SIRTA, a French Atmospheric Observatory for Clouds, Aerosols and Water Vapor

Institut Pierre Simon Laplace, France

H. Chepfer

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SIRTA : Atmospheric Remote Sensing

25 km south of Paris

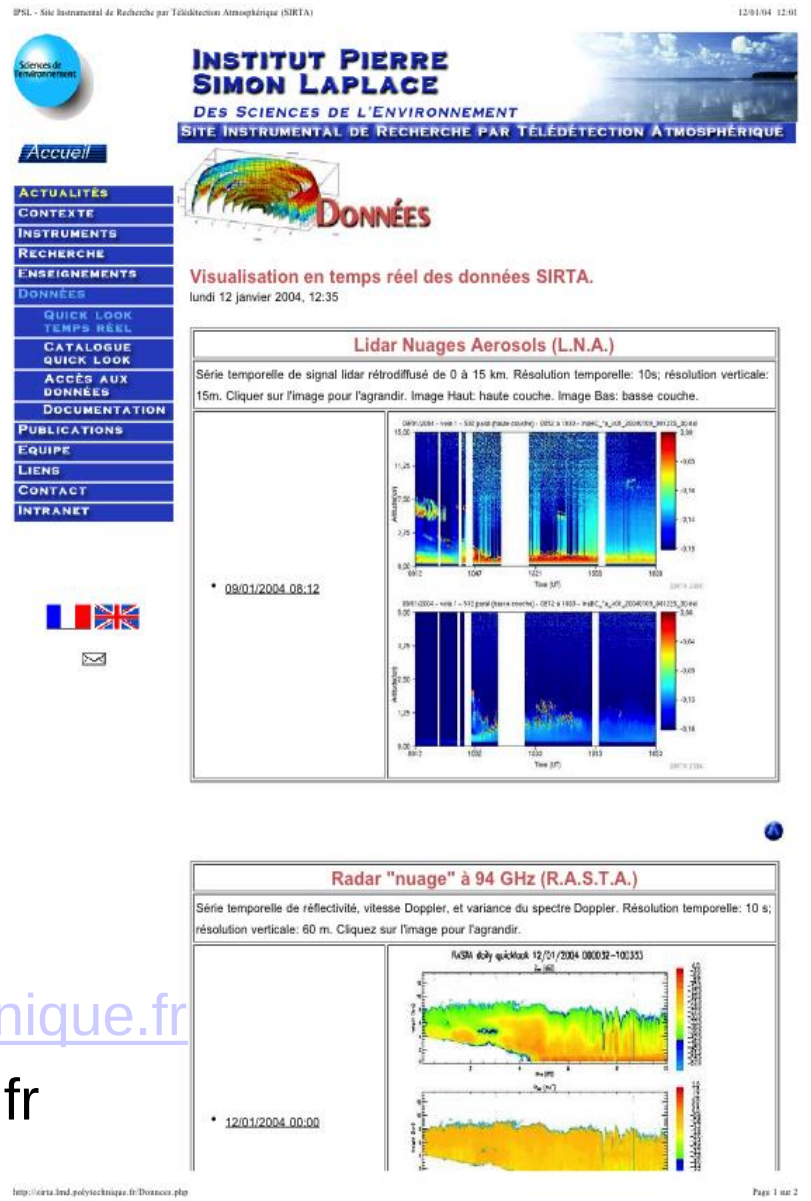
Palaiseau (48.7°N, 2.2°E)

SIRTA Instrumentation

LIDAR	***B-scat Lidar (532, 1064)***	***Clouds, aerosols properties***	***1999***
	Ceilometer (KNMI)	***Cloud, BL Height***	***2002***
	IR Doppler Lidar (10.6 μm)	3D Wind	1999
	Ozone Lidar (316 nm)	Ozone, aerosols	2003
	Raman Lidar (355 nm)	Water vapor, Profile	2003
RADAR	***Doppler Radar 95 GHz***	***Cloud properties***	***2002***
	Doppler Radar 5 GHz	Precipitation, 3D Wind	1999
RADIO-METER	***BB Radiometers***	***Radiative Fluxes (2003 BSRN)***	***1999***
	Sun-Photometer	***Aerosols, water vapor***	***2002***
	IR Radiometer	***Brightness temperature***	***2002***
	MW Radiometer	***Water vapor + liquid***	***1999***
IN-SITU	***Weather***	***Pres., temp., humidity, wind***	***1999***
	Spectro-pluviometer	***Diameter + drop velocity***	***1999***
	Radiosonde	***Vertical Profiles (00, 12 UT)***	***1999***
	Sonic Anemometer	Turbulent Fluxes	2004

SIRTA Data Access

- Data available online:
  - Back-scatter Lidar: 10/2002 - now
  - Cloud radar: 10/2002 - now
  - Radiative Fluxes: 04/2003 - now
  - Weather + RS : since 2001
- Data Visualization :
  - http://sirta.lmd.polytechnique.fr/
  - *« Real Time QL »*
  - *« QL catalogue »*
- Data Access :
  - ftp://sirtapub@perceval.lmd.polytechnique.fr
  - martial.haeffelin@lmd.polytechnique.fr



SIRTA and Observation Networks

GEWEX Cloud observatories:

- Vertical cloud structure, aerosols, water vapor, raditaive impact
- Validation of climate models
- Preparation of spatial missions

BSRN Site (WCRP) :

- Candidate station to BSRN
- To become BSRN member in 2004

AERONET/PHOTONS :

- Since 07/2002

European Networks

- **EARLINET** : Aerosol climatology over the European continent through lidar observation (21 sites)
- **CLOUDNET** : Study of cloud properties and their representation in NWP models (3 sites)
- **EURAT:** European Network of Advanced Atmospheric Observatories for Climate Studies

French Lidar Stations (5 sites)

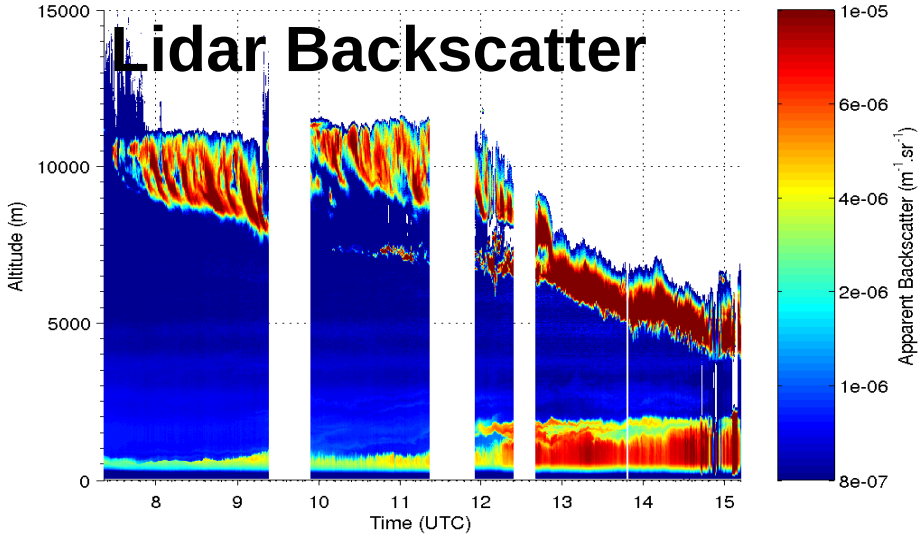
NDSC : Network of Detection of Stratospheric Changes

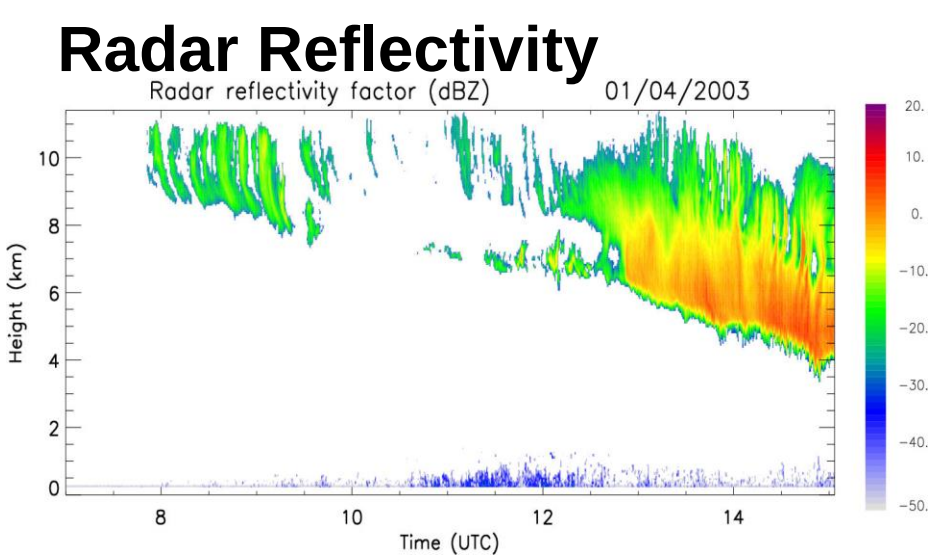
SIRTA : Cloud and Radiation Observatory

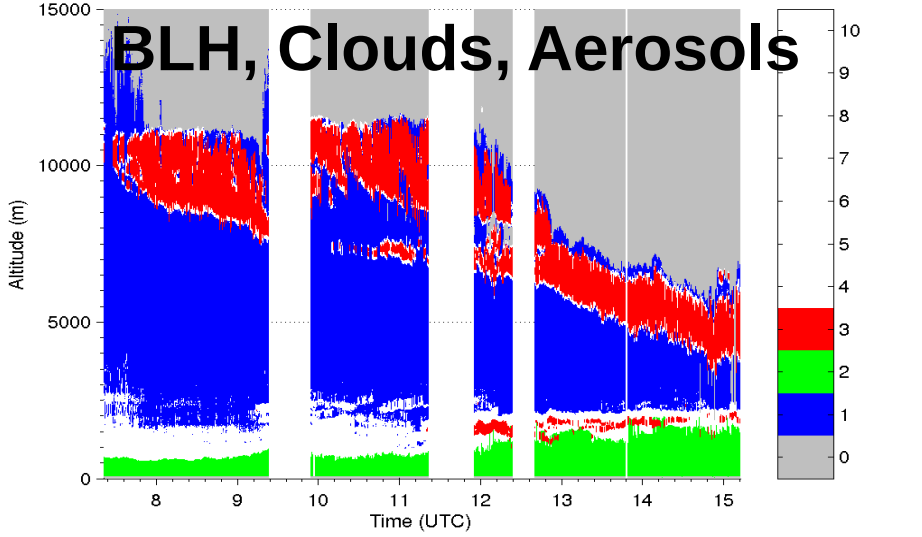
1. Advanced retrieval methods from SIRTA observations - Comparisons with satellite retrievals

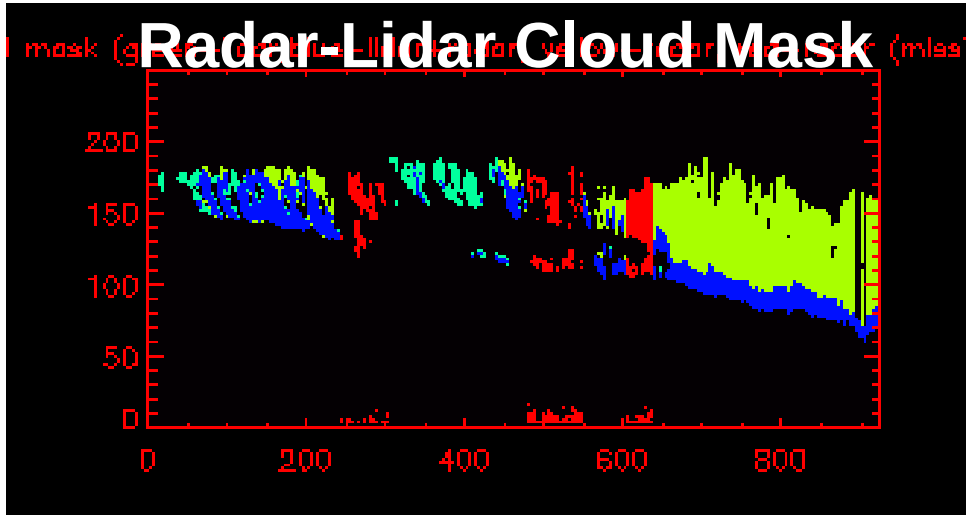
2. Models-Observations studies at SIRTA

Cloud Macrophysic : Radar/Lidar retrieval







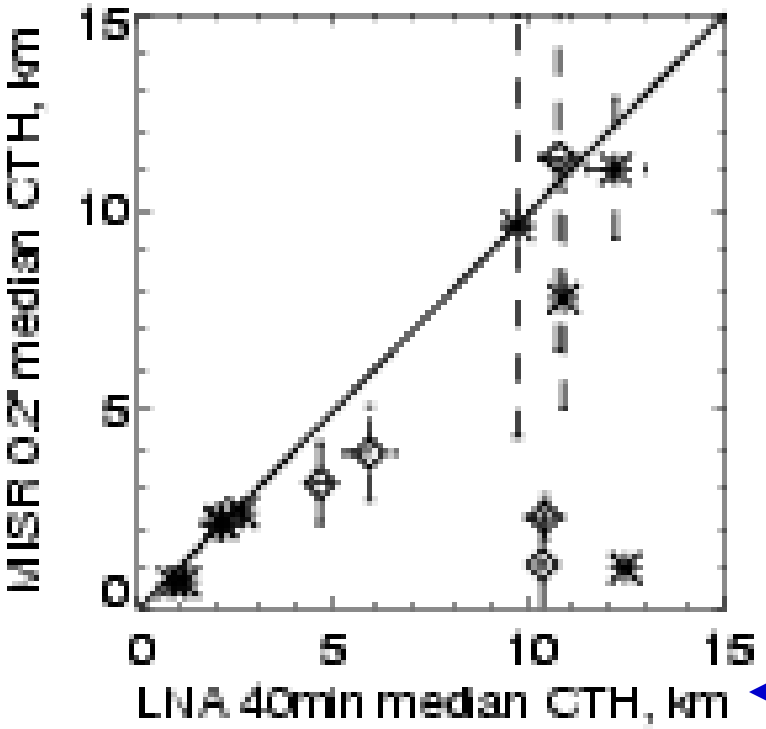


Available for the complete SIRTA dataset, Y. Morille

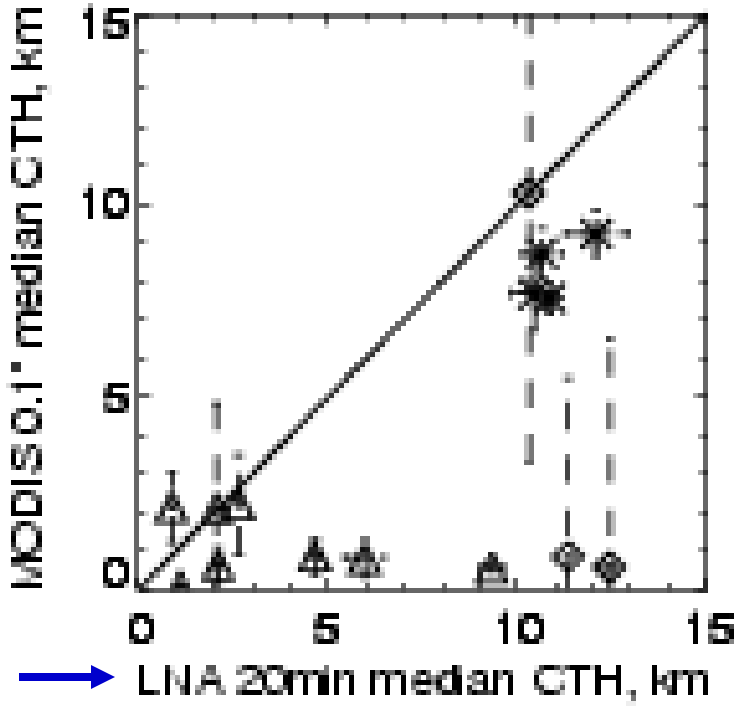
Cloud Macrophysic :

Cloud Top Height : Lidar – MISR – Modis comparisons

MISR



MODIS



← **LIDAR** →

*= single layer

◊ = multiple layers

*=CO_2-slicing only

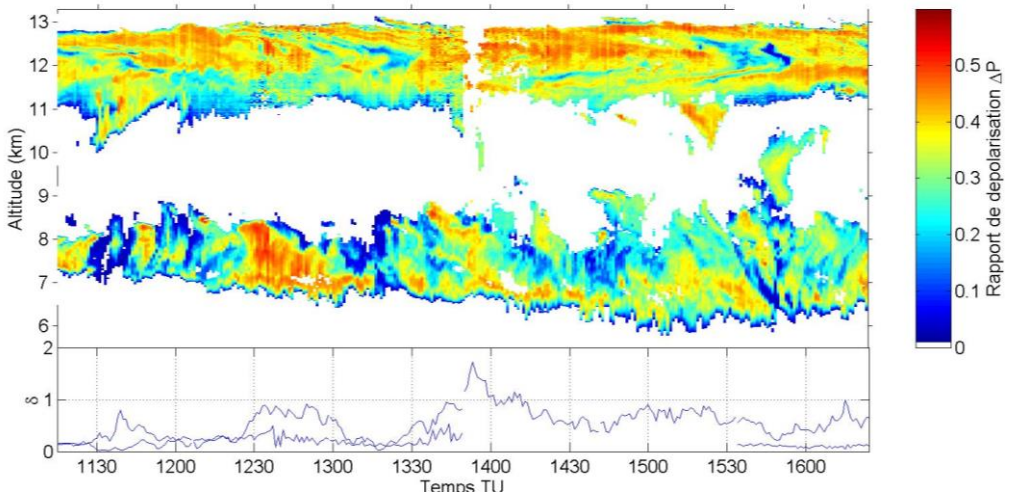
Δ=BT11 only

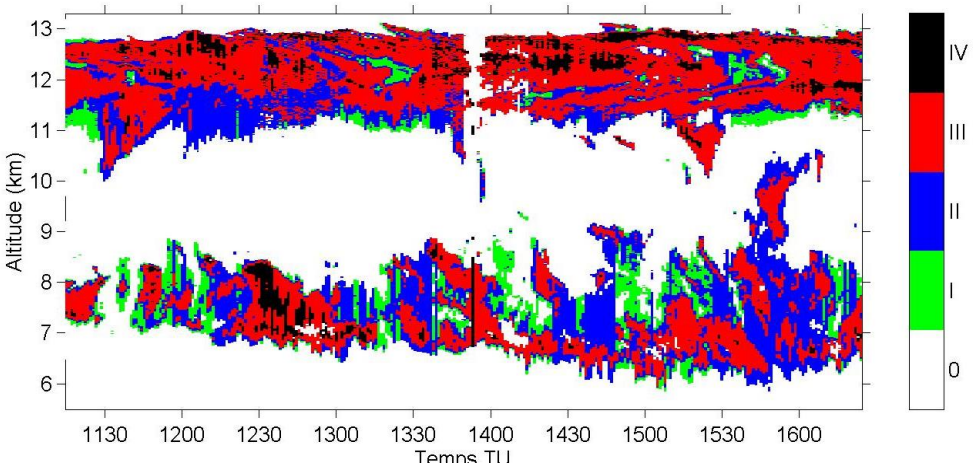
◊=CO_2-slicing & BT11

Naud et al., 2004, GRL.

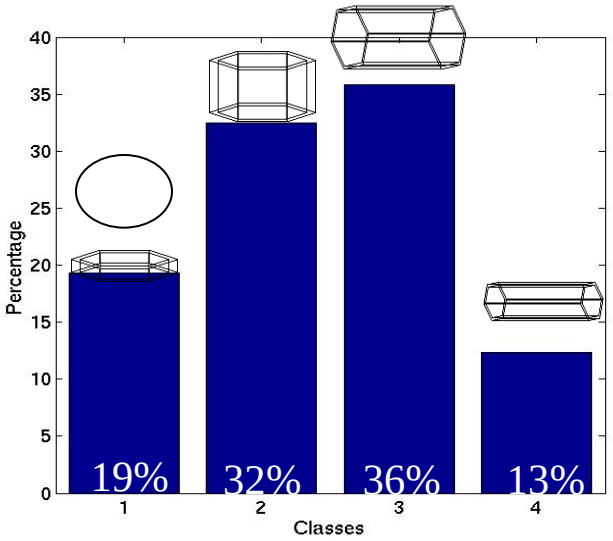
Cloud Microphysic: Ice Crystals Shape

Lidar depolarization





15 Cloud Cases:
Majority of 0.05 < Q < 1.1
Columns associated to low Temp



Shape Classification :
I : Q < 0.05 – plates or water
II : 0.05 < Q < 0.7 - thick plates
III : 0.7 < Q < 1.1- compacts
IV : Q > 1.1 – columns

Noel et al., Appl. Opt., 2002

Cloud Microphysic: Ice Crystals Size

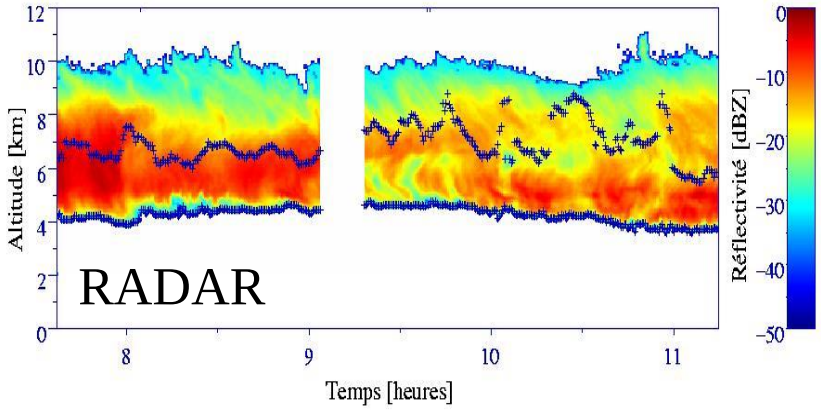
Calipso Method : Lidar (β, ΔP) + IR (8.7, 10.5, 12 μm)

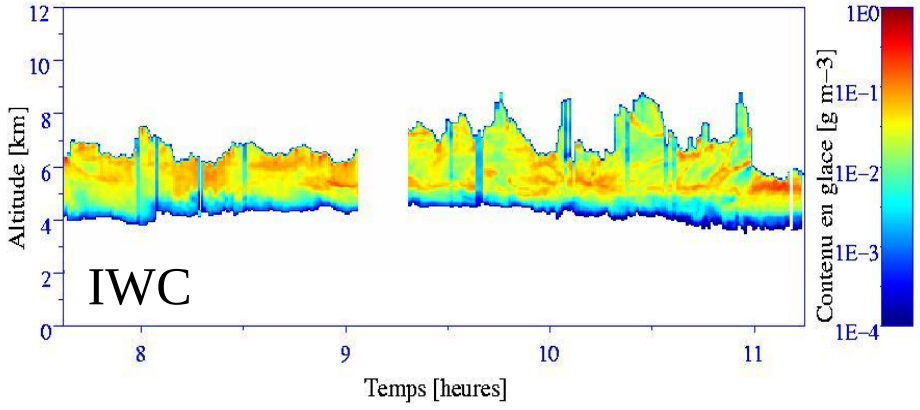
Chiriaco et al. MWR, 2004

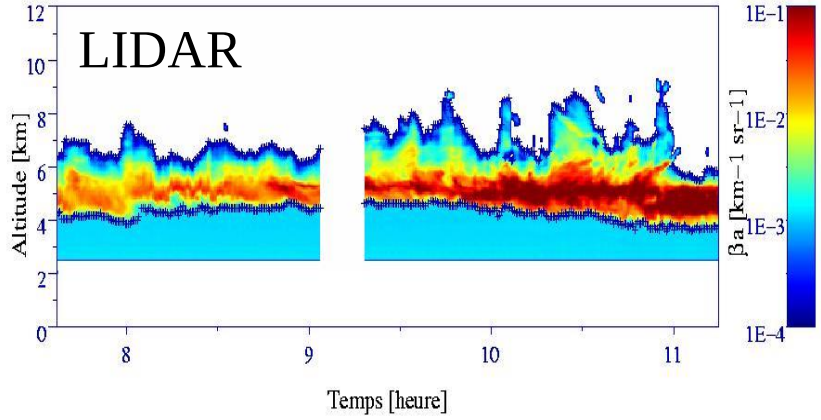
Comparisons Ceres (Minnis), Modis (Platnick/King), Calipso Methods

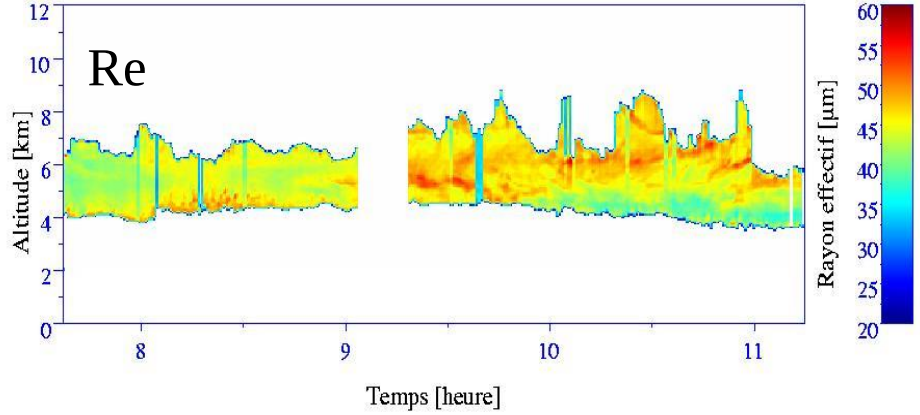
AGREEMENT between	*NUMBER of CASES (17)*	*COMMENTS*
CALIPSO/CERES/ MODIS	**5 cases** $0.2 < \delta < 3$	Cloud thin enough for CALIPSO Cloud thick enough for CERES / MODIS
CALIPSO / CERES	**2 cases** $0.1 < \delta < 4$	Particle size MODIS > CERES/CALIPSO
CALIPSO / MODIS	**1 case** $0.1 < \delta < 0.2$	Thin cloud
CERES/MODIS	**2 cases** $0.2 < \delta < 0.3$	Thin cloud
CALIPSO retrieval only	**7 cases** $\delta < 0.2$	No cloud detection by CERES / MODIS

Cloud Microphysic:
Ice Crystal Size, IWC from Lidar/Radar





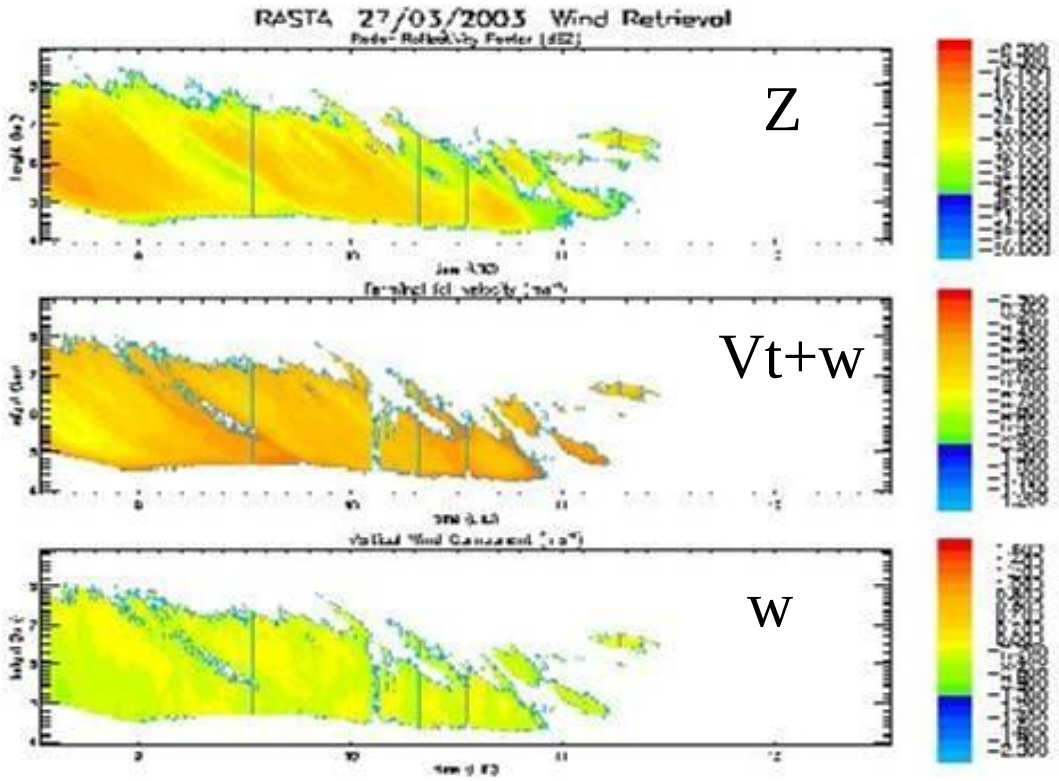




Applied to the complete SIRTA dataset, C. Tinel and D.Bouniol

Vertical Wind Velocity

- **Radar Reflectivity (Z) & Radar Doppler Mean velocity (Vt+w)**
- **Hypothesis : w << Vt, long term sampling**
- **Power law least square fitting (Vt+w, Z) => $Vt=aZ^b$**



- Apply $Vt = a\,Z^b$ to Z
  ⇒ Vt retrieval
- Substract Vt to the Mean Doppler velocity
  ⇒ w retrieval

A. Protat

1. Advanced retrieval methods from SIRTA observations - Comparisons with satellite retrievals

2. Models-Observations studies at SIRTA

Models plateforms

COMPERES project (IPSL)

Research Models :

Chimie-transport CHIMERE (IPSL)

GCM zoomed-nutged (IPSL)

Meso-scale MM5

Meso-scale Meso-NH (CNRM/LA)

CLOUDNET project (EC)

NWP models :

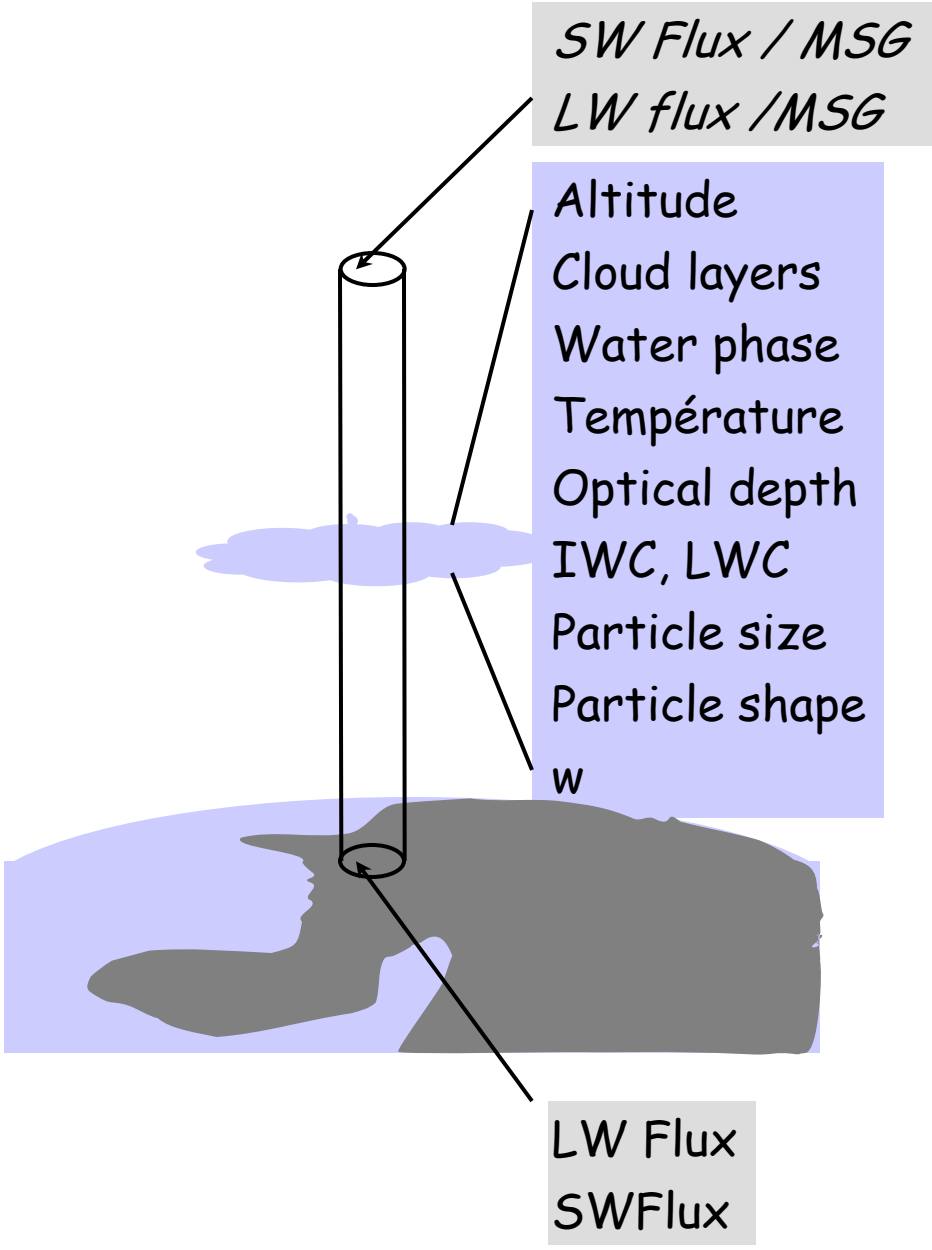
ARPEGE (MétéoFrance)

UKMO

KNMI

ECMWF

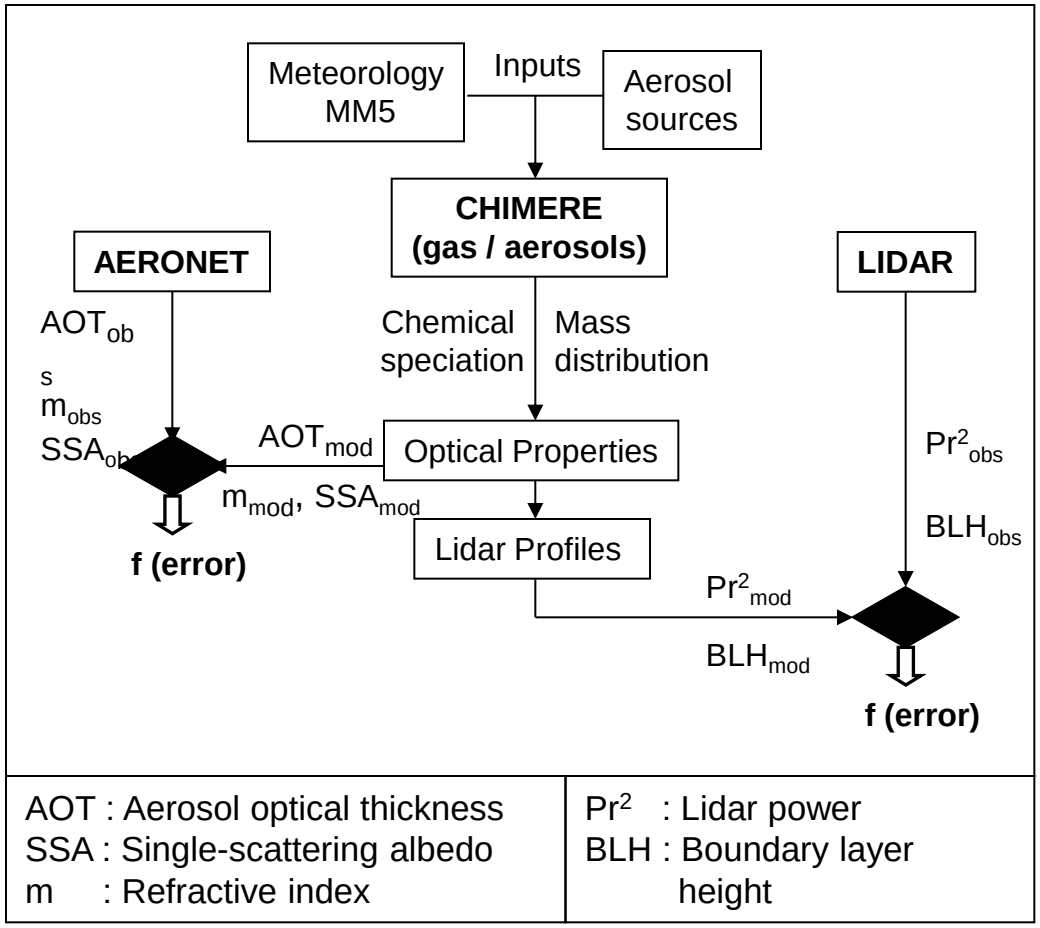
SIRTA Observations



Aerosols in Chemistry-Transport Model

Objective : ***Evaluation of CHIMERE Aerosol Module***

METHOD



AOT : Aerosol optical thickness SSA : Single-scattering albedo m : Refractive index	Pr^2 : Lidar power BLH : Boundary layer height

DATASET

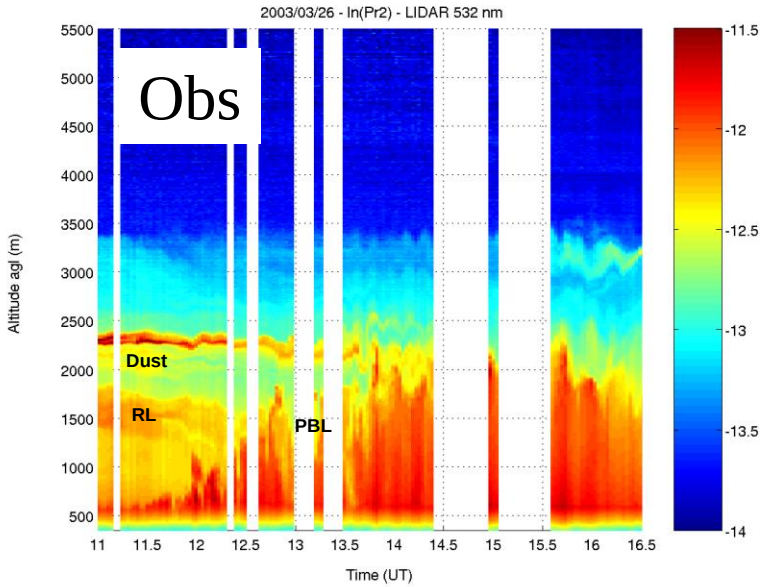
Photometer (Jan./Sep.03)
Refractive index : 132 days
Aerosol optical depth : 125 days

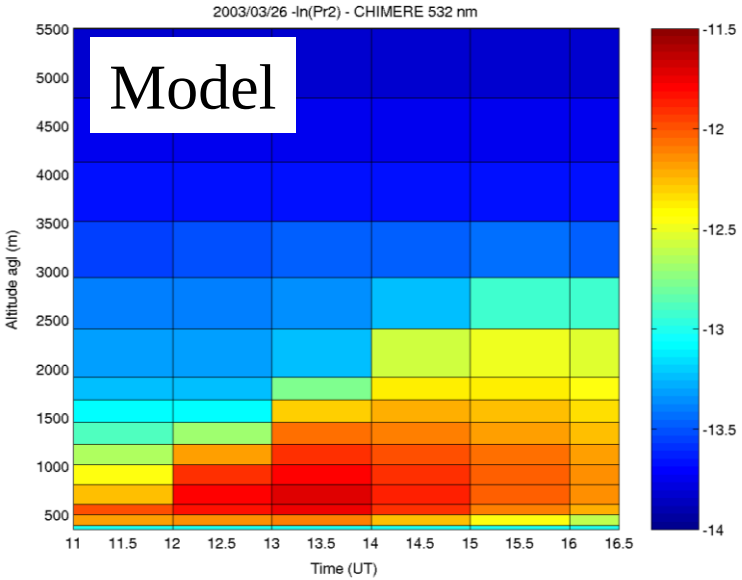
Lidar (Oct.02 / Avr.03)
29 days ; 108 h
Simulation of the lidar profile as an output of the model

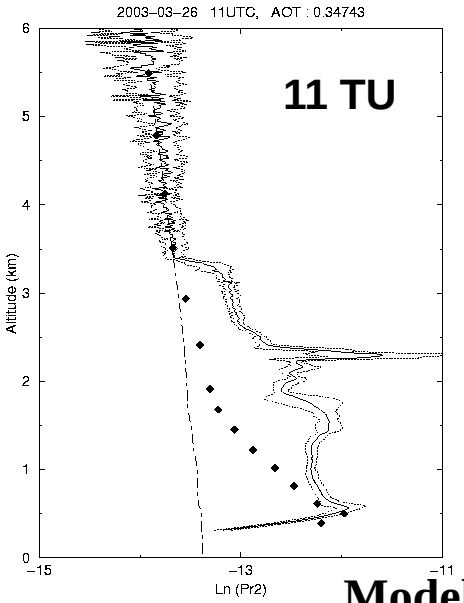
Hodzic et al., submitted to JGR

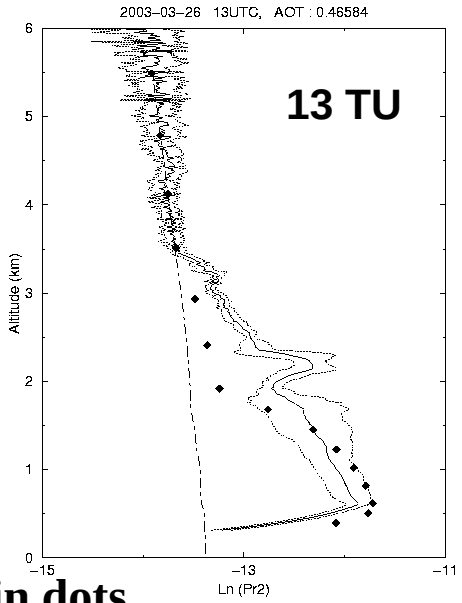
Aerosols in Chemistry-Transport Model

26 March : Simulated and Observed Lidar Profiles

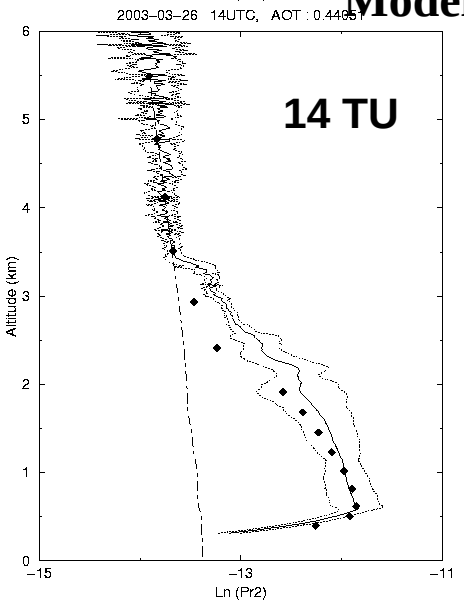


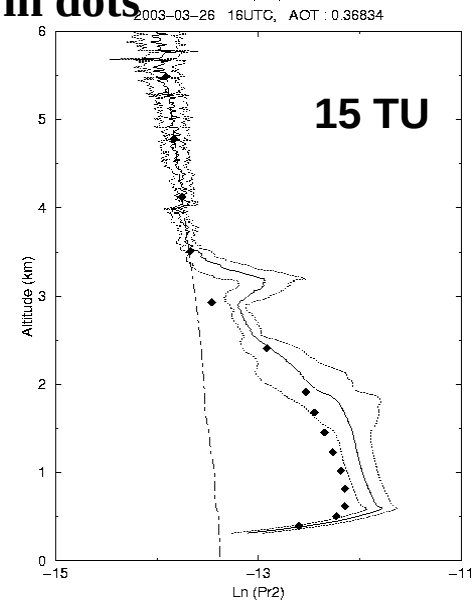






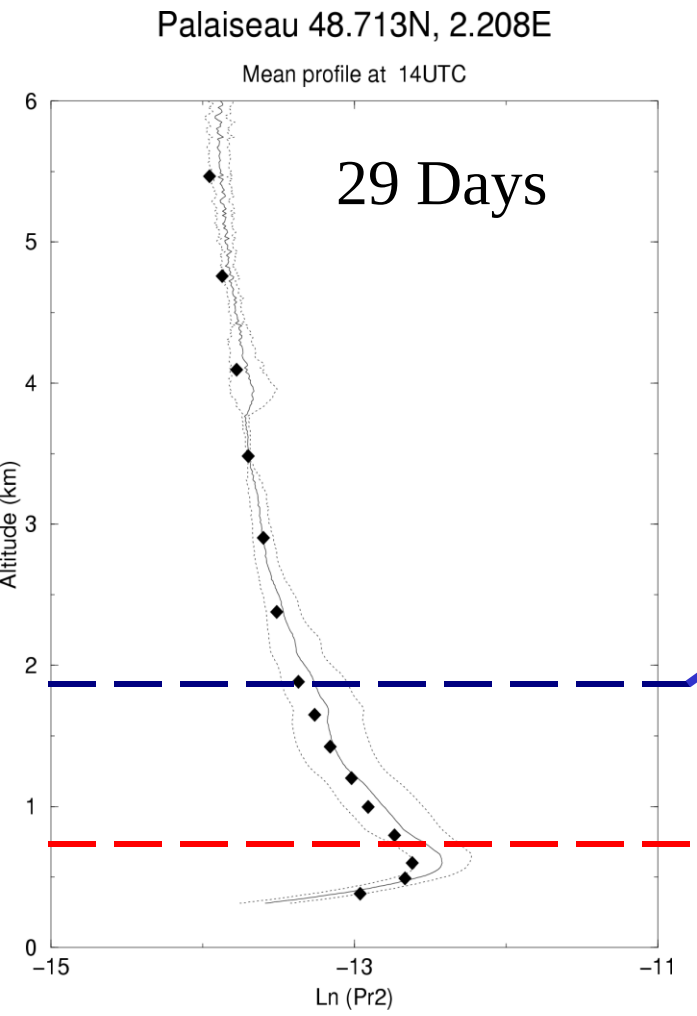
Model in dots

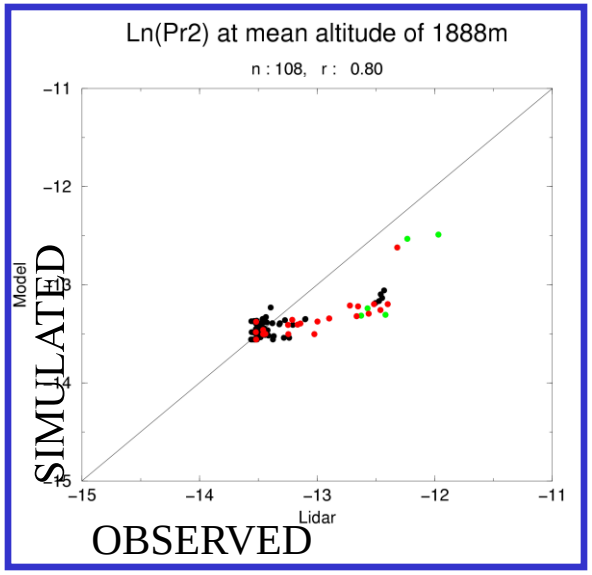




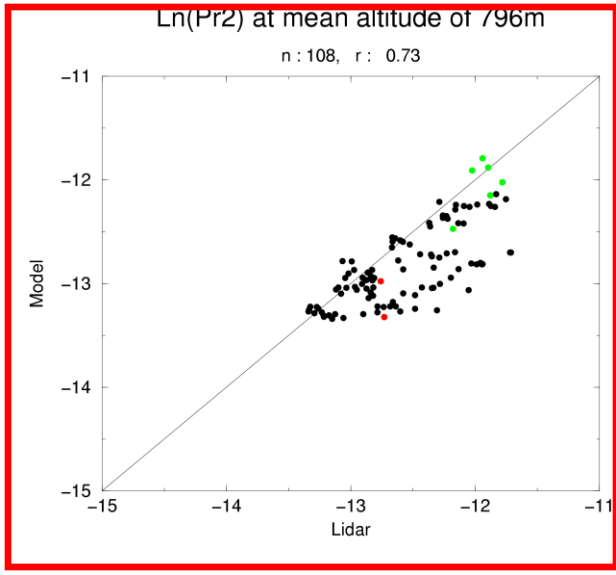
Aerosols in Chemistry-Transport Model:

29 Days : Mean Simulated and Observed Lidar Profiles





1888 m



796 m

Red dots : Model BLH < Lidar BLH

Green dots : 26 March (Dust)

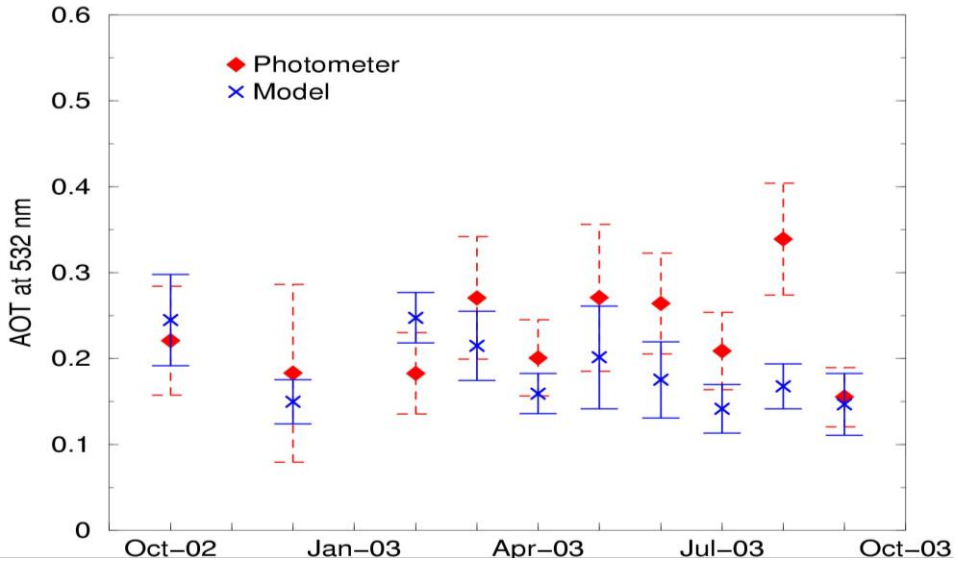
-BLH underestimated by the model ?

-Dust source missing

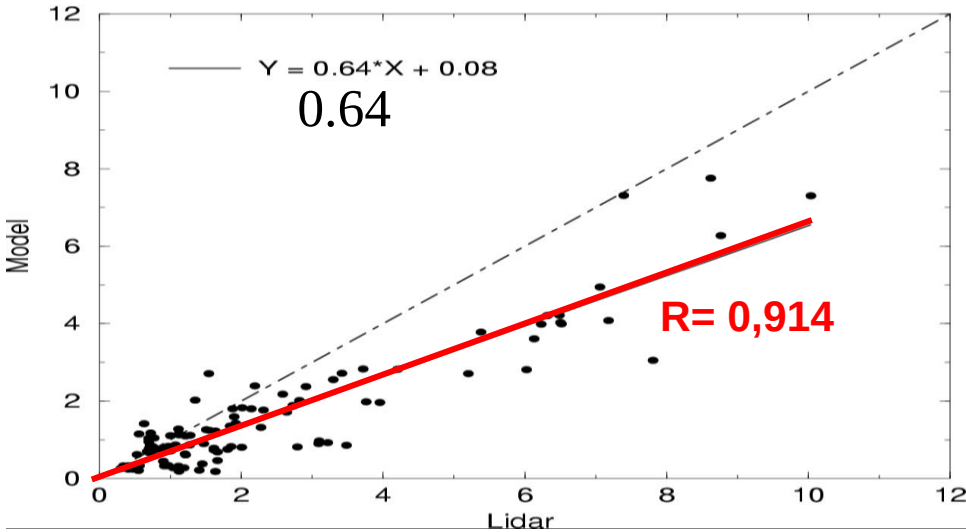
Aerosols in Chemistry-Transport Model :

Statistic of Aerosol Optical Depth

Photometer : δ 532nm



Lidar : integrated signal between 300 and 3000 m

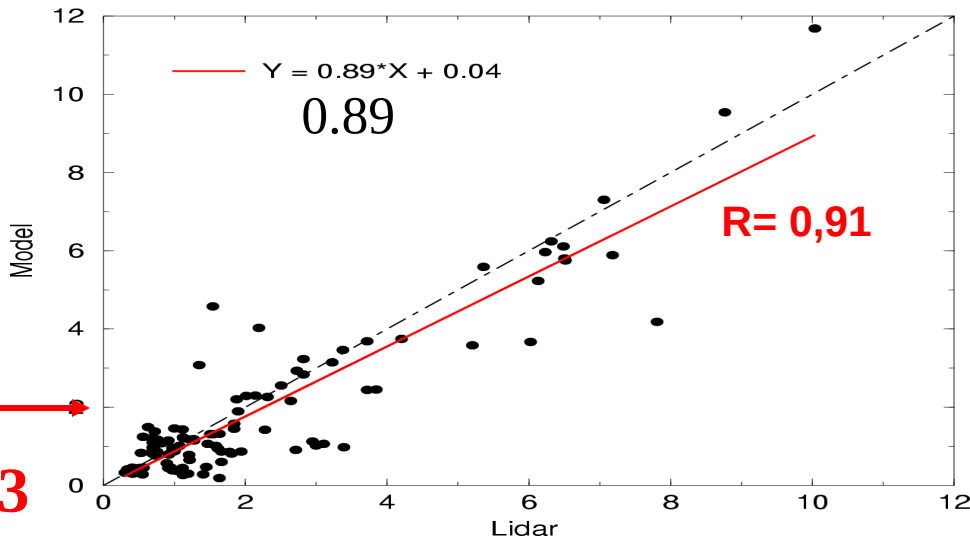


Possible causes for model under-estimation :

- Missing sources *(resuspension, dust)*

- Under-estimation of secondary species *sulfates, nitrates, SOA*

SOA x3

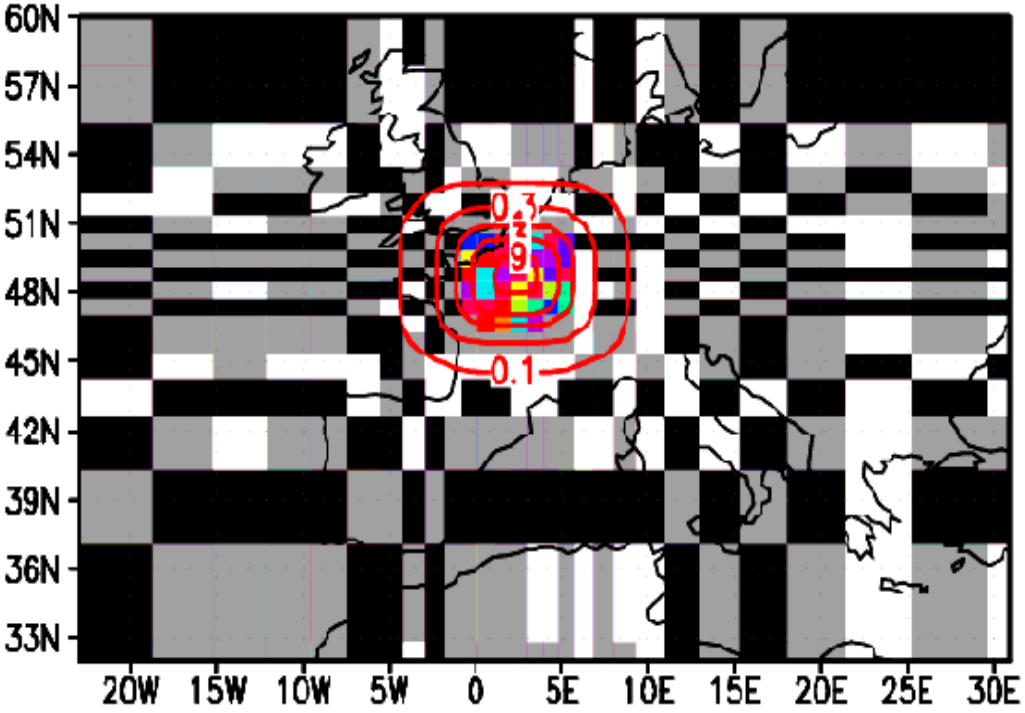


Boundary Layer in GCM

Objective : Evaluation of Boundary Layer description in GCM

METHOD:

GCM grid over SIRTA



Nudged by NCEP –Time constant

Zoomed (100km)

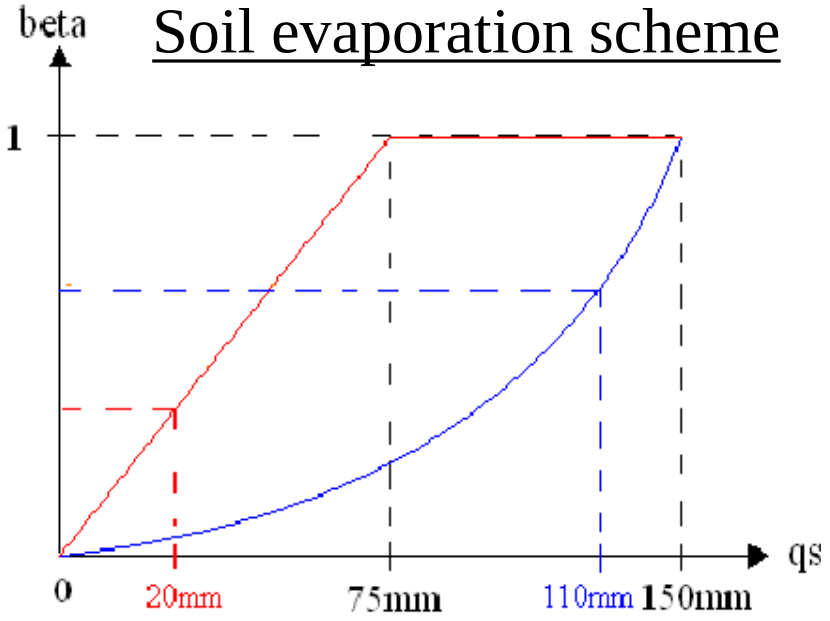
DATASET :

Ground base Radiative Fluxes
Ground base Temperature
Ground base Humidity
Lidar: Boundary Layer Height
Ceilometer : Cloud Base Height

F. Hourdin, A. Mathieu, C. Risi

Boundary Layer in GCM :
Sensitivity study to the surface scheme

Soil evaporation scheme



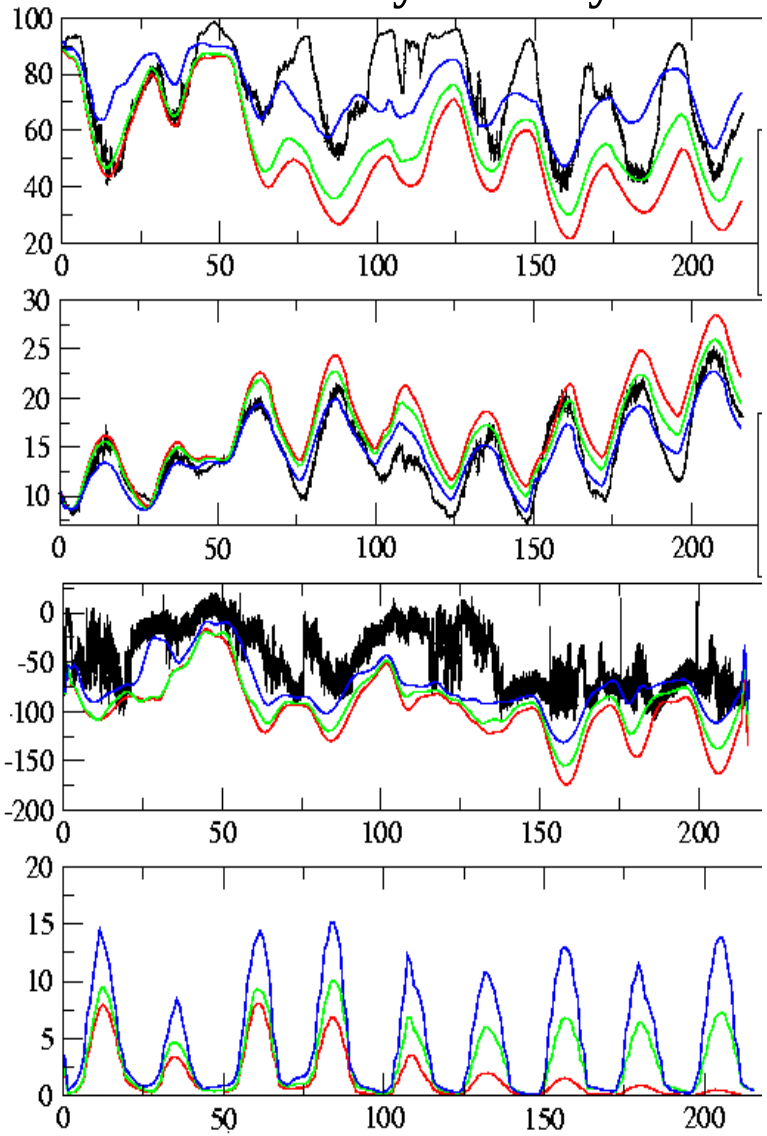
Dry scheme

Medium Dry scheme

Less Dry scheme

SIRTA observations

10 days in May 2003



'Less Dry' Scheme is Selected
HR diurnal variation under-estimated

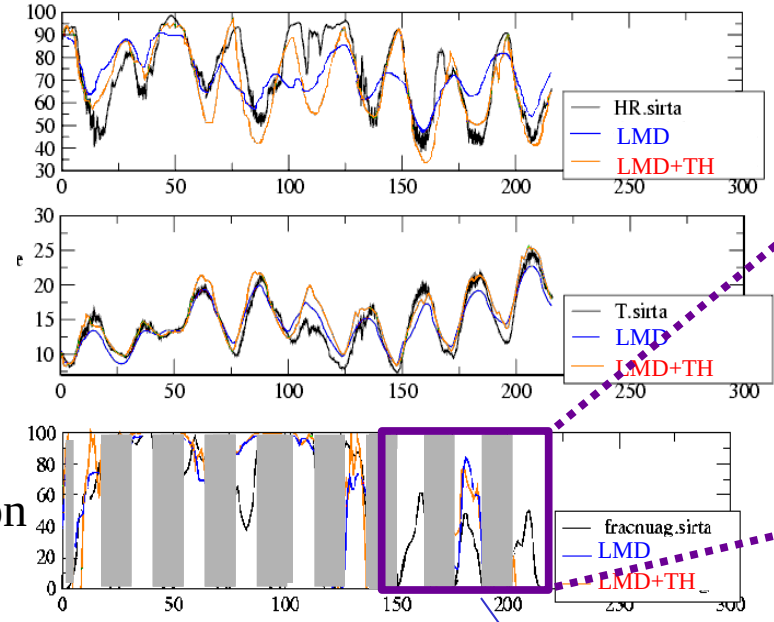
Boundary Layer in GCM :
Convective conditions - A Case Study

with thermic cells
without thermic cells
SIRTA observations

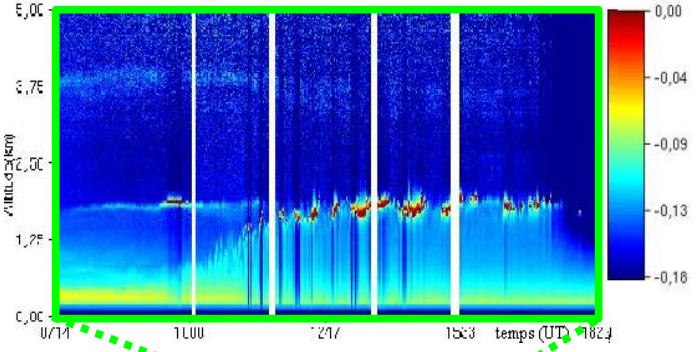
HR

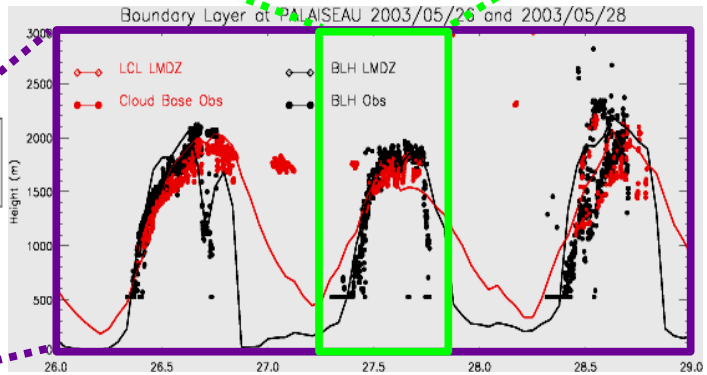
T

Cloud fraction



Lidar observations





Condensation Level in the Model
Cloud base derived from Lidar
BLH model
BLH derived from Lidar

Thermic cells improves HR diurnal variation

Cloud fraction underestimated

Boundary Layer in NWP Models :
Convective conditions – 60 Days

MODELS

ARPEGE :

41 vertical levels

Horizontal resolution SIRTA ~ 20X20 km

ECMO :

60 vertical levels

Horizontal resolution SIRTA ~50X50 km

DATASET

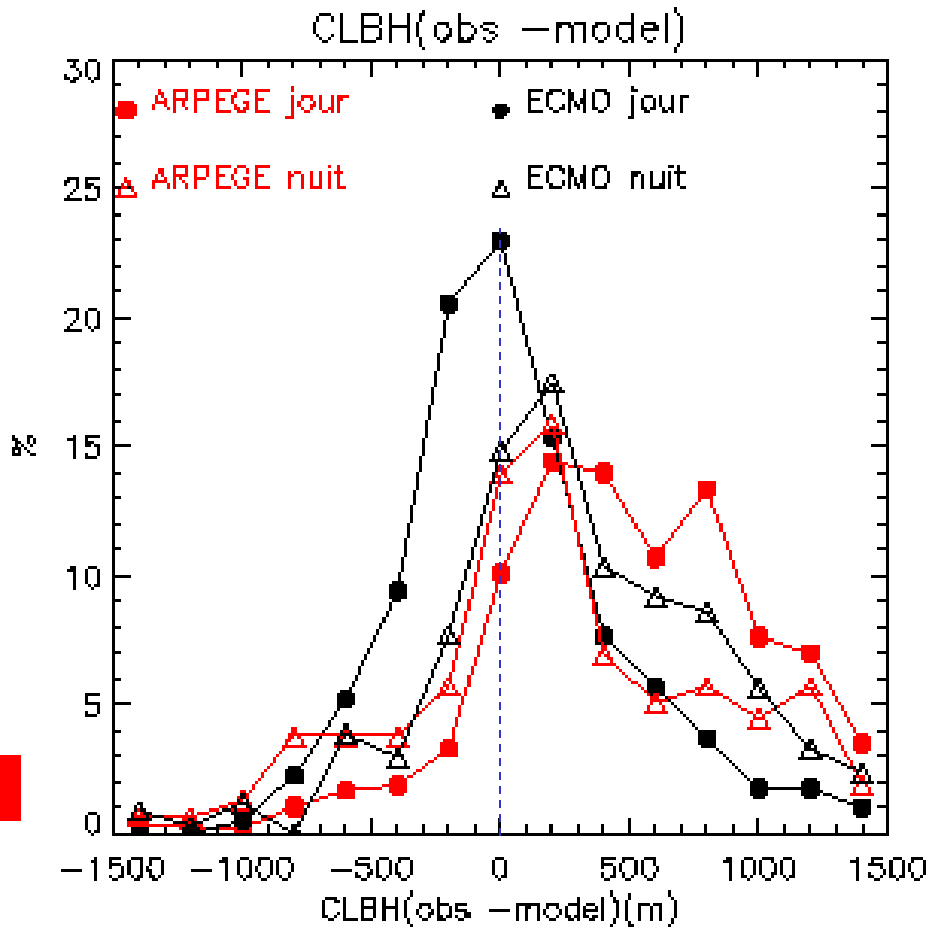
Ceilometer : 60 days

More than 300m Error on the Cloud Base Height :

ARPEGE 60% of time

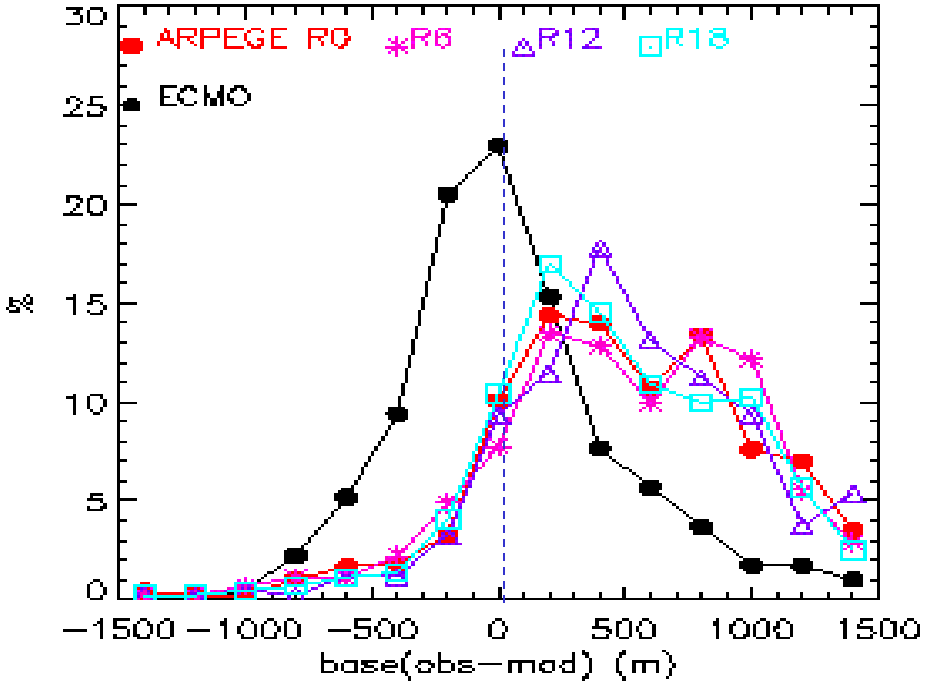
ECMO 40% of time

Cloud Base Height :Obs-Model

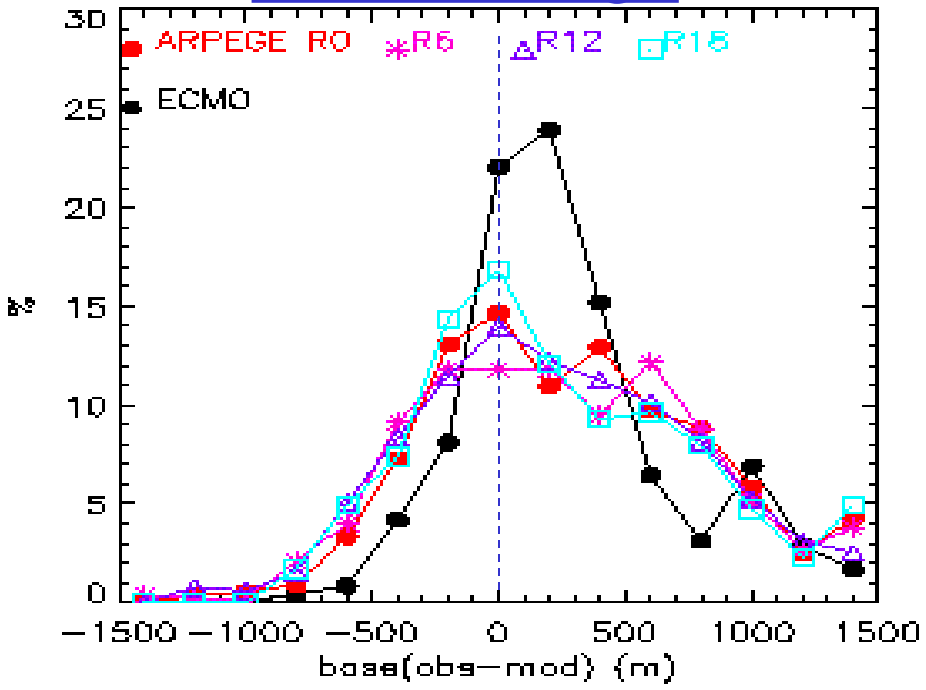


Boundary Layer in NWP Models :
Convective situations

Assimilation of Surface Conditions



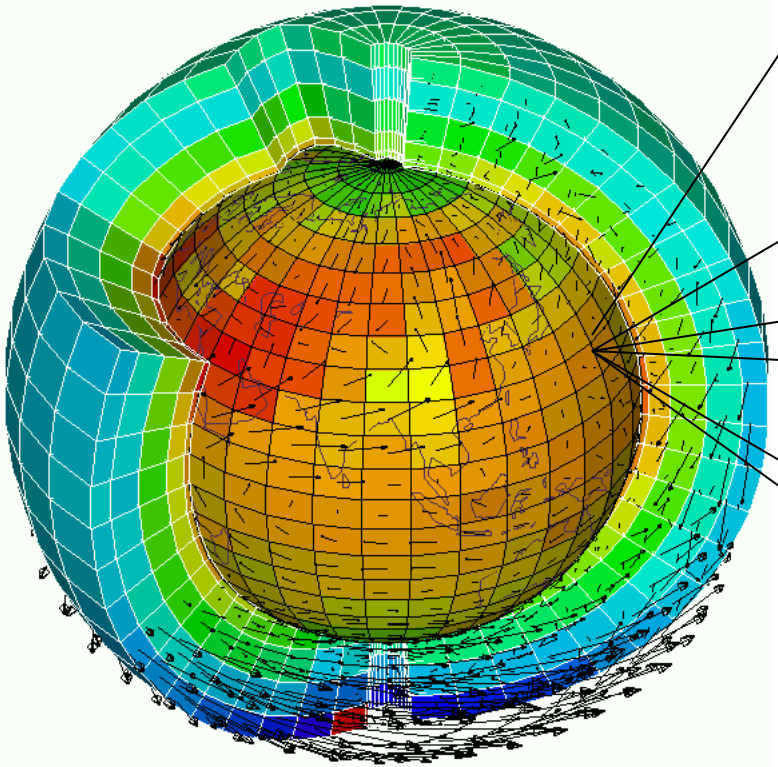
Assimilation of Surface conditions & Diagnostic instead of Parametrisation of Cloud Base Heigth



ARPEGE : Improvement due to Diagnostic (Condensation Level)
But Cloud Base Height still underestimated

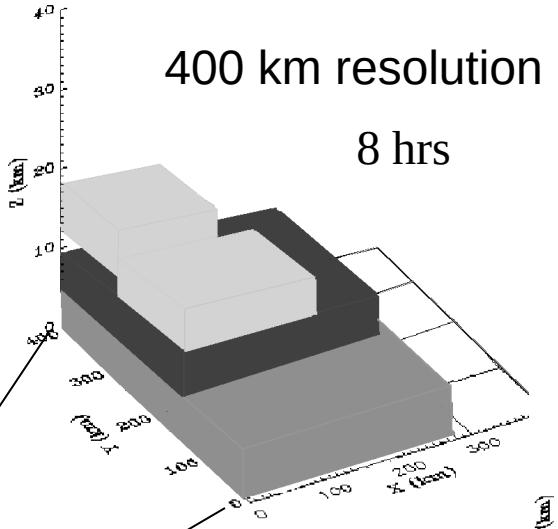
Cloud Overlap in GCM

LMD Global Climate Model
- 96 long. x 71 lat. x 15 layers
- 6 min. time step
- radiation
- cloud
- precipitation
- heat
- momentum
- moisture



400 km resolution

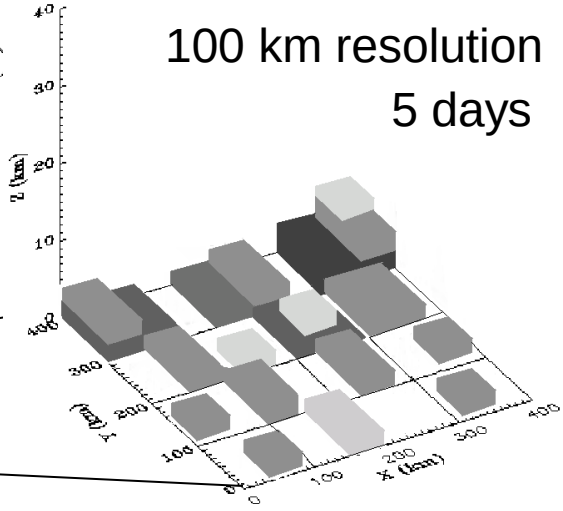
8 hrs

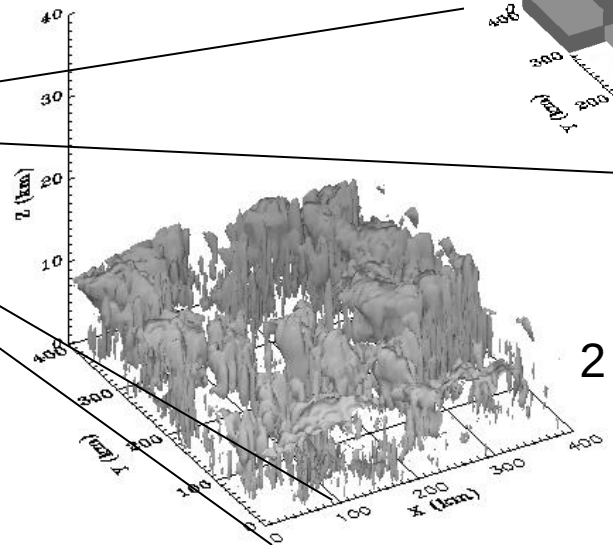


- Cloud resolution
- Time to complete 1 year simulation (NEC SX5)

100 km resolution

5 days

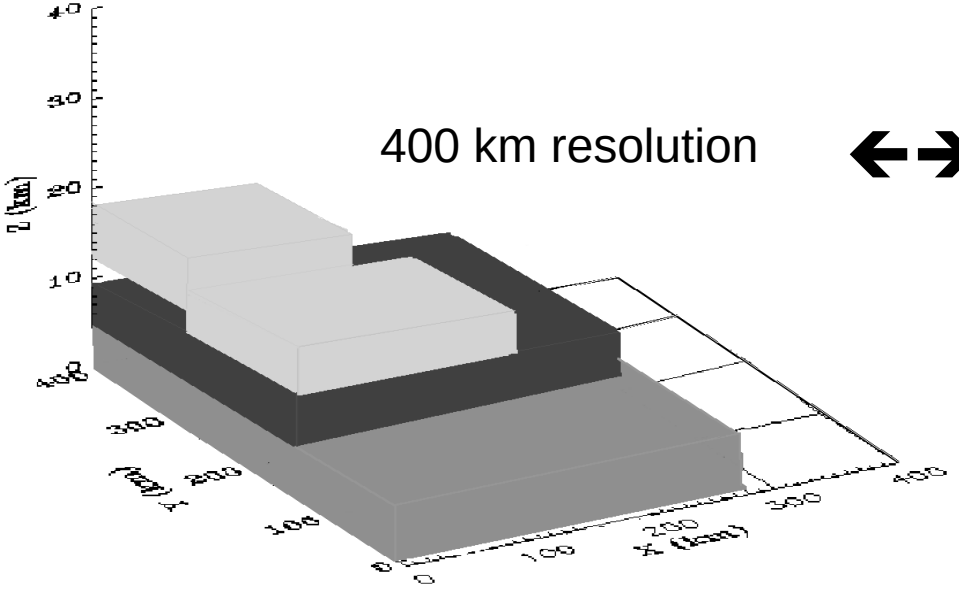


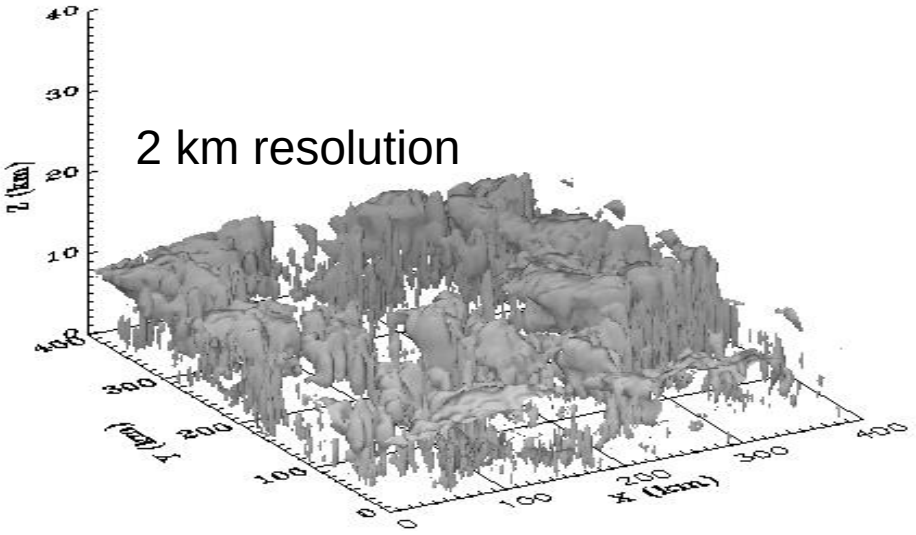


2 km resolution

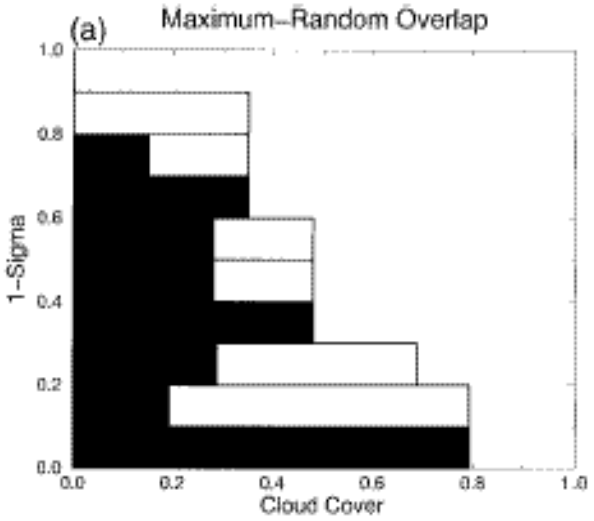
35 yrs

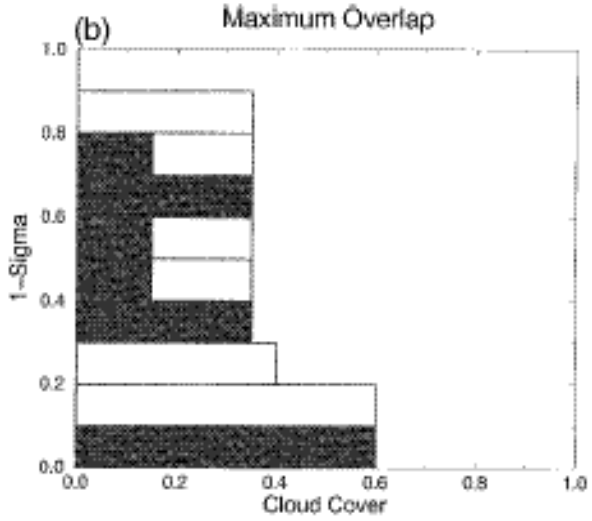
Cloud Overlap in GCM

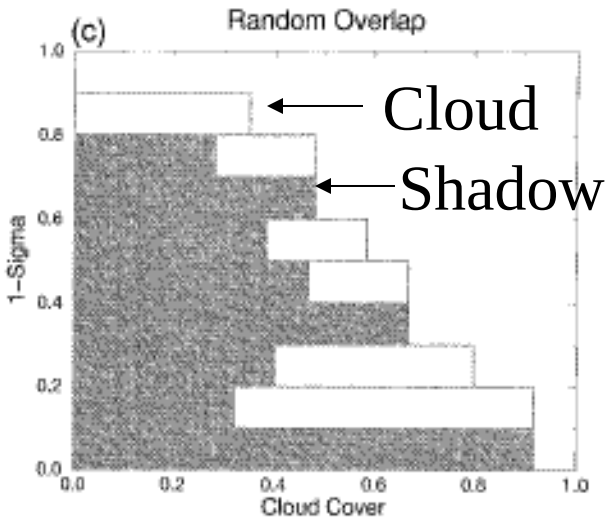




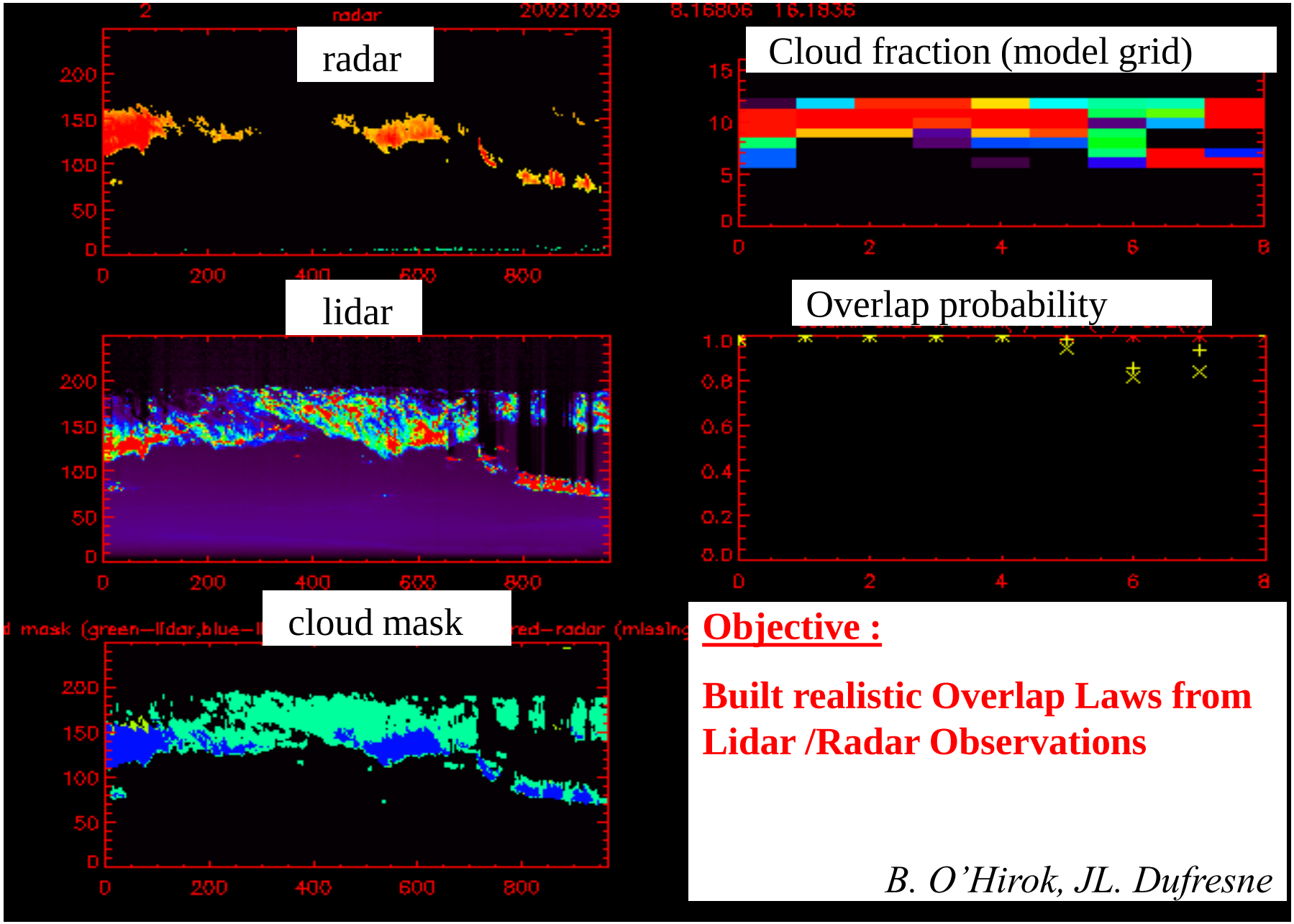
Different Overlap Laws







Cloud Overlap in GCM

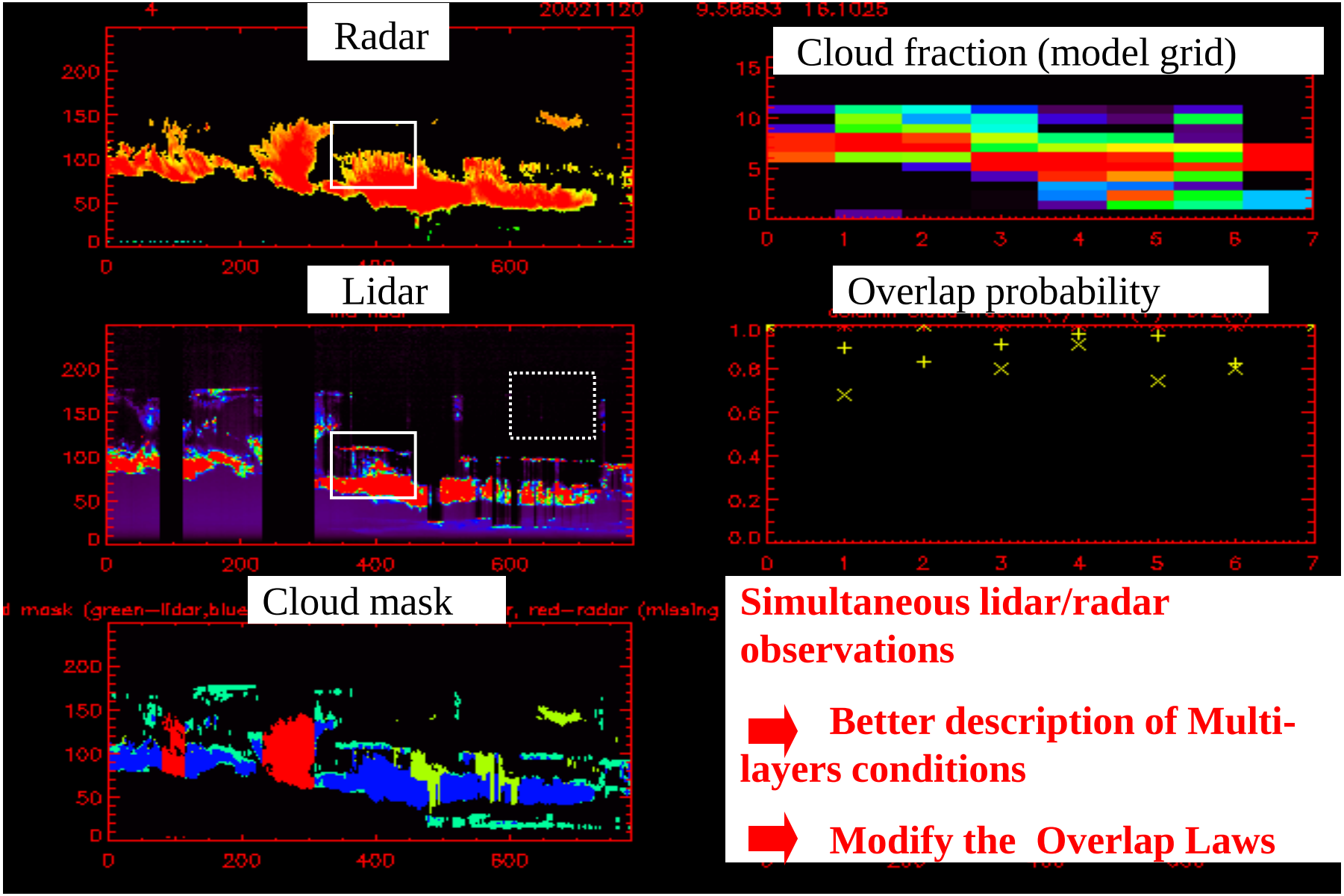


Objective :

Built realistic Overlap Laws from Lidar /Radar Observations

B. O'Hirok, JL. Dufresne

Cloud Overlap in GCM

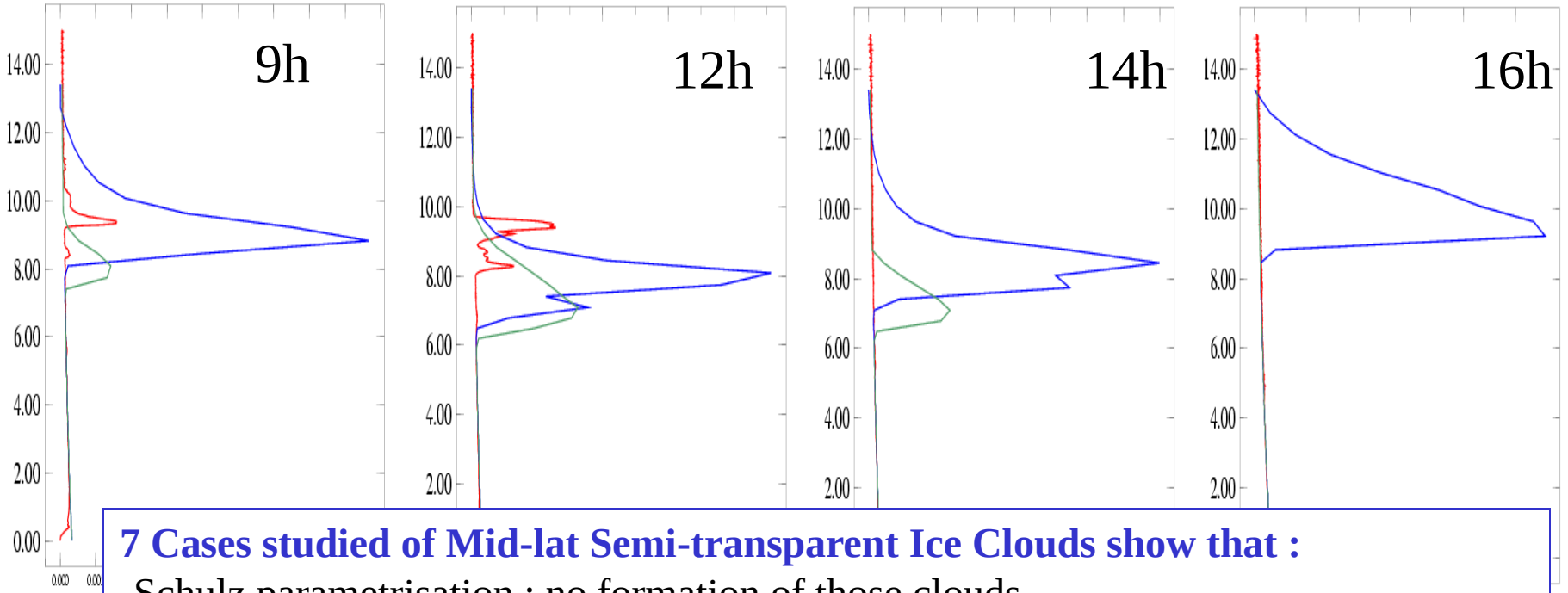


Ice clouds in Meso-scale Models

MM5 nutged by NCEP / Vertical resolution 200m
3 ice parametrisations: Schultz, Reisner1, Reisner 2 (particle nb)

Comparisons between simulated and observed lidar profiles Ex;17 March 2003

Observations **Model Reisner1** **Model Reisner2**



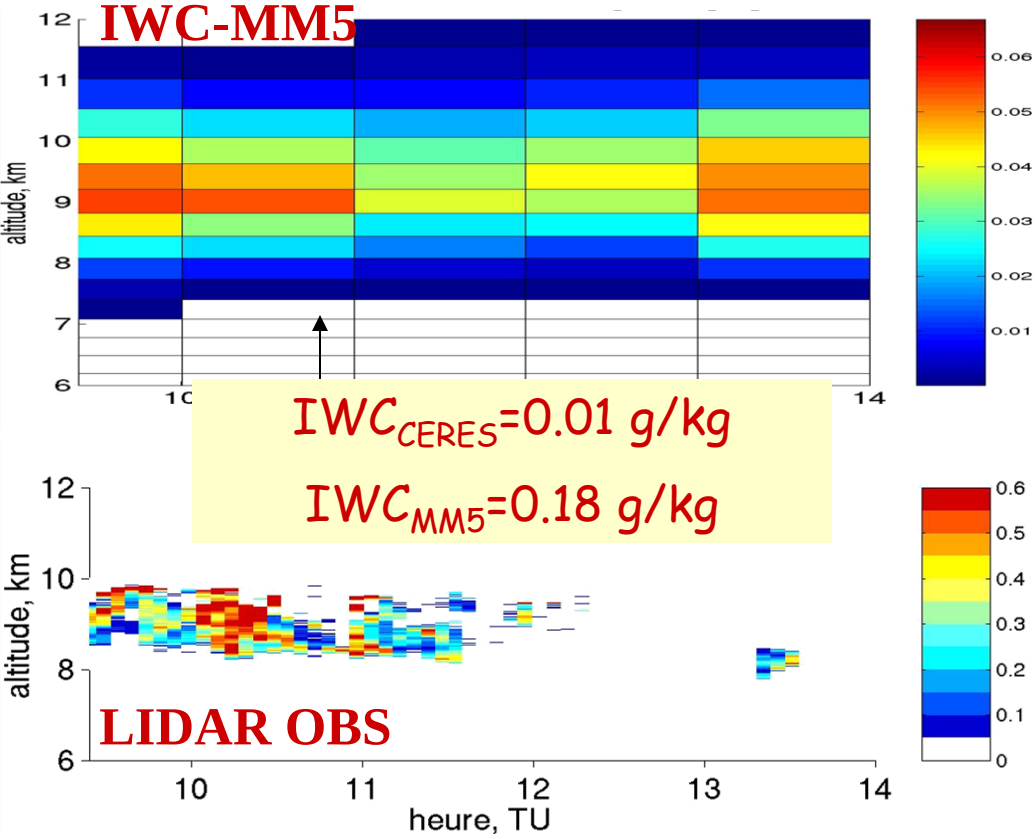
7 Cases studied of Mid-lat Semi-transparent Ice Clouds show that :

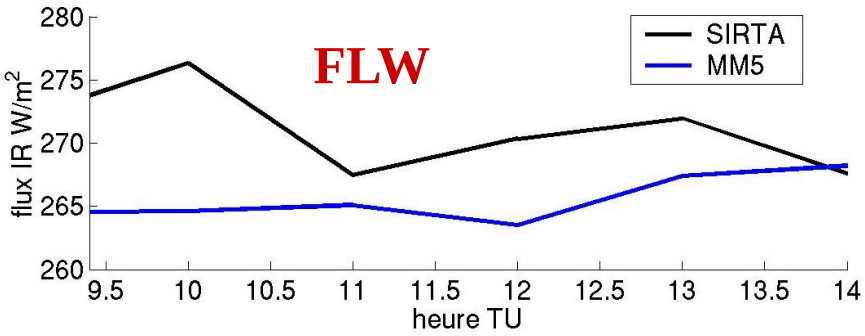
-Schulz parametrisation : no formation of those clouds

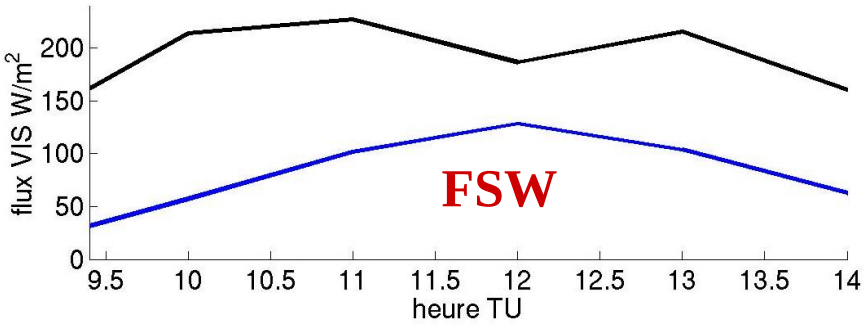
-Reisner 2 parametrisation : clouds too persistant and too thick

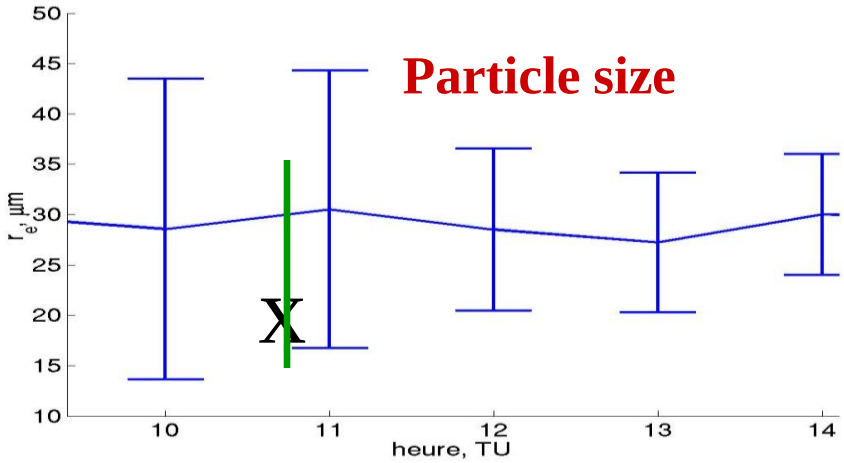
-Reisner 1 parametrisation : more adapted but seems to dissipate a little bit to fast

Ice clouds in Meso-scale Models









09 Dec 2003 (Param Reisner 2) :

Tcloud-mean (mod-obs)= -5K
IWC (mod – obs) = 0.15 g/kg
FSW (mod – obs) = - 70 W/m2
FLW (mod – obs) = - 5 W/m2
Re (mod- obs) = 10 µm

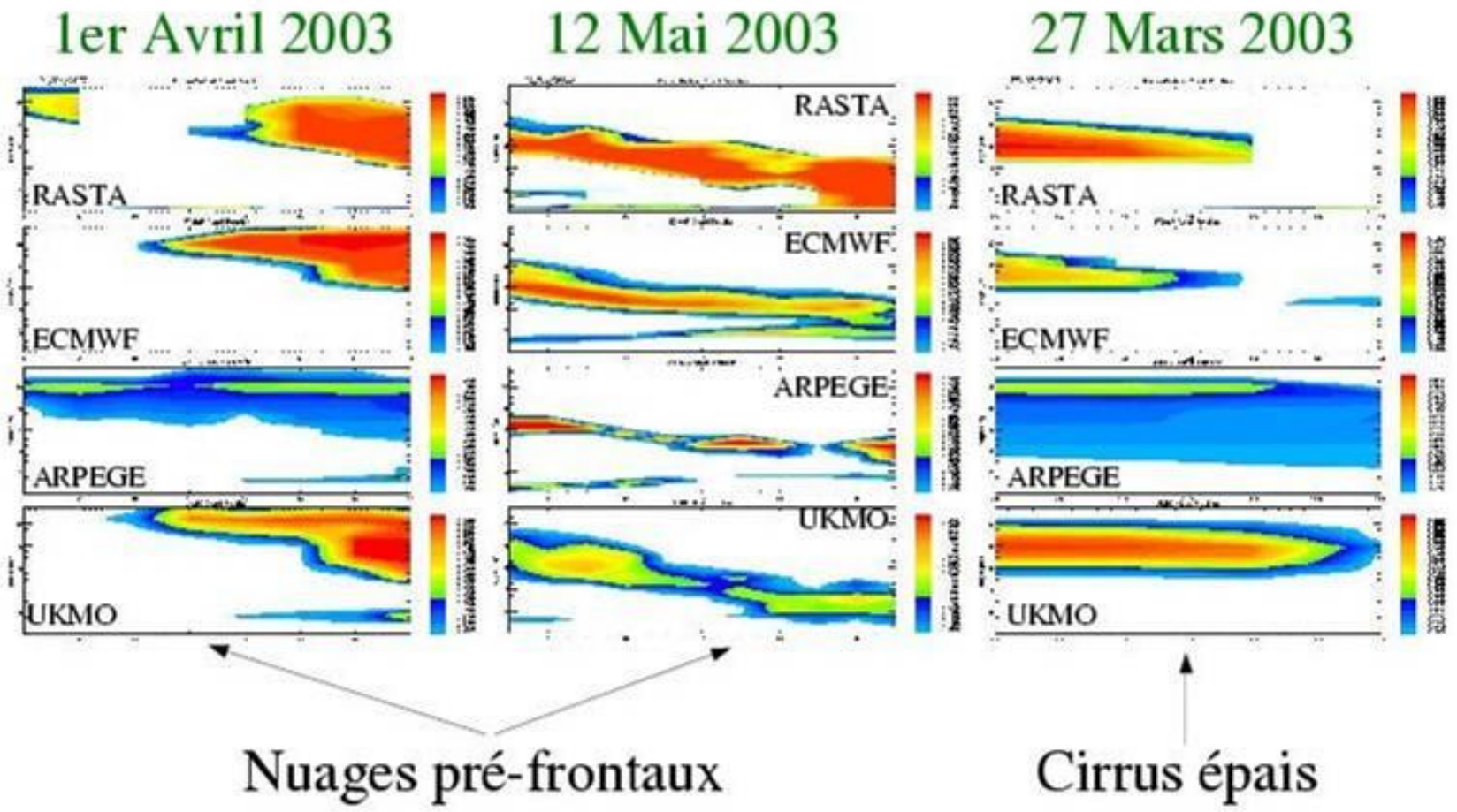
MM5

Calipso

X :Ceres

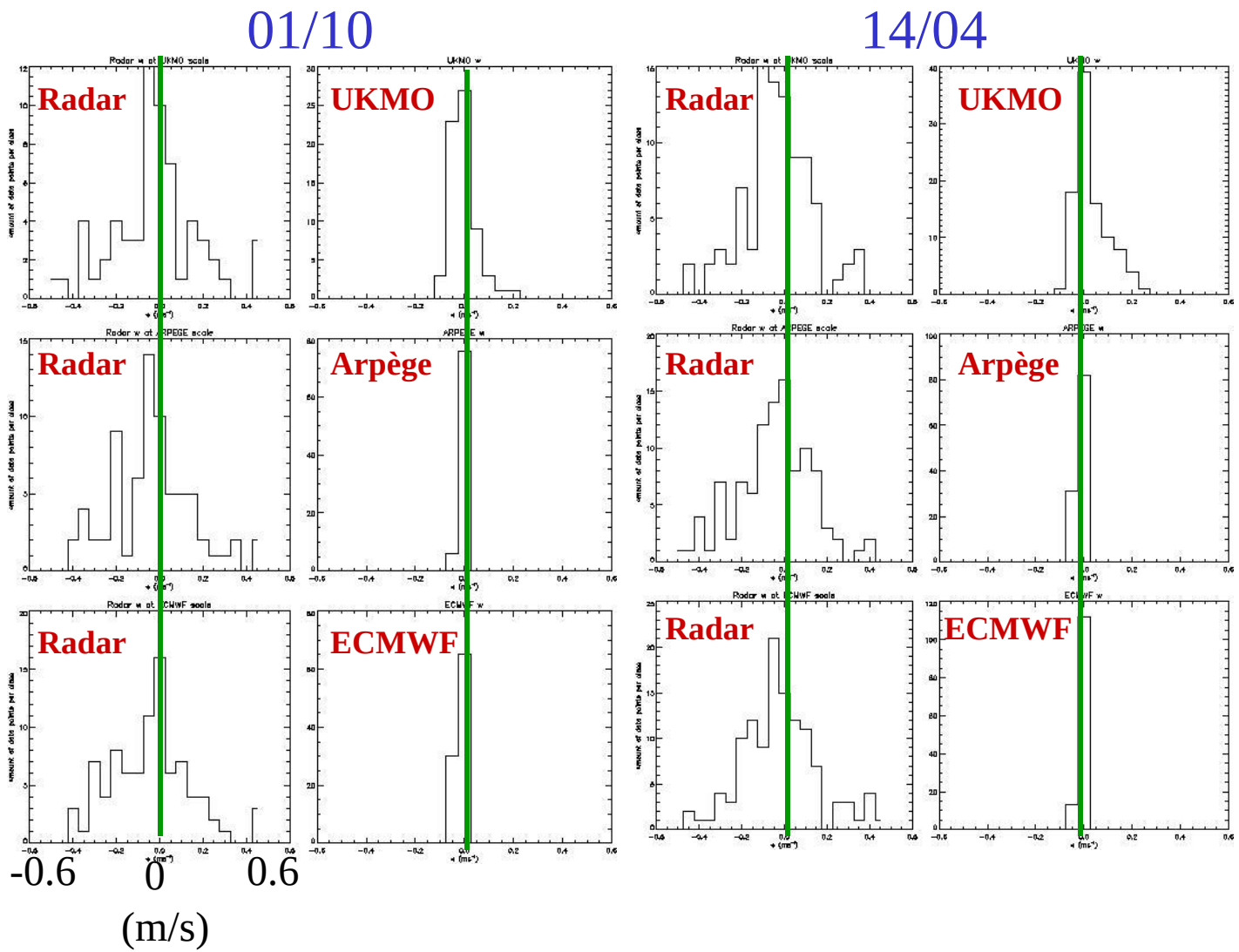
Systematic comparisons with NWP Models : Cloud Fraction

MODELS: ARPEGE,UKMO, ECMWF
DATASET: Radar 94GHz (RASTA)



D. Bouniol

Systematic comparisons with NWP Models : Vertical air velocity



Summary

Retrievals from SIRTA observations :

- Cloud top, base, phase (radar/lidar)
- Aerosol occurrence, altitude (lidar)
- Optical depths (lidar), Lwc and Iwc (radar)
- Particle size (lidar/radar and ir/lidar)
- Particle shape classification (lidar depolarization)
- Vertical air velocity (radar)
- *Validation and methodology studies for space retrievals (Calipso, Polder, Modis, Misr)*

Contribution of the SIRTA to Models / Observations studies :

- Evaluation of the '*Aerosol module'* of CHIMERE Chemistry-Transport model
- Evaluation of '*Boundary Layer scheme'* in LMDz GCM
- Evaluation of '*Boundary Layers Clouds'* in ARPEGE NWP model
- Built of statistic '*Cloud Overlap Laws'* for LMDz GCM
- Comparisons of '*Ice Cloud'* observed and simulated by MM5
- Systematic comparisons between *Cloud properties* observed and predicted by NWP models (UKMO, ARPEGE, ECMWF)

http://sirta.lmd.polytechnique.fr/ haeffelin@lmd.polytechnique.fr