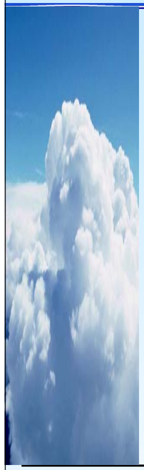


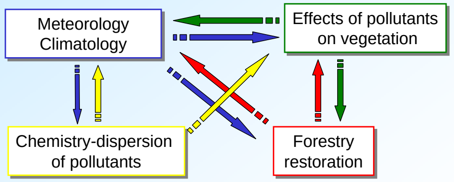
WORKSHOP: Climate Change Impacts on Mediterranean Plant Diversity

25-28 September 2007

CLIMATE CHANGES IN WESTERN MEDITERRANEAN

M.J. Sanz, M.J. Estrela, J. Miró, M. Millán, F. Pastor, D. Corell
Área de Climatología-Meteorología de la Fundación CEAM

Fundación CEAM



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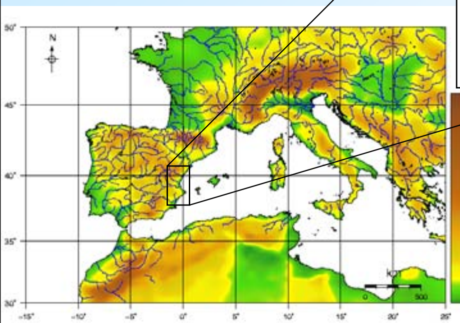
Index

Climatic background (orography)

- Western Mediterranean basin comprises a deep sea surrounded by high mountains (1800-2000 m)
- Two clearly distinct areas in the Valencian region: Coastal plains and mountainous inland

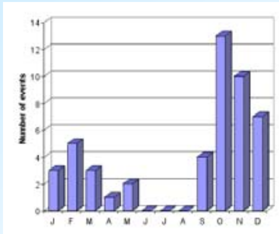


Climatic background (precipitation)

✓ **Spatial distribution**

- Annual average: 400-600 mm.
- Precipitation partially connected to orography
- Two areas with high pluviosity
- One arid area (less than 300 mm) in the south
- Most of the region less than 500 mm

✓ **Annual distribution of torrential rains**
(>125 mm/24h 1971-2000)



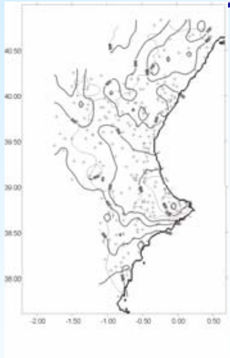


Figura 1. Distribución espacial de la precipitación

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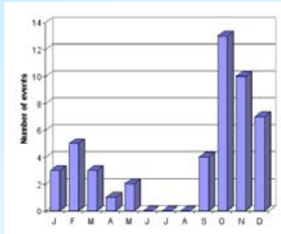

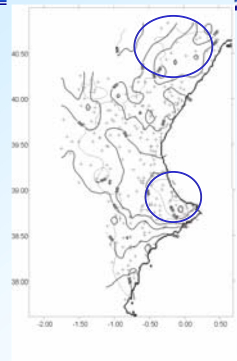

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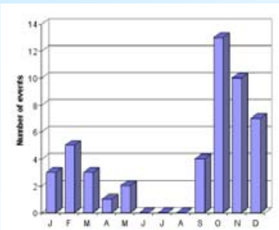


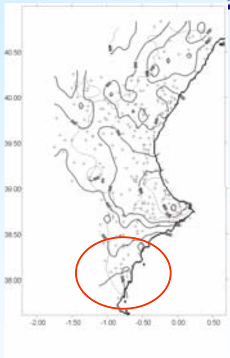


Figura 1. Distribución espacial de la precipitación

Precipitation

- Many studies in the last 20 years show changes in the precipitation in Europe
- So we planned a study with this objective and methology

OBJECTIVE

- Analyse the spatial and temporal variability of the rain in the Valencian region

METHODOLOGY

- Rain data from the National Meteorological Institute of Spain
- Daily rain records from 497 observatories
- Period: 1959-2000
- **Synoptic disaggregation of the rain**

Millán et al., *J. Climate*, **In Press**, (2005b)

Precipitation (disaggregation)

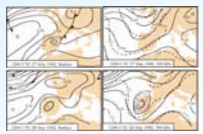
Disaggregation of precipitation by synoptic forcing

Atlantic frontal rains

- Related to Atlantic lows and frontal systems crossing the Iberian Peninsula from west to east
- Föhn in the Spanish East coast (“Ponientes”)
- Global contribution of 20% to the precipitation total in the Valencian region

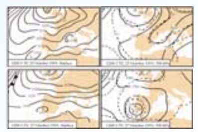
Summer storms

- Related to the sea-land breezes cycle
- From spring to late summer-autumn
- Storm mature stage favoured by cold air at upper levels
- Global contribution of 11% to the precipitation total in the Valencian region



Easterlies (Levantes)

- Related to easterly advections
- Along with cold air at upper levels in SE-SW Iberian peninsula can cause general torrential rains in south and east Spanish regions
- Global contribution of 65% to the precipitation total in the Valencian region



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76 % TOTAL PRECIPITACION

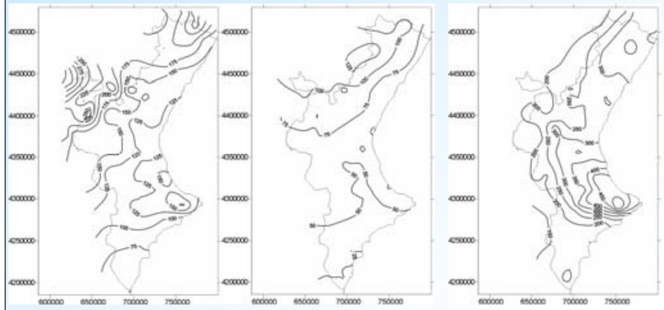
MEDITERRANEAN SEA GENESIS

Millán et al., *J. Climate*, **In Press**, (2005b)

Precipitation (disaggregation)

Spatial distribution by synoptic forcing

Atlantic frontal rains | Summer storms | Easterlies (Levantes)



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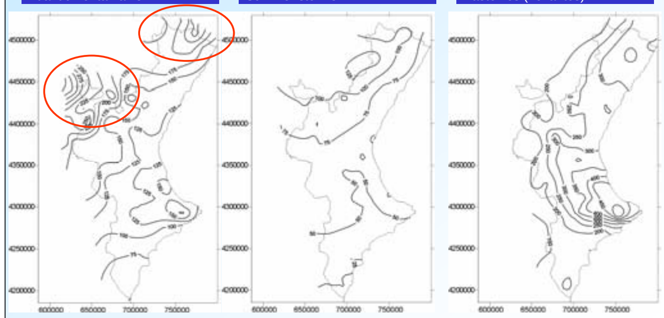

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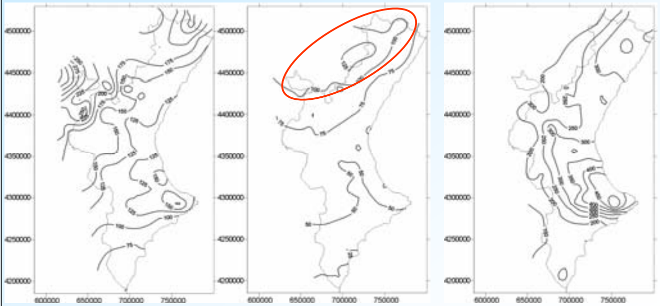

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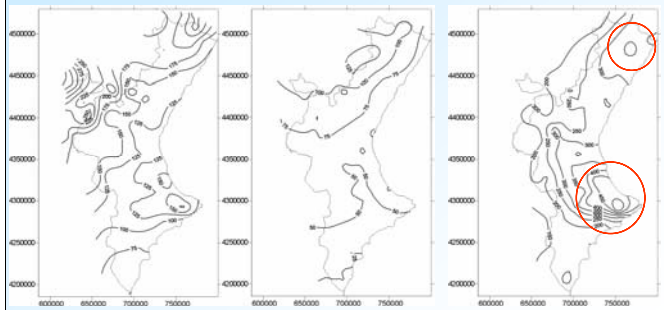

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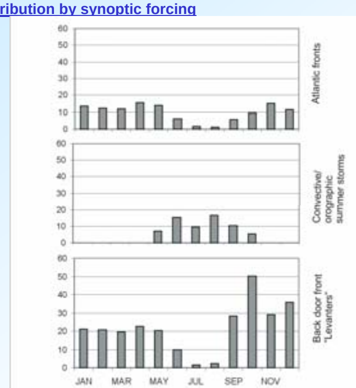
Precipitation (disaggregation)

Temporal distribution by synoptic forcing

Atlantic frontal rains

Summer storms

Easterlies (Levantes)



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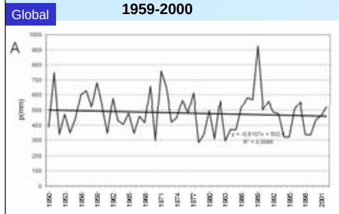
Precipitation (tendency)

Global **1959-2000**



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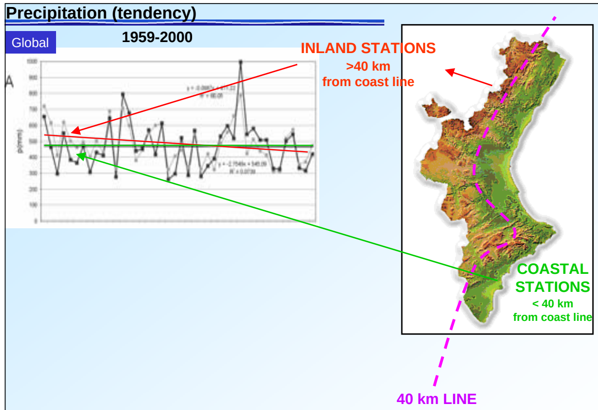

Precipitation (tendency)

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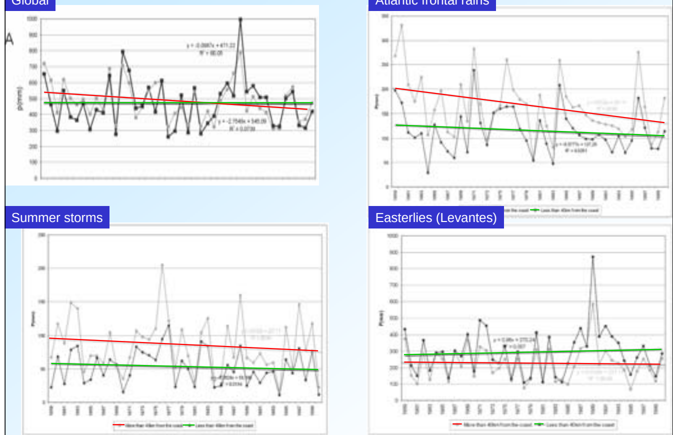
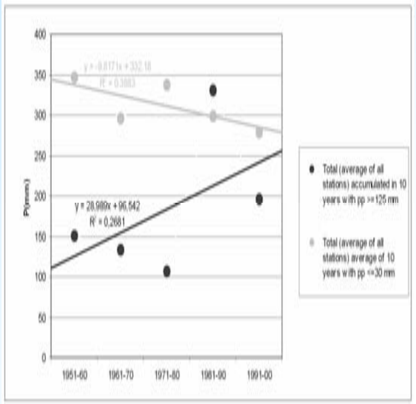


Precipitation (tendency)

• Decreasing trend in less than 30 mm rains

• Increasing trend in more than 125 mm rains (TORRENTIAL RAINS)



Precipitation

EVIDENCES

• Tendency to a reduction in precipitation in Valencia region

• This tendency changes between different types of rain:

✓ Decreasing trend in Summer Storms and Atlantic frontal rains all over Valencia region

✓ Increasing trend in Easterlies precipitations (torrential rains) on the coast

QUESTIONS

• Causes of summer storm reduction?

• Causes of atlantic frontal rain reduction?

• Causes of easterly advected torrential rains increase?

Precipitation

EVIDENCES

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• Causes of atlantic frontal rain reduction?

• Causes of easterly advected torrential rains increase?

Precipitation

OUR PROPOSAL

• Changes in land uses that cause less evaporation: increasing of the Lifting Condensation Level

•Accumulation of pollutants and water vapour over the Mediterranean Sea: heating the air masses and the Sea Surface Temperature (SST)

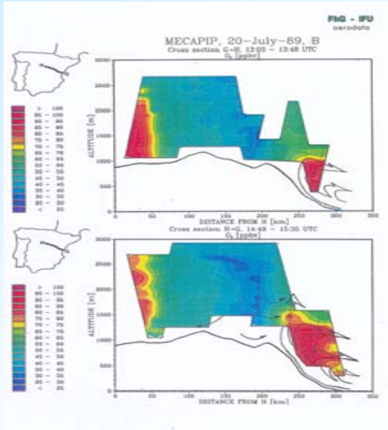
Feedback mechanisms disturbing hydrological cycle

Experimental evidence and modelling

Experimental evidence

• At summer sea breezes and upslope winds join and create *"combined breeze"*
• In the breeze front, return fluxes height increases as breeze enters further inland
•Mountain slopes act as orographic chimneys connecting surface winds with upper return fluxes
• Breeze front usually lies between 40-100 km from the coast

Millán et al., *Atmos. Environ.*, **30**, 1909-1924 (1997)



Experimental evidence and modelling

Experimental evidence

• Sea-land breeze upper return fluxes create stratified layers over the sea
• Next-day breeze transports lower layers towards the coast and stratified upper layers sink, while new layers replace the latter
•Numerical simulations show that 5 days are needed to renovate the 50 % of the contaminated air mass.

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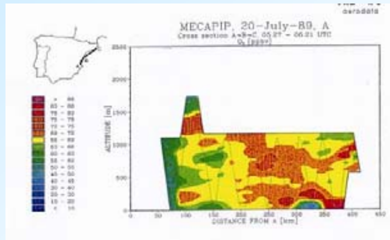

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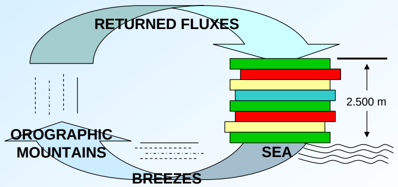


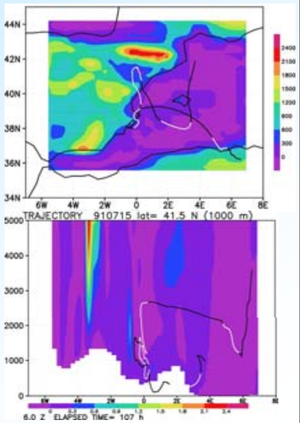
Millán et al., *Atmos. Environ.*, **30**, 1909-1924 (1997)

Experimental evidence and modelling

Modelling

•Trajectory of a particle emitted at 1000m height in the Lion Gulf as simulated with RAMS model with data from RECAPMA project (15/07/91)

•Total time computed: 4.5 days



Gangoiti et al., *Atmos. Environ.*, **35**, 6267-6276, (2001)

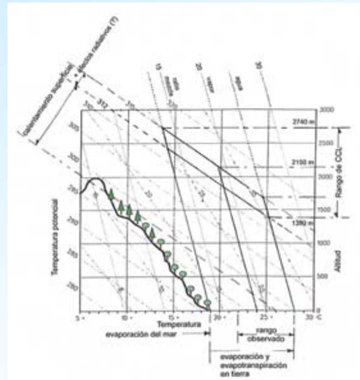
Feedback effects

Effect of the exchanges with the surface in the Lifting Condensation Level: Surface heating

Starting with a temperature of 23 ºC and a dew point of 19 ºC, LCL would happen at 500 m height

But air temperature raises its temperature 16 ºC along its path. So LCL would occur at 2500m height

If no additional humidity is present storms can not trigger if LCL lies long above the coastal mountains



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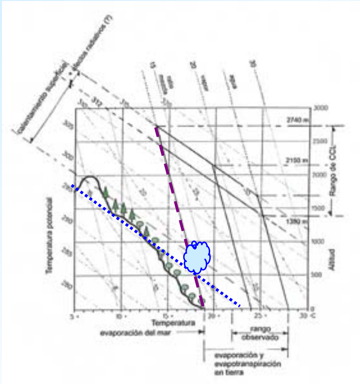

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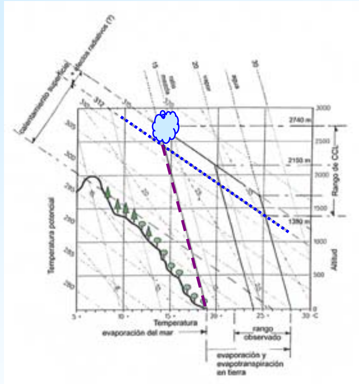

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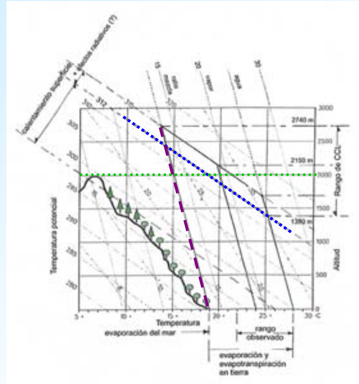


Feedback effects

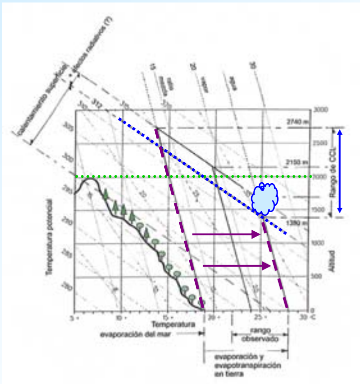
Effect of the exchanges with the surface in the Lifting Condensation Level: Evaporation and evapo-transpiration

Evaporation and evapo-transpiration give water vapour to the air mass raising its dew point

LCL lowers below mountain barriers so favouring precipitation

Comparing experimental data with meteorological modelling results, the radiative effects of pollutants and water vapour produce an increment between 1-3º C in the mass air, raising the LCL 100-300 m.

If rain doesn't occur, what happens with the water vapour accumulated in the air??



Feedback effects

Effect of the pollutants

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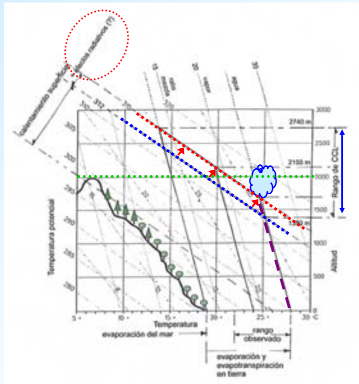


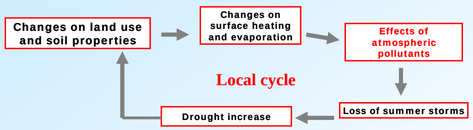
Conclusions

- Possible causes of Western Mediterranean rain regime perturbation
  - Changes on land use (more heating - less evaporation)
  - Changes in the atmospheric composition
    - Emission of pollutants (ozone,...)
    - More greenhouse effect gases (water vapour, pollutants,...)

- This can lead to less summer storms and more torrential rains (accumulation of water vapour and energy) that can propagate to the whole Western Mediterranean basin

- Why do we have an Atlantic frontal rains lost???

Conclusions



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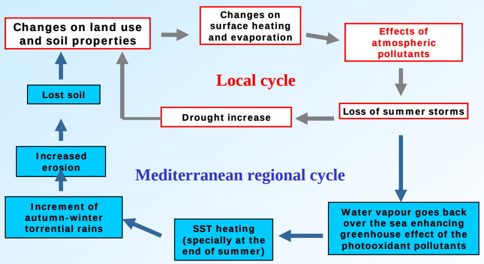

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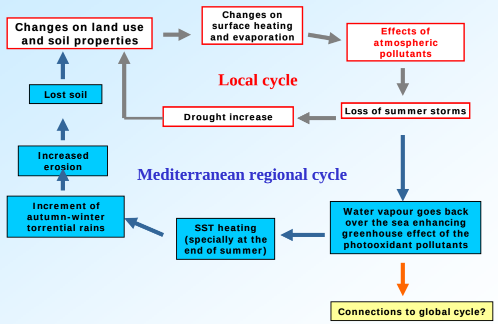

Thanks for your attention

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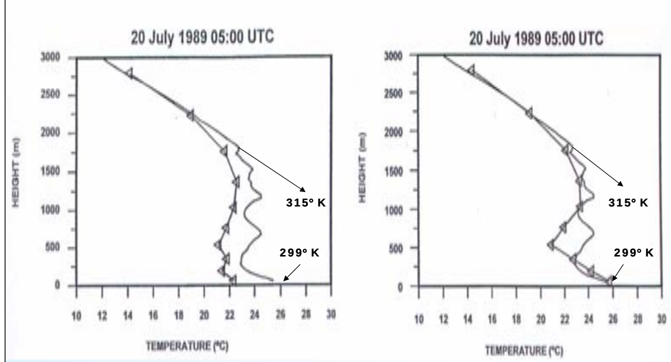
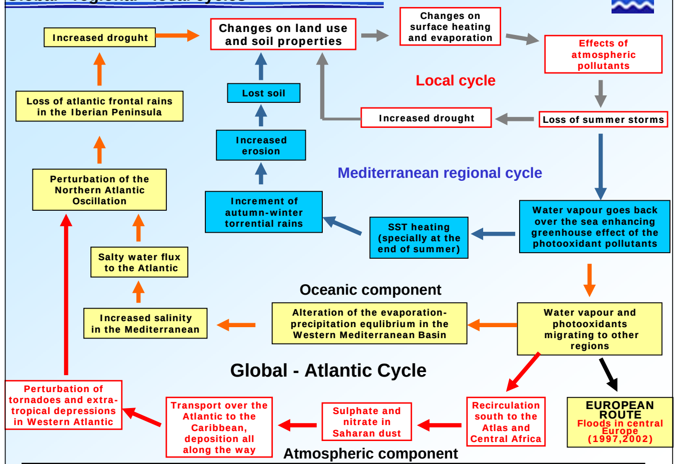
dacocus@ceam.es

Indice

Surface heating



Global - regional - local cycles



Experimental evidence and modelling

Conclusions

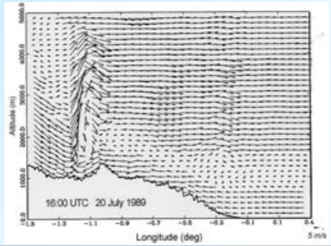
- At summer air masses acquire long residence times (7-10 days to remove 80% of the air mass below 3500 m)
- Air mass accumulate pollutants and water vapour
- In a completely developed circulation, sea breezes are confined between 150-300 m height along its path from the coast to the orographic chimneys
- No exchanges between surface and upper layers
- The only exchange is between sea breeze and earth's surface

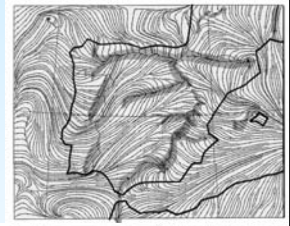
Experimental evidence and modelling

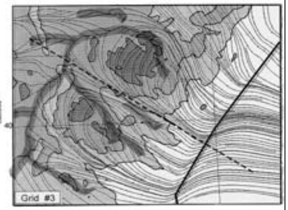
Modelling

Breeze front in Spain self-organise in convergence lines along mountain ranges, with compensatory subsidence between them. This systems conform the so-called "*Iberian Thermal Low*"

Millán et al., *J. Appl. Meteoro.*, **39**, 487-508 (2000)



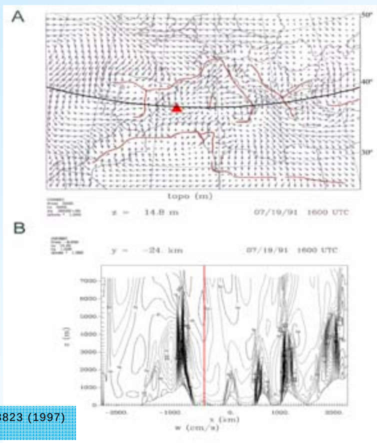




Experimental evidence and modelling

Modelling

- Finally, breezes all along the Western Mediterranean basin self-organise at a regional scale
- So, as surface winds feed "*combined breezes*", upper return fluxes between 2500-3500 m go back to the centre of the basin and sink, needed for continuity
- So, a regional circulation is established from the centre to the "outer" boundaries at surface and from the boundaries to the centre at upper levels

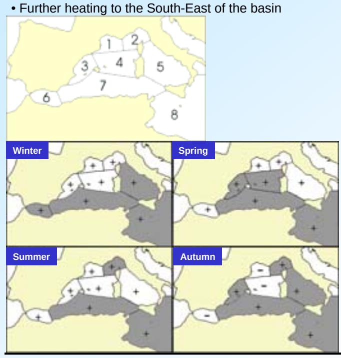


Millán et al., *J. Geophy. Res.*, **102, D7**, 811-8823 (1997)
Environmental Pollution, **118**, 167-186 (2002)

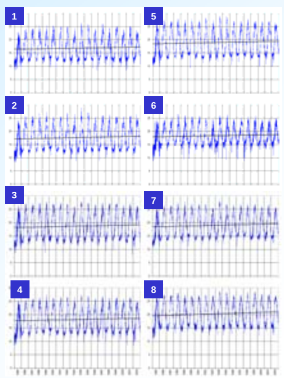
SST Tendencies

Regional tendencies

- Global trend to heating in the Western Mediterranean Basin
- Regional differences and seasonal differences
- Further heating to the South-East of the basin



SST (1985-2002)
(NOAA PATHFINDER/AVHRR)



Feedback effects

Effect of the pollutants

Evaporation and evapo-transpiration give water vapour to the air mass raising its dew point

LCL lowers below mountain barriers so favouring precipitation

High resolution meteorological modelling (not considering radiative effects of pollutants and water vapour) show a consistent negative 1-3º C bias respect to experimental data in layers below 2000-2500 m height.

If we assume that bias as additional heating of the surface layers, the result would be a rising of 100-300 m of the LCL.

This would favour feedback mechanisms towards the loss of summer storms and the addition