GODAE OceanView and its Coupled Prediction Task Team

Hal Ritchie

Environment Canada

Outline

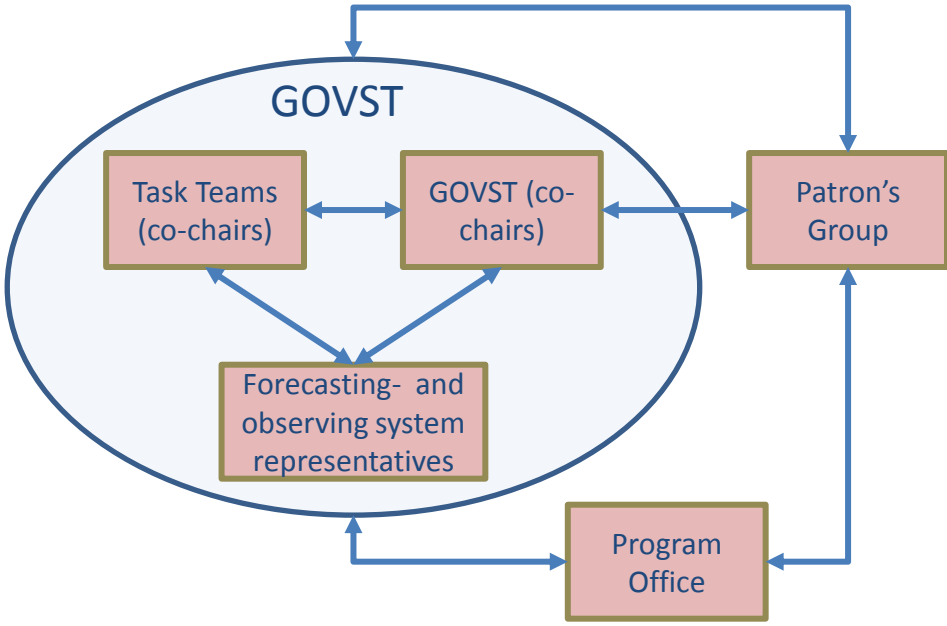
- GODAE Ocean View (GOV) Introduction
- GOV Coupled Prediction Task Team (CP-TT) Overview
- CP-TT activities and links with WGNE
- Examples of results from CP-TT members
- Summary

GOV Science Team (GOVST)

"Core Goal": GODAE OceanView continues the legacy of GODAE in providing leadership in consolidating and improving R&D for global & regional ocean analysis and forecasting systems.

GODAE Ocean View (GOV) is represented by the **GOV Science Team or GOVST**:

- *Representatives* from national, international and intergovernmental organisations with an expertise in operational ocean monitoring and forecasting



GOVST co-Chairs: Andreas Schiller (CSIRO, Australia) and Fraser Davidson (DFO, Canada)

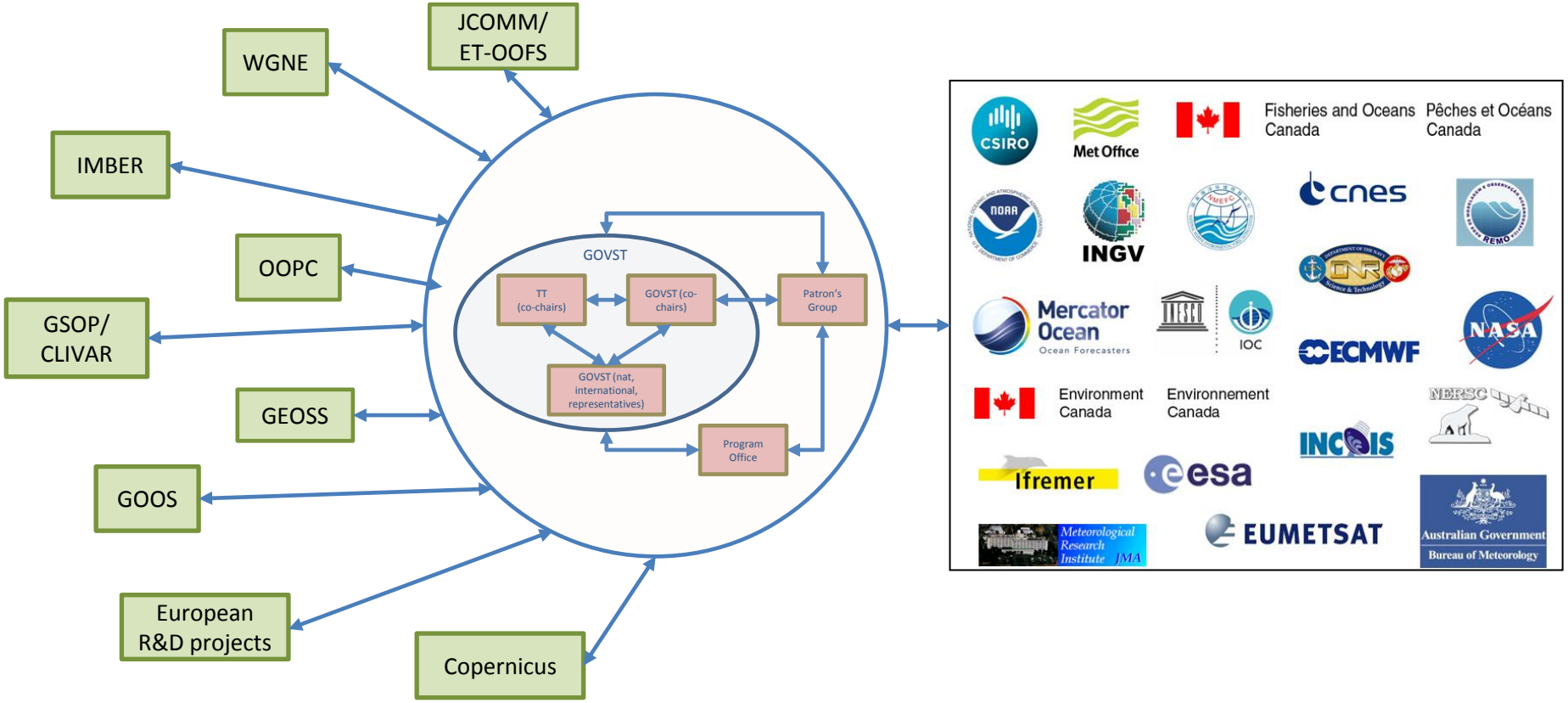
The GOVST is guided by a **group of Patrons** providing advice and advocacy to the members of the GOVST with regard to science activities, collaborations and resources.

The GOV is supported by the **programme office.**

GOV an International Programme

GODAE OceanView

" GOV is inherently an international endeavour": GOV provides a platform for international collaboration which is being integrated with parent bodies, international research programs and research initiatives related to ocean analysis and prediction including those within WCRP and IOC/WMO.



GOV structure & task teams

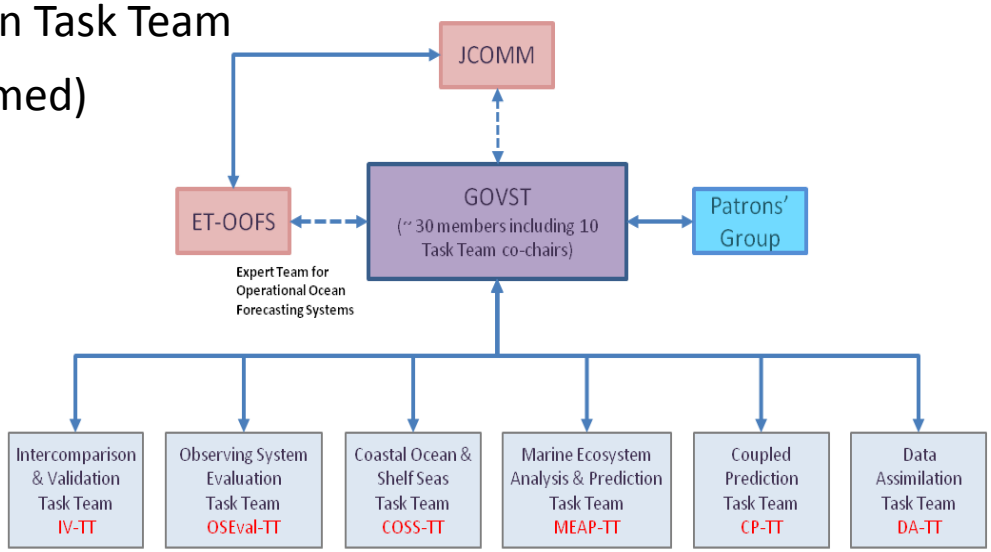
Task Teams: "GODAE OceanView aims to coordinate the development of new capabilities through a number of Task Teams (or TTs) which focus on specific topics of particular importance to GODAE OceanView."

All task team chairs are members of the GOVST.

The current GODAE OceanView task teams are:

- **COSS-TT**: Coastal Ocean and Shelf Seas Task Team
- **CP-TT**: Coupled Prediction *(renamed Oct 2014)*
- **IV-TT**: Intercomparisons and Validation Task Team
- **MEAP-TT**: Marine Ecosystem Analysis and Prediction Task Team
- **OSEval-TT**: Observing System Evaluation Task Team
- **DA-TT**: Data Assimilation (recently formed)

- TT address specific topics of particular interest to GOV
- TT work in collaboration with international programmes and research groups



Acknowledgements

With thanks to GOV Programme Office Coordinator Kirsten Wilmer-Becker,
most of the preceding material is based on

- Presentations/proceeding the latest GOV Annual meeting, Oct 2014 (see group picture below)
- GOV review (Washington, November 2013)
- Contributions from the GOV Task Team co-chairs

Coupled Prediction Task Team (**CP-TT**)

The mission goal of the CP-TT is to draw together the international scientific and technical expertise in ocean, sea-ice and wave prediction and to seek collaboration with equivalent expert groups in atmospheric-land surface-hydrology prediction to accelerate the scientific and technical development of fully coupled systems for short- to medium-range prediction.

Co-Chairs: Chris Harris (Met Office) and Hal Ritchie (Environment Canada)

Focus areas for activities and projects

- Coupled prediction in an Earth Systems Modeling context but with a focus on the role of and impact on oceans (e.g., ocean-ice-wave interactions)
- Coupled data assimilation in coordination with Data Assimilation Task Team

CP-TT (continued)

Main priorities for activities and projects

- Facilitate exchange of national and international programs of scientific progress
- Collation of quantified impact of earth system coupling for ocean-wave-sea-ice-atmosphere and interfacial flux phenomena
- Foster targeted research on particular topics of interest to GOV members (e.g., SST/diurnal cycle, sea ice impacts on boundary layer fluxes, wave coupling)

CP-TT Activities

Year 1

- Clarify and refine the CP-TT workplan and plan some items in more detail
- Agree suitable test cases / periods for comparison of coupled / uncoupled GOV systems
- Prepare an inventory of GOV coupled systems and related plans (coupling methods including sequencing of component models, relative resolutions of components, interpolations between components, details of where flux calculations are performed, initialization, treatment of rivers, etc.)
- Build links with WGNE starting with participating in WGNE-30
- Interact with the recently formed Coupled Global Modelling (CGM) Committee in the US
- Participate in DA-TT Workshop 20-22 May 2015 at Met Office, Exeter UK
- Start work on specific research areas (including SST/diurnal cycle)

CP-TT Activities (continued)

Year 2

- Continued work and reporting / exchange of results on research activities from the workplan agreed in year 1
- Common test cases inter-compared for GOV coupled systems
- **2nd Joint GOV-WGNE workshop on Modelling/DA/observations?**
- Continuing interactions with the DA-TT and CGM Committee
- Interactions with the IV-TT on metrics for coupled model performance

Year 3

- Prepare reports on comparisons of processes (e.g., SST/diurnal cycle, sea ice impacts on boundary layer fluxes, wave coupling,…) for common test cases
- Facilitate participation and exchanges for the Year of Polar Prediction
- Continuing interactions with the DA-TT, IV-TT, WGNE and CGM Committee

CP-TT Activities and Expected Outcomes

Year 4

- First high resolution GOV coupled global NWP systems operational
- Continuing interactions with DA-TT, IV-TT, WGNE and CGM Committee

Expected outcomes include

- Improved prediction of ocean-wave sea ice and atmospheric phenomena
- GOV systems extended to GOV Coupled Prediction systems
- Increased collaboration and scientific dialog between operational and research groups
- Facilitated sharing of algorithms and experience
- The bringing together of several task teams to tackle overarching issues

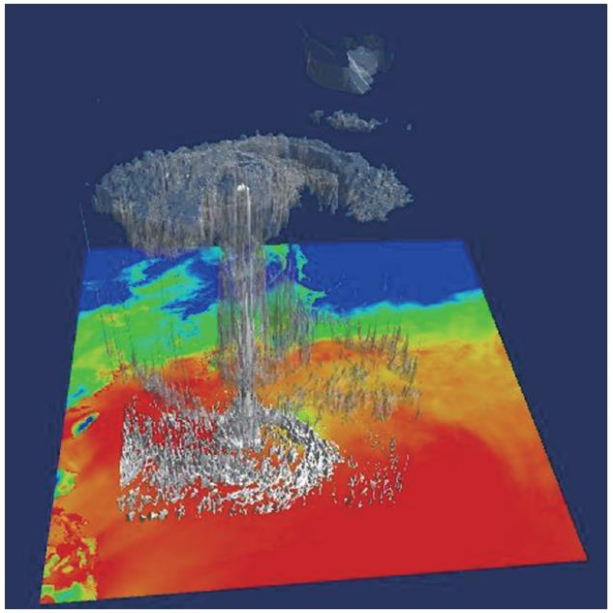
Research activity in the Meteorological Research Institute(MRI), Japan Meteorological Agency(JMA)

5-Year Research Projects in MRIJMA, associated with CP-TT

- Research on the improvement of typhoon track forecasting and objective intensity analysis
- Research on development of a coupled atmosphere-ocean data assimilation system

Atmosphere-wave-ocean coupled model for tropical cyclone simulations (Typhoon Talas in 2011)

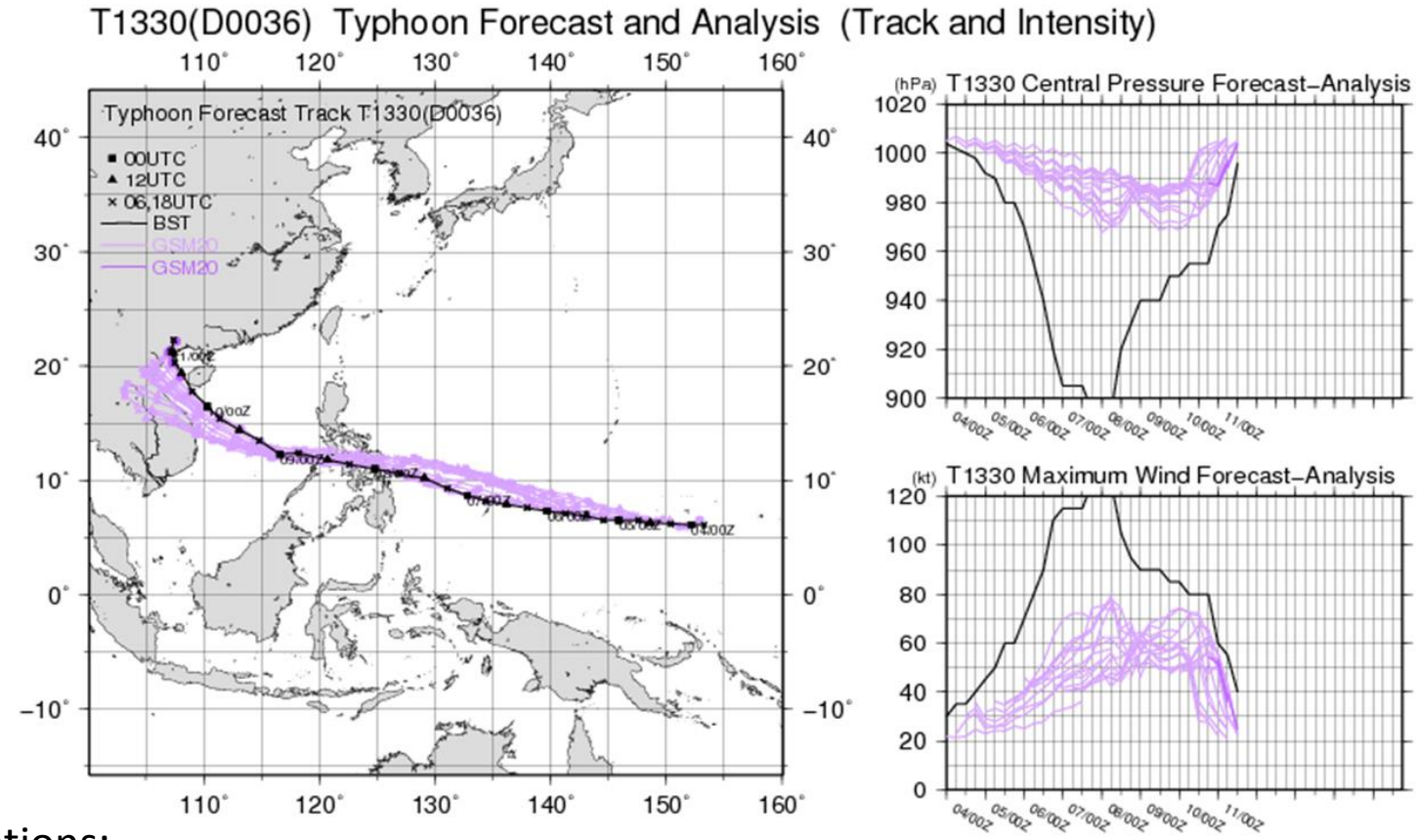
- A nonhydrostatic atmosphere model (operational model in JMA)
- A multilayer ocean model
- The third generation ocean surface-wave model (operational model in JMA)



http://www.mri-jma.go.jp/Research/project/plans_en/A3.html

Topic: Numerical simulation for Typhoon Haiyan in 2013 (AOGS2014@Sapporo)

GSM20km non-coupled model



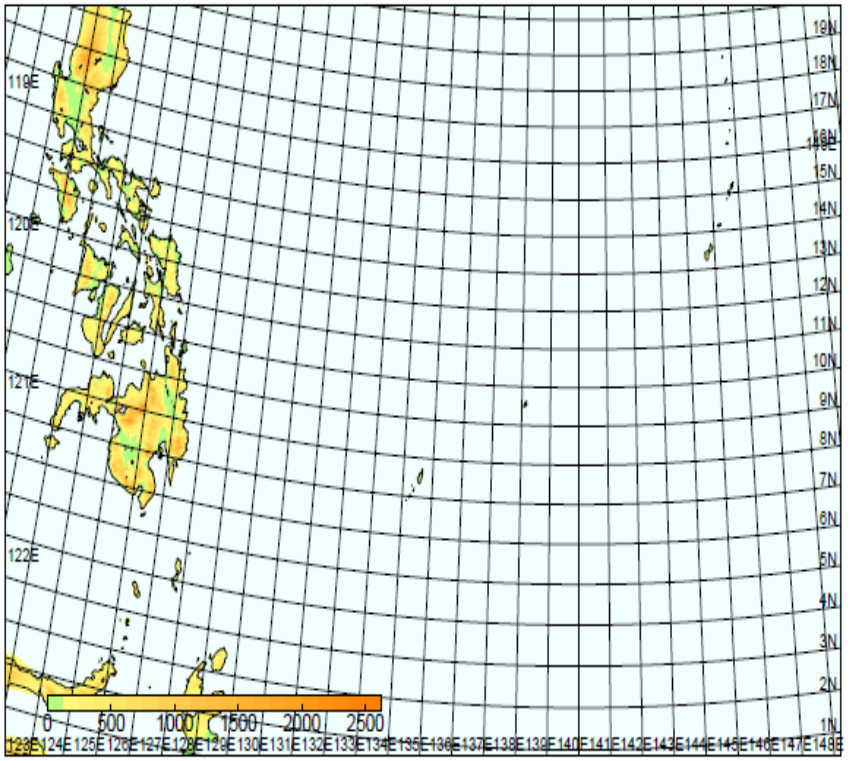
Motivations:

1. What mechanisms/processes are related to extremely rapid intensification of Haiyan?
2. Why could Haiyan reach the minimum central pressure (895 hPa according to RSMC Tokyo) lower than 900 hPa?
3. Roles of pre-existing oceanic conditions/Haiyan-induced sea surface cooling on extremely rapid intensification/extremely maximum intensity of Haiyan.

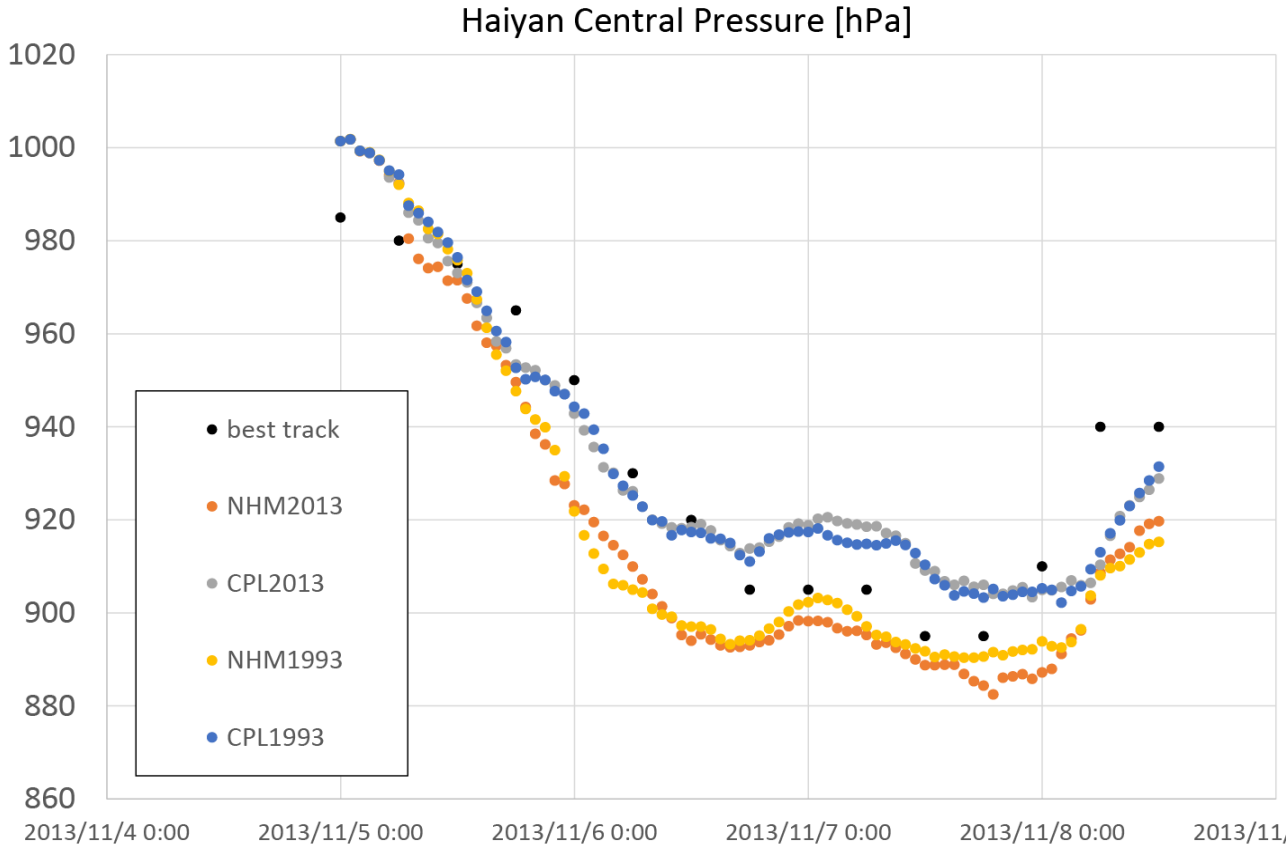
Experimental Design

- Initial integration time 0000 UTC on 5 November 2013
- Integration period 84 hours
- Atmospheric initial conditions
  JMA Global objective analysis data with a grid spacing of approximately 20 km
- Oceanic initial condition
  Daily analysis of the North Pacific version of MRI multivariate Ocean Variational Estimation (MOVE)
  NHM2013, CPL2013: Daily analysis on 5 September in 2013
  NHM1993, CPL1993: 10-day mean analysis on 5 September in 1993
- Model :
  A nonhydrostatic atmosphere model (NHM)
  A coupled NHM-wave-ocean model (CPL: Wada et al., 2010)
- Horizontal resolution: 2.5km
- Vertical levels: 54 (Top height ~27 km 40~1013m)
- Sea-spray parameterization (Bao et al., 2000) was used.

Computational domain



Results of simulated central pressure and horizontal distribution of SST



Four SST patterns

Coupled model

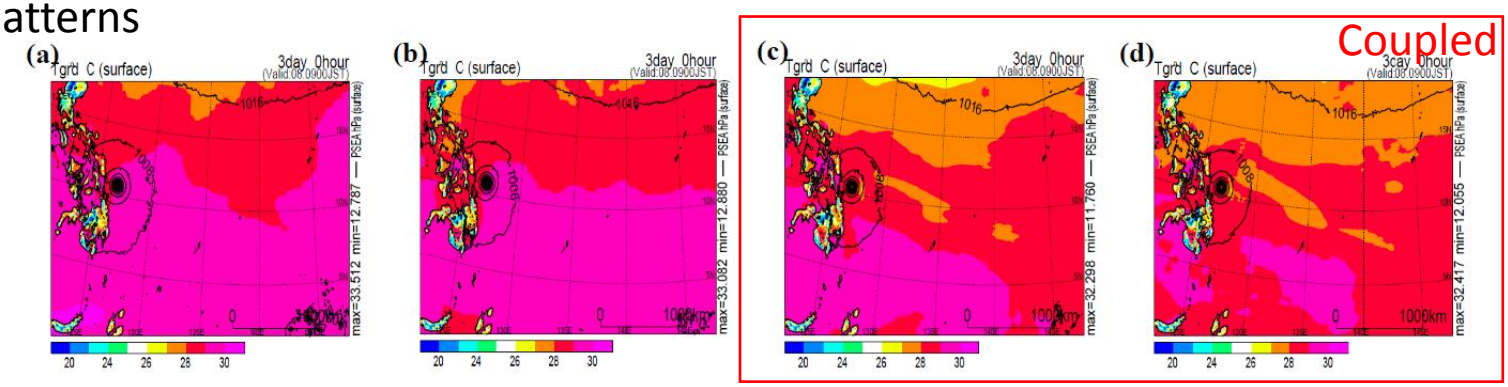
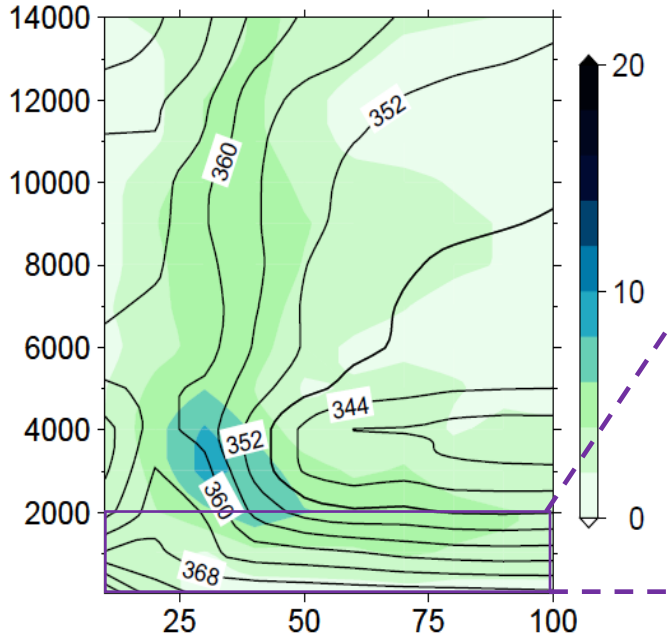


Figure 2 Horizontal distributions of sea surface temperature at 0000 UTC on 8 November (72 h integration time) in (a) NHM2013, (b) NHM1993, (c) CPL2013 and (d) CPL1993

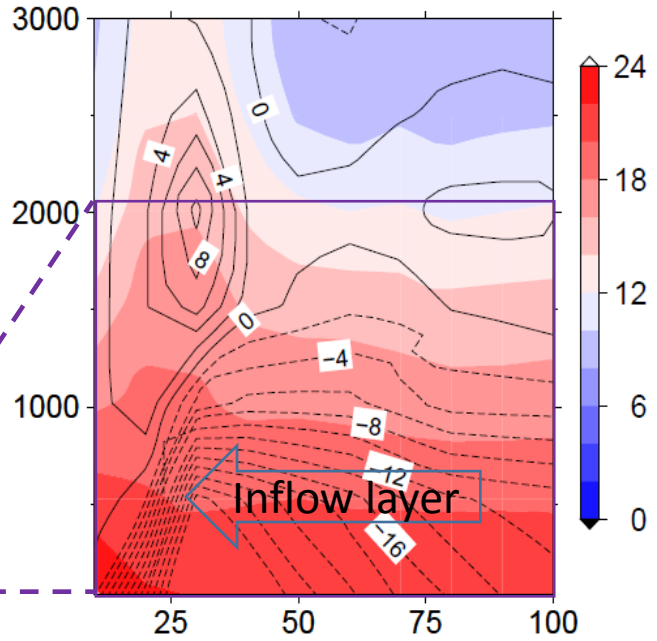
Axisymmetrical structure during rapid intensification (at 24h)

NHM

Contours:
Ave θ_e
Shades:
Std θ_e



Reduction in θ_e by CPL

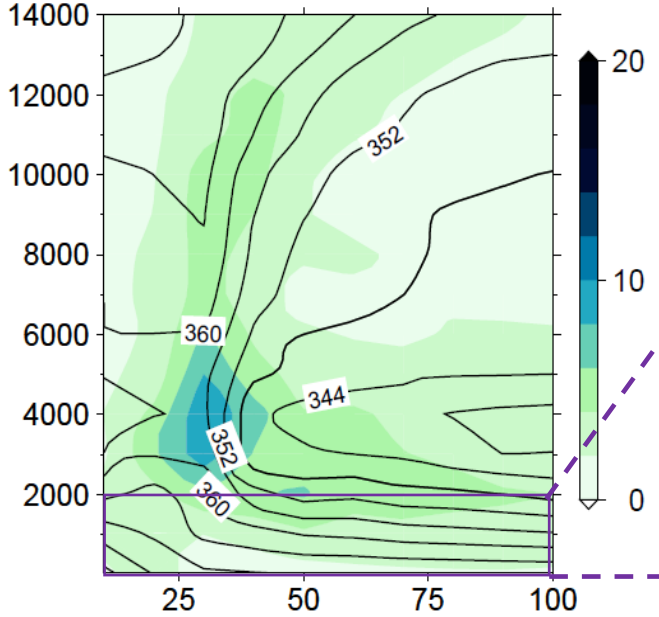


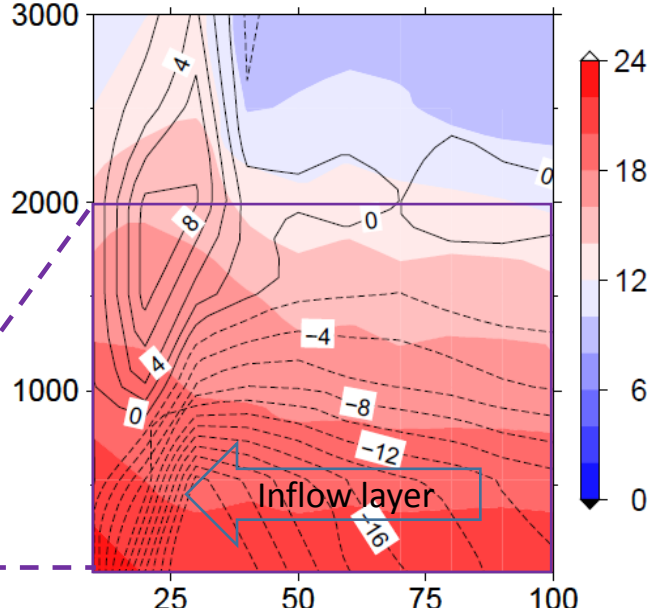
Reduction in Q_v by CPL

Contours:
Ave V_r
Shades:
Ave Q_v

CPL

Contours:
Ave θ_e
Shades:
Std θ_e





Contours:
Ave V_r
Shades:
Ave Q_v

FY2015 Research plan in the Meteorological Research Institute(MRI), Japan Meteorological Agency(JMA)

- Research on the improvement of typhoon track forecasting and objective intensity analysis

1. Migration of the coupled model to new MRI HPC (FX100) system (in progress)
2. Case studies using simulations by the coupled model
3. Introduction of the coupled model to a NHM-LETKF system in MRIJMA

- Research on development of a coupled atmosphere-ocean data assimilation system

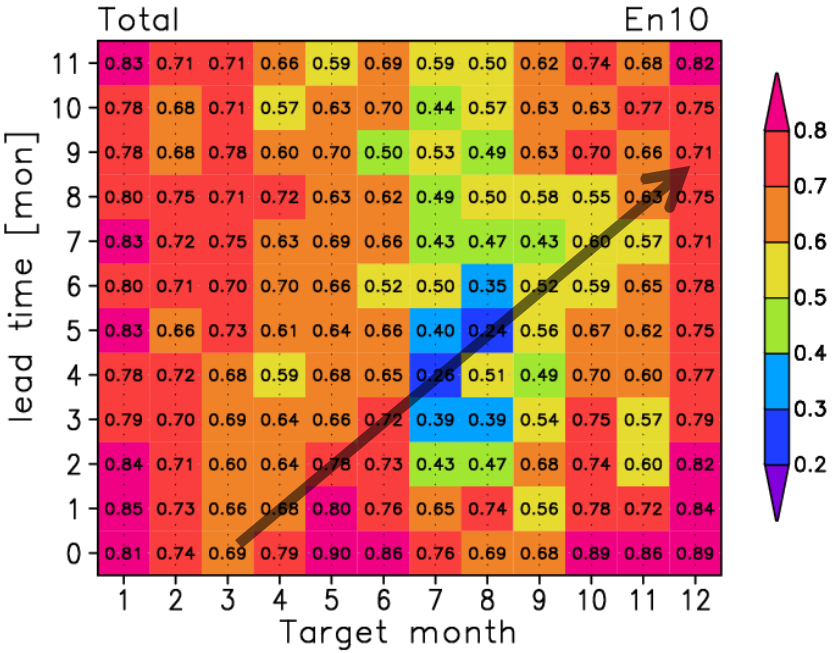
- Building the coupled system (in progress)

Interactive Sea Ice in JMA's New Seasonal EPS

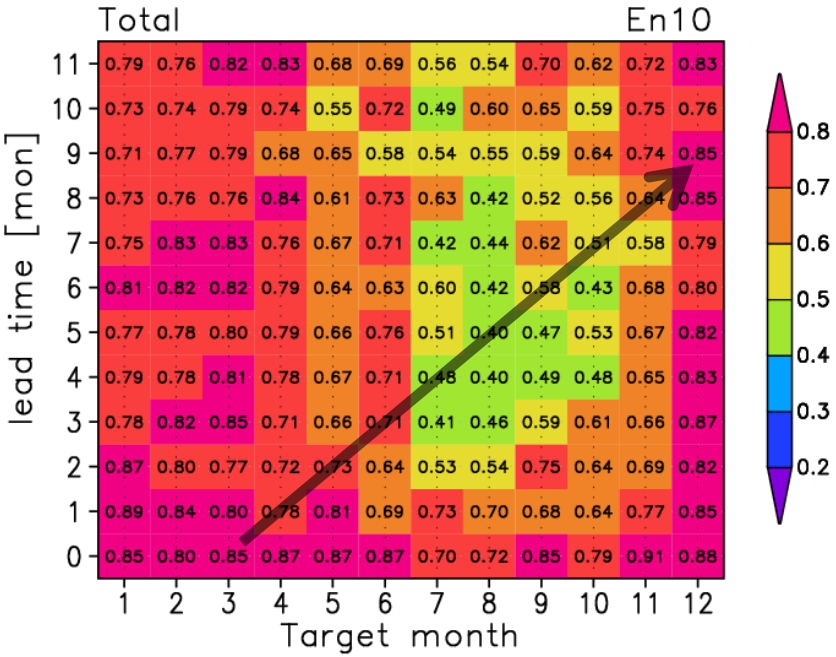
- An interactive dynamical sea ice model is introduced in the new system [JMA/MRI-CPS2]
- Sea ice prediction skills and atmospheric impacts are assessed with a set of hindcasts.

Arctic Sea Ice Prediction Skill [Rank Correlation]

Rank Correlation: Sea Ice Area



Rank Correlation: Sea Ice Extent



Sea Ice Area Total area of sea ice [area x SIC]

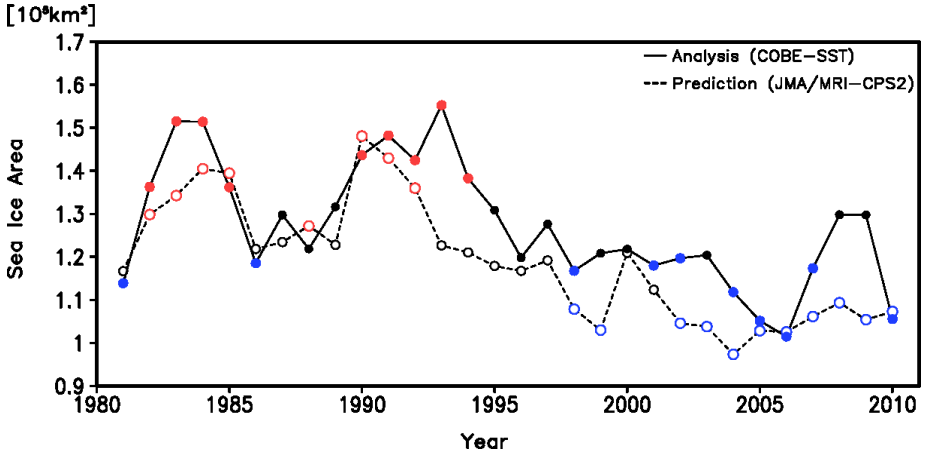
Sea Ice Extent Total area for sea ice concentration >= 15%

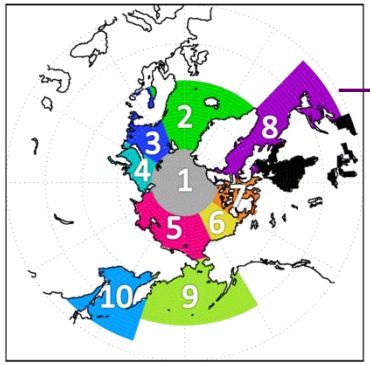
- Re-emergence of rank correlation skill is clearly seen in the hindcast, indicating relatively high potential predictability beyond the summer season.

[cf., Blanchard-Wrigglesworth et al. 2011]

Arctic Sea Ice Impacts | Labrador Sea Example

Observed and Predicted Sea Ice Area (SIA) for Labrador Sea (MAM, initial: Feb.)

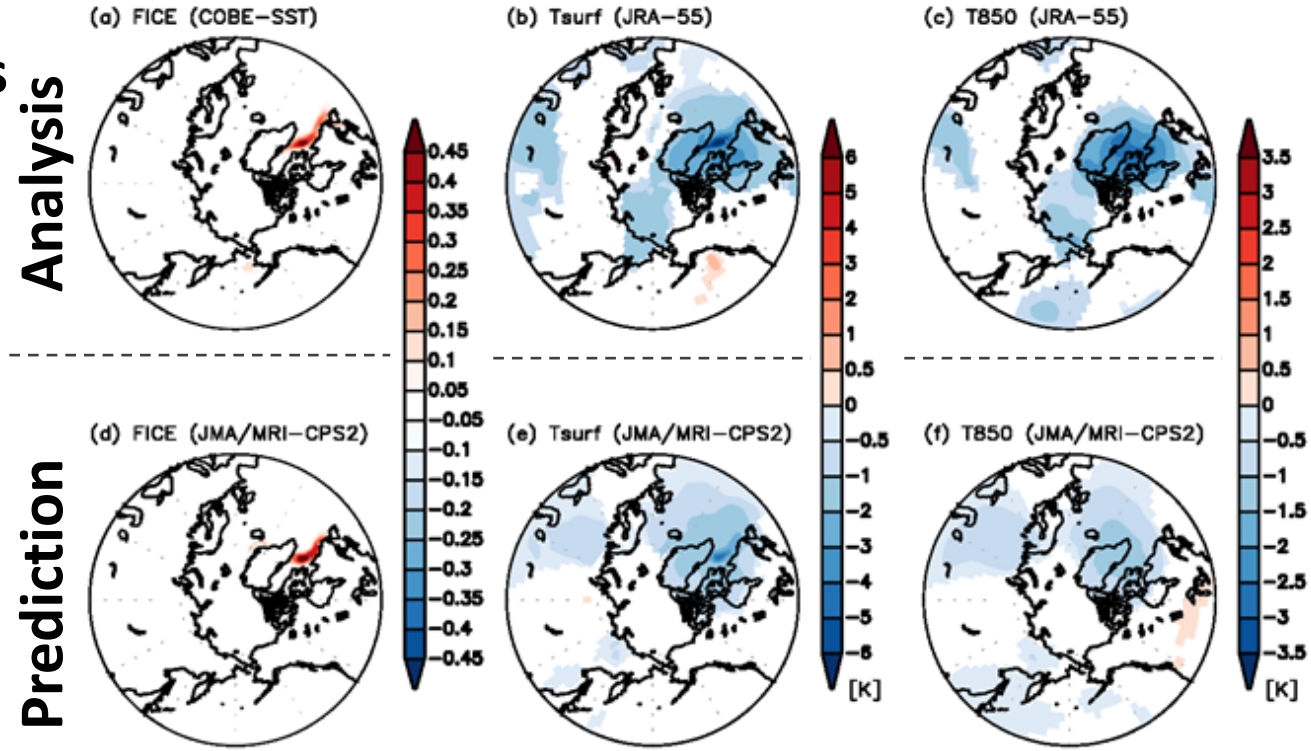




Composite differences of MAM anomalies
[high SIA – low SIA years, 1-month lead]

High SIA years:
’82,’84,’85,’90,’91,’92,’93,’94

Low SIA years:
’98,’01,’02,’04,’05,’06,’07,’10



Feasibility Study of Sub-seasonal Coupled Prediction with JMA's New Seasonal EPS

- Twin experiments [with and without coupling] are conducted.

  5-member ensemble forecasts during 1981-2010
  (Initial dates: 17 Dec., 1 Jan., 16 Jan. and 31 Jan.)

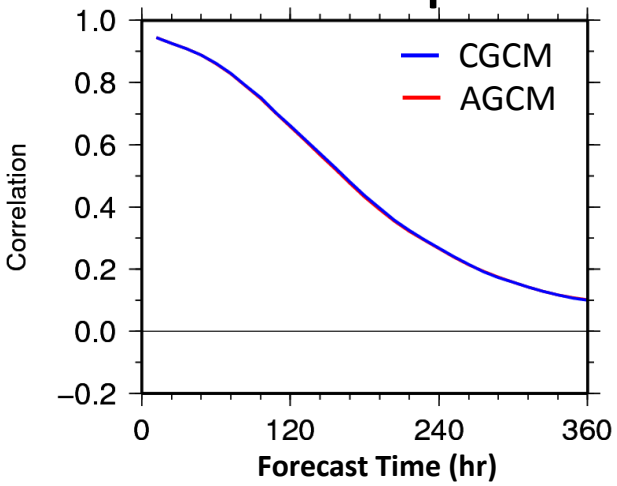
Lower Boundary Conditions	AGCM	CGCM
Sea Surface Temperature	Persisted anomaly (COBE-SST) Skin SST scheme adopted	Coupled to dynamical ocean model (global region) Skin SST scheme adopted
Sea Ice	Climatology	Coupled to dynamical sea ice model

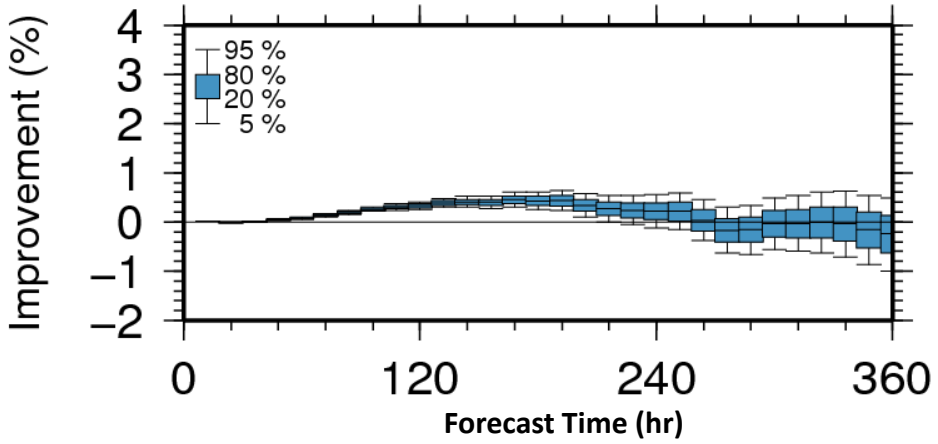
Takaya et al., 2014 WWOSC

Sub-seasonal Prediction with/without Ocean Coupling

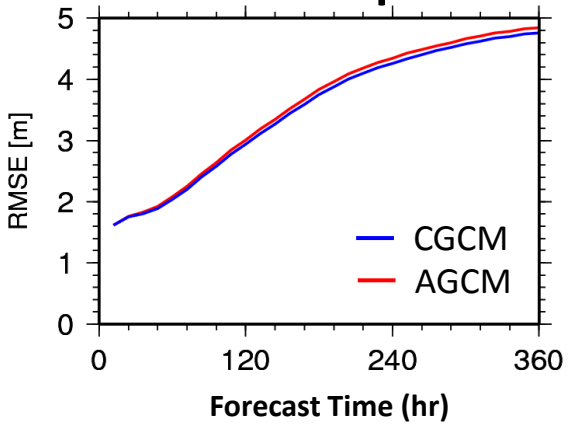
Retrospective 5-member ensemble forecasts from 17 Dec., 1 Jan., 16 Jan. and 31 Jan. during 1981-2010. (120 cases, 600 runs) were verified with the same atmospheric model.

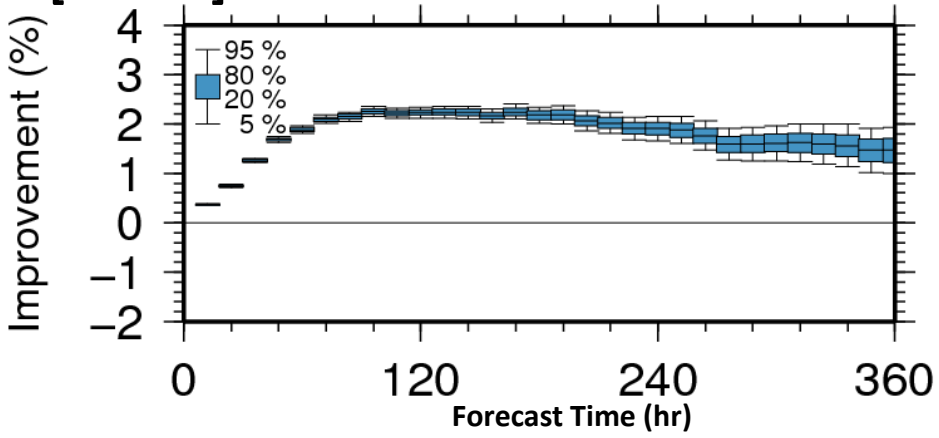
850-hPa Temperature Pattern Correlation [Global]





850-hPa Temperature RMSE [Global]





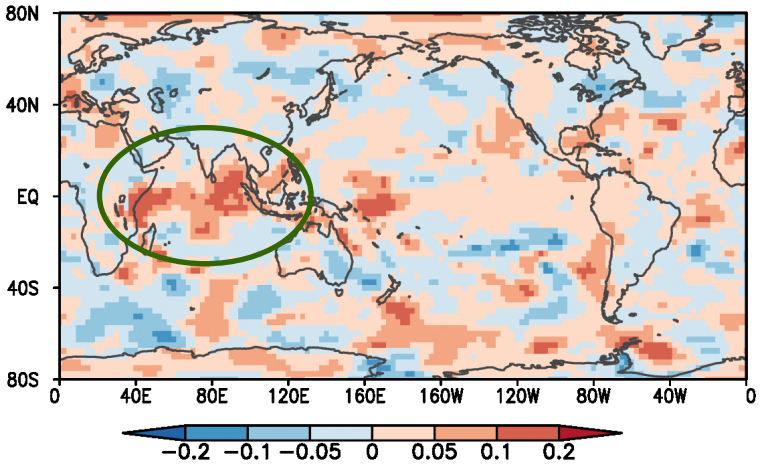
The ocean coupling improves skills in <u>some</u> (but not all) aspects.

Takaya et al., 2014 WWOSC

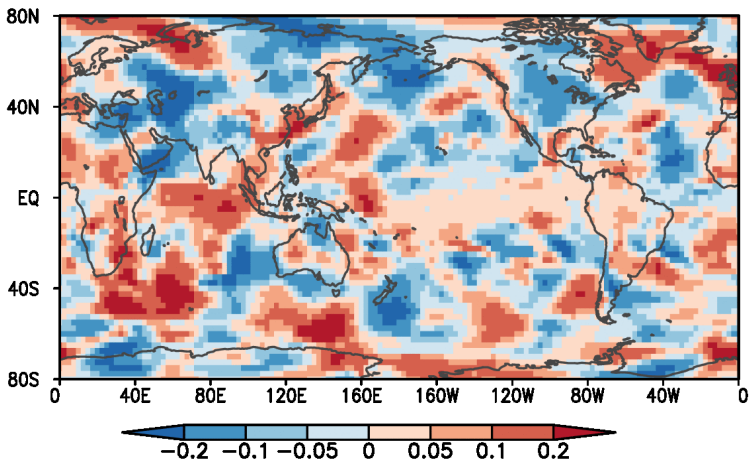
Sub-seasonal Prediction with/without Ocean Coupling

Correlation differences btw coupled and uncoupled predictions during boreal winter

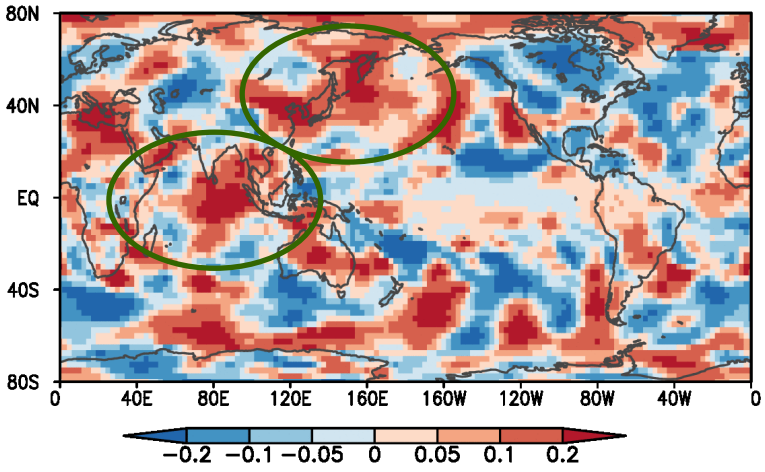
850hPa Temperature Week-2 (Day 9-15)



850hPa Temperature Week-3 (Day 16-22)



850hPa Temperature Week-4 (Day 23-29)



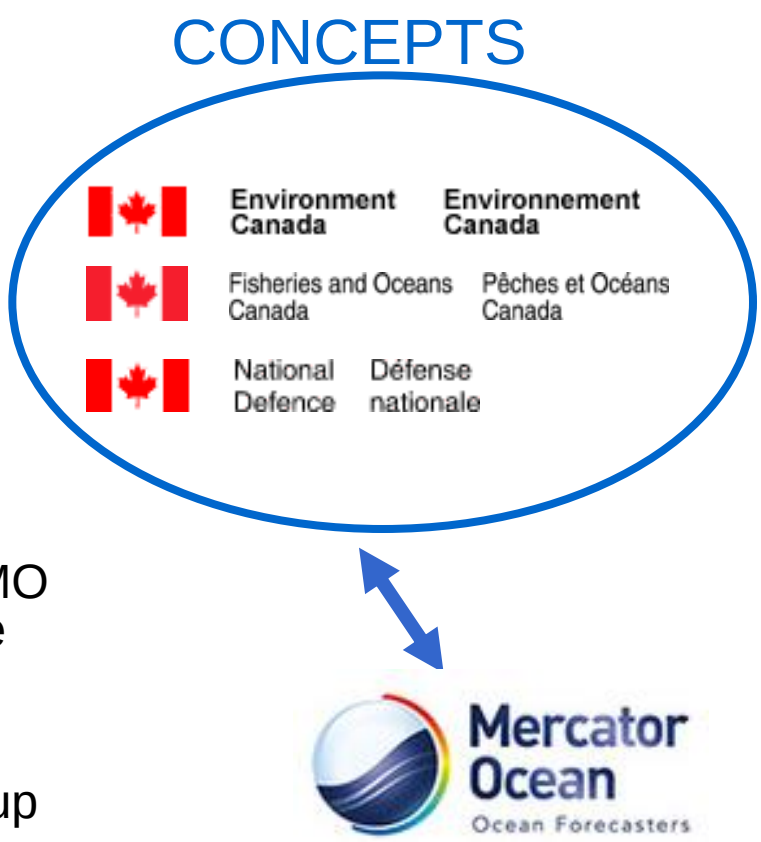
Red colors indicate that ocean coupling improves prediction skill of weekly-mean 850-hPa temperature.

Improvements over Indian Ocean in Week-2 may bring improvements in East Asia in Week-4.

Takaya et al., 2014 WWOSC

CONCEPTS Examples

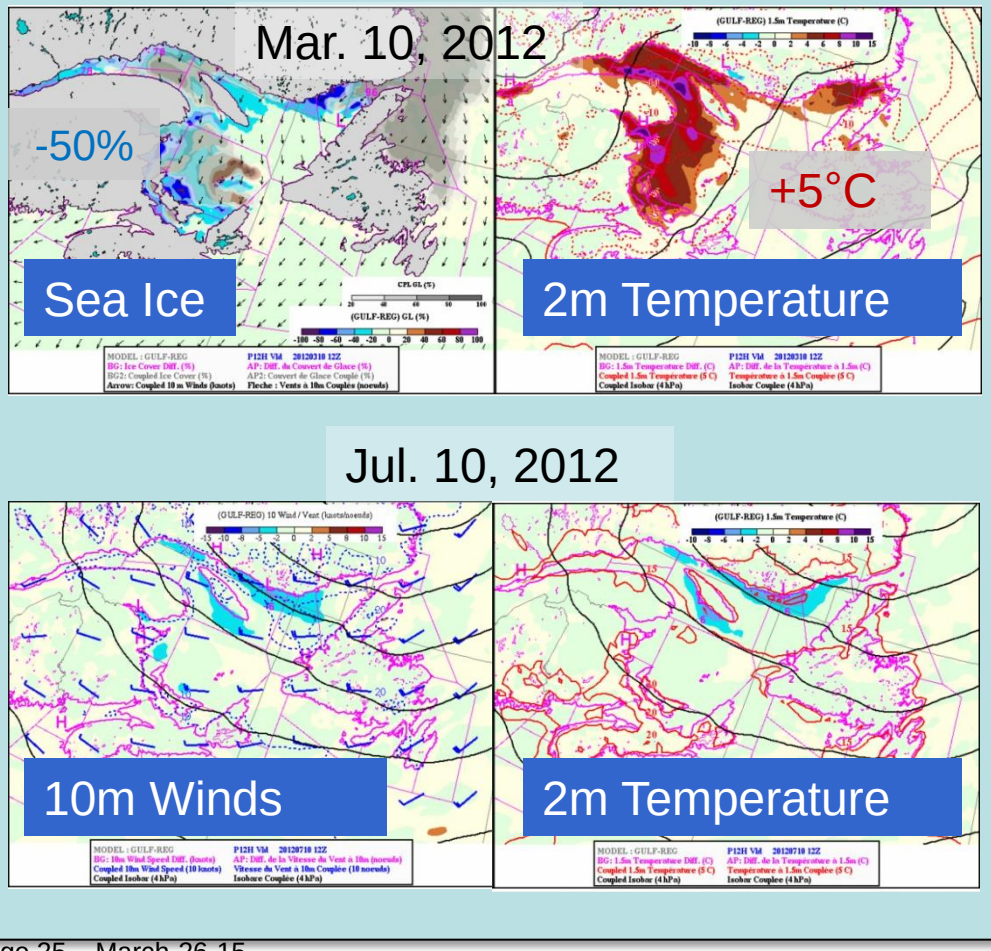
- Several new coupled systems under development as part of CONCEPTS
  - Canadian Operational Network of Coupled Environmental Prediction Systems
- Tri-departmental collaboration
  - To develop coupled atmosphere-ice-ocean forecasting systems
- Model development
  - Coupling GEM (Global Environmental Multi-scale) atmospheric model to NEMO (Nucleus for European Modelling of the Ocean)
- Collaboration with Mercator
  - French operational oceanographic group



Gulf of St. Lawrence (GSL) Coupled Atmosphere-Ice-Ocean Forecasting System

- Operational since June 2011
  - 48h forecast 4 times/day
- Coupled system:
  - Atmosphere
    - GEM (10 km)
  - Ice-ocean
    - NEMO-CICE (5km)
- Under development:
  - Atmosphere
    - GEM (2.5km),
  - Ice-ocean
    - NEMO-CICE(1km)
  - Include Great Lakes
  - PAN AM games

Coupled – Uncoupled differences



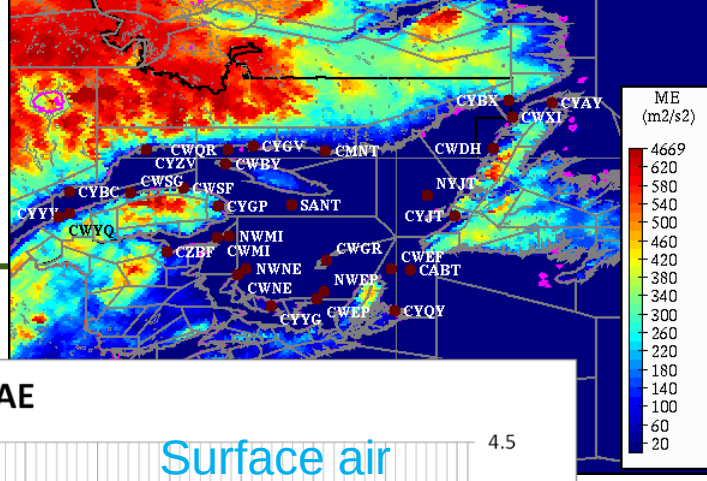
Environment Canada

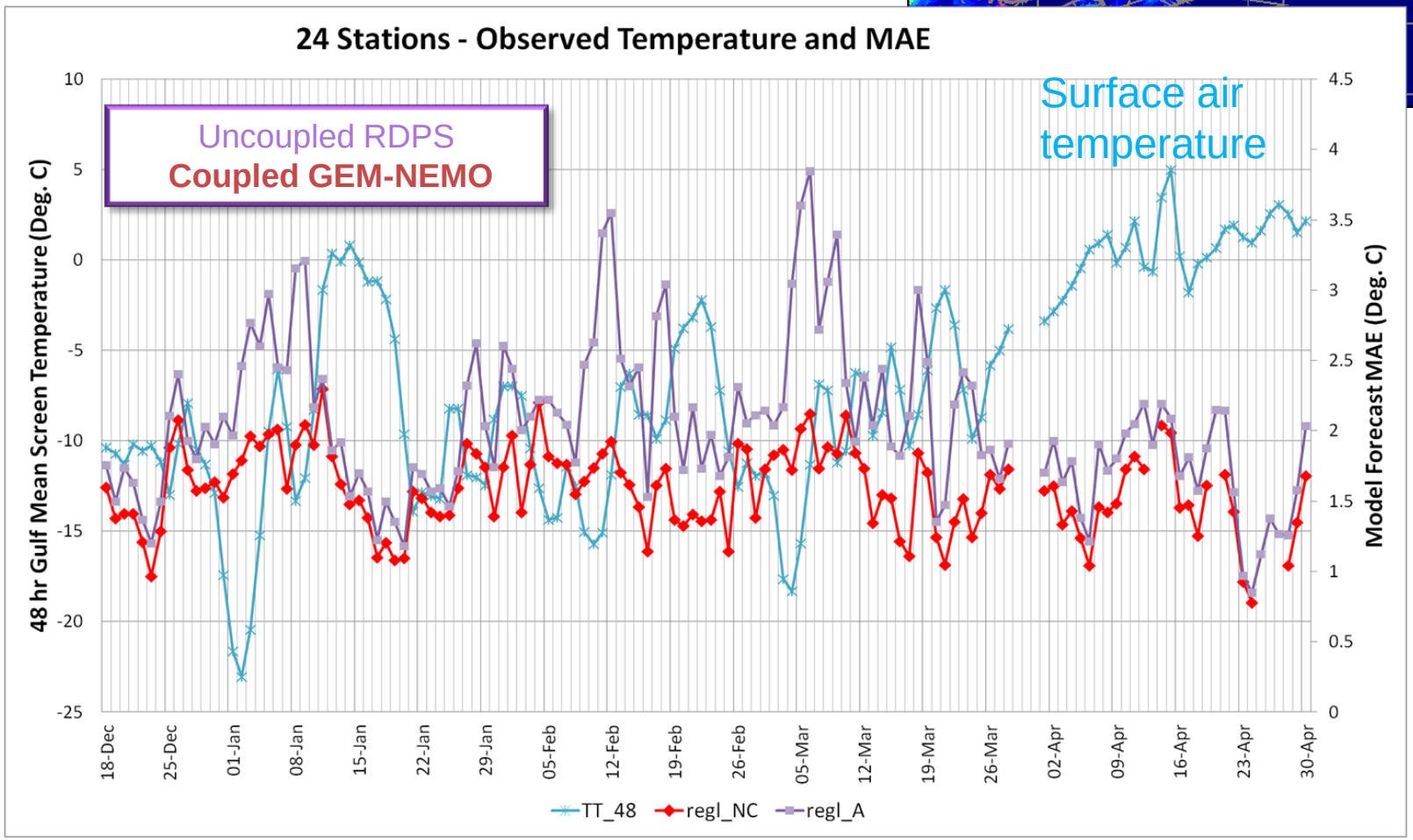
Francois Roy, Sarah Dyck, Mark Pilon, …

Canada

Real-time evaluation of Coupled GSL Forecasting System

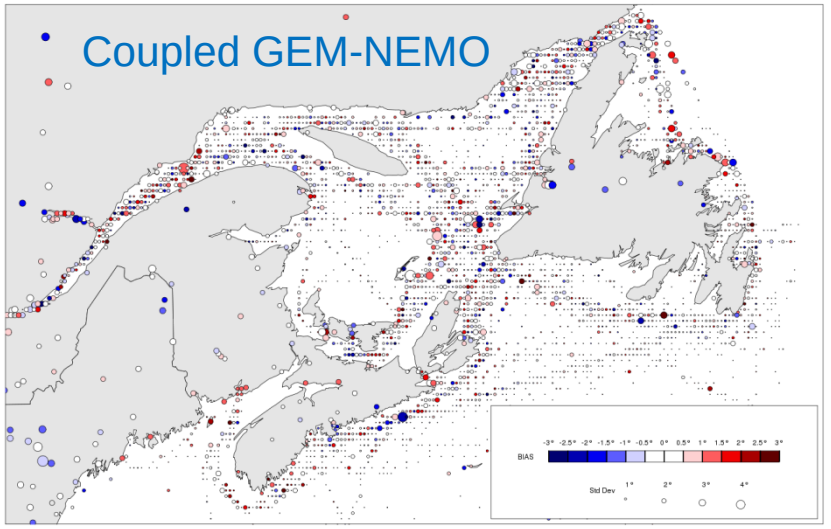
Mark Pilon, Sarah Dyck, Francois Roy

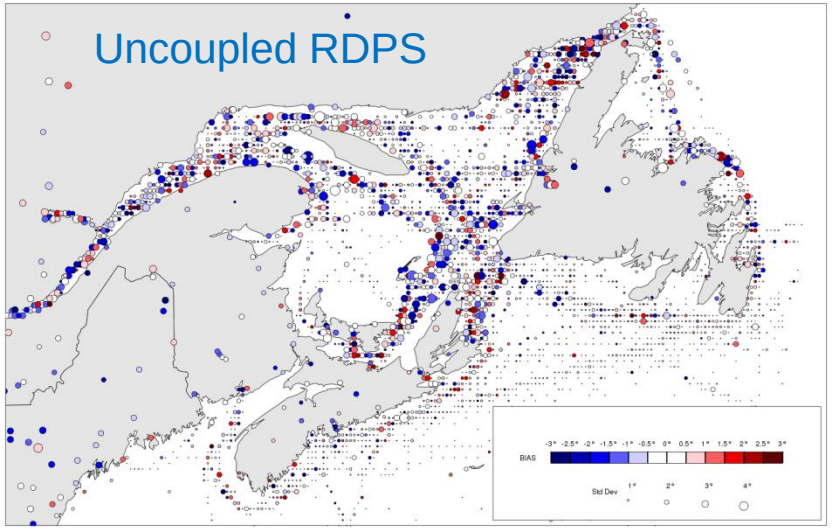




Real-time evaluation of Coupled GSL Forecasting System

- Evaluation against all surface temperature observations
  - 48hr forecasts over Jan-Mar 2014
  - Colours show bias
  - Standard deviation shown by the size of each circle
- Smaller errors in coupled system over water
- GSL is an ideal laboratory for studying impacts of coupling!

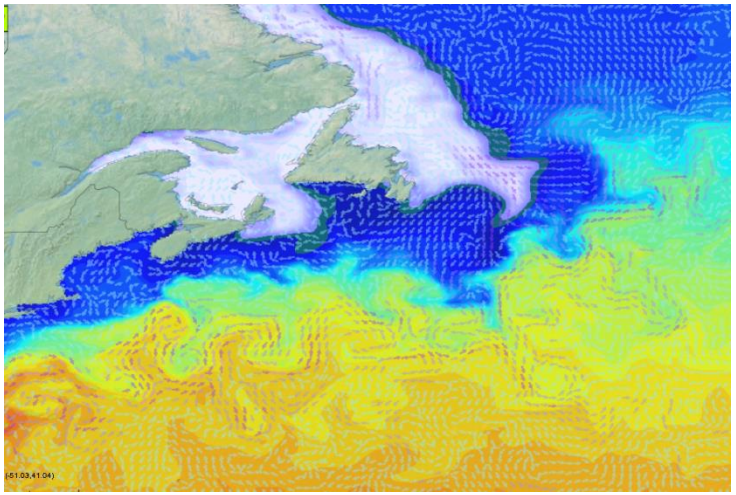


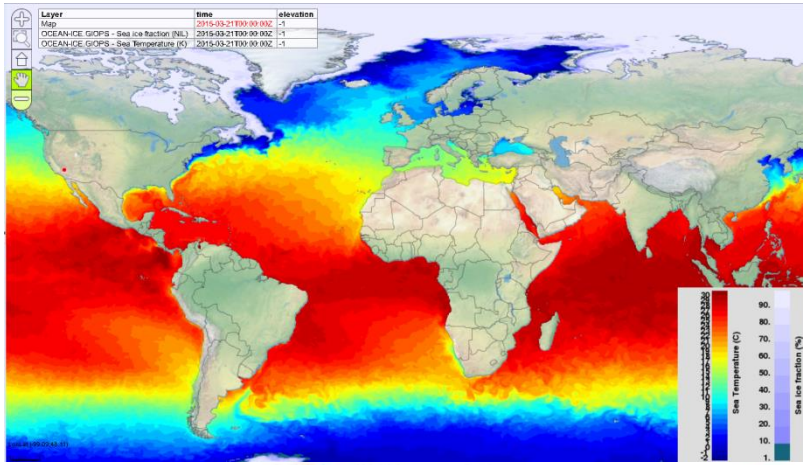


Global Ice-Ocean Prediction System

Dorina Surcel Colan, Matt Reszka, Francois Roy, Daniel Deacu, Yimin Liu, …

- Produces daily ice-ocean analyses and 10day forecasts
  - NEMO-CICE (~1/4°), < 15km in Arctic
- Mercator Ocean Assimilation System (SAM2):
  - Sea surface temperature
  - Temperature and salinity profiles
  - Sea level anomaly from satellite altimeters
- 3DVar Ice analysis:
  - SSM/I, SSM/IS, CIS charts, Radarsat image analyses
- Experimental implementation (March 2014)
- Purpose:
  - Boundary conditions for regional systems
  - Initialize seasonal forecasts
  - Emergency response
  - Global coupled forecasting

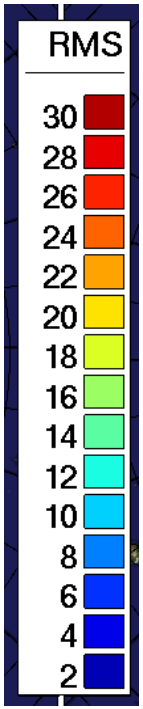


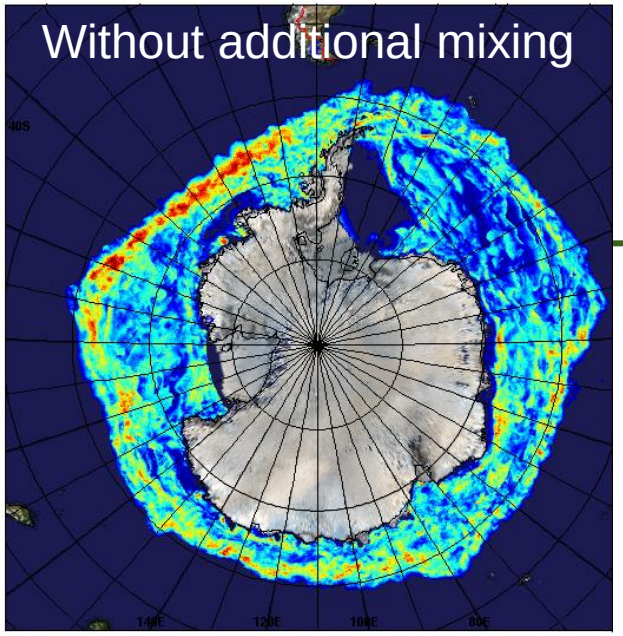


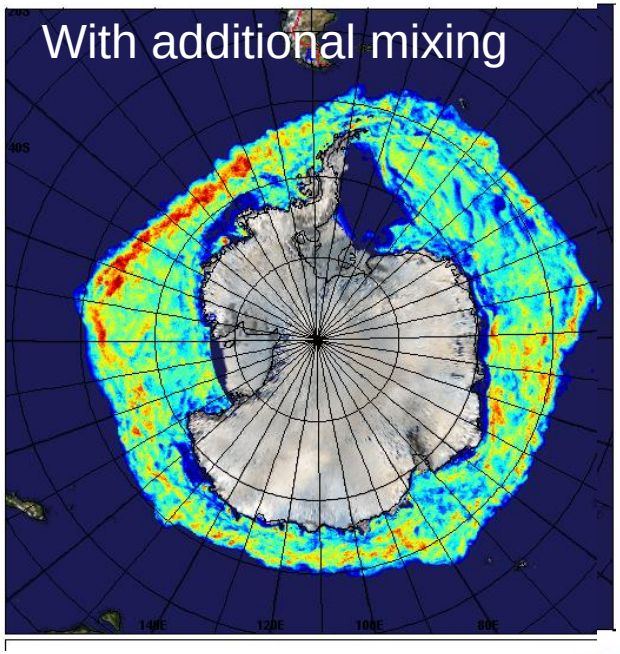
Smith et al., QJRMS, in review

Sea ice forecasting

- CMC Global Ice-Ocean Prediction System (GIOPS)
  - 7day RMS forecast error evaluated against analyses for 2011 (50 weekly forecasts)
  - Restricted to points where analysis changed by more than 10%
- Ice forecast skill exhibits strong sensitivity to ocean mixing
  - With/without parameterization for surface wave breaking
  - Comparison with Argo shows better results with additional mixing
  - Highlights need for more polar observations!





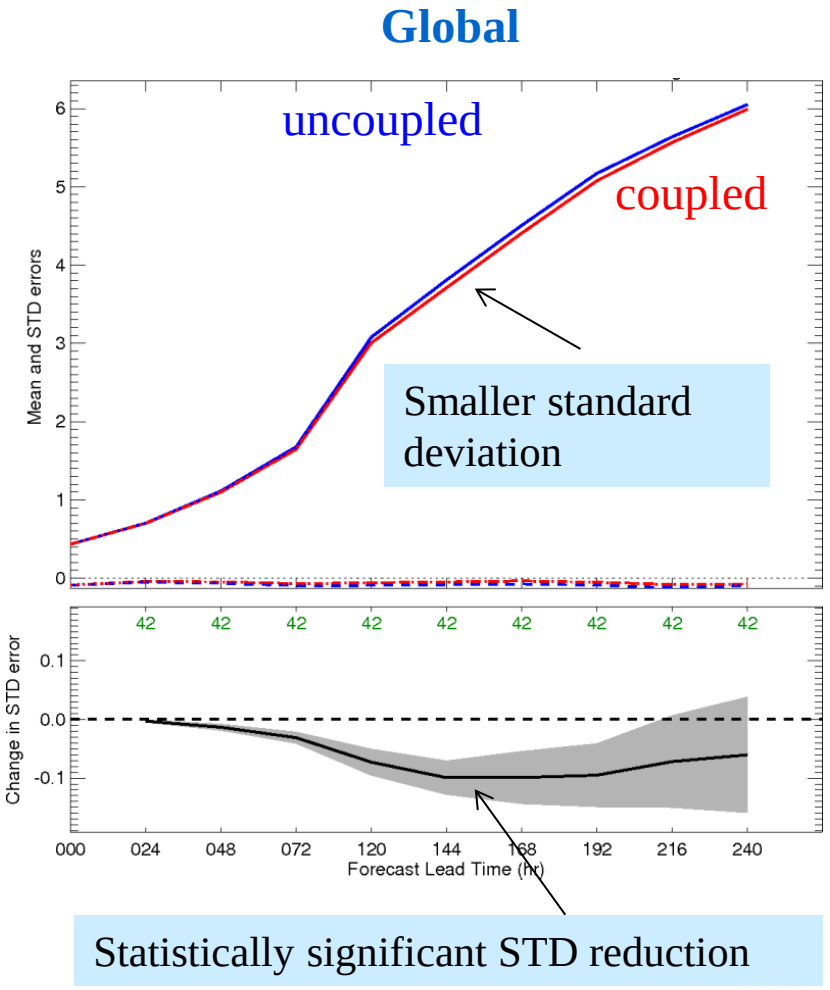


Smith et al., ECMWF Proc., 2013

Coupled Global Forecast Trials

Jean-Marc Belanger, Francois Roy, Daniel Deacu, Ryan Muncaster

- Coupled model:
  - Atm: GEM 66km
  - Ocean: NEMO-ORCA025 (1/4°)
  - Ice: CICE4
- Evaluation of summer trials underway
  - Daily 10day forecasts
  - Jul-Aug 2011
  - Verification against ECMWF for Global geopotential height at 1000hPa.



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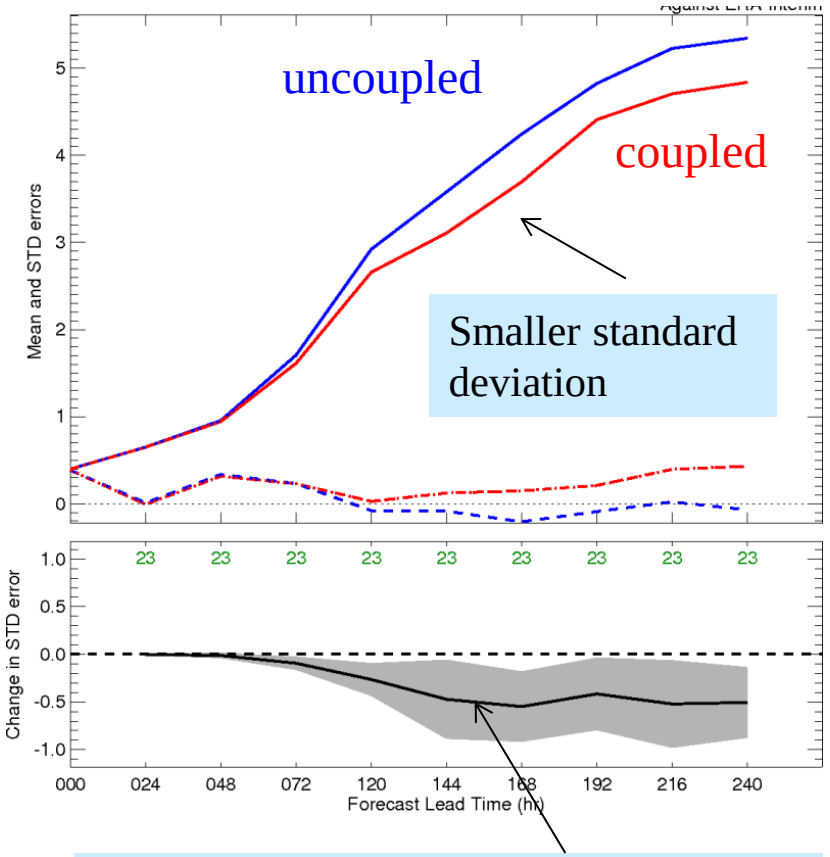
Kuroshio Region



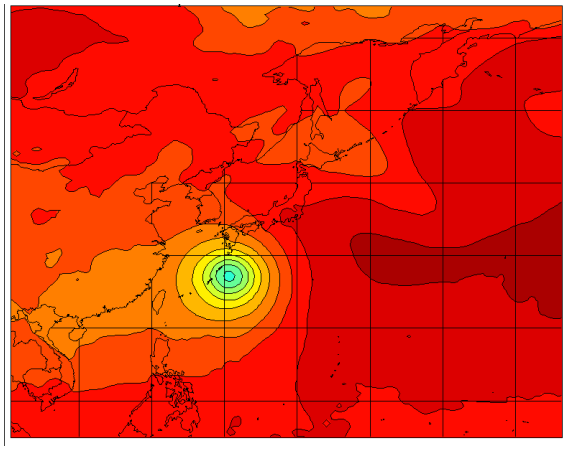
Global Coupled Atmosphere-Ice-Ocean Forecasting

Case Study : Typhoon-4 MA-ON (July 17, 2011)

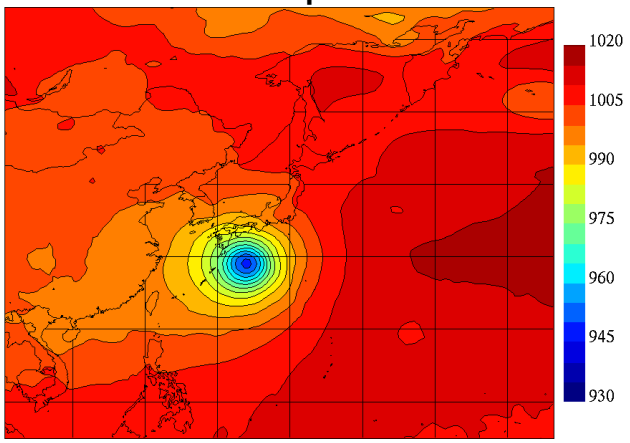
- Coupled experiments have been made using several different global configurations
- Coupling improves surface forecasts globally
- Large benefit for tropical cyclones

Sea level pressure

Coupled

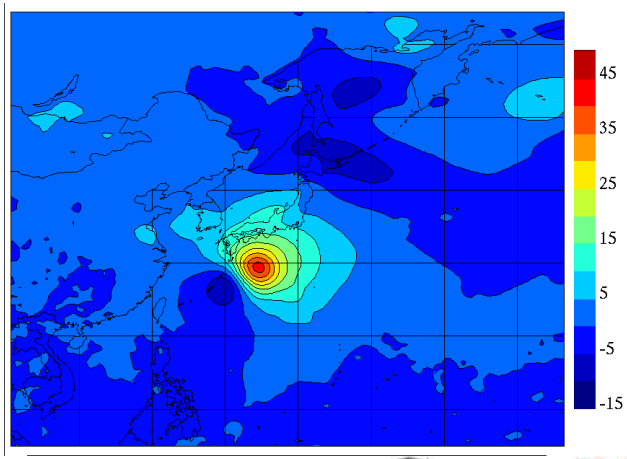


Uncoupled

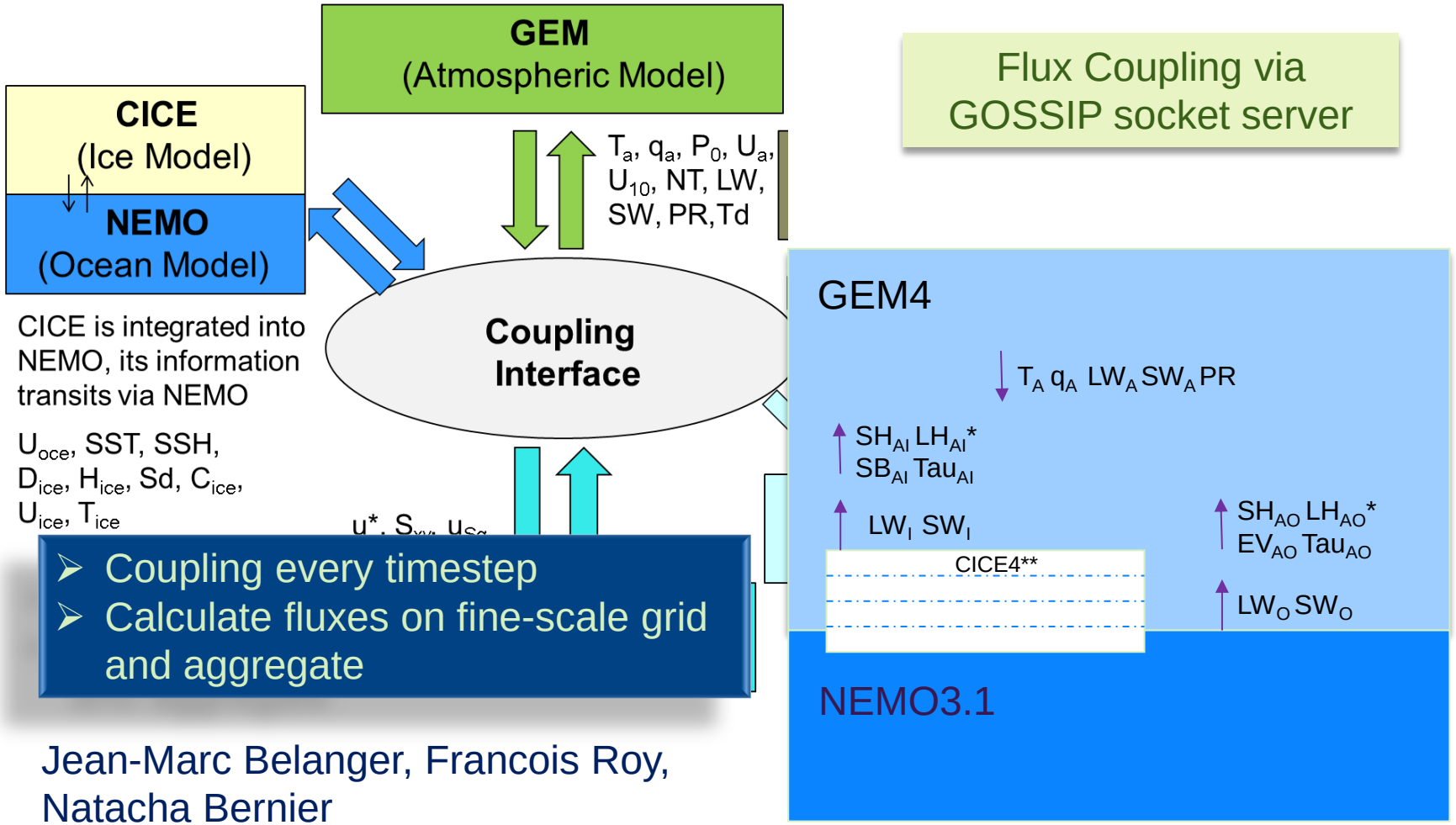


- Coupling results in weaker Typhoon
- Due mostly to reduced latent heat fluxes associated with SST cooling

Coupled-Uncoupled



Coupling Method



- Coupling every timestep
- Calculate fluxes on fine-scale grid and aggregate

Jean-Marc Belanger, Francois Roy, Natacha Bernier

Meetings and workshops

GODAE OceanView

Upcoming GOV meeting and workshops

- DA-TT workshop, 20-22 May 2015, Met Office, Exeter, UK
- MEAP-TT workshop, 23-24 June 2015, Halifax, Canada
- COSS-TT/ARCOM workshop, 31 Aug – 4 Sep 2015, Lisbon, Portugal
- 6th Annual GOVST meeting, 2-6 Nov 2015, Sydney, Australia

Summary

- GOV is coordinating an international effort of providing leadership in consolidating and improving global & regional ocean analysis and forecasting systems through its task teams.
- In particular, the Coupled Prediction Task Team (CP-TT) is drawing together international scientific and technical expertise in ocean, sea-ice and wave prediction and is fostering collaboration with expert groups in atmospheric – land surface – hydrology prediction to accelerate the development of fully coupled systems for short- to medium-range prediction.
- Research and development is in progress by CP-TT members to quantify the impacts of coupling for ocean-wave-sea ice – atmosphere phenomena and interfacial flux phenomena, which will be further pursued in the coming years.
- One particular CP-TT objective is to continue the links with WGNE related to coupled prediction as a follow up to our joint GOV-WGNE workshop that was held here at NCWCP in March 2013.

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Thank you!