Urban-scale Ensemble Simulations and the Paris 2024 Olympics Research Demonstration Project

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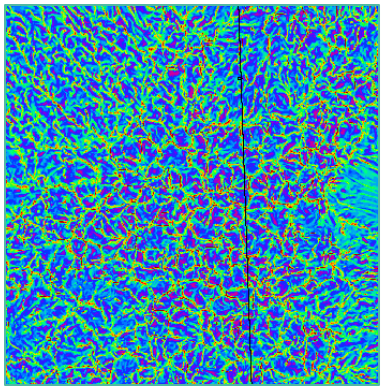
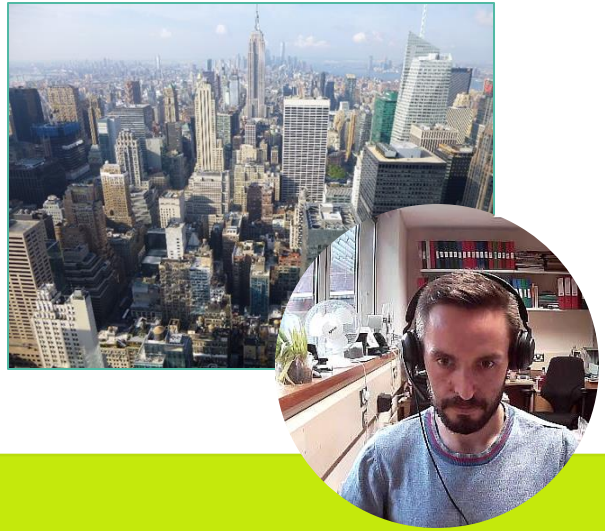
Convective Scale Workshop
10/09/2024

Urban-scale Modelling

Vision Statement:
Deliver an enhanced Urban-scale modelling capability (an atmospheric model with grid lengths in the range 25-300 m) for application across timescales to exploit next-generation supercomputing including sufficient understanding to specify practical systems.





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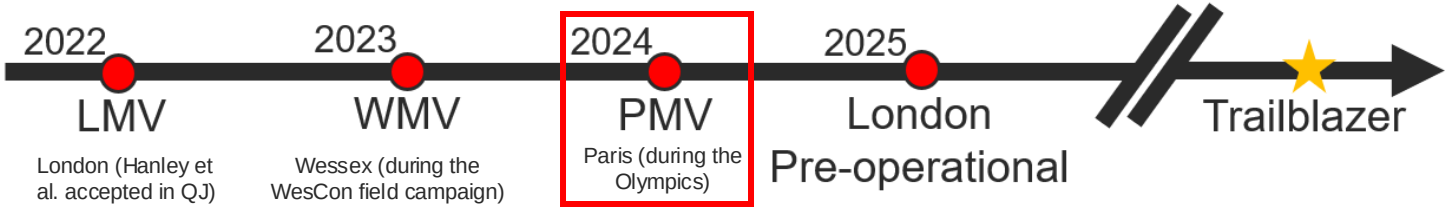
Vision Statement:
Deliver an enhanced Urban-scale modelling capability (an atmospheric model with grid lengths in the range 25-300 m) for application across timescales to exploit next-generation supercomputing including sufficient understanding to specify practical systems.

Ensembles are at the heart of our approach since the scales of interest are smaller than the predictable scales.



Paris 2024 Olympics Research Demonstration Project (RDP) **Model Intercomparison**

- Deterministic heatwave and thunderstorm hindcast intercomparison
- Ensemble thunderstorm hindcast intercomparison: CNRM, MO, DWD
- **Routine running** (11, 27 Jun, 16 Jul – 8 Sept):

Centre	Model	Grid Length
Meteo France (CNRM/GMME)	MesoNH	100 m (Paris and suburbs) / 300 m (Ile-de-France)
Meteo France (CNRM/GMAP)	AROME-500	500 m
Meteo France	AROME-DBLE	1.3 km
Met Office	PMV mem. 1	300 m
ECCC	GEM	100 m
NCAR	WRF	100 m
DWD	ICON	500 m

Opening ceremony on the Seine (didn't quite turn out that way!)

PARIS 2024

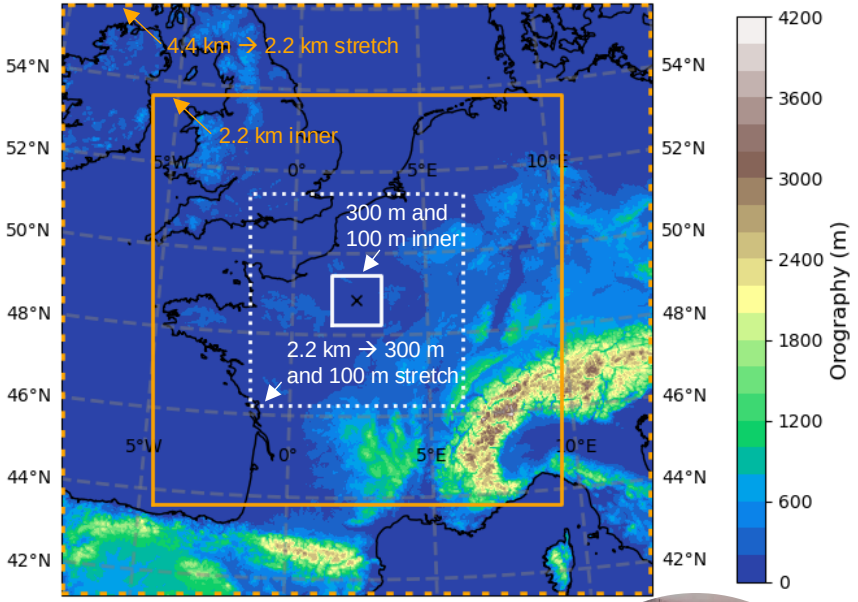
Olympics:
26 Jul – 11 Aug

PARIS 2024

Paralympics:
28 Aug – 8 Sept

Paris Model Variable (PMV)

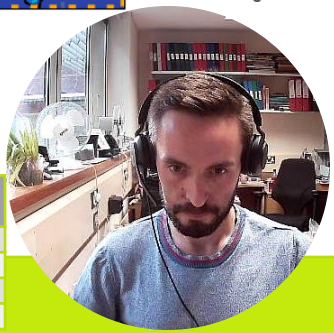
MO-G → 2.2 km (“PMV2K”) → 300 m (“PMV”)
2.2 km (“PMV2K”) → 100 m (hindcast only)



Nested domains:

- 18 ensemble members initialised from MO-G 21 UTC analysis (18 UTC cycle)
- Variable resolution
- RAL3.2
- Random perturbation scheme in the PMV2K
- CCI v2 land cover
- Paris anthropogenic heat emission value obtained from Varquez et al. (2021) dataset
- City LAI and soil moisture fixtures

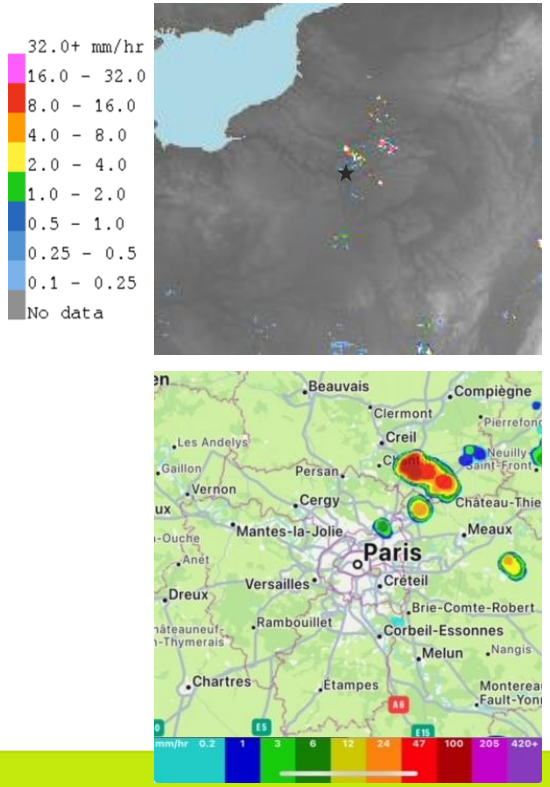
	Domain (lon x lat)	Inner	Vertical levels	Timestep
Global n640 (~30 km)	1280x960	-	70	4 min
4.4 km → 2.2 km	652x652	501x501	70	75 s
2.2 km → 300 m	878x878	451x451	70	12 s
2.2 km → 100 m	1982x1982	1353x1353	120	4 s



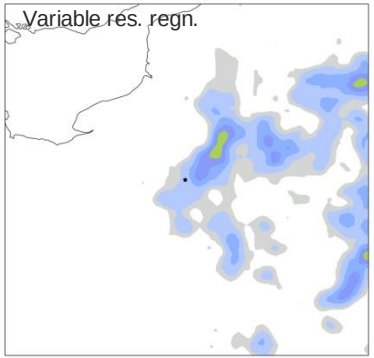
Scattered Showers Along a Weak Cold Front: 27/06/2024 12:00 UTC (T+15)

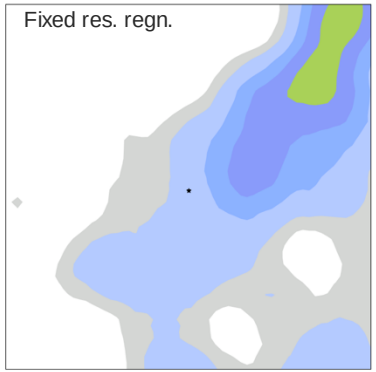
- Probabilities are calculated using a neighbourhood length of 17.5 km
- PMV (cf. PMV2K) better captures probability of precipitation NE of Paris
- Consistent with previous studies (LMV and WMV) where 0.3 km better captures the probability of showers associated with weak fronts

Radar

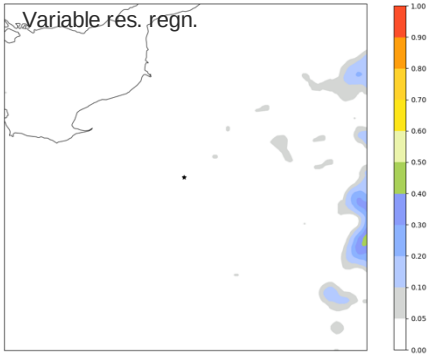


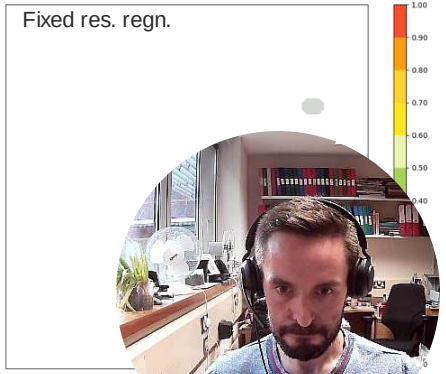
PMV (300 m) nhood max probability ppn > 4 mm/hr





PMV2K nhood max probability ppn > 4 mm/hr



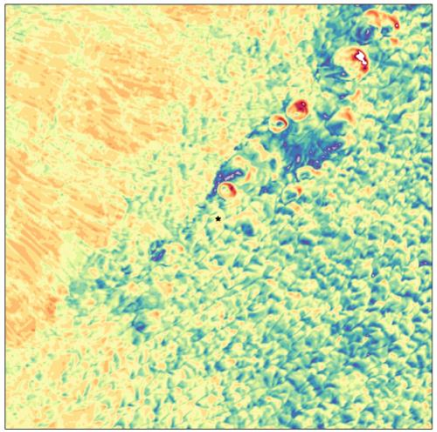


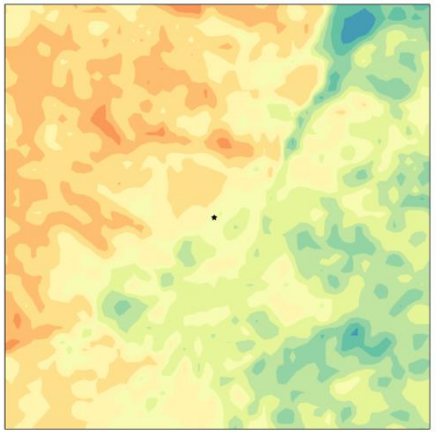
Scattered Showers Along a Weak Cold Front: 27/06/2024 12:00 UTC (T+15)

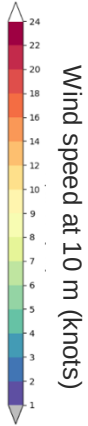
- PMV (cf. PMV2K) has a sharper convergence line with showers
- PMV (consistent with previous studies) tends to produce too many small cells
- What about other sub-km models?

PMV mem. 3

PMV2K mem. 3







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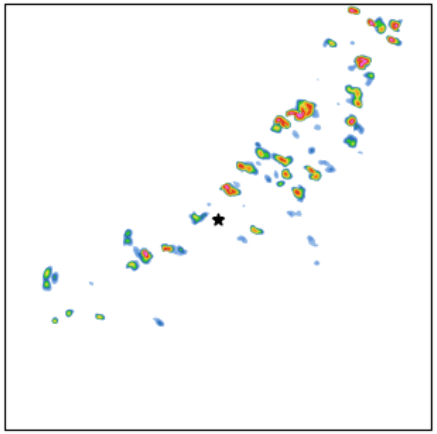

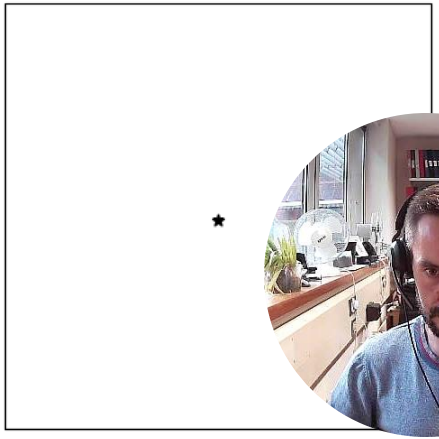

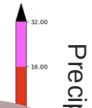

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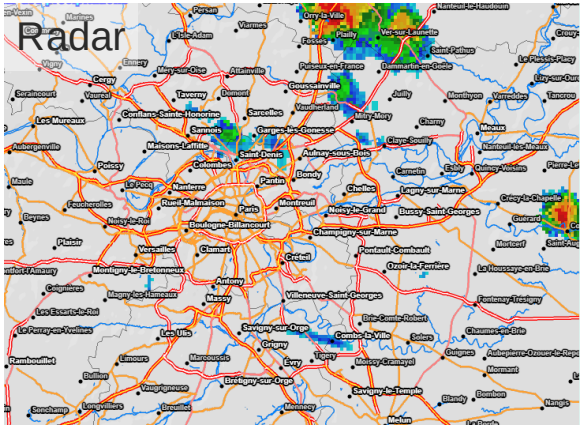
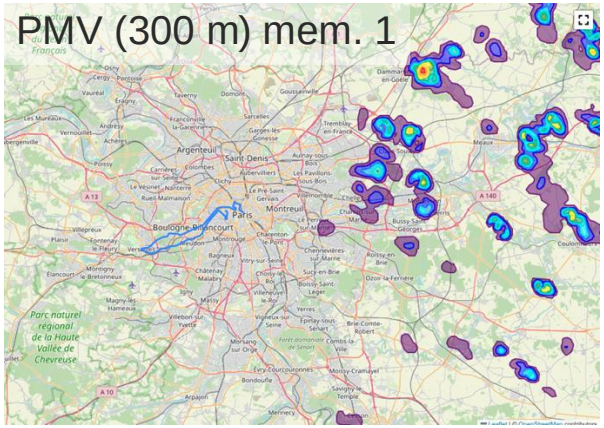
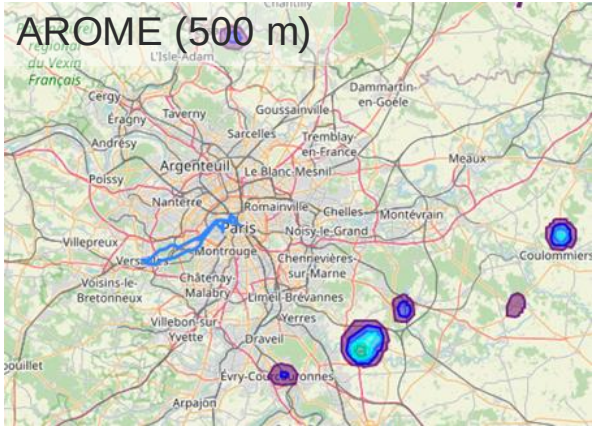
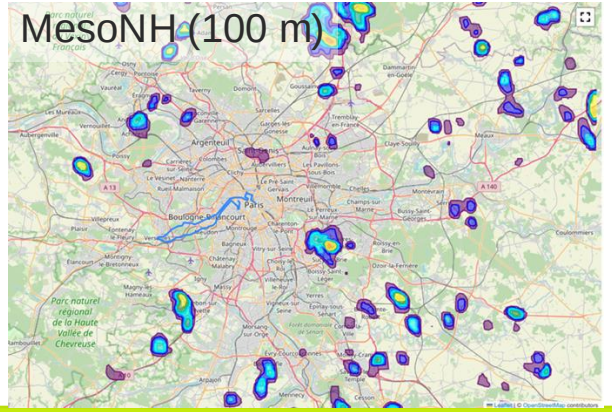
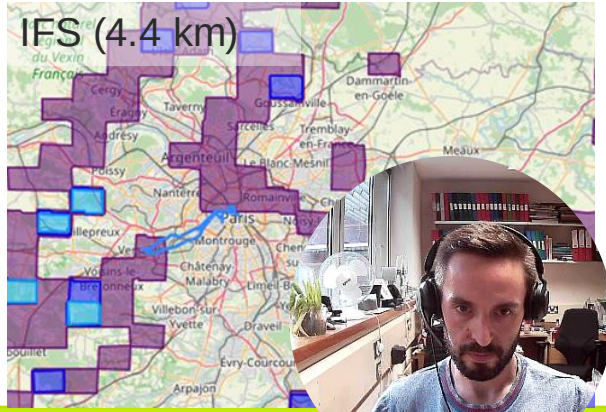






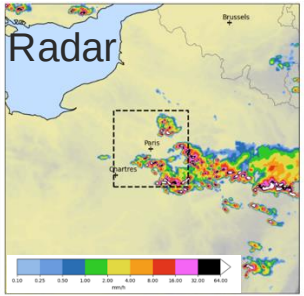
- Other sub-km models tend to have too many small isolated showers
- Hypothesis: convection under resolved leading to too high updraft velocities and precipitation
  → ParaChute (Turbulent Processes Programme funded by MO and NERC)

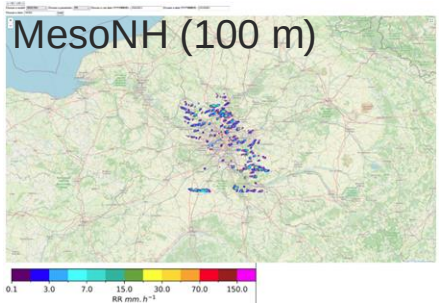


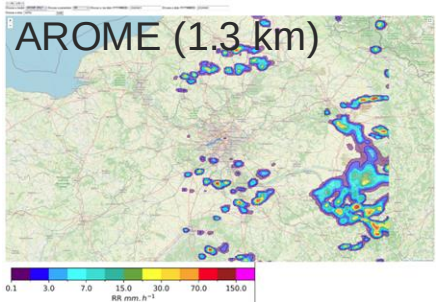


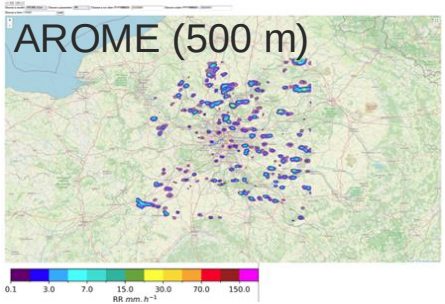
MCS Associated with a Trough: 01/08/2024 16:00 UTC (T+19)

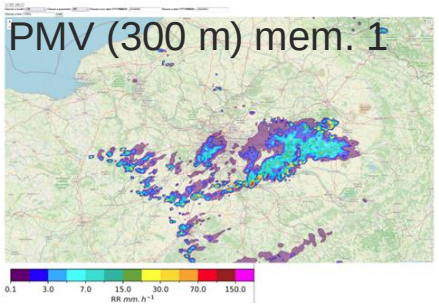
- PMV shows more large-scale structure
- Other models tend to have scattered showers
- However, …

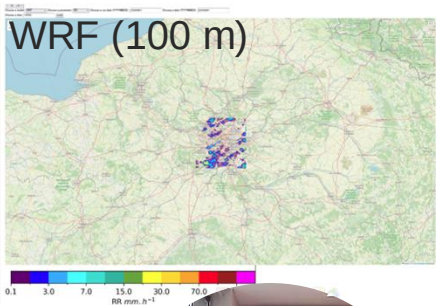


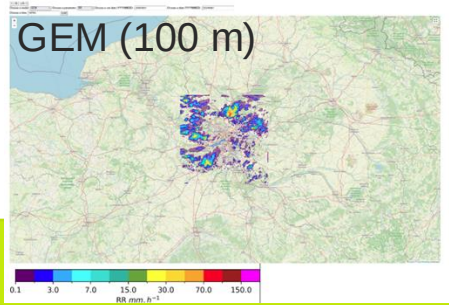


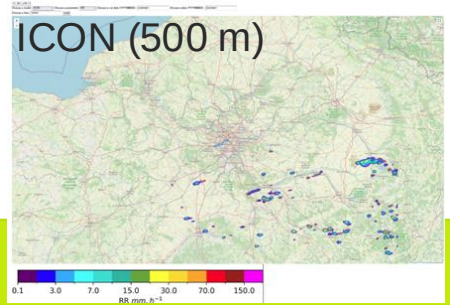




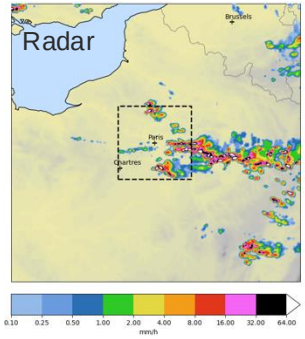




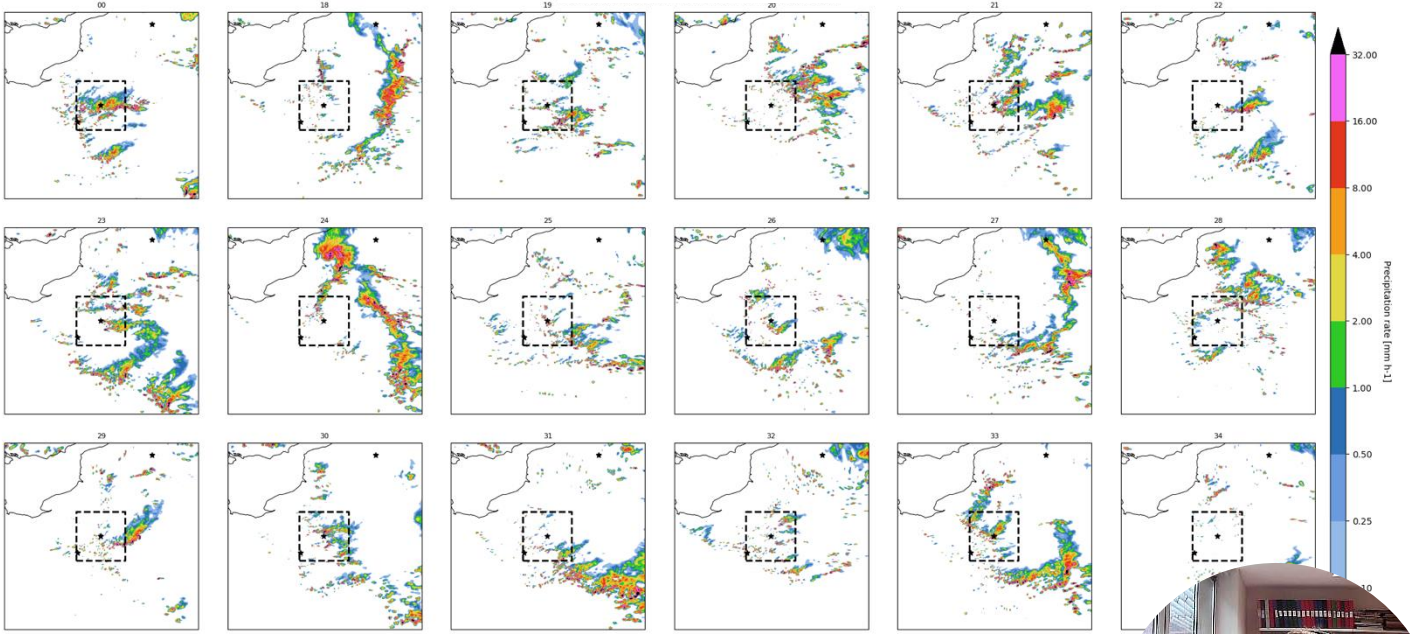




MCS Associated with a Trough: 01/08/2024 15:00 UTC (T+18)



PMV postage stamps



- PMV ensemble encompasses similar solutions to the other model solutions → the other models might give a different steer if they were ensembles

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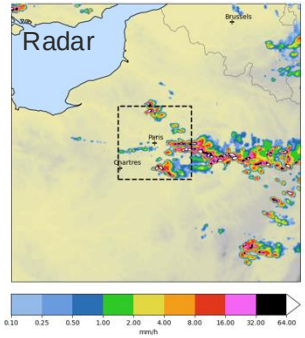

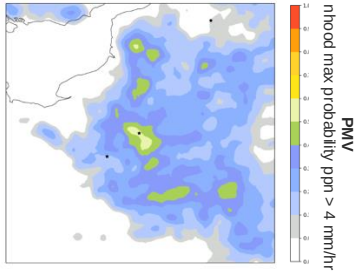

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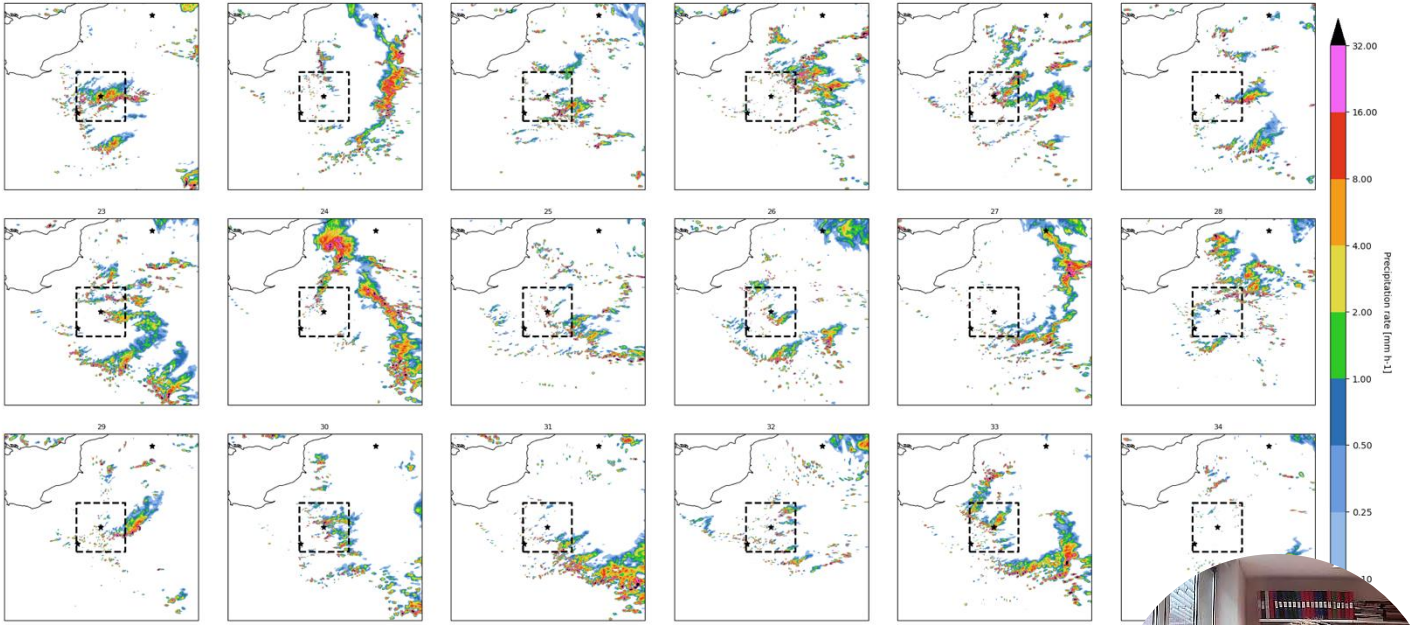

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- PMV often has different clusters which statistics based on the entire ensemble do not capture → ensemble clustering

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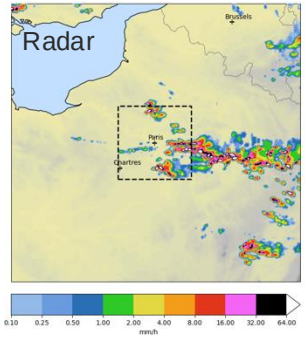

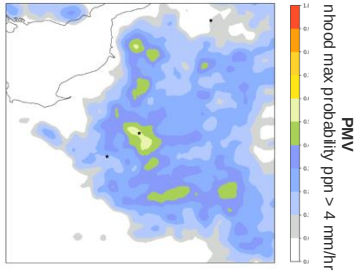

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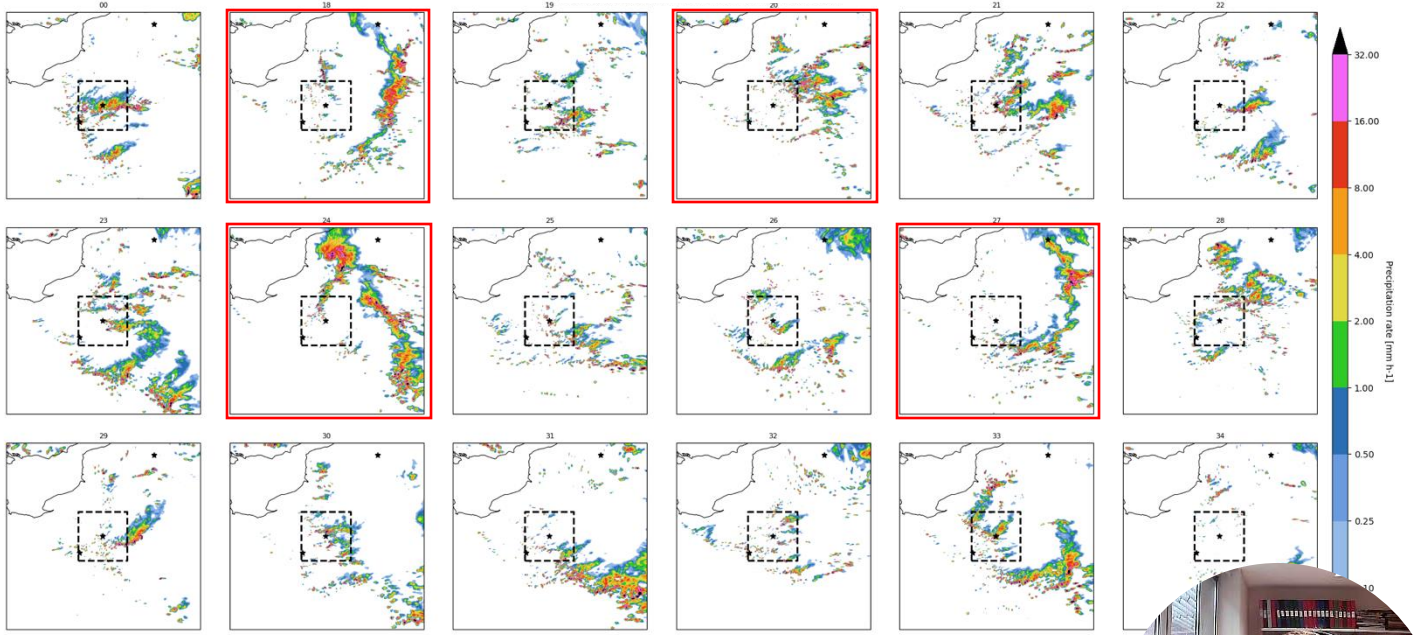

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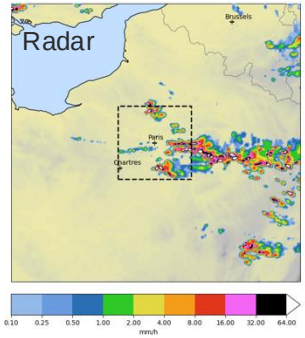

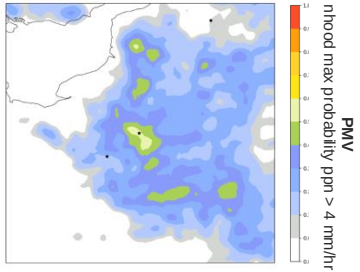

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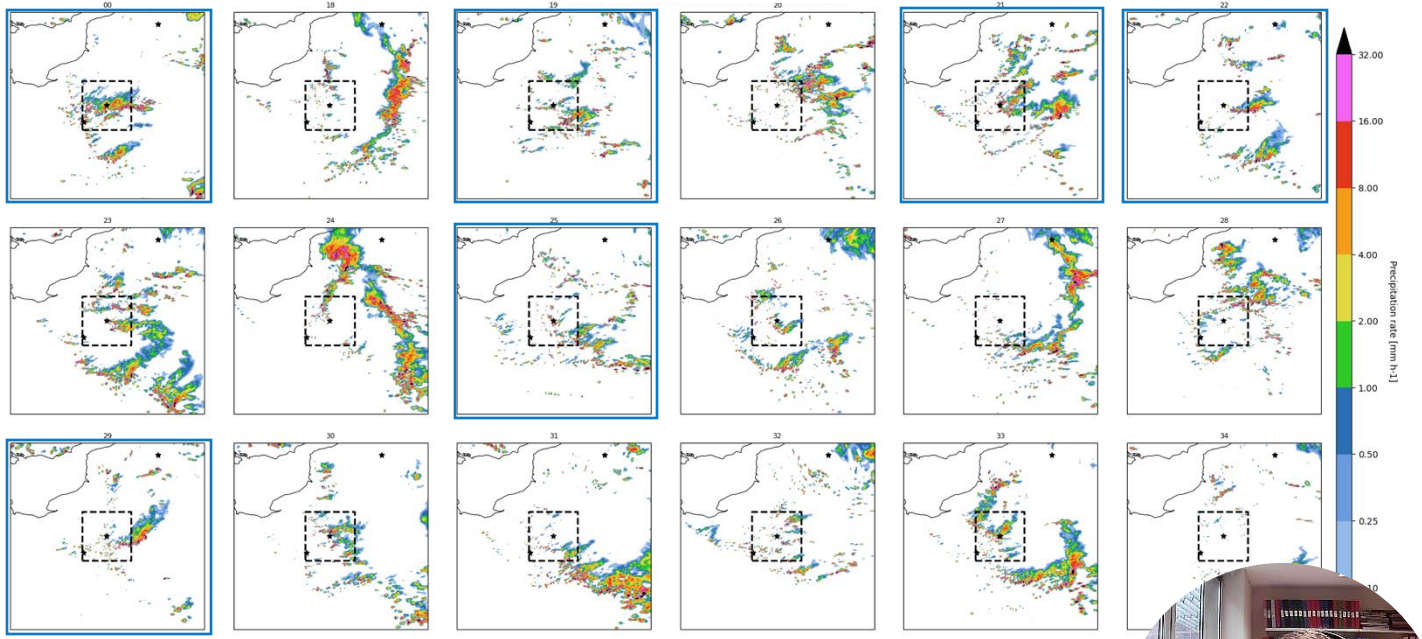

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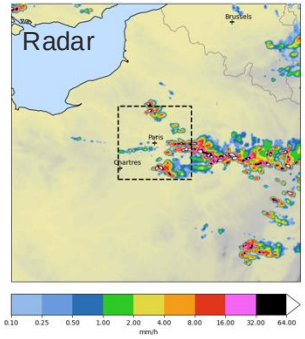

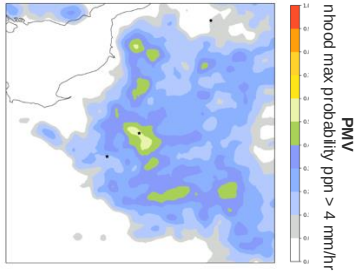

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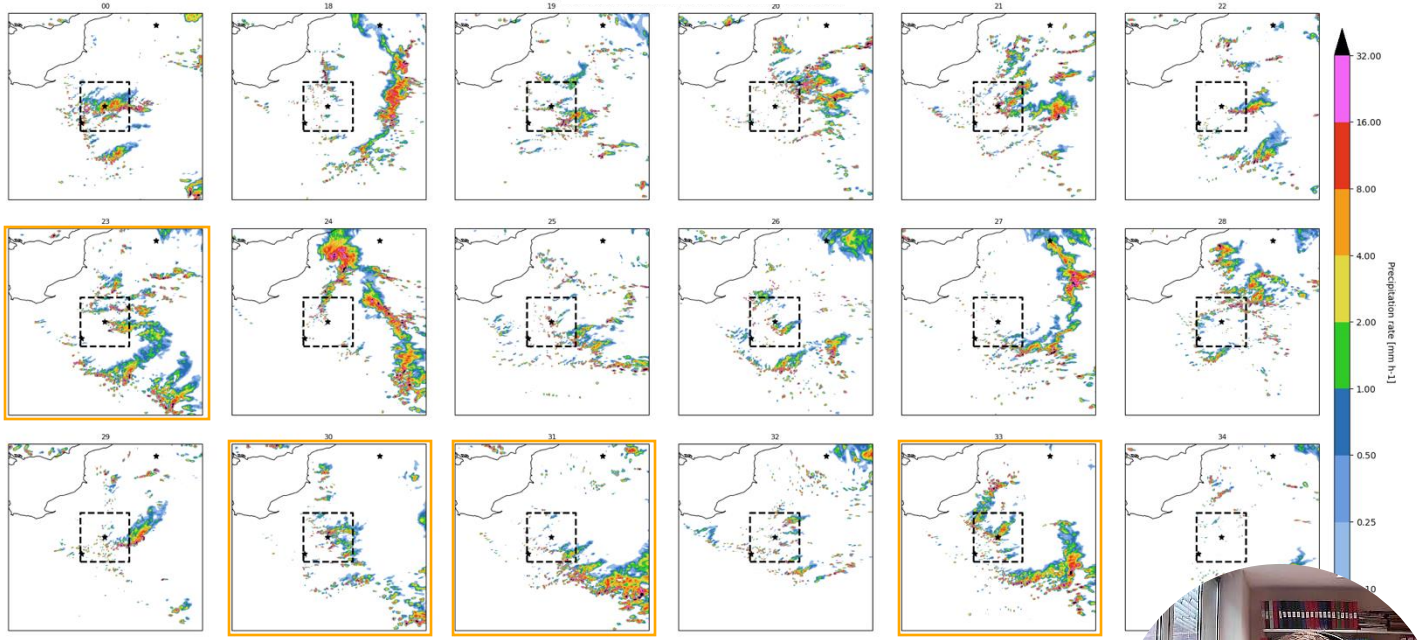

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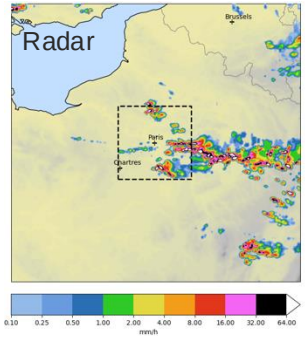

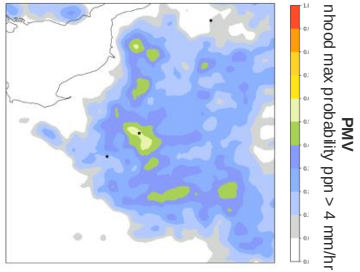

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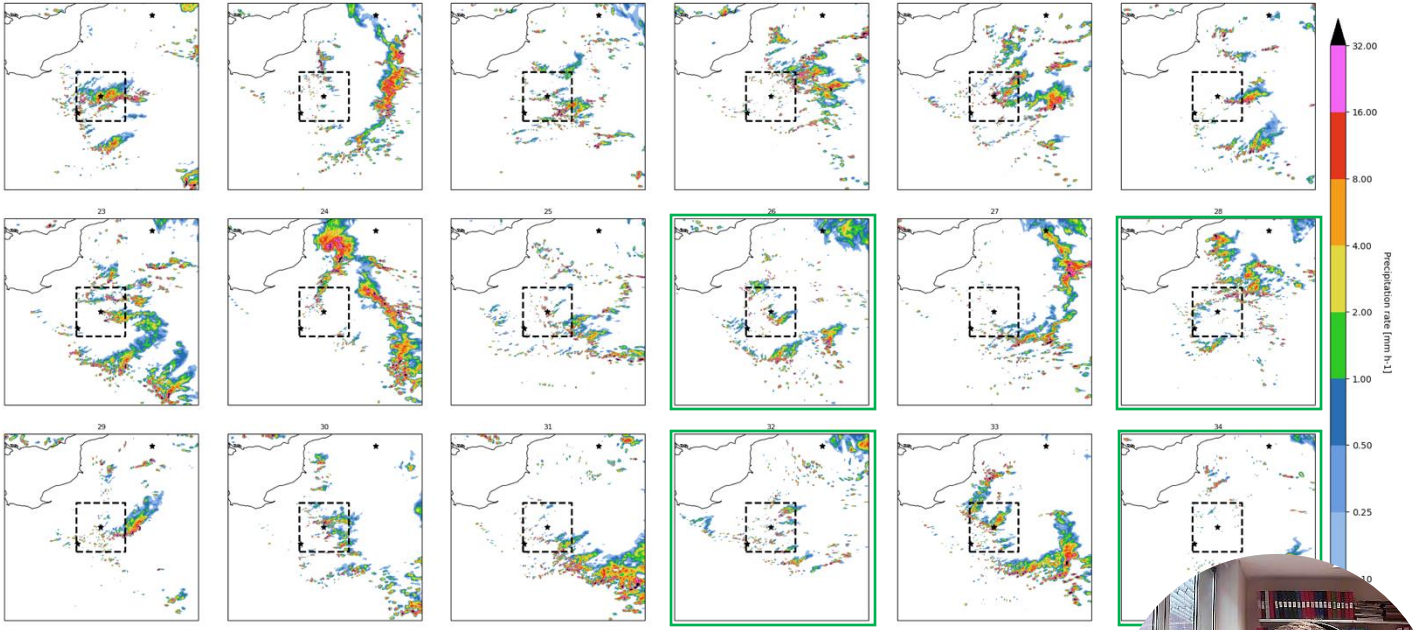

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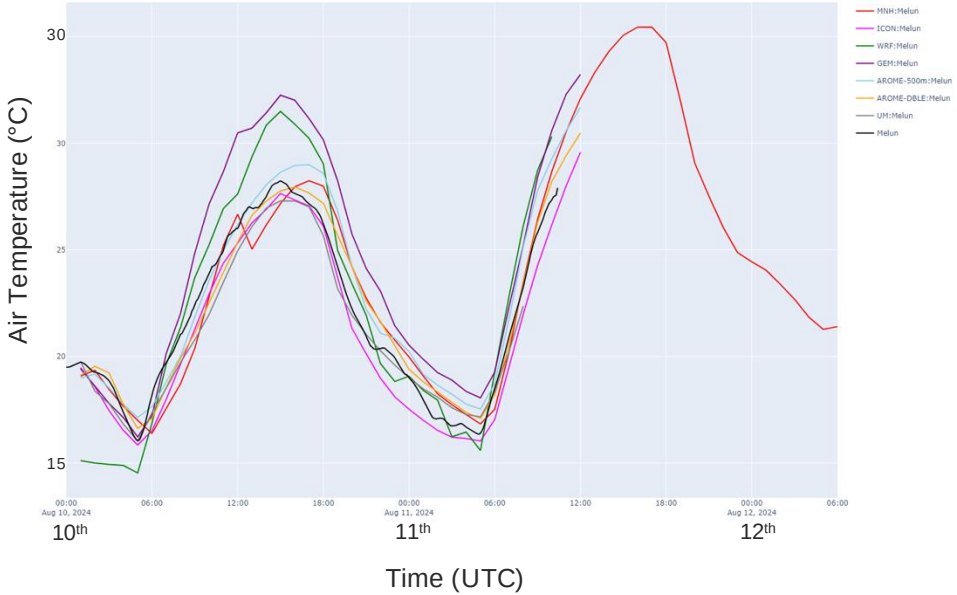
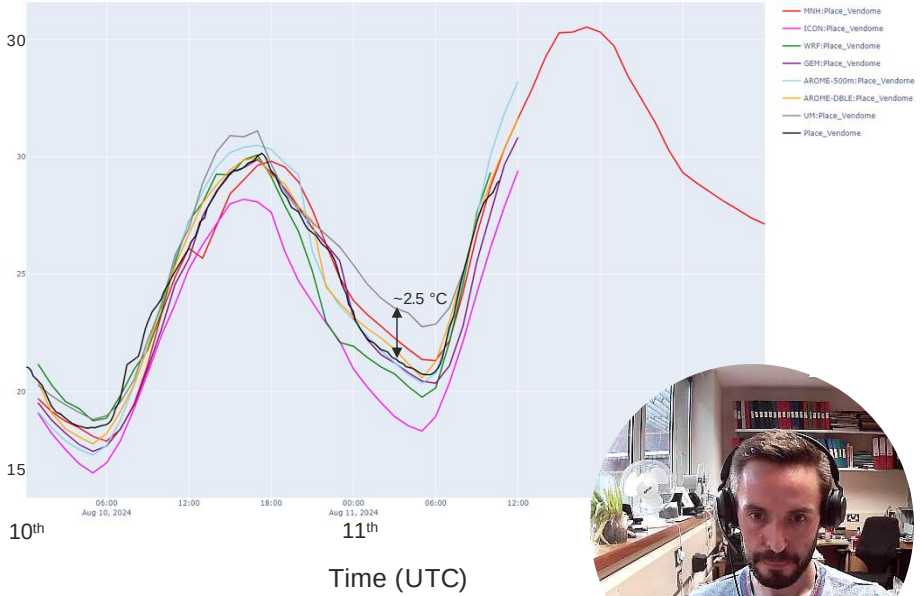
Marathon Heatwave Day: 10/08/2024

- Rural site: PMV good
- Urban site: PMV too warm on second night (trend throughout RDP)

Rural (Melun) – PMV is grey and obs. are black

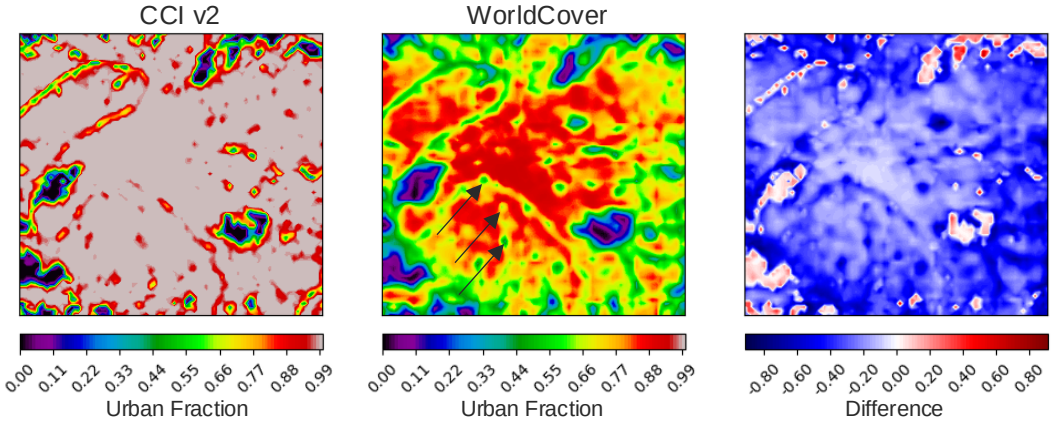


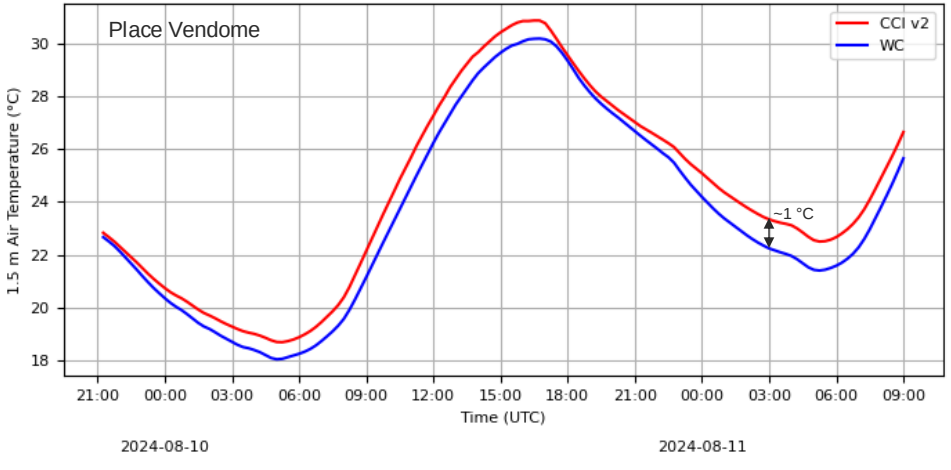
Urban (Place Vendome) – PMV is grey and obs. are black



Marathon Heatwave Day: 10/08/2024

- Updated urban fraction from CCI v2 to WorldCover
  - Lower urban fractions
  - Small parks better represented
  - More urban sprawl
- Reduces nighttime warm bias by ~1 °C
- Ongoing work:
  RAS branch (u-di676) with WSF3D (global, spatially varying) building morphology replacing empirical relationships (as well as LAI fix and WorldCover)





Summary

- Consistent with previous studies, the 300 m variable resolution ensemble does well compared to km-scale ensembles for scattered showers and upscaling when there are mesoscale forcings (e.g., convergence lines)

- Other sub-km models also tend to produce too many small precipitating cells
  → ParaChute: analyse WesCon data and develop scale aware turbulence schemes

- Ensemble clustering techniques would be beneficial (for communication and reducing computational cost)

- WorldCover improves nighttime air temperatures but land cover is not the full solution

- Ensemble thunderstorm intercomparison
  - Challenging for limited case studies, particularly when there are different ICs, LBCs, domain sizes
  - Ongoing: spread—skill relationships

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