New initiatives for Severe Weather prediction at ECMWF

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Ivan Tsonevsky, Fernando Prates, Richard Forbes

ECMWF

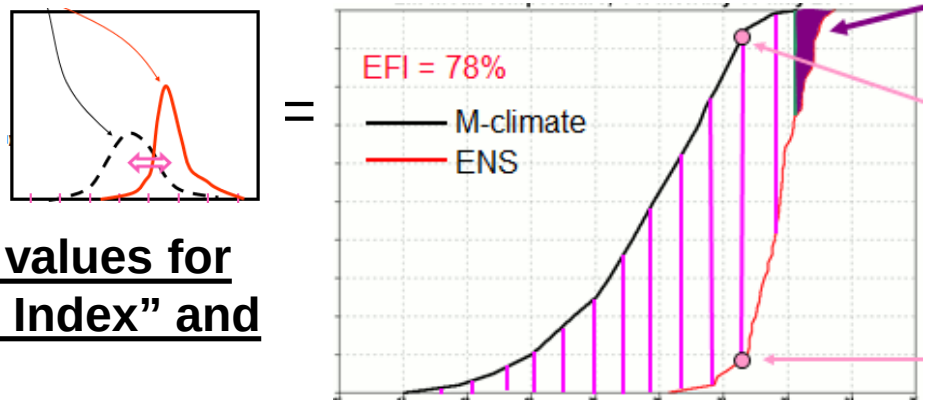
Layout

- **1. EFI-related developments:**
  - Upgraded Model Climate (M-Climate)
  - Extended lead times
  - New method of computation
  - EFI for CAPE
- **2. Diagnosis of Freezing Rain**
  - Changes to model physics
  - Precipitation type product
- **3. New Diagnostics**
  - Visibility
  - Precipitation rate / type
- **4. Tropical cyclone tracks**
  - Extension to day 10, BUFR products for genesis events
- **5. ecCharts - New Convective Indices**

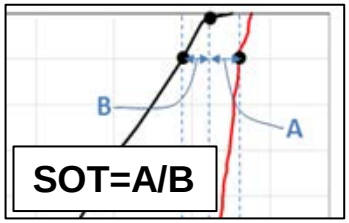
All developments to be described relate to user requests and feedback over recent years, and to ECMWF strategy in which improved prediction of severe weather is a key goal

1. EFI-related developments

First Aim



- **To have more stable, more accurate values for the EFI and SOT ("Extreme Forecast Index" and "Shift Of Tails")**
- **Recall that EFI & SOT depend on the difference between the forecast pdf (or cdf) and the M-climate pdf (or cdf), *which is a function of lead time***
- **EFI and SOT sometimes behave erratically, not because of changes in the forecast, but because of** sampling-related changes in M-Climate at different lead times. **So we need better sampling, i.e. more cases.**
- **It is particularly important to define the M-Climate tails, as EFI and SOT are particularly sensitive to these**
- **The problem is that the EFI can reduce or increase between one forecast and the next *without* the new forecast being any different…**
- **(any drifts in model forecast parameters need also to be captured, but except for tropical rainfall these drifts are generally small)**
- **Enhanced computer power will allow us to increase the number of realisations for the M-climate by a factor of ~4..**

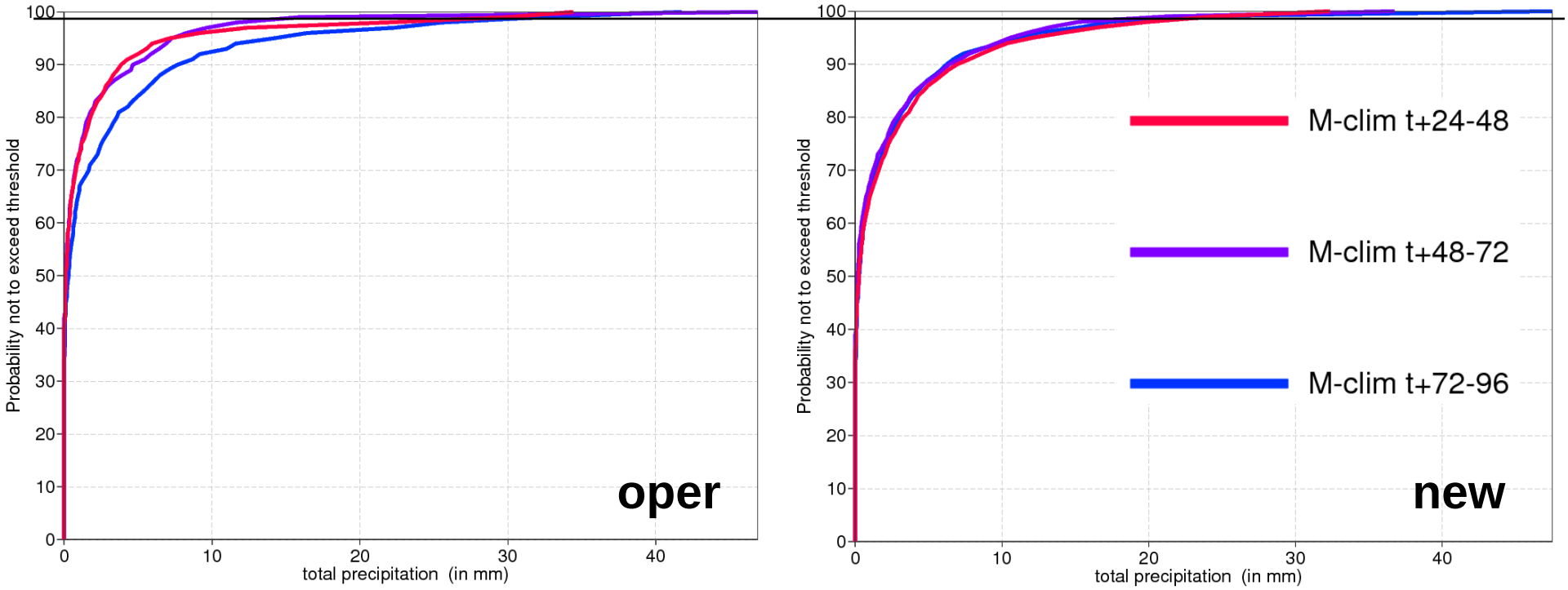


EFI Model climate

- **NOW: Operational M-climate:**
  - **5-member ensemble with model version in operations, re-forecasts 20 years back**
  - **Once a week – every Thursday**
  - **5 re-forecast runs centred on the week of interest (5 weeks in total)**
  - **Sample size: 500 values (5 members X 20 years X 5 start dates)**
- **FUTURE: New M-climate:**
  - **11-member ensemble, 20 years**
  - **Twice a week – every Monday and Thursday**
  - **9 re-forecast runs centred on the week of interest (5 weeks in total)**
  - **Sample size: 1980 values (11 members X 20 years X 9 start dates)**

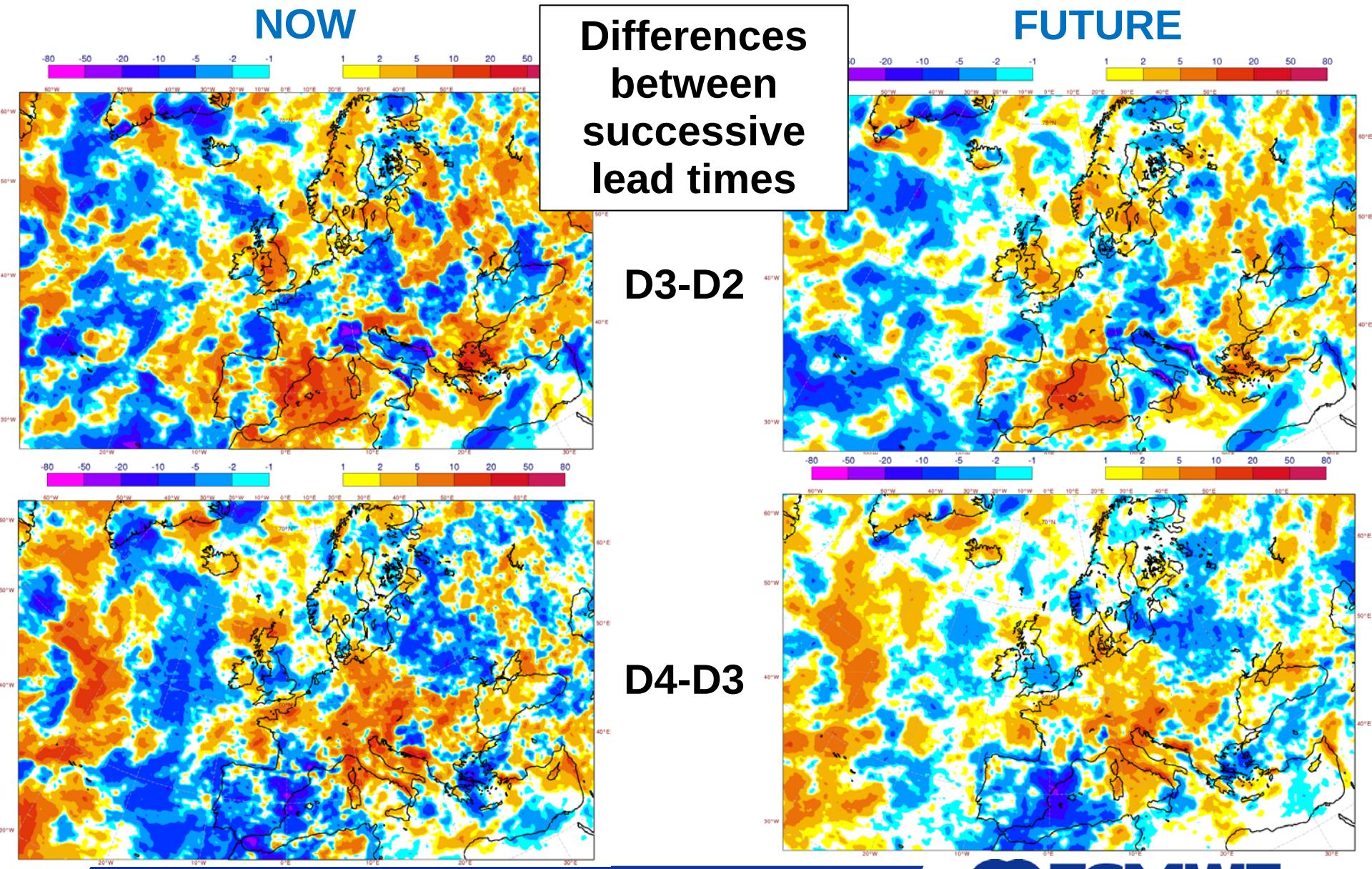
CDFs, M-climate, total precipitation, example at one location:

Lat: 48.2, Lon: 18.0



- **Less noisy tails with the new M-climate**

Total 1-day precipitation, M-climate 99th percentile, Europe



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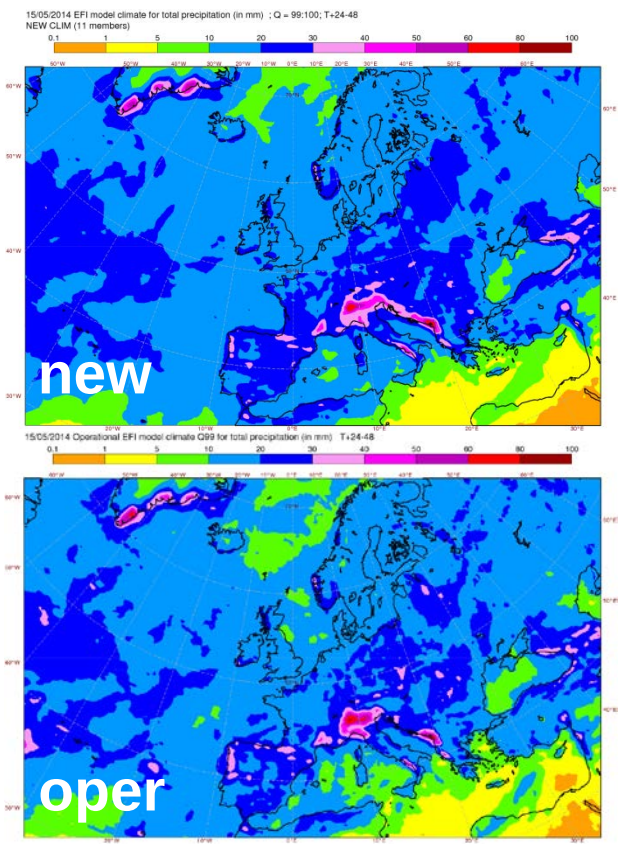
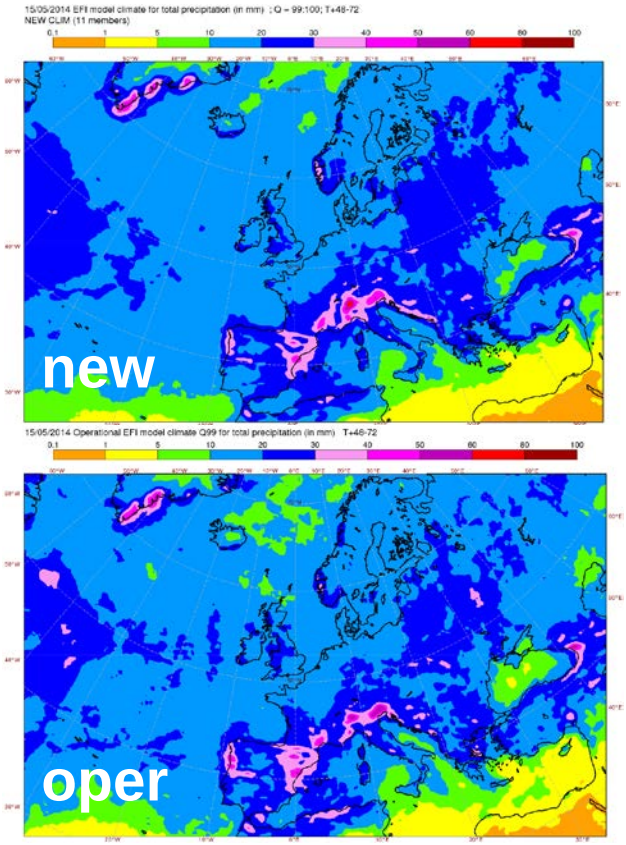
Total precipitation, M-climate 99th percentile, Europe

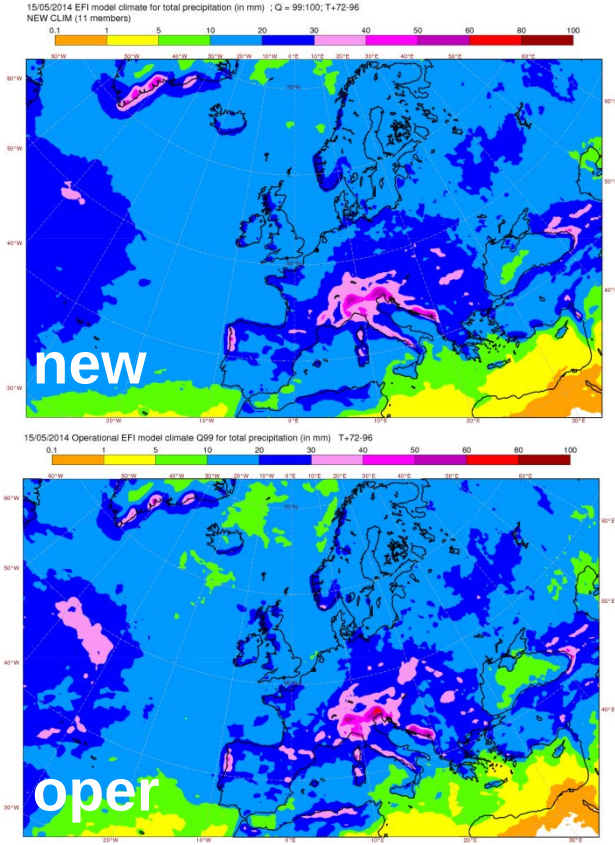
D2 (T+24-48h)

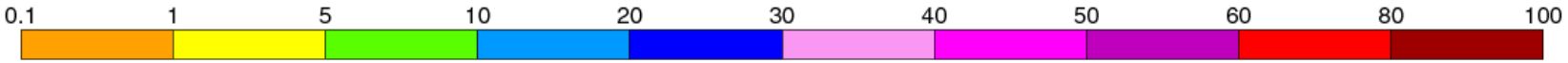


D3 (T+48-72h)



D4 (T+72-96h)





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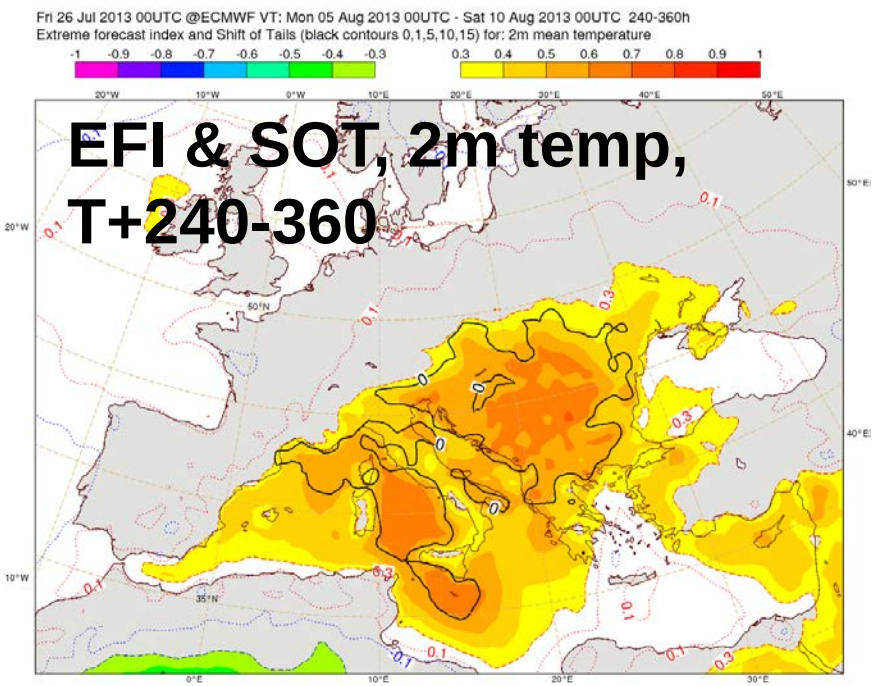
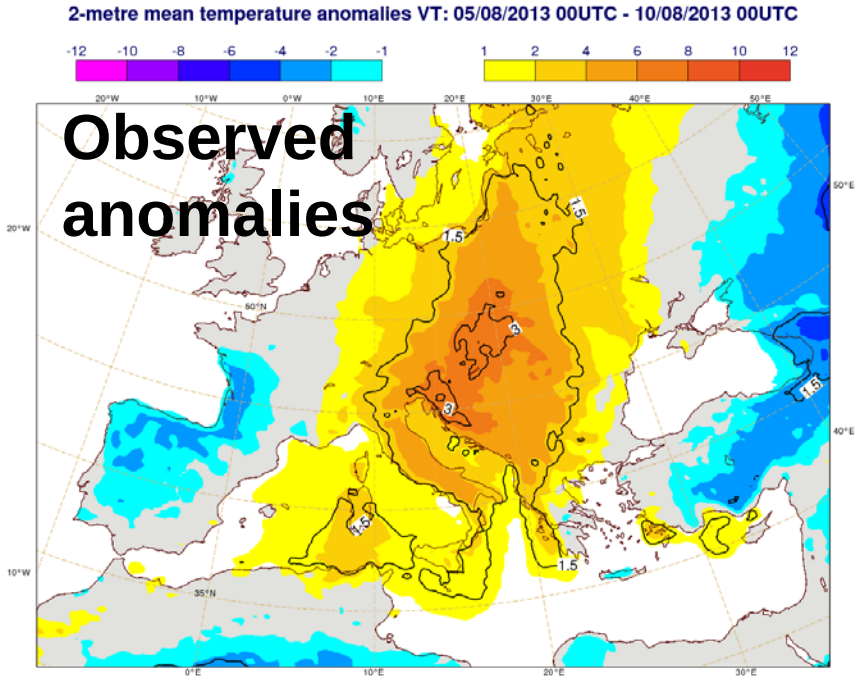
Second Aim

- **To extend EFI-related guidance beyond day 10**
- **Potential to provide pointers to potential severe weather even further in advance**
- **Often the signals are very small at these ranges, but not always…**
- **Generally we need to use lower thresholds for shading/contouring (for EFI, but not for SOT)**
- **Examples follow..**

EFI & SOT for temperature, T+240-360h



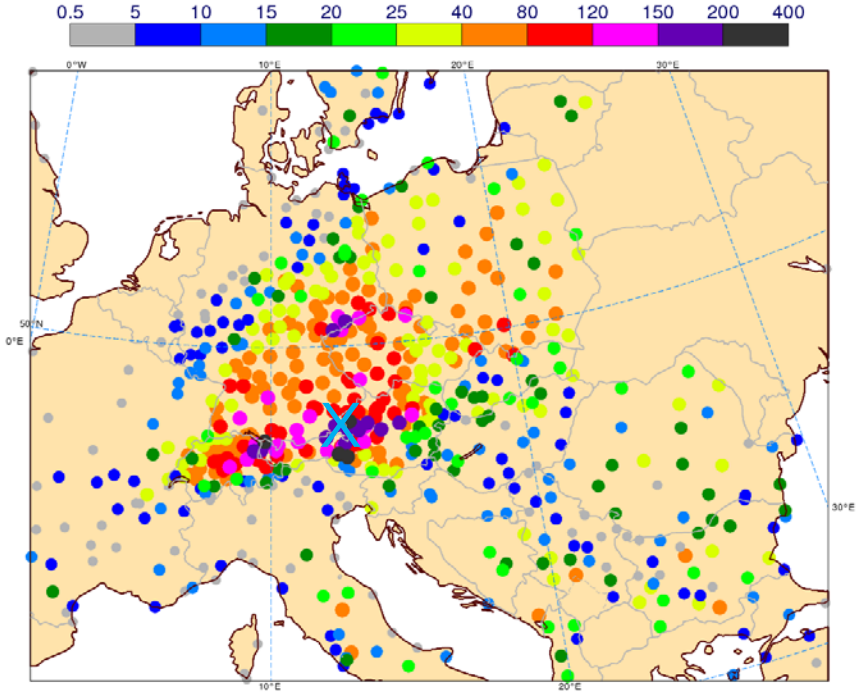


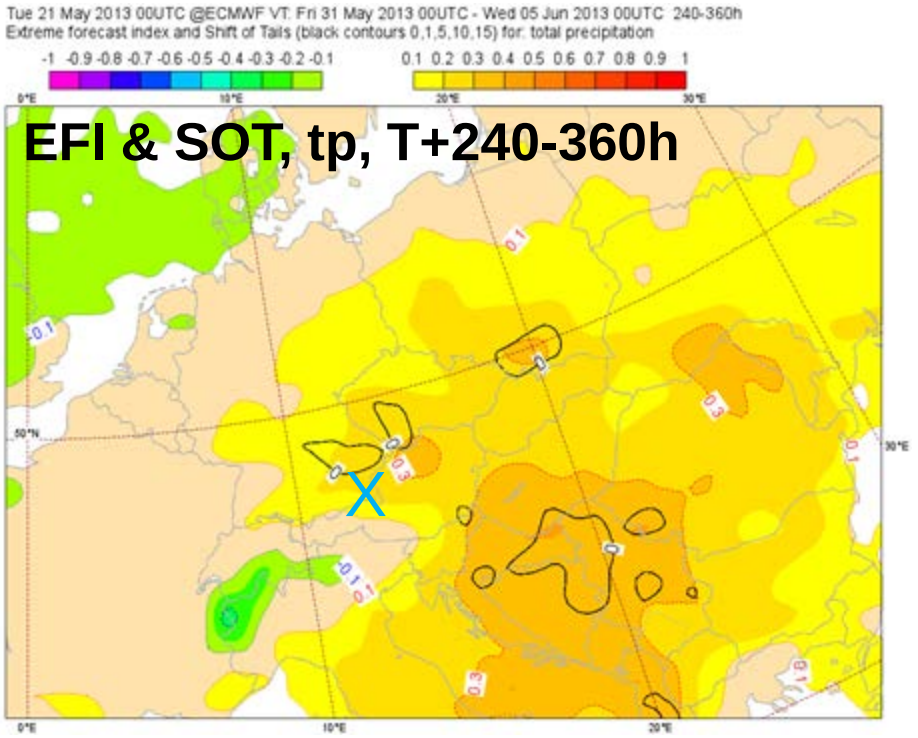
- **A heatwave affected many countries from the Mediterranean northwards to Scandinavia in early August 2013. Austria set a new high temperature record when temperatures in two locations in eastern Austria exceeded 40°C on 8th August.**
- **EFI gave an early signal of the likelihood of exceptionally hot weather .**

EFI & SOT for total precipitation, T+240-360h

Observed total rainfall

from 31/05/2013 00UTC to 05/06/2013 00UTC





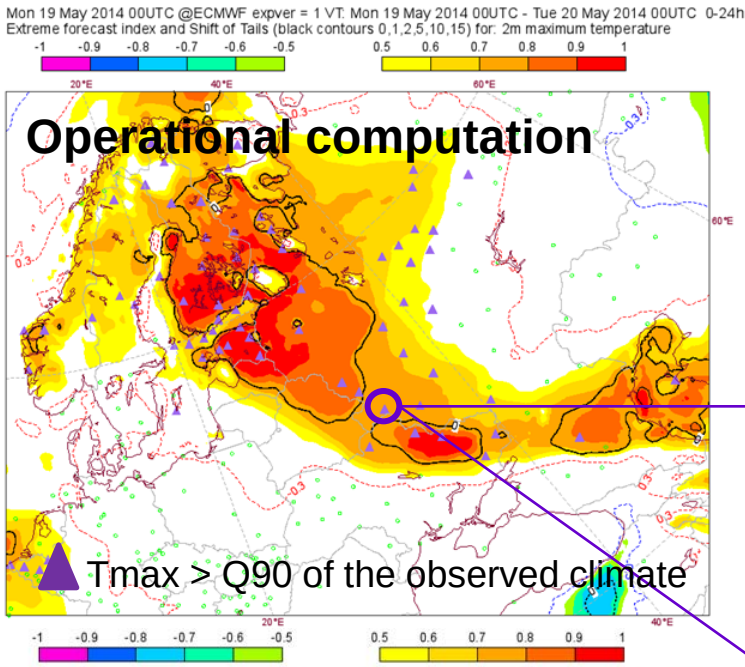
- **Several days of heavy rain led to severe flooding in Central Europe at the end of May and beginning of June 2013.**
- **An early signal of extreme precipitation appeared in the EFI and SOT forecast for T+240-360 lead time.**

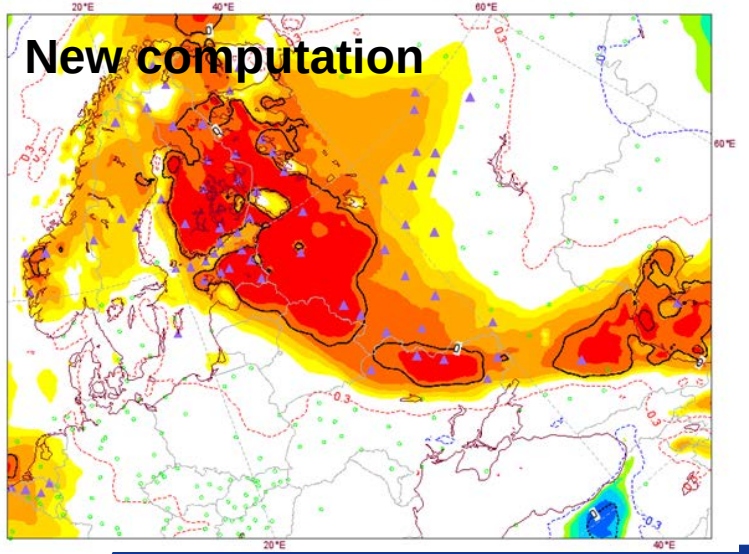
Third Aim

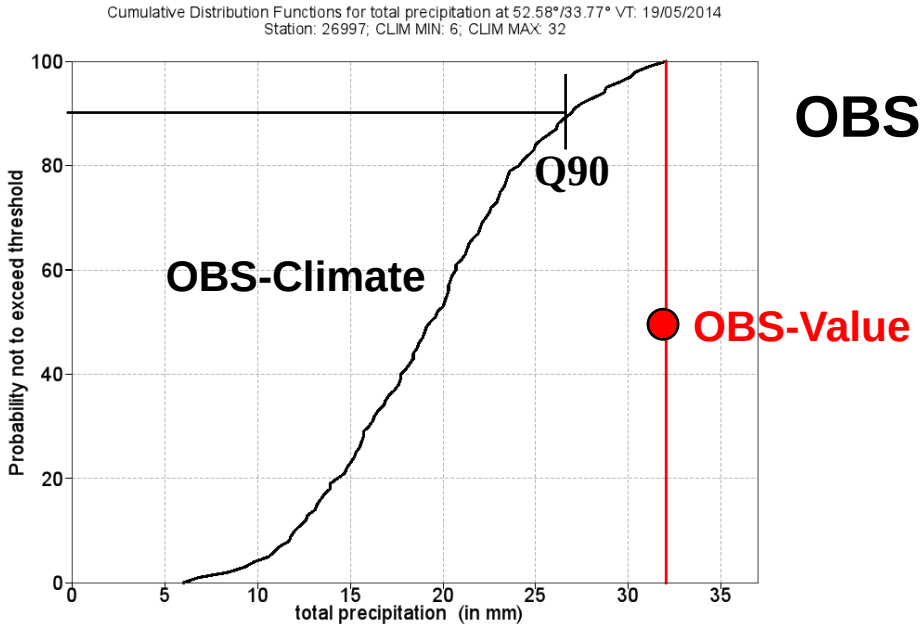
- **Improve integrity of computations**
  - **(1) Dispense with using M-climate over periods from 12UTC to 12UTC (can cause EFI jumpiness in e.g. maximum temperature due to double counting, particularly around 40°E)**
  - **(2) Better mathematical treatment of the EFI integral**
- **Illustrate (2) with a recent heatwave example…**
- **Impact on verification scores needs to be tested**

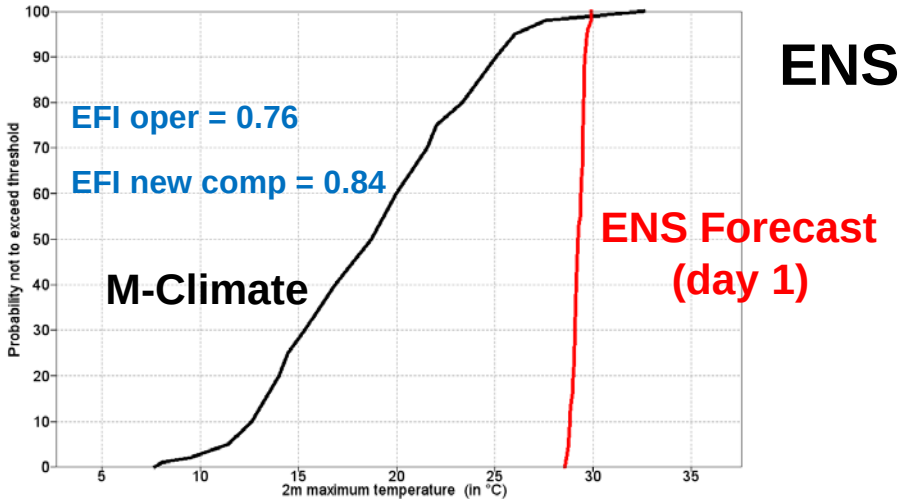
Thanks to
Michail Diamantakis

New computation for the EFI









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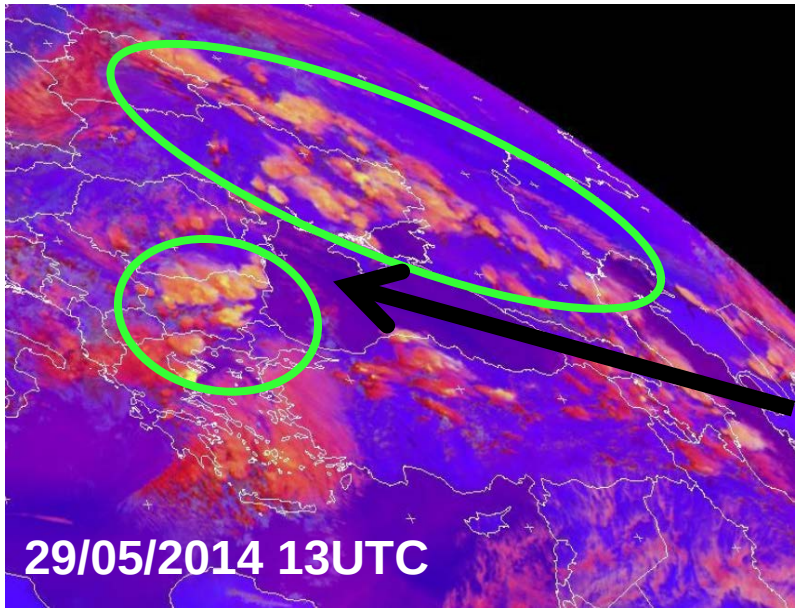
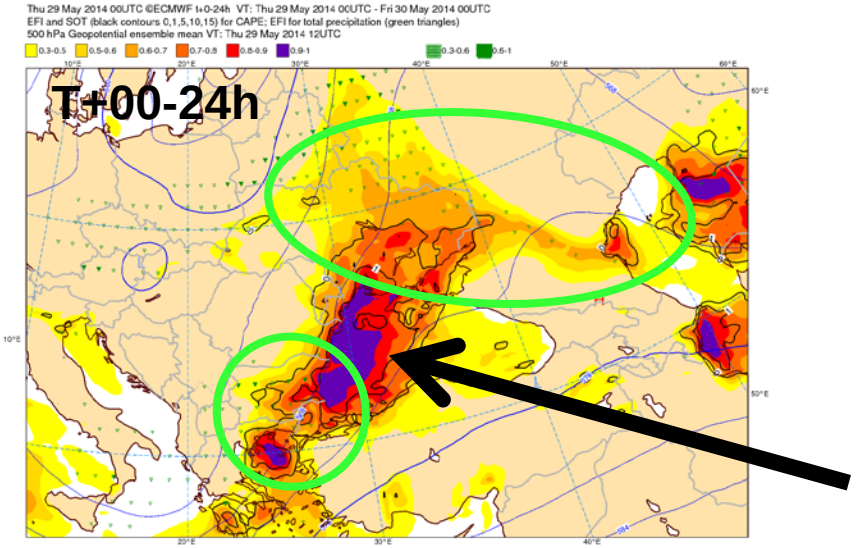
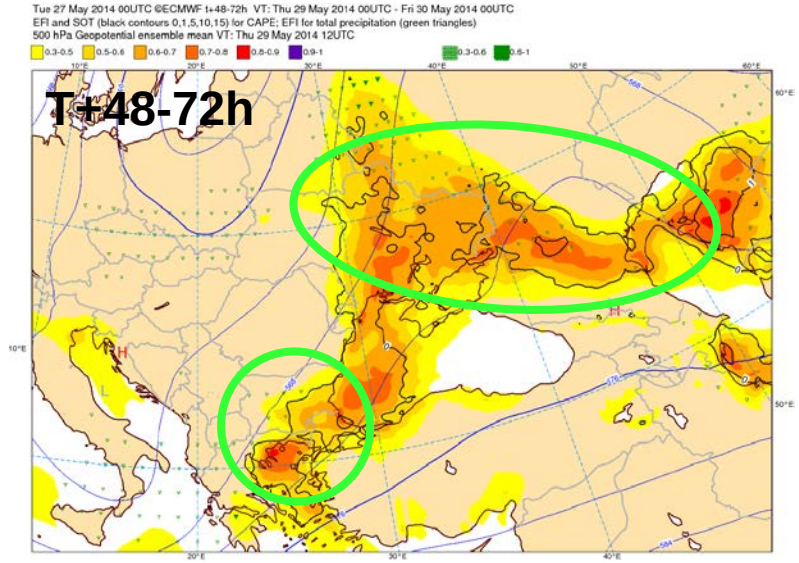
Fourth Aim

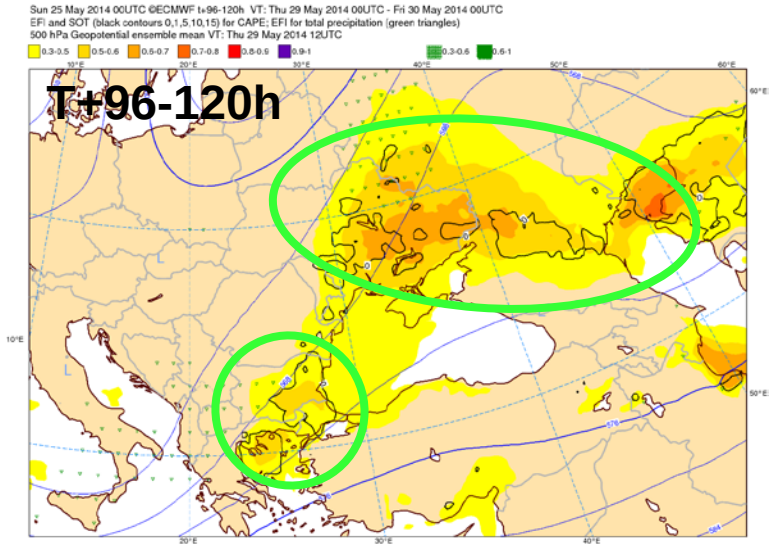
- **Introduce new variables, following user requests, to assist with predicting hazards related to vigorous convection**
- **EFI and SOT for CAPE**
- **Note that as with all EFI-type parameters this gives only a relative measure of the potential severity of any convective activity (for a given location at a given time of year).**
- **Caution is required to not "over interpret" – more so than with other EFI parameters.**

Severe convection, 29/05/2014, CAPE EFI/SOT









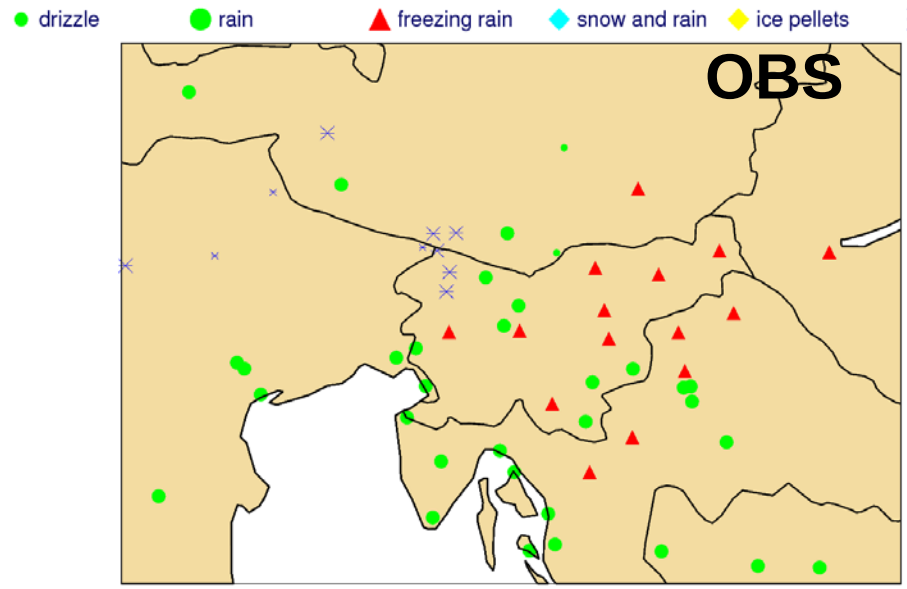
2. Diagnosis of Freezing Rain

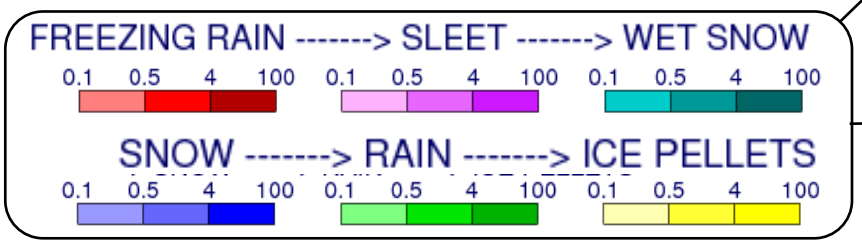
Freezing rain, Slovenia, beginning of Feb 2014

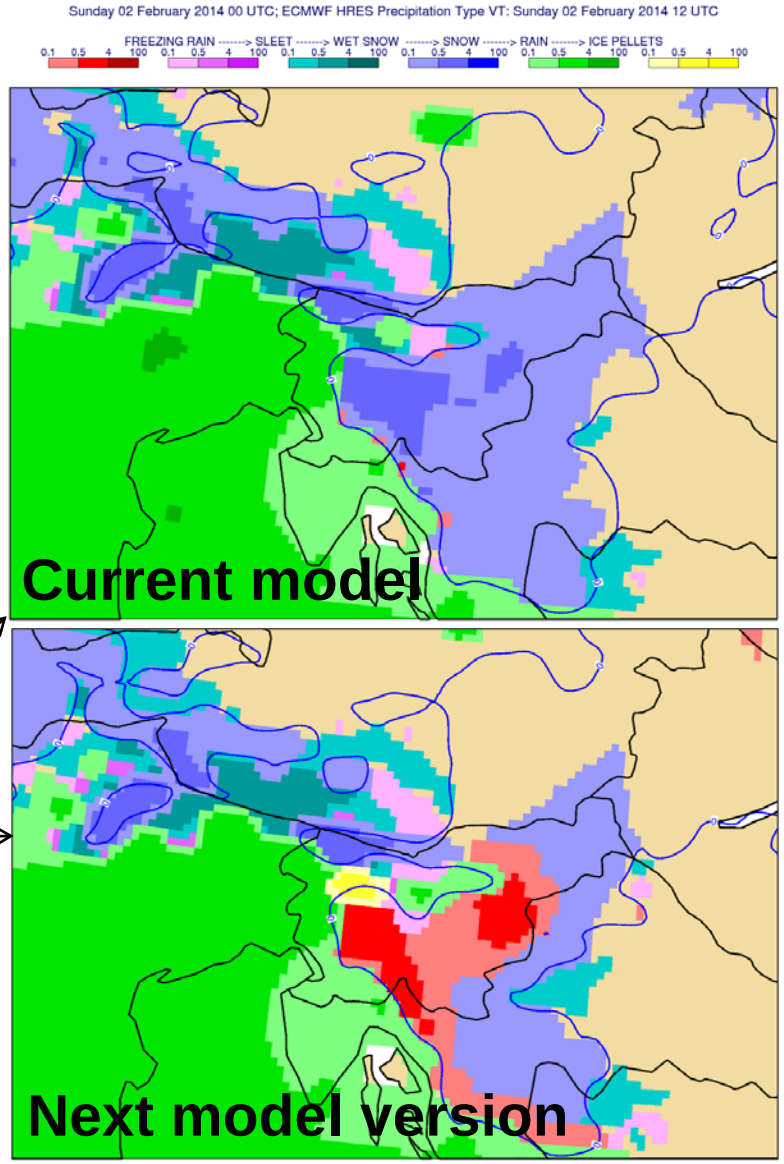
Photos are from Postojna, SW Slovenia on 3rd February 2014

- **An ice storm damaged forests and power lines in Slovenia at the beginning of February 2014.**
- **The Slovenian government said that more than 40% of the Alpine forests had been damaged.**
- **One in four homes in Slovenia left without electricity.**

2nd Feb 2014 12UTC







Two related ECMWF developments:

- **New precip type/rate diagnosis/diagnostics**
- **Model physics changes to markedly slow down the re-freezing of melted precipitation**

- **Next – ENS freezing rain probability…**

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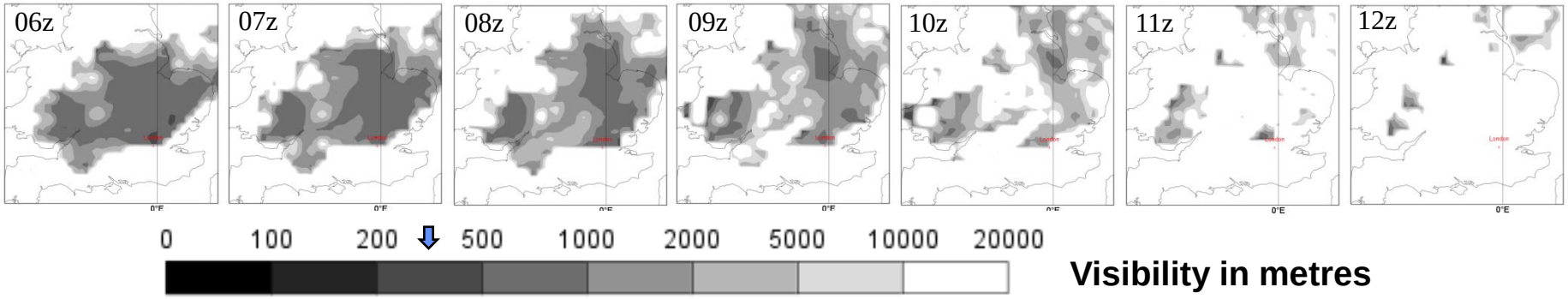
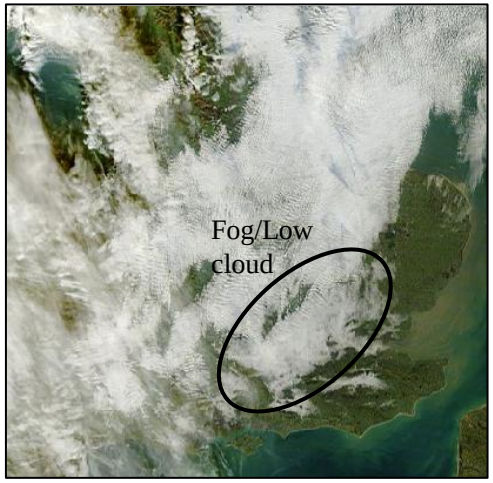
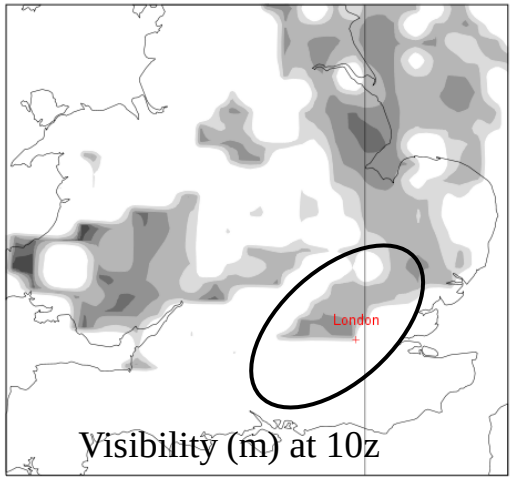
3. New Diagnostics

Visibility/Fog - Case study: UK 11 Dec 2013, HRES 12 hour forecast

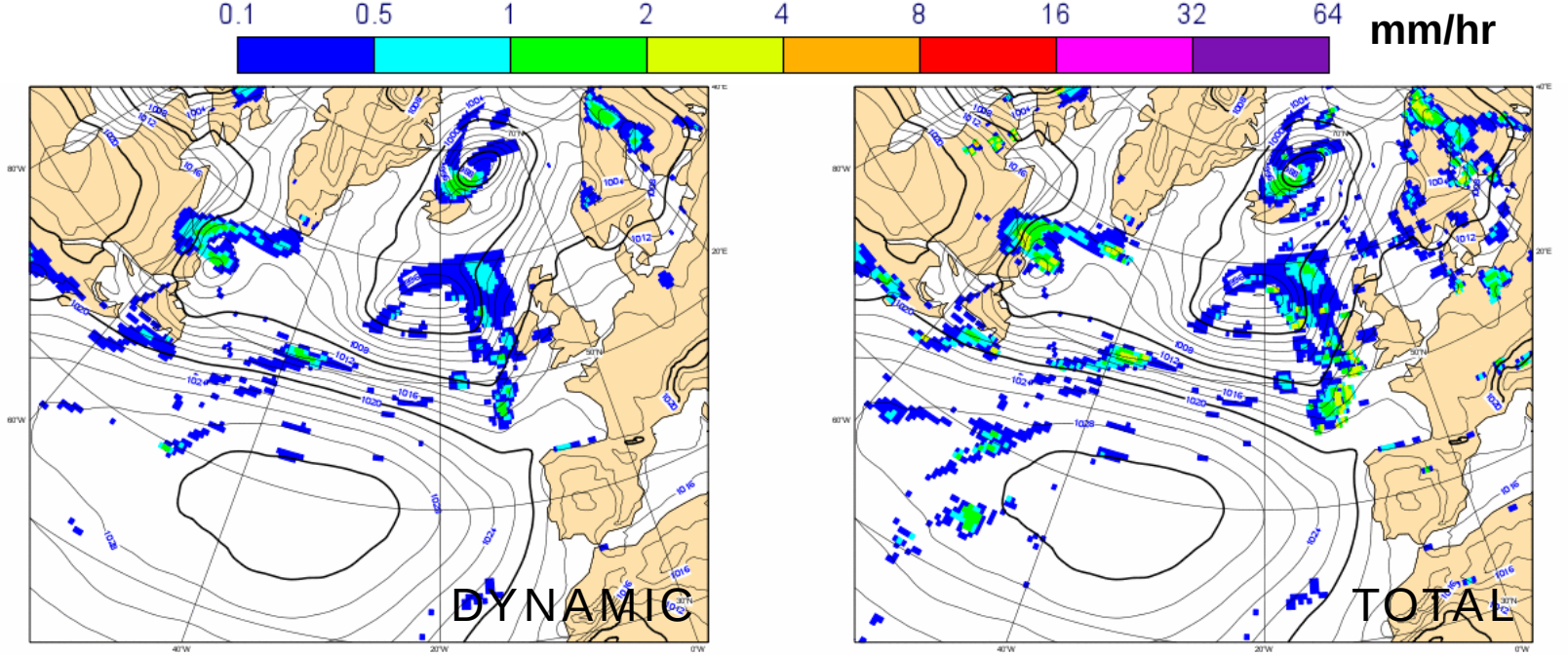


MODIS visible at ~10z



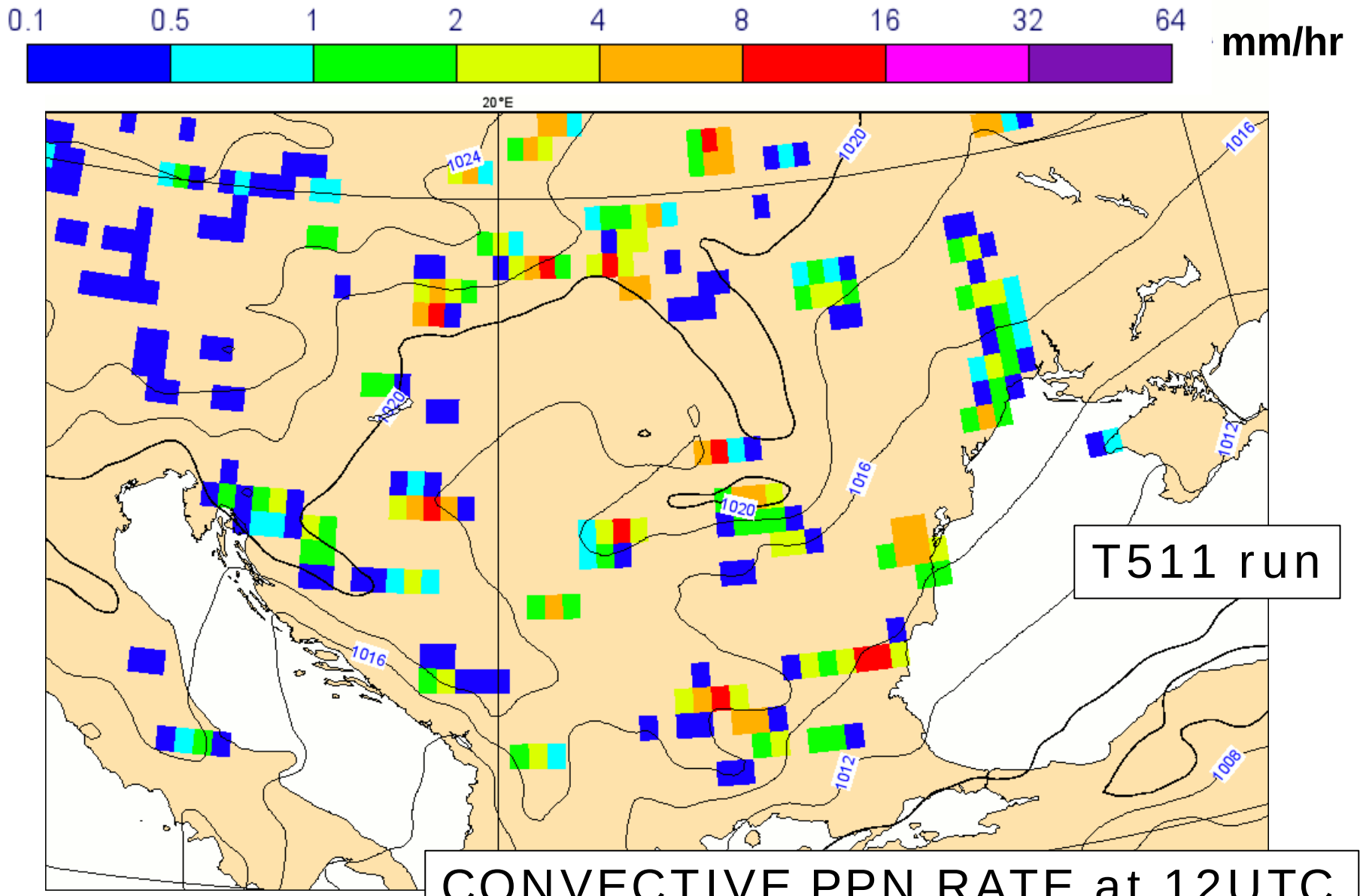


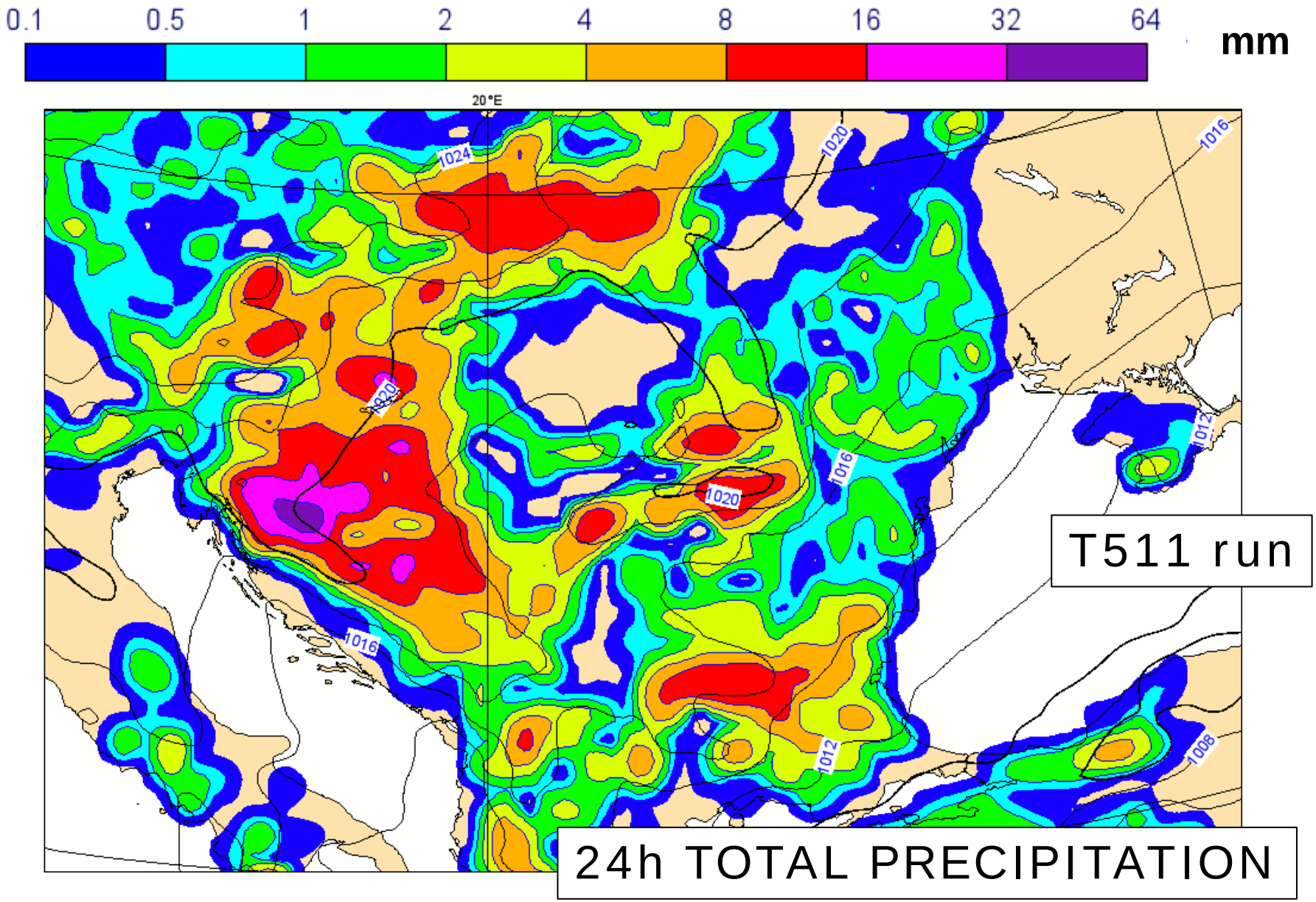
- Visibility is a new diagnostic for the next model version (primarily for fog/precip)
- For this case, observed fog in London (+elsewhere) overnight.
- IFS gives indication of low visibilities in generally the right area, and dissipates fog through the morning.
- Diagnostic most useful in probabilistic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



Precipitation rates

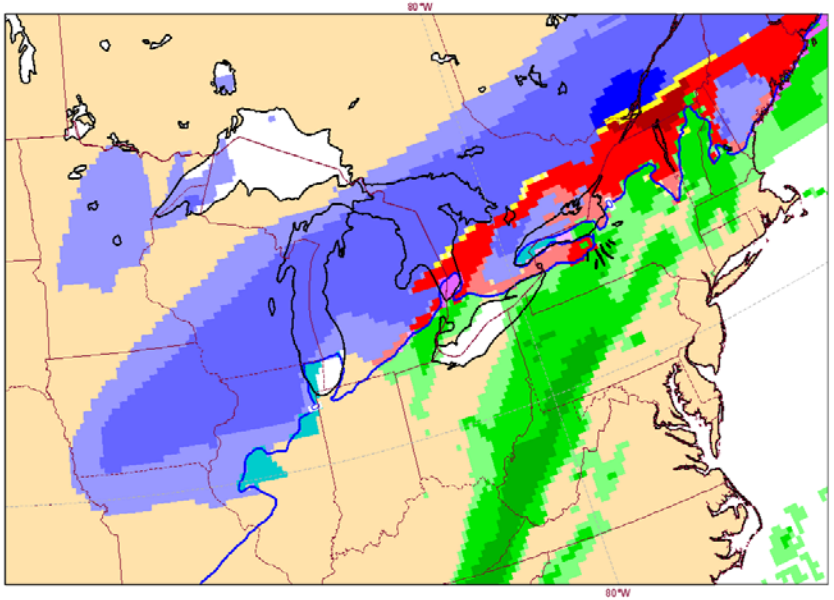
- Example run (at T511) from July 2013
- Output looks sensible
- For dynamic ppn that should be a given, for convective there could have been issues
- Maximum convective rate in this domain = 8-16mm/hr

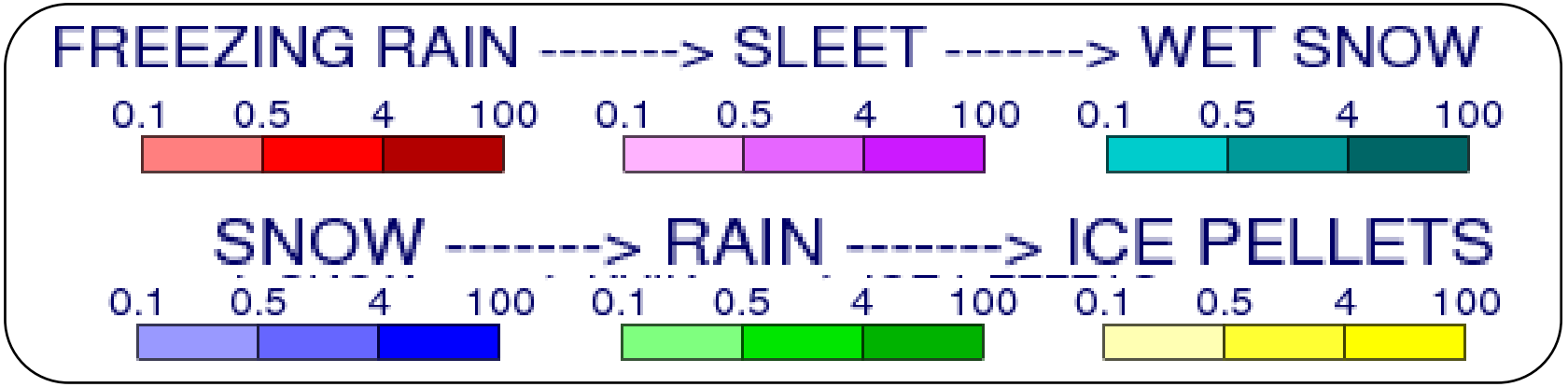

0.1
0.5
1
2
4
8
16
32
64
mm/hr
20°E
1024
1020
1016
1012
1008
T511 run
CONVECTIVE PPN RATE at 12UTC


0.1
0.5
1
2
4
8
16
32
64
mm
20°E
1024
1020
1016
1012
1008
T511 run
24h TOTAL PRECIPITATION

Precipitation Type

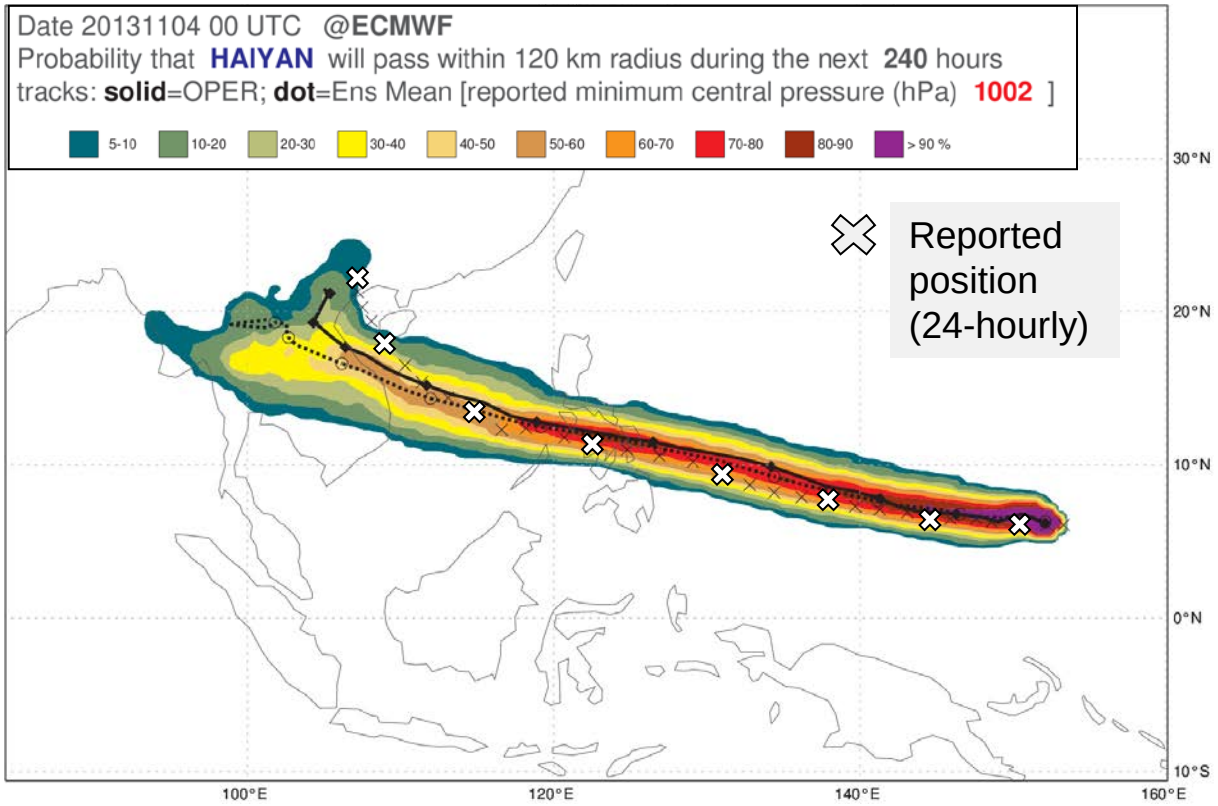
- As already illustrated…
- Plot to right shows Dec 2013 Toronto case





4. Tropical cyclone tracks

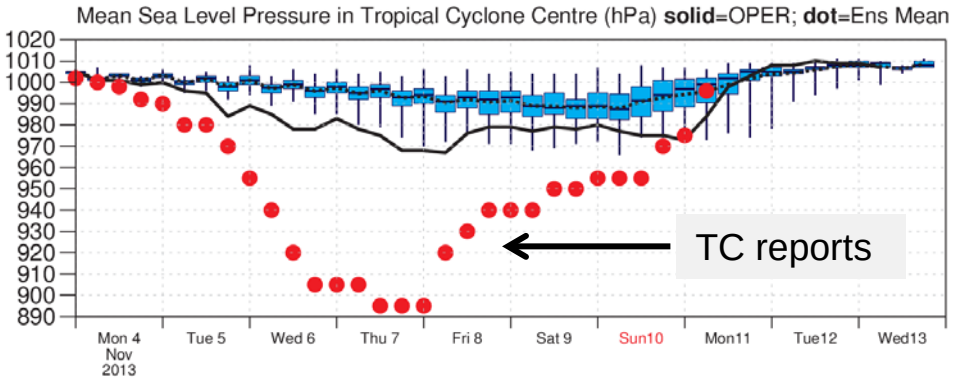
SUPER-TYPHOON HAIYAN, NOVEMBER 2013



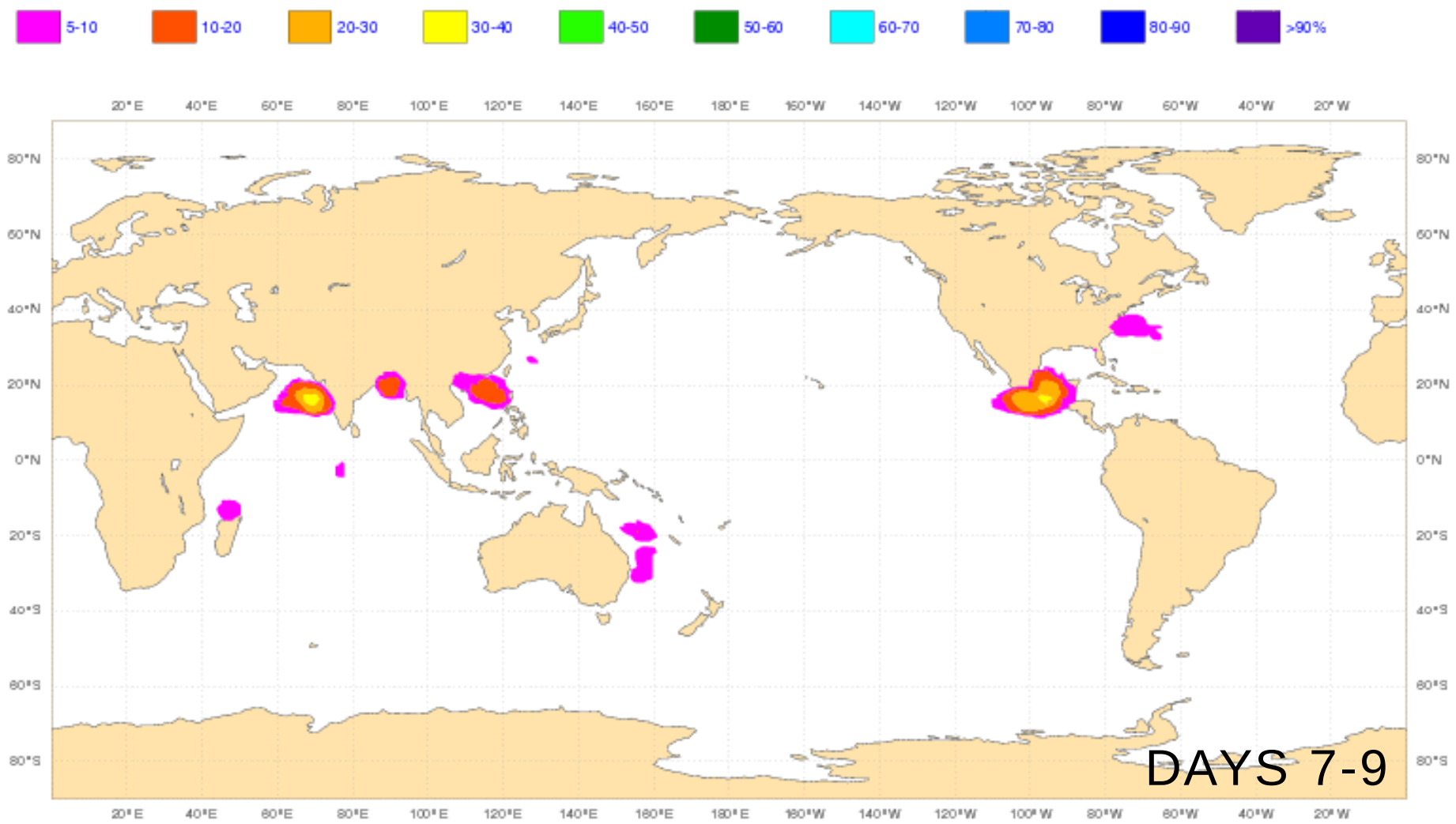
A new tracking algorithm for tropical cyclones was implemented on 1st December 2013.

The new TC tracks are produced for forecasts up to 240 hours (previously to 120 hours), or until the tropical cyclone dissipates if earlier.

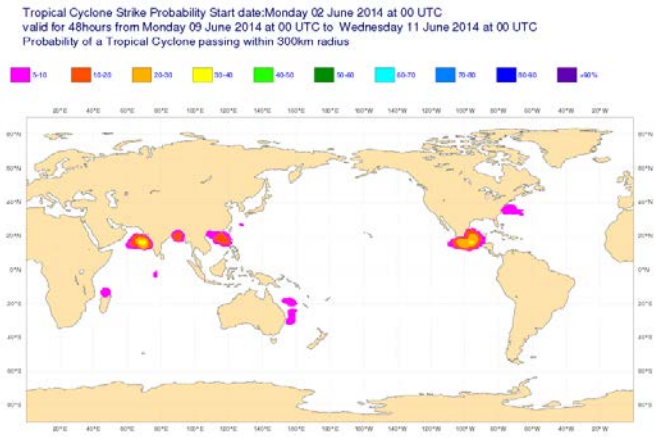
The tracker software is also now applied to forecast output every 6 hours (previously it was every 12h)



Tropical Cyclone Strike Probability Start date:Monday 02 June 2014 at 00 UTC
valid for 48hours from Monday 09 June 2014 at 00 UTC to Wednesday 11 June 2014 at 00 UTC
Probability of a Tropical Cyclone passing within 300km radius



TC tracks to BUFR format



- **Are/will be disseminated in BUFR edition 4 (BUFR-4) format for ENS & HRES**
- **BUFR-4 tracks of tropical cyclones (TCs) for which there are bulletins at analysis time already implemented in this format (1 Dec 2013 change) ("tracks of known TCs")**
- **BUFR-4 tracks of TCs which develop in forecasts (up to 10 days ahead) will be implemented operationally in due course ("genesis tracks") – a training dataset for this will be made available in advance.**
- **For genesis tracks an ID number (90, 91, 92,…) is assigned to each new TC feature together with a letter to identify the basin: 'E'-Eastern Pacific; 'W'-Western Pacific; 'L'-North Atlantic; 'S'-South Indian Ocean, etc. (making eg "90E")**
- **TCs with the same ID in different ENS members *are not necessarily related* (in space and time). We will not post-process to try to cross-reference new TCs between ENS members; users may choose to do this themselves.**

BUFR-4 metadata = file header

"Tracks of known TCs"

3 | Data | Data, bitmaps expanded

Name	Value	Units
IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	9.8E1	COMMONCODETABLEC-1
IDENTIFICATION OF ORIGINATING/GENERATING SUB-CENTRE	**	COMMONCODETABLEC-12
GENERATING APPLICATION	1.0E0	CODETABLEDEFINEDBYORIGI
STORM IDENTIFIER	1.003E3	CCITTIA5 (01E) 1
WMO LONG STORM NAME	5.301E4	CCITTIA5 (AMANDA) 1
TECHNIQUE FOR MAKING UP INITIAL PERTURBATIONS	2.0E0	CODE TABLE 1090
ENSEMBLE MEMBER NUMBER	1.0E0	NUMERIC
TYPE OF ENSEMBLE FORECAST	**	CODE TABLE 1092
YEAR	2014	A
MONTH	5	MON
DAY	28	D
HOUR	0	H
MINUTE	0	MIN
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	1.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	14.5	DEG 2
LONGITUDE (COARSE ACCURACY)	-112.9	DEG 2
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	4.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	14.7	DEG
LONGITUDE (COARSE ACCURACY)	-112.8	DEG
PRESSURE REDUCED TO MEAN SEA LEVEL	9.92E4	PA
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	3.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	14.1	DEG
LONGITUDE (COARSE ACCURACY)	-112.8	DEG
WIND SPEED AT 10 M	2.11E1	M/S

1- TC ID and NAME (e.g. 01E AMANDA)

2- Reported position

"Genesis Tracks"

3 | Data | Data, bitmaps expanded

Name	Value	Units
IDENTIFICATION OF ORIGINATING/GENERATING CENTRE	9.8E1	COMMONCODETABLEC-1
IDENTIFICATION OF ORIGINATING/GENERATING SUB-CENTRE	**	COMMONCODETABLEC-12
GENERATING APPLICATION	1.0E0	CODETABLEDEFINEDBYORIGI
STORM IDENTIFIER	1.003E3	CCITTIA5 (90E) 1
WMO LONG STORM NAME	5.101E4	CCITTIA5 (90E) 1
TECHNIQUE FOR MAKING UP INITIAL PERTURBATIONS	2.0E0	CODE TABLE 1090
ENSEMBLE MEMBER NUMBER	1.0E0	NUMERIC
TYPE OF ENSEMBLE FORECAST	**	CODE TABLE 1092
YEAR	2014	A
MONTH	5	MON
DAY	13	D
HOUR	12	H
MINUTE	0	MIN
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	1.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	**	DEG 2
LONGITUDE (COARSE ACCURACY)	**	DEG 2
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	4.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	8	DEG
LONGITUDE (COARSE ACCURACY)	-123	DEG
PRESSURE REDUCED TO MEAN SEA LEVEL	1.006E5	PA
METEOROLOGICAL ATTRIBUTE SIGNIFICANCE	3.0E0	CODE TABLE 8005
LATITUDE (COARSE ACCURACY)	8.5	DEG
LONGITUDE (COARSE ACCURACY)	-119.6	DEG
WIND SPEED AT 10 M	1.08E1	M/S

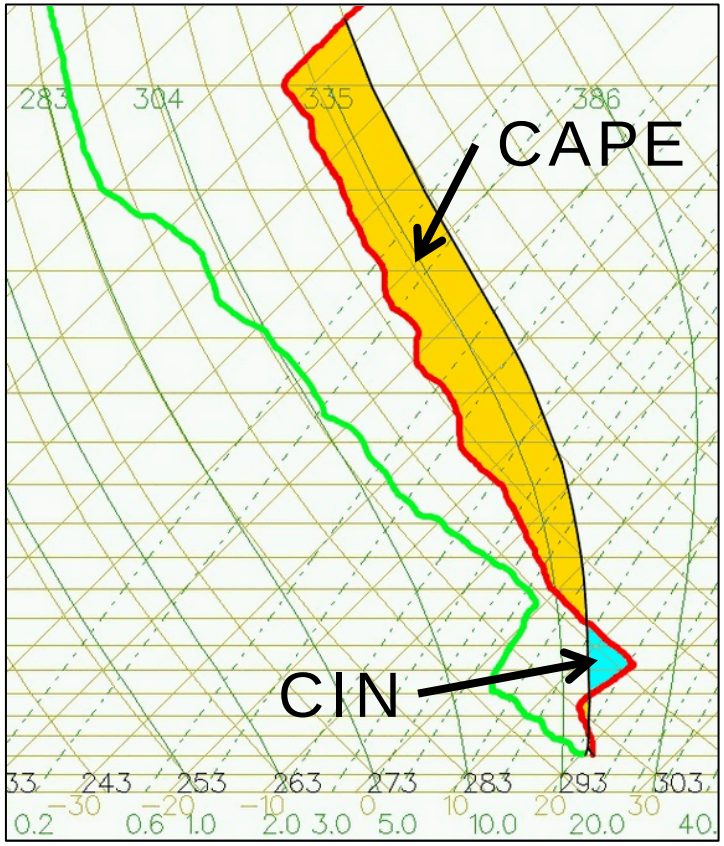
1- TC ID and NAME (e.g. 90E 90E)

2- Reported position (missing '**')

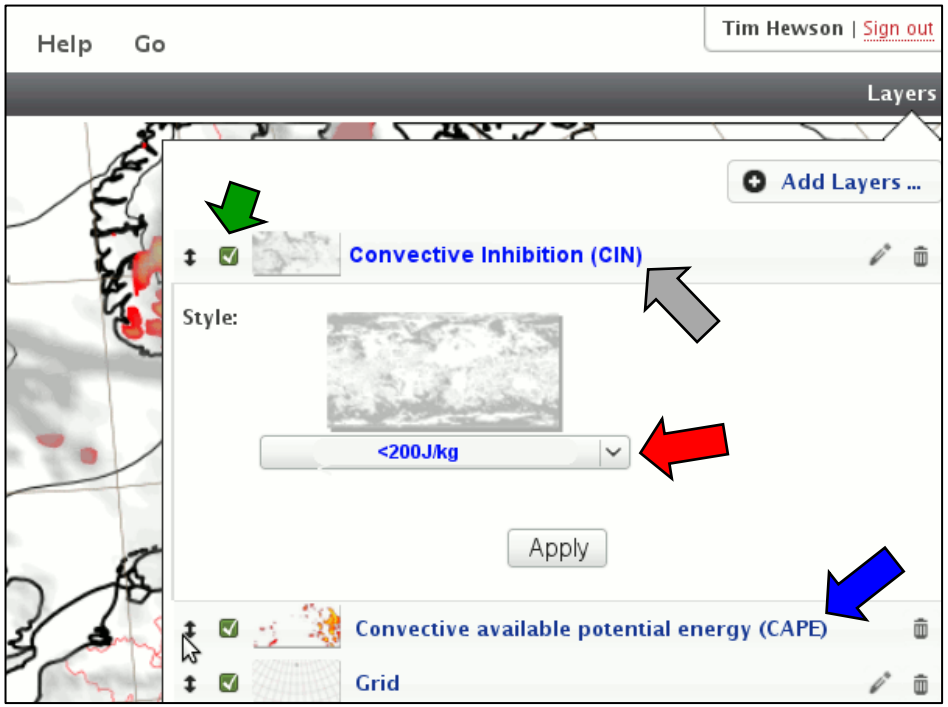
5. EcCharts - New Convective Indices

- **“CIN” = Convective Inhibition is being added**
- **“K Index” too, but not illustrated in this talk**

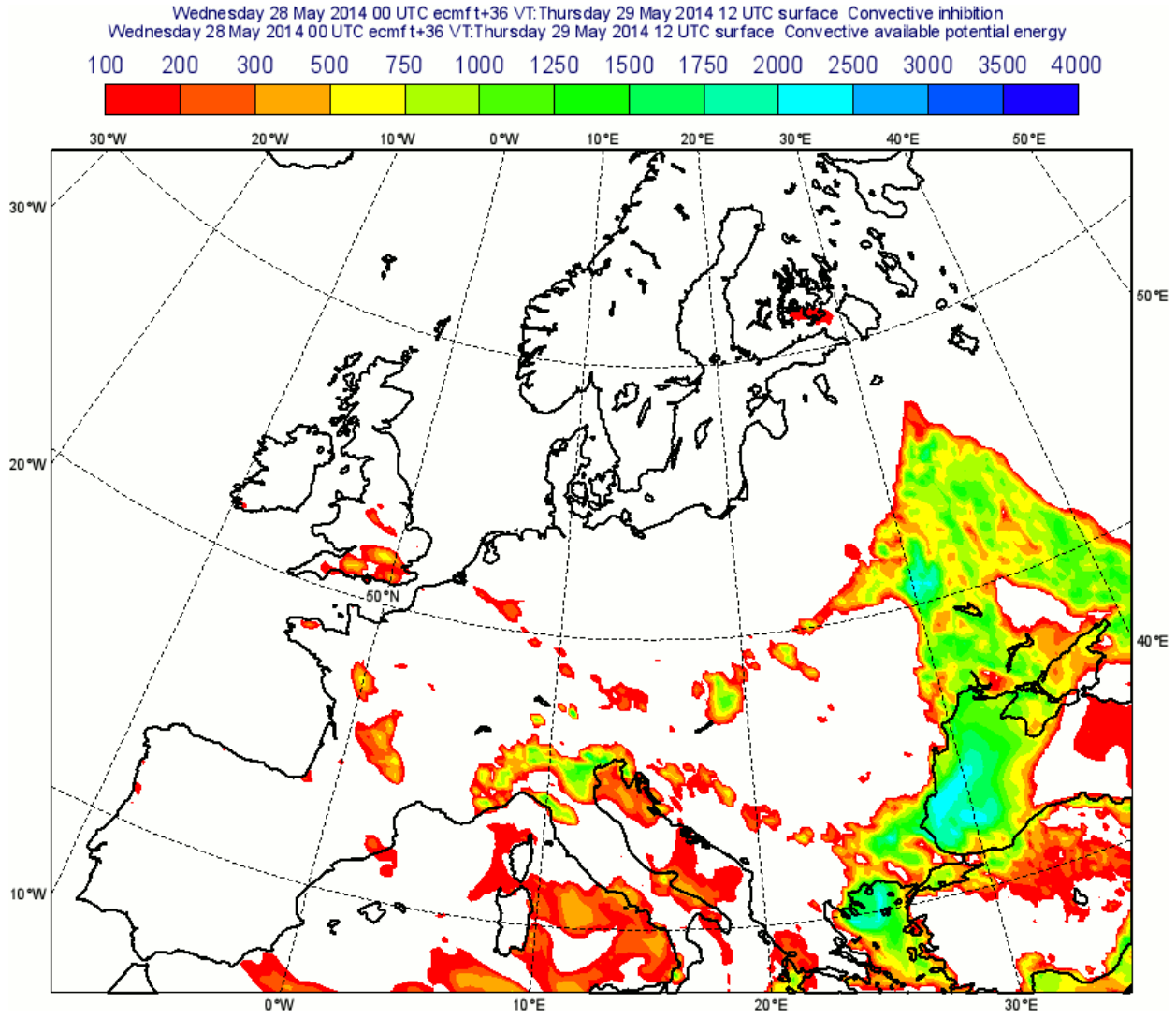
Sig convective activity usually requires **large CAPE**, & CIN < x



Use ecCharts as a “convection tool”...



CAPE + CIN (convective inhibition)



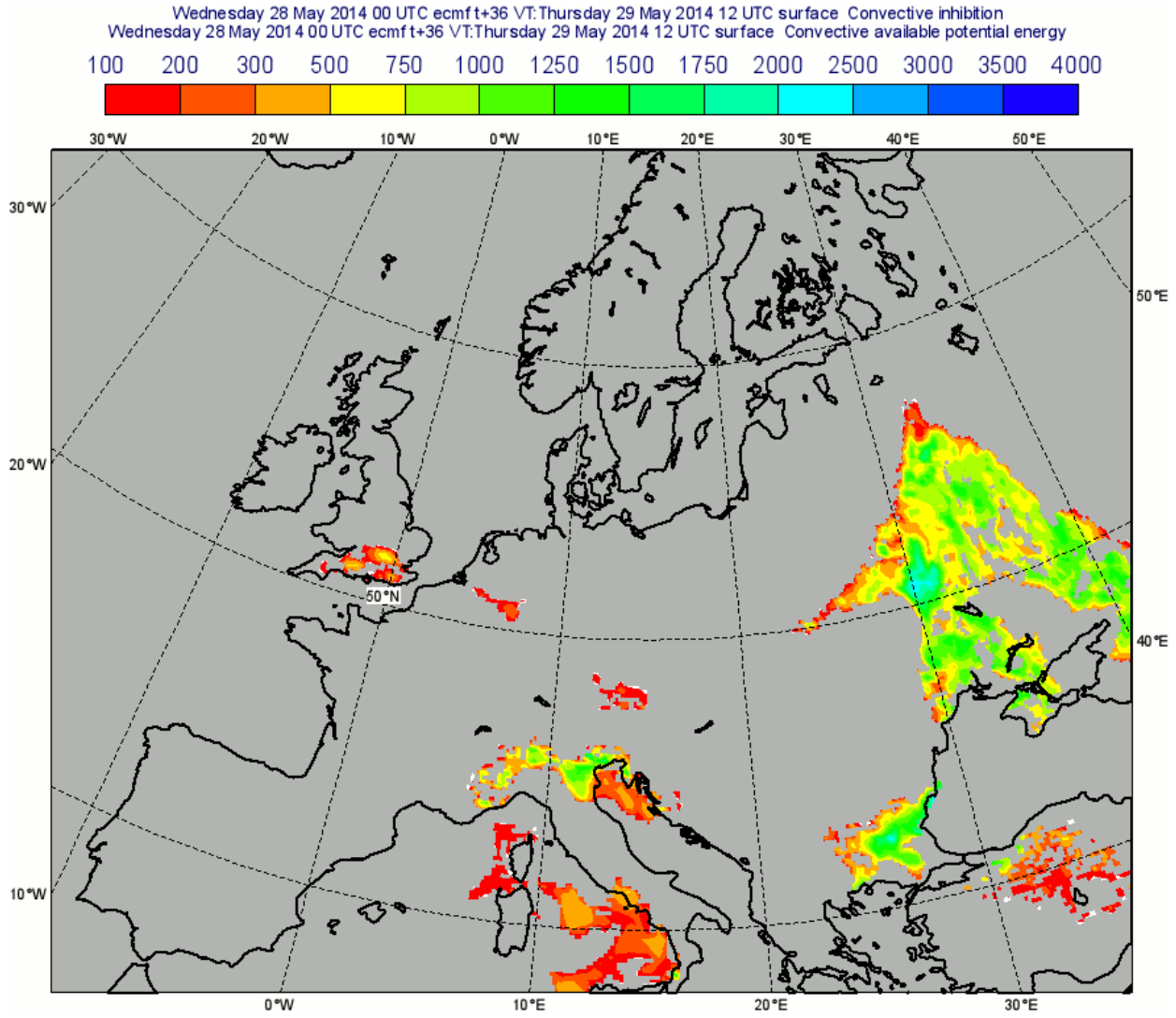
CAPE

where

CIN < ∞

ECMWF

CAPE + CIN (convective inhibition)



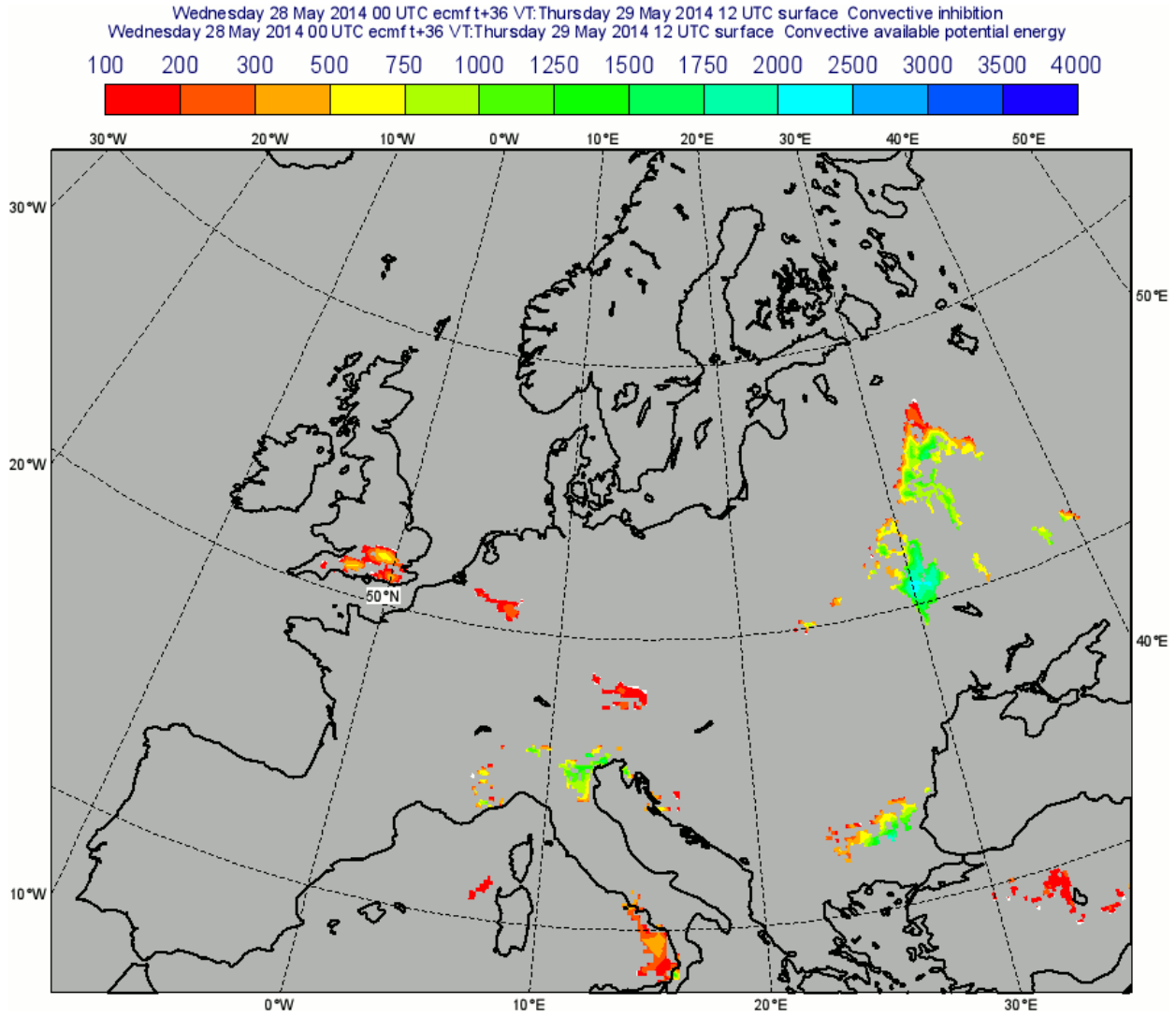
CAPE

where

CIN < 200 (J/kg)

ECMWF

CAPE + CIN (convective inhibition)



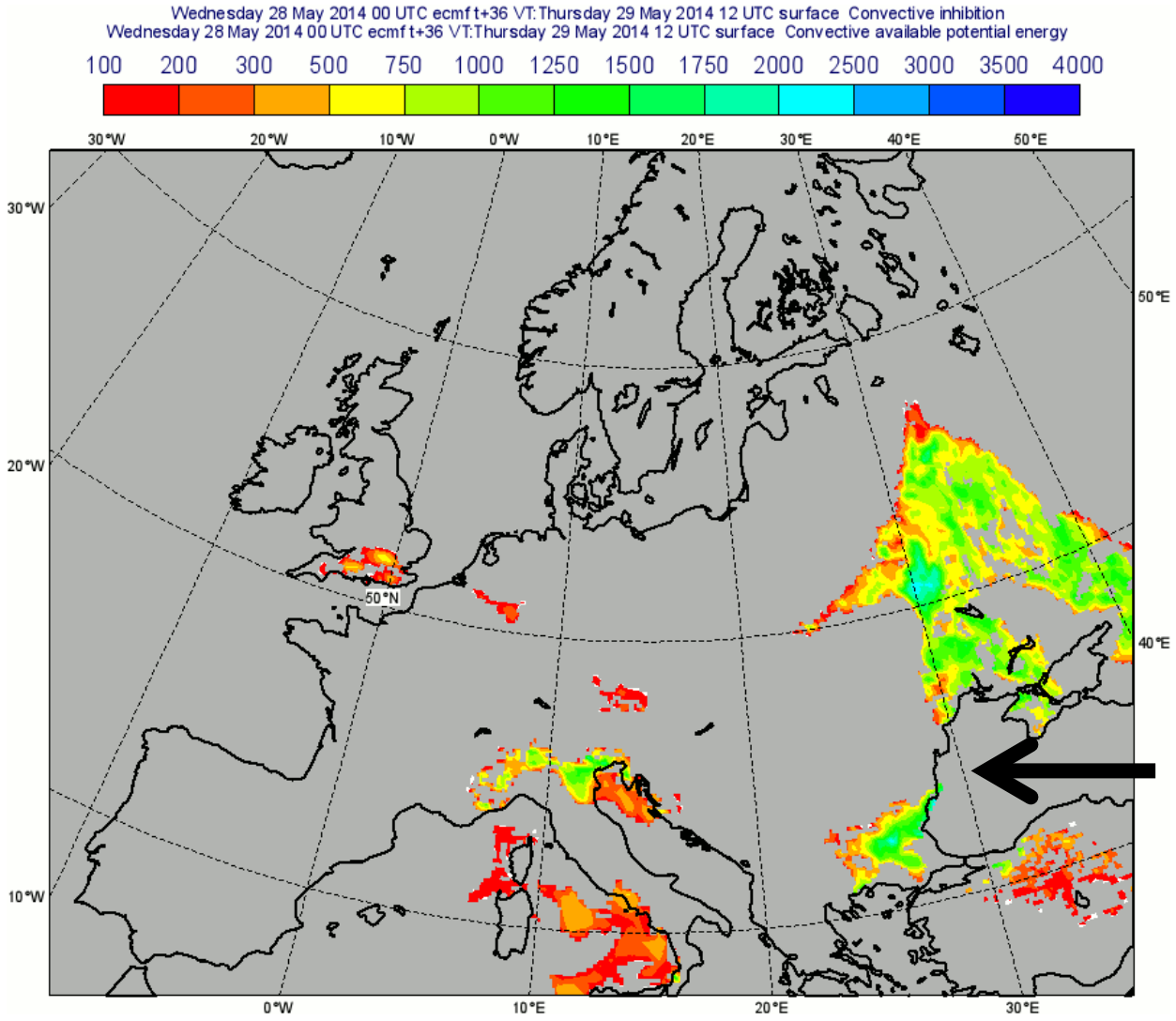
CAPE

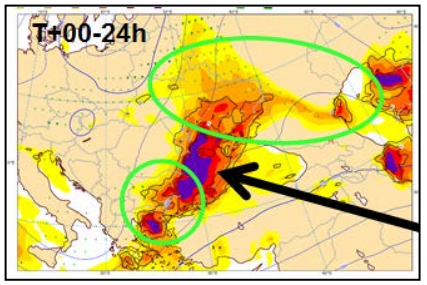
where

CIN < 50 (J/kg)

ECMWF

CAPE + CIN (convective inhibition)





In the earlier CAPE EFI example (same case) there was no convection here despite large EFI and SOT. Precluded by large CIN.

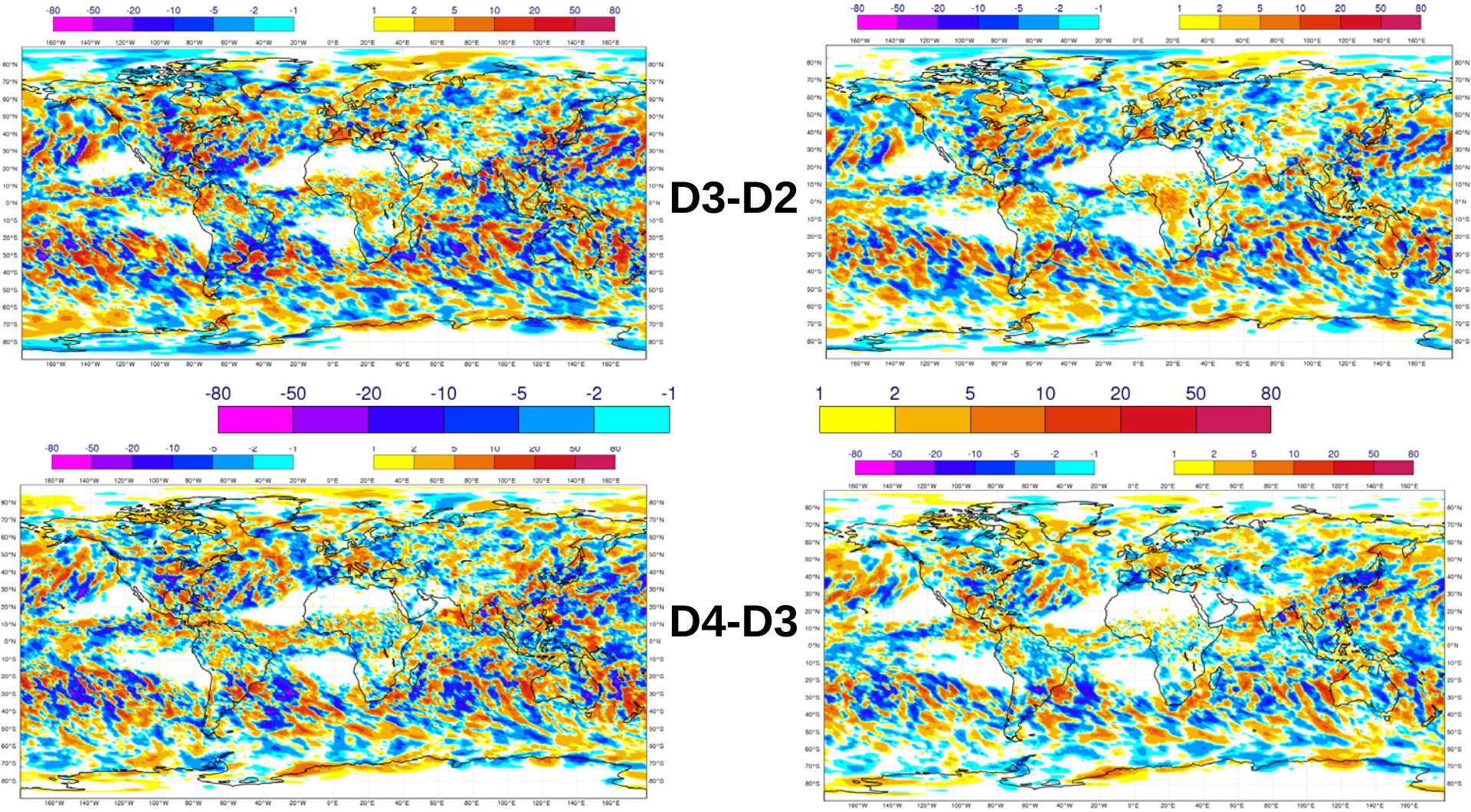
Summary = Intro!

- **1. EFI-related developments:**
  - Upgraded Model Climate (M-Climate)
  - Extended lead times
  - New method of computation
  - EFI for CAPE
- **2. Diagnosis of Freezing Rain**
  - Changes to model physics
  - Precipitation type product
- **3. New Diagnostics**
  - Visibility
  - Precipitation rate / type
- **4. Tropical cyclone tracks**
  - Extension to day 10, BUFR products for genesis events
- **5. ECcharts - New Convective Indices**

All developments to be described relate to user requests and feedback over recent years, and to ECMWF strategy in which improved prediction of severe weather is a key goal

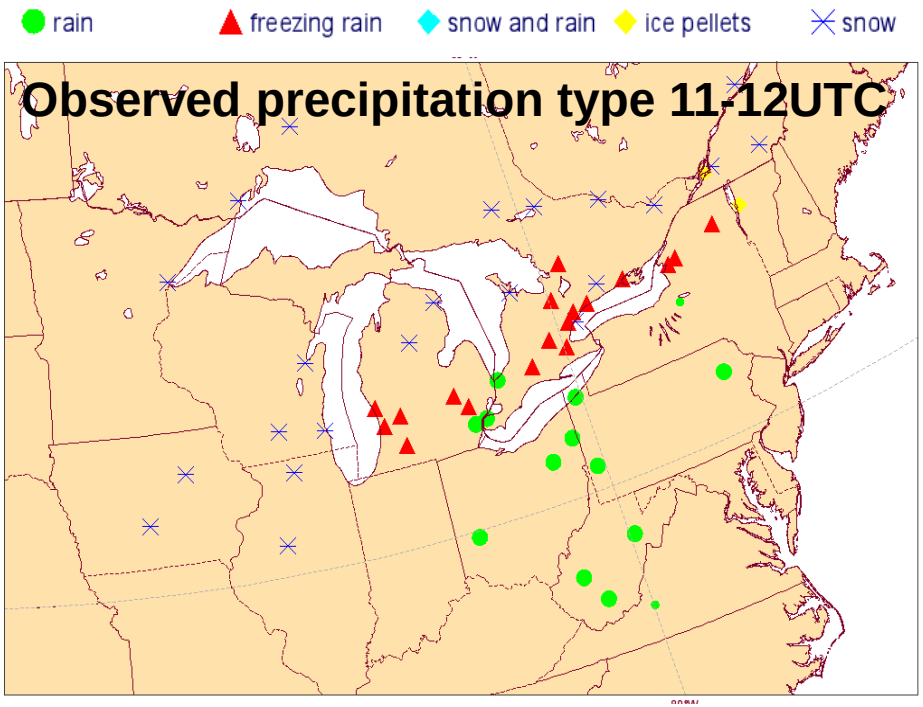
Total precipitation, 99th M-climate percentile, Globe

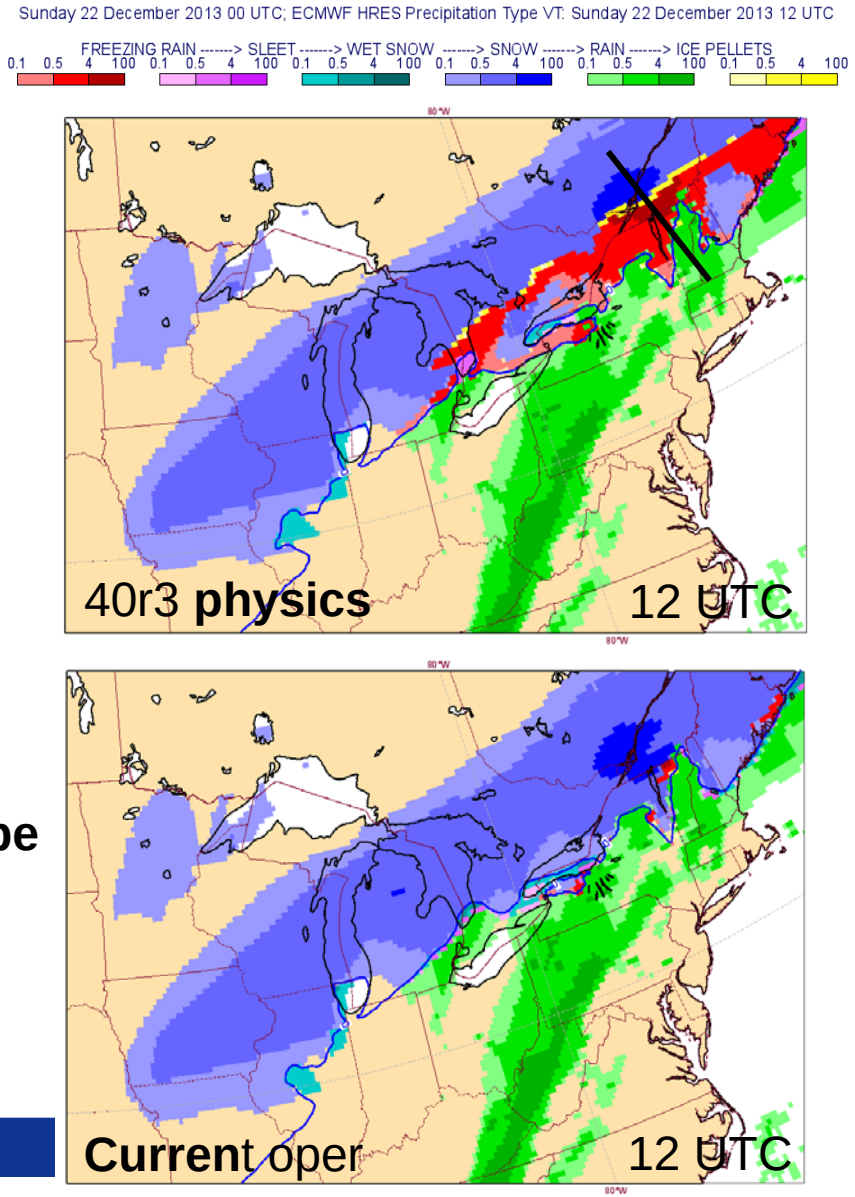
oper **Difference (in mm)** **new**



ECMWF

Prediction of Severe Weather: Freezing Rain
Case study: Toronto 22 Dec 2013





- **"Freezing rain" is supercooled rain that freezes on impact with the surface – can be a major hazard!**
- **Current operational model (40r1) has very little supercooled rain**
- **New physics for 40r3 improves prediction of "freezing" rain and diagnoses**