Outer Scale Definition

Model dependant

Infinite $\phi(\kappa) \propto (\kappa^2)^{-11/6}$

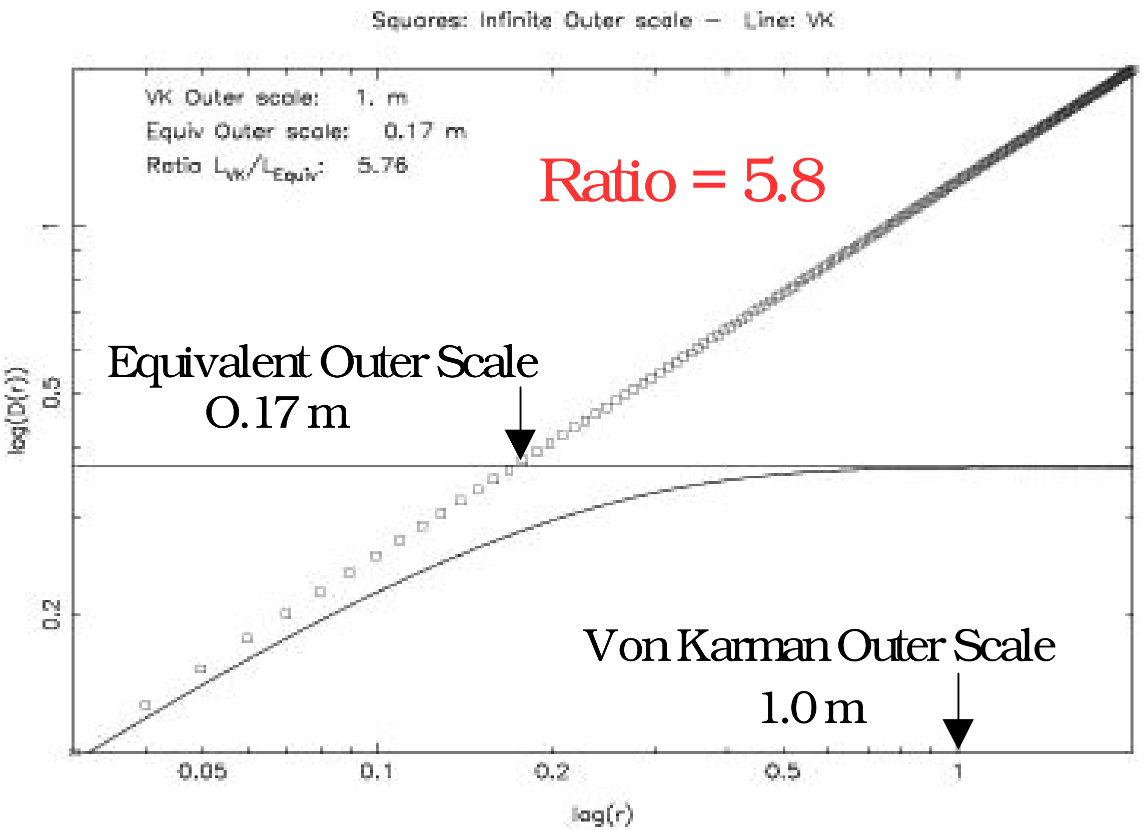
Von Karman $\phi(\kappa) \propto (\kappa^2 + (2\pi / L_0)^2)^{-11/6}$

Equivalent (Tatarski)

$$D_\theta(L_T) = C_\theta^2 \, L_\theta^{2/3} = \Delta\theta^2$$

$$C_\theta^2 = a^2 \, L_\theta^{4/3} \, (\mathrm{grad}\ \theta)^2$$

$$D_\theta(r) = \int_0^\infty \left(1 - \frac{\sin(Kr)}{Kr}\right) K^2 \Phi_\theta(K) \, dK$$



Saturation $\Delta\theta^2$

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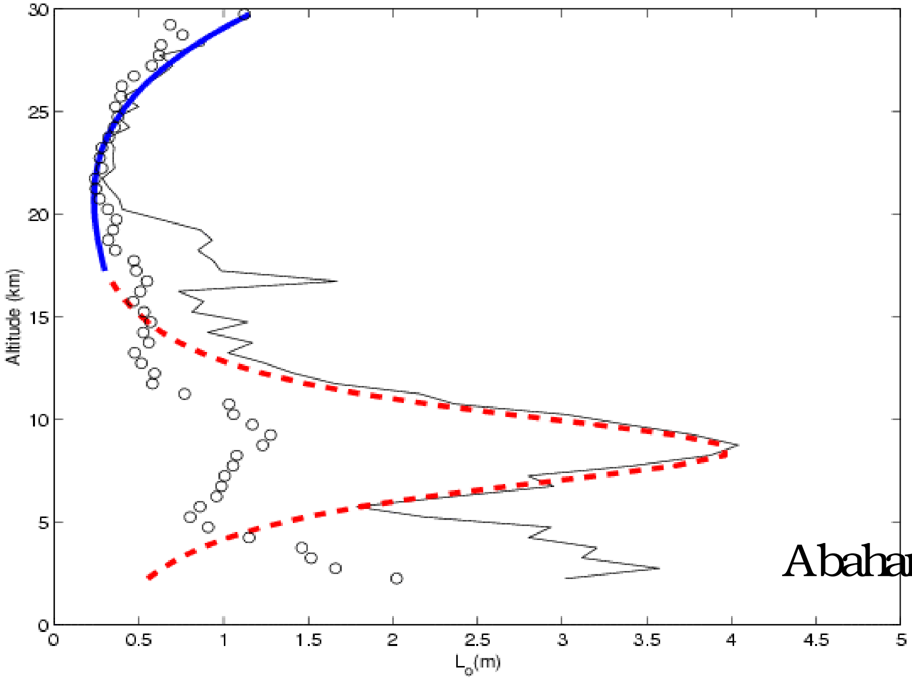
Outer Scale Scatter



Abahamid,Jabiri,Vernin et al.(2003),A&A, in press

Measurement	Instrument/Telescope		$\mathcal{L}_0$ (m)	Reference
in situ soundings				
Refractive index structure function	Balloons (Paranal, Chile)		2.5	Fuchs[9] 95
Interferometry				
Phase structure function (Ph.S.F.)	I2T (Calern, France)		~ 8	Mariotti *et al.*[10] 84
	SUSI (Australia)		5 ~ 10	Davis *et al.*[11] 95
Ph.S.F. + Phase temporal power spectrum (Ph.T.P.S.)	mounted on WHT (Canary Ils.)		$\sim 2 \times 2\pi$	Nightingale *et al.*[12] 91
	WHT + COAST (Cambridge, UK)		∞	Hannif *et al.*[13] 94
Ph.T.P.S., single baseline	Mark III (Mt. Wilson, USA)		> 2000	Colavita *et al.*[14] 87
Ph.T.P.S. with different baselines	Mark III (Mt. Wilson, USA)		~ 30	Buscher *et al.*[15] 95
	Mark III (Mt. Wilson, USA)		~ 30	Buscher *et al.*[16] 91
	ISI (Mt. Wilson, USA)		5 – 20	Bester *et al.*[17] 92
Spectral decorrelation	GI2T (Calern, France)		~ 22	Berio *et al.*[18] 96
Shack-Hartmann-kind technique with a single telescope				
AA structure function	CFH (Hawaii)		5 – 8	Tallon[19] 89
Zernike variances	3.6m ESO (La Silla,Chile)		~ 50	Rigault *et al.*[20] 91
AA variances	OHP (Provence, France)		5 – 100	Ziad *et al.*[21] 94
Tilt covariances	KECK (USA)		16 – 80	Takato *et al.*[22] 95
Shack-Hartmann-kind technique with multiple telescopes				
AA covariance	G.S.M. (Calern, France)		10 – 300	Agabi *et al.*[23] 95

Avila,Ziad et al.(1997)
JOSA, **14**,3070

Atmospheric Parameters Relevant to AO

To characterize r_0 , θ_{FCAO} , θ_{PCAO} , τ_{AO} , d_0 one needs to know vertical profiles of optical turbulence $C_N^2(h)$ and wind $V(h)$ with $0 < h < 20\text{-}30$ km

Operational Profilers

Generalized Scidar
Instrumented balloons

Prototype Profilers

Single Star Scidar's
Slodar

Other combinations

MASS + DIMM + V(h) from meteo model

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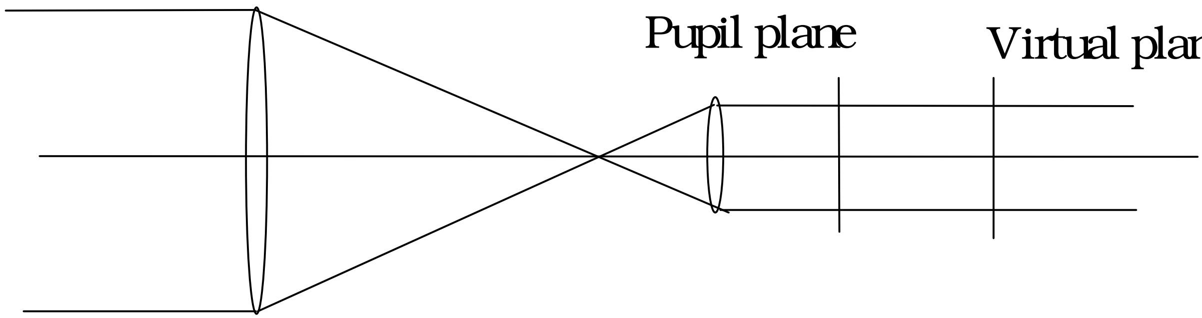
Single Star Scidar basic equation



$$C(\vec{r},\tau) = \sum_{i=1}^{N} C_i(\vec{r},h_i) * G(\vec{r},\sigma_{v_i}\tau) * S(\vec{r}) * \delta(\vec{r}-\vec{v}_i\tau)$$

$C_i(\vec{r}, h_i)$ Autocorrelation for a layer at altitude i

$G(\vec{r},\sigma_{v_i}\tau)$ Gaussian convolution due to wind variations

$S(\vec{r})$ Impulse response of the receiver

$\delta(\vec{r}-\vec{v}_i\tau)$ Displacement due to wind speed

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Single Star Scidar results

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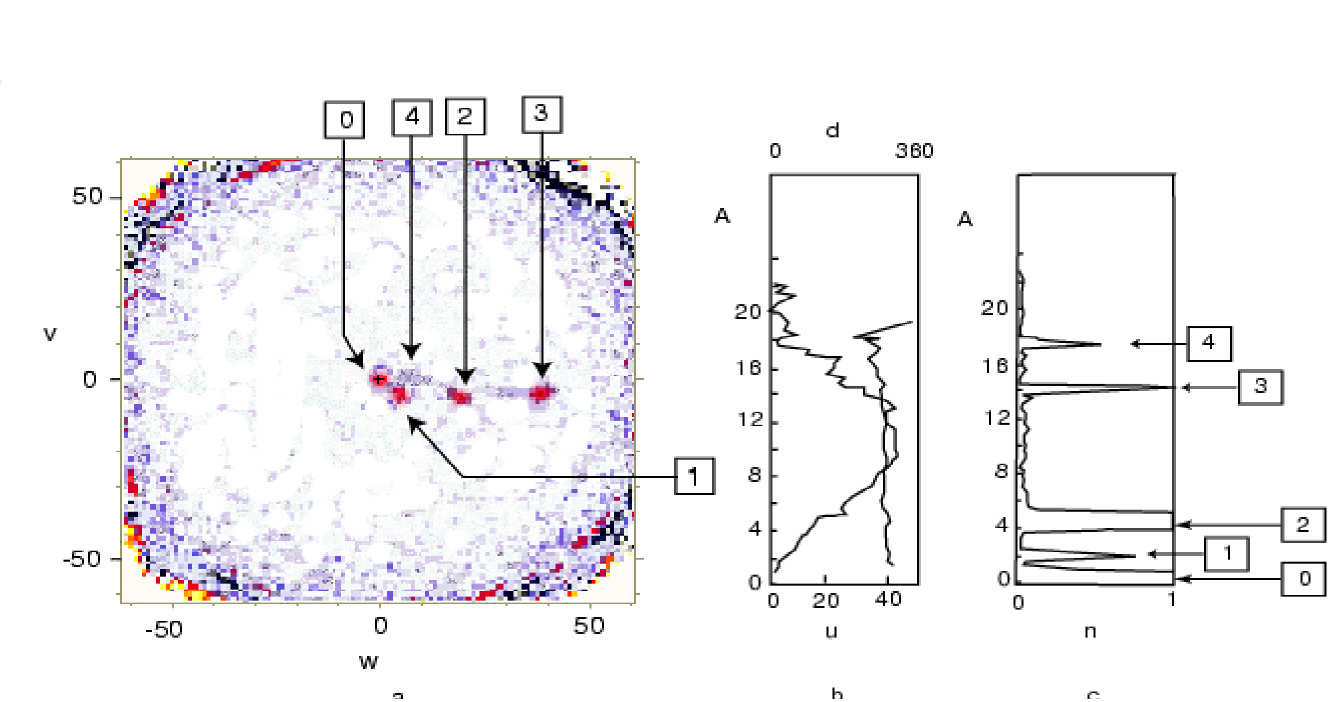

SCIDAR	étoile simple					Ballons		
couche	h_i (km)	σ_{v_i} (m/s)	$C_n^2(h_i)\Delta h_i$ ($\times 10^{-14}$ $m^{1/3}$)	$\lvert\vec{v}_i\rvert$ (m/s)	Direction (°)	h_i (km)	$\lvert\vec{v}_i\rvert$ (m/s)	Direction (°)
0	0.2 ±0.1	0.2	25 ± 1.0	0.2	-	0.1	0.1	-
1	2.0 ±0.2	0.8	07 ± 0.1	06	230	2.3	7	280
2	5.0 ±0.5	0.6	04 ± 0.1	18	255	4.5	20	270
3	12.5 ±1.5	0.4	03 ± 0.1	37	264	14	30	260
4	16.2 ±1.0	0.5	02 ± 0.1	05	260	17.5	6	265

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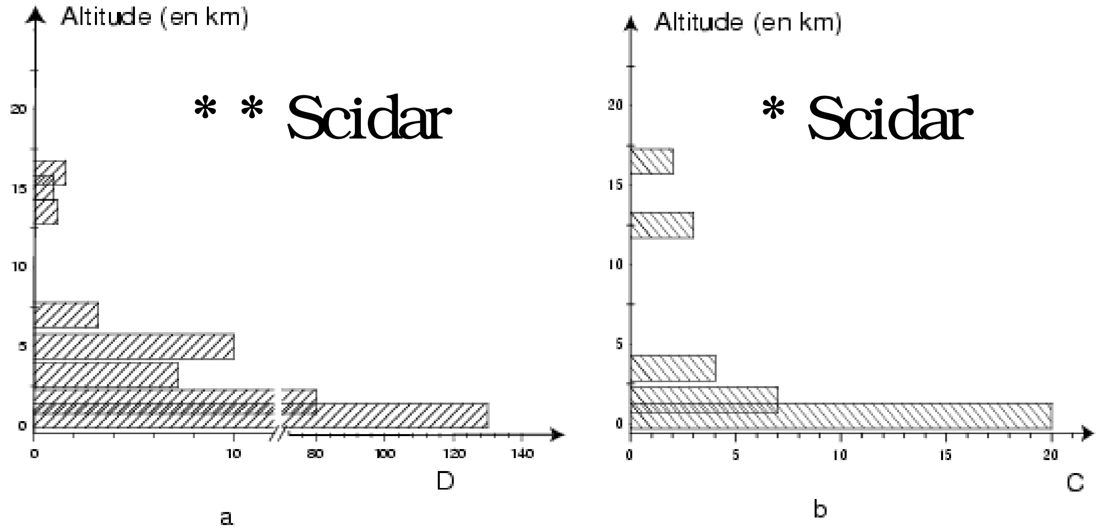
Single Star Scidar vs Generalized Scidar



Seeing** (21h09)=0.55”
Seeing** (22h54)=0.97”

Seeing* (21h20)=0.85”

Habib, Vernin, Benkhaldoun, Submitted to CRAS Paris

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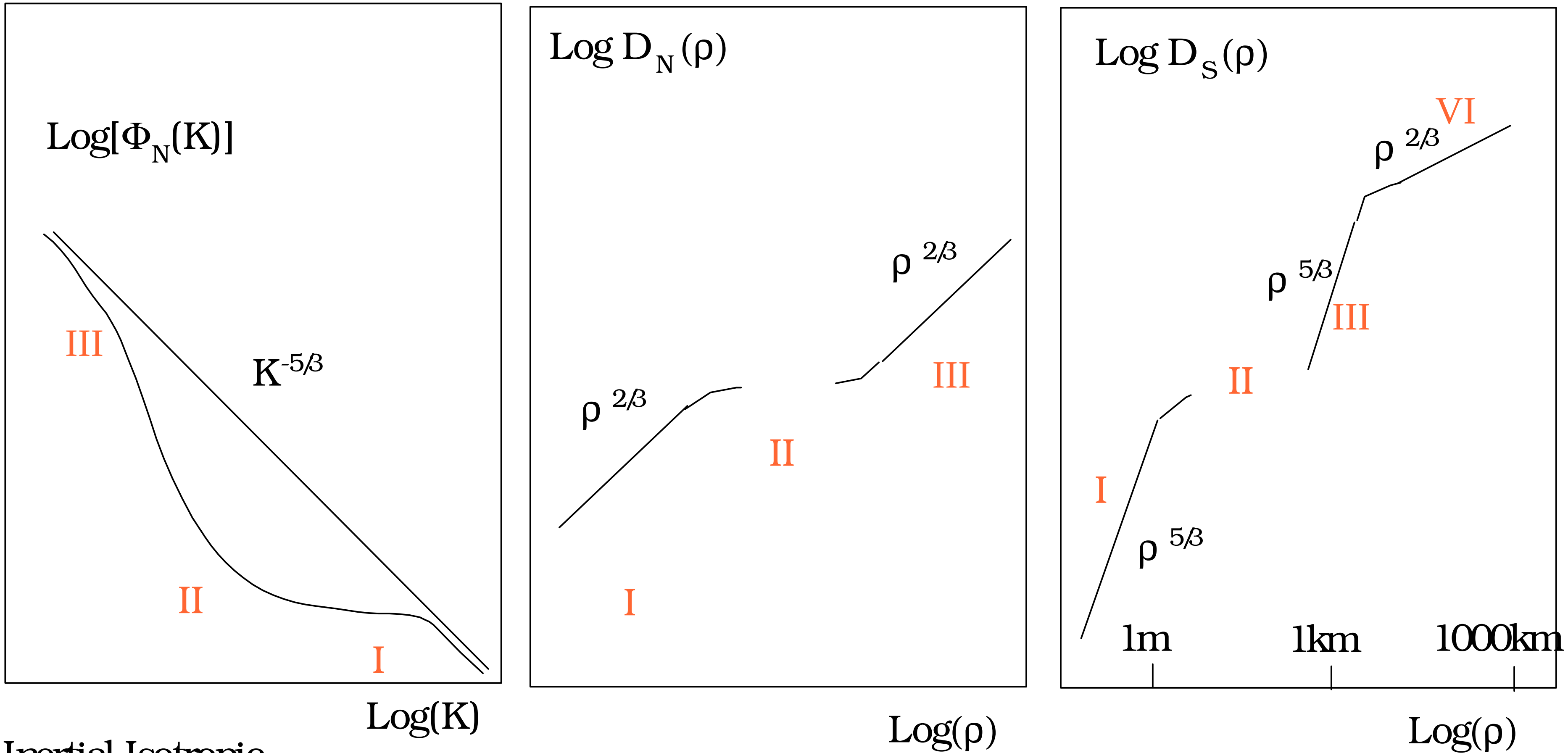
Phase Structure Function at various baselines

Coulman, Vernin, 1991, Appl. Opt., **30**, 118



I Inertial Isotropic

II Spectral Gap

III Anisotropic 2D turb.

Thin atmosphere
B < H

VI Thick atmosphere
B > H

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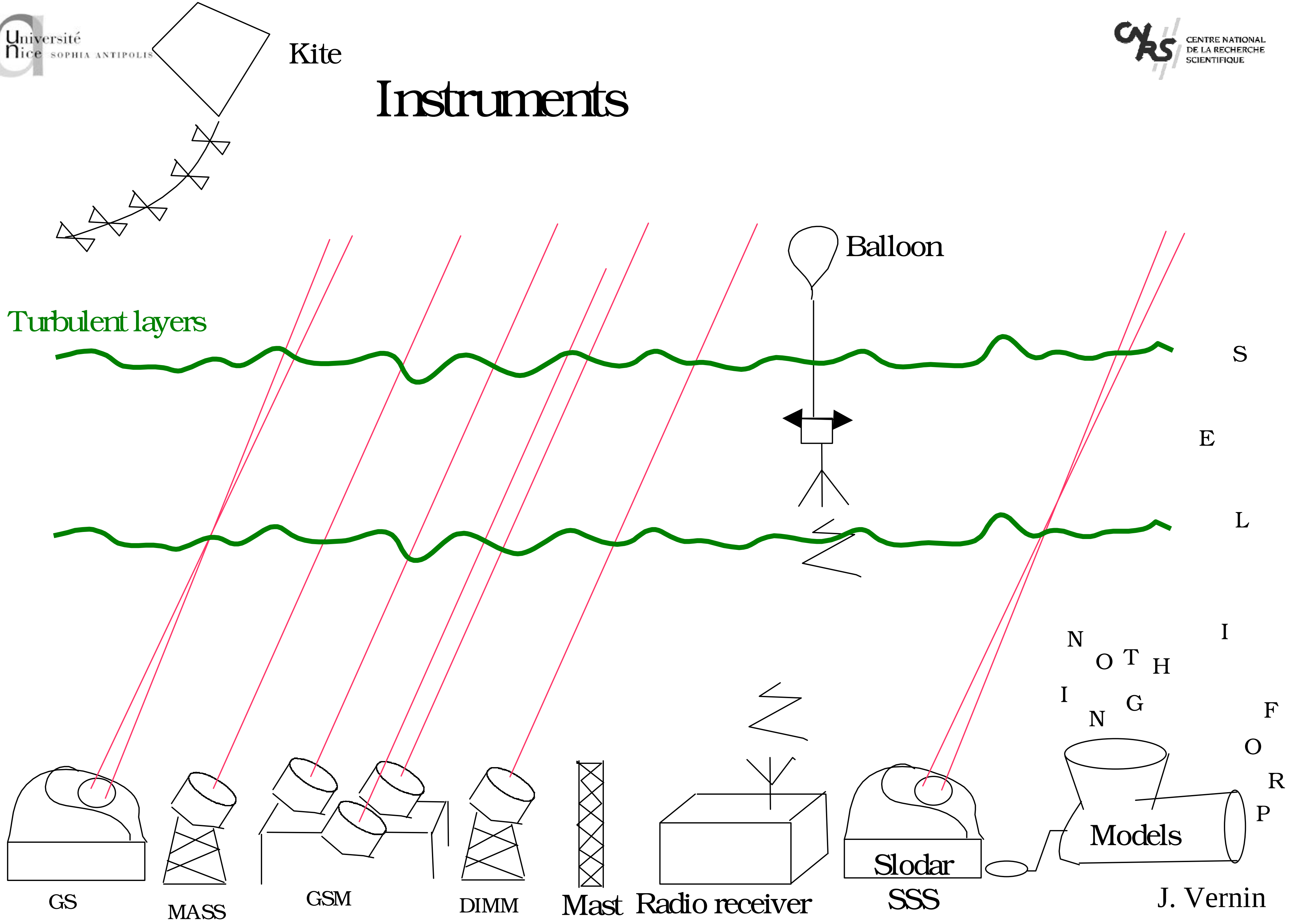
Instruments



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Which model for atmospheric turbulence?

- Verification of the atmospheric turbulence model
- Measurement of atmospheric parameters with the GI2T Interferometer

GSM Instrument

Université Nice Sophia Antipolis

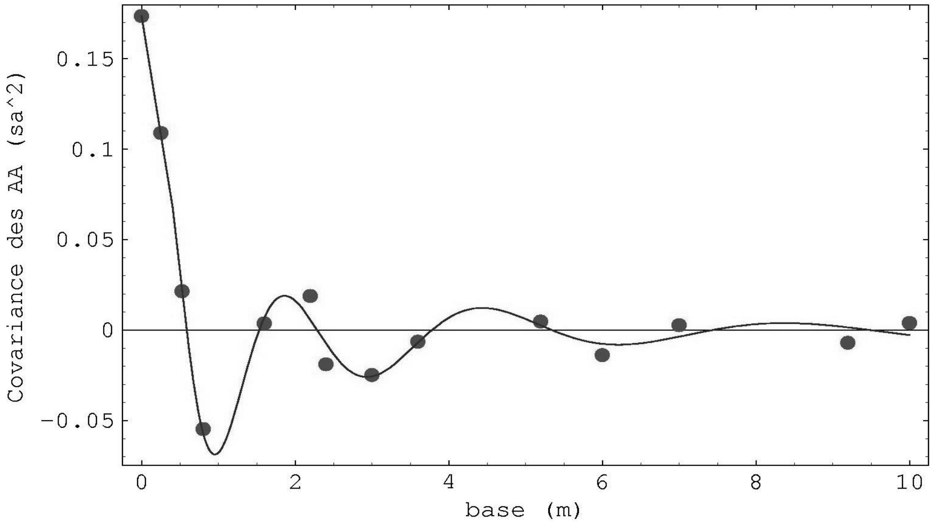
Jérome Maire LUAN

Verification of the atmospheric turbulence model

$$C_\alpha(x,0) = \frac{\lambda^2}{8\pi^2}\frac{\partial^2 D_\phi(x,0)}{(\partial x)^2}$$

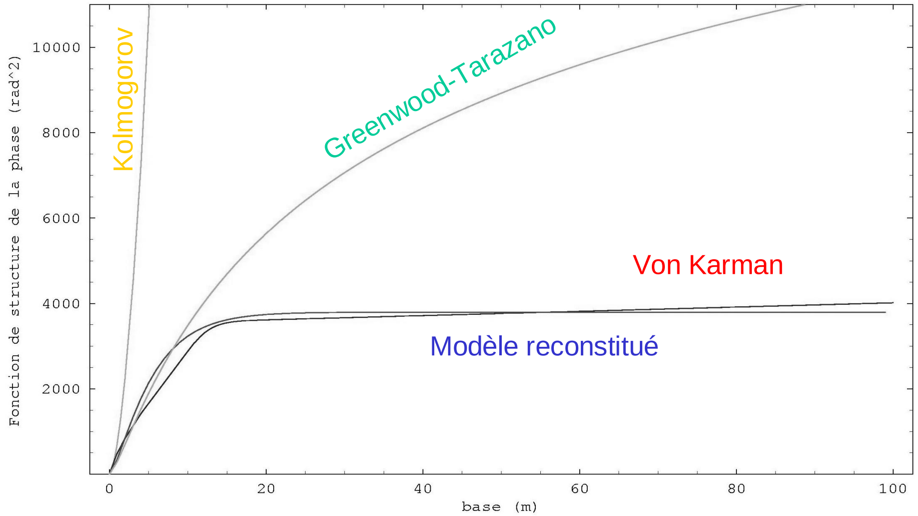
(F. Roddier, progress in Optics1981)

$$\Rightarrow \quad \mathbf{D}_\phi(x) = \frac{8\pi^2}{\lambda^2}\int\left[\int C_\alpha(x,0)dx\right]dx + Ax + B$$



AA longitudinal covariances measured with the GSM for differents baselines

L_0=25m r_0=6.4cm



Phase structure function reconstructed from GSM data with $\sigma_{OPD}=10\lambda$

Optical Path Difference in an interferometer

$$\sigma_{\mathrm{OPD}}(b) = \frac{\lambda}{2\pi}\sqrt{\left\langle \left|\varphi(\vec{r}) - \varphi(\vec{r} + b)\right|^2 \right\rangle} = \frac{\lambda}{2\pi}\sqrt{D_\varphi(b)}$$

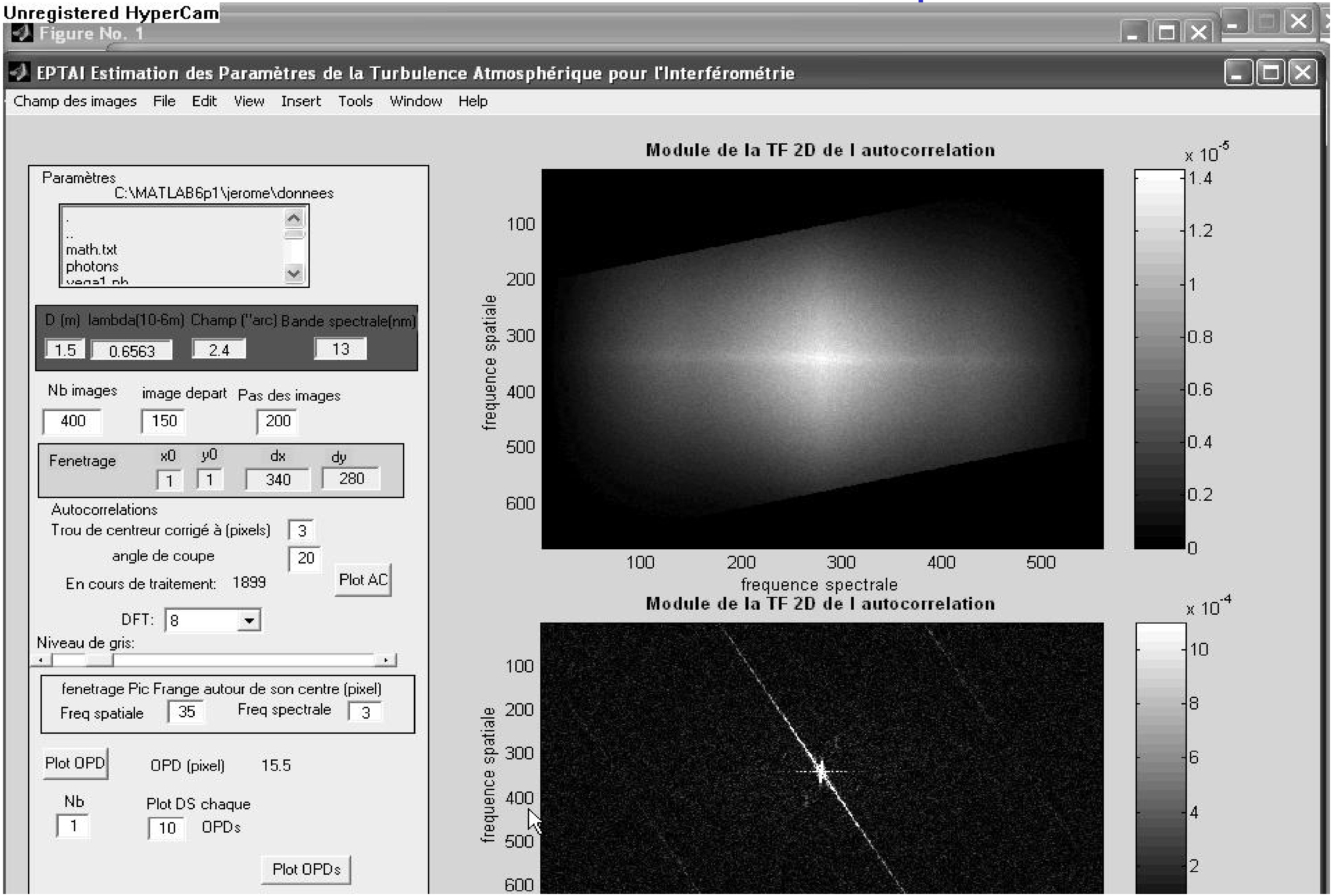
$$D_\varphi(b) = 4\pi \int f W_\varphi(f)\left[1 - J_0(2\pi f b)\right]\left[\frac{2J_1(\pi D f)}{\pi D f}\right]^2 df$$

- for the Von Karman model:

$$W_\varphi(f) = 0.0229\, r_0^{-5/3}\left(f^2 + \frac{1}{L_0^{\,2}}\right)^{-11/6}$$

R. Conan *Thèse de l'Université de Nice Sophia Antipolis* (2000)

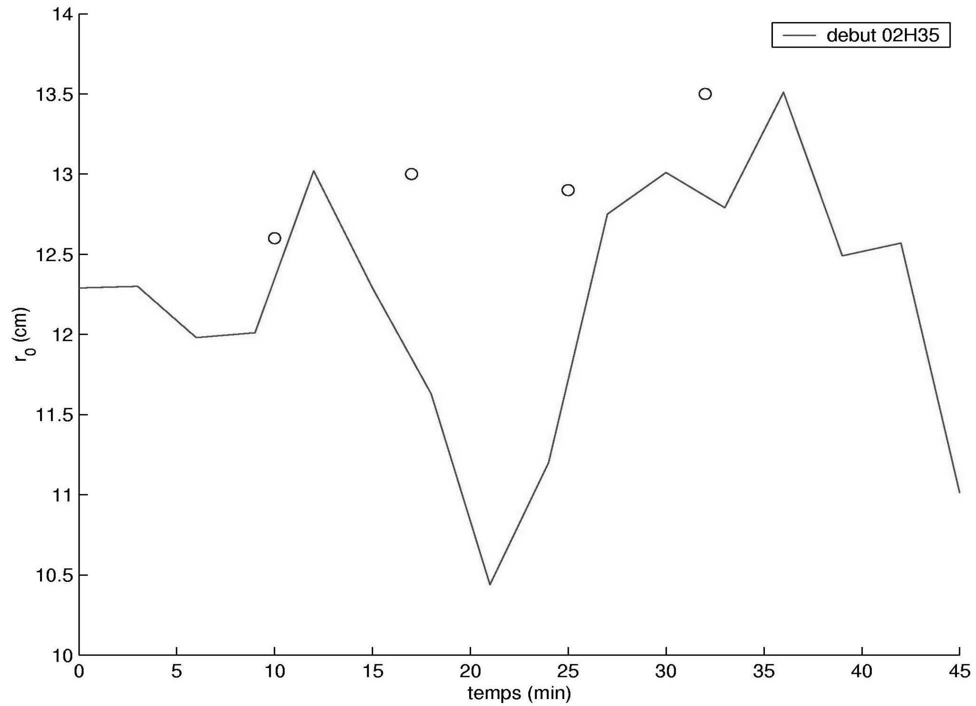
Estimation of the OPD & turbulence parameters with



Estimation of the turbulence parameters

GSM-GI2T observations and first results (06 June 2003)

Comparaison r_0 GSM et GI2T



Comparaison L_0 GSM et GI2T