ACCORD

A Consortium for COnvection-scale modelling Research and Development

On the process-oriented validation of weather forecasting models; status and perspectives in ACCORD

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Outlook

- Background & significance
- Summary of the Madrid WW and more
- Future perspectives in ACCORD

Motivation

Why do we need a process-oriented validation?

Storm-resolving NWPs & impact weather

Models are expected to provide a confidence in climate projections (many decades) and weather predictions for hours (sub-hours) to seasons

- Predicting the **mean weather** well; but storm-resolving NWPs focus more on deep convective weather systems => improving **extreme meteorological weather**

- **Impact weather** - extreme meteorological events from users' points of view
  (icing on roads, icing on structures, small-scale (local) showers, UAV aviation needs)

  - Need of **process-oriented weather forecast** (the mean weather forecast insufficient)

Option 1: improve parameterization

$$\frac{\partial q^{l,s}}{\partial t} + \mathbf{v}\nabla q^{l,s} = -\frac{1}{\rho}\nabla F_z^{l,s} + S_z^{l,s} + \frac{1}{\rho}\frac{\partial P^{l,s}}{\partial z}$$

Hydrometeors evolution

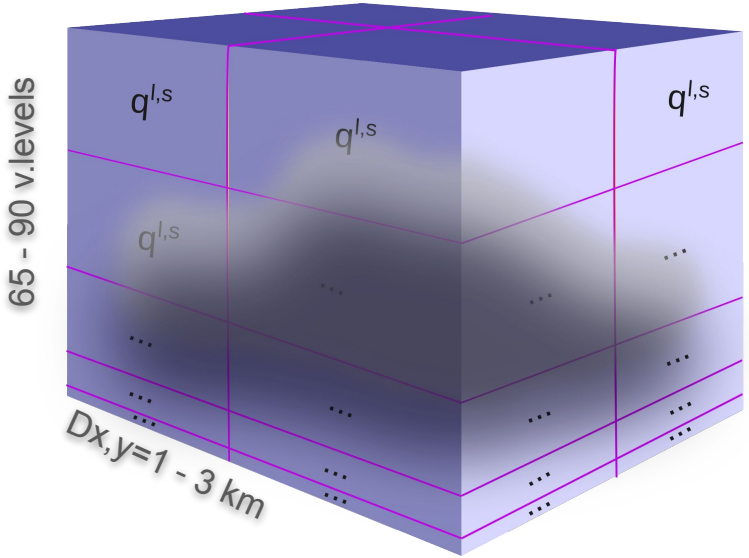
Large-scale transport (advection)

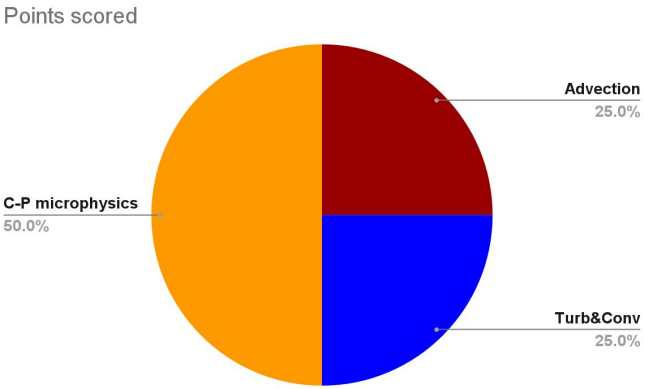
Turbulent and convection transport

Microphysics:

condensation, freezing, autoconversion,

Precipitation and sedimentation flux





Well established balance between large-scale and SGS contribution in NWP currently

Option 2: towards VHR in NWP? E.g. DE_330

$$\frac{\partial q^{l,s}}{\partial t} + \mathbf{v}\nabla q^{l,s} = -\frac{1}{\rho}\nabla \mathbf{F}^{l,s} + S_z^{l,s} + \frac{1}{\rho}\frac{\partial P^{l,s}}{\partial z}$$

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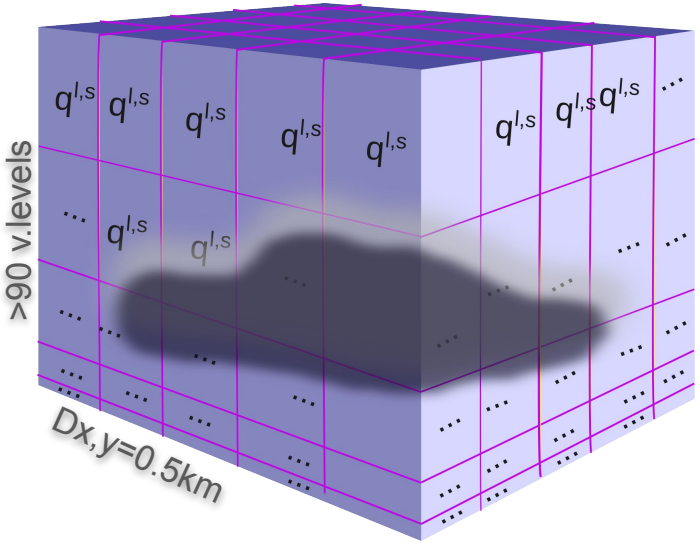
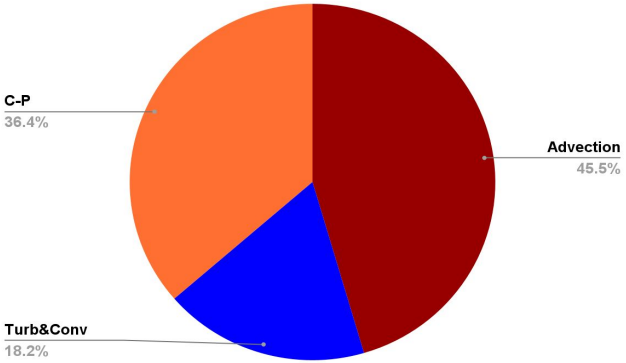




The balance between dynamics and SGS partitioning has to be reestablished for any new scale of interest.

Again, we need to adjust the parameterization

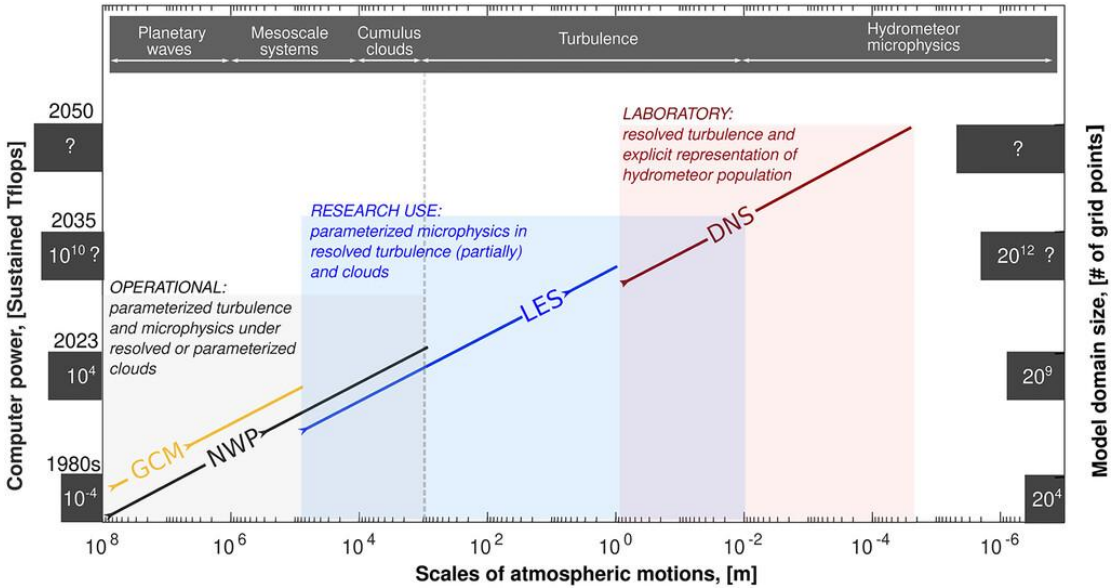
Challenge

In order to improve/adjust, one needs to understand first:

What is the “true”? How much (q, T, v, cloud, rain, snow, SGS mixing (1D vs 3D)? When? Where?

We need a reliable reference (*benchmarks*)

- Process-oriented weather forecast requires a process-oriented validation framework



[*Shapkalijevski, M. 2024, WAF*]

Motivation

Why do we need a process-oriented validation?

"A key opportunity to accelerate model improvement is greater incorporation of process-oriented diagnostics (PODs) into standard packages that can be applied during the model development process, allowing the application of diagnostics to be repeatable across multiple model versions and used as a benchmark for model improvement."

[Meloney et al. 2019, BAMS]

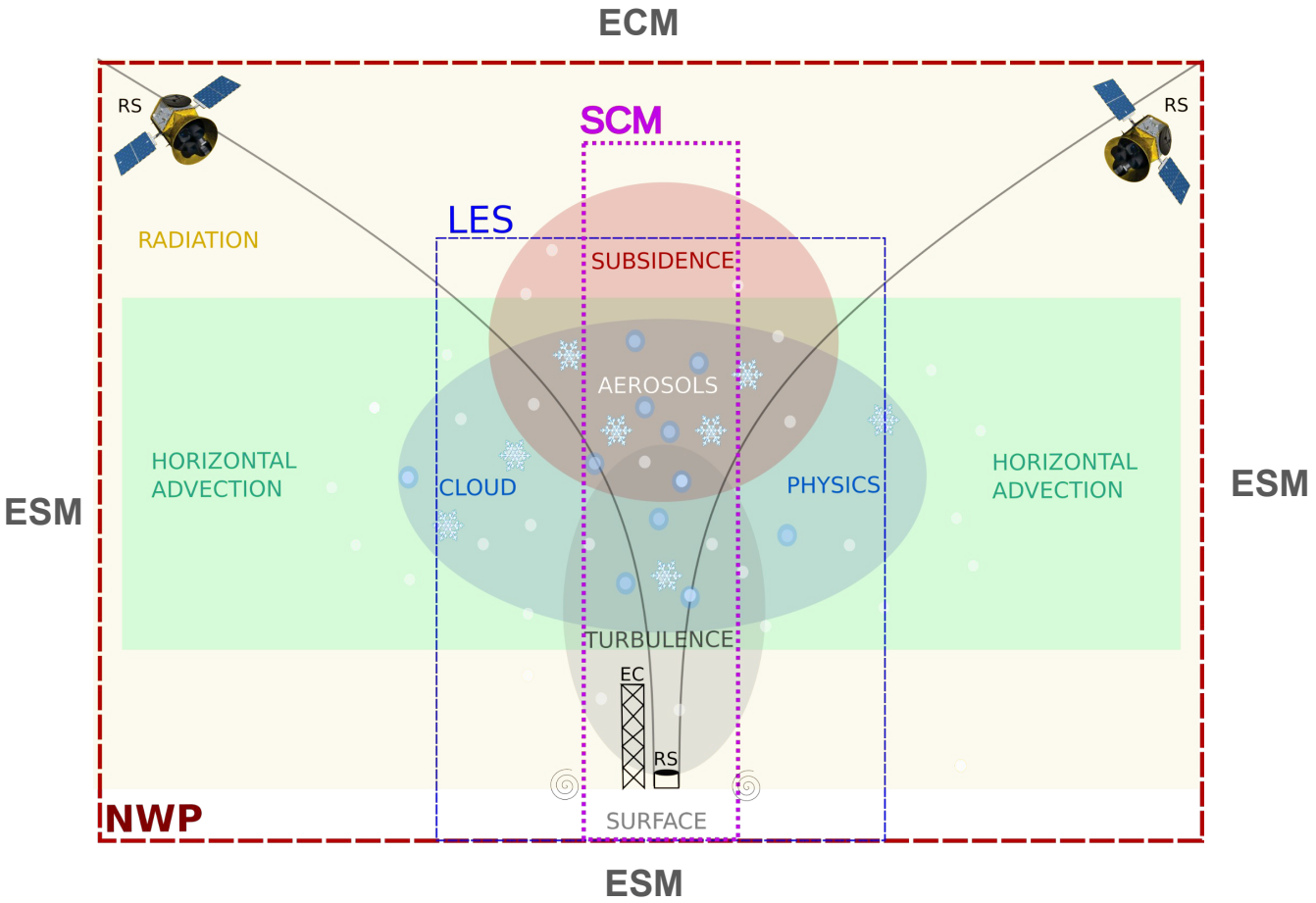
Maloney, E. D., and Coauthors, 2019: Process-Oriented Evaluation of Climate and Weather Forecasting Models. Bull. Amer. Meteor. Soc., 100, 1665–1686, https://doi.org/10.1175/BAMS-D-18-0042.1.

1st ACCORD WW on process-oriented validation

Click the link to the ww wiki page

accor_phys
accord_mqa
accord_sys
accord_surf
de_330
CloudNet -ASTRICS

Goal: build a common process-oriented validation framework



Acknowledgements to ...

- Hosts of the WW on process-oriented model validation at AEMET (Madrid, Nov. 2024)
- All participants (online and in person) during the working week
- All those who could not participate but contributed before and after
- TEAMx team/coordinator (Manuela Lehner) for the online access to their workshop

Methods

Models

- **GCM, Reanalysis (forcing)**
- **LEM (coarser to higher grids)**
- **LES (at supersites, locations of interests)**
- **SCM (at supersites, locations of interests)**
- **SURFEX offline**
- **Stand-alone models**
- **Learned-by-data models**

Observations

- **SYNOP (conventional)**
- **Remote Sensing (ground, space): LiDAR, MWR, Cloud radar, Ceilometer**
- **Tower: flux-gradients, radiation**
- **Non-conventional (other), specific campaigns**

Specialized tools

- Model output/interpolations: **DDH, EPyGrAM**
- Visualize/statistics: **various scripts (py, R)**

Methodology - draft framework

STEP 1:	Working problem **DEFINE**	Warm bias in vSBLs, Rain from OCC, cloudiness in high-pressure systems, …	…
STEP 2:	Affected (parameterization) scheme **SELECT**	Microphysics, convective and turbulent transport, radiation, surface-atmosphere exchange, …	
STEP 3:	Reference (REF) **CREATE**	Observations (a set off), LES	
STEP 4:	Controlled case (stand alone) **CREATE**	Parameterization vs reference **COMPARE & IMPROVE**	
STEP 5:	Improved scheme in 1D **TEST**	OFF => technical check (vs CTRL) ON => works as expected (vs REF)	
STEP 6:	Improved scheme in 3D **TEST**	OFF => technical check (vs CTRL) ON => works as expected (vs REF)	
STEP 7:	Domain-statistic verification **PERFORM**	Scors (e.g. HARP) Check effects on other variables	

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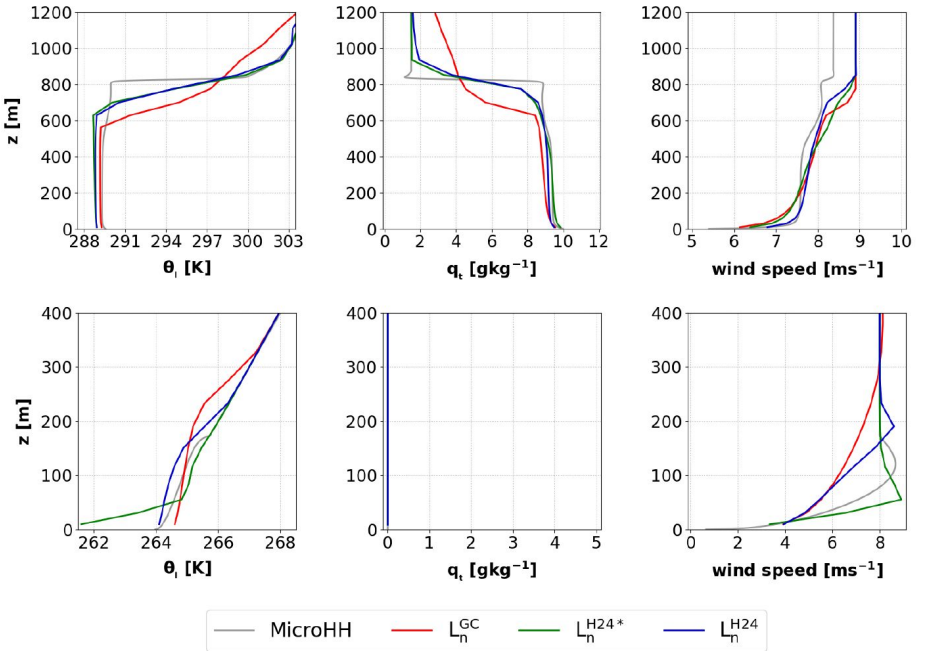
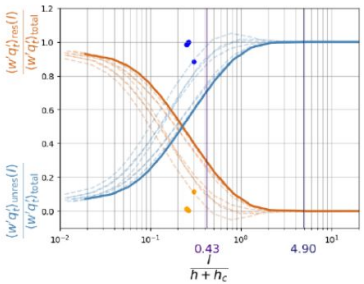
Status:

Status: turbulence and convection

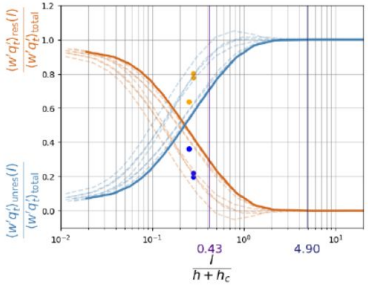
Process-oriented validation of the TOUCANS scheme [Mario Hrastinski via David Nemec]



Process-oriented validation of the EDMF scheme [Wim de Rooy via Emily Gleeson]



(i) HARMONIE run of the Cabauw case, at 500m resolution, with the original EDMF-scheme.



(iii) HARMONIE run of the Cabauw case, at 500m resolution, with the scale-adaptive MF-scheme, and the w_{max} threshold.

Status: Radiation and CAR

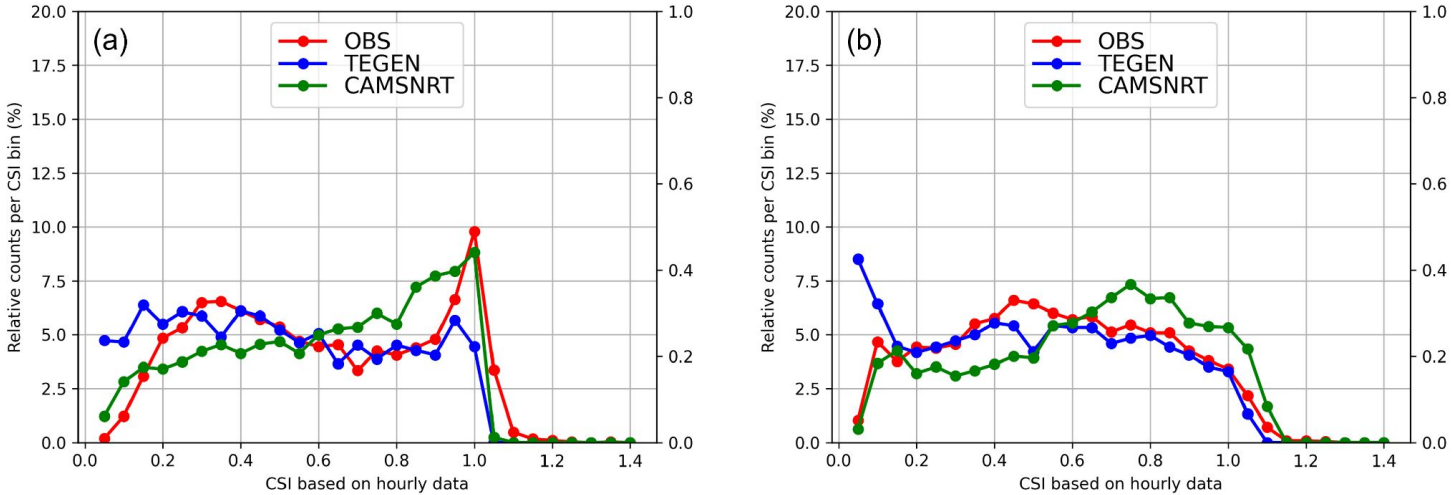


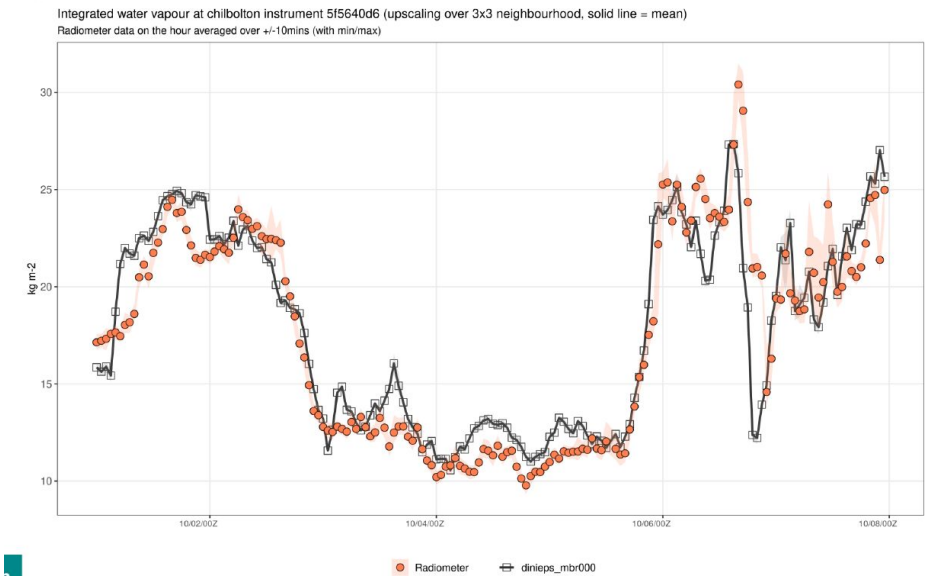
Figure 7. Distribution of CSI for summer (a) and winter (b) 2-week periods, obtained from observations over Ireland and from the results of two HARMONIE-AROME Cycle 46 experiments, with prescribed CDNC (Tegen) and with CDNC derived from CAMS data (CAMSNRT). [*Gleeson et al. 2024*]

Status:

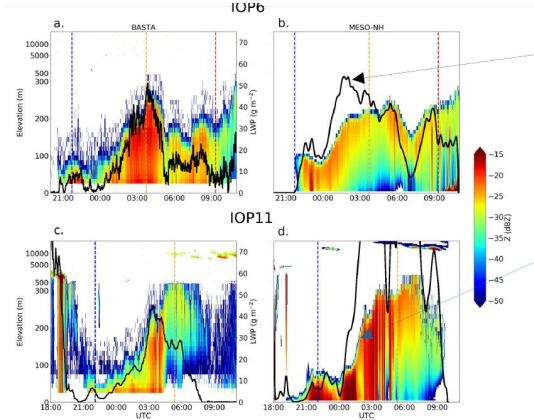
cloud-precipitation microphysics

Process-oriented validation of ICE3 in HARMONIE-AROME: IWV [James Fannon]:

Github/Repo: https://github.com/j-fannon/cloudnet_harmonie_comp
Tutorial (install within/link to HARP)
Scripts to plot/analyse



Process-oriented validation of LIMA scheme in Meso-NH using PHYEX
[Marie Mazoyer]



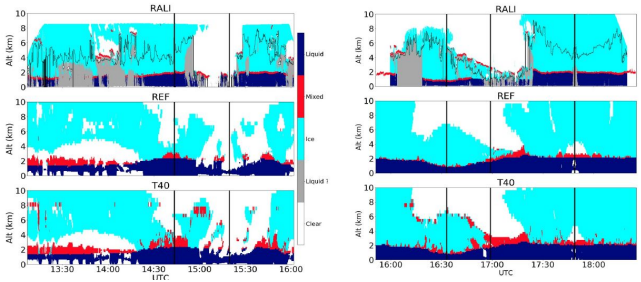
$$\mathbf{LWP} = \sum \left(r_c \rho dz \right)$$

$$\mathbf{CTH}\ (Z < -34\ \text{dBz})$$

CTH (?) in fullpos can be useful to have a systematic model evolution with the cloudnet

Fog process validation – SOFOG3D (Burnet et al, 2020)

Observation, Radar-Lidar (RALI) platform (Delanoë et al., 2013)
Meso-NH, mixed-phase clouds : LWC / (IWC + LWC) > 10 % (Korolev et al., 1998)

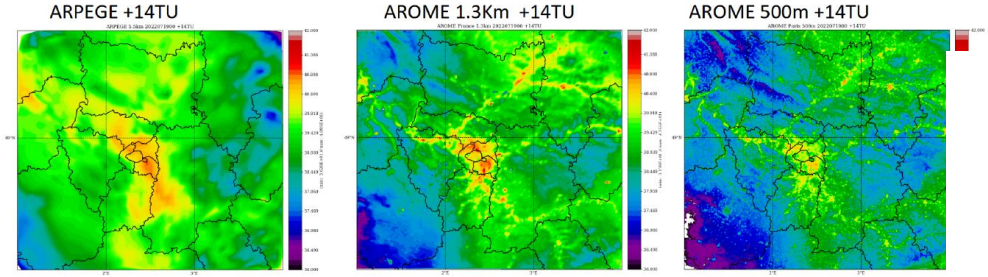


Status: surface forcing and near-surface diagnostics

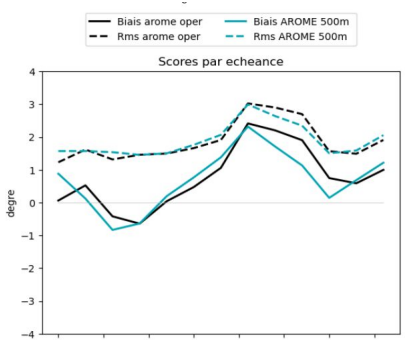
(more details by Patrick, Katya, Martina, Eric)

[Salomé Antoine]:

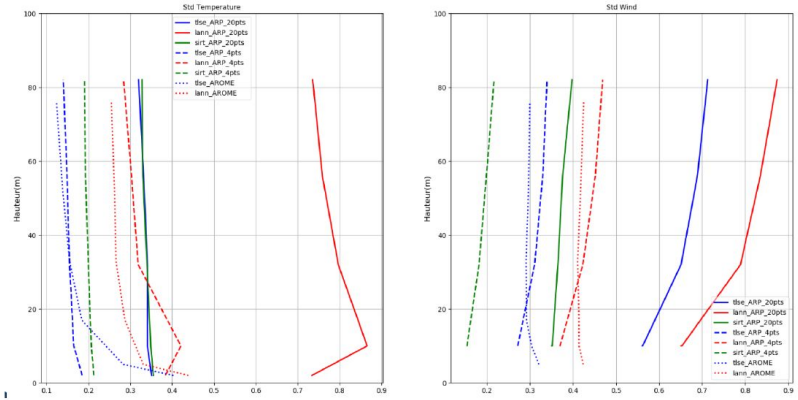
How to show the improvements of a new system?



(Images from E. Bazile)



How to compare models with different resolutions to obs?



- AROME (16pt) close to ARPEGE (4pt), especially for Toulouse

Status: important specialized tools (DDH, EPyGrAM 2.x)

[Jean-Marcel Piriou and all]:

Budget equation in η coordinate for the variable X :

$$\frac{1}{g}\frac{\partial}{\partial t}\left(\frac{\partial \pi}{\partial \eta}X\right) = \frac{1}{g}\frac{\partial \pi}{\partial \eta}\sum_{\mathcal{D}}\mathcal{T}_{\mathcal{D}} - \sum_{\varphi}\frac{\partial \mathcal{F}_{\varphi}}{\partial \eta} + \mathcal{E}$$

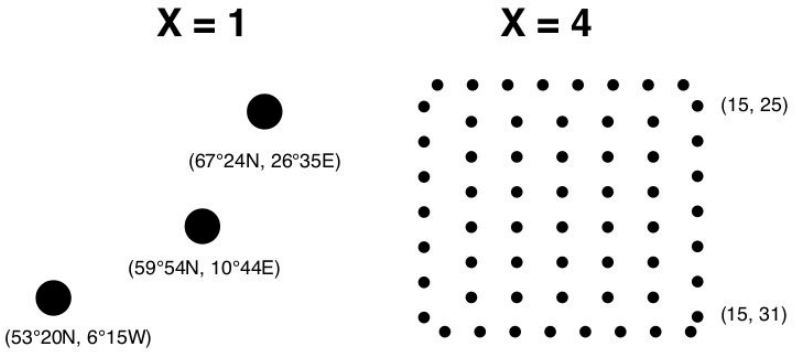
- $\mathcal{T}_{\mathcal{D}}$: Dynamical tendencies, e.g horizontal or vertical advection, pressure gradient, ...
- $\mathcal{F}_{\varphi}$: Physical fluxes, e.g [radiation, convection, turbulence, precipitation, ...], from parametrizations.
- $\mathcal{E}$: Residual, unexplained by physical or dynamical explicit terms, e.g [horizontal diffusion, semi-implicit correction, ...]

Output:

- **Budgets** : mass (PP), water vapour (QV), kinetic energy (KK), angular momentum (A1,A2,A3), entropy (SS), potential energy (EP), temperature (CT), etc.
- **Domains** : the whole model domain, zonal bands, limited area domains (rectangles, polygons), isolated grid points.

[Marvin Kähnert]:

BDEDDH(01,domain) = X

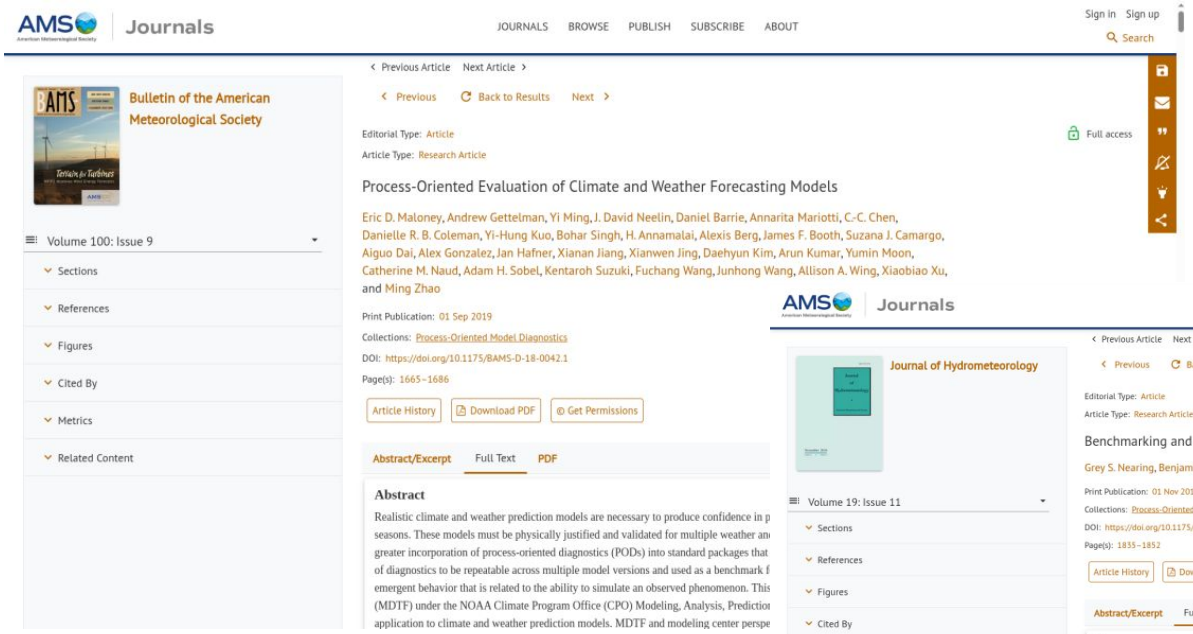


extract a single point of interest based on lon /lat

extract region of interest and investigate in detail

What's next?

- **Special issue from the AMS on process oriented diagnostics: learn from others**



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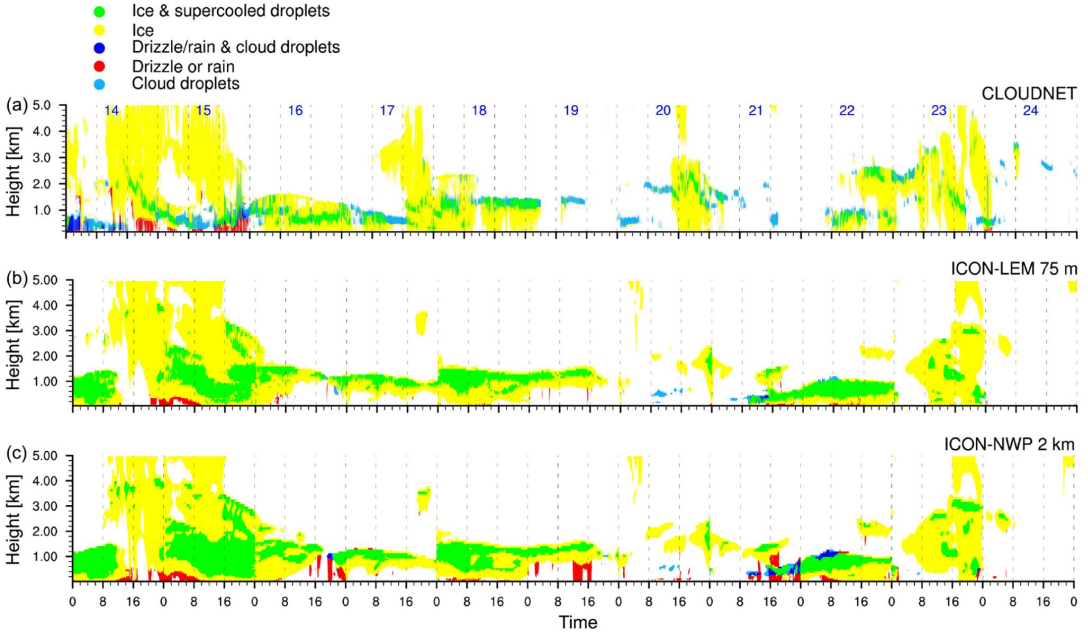

[*Scheman and Ebell, 2020, ACP*]

Schemann, V., Ebell, K., Pospichal, B., Neggers, R., Moseley, C., & Stevens, B. (2020). Linking large-eddy simulations to local cloud observations. Journal of Advances in Modeling Earth Systems, 12, e2020MS002209. https://doi.org/10.1029/2020MS002209

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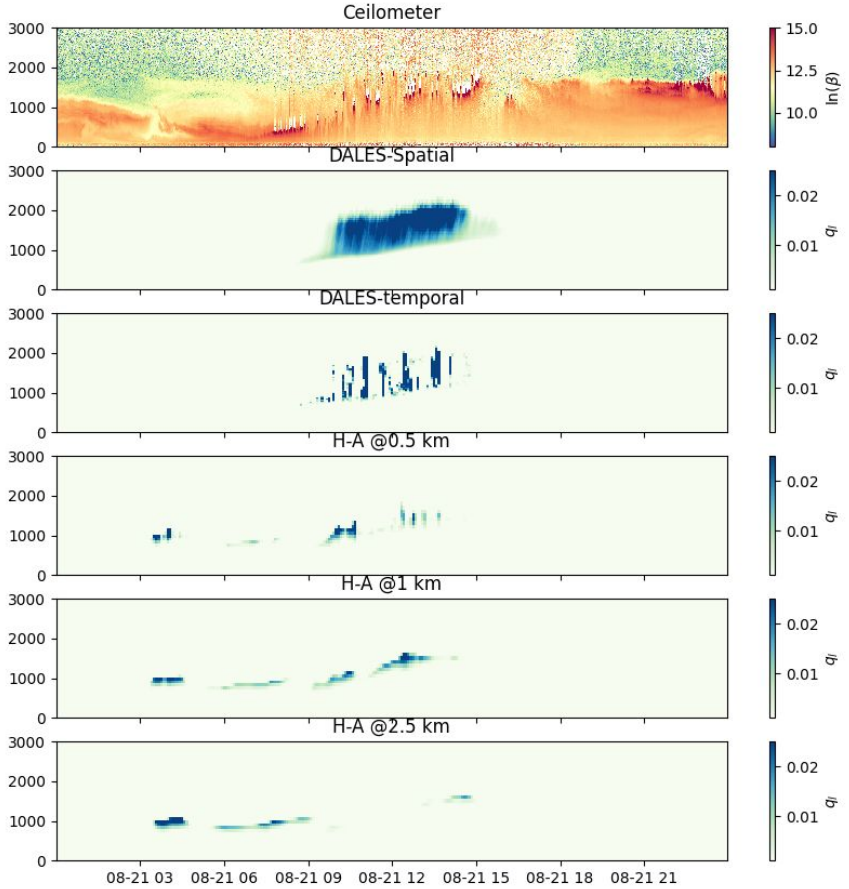
    - Target classification from model output & lwc, iwc (*on similar temporal scales*)
    - Link LiDAR (ceilometer), LES, NWP (time step output, DDH)



[Natalie Theeuwes]

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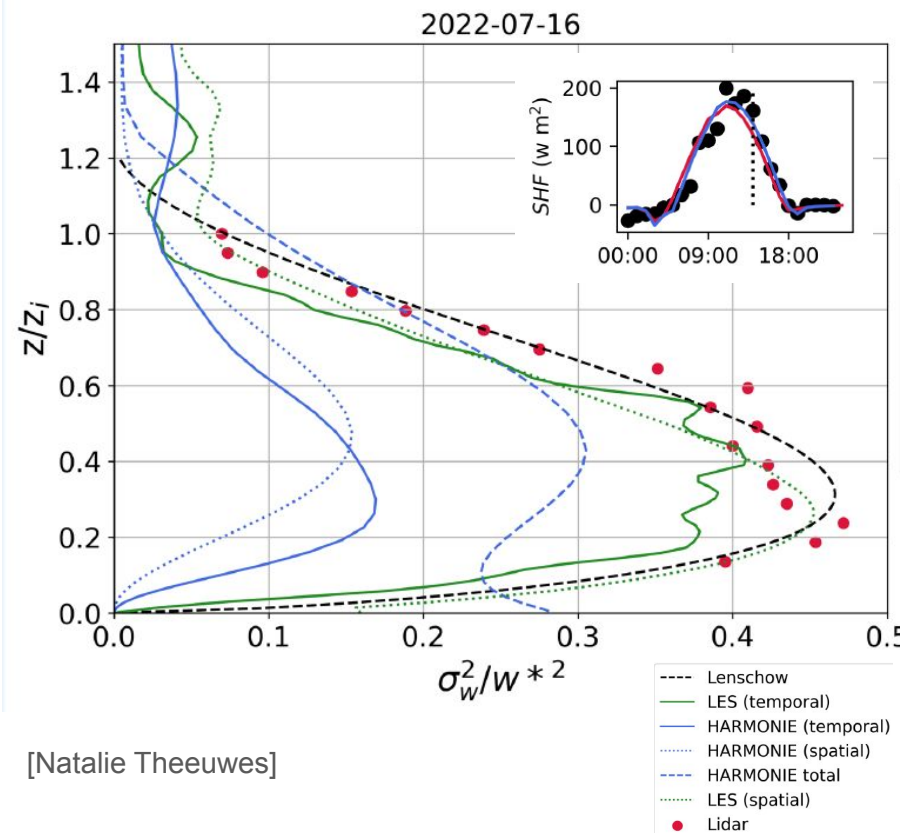
  - Link Doppler LiDAR, EC, LES, NWP



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- A common MUSC:
  - Cy49T2+
  - ARMCU (SURFEX/noSURFEX)
  - DAVAI test