

Verification of extreme events in NWP

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Philippines
Nov 2013



NW Europe
Dec 2013



British Isles
Feb 2014



United States
Feb 2014



Balkans
May 2014

ECMWF 'Severe Event Catalogue'

Jun 2013	Flood	Central Europe
Aug 2013	Flood	Russia
Sep 2013	Flood	Colorado
Oct 2013	Windstorm	NW Europe
Nov 2013	Typhoon Haiyan	Philippines
Nov 2013	Extreme rainfall	Sardinia, Italy
Nov 2013	Windstorm	Scandinavia
Dec 2013	Windstorm	NW Europe
Dec 2013	Windstorm+flood	British Isles
Dec 2013	Ice storm	Canada and US
Dec 2013	Extreme snowfall	Israel
Jan 2014	Cold spell	US
Jan 2014	Extreme snowfall	Central/Southern Europe
Feb 2014	Freezing rain	Slovenia
Feb 2014	Windstorm+flood	British Isles
Feb 2014	Extreme snowfall	Eastern US
Mar 2014	Windstorm	Scandinavia
Apr 2014	Tornadoes	US Midwest
May 2014	Flood	Balkans

Verification of extreme events

- **Case studies**

Problem: biased towards events that actually happened

Problem: generalization of results

Practical approach: combine with statistical evaluations

- **Statistical evaluation**

Problem: contradiction between 'extreme' and 'statistical'

Problem: scores degenerate for rare events

Practical approach: verify not-quite-so-extreme events and use specially designed scores

Verification of extreme events

	OBS yes	OBS no
FCST yes	a	b
FCST no	c	d

$$FB = \frac{a + b}{a + c} \quad \text{Frequency bias}$$

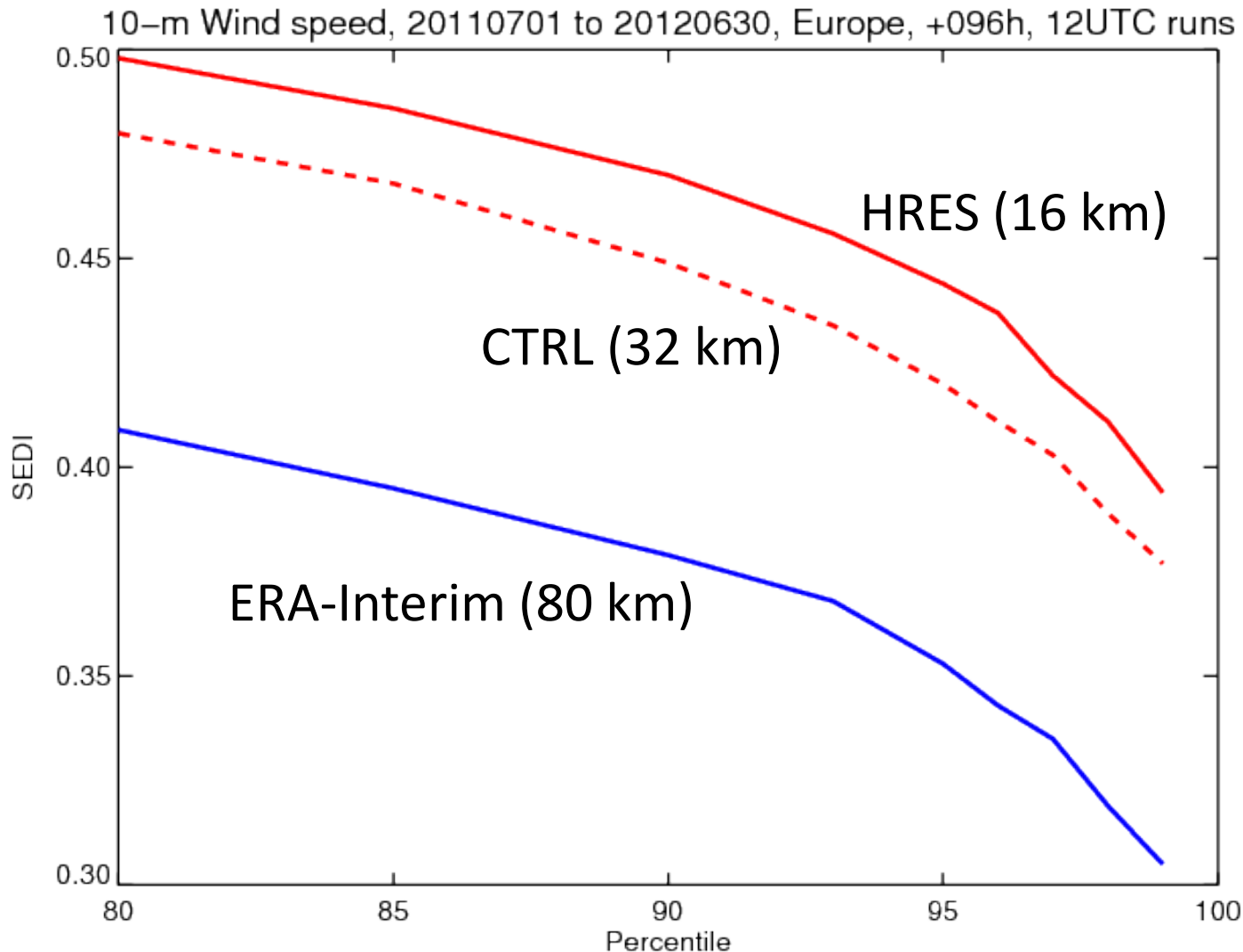
$$H = \frac{a}{a + c} \quad \text{Hit rate}$$

$$F = \frac{b}{b + d} \quad \text{False alarm rate}$$

$$SEDI = \frac{\log F - \log H - \log(1 - F) + \log(1 - H)}{\log F + \log H + \log(1 - F) + \log(1 - H)} \quad \text{Ferro and Stephenson (2011)}$$

Based on calibrated forecasts (corresponding to EFI concept)

Evaluation of high wind speeds, D+4



Evolution of forecast skill - precipitation

HRes wrt ERA Interim

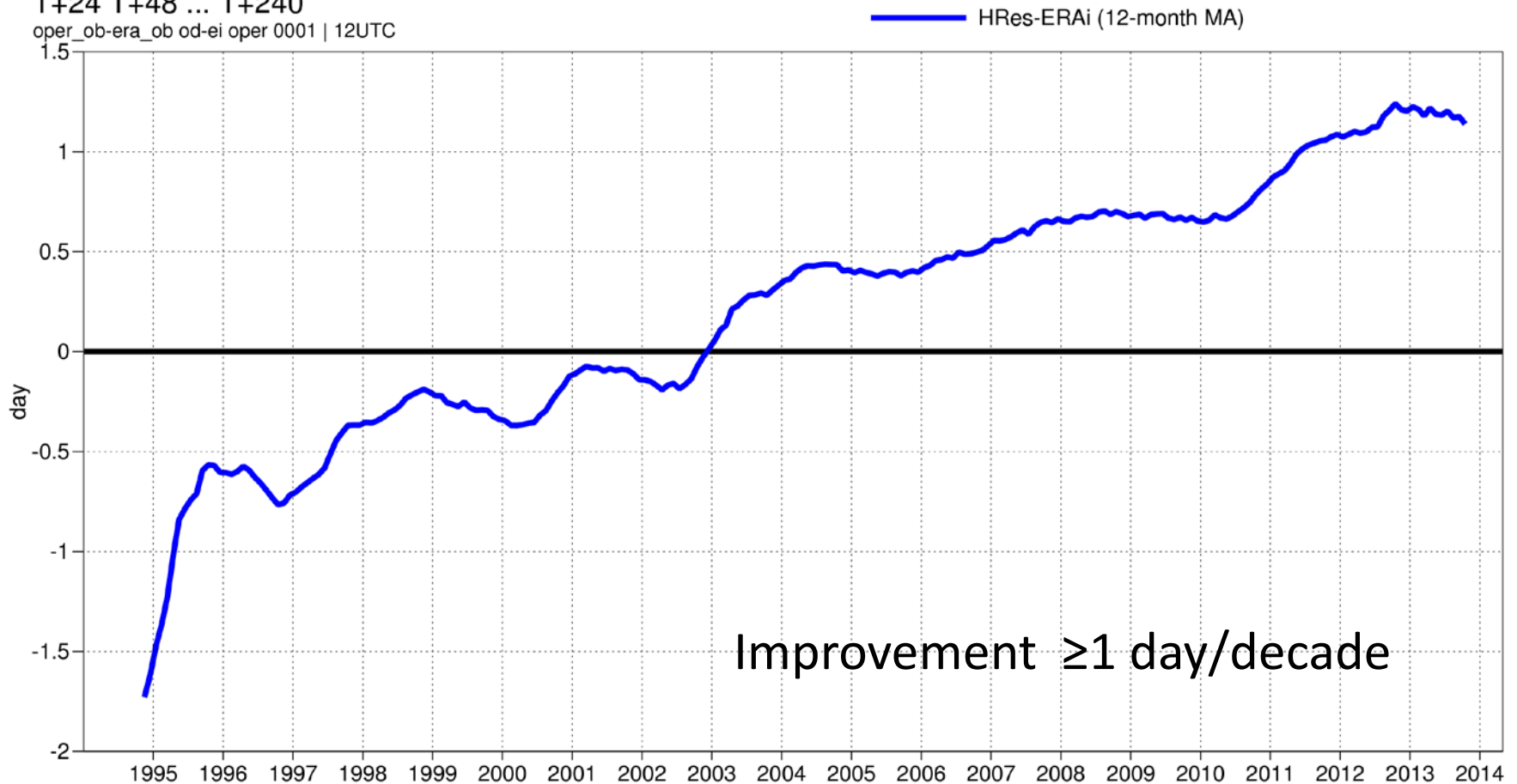
total precipitation

Lead time when 1-SEEPS reaches 0.45, difference of HRes and ERAI

Extratropics (lat -90 to -30.0 and 30.0 to 90, lon -180.0 to 180.0)

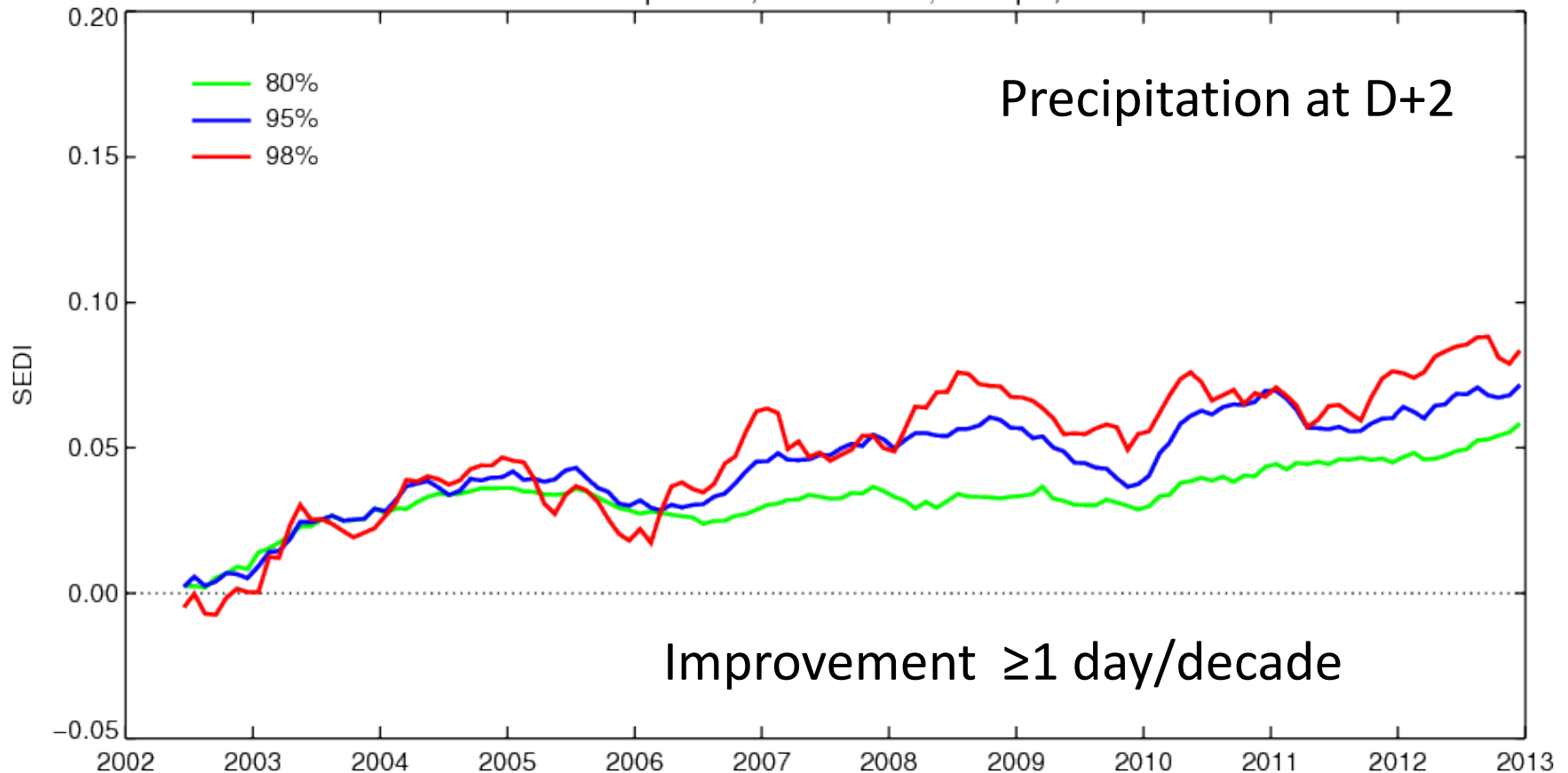
T+24 T+48 ... T+240

oper_ob-era_ob od-ei oper 0001 | 12UTC



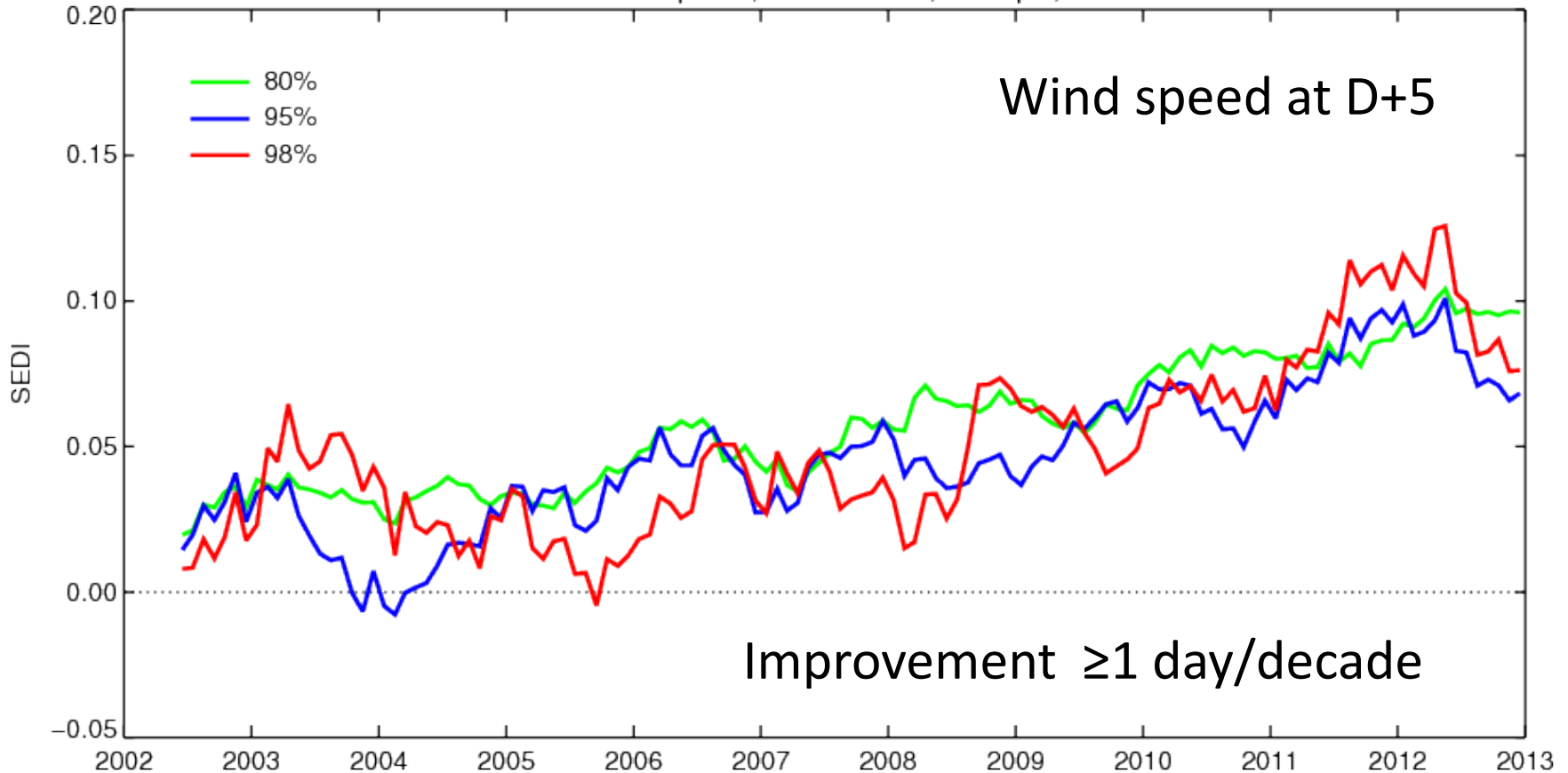
Evolution of forecast skill

24-h Precipitation, 12UTC run, Europe, T+048

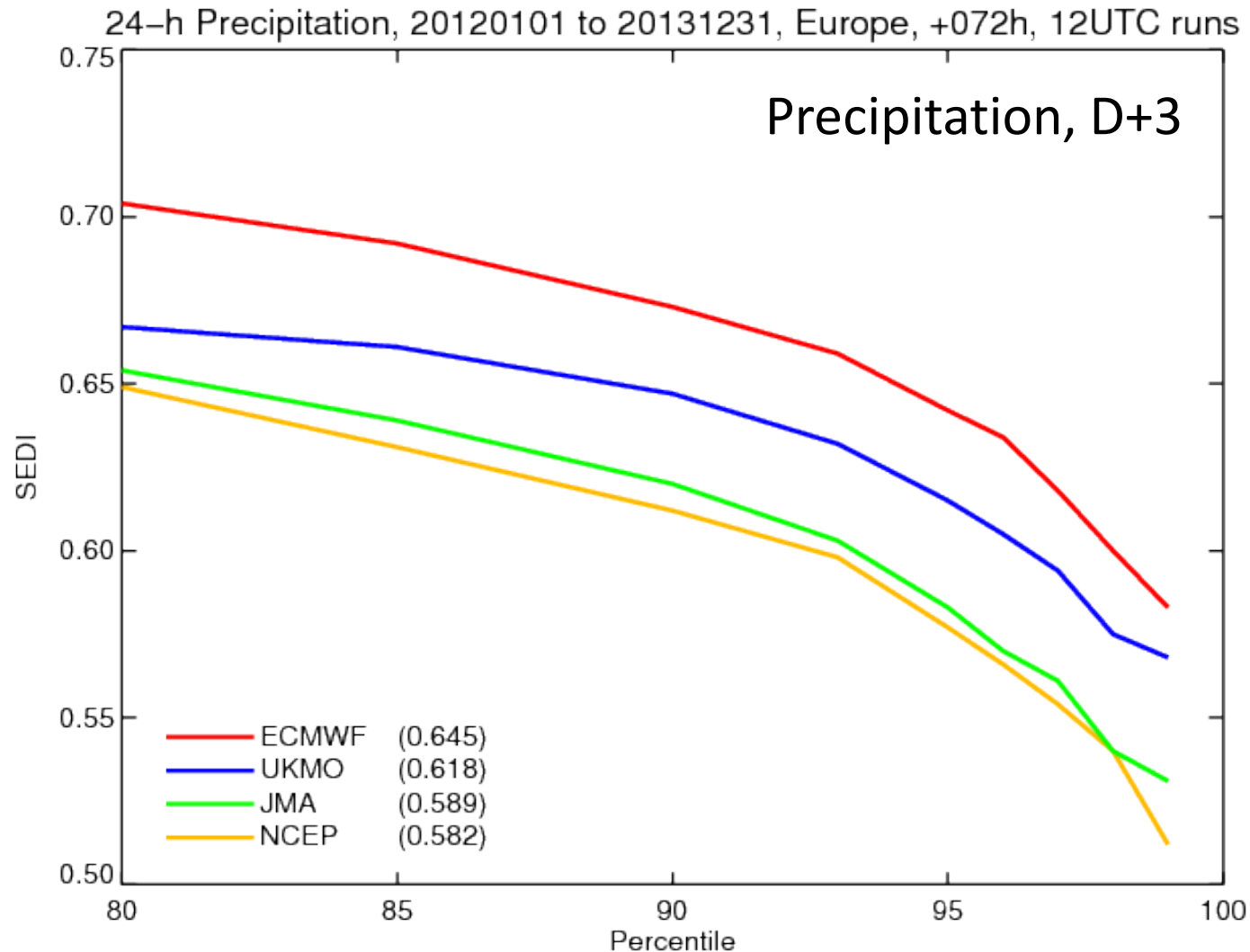


Evolution of forecast skill

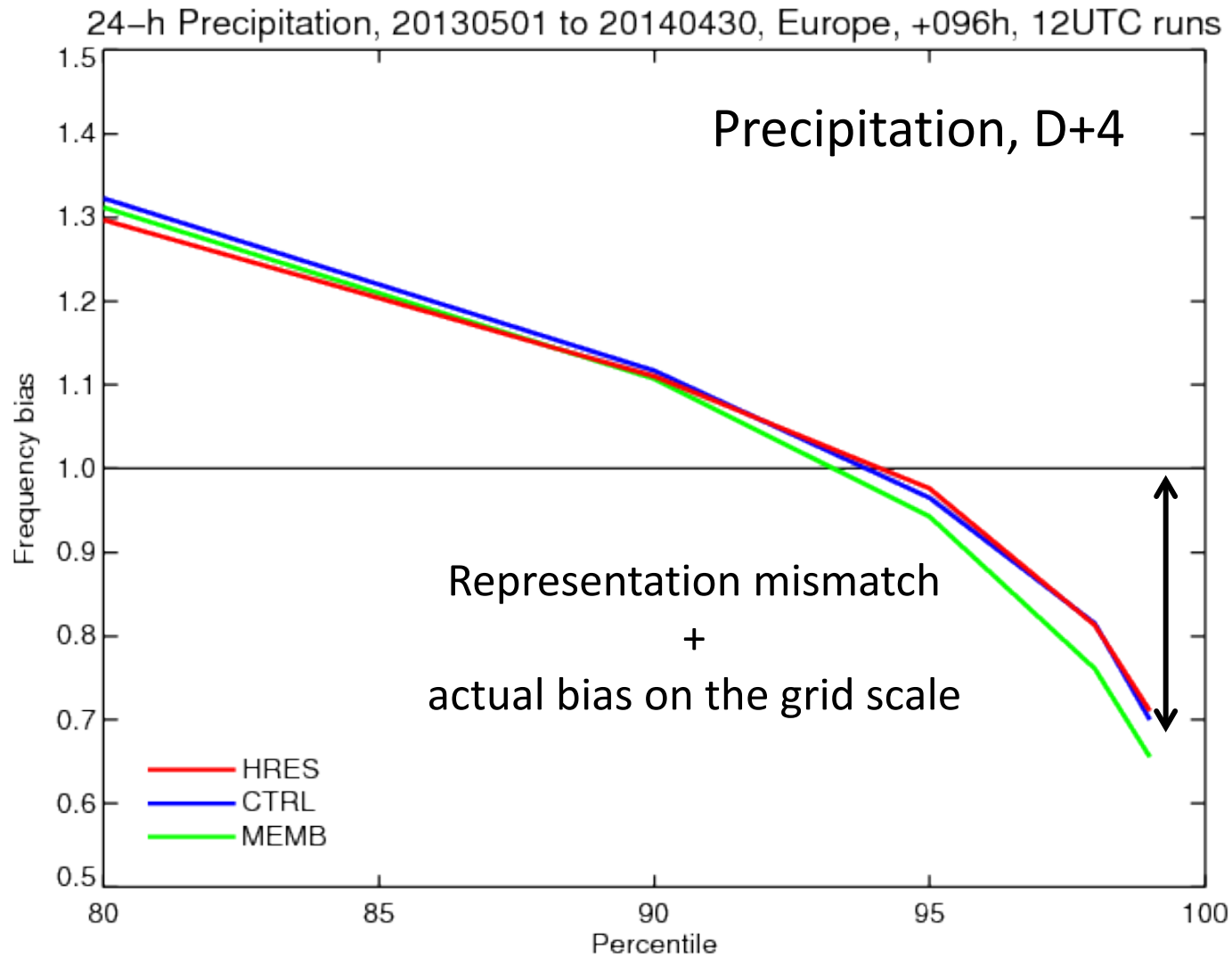
10-m Wind speed, 12UTC run, Europe, T+120



Model intercomparison



Frequency bias



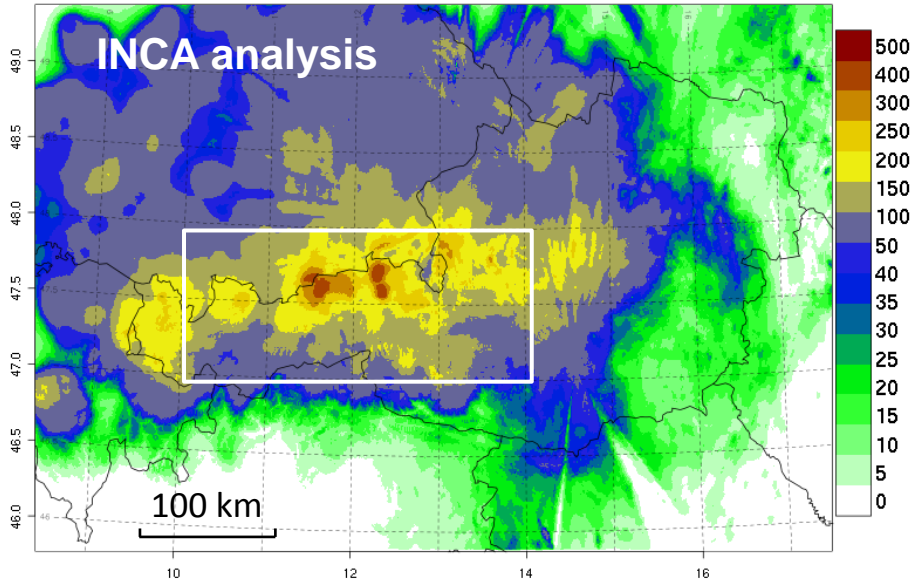
Central European flooding (Danube, Elbe)



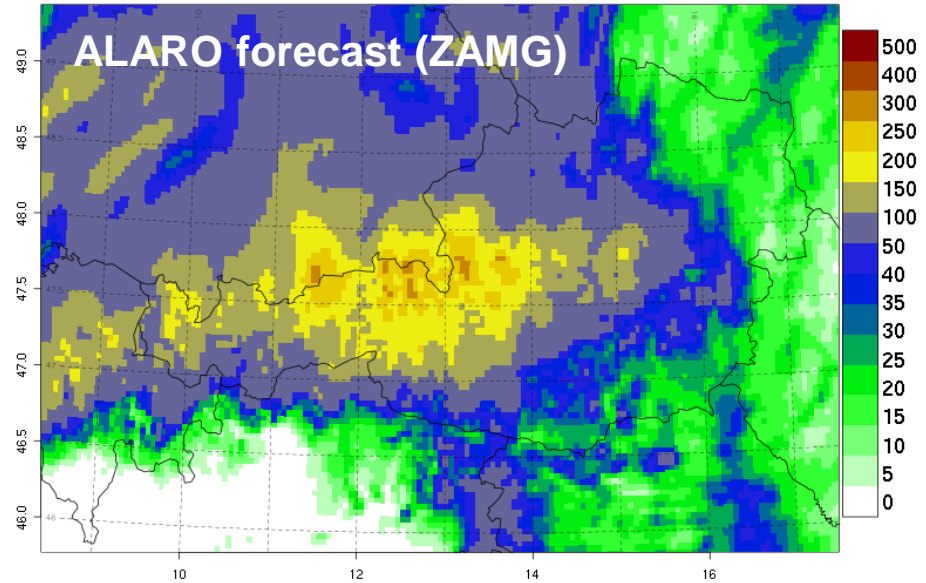
Passau, Germany, June 2013

Precipitation from 31/05/2013 00UTC to 03/06/2013 00UTC

72h precip. INCA 2013060300

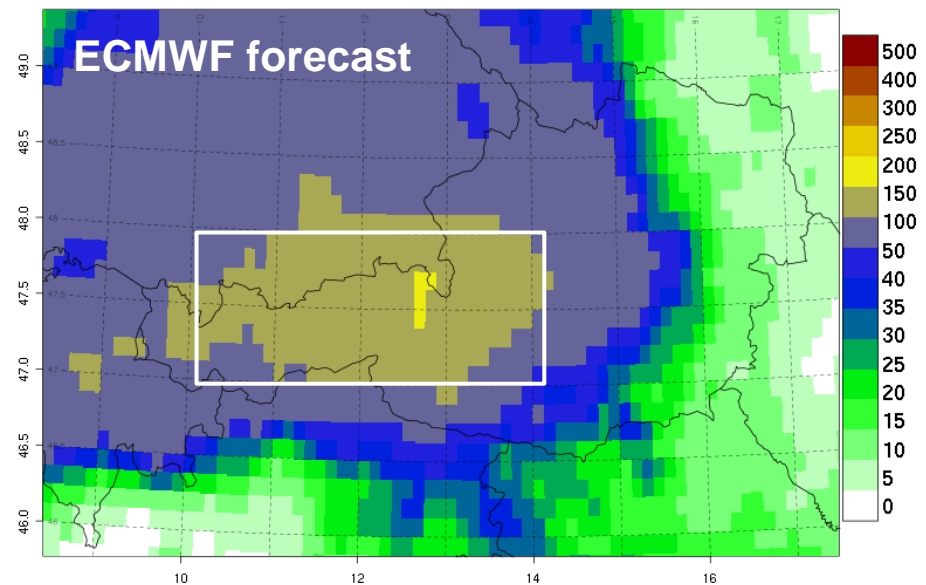


72h precip. ALARO5 2013053100+72



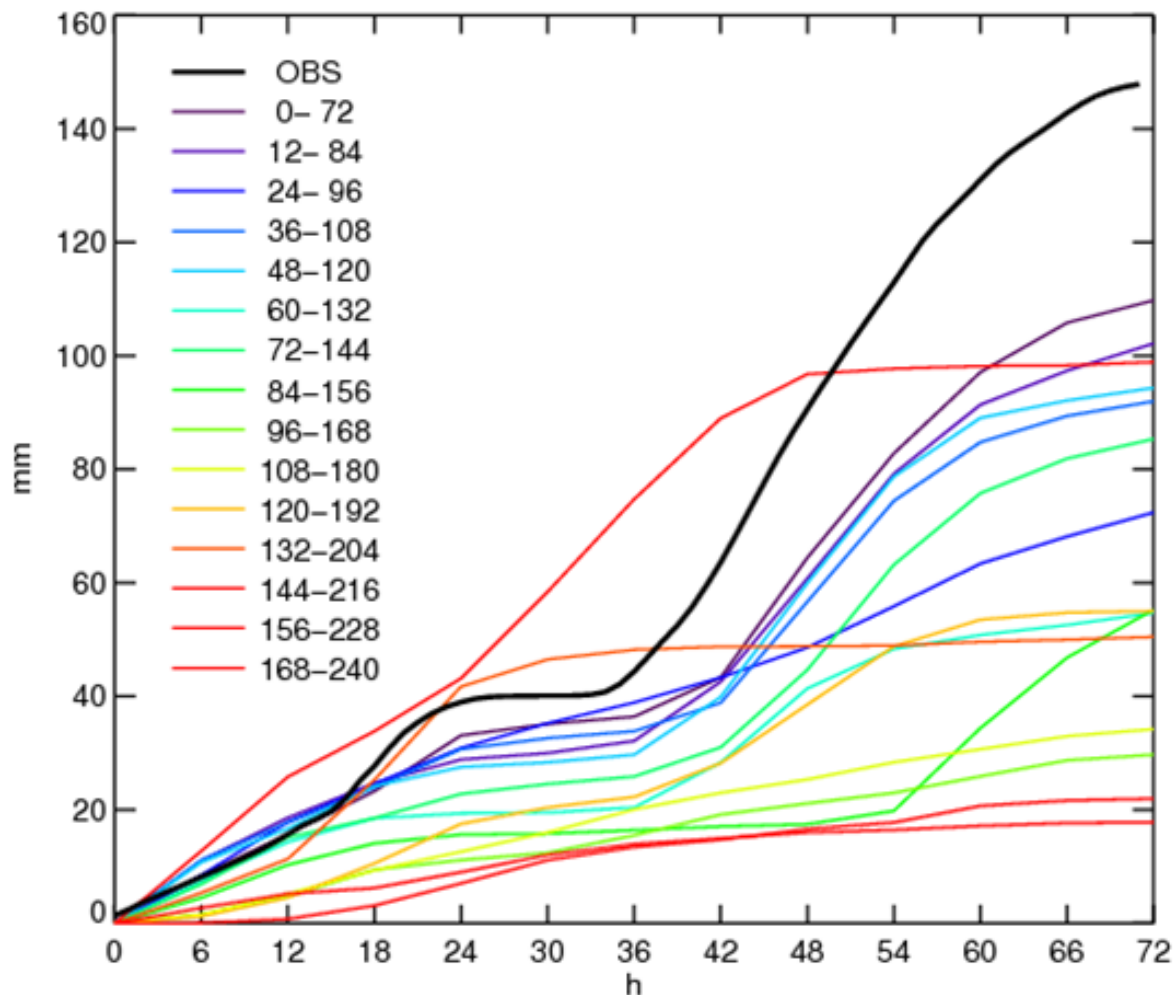
- **ALARO (5 km): very good at 100 km scale but local maxima underestimated**
- **ECMWF (16 km): correct location but underestimation of magnitude**

72h precip. ECMWF 2013053100+72



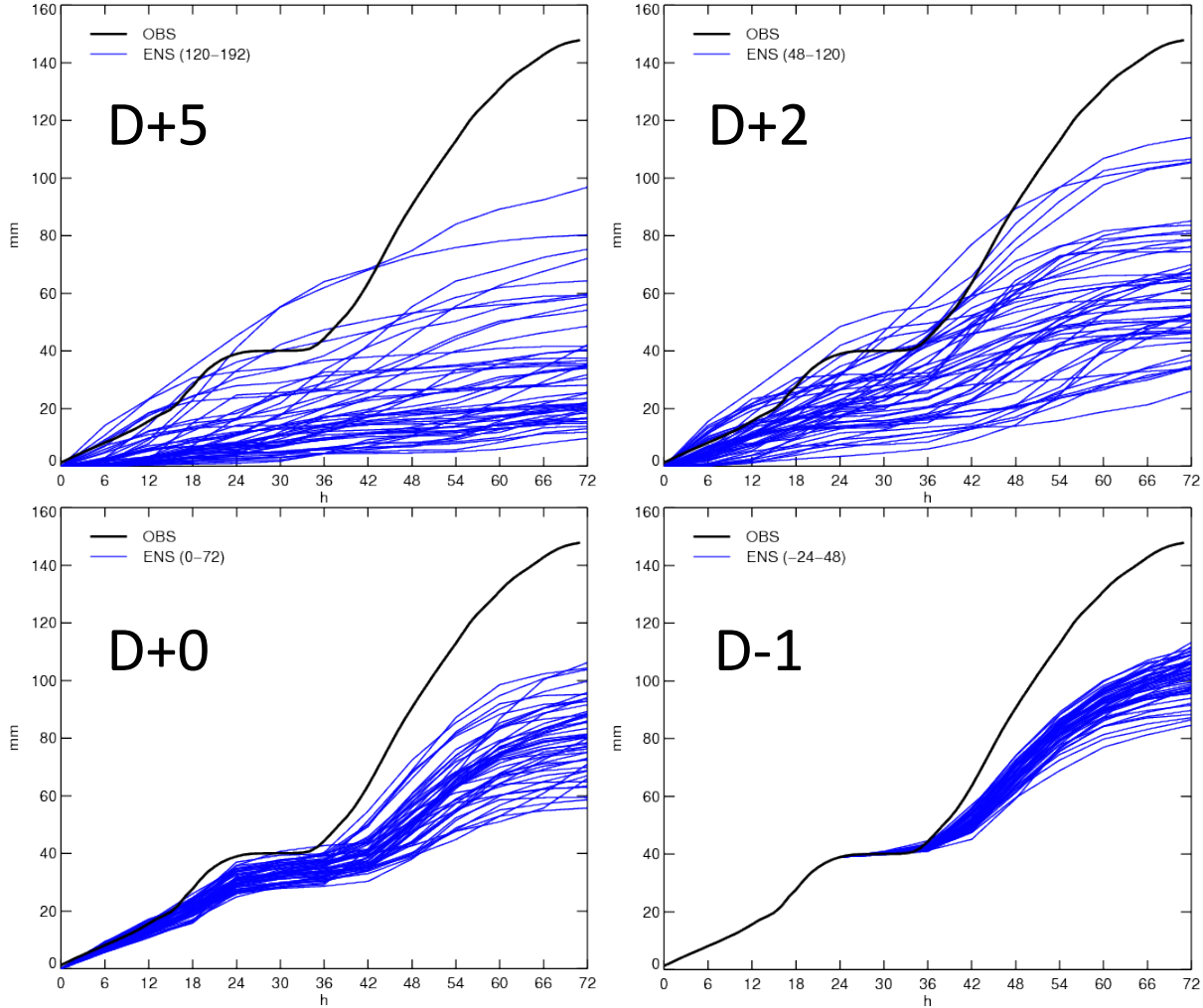
Cumulative precipitation - HRES

2013-05-31 to 2013-06-03



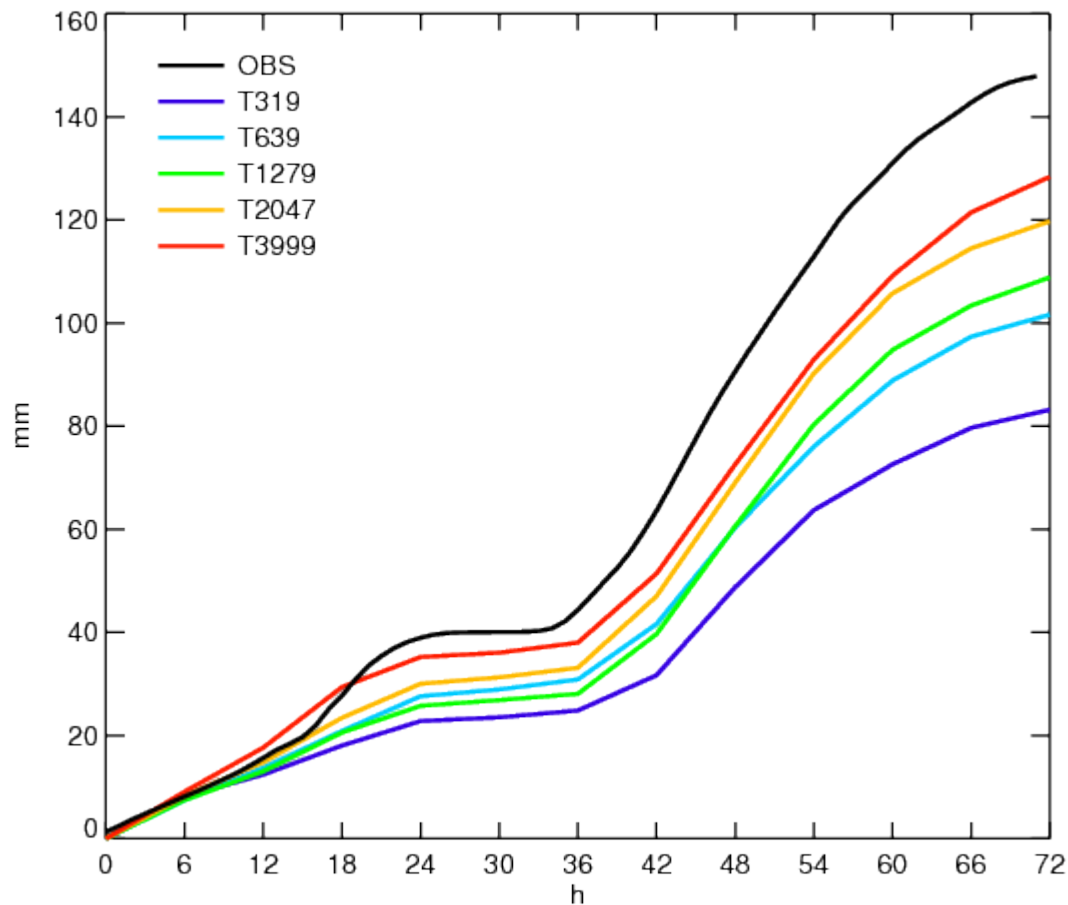
Cumulative precipitation - ENS

2013-05-31 to 2013-06-03



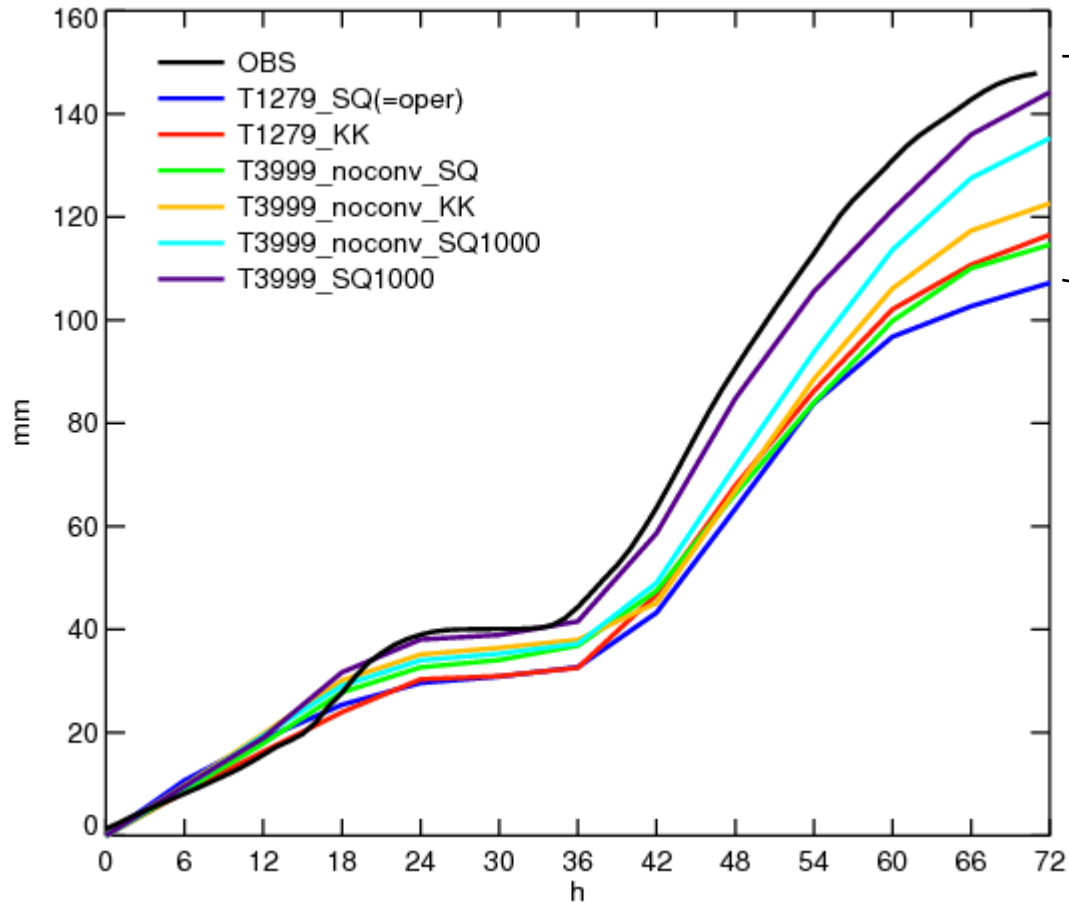
Cumulative precipitation - experiments

2013-05-31 to 2013-06-03



Cumulative precipitation - experiments

2013-05-31 to 2013-06-03



Observations

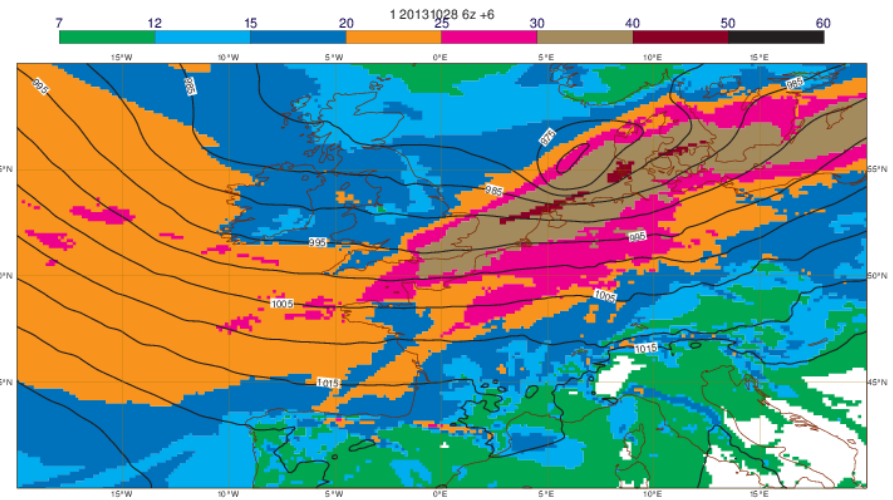
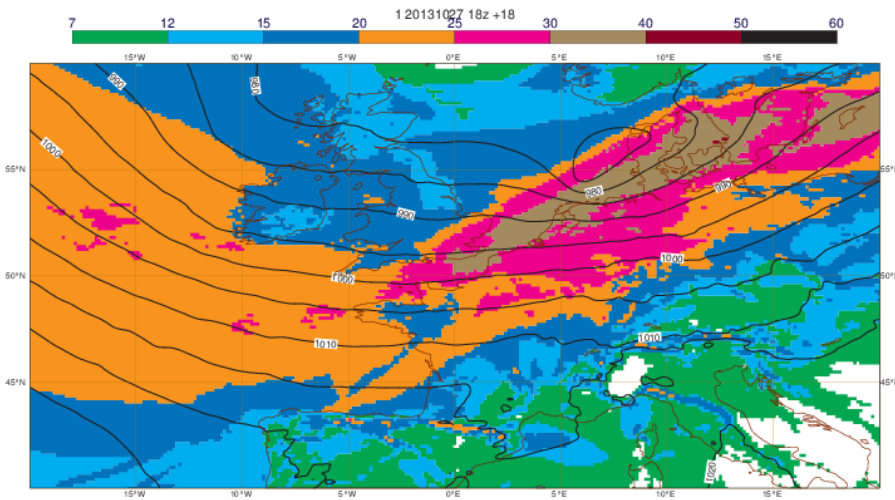
Increased resolution +
modified cloud physics

Operational model

Maximum wind gusts 28 October 6-24UTC

Ini: 27 October 18 UTC

Ini: 28 October 6 UTC



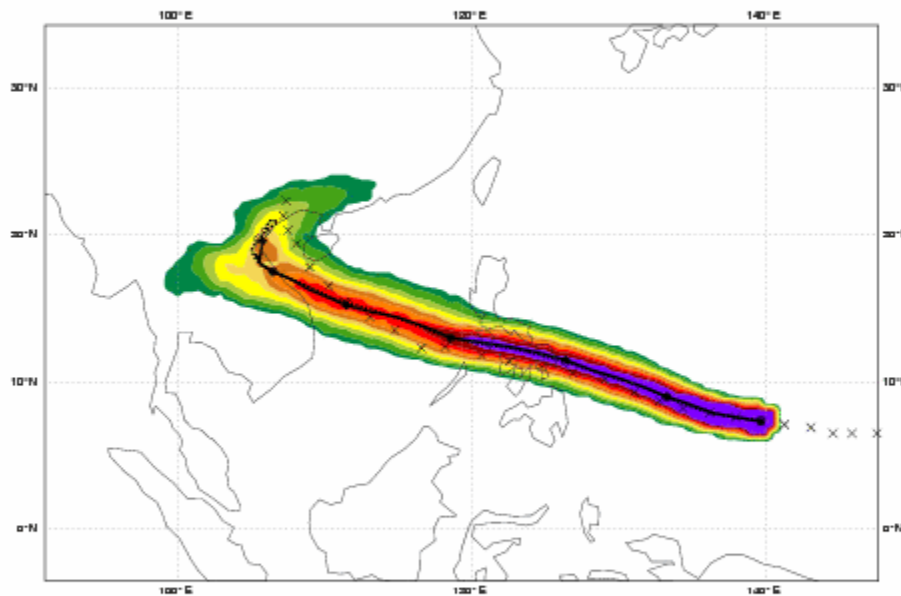
Observations

Haiyan, two days before landfall

Date 20131106 00 UTC @ECMWF

Probability that **HAIYAN** will pass within 120 km radius during the next 240 hours

tracks: **solid**-OPER; **dot**-Ens Mean [reported minimum central pressure (hPa) **955**]

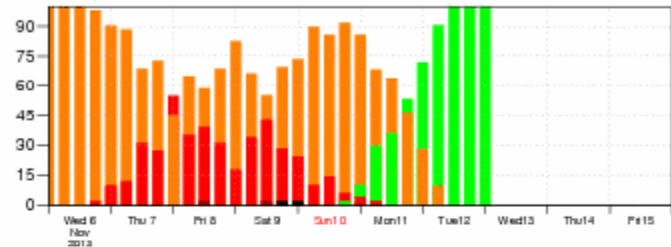


List of ensemble members numbers forecast Tropical Cyclone

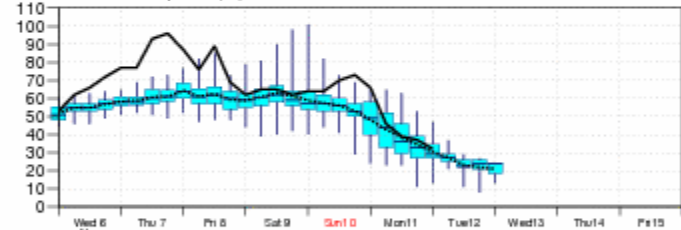
Intensity category in colours: **TD**[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[>95 kt]

+024 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+048 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+072 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+096 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+120 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+144 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+168 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+192 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+216 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
+240 h:	hr	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

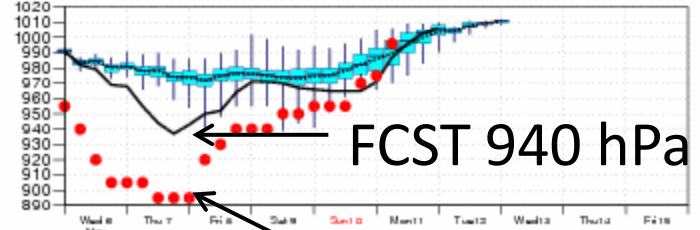
Probability (%) of Tropical Cyclone Intensity falling in each category
TD[up to 33] **TS** [34-63] **HR1**[64-82] **HR2** [83-95] **HR3** [>95 kt]



10m Wind Speed (kt) **solid**-OPER; **dot**-Ens Mean



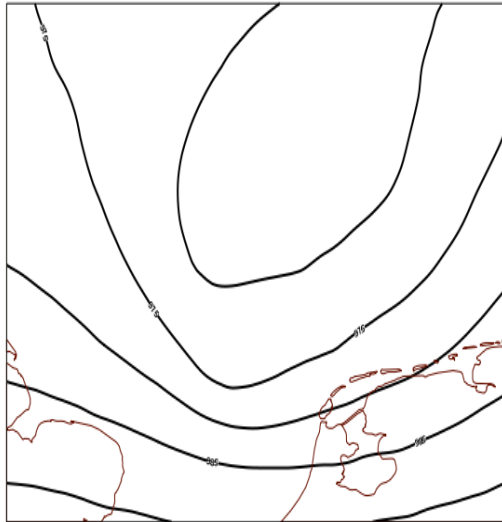
Mean Sea Level Pressure in Tropical Cyclone Centre (hPa) **solid**-OPER; **dot**-Ens Mean



FCST 940 hPa
 OBS <900 hPa

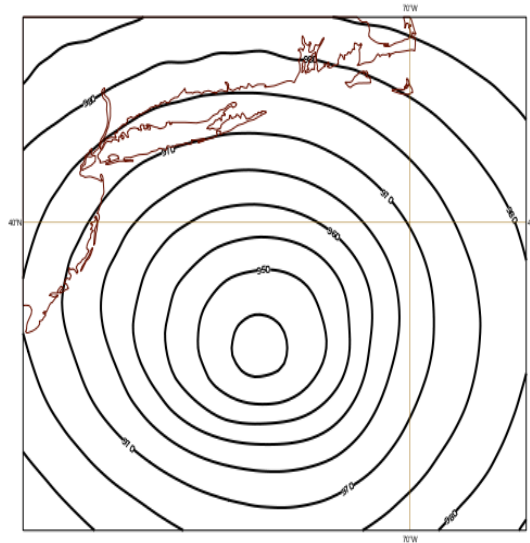
Scale of a storm

St Jude / Christian
2013-10-28



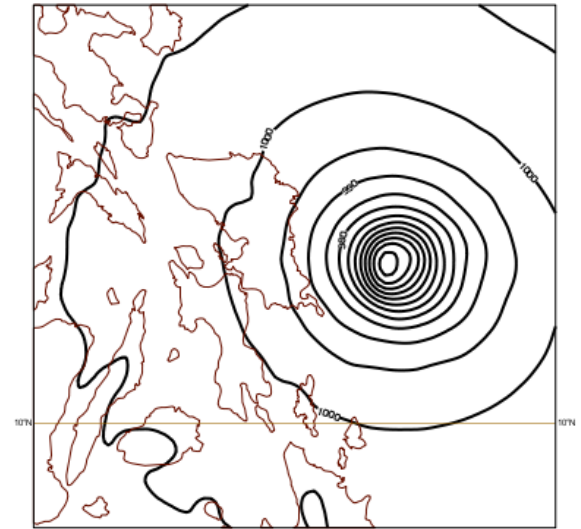
500 km

Sandy
2012-10-30



500 km

Haiyan
2013-11-08

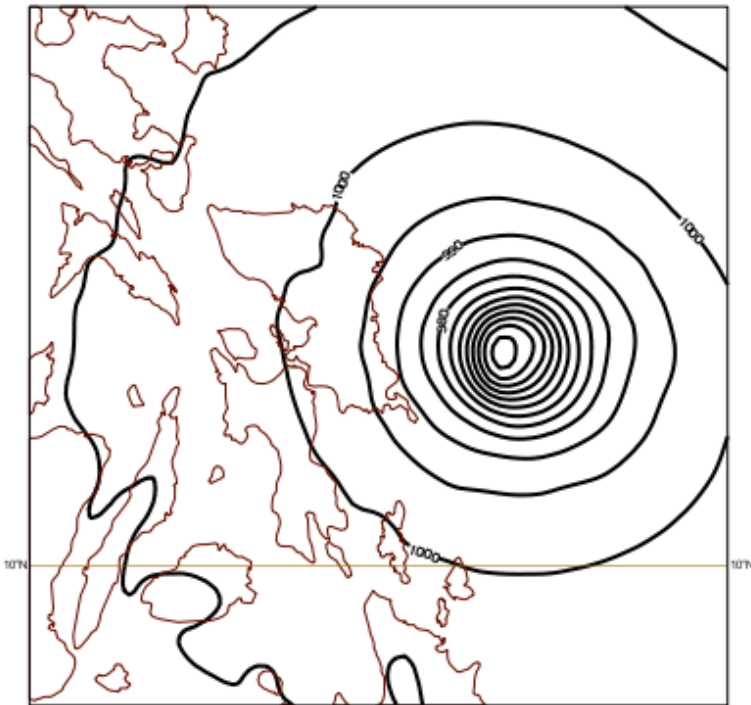


500 km

Effect of resolution

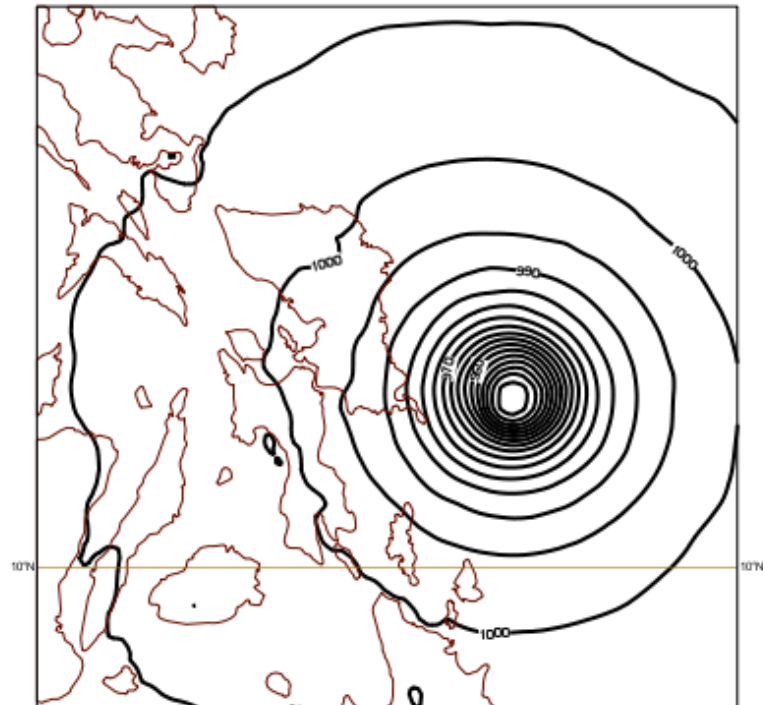
T1279 – min 943 hPa

2013-11-06 00:00:00 0z +48, Min pres: 943 (Obs: 895 hPa)



T2047 – min 922 hPa

2013-11-06 00:00:00 0z +48, Min pres: 922 (Obs: 895 hPa)

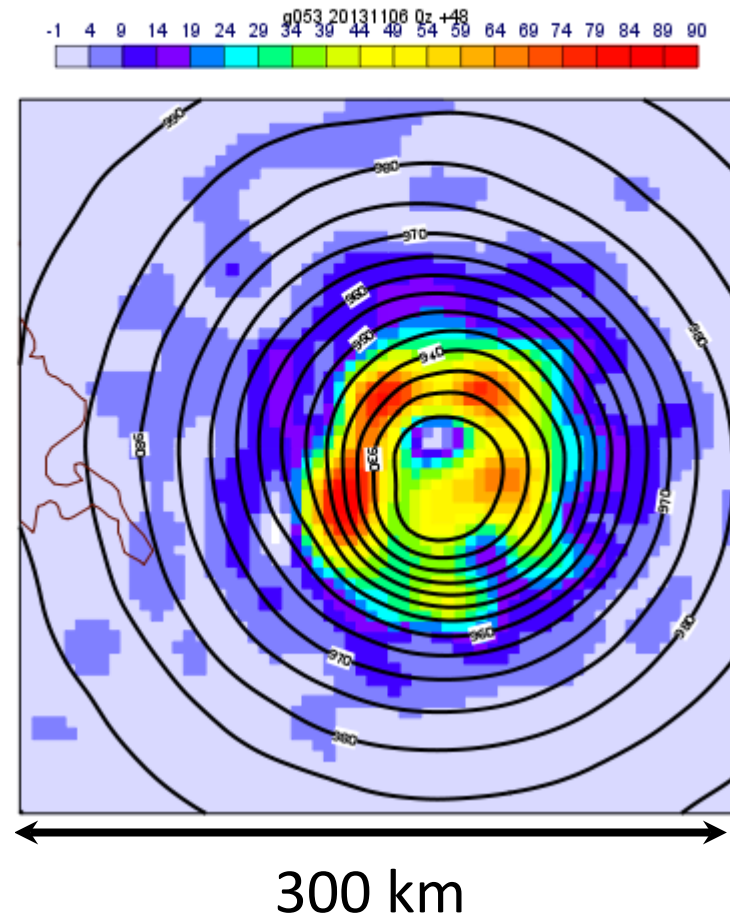
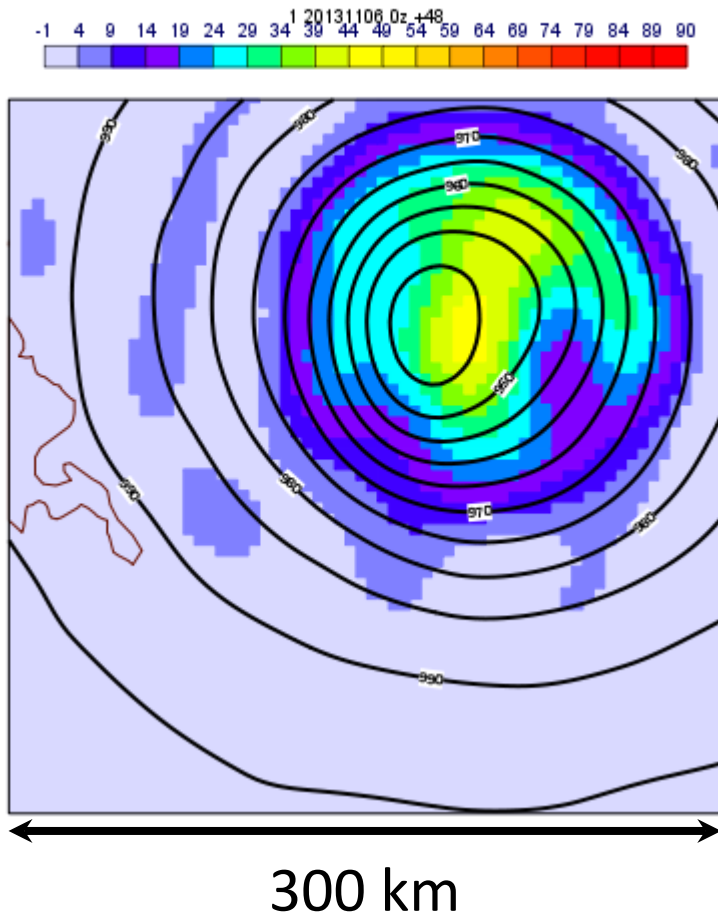


5° ≈ 500 km

850 hPa vorticity and MSL pressure

T1279 ($\Delta x=16$ km)

T2047 ($\Delta x=10$ km)



Conclusions

- **Location and timing of events usually well predicted**
- **Reduced intensity errors at higher model resolution**
- **Skill evolution for 98th percentile similar to overall skill evolution**
- **Case studies: provide physical and modelling insights**
- **Statistical evaluations: provide context, trends, quantify model improvements**