Derivation of AMVs from single-level retrieved MTG-IRS moisture fields

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Introduction

Objectives

- **Utilise high temporal and spatial resolution of MTG-IRS data**
- **Feature tracking using 3D moisture retrieval fields**

Motivation

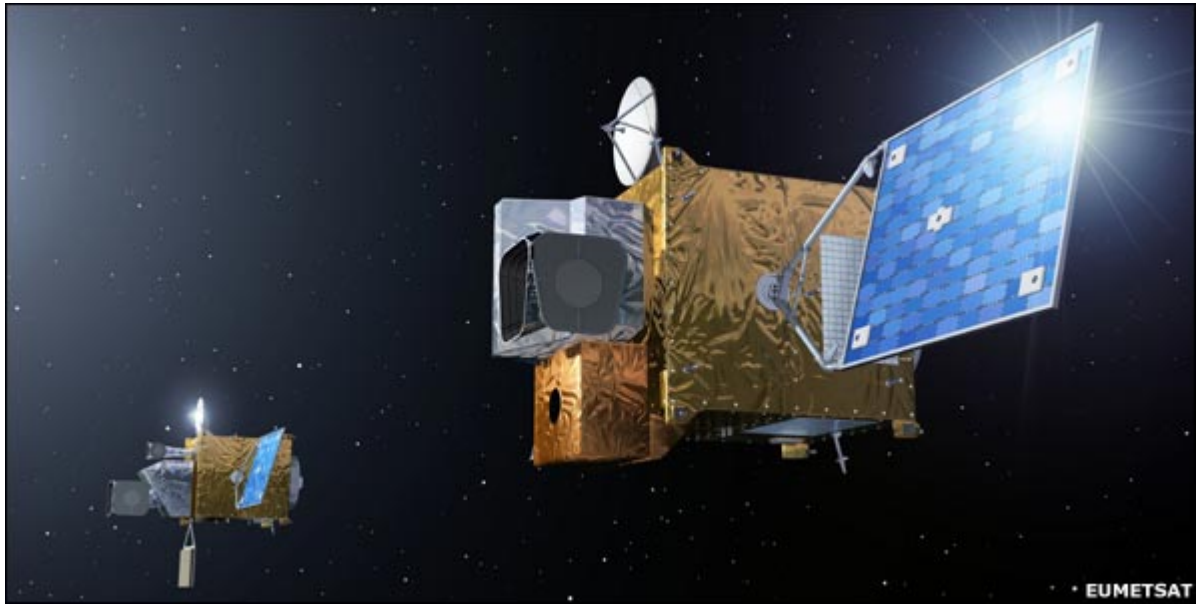
- **AMVs typically derived by tracking tracers (ie. clouds) in WV, IR and VIS channels**
- **Height assignment is main source of error**
- **Tracking on model levels = no need for height assignment**

Studies

- **Use Met Office UKV 1.5km model to generate simulated spectra**
- **Use NWPSAF 1DVar retrieval to generate single-level humidity fields**
- **Use feature tracking code to generate AMVs for comparison with true model winds**

MTG-IRS: Infrared sounder

- Launch ~2019 (imager launch ~2017/2018)
- Spectral resolution of 0.625cm^{-1} (cf IASI 0.25cm^{-1})
- Measurements in LWIR (800 channels 700-1210cm^{-1}) and MWIR (920 channels 1600-2175cm^{-1})
- Horizontal resolution ~4km; temporal resolution = 30 min
- Vertical resolution ~1km for T and q

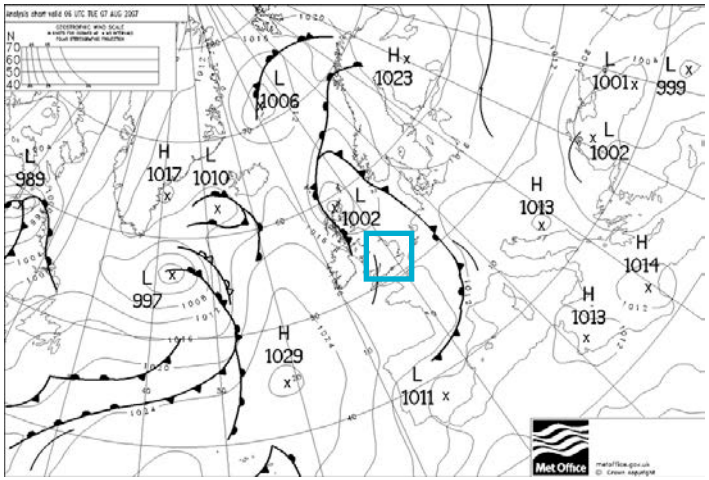


Simulation studies

INPUT: IASI coefficient file

RADIATIVE TRANSFER MODEL

INPUT: UKV1.5km forecast fields (case: convective initiation in clear-sky conditions)



OUTPUT/INPUT: Simulated clear sky brightness temperature spectra

INPUT: R matrix

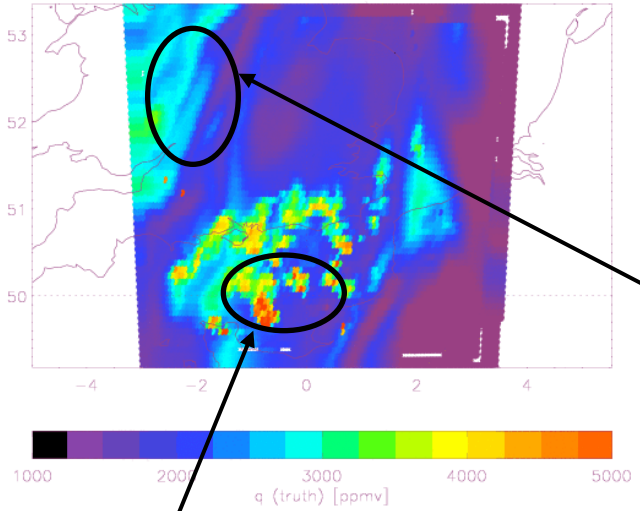
INPUT: B matrix

1DVAR

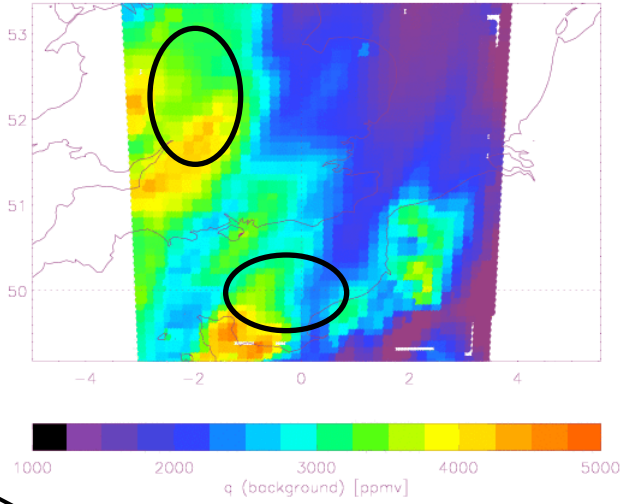
INPUT: B/g state from 12km MO NAE model

OUTPUT: Retrievals of temperature and humidity

MTG-IRS humidity retrievals @656hPa



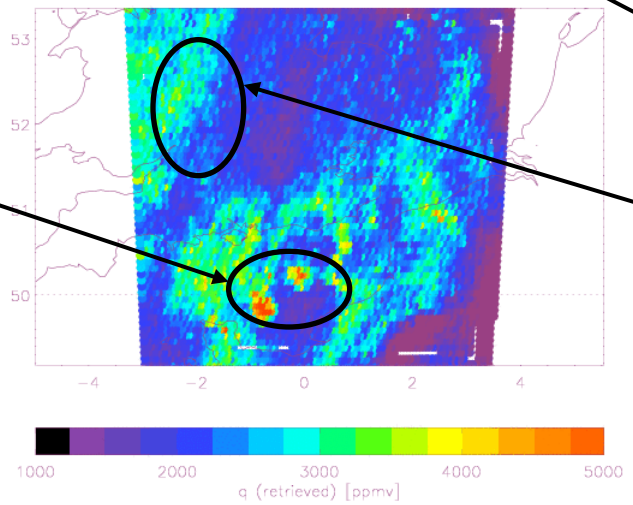
MODEL



BACKGROUND

Better representation of fine-scale structure

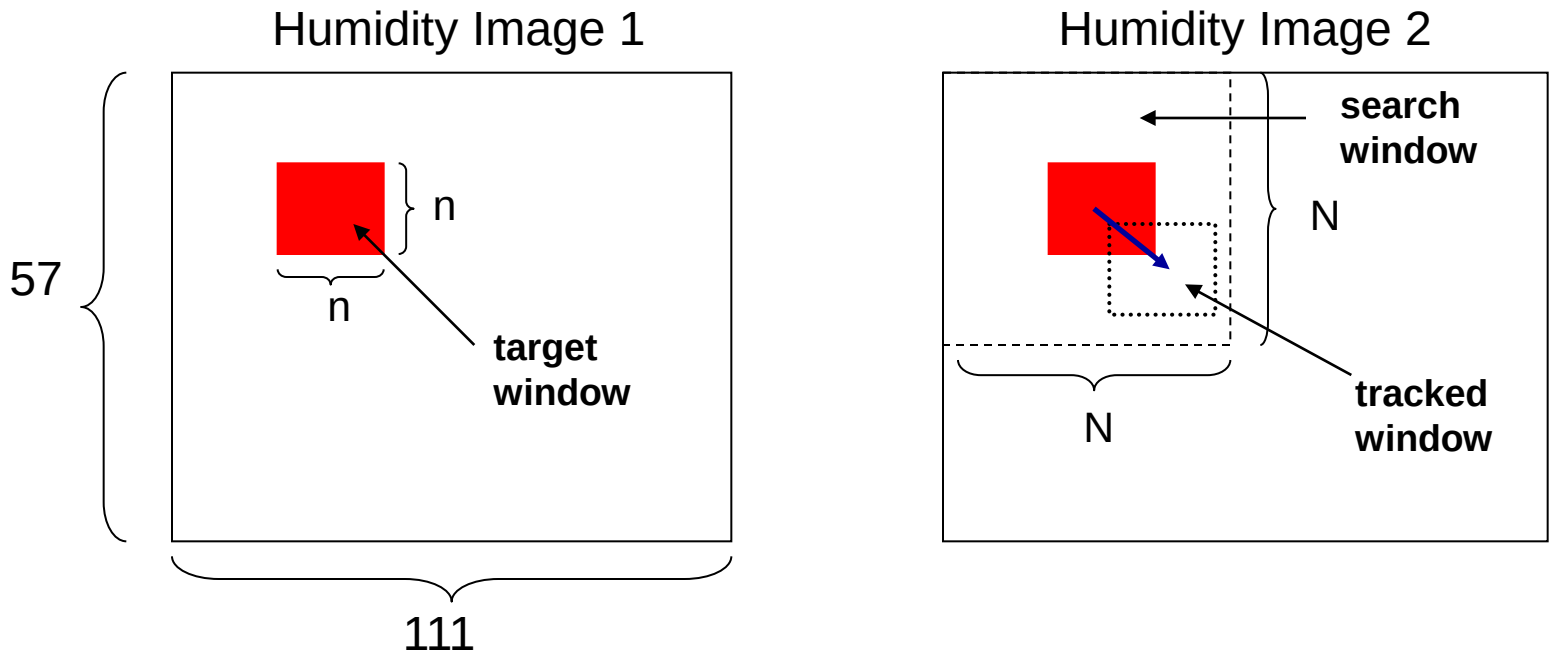
Better representation of gradient structure



RETRIEVAL

Feature tracking algorithm

- Modified CPTEC feature tracking software
- Target matching by minimising sum of square differences
- Correlation matching + contrast check + QC scheme
- Time interval between images = 30 minutes
- Target window size = 6x6, 8x8, 10x10, 12x12 pixels



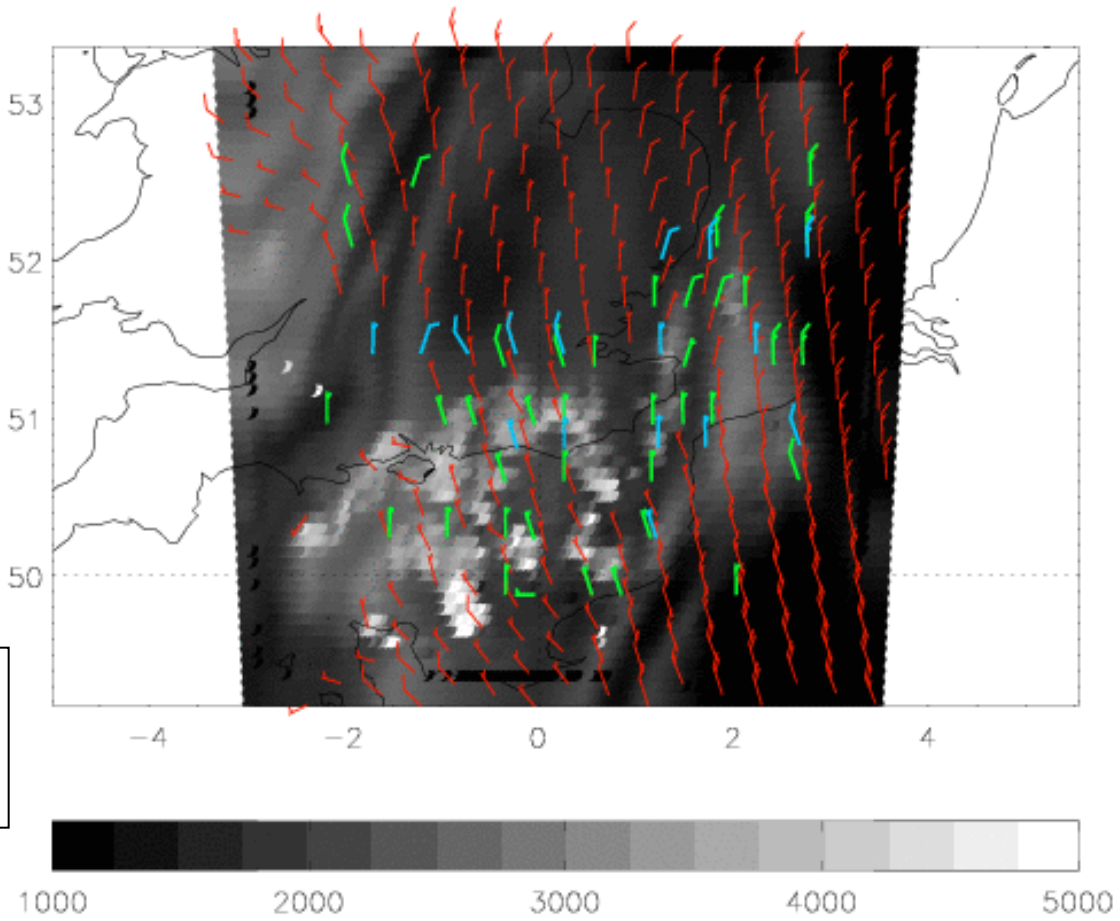
Tracking model fields @ 656hPa

Truth tracked winds d=6

Truth tracked winds d=10

Model wind field

0-2.5m/s	**No barb**
2.5m/s	**Short barb**
5m/s	**Long barb**

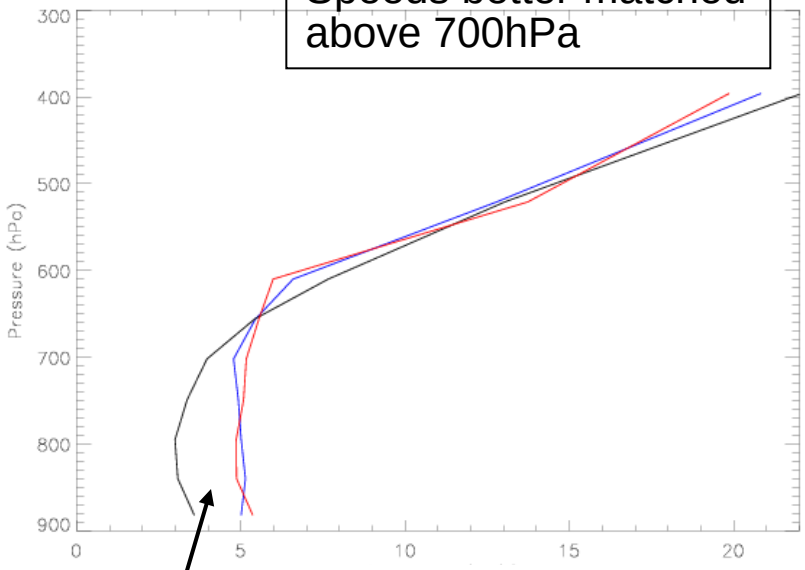


Humidity field at 09:30 [ppa]

Good representation of true wind field

Tracking model fields: MSB and MMVD

Speeds better matched above 700hPa



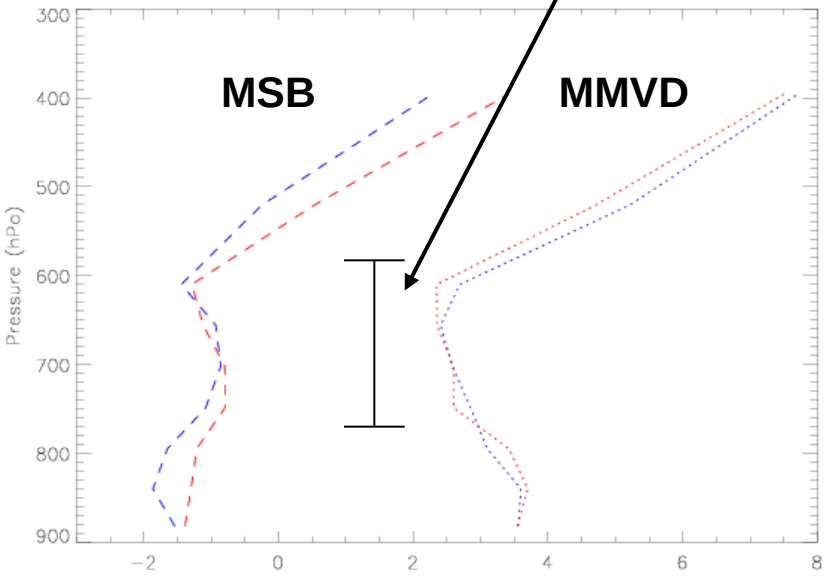
Derived winds are too fast below 700hPa – unable to track winds < 2.5m/s ?

---- model wind speed

---- wind speed d=6

---- wind speed d=10

Comparable MMVD errors in mid troposhere

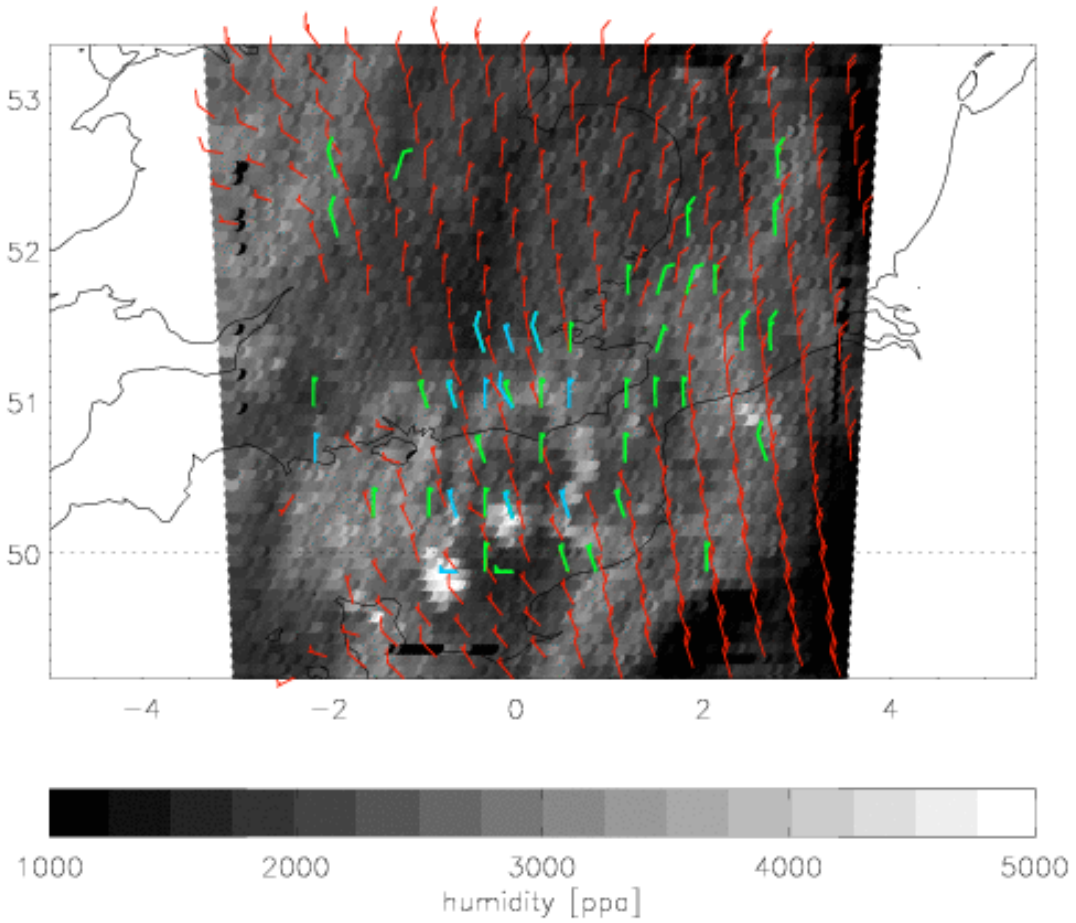


Tracking retrieval fields @ 656hPa

Retrieval tracked winds d=6

Model tracked winds d=6

Model wind field

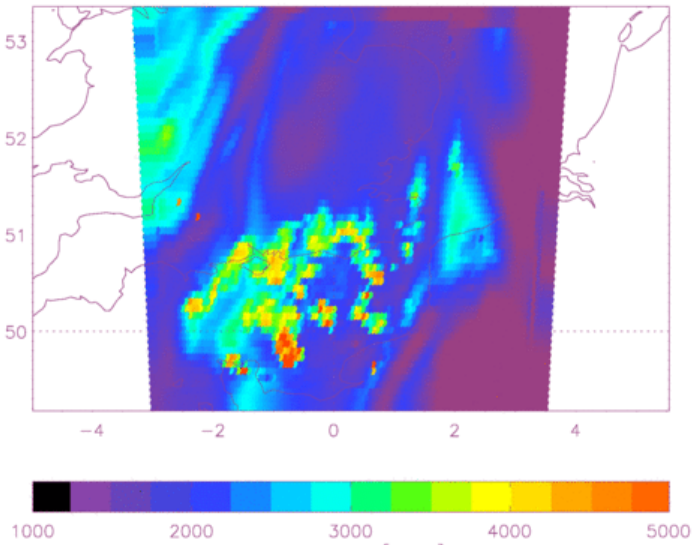


Humidity field at 09:30 [ppa]

0-2.5m/s	**No barb**
2.5m/s	**Short barb**
5m/s	**Long barb**

Sparser distribution and much fewer winds!

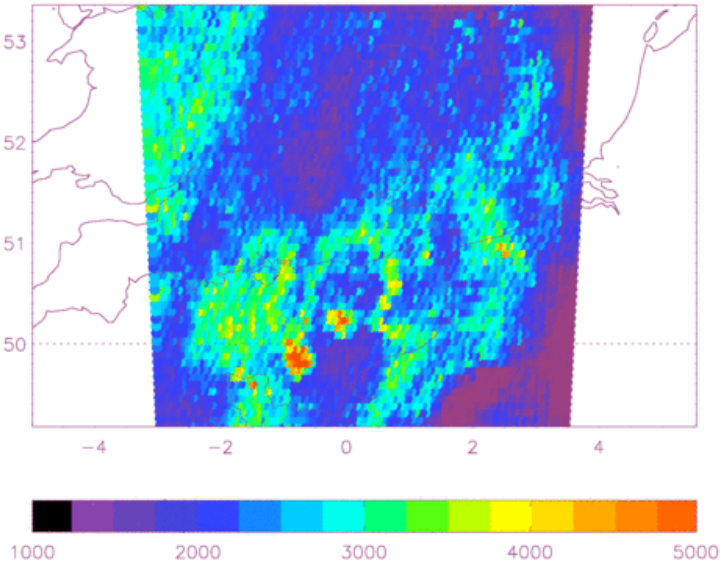
Are the humidity retrievals too noisy?



Model field @ 656hPa

Similar structure to model field but noise makes gradients less well-defined

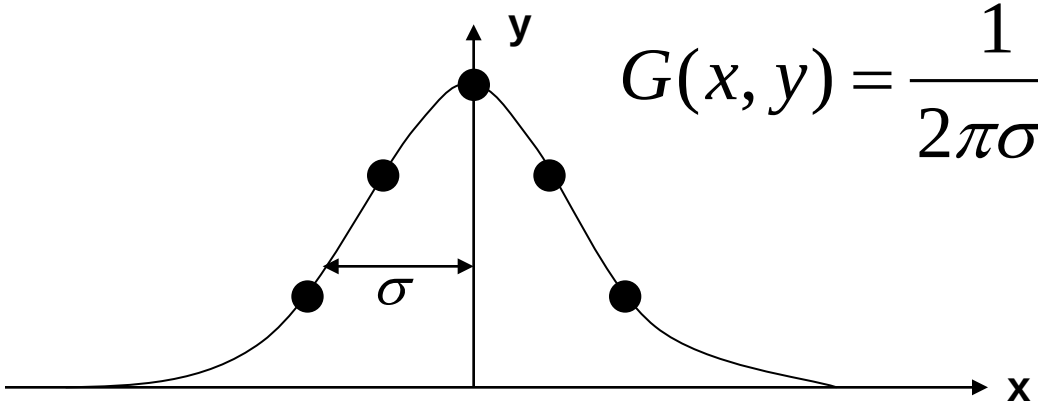
Results in far fewer feature tracked winds generated



Retrieval field @ 656hPa

Gaussian multi-scale representation

- Smoothing technique
- Convolution of the image with a 2D Gaussian kernel G(x,y)
- σ^2 dictates the spread of the Gaussian function and hence the level of smoothing/range of frequencies removed
- Choose σ^2 such that the noise is reduced without smoothing away fine-scale features and strong gradients



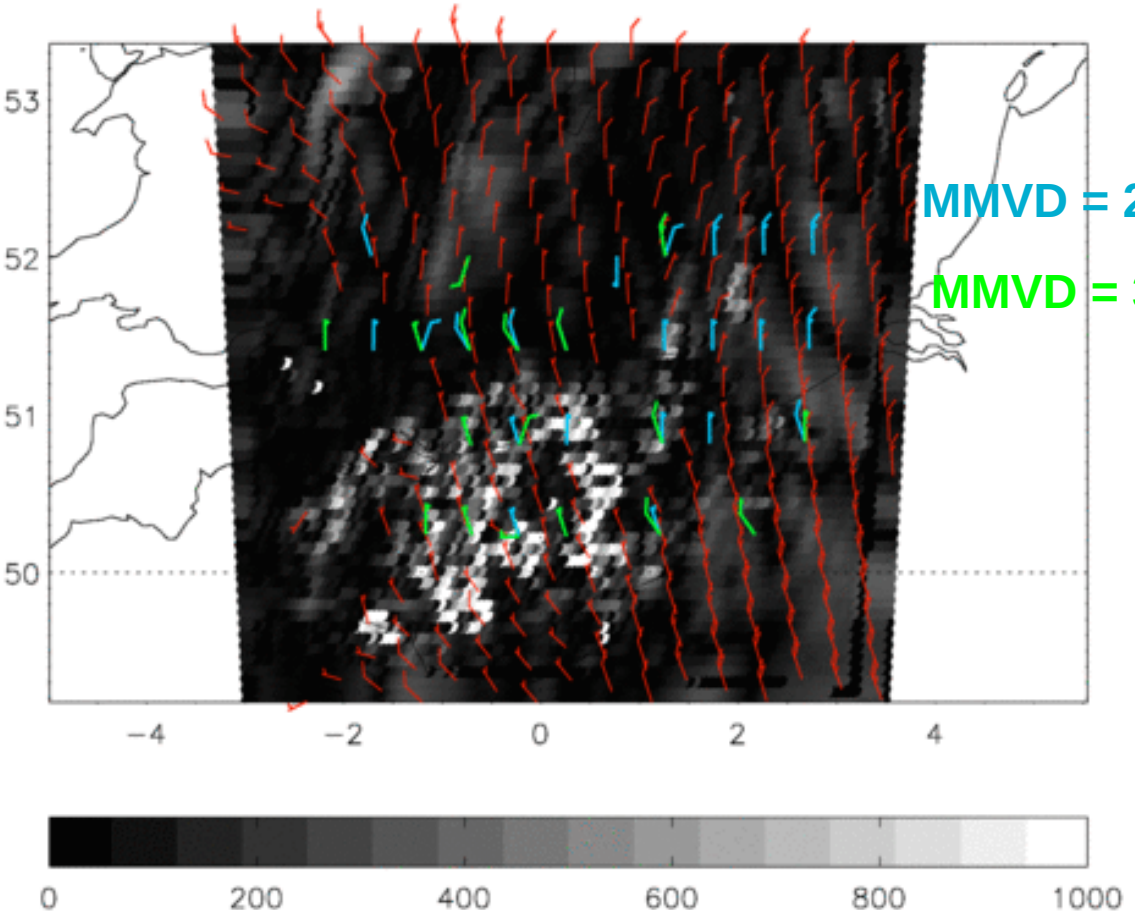
$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{-(x^2+y^2)/2\sigma^2}$$

Truth tracked vs smoothed retrieval tracked winds

Truth tracked winds d=10 (#winds = 22)

Smoothed retrieval tracked winds d=10 (#winds = 17)

Model wind field



MMVD = 2.35m/s

MMVD = 3.50m/s

0-2.5m/s	**No barb**
2.5m/s	**Short barb**
5m/s	**Long barb**

Difference in Q field between 09:00 & 09:30

More comparable with truth tracked winds

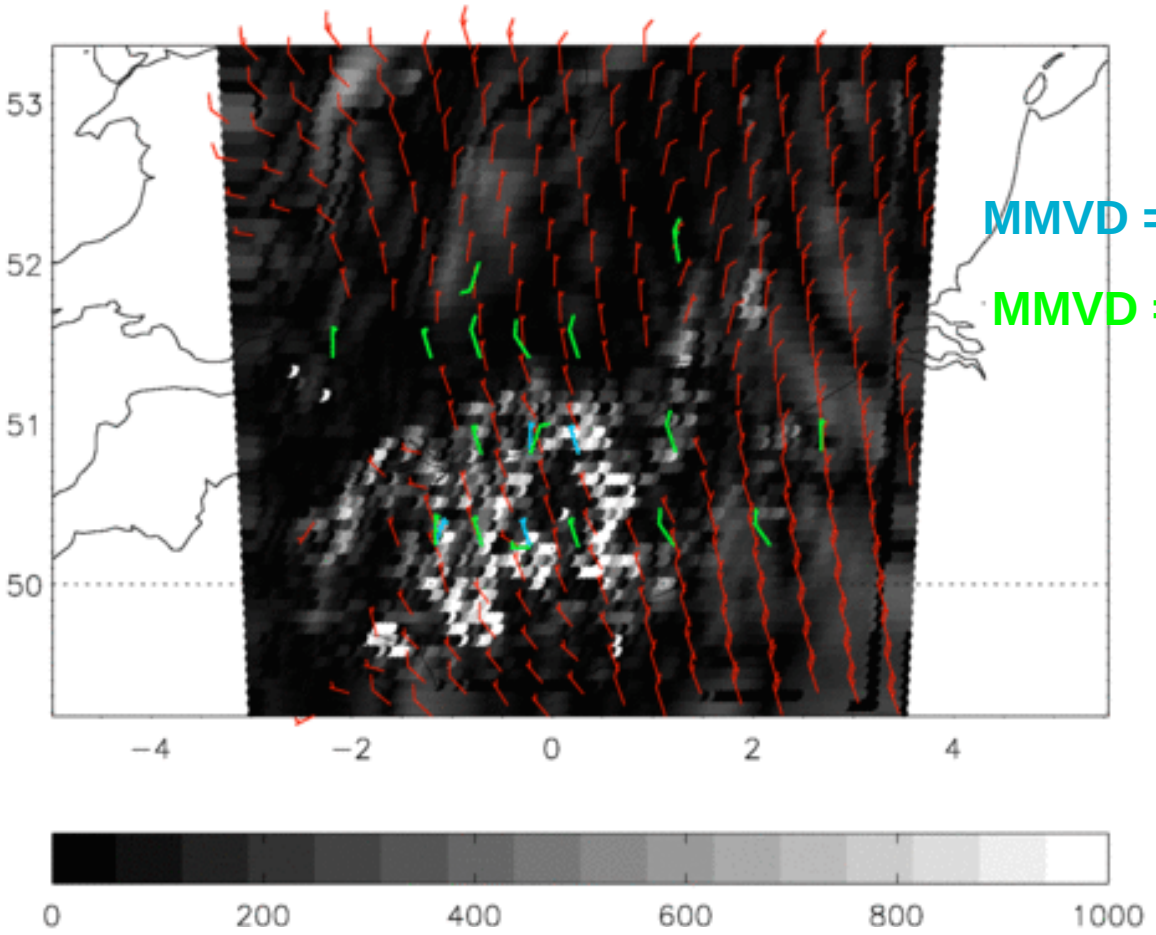
Smoothed vs retrieval tracked winds

Smoothed retrieval tracked winds d=10 (#winds = 17)

Retrieval tracked winds d=10 (#winds = 9)

Model wind field

0-2.5m/s	**No barb**
2.5m/s	**Short barb**
5m/s	**Long barb**



MMVD = 2.65m/s

MMVD = 3.50m/s

Difference in Q field between 09:00 & 09:30

More winds BUT increase in MMVD

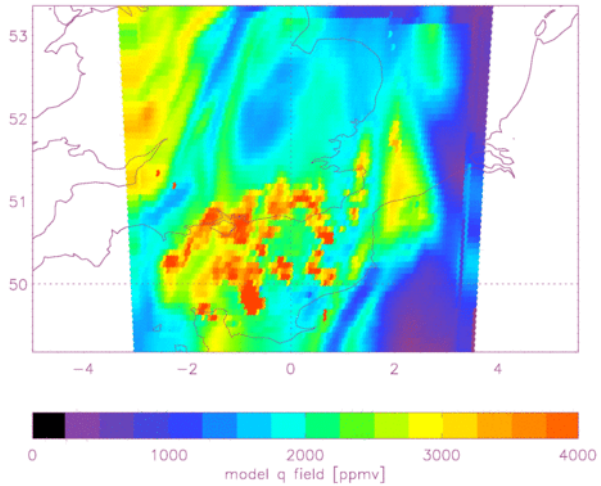
Summary

- Feature tracking in model humidity fields provides a good representation of the true wind field
  - Best results in mid-troposphere - comparable MMVD and MSB
- Tracking retrieval fields provides useful wind information but the quantity and distribution of the derived winds is significantly reduced relative to tracking model fields
  - Retrieval fields too noisy
  - Good quality but fewer AMVs
- Gaussian smoothing can eliminate the noise from the retrievals but still retain much of the trackable structure
  - Increased number of AMVs
  - Increased MMVD
  - Future work – optimal sigma? error thresholds?

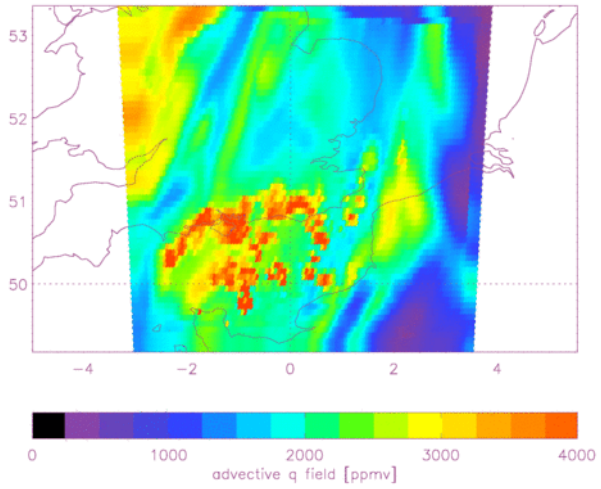
Questions and answers

Water vapour as a passive tracer @ 656hPa

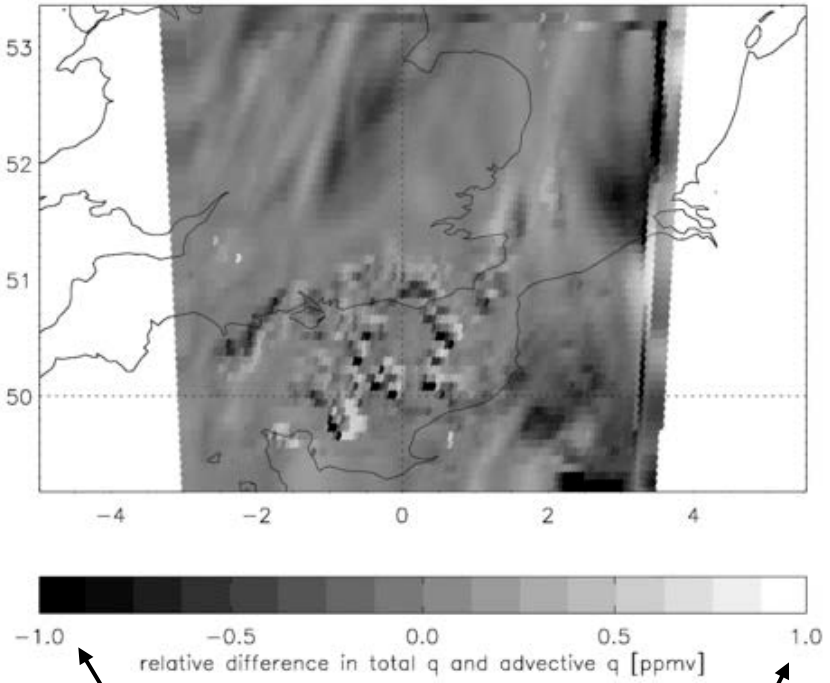
Model field Q



Advective field Q^A

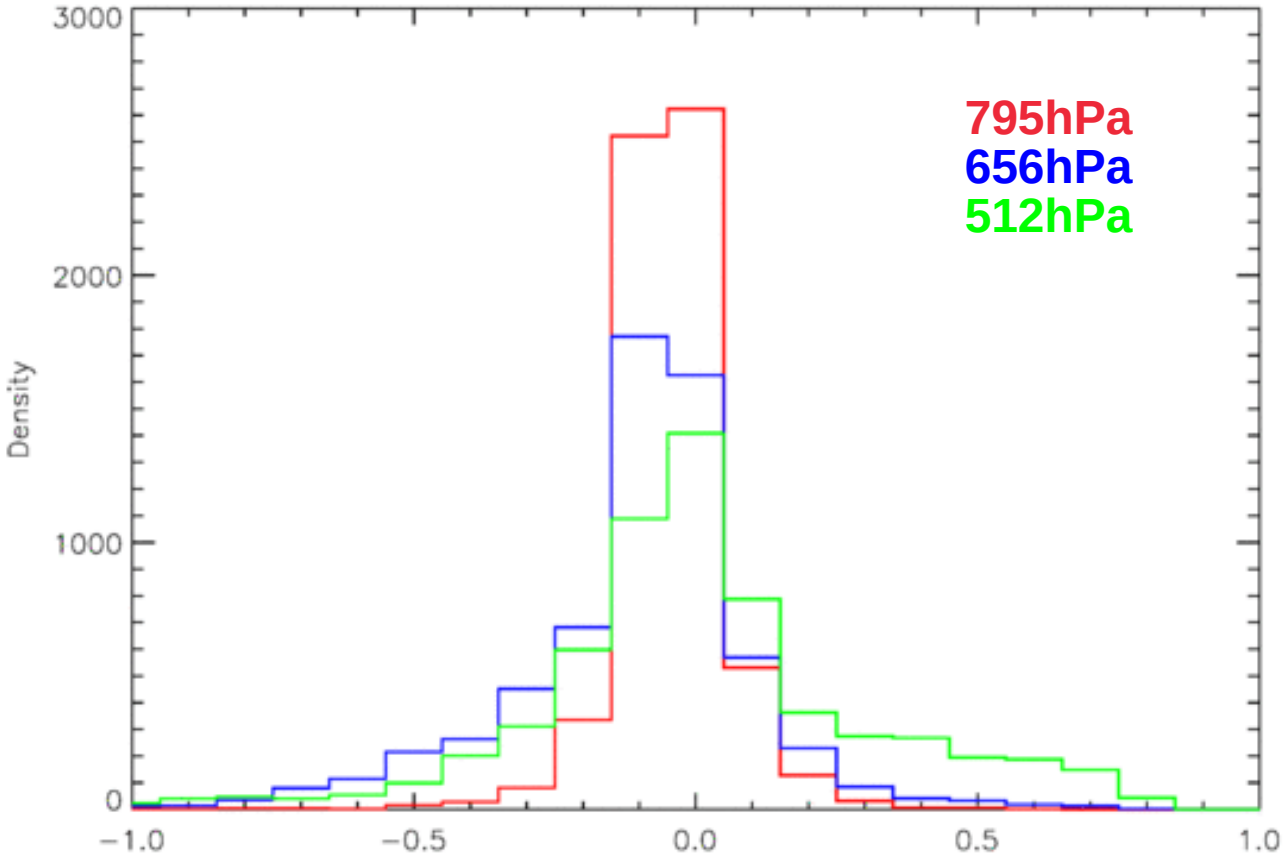


Relative change in humidity not due to advective motion $(Q-Q^A)/Q$



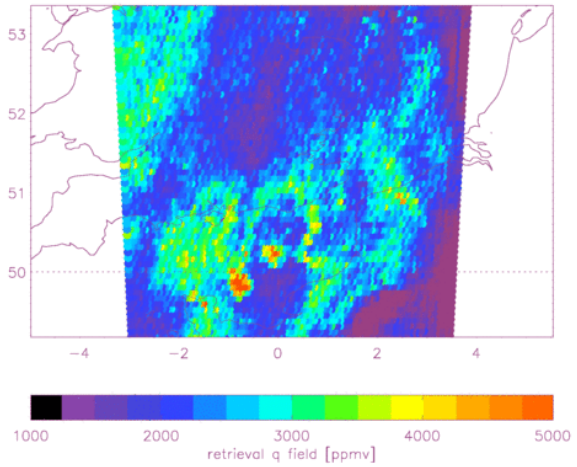
Values far from zero suggest a non-advective component of humidity flow

Water vapour as a passive tracer

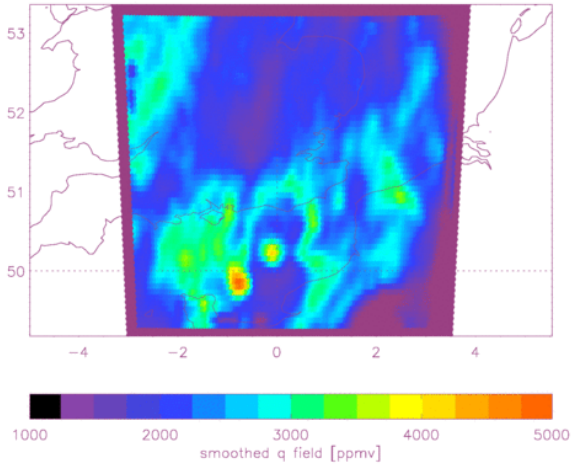


Smoothed retrievals @ 656hPa

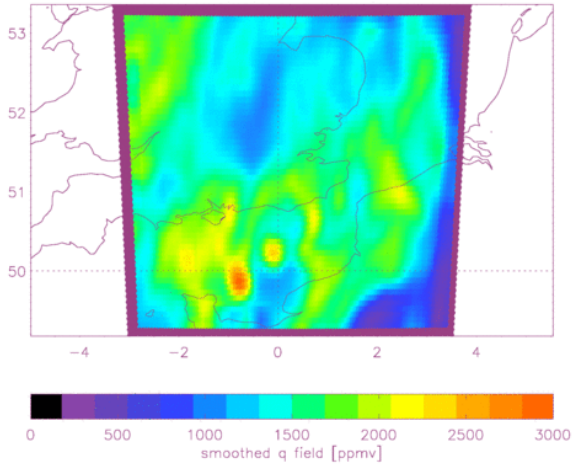
Retrieval field



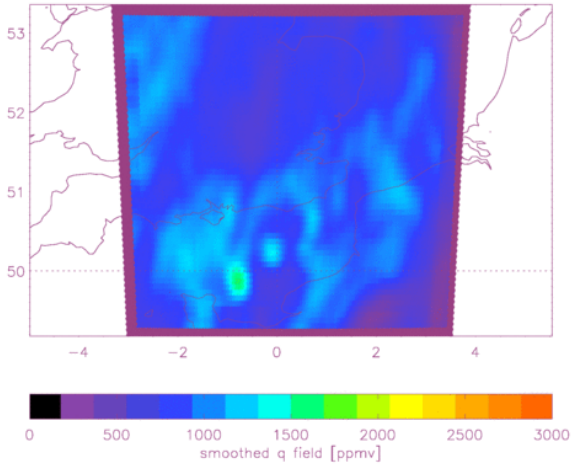
Smoothed retrieval field (sigma=1.0)



Smoothed retrieval field (sigma=2.0)



Smoothed retrieval field (sigma=3.0)



Comparison metrics

- Simulation study allows for direct comparison with UKV model winds

$$MSB = \frac{1}{N}\left(\sqrt{u_T{}^2 + v_T{}^2} - \sqrt{u_D{}^2 + v_D{}^2}\right) \equiv \frac{1}{N}\left(V_T - V_D\right)$$

$$MMVD = \frac{1}{N}\sqrt{V_T{}^2 + V_D{}^2 - 2V_T V_D \cos\left|\theta_T - \theta_D\right|}$$

where u_T, v_T, V_T, θ_T relate to the true winds

u_D, v_D, V_D, θ_D relate to the derived winds