The impact of additional soundings from the field campaigns NAWDEX/SHOUT 2016 and T-PARC 2008

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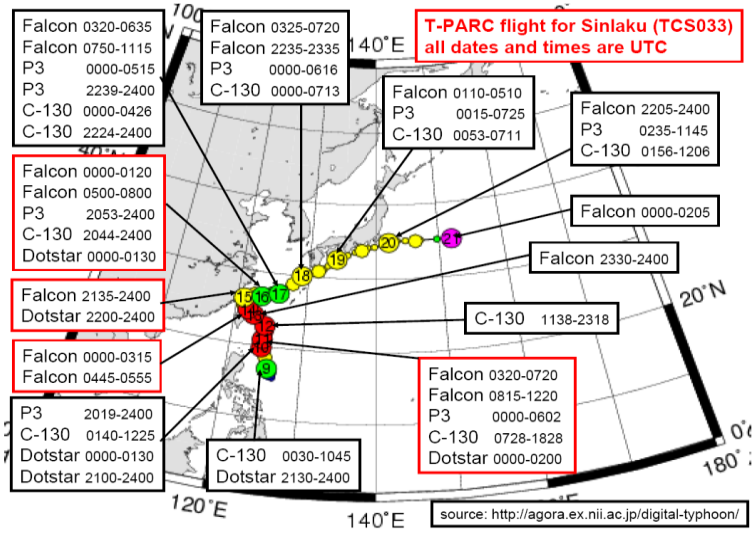
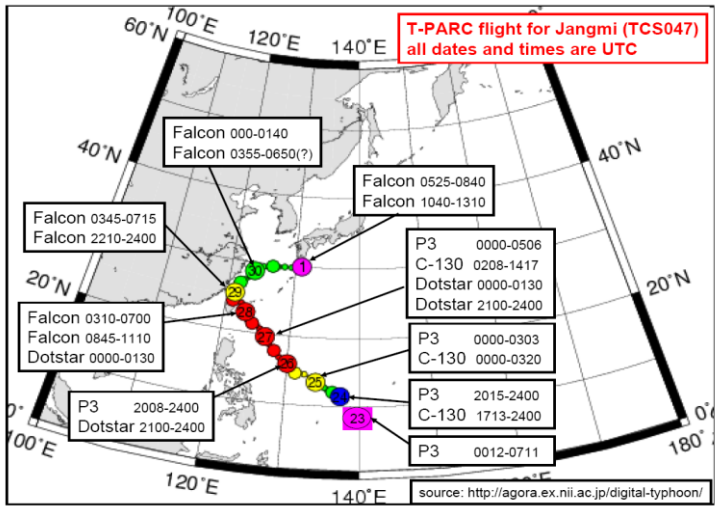
Thanks to contributions from other modelling groups!

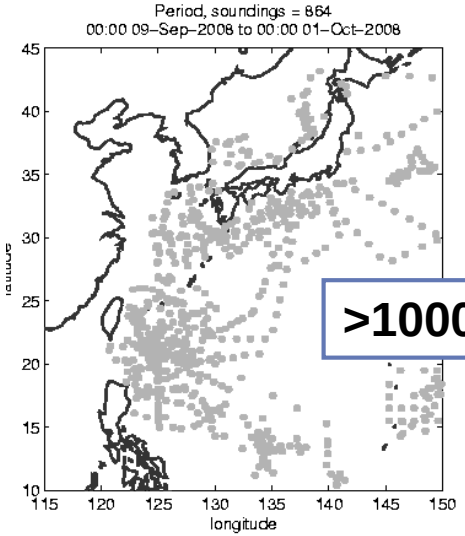
Content

- Impact of dropsondes (and additional radiosondes)
- Data denial experiments and FSOI
- Mainly ECMWF model, some results for other models
- Field campaigns T-PARC 2008 and NAWDEX/SHOUT 2016
- Observation in midlatitudes, near tropical cyclones and during extratropical transition (partly targeted, around 1000 additional soundings per campaign)

THORPEX Pacific Asian Regional Campaign (T-PARC, Aug – Oct 2008)







>1000 dropsondes

Evaluation of dropsonde impact from 4 aircraft

Period: Three weeks in September 2008

Typhoons: Sinlaku and Jangmi

Models:

- ECMWF (global, 4D-Var, 25 km res.)
- JMA GSM (global, 4D-Var, 20 km res.)
- NCEP GFS (global, 3D-Var, 38 km res.)
- WRF-ARW (regional, 3D-Var, 30 km res.)

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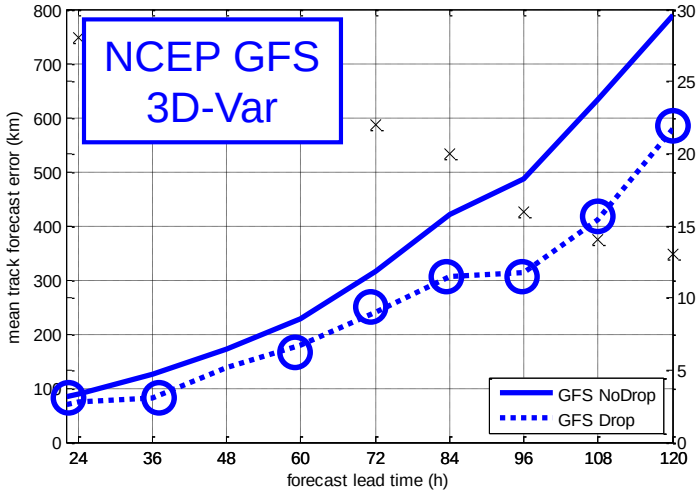
Hans-Ertel-Zentrum für Wetterforschung

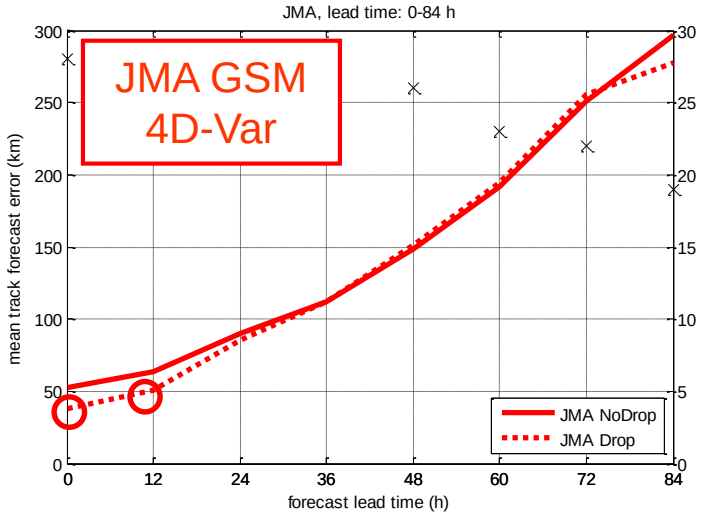
WAVES TO WEATHER

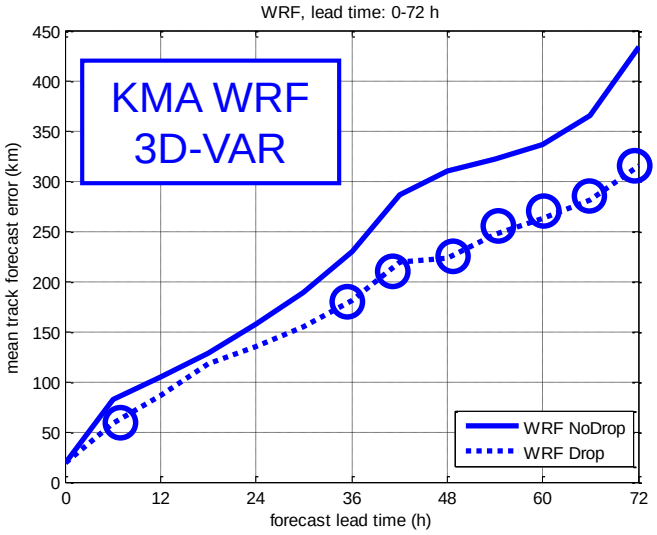
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

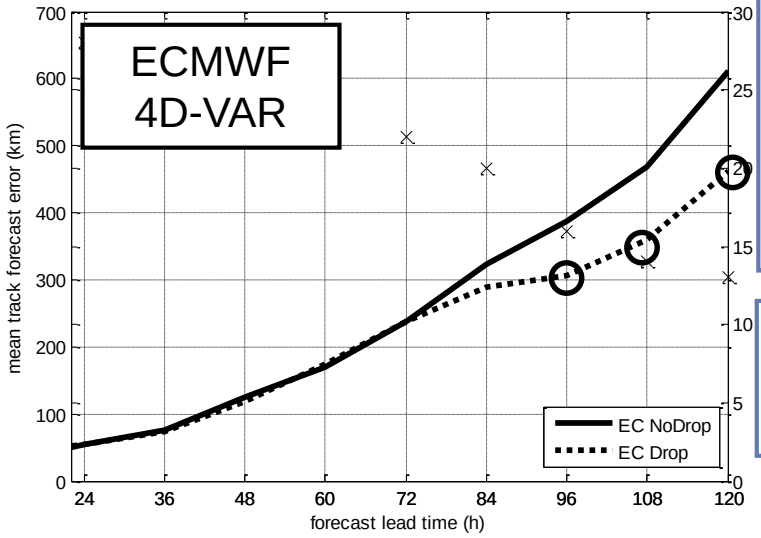
DWD

Influence of T-PARC dropsondes on typhoon track forecasts









Different scales!

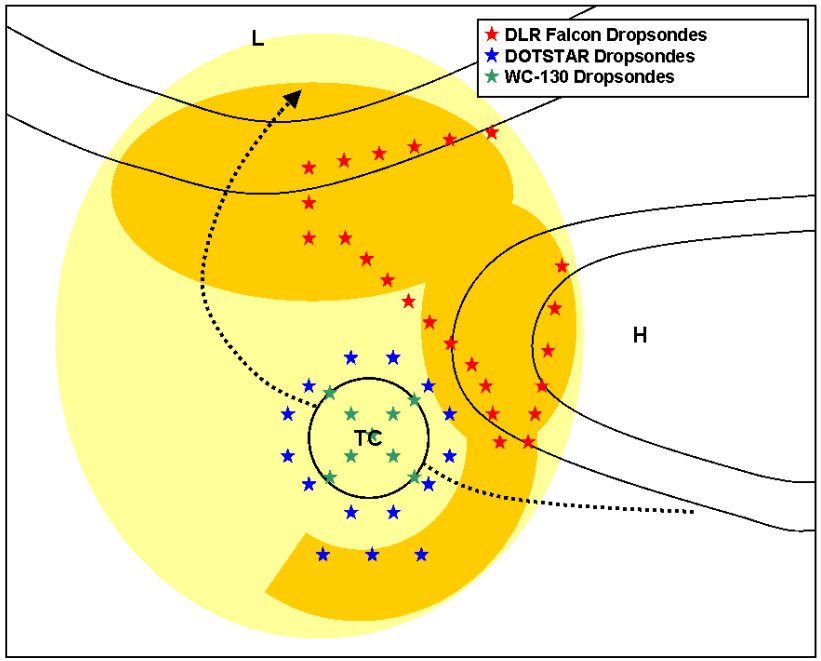
Issue with dropsondes within TC @JMA

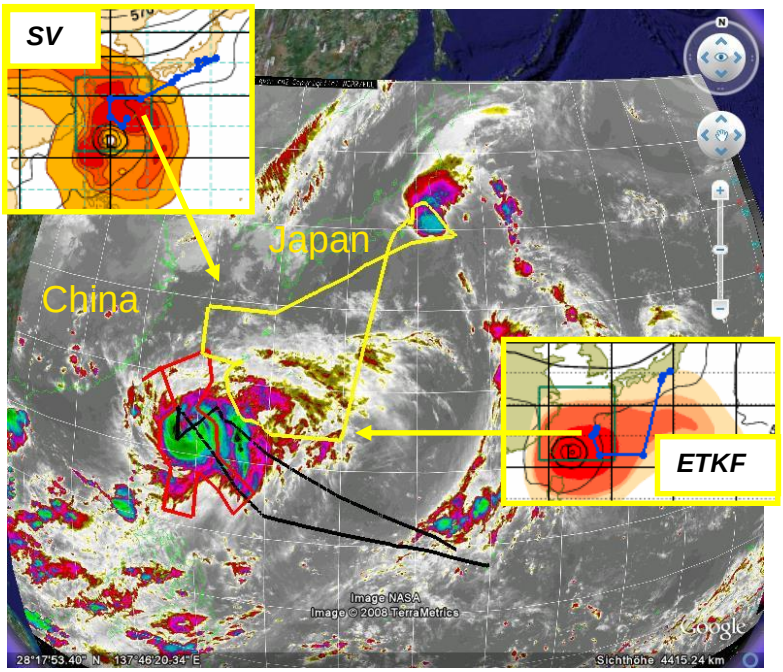
All models show some reduction of typhoon track forecast errors with dropsondes, but impact strongly depends on DA system

Larger impact in models with larger error

(Weissmann et al. 2011, MWR)

Comparison of dropsonde targeting strategies





Joint mission on 11 September

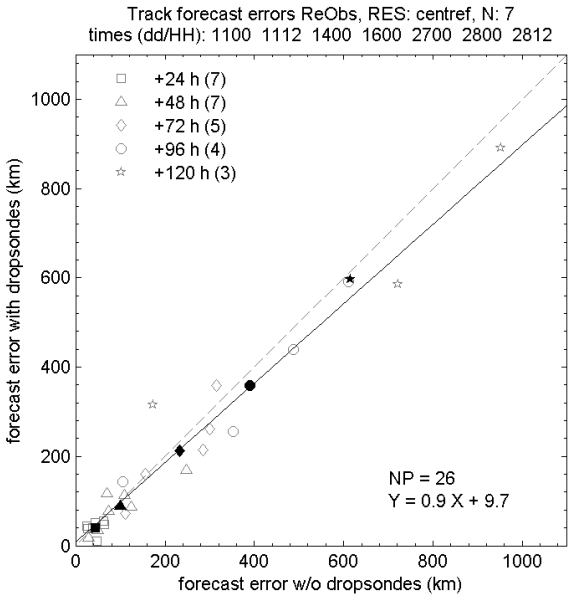
Concept for ideal mission and sensitivity experiments:

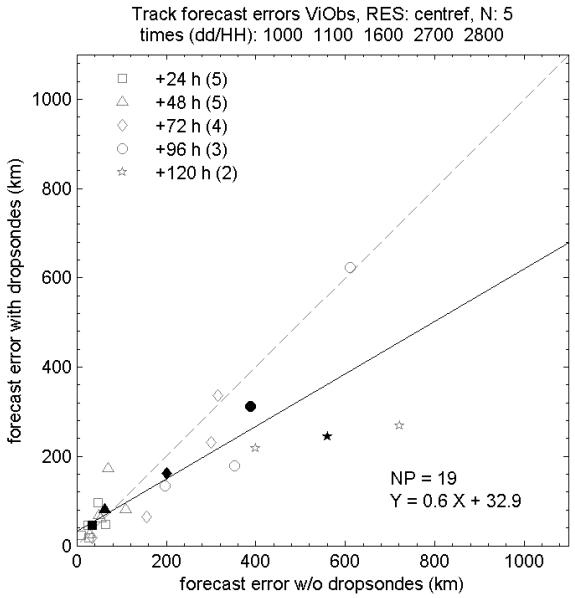
- Falcon obs. in sensitive area highlighted by e.g. SV, ETKF (red)
- DOTSTAR observations in typhoon surrounding (blue)
- WC-130 observations in typhoon center (green)

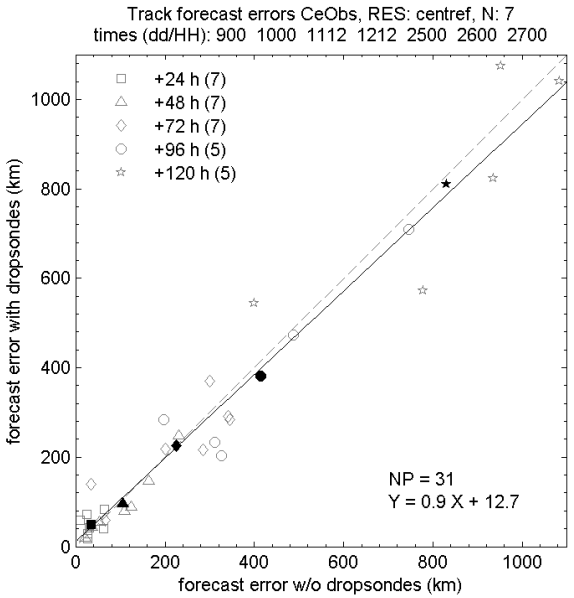
Evaluation of targeting strategies in ECMWF system

(Harnisch and Weissmann, 2010, MWR)

Which dropsonde observations are most beneficial?







Remote sensitive regions:
small positive to neutral impact

Possible reasons:
- SV resolution
- Insufficient sampling of region
- Low analysis error

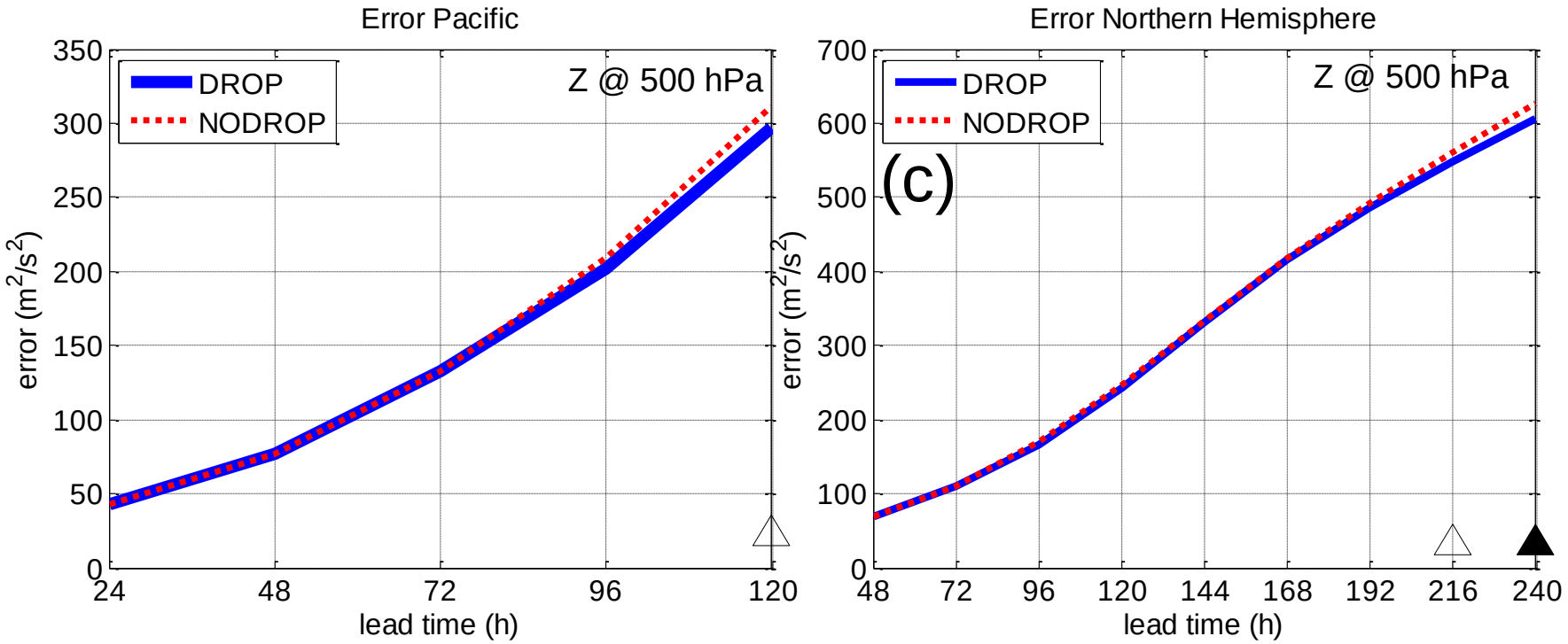
Typhoon vicinity:
improvement of the track forecast

Typhoon center and core:
overall neutral impact

Possible reasons:
- Model resolution
- Static B-matrix
- Dropsonde drift
- Observation error, QC

(Harnisch and Weissmann, 2010, MWR)

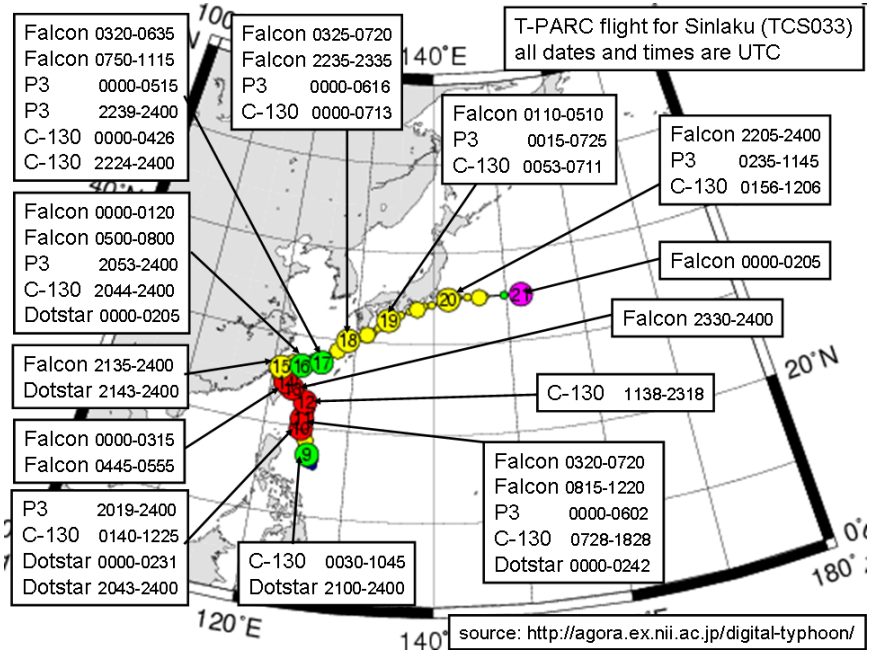
Influence on ECMWF midlatitude forecasts

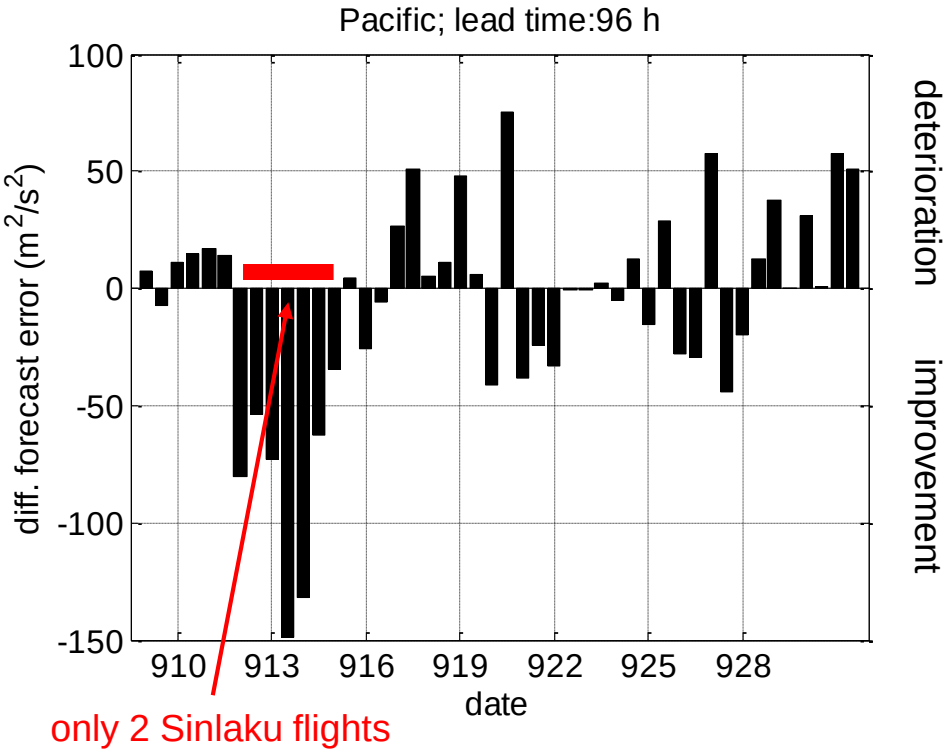


- Slightly reduced error over the northern Pacific and northern hemisphere

(Weissmann et al. 2011, MWR)

Influence on ECMWF midlatitude forecasts

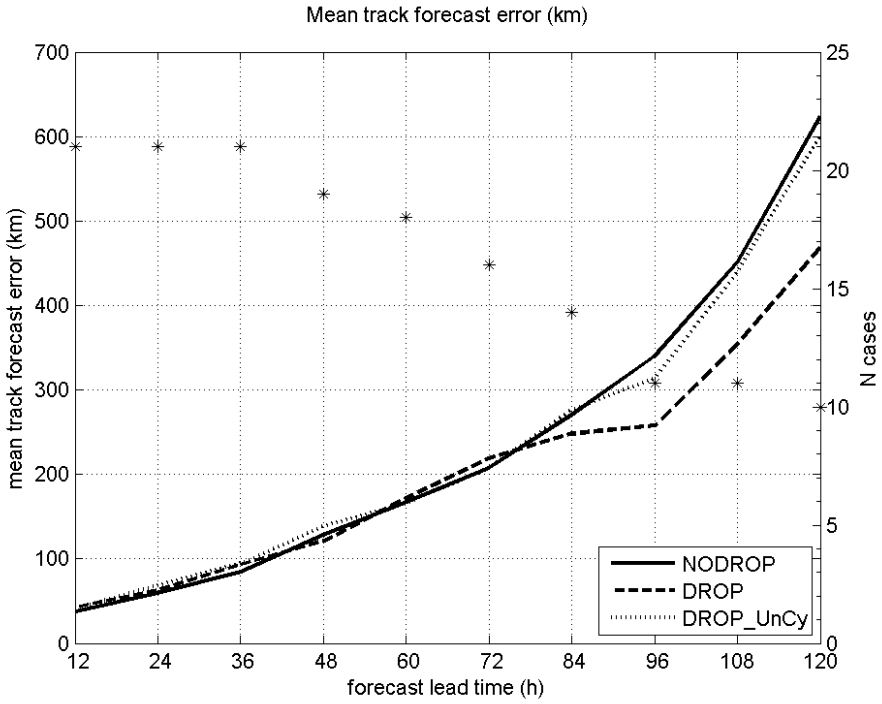


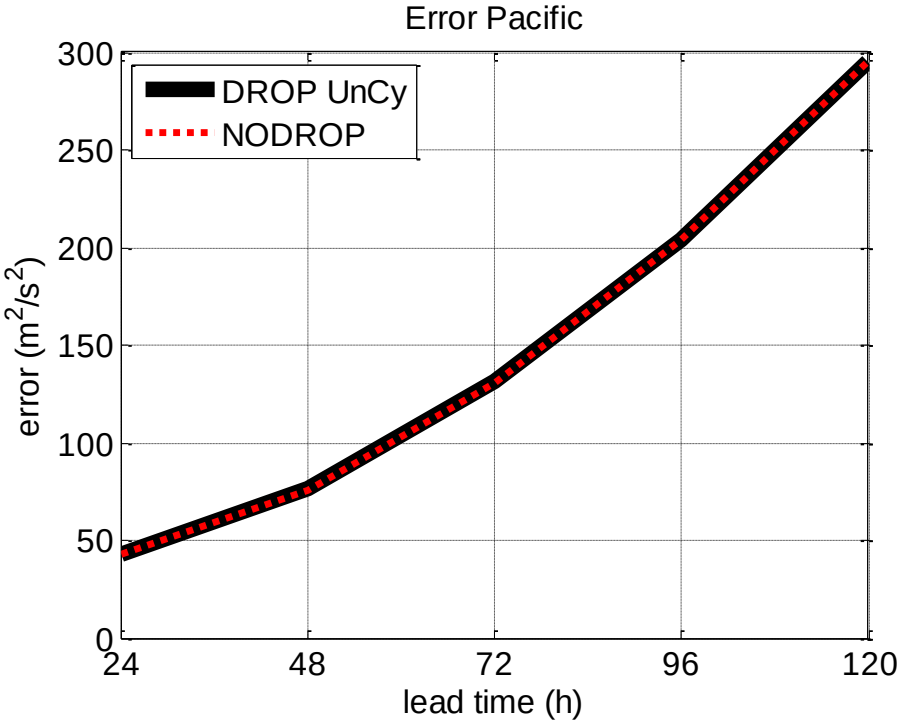


Improved track forecast --> improved first-guess for subsequent days --> imroved mid-latitude forecast

Overall neutral influence of observations during ET, although these were partly guided by SV calculations optimized for the Pacific

The importance of cycling





- Hardly any improvement without cycling

Conclusions from T-PARC 2008

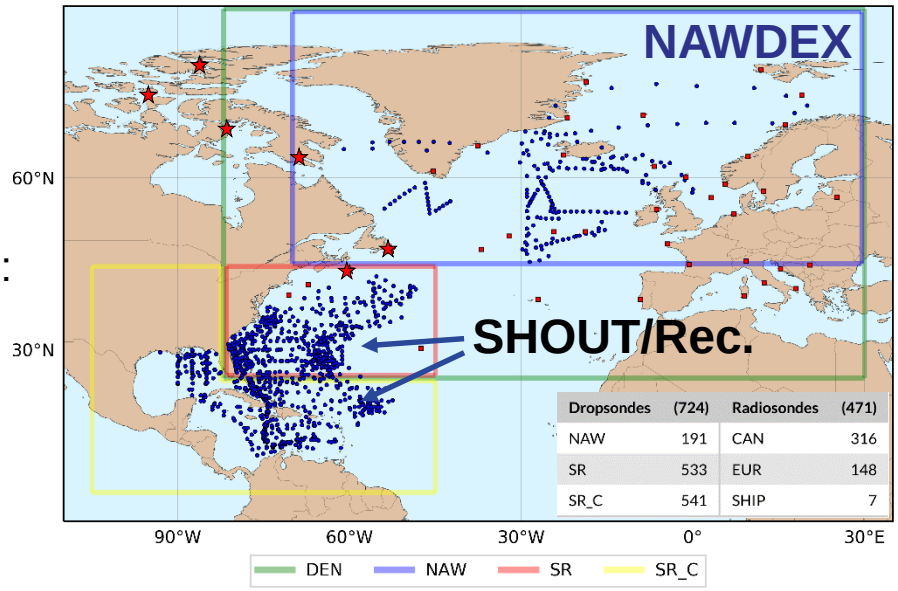
- Some typhoon track improvements in all models, larger improvement in less advanced data assimilation systems
- Indication for insufficient use of dropsondes in TC core and eyewall
- Only small improvement from dropsondes in „remote“ sensitive areas, larger improvement from dropsondes in the vicinity of the storm
- Cycling is essential, which makes impact assessment and targeting observations difficult
- Some improvements of ECMWF mid-latitude forecasts – impact related to cycling and ET, but not targeted observations in midlatitudes

NAWDEX and SHOUT (Sept. - Oct. 2016)

Cycled ECMWF data denial experiment

- Denial of soundings in green box
- 724 dropsondes (plus 541)
- 471 additional radiosondes Eperiment period:

  1 month
- Cycle 43r1, spearate EDA

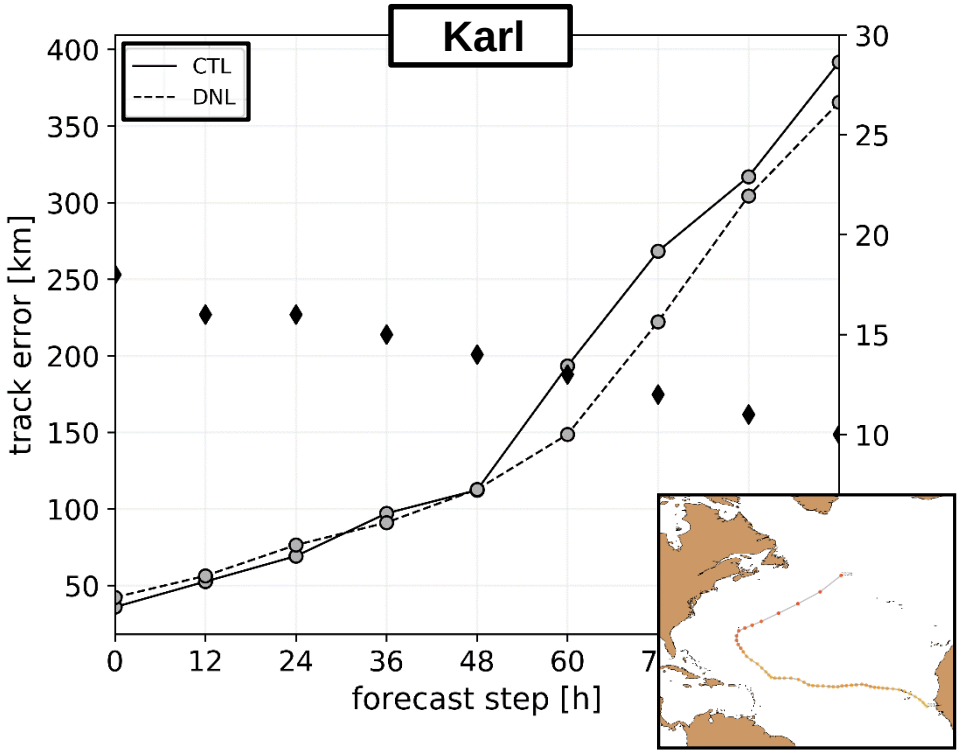


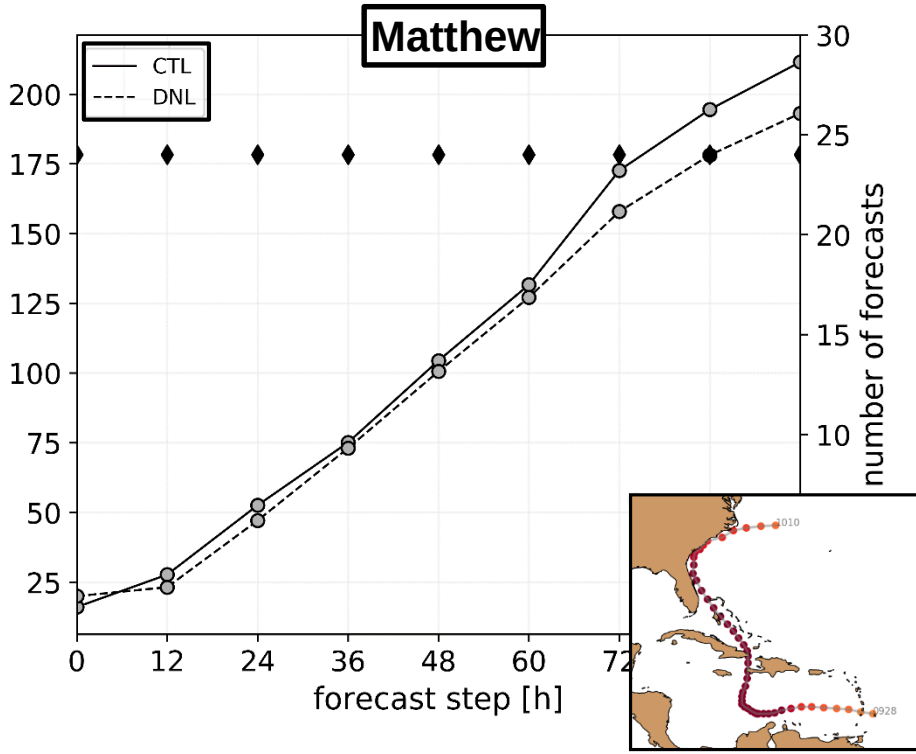
CTL: Assimilating oper obs + extra obs

DNL: Assimilating oper obs

(Schindler et al., submitted to MWR)

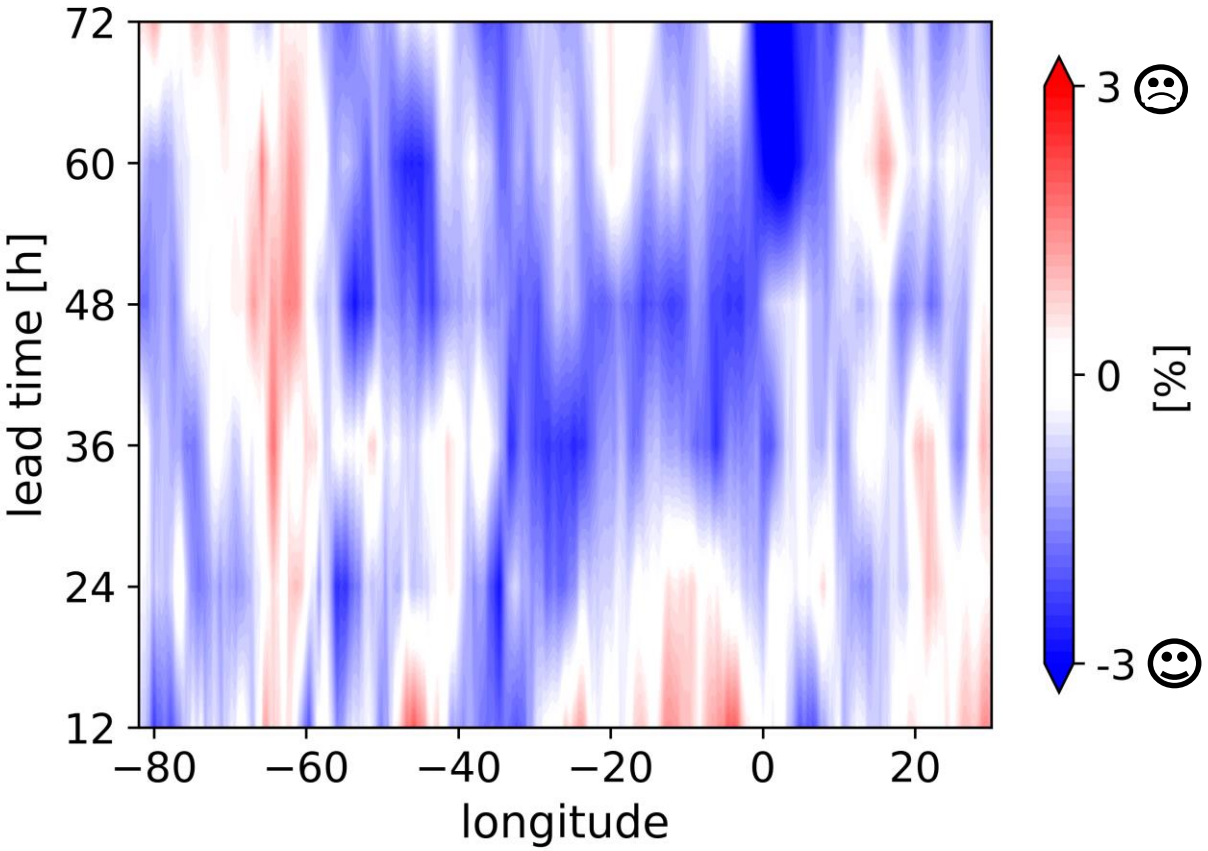
Track errors





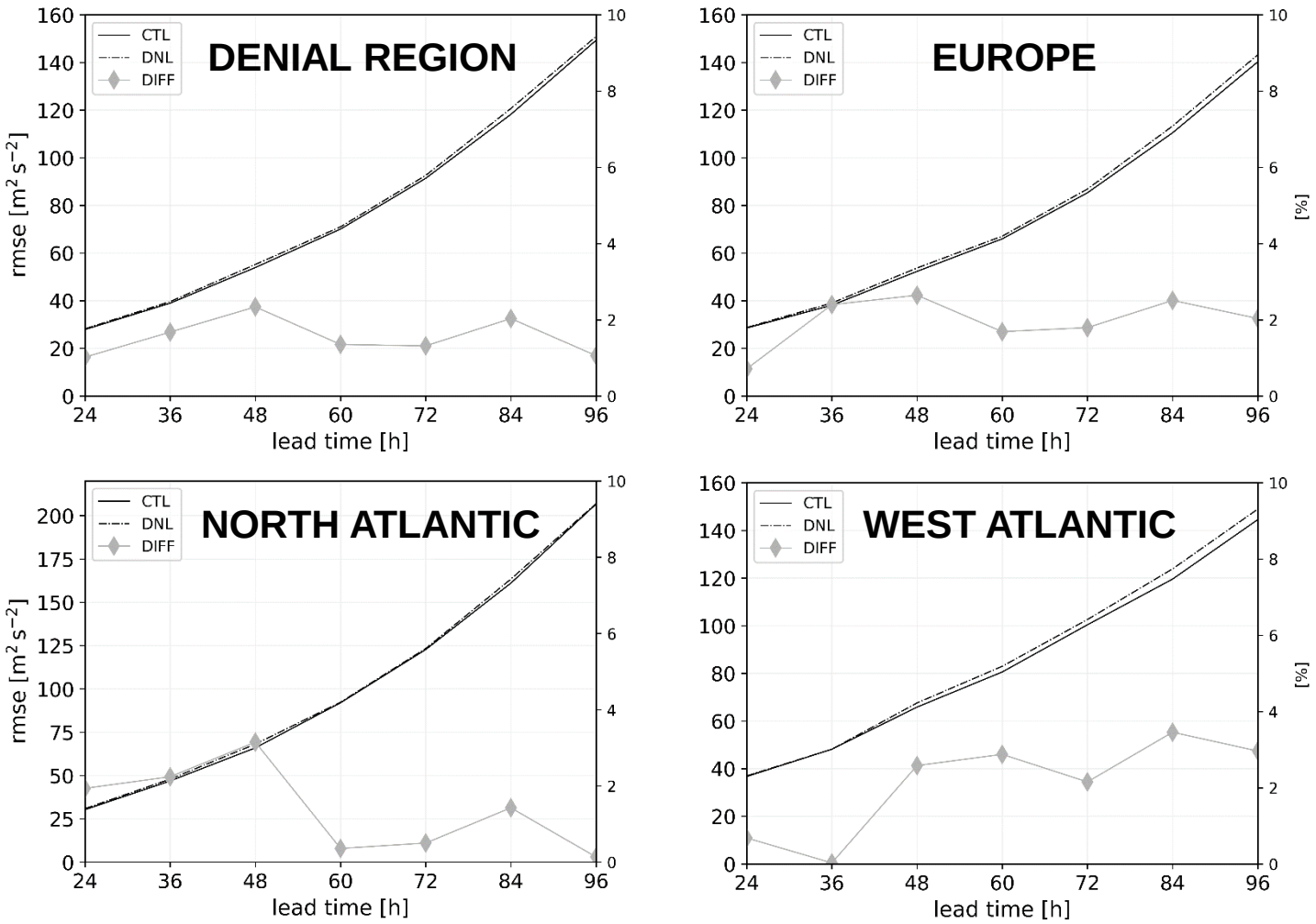
- Some deterioration for lead times > 60hrs
- However, no denial of dropsondes at early stages and qualitatively small differences

Mean absolute forecast error (30N – 80N)



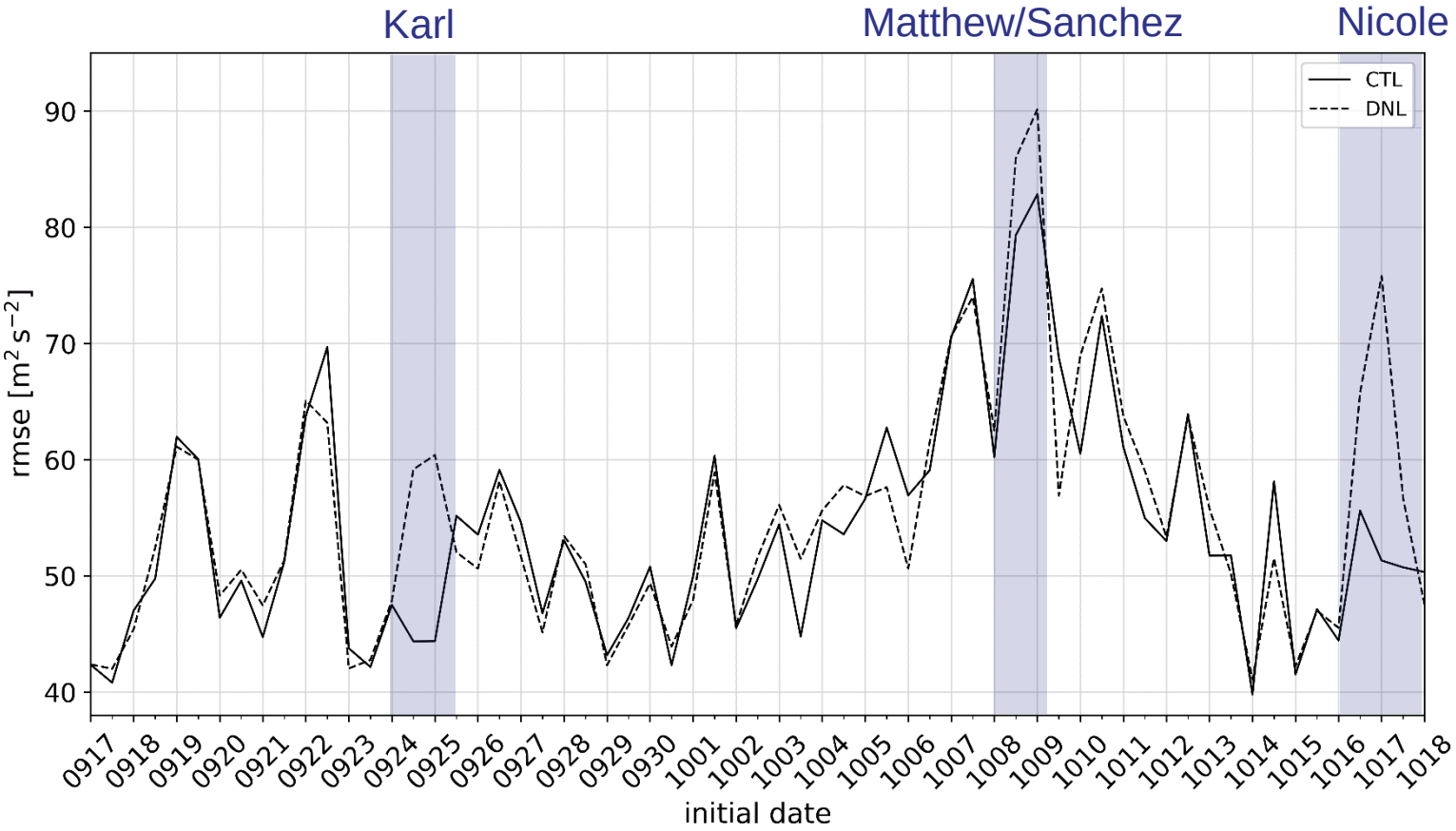
- Overall reduction in forecast error of CTL for all forecast lead times up to 72 hours

RMSE for different regions



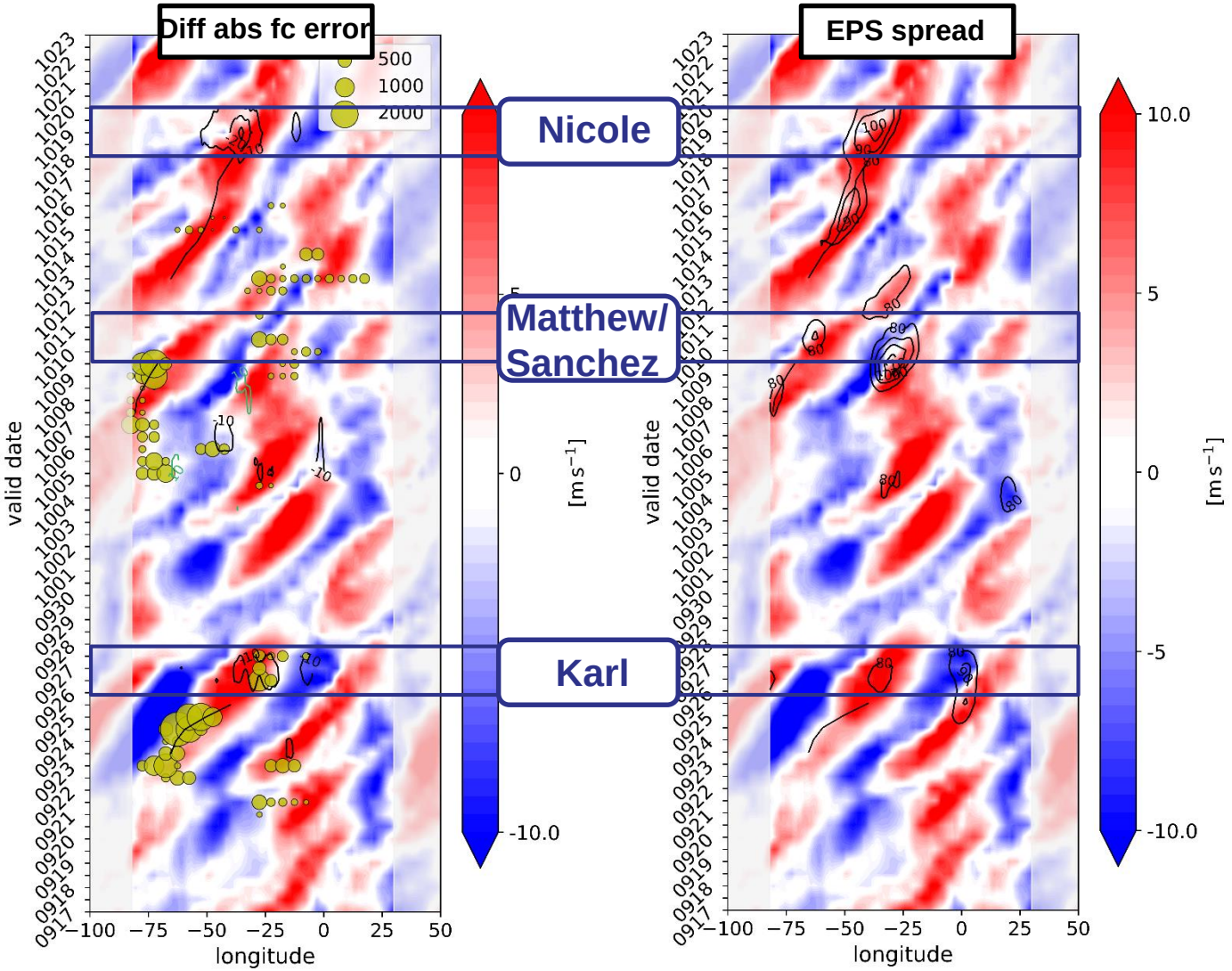
- Improvement up to 96 hrs (consistent for different verif. regions, levels, parameters)

Time series of RMSE for denial region (48h)



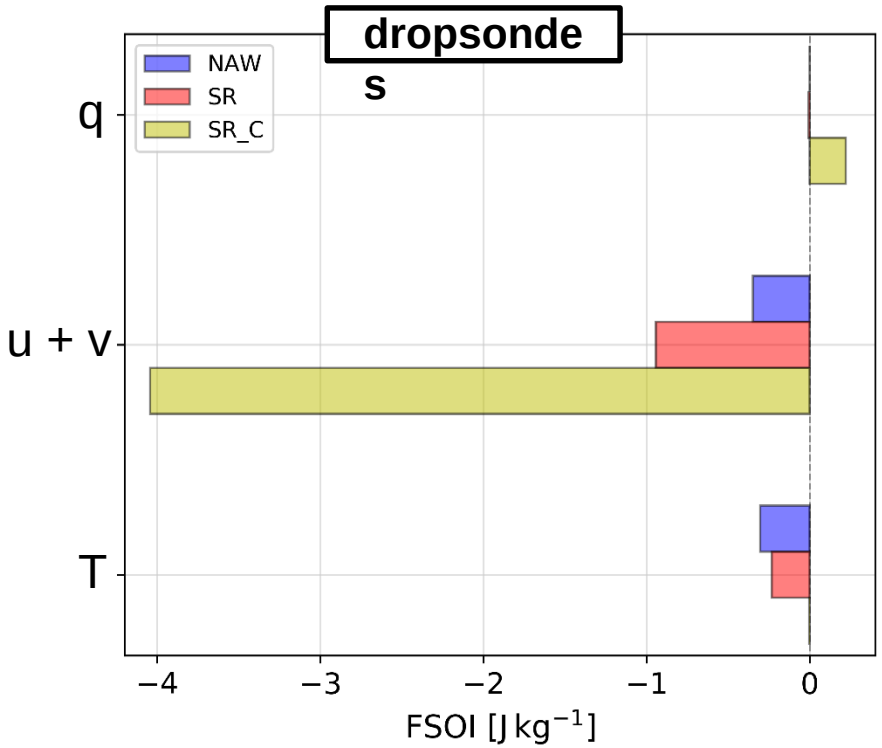
- Three episodes with large differences (Karl, Matthew/Sanchez, Nicole)

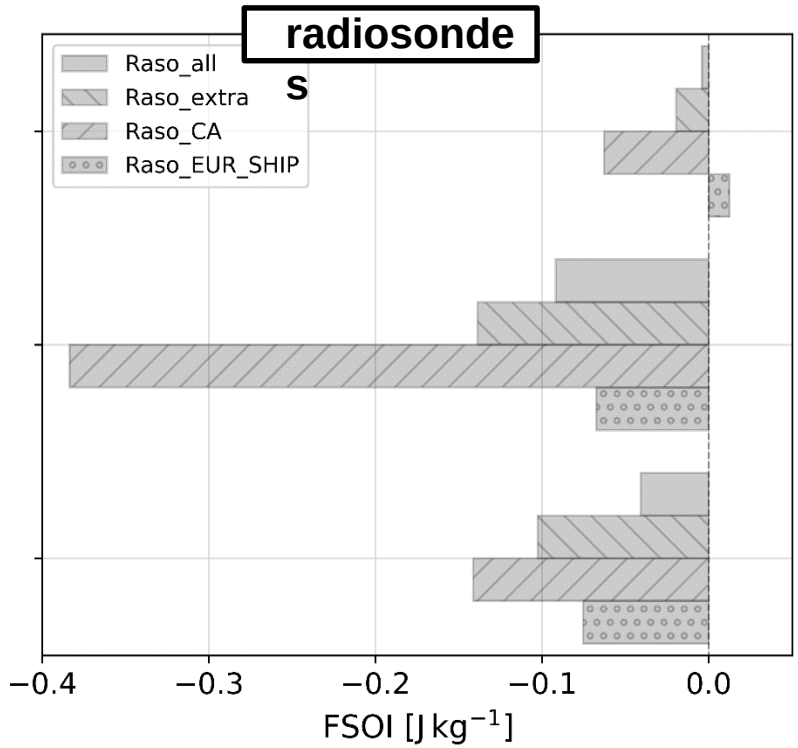
Hovmöller diagram with error difference / ensemble spread



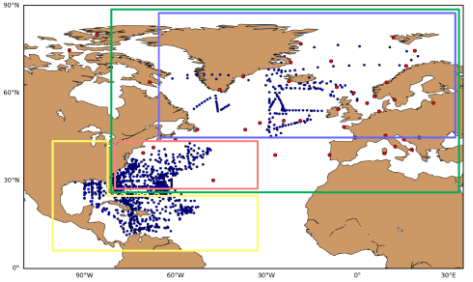
- Large sensitivity downstream of tropical cyclones

Mean impact (FSOI) per observation

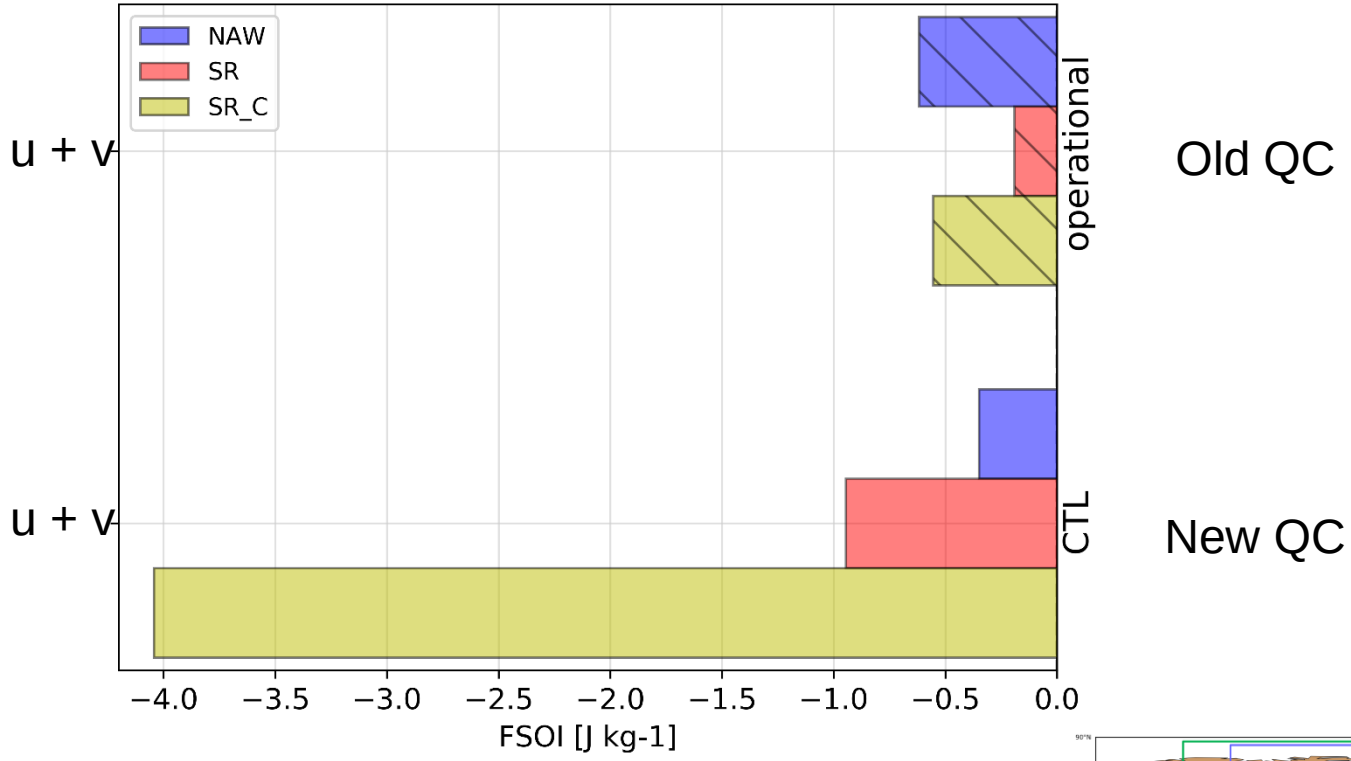


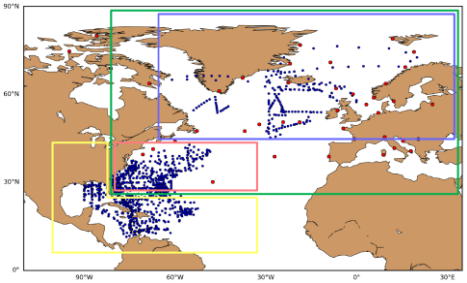


- Beneficial impact of dropsonde observations in denial region
- Large beneficial impact of wind for SR dropsondes
- Beneficial impact of extra radiosonde observations



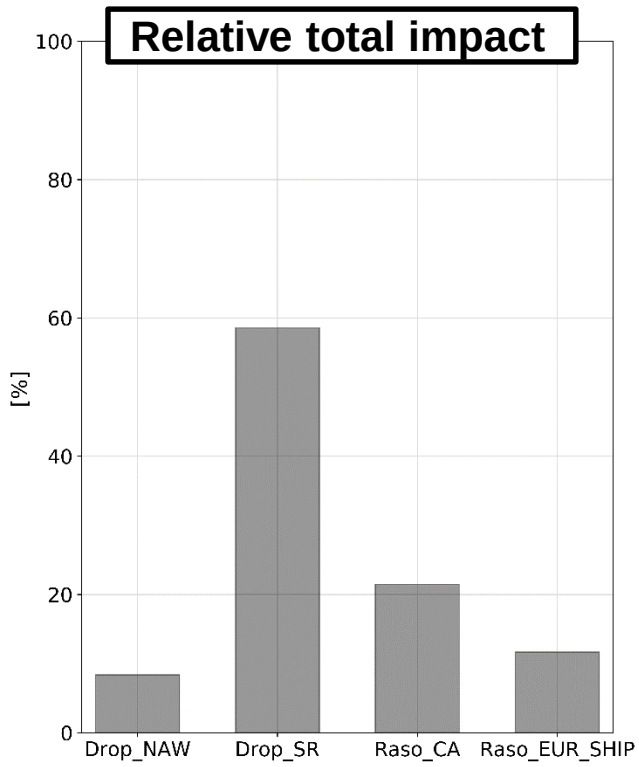
FSOI for modified dropsonde quality control (Bonavita et al. 2017)

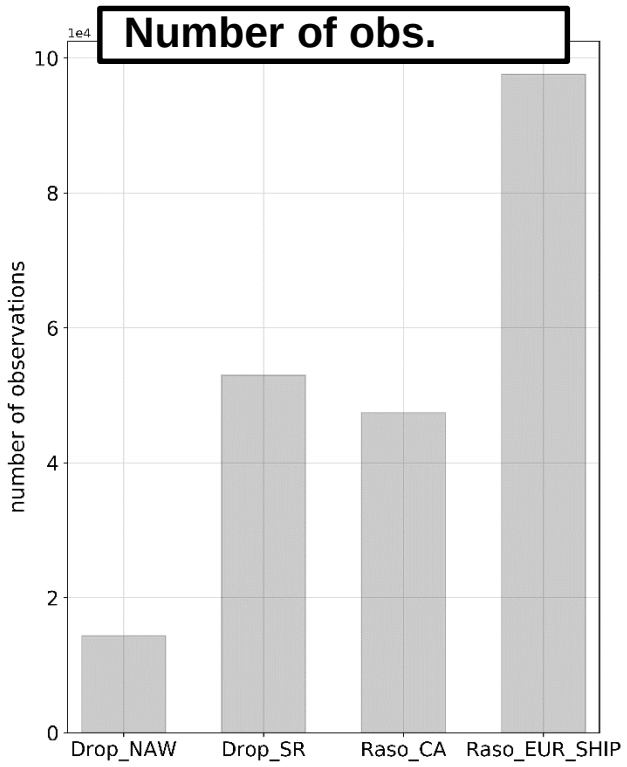


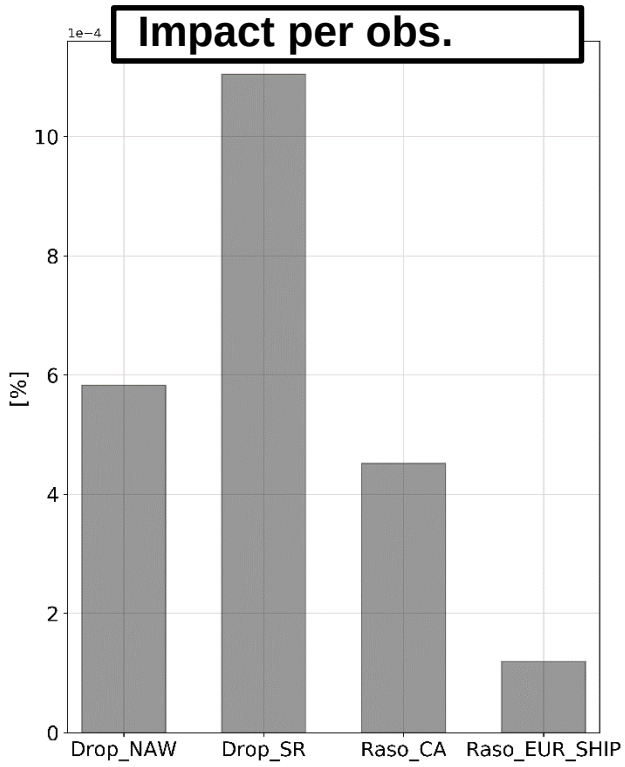


- New QC significantly increases impact of TC observations
- Slight decrease for midlatitude dropsondes
- Still drift not taken into account

Relative total impact (FSOI)







- Largest impact by SR dropsondes and CA radiosondes
- Largest impact per observation: SR dropsondes > NAW dropsondes > CA radiosondes
- Small impact by European extra radiosondes

Conclusions

Indication that dropsondes lead to improved tropical cyclone and midlatitude forecasts:

- Small in absolute terms, but large compared to the number of observations

Largest impact due to cycling (“indirect impact“):

- This makes it difficult to assess their impact and to target observations

Indication that dropsondes near tropical cyclones are particularly influential for cyclone tracks and midlatitudes:

- Tropical cyclones exhibit an easy target

Dropsonde impact strongly depends on the assimilation system, but magnitude similar in 2008 and 2016 at ECMWF despite all model changes (compensating effects?)

Better use of TC dropsondes at ECMWF, but still room for improvement (actual position, thinning, errors)