

IRRIGATION

WITH ECOCLIMAP SECOND GENERATION IN SURFEX/ISBA

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SURFEX User Workshop
19-03-2019

IRRIGATION IN ECOCLIMAP-SG (SECOND GENERATION)

The project:

- Agricultural practices like irrigation and its impact on **vegetation** and **water resources** need to be **better represented**
- **Aims:** be able to test long term scenarii: **irrigation sustainability**, effect of climate change on the urban heat island
- Inside the **project URCLIM** (12-month Post-Doctoral fellowship)
- **In the context** of the last update of SURFEX (v8.1) with a new ecosystem and surface database: **ECOCLIMAP-SG** (300m resolution)
<https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/wiki>



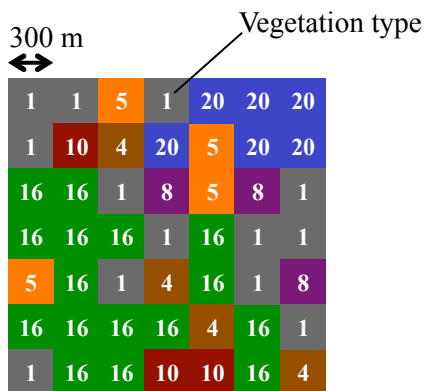
ECOCLIMAP-SG (SECOND GENERATION)

<https://opensource.umr-cnrm.fr/projects/ecoclimap-sg/wiki>

	ECOCLIMAP-1	ECOCLIMAP-2	ECOCLIMAP-SG
Year	2003	2013	2018
Resolution	1 km * 1 km	1 km * 1 km	300 m * 300 m
Vegetation Types	12 Including C4 irrigated	12 (then 19) Including C4 irrigated	20 (without irrigation)

ECOCLIMAP-SG new characteristics

- Global resolution 300 m x 300 m: 1 surface type / 300 m pixel
- Data include:
 - LAI (36 data/year: 10-day period)
 - Albedo (36 data/year: 10-day period)
 - Tree height
 - Land cover: 33 generic surface types from ESA-CCI-LandCover



THE 33 SURFACES TYPES IN ECOCLIMAP-SG

WATER

1. Sea and oceans (cov. 1)
2. Lakes (cov. 2)
3. Rivers (cov. 3)

URBAN (new)

24. urban LCZ1: compact high-rise
25. urban LCZ2: compact midrise
26. urban LCZ3: compact low-rise
27. urban LCZ4: open high-rise
28. urban LCZ5: open midrise
29. urban LCZ6: open low-rise
30. urban LCZ7: lightweight low-rise
31. urban LCZ8: large low-rise
32. urban LCZ9: sparsely built
33. urban LCZ10: heavy industry

VEGETATION

- | | | | | |
|-----------------------------------|---|--|---|--------------------------------|
| Ø | { | 4. Bare soil (veg. 1) | | |
| | | 5. Bare rock (veg. 2) | | |
| | | 6. Permanent snow (veg. 3) | | |
| TREES | { | 7. Boreal broadleaf deciduous (veg. 16) | | |
| | | 8. Temperate broadleaf deciduous (veg. 4) | | |
| | | 9. Tropical broadleaf deciduous (veg. 13) | | |
| | | 10. Temperate broadleaf evergreen (veg. 14) | | |
| | | 11. Tropical broadleaf evergreen (veg. 6) | | |
| | | 12. Boreal needleleaf evergreen (veg. 5) | | |
| | | 13. Temperate needleleaf evergreen (veg. 15) | | |
| | | 14. Boreal needleleaf deciduous (veg. 17) | | |
| | | SHRUBS | { | 15. Shrubs (veg. 19) |
| | | | | 16. Boreal grassland (veg. 18) |
| 17. Temperate grassland (veg. 10) | | | | |
| HERBACEOUS | { | 18. Tropical grassland (veg. 11) | | |
| | | 19. Winter C3 crops (veg. 7) | | |
| | | 20. Summer C3 crops (new) | | |
| | | 21. C4 crops (veg. 8) | | |
| FLOODED | { | 22. Tree cover, flooded (new) | | |
| | | 23. Shrub or herbaceous cover, flooded (new) | | |

→ Not irrigated veg. types

Legend:

#. Surface type number (ECOCLIMAP2 corresp.)

NB others ECOCLIMAP2: C4 crops irrigated (veg. 9) / Wetlands (veg. 12)

IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

ECOCLIMAP-SG Land cover:

33 surface types

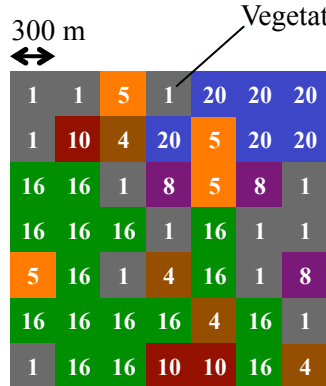


20 vegetation types
non irrigated



To be irrigated:
duplicate the vegetation type

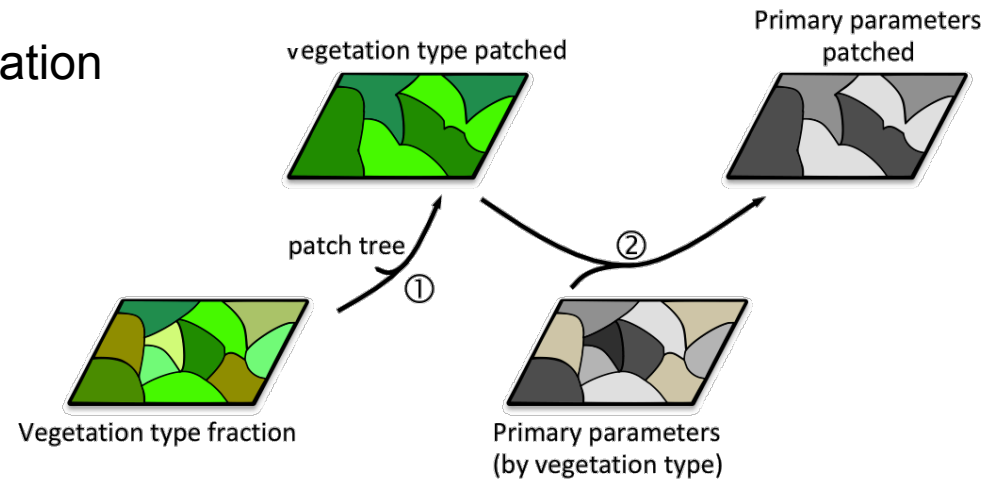
Using the vegetation patch principle



IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

- To duplicate irrigated vegetation type: **use the vegetation patch principle**

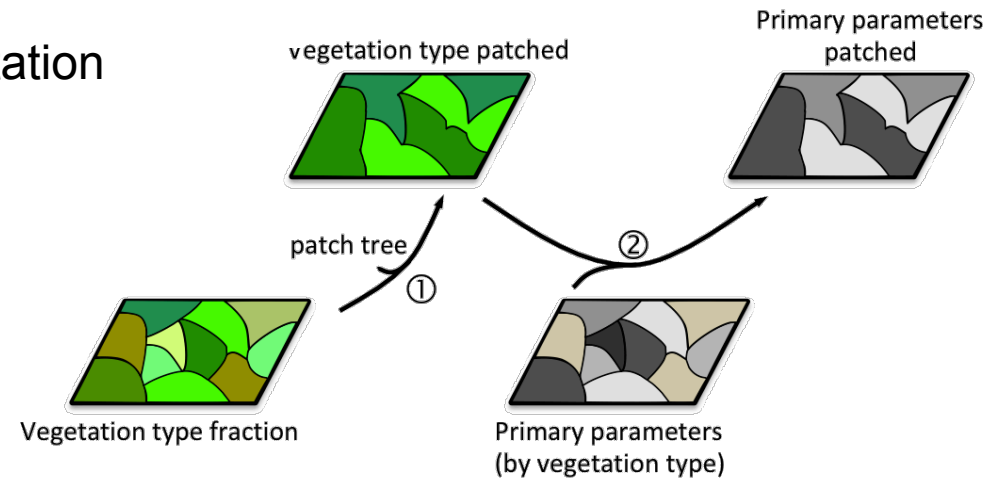
Patch principle: merging the standard vegetation type into patches



IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

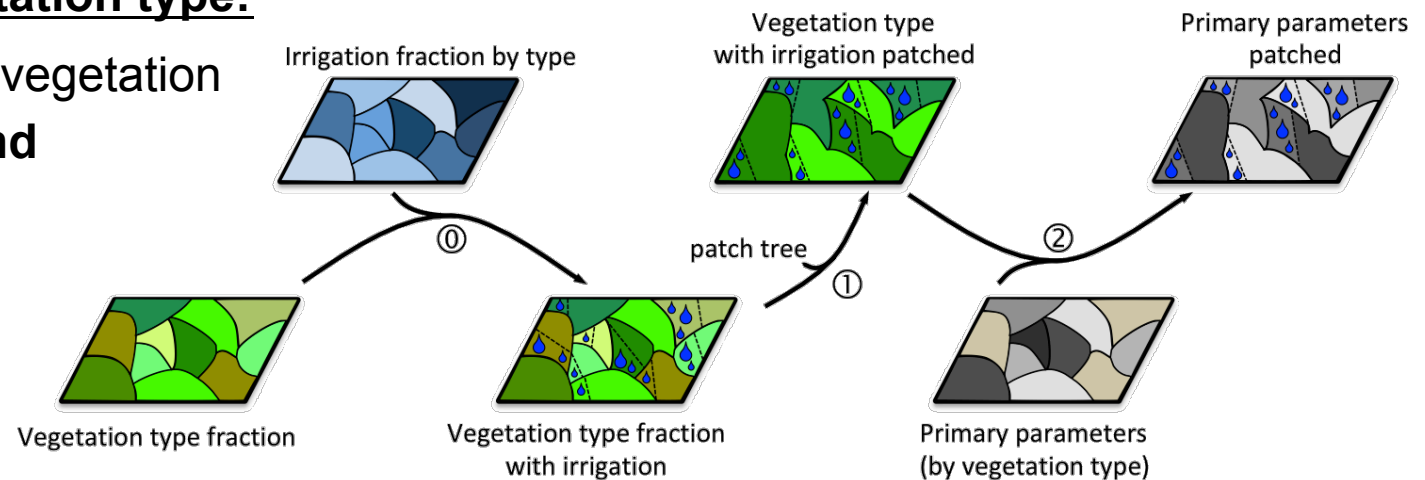
- To duplicate irrigated vegetation type: **use the vegetation patch principle**

Patch principle: merging the standard vegetation type into patches



Duplicate irrigated vegetation type:

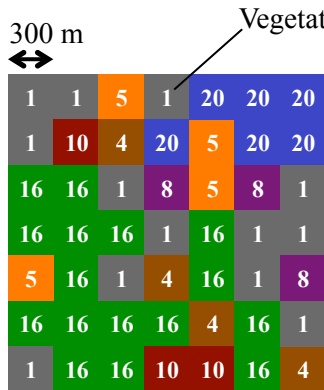
First, **distribute** standard vegetation type into **non-irrigated and irrigated** vegetation type



IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

ECOCLIMAP-SG Land cover:

33 surface types



20 vegetation types
non irrigated

To be irrigated:
duplicate the vegetation type

Irrigation:

3 types considered

Sprinkler



Flood



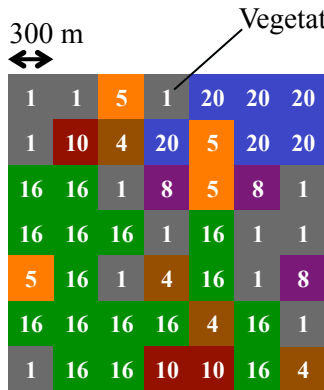
Drip



IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

ECOCLIMAP-SG Land cover:

33 surface types



20 vegetation types
non irrigated

To be irrigated:
duplicate the vegetation type

Irrigation:

3 types considered

Sprinkler

Flood

Drip



→ Until 80 different irrigation types simulated by pixel ←
(cpu consuming)

IMPLEMENTATION CHOICES

To reduce the number of the potentially 80 vegetation types

IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

IMPLEMENTATION CHOICES

To reduce the number of the potentially 80 vegetation types



**1 dominant irrigation
/ vegetation type
/ grid point**

*There is mainly one type of irrigation
by region by culture (e.g. flood for
rice (irrigated C3) in China)*

**Select which vegetation types
could be irrigated**

6 by default:

- *Winter C3 crops*
- *Summer C3 crops,*
- *C4 crops,*
- *Temperate broadleaf deciduous,*
- *Temperate broadleaf evergreen,*
- *Shrubs.*

Vegetation type reduction: 80 to 40

40 to 26

IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX



Irrigation:
Apply a **quantity of water** distributed over a **period of time**,
distinguishing the irrigation method:

- Like rain to represent **sprinkler** irrigation
- Directly on soil to represent **drip** or **flood** irrigation

Well documented:
Lawston & al., 2015
Ozdogan & al., 2010
Evans & Zaitchik, 2008

IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

I. Fields equipped for irrigation?

Irrigation maps*

II. Irrigation period?

Between germination and reaping*

III. Irrigation needed?

Irrigation trigger threshold*

IV. Link to water availability?

Through the **coupling with the TRIP** hydrological system:

- **Check the resources available**
- **Take into account scenarii** (water sustainability, leave a minimum flow in rivers...)



V. Irrigation

Water quantity and application period*

VI. Minimum return time ?

Between two irrigations*

*For each vegetation type and according to irrigation technique

IMPLEMENTATION OF IRRIGATION

I. Fields equipped for irrigation?

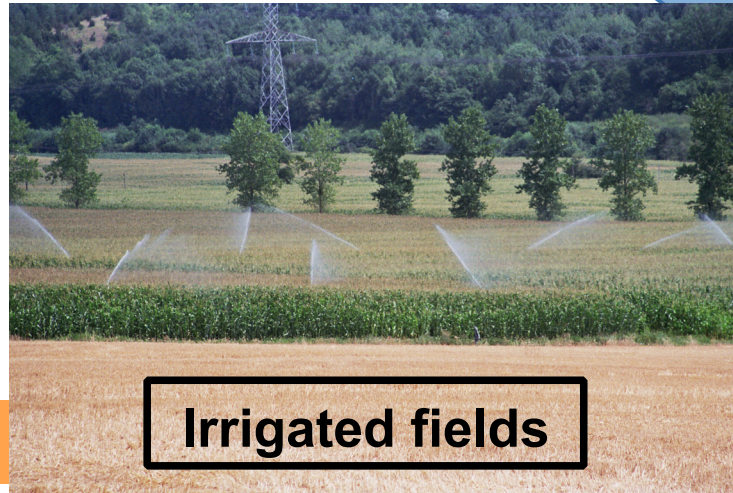
Irrigation maps* (300m resolution, from Meier et al., 2018)

II. Irrigation period?

Between germination and reaping*

III. Irrigation needed?

Irrigation trigger threshold*



IV. Link to water availability?

Through the **coupling with the TRIP** hydrological system:
- **Check the resources available**
- **Take into account scenarii** (water sustainability, leave a minimum flow in rivers...)

V. Irrigation

Water quantity and application period*

VI. Minimum return time ?

Between two irrigations*

*For each vegetation type and according to irrigation technique

Done

Accepted input:
maps, constants by crops or for all, or default

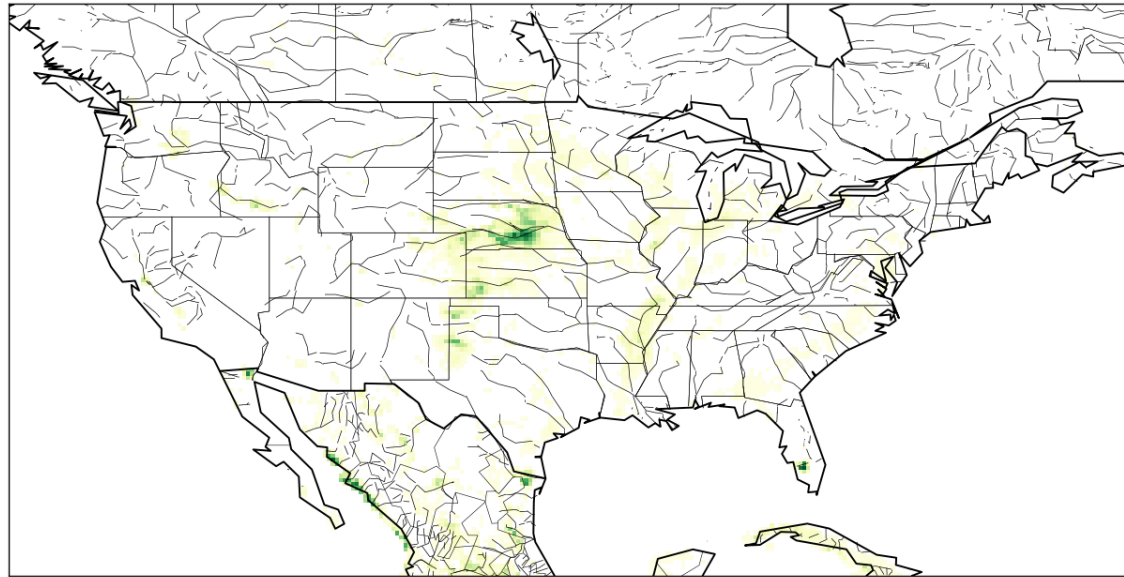
To do

Couple with TRIP
Compute variables by the model

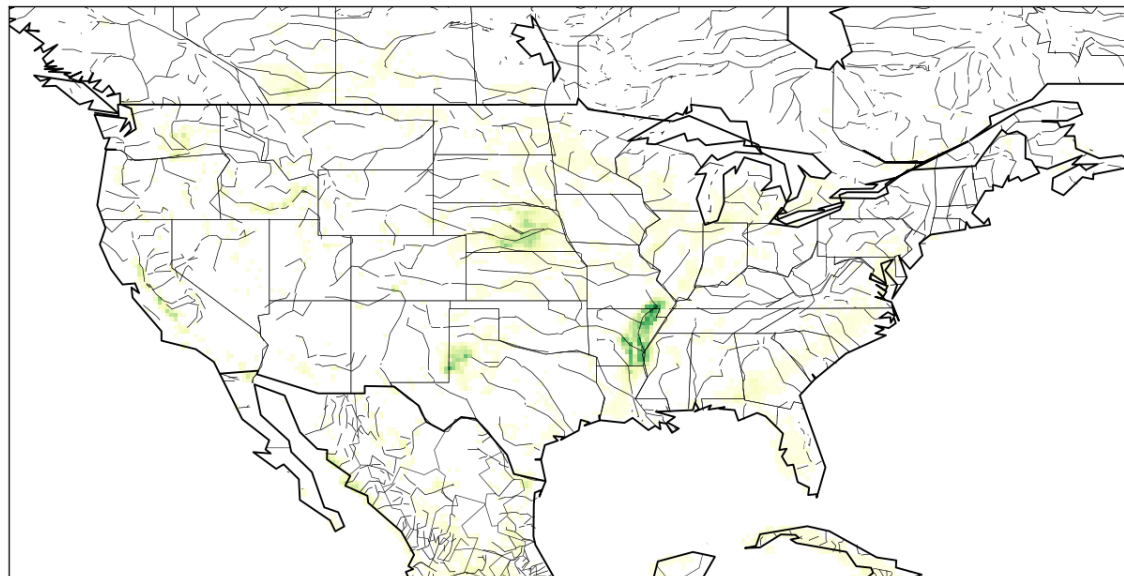
RESULTS : CASE OF USA (0.25° resolution)

Irrigation distribution

Fraction of irrigated C4 crops

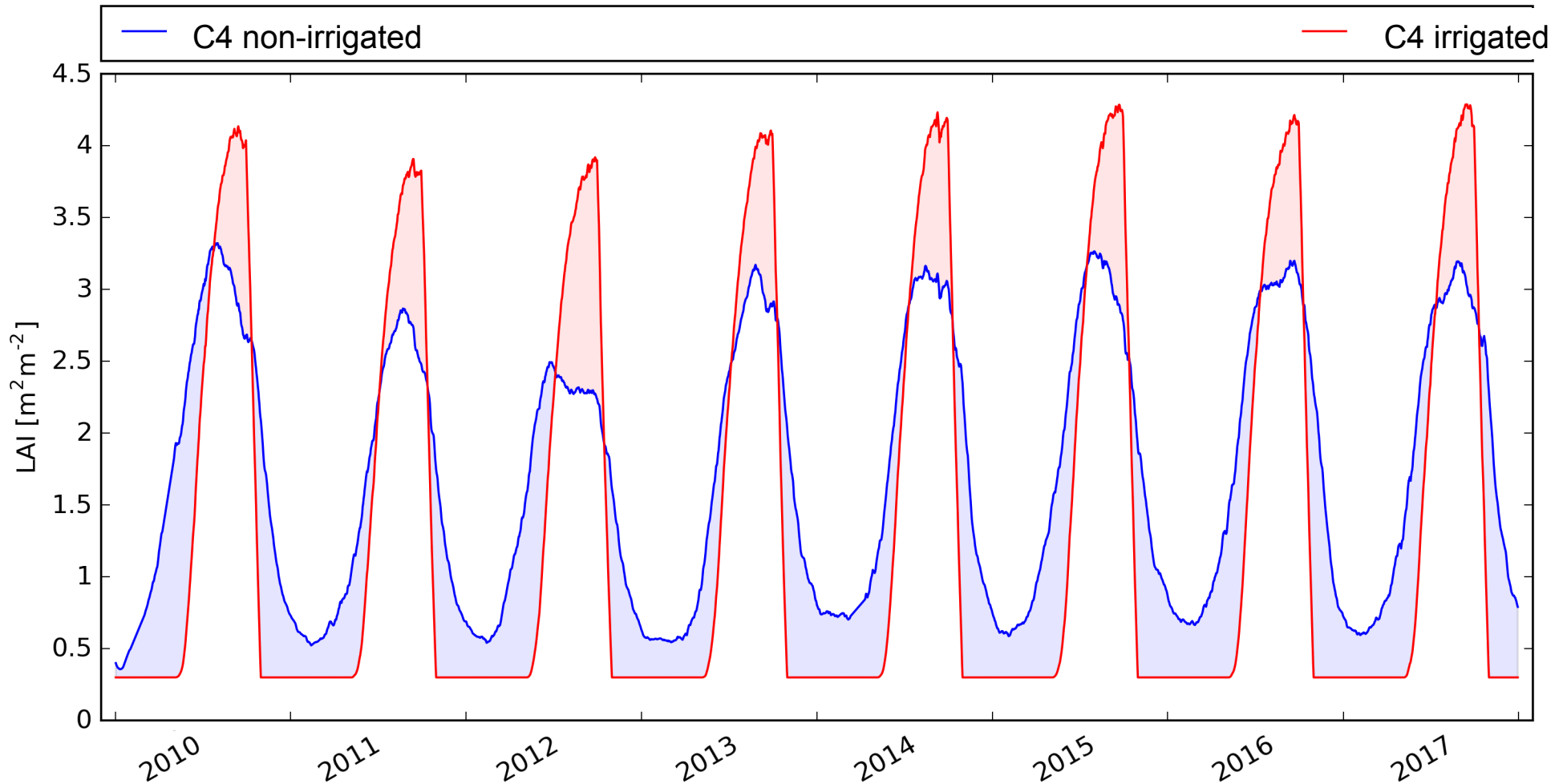


Fraction of irrigated summer C3 crops



RESULTS : CASE OF USA (0.25° resolution)

LAI C4 (non-irrigated vs irrigated)

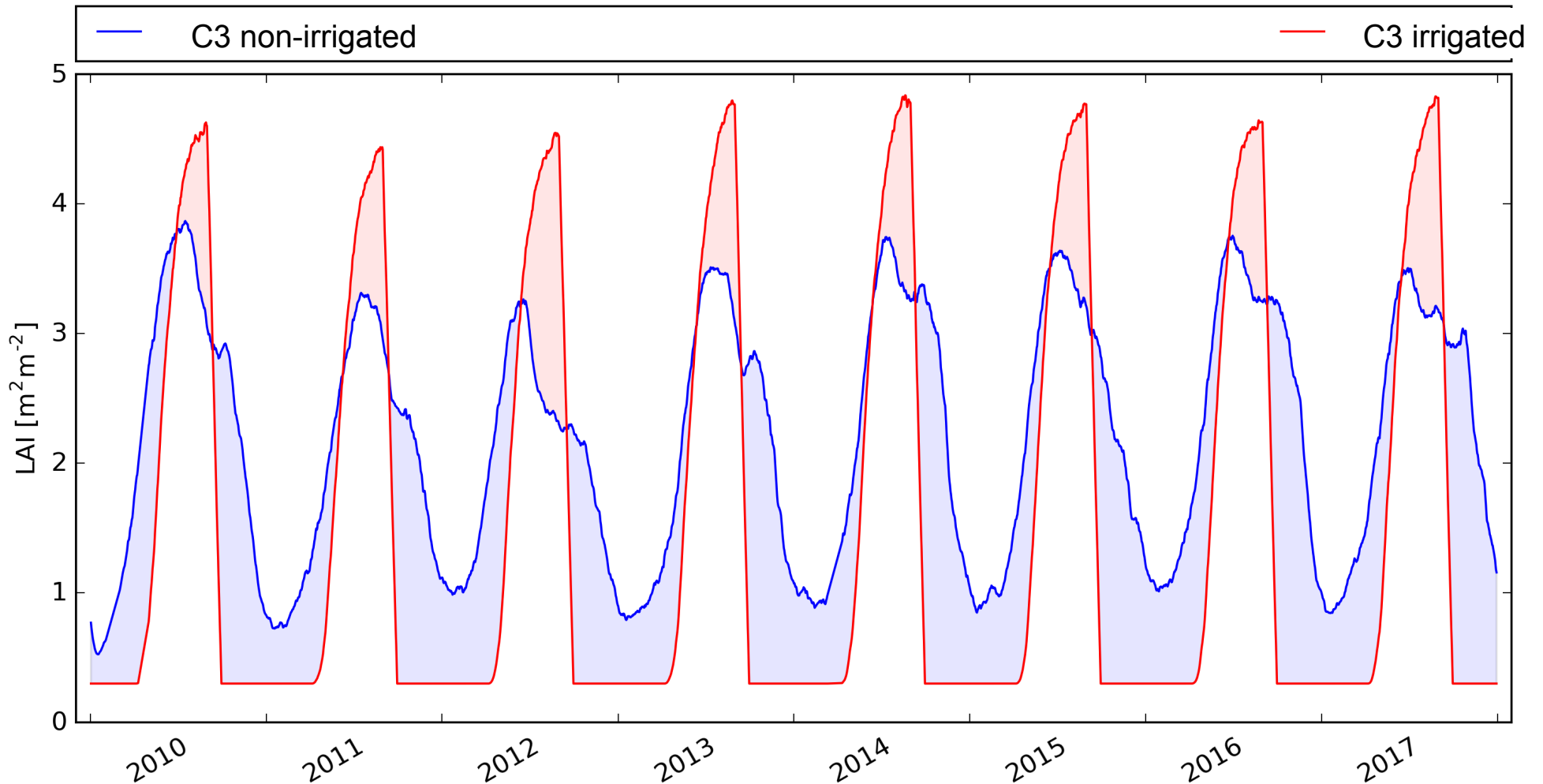


→ Impact of irrigation on LAI

- agricultural practice (germination & harvest) on seasonality
- water supply on amplitude

RESULTS : CASE OF USA (0.25° resolution)

LAI C3 (non-irrigated vs irrigated)



→ Impact of irrigation on LAI

- agricultural practice (germination & harvest) on seasonality
- water supply on amplitude

Results: Case of USA (0.25° resolution)

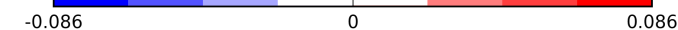
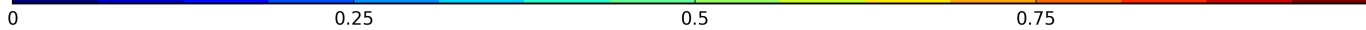
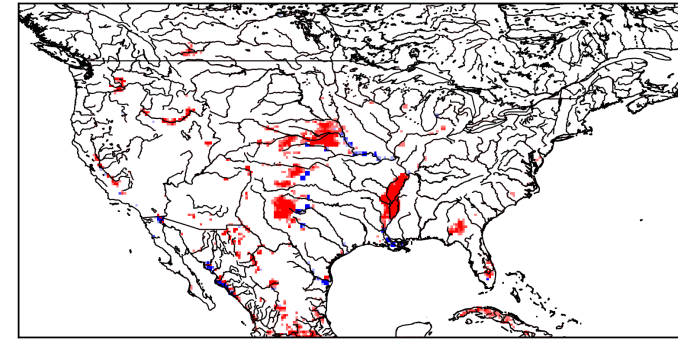
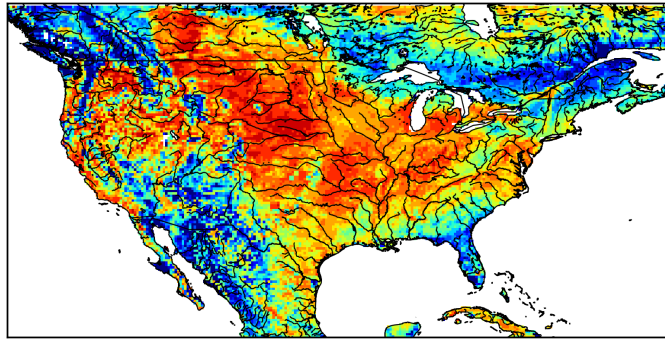
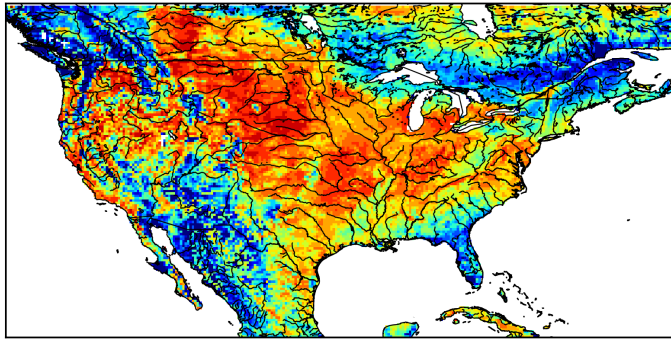
LAI statistics (non-irrigation vs irrigation and LAI-G0-V2 (obs. from Copernicus))

Correlation:

No irrigation

Irrigation

Irrigation – No irrigation

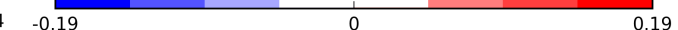
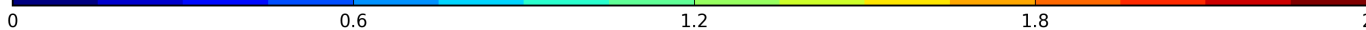
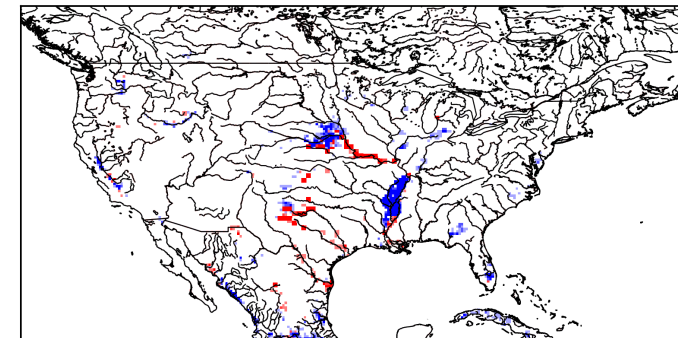
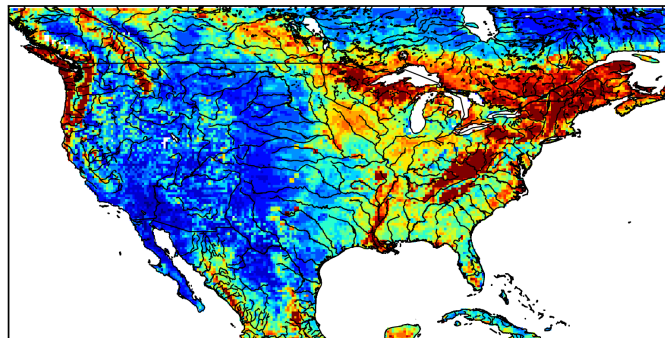
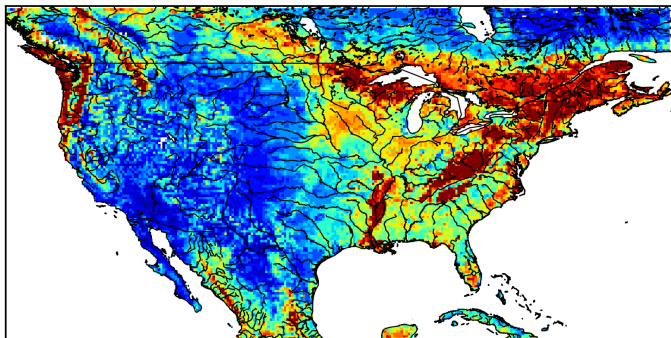


RMSD:

No irrigation

Irrigation

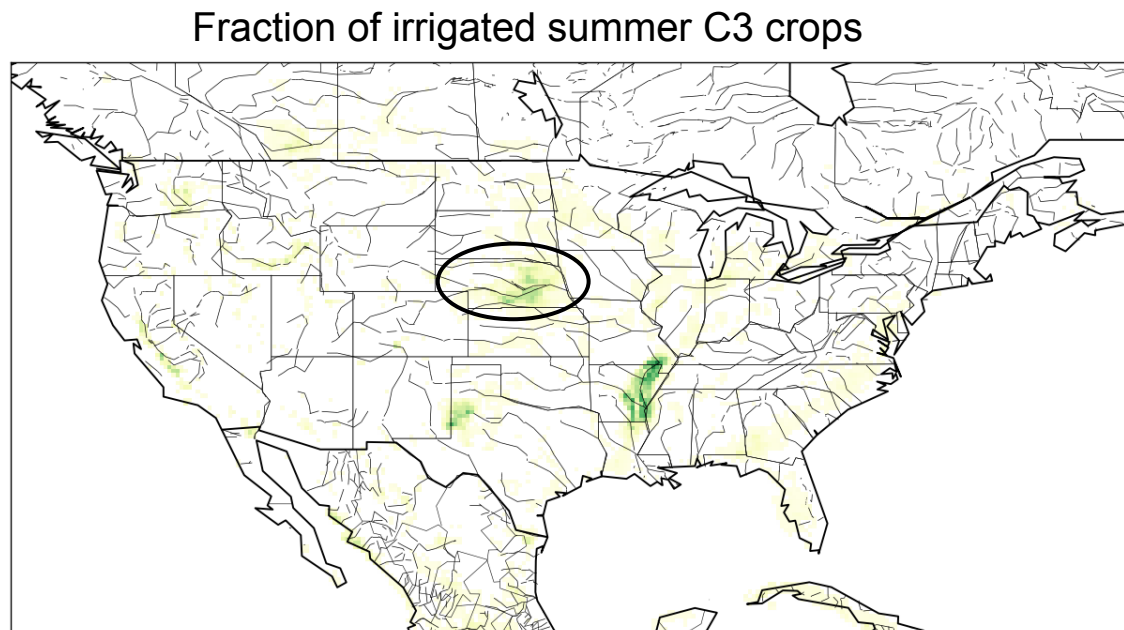
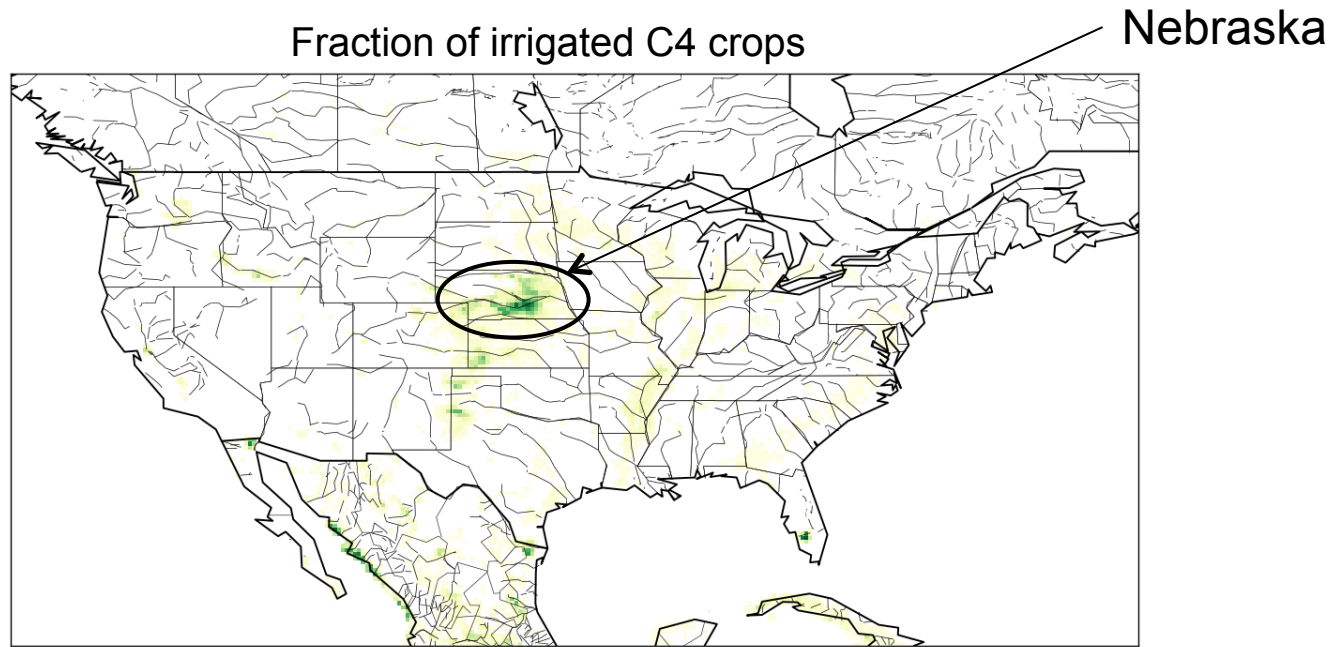
Irrigation – No irrigation



→ Better correlation & RMSD with irrigation

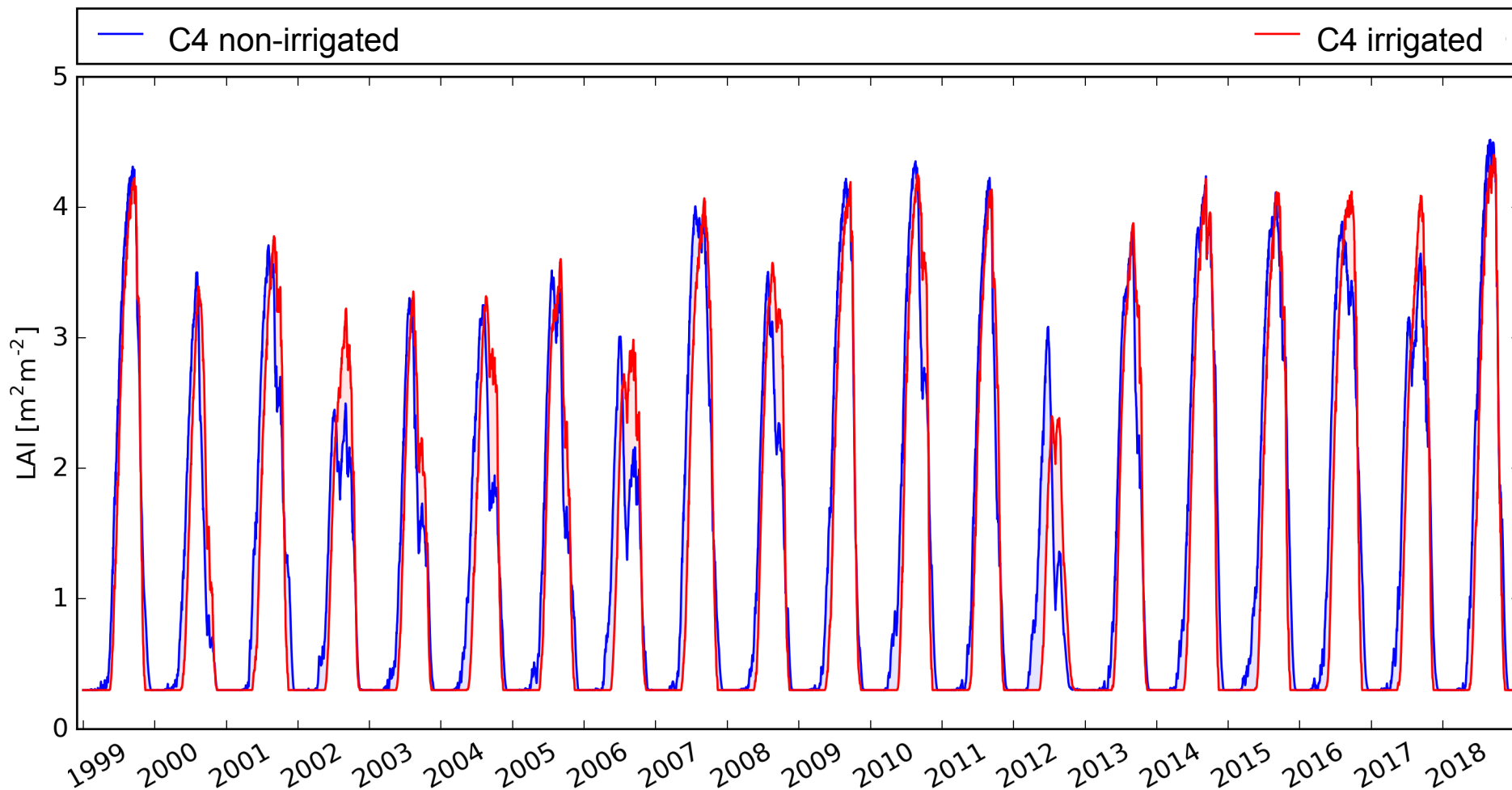
Results: Case of USA (0.25° resolution)

Irrigation distribution



RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

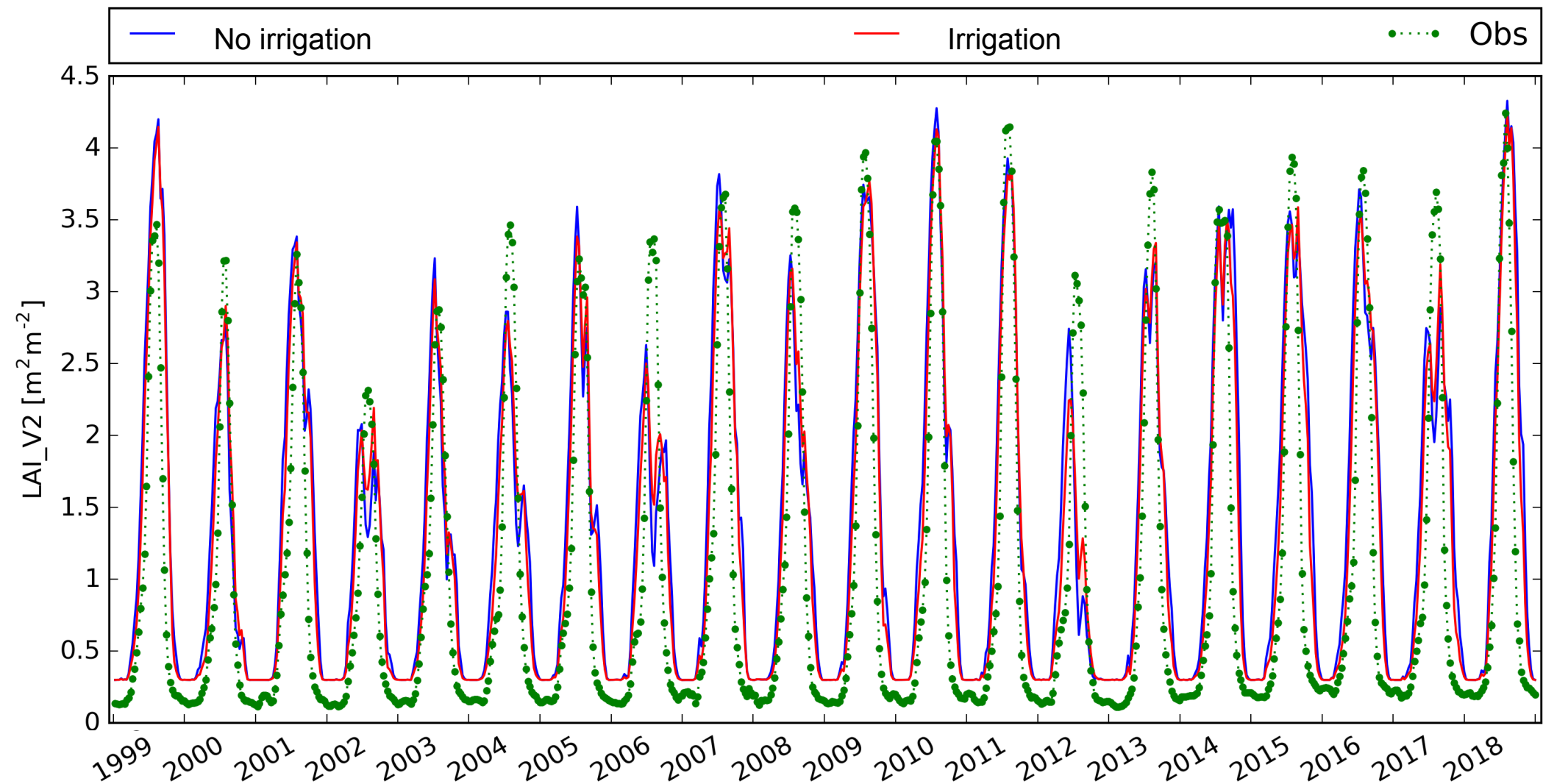
LAI C4 (non-irrigated vs irrigated)



Still impact of irrigation on LAI $\left\{ \begin{array}{l} \rightarrow \bullet \text{ agricultural practice (germination \& harvest) on seasonality} \\ \rightarrow \bullet \text{ water supply on amplitude} \end{array} \right.$

RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

LAI daily series (simulations -vs- observations with LAI G0-V2 from Copernicus)



→ **LAI more representative with irrigation,**
especially at the end of summer with a higher LAI.

RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

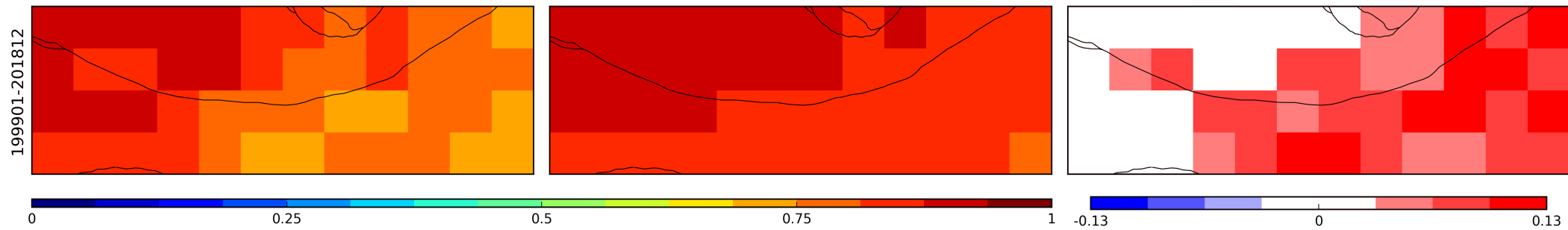
LAI statistics (no irrigation vs irrigation and obs. LAI (G0-V2 from Copernicus))

Correlation:

No irrigation

Irrigation

Irrigation – No irrigation

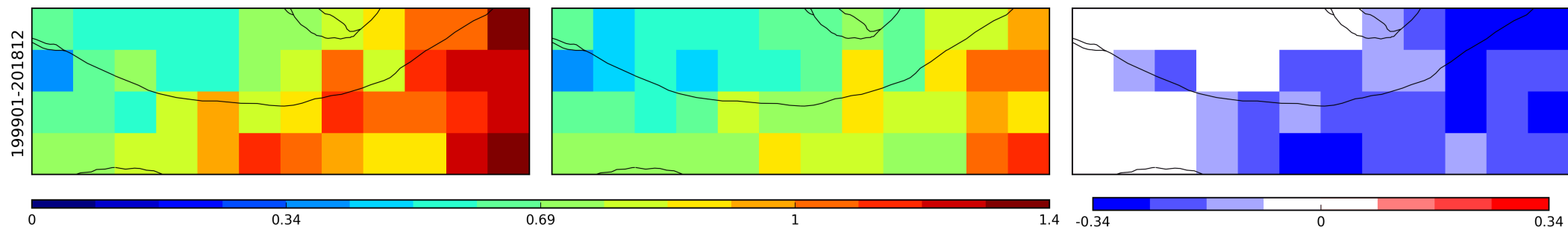


RMSD:

No irrigation

Irrigation

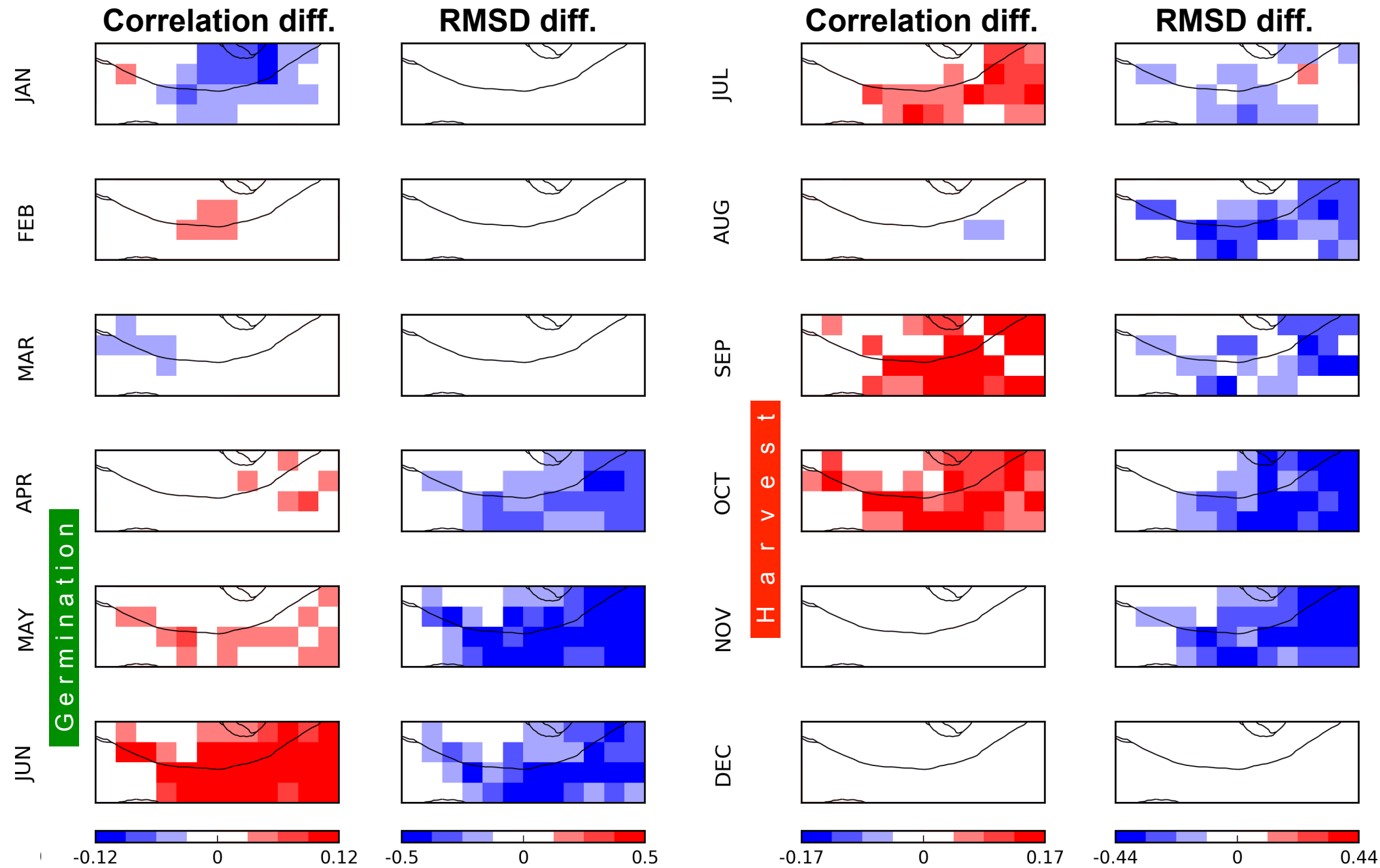
Irrigation – No irrigation



With irrigation:
→ Better correlation
→ Better RMSD

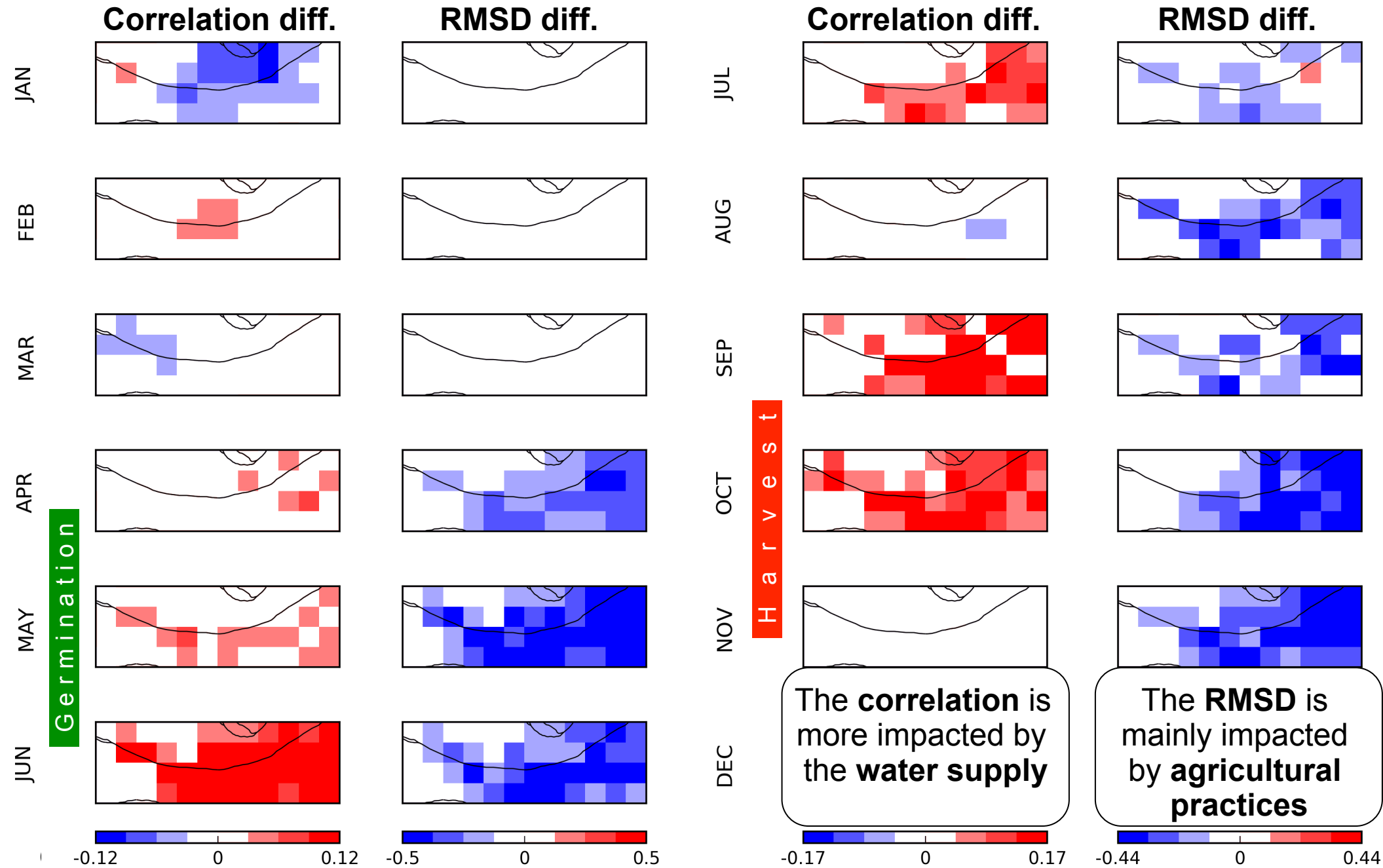
RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

LAI seasonal Statistics (no irrigation vs irrigation and obs. LAI (G0-V2 from Copernicus) -



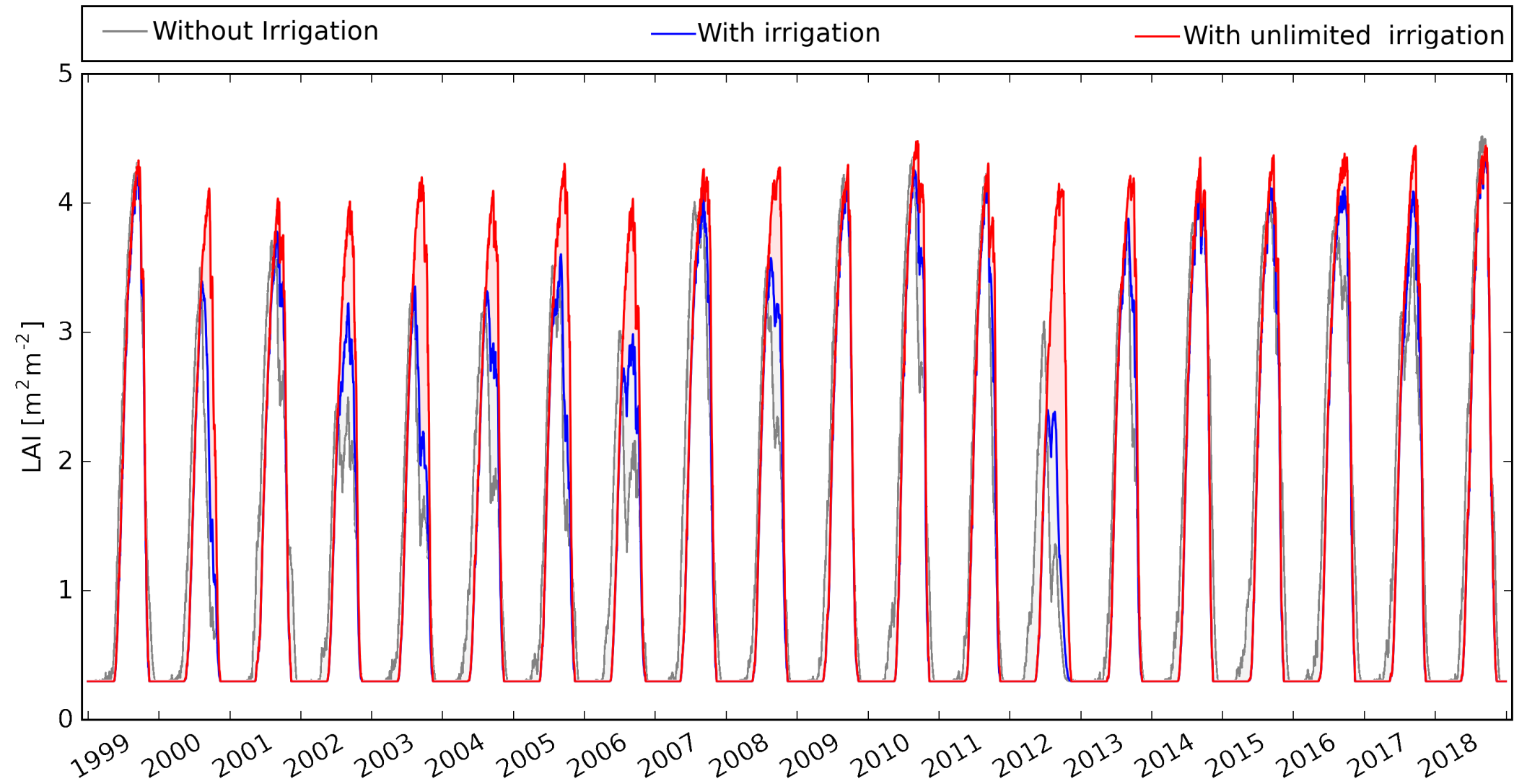
RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

LAI seasonal Statistics (no irrigation vs irrigation and obs. LAI (G0-V2 from Copernicus))



RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

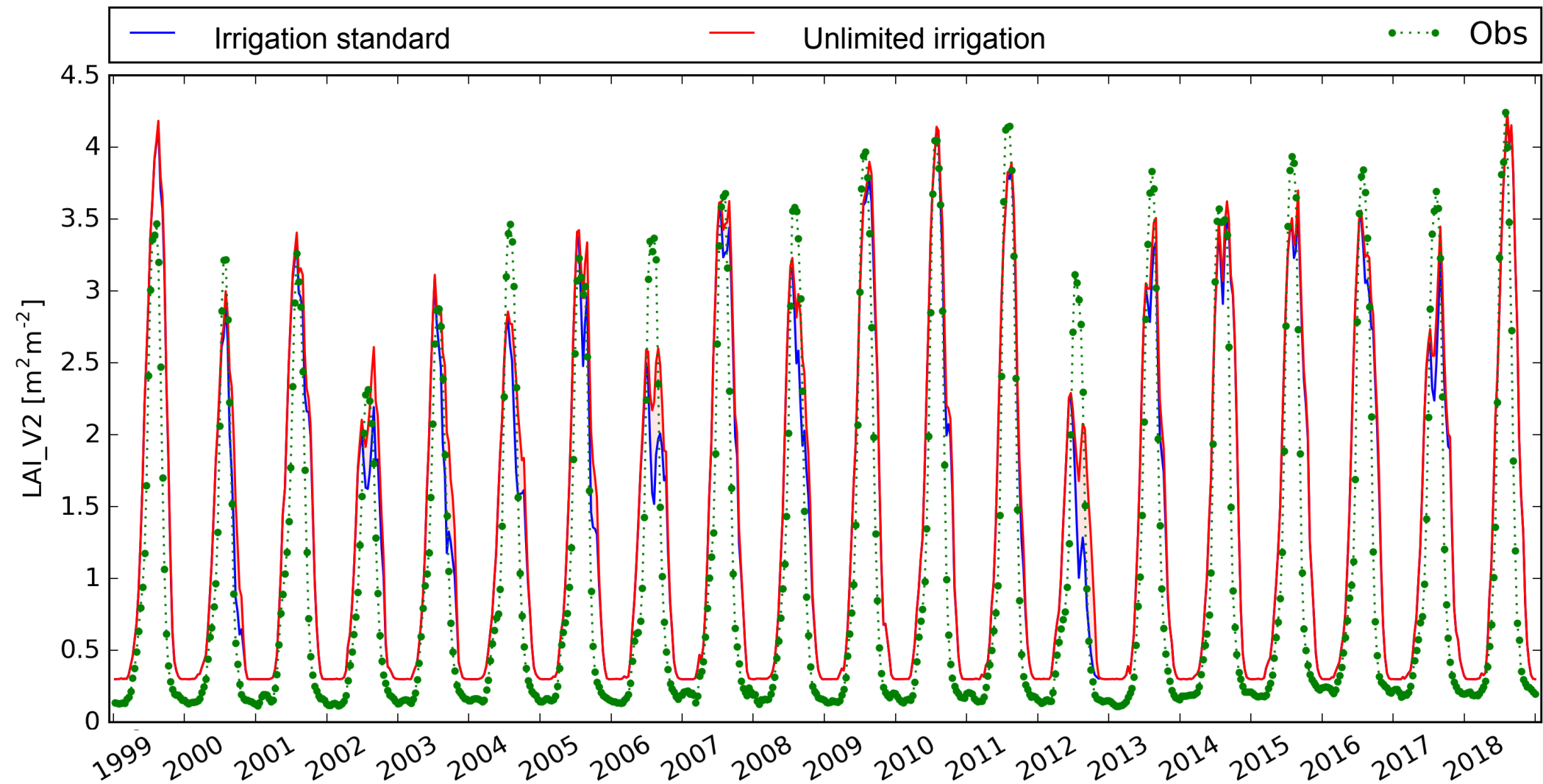
LAI C4 (non-irrigated vs irrigated vs unlimited irrigation, with TRIP): Sensitivity test



➔ Important impact of **increasing the irrigation** frequency on the **LAI maximum**

RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

LAI daily series (simulations -vs- observations with LAI G0-V2 from Copernicus)



➔ **Maxima better respected with unlimited irrigation.**

RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

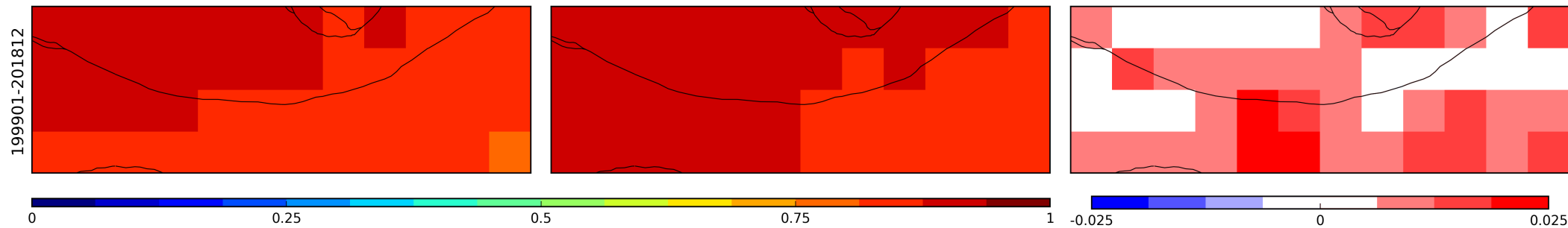
LAI Statistics (Irrigation vs unlimited irrigation and obs. LAI (G0-V2 from Copernicus))

Correlation:

Irrigation (standard)

Unlimited irrigation

Unlimited irrigation - Irrigation (standard)

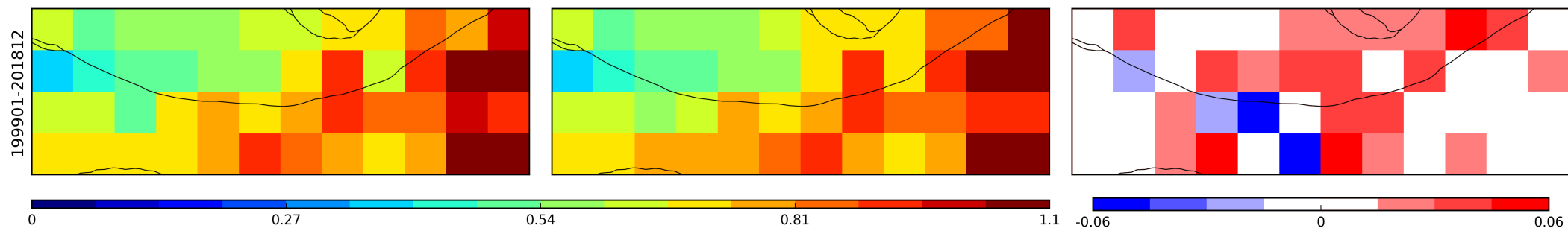


RMSD:

Irrigation (standard)

Unlimited irrigation

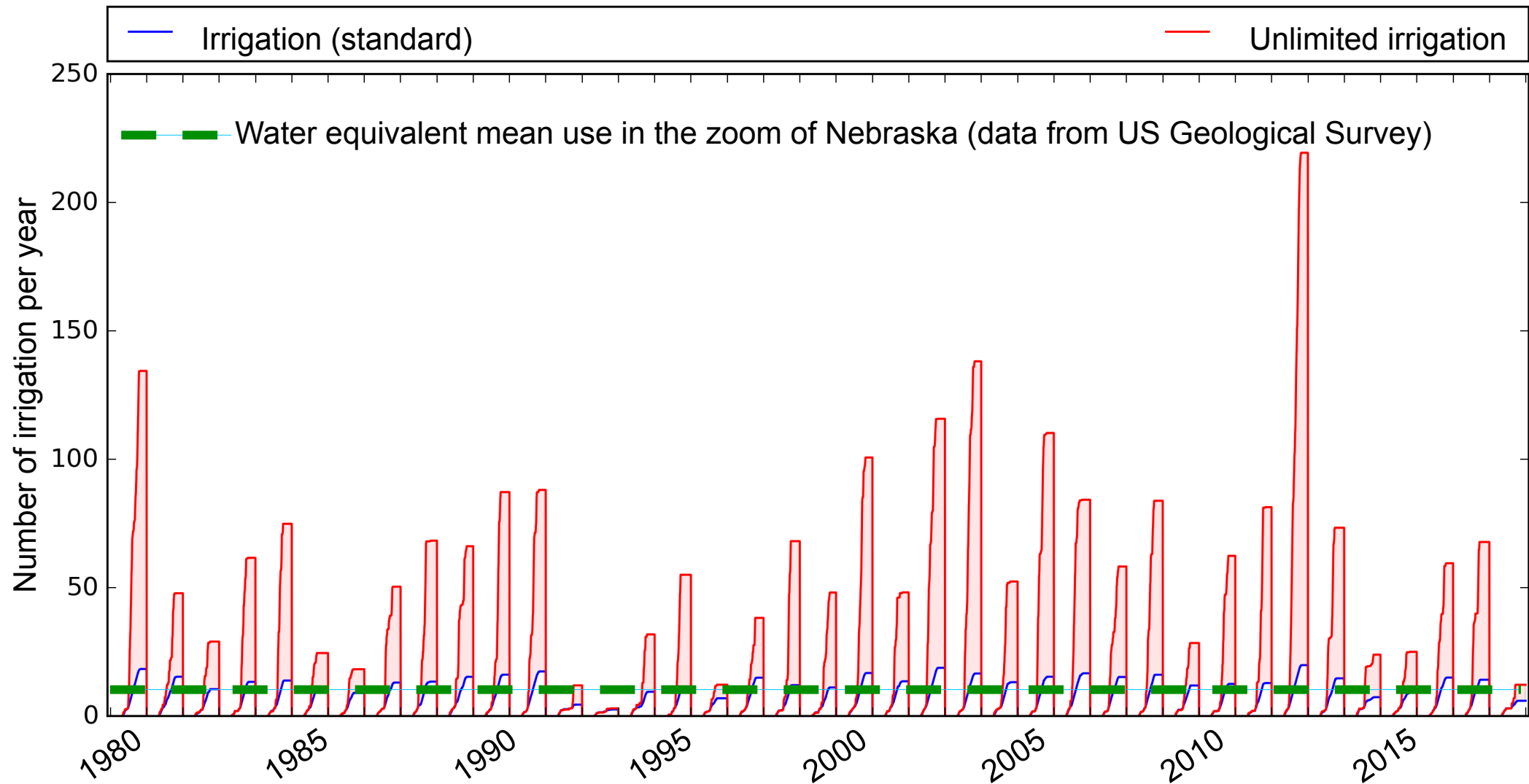
Unlimited irrigation - Irrigation (standard)



- Better correlation with more water
- RMSD less good (but depends on the season)

RESULTS: CASE OF ZOOM IN NEBRASKA (0.25° resolution)

Number of irrigation for C4 (Irrigation (standard) vs unlimited irrigation, and observations)



➔ **With unlimited irrigation, unrealistic water quantity is allocated !**

Thanks for your attention



THE 33 SURFACE TYPES IN ECOCLIMAP-SG

WATER

1. Sea and oceans (cov. 1)
2. Lakes (cov. 2)
3. Rivers (cov. 3)

URBAN (new)

24. urban LCZ1: compact high-rise
25. urban LCZ2: compact midrise
26. urban LCZ3: compact low-rise
27. urban LCZ4: open high-rise
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29. urban LCZ6: open low-rise
30. urban LCZ7: lightweight low-rise
31. urban LCZ8: large low-rise
32. urban LCZ9: sparsely built
33. urban LCZ10: heavy industry

Legend:

1. Surface type number

1. Vegtype number

A.Druel & al. - CNRM-Météo France

5. 8. Irrigated (ECOCLIMAP2 corresp.)

VEGETATION

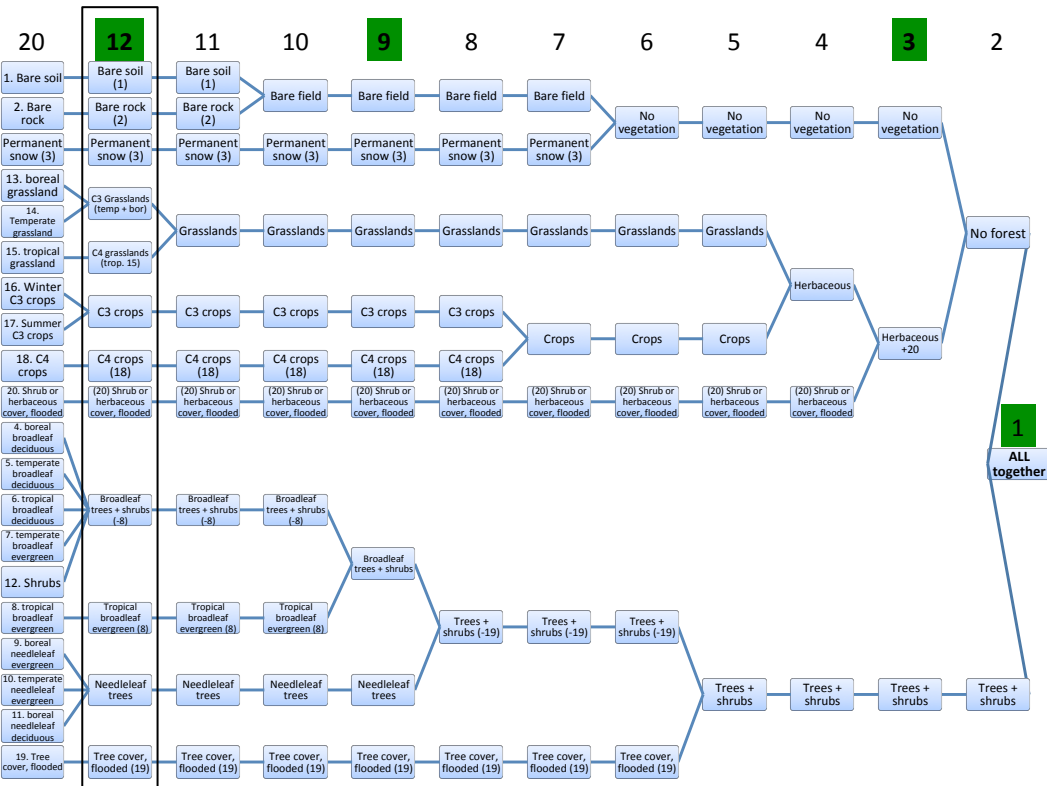
(Vegtype code in SURFEX)

Ø	1.	4. Bare soil (veg. 1)	NVT_NO
	2.	5. Bare rock (veg. 2)	NVT_ROCK
	3.	6. Permanent snow (veg. 3)	NVT_SNOW
TREES	4.	7. Boreal broadleaf deciduous (veg. 16)	NVT_BOBD
	5.	8. Temperate broadleaf deciduous (veg. 4)	NVT_TEBD
	6.	9. Tropical broadleaf deciduous (veg. 13)	NVT_TRBD
	7.	10. Temperate broadleaf evergreen (veg. 14) .	NVT_TEBE
	8.	11. Tropical broadleaf evergreen (veg. 6)	NVT_TRBE
SHRUBS	9.	12. Boreal needleleaf evergreen (veg. 5)	NVT_BONE
	10.	13. Temperate needleleaf evergreen (veg. 15) ..	NVT_TENE
	11.	14. Boreal needleleaf deciduous (veg. 17)	NVT_BOND
	12.	15. Shrubs (veg. 19)	NVT_SHRB
	13.	16. Boreal grassland (veg. 18)	NVT_BOGR
	14.	17. Temperate grassland (veg. 10)	NVT_GRAS
	15.	18. Tropical grassland (veg. 11)	NVT_TROG
HERBACEOUS	16.	19. Winter C3 crops (veg. 7)	NVT_C3W
	17.	20. Summer C3 crops (new)	NVT_C3S
	18.	21. C4 crops (veg. 8)	NVT_C4
FLOODED	19.	22. Tree cover, flooded (new)	NVT_FLTR
	20.	23. Shrub or herbaceous cover, flooded (new) ..	NVT_FLGR

NB others ECOCLIMAP2: C4 crops irrigated (veg. 9) / Wetlands (veg. 12)

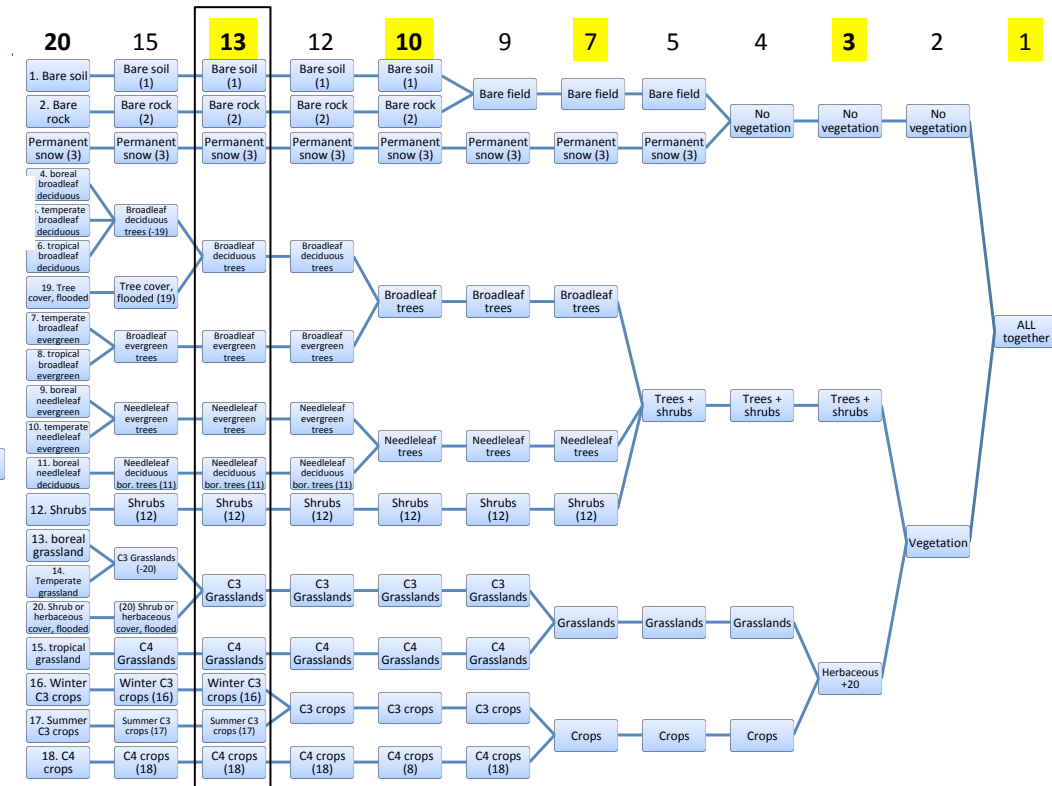
NB patches:

Current NPATCH tree (historical)



Based on ECOCLIMAP-I

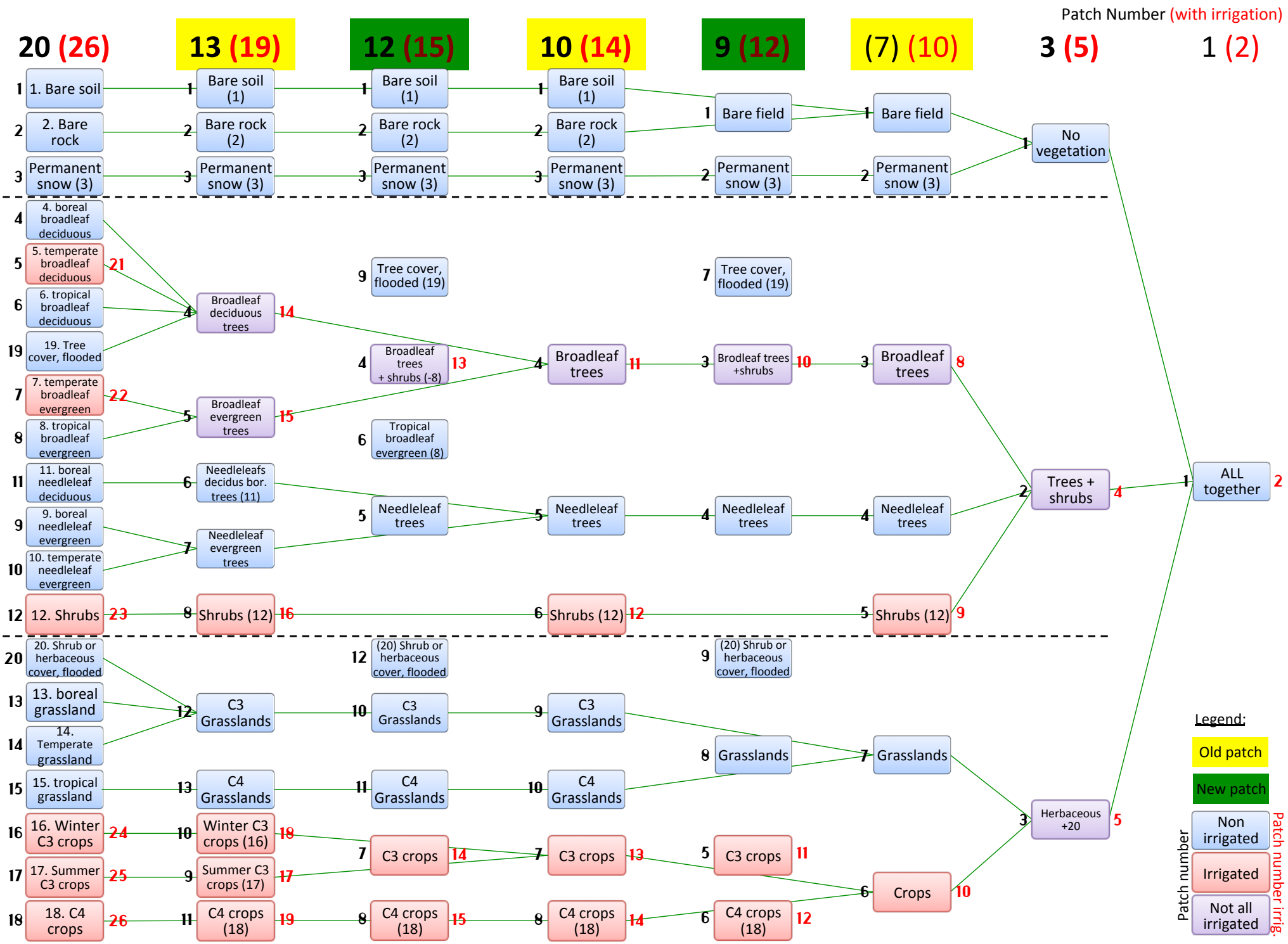
Proposal for a complete NPATCH tree overhaul



Based on vegetation characteristics

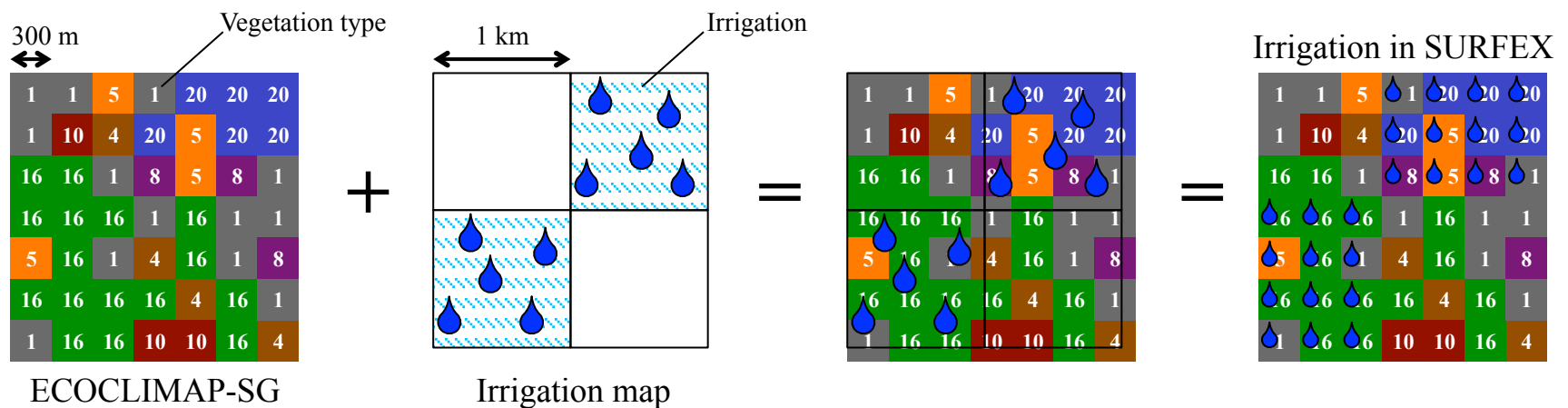
Merge

NPATCH tree proposal for SURFEX v9



Irrigation map

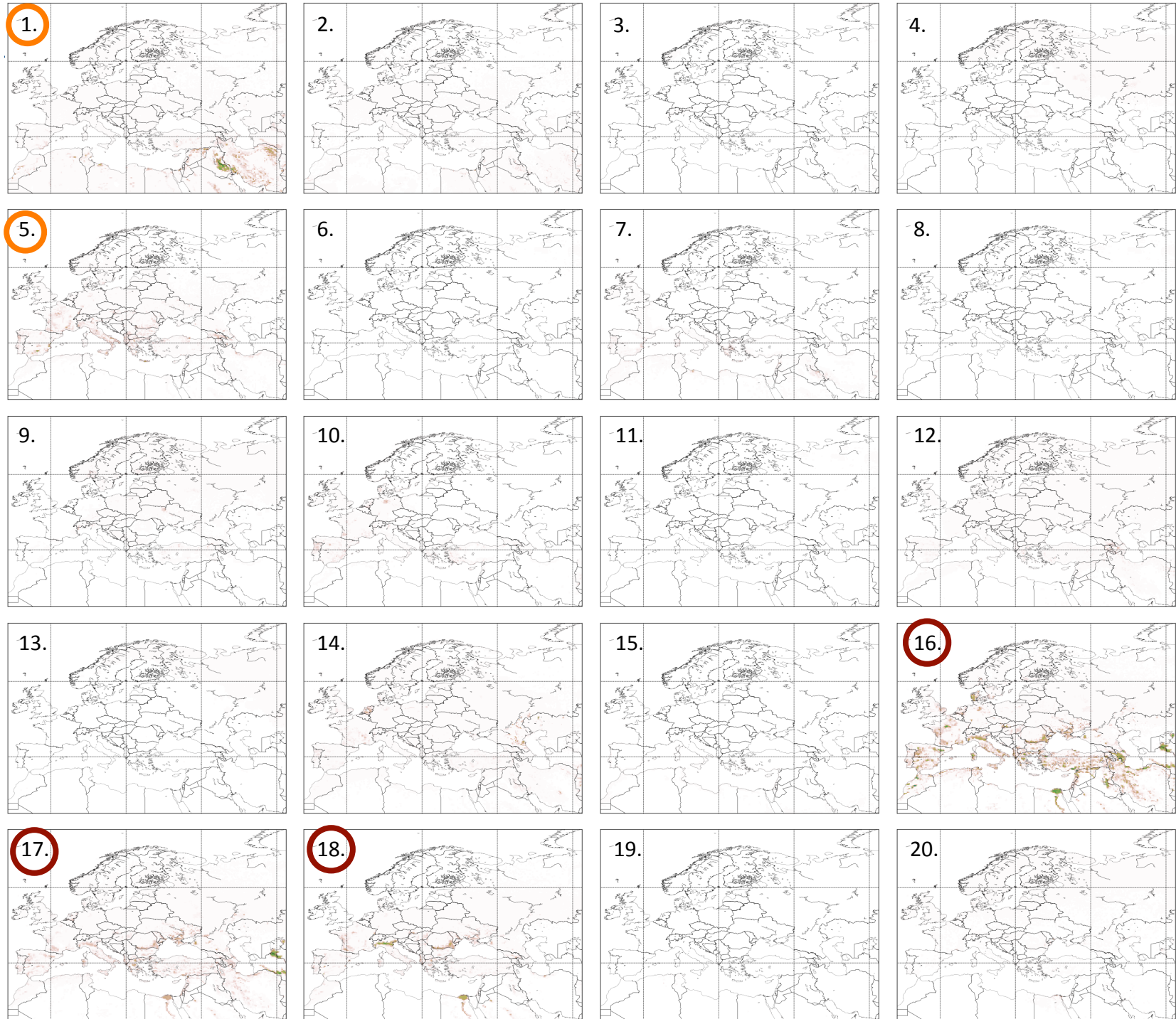
- ➔ Very high resolution map needed (for 300m ECOCLIMAP-SG)
- At world scale:
Use of **MEIER & al, 2018** irrigated area map available at **1km** resolution (based on *FAO statistical map, ESA-CCI-Land Cover (v1.6.1), NDVI and agricultural suitability*), downscaled with majority rules:
 - Crosse with surface type map ➔ irrigation map by vegetation type



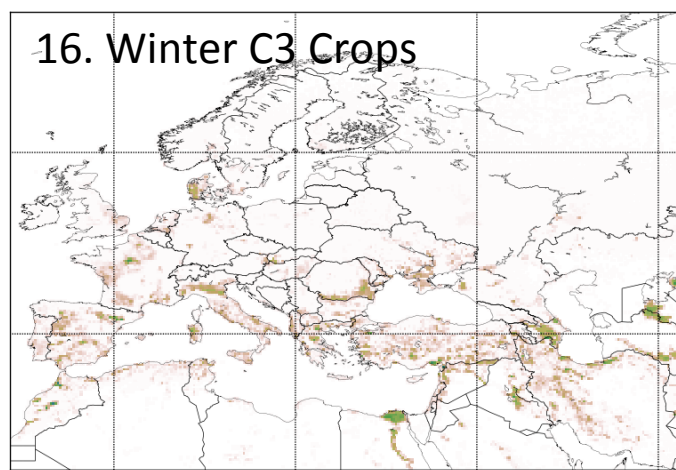
Irrigation map

- ➔ Very high resolution map needed (for 300m ECOCLIMAP-SG)
- At world scale:
Use of **MEIER & al, 2018** irrigated area map available at 1km resolution (*based on FAO statistical map, ESA-CCI-Land Cover (v1.6.1), NDVI and agricultural suitability*), downscaled with majority rules:
 - Crosse with surface type map ➔ irrigation map by vegetation type
 - Possibility (in a second time) to cross this map with dominant irrigation method by region from FAO statistics
- At shorter scale: possible to use other regional maps (as for USA in Lawston & al, 2015)

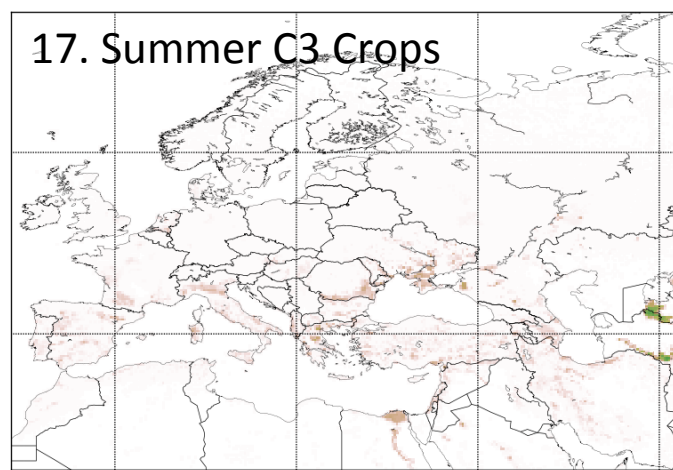
Irrigation map: By vegetation type in the model



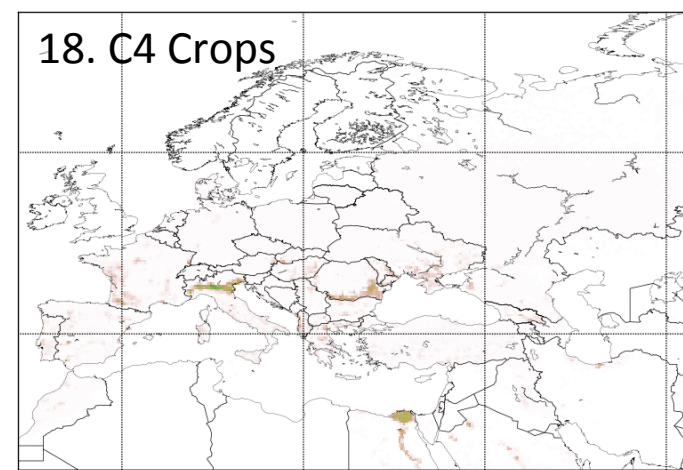
16. Winter C3 Crops



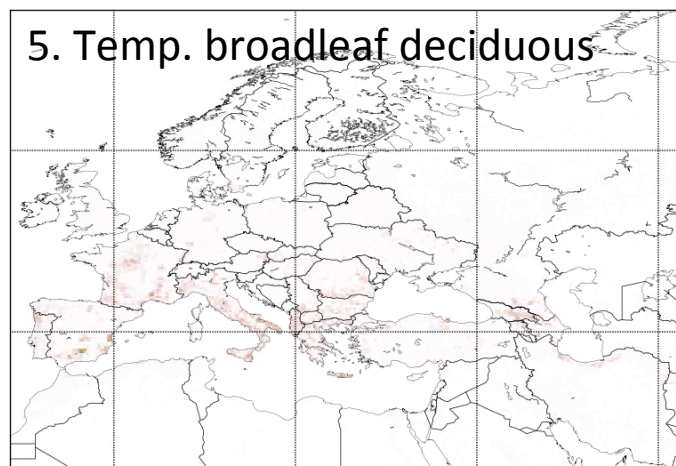
17. Summer C3 Crops



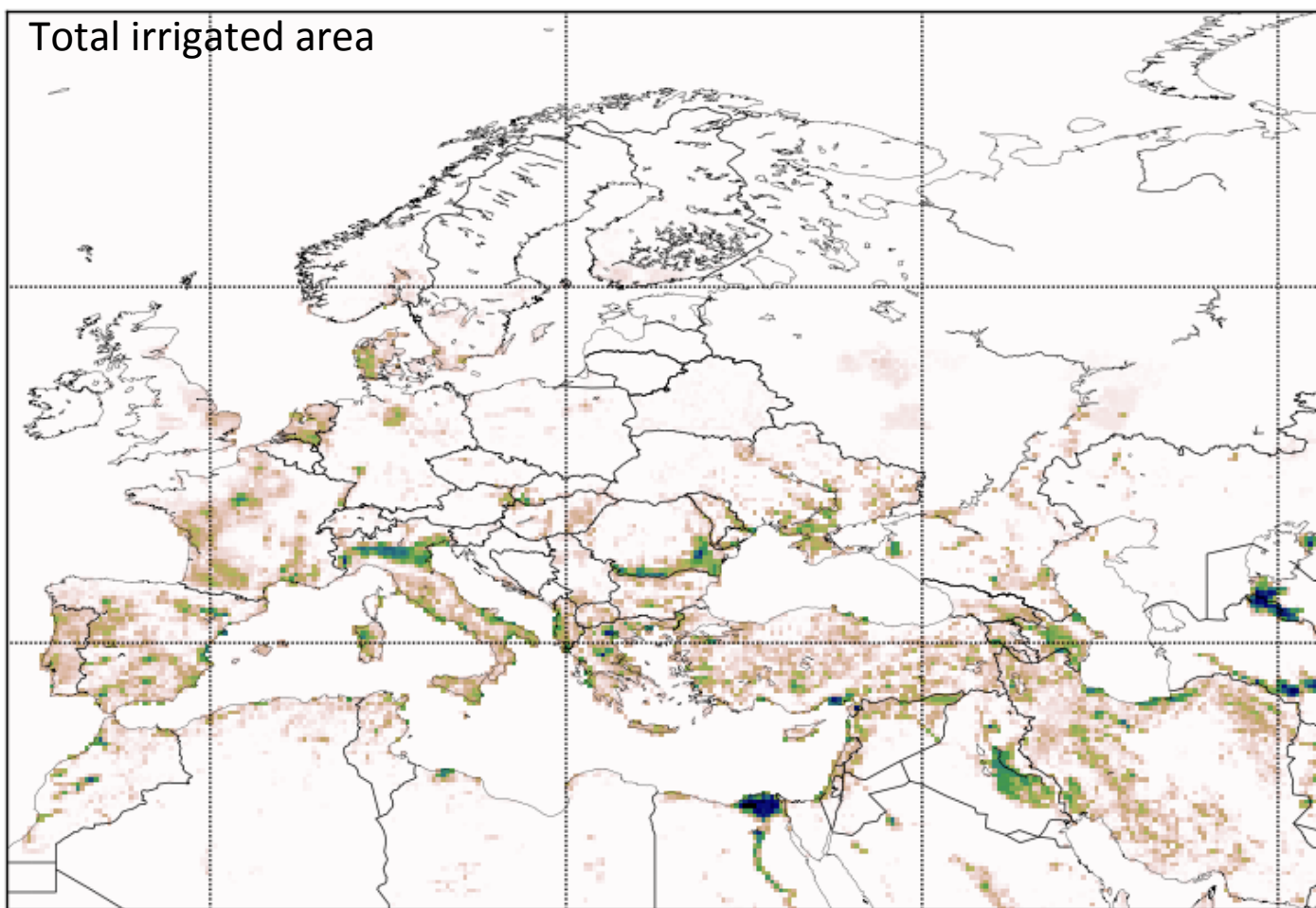
18. C4 Crops



5. Temp. broadleaf deciduous



Total irrigated area



1. Bare soil

