Qu'est-ce qui détermine la taille des dunes?

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Un peu de biblio…

DICTIONNAIRE ENCYCLOPÉDIQUE POUR TOUS

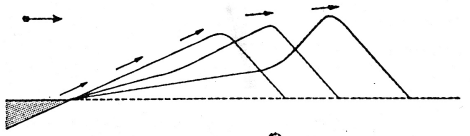
PETIT LAROUSSE

1965

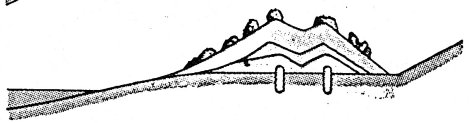
20e tirage

DUNDEE [*deun-dî*] n. m. (mot angl.). Bateau de pêche et de cabotage à deux mâts.

DUNE n. f. (lat. *dunum*, empr. au gaul.). Monticule sablonneux, édifié par le vent.

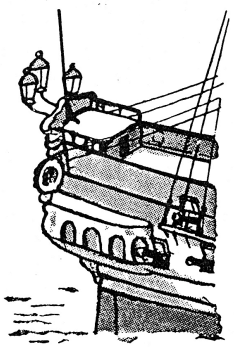


formation des dunes



fixation des dunes pieux et plantations servant à arrêter les sables

DUNETTE n. f. Superstructure sur le pont arrière d'un navire, et qui s'étend en largeur d'un bord à l'autre : *dans les bâtiments à voiles, les officiers étaient installés sous la dunette.*



dunette

DUO n. m. (lat. *duo*, deux). Morceau de musique pour deux voix ou deux instruments. ‖ *Fig.* et *fam.* Propos échangés entre deux personnes : *duo d'injures.*

DUODÉCIMAL, E, AUX adj. (du lat. *duodecimus*, douzième). Qui se compte, se divise par douze : *système duodécimal de numération.*

DUODÉNITE n. f. Inflammation du duodénum.

DUODÉNUM [*nom'*] n. m. (abrév. du lat. *duodenum digitorum*, de douze doigts). Première portion de l'intestin, qui succède à l'estomac et où débouchent les canaux pancréatique et cholédoque.

DUODI n. m. (lat. *duo*, deux, et *dies*, jour). Le deuxième jour de la décade, dans le calendrier républicain.

DUOPOLE n. m. Situation d'un marché sur lequel la concurrence ne s'exerce qu'entre deux vendeurs et une multitude d'acheteurs.

DUPE adj. et n. f. (anc. fr. *dupe*, huppe). Qui a été trompé ou qu'on peut tromper aisément.

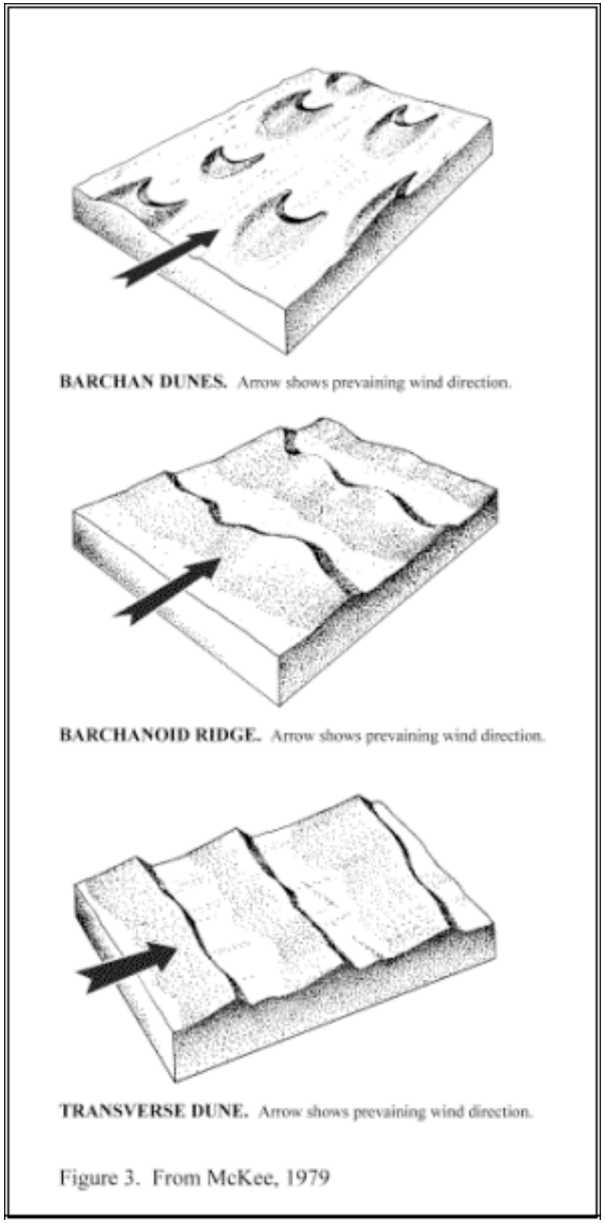
JE SÈME A TOUT VENT

LIBRAIRIE LAROUSSE

17, rue du Montparnasse, et boulevard Raspail, 114, Paris VI•

Types de dunes

- Régime de vent
- Sable
- Végétation

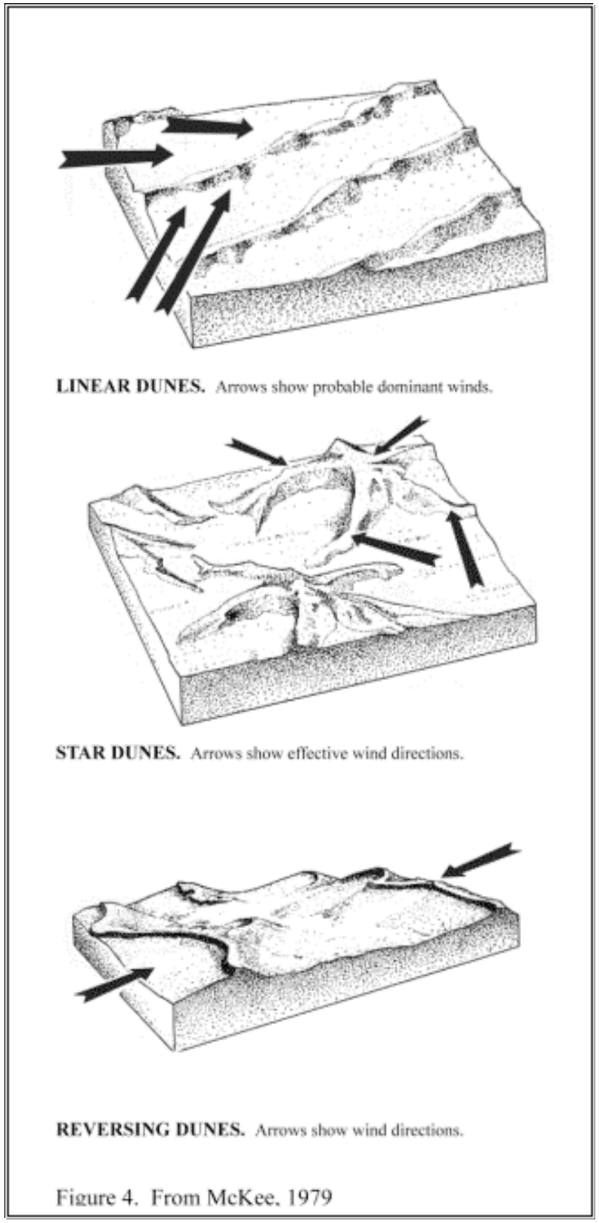


BARCHAN DUNES. Arrow shows prevaining wind direction.

BARCHANOID RIDGE. Arrow shows prevaining wind direction.

TRANSVERSE DUNE. Arrow shows prevaining wind direction.

Figure 3. From McKee, 1979



LINEAR DUNES. Arrows show probable dominant winds.

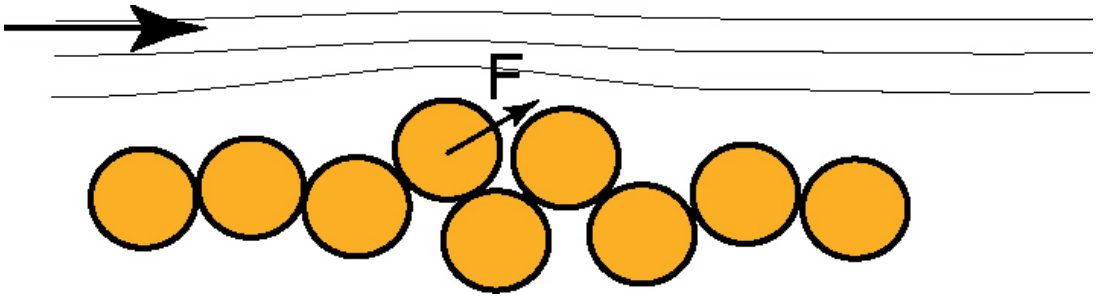
STAR DUNES. Arrows show effective wind directions.

REVERSING DUNES. Arrows show wind directions.

Figure 4. From McKee, 1979

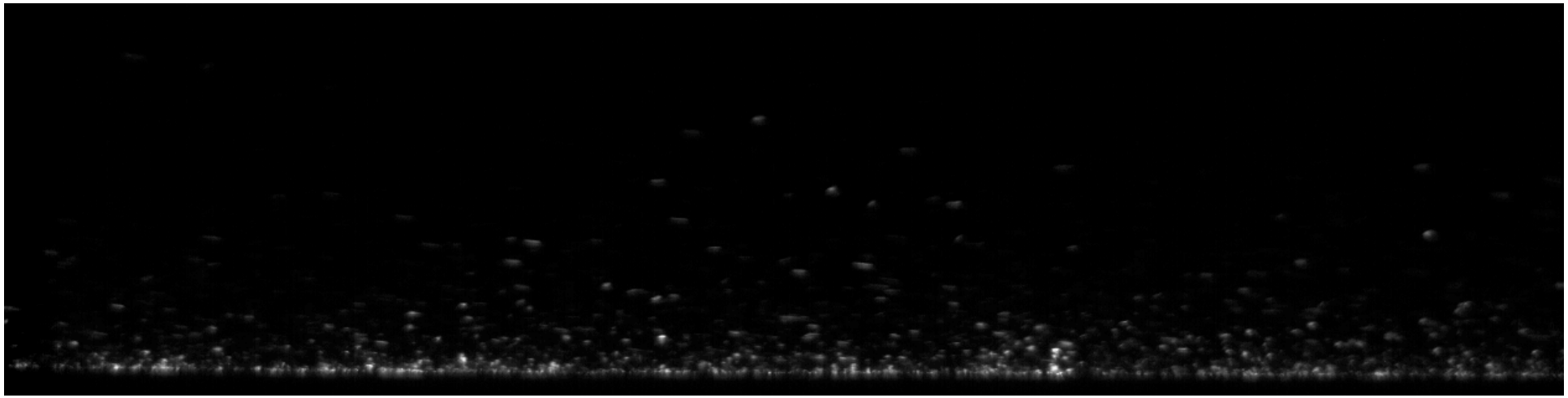
Transport des grains par le vent

Force/Vitesse seuil

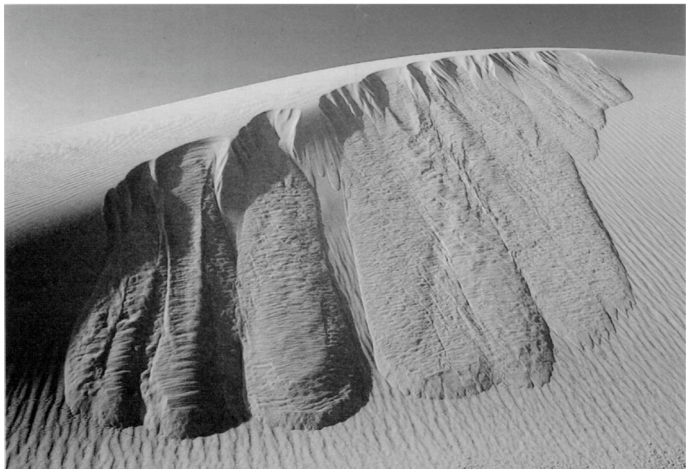


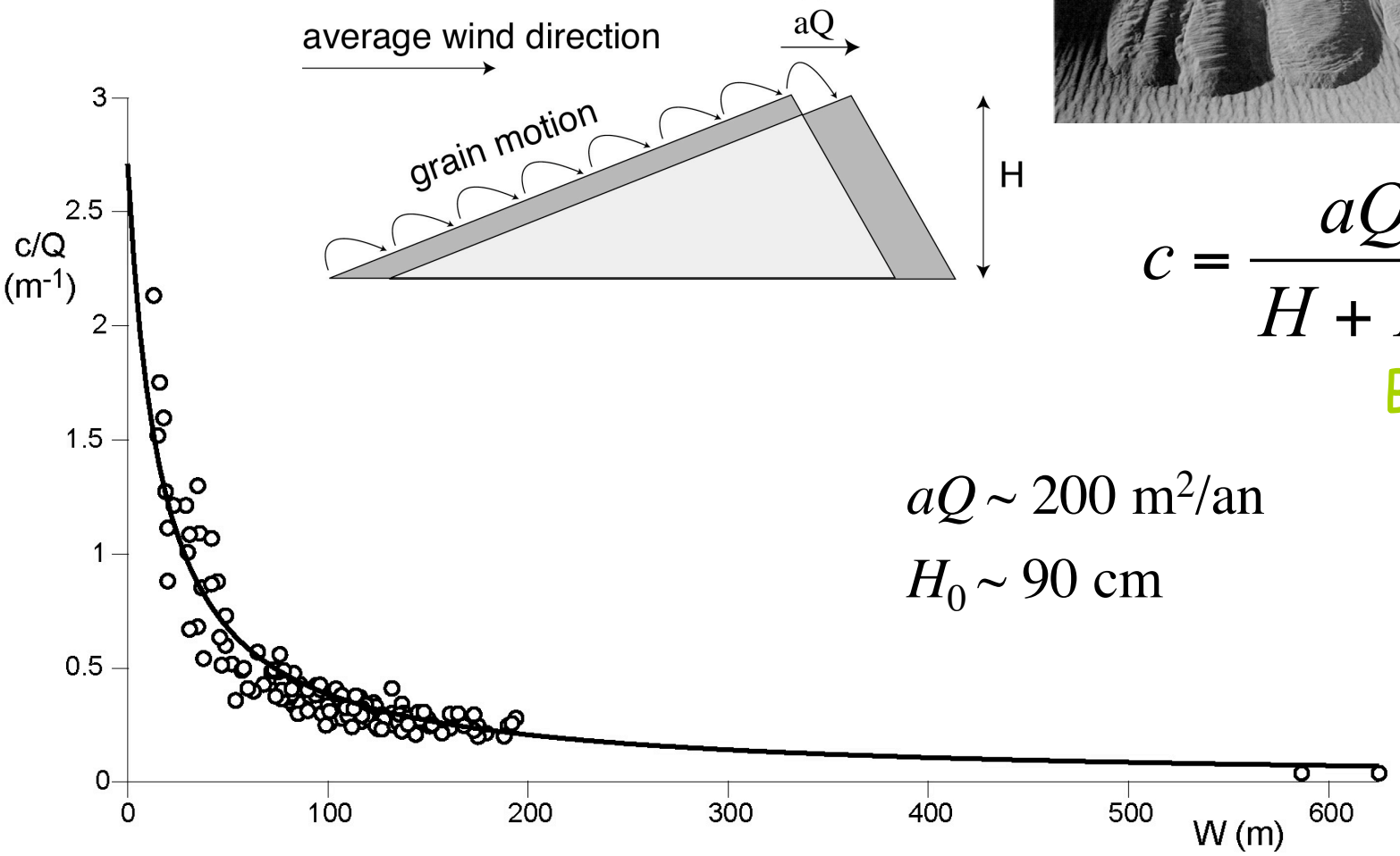
- **Saltation**
- **Reptation**
- **Tractation**

Champ: 12 cm x 3 cm Acquisition 1kHz



Vitesse de propagation





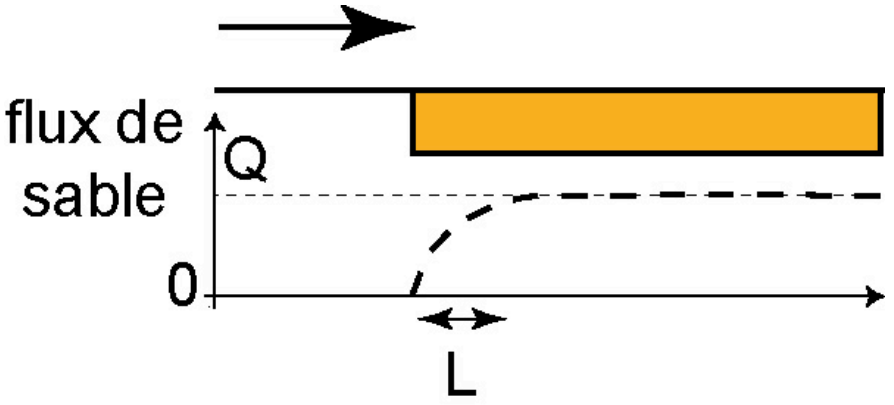
$$c = \frac{aQ}{H + H_0}$$

Bagnold

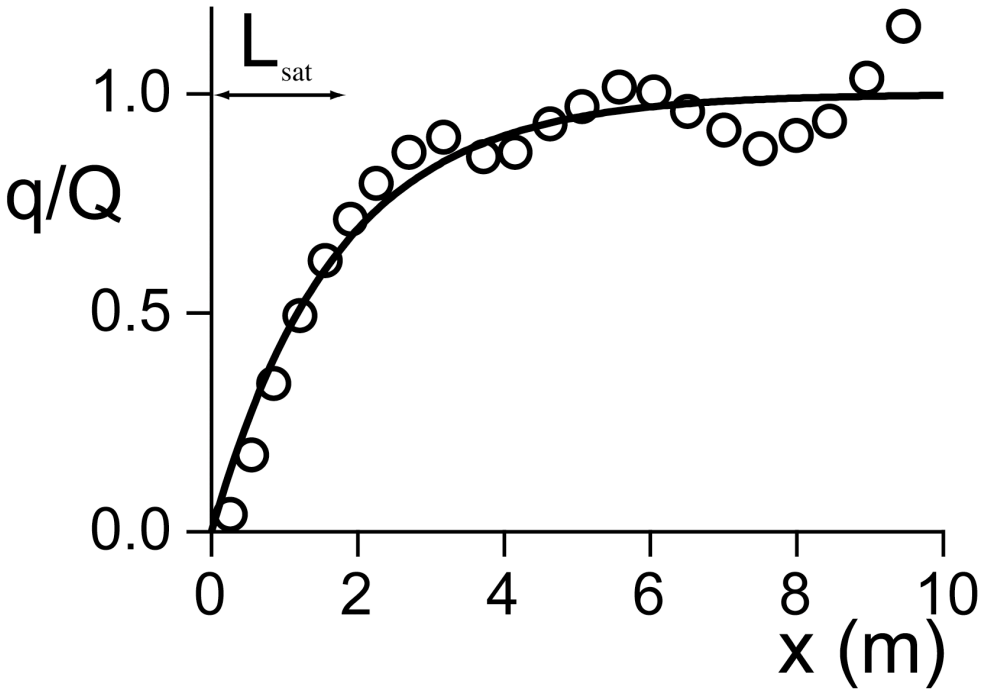
$aQ \sim 200$ m^2/an

$H_0 \sim 90$ cm

Longueur de saturation



$Q(\tau)$



Densité des grains

$$L_{sat} \propto \frac{\rho_s}{\rho_f} \times d$$

Densité du fluide

Diamètre des grains

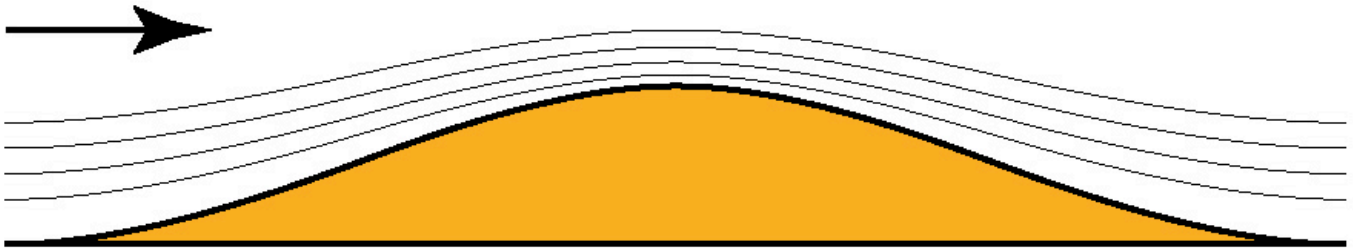
Mesure sur les dunes marocaines: $L \sim 1.7$ m

$$L_{sat} \partial_x q = q_{sat} - q$$

Équation de charge

Ecoulement du vent autour d'une bosse

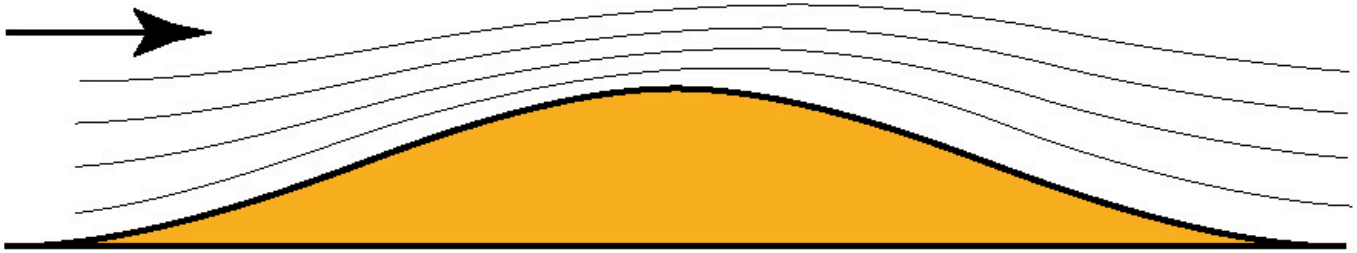
Erosion **Déposition**



$$\partial_t h + \partial_x q = 0$$

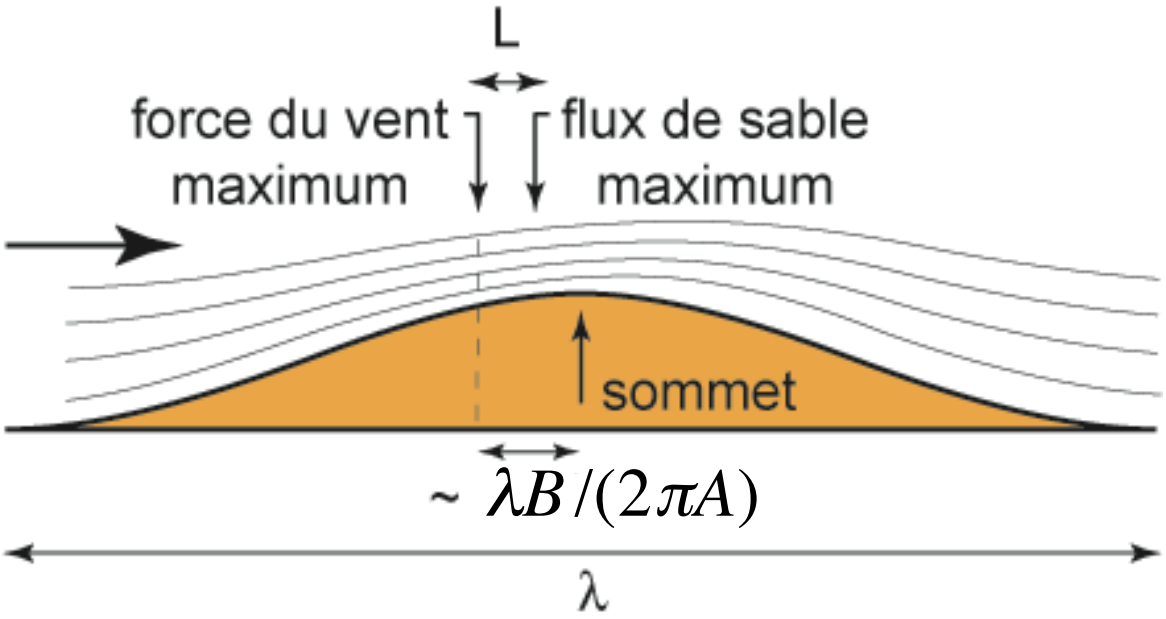
conservation de la matière

Asymétrie

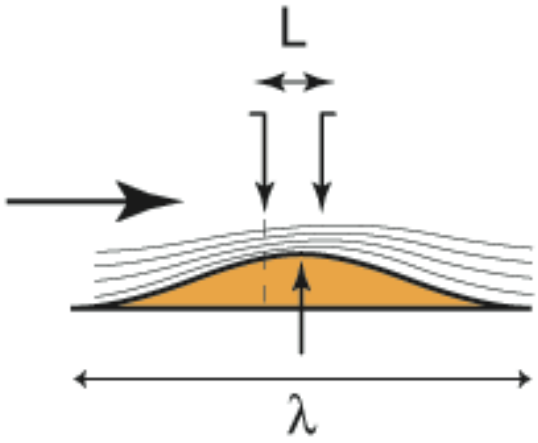


$$\hat{q}_{sat} = Q(A + iB)k\hat{h}$$

Stabilité d'une bosse

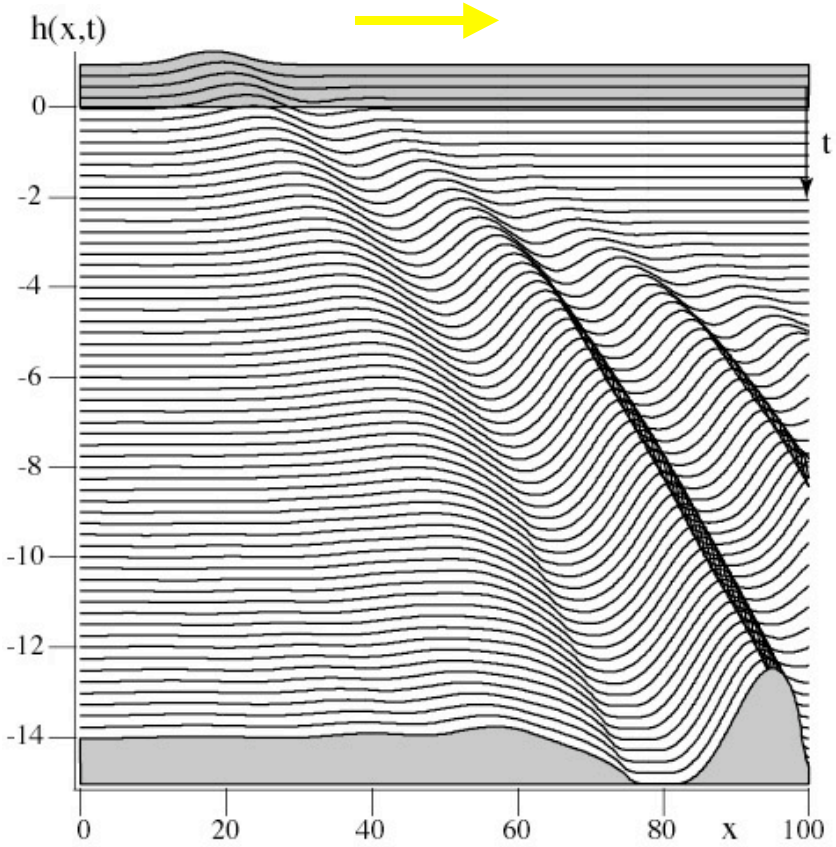


Instable -> dune



Stable

Instabilité convective



$$\sigma = Qk^2 \frac{B - AkL_{sat}}{1 + (kL_{sat})^2}$$

$$c = Qk \frac{A + BkL_{sat}}{1 + (kL_{sat})^2}$$

$$\lambda_{\max} = f(A/B)L_{sat} \sim 12L_{sat}$$

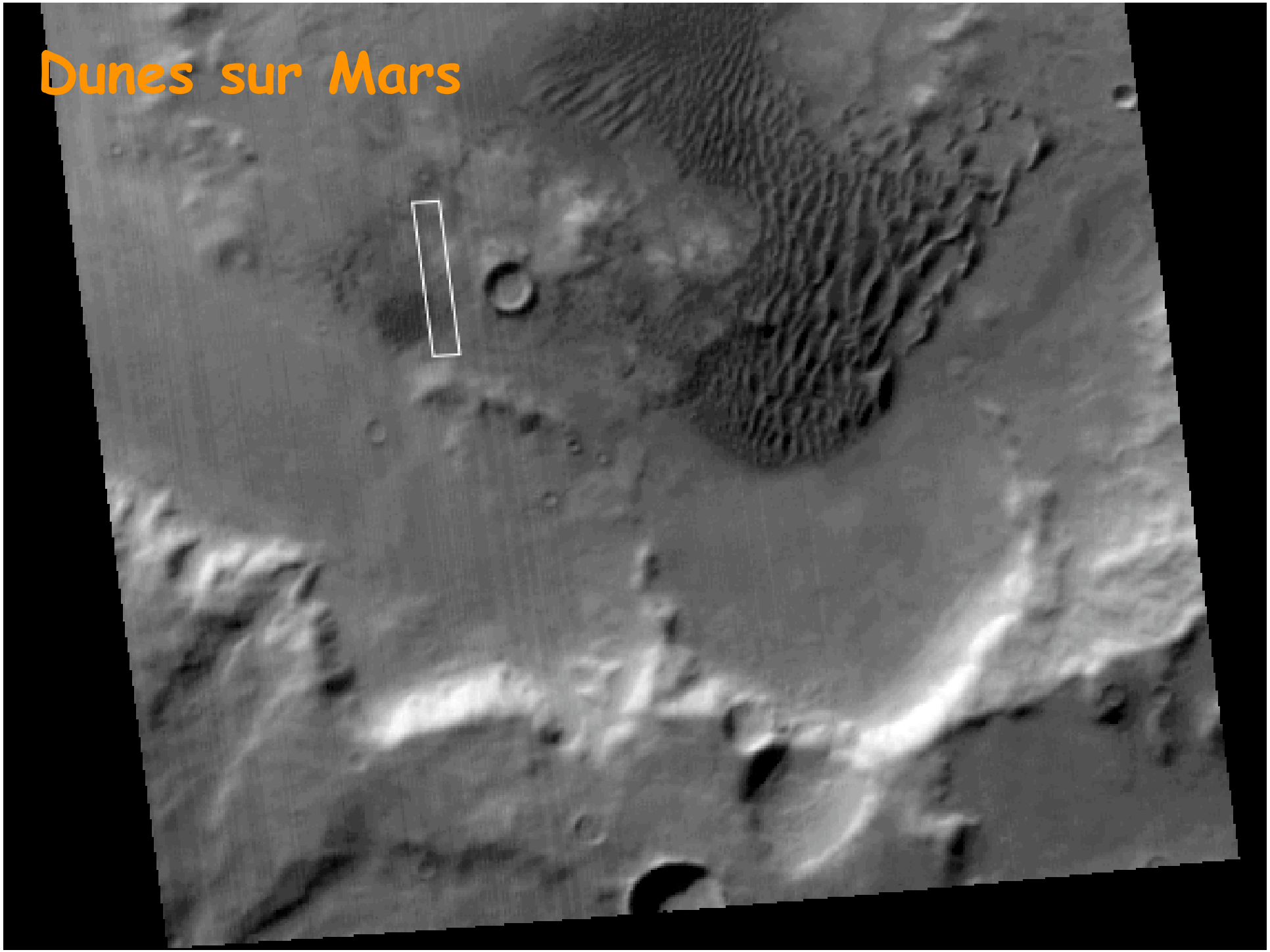
λ ***versus*** $\dfrac{\rho_s}{\rho_f} \times d$

ρ_f : **eau, air, atmosphères**

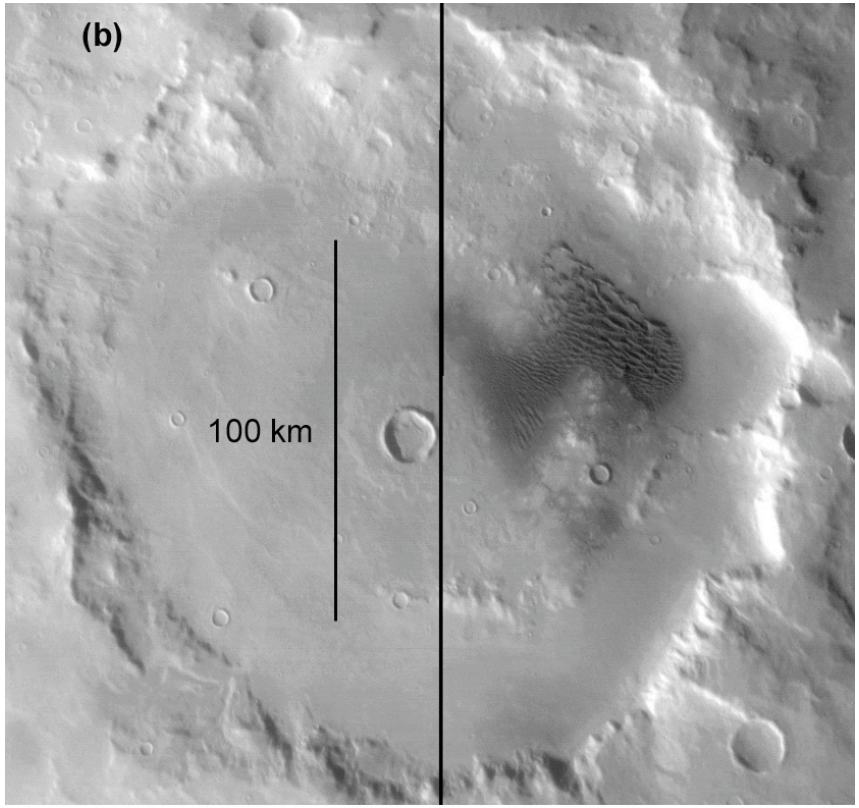
ρ_s : **sable, neige**

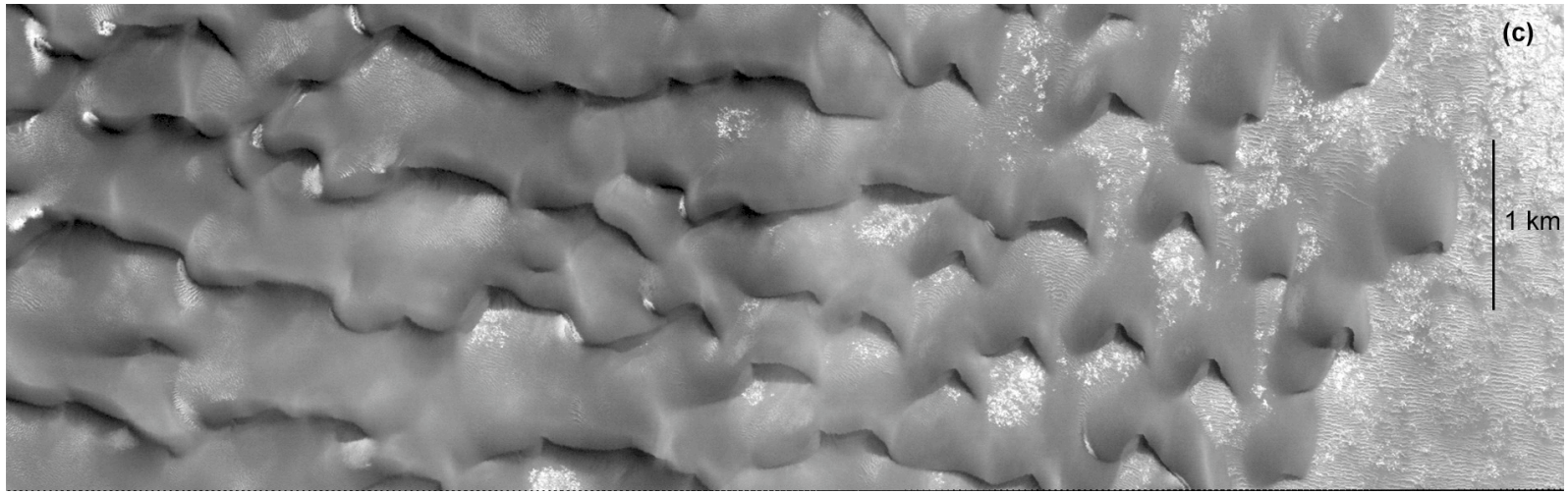
d : **sur Terre, sur Mars**

Dunes sur Mars

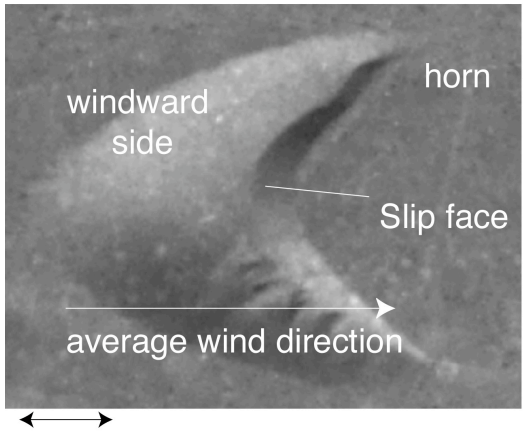


Dunes martiennes

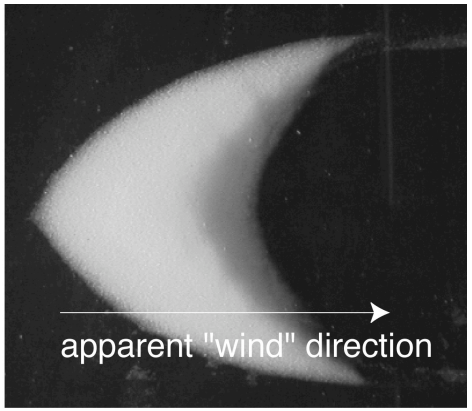




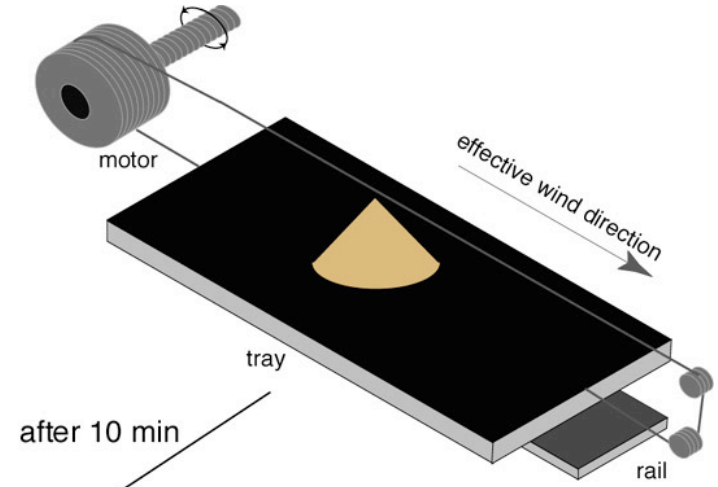
Dunes au laboratoire



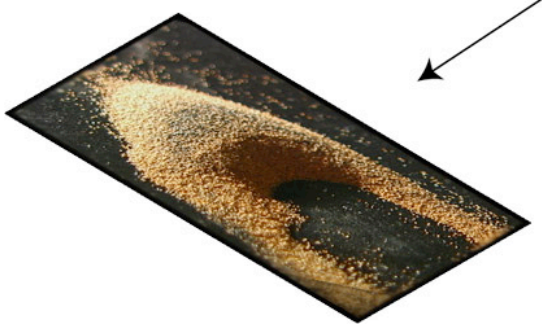
50 m



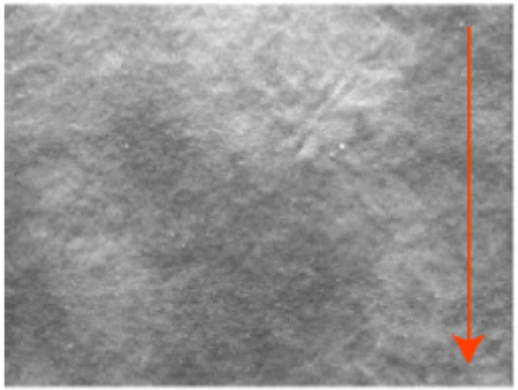
5 cm

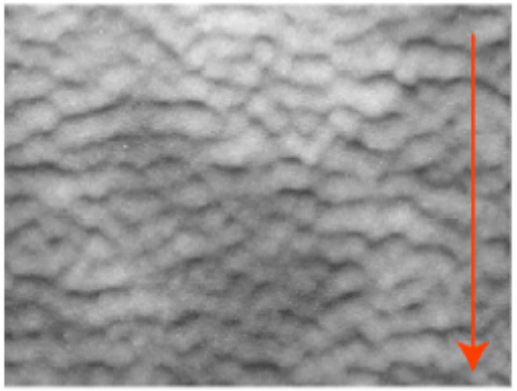


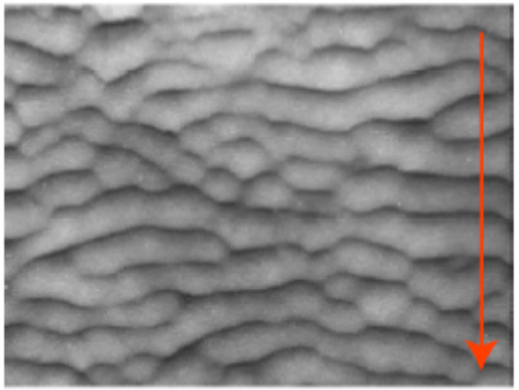
after 10 min



Thèse P. Hersen

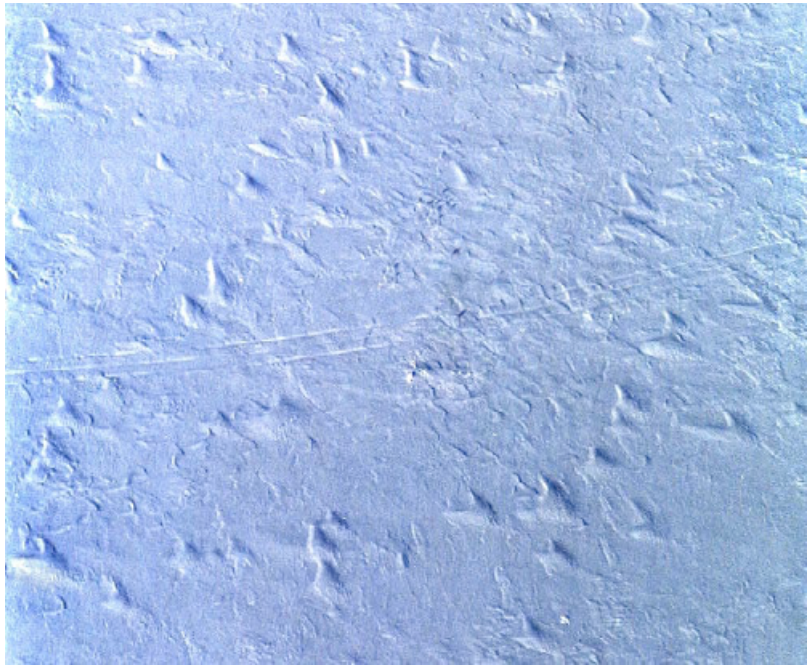




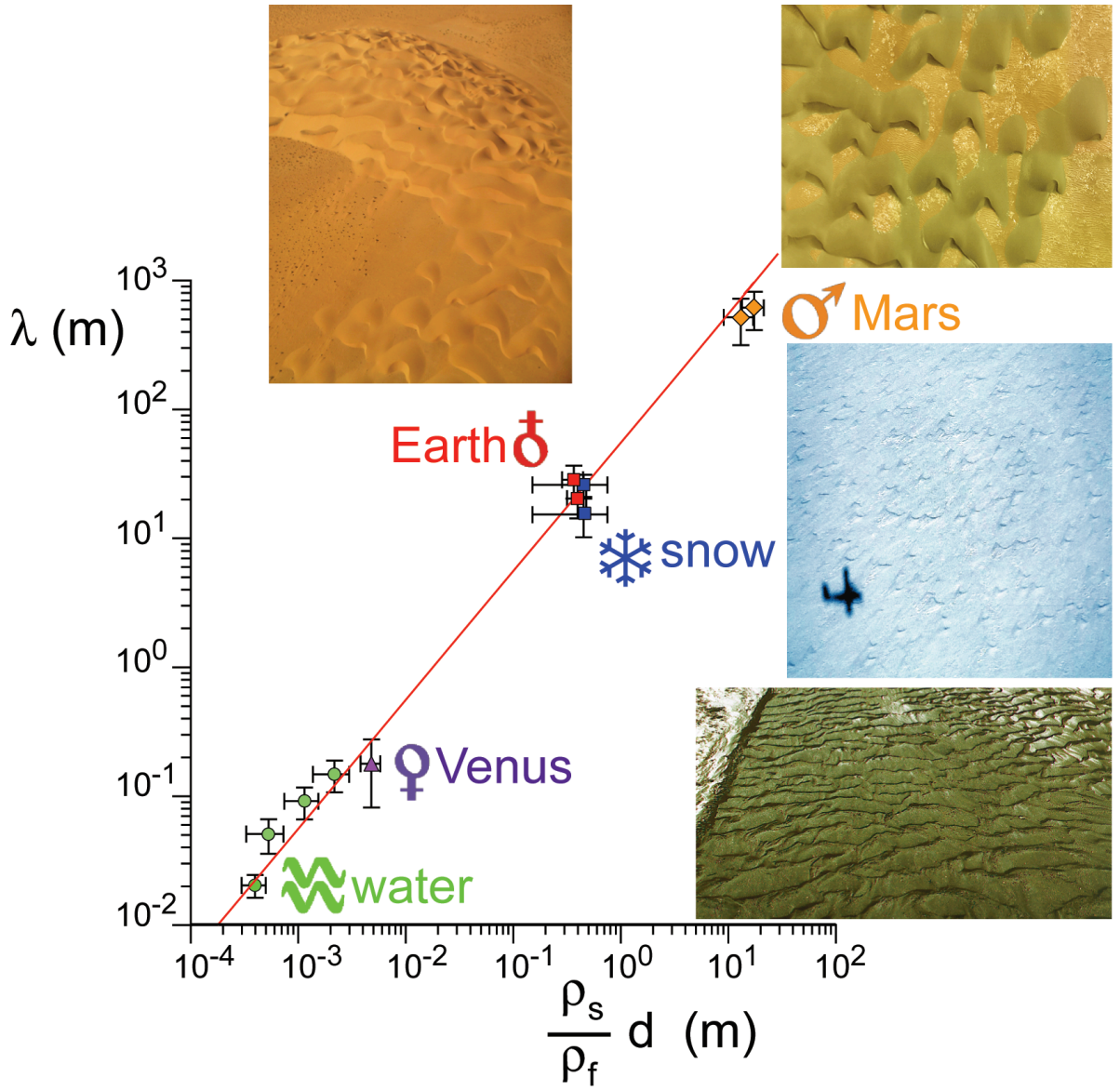


5cm

Dunes de neiges en Antarctique



Une loi d'échelle pour la taille des dunes



Echelles de temps

$$\sigma = Qk^2 \frac{B - AkL_{sat}}{1 + (kL_{sat})^2}$$

$$c = Qk \frac{A + BkL_{sat}}{1 + (kL_{sat})^2}$$

% du temps > seuil

$$\overline{Q} \propto \eta\alpha \sqrt{\frac{d}{g}} \frac{\rho_f}{\rho_s} u_{th}^2$$

$$\tau = (1+\alpha)\rho_f u_{th}^2$$

Sur Terre

$Q \sim 60 - 90$ m^2/an
$\eta \sim 65 - 85\%$
$\alpha \sim 1.5 - 2$

→ $\sigma^{-1} \sim 2$ semaines, $c \sim 200$ m/an

Sur Mars

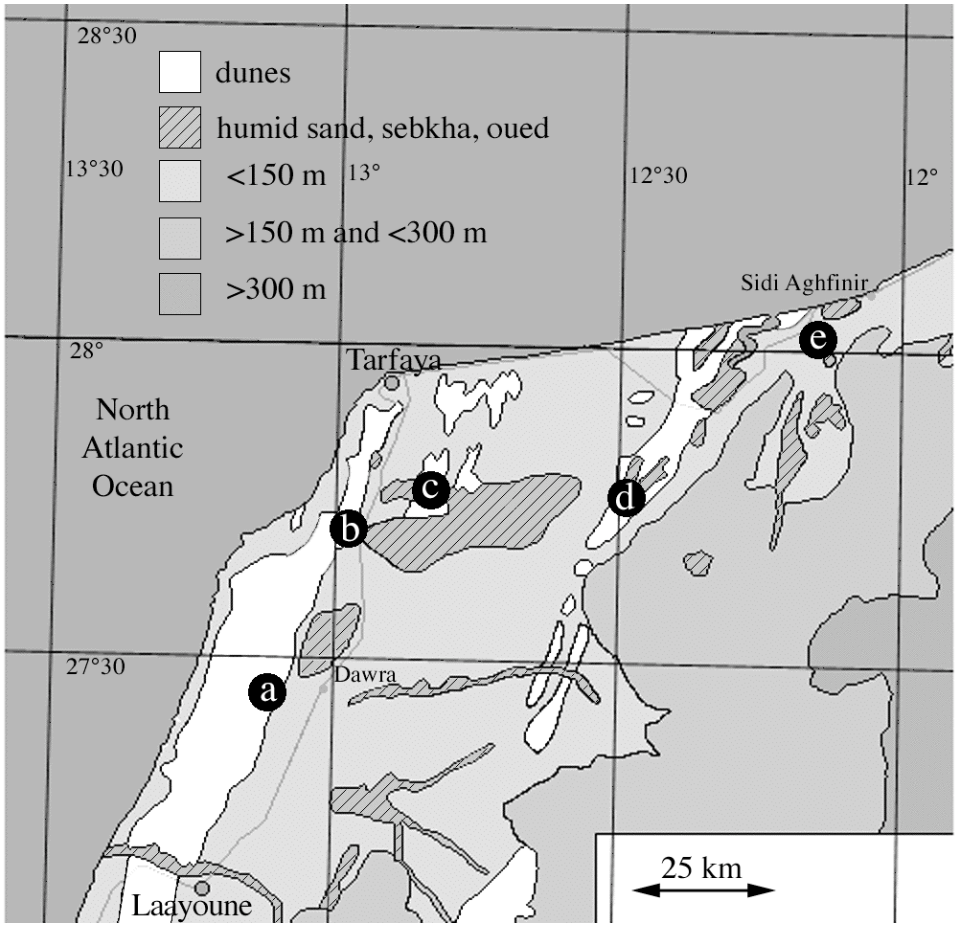
$\eta \sim$ quelques %
$\alpha \sim$ unité

→ x10^5 pour les temps
x10^{-4} pour les vitesses

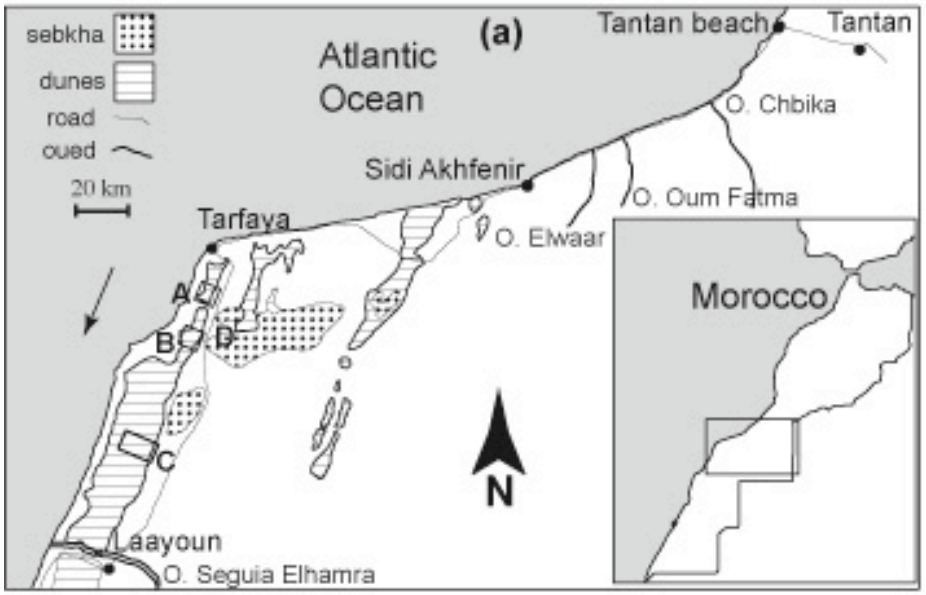
Dunes martiennes actives !

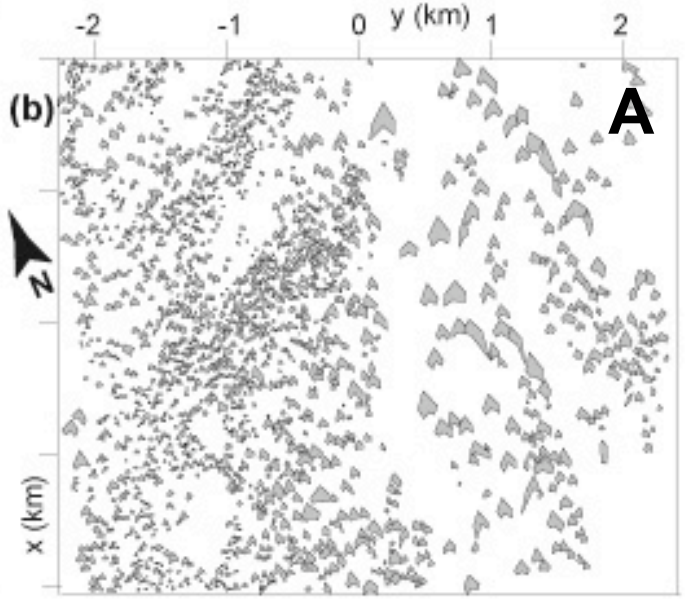
Sahara Atlantique

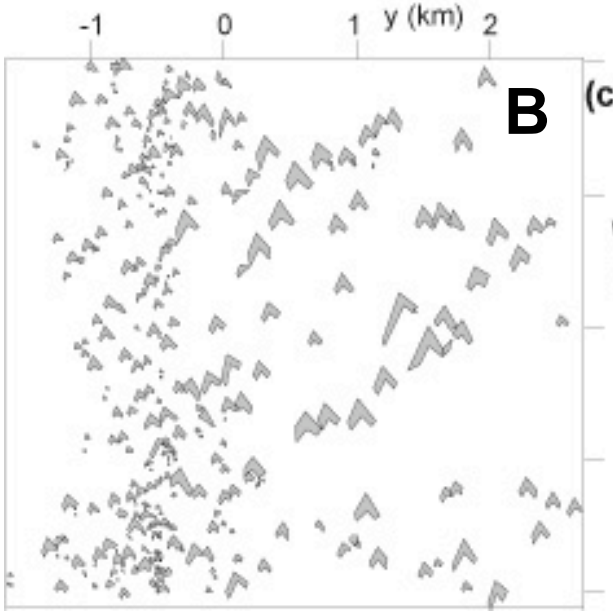
Alyzées

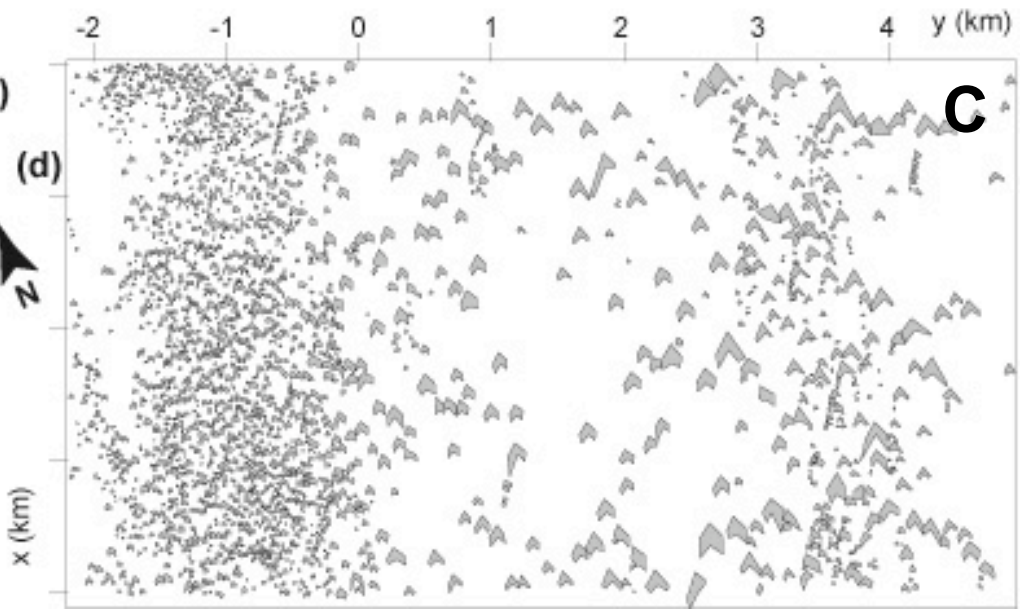


Tarfaya: sa plage, ses alizés, ses dunes…

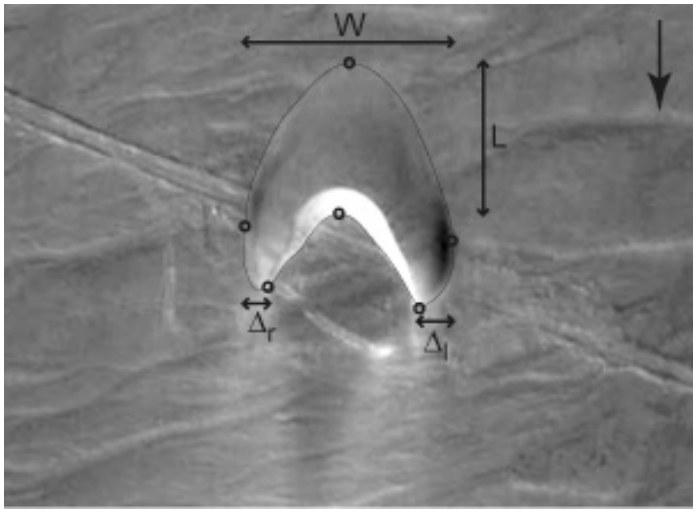


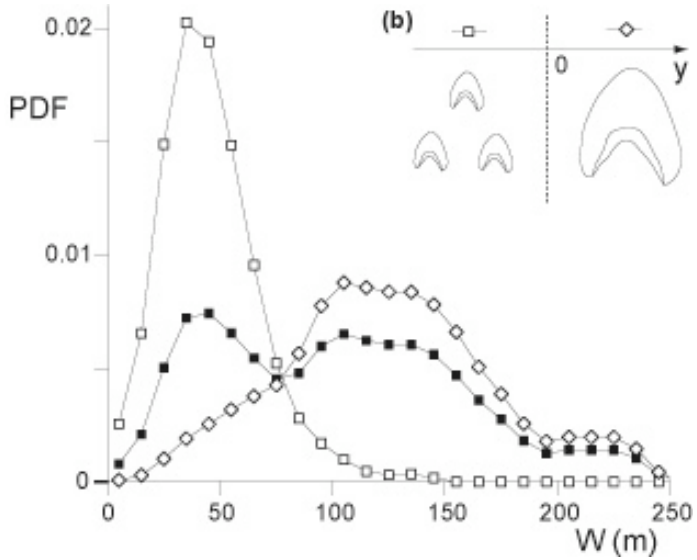


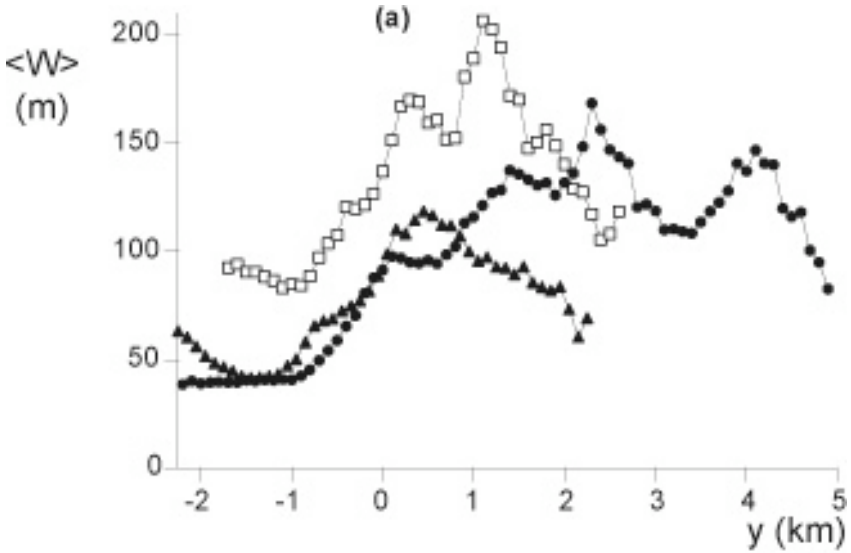


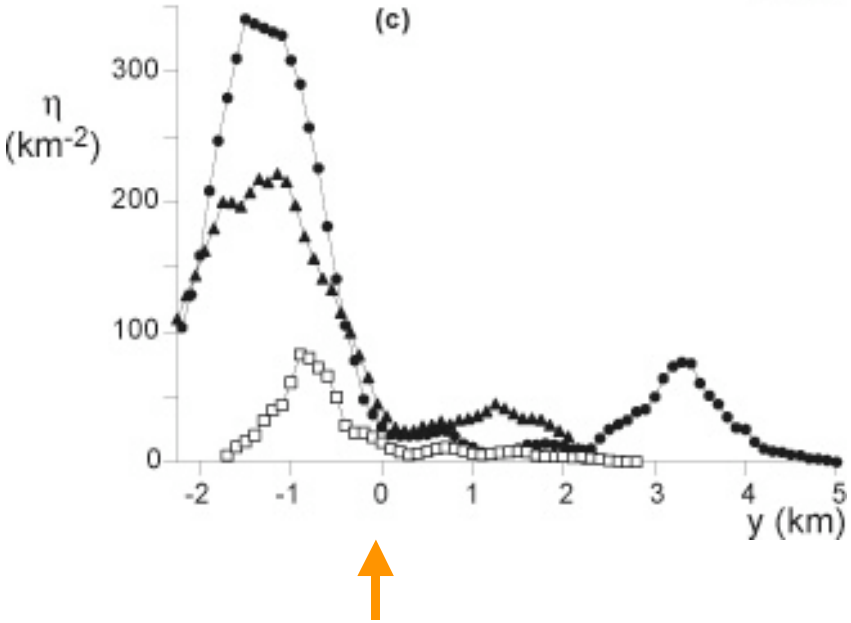


En 6 clics


W
L
Δ_r
Δ_l

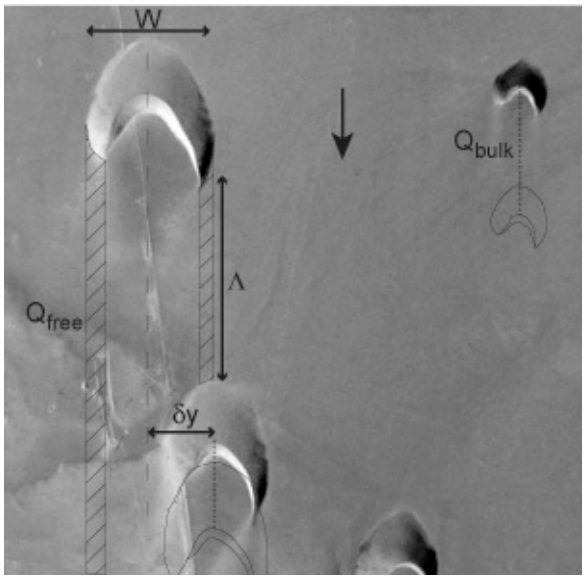

PDF
0.02
0.01
0
0
50
100
150
200
250
W (m)
(b)
0
y


<W>
(m)
(a)
200
150
100
50
0
-2
-1
0
1
2
3
4
5
y (km)


η
(km^{-2})
(c)
300
200
100
0
-2
-1
0
1
2
3
4
5
y (km)

Y a-t-il un paramètre au contrôle?

- Topographie
- Végétation
- Taille des grains
- Vent
- Flux de sable



δ_x

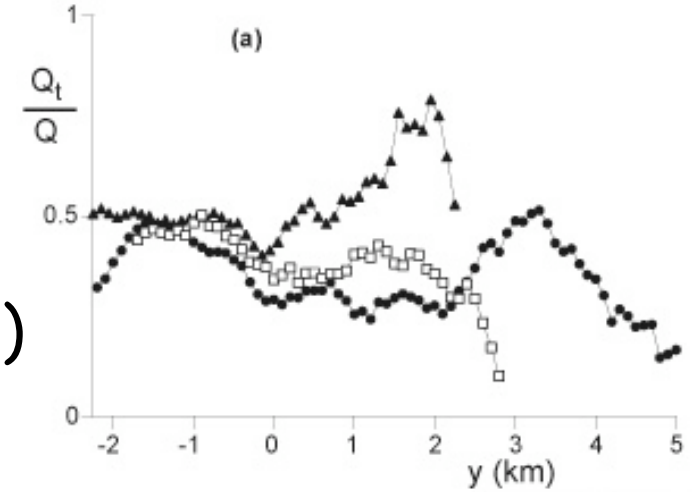
δ_y

Flux `bulk': $$Q_b = \frac{1}{\delta_x \delta_y} \sum_{i \in \mathcal{A}} c_i V_i$$

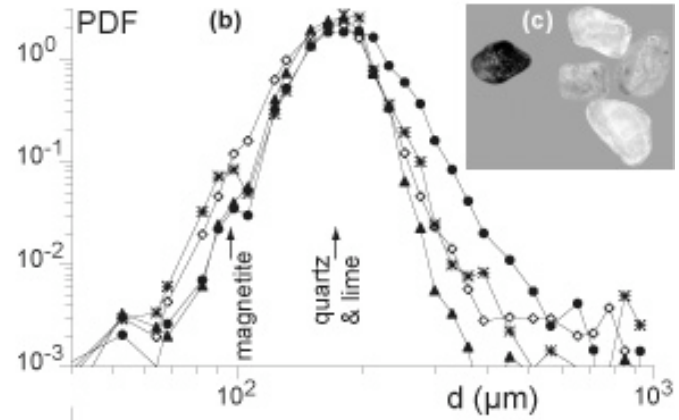
Flux `free': $$Q_f = \frac{Q}{\delta_x \delta_y} \sum_{i \in \mathcal{A}} \left(\Delta_i^l \Lambda_i^l + \Delta_i^r \Lambda_i^r \right)$$

Variations *versus* y

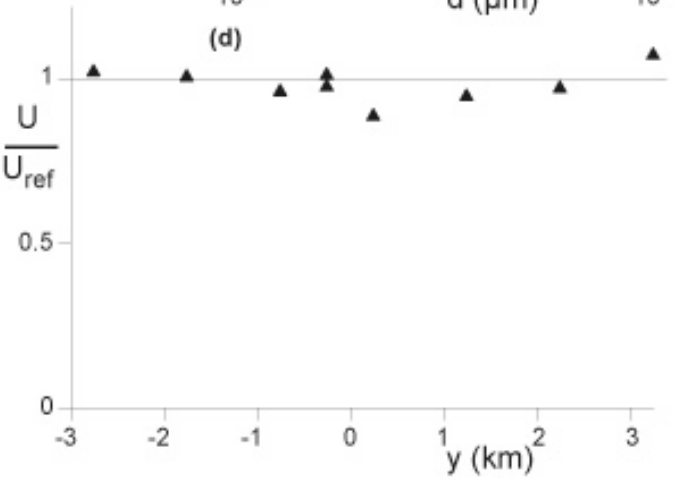
Flux
(bistabilité)



Grains

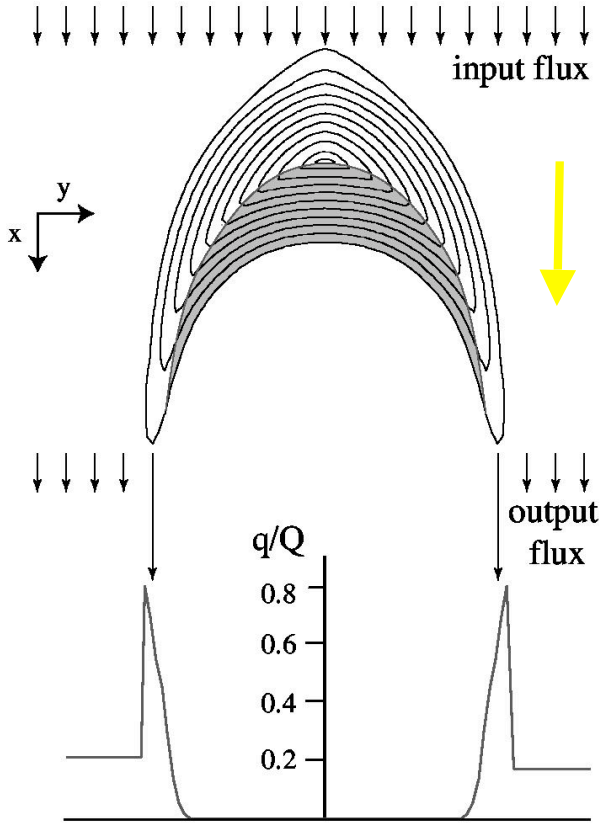


Vent



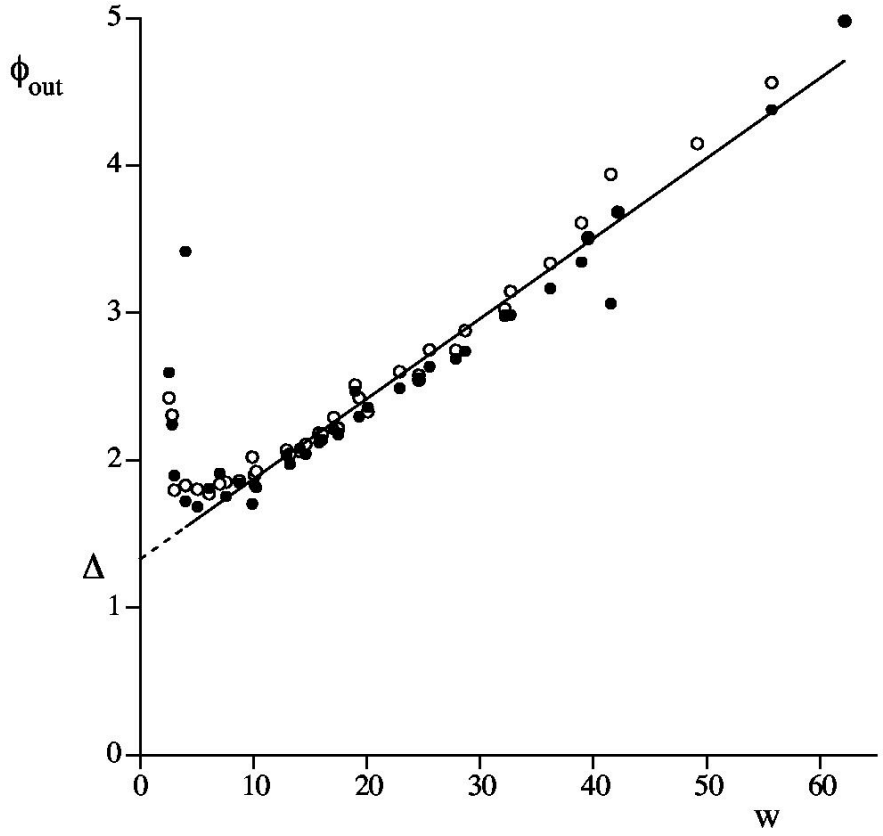
-> Sélection dynamique

Fuite en avant



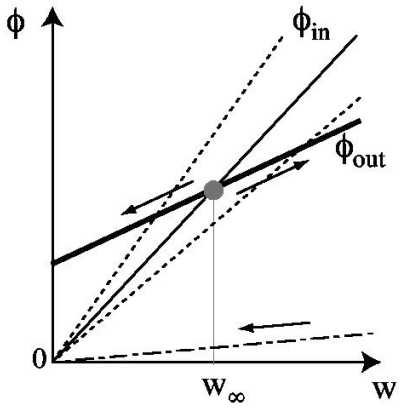
$$\phi_{in} = qW$$

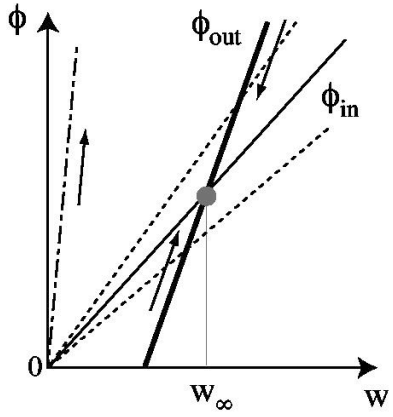
$$\phi_{out} = Q(\Delta + \alpha W)$$



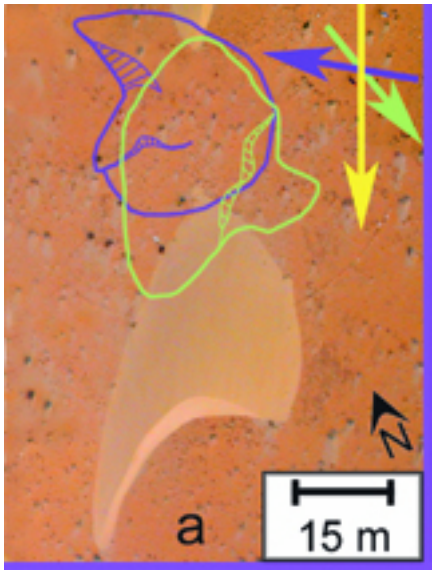
$\Delta>0$
unstable

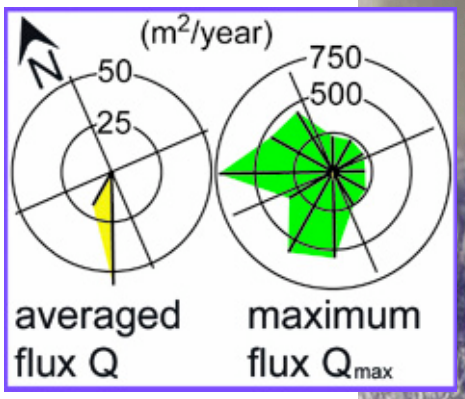
$\Delta<0$
stable

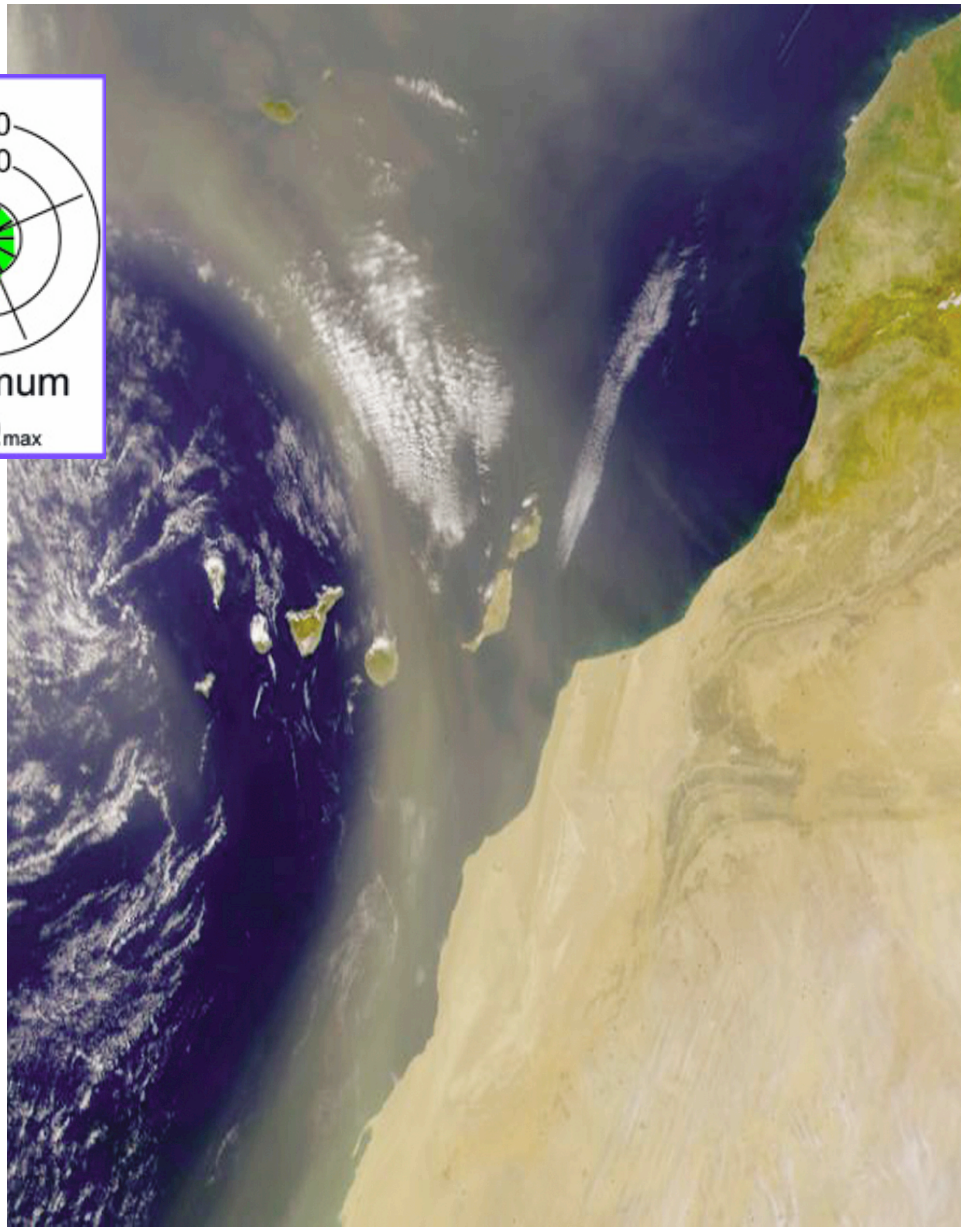




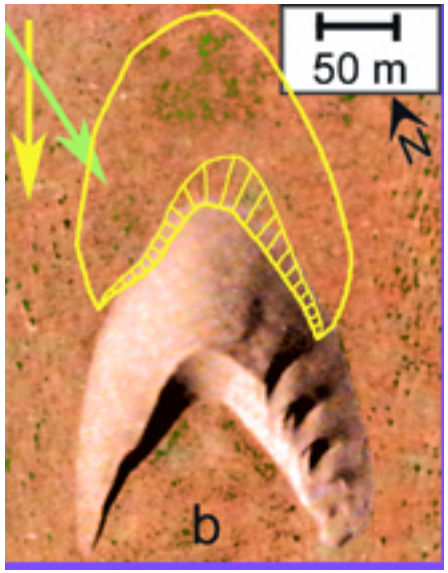
Tempêtes


a
15 m
N

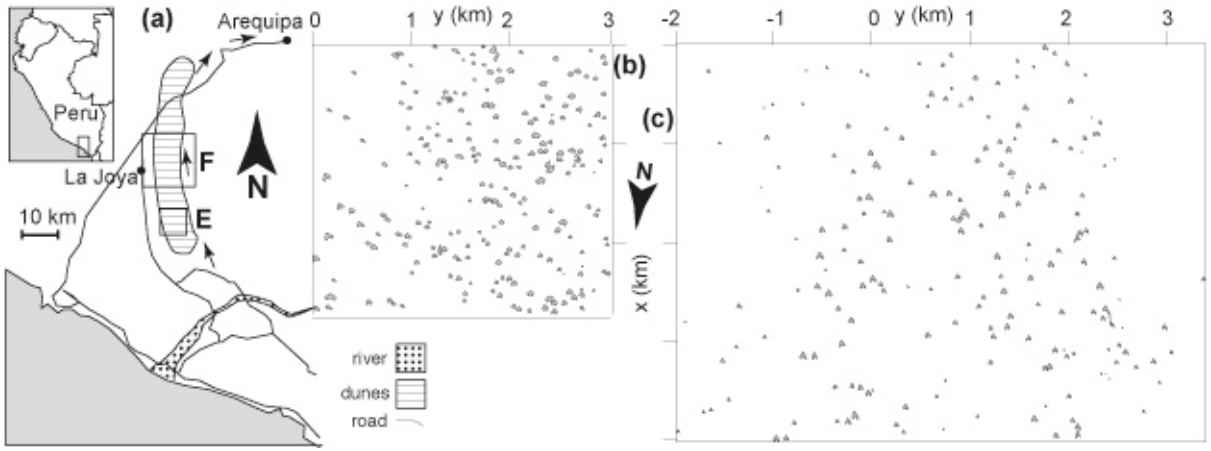

(m²/year)
N
50
25
750
500
averaged
flux Q
maximum
flux Qmax

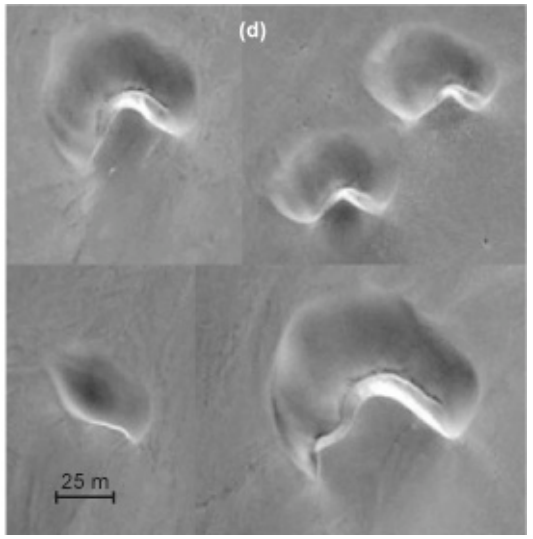


50 m
N
c

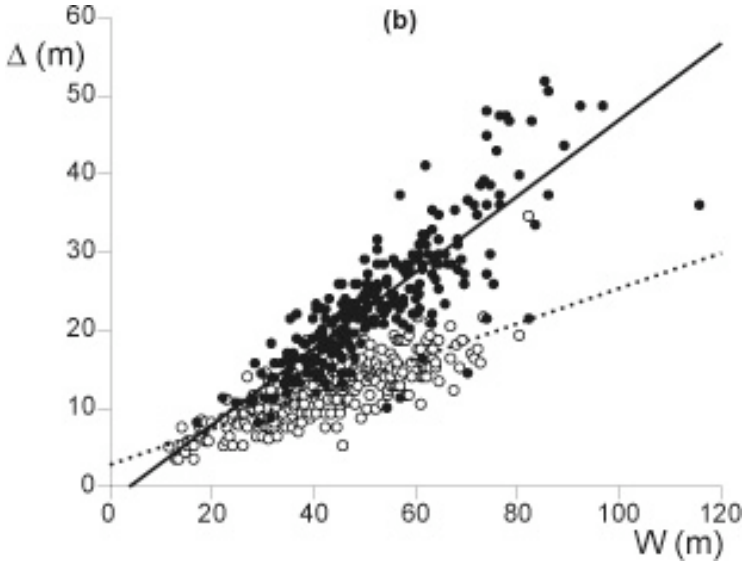

50 m
N
b

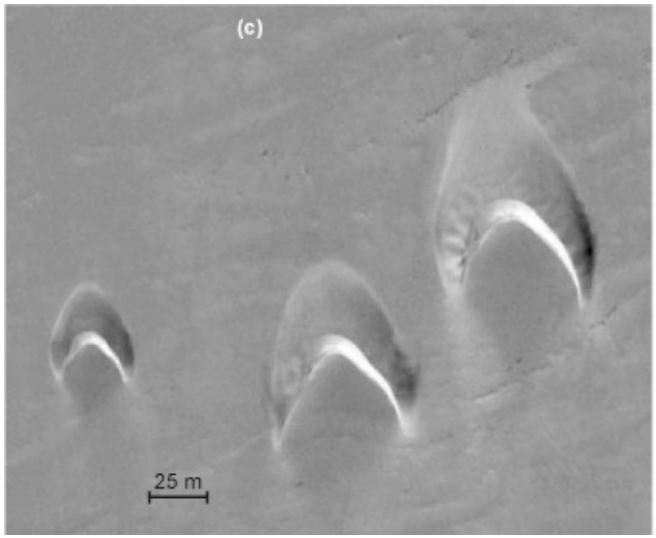
Vamos a la Joya





Mai 2003

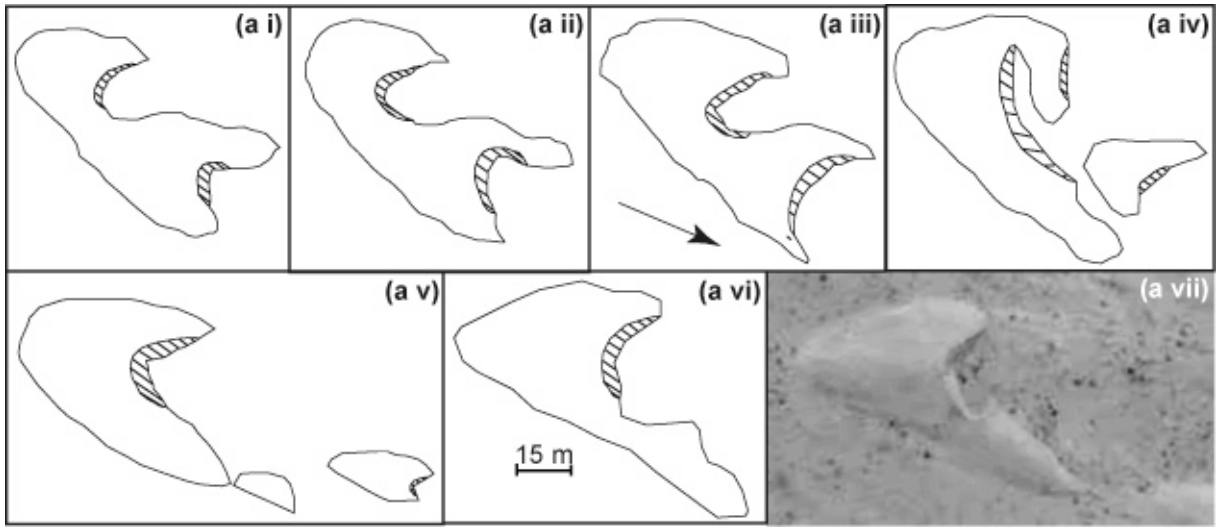


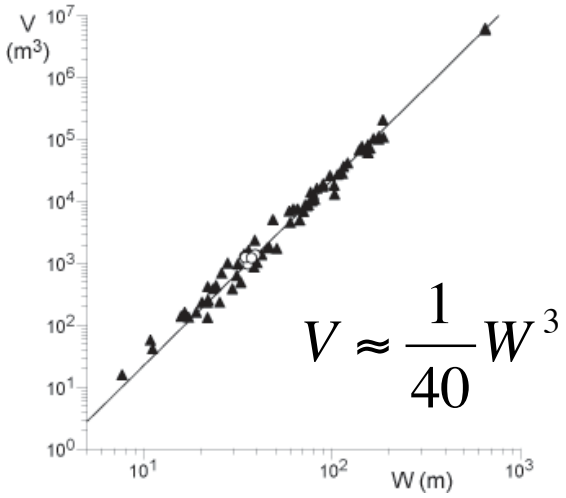


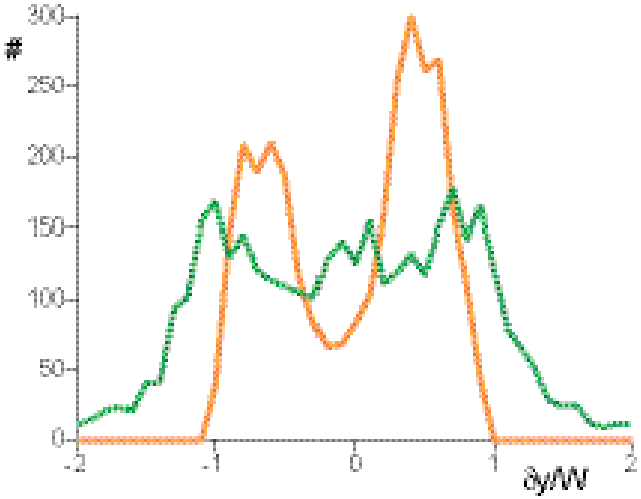
Février 2005

Collisions

Fusions partielles



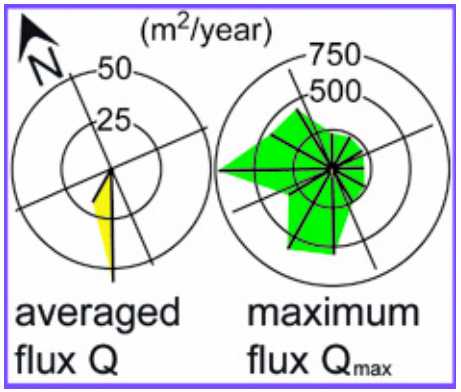




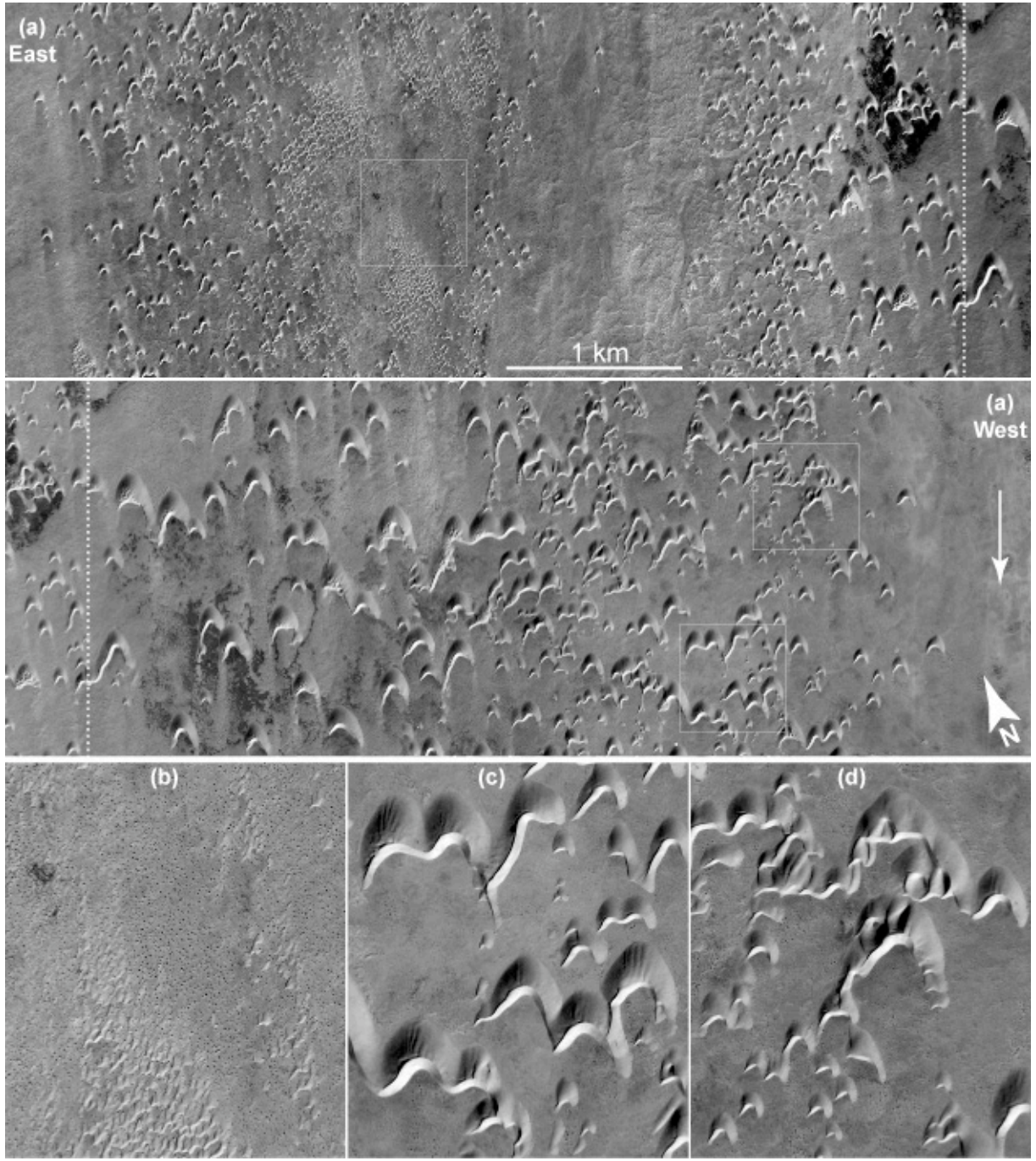
Ejections

Lecture de paysage

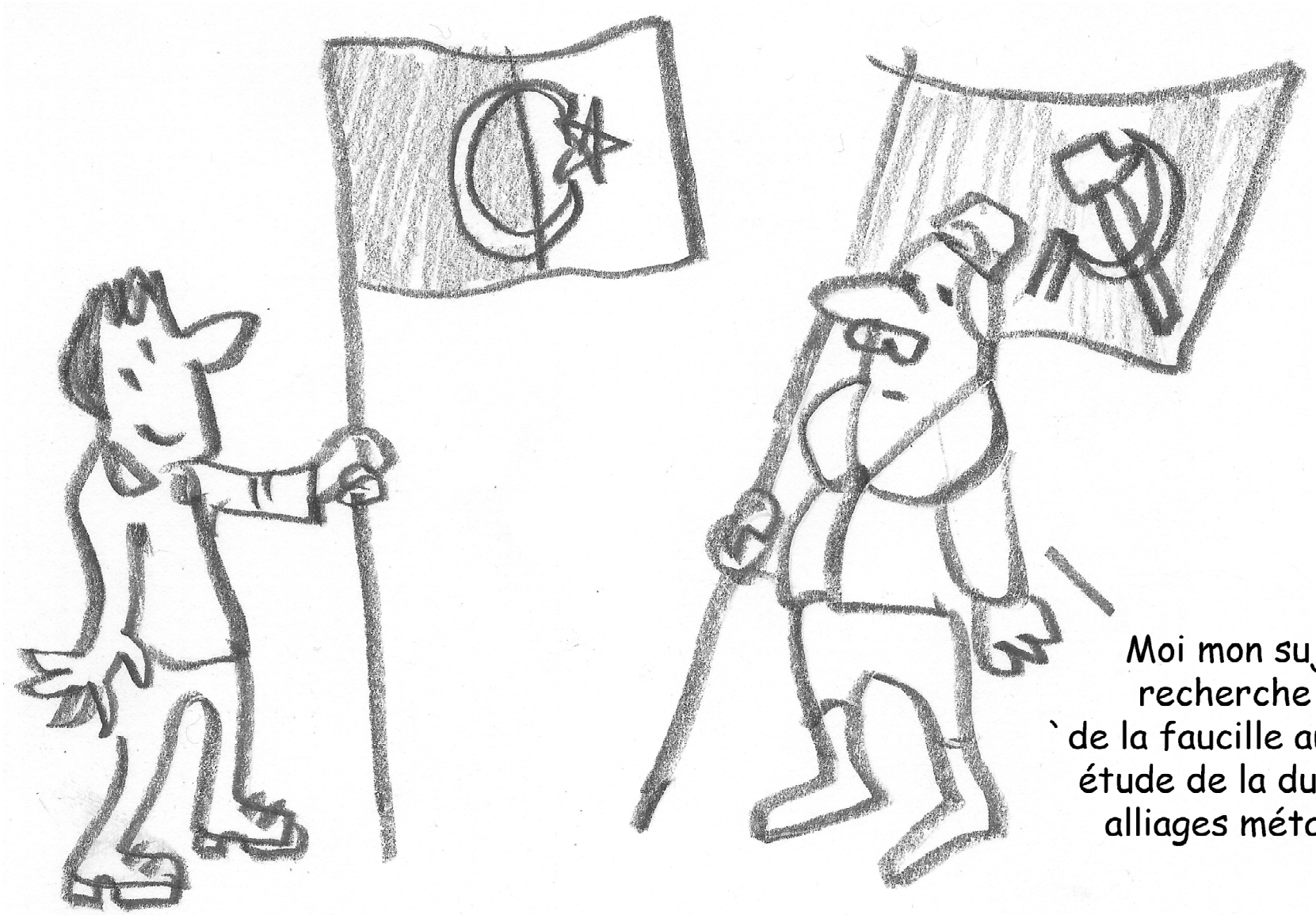
Tempêtes <-> Distance au bord



(b) Bistabilité
(c) Ondes
(d) `Canards'



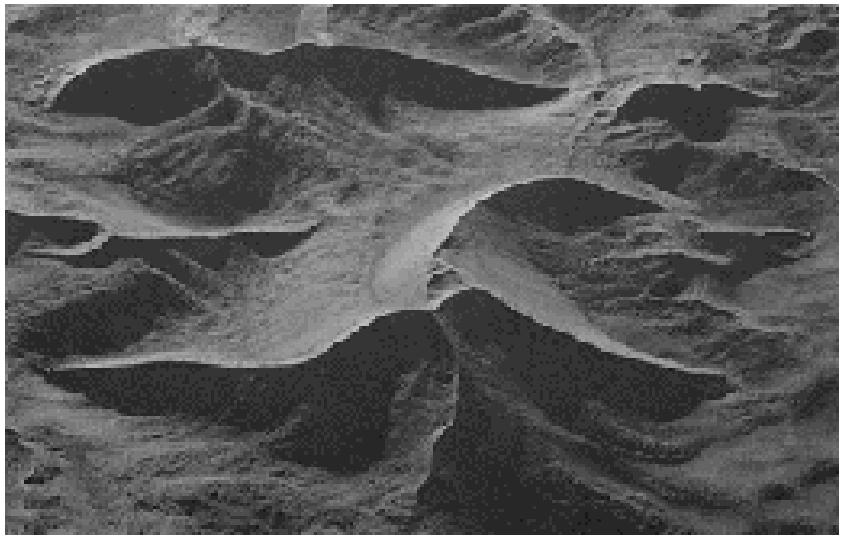
Des croissants aux étoiles: étude de la dynamique des dunes de sable



Moi mon sujet de recherche c'est ` de la faucille au marteau: étude de la dureté des alliages métalliques'

Dunes étoiles

Namibie

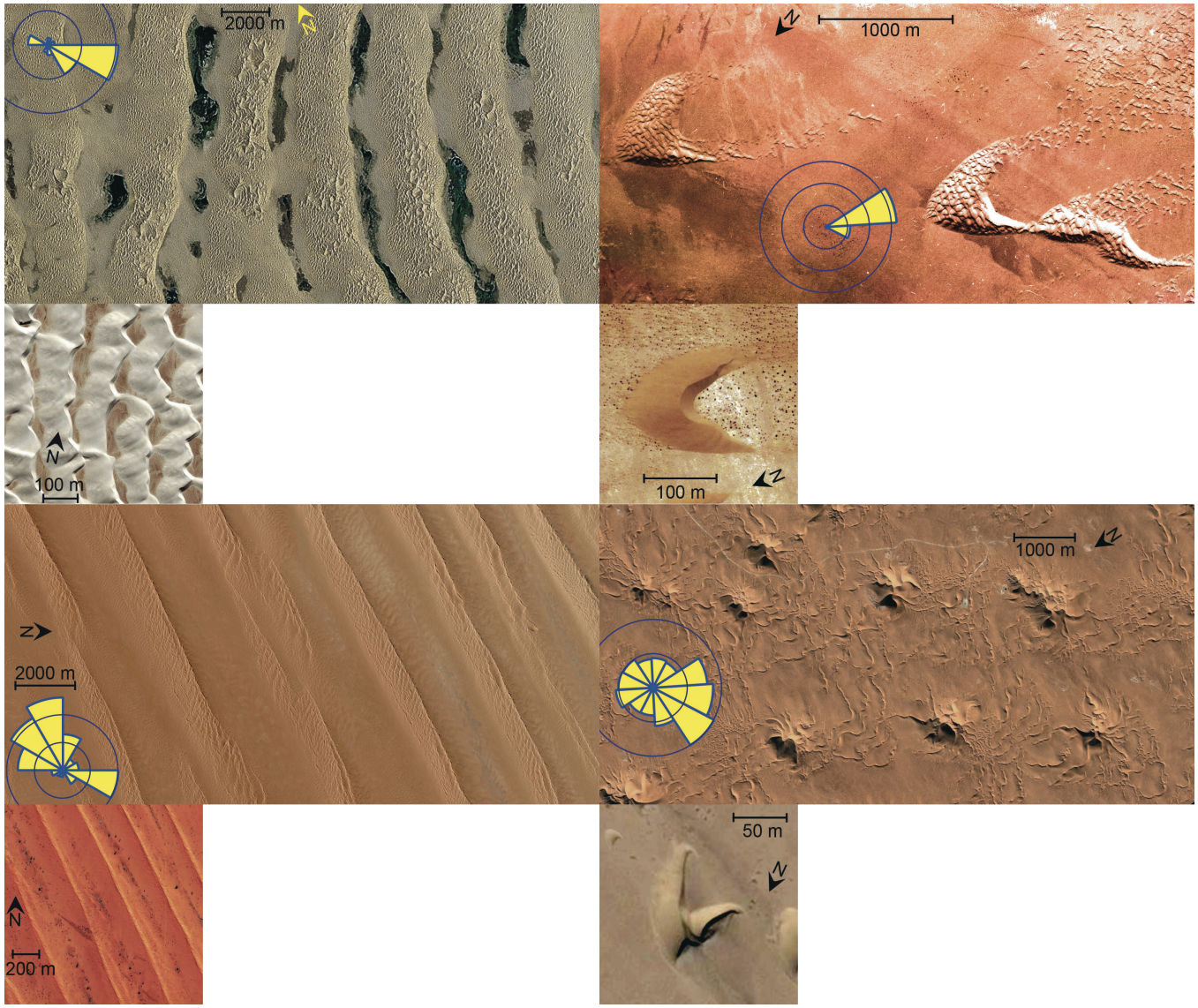


Algérie

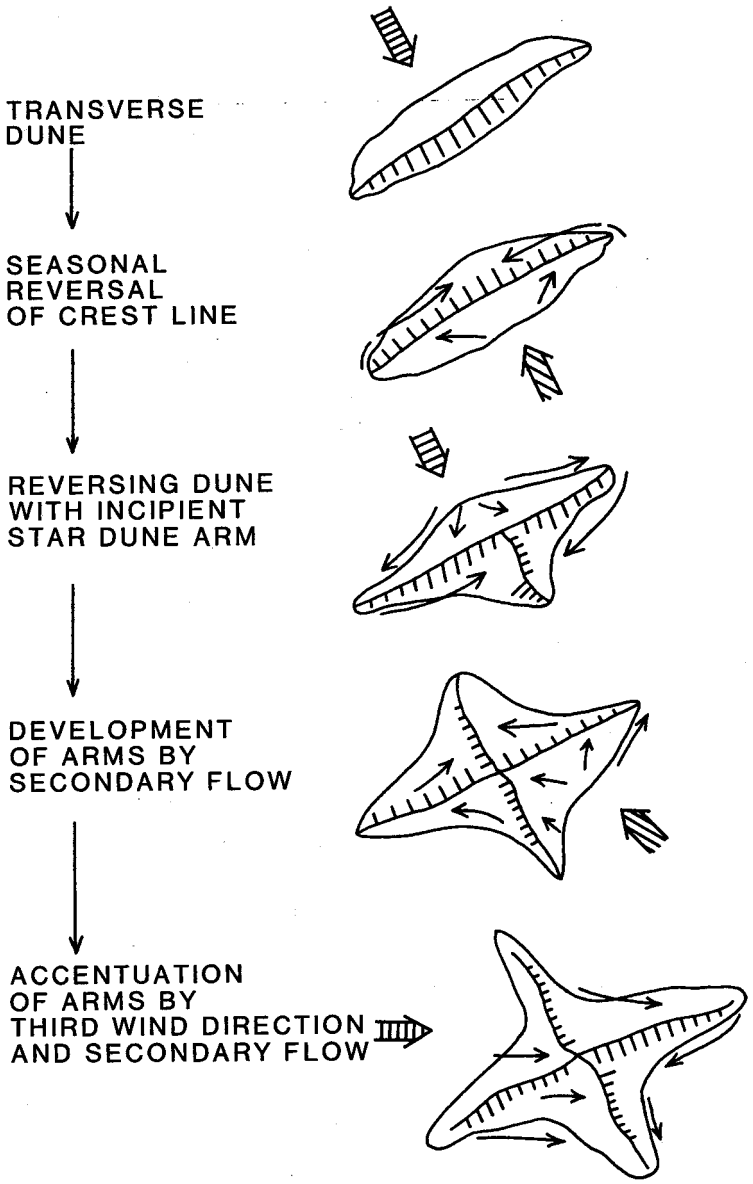
$H \sim 100$ m

$W \sim 1000$ m

Dunes géantes

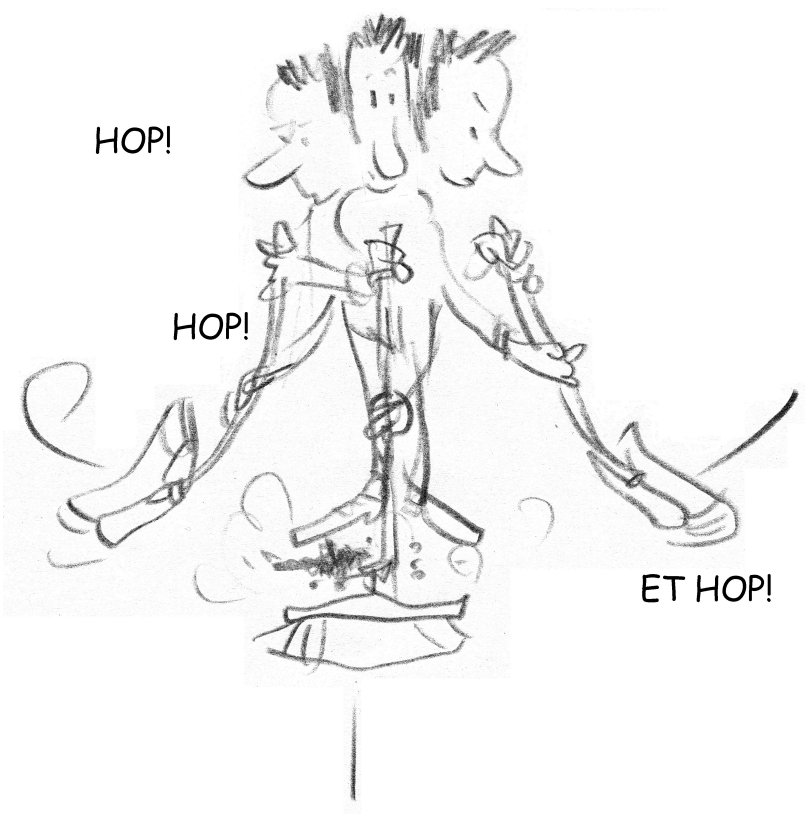


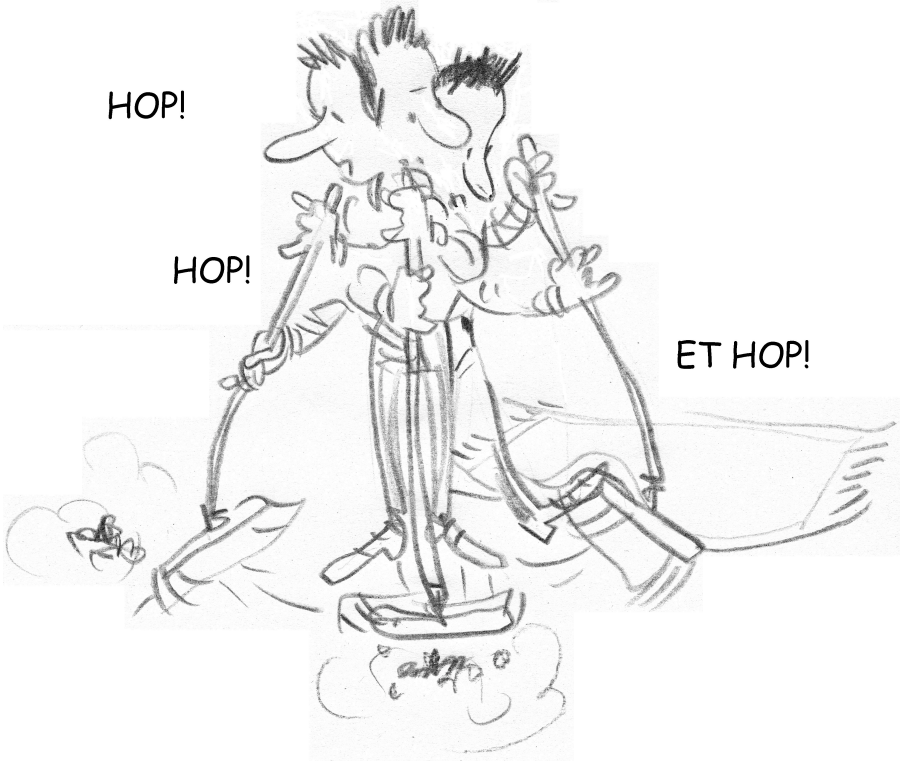
Une théorie pour les dunes étoiles ?



N. Lancaster 1989

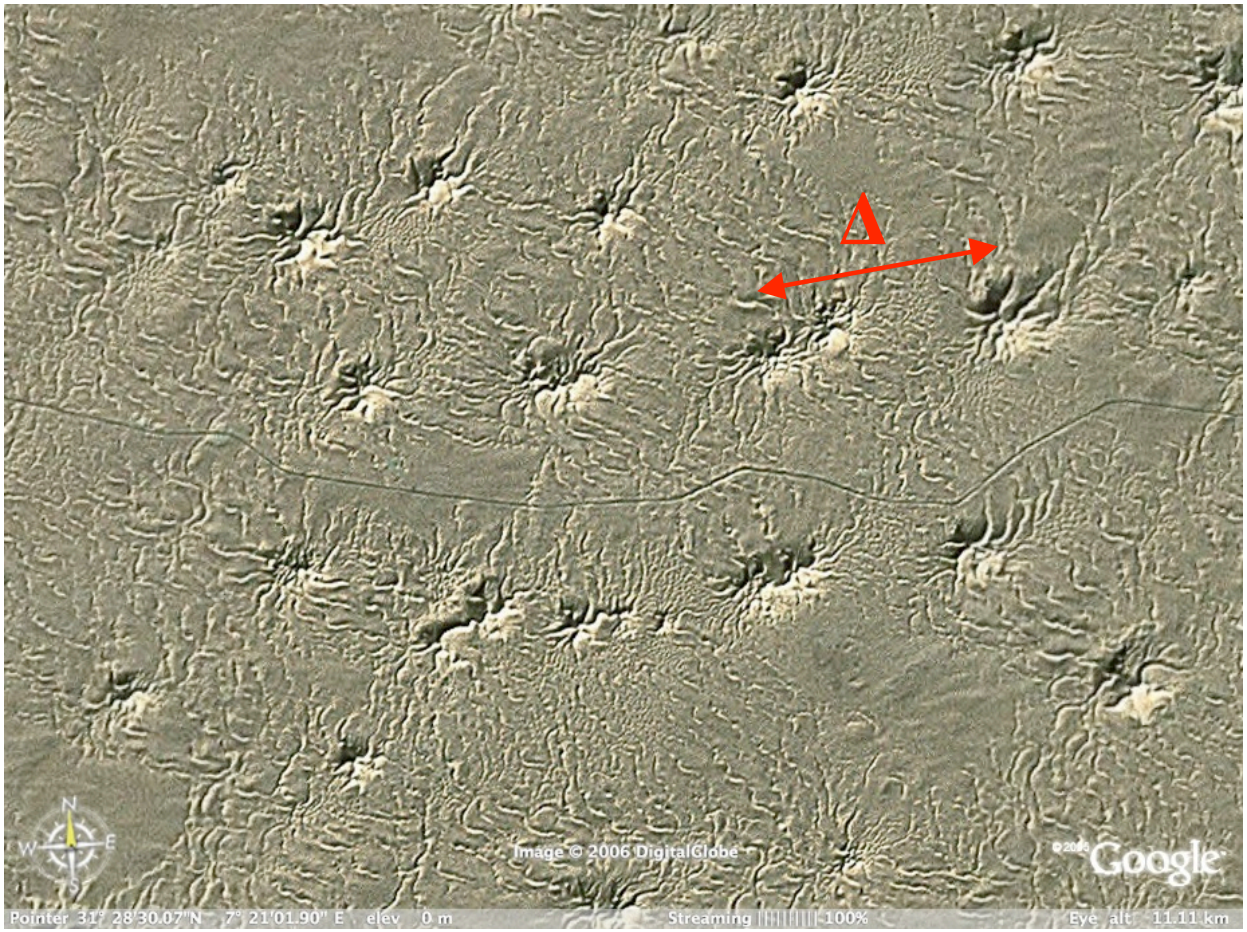
Une théorie pour les dunes étoiles ?





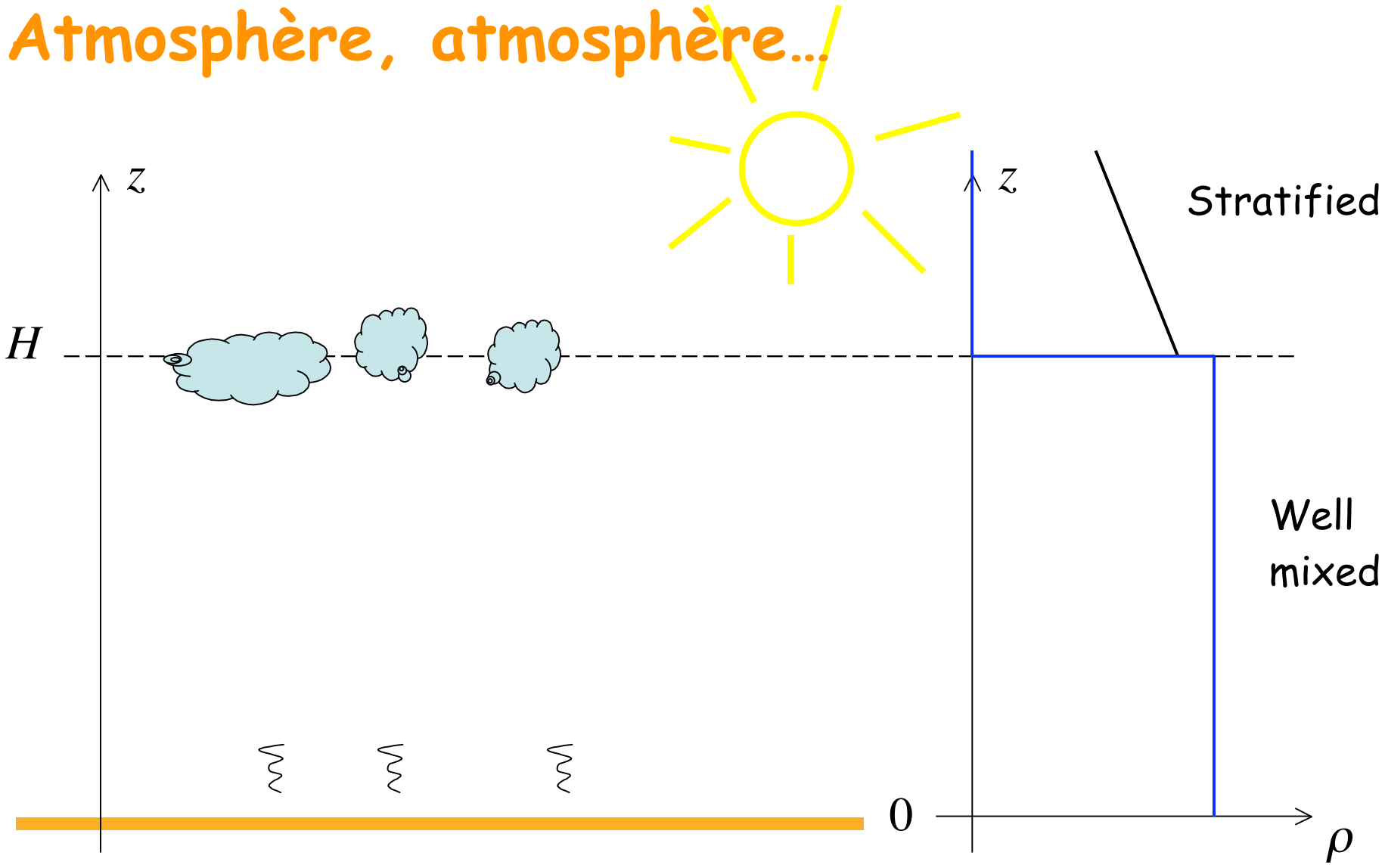
La théorie du « coup de balai » ne résiste pas à l'analyse pratique…

Echelles ?



$\Delta \sim 3$ km

Atmosphère, atmosphère…

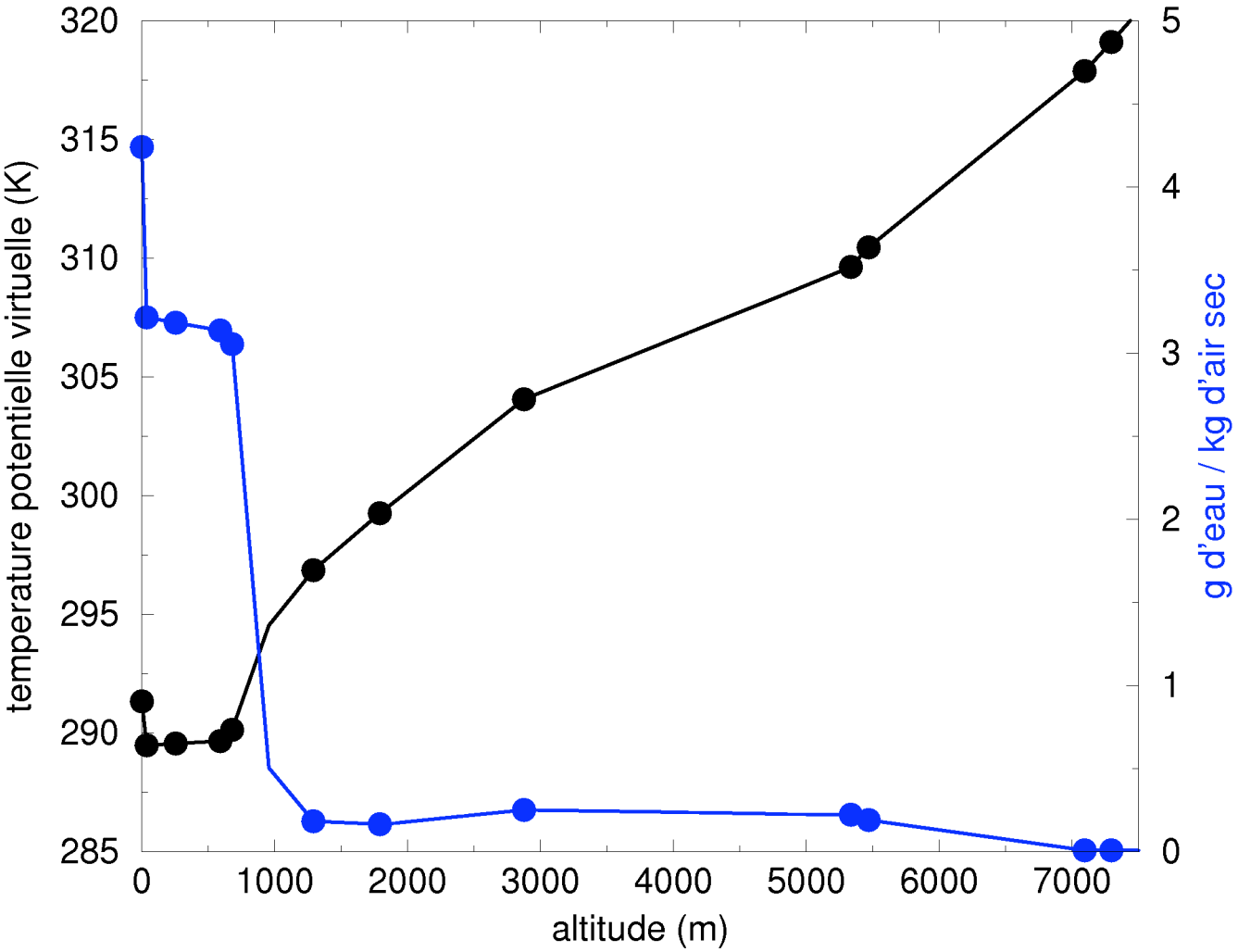


analogie avec une rivière

➔ `surface libre'

ABL

Radar
A
Lidar
I


320
315
310
305
300
295
290
285
temperature potentielle virtuelle (K)
0
1000
2000
3000
4000
5000
6000
7000
altitude (m)
5
4
3
2
1
0
g d'eau / kg d'air sec

JE PENSE AVOIR COMPRIS POURQUOI LES DUNES SUR TERRE SONT BIEN PLUS PETITES QUE CHEZ NOUS...

IL SUFFIRAIT QUE L'ATMOSPHERE TERRESTRE SOIT QUELQUES DIZAINES DE FOIS PLUS DENSE

MAIS ON NE CONNAIT PAS LA NATURE ET LA TAILLE DES GRAINS QUI COMPOSENT CES DUNES.

QUELQUES DIZAINES DE FOIS PLUS DENSE!

BIGRE!

SI TON HYPOTHESE EST VRAIE ON PEUT ALORS ABANDONNER L'IDEE DE JAMAIS TROUVER TOUTE TRACE DE VIE SUR CETTE PLANETE...

IL FAUDRAIT Y ENVOYER UN ROBOT - VOIRE UNE EXPEDITION - POUR EN AVOIR LE COEUR NET!