

Research developments at ECMWF

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ECMWF

Research highlights

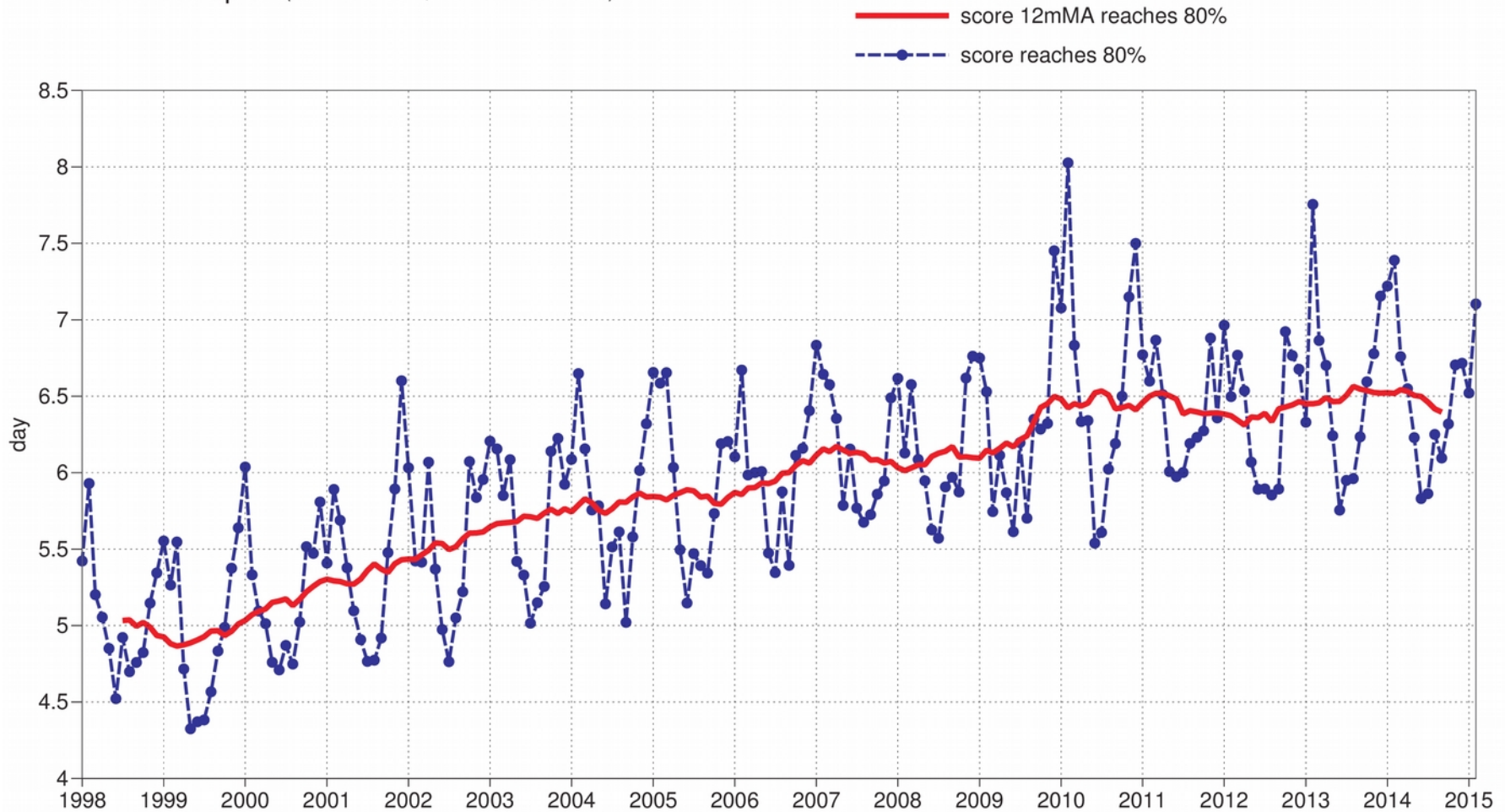
- Forecast scores
- Data assimilation
- Physics developments
- Cubic octahedral spectral grid
- Scalability

HRES headline score

500hPa geopotential

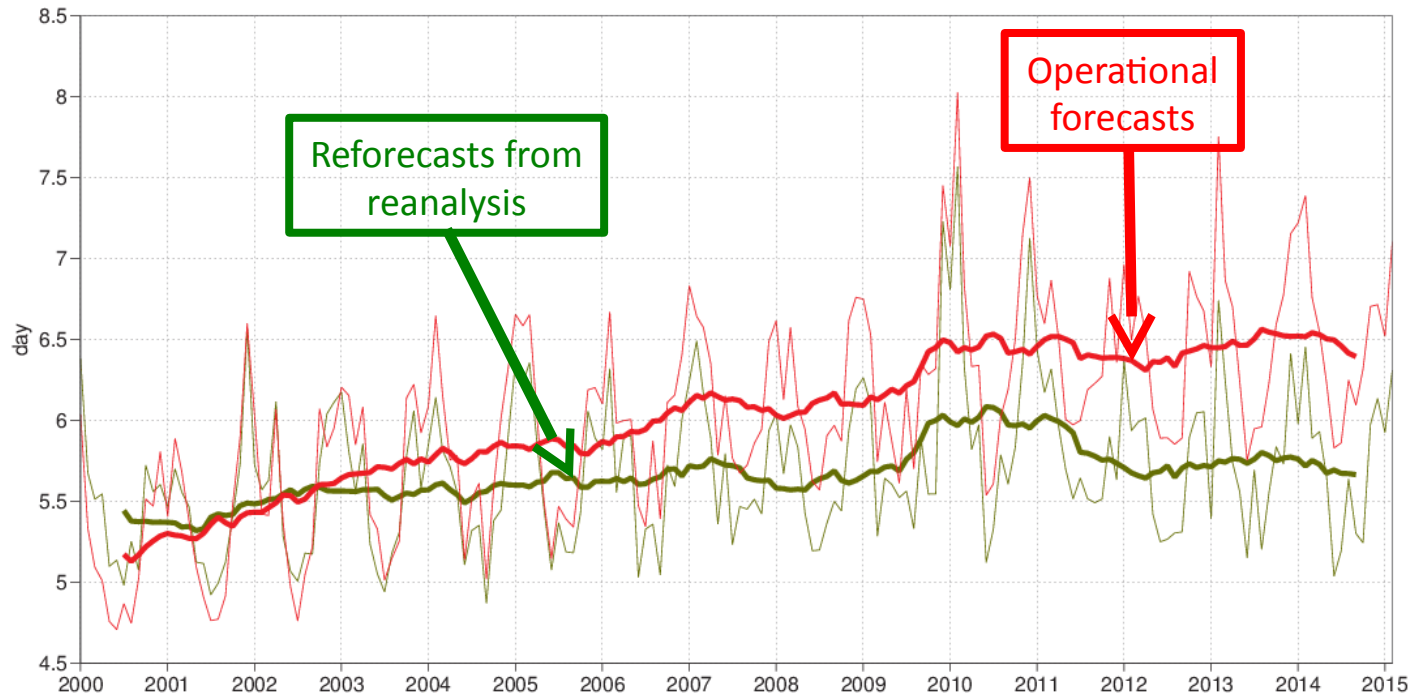
Lead time of Anomaly correlation reaching 80%

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)



ECMWF Headline Forecast Score

Z500, Time series of ACC=0.8, N.Hem



Z500 N hemisphere HRES v ERA-I

HRES - ERA

500hPa geopotential

Anomaly correlation

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)

T+0 T+12 ... T+240

oper_an-era_an od-ei oper 0001 | 00UTC,12UTC,beginning



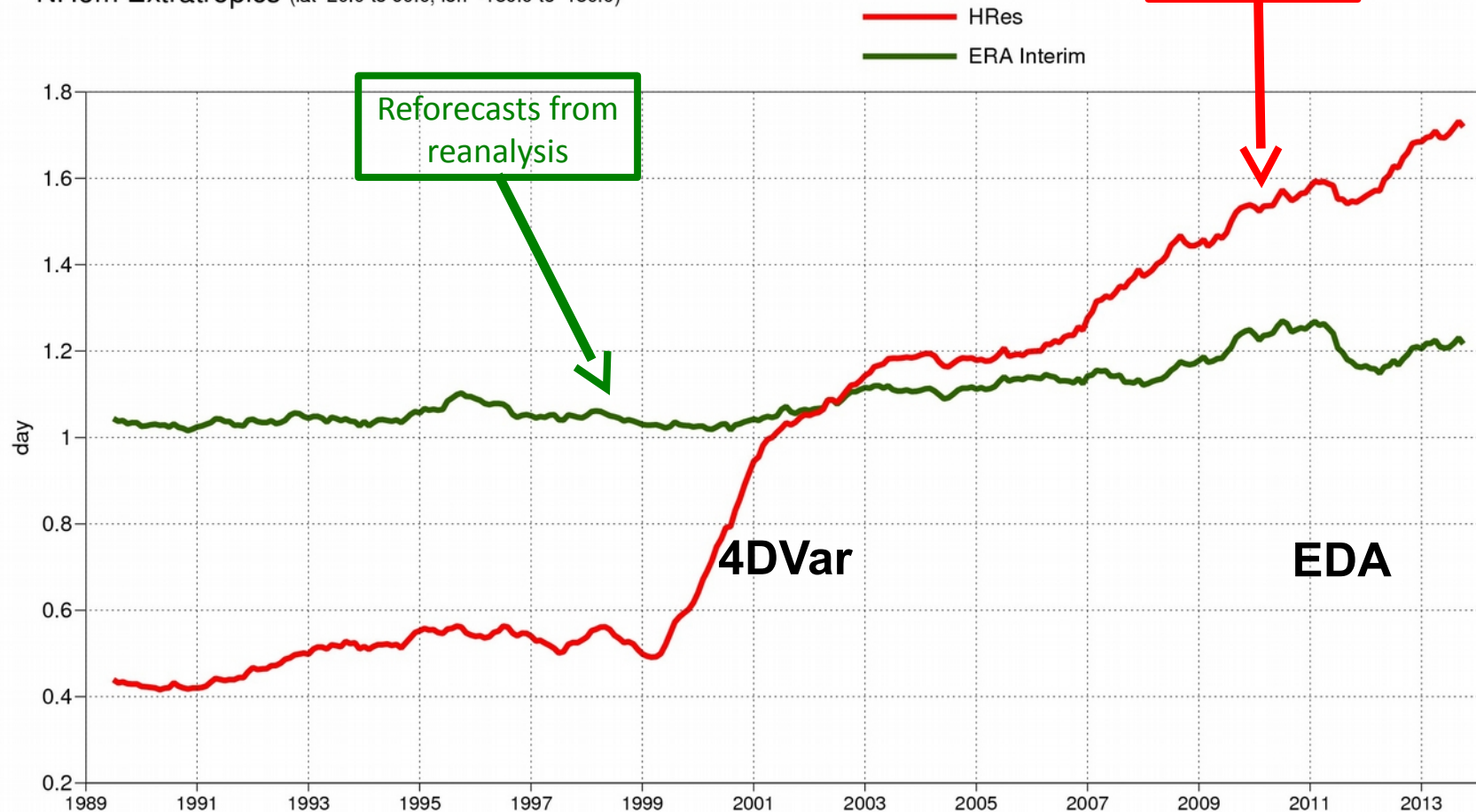
Initial state error reduction

HRes and ERA Interim 00,12UTC forecast skill

500hPa geopotential

Lead time of Anomaly correlation reaching 99.5%

NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)



Strategy for data assimilation

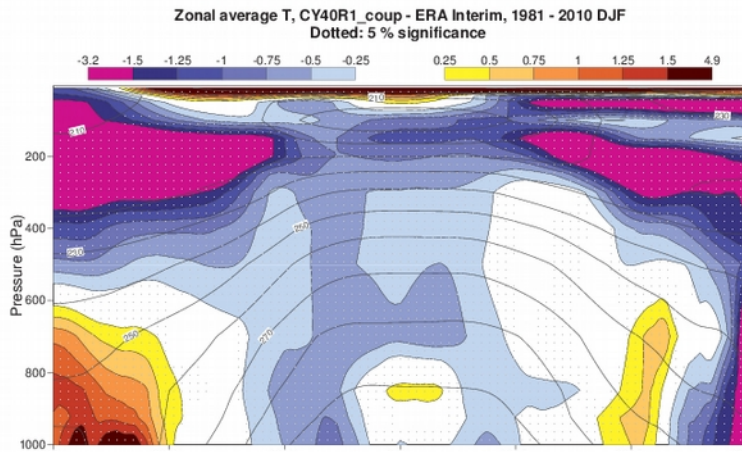
- Maintain hybrid 4DVar methodology
 - Consistent treatment of model/obs operators
 - Remote sensing data well handled
- Extend 4DVar window length
 - Model error
 - Scalability
- Develop EDA/EnDA
 - Filtering of variances/co-variances
 - Hybrid Gain EnDA
 - Seamless EDA/ENS

Model Physics

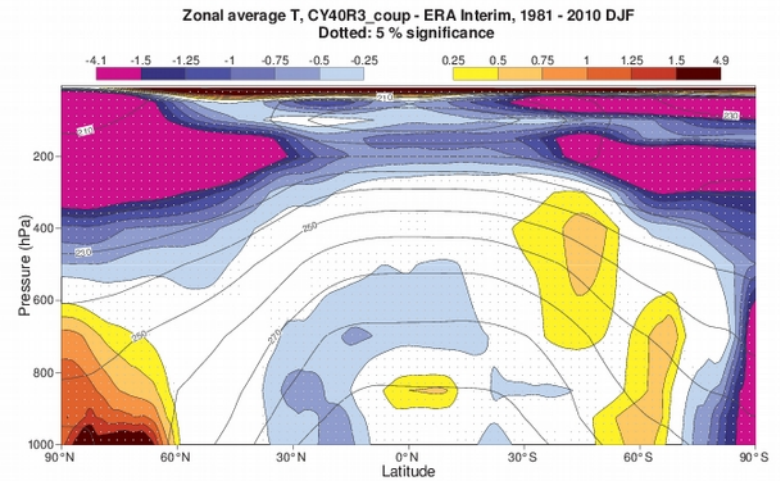
- Improved microphysics – supercooled liquid water
- Convection – detrainment formulation
- Boundary layer – surface properties
- Radiation accuracy
- Land surface modelling

Temperature biases

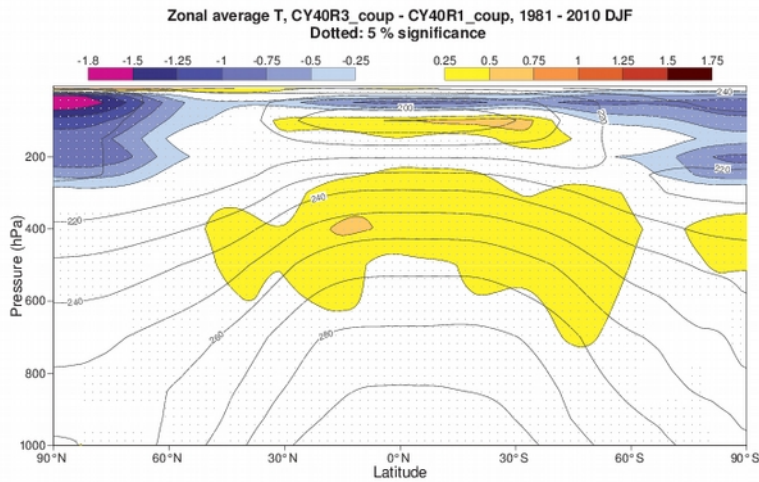
40r1-ERA



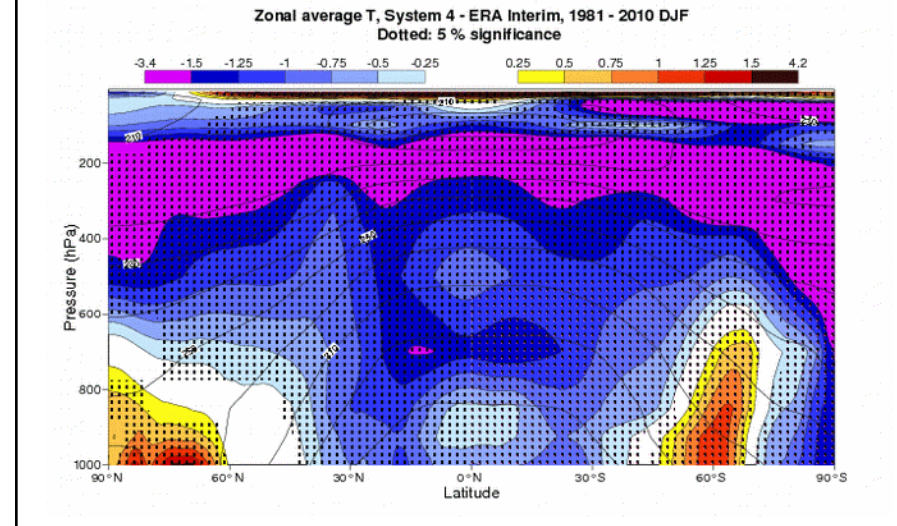
40r3-ERA



40r3-40r1



System 4-ERA



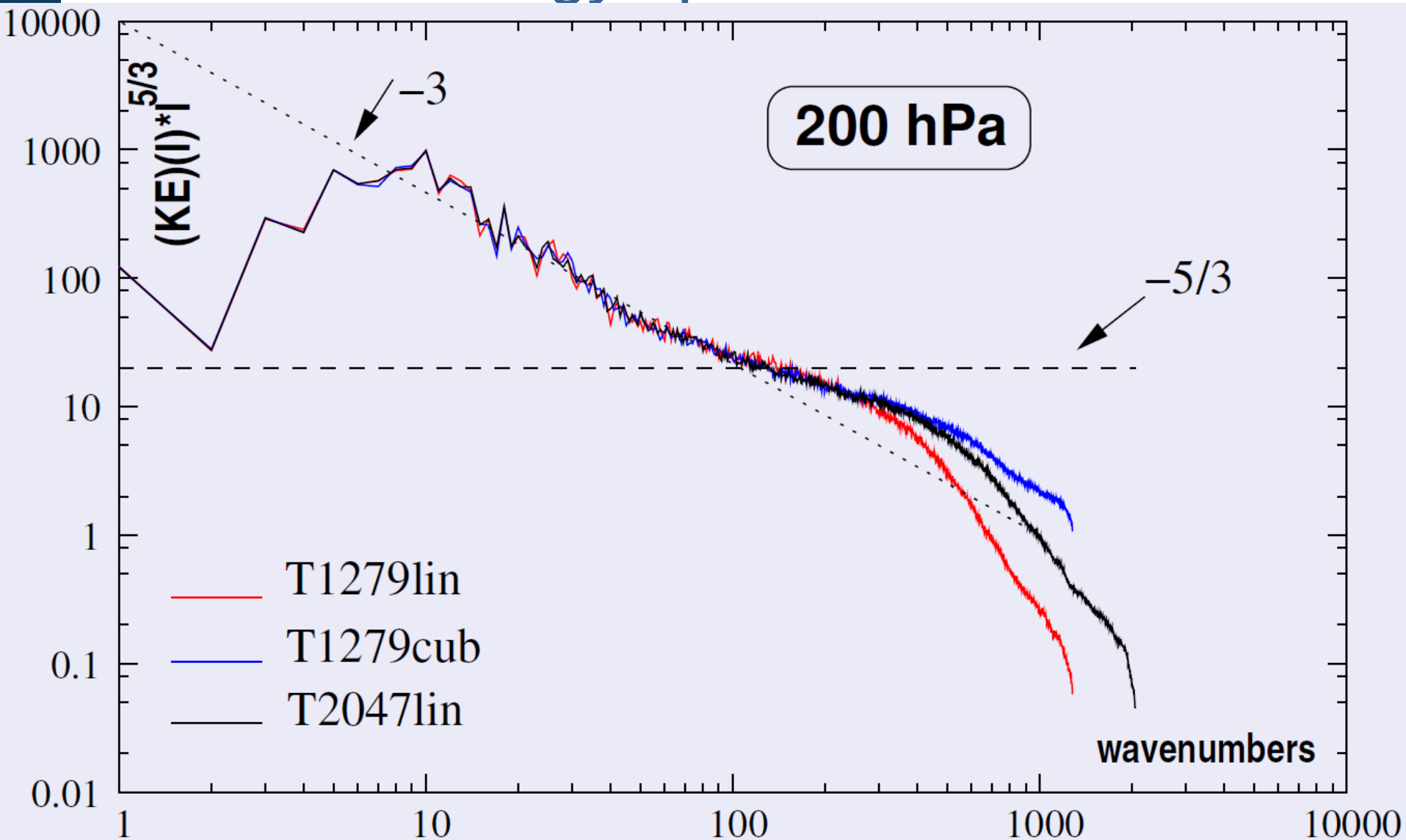
Model Numerics

- Resolution increases – improved surface fields
- Modified semi-Lagrangian scheme
- Dynamical core developments – scalability
- Cubic octahedral spectral grid

Horizontal resolution

- Increased resolution in 2015
 - 16 km → 8-10 km (atm)
 - 1 → ¼ deg (ocean)
- In the future:
 - ~5 km ensembles by 2025
- Computing requirements:
- 60 MW!! (Scalability)

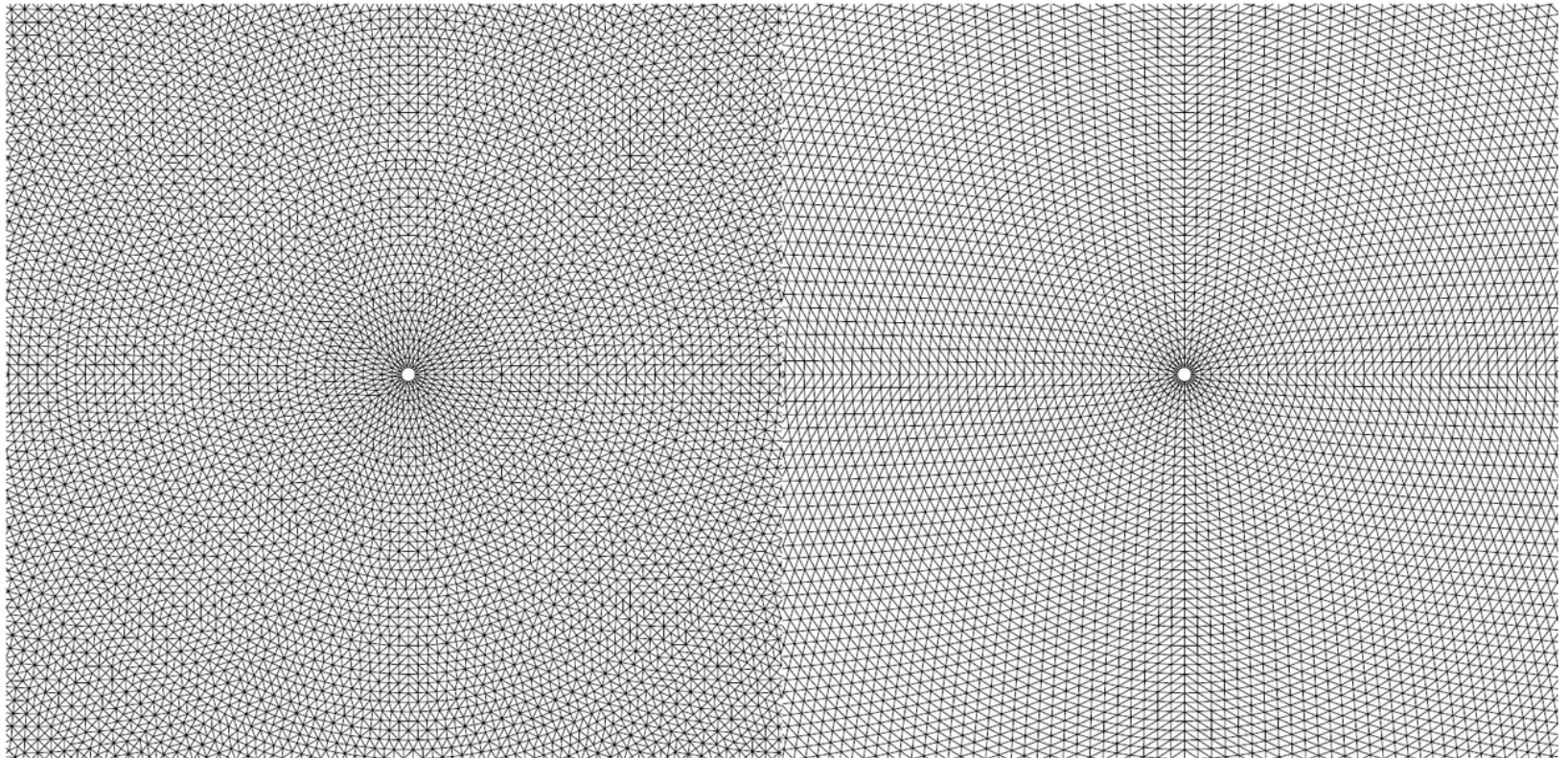
Kinetic energy spectra at 200 hPa



New Octahedral grid

Old

New



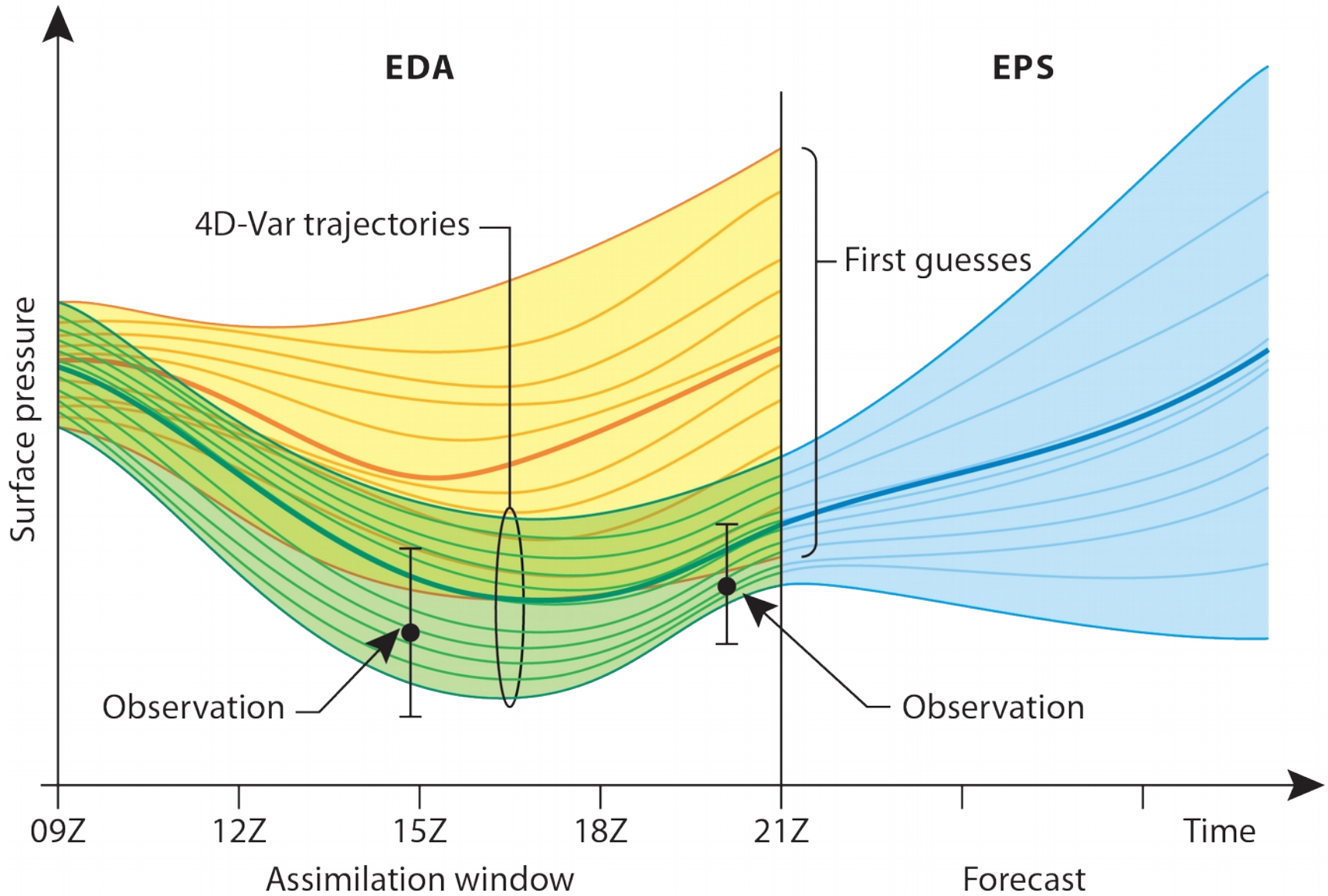
Scalability activities

- Preparation for future HPC architectures (2018 onwards)
 - Data assimilation (OOPS)
 - IFS dynamical core
 - Model code optimisation
 - Other code optimisations (observation handling)

Conclusions

- Scores continue to improve – slowdown of rate?
- Cubic, octahedral spectral grid
- Scalability

Ensemble assimilation and prediction

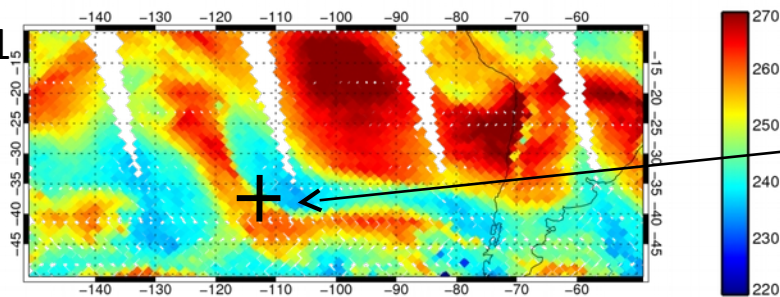


Water vapour in the presence of cloud



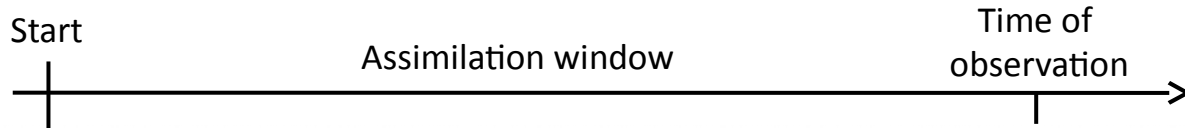
GOES 10 μ m
Dundee receiving
station

Metop-B MHS 183 \pm 1
GHz

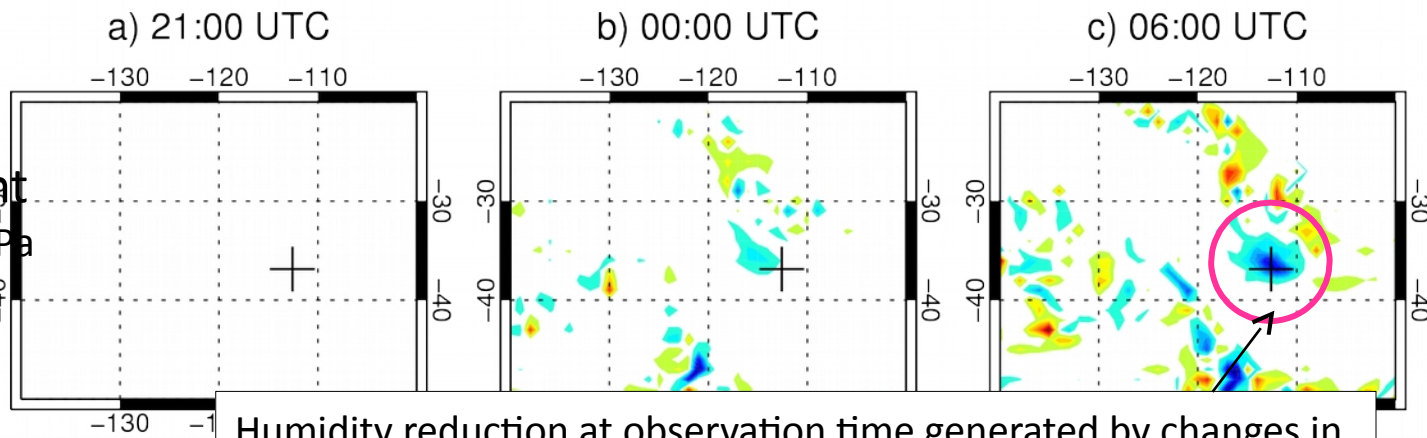


06Z, 15 Aug 2013
37°S 113°W
Observation rejected in old
'clear-sky' approach

Water vapour in the presence of cloud - 183 ± 1 GHz

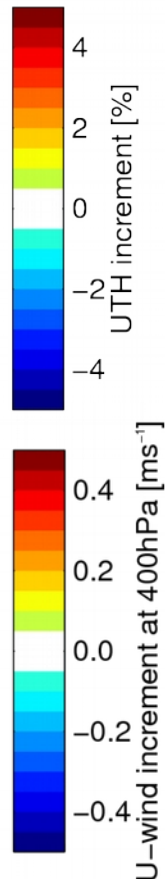
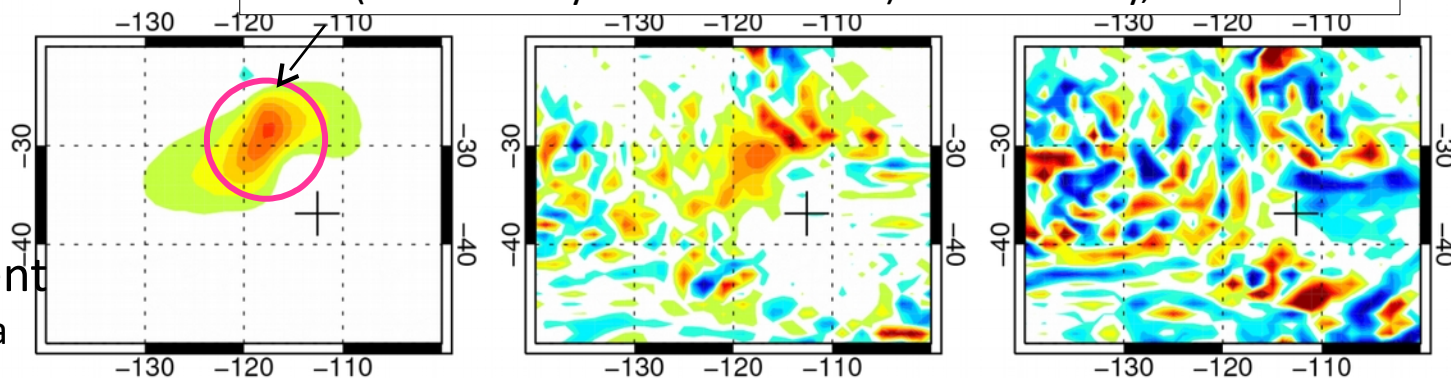


UTH
increment
(200-500 hPa
mean RH)



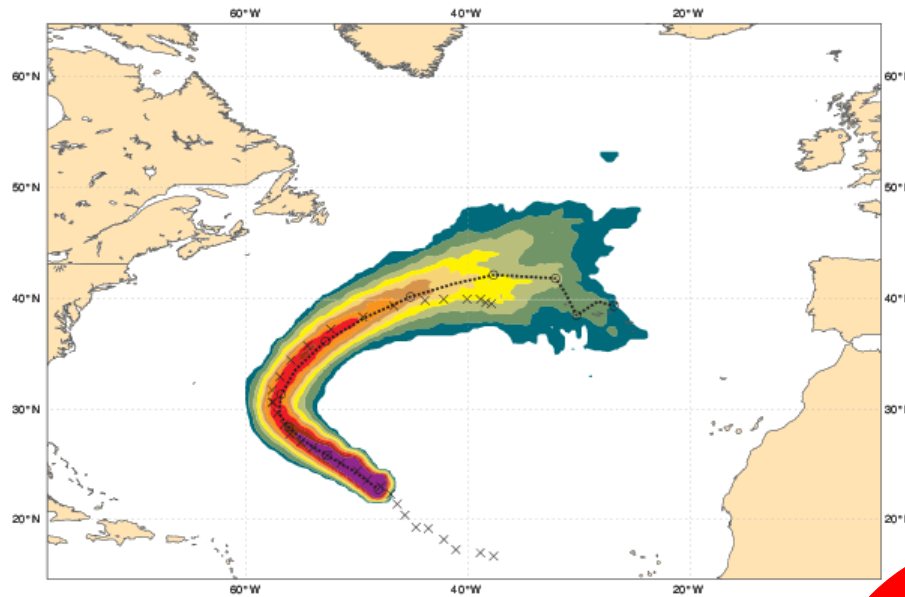
Humidity reduction at observation time generated by changes in wind (and other dynamical variables) 1000km away, 9h earlier!

Zonal
wind
increment
at 400 hPa



Date 20140914 00 UTC @ECMWF

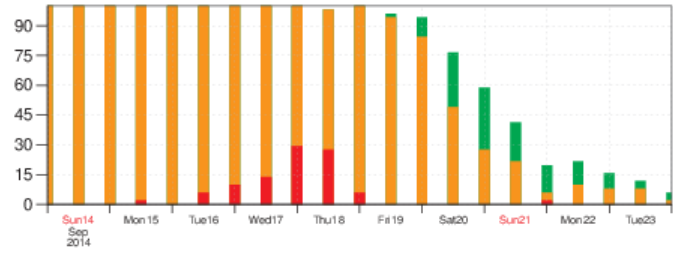
Probability that **EDOUARD** will pass within 120 km radius during the next 240 hours
 tracks: **solid**=HRES; **dot**=Ens Mean [reported minimum central pressure (hPa) **994**]



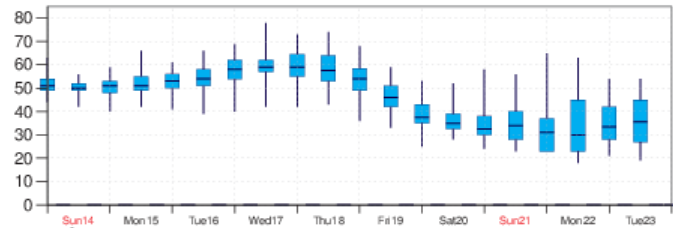
List of ensemble members numbers forecast Tropical Cyclone
 Intensity category in colours: **TD**[up to 33] **TS**[34-63] **HR1**[64-82] **HR2**[83-95] **HR3**[>95 kt]

+024 h:	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
+048 h:	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
+072 h:	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
+096 h:	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
+120 h:	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
+144 h:	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 44 45 46 47 48 49 50
+168 h:	02 03 04 05 08 10 11 12 13 14 19 20 22 24 25 26 27 28 29 30 31 33 34 35 36 37 38 42 44 45 46 48 49 50
+192 h:	10 20 21 25 27 28 31 34 36 47
+216 h:	10 20 21 27 28 29 31 34
+240 h:	10 20 21 31

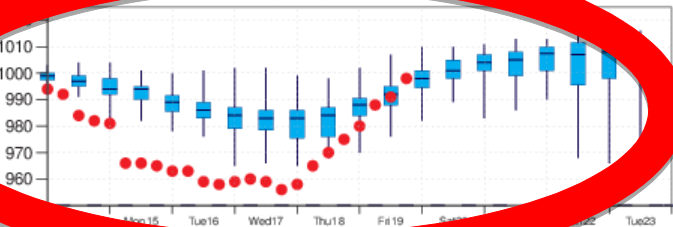
Probability (%) of Tropical Cyclone Intensity falling in each category
TD[up to 33] **TS** [34-63] **HR1** [64-82] **HR2** [83-95] **HR3** [> 95 kt]



10m Wind Speed (kt) **solid**=HRES; **dot**=Ens Mean



Pressure in Tropical Cyclone Center (hPa) **solid**=HRES; **dot**=Ens Mean

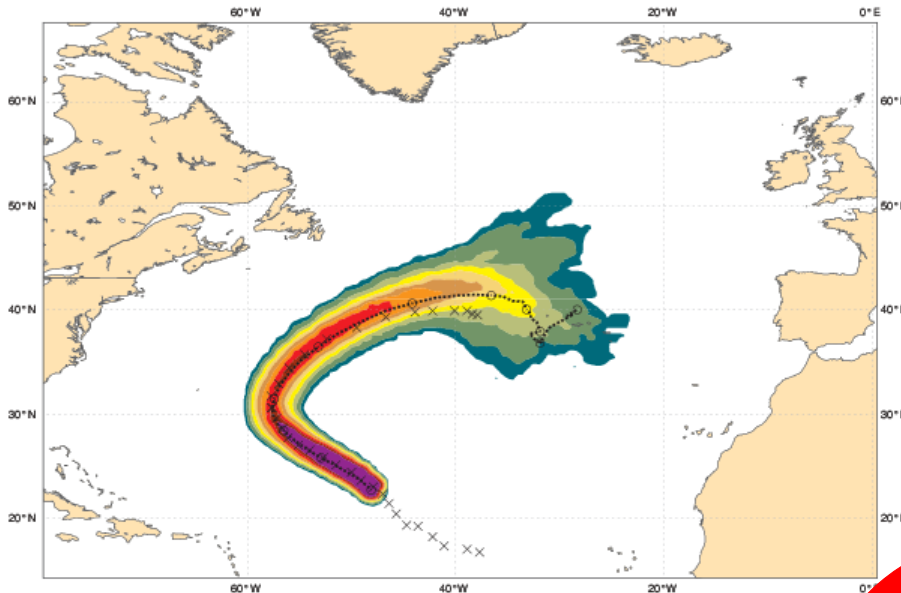


TL1279 An, TL399 EDA, TL639 ENS

Low spread and deepening not captured

Date 20140914 00 UTC @ECMWF

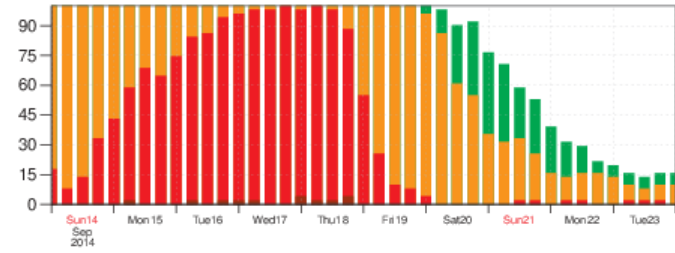
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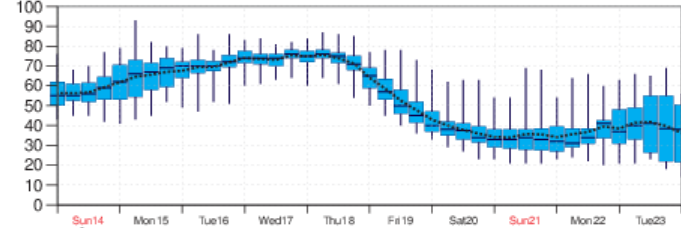
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+024 h:	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
+048 h:	ct	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29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

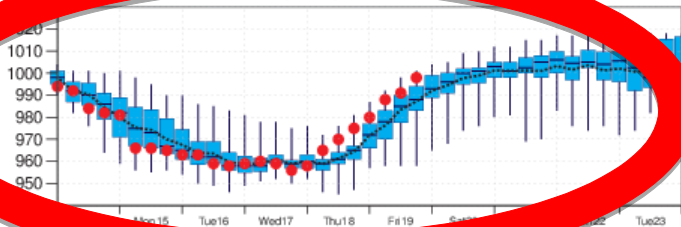
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Pressure in Tropical Cyclone Center (hPa) **solid**=HRES; **dot**=Ens Mean



TL1279 An, 399 EDA, T639 ENS (new grid)

Deepening is captured and spread reflects uncertainty

Grid resolution

Old

New

