

LYNVARSLING, NYTT NASJONALT VARSLINGSSYSTEM, MULIGHETER OG BEGRENSNINGER.

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Outline



The forecast problem

The forecast system

The forecast evaluation

The future

The forecast problem - I

Lightning present a safety risk to helicopters

(not random - winter time – offshore – negatively charged)

To trigger lightning we need to build up electrical charge in the atmosphere

This happen in the presence of high vertical velocities and different hydrometeors

(convective activity)

The forecast problem - II

Convective clouds (i.e. cumulonimbus)

- Humid, warm lower troposphere
- Relatively colder air above
- Cloud characteristics depends on;
 - Vertical temperature profile
 - Availability of humidity
 - Stable layers aloft
 - Wind shear

“Summer convection”
“Cold air outbreaks”

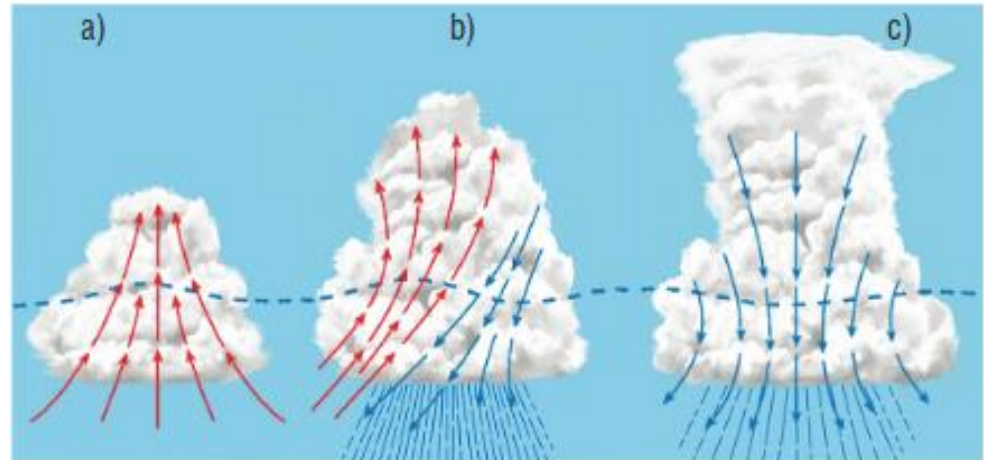
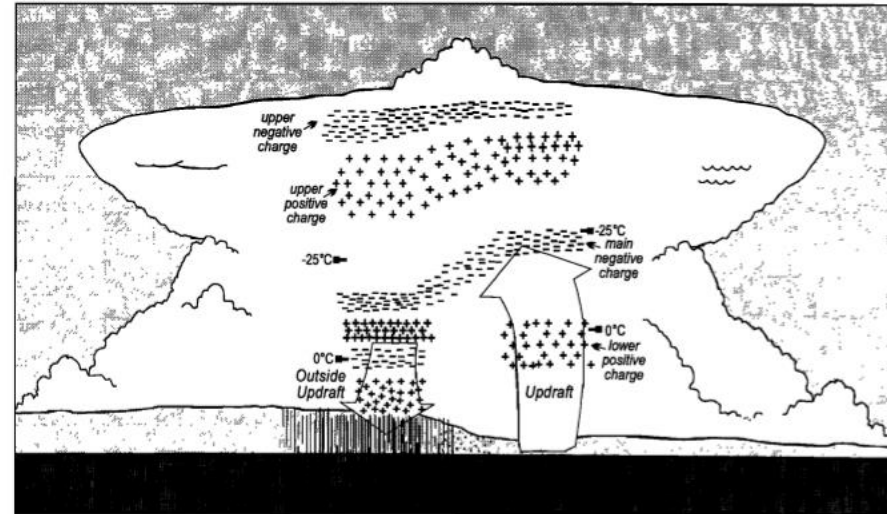


Figure 2 - The thundercell at different stages of its lifetime: a) development stage, when only updrafts are generated; b) mature stage, when updrafts and downdrafts coexist; c) dissipating stage, when only downdrafts subsist.

The forecast problem - III

- **Collision between hydrometeors** exchange charge on particle level.
- **Graupel** play an important role. How graupel charge depend on temperature (positive below -10°C , negative above -10°C) and liquid water content.
- **Up/downdrafts** and different **fall speeds of hydrometeors** create charge separation within the cloud.
- Complex charge structure & necessary with vertical extent.



Stolzenburg et al. (1998)

The forecast problem - IV



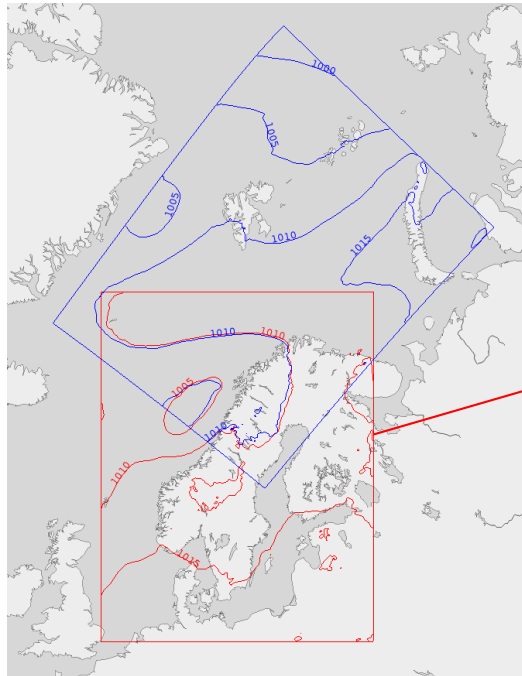
Foto: Kristine Gjesdal

Winter

Cold air & relatively warm water
main charge level (-10°C) closer to surface
Lower cloud tops (tropopause)

Negatively charged helicopters connect
with positive “pockets” in convective clouds
(cumulonimbus)

The forecast system - I



AROME-MetCoOp

*Numerical weather prediction model
basis for all forecasts at MET Norway*

2,5km grid point distance

65 vertical levels

4 x daily (00,06,12,18UTC)

available approx. 2hr 45min later

AROME-Arctic

Similar set up – but different domain

The forecast system - II

Helicopter Triggered lightning Index (HTI)

$$HTI = (T_{ind,750m} + W_{ind,750m} + Precip_{ind} + LowCloud_{ind}) / 4.$$

min value = 0 , no risk

max value = 1 , high risk

continuous index, updated every 6hr

$$T_{ind,750m} = 1 \text{ when } -1C > T_{750m} > -6C$$

$T_{ind,750m}$, linear approach to 1 from 0C to $-1C$ and from $-7C$ to $-6C$

$$W_{ind,750m} = \max \text{ value in a neighbourhood area of } [\min(1, W/0.75)]$$

$$Precip_{ind} = \max \text{ value in a neighborhood area of } [\min(1, prec/0.75)]$$

$$LowCloud_{ind} = \text{maximum cloud cover minus minimum cloud cover in a neighborhood area}$$

temperature
vertical velocity
precipitation intensity
cloud variability

The forecast system - III

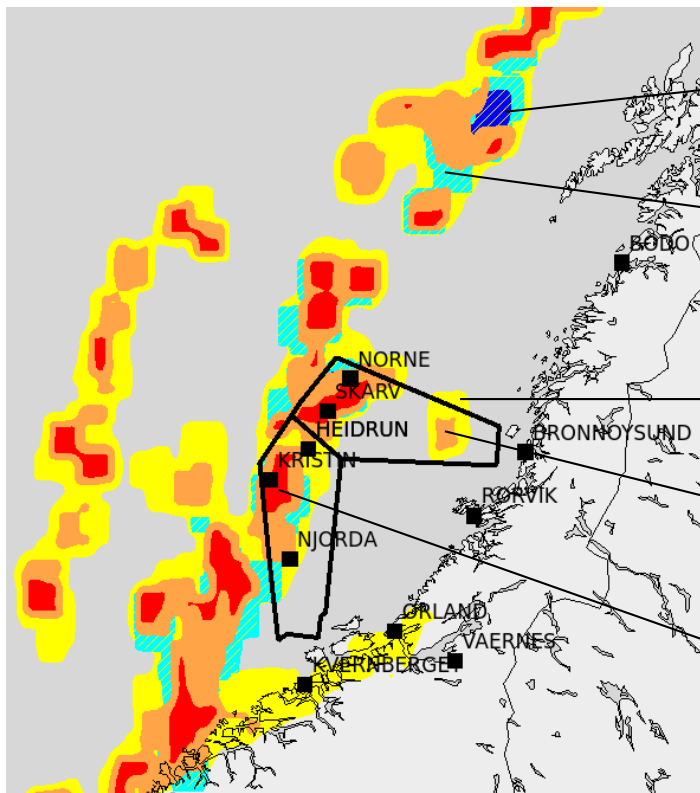
- **Probability of lightning**, based on AROME-MetCoOp model output
 - Logistic regression with input:
 - CAPE (Convective Available Potential Energy), horizontal maximum in a neighborhood area
 - W (vertical velocity lower troposphere), horizontal and vertical maximum in a neighborhood area
 - SI (Shawalter index), horizontal minimum in a neighborhood area.
 - Output, probability lightning strike within a neighborhood area.
 - Updated every 6hr

- **Probability of lightning**, “now casting” based on observations
 - at least one event within 40x40 km² and 1 hour
 - Forecasts: probability of a lightning event +1, +2, ..., +6 hours ahead (hourly updates)
 - Method: logistic regression with input
 - proportion of the 9 nearest boxes with lightning events the last hour
 - proportion of the 9 nearest boxes with lightning events the second last hour
 - whether the lightning activity is increasing (binary)
 - separate logistic regression models for each lead time
 - models estimated using ~8 years of lightning data over the North Sea
 - Output, probability lightning strike within a neighborhood area.
 - Updated every hour

The forecast system - IV

Forecast maps are created at MET Norway,

distributed and presented at www.ippc.no



High risk thunder
(dark blue, prob > 12%)

Risk thunder
(light blue, prob > 4%)

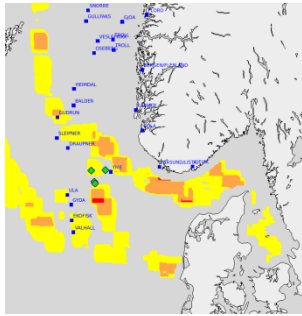
Low risk HTI
(yellow, HTI > 0.76)

Moderate risk HTI
(brown, HTI > 0.95)

High risk HTI
(red > 0.999)

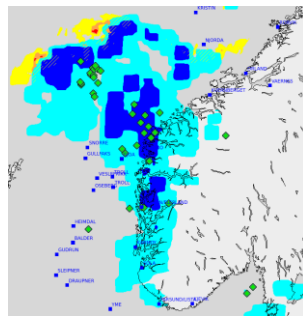
The forecast evaluation – I

Lightning related incidents



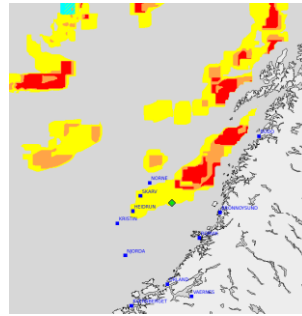
21.01.2015:

On the track between **Sola** and Valhall at 17.05LT at 3000ft (lightning strike). In an area with a yellow forecast issued. However, the forecast maps show that the flight has just passed through a distinct line of yellow, brown and red.



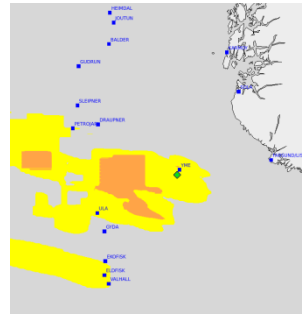
08.11.2013:

Close to **Flesland** at 14.53LT at 1600ft (lightning strike observed close to helicopter). For the Norwegian west coast there are issued a light blue forecast and close to Bergen/Flesland even a dark blue forecast is issued.



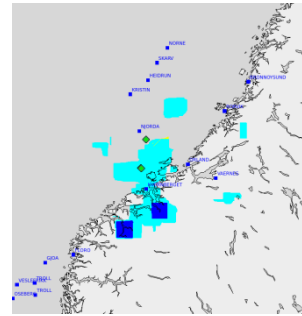
10.04.2013:

Approximately 75NM west of **Brønnøysund** at 12.15LT (static discharge). The registered lightning is at the edge of a yellow area and just south of a brown/red area.



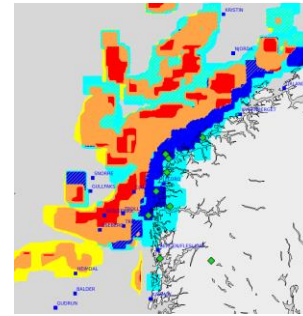
18.03.2013:

Approximately 70NM away from **Sola** at 21.20LT (static discharge or lightning strike). The registered lightning is within an area with a yellow forecast east of an area with brown risk.



22.02.2012:

Close to **Kristiansund** at 2800ft (lightning strike). Blue forecasts are issued close to Kristiansund.



21.10.2010:

Close to **Florø** at 8.15LT at 1500ft (lightning strike). Light and dark blue forecasts are issued close to Florø and brown and red forecasts are issued just offshore of Florø.

The forecast evaluation - II

	<i>Cumulonimbus</i>	<i>Towering cumulus</i>	<i>Showers</i>	<i>Snow</i>	<i>Rain</i>	<i>Graupel</i>	<i>Drizzle</i>	
	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
YELLOW	29,6%	5,8%	50,3%	6,4%	21,7%	2,0%	0,3%	6,6%
NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

Observations conditioned by forecasts

(Norne, Heidrun, Gullfaks, Oseberg, Heimdal, Sleipner, Ekofisk)

The forecast evaluation - II

	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
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NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

9,9% times a warning is issued
1,1% a red warning is issued

The forecast evaluation - II

	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
YELLOW	29,6%	5,8%	50,3%	6,4%	21,7%	2,0%	0,3%	6,6%
NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

49,8% red warnings give observed CB/TCU

58,6% red warnings give showers

The forecast evaluation - II

	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
YELLOW	29,6%	5,8%	50,3%	6,4%	21,7%	2,0%	0,3%	6,6%
NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

CB/TCU/showers are less frequent observed with less severe forecasts

The forecast evaluation - II

	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
YELLOW	29,6%	5,8%	50,3%	6,4%	21,7%	2,0%	0,3%	6,6%
NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

More solid precipitation and more graupel with more severe warnings

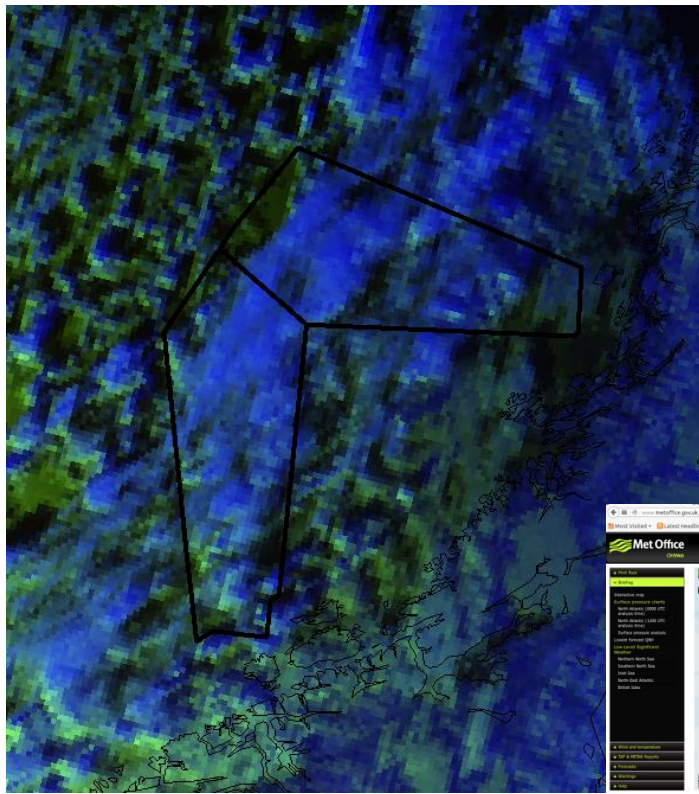
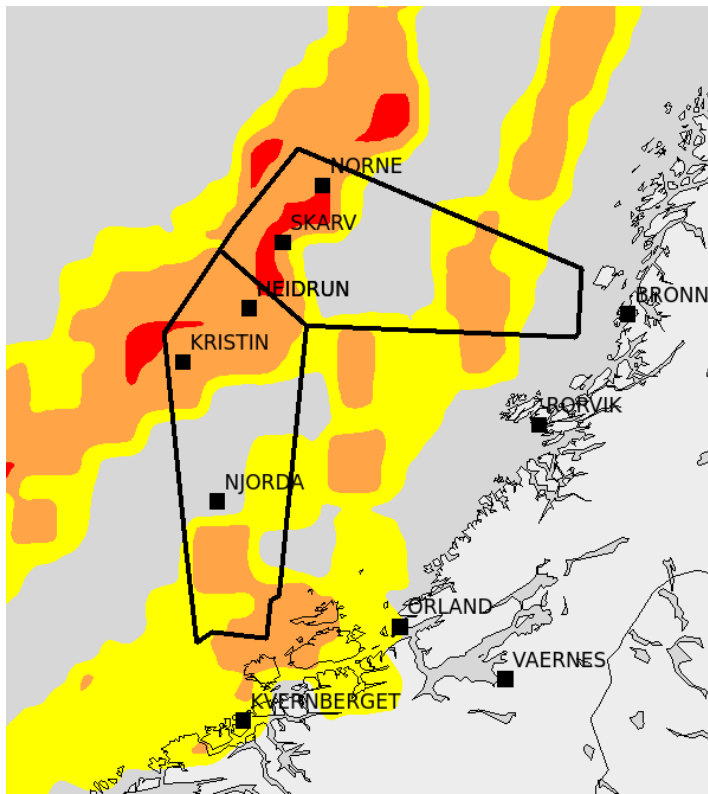
The forecast evaluation - II

	CB	TCU	SH	SN	RA	GS/GR	DZ	TIME
RED	44,3%	5,5%	58,6%	10,1%	26,6%	3,4%	0	1,1%
BROWN	31,4%	5,9%	53,3%	11,6%	21,6%	1,6%	0,2%	2,1%
YELLOW	29,6%	5,8%	50,3%	6,4%	21,7%	2,0%	0,3%	6,6%
NO WARN	9,4%	3,8%	19,0%	1,9%	19,3%	0,2%	1,8%	90,2%

Still some CB/TCU/Showers/graupel in cases with no warning.

The forecast evaluation – IV

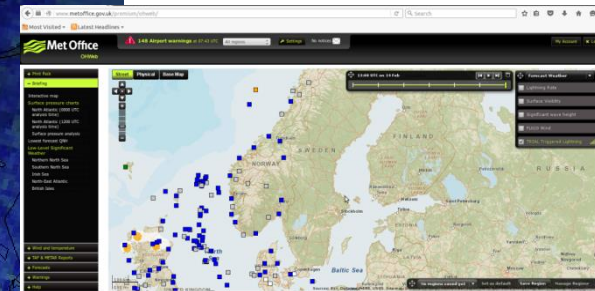
case 14.02.2016 14UTC



Satellite picture
Cloud top temperature $\sim -35^{\circ}\text{C}$
 \Rightarrow Cloud top height $\sim 5000\text{m}$

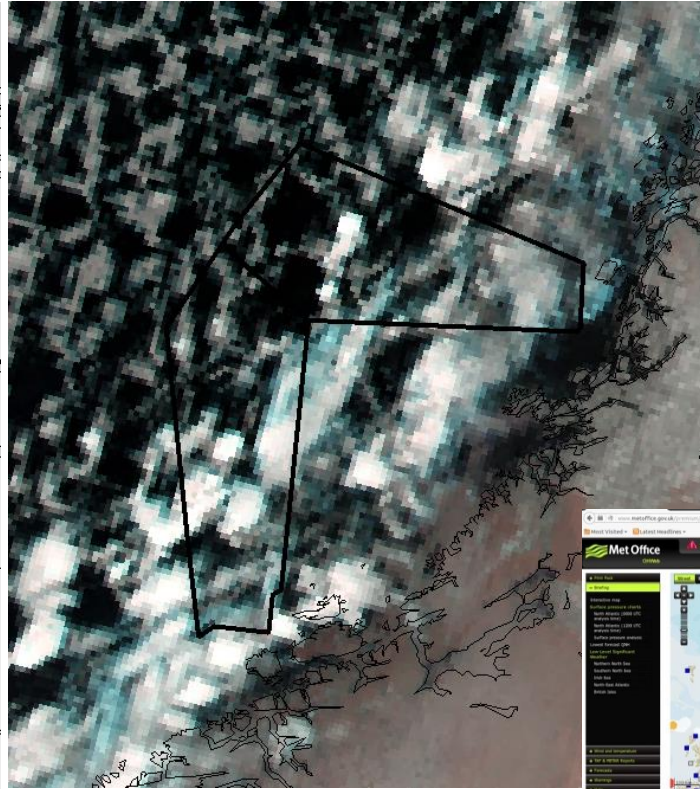
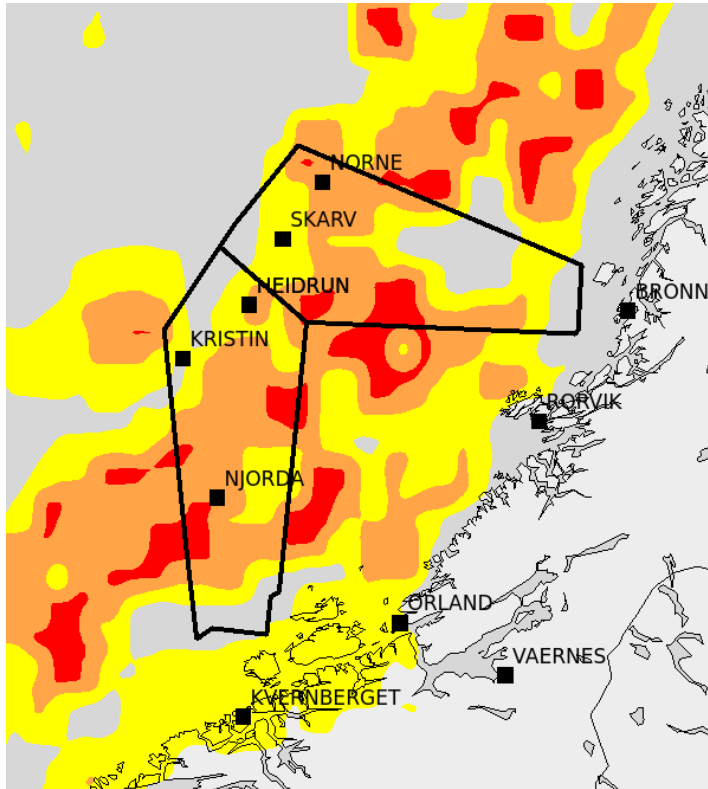
Metar-data
Norne: Showers (snow)
Heidrun: CB/Showers
Kristiansund: Light showers (snow)

Cloud base
FEW011-015
BKN 020-200



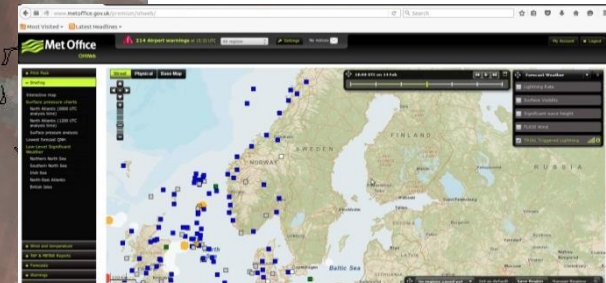
The forecast evaluation – V

case 14.02.2016 18UTC



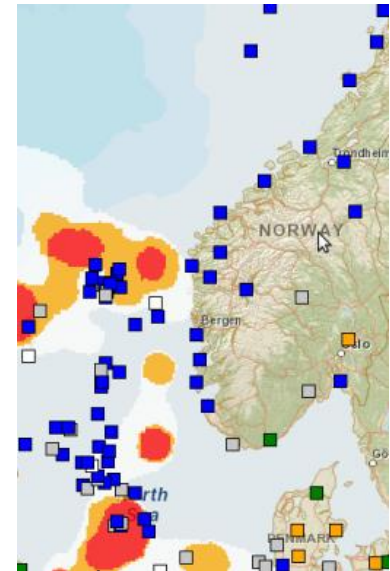
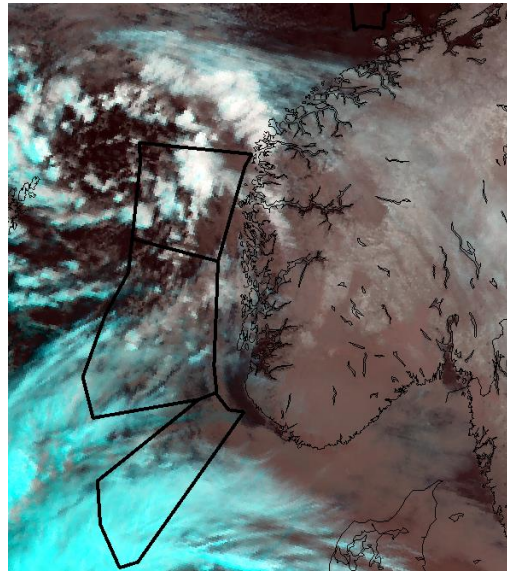
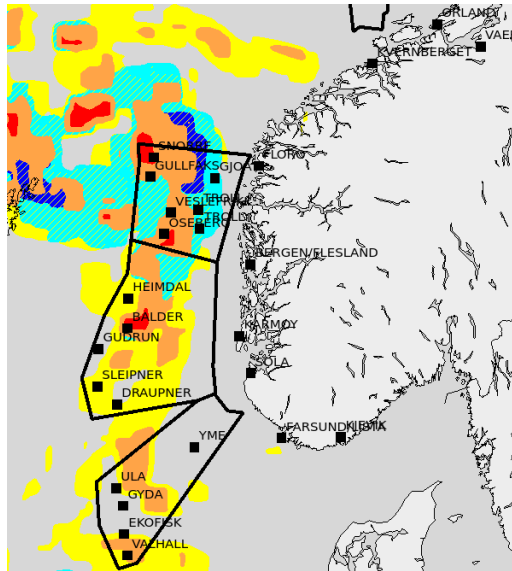
Satellite picture
Cloud top temperature $\sim -40^{\circ}\text{C}$
 \Rightarrow Cloud top height $\sim 5200\text{m}$

Metar-data
Norne: FEW015 (CB at 1720UTC)
Heidrun: FEW023
Kristiansund: Light showers (snow)



The forecast evaluation – VI

case 14.01.2016 15UTC



Coastal airports: some with showers (sleet)

Oseberg: CB/ Showers

Sleipner: SCT020 BKN060

Cloud top temperatures (satellite) $\sim -50^{\circ}\text{C}$ ($\sim 6700\text{m}$), cloud base 1500-2000ft

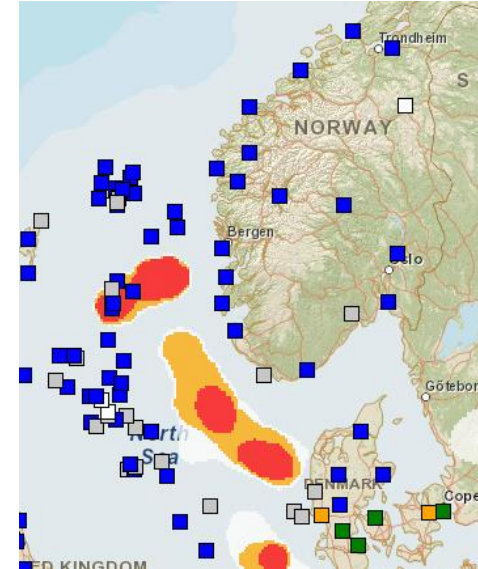
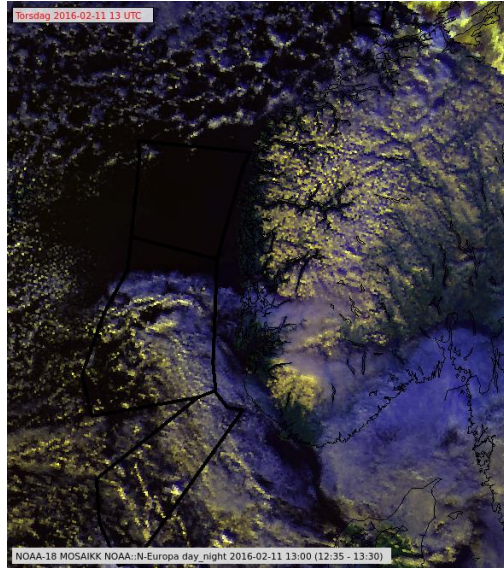
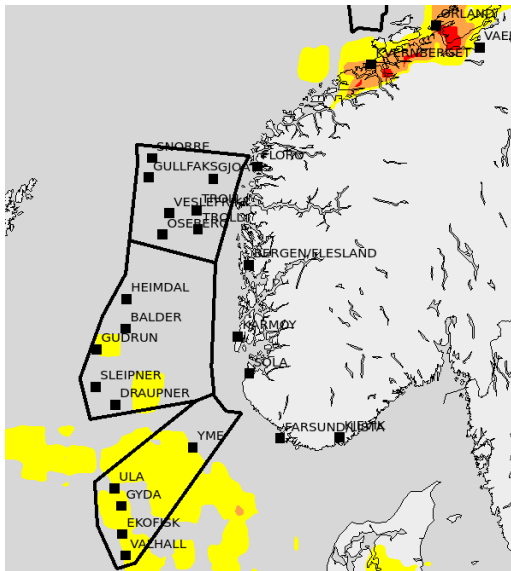
Gullfaks: CB/Showers (rain)

Heimdal: Showers

Ekofisk: CB/Showers

The forecast evaluation – VII

case 11.02.2016 13UTC



Ørlandet/Kristiansund/Molde:

Værnes/Molde/Florø/Bergen/Sola/Gullfaks/Oseberg/Ekofisk:

Heimdal:

CB, Showers, snow

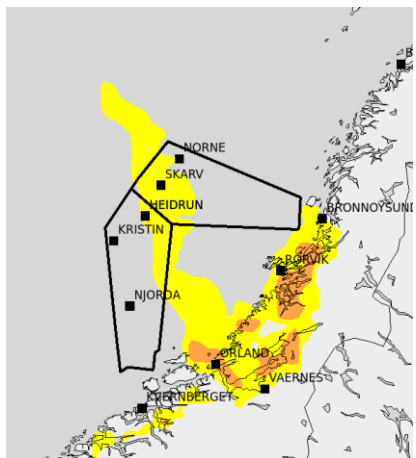
nice weather

Showers (vicinity)

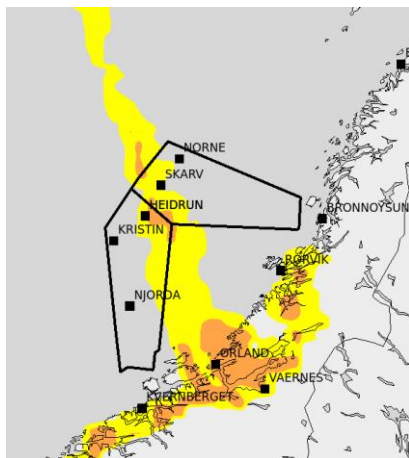
Cloud top temperatures $\sim -17^{\circ}\text{C}$ ($\sim 3000\text{m}$)

The forecast evaluation – VIII

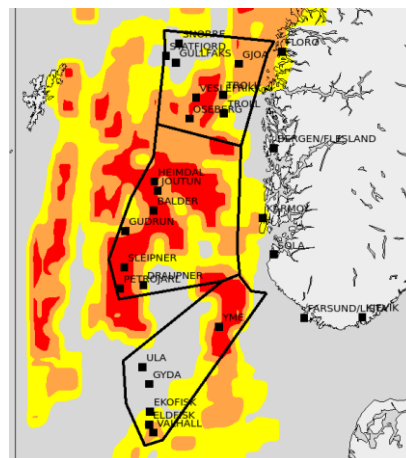
forecast jumpiness



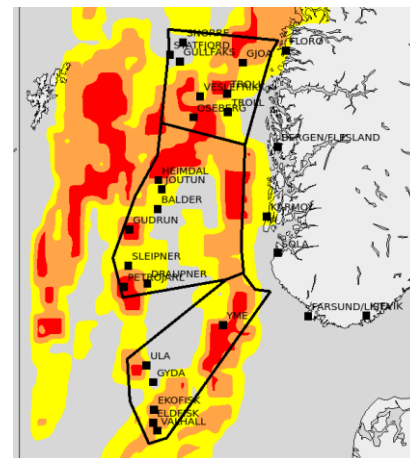
“long forecast”



“short forecast”



“long forecast”



“short forecast”

The forecast evaluation – IX

Bristow (Sola)



Based on 23 reports from flights from Sola, February - April

Lessons learned: HTI chart

	OH - web	HTI
Good correlation	12	18
Poor correlation	4	2
Best correlation	1	5
Most restrictive	12	4
Equally restrictive		4

The forecast evaluation – X Bristow (Sola)

Conclusion

Bristow Norway AS finds that the HTI product in its existing form is a valid tool to be used, in order to avoid helicopter triggered lightning on the North Sea.

We consider the HTI more exact and better suited for operational use, than the OH Web based Triggered Lightning product.

We do emphasize that high focus is kept on verifying that the HTI product is consistent with our expectations - in terms of accuracy – during the implementation phase. This is especially important for operations in the Barents Sea, where available data is less accurate.

The forecast evaluation – XI



CHC (Kristiansund)

Based on 12 flights from Kristiansund

Oppløsning og nøyaktighet

- Tilstrekkelig til å gi indikasjon på HTL forhold i et område slik at farlige områder kan unngås visuelt eller radar. I tillegg gis rom for å ta med tilstrekkelig drivstoff for re-routing.

Approved for Public Release.
Distribution Unlimited.

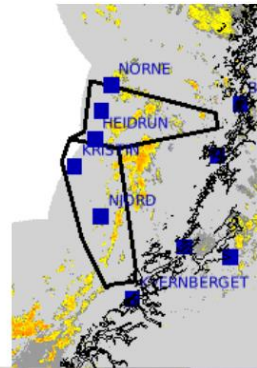
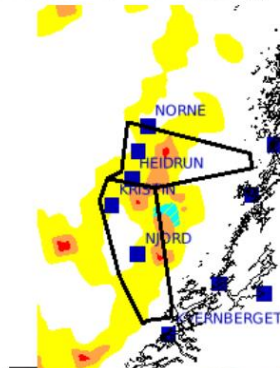
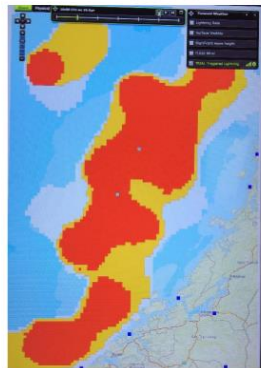


REPORT OF TEST RESULTS

Report : MET Norway HTL forecast evaluation COPY NO. 1 of 1

Evaluation of the MET Norway HTL forecast
as published on IPPC.NO during the winter 2015/2016
for offshore helicopter passenger operations
to the Norwegian continental shelf.

By
Tore Kjelvik
CHC Helikopterservice AS
15th of September 2016



The forecast evaluation – XII

CHC (Kristiansund)

Summary:

The forecast HTL was recognizable as weather, and when compared to observed weather the movements and positions of HTI and related weather systems could be compared and identified. This made the forecast believable, and will be a contribution to weather situational awareness with regard to avoiding HTL and conventional lightning conditions. Accuracy and resolution of forecasted HTL seemed trustworthy and increased alertness and emphasis on circumnavigation around showers. In all, 1 Part I deficiency, 2 Part II deficiencies and 1 enhancing characteristic were identified.

Within the Scope of this test the MET Norway HTL forecast system demonstrated potential for the offshore helicopter passenger transport mission, and will be satisfactory upon correction of the Part I deficiency. Replacement of the OH Web HTL forecast system is recommended for further adjustment, enhancement and evaluation of the MET Norway HTL forecast system.

The future

Appendix 3

Helicopter Triggered Lightning Index

Colour code	Risk	Action
Red	High	Do not plan Flights into Red areas
Brown	Medium	Enter these areas subject to the following conditions. <ul style="list-style-type: none">• Maintain at least 10 NM from CB cells• Avoid heavy precipitation by continuous use of weather radar en route• If possible maintain VMC below cloud base• Avoid wherever safe to do so, the temperature band between -2°C and +2°C• At least 5% additional contingency fuel shall be carried <p>NOTE: During hours of Night, Brown shall be considered Red, and procedures for Red should be followed.</p>
Yellow	Low	No restrictions, but proper caution towards actual conditions (CB's, heavy precipitation, temperature) that may contribute to Triggered Lightning should be exercised. <p>NOTE: During hours of Night, Yellow shall be considered Brown, and procedures for Brown should be followed.</p>
Dark Blue	12% risk of conventional lightning	Enter these areas subject to the following conditions.
Light Blue	4% risk of conventional lightning	<ul style="list-style-type: none">• Maintain at least 10 NM from CB cells• Avoid heavy precipitation by continuous use of weather radar en route• If possible maintain VMC below cloud base• Avoid wherever safe to do so, the temperature band between -2°C and +2°C• At least 5% additional contingency fuel shall be carried

Note: This document is not based on national legislation. It is based on experience and operating procedures from current Off Shore Helicopter Operators. The Procedures are defined in corporation with the Oil Industry Companies.

The forecast system is ready for the winter 2016/17.

Under the trial forecast period HTI only issued offshore. Will start to forecast at coast as well this winter (examples in this presentation include coast)

Procedures for use is needed (suggestion by Bristow/CHC provided).

More frequent (10min) updates of observations, radar and observed lightning, this winter. Latest observations will be shown together with corresponding forecast.

A separate spot at www.ippc.no

More robust internal production is under implementation at MET Norway.

A full report on the system and evaluation of the trial period is soon finished

Some other issues also on the list, but not judged as critical.

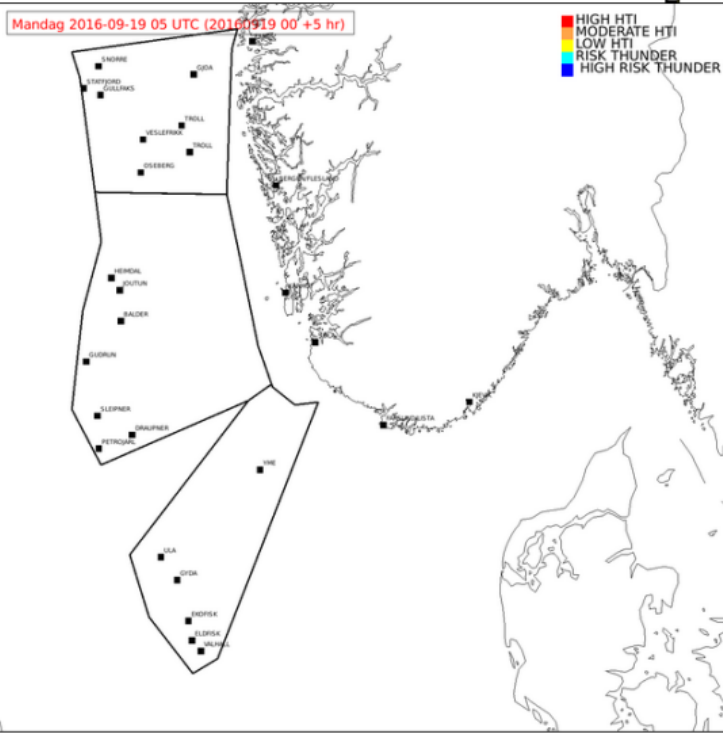
Lightning Warnings Maps - Trial warnings - Helicopter triggered lightning index only issued offshore.

Part of Norway	Type of Warning Map	Commands	
MidNorway	Observations - lightning and precipitation.	Lightning Observations	Animation
MidNorway	Warning - Probability of lightning.	Lightning Warning	Animation
Norway	Observations - lightning and precipitation.	Lightning Observations	Animation
Norway	Warning - Probability of lightning.	Lightning warning	Animation
WestNorway	Observations - lightning and precipitation.	Lightning Observations	Animation
WestNorway	Warning - Probability of lightning.	Lightning Warning	Animation

Mapname: **WestNorway** Added to IPPC: **19.09.2016 11:11** Map Type: **Warning. Probability of lightning.**

Choose to view another map by clicking on the links below.

Time: [05:00] [06:00] [07:00] [08:00] [09:00] [10:00] [11:00] [12:00] [13:00] [14:00] [15:00] [16:00] [17:00] [18:00] [19:00] [20:00] [21:00] [22:00] [23:00] [00:00] [01:00] [02:00] [03:00] [04:00] [05:00] [06:00] [07:00] [08:00] [09:00] [10:00] [11:00] [Print]



Thank you for your attention!

Questions?

**morteno (a) met.no
22963359**