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Forecasting for an Integrated Energy System

Conor Sweeney, UCD, Ireland

Wednesday, 20th June 2018

ESIG 2018 Forecasting Workshop, St Paul, MN
Outline

1. Forecast Applications
2. Forecast Ranges
3. Reanalysis Data
4. ShortWave Radiation
5. Wind/SW correlations
6. Systematic Errors
7. PostProcessing
8. Weather and Demand
9. Probabilistic Forecasting
10. MultiVariate Spatial PP
Forecast Applications

Wind

Solar/PV

Ramping

Thermal: Heating/cooling

Clouds: Lighting

Precipitation: WWT

Extremes, Return periods

Return Level Plot (1981-2010) - Point 635
Forecast Applications

Wind
Solar/PV

Thermal: Heating/cooling
Clouds: Lighting
Precipitation: WWT
Extremes, Return periods

Trading, Hedging.

Ramping

Electricity
Gas
Water

E E G
E E G
E W
E G W

$
Forecast Ranges

Nowcasting/Stats:
Short term. < 6 hours. Stats.

Operational:
Short range: 6 hours to 5+ days.

Medium range: 15 days

Extended range: 32 day

Long range. Seasonal: 1-3 months

And this!
Reanalysis Data

Observations:
- 10 metre wind
- ShortWave radiation

Common validation period:
1982-2007
ShortWave Radiation (SW)

Large relative errors.
Coast bias: Modelled clouds.
Spatial SW

Land/sea pattern
Wind/SW correlations

Year-on-year changes > average monthly.
Spatial Wind/SW correlations

10m wind speed vs SW: 850hPa Westerlies

10m wind speed vs SW: 850hPa Easterlies

Influence of orography
Correlation changes with wind direction
Not seen in global reanalyses
Systematic Errors

Adaptive PP
- train from past x days

Machine learning
- Physical reason?

![Graph showing relationship between Reanalysis Temperature and Error. The x-axis represents Reanalysis Temperature in °C, ranging from 11.5 to 13.5. The y-axis represents Error, ranging from -0.8 to 0.4. The graph includes data points and a trend line.]

- NWP
- PP
- ?
- DMO
PostProcessing

Reanalysis Skill Scores

Reanalysis Skill Scores

Reanalysis Skill Scores

RMSE MÉRA
RMSE ERA-Interim
RMSE MERRA2
ME MÉRA
ME ERA-Interim
ME MERRA2
Don’t Average everything

https://www.youtube.com/watch?v=9D451XcuQmY

Largest SW errors: T at 500hPa
All Ireland Electricity Demand Profiles

**Total Demand - Fourier Fit = Residual Demand**

**Annual trend:**
- Climate, GDP, elec price, tech, society.

**Seasonal:**
- Temperature, daylight...

- Day of Week
- Holidays
- Weather
Weather Driven Demand

\[ D_R = aT_e + bT_e^2 + c\text{Cloud} + d\text{Wind} + e\text{Day} + f\text{Hol} + g\text{Xmas} \]

\[ D_{RW} = D_R - e\text{Day} - f\text{Hol} - g\text{Xmas} \]

Atmospheric patterns \(\propto\) Demand. Extremes. Spatial Demand
Probabilistic forecasting

Chaos

High-Res Ensembles
- Adaptive physics
- Satellite updates

Post-processing

Bayesian Model Averaging
MultiVariate Spatial Post-Processing

Wind speed, direction. T2m. Cloud, type. Stability, CAPE.

Spatial input:
Pattern recognition
- MSLP.
- Jet stream.
- 500hPa T

Spatial PP: Hyperparameter surface

Extremes:
- GEV
- Subsurface
Thank you.