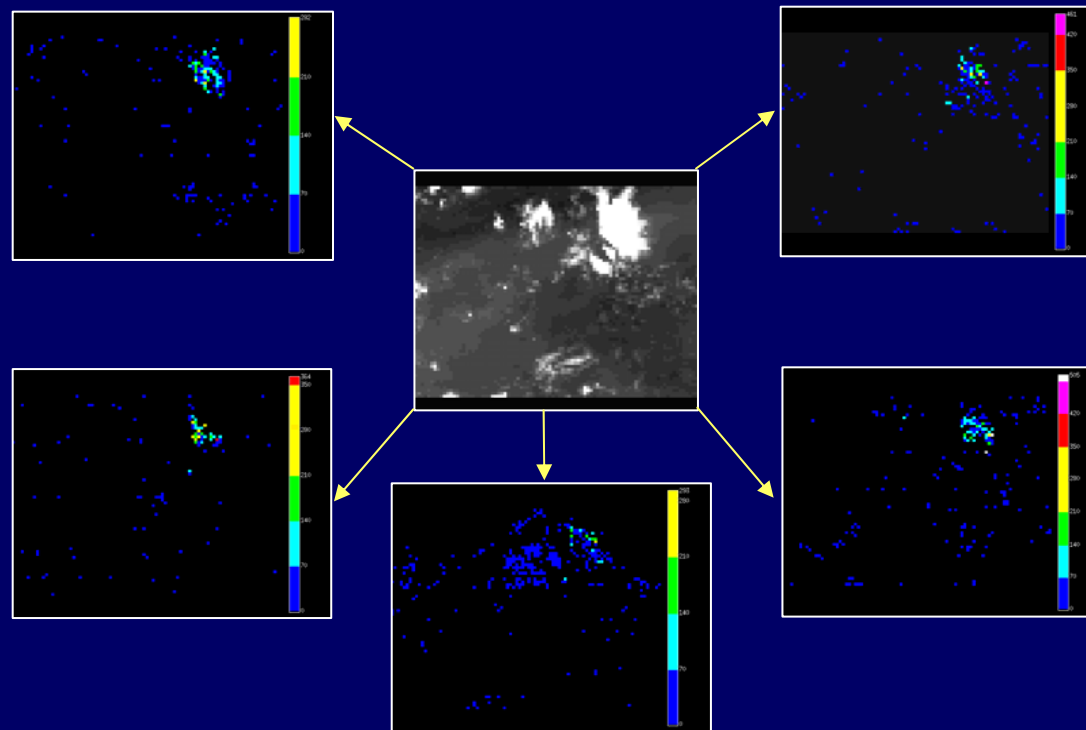
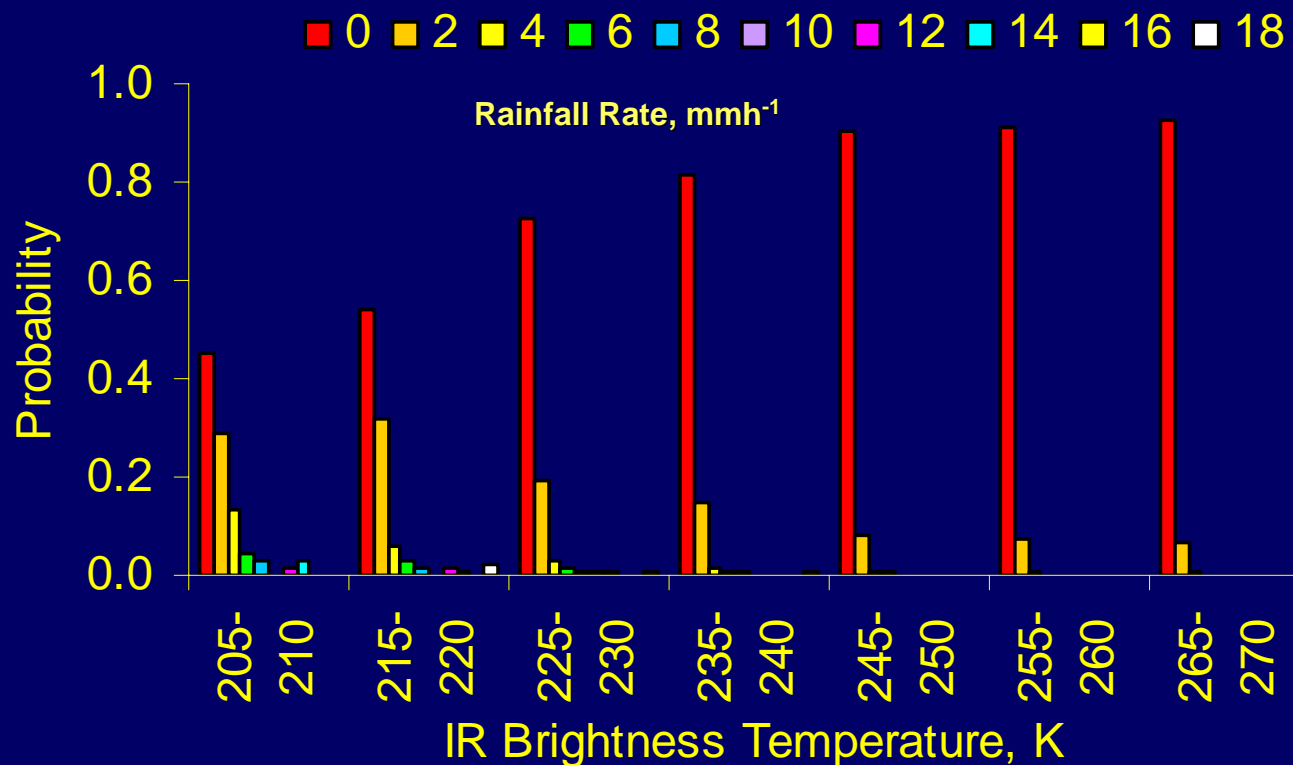
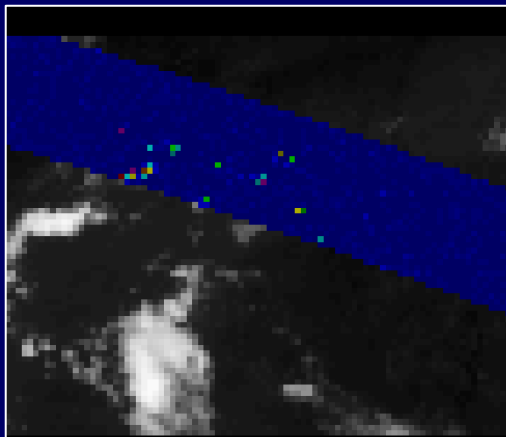


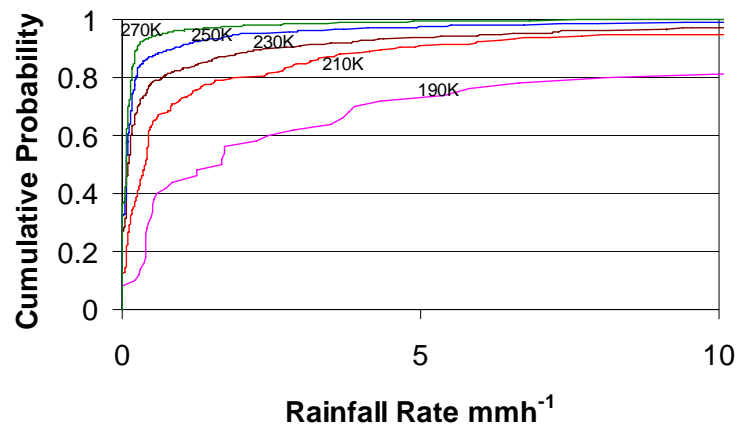
ENSEMBLE UNCERTAINTY REPRESENTATION IN SATELLITE QPE



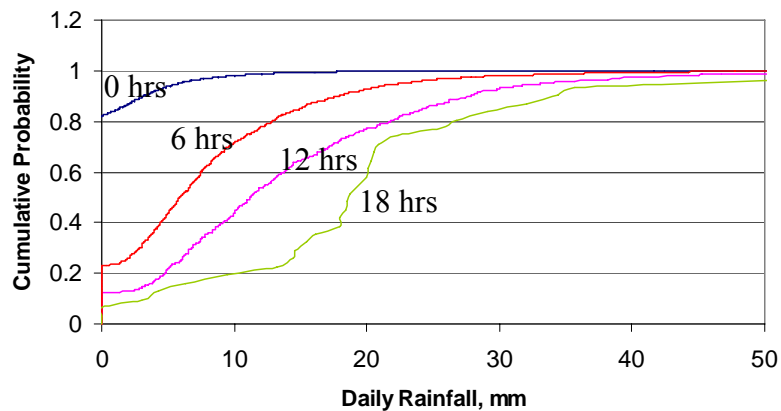
Tim Bellerby, Jizhong Sun, University of Hull, UK



1. **Satellite precipitation products display a complicated uncertainty structure**
 - Need to model the full CDF
2. **Uncertainty is spatially and temporally correlated**
 - Need to use ensemble representations



$$F(R|T_b) \approx \Phi(R; \alpha(T_b), \beta(T_b), \dots)$$



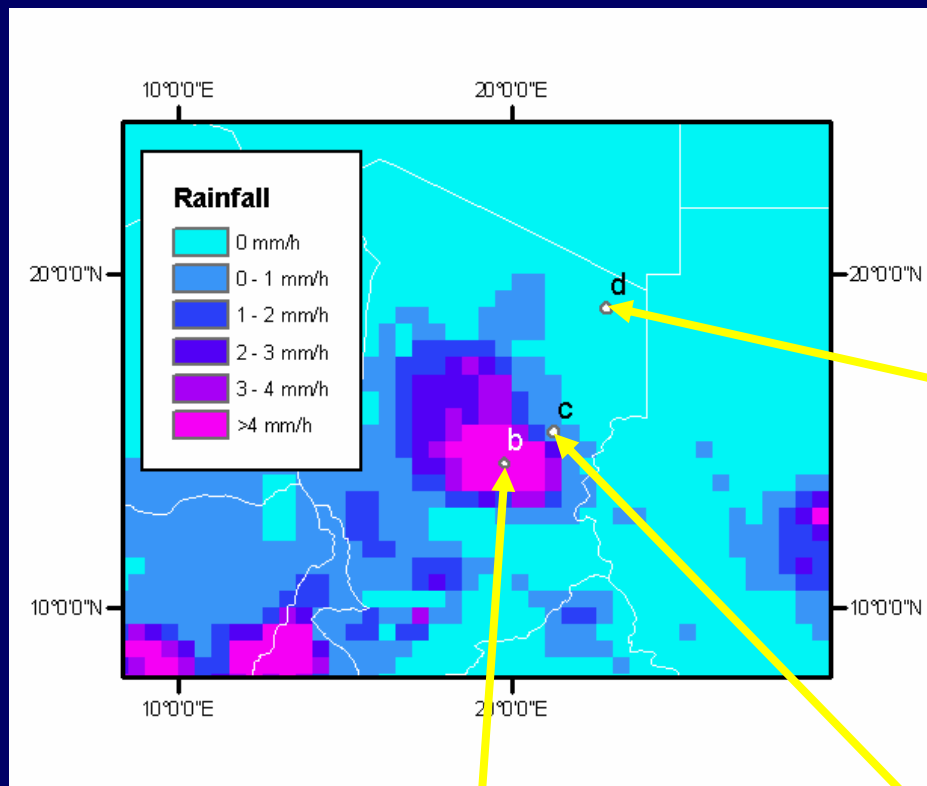
$$F(R|CCD) \approx \Phi(R; \alpha(CCD), \beta(CCD), \dots)$$

$$R^* = r(S_1, S_2, S_3, \dots)$$

$$F(R|R^*) \approx \Phi(R; \alpha(R^*), \beta(R^*), \dots)$$

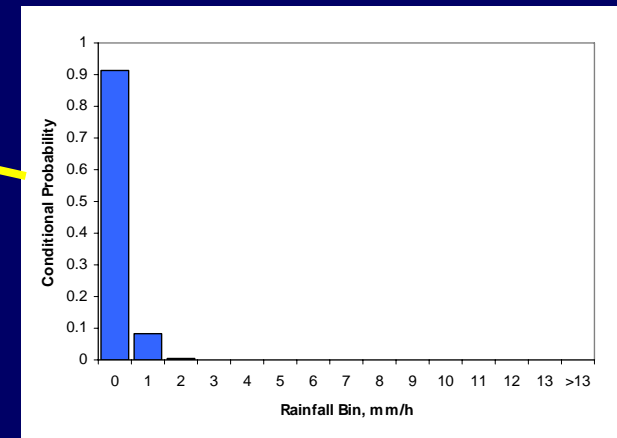
Need to generalise to $F(R|S_1, S_2, S_3, \dots)$

23:30 UTC on 6th July 2003

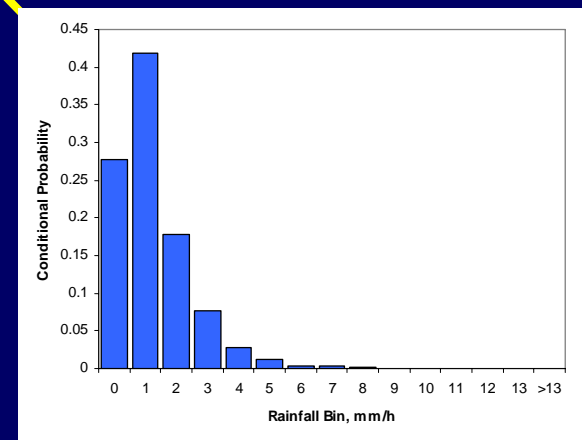


ANN estimation of Precipitation CDF (34 Inputs)

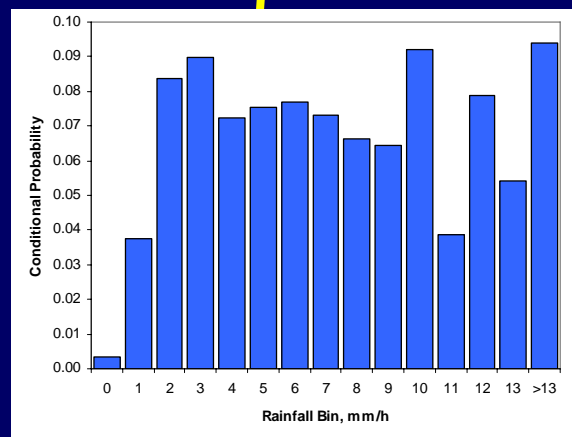
0.03 mm/h



0.77 mm/h



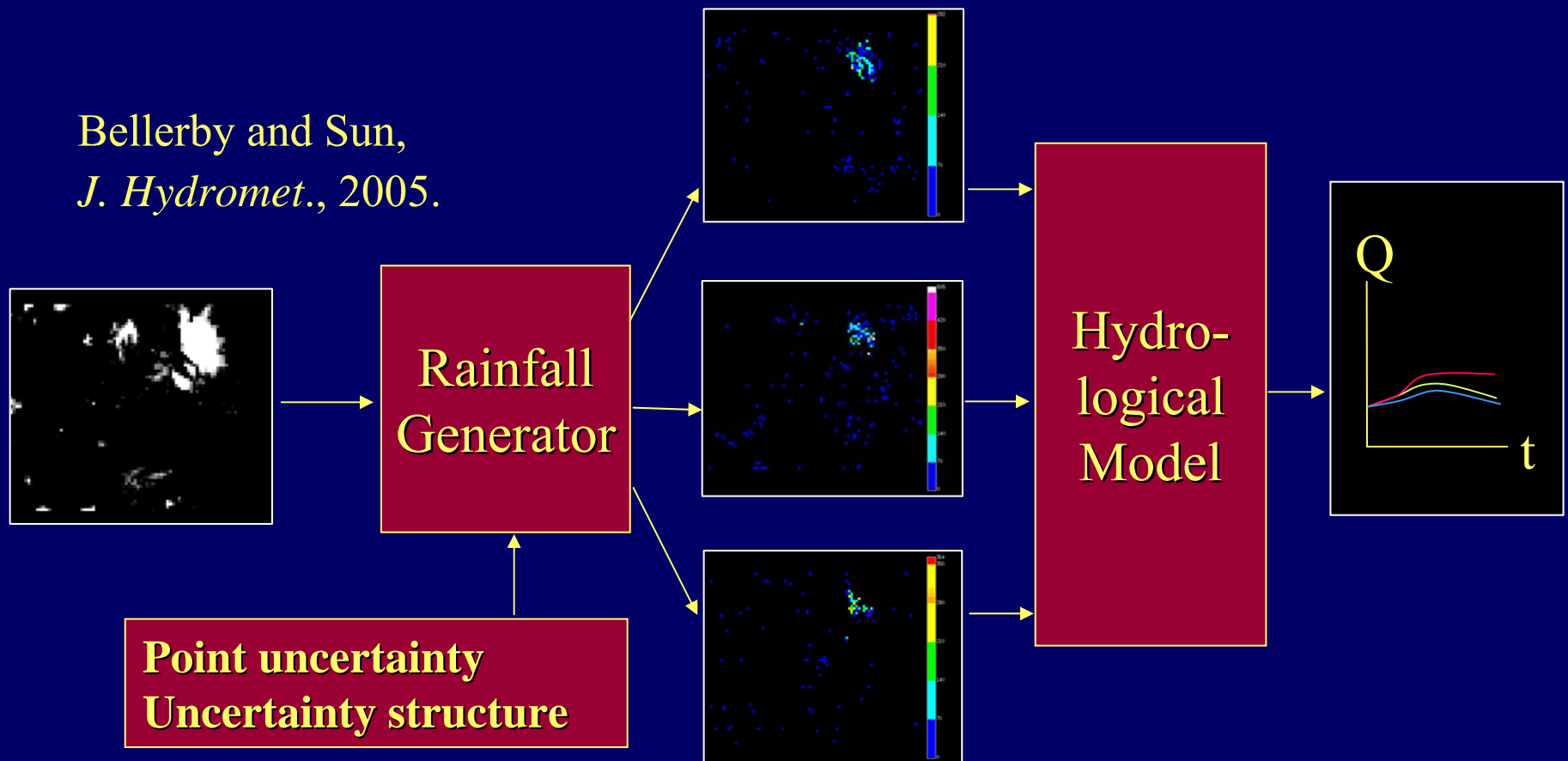
7.12 mm/h

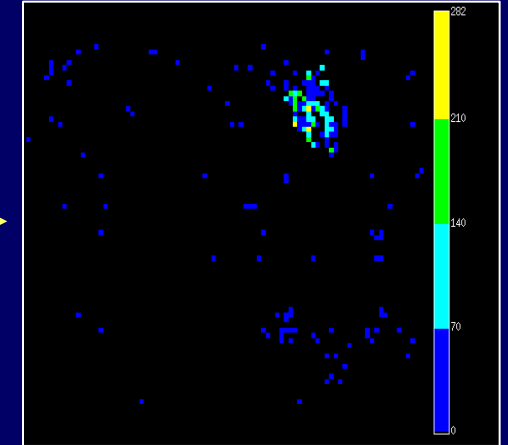
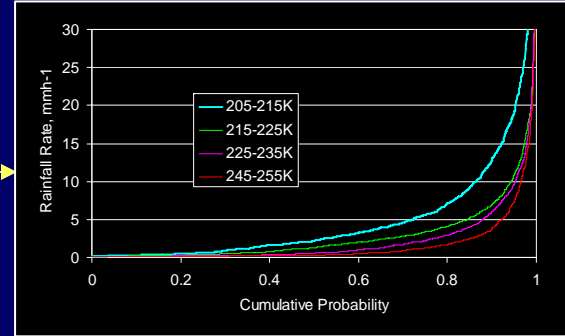
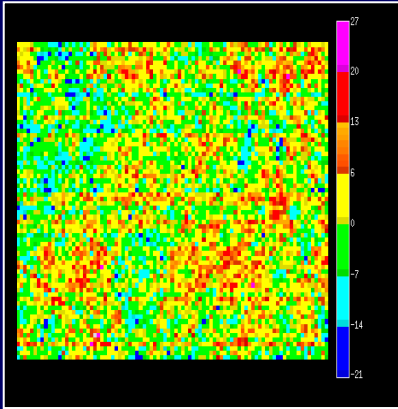


Bellerby, J. Hydromet, in press

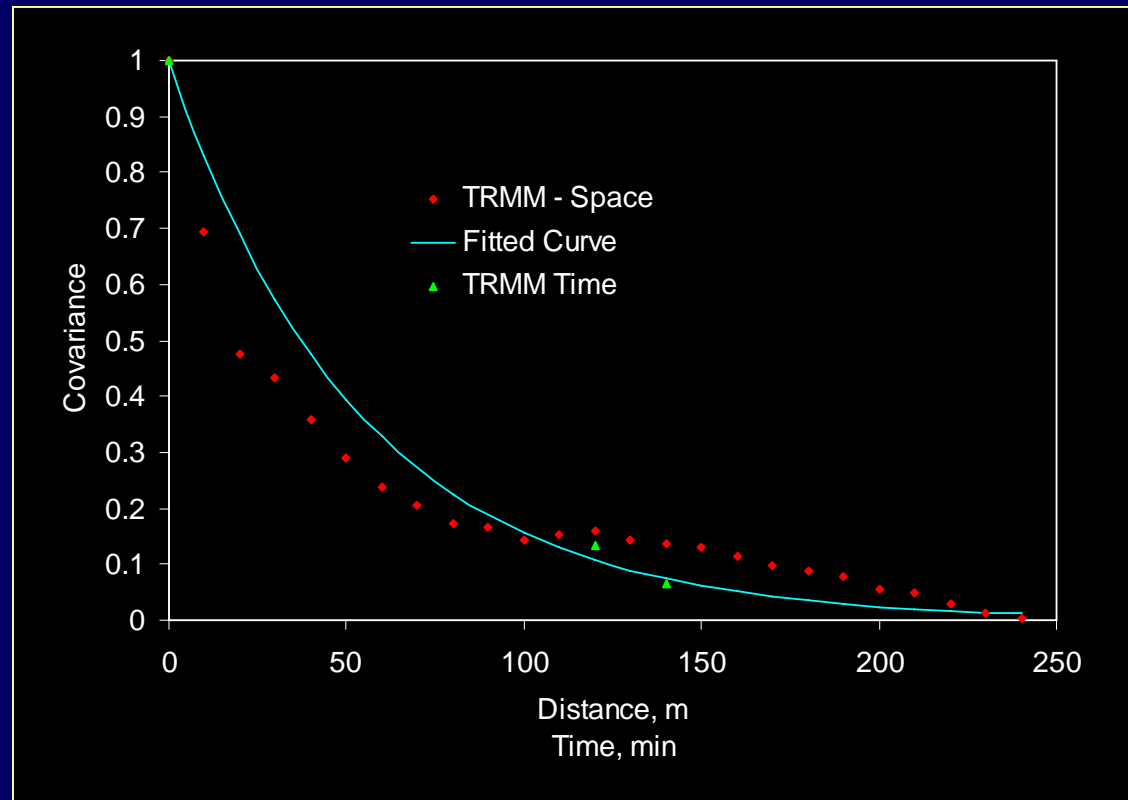
- For Satellite Rainfall Retrievals $E[R|S]$ does not display many of the structural characteristics of the ‘observed’ rainfall field
- Uncertainty in rainfall retrieval is spatially and temporally correlated

Bellerby and Sun,
J. Hydromet., 2005.



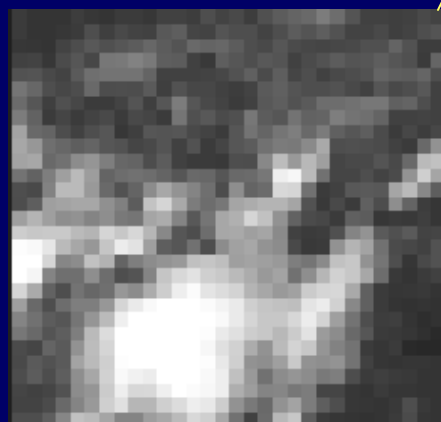


$$R_i(\mathbf{x}, t) = \begin{cases} F^{-1}(N(z_i(\mathbf{x}, t)); S(\mathbf{x}, t)) & N(z_i(\mathbf{x}, t)) \geq F(0; S(\mathbf{x}, t)) \\ 0 & N(z_i(\mathbf{x}, t)) < F(0; S(\mathbf{x}, t)) \end{cases}$$

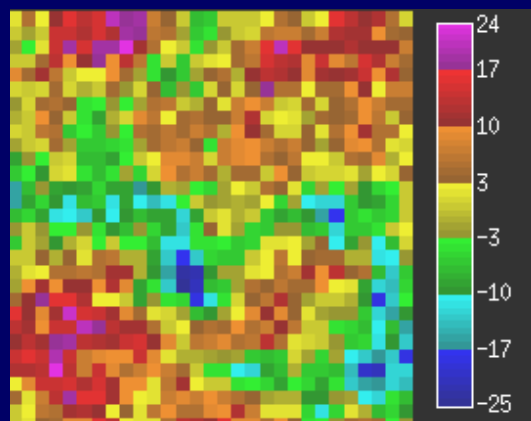


$$z^*(\mathbf{x}, t) = \begin{cases} N^{-1}(F(R^*(\mathbf{x}, t); S(\mathbf{x}, t))) & \text{if } R^*(\mathbf{x}, t) > 0 \\ \text{Undefined} & \text{if } R^*(\mathbf{x}, t) = 0 \end{cases}$$

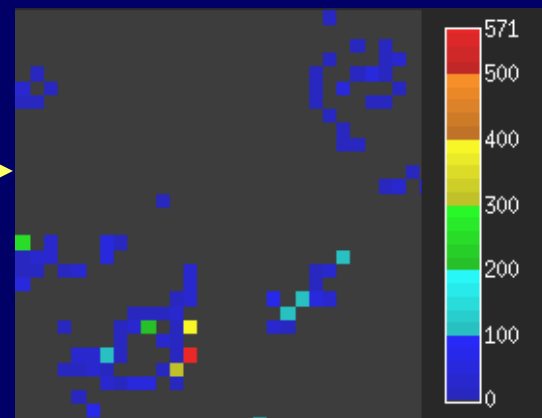
$$C(\delta \mathbf{x}, \delta t) = e^{-\sqrt{a\delta x^2 - b\delta t^2}}$$



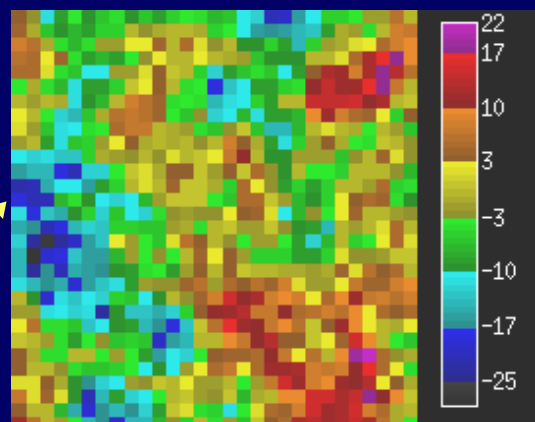
GOES Band 4
16:15 LT
22/8/98



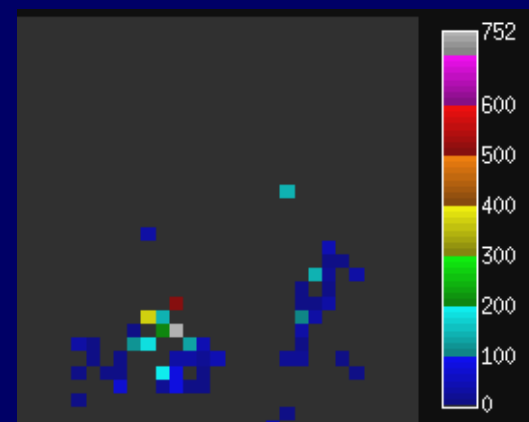
Random field
Tenths of a standard deviation



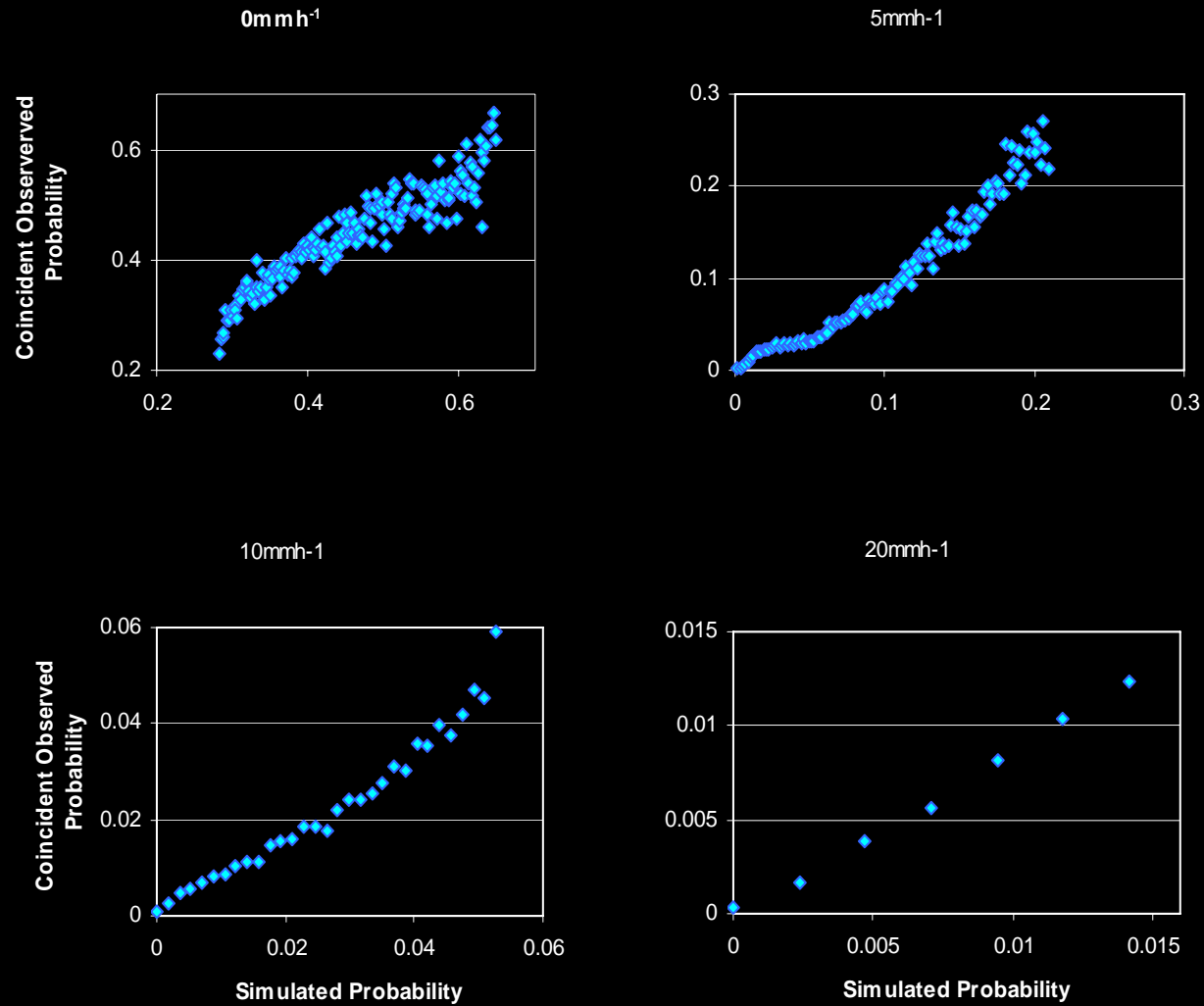
Rainfall
Tenths of a millimetre



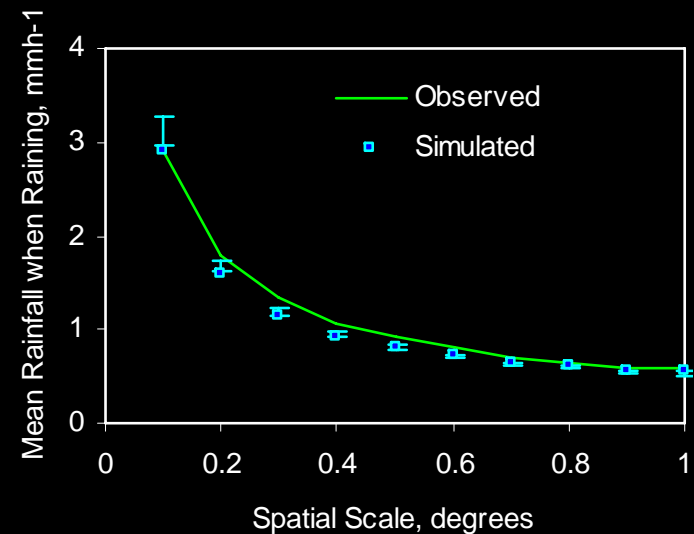
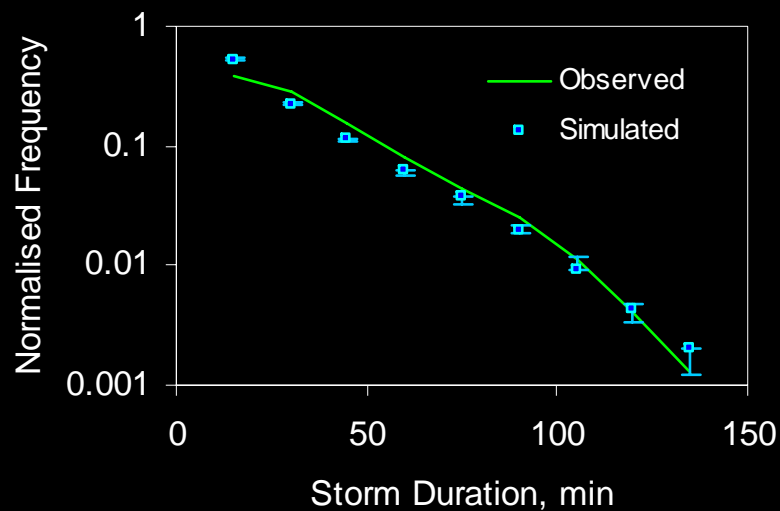
3D Turning Bands



Validation: Point CDFs



Validation: Spatial and Temporal Structure



Summary

- Point rainfall retrieval uncertainties:
 - Parametric model for single input
 - Histogram model for multiple inputs
- Ensemble uncertainty modelling
 - Accounts for spatial and temporal correlation of uncertainty
 - Generates rainfall fields with realistic structures suitable for driving hydrological models