The HyMeX experiment

M.NURET

CNRM-GAME, Météo-France & CNRS

http://www.hymex.org

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Plan

Introduction

SOP1 Observation strategy

SOP1 execution and coordination

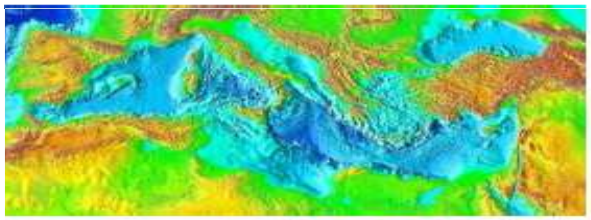
SOP2

Conclusion

Introduction

WHY HYMEX? : motivations and

HYMEX = **HY**drological cycle in the **M**editerranean **EX**periment



*A nearly enclosed **sea** surrounded by **very urbanized littorals** and **mountains** from which numerous **rivers** originate*

⇨ **A *unique highly-coupled*** (Ocean-Atmosphere-Land) ***system***

⇨ **A region prone to *high-impact events* related to water cycle:**

Heavy precipitation, flash-flooding during fall
Strong winds, large swell during winters
Droughts, heat waves, forest fires during summers

⇨ ***Water resources: a critical issue***

Freshwater is rare and unevenly distributed in a situation of increasing water demands and climate change (180 millions people face water scarcity)

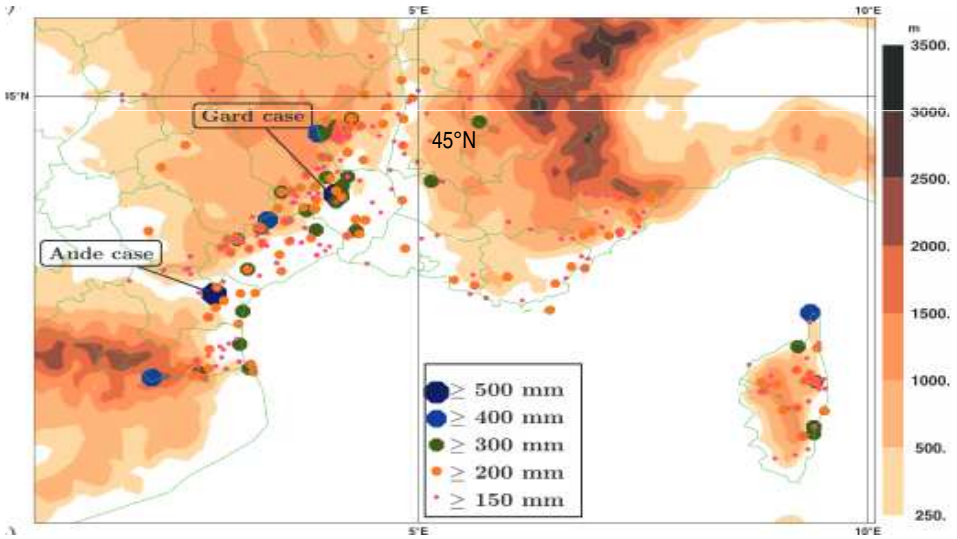
⇨ The Mediterranean is one of the two main ***Hot Spot regions*** of the ***climate change***

Large decrease in mean precipitation, increase in precipitation variability during dry (warm) season, large increase in temperature (+1.5 à + 6°C in 2100)

⇒ **Need to advance our knowledge on *processes related to water cycle within all Earth compartments*, to progress in the *predictability of high-impact weather* events and their evolution with *global change*.**

Introduction

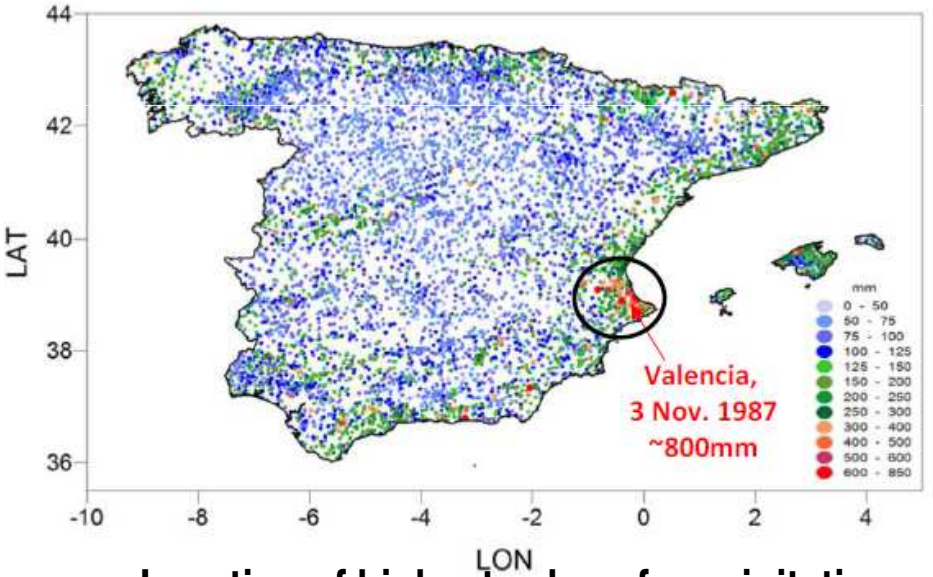
High Precipitation Events (HPE) leading to casualties



Location of highest value of precipitation (daily rainfall > 150mm, period 1967-2006)

From daily raingauge Météo-France network

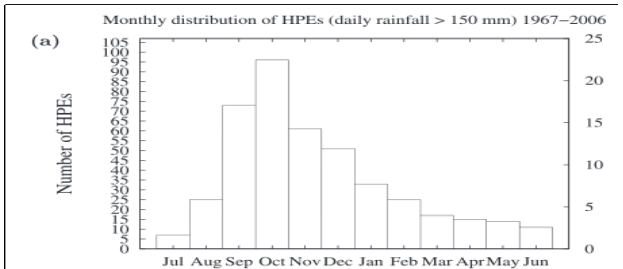
Ricard,D. V.Ducrocq and L. Auger, 2012 (JAMC)



Location of highest value of precipitation (daily rainfall period 1910-2008)

From daily raingauge AEMET network

Ramis,C. V. Homar, A. Amengual, R. Romero, S. Alonso, 2013 (NHESS)



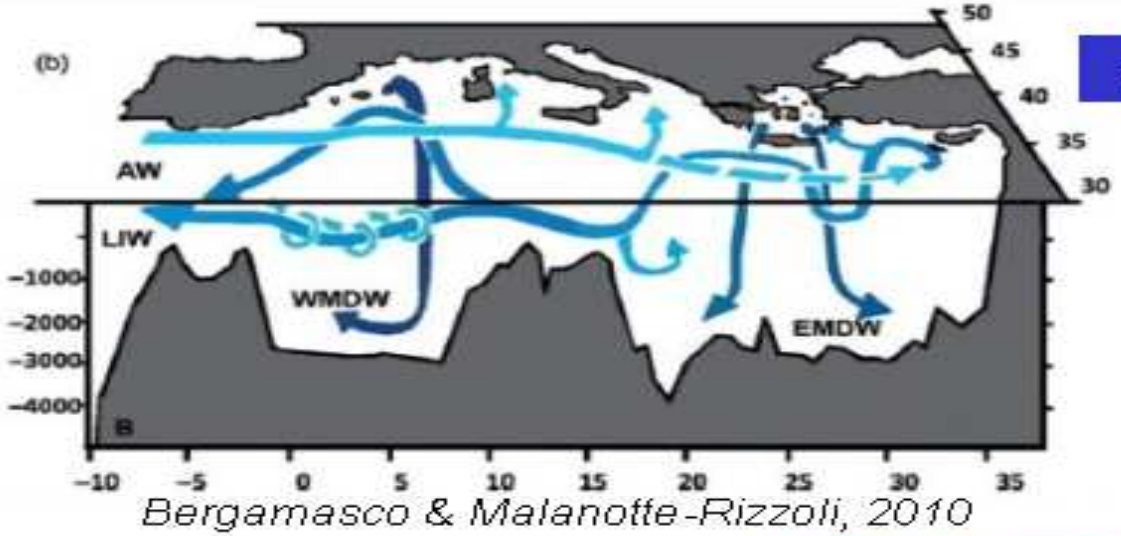
Monthly distribution of HPE (daily rainfall > 150mm) over France 1967-2006

Autumn is the prefered period for HPE

Introduction

WHY HYMEX? : motivations and societal stakes

Dense water formation in the mediterranean sea ←→ link with climate change (impact on thermohaline circulation), need to improve our knowledge on dense water formation (convection)



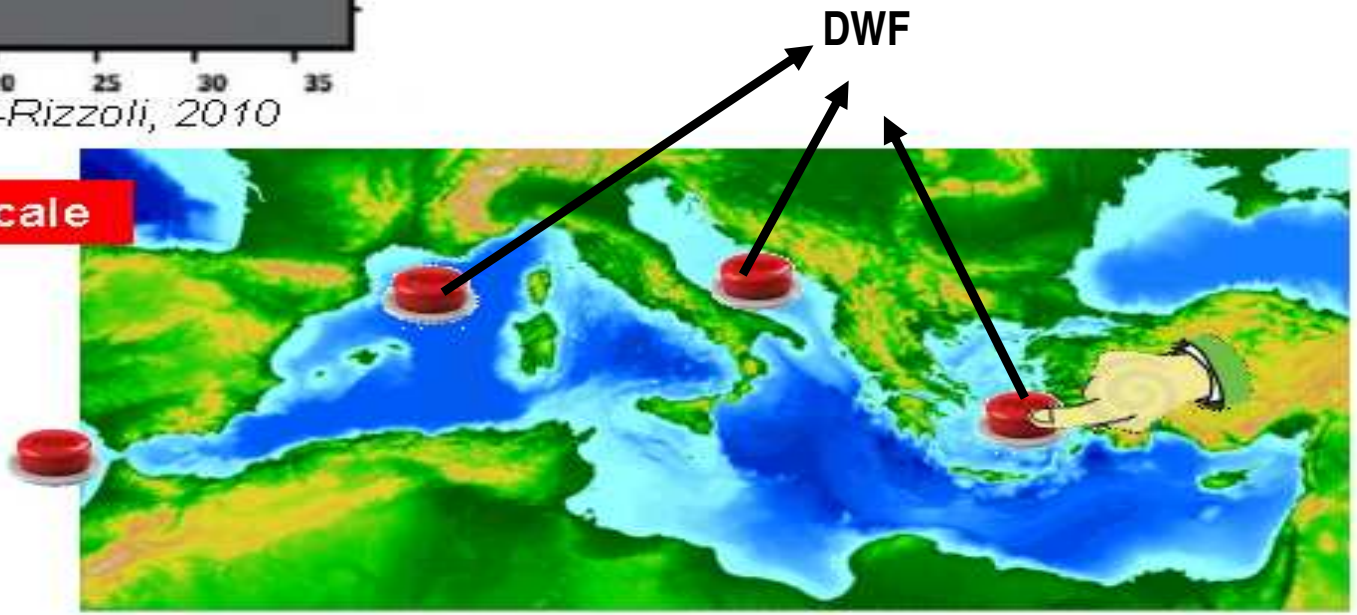
Bergamasco & Malanotte-Rizzoli, 2010

at interannual and basin scale

a complex circulation resulting from a complex heat and water budget

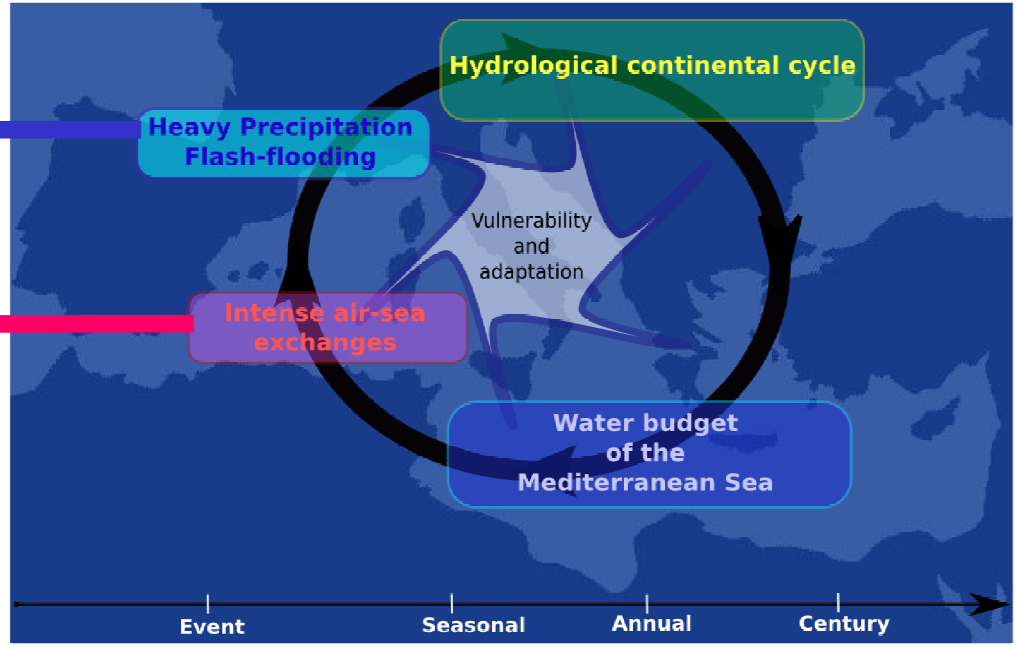
at seasonal and sub-basin scale

Specific processes that govern the Mediterranean hydrologic properties take their origin in winter and in specific regions



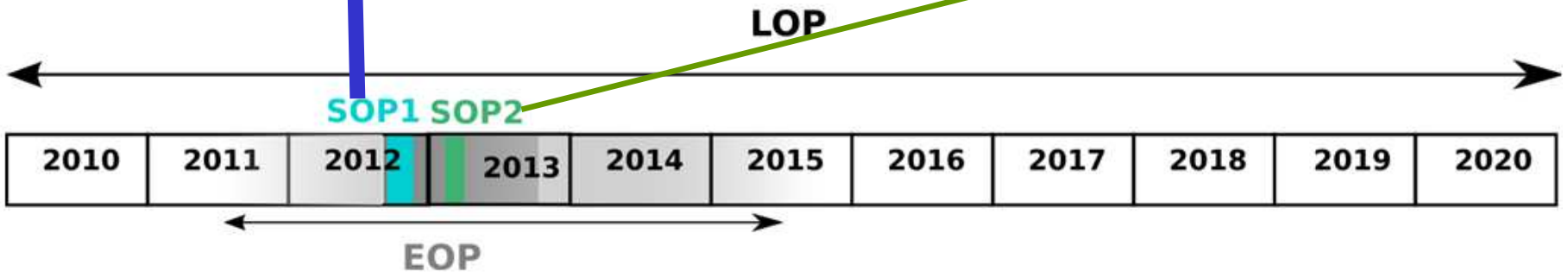
Introduction

2012-2013 : 2 field campaigns (SOP)
in Northwestern Mediterranean



SOP1: Heavy precipitation and flash-flooding
5 Sept-6 Nov 2012

SOP2: Intense air-sea exchanges
(severe winds, dense water formation)
1 Feb- 15 March 2013



Introduction

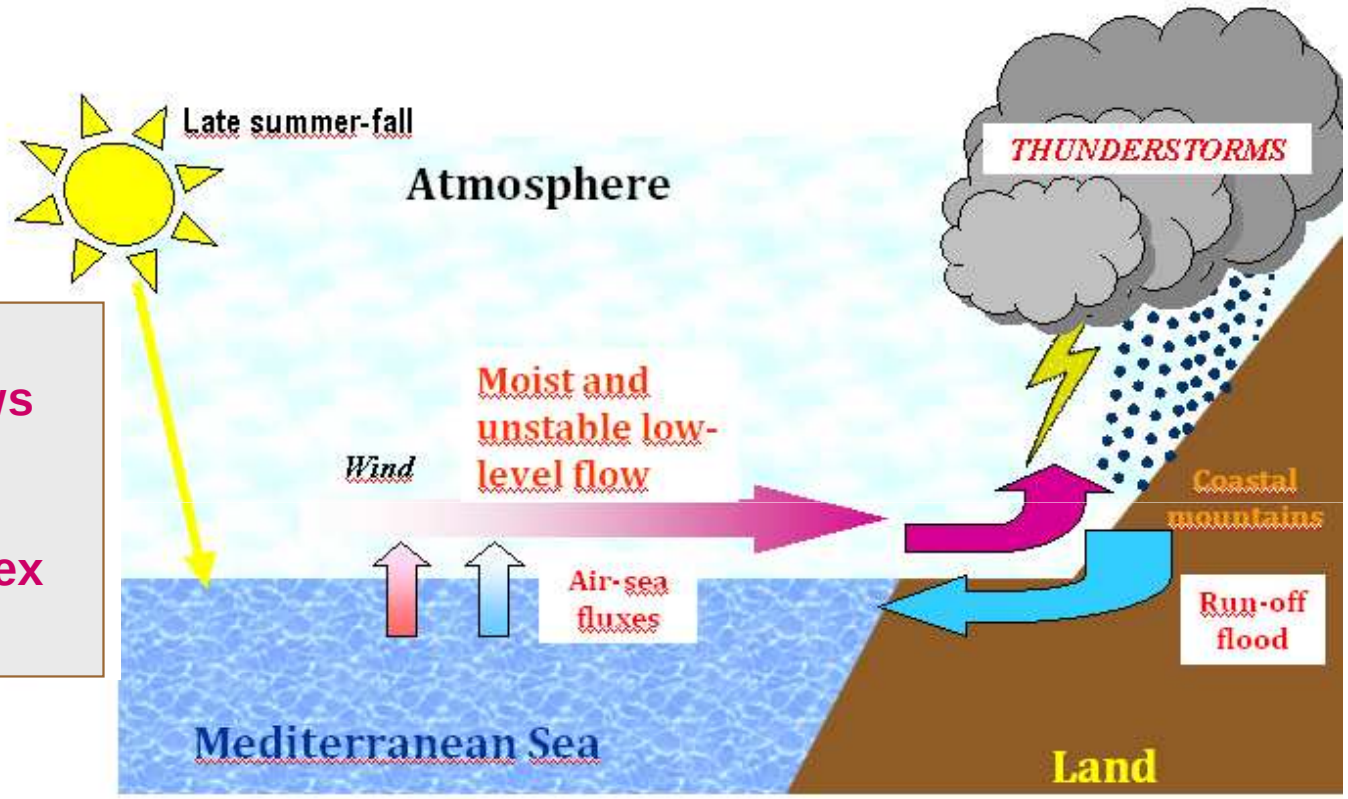
- A 10-year (2010-2020) multidisciplinary (atmosphere, ocean, hydrology, human sciences) program on the Mediterranean water cycle
- ~400 scientists from 20 countries
- HyMeX is endorsed by WWRP/JSC & THORPEX and WCRP/GEWEX & CORDEX

The Observation Strategy of SOP1

SOP1 objectives

SOP1 aimed to obtain detailed information on four key components:

Microphysics and dynamics of precipitating systems leading to HPE



Upstream marine flows and their interaction with complex terrain

Distributed hydrological response of the Mediterranean watersheds

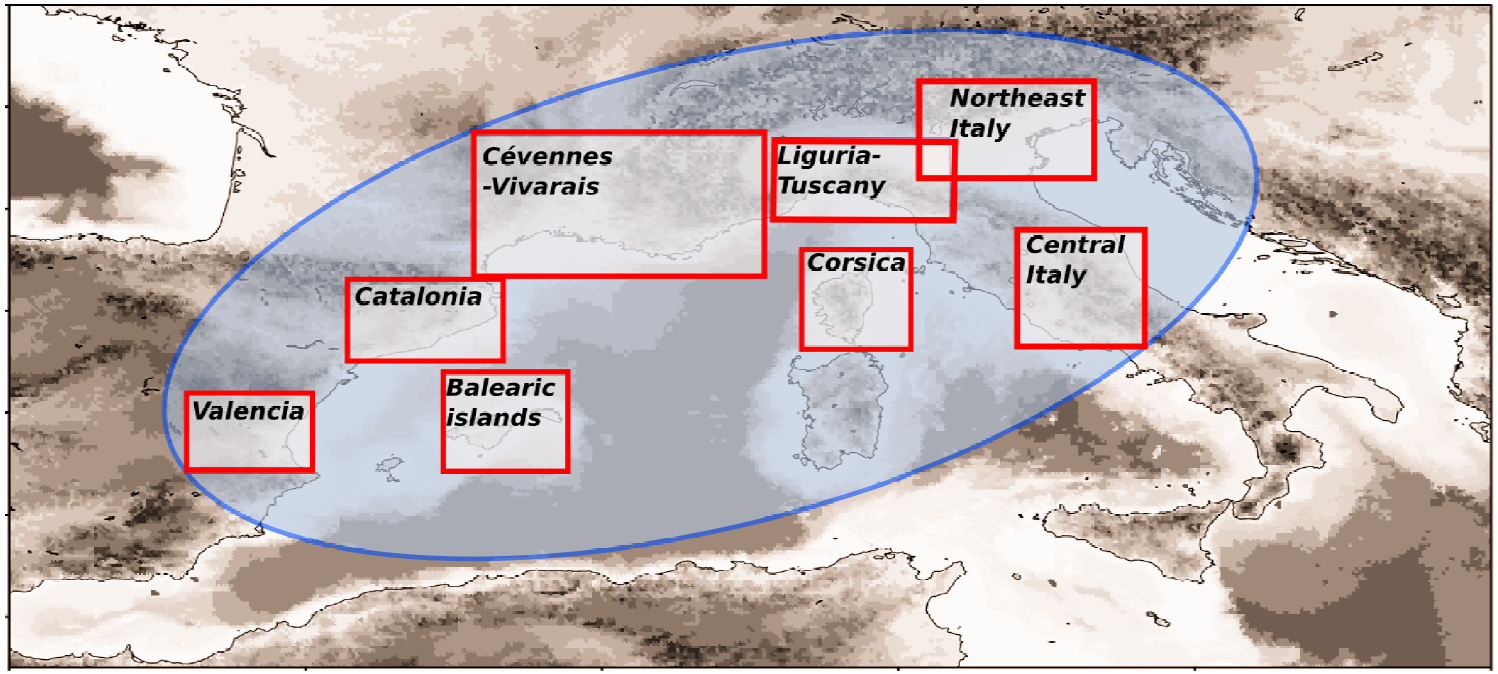
Air-sea exchanges and ocean mixed layer thermal heat content

The SOP1 domain and period

Criteria:

- **An area prone to heavy precipitation events with an expected number of events in a 2 months period > 10 .**
- **An area with operational meteorological and hydrological observations networks well furnished to provide a high-level observation background that the field campaign research instruments will complement.**
- **A 2 month period centered on the climatological peak of convective heavy precipitation events**

SOP1: from 5 September to 6 November 2012



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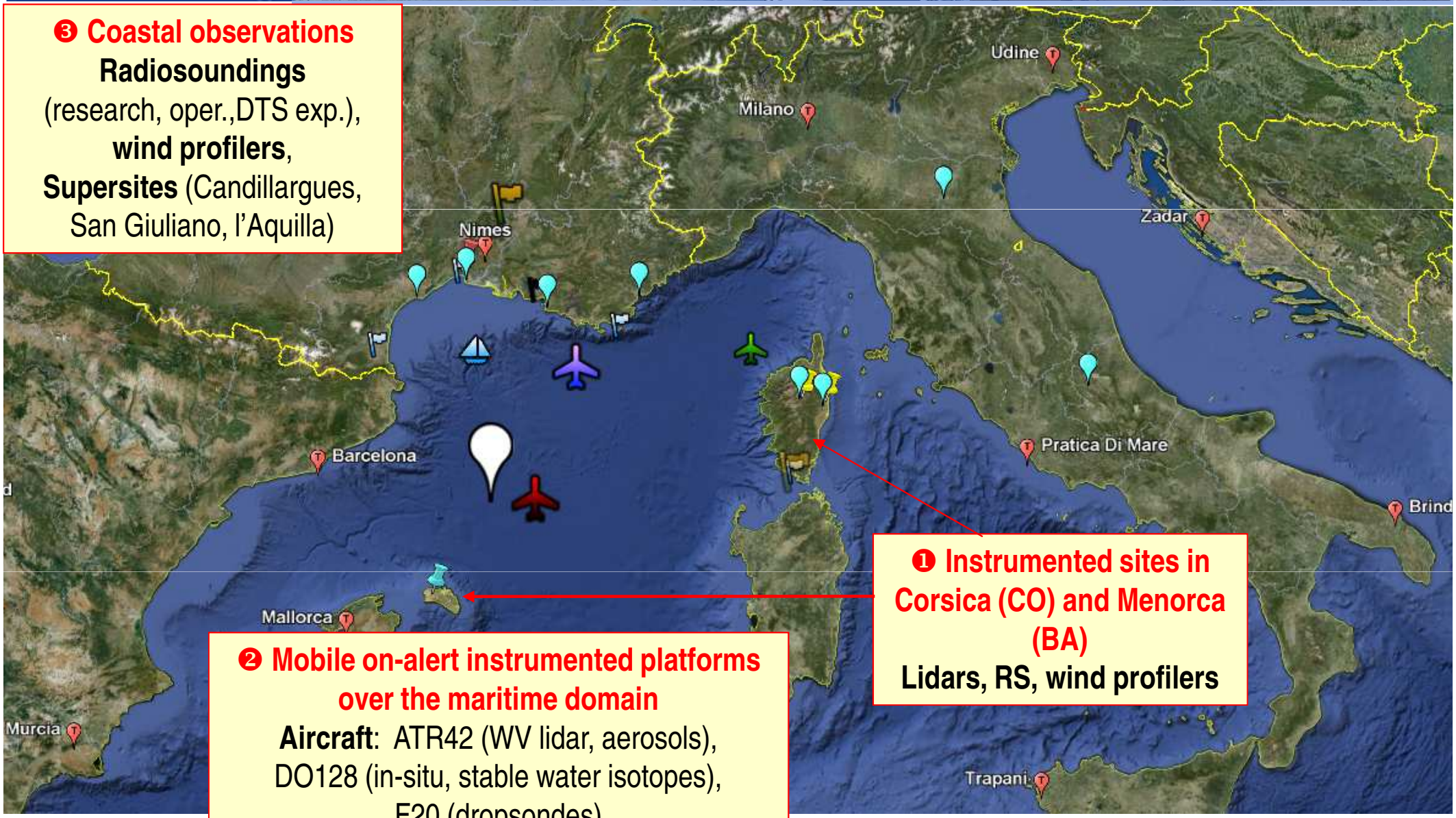
Upstream Marine flows



❸ Coastal observations
Radiosoundings
(research, oper.,DTS exp.),
wind profilers,
Supersites (Candillargues, San Giuliano, l'Aquilla)

❶ Instrumented sites in Corsica (CO) and Menorca (BA)
Lidars, RS, wind profilers

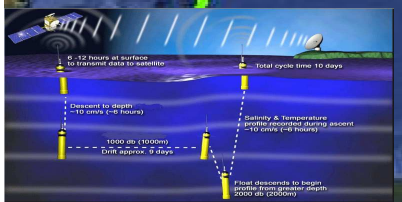
❷ Mobile on-alert instrumented platforms over the maritime domain
Aircraft: ATR42 (WV lidar, aerosols), DO128 (in-situ, stable water isotopes), F20 (dropsondes)
Boundary layer balloons
Ship *Le Provence* (RS)

HyMeX

Mediterranean Sea

ARGO float
SVP-BS
SVP-BTC
Marisonde
Glider

AZUR Buoy
P/T Provence
LION Buoy
Hannon
Eudoxus
23:30 UTC
Campe
SOO
Marfret-Niolon



❶ Air-Sea fluxes

DO128 + ATR42 **aircraft**
(turbulent fluxes)
Ship *Le Provence* (fluxes mast, swell recorder)
Marisondes and SVP
Fixed Météo-France **buoys**
SOO Marseille-Algiers

❷ Upper ocean

Gliders (0-1000m), ARGO **floats**
Boats: Le Thethys cruise (Sept.) and Le Provence (3 IOP): CTD
MF **buoys** (mooring lines),Corsica channel **mooring**

oogle earth

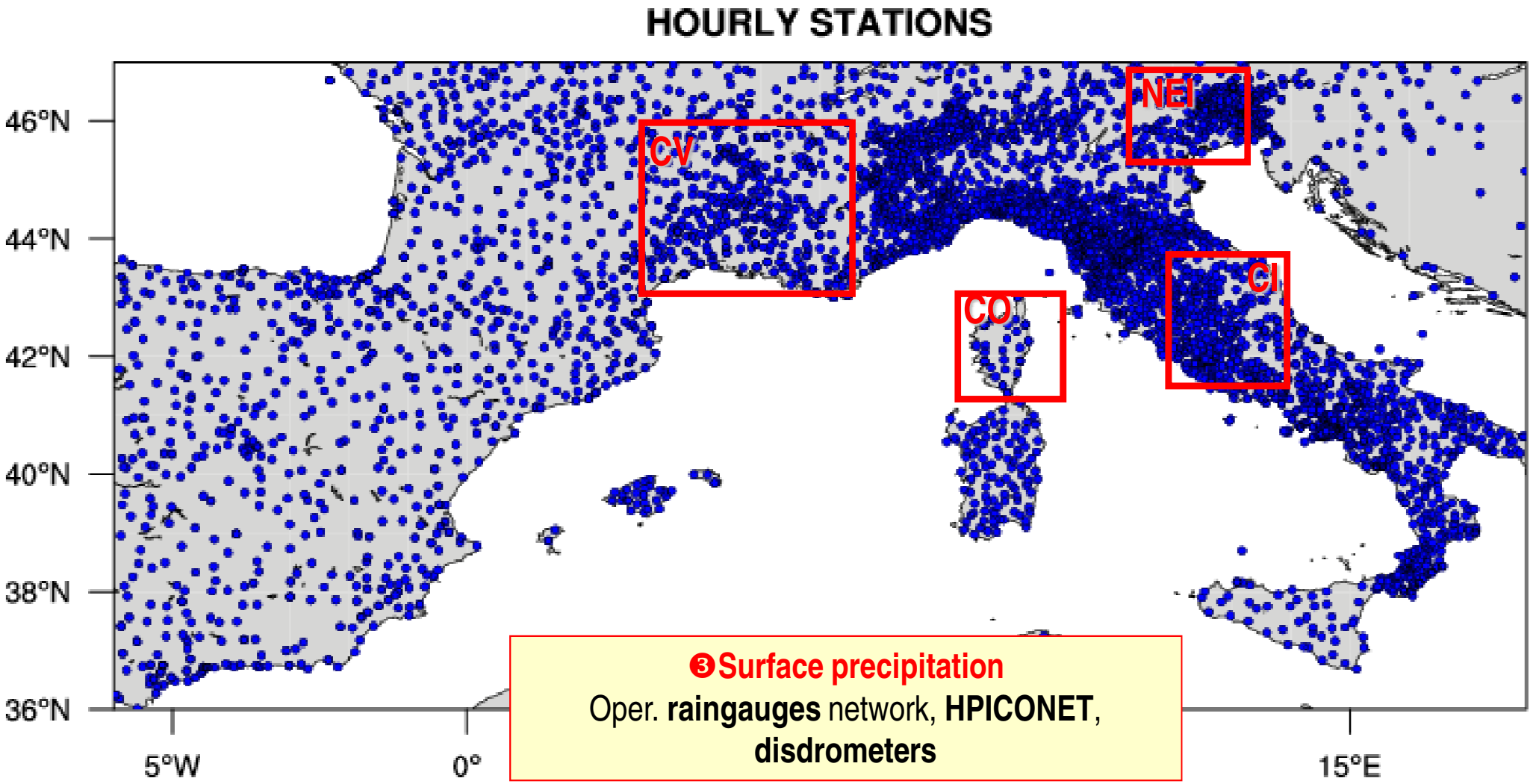
HyMeX Precipitating systems

❶ Microphysics and circulation within precipitating systems

Aircraft F-20 (cloud radar, microphysics probes)
operational + research **radars** (Doppler, polarimetrics)
4 **instrumented sites** : CV, CI, CO, NEI

❷ Electrical activity precipitation

Lightning Mapping array, field mill, … in CV



❸Surface precipitation

Oper. **raingauges** network, **HPICONET**, **disdrometers**

HyMeX Hydrological measurements

➢Nested-catchment instrumentation

❶ medium/large watersheds (transfer in river and flooding)
Discharge and precipitation estimation
Gard, Ardèche

❷ small watersheds (Distributed hydrology observations)
discharge, infiltration, soil moisture
Valescure, Tourgueuille, Avene, Auzon

❸ Hillslope (process understanding on runoff generation and concentration)
Soil moisture, infiltration, stable water isotopes, geochemistry

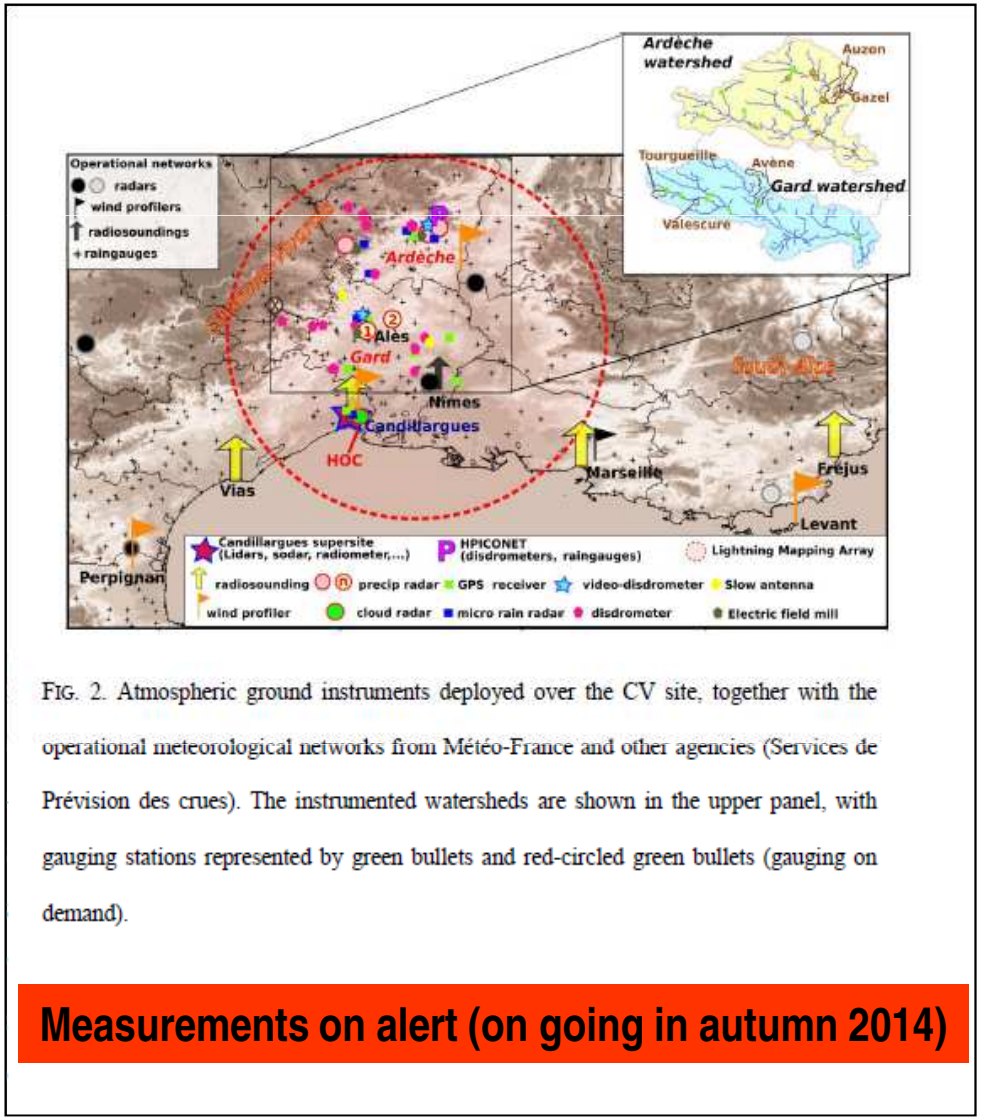


FIG. 2. Atmospheric ground instruments deployed over the CV site, together with the operational meteorological networks from Météo-France and other agencies (Services de Prévision des crues). The instrumented watersheds are shown in the upper panel, with gauging stations represented by green bullets and red-circled green bullets (gauging on demand).

Measurements on alert (on going in autumn 2014)

The SOP1 execution and coordination

- More than 200 instruments deployed
- About 300 scientists on the field

HyMeX The field campaign coordination

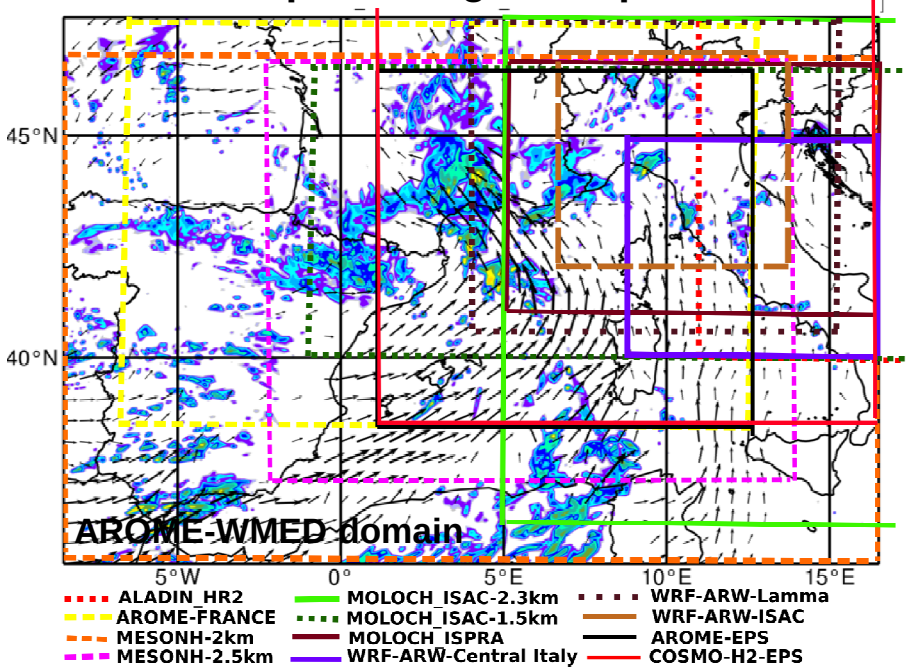
The HyMeX Operation Center (HOC) was located surroundings Montpellier, close to the French research aircraft base and the Candillargues supersite.

A major challenge: take-off time for day D and flight plans to be decided day D-1 before 11h ⇨ forecast of location and precise timing of deep convection 24-48h in advance

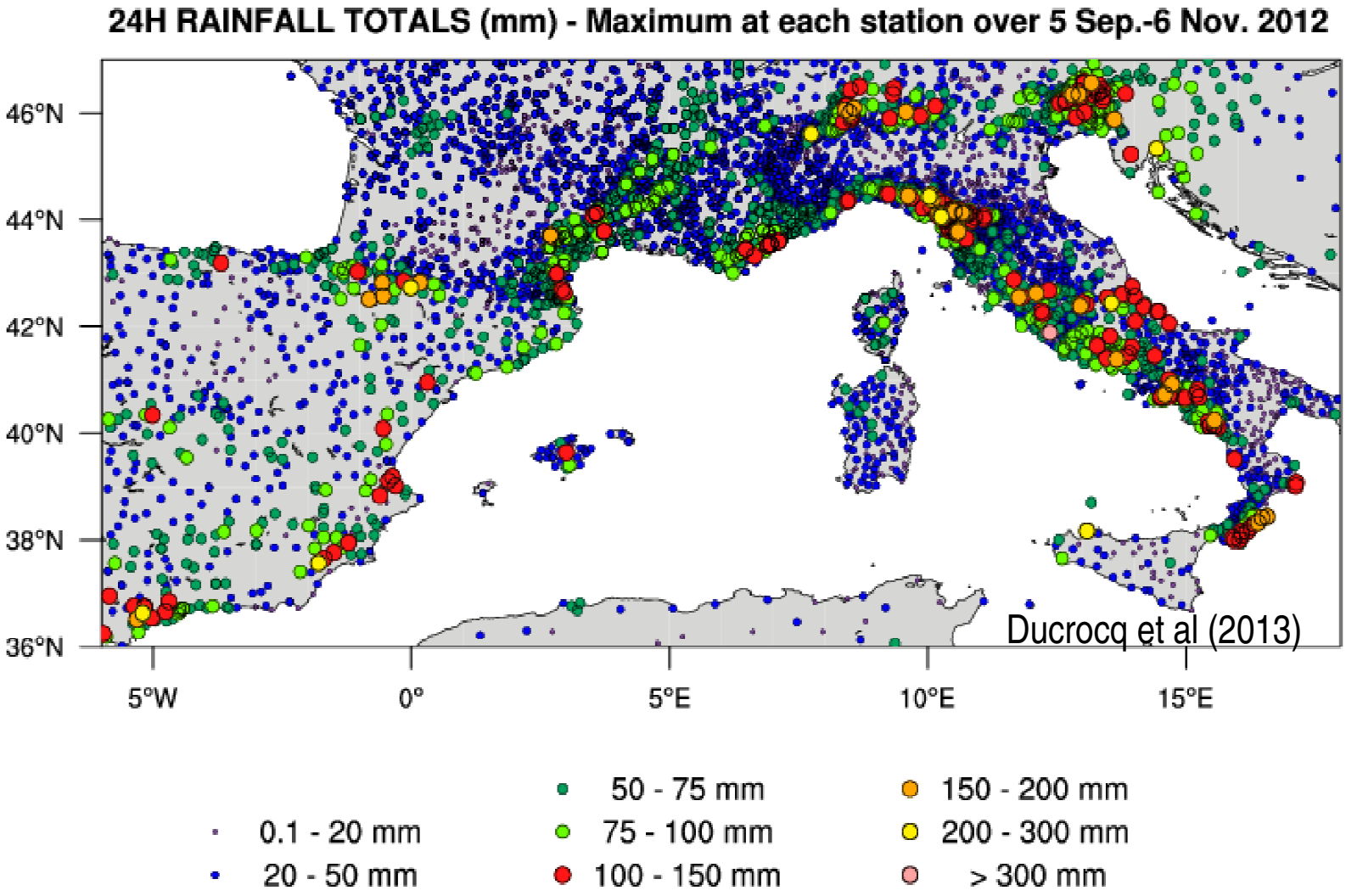
⇨ **A dedicated Météo-France forecaster at HOC and morning daily briefing 7/7, in visioconference with L'Aquila and Palma for forecast over Spain and Italy.**

⇨ **Several dedicated NWP systems for the SOP (AROME_WMED over the whole Western Mediterranean, WRF for Italy,...): 30 models available on the field campaign website + 6 NWP-driven hydrological and ocean models**

Convection-permitting atmospheric models



HyMeX The Heavy Precipitation Events

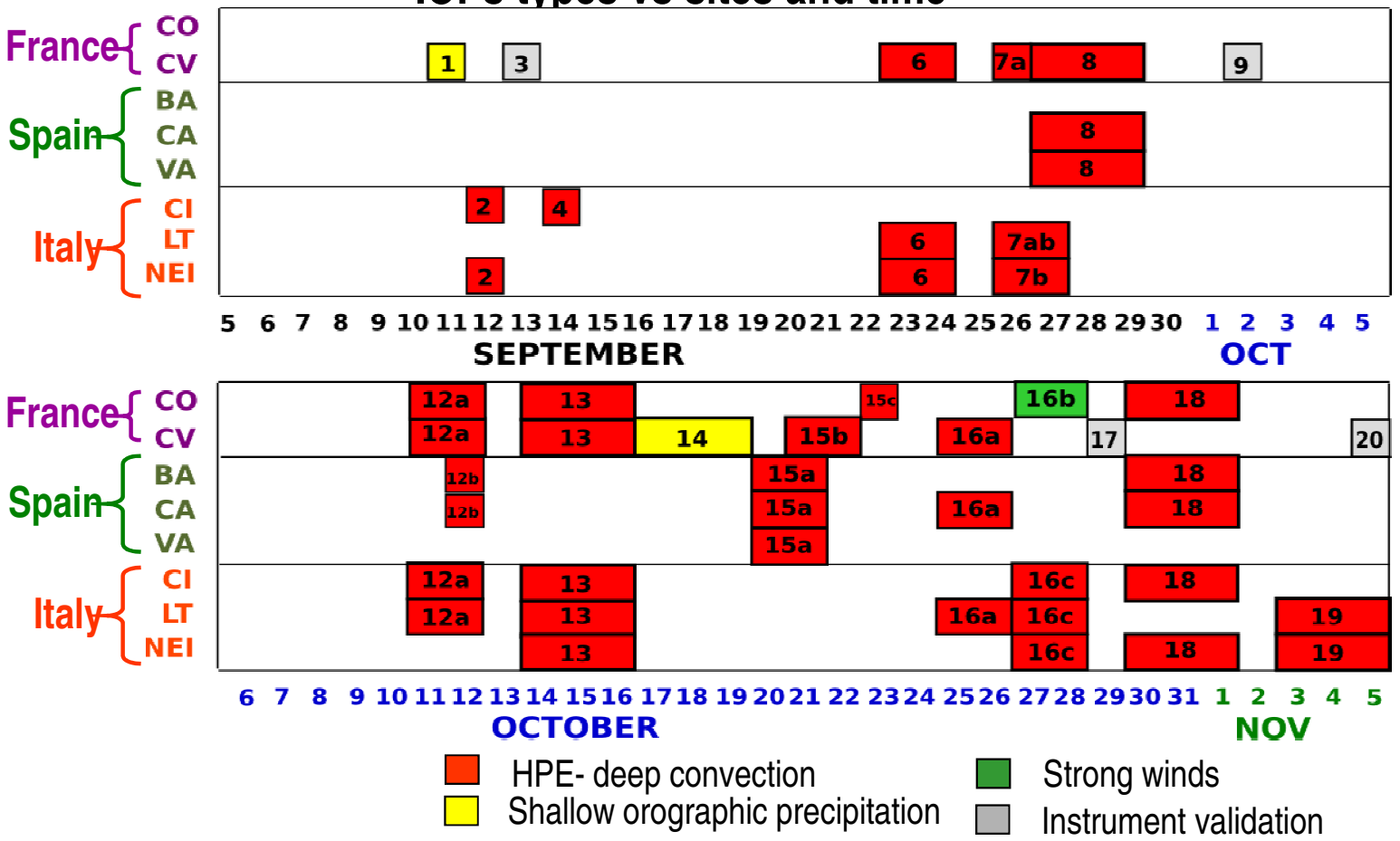


⇨ 20 days with at least 100mm/24h recorded by a raingauge station

⇨ HPE recorded over all the Northwestern Mediterranean, but more in Italy

HyMeX The Intense Observation Periods (IOPs)

IOPs types vs sites and time



⇨ 16 IOPs dedicated to HPE

⇨ Severe events with fatalities and damages

HyMeX — The Aircraft Missions

251 Flight hours:

- **SAFIRE/ATR42: 87 h**
  - ⇨ Survey of the upstream flow

  Payload : WV Leandre II Lidar, aerosols, turbulent air-sea fluxes

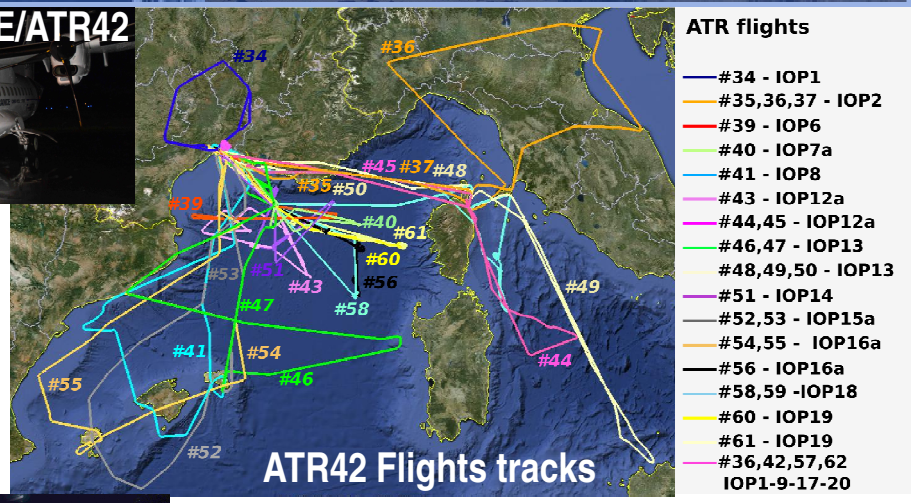
- **SAFIRE/F20: 69 h**
  - ⇨ Dynamics and microphysics within precipitating systems

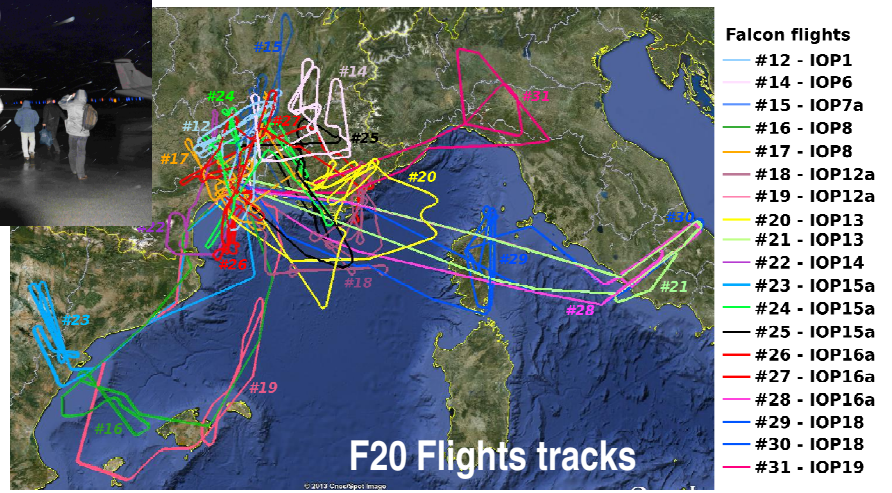
  Payload :cloud radar, cold microphysics probes, dropsondes launched over the Sea

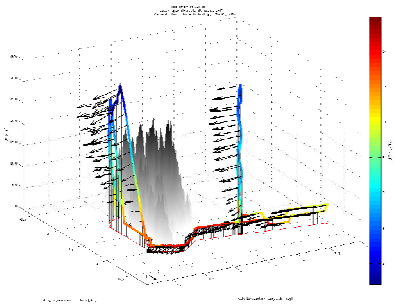
- **KIT/DO128: 95 h**
  - ⇨ over and offshore Corsica

  Payload : air-sea fluxes, stable water vapour isotopes

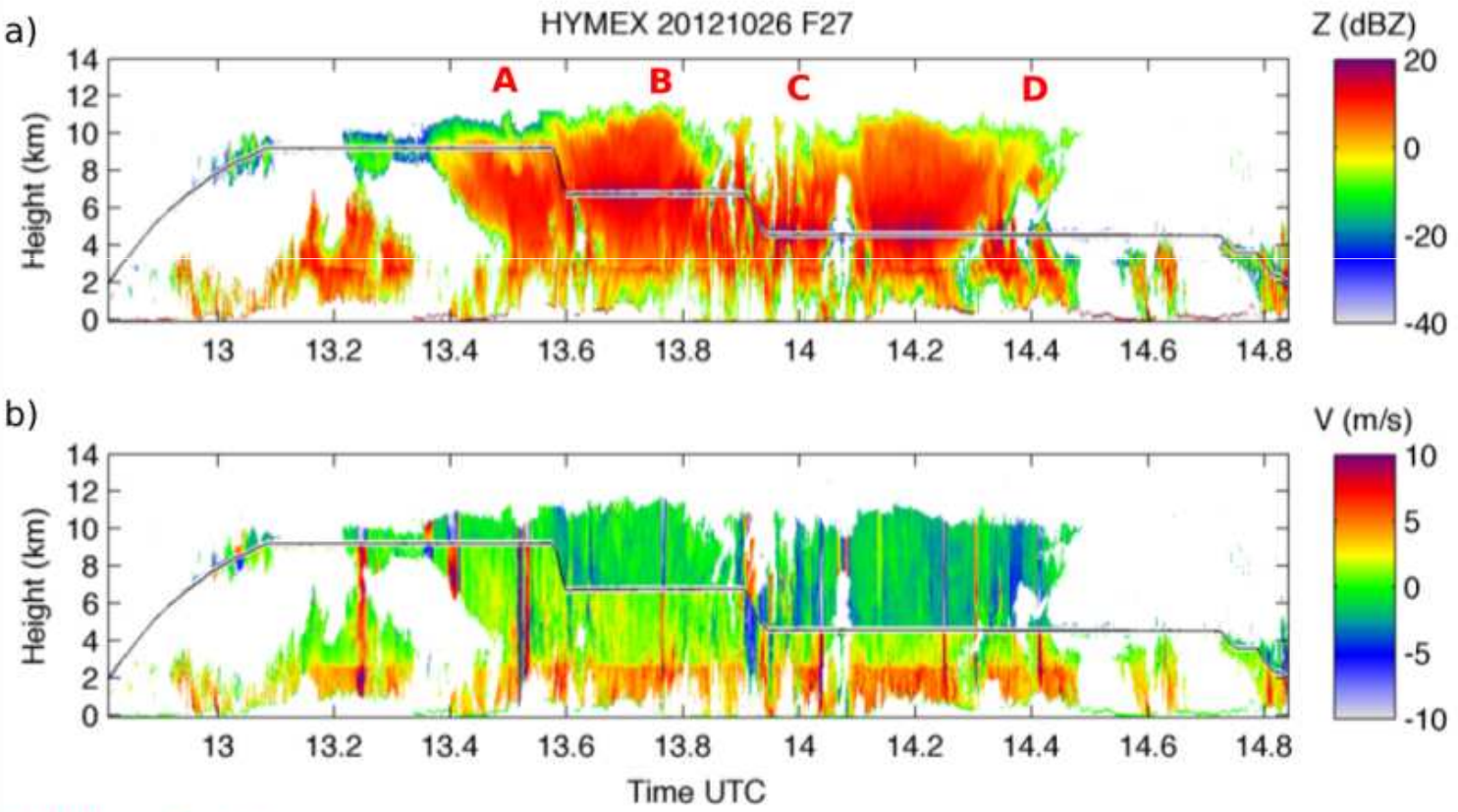
+ T-NAWDEX flights (1-20 Oct. 2012)



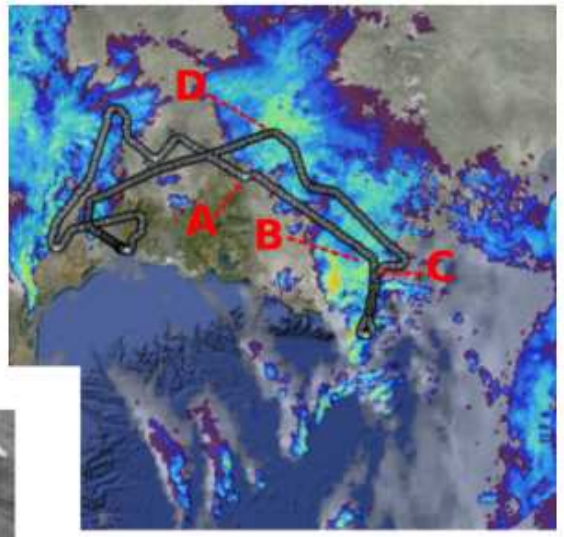




HyMeX Example of airborne measurements



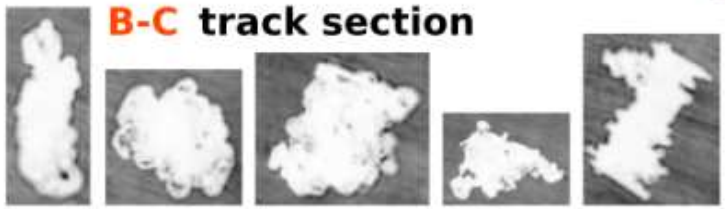
Reflectivity and Vertical Doppler velocity from the RASTA (95GHz) cloud radar along the Falcon-20 flight track – IOP16



⇨Microphysics parameterization of convection-permitting models

⇨Data assimilation

⇨Ground radars cross-validation



Hydrometeor sampled along the flight track

HyMeX Conclusion-SOP1

➢ **The field campaign has been successful regarding:**

- the **number of events** observed: **23 IOPs**, with 16 IOPs dedicated to HPE over Italy, France and Spain.
- the **variety of events**: convective and squall lines, V-shape quasi-stationary MCS, tornado, orographic precipitation, cyclogenesis,…

and with different levels of predictability that allow both:

(i) IOP process studies (ii) predictability studies (model improvement, data assimilation), by synergistic use of SOP1 observations and models

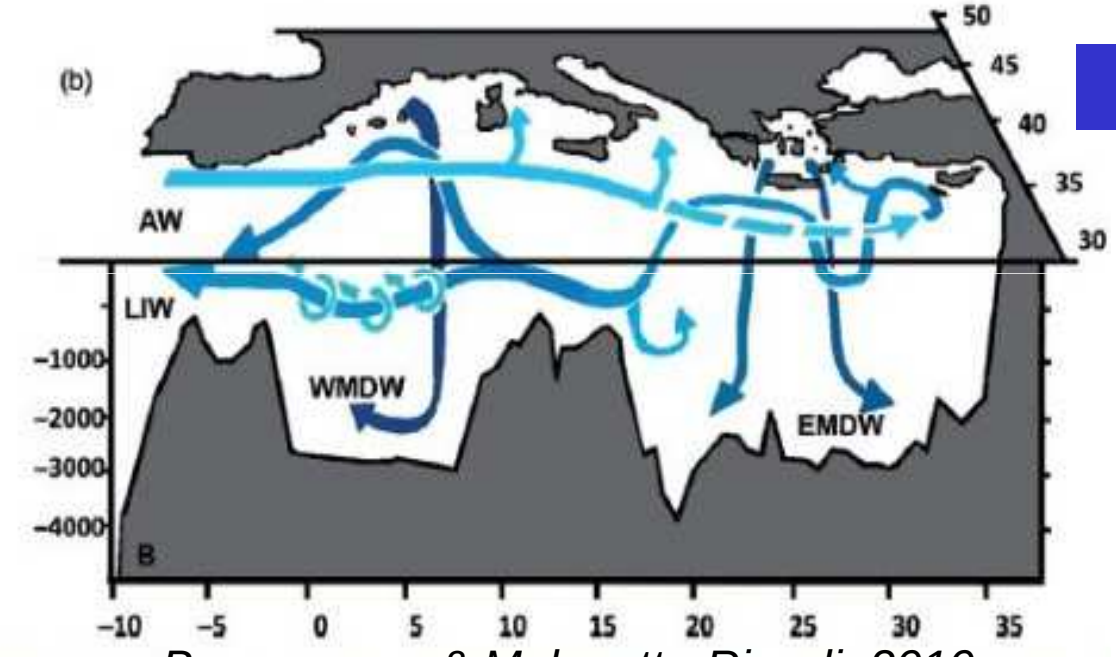
➢ **Difficulties encountered**:

- strong limitations imposed by the French **Air Traffic Control**, but impacts attenuated thank to a dedicated controller and French military zones over the NW Med. Sea.
- installation of the **wind profilers** in Balearic Islands impossible although all our efforts, but an interesting alternative has been found in France
- **few flash-flood events over the CV** watersheds in 2012, but hydrological measurements will continue during three next autumns (on-going EOP in 2014).

SOP2

(1st Feb.-15 March)

SOP2 objectives



Bergamasco & Malanotte-Rizzoli, 2010

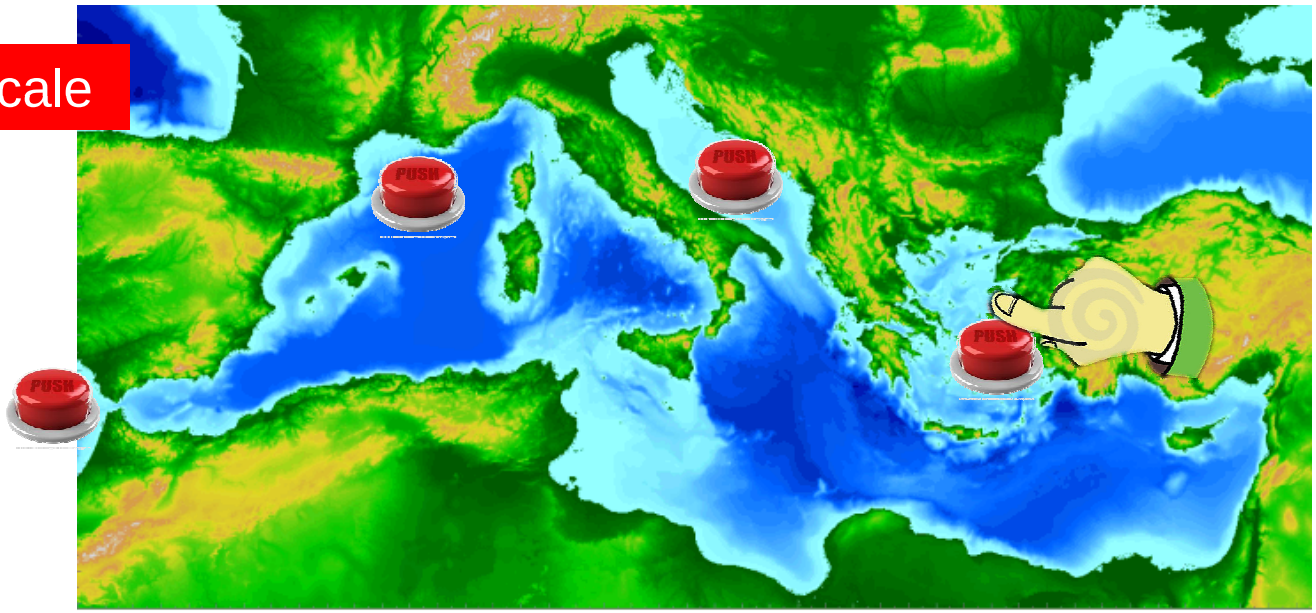
at interannual and basin scale

a complex circulation resulting from

a complex heat and water budget

at seasonal and sub-basin scale

Specific processes that govern the Mediterranean hydrologic properties take their origin in winter and in specific regions

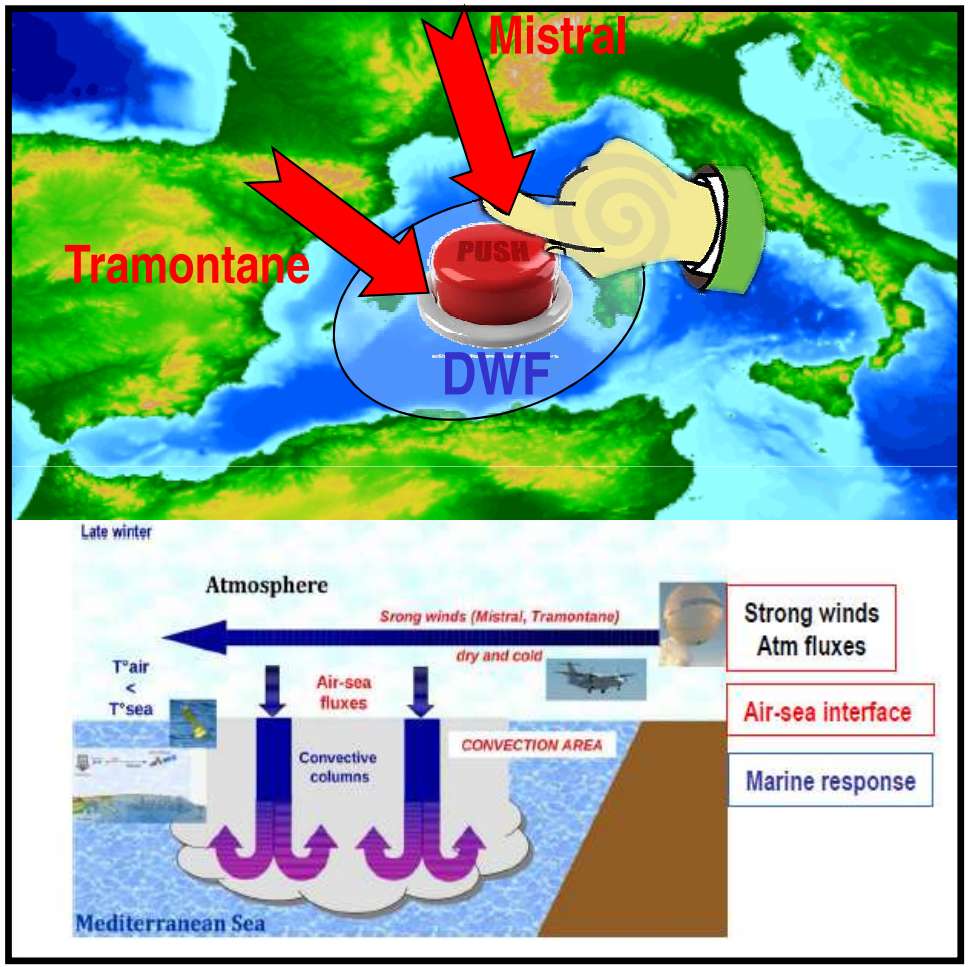


HyMeX The SOP2 domain and period

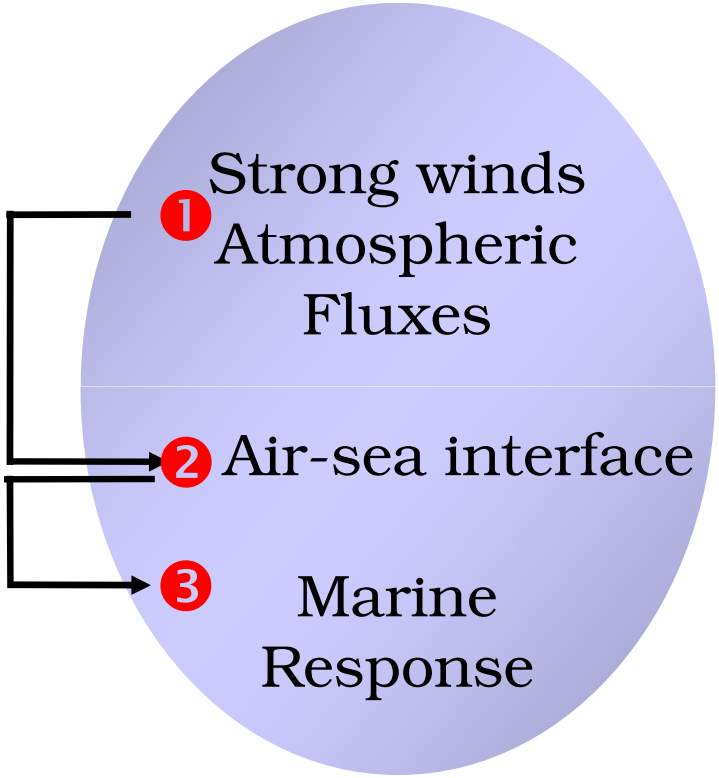
Domain: Gulf of Lion (NW Med Sea)

an area prone to ocean convection and dense water formation (DWF) under the influence of strong regional winds (Mistral, Tramontane)

SOP2: from 1st February to 15 March 2013

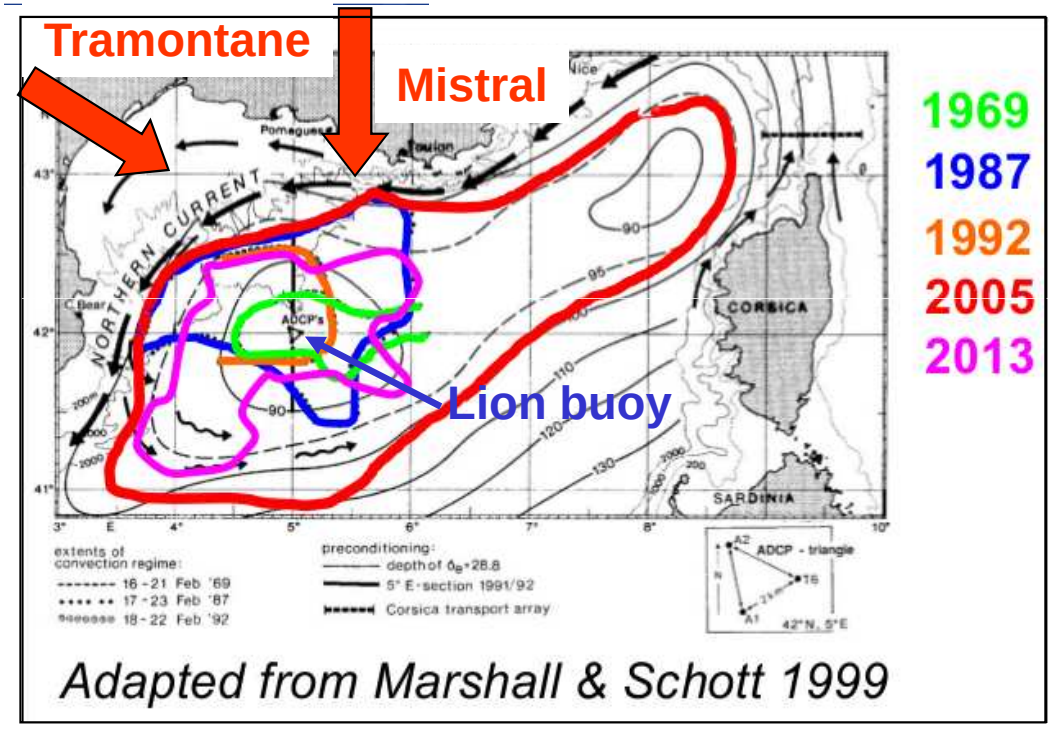


Observation strategy

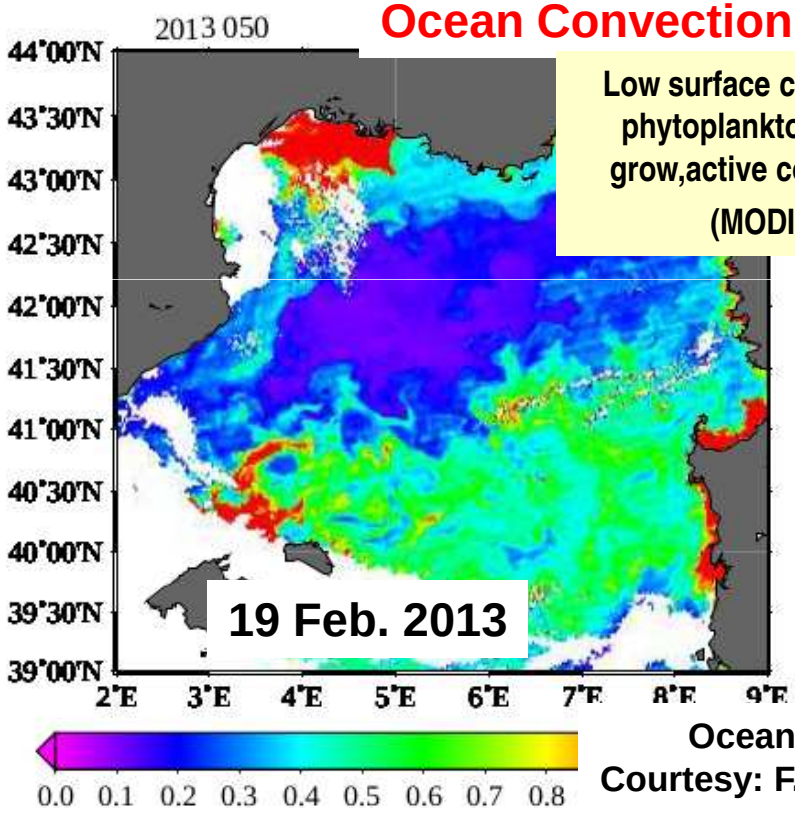


HyMeX

The SOP2 events



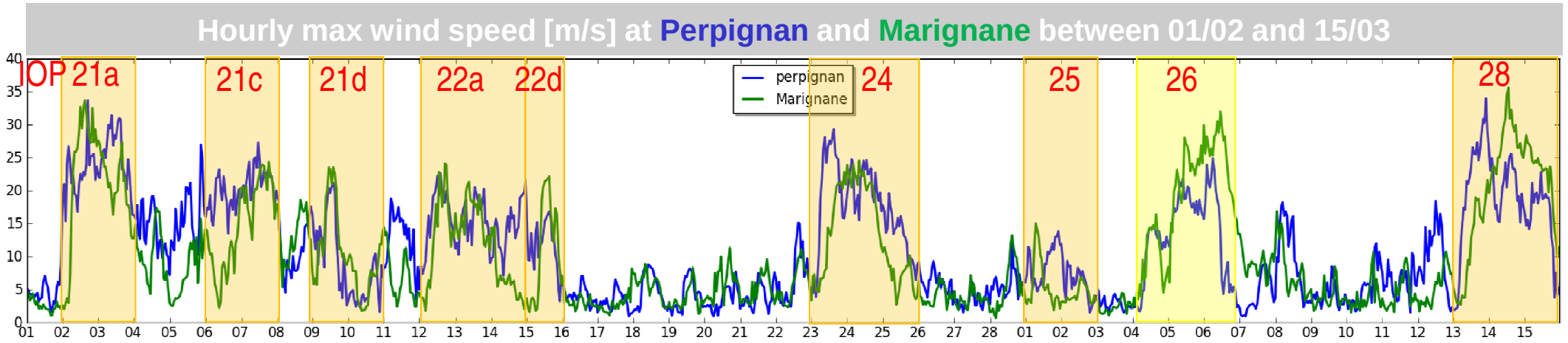
Ocean Convection in 2013



Low surface chlorophyl, phytoplankton do not grow,active convection (MODIS)

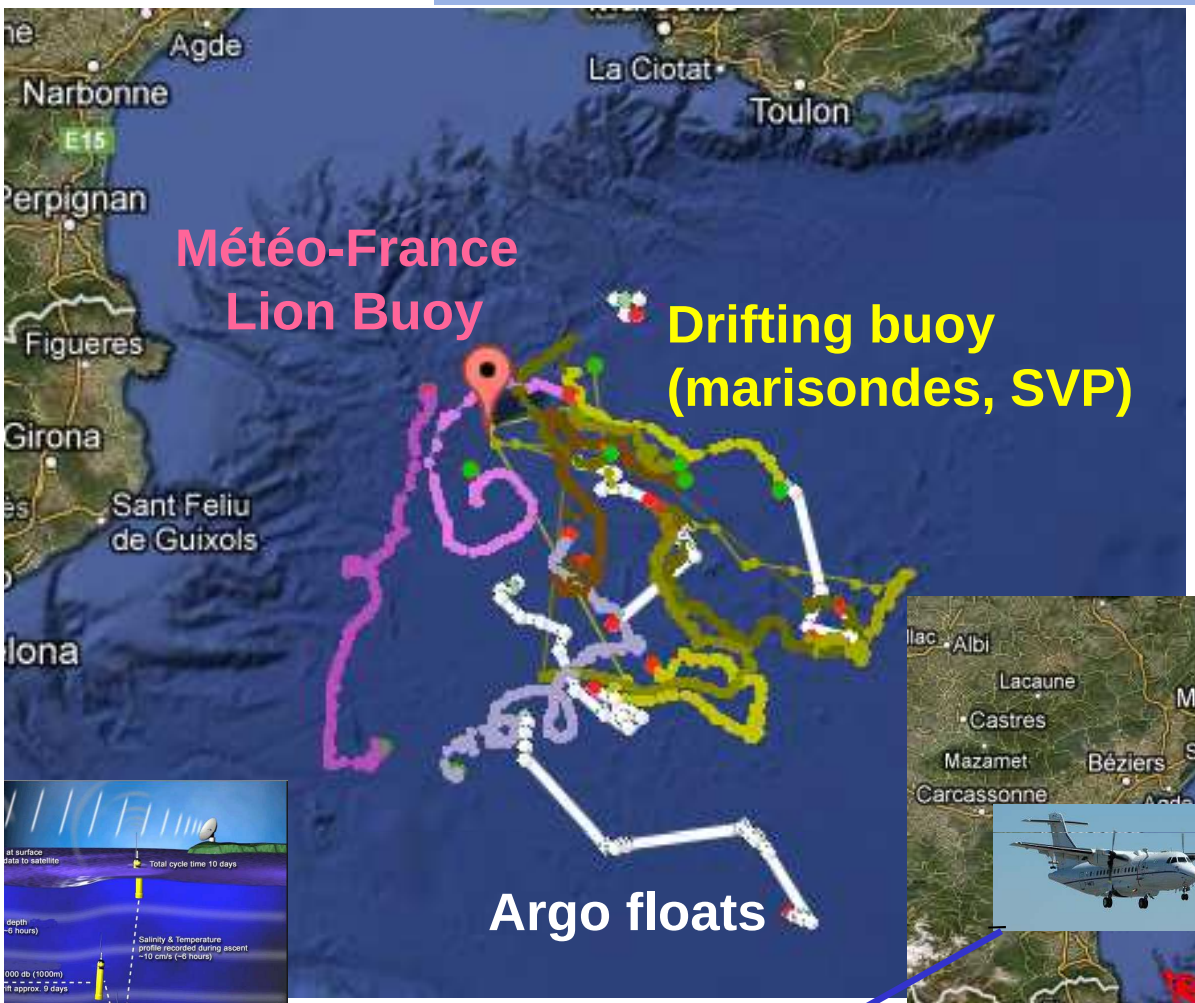
Ocean color
Courtesy: F. D'Ortenzio

8 strong wind events, incl 4 with intense wind gusts up to 35 m/s:



HyMeX

Measurements in the Gulf of Lion



Boundary layer balloons
Radiosoundings
launched from
Candillargues/Marseille

SAFIRE/ATR42 aircraft (air-sea fluxes, wave radar -Kuros)

Conclusion and Outlooks

❑ **Successful field campaigns with:**

- SOP1: 16 heavy precipitation events, many cases in Italy

- SOP2: 8 strong wind events and 5 dense water formation events during SOP2

- ⇨ numerous and unique observation datasets collected !

❑ **Work in progress to make available the field campaign observations in the HyMeXdatabase (400 datasets obs. + models, 500 registered users)**

❑**Publications: 175 peer-reviewed articles,**

- ❑ ***HyMeX overview, Drobinski et al. (2014) BAMS***
- ❑ ***SOP1 overview, Ducrocq et al. (2014), BAMS***
- ❑ ***EOP Hydrology, Braud et al. (2014), HESS***
- ❑ ***SOP2 overview, Estournel et al., in preparation***

Students, 55 PhD, on going

Thanks for your attention !

http://www.hymex.org , http://sop.hymex.org