Norwegian Meteorological Institute

Latest progress in HARMONIE Climate, and links to NWP

Oskar Landgren, MET Norway, oskar.landgren@met.no
and the HCLIM members

2024-04-19, ACCORD ASW, SMHI, Norrköping, Sweden

HARMONIE-Climate (HCLIM)

HCLIM – the climate branch of HARMONIE
Used for regional climate modelling by HCLIM member institutes

Multiple physics: ALADIN (>~8 km), HARMONIE-AROME (<5 km)
(previously also ALARO-0)
Land surface model: SURFEX

Current versions:
cy43 for production
cy46 development ongoing

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Improving understanding of impacts of climate change on the local scale (cities, municipalities, regions…)

Data provision to national climate change assessments

Improving model representation of climate-relevant processes

Organisation

Member institutes:
AEMET
DMI
FMI
HungaroMet
KNMI
MET Norway
Met Éireann
SMHI

Two 30% positions:
Project leader: Oskar Landgren (MET Norway)
System manager: Bert van Ulft (KNMI)

Collaboration with and benefits for NWP

- Long-term evaluation of model biases without influence of data assimilation
- Testing new parameterisations
  - ALADIN physics allows long-term evaluation of e.g. SURFEX developments
- Multiple atmospheric physics
  - HARMONIE-AROME (very close to NWP setup)
  - ALADIN for larger domains and decadal/centennial timescales
- System developments
  - Different aerosol inputs (MERRA-2, GCMs, CAMS-NRT, …)
  - Single precision
  - New domains: Antarctic, Arctic, …
  - …

Contributions to CORDEX ensembles

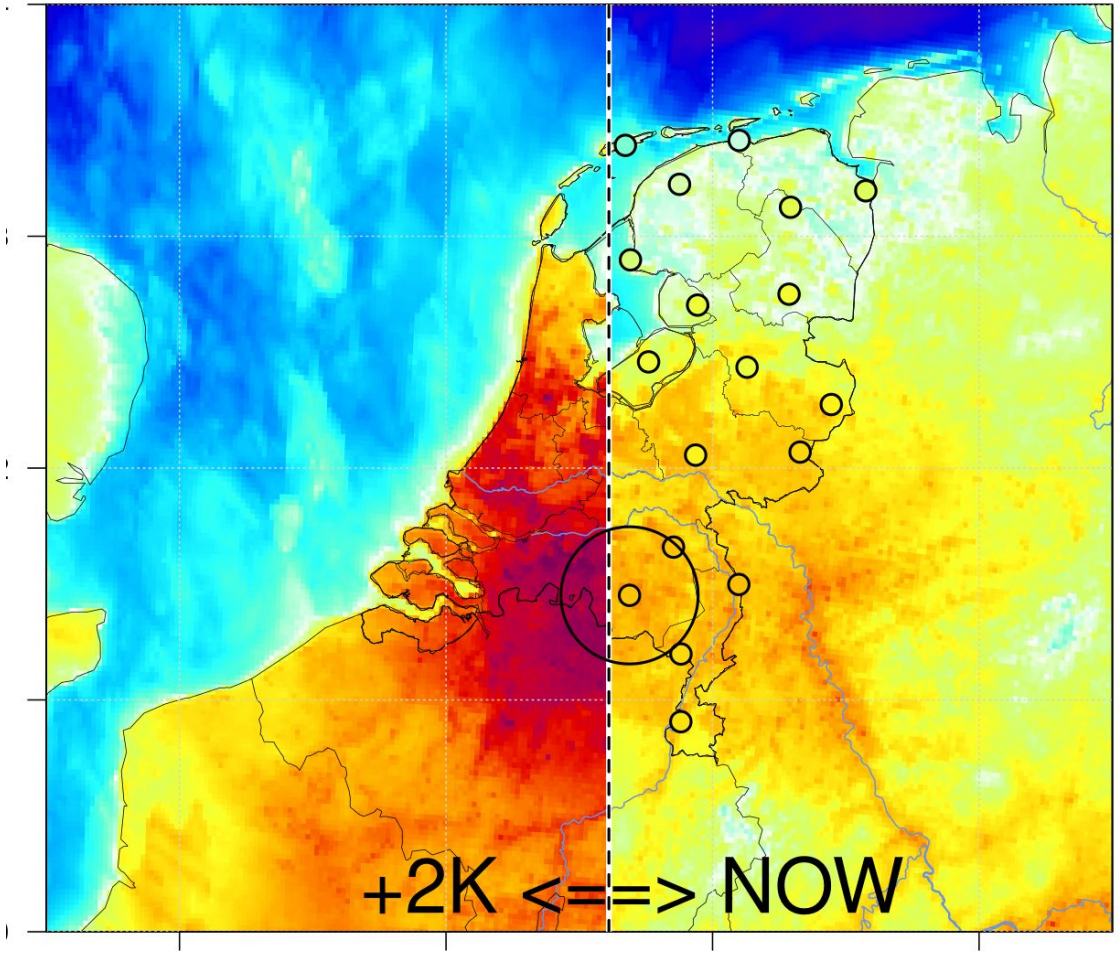
Euro-CORDEX (SMHI and METNO)
HCLIM43-ALADIN, 12.5 km, 1951-2100:
11 members completed

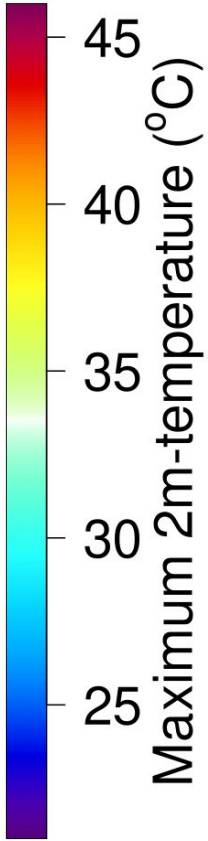
Polar CORDEX (DMI and METNO)
HCLIM43-ALADIN, 11 km, 1985-2100:
4 members running (2 Arctic, 2 Antarctic)

CORDEX FPS Convection (DMI, KNMI, METNO and SMHI)
HCLIM38-AROME, 3 km, Alps:
ERA-Interim: 1999-2009
EC-Earth RCP8.5: 1995-2005, 2040-2050 and 2089-2099,
2 members completed (nested into
HCLIM43-ALADIN or RACMO)
on ESGF: https://esgf-data.dkrz.de/search/cordex-dkrz/?institute=HCLIMcom

Pseudo-global warming (PGW)

c) Future Weather: 2019-07-24//2019-07-26





Boundary data:
ERA5 + Δ from
global climate models
(e.g. 3D T, U, V, Q
from a future
+2-degree period)

Rainfall extremes and climate change: lessons from PGW simulations with HCLIM

Italy's deadly floods are yet another example of climate change extremes, experts say

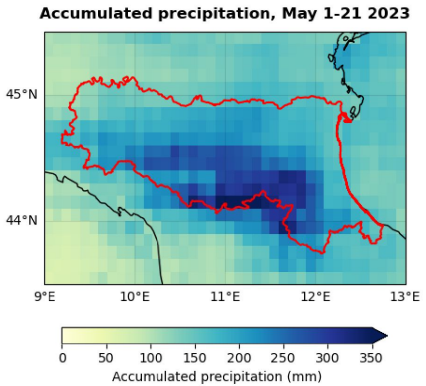
A man walks his dog through a flooded street in the village of Castel Bolognese, Italy. – Copyright AP Photo/Luca Br

By **Euronews Green** with **APTN** • Updated: 22/05/2023

Were Italy's devastating floods really caused by climate change? This new study suggests not

The floodwaters were so high, firefighter and coastguard helicopters were needed to r

World Weather Attribution



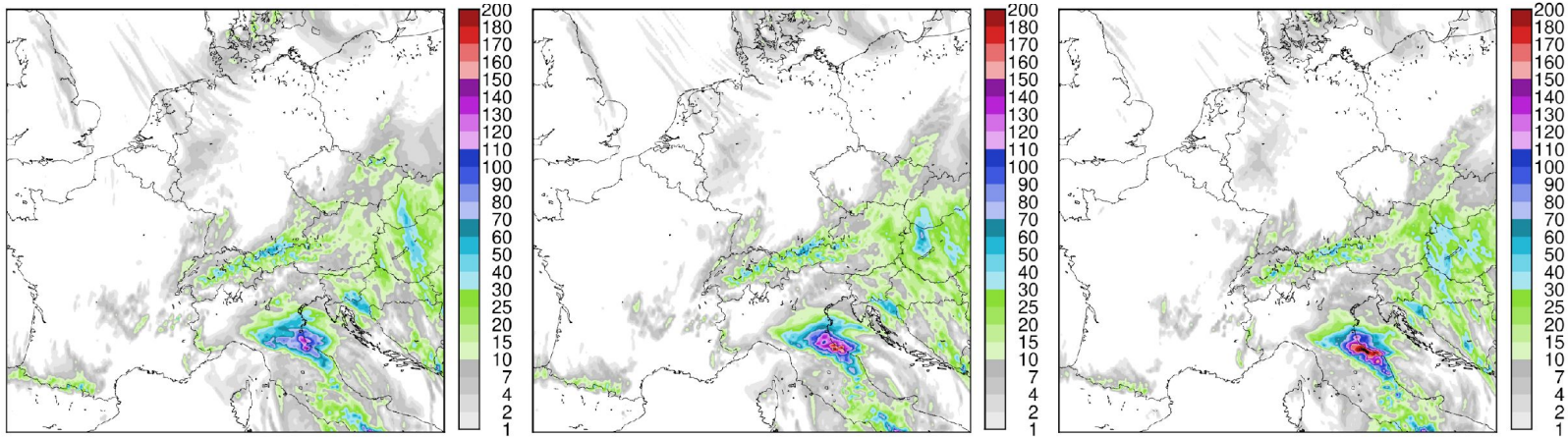
Analysis of 21-day precipitation change in RCMs

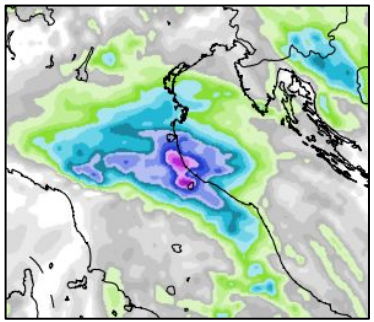
HCLIM 24-48h forecast for 20230516 (wettest day from period)

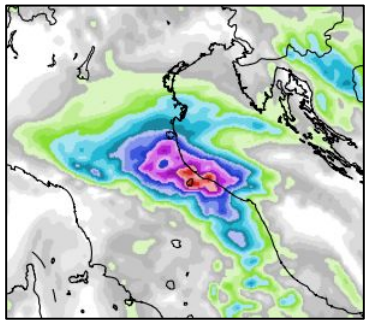
-1.5 degree cooler climate

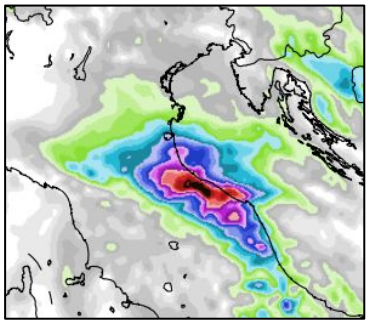
present-day

1.5 degree warmer climate



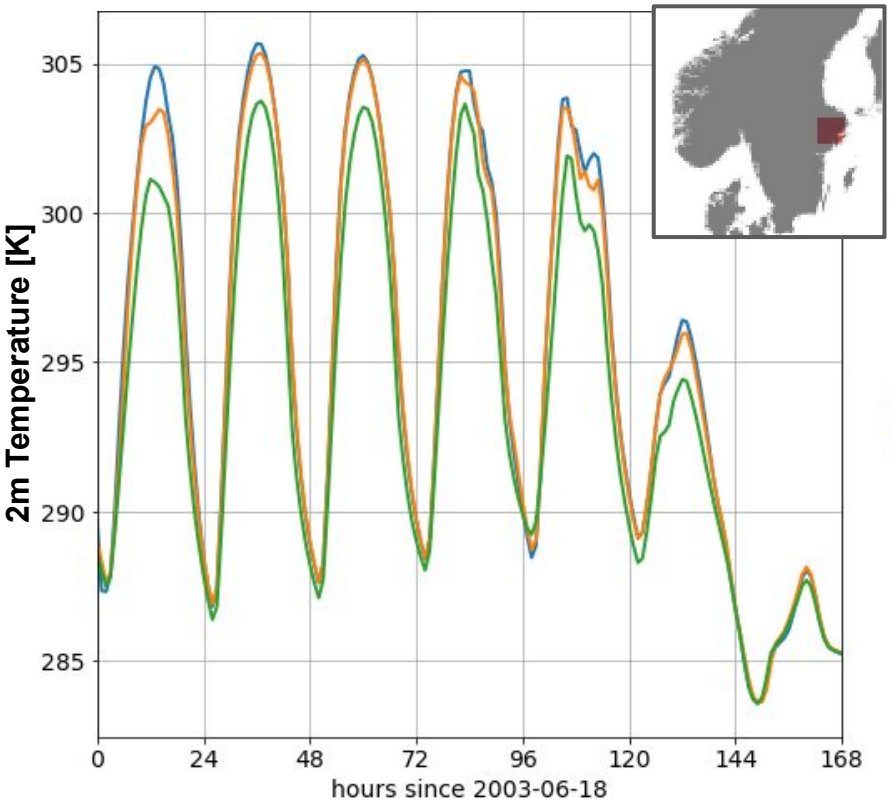


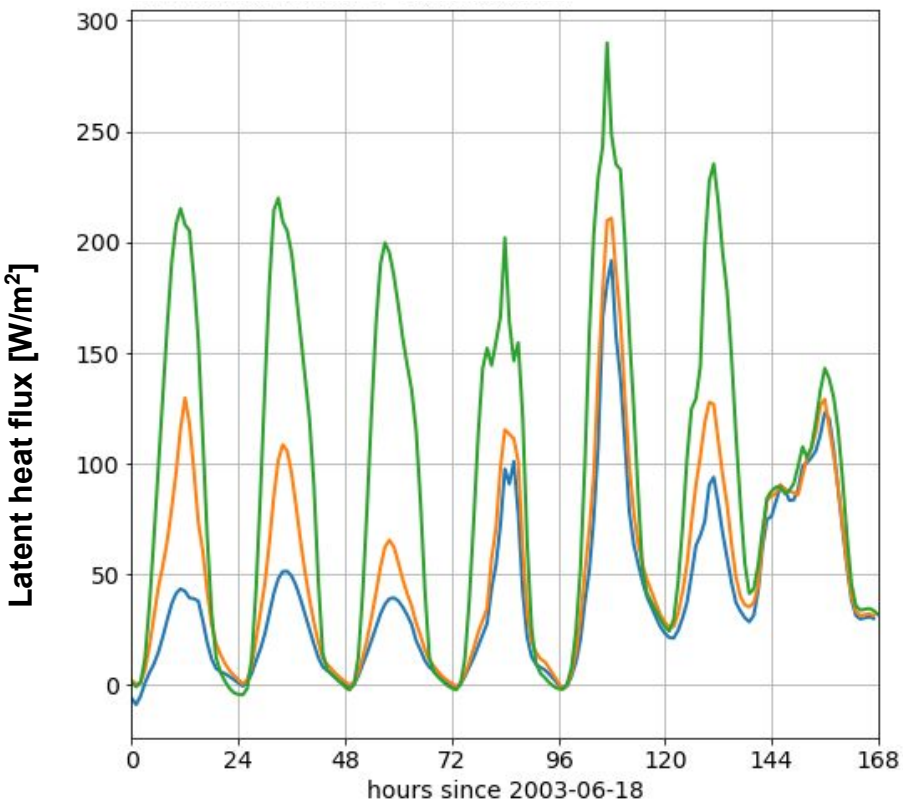




Soil spin-up

Motivation on improving soil spin-up procedure in HCLIM



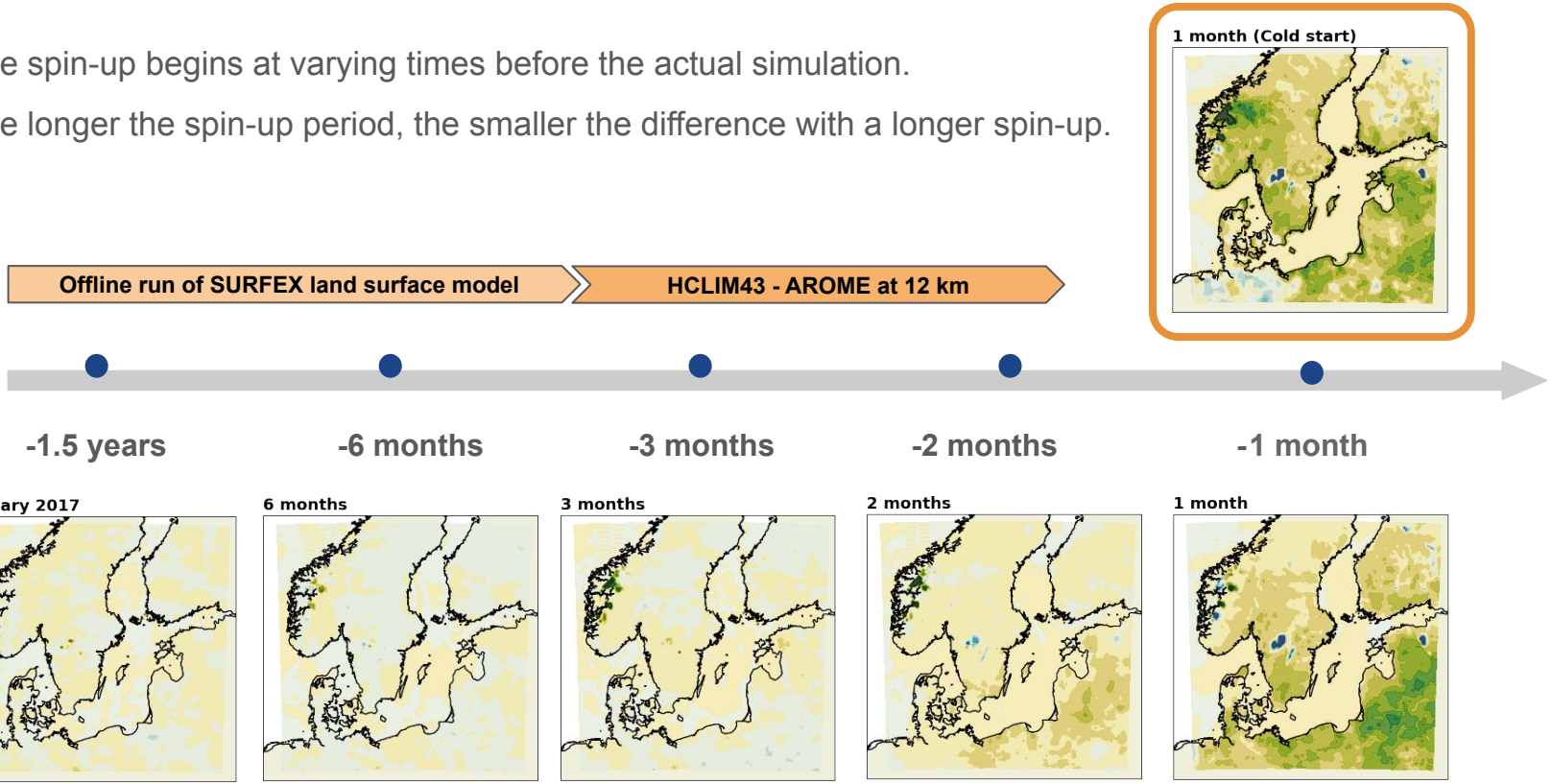


Legend: *Cold start* | *Spin-up time: 1 week* | *Spin-up time: 3 years*

Testing of spin-up with HCLIM

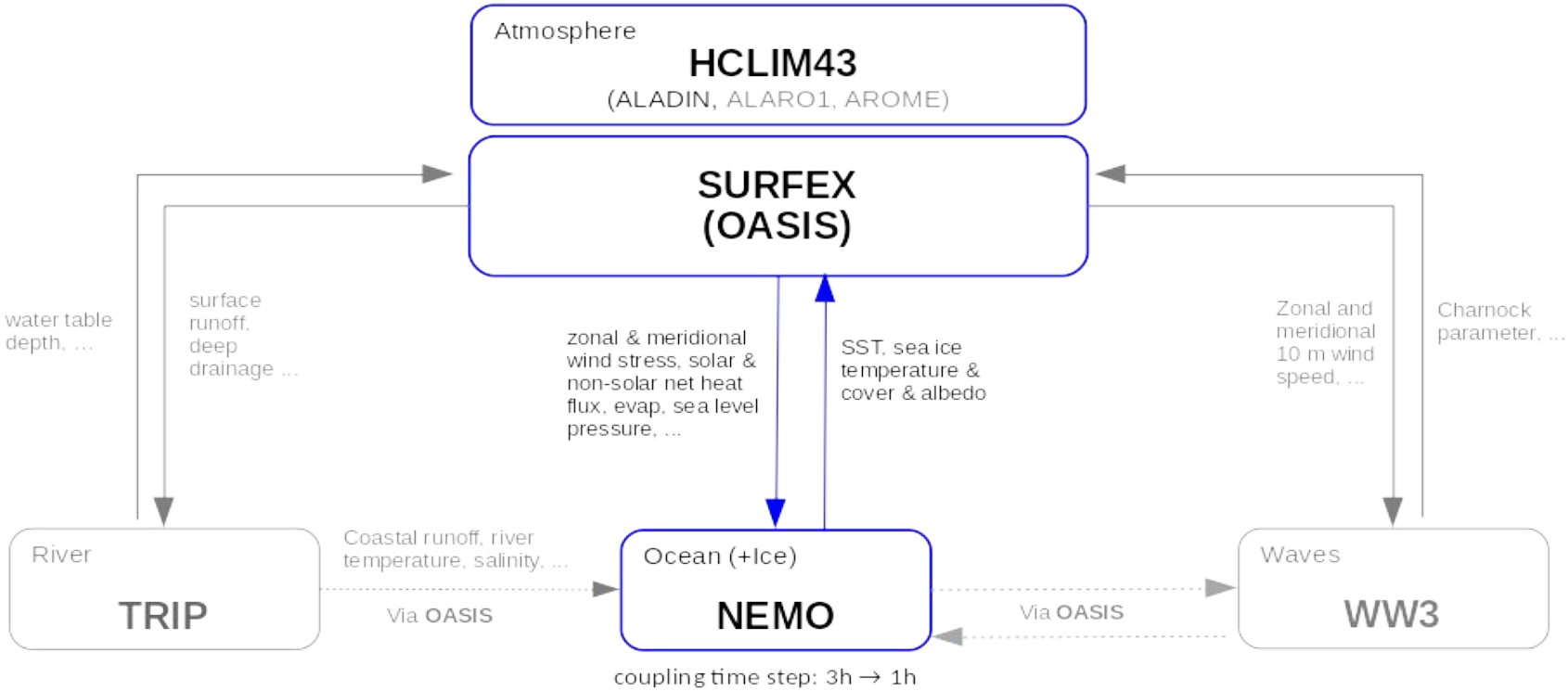
T_{2m} (K) (Time average for June 2018)
Δ respect to the long spinup

- The spin-up begins at varying times before the actual simulation.
- The longer the spin-up period, the smaller the difference with a longer spin-up.



Coupling

HARMONIE - NEMO coupling



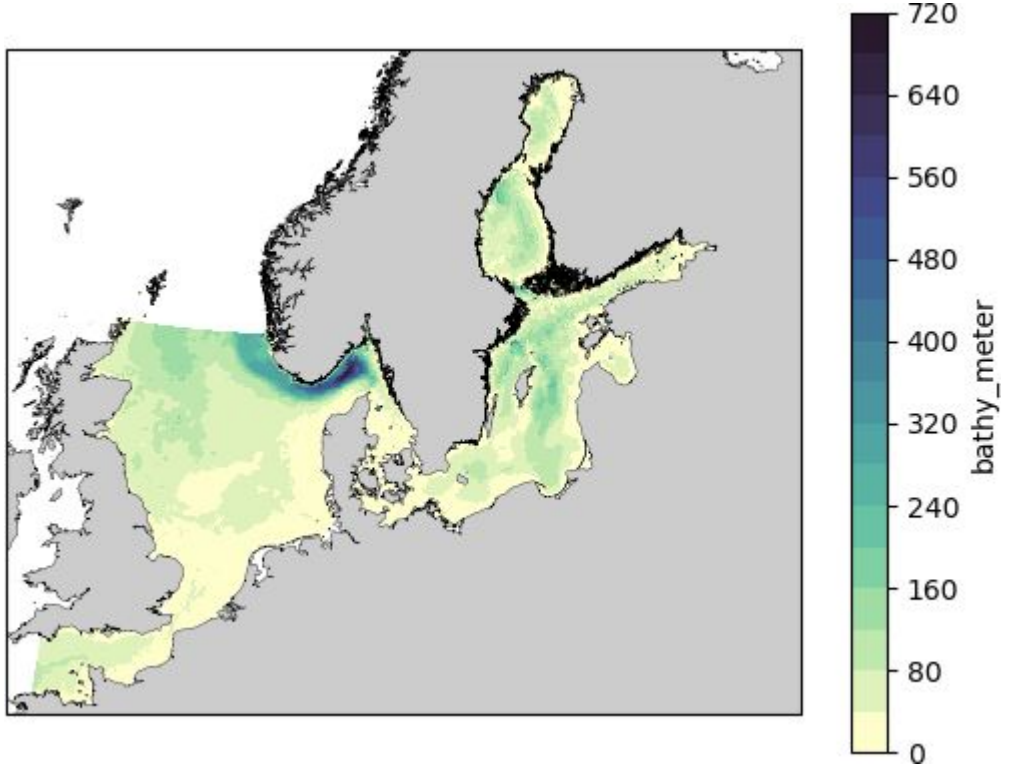
HCLIM/NEMO coupling set-up in NEMO side

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)

Configuration details:

Horizontal advection: UBS
(Upstream-Biased Scheme)
Vertical advection: GLS
(Generic Length Scale closure)
Vertical convection: EVD
(Enhanced Vertical Diffusion)



Outlook

- Many members, critical mass
- Ongoing activities with regular meetings (aerosol, coupling, PGW, …)
- NWP collaboration works much better now that we are on same version but can be improved (e.g. sharing evaluation tools and datasets)
- From discussion at climate side meeting:
  Improving collaboration between ACCORD climate groups,
  inviting others to topic meetings

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Thank you for your attention!

Contact: oskar.landgren@met.no

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Extra slides

Development tasks
Development of cy46 in climate mode (collaboration with NWP): - Forward phasing of HCLIM43 mods to NWP - Re-add HCLIM-specifics (e.g. GHG from netcdf) - See https://github.com/orgs/Hirlam/projects/4
Testing and evaluation of cy43 and cy46. Analysis of long-term biases in collaboration with NWP. Strengthen the collaboration with NWP to solve the biases.
Continue development of RCAT (Regional Climate Analysis Tool), a parallelized python tool for analysing large amounts of data due to very high resolutions. Includes model evaluation, analysis, and providing input to model development. Solve installation issues in different machines and include new developments.
Polar regions and ice sheet modelling: - Surface scheme improvements - Technical mods for polar regions
Groundwater and its SURFEX v8 implementation. Coupling with the new CTRIP MeteoFrance version at 0.12 degrees, test groundwater default parametrization and a new one.
Coupling with the ocean (NEMO). Get HCLIM coupled with NEMO. Coordinate with NWP people working on it and with the Oceanography group at SMHI.
Treatment of aerosols. Needed for future projections, we aim at including aerosols fields as forcing from different GCMs.
Rewrite HCLIM part of the scripting system following developments in NWP/DEODE
Single precision tests in collaboration with NWP (RWP2022 tasks SY1.5 & SY1.7). Check impact on results and speed-up.
Follow GPU-refactoring of code and impact for HCLIM-ALADIN
Developments for Pseudo Global Warming techniques: generation of boundary conditions which includes increments of the forcing fields ● https://github.com/HCLIMcom/HCLIM_pgw ● https://github.com/romick-knmi/HCLIM/tree/feature/netcdf_pgw_CY46
... ...

HCLIM/NEMO coupling set-up (first test experiment with AROME)

ATMOSPHERE

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/Hirlam/HCLIM/discussions/107 -. Nathan coupled HCLIM-ALADIN with NEMO. All branches come from the former HCLIM repository branch https://github.com/Hirlam/HCLIM/tree/esm_coupling, based on Erin Thomas' WW3 developments)

HCLIM version: cy43 (commit: ffb237c, 2021-03-24)

SURFEX **version**: v 8.1

Domain: EUR11 (around **12 Km** grid)

LBCs: ERA5 (3h)

PHYSICS="AROME"

HCLIM coupling with NEMO

Typical set of variables interchanged between atmospheric and ocean models. First group is sent from ATM to OCEAN. Second group from OCEAN to ATM

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

Over sea and over ice

E, P and Snow

+ Ice cover, temperature and albedo

HCLIM-AROME/NEMO coupling set-up

NEMO time step: 150s
HCLIM time step: 60s

Coupling period: 7200 seconds (2h)
Lag (NEMO): 150s (1 ts)
Lag (HCLIM): 60s (1 ts)

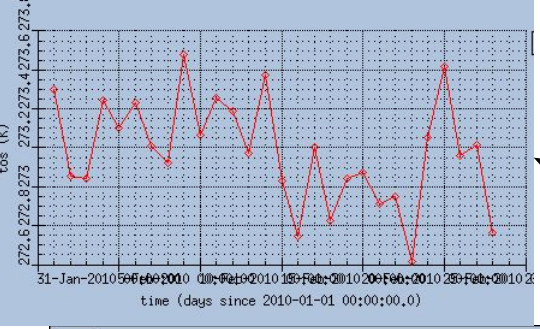
(Also test with Lag = 0 for HCLIM have been done)

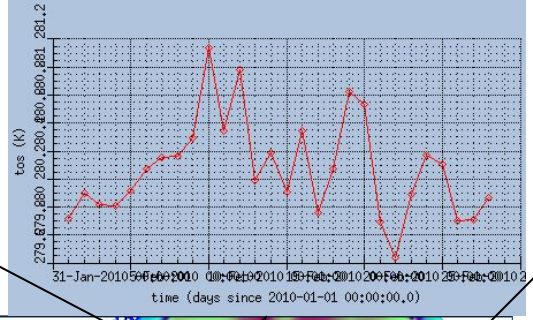
HCLIM/NEMO coupling current problems

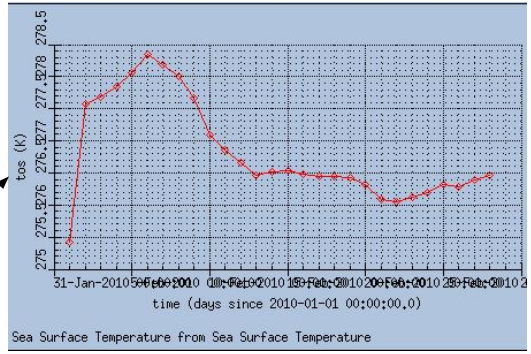
- After 10 hours the model starts to generate negative LW_RAD (downwards LW) values that make the model crash (overwriting negatives with zeros makes the simulation to end a month)
- The coupling runs for a month but doesn't restart. (Possible reason: NEMO code doesn't check that the current time corresponds to a multiple of the coupling timestep and tries to send/receive every nemo timestep while OASIS stops (I think) sending/receiving a timestep before the end of the simulation.)

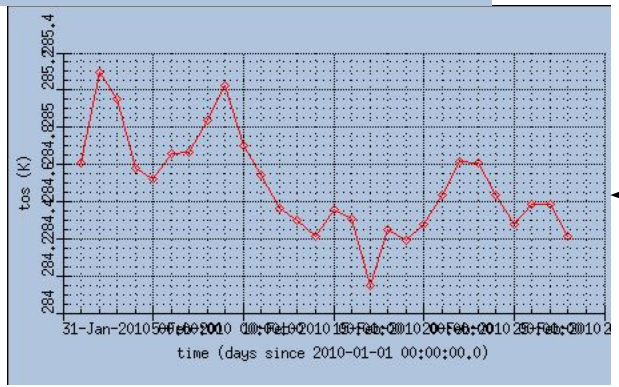
Other possible sources of problems:

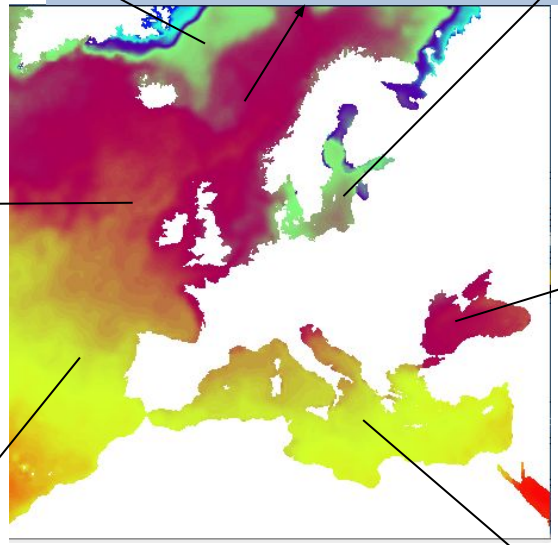
- Discontinuity at the border between SURFEX OCEAN data & NEMO domain
- Inconsistent initial fields between atmosphere and ocean that can lead to instabilities?
- Wrong masks?
- Wrong configuration?

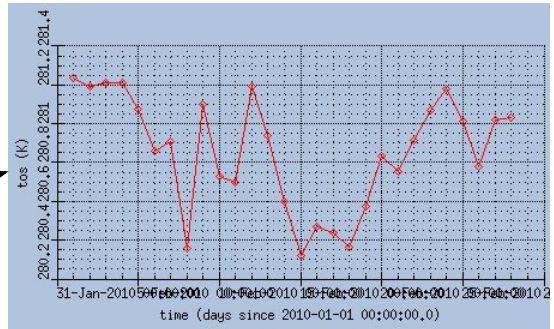


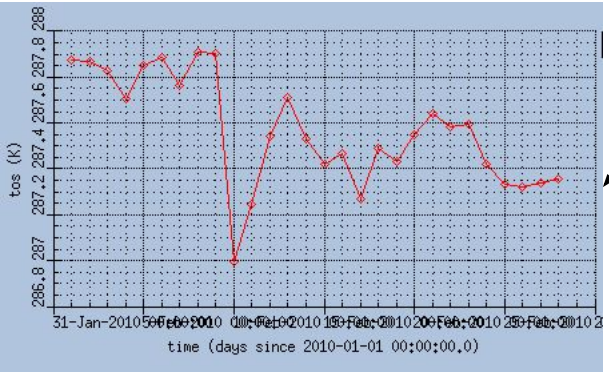


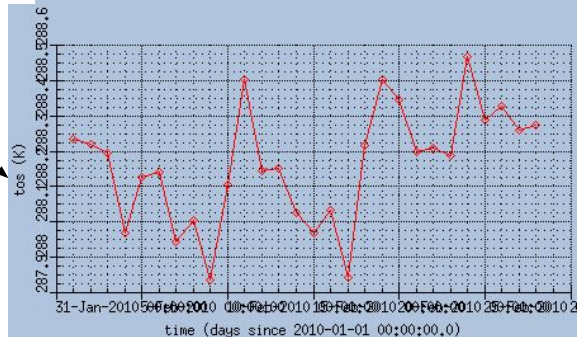




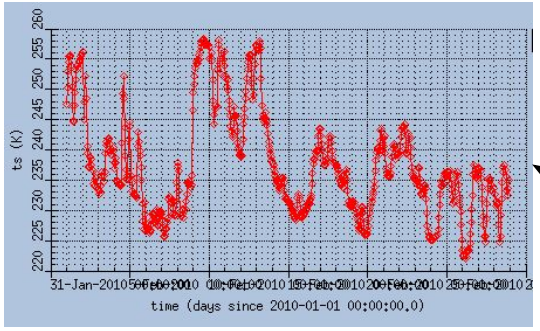


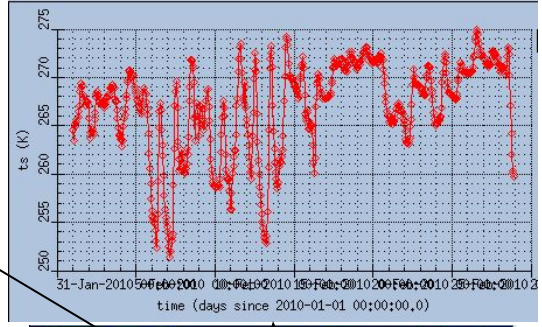


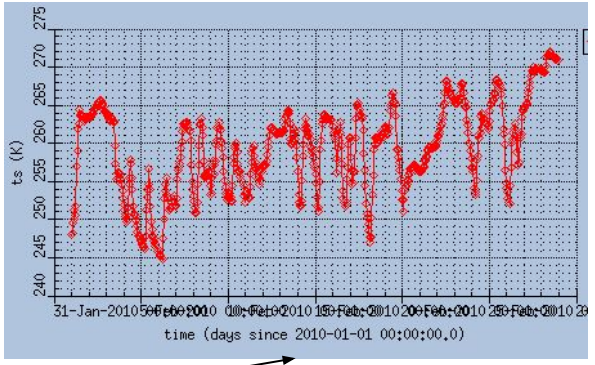


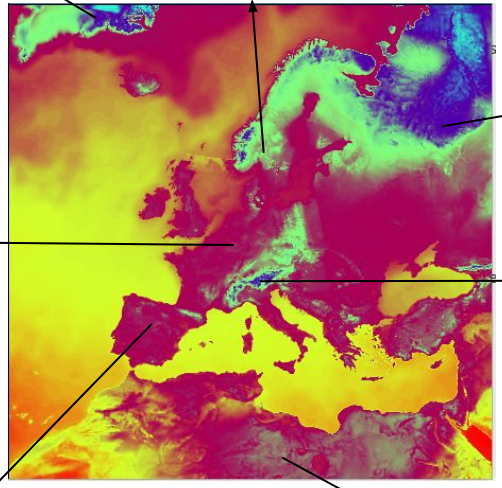


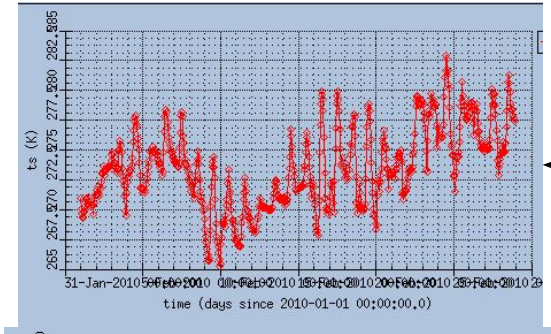
SST February 2010

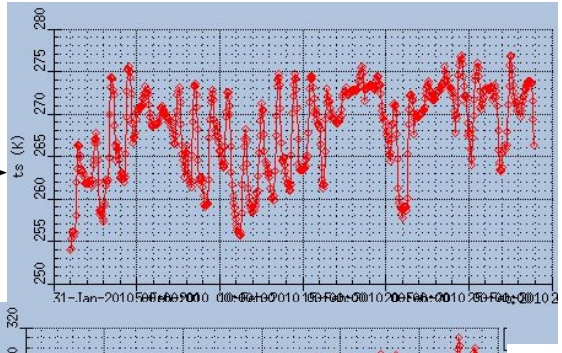


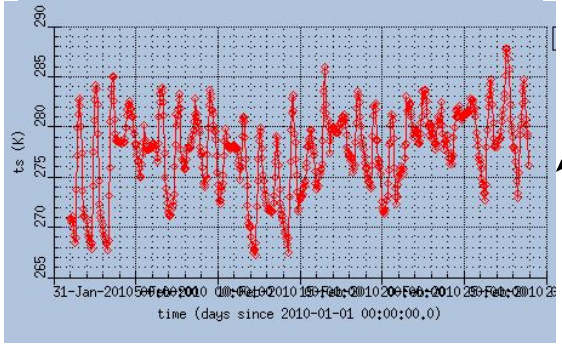


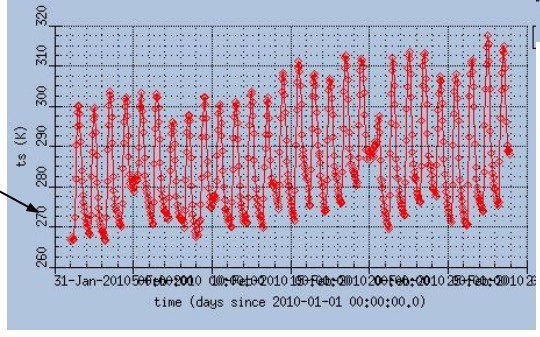












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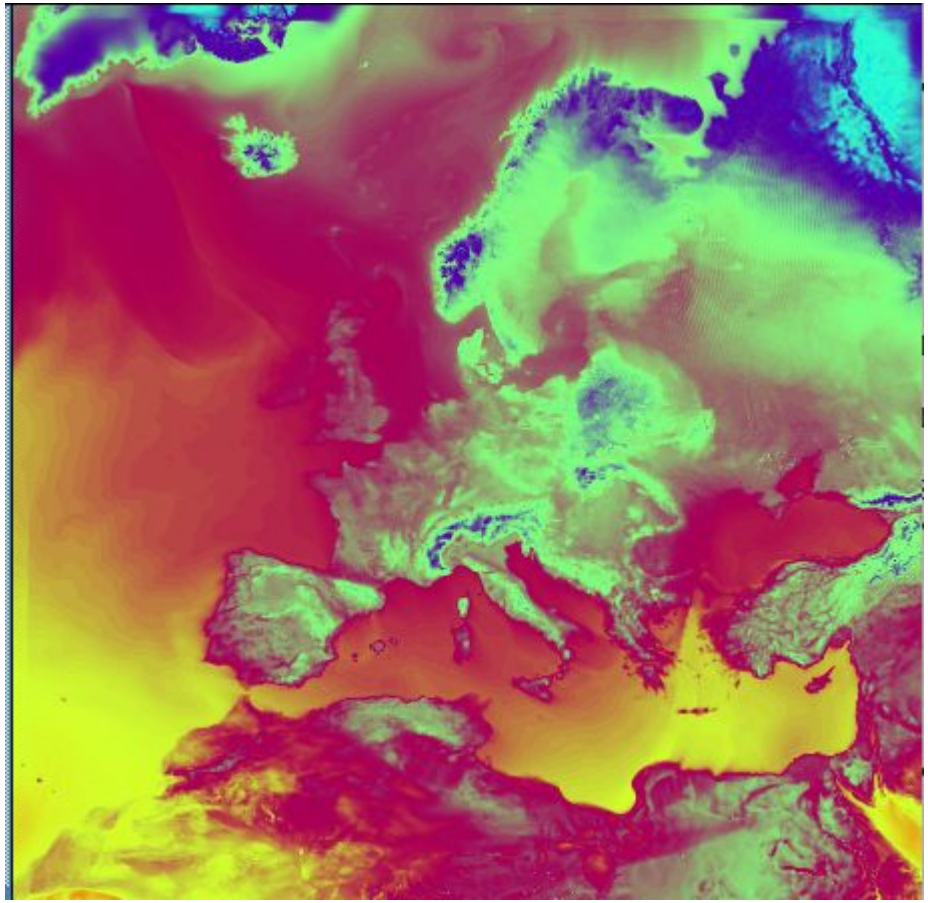

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