# Data Assimilation for NWP with the ICON Global Model

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Deutscher Wetterdienst (DWD)

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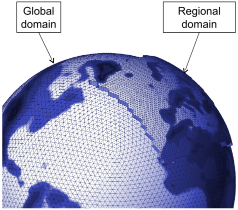
# ICON model




Operational global model since January 2015!

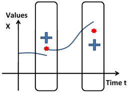
ICOsahedral Non-hydrostatic global model.

Developed jointly by DWD and MPI-M.

- Defined on a triangular unstructered icosahedral grid.
- Non-hydrostatic dynamical core.
- Grid point model (non-spectral).
- Improved physics.
- Two way nests, eventually to replace limited area models.
- 90 z-coordinate levels up to 75 km (aprox. 0.026hPa).

# Data assimilation for ICON

## Variational 3DVar

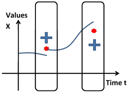



Deterministic analysis with a climatological covariance matrix.

- × Uncertainty is nearly static.
- × Not situation dependent.

# Data assimilation for ICON

### Variational 3DVar

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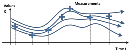
### LETKF EDA




Ensemble of initial states that characterize the analysis probability distribution (Hunt et al 2007).

✓ Uncertainty = Ensemble spread.

✓ Dynamic and situation dependent uncertainty.

× Finite size ⇒ spurious correlations ⇒ localization.

× Ensemble mean is not a physical state.

# Data assimilation for ICON

**Hybrid EnVar**

The analysis is computed as a deterministic 3DVar with part of the uncertainty coming from the LETKF: $B = \alpha B_{LETKF} + (1-\alpha) B_{NMC}$ (Buehner and Carron 2007).

- High resolution deterministic physical estate.
- Flow dependent uncertainty.
- Uncertainty also dependent on climatology.

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Operational since January 2016!

### Particle Filters

Currently under active research.

# Current operational setup

## Deterministic setup

- 13 km horizontal resolution, 90 vertical levels.
- 6.5 km nest over Europe with 60 vertical levels.
- 3 hourly updates.
- Incremental analysis update with a symmetric 3 h window.
- 3 hourly snow analysis.
- Sea surface temperature and soil moisture analysis daily at 0 UTC.
- Snow, SST and SMA additional analysis on the nest.
- Weight of the ensemble B: 0.75.
- 7 day long forecasts twice daily at 0 and 12 UTC.

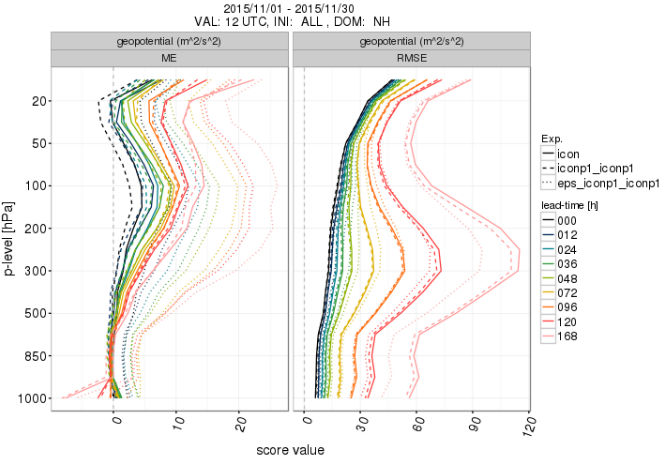
# Current operational setup

## Ensemble setup

- 40 members, 40 km resolution (20 km over Europe).
- 3 hourly updates, 3 h symmetric IAU window.
- Deterministic snow analysis used for all members.
- SST perturbations (1K; 100, 1000 km, 24 h).
- Mean SMA relaxes to deterministic SMA.
- Relaxation to prior perturbations with 0.75 coefficient.
- Additive inflamation, bounds depending on the layer (0.9 - 1.5).
- Horizontal localization: 300 km.
- Vertical localization: 0.3logp (surface) to 0.8logp (top).
- 7 day long forecasts twice daily at 0 and 12 UTC (not used).

# Verification against radiosondes: northern hemisphere

Bias and RMSE for geopotential.



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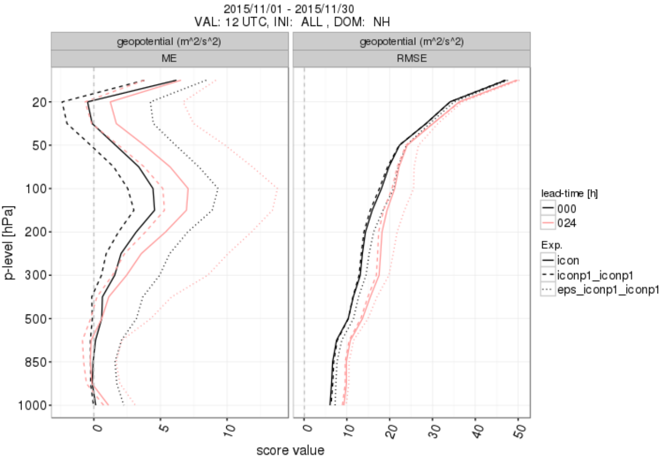
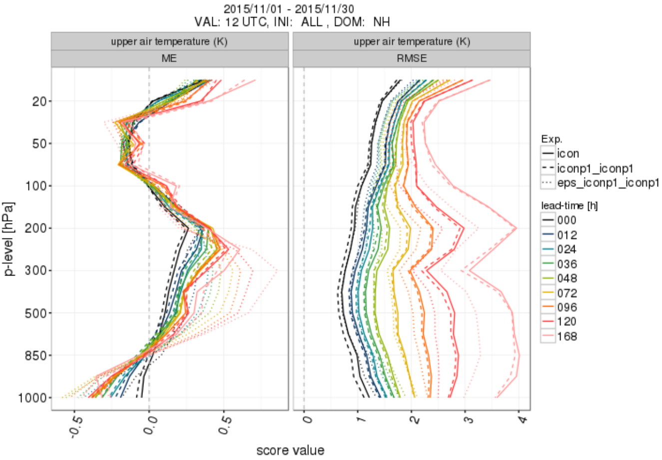


# Verification against radiosondes: northern hemisphere

Bias and RMSE for temperature.



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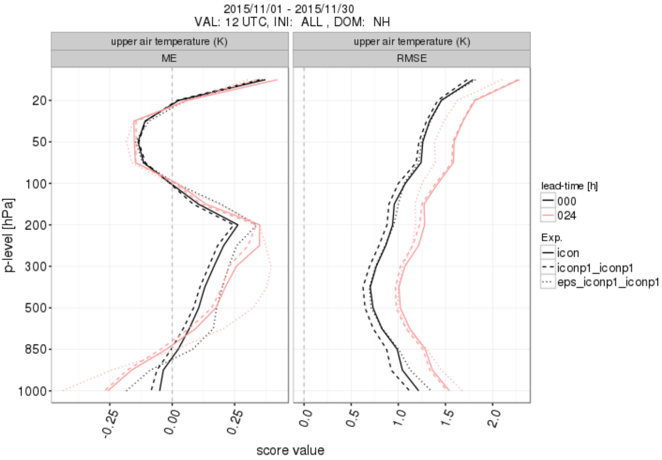
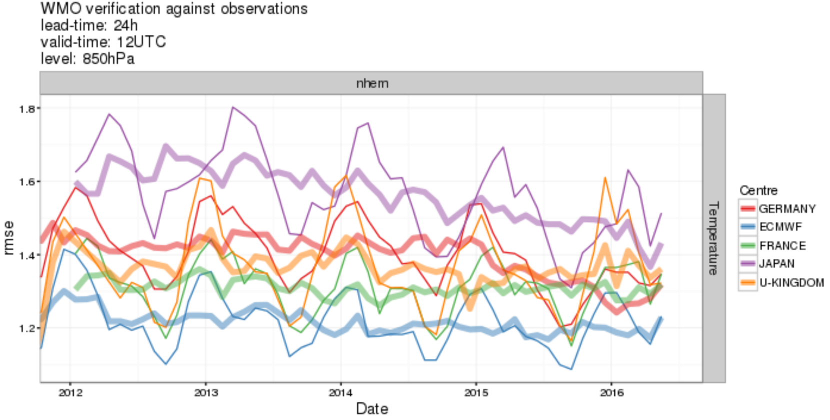


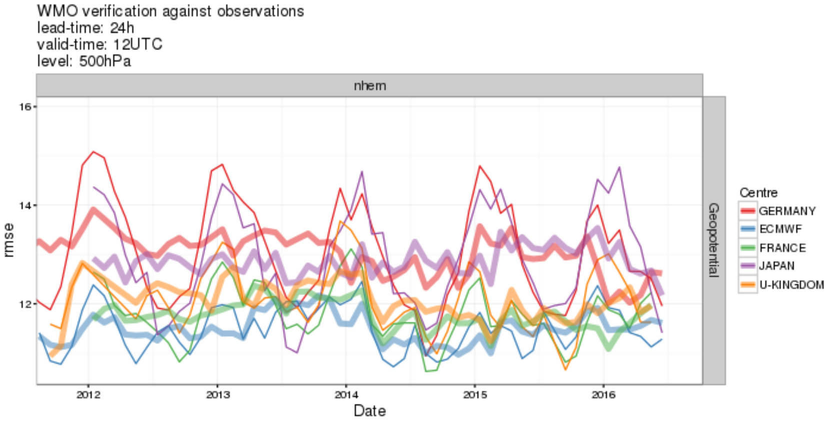
# WMO global model verification comparison

RMSE 850 hPa temperature, 24 hour forecast, northern hemisphere.



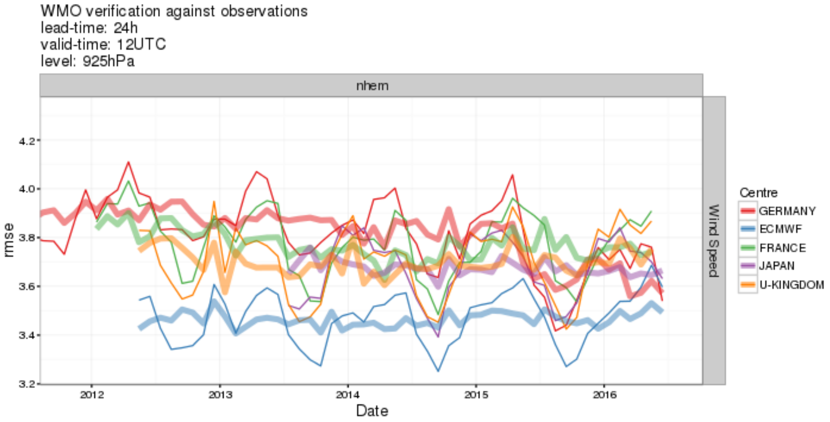
# WMO global model verification comparison

RMSE 500 hPa geopotential, 24 hour forecast, northern hemisphere.



# WMO global model verification comparison

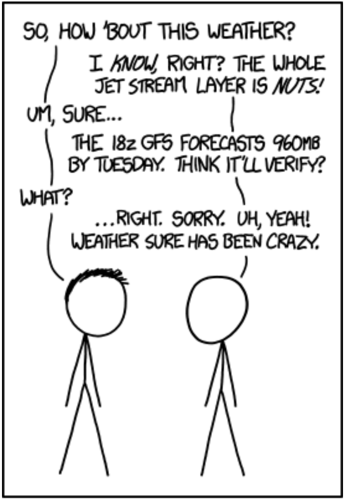
925 hPa wind speed, 24 hour forecast, northern hemisphere.



# To sum up...

- Hybrid EnVar is now operational at DWD.
- To that effect an ensemble DA (LETKF) has been developed.
- Still many things to try and improve in our LETKF! physical parametrization perturbations, soil moisture and snow perturbations, improved sea surface temperature perturbations, observation perturbations, improved localization, fine tuning...
- The ICON EPS under development already looks promising.
- Short term goals: improved use of satellite data (and other).
- Long term goals: particle filters?

Thanks for your attention!

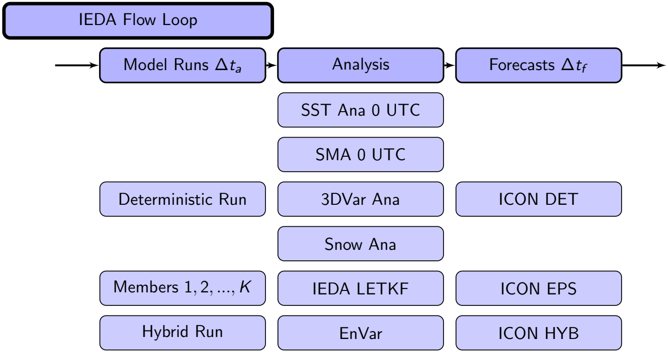



WEATHER GEEKS HAVE IT TOUGH.

(http://xkcd.com/1324/)

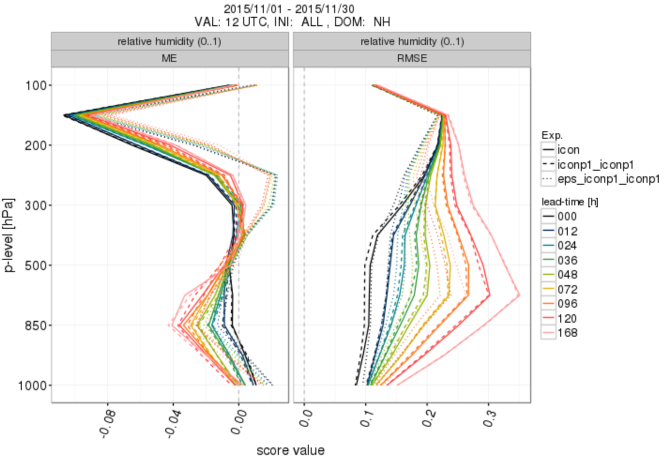
# BACY (*Basic Cycling*) Environment

Cycling is crucial!



# Verification against radiosondes: northern hemisphere

Bias and RMSE for relative humidity.



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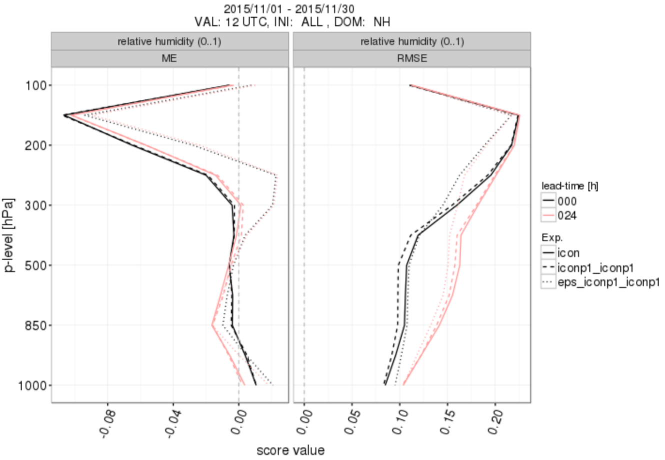
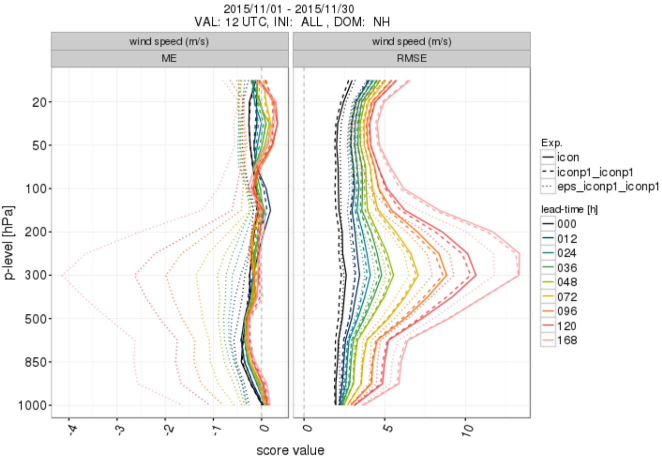


# Verification against radiosondes: northern hemisphere

## Bias and RMSE for wind speed.



# Verification against radiosondes: northern hemisphere

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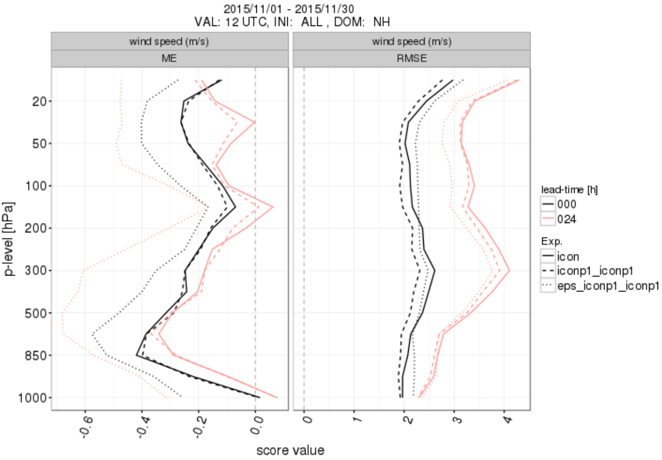
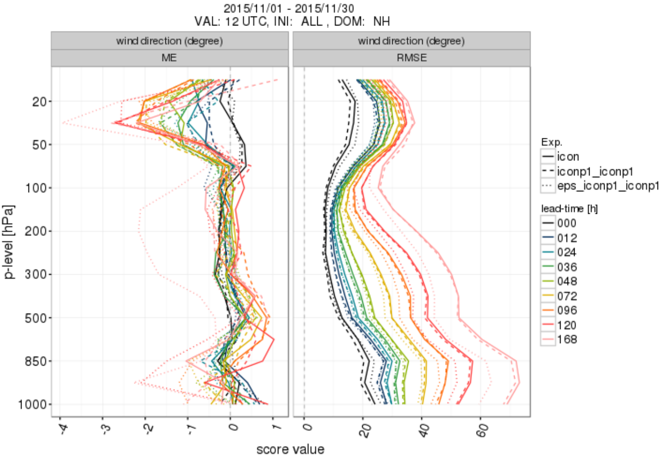


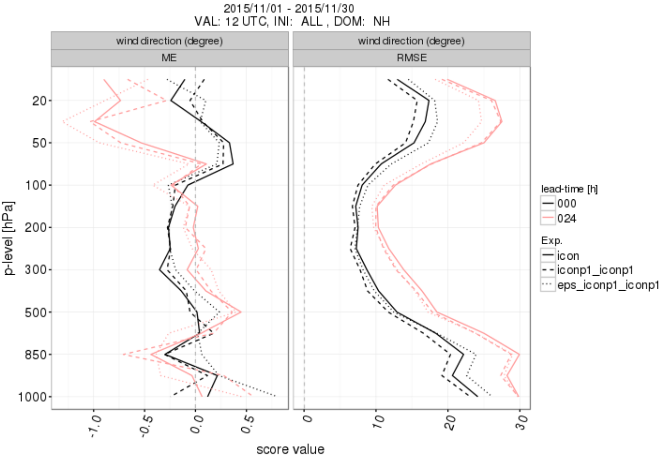
# Verification against radiosondes: northern hemisphere

## Bias and RMSE for wind direction.



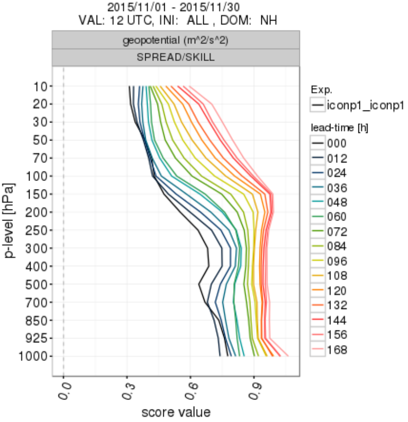
# Verification against radiosondes: northern hemisphere

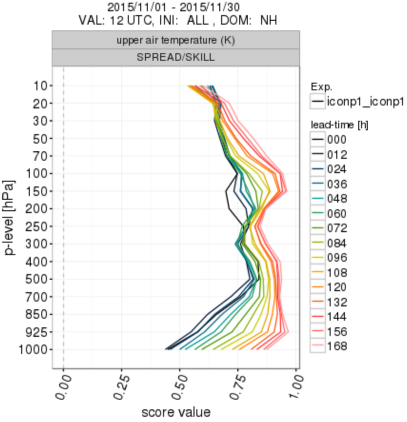
Bias and RMSE for wind direction.



# Verification against radiosondes: spread/skill

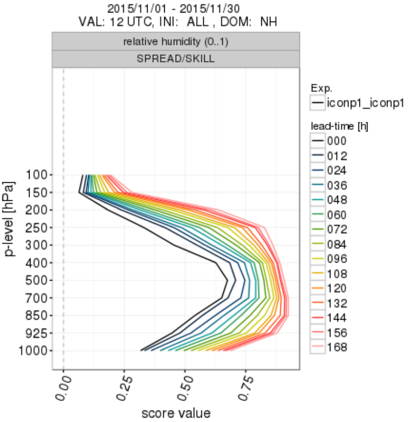
Geopotential and temperature, northern hemisphere.



# Verification against radiosondes: spread/skill

## Relative humidity and u-component, northern hemisphere.



# Verification against radiosondes: summary

## EnVar vs 3DVar.

RMSE, percentual change aggregated to all lead times.

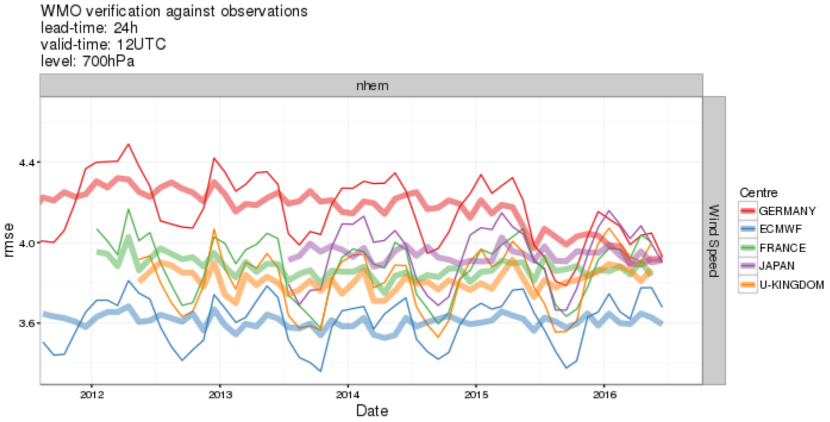
# Verification against radiosondes: summary

## EPS vs EnVar.

RMSE, percentual change aggregated to all lead times.

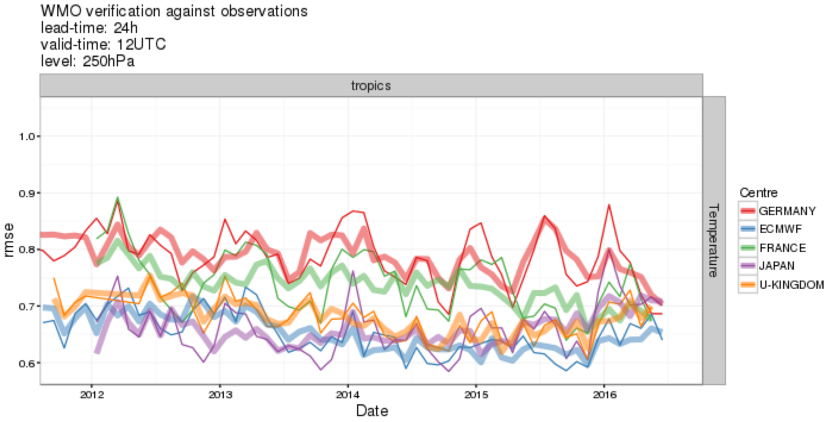
# WMO global model verification comparison

700 hPa wind speed, 24 hour forecast, northern hemisphere.



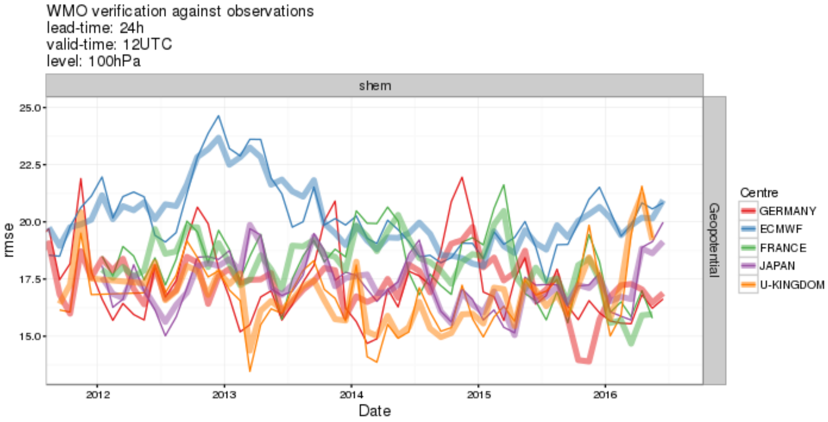
# WMO global model verification comparison

RMSE 250 hPa temperature, 24 hour forecast, tropics.



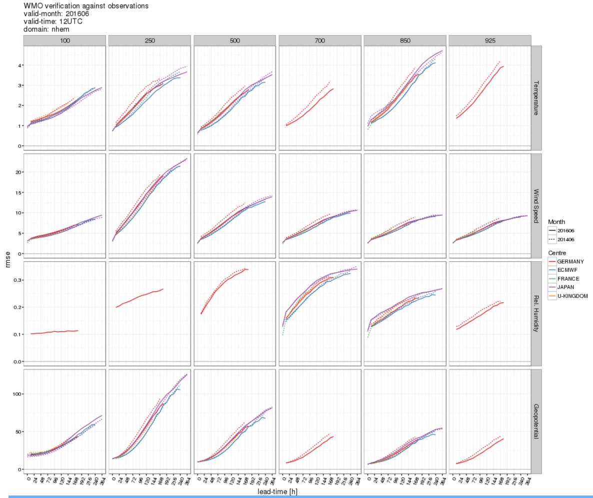
# WMO global model verification comparison

100 hPa geoptential, 24 hour forecast, southern hemisphere.



# WMO global model verification comparison

RMSE with lead time, June 2014 vs 2016, northern hemisphere.



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RMSE with lead time, June 2014 vs 2016, southern hemisphere.