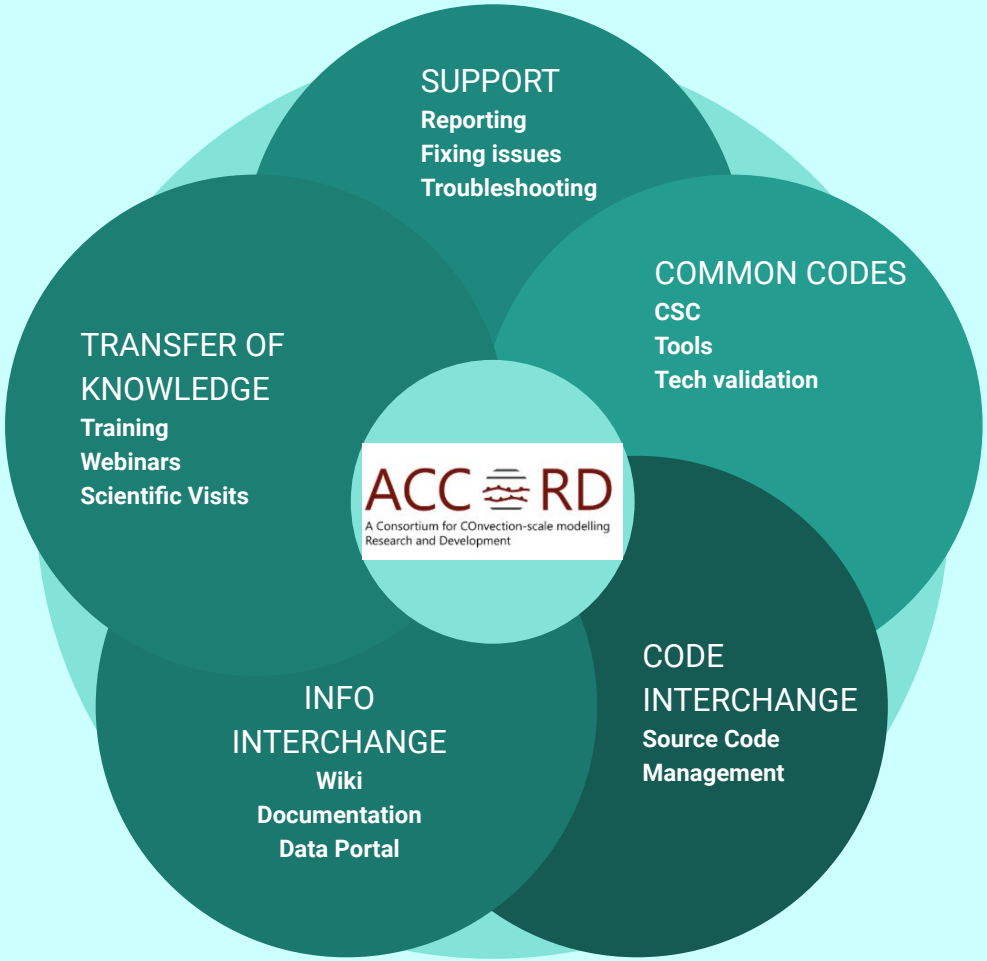
ACCORD

A Consortium for COnvection-scale modelling Research and Development

Summary of sessions and related side-meetings by Area Leaders, CSC Leaders, Integration Leader and chairs

All Staff Workshop 2023, 31 March 2023, Tallinn and hybrid

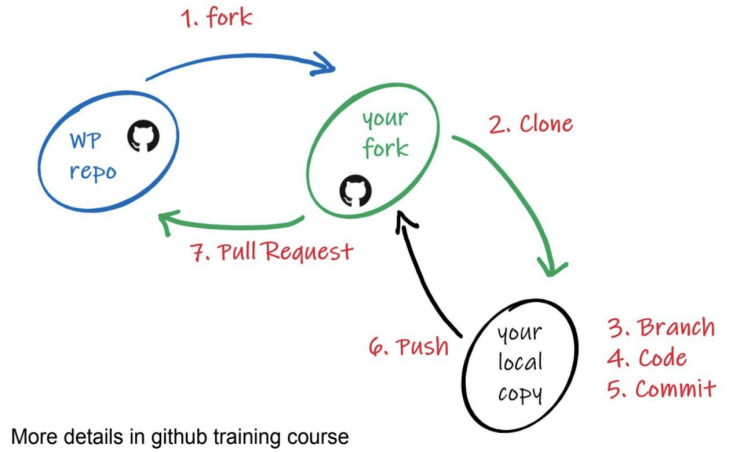
Code, System and Transversal Activities



Create a sense of community

D. Santos, D. Degrauwe, P. Termonia, A. Mary

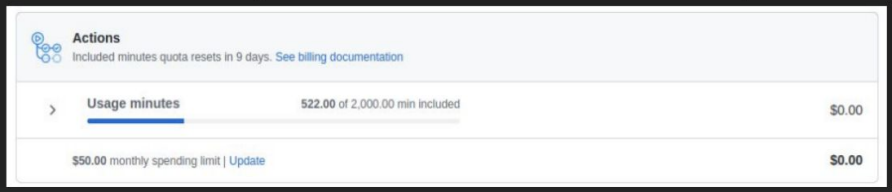
Code, System and Transversal Activities



More details in github training course

Continuous Integration (Github actions)

- `push2hirlam.yml`
  - Runs on any commit to Hirlam/Harmonie. Pushes changes to hirlam.org
- `documentation.yml`
  - Runs if changes in `docs/`
  - Creates html pages. deploys to HarmonieSystemDocumentation (public repo)
- `compile.yml`
  - Runs If changes to `src/`, `util/`
  - Runs cmake in cloud. Check e.g. project dependencies
- `CompatHelper.yml`
  - Runs monthly. Checks for new versions of Julia dependencies for documentation.yml



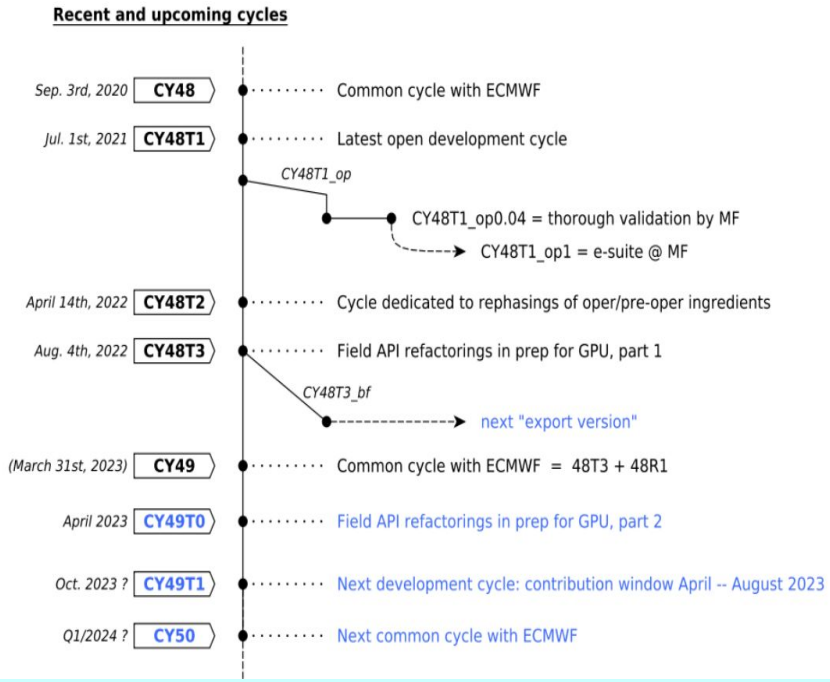
Documentation

Technical setup

- HTML pages automatically created by github action (including previews for PRs)
- HTML pages deployed to public repository HarmonieSystemDocumentation
- Github automatically starts web server (github pages)
- Google search console and Google analytics
- Documentation created using Julia + `Documenter.jl`
- Support for graphs BlockDiag, BPMN, Bytefield, C4, D2, DBML, Ditaa, Erd, Excalidraw, GraphViz, Mermaid, Nomnoml, Pikchr, PlantUML, Structurizr, SvgBob, UMLet, Vega, Vega-Lite, WaveDrom, WireViz

ACCORD
A Consortium for COnvection-scale modelling Research and Development

Code, System and Transversal Activities



CY49T1

Next ACCORD Development cycle

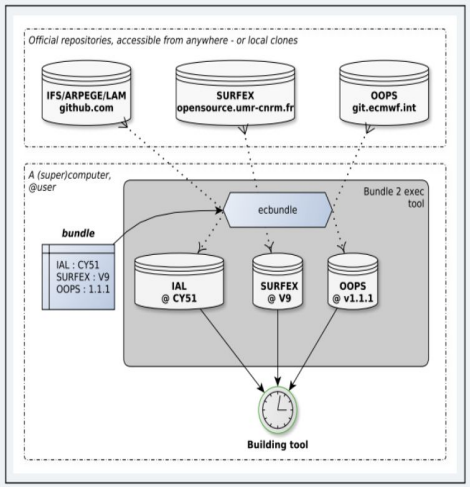
- Call for contribution April → August 2023
  Target declaration Oct. 2023
- Contents :
  - Surfex v8.1^{++} ($\approx$ 48T2 + 46H1)
  - PHYEX
  - rephasings MF e-suite `48T1_op1`
  - … (https://docs.google.com/spreadsheets/d/1h2ft2Fl0N4WMrz61faeu6xk6fOGI0Hgy9UrguW4lTTY/)
- Continuous Integration on ACCORD forge
- Will be a basis for next MF e-suite

DAVAÏ validation system

- **Porting** to ECMWF : ∼OK
- **Accessible dashboard** : `https://www.umr-cnrm.fr/davai/`
- **Bundling**-ready
- Systematic testing of **SP** on a subset of configurations
- **Required** for contributions to 49T1, on `belenos` or ECMWF's Atos@bologna
- **Getting started** : cf. `https://github.com/ACCORD-NWP/DAVAI-env` and there-mentioned User Guide

DAVAÏ trainings

- **Users-oriented webinars** for 49T1 contributors : *cf. above link*
- **Developers-oriented WW** (porting, maintaining, addition of tests) : Nov.2022 (→ introducing ALARO tests) + spring 2023



- `CY49` :
  - oops
  - (fiat)
  - (ectrans)
- in `gmkpack` : → `hub/`
- Tools for wrapping (ec)bundle+gmkpack : `IAL-build` on ACCORD forge
- Historisation of bundles : `IAL-bundle` on ACCORD forge

Code, System and Transversal Activities

Principles for porting (from ECMWF)

- No vendor directives in the code, except for well identified parts (spectral transforms, Field API library, etc.)
- Transform grid-point code using scripts
- Encapsulate field data using Field API

apl_arpege.F90

- Use Field API **everywhere**
- No more PGFL, PGMV, etc.
- No more module variables
- Finalized in cycle 48t3
- Refactor acvppkf.F90 (Judicael Grasset)

Generate **3 parallel** sections

- OpenMP : traditional OpenMP, on the host
- OpenMPSingleColumn : host, for validation
- OpenACCSingleColumn : device
- Select section at runtime

The Device

Transform NPROMA routines into OpenACC routines

- Scripts based on fxtran
- Best method = “single directive” (aka “SCC”)
- Use a pre-allocated stack buffer for temporary arrays
  - → Port easily large kernels using single directive method
  - → Optimal memory re-use
  - → Process routines independently
- actke.F90 → actke_openacc.F90, etc.

The Host

Transform NPROMA routines into parallel routines

- Scripts based on fxtran
- Method = “pointer parallel”
- Use custom directives
- apl_arpege.F90 → apl_arpege_parallel.F90
- apl_alaro.F90 → apl_alaro_parallel.F90
- etc.

Code, System and Transversal Activities

- Top 500 HPC systems:

  16 out of 20 top systems have accelerators

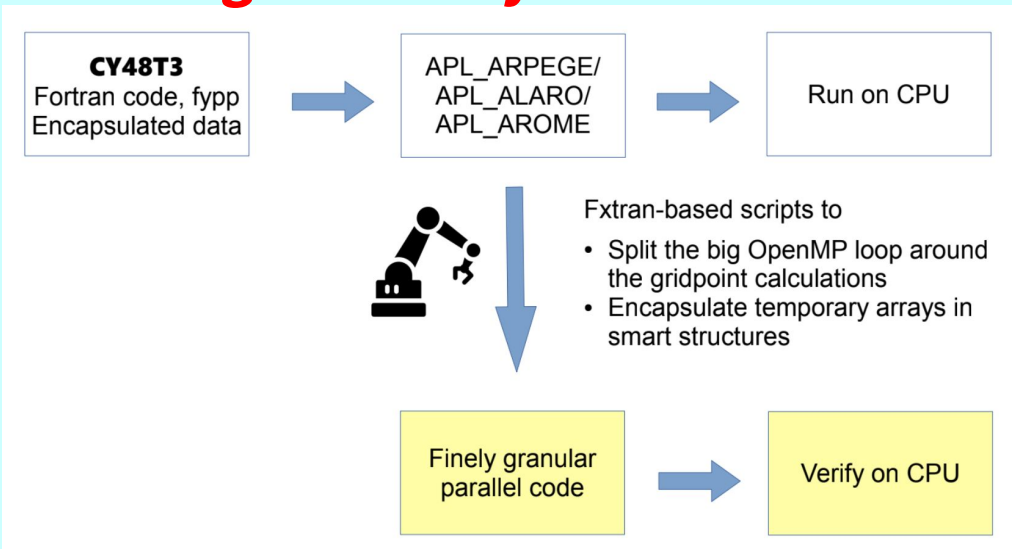
- Green 500:

  40 first systems have accelerators

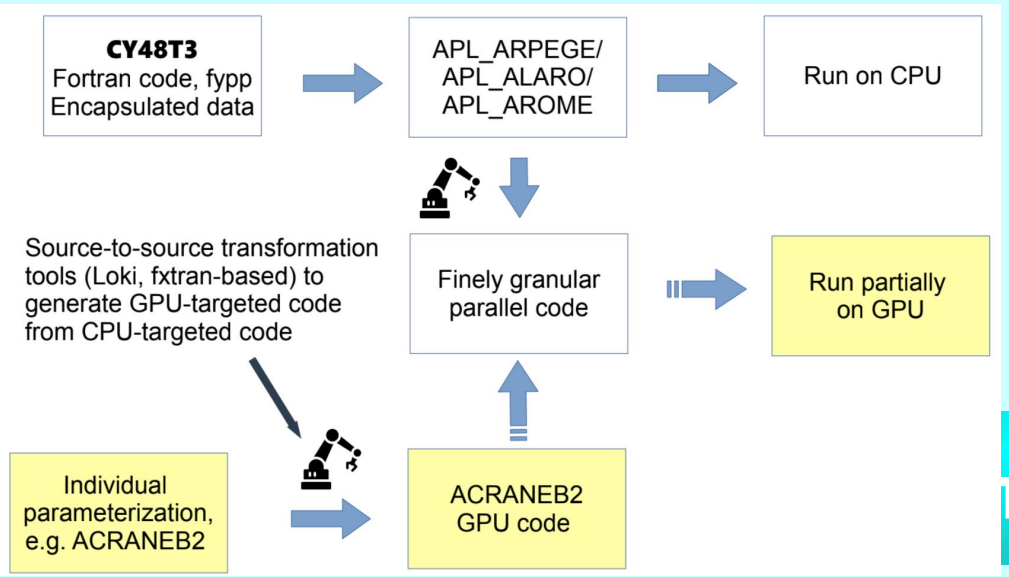
- EuroHPC infrastructure is targeted in the DE_330 project

- Trend towards using external HPC facilities for research and even operations

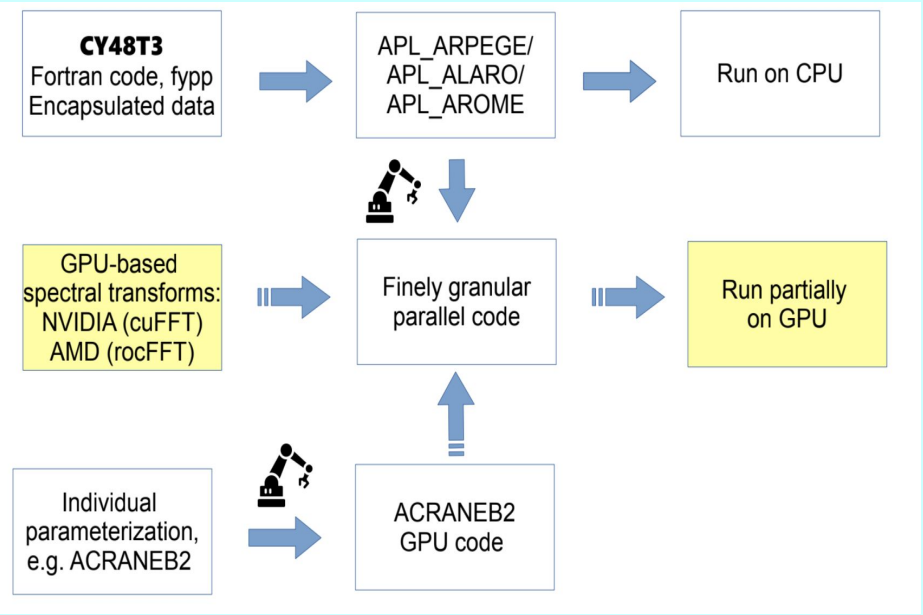
Parallel granularity



Source-to-source transformation



Spectral transforms on GPU



Code, System and Transversal Activities

Initial Conditions

very long subroutines and big computational blocks are not suitable for automatic translation to GPUs

ALARO physics called from the same aplpar as ARPEGE

Code and structures used in ARPEGE and ALARO are similar

Computations done at all levels in the code

Many items shared with ARPEGE:

- Data flow
- Allocations of local variables
- Initialization …

apl_alaro set up, Identified blocks with clear input and output

Initialization block (including correction of negative values)

- Turbulence
- Mixing length
- Microphysics and convection
- Radiation
- Diagnostics and postprocessing (will have to be distributed)
- Surface (turbulence)
- Dust

Testing apl_alaro on belenos

Three tests set up on belenos for various physics set ups of ALARO:

- Alaro 0
- Alaro 1
- Alaro 1 with graupel

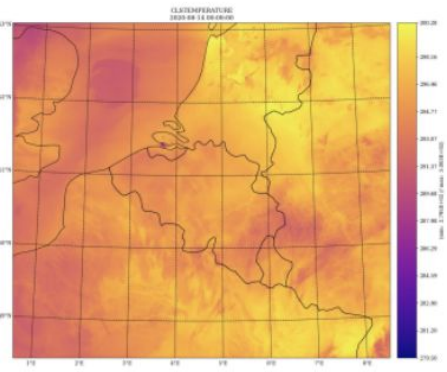
Also a small test on ECMWF machine

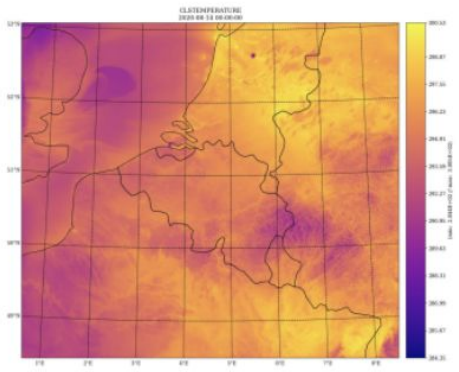
- To be complemented with the tests from belenos (SBU accounting)

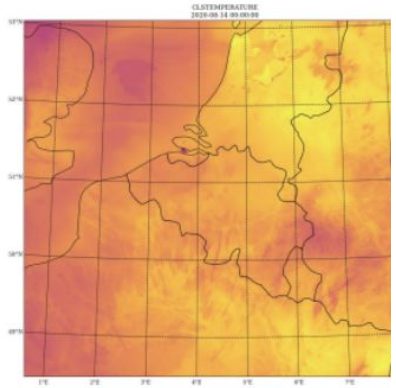
What is considered done gives bit-reproducible results

After the working week

- created 48t3 rootpack and test cases on ECMWF ATOS
- finish extraction of blocks
  a. Done for radiation
  b. Postprocessing either done or part of other blocks
  c. Turbulence and microphysics making good progress
  d. Initialization and surface
- apply fxtran-based scripts on refactored APL_ALARO
- find solution for array GFL fields EXT and EZDIAG
- remove references to PGFL, ZTENDGFL, PGFLT1 and PGMVT1
- minor changes to be carried out







Tests using ALARO (VHR example)

Test prepared for AROME using CY43T1 on Belgian domain in 700m

- https://opensource.umr-cnrm.fr/projects/accord/wiki/Belgium_Arome_700m (Thomas Vergauwen)

Has been adapted to run ALARO with or without SURFEX

Details here

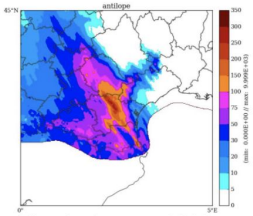
https://opensource.umr-cnrm.fr/projects/accord/wiki/Belgium_ALARO_700m

Code, System and Transversa

DESTINATION EARTH

Mission: Build a workflow that brings us a hectometric resolution forecast with any of AROME/ALARO/HARMONIE-AROME anywhere in Europe within the hour, and couple it with the appropriate impact model, on LUMI@CSC

Detect a possible extreme event from the global mode



The Aude case 2018

Activate the appropriate setup over the domain of interest on < 1km resolution

Run the relevant impact model

A more data centric approach

We are starting with

- GRIB2 output to files
- Store in FDB (ECMWF Field DataBase)
- Puts some requirements on GRIB2
- Huge job together with ECMWF on defining a new SURFEX GRIB2 template
- Preparing for sub hourly output and ccsds packing

Exploring

- Writing directly to FDB from the NWP model, and other applications
- Read directly from FDB for downstream applications
- Removes a few unnecessary/costly IO steps

Aiming at

- Interface with the new ECMWF multiplex IO server accessing/pushing data runtime
- Do the work while data is in memory!
- Isn't necessarily happen during this phase

Details about the scripting

- Python based (surprise surprise)
- Large focus on following standards, unit testing, code coverage from the beginning. Apply github pipelines and CI/CD processes
- Modularity, e.g. separate ecflow from the tasks
- All tasks should be possible to run stand alone for easier development and debugging
- Config file driven (yaml, toml, json)

ECMWF https://github.com/DEODE-NWP

Worrying about the speed of all components, some examples

- PGD is now in the time critical path, strong requirements on speed
  - Use MPI parallelized version
  - Reduce input data amount by tiling
- PREP is not very fast by default
  - Use MPI parallelized version
- Run forecast model in single precision
  - Fine in a "clean" setup, but coupling AROME -> AROME poses challenges

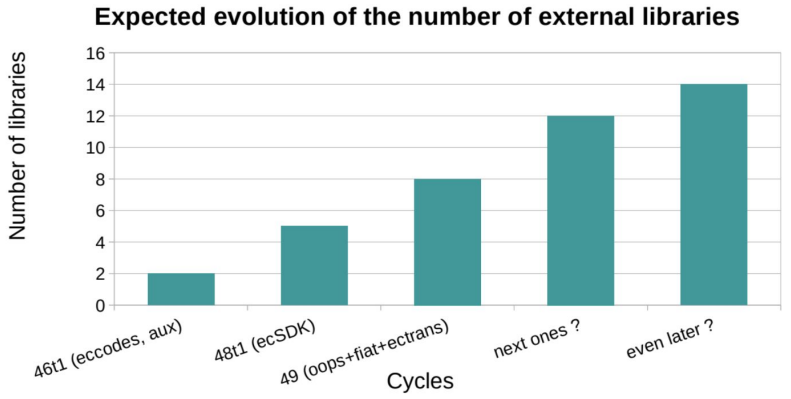
Highly dependent developments done by others!

ACCORD
A Consortium for COnvection-scale modelling Research and Development

Code, System and Transversal Activities

1) The quantic jump from cycle 48t* to cycle 49t0

- New auxilary files (RTTOV new version and new RRTM data files)
- Several namelist key-variables movments from dynamics
- Project PHYEX (Meso-NH physics) for which mpa/ is its Arome interface
- Part of auxilary code « ifsaux » replaced by an external library « fiat » in another code repository
- Global spectral transforms « trans » replaced by an external library « Ectrans » in another code repository
- « algor » partly moved to fiat or ectrans
- oops_src replaced by «OOPS» in another code repository
- Also new fields in IFS GRIB files (5 snow layers, …)
- New compression algorithm in IFS GRIB files in cycle 48R1 (libaec) requiring an update of eccodes library
- Important code refactoring for GPUs, incl. .fypp files *(from cycle 48t3)*



=> more complex management of libraries through multiple repositories

CPU
Single Instruction
Multiple Data
(SIMD – n ~ 8)

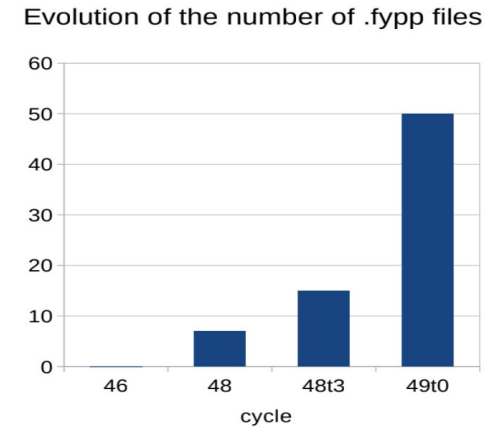
VECTOR ENGINE
Vector pipelining
n=256

GPU
Single Instruction
Multiple Threads
(SIMT n ~20000)

2) GPUs (and some consequences) for dummies

Strategy :

- *Reorganize the data layer*. This work has started with the help of a source code preprocessor : fypp (https://fypp.readthedocs.io/en/stable/fypp.html).
  Appears in cycle 48t3.
- *Reorganize the code* to isolate the pure computational part, by the creation of an adequate interface layer.
- Develop and use a software before compilation, to transform the source code and make it compliant with the targeted hardware (CPU, GPU, …) : loki, fxtran.



Dynamics

- **Lace Activities**
  - Predictor corrector on demand : having a more stable configuration at a reasonable cost, a new criterion based on a percentage of gridpoint having a vertical divergence derivative over a threshold
  - Frame approach in LBC : compress the coupling file size, not so obvious, framed files at full resolution still have a large size, it requires to work with the initial resolution.
- **Testing Very High Resolution HARMONIE-AROME**
  - Hector configuration E suite @750m cubic. dt=3 RDAMP*=10, 3Dvar. Main improvement comes from moving to 90 levels. Better in general but not everywhere.
  - Testing impact of LBC Best results with IFS boundaries, age matters with coupling to HARMONIE AROME (not for IFS)
  - Current challenges in DE_MF_330 over orography : 500m probably OK, but 200m too difficult right now, resolution gap might be a problem, we might try to use initial spurious oscillations damping techniques.

Dynamics

- **Questions/Discussions**
  - Remarks on the impact of code refactoring on change on timestepping scheme on demand.
  - Hector configuration night small degradation linked with physics parameter tuning
  - older LBC from IFS linked with spinup issue ? (for LBC from HARMONIE-AROME the latest are better)
  - The link with first level height and stability, clearly moving from 65 to 90 with HARMONIE-AROME decreased the stability, other experiments suggest the link between first model height and stability is not so obvious, we have more to think in terms of optimal vertical level distribution.
  - Vertical levels are increased more in the boundary layer and in the troposphere than upper levels when moving to more levels.

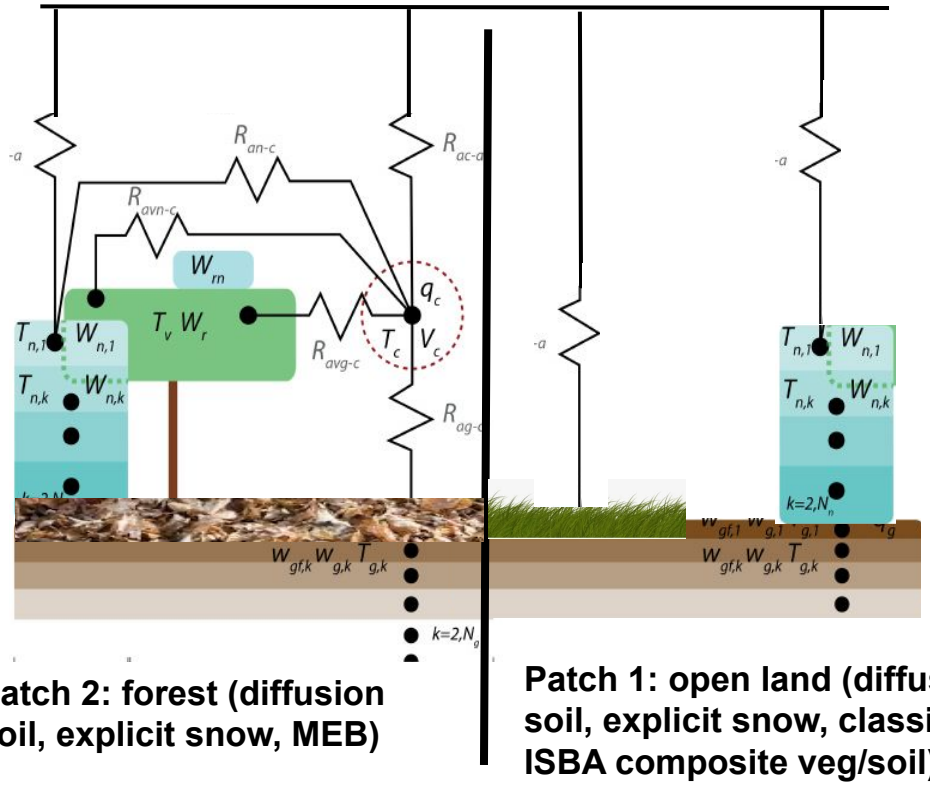
Plenary Surface session

Chair: Ekaterina Kurzeneva co-chair Rafiq Hamdi

- **SAMUELSSON Patrick: Overview of ACCORD surface activities**
- **TOTH Helga: SEKF Surface Assimilation in Hungary**
- **BATRAK Yurii: Sea ice in the CARRA reanalyses**
- **MARIMBORDES Sophie: Towards an ensemble approach to surface analysis for the NWP model AROME**
- **NIELSEN Kristian Pagh: Forecasting solar PV yield**
- **LEBEAUPIN BROSSIER Cindy: The AROBASE project: Towards a kilometer-scale AROME-based multi-coupled modeling and forecasting system**

Current recommended setup of new surface physics

Experiments and experience so far how the design of new surface physics should look:



Patch 2: forest (diffusion soil, explicit snow, MEB)

Patch 1: open land (diffusion soil, explicit snow, classical ISBA composite veg/soil)

Recommendation: at least 2 patches, maybe more (e.g. bare soil)

E.g., this is the design we have decided to use for Deode.

So, if you have the idea to go for another combination you should motivate it well :-)

E.g. using the sophisticated 12-layer ExplSnow scheme over forested regions without MEB, meaning that you have a pile of snow separated from the forest, is not working well.

Aaron Boone's experience is that MEB also helps in semi-arid forested areas to prevent excess soil evaporation.

Surface data assimilation - overview

Operationally, OI surface assimilation is still our working horse in most setups with assimilation.

Circumstances decide how short-medium term solutions beyond OI look in our consortia:

Ensemble NWP system: OI for soil with EPS-coeff.

Ensemble NWP system: EnKF-based solution

Deterministic and Ensemble NWP system: (S)EKF-based solution

MetHungary by Helga Toth

Crowd-sourced focus: TITAN/gridPP spatialisation

Less weakly coupled atm-surface assimilation

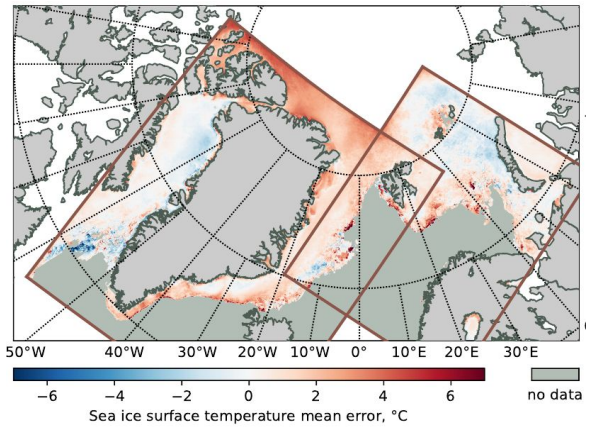
Katya & Roel

OI soil for the diffusion soil scheme

2D-Var
2D-EnVar

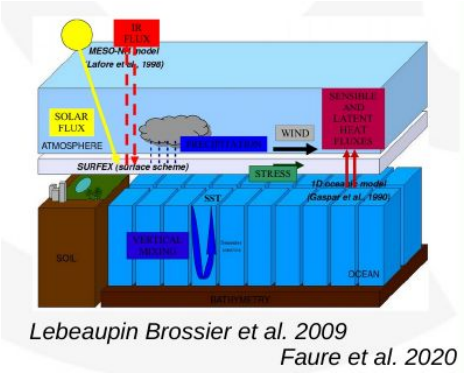
Météo-France by Sophie Marimbordes

Sea and sea ice



SICE by Yurii Batrak for CARRA

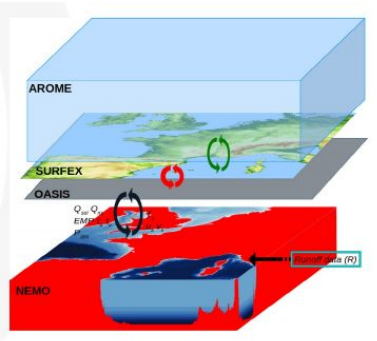
SURFEX common branch includes two ice schemes, SICE (used in HARMONIE-AROME) and GELATO (used in Arpege).



Lebeaupin Brossier et al. 2009
Faure et al. 2020

Sea-column model mentioned by Cindy Lebeaupin Brossier for the AROBASE project.

SURFEX includes the 1D-ocean model which is used in the AROME overseas setups by Météo-France.



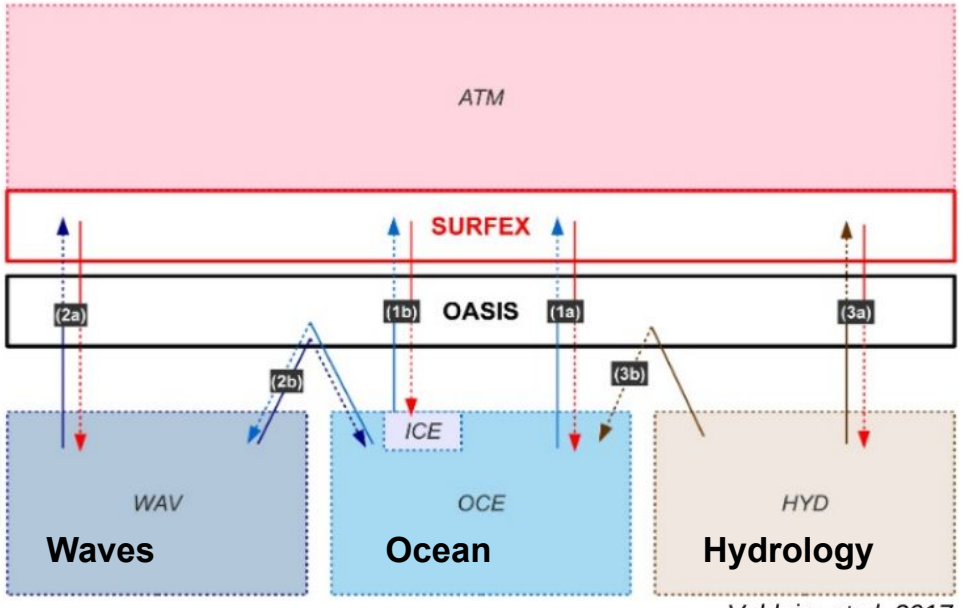
M2 internship Q. Misi (2022)
PhD M. Marquillie (2021-2024)

AROME-SURFEX-OASIS-NEMO/SI³/TOP-PISCES/MFWAM mentioned by Cindy Lebeaupin Brossier for the AROBASE project.

With the OASIS coupler (included in SURFEXv8.1) any external model can be coupled to SURFEX

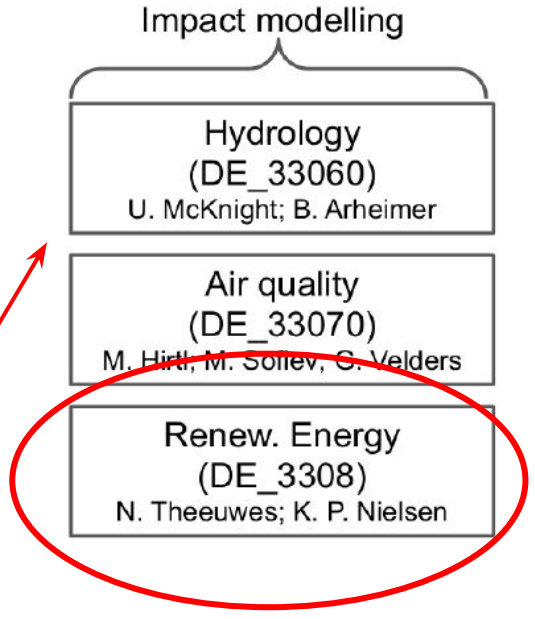
OASIS allow coupling to various models

From Cindy's presentation



Voldoire et al. 2017

From Kristian's presentation related to activities in Deode



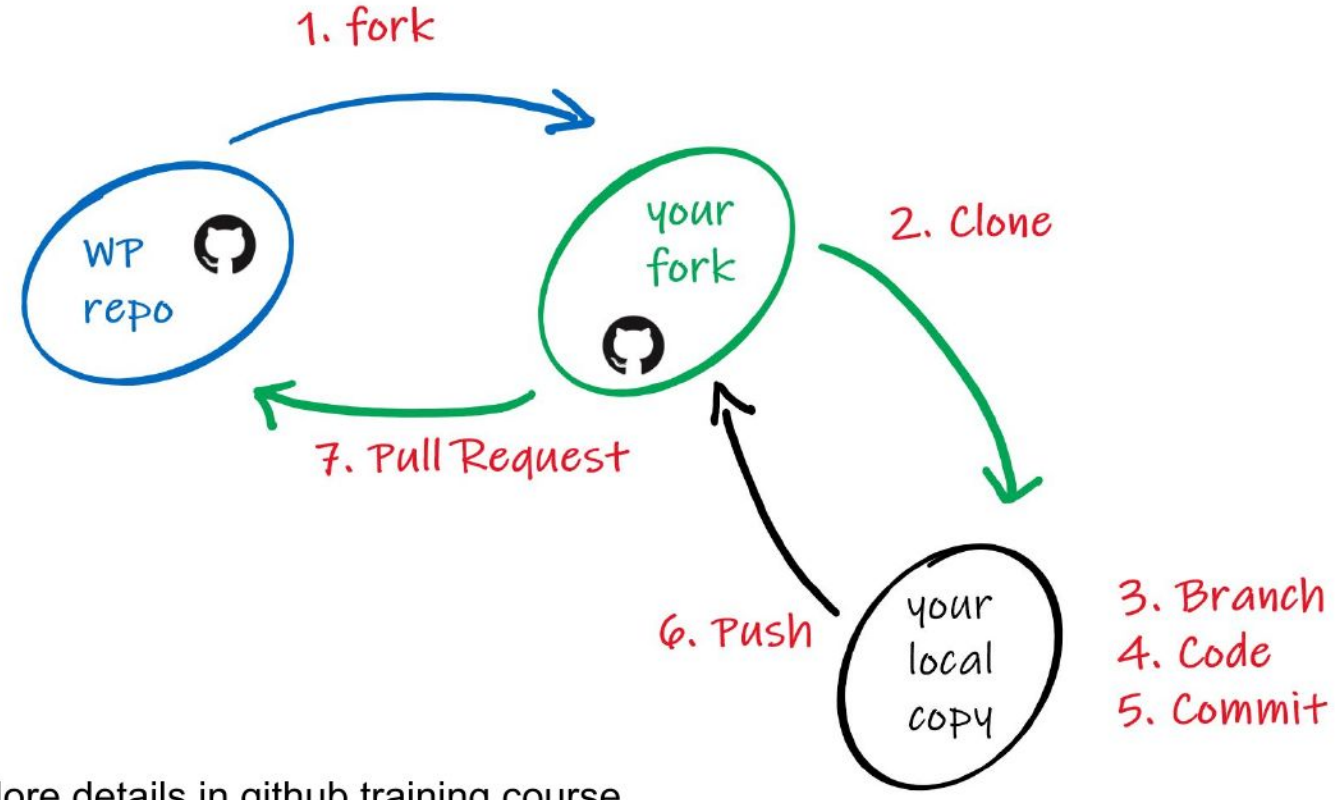
Forecasting solar PV yield by Kristian P. Nielsen

ACCORD GitHub and specifically the SURFEX-NWP repository

STAPPERS Roel: [Experiences and workflows in Github for Harmonie]

MARY Alexandre: [Cycles and source code management]

SANTOS Daniel: [Moving towards a more common and transparent environment for ACCORD systems]



More details in github training course

Meteorological Quality Assurance

Chairing: *Christoph Wittmann, Joël Stein*

Methods

1. SINGLETON Andrew: Fractions Skill Score for ensembles with harp
2. STEIN Joel: Use of the neighborhood Brier divergence for ensemble forecasts verification
3. SUZAT Florian: SCOOPS prototype : scores using OOPS screenings

Applications

4. WHELAN Eoin: Verification of early common UWC-W forecasts
5. TASCU Simona: Verification activities in RC-LACE
6. TÓTH Boglárka: Verification results of AROME-EDA winter experiment

Plans

7. FORTELIUS Carl: Organizing user-developer interaction in ACCORD

Andrew Singleton:
Fractions Skill Score for ensembles with harp

Comparing spread and skill at different scales without reference to the ensemble mean:

error fractions skill score, dispersion fraction skill score

C. Fortelius

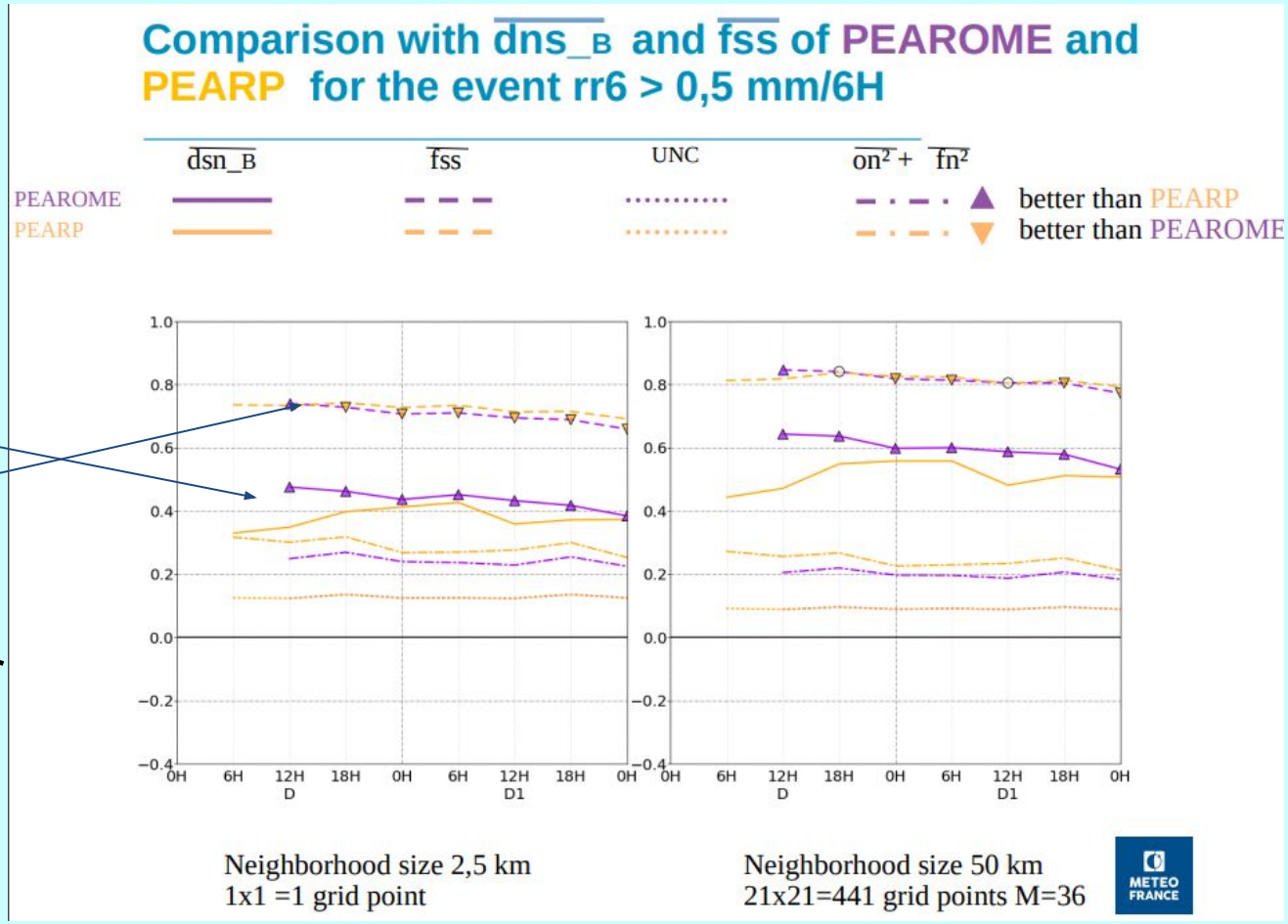
ACCORD
A Consortium for COnvection-scale modelling Research and Development

Joel Stein: Use of the neighborhood Brier divergence for ensemble forecasts verification

dn_B is a proper score

skill score dsn_B keeps the order given by the Brier divergence (unlike fss)

Stein and Stoop (2023) in revision for Monthly Weather Review



C. Fortelius

ACCORD
A Consortium for COnvection-scale modelling Research and Development

Florian Suzat: SCOOPS prototype : scores using OOPS screenings

Scores using as reference the **observations and observation operators applied in data assimilation (screening)**

Highly sophisticated software and user interface

Eoin Whelan: Verification of early common UWC-W forecasts

- Comprehensive operational verification based on **harp**
- Organized user feedback: forecaster meetings, web page
- Under preparation
  - Correct time and place of radio soundings
  - Scatterometer data
  - Verification using **screening** (opportunities for joining forces with SCOOPS developer(s)?)

Simona Tascu: Verification activities in RC-LACE

- Extending use of **harp**
  - e.g. simulated IR channels (Austria)
- Subjective verification approaches
- Model output post-processing
  - e.g. ML post-processing of global radiation from AROME EPS (Hungary)
- Database of cases

Boglárka Tóth: Verification results of AROME-EDA winter experiment

Example of a carefully planned and executed evaluation comprising statistics for extended periods and case studies

Verification method

Objective

OVISYS

Objective VerIfication SYStem

- Perl-based
- Pointwise verification
- **Deterministic** verification metrics
- RMSE, bias
- EPS-mean, EPS-control

Self-developed verification system

- **Probabilistic** verification metrics
- Fortran + Metview macros
- CRPS, Spread-Skill, Brier-score, bias, Percentage of outliers, Talagrand

Hirlam-Aladin R Package for verification

- **Probabilistic** verification metrics
- First tests at the end of 2020
- Available from Autumn of 2022

Subjective

By the model developer
By the forecasters

HAWK macros

Local perturbation tests: EDA experiments

3 periods:

- **1-31 July of 2021**, Forecasts at 00 UTC, +24h, Spinup: 10 days
- **1-31 January of 2022**, Forecasts at 00 UTC, +24h, Spinup: 10 days
- **15.11-15.12. 2022**, Forecasts at 00, 12 UTC, +48h, **quasi-operational** run: August 2022

Carl Fortelius: Organizing user-developer interaction in ACCORD

Proposal:

- Collection of feedback from member institutes by dedicated ***user representatives***
- Focus on ***meteorological phenomena***
- Actions and response coordinated by MG

Ensemble Prediction System

Perturbations

- Progress and plans for **SPP**=**S**tochastically **P**erturbed **P**arameterizations **OR** maybe for
- **S**urface **P**arameter **P**erturbations **OR**
- **S**ensitive **P**arameter **P**erturbations **OR**
- **S**mart (i.e. flow-dependent) **P**arametrization **P**erturbations **OR**
- **S**ingle **P**recision **P**erturbations

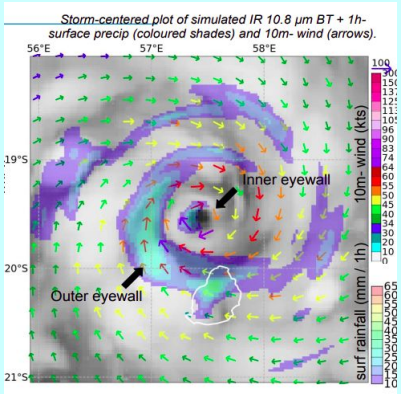
Multiple issues observed for SP SPP:

- Linked to "divergence" in SP patterns from DP behaviour
- Appears to be resolved thanks to Ole's changes

Ensemble Prediction System

Operations

➢ AROME-OM EPS operational for 5 tropical domains. Example showing that AROME-OM EPS is capable of forecasting intensity and structure of a tropical cyclone



➢ Upgrades of several EPS's since last ASW

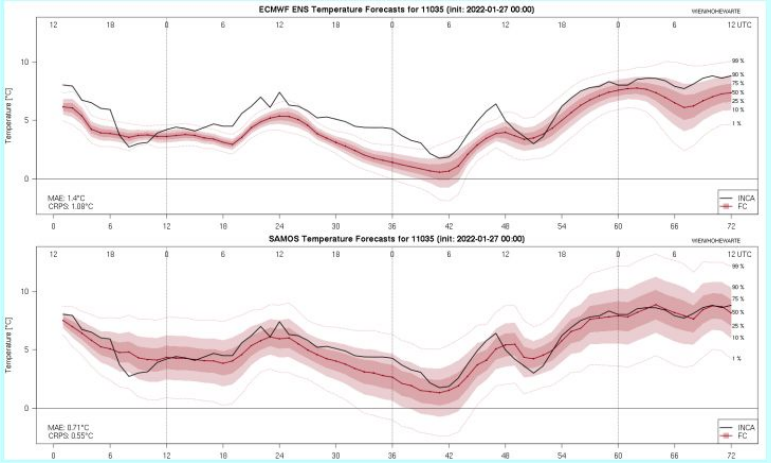
➢ Plans for

- new UWC-West EPS
- 1km resolution, possibly extended C-LAEF domain involving more LACE countries
- convection-permitting ALARO-EPS for Slovakia

Ensemble Prediction System

Post-processing

- ➢ Analog ensemble forecasting system for low visibility in Moroccan airports using deterministic AROME forecast and analogs
- ➢ EMOS calibration of global radiation ensemble from AROME-EPS
- ➢ Calibration of 100m wind speed from AROME-EPS using multilayer perceptron machine learning
- ➢ Seamless calibrated ensemble forecast using standardized anomaly model output statistics (SAMOS) from GeoSphere Austria



Data Assimilation - algorithms

- 3DEnVar in OOPS:
  - Covariances directly sampled from the ensemble, flow-dependent increments
  - All relevant components for 3D-Var/EnVar from cy48t1
  - Clear benefit on forecast despite less fit to observations at analysis time
  - Flexibility of the system (vertical dependent localization, other extensions)
  - Pure EnVar preferred over hybrid
- Evaluation of subhourly DA cycle:
  - Experiments with synthetic Doppler winds, FA&3D-Var&VC (10m, 20m, 1h)
  - Sub-hourly experiments performed worse than hourly runs

Data Assimilation - observations

- Footprint operators in (radiance) DA
  - Improve representation of the background
  - Positive impact in complex areas (coastlines, ice edges)
  - Current implementation costly (frequent calls of RT operator)
- Radar assimilation:
  - Bayesian inversion needs further adjustments (ALARO in Central Europe)
  - Wind aliasing solution validated in the NWP context but outside DA, impact studies needed (and possible implementation at OPERA)
- Surface pressure observations from ships
- Beneficial impact SEVIRI WV channels over Spanish domain (sea) with simple VarBC implementation

Data Assimilation - alternative observations

- ZTD observations from trains
  - Feasibility study done on a limited data sample, acceptable quality demonstrated
  - Challenge: design of bias correction
- Rain-rate estimates from telecommunication microwave links assimilated with 1D+3D-Var method
- Is there potential to scale-out these obs. networks?

Applications

- Plenary session : Applications. Chair: Laura Rontu co-chair Matthieu Plu
  - PLU Matthieu: The Meteo-France 48t1 e-suite: summary of content and performance
  - YANG Xiaohua: Operational on-demand VHR weather forecasts
  - RANDRIAMAMPIANINA Roger: Destination Earth On-Demand Extremes Digital Twin
  - THEEUWES Natalie: The Hectometric Modelling Challenge
  - BAZILE Eric: ARRA : A kilometric re-analysis with AROME over France

In the application session 5 overview presentations were given. 14 questions from in-situ and online participants were asked in order to clarify various details shown in the presentations. General (development) discussions did not take place.

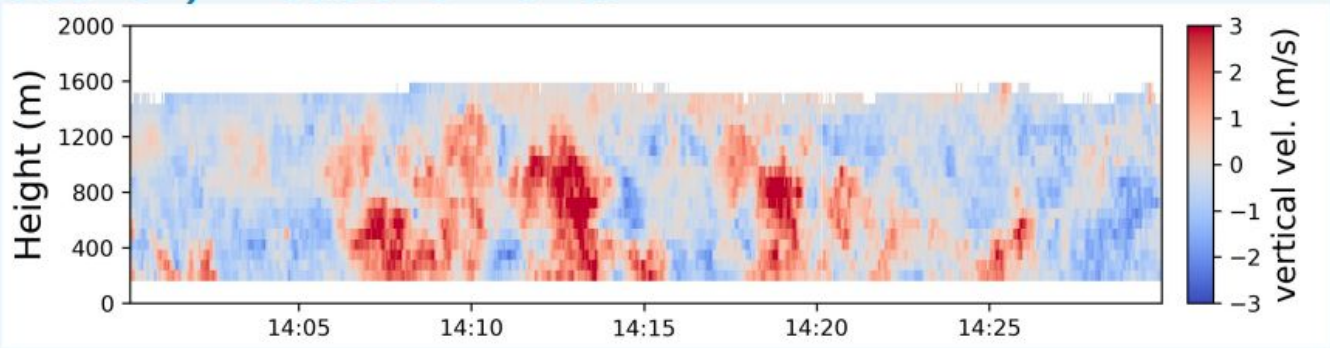
- **Mathieu Plu suggested that in the MF 48t1 e-suite improved scores of AROME-FRANCE and ARPEGE were mainly related to improved 3D-EnVar data assimilation.**
- **Xiaohua Yang showed that operational HARMONIE-AROME setups with 750m/65L resolution over 6 domains in Greenland improved wind forecasts, clearly decreasing the false storm alarms. Regular runs are expensive, on-demand affordable.**
- **Roger Randriamampianina stressed the importance of collaborative design, development and production in DEODE Extreme DT project. Together with ECMWF, important work in defining model output variables has been done.**
- **Nathalie Theeuwes reported about a collaborative workshop to prepare a manuscript about hectometric modelling challenge. She demonstrated the potential of new doppler lidar observations for verification of hectometric HARMONIE-AROME and LES results (a screenshot on the next page).**
- **Eric Bazile discussed the various ways to treat initial and boundary conditions for AROME-FRANCE-based reanalysis ARRA. Incremental analysis update was shown to be useful, impact depending on variable and forecast lead time.**

Applications

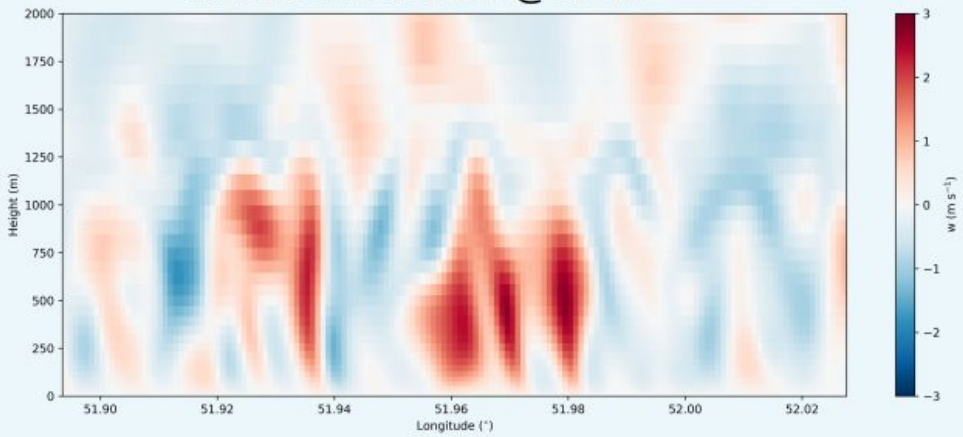
- Plenary session : Applications. Chair: Laura Rontu co-chair Matthieu Plu
  - PLU Matthieu: The Meteo-France 48t1 e-suite: summary of content and performance
  - YANG Xiaohua: Operational on-demand VHR weather forecasts
  - RANDRIAMAMPIANINA Roger: Destination Earth On-Demand Extremes Digital Twin
  - THEEUWES Natalie: The Hectometric Modelling Challenge
  - BAZILE Eric: ARRA : A kilometric re-analysis with AROME over France

from Nathalie Theeuwes' presentation:

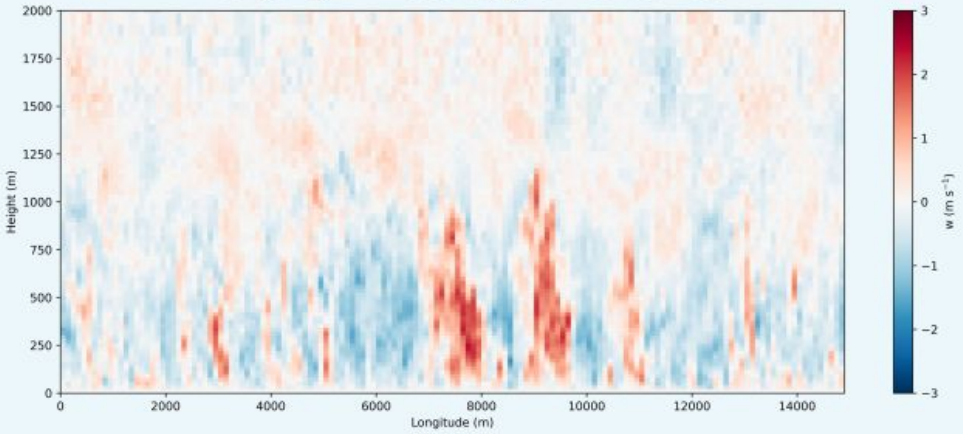
New (research) measurements



HARMONIE-AROME @ 100 m



LES @ 19 m – coarsegrained to 100m



Royal Netherlands Meteorological Institute

10

Physics parametrisations

- Physics parametrisation - current developments
- Parametrisation in higher-grid mesh simulations - impact studies & perspectives
- Surface-atmosphere coupling and diagnostics
- AI in NWP (parametrisations)

E. Bazile, J. Onvlee, M. Tudor, M. Shapkaljevski

Physics parametrisations

❖ Physics parametrisation - current developments

- ➢ microphysics
  - ■ *David presented the work done with prognostic graupel in ALARO, the slower fall speed contributes to higher evaporation rates and modifies temperature profiles and geopotential heights, reduces convective prec maxima (good thing), worsening of surface,introducing new evaporation improved precipitation and upper air, but worsened the surface scores*
- ➢ aerosols and their interaction with clouds and radiation
  - ■ *Yann presented how AROME-F uses and plans to use aerosols, from ICE3 to LIMA and near-real-time aerosols (NRT). Similarly, Laura presented how CAMS near real time aerosols are used in HARMONIE radiation and microphysics and consequences on the forecast*

Take home message: *The availability and possibility of using near-real-time aerosols as an input in our NWPs is beneficial for the forecast. There is a need of using the NRT aerosols and in more dynamic/prognostic mode (advection/transport, removal by deposition). Using more complex microphysics - more realistic precipitation forecasts (prognostic groupel, LIMA).*

Physics parametrisations

❖ Parametrisation in higher-grid mesh simulations - impact studies & perspectives

- ➢ from nowcasting to climate simulations
  - ■ *Erik G. showed examples of operational nowcasting system, as well as successfully running VHR experiments (2.5 km to 200 m)*
  - ■ *Radmila presented ALARO climate simulations in 2.3 km with results comparable to other clim models*

- ➢ combined effects of horizontal diffusion (pseudo), shallow-convection & dynamics in NWP over steep orography
  - ■ *Erik B. challenges is to find the optimal tuning (resolution, stability - computation efficiency): provided a list with the optimal settings and questions*
- ➢ scale-aware SGS transport & cloud schemes
  - ■ *Wim* showed preliminary results of using scale-aware SGS transport scheme for the 'gray zone'

- ➢ 3D physics (Radiation & Turbulence) - from the side meeting
  - ■ Radiation: organise the work on SPARTACUS and ecRAD (same as last year); decide what would be technically needed to work; make some studies (possibility/impossibilities) and human power
  - ■ Turbulence: Goger term is well computed and implemented in AROME-F (cy48t1) and ALARO; detailed validation is ongoing , 3D physics meeting postponed? (TBD)

Take home message: *we are starting to apply parameterization suitable for hectometric scale and steep orography; however there are still some challenges (e.g. how radiation should be used, dynamics stability at 200m resolution)*

Physics parametrisations

- **Surface-atmosphere coupling and diagnostics**
  - near-surface temperature over mountains
    - *Danae and Ingrid presented analysis and suggestions for improving model diagnostics (overcoming the T2M cold biase, lightning, storm helicity, thermal vertical velocity, snow depth)*
  - thermal (static) stability
    - *Marvin identifies the need of model separation of the thermal stability in the stable range into weakly and very stable; physics behind defer (coupled vs decoupled near-surface-atmosphere)*

Take home message: ongoing study on identifying and possibly improving surface-atmosphere coupling parametrisations in very stable thermal stability (low wind speed), as well as model diagnostics

Physics parametrisations

- **AI in NWP parametrisations**
  - exploring possibilities: Thomas presented a Review on studies showing AI based weather prediction (FourCastNet vs Pangu-Weather vs GraphCast), while Matthew identifies possibilities how ML can help improving the NWP (Hybrid ML+NWP)

Take home message: can AI/ML models be reliable for regional to VHR weather prediction? - current best AI models for WP cannot reproduce the fine scales. Explore possibility of using ML to improve NWP: emulating model components (e.g. radiation), observational operators, online correcting the model bias,

Very High Resolution side meeting: results

- Eric Bazile: 500m and 200m runs for TEAMX case and 3 November Innsbruck case
  - assessed the impact of many options: cubic/quadratic/linear; time step; effect of coupling
  - many diagnostics evaluated: energy spectra, plots, TKE fields, RR, all illustrate noisy results especially at 200m
  - current conclusion: run VHR configs over complex orography at 500m, not 200m
  - Erik Gregow: 200m simulation of storm over SW Finland (dt=15s, no PC) was doing fine (mild orography !)
- Christoph Wittmann complements with illustration of model verification using panelification with INCA as ref data
- Carl Fortelius shows a simple user-interfaced tool to plot spectral and gridpoint norms from log files

Very High Resolution side meeting: discussion about dynamics and algo

- on the experimental side:
  - assess the impact of diffusion, possibly retune
  - use cubic grid for stability, perhaps OK even if the model resolution becomes “hybrid” ?
  - also study convective cases in weak flow
- emphasize research on dynamics, focus on studying ways towards more stability (perhaps at the expense of accuracy) => promote such work to newcomers with applied maths profile
- importance of initial conditions balance w/r orography could be studied: digital filters?, other ?

Very High Resolution side meeting: discussion about link with physics

- is there a stability issue in the link between dynamics and physics ?
  - study the effect of physics called less often than dynamics ?
- surface: tiles still needed at 200m
- radiation calculations on a coarser grid than the model ?
  - with current radiation codes, we could run it at 4km and use SPARTACUS for assessing 3D effects
  - how to ensure a consistent energy budget for a coarse grid radiation and a fine resolution surface and tiles ?
- the “cubic grid dilemma”: what is the actual resolution of a model run on a cubic grid ?
  - how to interpret the horizontal gradients when the spectra are significantly truncated ? (eg 3D effects in turbulence)

Very High Resolution side meeting: continuation of VHR WG ?

- rather a consensual “yes” for continuing
- open to more participants: interested people should contact Claude
- meetings likely less frequent than in the 2021-2023 phase (perhaps 2/year)
- the agenda will be very open, teams will be largely invited to show their results, raise questions, show or discuss model diagnostics for VHR
- perhaps from time to time, invite an expert (from ACCORD, from outside), to give a talk on a topic of interest (?)
- reminder: the material collected by the VHR-WG is available to all ACCORD staff with access to the wiki
- position w/r DEODE: ACCORD activity is long term R&D, where DEODE has extremely constrained timing and must deliver in about 20 months