The Aqui-FR project: towards an operational forecast platform for the main regional multilayer aquifers in France.

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Why Aqui-FR?

- The purpose is to have operational **hydrological** and **hydrogeological forecast** platform over France.
- Surface water flow forecast skills are better where groundwater is represented (even with no explicit representation of water abstraction)
- While numerous regional groundwater models are already available, they usually don’t take into account weather forecasts

Singla et al. 2012

**Forecast ability summer river flow 3 months ahead**

The SIM hydro-meteorological system that runs operationally at Meteo France
Why Aqui-FR?

- **Aqui-FR** thought as a *valorizing tool* of the groundwater modeling work done in France
- Based on *existing* groundwater modeling studies, with a focus on well established *groundwater models* (EauDyssée from Mines-ParisTech and Marthe/Gardenia/Eros from BRGM)
- Favor the *development* where such regional models are still lacking

- We aim at developing an *efficient* and *accurate* tool of groundwater level and surface water flow forecasts, for better *water management especially during droughts*

<table>
<thead>
<tr>
<th>1958</th>
<th>Present</th>
<th>10 days</th>
<th>3-6 months</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reanalysis</td>
<td>Real time monitoring</td>
<td>Short term forecast</td>
<td>Seasonal forecast</td>
<td>Climate projections</td>
</tr>
</tbody>
</table>
What is included?

**EauDyssée**
- 1 to 4 layers, 125 m
  - Viennot, Abasq, 2013

**EauDyssée**
- 3 layers, 1km
  - Monteil, 2011

**Marthe**
- 8 layers, 1 km
  - Douez et al., 2010

**EauDyssée + Marthe**
- 4 layers, 250m
  - Thierion, 2007, Croiset et al., 2013

**Marthe**
- 10 layers, 100 m
  - Buscarlet et al., 2011

**Marthe + EauDyssée**
- 1 layer, 100m
  - Amraoui 2004, Korkmaz 2007

**EauDyssée**
- 6 layers, 1 km
  - Viennot 2009

**EauDyssée + Marthe**
- 1 layer, 125 m
  - Chardigny 2009, Thierion 2011, Noyer & Elsass 2006

All these regional models needed to be recalibrated
- Surfex (Météo-France land surface model)
- surface water budget
What is included?

**EauDyssée**
- 1 to 4 layers, 125 m
  - Viennot, Abasq, 2013

**EauDyssée**
- 3 layers, 1 km
  - Monteil, 2011

**Marthe**
- 8 layers, 1 km
  - Douez et al., 2010

**Marthe**
- 15 layers, 2 km
  - Pédrion et al., 2005
  - Under adaptation

**EauDyssée + Marthe**
- 4 layers, 250 m
  - Thierion, 2007, Croiset et al., 2013

**Geosciences-Rennes**
- 1 to 4 layers, 125 m
  - Viennot, Abasq, 2013

**EauDyssée**
- 6 layers, 1 km
  - Viennot 2009

**Marthe**
- 10 layers, 100 m
  - Buscarlet et al., 2011

**Marthe + EauDyssée**
- 1 layer, 100 m
  - Amraoui 2004, Korkmaz 2007

**EauDyssée + Marthe**
- 1 layer, 125 m
  - Chardigny 2009, Thierion 2011, Noyer & Elsas 2006

**EauDyssée**
- 1 layer, 1 km
  - Golaz, 2000

**EauDyssée**
- 3 layers, 1 km
  - Monteil, 2011

**EauDyssée + Marthe**
- 1 layer, 250 m
  - Thierion, 2007, Croiset et al., 2013

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- 1 layer, 100 m
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- 6 layers, 1 km
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**EauDyssée**
- 1 to 4 layers, 125 m
  - Viennot, Abasq, 2013

**Geosciences-Rennes**
- Q. Courtois et al., 2019
  - Under development

**Marthe**
- 10 layers, 100 m
  - Buscarlet et al., 2011

**Marthe + EauDyssée**
- 1 layer, 100 m
  - Amraoui 2004, Korkmaz 2007

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- 6 layers, 1 km
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How does it work?

Aquí-FR structure in the Open-Palm parallel coupler

Efficiently communicating through a buffer

USE palmlib !*I The PALM interface
USE palm_user_param !*I The PALM constants

cl_space = 'one_double'
cl_object = 'main_dt_time'
cALL PALM_PUT(cl_space, cl_object, PL_NO_TIME, PL_NO_TAG, ZMAIN_DT_TIME, il_err)

Water head, river ground water exchanges

Water flow

Atmospheric forcing/
Runoff, infiltration

Efficiently communicating through a buffer
1958-2018 Reanalysis – long term evaluation

Nash Coefficient

- 58% < 5 m
- 74% < 8 m
- 24% < 2 m

See Vergnes et al. (CMWR 2018 and in prep.)
Main application – tool for decision makers

- Indicator for making the best management decisions?
  - Based on averaged levels
  - Based on ground water and river flow anomalies
1958-2018 Reanalysis

- **Standardized Piezometric Level Index** (Similarly to the Standardized Precipitation Index and the Standardized Soil Wetness Index)
  - More coherent comparison
  - In place since 2017 for the BRGM Hydrogeological Report (based on observed levels) – snapshot

Seguin et al. 2015
1958-2018 Reanalysis

- Mean SPLI over the whole Aqui-FR domain
  - Reference period from 1981 to 2010

> 10 years wet
> 5 years wet
> 2.5 years wet
> 2.5 years dry
> 5 years dry
> 10 years dry
1958-2018 Reanalysis

- Mean SPLI over the whole Aqui-FR domain
  - Better interpretation of future water level in terms of return period

03/1973

04/2001

> 10 years wet
> 5 years wet
> 2.5 years wet
> 2.5 years dry
> 5 years dry
> 10 years dry
« Real time » monitoring of SPLI

- We aim at producing such maps 3 to 6 month ahead
Brief comparison between surface and groundwater droughts

Vidal et al. 2010b

- Complex non linear relationships between the surface droughts and groundwater droughts

- Importance of groundwater dynamic (spatial and temporal)

1976
1989
2003
2011

1973
1992
2006
2012

Mean duration (months)

Mean area (%)
Relationship between Groundwater-river exchanges, recharge and SPLI – preliminary analysis

- For the same recharge value, there is more than 60% variation in groundwater-river exchanges.
- Low SPLI related to lower groundwater-river exchanges.
- Dynamic of the aquifer.
- Importance of groundwater in supporting the river flow.
- Towards a better understanding quantification of the water available for abstraction and human use.
Ongoing and future tasks

- Take into account **new aquifers and models**
- Run **hindcasts** in order to test Aqui-FR **forecast ability** with Arpege-S6)
  - Seasonal hindcasts (Post-Doc D. Leroux)
- Further assessment of **uncertainties**
  - Ensemble simulations (weather forecast uncertainty)
  - Sensitivity studies (anthropic activities)
  - Multi-models comparison (groundwater modelling)
- Better assessment of initial condition (**Data assimilation** and inverse methods, Master student A. Gervereau)
- **Connect the regional basins together** (especially for imposed river boundary conditions) through the use of the RHT hydrological network
- Build **output products** with end users
Thank you for your attention.