Land surface Interactions with the Atmosphere over the Iberian Semi-arid Environment (LIAISE)
Overview of the Field Campaign Intense Phase

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<table>
<thead>
<tr>
<th>Institution</th>
<th>Location</th>
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<tbody>
<tr>
<td>1 CNRM Météo-France/CNRS, Toulouse, France</td>
<td>5 UIB, Balearic Islands, Spain</td>
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<td>2 LMD, IPSL, Paris, France</td>
<td>6 UKMO, Exeter, UK</td>
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<td>3 IRTA, Lleida, Spain</td>
<td>7 U. Wageningen, Netherlands</td>
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<td>4 Observatori de l'Ebre, Roquetes, Spain</td>
<td>8 SMC, Barcelona</td>
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Context

- Climate projections from the CMIP predict that the Mediterranean region will be a climate change “hot-spot” during 21st century, **BUT** such regions have biases in models.

- Mediterranean basin has highly heterogeneous land cover - driven by limited soil moisture and nature of precipitation, **BUT** LSMs lack the ability to capture such features.

- Semi-arid regions where the coupling between soil moisture and precipitation is potentially at its greatest.

- Irrigation can impact local atmospheric boundary layer (ABL) growth, meso scale meteorology, possibly clouds-convection → generally simple or not in LSMs !

- Water resources are limited, depend to a certain extent on water natural *water towers*, reservoir functioning, and impact on discharge.

- Human activities are playing a key role in modifying the continental water cycle, and therefore must be accounted for in projections (WCRP).
Science Questions

Focus on the Ebro basin in the NE Iberian peninsula

1) What are the key natural and anthropogenic semi-arid surface processes that modulate or control infiltration and runoff and govern turbulent fluxes and their spatial heterogeneity in a semi-arid region?

2. How does the highly heterogeneous (natural and anthropized) surface impact boundary layer development, mesoscale circulations and potentially precipitation recycling over this region via feedbacks with the atmosphere?

3. What is the sustainability of ground water and reservoirs in the face of expanding agricultural and farming activities, especially in light of projected future warming and drying over this region?
Measurement Strategy

Intense observations of surface and ABL when contrasts between anthropized (irrigated) and natural surfaces are a MAXIMUM and water needs LARGEST

**LOP** : April-October, 2021 → surface flux stations, surface satellite products, lysimeters, soil moisture & soil T…

**SOP Summer**/July 15-29 → Lower atmosphere & SEB, lidar, UHF, scintillometers

**IOP** 11 of the 15 SOP days (aircraft, drones/UAVs, balloons, hourly soundings..)

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**Dynamics**:
- Wind profilers
- hourly RS

**Turbulence**:
- 50m mast,
- tethered balloon,
- ATR42 aircraft
+ SEB

+ numerical simulations
LES and sensitivity tests
Heterogeneity of land cover

- 2 contrasting areas owing to irrigation
- 7 Sites (SEB, soil moisture, T...), irrigated and rain-fed areas

The LIAISE study zone in Catalonia (NE Spain) with surface site locations plotted over a map of crop ET (17th July 2021) using a Two-Source Energy Balance (TSEB) model w/images from Sentinel-2 and Sentinel-3. Prepared by IRTA.
The LIAISE study zone in Catalonia (NE Spain) with surface site locations plotted over a map of crop ET (17th July 2021) using a Two-Source Energy Balance (TSEB) model w/images from Sentinel-2 and Sentinel-3. Prepared by IRTA.
Common Observations:
- 50m mast: fluxes
- LAI, soil moisture, T
- UHF wind profiler
- radiosoundings (each hour of IOP days)
- airplane-based sfc & atmos measures

Other atmos observations
- lidar: q, T
- fluxes from tethered balloon
- temperature (vertical & horizontal-sfc)
  By DTS (distributed temperature sensing)
- Scintollometers (H, LE)

Biogeophysical
- vegetation fluorescence (passive and active fluorescence and gas exchange)
- CO2 assimilation (A-PAR)
- stomatal conductance
- photochemical yield
- Fluorescence
- chlorophyll content
- vegetation height
- leaf reflectance,
- LAI
- water and carbon isotopes...
Midday leaf gas exchange across sites

- Measured between 11:00 and 15:00 with PAR resembling sun/shade light levels of the specific canopy.
- Clear differences between sun-lit and shaded leaves.
- Stomatal conductance in alfalfa is extremely high with very high ci/ca-ratios (0.5 – 0.7 is typical).
- Maize can function at very low ci/ca-ratios due to C4 photosynthesis.
Diurnal cycle for 3 days at La Cendrosa (CNRM)

15/07/2021 La Cendrosa
Temperature

20/07/2021 La Cendrosa
Temperature

28/07/2021 La Cendrosa
Temperature

15/07/2021 La Cendrosa
Flux HS-LE 3m

20/07/2021 La Cendrosa
Flux HS-LE 3m

28/07/2021 La Cendrosa
Flux HS-LE 3m

250 W/m²

400 W/m²

Growth → 4 cm/day
A wind, temperature, H2O and CO2 scanning lidar mobile observatory for a 3D thermodynamic view of the atmosphere

Vertical mode → profiles of scalar, moments and eddy-covariance fluxes

Horizontal and vertical cross-section of the atmosphere: M-O similarity theory in surface layer —> surface flux heterogeneity in a semi-arid region

3D-lidars mobile station:
- COWI: CO2 & V
  Doppler and DIAL: 2 µm
- TERA: T & H2O, Raman lidar-0.355 nm

F. Gibert, D. Edouart, P. Monnier, C. Cénac, J. Lopez, J. Collignan
Frequent Radiosounding releases (during SOP) (CNRM, UKMO)

- **Wet/Irrigated**
  - (La Cendrosa)
  - 152 hourly RS releases
  - Up to ~ 3km z
  - 11 of 11 IOPS

- **Dry/Rain-fed**
  - (Els Plans)
  - 116 RS releases
  - Up to ~ 8km
  - 7 IOPs
In-situ atmospheric measurements

Vertical profiles of TKE over irrigated area (La Cendrosa), and over dry area (Els Plan)

<table>
<thead>
<tr>
<th>Date</th>
<th>TKE (m^2 s^-2)</th>
<th>Height (m agl)</th>
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<tr>
<td>17/07</td>
<td></td>
<td></td>
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<tr>
<td>20/07</td>
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<tr>
<td>21/07</td>
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In-situ atmospheric measurements

Flight plan - Chronogramm - 1

Surface leg

Irrigated

Dry

FL200

FL100

0770 ft agl

1500 ft agl

13:17 UTC

13:29 UTC

Above the ML

Within the ML

m (a.g.l.)

m (a.g.l.)

0.5

1.0

1.5

2.0

ZI (13 UTC)

ZI (14 UTC)

Flight level (Glori)

La Cendrosa

Els Plans

ATR Flight #44 - 20210721 - GLO - 4700 ft QNH - ps2 - 1240 m - Air vertical velocity

ATR Flight #44 - 20210721 - GLO - 4700 ft QNH - ps4 - 1243 m - Air vertical velocity

M. Lothon & F. Lohou
Surface Monitoring from Aircraft: July 17

SLAP (NASA) → soil moisture (Langley King Air UC-12)

- SMAP simulator
- 1.4 GHz passive, 1.2GHz active microwave
- 100x200m pixel res (at ~1 km height)
- 9 flights, swath widths up to 8km

HyPlant (Julich - JFZ) → SIF (SAFIRE ATR42)

- SIF and surface reflectance (4-5m pixel res.)
- 8 flight days = 200 flight lines = 400 datasets
- + Ground-based and UAV measures of SIF
- high res or lower res (10m, for spatially dist. Modeling)

**ALSO**

ATR42 : GNSS-R dual polarization → GLORI soil moisture
CzechGlobe: NIR and longwave IR hyperspectral imaging sensors
Results/Outcome:

• A comprehensive database: surface-based and aircraft measurements of surface and hydrological fluxes and states, and properties of the PBL:
  - Airplanes: ATR42, NASA King Air, CzechGlobe (atmos & sfc monitoring)
  - UAVs (hi-res spatially distributed → surface, atmosphere, topography/DEMs)
  - UHF, wind-cube, lidar, scintillometers...
  - tethered balloons, frequent radio-soundings, 2 - 50m towers
  - 7 sites: SEB, soil moisture, lysimeters, Tg, biogeophysical → ET (evapotranspiration)

• Improved understanding and representation of anthropogenic processes in LSMs used for hydrological monitoring, weather fcsts and climate studies → Modeling Studies begun!

Links with the new CC-dET initiative (GHP), GLAFO (GLASS)


• 1st LIAISE Science Conf & GEWEX-ET Crosscutting workshop → https://www.hymex.fr/liaise/conf_22.html