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Impact of Terrestrial and Satellite Observations over the Polar Regions on the ECCC Global Weather Forecasts during the YOPP Special Observing Periods

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Introduction

One goal of YOPP is to make recommendations to WMO and meteorological centers on the future configuration of the observing system in polar regions. With the growing human activities and the importance to provide accurate weather information and forecasts in the Arctic, it is indeed relevant to examine the value of in situ and satellite observations in high-latitude. The role of the various types of observations over the globe in numerical weather prediction at mid-latitude is now better understood. The impact of observations in the Arctic is less clear since terrestrial observations are sparse and satellite observations are affected by ice and snow for which the emissivity properties can be difficult to estimate. YOPP provides a good opportunity to examine the relative importance of the various satellite and terrestrial observations in the Arctic and the impact of observations in high-latitude on the forecast skill in mid-latitudes.

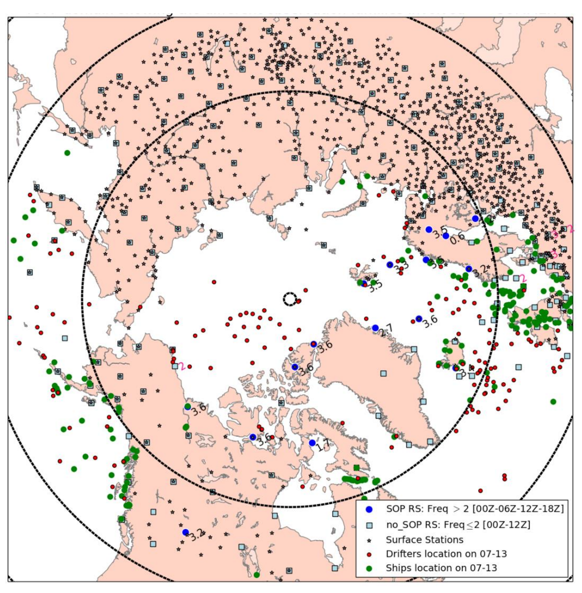
In this study, we carried out Observing System Experiments (OSEs) poleward of 60 degrees over the North and South Poles for the two four-month periods: December 2017 to March 2018 and June to September 2018. The selected data denied poleward of 60 degrees are the following: microwave radiances, hyperspectral infrared radiances, conventional observations, GPS-RO, AMVs as well as all satellite data. A few additional OSEs were also conducted to examine the relative impact of temperature and humidity sensitive microwave radiances and the impact of the additional radiosondes that were launched during the YOPP special observing periods.

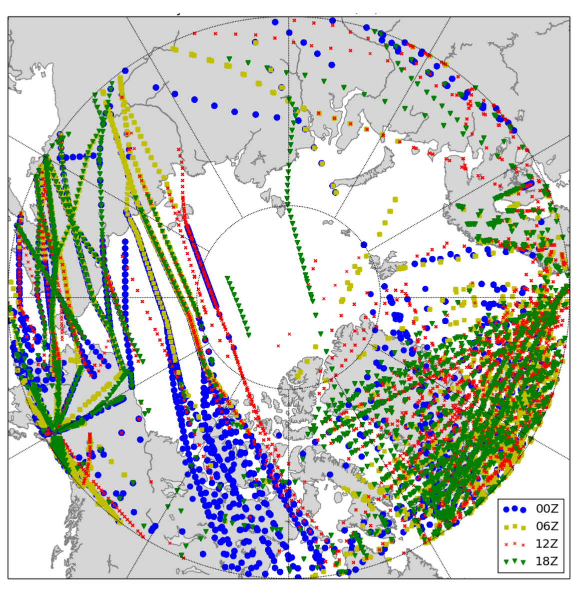
Observing System Experiments

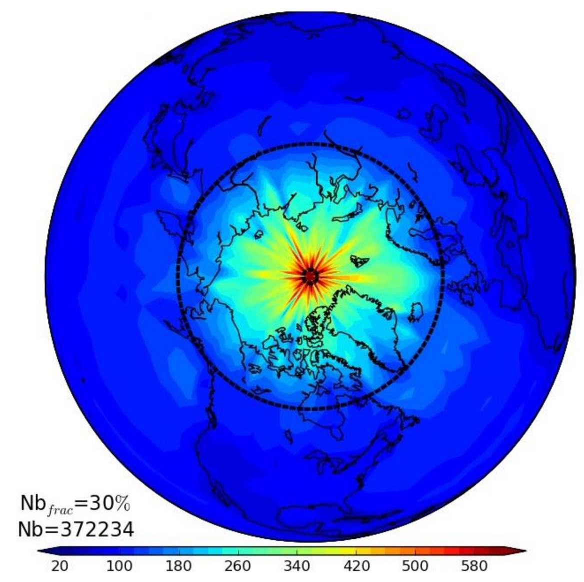
Observation Type	Instruments/Networks (Satellites)
Conventional	Radiosondes and Pilots Aircraft reports Surface Stations Drifters, Ships and Buoys
Microwave Radiances	AMSU-A (NOAA-15,18,19, Aqua, Metop-A,B) ATMS (S-NPP) SSMIS (imager only F-17,18)
Infrared Radiances	AIRS (Aqua) IASI (Metop-A,B) CrIS (S-NPP)
GPS-RO	(Metop-A,B, COSMIC, GRACE-A, TANDEM-X, TERRASAR-X)
AMV	Geostationary (GOES-15,16, METEOSAT-8.10, Himawari-8) Polar (NOAA-15,18,19, Aqua, S-NPP, Metop-A,B)
Scatterometer	ASCAT (Metop-A,B)

Experiment	ID
1. Control (no denial)	CONTROL
2. Remove **microwave radiances** where abs(lat)>60	NO_MW
3. Remove **infrared radiances** where abs(lat)>60	NO_IR
4. Remove **conventional** observations where abs(lat)>60	NO_CONV
5. Remove **AMVs** where abs(lat)>60	NO_AMV
6. Remove **GPS-RO** where abs(lat)>60	NO_RO
7. Remove **radiosondes** where abs(lat)>60	NO_RAOBS
8. Remove **surface pressure** obs. where abs(lat)>60	NO_PSM
9. Remove **YOPP SOP additional observations**	NO_YOPP
10. Remove **all satellite** observations where abs(lat)>60	NO_SAT

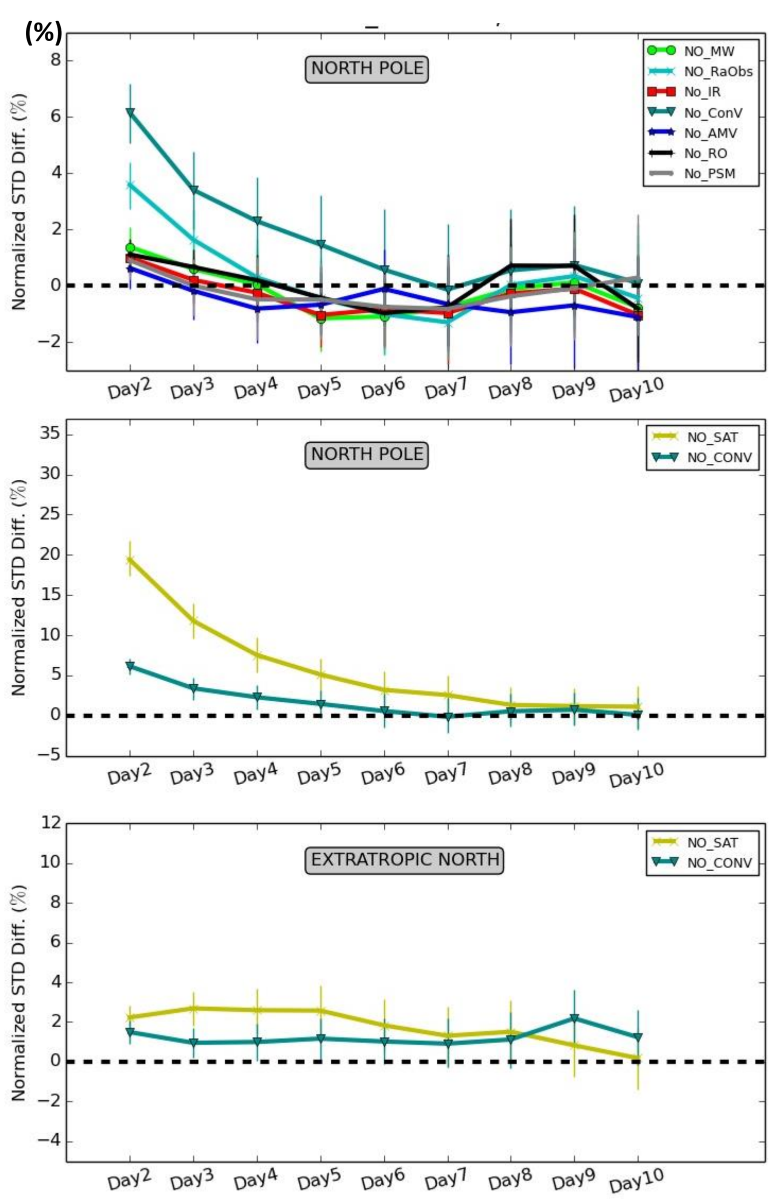
Typical Daily Surface and Radiosonde, Aircraft and AMSU-A Observations



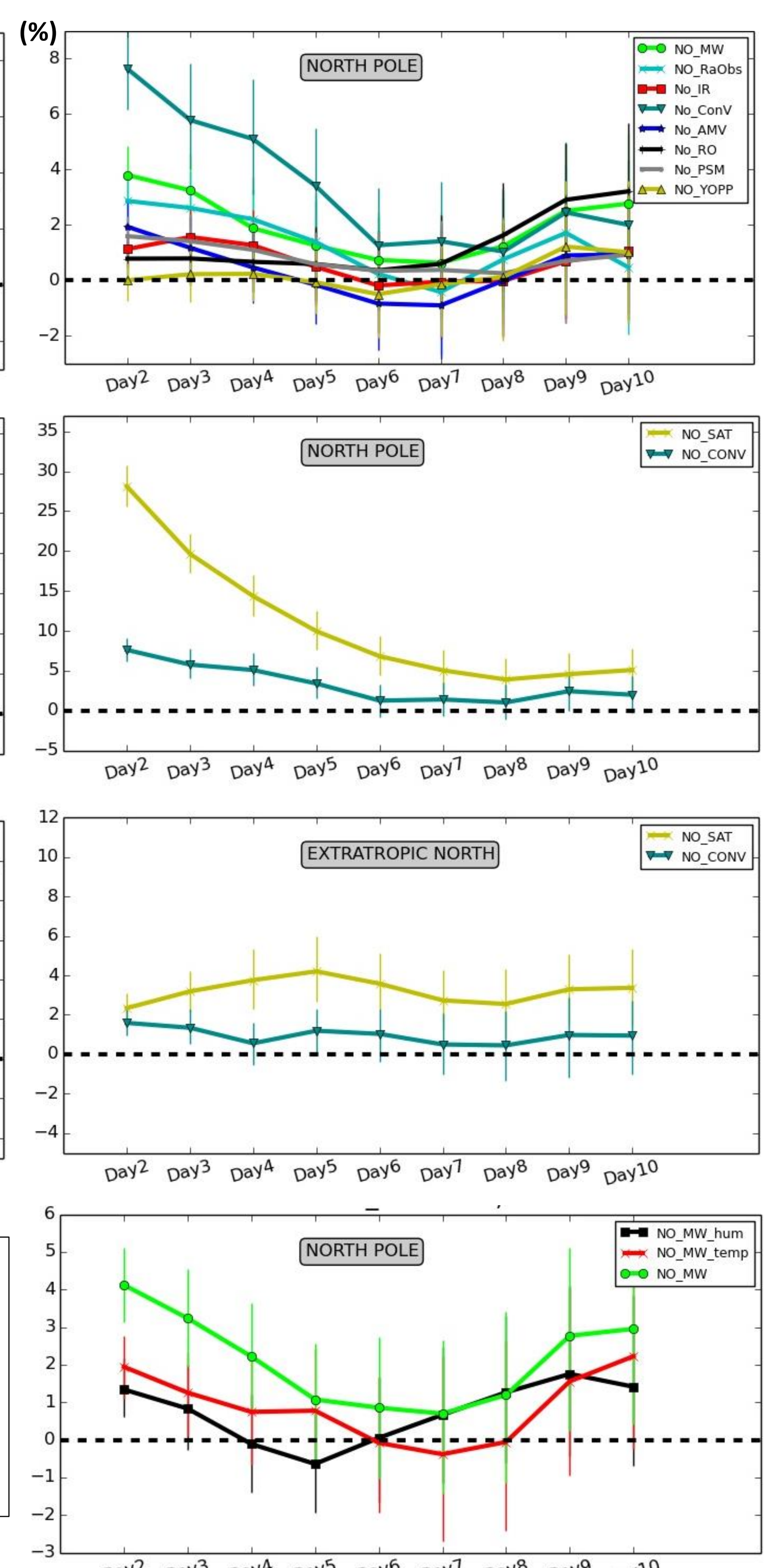




Winter 2018

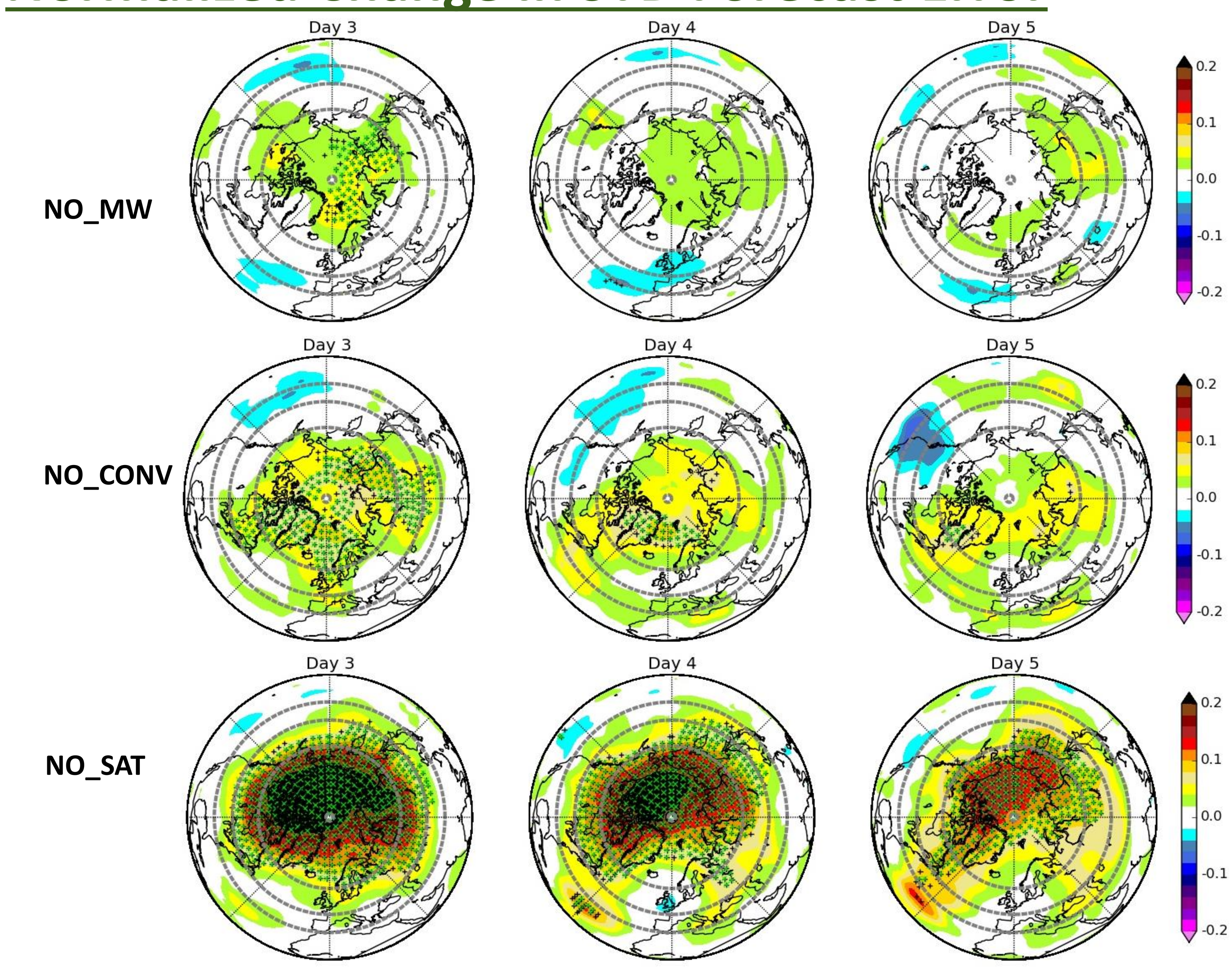


Summer 2018

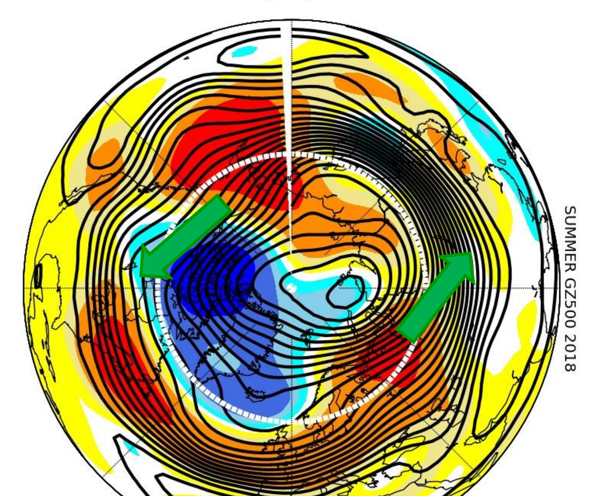


Percentage change in standard deviation of Z500 forecast error with respect to the CONTROL experiment as a function of forecast day. Error bars indicate 95% confidence intervals.

Normalized Change in STD Forecast Error



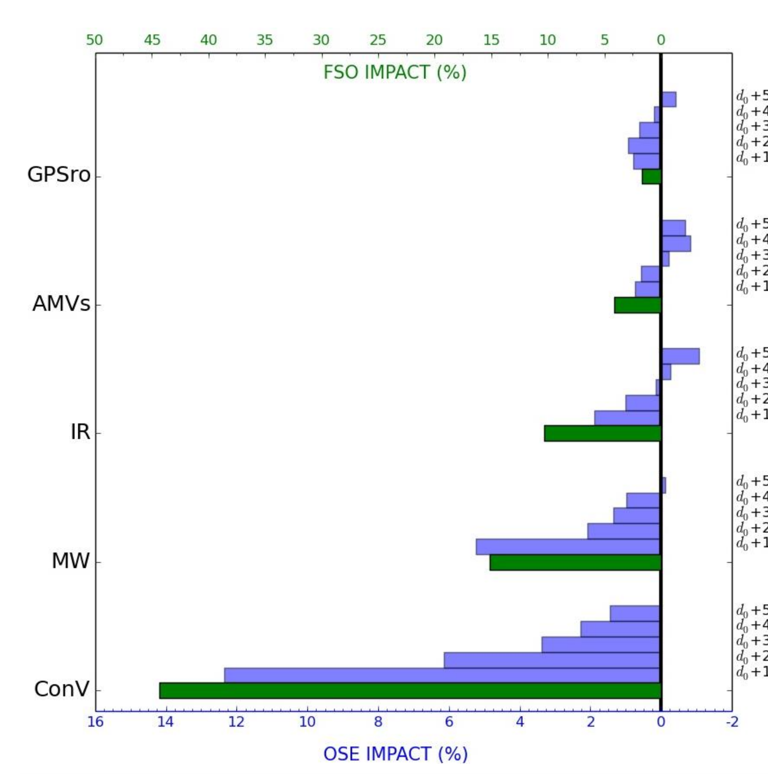
Summer 2018

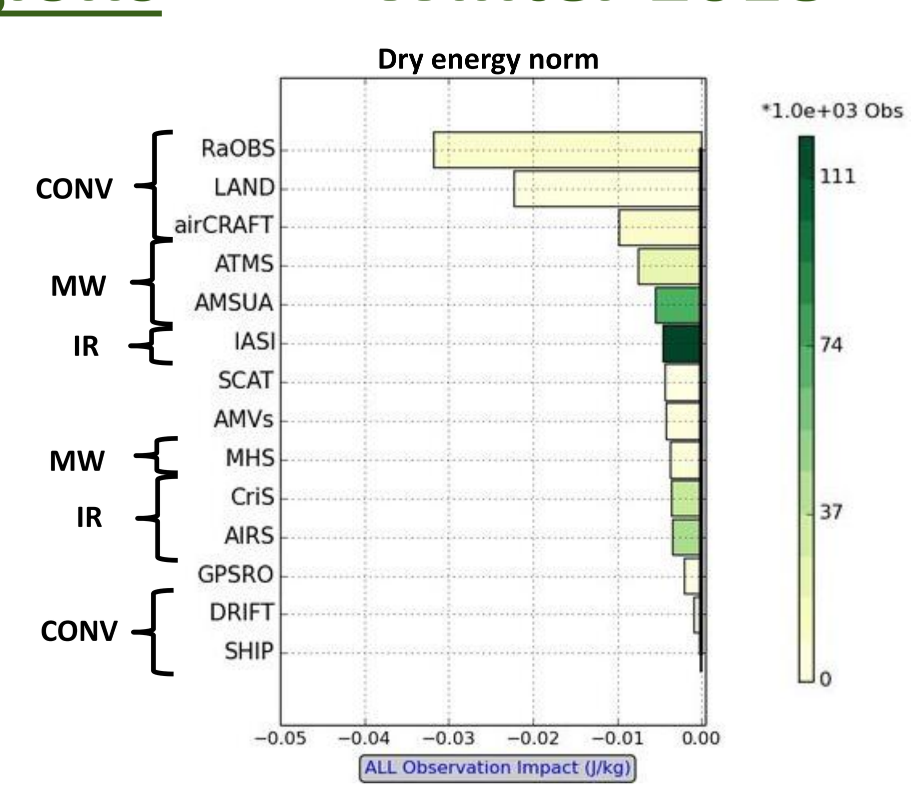


Normalized change in standard deviation of Z500 forecast error with respect to the CONTROL experiment for day 3, day 4 and day 5 for the NO_MW, NO_CONV and NO_SAT experiments. The bottom right figure is the mean Z500 (contours) and anomalies (shading) for summer 2018

FSOI over the Polar Regions

Winter 2018





The Forecast Sensitivity to Observation Impact (FSOI) technique provides the relative impact of each observation on the error reduction in 24-h forecasts due to the assimilation of observation in the 6-h assimilation window.

Conclusions

- The impact of all satellite data on Z500 forecasts in the Arctic is much larger than the impact of the conventional data.
- Among the satellite data, the microwave radiances has the largest impact followed by the infrared radiances. The impacts of AMVs and GPS-RO are much smaller in the troposphere over the North Pole.
- Among the conventional data, the radiosonde and surface stations networks have the largest impacts. The impact of Aircraft data on forecasts is small because of the lack of ascend/descent profiles north of 60N.
- The impact of conventional data is larger than that of microwave radiances in both winter and summer seasons. The impact of microwave humidity sounders is smaller than that of temperature sounders because only clear sky radiances are assimilated and the SSMIS sounders as well as the MWHS and MWHS-2 instruments are not used in the ECCC systems.
- The impact of observations in the Arctic on forecasts in the midlatitudes is larger over the eastern Canada and northern Asia where climatological troughs are located. This is true for both seasons examined.
- In all experiments, the background error statistics are those from the CONTROL experiments in which all observing networks are assimilated. As a result, the assimilation becomes suboptimal for OSEs in which a large volume of data is denied, such as the NO_SAT experiment. In this case, the impact on forecast can be overestimated because less weight is given to the remaining observations in the analysis. A few NO_SAT experiments with inflated background error variances as well as a coupled NO_SAT EnKF experiment are currently carried out to assess this effect.