



# IMPLEMENTATION OF A NEW IRRIGATION SCHEME in the ISBA land surface model

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# IRRIGATION IN ECOCLIMAP-SG (SECOND GENERATION)

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## Motivation:

- To improve the representation of human impact on Earth system, agricultural practices like irrigation and its impact on **vegetation** and **water resources** need to be **better represented**.
  - ➔ Potentially improve forecast skills (*Ozdogan et al., 2010*)
- **Goals:** be able to test long term scenarii: **irrigation sustainability**, effect of climate change on the urban heat island.
- **In the context** of the last update of SURFEX (v8.1) with a new ecosystem and surface database: **ECOCLIMAP-SG**.

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

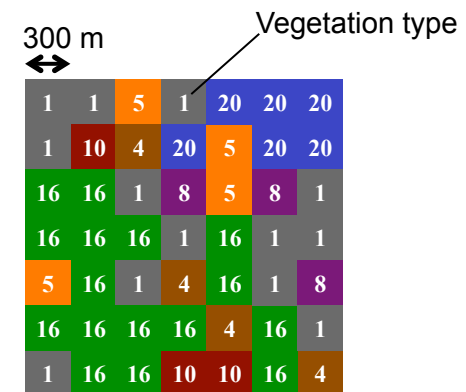
# ECOCLIMAP-SG (SECOND GENERATION)

**ECOCLIMAP-SG** main changes:

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

## ECOCLIMAP-SG

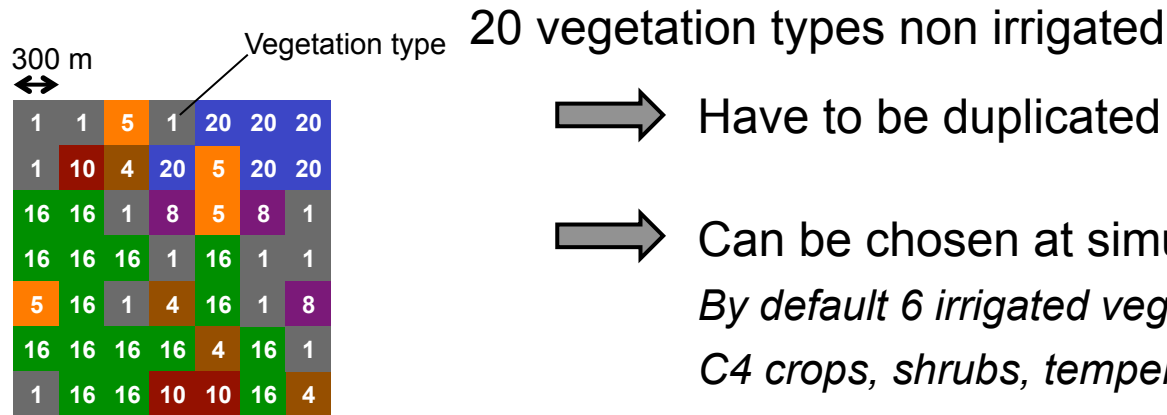
- New vegetation description  
(covers, LAI, albedo, tree height, ...)
- Global resolution 300 m x 300 m:  
1 surface type per pixel



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

# IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

## ECOCLIMAP-SG Land cover:

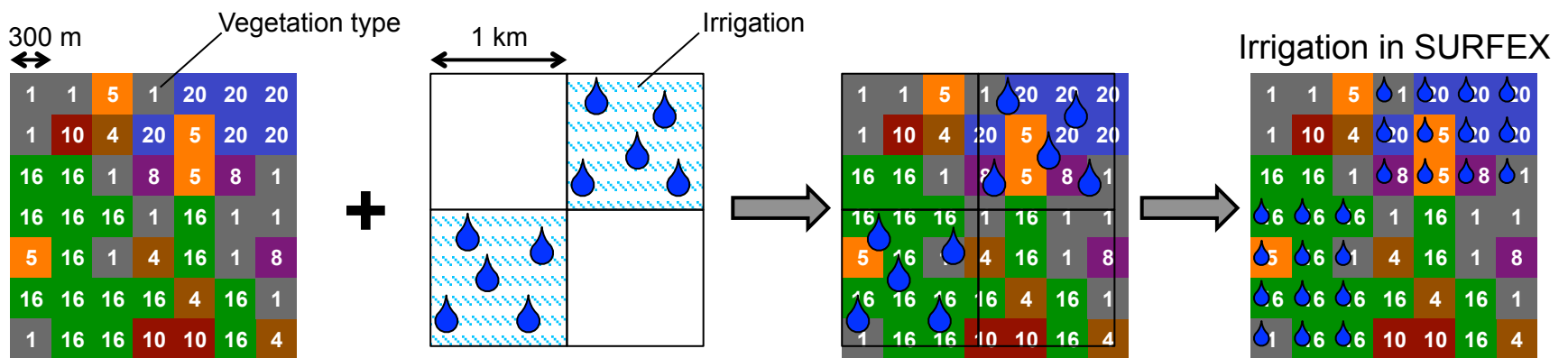


➡ Have to be duplicated to be irrigated

➡ Can be chosen at simulation setup

*By default 6 irrigated vegetation type: winter & summer C3 crops, C4 crops, shrubs, temperate broadleaf deciduous and evergreen trees.*

## ➔ High resolution irrigation map needed:



ECOCLIMAP-SG

Irrigation map  
From Meier et al., 2018



# IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

## What is irrigation?

To apply a **quantity of water** distributed over a **period of time**

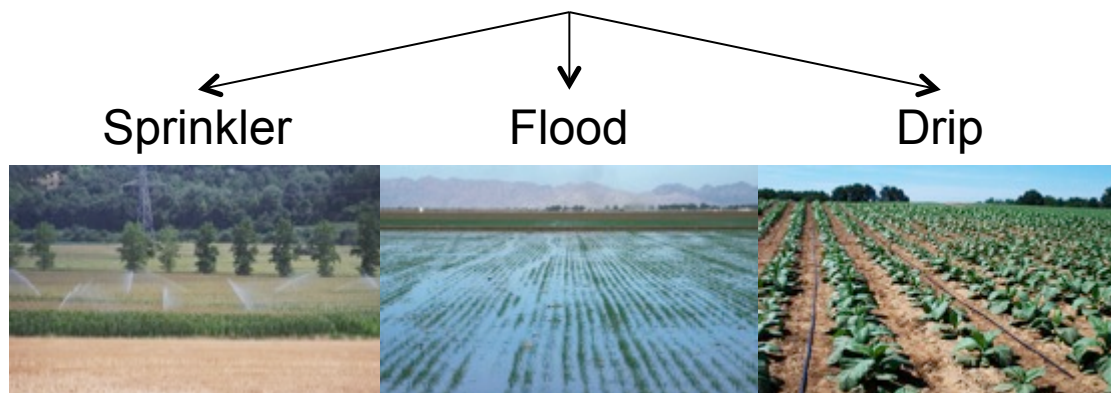
→ Well documented in large scale land surface model, e.g.:

*Lawston et al., 2015, jhm*

*Ozdogan et al., 2010, jhm*

*Evans & Zaitchik, 2008, hess*

→ Three irrigation methods are represented:



# IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

## I. Fields equipped for irrigation and types?

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

## II. Irrigation period?

Agricultural practices:  
Between germination  
and reaping dates



## III. Irrigation needed?

Irrigation trigger threshold

## IV. Link to water availability?

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

## V. Irrigation

Water quantity and  
application period

## VI. Minimum return time ?

Between two irrigations



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**Implemented**

→ Can be specify  
for each vegetation  
type and grille point

**To do**

Water availability

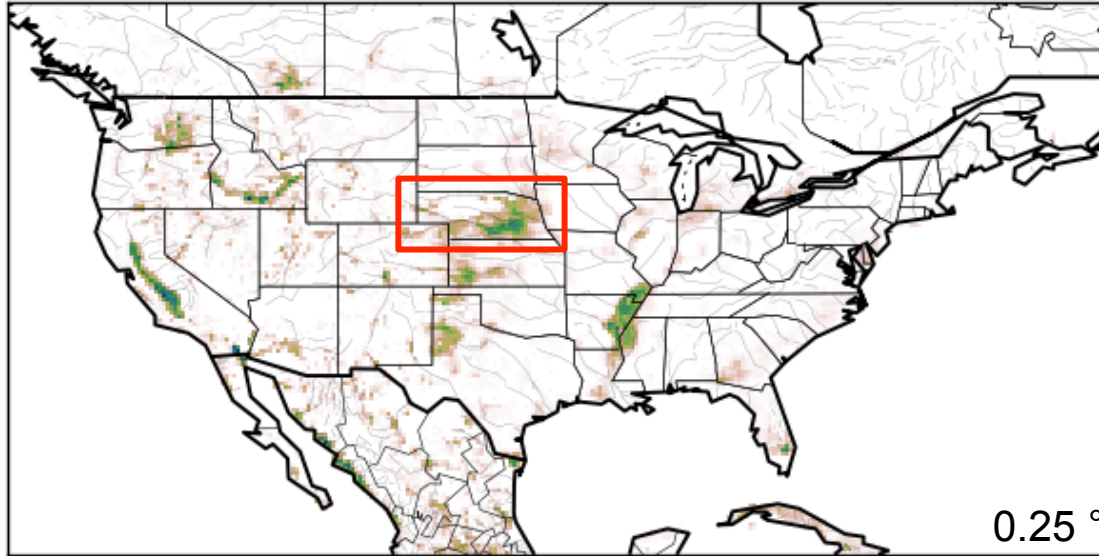
## VI. Minimum return time ?

Between two irrigations

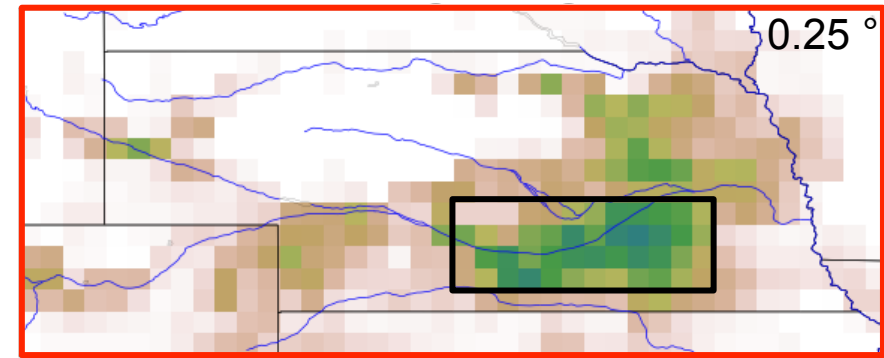
# Results: Nebraska test case (0.25° resolution)

## Irrigation distribution

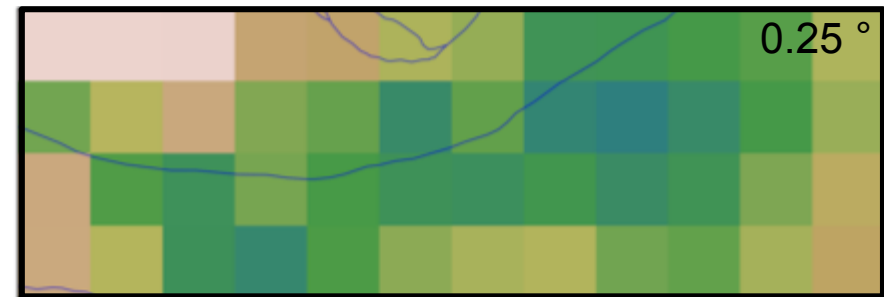
(a) Continental United State (0.25°)



(b) Nebraska (0.25°)



(c) Selected zone in Nebraska (0.25°)



### Simulation configuration:

- Vegetation description: ECOCLIMAP-SG
- Irrigated vegetation: crops (C3 & C4)
- 1979-2018 (with 20 years of spinup)
- Crop seasons (mid-May to mid-September)
- 3 simulations: reference, agricultural practices, and agricultural practices with irrigation
- 1 irrigation = 30 mm

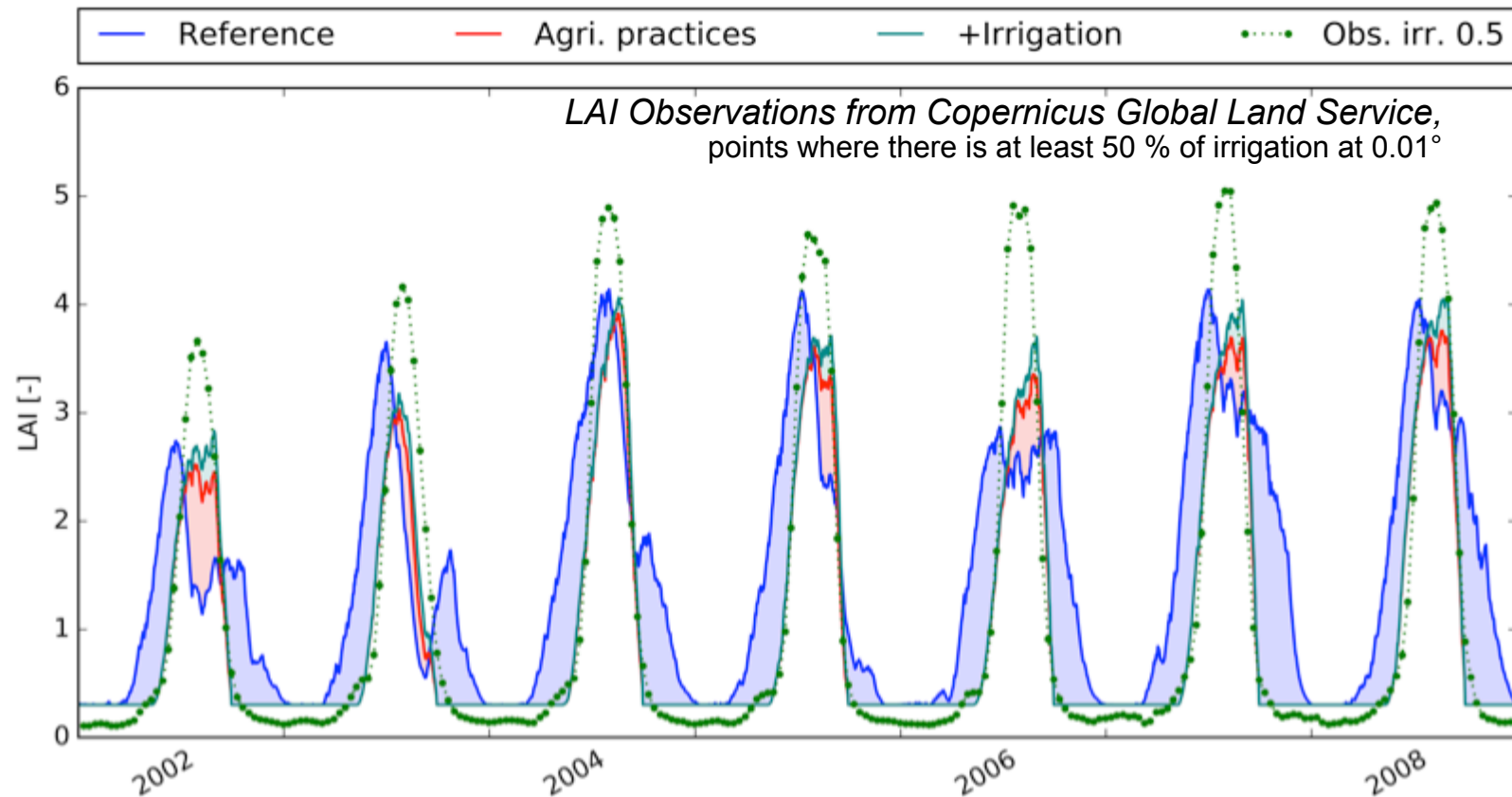


# RESULTS:

## Seasonal LAI of crops (C3 & C4)

(Irrigated fraction on selected area)

Time series of crops LAI variation, 2002-2008



- ➔ Agricultural practices improve the seasonal cycle, but not the inter-annual variability
- ➔ Irrigation further improves the peak
- ➔ **Better agreement with agricultural practices and irrigation**

# RESULTS:

## Seasonal LAI

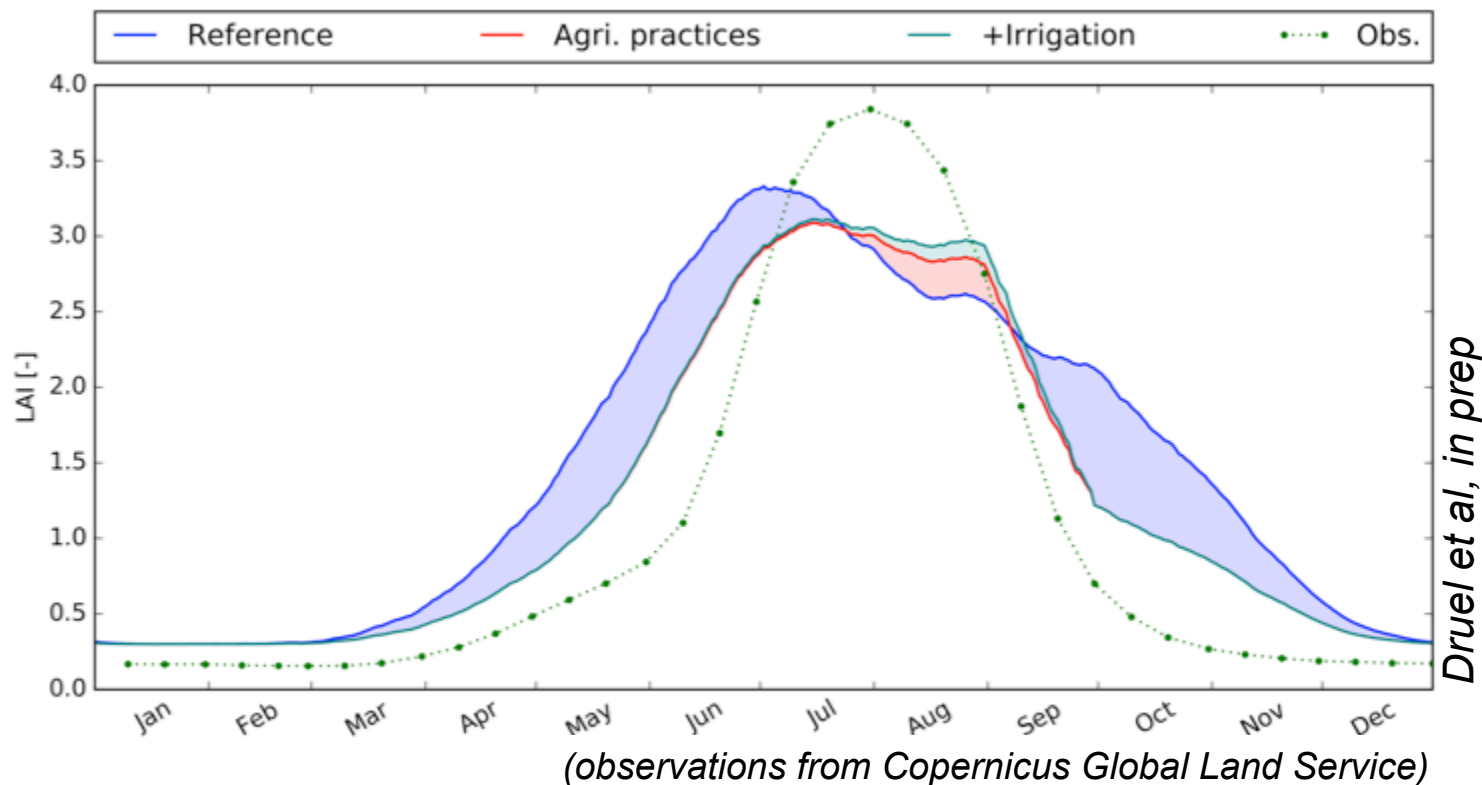
(selected area)

For all vegetation types

→ Lower LAI simulated than in observations

→ Better agreement with agricultural practices and irrigation

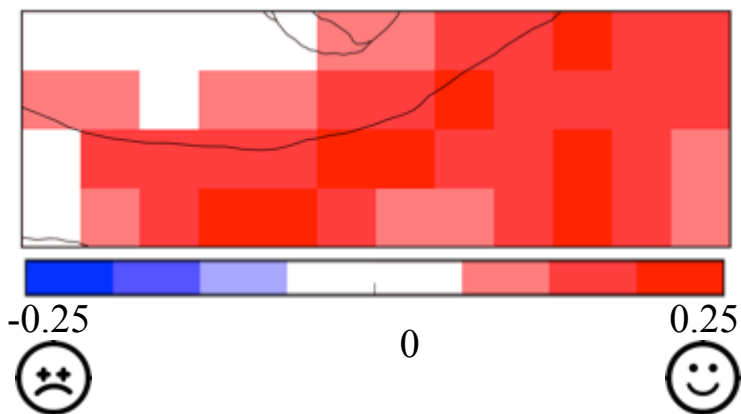
(a) Seasonal LAI variation of all vegetation, mean 1999-2018



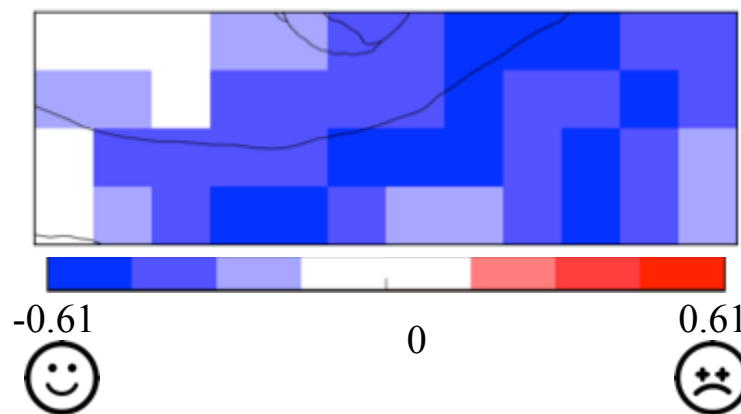
Druel et al, in prep

### Score differences:

(b) Correlation: Irrigation - Reference



(c) RMSD: Irrigation - Reference

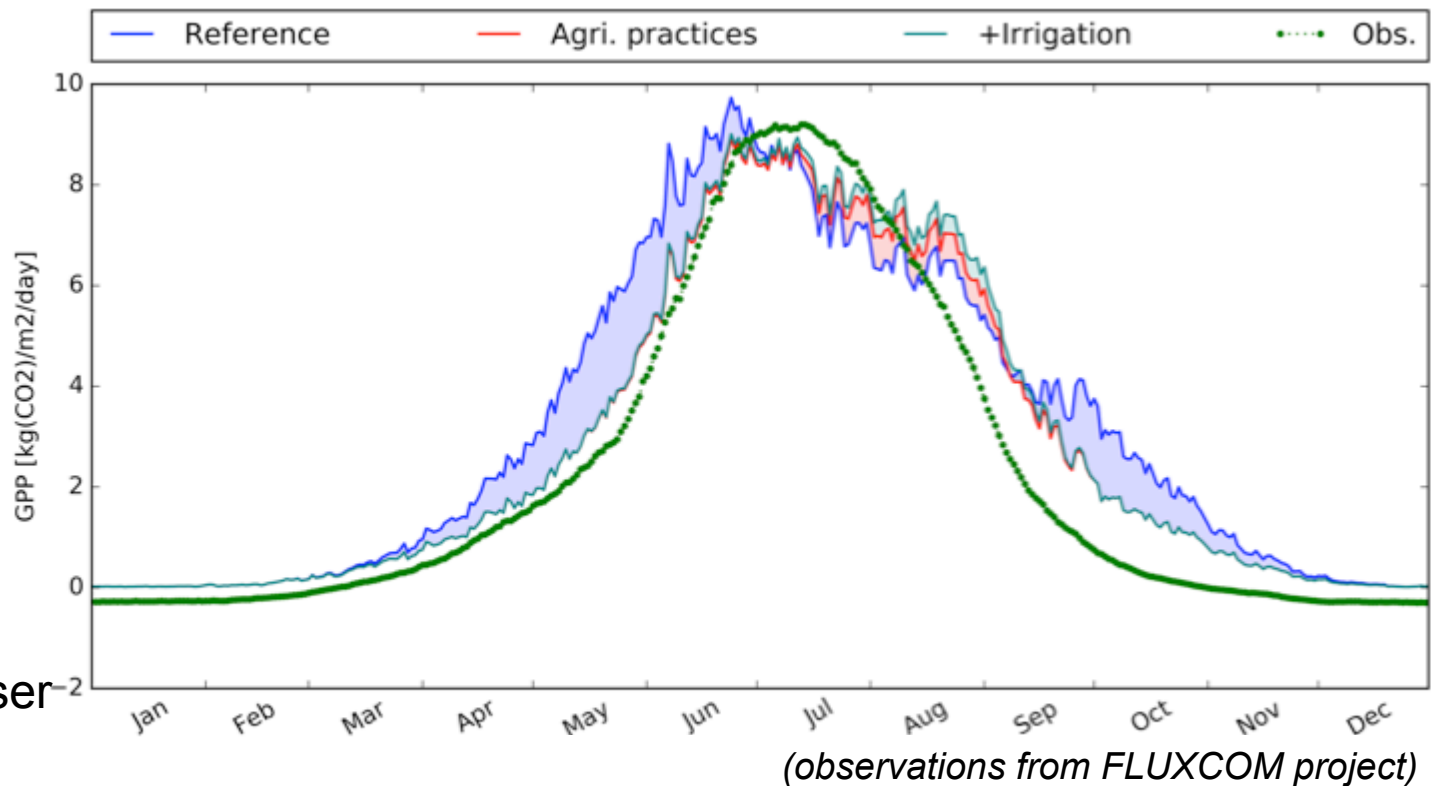


Druel et al, in prep

# RESULTS:

## Seasonal GPP (selected area)

(a) Seasonal GPP variation of all vegetation, mean 1980-2013

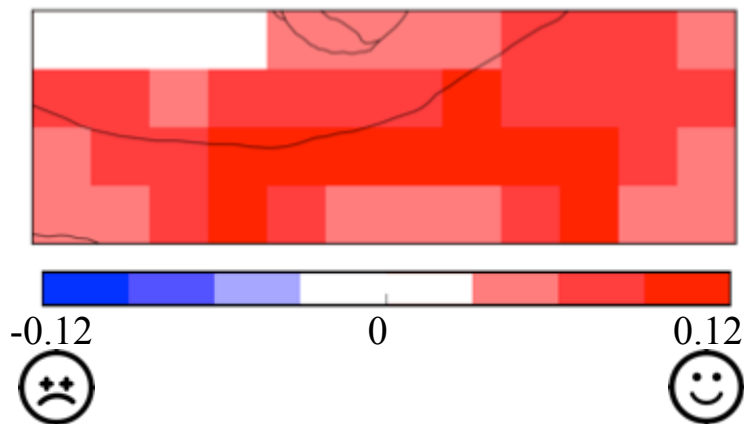


→ Amplitude of signal closer to the observation

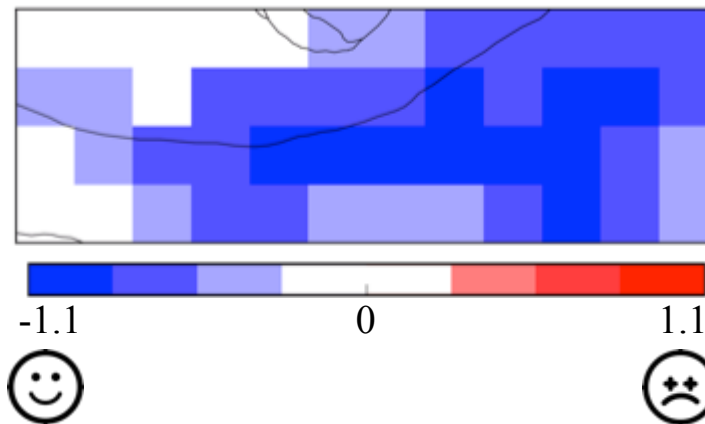
→ **Better agreement with agricultural practices and irrigation**

### Score differences:

(b) Correlation: Irrigation - Reference



(c) RMSD: Irrigation - Reference

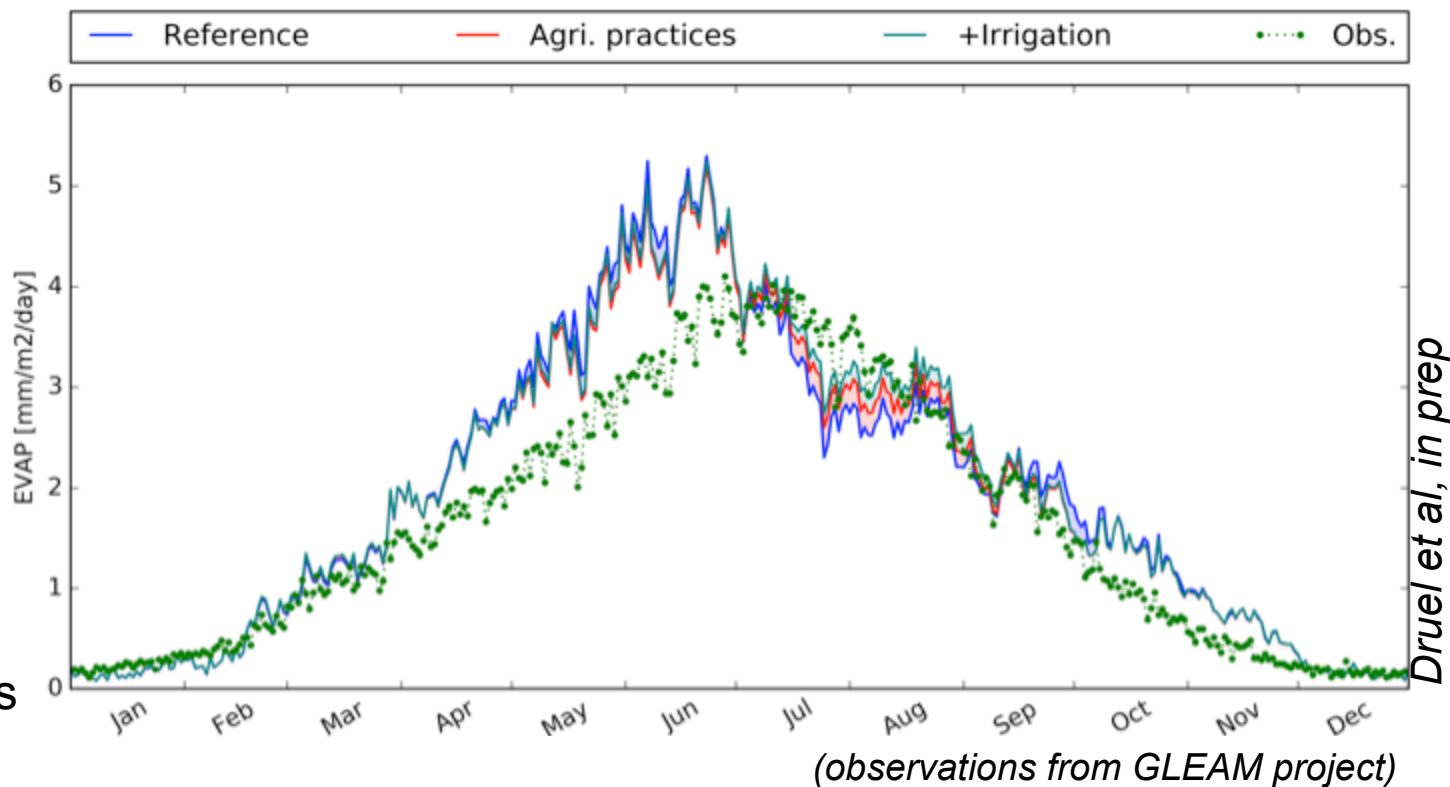


Druel et al, in prep

# RESULTS:

## Seasonal evapotranspiration (selected area)

(a) Seasonal evaporation variation of all vegetation, mean 2003-2018

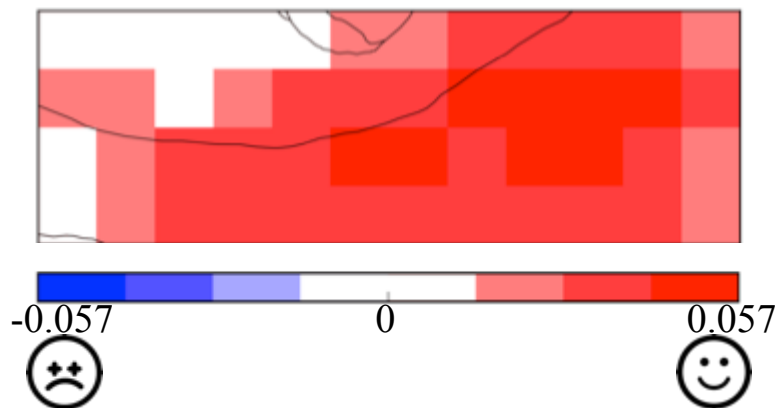


→ Maintains significant bias from April to June

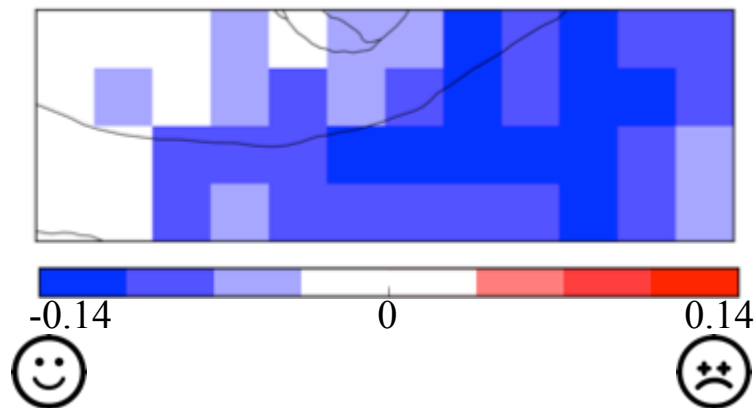
→ **Better agreement with agricultural practices and irrigation**

### Score differences:

(b) Correlation: Irrigation – Reference



(c) RMSD: Irrigation – Reference



# RESULTS:

## Seasonal land surface temperature (selected area)

→ Relatively small changes

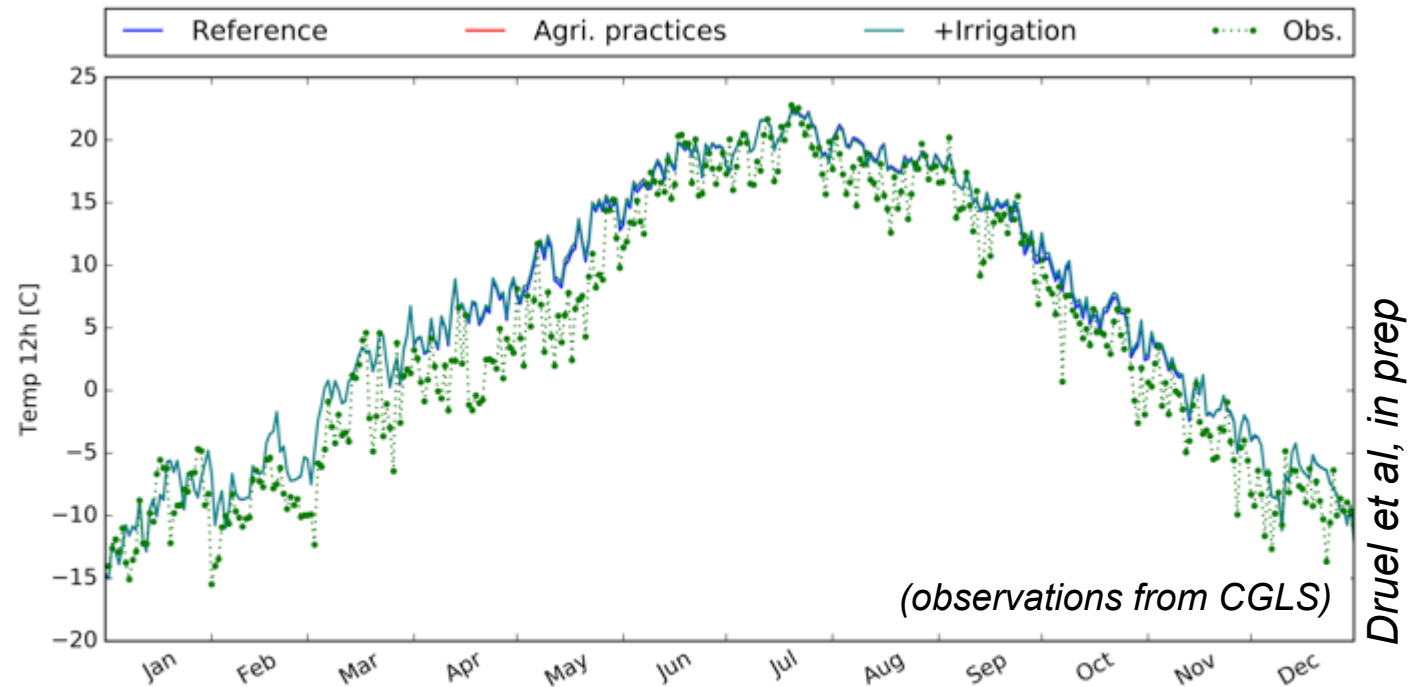
→ But significant for the temperature difference!

In summer:

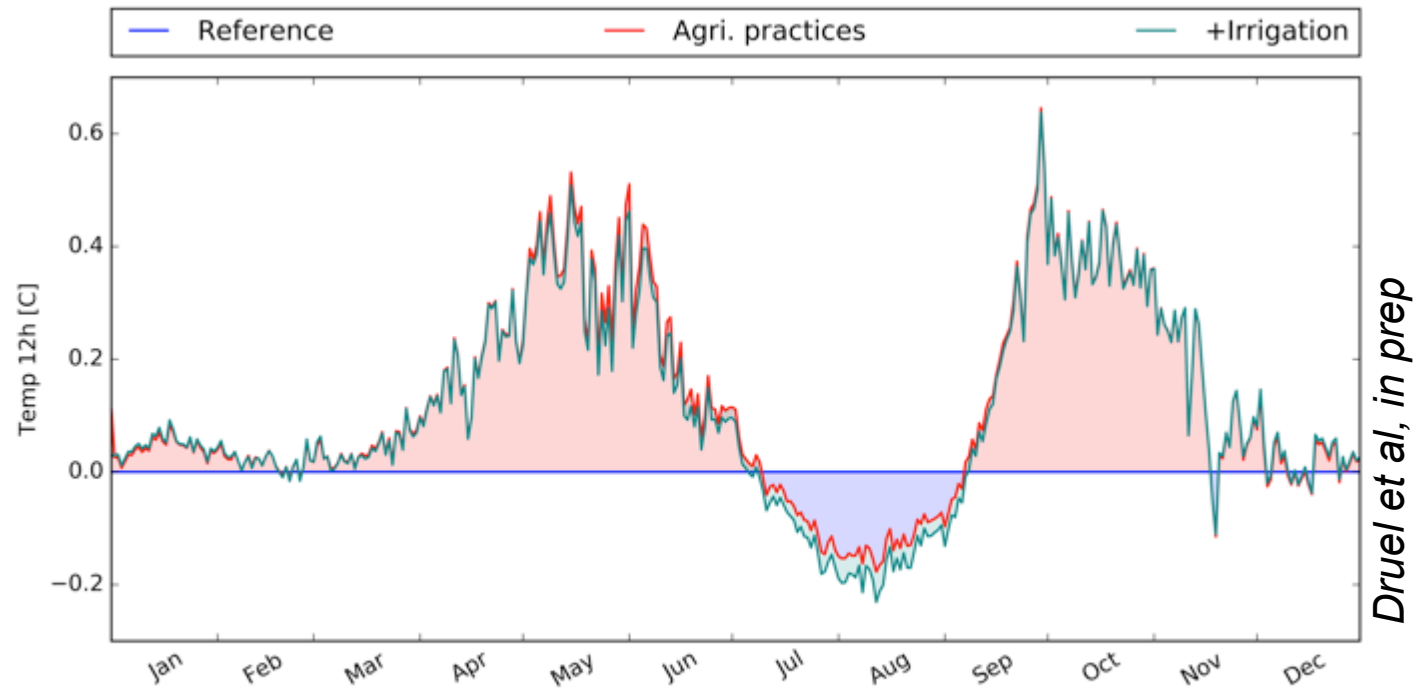
→ Cooling impact in summer when irrigation is stronger

→ Better scores

(a) Seasonal land surface temperature variation, mean 2009-2018 at 12h



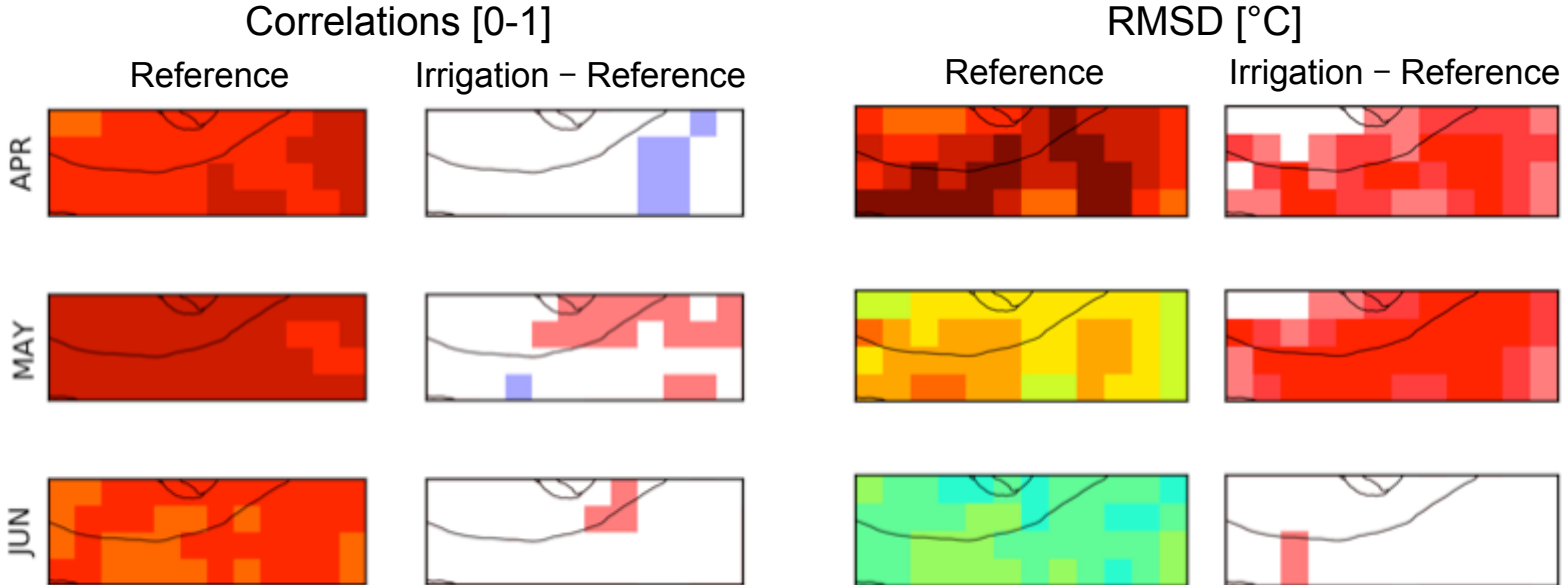
(b) Seasonal land surface temperature variation difference, 2009-2018 at 12h



# RESULTS:

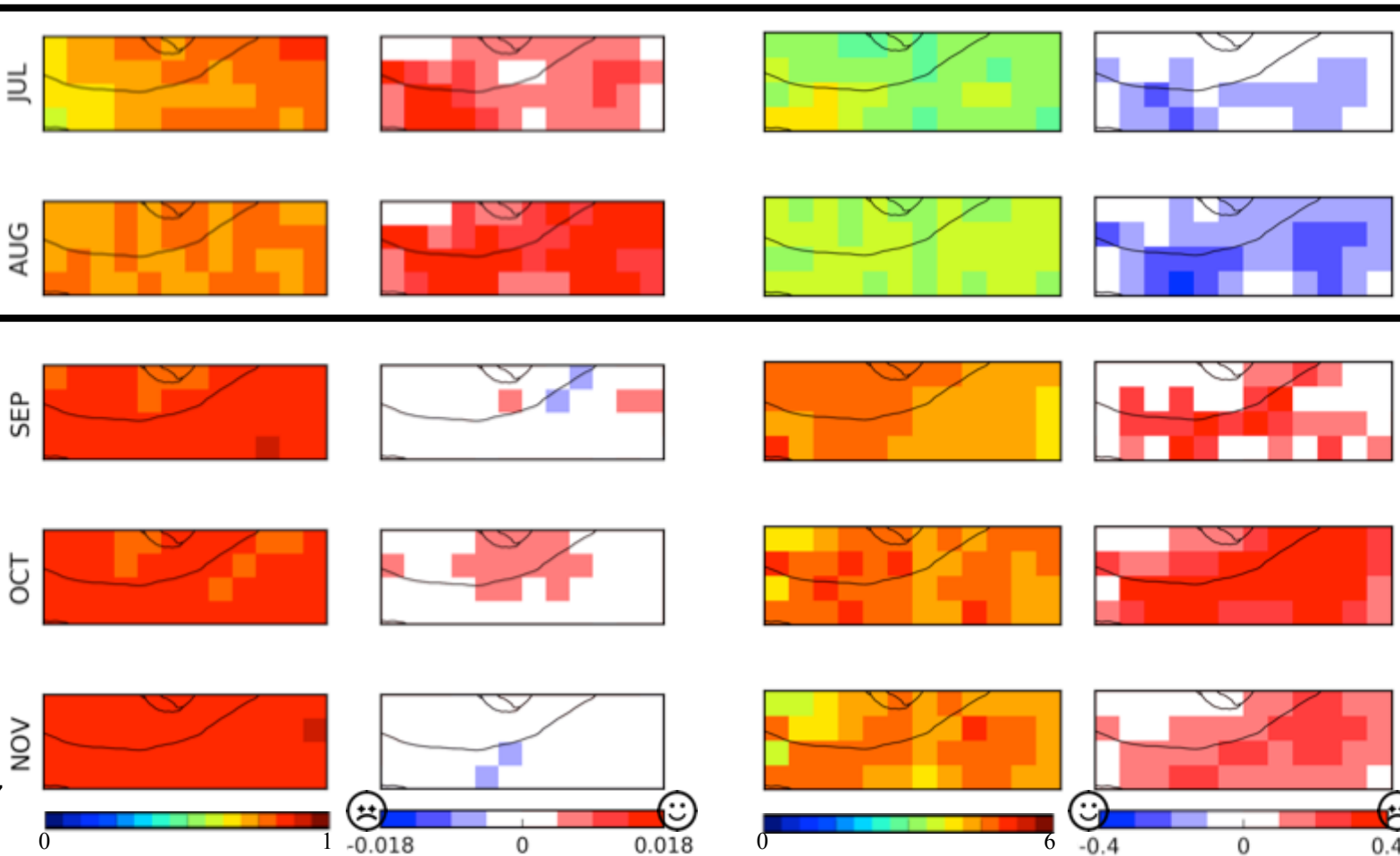
Seasonal  
land surface  
temperature  
(selected area)

Germination



Impact  
mainly  
attributed  
to irrigation

Harvest



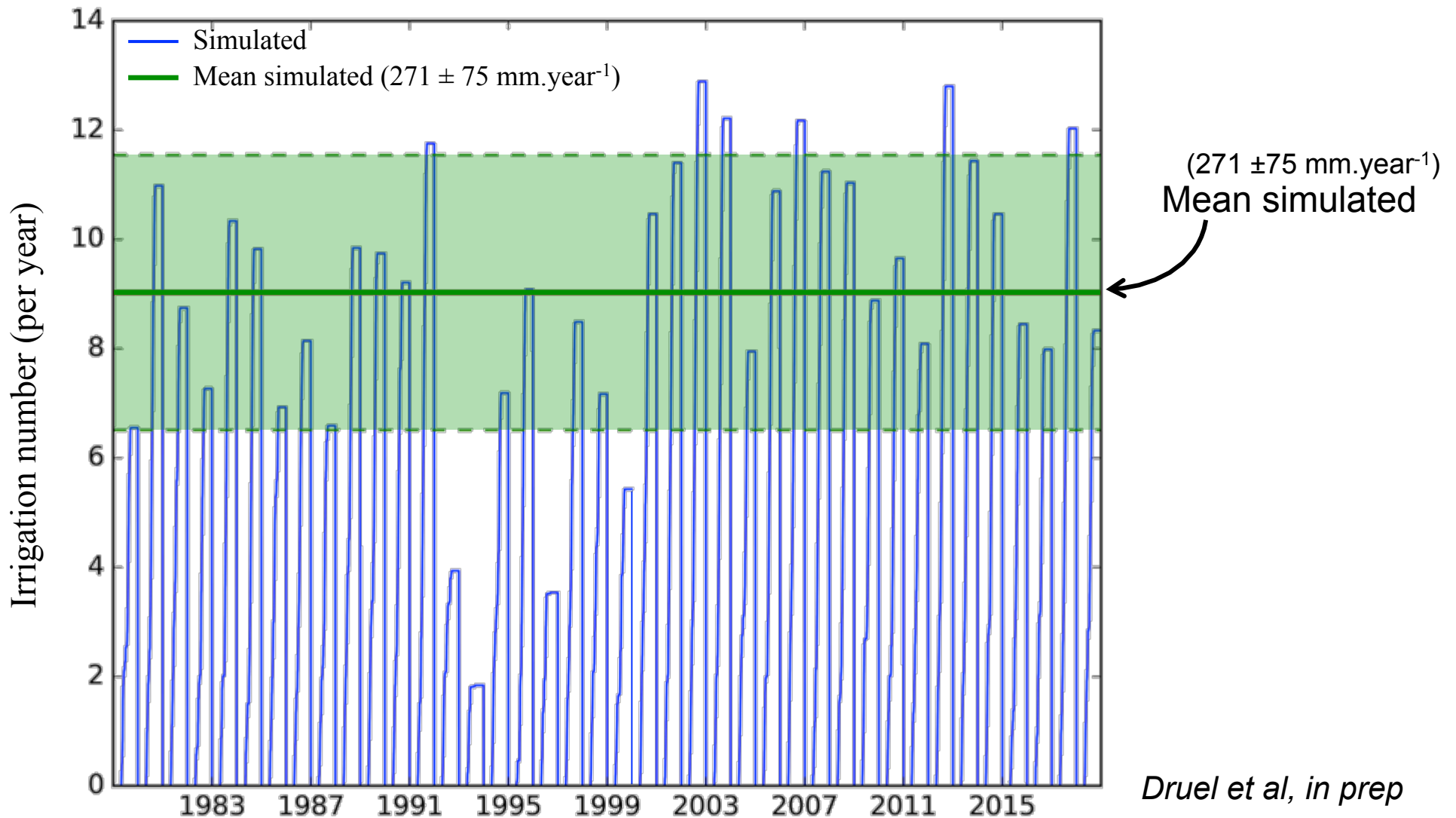
Druel et al, in prep

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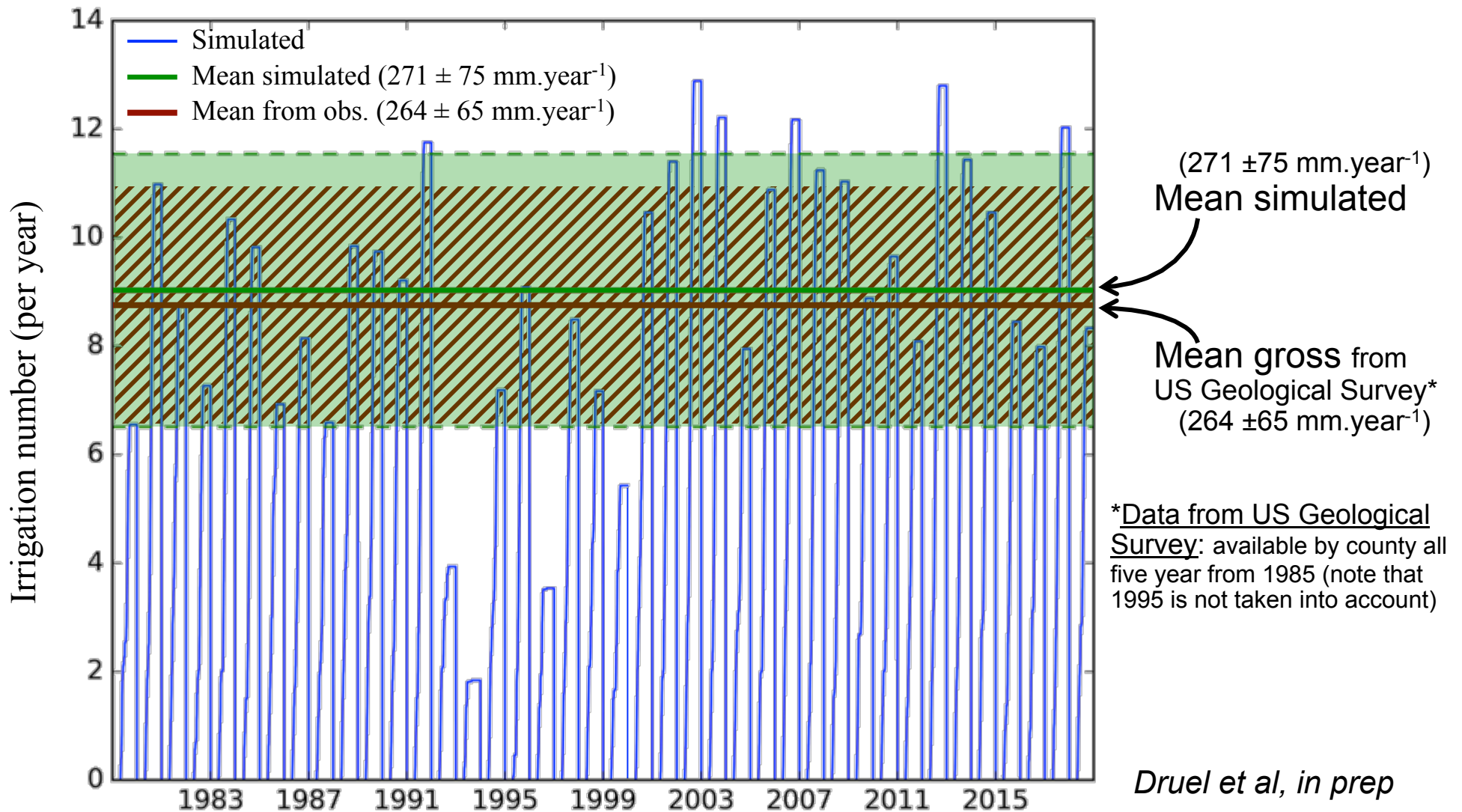
# Results: Nebraska test case (0.25° resolution)

## Number of irrigation for crops (per year)



# Results: Nebraska test case (0.25° resolution)

## Number of irrigation for crops (per year)



→ The quantity of water simulated for the irrigation is coherent with uses

# CONCLUSION

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## → **Great flexibility** of irrigation-related configurations

(type of vegetation irrigated, irrigation trigger threshold, time between irrigations, duration of irrigation, multi-annual season...)

## → **Good representation of irrigation:**

- Reproduces a coherent **water quantity used** for irrigation
- For all tested output, by taking into account agricultural practices and irrigation, there is a **better agreement with observations**
- Shows the potential **impact on local carbon, energy and water cycles**

## → **Included in the next version** of SURFEX (V9 in development)

# PERSPECTIVES

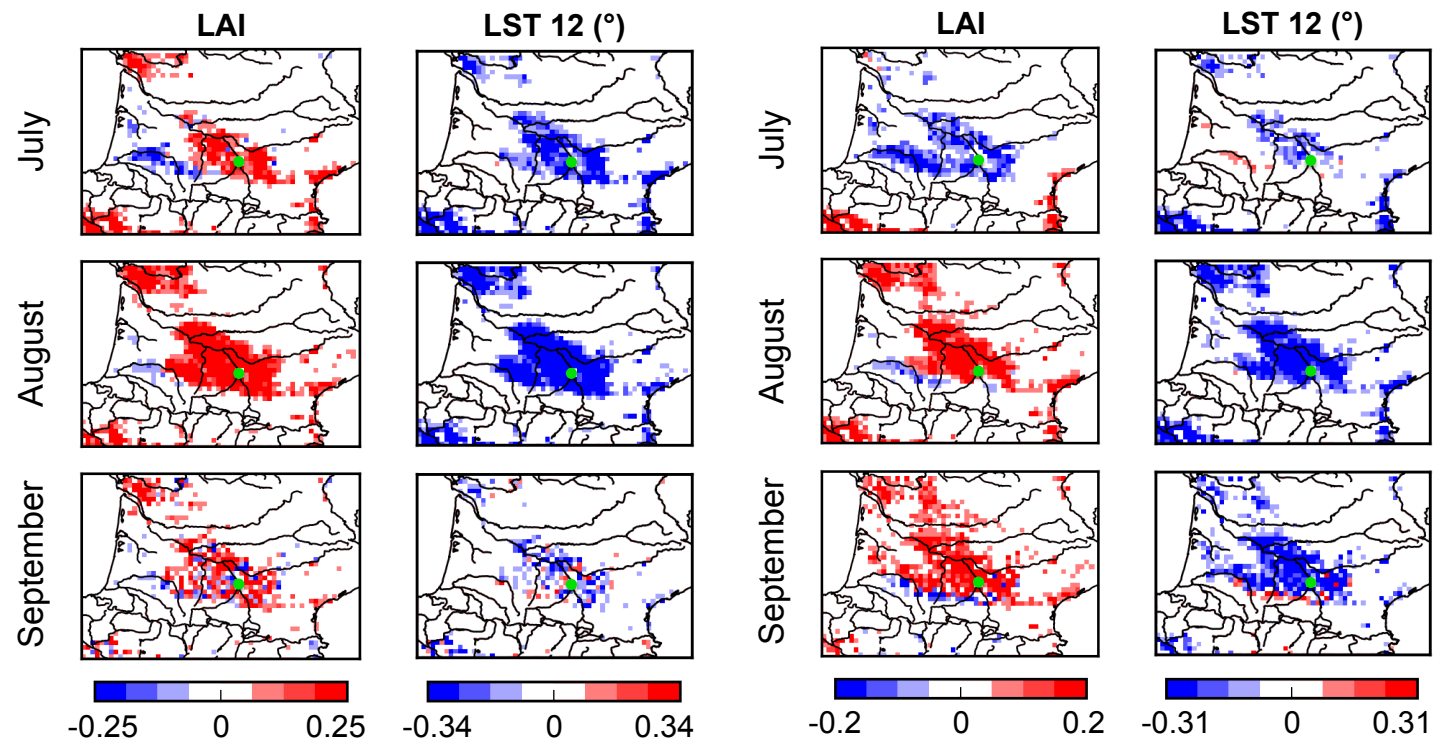
## Implementation:

- Couple with Météo-France hydrological system (planned for 2020)
- Develop maps of irrigation seasons and types?

## Explore new possibility of simulation

- Example: **Irrigated vs. non irrigated in 2017**      **Irrigated vs. non irrigated in 2018**

South-West  
of France  
0.1°





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
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

Legend:

1. Surface type number

1. Vegtype number

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
T	4.	7. Boreal broadleaf deciduous (veg. 16) .....	NVT_BOBD
	5.	<b>8. Temperate broadleaf deciduous</b> (veg. 4) ....	NVT_TEBD
	6.	9. Tropical broadleaf deciduous (veg. 13) .....	NVT_TRBD
	7.	<b>10. Temperate broadleaf evergreen</b> (veg. 14) .	NVT_TEBE
	8.	11. Tropical broadleaf evergreen (veg. 6) .....	NVT_TRBE
	9.	12. Boreal needleleaf evergreen (veg. 5) .....	NVT_BONE
S	10.	13. Temperate needleleaf evergreen (veg. 15) ..	NVT_TENE
	11.	14. Boreal needleleaf deciduous (veg. 17) .....	NVT_BOND
	12.	<b>15. Shrubs</b> (veg. 19) .....	NVT_SHRB
	13.	16. Boreal grassland (veg. 18) .....	NVT_BOGR
	14.	17. Temperate grassland (veg. 10) .....	NVT_GRAS
H	15.	18. Tropical grassland (veg. 11) .....	NVT_TROG
	16.	<b>19. Winter C3 crops</b> (veg. 7) .....	NVT_C3W
	17.	<b>20. Summer C3 crops</b> (new) .....	NVT_C3S
	18.	<b>21. C4 crops</b> (veg. 8) .....	NVT_C4
F	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)