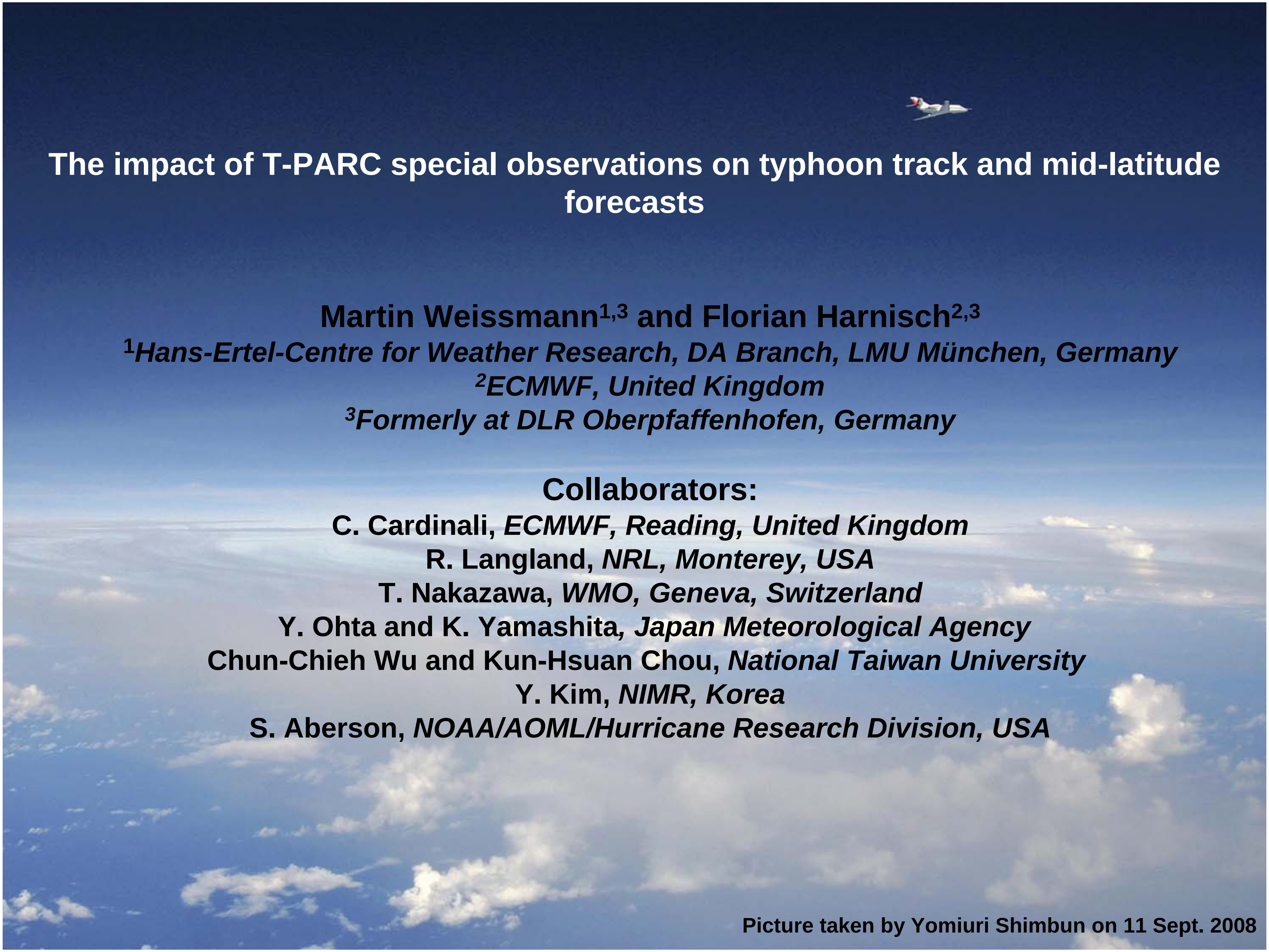


The impact of T-PARC special observations on typhoon track and mid-latitude forecasts

Martin Weissmann[1,3] and Florian Harnisch[2,3]

[1]*Hans-Ertel-Centre for Weather Research, DA Branch, LMU München, Germany*

[2]*ECMWF, United Kingdom*

[3]*Formerly at DLR Oberpfaffenhofen, Germany*

Collaborators:

C. Cardinali, ***ECMWF, Reading, United Kingdom***

R. Langland, ***NRL, Monterey, USA***

T. Nakazawa, ***WMO, Geneva, Switzerland***

Y. Ohta and K. Yamashita***, Japan Meteorological Agency***

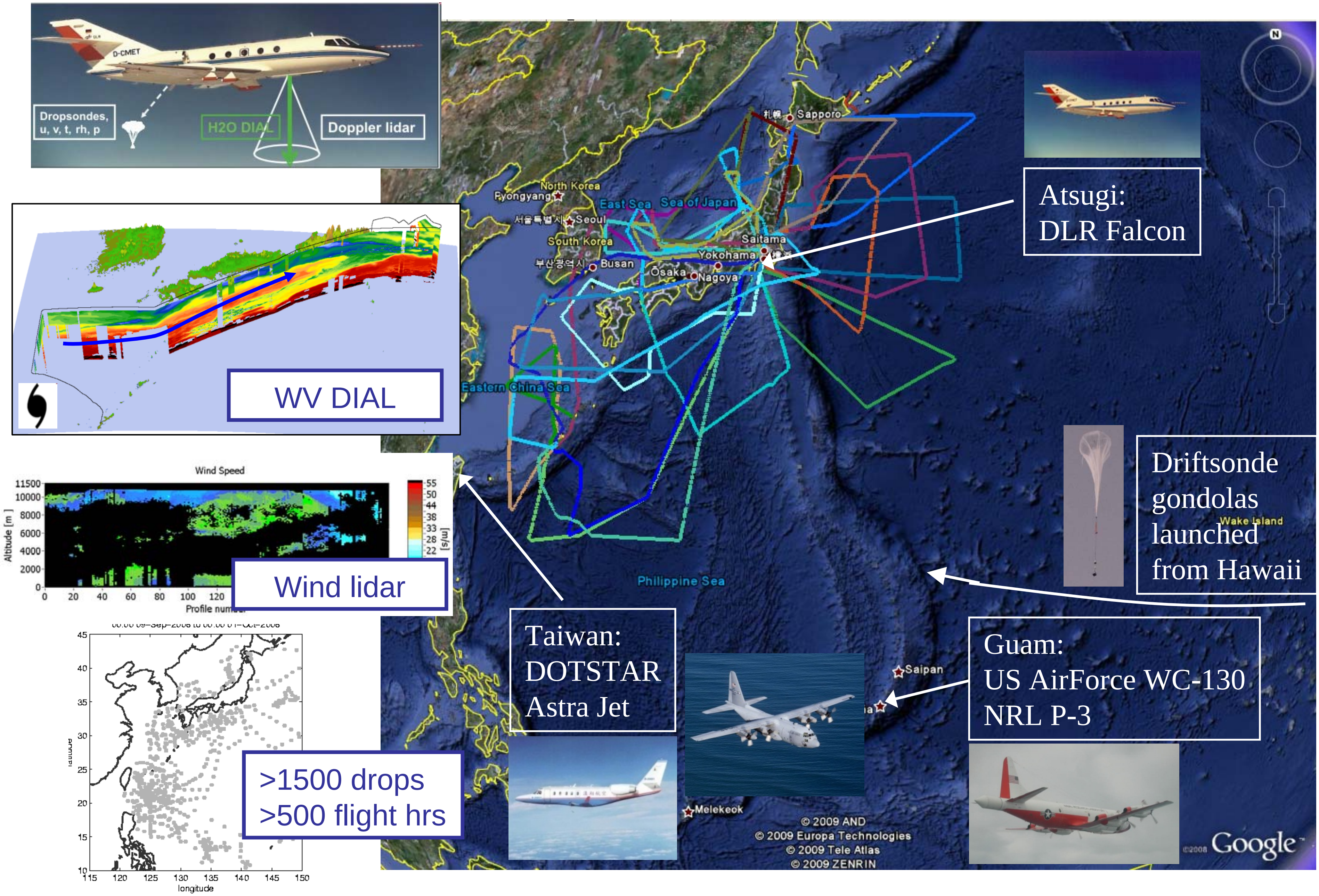
Chun-Chieh Wu and Kun-Hsuan Chou, ***National Taiwan University***

Y. Kim, ***NIMR, Korea***

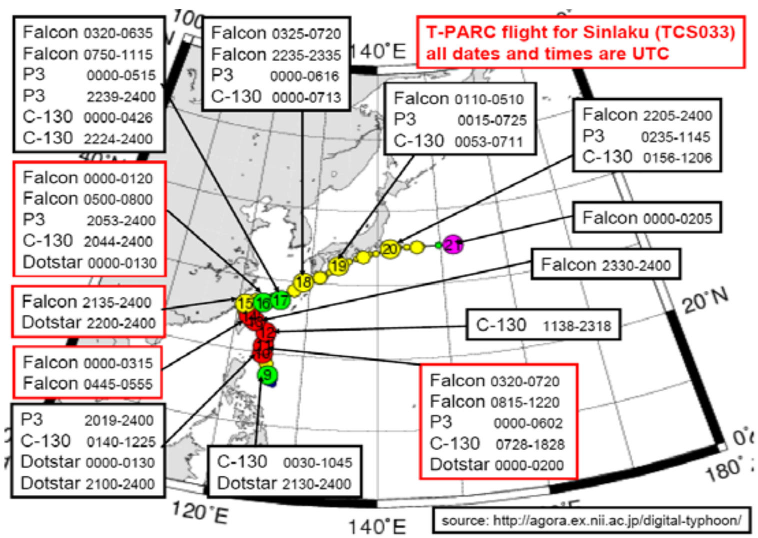
S. Aberson, ***NOAA/AOML/Hurricane Research Division, USA***

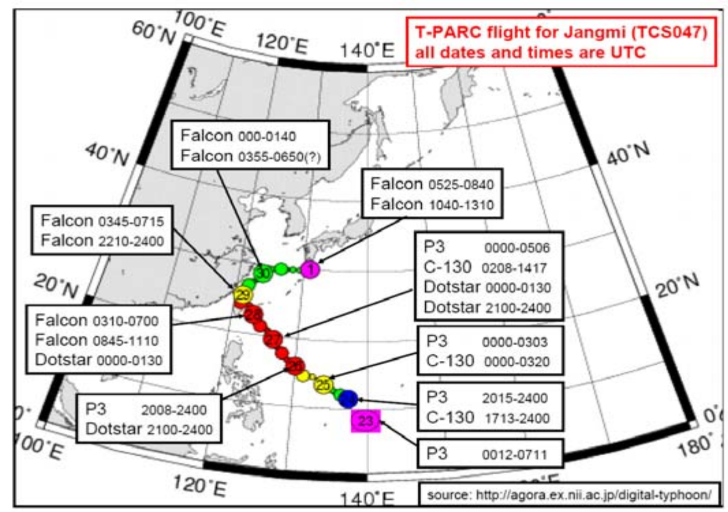
Picture taken by Yomiuri Shimbun on 11 Sept. 2008

THORPEC Pacific Asian Regional Campaign August – October 2008



Dropsonde impact for tropical cyclone track forecasts (2 typhoons, 3 weeks)

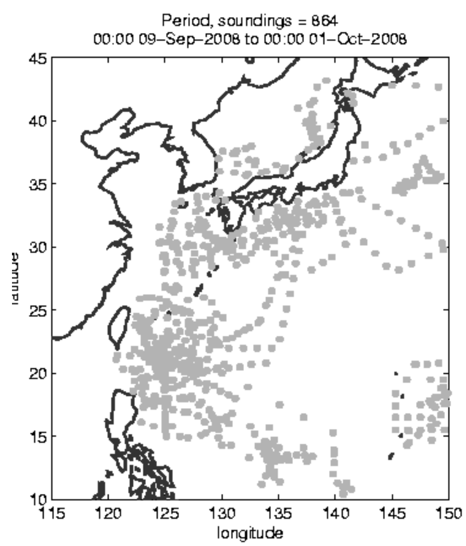




Dropsondes

Sinlaku+Jangmi

ECMWF
JMA GSM
NCEP GFS
WRF-ARW

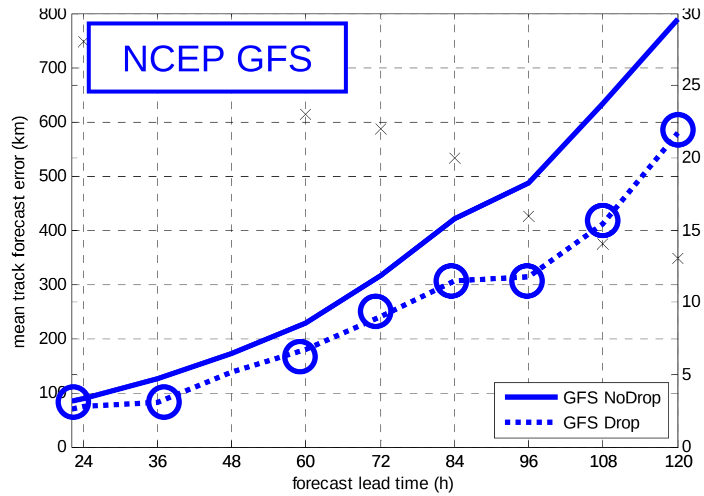


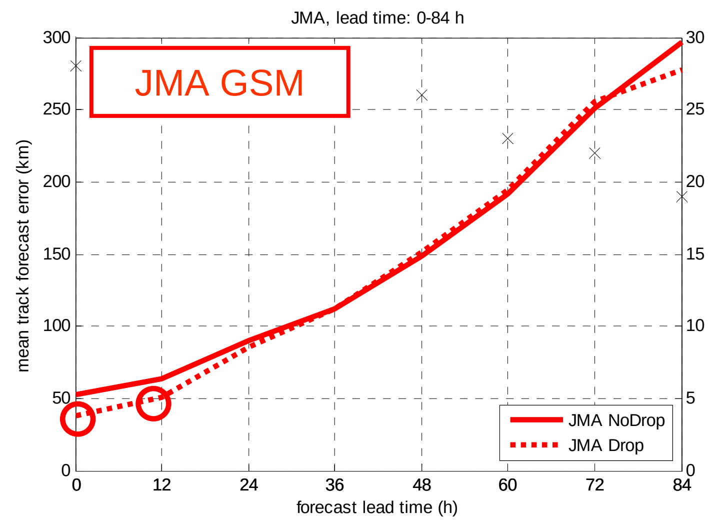
Model set-up used for the evaluation of dropsonde impact

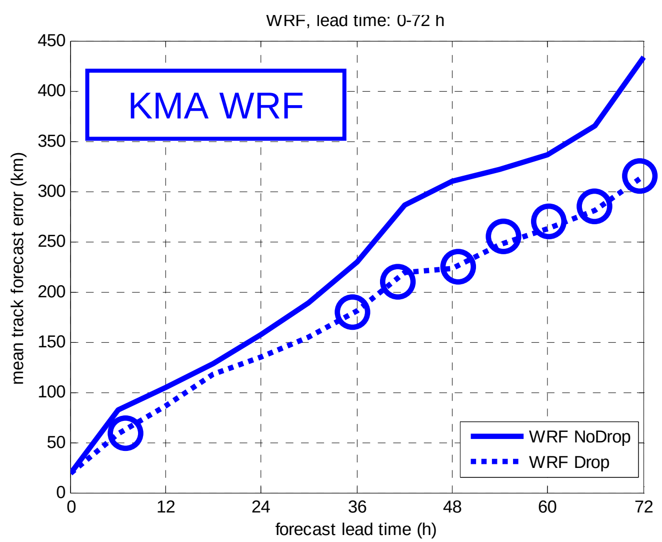
	ECMWF IFS	JMA GSM Japan	KMA WRF NIMR KOREA	NCEP GFS
Resolution	TL799L91 (~25 km)	TL959L60 (~20 km)	30 km	T382L64 (~38 km)
DA-method	12h 4D-VAR	6h 4D-VAR	6h 3D-Var	6h 3D-Var
Domain	Globe	Globe	190*190 grid points	Globe
Bogus	NO	NO (YES in oper. version)	NO	vortex relocation, bogus if no vortex in first guess (rare)
Use of TC core and eyewall observations	YES	YES	YES	NO
Denied observations	Pacific dropsondes driftsondes JMA ship SYNOP JMA ship TEMP	Pacific dropsondes JMA ship TEMP JMA special TEMP	Atlantic dropsondes	Atlantic and Pacific dropsondes driftsondes

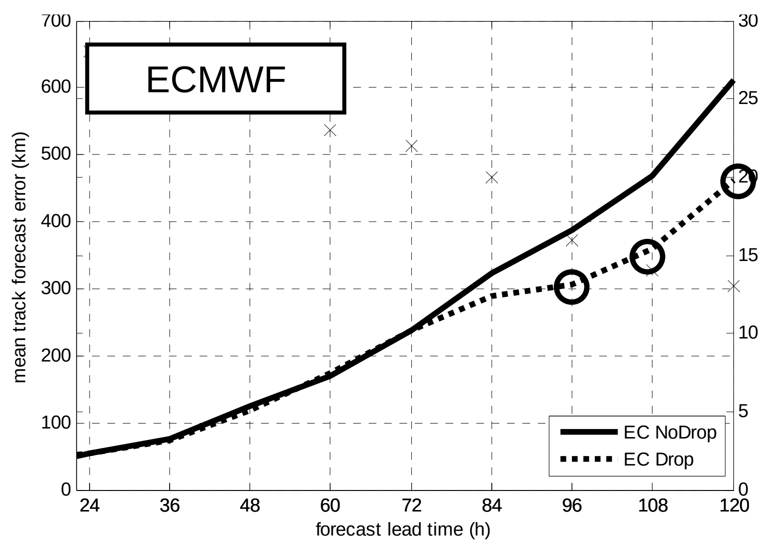
(Weissmann et al. 2011, MWR)

Influence of T-PARC dropsondes on typhoon track forecast in different models

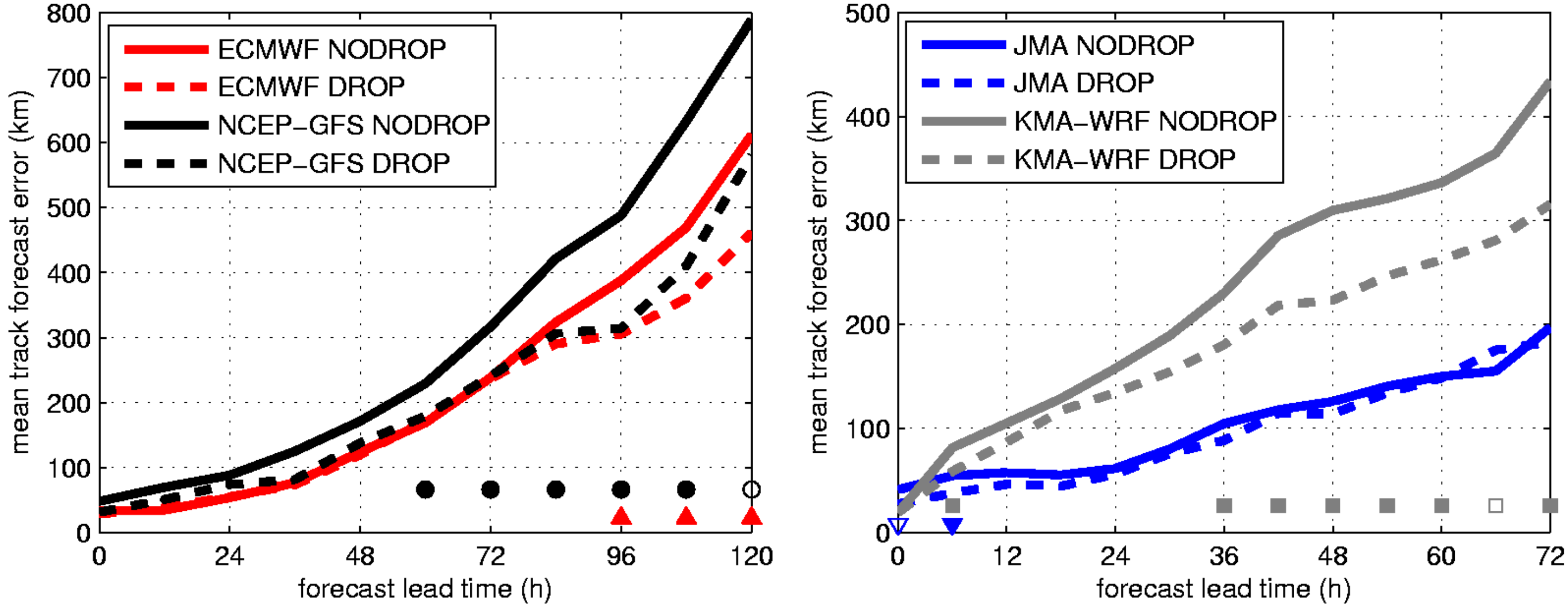








Influence of T-PARC dropsondes on typhoon track forecast in different models

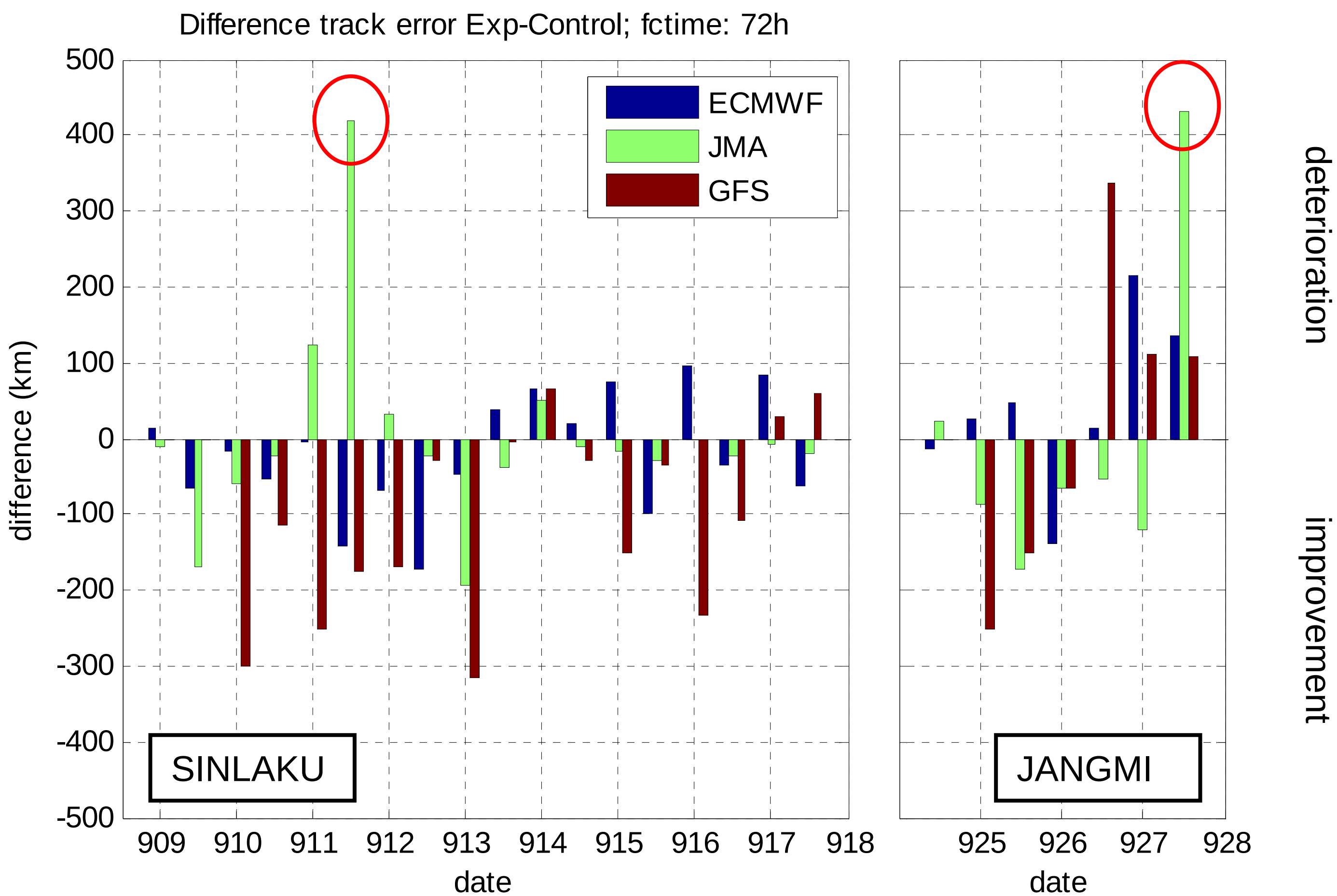


- large improvement in NCEP-GFS and WRF (models with 3D-Var and larger errors)
- lower impact in JMA and ECMWF (4D-Var, more satellite observations, lower errors)
- best forecast both with and without dropsondes of ECMWF
- GFS with dropsondes comparable to ECMWF despite 3D-Var and less satellite observations
- The extensive use of satellite observations may also limit the influence of dropsondes

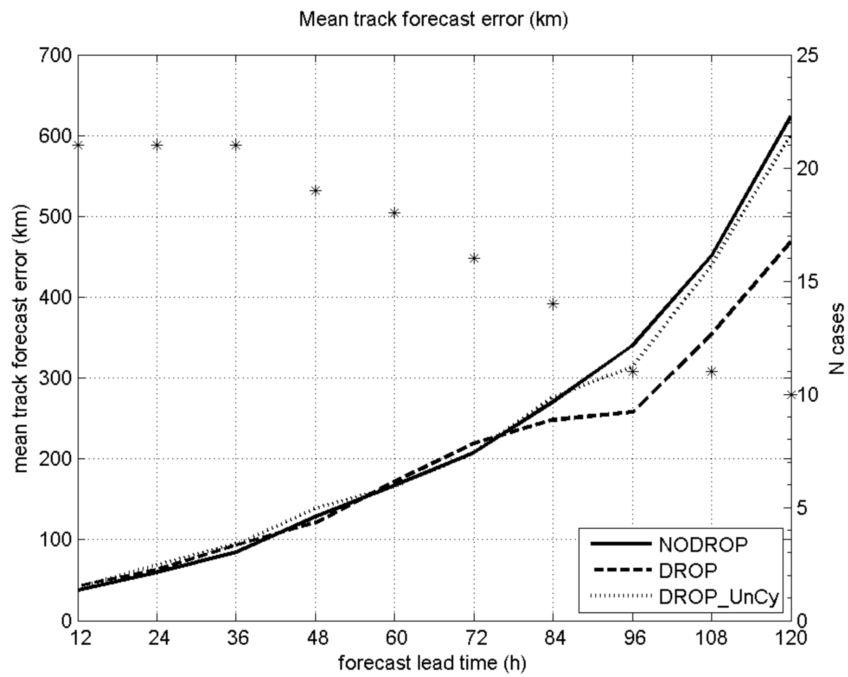
(Weissmann et al. 2011, MWR)

Dropsonde impact for individual forecasts

Low mean impact of JMA due to two deteriorating forecasts, whereas majority of forecasts improves (both deteriorating forecasts contain observations in typhoon core and eyewall region)



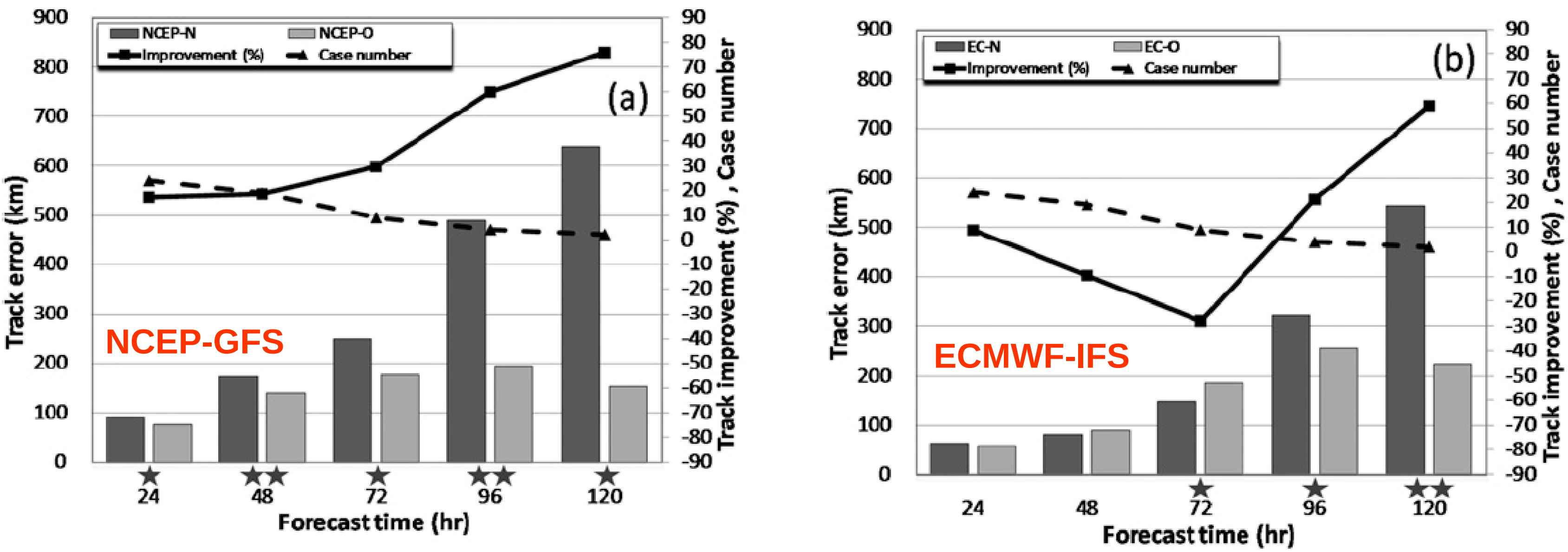
Cycled and uncycled ECMWF experiments



Only cycled experiments show typhoon track and downstream forecast improvement

(Weissmann et al. 2011, MWR)

Impact of DOTSTAR dropsondes on TC track forecasts over several years



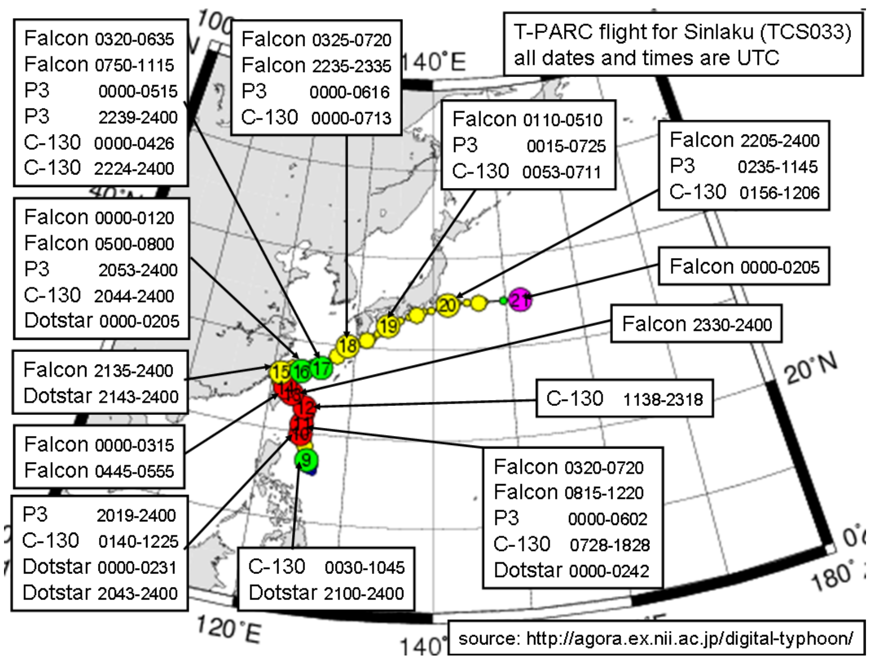
Results for all DOTSTAR flights:

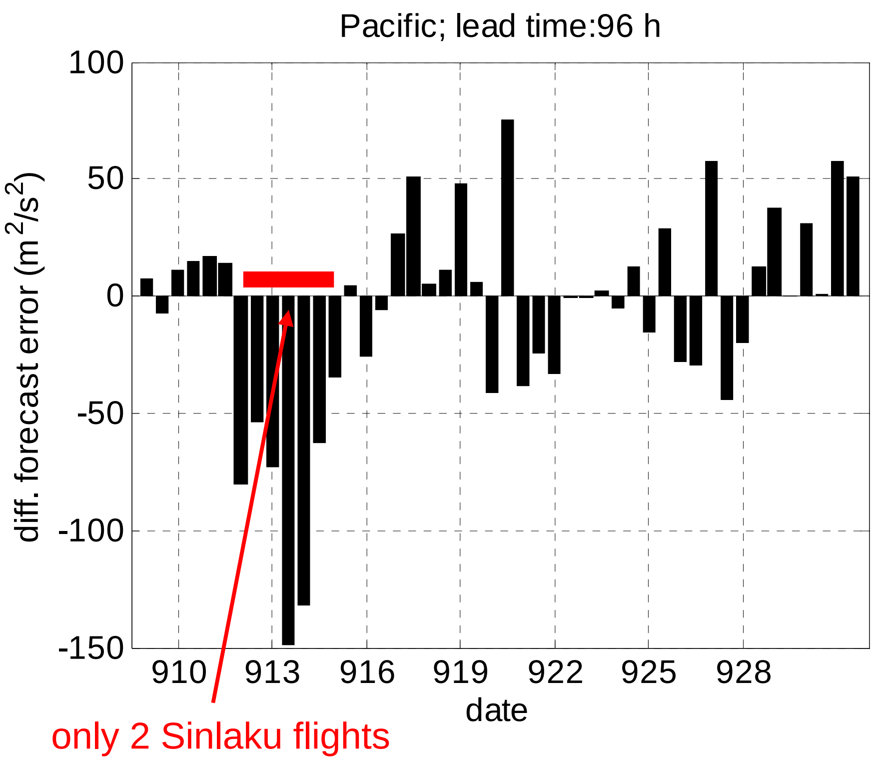
- clear improvement for NCEP-GFS, 60% of cases improve, significant reduction, 10-20% on average

- ambiguous results for ECMWF (no cycling)

(Chou et al. 2011, MWR)

Dropsonde impact on ECMWF mid-latitude forecasts



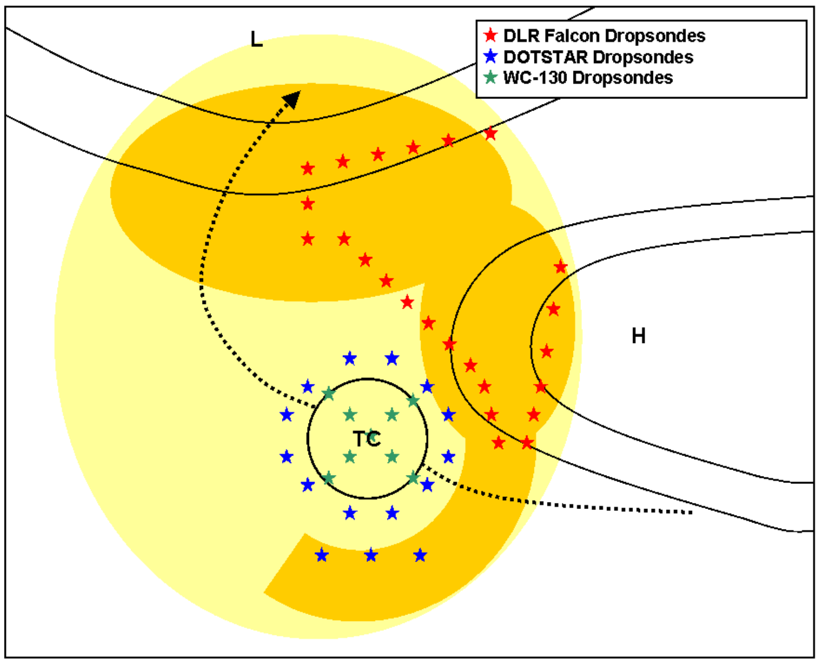


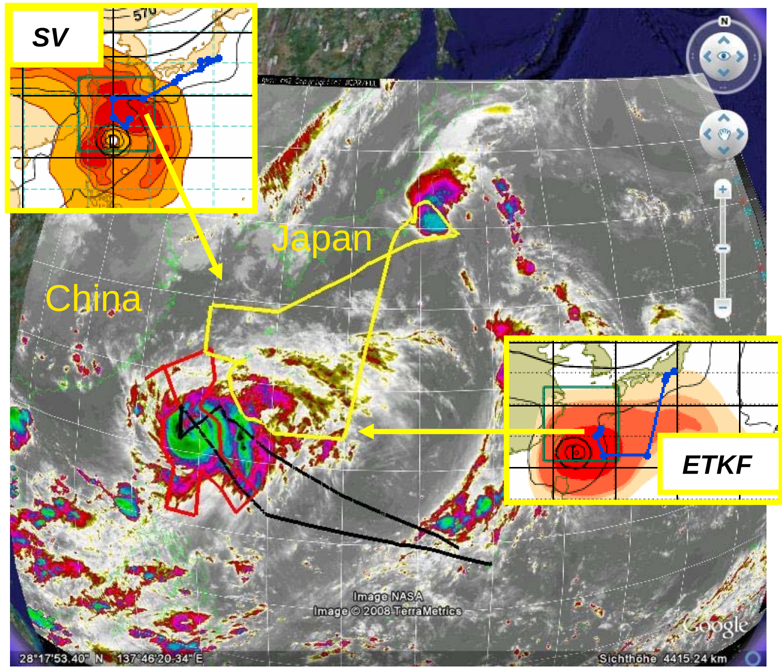
improved track forecast --> improved first-guess for subsequent days --> imroved mid-latitude forecast

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

indirect improvement through improved TC track and cycling *(Weissmann et al. 2011, MWR)*

Comparison of dropsonde targeting strategies



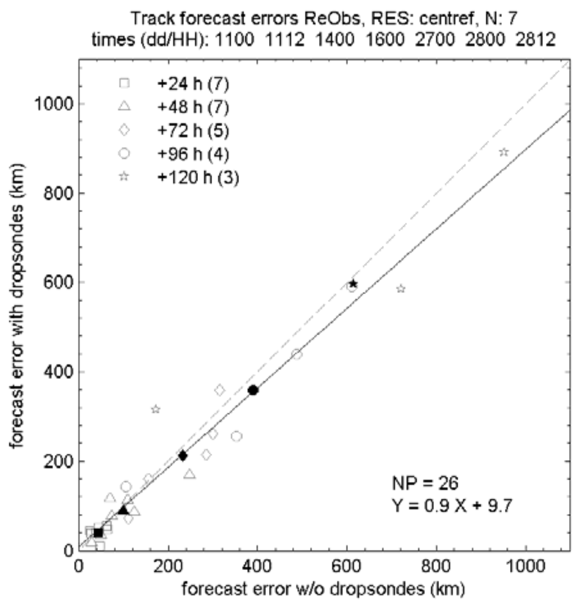


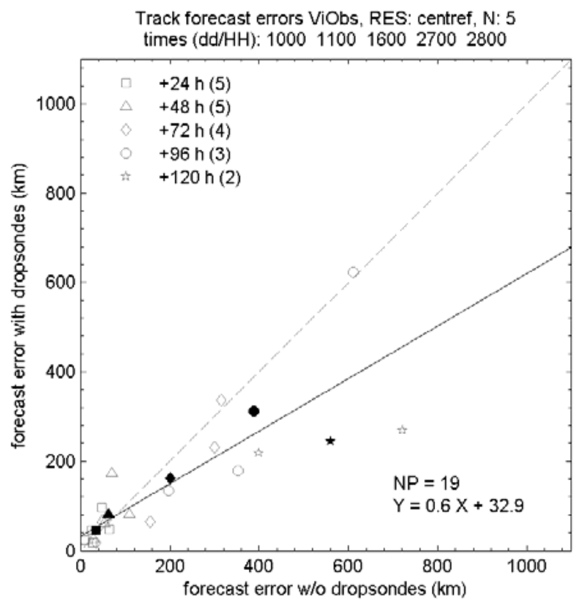
Concept for ideal mission and sensitivity experiments:
- WC-130 observations in typhoon center (green)
- DOTSTAR observations in typhoon surrounding (blue)
- Falcon obs. in sensitive area highlighted by e.g. SV, ETKF (red)

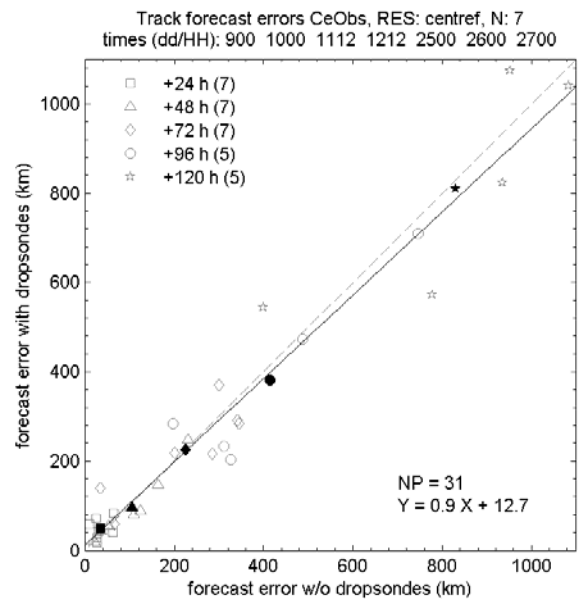
Joint mission on 11 September

(Harnisch and Weissmann, 2010, MWR)

Which dropsonde observations are most beneficial?







'remote' sensitive regions
small positive to neutral impact

typhoon vicinity:
improvement of the track forecast

typhoon center and core:
overall neutral impact,

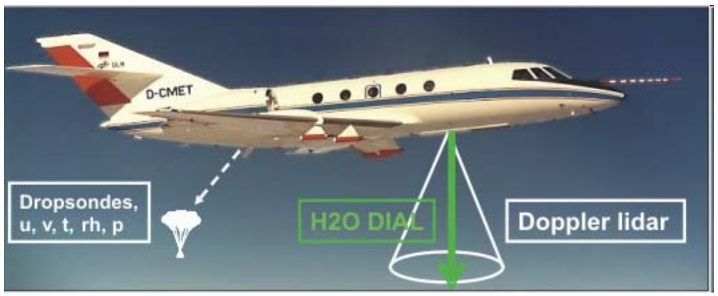
SV resolution?
Insufficient sampling of SV region?
Analysis error?

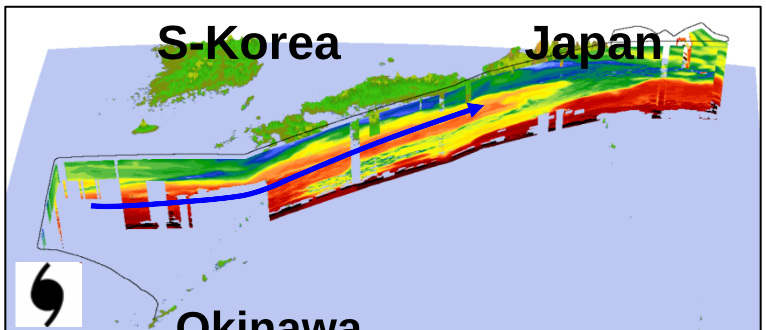
Model resolution
Global B-matrix?
Observation error

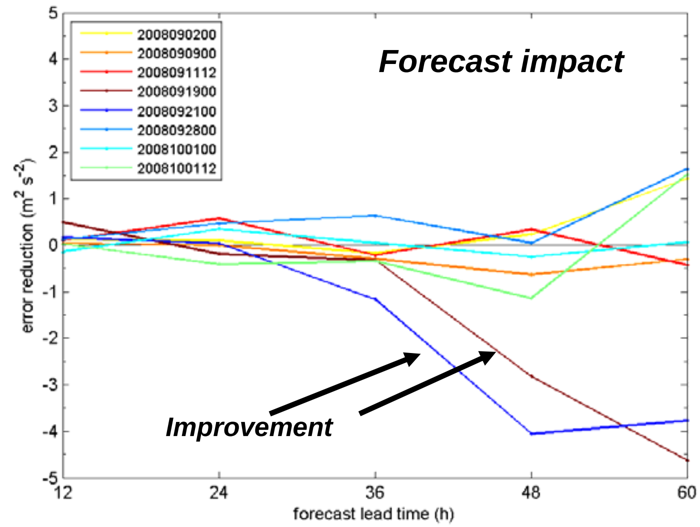
ECMWF Integrated Forecast System

(Harnisch and Weissmann, 2010, MWR)

Water vapour lidar (DIAL) assimilation in ECMWF (Harnisch et al. 2011 QJ)







System developed as airborne demonstrator for WALES satellite mission (cancelled)

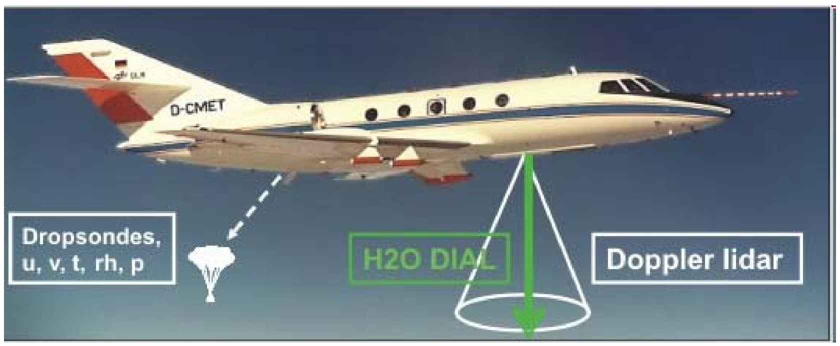
Observations from 8 flights assimilated in ECMWF system

Verification with independent dropsondes shows analysis improvement

Weak forecast impact in most cases, but improvement in two events with modified downstream development

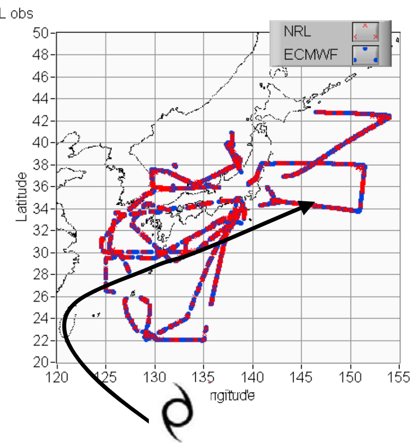
(Harnisch et al. 2011, QJ)

Doppler wind lidar (DWL) assimilation in ECMWF and NOGAPS



Airborne scanning DWL (same DWL as for A-TReC):
- coherent 2 µm Doppler lidar (Mie-signal)
- on average 30% of profile with wind observations
- step-and-stare scan with 24 positions
- vertical profile of horizontal wind
- horiz. resolution ~5 km
- vert. resolution 100 m
- accuracy: 0.5 - 1 m/s
- representative observations

Dropsondes not used



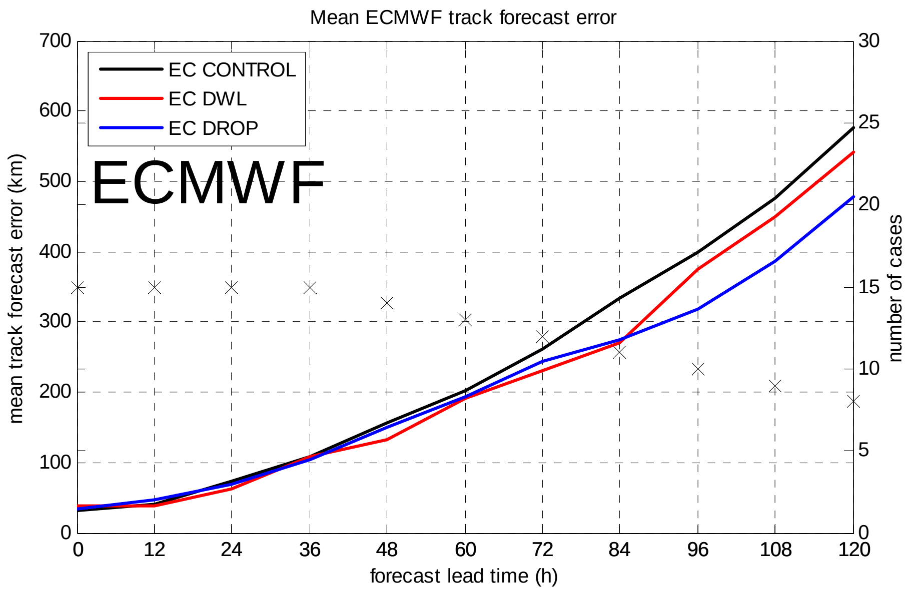
	NRL	EC used
assimilation	4D-Var	4D-Var
resolution	55 km	25 km
DWL processing	super-obs	thinning
DWL obs.	4368	9578
assigned error	1.8 m/s	1.5 m/s
an-increment	1.3 m/s	1.8 m/s
all obs. per day	3 million	18 million

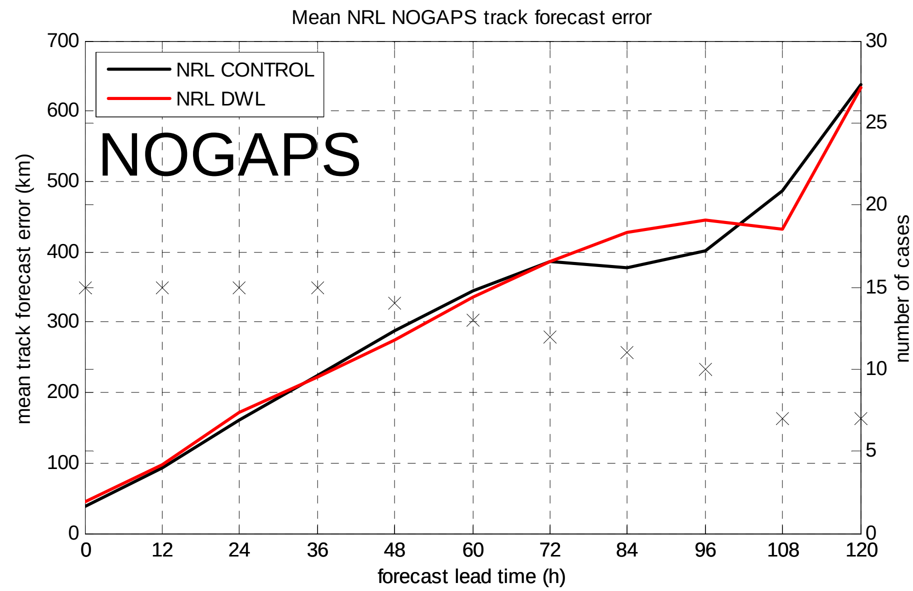
larger weight at ECWMF
--> larger increment at location of DWL

fewer observations in NRL analysis
--> larger analysis difference

(Weissmann et al. 2012, QJ)

DWL impact on typhoon track forecast





ECMWF:

9% reduction of 12-120 h forecast error with DWL on one aircraft

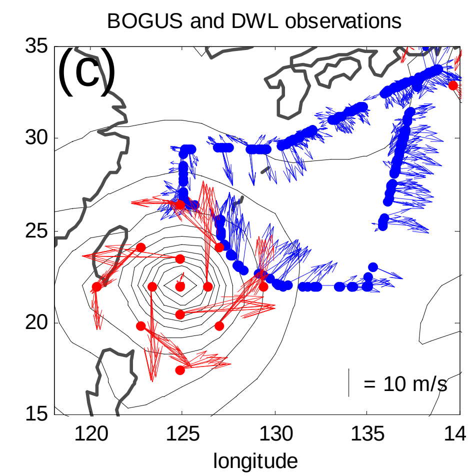
8% with dropsondes from four aircraft

NOGAPS:

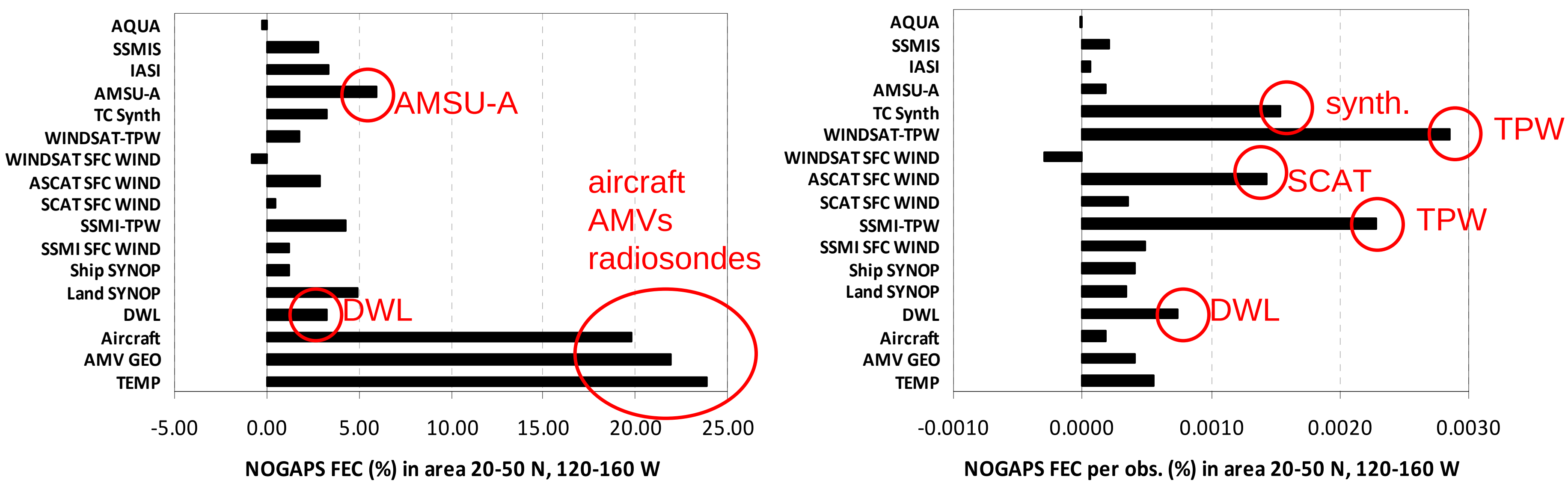
Neutral impact on typhoon track forecast

Synthetic bogus seems to limit impact of other observations

Experiment without bogus shows larger DWL impact, but very weak cyclone



Adjoint observation impact calculation (NOGAPS)



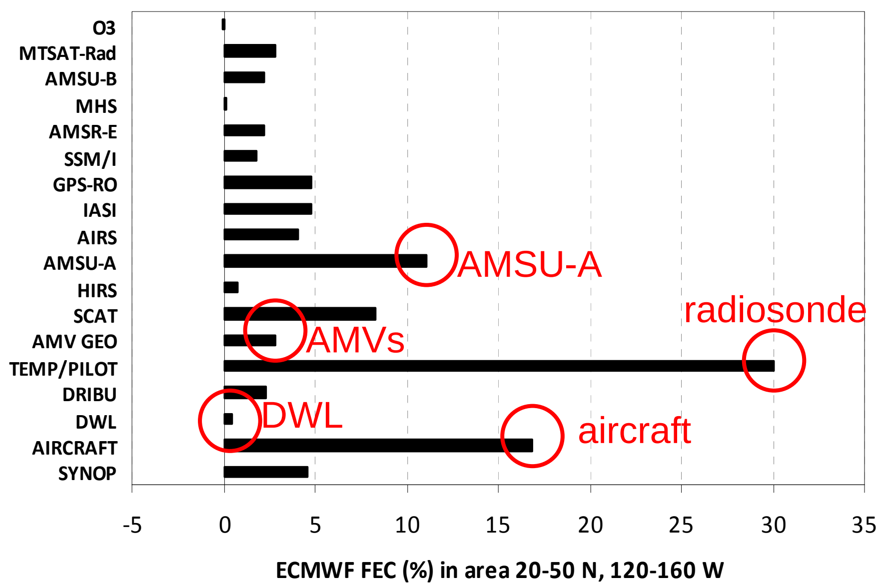
Relative reduction of global 24-h forecast error by different observations *(calculated by Rolf Langland)*

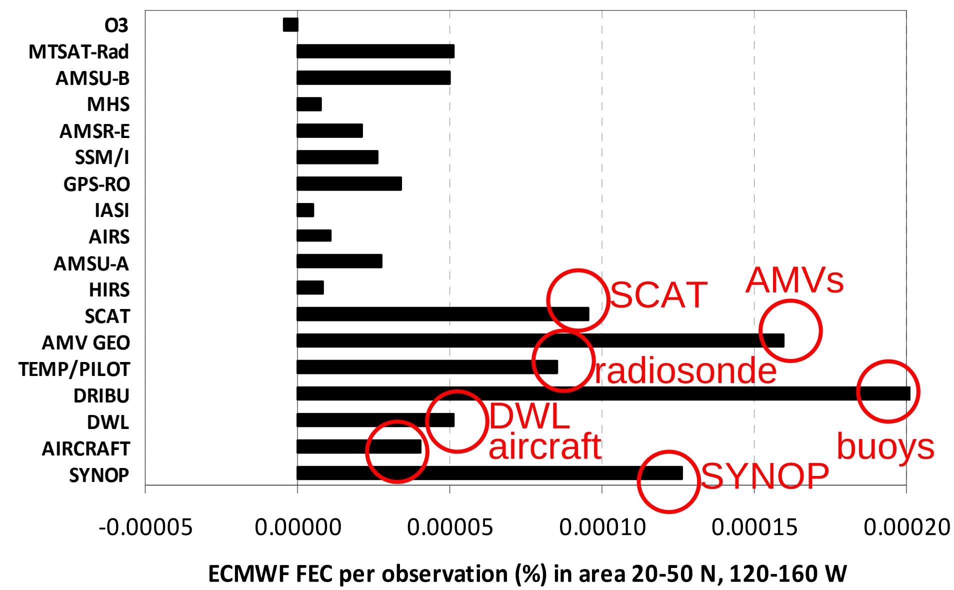
- positive contribution of DWL (also in data denial experiment, not shown)
- highest impact from conventional observations (also globally, not shown)
- comparably high impact of AMVs (also globally, not shown)
- large influence of TPW (but few), bogus (synth) and SCAT (near storm)
- besides these types, large DWL impact per observation

(Weissmann et al. 2012, QJ)

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN FAKULTÄT FÜR PHYSIK METEOROLOGIE | DLR Deutsches Zentrum für Luft- und Raumfahrt e.V. in der Helmholtz-Gemeinschaft | Hans-Ertel-Zentrum für Wetterforschung Deutscher Wetterdienst | PANDOWAE

Adjoint observation impact calculation (ECMWF)





Relative reduction of global 24-h forecast error by different observations *(calculated by Carla Cardinali)*
(different sample size as NOGAPS results, DWL only in 30% of analyses)

- radiances dominate globally, but not in the region of the storm
- highest impact from radiosondes and aircraft, followed by AMSU-A
- highest impact per observation from buoys, AMVs and SYNOP (followed by SCAT, TEMP, DWL and aircraft)
- DWL comparable to aircraft (twice as many observations as in NOGAPS)

Overall, the total DWL impact was about half of the NOGAPS impact (more other observations)

(Weissmann et al. 2012, QJ)

Conclusions

Comparison of dropsonde impact in different models:
- Large impact in NCEP GFS and KMA WRF (models with 3D-Var, less satellite obs and larger errors)
- Some improvement also in ECMWF
- Most JMA track forecasts improve, but issues with core/eyewall drops (also used at ECMWF, but not in GFS)

Specific ECMWF results:
- Forecast improvement only with cycled experiments
- Improvement downstream in mid-latitudes resulting indirectly improved TC forecast, better first-guess (cycling)

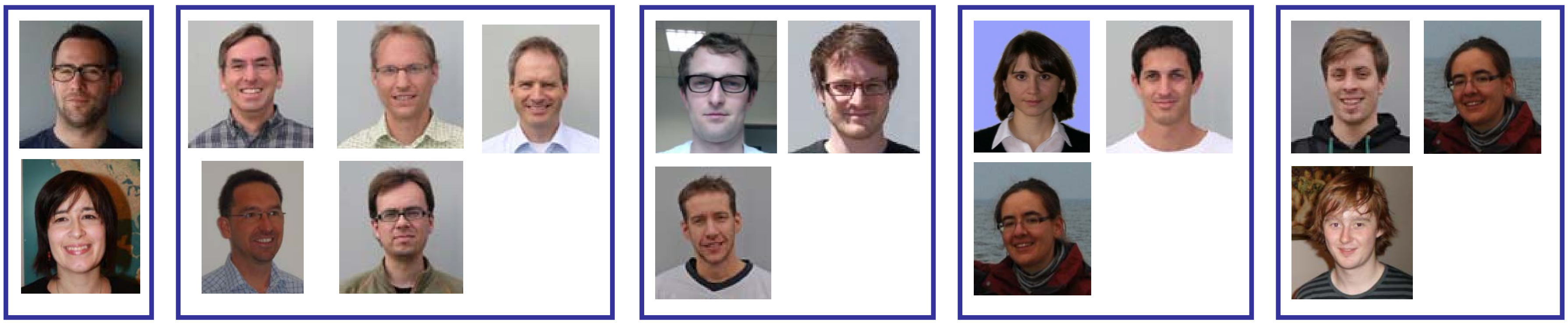
Overall, targeted dropsondes are beneficial for TC forecasts, whereas results for mid-latitude targeting are neutral

DIAL assimilation:
- Improved humidity analysis, but weak forecast impact in most cases
- Forecast impact when humidity is transported in mid-latitudes and downstream development is modified

Doppler wind lidar
- Overall confirmation of high observation impact shown in Weissmann and Cardinali (QJ, 2007)
- DWL FSO impact twice as high in NOGAPS, presumably due to less satellite observations
- TC track improvement at ECMWF comparable to dropsondes although fewer DWL flights
- No track improvement in NOGAPS, indication that TC impact is limited by bogus observations
- Confirms high expectations for ADM-Aeolus satellite (despite some differences of the systems)

Hans-Ertel-Centre for Weather Research, Data Assimilation Branch @ LMU

Ensemble-based convective-scale data assimilation and the use of remote sensing observations



Project lead | **Additional supervisors** | **Post-Docs** | **PhD students** | **Master students**

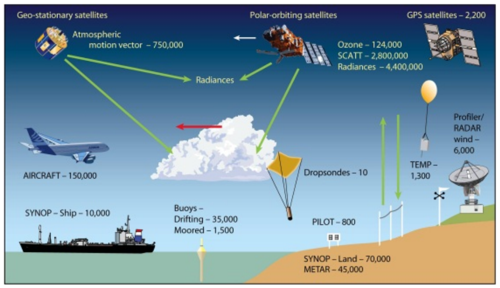
M. Weissmann, T. Janjic-Pfander (MIT/AWI/DWD), R. Buras, G. Craig, K. Folger, M. Haslehner, F. Heinlein, C. Keil, P. Kostka, C. Kühnlein, H. Lange, B. Mayer, M. Sommer, M. Würsch, *MIM LMU München*

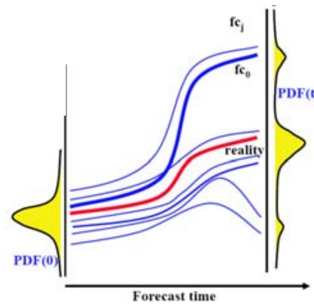
O. Reitebuch, *IPA, DLR Oberpfaffenhofen*

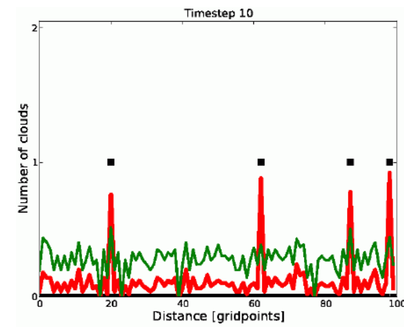
DWD Cooperation

R. Potthast, H. Anlauf, A. Cress, R. Faulwetter, C. Gebhardt, M. Köhler, C. Köpken-Watts, H. Reich, A. Rhodin, A. Schomburg, C. Schraff, O. Stiller, S. Theis

Project overview







1) Observation impact

Tools to quantify the analysis and forecast impact of observations in regional LETKF system

Monitoring of observations

Optimized use of observations

2) Satellite observations

VIS+NIR radiances MSG SEVIRI

Improved AMV height assignment with lidar

(ADM-Aeolus)

(lightning)

3) Ensembles

Improved representation of uncertainty in EPS

KENDA initial perturbations

Impact time of observations and flow-dependence of predictability

4) DA Methods

Suitable methodes for conv-scale DA

Test with idealized toy-models

Robust DA-methods for strongly non-linear systems with non-Gaussian error statistics

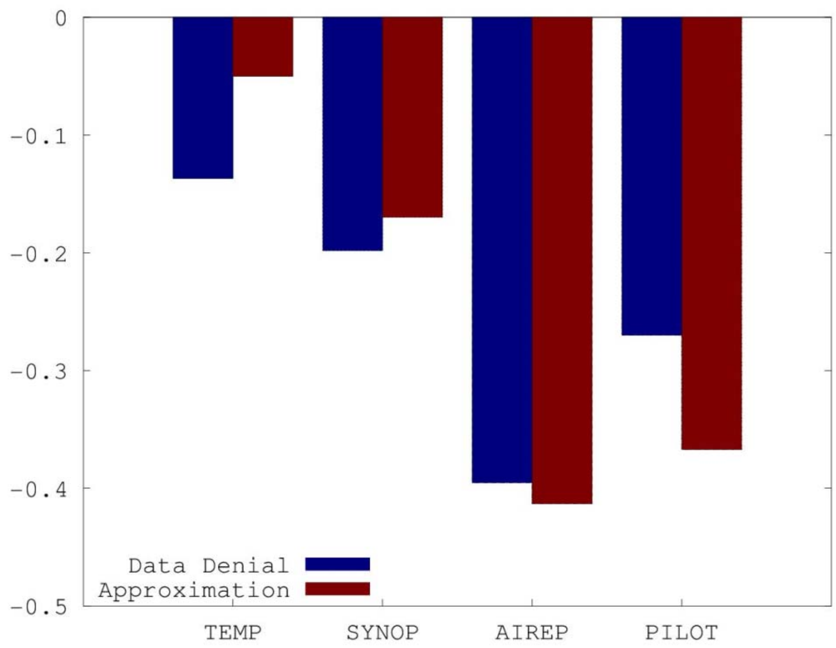
Calculating forecast impact of observations in limited area LETKF system of DWD

DWD is developing an LETKF system for regional model

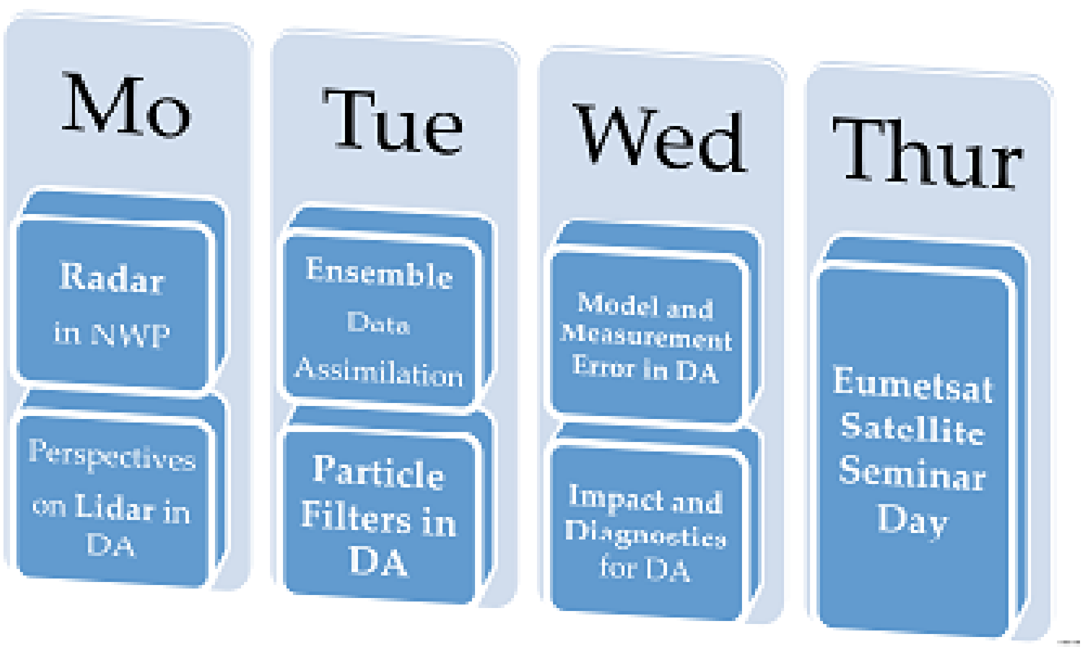
Within our DWD-funded university research group we want to evaluate observation impact (as demonstrated by Yoichiro Ota)

Technical implementation is ongoing

Reasonable results for relative analysis impact *(Matthias Sommer)*



International Symposium on Data Assimilation, Offenbach 8-12 October 2012



Session on Impact and Diagnostics for DA (organized by G. Craig and myself)

Organizing Committee
Andreas Rhodin (DWD)
Christina Köpken-Watts (DWD)
Roland Potthast (Uni Reading/ DWD)
Tijana Janic-Pfander (MIT/DWD/LMU)
Martin Weissmann (LMU Munich)
Peter Jan van Leeuwen (Uni Reading)
Amos Lawless (Uni Reading)

Scientific Advisory Committee:
Massimo Bonavita, ECMWF, Reading
Angelika Bunse-Gerstner, University of Bremen
Marc Bühner, Canadian Met Service, Dorval
George Craig, LMU Munich
Tijana Janjic-Pfander, MIT/DWD/LMU
Andreas Hense, University of Bonn
Eugenia Kalnay, Maryland
Amos Lawless, University of Reading
Peter Jan van Leeuwen, University of Reading
Ulrich Löhnert, University of Cologne
Roland Potthast, University of Reading/ DWD
Sebastian Reich, University of Potsdam
Andreas Rhodin, DWD
Clemens Simmer, University of Bonn
Martin Weissmann, University Munich
Volker Wulfmeyer, University of Hohenheim