UPC Remote Sensing Lab:

Teaching and Research in Remote Sensing

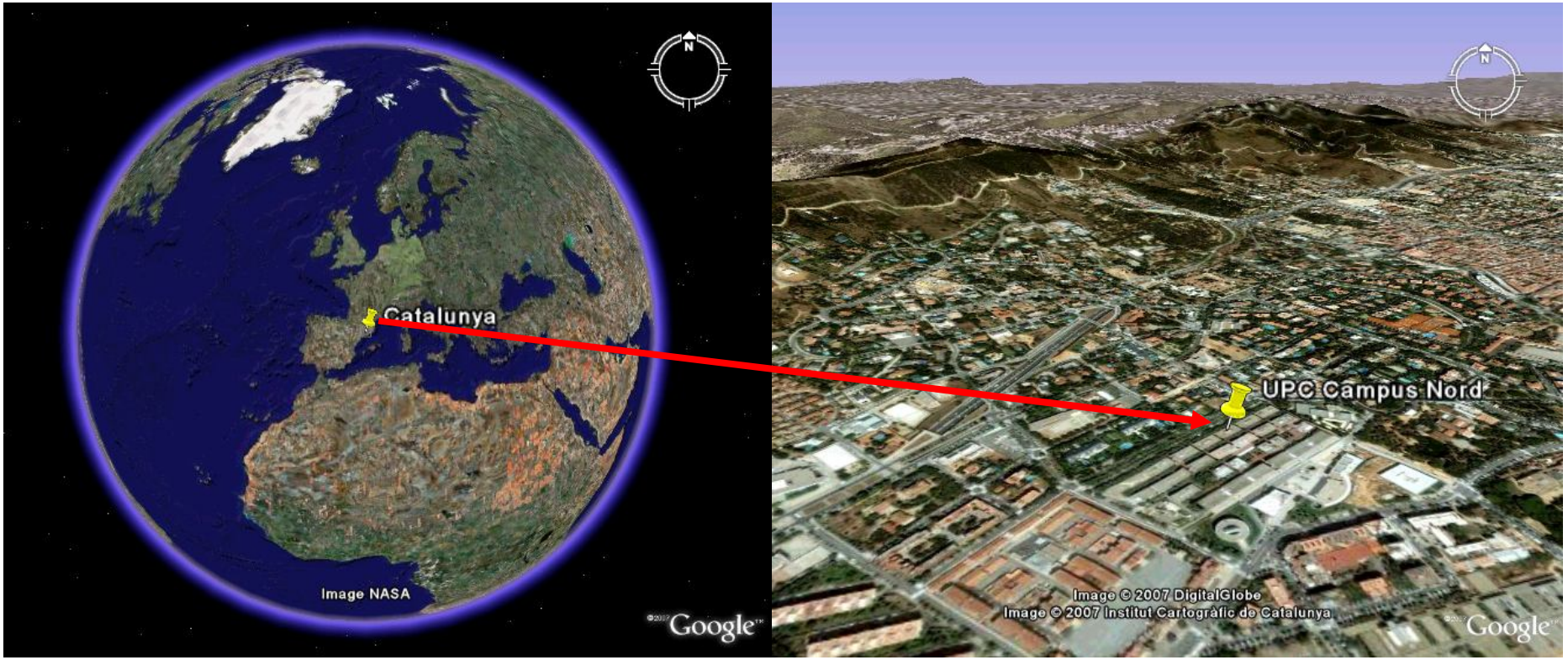
http://www.tsc.upc.edu/rs

Remote Sensing Lab Location

Within the Group of Engineering and Photonics Group (EEF),

Departament of Signal Theory and Communications (TSC),

Universitat Politècnica de Catalunya (Campus Nord, Barcelona)

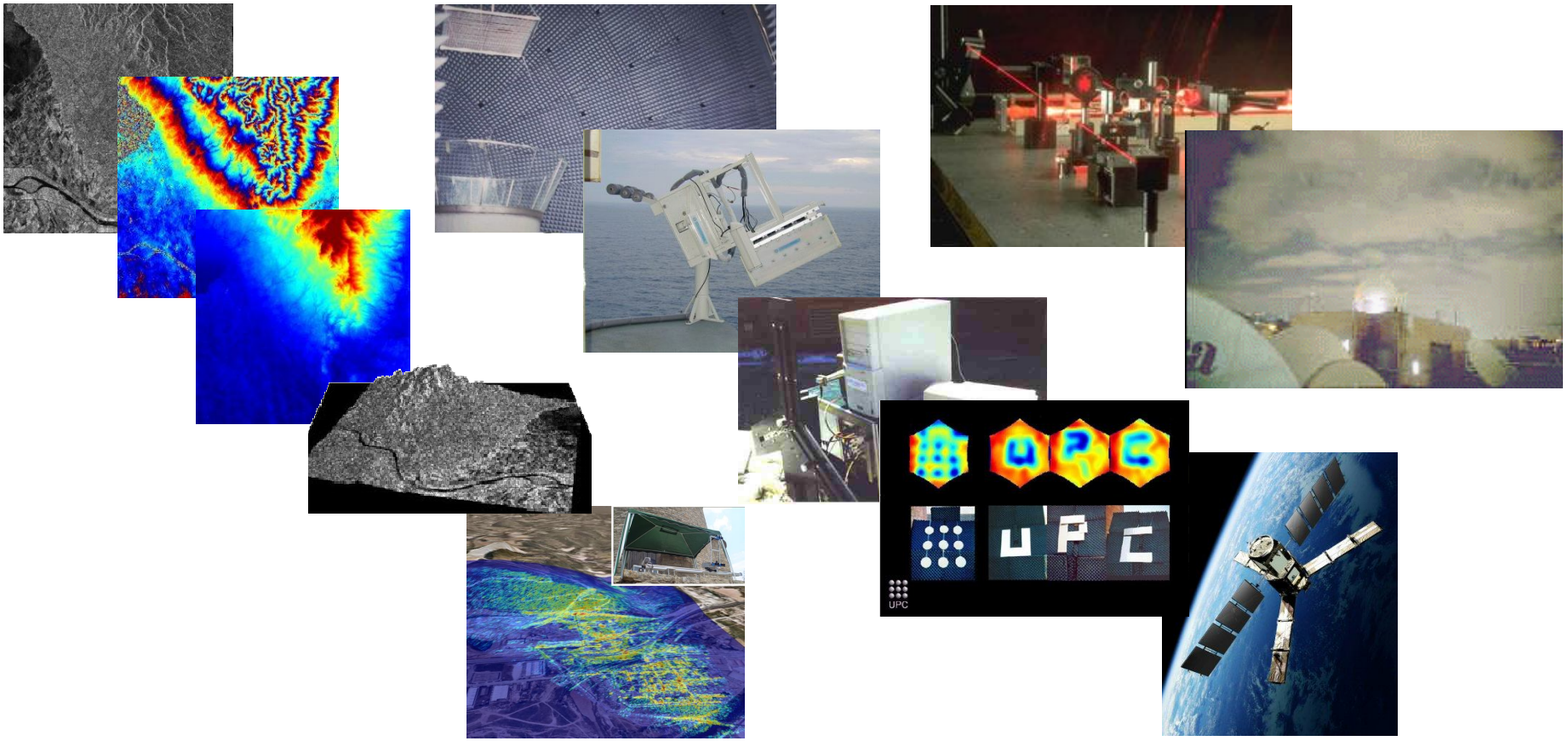


Remote Sensing Lab Activities

RADAR

RADIOMETRY

LIDAR

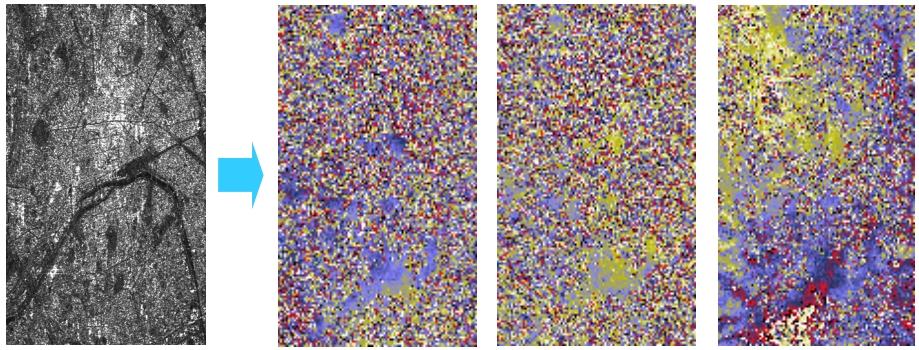


http://www.tsc.upc.edu/rs/

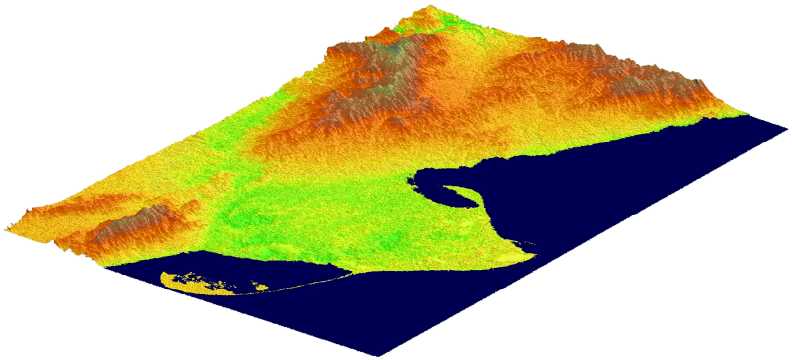
SYNTHETIC APERTURE RADAR (SAR)

Orbital Differential Interferometry

From SAR images to Differential Interferograms



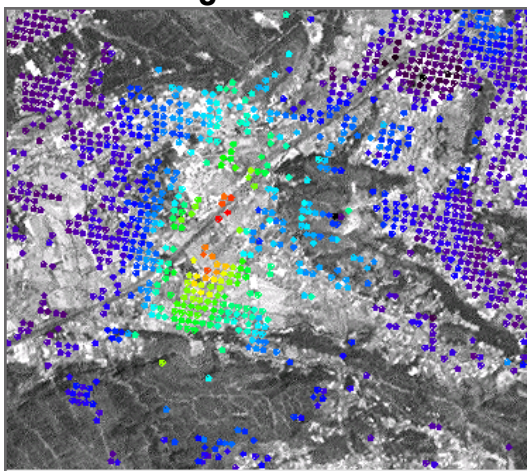
Classical Interferometry



Digital Elevation Models

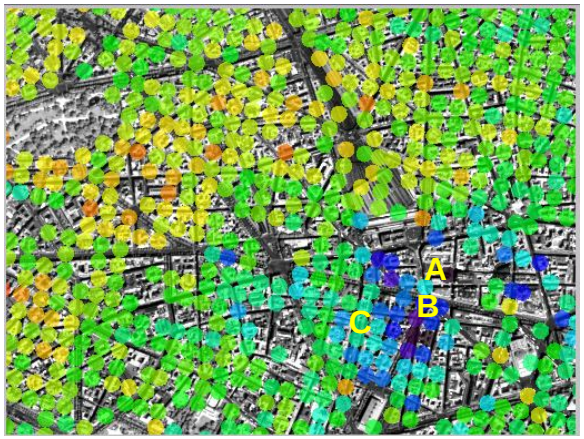
Multiple Images DInSAR (CPT) → Deformation Monitoring

Mining activities



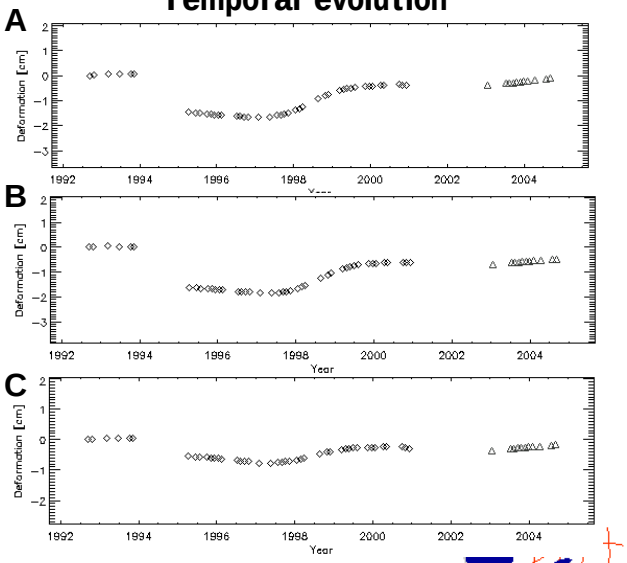
-2.1 0.3 cm/y

Urban works impact



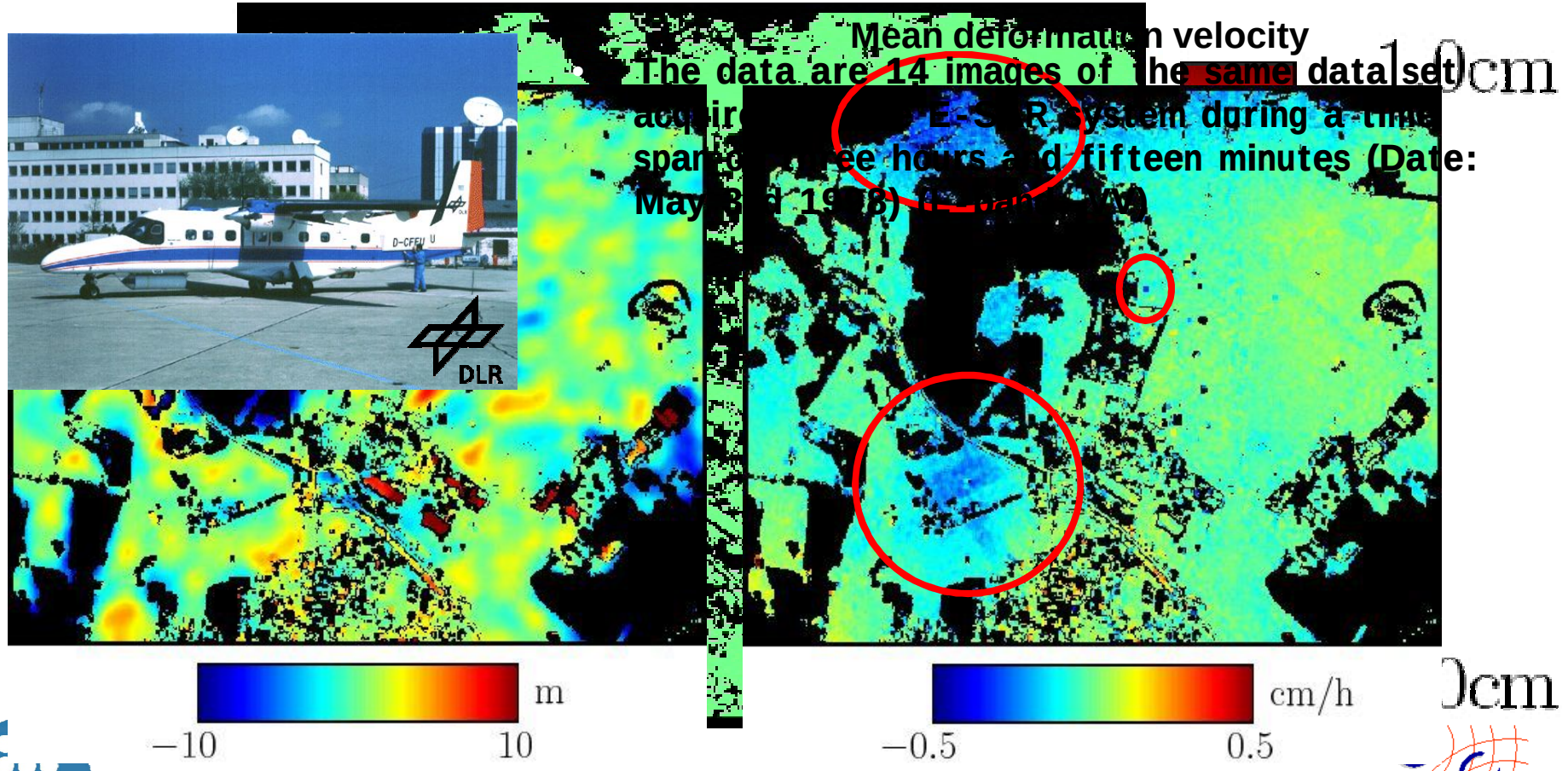
-1.6 0.6 cm/y

Temporal evolution



Airborne DInSAR Processing

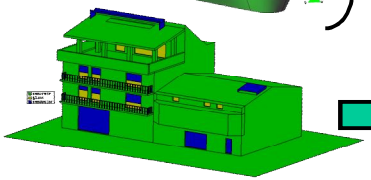
- **Advanced topography dependent motion compensation algorithms with estimation of the residual motion errors.**
- **DLR E-SAR data processed to obtain accurate DInSAR products: DEM error, deformation velocity and deformation time-series.**



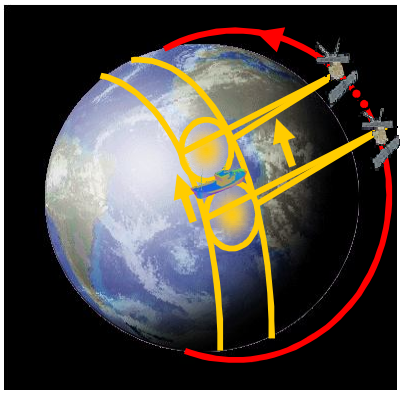
SAR Simulator of Complex Targets: GRECOSAR

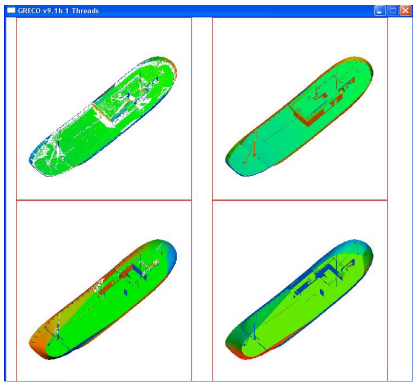
Accurate RCS estimation via high-frequency methods with sensor flexibility, target environment (ship dynamics and sea surface) and computer efficiency.

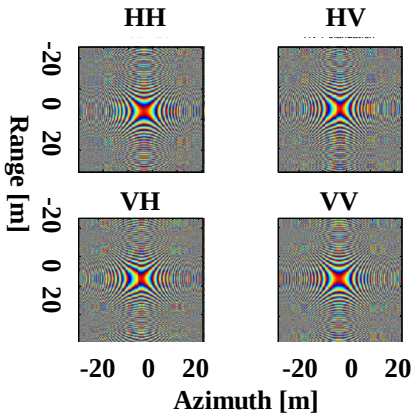
Target + environment



Step 0: Inputs

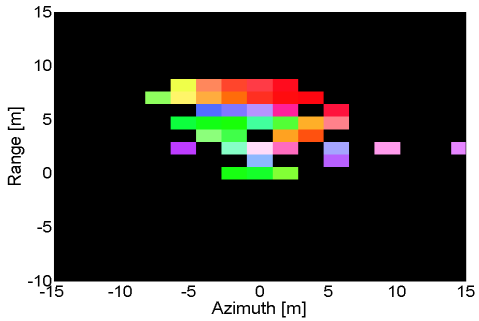




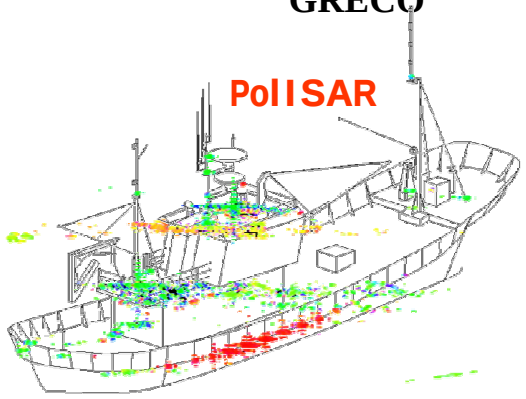


Step 1:Scenario definition → Step 2: EM solver GRECO → Step 3: Raw data & processing

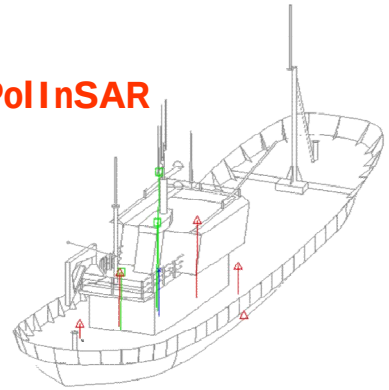
PolSAR



PolISAR



PolInSAR

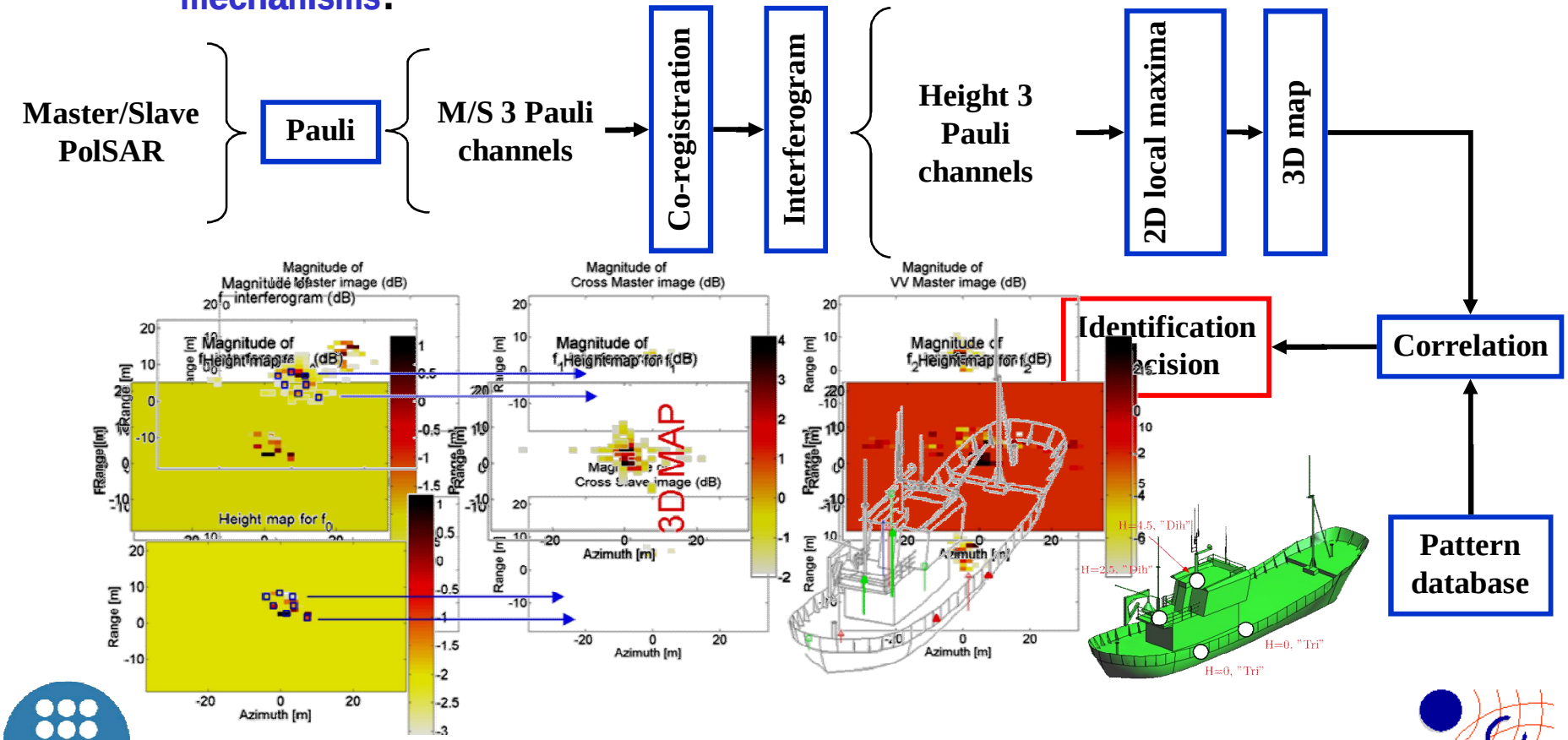


Step 4: Outputs

Vessel Identification Method: PolInSARm

3D Identification of hot spots with single-pass PolInSAR imagery.

- ➔ Each ship has a particular distribution allowing their discrimination.
- ➔ These hot spots correspond to strongly polarized trihedral and dihedral-like mechanisms.

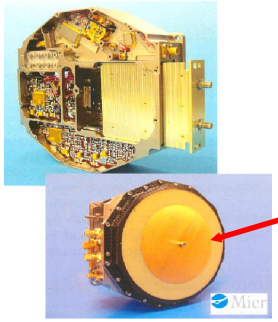


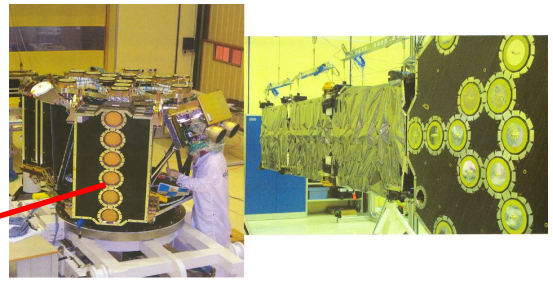
MICROWAVE RADIOMETRY

MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (i)

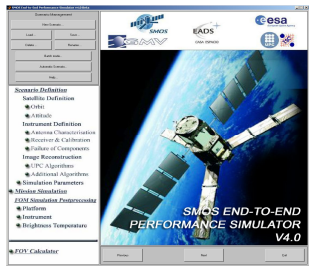
SMOS activities (1993-today)

1. **Instrument**: Analysis, performance, calibration, imaging...
   → Subsystem specificacions (EADS-CASA, MIER, YLINEN...)

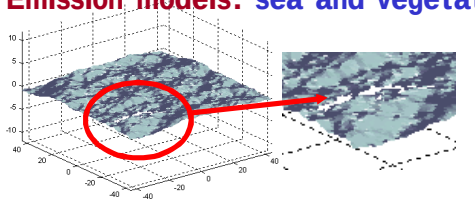




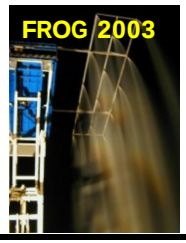
SEPS:
SMOS End-to-end Performance Simulator

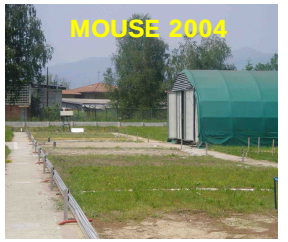


2. **Numerical Emission models**: sea and vegetation-covered land



3. **Field experiments**: sea and land emissivity





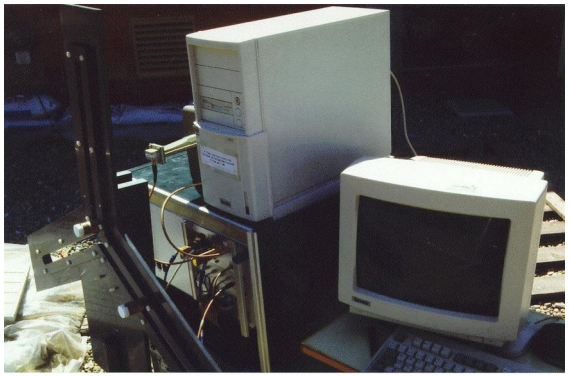
...

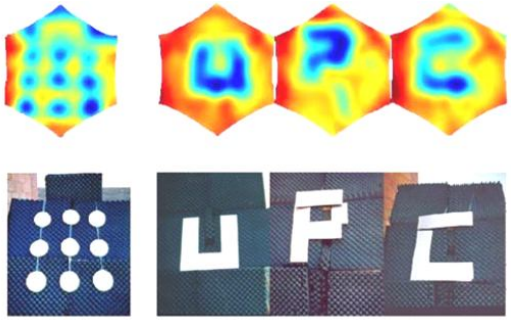
4. **Development of sea surface salinity and soil moisture retrieval algorithms from multi-angular radiometric measurements**

MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (ii)

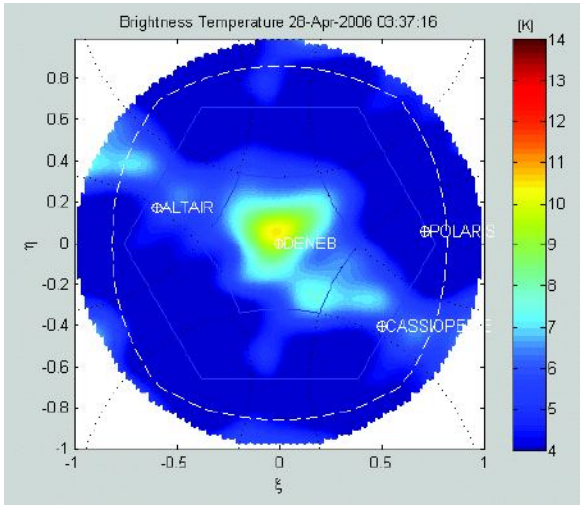
Field experiments for Instrument Concept validation

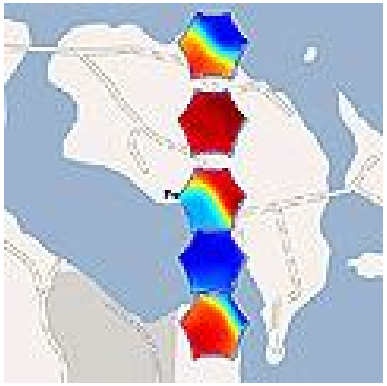
- *Early concept demostrations (1995)*





- *SMOSillo* data processing and 1st 2D images (2006)





MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (iii)

Field experiments for Ocean Salinity:

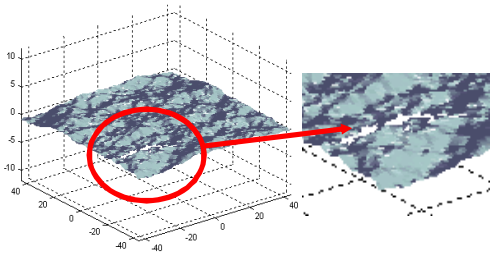
WISE 2000 & 2001 (6 institutions, 29 researchers)

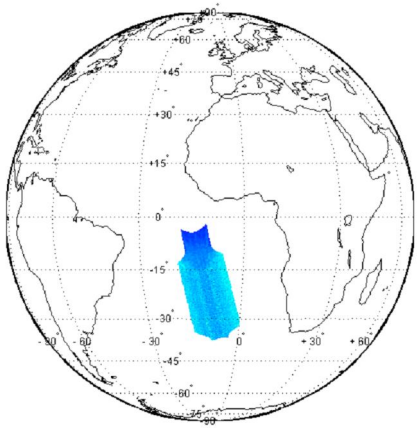
FROG 2003 (3 institutions)

Casablanca oil rig (Repsol)

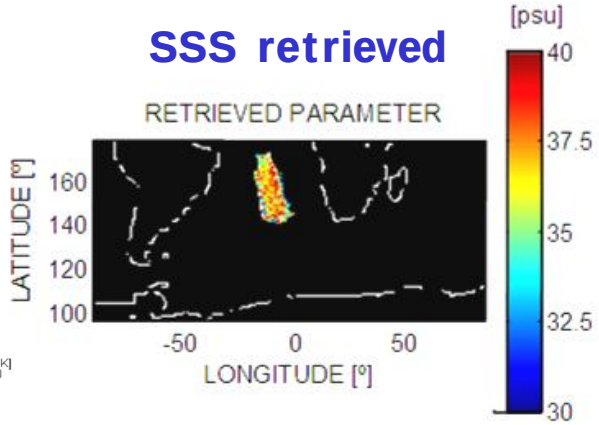
MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (iv)

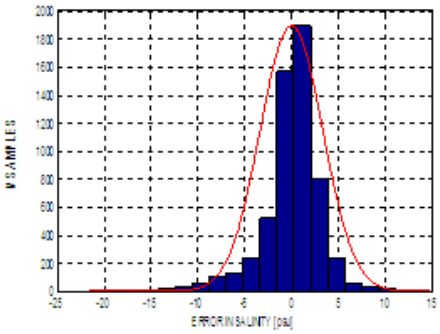
Sea emission modelling and sea surface salinity retrieval algorithms
(SEPS - L2 prototype processor to test SMOS Ocean Salinity retrieval algs.)



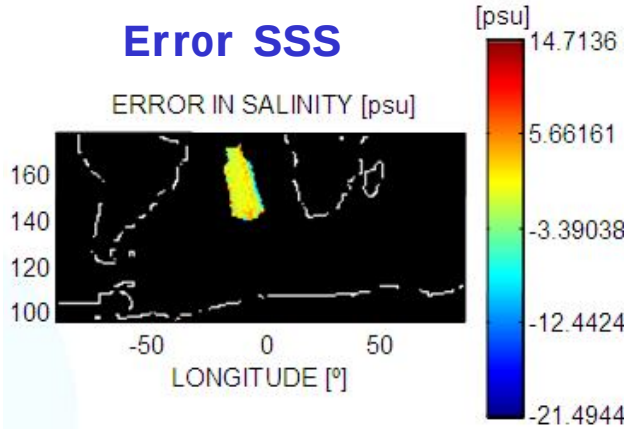


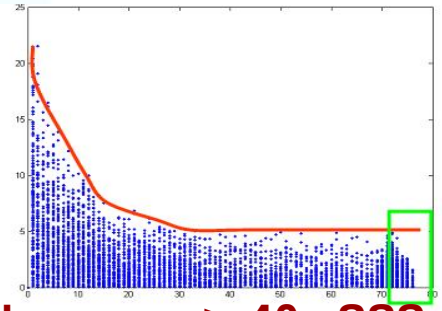
SSS retrieved





Error SSS





$N_{observations}$ > 40: SSS_{rec} OK

MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (v)

Field experiments for Soil Moisture:

SMOS REFLEX '03 & '06: Vineyard fields in SMOS CAL/VAL Valencia Anchor Station reference area

MOUSE '04:
Bare soil emissivity for different types of soils (JRC, Ispra, Italy).

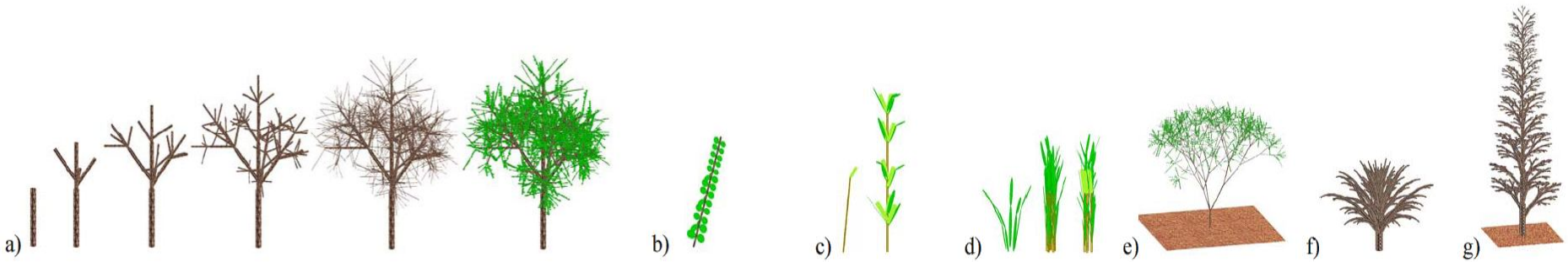
TuRTLE '06:
Topography effects (El Brull, Barcelona)

SMOS T-REX '04 & '06:
Analysis of soil roughness effects (Agramunt, Lleida)

MICROWAVE RADIOMETRY:
Participation in the SMOS/MIRAS project (1993-today): (vi)

Vegetation-covered land emission modelling and soil moisture retrieval algs.:

L-systems generation of canopies:



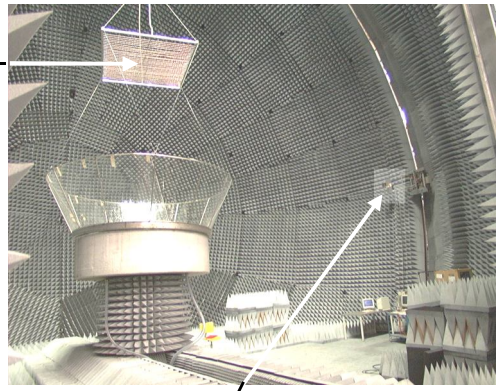
Radiative Transfer Equation solution and τ-ω model fit

$$\frac{d\bar{e}(\theta,\phi)}{ds} = -\bar{\bar{k}}_e(\theta,\phi)\ \bar{e}(\theta,\phi) + \bar{F}(\theta,\phi) + \int_0^{2\pi}\int_0^{\pi} \bar{\bar{P}}(\theta,\phi,\theta',\phi')\,\bar{e}(\theta',\phi')\,d\Omega' ,$$

$$e_{v,h} = \left(1+\frac{\Gamma_{v,h}^{soil}}{L_{v,h}^{canopy}}\right)\left(1-\frac{1}{L_{v,h}^{canopy}}\right)\left(1-\omega_{v,h}^{canopy}\right) + \frac{1-\Gamma_{v,h}^{soil}}{L_{v,h}^{canopy}}$$

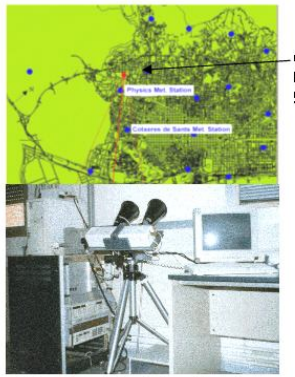
MICROWAVE RADIOMETRY: Other activities (i)

1. Interferometric radiometry for rain detection:



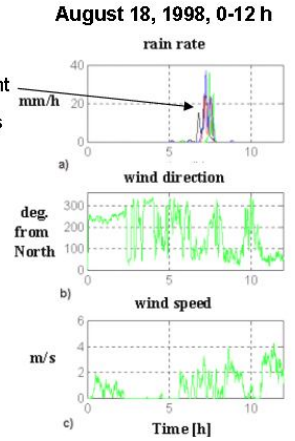
Short baseline formed by UPC X-band interferometric radiometer (JRC, Italy)

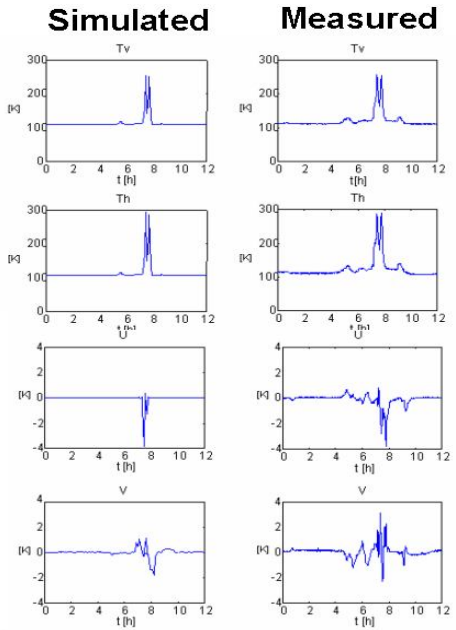
2. Polarimetric radiometry of the sea and rain events :



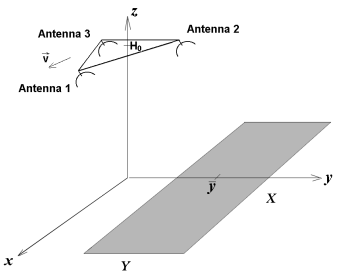
X-band polarimetric radiometer

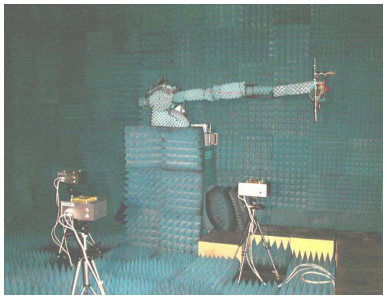
different rain gauges





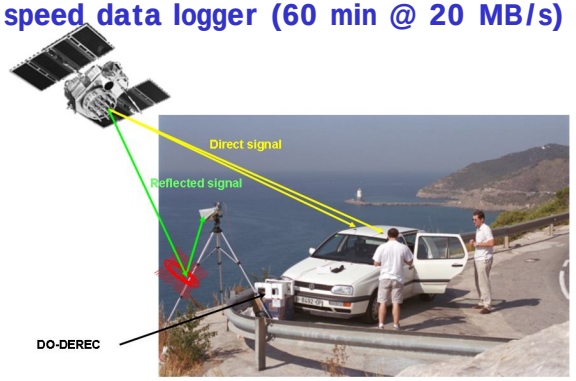
3. New synthetic aperture radiometer concepts (2000-2003):





4. Development of GNSS-R instruments to determine sea state (2003-present):

1st 3 channel GPS-R developed in 2001 for IEEC (Barcelona) with high speed data logger (60 min @ 20 MB/s)



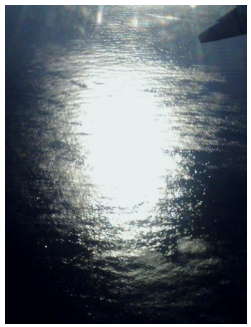
MICROWAVE RADIOMETRY:Other activities (ii)

5. PAU

- Imperfect understanding of T_B dependence with sea state: neither U_{10}, nor SWH
- Measurement of "sea roughness" at same scale than electromagnetic wavelength
- Possible solution: PAU = Passive Advanced Unit for ocean monitoring
  (proposal to ESF 2003, awarded with EURYI 2004)

PAU = Combination in a single instrument of 3 different sensors,
based on previous experience (SMOS, DODEREC...)

PAU-RAD: new type of radiometer ⇒ measure T_B
PAU-GNSS/R: GPS (L1) reflectometer ⇒ sea state
PAU-IR: IR radiometer ⇒ SST



As the Sun glint over the sea

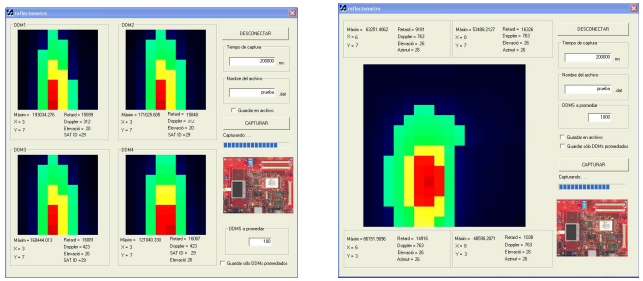
MICROWAVE RADIOMETRY: Other activities (iii)

PAU-one receiver (OR) and PAU-one receiver/airborne (ORA):

ground-based and airborne demonstrators of hybrid radiometer-reflectometer

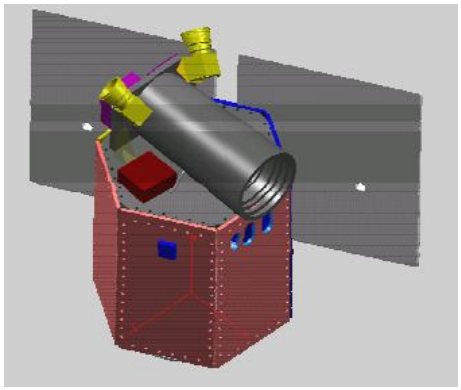
PAU-One Receiver

PAU-One Receiver/Airborne



Real-time generation (1 ms) of DDMs for 4 satellites, or a larger DDM for 1

PAU in SeoSAT proposal: phase A study finished

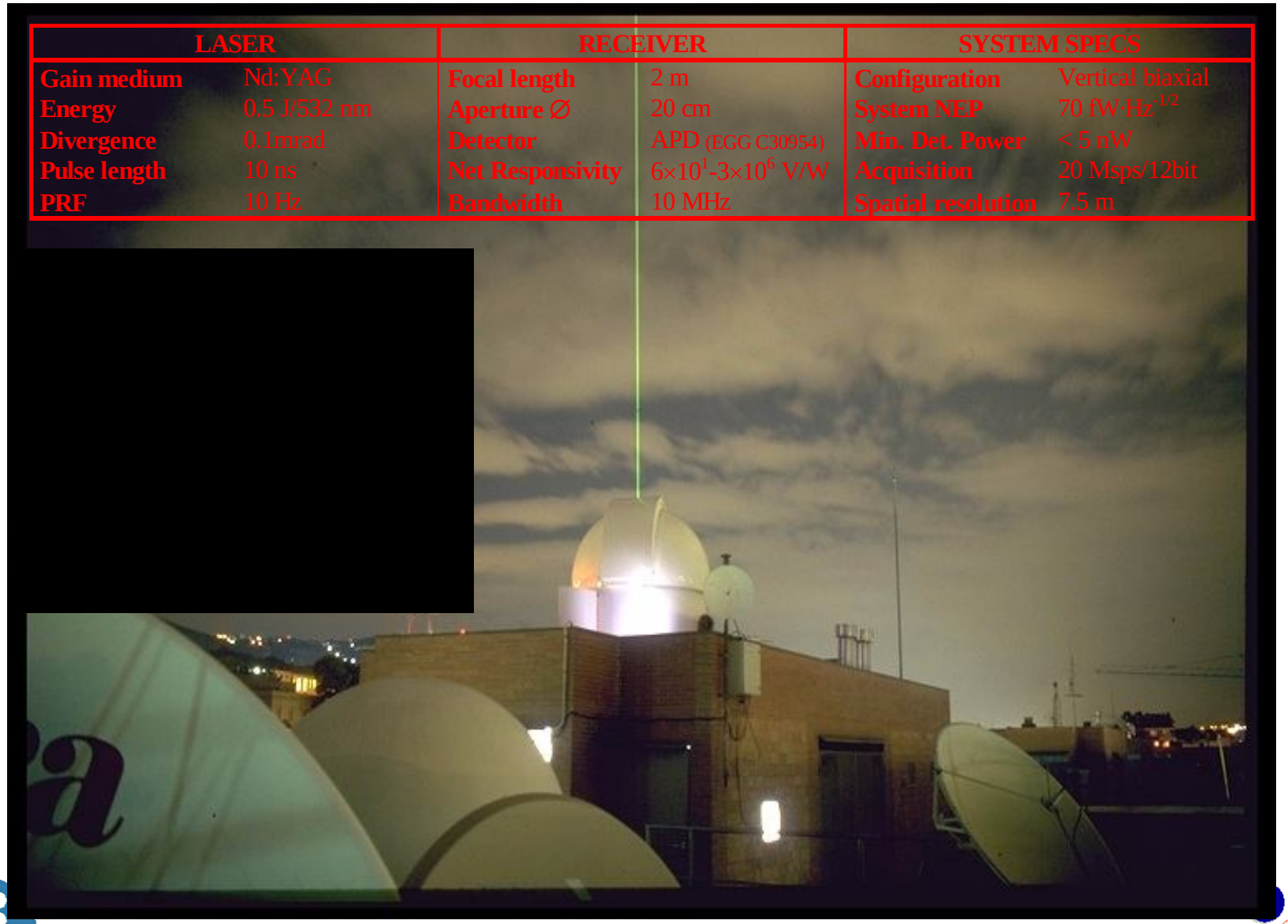


SeoSAT (Spanish Earth Observation Satellite)
Call for ideas for SSI October 2006.

LIDAR

(1+0 ELASTIC) BACKSCATTER LIDAR STATION

LASER		RECEIVER		SYSTEM SPECS	
Gain medium	Nd:YAG	Focal length	2 m	Configuration	Vertical biaxial
Energy	0.5 J/532 nm	Aperture ∅	20 cm	System NEP	70 fW·Hz$^{-1/2}$
Divergence	0.1mrad	Detector	APD (EGG C30954)	Min. Det. Power	< 5 nW
Pulse length	10 ns	Net Responsivity	6×10^{1}–3×10^{6} V/W	Acquisition	20 Msps/12bit
PRF	10 Hz	Bandwidth	10 MHz	Spatial resolution	7.5 m



3-D SCANNING (2+1) ELASTIC/RAMAN LIDAR

Fig. 1

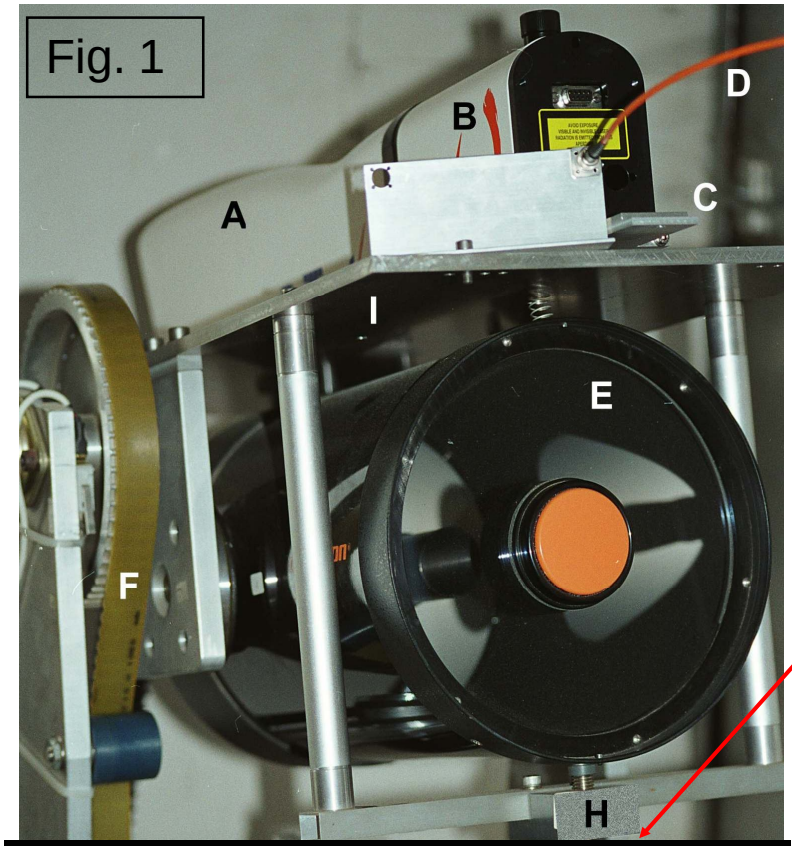
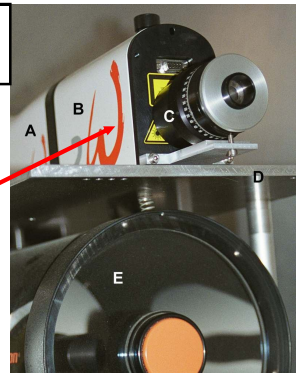


Fig. 2

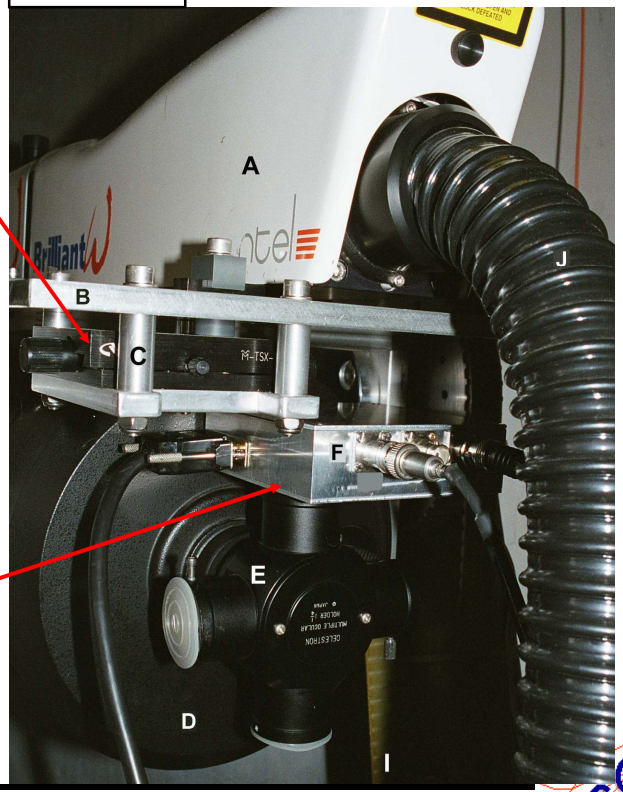


Nd:YAG Freq. Doubler

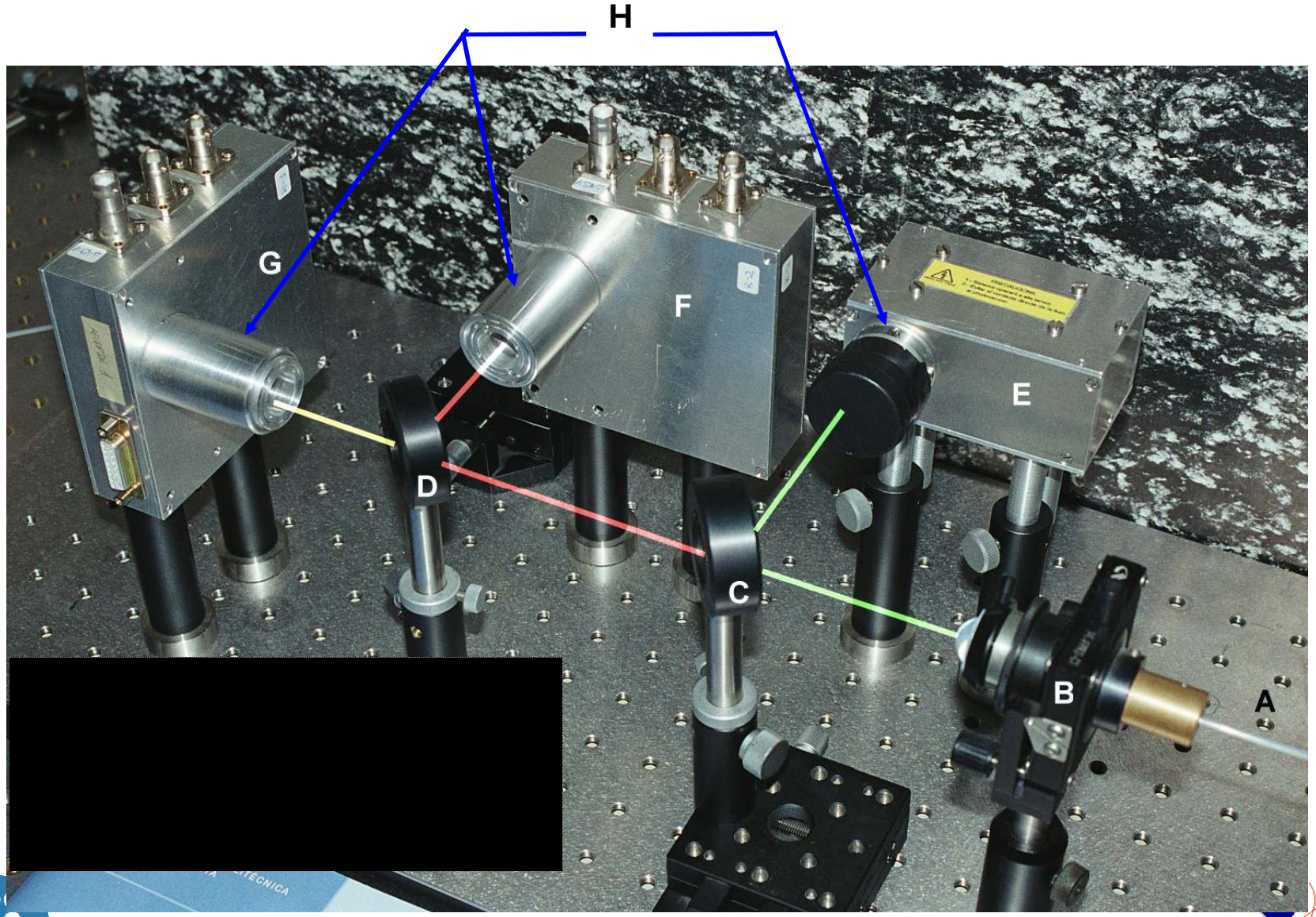
Fig. 3

Alignment

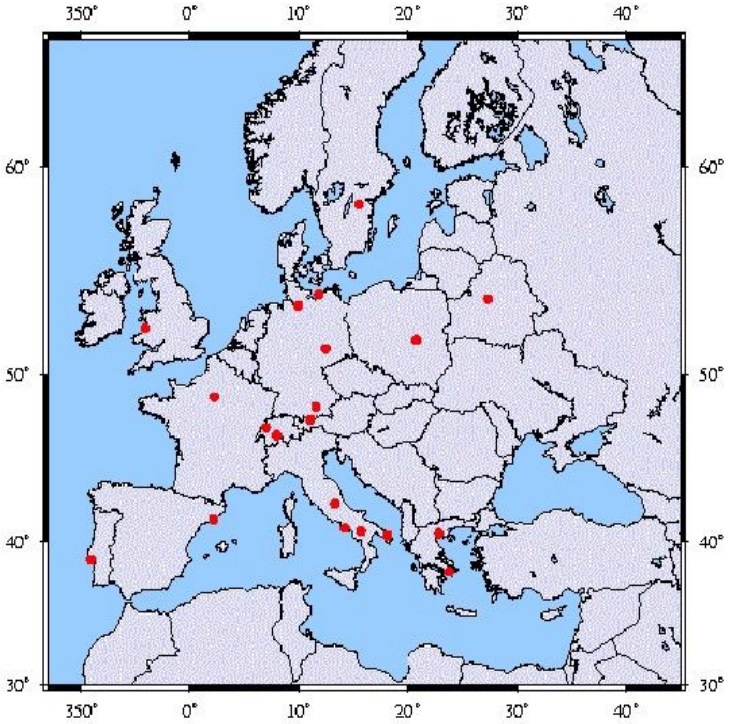
O/E receiver



3-D SCANNING (2+1) ELASTIC-RAMAN LIDAR



LIDAR NETWORKS (I): EARLINET

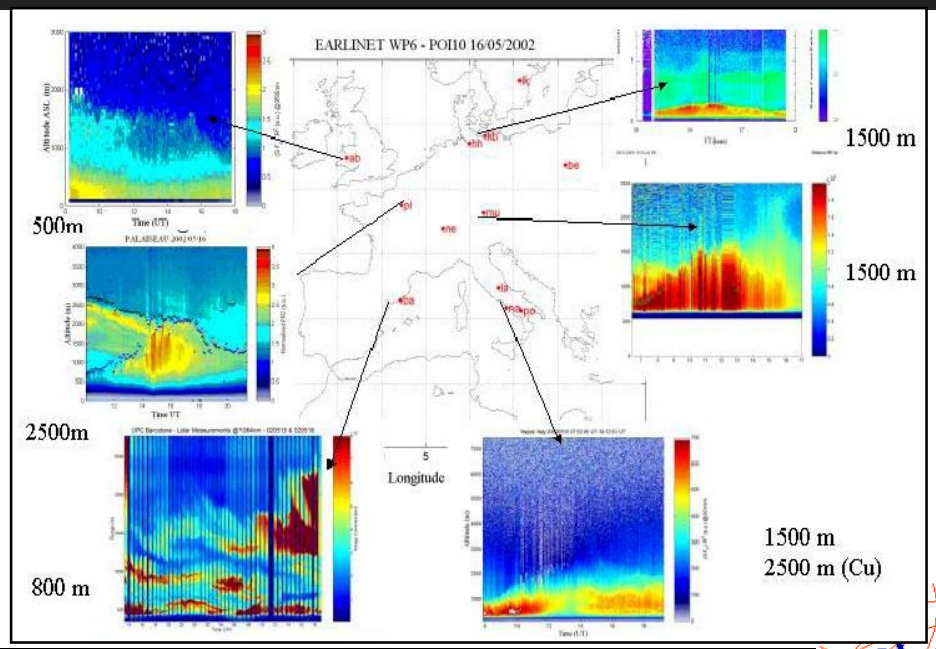


European lidar network intercomparison (Palaiseau, 2002).
Regular/alert measurements (FP5-EARLINET, 2000-today)

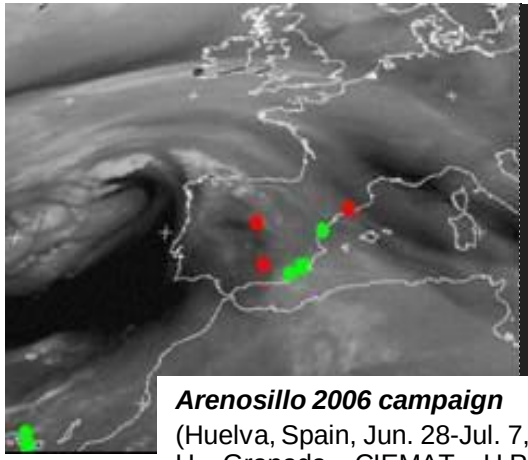
(2000-now) EARLINET (European AeRosol LIdar NETwork)
Supported by FP5&FP6 EU-projects (EARLINET, and Coord. Action EARLINET-ASOS)+national funding initiatives. *RSLAB (main contractor)*

Achievements:

1) Terrestrial lidar network joining over 21 lidar stations
2) Distributed database of the horizontal, vertical, and temporal distribution of aerosols on a continental scale
3) Co-ordinated measurements:
   - 3.1 On a regular basis (3 per week),
   - 3.2 Alerts (e.g. Saharan dust intrusions, fires, ...),
   - 3.3 (2006-today) Coincident with CALIPSO satellite (NASA-CNES) overpasses
4) Quality protocol: Instrument & algorithm level



LIDAR NETWORKS (II): SPANISH LIDAR NETWORK

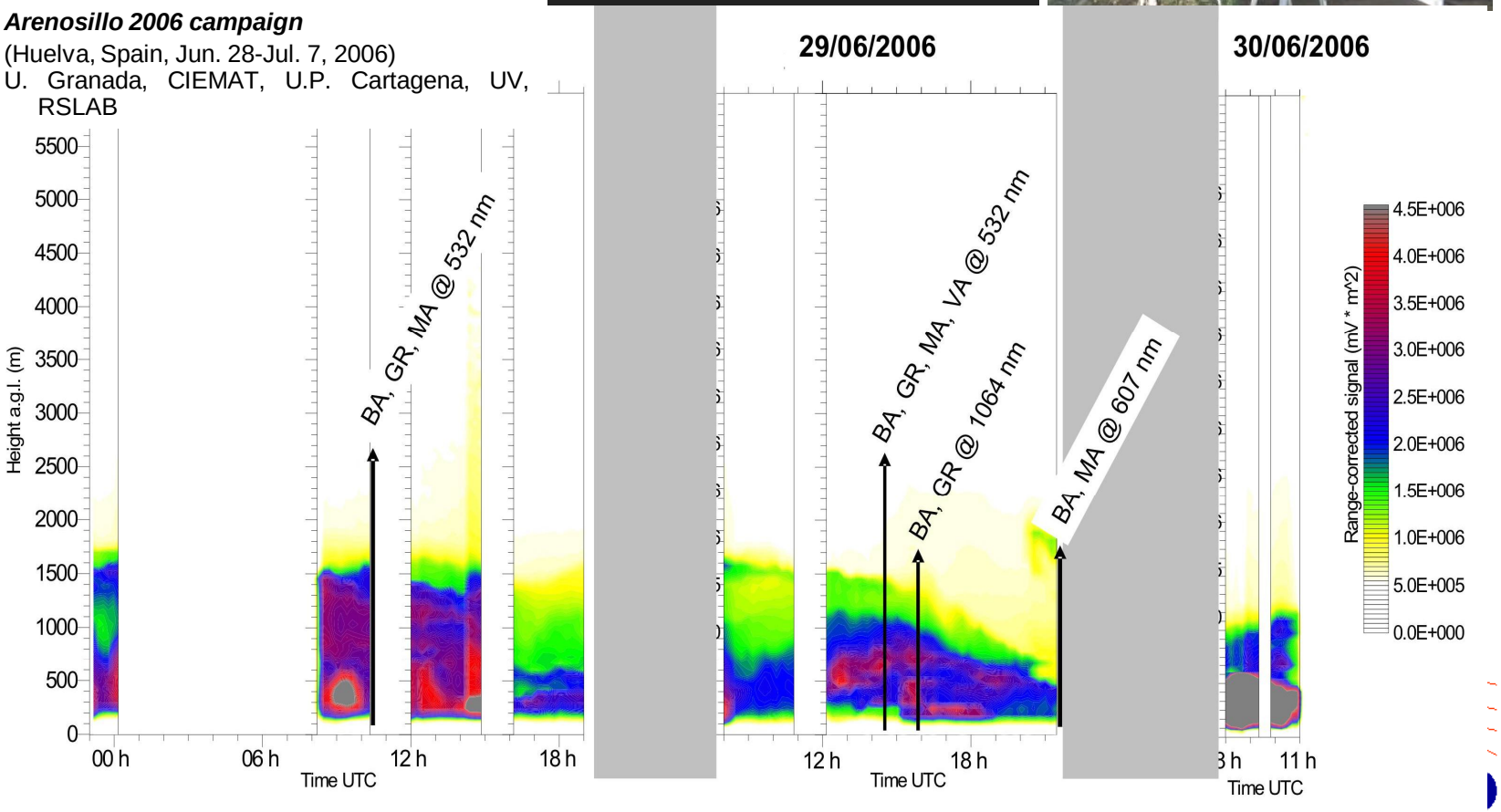


(2006-now) Spanish Lidar Network
RSLAB (coord.), U. Granada, CIEMAT, U.P. Cartagena, U. Valencia, U. Laguna, INTA, U. Murcia

Goals:

1) Extend EARLINET actions
   QA: Instruments & algorithms
   With ground and column in-situ sensors
2) Promote the Spanish terrestrial network
3) Spatial coverage aerosol meas. on Spain

Arenosillo 2006 campaign
(Huelva, Spain, Jun. 28-Jul. 7, 2006)
U. Granada, CIEMAT, U.P. Cartagena, UV, RSLAB



LIDAR SIGNAL PROCESSING

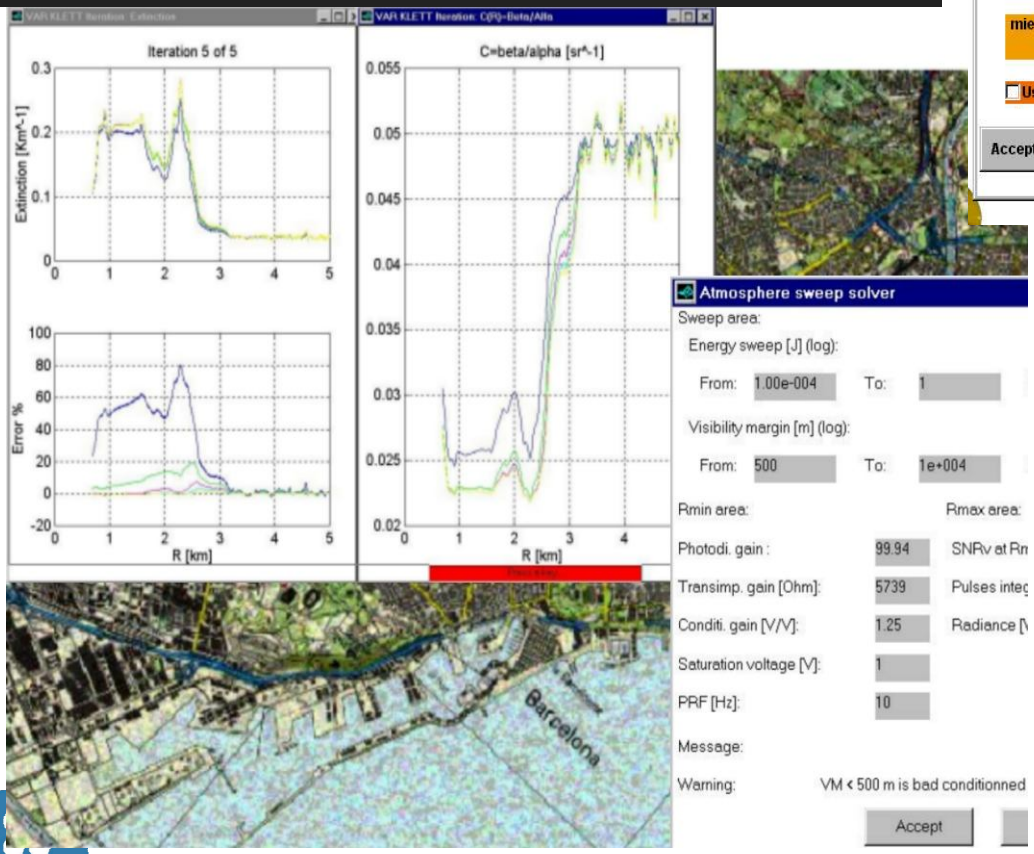
(1993-2000) LINK-LIDAR end-to-end simulator

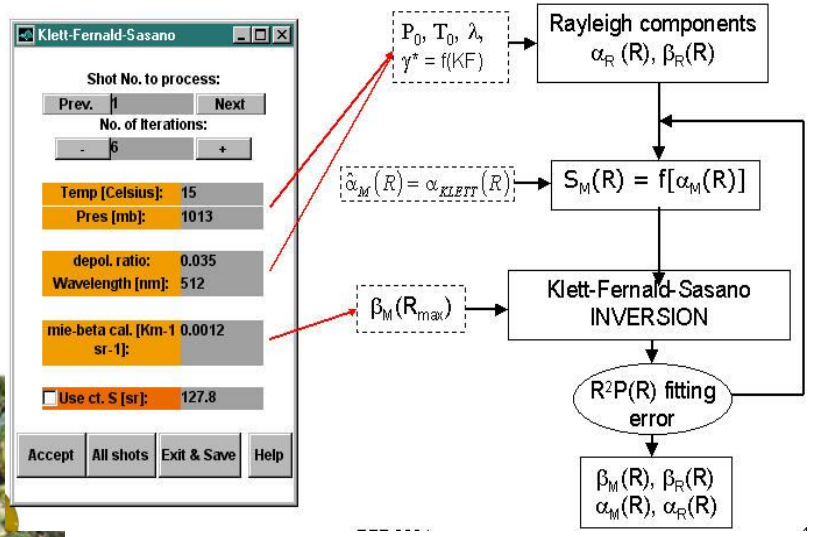
Achievements (i):

1) Link-atmos: Optical scattering + propagation models

2) Link-budget: End-to-end elastic/Raman link budget (system range, SNR, NEP assessment,...), O/E receiving chain performance simulation

3) Link-detect: Signal pre-processing and elastic inversion





(1993-2000) Elastic/Raman lidar inversion
(atmospheric aerosol extinction and backscatter inversion)

Achievements (ii):

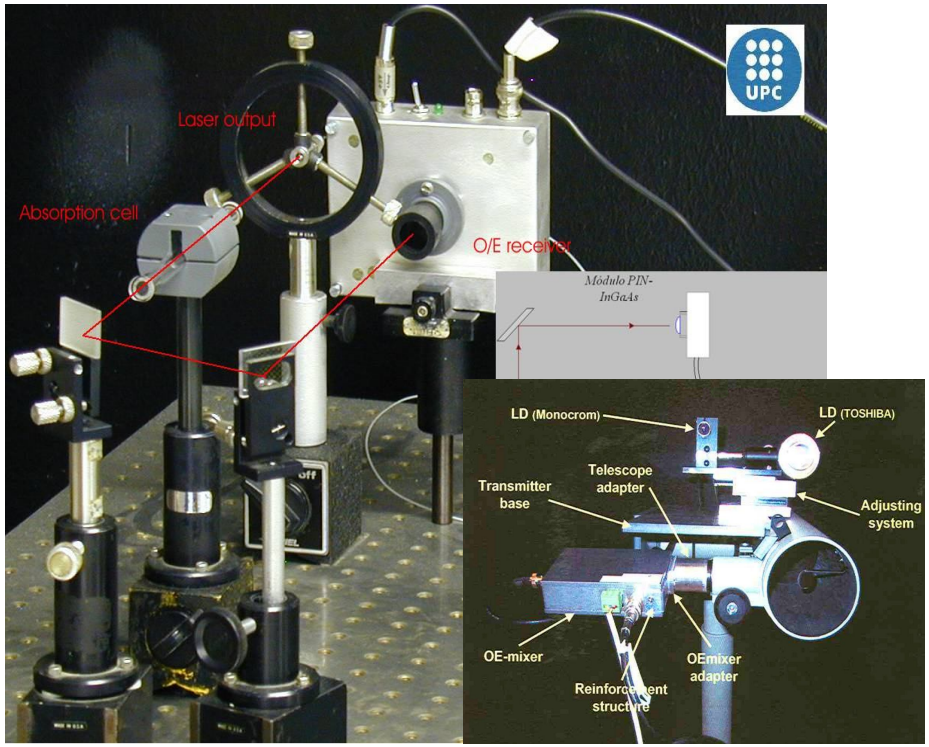
1) Link-detect: Full platform for signal pre-processing and inversion (elastic + Raman algorithms)

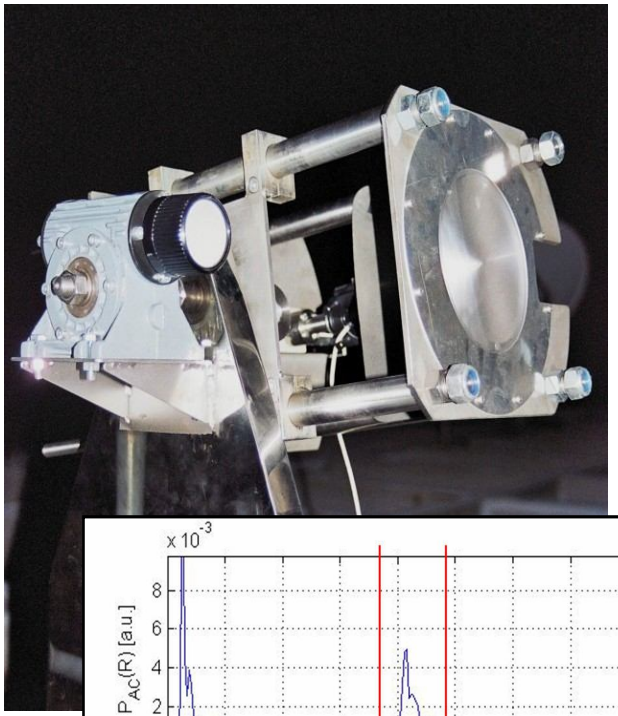
2) Assessment of lidar inversion errors, e.g. [Collis, 1996] & [Klett, 1985] methods

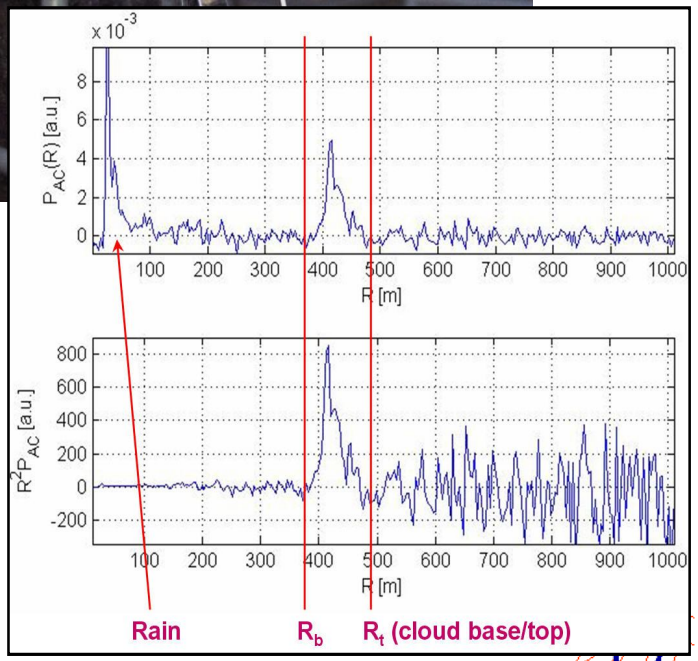
3) Adaptive solutions (EKF) of lidar Eq.

4) Raman lidar algor: Statistical errorbars

GAS DETECTION AND CEILOMETER PROTOTYPES







(2002-today) Gas-detection experiments

1) CC (column content) CO_2 test set-up experiments using TDLAS (Tunable Diode Laser Absorption Spectroscopy) and WMS techniques
2) Range-resolved CW-LFM ladar (range finder)

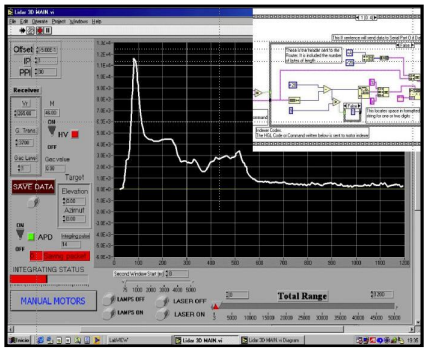
(2005-today) Low-cost ceilometer
(Dena Desarrollos S.L. - RSLAB)

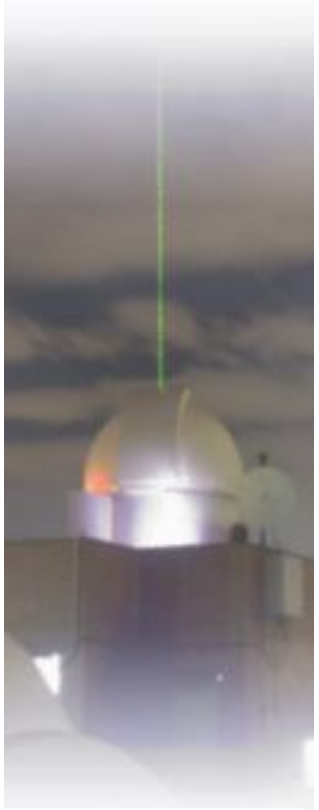
Low-energy (2 μJ), 5-kHz PRF, 905-nm wavelength prototype

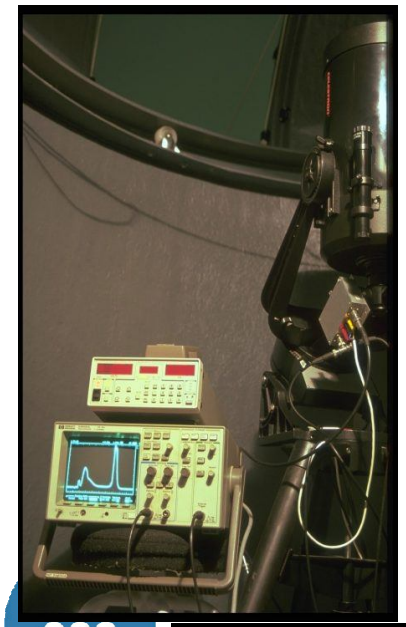
LIDAR SUMMARY

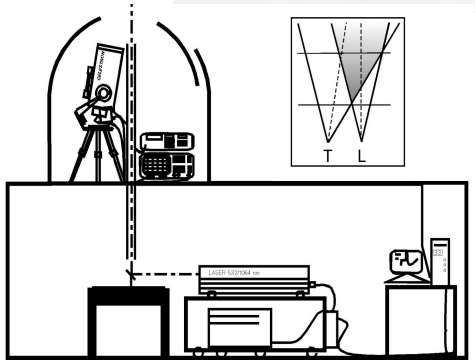
Vertical-sensing backscatter **LIDAR Station** (1 VIS channel, 1993-1996): Pollution/aerosol monitoring

➔ Systems and control soft.







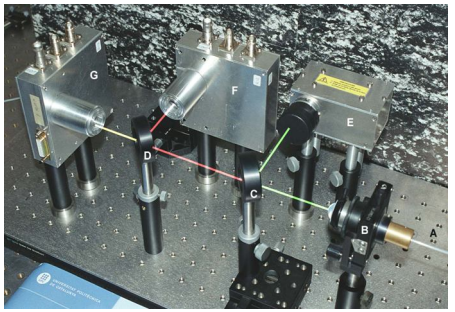


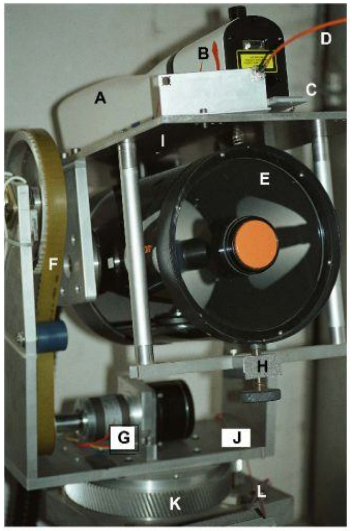
3-D scanning multi-spectral LIDAR Phases:

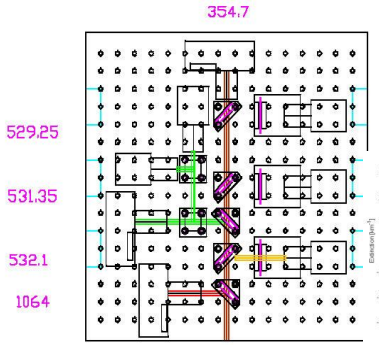
1) UV-VIS-NIR Elastic channels (1997-2003): Pollution/aerosols

2) Raman: N_2, water vapor (2003-9)

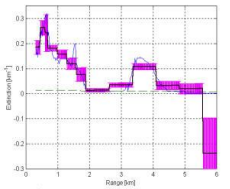
3) Temperature (2009-...)

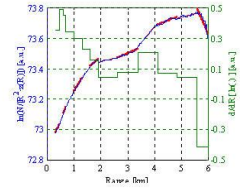






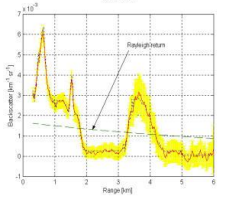
Polychromator and O/E receiver design

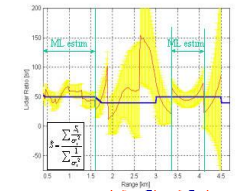




Development of new inversion algorithms

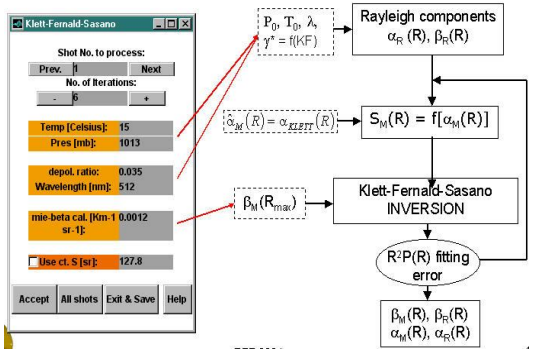
Atmospheric extinction and backscatter





LIDAR SUMMARY

Measurement campaigns (National & Internatl.) Air quality (1997-today): Aerosol/Pollution load and PBL

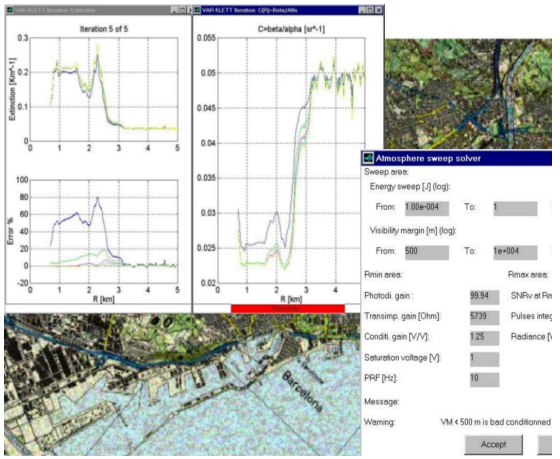


State-of-the-art **lidar signal processing:**

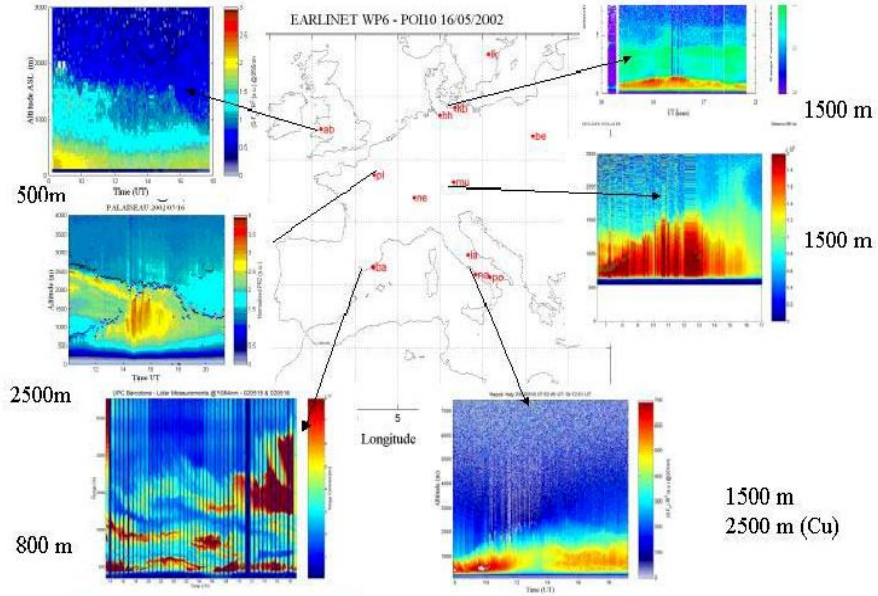
1) End-to-end simulators

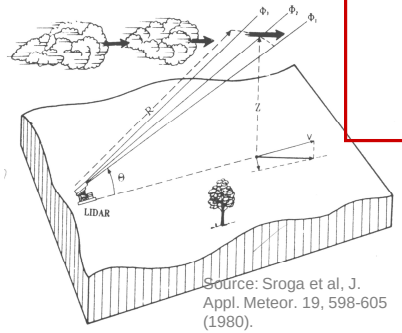
2) Adaptive estimation

3) Errorbars and statistical modelling



European lidar network intercomparison (Palaiseau, 2002). Regular/alert measurements (FP5-EARLINET, 2000-today)





Source: Sroga et al, J. Appl. Meteor. 19, 598-605 (1980).

2-D **air-quality** meas. (2004-today)

Environmental models (BSC-RSLAB)

Wind-field meas. (ELT, Chile 2007?)