

SiPRÉ, a software simulator of the perturbation of radars by wind turbines

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retour sur innovation

Summary

1. Introduction - Context
2. Simulator SiPRÉ
3. Validation
4. Conclusions/perspectives

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Introduction

Context

- Perturbations are observed on radars (meteo, military, ...) due to wind turbines
- High RCS, masking effects, multipath, ...
- Consequently some wind farm projects are cancelled to avoid perturbations (more than 3 GW in France)



Example of perturbation (from the internet)

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Context

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- High RCS, masking effects, multipath, ...
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Governmental Working Group (Radeol)

Ministry/radar operators/wind industry

→ Ademe* in charge of development of studies to help solving the problem

Ademe specifications

Step 1: Simulation tool (---> SiPRÉ)

Step 2: Improvement of wind turbine **

Step 3: Radar improvement

Onera and OKTAL-SE were asked to develop the simulator

* Agence de l'Environnement et de la Maîtrise de l'Energie

** EODIS : development of a low RCS blade (Astrium-Onera-Plastinov)

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SiPRÉ (Simulation de la perturbation des Radars par le Éoliennes) (Simulation of the perturbation of Radars by Wind Turbines)

Technical objective

Develop a simulation tool, **refined** and **validated**, of the perturbation of radars by wind turbines

Uses (R & D)

- Better understanding of the origin of the perturbations
- Specify and study modifications on wind turbine
- Study and develop improvement on radars (signal processing) to mitigate the perturbation

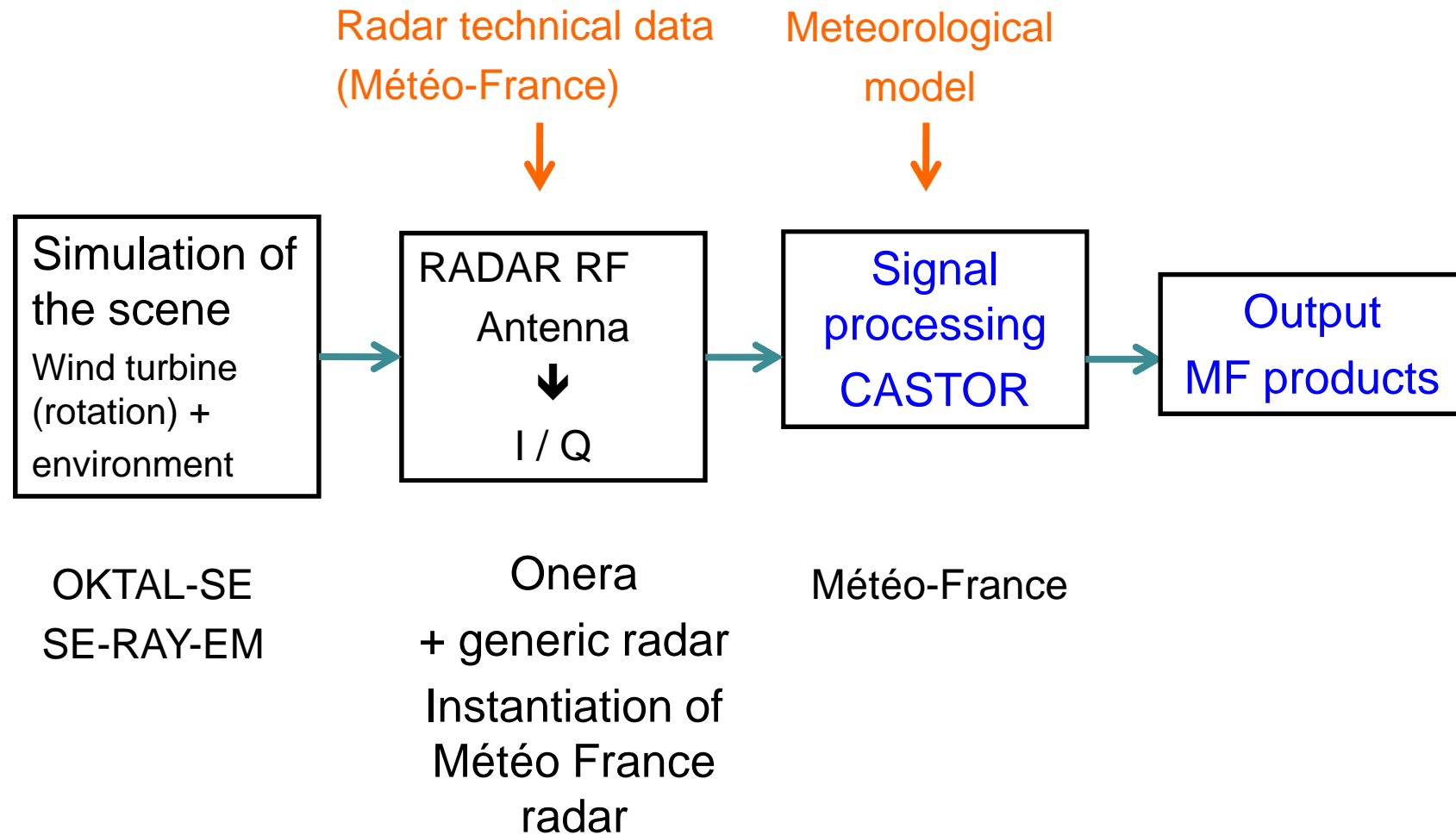
First version of the simulator

- Meteorological radars

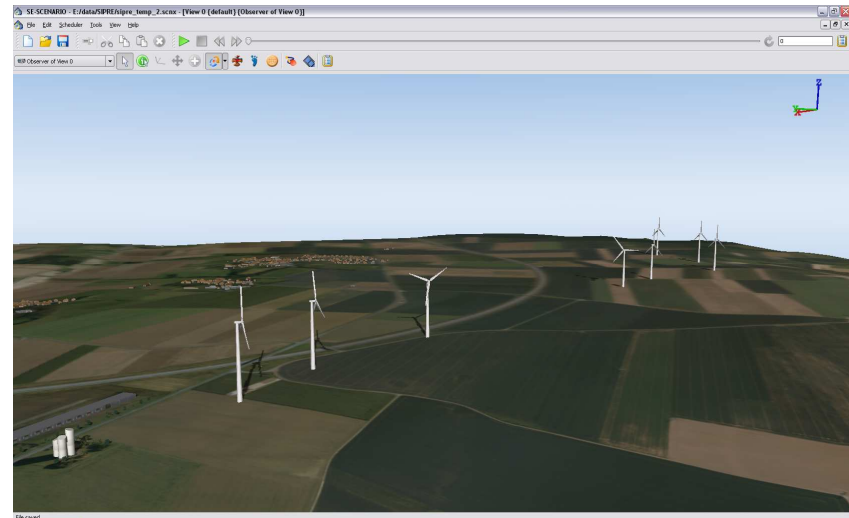
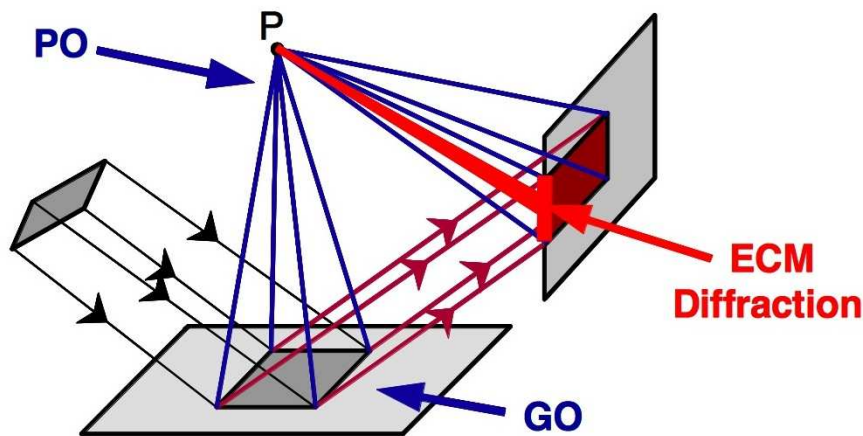
Project

- Funding: Ademe (+ Onera + OKTAL-SE)
- Consortium : Onera, OKTAL-SE (+ Météo-France, REpower)

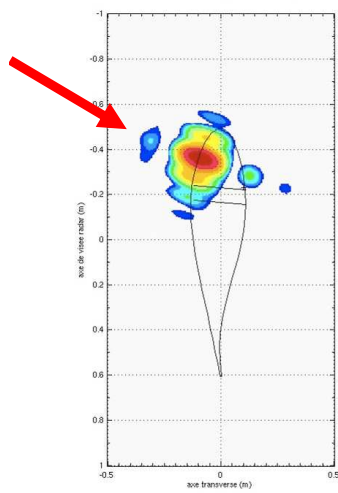
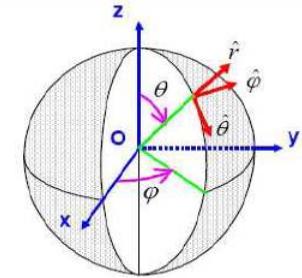
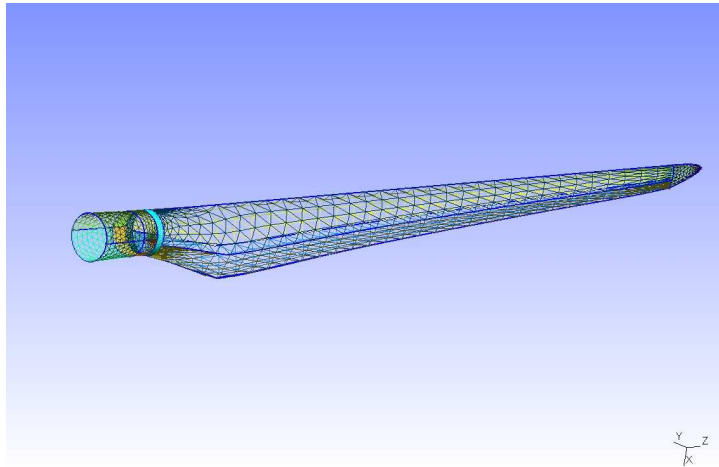
Architecture of SiPRÉ simulator



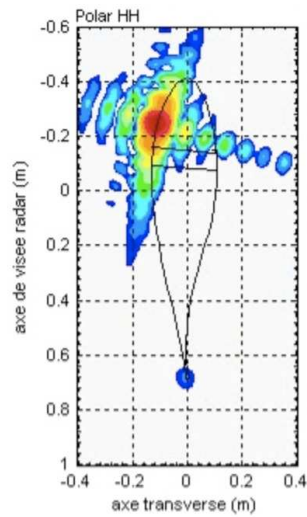
- Association of ray technique (SBR) & electromagnetic asymptotic formulations
- Multiple reflections computation Scattering and using Geometrical Optics and Physical Optics
- Edge diffraction
- Reflection and scattering on multilayer dielectric materials, propagation, reflection, and transmission
- Dedicated models for clutter materials including speckle effects
- Complete database of the scene (tens of km) : DTM, terrain cover, wind turbines, buildings



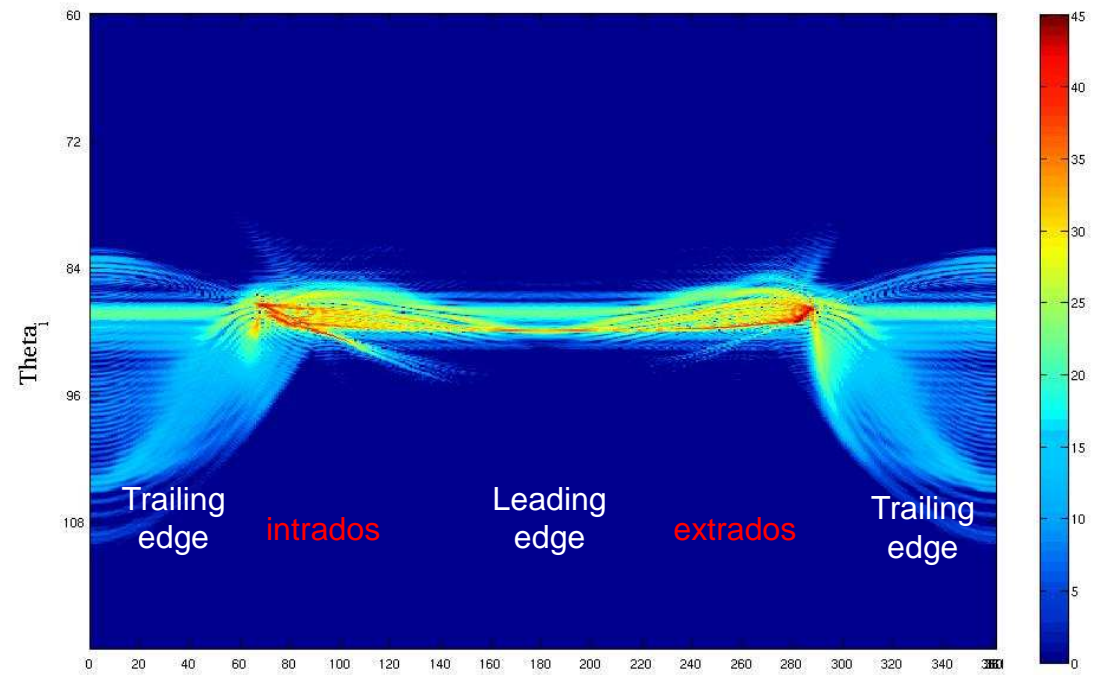
SE-RAY-EM™ RCS of a blade



computed



measured



RCS of the blade vs theta and phi

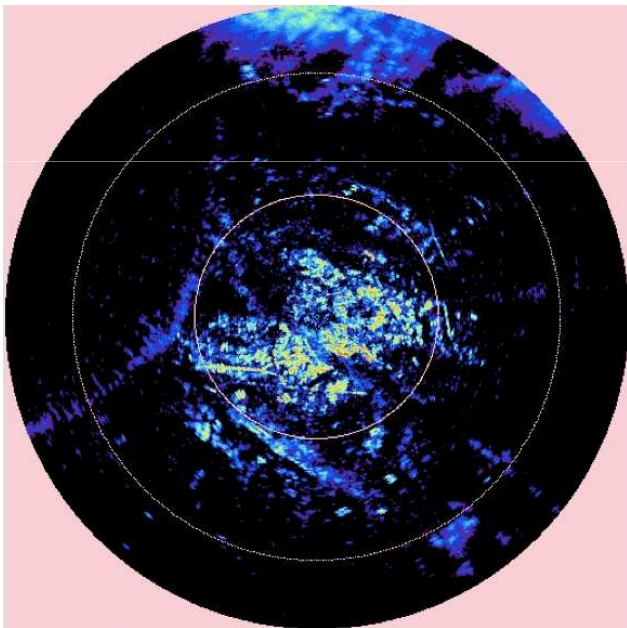
Radar model

- Generic radar → instantiation
- Waveform generation
- Time management
- Antenna : diagram, rotation
- RF hardware transfer function model

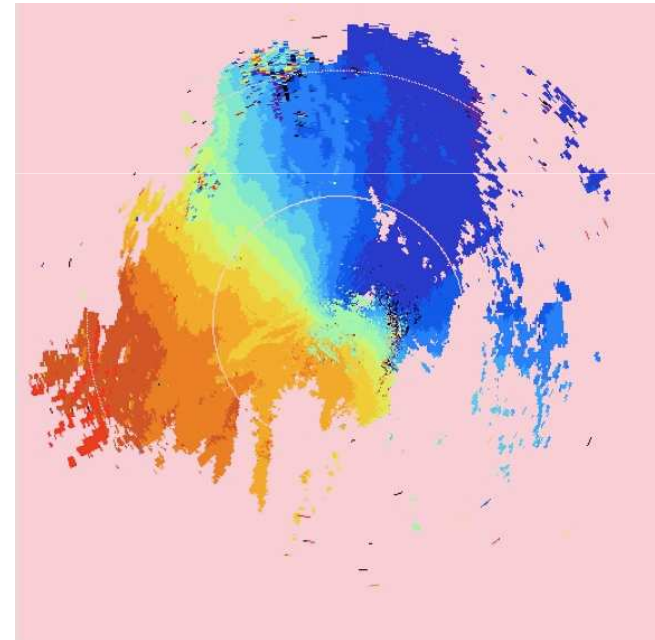
- Input : list of rays from SE-RAY-EM + EM information (amplitude, phase, time delay, ...)
- Output : I/Q signal

CASTOR™ - Meteorological signal processing

- Operational software developed by Météo-France
- Exemples of meteorological products



reflectivity



wind speed

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Validation – Measurements site : Abbeville (september 2011)



Météo-France radar – C Band bipolar

Medycis (Onera) high resolution radar

Wind farm Mont Bergerons 1 (distance 5600m)

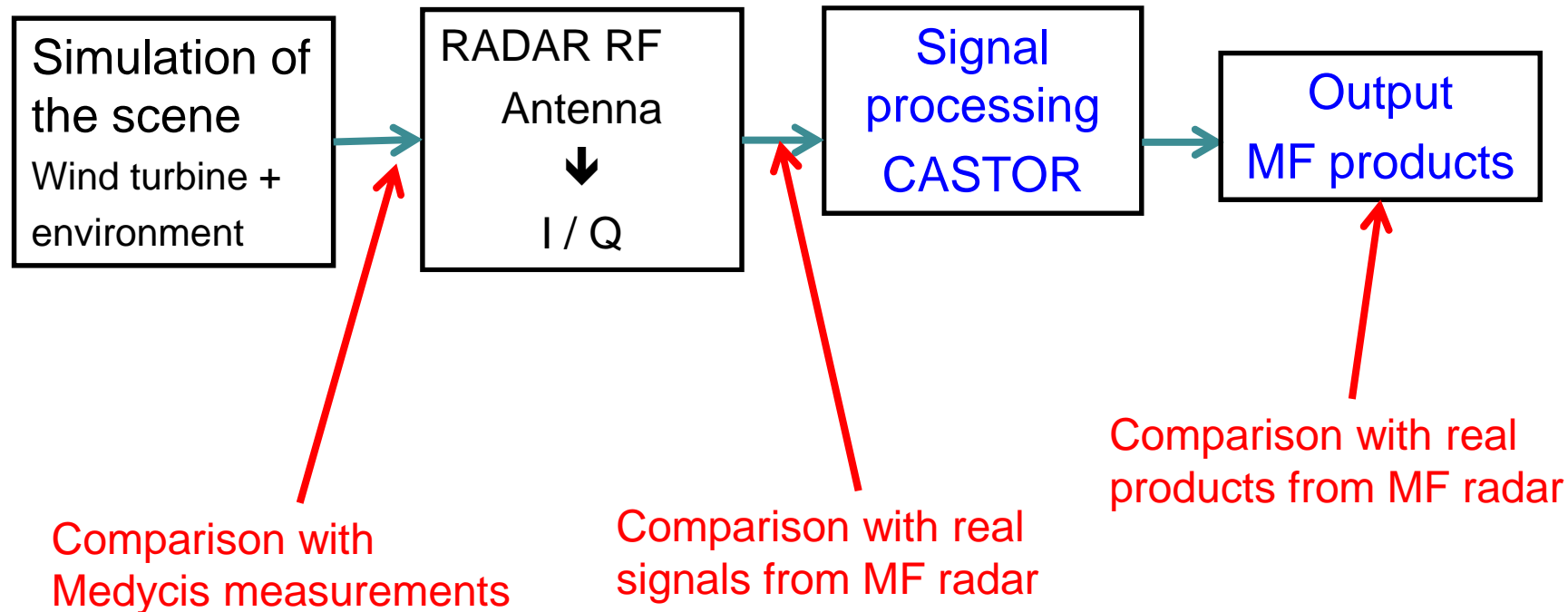
- operation : EOLFI

- wind turbine : Repower



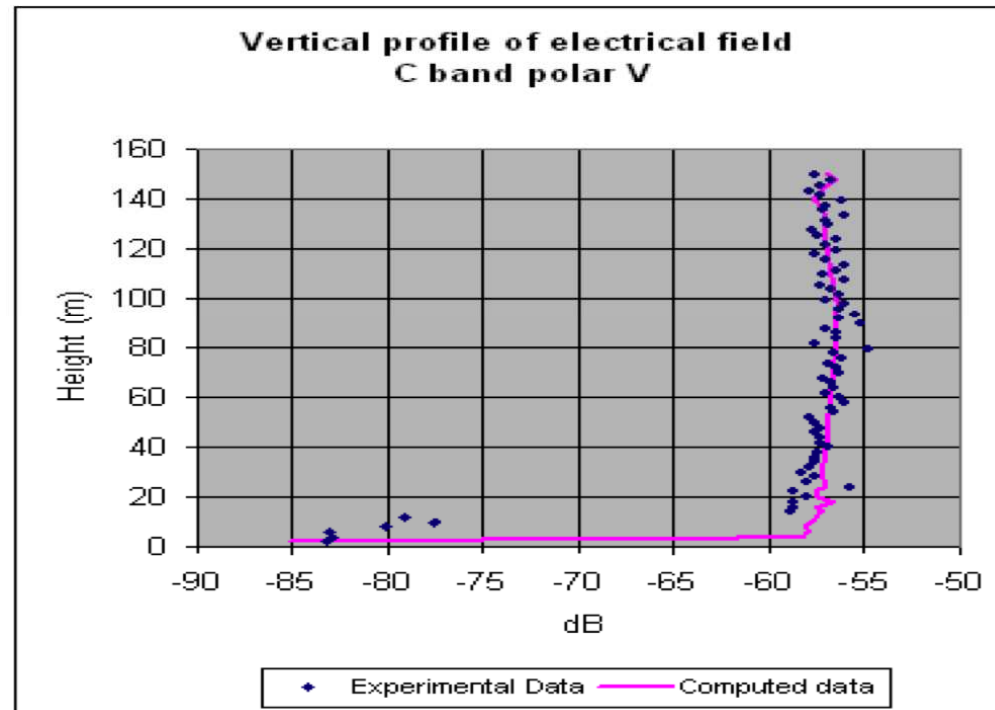
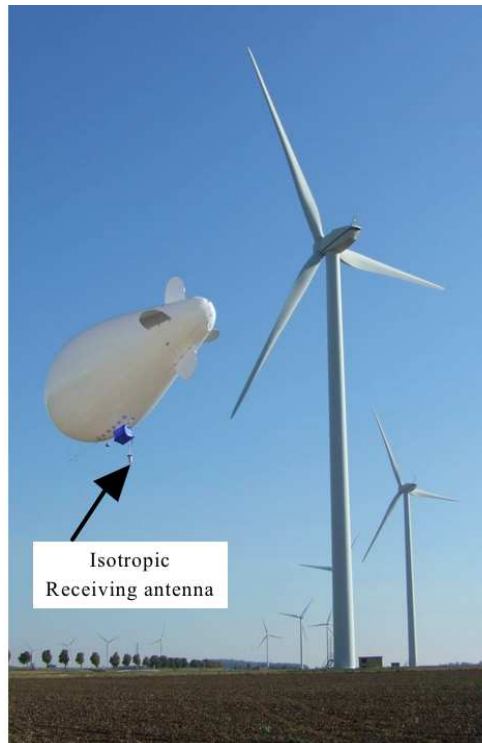
See poster : Marcellin J.-P., Cheraly A., Petex J.-F., Phan H.-K. , 2012, Measurement of Doppler Radar Signature of wind turbines at high resolution in distance , ERAD 2012, Toulouse, 24-29 June 2012

Validation of SiPRÉ simulator



Validation – EM field vertical profiles

Météo-France radar - Bande bipolar



Measurement : EM field meter altitude : 0 -150 m

Calculation: SiPRÉ – terrain + cover + buildings

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Conclusions/perspectives

- The SiPRÉ software development is under achievement
- Validation by comparison with measured data (Abbeville campaign) is going on

Further work

- step 1 : development of a new version of the software for military radars (Onera, OKTAL-SE, Thales) funded by French MOD
- step 2 : development of a derived version of the software SiPRÉ
 - SiPRÉ – R&D : suited for applied research (stealth, signal processing, ...)
 - SiPRÉ – OAD : adapted for studies on the impact of new wind farms on meteorological radars
- step 3 : new validation campaigns

Thank you for your attention.

Onera and OKTAL-SE want to thank Météo-France **for the provision of software CASTOR® and weather module, and its cooperation during the measurement campaign.**