

Direct Insertion of Sea Ice in C-NOOFS

Jennifer Wells⁽¹⁾, Gregory Smith⁽²⁾, Andry Ratsimandresy⁽¹⁾,
Melanie Cooke⁽¹⁾, Jeff Laham⁽¹⁾ and Fraser Davidson⁽¹⁾

(1) DFO-Northwest Atlantic Fisheries Center, St. John's, NL, Canada

(2) EC-Canadian Meteorological Centre, Dorval QC, Canada



Outline

- **Background**
 - C-NOOFS
 - Motivation
- **Method**
 - Thickness Adjustment
 - Ice Insertion Procedures
 - Fitted Data Assumption
- **Results**
 - C-NOOFS Monitoring System
 - Seasonally Averaged Statistics (Ice, SST, SSH)
- **Concluding Remarks / Future Directions**

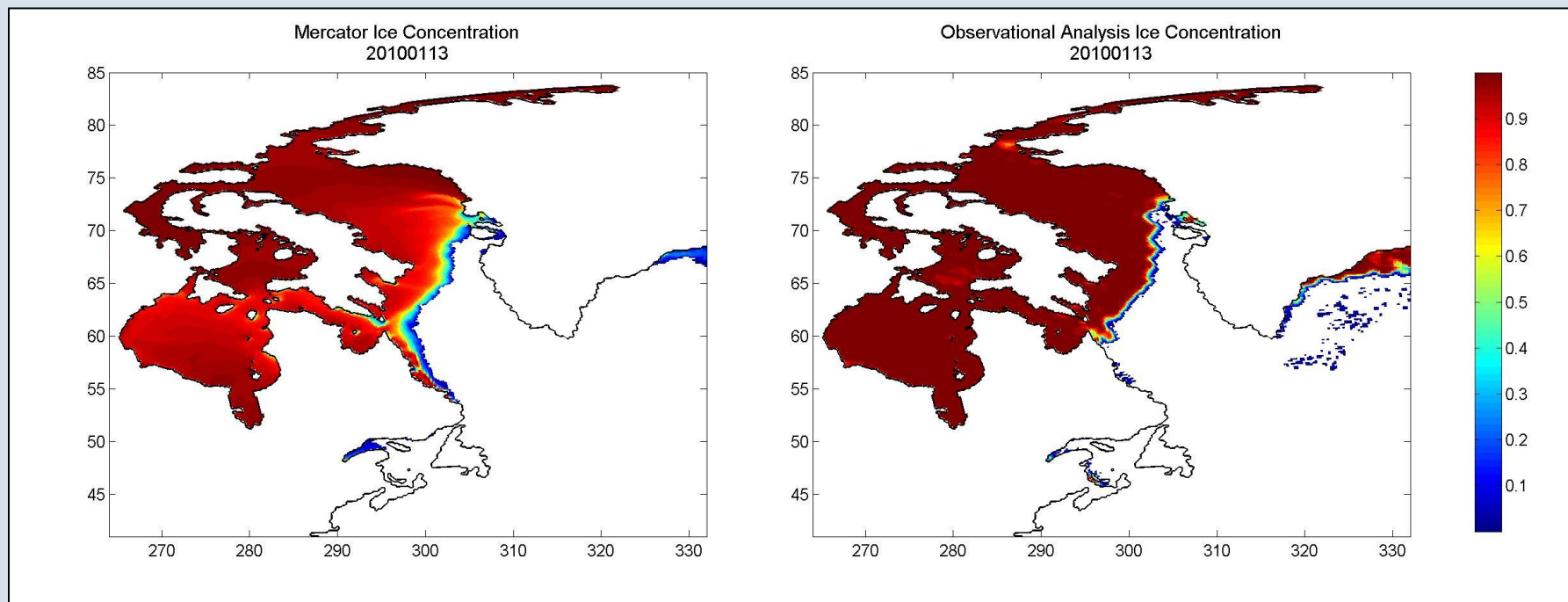


C-NOOFS

- Canada-Newfoundland Operational Ocean Forecasting System.
- A pre-operational ocean forecast model for the Northwest Atlantic (NWA).
- Two 10-day forecasts daily: NWA025 and NWA12 with $1/4^\circ$ (20km) and $1/12^\circ$ (6 km) resolutions respectively.
- Use Mercator-Ocean model analyses and forecasts for initialization and boundary conditions, and take atmospheric forcing from CMC operational global forecasts.



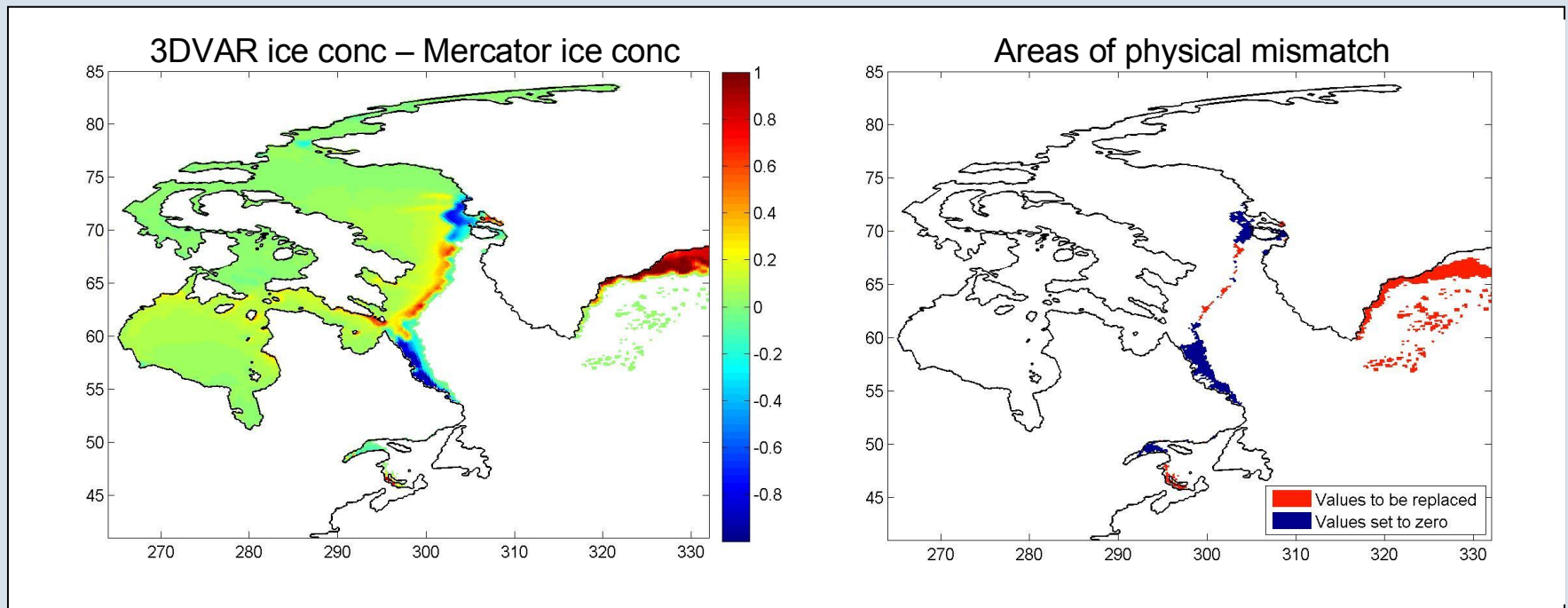
Motivation



- Currently, C-NOOFS relies on weekly Mercator-Ocean (MO) forecast results for ice.
- Efforts are underway to replace these Mercator ice values with 3DVAR ice analyses from CIS/CMC.



Thickness Replacement



- The 3DVAR ice assimilation system does not currently provide an analysis of ice thickness.
- A mismatch exists between physical areas covered by the ice concentrations from M-O and from 3DVAR ice.
- Replacement thickness values must be determined for missing thickness values corresponding to 3DVAR ice concentrations.

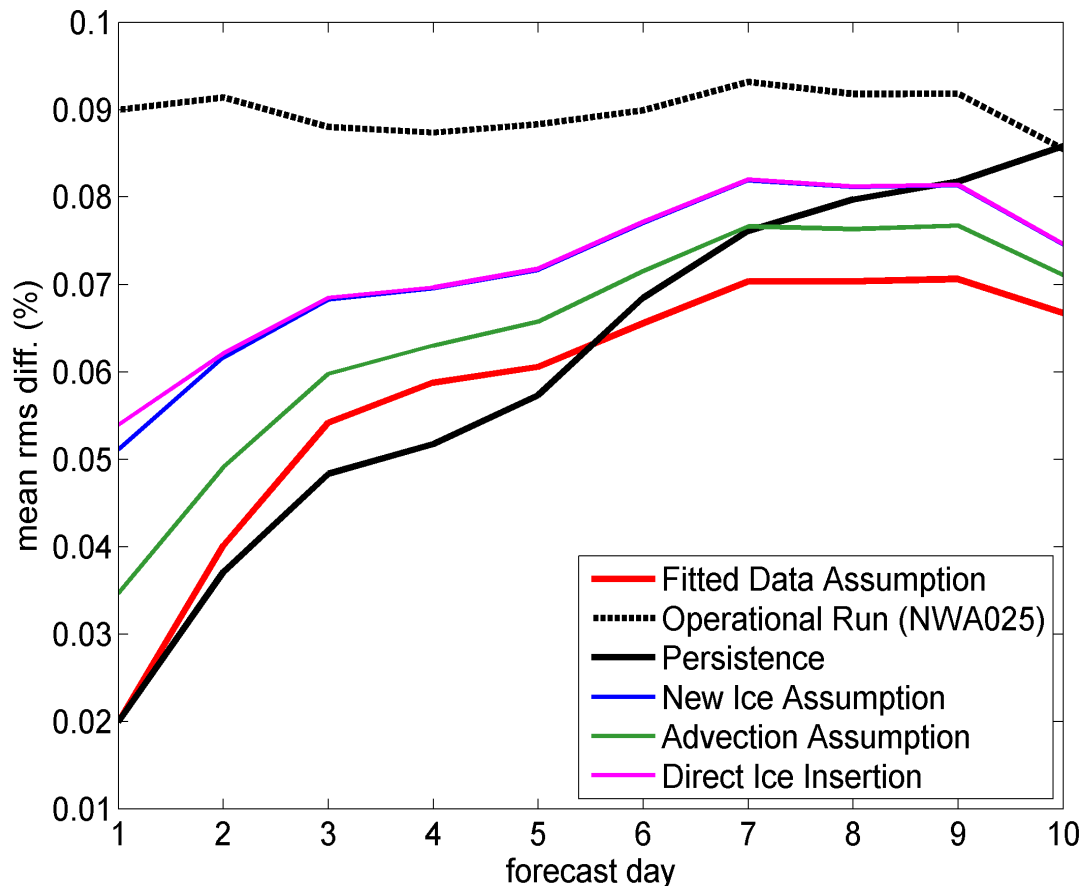


Ice Insertion Procedure

- **Direct Insertion**
 - Directly insert the 3DVAR ice analysis concentrations into C-NOOFS.
 - Do not make a thickness adjustment.
- **New Ice Assumption**
 - Assume missing thicknesses represent newly formed ice ($T = 10$ cm).
- **Advection Assumption**
 - Assume missing thickness values are equal to neighbouring values of ice thickness.
 - If no neighbouring value exists within a 9-point grid, set missing thickness value to 10 cm.
- **Fitted Data Assumption**
 - Calculate replacement values for missing thickness based on the relationship between Mercator ice concentration and Mercator thickness.



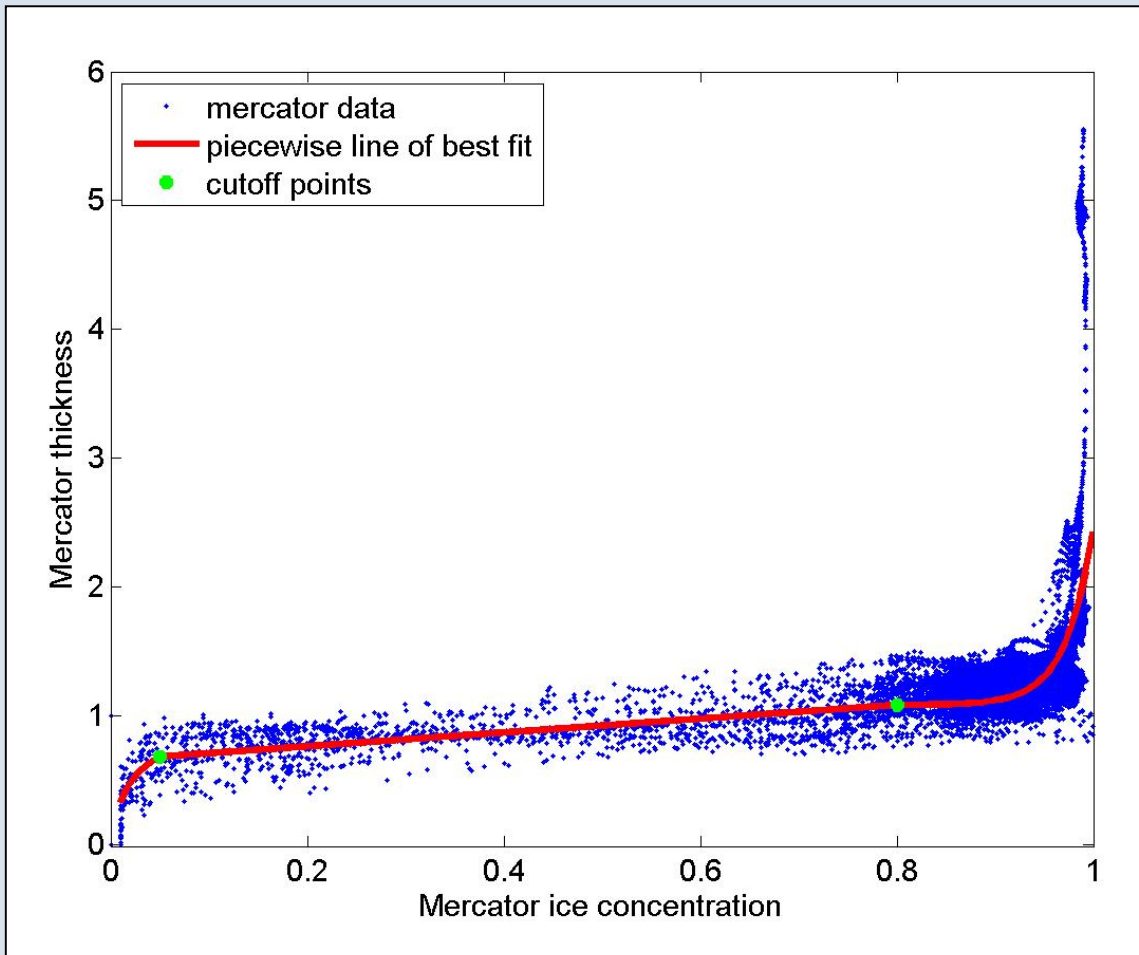
Results of All Thickness Assumptions



- All results for January 13, 2010
- A 10 day forecast is performed using each ice insertion method.
- Plot represents the percent difference between model results and 3DVAR ice analysis.
- An improvement is seen in the ice forecast compared to the operational (NWA025) run.
- The fitted data assumption beats persistence after 5 days.



Fitted Data Assumption



Low

- Ice Conc = 0.01 to 0.05
- Log Function

Medium

- Ice Conc = 0.05 to 0.8
- Linear Fit

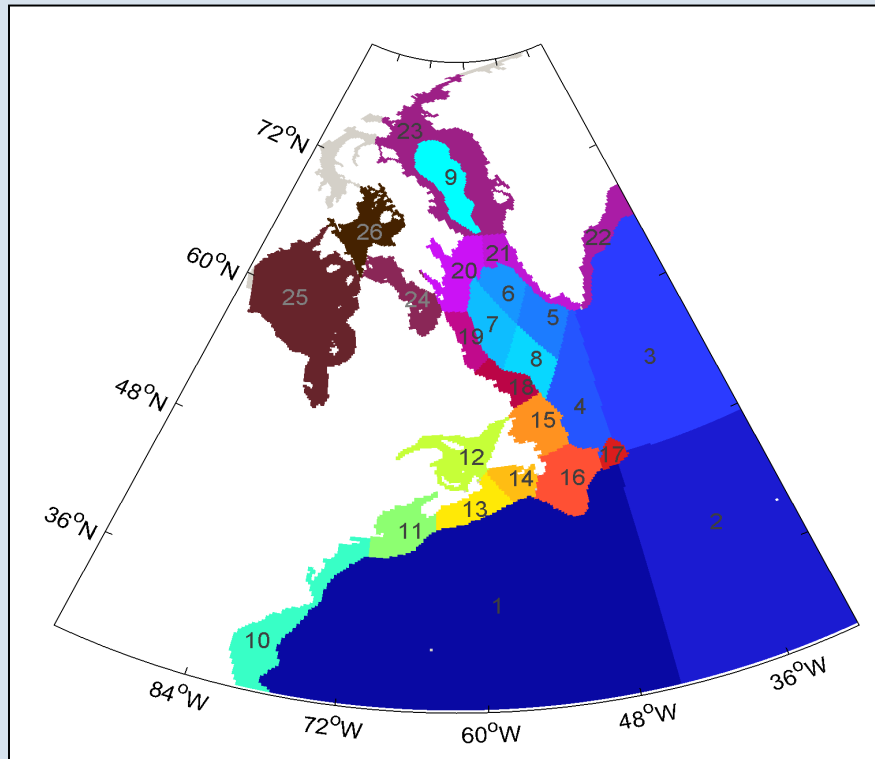
High

- Ice Conc = 0.8 to 1
- Exponential Fit

*For January 13, 2010



C-NOOFS Monitoring System



Comparisons:

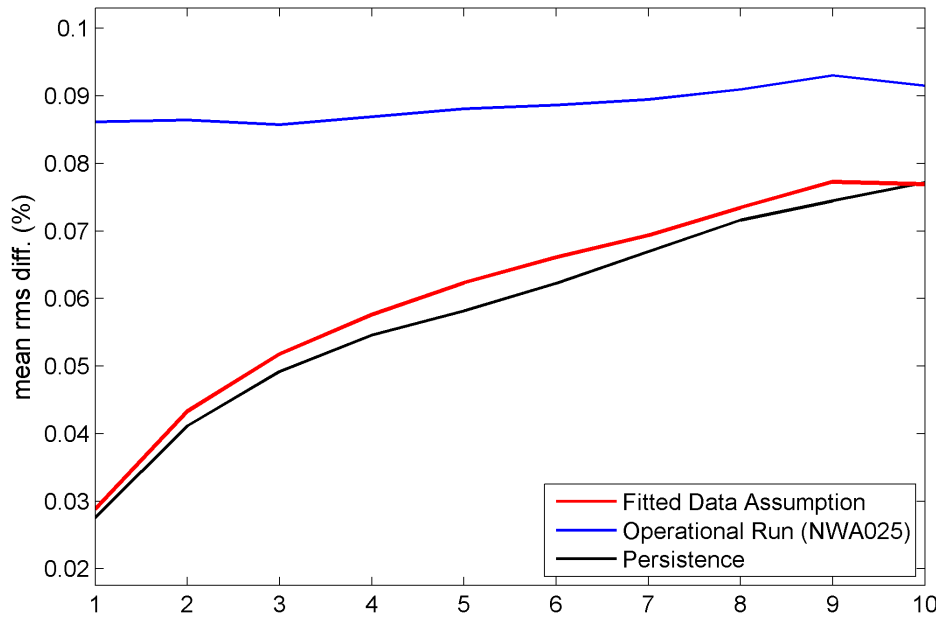
- Model output vs. 3DVAR Ice
- Model output vs. CMC SSTana
- Model output vs. AVISO SSH

- Z1 – Gulf Stream
- Z2 – NA Drift South
- Z3 – Drift North
- Z4 – NWA
- Z5 – LSSE
- Z6 – LSNE
- Z7 – LSNW
- Z8 – LSSW
- Z9 – Baffin Bay
- Z10 – Cape Hatteras
- Z11 – Gulf of Main
- Z12 – Gulf of St. Lawrence
- Z13 – Scotian Shelf
- Z14 – South Coast of NL
- Z15 – NL Shelf
- Z16 – Grand Banks
- Z17 – Flemish Cap
- Z18 – Labrador Shelf South
- Z19 – Labrador Shelf North
- Z20 – Hudson / Baffin Outflow
- Z21 – West Greenland Current
- Z22 – East Greenland Current
- Z23 – Baffin Bay Shelves
- Z24 – Hudson Outflow
- Z25 – Hudson Bay
- Z26 – Fox Basin

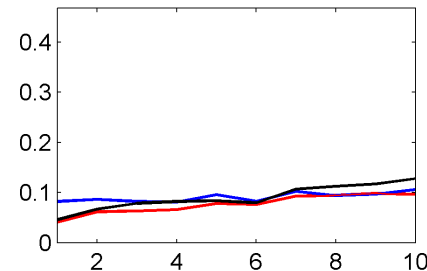


Seasonally Averaged Statistics for Ice

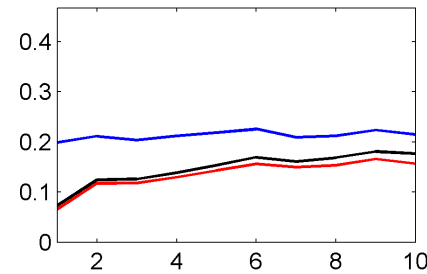
Whole Domain



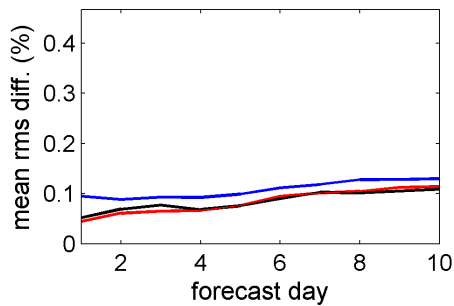
Zone 07 - Lab Sea NW



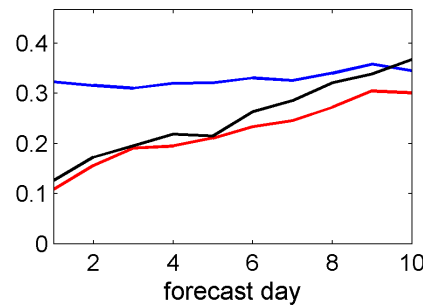
Zone 12 - Gulf of St. Lawrence



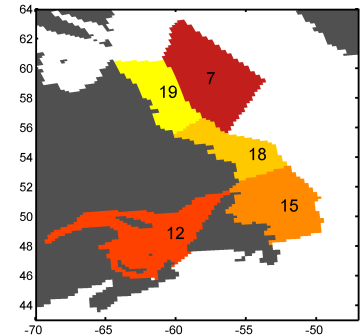
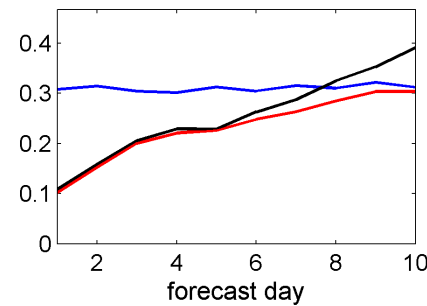
Zone 15 - NL Shelf



Zone 18 - Labrador Shelf South



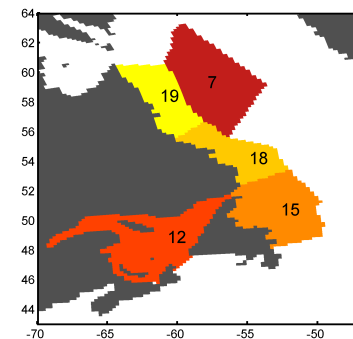
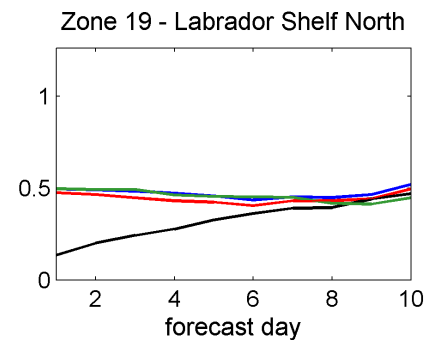
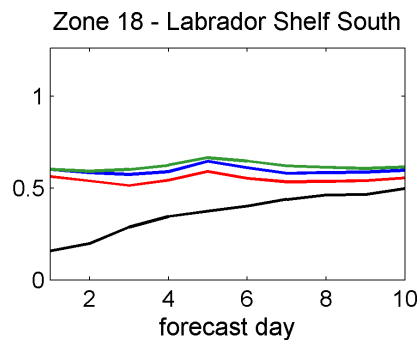
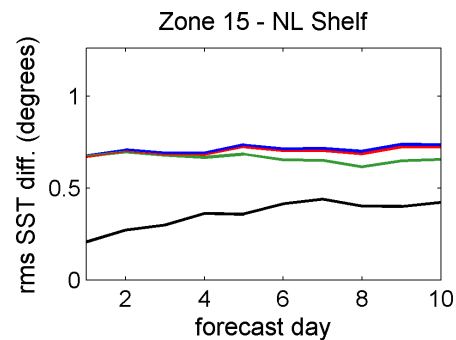
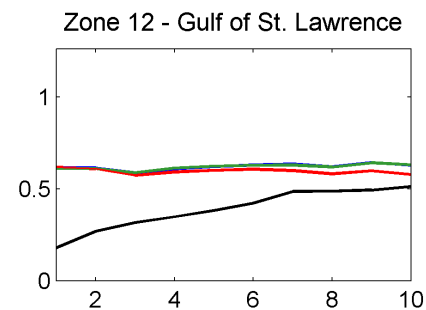
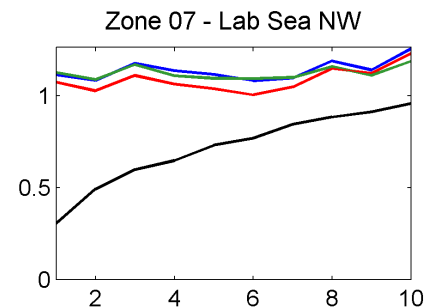
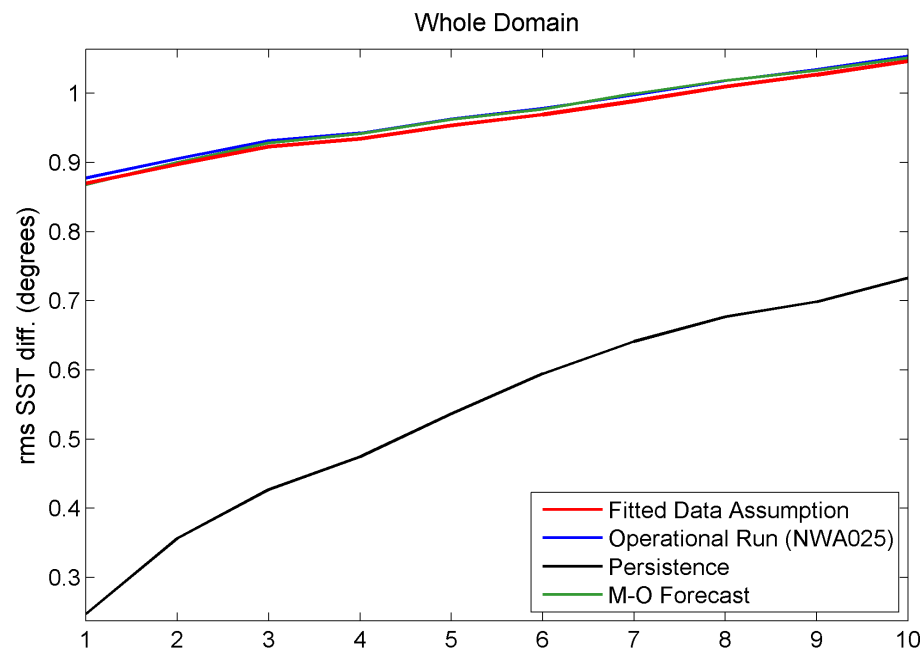
Zone 19 - Labrador Shelf North



Averaged over
all Wednesdays
in Winter 2010
(Jan - Mar)



Seasonally Averaged Statistics for SST



Averaged over
all Wednesdays
in Winter 2010
(Jan - Mar)



Concluding Remarks

To Date:

- Best results achieved by replacing missing thickness values using a fitted data assumption.
- Insertion of 3DVAR Ice Analysis data leads to improvements in model results.

Next Steps:

- Repeat direct insertion on NWA12.
- Include ice thickness data from 3DVAR analysis and snow analysis from CMC.
- Combine the 3DVAR ice analysis system and Mercator-Ocean's SAM2 ocean analysis system.
- Investigate how ice forecast skill is affected by adding an updated ice model and atmospheric winds, as well as assimilation of coastal SSH data.

Ultimate goal:

- Ice and Ocean data analysis coupled to the NEMO Ocean Code.



The End

Our Thanks To:



Environment
Canada

Environnement
Canada

For More Information:

- <http://www.c-noofs.gc.ca>
- <http://www.c-noof.gc.ca:8080/ncWMS/godiva2.html>



Fisheries and Oceans
Canada

Pêches et Océans
Canada

Canada 