Kortfristiga prognoser för solenergi över västra medelhavet

Plataforma Solar de Almería http://www.psa.es

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FP7-projekt med stöd från den Europeiska Kommissionen

Översyn

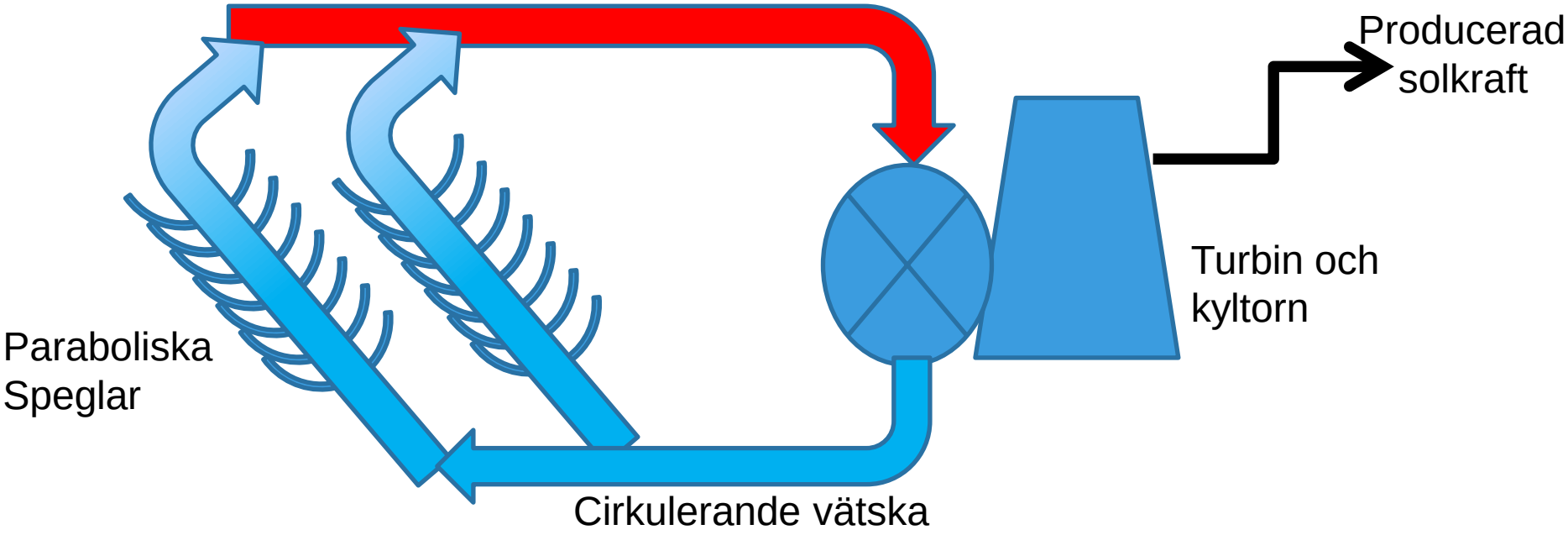
- Motivation
- Metoder:
  - Olika nowcasting metoder i DNICast-projektet
  - Solenergi-nowcasting med Harmonie
- Första resultat
- Slutsatser

Motivation

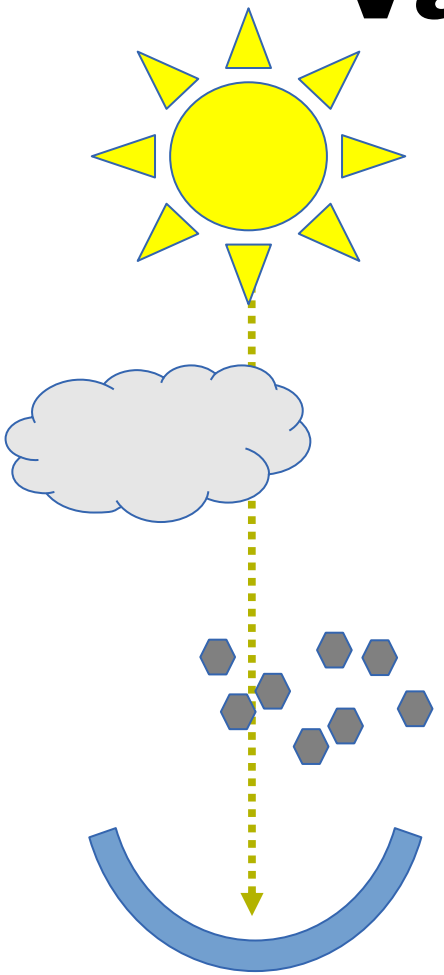
Användarbehovet (från DNICast-deliverable D2.1):

- Styra cirkulationshastighet i termisk solkraftsanläggningar inom minuter för driften
- Planera driften under nästa 3-6 timmar

(- El-produktion under nästa dygn för elektriska gridden och handel)



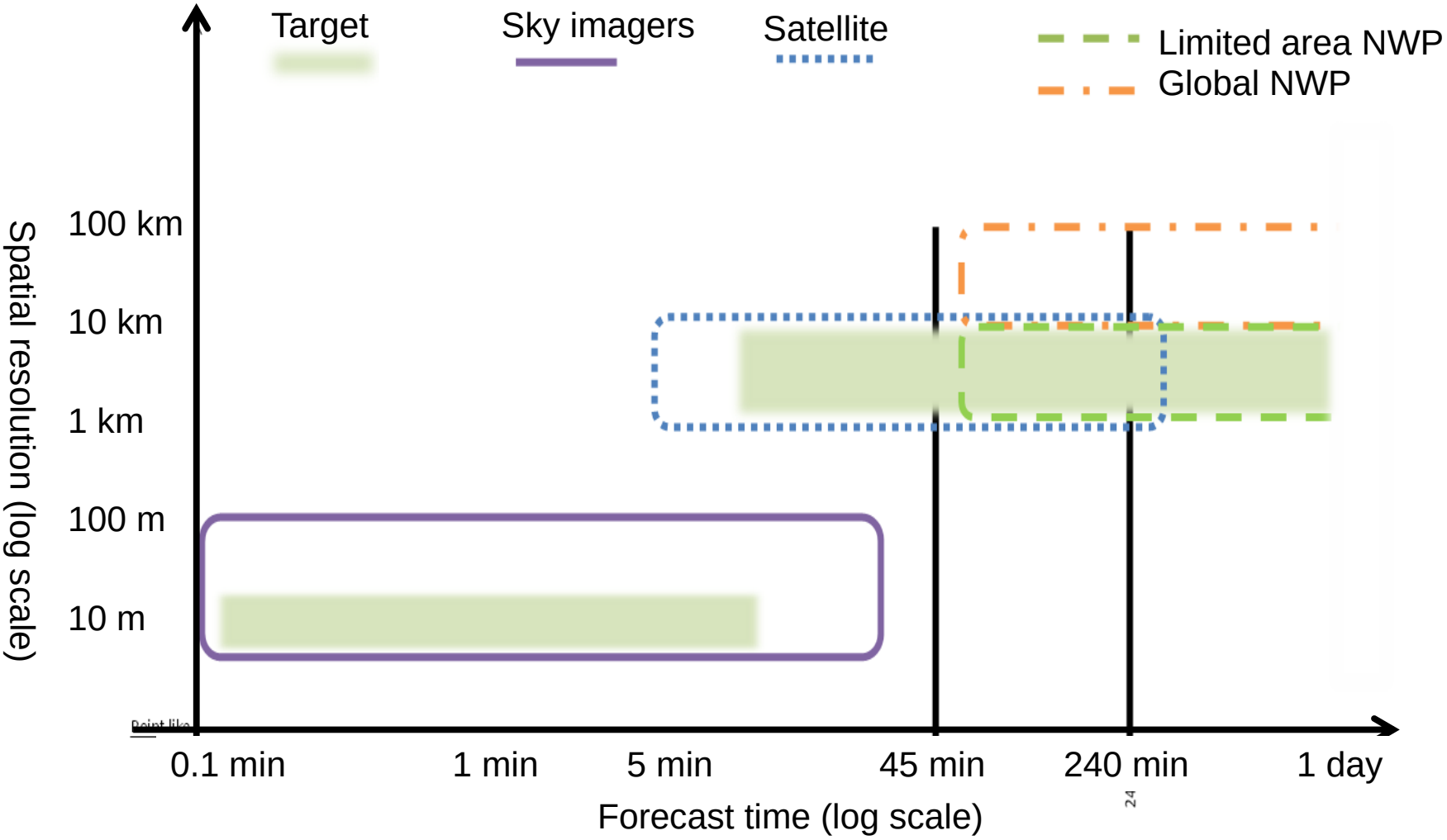
Vad ska förutsägas?



- Direct normal irradiance
- Moln
- Aerosoler

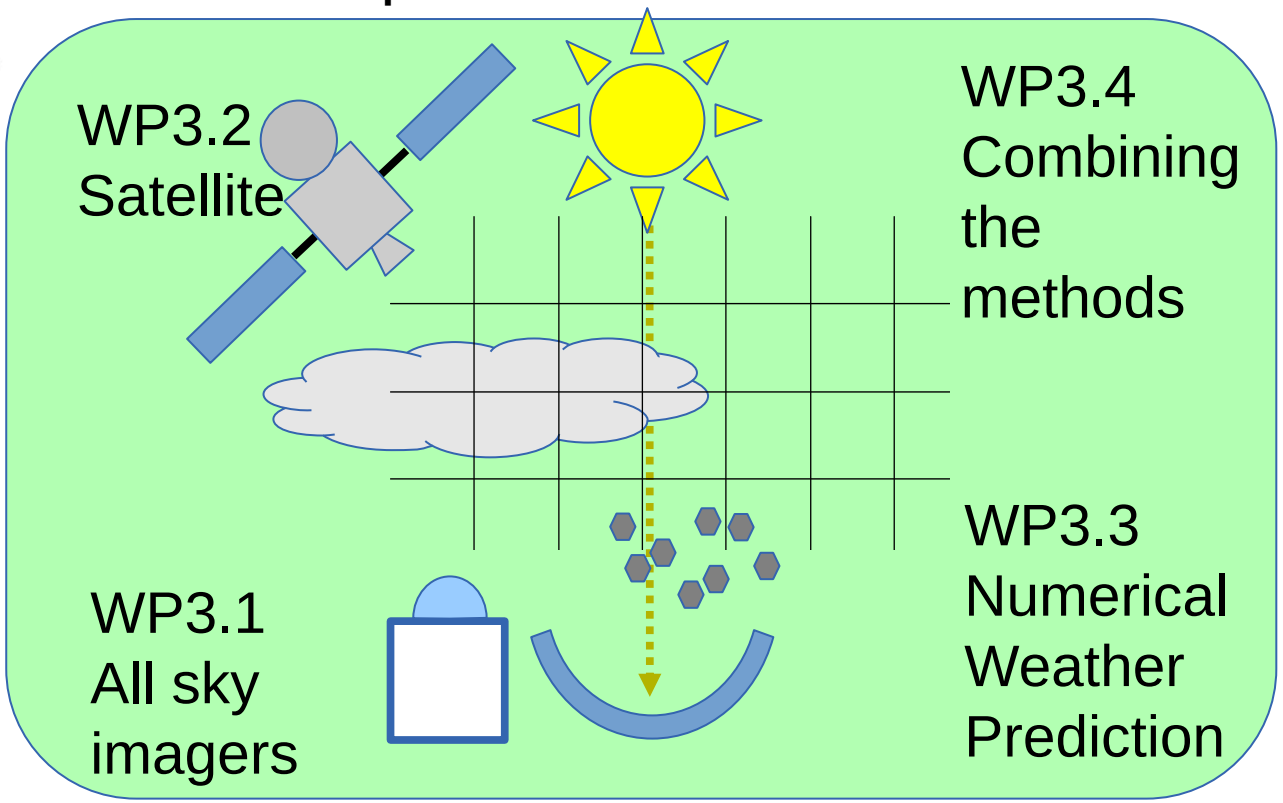
- Lokal prognos för en termisk solar anläggning, ungefär 1 kvadratkilometer
- Prognoslängd: 0 till 240 minuter

Mål för rumsliga och tidsmässiga skalor

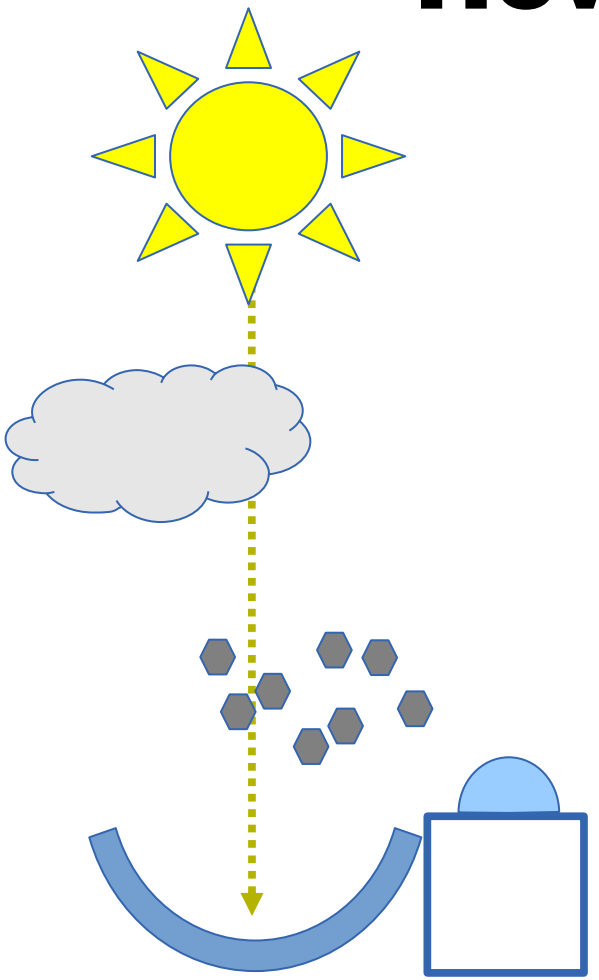


Current project DNICast

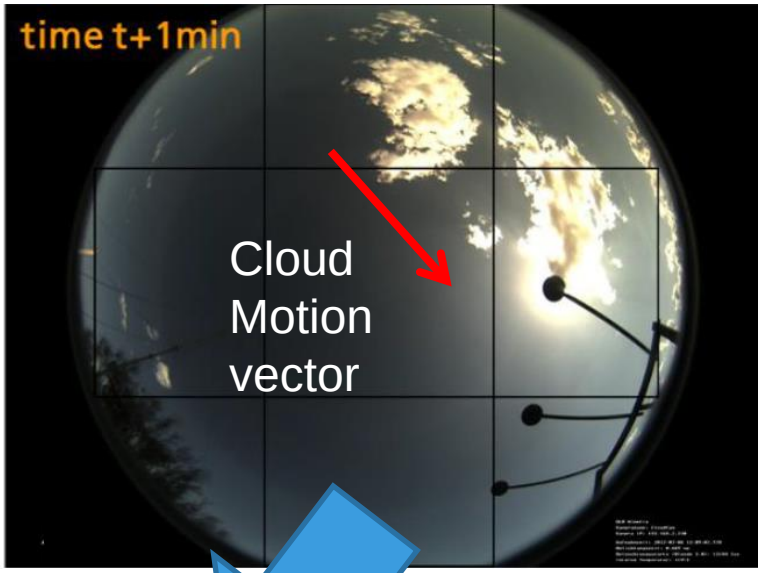
- FP7-project: Direct Normal Irradiance Nowcasting methods for optimized operation of concentrating solar technologies (October 2013 - September 2017)
- Main contribution to WP3 with objective:
- **Develop and combine** a variety of **complementary methods** for the nowcasting of DNI **that cover different parts** of the window from 1-360 min.
- 12 partners:

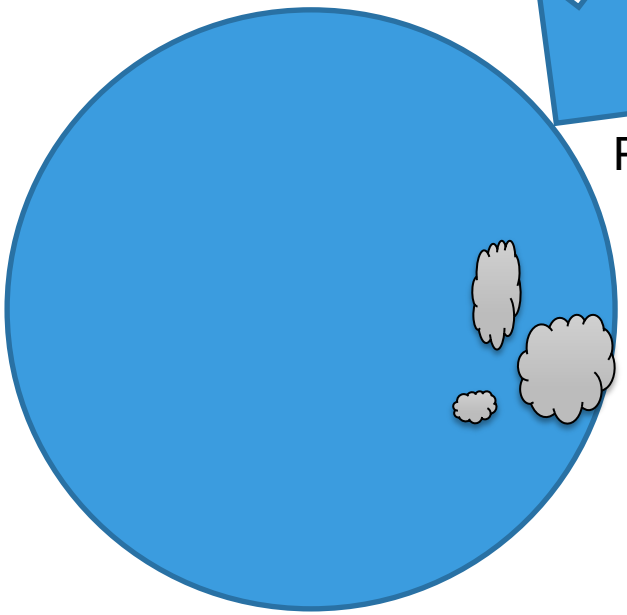


How to forecast



- Ground-based observations by **all-sky imagers** (led by UniPatras)**:**
  - Calibrated images for cloud detection and classification
  - Cloud velocities from two consecutive images
  - Forecast with extrapolation
  - Forecast length: ~ 30 minutes
  - Spatial resolution: ~ 100 m
  - Domain: local, ~ 1 km

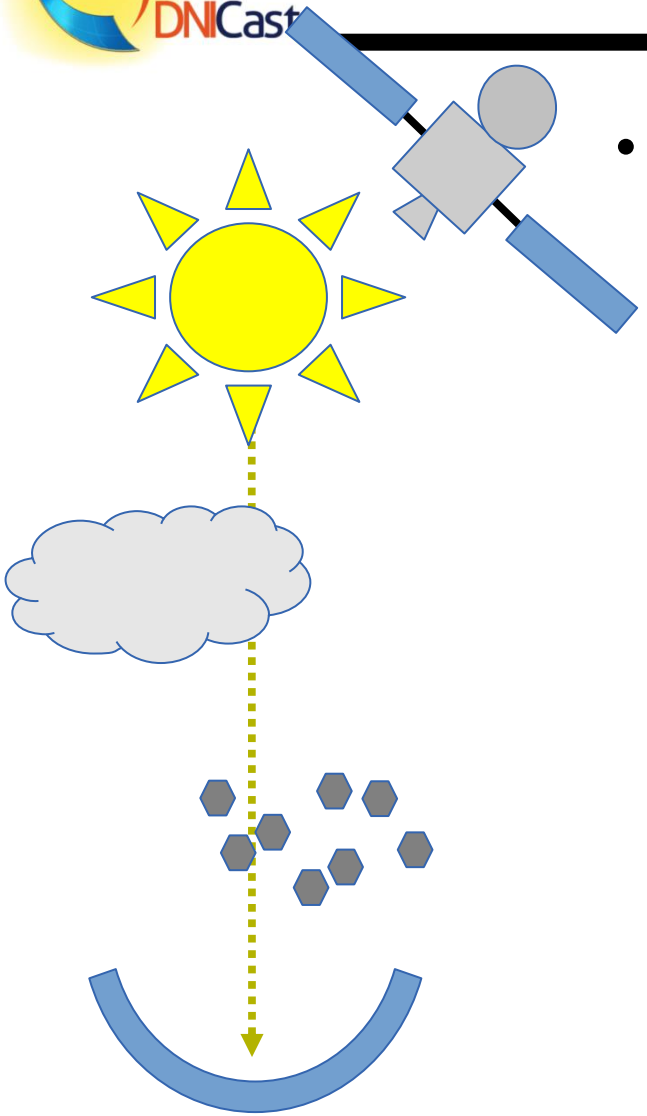




Forecast time t + 30 min

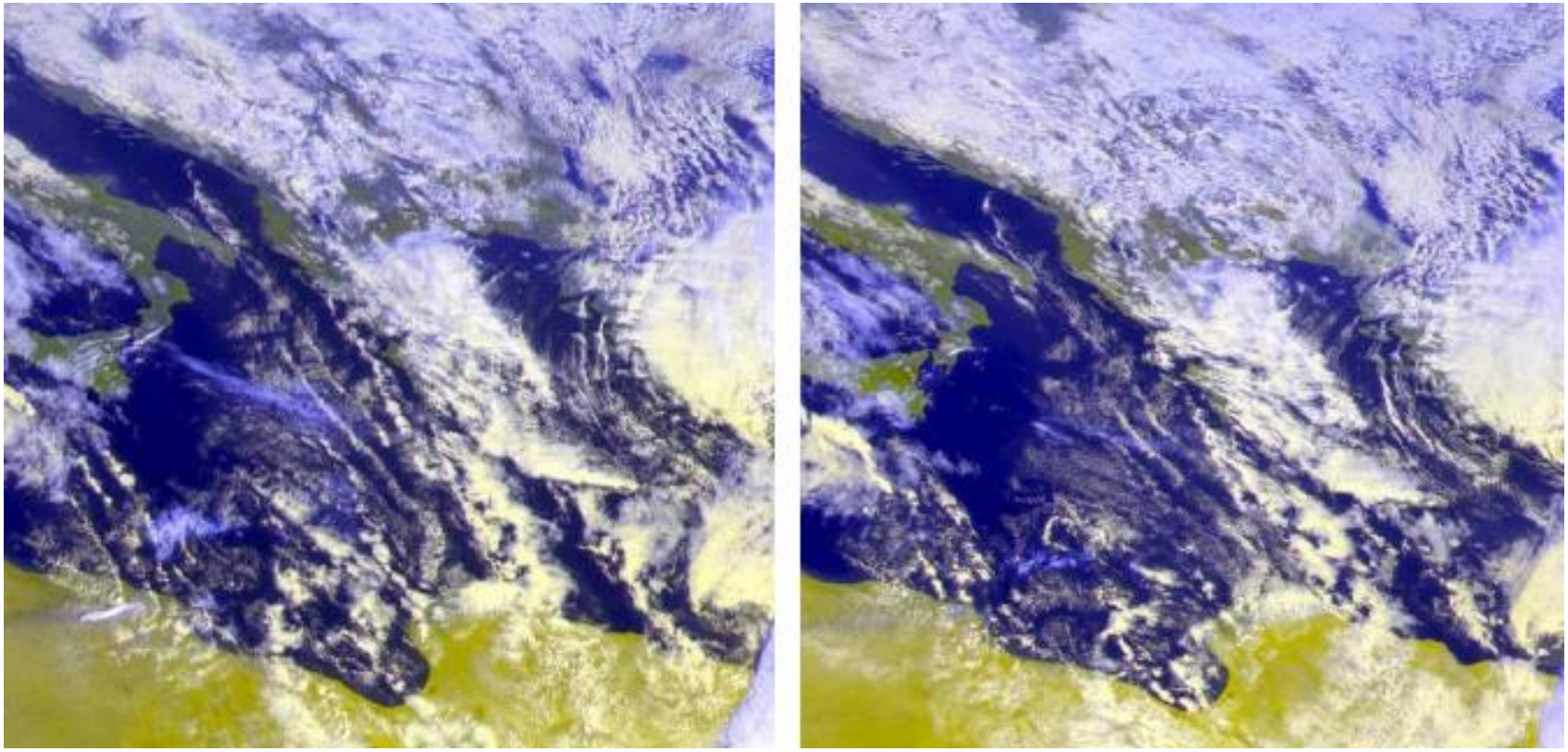
Pictures from Andreas Kazantzidis (UniPatras)

How to forecast



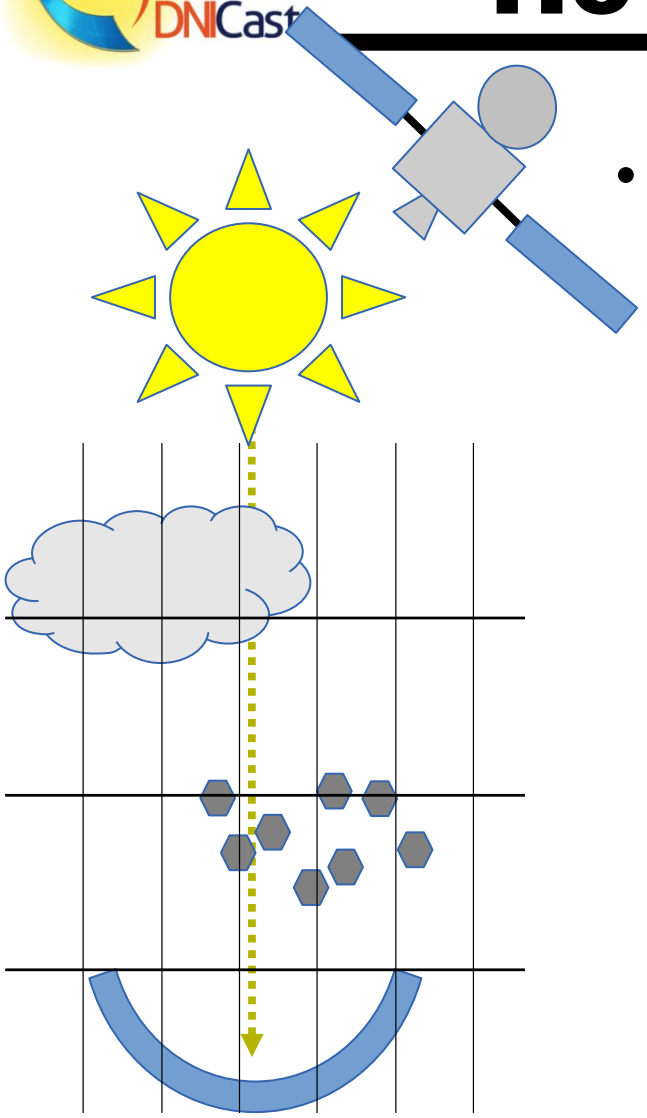
- **Satellite**-based observations (led by DLR-DFD)**:**
  - Utilize satellite imagers
  - Optimize with rapid scan and high-resolution observations
  - Cloud motion vectors from optical flow techniques
  - Forecast with extrapolation
  - Forecast length: ~ 5-60 minutes, possibly up to 240 minutes
  - Spatial resolution: ~ 3 km
  - Domain: regional

Satellite-based observations



Cloud fields from Meteosat Second Generation ”High Resolution Visible”, centered over Greece (source DLR-IPA)

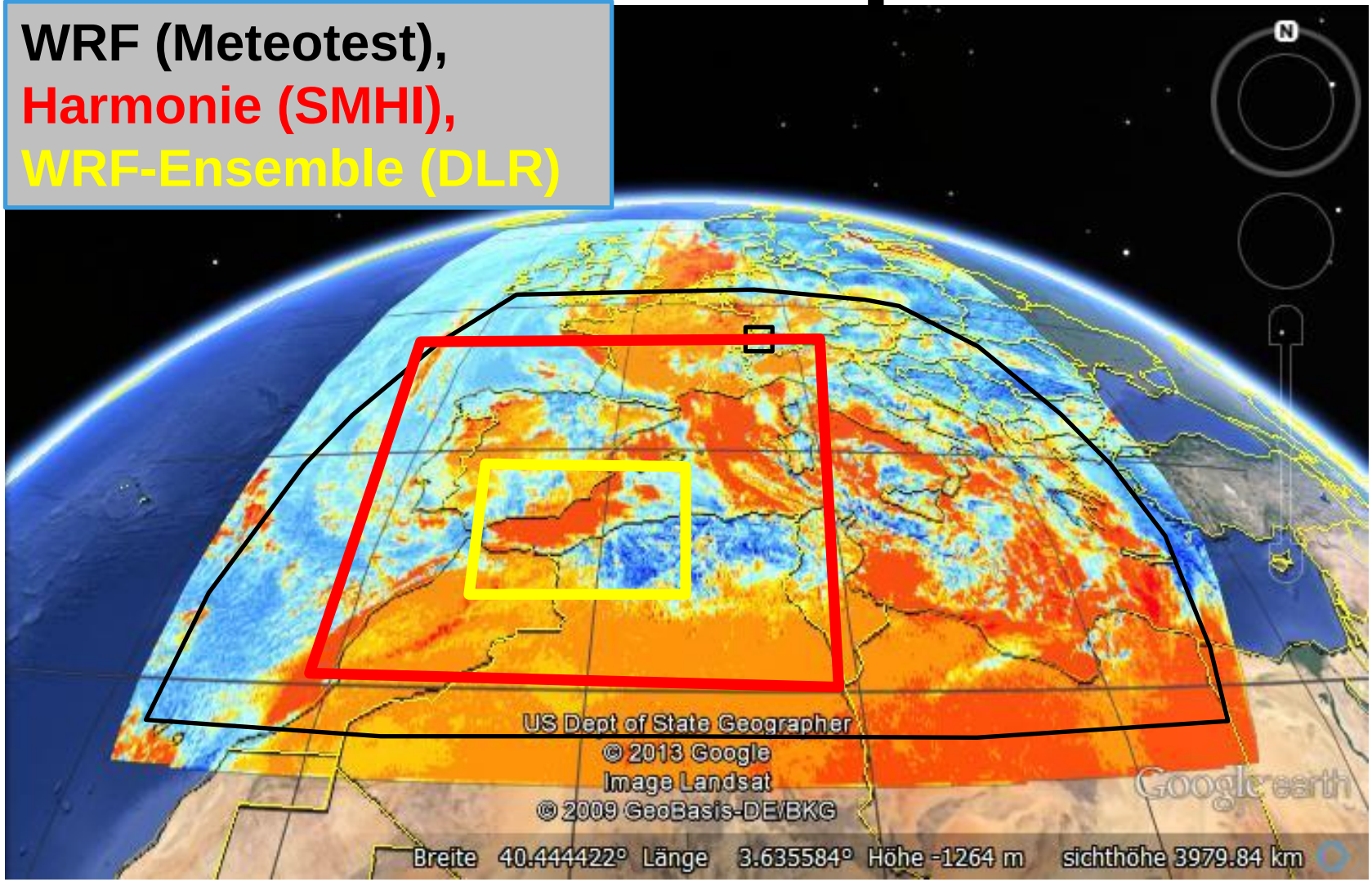
How to forecast



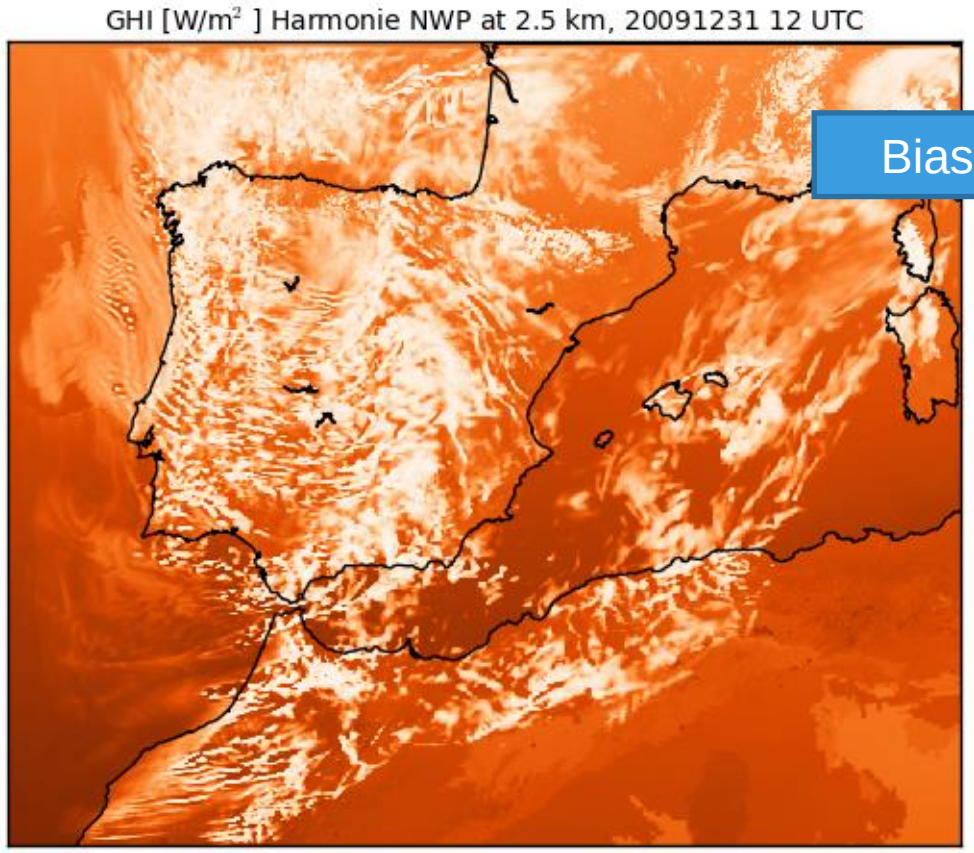
- **Numerical weather prediction** (led by SMHI)**:**
  - Estimating initial state using all available information
  - Solving the forecast equations as realistically as possible
  - Time-critical production limits computational size
  - Forecast length: up to 240 minutes, and longer
  - Spatial resolution: ~ 3-20 km
  - Domain: regional to global

Numerical weather prediction

WRF (Meteotest),
Harmonie (SMHI),
WRF-Ensemble (DLR)

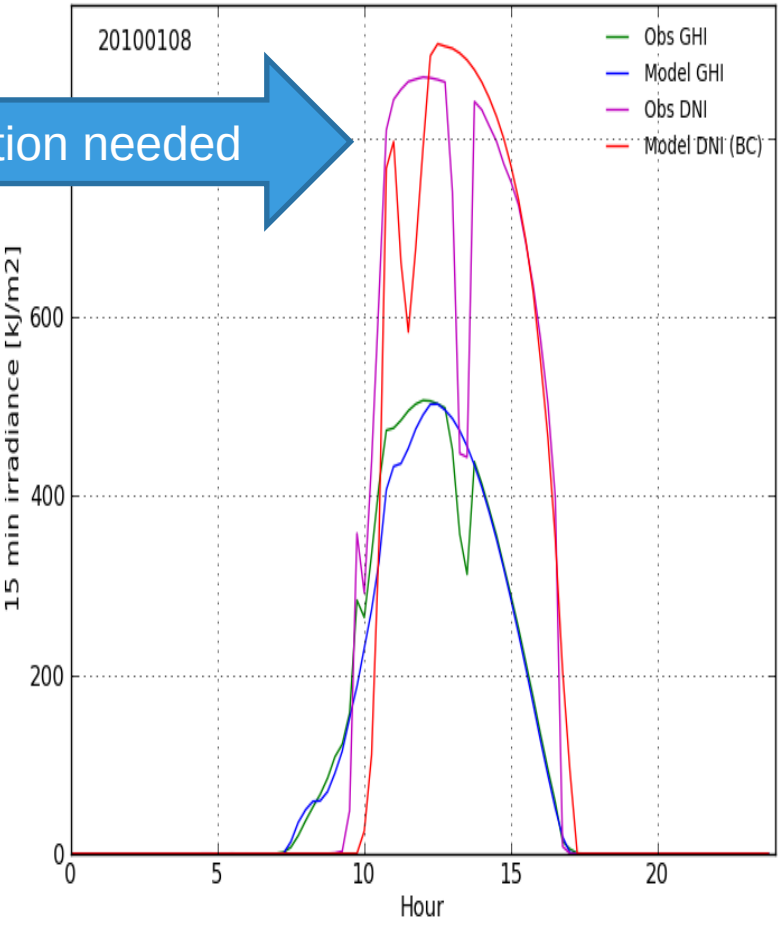


First model results for DNI-forecasts from Harmonie-Arome



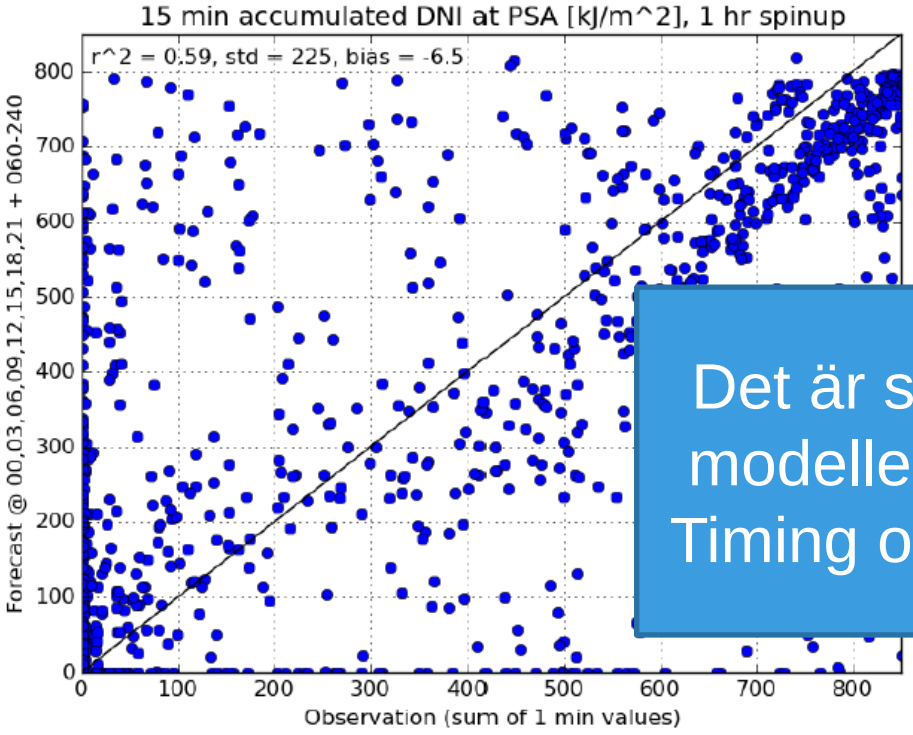
Bias correction needed

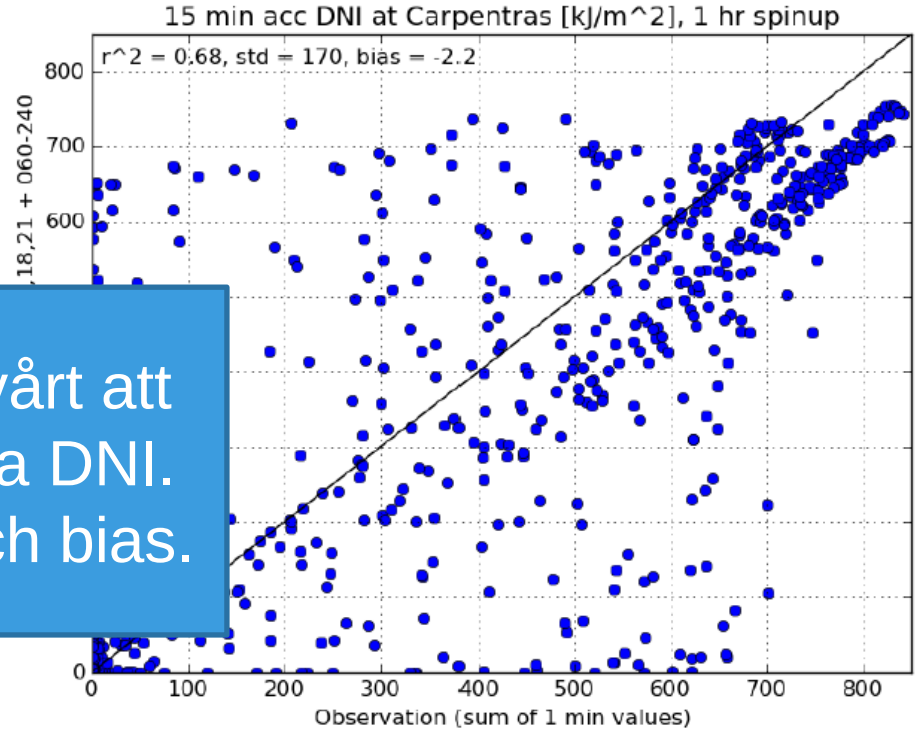
Model and obs at Plataforma Solar de Almeria



DNI at PSA and Carpentras, 201001

Prognoser med HARMONIE-AROME

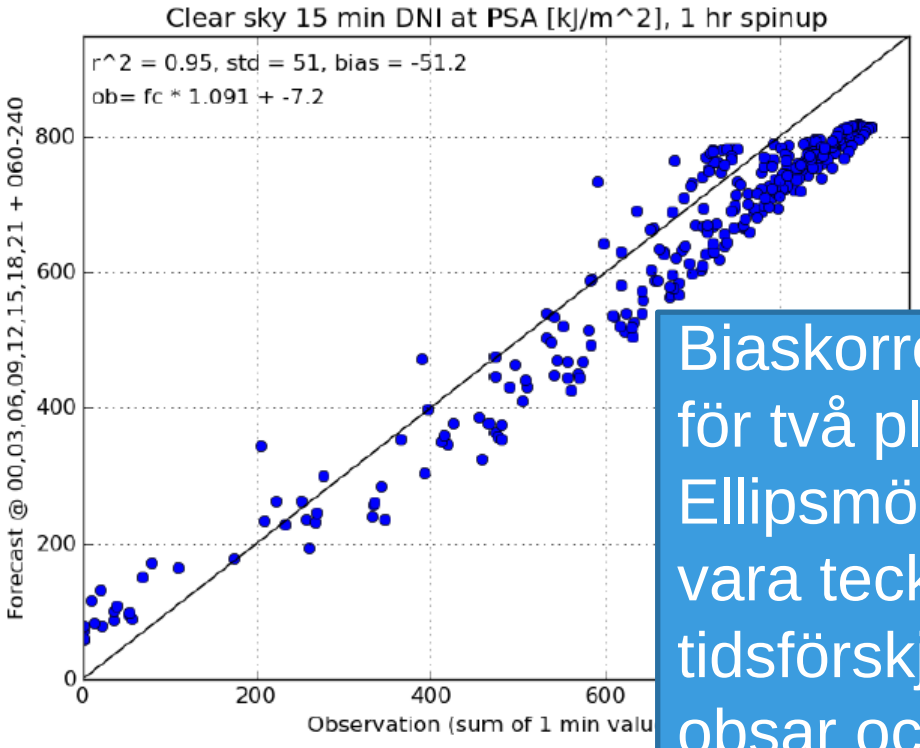


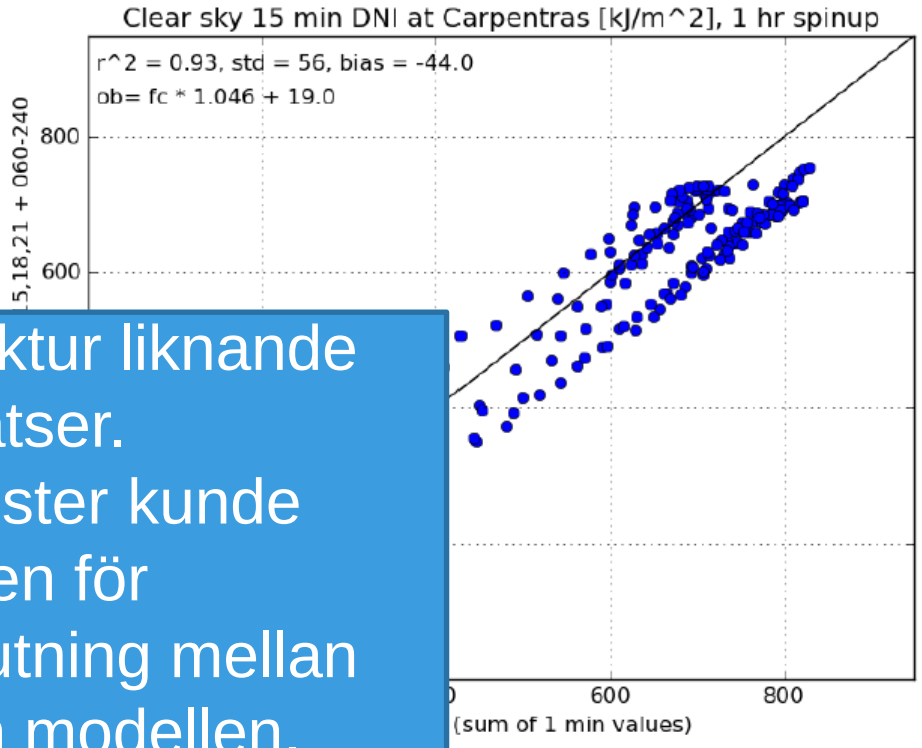


Det är svårt att modellera DNI. Timing och bias.

Only cases where the sun is above the horizon.

Clear sky according to model (ctot < 0.01)





Biaskorrektur liknande för två platser. Ellipsmönster kunde vara tecken för tidsförskjutning mellan obsar och modellen.

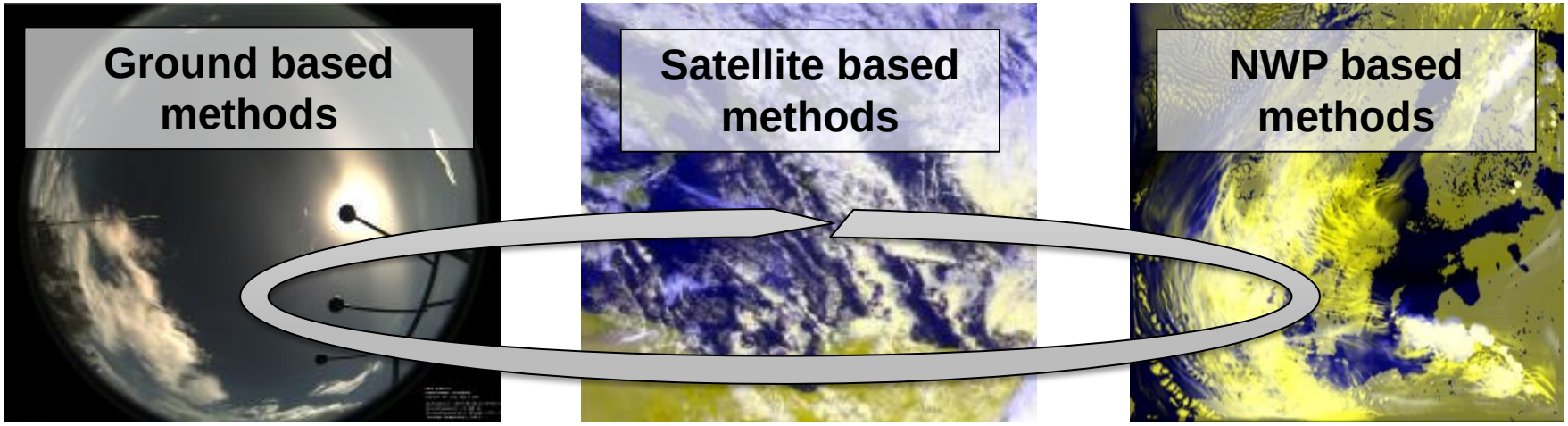
Cases where |ob-fg| > 1 std(ob-fg) filtered out: model says clear but probably cloudy.

Is higher resolution useful?

- Small-scale features in clouds have only a short predictability, if initialized correctly.
- Use of neighborhood method, over certain surrounding area, e.g. 20km x 20km and time interval.
- Calculate statistical measure for area: min, max, mean, median
- Result: Probability forecast for area

Useful information for energy production?

Combining methods for the best forecast

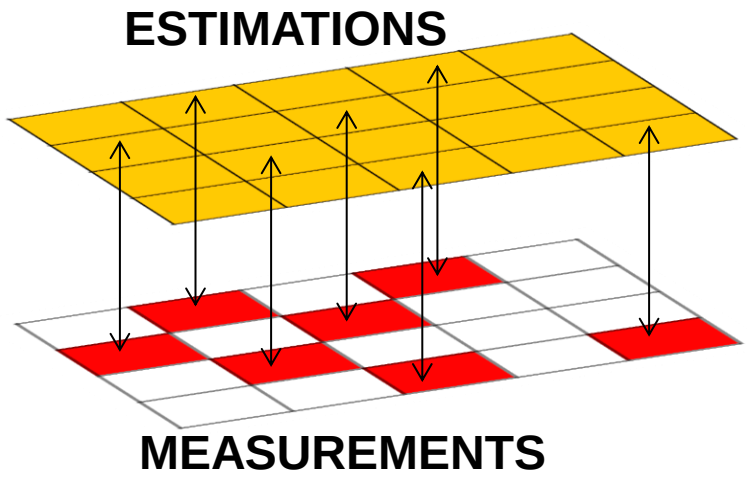


Images: SMHI, DLR

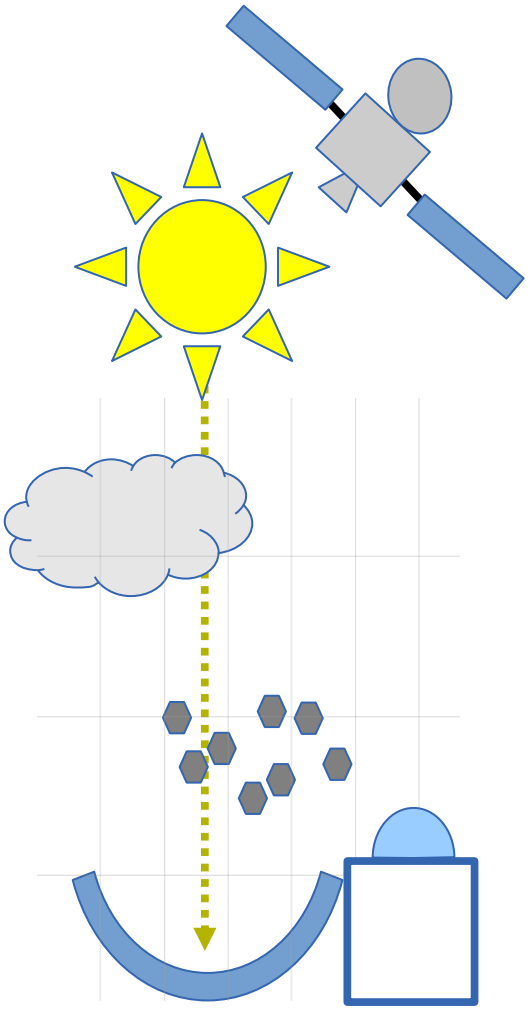
Machine learning techniques (soft computing) combine the different forecasts in an optimal way.

For example:

FIS (Fuzzy inference systems),
SVM (Support vector machine)
KNN (K nearest neirbourgs)
NN (Neural networks)



Conclusions



- Metoder för DNI prognoser baseras på mark- och satellit-observationer, NWP och statistisk kombination.
- Olika rumsliga och tidsmässiga skalor adresseras härmed.
- Första resultat med HARMONIE-AROME visar behov för bias-korrektur och möjligtvis problem med modelltiden.
- Högupplöst modelldata innehåller mycket information. Hur blir det nyttigt för slutanvändaren?


Tack!
Frågor?

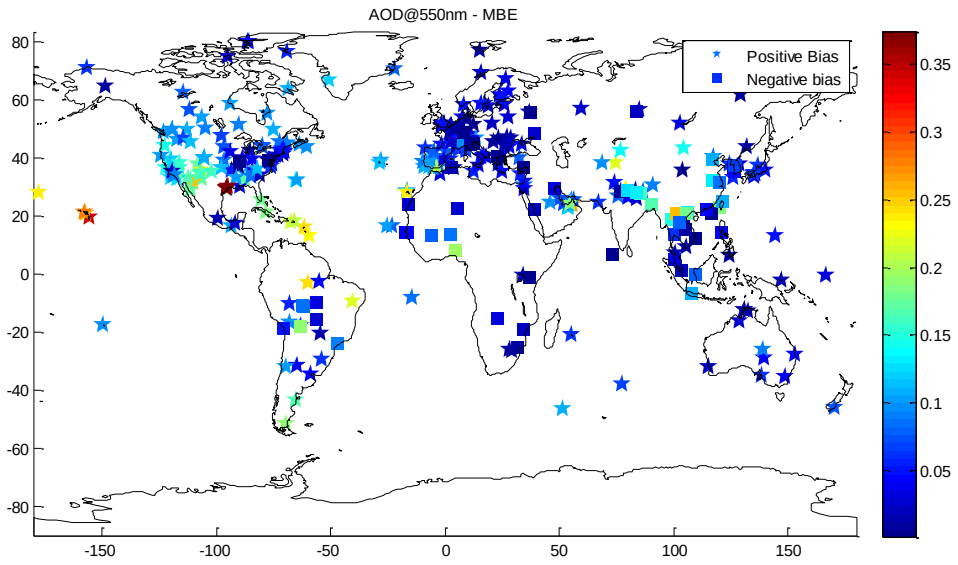
How to forecast aerosols

- Collect available observational information, e.g. from the WMO Sand and Dust Storm Warning Assessment and Advisory System's (SDSWAS) activity

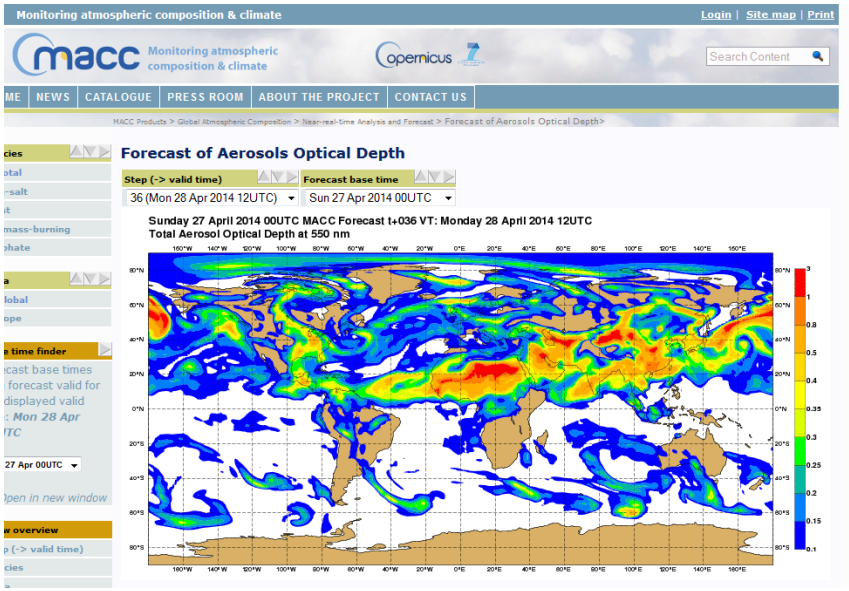
How to forecast aerosols

Global data assimilation of aerosols in the project ”Monitoring Atmospheric Composition and Climate” (**MACC**)

- MACC delivers for Europe / Northern Africa generally good estimations
- Easily (and freely) available



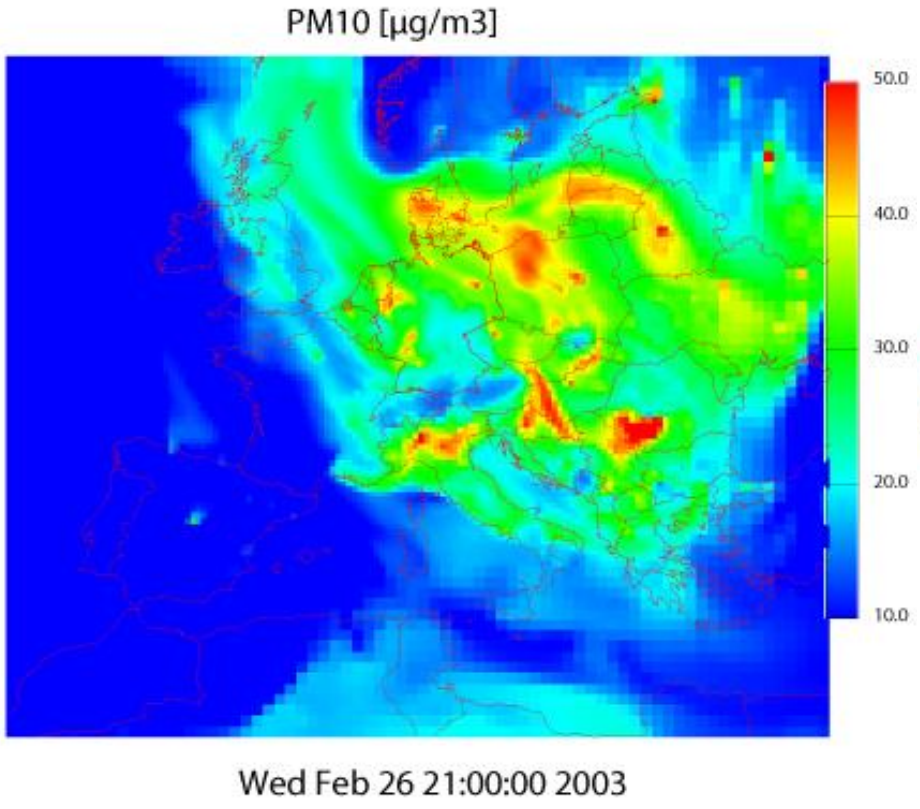
MBE of MACC AOD 550 nm
Source: Mines Paristech / IEA SHC 46

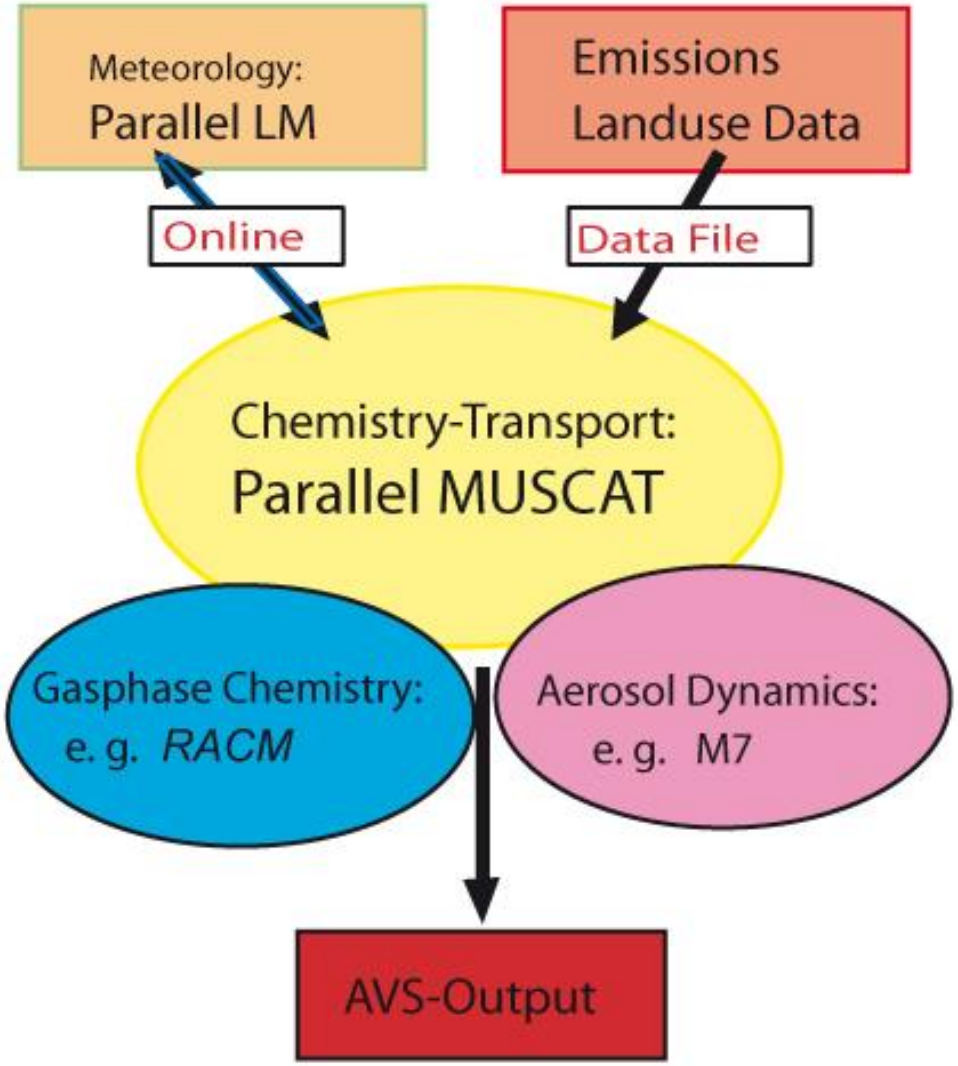


MACC homepage

How to forecast aerosols

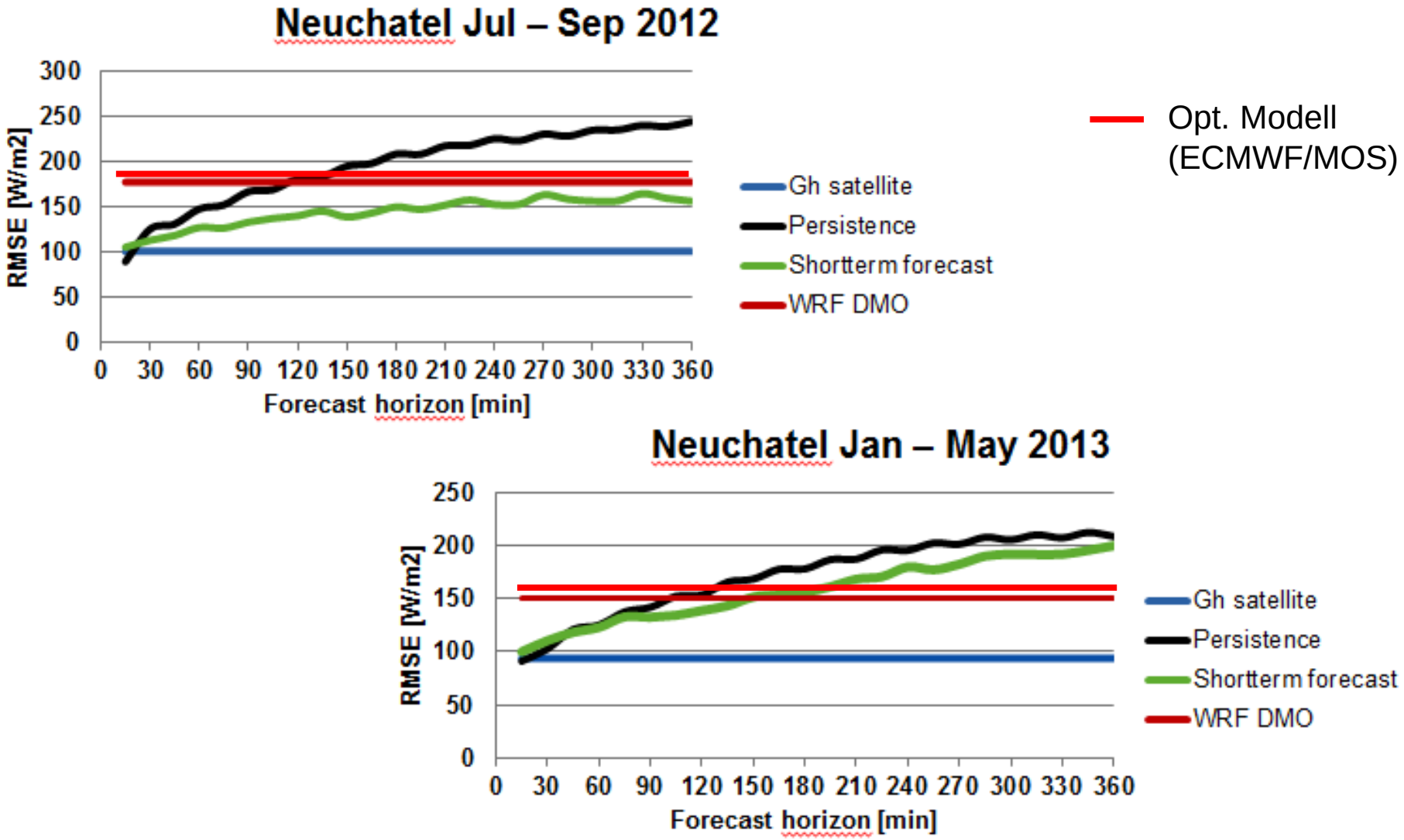
- High resolution aerosol modelling with COSMO-MUSCAT (TROPOS)





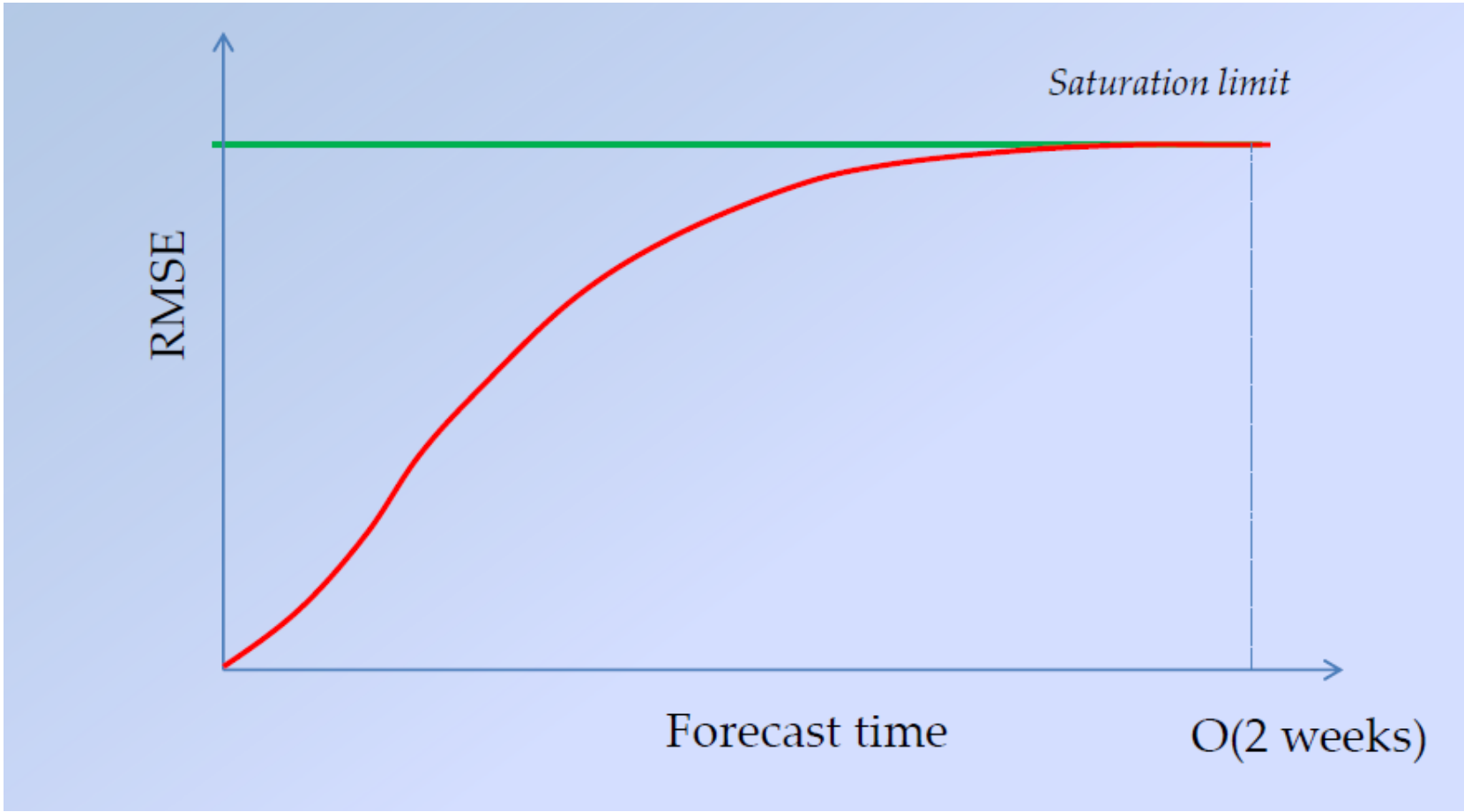
Source: TROPOS

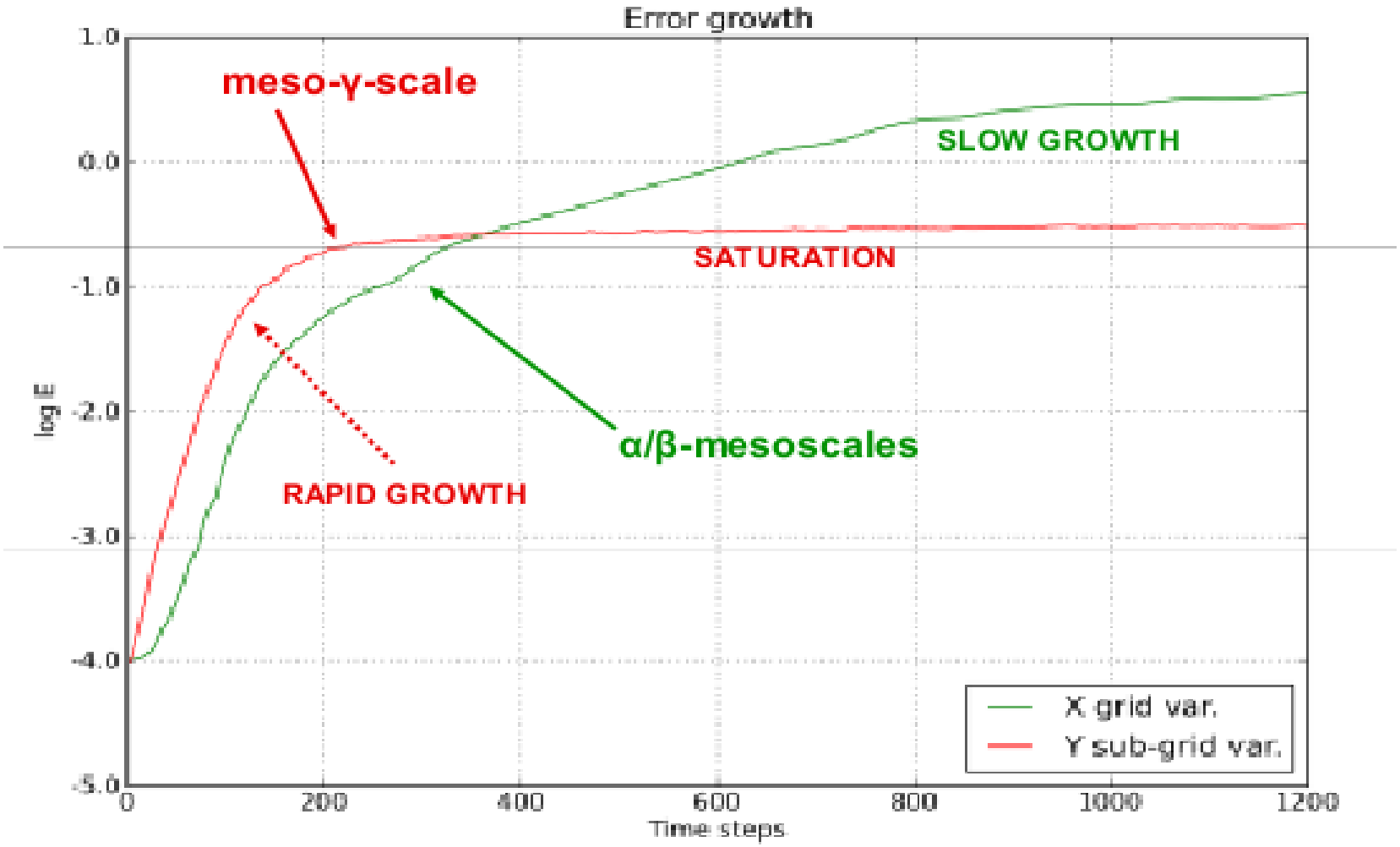
Results: Forecast error for SMHI
Global horizontal irradiance



Why is forecasting difficult?

Theoretical growth of forecast error





From Lorenz-96 model: Error growth for two different length scales. The smaller length scale meso-gamma saturates faster.

Combining methods for the best forecast