Observations needed for verification of additional forecast products

Clive Wilson (& Marion Mittermaier)

12th Workshop on Meteorological Operational Systems, ECMWF, 2 - 6 November 2009

Additional forecast products

- Higher resolution models
- More realism in parameterization schemes
  - Demand for additional products – routinely available
  - More weather/surface products
- Questionnaire – user requirements as part of “Review of the verification measures applied to medium-range forecasting”-August 2008.
- 18 countries responded :
  - “weather interpretation” products (deterministic & EPS) for guidance for the issue of warnings of thunderstorms, fog and freezing rain.
  - EPS calibrated percentiles for rarer events for wind gusts, mean wind, accumulated precipitation and extreme temperatures
- Expert Team meeting on Verification, Sept 2008

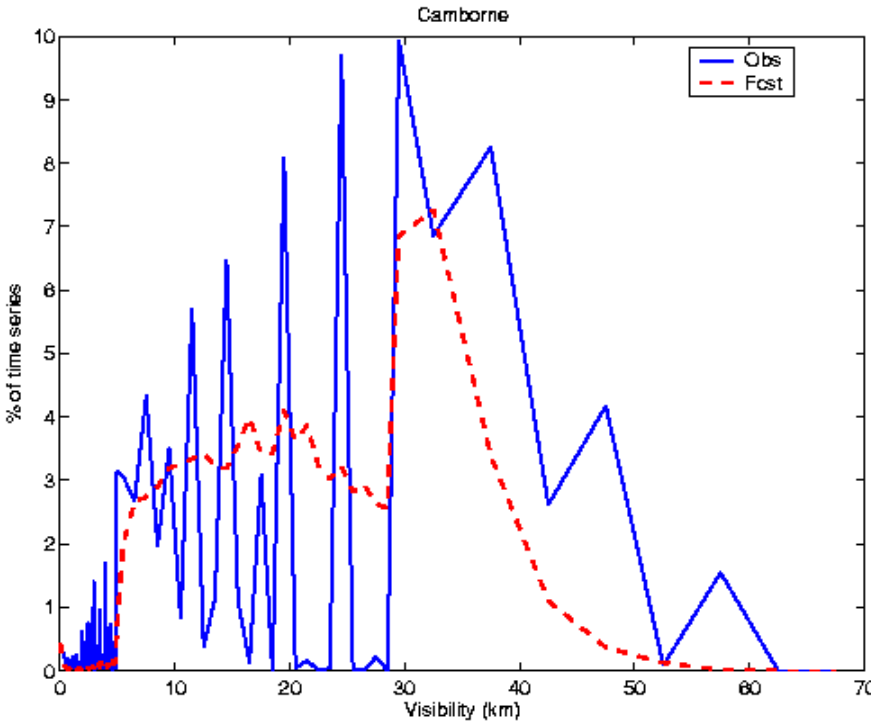
Additional forecast products - recommended by Expert Team

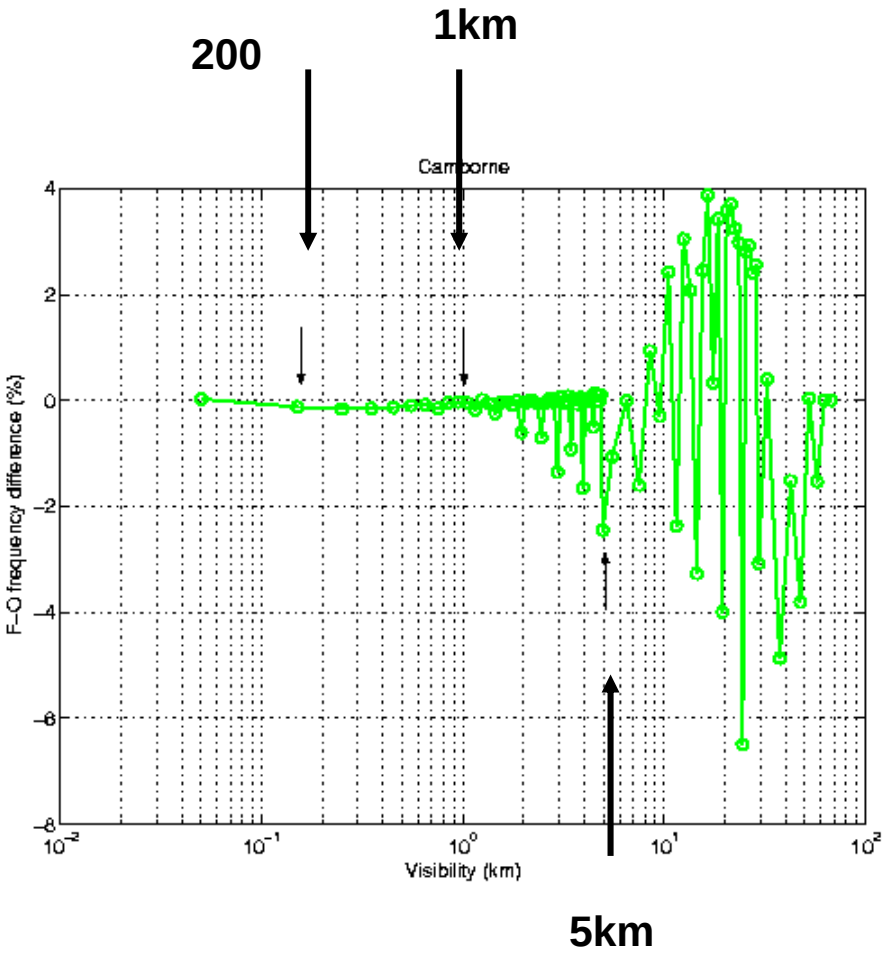
- Visibility/fog
- Stability indices in addition to CAPE
- Freezing rain and/or freezing level
- Height of lowest significant cloud base
- Rainfall accumulations over long durations (several days or for specific events), or rainfall duration
- Classification/clustering/regime
- Calibrated probability products (percentiles) of model and observed climate for extreme events

Visibility/ Fog

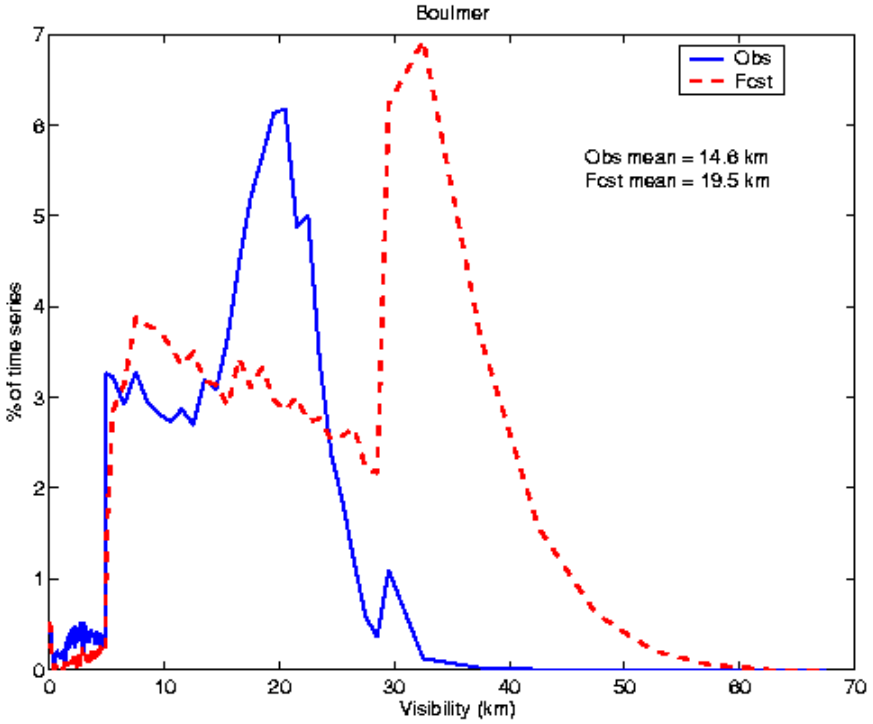
- SYNOP/SHIP, METAR
  - Automatic v manual
  - Thresholds for verification
- Fog
  - night-time MSG SEVIRI channels no. 4 (3.9 microns) and no. 9 (10.8 microns) – brightness difference

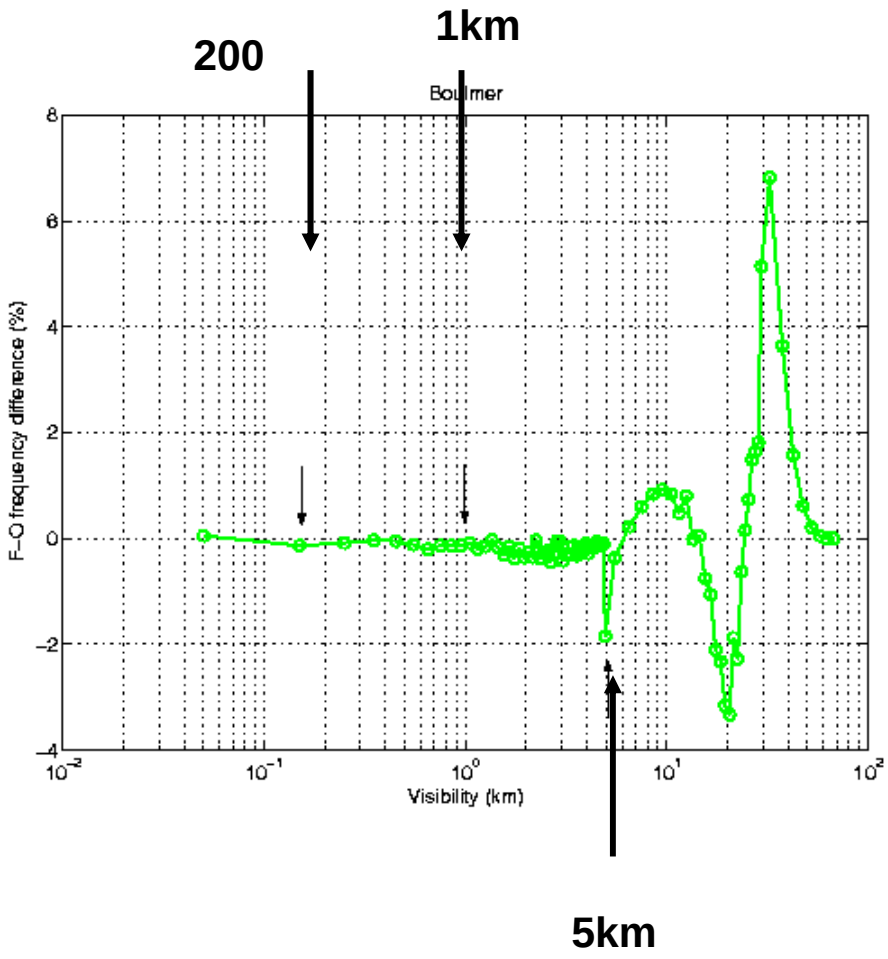
Visibility/ Fog – observer – 100m <5km, 1km >5





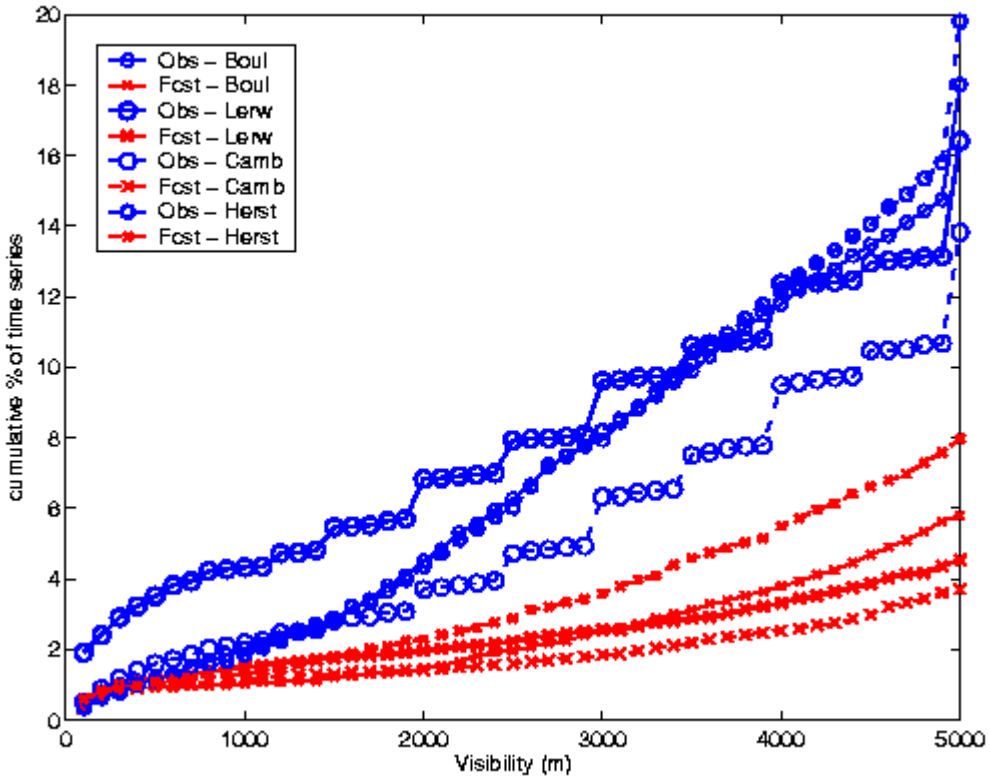
Visibility/ Fog – automatic



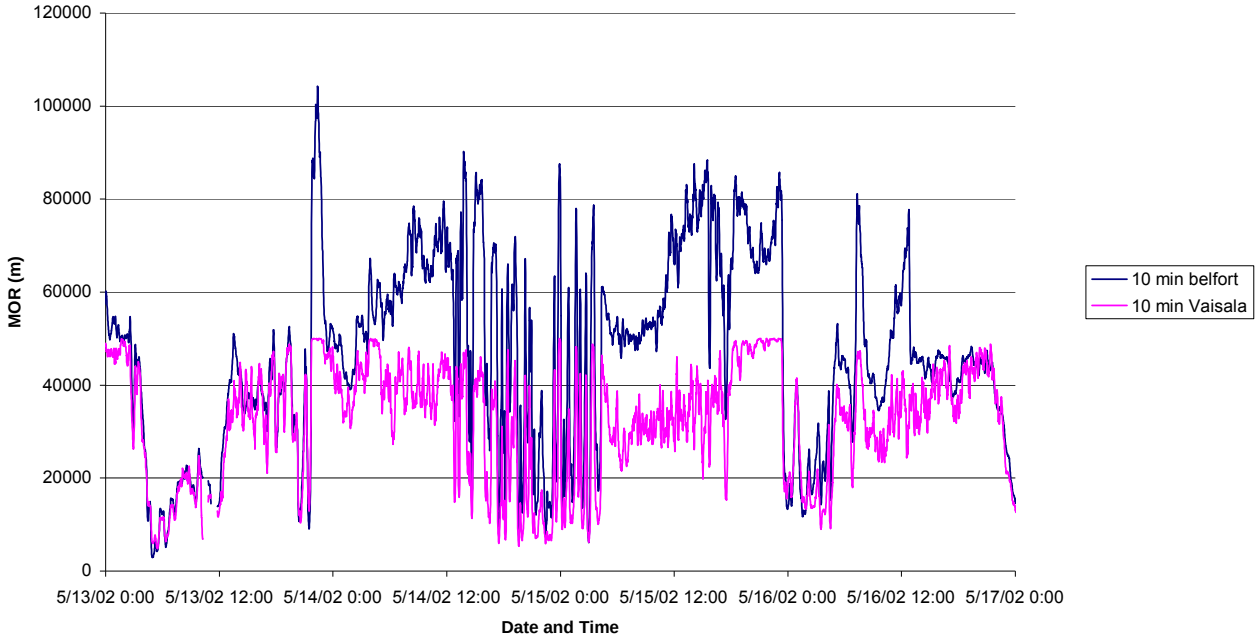


Visibility/fog <5000m

NB low sample sizes

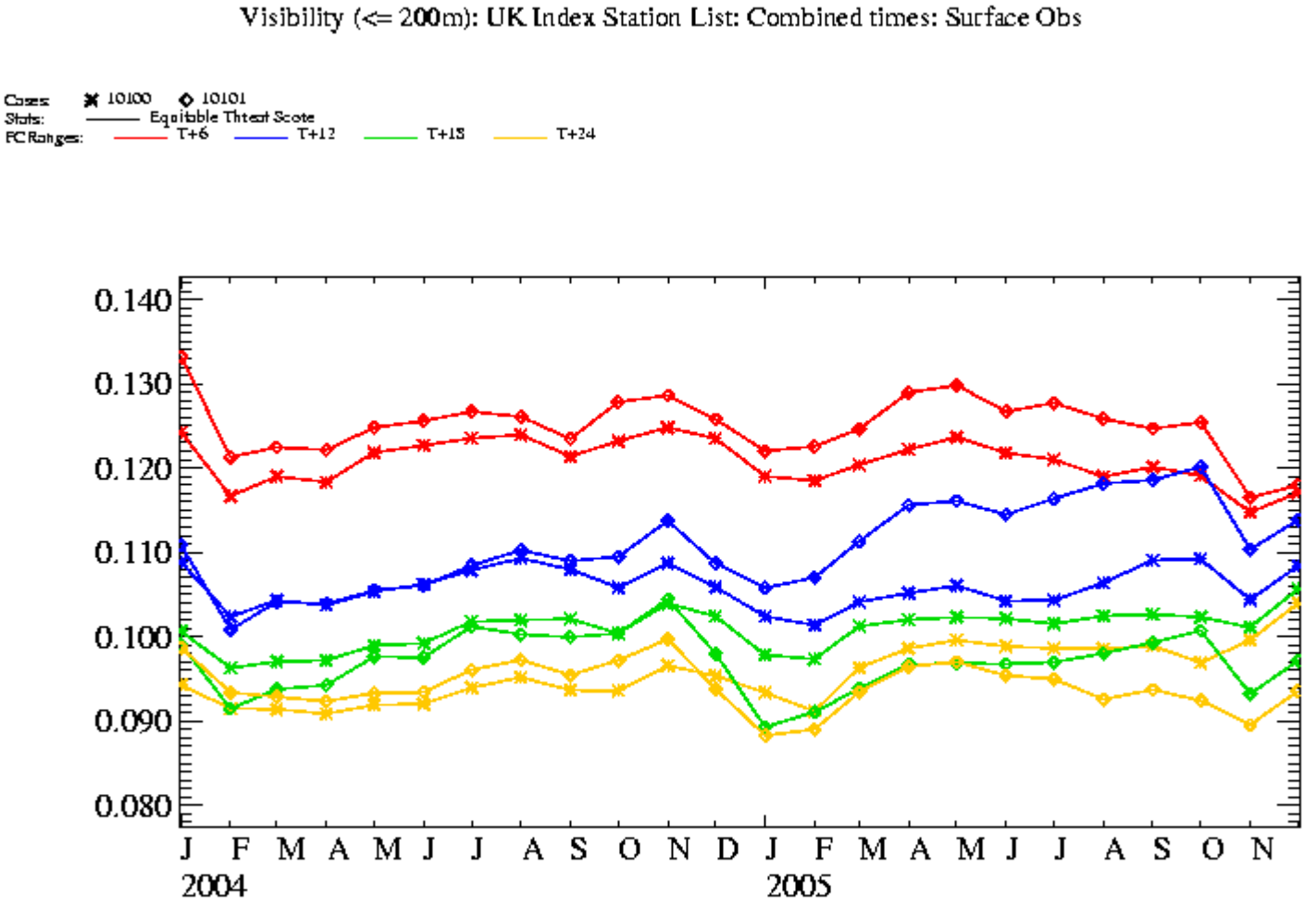


Visibility/ Fog – automatic Instrument differences Short period variability



Tom Butcher

Fog – comparing all obs(*) with manual only (◊)



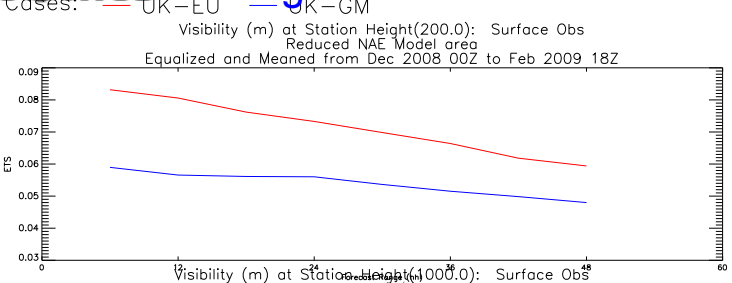
Station Based Verification System

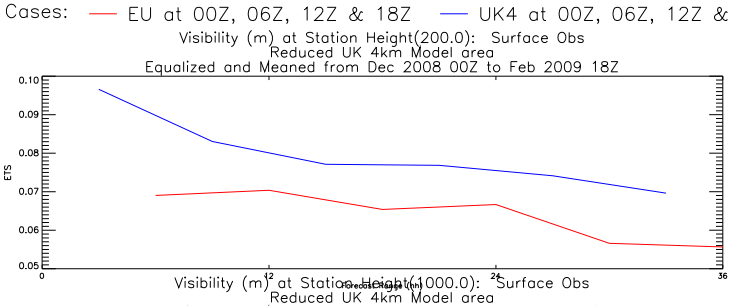
Visibility verification ETS–surface

NAE -12km
global

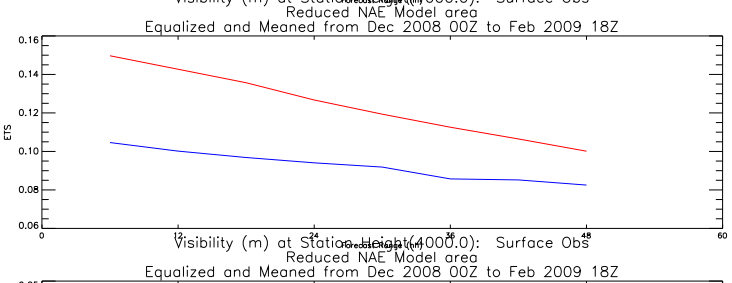
NAE- 12km
UK4 – 4km

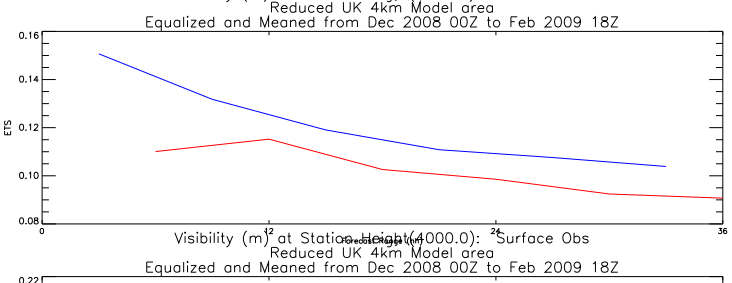
200m



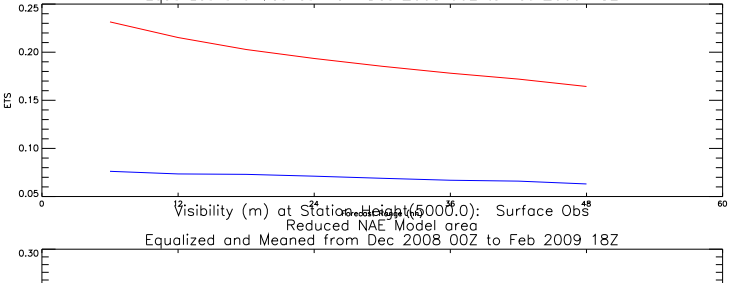


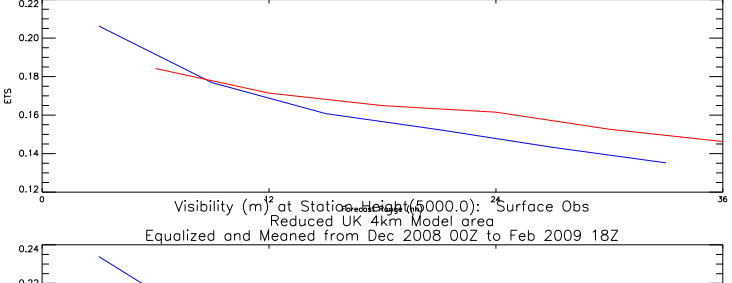
1km



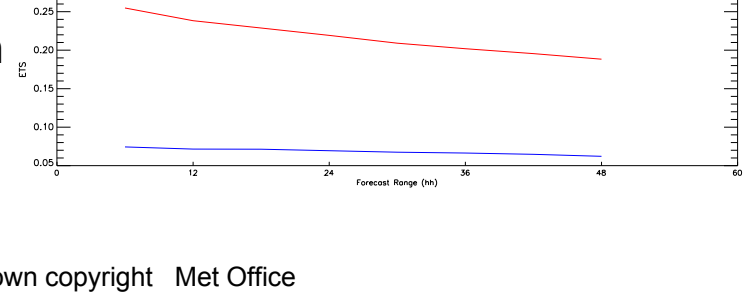


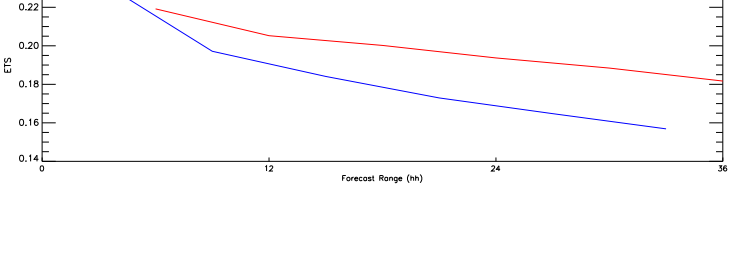
4km





5km

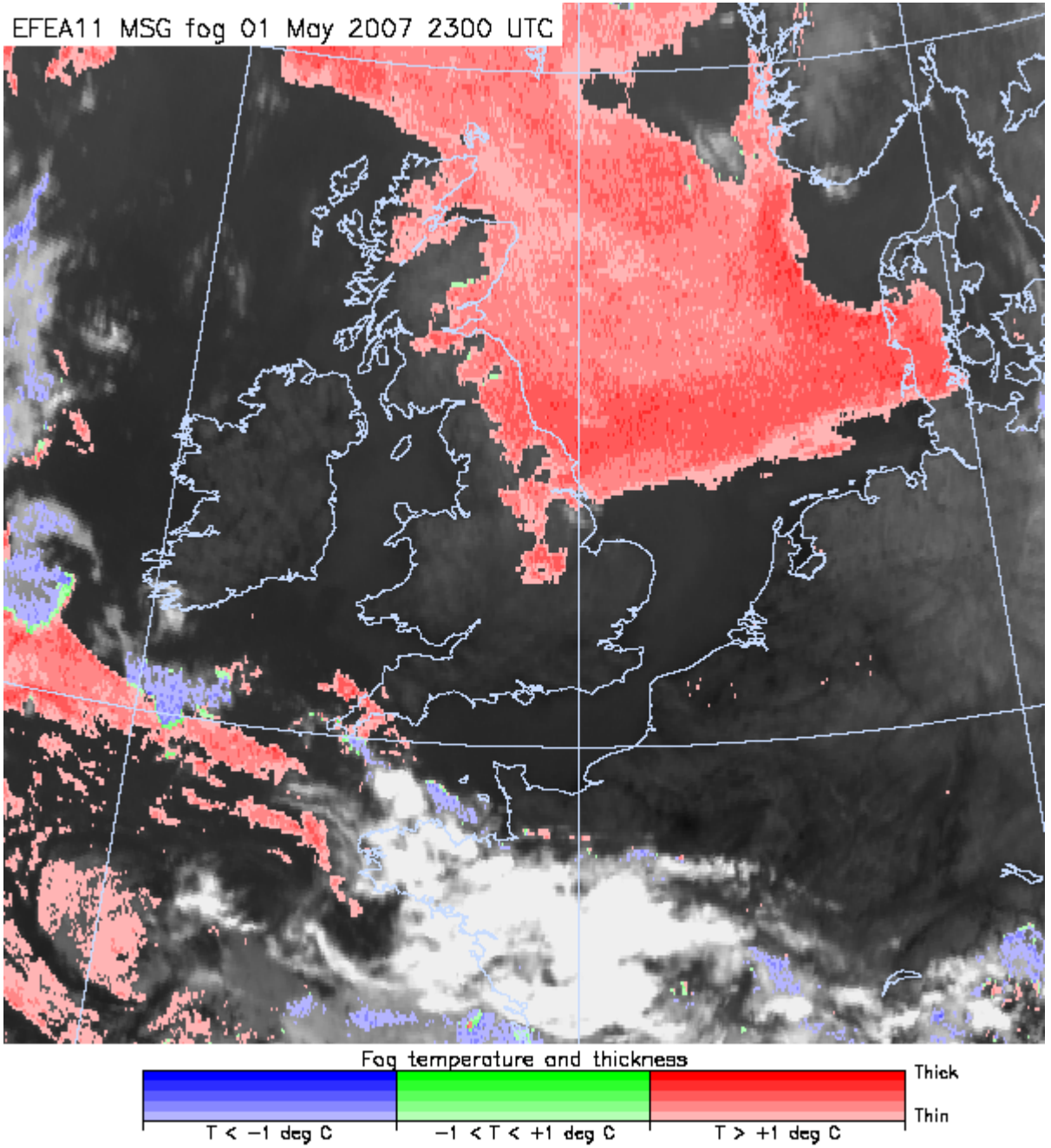




Fog

MSG – SEVIRI

night-time MSG SEVIRI channels no. 4 (3.9 microns) and no. 9 (10.8 microns) – brightness difference

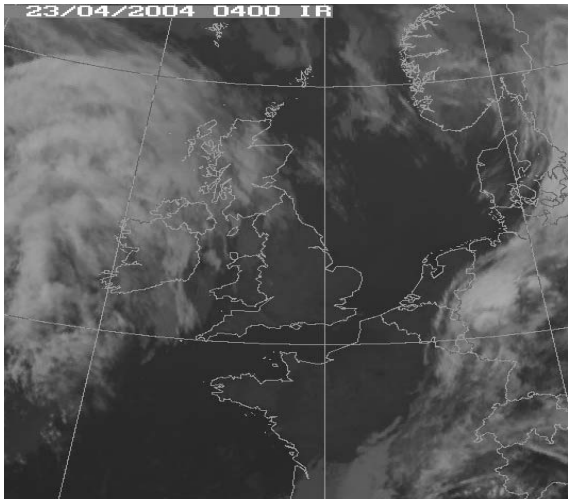


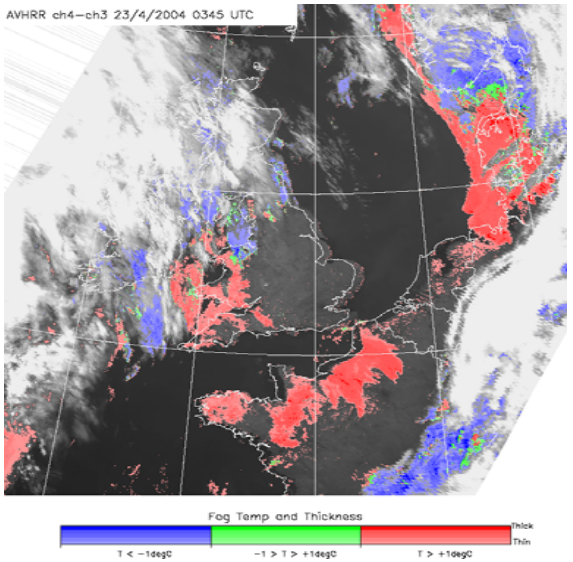
Fog detection -shortcomings

- Lack of sensitivity around dawn/dusk
  - Significant 3.9 microns solar rad
- Thresholds set too low for difference
  - Spurious fog
- Contamination by overlying ice cloud
  - 3.9 micron wavelength radiation is absorbed significantly more strongly by ice crystals than by water droplets

Fog – 23rd April 2004 0400Z

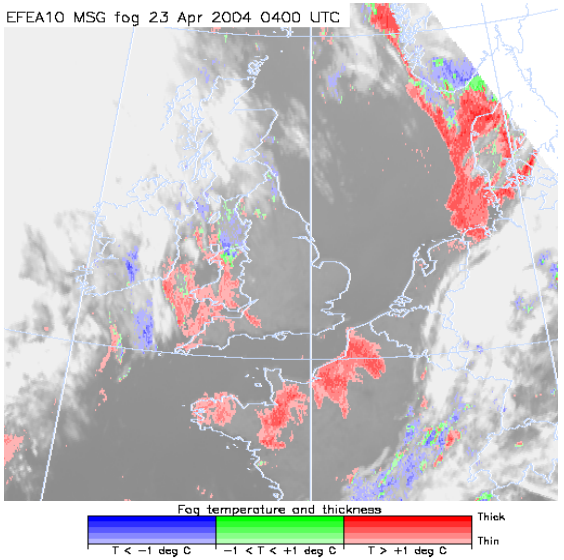
Met-8
10.8

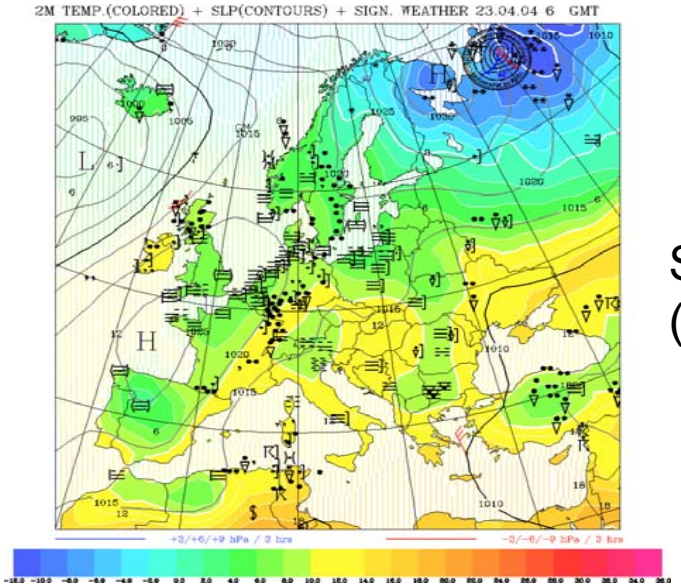




AVHRR
(0345Z)

Met-8
Fog

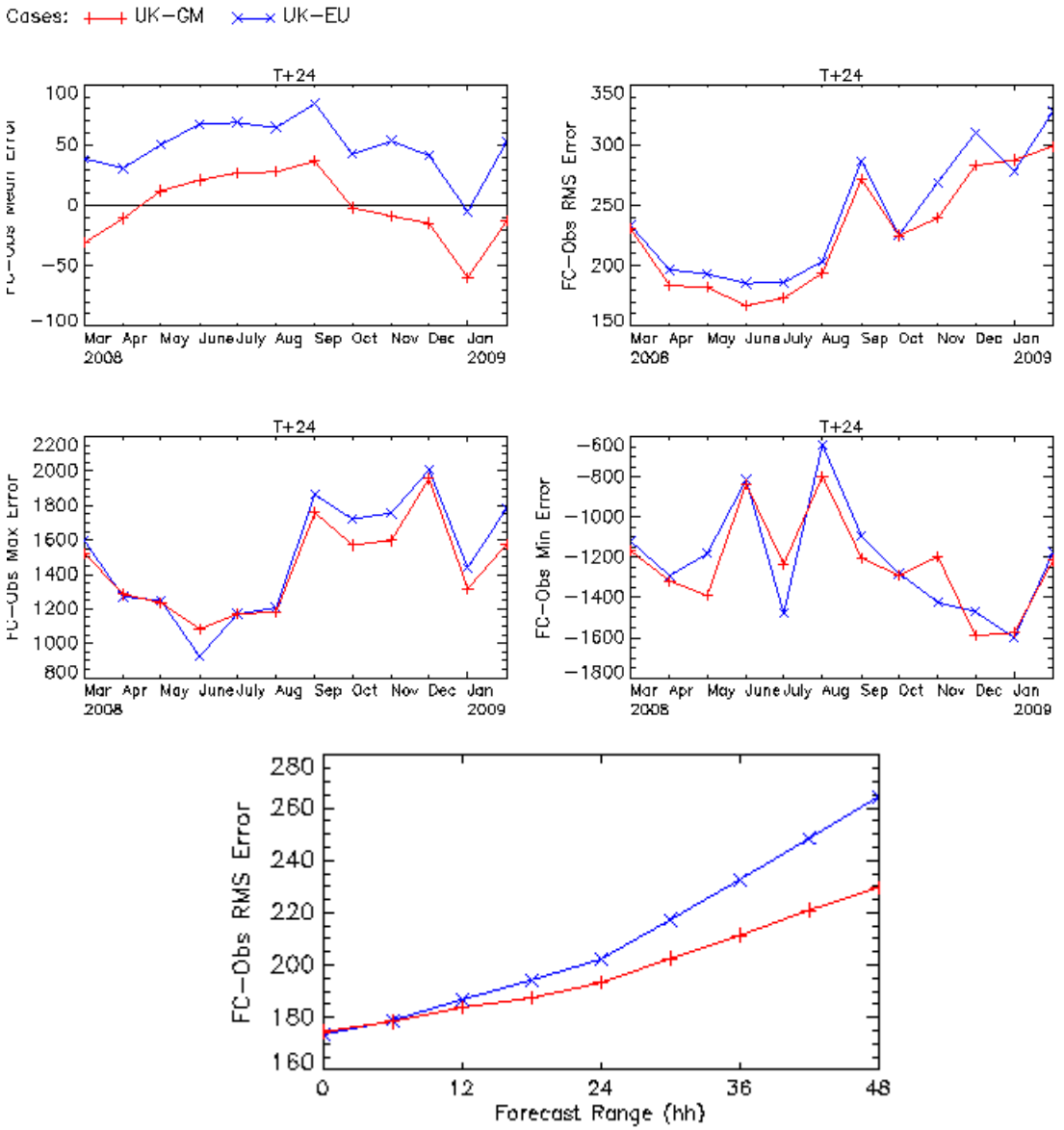




Surface obs
(06Z)

Courtesy, Pete Francis

Freezing level - sondes



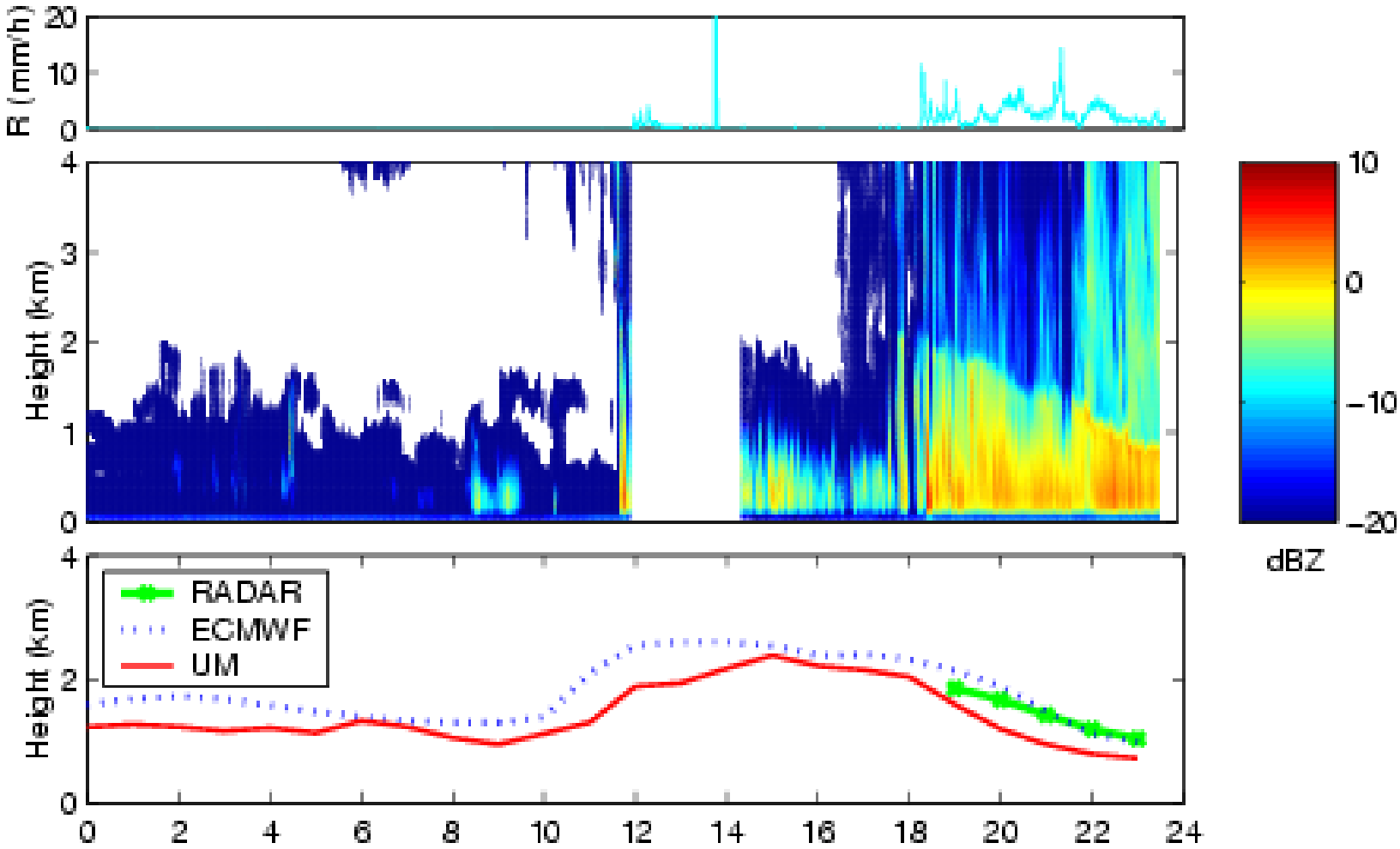
Freezing Level

Galileo cloud radar
- 3 mm
- 60 m resolution
- typically vertically pointing

Chilbolton (CAMRa)
- 10 cm 25 m dish 0.28^{o}
- Sampling up to 20-30^{o}
- Range-Height data

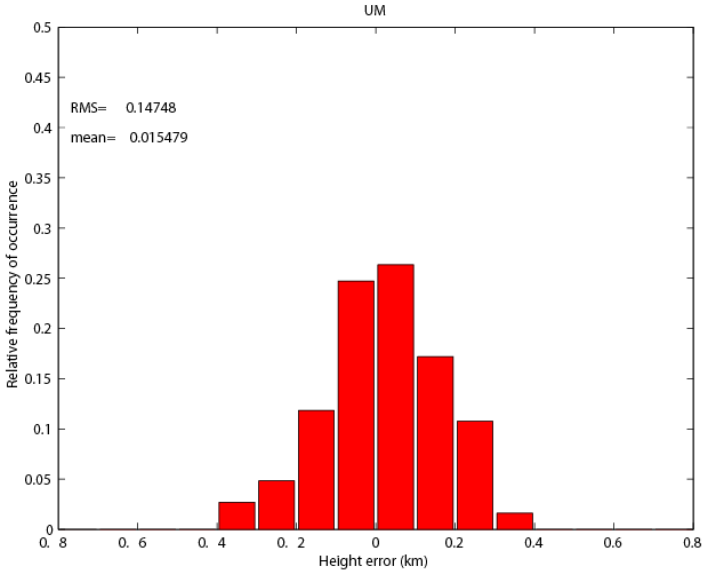
Operationally
- 4 elevations up to 2.5-4^{o}
- 1^{o} beam width
- Plan-Position data (PPI)

Freezing level- Vertically pointing radar

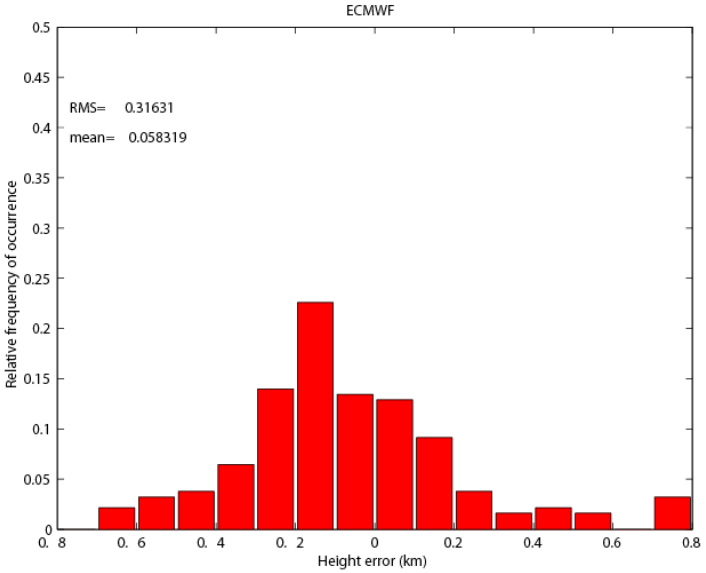


Courtesy Marion Mittermaier

How accurate are the freezing level heights? 1 year data



Frequency



Height error

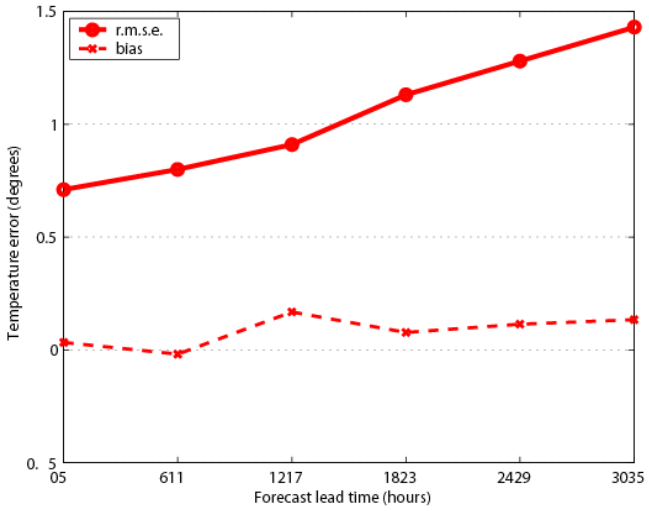
UM (t0-5h

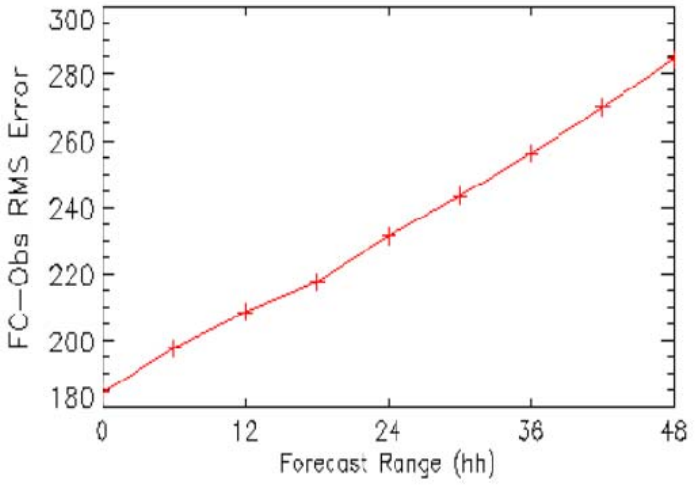
- 147 m error, 15 m bias
- Symmetrical
- < 200 m, never > +/- 400 m

ECMWF (t12-36h)

- 316 m error, 58 m bias
- skewed
- Max > 800 m, isothermal case

Effect of forecast lead time





UM

- bias 0.15ºC and rms increases from 0.7 to 1.4ºC at t+36h
- ECMWF has 0.7-0.8ºC errors for t+24h forecast over European region

Met Office continuous sonde verification

- all wx, whole domain
- ~ 170 m at t+0h growing to 270 m at t+48h

Mittermaier and Illingworth, 2003, QJRMS

Other products

- Stability Indices in addition to CAPE
  - Sonde
  - satellite
- Freezing rain
  - Mostly subject assessment of alarms, eg MeteoSwiss, too rare for reliable statistics ?

Lifting Index – GII EUMETSAT

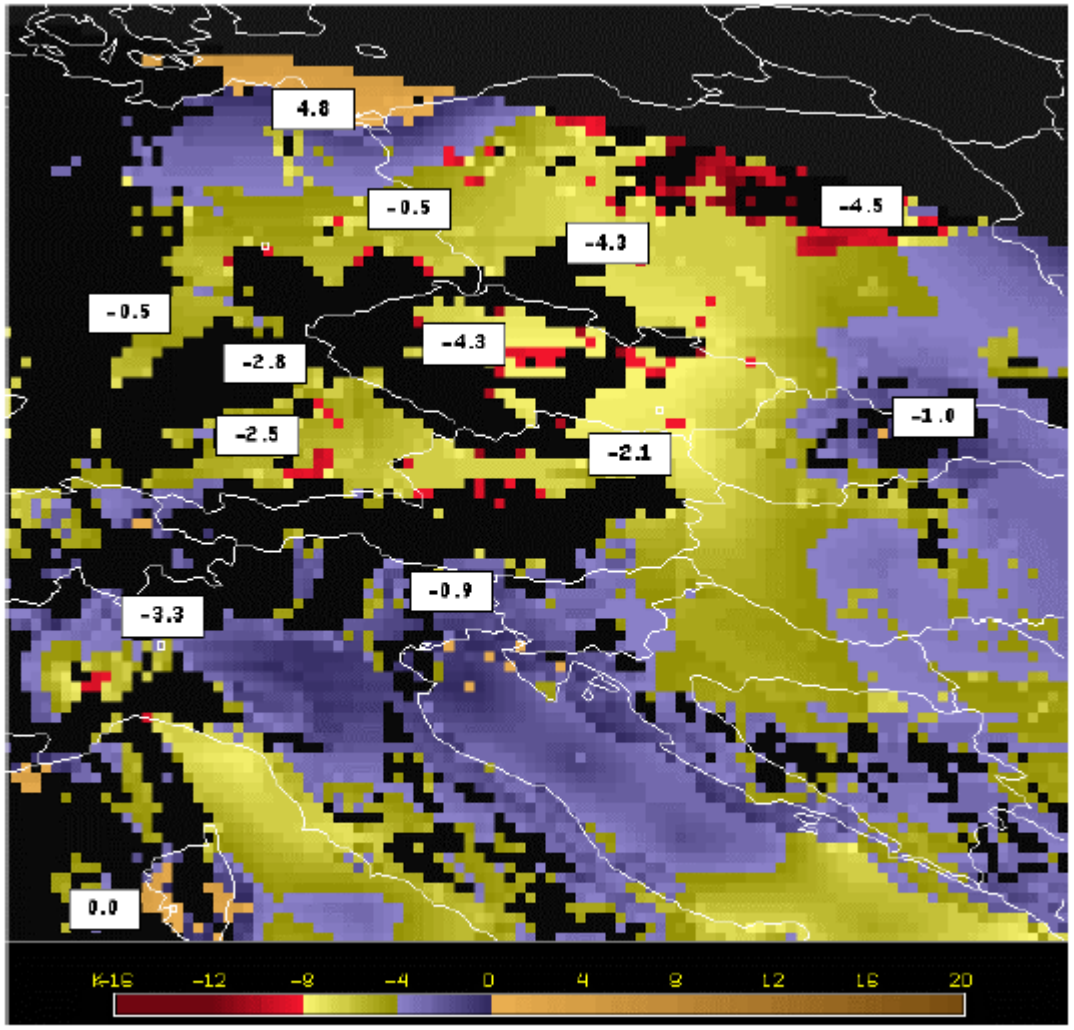


Figure 5: Lifted Index over Central Europe, together with local radiosondes.

Lifting Index – GII EUMETSAT

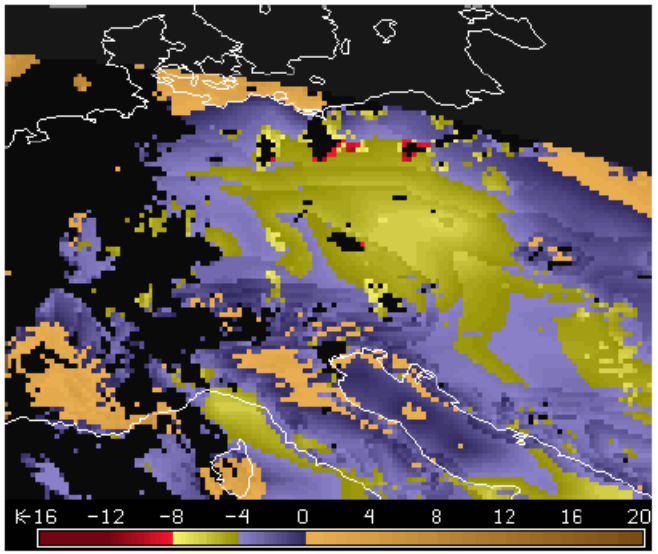


Figure 6: Lifted Index for 05 June 2003, 0900 UTC for Central Europe. Increasing negative values, i.e. increasing instability, are shown in blue to yellow to red, while brown denotes stable air. Again, the black areas are clouds.

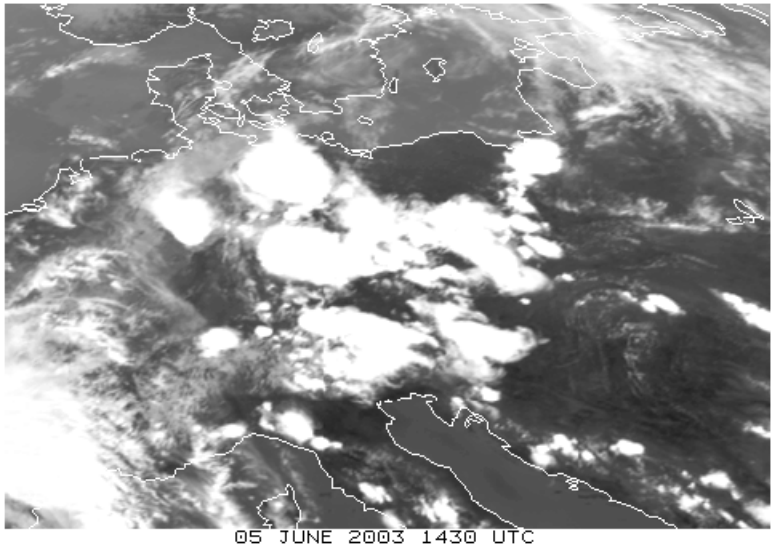
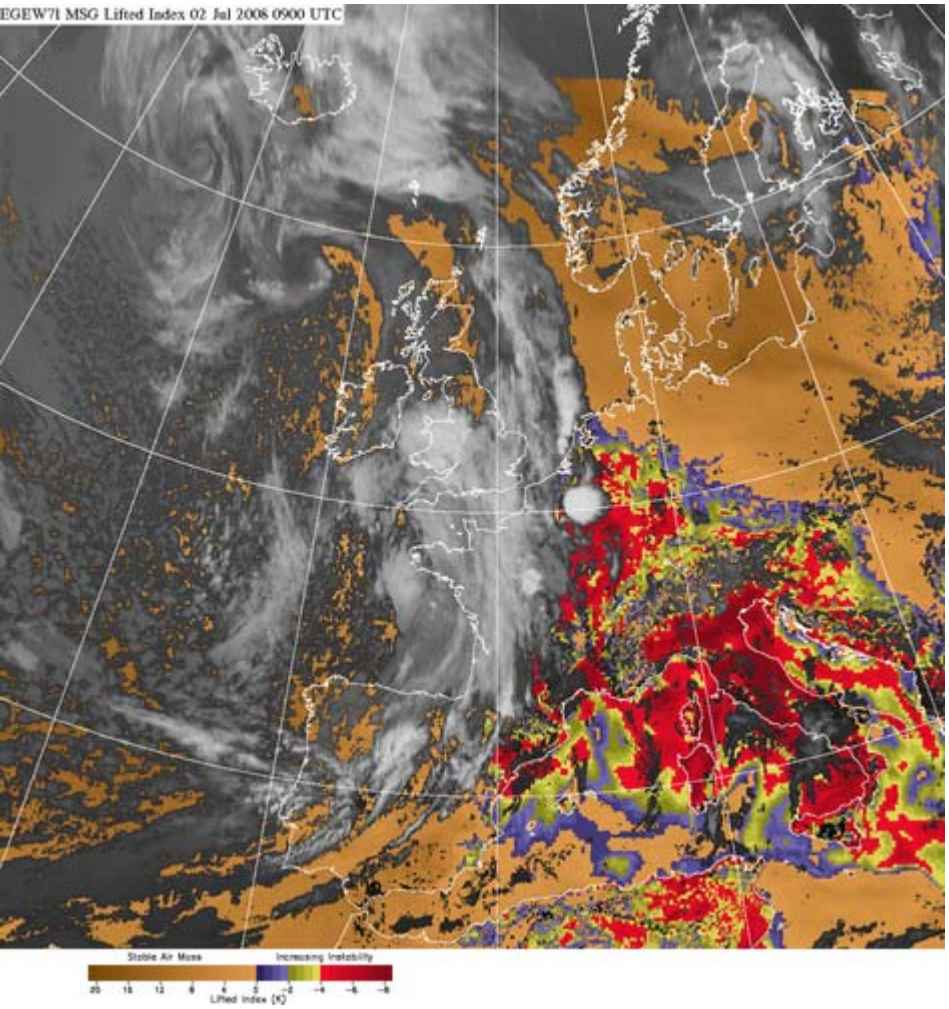
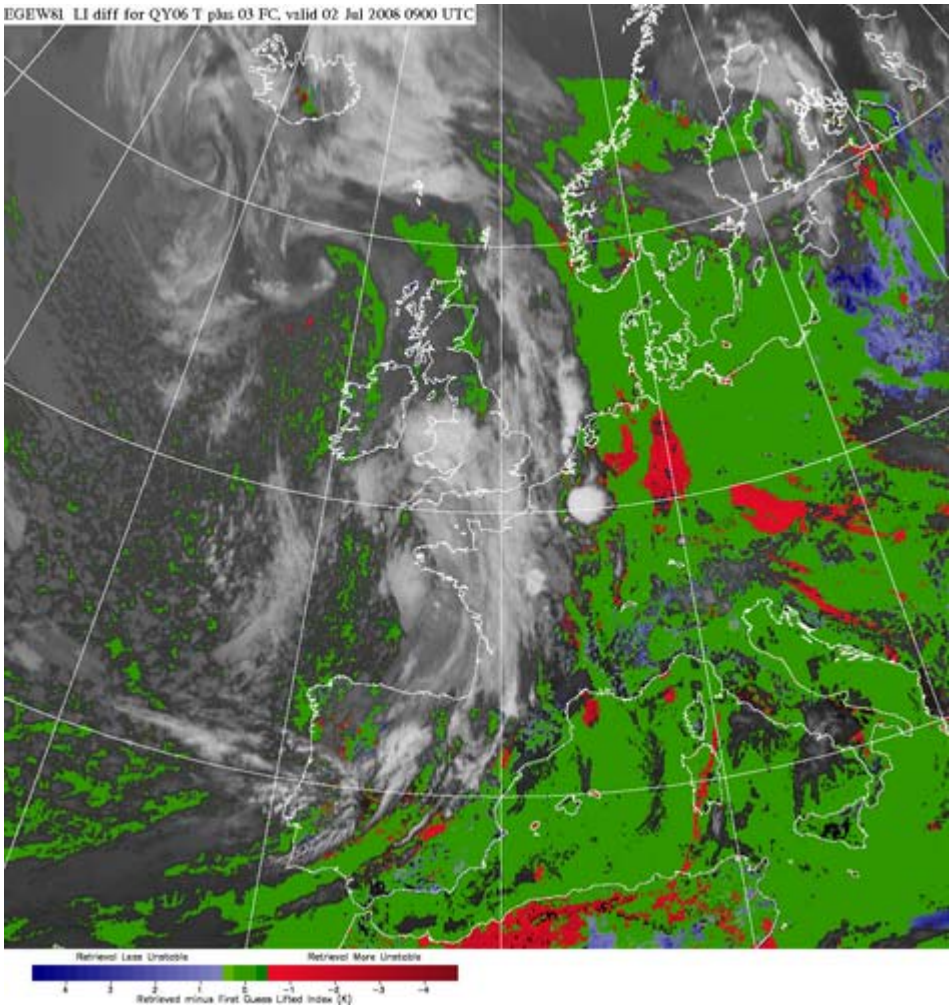


Figure 7: IR image for 05 June 2003, 1430 UTYC, i.e. 5.5 hours after the GII retrieval of Fig. 6. Clearly visible is the strong convective activity which has started in the meantime.

Lifting Index = $T^{obs} - T^{lifted\ from\ surface}$ at 500 hPa -09UTC 2 Jul 2008

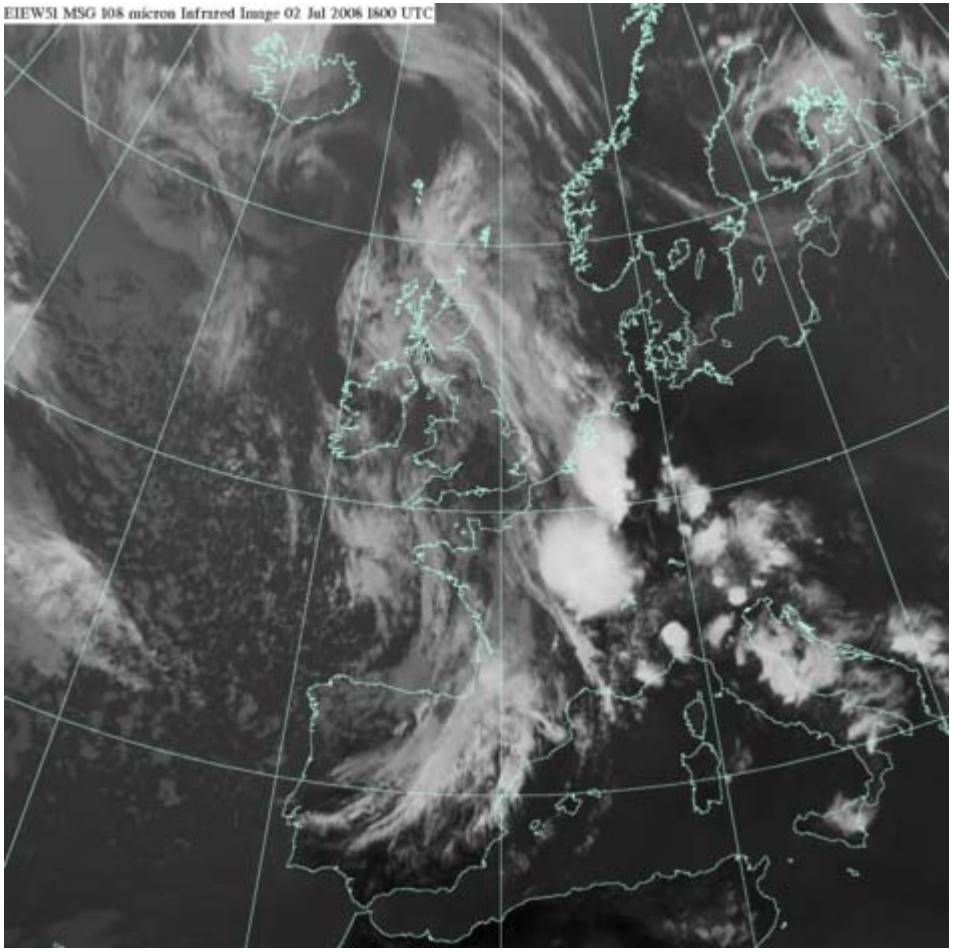


Index



Difference from model background T+3

Lifting Index – IR @ 18UTC

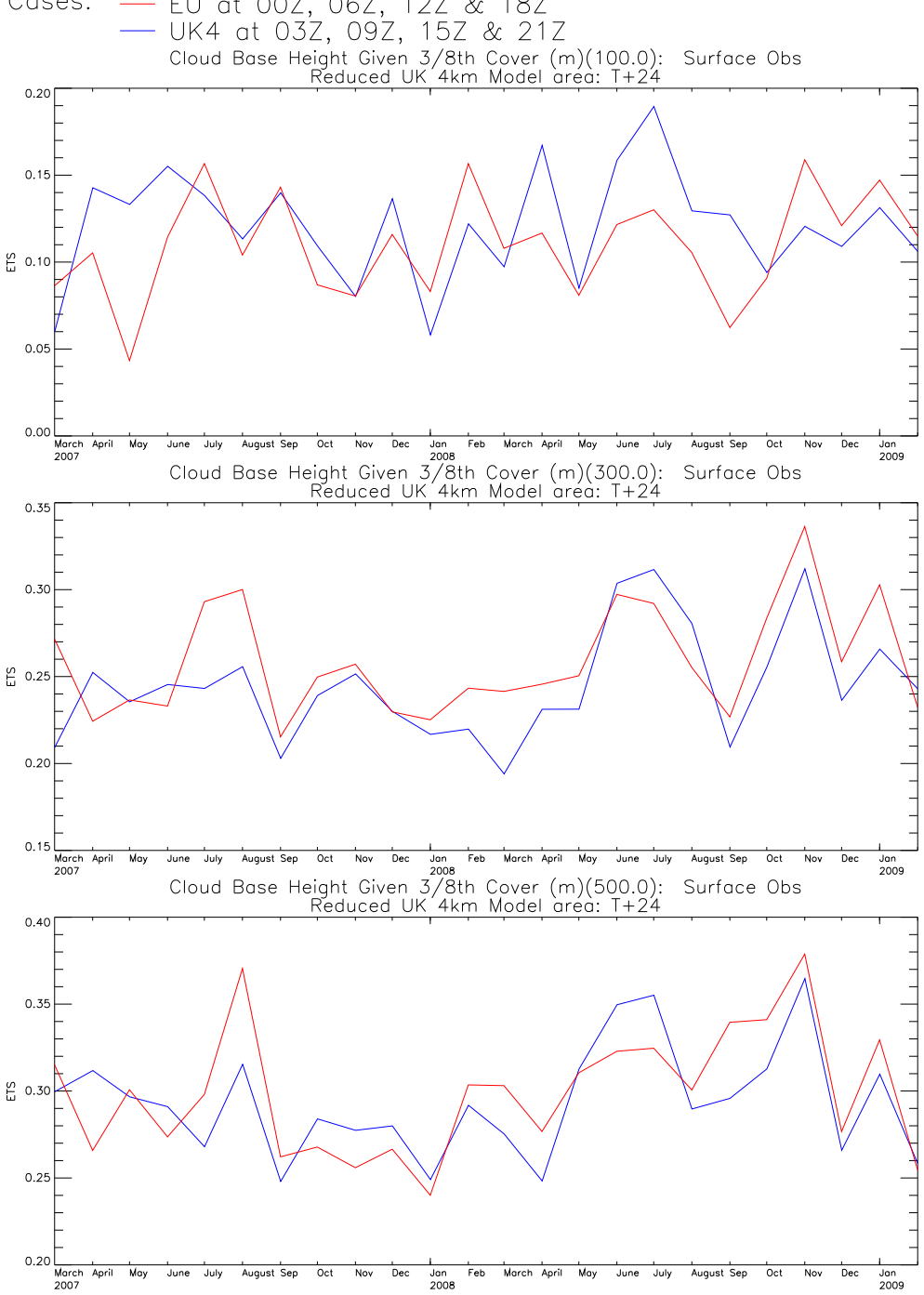


Height of lowest significant cloud base

- Surface based
  - Manual observations – full sky
  - Automatic – limited
  - Laser cloud base height recorders
- Satellite + model

Met Office

NAE – 12km
UK 4km

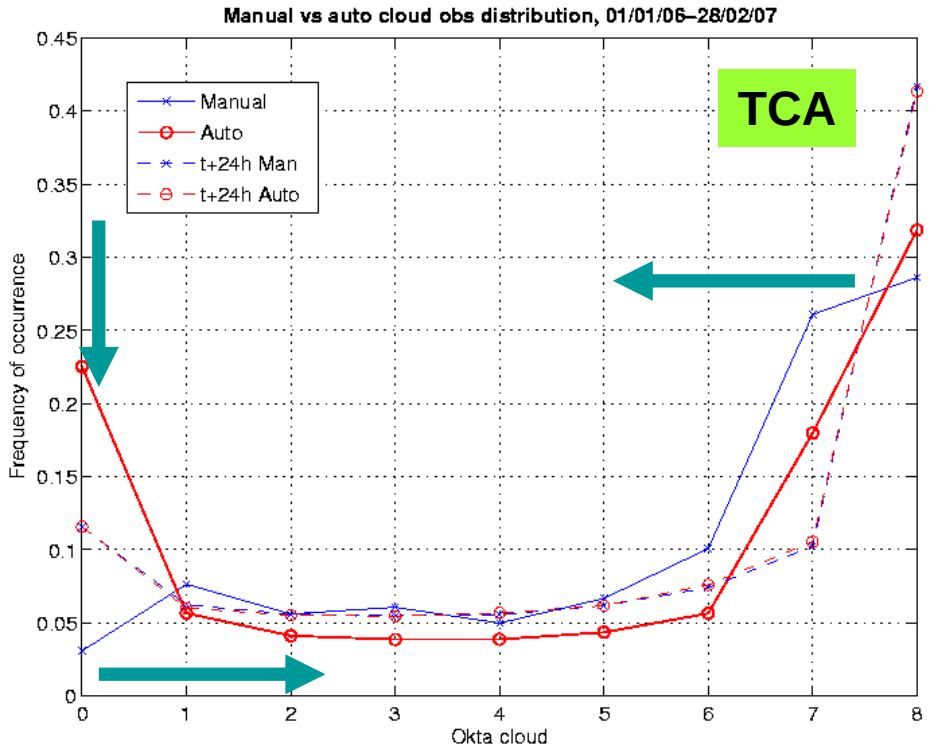


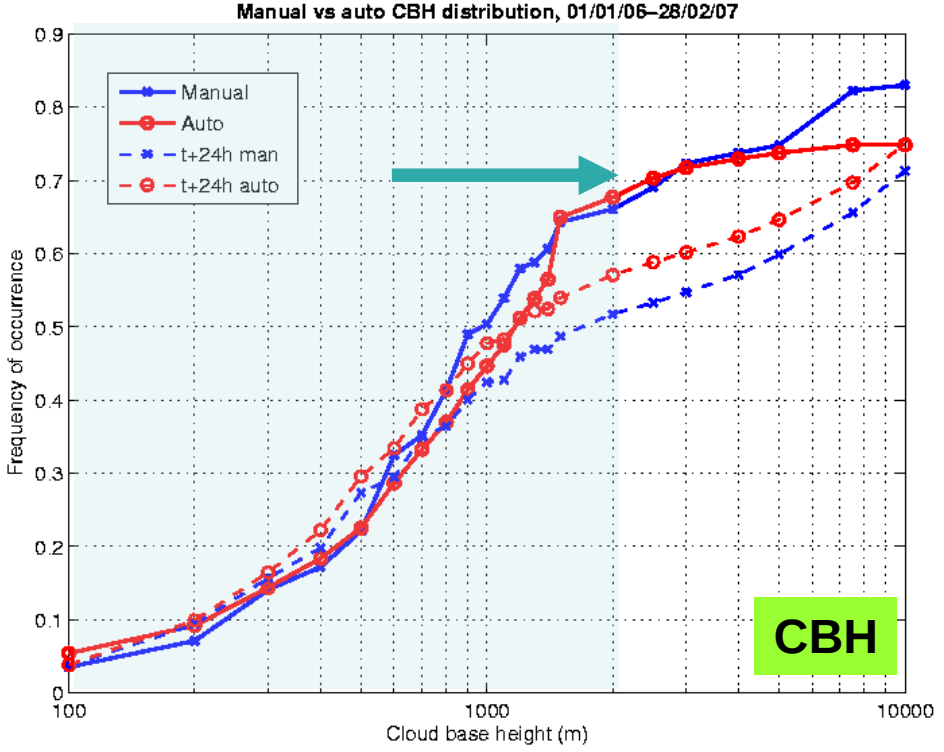
Cloud - Surface observations

- Most widely used but, for automated cloud observations the following problems have been identified:
  - observations of medium and high cloud limited;
  - too little cloud reported when it rained with under-estimation worse when it snowed;
  - well scattered cloud poorly represented;
  - CBH too high
- Manual obs are dwindling and replaced by automated ones.
- Day/night biases

TCA and CBH distributions

- 14 months of data for Block 03 stations
- Auto obs have greater proportion of no cloud (due to instrument limitations, can't see high cloud)
- Observers hedge away from the boundaries.
- For CBH artifical cloud ceiling visible in cdf

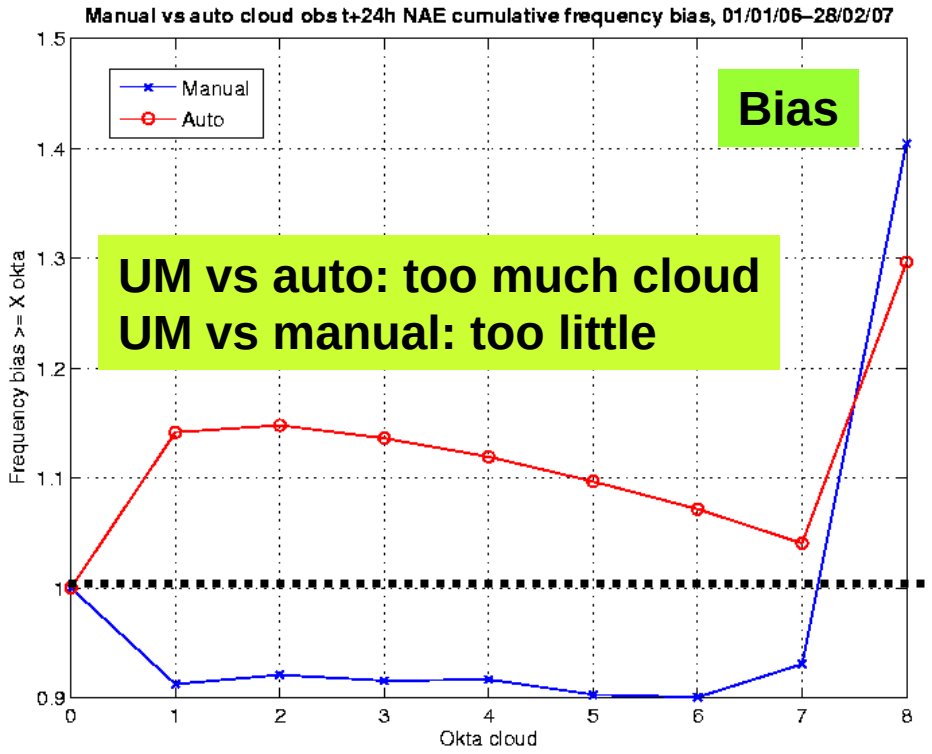


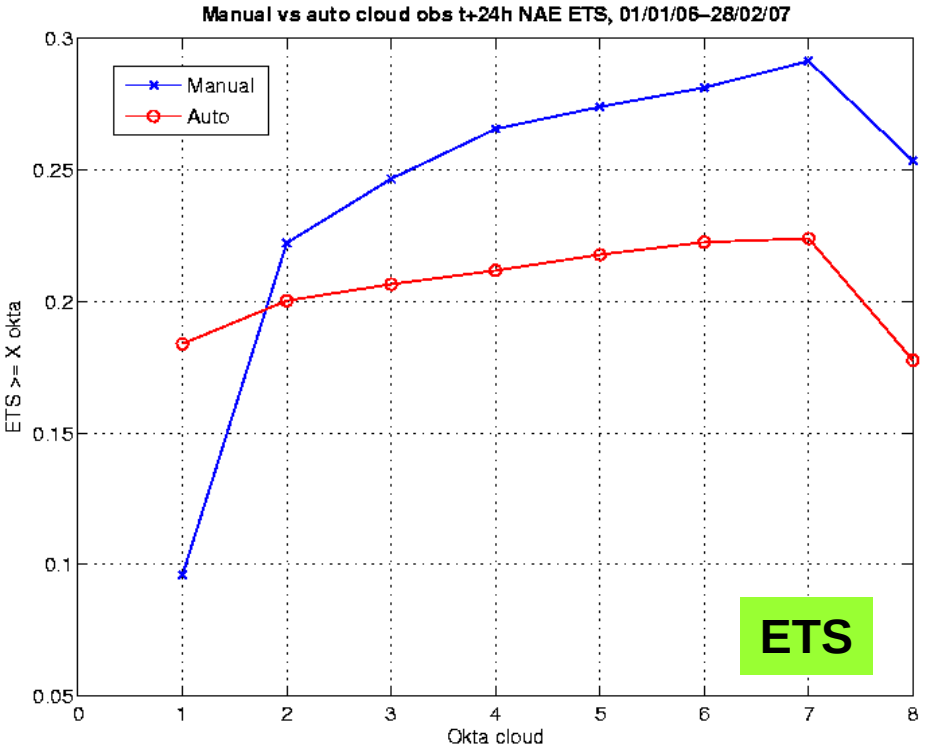


Courtesy Marion Mittermaier

How does obs type affect verification measures?

Manual and auto TCA have biases of equal but opposite magnitudes.

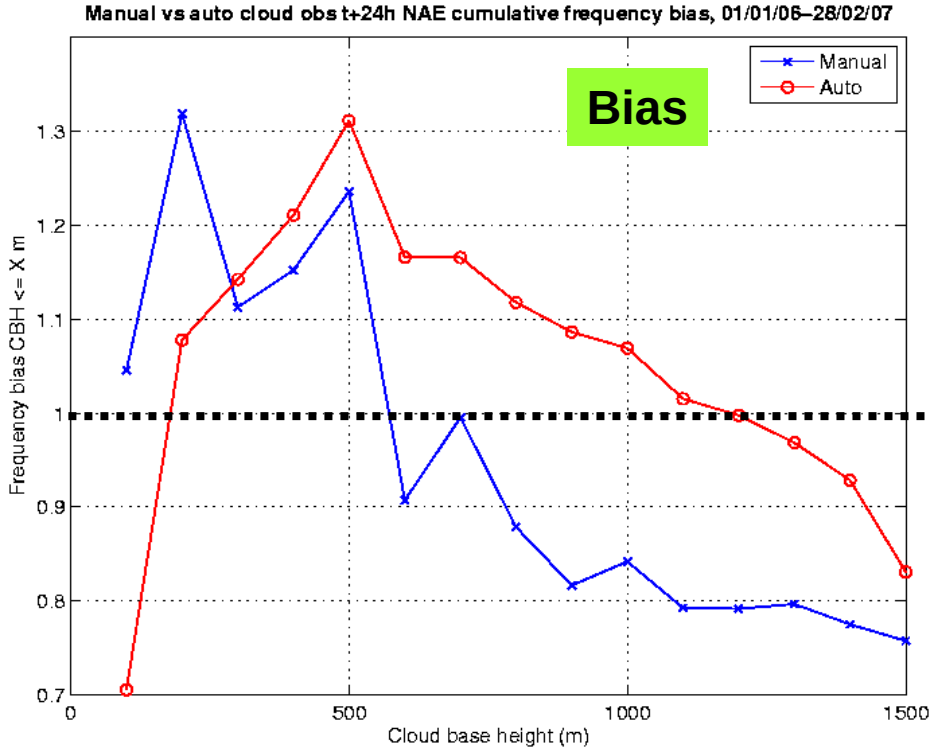


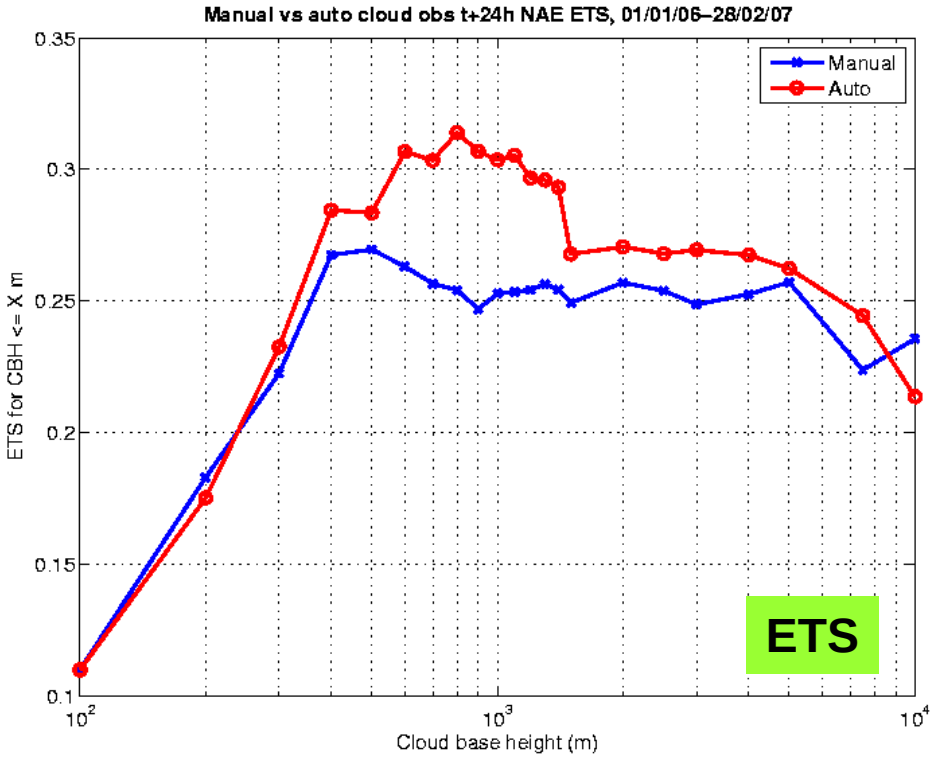


Courtesy Marion Mittermaier

How does obs type affect verification measures?

- Picture more mixed for CBH
- Marked difference in bias for very low (“on the deck”) cloud
- Over-prediction of low CBH changes to under-prediction vs man obs ~500 m, vs auto 1200m.





Cloud observations- summary

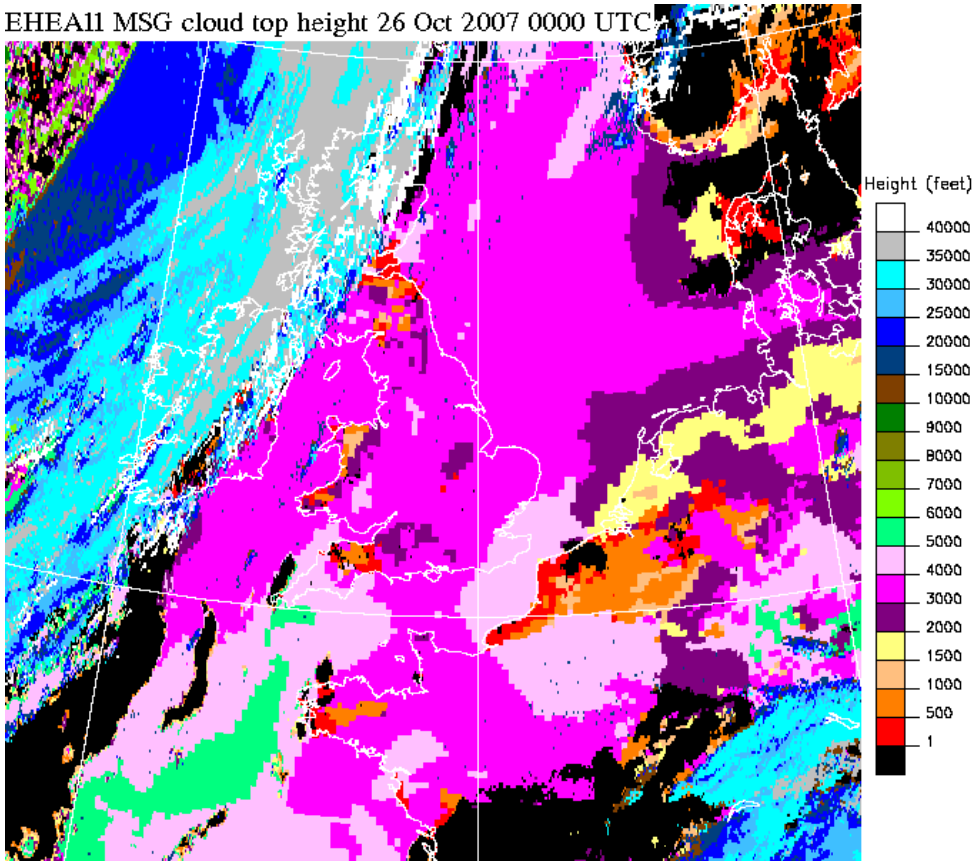
- Manual observations are a “dying breed”.
- Using sparse and irregularly distributed observations for verifying high-resolution models is generally not recommended.
- We need to seek alternative data sources to establish whether forecast models are providing a more realistic and accurate representation of the atmosphere.
- **Cloud is one of the most difficult parameters to** predict accurately, yet the impact of cloud biases has huge **knock-on effects** on other parameters, such as temperature.

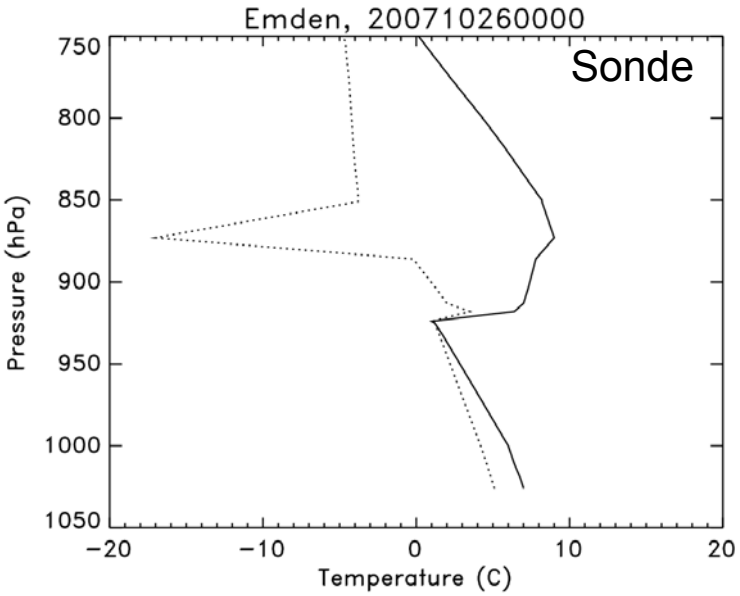
Satellite derived cloud top- Stable Layers method

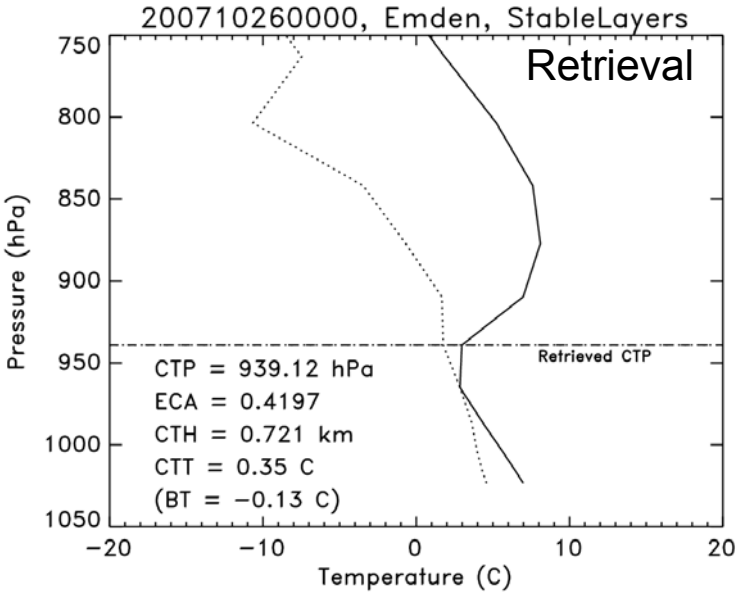
- Scheme matches up an NWP forecast BT profile (overcast BTs calculated using RTTOV-7) and the measured MSG 10.8 μm channel BT, also taking into account model atmospheric stability
- Based on work carried out by Stephen Moseley for the old Meteosat-7 CTH scheme in Nimrod (FRTR no. 424)

Stable Layers example

Emden, 26/10/2007, 00Z







Long duration/specific events rainfall accumulations

- Gauges
- Radar
  - OPERA data hub
- Process for event (case study)

OPERA - radars

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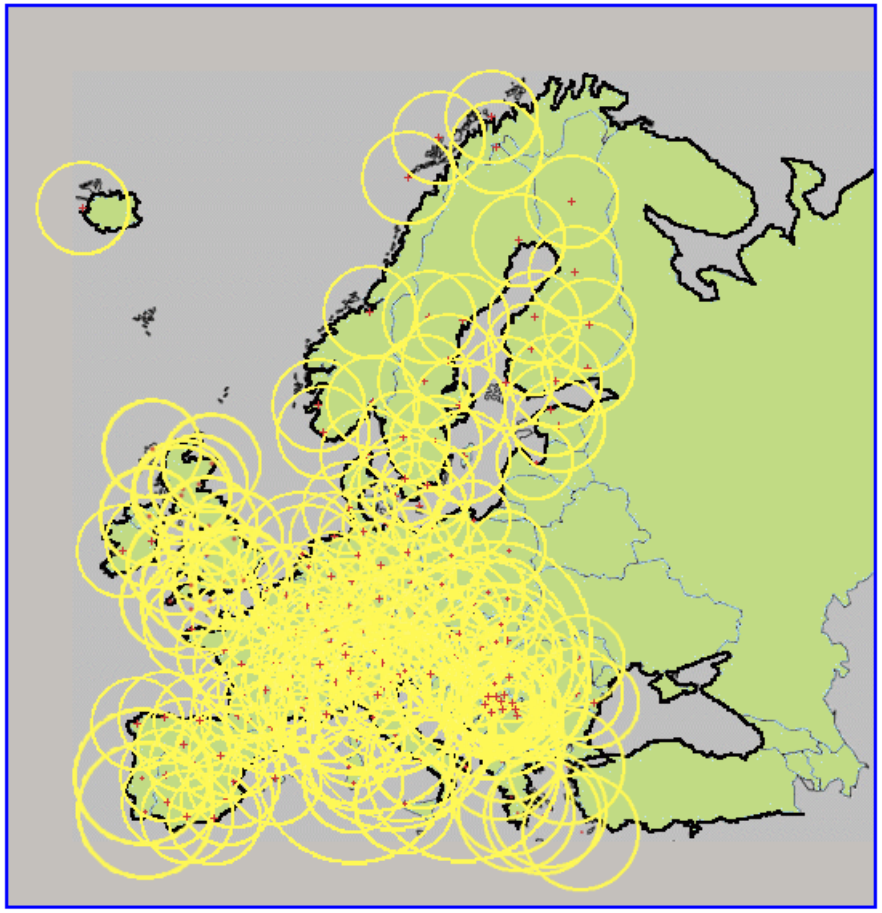
- all
- S
- C
- X

- all
- Doppler
- not Doppler

- all
- polarization (dual)
- not polarization

Number of selected radars : 191



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- not Doppler

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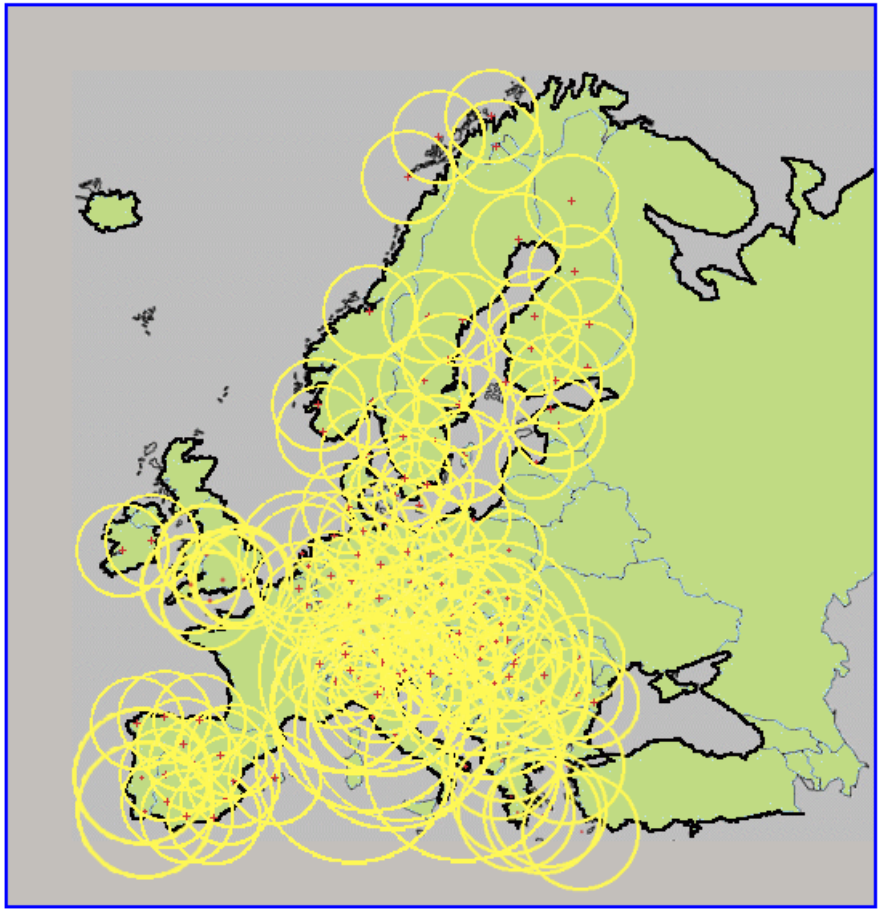
- polarization (dual)
- not polarization

Number of selected radars : 139



OPERA - radars

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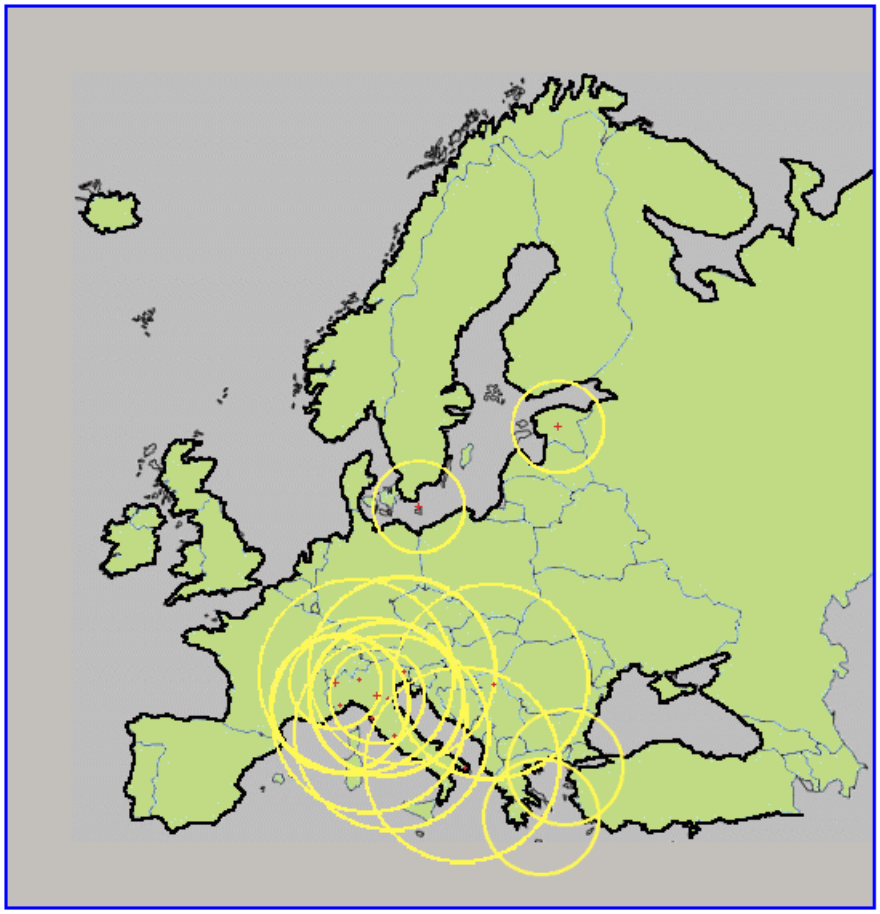
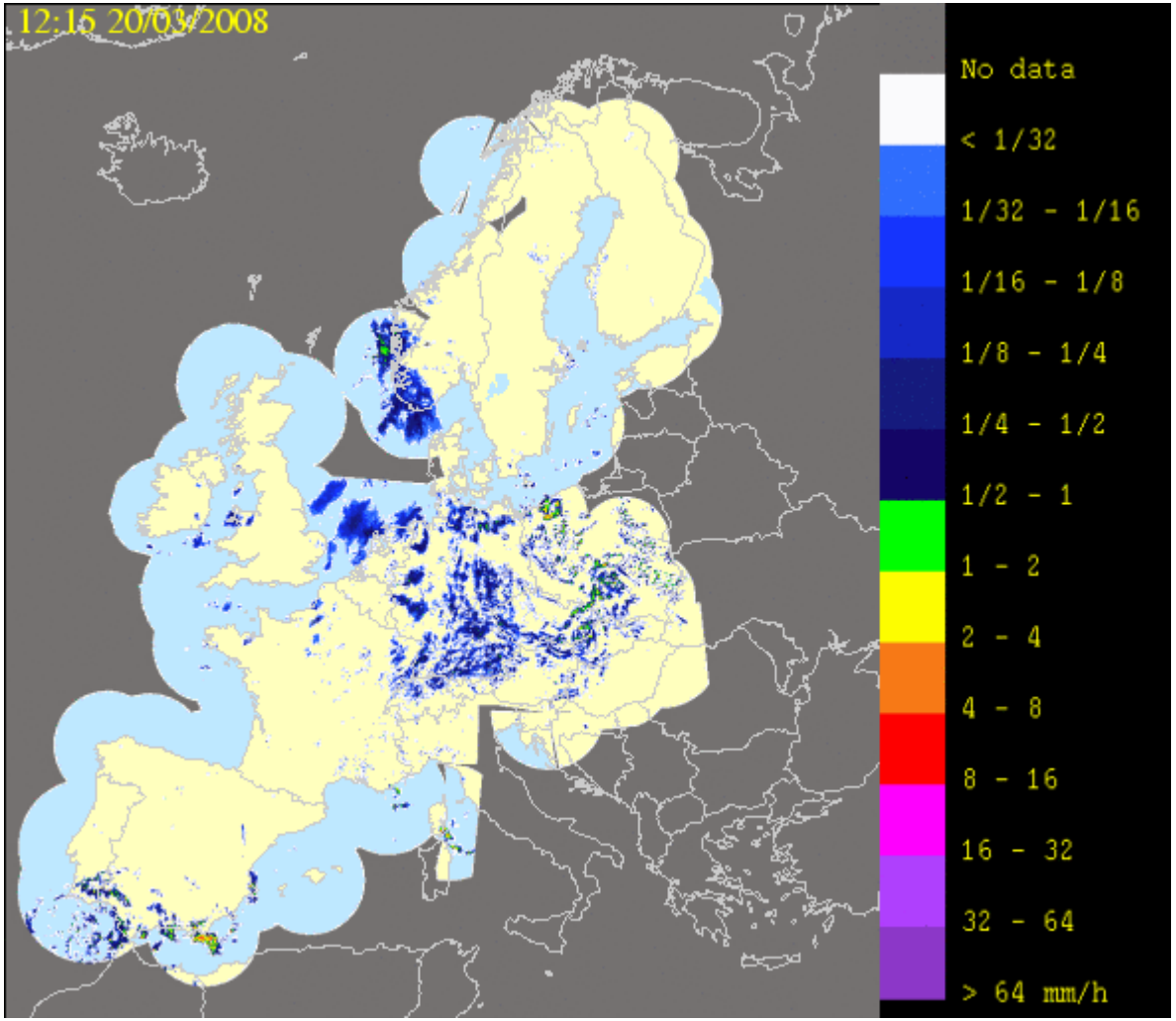
- not polarization

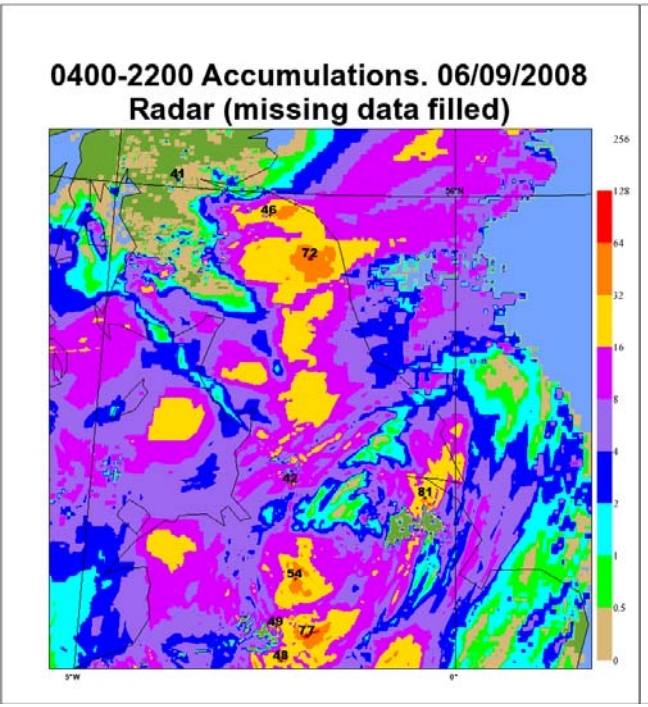
Number of selected radars : 14

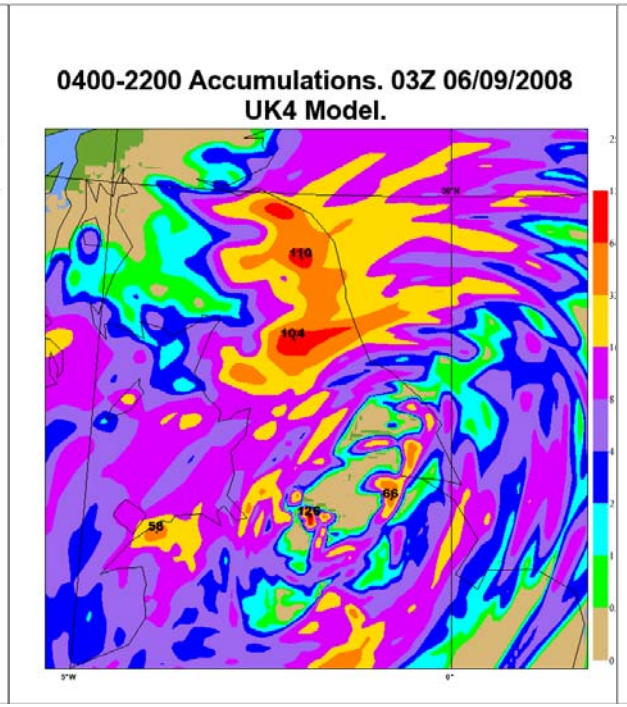


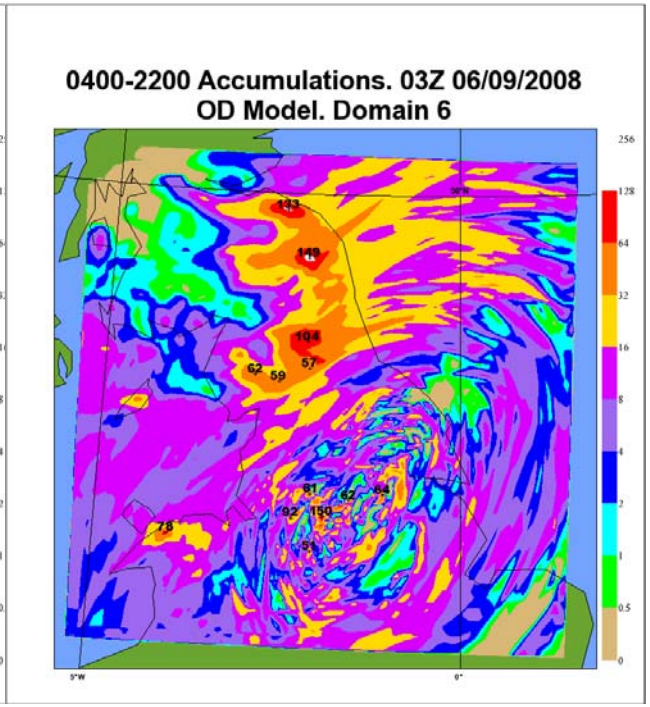
OPERA - composites



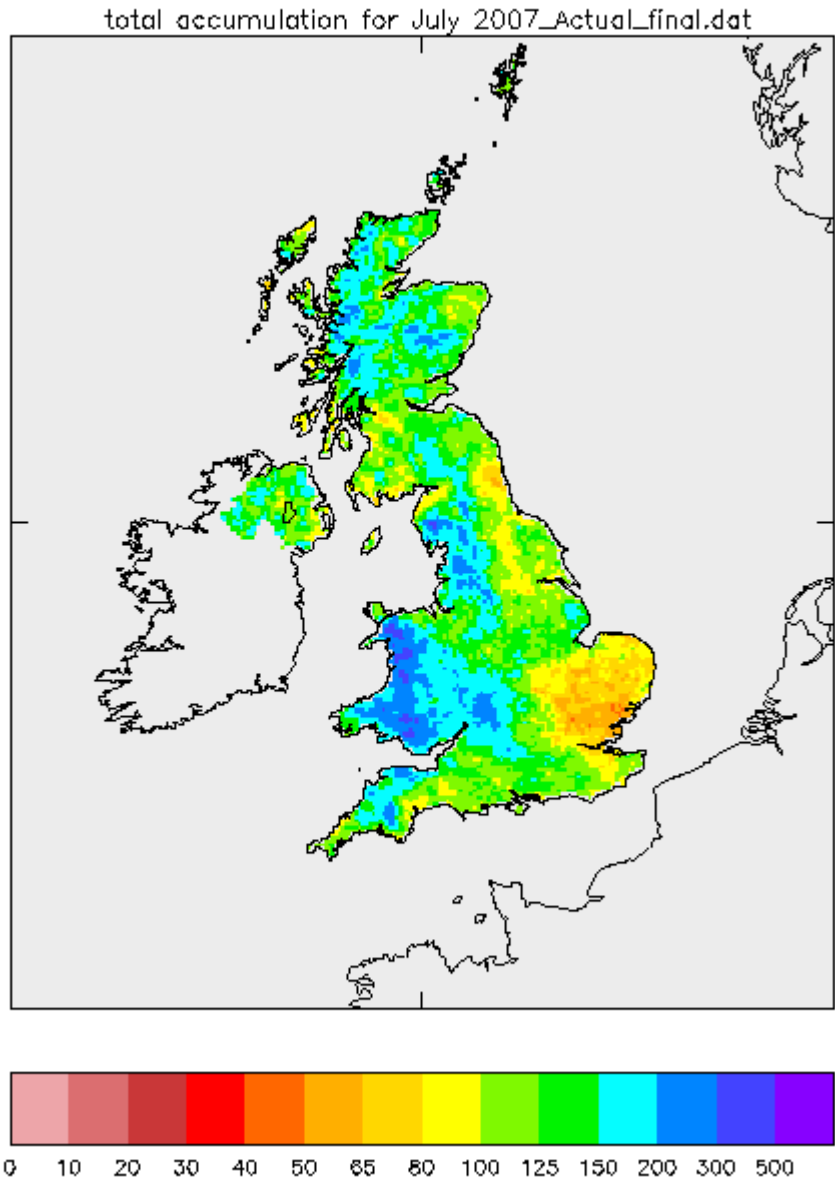
Morpeth flooding Event

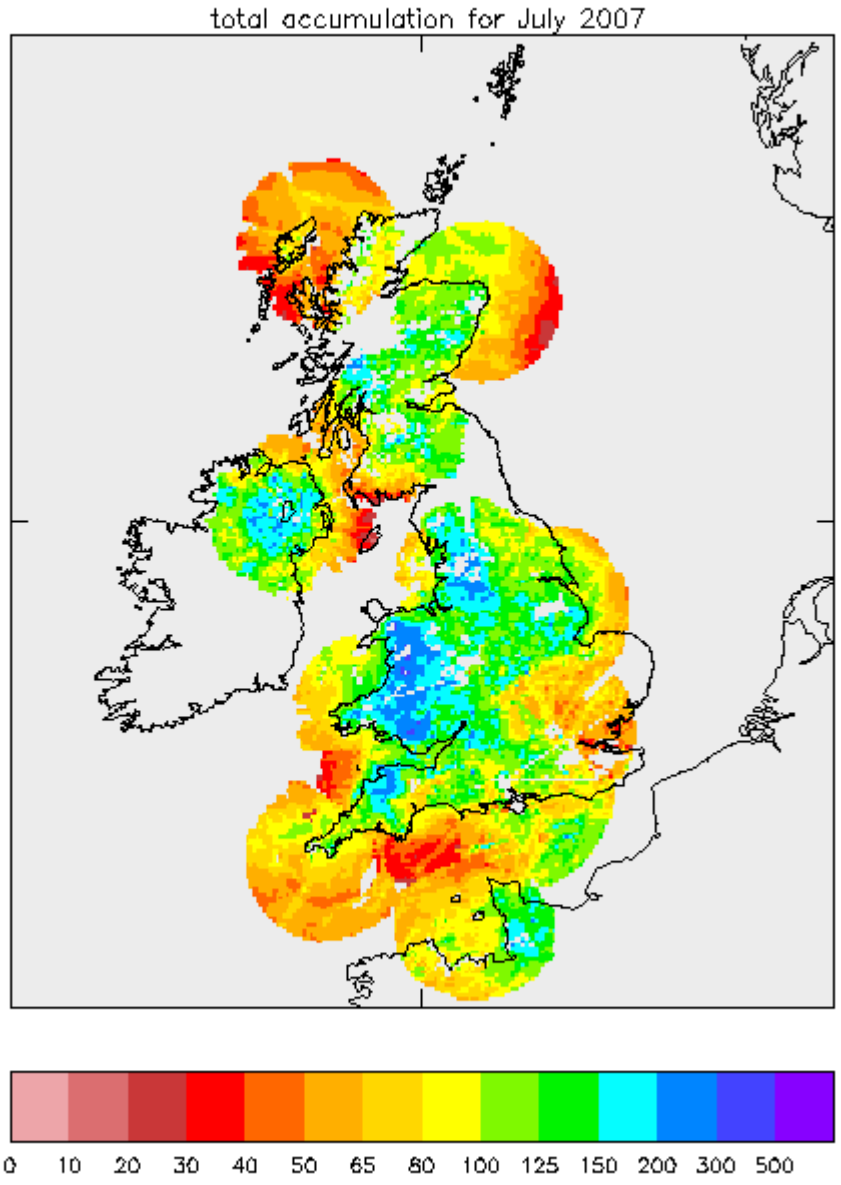




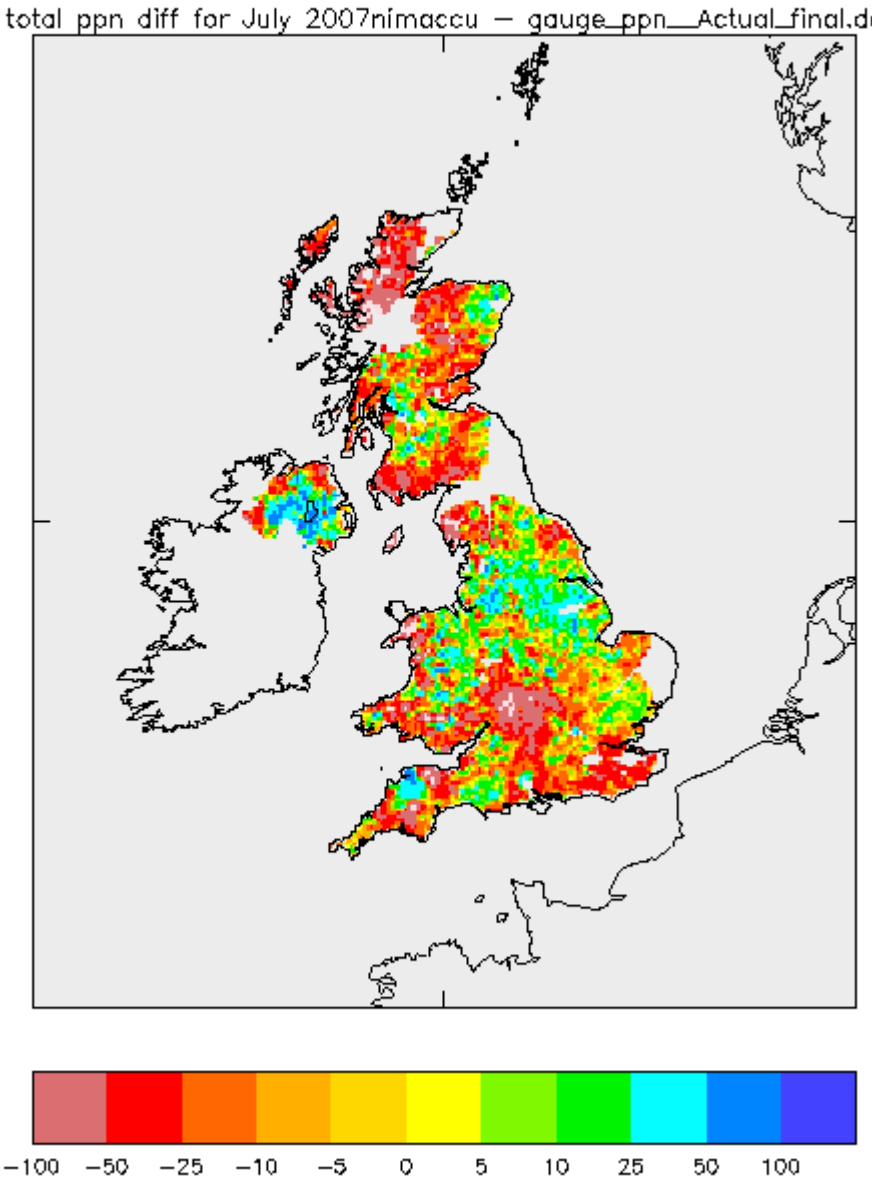


Gridded Gauges July 2007 Radar

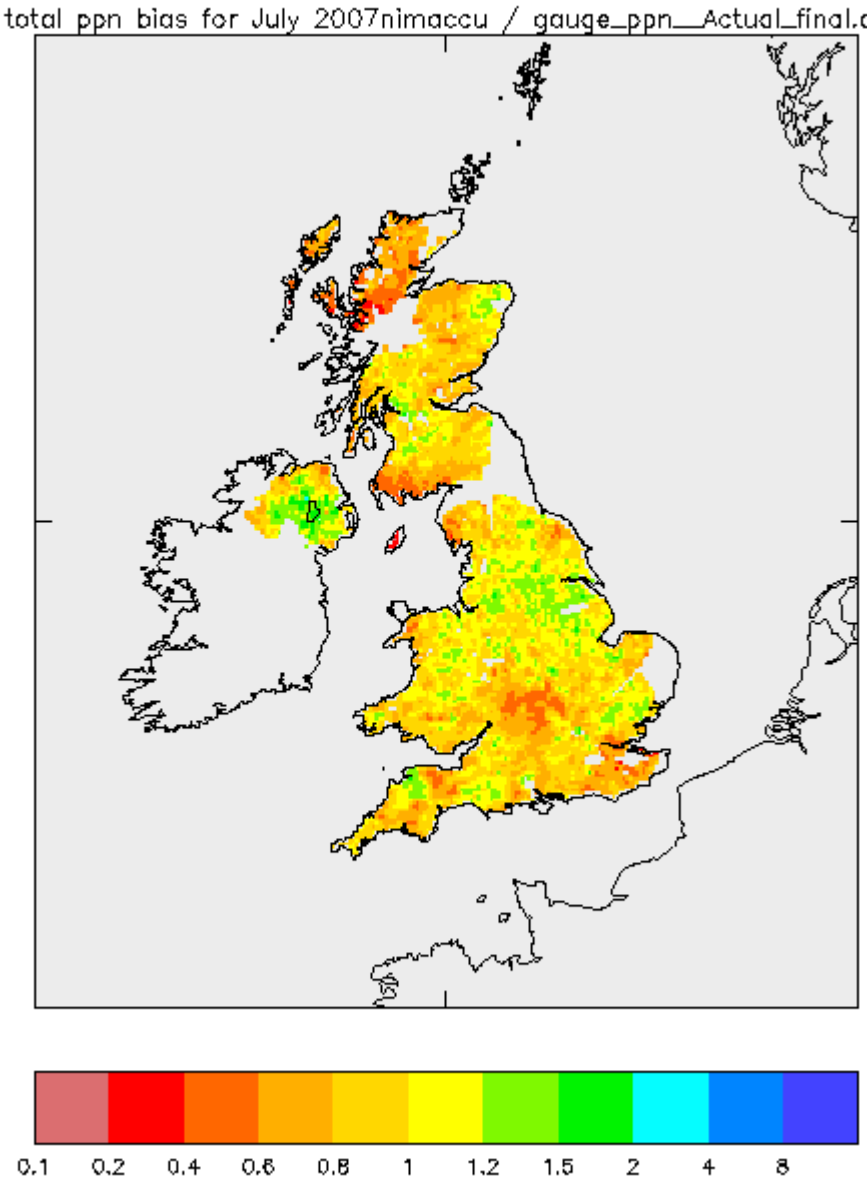




Radar – gauge (mm) July 2007

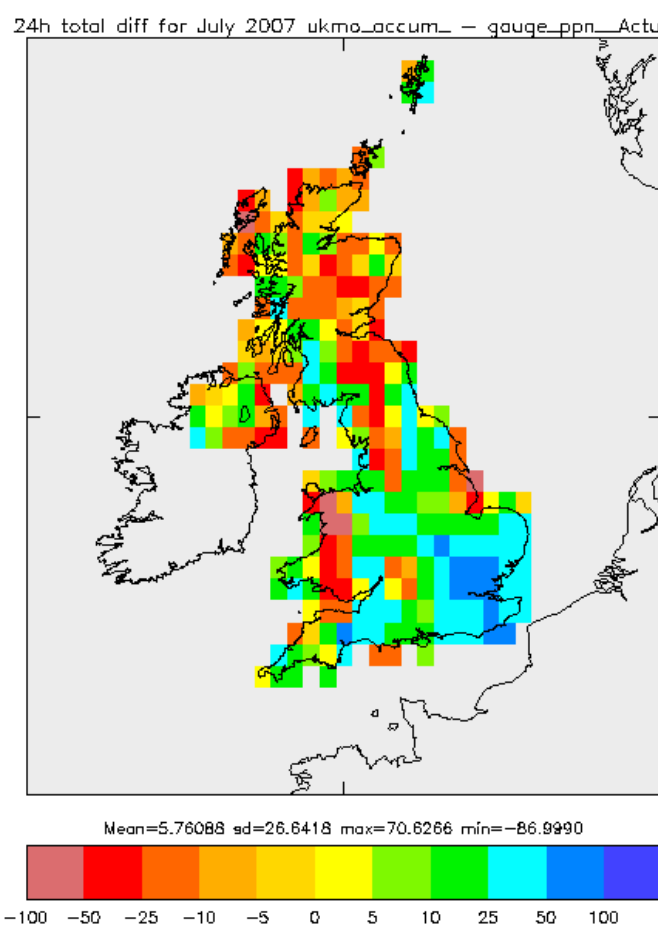


Radar/gauge

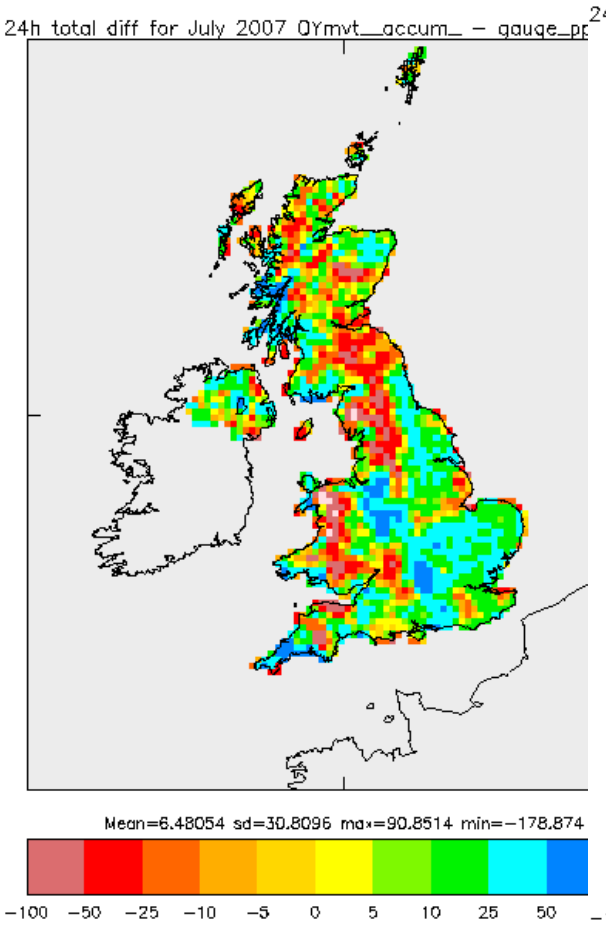


Forecast monthly totals – July
Errors v gauges

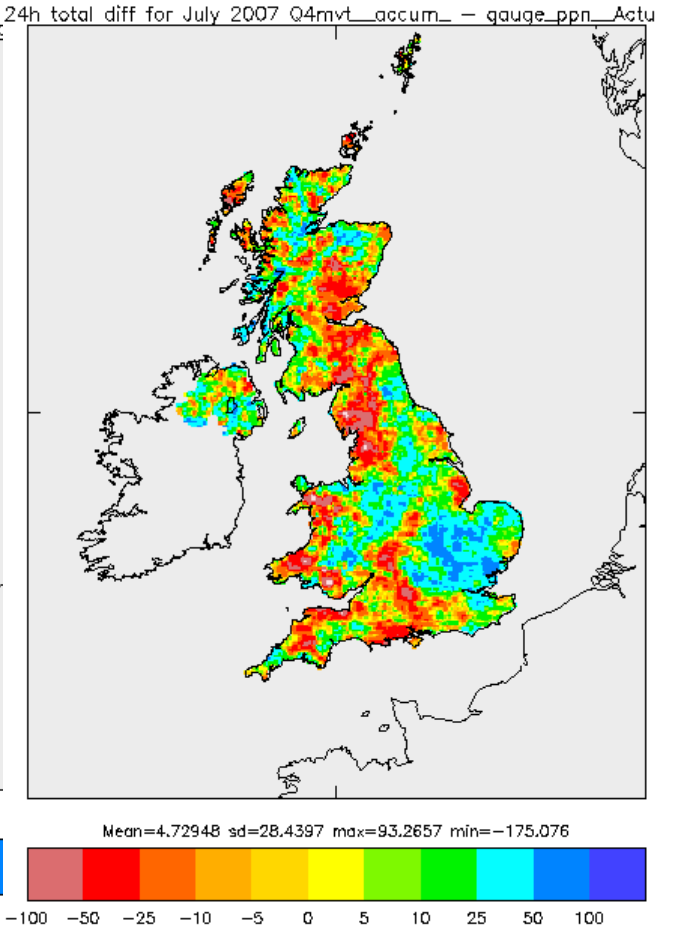
40 km

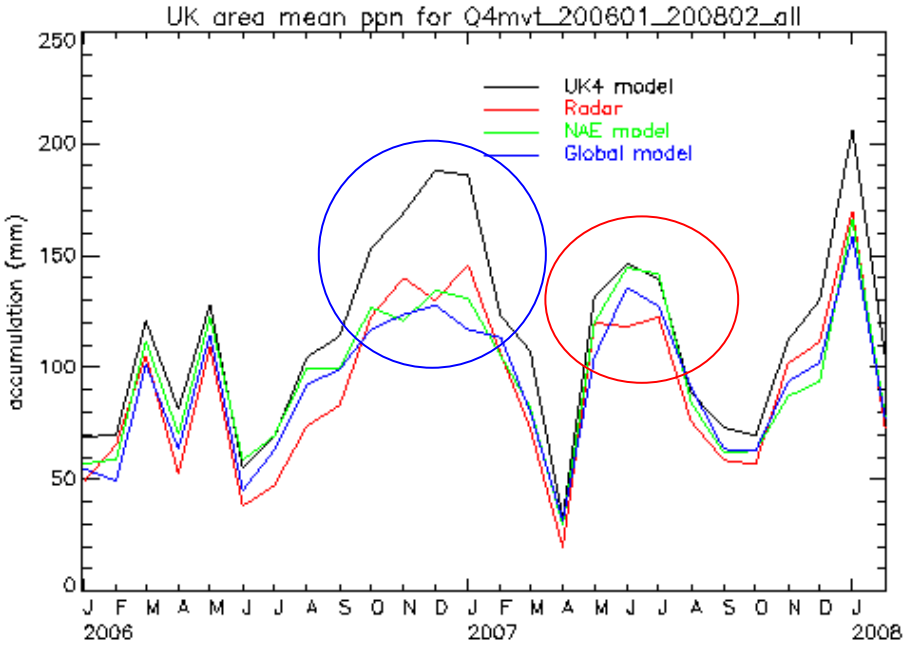


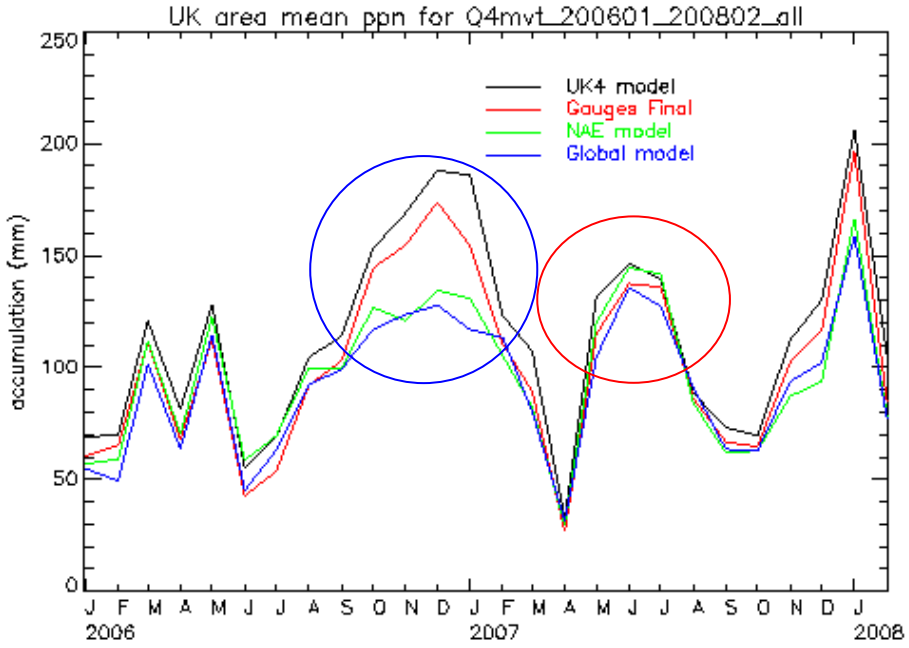
12km

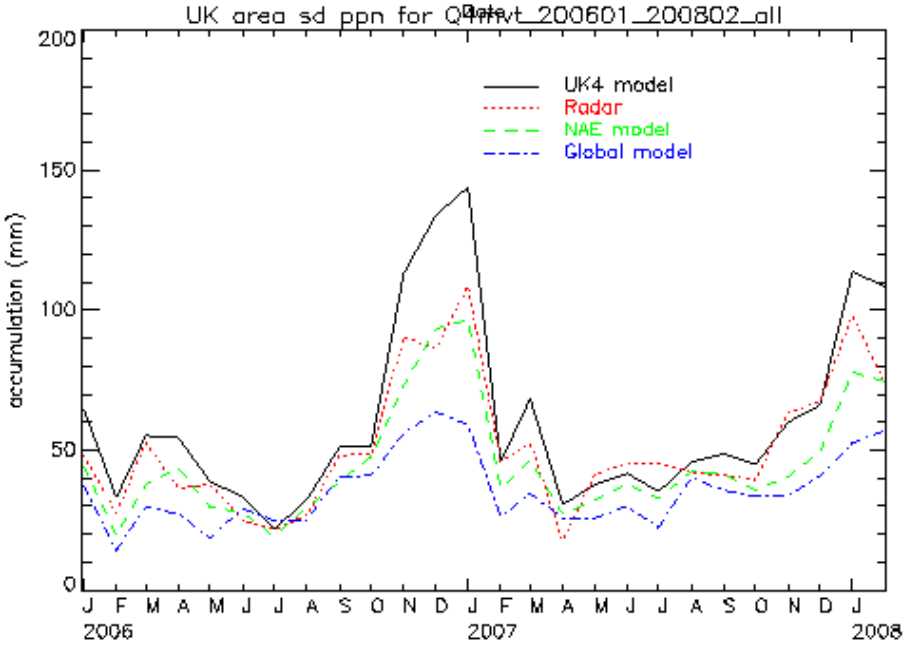


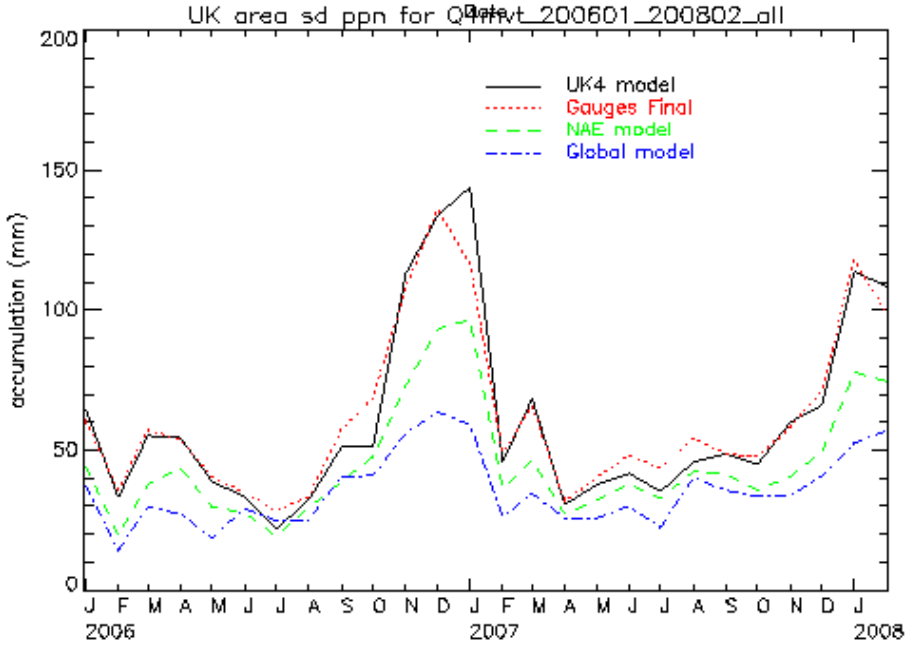
4km











Summary

- Additional products place great demand on observations for effective verification/validation
- Declining manual observational network
  - Greater automation
    - Need to determine different characteristics of manual/automatic obs
    - Understand influences on verification
  - More remote sensing – active/passive
  - More exploitation of satellite products