This project (APPLICATE) has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727862.

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Arctic Observing System Experiments at ECMWF for the APPLICATE project

Heather Lawrence, Niels Bormann, Irina Sandu, Jonny Day, Jacky Farnan, Peter Bauer, Linus Magnusson

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Background: Weather Prediction in the Arctic

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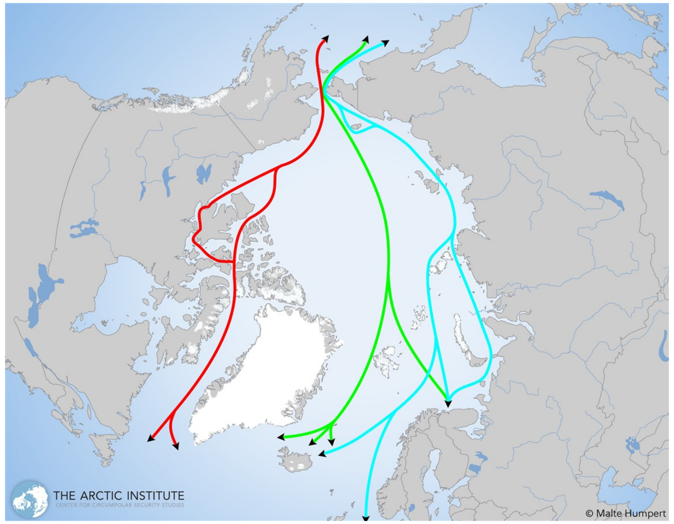
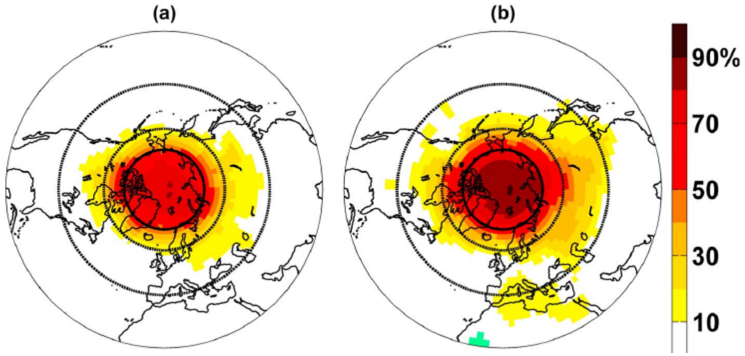
Future Arctic Shipping routes





T. Jung et. al. 2014

- Less sea-ice presents opportunities for new shipping routes, tourism
- More demand for forecasts in the Arctic

+ Improved initial conditions in the Arctic lead to improved forecasts over Eurasia and North America

What is the impact of Arctic observations on forecasts?

Conventional observations

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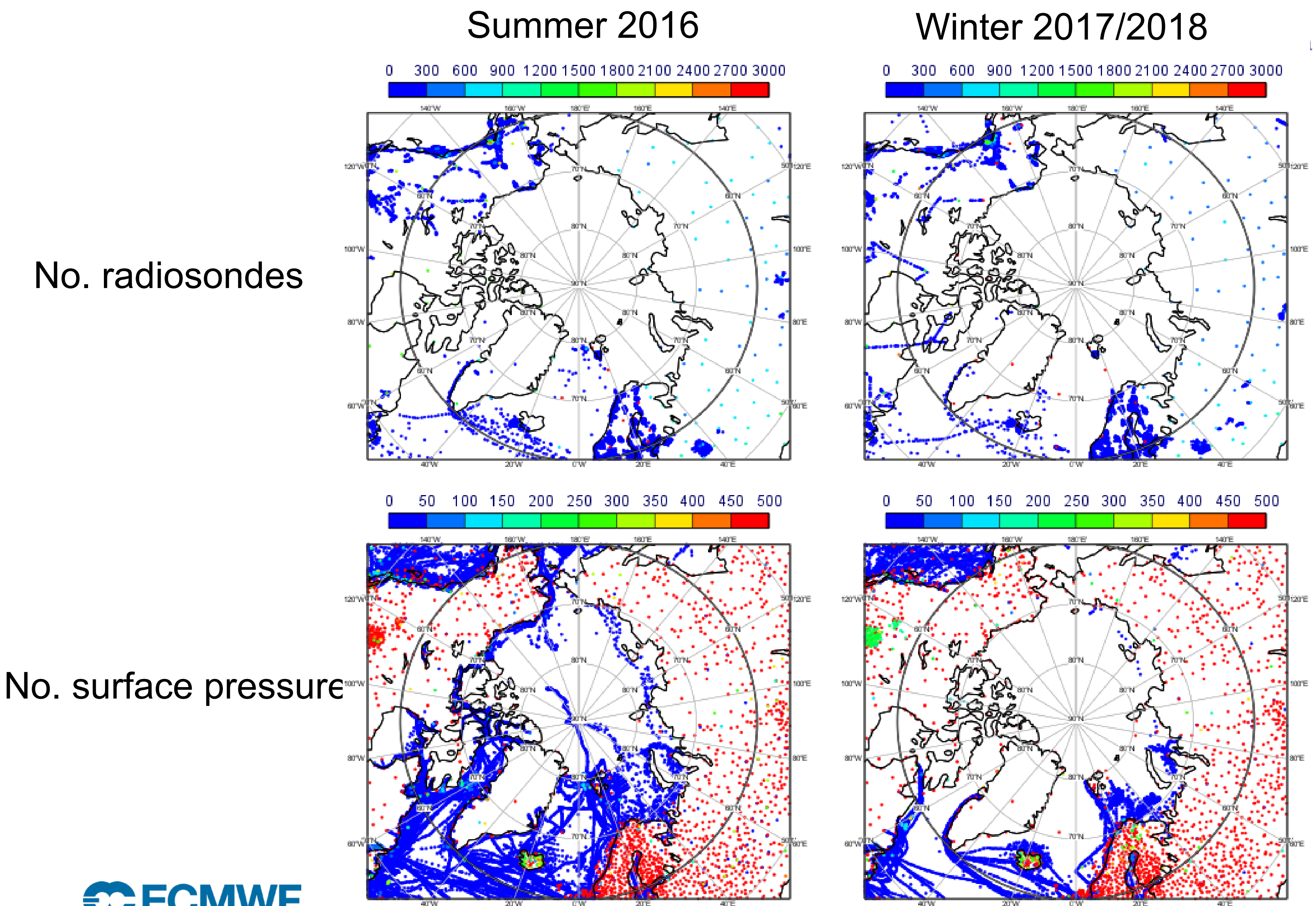

Less conventional data north of 70N than at Northern mid-latitudes

Also more expensive and difficult to obtain

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Satellite observations

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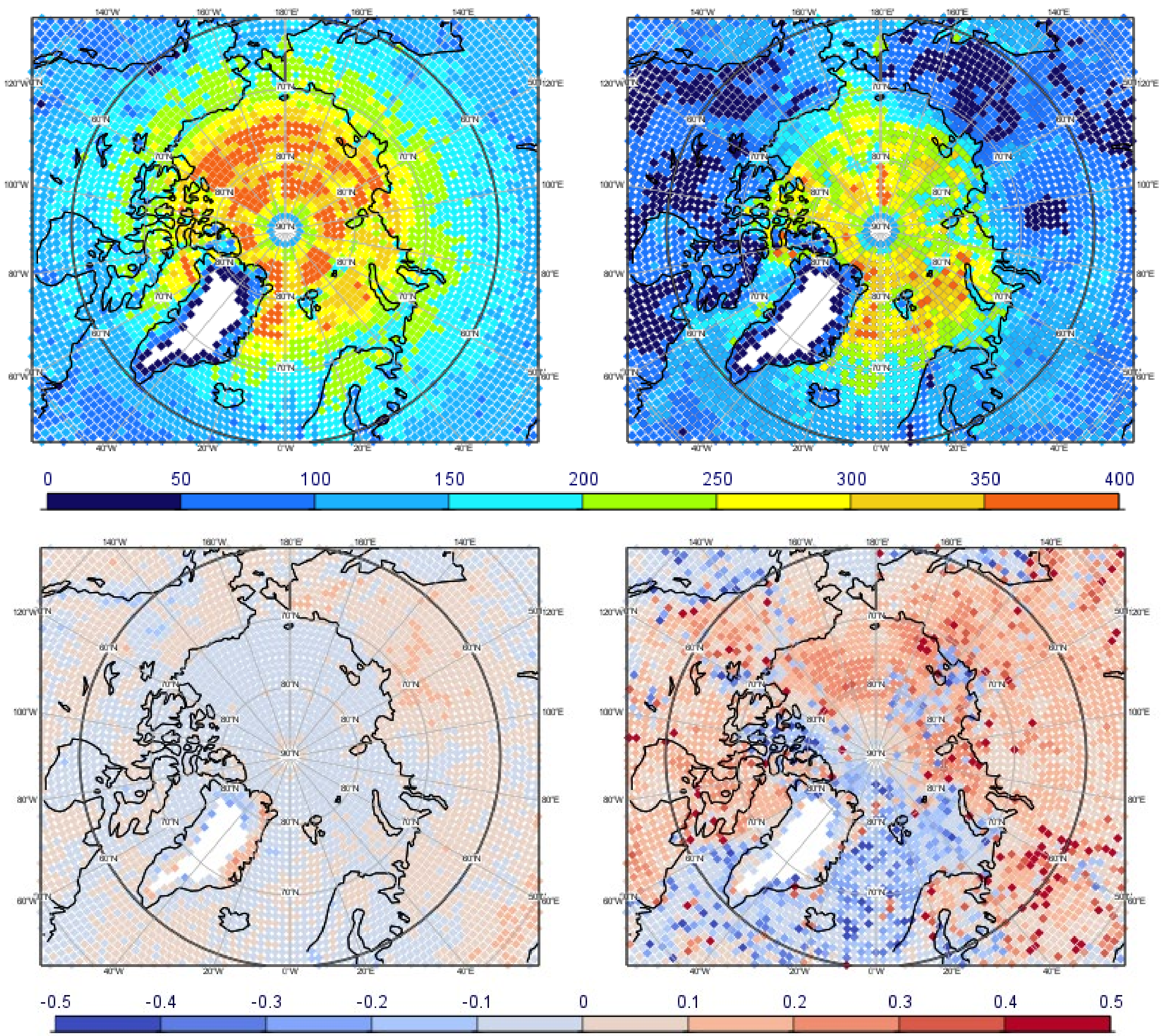
NOAA-15 AMSU-A channel 5

No. obs

Mean(O – B)



- better coverage from polar orbiting satellites than anywhere else
- more challenges with their use (model errors, radiative transfer modelling)
- more data rejected for tropospheric channels in winter

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Observing System Experiments (OSEs)

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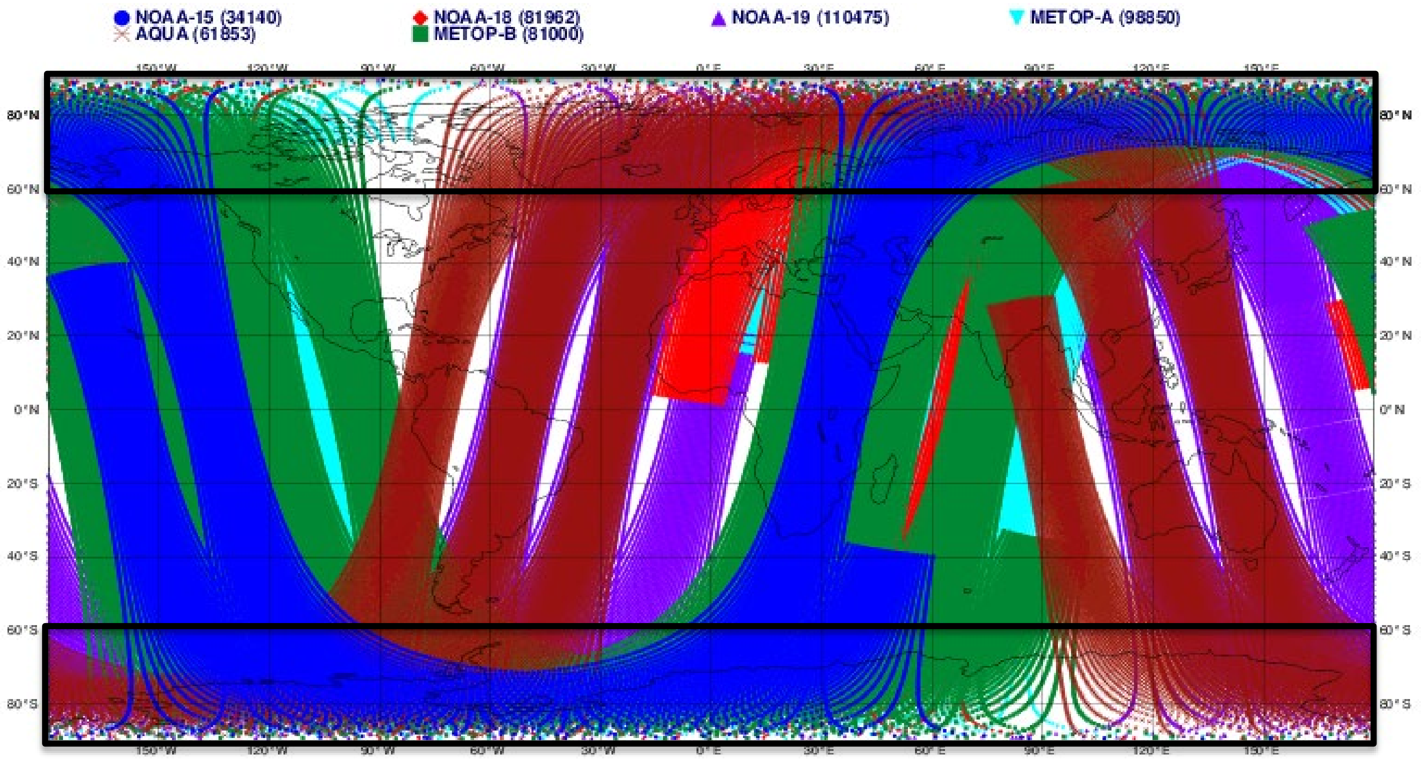
Remove observations at lat>60N and lat<-60S:



Analyse the % increase in forecast error when observations are removed from the Arctic

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Observing System Experiments (OSEs)

Test the impact of:

- All conventional observations
- All microwave observations
- All infrared observations
- GPSRO observations
- AMVs

2 x 4 months of experimentation:

- June – September 2016
- December 2017 – March 2018
- TCo399 ~25 km resolution

Short-range forecast fits to polar radiosondes

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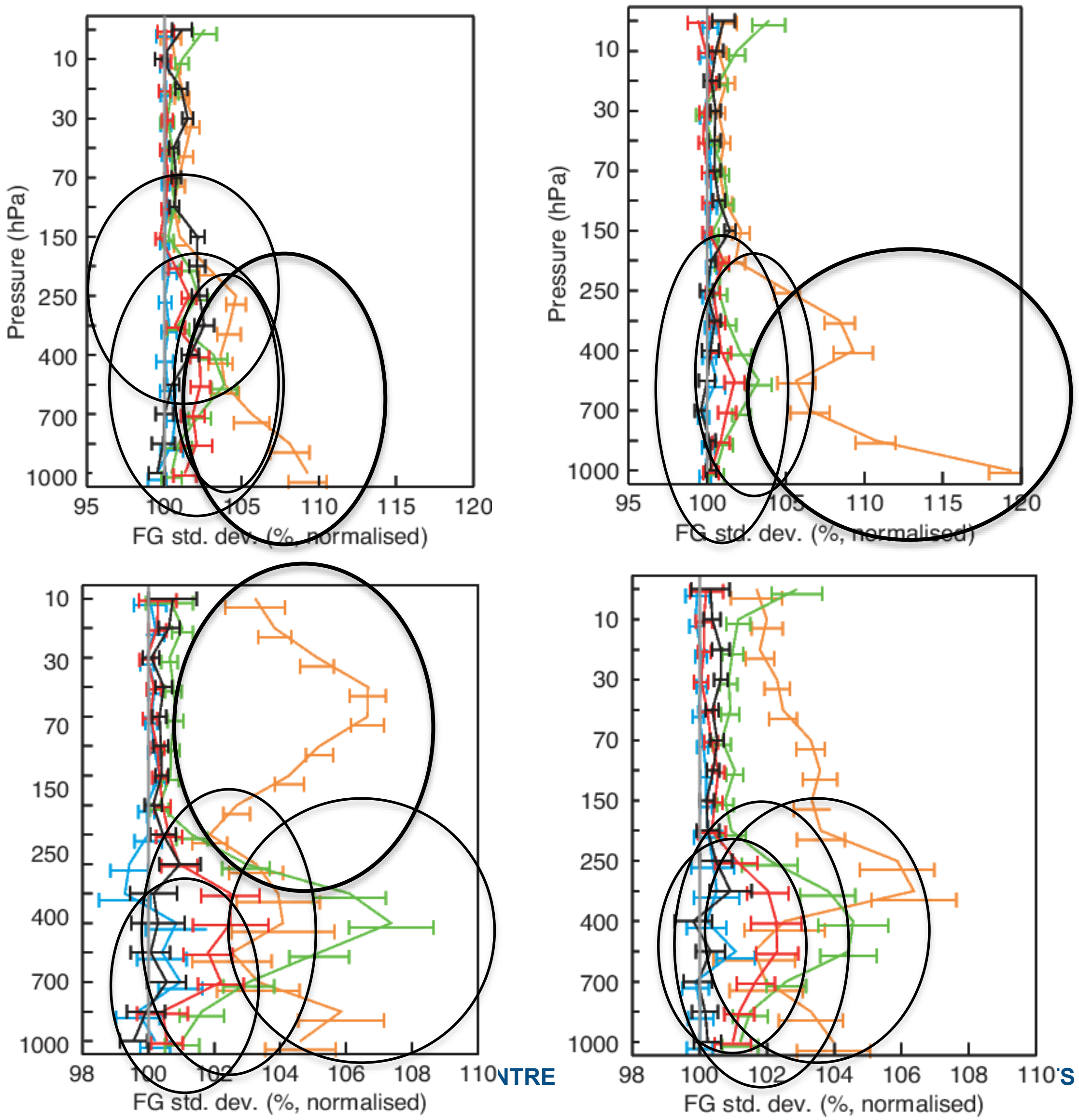
SUMMER 2016 **WINTER 2017/18**

Temp-T
60 – 90 N

wind
60 – 90 N



Conventional:
- Troposphere 700 – 1000 hPa temperature
- Stratospheric wind

Microwave:
- Temperature 500 hPa
- Wind 300 – 500 hPa

Infrared:
- Temperature 1000 - 300 hPa
- Wind 700 – 300 hPa

GPSRO
- Summer temperature 300 – 150 hPa

AMVs
- Wind, temperature 850 – 500 hPa

Medium-Range Forecast Scores: Z500 Arctic and N. Midlat

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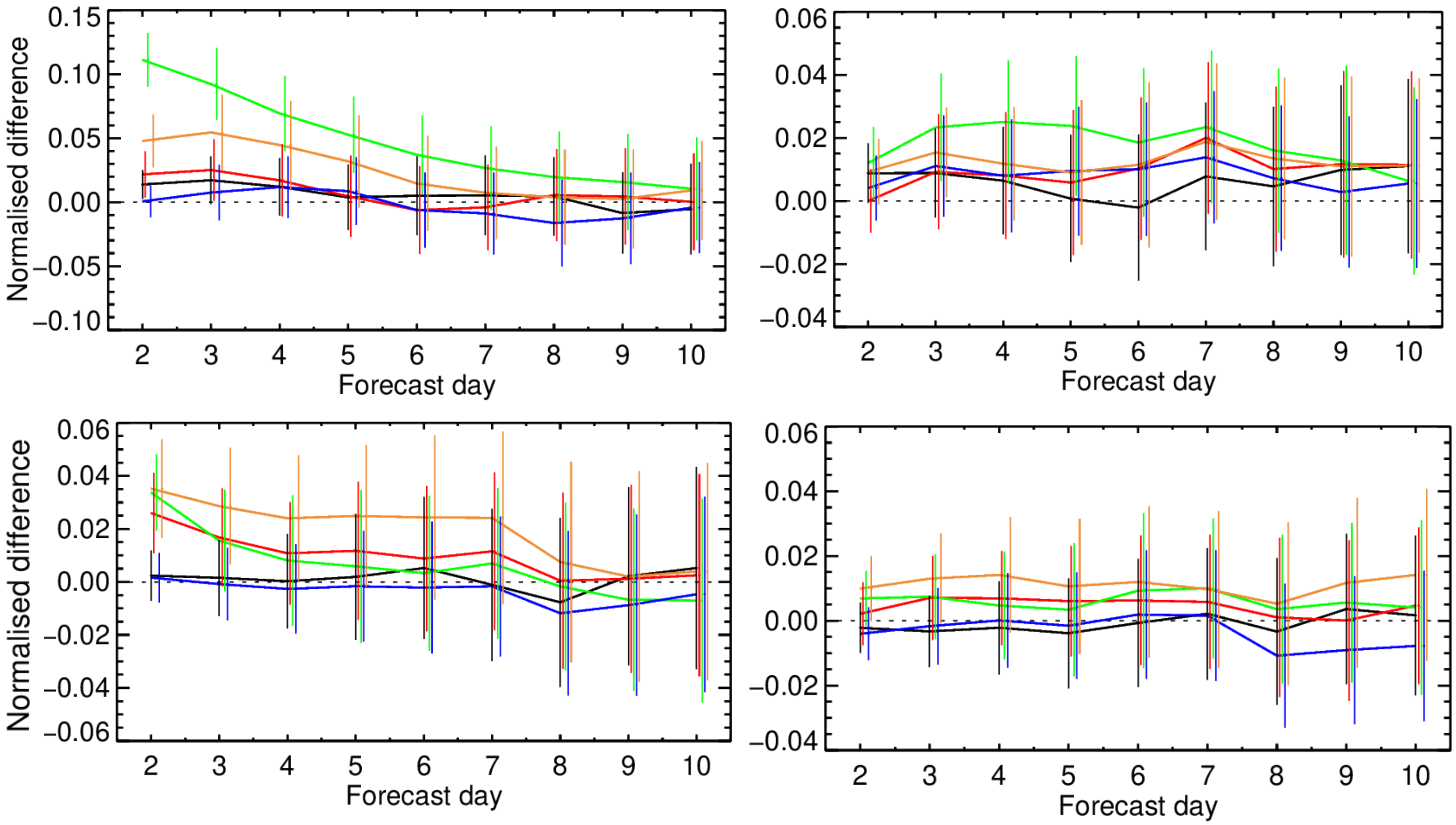
Arctic | **Mid-latitudes**

Summer 2016

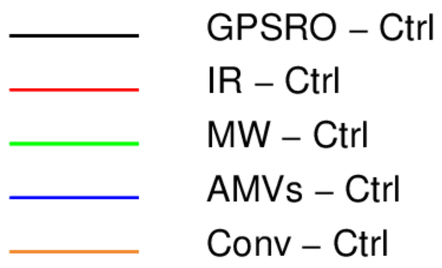
Winter 2017/18



Forecast Day   Forecast Day

Summer:
- Microwave
- Conventional
- Infrared
- GPSRO, AMVs

Winter:
- Conventional
- Infrared/Microwave



Polar OSEs: Arctic to mid-latitude impact

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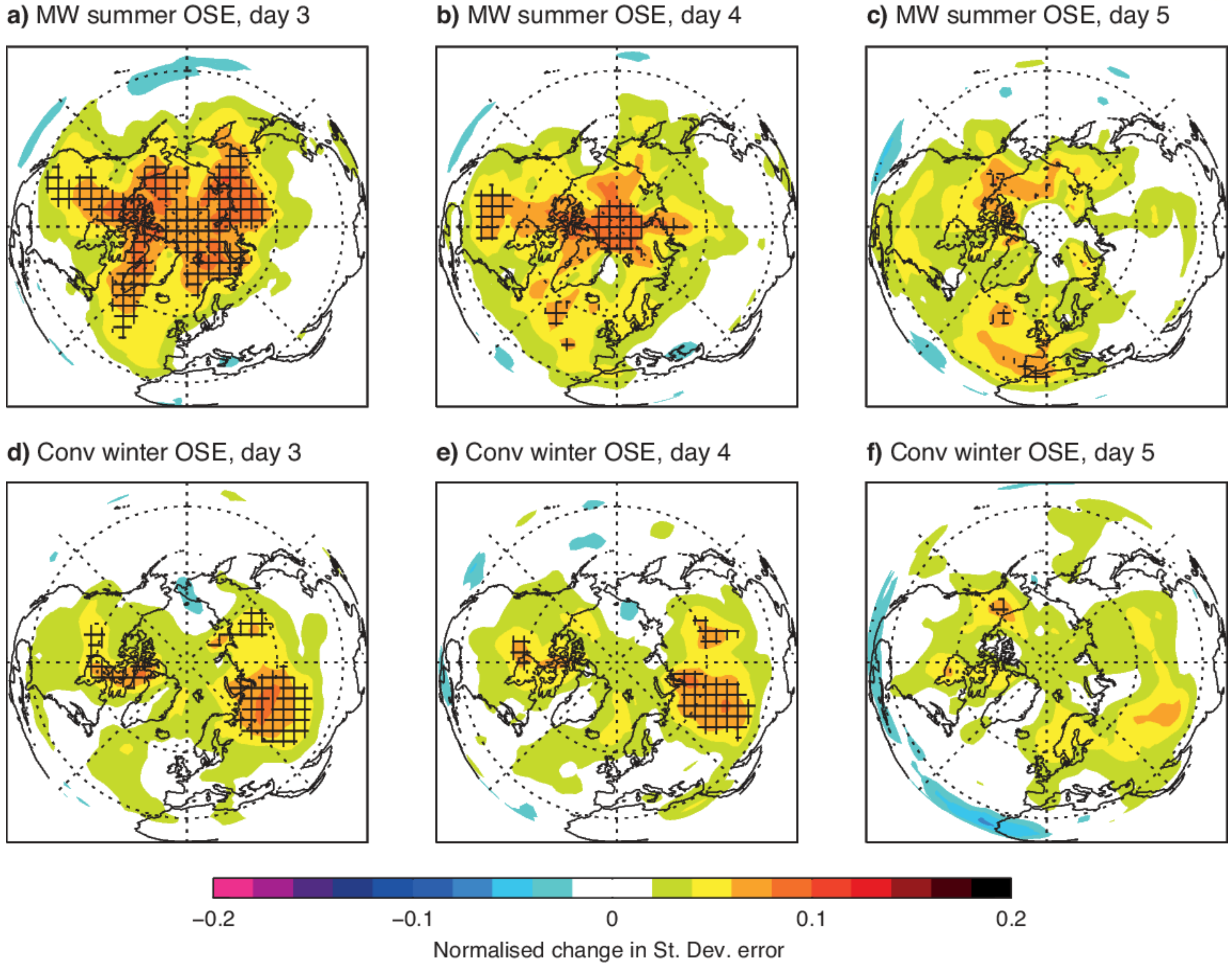
Microwave Summer
Z500 scores

Conventional winter
Z500 scores



FSOI: Forecast Sensitivity to Observation Impact

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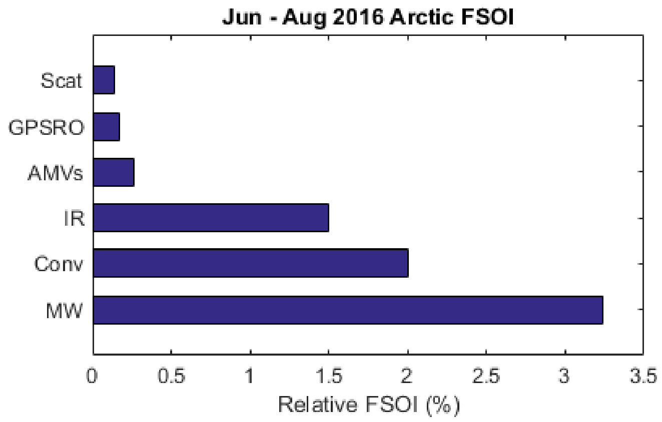
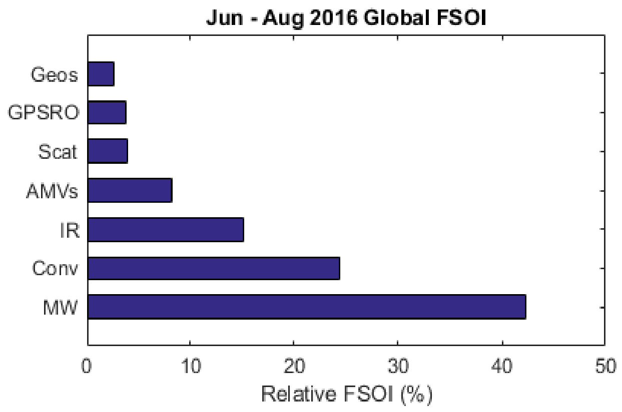
Adjoint-based method of measuring observation impact (Cardinali, 2009)

Arctic:

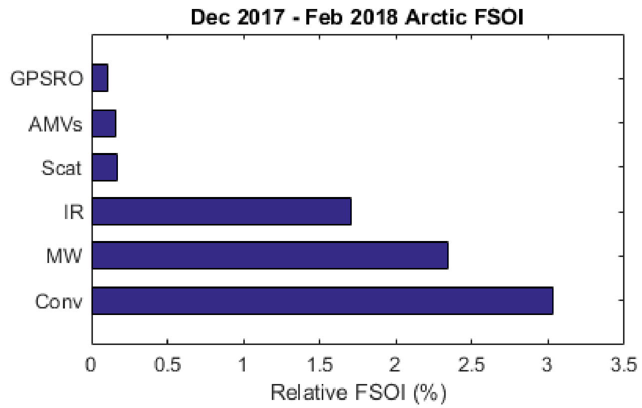
Global:

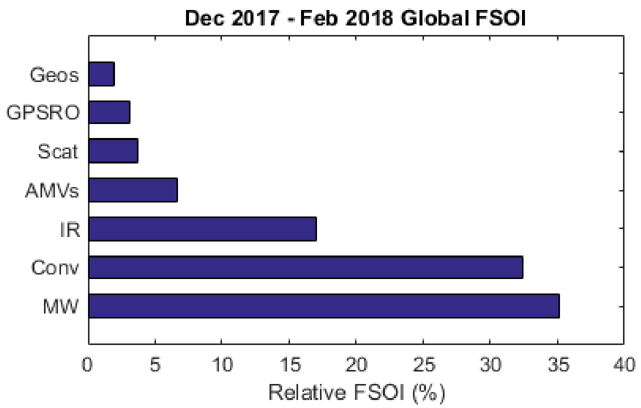
Summer 2016





Winter 2017/18





Globally:
1. Microwave
2. Conventional
3. IR

Arctic summer:
1. Microwave
2. Conventional
3. IR

Arctic winter:
1. Conventional
2. Microwave
3. IR

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Conclusions

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- Microwave, conventional and infrared data are key observing systems in the Arctic, as elsewhere
- We make good use of satellite data in the Arctic summer – similar to SHEM
- Microwave impact is lower in winter….

  Improve data use over snow e.g. with:

  - Modelling of snow emission/reflection using snow model developed in APPLICATE
  - Lambertian reflection
  - Improved skin temperature estimates?

- Impacts are always subject to the sophistication/maturity of the data use. Investment in the data use may be at least as important as investment in further observations.

Reference: H. Lawrence et. al. QJRMS (2019) https://doi.org/10.1002/qj.3628

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Extra slides

Summary of OSE experiments

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Group		ECMWF (25km)	Env. Canada (39km)	DWD (13km)	MetNo (AROME Arctic)
	Period	JJA 16 + DFJM 17/18	DJFM17/18 + JJAS 18	FM18 JJ18 TBD	FM18
Main	CTL (all obs, including YOPPobs)	✓	✓	✓	✓
Main	Microwave (MW)	✓	✓	✓	✓
Main	Infrared (IR)	✓	✓		✓
Main	Conventional (Conv)	✓	✓		✓
Main	GPSRO	✓	✓		
Main	AMVs	✓	✓	✓	✓
Conv split	Radiosondes	✓	✓	✓	✓
Conv split	Buoys	✓			
Conv split	Synop	✓			
Conv split	Surface pressure	✓	✓	✓	✓
Conv split	YOPP obs	✓	✓	✓	✓
MW split	MW temperature	✓	✓		
MW split	MW humidity	✓	✓		

impact of obs through DA and LBC

Polar vs Global OSEs: Mid-latitude to Arctic impact

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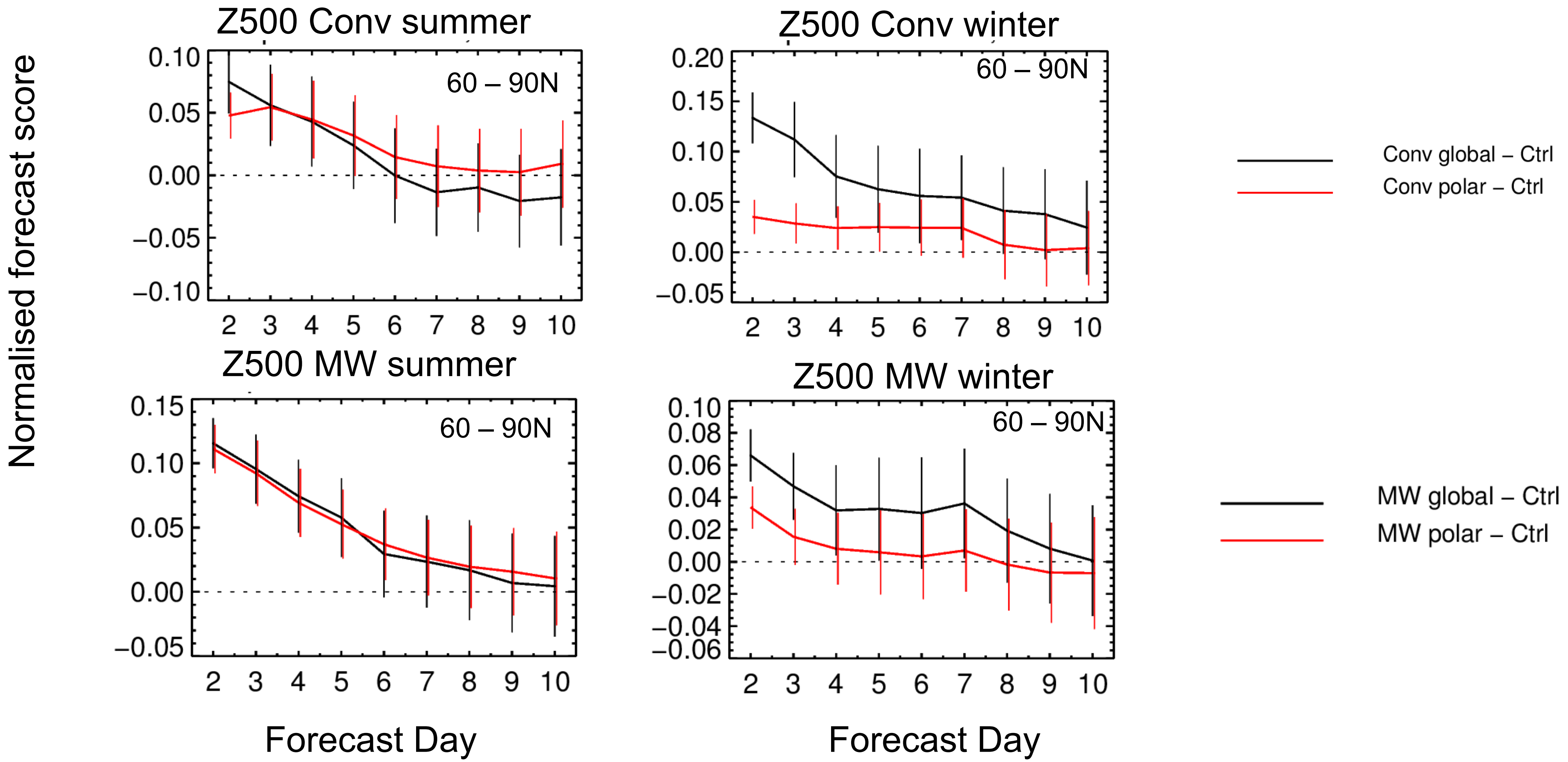
Mid-latitude observations influence Arctic weather forecasts in winter:



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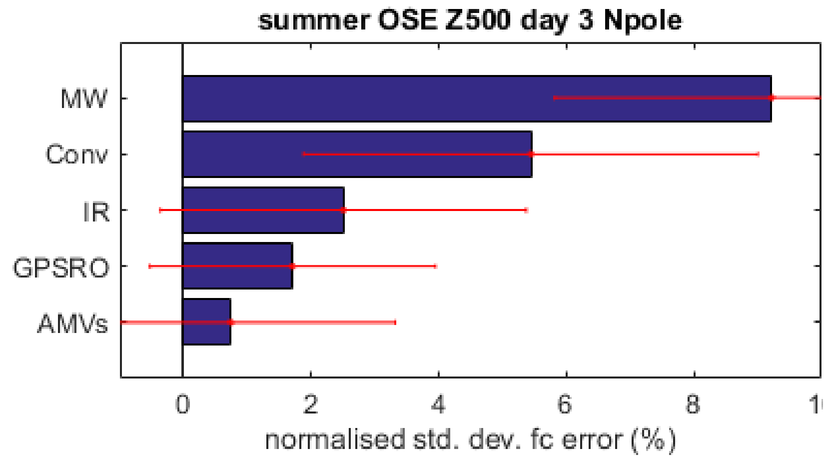
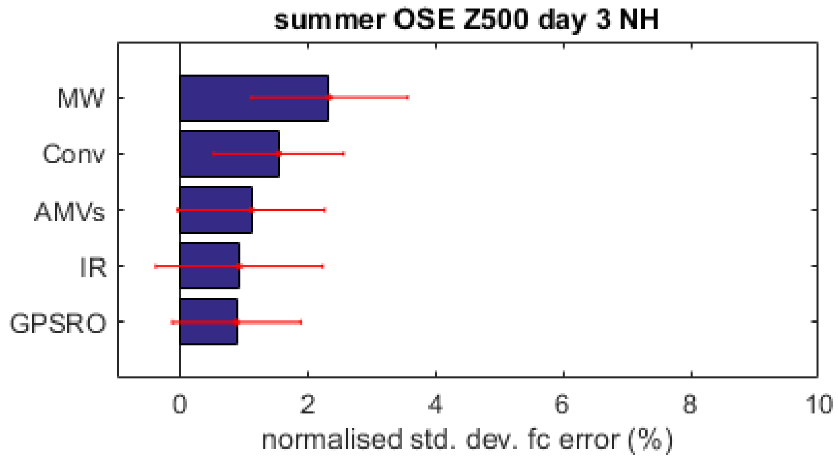
Degraded forecast skill in the Arctic and Northern Mid-latitudes

60 – 90 N

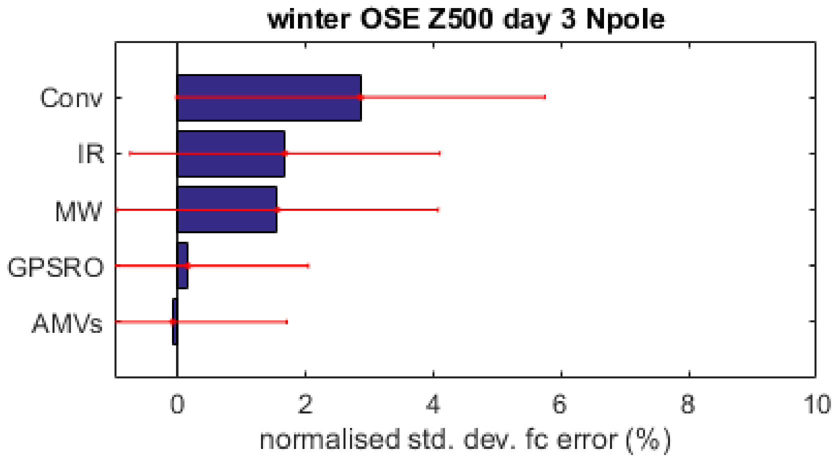
summer

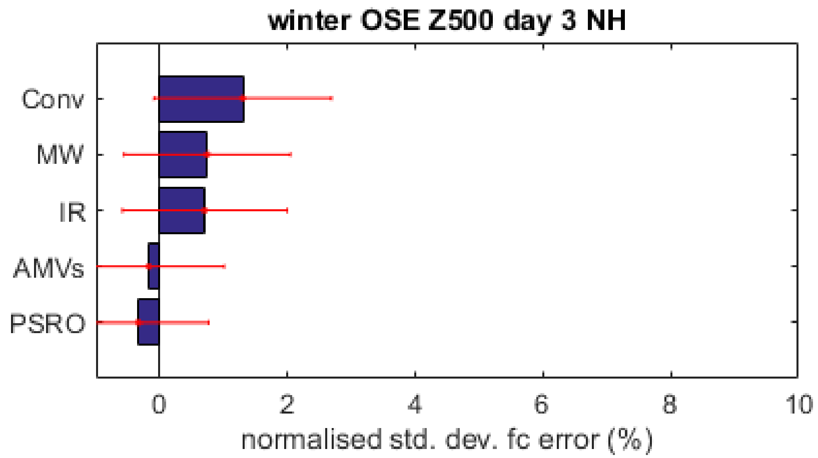


20 – 60 N



winter





Summer:

- Microwave
- Conventional
- Infrared
- GPSRO, AMVs

Winter:

- Conventional
- Less impact overall from each observation type

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H. Lawrence et al., in preparation