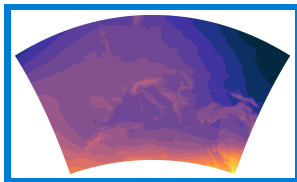


The Regional Earth System Model of IPSL (RegIPSL), a contribution to MEDCORDEX

Jan Polcher¹, Romain Pennel¹, Thomas Arsouze^{1,2}, Karine Béranger^{1,4},
Sophie Bastin³, Marc Stefanon¹, Philippe Drobinski¹, Lluís Fita⁵



MedCORDEX Workshop - Mallorca - March 14th 2018

¹LMD/IPSL, École Polytechnique, Palaiseau, France ²ENSTA ParisTech, Palaiseau, France ³LATMOS/IPSL, Guyancourt, France
⁴IGE, Grenoble, France ⁵CIMA, Buenos Aires, Argentina

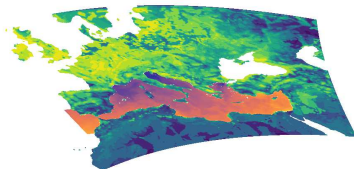
RegIPSL-MED configuration



OCEAN : NEMO-MED12

- ▶ NEMO v3.6 stable
- ▶ $1/12^\circ$ horizontal resolution : extraction of ORCA $1/12^\circ$ grid
- ▶ 75 vertical levels
- ▶ Atlantic buffer zone (not coupled)
- ▶ Black sea not included

RegIPSL-MED configuration



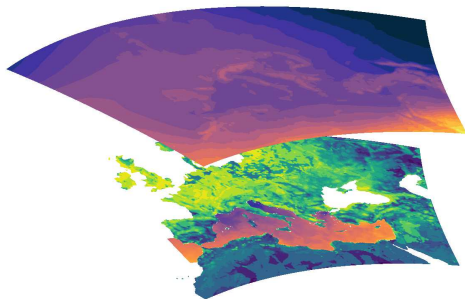
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LAND : Orchidee

- ▶ ORCHIDEE - Reg Routing version
- ▶ Regional routing with 36 vertices per grid box
- ▶ 200 rivers outflow to the ocean
- ▶ No interactive phenology

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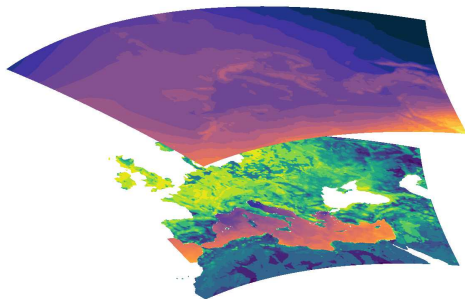
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- ▶ WRF 3.7.1
- ▶ 20km resolution Lambert conformal projection
- ▶ 46 vertical levels
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- ▶ New T2/Q2 parametrization
- ▶ Microphysics WSM5 / PBL MYNN2.5 / spectral nudging / Tegen

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I/O : XIOS

- ▶ XIOS with all 3 components (XIOS implemented into WRF)
- ▶ Standard CORDEX outputs

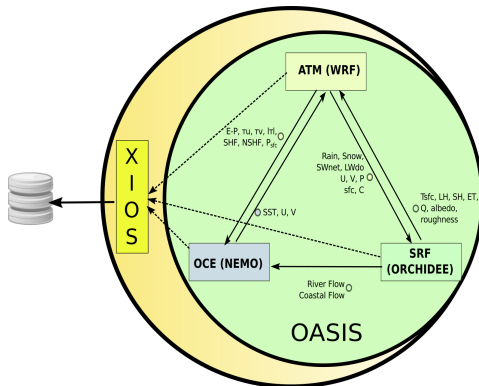
Coupling : OASIS3-mct

- ▶ ≈ 40 variables exchanged
- ▶ every 60 seconds (WRF/ORCH) ; every hour for NEMO
- ▶ Interpolation performed by oasis

Coupled variables

RegIPSL-MED

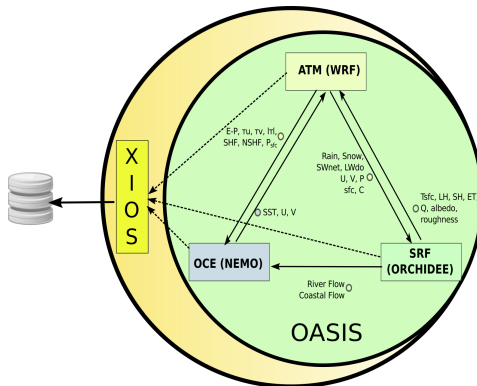
- ▶ Coupling : Not through subroutines => oasis3-mct
- ▶ 40 variables exchanged / different time step
- ▶ Estuaries directly on NEMO-MED grid
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Coupled variables

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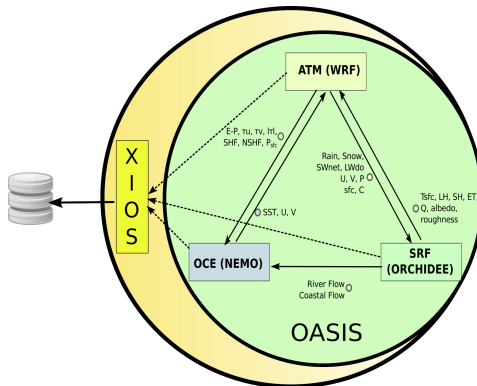
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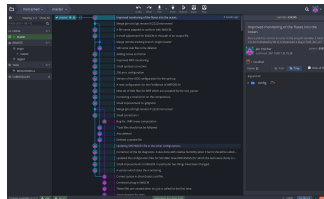


Development workflow

- ▶ Weekly Thursday meeting on Rendez-Vous :
open for discussion !
- ▶ Git versioning :
(`git+ssh://git@git.renater.fr:2222/morcemed.git`)
- ▶ Coupled system ready to run at major French
computing center (portability should be easy to
new infrastructure)
- ▶ Set of "plug & play" configurations :
 - ▶ ORCHIDEE off-line
 - ▶ NEMO off-line
 - ▶ WRF with original land surfaces
 - ▶ ORCHIDEE+NEMO
 - ▶ WRF+ORCHIDEE
 - ▶ *WRF+NEMO+ORCHIDEE*
- ▶ Up to date documentation wiki :
`https://sourcesup.renater.fr/wiki/morcemed`

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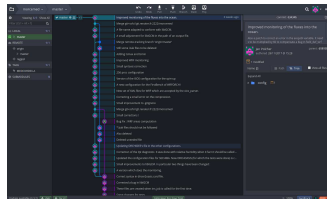
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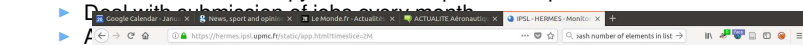
Production workflow

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 - ▶ Limited amount of config files / independant of the machine / human readable / portable
 - ▶ Deal with transfer / copy / archive of input and output files
 - ▶ Deal with submission of jobs every month
 - ▶ Allow post-processing
 - ▶ Performance monitoring
- ▶ Simulations are monitored on the HERMES system.
- ▶ Real-time monitoring : time series and atlas (CLiMAF)

https://prodn.idris.fr/thredds/fileServer/ipsl_public/rron972/RegIPSL/PROD/MEDCORDEX-A/WRFORCH/MONITORING

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HERMES Simulation Monitoring v1.3.0.2

Simul

Real-t

https://

MONITORING

2017-12-20T15:13:18 :: SIMULATION RESTARTED :: SOA04 is RUNNING Simulations: Total = 9554; Filtered = 13.

Start Date: < 2 months, Tag / Model: , Exp. Project: , Experiment: , Machine: , Space: , Login: , Compute State:

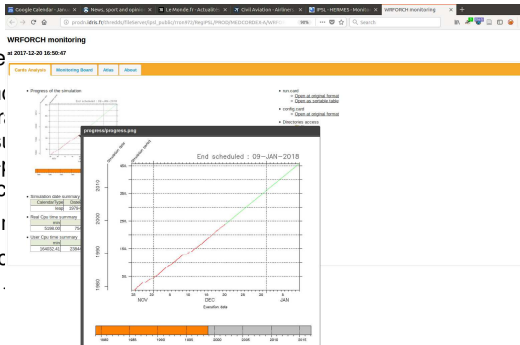
Filter by name: WRF Sort by: Name, Asc, Page 1 of 1, 25 / page, Permissions

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run	Test2WRFORCH	8	0 0 1 0	0 0 0 0	IRIS-ADA	mon072	regtest	Test2M_PastProc	PROD	...	...	...
run	WRF	1	0 0 1 0	0 1 0 2	IRIS-ADA	mon171	regtest	WRF_NDROS_10	PROD	...	...	...
run	WRF	6	0 0 1 0	0 0 0 1	IRIS-ADA	mon171	regtest	WRF_NDROS_3H	PROD	...	...	...
run	WRF	14	0 0 1 0	0 0 0 0	IRIS-ADA	mon060	regtest	FirstBench	DEVT	...	...	...
run	WRFORCH	2	-1 203 25 0	2 429 27 13	IRIS-ADA	mon072	regtest	MEDCORDEX-A	PROD	50 %	M	BI
run	WRFORCH	22	0 0 1 0	0 0 0 0	IRIS-ADA	mon072	regtest	Test2WRFORCH	PROD	...	...	...
run	WRFORCH	41	0 32 5 0	0 78 1 0	IRIS-ADA	mon072	regtest	FirstBench	PROD	97 %	M	BI
run	WRFORCH	2	0 0 1 0	0 0 0 0	IRIS-ADA	mon072	regtest	FirstBench	DEVT	...	...	...
run	WRFORCH	10	0 7 6 0	0 4 2 7	IRIS-ADA	mon072	regtest	Test2M_PastProc	PROD	92 %	M	BI
run	WRFORCH	3	0 0 1 0	0 0 0 0	IRIS-ADA	mon171	regtest	Test_WRFORCH_JAN	PROD	...	...	...
run	WRFORCH	1	0 0 1 0	0 1 0 2	IRIS-ADA	mon171	regtest	Test_NewORCH	PROD	...	...	...
run	WRFORCH	1	0 0 1 0	0 1 0 2	IRIS-ADA	mon171	regtest	Test_WRFORCH_OLDORCH	PROD	...	...	...

QUEUED | RUNNING | COMPLETE | LATE | ERROR | M - Monitoring | IM - Inter-Monitoring

HERMES Simulation Monitoring v1.3.0.2 © 2017 IPSL

Production workflow



► Jobs management

- Limited amount of jobs
- Deal with thousands of jobs
- Deal with simulations of various sizes
- Allow post-processing
- Performance

► Simulations are interactive

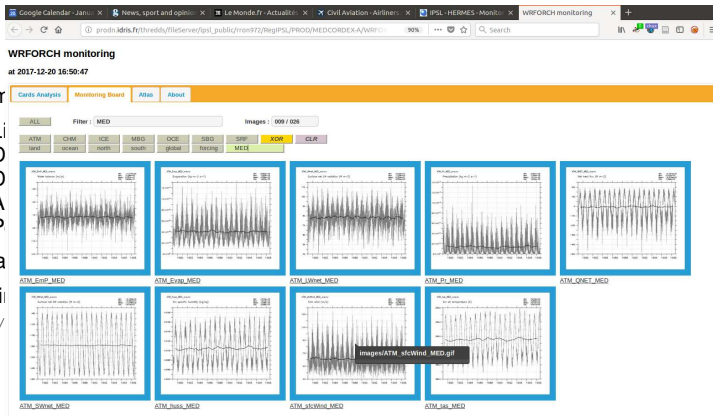
► Real-time monitoring

<https://prodn.idris.fr/monitoring/>

isateur

readable / portable

A/WRFORCH/MONITORING

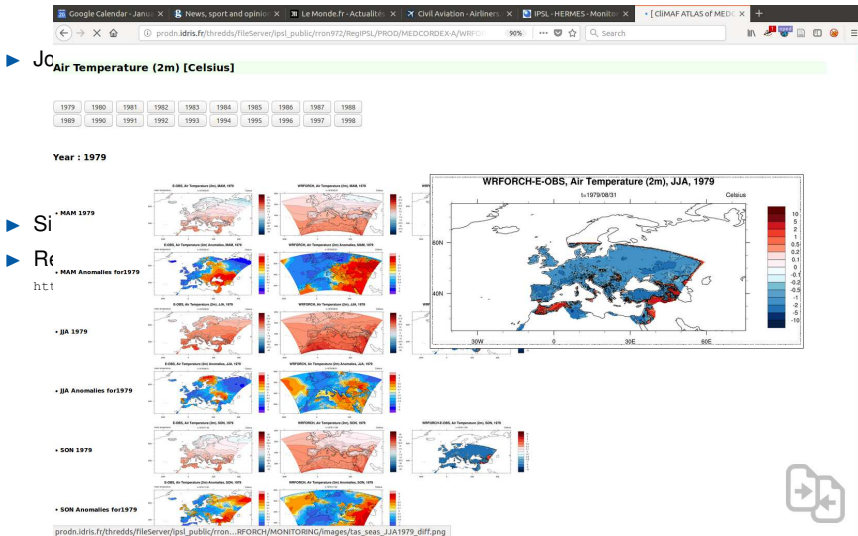


/ portable

NITORING

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javascript:popimage("images/ATM_sfcWind_MED.gif")
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Production workflow



able

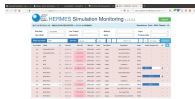
IG



Production workflow

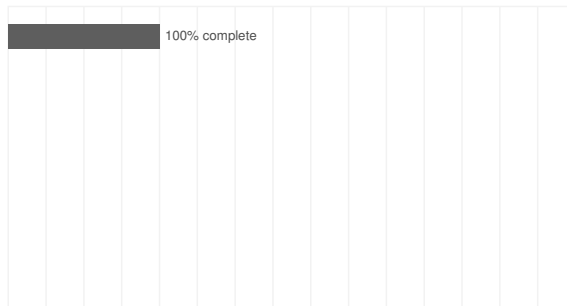
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Simulation production 2018

ERA-I: WRF-ORCHIDEE



ERA-I: WRF-ORCHIDEE

- ▶ Hindcast 1979 - 2014
- ▶ ERA-Interim forcing

Evaluation data

The Earth2Observe off-line simulation used for comparison :

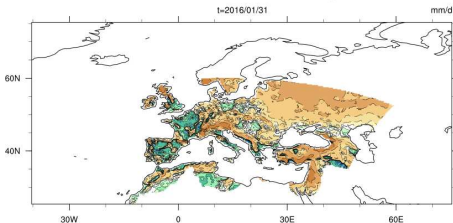
- ▶ In order to evaluate the added value of coupling to a RCM, we also compare to a state of the art off-line simulation with ORCHIDEE : Earth2Observe land-surface re-analysis.
- ▶ E2OFD is used as a forcing :
 - ▶ 1/4° forcing data.
 - ▶ Covers the 1979-2014 period.
 - ▶ WFDEI is statistically downscaled 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 (observations)
 - ▶ CMORPH, CSMaP, TRMM (satellite)
 - ▶ ERA-I and JRA-55 (reanalysis)

The observational based products :

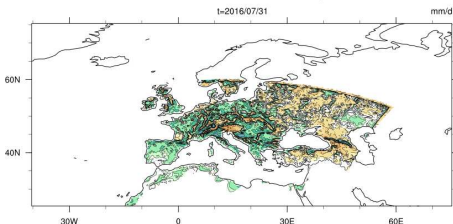
- ▶ E-OBS version 16 is used to validate rainfall and near-surface temperature
- ▶ Climatologies and anomalies are computed relative to the period 01/1979-12/2016.
- ▶ FluxNet version 5, is used.
- ▶ Rivers and freshwater discharge is validated against GRDC data.

Evaluation with E-Obs : Rainfall

WRFORCH-E-OBS, Rainfall, January - Clim



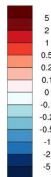
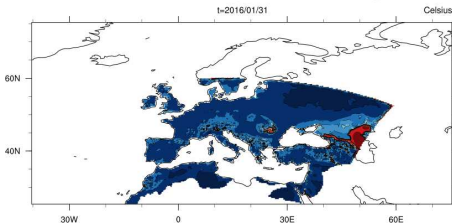
WRFORCH-E-OBS, Rainfall, July - Clim



- ▶ E-Obs only reports rainfall !
- ▶ 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 ($\sim 0.5\text{mm/d}$).
- ▶ Beware of systematic biases in the observations, especially over topography !

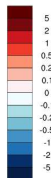
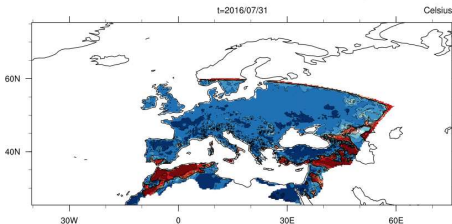
Evaluation with E-Obs : 2m air temperature

WRFORCH-E-OBS, Air Temperature (2m), January - Clim

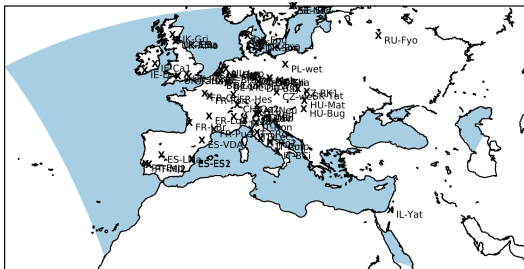


- ▶ Cold bias of the model is systematic ($\sim 1^\circ\text{K}$ in summer).
- ▶ Larger in winter and in the Eastern part of the domain.
- ▶ No clear East-West structure of the bias in summer.
- ▶ Smallest bias over mountain ranges.
- ▶ Some areas in North-Africa are too warm.
- ▶ The amplitude of the diurnal cycle is underestimated over most of the domain. The exception is North-Africa.

WRFORCH-E-OBS, Air Temperature (2m), July - Clim



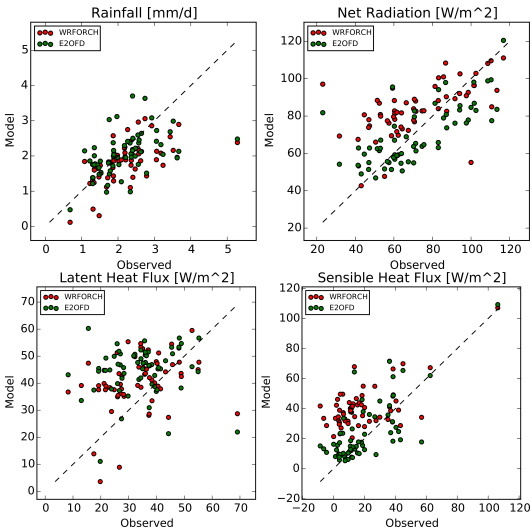
Evaluation over FluxNet stations



- ▶ Here we also compare with the E2OFD forced version of ORCHIDEE to evaluate the impact of coupling.

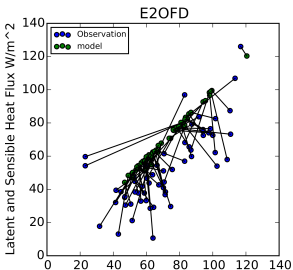
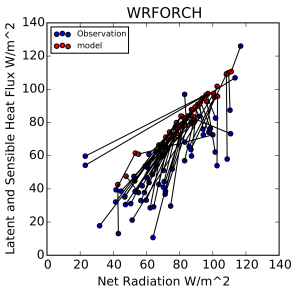
- ▶ Longest records are from 1996 to 2006, but only for some stations : NL-Loo, FR-Lbr, BE-Vie, FR-Hes, FR-Pue, ...
- ▶ 73 stations in Europe as used for validation covering the full range of climates in Europe.
- ▶ The quality and length of record are very variable.
- ▶ Some stations were excluded as the record was too short or had obvious measurement issues.
- ▶ The size of the ensemble allows to identify some general issues with the surface fluxes.

Statistics over all stations



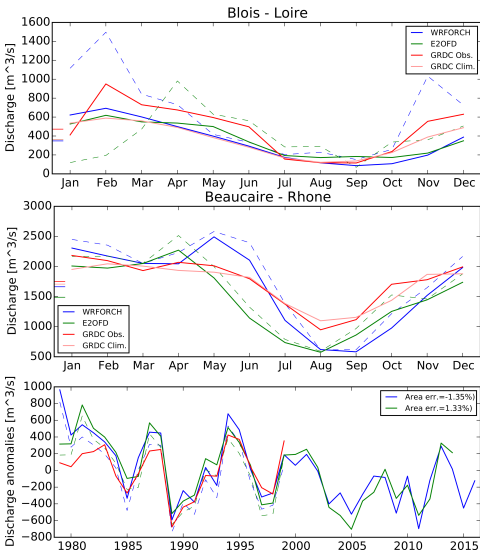
- ▶ Rainfall is quite well reproduced at the stations.
- ▶ The WRFORCH, in contrast to E2OFD, has a positive bias on radiation.
- ▶ ORCHIDEE seems to systematically overestimate evaporation in both configurations : WRFORCH and E2OFD.
- ▶ The radiation bias in WRFORCH seems to affect essentially the sensible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

Energy conservations in the data and model



- ▶ 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.
- ▶ Similar diagnostics can be done for the water balance. But because runoff is not observed, the closure cannot be evaluated.

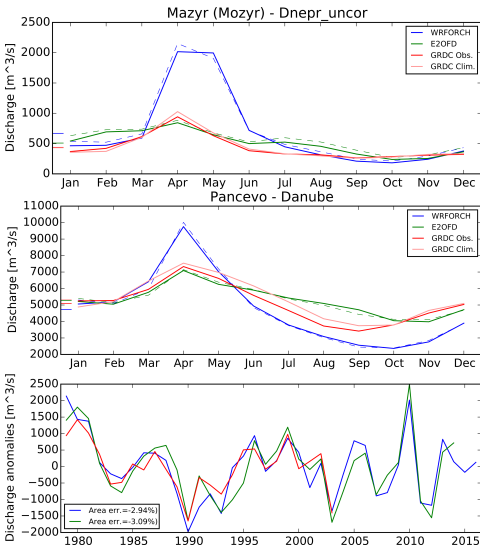
Validating river discharge at GRDC stations



- ▶ The hydrographs are quite similar between both data sets.
- ▶ Over the Loire the discharge is slightly underestimated.
- ▶ But the model reproduces well the climatology at the GRDC station with both forcing.
- ▶ The inter-annual variability is quite realistic in both cases.
- ▶ Over the Rhone, E2OFD has substantially less water.
 - ▶ This is explained by lower orographic rainfall in E2OFD, and
 - ▶ Larger evaporation in E2OFD.

(Dashed lines are the average of the modelled years which overlap with observations.)

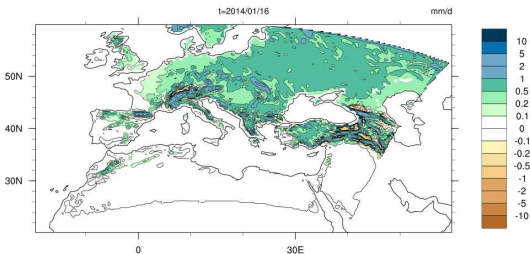
The role of snow in river discharge



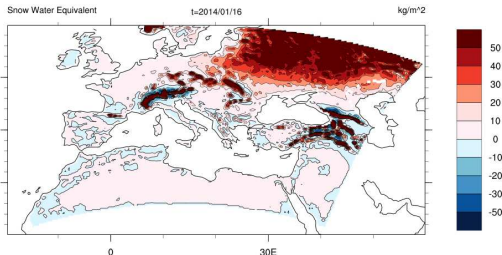
- ▶ Over Eastern basins WRFORCH demonstrates a strong peak during the snow melt period.
- ▶ This is documented over 2 basins (Dnepr and Danube) but is more general in Eastern European basins.
- ▶ As the routing scheme has been tuned with off-line simulations, it is not possible to say if this feature originates from the forcing or is linked to model parameters.
- ▶ Generally the inter-annual variability is better for WRFORCH.

Difference in the snow processes between both versions

WRFORCH-E2OFD Snowf, January - Clim



WRFORCH-E2OFD SWE, January - Clim

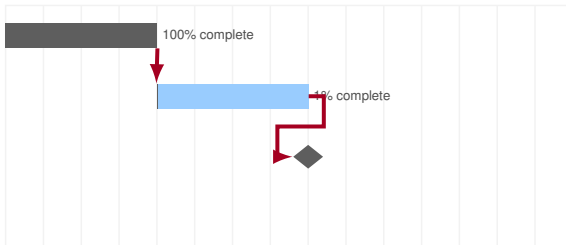


- ▶ Snowfall is higher in WRFORCH over the entire domain with maximal values over orography (2-5mm/d) and Eastern Europe (0.5-1mm/d).
- ▶ This leads to a larger snow accumulation in January and later in the season (20-50 kg/m²).
- ▶ The colder surface and PBL in WRFORCH contributes to the larger snowfall and accumulation.
- ▶ The higher net radiation in WRFORCH does not seem to be a factor.
- ▶ The snow-fall in E2OFD should not be considered as a reference !

An independent validation of the snow cover is needed !

Simulation production 2018

ERA-I: WRF-ORCHIDEE



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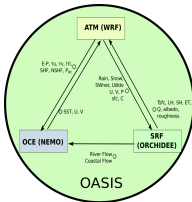
- ▶ Hindcast 1979 - 2014
- ▶ ERA-Interim forcing

WRF-ORCH: NEMO-ORCHIDEE

- ▶ Hindcast 1979 - 2014
- ▶ NEMO-ORCHIDEE forced by ERA-I WRF-ORCH (no retroaction)
- ▶ **Assess water budget and convection**

Today's status : *NEMO-ORCHIDEE*

- ▶ **NEMO-ORCHIDEE** second step towards full coupling (*first step see Jan's talk*)
- ▶ Proto atmosphere (*driver*) to test future coupling using outputs of WRF-ORCHIDEE simulation

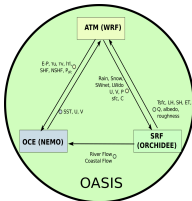


Driver to mimic an atmosphere :

- ▶ coastal run off and estuaries send directly from Orchidee to Nemo
- ▶ SST, U and V send to *driver*
- ▶ Net heat fluxes computed by the driver using SST from NEMO
- ▶ Wind stress computed by the driver using ocean currents

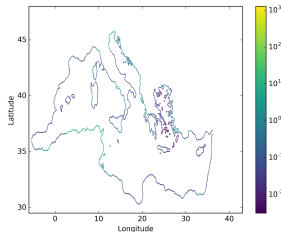
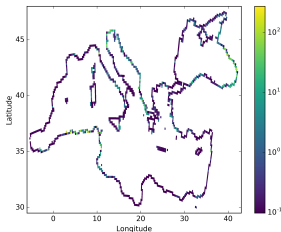
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- ▶ **NEMO-ORCHIDEE** second step towards full coupling (*first step see Jan's talk*)
- ▶ Proto atmosphere (*driver*) to test future coupling using outputs of WRF-ORCHIDEE simulation



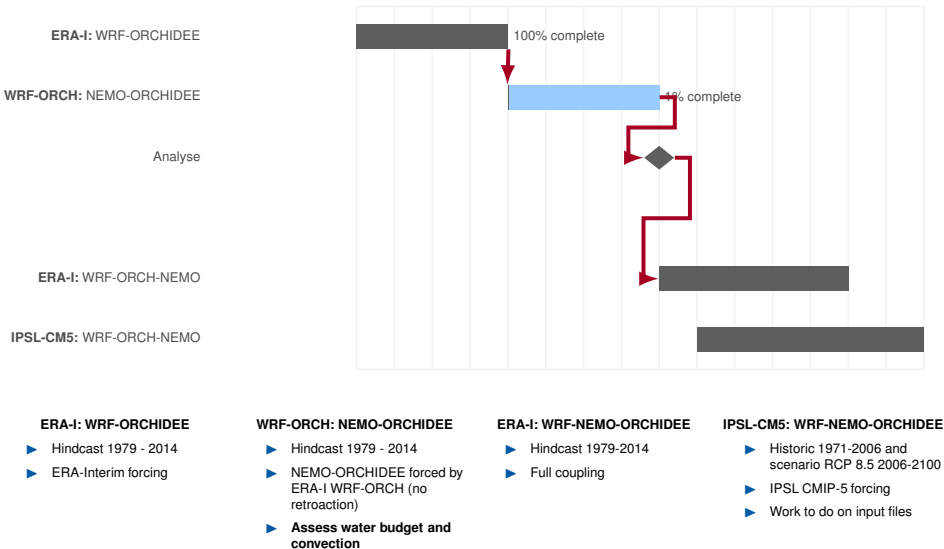
Driver to mimic an atmosphere :

- ▶ coastal run off and estuaries send directly from Orchidee to Nemo
- ▶ SST, U and V send to *driver*
- ▶ Net heat fluxes computed by the driver using SST from NEMO
- ▶ Wind stress computed by the driver using ocean currents



Mapping of coastal flow between ORCHIDEE (left) and NEMO (right) grids
resolution increase / Black Sea parametrisation

Simulation production 2018



Future projects



- ▶ CHIMERE / WRF already ready
- ▶ Needs to integrate WRF developments
- ▶ Integrate CHIMERE in the RegIPSL environment
- ▶ CHIMERE / ORCHIDEE : *work in progress*
- ▶ future : CHIMERE / PISCES

DYNAMICO



- ▶ New dynamical engine for atmosphere / LMDZ physics
- ▶ Limited area version of DYNAMICO (Idealized version next year ?)
- ▶ Non-hydrostatic physics

- ▶ Facilitate the preparation of configurations over other regions (South America in preparation).
- ▶ *FPS Alps* : Move to higher resolution (Convection permitting over Europe).
- ▶ Use of the ERA5 re-analysis.
- ▶ *FPS Air/sea* : Study the coupling with NEMO-MED36, impact of mesoscale in an eddy resolving context