The Norwegian Climate Prediction Model (NorCPM)

Noel Keenlyside, Francois Counillon, Ingo Bethke, Yiguo Wang, Mao-Lin Shen, Madlen Kimmritz, Marius Årthun, Tor Eldevik, Stephanie Gleixner, Helene Langehaug, Anne Britt Sandø, Lea Svendsen, Yongqi Gao

BCCR - Bjerknes Centre for Climate Research, Geophysical Institute (U. of Bergen), NERSC - Nansen Environmental and Remote Sensing Center, IMR - Institute of Marine Research

Yvan Orsolini*, Fei Li
NILU - Norwegian Institute for Air Research, *BCCR - Bjerknes Centre for Climate Research
Norwegian Climate Prediction Model (NorCPM)

Earth System model (NorESM1-M)

- Atmospheric chemistry
- CAM
- GICE
- CLM
- River routing
- NorESM-O
- HAMOCC

atm 2°; ocean+ice 1°

Data assimilation (EnKF)

- 30 members

Potential for long-term reanalysis (1850 – present), but so far from 1950-2010

V0 system: SST anom
V1 system: SST anom + ocean Temp-Salinity
V2 system (in prep): Ice-concentration

Counillon et al., Tellus 2014 & 2016
Focus on Arctic - North Atlantic climate

Oceanic influence

- Norwegian SAT, precipitation, and Arctic sea ice co-vary with Norwegian Sea SST.

- Climate impacts associated with regional SST anomalies are complementary to those of the NAO.

Årthun et al., Nat. Comm., 2017
NorCPM: Annual Hindcasts

- 9 ensemble members
- Retrospective forecast period from 1985 to 2010
- Forecast start from Feb, May, Aug and Nov
- Forecast length: 12 months
- Historical external/RCP8.5 forcing
- Ocean/Atm/Land initialised with re-analyses with SST anom assimilation

Courtesy of Y. Wang
ENSO seasonal prediction skill matching other systems, but initialised only with SST

Anomaly Correlation Sea Surface Temperature for Niño 3.4 index (NOAA OISST) 1985-2010

North American Multi-model Ensemble

NorCPM

Courtesy of Stephanie Gleixner
SST seasonal prediction skill high in Nordic Seas

Anomaly Correlation for Sea Surface Temperature with observations
Period 1985-2010, 9 ensemble members

6-month lead from 1st of August

Courtesy of Stephanie Gleixner
Anomaly correlation skill, 6-month predictions, SST NorCPM, North American Multimodel Ensemble
Assessing the benefit of ocean T-S data for seasonal prediction skill

Seasonal forecast skill (currently) not improved by adding subsurface ocean temperature and salinity data

Courtesy of Yiguo Wang
Seasonal forecast skill (currently) not improved by adding subsurface ocean temperature and salinity data.

Nino 3.4 SST, 1985-2010, 4 start dates per year

Anomaly Correlation

Root mean square error

Nino 3.4 SST correlation (with HadISST)

Nino 3.4 SST RMSE

- - - Persistence
Blue: NorCPM SST–anom ini
Red: NorCPM SST–TS–anom ini

Courtesy of Yiguo Wang
Testing assimilation of ice concentration

Earth System model (NorESM)

- Atmospheric chemistry
- CAM
- CLM
- River routing
- NorESM-O
- HAMOCC

Data assimilation (EnKF)

30 members

Synthetic sea ice

Monthly aggregated ice conc. from model: NorESM at a different time (pre industri.)

Future: satellite-derived SIC, thickness

V0 system: SST
V1 system: SST+T-S
V2 system: Ice-concentration

What is the best way to assimilate this data:
- Weakly coupled DA / Strongly coupled DA ?
  (i.e. assimilation with/w.o. ocean)
Test assimilation of SIC with a fully coupled system (ocean-sea ice) (i.e. strongly coupled data assimilation) and with a multi-category sea ice model

Correlation between ice concentration at green dot and sub-surface Salinity

Correlation between ice concentration at green dot and sub-surface Salinity

Strong coupled DA:
✓ SIC, thick, and thermos in every category
✓ T and S in the mixed layer depth
Ensemble KF: handle the flow-dependent and strongly anisotropic cross-covariance between ocean and sea ice

Sakov et al. 2012

Courtesy of F. Counillon, M. Kimmritz, Y Gao
What do we gain by assimilating ice concentration compared to a free ensemble run

Mean RMSE reduction compared to FREE over 10-year reanalysis

Blue means improvement!

Courtesy of F. Counillon, M. Kimmritz, Y Gao
Norwegian Climate Prediction Model (NorCPM) : used in SNOWGLACE

Seasonal hindcasts (3 months)

Land: land model (CLM) off-line run
Atmosphere: nudging period with ERAINT
Ocean & sea ice: NorCPM re-analyses

Also : High top (WACCM) : 140 km (full stratos chemistry)

YOPP Proposal submitted

SUBSEASONAL-TO-SEASONAL PREDICTION FOR THE ARCTIC
(S2S-ARCTIC)

Yvan J. Orsolini 1,3 (Project Manager), Francois Counillon 2,3,4, Yongqi Gao 2,3,5, Noel Keenlyside 2,3,4, Madlen Kimmritz 2, Fei Li 1, Fumiaki Ogawa 3,4, Nour-Eddine Omrani 3,4, Mao-Lin Shen 3,4

International Collaborators

Hisashi Nakamura, Research Center for Advanced Science and Technology, Univ. of Tokyo, Japan

Jun Inoue, National Institute of Polar Research, Japan

Francisco Doblas-Reyes, Barcelona Supercomputing Centre, Barcelona, Spain

Cecilia Bitz, Univ. of Washington, Seattle, USA

Daniela Domeisen, ETH Zurich, Switzerland
Conclusions

- Weakly coupled data assimilation of SST anomalies using EnKF has potential for skilful long-term reanalysis (1850 to present) in the North Atlantic, North Pacific, and Tropical Pacific.
- NorCPM with only SST achieves competitive skill in seasonal predictions compared to NMME systems.
- **(decadal prediction)** good skills up to 3-4 years for S2D, with degradation beyond due to model limitation in east subpolar gyre

- Ongoing development for assimilation of ice concentration tested in idealised experiment: it is best to update the multicategory sea ice & ocean (Strongly coupled DA) with flow dependent covariance (EnKF)
  - Assimilation of ice concentration reduces substantially error in thickness, and ocean T & S without introducing a drift
RESERVE SLIDES
SLP in winter

Initialisation with SSTA

SLP correlation @ DJF

Anomaly Correlation (NCEP) 1985-2010

Initialisation with SSTA, T-S A

SLP correlation @ DJF

start date: April

start date: July

Courtesy of Yiguo Wang
Anomaly correlation skill, 6-month predictions, SST
NorCPM, North American Multimodel Ensemble