# Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour distribution and variability

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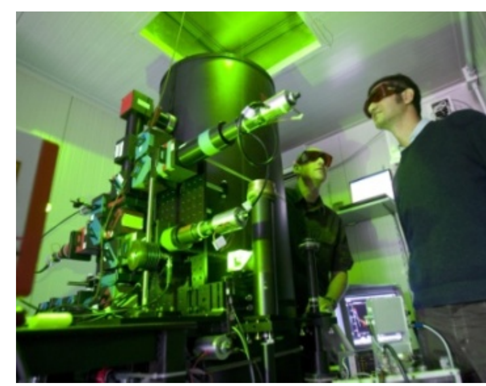
HyMeX

**9th HyMeX Workshop**
**21-25 September 2015, Mykonos, Greece**



# *BASIL Raman Lidar* $3\beta+2\alpha+2\delta+H_2O+T$

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**Measured parameters:**

- particle backscattering coeff. @ 355, 532 and 1064 nm $3\beta$
- particle extinction coeff. @ 355 and 532 nm $2\alpha$
- depolarization ratio @ 355 & 532 nm,
- atmospheric temperature (Rotational Raman technique)
- water vapour mixing ratio (Vibrational Raman technique)
- relative humidity from simultaneous measurements of temperature and water vapor mixing ratio

**Resolution of raw data:**
vertical 7.5 m, temporal 1-10 sec
**Typical resolution of measured parameters:**
vertical 30 m, temporal 1 min

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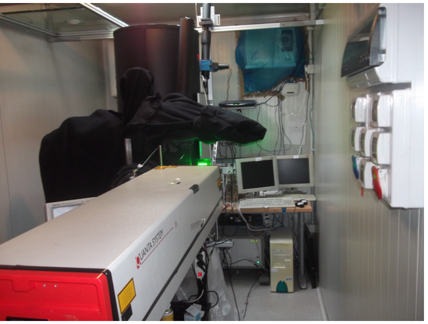


HyMeX

Hydrological Cycle in the Mediterranean Experiment, *HyMeX-SOP1*

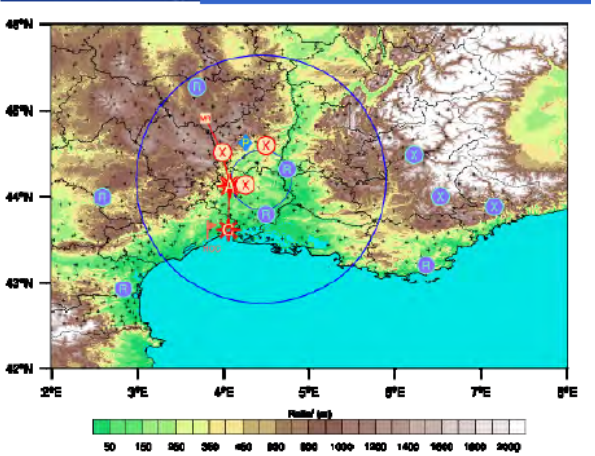
5 September - 5 November 2012

Supersite Cévennes Vivarais - Candillargues

(Southern France, Lat: 43°37' N, Long: 4° 4' E, Elev.: 0 m)

More than 600 hours of measurements distributed over 51 days and 19 IOPs.

HyMeX



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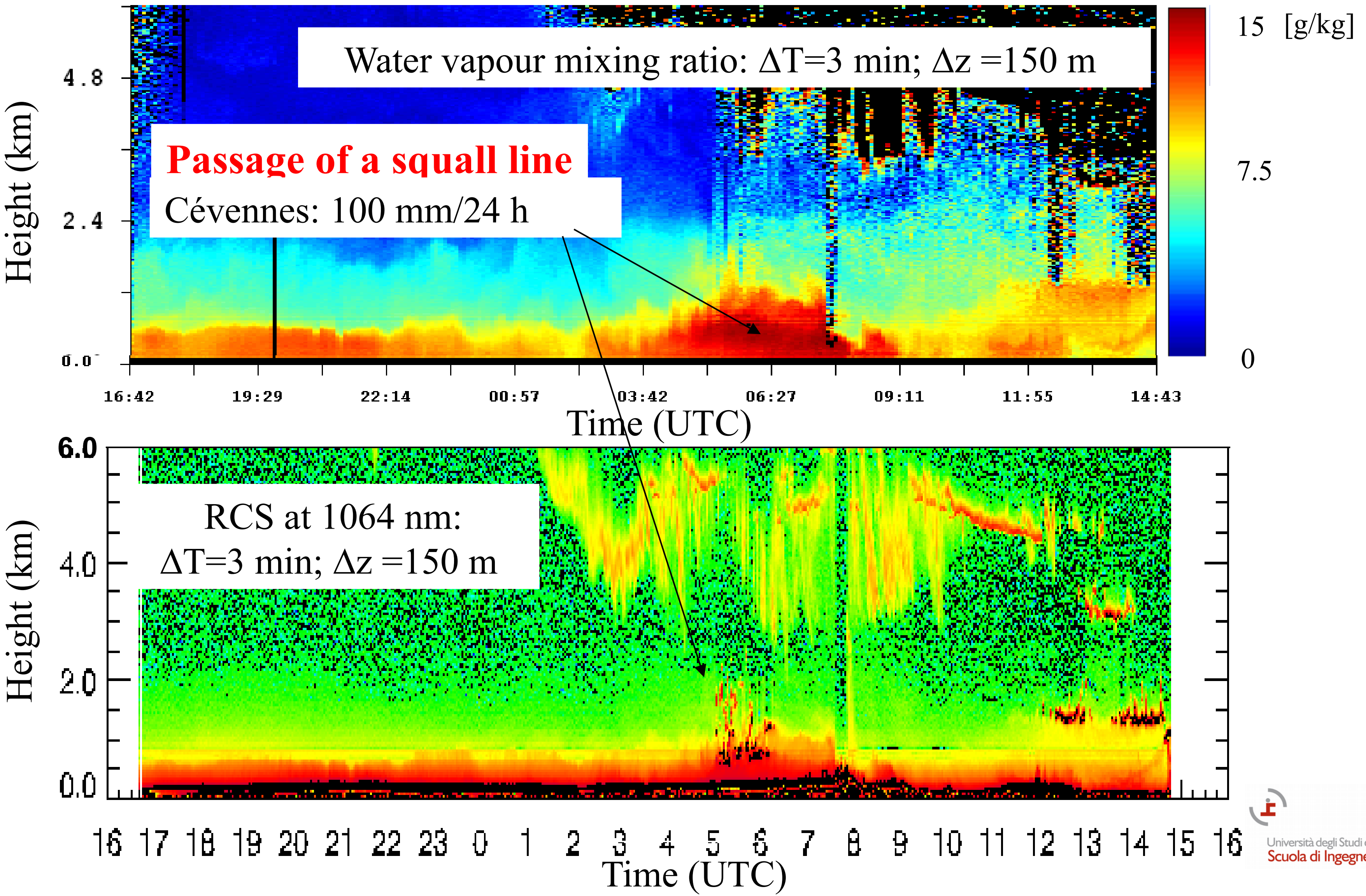
HyMeX

BASIL was deployed in Southern France (Candillargues) to measure the water vapour inflow in this area, which is an important piece of information to improve the comprehension and forecasting capabilities of heavy precipitations in the Northwestern Mediterranean basin.

## Highlights from HyMeX – SOP1

**BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E, IOP 7 - 25-26 September 2012**

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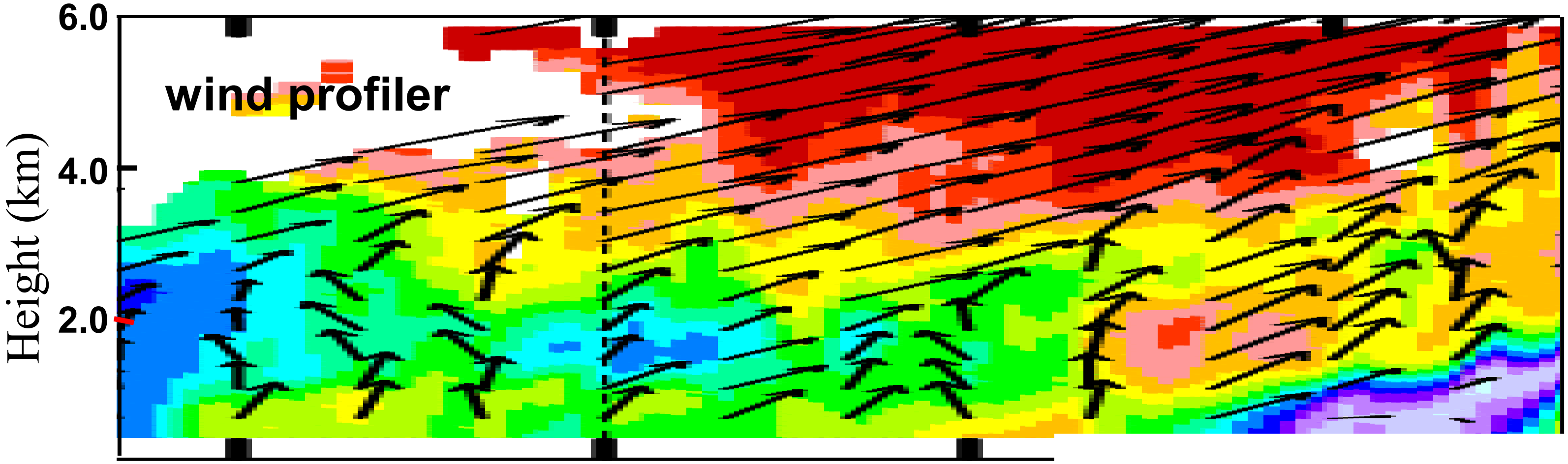
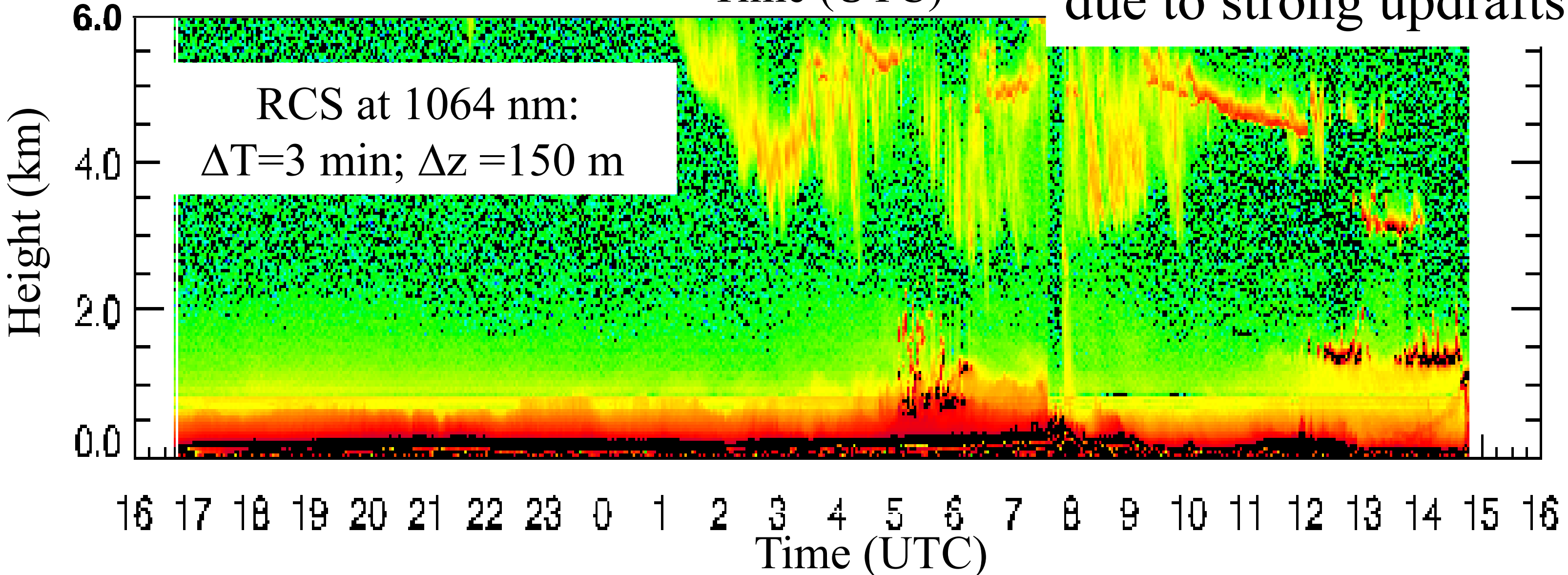
# Highlights from HyMeX – SOP1




Aerosol upward transport due to strong updrafts



# Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour variability

Water vapour measurements from BASIL and LEANDRE2, complemented by high resolution numerical simulations from two mesoscale models (Arome-WMED and MESO-NH), have been considered to investigate **low-level wind reversals** associated with transition events from Mistral/Tramontane to southerly marine flow taking place in the Montpellier region.

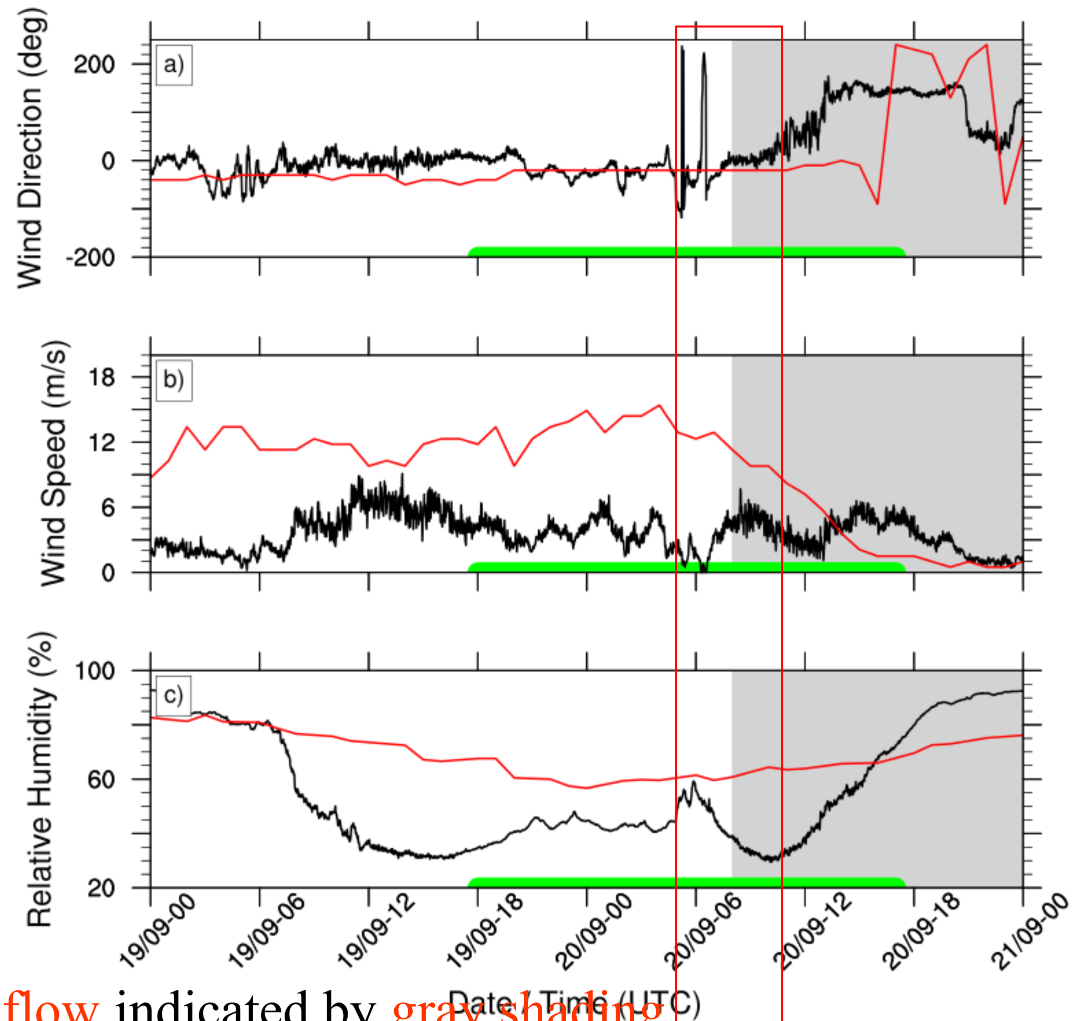
**2 events in the time frame September-October 2012 (19-20 September 2012, 9-17 October 2012 )**

Low-level wind reversals associated with transitions from predominantly Northerly Mistral flow to a predominantly Southerly flow are found to have a strong impact on water vapour transport, leading to a large variability of the water vapour vertical and horizontal distribution.

The high spatial and temporal resolutions of the lidar data (BASIL & LEANDRE2) allow monitoring the time evolution of the three-dimensional water vapour field during these transitions, which is also well captured by the mesoscale models.

# Case study on 19-20 September 2012

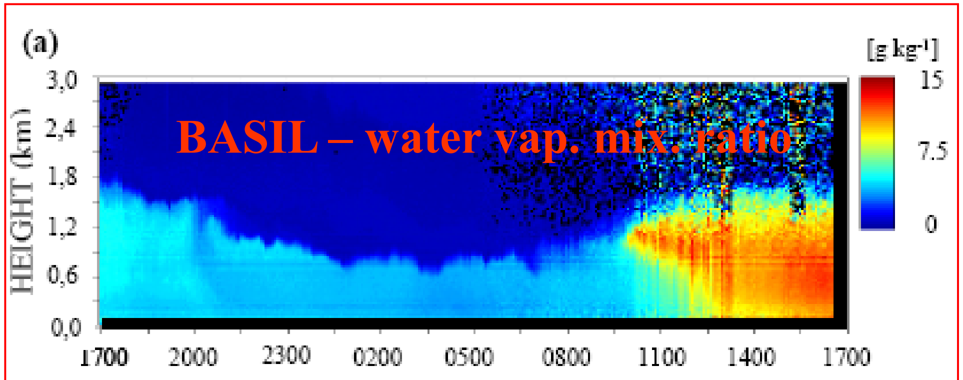
Wind direction and speed and relative humidity for the period from 0000 UTC on 19 September 2012 to 0000 UTC on 21 September 2012 from a met surface station in **Candillargues (black lines)** and from an **offshore buoy station in the Gulf of Lion (red lines)**.




Transition from a **weak Mistral /Tramontane event** to a **southeasterly marine flow** around **0800 UTC on 20 September 2012.**

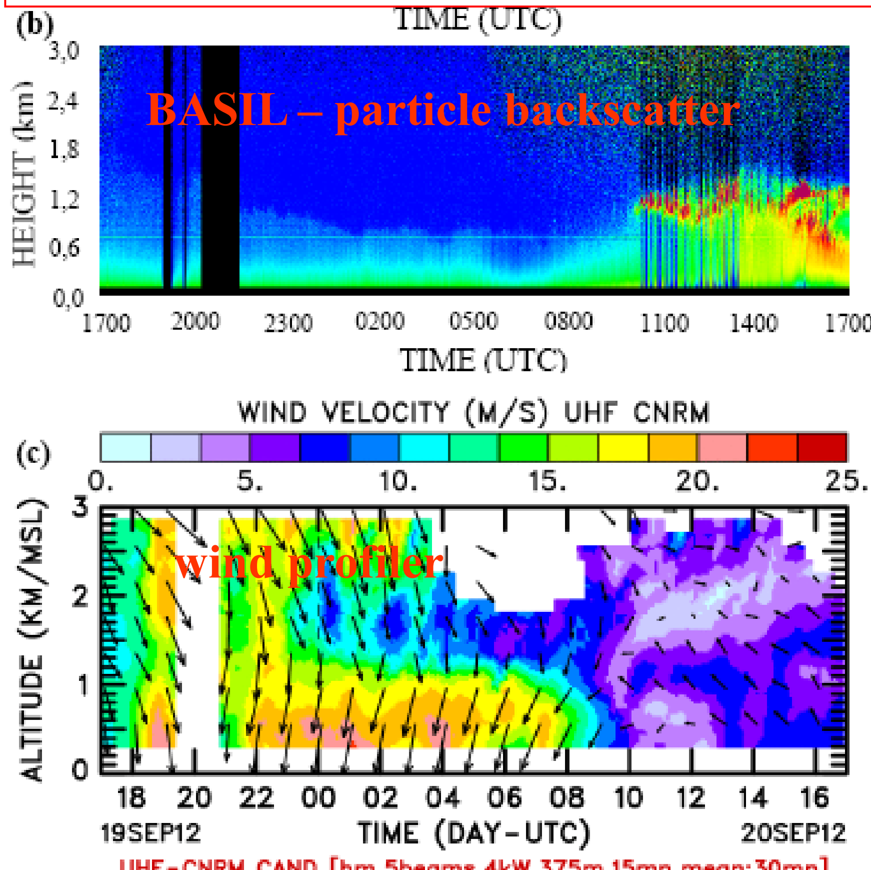
- wind direction from 0 to 150 degrees (from N to SE),
- wind speed from 6 to 2 $ms^{-1}$ in Candillargues
- wind speed from 12 to 1 $ms^{-1}$ offshore
- RH from 30 to 90 % in Candillargues
- RH from 52 to 65 % offshore.

Period corresponding to southeasterly flow indicated by gray shading. The red box represents the time interval for which the lidar data are considered, which includes the transition period.




Arrival of the moist air in Candillargues associated with the southeasterly marine flow starting from approx. 0900 UTC.

In the BL, strong gradient in the water vapour field visible starting from 0930 UTC.

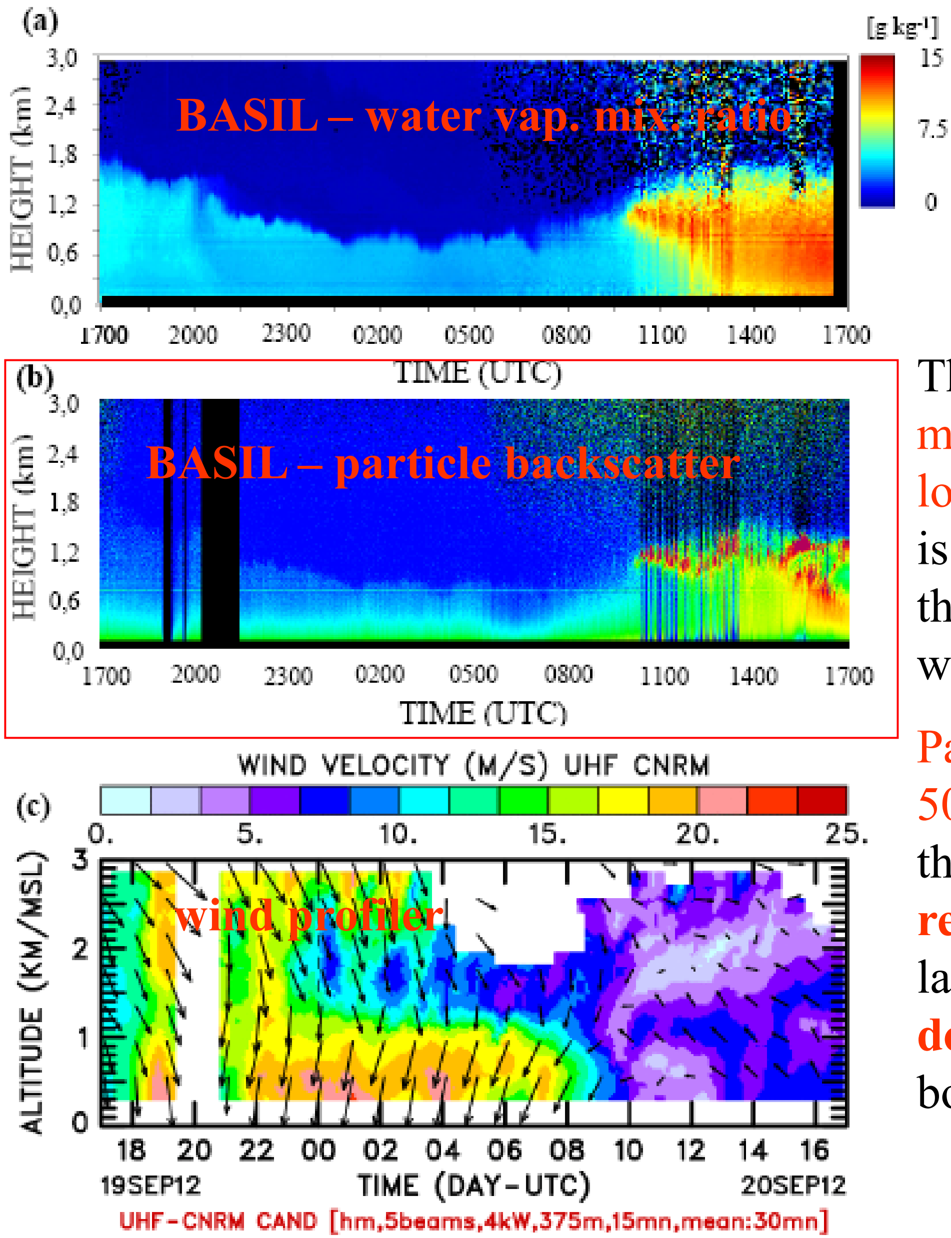



During the Mistral/Tramontane flow, before the arrival of the humid layer, the mixing ratio values in the boundary layer are not exceeding 5-6 g $kg^{-1}$.

The humid layer associated with the marine flow is found to extend up to the boundary layer top, with mixing ratio values as large as 15 g $kg^{-1}$.

Above the boundary layer top the water vapour variability is very limited, with mixing ratio values not exceeding 3 g $kg^{-1}$, both before and after the arrival of the marine flow.

The humid layer is first revealed in the upper portion of the boundary layer and then it is found to progressively fill the boundary layer extending down to the surface.

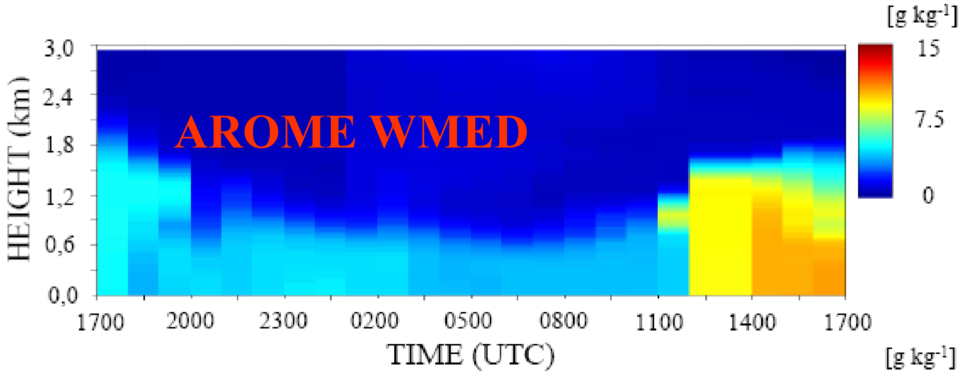


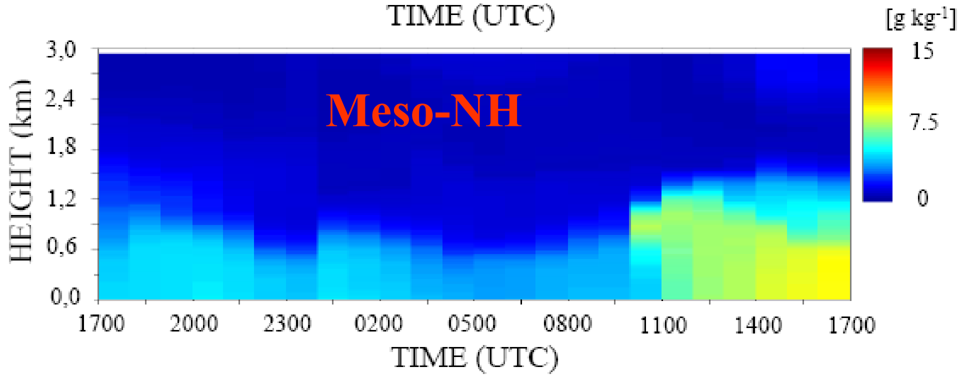

Shortly after the low-level wind reversal, a drastic change (increase) in particle backscatter caused by the arrival of an aerosol-loaded moist air associated with the southeasterly marine flow.

The warmer and more humid air advected by the marine flow is characterized by a larger aerosol loading, predominantly of maritime origin, which is replacing the colder and drier air advected by the Mistral/Tramontane flow, primarily loaded with continental aerosol.

Particle backscatter is found to increase by approx. 50 % as a result of the marine flow arrival. As for the water vapour, the **aerosol layer** is **first revealed** in the **upper portion of the boundary** layer and then is found to **progressively extend down to the surface**, completely filling the boundary layer.

Clouds at the top of the boundary layer are also observed to form starting at 1030 UTC on 20 September 2012 (reddish points in the figure).

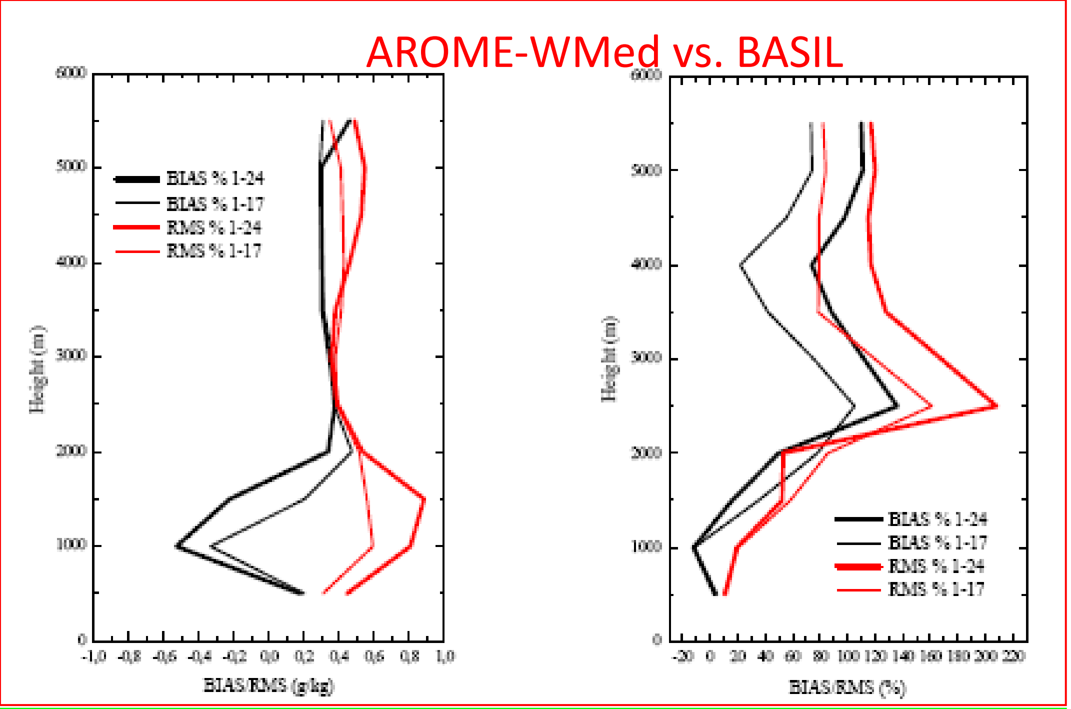


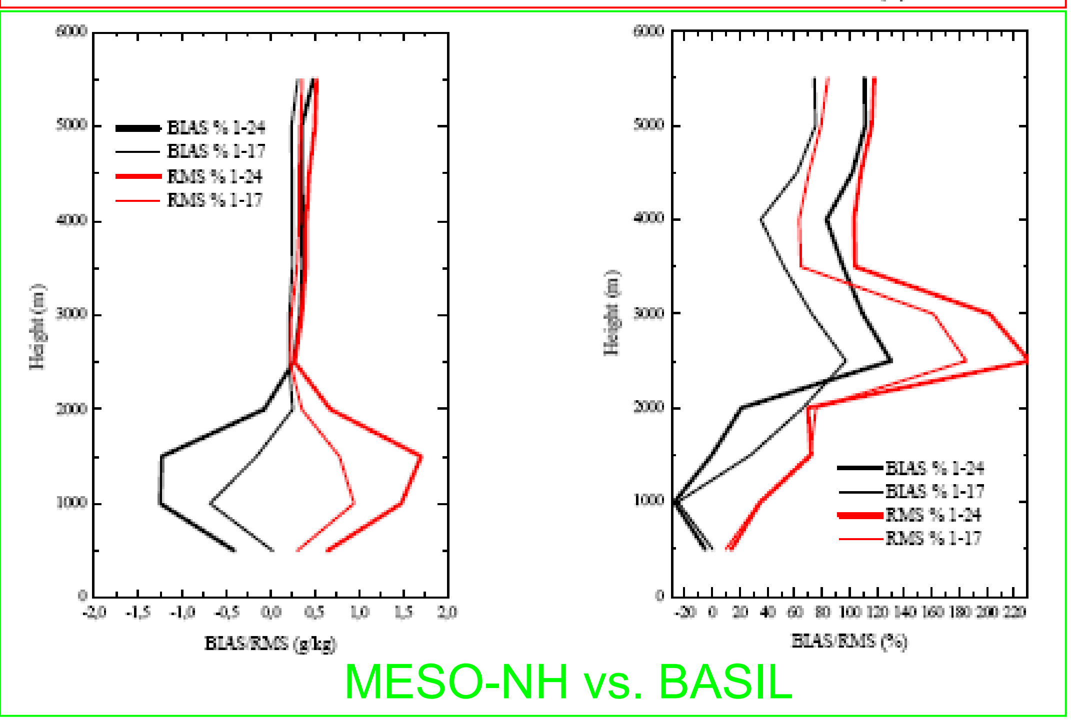




Meso-NH - AROME-WMED forecasts: hourly time steps.

Meso-NH and AROME-WMED properly simulate the time-height structure of the humidity field observed by BASIL, reproducing the arrival of the humid air in the boundary layer with similar mixing ratio values (8-12 g kg-1) for AROME-WMED and slightly lower values (in the range 6-8 g kg-1) for Meso-NH.

The depth of the moist layer also seems to be slightly different for the two models, with the estimate by AROME-WMED being in better agreement with BASIL (moist layer extending for both up to approx. 1500 m) than the one from Meso-NH (moist layer extending up to approx. 1300 m).



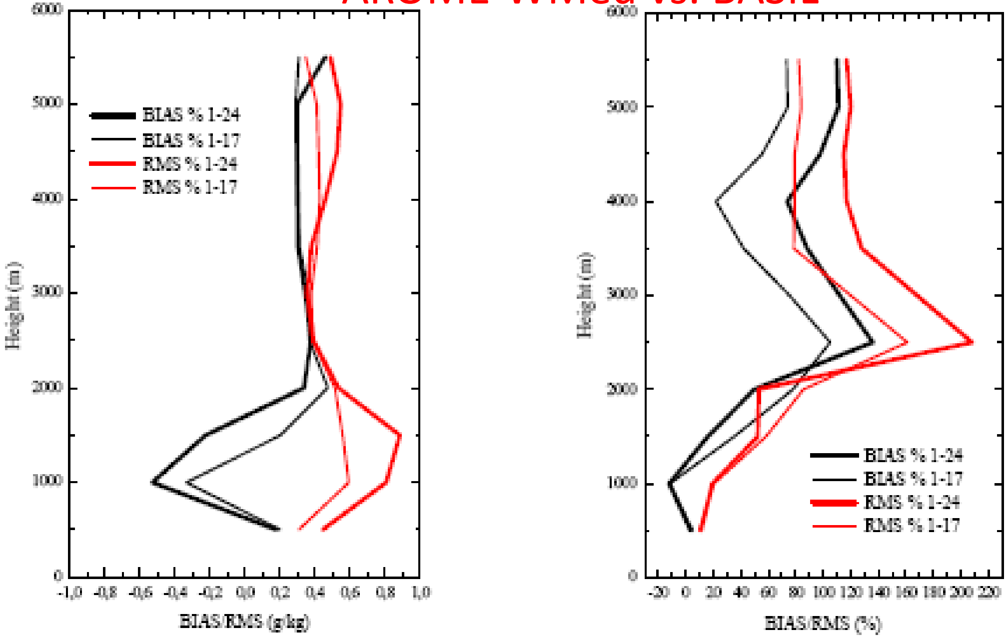

The bias and root mean square (RMS) deviation between BASIL and the two mesoscale models have been computed. Bias and RMS deviations have been computed in the altitude range from **0.5 to 4.5 km** a.s.l., considering **0.5 km intervals.**

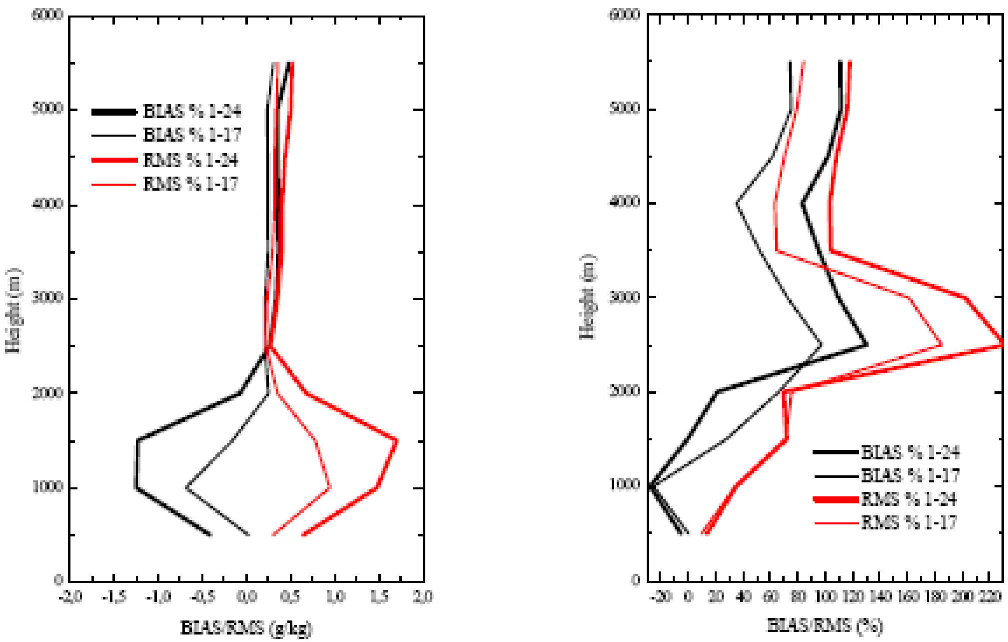
**Left panels: mean absolute bias** and **RMS deviation** (expressed in g/kg) of AROME-WMED/MESO-NH vs. BASIL.

**Right panels**: **mean relative bias** and **RMS deviation** (expressed in %), of AROME-WMED/MESO-NH vs. BASIL.

Mean profiles are obtained considering all 24 profiles.

AROME-WMed vs. BASIL




MESO-NH vs. BASIL

AROME-WMED vs. BASIL

within the BL

mean absolute bias < ±0.6 g/kg

above the BL

mean absolute bias < ±0.3 g/kg

MESO-NH vs. BASIL

within the BL

mean absolute bias < ±1.25 g/kg

above the BL

mean absolute bias < ±0.3 g/kg

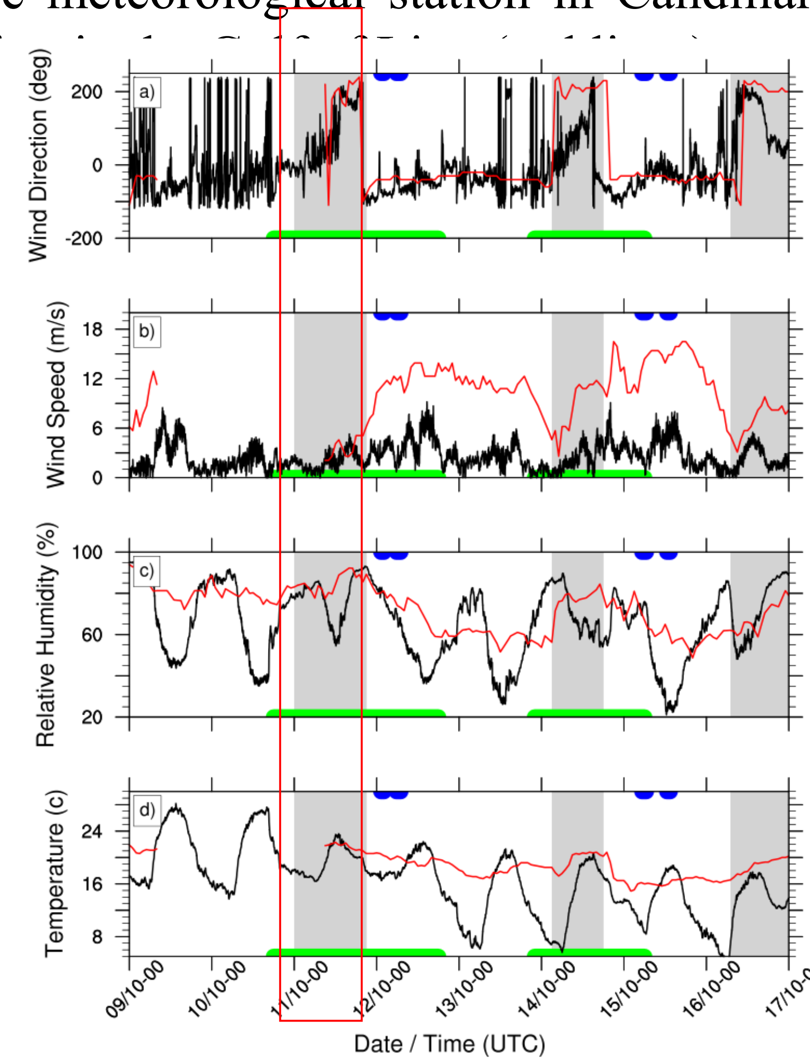
# Case studies within the period 9-17 October 2012

During the period 9-17 October 2012 several flow transitions took place over southern France. Surface wind direction and speed, relative humidity and temperature over the period from 0000 UTC on 9 October 2012 to 0000 UTC on 17 October 2012 as measured by the surface meteorological station in Candillargues (black lines) and by the offshore buoy sta

A first wind reversal episode occurred around 0000 UTC on 11 October 2012 when a transition from a weak Mistral to a southerly marine flow was observed, accompanied by an unequivocal significant change in wind direction and speed, relative humidity and temperature

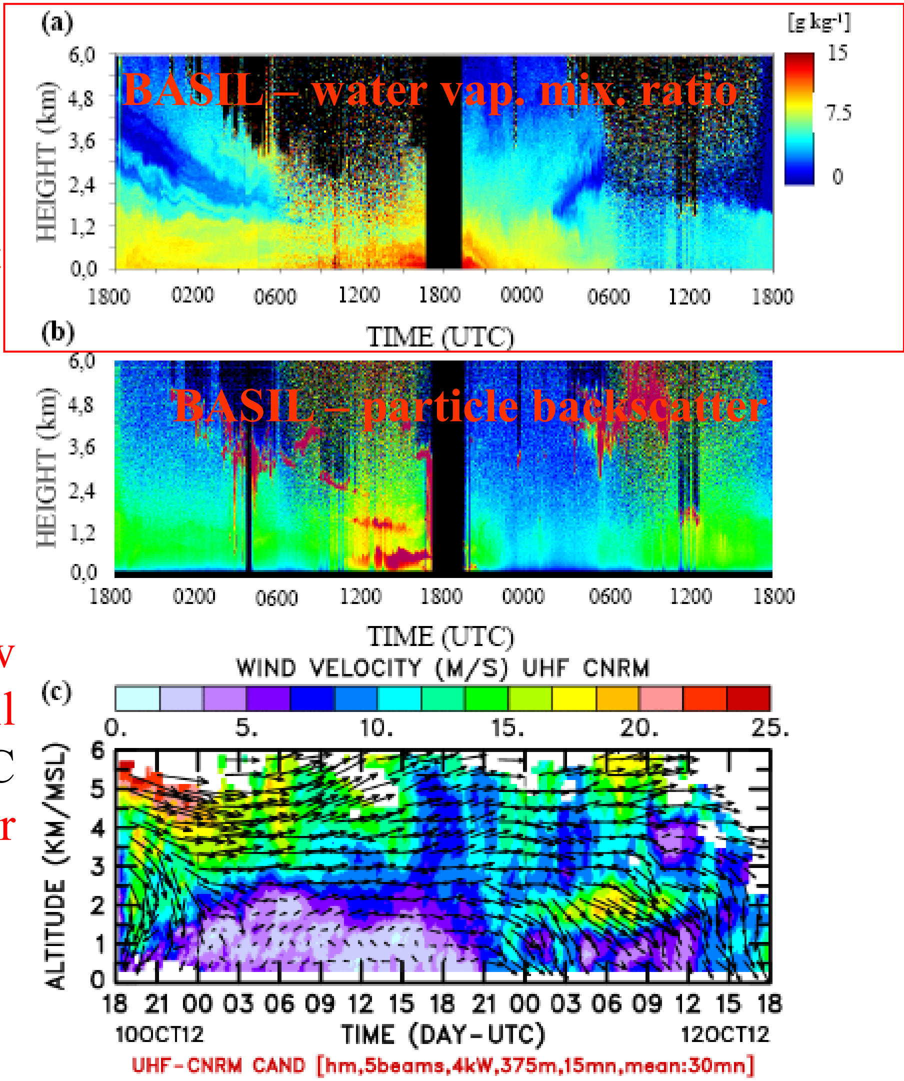
Periods corresponding to southern flows are indicated by gray shading.

The red box represents the time interval we considered for the lidar data are considered, which includes the transition period.



# Case studies within the period 9-17 October 2012

Arrival of the moist air in Candillargues associated with the southeasterly flow starting at approx. 0500 UTC on 11 October.




Before the arrival of the humid layer, the mixing ratio values in the boundary layer are not exceeding 5-6 g $kg^{-1}$.

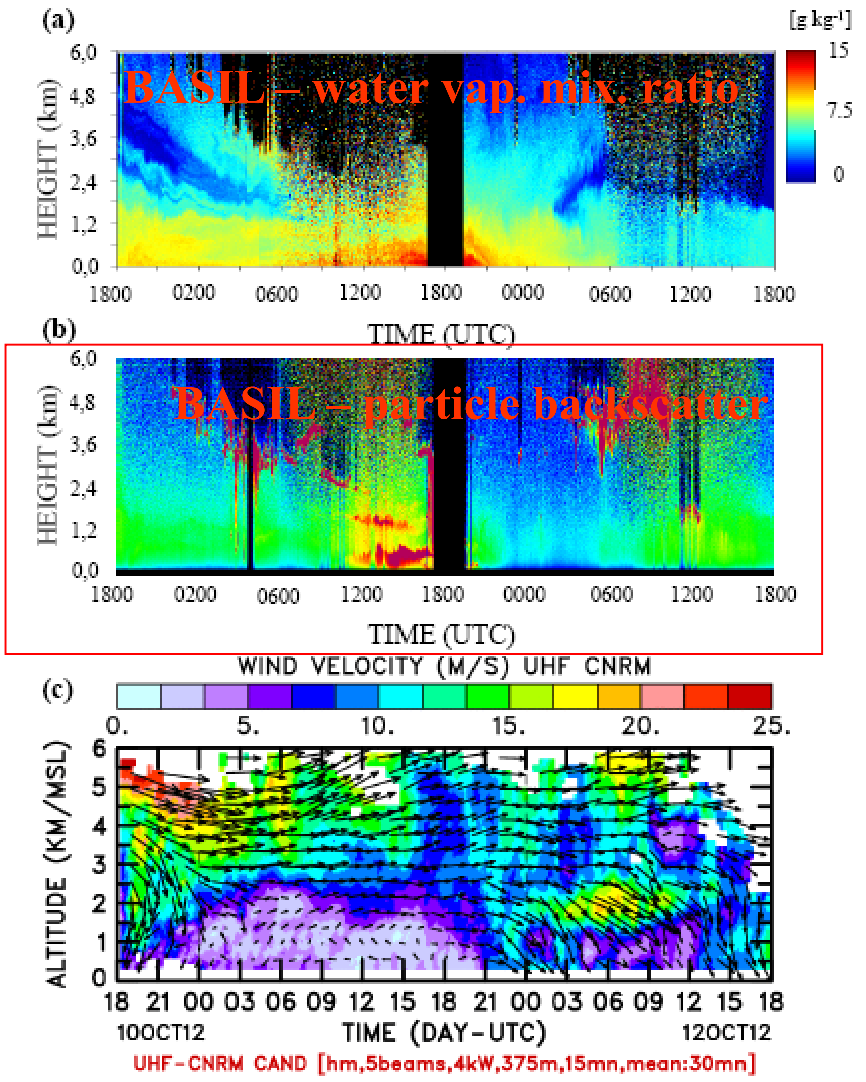
The humid layer associated with the southeasterly flow, extending up to the boundary layer top, is characterized by mixing ratio values as large as 12 g $kg^{-1}$.

BASIL data indicate that the southeasterly flow determines increasing amounts of moisture until the northwesterly wind sets in (around 0000 UTC on 12 October 2012) and starts bringing drier air with time.

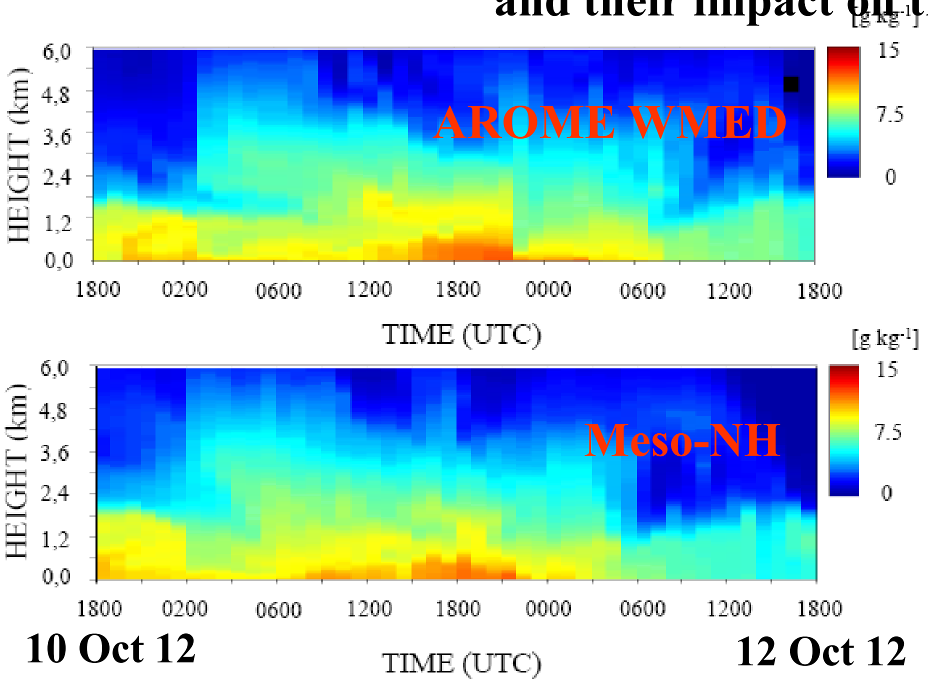
Around 0900 UTC on 12 October 2012, boundary layer water vapour mixing ratio values are found to progressively decrease down to 4-6 g kg-1 because the onset of the northerly flow and the arrival of the associated dry air.

# Case studies within the period 9-17 October 2012

30-40 % increase in particle backscatter caused by the arrival of the warmer and more humid aerosol-loaded air advected by the southerly marine flow, replacing the colder and drier air advected by the Mistral.

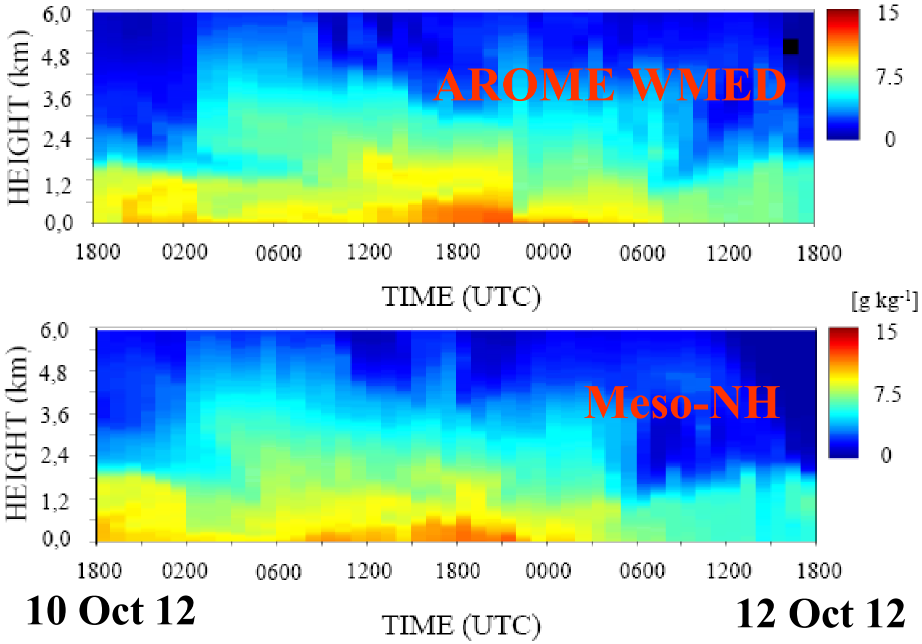


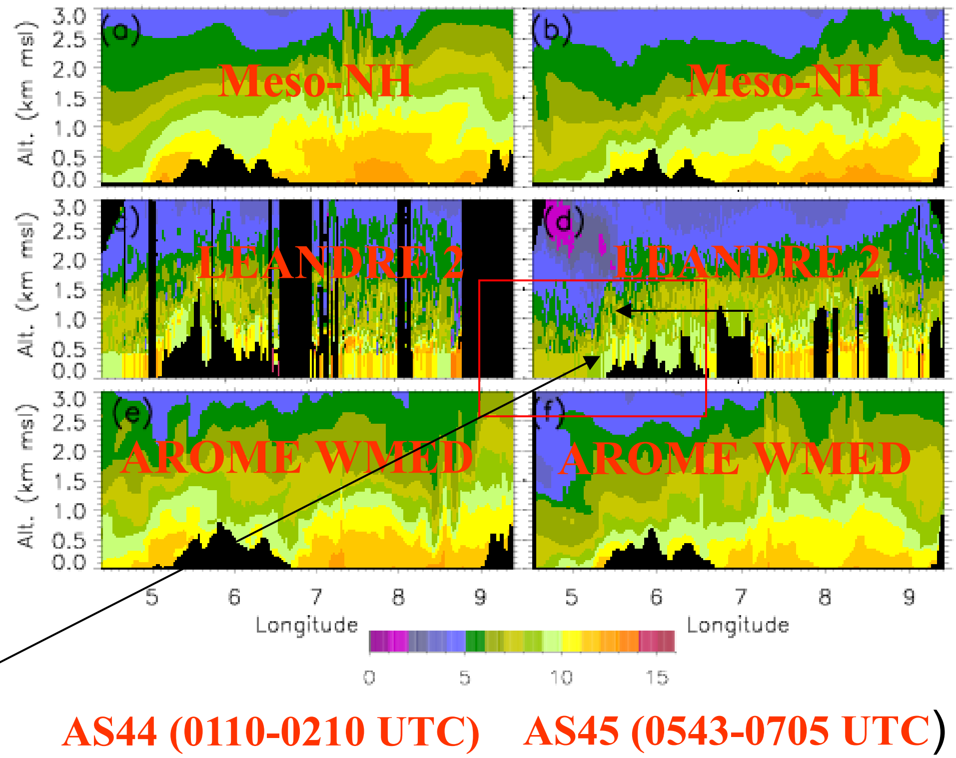
## Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour variability




Meso-NH and AROME-WMED properly simulate the time-height structure of the humidity field observed by BASIL, reproducing the arrival of the humid air in the boundary layer with similar mixing ratio values (14-15 g kg-1).

# Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour variability

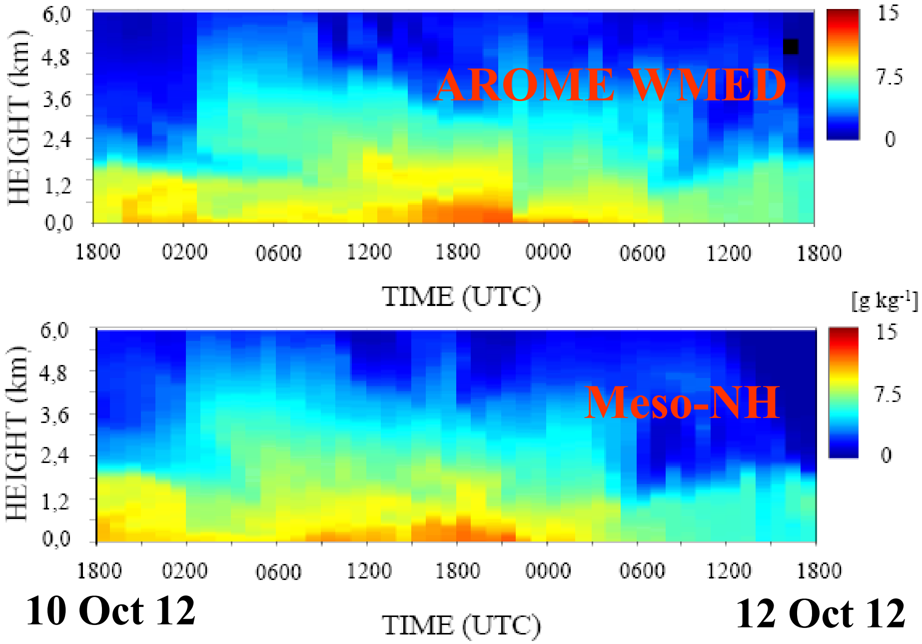


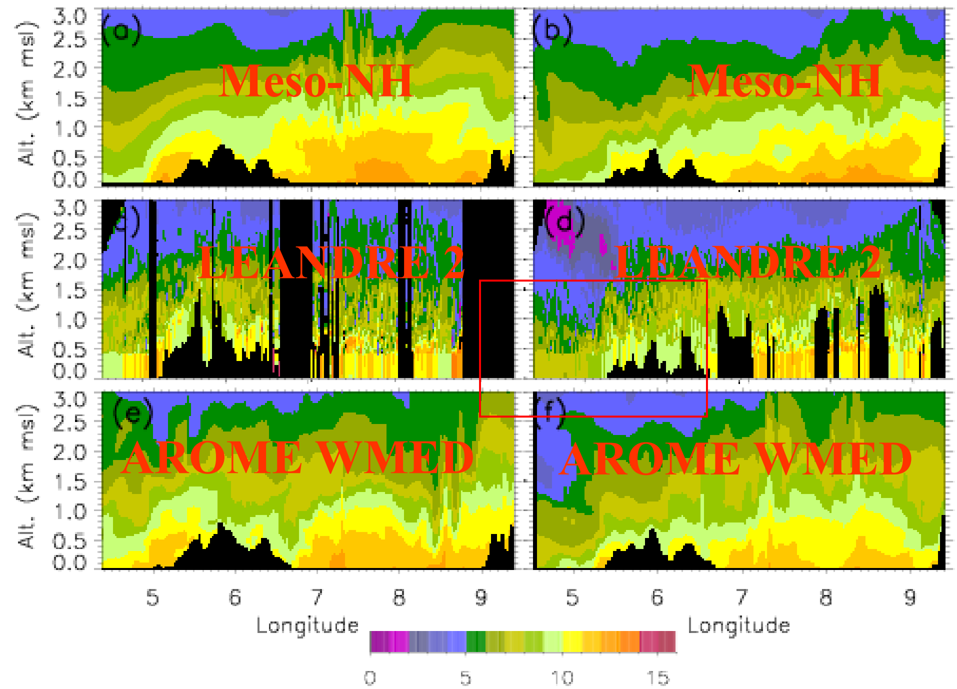




The thinning humid layer captured by LEANDRE 2 is probably the effect of the arrival of the southerly marine flow, with a larger vertical extent and higher mixing ratio values offshore and a lower vertical extent and smaller mixing ratio values onshore.

The high spatial and temporal resolutions of the lidars (BASIL and LEANDRE 2) allow monitoring the time evolution of the three-dimensional water vapour field during these transitions from predominantly northerly Mistral/Tramontane flow to a predominantly southerly flow, which results to be also quite well captured by the mesoscale models.

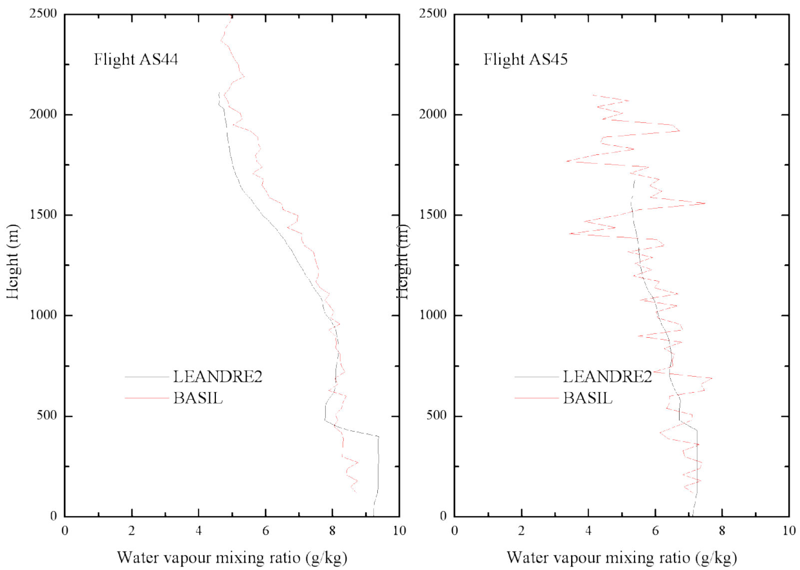
# Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour variability




**AS44 (0110-0210 UTC) AS45 (0543-0705 UTC)**

Profile-to-profile comparison BASIL vs. LEANDRE 2
0110-0118 UTC and 0650-0705 UTC on 12 October 2012




The high spatial and temporal resolutions of the lidars (BASIL and LEANDRE 2) allow monitoring the time evolution of the three-dimensional water vapour field during these transitions from predominantly northerly Mistral/Tramontane flow to a predominantly southerly flow, which results to be also quite well captured by the mesoscale models.

## Future continuation

- Possibility to further refine the study with the consideration of atmospheric temperature measurements performed by BASIL to reveal signatures of these flow transitions also in the measurements of the temperature field.

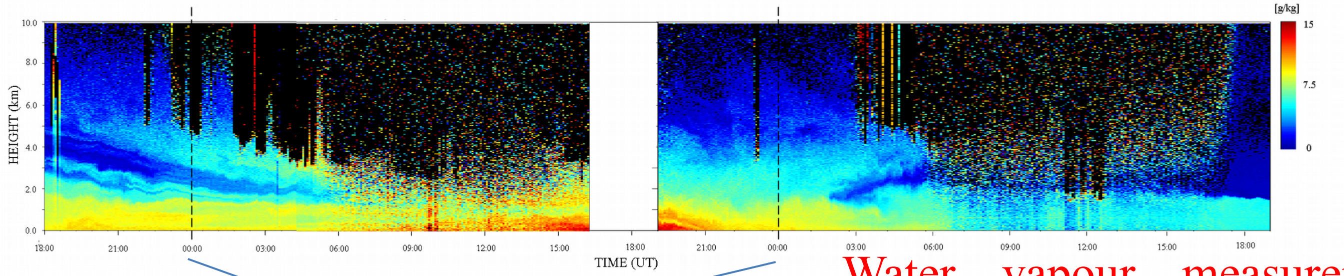
- Possibility to extend this kind of observation/modelling comparison to different meteorological scenarios, with a special attention to those associated with heavy precipitation events in the area of study.

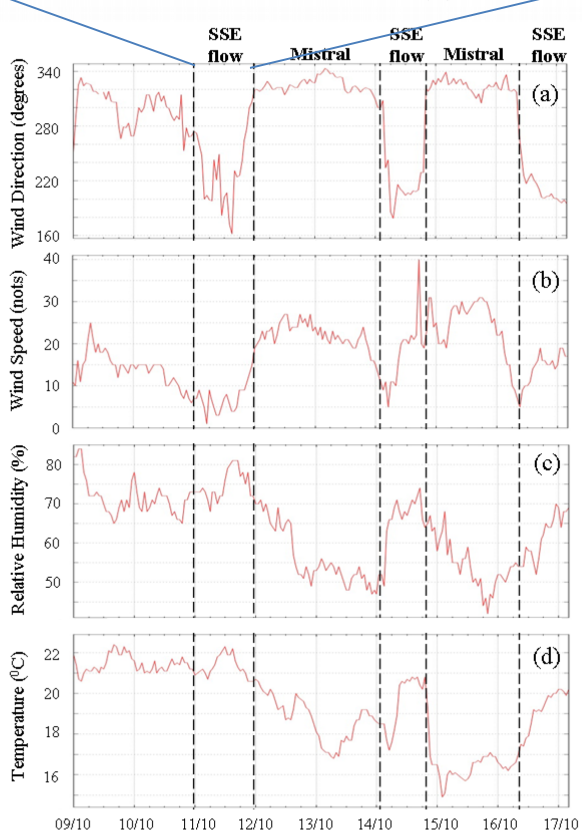
Time evolution of the water vapour mixing ratio as measured by BASIL over a period of 49 h from 18:00 UT on 10 October 2012 to 19:00 UT on 12 October 2012, clearly revealing the change in the humidity field associated with the low-level wind reversal and the onset of the Southerly (sea-breeze) flow.

The variability of surface wind direction and speed and relative humidity fields clearly identify the transition from the Mistral event to a Southerly flow (sea breeze event) around 00:00 UT on 11 October 2012.

time evolution of the wind direction and speed and relative humidity for the period from 0000 UTC on 19 September 2012 to 0000 UTC on 21 September 2012 from a meteorological surface station located in Candillargues (black lines).

# Observation of low-level wind reversals in the Montpellier region



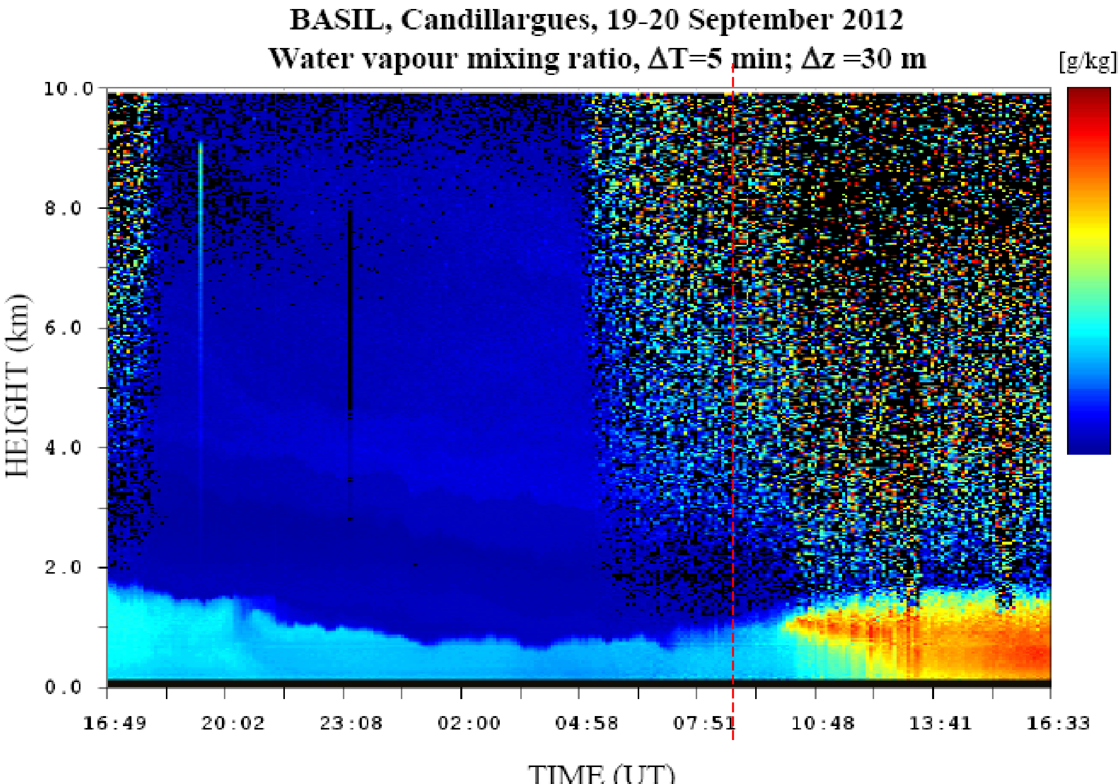

Water vapour measurements from BASIL and LEANDRE2, complemented by high resolution numerical simulations from two mesoscale models (Arome-WMED and MESO-NH), have been considered to investigate low-level wind reversals associated with Mistral/Southerly flow (sea breeze) transition events. Low-level wind reversals associated with transitions from predominantly Northerly Mistral flow to a predominantly Southerly flow are found to be characterized by a large variability of the water vapour vertical and horizontal distribution.

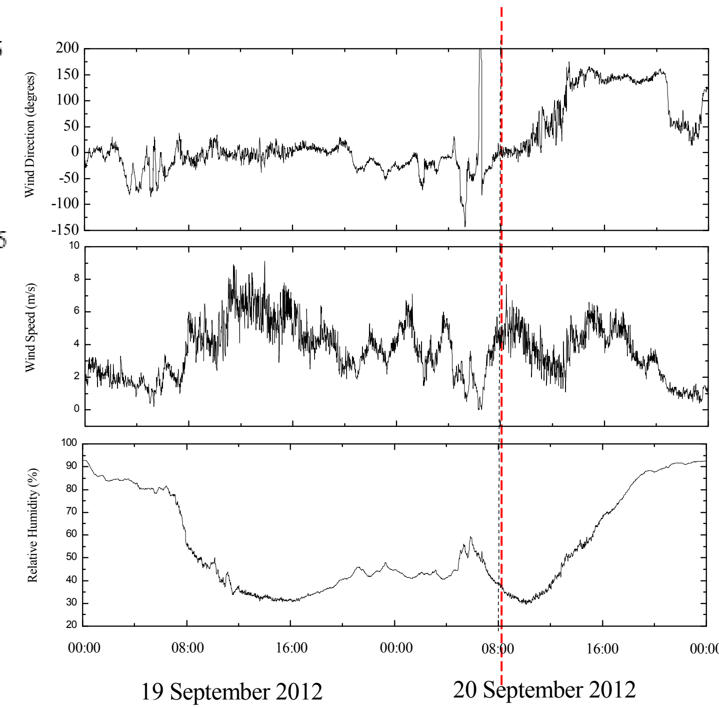
The variability of surface wind direction and speed and relative humidity fields clearly identify the transition from the Mistral event to a Southerly flow (sea breeze event) around 00:00 UT on 11 October 2012

Time evolution of the water vapour mixing ratio as measured by BASIL over a period of 49 h from 18:00 UT on 10 October 2012 to 19:00 UT on 12 October 2012, clearly revealing the change in the humidity field associated with the low-level wind reversal and the onset of the Southerly (sea-breeze) flow.

**Observation of low-level wind reversals in the Montpellier region and over the Gulf of Lion**

Water vapour measurements from BASIL and LEANDRE2, complemented by high resolution numerical simulations from two mesoscale models (Arome-WMED and MESO-NH), have been considered to investigate Mistral/sea breeze transition events. Low-level wind reversals associated with these transitions are found to have a strong impact on water vapour transport, leading to a large variability of the water vapour vertical and horizontal distribution.

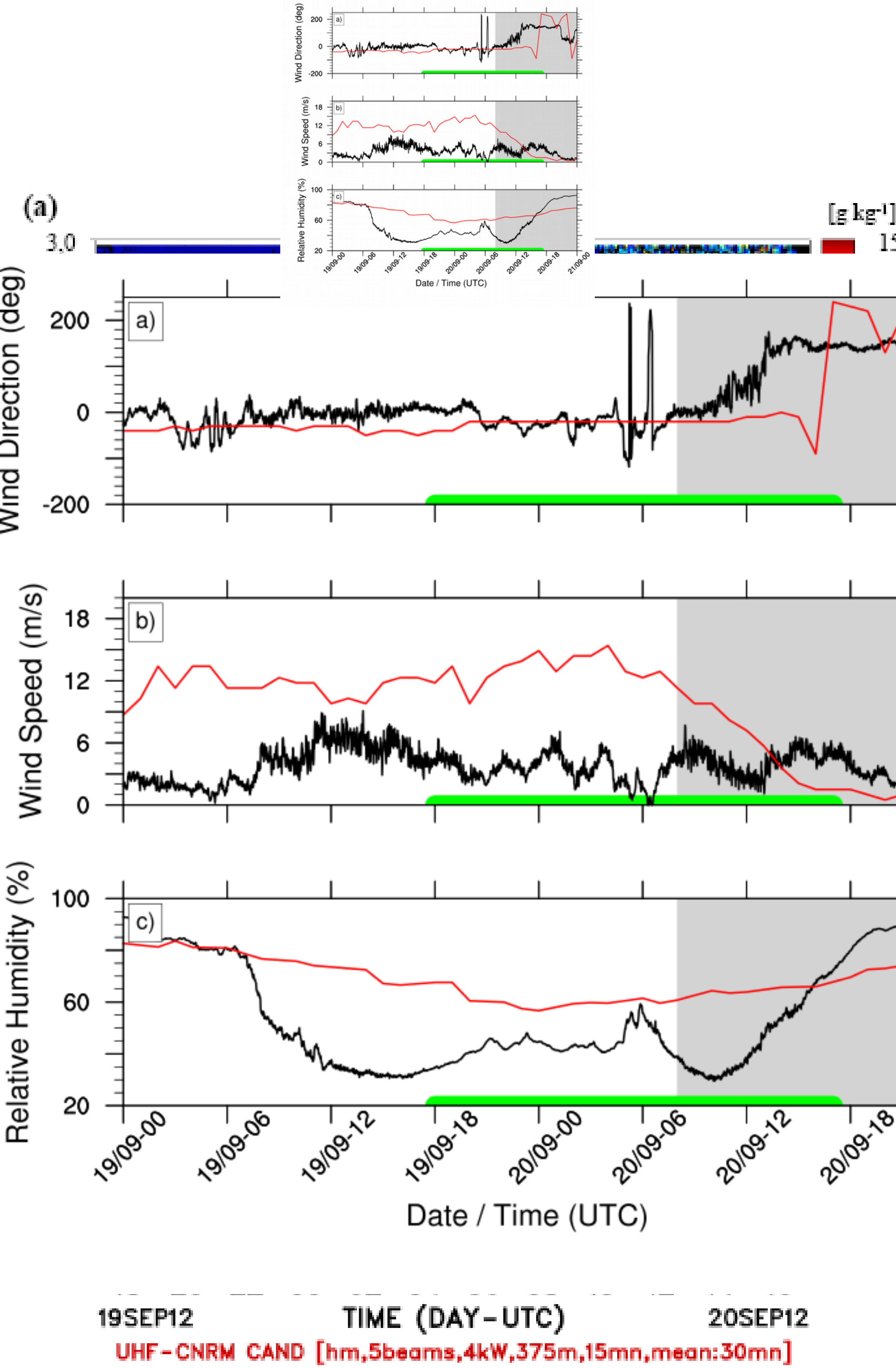



Time evolution of the water vapour mixing ratio as measured by BASIL from 16:49 UT on 19 September 2012 to 16:33 UT on 20 September 2012.

The variability of surface wind direction and speed and relative humidity fields clearly identify the sea breeze onset from a previous weak Mistral event around 08:00 UTC on 20 September 2012.

Time evolution of the water vapour mixing ratio as measured by BASIL over a 24 h time period from 1700 UTC on 19 September 2012 to 1700 UTC on 20 September 2012.




ıl of the moist air in Candillargues ated with the southeasterly marine flow g from approx. 0800 UTC.

; gradient in the water vapour field ; starting from 0930 UTC.

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ıumid layer associated with the marine is found to extend up to the boundary top, with mixing ratio values as large as g-1.

; the boundary layer top the water vapour variability associated with the marine flow arrival is very limited, with mixing ratio values

**Observation of low-level wind reversals in the Gulf of Lion area and their impact on the water vapour distribution and variability**

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# Water vapour intercomparison effort in the framework of HyMeX: airborne-to-ground-based lidar systems

**Intercomparison which involved three lidars:**

- airborne DIAL LEANDRE2 (CNRS DIAL),
- ground-based Raman lidar BASIL,
- ground-based Raman lidar WALI

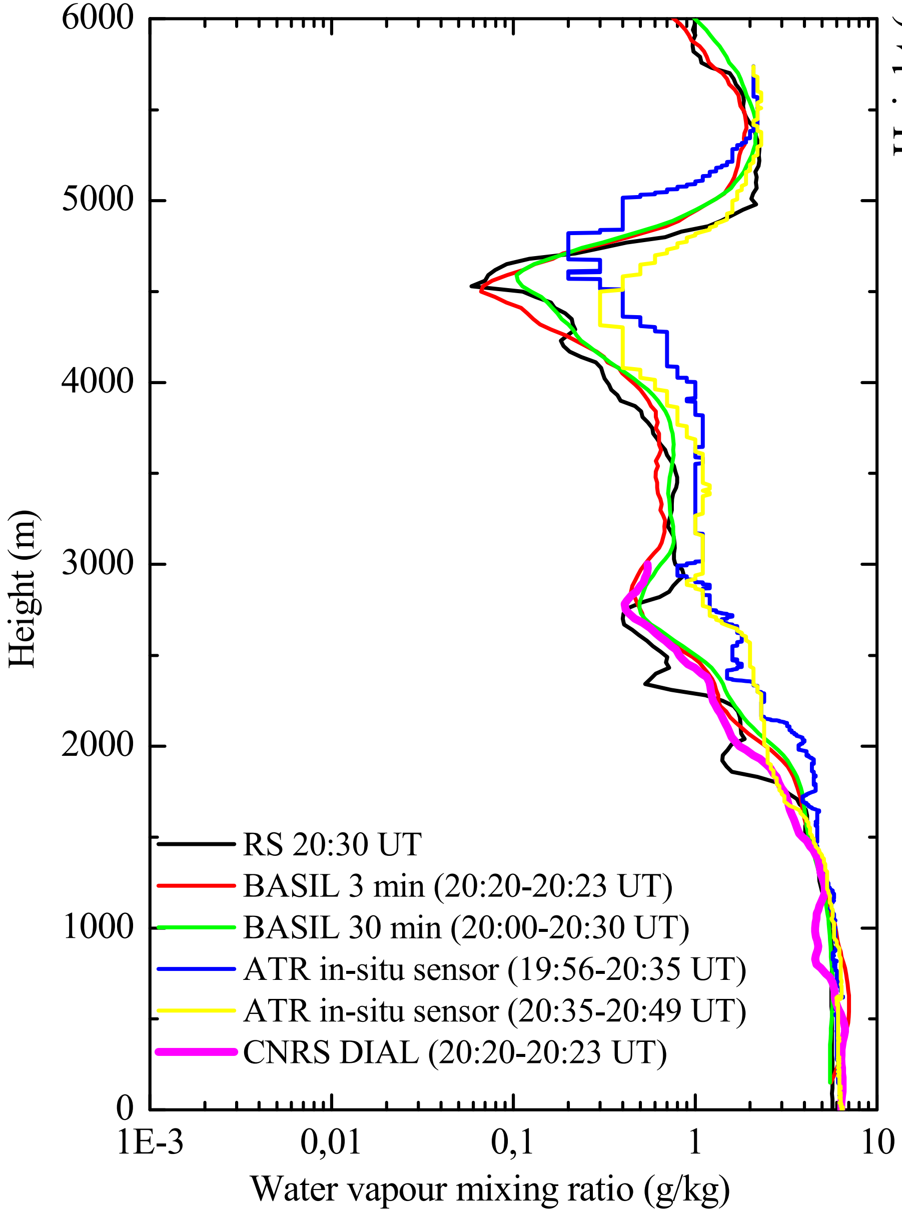
**Additional water vapour sensors:**

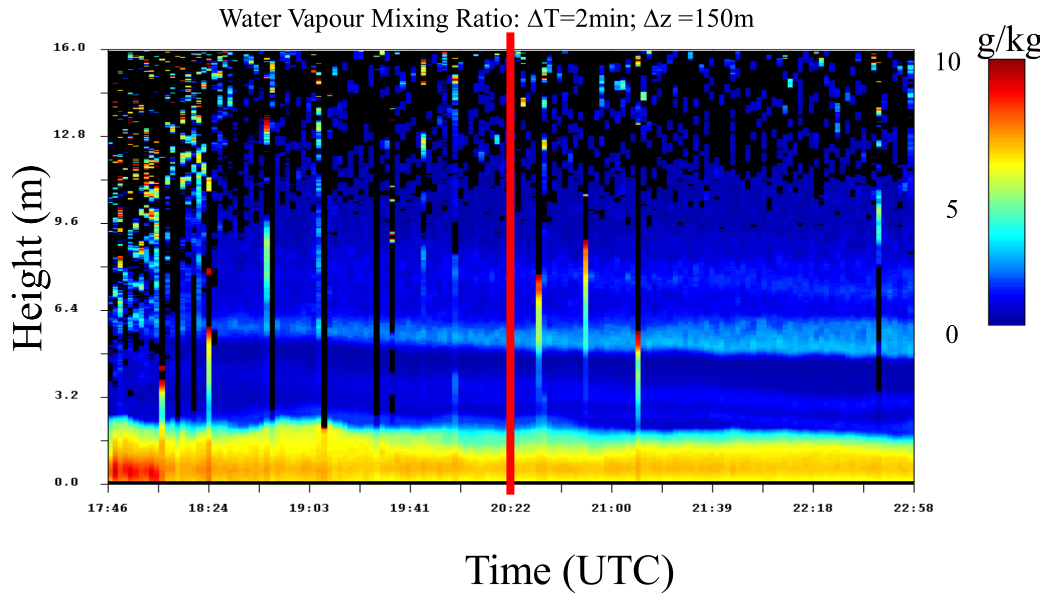
radiosondes,
aircraft humidity in-situ sensor.

**The main objective of this effort is to provide accurate error estimates for these different systems.**

The effort benefitted from few **dedicated ATR42 flights** in the frame of the **EUFAR Project "WaLiTemp"**.

# IOP 3 - WALITEMP EUFAR
# Lidar validation flight on 13 September 2012

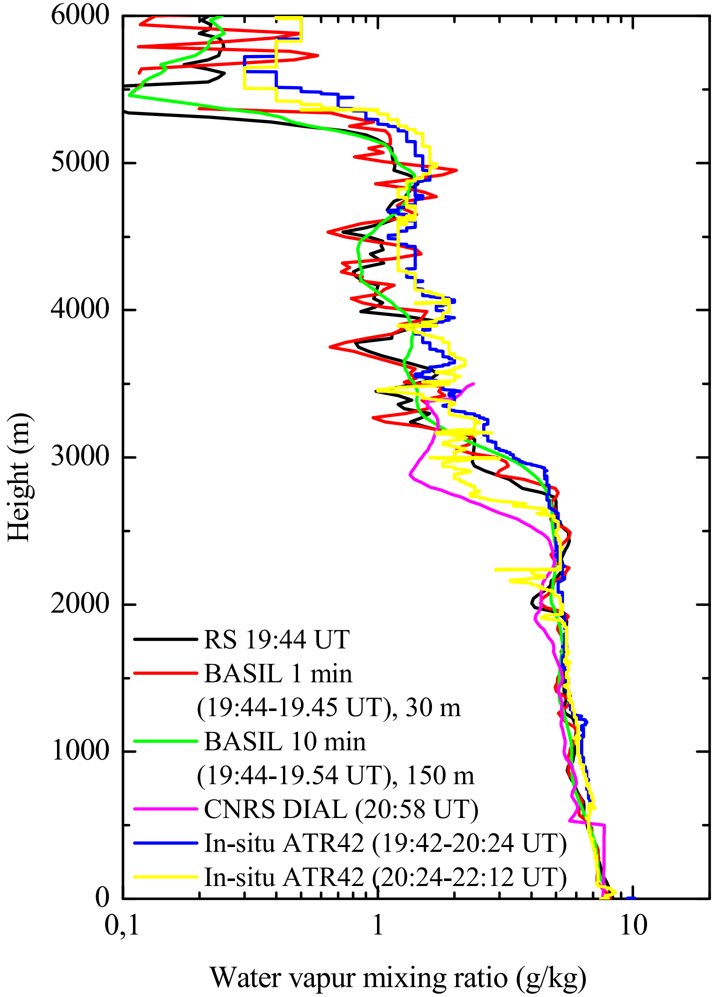


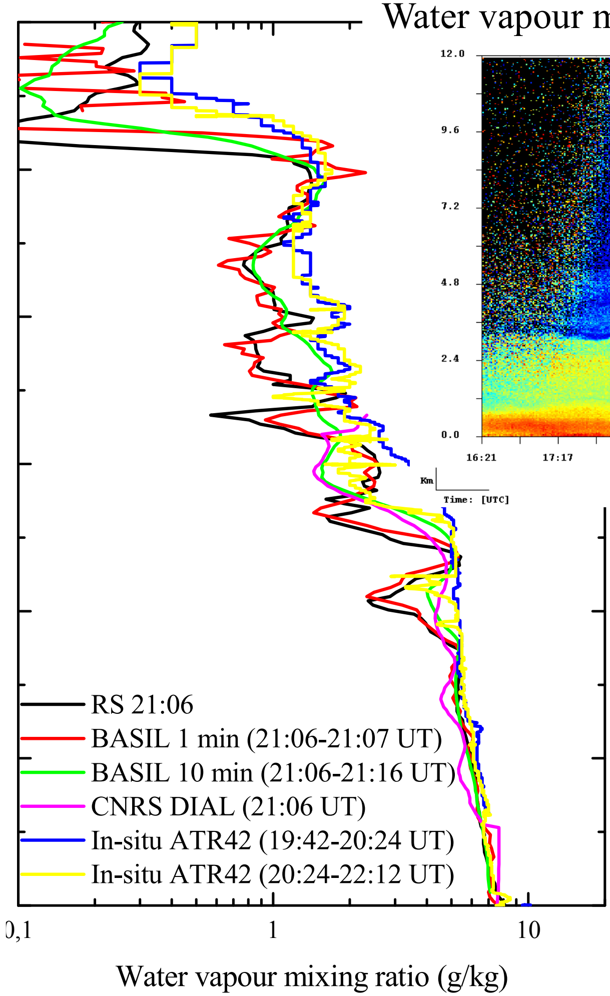




Distance between LEANDRE II and BASIL: 5-10 km

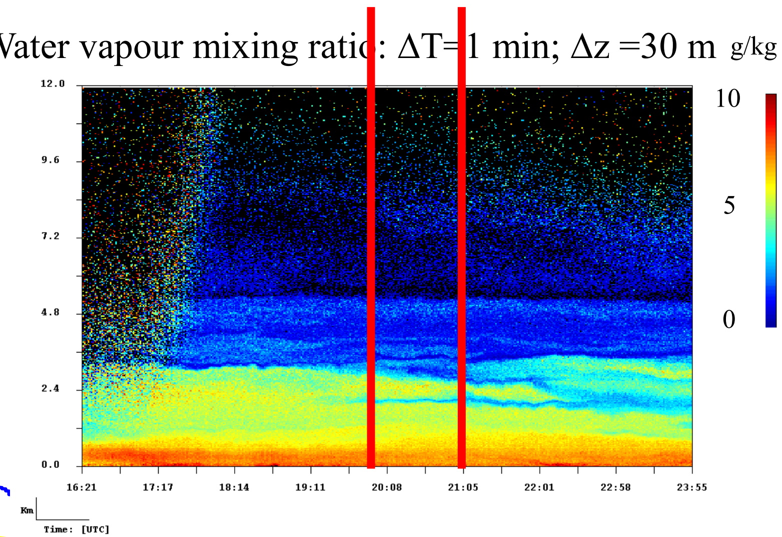
**8th HyMeX Workshop**
**15-18 September 2014, Valletta, Malta**

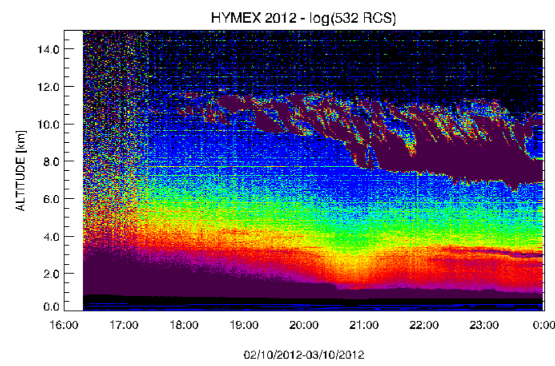
# IOP 9 – WALITEMP EUFAR
# Lidar validation flight on 2 October 2012 (19.44 & 21:06 UTC)



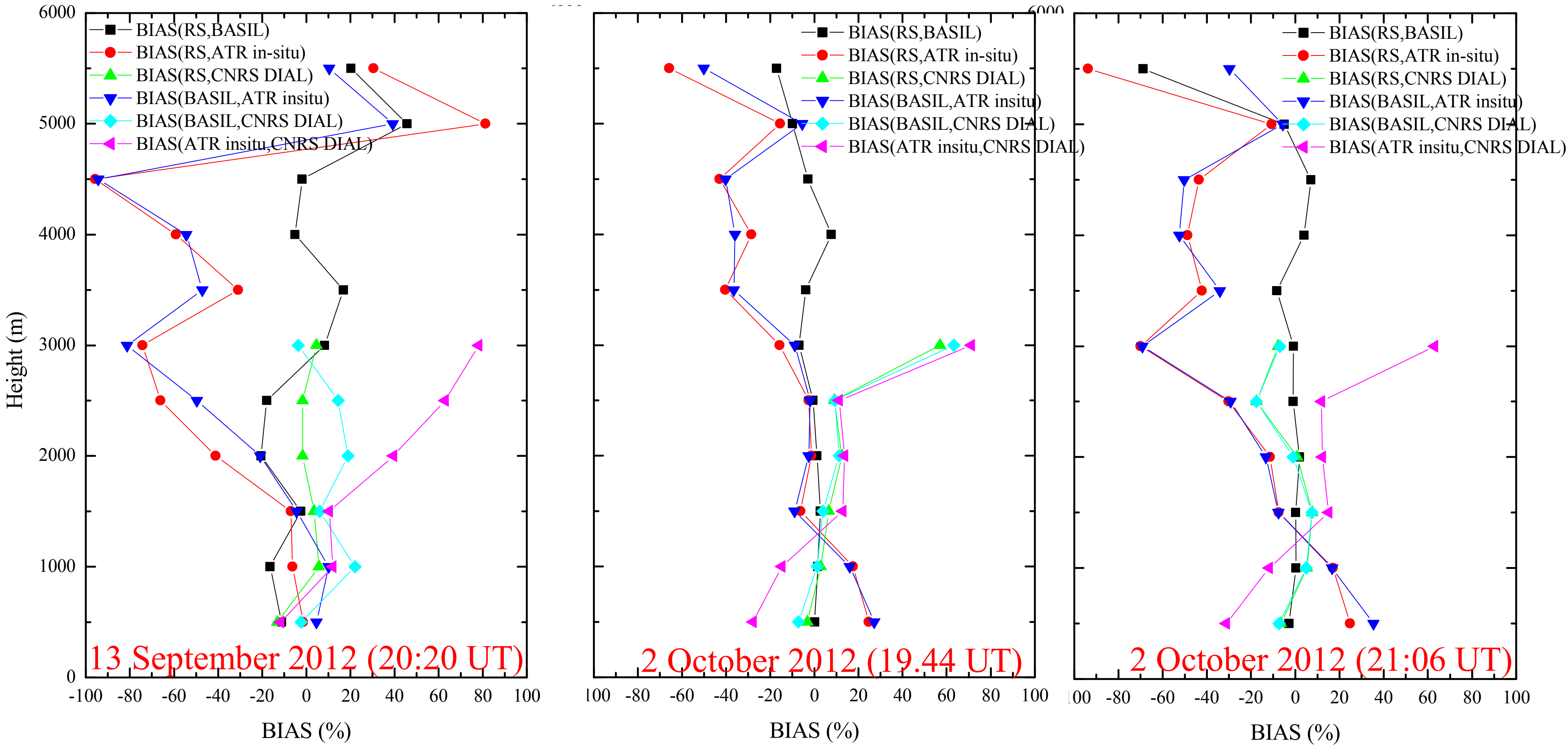

Water vapour mixing ratio: ΔT=1 min; Δz =30 m




HyMeX

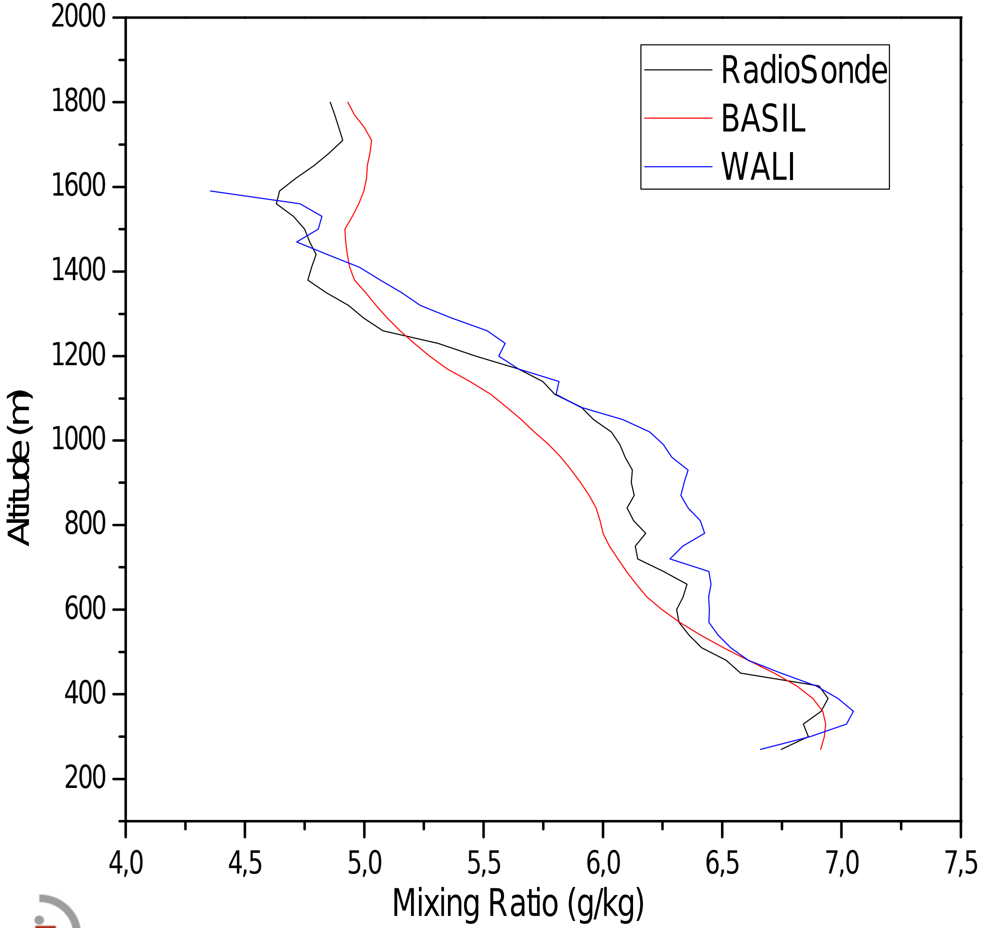
# Mutual biases among the sensors

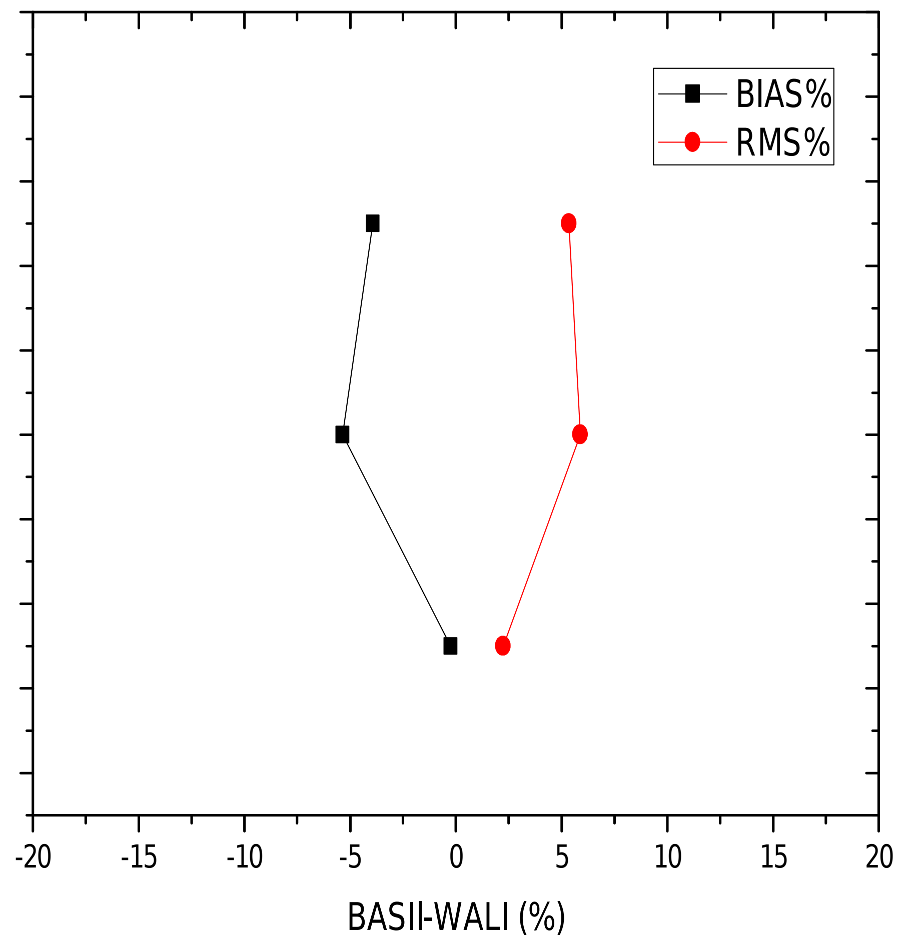



| Sensor Comparison | 13 sett (%) | 2 Oct I (%) | 2 Oct II (%) | Mean % |
|---|---|---|---|---|
| RS vs BASIL | 1.40 | -2.54 | 6.67 | -2.60 |
| RS vs. ATR insitu | -24.53 | -16.03 | -28.72 | -23.09 |
| RS vs. LEANDRE2 | -0.41 | 14.16 | -2.98 | 3.58 |
| BASIL vs. ATR insitu | -26.13 | -13.38 | -21.75 | -20.42 |
| BASIL vs. LEANDRE2 | 9.25 | 13.66 | -3.36 | 6.51 |
| ATR insitu vs LEANDRE2 | 31.89 | 11.07 | 9.87 | 17.61 |

# BASIL- WALI

Specific attention is also dedicated to the WALI/BASIL inter-comparison effort which took place in Candillargues on 30 October 2012 This is the comparison at 21:00 UT. mean BIAS % <3% and mean RMS <5%



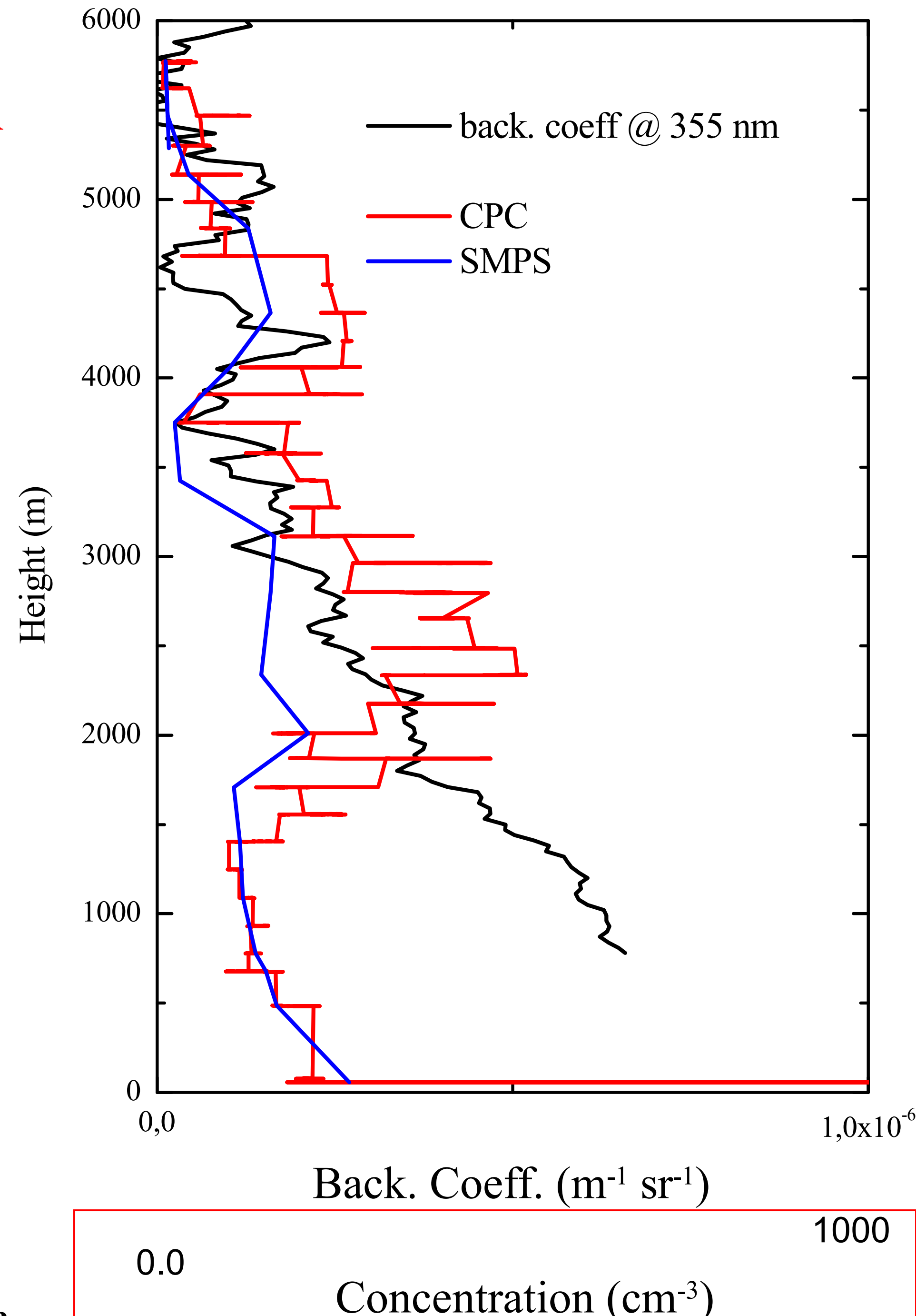
# Comparison of particle backscatter profiles from BASIL with in-situ microphysical sensors onboard the ATR

## EUFAR – ATR Flight n. 38
## 13 September 2012

**Scanning Mobility Particle Sizer (SMPS)**
SMPS,VMPS
Particle size distribution 0.02-0.5 μm
Total concentration ($cm^{-3}$)

**Condensation Particle Counter (CPC)**
5 nm < radius < 2.5 μm
Aerosol number concentration ($cm^{-3}$)

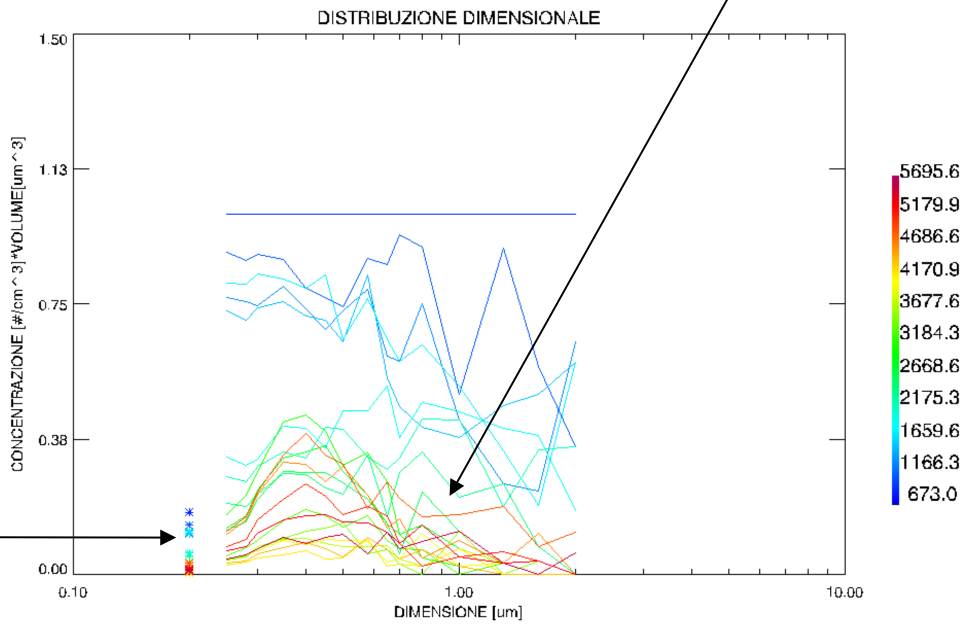
Good agreement between CPC and SMPS and the lidar BASIL. The lidar correctly identifies the various aerosol layers in spite of the low concentration (« clean » air with a concentration less than 1000 $cm^{-3}$).



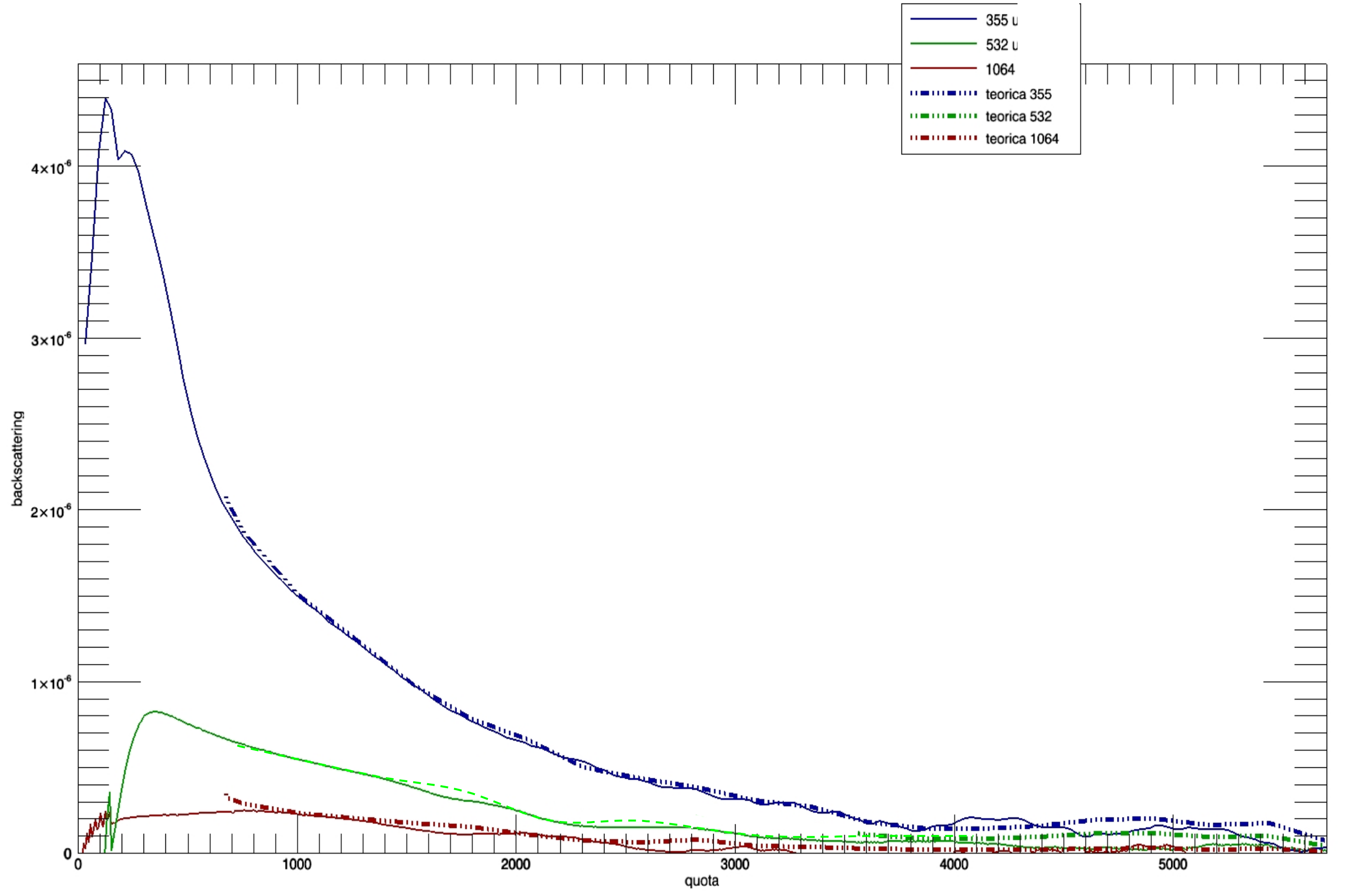
# EUFAR – ATR Flight n. 38
# 13 September 2012

## Optical Particle Counter- GRIMM in situ sensor 0.25um-2.5um
## Size distribution

altitude increase. Coarse aerosol mode disappears

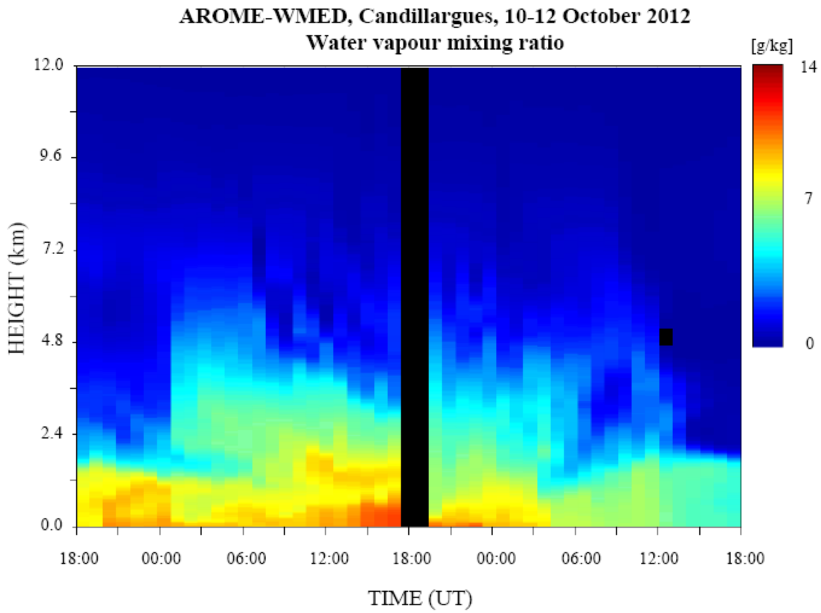


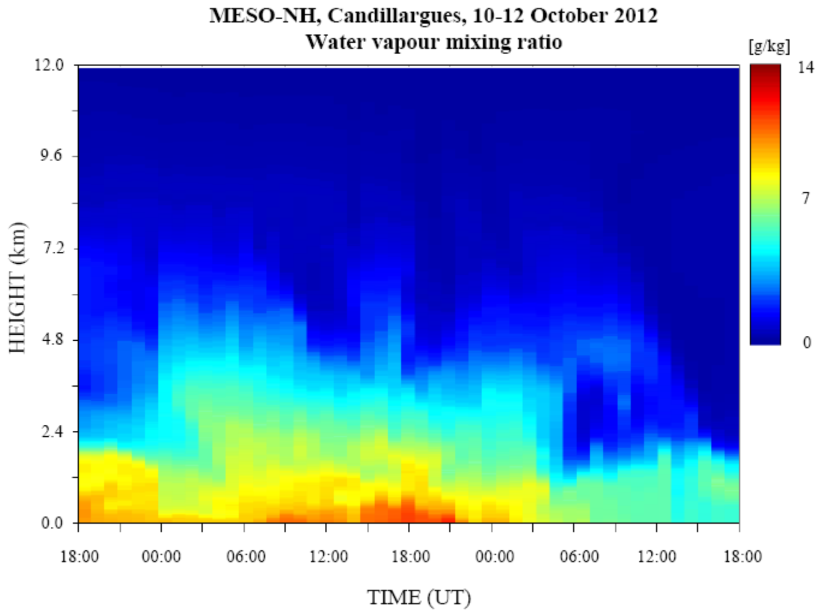

Total particle number




Backscattering coefficient at 355,532 and 1064nm as measured by BASIL and computed through the Mie theory based on the use of particle size distribution from the Optical Particle Counter- GRIMM in-situ sensor 0.25um-2.5um.

Fine mode: soot
Accumulation mode: water-soluble
Coarse mode: Dust-like

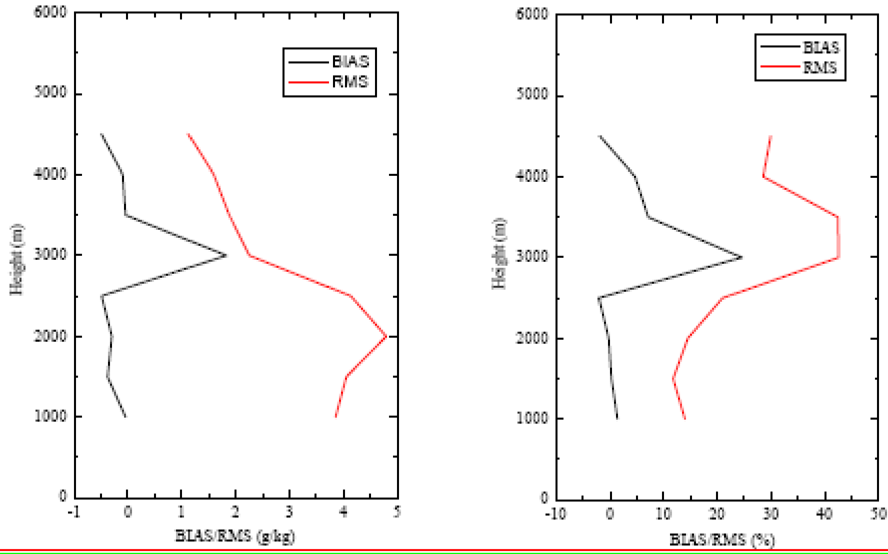


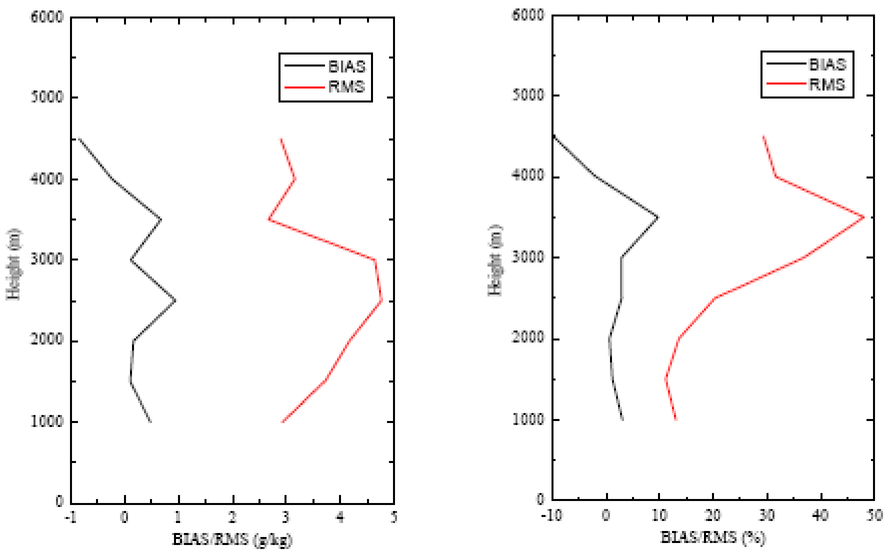




The transition between Mistral and Southerly (sea breeze) flow is also well captured by the mesoscale models AROME-WMED and MESO-NH.

The depth of the moist layer seems to be well estimated by the 2 models.

AROME-WMed vs. BASIL




MESO-NH vs. BASIL

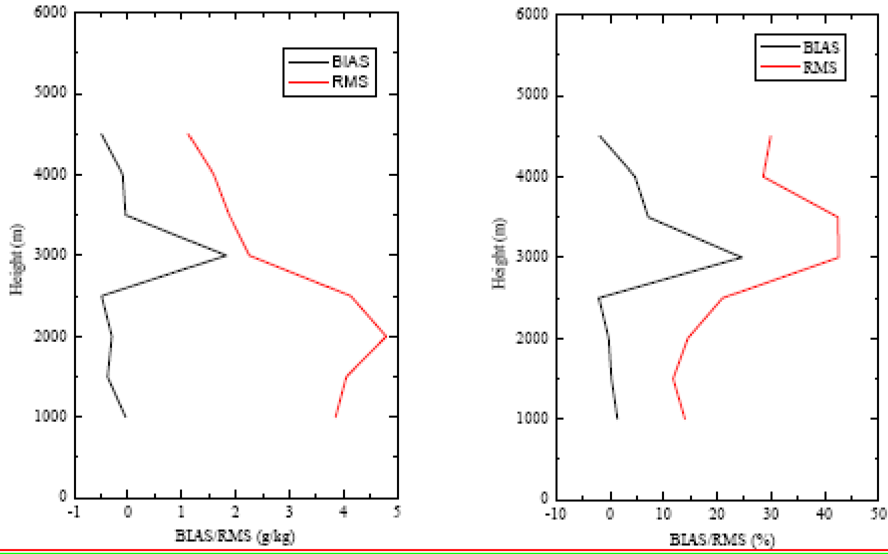
Bias and RMS deviations have been computed in the altitude range from **0.5 to 4.5 km** a.s.l., considering **0.5 km intervals.**

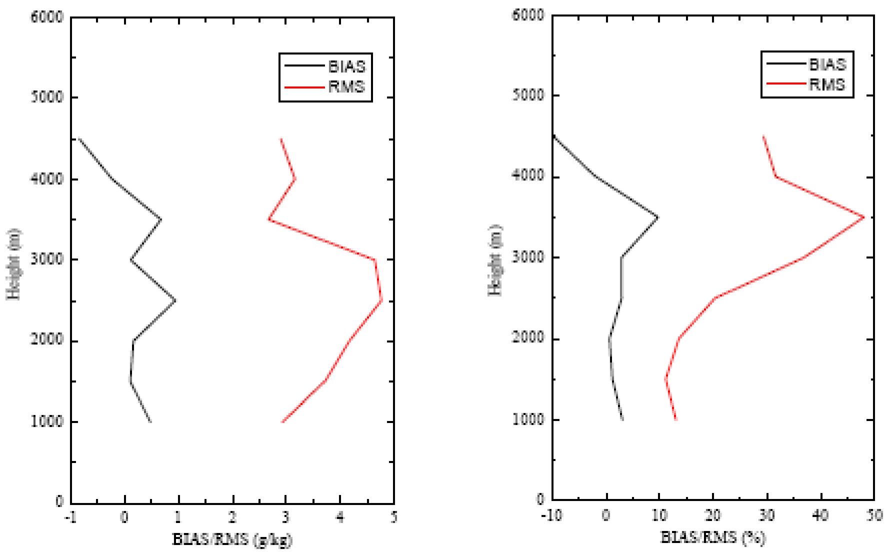
**Left panel:** Absolute bias and RMS deviation (expressed in g/kg) of AROME-WMED/MESO-NH vs. BASIL.

**Right panel**: Relative bias and RMS deviation (expressed in %), of AROME-WMED/MESO-NH vs. BASIL.

Mean profiles are obtained considering all 48 profiles.

## AROME-WMed vs. BASIL



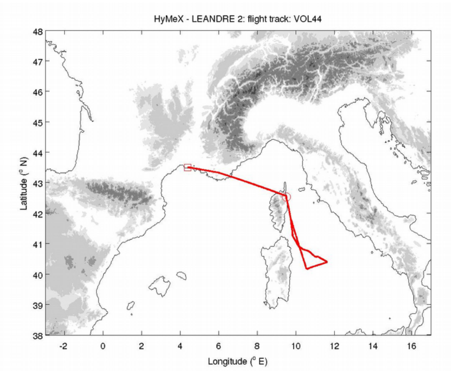




## MESO-NH vs. BASIL

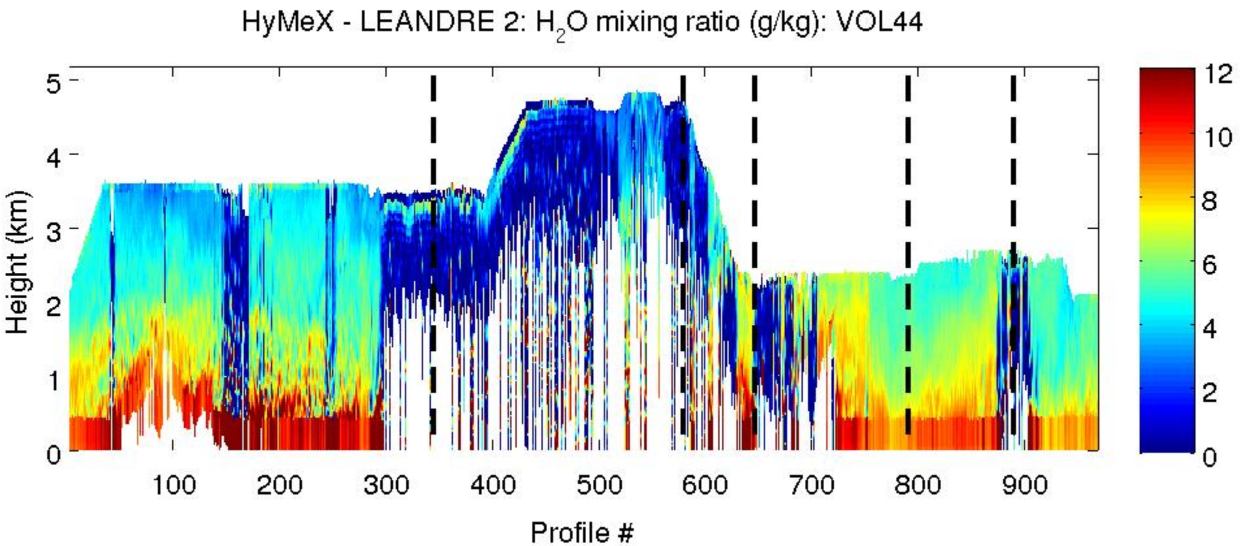
For what concerns the comparison of AROME-WMED vs. BASIL, the mean absolute bias is smaller than ±0.5 g/kg, while the mean relative bias is smaller than 5 %.

For what concerns the comparison of MESO-NH vs. BASIL, the mean absolute is smaller than 0.8 g/kg and relative bias is smaller than 10 %.

# Flight AS44 12/10/2012 (0110-0422 UTC)

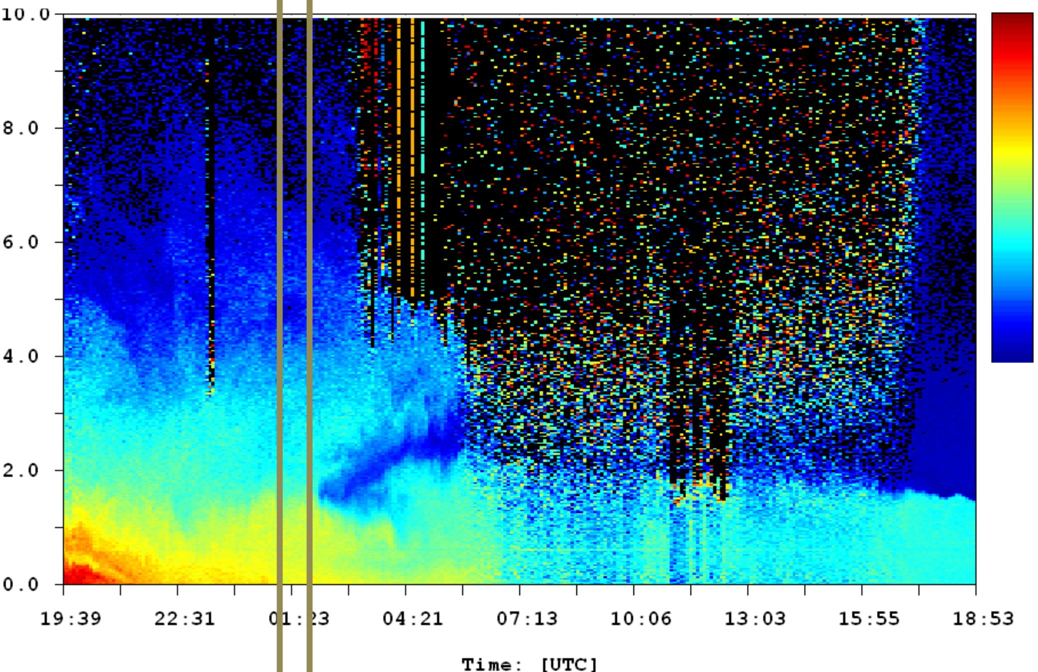



CNRS-DIAL/LEANDRE 2 water vapour mixing ratio data (longitude-height cross-sections) for flight AS44 on 12 October 2012, covering the time interval 01:10-02:10 UT

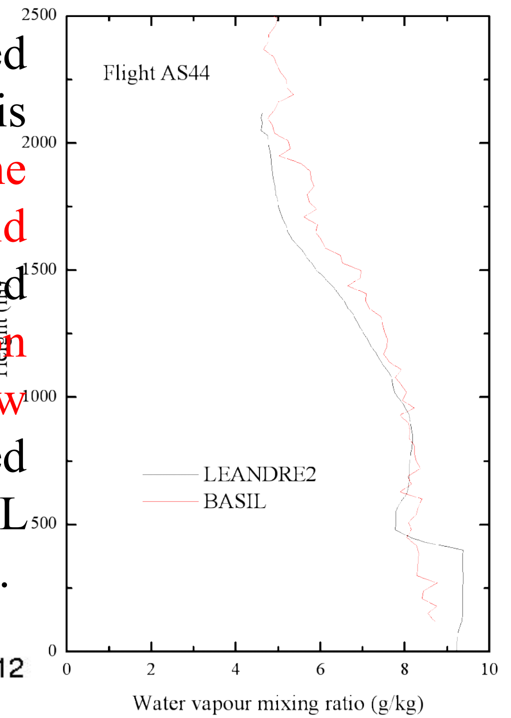


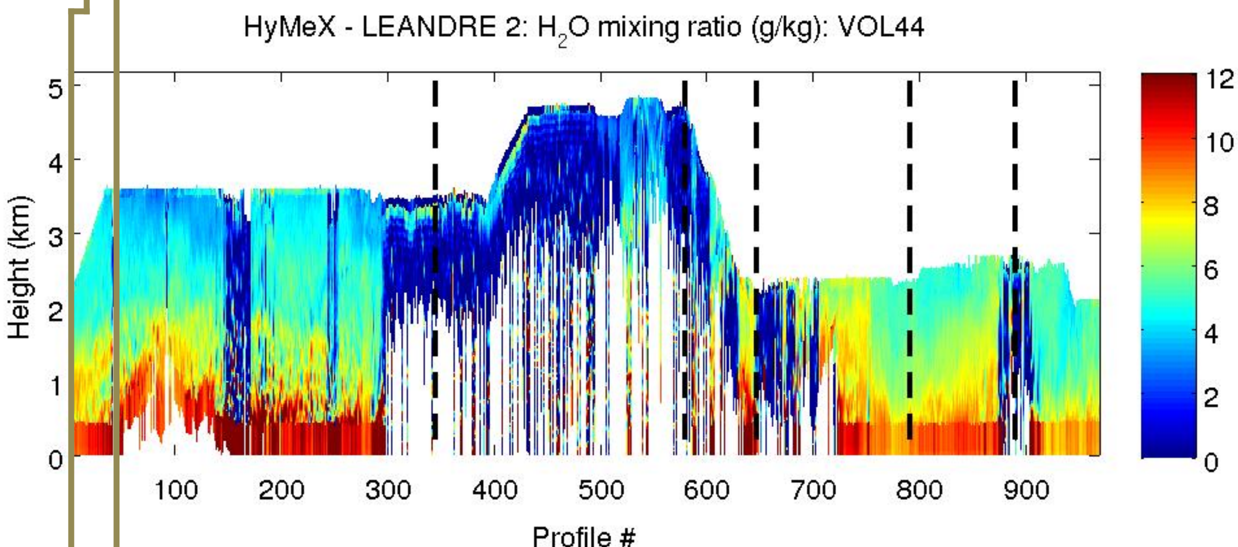
# Flight AS44 12/10/2012 (0110-0422 UTC)

An overpass in the proximity of Candillargues took place shortly after take-off in time interval 01:10-01:18 UT.




The considered time interval is shortly before the humidity field reversal associated with the transition to Mistral flow which is captured by both BASIL and LEANDRE 2.




The good agreement between the two lidars is clearly revealed by the profile-to-profile comparison.

## Characterization of moisture turbulence processes

Measurements from BASIL are also used to characterize Planetary Boundary Layer moisture turbulence processes. Spectral analyses can be performed based on the use of high-resolution water vapour mixing ratio data (10 sec) for specific case studies. The goal is to estimate higher-order moments of the water vapour mixing ratio in the boundary layer (including noise and sampling errors), with a specific focus on the integral scale, mixing ratio variance, skewness, and kurtosis profiles.

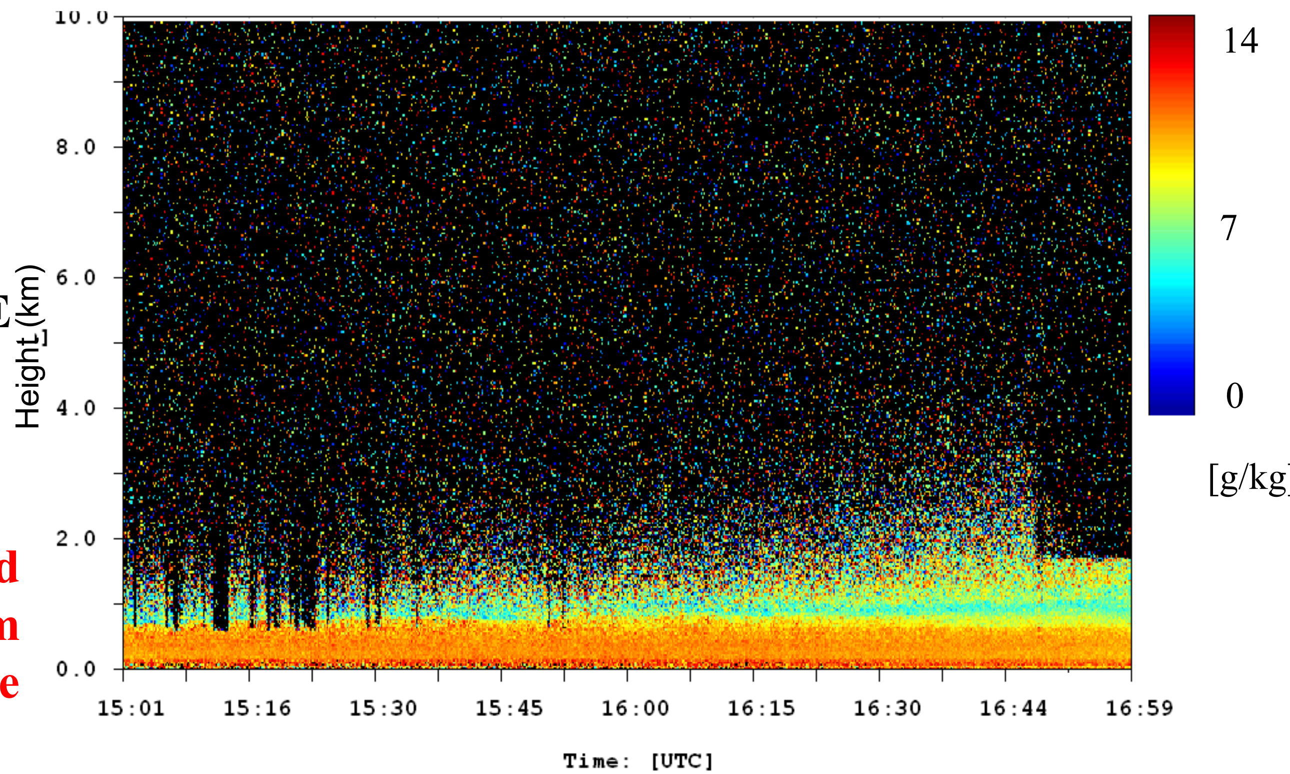
Water vapour variance is a key parameter in a variety of turbulence, convection, and cloud parameterizations (Tompkins 2002; Berg and Stull 2005; Gustafson and Berg 2007).

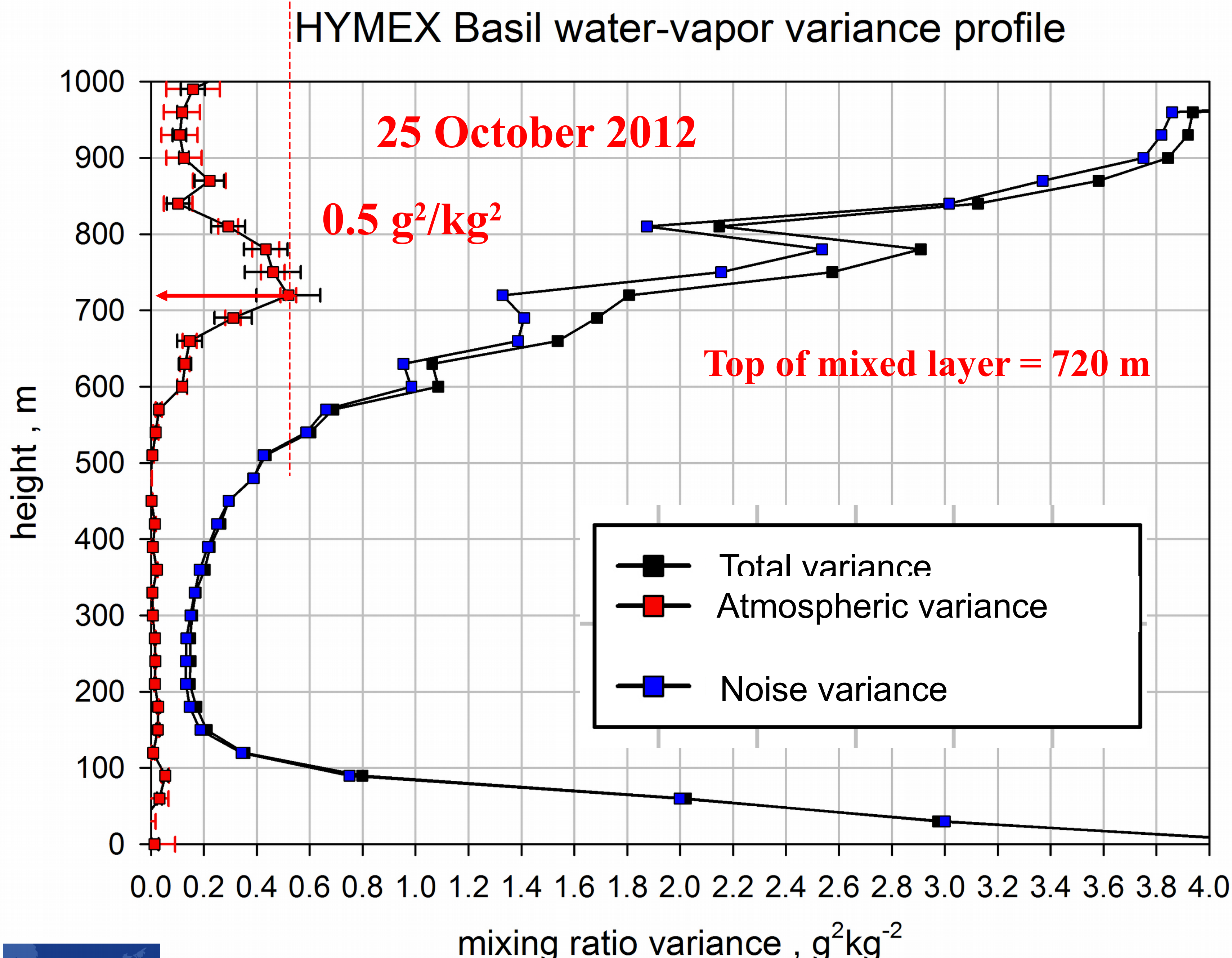
The major advantage in the application of powerful Raman lidars lies in the simultaneous investigation of turbulence properties from the surface layer to and through the entrainment zone.

**IOP 16a - BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E 25 October 2012**

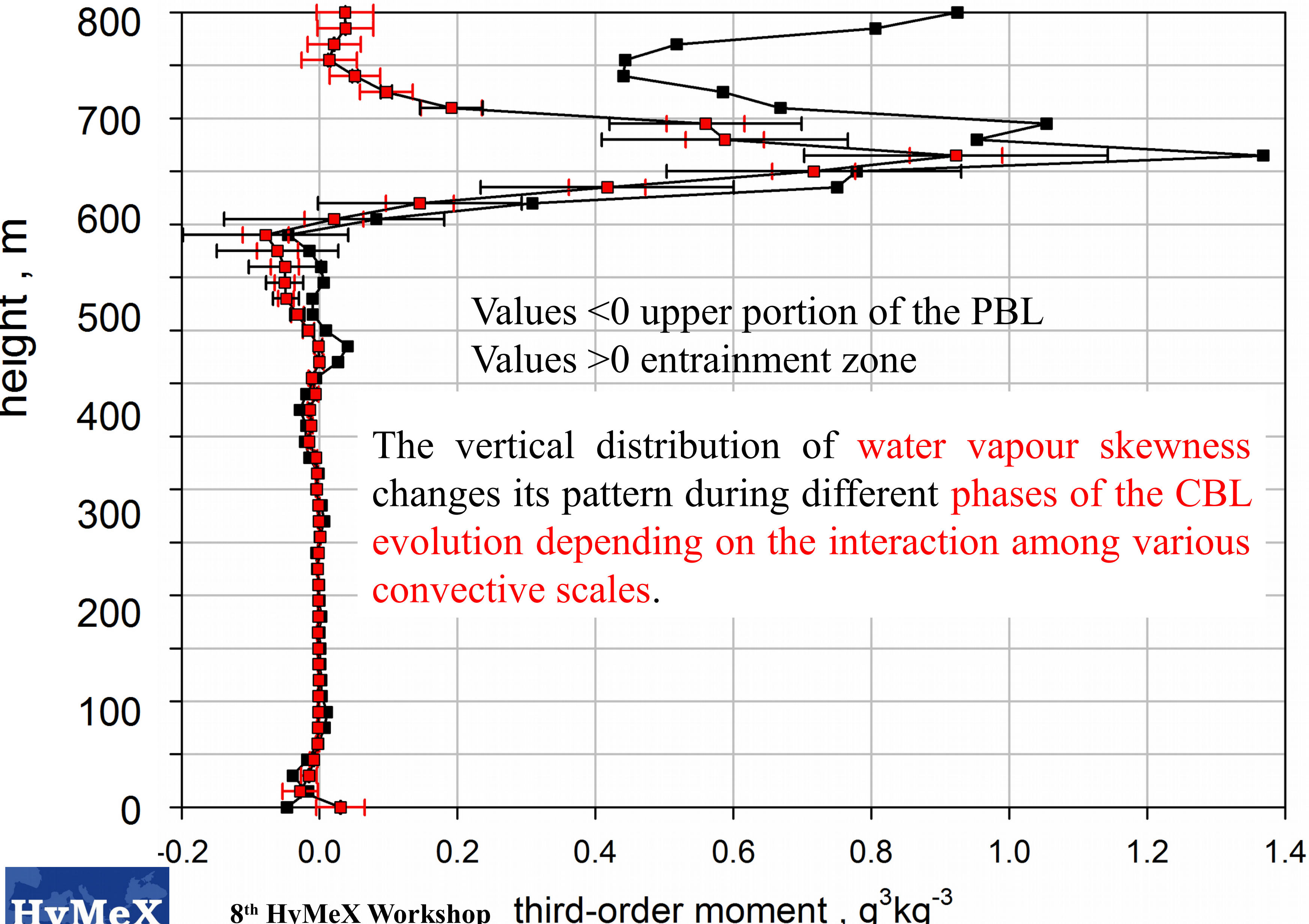
Water vapour mixing ratio: $\Delta T$=10 sec; $\Delta z$ =30 m

**We selected a 2 h period characterized by a uniform mixed layer in a convective boundary layer.**

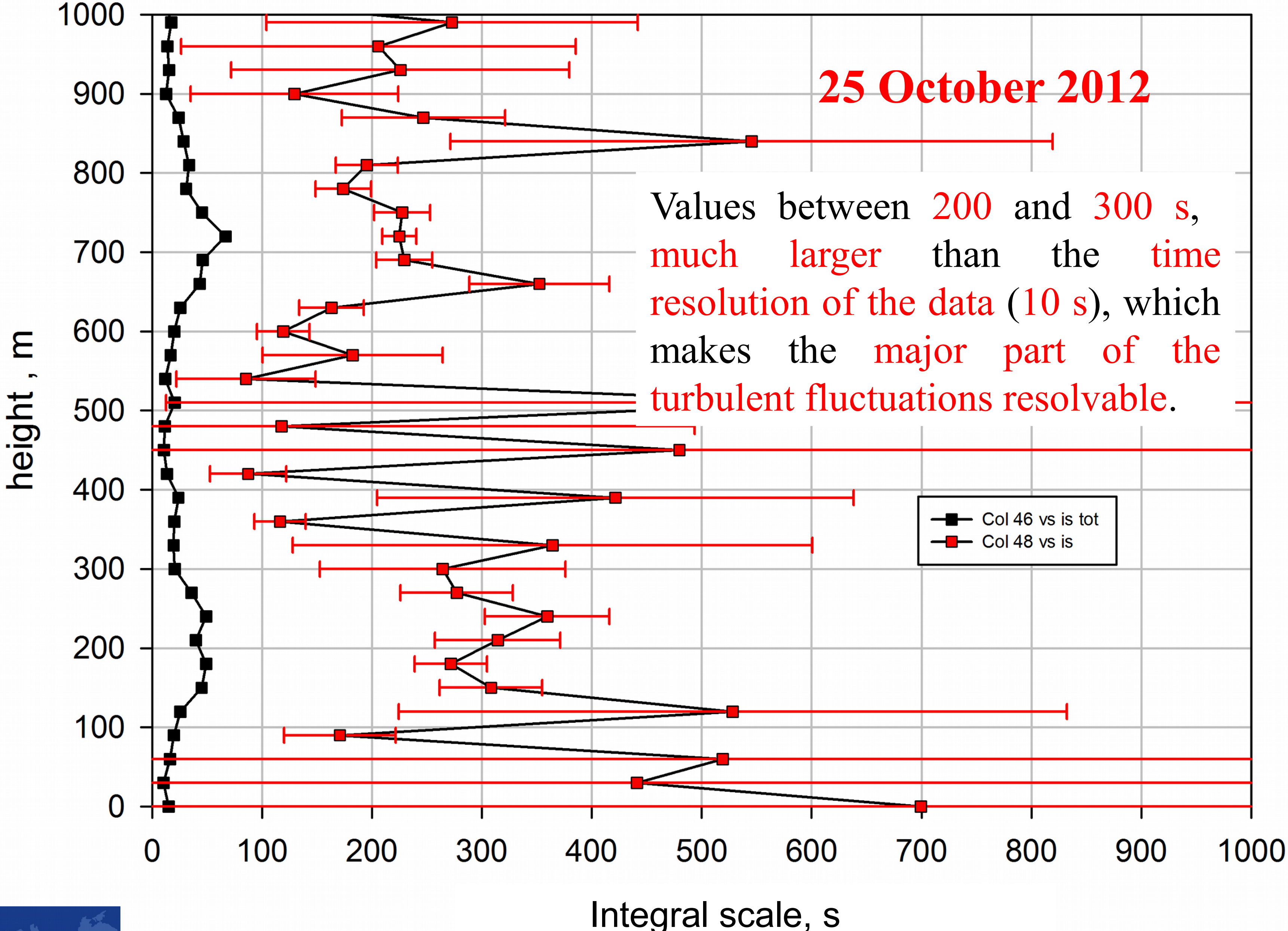



HYMEX Basil water-vapor variance profile
25 October 2012
0.5 g²/kg²
Top of mixed layer = 720 m
height , m
mixing ratio variance , g²kg⁻²
Total variance
Atmospheric variance
Noise variance
1000
900
800
700
600
500
400
300
200
100
0
0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8 3.0 3.2 3.4 3.6 3.8 4.0

# HYMEX Basil third-order moment profile

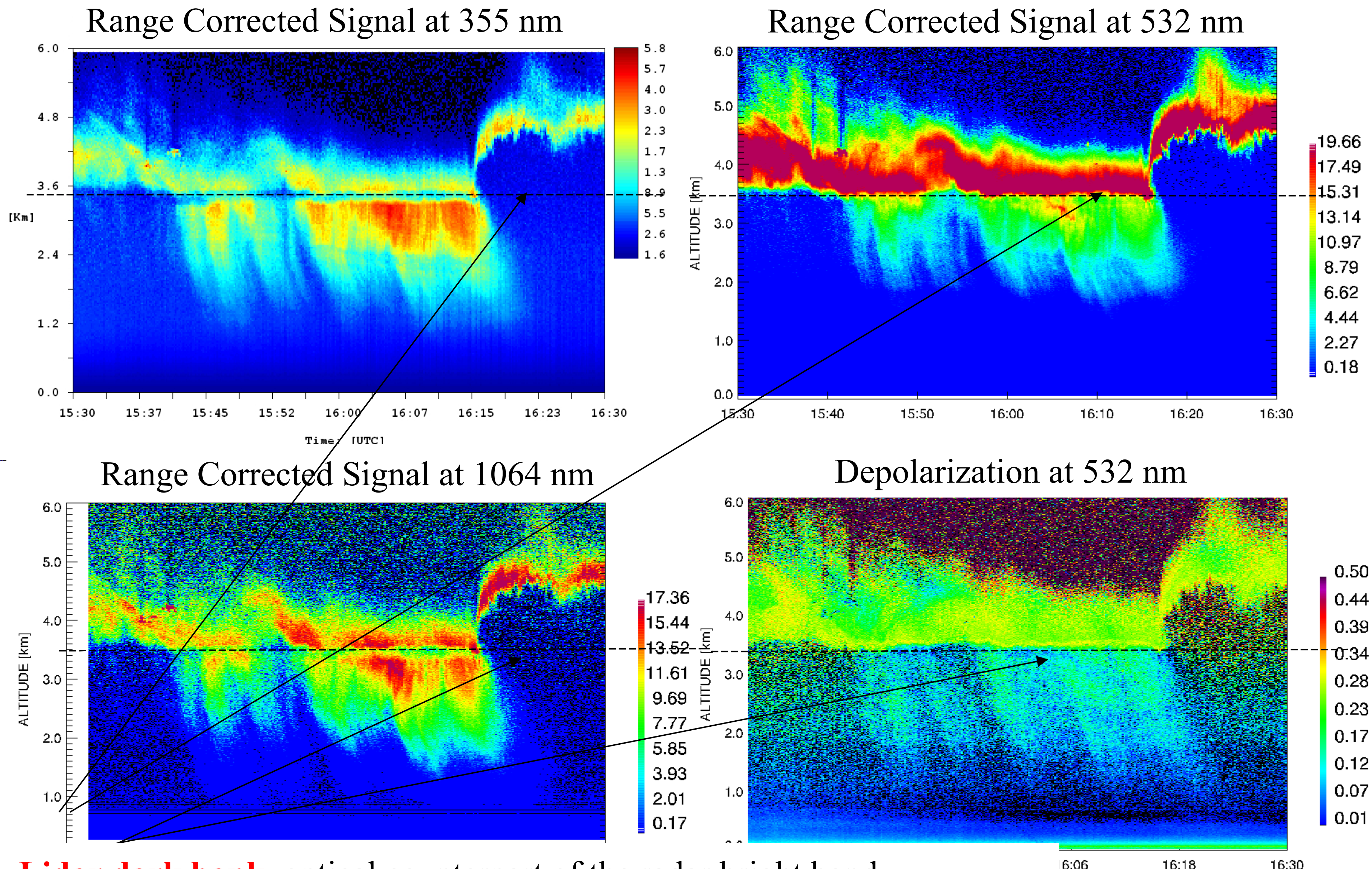


# HYMEX Basil water-vapor integral scale profile



# Measurement of the dark-band at three wavelengths + depolarization

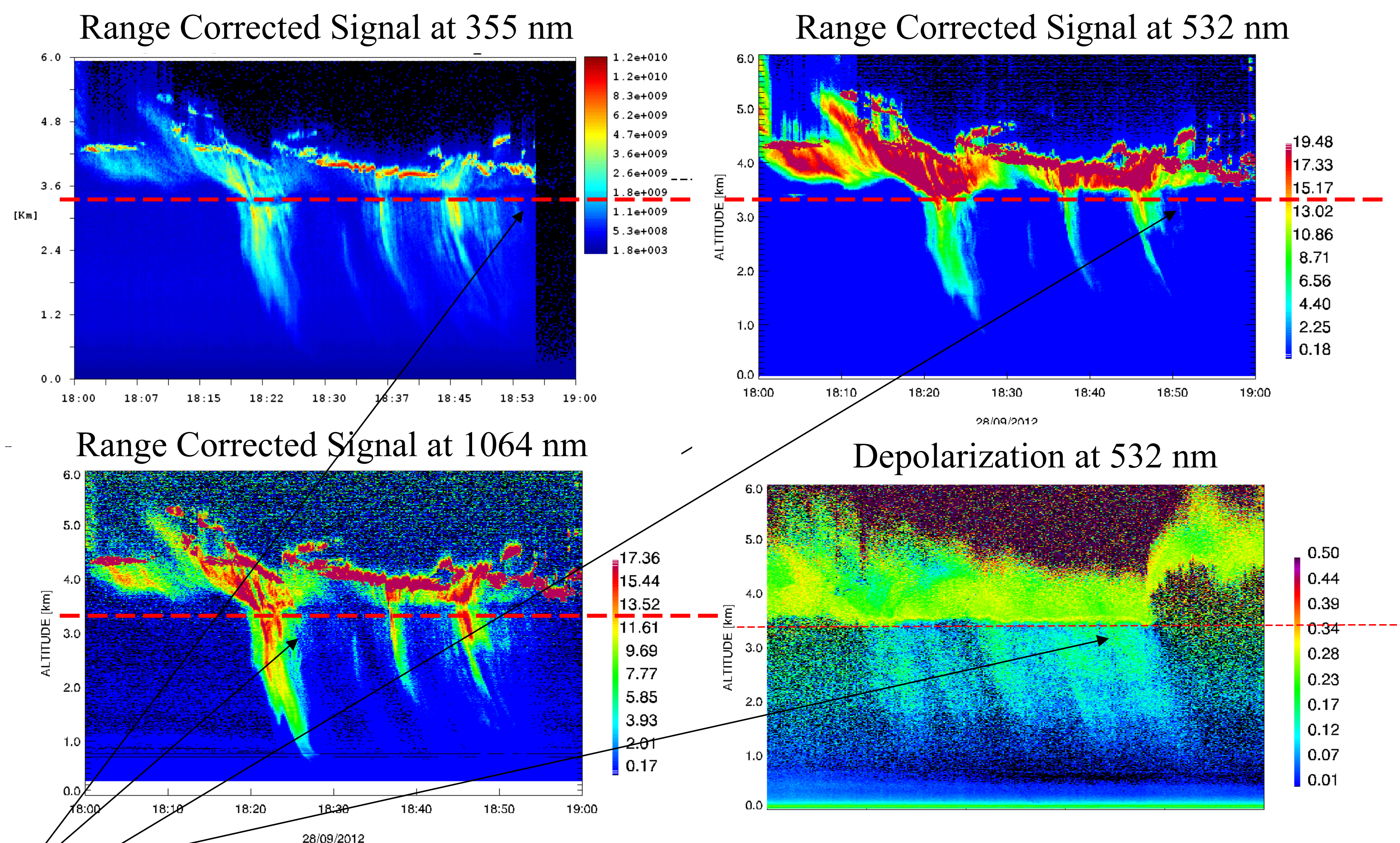
## IOP 8, 28 September 2012




**Lidar dark bank**, optical counterpart of the radar bright band associated with melting processes in the melting layer (freezing level=2.5 km)

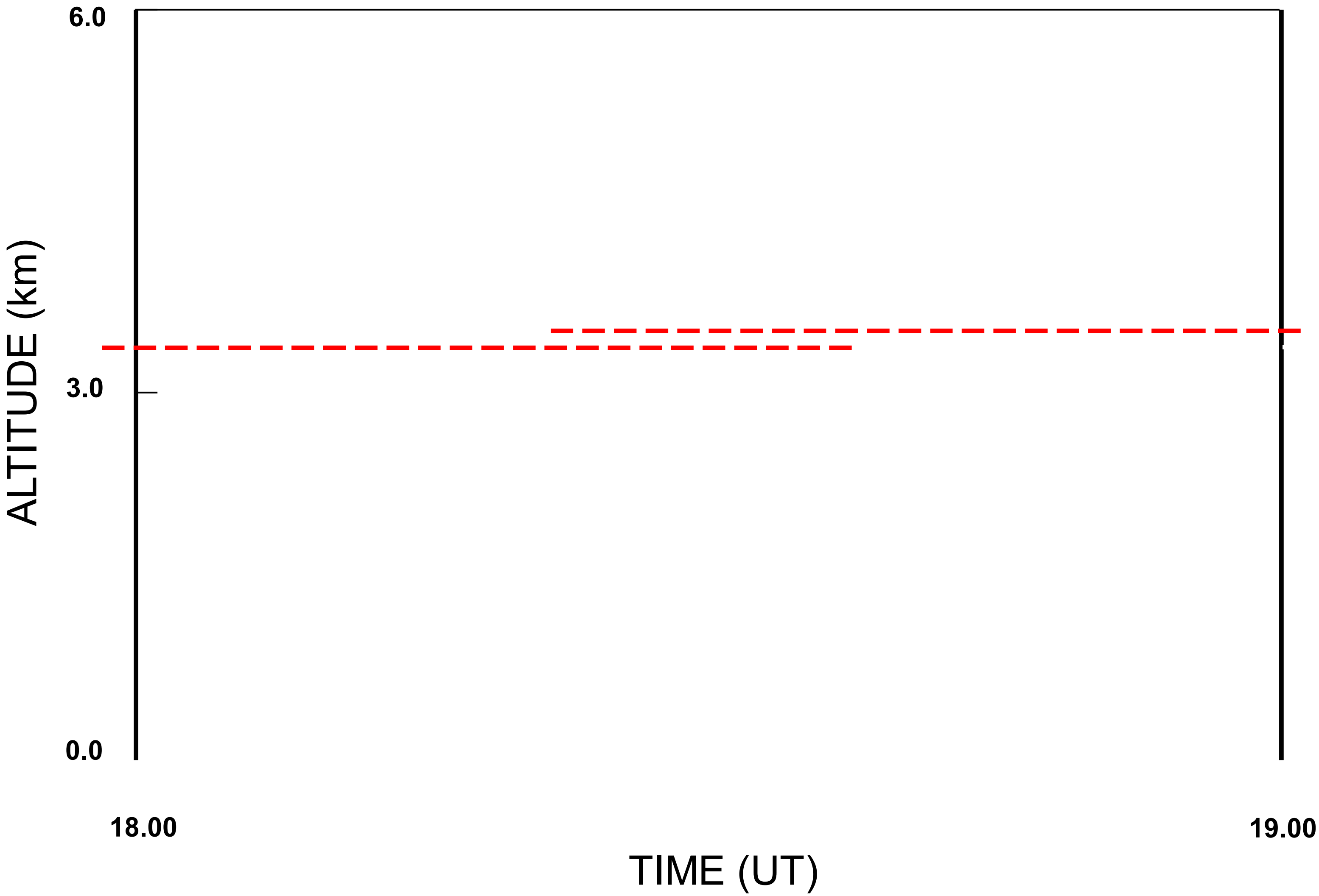
# Measurement of the dark-band at three wavelengths + depolarization

## IOP 8, 28 September 2012

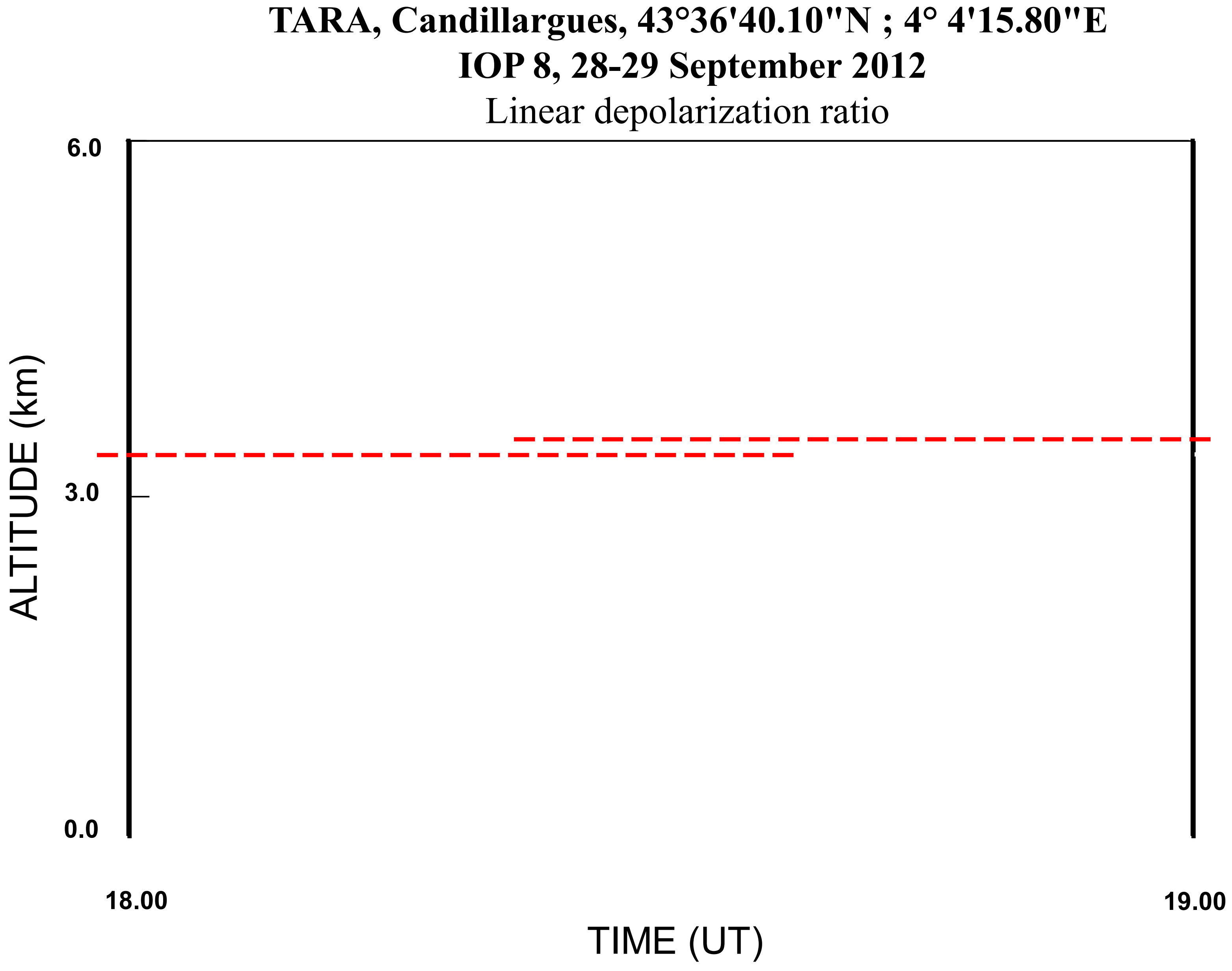



**Lidar dark bank**, optical counterpart of the radar bright band associated with melting processes in the melting layer (freezing level=2.5 km)

## TARA, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E
## IOP 8, 28-29 September 2012
Reflectivity, horizontal polarization



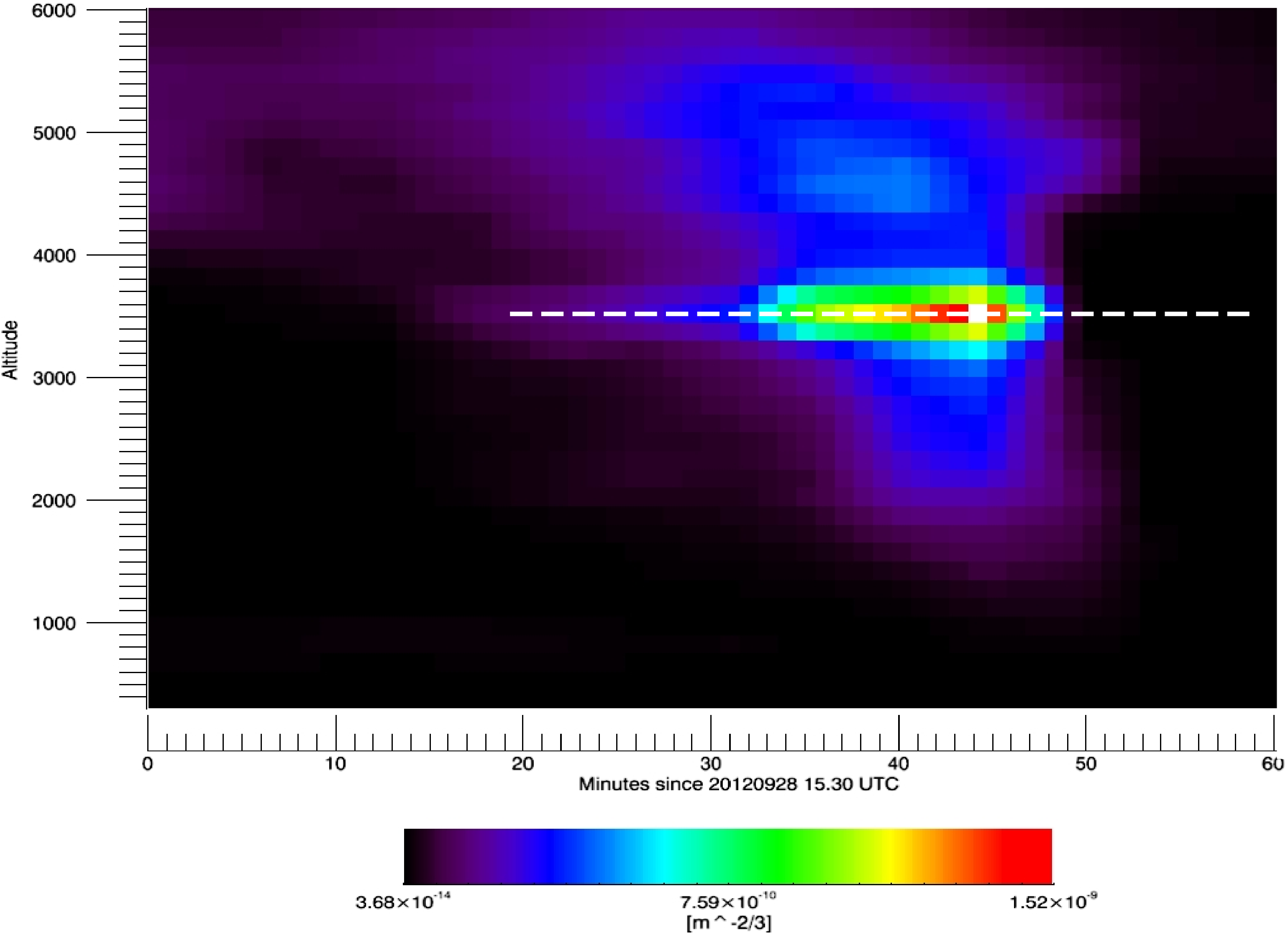

**S-band (3.298 GHz)**
**horizontal/vertical polarisations) FMCW radar**


TARA, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E
IOP 8, 28-29 September 2012
Linear depolarization ratio
6.0
3.0
0.0
ALTITUDE (km)
18.00
19.00
TIME (UT)

# WIND PROFILER, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E

## IOP 8, 28-29 September 2012

Reflectivity, horizontal polarization

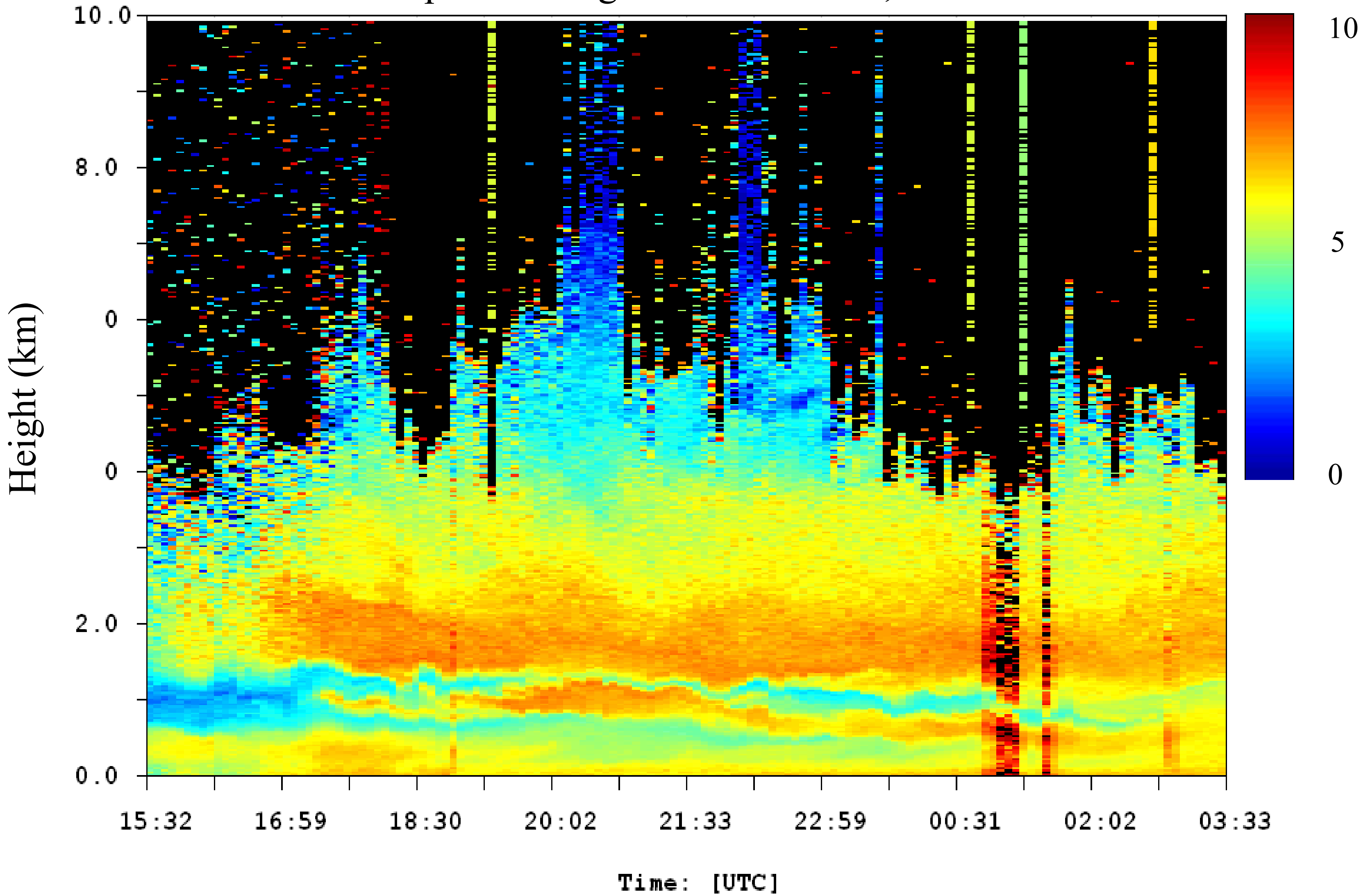



**UHF Wind Profiler 1.290 MHz**

**IOP 8 - BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E**

**28-29 September 2012**

Water vapour mixing ratio: ΔT=5 min; Δz =30 m



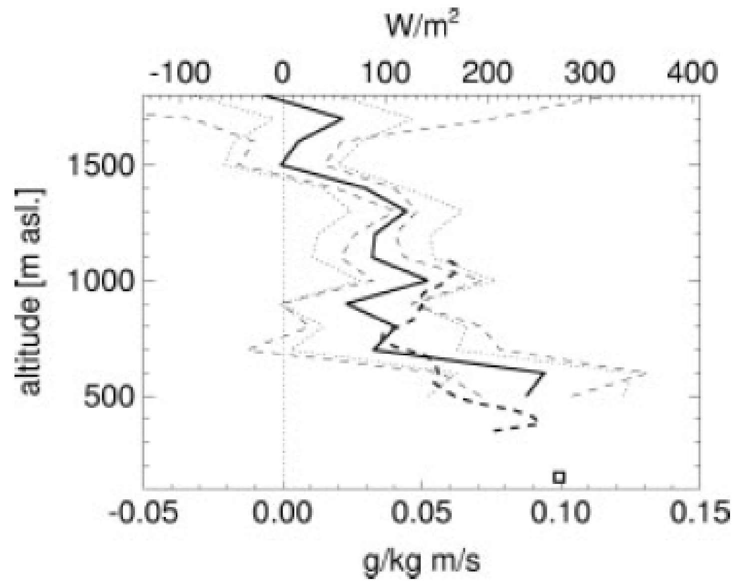
# Water vapour and latent heat flux measurements

During the Convective and Orographically-induced Precipitation Study (COPS) BASIL and the Univ. of Saltford Doppler wind lidar were zenith-pointing in the Supersite Rhine Valley (Rhine Valley, Germany ).

Vertical profiles of specific humidity and latent heat flux in a convective boundary layer (CBL) have been obtained and reported for the first time based on the use of the combination of a water vapour Raman lidar and a Doppler wind lidar.

The time resolution of BASIL and the Doppler lidar is 5 s. In order to reduce statistical fluctuations in the water vapour and wind profiles an integration time of 75 s was chosen.

approx. 10 m




**Covariance of the vertical velocity and specific humidity fluctuations**

**Latent heat flux=2.7MJ/m$^3$< w’·q’>**

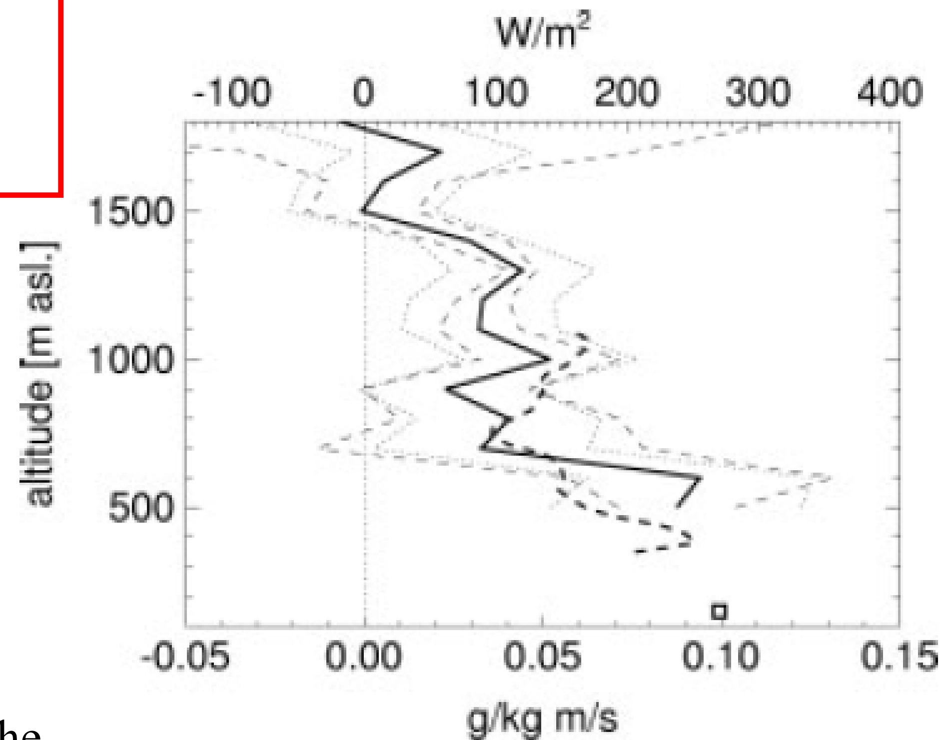
Specific humidity flux = <w’·q’>
w’=vertical velocity fluctuation
q’=specific humidity fluctuations

Ground-based flux profiles compared with an airborne profiles obtained from combination of the DLR DIAL water va profiles and KIT Doppler lidar wind profile board the DLR Falcon.

Solid line: Latent heat flux profile from the airborne lidars over the Rhine valley along the northern half of flight leg D, 1149–1155 UTC, 65 km long.

Thick dashed line: Latent heat flux profile from the ground-based lidars, 1114-1157 UTC.

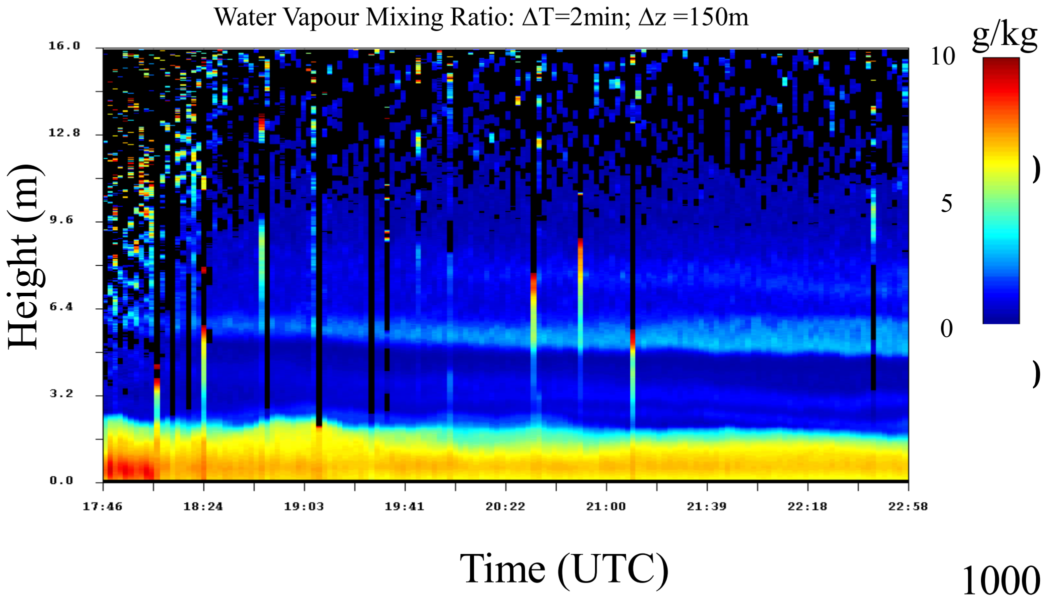
The distance between supersite R and the northern part of leg D is approx. 15 km.



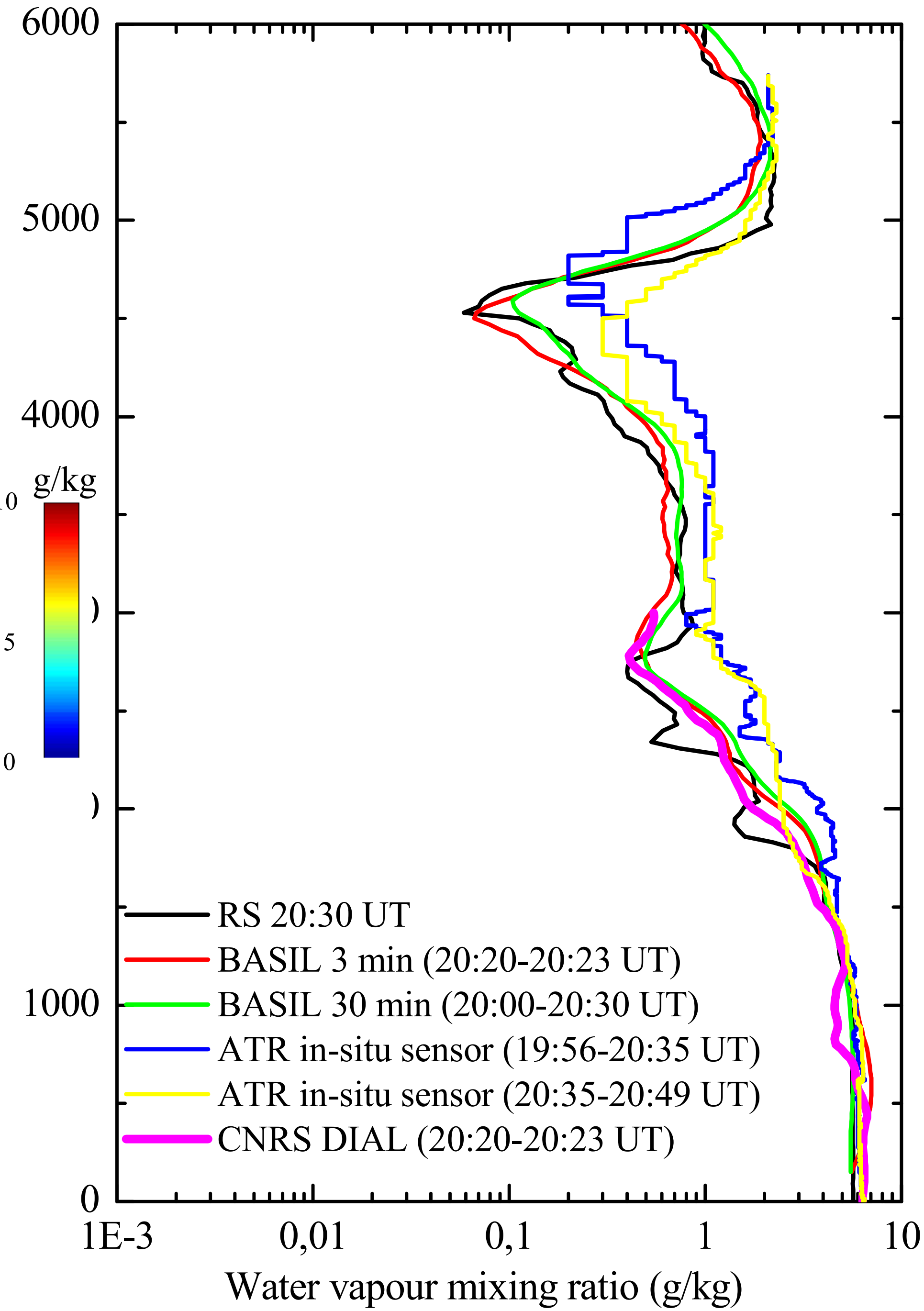

The agreement between the airborne and ground lidar flux profiles is fairly good.

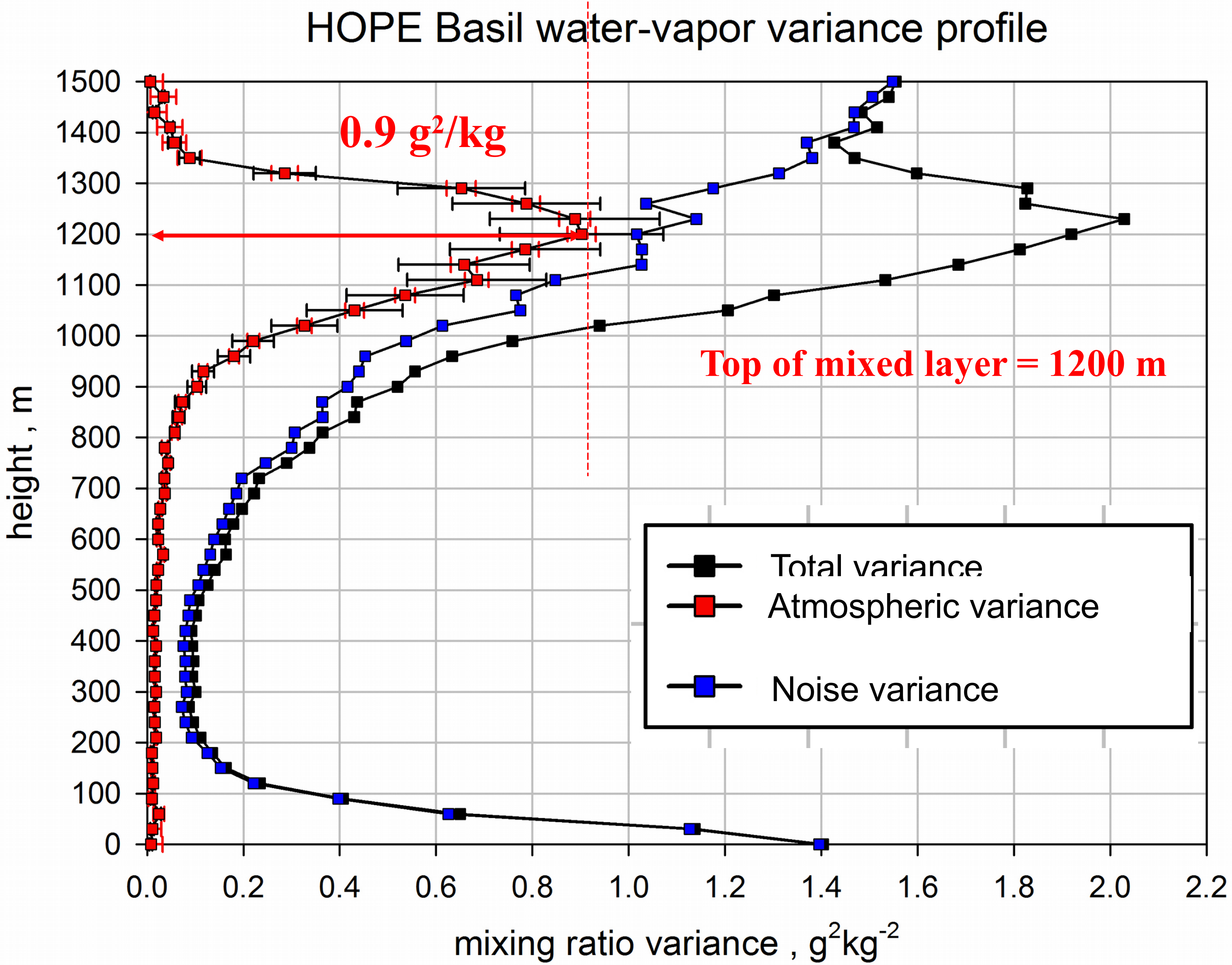
Kiemle C, Wirth M, Fix A, Rahm S, Corsmeier U, **Di Girolamo P**. 2011. Latent heat flux measurements over complex terrain by airborne water vapour and wind lidars. *Q. J. R. Meteorol. Soc.* **137**:190–203. DOI:10.1002/qj.757

# IOP 3 - WALITEMP EUFAR
# Lidar validation flight on 13 September 2012 (20.20 UTC)

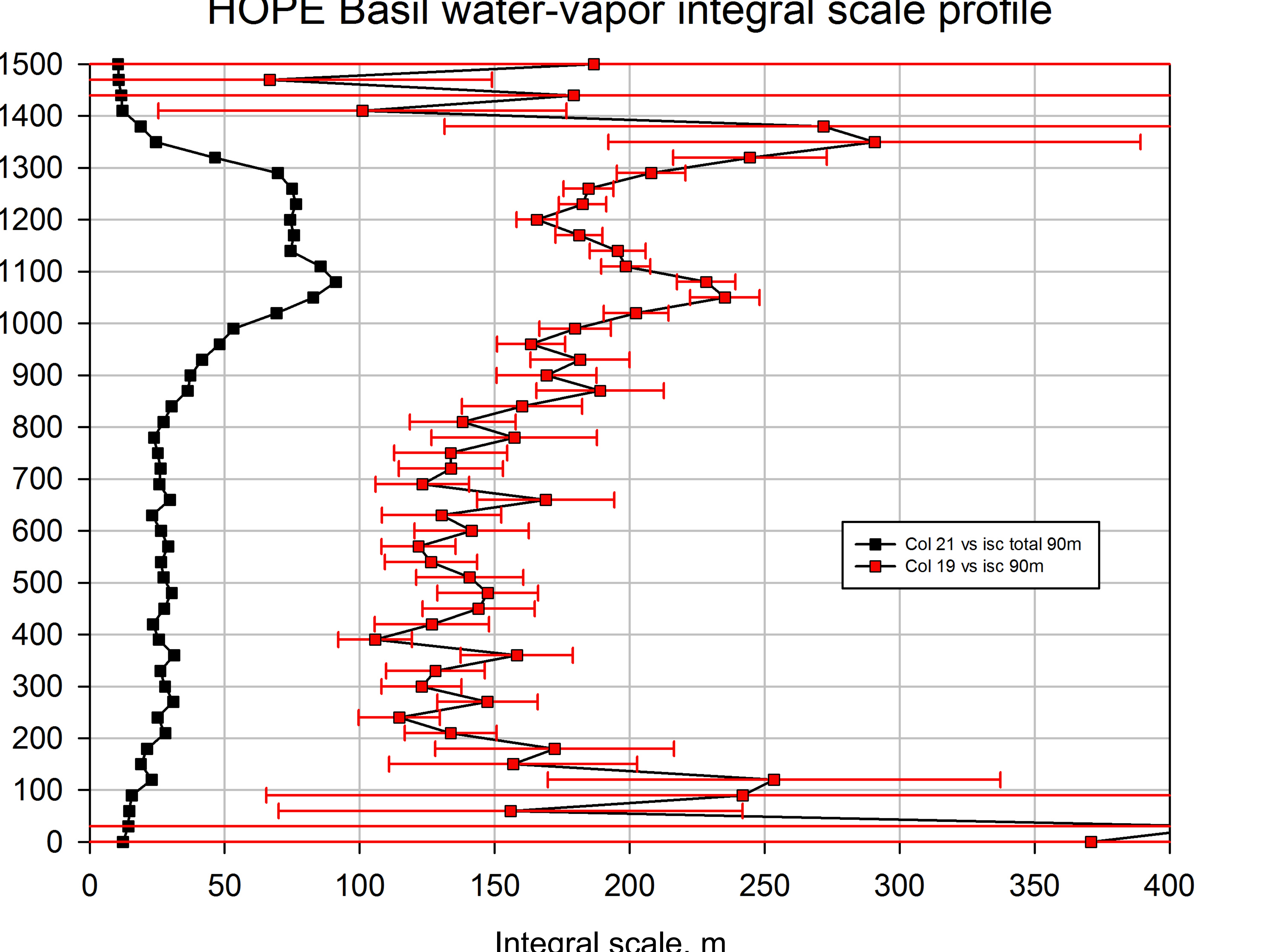



Distance between LEANDRE II and BASIL: 5-10 km





HOPE Basil water-vapor variance profile
0.9 g²/kg
Top of mixed layer = 1200 m
height , m
mixing ratio variance , g²kg⁻²
Total variance
Atmospheric variance
Noise variance

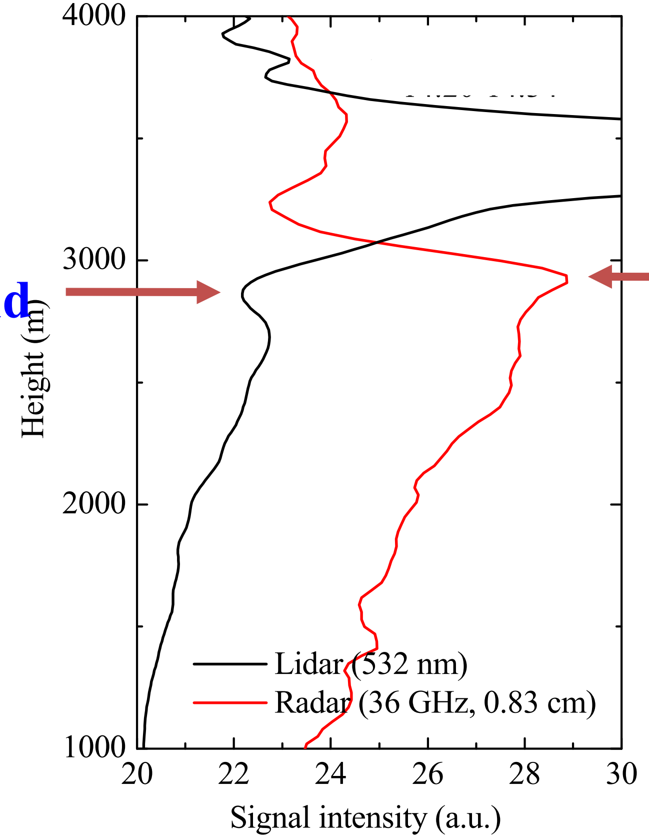

HOPE Basil water-vapor integral scale profile
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
0
50
100
150
200
250
300
350
400
Integral scale, m
Col 21 vs isc total 90m
Col 19 vs isc 90m

# Measurement of the dark-band at three wavelengths + depolarization

Changes in scattering properties of precipitating particles take place during the snowflake-to-raindrop transition, near the $0^0$C isotherm.

- **Maximum** in **radar reflectivity** at microwave wavelengths (**Radar bright band**).
- **Minimum** in **particle backscatter** in the optical domain (**Lidar dark band**, *Sassen and Chen, 1995)*

**Lidar dark band**

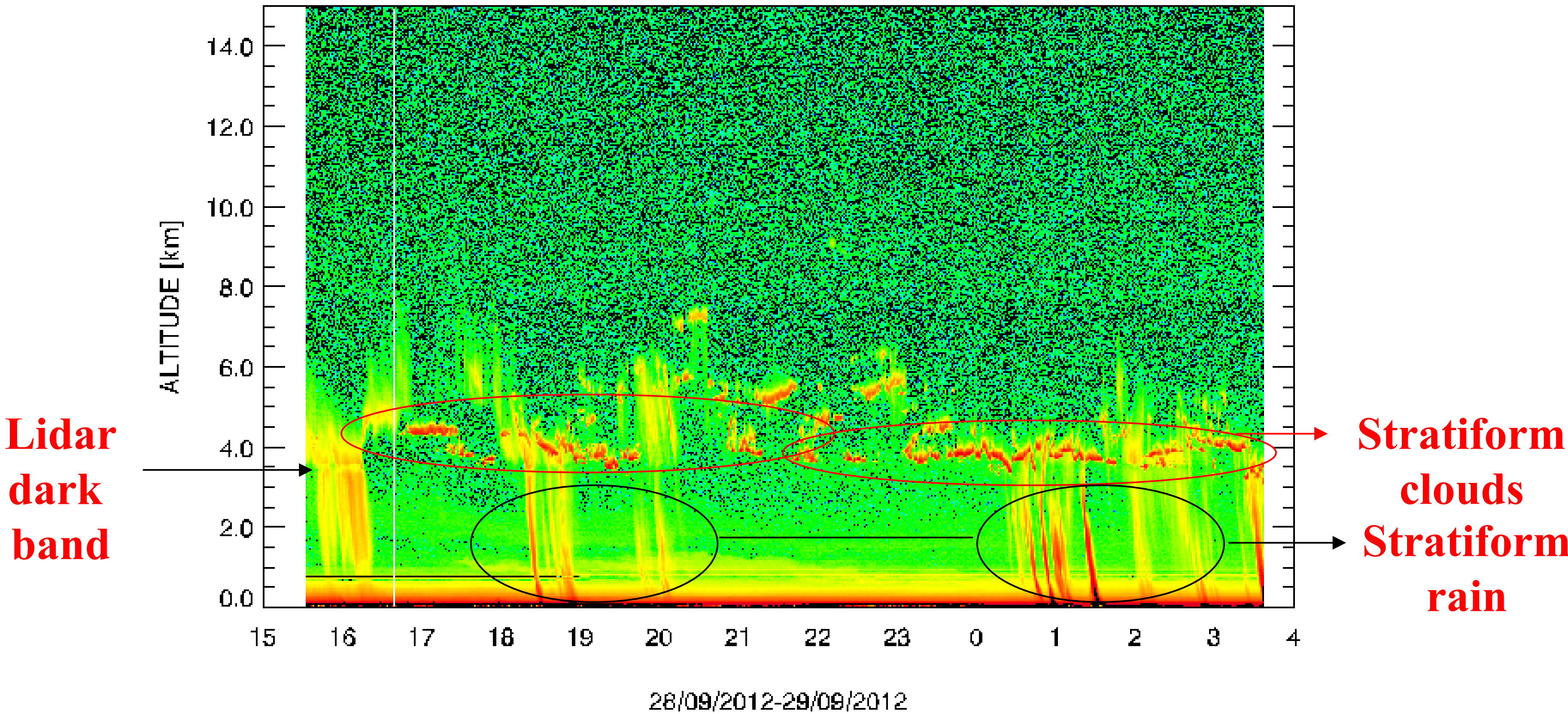



**Radar bright band**

**BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E**

**IOP 8, 28-29 September 2012**

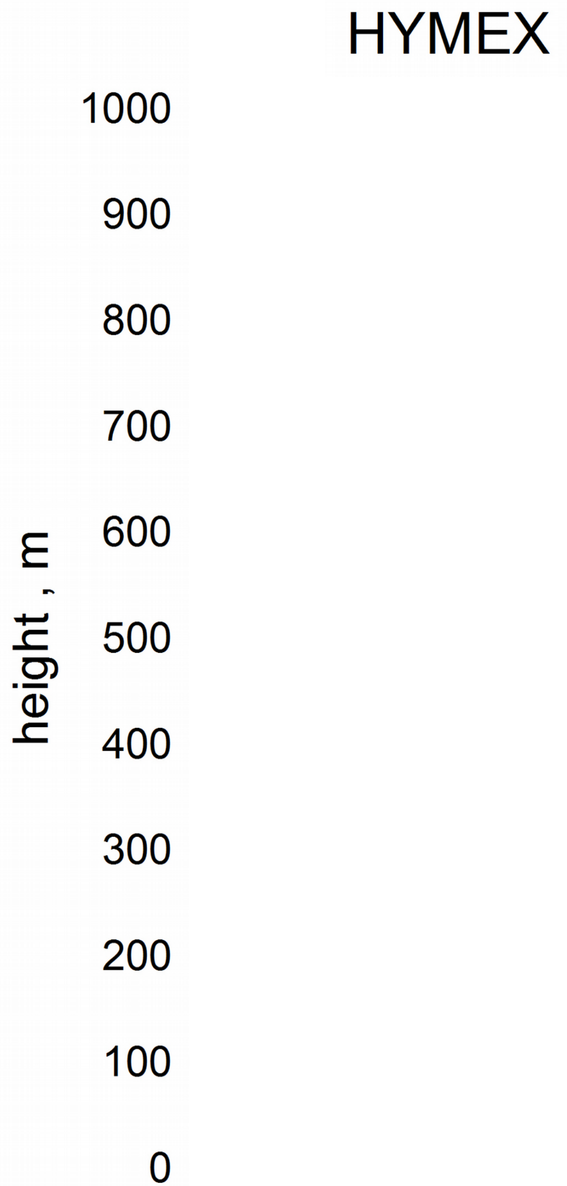
Range Corrected Signal at 1064 nm: ΔT=1 min; Δz =30 m



Passive Cavity Aerosol Spectrometer Probe
SPP-200

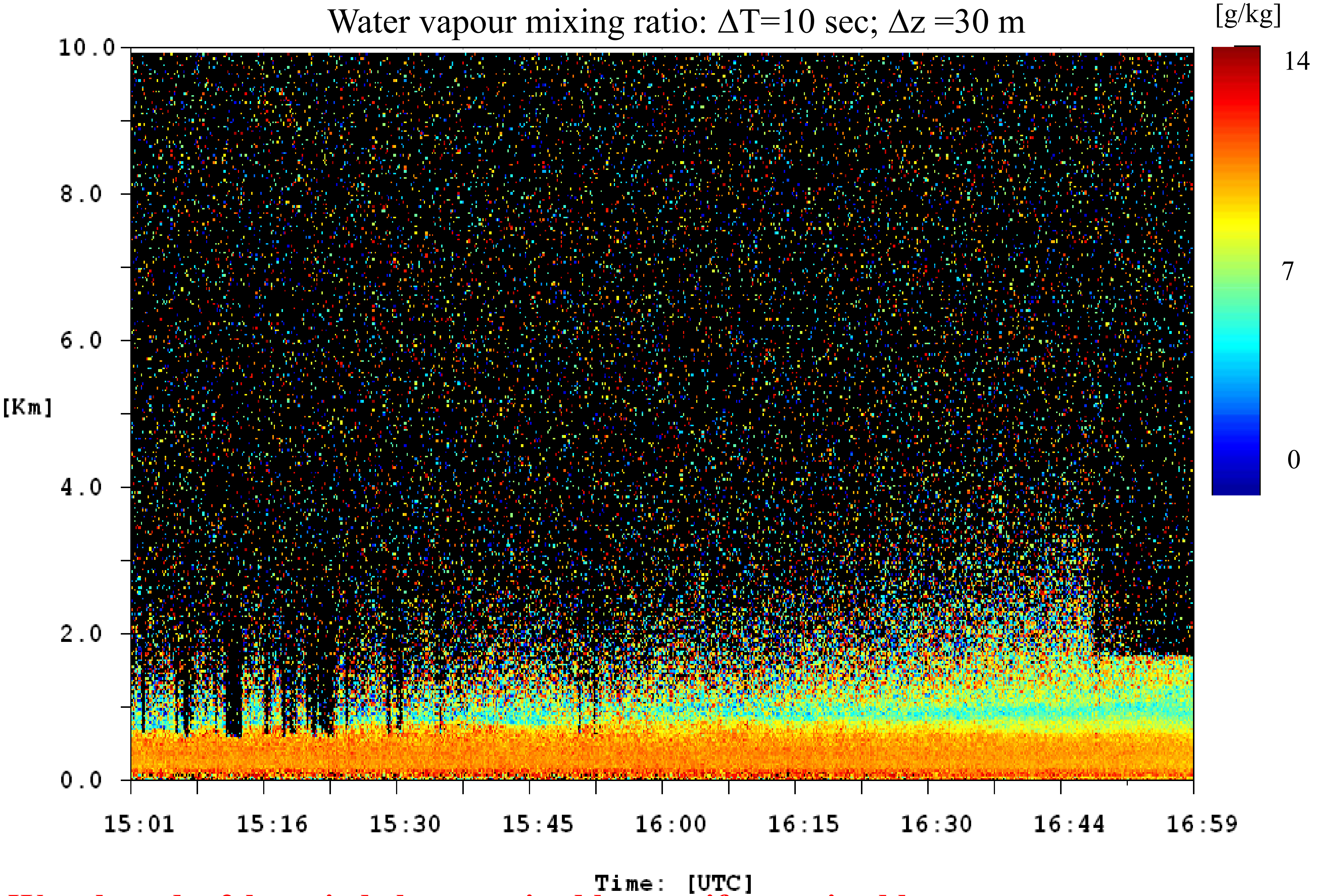
Aerosol in situ particle size distribution
[ 0.25 - 10 microns diameter] 32 channels.
(0.25 - 2.5 microns 16 channels)
14 microns
Optical Particle Counter.  GRIMM

Aerosol number concentration ($cm^{-3}$) measured by
CPC (radius < 2.5µm
Radius > 5 nm )


HYMEX
1000
900
800
700
600
500
400
300
200
100
0
height , m

## IOP 16a - BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E
## 25 October 2012

Water vapour mixing ratio: $\Delta T$=10 sec; $\Delta z$ =30 m

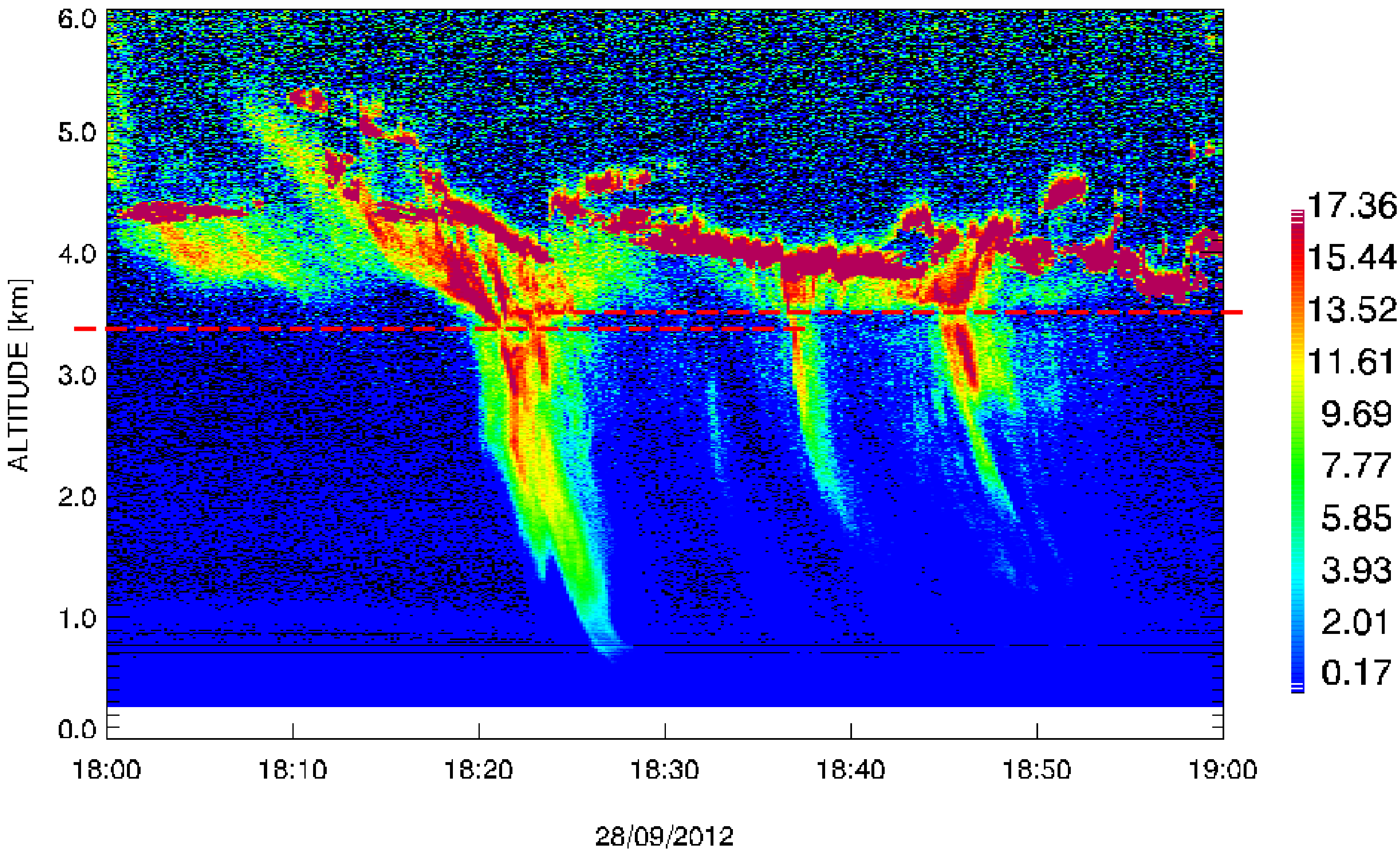


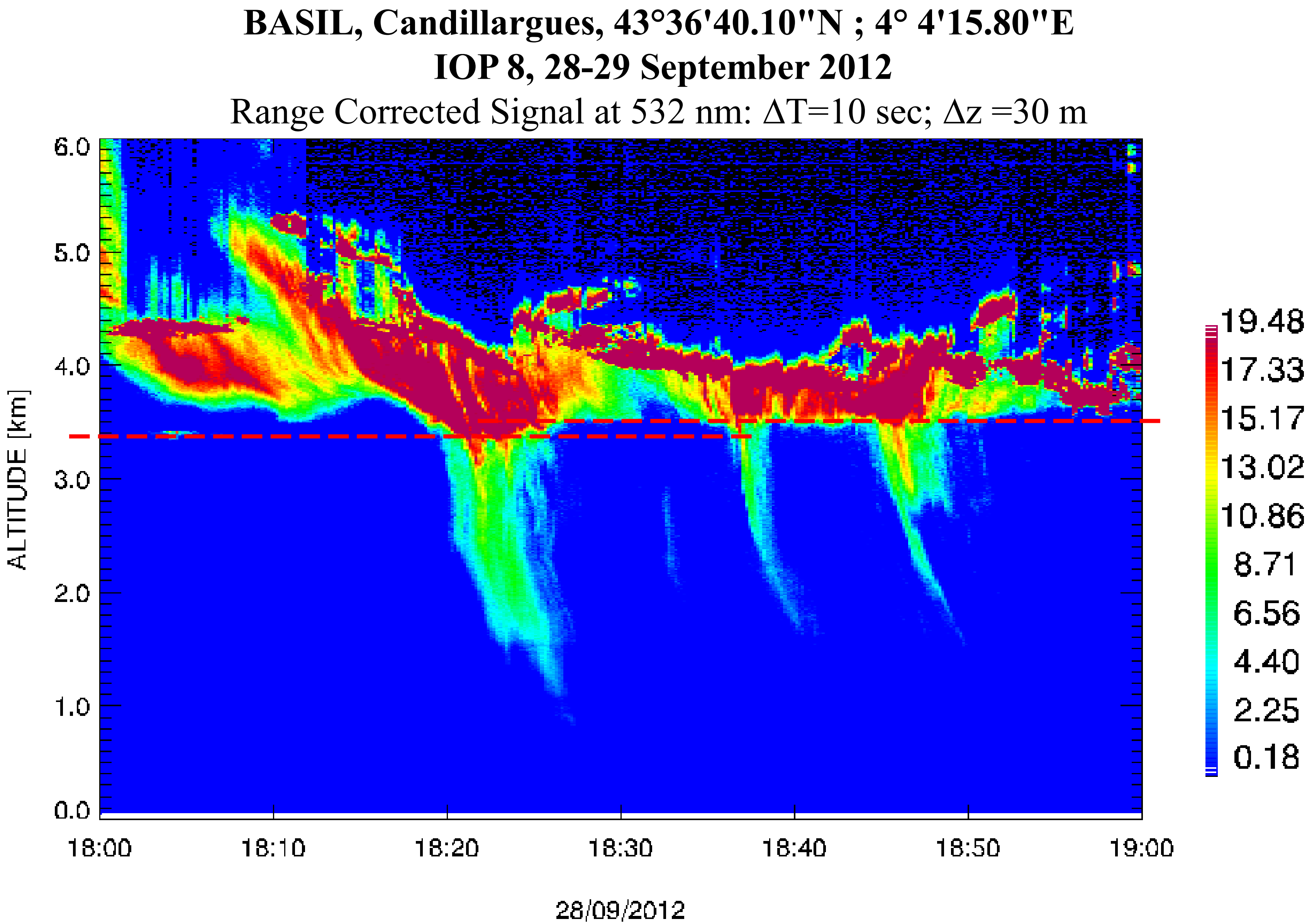

**We selected a 2 h period characterized by a uniform mixed layer as a result of clean air convection**

**BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E**

**IOP 8, 28-29 September 2012**

Range Corrected Signal at 1064 nm: $\Delta T$=10 sec; $\Delta z$ =30 m




BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E
IOP 8, 28-29 September 2012
Range Corrected Signal at 532 nm: ΔT=10 sec; Δz =30 m
ALTITUDE [km]
6.0
5.0
4.0
3.0
2.0
1.0
0.0
18:00
18:10
18:20
18:30
18:40
18:50
19:00
28/09/2012
19.48
17.33
15.17
13.02
10.86
8.71
6.56
4.40
2.25
0.18

**BASIL, Candillargues, 43°36'40.10"N ; 4° 4'15.80"E**

**IOP 8, 28-29 September 2012**

Range Corrected Signal at 355 nm: ΔT=10 sec; Δz =30 m