Data assimilation for improving short-range DNI forecasting

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Magnus Lindskog, Tomas Landelius and Heiner Körnich

Swedish Meteorological and Hydrological Institute

Outline

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- Background
- Use of SEVIRI radiances
- 4D-Var
- Initialisation with MSG-based cloud product
- Conclusions

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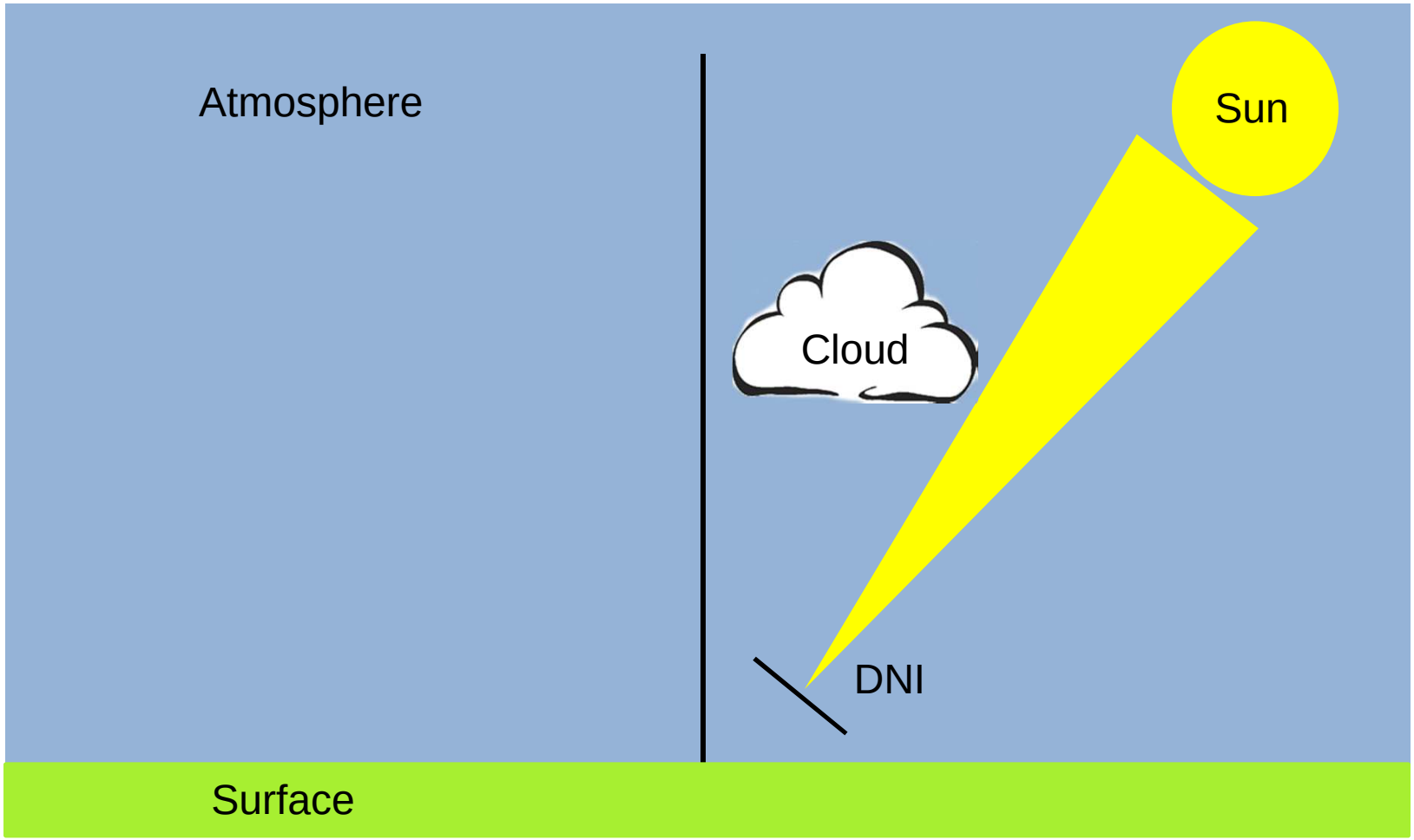
Direct Normal Irradiance (DNI)

Direct Normal Irradiance (DNI) is the amount of solar radiation received per unit area by a surface that is always held perpendicular (or normal) to the rays that come in a straight line from the direction of the sun at its current position in the sky.



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DNICAST

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

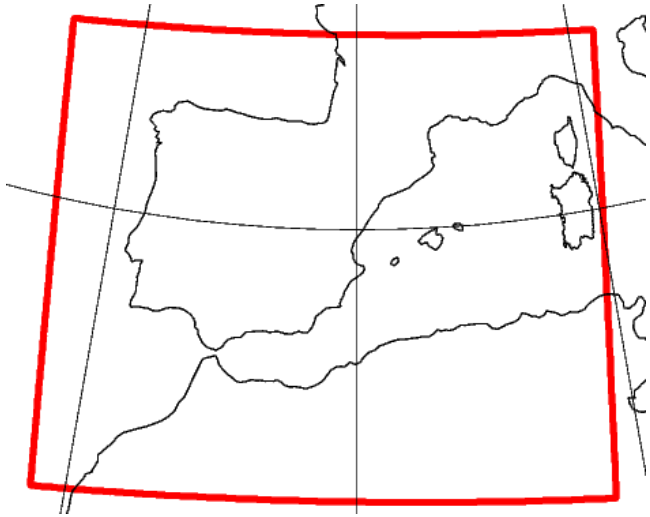
a 4-year project (2013-2017) under the European Union's Seventh Programme for research, technological development and demonstration framework

Solar power plant

Background

SMHI contribution to DNICAST project

- Set-up of HARMONIE system (cy38h1.2) over South European domain (red frame) with an 2.5 km horizontal grid resolution and with 65 vertical levels.
- Produce short-range (~ 6-12 h) forecasts of DNI and wind for extendend periods with reference data assimilation and forecast ingsystem (3D-Var, conv obs., AMSU, MHS).
- For a limited time-period (April, 2013), investigate the impact on forecast quality of assimilating more types of observations (SEVIRI radiances) and of applying alternative methods (4D-Var, initialisation with MSG based cloud product).

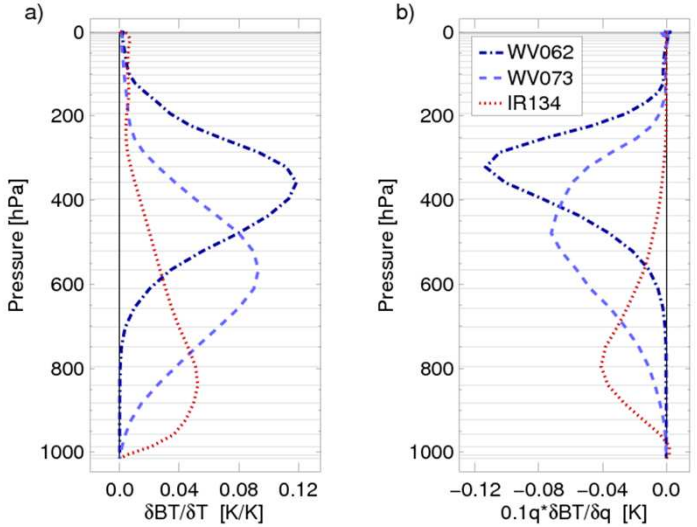


DNICAST HARMONIE South European domain.

Use of SEVIRI radiances

- SEVIRI - Spinning Enhanced Visible and Infra-red Imager.
- On-board METEOSAT second generation geostationary satellites (MSGs).
- Imaging cycle of 15 minutes.
- ~4 km horizontal resolution over DNICAST South European domain.
- 12 channels, we use 2 (wv062 and wv073).
- Cloud-mask and cloud-top pressure from NWC SAF product.
- Clear-sky radiances used.
- Spatial thinning (~25 km) and a variational bias correction applied (one off-set variable, time adaptivity parameter nbg_msg_hr set to 4000).

SEVIRI observations



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

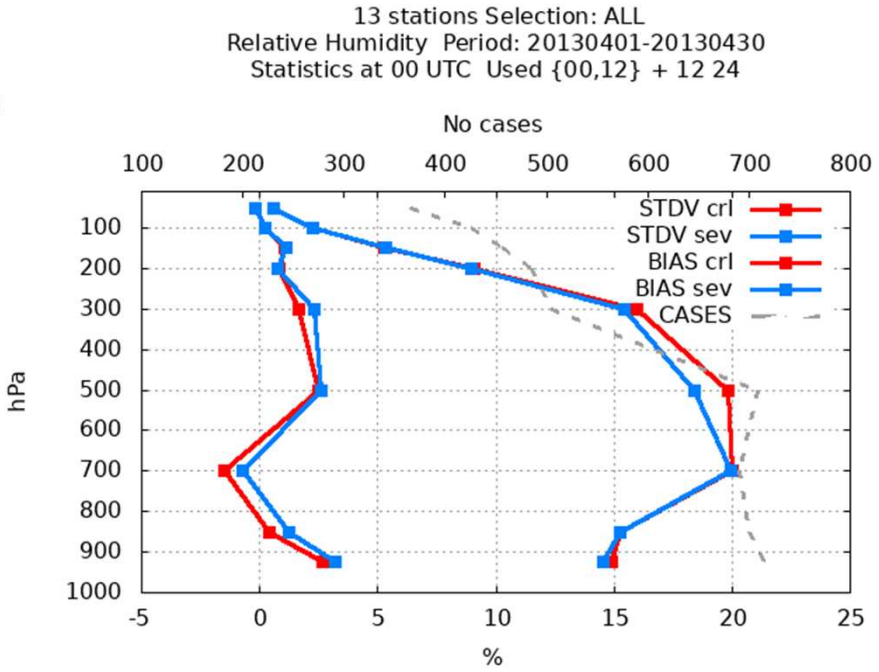
(Fig 2., QJR, 135, by Stengel et al., 2009)

(our gratitude to Máté Mile at Hungarian Meteorological Service)

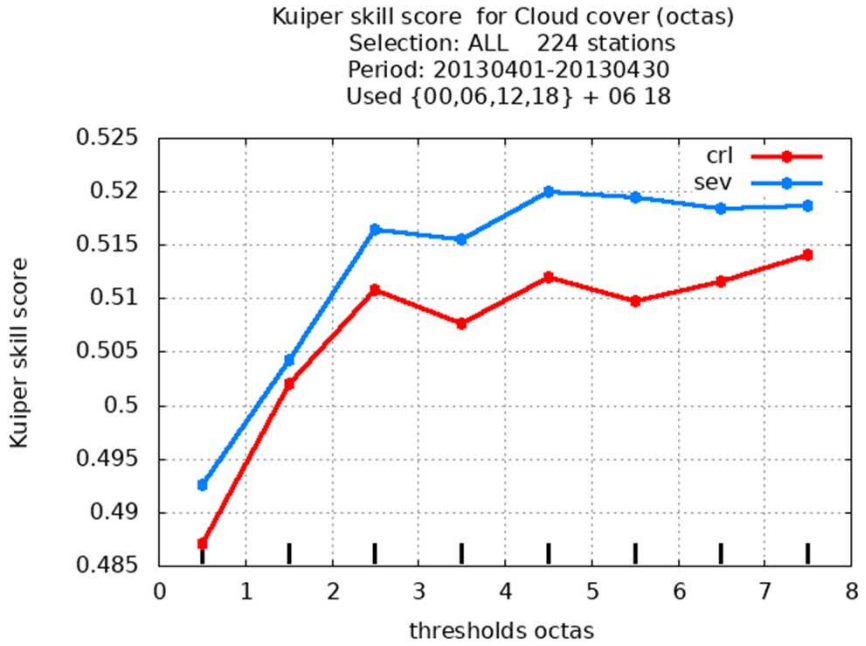
Use of SEVIRI radiances

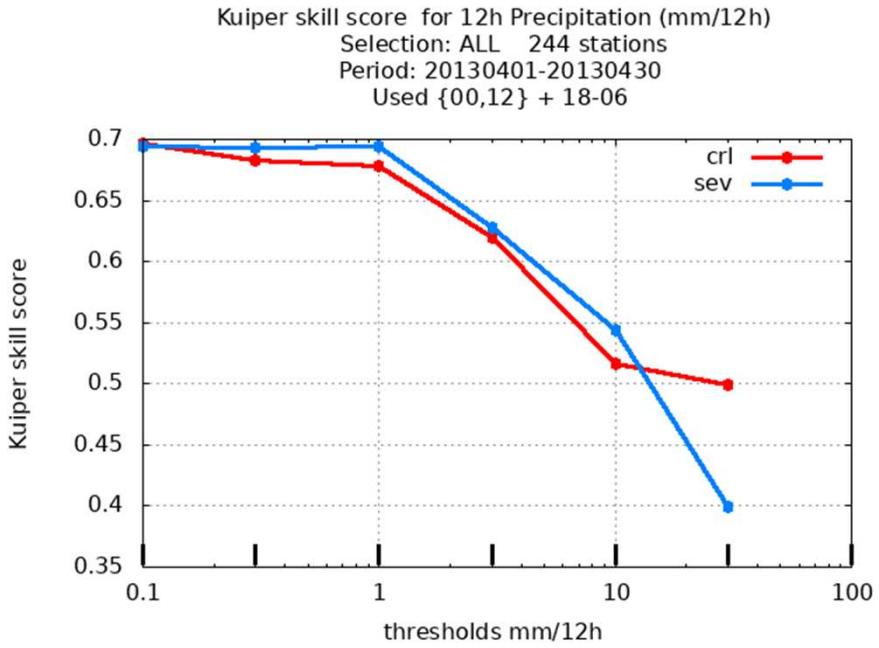
Scores for verification against observations (April, 2013)

std and bias for relative humidity →



Kuiper skill score for
Cloud Cover and 12h precipitation





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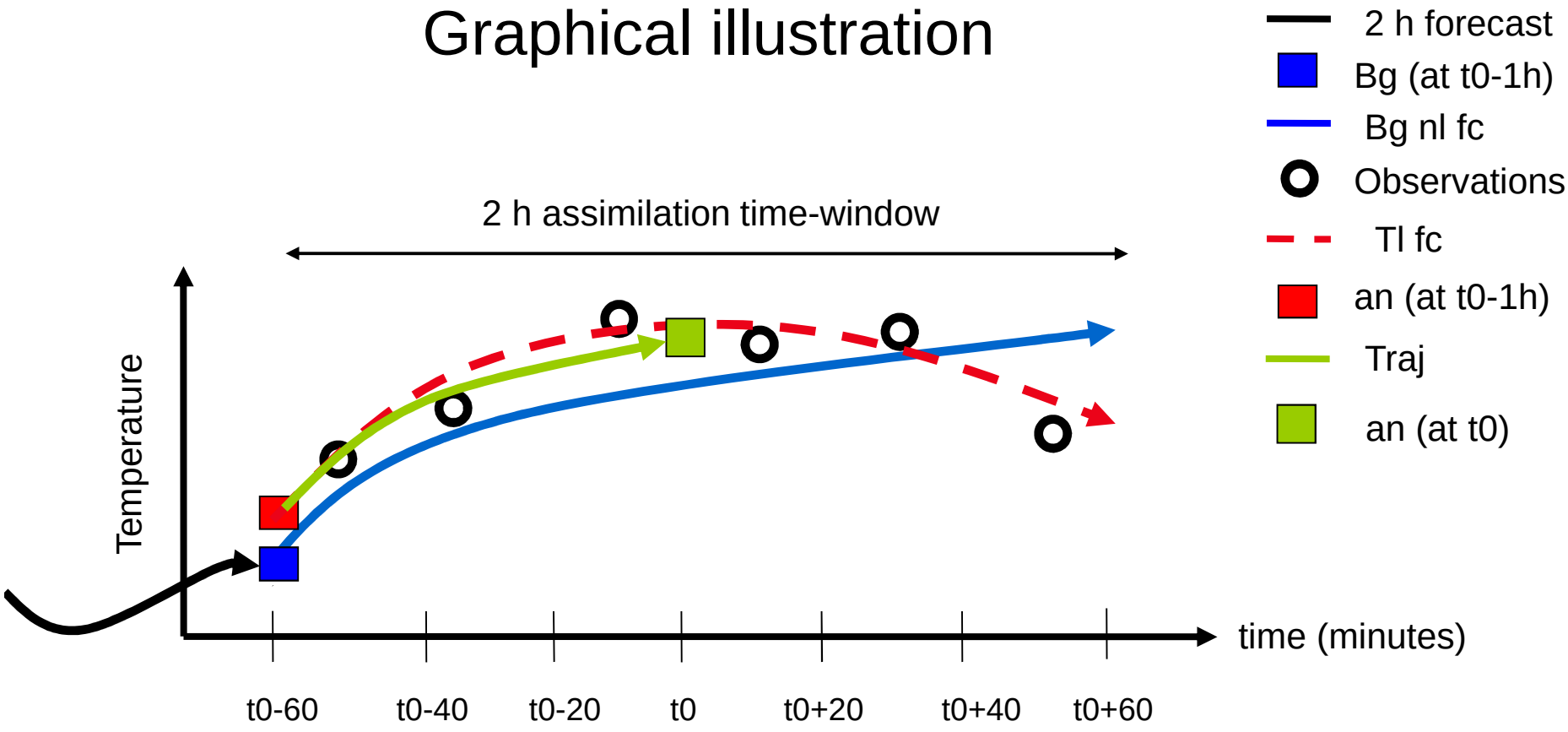
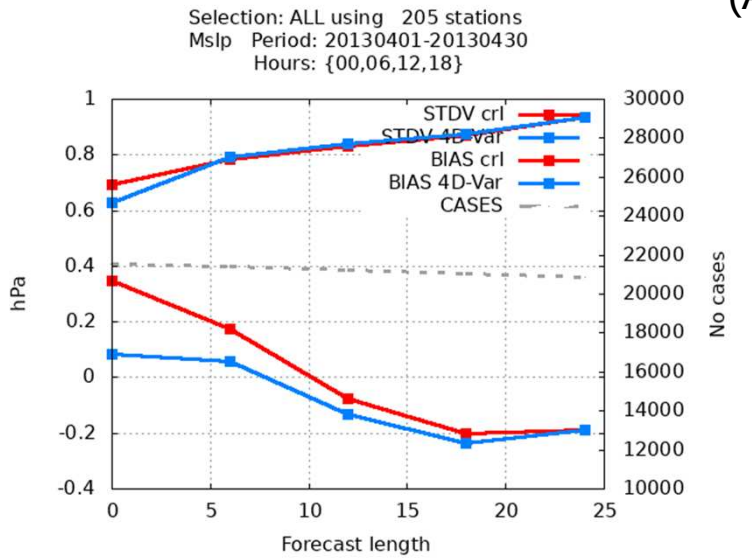
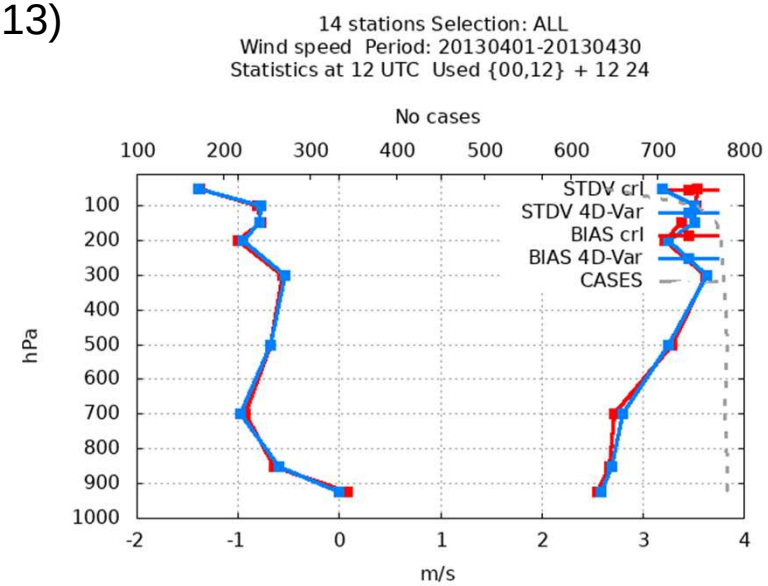
Graphical illustration

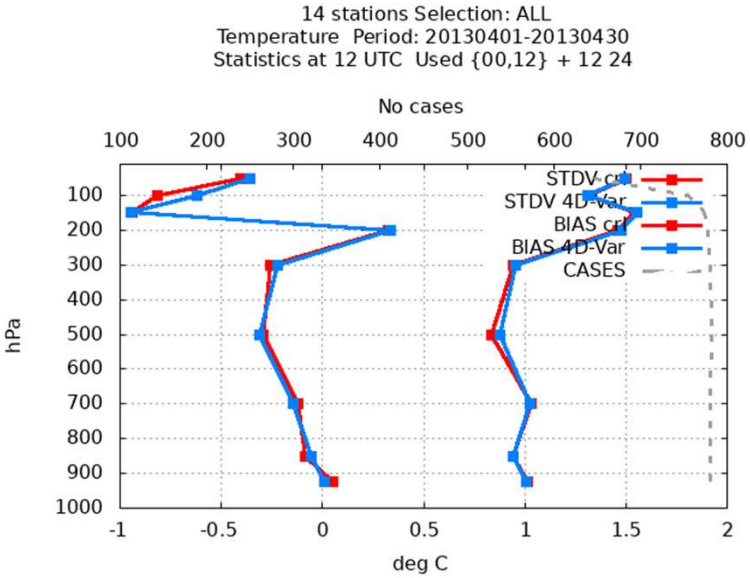


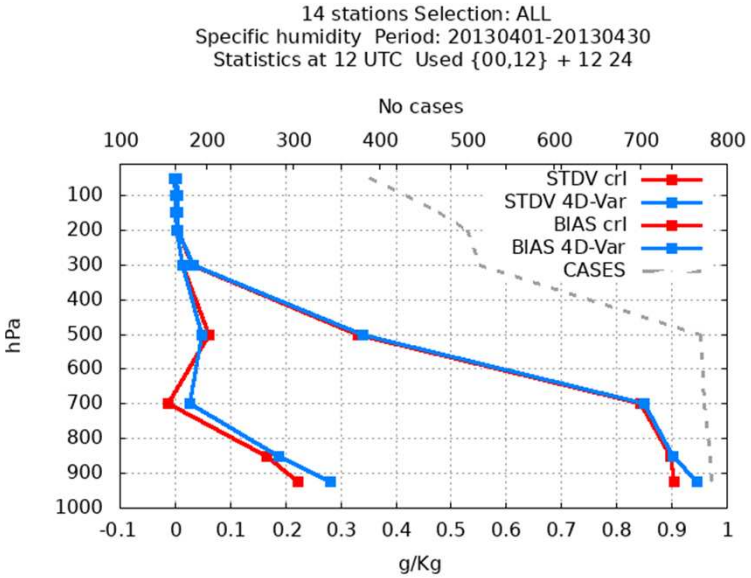
4D-Var

Scores for verification against observations
(April, 2013)









Based on van der Veen, 2012, *MWR*, doi:10.1175/MWR-D-12-00021.1

1. Generate 3-D cloud cover (N) from cloud mask, cloud top temperature and cloud base height. These fields are 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.

Relation between specific humidity (q) and 3D-cloud cover (N):

$$q = q_{sat}.((1-C).\sqrt{N}+C)$$

$$q = \min(q, C.q_{sat})$$

$$C = rh_{max} - (rh_{max} - rh_{min}).\sin(\pi \frac{p}{p_s})$$

Preserve buoyancy when changing humidity (keep T_v constant):

$$T_v = T(1+0.61q - q_l - q_i - q_r - q_s - q_g)$$

(our gratitude to Sibbo van der Veen at KNMI)

Initialisation with MSG based cloud product

Case study: +0h and +3h forecast of total cloud cover compared with MSG based cloud product

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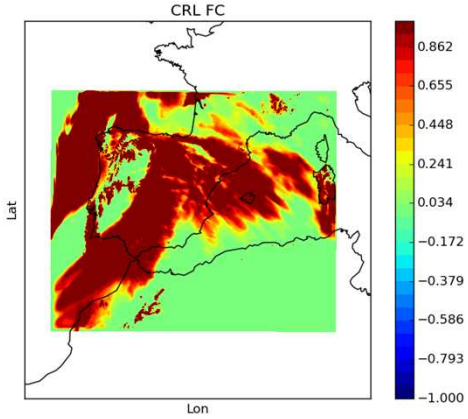

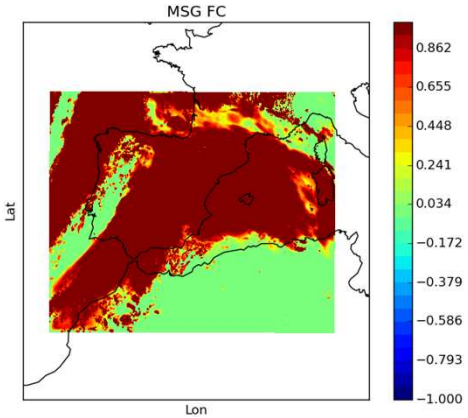

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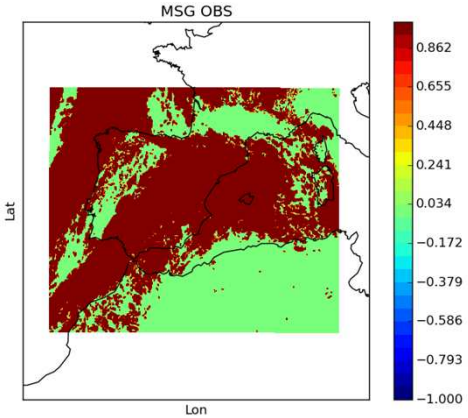

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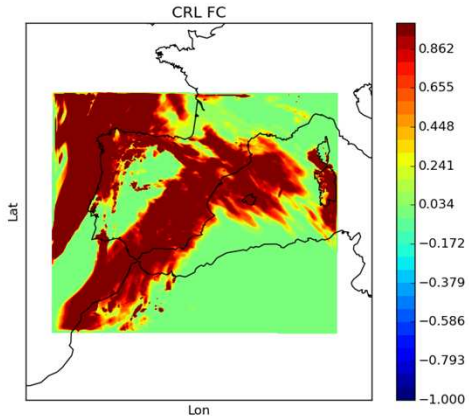
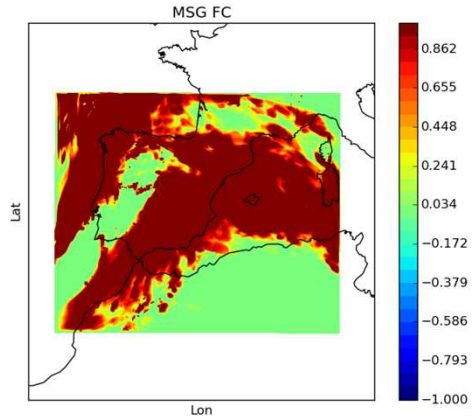
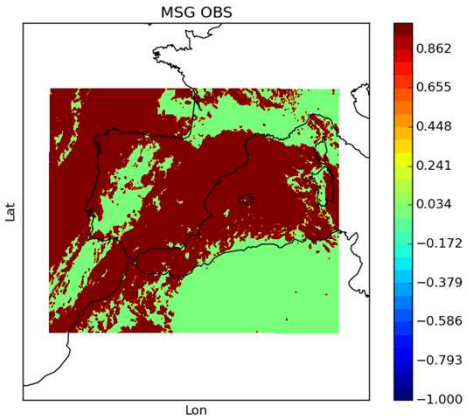
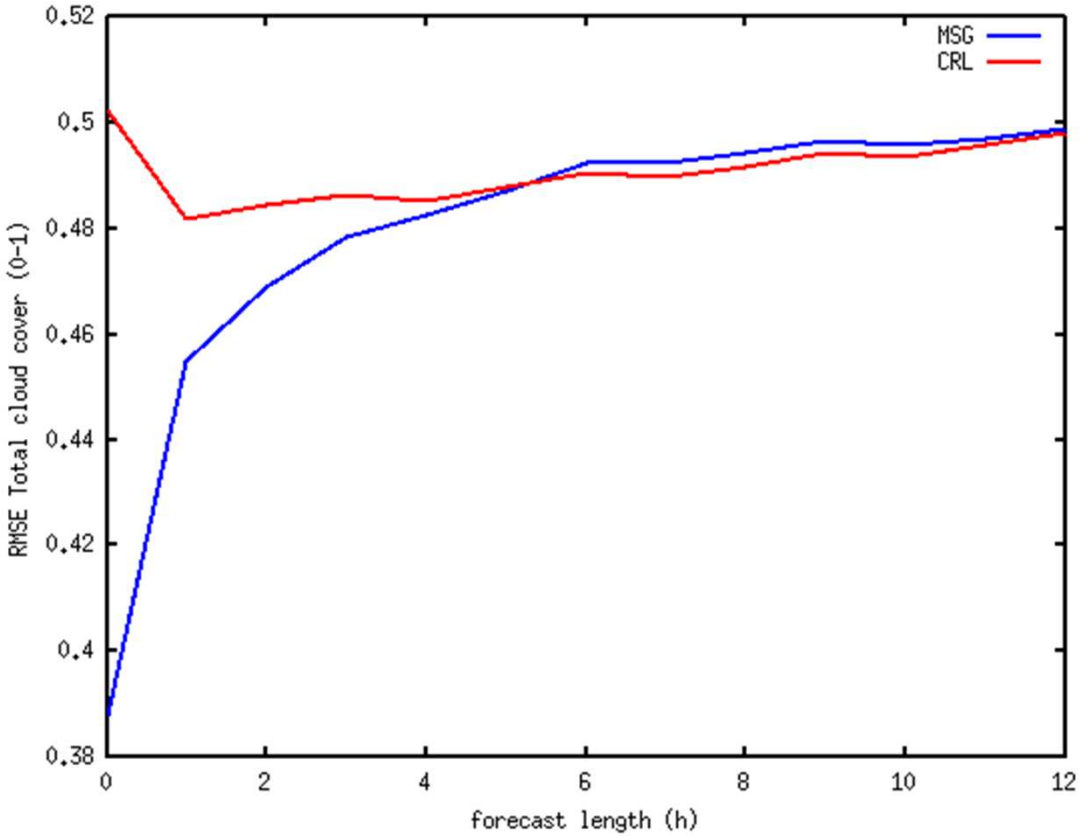




2013032121 fc obs



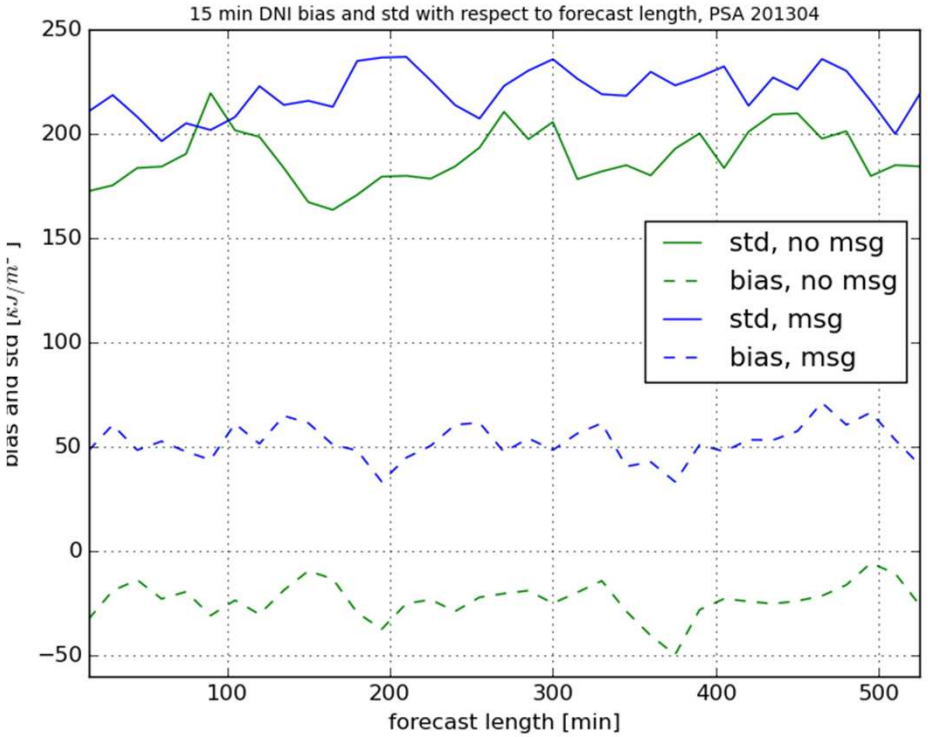
Verification of total cloud cover forecasts against MSG based cloud cover product
(April, 2013)



Verification of DNI forecasts at Almeria station

Location of Almeria station

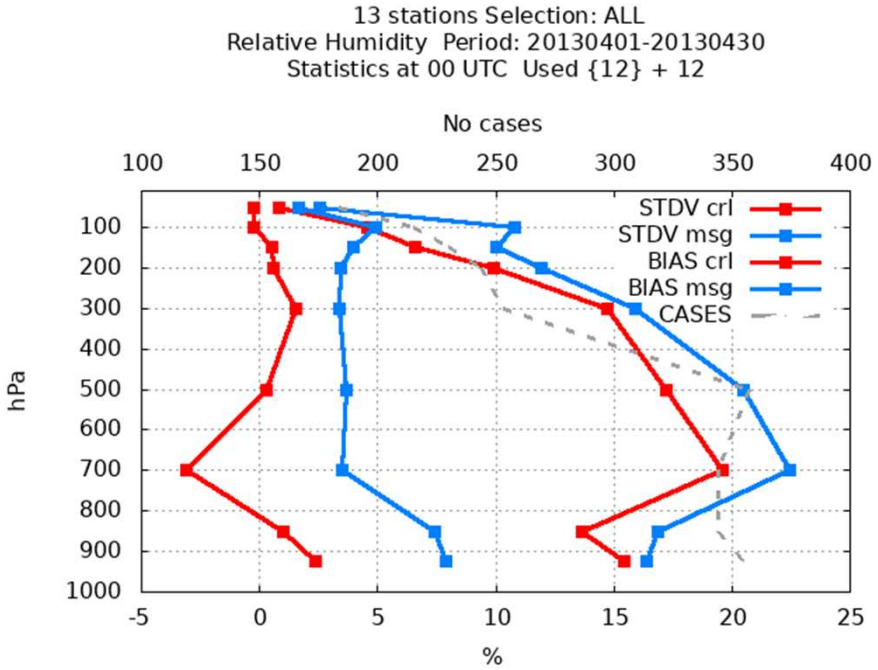
Almeria solar power plant

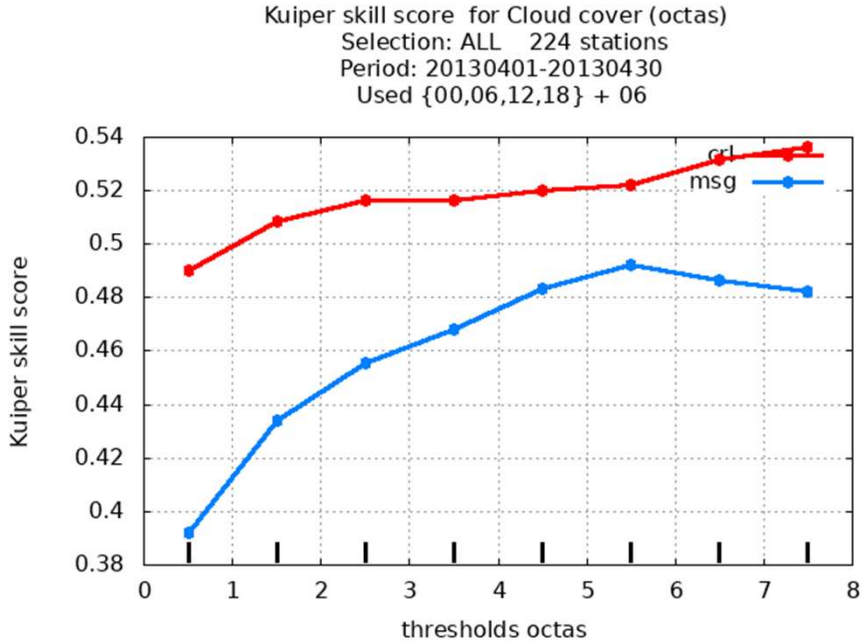


0-9 h forecast length

bias=ob-model. Hence too little clouds in noMSG and too much with MSG.

Verification of relative humidity and total cloud cover forecasts against SYNOP observations (April, 2013)





Conclusions

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- 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. The 4D-Var based forecasts would benefit from more observations (SEVIRI, Mode-S), assimilation of radiosonde observations at correct location/time, and application of a more advanced simplified moist physics.
- Initialisation with MSG-based cloud product is a promising approach for short-range DNI forecasts but some improvements in our set-up are needed. There are several potential improvements, for example: estimation of cloud base, interpretation/usage of NWC SAF cloud type and quality flags and relation specific humidity and cloud cover.
- Ideally, initialisation of MSG based cloud product should be carried out simultaneously with the variational data assimilation.