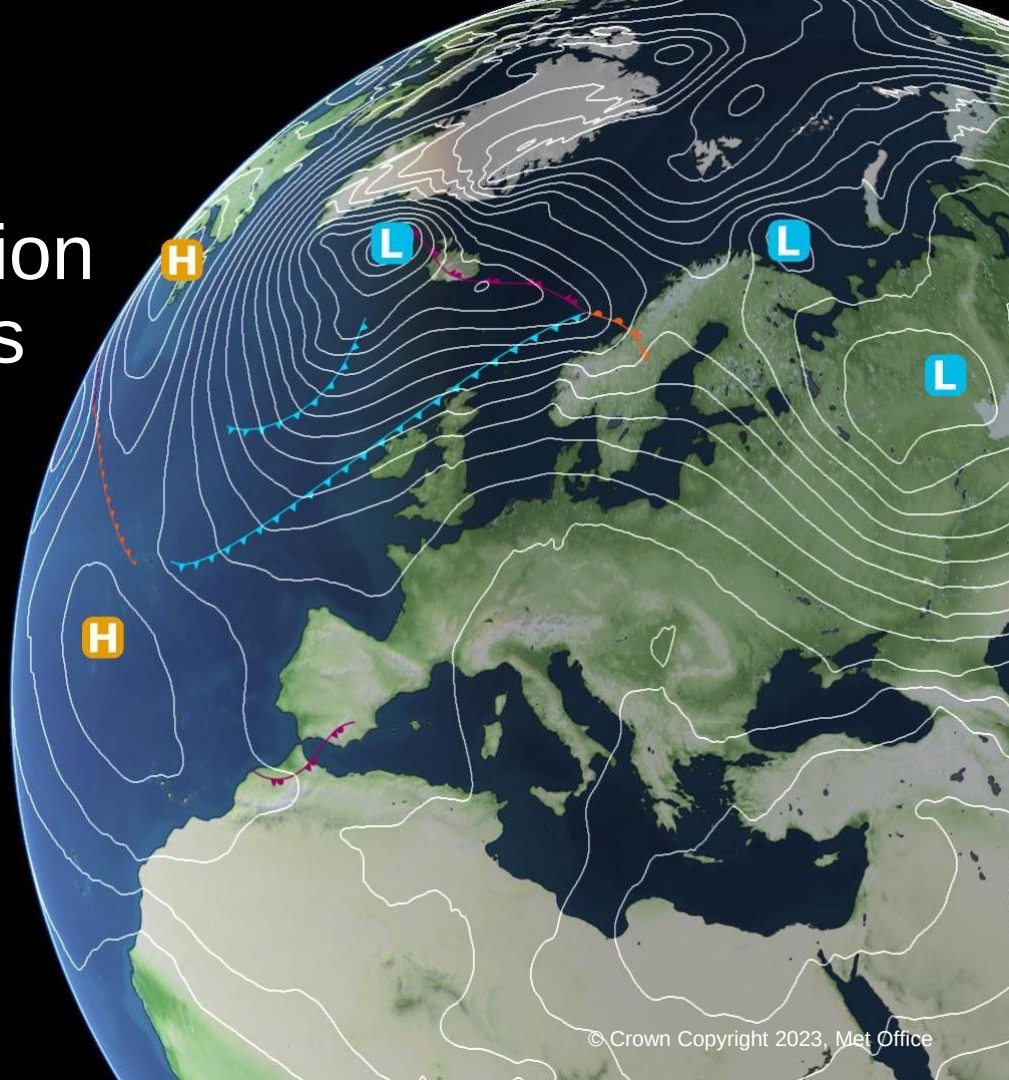
Using Road States for Simplifying Communication of Probabilistic Forecasts



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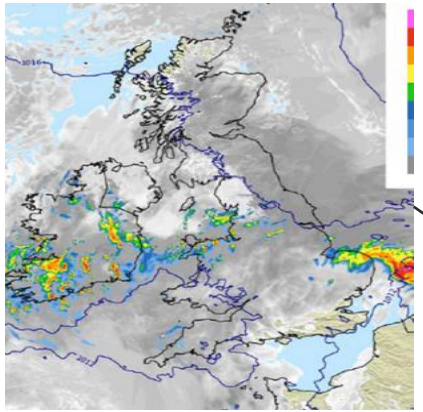
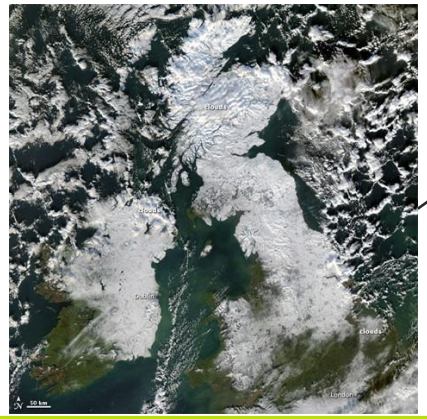
Numerical Weather Prediction

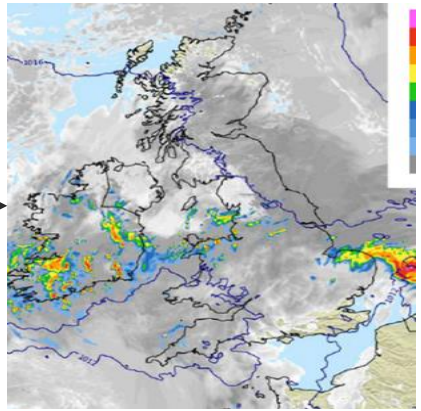


T+0

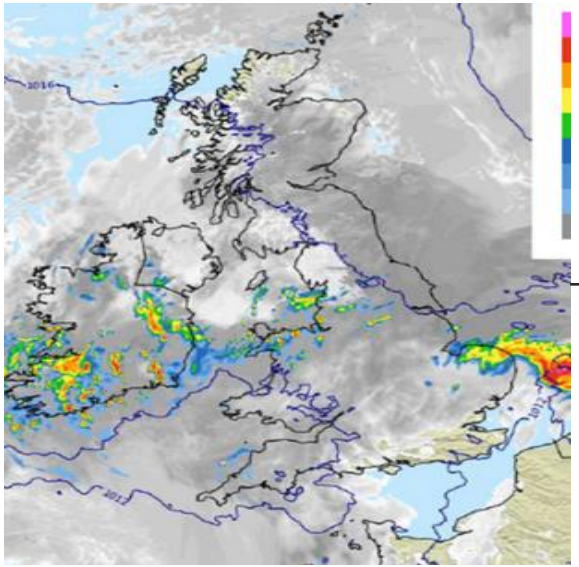


Met Office Unified Model (UKV)

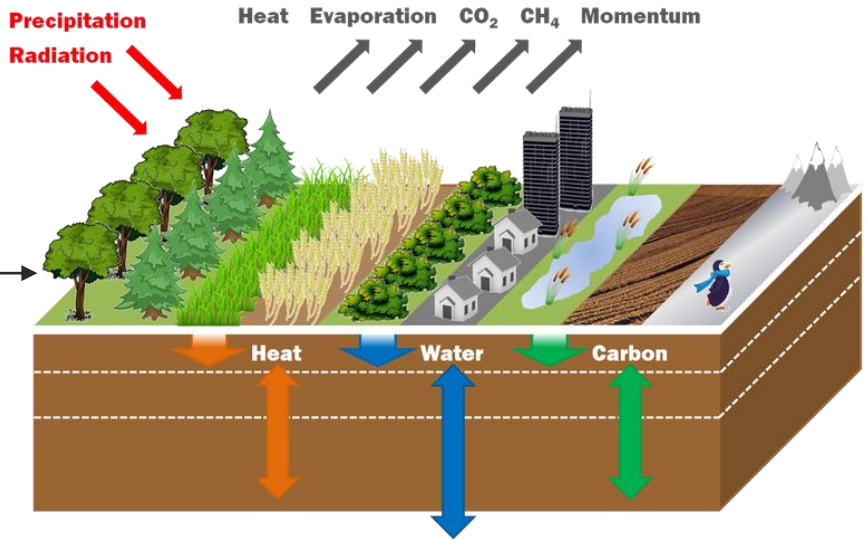
T+12



Site Extraction

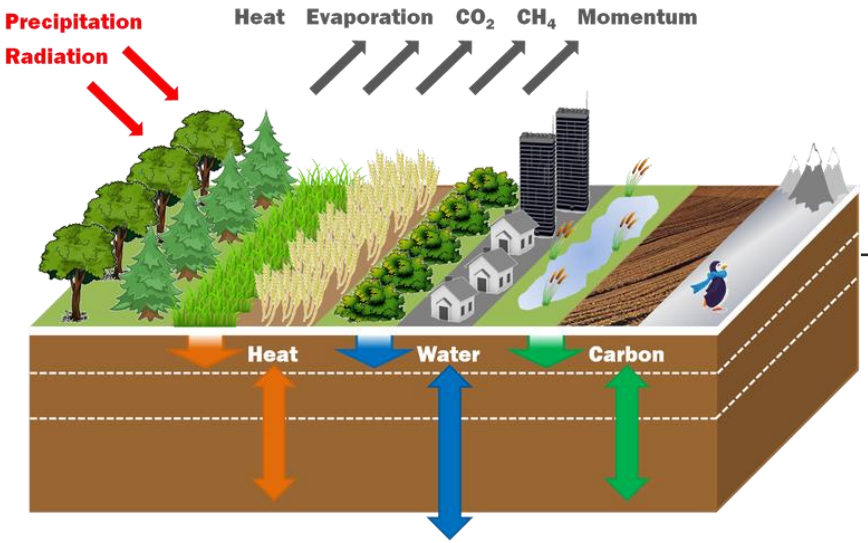


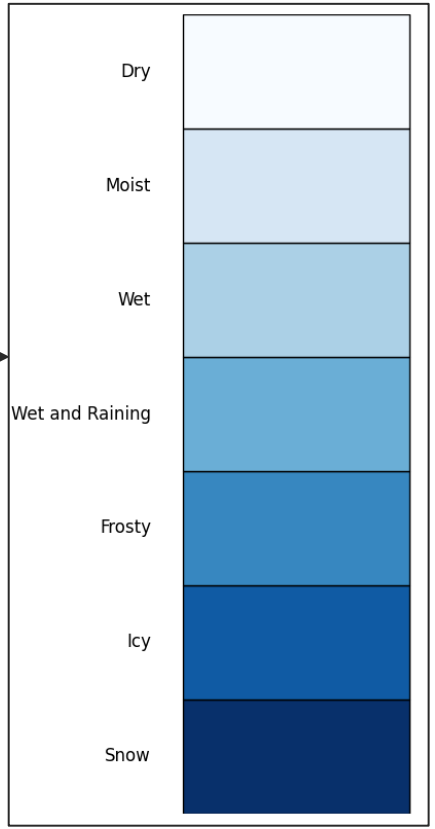
Surface Exchange Scheme



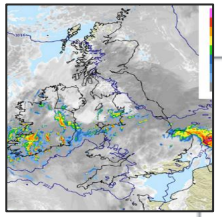
Best et al. (2011).

Road State Generation

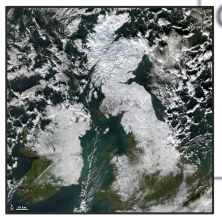




Forecasting as Information Compression

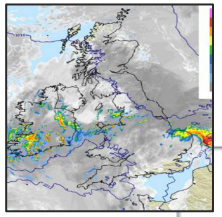


Previous NWP Output



Observational Data (Satellite + Radar)

~20Gb



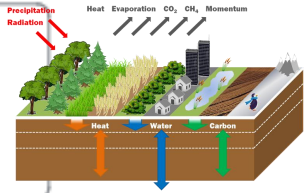
Numerical Weather Prediction (UKV / MOGREPS-UK)

~17GB

Site Extraction

~20KB/Site

Road Surface Model (JULES)



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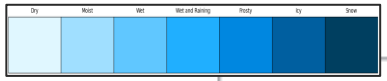
Road State Generation



~1byte/site

Decision

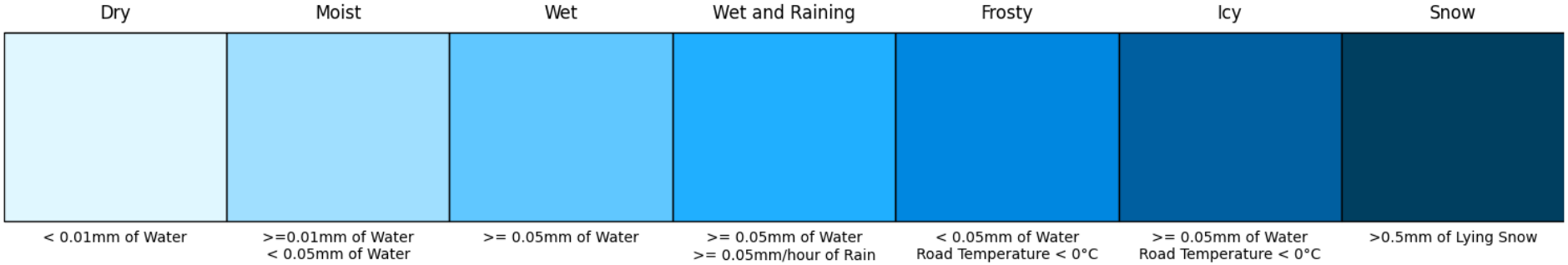
Sibley, Andrew & Cox, Dave & Tappin, David. (2021).
Bulgin, C. (2021).

Simplifying our Road States

The old system derived current state from current road conditions **and** previous states.

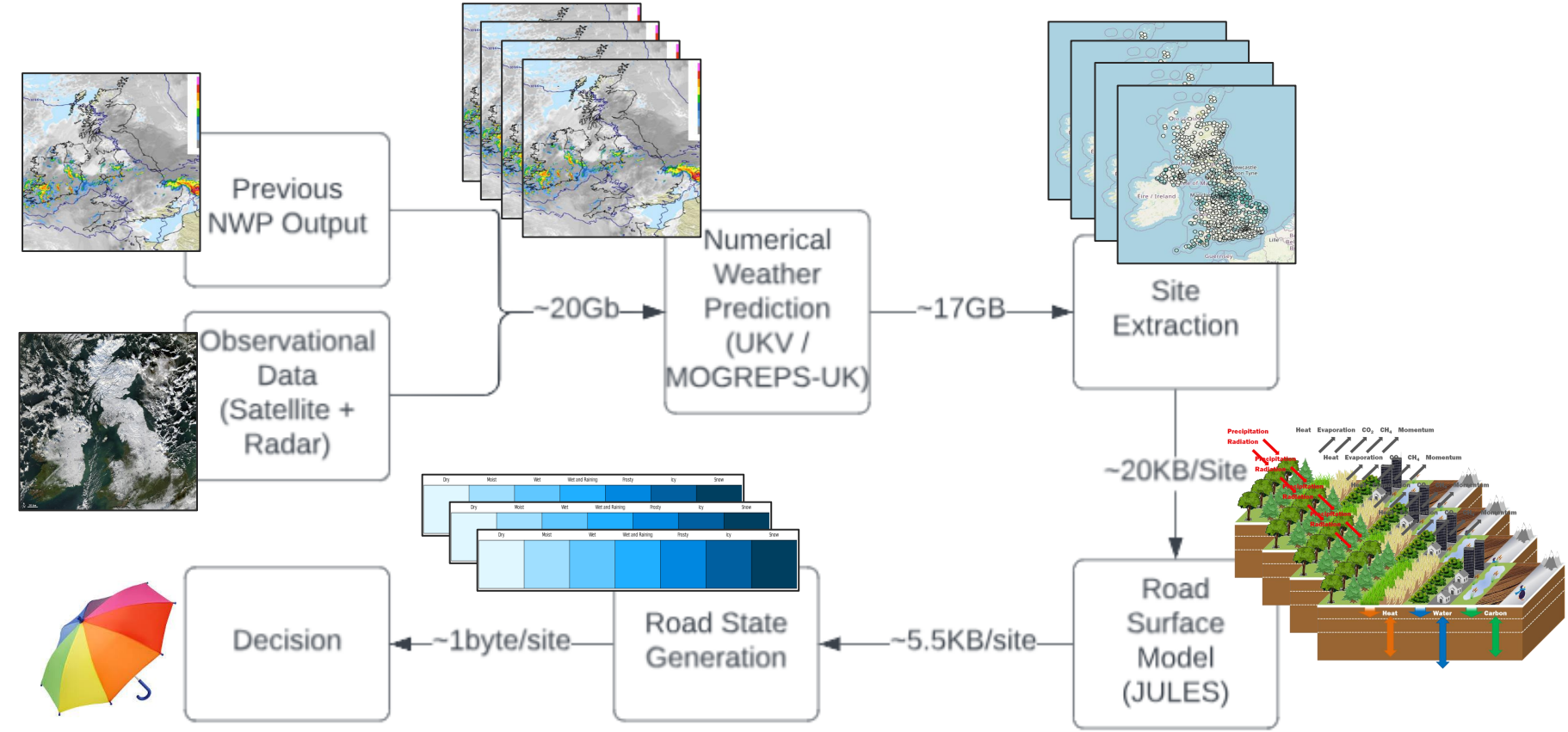
- Allows errors to propagate between timesteps.
- Incompatible with ensemble forecasting.
- Makes it hard to communicate what each state actually means.

Simplified Road State Definitions



Where the conditions for multiple states are satisfied, the right-hand state takes precedence.

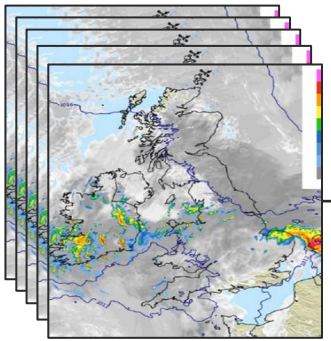
Ensemble Forecasting



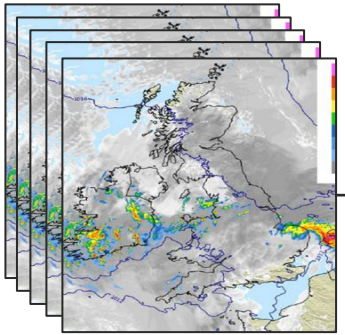
Sibley, Andrew & Cox, Dave & Tappin, David. (2021).
Bulgin, C. (2021).

Ensemble Forecast Example

10 Member Ensemble. 5 Members Predict Cold & Dry; 5 Predict Warm & Wet.



5 Members



5 Members

$$P(RST < 0^{o}C) = \frac{5}{10} = 50\%$$

$$P(Standing\ Water) = \frac{5}{10} = 50\%$$

What's the Probability of Ice?

$P(RST < 0^oC) = 50\%$ ✓

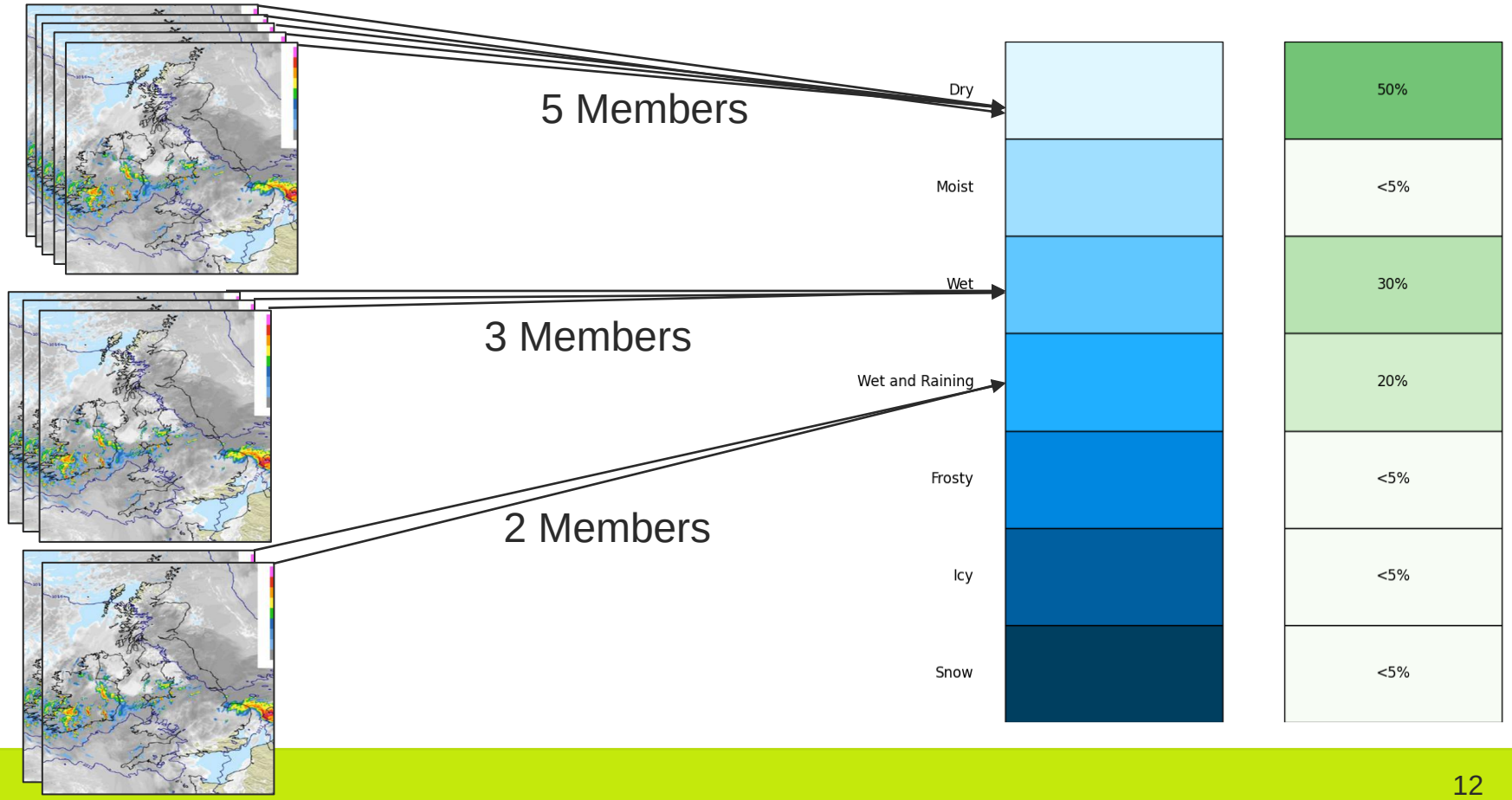
$P(Standing\ Water) = 50\%$ ✓

$P(Ice) = P(RST < 0^oC) \times P(Standing\ Water) = 50\% \times 50\% = 25\%$ ✗

If we treat the variables as independent, we can end up with answers that no ensemble member predicted.

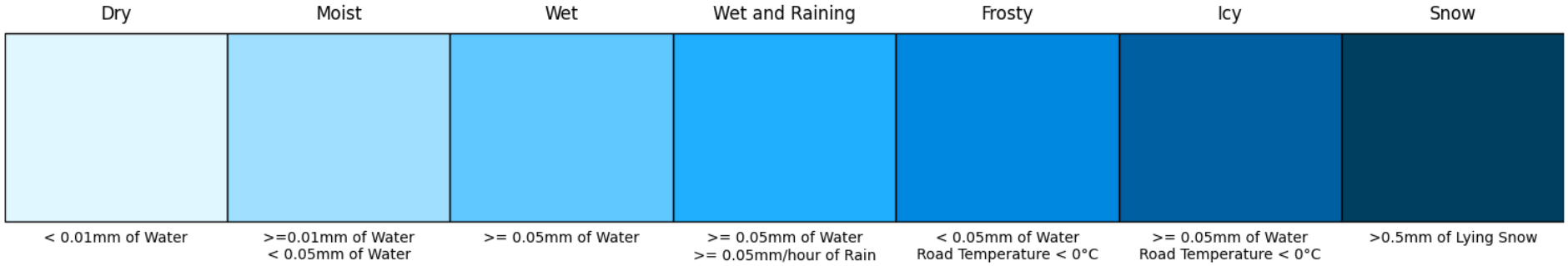
We need a better way of combining ensemble members.

Ensemble Visualisation with Road States



Conclusions

- Road Forecasts can be compressed into Road States.
- Simplifying Road States improves forecast communication.
- Road States provide one option for interpreting ensemble forecasts.

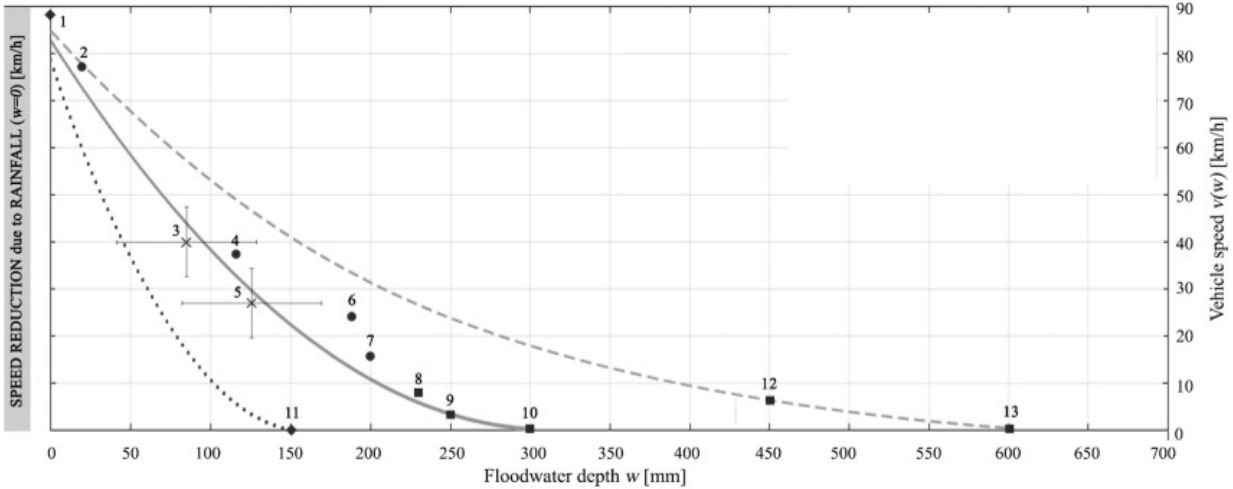


References

1. Sibley, Andrew & Cox, Dave & Tappin, David. (2021). Convective rear-flank downdraft as driver for meteotsunami along English Channel and North Sea coasts 28–29 May 2017. Natural Hazards. 106. 1-21. 10.1007/s11069-020-04328-7.
2. Bulgin, C. E. (2021, February 11). Why do clouds matter when we measure surface temperature from space? *Weather and Climate @ Reading*. https://blogs.reading.ac.uk/weather-and-climate-at-reading/2021/why-do-clouds-matter-when-we-measure-surface-temperature-from-space/
3. Best, M. J., Pryor, M., Clark, D. B., Rooney, G. G., Essery, R. L. H., Ménard, C. B., ... & Harding, R. J. (2011). The Joint UK Land Environment Simulator (JULES), model description–Part 1: energy and water fluxes. *Geoscientific Model Development, 4*(3), 677-699. https://doi.org/10.5194/gmd-4-677-2011
4. Pregnolato, M., Ford, A., Wilkinson, S. M., & Dawson, R. J. (2017). The impact of flooding on road transport: A depth-disruption function. *Transportation Research Part D: Transport and Environment, 55*, 67-81. https://doi.org/10.1016/j.trd.2017.06.020
5. Ong, G. P., & Fwa, T. F. (2008). Hydroplaning risk management for grooved pavements. In *7th International Conference on Managing Pavement Assets* (pp. 23-28).

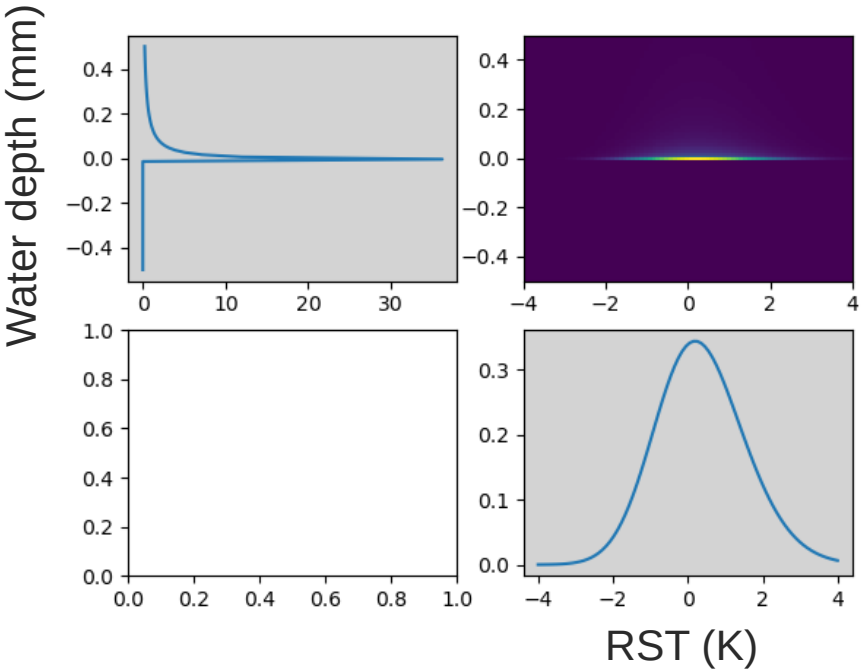
Moist/Wet Threshold

- Based on empirical studies of journey time disruption and hydroplaning risk.
- Threshold set for 10% disruption at 112km/h (70mph).



Pregnolato, M., Ford, A., Wilkinson, S. M., & Dawson, R. J. (2017).
Ong, G. P., & Fwa, T. F. (2008).

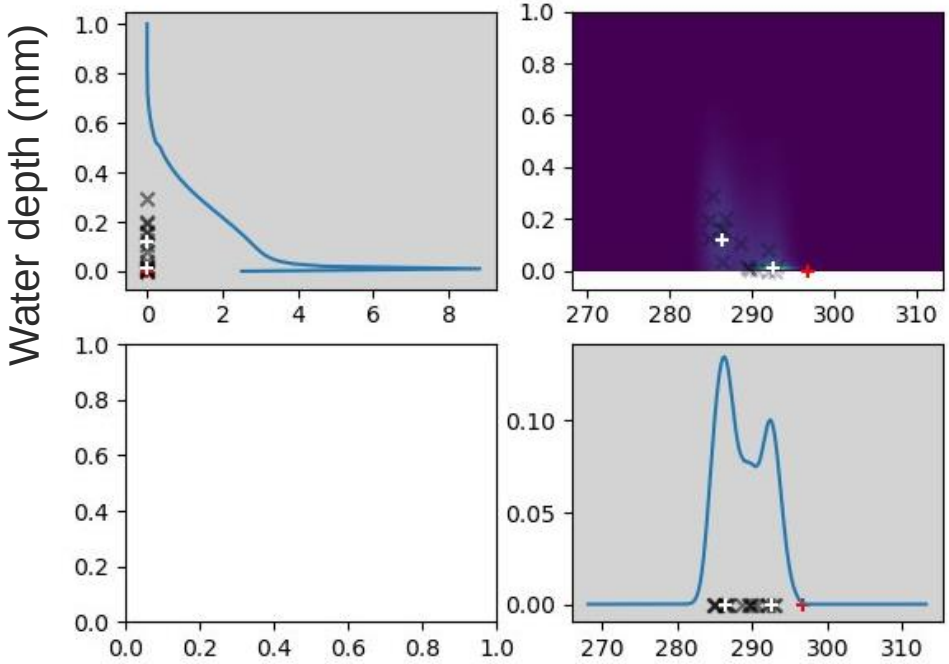
Defining our Kernels



- Use daughter ensemble approach *(Wang & Bishop 2005, Roulston & Smith 2003)*
- RST uses a skew normal distribution
- Water depth more complex
  - Skew normal when water is present on road
  - Gamma used when road is dry (<0.005 mm)
- Finally convolve distributions to construct domain that can produce pseudo-deterministic forecast

Application of KDE

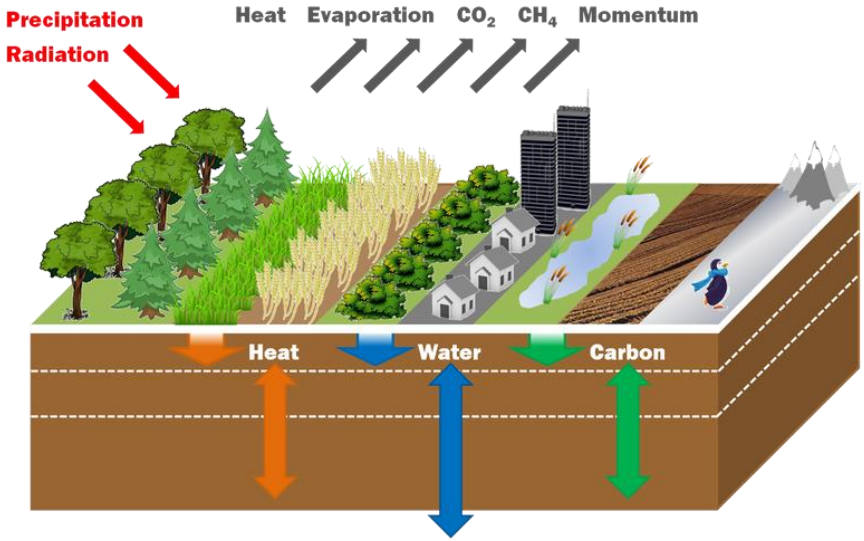
- Example site taken on A30 on 1st May 2019, using 18 MOGREPS-UK ensemble members (previous 6 hours) for KDE
- Create PDFs for RST and water depth, then convolve
- Black crosses are forecasts, red cross is observation, white crosses are maxima in probability domain



Met Office

JULES

Joint UK Land Environment Simulator



Source: https://jules.jchmr.org/content/about

JULES “road” tile