

Testing target cy43h surface options in climate mode: First results

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Outline

New Surface options in cy43 (wishlist)

Why climate mode?

Setup of first experiments using the wishlist

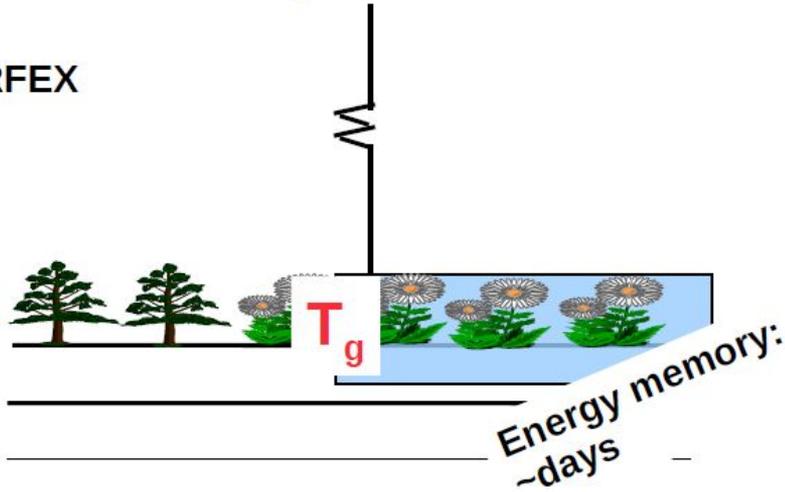
Surface bias assessment: First results

Conclusions

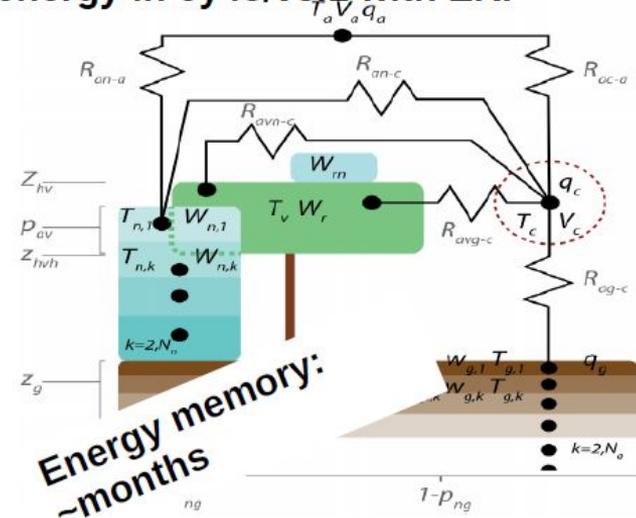
New surface options in cy43h

Force-restore in cy40/v7.3 with OI

SURFEX



Multi level/energy in cy43/v8.1 with EKF



- Most of the development in the HIRLAM's surface group is done now in cy43h since SURFEX8.1 code was introduced there last summer.
- We work in the introduction of a more advanced set of SURFEX land-surface physics: (diffusion soil, explicit snow, Multi-Energy Balance) in combination with SEKF assimilation.
- The first meteorological release of cy43h (harmonie43h2.1) can maybe be expected in autumn 2019. **It will still keep Force-restore and D95 snow** but will include some updates already tested in cy43h or previous releases.

Wishlist of SURFEX 8 namelist options

```
&NAM_ISBA
CISBA = 'DIF' ! Activate diffusion soil heat transfer
YSOC_TOP = 'soc_top' ! Read top soil organic carbon field
YSOC_SUB = 'soc_sub' ! Read deep soil organic carbon field
CPHOTO = 'NON' ! Jarvis formula is used for plant transpiration (nothing else is available for NPATCH<12)
LTR_ML = .FALSE. ! Radiative transfer in vegetation (but see LMEB option below).
NPATCH = 2-4 ! Number of patches. 2 means separate forest and open land. 3 would mean an additional patch
              with permanent snow (glaciers). 4 would mean yet an additional patch for bare soil)
LMEB = .TRUE. ! Use Multi-Energy Balance (explicit canopy). Automatically sets LTR_ML = .TRUE.
CPEDO_FUNCTION = 'CO84' ! Should be used for DIF
XUNIF_RUNOFFB = 0.2 ! Used in combination only with CRUNOFF = 'DT92'. Tunable
/
&NAM_MEB_ISBA
LMEB_PATCH = .F., .T., ! Use MEB for forest but not for open land (with NPATCH=2)
LMEB_LITTER = .TRUE. ! Use litter on ground in forest.
/
&NAM_ISBAN
CSCOND = 'PL98' ! Type of soil thermal conductivity
CSNOWRES = 'RIL' ! Maximum Richardson number limit for stable conditions ISBA-SNOW3L turbulent exchange option.
CALBEDO = 'CM13' ! Albedo by cover and vegetation type processed from satellite data.
/
&NAM_SGH_ISBAN
CRUNOFF = 'DT92' ! DT92 means Dumenil and Todini (1992) subgrid runoff (should be used in combination with XUNIF_RUNOFFB=0.2).
              SGH means Decharme et al. (2006) Topmodel like subgrid runoff. This was developed for coarser resolution and requires
              subgrid slope information
CRAIN = 'SGH' ! Activate spatial distribution of rainfall.
CHORT = 'DEF' ! DEF=no Horton runoff. SGH activates the Horton surface runoff for intense rain on dry soil with limited infiltration capacity.
              This option was added in the climate model: it has to be evaluated carefully for NWP applications before taking the decision of its use.
LSOC = .TRUE. ! Activate soil organic carbon effect.
/
&NAM_PREP_ISBA_SNOW
CSNOW = '3-L' ! Explicit snow scheme (default 12 layers)
/
```

- New surface physics options: **DIF, 3-L Snow scheme, MEB**
- Sub-options defined according to past experience in the HCLIM community & with the help of SURFEX staff (Patrick, Aaron)
- New physiography: ECOCLIMAP-SG

Why running “climate mode” for nwp development?

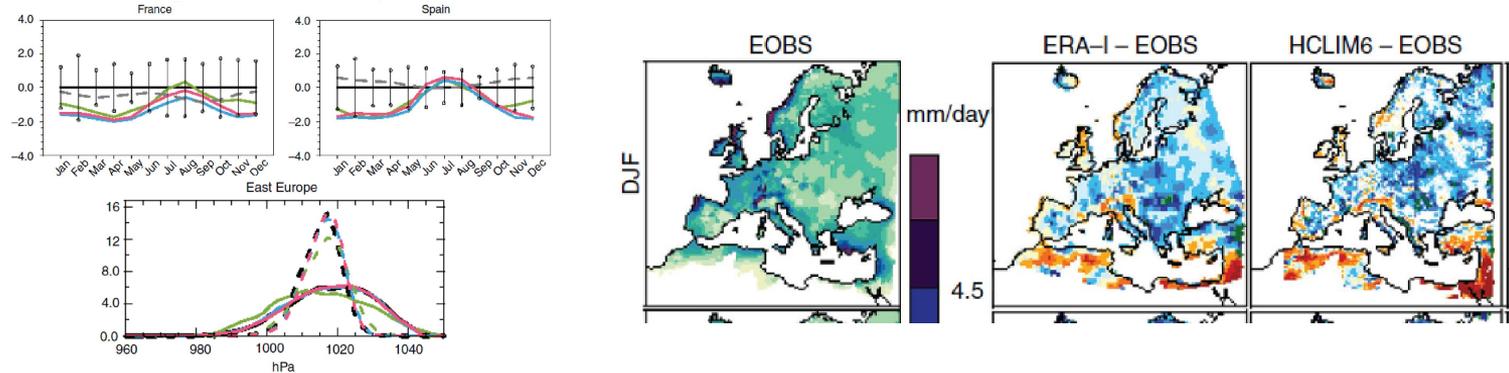
- All NWP forecasting systems have biases.
- In principle, the role of data assimilation should not be to compensate for biases in the system.
- We expect changes in sfc-atm interactions introduced by the new surface components in cy43h.
- So we study the system in climate mode to identify and reduce biases before data assimilation is activated.

Climate mode status in cy43h

- SURFEX version updated to 8.1 last summer
- Update of SST during the Forecast (LMCC01_MSE=.TRUE.). A solution for updating Sea Ice not yet available (but RC working on it)
- The common CY43 git repository can be used for “climate mode” experiments. Good since we can keep our tests as close as possible to the development branch.
- Progress is slow since we’re early testers of cy43h and we’re trying many new options simultaneously. Also some issues we find are specific to the climate runs.
- We plan to run climate experiments over 2-4 domains to observe the impact of the new surface over different regions. People involved: Samuel Viana, Emily Gleeson, Patrick Samuelsson, RC colleagues.

Evaluation of cy43h model bias in climate mode.

- Methodology inspired by Lindtstedt et al. (2015): Seasonal & yearly PDFs, Annual cycles, maps, etc.

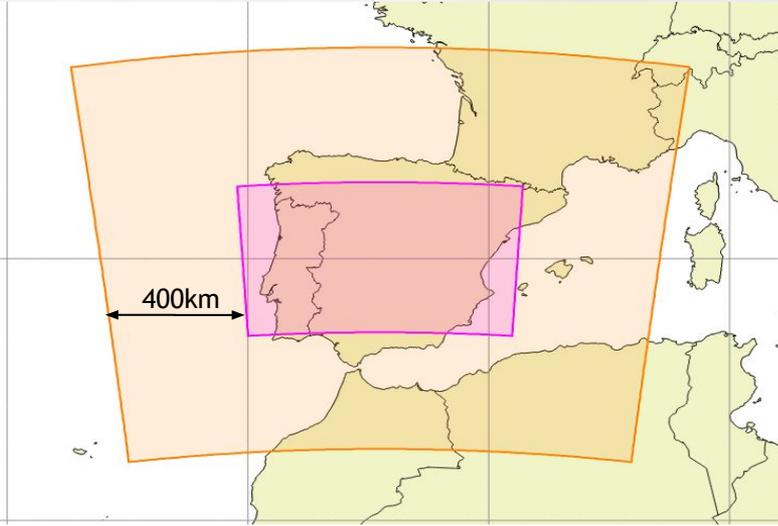


- Need to find a proper reference data for every variable:
 - **Atmospheric fields (pcp, T+, T-...)** can be compared against HR databases available from the different NWS.
 - Surface fields: ESA CCI Soil moisture, ERA5, etc.
 - Direct validation of surface fluxes when available

First cy43h long runs in climate mode

- Common setup for tests already done (not target sfc configs in **red**):
 - Full wishlist (**except MEB**)
 - ERA5 BCs.
 - **ECOCLIMAP II**
 - LUNBC=OFF (upper level boundary relaxation scheme)
 - LESPCPL=ON: Upper level spectral nudging to constrain the large scales (shorter simulations)
 - NPATCH=2 (Separate energy budgets for open-land & forest)
- So far only tested over domains without sea-ice (IBERIA & IRELAND)

DOMAIN: IBERIAxxm_2.5

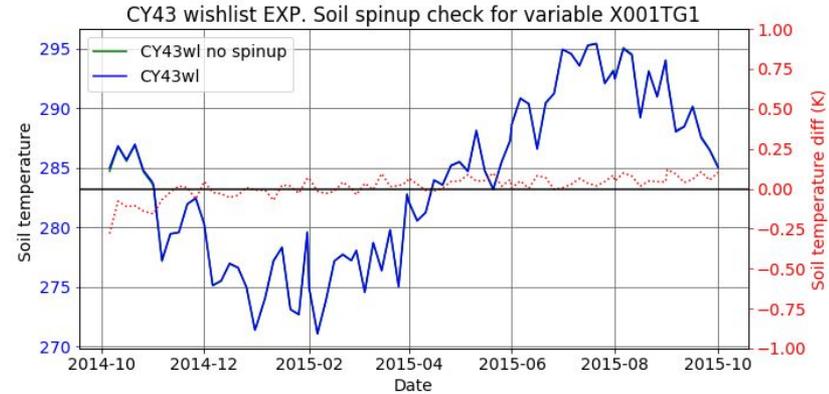
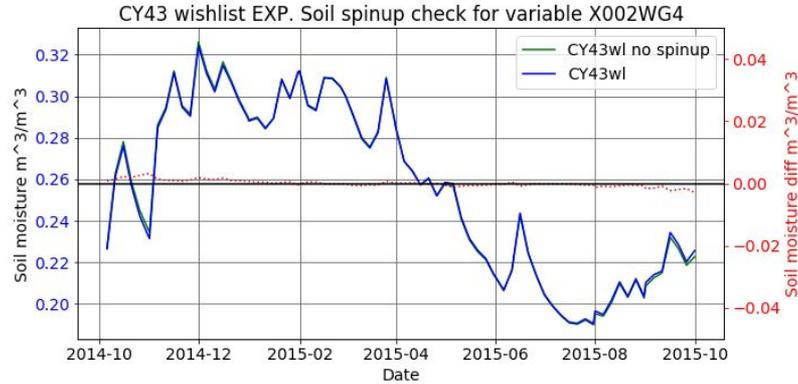


- Medium-sized domain as a compromise
- Assuming ~400km as spin-up distance for precipitation
- Integration time: ~1 week / year when everything works fine.

2 experiments:

1. From 10/2013 to 01/2018. ECOCLIMAPII (4 years).
2. From 10/2014 to 10/2015. ECOCLIMAPII. Purpose: to study surface spin up time.

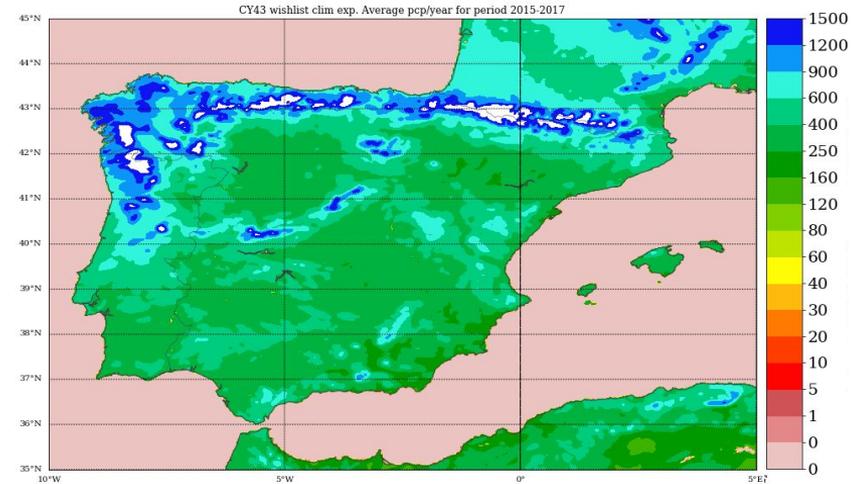
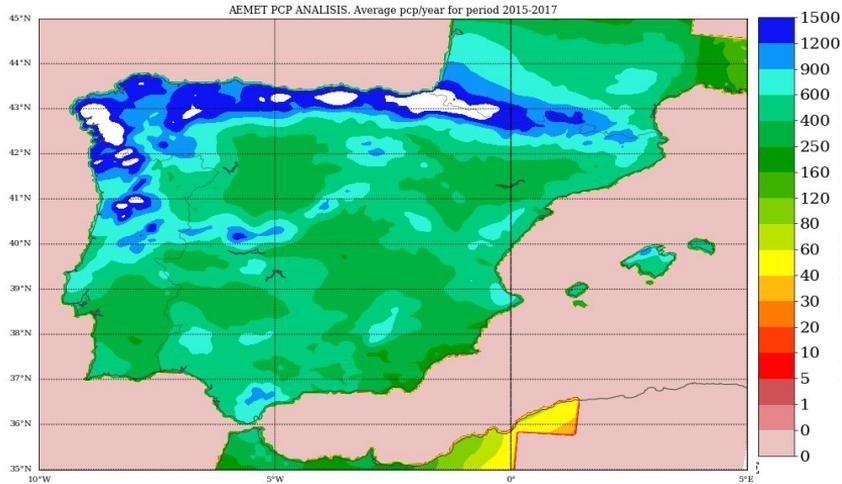
Checking the soil spin-up time



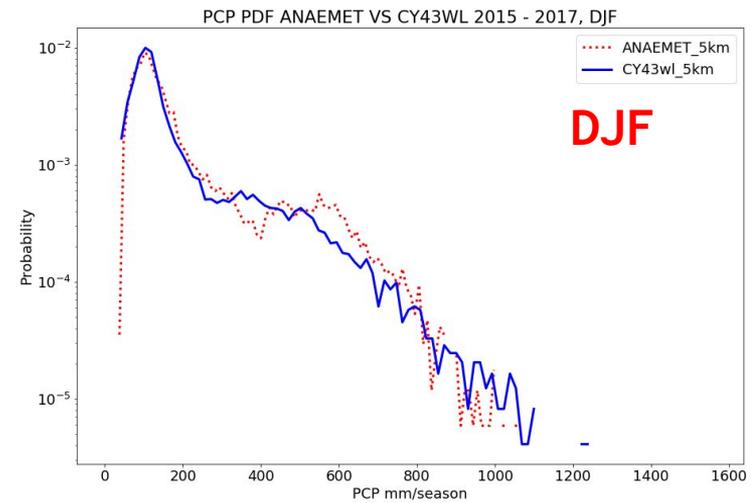
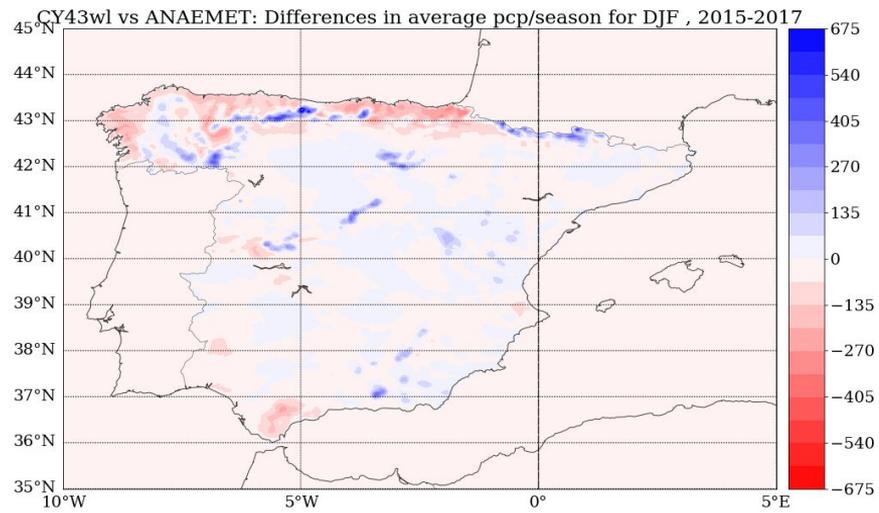
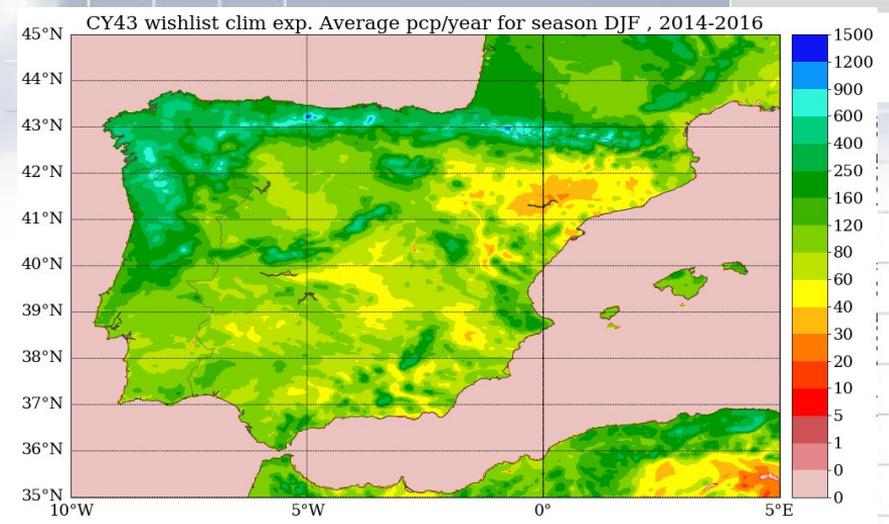
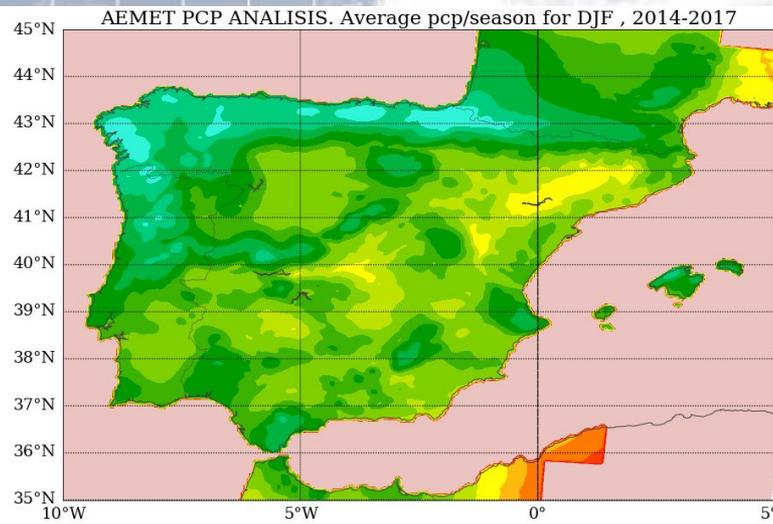
- Upper soil layers up to around 20-cm reach equilibrium in around 3 months (similar to F-R).
- Deep layers: For soil moisture 6-8 months is enough; for soil temperature a difference of 0.5-1 K remains after 1 year.

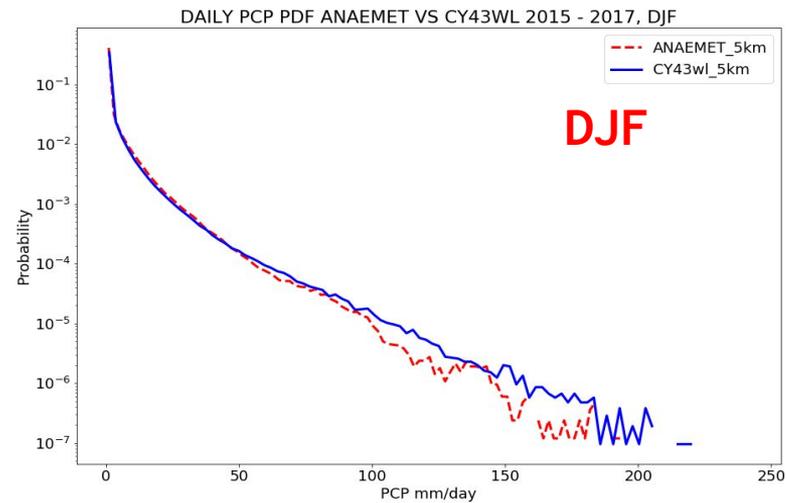
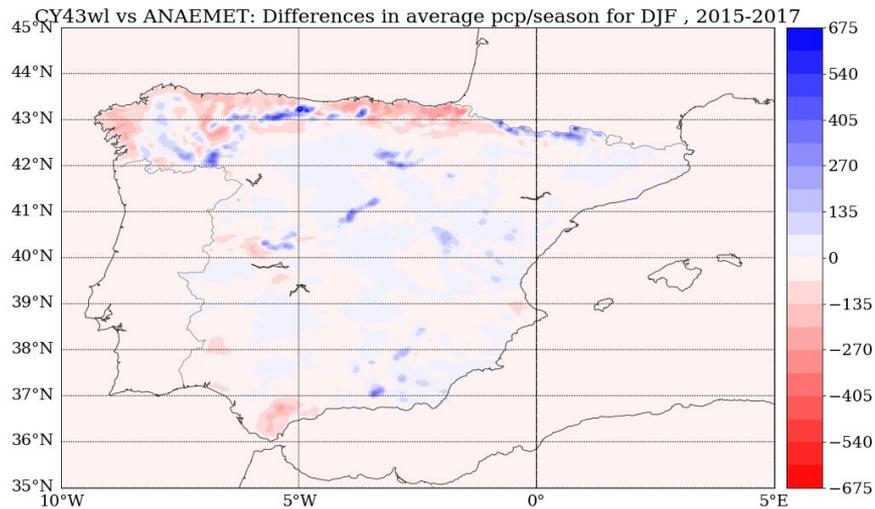
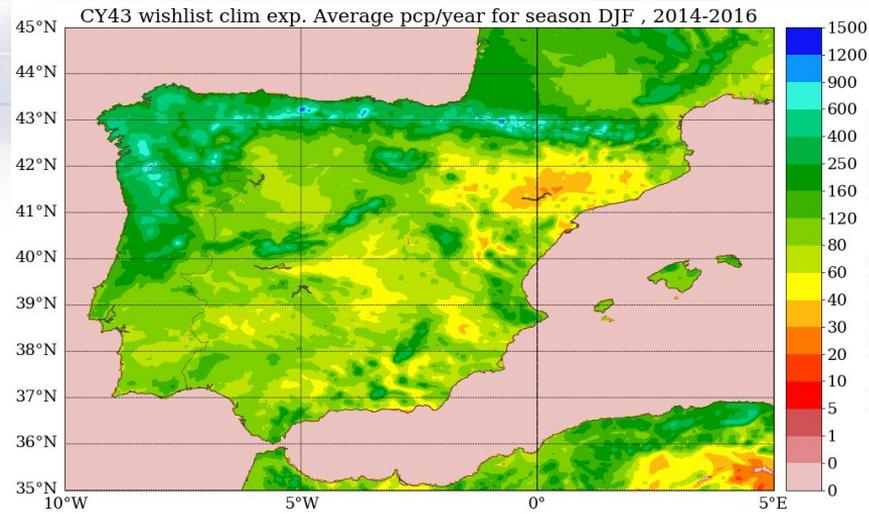
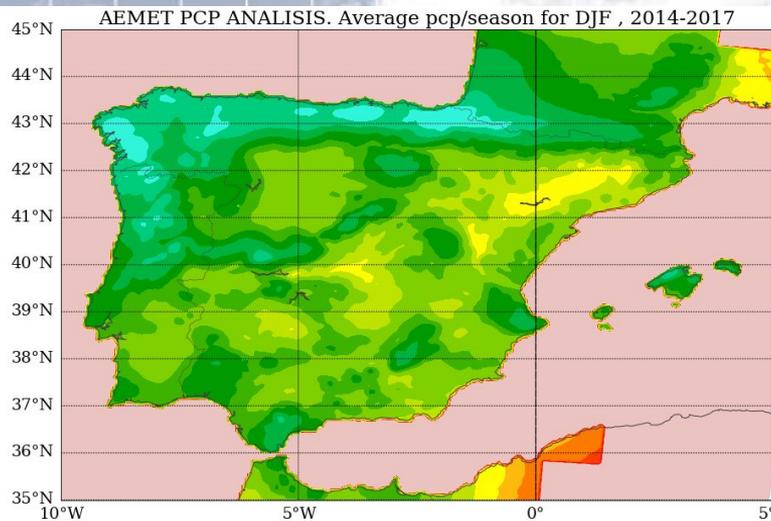
First results for PCP, TMAX, TMIN

- Analysis for years 2015-2017 (1st year left out for spin up)
- Reference: AEMET SPAN objective analysis (5km) for PCP, T2M_max, T2M_min

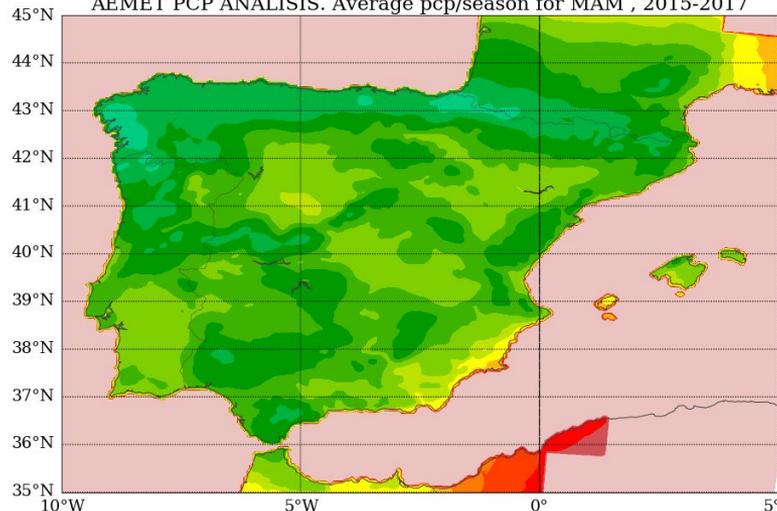


- Average pcp/year during the period 2015-2017 doesn't look bad, but...

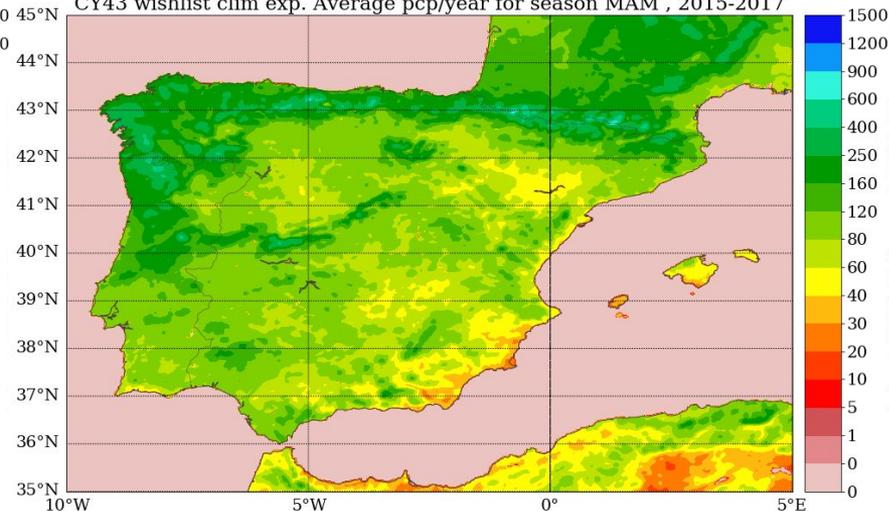




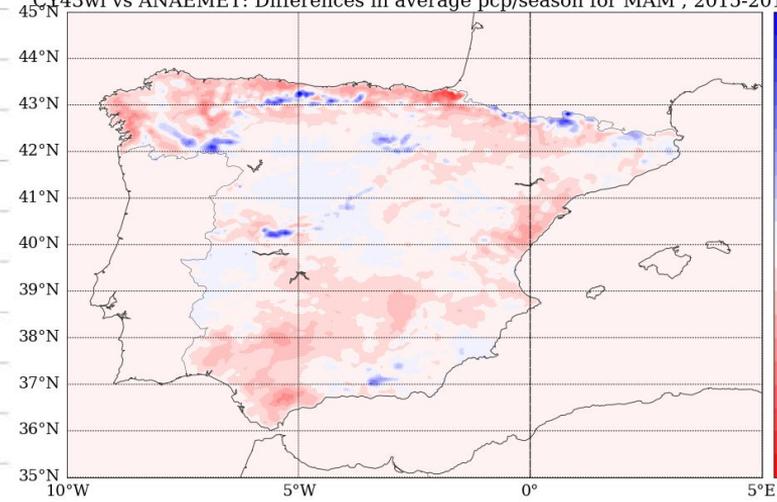
AEMET PCP ANALISIS. Average pcp/season for MAM , 2015-2017



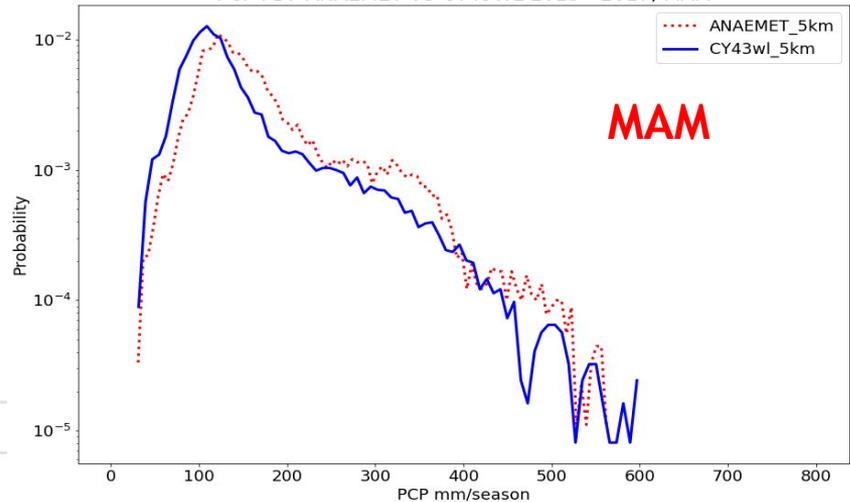
CY43 wishlist clim exp. Average pcp/year for season MAM , 2015-2017



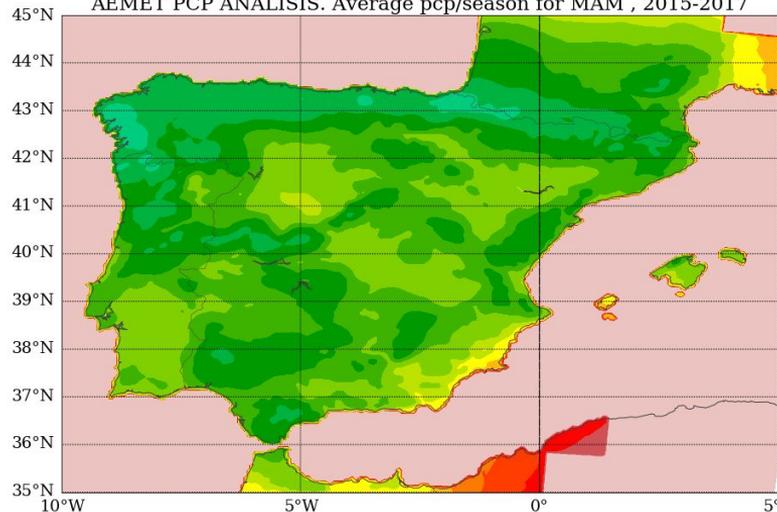
CY43wl vs ANAEMET: Differences in average pcp/season for MAM , 2015-2017



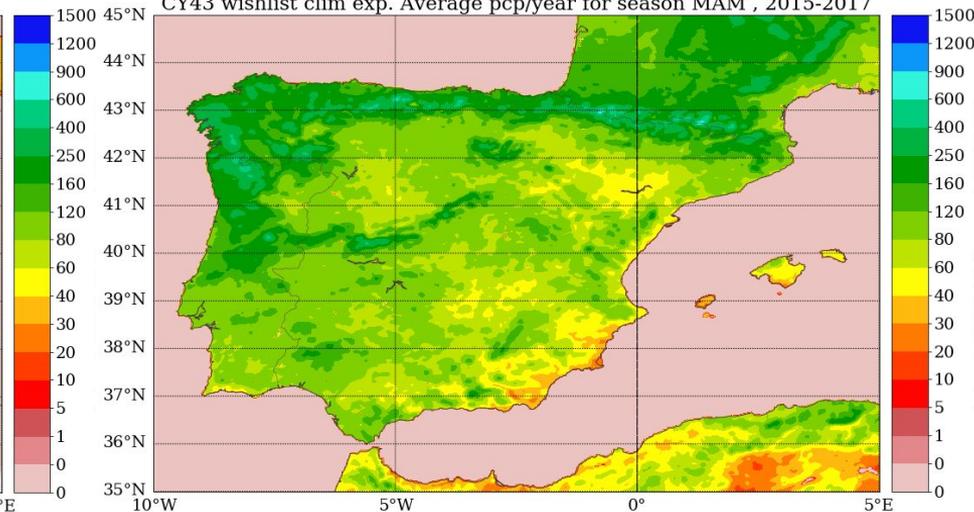
PCP PDF ANAEMET VS CY43WL 2015 - 2017, MAM



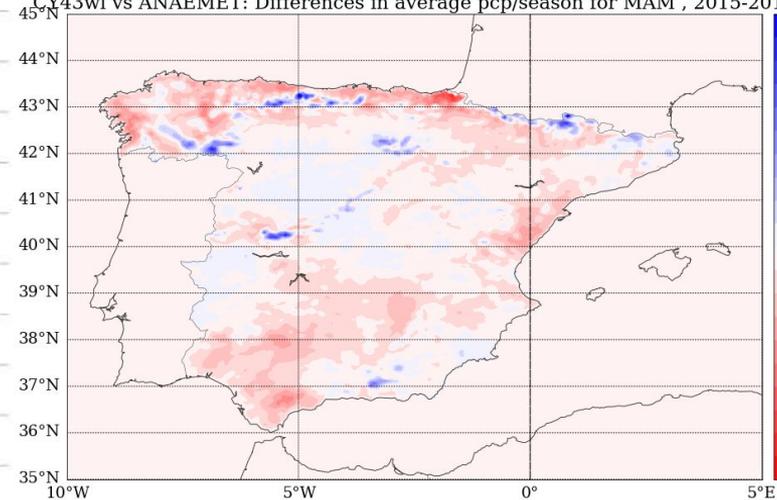
AEMET PCP ANALISIS. Average pcp/season for MAM , 2015-2017



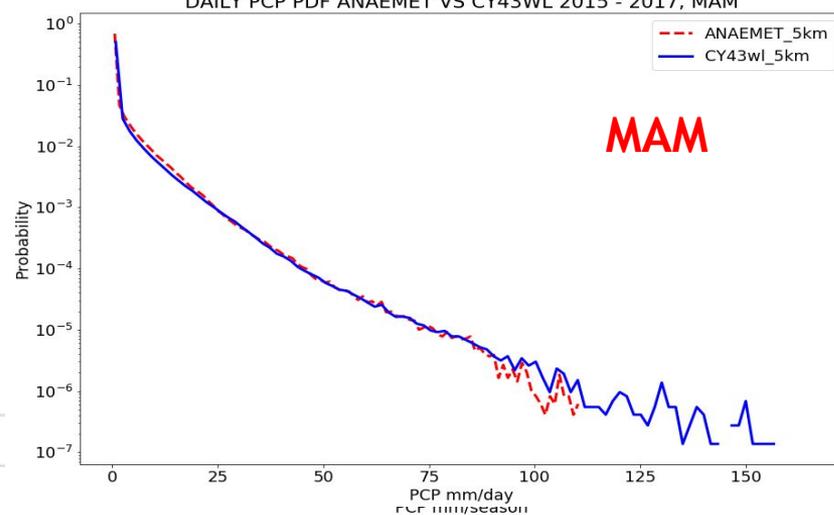
CY43 wishlist clim exp. Average pcp/year for season MAM , 2015-2017

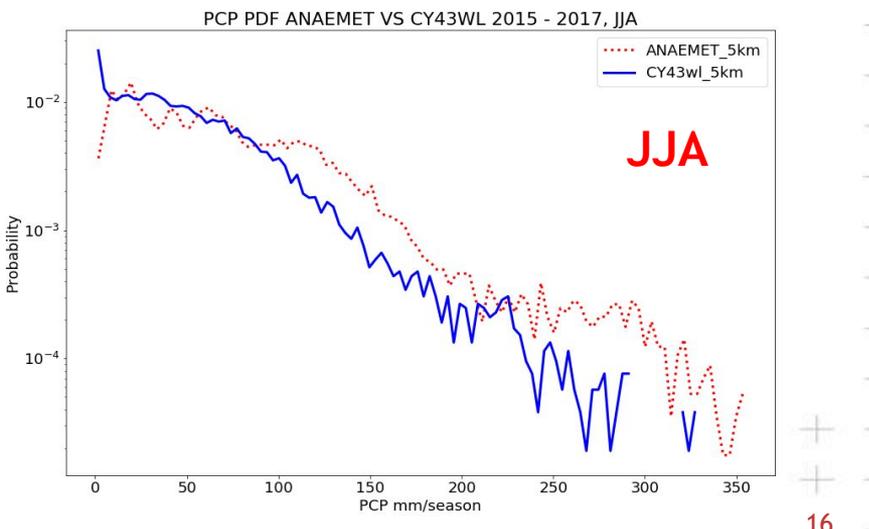
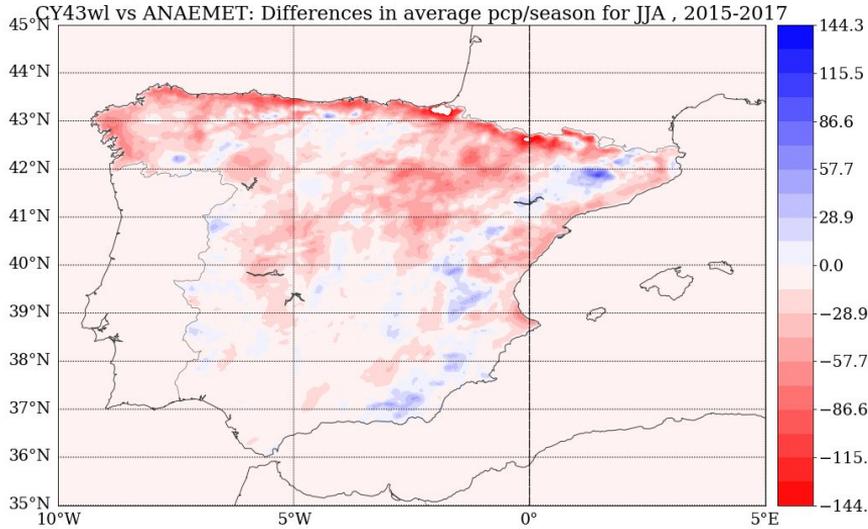
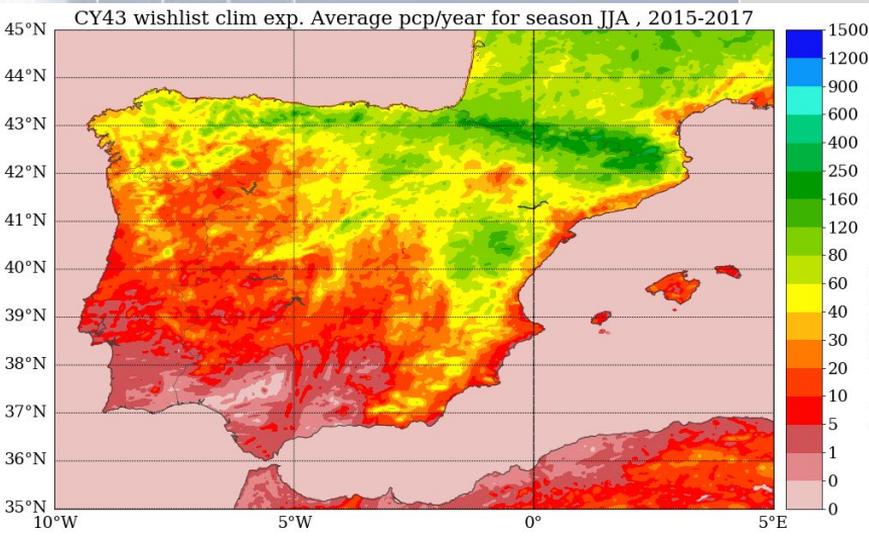
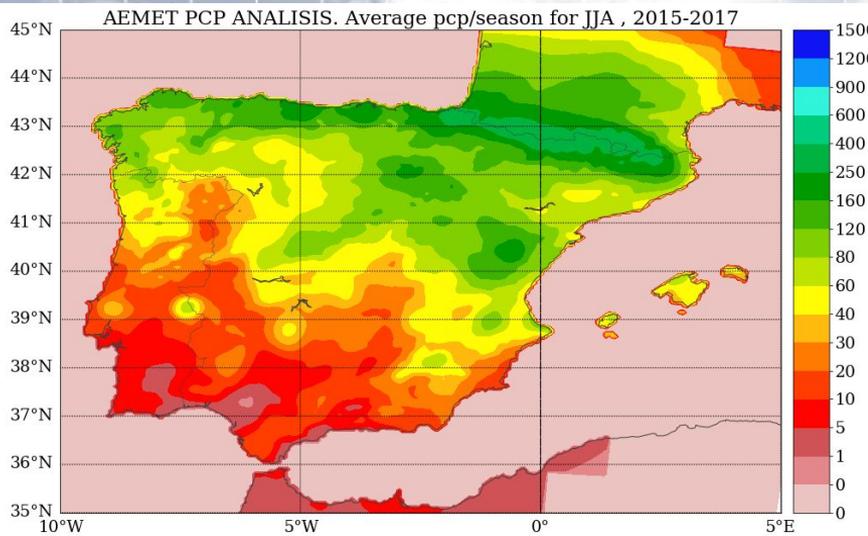


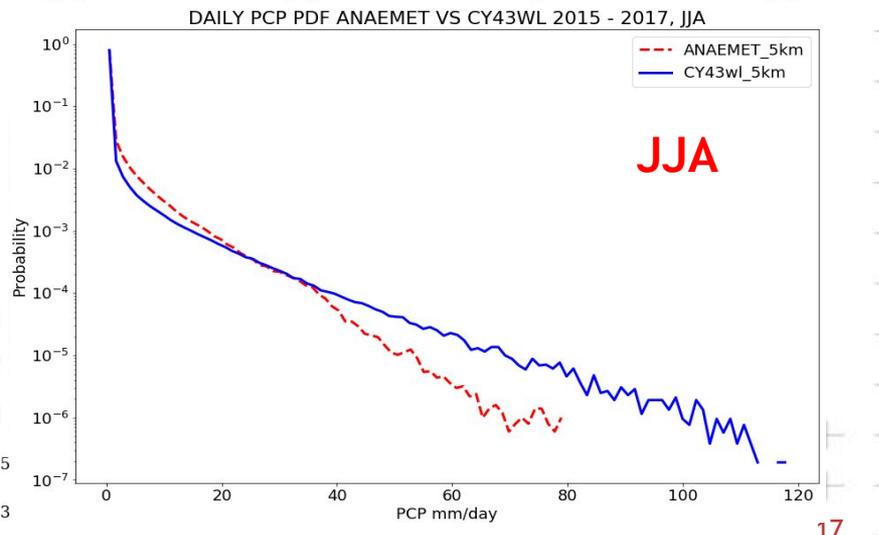
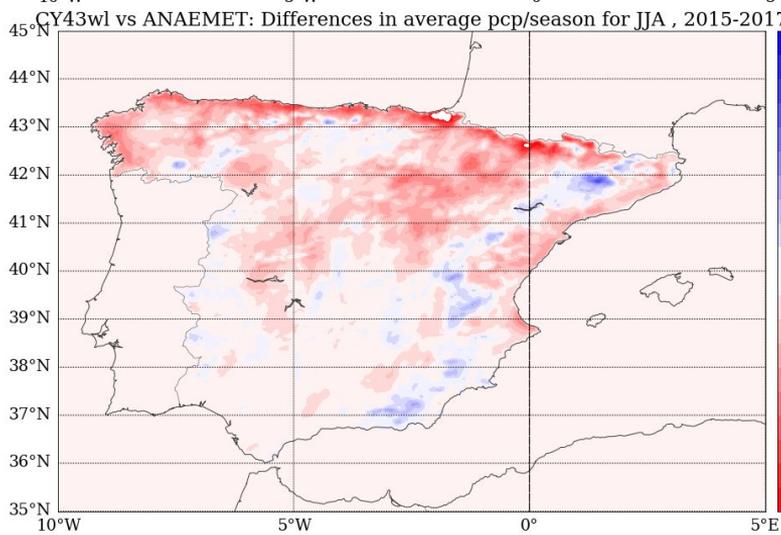
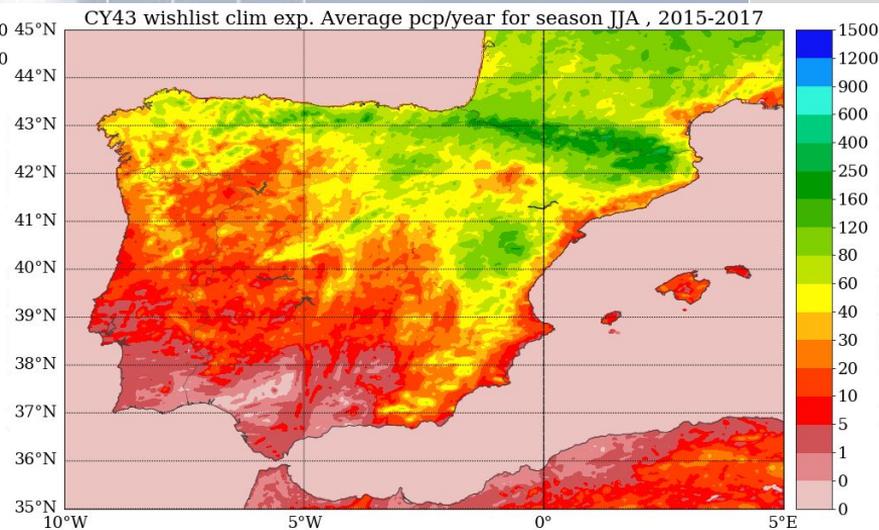
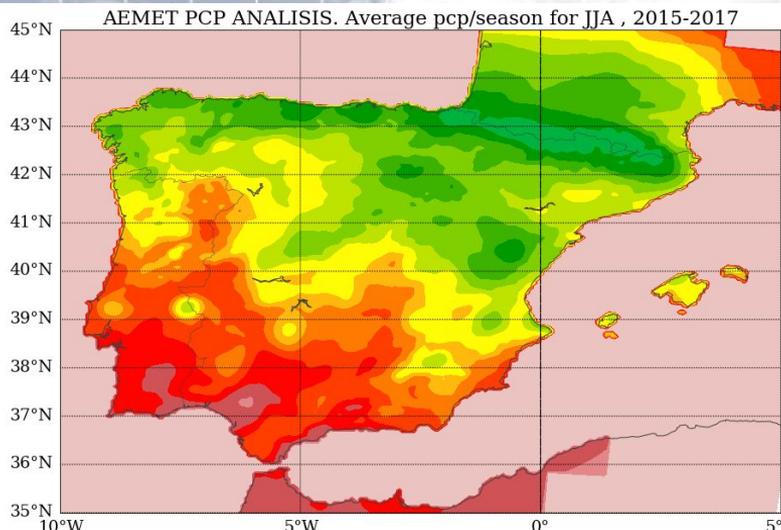
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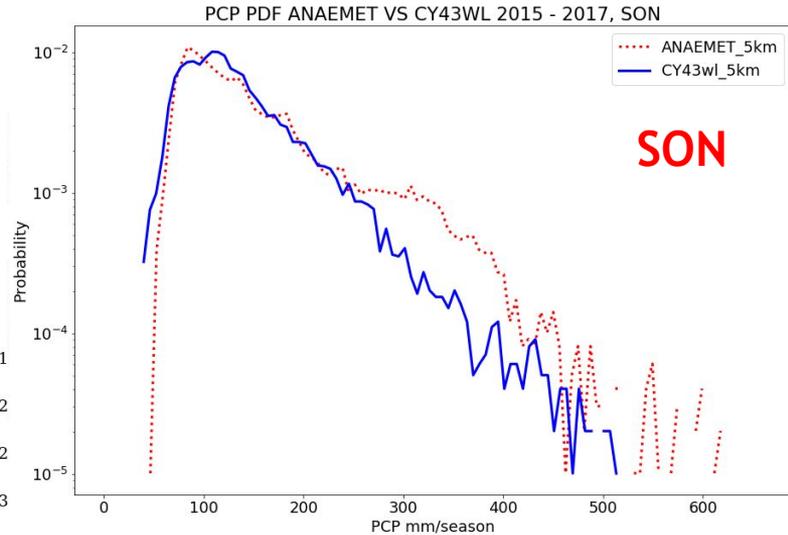
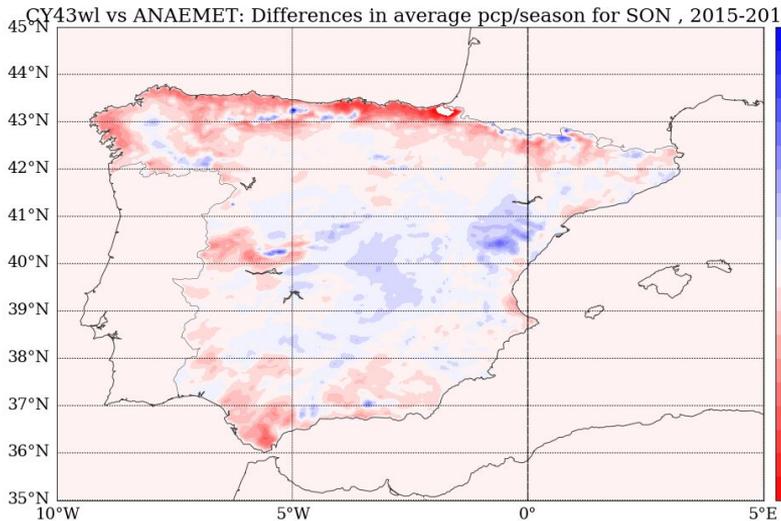
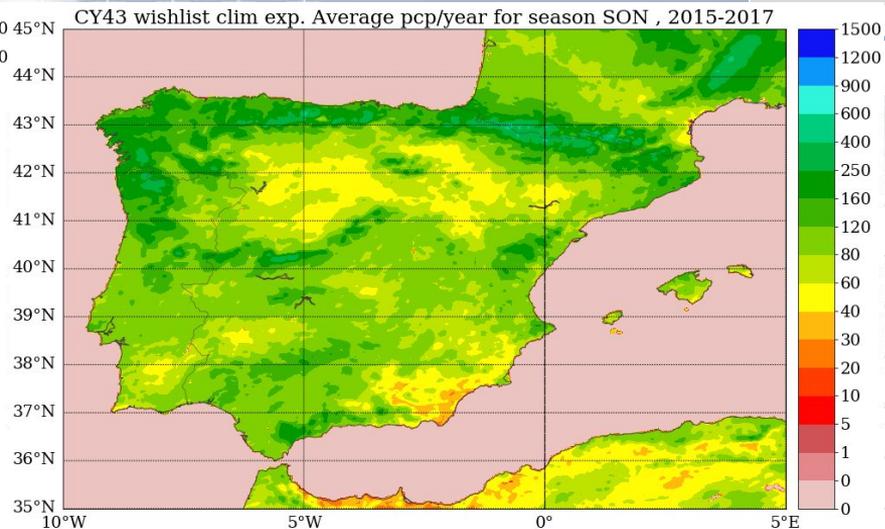
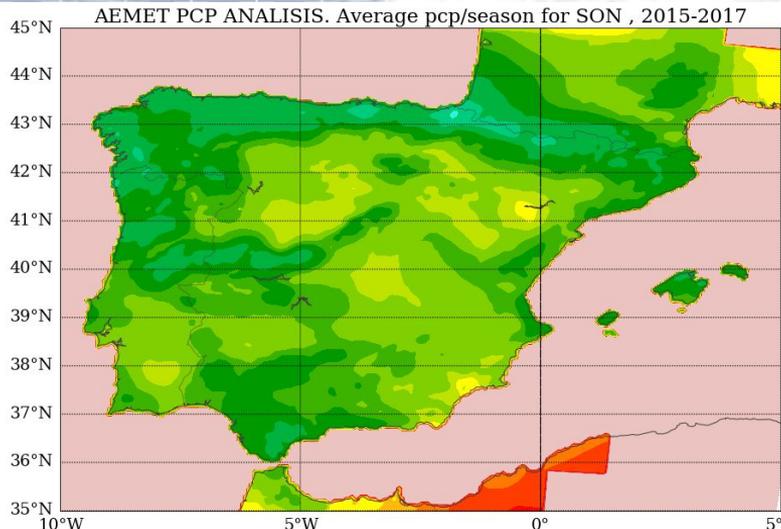


DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, MAM

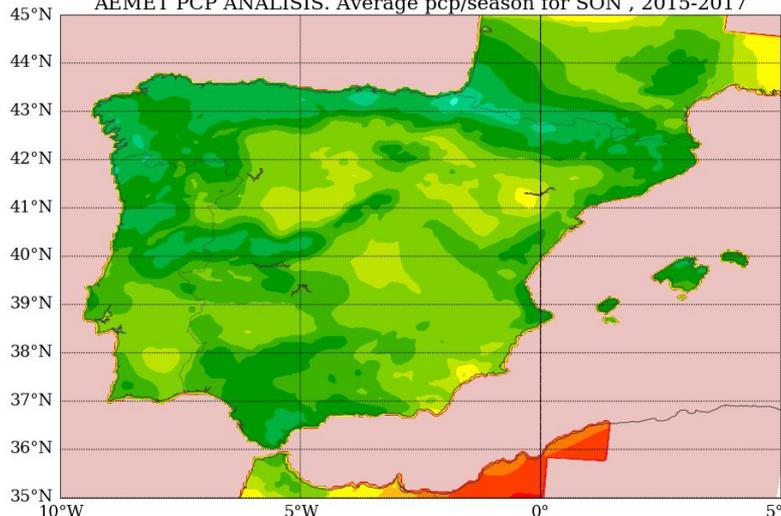




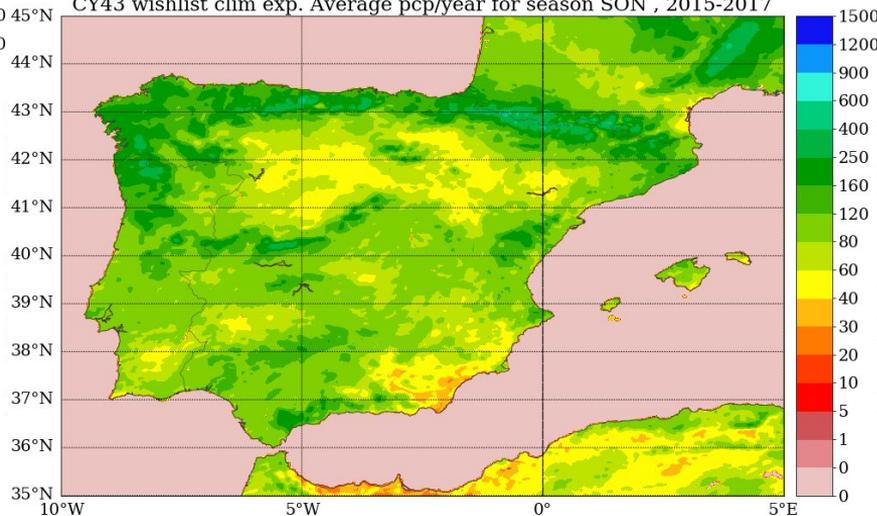




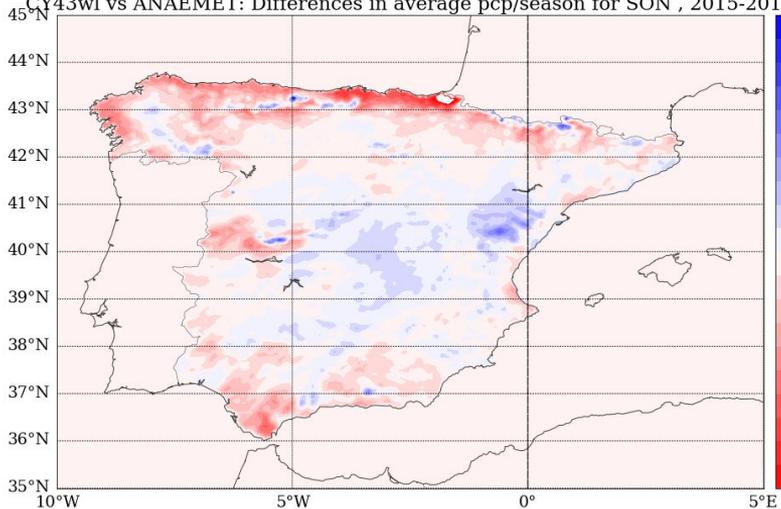
AEMET PCP ANALYSIS. Average pcp/season for SON , 2015-2017



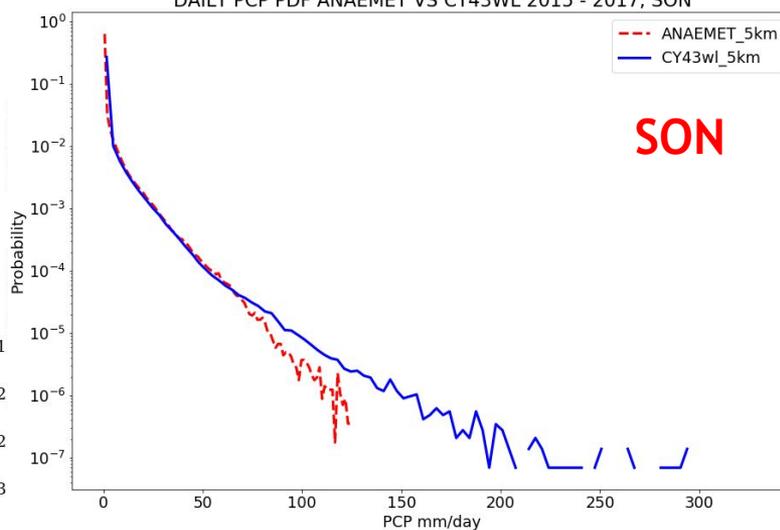
CY43 wishlist clim exp. Average pcp/year for season SON , 2015-2017



CY43wl vs ANAEMET: Differences in average pcp/season for SON , 2015-2017



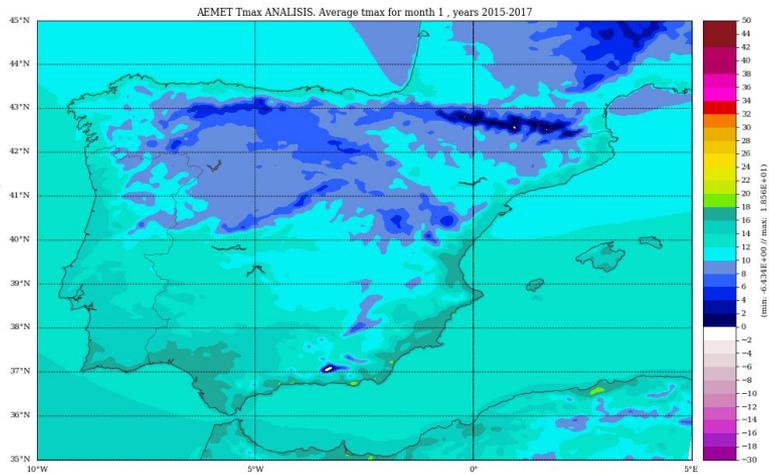
DAILY PCP PDF ANAEMET VS CY43WL 2015 - 2017, SON



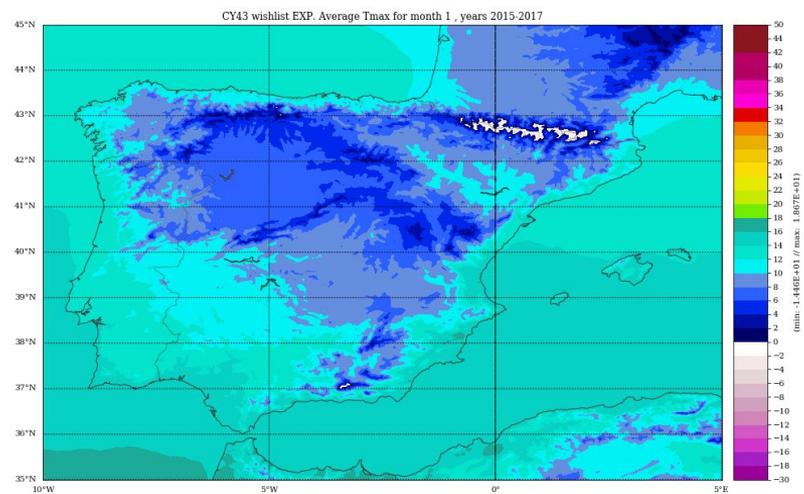
- The model tends to underestimate pcp (seasonally).
- Over complex orography (where model appears to “overestimate” pcp), the reference data (coarser) is probably too dry.
- Worst results during the convective season. Very little precipitation over the east coast & Balearic islands.
- Daily & seasonal PDFs reproduce correctly the reference data in winter & spring.
- Daily & seasonal PDFs show opposite biases during the convective season: better to compare station vs gridpoint data there.

AEMET ANALYSIS

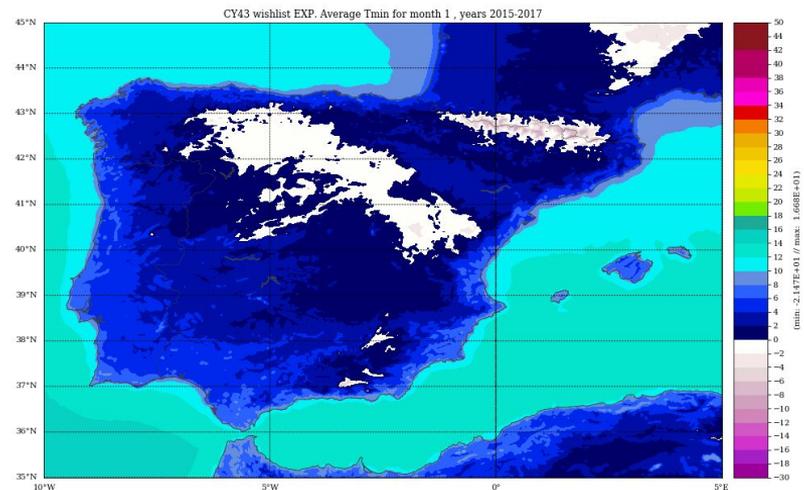
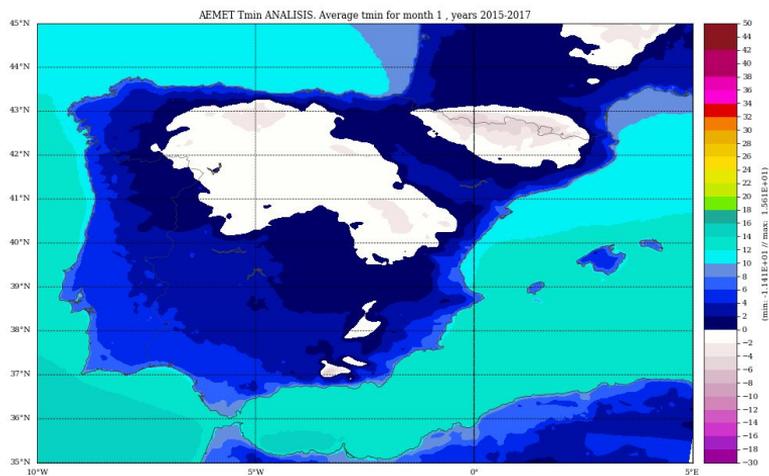
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CY43wishlist

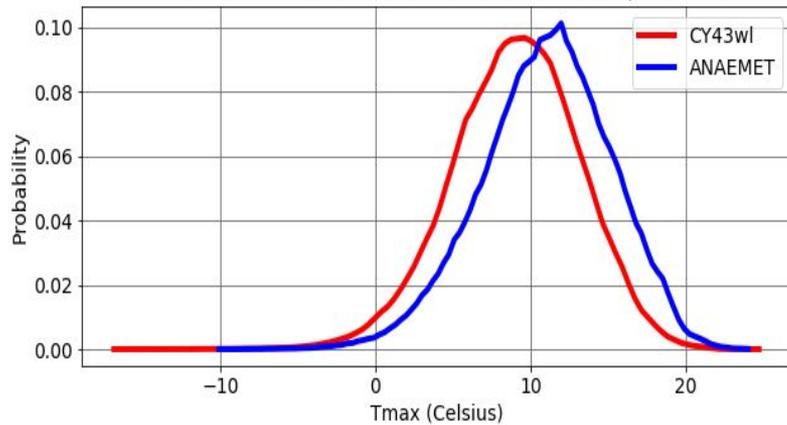


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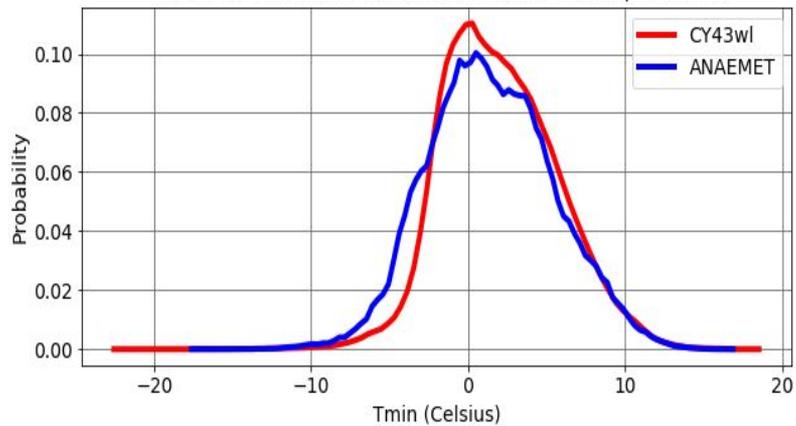


CY43wishlist

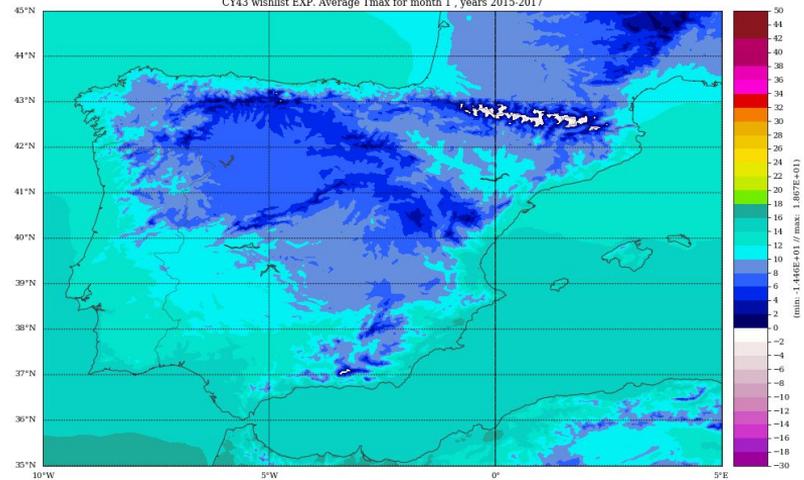
TMAX PDF ANAEMET VS CY43WL 2015 - 2017, month 1



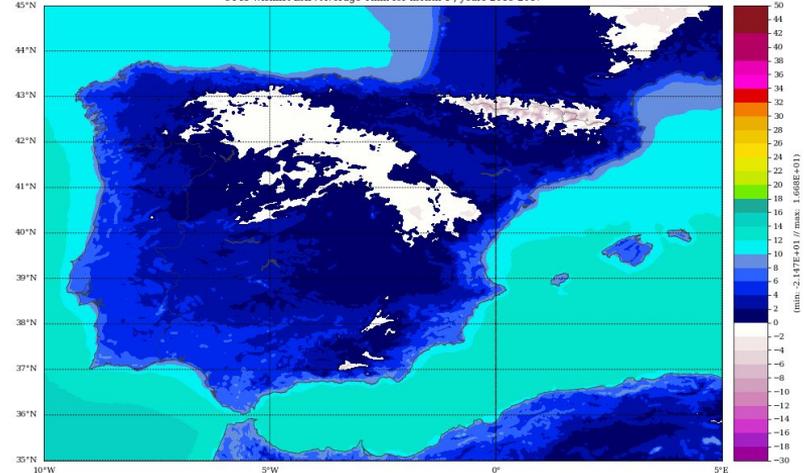
TMIN PDF ANAEMET VS CY43WL 2015 - 2017, month 1



CY43 wishlist EXP. Average Tmax for month 1 , years 2015-2017

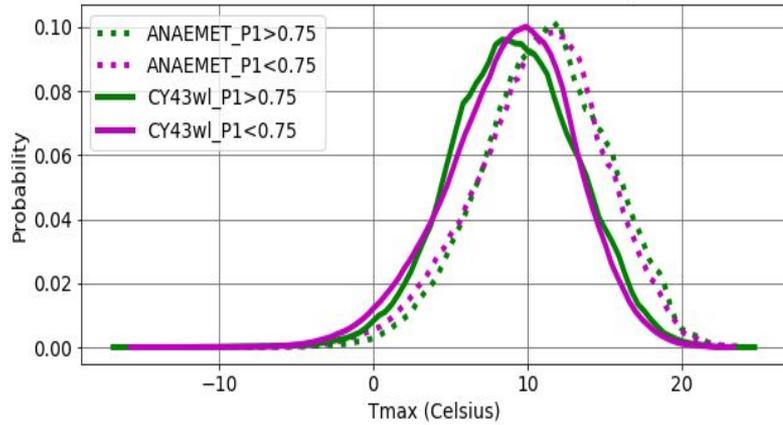


CY43 wishlist EXP. Average Tmin for month 1 , years 2015-2017

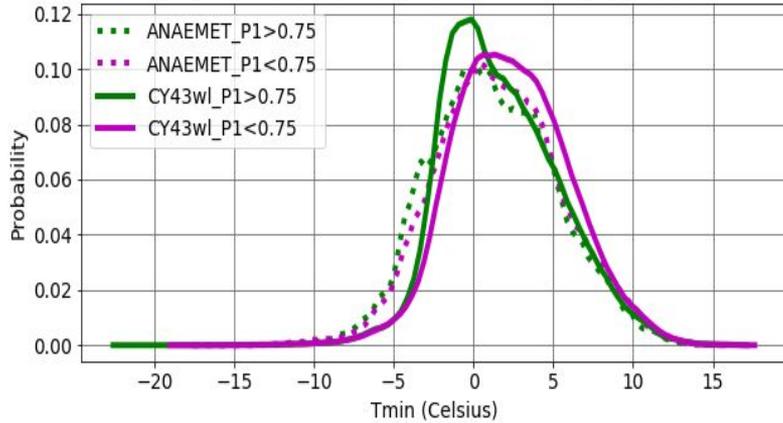


CY43wishlist

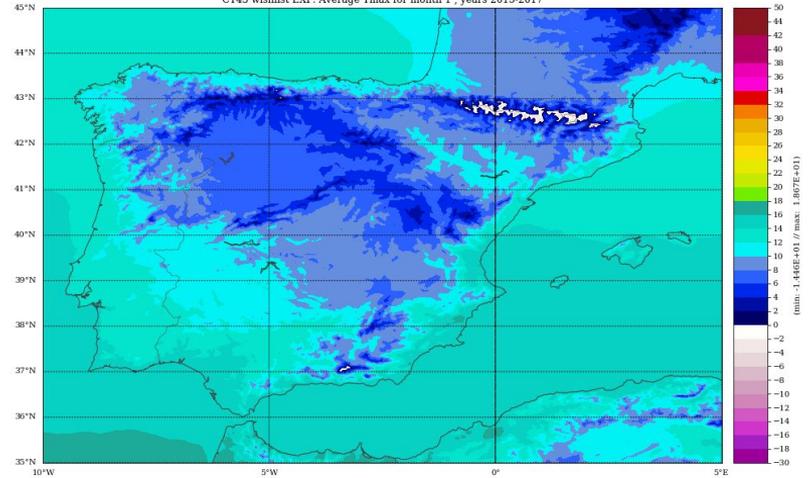
TMAX PDF ANAEMET VS CY43WL 2015 - 2017, month 1



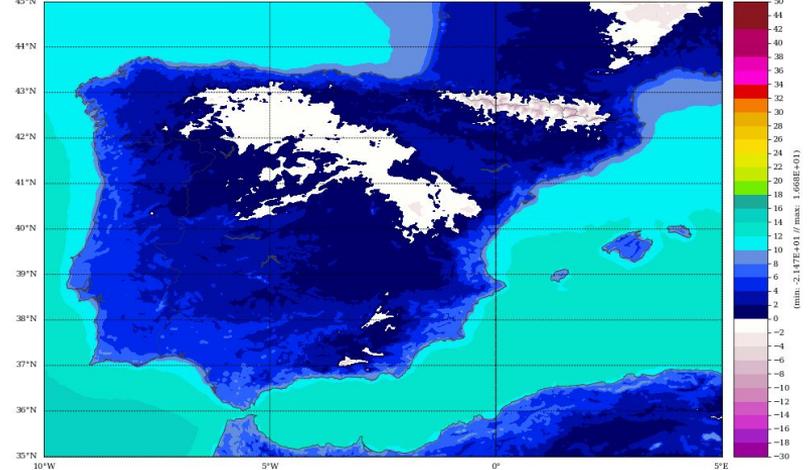
TMIN PDF ANAEMET VS CY43WL 2015 - 2017, month 1



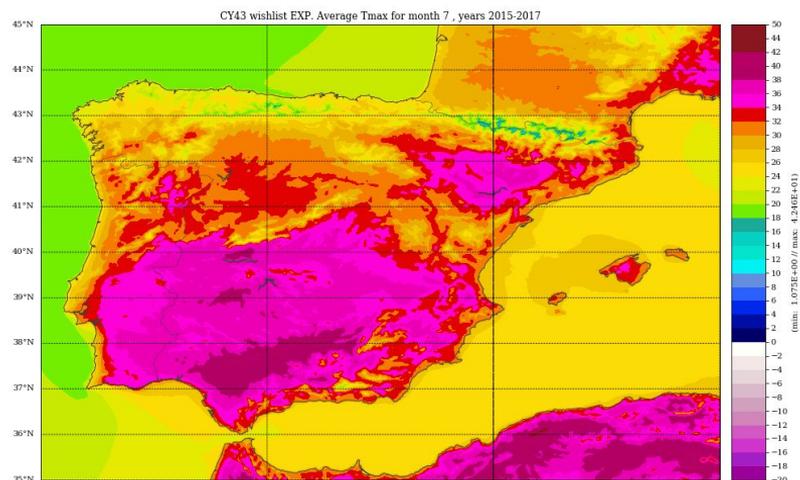
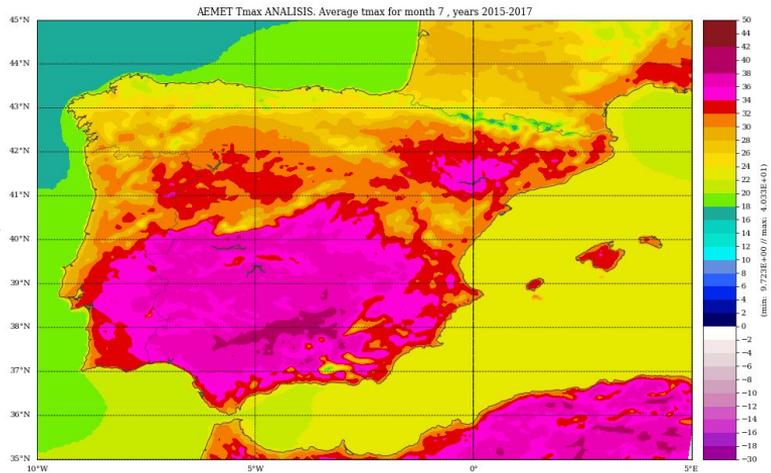
CY43 wishlist EXP. Average Tmax for month 1, years 2015-2017



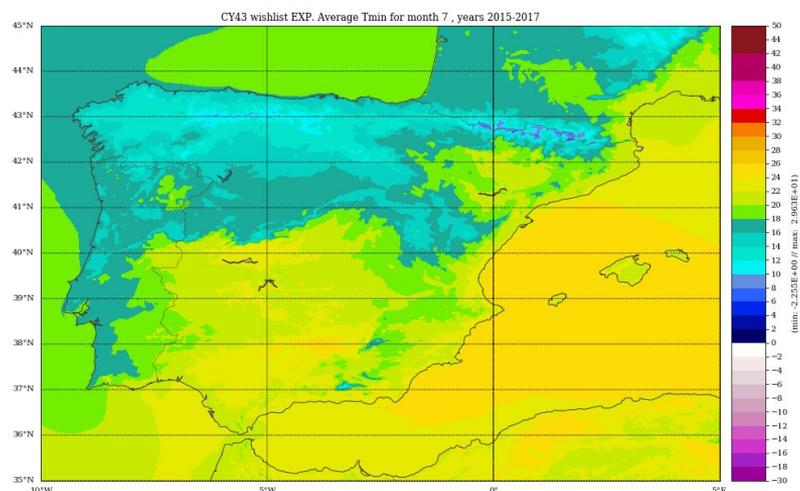
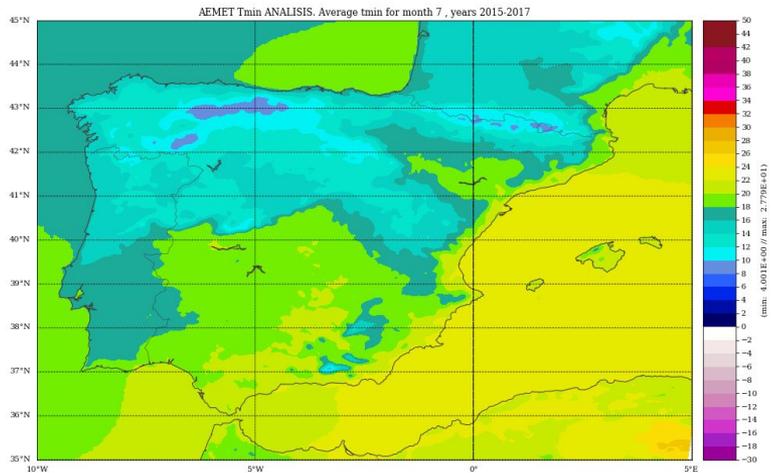
CY43 wishlist EXP. Average Tmin for month 1, years 2015-2017

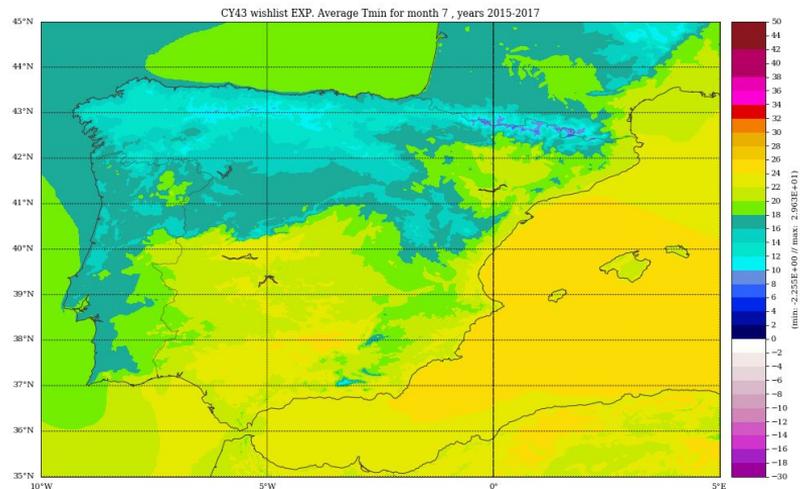
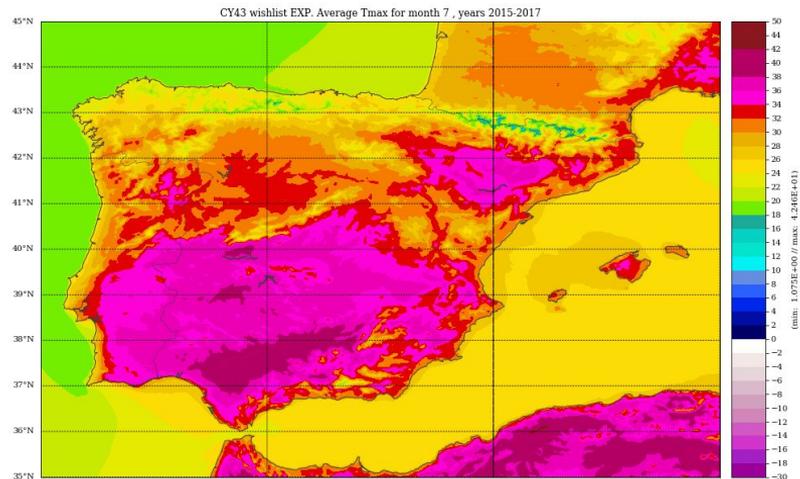
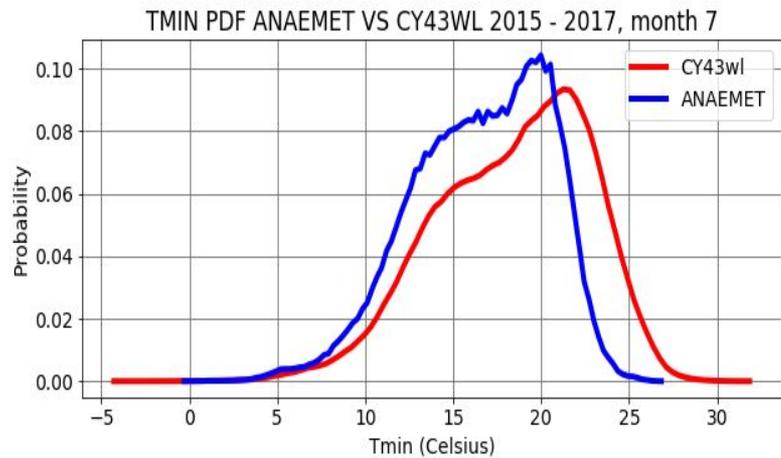
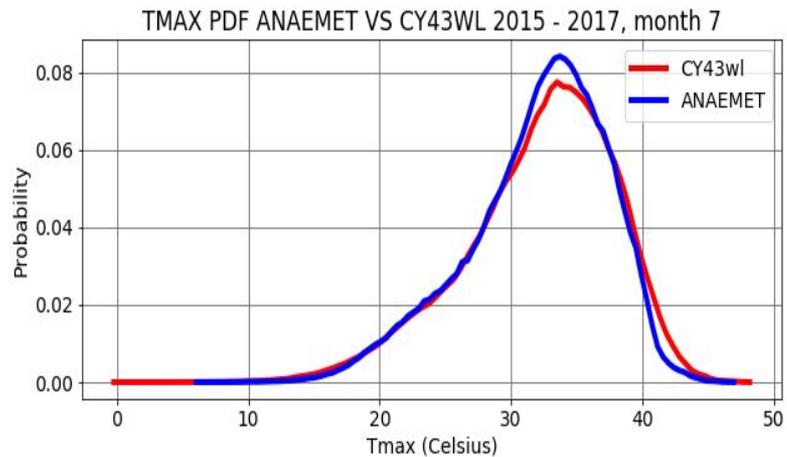


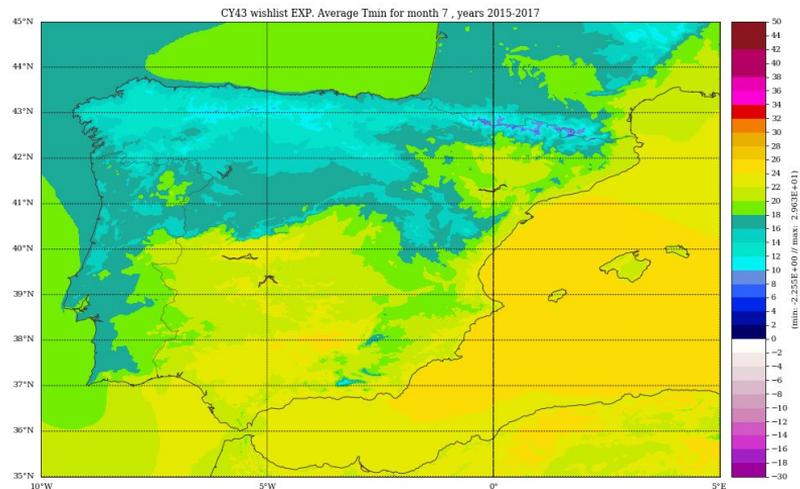
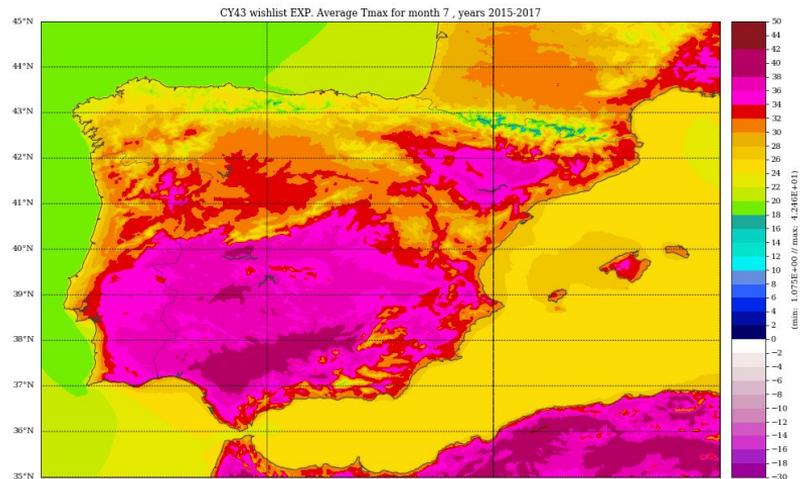
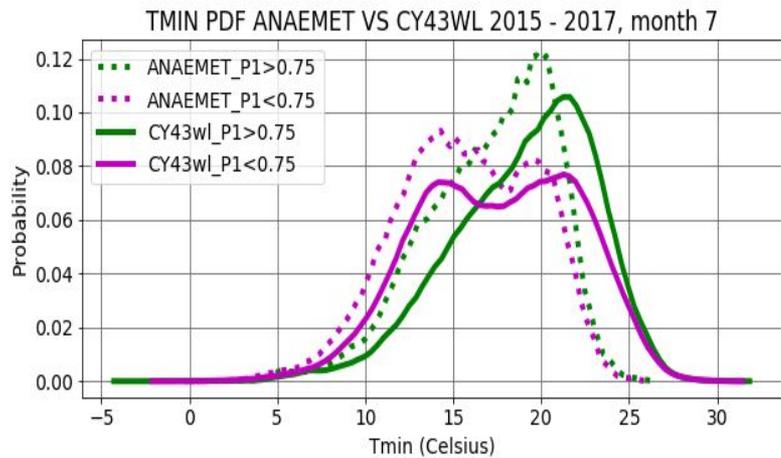
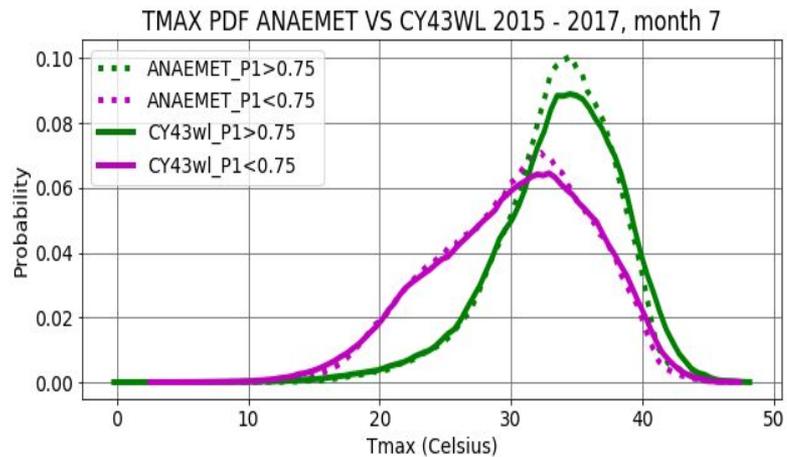
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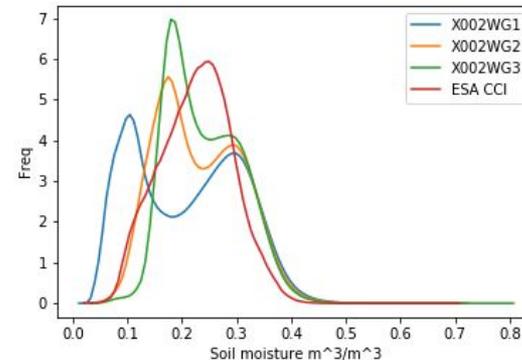
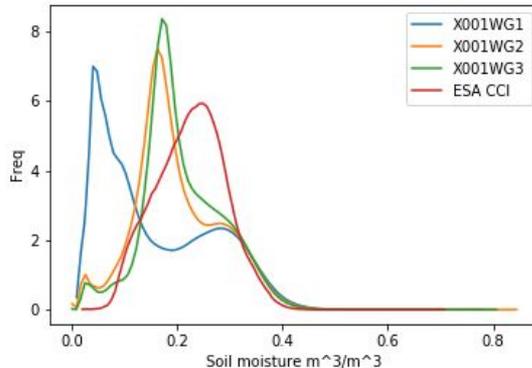




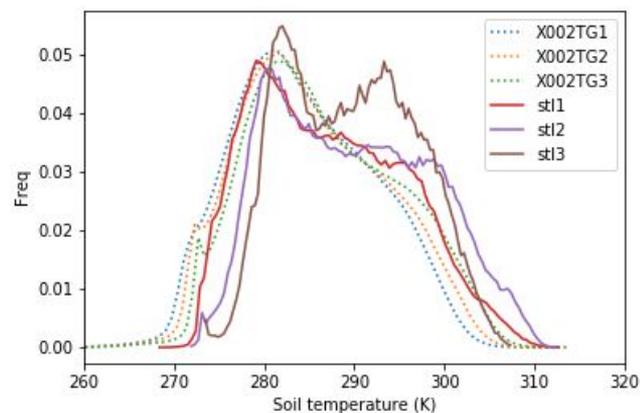
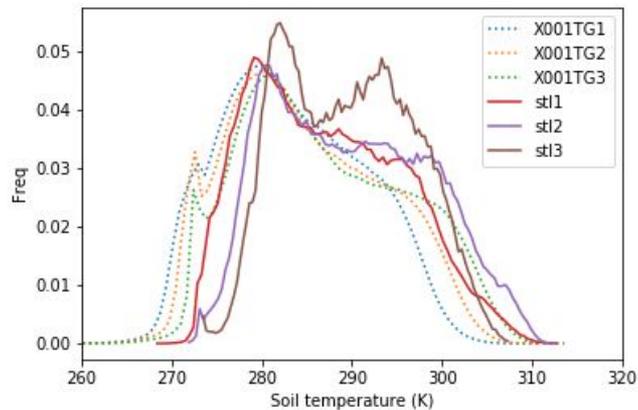
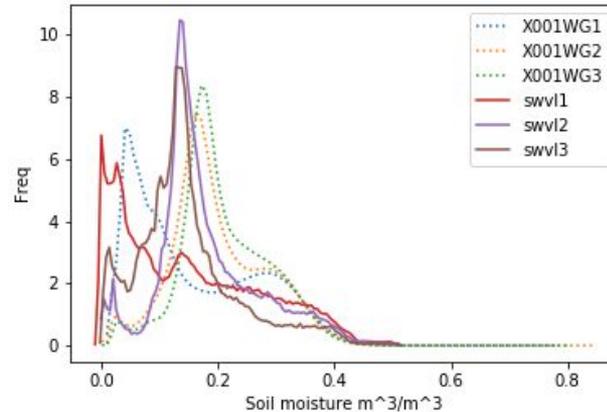
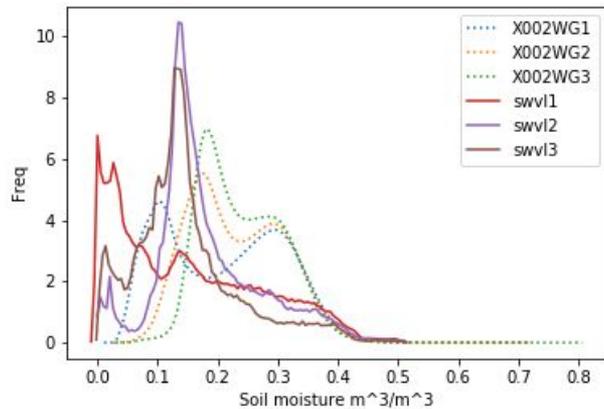
- T2M_max: Good results in general, cold bias in winter
- T2M_min: Warm bias, larger in summer
- T2M_min: Problems to reproduce frost conditions in wintertime linked to open-land patch (P1) physics

Direct soil moisture validation: Is it possible?

- Soil moistures in LSMs are highly model-dependent quantities and therefore they're difficult to validate i.e. against in-situ or satellite derived data. In addition, satellite products usually have their own LSMs.
- Nevertheless, different model/observations tend to show similar temporal variability when scaled conveniently (for instance through long-time average & standard deviation) Koster, R.D., Z. Guo, R. Yang, P.A. Dirmeyer, K. Mitchell, and M.J. Puma, 2009: [On the Nature of Soil Moisture in Land Surface Models](#). J. Climate, 22
- Example: ESA CCI Soil moisture (0.25°) product doesn't look comparable to any of the first soil layers from DIF scheme.



CY43h soil moistures & temperatures against first soil layers in ERA5



Validation of surface fluxes

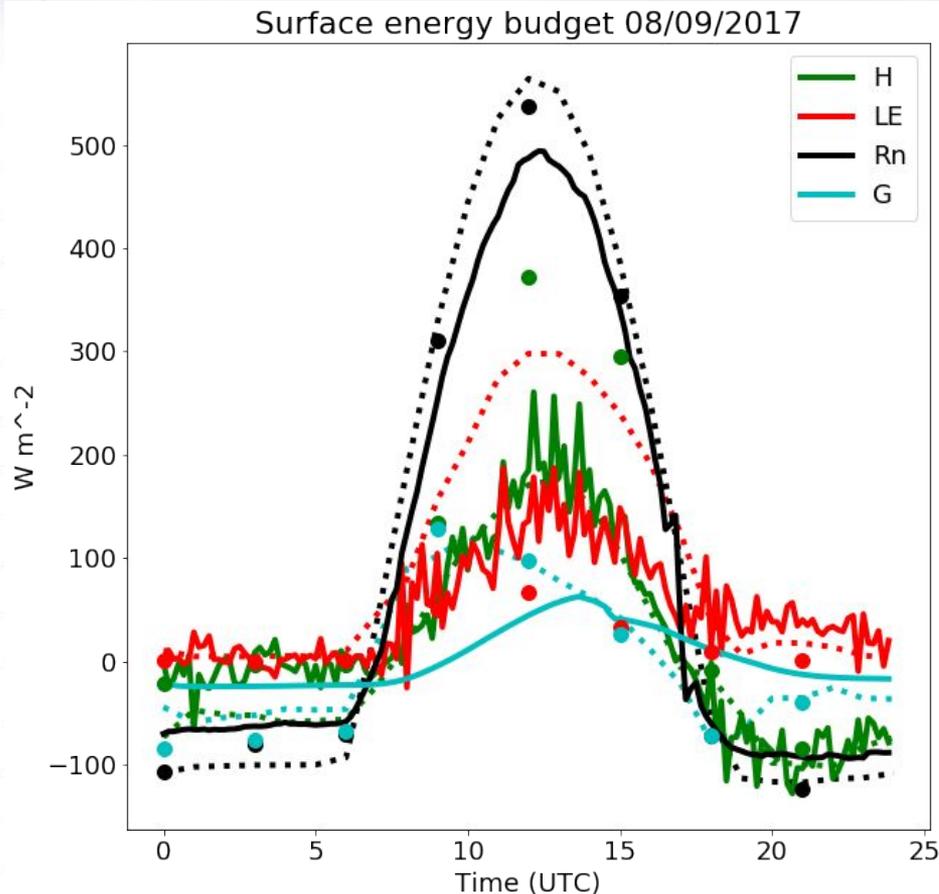
- In principle, direct validation through surface fluxes would be the “ideal” way to evaluate a LSM for NWP purposes.
- We expect impacts in the surface energy balance (SEB) caused by the new surface components/settings in the system (DIF, ES, MEB, ECOCLIMAP-SG, OROTUR, increase of Ri_max...).
- Problems:
 - Direct observations are scarce (eddy covariance sites)
 - Observations through long periods are not frequent
 - There’s usually question marks over the representativity of point data
- Ok, but at least we should make sure that the SEB is modified in the right direction.

Flux sites / domains under consideration



- [CESAR site](#) (Cabauw, Netherlands). All SEB components, 2000-2019 coverage, public data
- [ICOS Sweden stations](#). All SEB components
Forest: Hyltemossa, Norunda, Svartberget
Open land (crop): Lanna
2014-2017 public data, more recent data on request.
- La Herreria site from [GUMNET](#) (Spain). All SEB components, data from 06/2016, public data available on request.

SEB example for a single day



- Solid lines: SEB data from a experimental site in northern Spain
- Dotted lines: CY43wishlist experiment (acting as a downscaling tool)
- Points: AEMET's Operational run

Conclusions

- We try to reduce the biases by new surface physics before DA is applied
- A first multi-year simulation over IBERIA is studied for:
 - A general overview of the model performance with new surface
 - Testing methods for surface analysis
- Better results for temperature than for precipitation. Need to further investigate possible surface connections.
- More tests will follow after all the target surface components become available in cy43h (sea-ice update, MEB...)

Thank you!