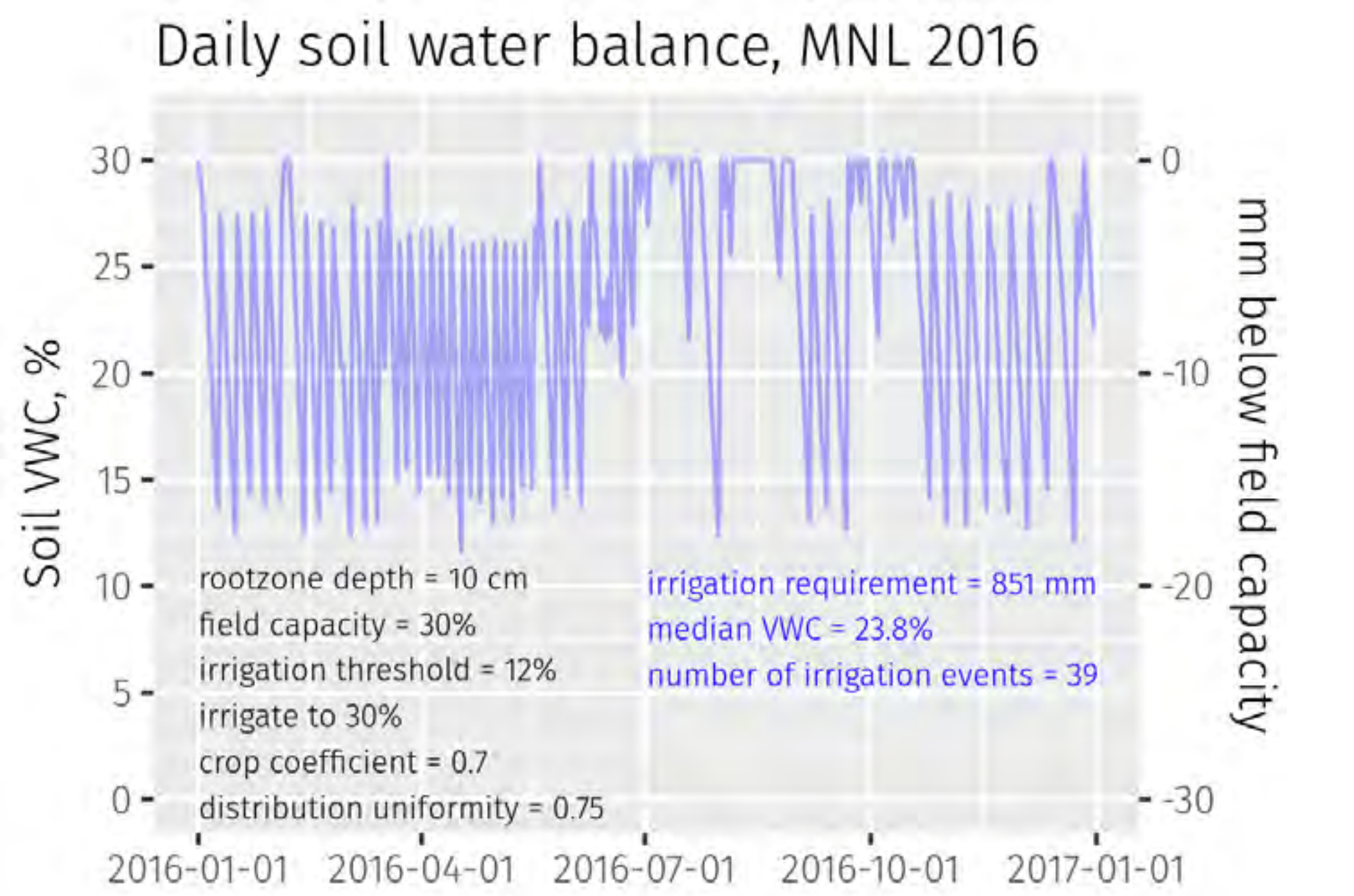
When using a more drought tolerant grass, the required crop adjustment (K_c) goes down.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 12%
irrigate to 25%
crop coefficient = 0.6
distribution uniformity = 0.75
irrigation requirement = 746 mm
median VWC = 20.3%
number of irrigation events = 48
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Increase the field capacity from 25 to 30%

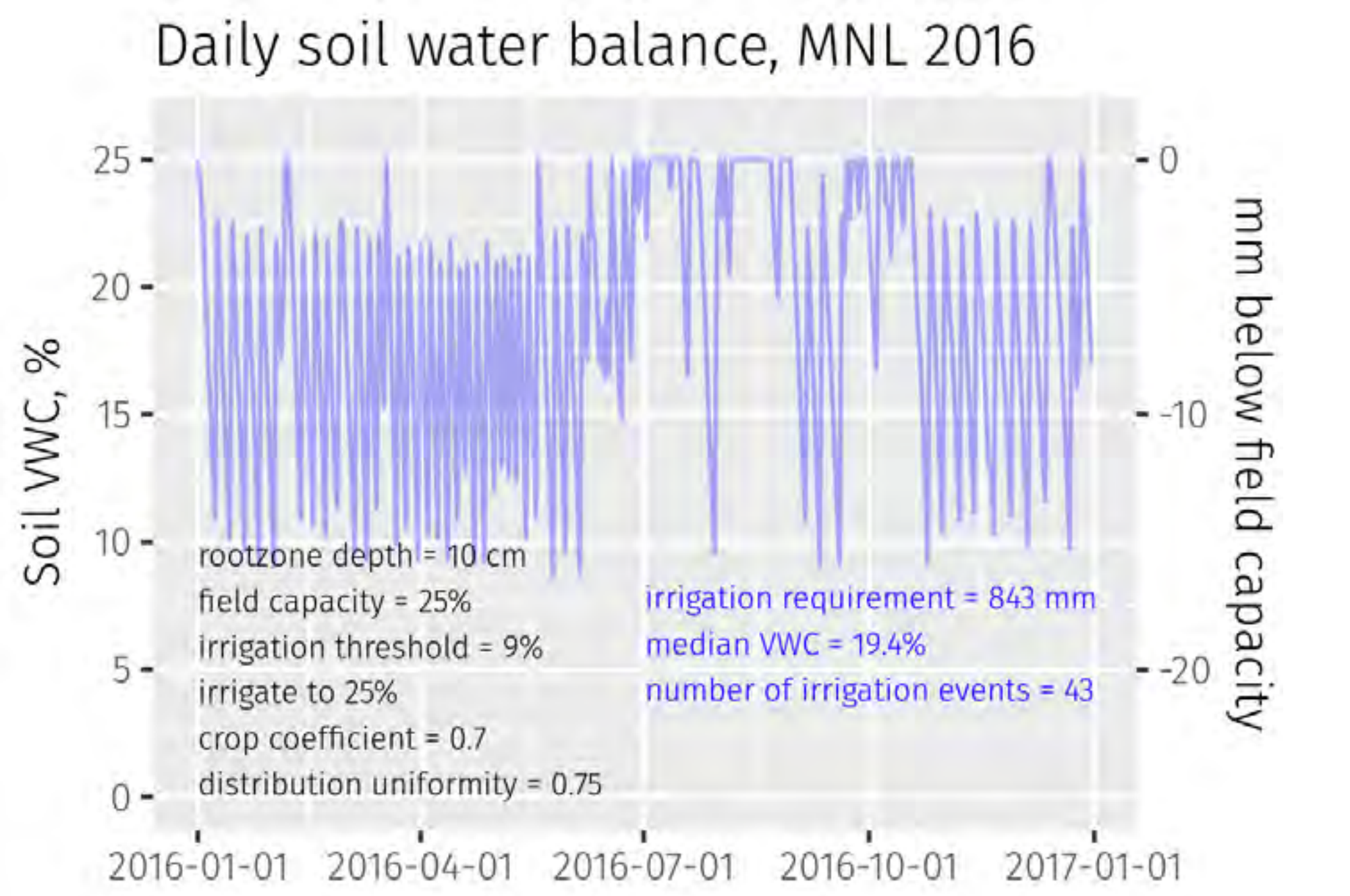
This will increase the effective precipitation.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
30
25
20
15
10
5
0
0
-10
-20
-30
rootzone depth = 10 cm
field capacity = 30%
irrigation threshold = 12%
irrigate to 30%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 851 mm
median VWC = 23.8%
number of irrigation events = 39
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Irrigate at 9% rather than 12%

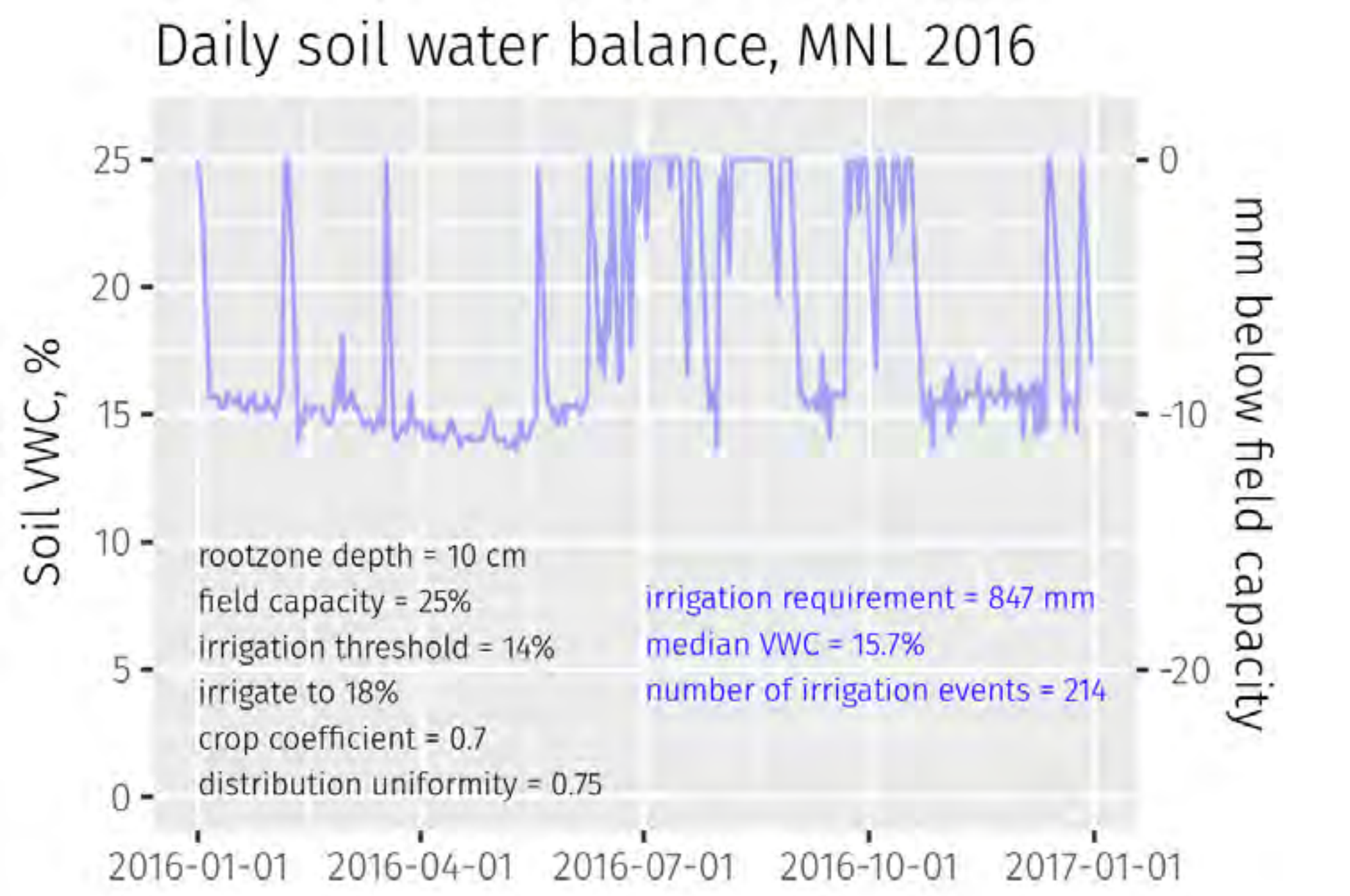
This is the type of change one might make when using a soil surfactant.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 9%
irrigate to 25%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 843 mm
median VWC = 19.4%
number of irrigation events = 43
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Irrigate more frequently, but don’t fill to field capacity

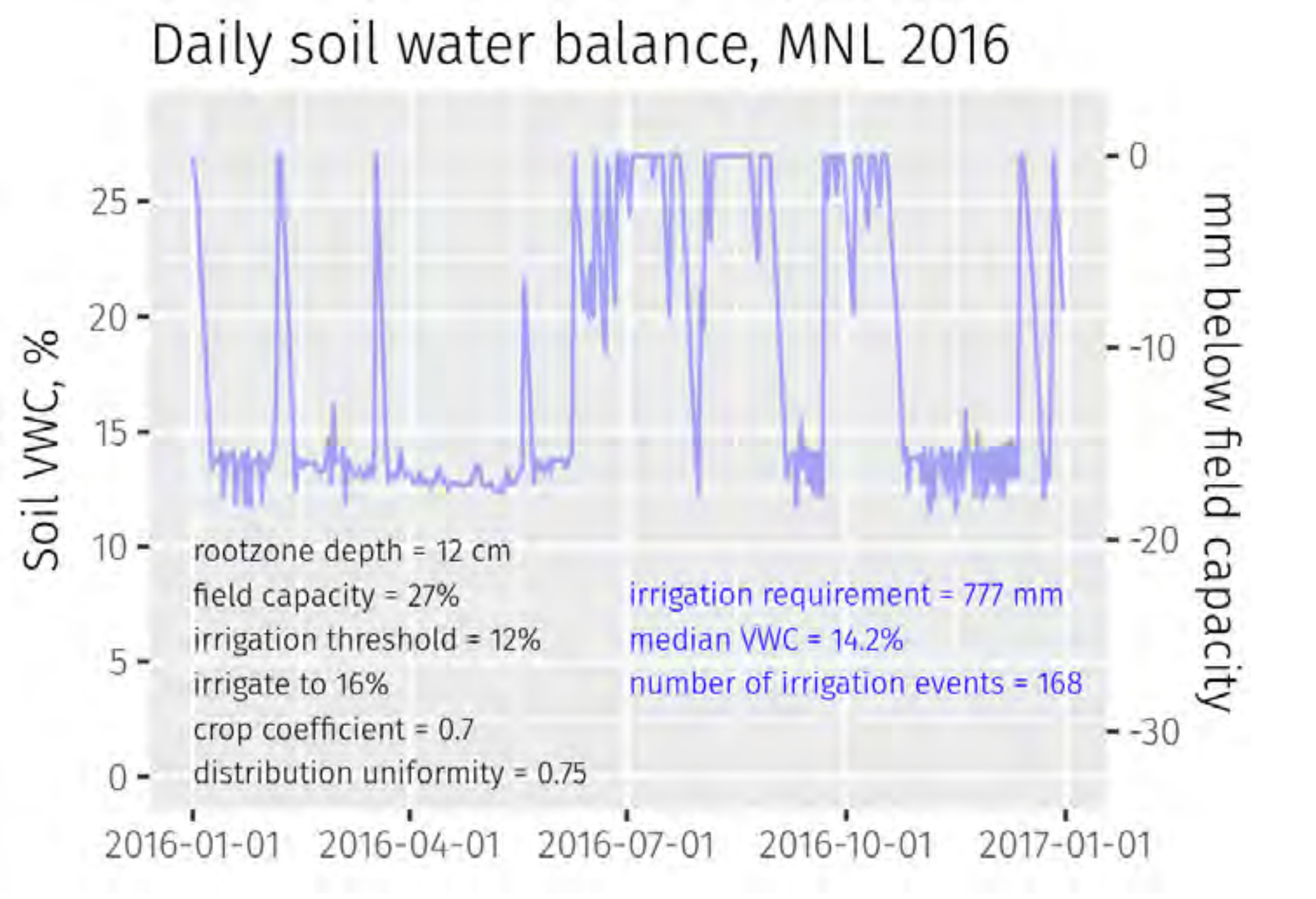
This will increase the effective precipitation.


Daily soil water balance, MNL 2016
Soil VWC, %
mm below field capacity
25
20
15
10
5
0
0
-10
-20
rootzone depth = 10 cm
field capacity = 25%
irrigation threshold = 14%
irrigate to 18%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 847 mm
median VWC = 15.7%
number of irrigation events = 214
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

Changing the irrigation “rules”

Or make many small changes

Try this with the *Shiny* irrigation apps at `www.asianturfgrass.com`.


Daily soil water balance, MNL 2016
Soil VWC, %
25
20
15
10
5
0
0
-10
-20
-30
mm below field capacity
rootzone depth = 12 cm
field capacity = 27%
irrigation threshold = 12%
irrigate to 16%
crop coefficient = 0.7
distribution uniformity = 0.75
irrigation requirement = 777 mm
median VWC = 14.2%
number of irrigation events = 168
2016-01-01
2016-04-01
2016-07-01
2016-10-01
2017-01-01

For more information

1. These slides at `https://speakerdeck.com/micahwoods`
2. Daily soil water balance in chapter 2 of *Effective Rainfall in Irrigated Agriculture*: `http://www.fao.org/docrep/x5560e/x5560e00.htm`
3. Gross & Hartwiger's article on Water Budgets in the *Green Section Record*, 1 April 2016