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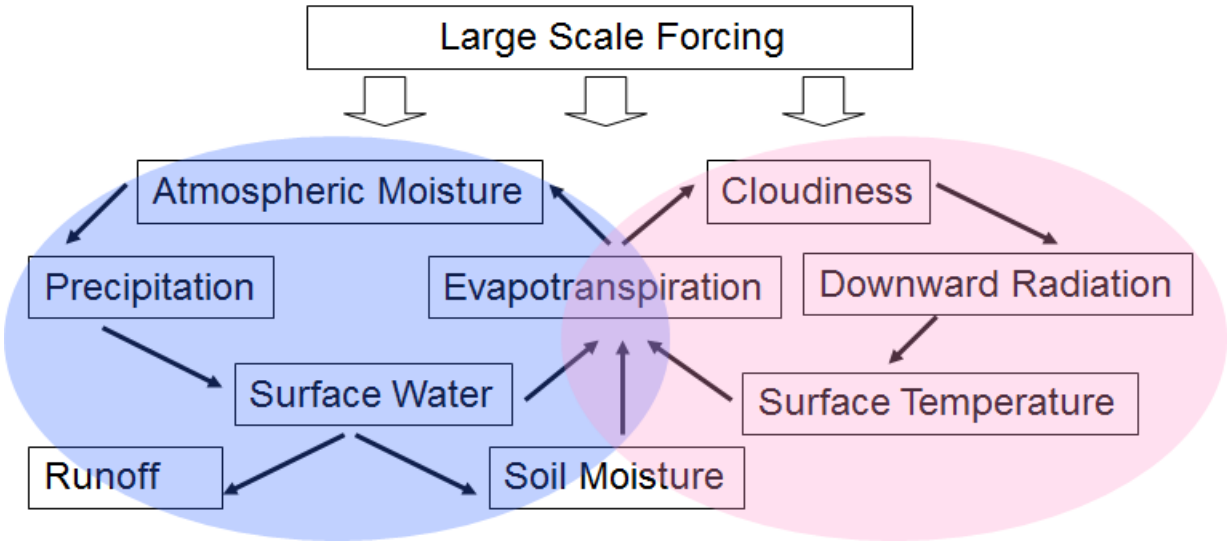
Towards advances in modelling of heavy precipitation by the synergetic use of convection-permitting simulations and state-of-the-art observations

S. Khodayar, A. Caldas and S. Helgert

Institut of Meteorology and Climate Research, Karlsruhe Institute of Technology (KIT)

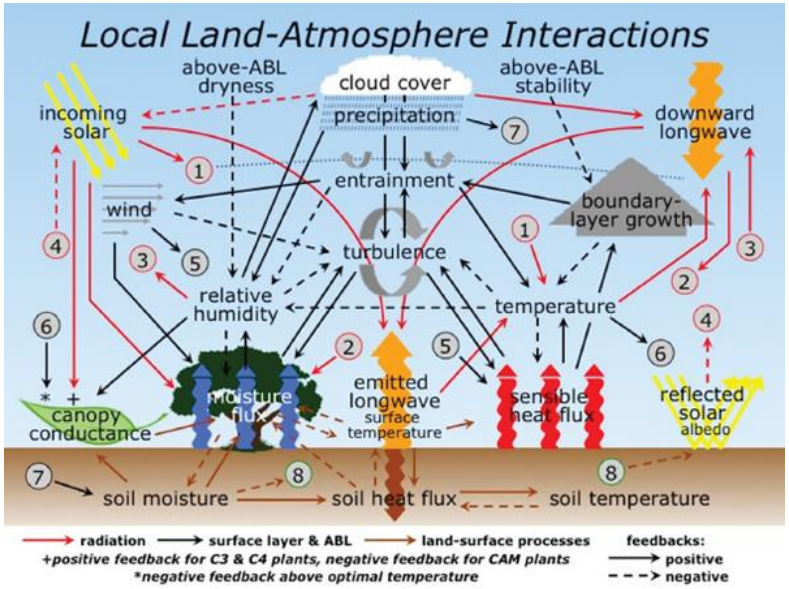


Challenge

- In addition to large-scale drivers, **understanding specific processes and feedbacks acting at local to regional scales** is essential to understand the genesis and evolution of extreme events.

- A **misrepresentation of feedback mechanisms** in models is an important source of **uncertainty**.

- Processes and **feedbacks** contributing to the occurrence of extreme phenomena **are complex and manifold**. We focus our efforts in two components of the WC and related feedbacks: **the soil water content and the atmospheric moisture.**



Schematic showing the many interactive processes in the land surface and atmospheric boundary layer (ABL). Ek and Holtslag (2004)

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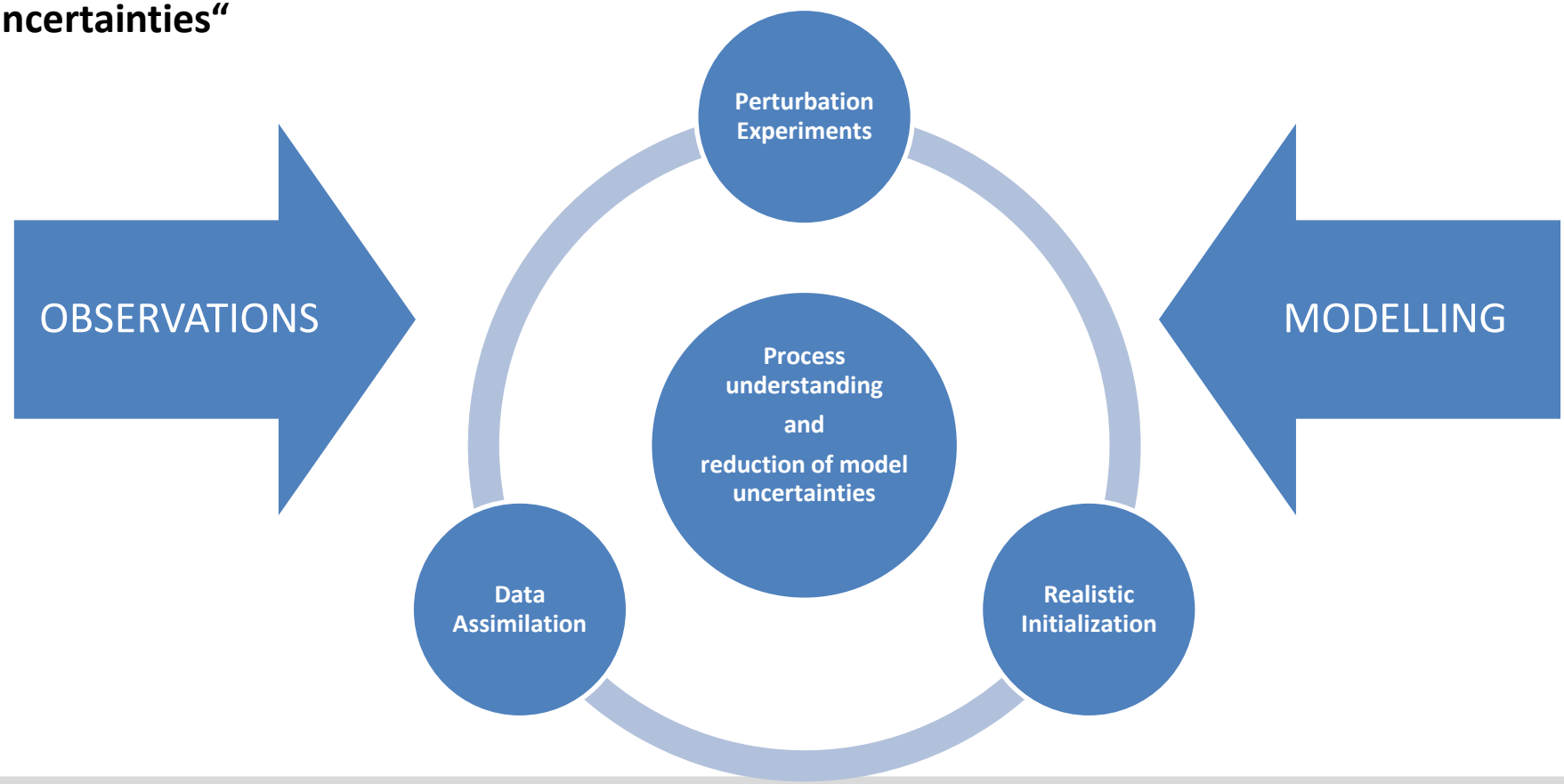
Goals and Research Methodology Strategy

„Process-based evaluations across space/time scales using the synergy of state of the art technologies and high-resolution modelling to improve understanding and reduce model uncertainties“



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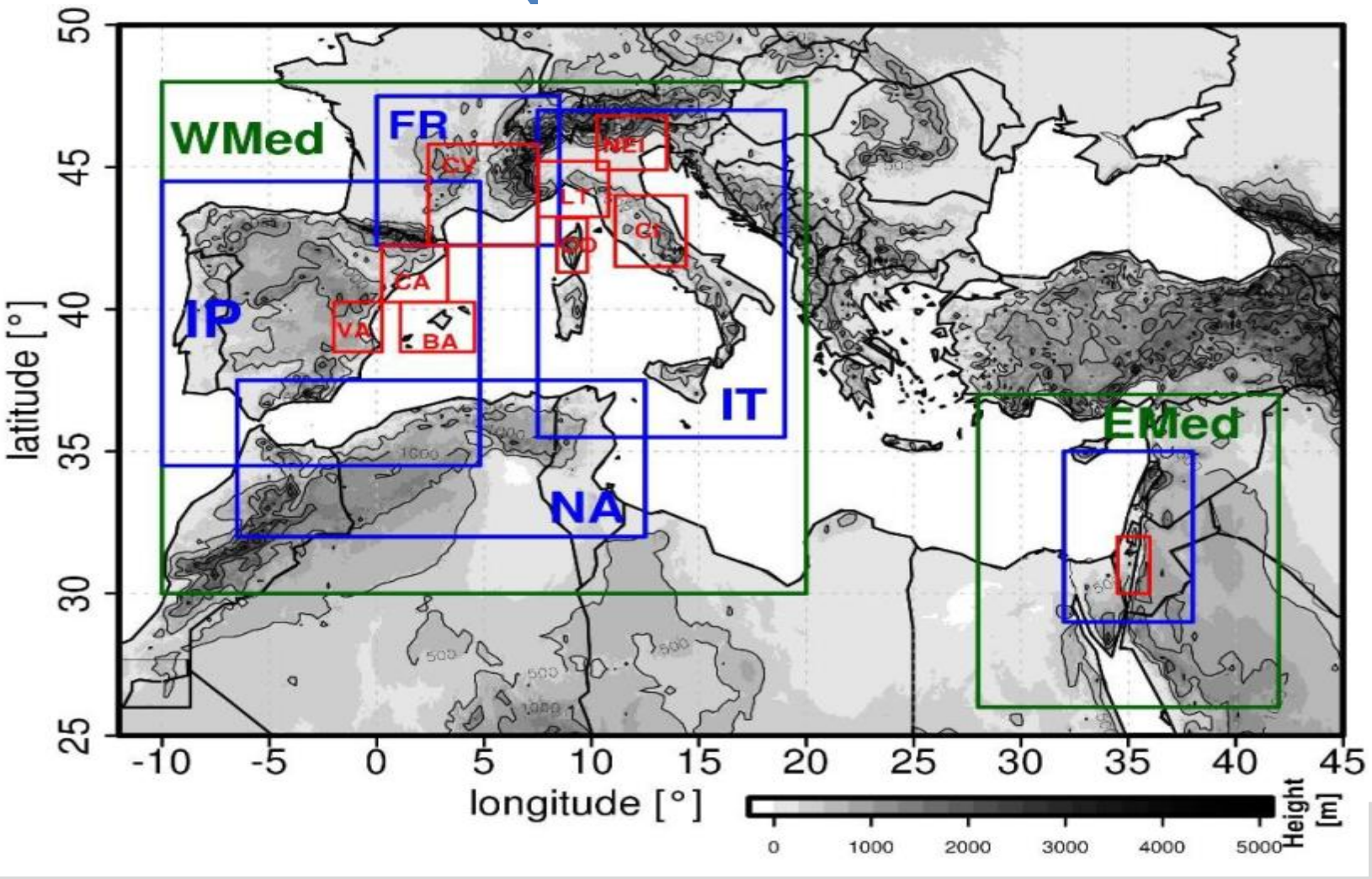
MODELLING



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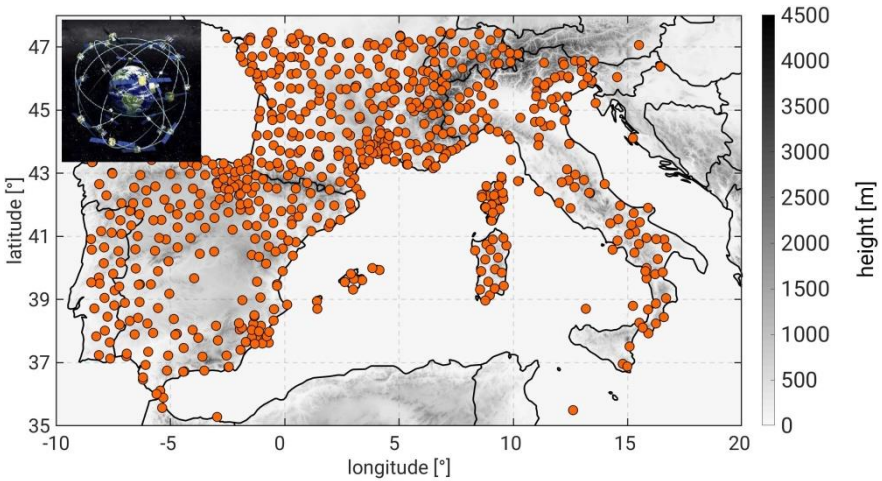
OBSERVATIONS

Experimental field campaign

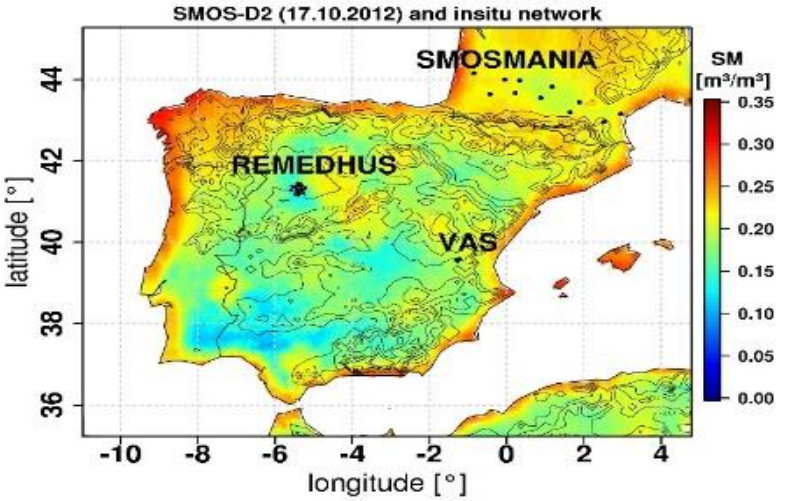
HyMeX (Hydrological Cycle in the Mediterranen Experiment)



Position of GPS stations from several European networks, jointly post-processed to offer a unique merged product with a 10-minute frequency in the framework of HyMeX

Remote sensing products

SMOS (Soil Moisture Ocean Salinity) space mission



SMOS dissagregated 1 km product over the Iberian Peninsula

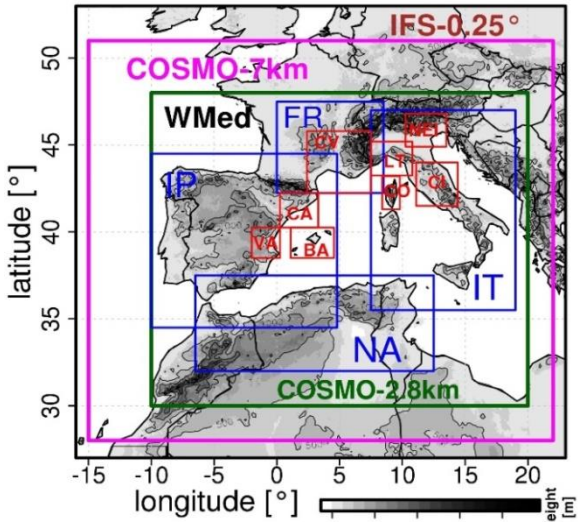
Relevance of extreme soil conditions for seasonal precipitation in the WMed

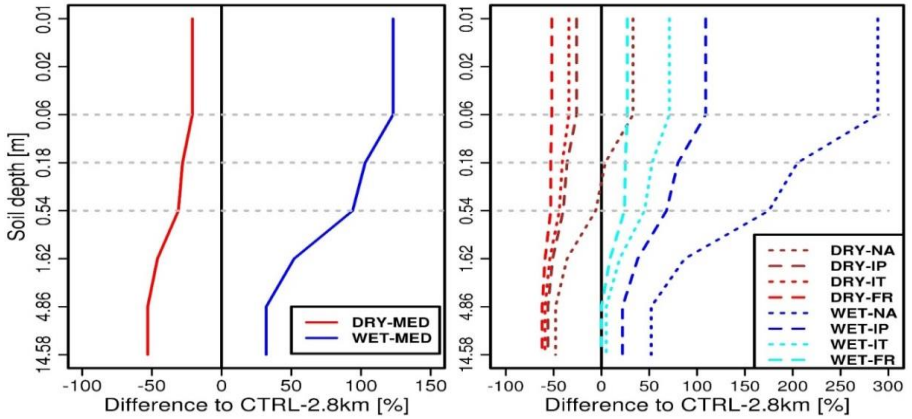
- **COSMO-CLM seasonal SON 2012**
- ECMWF-IFS -> 7 km -> 2.8 km
- ½ month spin up time
- 2 sensitivity experiments + CTRL
  - **WET** initial SM scenario

    Every GP set to max field capacity
  - **DRY** initial SM scenario

    Every GP set to min wilting point

- **Impact regional dependent**
- Higher impact: WET on dry areas





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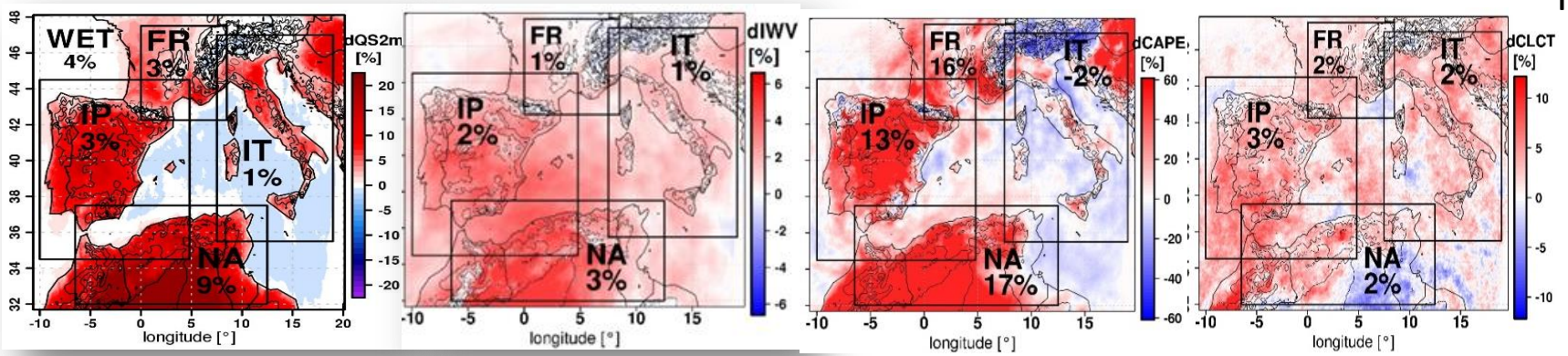
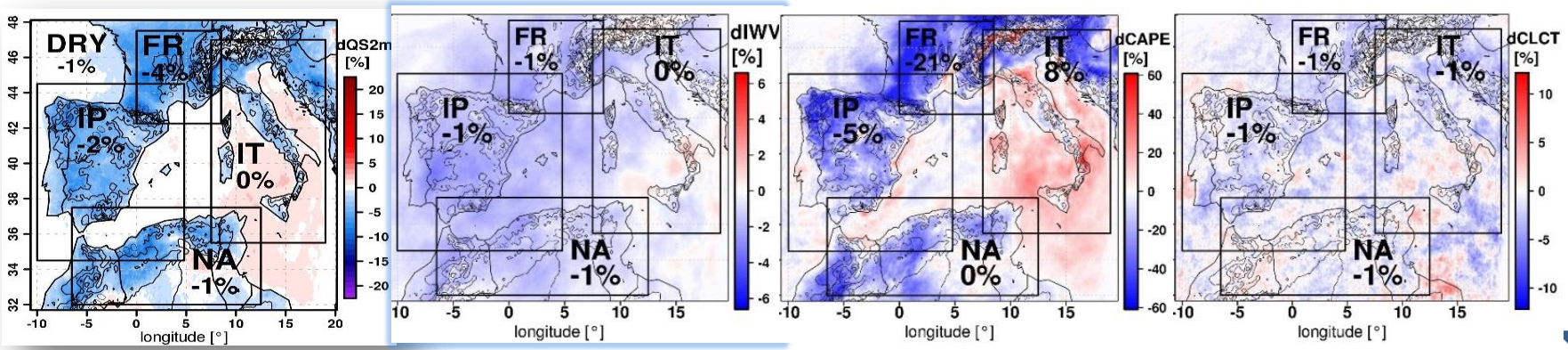
Impact on atmospheric conditions → Positive feedback, different strenghts

Increase



Humidity 2m | IWV | CAPE | Total cloud cover



Decrease

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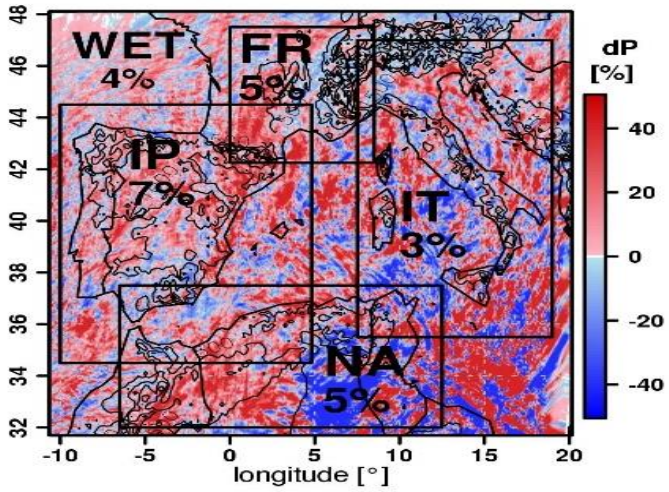
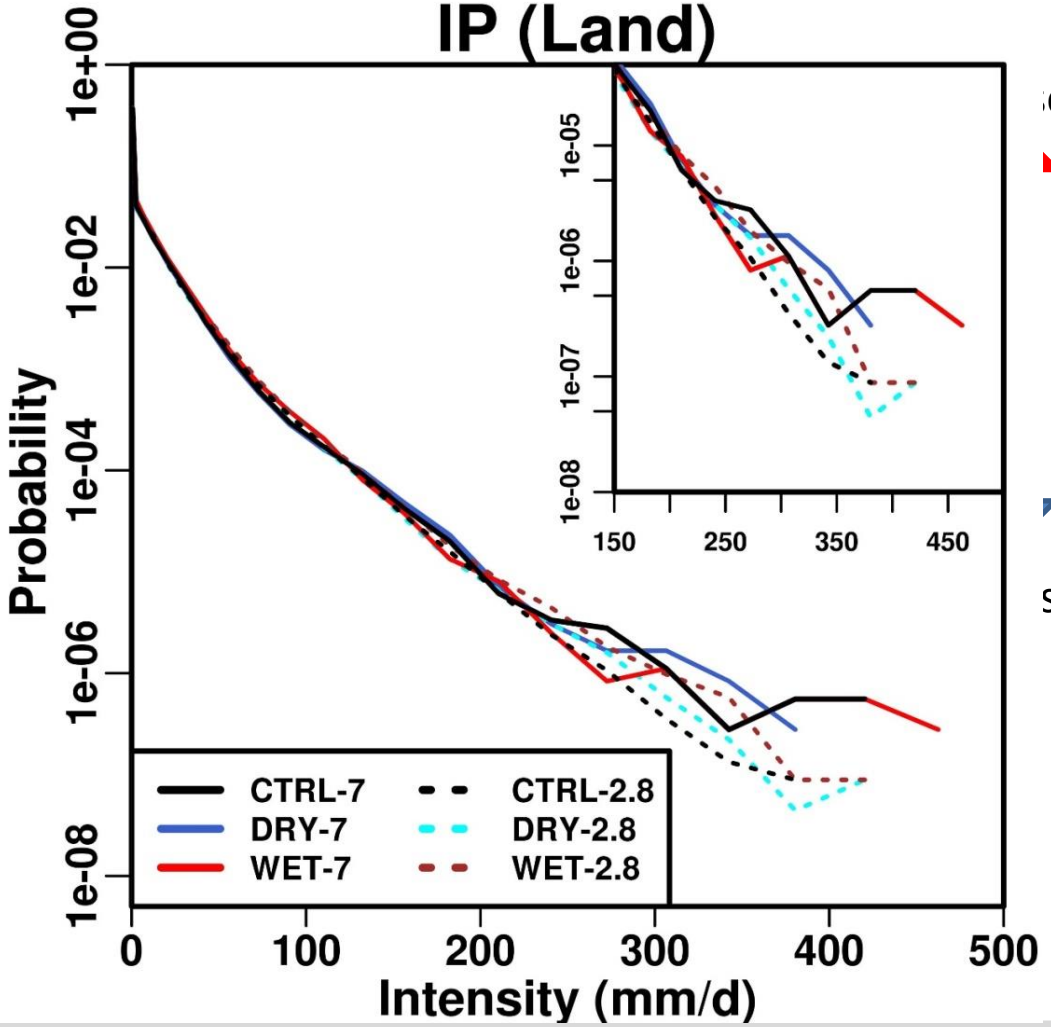
Impact on mean and extreme precipitation





Process understanding IOP 8 → modification BL conditions and wind circulations

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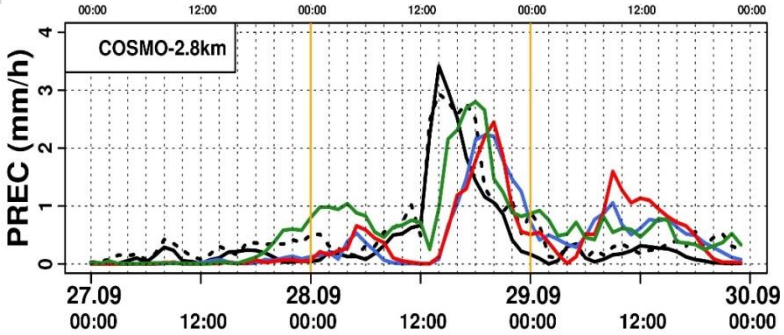
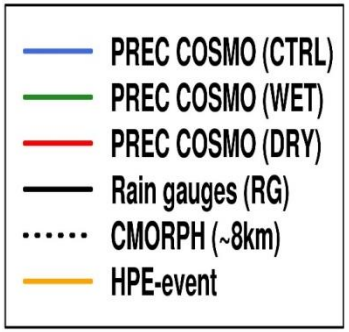
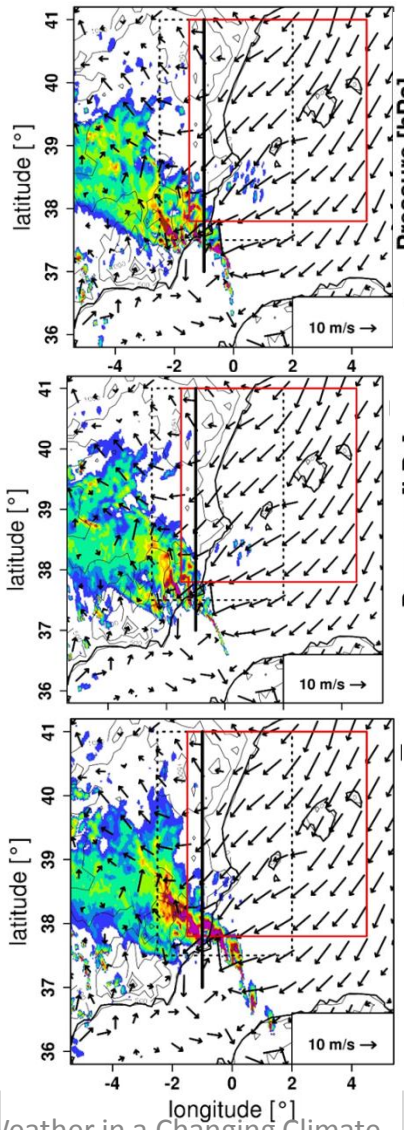
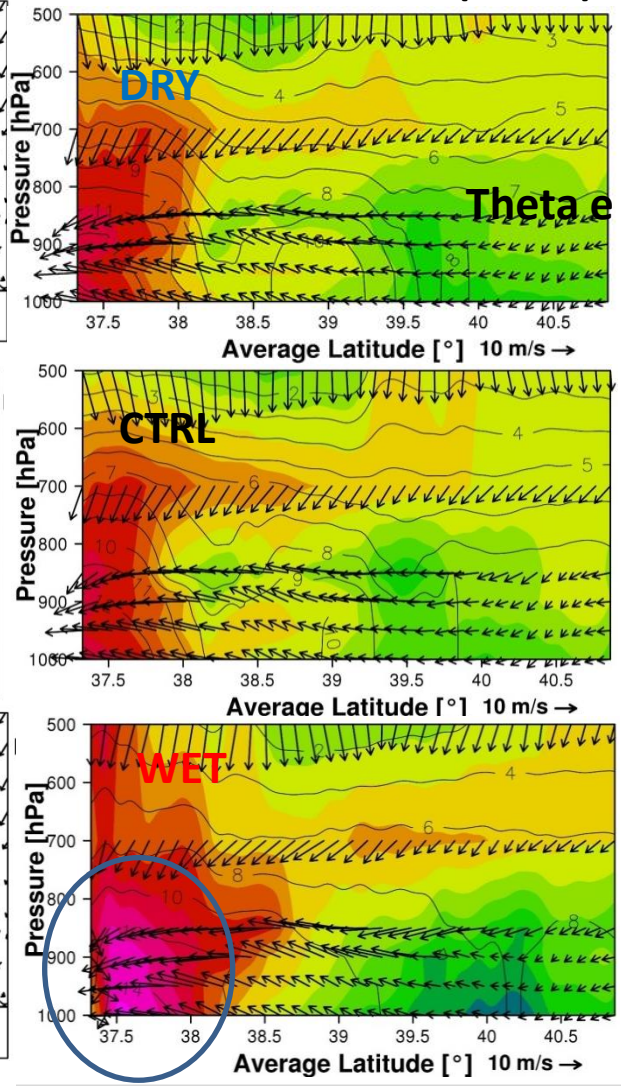




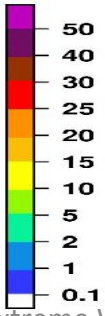
PREC 15 UTC (28.09)

PREC 14 UTC (28.09)





PREC [mm/h]



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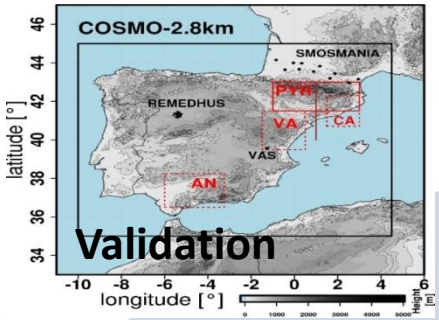
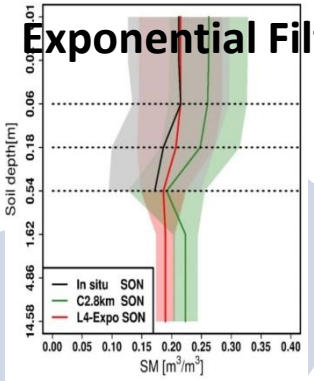
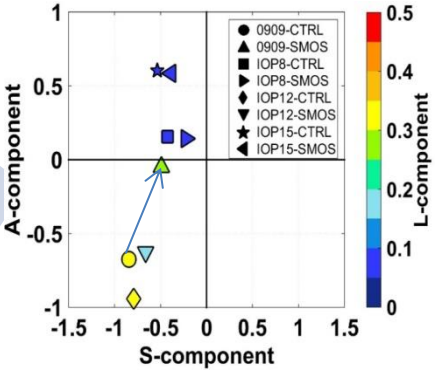
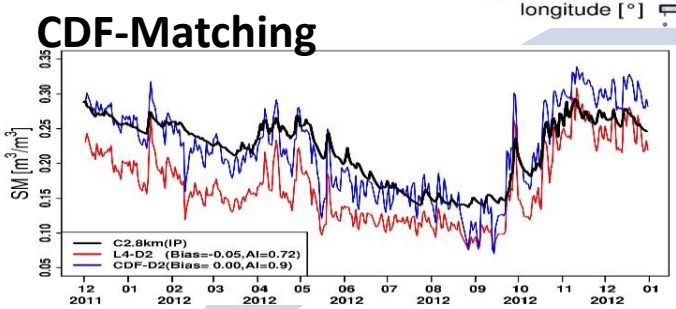
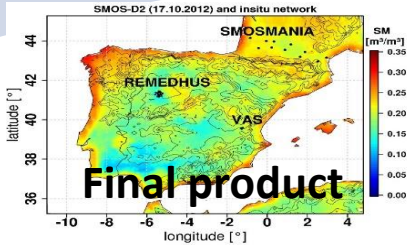
Improvement with realistic soil moisture initialization using SMOS 1 km dissagragated?



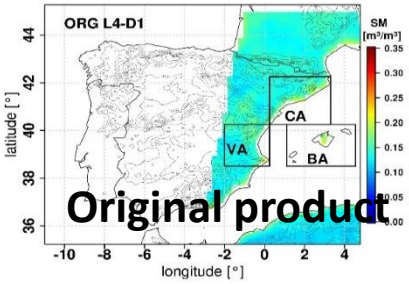








SAL verification of QPF after RI



Sebastian Helgert, Poster session

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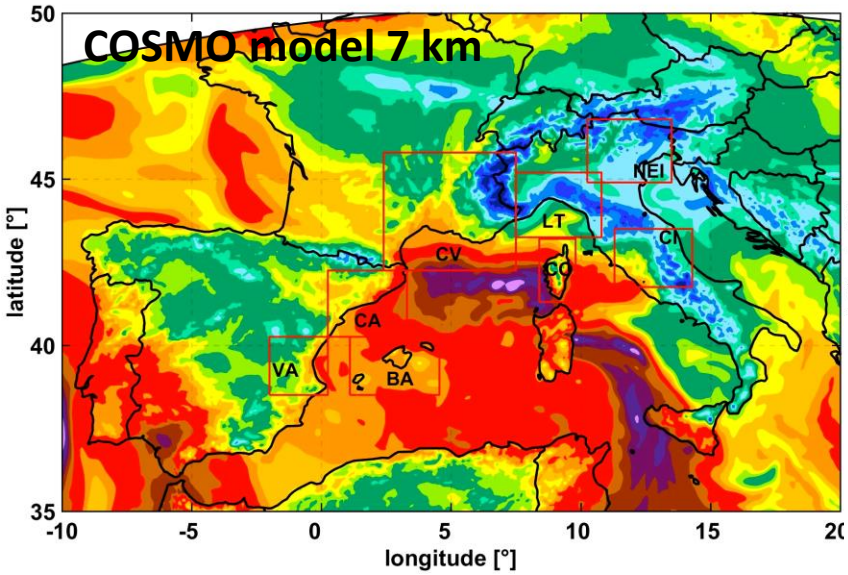
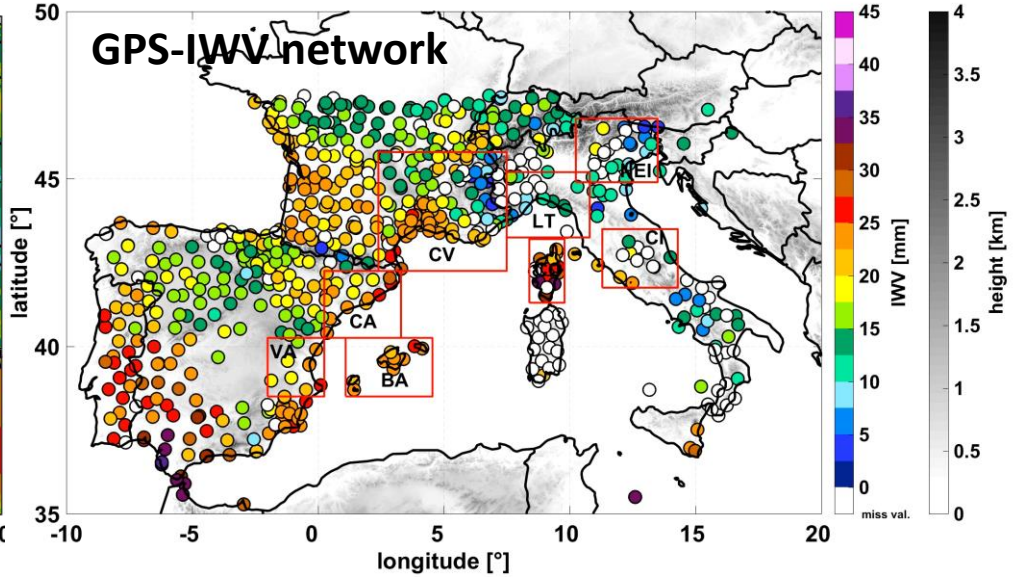
Modelling of atmospheric water vapour





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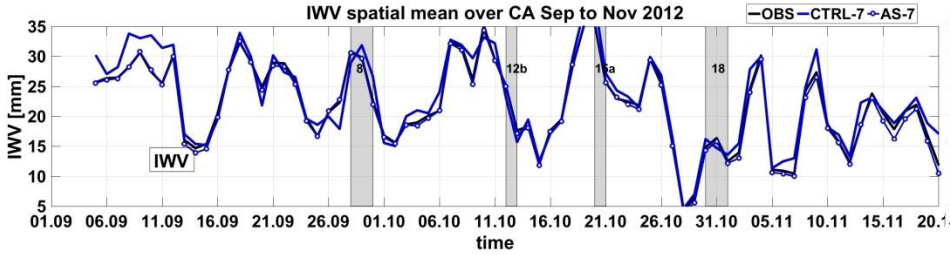
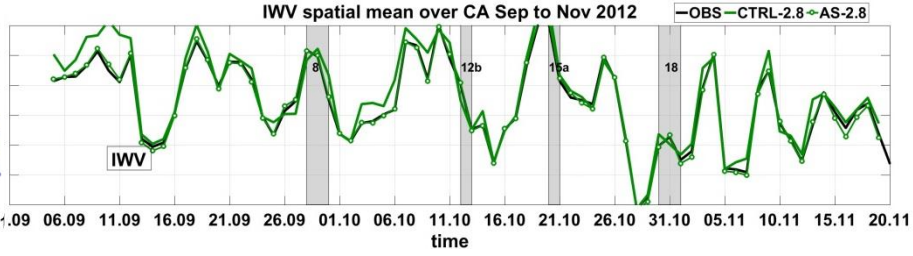
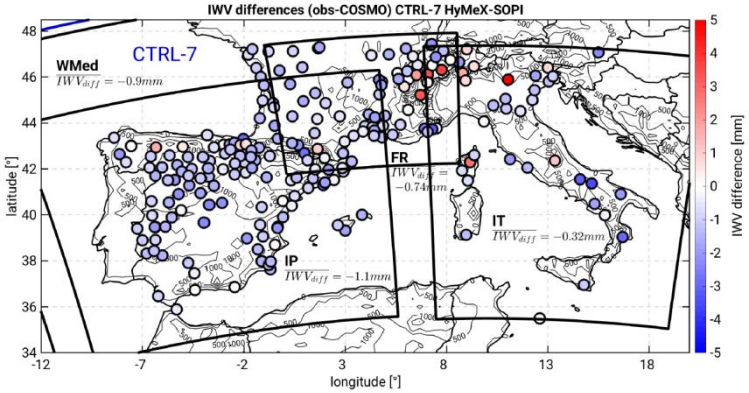
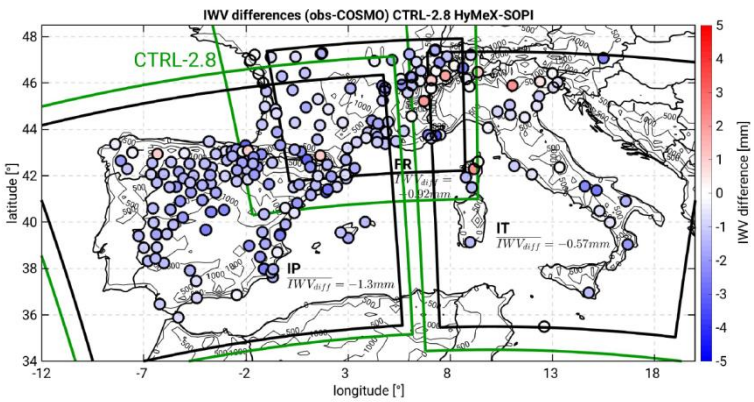
How accurate is atmospheric moisture modelling?

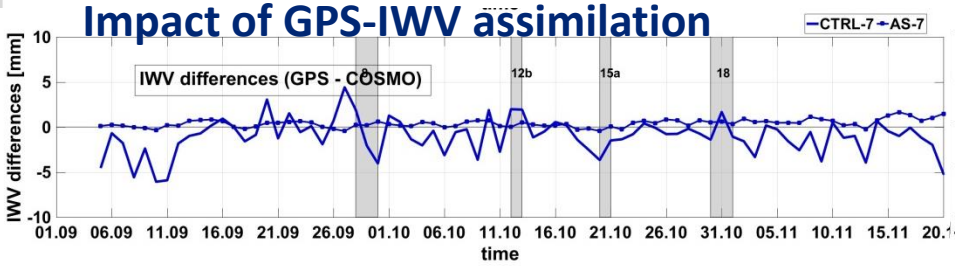


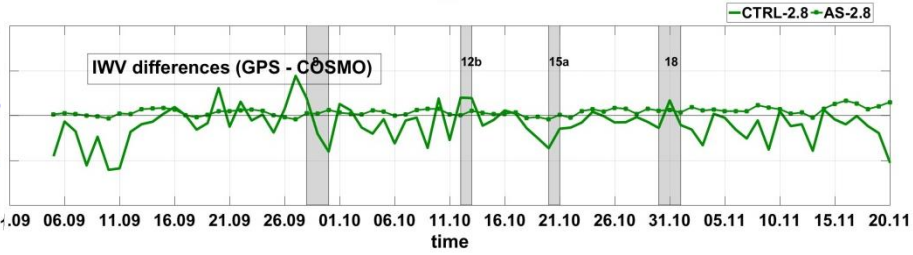






Impact of GPS-IWV assimilation





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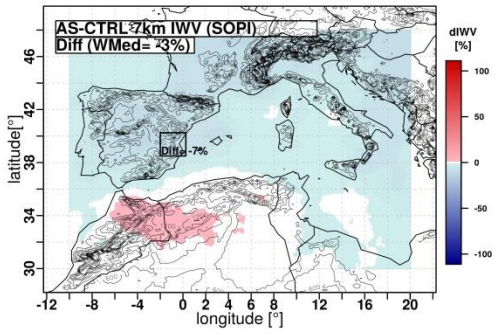
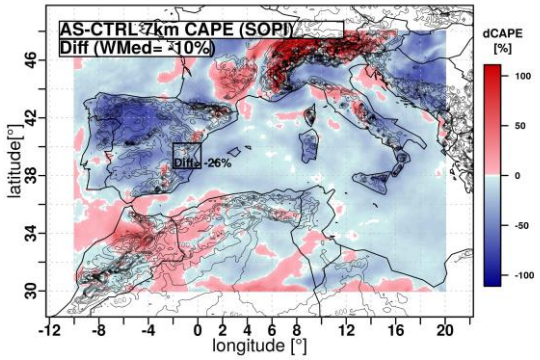
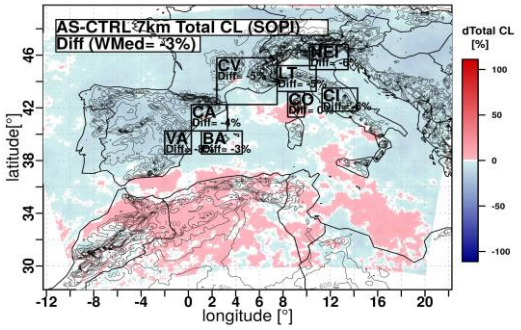
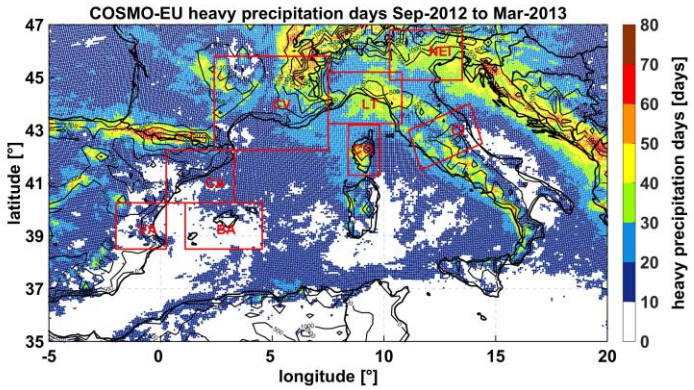
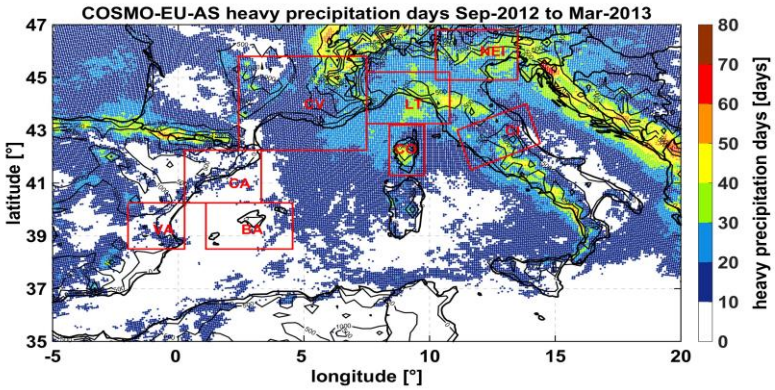
Impact of GPS-IWV assimilation on atmospheric conditions and precipitation











The number of wet days (with precipitation over 10 mm/day) is reduced

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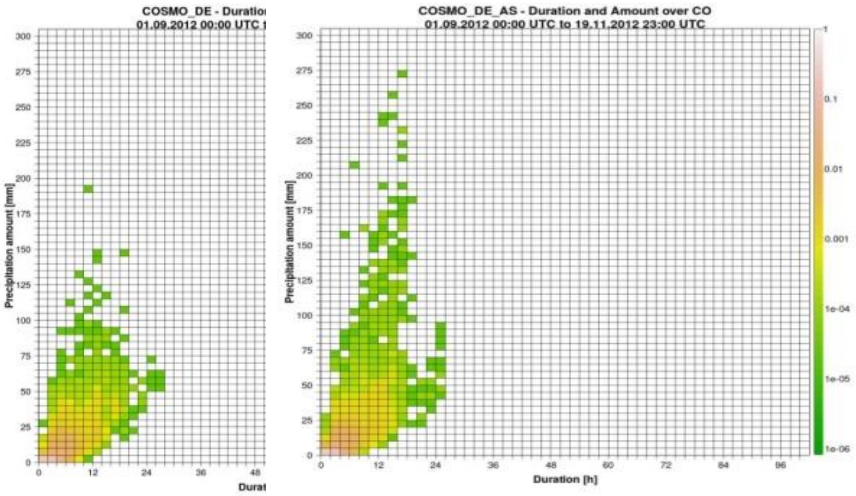
Impact on precipitation

- EU-7 km CTRL vs AS →

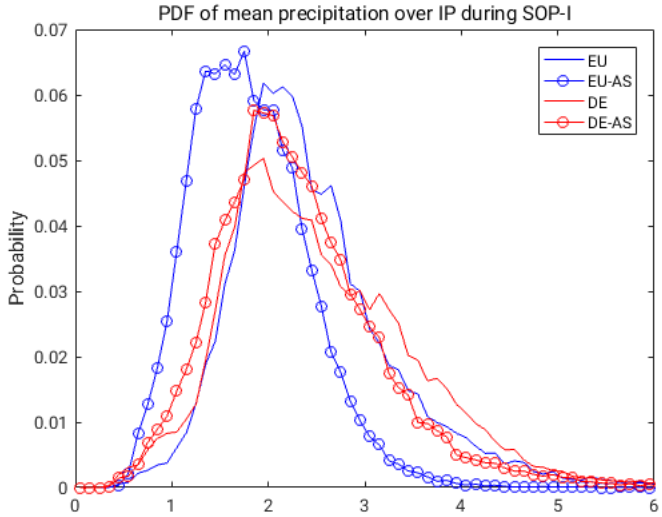
change in the mean and in the variability

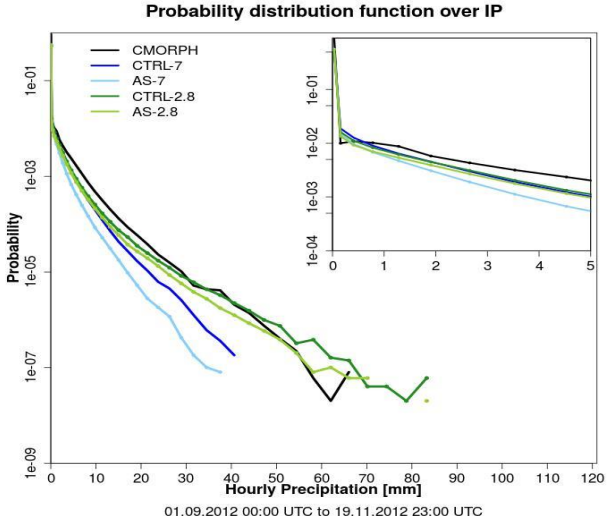
- DE-2.8 km CTRL vs AS →

Increase in the mean, reduction in the higher extreme



- Increase in short-duration large-amount precipitation events





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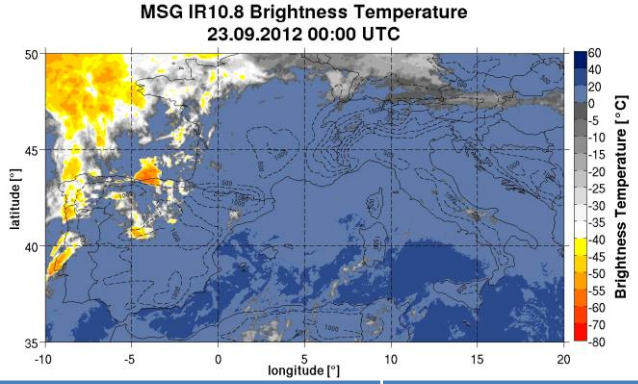
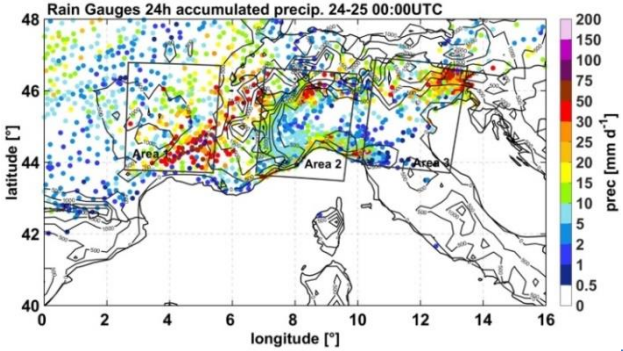
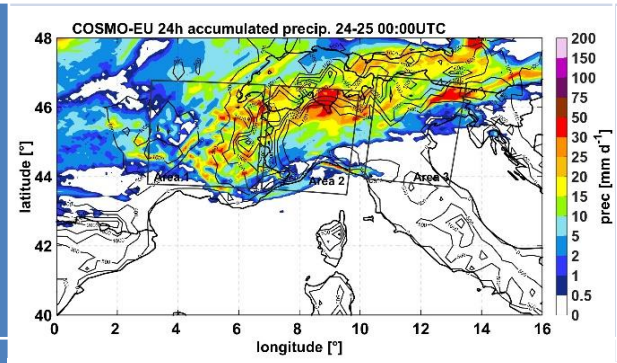
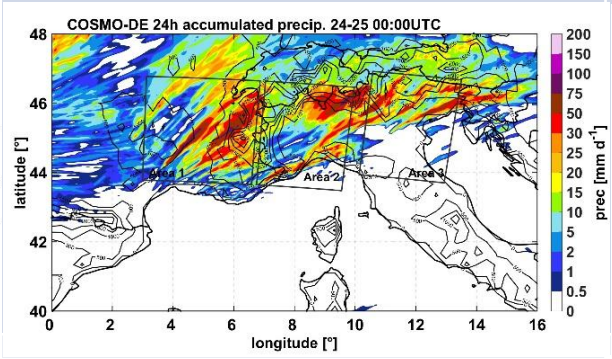
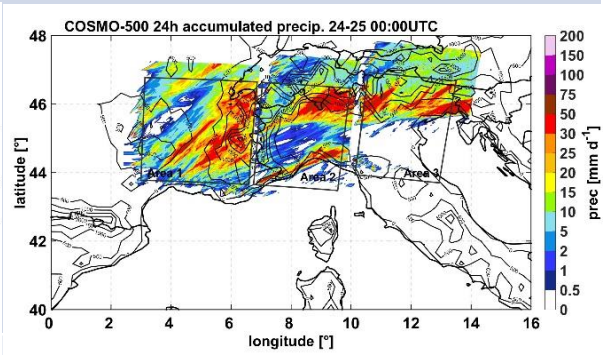
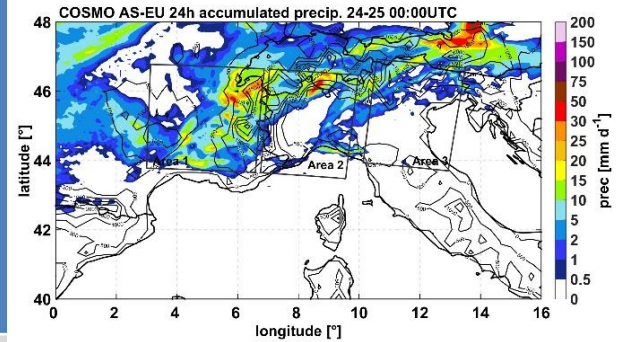
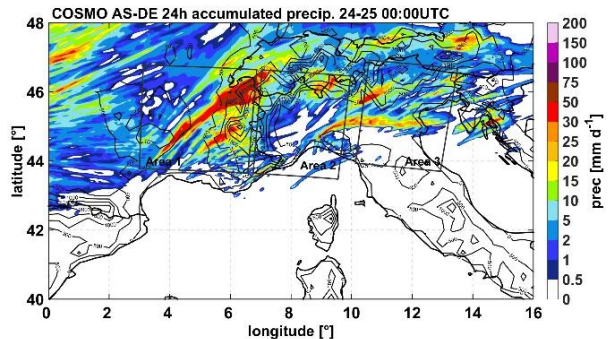
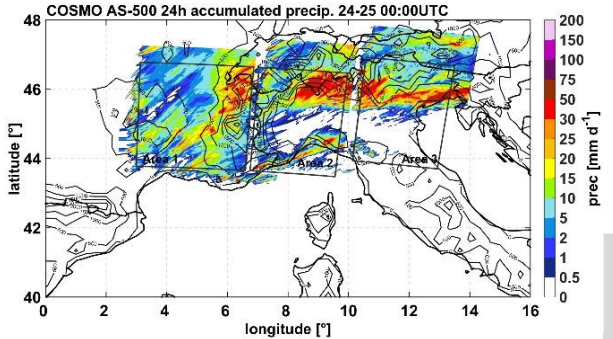
Alberto Caldas-Alvarez, Monday Talk

Impact on HP modelling on IOP6: GPS-IWV assimilation across resolution





	COSMO-7km	COSMO-2.8km	COSMO-500
CTRL			
Assimilated			

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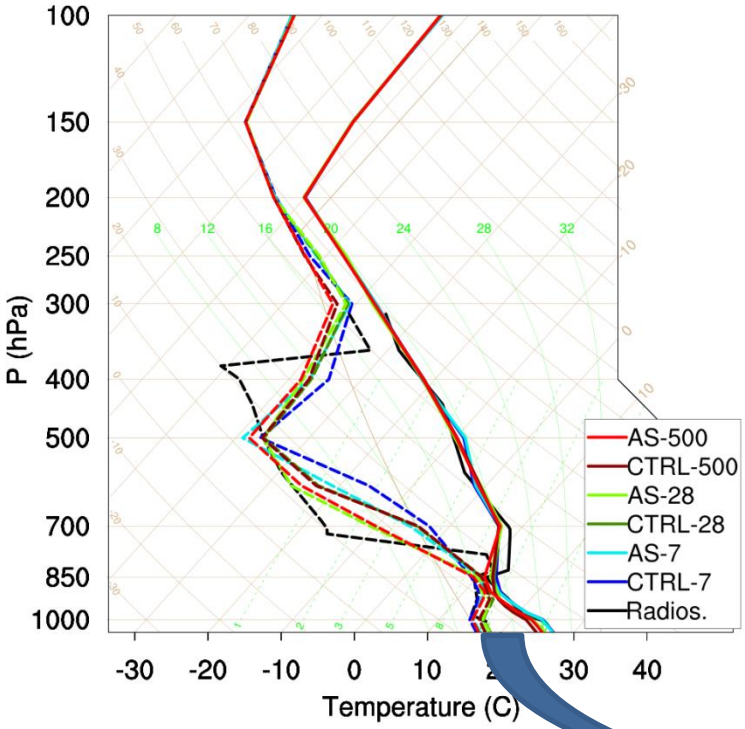
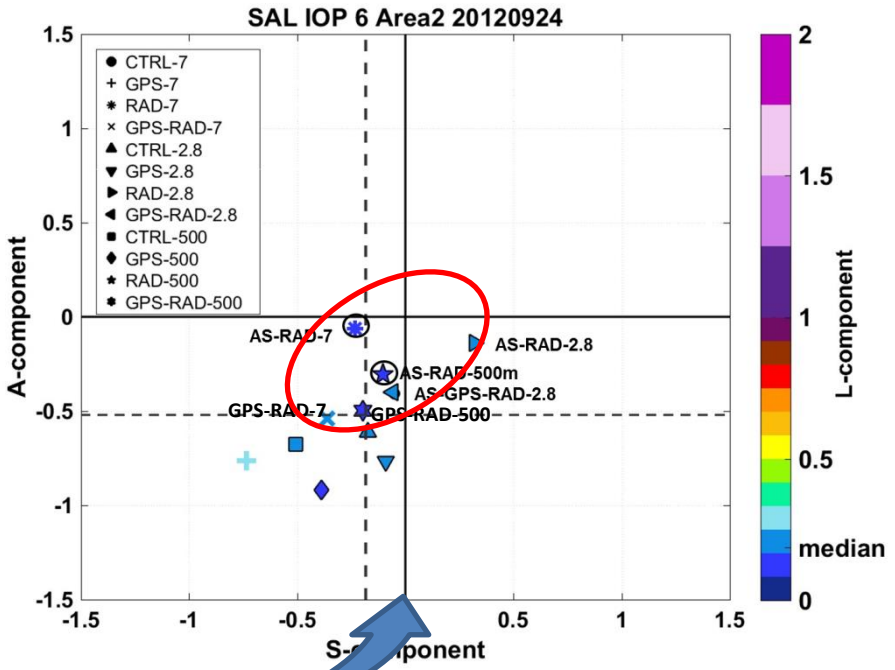
Negative impact on HP modelling on IOP6: GPS-IWV assimilation across resolution





DA drying the atmosphere 6 hours prior to CI
every horizontal grid resolution
Large vertical estratification discrepancy

GPS+RAD ASSIMILATION

RAD affects structure and location,
GPS modulates amount

Conclusions

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- In this study, we address:

(a) The benefit of using a combination of CRM and state-of-the-art observations to improve modelling of heavy precipitation.

(b) The contribution of soil conditions, atmospheric moisture characteristics and related feedbacks on the occurrence of heavy precipitation events.

- We identified a **positive soil moisture-atmosphere-precipitation feedback in the WMed subregions across model resolution**.

- Definition of **initial soil moisture conditions** with high-resolution **disaggregated 1 km soil moisture** from state of the art satelite missions shows promising results.

- A perturbation in the initial soil moisture scenarios directly affects **boundary layer thermodynamic** (increase of thetae) **and dynamical processes** (modification of convergence fields). Thus, mechanisms that lead to the occurrence of extreme precipitation events.

Conclusions

- The **assimilation** of total column water vapour information (**GPS-IWV**) significantly **improves the modelling** accuracy of this variable over the whole Wmed.

- We identify a **clear impact on the modelled precipitation**, especially of the intense events, for the three grid spacings (7km, 2.8km and 500m). In general, **higher resolution GPS-IWV assimilated runs show better agreement** with precipitation observations over the autumn period. But, this is not always the case for individual events.

- The **assimilation of GPS-IWV modulates the precipitation amount**, but neither the structure or location of precipitation are largely corrected/affected.

- A better definition of the vertical estratifcation of atmospheric moiture is crucial to improve the modelling of HP. The **combination of GPS-IWV and RAD assimilation at high resolution reveals the better results**.

- The assimilation of selected radiosondes (upstream of hot spots for each region/TGA) in combination with GPS-IWV information could be promising.