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

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GEWEX Irrigation Cross-Cut Meeting November 4-5

Study the vegetation and terrestrial water cycles

- **Current fleet of Earth Satellite missions holds an unprecedent potential to quantify Land Surface Variables (LSVs)**
  [Lettenmaier et al., 2015, Balsamo et al., 2018]

➔ Spatial and temporal gaps & cannot observe all key LSVs (e.g. RZSM)

- **Land Surface Models (LSMs)** provide LSV estimates at all time/location

➔ LSMs have uncertainties

- Through a weighted combination of both, LSVs can be better estimated than by either source of information alone *[Reichle et al., 2007]*

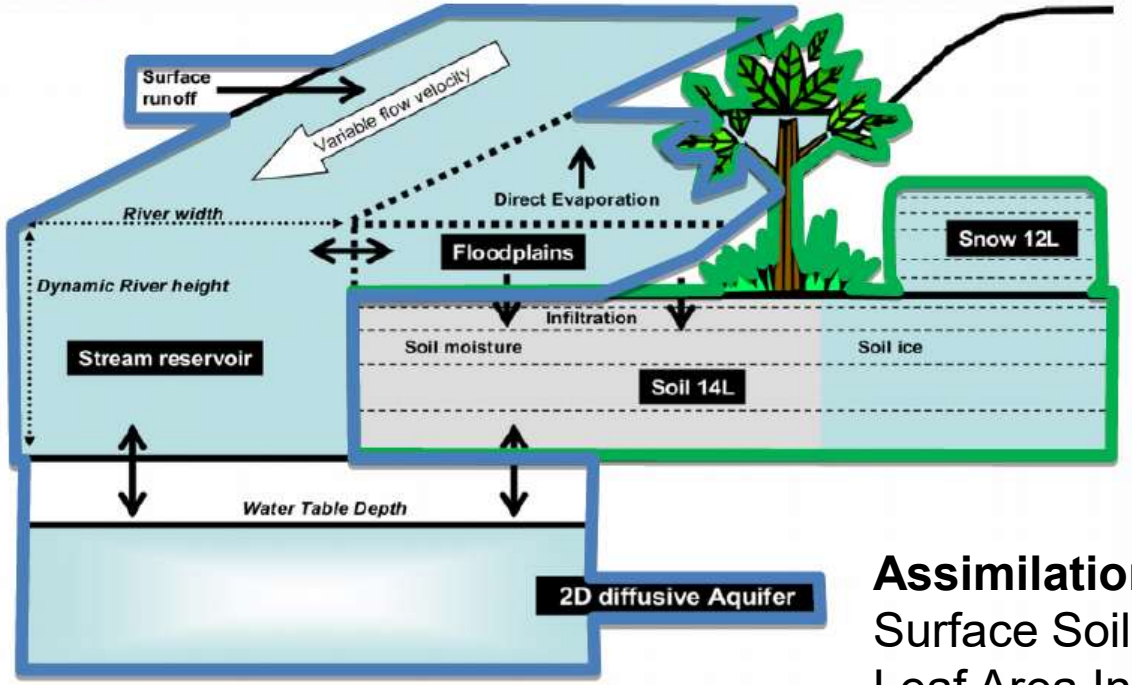
➔ **Data assimilation**
Spatially and temporally integrates the observed information into LSMs in a consistent way to unobserved locations, time steps and variables

LDAS-Monde: an overview

LDAS-Monde developed by Meteo-France's research service CNRM. [Barbu *et al.*, 2014; Albergel *et al.*, 2017, 2020]

- Offline system (no coupling between atmosphere and land surface)
- Can be run at various scales from France at 8km res. to continental and global scale at 0.25° spatial resolution

LDAS-Monde is available through the opensource SURFEX platform
http://www.umr-cnrm.fr/surfex/

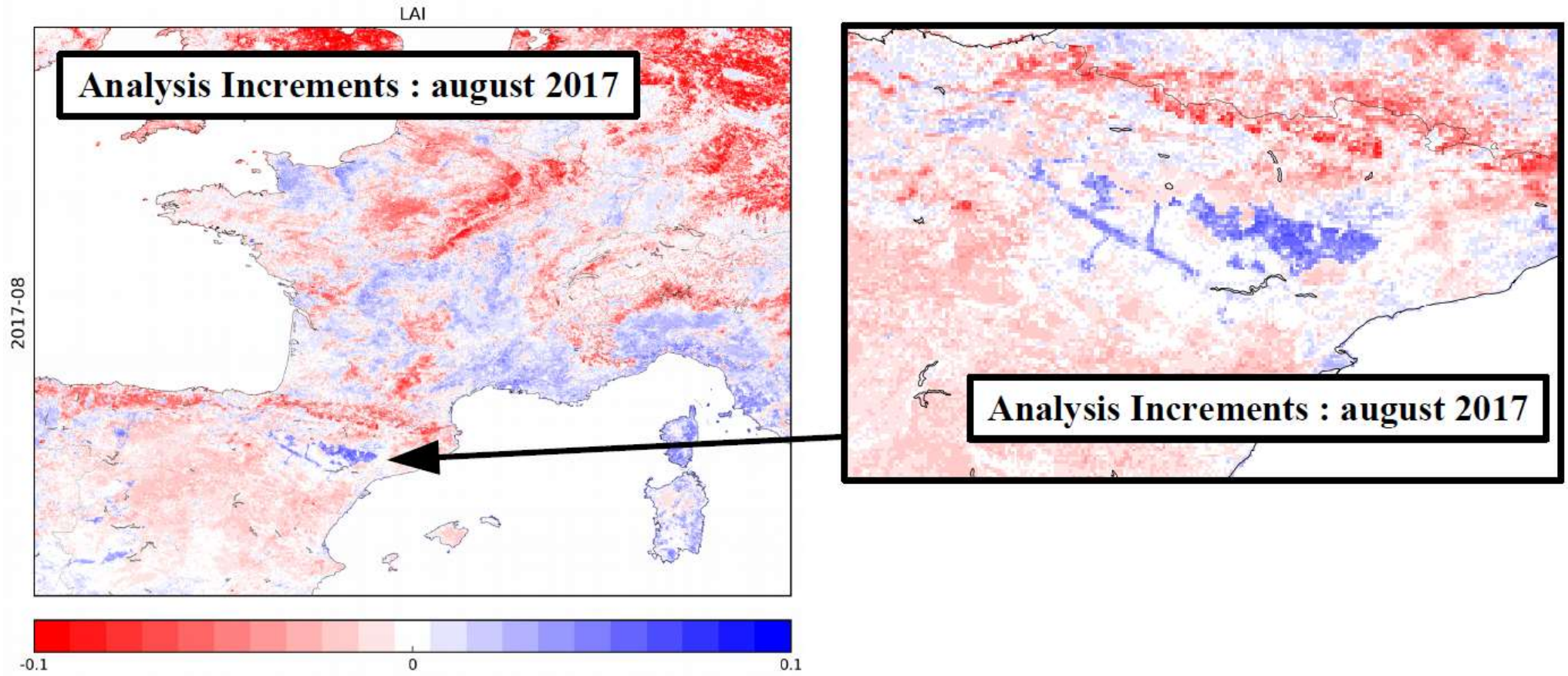


LDAS-Monde involves:

- Land surface model: **ISBA** (Interaction Sol-Biosphere-Atmosphere)
- River routing system: **CTRIP** (CNRM version of Total Runoff Integrating Pathways)
- Data assimilation routines

Assimilation of satellite derived observations:
Surface Soil Moisture (SSM)
Leaf Area Index (LAI)

LDAS-Monde : DA specific patterns



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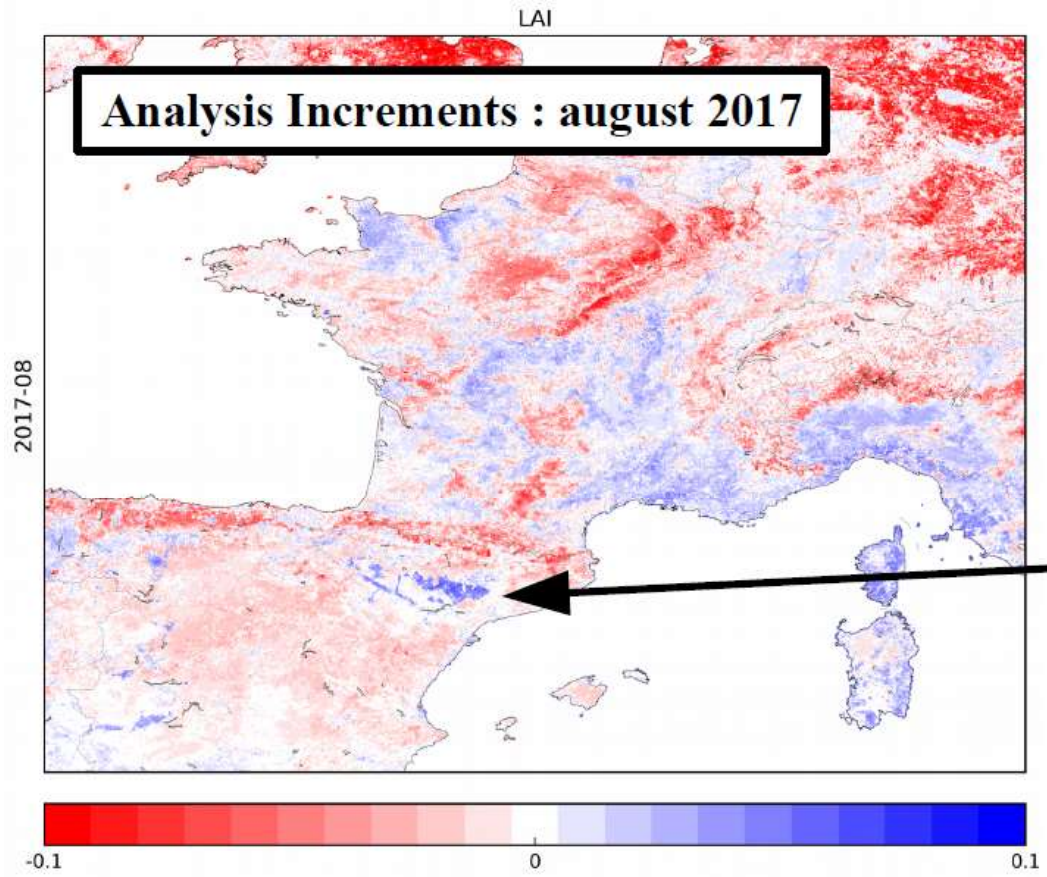
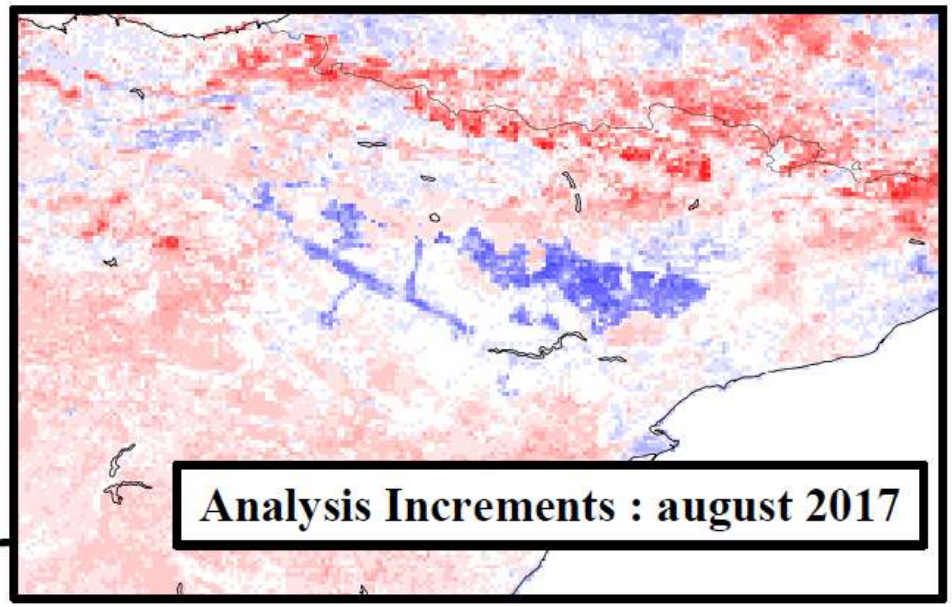
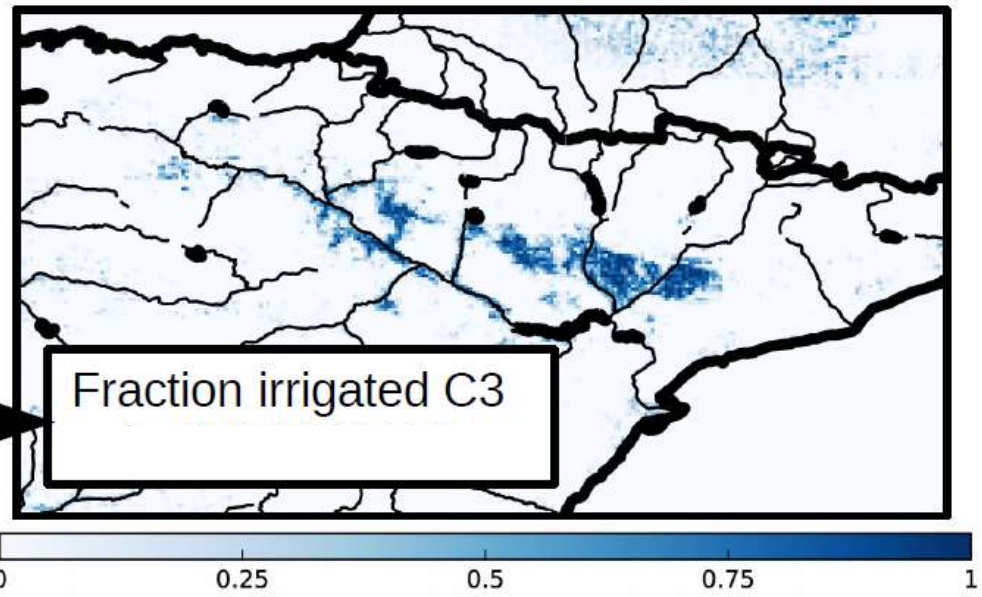




- **Data assimilation compensates for missing process: irrigation**



IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

I. Fields equipped for irrigation and types?

II. Irrigation period?

III. Irrigation needed?

IV. Link to water availability?

V. Irrigation

VI. Minimum return time ?

What is irrigation?
To apply a quantity of water distributed over a period of time

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 emergence and harvest 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

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Between two irrigations

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Implemented
➔ Can be specify for each vegetation type and grille point

To do
Water availability

Druel et al., 2021, GMD Discussion, https://gmd.copernicus.org/preprints/gmd-2021-332/

IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

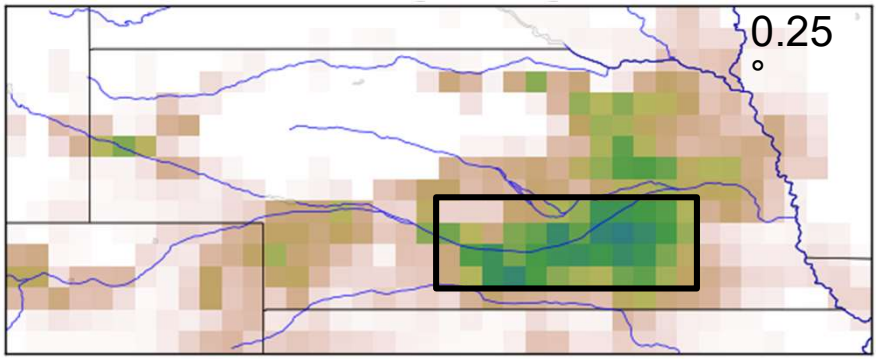
Simulation configuration:

- Irrigated vegetation: crops (C3 & C4)
- 1979-2018 (with 20 years of spinup)
- 3 ISBA simulations: reference, agricultural practices, and agricultural practices with irrigation

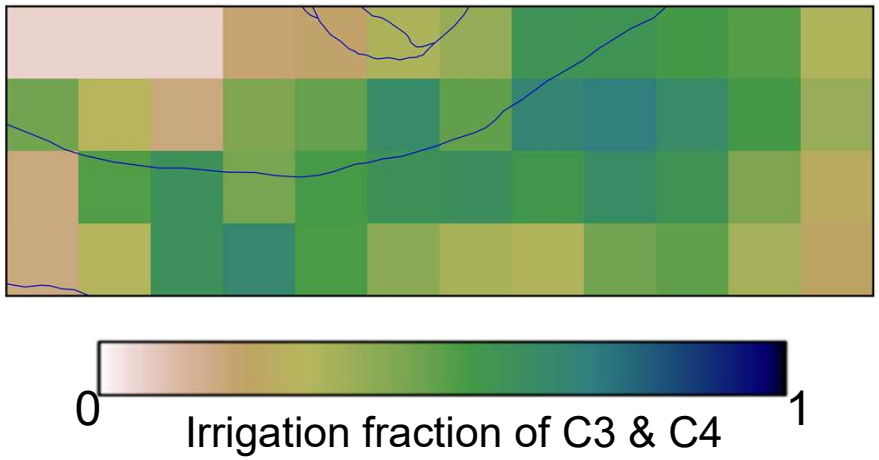
Table 2 – Irrigation parameters.

Symbol	Definition	Default value (this study)
I_T	Irrigation type	sprinkler
I_{NT}	Irrigated nature type	C3 crops, C4 crops, shrubs
I_W	Water amount per irrigation water turn	30 mm
I_D	Irrigation water turn duration	8 hours
SWI_1	SWI threshold for triggering the first water turn	0.70
SWI_2	SWI threshold for triggering the second water turn	0.55
SWI_3	SWI threshold for triggering the third water turn	0.40
SWI_{4+i}	SWI threshold for triggering the following water turns (i, integer > 0)	0.25
Δt_{Wn}	Minimum time lapse between two water turns	7 days
Δt_{WH}	Minimum time lapse between the last water turn and the harvest	15 days
t_E	Emergence date	15 May (± 15 days)
t_H	Harvest date	15 September (± 15 days)

Nebraska (0.25°)



(Selected zone in Nebraska (0.25°)



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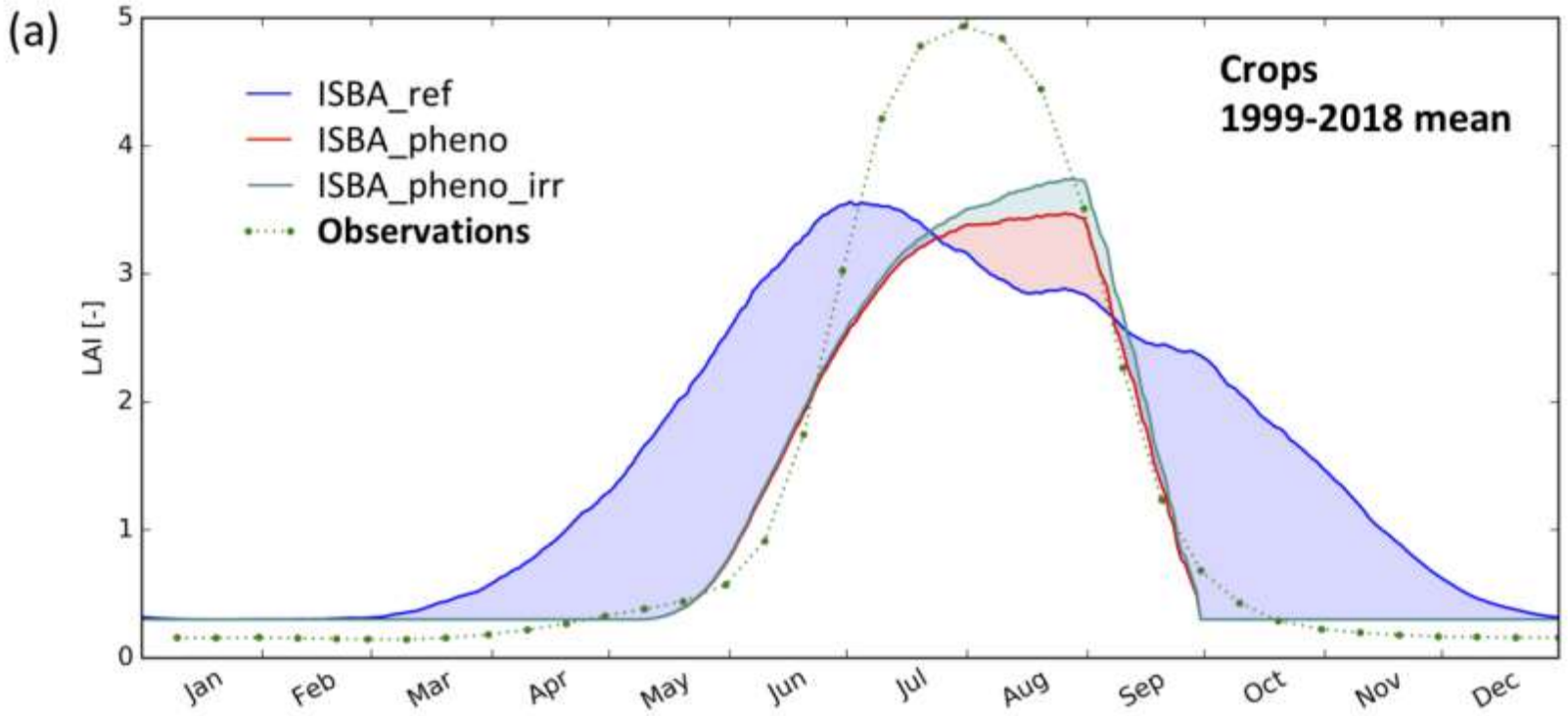

Figure 4 – LAI (m^2 m^{-2}) of irrigated crops (C3 or C4) in the most densely irrigated part of Nebraska (Fig. 1e): (a) seasonal variation for the time period from 1999 to 2018, (b) daily time series from 2002 to 2008. Simulated LAI is shown for the irrigated fraction, from the reference simulation (ISBA_ref, blue line), and from the simulations with only agricultural practices and with agricultural practices and irrigation (ISBA_pheno, red line, and ISBA_pheno_irr, cyan line, respectively). Satellite-derived LAI observations (green dots) are for areas where the fraction of C3 or C4 irrigated crops is larger than 50 %.

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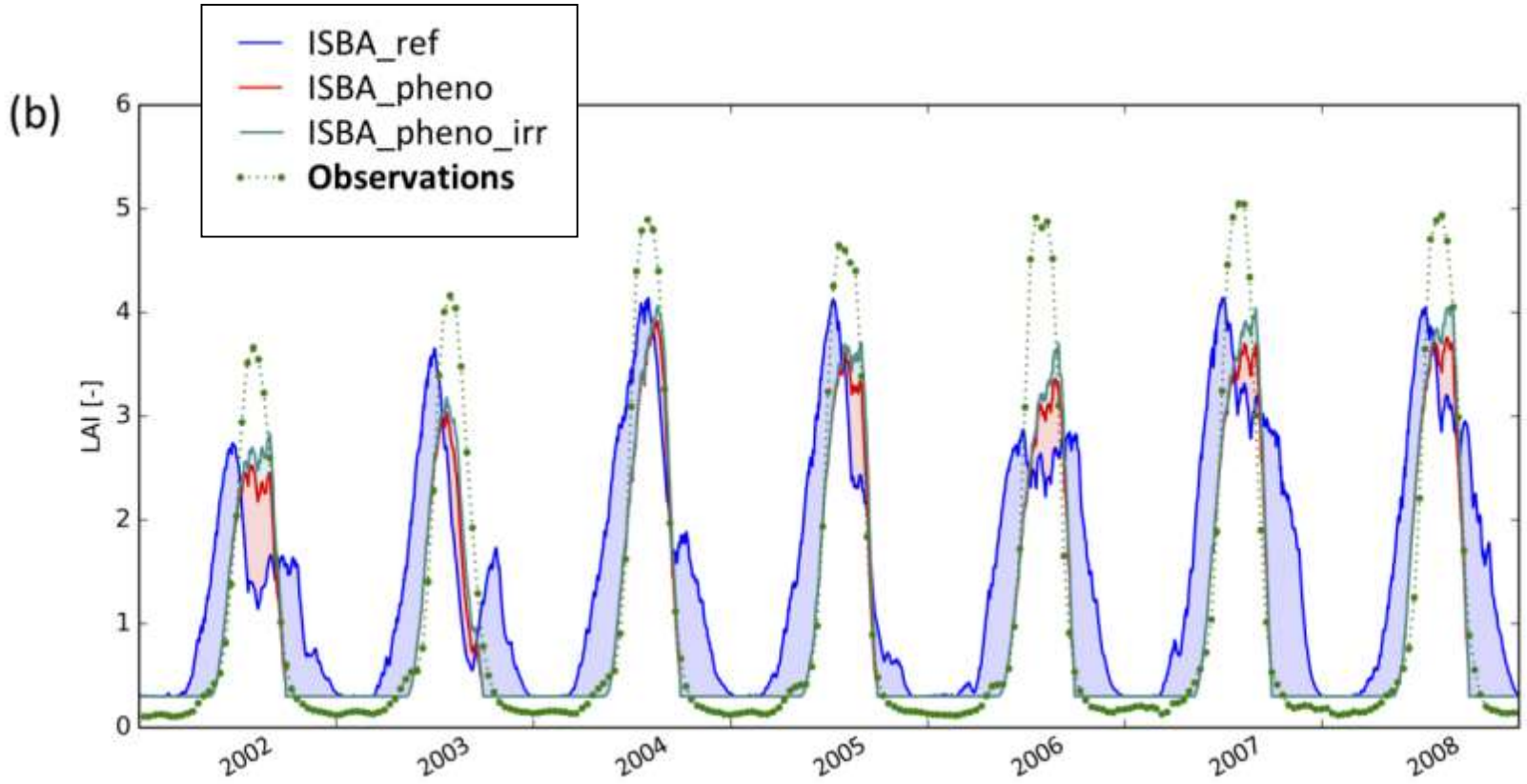

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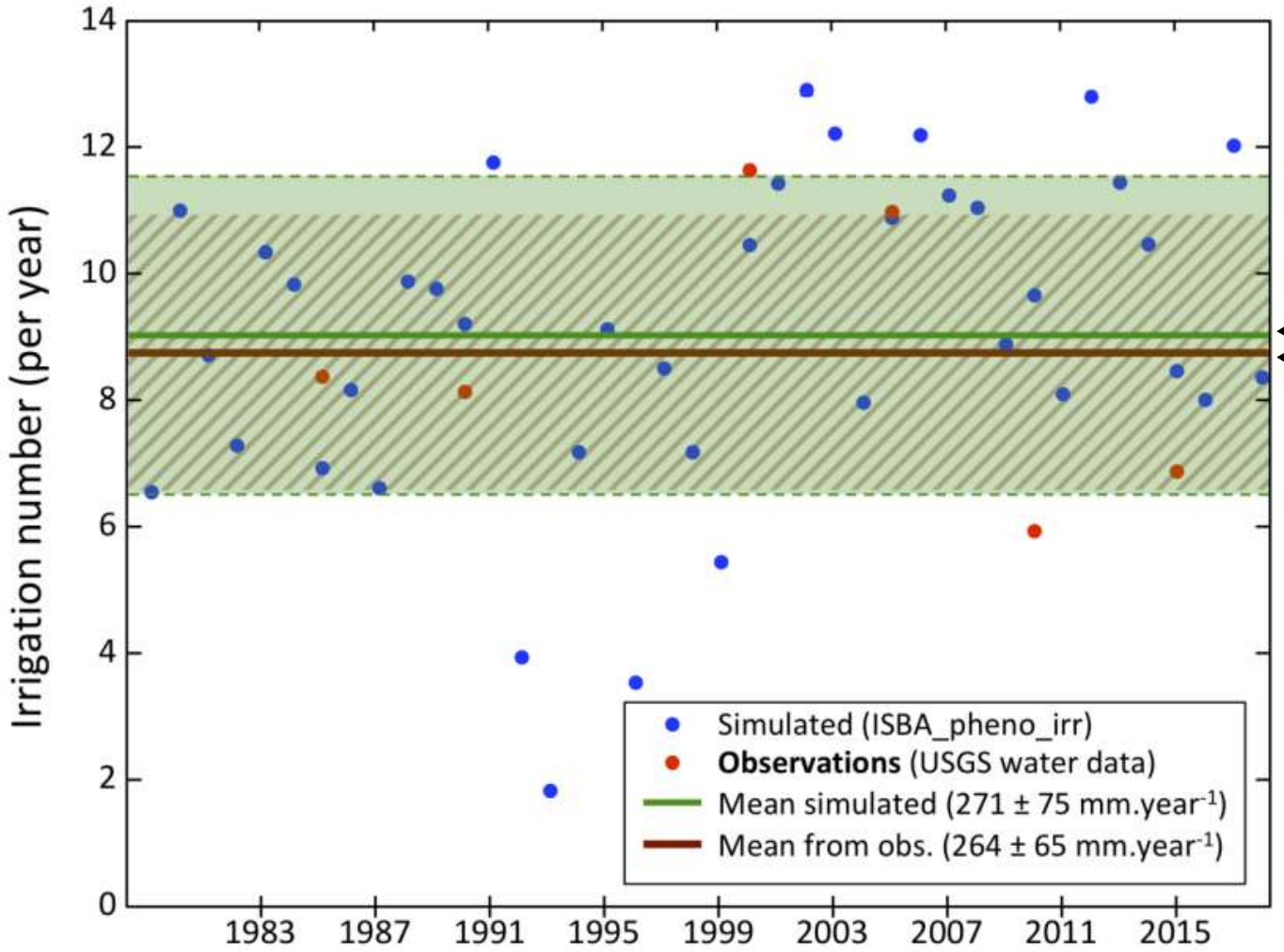
IMPLEMENTATION OF IRRIGATION IN ISBA/SURFEX

Number of irrigation for crops (per year)



(271 ±75 mm.year^{-1})
Mean simulated

Mean gross from
US Geological Survey*
(264 ±65 mm.year^{-1})

*Data from US Geological Survey: available by county all five year from 1985 (note that 1995 is not taken into account)

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

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CONCLUSION

➔ **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)

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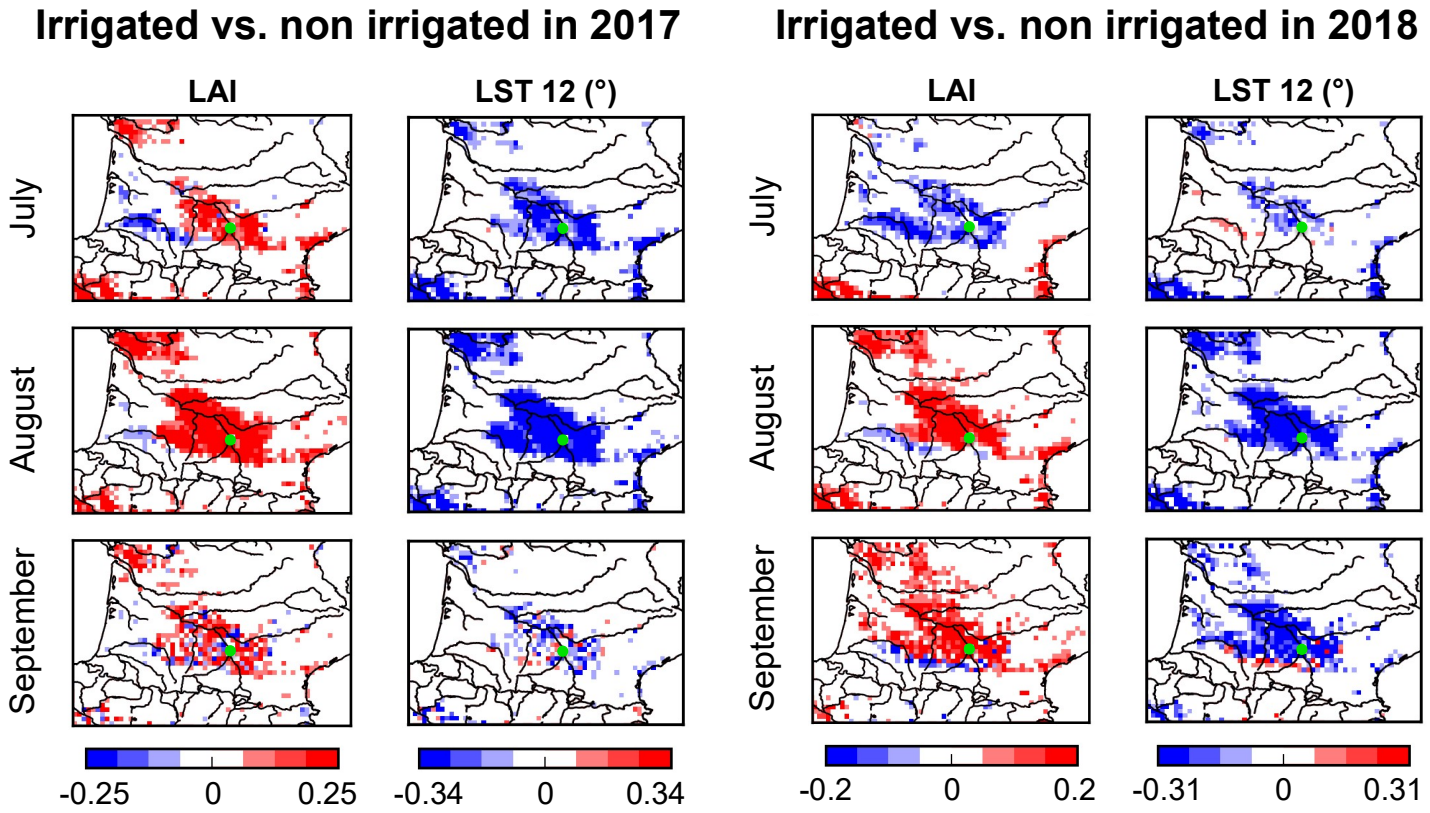
PERSPECTIVES

Explore new possibility of simulation

- Example:

South-West of France 0.1°



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