

# Introducing the Storm Karl case study

A hands-on introduction to NWP modelling – OpenIFS Practicals

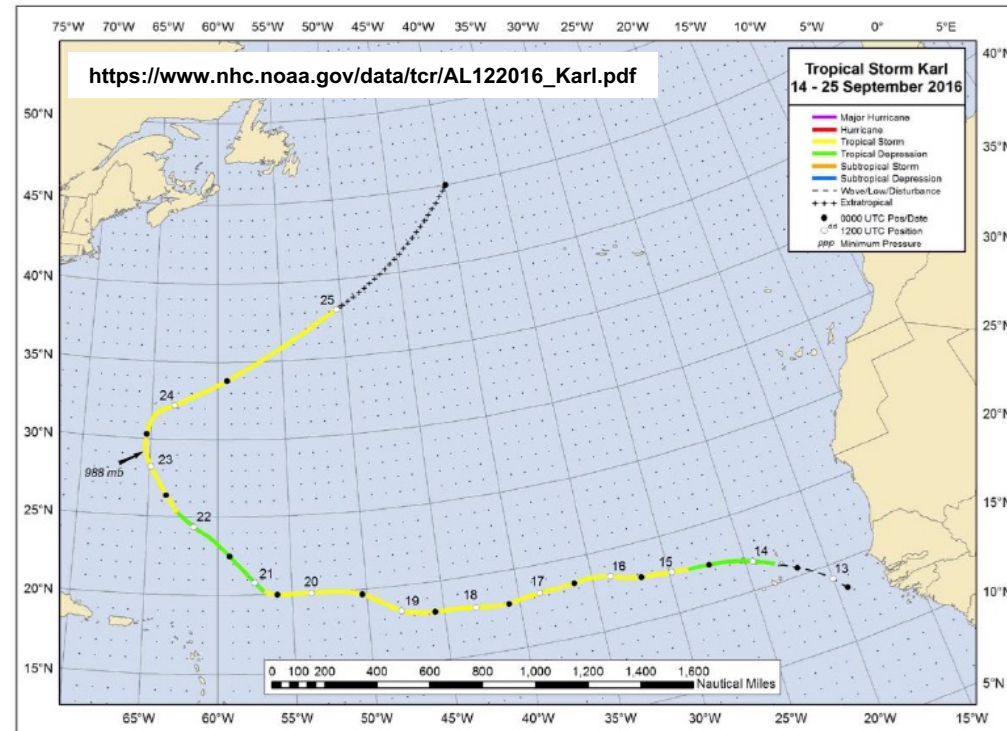
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# Storm Karl – September 2016



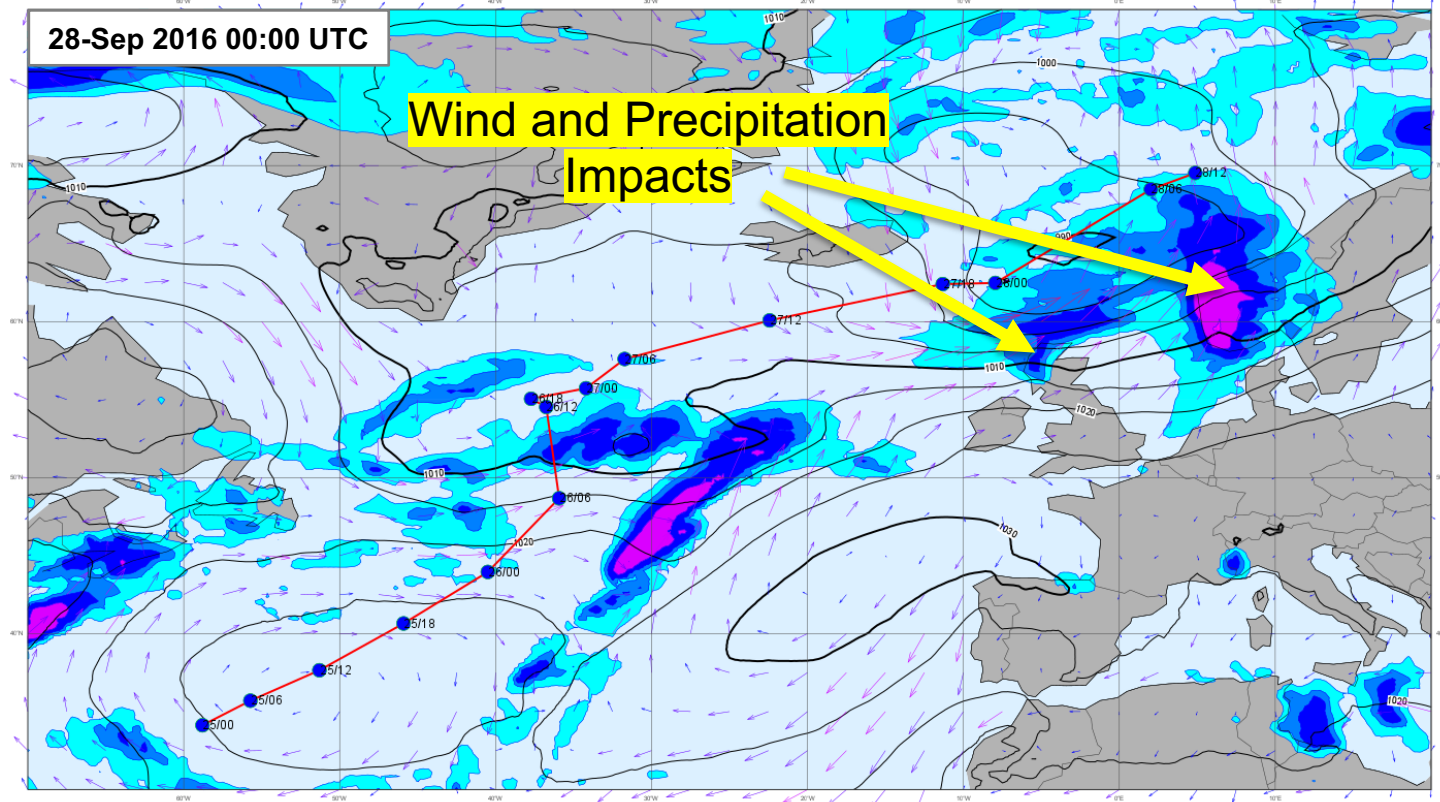
TROPICAL STORM KARL NEAR BERMUDA AT 1715 UTC 23 SEPTEMBER 2016. IMAGE COURTESY OF NASA.  
[https://www.nhc.noaa.gov/data/tcr/AL122016\\_Karl.pdf](https://www.nhc.noaa.gov/data/tcr/AL122016_Karl.pdf)



*Track from the National Hurricane Center*

- Karl was a **long-lived tropical system** in September 2016
- **15 Sep:** It reached **tropical storm (TS)** intensity
- **25 Sep:** Karl became an **extra-tropical storm (ET)**

# Weather impacts of Storm Karl



- **25 Sep:** ET Storm Karl continues to **move rapidly poleward**
- **26 Sep:** It **interacts with the jet stream** and **re-intensifies**
- **27 Sep:** A **strong jet streak** (~90 m/s) passed to the North of the United Kingdom
- **28-30 Sep:** Moisture transport and strong surface winds resulted in **flooding and wind damage** in Norway

# Storm Karl – Press Coverage

NORWAY PANORAMA

## Tropical Storm Karl Can Hit Norway



Photo : MeRyan/Flickr

Tropical Storm Karl has formed over the far eastern Atlantic, becoming the eleventh named storm of the season, the National Hurricane Center in the United States. On Thursday night, the storm weakened, but is expected to strengthen again to a tropical storm before it passes Bermuda on Saturday.

<https://www.tnp.no/norway/panorama/5376-tropical-storm-karl-can-hit-norway>

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## New storm warnings posted over 'Karl'

September 26, 2016

SHARE

Residents of Western Norway were being warned on Monday to batten down the hatches once again over the next few days. The remains of the tropical storm called "Karl" were expected to bring strong winds and lots of rain, according to state meteorologists.

"We're expecting winds to rise on Tuesday, and that we'll get between 70 and 100 millimeters of precipitation during a period of 18 hours," meteorologist Steinar Skare told state broadcaster NRK.

The storm warnings were posted from early Tuesday through Wednesday morning, from Boknafjorden in the south to Stad in the north. That pretty much means heavy rain along the West Coast from south of Stavanger to Bergen and north beyond Ålesund.

The remains of the tropical storm were colliding with other low-pressure systems over the Atlantic and the bad weather was all moving towards Norway, Skare said. After a period of unusually summer-like temperatures and barely a breeze, the first of the autumn storms was setting in. Skare called it "ordinary bad weather," though, stressing that "Karl" itself had weakened considerably.

newsinenglish.no staff

<https://www.newsinenglish.no/2016/09/26/new-storm-warnings-posted-over-karl>

## UK STORM WARNING: Britain to be SMASHED by 70mph remnants of Hurricane Karl TOMORROW

AUTUMN will dish up the first storm of the season this week with parts Britain on alert for 70mph gales and torrential downpours.

3:42, Tue, Sep 27, 2016 | UPDATED: 16:16, Tue, Sep 27, 2016

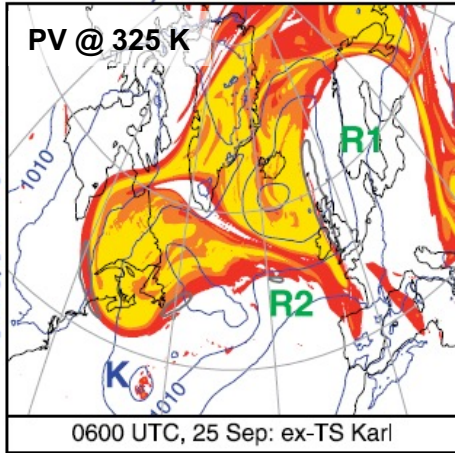


The Met Office has issued a severe weather warning for Scotland...  
<https://www.express.co.uk/news/weather/714909/UK-weather-storm-gales-rain-October-hurricane-Karl>

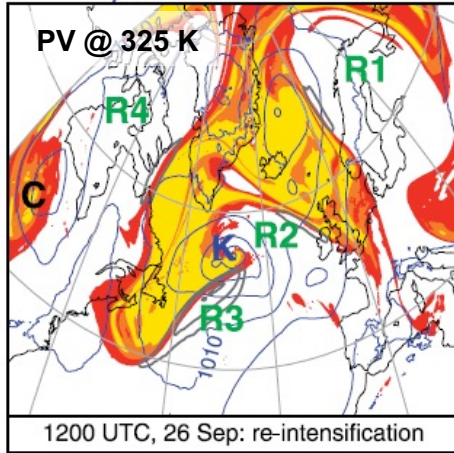
# Extra-tropical development of Karl

SEQUENCE A

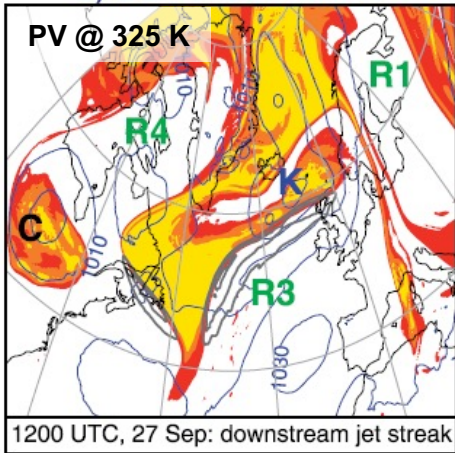
## 1) TRIGGER



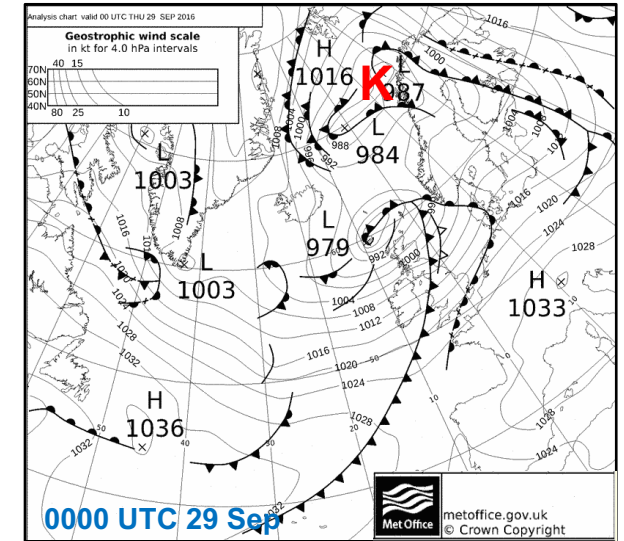
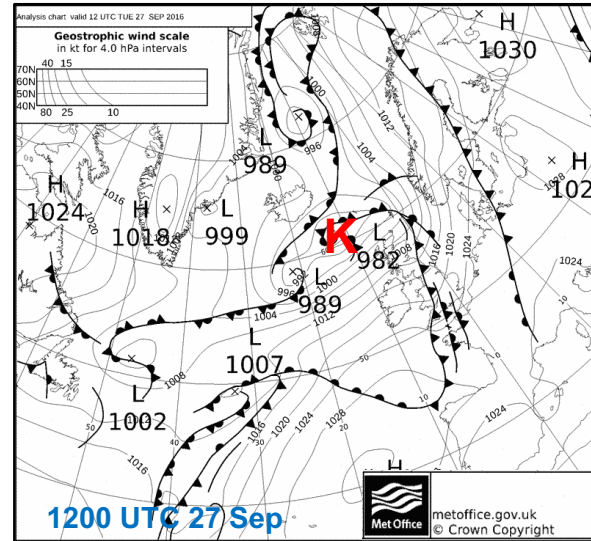
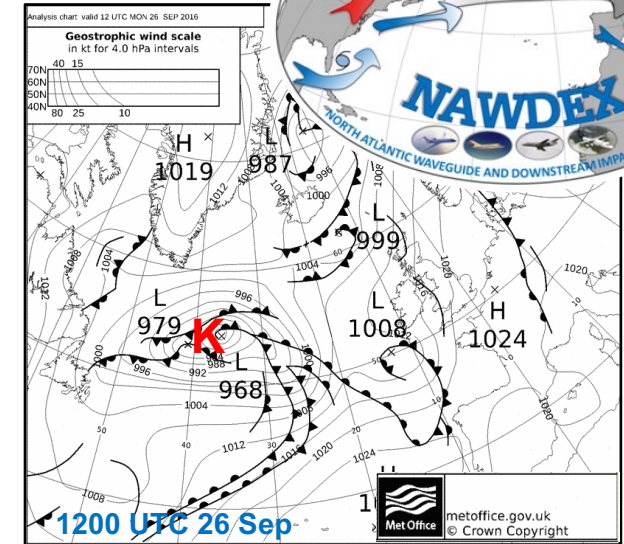
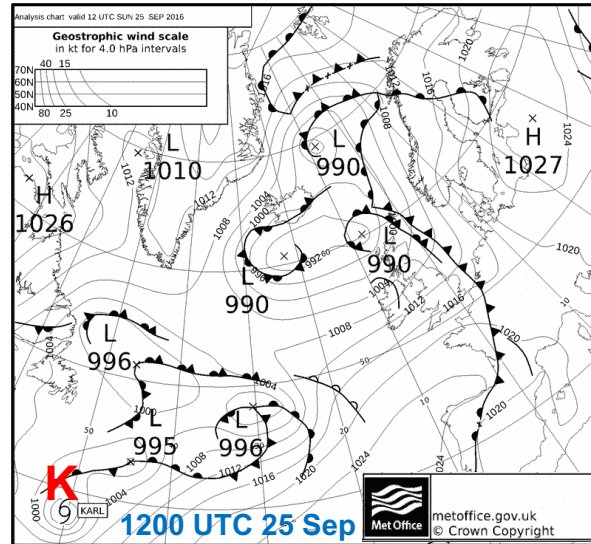
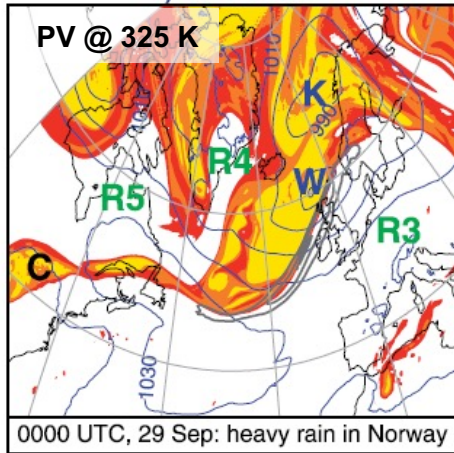
## 2) INTERACTION



## 3) DEVELOPMENT



## 4) IMPACT



Schäfler et al. (2018) *BAMS* doi:10.1175/BAMS-D-17-0003.1

[http://www1.wetter3.de/archiv\\_ukmet\\_dt.html](http://www1.wetter3.de/archiv_ukmet_dt.html)

# OpenIFS Experiments – What we will do

- **Control forecast experiment:**

- Using **OpenIFS 48r1** at **78 km gridpoint** resolution with **91 vertical levels** (T255L91), initial data and sea surface temperatures from **ECMWF ERA5 reanalyses**, (compared with the **ECMWF operational forecast** at 9 km global resolution).
- Forecast for **6 days from 2016-09-25 00 UTC** with 6-hourly output of model fields.
- **Single forecast** only, i.e. no ensembles.
- This forecast will be our **reference experiment**.

- **Perturbation experiments (sensitivity studies):**

- **Repeats** of the above forecast with the same resolution and initial state, but **with modified physical model processes**, such as:
  - change of **temperature tendencies** from model physics (latent heat, radiation) affecting dynamics,
  - change of **ice and warm** rain formation processes,
  - change of energy input from **sea surface temperatures**.