Recent developments in forecasting high impact surface-weather in the ECMWF model (heavy rain, freezing rain and fog)

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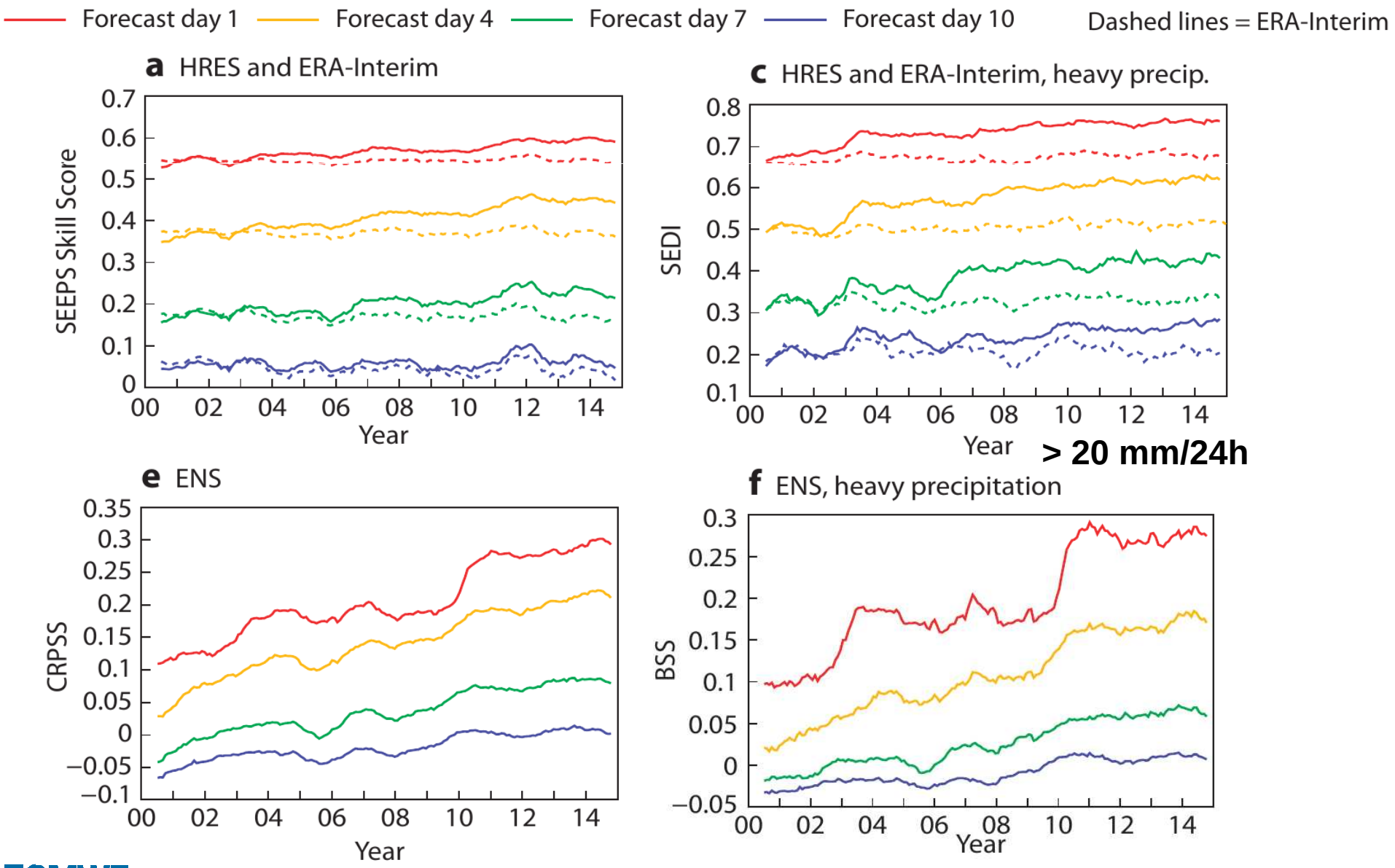
With thanks to Thomas Haiden, Tim Hewson, Linus Magnusson, Ivan Tvonevsky

Heavy Rain

ECMWF

Improvement in precipitation skill - last 15 years

Evolution of extra-tropical 24-hour precipitation skill (12 month running mean)

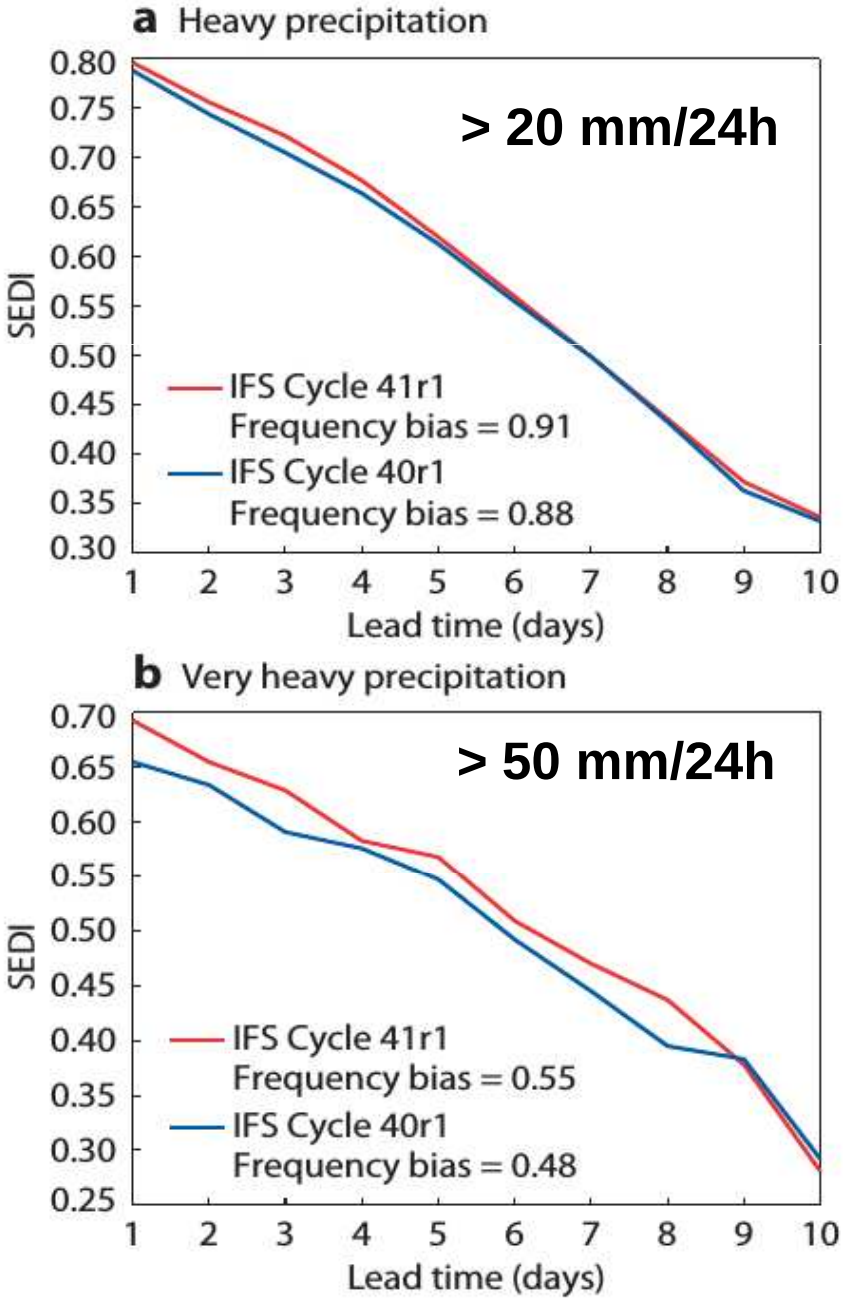


(Forbes et al., 2015, ECMWF Newsletter 144)

Improvement in precipitation skill in IFS Cy41r1

Cy41r1, May 2015-

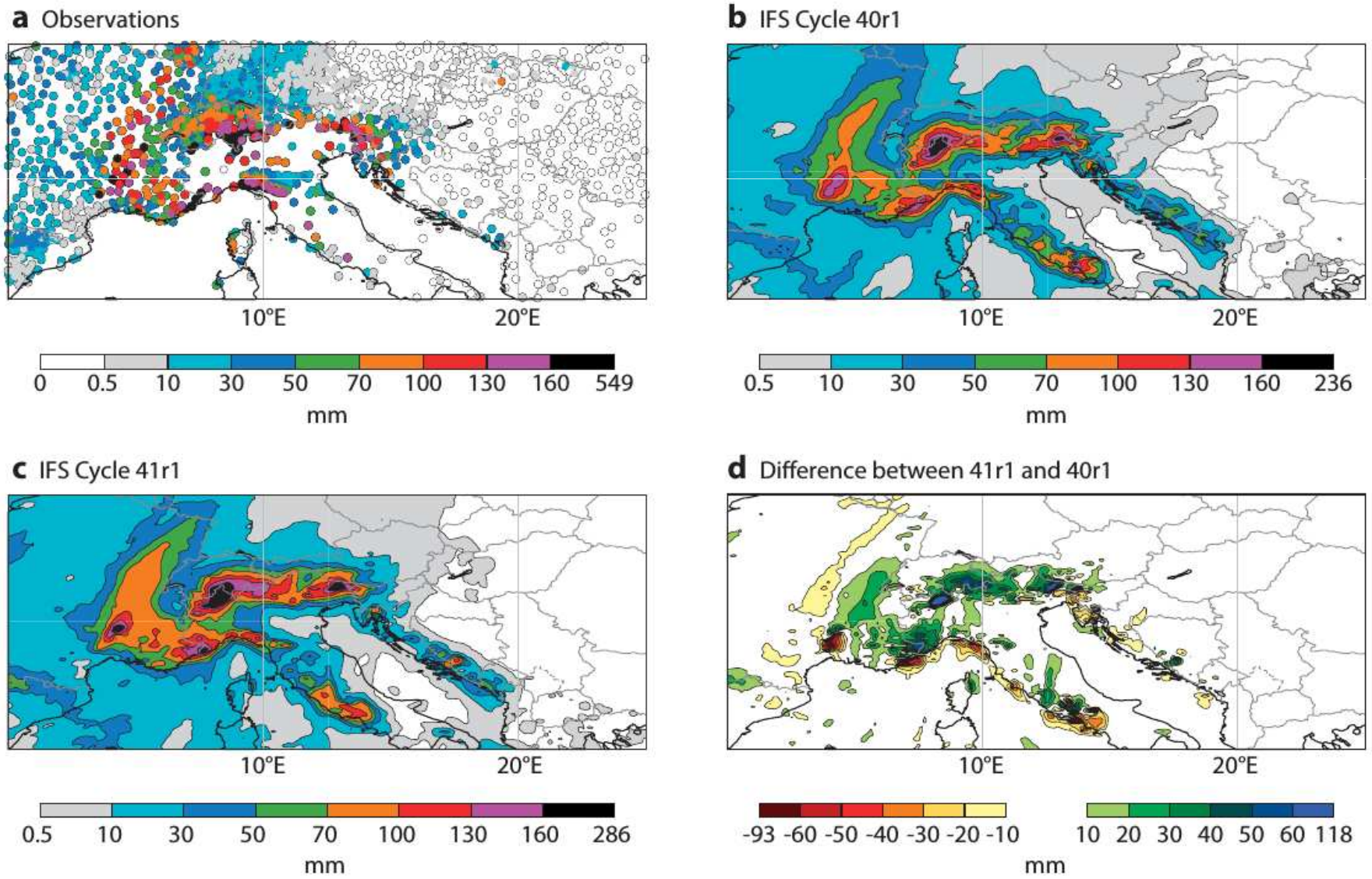
- Autoconversion/accretion changed from Sundquist (1978) to Khairoutdinov and Kogan (2000)
- Mixed phase changes – deposition and snow riming
- In deep cloud systems changes have significant impact, more non-linear precipitation process
- Improves skill for heaviest rain



(Forbes et al., 2015, ECMWF Newsletter 144)

Case study – Floods in Italy 3-5 Nov 2014

Precipitation accumulation 3-5 Nov 2014



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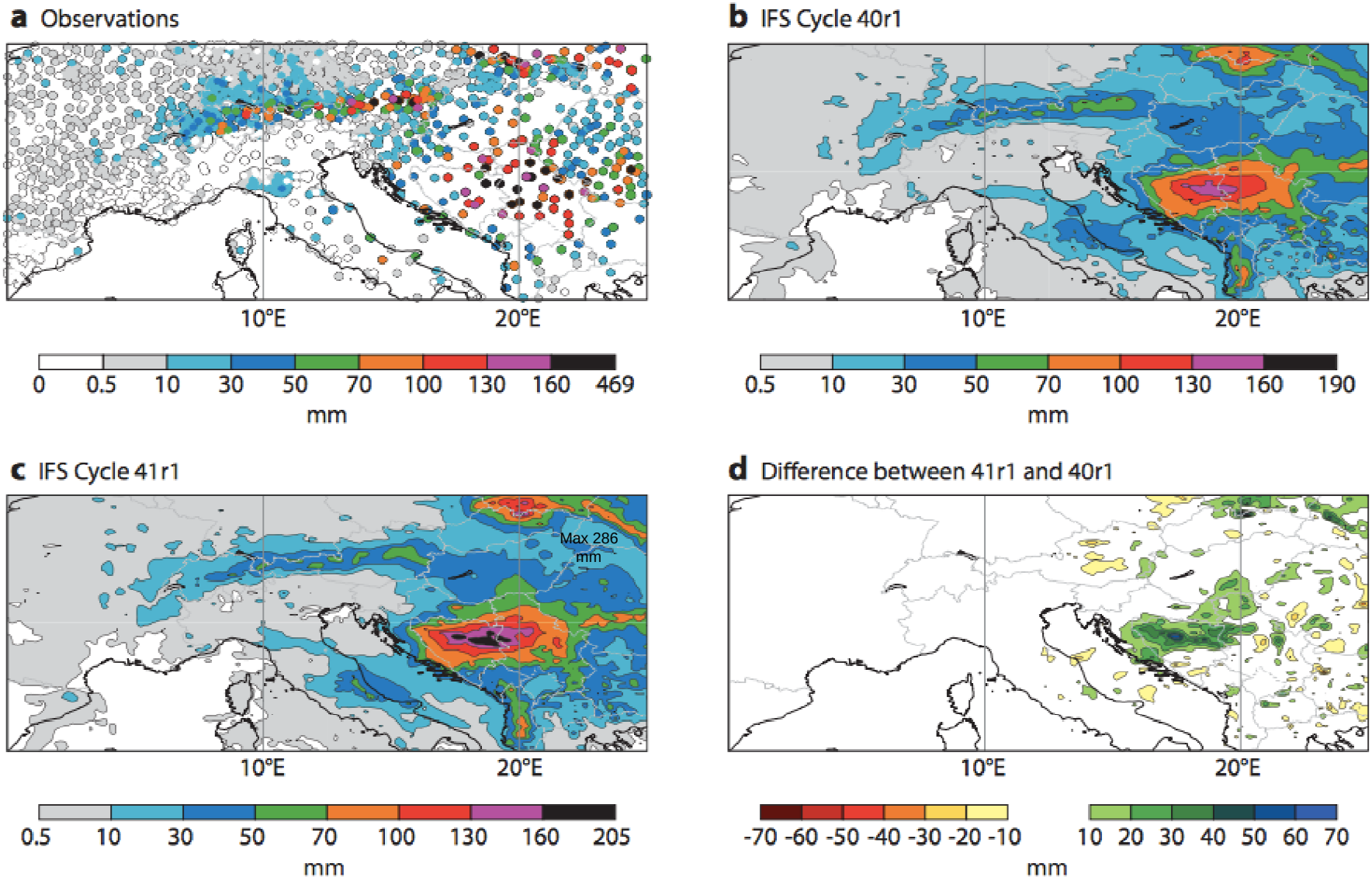
(Forbes et al., 2015, ECMWF Newsletter 144)

Case study – Floods in Balkans 13-15 May 2014

Precipitation accumulation 13-15 May 2014



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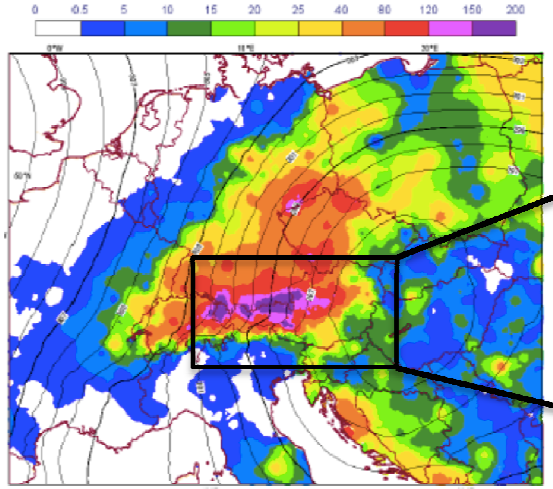
(Forbes et al., 2015, ECMWF Newsletter 144)

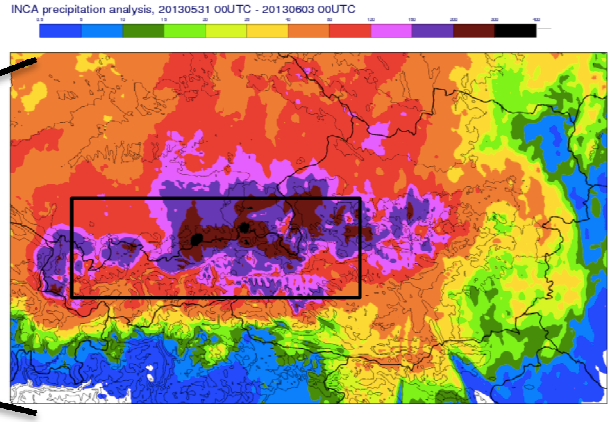
Central European floods, 2013

Haiden et al.,2014, ECMWF Tech Memo 723

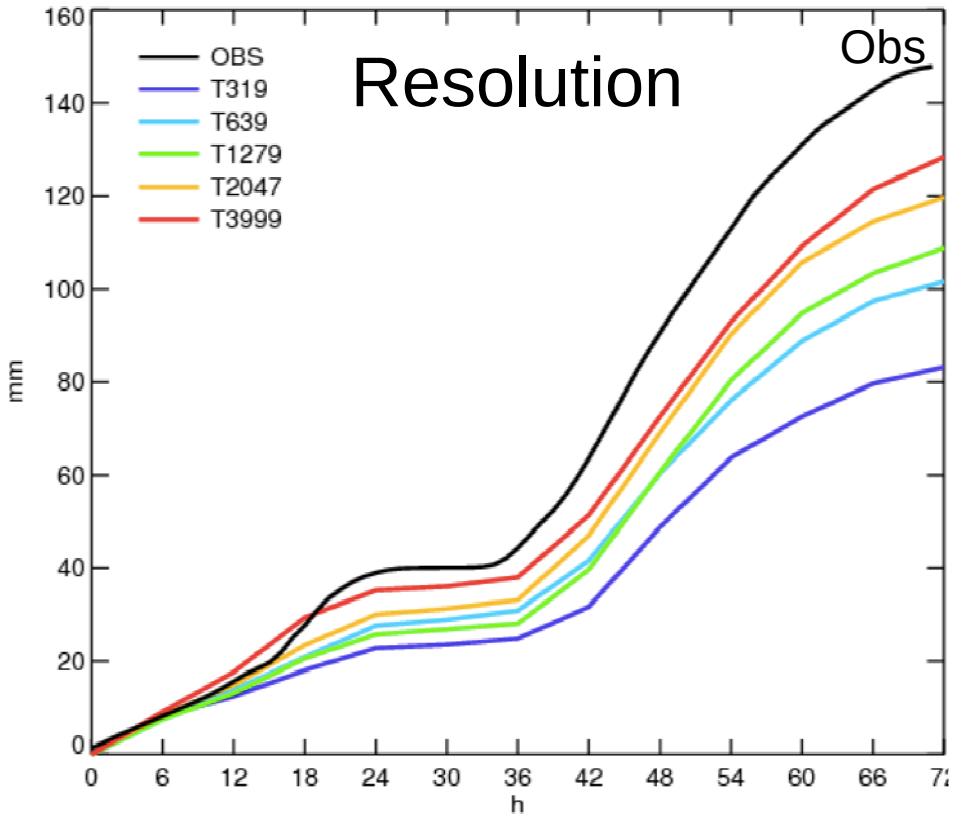
Accumulated precipitation, 3 day forecast from 31 May 2013

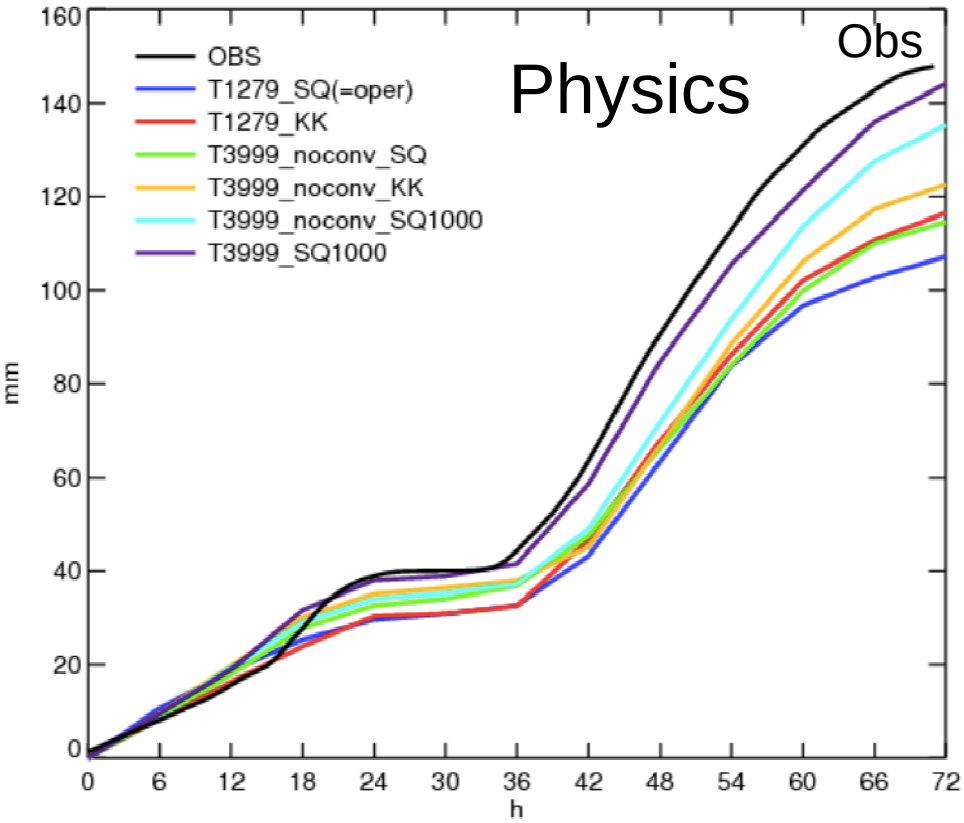
Operational IFS forecast





INCA analysis



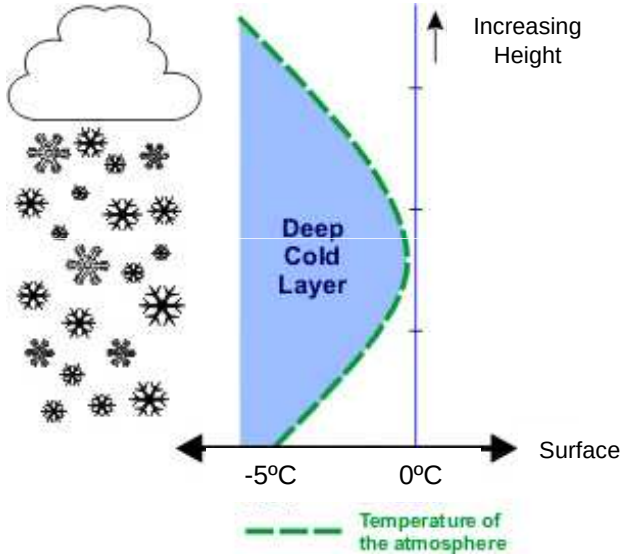


Freezing Rain

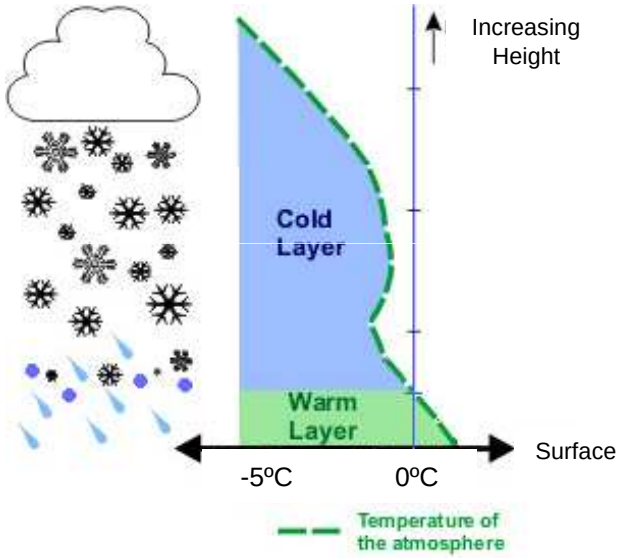
ECMWF

Precipitation type – a new diagnostic from the IFS

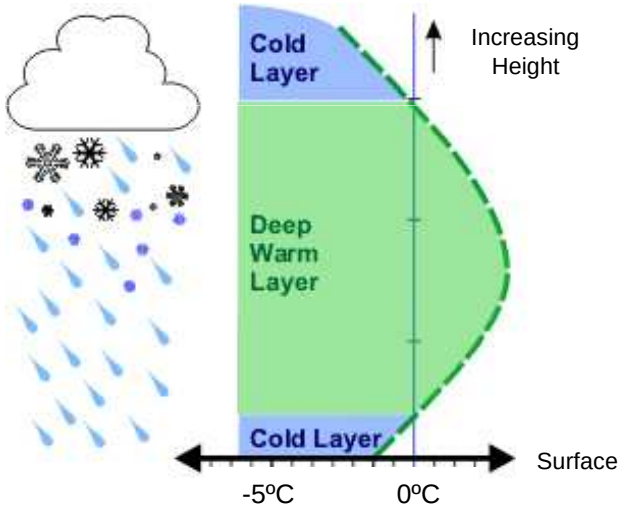
rain / snow / wet snow / mix rain-snow / ice pellets / freezing rain



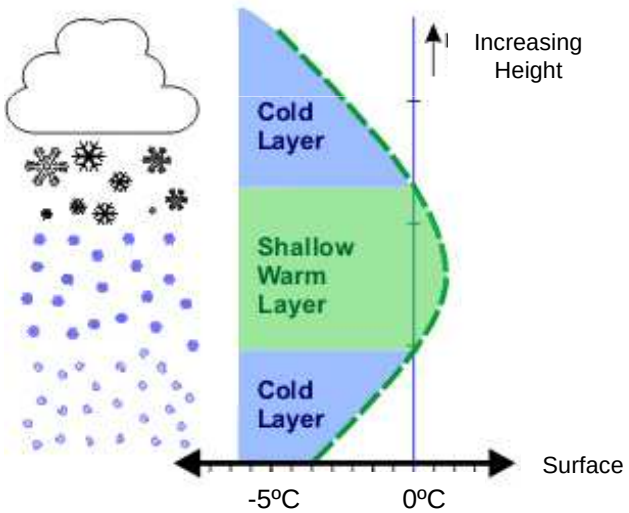
Snow



Sleet (melting snow) or rain



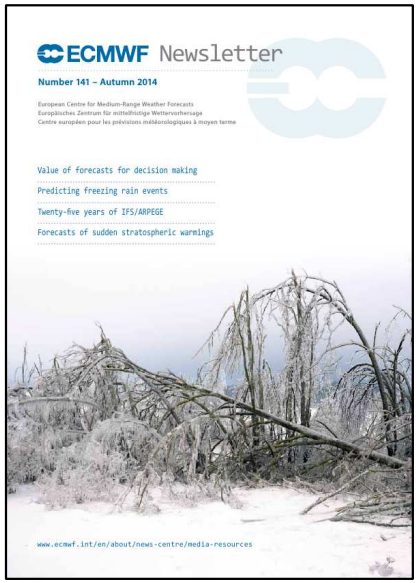
Freezing rain



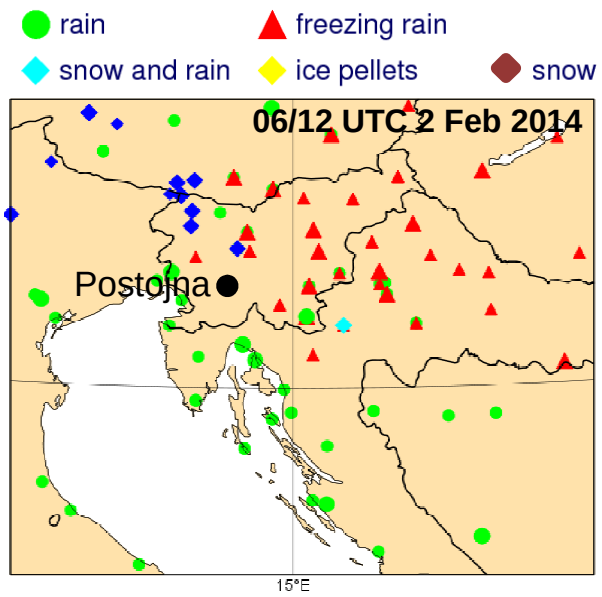
Ice pellets

Predicting high-impact freezing rain events

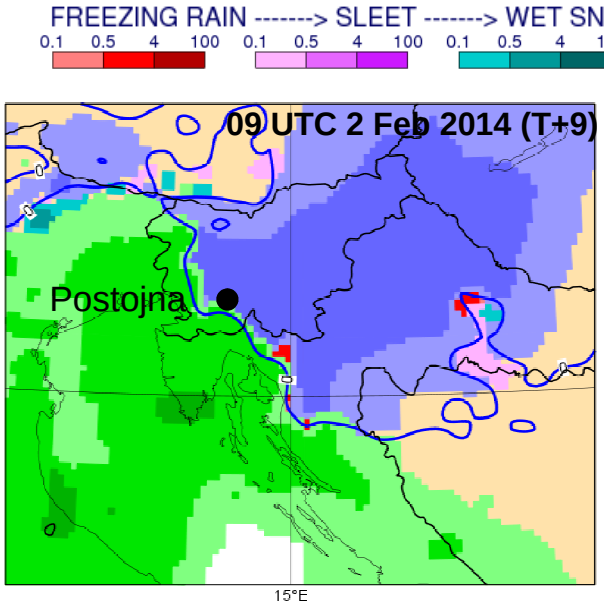
- Case Study: Slovenia/Croatia 02 Feb 2014
- Freezing rain caused severe disruption and damage, tranports/power/forests…
- IFS physics at the time (40r1) not able to predict
- New physics in 41r1 allows prediction of freezing rain events
- Evaluation in HRES/ENS shows potential for useful forecasts
- Article in EC Newsletter Autumn 2014 (but note results below are with new rain freezing physics)



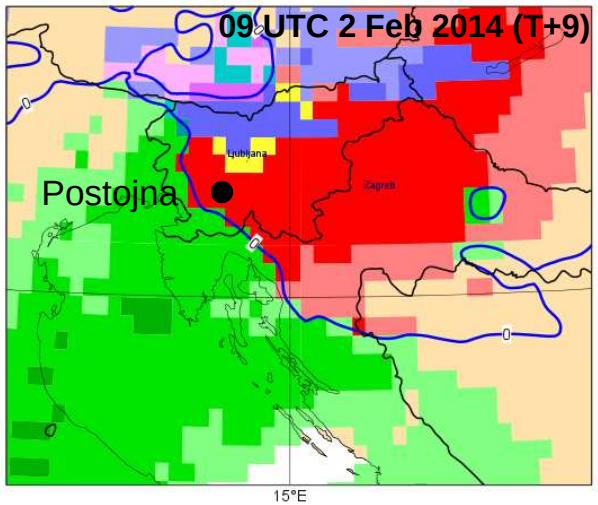
ECMWF Newsletter 141



SYNOP Observations



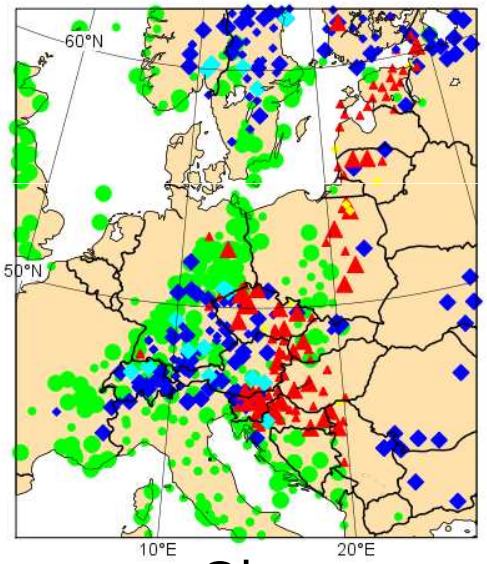
IFS HRES 40r1



IFS HRES 41r1

Probability of freezing rain accumulation from the IFS ensemble

Case Study: 02 Feb 2014



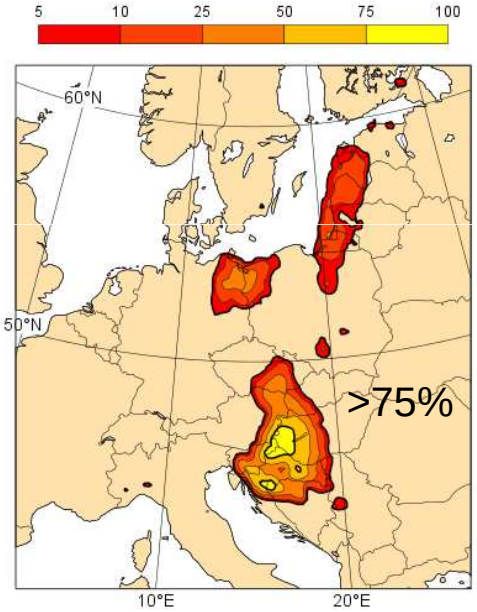
Obs

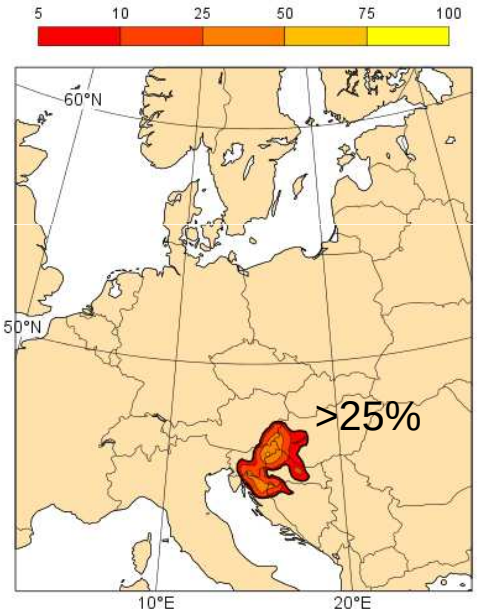
- rain
- snow
- freezing rain
- snow and rain
- ice pellets

Prob (fzra > 1mm)

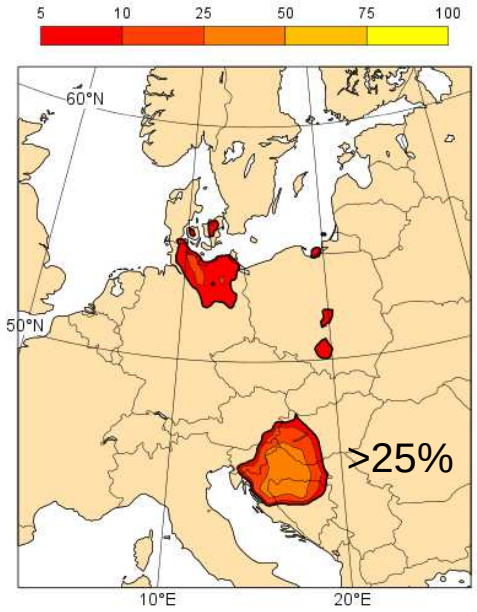
Prob (fzra > 5mm)

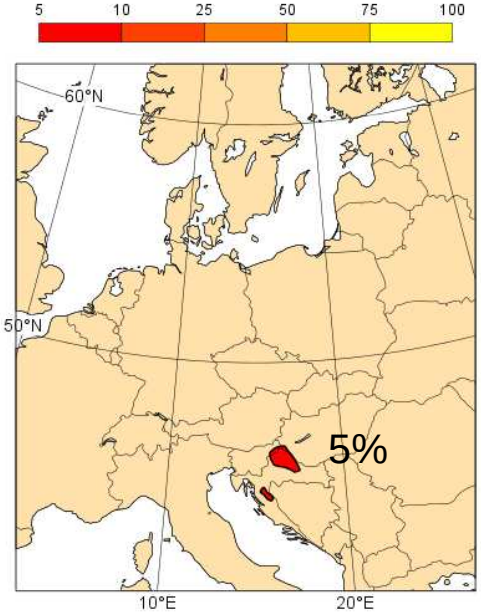
Day 3 forecast





Day 5 forecast





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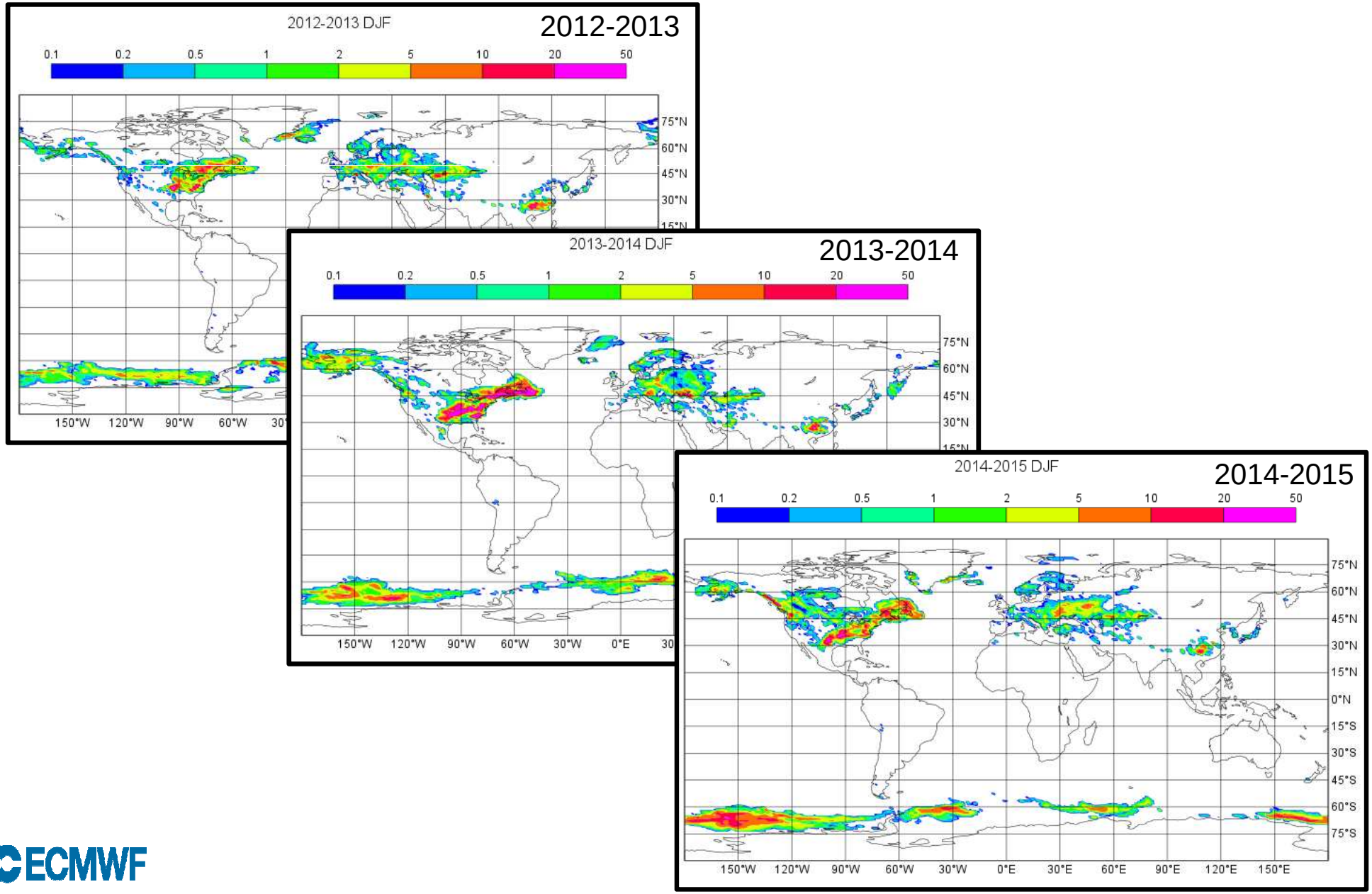
A global “climatology” of freezing rain? (very preliminary results!)

Total accumulated freezing rain (mm)
from all events in DJF



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Visibility and Fog

Prediction of severe weather: Visibility/Fog

- Visibility – new diagnostic in IFS Cy41r1 (May 2015-)

  Background aerosol seasonally varying climatology – currently Tegen et al. 1997

  Rain and snow precipitation

  Cloud liquid water/ice (i.e. fog)

  Visibility is calculated using an exponential scattering law and a visual range defined by a fixed liminal contrast of 0.02 based on extinction due to clean air, aerosol, cloud and precipitation

- Many limitations!

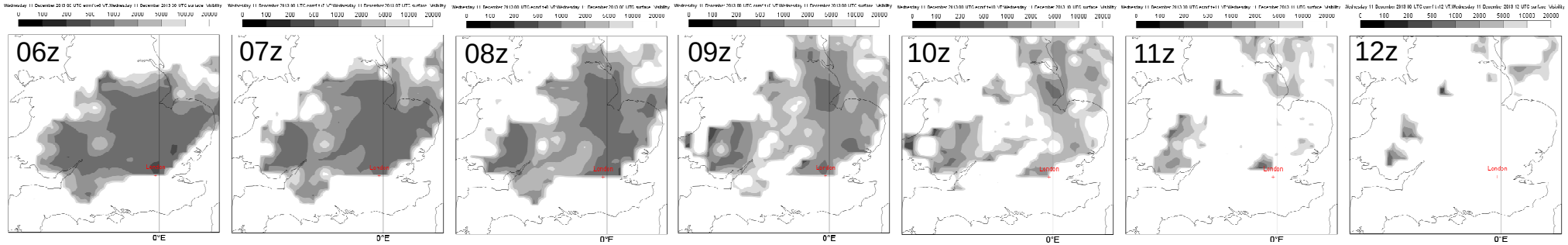
  "Fixed aerosol" – will change to MACC-based aerosol climatology with RH-dependent size distribution. Use of prognostic aerosol in MACC at some point in the future…

  Fixed particle size for cloud and precipitation particles (single moment microphysics), could introduce variable (diagnostic) particle size distributions

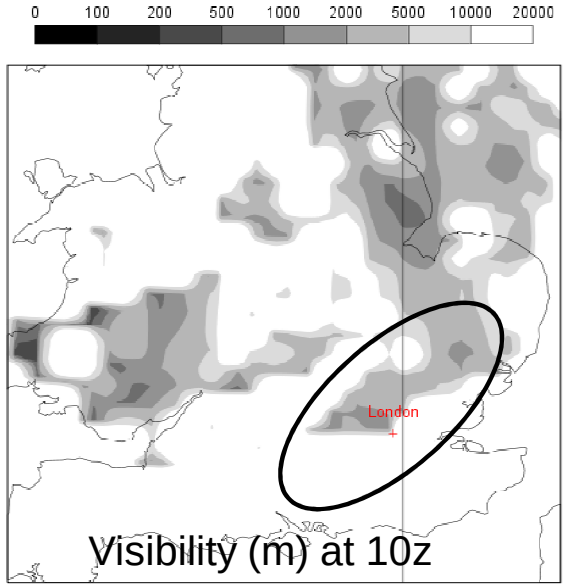
  Relatively low resolution – orography, 10m lowest model level, correct physics??? (turbulence, microphysics, radiation interactions…)

Prediction of severe weather: Visibility/Fog

Case study: UK 11 Dec 2013, 12 hour forecast



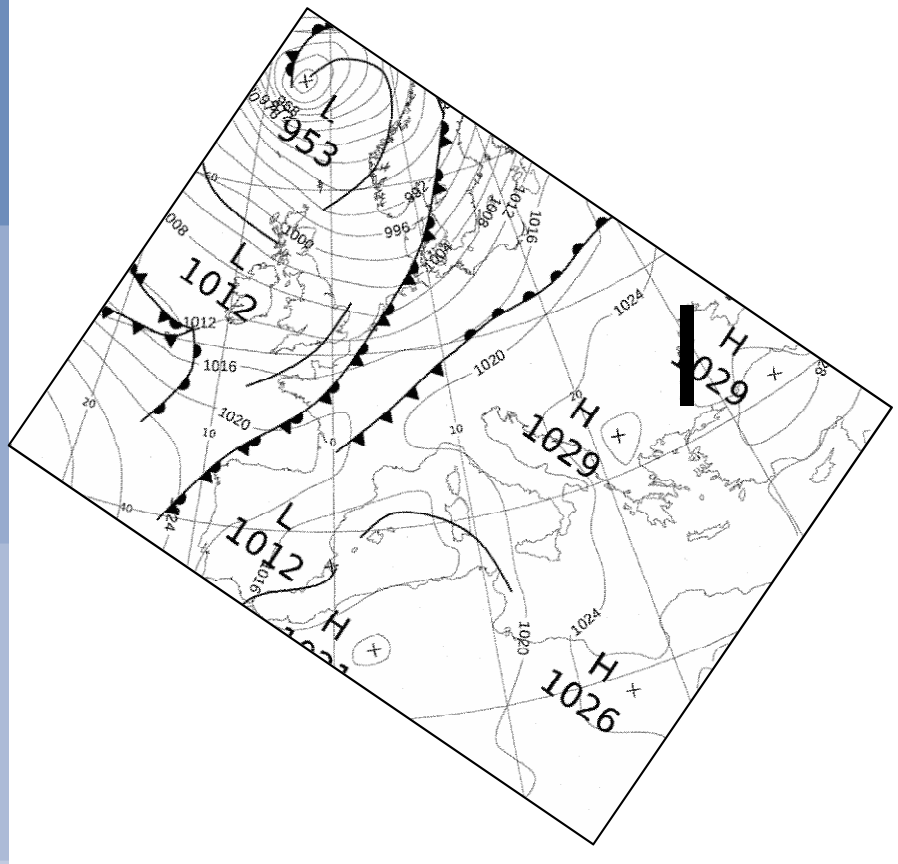
MODIS visible at ~10z

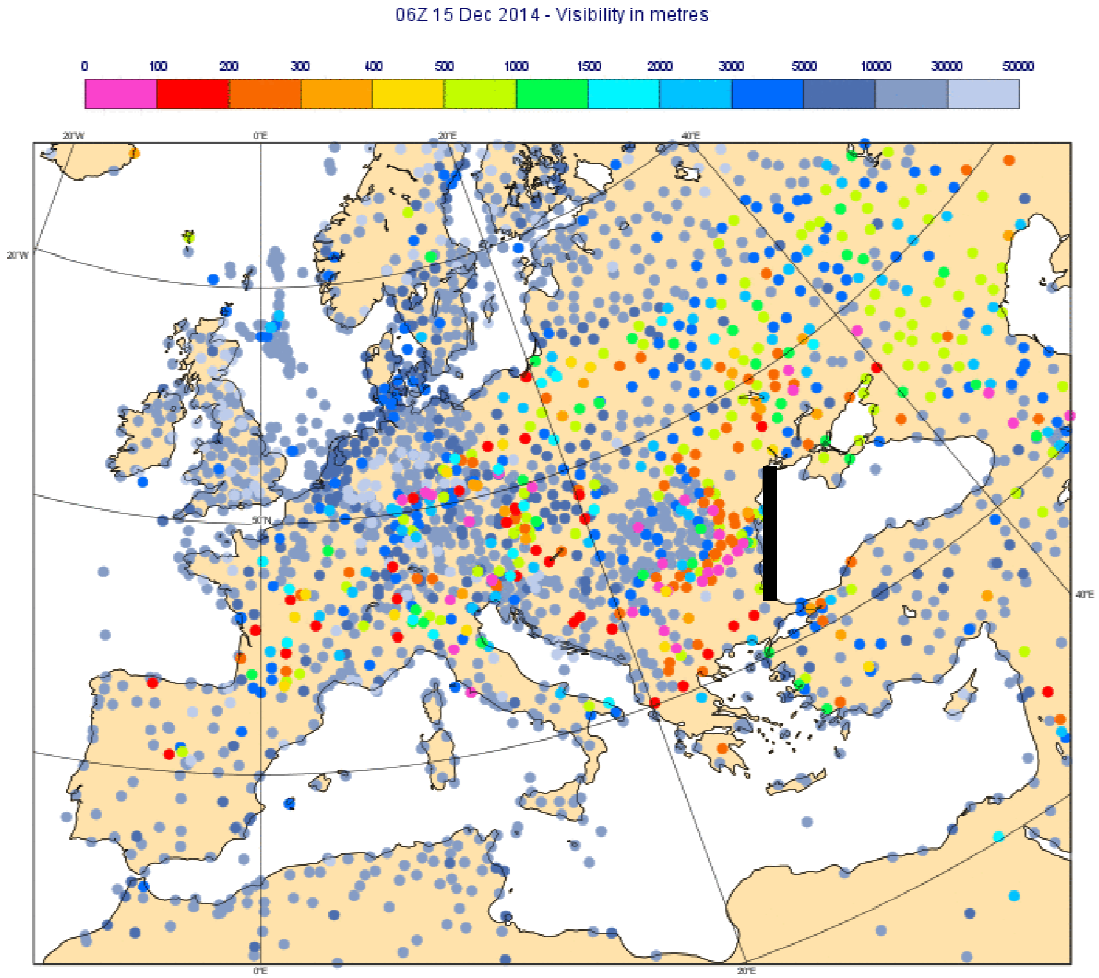


- Visibility is a new diagnostic for IFS 40r3 (primarily for fog/precip)
- For this case, observed fog in London (+elsewhere) overnight.
- IFS give indication of low visibilities in generally the right area, and dissipates through the morning.
- Diagnostic most useful in probabilistic mode

Prediction of severe weather: Visibility/Fog

Case study: 15 Dec 2014





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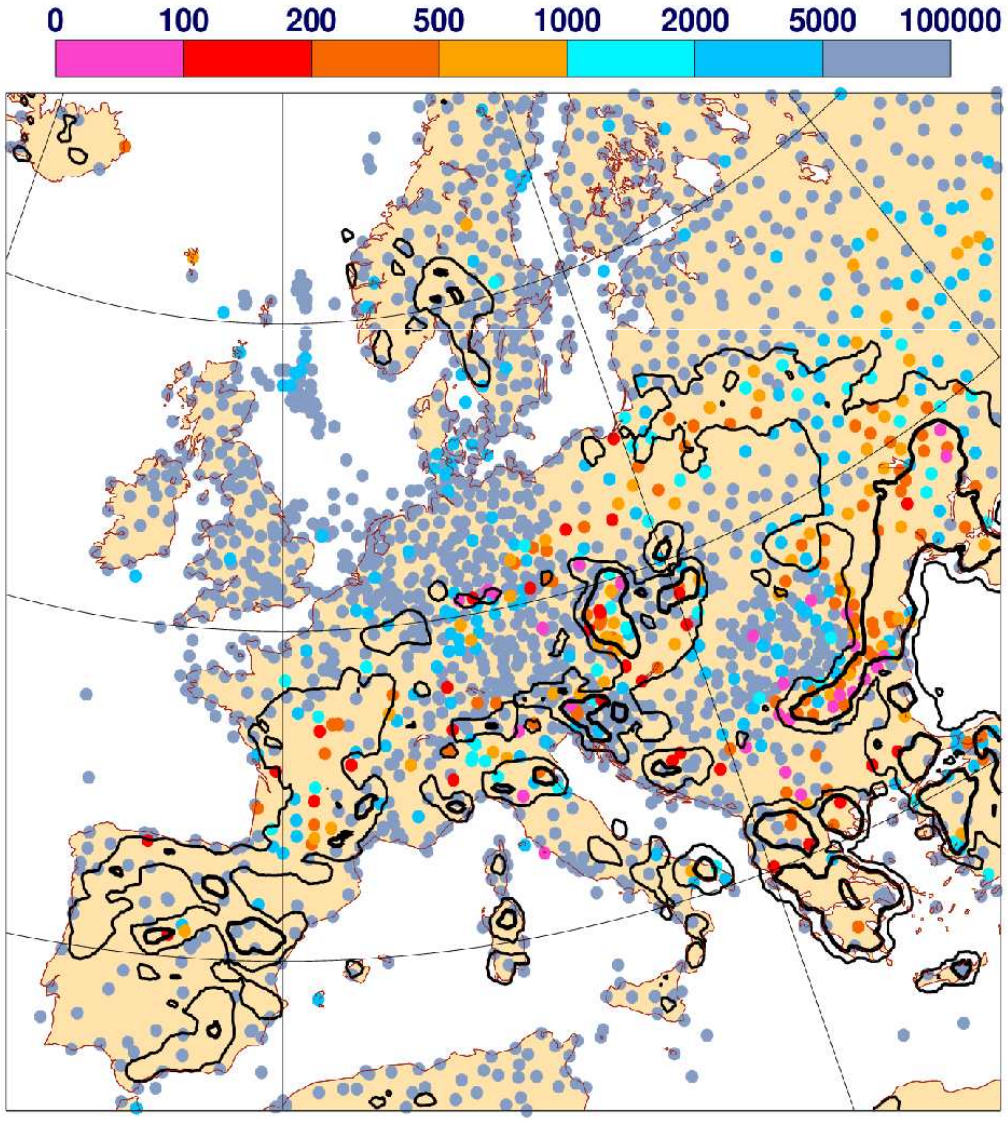
Prediction of severe weather: Visibility/Fog

Case study: 15 Dec 2014, 3 day probability forecast from IFS ensemble

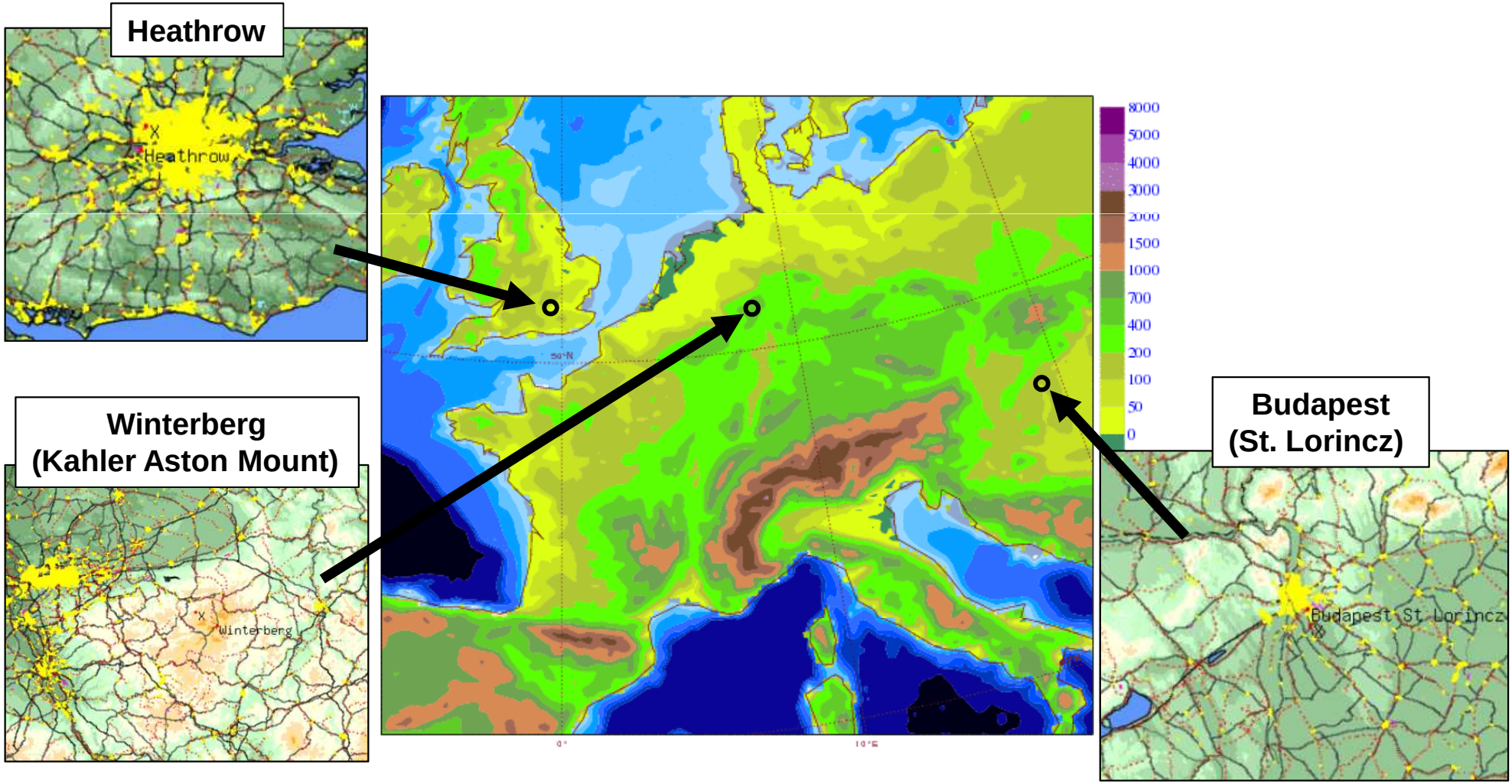


Observed visibility (m) at 06Z 15 Dec 2014 (dots)
ENS 3-day forecast probability of fog (<1000m) >10% (thin), **>50% (thick)**

ECMWF

Prediction of severe weather: Visibility/Fog

Case study: 15 Dec 2014



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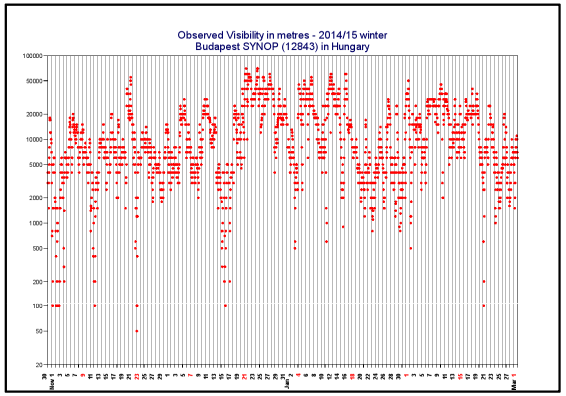
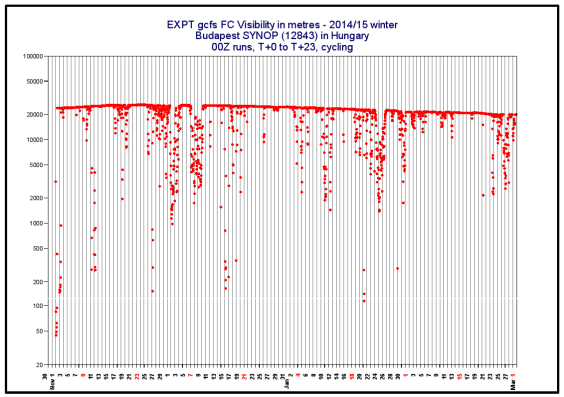
Prediction of severe weather: Visibility/Fog

Specific sites: Nov-Mar 2014-2015

Obs



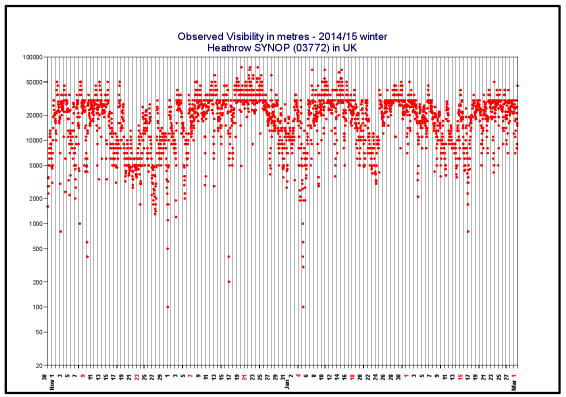
IFS 24 hr fc

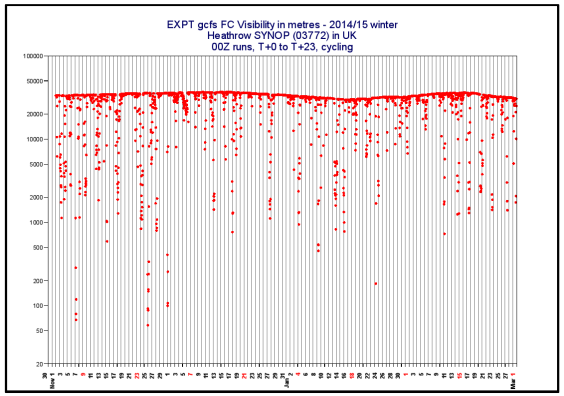


Budapest

Climate
Continental
Aerosol rich
Low-lying
Fog-prone

Background Vis bit high
Too little variability

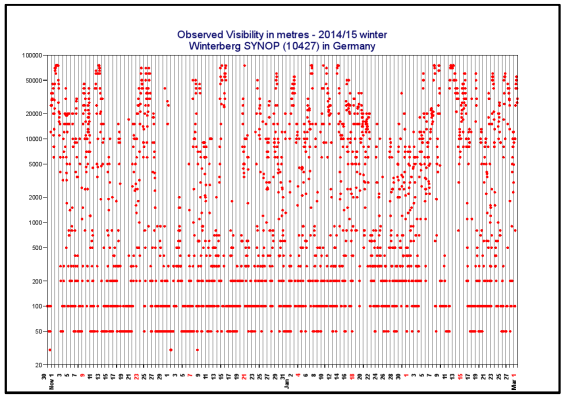


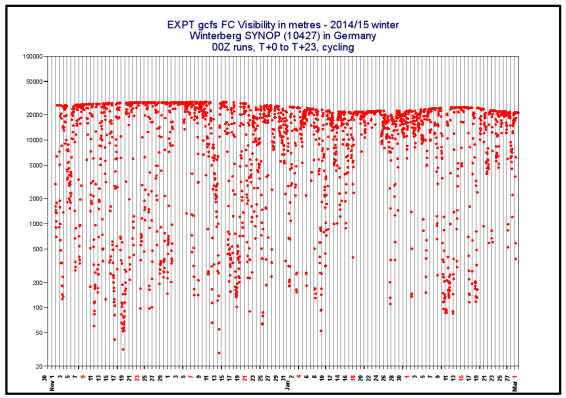


Heathrow

Climate
More maritime
Fewer aerosol
Low-lying
Fog-prone

Background Vis reasonable





Winterberg

Climate
Exposed
High altitude
Prone to hill fog

Vis too high BUT model grid point is **606m,** obs is **859m**

ECMWF

Tim Hewson

Summary

- Predicting high impact surface weather in the medium-range has significant value!
- Need to evaluate short range to show the model has the capability/correct physics
- IFS Cycle 41r1 operational from 12 May 2015
  - Improvements in prediction of heavy rain (flooding)
  - New precipitation type diagnostic, including freezing rain
  - New visibility diagnostic (fog forecasting) – experimental!
- For the medium-range, ensemble probabilities most useful
- Further evaluation and improvements required! (particularly visibility/fog - aerosol)