Hydrological forecast systems using SURFEX

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Since 2003 Météo-France operates daily the SAFRAN-SURFEX-MODCOU model chain for water resources real-time monitoring.

SAFRAN-SURFEX-MODCOU reanalysis [August 1958 – Present]

**Context**

**SAFRAN**

*Input:* Guess + Observations  
*Output:* Atmospheric forcing 8km grid – hourly time step

**SURFEX (ISBA-DIF)**

*Input:* Atmospheric forcing  
*Output:* Water & Energy fluxes

**MODCOU**

*Input:* Drainage & Runoff  
*Output:* Daily river discharges

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Daily SWI over France – comparison to climatology

SWI anomaly - 14/03/2019
## Context

- Forecast applications, use of:
  - atmospheric forecast instead of SAFRAN analysis forcing,
  - real-time analysis outputs for SURFEX & MODCOU initial states from

<table>
<thead>
<tr>
<th>Atmospheric forecasts</th>
<th>SURFEX (ISBA)</th>
<th>MODCOU</th>
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<tbody>
<tr>
<td><strong>Input</strong> :</td>
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<tr>
<td>Temperature &amp; Precipitation Forecasts</td>
<td>Atmospheric forcing</td>
<td>Drainage &amp; Runoff</td>
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<td>Climatology from SAFRAN for other parameters</td>
<td>Initial State from real-time analysis</td>
<td>Initial State from real-time analysis</td>
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<td><strong>Output</strong> :</td>
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<td>Atmospheric forcing 8km grid</td>
<td>Water &amp; Energy fluxes</td>
<td>Daily river discharges</td>
</tr>
</tbody>
</table>

N - members
Plan

1) 10-day range Hydrological Ensemble Prediction System
2) Hydrological LongTerm Prediction Systems
1) 10-day range Hydrological Ensemble Prediction System

- Atmospheric forecasts: EPS from ECMWF
- 3hourly temperature & precipitation - resolution 0.25°; interpolated on the 8km grid
- Validity: up to 10 days
- Frequency: 1 per day – Base time 00hUTC
- Validation over 2 years; Reference: SAFRAN-SURFEX-MODCOU Reanalysis

Application for flood episodes:

- End user: authority in charge of flood forecasts (SCHAPI)
- Information at some specific locations with 2 thresholds <= yellow/orange awareness levels
1) 10-day range Hydrological Ensemble Prediction System

- Study Case May-June 2016 flood event over Seine Basin (31/05/2016)
1) 10-day range Hydrological Ensemble Prediction System

- Study Case May-June 2016 flood event over Seine Basin. Station Chalette – Loing River

Forecasts from 21/05/2016 Base time to 04/06/2016 Base time

Awareness table for the highest threshold
12/05/2016 Base time to 31/05/2016 Base time
1) 10-day range Hydrological Ensemble Prediction System

- Application for water resources management
  - Main variables: SWI & SWE

Daily Soil Wetness Index: Doubs County
SIM2 Analysis & HEPS Base time 20190314 - 00h

Daily Snow Water Equivalent: Pyrenees
SIM2 Analysis & HEPS Base time 20190314 - 00h
Plan

1) Hydrological Ensemble Prediction System
2) Hydrological LongTerm Prediction Systems
2) Hydrological LongTerm Prediction Systems

- Two kind of long-term prediction systems (up to 6-months):
  - **Climatological forecasts**: Atmospheric forecasts = Forcing from SAFRAN reanalysis (1958-present)
  - **Seasonal forecasts**: Atmospheric forecasts from Météo-France System 6
    - Available each month – Lead-time: 7months / 51 members / Resolution @ 0.5°
    - Need to be corrected to force impact models, Correction of daily precipitation & 6h-temperature with quantile mapping. Quantiles from:
      - Hindcast of the SF system: 1993-2016 period – 25 members
      - SAFRAN reanalysis (reference)

Cumulative distribution function of daily precipitation (month of June)
2) Hydrological LongTerm Prediction Systems

— Seasonal Prediction system: Quality depends on the month of initialization and the lead-time

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<thead>
<tr>
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<th>Init 09</th>
<th>Init 10</th>
<th>Init 11</th>
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<tbody>
<tr>
<td>September</td>
<td>0,6</td>
<td></td>
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</tr>
<tr>
<td>October</td>
<td>0,69</td>
<td>0,68</td>
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<tr>
<td>November</td>
<td>0,18</td>
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<tr>
<td>December</td>
<td>0,26</td>
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<td>January</td>
<td>0,31</td>
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<td>0,5</td>
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<tr>
<td>February</td>
<td>0,3</td>
<td>0,39</td>
<td>0,6</td>
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<tr>
<td>March</td>
<td>0,43</td>
<td>0,3</td>
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<tr>
<td>April</td>
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<td>0,3</td>
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=> Before using a real time forecast it's worth analysing the quality of the re-forecast experiment for this specific initialization month...
2) Hydrological LongTerm Prediction Systems

- Two kind of long-term prediction systems (up to 6-months):
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Cumulative distribution function of daily precipitation (month of June)
2) Hydrological LongTerm Prediction Systems

- Real-time production:
  - Monthly briefing with end-user: authority which manages lakes over the Seine basin. Aim: Fill lakes during winter in order to reduce winter-floods + ensure river flow during low flow period
  - Comparison between seasonal and climatological forecasts
2) Hydrological LongTerm Prediction Systems

- Snow Water Equivalent forecasts
- Scores: good performance but... skill versus climatological forecasts needs to be evaluated
2) Hydrological LongTerm Prediction Systems

- Snow Water Equivalent forecasts – Example Initialization 20190301

Daily Snow Water Equivalent: French Alps
SIM2 Analyzis & Climatological Forecast Application
Initialization: 20190301

Daily Snow Water Equivalent: French Alps
SIM2 Analyzis & Seasonal Forecast Application
Initialization: 20190301
Conclusion & Perspectives

- Use of SURFEX in real-time to monitor the current situation but also to make forecasts
- Useful for flood event anticipation (medium-range) but also for water resources management (medium to long term forecasts) – Collaboration with end-users

Perspectives:
- Extension of EPS from 10 to 14 (30) days & build a seamless forecast system
- New methodology to correct seasonal forecasts coming from the atmospheric model
- Extension to groundwater resources using Aqui-FR (cf. D.Leroux talk)
- Adapt the climatological/seasonal forecast application to other domain within MEDSCOPE project using SURFEX-CTRIP and UERRA reanalysis as reference for bias correction

MEDSCOPE Domain
Thank you for your attention