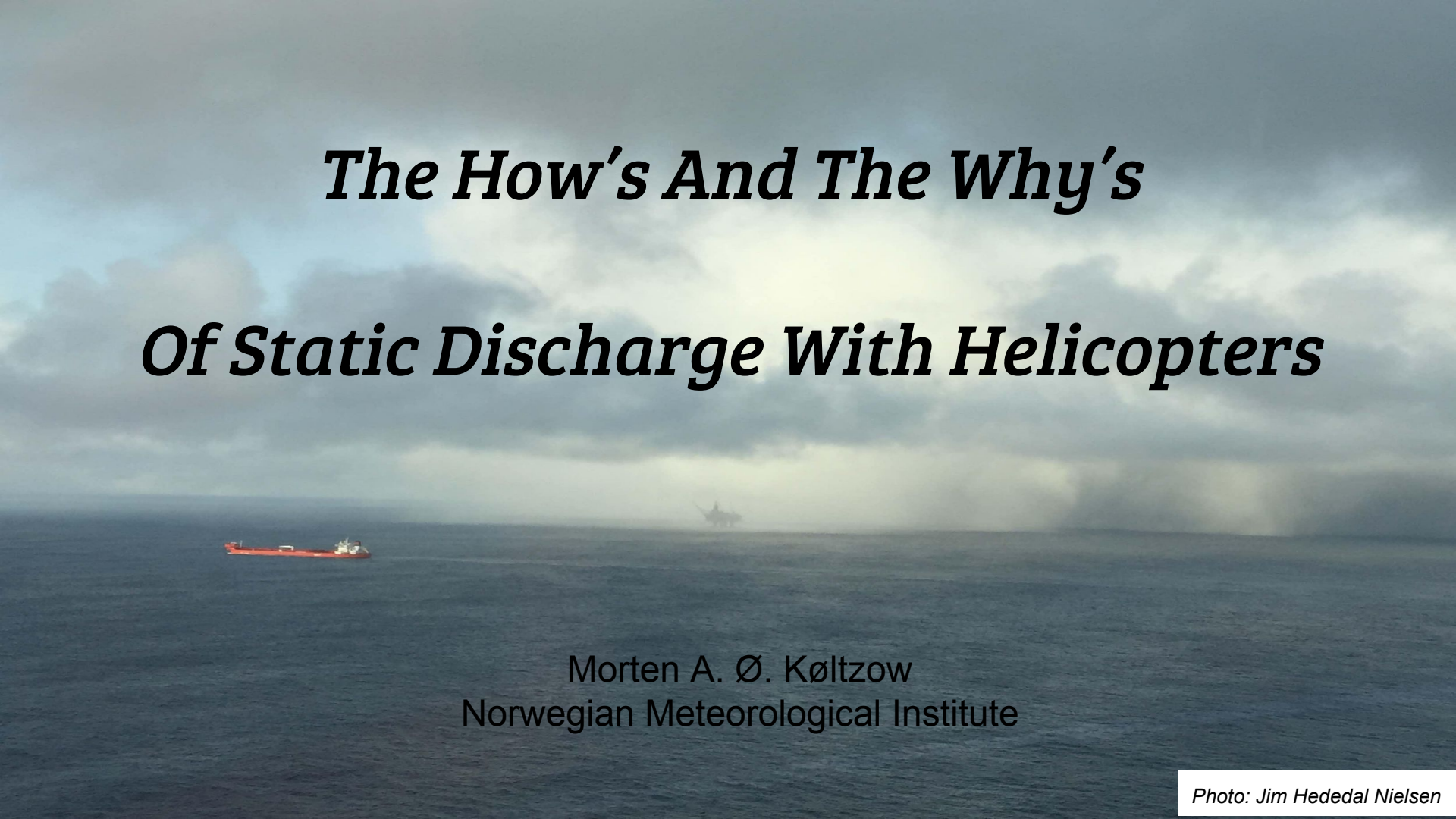
The How's And The Why's

Of Static Discharge With Helicopters



Morten A. Ø. Køltzow
Norwegian Meteorological Institute

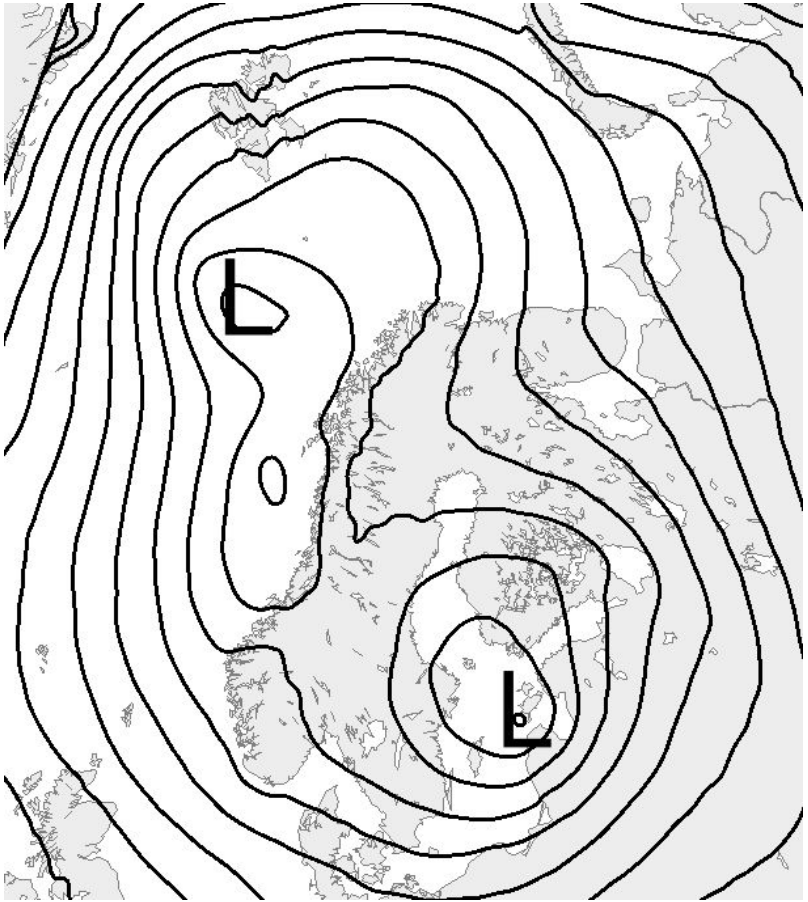
Photo: Jim Hededal Nielsen

Lightning

an electrical discharge
of very short duration and high voltage
(cloud-to-cloud or cloud-to-ground).

Why lightning?

Large scale weather:
Surface heating, cold air above (summer)
Cold (Arctic) air over warm water
Fronts (cold/occluded)



Why lightning?

Large scale weather:
Surface heating, cold air above (summer)
Cold (Arctic) air over warm water
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Convective cloud scale (i.e. cumulonimbus):
Warm air at lower levels make the atmosphere vertical unstable, add moisture and some trigger mechanism for vertical motions and convection starts.

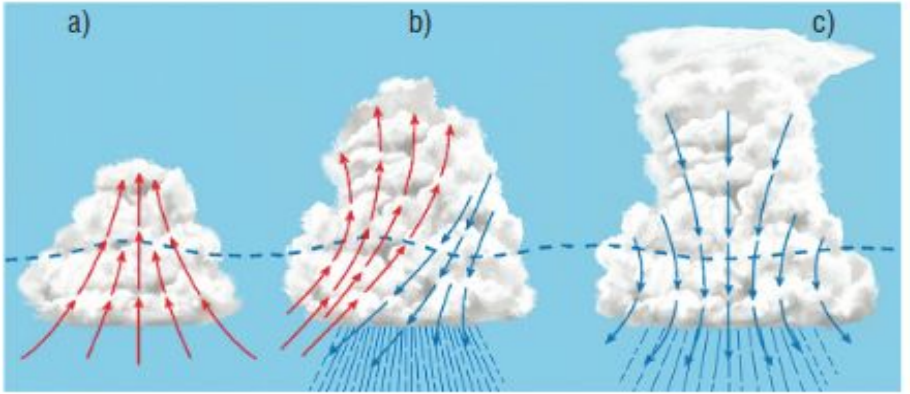

Figure 2 - The thundercell at different stages of its lifetime: a) development stage, when only updrafts are generated; b) mature stage, when updrafts and downdrafts coexist; c) dissipating stage, when only downdrafts subsist.

From: **Electrical Environment in a Storm Cloud**, 2015, S.Soula

Why lightning?

Large scale weather:
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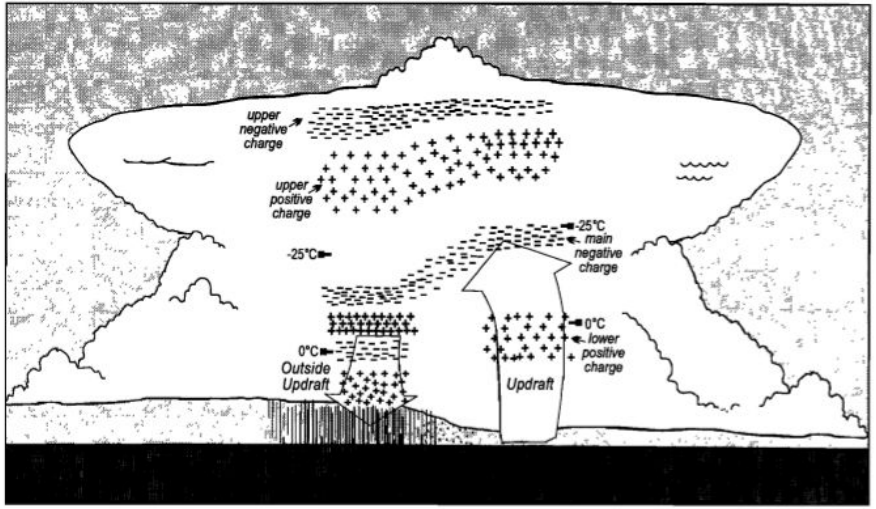
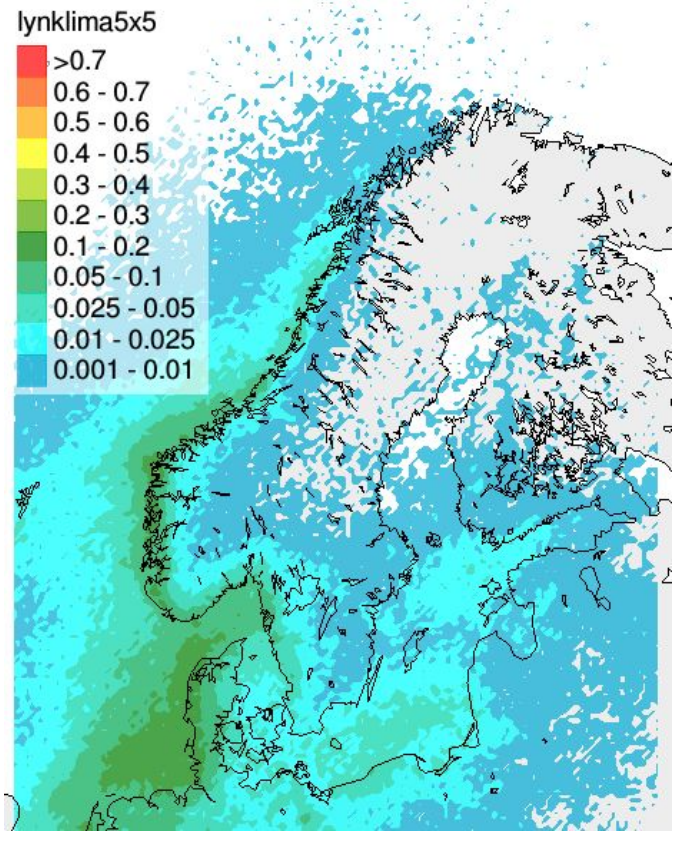
Micro-scale:
Hydrometeors (droplets, snow, graupel …) collide and exchange electrical charge. Most efficient at ~ -10C. The hydrometeors are transported differently in updrafts creating build up of charge.



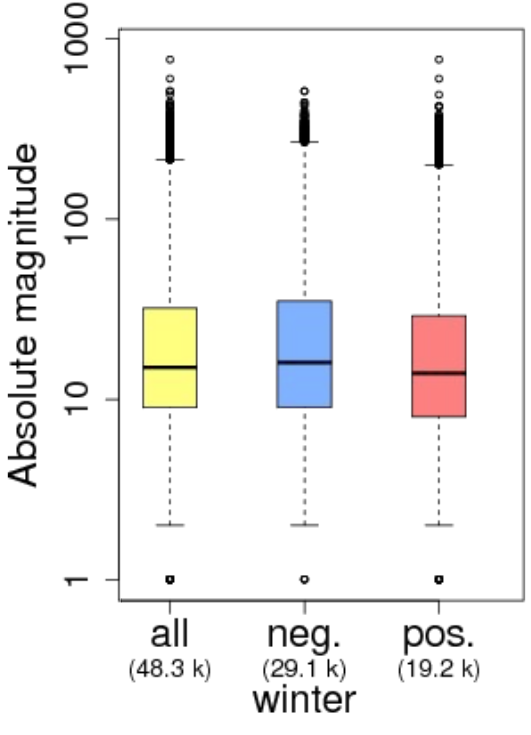
Stolzenburg et al. (1998)

A winter lightning climatology

% of hour with lightning (within 12x12km)
Cold season



Strength (kA)



based on ~ 14 years of observations

Static discharge = Helicopter Triggered Lightning (HTL)

an electrical discharge between helicopter and cloud

(not necessarily observed “natural lightning” in vicinity,
but similar weather conditions)

Why helicopter triggered lightning?

Negatively charged helicopters

Why helicopter triggered lightning?

Negatively charged helicopters

Similar weather types as natural lightning
(but not always observed nat. lightning)

Why helicopter triggered lightning?

Negatively charged helicopters

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Winter:
Charged regions in clouds appear at lower altitudes
(cold part of clouds, with charge exchange, closer to surface 0C)

Why helicopter triggered lightning?

Negatively charged helicopters

Similar weather types as natural lightning
(but not always observed nat. lightning)

Winter:
Charged regions in clouds appear at lower altitudes
(cold part of clouds, with charge exchange, closer to surface 0C)

Typical flight levels closer to charged regions

Helicopter Triggered Lightning (HTL) consequences

Direct thermomechanical effects on helicopters, *caused by extremely high electrical currents passing through the aircraft, can heat up materials and cause extensive or even catastrophic mechanical damage.*

Indirect effects on helicopters, *due to electromagnetic coupling with the helicopter's electrical and electronic systems, can disrupt or damage electronic equipment if it is not protected.*

(http://www.helicopters.airbus.com/website/en/ref/WHEN-LIGHTNING-STRIKES_133.html)

Helicopter Triggered Lightning (HTL) consequences

Helicopter Triggered Lightning (HTL) consequences

Bristow Helicopters
Flight 56C
19 January 1995

By Air Accidents Investigation Branch - http://www.aaib.gov.uk/cms_resources.cfm?file=/2-1997%20G-TIGK.pdf, OGL 3, https://commons.wikimedia.org/w/index.php?curid=38143031

A brief review : "Lande"

SAE TECHNICAL
PAPER SERIES

1999-01-2398

Lightning Strikes on Helicopters – Effects, Detection and Avoidance

Knut Lande
Helikopter Service AS

Reprinted From: Proceedings of the 1999 International Conference on Lightning and Static Electricity (ICOLSE) (P–344)

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International Conference on Lightning and Static Electricity
Toulouse, France
June 22-24, 1999

400 Commonwealth Drive, Warrendale, PA 15096-0001 U.S.A. Tel: (724) 776-4841 Fax: (724) 776-5760

LIGHTNING STRIKE AVOIDANCE PROCEDURE

Conditions for lightning strike

- Outside Air Temperature 0 ± 2°C
- "Dry" precipitation (light snow, snow grains, ice pellets)
- Within 5NM of a Cumulus Nimbus
- Increased precipitation static (CB)
- Visible corona at night (St. Elmos fire)

AVOIDANCE

- Reroute or divert to alternate landing site.
- Pass outside of 5 NM from a CB.
- Descend to warmer OAT (+ 3°C or minimum 500 ft ASL)
- Consider landing at the closest landing site (helideck, rig, suitable landing site).
- If TS or CB activity, use radar to avoid build-ups by more than 5NM.

POST STRIKE PROCEDURE

If struck by lightning as indicated by:

- Flash and/or bang
- Increased vibrations
- Possible failed electrical or avionics equipment.

If abnormally high vibration level:

- Consider land/ditch immediately

If slightly higher vibration level:

- Land as soon as possible at a suitable landing site.

AVOIDANCE PROCEDURE

based on
~ 70 reported cases
(Norway 1979-1999,
UK (1991-1999)

A brief review: "Wilkinson"

METEOROLOGICAL APPLICATIONS
Meteorol. Appl. **20**: 94–106 (2013)
Published online 30 March 2012 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/met.1314

RMetS
Royal Meteorological Society

Investigation and prediction of helicopter-triggered lightning over the North Sea

Jonathan M. Wilkinson,* Helen Wells, Paul R. Field and Paul Agnew
Met Office, Exeter, UK

ABSTRACT: Helicopter-triggered lightning is a phenomenon which affects operations over the North Sea during the winter. It is thought that the presence of the helicopter triggers the majority of lightning strikes, since there is generally little or no natural lightning activity in the area in question prior to or following the strike, and strike rates are much higher than would be expected if due purely to chance. However, there has been little progress to date in the ability to predict triggered lightning strike occurrence with NWP data. Previous attempts have resulted in forecasts which are insufficiently discriminating (i.e. high false alarm rate) to be of practical use.

In this study, previous work on triggered lightning is reviewed and case studies are examined in order to identify common meteorological conditions for helicopter-triggered lightning strikes. Using forecast data from the Met Office Unified Model, an algorithm for triggered lightning risk was produced based on outside air temperature and precipitation rate. Evaluation against past helicopter strike cases has demonstrated that the new algorithm successfully forecasts lightning risk on 80% of occasions when triggered lightning occurred. In addition, the algorithm correctly forecast 8/9 natural lightning strikes which were observed in the operating area during winter 2010–2011. The areas of risk highlighted are usually small, which should allow helicopter operators to plan flights around high risk regions. The information in this study can also be used to inform helicopter operators of the likely conditions in which triggered lightning strikes occur.

KEY WORDS Unified Model; microphysics; thunderstorm electrification; convective clouds; cold air outbreak; aviation

Received 16 December 2011; Revised 20 February 2012; Accepted 27 February 2012

In depth study on the meteorological aspects of triggered lightning and basis for

UK MET OFFICE WARNING SYSTEM.

https://www.bbc.co.uk/news/uk-scotland-north-east-orkney-shetland-31206363

A brief review: "Met Norway"

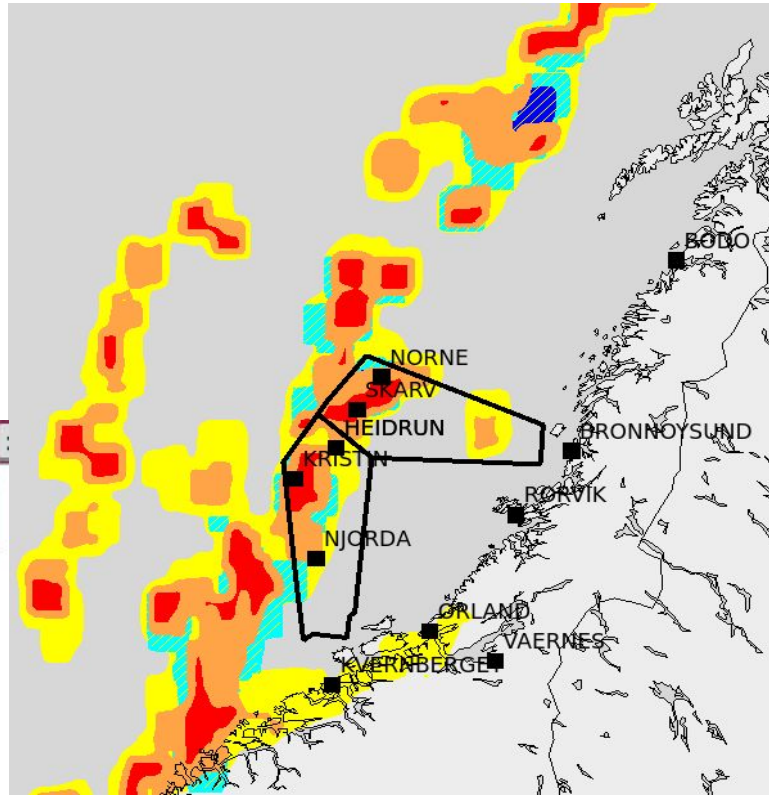
MET NORWAY FORECAST SYSTEM

- Based on *Lande*, *Wilkinson*, analysis of *recent incidents* and the operational *high resolution weather model* at MET Norway
- Available at ippc.no (automatic generated product)
- Evaluation after/ dialogue during each season
- Winter seasons 15/16 (first trial), 16/17 (trial), 17/18 & 18/19 (main tool)

Lightning Maps

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

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

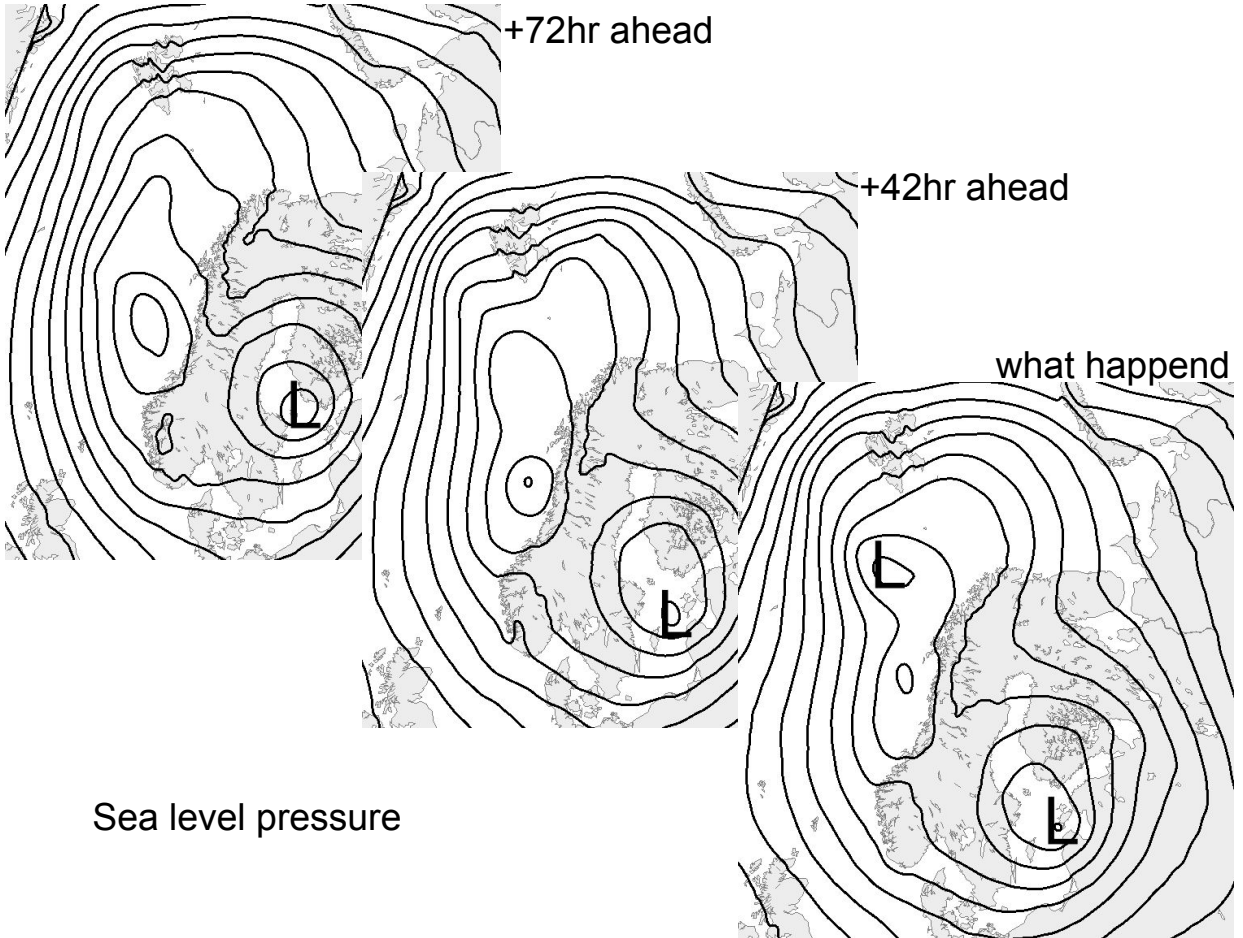


Low risk HTL (yellow)
Medium risk HTL (brown)
High risk HTL (red)

How to forecast lightning?

Large scale weather forecasting

- Spatial scales ~ 1000 km
- Temporal scales ~ days
- (Often) High predictability
- Well forecasted



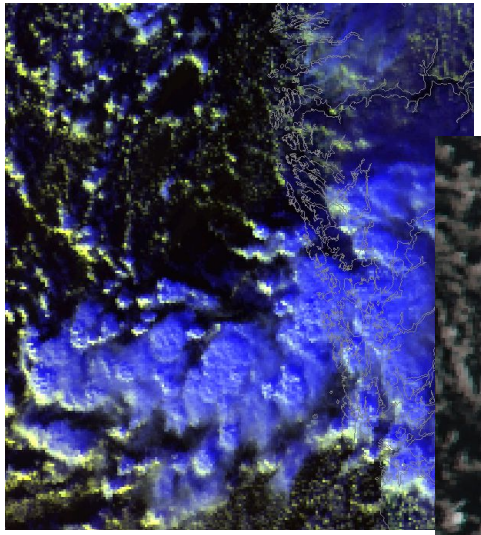
How to forecast lightning?

Convective scales

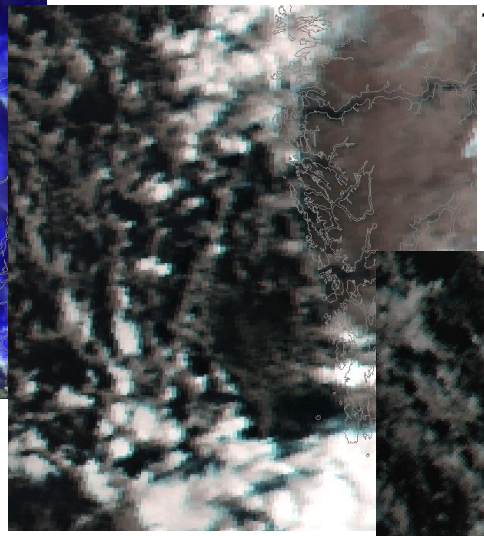
- Spatial scales ~ 1-10 km
- Temporal scales ~ hours
- Low predictability
- Difficult/impossible to forecast exact position of individual cells. Location and intensity varies fast

Micro-scales

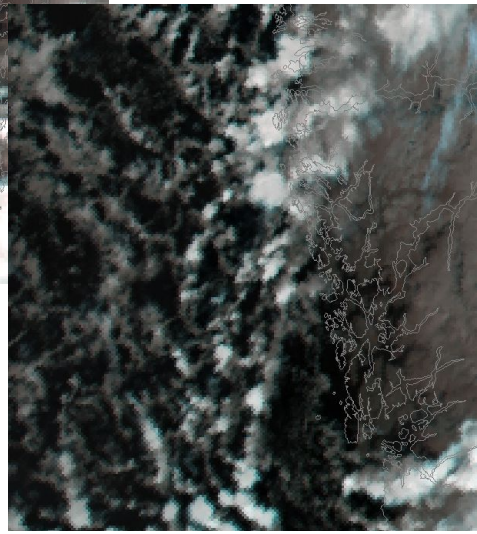
What happens inside the clouds, can in a forecasting perspective, only be estimated.



13.46UTC



15.29UTC



16.47UTC

satellite pictures of cloud top temperatures
(more white colors = deeper convection)

How to forecast weather?

In practise:

Every 6hr we collect observations of the atmosphere, make an analysis of the weather at that very moment and compute how it develops.

Numerical weather Prediction model (2.5km between computational points, partly resolving convection). The resolution of forecasts are limited by computational costs.

How to forecast helicopter triggered lightning?

The micro-scale processes of lightning is not explicitly described in the models. Needs to be estimated, by "Helicopter Triggered Index".

Helicopter trigged 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

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

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

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

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

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

Notice that forecast is related to typical flight level
(model values are averages of 2.5 x 2.5km, not point values)

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Show HTI on maps colored with:

High risk HTL (red)

Medium risk HTL (brown)

Low risk HTL (yellow)

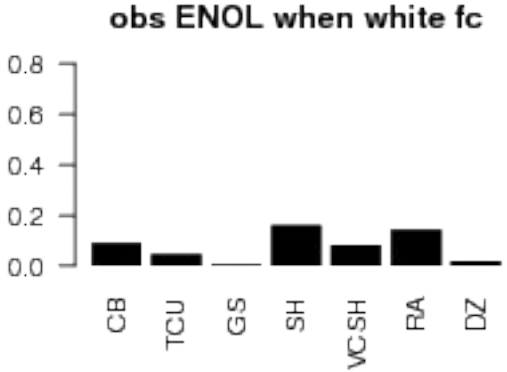
HTI very close to 1

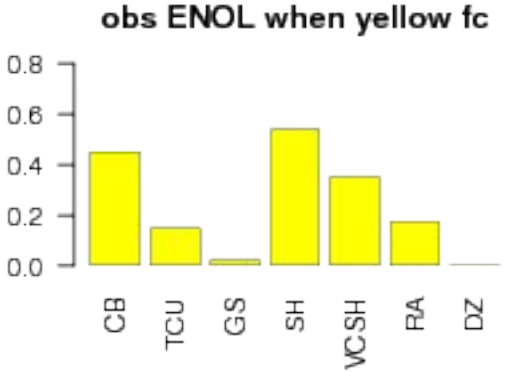
HTI close to 1

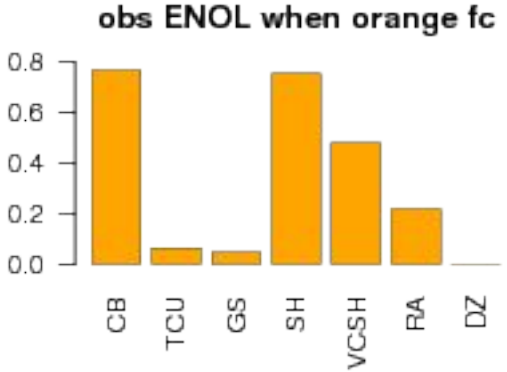
HTI contr from all 4 terms

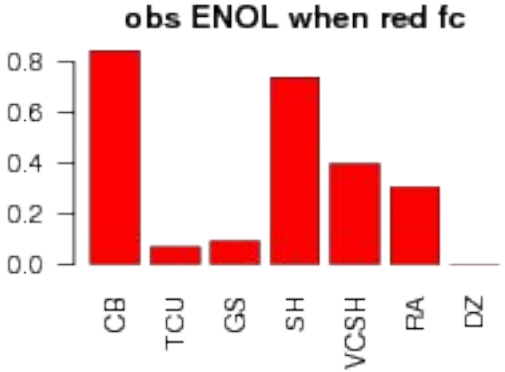
Correspondence between forecast and observed weather?

What is observed given a white, yellow, brown, red forecast?







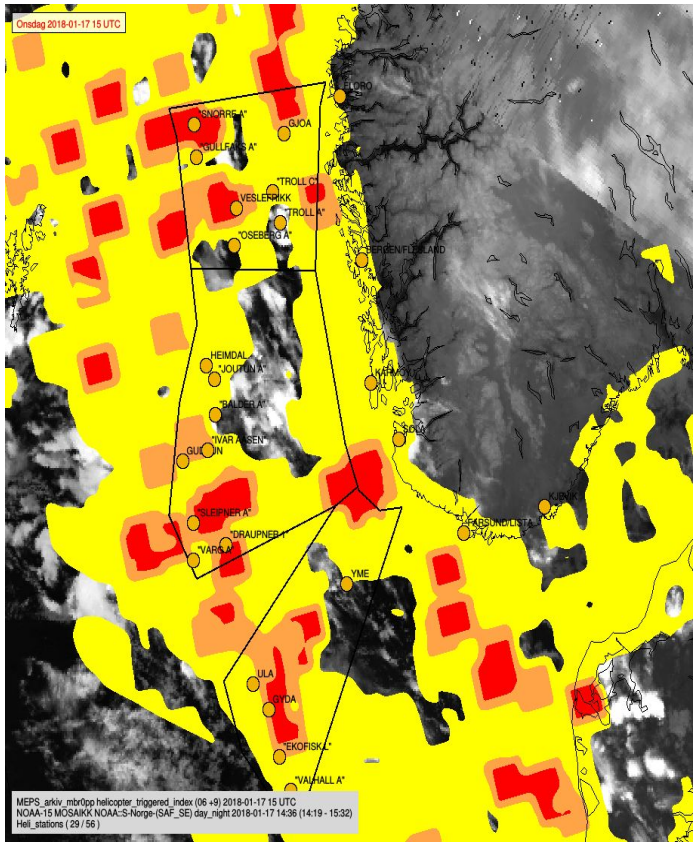


When a high risk is forecasted

“Triggered lightning conditions” are frequently observed

So if this is the forecast, do you fly?

Low risk HTL (yellow)
Medium risk HTL (brown)
High risk HTL (red)

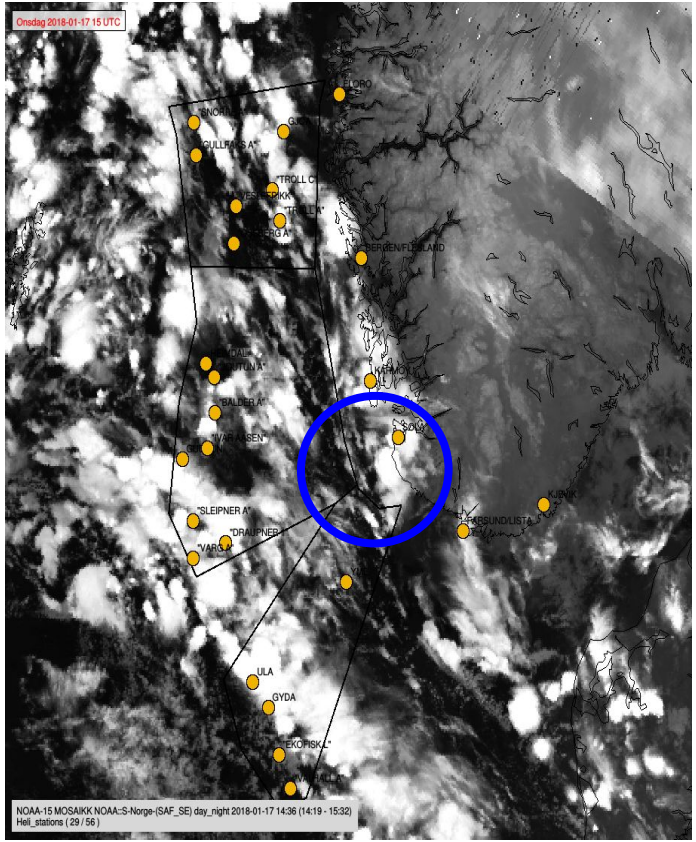


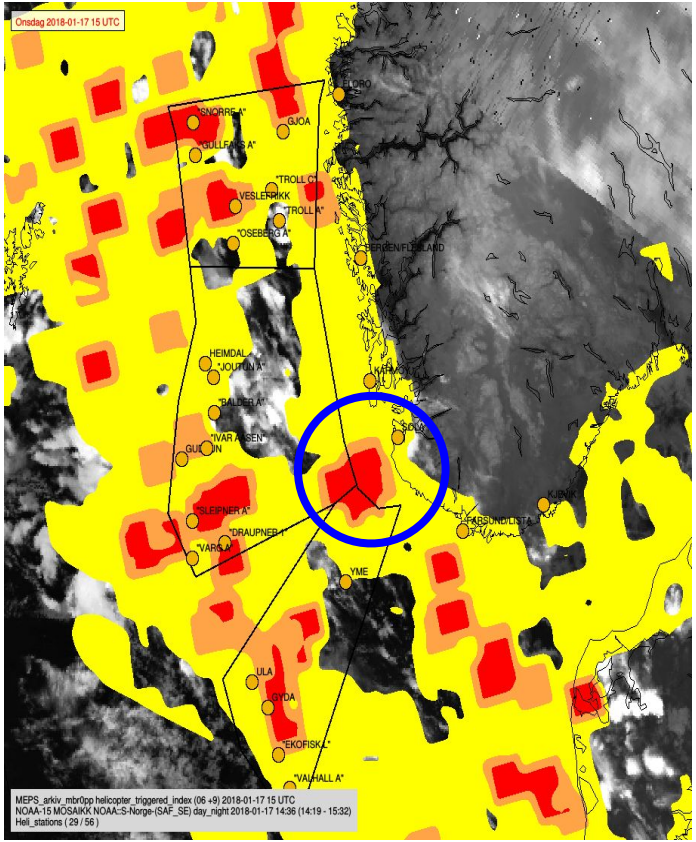
In addition pilots consider:

- *forecasts valid hours before/after*
- *radar and other observations*
- *extra contingency fuel to deviate areas*
- *possible re-routing*
- *their experience*
- *advice from operational duty officer in company*

17.January 15UTC

The forecast do have inaccuracies!





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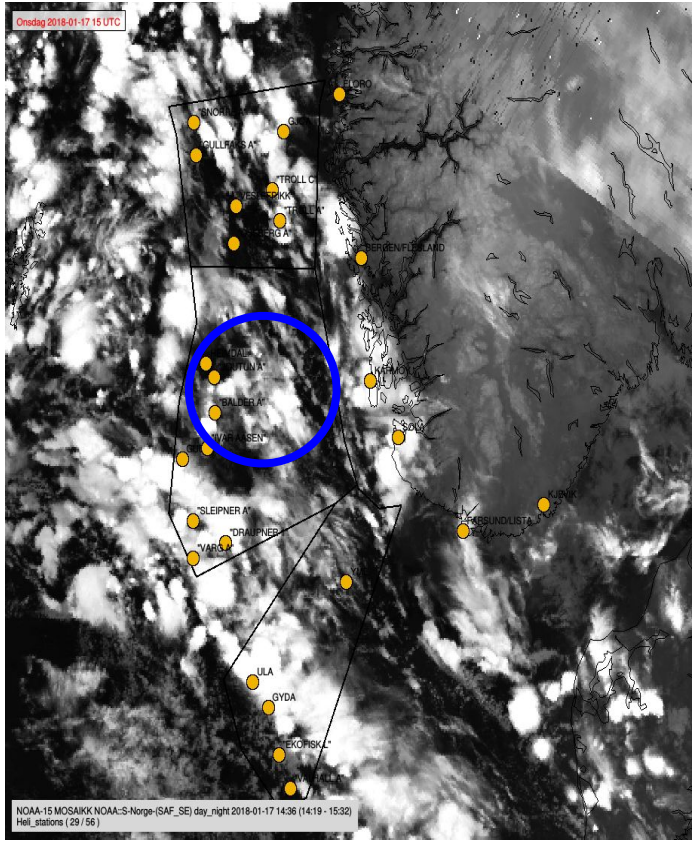

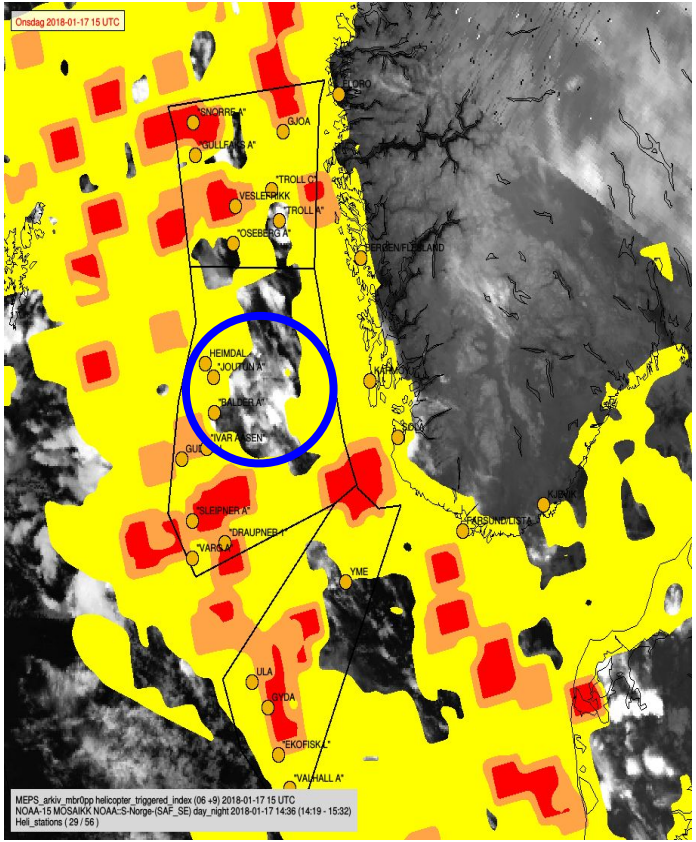

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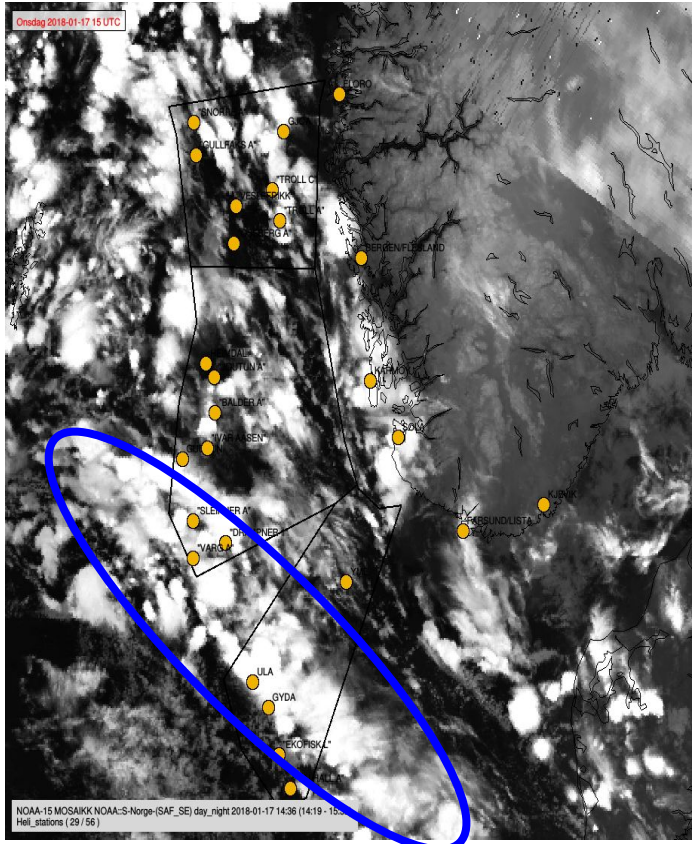
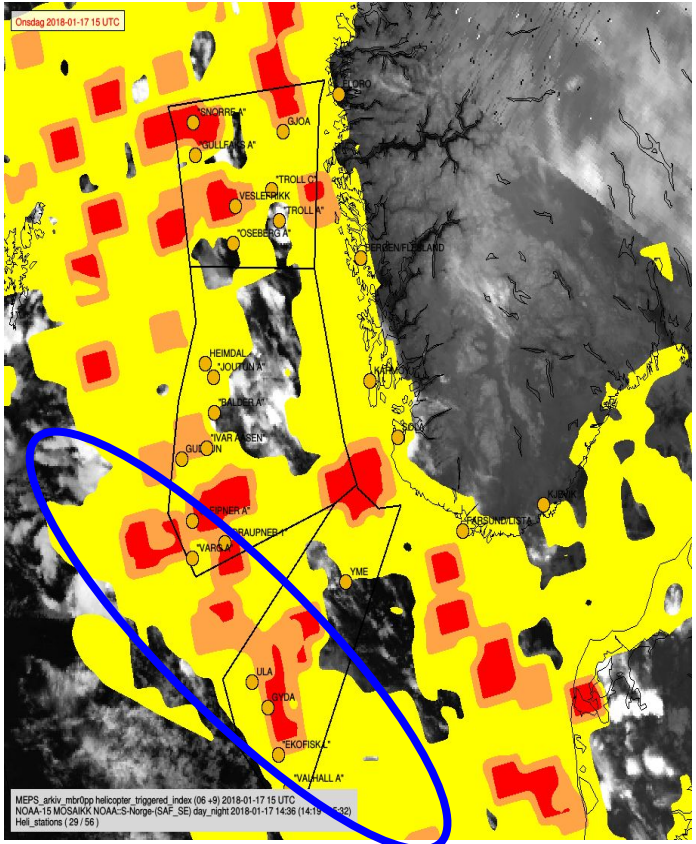




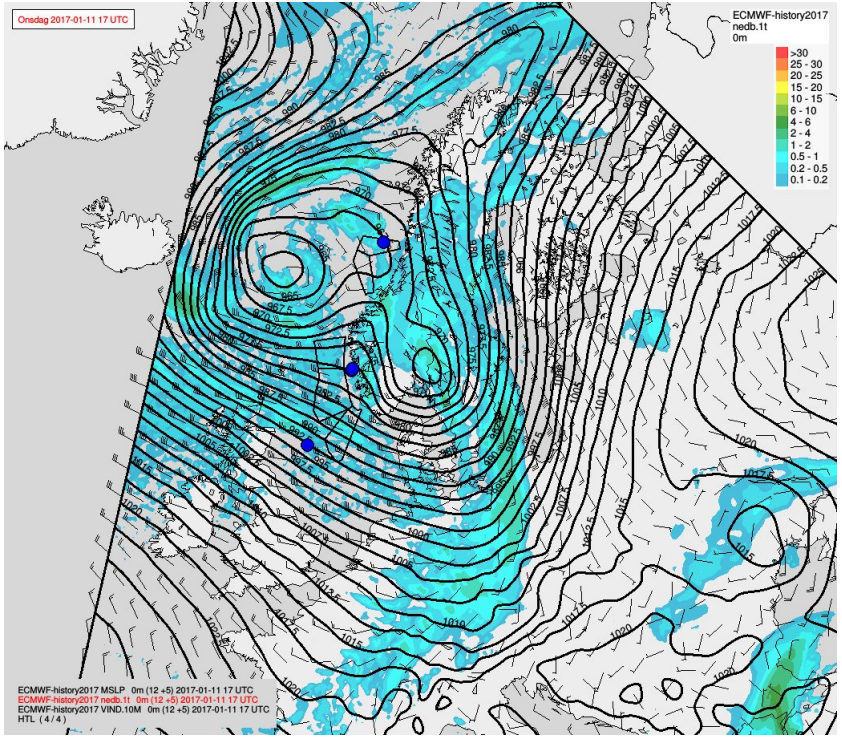
Low risk HTL (yellow)
Medium risk HTL (brown)
High risk HTL (red)

17.January 15UTC

What to learn from recent triggered lightnings?

Large scale weather:

- *Long fetch over ocean*
- *Reduced vertical stability*



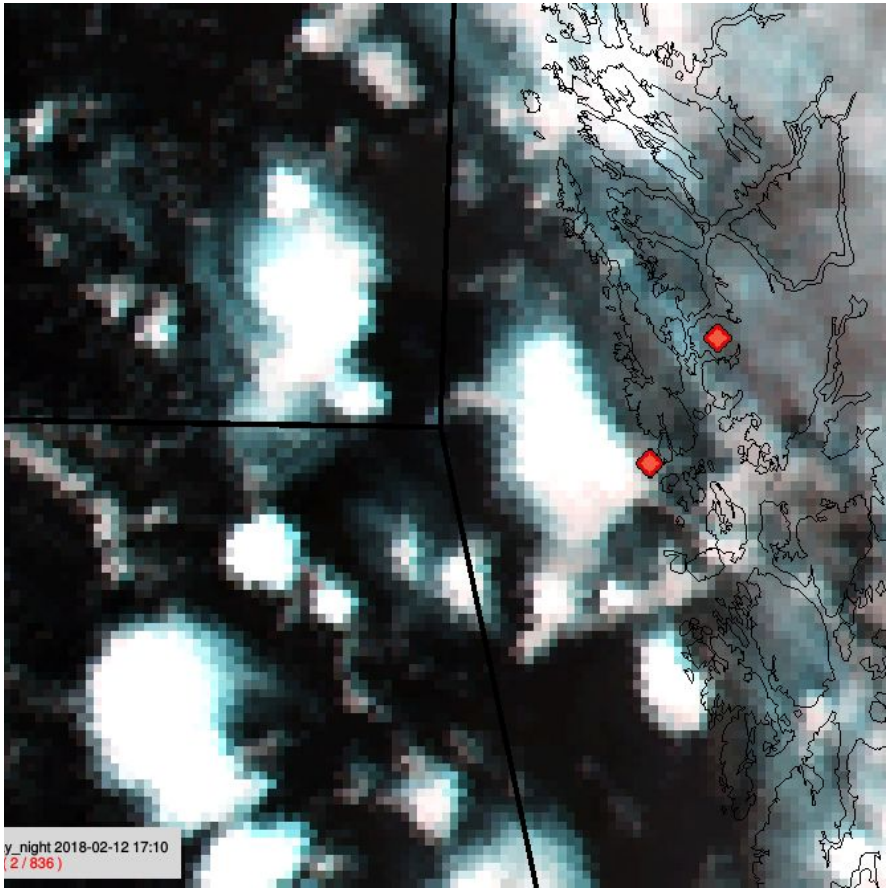
What to learn from recent triggered lightnings?

Large scale weather:

- *Long fetch over ocean*
- *Reduced vertical stability*

Observed weather:

- *~ 0C,*
- *light snow / snow showers*
- *CB (fronts, embedded, “ocnl”)*
- *Deep or shallow convection*
- *Reduced visibility for pilots (dark or front systems)*



What to learn from recent triggered lightnings?

Large scale weather:

- *Long fetch over ocean*
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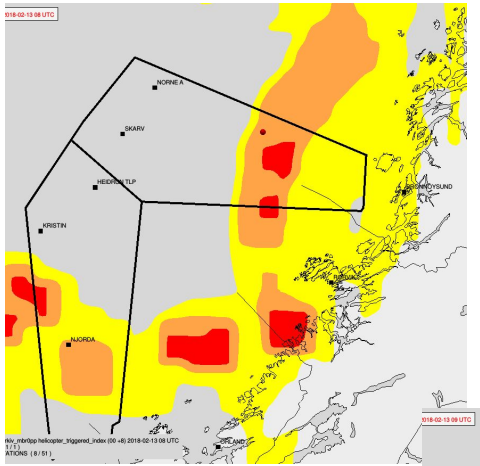
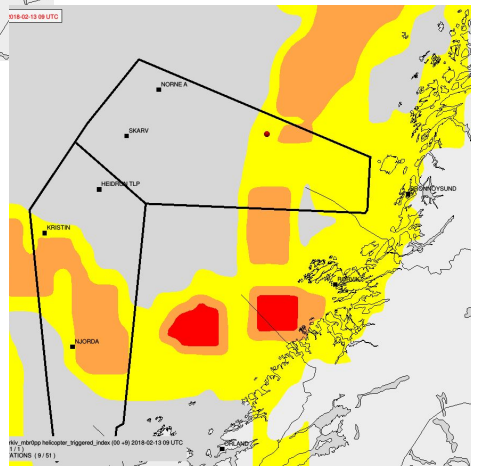
- *flights in ~ 0C,*
- *light snow / snow showers*
- *CB (fronts, embedded, “ocnl”)*
- *Deep or shallow convection*
- *Reduced visibility for pilots (dark or front systems)*

Forecasts:

- *Forecasted risk (i.e. brown) nearby, but not necessarily “spot-on” in space/time.*
- *Often when the the forecast risk changes.*





forecast valid 1hr later

Pilots feedback

- **Main feedback: useful tool - convective activity is seen where expected from the forecast**
- **Improved tuning of thresholds for red - brown - yellow forecasts possible (under discussion)**
- **The forecast are from time to time “jumpy north of Brønnøysund”**
- **Consistent warnings in “flow against topography” create frustration**

and finally ....

The way forward towards

- **improved forecasts,**
- **consistent interpretation,**
- **best practical usage**

is a cooperation between helicopter services, oil companies, Avinor and MET Norway

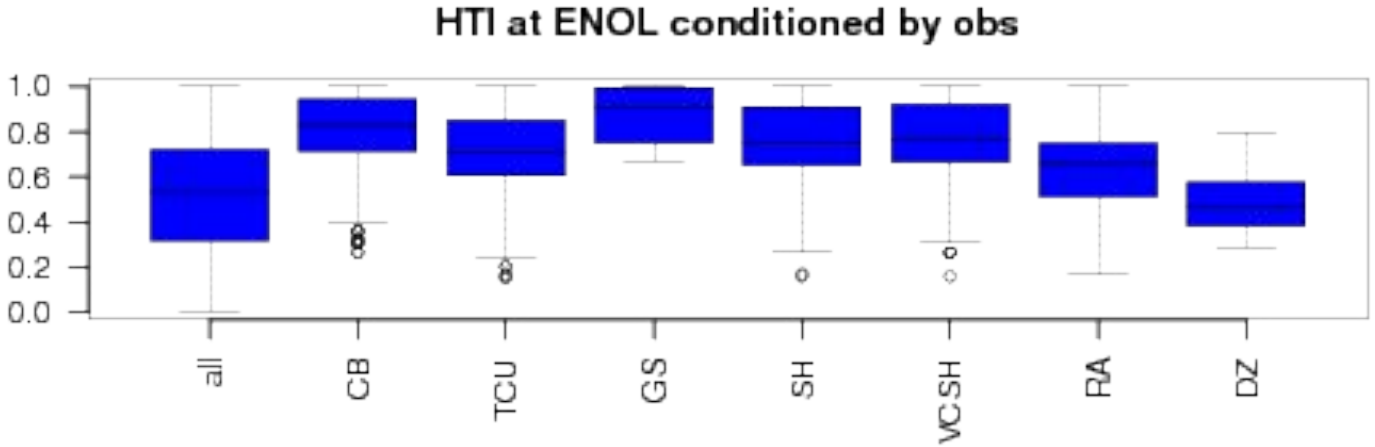
Thank you for your attention!

Questions?

morteno(@)met.no
Norwegian Meteorological Institute open data:
thredds.met.no, api.met.no

Correspondence between forecast and observed weather?

What is the forecast given a specific observation?

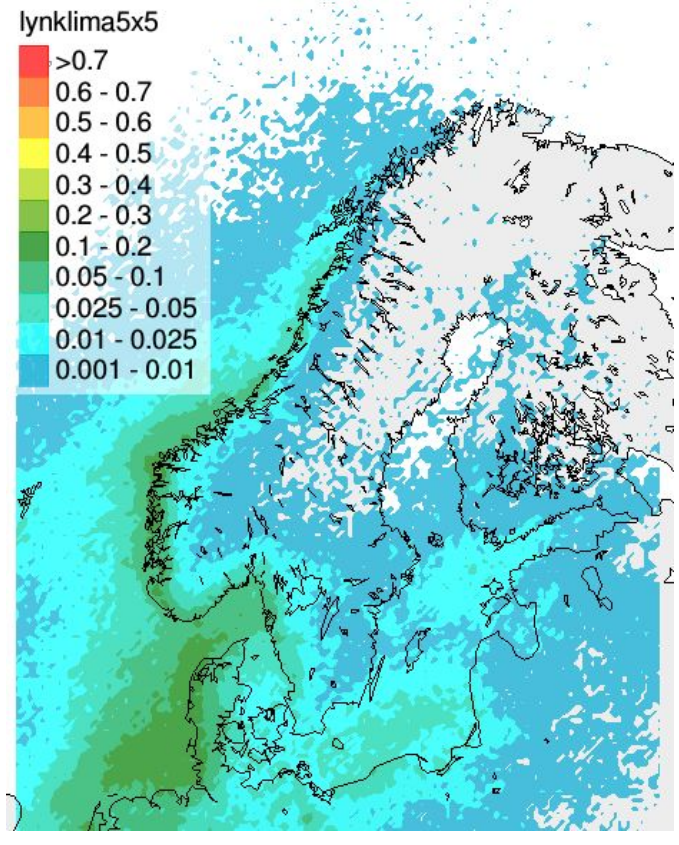


IF "TRIGGERED LIGHTNING CONDITONS" ARE OBSERVED
A HIGH RISK IS ALSO FORECASTED

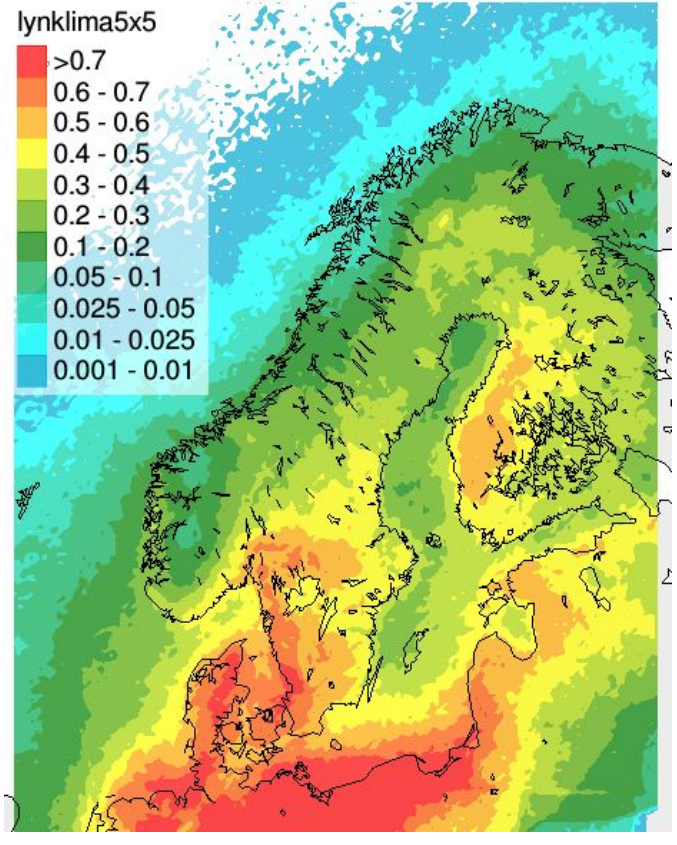
A lightning climatology

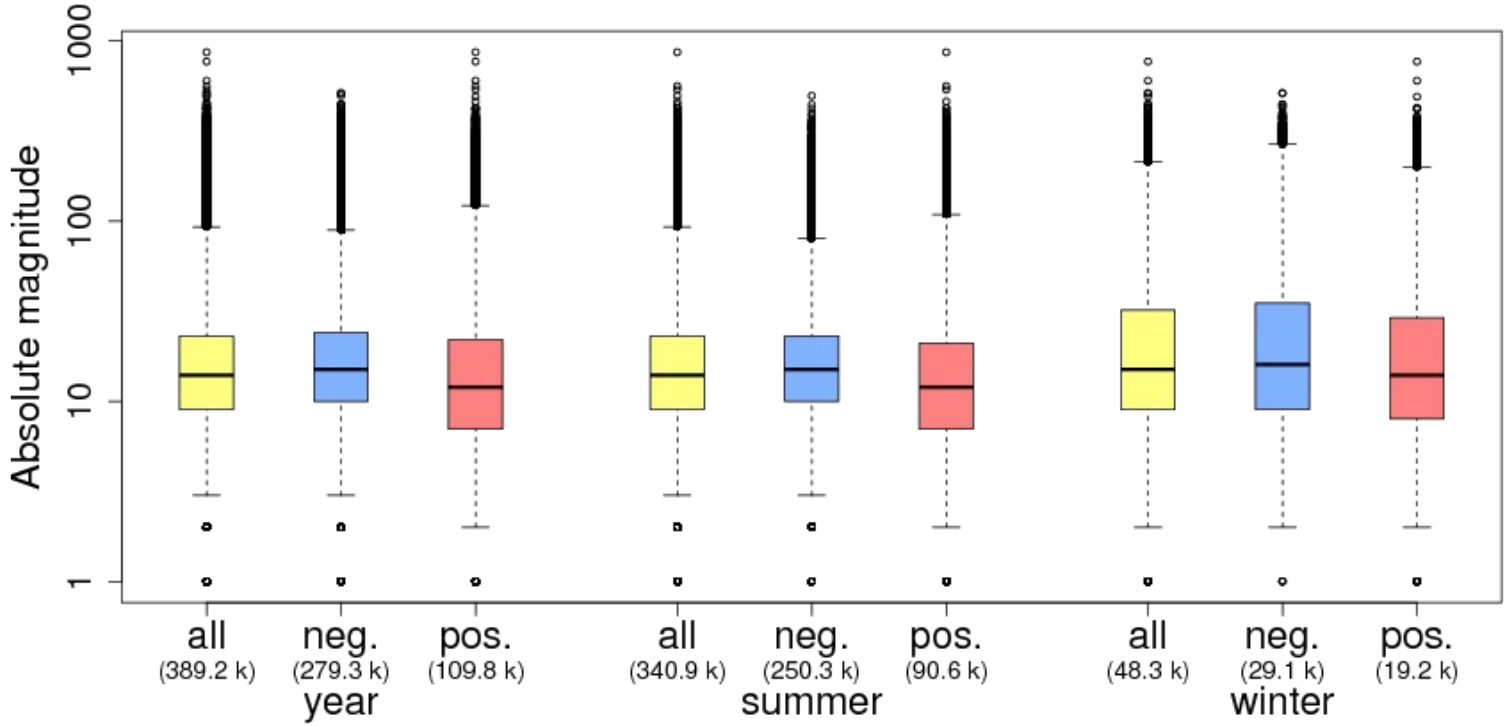
% of hour with lightning

Cold season



Warm season




Absolute magnitude
1000
100
10
1
all
(389.2 k)
neg.
(279.3 k)
pos.
(109.8 k)
year
all
(340.9 k)
neg.
(250.3 k)
pos.
(90.6 k)
summer
all
(48.3 k)
neg.
(29.1 k)
pos.
(19.2 k)
winter