Peuplement

Une maquette

Particle Image Velocimetry

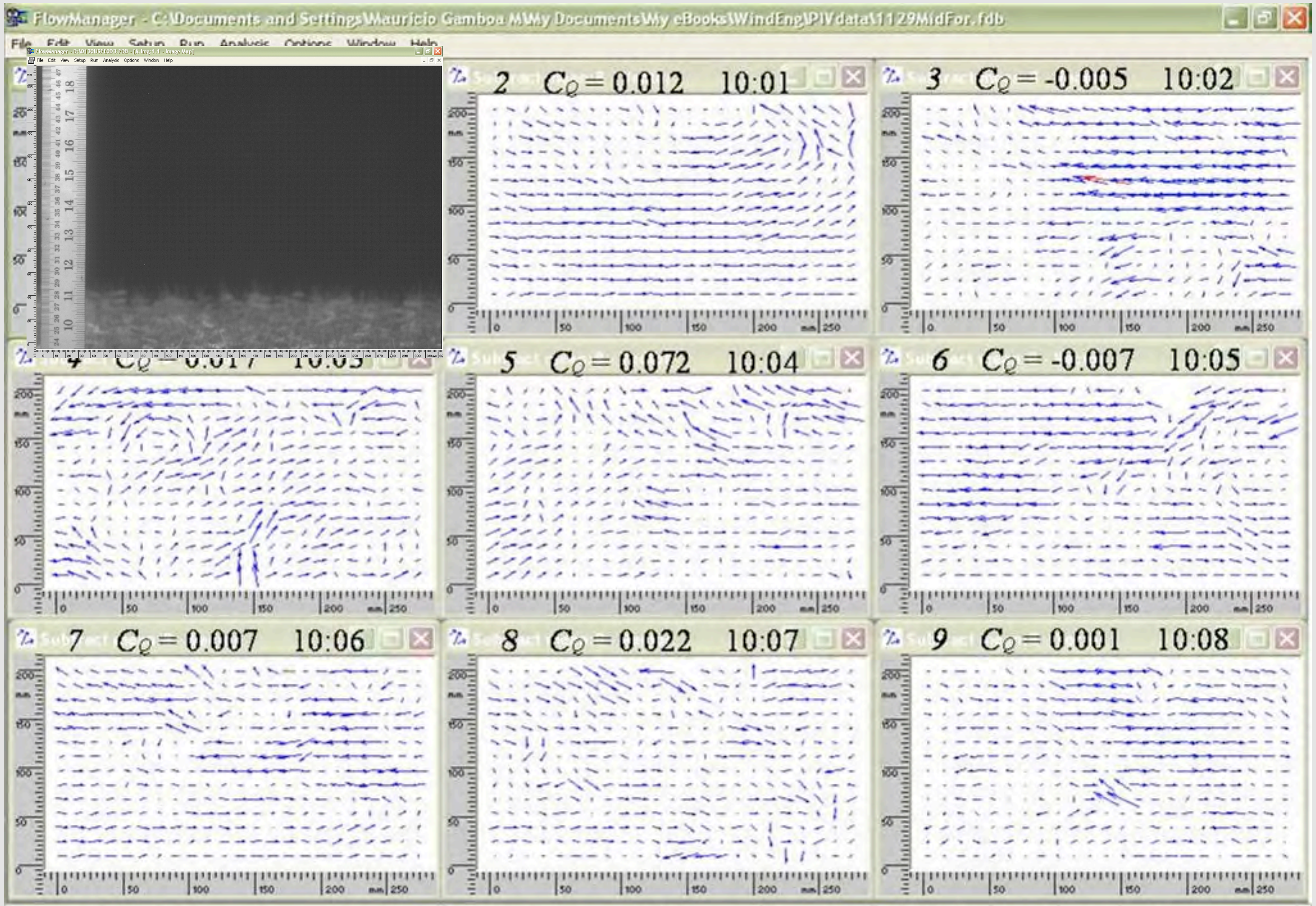

FlowManager - C:\Documents and Settings\Mauricio Gamboa M\My Documents\My eBooks\WindEng\PIVdata\1129MidFor.fdb
File Edit View Setup Run Analysis Options Window Help
2 $C_Q = 0.012$ 10:01
3 $C_Q = -0.005$ 10:02
4 $C_Q = 0.017$ 10:03
5 $C_Q = 0.072$ 10:04
6 $C_Q = -0.007$ 10:05
7 $C_Q = 0.007$ 10:06
8 $C_Q = 0.022$ 10:07
9 $C_Q = 0.001$ 10:08
0 50 100 150 200 mm 250

Figure 4.21 *Mid-Forest flows*. 1129MidFor.fdb Setup 1. Sequence of PIV instantaneous velocity fluctuations, simultaneously measured tree-balance bending moment coefficients (C_Q) and full-scale time (mm:ss). The coordinate system of each flow map is the same illustrated in figures 4.11 and 4.12.

Modélisation du vent et de la turbulence

Petite échelle : mécanique des fluides

- Aquilon (Trefle, Bordeaux 1)

Plus grande échelle : modèles atmosphériques

- ARPS (USA)
- Méso-NH (Météo-France, LA)

Les équations d'Aquilon

Qté mouvement

$$\square\frac{\partial <\overline{u_i}>}{\partial t} + \square <\overline{u_j}> \frac{\partial <\overline{u_i}>}{\partial x_j} = \square\frac{\partial}{\partial x_i}\left(<\overline{P}> + \frac{2}{3}\square k\right) + \frac{\partial}{\partial x_j}\left[\square_t\left(\frac{\partial <\overline{u_i}>}{\partial x_j} + \frac{\partial <\overline{u_j}>}{\partial x_i}\right)\right] \square \square C_d\, a\sqrt{<\overline{u_j}><\overline{u_j}>}<\overline{u_i}>$$

Energie

$$\square\frac{\partial k}{\partial t} + \square <\overline{u_j}> \frac{\partial k}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\frac{\square_t}{\square_k}\right)\frac{\partial k}{\partial x_j}\right] + \square P_k \square \square\square + \square C_{Pw}\, C_d\, a[<\overline{u_j}><\overline{u_j}>]^{3/2} \square \square C_{\square w} C_d\, a\sqrt{<\overline{u_j}><\overline{u_j}>}\,k$$

Dissipation

$$\square\frac{\partial \square}{\partial t} + \square <\overline{u_j}> \frac{\partial \square}{\partial x_j} = \frac{\partial}{\partial x_j}\left[\left(\frac{\square_t}{\square_\square}\right)\frac{\partial \square}{\partial x_j}\right] + \square C_{\square 1}\frac{\square}{k}P_k \square \square C_{\square 2}\frac{\square^2}{k} + \square C_{P\square w}\frac{\square}{k}C_d\, a[<\overline{u_j}><\overline{u_j}>]^{3/2} \square \square C_{D\square w} C_d\, a\sqrt{<\overline{u_j}><\overline{u_j}>}\,\square$$

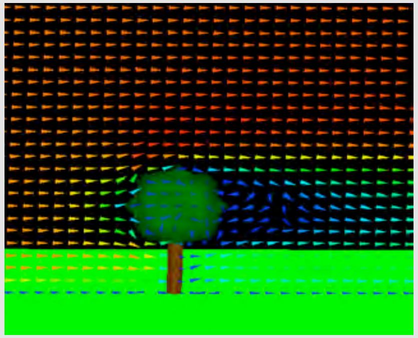
$\square_k$	$\square_\square$	$C_\square$	$C_{\square 1}$	$C_{\square 2}$	C_{Pw}	$C_{\square w}$	$C_{P\square w}$	$C_{D\square w}$
0.74	1.3	0.0256	1.13	1.9	0.8	4	1.5	3.24

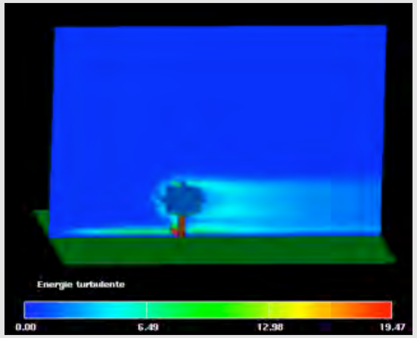
Adaptation aux cas :

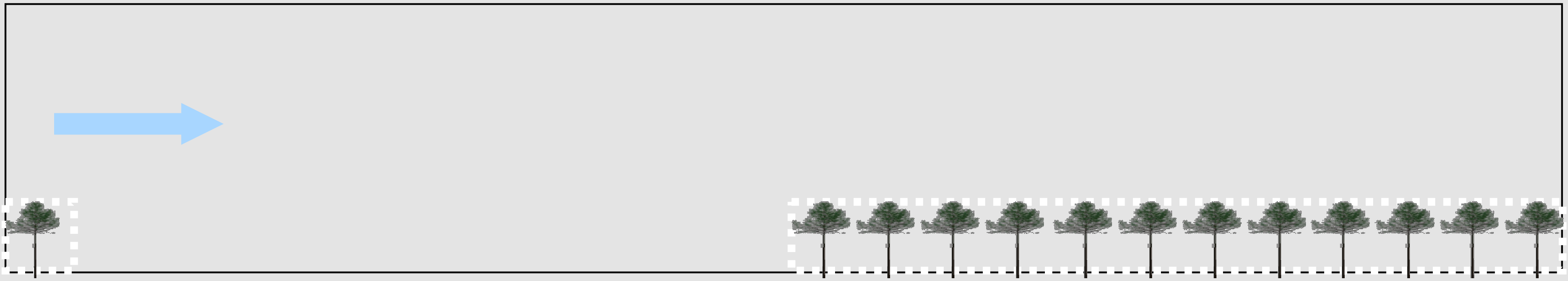
. d'arbres

. de peuplements forestiers

. de paysages

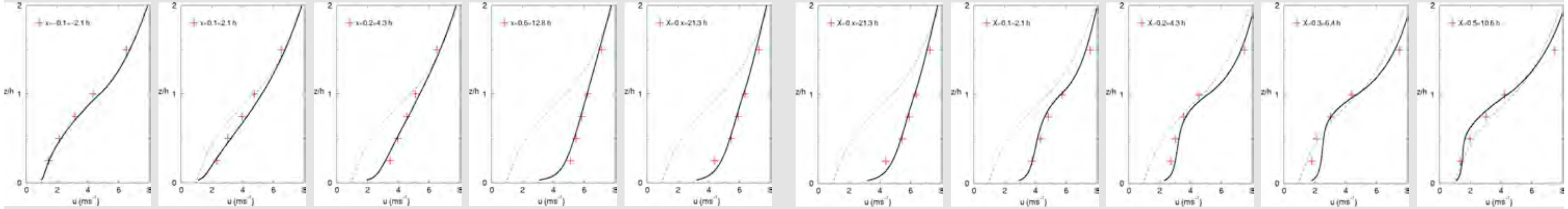




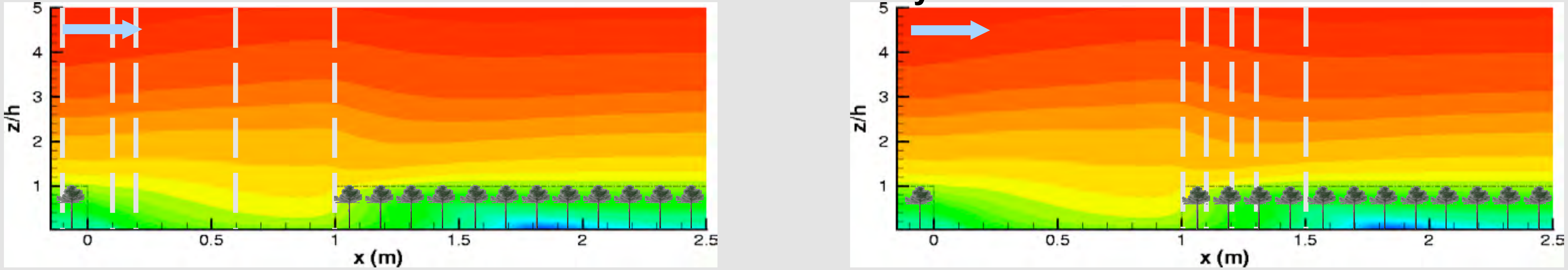


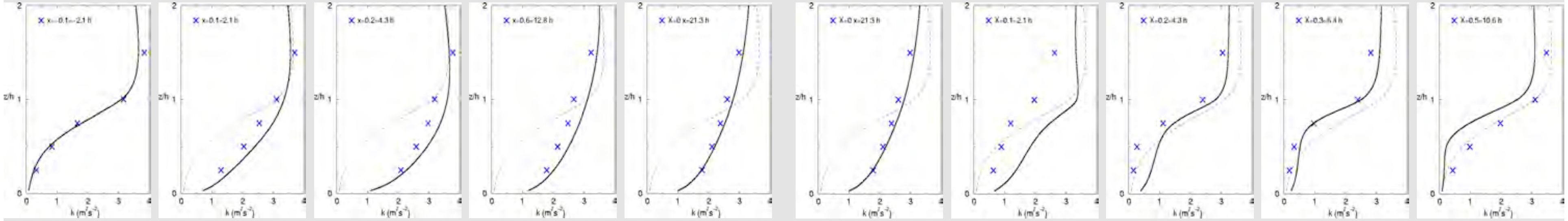
Peuplement

Simulation Aquilon

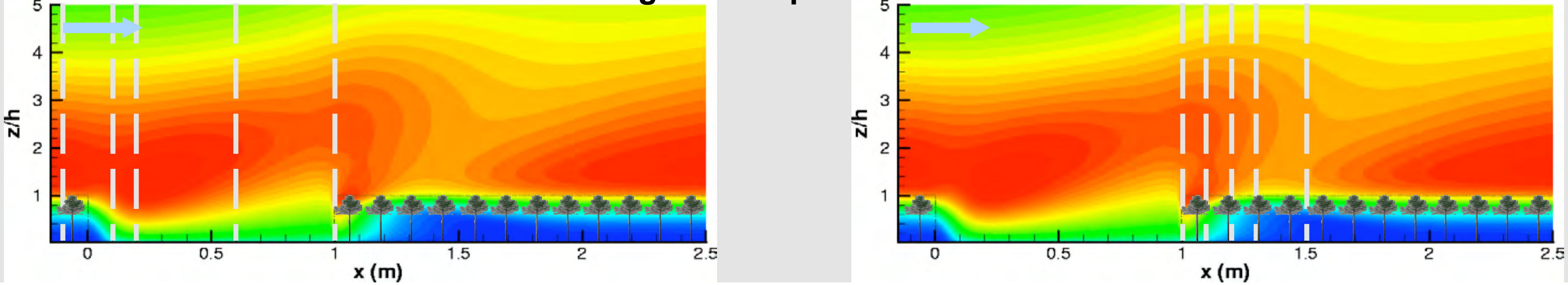


Vitesse horizontale moyenne



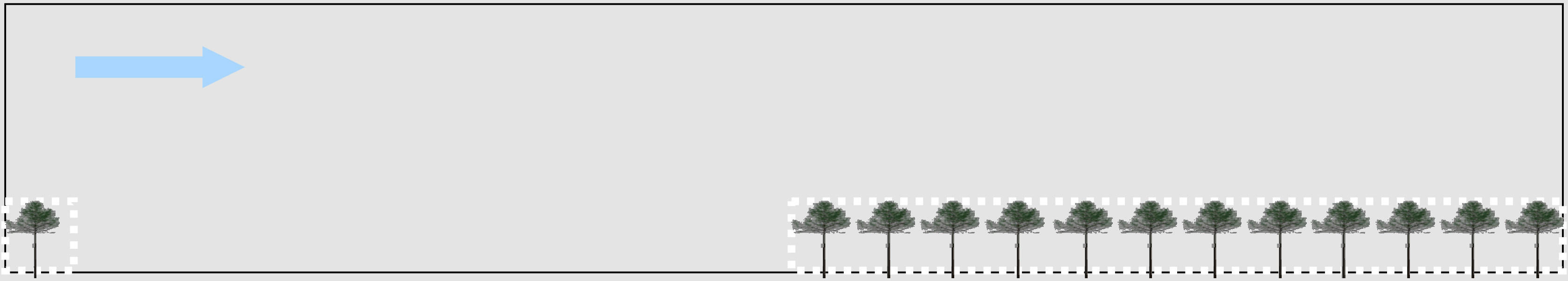


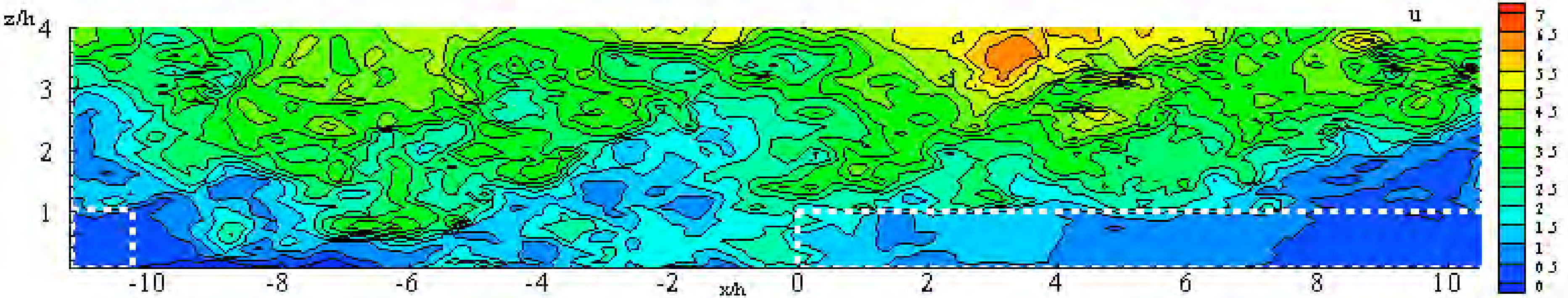
Energie cinétique turbulente

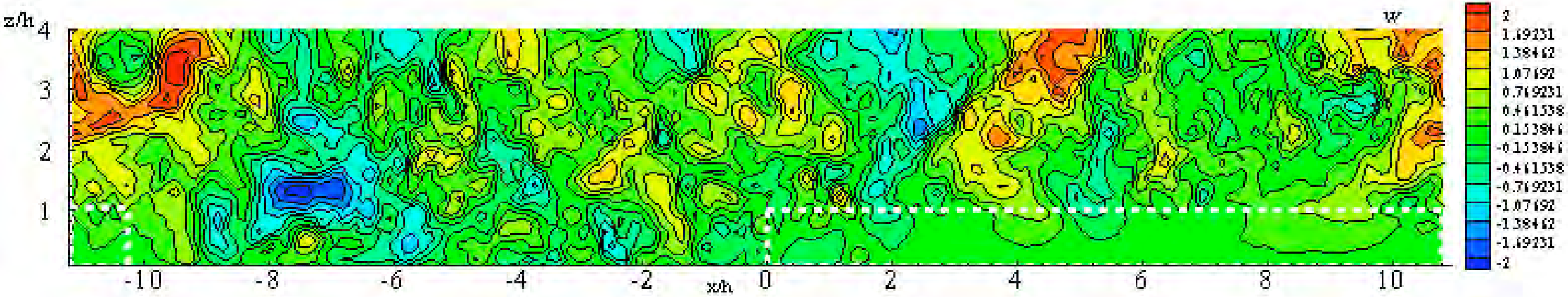


Peuplement

Simulation ARPS

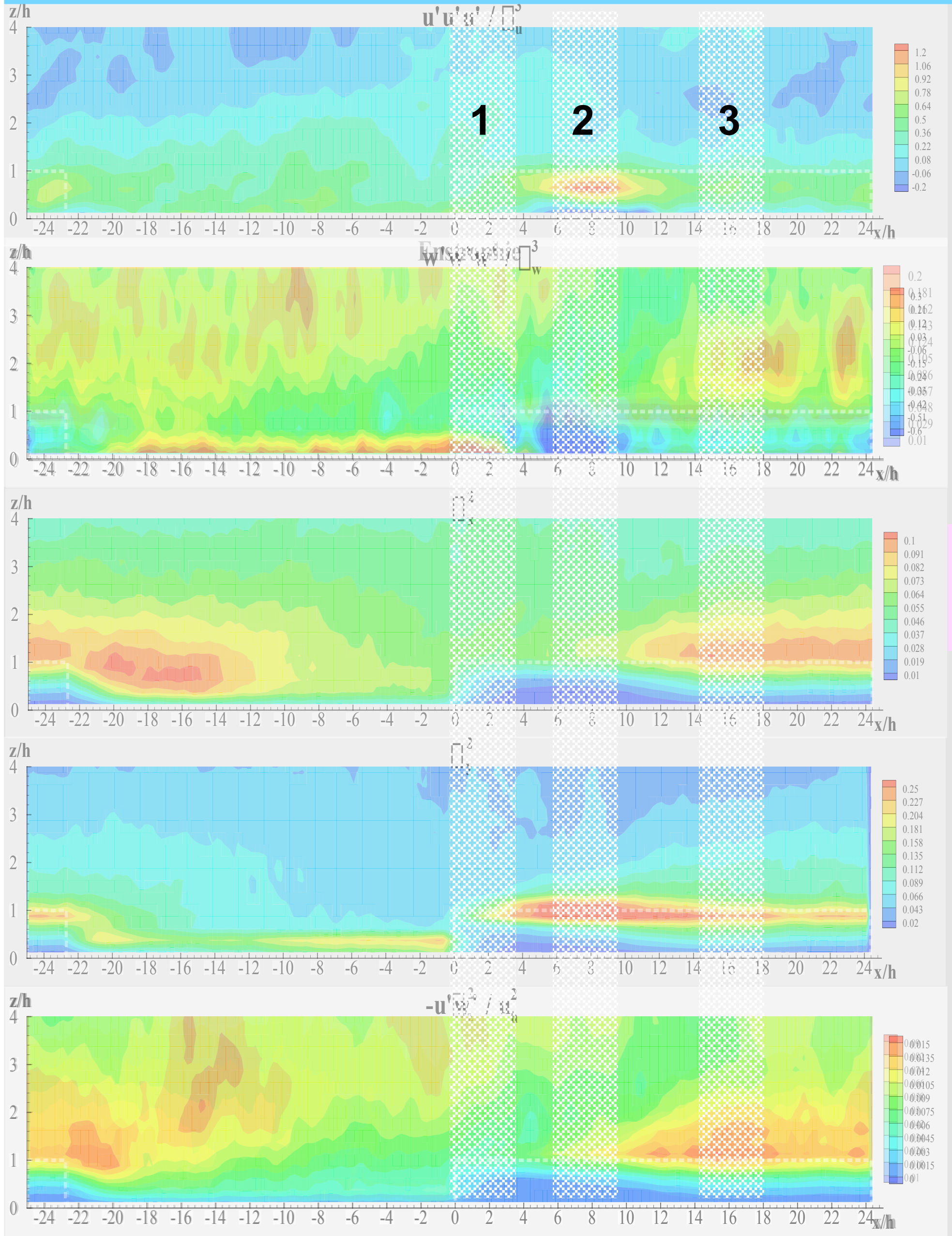


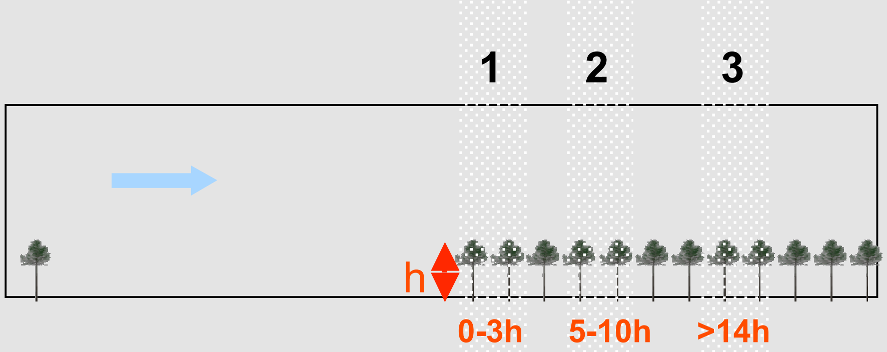




Peuplement

Simulation ARPS





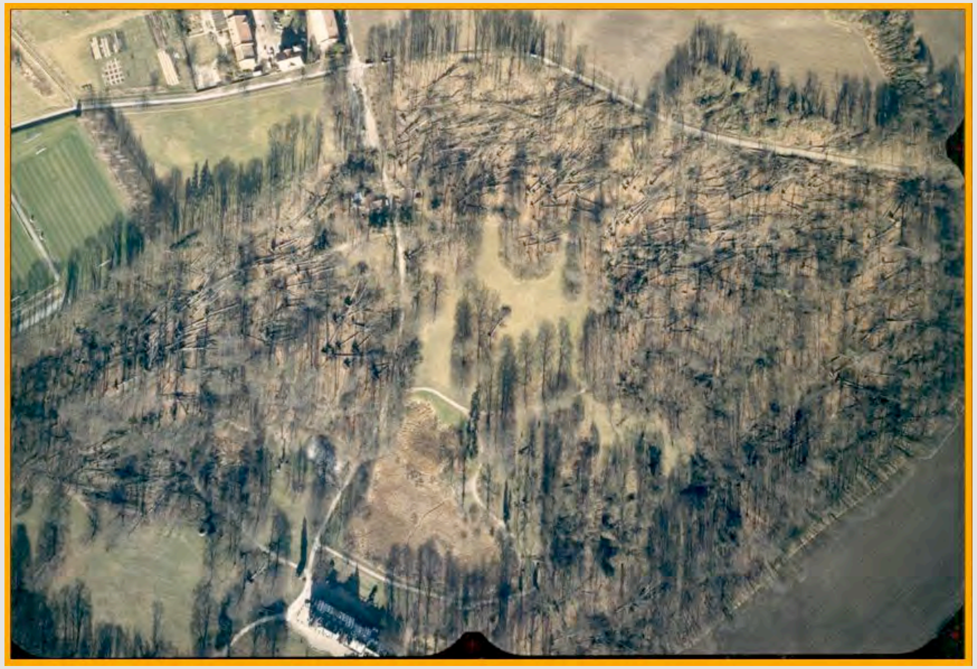
1
2
3
h
0-3h
5-10h
>14h

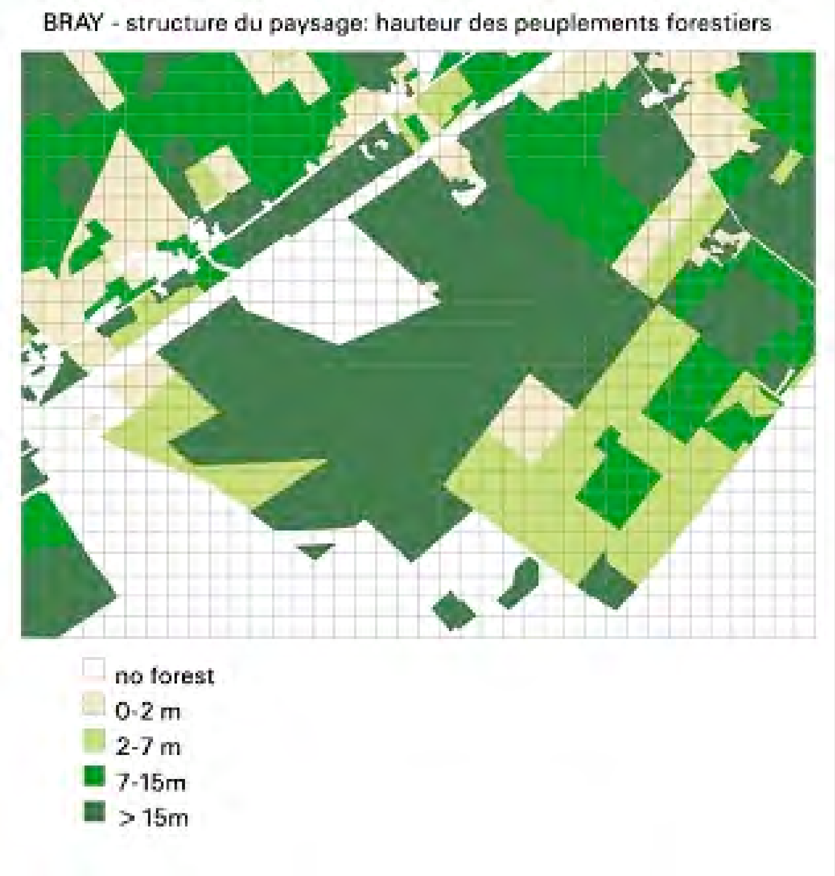
Activité turbulente	-	++	+
Organisation des transferts	-	+	++

Paysage

100 m

1 km

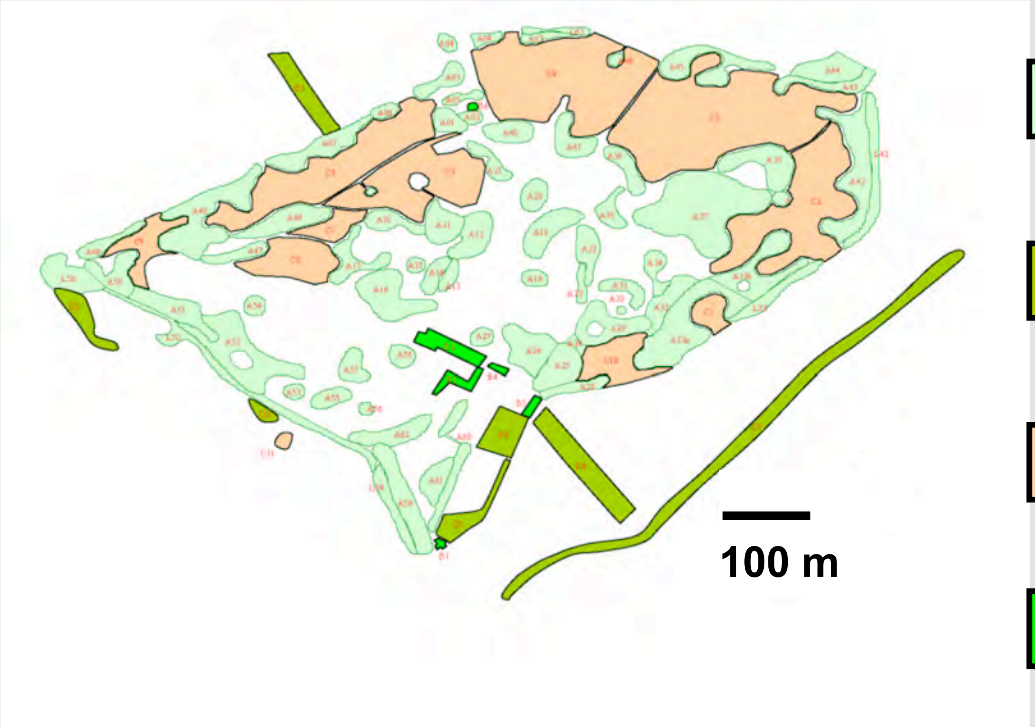



BRAY - structure du paysage: hauteur des peuplements forestiers
no forest
0-2 m
2-7 m
7-15m
> 15m

Paysage

Simulation Aquilon

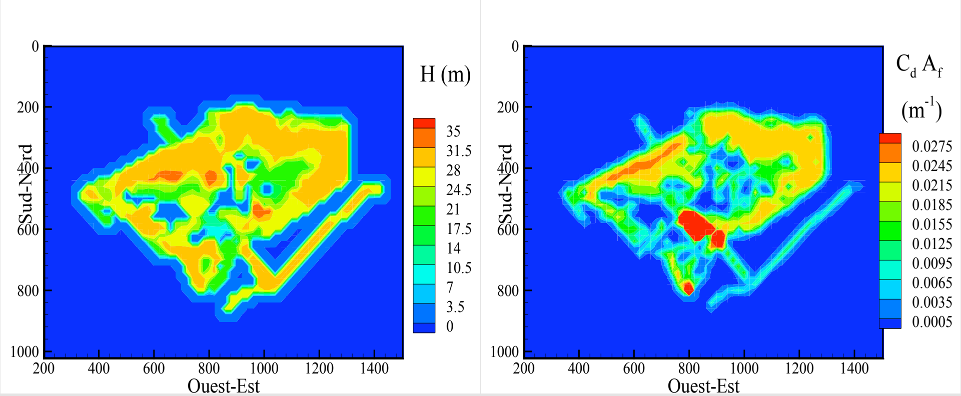
Un parc urbain ravagé par la tempête

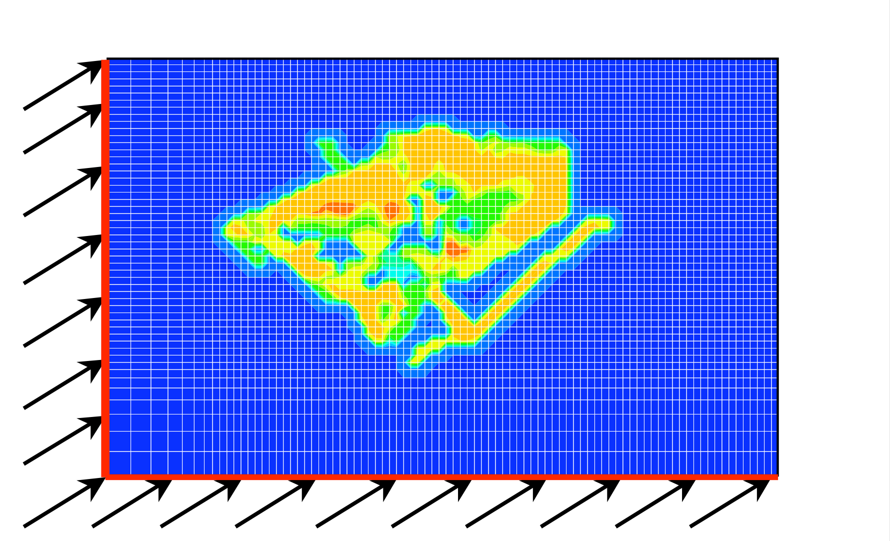


- 🟩 Zones boisées
- 🟩 Zones boisées en dehors du parc
- 🟧 Zones boisées détruites en 1999
- 🟩 Bâtiments

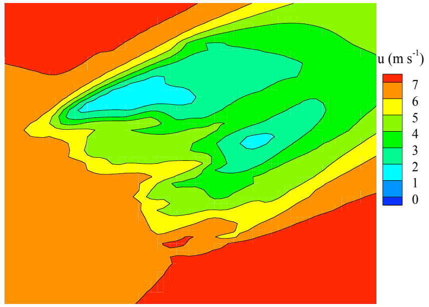
Simulation Aquilon

Parc en 1999

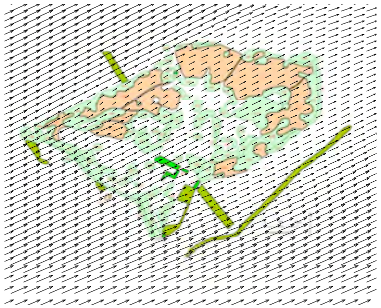

0
200
400
600
800
1000
Sud-Nord
200
400
600
800
1000
1200
1400
Ouest-Est
H (m)
35
31.5
28
24.5
21
17.5
14
10.5
7
3.5
0
$C_d\,A_f$
(m^{-1})
0.0275
0.0245
0.0215
0.0185
0.0155
0.0125
0.0095
0.0065
0.0035
0.0005



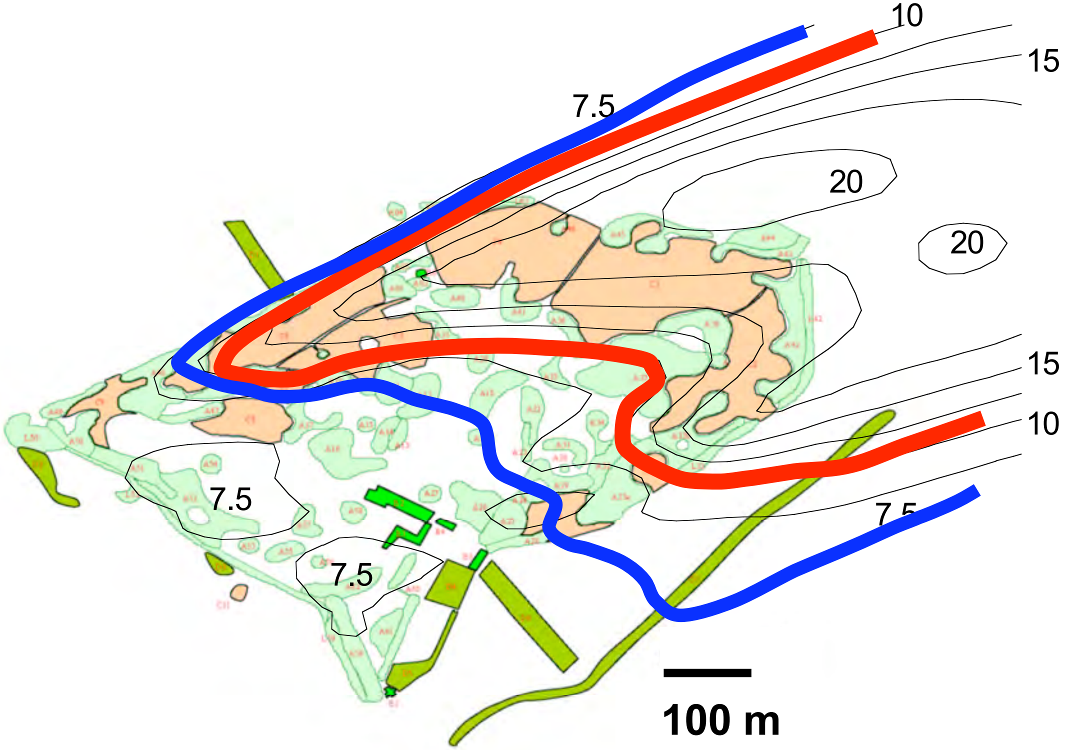
29 m au-dessus du sol


u (m s^{-1})
7
6
5
4
3
2
1
0

29 m au-dessus du sol



Simulation Aquilon

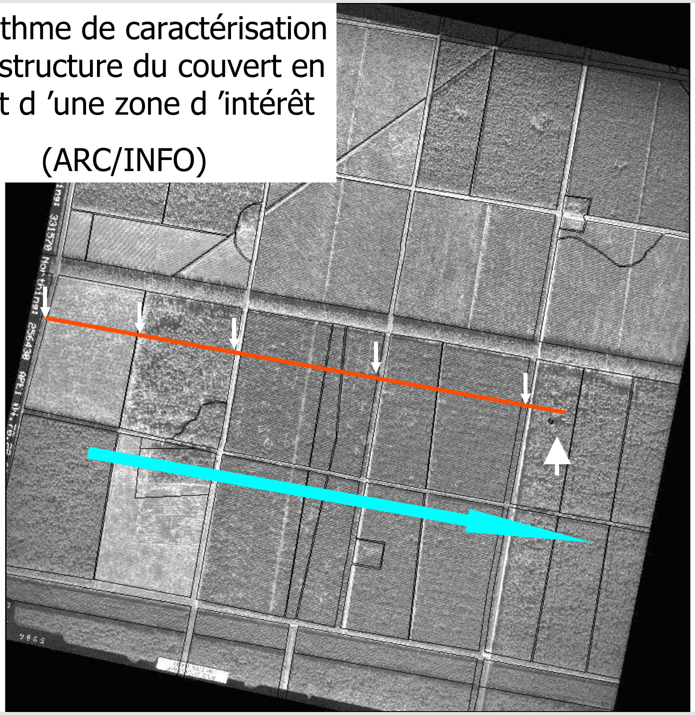

10
15
7.5
20
20
15
10
7.5
7.5
7.5
100 m

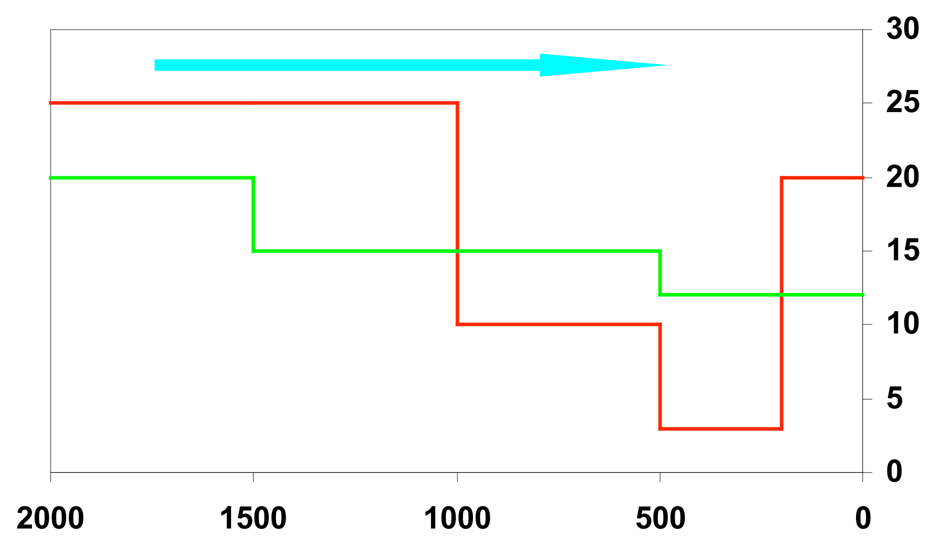
Observation des dégâts

Dispositif Nezer (300 parcelles)
SIG + algorithmes

Algorithme de caractérisation de la structure du couvert en amont d 'une zone d 'intérêt

(ARC/INFO)



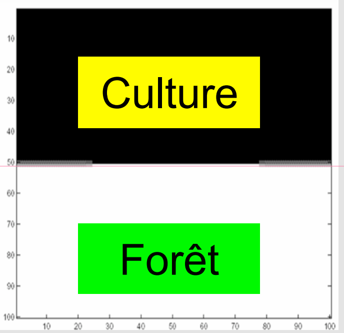


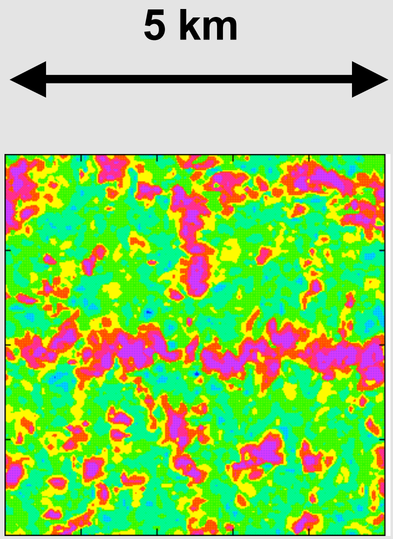
Relation entre dégâts locaux et :
. caractéristiques locales +
. profil du paysage amont

Effet différence de hauteur entre deux parcelles

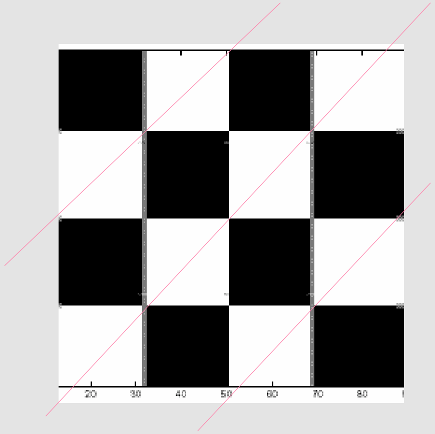
Simulation Méso-NH

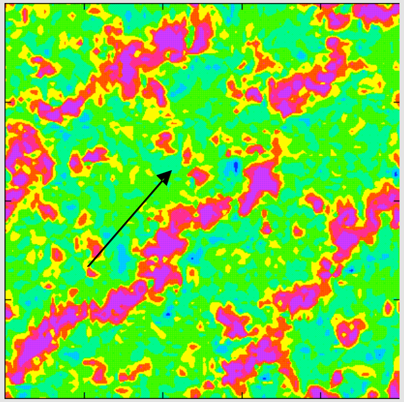
Arrangement spatial et fragmentation


Culture
Forêt
10
20
30
40
50
60
70
80
90
100



Damiers de rugosités

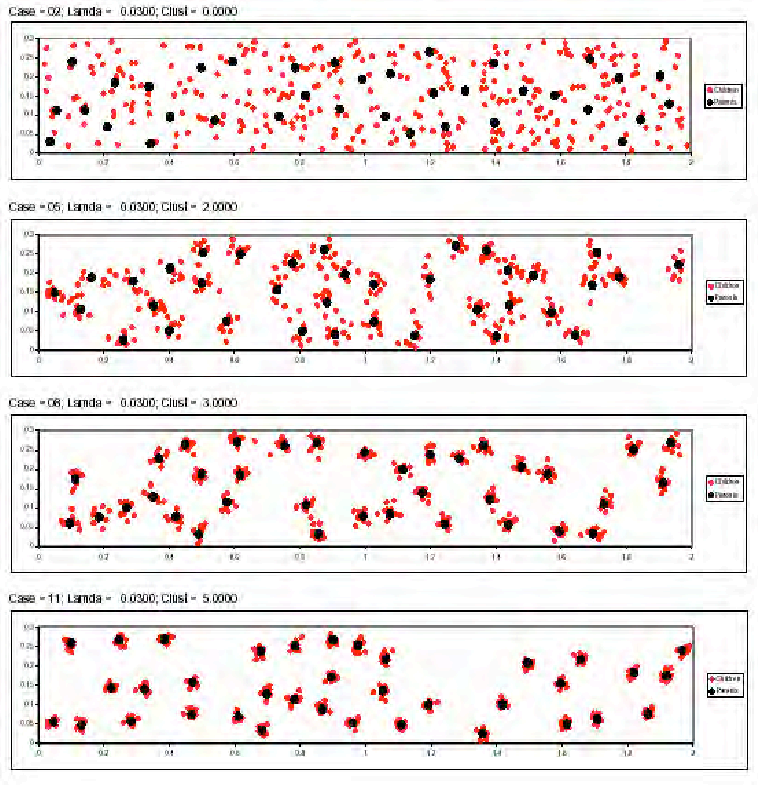

20
30
40
50
60
70
80



Une maquette

Soufflerie, CSIRO, Canberra

3 densités X 4 agrégations

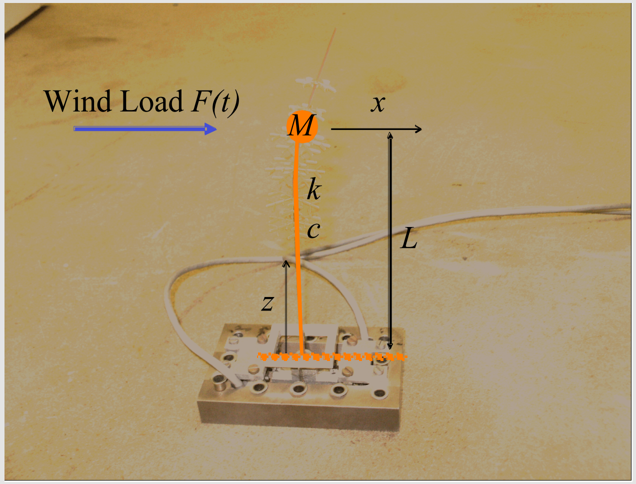


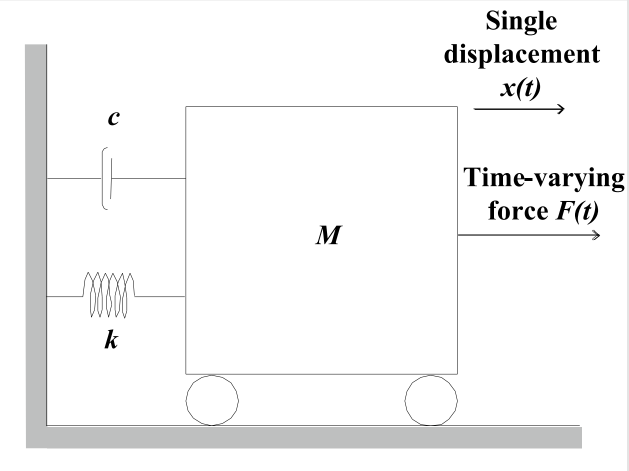
fragmentation

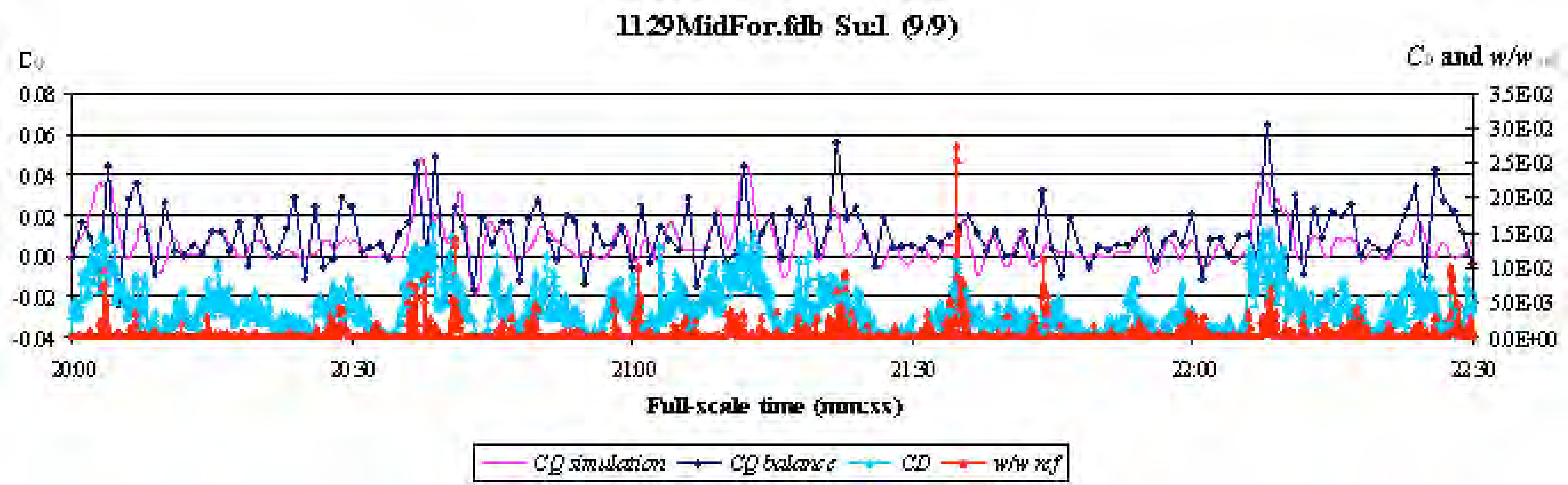
agrégation

Fragmentation ↗, traînée ↗ (40%)

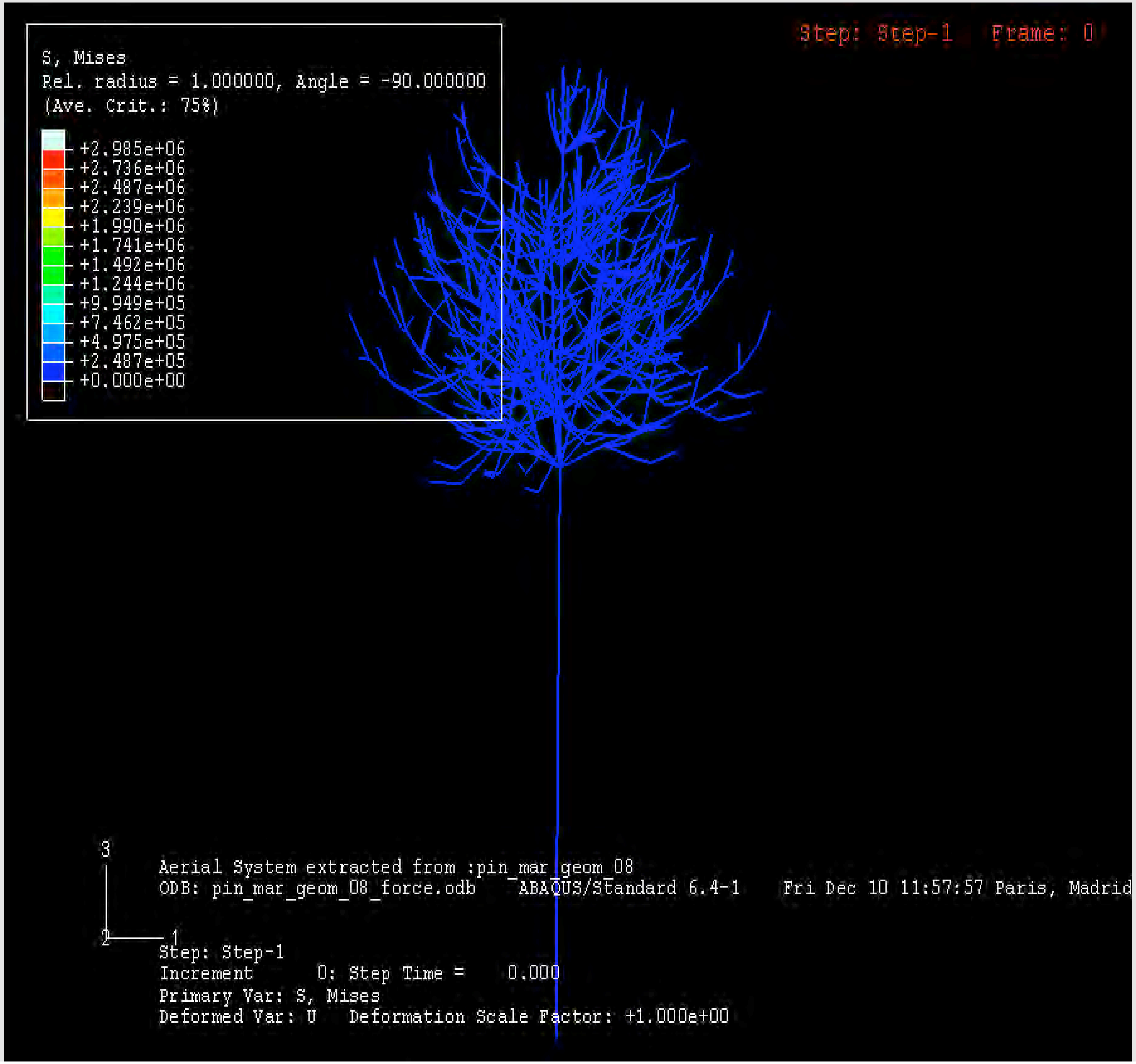
Couplage vent-arbre


Wind Load F(t)
M
x
k
c
L
z


Single displacement x(t)
c
M
Time-varying force F(t)
k



Couplage vent-arbre



Step: Step-1 Frame: 0
S, Mises
Rel. radius = 1.000000, Angle = -90.000000
(Ave. Crit.: 75%)
+2.985e+06
+2.736e+06
+2.487e+06
+2.239e+06
+1.990e+06
+1.741e+06
+1.492e+06
+1.244e+06
+9.949e+05
+7.462e+05
+4.975e+05
+2.487e+05
+0.000e+00
3
2
1

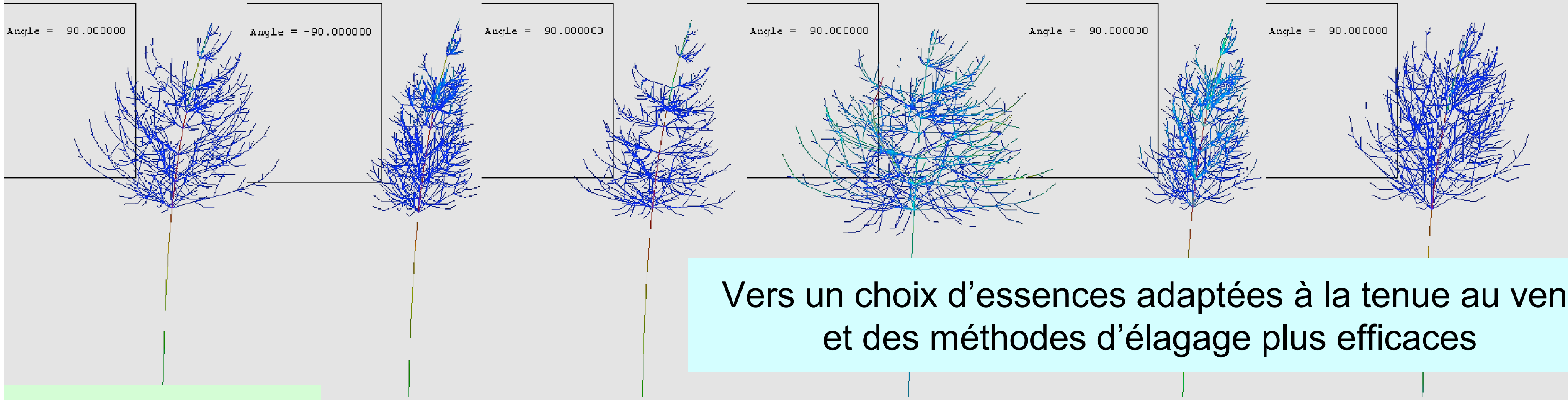
```
Aerial System extracted from :pin_mar_geom_08
ODB: pin_mar_geom_08_force.odb    ABAQUS/Standard 6.4-1    Fri Dec 10 11:57:57 Paris, Madrid

Step: Step-1
Increment      0: Step Time =     0.000
Primary Var: S, Mises
Deformed Var: U   Deformation Scale Factor: +1.000e+00
```

Conclusion

Plans d'expériences numériques

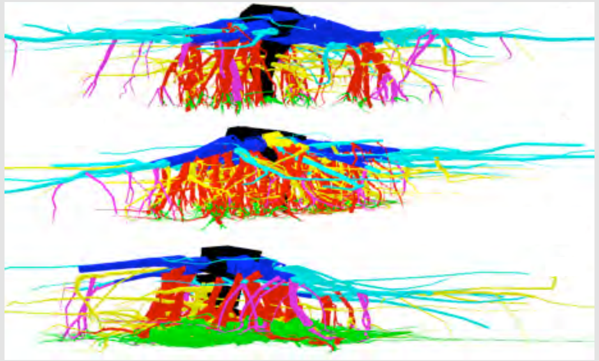
Arbre : étude des relations forme-stabilité

Parties aériennes


Angle = -90.000000
Angle = -90.000000
Angle = -90.000000
Angle = -90.000000
Angle = -90.000000
Angle = -90.000000

Vers un choix d'essences adaptées à la tenue au vent et des méthodes d'élagage plus efficaces

Racines



Vers un meilleur développement du pivot et des racines traçantes dans le jeune âge, gestion des éclaircies

Plans d'expériences numériques

Peuplement, paysage : environnement de l'arbre

Intra-parcelle :
densité, hétérogénéité, trouée, mélanges…

Régions de lisière :
forme de la lisière, répartition biomasse…

Structure du paysage :
différence hauteur, clairières, pare-feux, fragmentation…

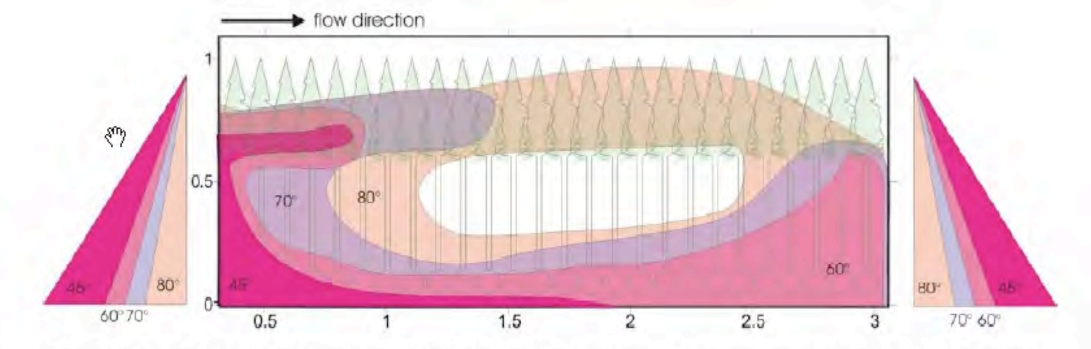


Figure 6. Zone of positive pressure coefficients inside the forest (coloured area) as a function of forest edge angle (45° to 80°, see tab. 1 for details); smoothed data.

Synthèse

Approche pluri-disciplinaire
(biomécanique + mécanique des fluides)

Combinaison d'observations, mesures in-situ,
expérimentations en soufflerie, modélisation

Nouveautés :

Constitution de **bases de données** et d'**outils de calcul**
(comportement des arbres et du vent)

Synthèse

Les sollicitations qui font bouger l'arbre

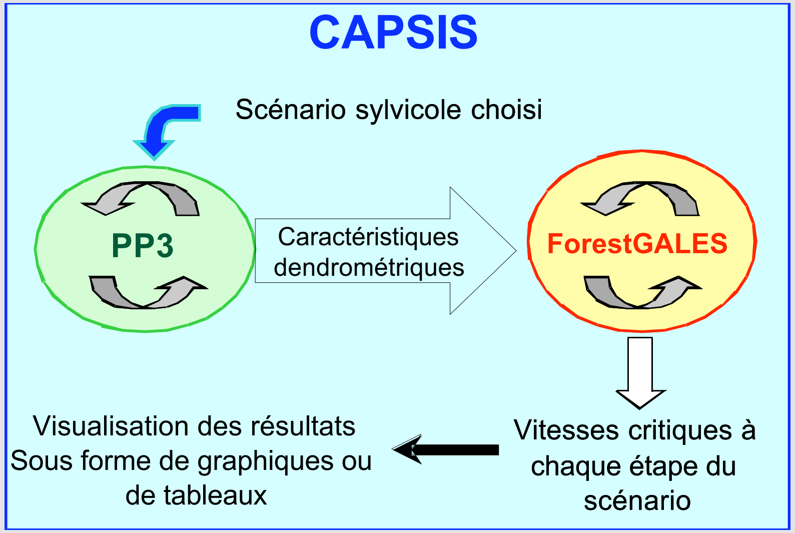
La réponse de l'arbre à ces sollicitations

Outils de recherche, mécanistes,

pour simulations et analyses fines

Vers des systèmes experts

Alimentation des systèmes experts
Meilleure prise en compte du vent



CAPSIS

Scénario sylvicole choisi

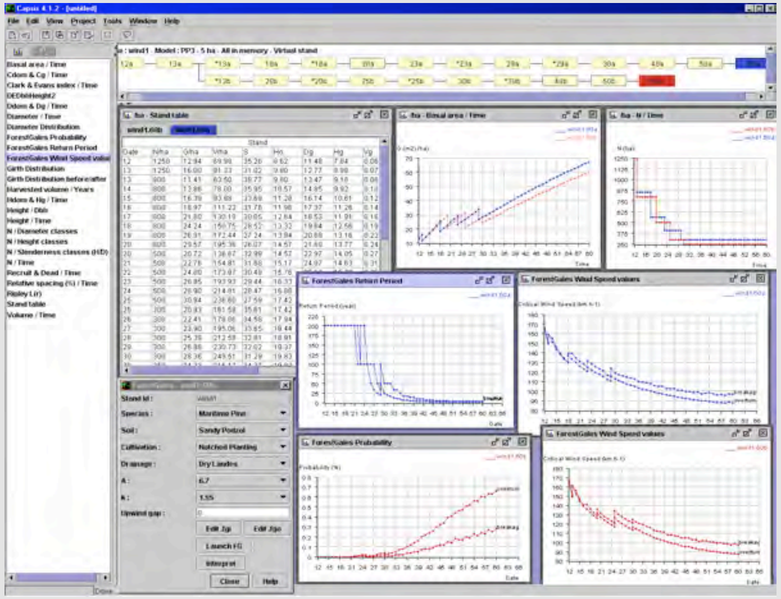
PP3

Caractéristiques dendrométriques

ForestGALES

Vitesses critiques à chaque étape du scénario

Visualisation des résultats
Sous forme de graphiques ou de tableaux



Voir exposé C. Méredieu

Conclusion

Le bilan

5 thèses, 9 articles publiés,
15 conférences…

H. Foudhil	2002	Ephyse	Venfor
D. Sellier	2004	Ephyse, LRBB	Venfor
M. Gamboa-Marrufo	2004	Univ. Oxford	Venfor
L. Dupuy	2003	LRBB	Pin et Vent
V. Cucchi	2004	Ephyse, LRBB	CapForêt

A. Achim, R. Belcher, D. Bert, Y. Brunet, J.P. Caltagirone, H. Cleugh, D. Courault, B. Courbaud, V. Cucchi, F. de Coligny, F. Danjon, A. Danthez, S. Dayau, A. Denis, M. Devalance, A. Druilhet, S. Dupont, J.J. Finnigan, T. Fourcaud, H. Foudhil, M. Gamboa-Marrufo, B. Gardiner, D. Garrigou, D. Guyon, D. Hughes, M. Irvine, F. Krzikalla, E. Lamaud, F. Lohou, A. Lopez, C. Meredieu, A. Morse, M. Najar, K.T. Paw U, M.R. Raupach, D. Sellier, R.H. Shaw, D. Soulier, A. Stokes, C. Wood