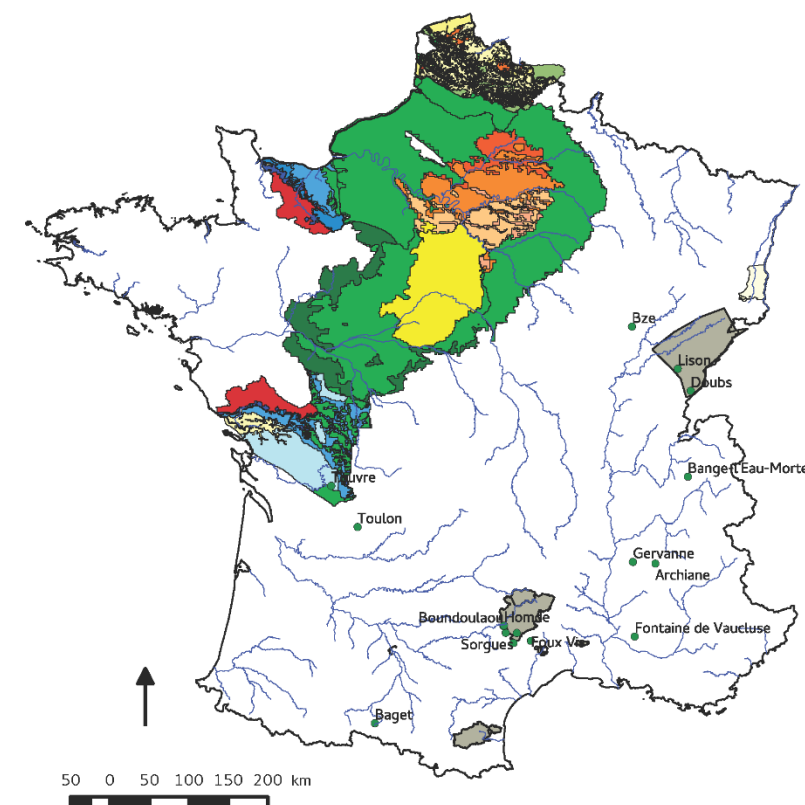




Groundwater seasonal forecasts using the French Aquif-FR platform

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(AFB, CNRM, BRGM, Mines-Paritech, Geosciences Rennes, CERFACS, IPSL, LHYGES)



Aqui-FR project

- Objectives
 - Provide monitoring and forecasts of the groundwater resources in France (10-day, seasonal, long term)
 - Better understand and manage properly our resources
- Hydrological forecasts
 - Rely on existing hydrogeological applications (1 to 10 layers, 100m-1km resolution)
 - River discharge forecast skills are better where groundwater is represented (Singla et al., 2010)
- Expertise at Meteo-France in terms of seasonal forecasts
 - ARPEGE System 6 (and System 7 in July 2019)

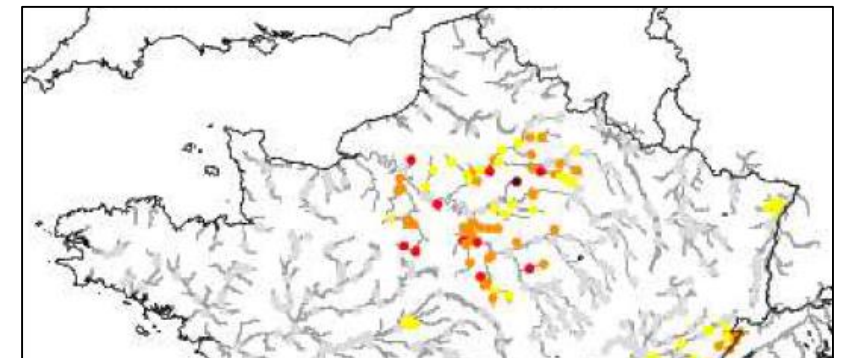
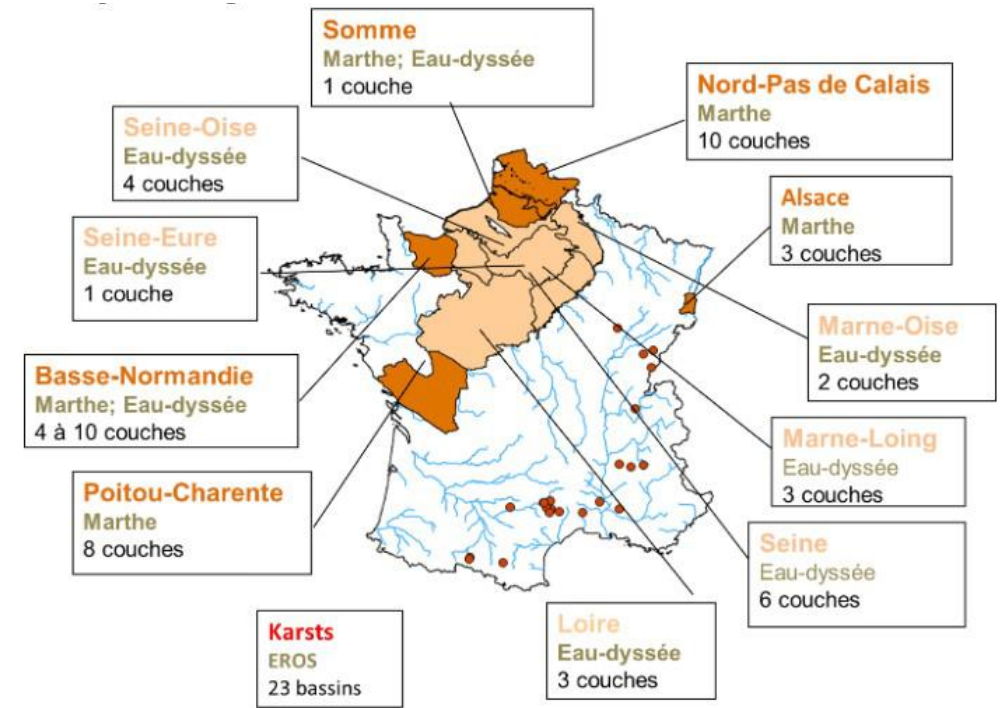
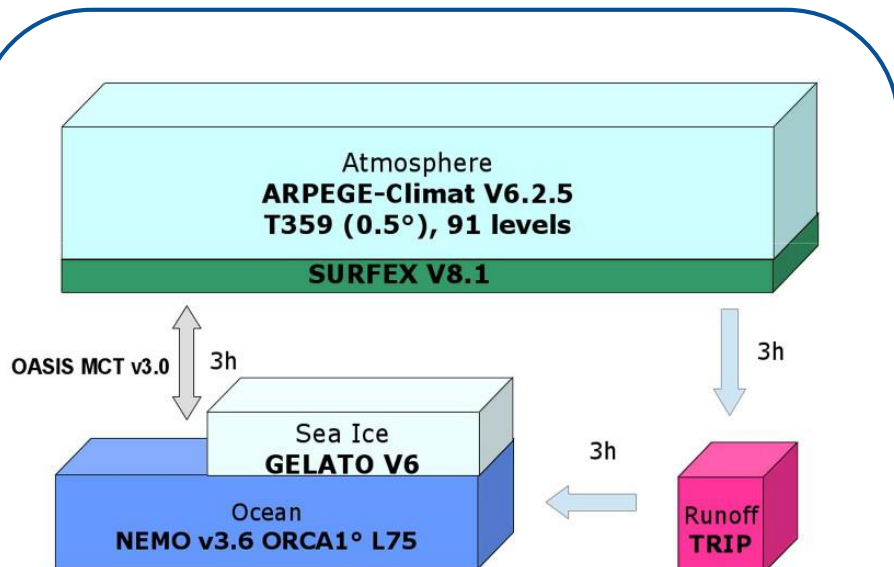


Fig. 6. Correlation maps of river flows (b) between Hydro-SF and the SIM reanalysis reference run for the spring season. Scores are calculated over the 1960–2005 period.

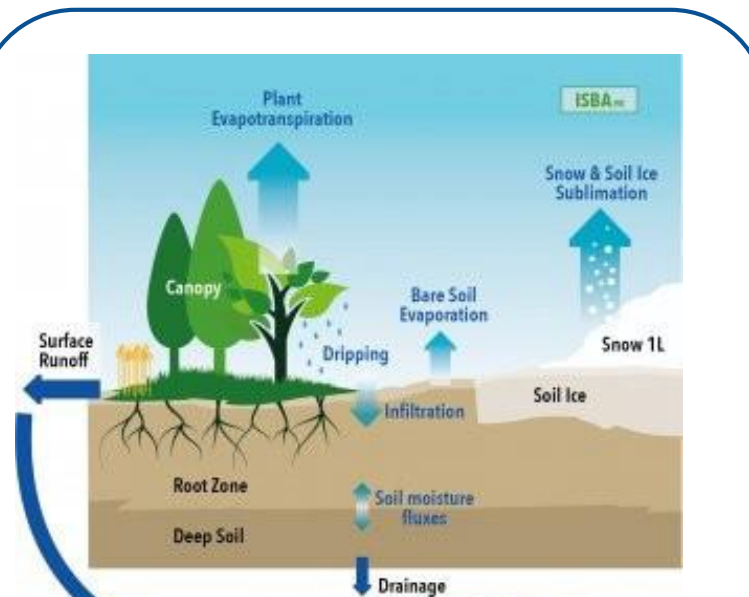


Aqui-FR platform



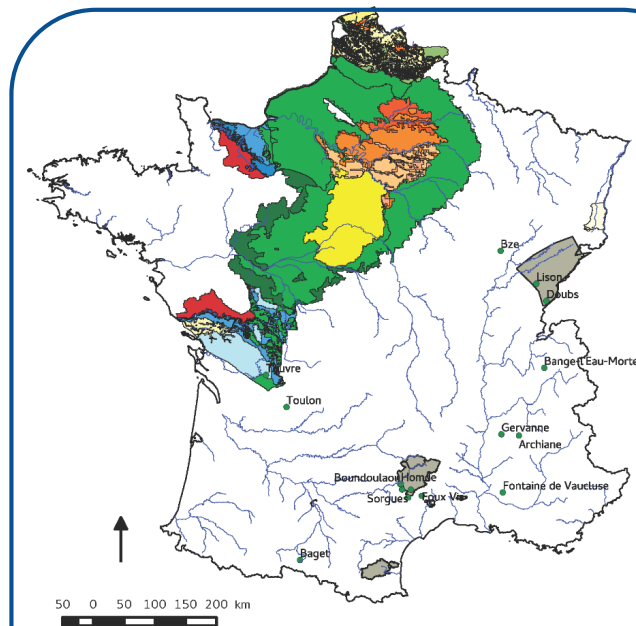
Atmospheric conditions:

- Long run, SAFRAN (REA, 1959-2019)
 - 6-month forecasts, ARPEGE S6 (PSE, 25 members for hindcast 1993-2016, 51 members in “real-time”)
- (8 km)



SURFEX:

- V8, ISBA-DIF (SIM2 version before MODCOU)
 - Daily cumulated drainage and runoff (25 or 51 scenarios)
- (8km)



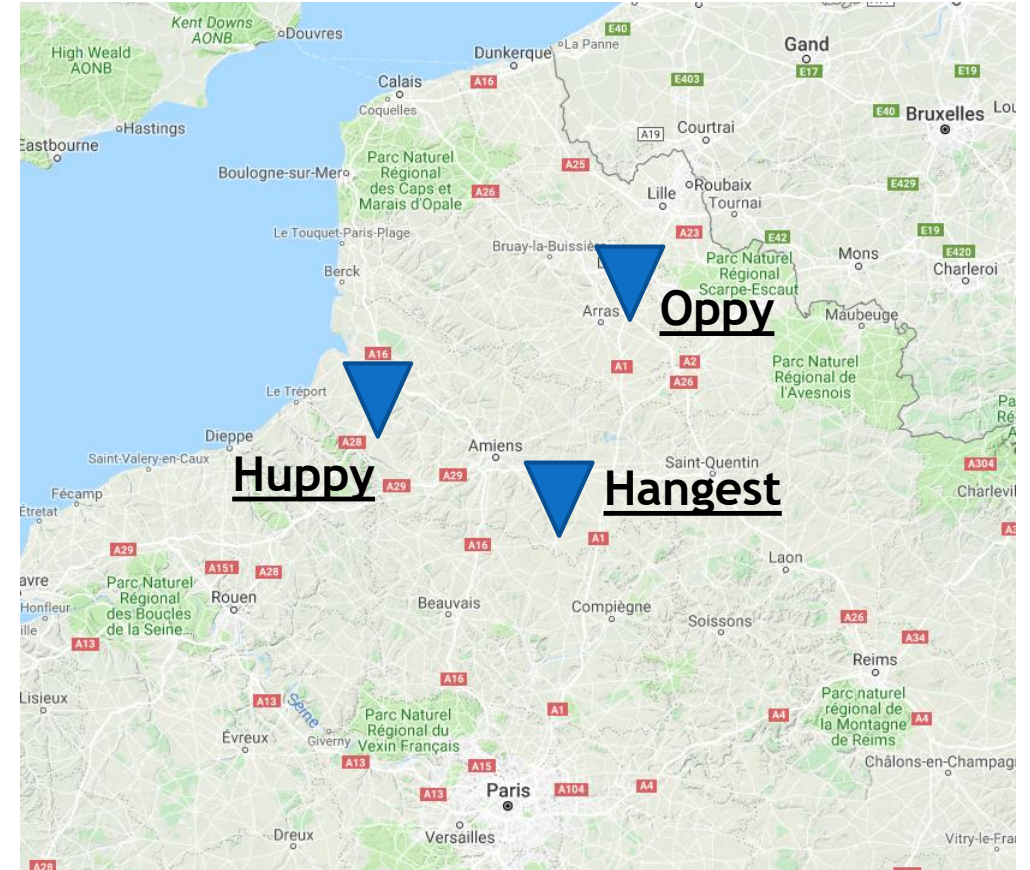
AQUI-FR:

- Groundwater level, exchange with rivers, river discharge
- H: monthly over each point, daily for piezo stations

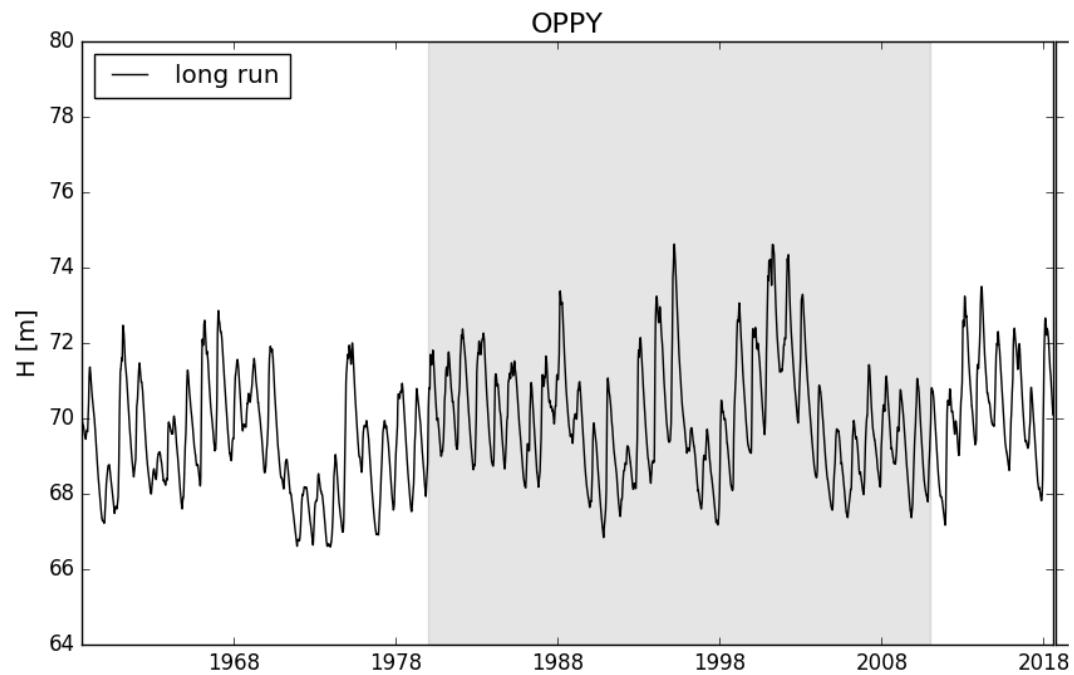
Groundwater simulations – piezometric stations

- Long run from reanalyzed forcing data (August 1958 – July 2018)
↓
- Extended long run (i.e. real-time mode) until January/February/March 2019 for initial states
↓
- Seasonal forecasts for the 6 following months

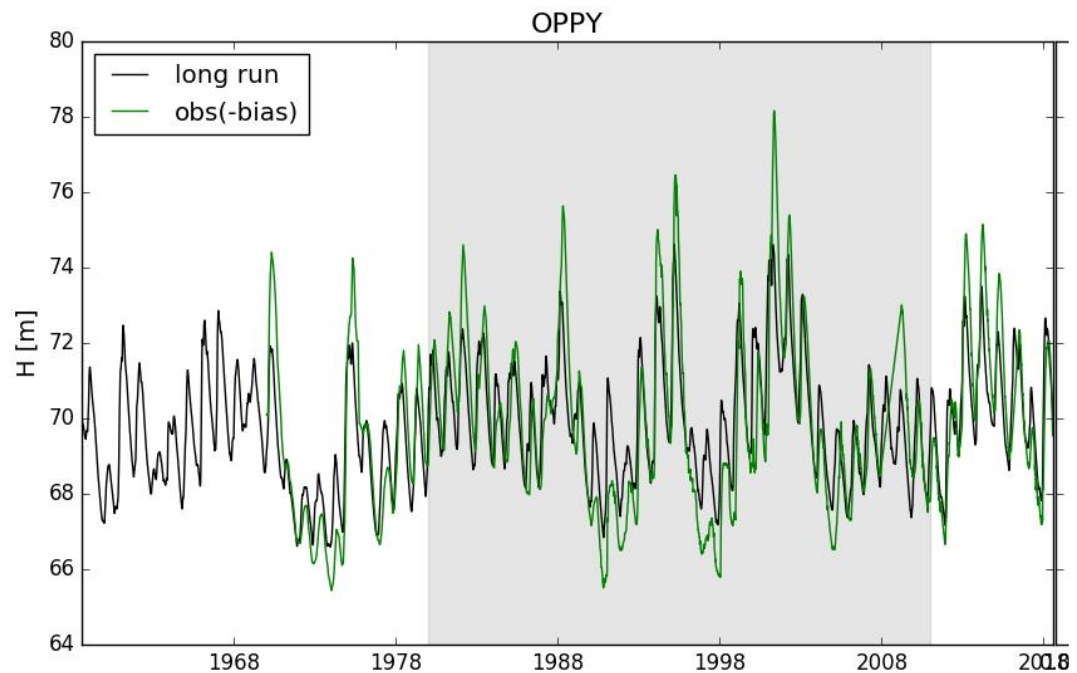
- Long run can be compared to in situ observations
- Bias between simulations and ground measurements due to model calibration (on going work)



Groundwater simulations – piezometric stations



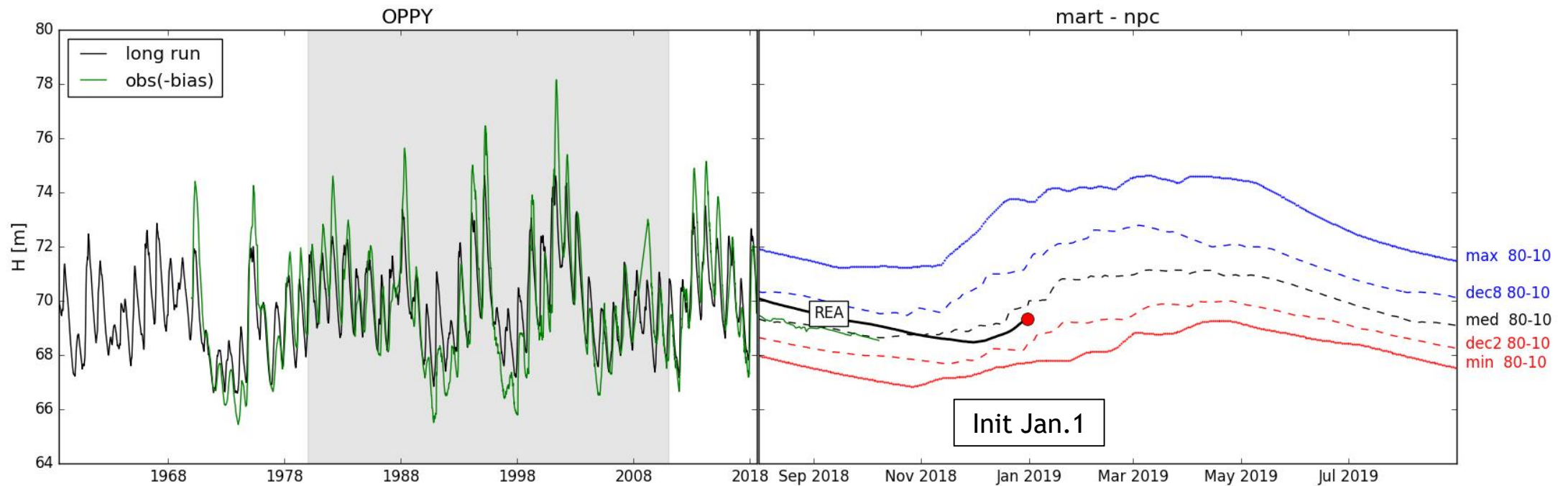
Groundwater simulations – piezometric stations



$R = 0.84$

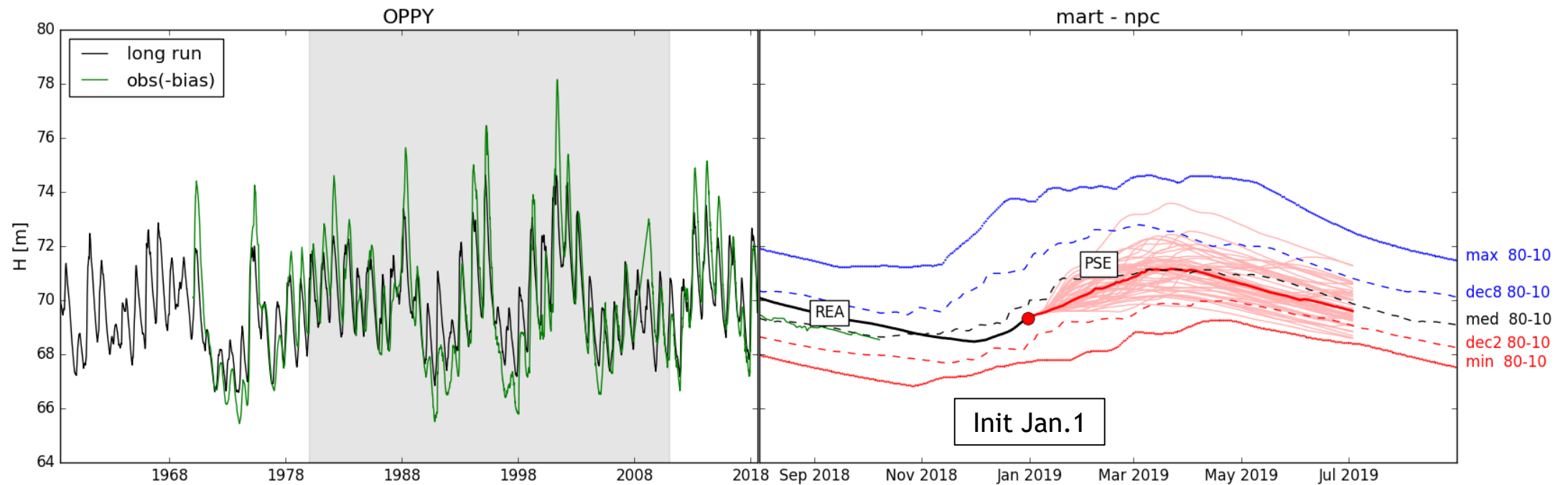
$uRMSE = 1.2 \text{ m}$

Groundwater simulations – piezometric stations



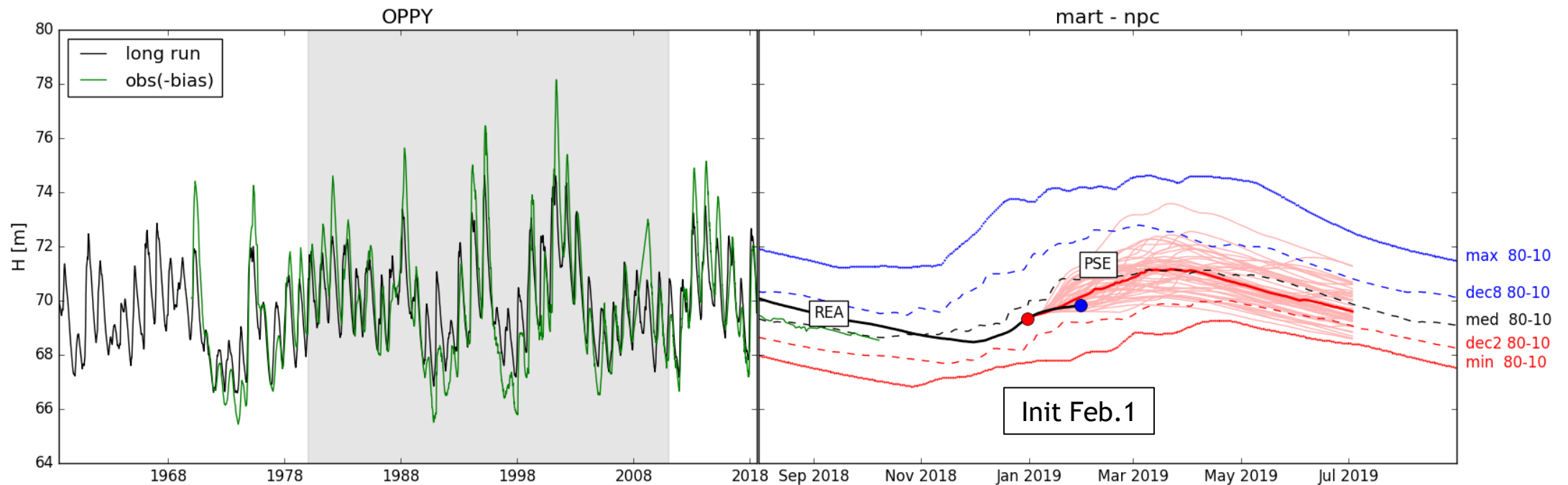
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Groundwater simulations – piezometric stations



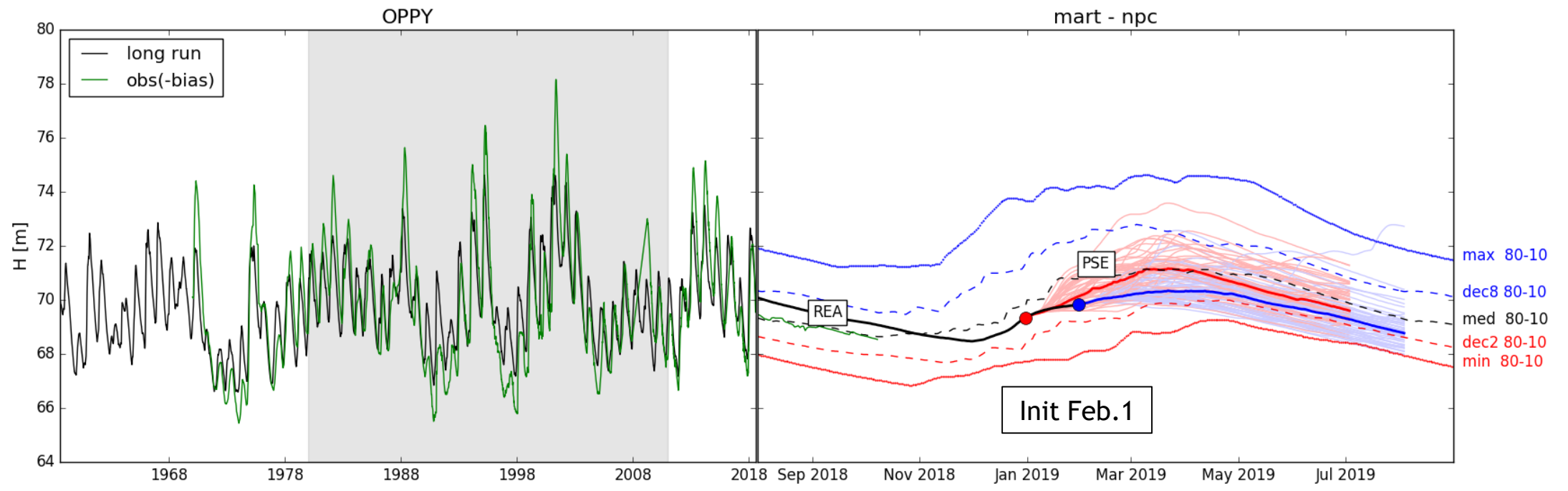
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Groundwater simulations – piezometric stations



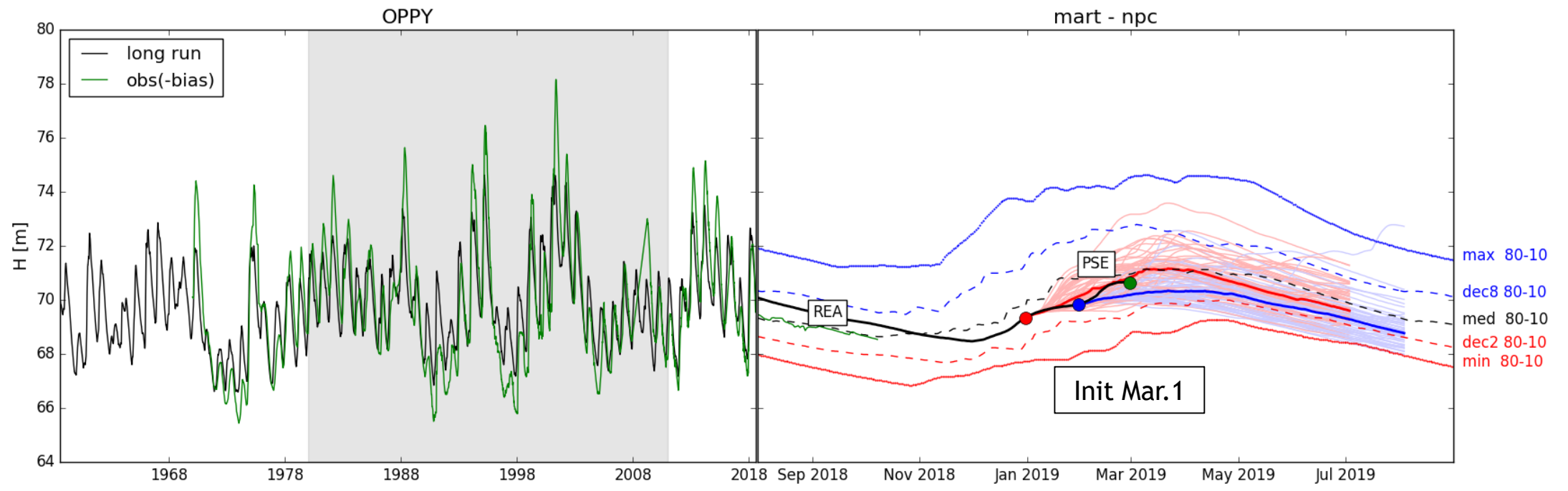
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Groundwater simulations – piezometric stations



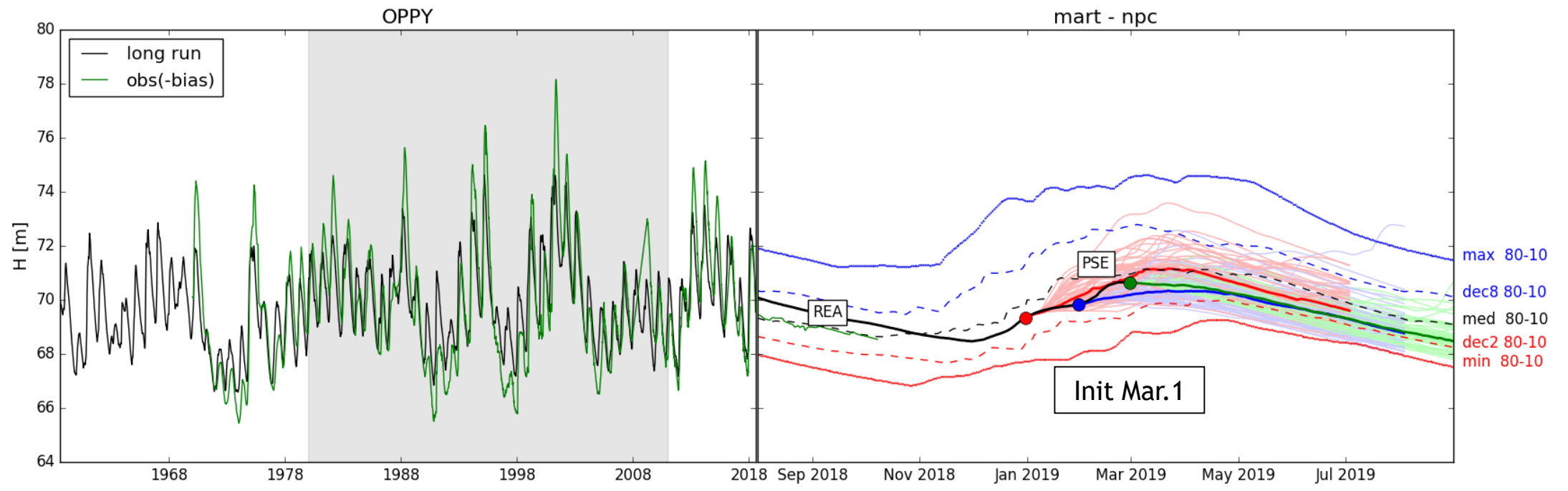
R = 0.84
 uRMSE = 1.2 m

Groundwater simulations – piezometric stations



R = 0.84
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Groundwater simulations – piezometric stations

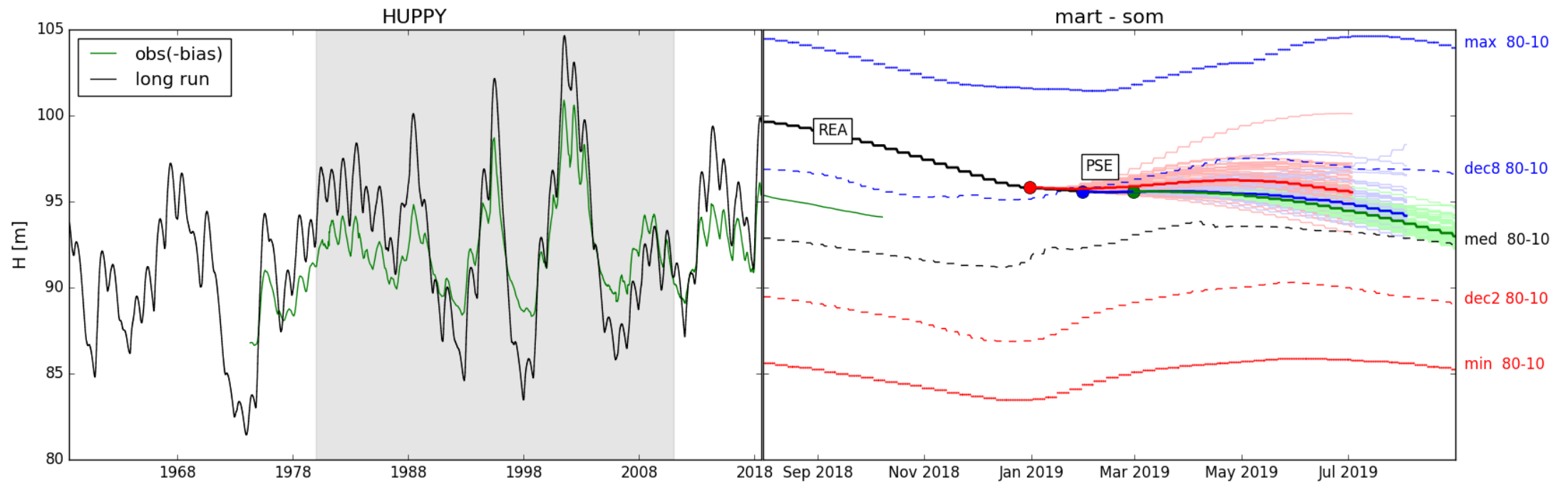


R = 0.84
uRMSE = 1.2 m

Groundwater simulations – piezometric stations



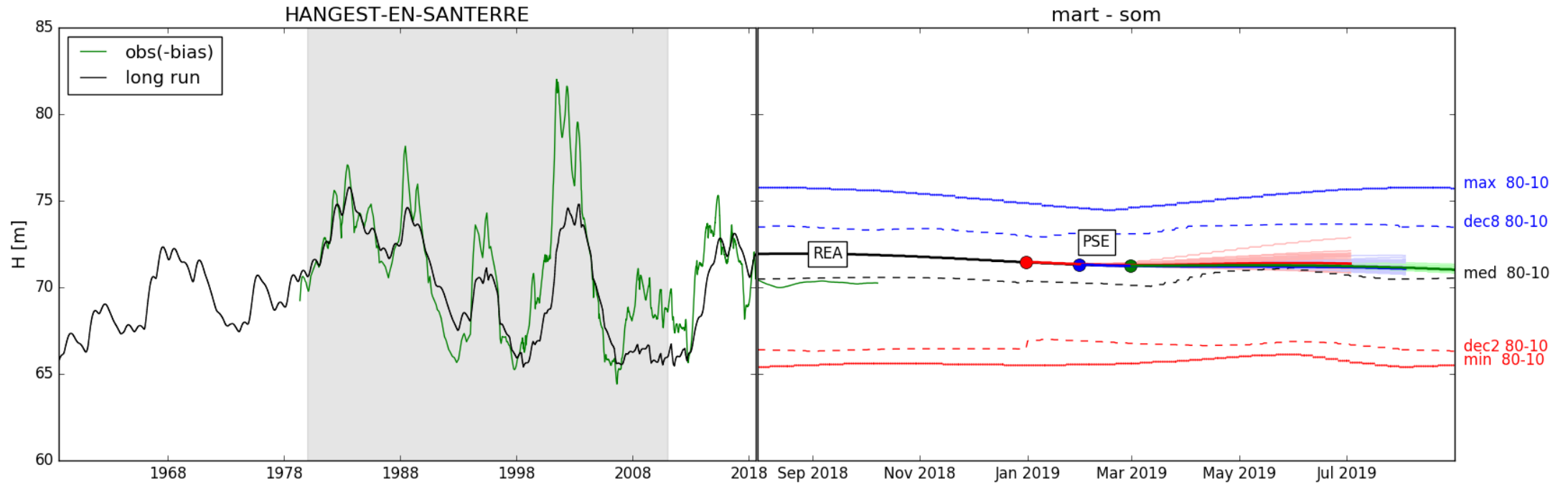
Huppy



$R = 0.87$

$uRMSE = 2.2 \text{ m}$

Groundwater simulations – piezometric stations

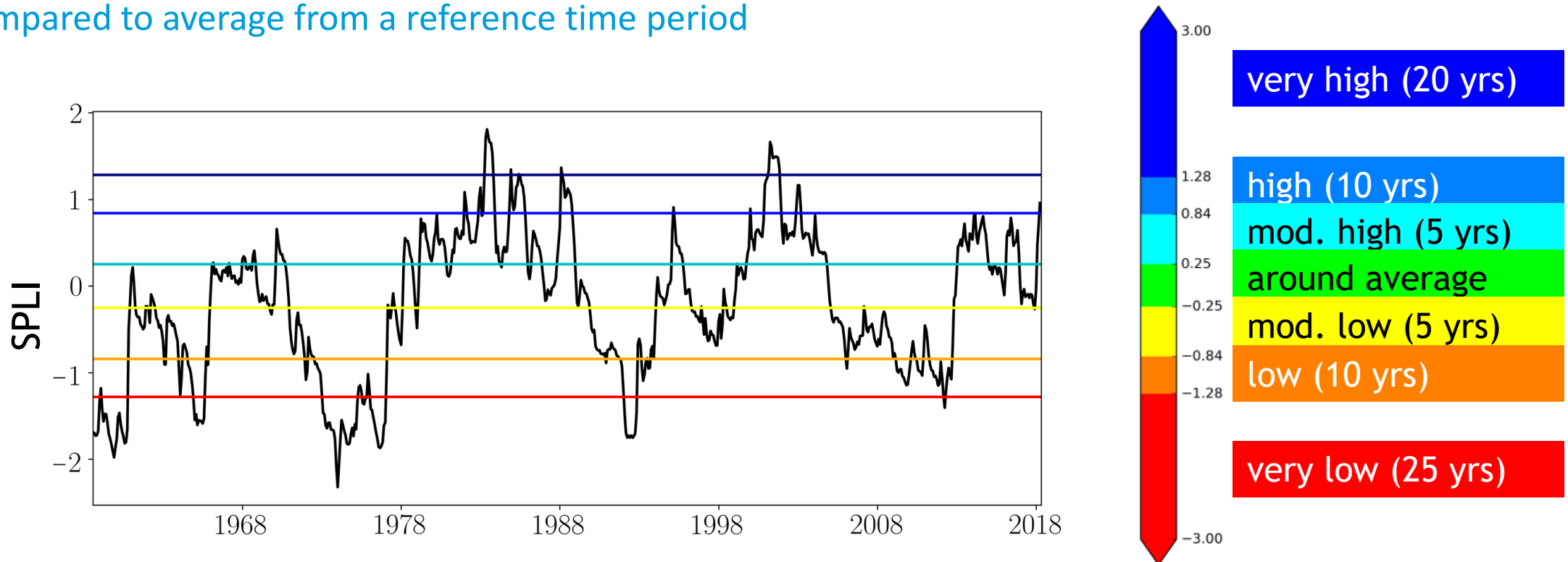


$R = 0.76$

$uRMSE = 1.9 \text{ m}$

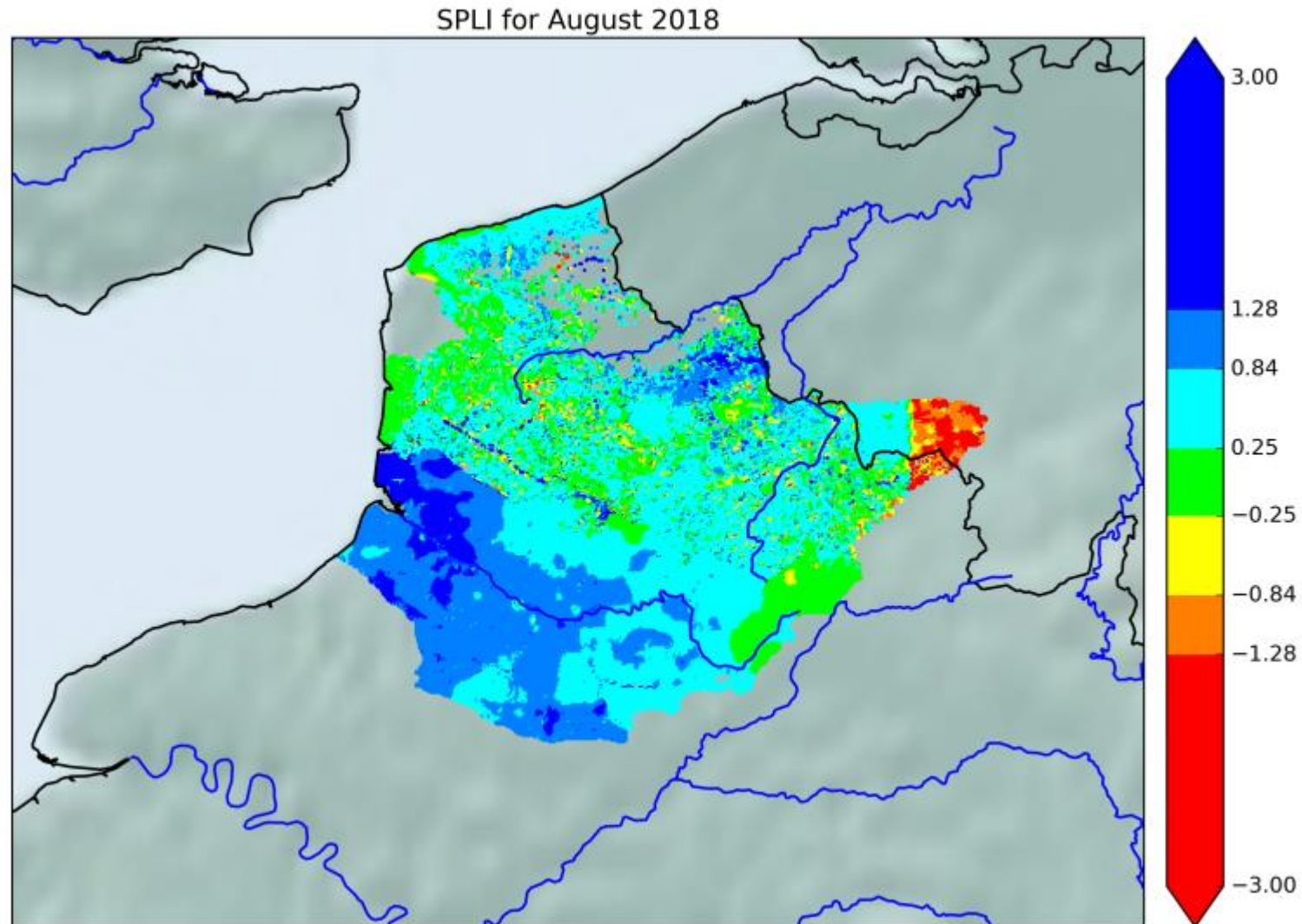
Standardized Piezometric Level Index

- In order to be able to compare the different levels on a same map (only topography otherwise), we use a frequential index called SPLI based on the return frequency
 - $SPLI < -1.28$: 20 year **dry** can mean a severe drought as it only happens every 20 years in average
 - $SPLI > +1.28$: 20 year **wet** can mean a risk of flooding if the groundwater reaches the surface
 - compared to average from a reference time period



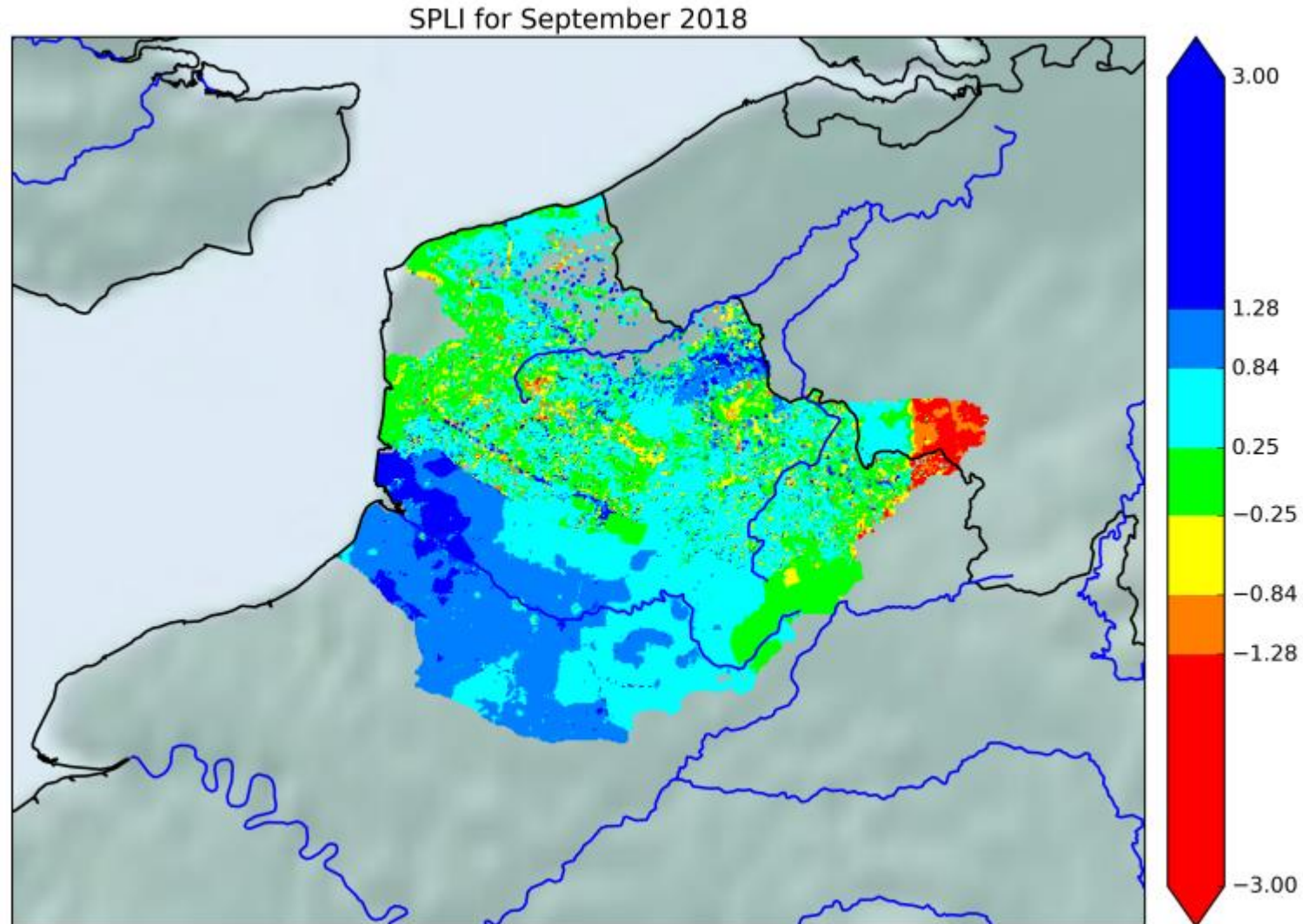
Groundwater simulations – spatial maps

- Start on August with rather wet conditions (at least more humid than usual)



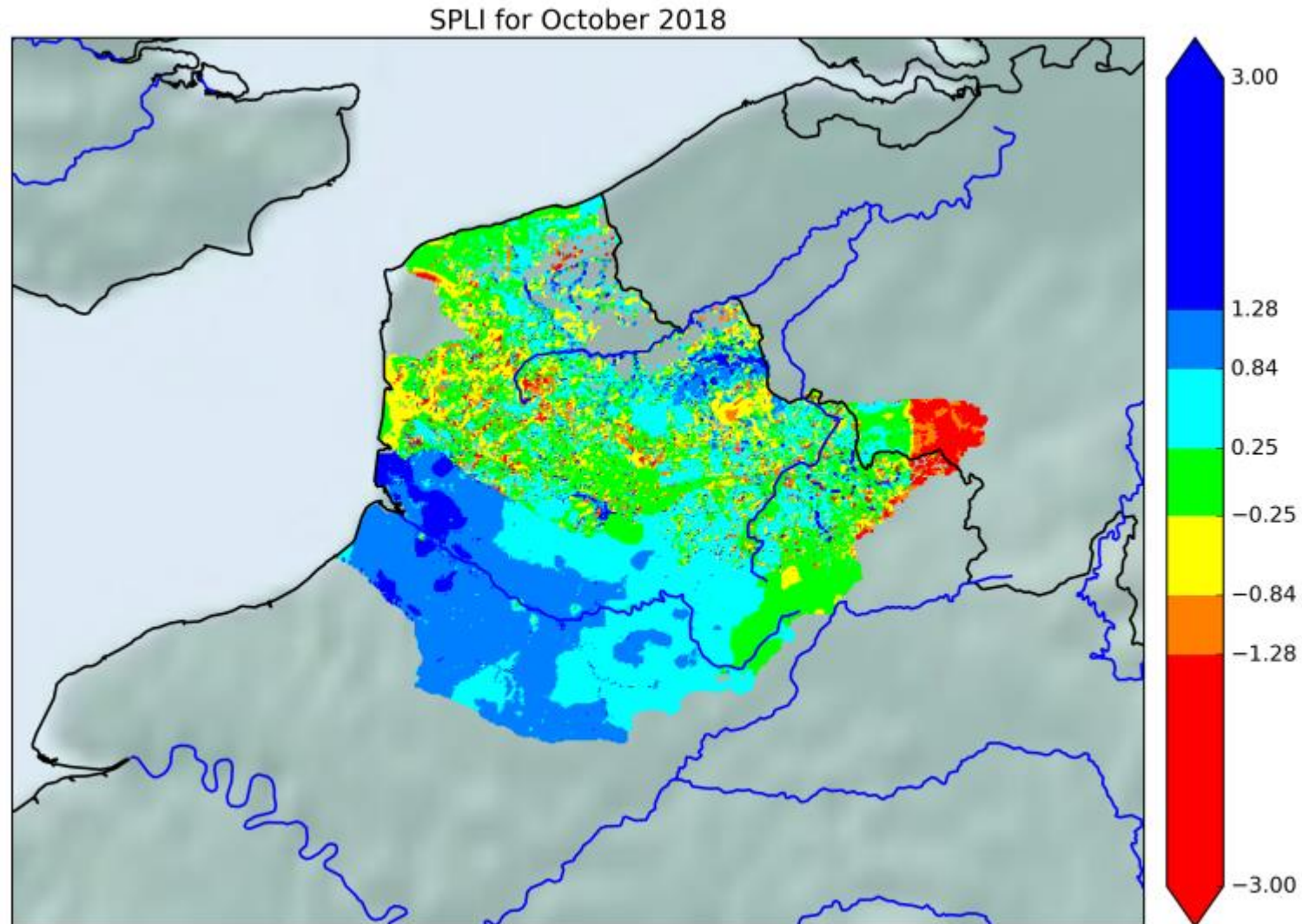
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- Then it dries more and more



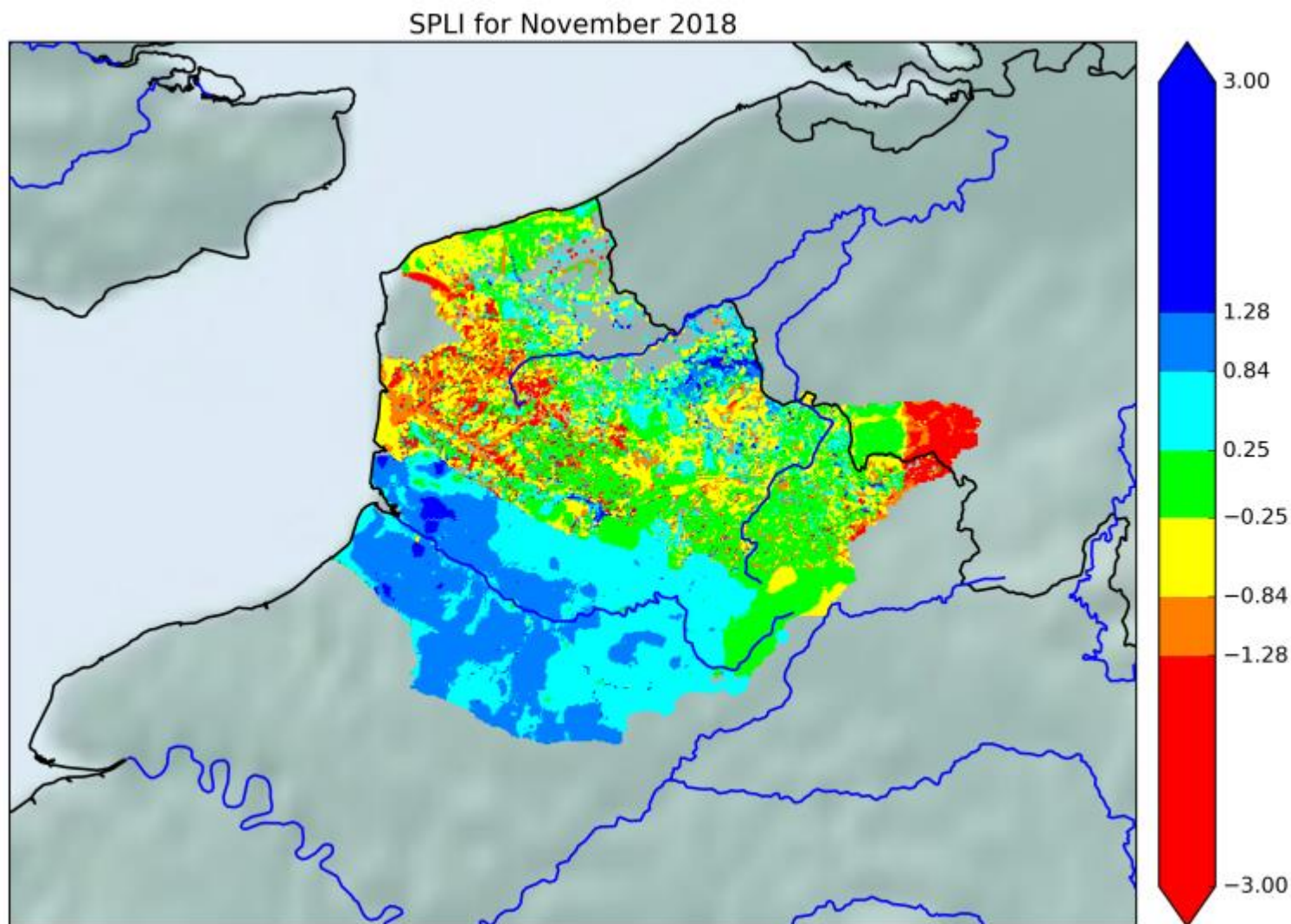
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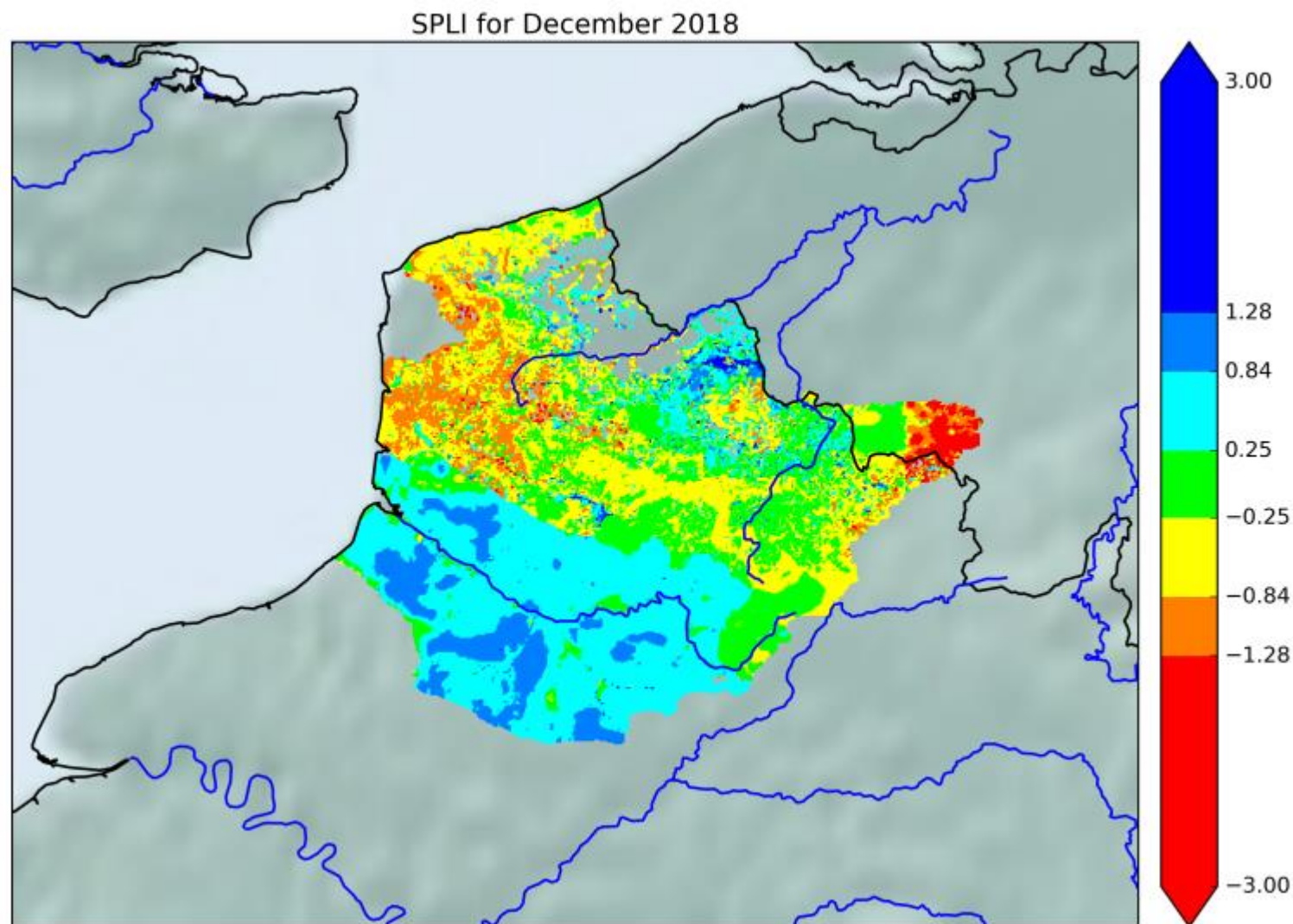
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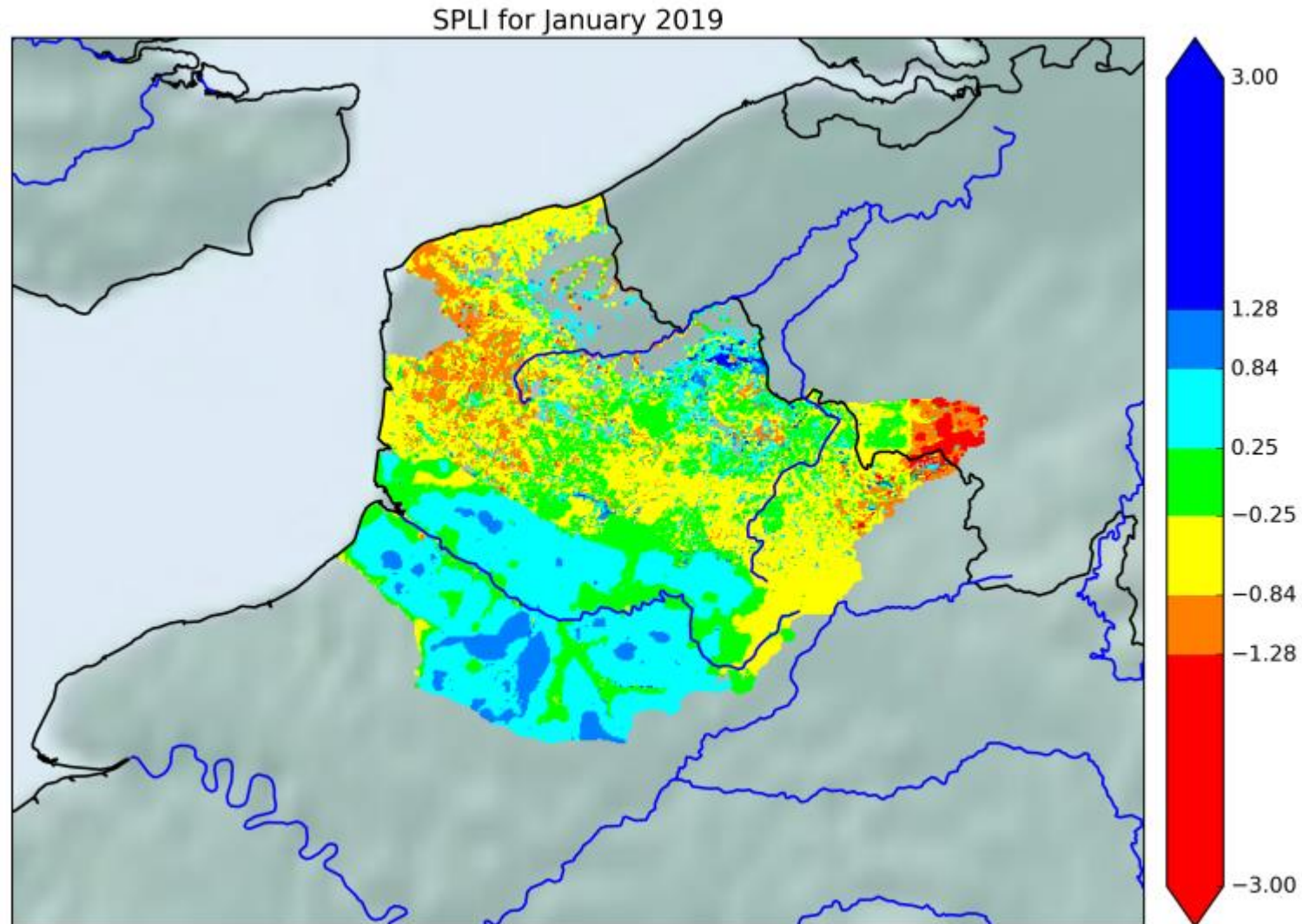
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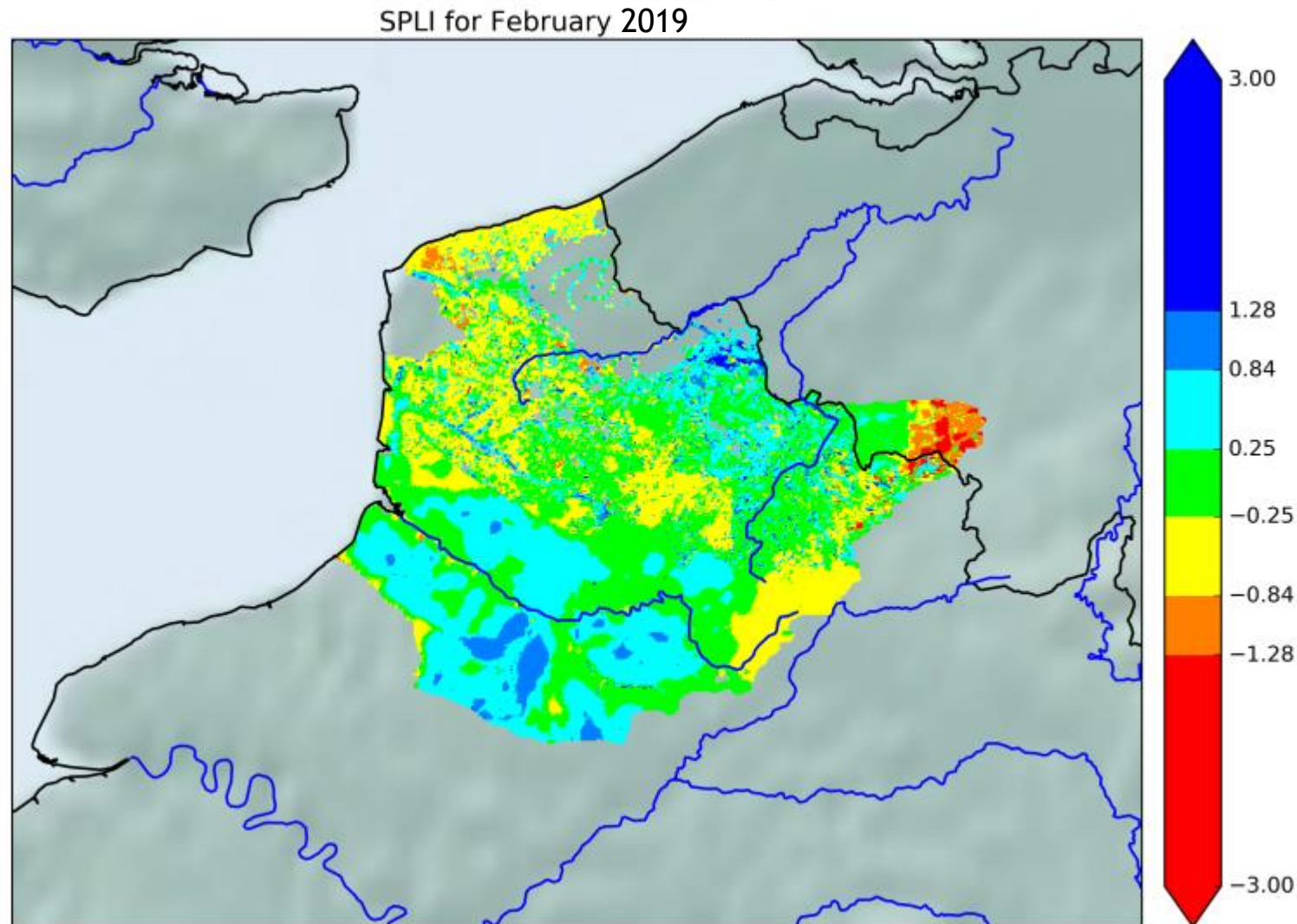
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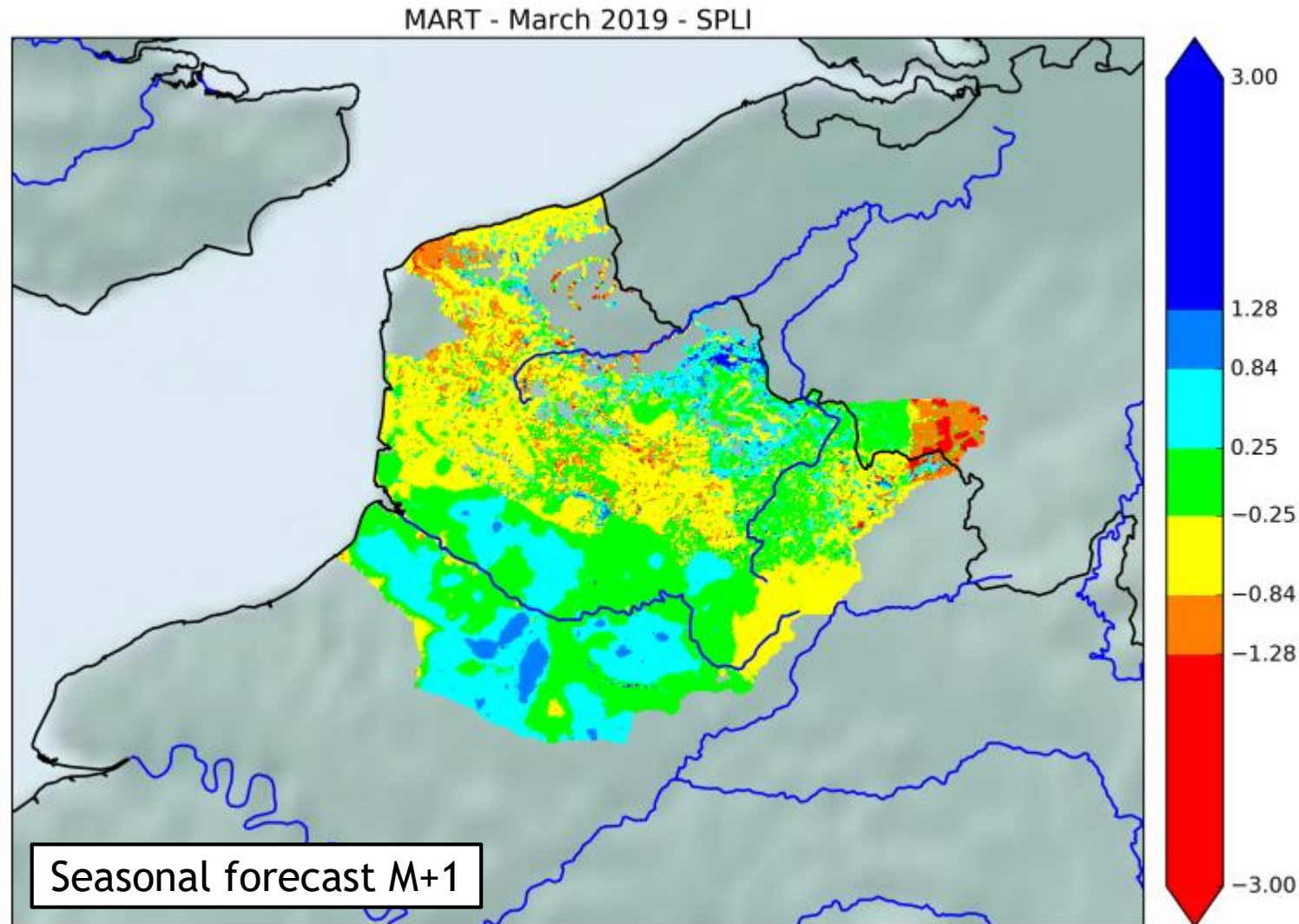
Groundwater simulations – spatial maps

- Start on August with rather wet conditions (at least more humid than usual)
- Then it dries more and more
- It dries until the groundwater levels go below the normal



Groundwater simulations – spatial maps

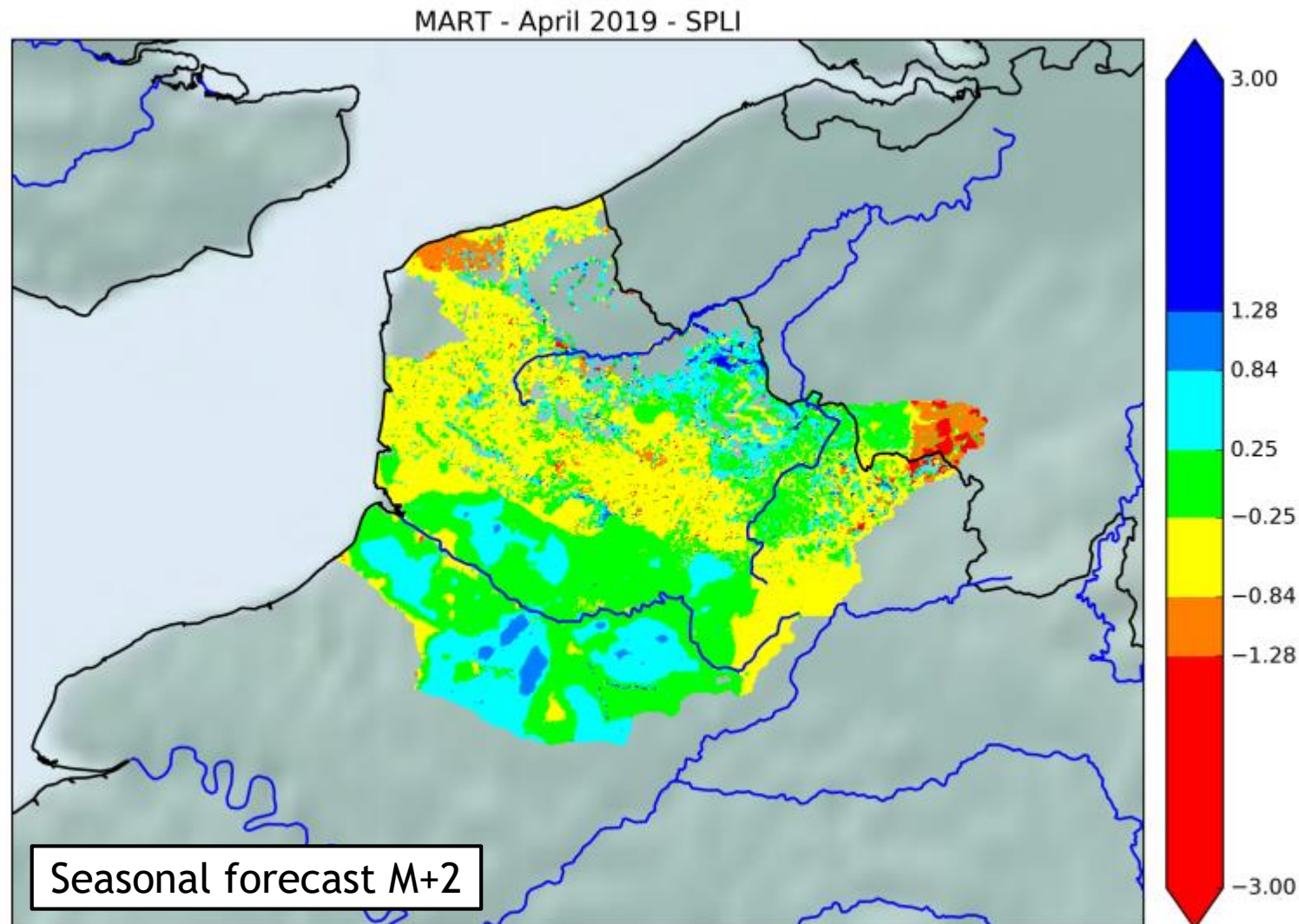
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- Median of seasonal forecasts indicates drying continues

Groundwater simulations – spatial maps

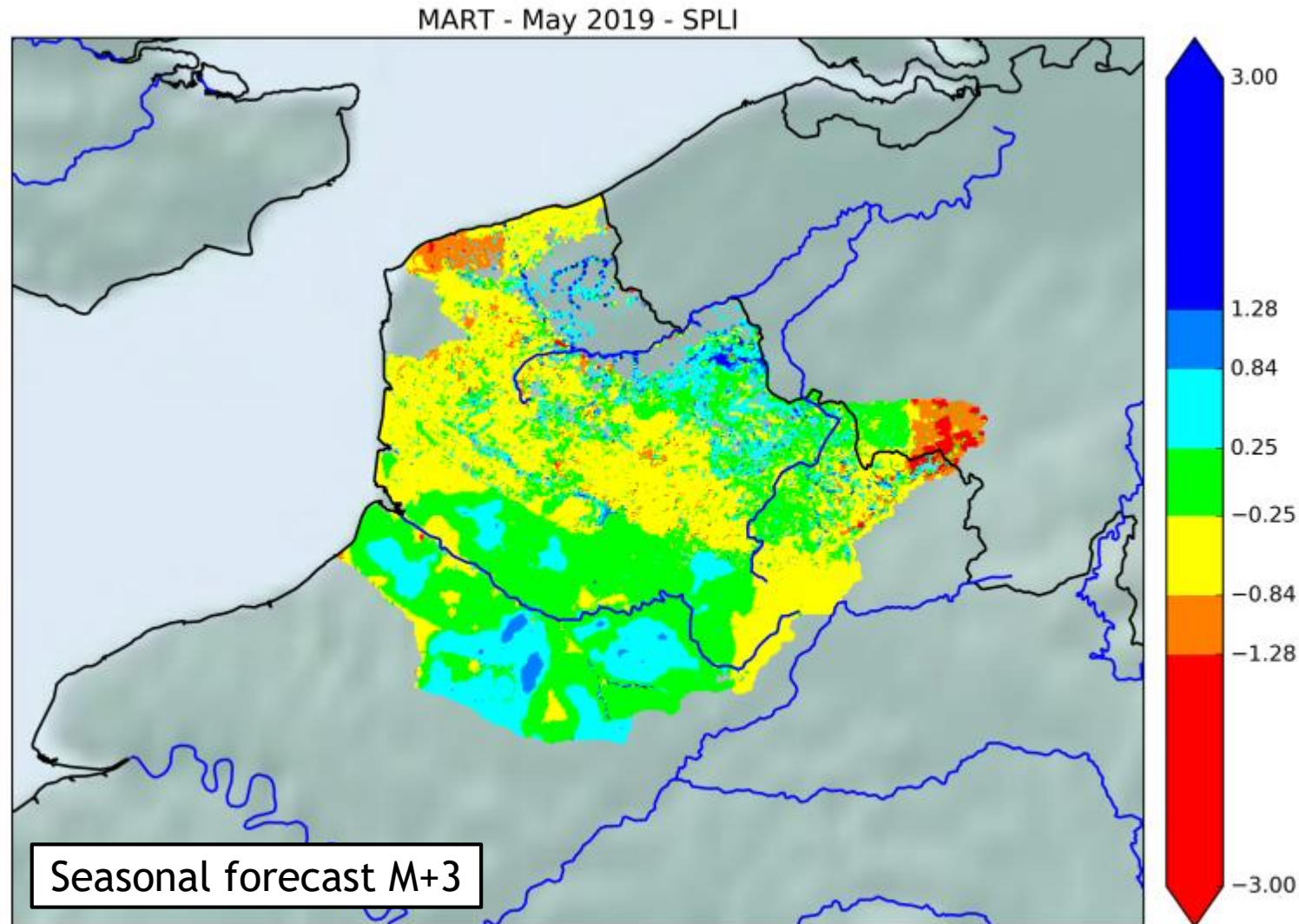
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- Median of seasonal forecasts indicates drying continues ...
- Especially in the Northern part

Groundwater simulations – spatial maps

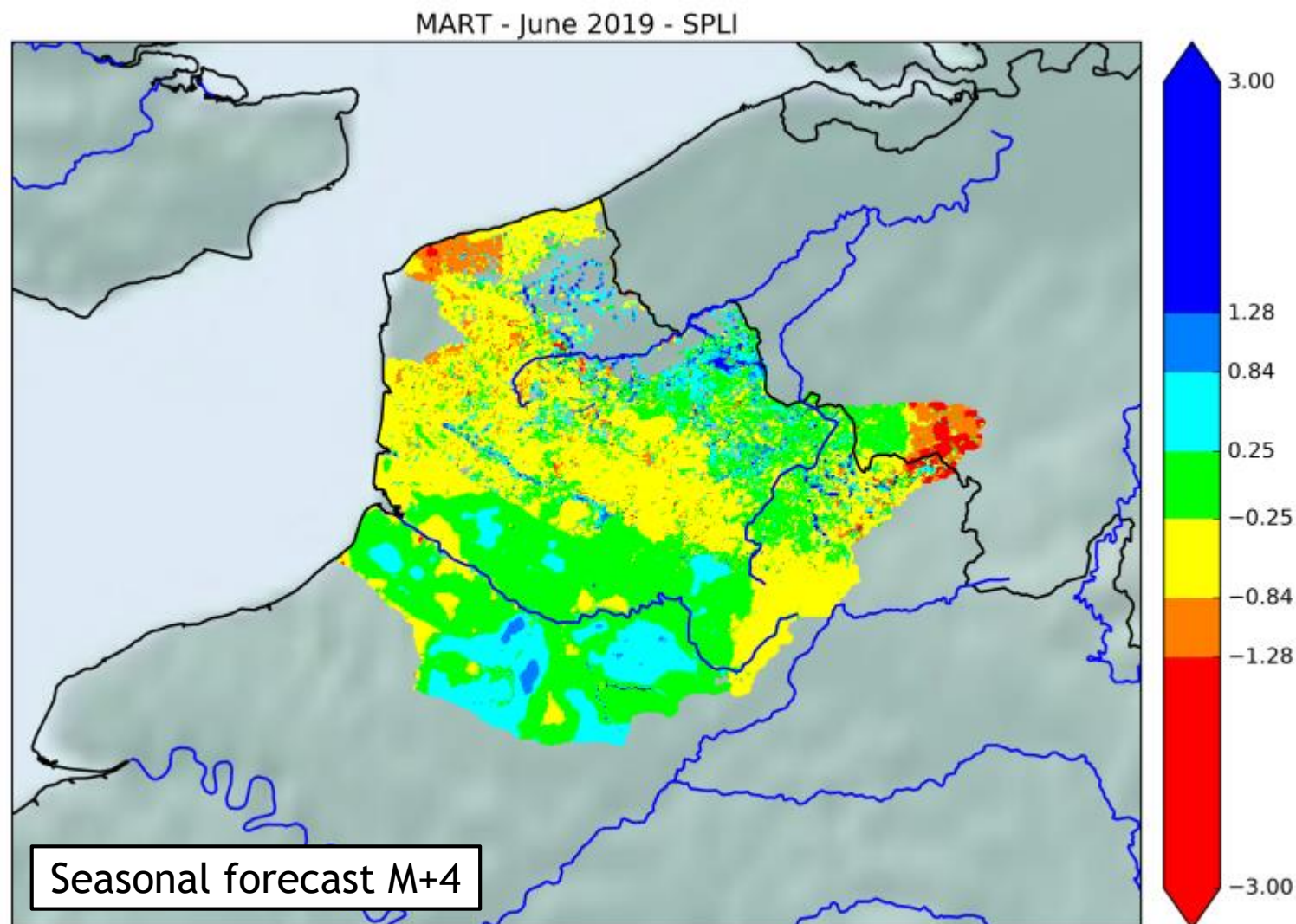
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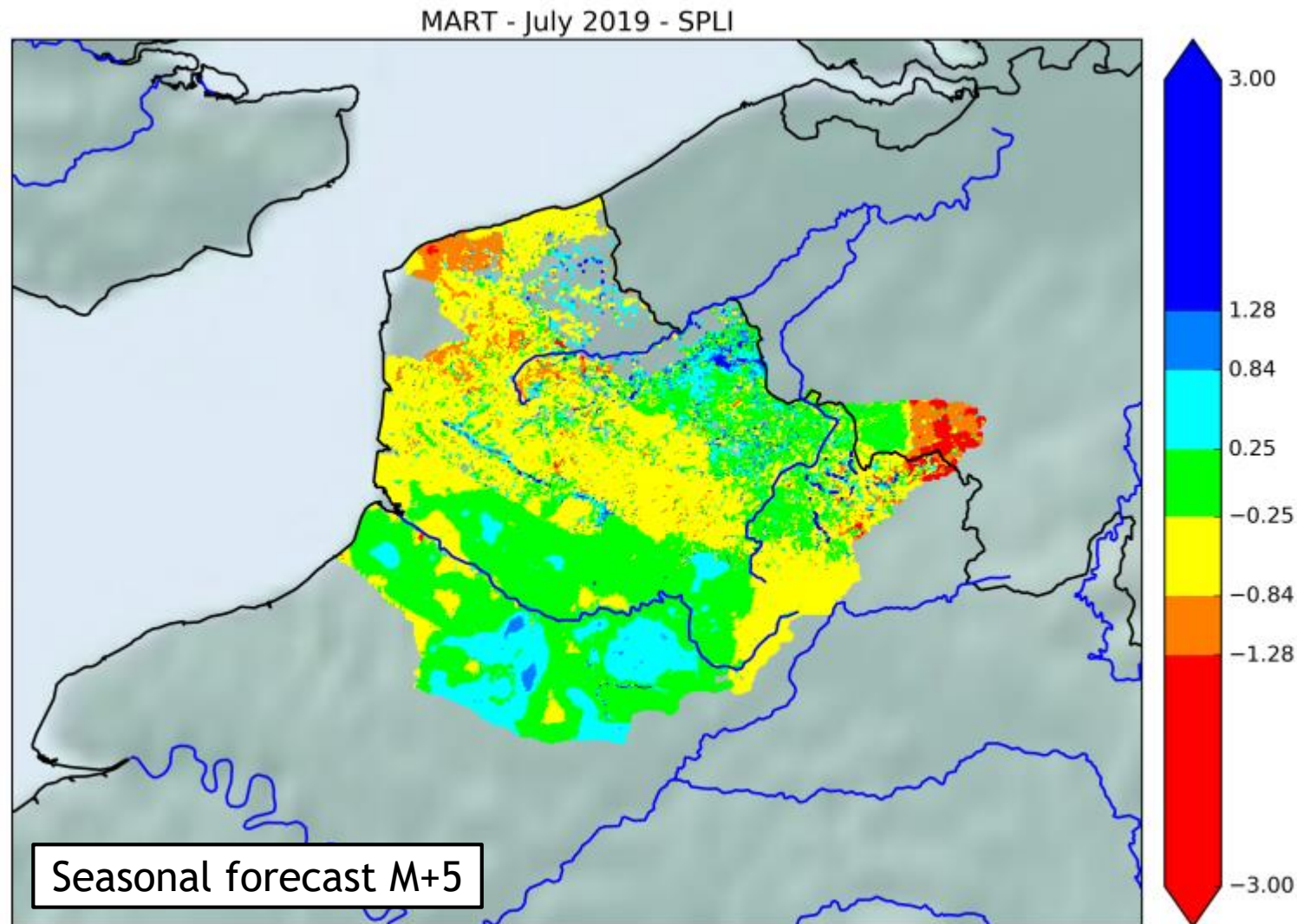
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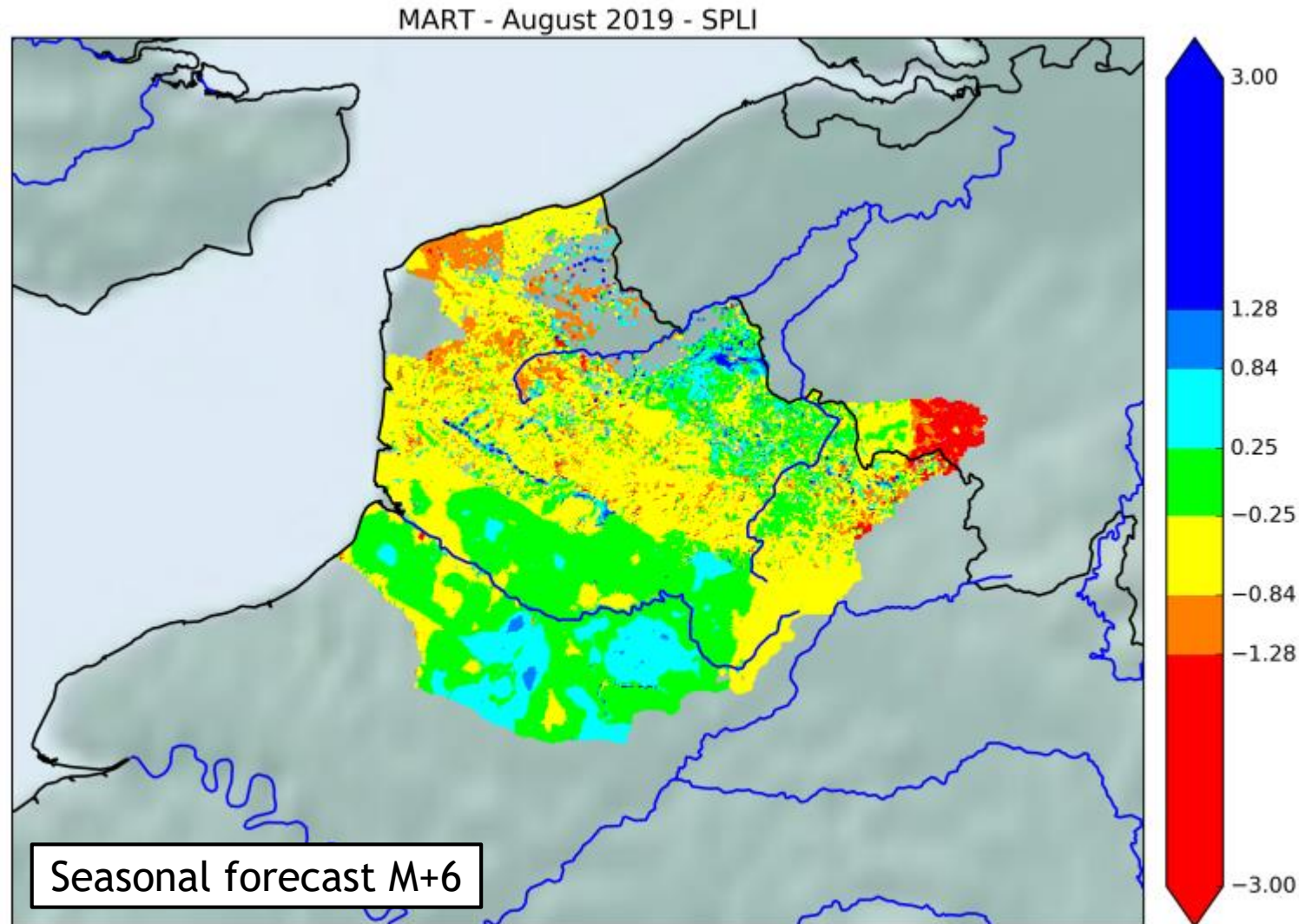
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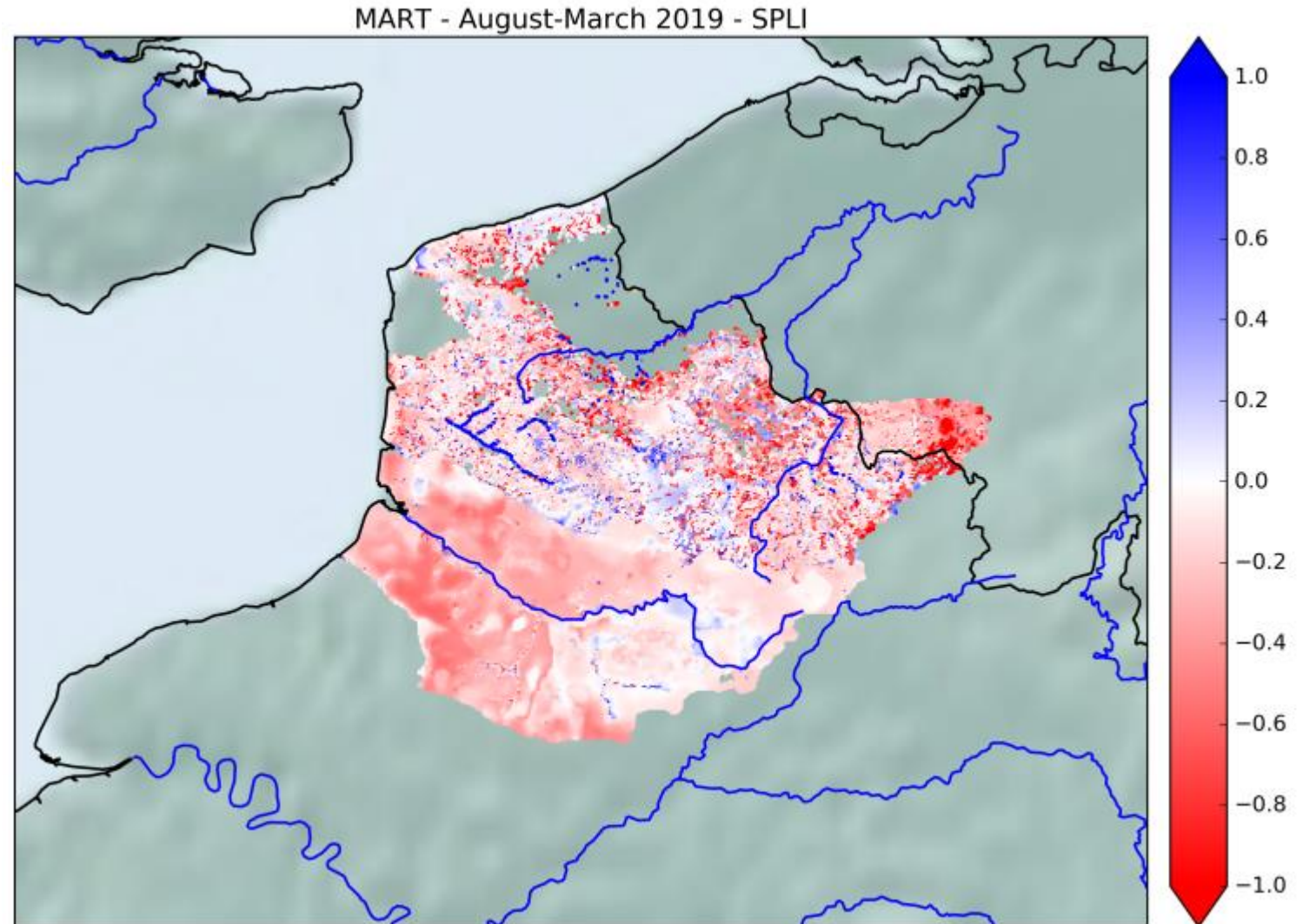
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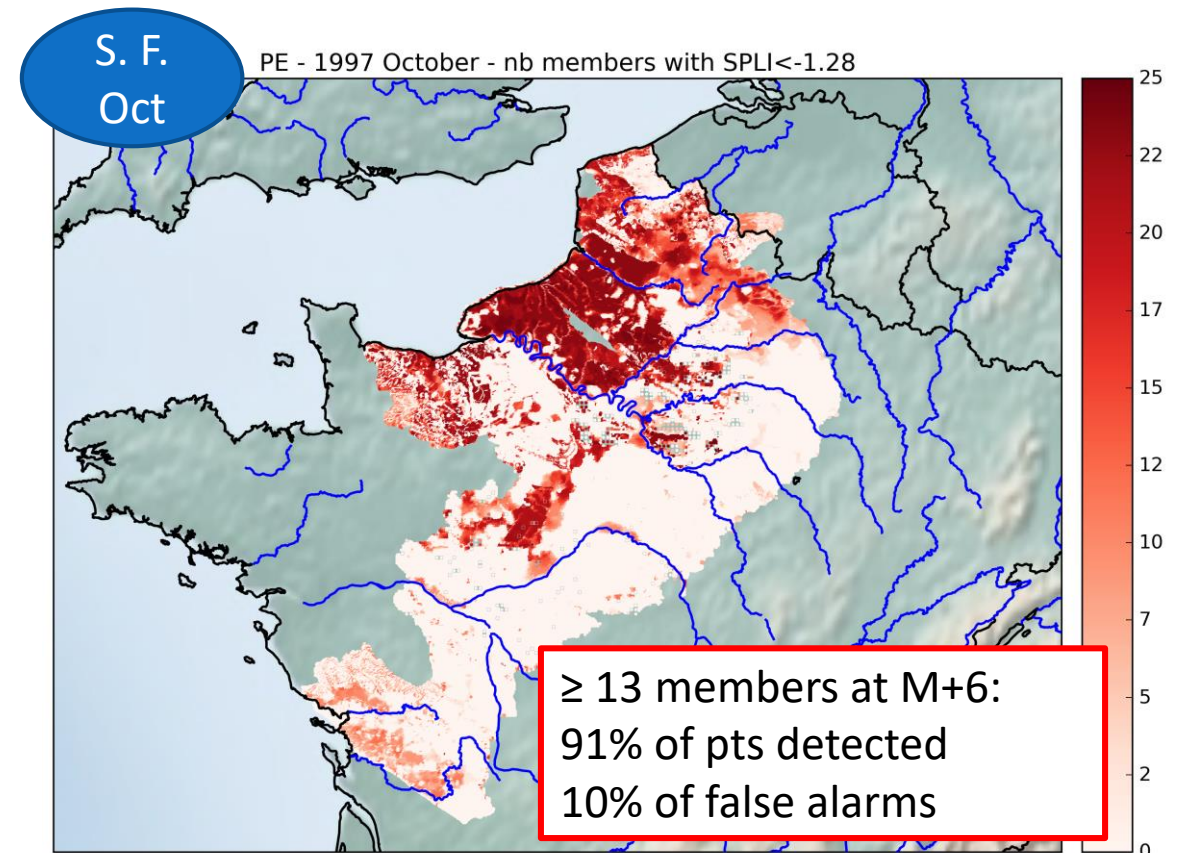
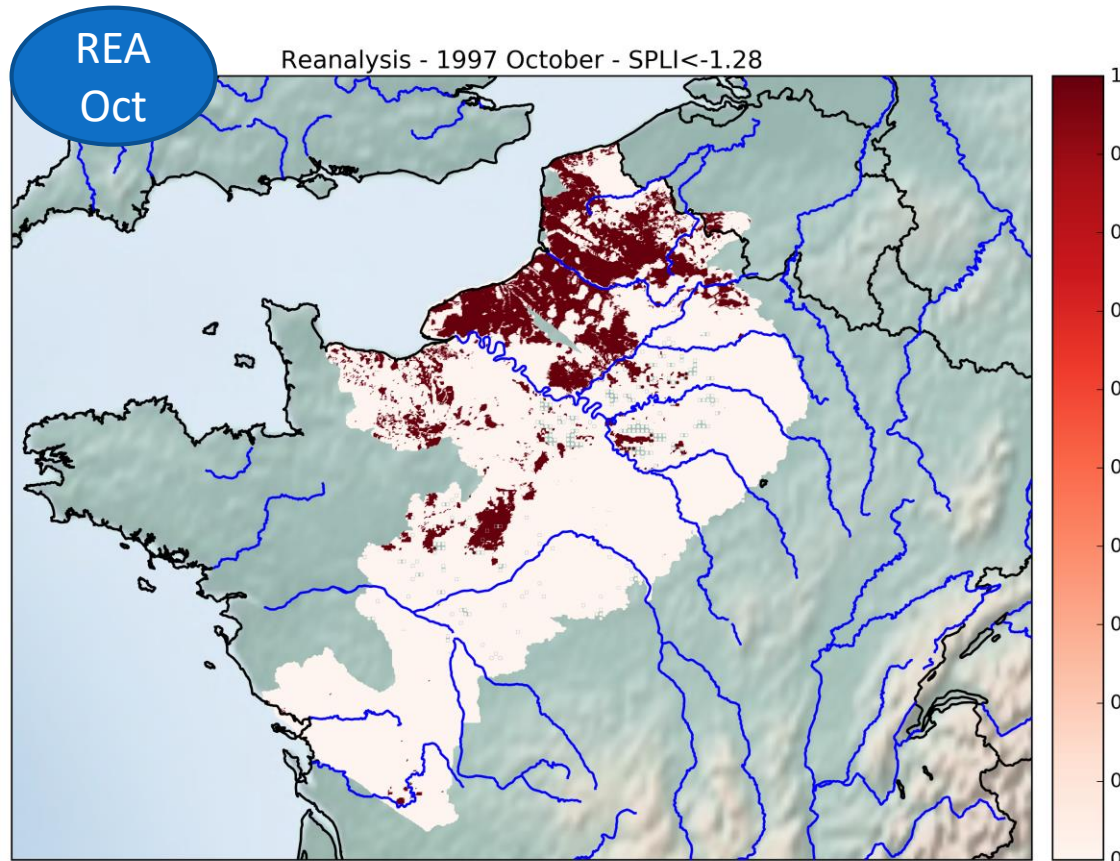
Groundwater simulations – spatial maps

- Difference between SPLI medians from August and March (final state – initial state)
- $\text{Diff} < 0$ indicates a faster decreasing of the groundwater levels than usual



Drought detection – example (init in May -> October)

- 1997: dry year over most of France (~30% of the Aqui-FR domain)
- Long run REA gives the dry points and SF gives the number of members with low SPLI



Perspectives

- Ongoing work on the Aqui-FR platform:
 - Calibration of the models to reduce the biases
 - More aquifer applications (Bretagne, Adour-Garonne, ...)
 - Evaluation of the 2 forcing versions
- Ongoing work and perspectives for the seasonal forecasts:
 - Evaluation on the hindcast period (1993-2016) compared to in situ, long run, climatology, persistency
 - Accuracy index of the S.F. depending on the month initialization
 - Drought forecasts (number of members/scenarios indicating a drought)
 - Long term projections (end of the 21st century)