JOINT WMO TECHNICAL PROGRESS REPORT ON THE GLOBAL DATA PROCESSING AND FORECASTING SYSTEM AND NUMERICAL WEATHER PREDICTION RESEARCH ACTIVITIES FOR 2017

Finland / Finnish Meteorological Institute (FMI)

1. Summary of highlights

This report describes the essential features of the numerical weather prediction (NWP) systems operational at the Finnish Meteorological Institute (FMI) during the year 2017. The systems are based on mesoscale ALADIN-HIRLAM forecasting system HARMONIE-AROME, hereafter called HARMONIE (Bengtsson et al., 2017 ; http://hirlam.org/index.php/hirlam-programme-53/general-model-description/mesoscale-harmonie) and the synoptic scale HIRLAM (Undén et al., 2002 ; http://hirlam.org/index.php/hirlam-programme-53/general-model-description/synoptic-scale-hirlam) NWP systems, maintained by the international HIRLAM-C consortium (http://hirlam.org/). HIRLAM-C is formed by the national meteorological agencies of Denmark, Estonia, Finland, Iceland, Ireland, Lithuania, the Netherlands, Norway, Spain, and Sweden. The development of HARMONIE is a joint effort of two European modelling consortia: HIRLAM-C and ALADIN.

HARMONIE is a non-hydrostatic, convection-permitting meso-gamma scale model with horizontal resolution of 2.5 km. During 2017, HARMONIE versions cy38h12 and cy40h11 (from September 5, 2017) were in operational use at FMI as the main NWP product. HARMONIE version cy40h11 is the control member of HARMONIE EPS system (MEPS) that FMI is running in Nordic MetCoOp cooperation (Andrae, 2018) with the meteorological institutes of Sweden (SMHI) and Norway (MET). Additionally, FMI is running one of the MEPS members.

HIRLAM is a hydrostatic model with 7.5 km horizontal resolution. It is maintained at version 7.4, but is not developed further. During 2017, FMI has continued to work as the lead centre for operational running of the common reference version of HIRLAM (RCR). In this capacity, FMI uses operationally the reference version, and makes all forecast products available to the whole consortium in a common archive at the ECMWF.

A comprehensive technical and meteorological monitoring of the forecast systems (HARMONIE and HIRLAM) can be followed in real time on the project web pages (Kangas and Sokka, 2005). An on-line model intercomparison showing forecast v. measurements for a set of meteorological measurement masts is also included in the monitoring suite (Kangas, 2011; Kangas et al. 2016, Kangas et. al. 2017a).

Several research projects address development and improvements of specific features of the NWP models, such as surface interactions especially over snow/ice surfaces and lakes. Some products of the reference runs are shared within the EUMETNET SRNWP-PEPS project.

2. Equipment in use

The operational HIRLAM forecasts are run on FMI's own Cray XC30 computer with 2 x 3420 cores and peak performance of 70 TFlops. The computer consists of two identical units, one being the main operational platform and the other one acting as a backup and research system.

Starting from September 5, 2017, operational HARMONIE run at FMI was replaced by the control member of HARMONIE EPS system (MEPS) run by the MetCoOp cooperation project (Andrae, 2018). FMI itself is running one of the MEPS ensemble members on its XC30 computer.

3. Data and Products from GTS in use

The GTS data used by FMI/MetCoOp models include:

HARMONIE	**HIRLAM**
SYNOP SHIP BUOY AIREP AMDAR ACARS TEMP PILOT	SYNOP SHIP BUOY AIREP AMDAR ACARS TEMP PILOT

4. Forecasting system

4.1 System run schedule and forecast ranges

FMI is using ECMWF global products for medium range forecasting. In addition, FMI maintains two nested data-assimilation/forecasting suites for limited area short range forecasting: HARMONIE (MetCoOp cooperation) and HIRLAM. The run schedules and forecast ranges of the models are shown in Table 1, while the integration areas of the suites are visualized in Figure 1. HARMONIE covers Scandinavia, while HIRLAM covers a larger "Atlantic area".

Table 1. Run schedules and forecast ranges of the FMI LAM suites.

	HARMONIE (*MetCoOp cntrl run)*		***HIRLAM***	
	range	available	range	available
1	00 + 66 h	02:45 UTC	00 + 54 h	03:10 UTC
2	06 + 66 h	08:45 UTC	06 + 54 h	09:10 UTC
3	12 + 54 h	14:45 UTC	12 + 54 h	15:10 UTC
4	18 + 54 h	20:45 UTC	18 + 54 h	21:10 UTC

As an example, Figure 2 illustrates the computers and data flows of the FMI HIRLAM system. The observations from various sources including Baltic SST/ice data from the FMI Marine Service group and Finnish lake surface temperature observations from Finnish Environment Institute (SYKE) are first collected to an auxiliary operational server, processed, and then transferred to the main computing platform for the actual computations. The same applies to the boundary data obtained from the ECMWF. After computations, the numerical results are loaded into the FMI real time data base for various uses by duty forecasters, researchers, and automated forecast post-processing applications. Likewise, the graphical products are made available through the FMI intranet. A local archiving on an FMI server also takes place. Finally, in accordance with the RCR status, input and output data of the HIRLAM are made available to the HIRLAM community by archiving the data to the ECMWF's ECFS using the ecaccess gateway. A graphical interface for monitoring the system is provided to the HIRLAM community through a common web portal at http://hirlam.org/.

FMI HARMONIE is run as a part (control run) of the MetCoOp ensamble runs (MEPS; Andrae, 2018). The results can be monitored through local graphical interface as well as through internal MetCoOp project pages.

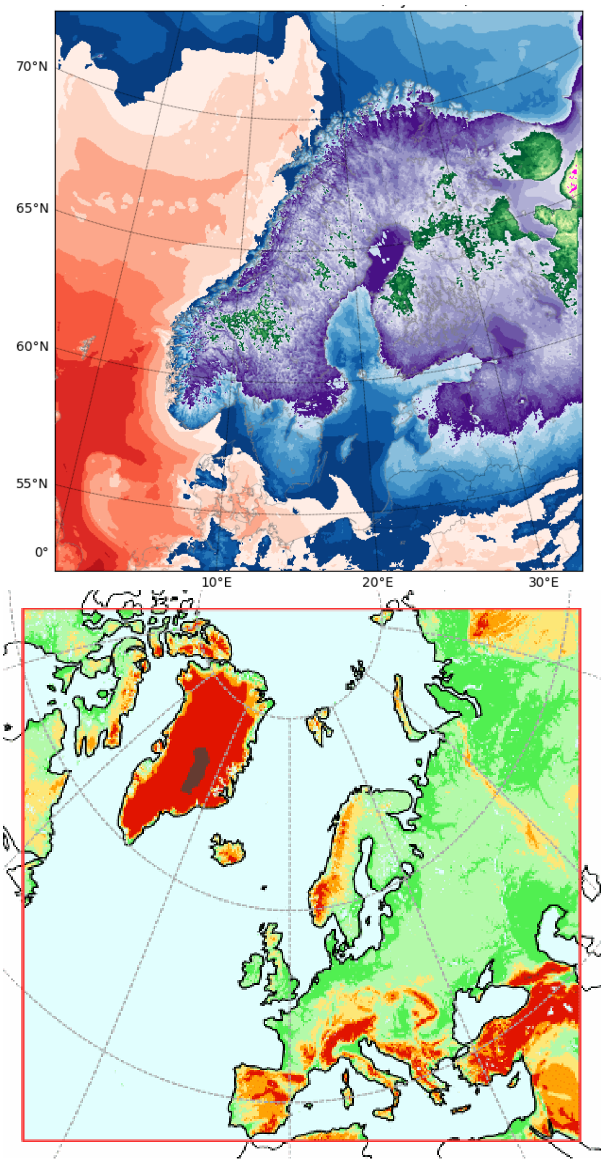

Figure 1. Integration areas of the operational LAM suites (HARMONIE (above) and HIRLAM).

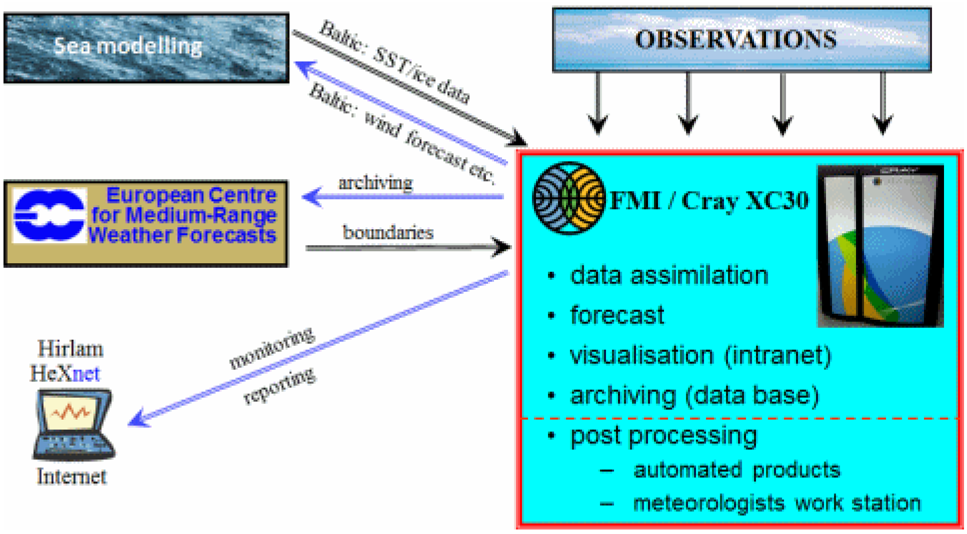

Figure 2. Computers and data flows of the FMI LAM system (RCR-HIRLAM shown here).

4.3 Short-range forecasting system (0-72 hrs)

4.3.1 Data assimilation, objective analysis and initialization

4.3.1.1 In operation

HARMONIE

Upper air analysis
- 3-dimensional variational data assimilation (3DVAR)
- Version: HARMONIE cy40h11
- Parameters: surface pressure, temperature, wind components, specific humidity

Surface analysis
- SURFEX surface scheme using two patches for the nature tile and FLAKE for fresh water tile
- Parameters: SST, snow depth, screen level temperature and humidity, soil temperature and humidity in two layers

Levels
- 65 hybrid levels

Observation types
- SYNOP, SHIP, BUOY, AIREP, AMDAR, ACARS, TEMP, PILOT, ATOVS-AMSU-A, ATOVS-AMSU-B, ATOVS-MHS, RADAR(dbz), ASCAT, GNSS, IASI

Boundaries:
- Time dependent lateral boundary conditions from the ECMWF received four times each day on the HARMONIE grid with a temporal resolution of 3 hrs, obtained via the ECMWF boundary conditions optional project

Background:
- Three hour forecast of the previous cycle valid at the beginning of the date window

Cut-off time:
- 1h 15 min for the main cycles (00, 06,12, 18 UTC), longer but variable for intermediate cycles (03, 09, 15, and 21 UTC)

Cycling:
- 3h cycle

HIRLAM

Upper air analysis
- 4-dimensional variational data assimilation (4DVAR) with no explicit initialization
- Version: HIRLAM 7.4
- Parameters: surface pressure, temperature, wind components, specific humidity

Surface analysis
- Separate analysis, consistent with the mosaic approach of the surface/soil treatment
- Parameters: SST, fraction of ice, snow depth, screen level temperature and humidity, soil temperature and humidity in two layers
- Finnish lake surface temperature observations (from Finnish Environment Institute)

Levels
- 65 hybrid levels

Observation types
- SYNOP, SHIP, BUOY, AIREP, AMDAR, ACARS, TEMP, PILOT, ATOVS-AMSU-A, ATOVS-AMSU-B, ATOVS-MHS

Boundaries:
- Time dependent lateral boundary conditions from the ECMWF received four times each day on the RCR grid with a temporal resolution of 3 hrs, obtained via the ECMWF boundary conditions optional project

Background:
- Three hour forecast of the previous cycle valid at the beginning of the date window

Cut-off time:
- 2h

Cycling:
- 6h cycle
- Reanalysis step every 6 h, before the main run, to blend with large-scale features of the ECMWF analysis

4.3.1.2 Research performed in this field

Lake data-assimilation

In operational HIRLAM system, the lake water surface in-situ measurements are used for the analysis, but not for the initialisation of the prognostic lake parametrisations within the new NWP model cycle. For the objective analysis of the lake surface state, the structure functions for the sea surface temperature are currently used. New structure functions based on the lake water surface temperature (LSWT) observations have been obtained and tested. For the first time, the dependence of the statistical properties of LSWT on lake depth was determined (Kheyrollah Pour et al., 2017). An overview of the recent lake activities may be found in the 5th Workshop "Parameterisation of Lakes in NWP and climate modelling" (http://www.flake.igb-berlin.de/Lake17/.

Snow data assimilation

The implementation of satellite-based snow data to the HARMONIE and HIRLAM surface data assimilation system has been continued in international cooperation. Snow extent data from EUMETSAT H SAF H31 (geostationary orbiting satellites) and H32 (polar orbiting satellites) were compared with HARMONIE analysis fields, SYNOP observations and the GLOBSNOW project data. Assimilation of the spaceborne microwave radiometer data with the snow emission model as forward operator to initialise the snow density, temperatures and albedo are being discussed. FMI NWP research group actively participates in COST Action ES1491 HarmoSnow. The main purpose of the Action is the harmonization of snow observations, with the perspective to advance snow data assimilation in European NWP and hydrological models and show its benefit for the relevant applications.

4.3.2 Models

4.3.2.1 In operation

HARMONIE

Basic equations:
- Non-hydrostatic fully compressible Euler equations

Independent variables:
- Bi-fourier wave numbers, hybrid level, time

Dependent variables:
- Horizontal wind vector, vertical divergence, non-hydrostatic pressure departure, temperature, specific humidity, 5 species of condensed water, cloud cover, turbulent kinetic energy

Integration domain:
- 900 x 960 grid points in in a Lambert conformal conic projection grid, 65 vertical hybrid levels

Grid length:
- 2.5 km

Grid:
- Arakawa-A (unstaggered)

Time-integration:
- Two-time level semi-implicit semi-Lagrangian

Orography:
- GTOPO30 database

Physical parameterisation:
- SW radiation : ECMWF Morcrette radiation scheme with 6 spectral bands
- LW radiation : ECMWF RRTM scheme with 16 spectral bands
- Shallow convection using combined eddy diffusivity mass flux scheme
- Pinty-Jabouille microphysics including five categories of micrometeros
- 1D prognostic Cuxart-Bougeault TKE scheme
- SURFEX surface scheme with four land cover types, including lake parameterisation with frewswater lake scheme FLAKE

Horizontal diffusion:
- SLHD (Semi-Langrangian-Horizontal diffusion) non-linear scheme

Forecast length:
- 66 hours at 00, 06, 12, and 18 UTC

Output frequency:
- 1 hour

Boundaries:
- Boundaries from the ECMWF optional BC runs
- Projected onto the HARMONIE grid at ECMWF
- Boundary file frequency 3 hours, updated four times daily

HIRLAM (RCR)

Basic equations:
- Primitive equations in flux form

Independent variables:
- λ,θ (transformed latitude-longitude coordinates, with the south pole at 30° S, 0°E), η (hybrid level), t (time)

Dependent variables:
- Logarithm of surface pressure, temperature, wind components, specific humidity, specific cloud condensate, turbulent kinetic energy

Integration domain:
- 1036 x 816 grid points in transformed latitude-longitude grid, 65 vertical hybrid levels

Grid length:
- 0.068° (~7.5 km)

Grid:
- staggered grid (Arakawa C)

Time-integration:
- 2 time level semi-Lagrangian semi-implicit (time step 2.5 min)

Orography:
- HIRLAM physiographic data base, filtered

Physical parameterisation:
- Savijärvi radiation scheme
- Orographic radiation parameterisation
- Kain-Fritsch convection scheme
- Rasch-Kristjansson microphysics

- Turbulence based on turbulent kinetic energy
- Surface fluxes according to drag formulation
- Surface and soil processes using mosaic approach; specially treated interactions between forest canopy and snow: double energy balance formulation
- Meso-scale orographic drag parameterisation
- Lake parameterisation, freshwater lake scheme FLAKE

Horizontal diffusion:
- Implicit fourth order

Forecast length:
- 54 hours at 00, 06, 12, and 18 UTC

Output frequency:
- 1 hour

Boundaries:
- Frame boundaries from the ECMWF optional BC runs
- Projected onto the HIRLAM grid at ECMWF
- Boundary file frequency 3 hours
- Updated four times daily

4.3.2.2 Research performed in this field

Large-scale atmospheric circulation

The linkages the Arctic and mid-latitudes were addressed with a focus on weather extremes (Vihma, 2017a). The large-scale processes responsible for extreme events were reviewed.

Boundary layer and mesoscale meteorology

The structure and processes of the atmospheric boundary layer in high latitudes were studied on the basis of tethersonde soundings and weather mast observations with focus on summertime temperature inversions over the Antarctic ice sheet (Nygård et al., 2017) and Arctic sea ice (Palo et al., 2017)..

Development of measurement techniques

Novel observation techniques for wind gusts were developed based on Doppler lidar data (Suomi et al., 2017).

Lake and sea ice modelling

A method was developed to evaluate sea ice concentration and thickness on the basis of combined use of satellite remote sensing and thermodynamic modelling. The method was applied for the Bohai Sea (Karvonen et al., 2017). Thermodynamic model experiments for sea ice and snow thickness were carried out in the Arctic (Tian et al., 2017) and Antarctic, with a particular focus on a period of simultaneous growth of first-year ice and melt of second-year ice (Zhao et al., 2017).

4.3.3 Operationally available NWP products

All HARMONIE and HIRLAM products on both model and constant pressure levels are available for applications in the FMI real-time data base with a frequency of one hour. In compliance with the European Directive on the re-use of public sector information (Directive 2003/98/EC, known as the 'PSI Directive'), the latest forecasts of both HARMONIE and HIRLAM are freely available via the FMI Open Data interface (https://en.ilmatieteenlaitos.fi/open-data).

HARMONIE and HIRLAM forecasts are also available to duty forecasters on workstations. The geopotential, temperature, relative humidity and three-dimensional wind fields are available on constant pressure levels (1000, 925, 850, 700, 500, 400, 300 and 250 hPa). In addition, surface pressure, 10-metre wind, 2-metre temperature, intensity of precipitation and accumulated large-scale and convective precipitation, surface fluxes of sensible and latent heat and net radiation are available. Also several derived parameters such as type of precipitation, stability index, fog, cloudiness, visibility, icing index, lightning intensity, CAPE etc. are computed from every forecast.

The nearest grid point values are picked up to produce forecasted vertical soundings of temperature, dew point deficit and wind at selected points.

4.3.4 Operational techniques for application of NWP products

4.3.4.1 In operation

HARMONIE and HIRLAM forecasts provide guidance to duty forecasters, and are used as a basis for a large number of automated forecasts distributed to the general public and various authorities. They are also used as input (forcing) for many specialized applications, such as forecasting of road conditions, waves and currents in the Baltic Sea, potential dispersion of radioactive pollutants, toxic chemicals, forest fire smoke, volcanic ash, pollen, and air quality.

4.4 Nowcasting and Very Short-range Forecasting Systems (0-6 hrs)

4.4.2 Models for Very Short-range Forecasting Systems

4.4.2.2 Research performed in this field

The development of LAPS (Local Analysis and Prediction System; Albers et. al., 1996) has been continued for utilization in now-casting activities and within other operational products at FMI. The system is in daily operational use, producing 3D-analysis at every hour. The model area covers both the Finland and the whole Scandinavian domain with 3 km grid size. Measurements utilized within the analysis are taken from MSG9-satellite, NWCSAF products, radars, NORDLIS-lightning data, lidars, air-reports (AMDAR), SYNOP, METAR, road-weather stations and the dense measurements network in and around Helsinki (http://testbed.fmi.fi/). New observational data sources are investigated as ingest for the LAPS analysis: scatterometer data, IASI sounder profiles, GPS etc.

The LAPS system generates a fine-scale analyses of weather elements such as 2D surface analysis and 3D cloud-, temperature- and wind analysis. These products are used for now-casting activities, post-processed radiation calculations and for the determination of wind power potential (including losses due to icing) etc. The LAPS-analysed upper air fields are ingested by HARMONIE in order to generate a short-term forecasts (0-12 hours), a system which is running 4 times per day.

Special focus has been on developing the LAPS 1-hour precipitation accumulation analysis. To accomplish this, LAPS assimilates radar and lightning data, together with surface rain-gauge observations (Gregow et. al., 2013, Gregow et. al., 2017). The LAPS precipitation accumulation output is applied in FMI operational products, such as fire-weather index and road weather model, and delivered to end-users within hydrological applications (e.g. the Finnish Environment Institute (SYKE)). LAPS has also been used in research of wind-power production in winter conditions, i.e. icing on wind-turbine blades (Gregow et al., 2015).

4.5 Specialized numerical predictions

FMI operates a set of air-quality / pollution dispersion models. A re-analysis of global, European and Fennoscandian air pollution by trace gases and particulate matter (1980 -> 2017) is going on, the first version of the dataset has been finished. A detailed air quality simulations with 1km resolution covering the whole Finland has been conducted.

A road weather model based on weather forecast model output to produce traffic and pedestrian walking conditions and warnings as well as road maintenance advice is run operationally several times a day during wintertime.

4.5.1 Assimilation of specific data, analysis and initialization

4.5.1.1 In operation

A 3D-VAR based chemical data assimilation system is in use with the SILAM model for near-real time analysis of the previous day concentrations of O_3, SO_2, NO_2, and $PM_{2.5}$. On annual basis, the re-analysis of birch pollen concentrations is performed using 4D-VAR.

4.5.2 Specific Models

4.5.2.1 In operation

SILAM : Meso-to-global scale dispersion model

- lagrangian and Eulerian, meso-to-global, troposphere-and-stratosphere model
- research and operationaö (Sofiev at al., 2015a)
- species include gases following CBM-4 with expansions towards CBM-5, plus expansions to the stratosphere
- halogens and stratospheric aerosols
- up to several hundred radioactive nuclides
- forest fire smoke, probabilities, age of air
- natural pollen: European wide flowering and dispersion model for multiple species (Sofiev et al., 2015b)

RoadSurf *:* road weather model with various derivatives (Kangas et al., 2015)

- road surface temperature and road condition as well as traffic warnings
- pedestrian walking condition and warnings ; also a hi-res version employing LAPS analysis
- road maintenance timing advice
- road surface friction; a statistical model for friction between road surface and tires (Juga et al., 2013)
- snowdrift index (Hippi et al., 2014)

Ocean modeling

- Storm surge models
  - *OAAS* and *WETEHINEN 2D* water level models. Forecast the sea level at the Finnish coast of the Baltic Sea, level correction to the forecasts is made utilising Finnish tide gauge observations. Forecast length +54h using HIRLAM RCR forcing and +120h with ECMWF forcing
  - A new system to produce ensemble water level forecasts has been impmemented. The 2D modelling system has two components: a water-balance component to describe the Baltic Sea water volume variations and anotherone to calculate the short-term variations in the Baltic Sea water levels. The model uses ECMWF EPS forecast as forcing (control and 50 perturbated forecasts) and the forecast length is 10 days
- Wave model *WAM*
  - Wave forecasts for the Baltic Sea with wave model WAM cycle 4.5.4 (e.g. Komen et al., 1994)
  - Horizontal resolution of 4 nmi and 1nmi for the Baltic Sea and nested grid with 0.5 nmi for the Archipelago Sea; the model grid is built to take into account the specific characteristics of the dissected shorelines of the northern Baltic Sea (e.g. Tuomi et al., 2012, Tuomi et al., 2014)
  - Forecasts four times a day using wind forcing from FMI's NWP system HIRLAM with forecast length of 54 hours and two times a day using wind forcing from ECMWF deterministic NWP system with forecast length of 5 days (with the 4 nmi grid) and from FMI's NWP system HARMONIE (1nmi)
  - Seasonal ice cover is taken into account by excluding from calculation grid points having over 30% ice concentration; the ice conditions are updated daily based on data produced by FMI's Ice Service
- Circulation model *HBM*
  - Temperature, salinity, and current forecasts for the Baltic Sea with 3D circulation model HBM. Provides also forecasts for sea ice and sea level
  - Horizontal resolution of 1 nmi for the Baltic Sea with two-way nested grid at the Danish Straits with 0.5 nmi resolution
  - Forecasts two times a day (00 and 12 UTC) using meteorological forcing from FMI's NWP system HIRLAM with forecast length of 54 hours and two times a day using meteorological forcing from ECMWF deterministic NWP system with forecast length of 3 days
- Ice model *HELMI*
  - Forecast of ice concentration and ice drift for different ice classes for the Northern Baltic Sea with 1 nmi resolution
  - Forecasts four times a day using meteorological forcing from FMI's NWP system HIRLAM with forecast length of 54 hours

Icing model for predicting risk of atmospheric icing on wind turbines

- based on ISO STANDARD 12494. Previously used to create Finnish Icing Atlas (Hämäläinen and Niemelä, 2016)
- frequency and intensity of icing is post-processed from HARMONIE-AROME output: wind, temperature, liquid water content
- The pre-operational testing was completed during spring 2017 and user feedback was positive. The operational forecasting for atmospheric icing on wind turbines started in the beginning of October 2017

4.5.2.2 Research performed in this field

Atmospheric composition studies for health and climate

SILAM has been applied at a multitude of scales from global to gamma-mesoscale analysing the impact of atmospheric composition and emission abatement measures on climate, environment and health (Lehtomäki et al., in press).

Intelligent transportation systems

During 2017, FMI participated in several projects which aim to develop methods to optimally implement mobile observations to the forecasting system (Sukuvaara et al., 2018). In Intelligent Arctic Trucks project, observations are performed by additional devices attached to mining trucks driving a route between Kemi Harbour and Kevitsa copper and nickel mine in northern Finland. The observations are used to make dedicated road condition forecasts for the route. A larger scale project WiRMa (Industrial Internet Applications in Winter road Maintenance) aims to develop real-time analytics and forecasting system to support winter road maintenance. The project area covers northern Finland, Sweden and Norway.

FMI has studied the accuracy of mobile observations by comparing them to road weather station (RWS) measurements together with Oulu University. The compared variable was road surface temperature and the mobile instrument was optical Teconer RTS411. Most RWSs measured road surface temperature with asphalt embedded sensors. According to the study, road condition (e.g. dry, wet, icy …) has considerable effect to the difference between Teconer and RWS measurements. A linear adjustment equation for mobile observation was developed in the study to make them correspond better the RWS measurements.

FMI has done co-operation with Jyväskylä University of Applied Sciences to detect visibility from road side cameras or on-board cameras using neural networks and machine learning. The aim is to make three level visibility detection based on camera data. The system classifies the visibility into three classes; normal low or very low visibility.

Within the framework of the Era4cs project URCLIM, the FMI road weather model is coupled to the HARMONIE-AROME system via the Town Energy Balance model TEB, and used to estimate how winter time traffic conditions will respond to changes in the climate of the Helsinki region.

4.5.3 Specific products operationally available

- 48-hr forecast of air quality in Northern Europe based on HARMONIE forecasts, resolution 0.022°
- 120-hr forecast with 24 hour hindcast of air quality in Europe based on IFS forecast dissemination, resolution 0.1°
- 120-hr forecast of air quality in Asia based on IFS forecast dissemination, resolution 0.1°
- 120-hr forecast of global atmospheric composition based on IFS forecast dissemination, resolution 0.5°
- 48-hr forecast of road traffic and pedestrian walking conditions as well as road maintenance advice, several times/day (during wintertime):
- wave forecast 4 times a day for the Baltic Sea using wind forcing from FMI's NWP system HIRLAM with forecast length of 54 hours and 2 times a day for the Baltic Sea using wind forcing from ECMWF deterministic NWP system with forecast length of 5 days (with the 4 nmi grid) and from FMI's NWP system HARMONIE (1 nmi)
- sea Surface Temperature, salinity, and current forecasts for the Baltic Sea two times a day (00 and 12 UTC) using meteorological forcing from FMI's NWP system HIRLAM with forecast length of 54 hours and two times a day using meteorological forcing from ECMWF deterministic NWP system with forecast length of 3 days
- ice concentration and drift forecast for the Baltic Sea region four times a day using meteorological forcing from FMI's NWP system HIRLAM with forecast length of 54 hours

5. Verification of prognostic products

5.1 Annual verification summary

The figures below show the monthly bias (lower curves) and rms-error (upper curves) of screen level temperature and 10m wind for HIRLAM RCR version V74 starting for HIRLAM (Figs. 3 and 4, starting from

1995) and for HARMONIE-AROME (Figs. 4 and 5, starting from 2009). The verification is done for observations from the so-called EWGLAM station list (HIRLAM) and from Finnish stations (HARMONIE). The forecast length is 48 hours for HIRLAM and 24 hours for HARMONIE. Line colours indicate model versions, and hor HIRLAM, the black long line shows running average.

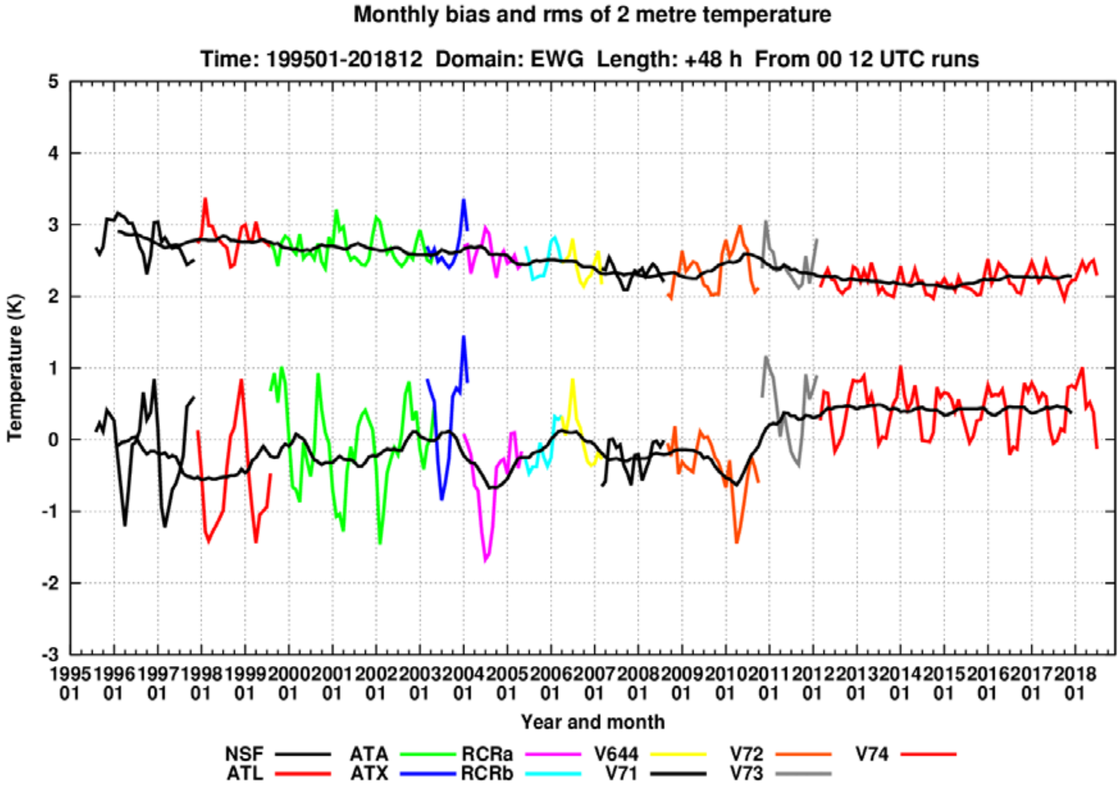

Figure 3 : HIRLAM long-term verification: screen level temperature.

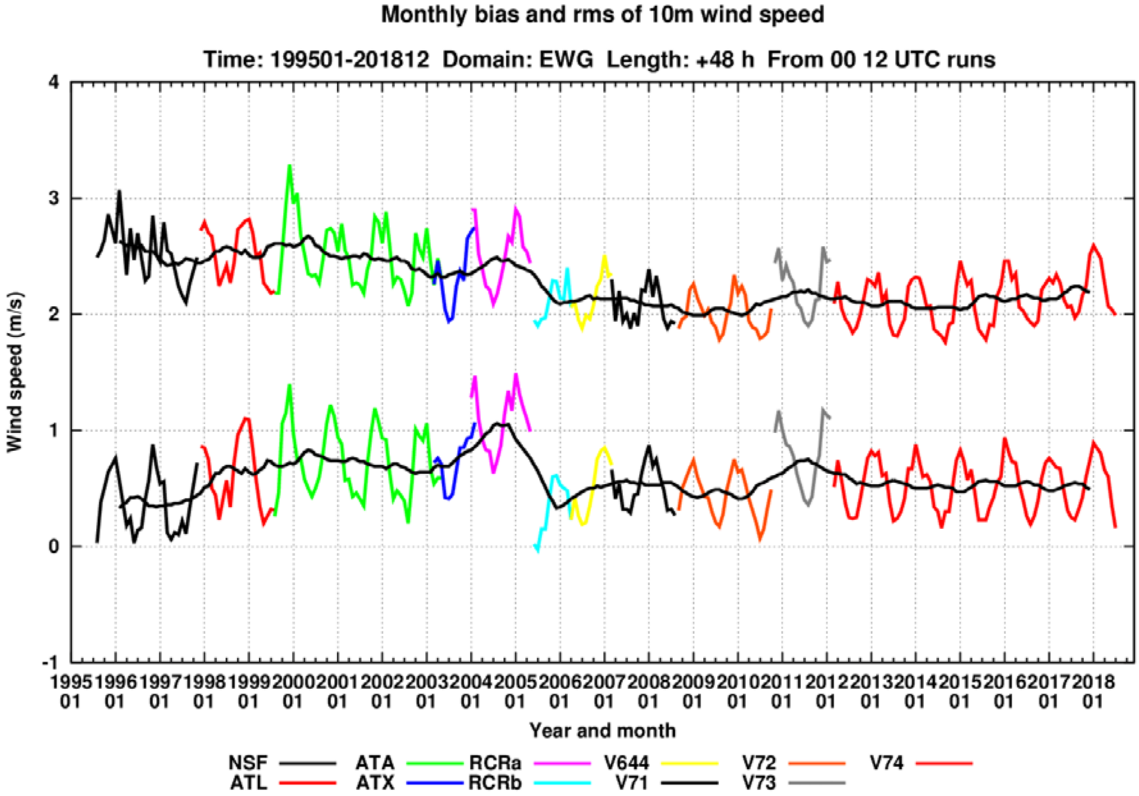

Figure 4 : HIRLAM long-term verification : 10m wind.

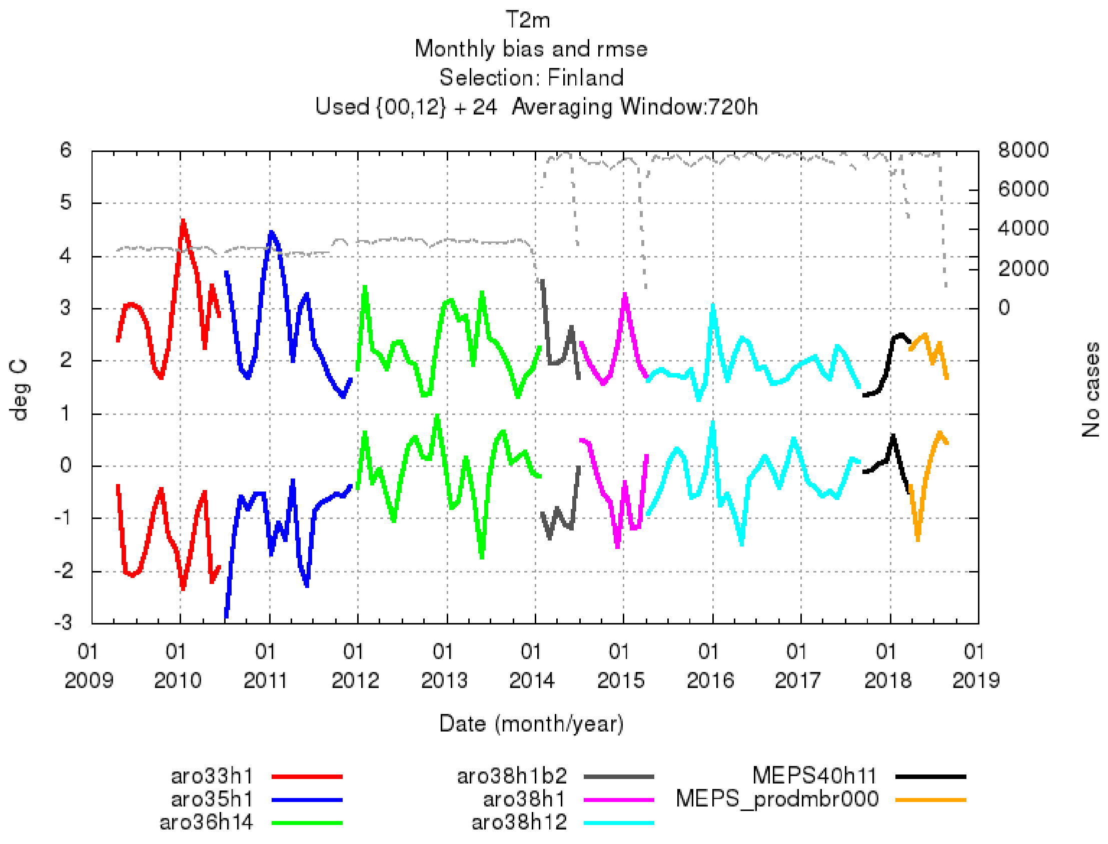

Figure 5 : HARMONIE long-term verification: screen level temperature.

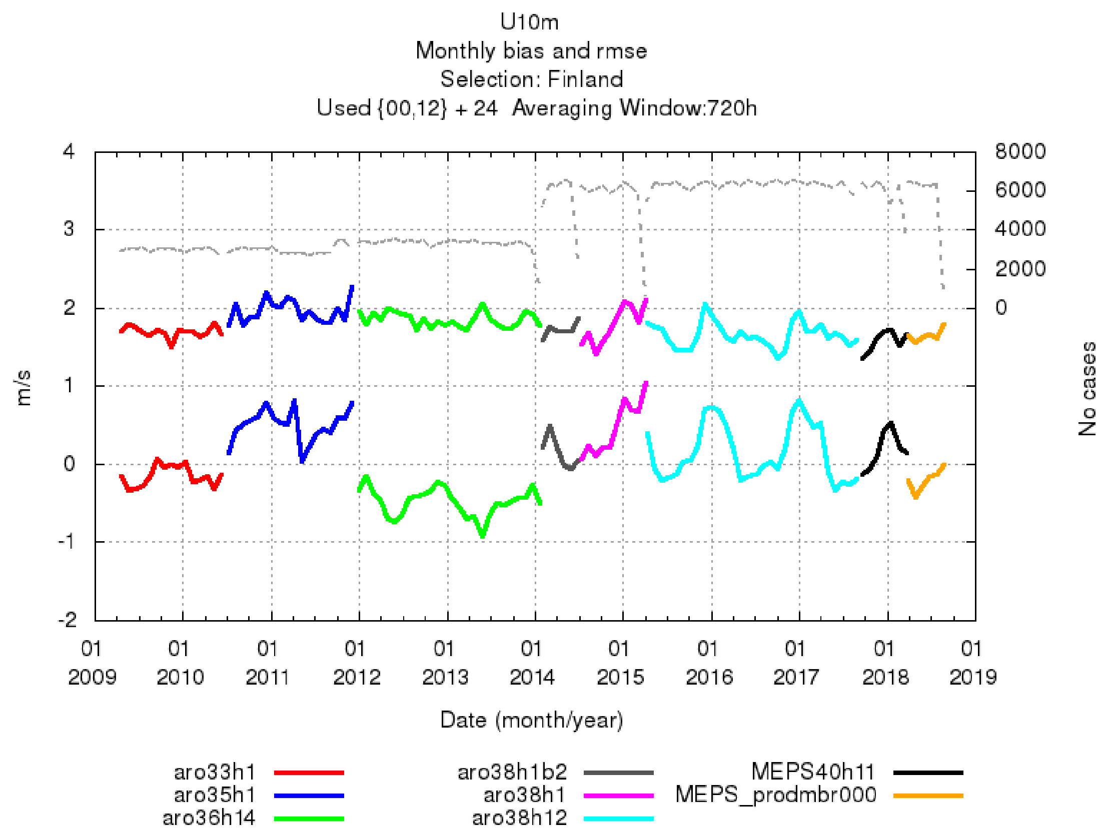

Figure 6 : HARMONIE long-term verification: 10m wind.

6. Plans for the future

6.1 Development of the GDPFS

The joint HARMONIE MEPS ensamble forecast co-production within the MetCoOp will be contunued with enhancements in the model. A frequently-updated short range forecast system serving nowcasting and very short lead time forecasting is being developed and is planned to enter pre-operational phase in 2018.

6.2 Planned research Activities in NWP, Nowcasting and Long-range Forecasting

Current research activities in atmospheric modelling include

- the assimilation of remote sensing data
- surface data assimilation (lakes, snow)
- effect of orography and aerosols
- utilization of probabilistic forecasting for renewable energy production (HARMONIE-EPS)
- modelling of built environment and related forecasting
- HARMONIE-MEPS based nowcasting within the framework of MetCoOp co-operation.

Research and development of SILAM are concentrated on:

- development of data assimilation algorithms, EnKF / EnKS and 4D-VAR, and related topic of inverse problem solution
- ensemble forecasting
- data fusion
- pollen forecasting
- chemistry mechanism development
- fire system development

7. References

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