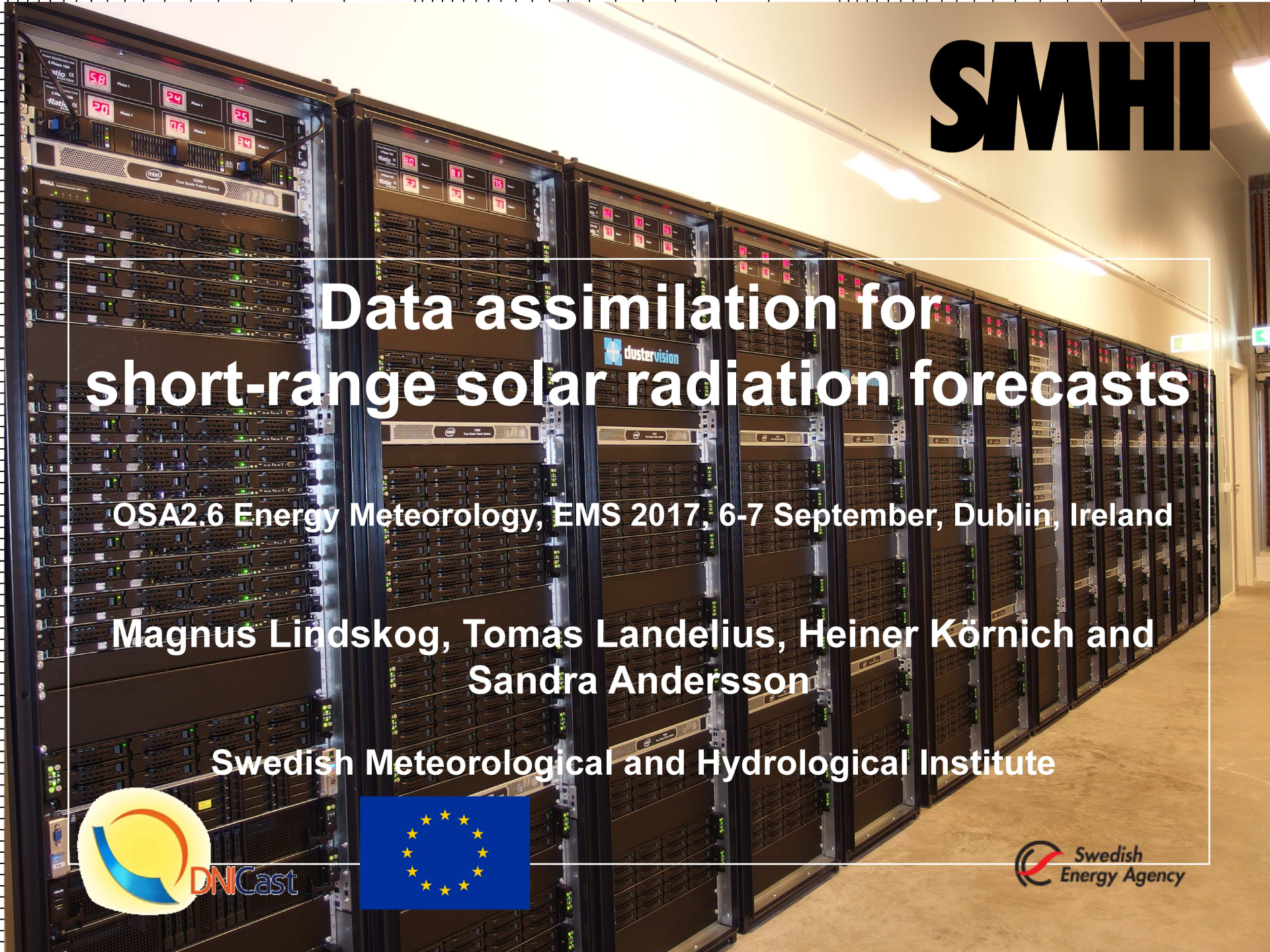

Data assimilation for short-range solar radiation forecasts

OSA2.6 Energy Meteorology, EMS 2017, 6-7 September, Dublin, Ireland

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SMHI

DNICast

Swedish Energy Agency

Background

Direct Normal Irradiance Nowcasting methods for optimized operation of concentrating solar technologies - DNICast

A 4-year project (2013-2017) under the European Union's Seventh Programme for research, technological development and demonstration framework

Solar radiation forecasts for control and monitoring of the electrical grid

A 2-year project (2017-2018) project involving SMHI and Tekniska Verken in Linköping, financed by the Swedish Energy Agency

Numerical Weather Prediction for short-range solar energy forecasting

Prerequisities:

- Good solar radiation forecasts
  - need good cloud forecasts
    - needs a good starting point.

- The uncertanties of forecasts should be addressed.

How?

- Use frequent satellite data to intialize model cloud and wind fields.

- Use an ensemble system to estimate uncertainties.

Background

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Set-Up of HARMONIE-AROME system

- Part of the shared ALADIN-HIRLAM system
- NWP system is set up over a Southern (cy38h1.2) and a Northern (cy40h.1.2) domain.
- Horizontal model grid-distance of 2.5 km and 65 vertical model levels.
- Southern domain (April, 2013): investigated the impact on short-range forecast quality (focus on of clouds) of assimilation improvements:
  1) assimilation of clear-sky SEVIRI radiances, 2) cloud initialisation using NWC SAF data.
- Northern domain: probablistic forecasts using an ensemble (10 members) and plan to apply cloud initialisation using combined geostationary and polar NWC SAF data.

Southern (left) and Northern (right) HARMONIE-AROME model domains

Assimilation of clear-sky SEVIRI radiances

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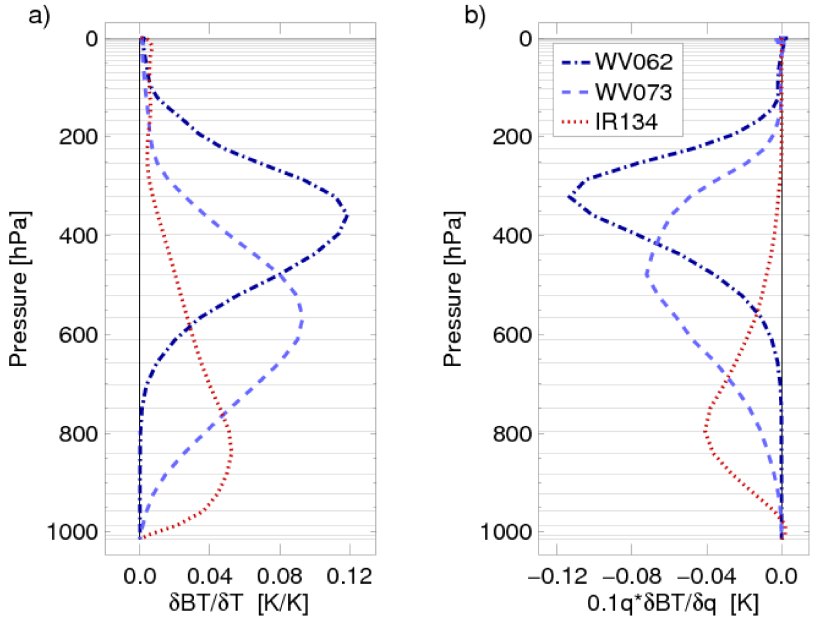
SEVIRI - Spinning Enhanced Visible and Infra-red Imager.

- On-board METEOSAT second gen. geostationary satellites
- Imaging cycle of 15 minutes.
- ~4 km horizontal resolution over South European domain.
- 12 channels, we use 2 (wv062 and wv073).

SEVIRI observations



Mean temperature (T) and moisture (q) Jacobians in clear-sky (CLS) conditions.

(Fig 2., QJR, 135, by Stengel et al., 2009)

(our gratitude to Máté Mile at Hungarian Meteorological Service)

Assimilation of SEVIRI radiances with 4DVar

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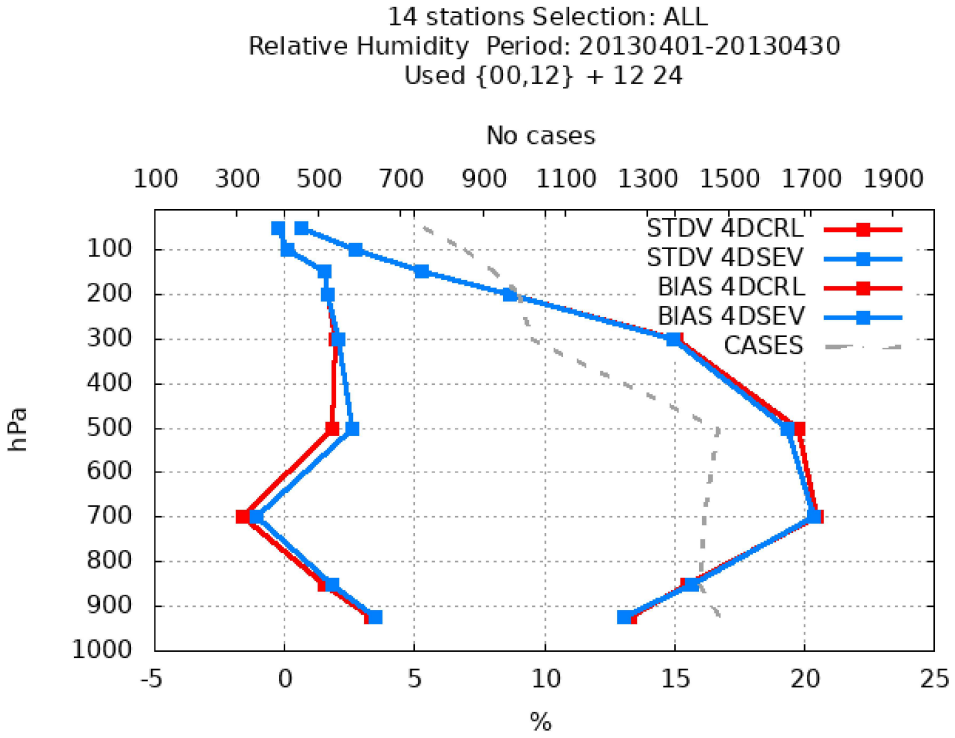
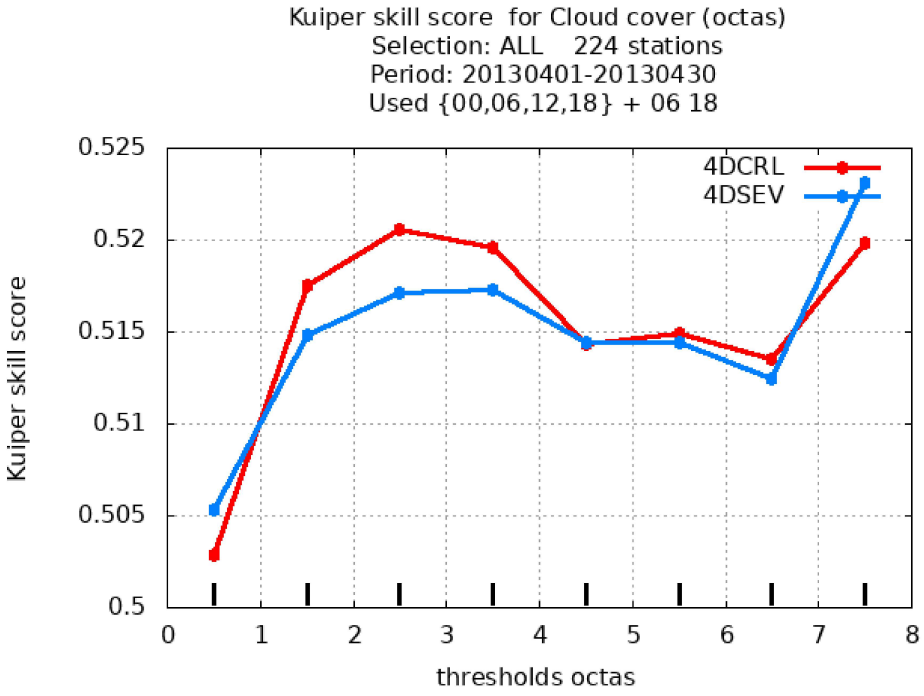
(Forecast minus obs) statistics for relative humidity



Kuiper skill score for cloud cover



Control exp

SEVIRI assim. exp

Based on van der Veen, MWR 2012

1. Generate 3-D cloud cover from cloud mask, cloud top temperature and cloud base height based on input from MSG based NWP-SAF products and climatological cloud base heights.

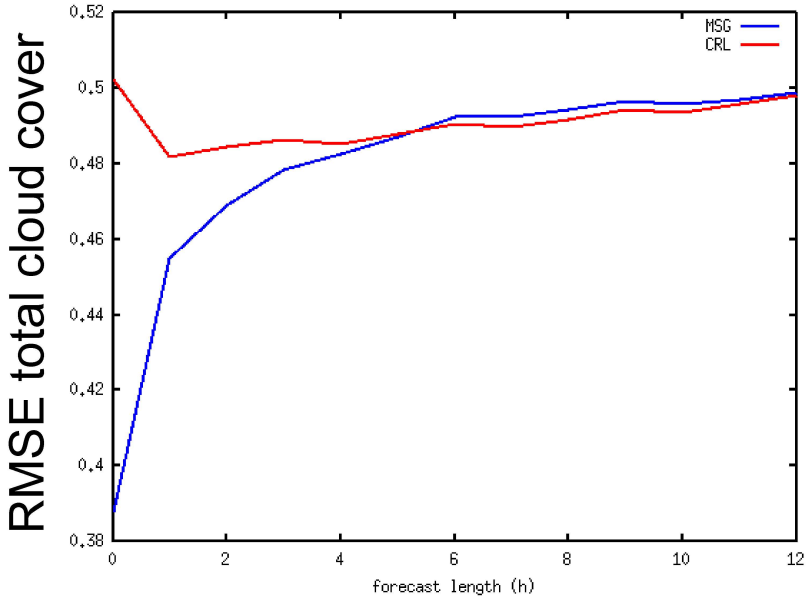
Cloud top temperature (K)

Cloud base height (m)

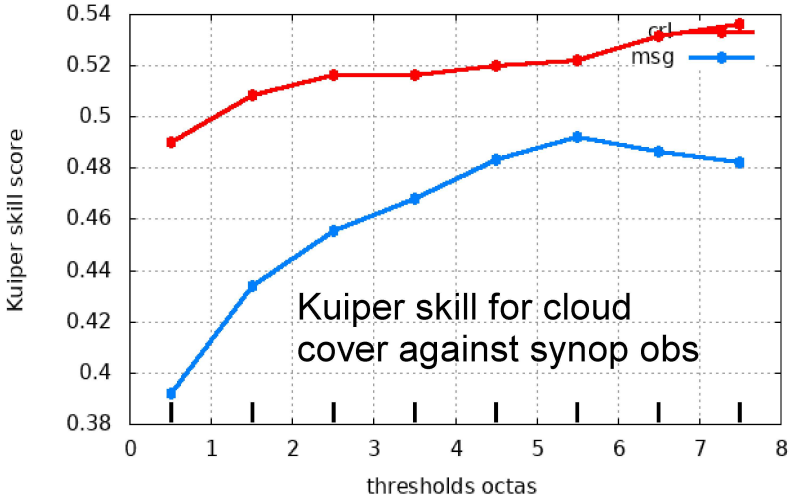
2. Based on product from step 1 modifiy model specific humidity and temperature fields preserving buoyancy and keeping T_v constant.

(our gratitude to Sibbo van der Veen at KNMI)

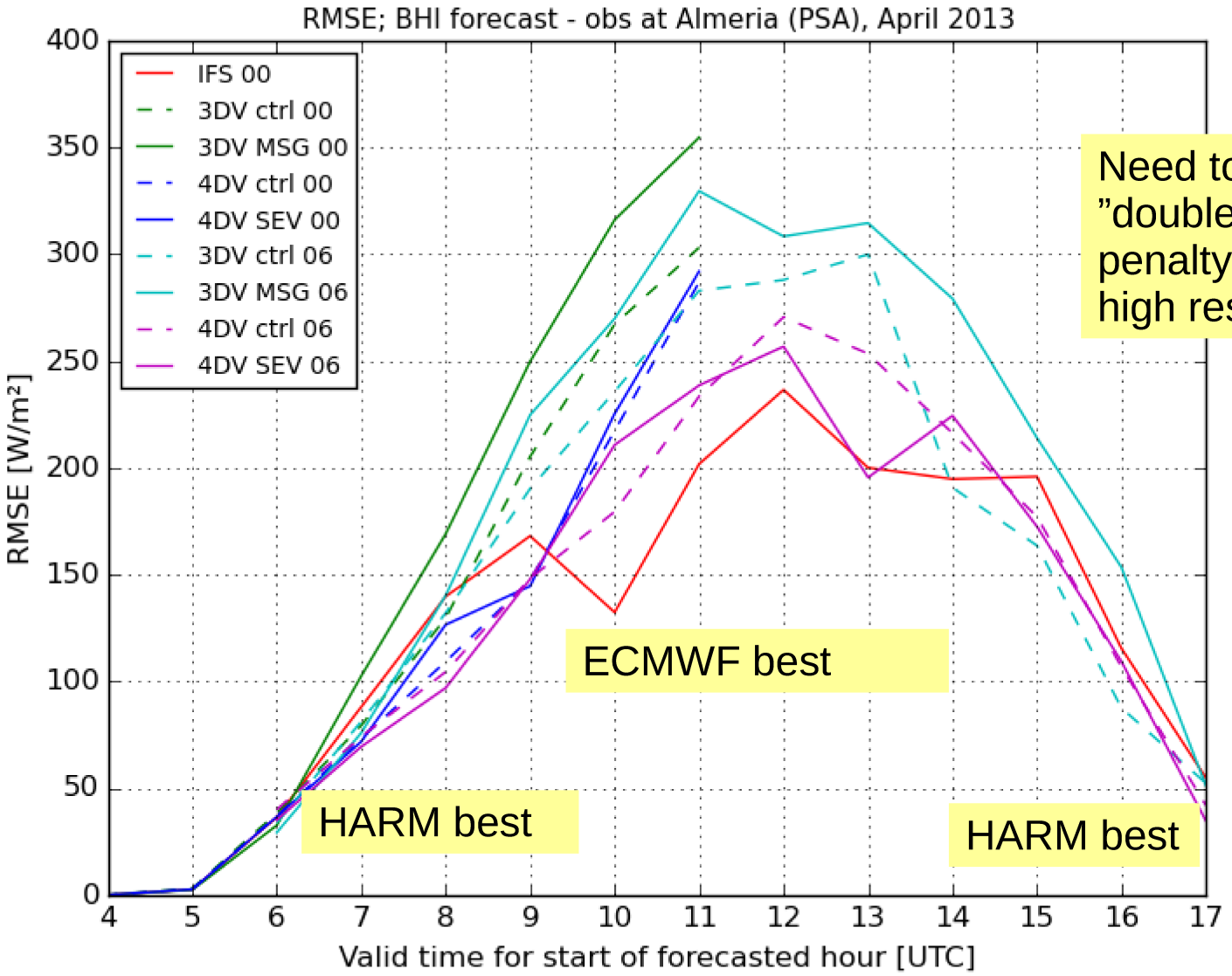
Verification against MSG cloud cover



Selection: ALL 224 stations
Period: 20130401-20130430
Used {00,06,12,18} + 06



RMSE; Beam horizontal irradiation in Almeria (PSA)



Satellite-based cloud cover for high latitudes

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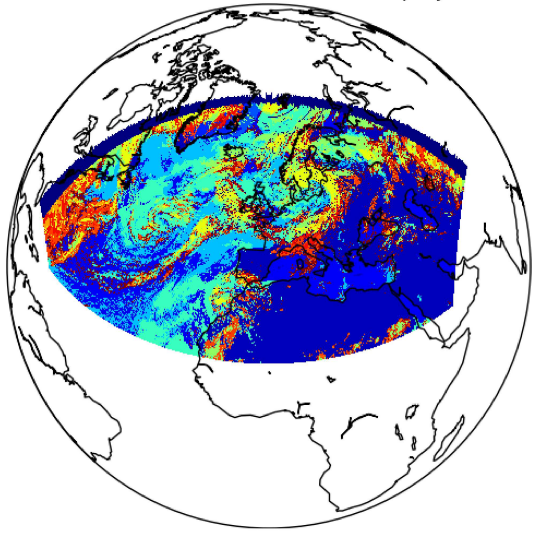
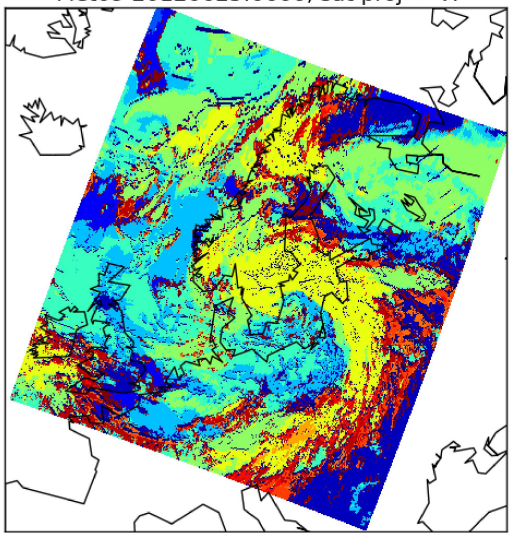
Combining geostationary and polar cloud data with PyTroll

Met09 20120625:0600, sat proj

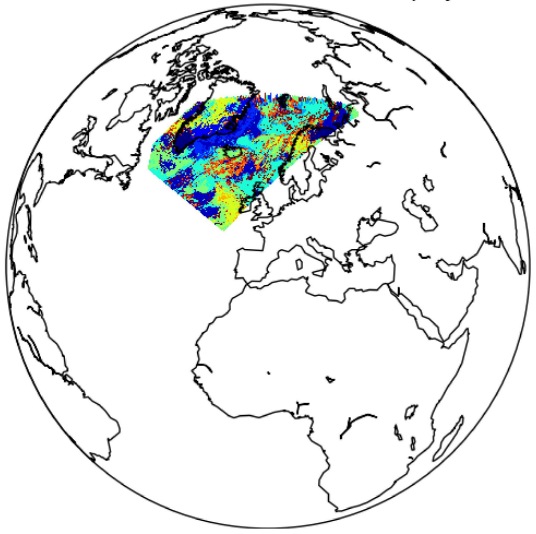


Met09 20120625:0600, sat proj -> X

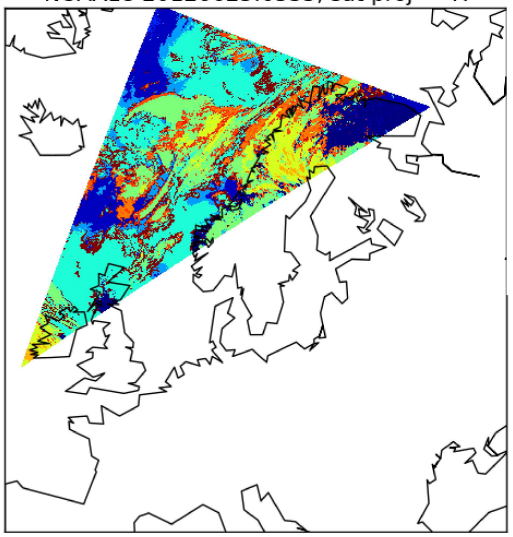


Data + quality info

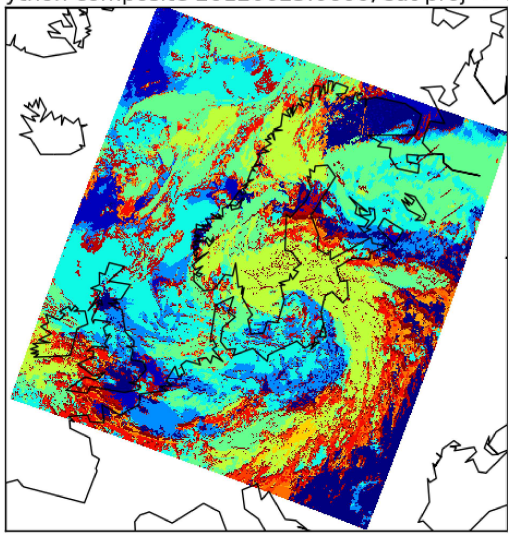
NOAA18 20120625:0535, sat proj



NOAA18 20120625:0535, sat proj -> X



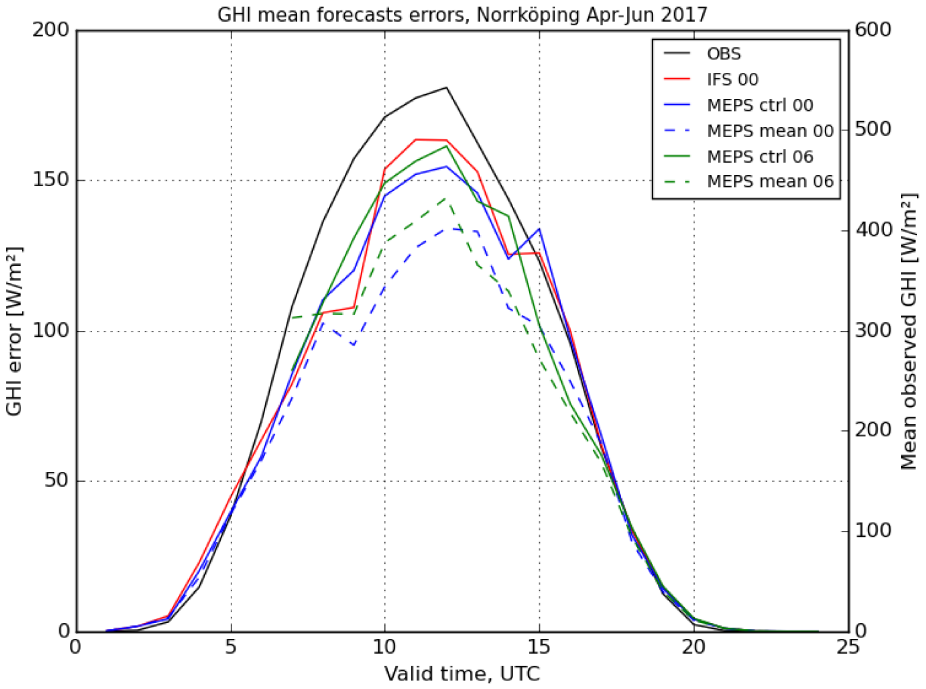
Python composite 20120625:0600, sat proj ->



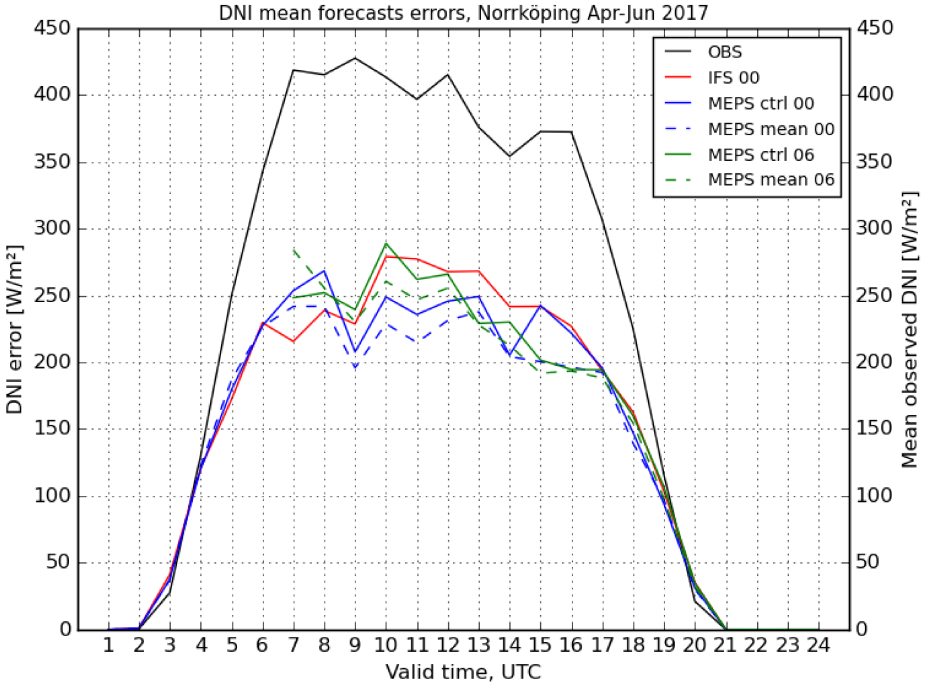
Data + quality info

Comparison: IFS and MEPS vs observations

GHI mean forecast errors



DNI mean forecast errors



Ensemble mean improves the scores.

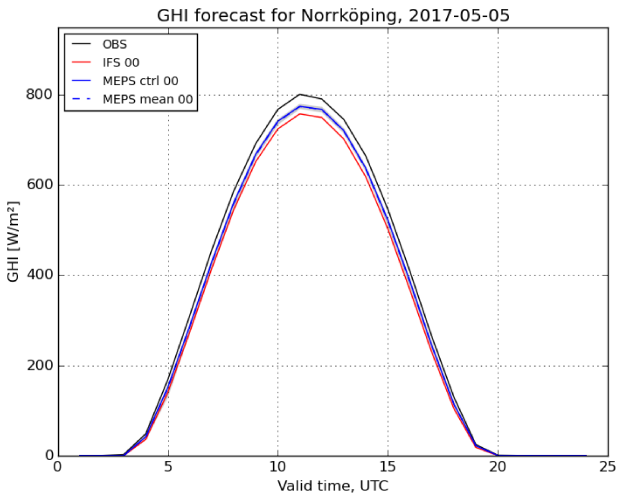
Forecast from 00 best from 01-12 then fc from 06 is better (or as good).

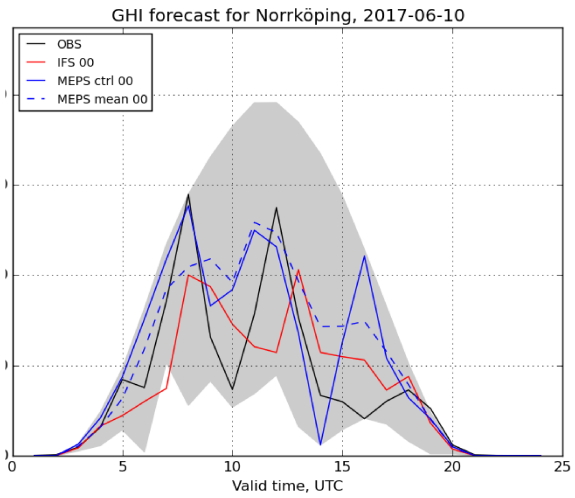
MEPS GHI information: 3 cases

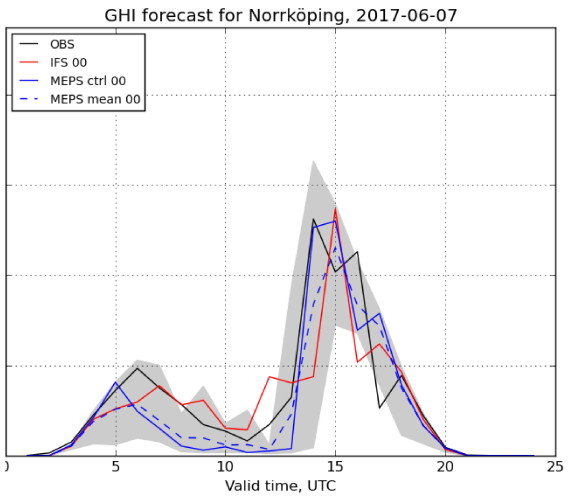
Clear and certain

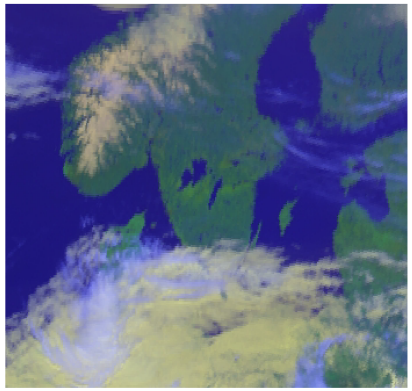
Mixed and uncertain

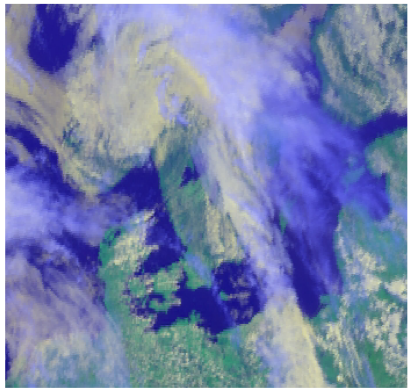
Overcast and certain
(middle of the interval)

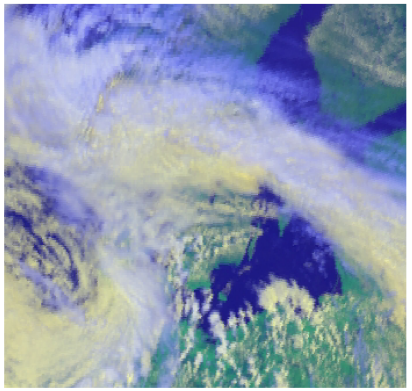








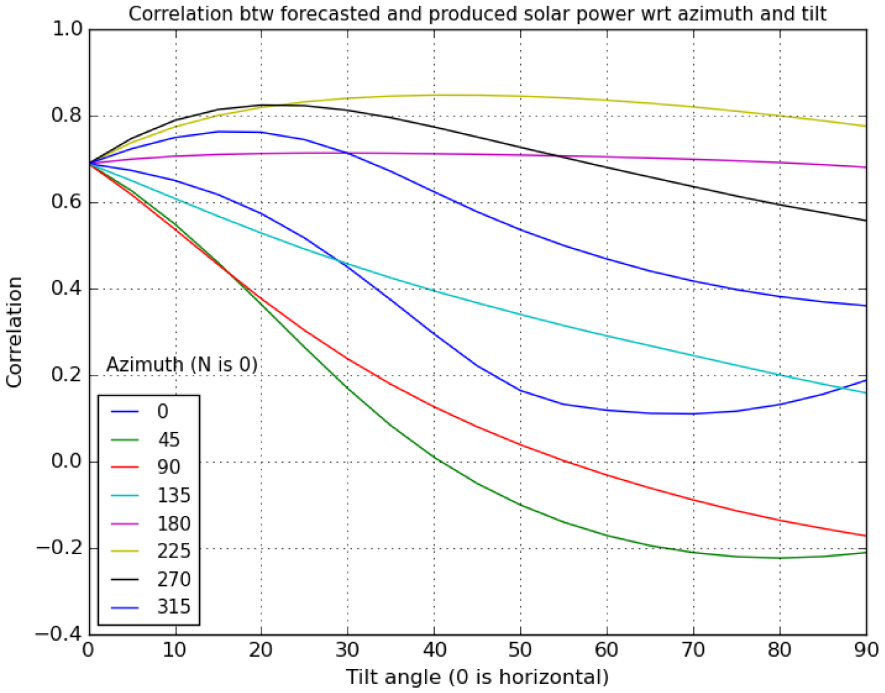




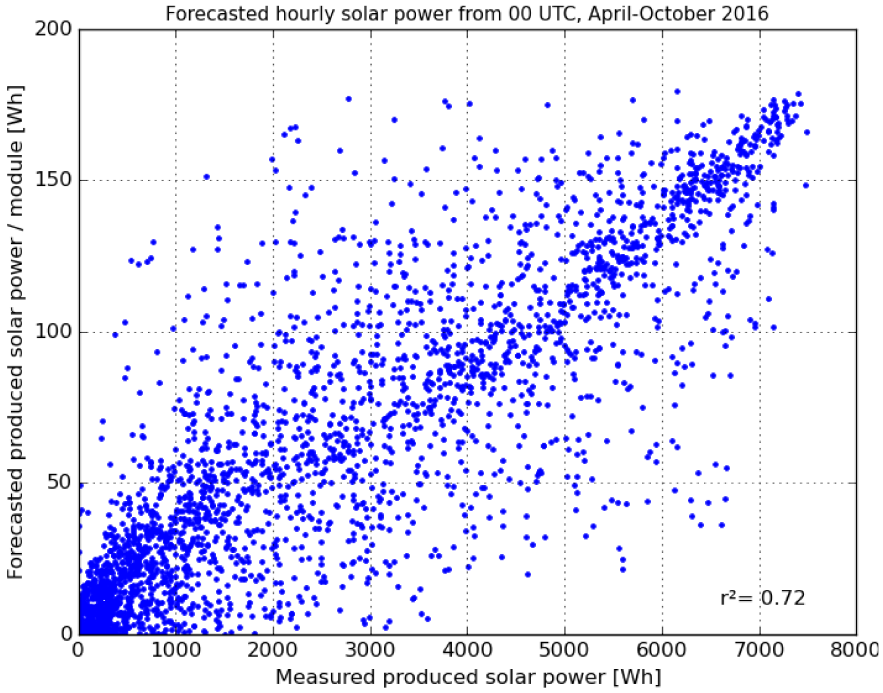
1200 UTC

Forecasting solar power production

Determine positioning of solar panel

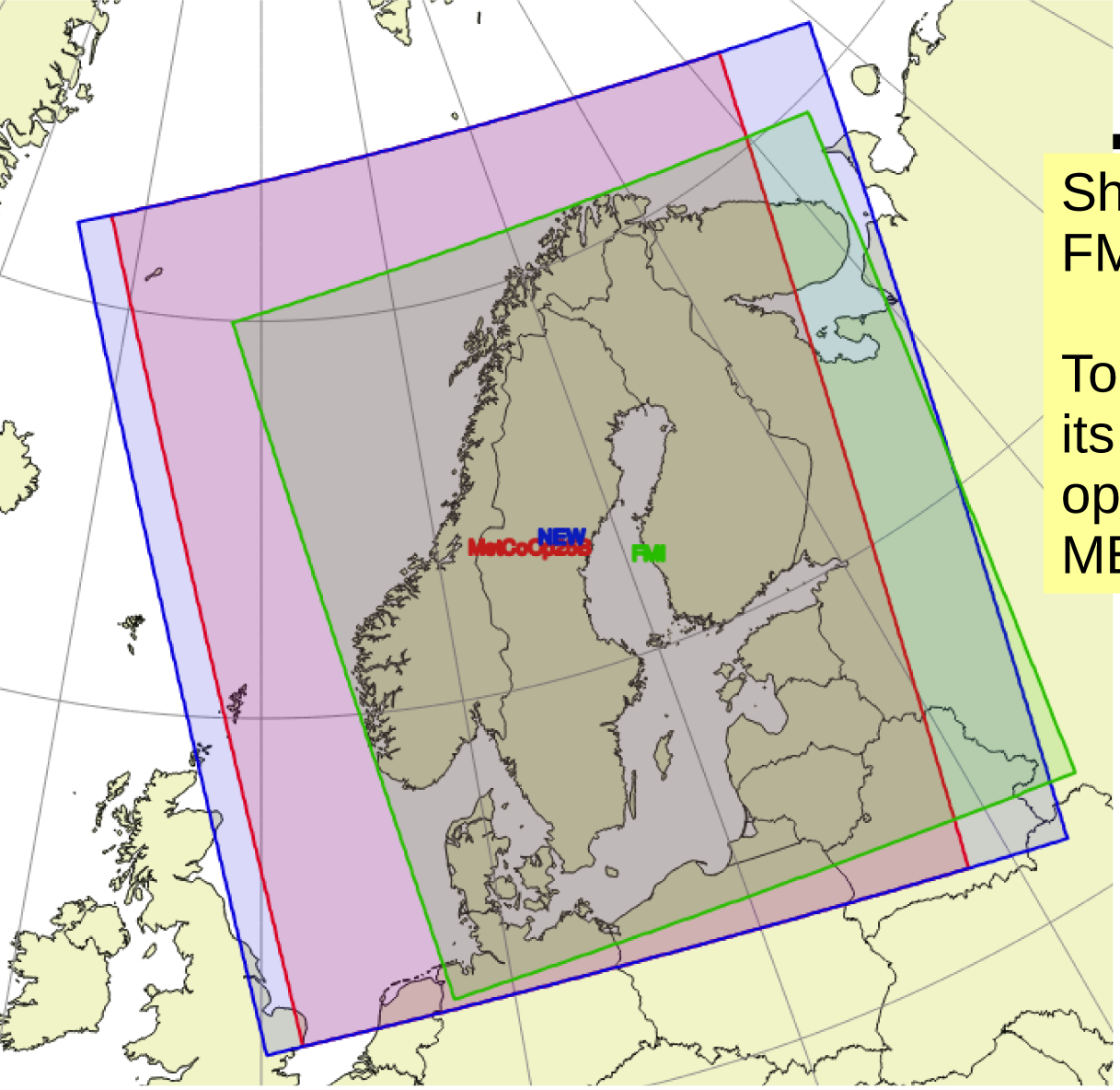


Scatter diagram forecast vs. measured solar power



Preliminary results using the open source pvlib for python photovoltaic system modelling package:

- Estimate module tilt and azimuth angles from NWP & production time series.
- Use NWP forecast to model produced solar power for a type module.



SMHI

Shoutout to our friends at FMI!

Today, MetCoOp increases its domain and produces its operational forecasts with MET, SMHI and FMI.

Conclusions

SMHI

• **Assimilation of SEVIRI** radiances has a positive impact on short-range humidity forecast.

• The impact of 4D-Var is rather neutral for forecasts of ‘dry’ variables and negative for humidity forecasts. **4D-Var development** ongoing!

• **Initialisation with MSG-based cloud product** is a promising approach for short-range DNI forecasts. For high latitudes, PyTroll combines data from geo-stationary and polar-orbiting satellites.

• Information in the ensemble can be used to quantify the **uncertainty in solar radiation forecasts**.

• Promising first results using NWP for **PV production forecasts**.

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Thank you for your attention! Questions?

Swedish Energy Agency