The HyMeX (*) project

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> *Hydrological cycle in the Mediterranean eXperiment

OUTLINE

Objectives and Observation Strategy

Atmosphericcremotelsensing in HyMeXyle

Main Objectives

 To improve our understanding of the water cycle, with emphases on the predictability and evolution of intense precipitation events within the Mediterranean basin

• by monitoring and modelling:

the Mediterranean *coupled system* (atmosphere-land-ocean), its *variability* (from the event scale, to the seasonal and interannual scales) and its characteristics over *one* decade in the context of global change

To evaluate the societal and economical vulnerability to extreme events and the adaptation capacity.

Major disciplines: Meteorology, Oceanography, Hydrology, Climatology, Societal sciences

Motivations and Societal Stakes

<u>The Mediterranean</u> <u>basin</u>:

A nearly enclosed sea surrounded by very urbanized littorals and mountains

2.5 millions km²





A unique highly coupled system (Ocean-Atmosphere-Continental surfaces)

Main Scientific Topics





Main Scientific Topics

Mesoscale convective systems Slow-moving frontal systems

> **Heavy Precipitation Flash-flooding**

Hydrological continental cycle

Better understanding of *intense weather* events:



Mediterranean cyclogeneses **Regional winds** (Mistral, Bora, Tramontana)

Event

Key questions:

What are the ingredients and their interactions necessary to produce an extreme event? What will be the evolution of intense events with the global climate change?

Century

Seasonal

Annual

<u>Topic 3:</u> Heavy precipitation and flash-flooding

Deep convection

Main properties :

- Both strong rain intensity (~100 mm.h⁻¹) and

intermittency

- Depends on the large scale forcing (SST, PV, etc ...) and
- the presence of the relief (enhancement, location)



09/09/2002 02:00:00



Shallow banded convection



Courtesy of S. Anquetin

<u>Topic 3:</u> Heavy precipitation and flash-flooding

Large scale meteorological environment propitious to heavy precipitation events relatively well known, progress has to be made to better understand the mechanisms that govern the *precise location* of the anchoring region of the stationary precipitating systems as well as those that produce in some cases *uncommon amount of precipitation*



Observation strategy

 « Nested » approach necessary to tackle the whole range of processes and interactions and estimate budgets



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 « Nested » approach necessary to tackle the whole range of processes and interactions and estimate budgets



HyMeX Observation strategy

« Nested » approach for the 1st EOP/SOP

TARGET AREAS



HyMeX Examples of observation networks for



Observation strategy for the SOP

Observations over land:

Hydrometeorological sites and supersites: observations of precipitating systems and inflow, rivers and continental surfaces (nested watersheds)

Examples of contributions received for the HyMeX Implementation Plan :

- mobile/fixed radars (LAMP; New Zeland, Univ. Honenheim, DLR, NOVIMET, NSSL)

 water vapour lidar and aerosols (IGN-SA)
 water vapour and Temperature lidars (Univ. Honenheim),

Doppler wind lidar (IMK)

Cloud radars (IMK, DLR),

Micro-rain radars (DLR, LaMP)

-Sodar (CNRM)

- electricity receiver PROFEO (ONERA)
- CCN/IN measurements (LAMP; CNRM)
- GPS receivers (GM)
- Soundings (IMK, CNRM)
- energy budget stations (IMK, CNRM)
- atmospheric surface and soil moisture measurements (CNRM, HSM, IMK)
- Disdrometers (LTHE, DLR)
- Ceilometers, photometers (CNRM)



4 target areas during the SOPs

Observation strategy for the SOP

Hydrometeorological sites and supersites: Observations of precipitating systems and inflow, rivers and continental surfaces (nested watersheds)

Observations over the Sea:

Observations of the atmosphere and ocean boundary layers, air-sea fluxes (annual cycle, intense events), dense water formation and propagation

Examples of contributions received for the HyMeX Implementation Plan :

mooring, buoys

- ARGO free-drifting

- glider transect

- GPS and XBT on-board ferries

research vessels with air-sea fluxes measurements, soundings, ocean soundings, X-band radar ?
 Boundary layer Pressurised Balloons

Aeroclipers for measuring air-sea fluxes ?

- aircraft (DO128-IMK ?) for measurements in the marine boundary layer

· . . .

Observation strategy for the SOP

<u>Hydrometeorological sites and supersites:</u> Observations of precipitating systems and inflow, rivers and continental surfaces (nested watersheds)

Observations over the Sea:

Observations of the atmosphere and ocean boundary layers, air-sea fluxes (annual cycle, intense events), dense water formation and propagation

Observations of the free troposphere: Observations of the Mediterranean cyclogeneses, and precipitating systems over Northwestern Med. and their environment over Western Mediterranean regions



Examples of contributions received for the HyMeX Implementation Plan :

- soundings (enhancement of existing and additional soundings) link with EUCOS-MEDEX
- French research aircrafts : ATR42 (low and middle troposphere) & Falcon20 (upper levels)
- NRL/P3 ELDORA (cloudy and precipitating systems)
- HALO-NEPTUNE ??
- + Satellite products (METEOSAT, METOP,...)



SOP1: 15 Sept.- 15 Nov. Heavy rainfall and flash-flooding, Ocean state prior the dense water formation for SOP1.1

Monthly frequency of intense cyclones (ERA40 1957-2002) (Homar, 2007)



J F M A M J J A S O N D

SOP2: March-April Dense water formation and convection formation Cyclogeneses and severe regional winds





SOP1: 15 Sept.- 15 Nov. Heavy rainfall and flash-flooding, Ocean state prior the dense water formation for SOP1.1 Dense water propagation for SOP1.2

Monthly frequency of intense cyclones (ERA40 1957-2002) (Homar, 2007)



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HyMeX Organisation

<u>Deliverables</u>	A second s		
Prospective document	White book edition Promotion in international conferences	Science Plan Implementation Plan Search for fundings	
20	06 Phase 1 20	08 Phase 2 2010	D
Nov. 2005: "Mediterranean" OA prospective workshop	Jan. 2007: 1st Mediterranean- HyMeX workshop Dec. 2006: 1st issue of the HyMeX white book	June 2008 2nd HyMeX workshop End 2008 1st draft of the Implementation Plan End 2008 1st draft of the Implementation Plan & Science Plan & 3rd HyMeX Workshop	
Forum, prospective editorial committee	White book editorial and reviewing committees	International Scientific Steering Committee (ISSC) Executive ISSC (Exec-ISSC) Working groups (WG)	

HyMeX Organisation

Contributions in each WG







Atmospheric Remote Sensing during HyMeX

Wind profiler network (EOP & SOPs)
 2 year project

Weather radar network (EOP & SOPs)
 4 year project

Remote sensing profiling station (EOP & SOPs)
 2 year project

Profiler radar network (EOP)

^vUHF (1.2 GHz; 75m < Z < 5000m)

VHF (45 ou 72 Mhz; 1.5 km < Z < 10 km)

200 km

Observe upstream conditions

2 year period (2011-2013)



Weather radar network (EOP)



AEMET **METEOCAT**

- **METEO-FRANCE**
- ENAV ARPA SARDEGNA DPC ARPA PIEMONTE
- IAF \bigcirc

« QPE » Radar network 4 year period (2010-2014) Spatio-temporal distribution of precipitation over the sea + VAD

▲ Operational radars → Ow cost & ²continuous sampling



- Heterogeneity of data
- Data exchange policy
- (may be simplified thanks to OPERA)
- Limited range q

Shipborn X-band radar on 1 commercial ferry boat

Shipborn X-band radar research vessel Atalante

Weather radar network (EOP)



« HPE » Radar network
 4 year period (2010-2014)
 Convective systems in Southern France

3-D wind & reflectivity fields + Particle Id.

Real-time during whole EOP

« Low Resolution » domain (350x350x12 km3)

 $\Delta T = 15'; \Delta X = 2.5 \text{ km}$

Weather radar network (SOP)



• « HPE » Radar network SOPs Convective systems in South-Eastern France

> « High resolution » domain (200x200x12 km3) 3-D wind & reflectivity fields + Particle Id + Radar refractivity retrieval $\Delta T = 5'; \Delta X = 1 \text{ km}$

(real-time analysis)





OPERATIONAL COMPOSITE OF RADAR REFLECTIVITY

EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-21 00 UTC - Z (dBZ) + (U,V)





Alt = 500 m AMSL



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-21 12 UTC - Z (dBZ) + (U,V)



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-22 00 UTC - Z (dBZ) + (U,V)



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-22 02 UTC - Z (dBZ) + (U,V)



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-22 04 UTC - Z (dBZ) + (U,V)



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-22 06 UTC - Z (dBZ) + (U,V)



EXAMPLE OF 3D WIND RETRIEVAL FROM OPERATIONAL RADAR SYSTEMS 2008-10-22 08 UTC - Z (dBZ) + (U,V)





Mobile research radars will be deployed **during the SOPs** to improve the radar coverage as well as to provide information in regions/watersheds not well covered by operational radar systems



LAMP (Fr)

(Privas) Conventional radar

Auckland Univ. (NZ)

(Mt. Aigoual) Conventional radar

HCMR (Gr)

(Mt. Lozère) Doppler & Dpol

EPFL MXPol (Sw)

(Ales) Doppler <u>& Dpol</u>

NSSL SMART-R2 (US)

(Carpentras) C-band Doppler & Dpol

NSSL X-POL (US)

(GBRS site) Doppler <u>& Dpol</u>

(Arles) Doppler & Dpol

1.2

NRL-P3 (ELDORA)

860

880

840

Multicle Develop Area - 2044/204 Jun 2 - 411 = 1.5 km

OR

NOAA-P3 (NSSL Tail radar)

X lambert IIE - 680 km - 880 km

200 km

2000

RS site

(Montpellier)

1980

1960

LAMP (Fr)

(Privas) Conventional radar

Auckland Univ. (NZ)

(Mt. Aigoual) Conventional radar

HCMR (Gr)

(Mt. Lozère) Doppler & Dpol

EPFL MXPol (Sw)

(Ales) Doppler & Dpol

NSSL SMART-R2 (US)

(Carpentras) C-band Doppler & Dpol

NSSL X-POL (US)

(GBRS site) Doppler & Dpol

(Arles) Doppler & Dpol



Other research topics

Operational exploitation of dual-polarimetry

Design of radar network in region of complex terrain

Assimilation of wind vectors in high res NWP systems

Remote sensing supersite near Montpellier

(EOP 2011-2013)

A fixed, instrumented, site dedicated to ground-based remote sensing will be set up near Montpellier.

Météo-France will take care of the infrastructure (location, electricity, communication). The CNRM will deploy its instruments to document the characteristics of the low-level upstream flow, as well as to conduct research on integrated remote sensing profiling stations and perform instrument inter-comparisons, ...

Remote sensing profiling station







Possible location: Mauguio (Montpellier airport)

Secured and equipped site

Météo-France local center on the premise

Remote sensing profiling station:

Available instruments

Degreane PCL 1300 mobile UHF wind profiler (1274 MHz)





Remote sensing profiling station:

Available instruments

VHF wind profiler (45 Mhz) + RASS system





Remote sensing profiling station:

<u>Available instruments</u>

Backscattering Lidar & Laser Ceilometer



Remote sensing profiling station:

RS station
GPS station
Surface Met. and Flux stations
Captive balloon





Available instruments

Remote sensing profiling station:

Possibly available instruments

Doppler sodar & Doppler lidar

X-band Doppler radar (SOPs)





Remote sensing profiling station:

Needed instruments

Photometer (to estimate lidar ratio)

· Water vapor lidar

Doppler lidar

More X-band Doppler radars - Cloud radar

Microwave radiometer profiler

Collaborations are needed to have a full set of instruments deployed during (at least) a couple of SOPs

Thanks for your attention

http://www.cnrm.meteo.fr/hymex/

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