The Genesis of Complex Water Vapour Field Structures and Low-Level Cold Pools: Characterization of their Role in the Activation of Mesoscale Convective Systems based on the Combined Use of Raman Lidar and DIAL Measurements, and MESO-NH Model Simulations

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Università degli Studi della Basilicata • 1982 •

Dry layers and cold pools play an important role in the genesis and evolution of the mesoscale convective systems and the heavy precipitation events (HPEs)

The role of dry layers in triggering convection has been longly argued …

Convection may be strongly forced by descending dry layers associated with the tropopause folding events and the consequent low-level moist convergence.

Russell et al., Tellus (2009), 61A, 250–263

Very dry layers, with a WVMR less than ~2 g kg^{-1}, descending from the mid-troposphere down to the PBL top, have been reported to be play a major role in convective initiation and maintenance of back-building mesoscale convective systems.

Lee et al., Quarterly Journal of the Royal Meteorological Society, 2016, 142(700),2623-2635.10.1002/qj.2851

The subsidence in the dry layer regions within the tropical troposphere may help to suppress convection and lead to overall drying in these regions.

Randel et al. (2016), Dry layers in the tropical troposphere observed during CONTRAST and global behavior from GFS analyses, J. Geophys. Res. Atmos., 121, 14,142–14,158, doi:10.1002/2016JD025841.

Cold pools

Low-level cold pools are important in the genesis and development of deep convection and heavy precipitation events, especially in the north-western Mediterranean coasts especially in autumn (Ducrocq *et al.*, 2008).

Bouin *et al.* (2017) → Prognostic variables to identify cold pools
Virtual potential temperature
Equivalent potential temperature

Virtual potential temperature, directly related to the air masses density, is commonly used as a proxy for cold pools (e.g. Ducrocq *et al.*, 2008; Bresson *et al.*, 2012).

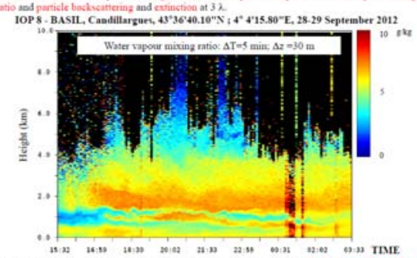
$$\theta_v(z) = T(z)\left(\frac{p_0}{p(z)}\right)^{R/cp}\left(1 - x_{H_2O}(z)\right)$$

Equivalent potential temperature, which characterizes the heat and moisture content of the inflow, is also considered

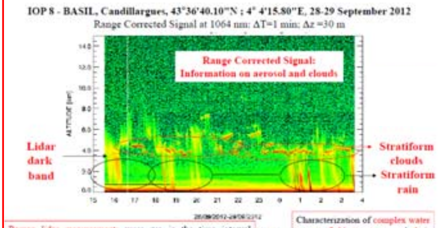
$$\theta_e(z) = T(z)\left(\frac{p_0}{p(z)}\right)^{R/cp} exp\left(\frac{Lw_s[T(z),p(z)]}{c_pT(z)}\right)$$

Virtual potential temperature threshold value = 23 °C ≈ 296 K
Equivalent potential temperature threshold value = 52 °C

The Univ. Basilicata Raman lidar system (BASIL) was deployed in Candillargues (S. France) during HyMeX-SOP 1 (September-November 2012), providing high-resolution and accurate measurements, both in daytime and night-time, of atmospheric temperature, water vapour mixing ratio and particle backscattering and extinction at 3 λ.



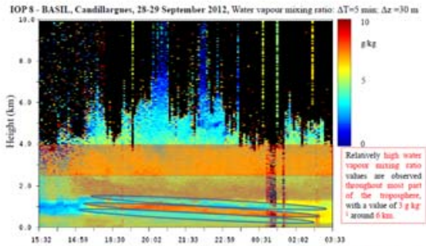
Measurements carried out by BASIL on in the time period 28-29 September 2012 reveal a water vapour field characterized by a quite complex vertical structure.



Raman lidar measurements were run in the time interval between two consecutive heavy precipitation events. ↔ Characterization of complex water vapour field structures and their genesis is also beneficial for a deeper comprehension of the two HPE events.

Raman lidar measurements reveal the presence of very light precipitation events around 16:00 UTC and in the time intervals 18:30-20:30 UTC and 00:30-03:30 UTC.

The figure above reveals the presence of Virga events (black ellipses), with most precipitating particles sublimating before reaching surface (complete subl. observed only during the first event at 16:00 UTC).



Relatively high water vapour mixing ratio values are observed throughout most part of the troposphere, with a value of 3 g kg^{-1} around 6 km.

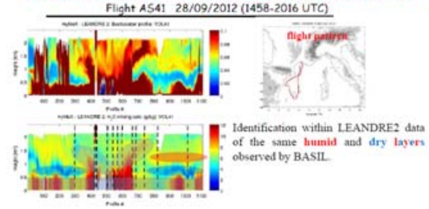
Throughout most of the observation period, lidar measurements reveal the presence of **four distinct humid layers** and two dry layers.

Based on the combined use of BASIL obs and MESO-NH & HYSPLIT back-trajectory anal.
we find that the humid air masses feeding the precipitation system
Origin: North Atlantic, Tropical Atlantic (4-5 days earlier) and Tropical Africa (10 days earlier)
Transport: Transport in the lower troposphere for 3-4 days,
Subsidence: uoon reaching the Mediterranean 12-40 hours before HPEs

Comparison with airborne H_2O LEANDRE2 DIAL measurements

AS41 28/09/12 #8 Survey of moist inflow towards northern Spain (CA & VA) F/F20

Flight AS41 28/09/2012 (1458-2016 UTC)

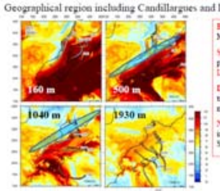


Identification within LEANDRE2 data of the same **humid** and **dry layers** observed by BASIL.

The exact correspondence, in terms of back-trajectories computation and water budget, between the humid layers observed by BASIL and those identified in LEANDRE2 measurements has been verified based on a dedicated simulation effort.

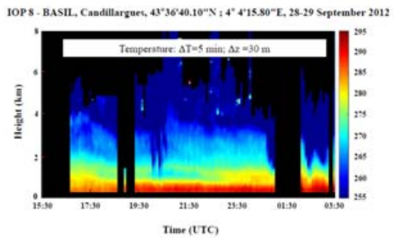
MESO-NH simulations at different altitude levels confirm the presence of these dry layers

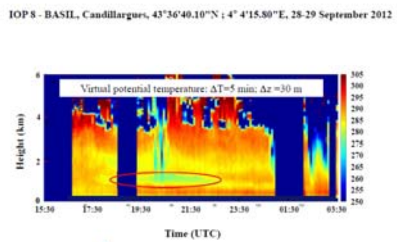
Geographical region including Candillargues and locations of LEANDRE 2 measurements



Background: MESO-NH water vapour mixing ratio values
Stars: position of Candillargues and few locations of LEANDRE 2 measurements
Dots and their colors: trajectories and the corresponding water vapour mixing ratio values.
Numbers at the end of the trajectories: initial trajectory heights at 00:00 UTC on 28 September 2012.

Time evolution of the atmospheric temperature over the same period previously considered for water vapour





Cold pools → Virtual potential temperature threshold value < 23 °C ≈ 296 K