Evaluation of the water cycle in the first MEDCORDEX simulation

J. Polcher, Romain Pennel, Thomas Arsouze, Sophie Bastin, Lluis Fita, Karine Beranger
IPSL (LMD+LATMOS+CIMA)

- Presentation of the model and validation data
- Climatology of the simulation
- Comparing to FluxNet stations
- Fresh water discharge to the ocean
- Known issues
- Perspectives

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The ORCHIDEE version used

- The HEAD version of the ORCHIDEE-ROUTING branch was used.
- Most of this version comes from TRUNK version #3965 of October 2016.
- The major addition is the regional routing scheme (T. Nguyen)
- The configuration was chosen as follows :
  - *Explicit snow and soil freezing with enhanced infiltration (FROZ_FRAC_CORR=2)*
  - *The OASIS driver is used*
  - *USDA soil maps*
  - *Dynamical roughness*
  - *ESA-CCI vegetation map at N640 resolution*

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The off-line simulation used for comparison

- In order to evaluate the added value of coupling to a RCM we also compare to a state of the art off-line simulation.
- E2OFD is used as a forcing :
  - *1/4° forcing data.*
  - *Covers 1979-2014 period.*
  - *WFDEI is statistically downscaled to 1/4°.*
- Rainfall is obtained from MSWEP (Beck et al. 2017) : a 3hourly merged product of in-situ, remote sensed and re-analysis :
  - *CRU and GPCC*
  - *CMORPH, CSMaP, TRMM*
  - *ERA-I and JRA-55*

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Validation data used

- E-OBS version 16 is used to validate rainfall and near-surface temperature
  - *Climatologies and anomalies are computed relative to the period 01/1979-12/2016.*
- FluxNet version 5 compiled by Nicolas Vuichard in 2013 is used
- Rivers and freshwater discharge is validated against GRDC data.

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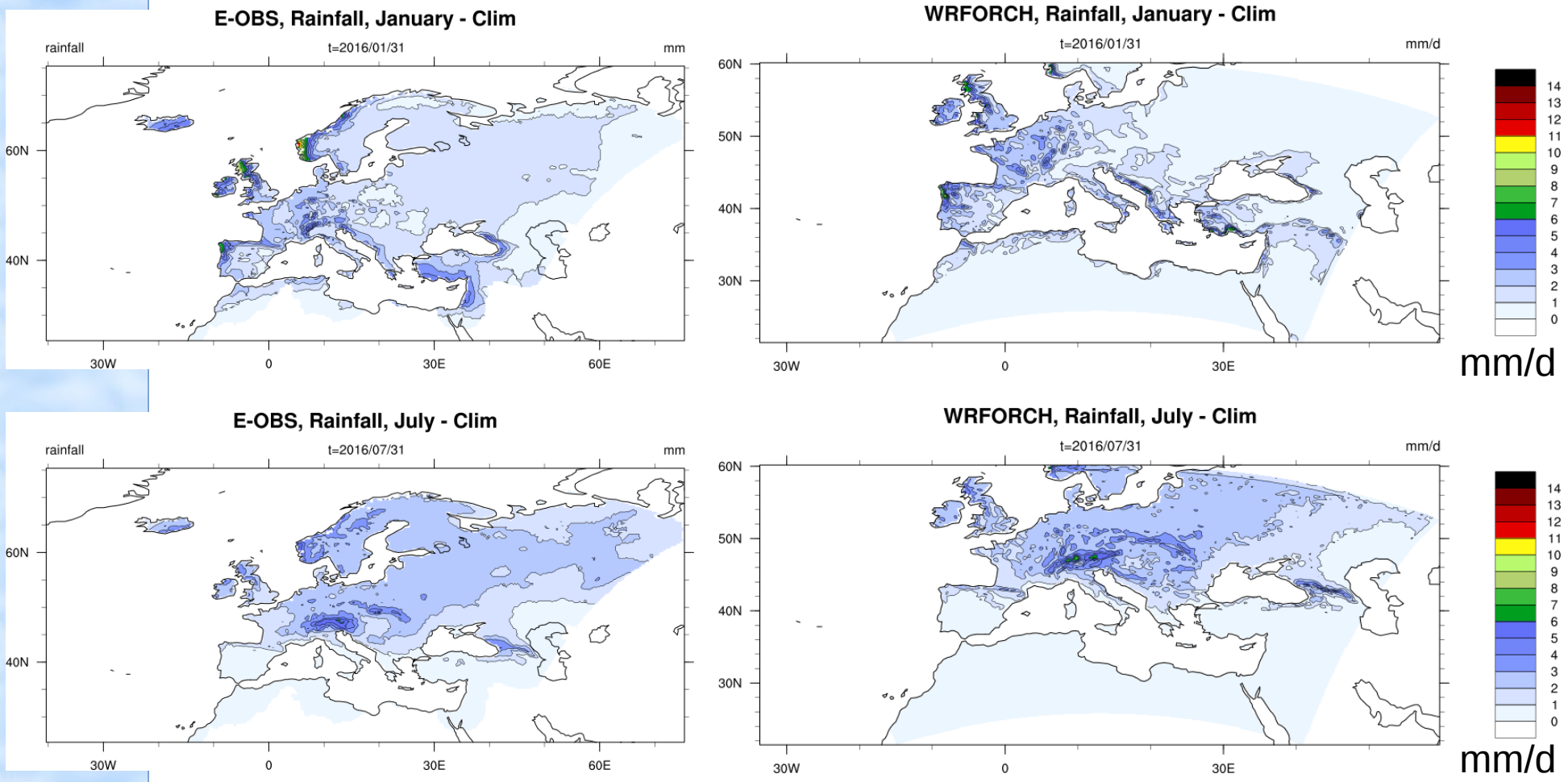
Rainfall validation



The downscaled fields show finer details especially over topography.

The West-East and South-North gradients are quite similar in the E-OBS and the model.

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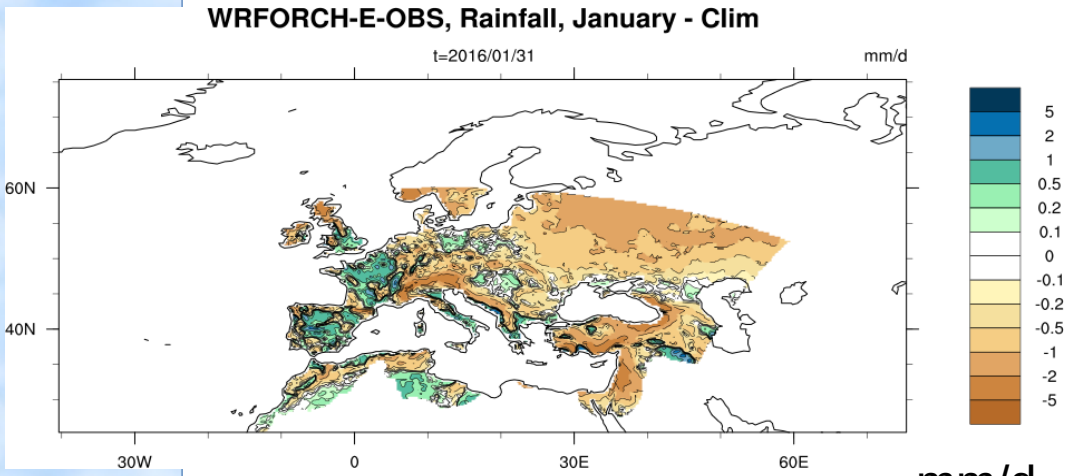
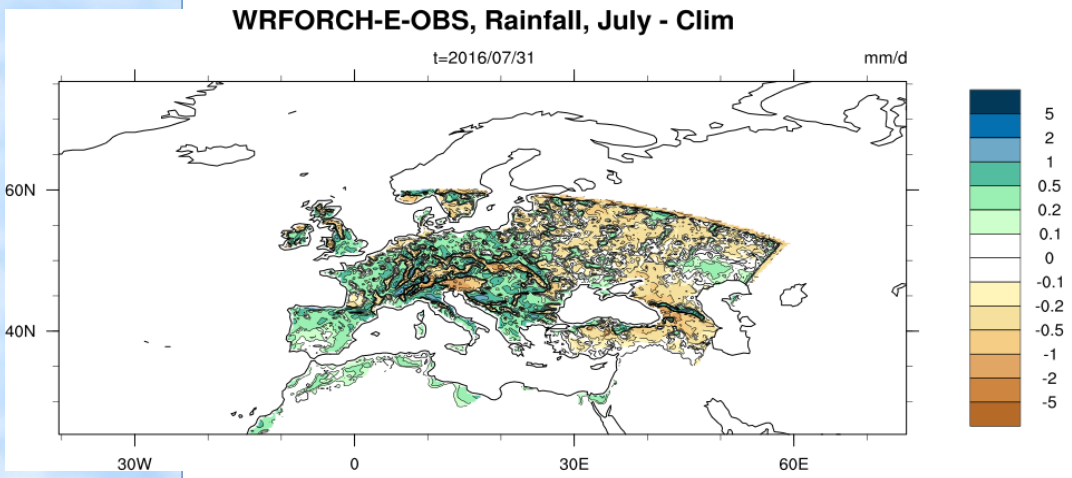
Rainfall validation



mm/d



- Dry bias in winter rainfall in the East. Could be due to too much snow-fall in the model.
- The Western coasts are too wet, but the bias is less than 1mm/d.
- In summer the biases are less structured but with a tendency to overestimate rainfall (~0.5mm/d).
- Beware of systematic biases in the observations !

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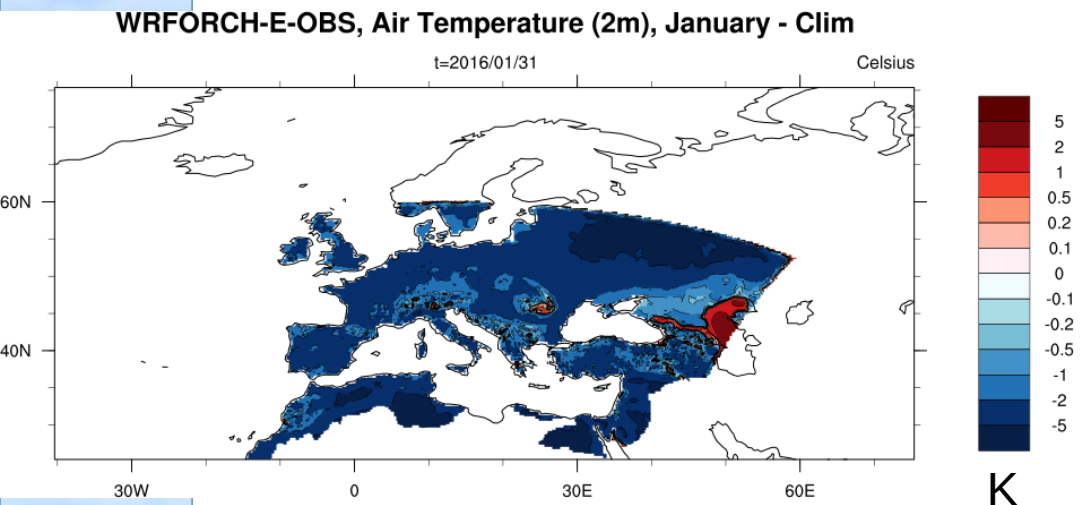
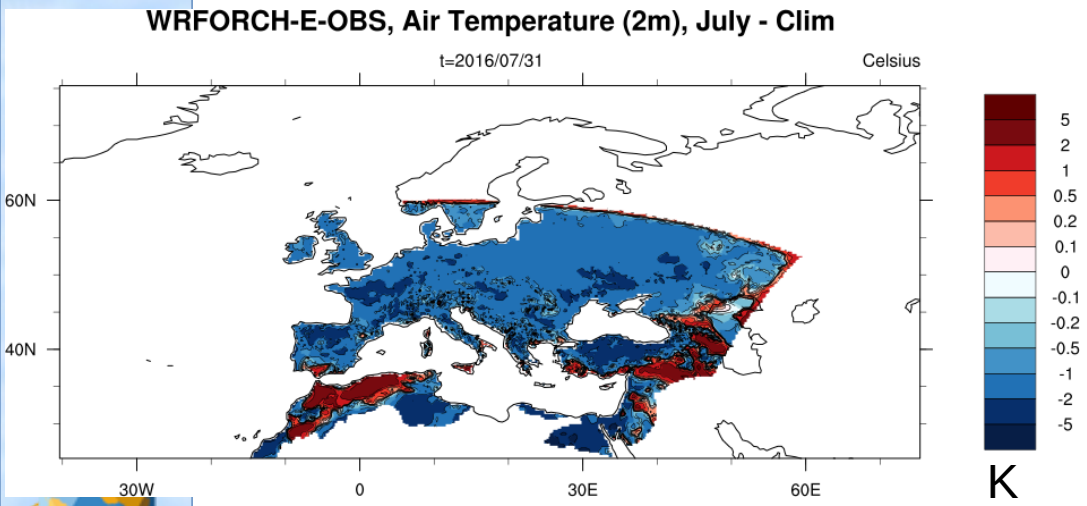
2m Temperature Validation





- Cold bias of the model is systematic (~1°K in summer).
- Larger in winter and in the Eastern part of the domain.
- No clear East-West structure of the bias in summer.
- Smallest bias on mountain ranges.
- Some areas in North-Africa are too warm.

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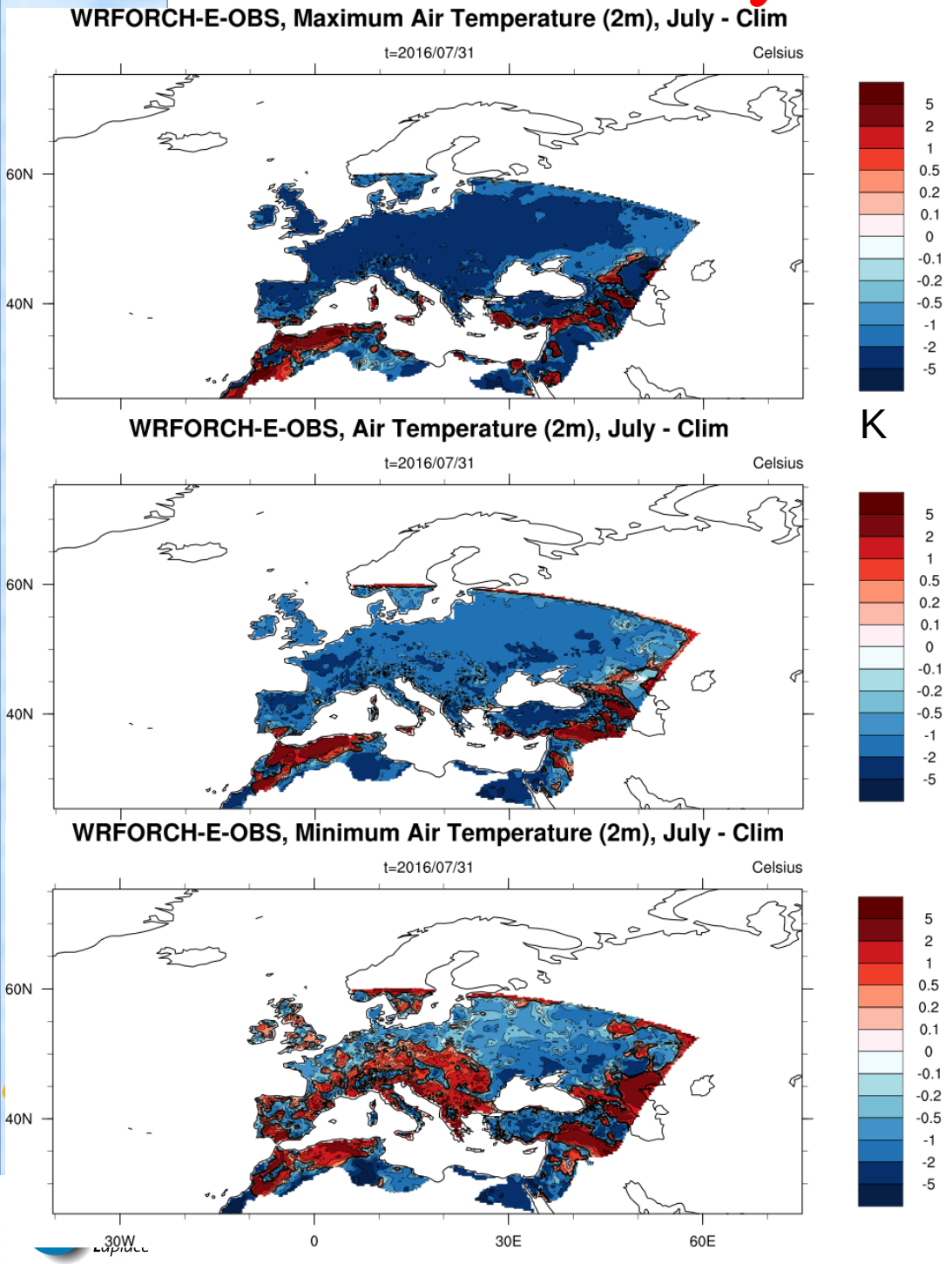
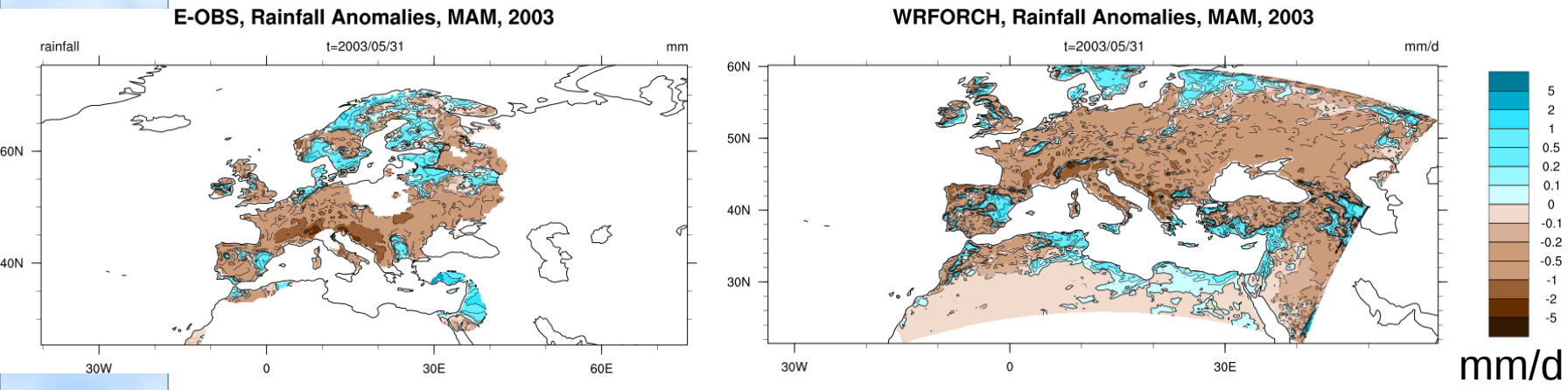
Diurnal cycle of 2m temperature

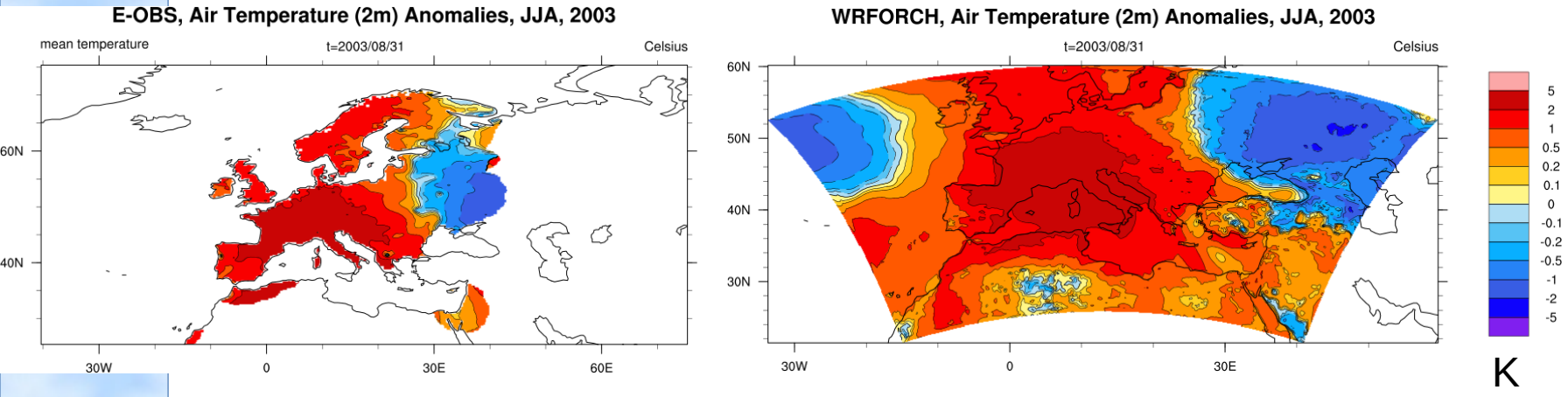


- Cold bias is systematic over Europe.
- The diurnal mean in North-Africa is systematically too warm.
- The error is smaller for the minimum temperatures than for maximum values.
- The amplitude of the diurnal cycle seems underestimated over the entire domain.

Anomalies of year 2003



The model reproduces the spring time rainfall deficit in amplitude and spatial pattern.



The temperature anomaly (+2°K) in summer 2003 is well reproduced.
The model underestimates its spatial extent in Central Europe.

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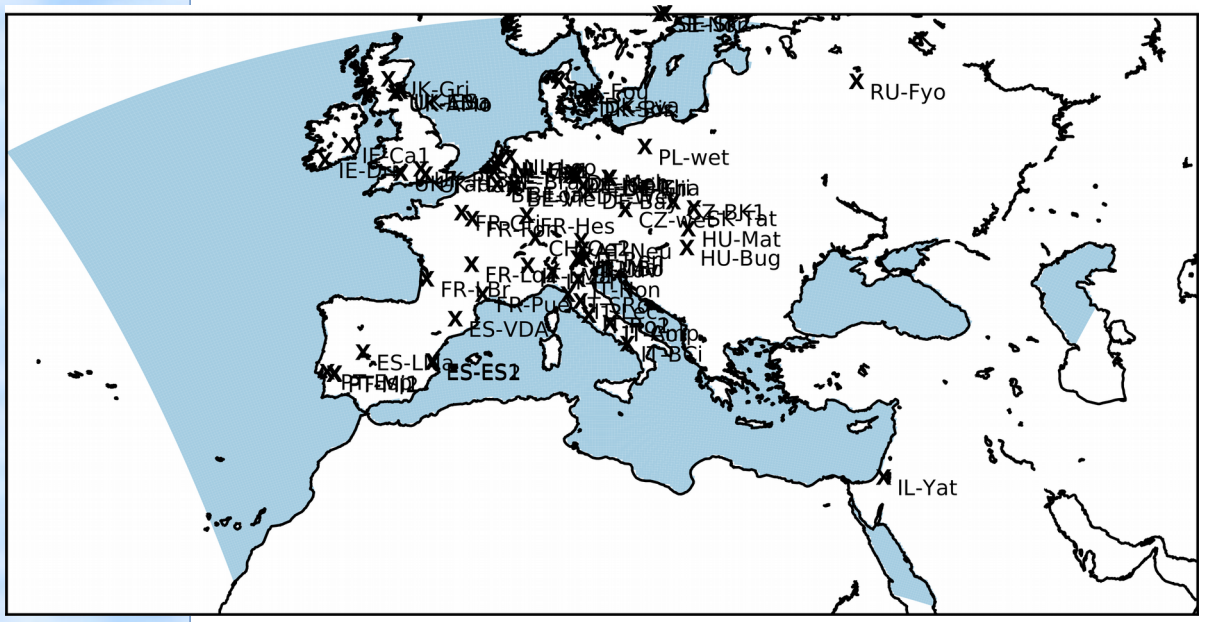
FluxNet station validation



- Longest periods are 1996 to 2006, but only for some stations : NL-Loo, FR-Lbr, BE-Vie, FR-Hes, FR-Pue, ...

- 73 stations in Europe as used for validation covering the full range of climates in Europe.
- The quality and length of record are very variable.
- Some stations were excluded as the record was too short or had obvious measurement problems.
- The size of the ensemble allows to identify some general issues with the surface fluxes.

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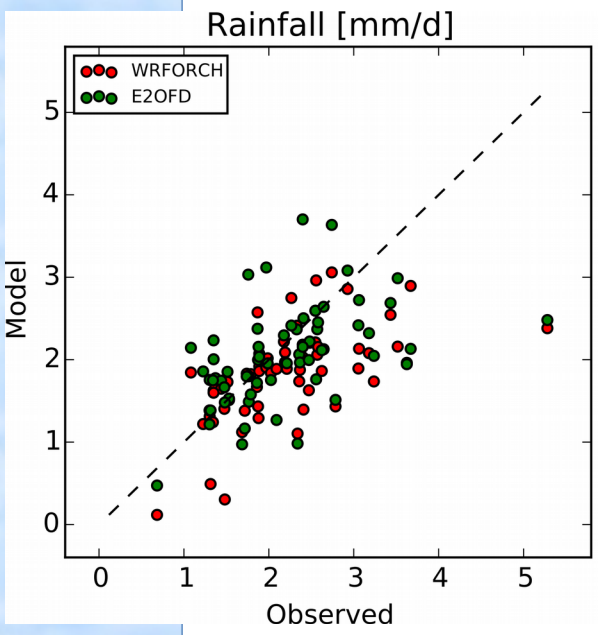
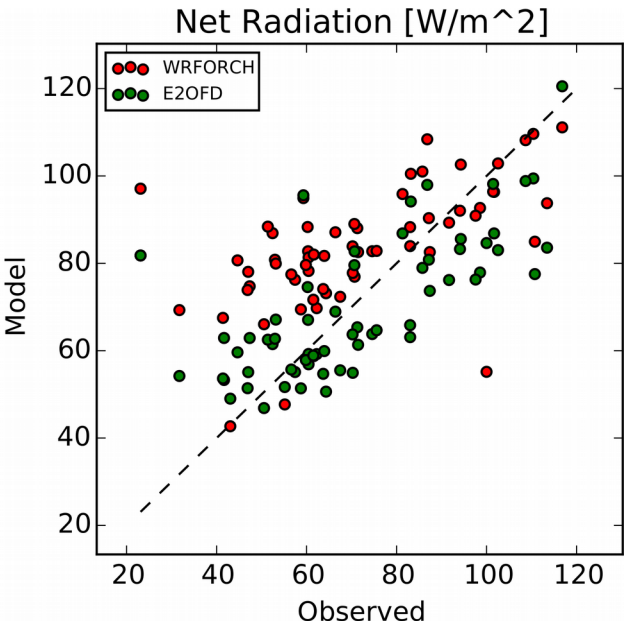
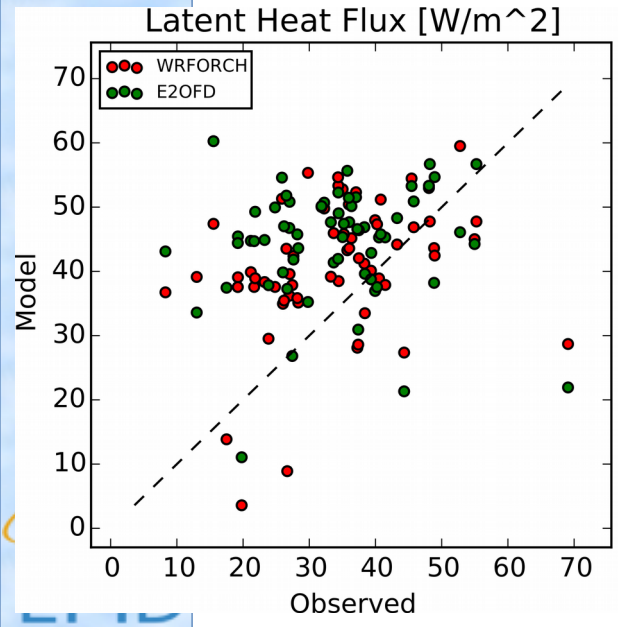
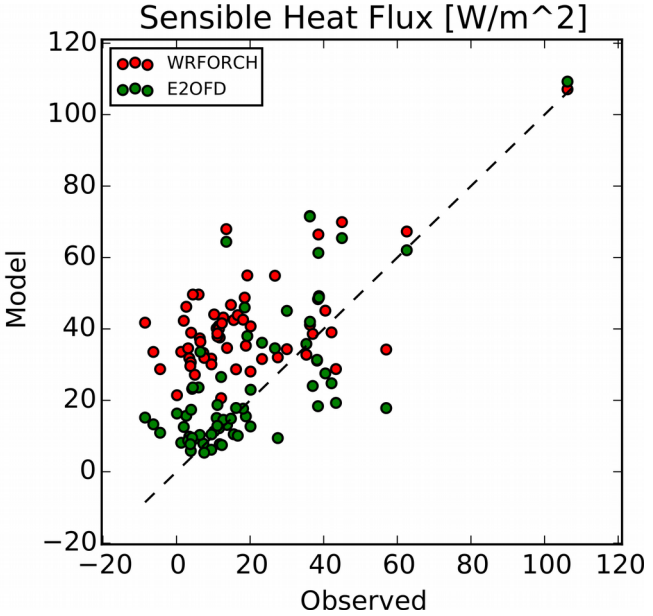
Statistics over all stations









- Rainfall is quite well reproduced at the stations.
- The WRFORCH, in contrast to E2OFD, has a positive bias on radiation.
- ORCHIDEE seems to overestimate systematically evaporation (WRFORCH & E2OFD).
- The radiation bias seems to affect essentially the sensible heat flux.

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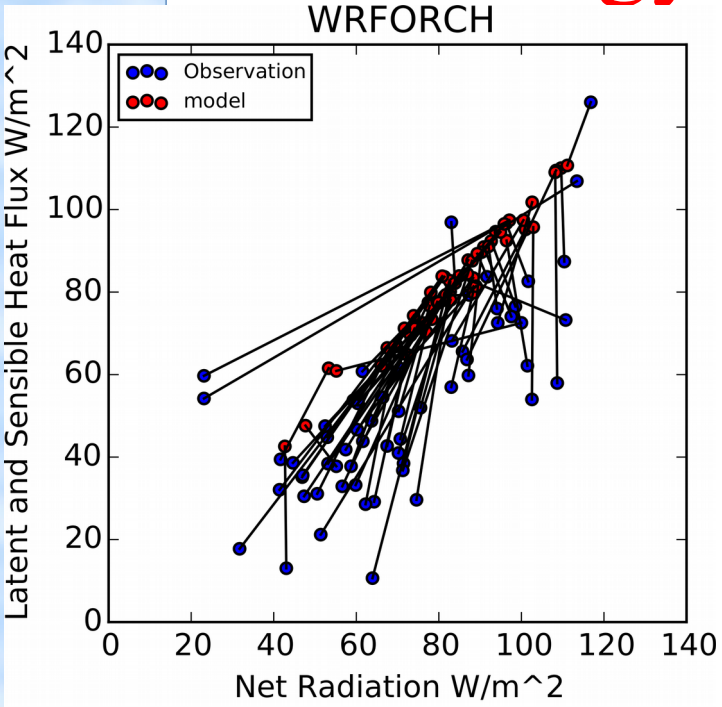
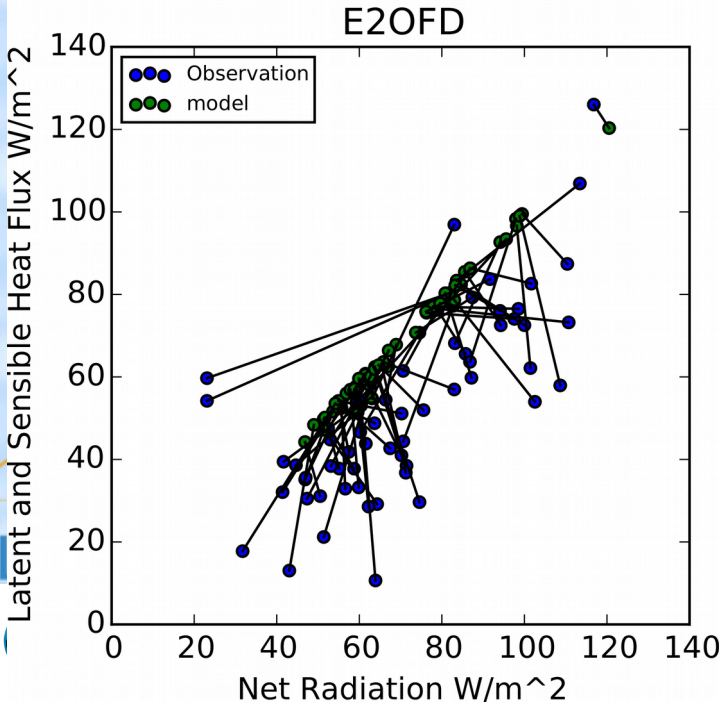
Energy imbalance in FluxNet data



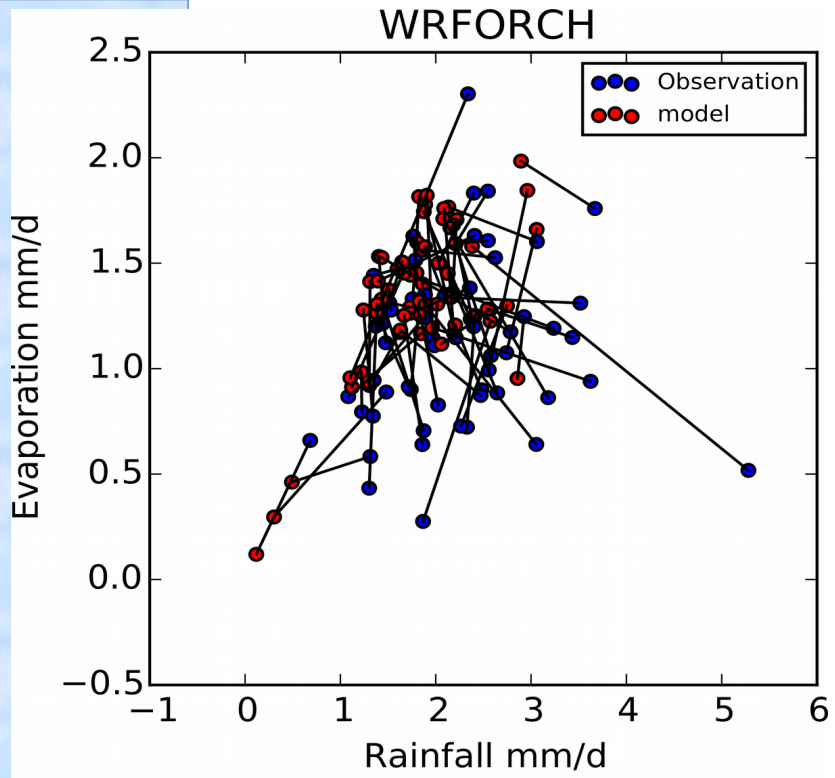


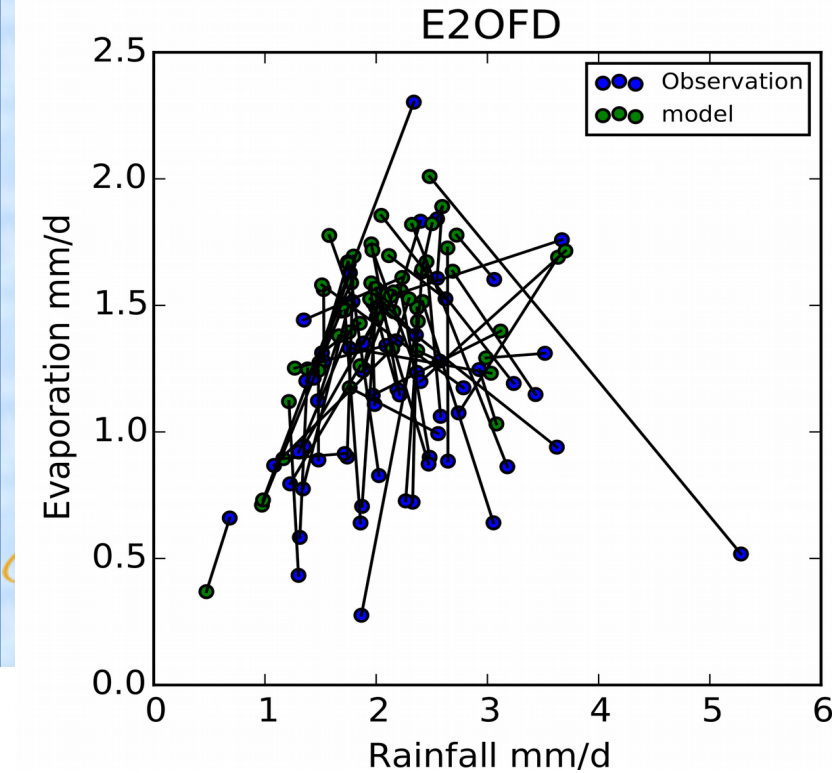
For both versions of the model (coupled and off-line) the stations display an equilibrium between net radiation and the sum of turbulent fluxes.

For the FluxNet data, there is generally a disequilibrium between in-coming and out-going energy.

The imbalance in FluxNet station data can either be :

- Too high observed net radiation, or
- Underestimated turbulent fluxes.





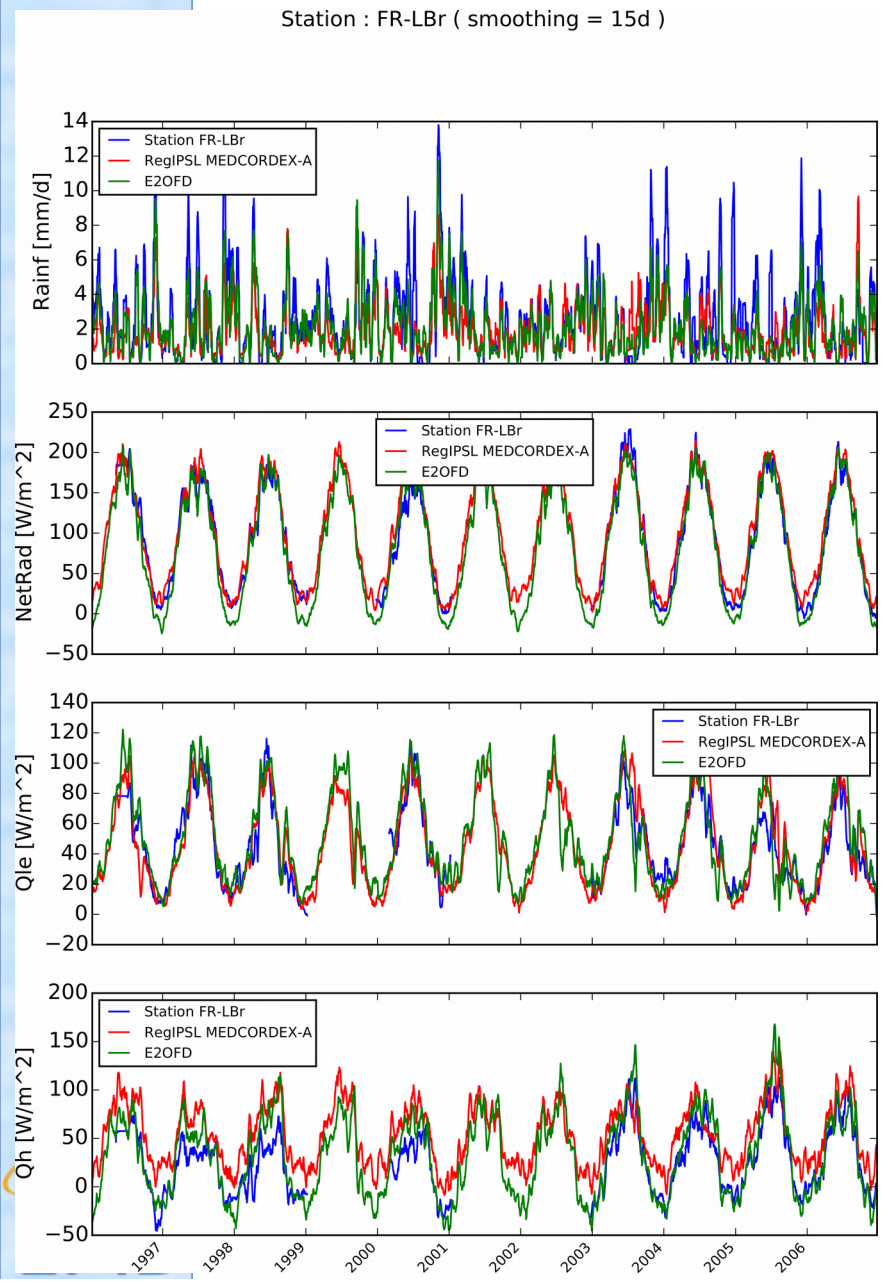
Water imbalance

Because of runoff and longer time scales in the water cycle, there is no equilibrium between E and P.
The ratio P over E is better organized in the model.
Generally the observations indicate that less rainfall returns to the atmosphere than the model predicts.

This can be characterized by a simple ratio :

- E/P ~= 0.5 for observations
- E/P ~= 0.75 for the model

Station of Le Bray



- Results on the various stations are quite divers. Either because of the surface properties specified for ORCHIDEE or the quality of the observations.
- Some stations stand out with a remarkable match : Le Bray in the Landes.
- Radiation is well captured with both forcing data sets (winter underestimation in E2OFD).
- Evaporation is slightly overestimated in summer.
- The problem comes from sensible heat which is overestimated especially at the beginning of the time series.

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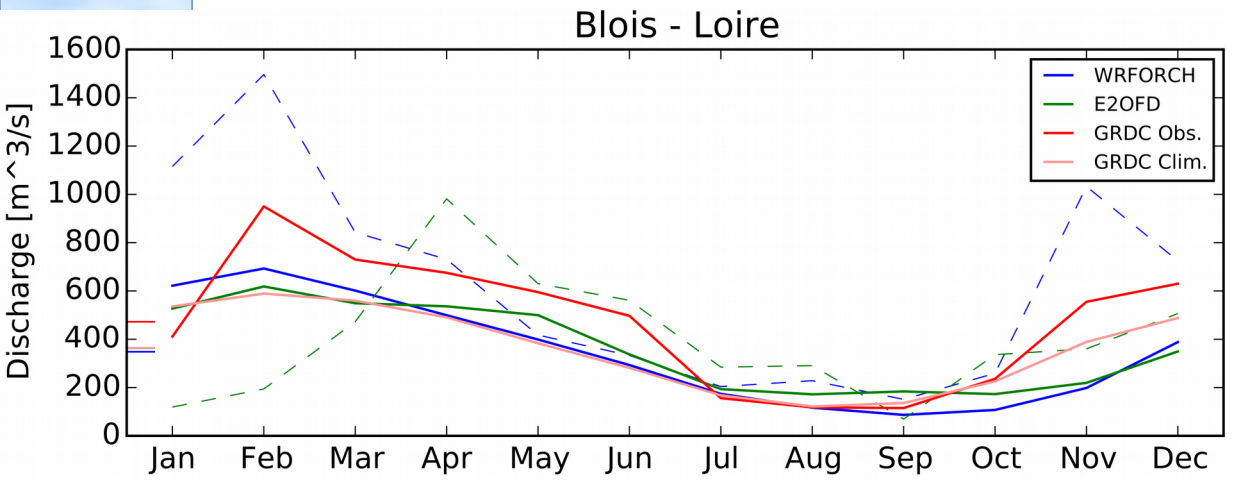
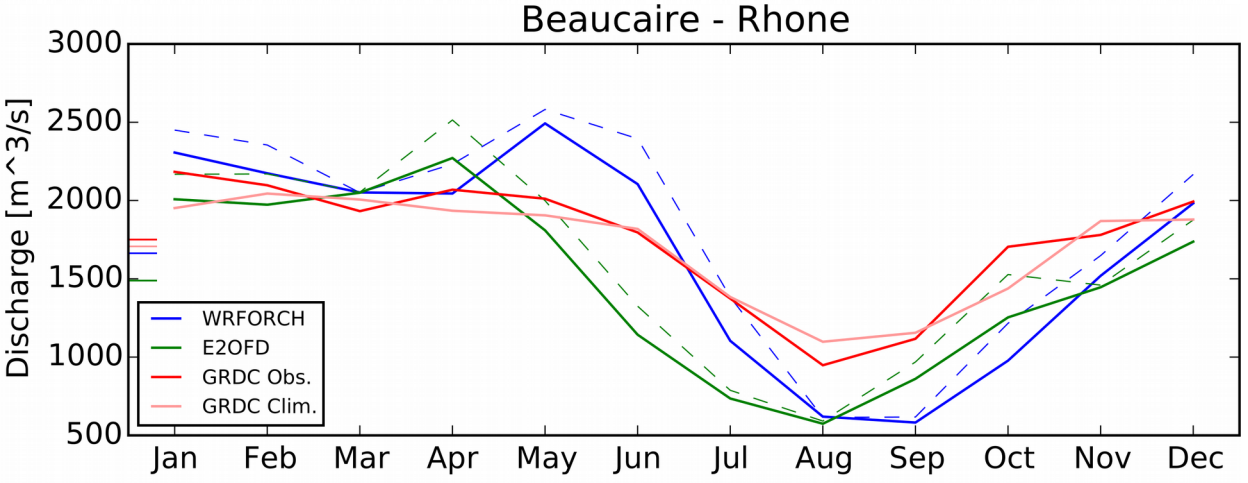
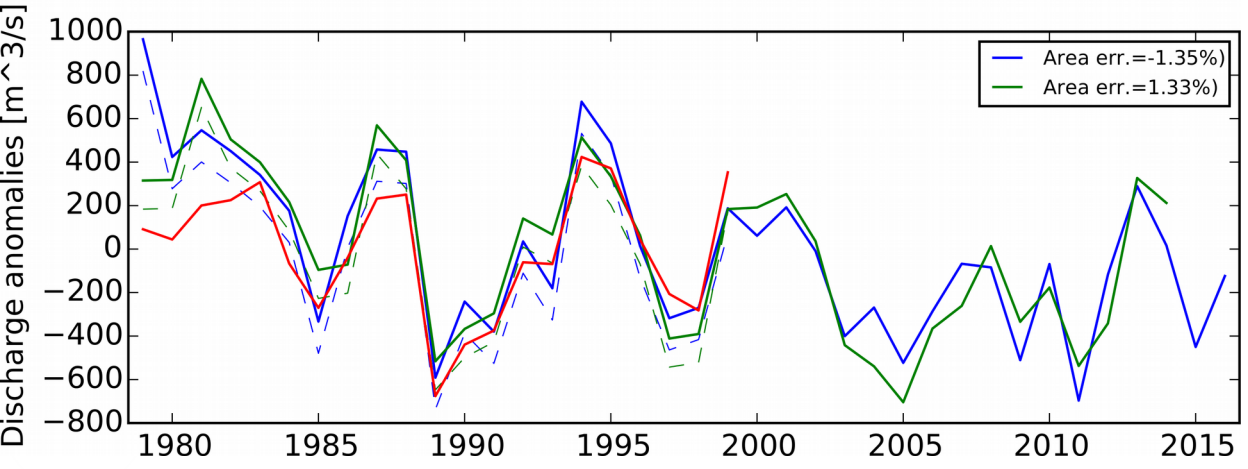
Validating the river discharge



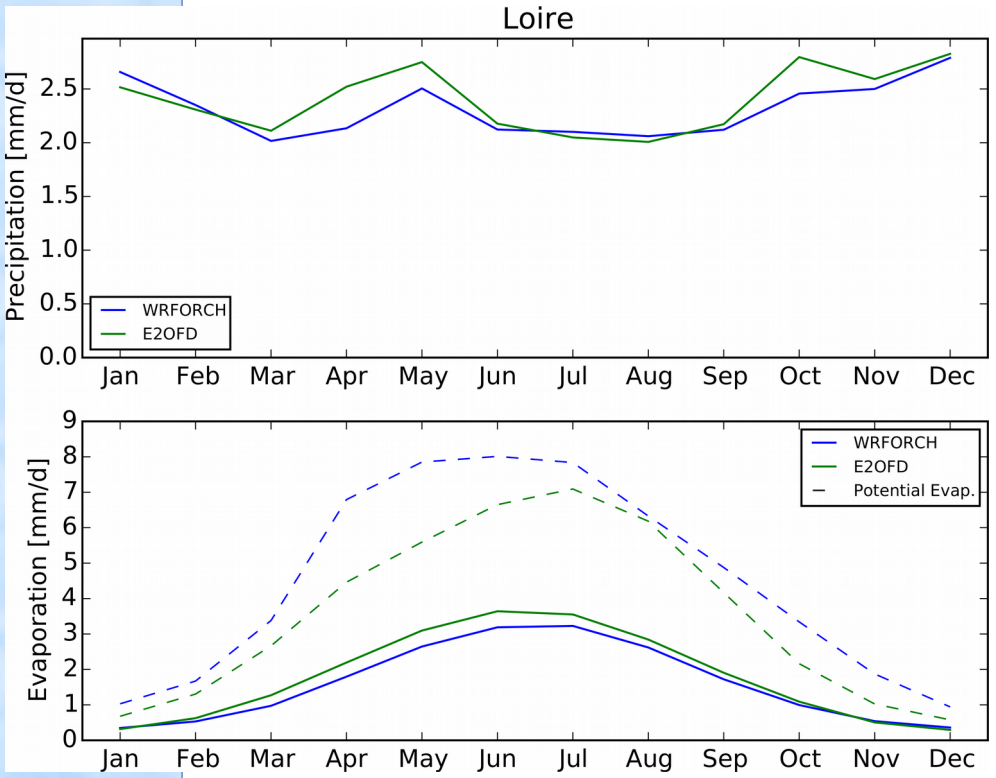


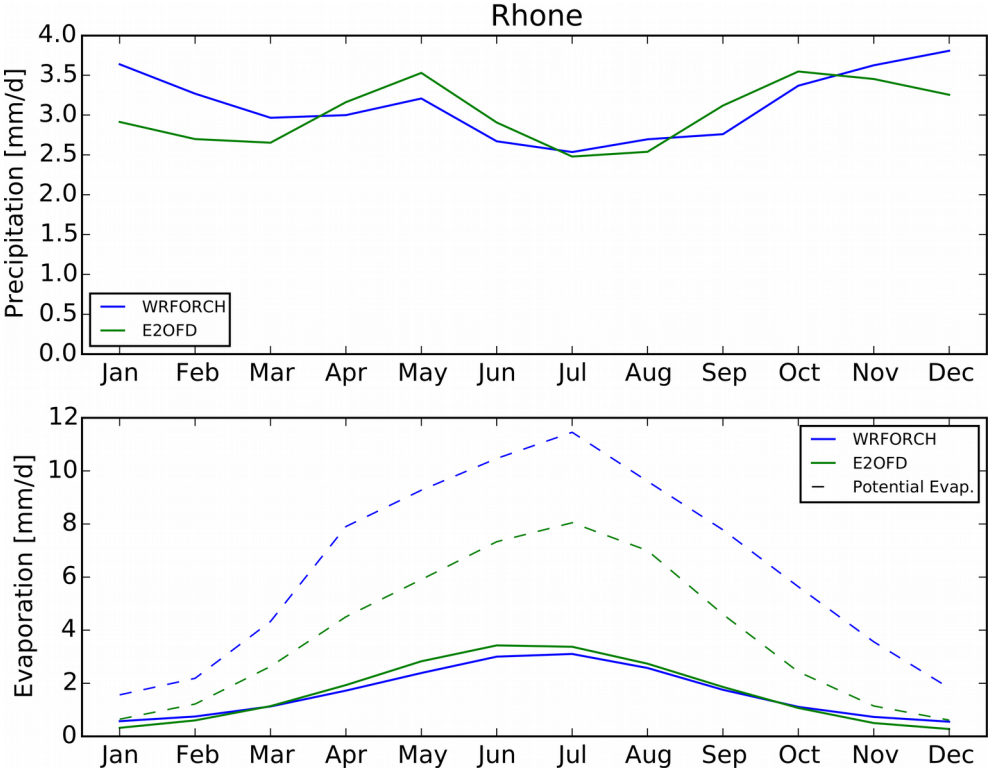


- The hydrographs are quite similar between both data sets.
- For the Loire an Rhone the discharge is underestimated (consistent with over estimated E !).
- The inter-annual variability is quite realistic in both cases.
- On the Rhone, E2OFD has far less water. Is this linked to issues in orographic rainfall ?

(dashed lines is for the climatology using only years with observations.)

Some elements for the two French basins





- Over the Loire E2OFD has slightly more rainfall.
- Over the Rhone, WRFORCH has more rainfall. This originates in winter over the Alps.
- WRFORCH has more potential evaporation throughout the year.
- Actual evaporation is larger for E2OFD (Not obvious over the FluxNet stations !).
- These last two results are general over the domain.

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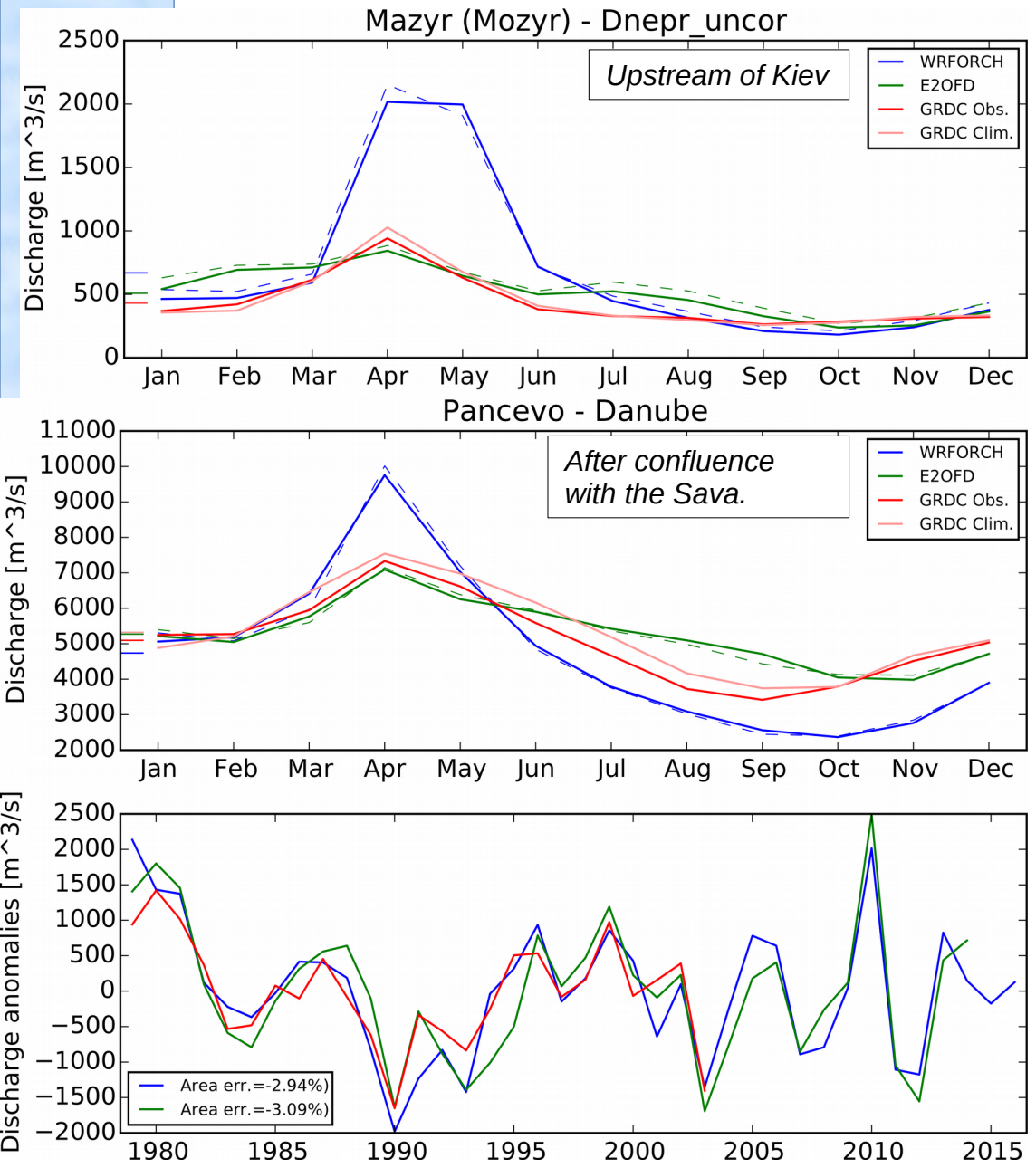
The role of snow in river discharge



- Over Eastern basins WRFORCH demonstrates a strong peak during the snow melt period.
- This is documented over 2 basins (Dnepr and Danube) but is more general in Eastern European basins.
- Generally the inter-annual variability is better for WRFORCH.

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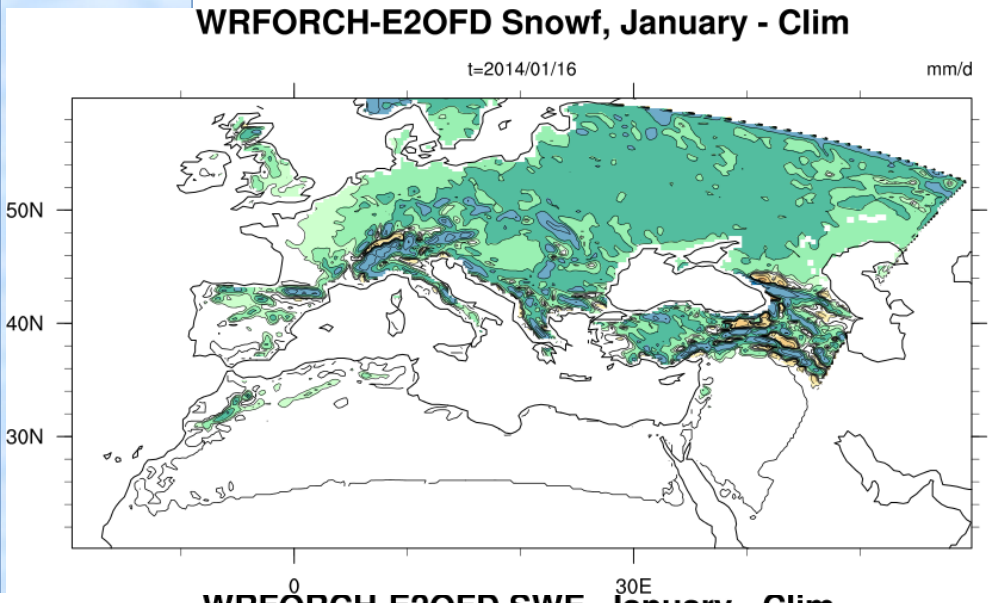
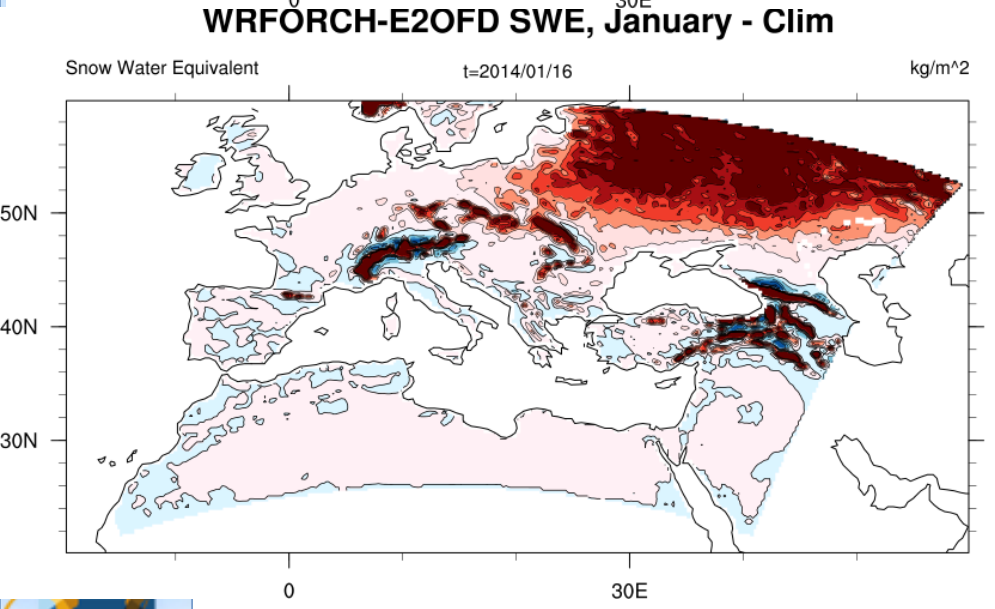
Issues with snow fall

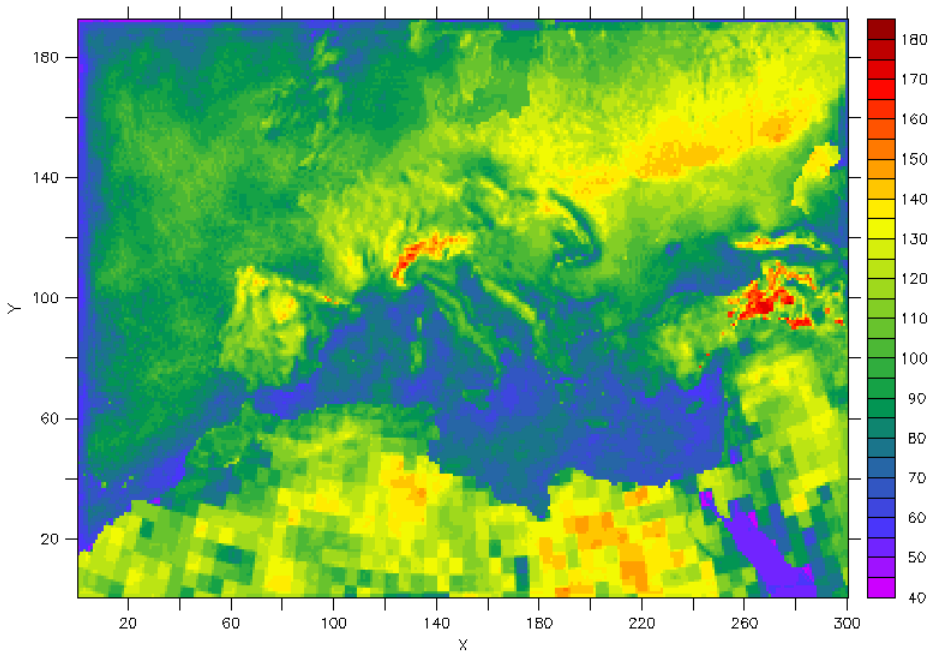


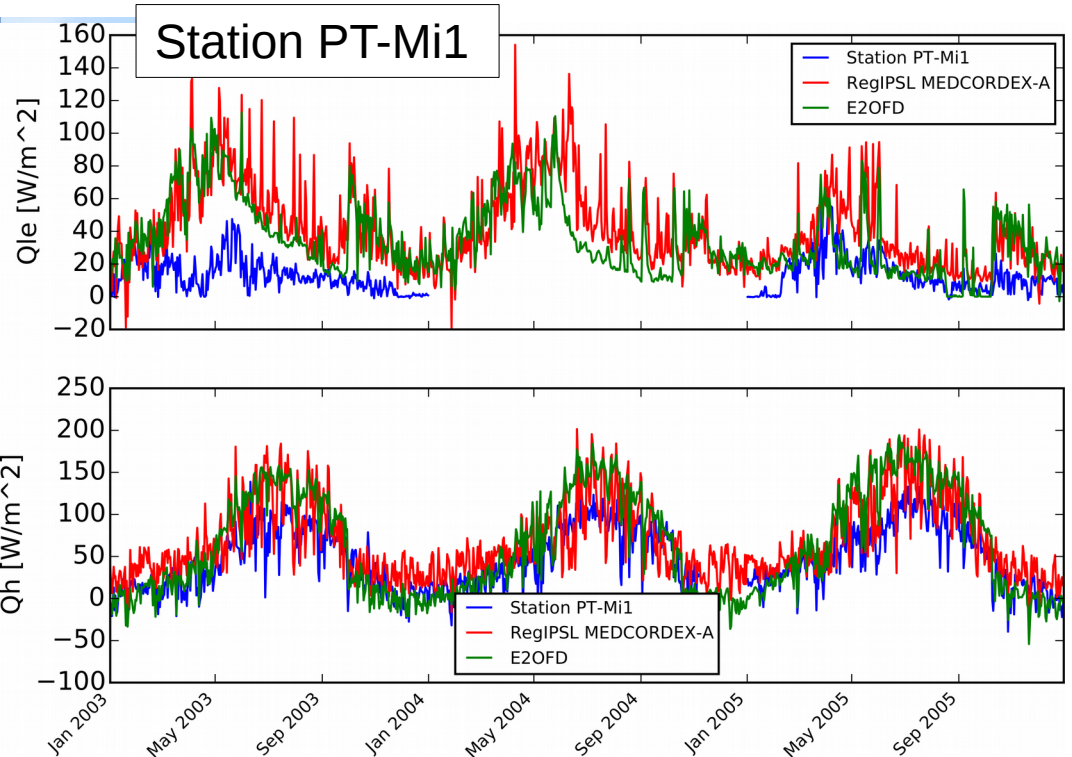


- Snowfall is higher in WRFORCH over the entire domain with maximal values over orography (2-5mm/d) and Easter Europe (0.5-1mm/d).
- This leads to a larger snow accumulation in January and later in the season (20-50 kg/m²).
- The colder surface and PBL in WRFORCH contributes to the larger snowfall and accumulation.
- The higher net radiation in WRFORCH does not seem to be a factor.

An independent validation of the snow cover is needed !

The ugly stuff





The coupled model WRFORCH was very stable during the 30 year simulation. Some issues still need to be fixed :

- Some of ORCHIDEE's fields are still too coarse (background albedo, PFT, soil types).
- The coupling is explicit.
- The WRF PBL scheme does not allow for an implicit coupling
- WRF's numerical schemes will need to be improved to have a more efficient model and stable fluxes.

Conclusions

- The coupling of ORCHIDEE to a regional climate model is operational.
- WRF provides a higher net radiation to the surface than E2OFD and FluxNet.
- Compared to an off-line simulation, ORCHIDEE provides less evaporation when coupled.
- The cold bias could be linked to the overestimation of evaporation or sensible heat flux.
- WRF provides more realistic rainfall, especially over orography. How about snow fall ?
- The water cycle is comparable to that of an off-line simulation.
- We are ready to move RegIPSL to convection permitting resolutions (5-3km). That will provide new opportunities for ORCHIDEE.

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