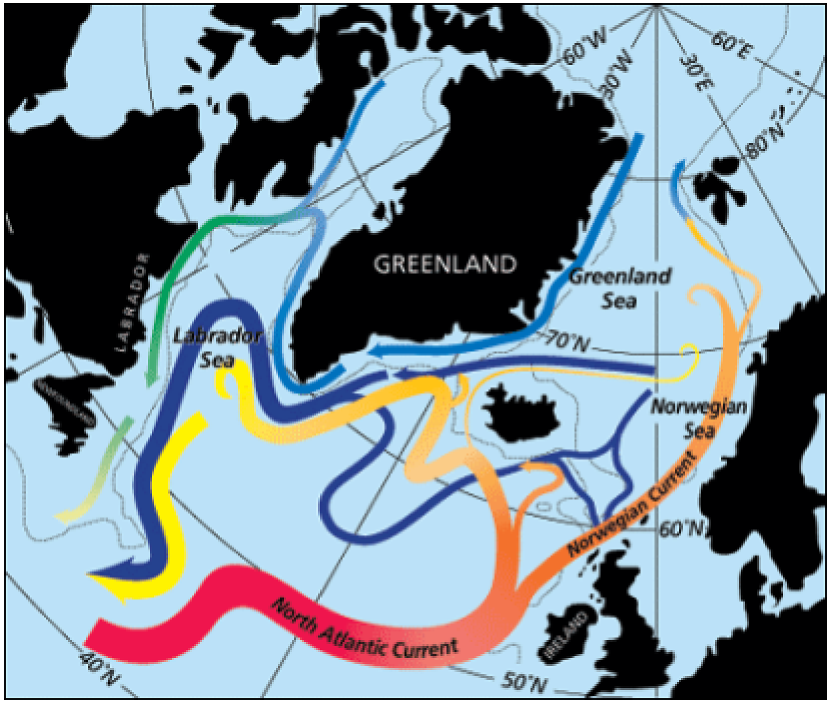
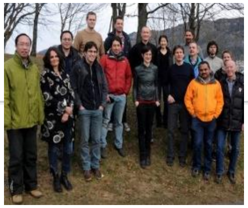
EPOCASA Project: Coord. N. Keenlyside

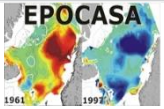
To improve our understanding of seasonal-to-decadal predictability in the Atlantic Sector

- Development of a Climate prediction system
- Predictability of Subpolar Gyre
- What mechanisms support the predictability?
- How to enhance the predictability base on our understanding?

- Tool: Norwegian Climate Prediction model (NorCPM)

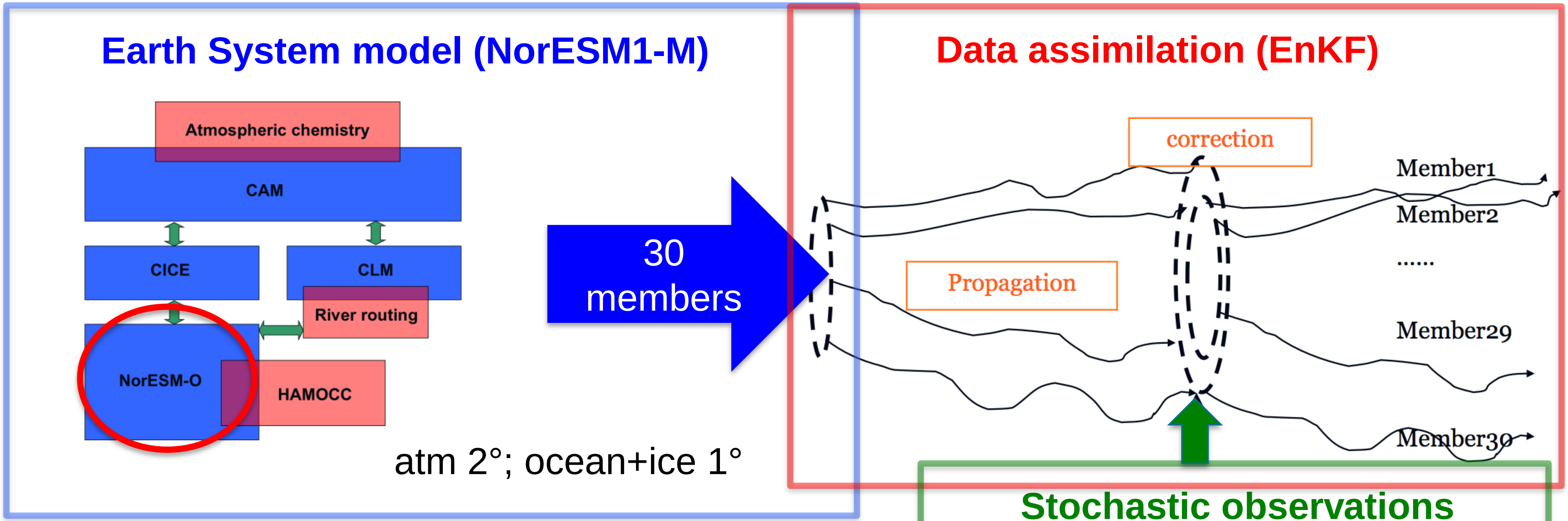






Norwegian Climate Prediction Model (NorCPM) V1

See Counillon et al. (2014, 2016) Tellus

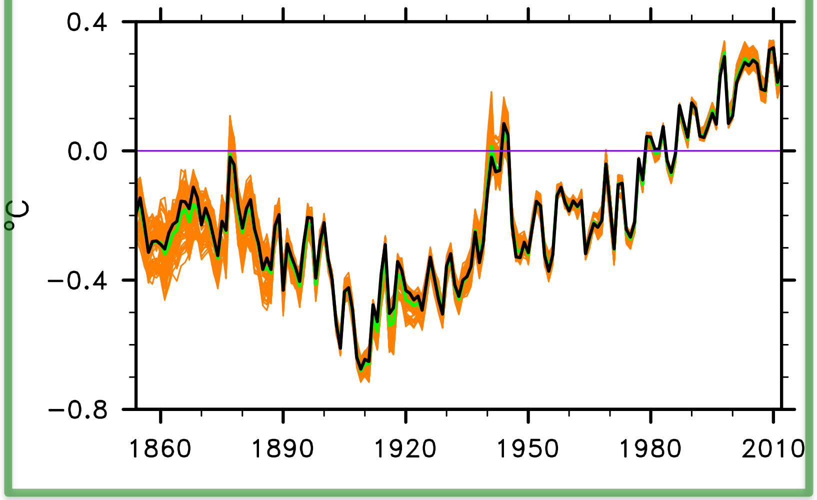


Earth System model (NorESM1-M)

atm 2°; ocean+ice 1°

Data assimilation (EnKF)

Stochastic observations
HadISST2



Long term objectives:

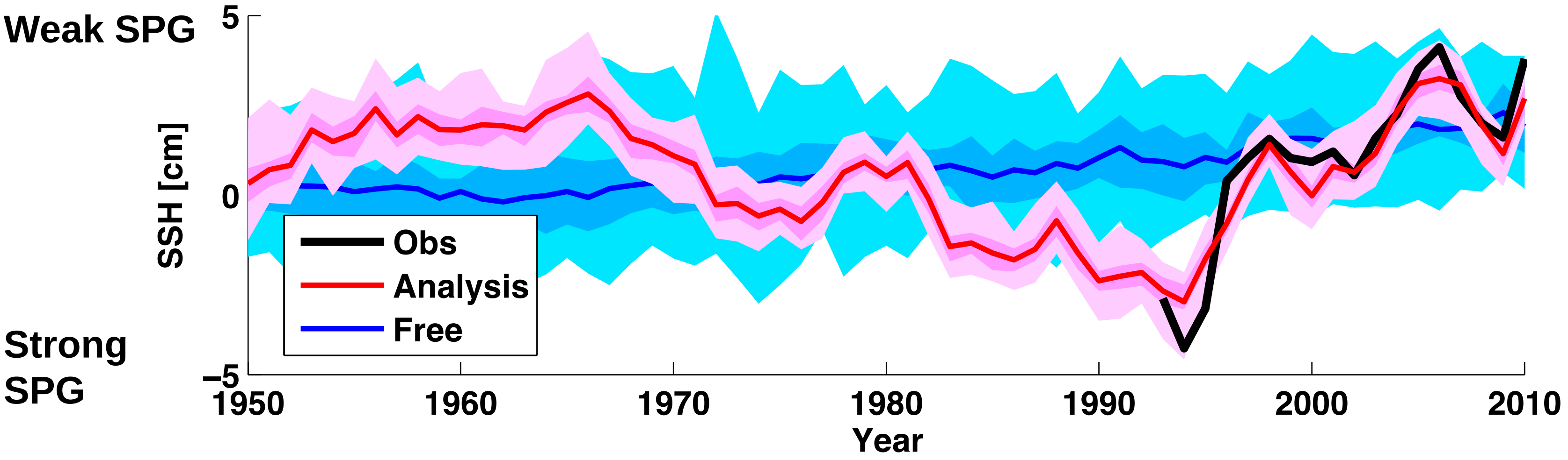
- Seasonal-to-decadal prediction (CMIP6)
- **Long term reanalysis (1850 – present)**

Assimilation :

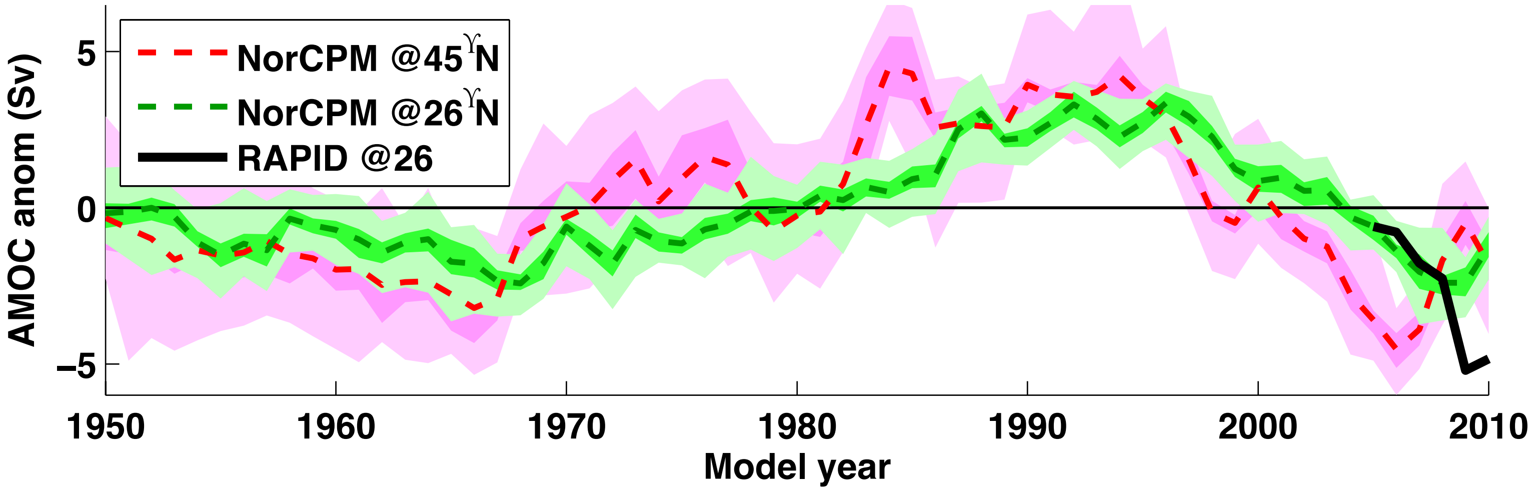
SST, temp-salinity
Sea Surface Height (testing)
Ice concentration & thickness (in development)

SST assimilation constrains large-scale North Atlantic Ocean circulation

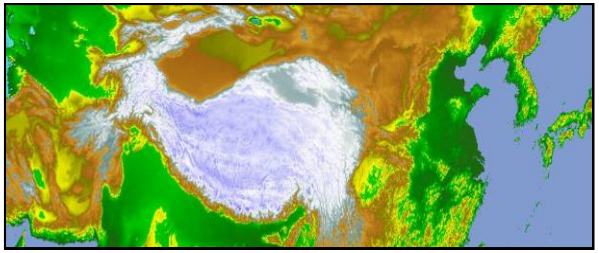
Subpolar gyre index based on SSH

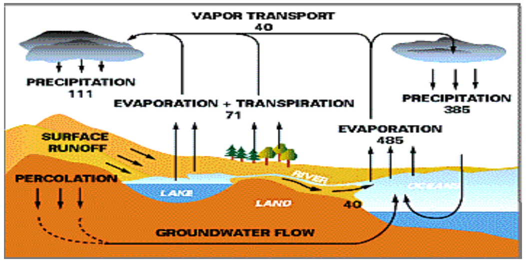


Atlantic Meridional Overturning Circulation index



- Good match with independent observation for AMOC and SPG
- **Potential to reconstruct North Atlantic variability from 1850-present**





Influence of springtime Himalayan-Tibetan Plateau snow on the onset of the Indian summer monsoon

Yvan J. Orsolini[1,2]

Collaborators : **Retish Senan[3], Antje Weisheimer[4], Gianpaolo Balsamo[4], Emanuel Dutra[4], Frederic Vitart[4]**

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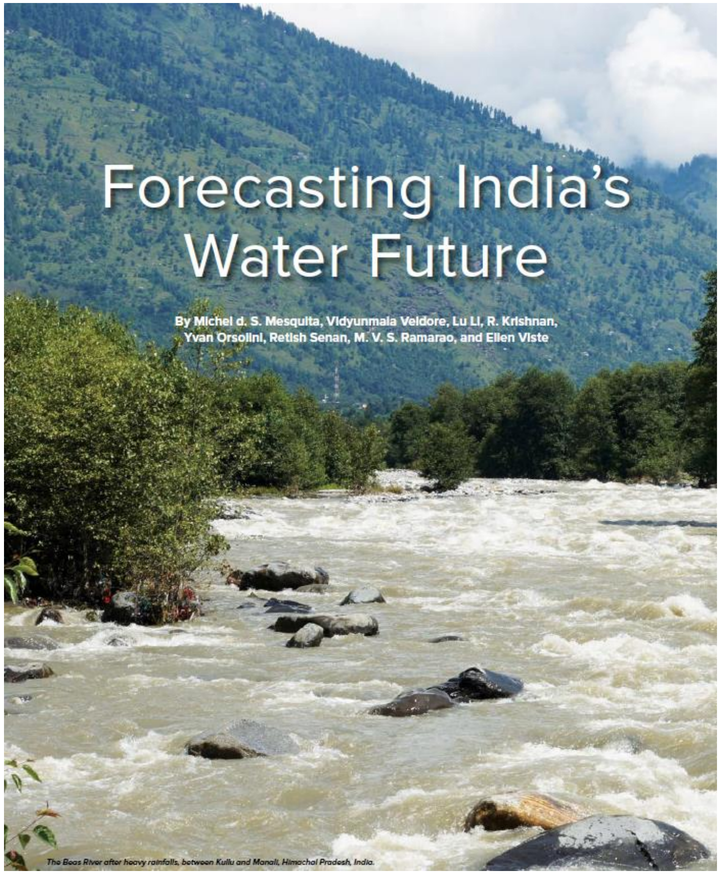
[2]University of Bergen, Norway
[3]Department of Geosciences, University of Oslo, Oslo, Norway
[4]ECMWF, Reading, UK

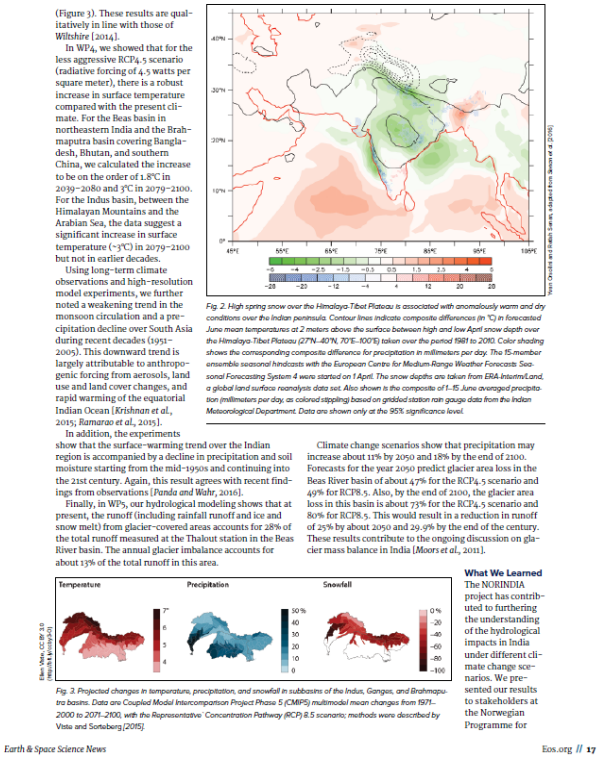
NORINDIA project funded by the Research Council of Norway
(2012-2015)
Climate Change and its Impacts on Selected Indian Hydrological Systems using Earth System and High-Resolution Modeling
Coordinator: Michel Mesquita (University of Bergen)



Forecasting India's Water Future

By Michel d. S. Mesquita, Vidyunmala Veldore, Lu Li, R. Krishnan, Yvan Orsolini, Retish Senan, M. V. S. Ramarao, and Ellen Viste

The Beas River after heavy rainfalls, between Kullu and Manali, Himachal Pradesh, India.



(Figure 3). These results are qualitatively in line with those of *Wiltshire* [2014].

In WP4, we showed that for the less aggressive RCP4.5 scenario (radiative forcing of 4.5 watts per square meter), there is a robust increase in surface temperature compared with the present climate. For the Beas basin in northeastern India and the Brahmaputra basin covering Bangladesh, Bhutan, and southern China, we calculated the increase to be on the order of 1.8°C in 2039–2080 and 3°C in 2079–2100. For the Indus basin, between the Himalayan Mountains and the Arabian Sea, the data suggest a significant increase in surface temperature (~3°C) in 2079–2100 but not in earlier decades.

Using long-term climate observations and high-resolution model experiments, we further noted a weakening trend in the monsoon circulation and a precipitation decline over South Asia during recent decades (1951–2005). This downward trend is largely attributable to anthropogenic forcing from aerosols, land use and land cover changes, and rapid warming of the equatorial Indian Ocean [*Krishnan et al.*, 2015; *Ramarao et al.*, 2015].

In addition, the experiments show that the surface-warming trend over the Indian region is accompanied by a decline in precipitation and soil moisture starting from the mid-1950s and continuing into the 21st century. Again, this result agrees with recent findings from observations [*Panda and Wahr*, 2016].

Finally, in WP5, our hydrological modeling shows that at present, the runoff (including rainfall runoff and ice and snow melt) from glacier-covered areas accounts for 28% of the total runoff measured at the Thalout station in the Beas River basin. The annual glacier imbalance accounts for about 13% of the total runoff in this area.

Climate change scenarios show that precipitation may increase about 11% by 2050 and 18% by the end of 2100. Forecasts for the year 2050 predict glacier area loss in the Beas River basin of about 47% for the RCP4.5 scenario and 49% for RCP8.5. Also, by the end of 2100, the glacier area loss in this basin is about 73% for the RCP4.5 scenario and 80% for RCP8.5. This would result in a reduction in runoff of 25% by about 2050 and 29.9% by the end of the century. These results contribute to the ongoing discussion on glacier mass balance in India [*Moors et al.*, 2011].

Fig. 2. High spring snow over the Himalaya-Tibet Plateau is associated with anomalously warm and dry conditions over the Indian peninsula. Contour lines indicate composite differences (in °C) in forecasted June mean temperatures at 2 meters above the surface between high and low April snow depth over the Himalaya-Tibet Plateau (27°N–40°N, 70°E–100°E) taken over the period 1981 to 2010. Color shading shows the corresponding composite difference for precipitation in millimeters per day. The 15-member ensemble seasonal hindcasts with the European Centre for Medium-Range Weather Forecasts Seasonal Forecasting System 4 were started on 1 April. The snow depths are taken from ERA-Interim/Land, a global land surface reanalysis data set. Also shown is the composite of 1–15 June averaged precipitation (millimeters per day, as colored stippling) based on gridded station rain gauge data from the Indian Meteorological Department. Data are shown only at the 95% significance level.

Ellen Viste, CC BY 3.0 (http://bit.ly/ccby3-0)

Fig. 3. Projected changes in temperature, precipitation, and snowfall in subbasins of the Indus, Ganges, and Brahmaputra basins. Data are Coupled Model Intercomparison Project Phase 5 (CMIP5) multimodel mean changes from 1971–2000 to 2071–2100, with the Representative Concentration Pathway (RCP) 8.5 scenario; methods were described by Viste and Sorteberg [2015].

What We Learned

The NORINDIA project has contributed to furthering the understanding of the hydrological impacts in India under different climate change scenarios. We presented our results to stakeholders at the Norwegian Programme for

The Beas River at Mandi, Himachal Pradesh, India. NORINDIA placed special importance on assessing the future runoff of the Beas, one of the major rivers in the Indus basin, because it plays a key role in current and future plans for hydropower generation in India.

Research Cooperation with India (INDNOR; see http://bit.ly/INDNOR-programme) collaborative meeting in 2015. This meeting gathered participants from three other India-related projects to discuss changes in climate and the consequent hydrological impact. We hope that NORINDIA will make a significant contribution to stakeholders and policy makers with respect to the future of water resources in India.

A continuing project called "C-ICE: Counteracting effect of future Antarctic sea-ice loss on projected increases of summer Monsoon rainfall" (see http://bit.ly/C-ICE) has been funded, and was expected to start as the magazine went to press. The program will investigate the sensitivity of ISM to future Antarctic sea ice loss, which may partially counteract the general tendency toward increased monsoon rainfall over India and may also contribute to increasing its subseasonal variability.

Acknowledgments

We thank the Norwegian Research Council and Statkraft for providing funding to the NORINDIA project with grant 216576.

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ARTICLE IN AGU EOS Magazine:

Mesquita, M. d. S., V. Veldore, L. Li, R. Krishnan, Y. Orsolini, R. Senan, M. V. S. Ramarao, and E. Viste (2016), Forecasting India's water future, *Eos, 97,* doi:10.1029/2016EO049099. Published on 31 March 2016.

NORINDIA

NORINDIA project funded by the Research Council of Norway
(2012-2015)

Climate Change and its Impacts on Selected Indian Hydrological Systems using Earth System and High-Resolution Modeling

Coordinator: Michel Mesquita (University of Bergen)

BIRKELAND CENTRE
FOR SPACE SCIENCE

Solar effects on natural climate variability in the North Atlantic and Arctic (SOLENA)

Project funded by Research Council of Norway 2016-2019

Yvan J. Orsolini [1,2,5] (Project Manager), Odd Helge Otterrå [3,5], Frode Stordal [4], Thomas Toniazzo [3], Hilde Nesse [2], Noureddine Omrani [5], Noel Keenlyside [6]

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Prof. Ulrike Langematz, Free University of Berlin, Germany
Dr. Alain Hauchecorne, LATMOS, CNRS, Paris, France

❑ **UNIFIED MODELLING APPROACH FOR BOTH UV-RADIATION and PARTICLE PRECIPITATION**
❑ **USE OF WHOLE-ATMOSPHERE CHEMISTRY-CLIMATE MODEL (WACCM) COUPLED TO OCEAN**
❑ **ROLE ON NAO IN MODULATING SOLAR CYCLE ATMOSPHERIC IMPACTS**

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Summertime Arctic sea ice and storm track

AUG 2012 storm

Summer months with high sea ice melt rates (HMR) have

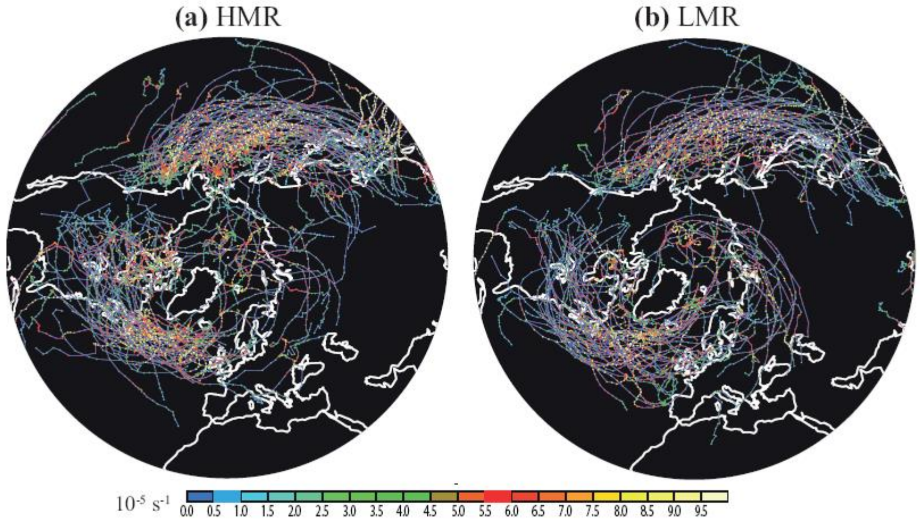
☐ fewer storms, less precipitation and snowfall over the Arctic.

☐ Enhanced precipitation over northern Europe (Great Britain, Scandivania)

✓*Previous work by Screen et al. (2011; 2013), Tang et al. (2013)*

➢To investigate implications for seasonal forecasts

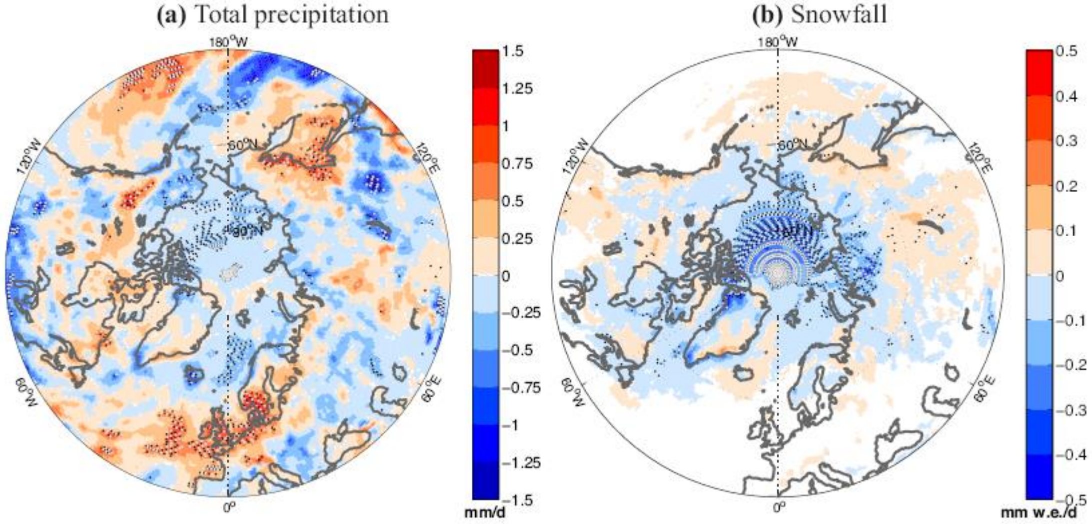
Knudsen, E., Orsolini, Y.J., Furevik, T. and K. Hodges, Observed anomalous atmospheric patterns in summers of unusual Arctic sea ice melt, *J. Geophys. Res,*, 2015.



Paths of major summer storms (MJJA)

high melt

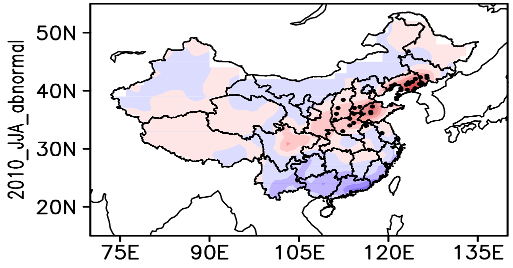
low sea-ice melt

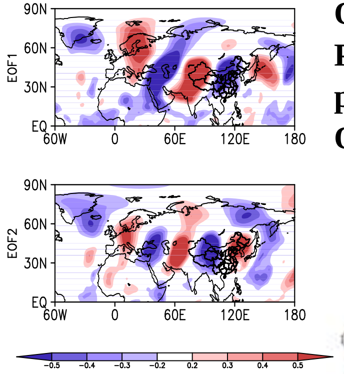


Anomalies of precipitation and snowfall (MJJA)

Summertime teleconnections from Atlantic to the Far East

Precip anom. China 2010





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ERAINT

ENS MEAN

Indivual members

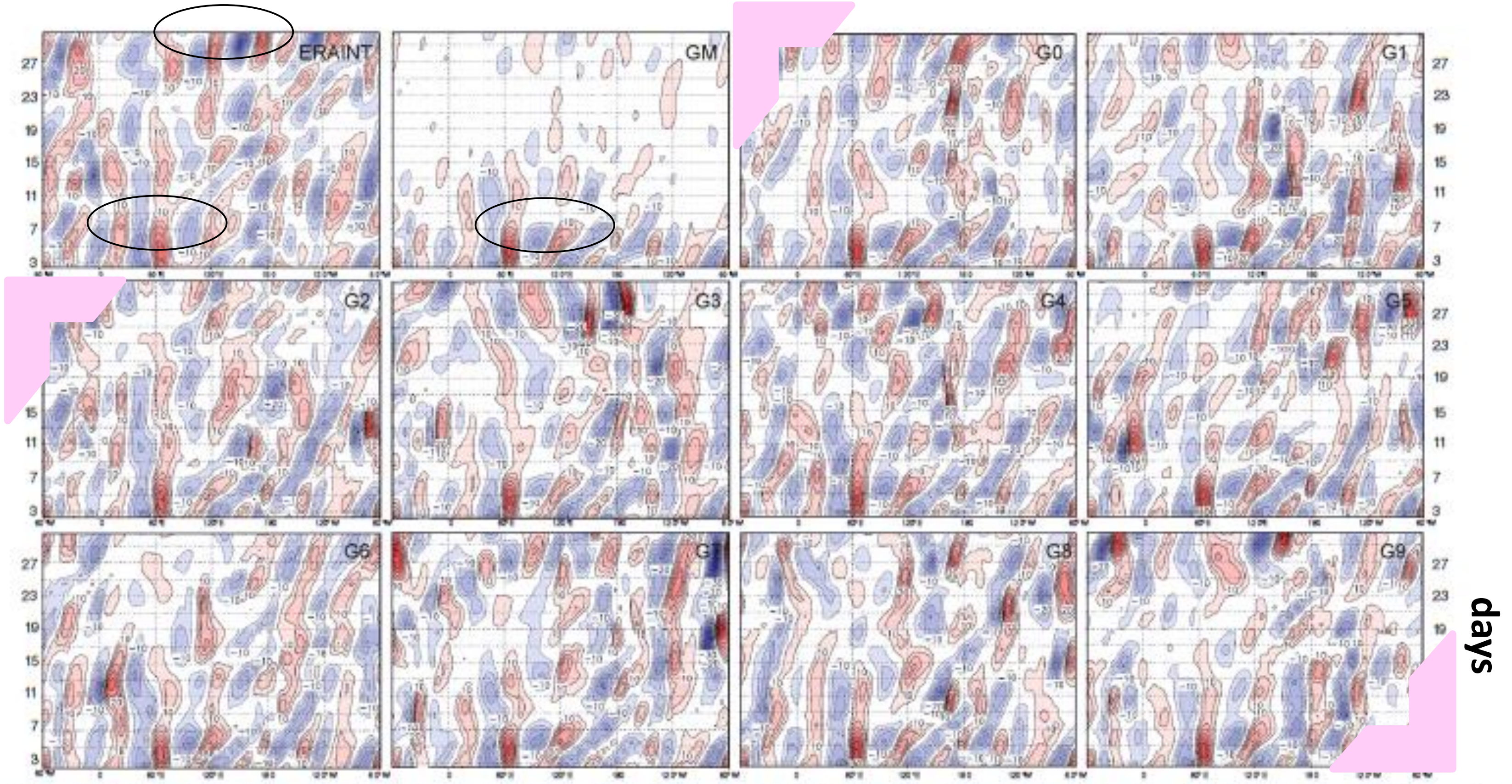

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Figure 7. Hovmüller plots of meridional wind anomaly at 200 hPa throughout August 2010 in the latitude band 40–45°N, in ERA-Interim, in the ensemble mean and in all members. Model anomaly is calculated from a 10-year climatology (2000–2009). G0–G9 correspond to individual members and GM to the ensemble mean. Contour interval is 5 m/s.

long

Høvmueller plot

V 200 hPa

AUGUST 2010

Monthly fc

ECMWF IFS

Eastward-propagating wavetrains important for summertime precipitation over Far East

(e.g extreme precipitation event in August 2010), but poorly forecasted even on monthly time scale