Potential of a low stratus risk product for the mitigation of irradiation and PV power production forecast error

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Outline

1) Analysis of the day-ahead PV power forecast error

2) Example of a day marked by low stratus

3) Approach to a calibration considering low stratus

4) Results

5) Next steps

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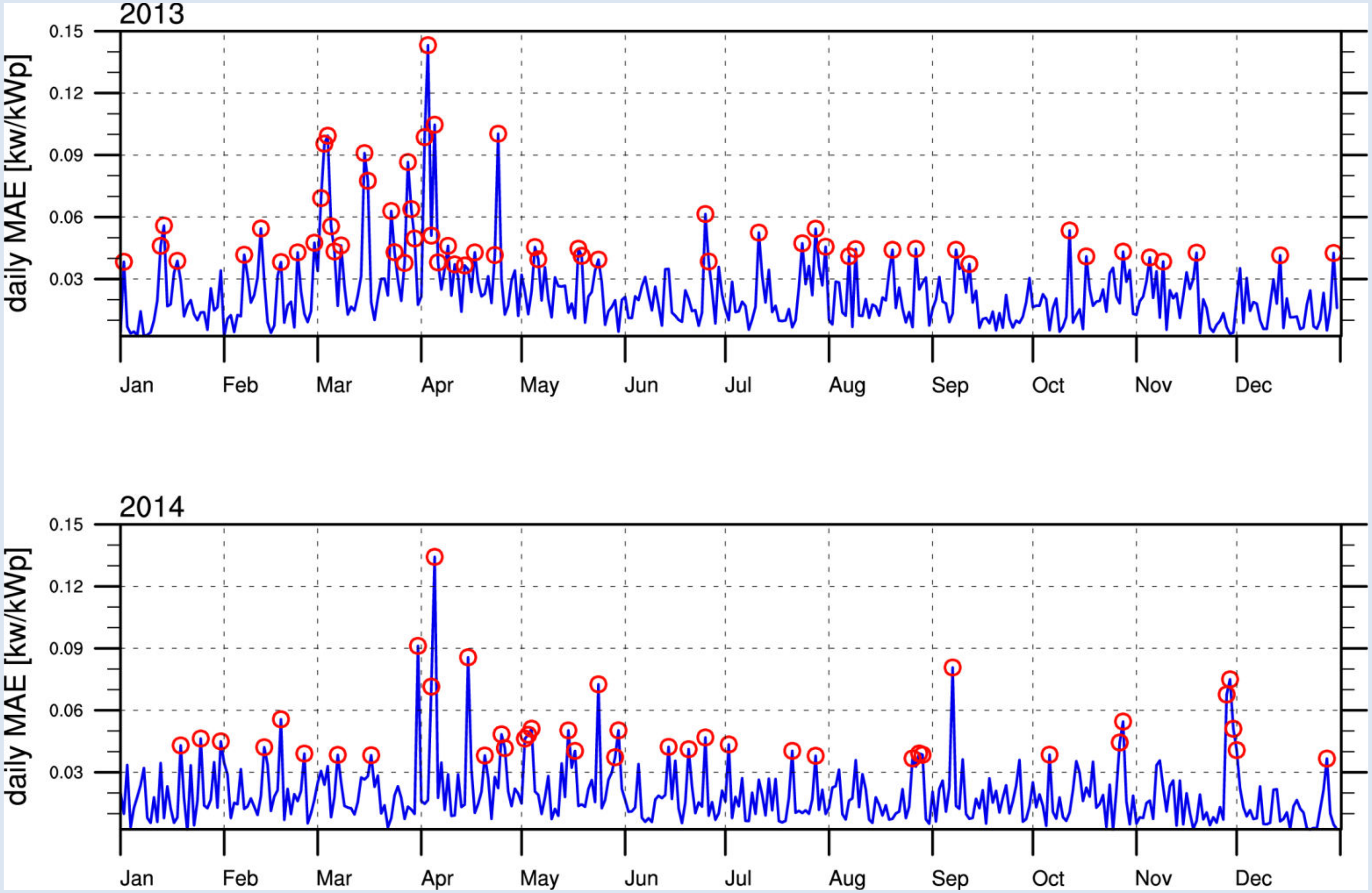
Analysis of the DA PV forecast errors

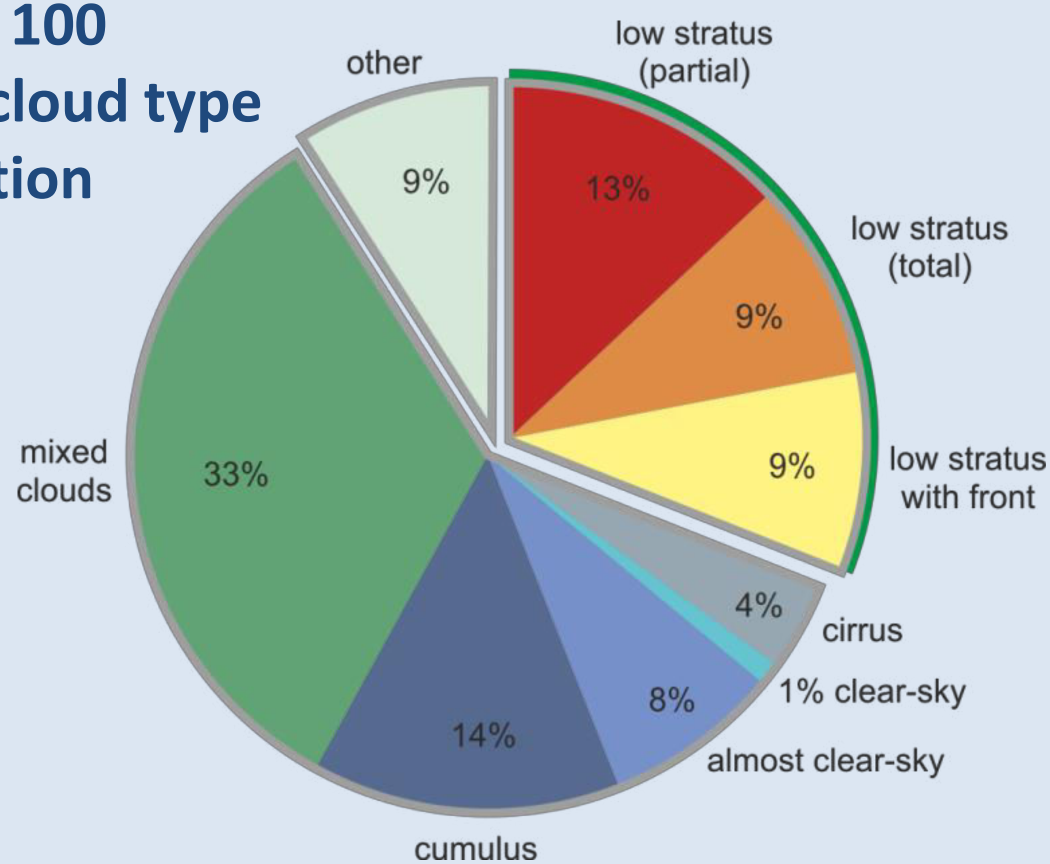
- ➔ The analysis is based on the estimates and day-ahead forecast of the PV power generation provided by the German TSOs
- ➔ The daily MAE values for Germany have been evaluated over two years (2013-2014)
- ➔ The 100 days with the highest errors were identified and the prevailing weather situation manually evaluated by the DWD


Analysis of the DA PV forecast errors



Analysis of the DA PV forecast errors

Distribution of the 100 days according to cloud type and weather situation



→ **A large share of the days with large error are marked by the presence of low stratus**

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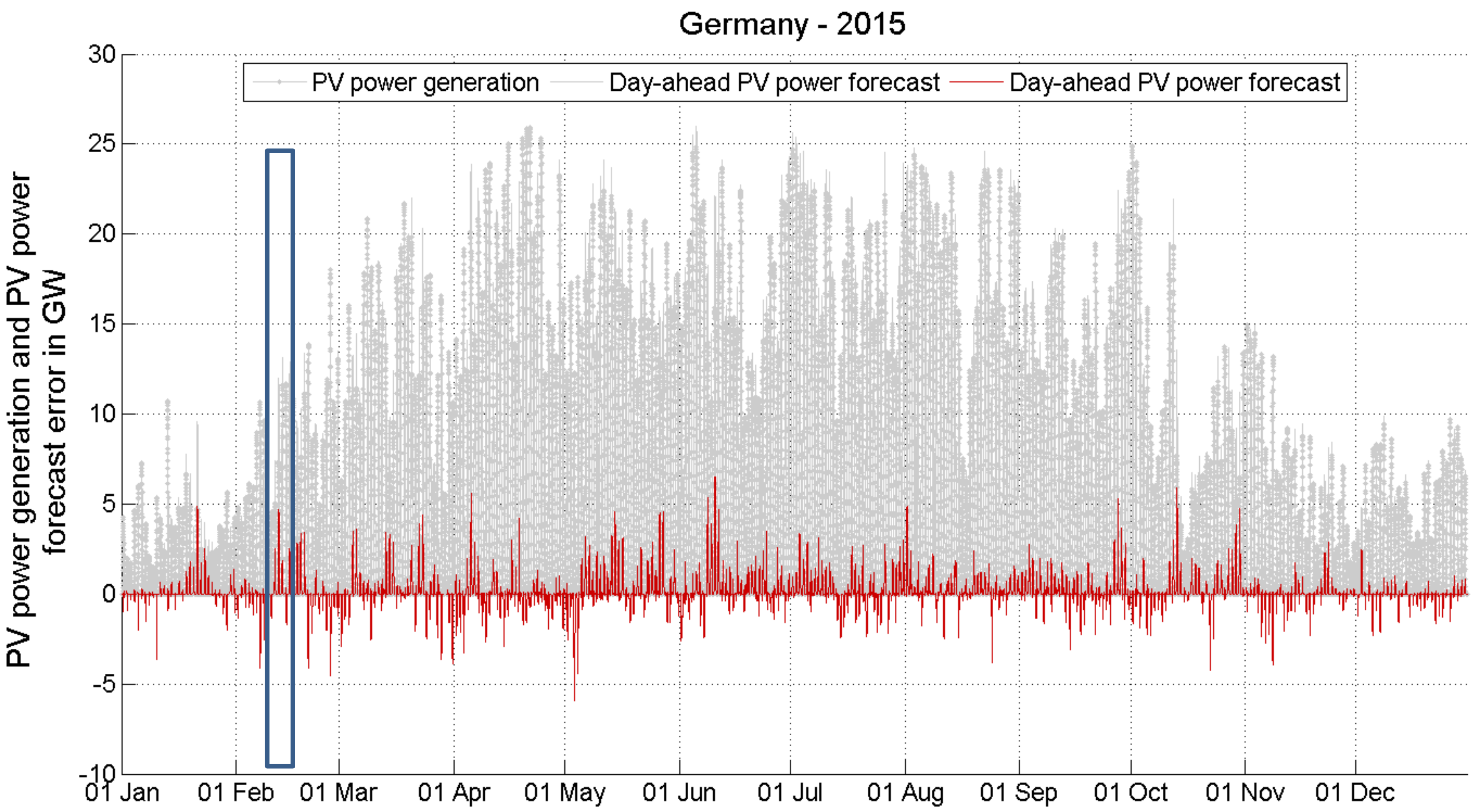
Example of a day with low stratus

Example: TSOs reported a large PV forecast errors on 12/02/2015



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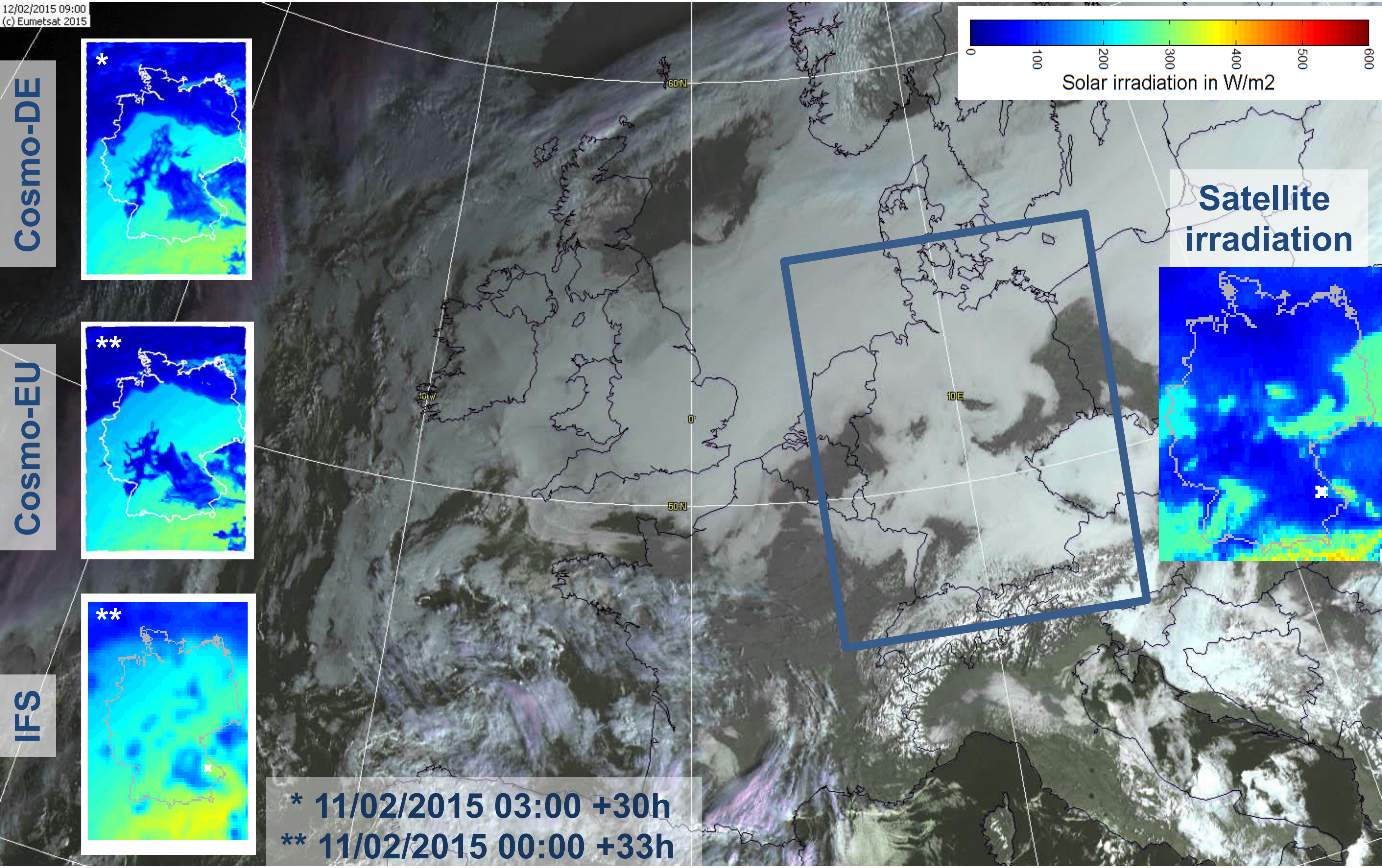
Example of a day with low stratus



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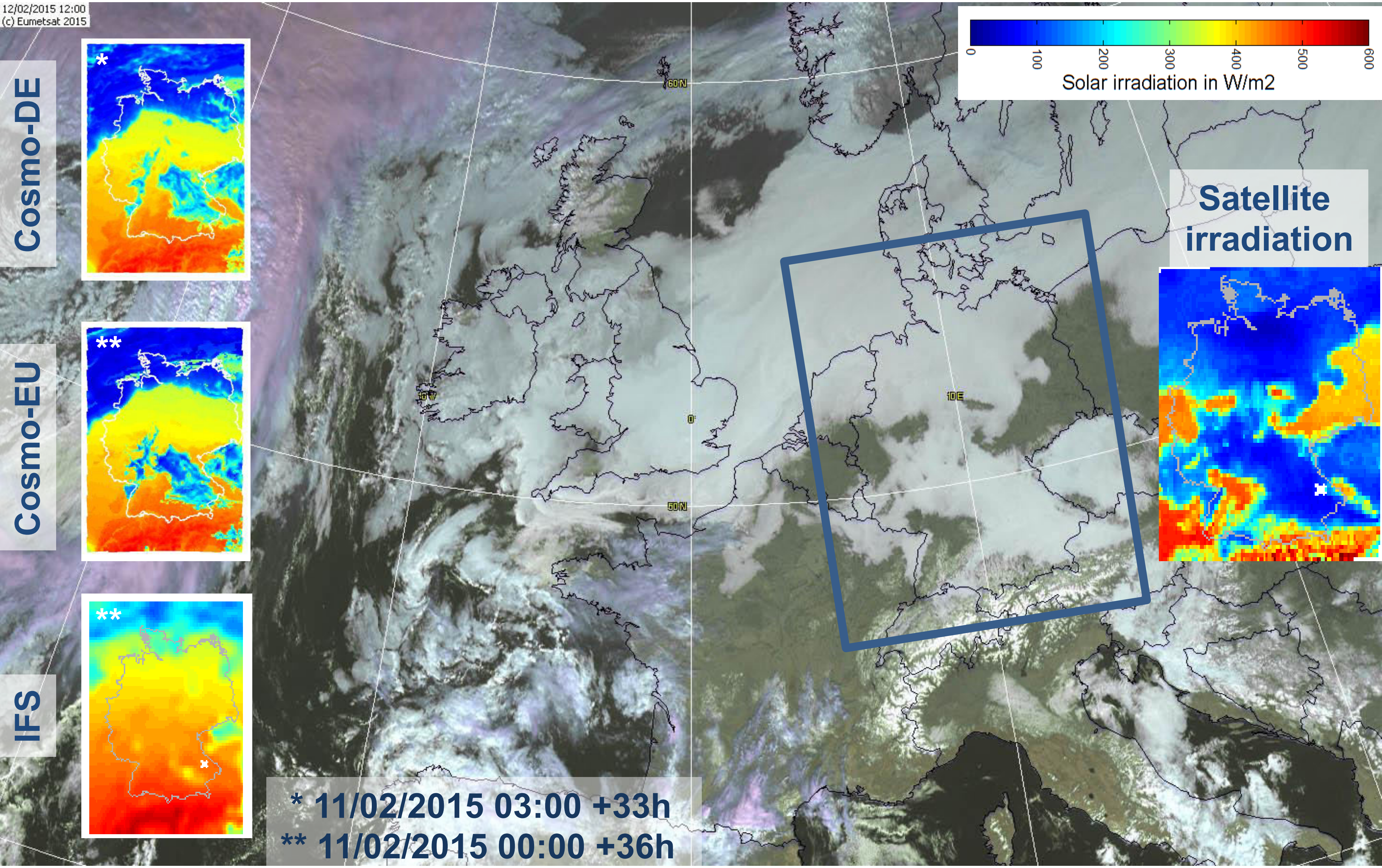

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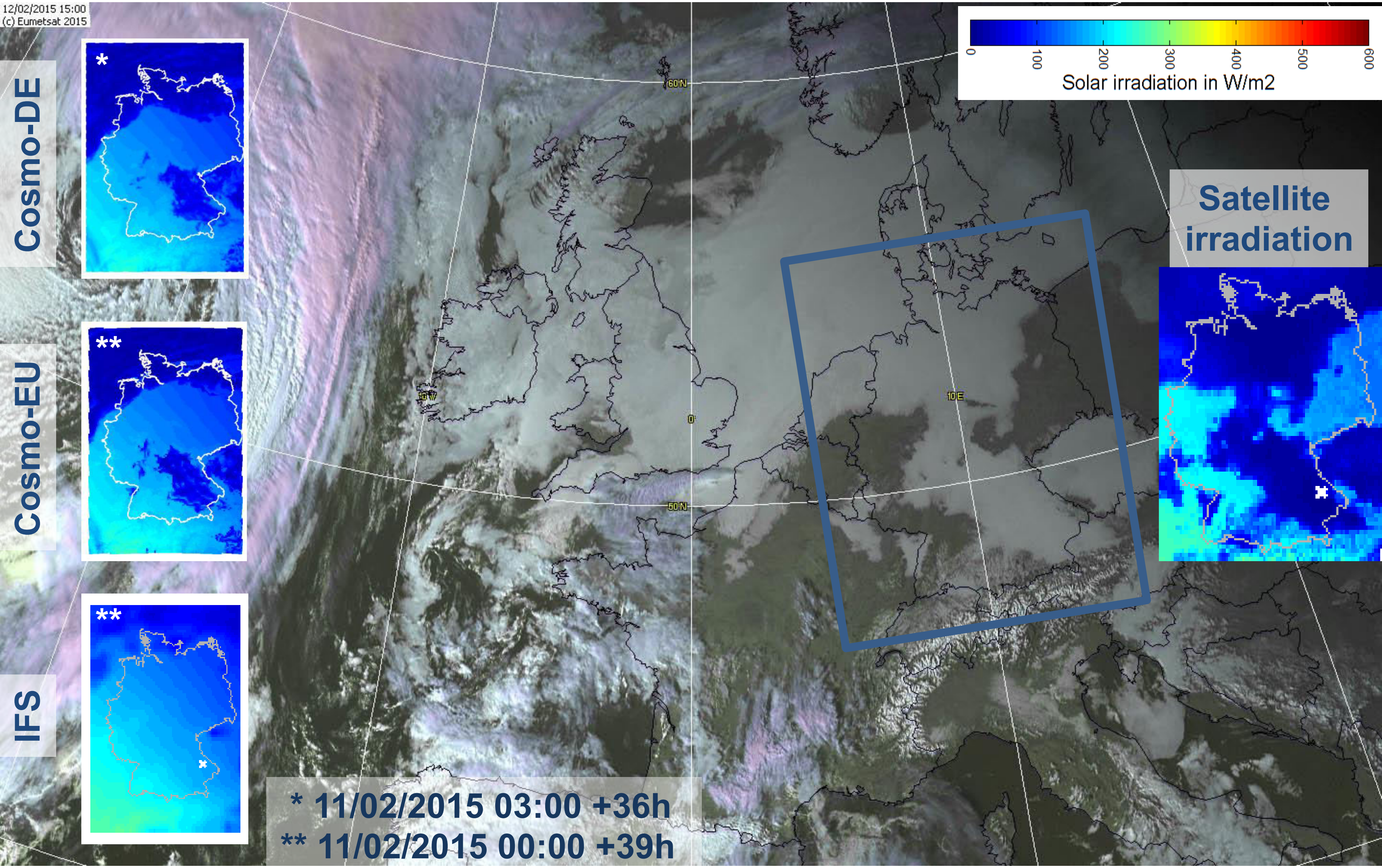

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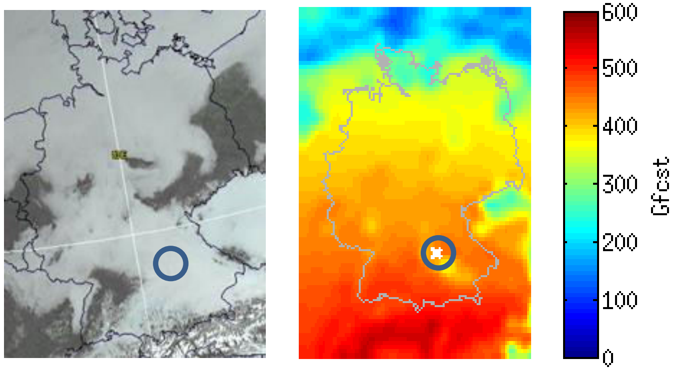

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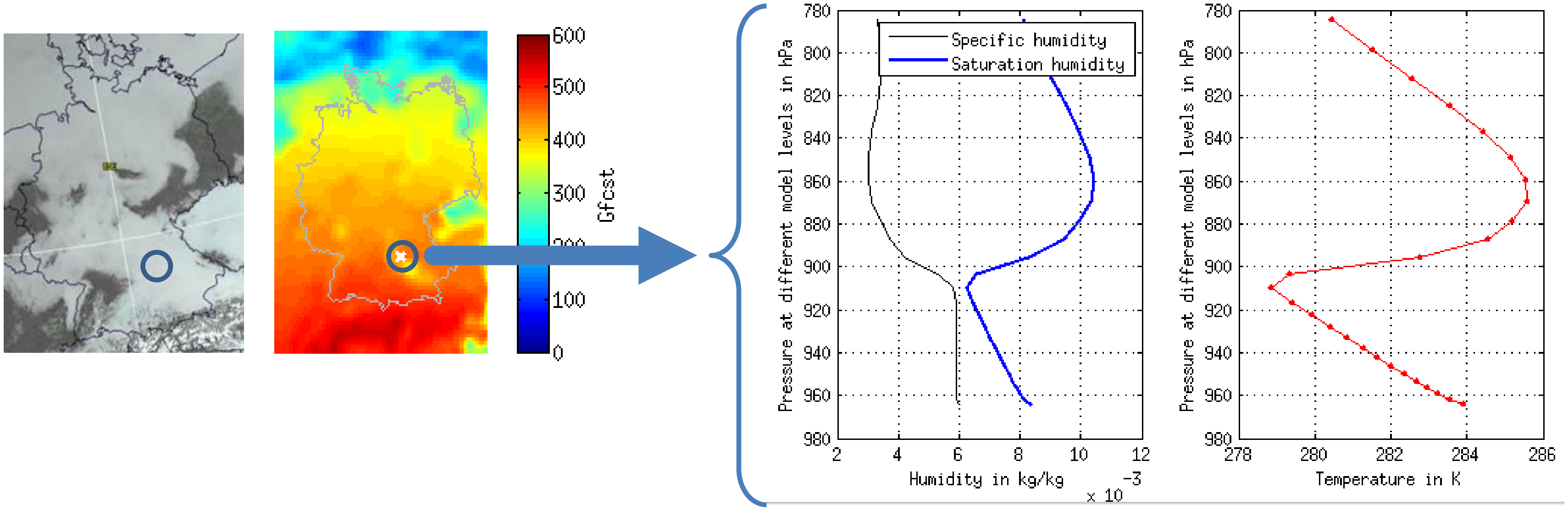

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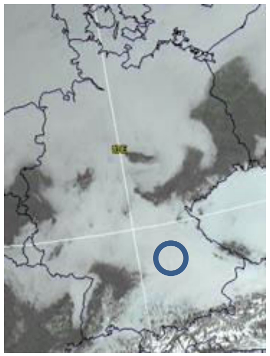

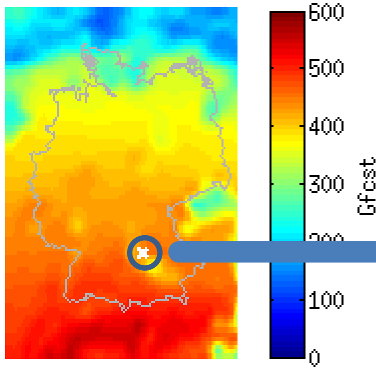

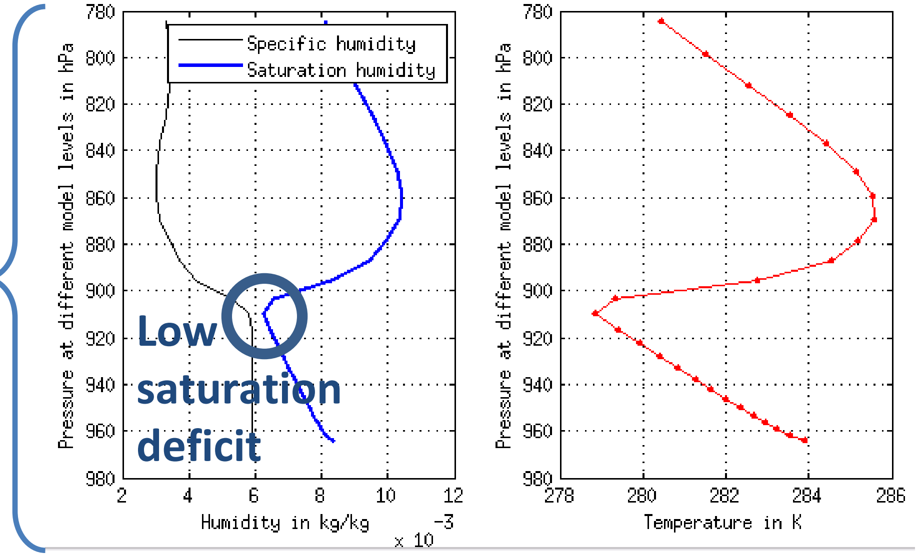

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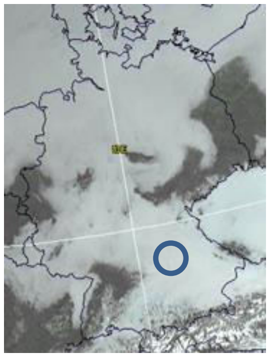

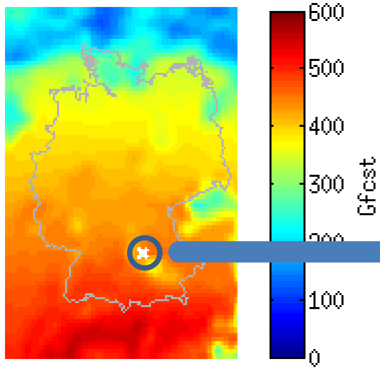

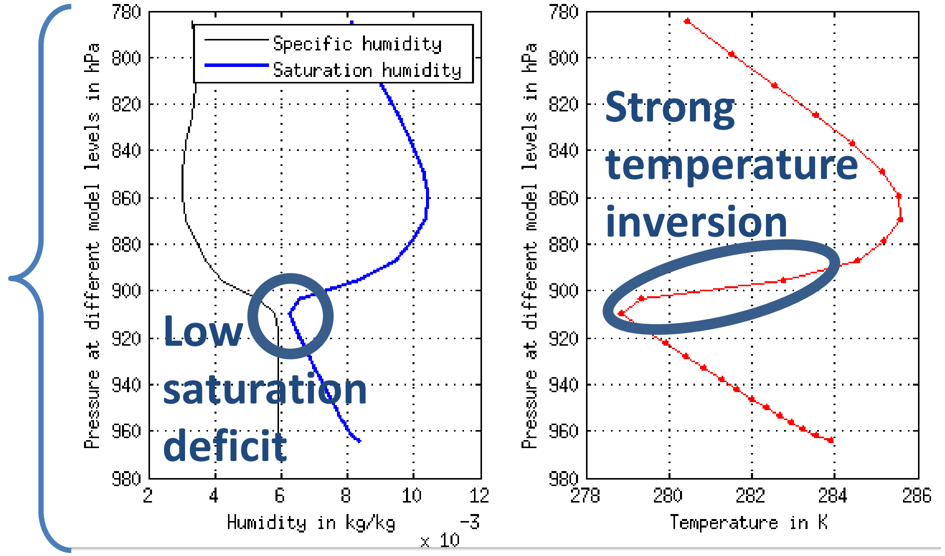

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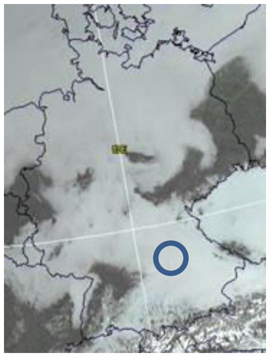

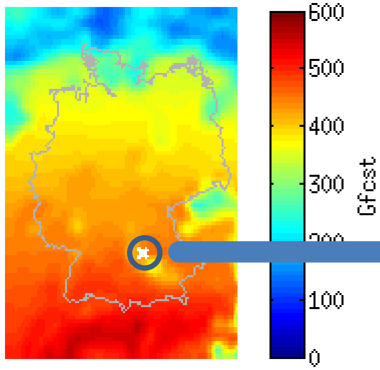

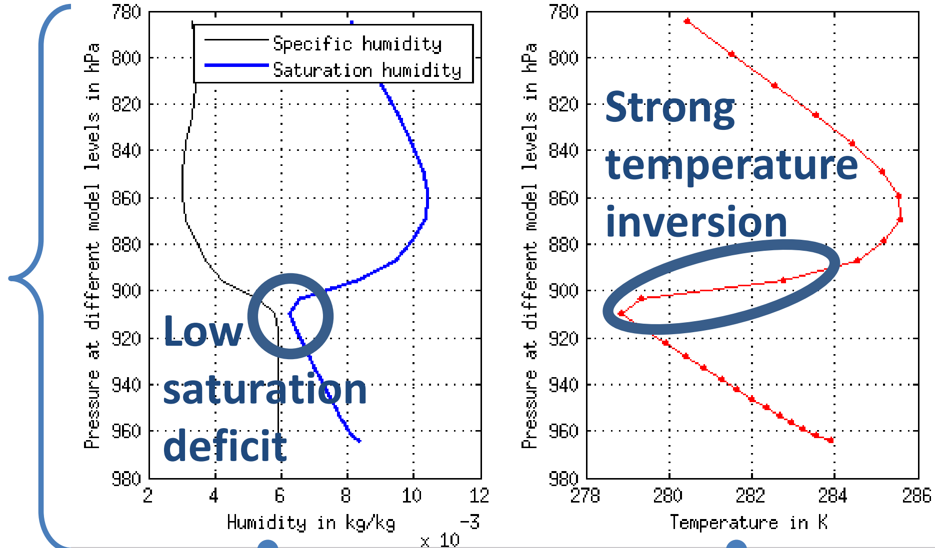

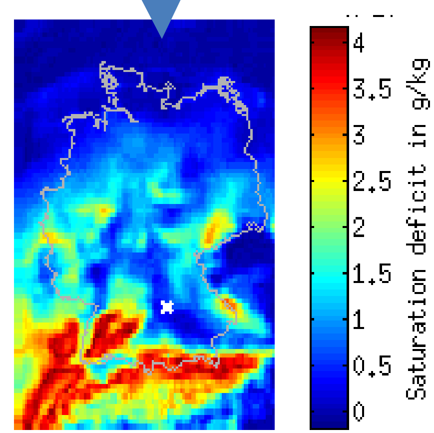

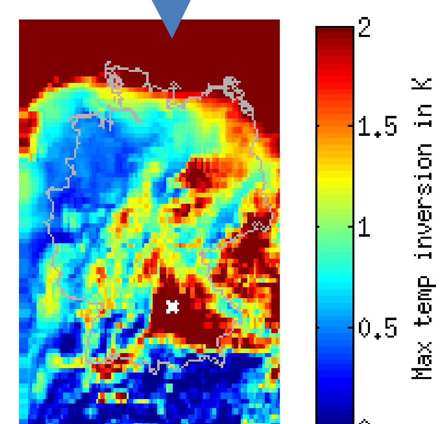

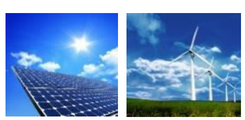

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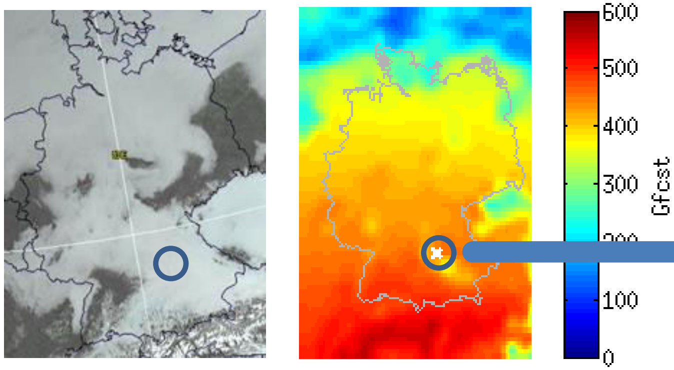
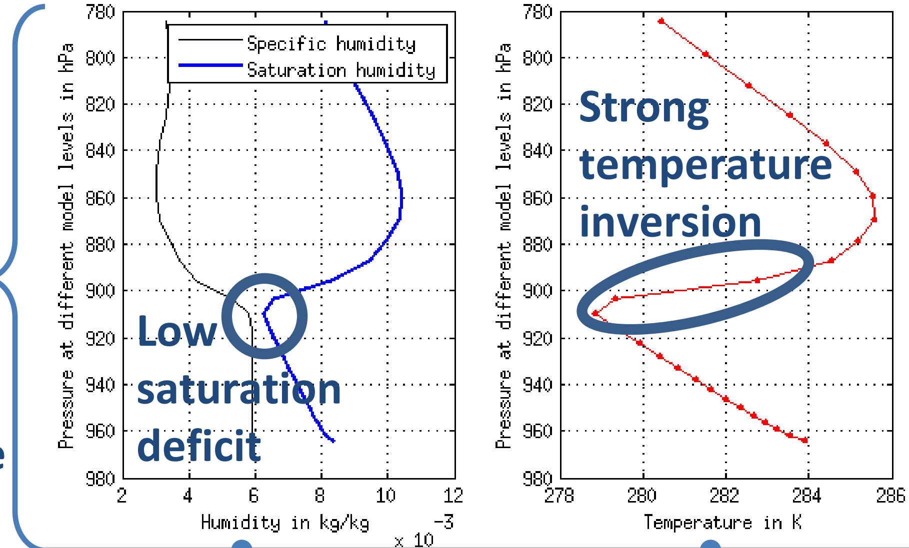
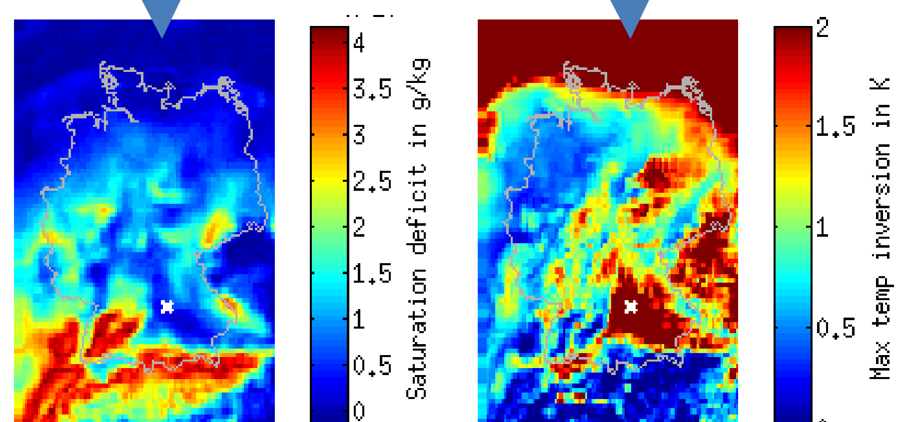




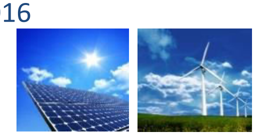


Adaptation of the SK-scheme (*)(**) for the detection of LS:

- Strong temperature inversions below 800 hPa
- Low saturation deficit below the temperature inversion

*Seidl H., Kann A.: New approaches to stratus diagnosis in Aladin. Aladin Newsletter 22, July 2002.

** Köhler C., Steiner A., Saint Drenan Y.-M., Metzinger I., Ritter B., Critical Weather Situations for Renewable Energies - Part B: Low Stratus Risk for Solar Power, Submitted to Renewable Energy, January 2016



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Calibration approach

Choice of the fit function

$$G_{corr} = \left[\left(a_{11}\tilde{T}I + a_{12}\tilde{S}D + a_{13}\tilde{T}I \cdot \tilde{S}D \right) + \left(a_{21}\tilde{T}I + a_{22}\tilde{S}D + a_{23}\tilde{T}I \cdot \tilde{S}D \right) \left(\frac{G}{G_{TOA}} \right) \right] G_{TOA}$$

$$with \quad \tilde{S}D = \max\left[0, \left(SD_0 - SD\right)\right] \qquad \tilde{T}I = \max\left[0, \left(TI - TI_0\right)\right]$$

G	irradiance forecast [W/m^2]
G_{corr}	corrected irradiance forecast [W/m^2]
G_{poa}	extraterrestrial irradiance [W/m^2]
TI	max temperature inversion below 800 hPa [°C]
TI_0	TI above which the correction scheme is activated [°C]
SD	saturation deficit below the temperature inversion [kg/kg]
SD_0	SD below which the correction scheme is activated [kg/kg]
a_{ij}	calibration coefficients


Calibration approach

Choice of the fit function

$$G_{corr} = \left[\left(a_{11}\tilde{T}I + a_{12}\tilde{S}D + a_{13}\tilde{T}I \cdot \tilde{S}D \right) + \left(a_{21}\tilde{T}I + a_{22}\tilde{S}D + a_{23}\tilde{T}I \cdot \tilde{S}D \right) \left(\frac{G}{G_{TOA}} \right) \right] G_{TOA}$$

with

$$\tilde{S}D = \max\left[0, \left(SD_0 - SD\right)\right]$$

$$\tilde{T}I = \max\left[0, \left(TI - TI_0\right)\right]$$

Activation of the correction scheme for $TI > TI_0$ & $SD < SD_0$

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a_{ij}	calibration coefficients


Calibration approach

Choice of the fit function

Different corrections coefficients for clear sky and overcast sky

$$G_{corr} = \left[\left(a_{11}\tilde{TI} + a_{12}\tilde{SD} + a_{13}\tilde{TI}\cdot\tilde{SD} \right) + \left(a_{21}\tilde{TI} + a_{22}\tilde{SD} + a_{23}\tilde{TI}\cdot\tilde{SD} \right) \left(\frac{G}{G_{TOA}} \right) \right] G_{TOA}$$

with $\tilde{SD} = \max\left[0, \left(SD_0 - SD\right)\right]$ $\quad \tilde{TI} = \max\left[0, \left(TI - TI_0\right)\right]$

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Calibration approach

Choice of the fit function

Simple additive model with a cross term

$$G_{corr} = \left[\left(a_{11}\tilde{T}I + a_{12}\tilde{S}D + a_{13}\tilde{T}I \cdot \tilde{S}D \right) + \left(a_{21}\tilde{T}I + a_{22}\tilde{S}D + a_{23}\tilde{T}I \cdot \tilde{S}D \right) \left(\frac{G}{G_{TOA}} \right) \right] G_{TOA}$$

with $\tilde{S}D = \max\left[0, \left(SD_0 - SD\right)\right]$ $\quad \tilde{T}I = \max\left[0, \left(TI - TI_0\right)\right]$

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Choice of the fit function

$$G_{corr} = \left[\left(a_{11}\tilde{T}I + a_{12}\tilde{S}D + a_{13}\tilde{T}I \cdot \tilde{S}D \right) + \left(a_{21}\tilde{T}I + a_{22}\tilde{S}D + a_{23}\tilde{T}I \cdot \tilde{S}D \right) \left(\frac{G}{G_{TOA}} \right) \right] G_{TOA}$$

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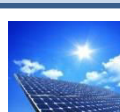
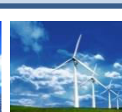
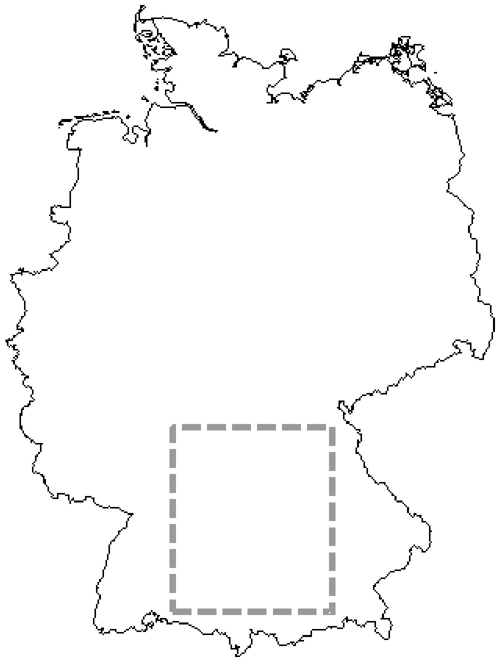
Coefficients are assumed constant in time and space

Calibration approach



- The calibration is evaluated for the south of Germany
- Satellite-derived irradiance (HC3v4) and IFS forecast are used
- The coefficients a_{ij} are evaluated by a multiple linear regression
- The correction is evaluated for the time period 01/2015 –06/2015
- The effect of the calibration is assessed for the time period 07/2015-12/2012

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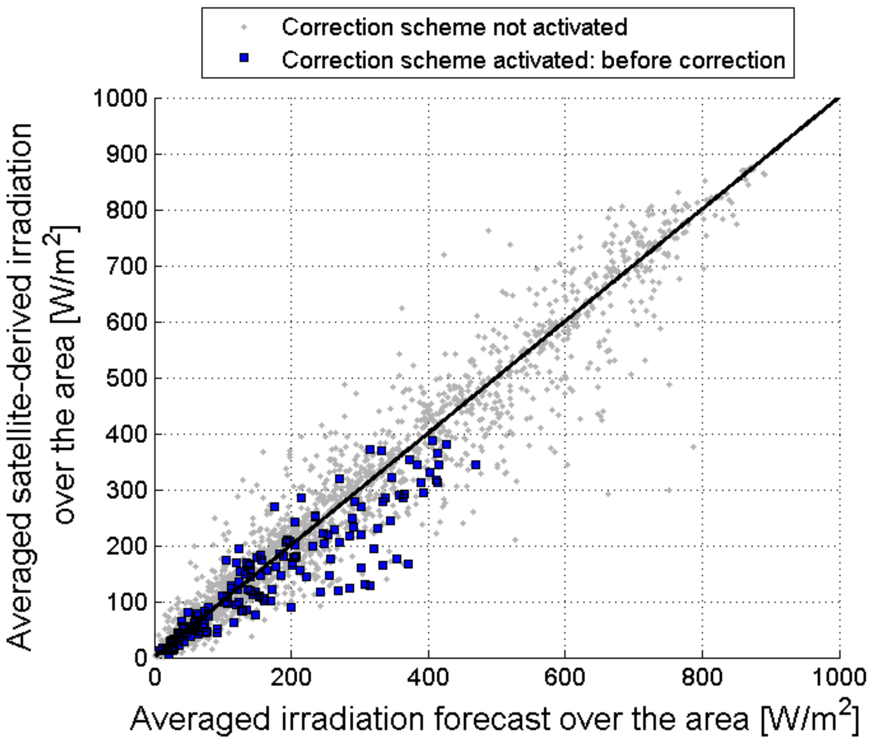
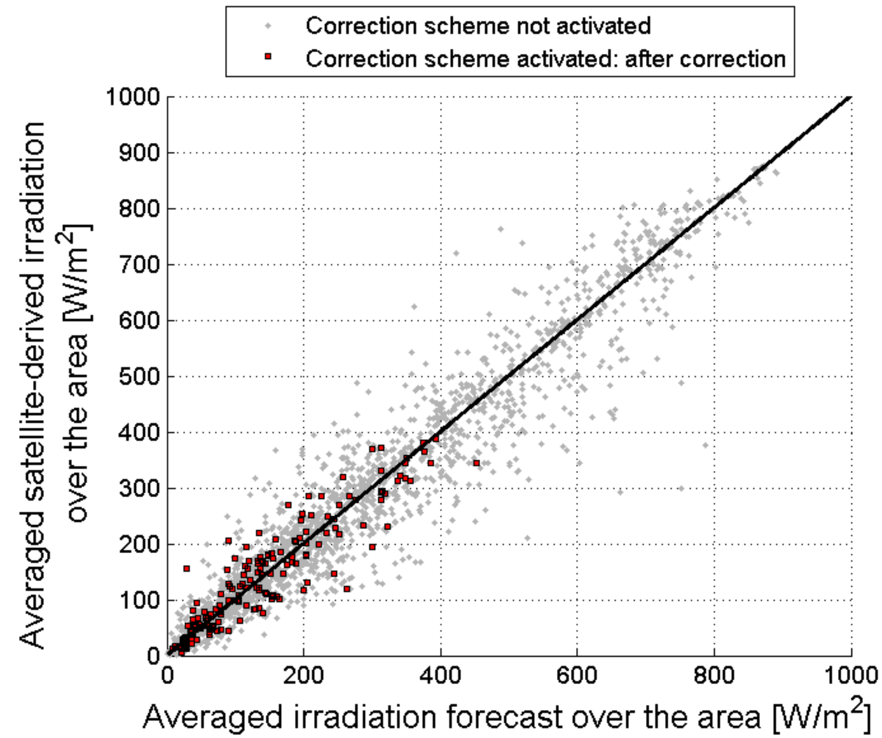
Results





- Correction scheme activated for 172 from 2046 time steps
- When the correction scheme is activated, RMSE: 56.2 -> 38.4 W/m2
- For the complete test data set, RMSE: 58.3 -> 57.0 W/m2

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Next steps

- Train & test of the approach for a whole year
- Parameter varying in space and time
- Test of the approach with ICON-EU & Cosmo-DE
- Application of the approach to PV power forecast
- Assessment of the improvement for the TSO forecasts
- Integration of further explanatory variables

Thank you for your attention!

Questions?