Bow echo detection and rainfall scenarios : two ways to extract relevant information from convective-scale ensembles

Arnaud Mounier, Laure Raynaud, Lucie Rottner and Matthieu Plu

CNRM, Université de Toulouse, Météo-France, CNRS, Toulouse, France

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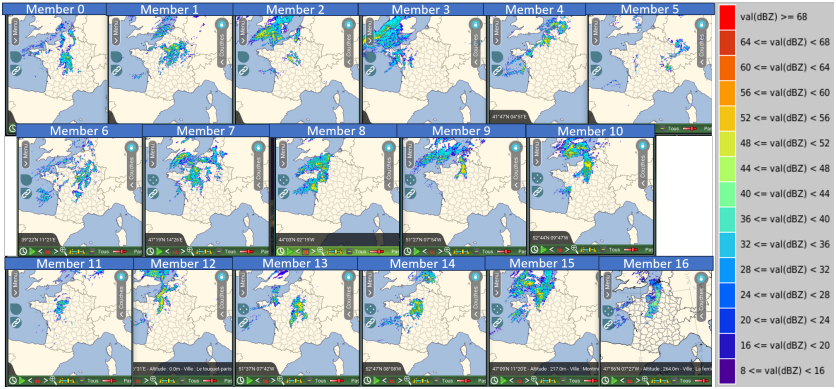
arnaud.mounier@meteo.fr

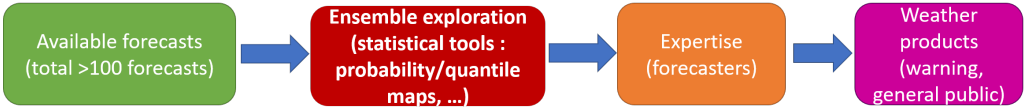
AROME-EPS : convective-scale ensemble at Météo-France

- AROME-EPS : 17 members (including one unperturbed member). Horizontal resolution of 1.3km, runs 4 times a day and lead times up to 51h.
- Built to especially improve severe convective storm forecasts (MCS, ...).

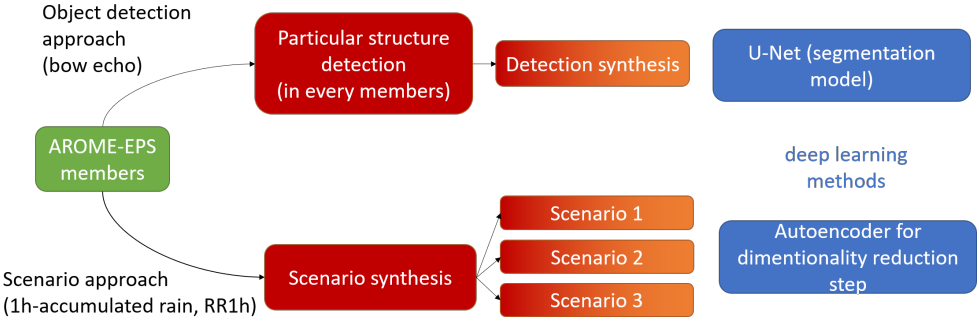


Reflectivity fields of 17 AROME-EPS members.

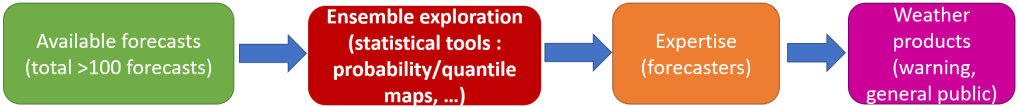
Use of ensemble forecasts still challenging



Question: How to extract new relevant information for forecasters and facilitate the use of ensemble forecasts ?



Bow echo detection



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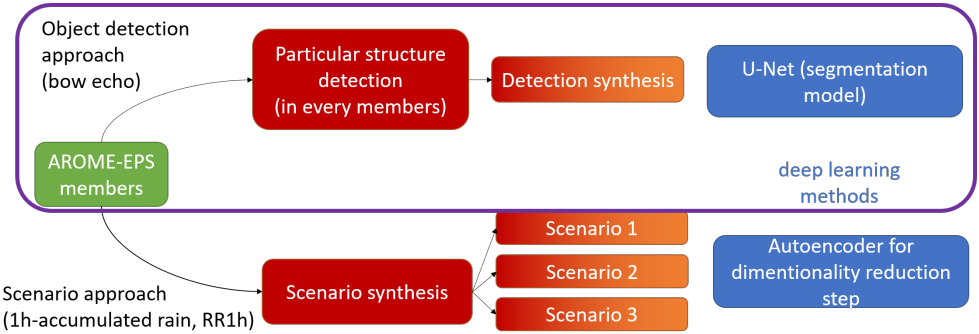
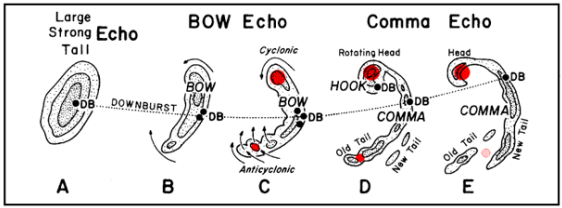


Bow echo (BE) : description

Main features :

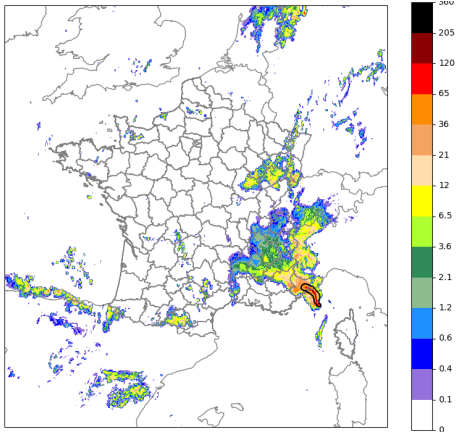
- Bow echo (BE) : Mesoscale convective system with a bow signature in reflectivity field.
- Rare event : <10 per year in France
- strong wind gust : possibly > 150 km/h, record : 225 km/h in Corsica (August 2022).



Source : NOAA

Bow echo detection : workflow

- Input data : reflectivity field (univariate detection).
- **To our knowledge, no existing method to detect BE $\Longrightarrow$ BEs are hand-labeled in model data.**
- training database : $\approx$ 500 hand-labeled BEs.
- U-Net architecture (segmentation model and satisfactory results with few data)
- **Objective and subjective U-Net evaluation** : feedback with a group of 10 forecasters.
- **Synthesis plots** designed with forecasters to summarize BE risk in AROME-EPS and deterministic models.
- More information in Mounier et al. (2022b)
- Daily production in a research mode since 2021. **Production to be operationalized in the coming months**.

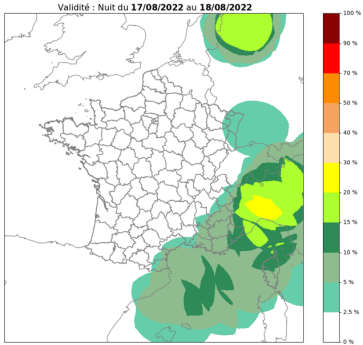


Reflectivity field + BE detection (black contour)

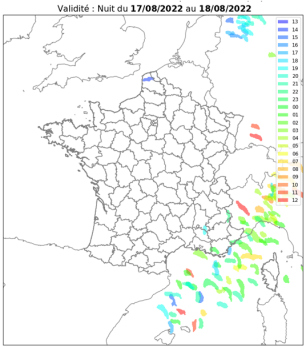
Bow echo use case : Corsica 2022 (wind gusts up to 225 km/h)

BE in Corsica (18 August 2022 ≈ 6UTC). Example of AROME-EPS run (17 August 03UTC) :

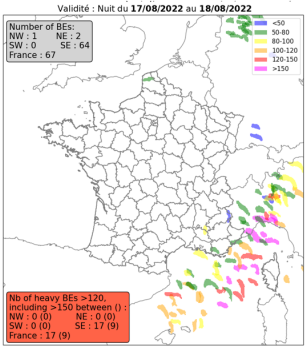
Probabiliy maps (space-time tolerance)



Paintball (UTC hours of BE detections)



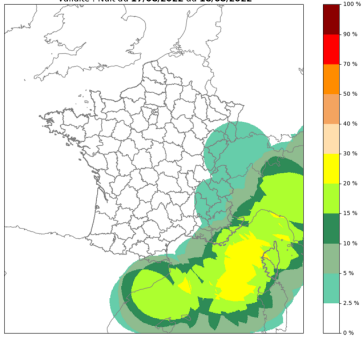
Paintball (wind gusts under BE)



Bow echo use case : Corsica 2022 (wind gusts up to 225 km/h)

AROME-EPS run at 15UTC (12h later).
BE number with gust > 150 km/h (magenta) significantly increased.

Probabiliy maps (space-time tolerance)



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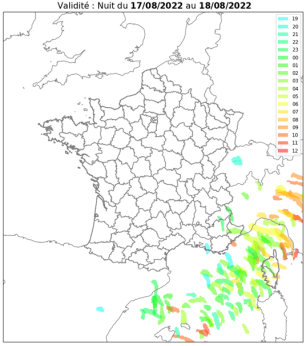

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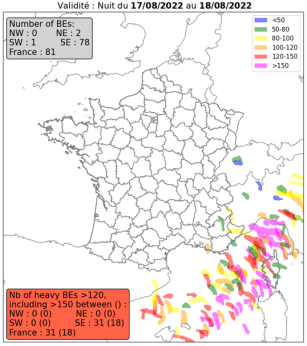
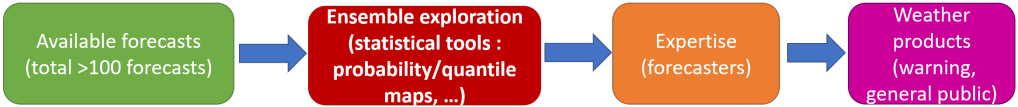


Synthesis plots help forecasters to take into account AROME-EPS in the decision process.
However, only for specific events with this method...

Weather scenarios



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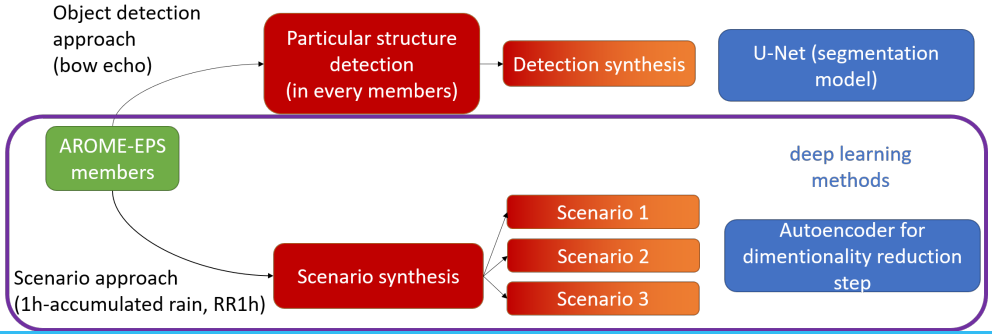
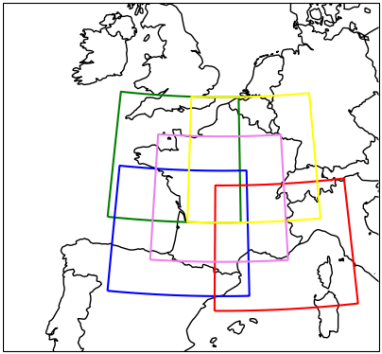


Weather scenarios : main features

Aim : automatically generate a few scenarios, representative of the different possible outcomes. Each scenario is a reduced set of EPS members.

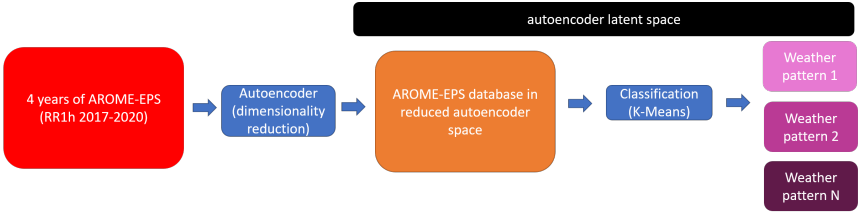
After interactions with forecasting department :

- ❏ Time-lagged ensemble to increase the ensemble size (34 members instead of 17 members)
- ❏ Weather scenarios should include also deterministic models
- ❏ Meteorological variable : 1h-accumulated rain (RR1h)
- ❏ Regional scenarios are computed (more suitable for convective scale and, if entire domain, not enough members compared with atmospheric degrees of freedom). Focus on South-East area.



5 regional domains : NW,NE,SW,SE and Center.

Methodology

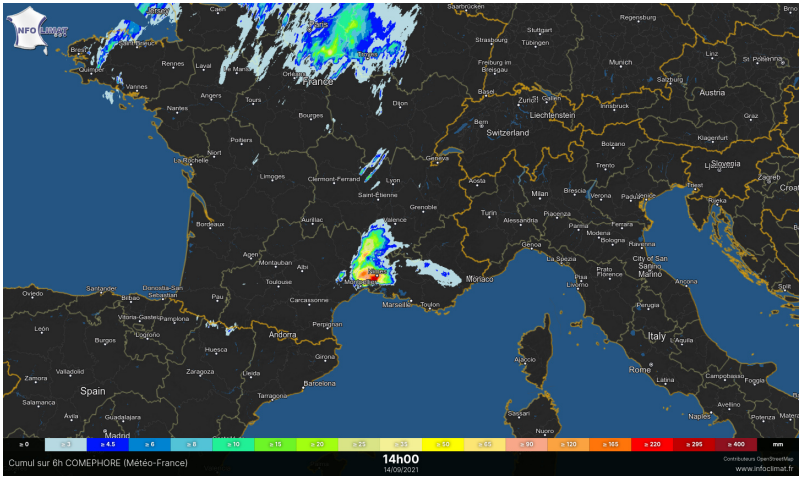


Step 1 (offline): Weather patterns (~ weather regimes) with a large AROME-EPS database.

Step 2 (online): AROME-EPS members of the day, classification with weather patterns.

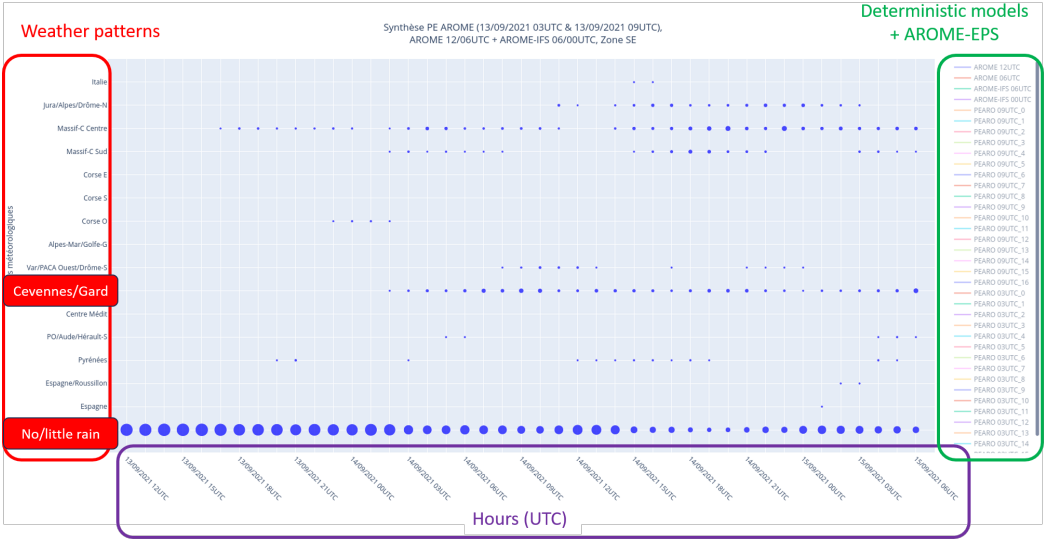
Inspired by Neal et al. (2016) and Karim et al. (2020). More information in a ECMWF workshop presentation (Mounier et al., 2022a).

Final product example : 14 September 2021



Observed 6h-accumulation rain between 06h and 12h UTC ($>$ 200 mm)

Final product : interactive plot presentation



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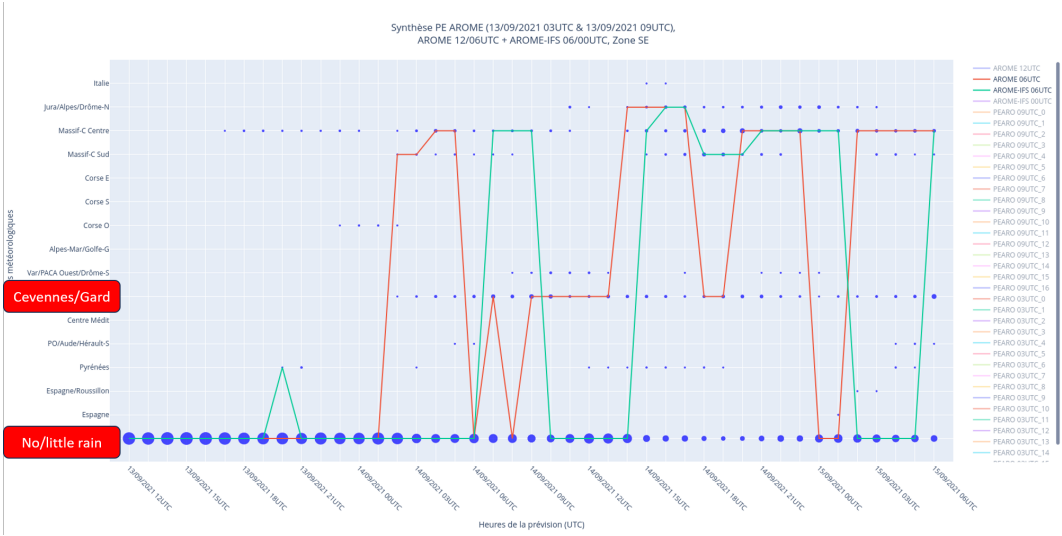

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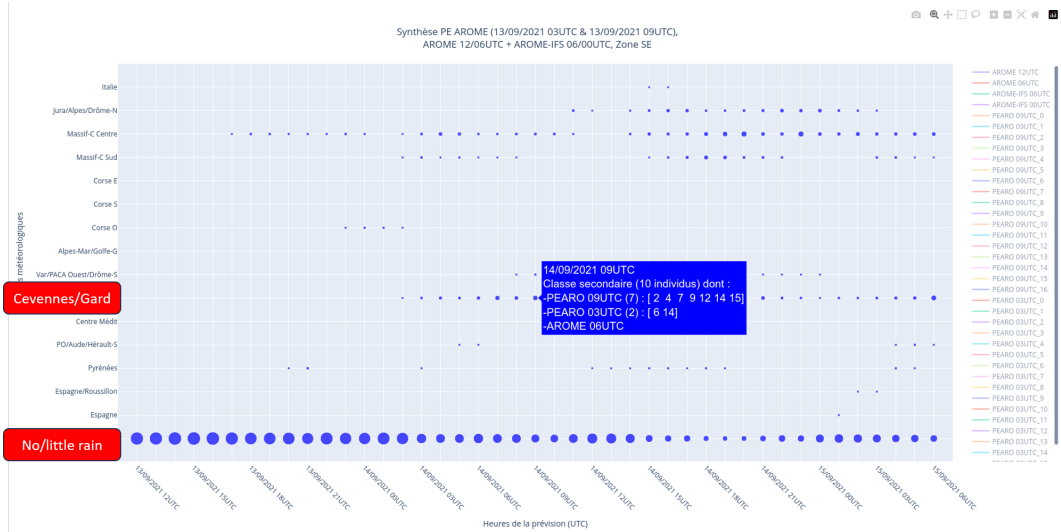

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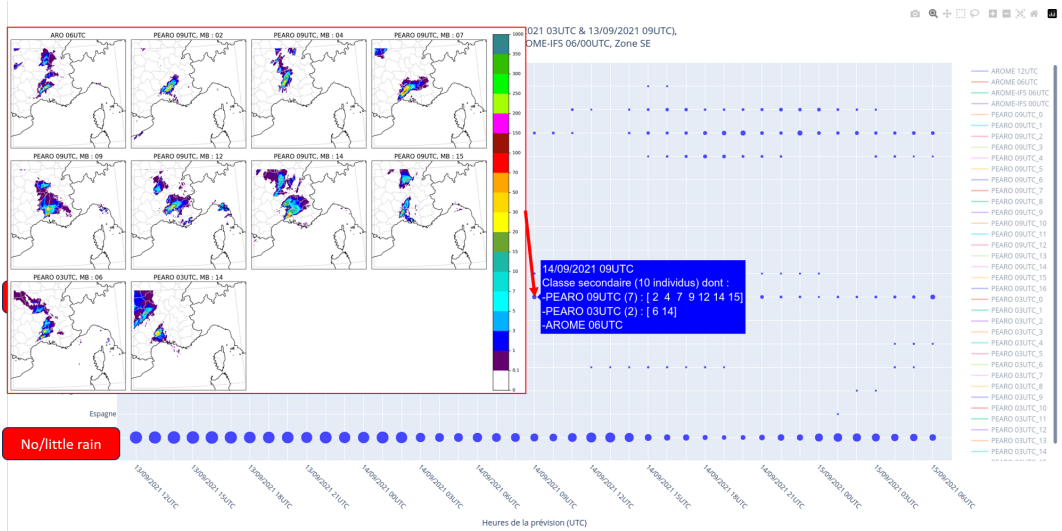
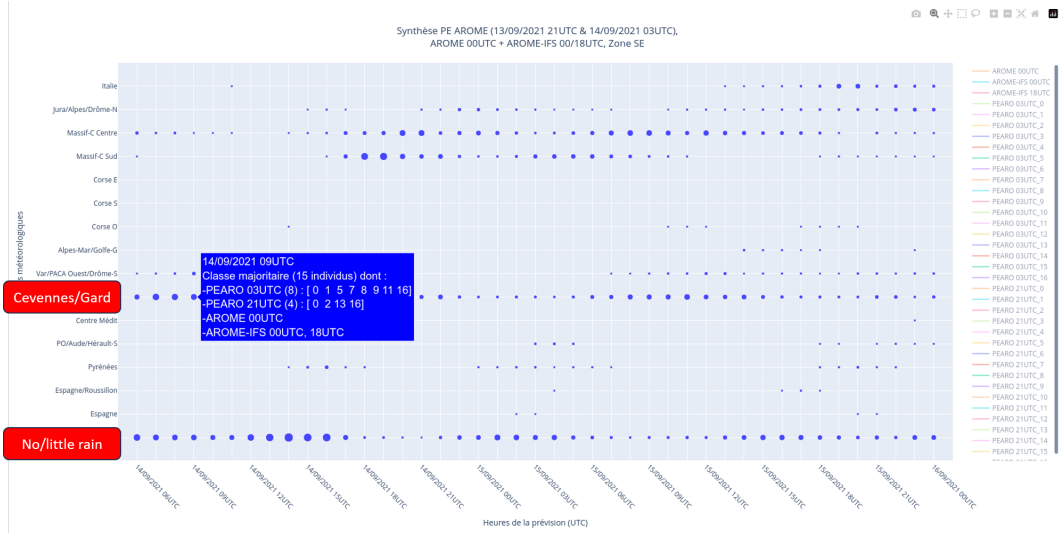


Final product : interactive plot evolution with new AROME-EPS runs



Conclusion and future work

- Conclusion :
  - Bow echo detection : useful to focus on a specific object in ensemble forecasts, operational product soon
  - Rainfall scenarios : new methodology (autoencoder + classification), 2 articles in preparation. Daily experimental production since summer 2023.
  - Interactions with forecasters at different steps.
- Future work :
  - Supercell detection (similar to bow echo methodology)
  - For rainfall scenarios, add a severity indicator
  - Extension of rainfall scenarios to other areas (Thibault Malbesin's internship for North-West) but also other variables (6h-accumulated rain, wind ?). Multivariate scenarios ? (Rain+Wind)
  - New methodology to develop "user-oriented" scenarios (renewable energy, Flore Roubelat's thesis)

References

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