HyMeX SOP1, Fall 2012

Coherence between multi-instrument and multi-model atmospheric moisture retrievals in the framework of the HyMeX-SOP1

Patrick Chazette(1), Cyrille Flamant(2), Xiaoxia Shang(1), Julien Totems(1), Jean-Christophe Raut(2), Alexis Doerenbecher(3), Véronique Ducrocq(3), Nadia Fourrié(3), Olivier Bock(4), and Sophie Cloché(5)

(1) Laboratoire des Sciences du Climat et de l’Environnement (LSCE), UMR8212, Laboratoire mixte CEA-CNRS-UVSQ, CEA Saclay, 91191 Gif-sur-Yvette, France.
(2) Sorbonne Universités, UPMC Université Paris 06; Université Versailles St-Quentin; CNRS/INSU; LATMOS-IPSL, UMR 8190, 75005, Paris, France.
(4) IGN LAREG, Univ. Paris Diderot, Sorbonne Paris Cité, 75013 Paris, France.
(5) Institut Pierre-Simon Laplace, LMD, Ecole Polytechnique, Palaiseau, France.

Ground station for monitoring and characterization of atmospheric moisture in the center of the Western Mediterranean basin.

Funded by the IODA-MED Grant ANR-11-BS56-0005, the MUSIC Grant ANR-14--CE01-01 & MISTRALS
WALI: transportable Water vapor & Aerosol Lidar

4 modular channels:
- Elastic (co- and cross-polarized) at $355 \pm 0.1$ nm
- $N_2$ Raman at $387 \pm 0.05$ nm
- $H_2O$ Raman at $407 \pm 0.05$ nm

Chazette et al., AMT, 2014

Versatile, eyesafe
Refractive telescopes (150 mm) => high transmittance, optical stability
Large FOV (3 mrad) => low overlap (~100 m when best focus)
WVMR up to ~10 km range in 20 min during night-time
Intercomparison strategy

AROME-WMED (HyMeX)
Dedicated NWP model
Model developed and run by Météo-France, for the HyMeX program (extreme precipitation prediction)

WRF
Open access NWP model
Model run by J-C Raut with fine modelization of the boundary layer processes

- WALI
- IASI & AIRS
  Infrared Spectrometer
  Water vapor profiles with low resolution, constrained by weight functions of spectral channels
- MODIS
  Space-borne products
- Airborne data

Chazette et al., 2014 ACP
Chazette et al., 2015a QJRMS
AROME-WMED vs WALI

Is this well reproduced by models?

AROME-WMED (HyMeX) Dedicated NWP model
Model developed and run by Météo-France, for the HyMeX program (extreme precipitation prediction)
NWP and research models vs WALI: IWVC

Table 5: Statistics on the comparison between the integrated water vapour content derived from lidar measurements and others data set (GPS measurements, AROME-WMED, ECMWF and WRF models). The Pearson coefficient $r^2$ for the different linear fits is also given.

<table>
<thead>
<tr>
<th>Altitude range (km)</th>
<th>Slope</th>
<th>Bias (kg m$^{-2}$)</th>
<th>RMSE (kg m$^{-2}$)</th>
<th>$r^2$</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>0.5-6</td>
<td>1.0</td>
<td>5.1</td>
<td>1.5</td>
<td>0.93</td>
</tr>
<tr>
<td>AROME-WMED</td>
<td>0.5-6</td>
<td>0.95</td>
<td>1.3</td>
<td>2.3</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>1.5-6</td>
<td>1.00</td>
<td>0.8</td>
<td>1.5</td>
<td>0.91</td>
</tr>
<tr>
<td>ECMWF</td>
<td>0.5-6</td>
<td>0.84</td>
<td>2.3</td>
<td>2.1</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>1.5-6</td>
<td>0.89</td>
<td>1.2</td>
<td>1.3</td>
<td>0.91</td>
</tr>
<tr>
<td>WRF</td>
<td>0.5-6</td>
<td>0.88</td>
<td>3.3</td>
<td>1.8</td>
<td>0.88</td>
</tr>
<tr>
<td></td>
<td>1.5-6</td>
<td>0.95</td>
<td>1.8</td>
<td>1.4</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Lidar calibration drift <<10%
WALI is stable

Underestimation for sunphotometer retrievals of IWVC
WVMR profiles

Table 6: Scores of inter-comparisons of WVMR retrieval by WALI and AROME WMED (WALI – AROME WMED), and WALI and ECMWF (WALI – ECMWF). The results are given during night-time for several atmospheric layers, in terms of correlation (COR) and root mean square error (RMSE).

<table>
<thead>
<tr>
<th>Altitude Range (km amsl)</th>
<th>COR</th>
<th>RMSE (g kg⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WALI-AROME WMED</td>
<td>WALI-ECMWF</td>
</tr>
<tr>
<td>0.5-1.5</td>
<td>0.68</td>
<td>0.68</td>
</tr>
<tr>
<td>1.5-3.0</td>
<td>0.87</td>
<td>0.88</td>
</tr>
<tr>
<td>3.0-6.0</td>
<td>0.88</td>
<td>0.85</td>
</tr>
<tr>
<td>0.5-6.0</td>
<td>0.84</td>
<td>0.83</td>
</tr>
</tbody>
</table>

- WRF slightly better than AROME WMED when compared to WALI, especially in the lower levels
- Lack of proper moisture constraint at the surface?

Chazette et al., 2015a
QJRMS SOP 1 Special Issue
Airborne measurements vs WALI

14/10/2012
Mean RMSE ~1.3-1.5 g kg\(^{-1}\)

Boundary Layer Pressurized Balloons (BLPB)

<table>
<thead>
<tr>
<th>Balloon case (BC)</th>
<th>Date</th>
<th>RMSE (g kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>WALI-BLPB</td>
</tr>
<tr>
<td>BC0</td>
<td>26/09/2012 0157 UTC</td>
<td>0.8</td>
</tr>
<tr>
<td>BC4a (event 4)</td>
<td>11/10/2012 0202 UTC</td>
<td>1.2</td>
</tr>
<tr>
<td>BC4b (event 4)</td>
<td>14/10/2012 0814 UTC</td>
<td>1.3</td>
</tr>
<tr>
<td>BC5 (event 5)</td>
<td>18/10/2012 0255 UTC</td>
<td>0.9</td>
</tr>
<tr>
<td>BC6a (event 6)</td>
<td>25/10/2012 2100 UTC</td>
<td>1.1</td>
</tr>
<tr>
<td>BC6b (event 6)</td>
<td>26/10/2012 0536 UTC</td>
<td>0.9</td>
</tr>
</tbody>
</table>

25/10/2012
Mean RMSE ~1.1 g kg\(^{-1}\)
Combining moisture datasets

HPE over the CV area during IOP 15b

Temporal evolution of the 10.8 µm channel SEVIRI-derived brightness temperature over the Cevennes-Vivarais region (2-5° E and 43.2-45.5° N).

Chazette et al., 2015b
QJRMS SOP 1 Special Issue
Combining moisture datasets

MODIS IWVC 700-300 hPa: 19 & 20 October 2012

- Transport of moisture between 700 and 300 hPa from WA (observations and models)
- Tropical plume co-located with storm track (SEVIRI imager)
- Vertical structure of the plume documented by WV lidar WALI

HyMeX

MSG/SEVIRI
0600 UTC
20 October 2012
Main highlights

- Good agreements between lidar, airborne & balloon-borne WV measurements
- Good agreements between lidar & GPS and NWP and research models
- Combination of space-borne and ground-based remote sensing water vapour observations as well as mesoscale models show moist tropical plumes ahead of cold fronts that may impact HPEs in the western Mediterranean (at least IOP 15b).
- The existence of the moist filament over the western Mediterranean is certainly favourable for the development of deep convective systems, as the moistening in the lower level will help overcome convective inhibition and produce strong updrafts.

Further activities:

- The contribution of the MCSs to the moistening of their environment is an open question that will be investigated in forthcoming studies.
- The presence of moist tropical filaments and their possible spatial coincidence with well-defined storm tracks and near surface convergence lines over the western Mediterranean should also be investigated for other HyMeX IOPs.