

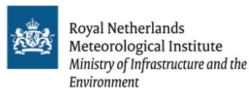
Updates from HCLIM

Oskar Landgren and the HCLIM group
with special thanks to Ignacio Prieto Rico, Juan Carlos Sanchez Perrino,
Kristiina Verro, Yi-Chi Wang and Fuxing Wang for contributions

ACCORD All Staff Meeting, Zalakaros, Hungary
2025-04-04

oskar.landgren@met.no

Happy & growing community



Universities

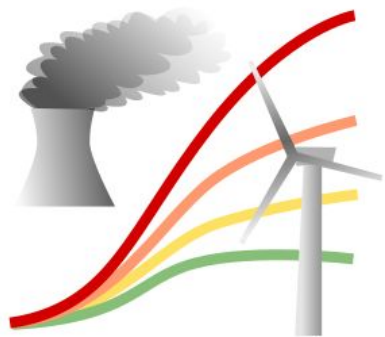


Sep 2024: First working week, 28+6 people attending

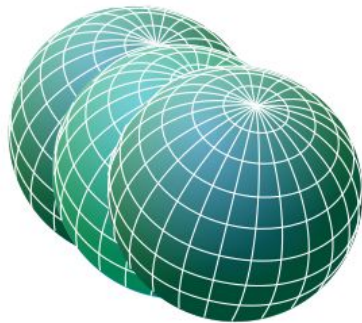


HCLIM

HARMONIE-Climate

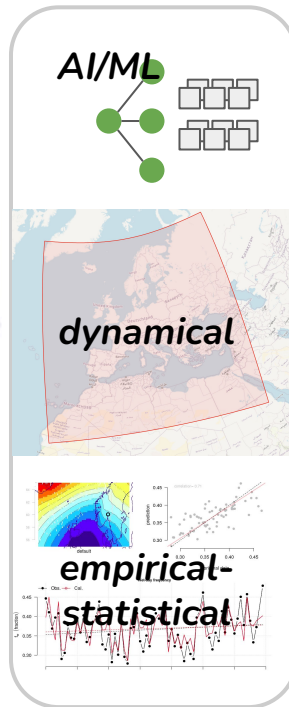


1. Future scenario



2. Global climate models (CMIP)

Coarse resolution.
Cannot represent what happens locally.



3. Regional downscaling

Represent small-scale (local) phenomena based on large-scale.

Finer-scale
(e.g. 12 or 3 km)
climate data

hydrology,
epidemiology,
engineering,
agriculture,
energy ...

4. Impact modelling



5. Users

HCLIM = HARMONIE-Climate

- HARMONIE scripting system, code currently at cy46
- Multiple physics choices:
 - HARMONIE-AROME (convection-permitting, both non-hydr.st. & hydr.st.)
 - ALADIN (≥ 10 km)
 - previously also ALARO-0
- Land surface: SURFEX, including ISBA, 12L ISBA-ES, TEB, SICE, FLake etc.
- Ocean: Not by default, but ongoing work on coupling to NEMO

Working groups

- Aerosols near-real-time and simpler monthly data
- Artificial intelligence & machine learning early, focus on emulators
- Coupling ocean, river routing
- Documentation & website logo
- Evaluation many coordinated sensitivity experiments
- Pan-European downscaling hydrostatic AROME, common domain?
- Polar snow and glaciers
- Pseudo-global-warming for climate change attribution studies
- System technical developments and improvements

Most groups have regular meetings.

Happy to have people from other model groups join! Please get in touch.

Polar

Recently completed climate scenario simulations (HCLIM43-ALADIN 11 km, 1985-2100, SSP370):

- Arctic CORDEX, 2xGCMs (CNRM-ESM2-1, NorESM2-MM)
METNO (O. Landgren, B. Bhatt, H. Haakenstad)
- Antarctic CORDEX, 2xGCMs (MPI-ESM1-2-LR, CESM2)
DMI (R. Mottram, A. Torres, O. Christiansen)

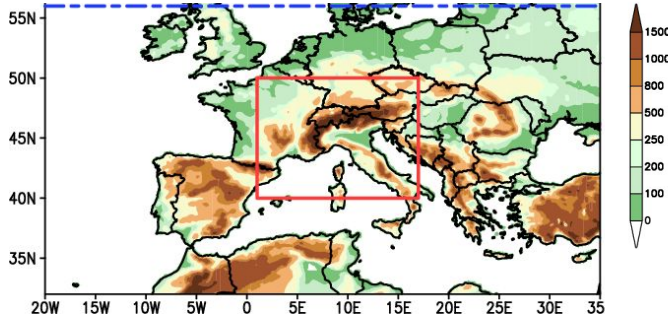
Ongoing work:

- Setting up Copenhagen Ice Sheet Surface Energy and Mass Balance model (CISSEMBEL):
 - Offline: using HCLIM43-ALADIN 11 km PolarRES forcing
 - Online: coupled HCLIM-CISSEMBEL to run it operationally over Greenland and Antarctic ice sheets.
- Implementing ISBA-CROCUS snow model in HCLIM and test Arctic-CROCUS modifications (Wooley et al. 2024), and to develop further the snow properties in the snow model in HCLIM.

AI/ML - HCLIM emulator

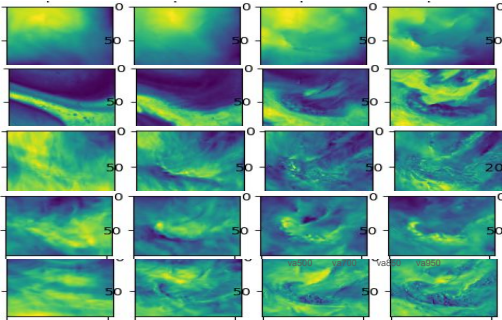
- Motivation:
 - HCLIM-AROME (km-scale) CPM expensive;
 - Emulate AROME (km-scale) using HCLIM-ALADIN (12 km) data by ML
- ML models
 - Generative Adversarial Network (SRGAN, Ledig et al. 2016)
 - Convolutional Neural Network (Rampal et al. 2021)
 - ...etc.
- Data
 - CORDEX FPS CPM
(2000-2009; 8-year training, 1-year validation, 1-year testing)
 - Inputs:
 - $x = u, v, t, q, zg,$
at 500, 700, 850, 950 hPa at 12 km; 16 inputs
 - Output:
 - pr/tas at 3 km

Domain of CORDEX FPS (red square)



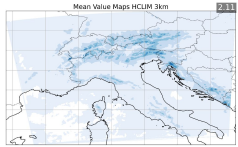
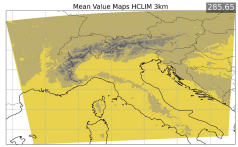
Modified from Jacob et al. 2020

HCLIM-ALADIN (12km)



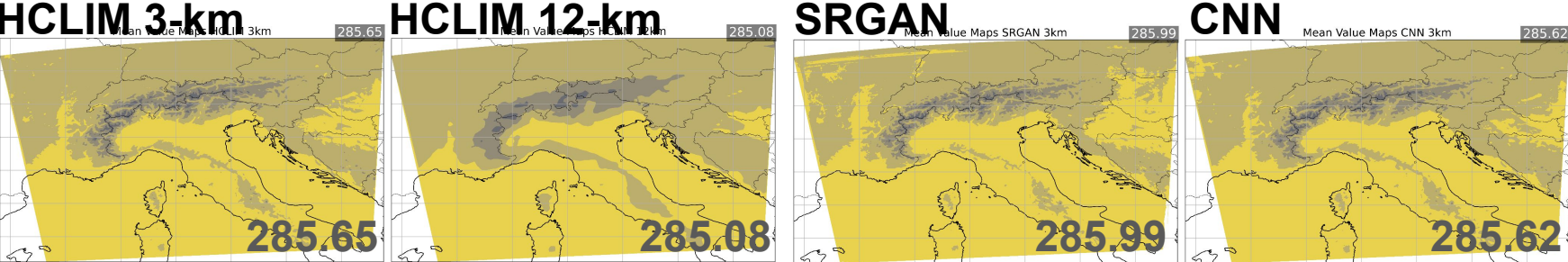
HCLIM-AROME (3km)

ML
→

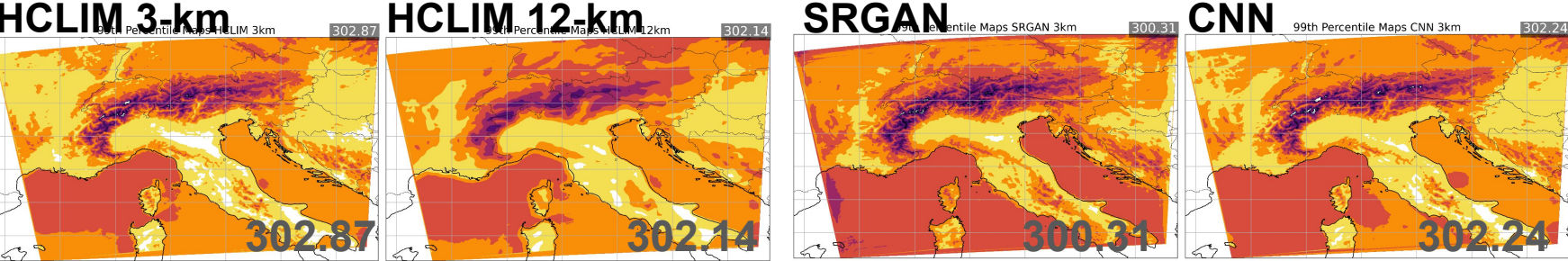


HCLIM emulator - Results for Temperature

Averaged Temperature

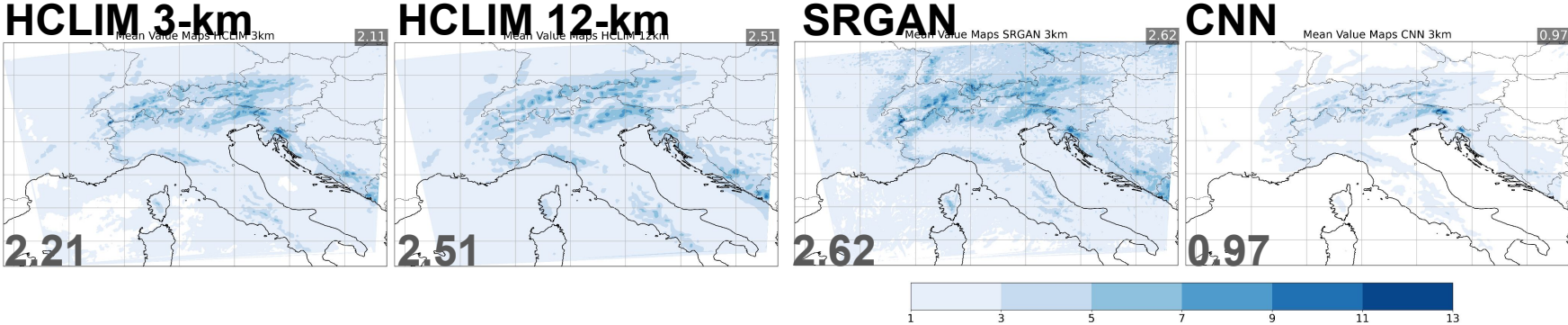


Extreme Temperature (> 99 percentile)

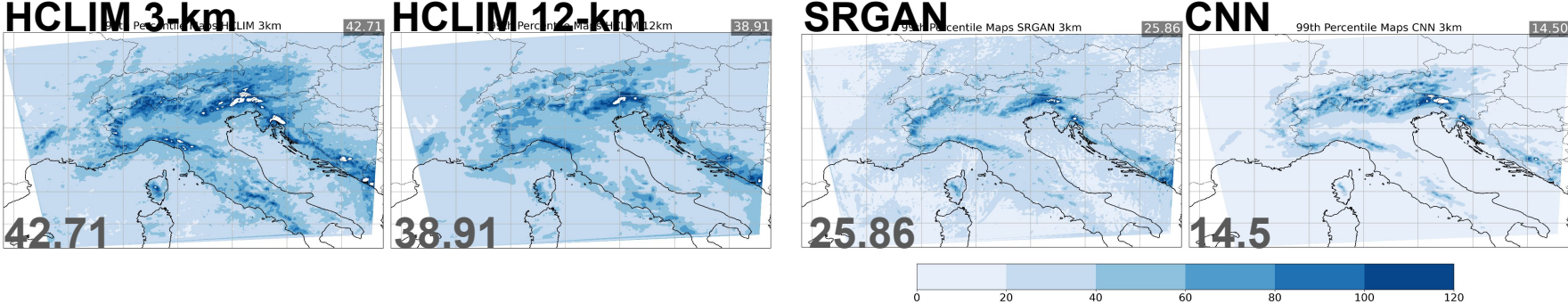


HCLIM emulator - Results for Precipitation

Averaged precipitation



Extreme Precipitation (> 99 percentile)

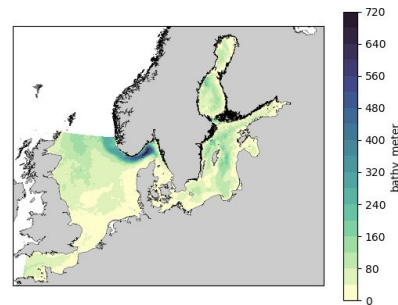


HCLIM coupling with the ocean (hclim43-nemo)

Juan Carlos Sanchez
(AEMET)

First experiment in the Baltic Sea:

OCEAN : NEMO version: 4.2
Domain: NORDIC-NS2
Resolution: 2 Nautical Miles (619x523x56)
z* with partial steps
Initial Conditions: Spinup for 1961 start (dummy start with all ocean fields)
Boundary Conditions: ORAS (U, V, salinity, temperature)



ATMOSPHERE : HCLIM version: cy43 SURFEX version: v 8.1 Domain: EUR11 (around 12 Km grid) LBCs: ERA5 (3h)
PHYSICS="AROME"

Repository: https://github.com/jcsanchezp21/HCLIM/tree/esm_coupling_nemo_nathan (based on a previous work by Nathan https://github.com/jgrivault/HCLIM/tree/esm_coupling_nemo -include some issues/wiki, etc...for discussions see also <https://github.com/Hirnam/HCLIM/discussions/107> - Nathan coupled HCLIM-ALADIN with NEMO. All branches come from the former HCLIM repository branch https://github.com/Hirnam/HCLIM/tree/esm_coupling, based on Erin Thomas' WW3 developments)

Exchanged variables:

NEMO time step: 150s

HCLIM time step: 60s

Coupling period: 600 seconds
(10 minutes)

Lag (NEMO): 150s (1 time step)

Lag (HCLIM): 60s (1 time step)

Variable	Description	Units
Q_{ns}	Non solar heat flux	$A \rightarrow O$ $W.m^{-2}$
Q_{sr}	Solar heat flux	$A \rightarrow O$ $W.m^{-2}$
$\tau_{x,y}$	Momentum flux	$A \rightarrow O$ $N.m^{-2}$
E-P	Evaporation minus precipitation	$A \rightarrow O$ $kg.m^{-2}.s^{-1}$
P_{atm}	Atmospheric surface pressure	$A \rightarrow O$ Pa
SST	Sea surface temperature	$O \rightarrow A$ K
u_{cur}, v_{cur}	Sea surface currents	$O \rightarrow A$ $m.s^{-1}$

Over sea and over ice

E, P and Snow

+ **Ice cover,
temperature
and albedo**

HCLIM coupling with the ocean (hclim43-nemo)

Juan Carlos Sanchez
(AEMET)

Updates:

- The development branch is technically working in the Baltic Sea domain
- ... but you have to deactivate MEB and sea ice (besides the already deactivated TEB - SURFEX current version doesn't provide TEB coupling routines -)

Problems:

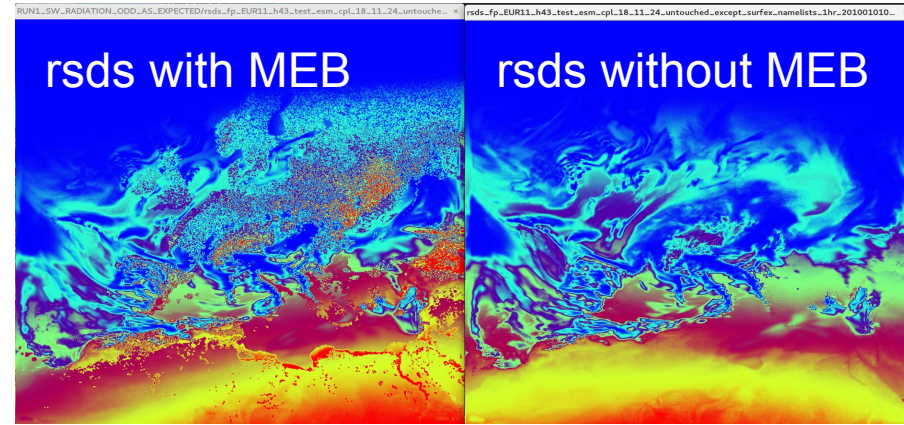
- If you try to run with MEB and/or sea ice you obtain negative downwards LW which is not expected in the code and lead to crashes. (This doesn't happen if you couple with hydrology)
- First results are not good and there is a cool bias specially over Baltic Sea.
- It is not easy to define new domains for NEMO and the creation of initial files for OASIS it is not automated for starting the experiment (it is automated for restarting)

By the way, too high **TG** temperatures (**up to 70°C**) appear into **MEB** routines **EVEN WITHOUT USING THE COUPLING**. At HCLIM model we don't use assimilation... but anyway... HAVE ANYONE AT NWP SEEN THESE VALUES!? A debug print example:

```
In e_budget_meb after where PTG= 335.20887582451041      335.25289159235325
335.95711529958265      344.00117147520939      340.61149255443496
```

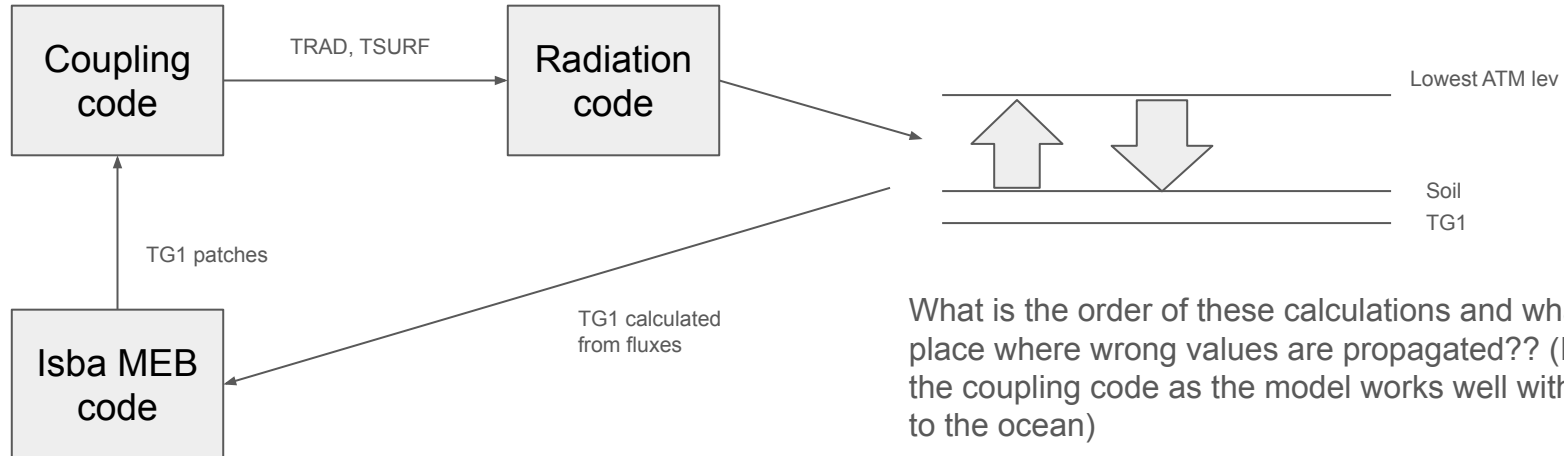
HCLIM coupling problems

- MEB causes problems in coupled mode but it works in default non-coupled experiments. There is some interaction between both. Strikingly MEB is for nature tile and the coupling is over the ocean. Patchy SW radiation pattern when using MEB (left image)
- Also, we are not able to use sea ice



TRAD y TSURF are updated in the coupling code as an average of all tiles. They are used as lowest atmospheric level temperature in radiation calculations.

The radiative fluxes between atmosphere and soil are used to calculate TG1 (This flux must be wrong as TG is too high sometimes)

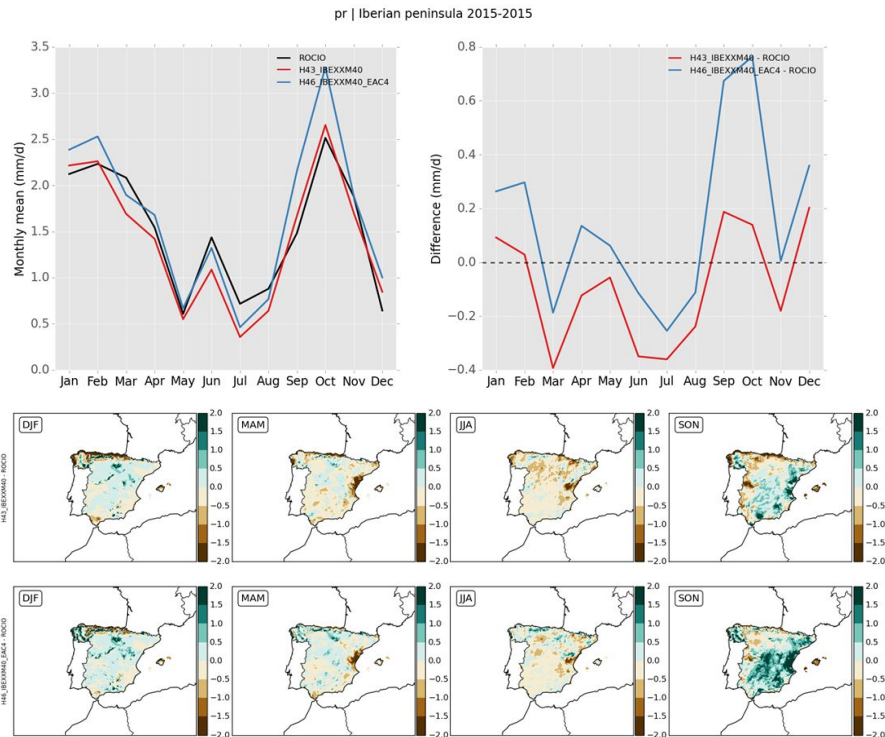
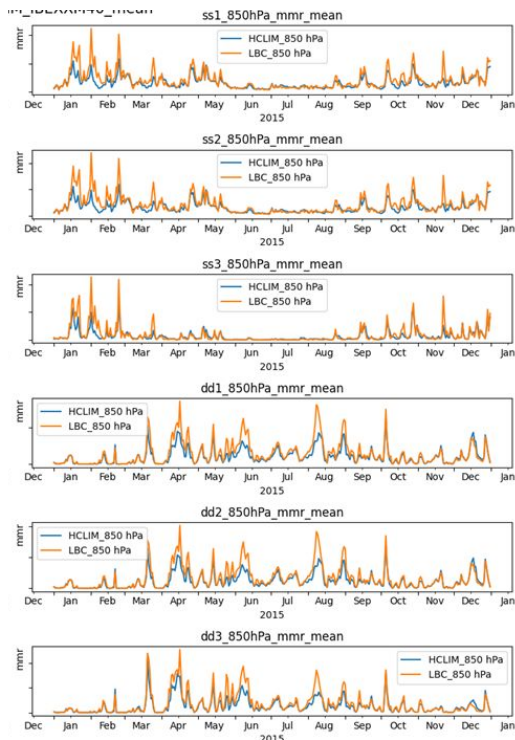


What is the order of these calculations and what is the first place where wrong values are propagated?? (It should be the coupling code as the model works well without coupling to the ocean)

HCLIM interactive aerosols in HCLIM46

Ignacio Prieto & Daniel Martín
(AEMET)

- Adapted NWPcy46 in HCLIM46 for using interactive aerosols.
- Instead of CAMS Forecast HCLIM uses CAMS reanalysis (MARS class=mc expver=eac4, 0.75°x0.75° lat/lon grid, 60 levels)
- Under development. Just preliminary results over Iberian Peninsula domain



Outlook/wishlist for next year, with links to NWP

- Continue to provide multi-year simulations for evaluation (e.g. NRT aerosols, coupling, other sensitivity tests)
- Pan-European convection-permitting tests
- AI/ML for downscaled climate scenarios

Potential new links?

- DEODE scripting system?
- ALARO-1 with SURFEX?