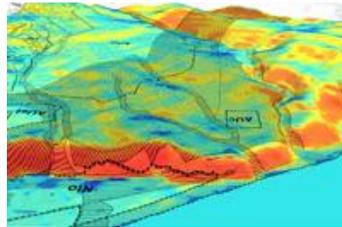# Intra-day and Day-ahead Forecasting for Energy Traders on European Markets

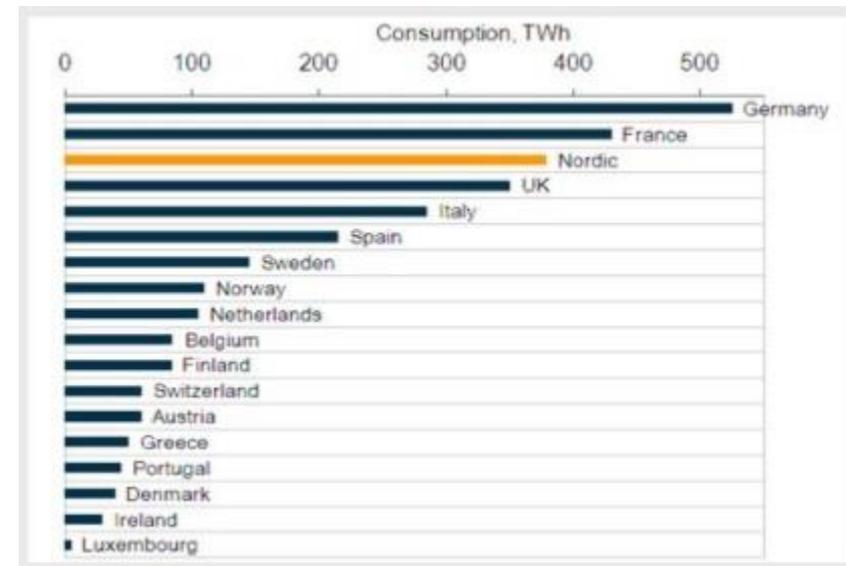Laurent HUET – Lead Data Scientist

European Power Markets: A Brief Overview
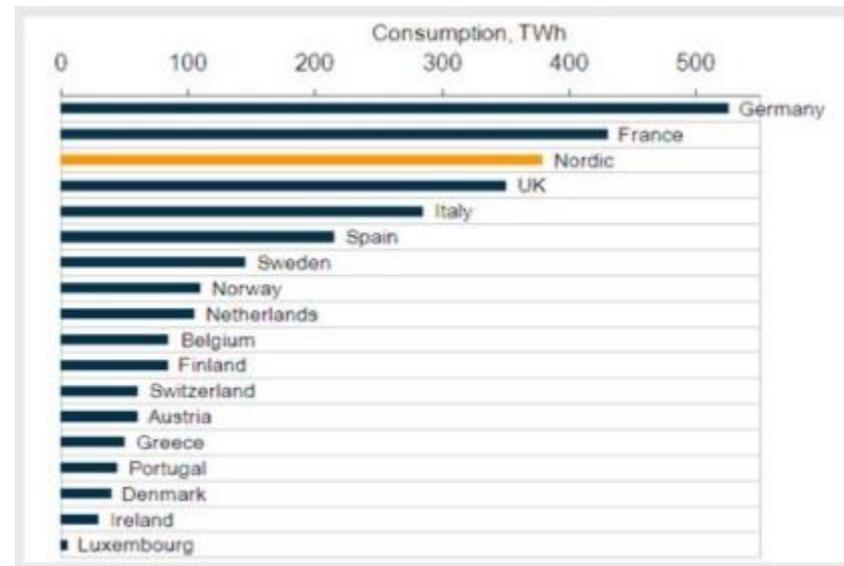
Multiple European Power Markets...

- **A dozen power exchange markets across Europe**

- **With an unequal consumption**
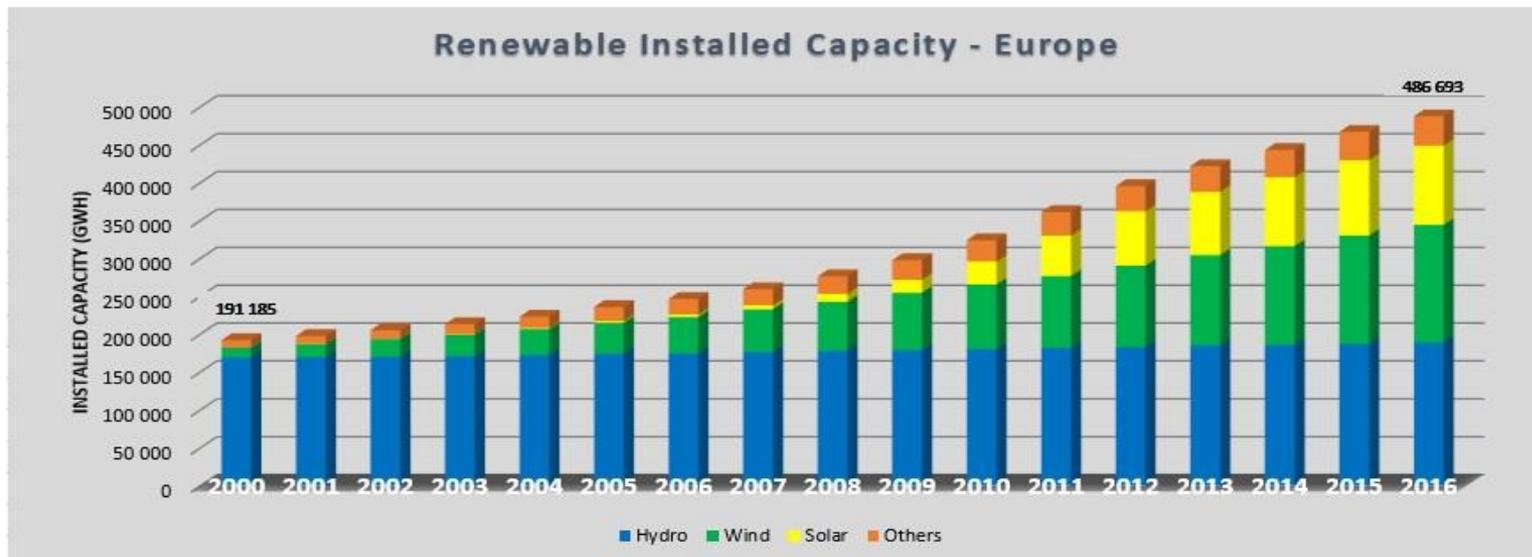
…with multiple relations…

- **A dozen power exchange markets across Europe**

- **With an unequal consumption**

- **Unequal cross-border energy transit**

...form a global and evolving market

- **A market in constant regulation and evolution**

Renewable Installed Capacity - Europe

486 693

191 185

INSTALLED CAPACITY (GWH)

500 000
450 000
400 000
350 000
300 000
250 000
200 000
150 000
100 000
50 000
0

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

■ Hydro ■ Wind ■ Solar ■ Others

- Wind and solar generations are driving the rise in renewable capacity
- 40-45 % of the energy to be sourced from renewable energy sources by **2025**
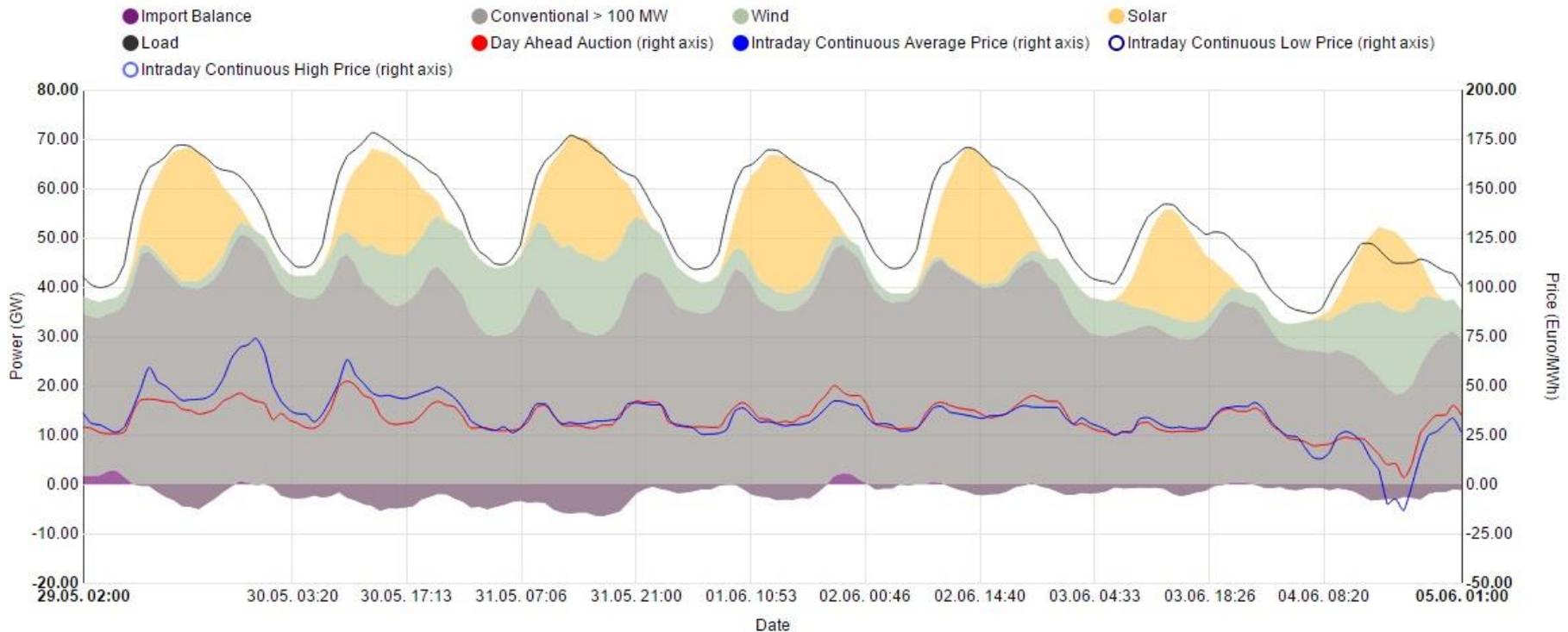- Over 80% expected by **2050**

Need for national and regional forecasts

Impact of the renewable production on the prices

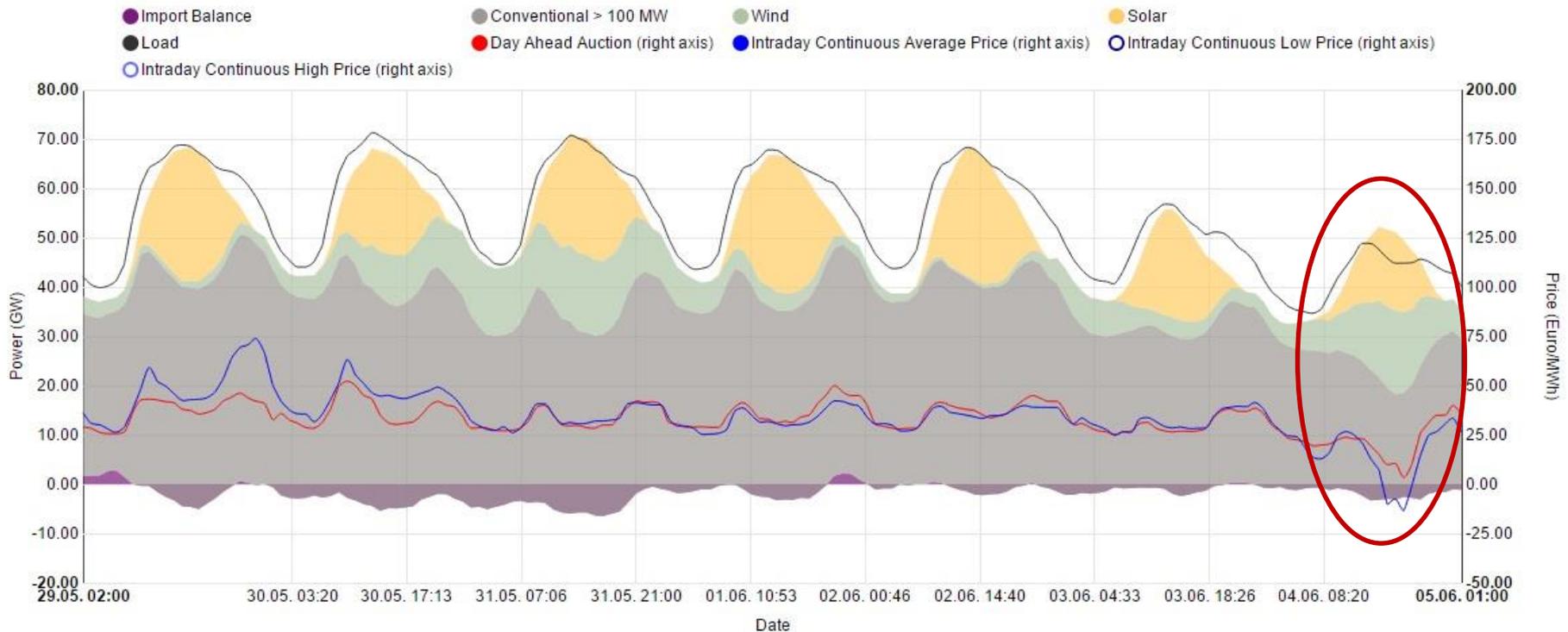- **A German example:** week 29/05/2017 to 05/06/2017

Electricity production and spot prices in Germany in week 22 2017

# Impact of the renewable production on the prices

- **A German example:** week 29/05/2017 to 05/06/2017

Electricity production and spot prices in Germany in week 22 2017

Power Exchange Rules

- **Balancing of renewable power by TSOs**

- **Example for the EPEX exchange:**

  - **Day-Ahead Auction:**
    - Electricity traded for delivery the following day in 24 hour intervals
    - The daily auction takes place at 12.00 pm, 7 days a week

  - **Intra-day Auction:**
    - Electricity traded for delivery on the same or the following day in 15 min intervals
    - Trading is continuous 7 days a week and 24 hours a day

- **Unbalances have to be adjusted with expensive balancing power**
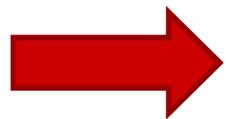
  ➡ **Need for accurate Intra-day and Day-Ahead forecasts**

Solar forecasting techniques

Different technologies combined for a continuous forecast

Ground-based
sky images

Satellite
observations

(CR: Eumetsat)

Numerical
Weather
Prediction
models

Time series

| 0 | 1h | 6h | 48h | 0 | 72h |
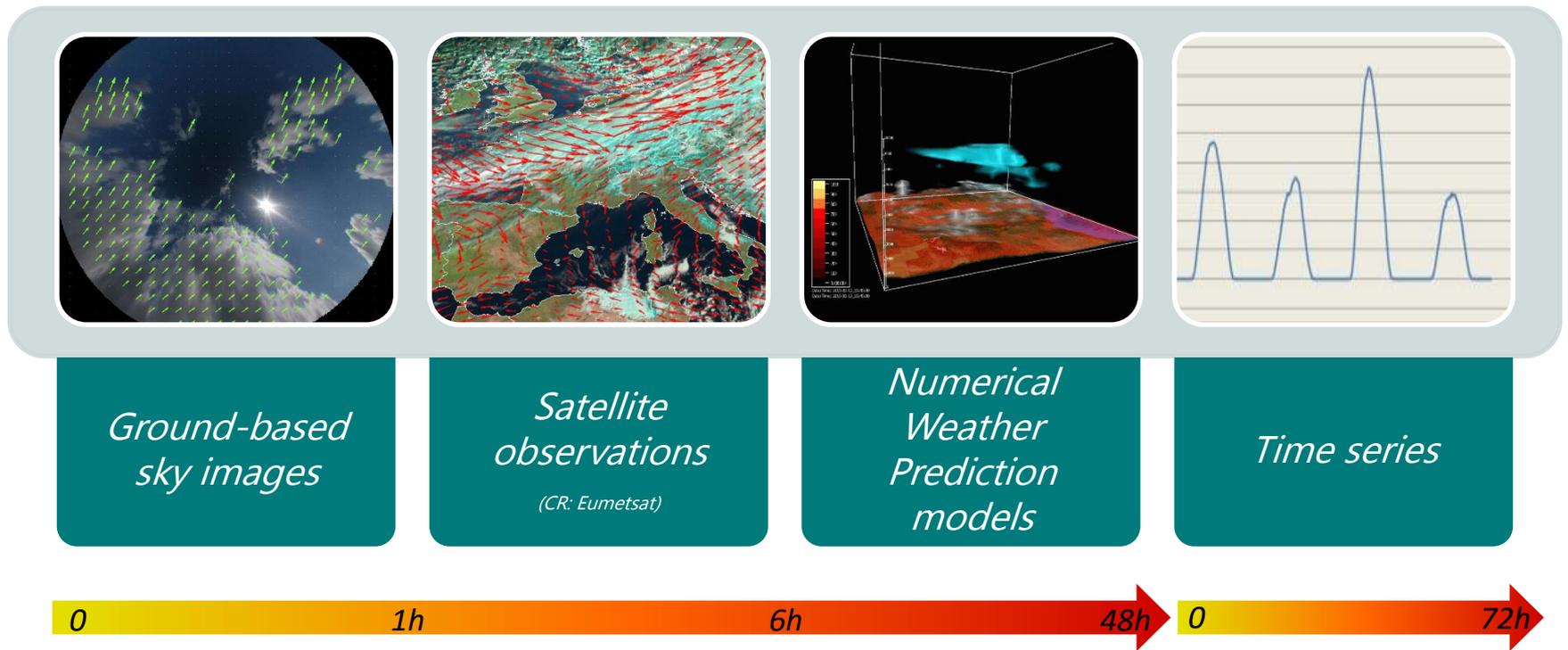
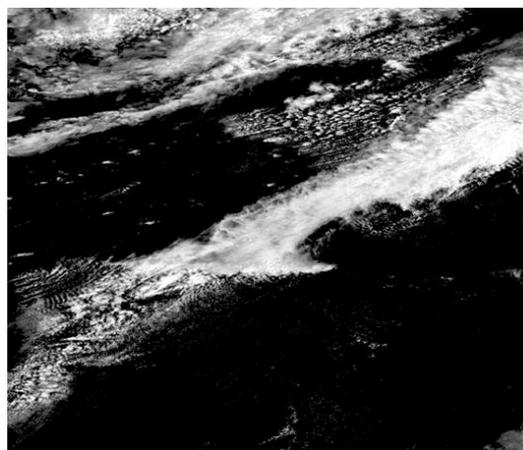# Intra-day forecasts (Satellite)

- Global coverage and live access to 5 geostationary satellites
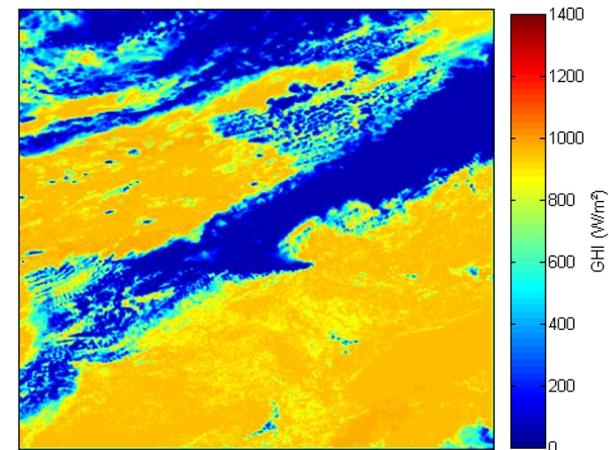- Cover horizons from 10 minutes up to 6 hours ahead
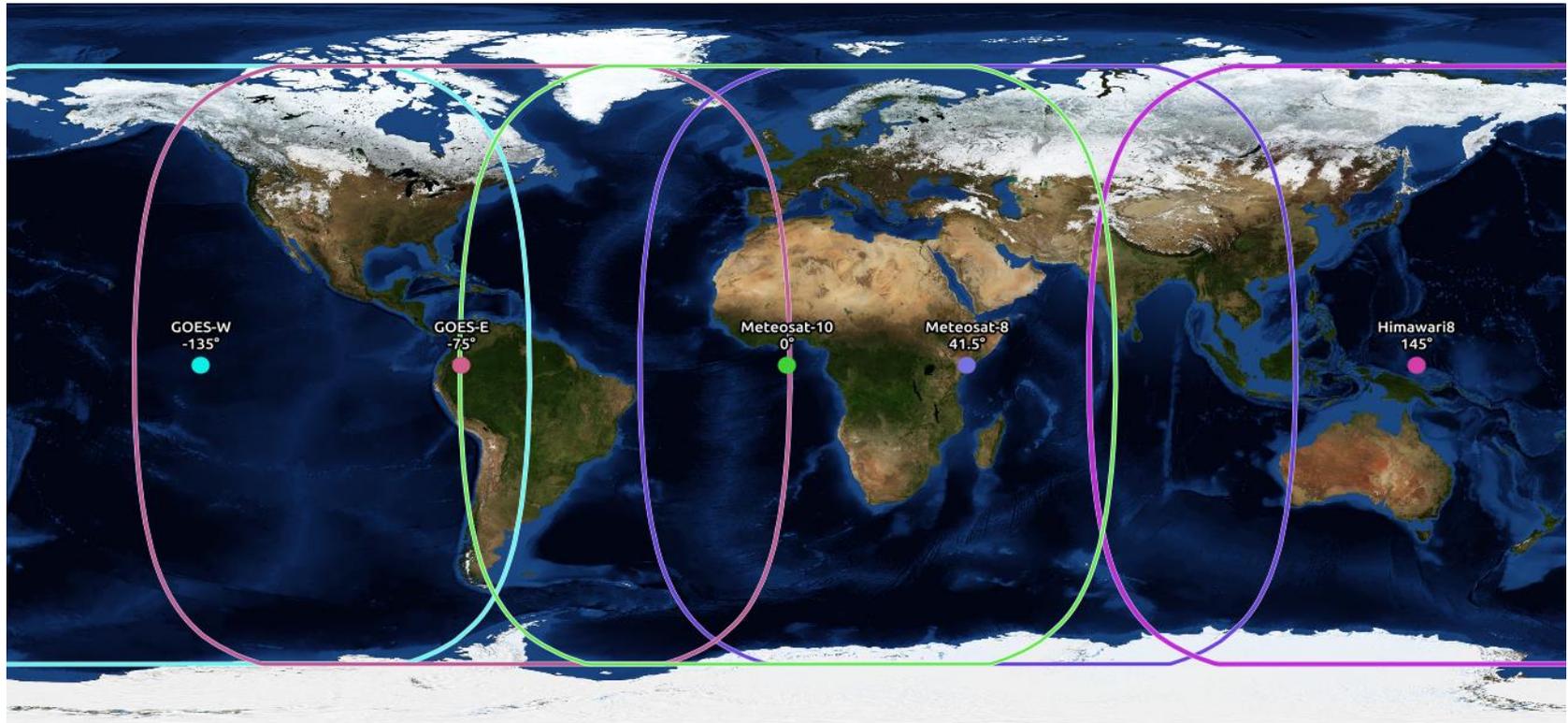
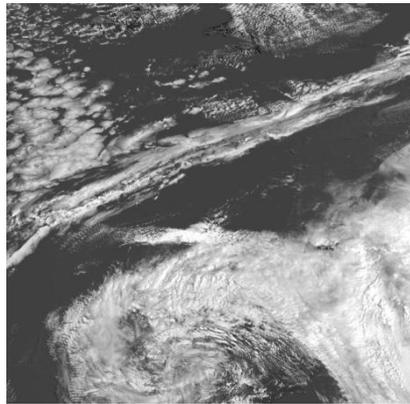# Intra-day forecasts (Satellite)
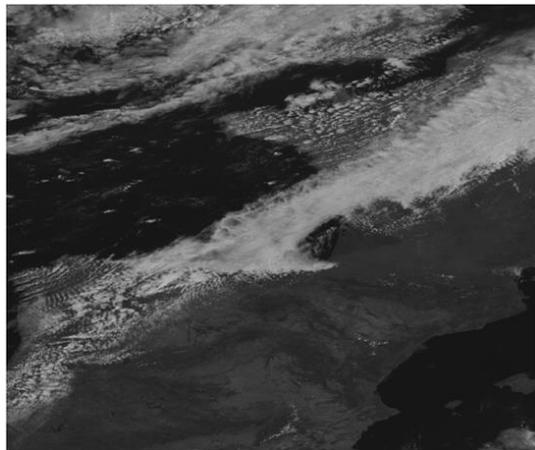
| **MSG HRV image** (June 6th 2012, 1200 UTC) | **Cloud index:** comparison between actual and clear sky reflectance for a given pixel | **GHI:** global horizontal irradiation at ground level |

Intra-day forecasts (Satellite)

T0 – 15 min. Cloud index map
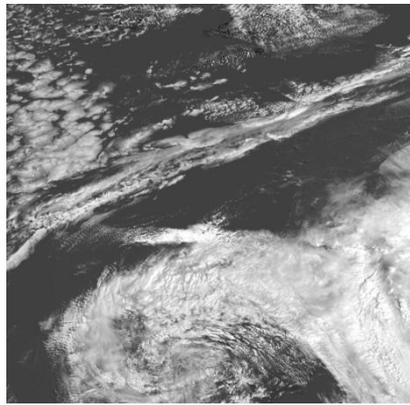
T0 Cloud index map

Cloud motion vector extraction
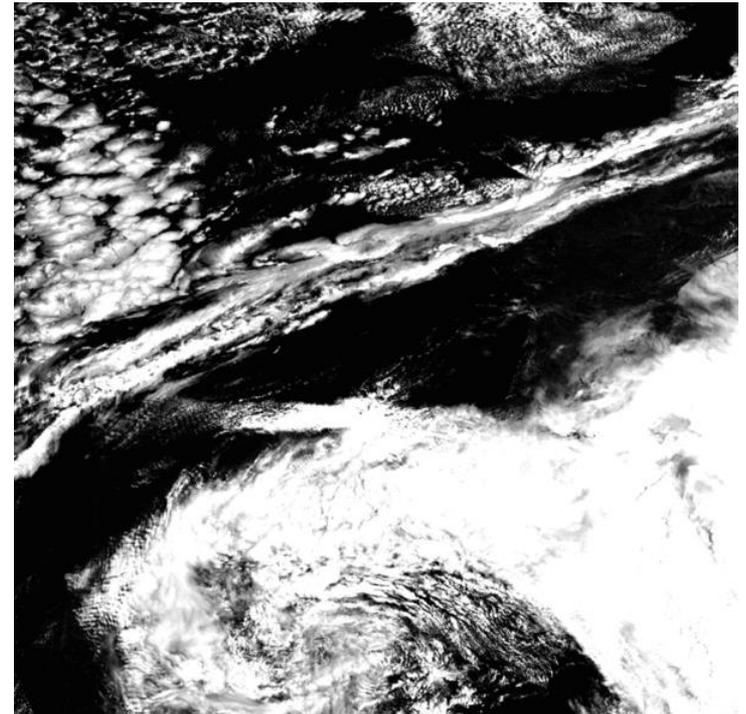
Cloud motion extrapolation – 6 hours ahead (15 min step)

Night time forecasts (Satellite)
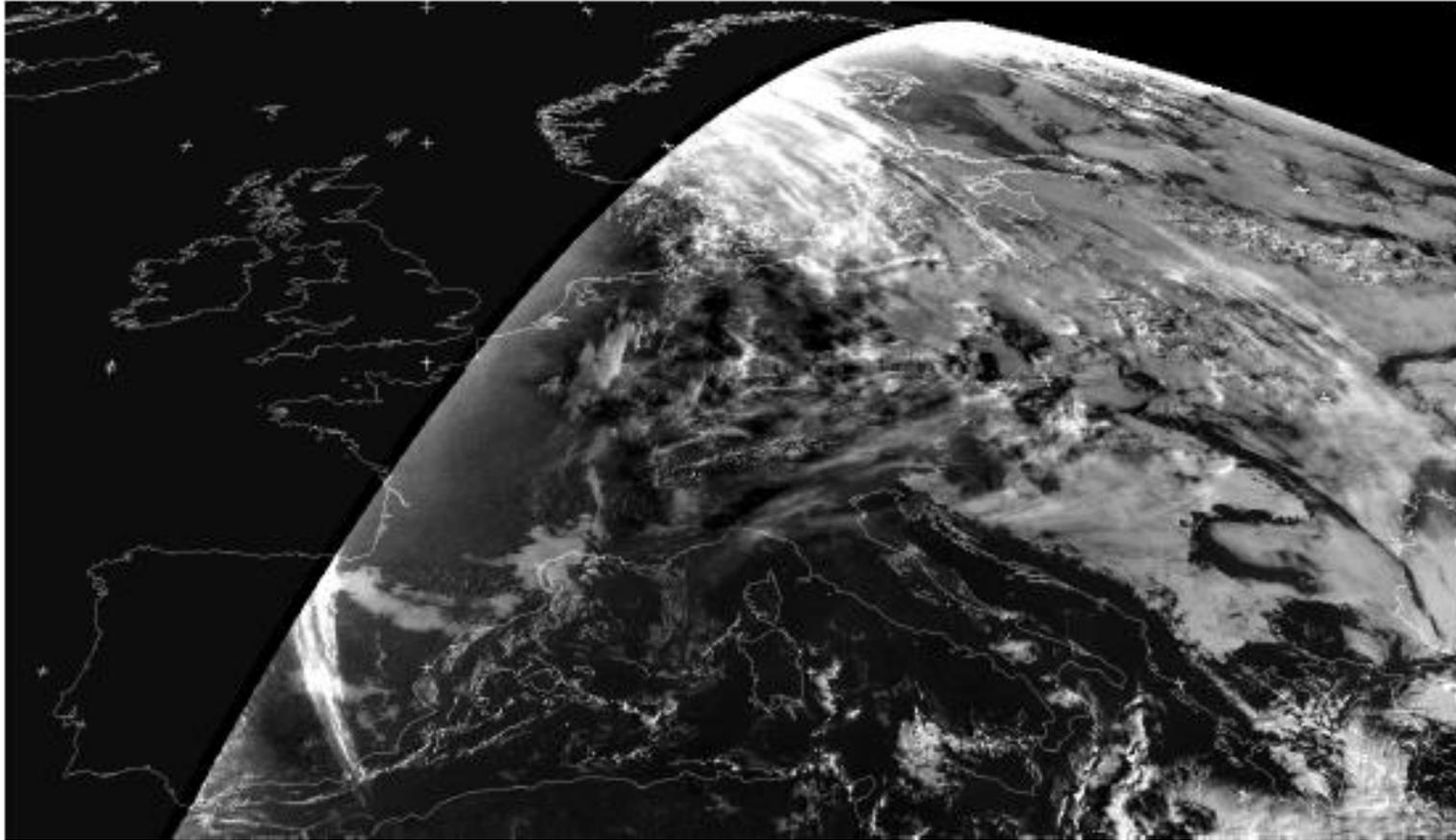
Day-Ahead forecasts (NWP)
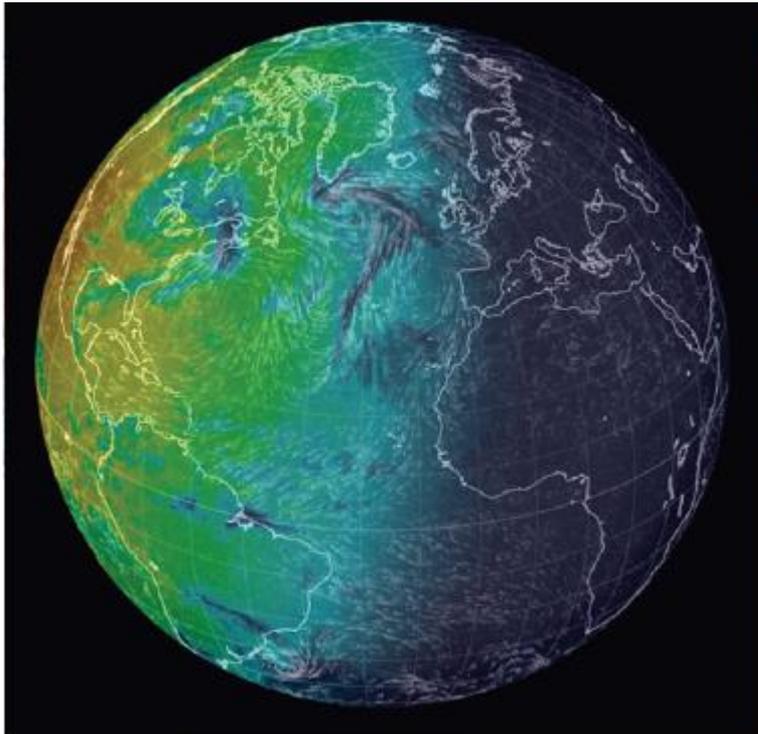
- **Several Models**   **Institutes**
  - ECMWF   (EU)   ECMWF
  - ICON   (DE)   DWD
  - HIRLAM   (EU)   HIRLAM
  - ARPEGE   (FR)   MétéoFrance
  - EURO4   (UK)   MetOffice
  - GFS   (US)   NWS
  - Others investigated

- **Regional Fine Tuning**
  - Weather and Research Forecast (WRF)
  - Initialised by **global outputs**
  - Adapted cloud radiative transfer model
    - According to local climate conditions

Individual PV plant forecasting

Satellite
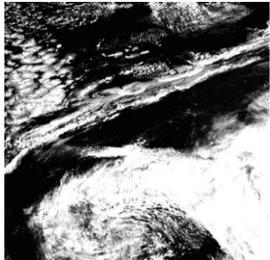
NWP
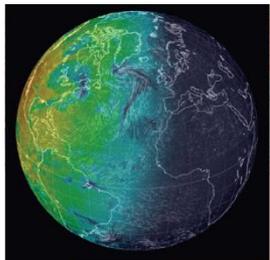
Irradiance forecast
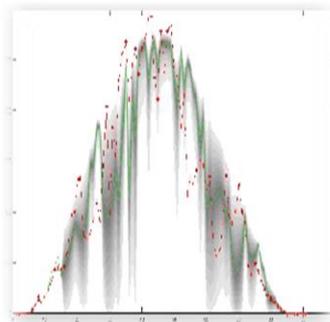
Irradiance to Power
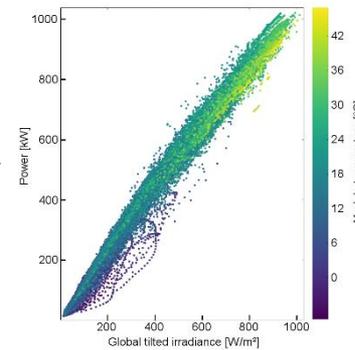
Power forecasts
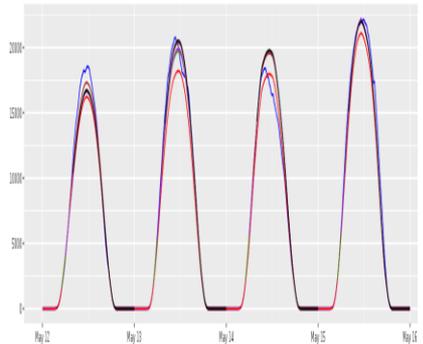
PV panels details (tilt, inclination, tracking system…)

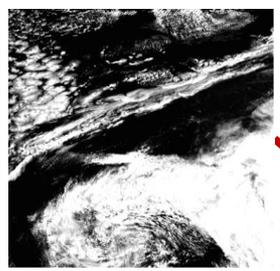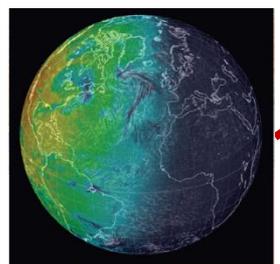# Regional Forecasting – Physical Approach
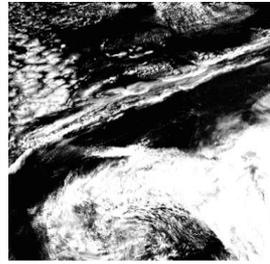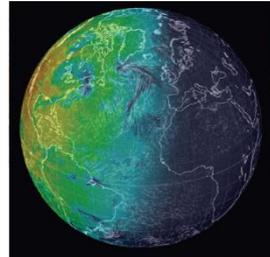
Satellite

NWP

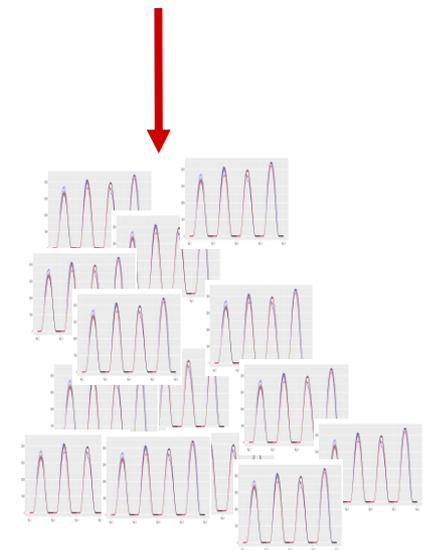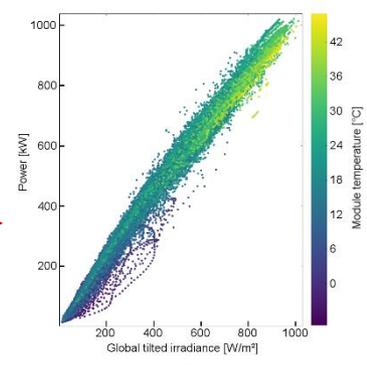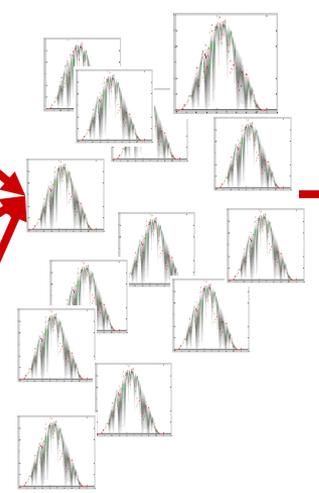# Regional Forecasting – Physical Approach
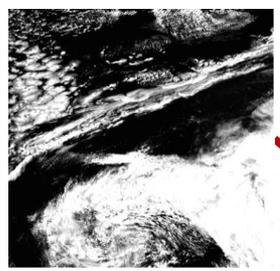
Satellite

NWP

Map

Individual irradiance forecasts

Regional Forecasting – Physical Approach

Satellite

NWP

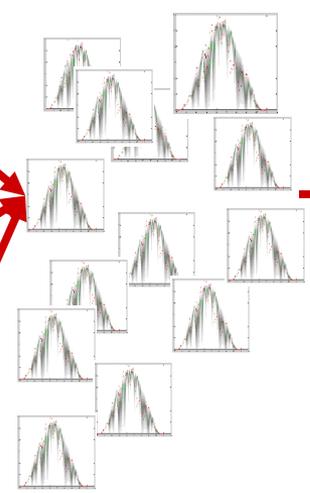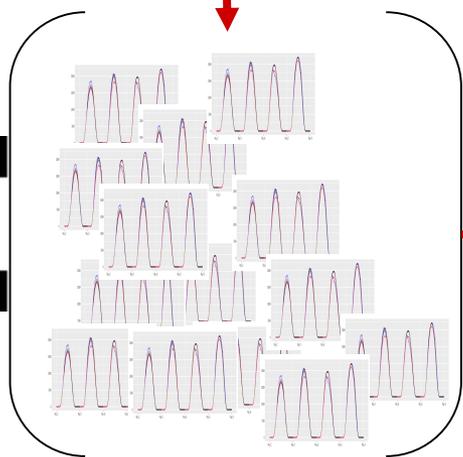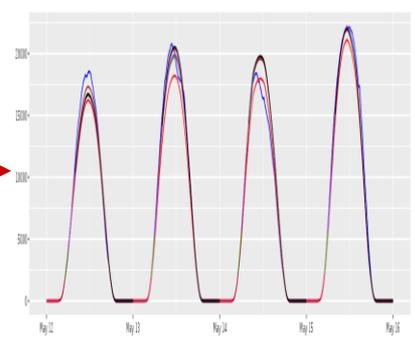**Map**
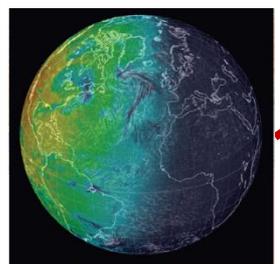
Individual irradiance forecasts
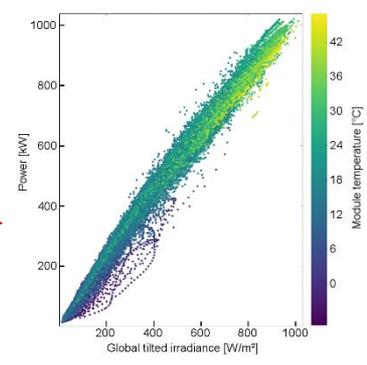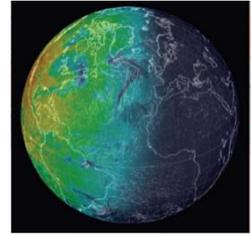
Power forecasts

Regional Forecasting – Statistical Approach

Satellite

NWP
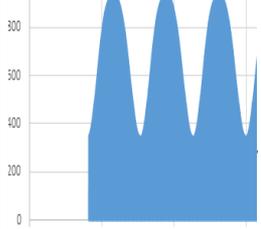

Irradiance Temperature, Wind Speed ...
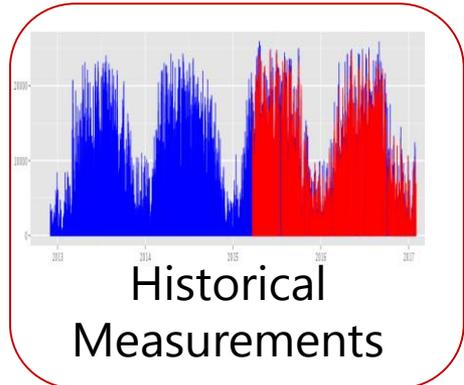
Map

Seasonality
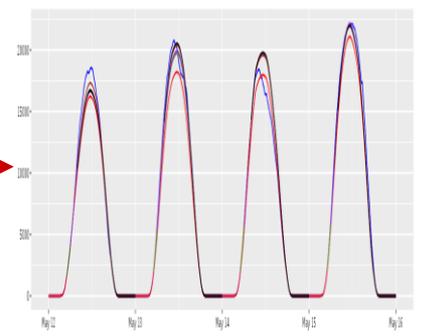

Machine Learning Algorithm

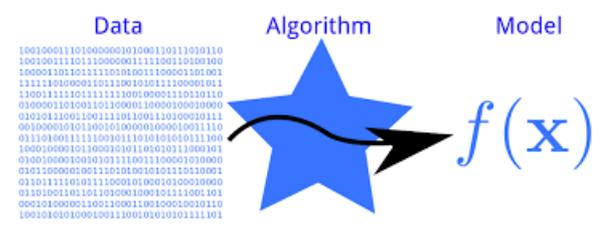TRAINING TRAINING

Historical Measurements

Power forecasts

20

Conclusion

- **The European market: challenges ahead**

- **Forecasts improvements with new technologies**

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