SNOWGLACE

Impact of snow initialisation on subseasonal-to-seasonal forecasts

A new WCRP WGSIP SCIENCE INITIATIVE

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AIM OF THIS INITIATIVE

The aim of this initiative is to evaluate how individual state-of-the-art dynamical forecast systems vary in their ability to extract forecast skill from snow initialization. The modeling strategy follows the one develop during previous initiatives, GLACE 1 and 2, aimed at assessing the impact of soil moisture on seasonal forecast (e.g. Koster et al., 2011).

Planned experiments : multi-model seasonal (about 3-month) simulations covering over a decade (2004 →…), with either realistic or else climatological snow conditions, and start dates throughout fall to spring.

These experiments would be relevant both for the assessment of forecasting skill but also

i) for attribution of climate variability and extreme events to snow forcing.
ii) for subseasonal-to-seasonal predictions during YOPP

REFERENCES:
Koster R.D. et al. (2011), GLACE2: the second phase of the global land atmosphere coupling experiment: soil moisture contributrion to subseasonal forecast skill. J Hydrometeorol 12:805–822.

Orsolini, Y.J., Senan, R., Balsamo, G., Doblas-Reyes, F., Vitart, D., Weisheimer, A., Carrasco, A., Benestad, R. (2013), Impact of snow initialization on sub-seasonal forecasts , Clim. Dyn., DOI: 10.1007/s00382-013-1782-0

Jeong, J.H., H.W. Linderholm, S.-H. Woo, C. Folland, B.-M. Kim, S.-J. Kim and D. Chen (2013), Impact of snow initialization on subseasonal forecasts of surface air temperature for the cold season, J. Clim., 26, 1956-1972, doi:10.1175/JCLI-D-12-001.59.1

UPDATE (NOV 2016)

Funding (so far) : Research Council of Norway (4 years, started NOV 2015), Korean Meteorological Administration (3 years, started in May 2016), EU project SPECS (until NOV 2016)
1 full time postdoc at NILU (September 2016-September 2018)

Participating members (so far) : ECMWF (UK), BSC (Spain), NILU (Norway), Chonnam University (South Korea), KOPRI (South Korea), UNIST (South Korea), IAP (China), Gøteborg University (Sweden)

Planned experiments : multi-model seasonal (about 3-month) simulations covering at least a decade (2004 →…), with either realistic or else climatological snow conditions, and start dates throughout fall to spring.

✓ Completed experiments : ECMWF
✓ Analysis : deterministic and probabilistic forecast (skill score, reliability diagrams,…)

✓ Also from SPECS project (BSC and Meteo-France, with slightly different protocol, snow+soil moisture)

Data Center : to be established in Korea (KOPRI), with support of 1 person

Joint meeting : tentatively in Beijing (IAP) in March

SNOWGLACE-related presentations (autumn 2015): at LS3MIP workshop (Zurich), and s2s workshop (Reading)

Two new papers on impact of snow initialisation (ECMWF seasonal forecast system):

Senan, R., Orsolini, Y.J., Weisheimer A., Vitart, F., Balsamo, G., Stockdale, T., Dutra, E., Doblas-Reyes, F., D. Basang, Impact of springtime Himalayan-Tibetan Plateau snowpack on the onset of the Indian summer monsoon in coupled seasonal forecasts, Clim. Dyn., Vol. 47, Issue 9, pp 2709–2725, doi:10.1007/s00382-016-2993-y. (2016)

Orsolini, Y.J., Senan, R., Vitart, F., Weisheimer, A., Balsamo, G., Doblas-Reyes F., Influence of the Eurasian snow on the negative North Atlantic Oscillation in subseasonal forecasts of the cold winter 2009/10, Clim. Dyn., vol47, 3, pp 1325–1334, DOI: 10.1007/s00382-015-2903-8 (2016)

EXAMPLE RESULTS (older simulations) : SPRING PERIOD

Impact of the springtime Himalayan-Tibetan Plateau snow on the onset on the Indian summer monsoon in coupled forecasts

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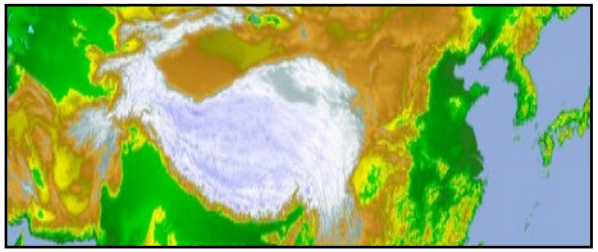


NORINDIA

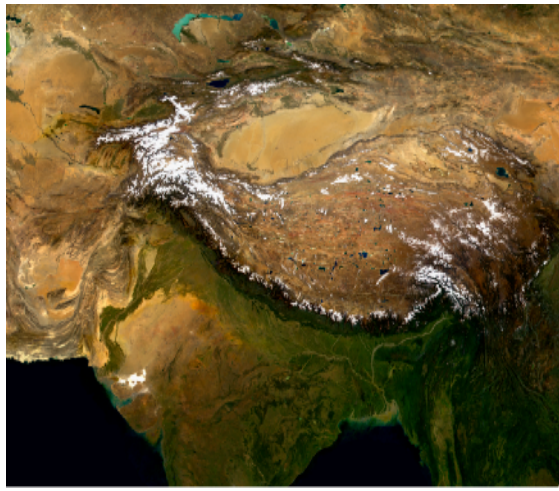
NORINDIA project funded by the Research Council of Norway (2012-2015)

NILU

EXAMPLE RESULTS (older simulations) : SPRING PERIOD

Attribute the impact of snow initialisation over the Himalaya-Tibet Plateau region (HTP) on the Indian summer monsoon onset in actual predictability experiments

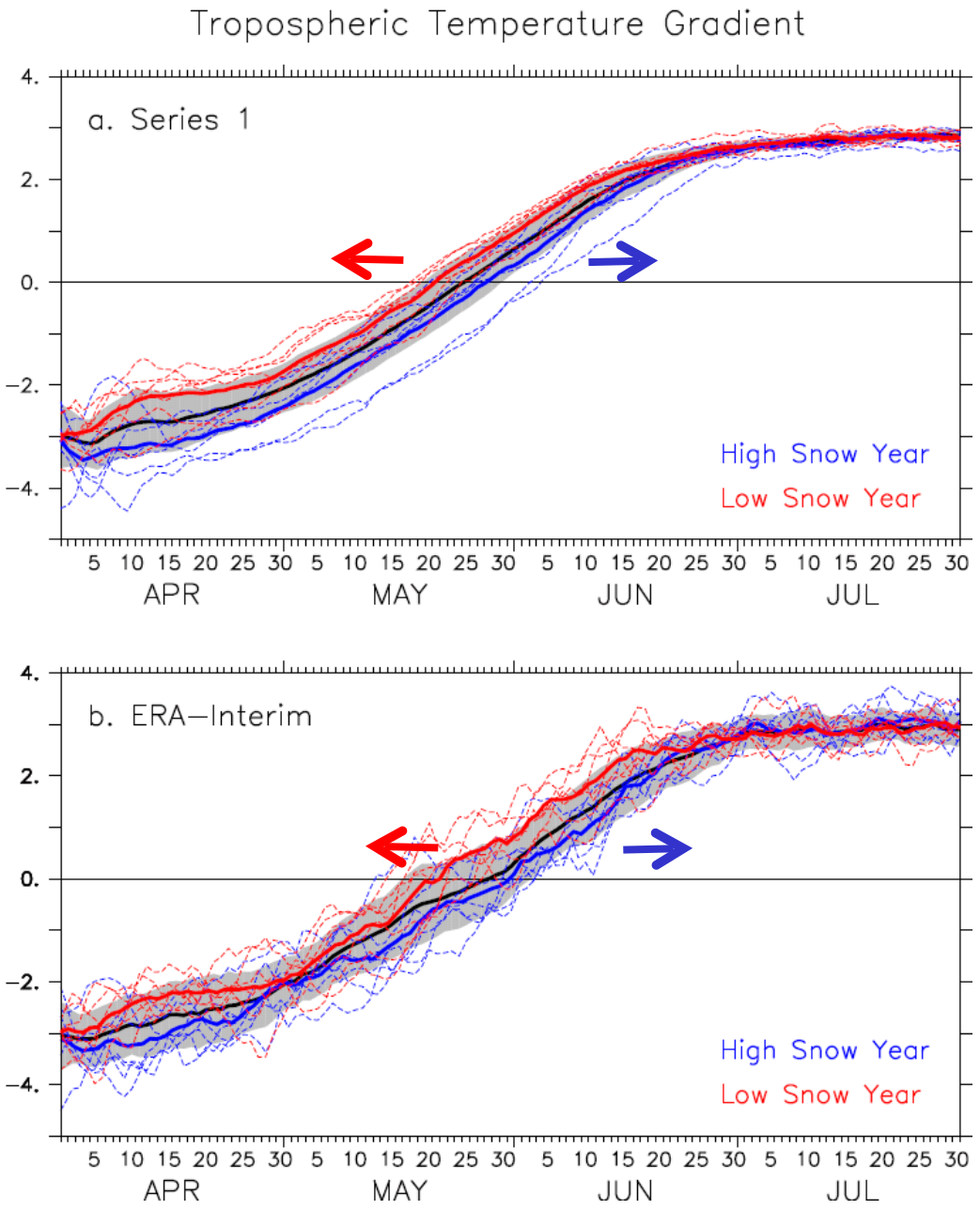
HTP



- **Revisit the "Blanford hypothesis" with a state-of-the-art ensemble prediction system**
- **Coupled ECMWF seasonal forecasting system in operational mode, plus dedicated experiments**
- **Verification : ECWMF Atmospheric or Land Re-analyses**

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.

ONSET as reversal of North/South tropospheric temp. gradient

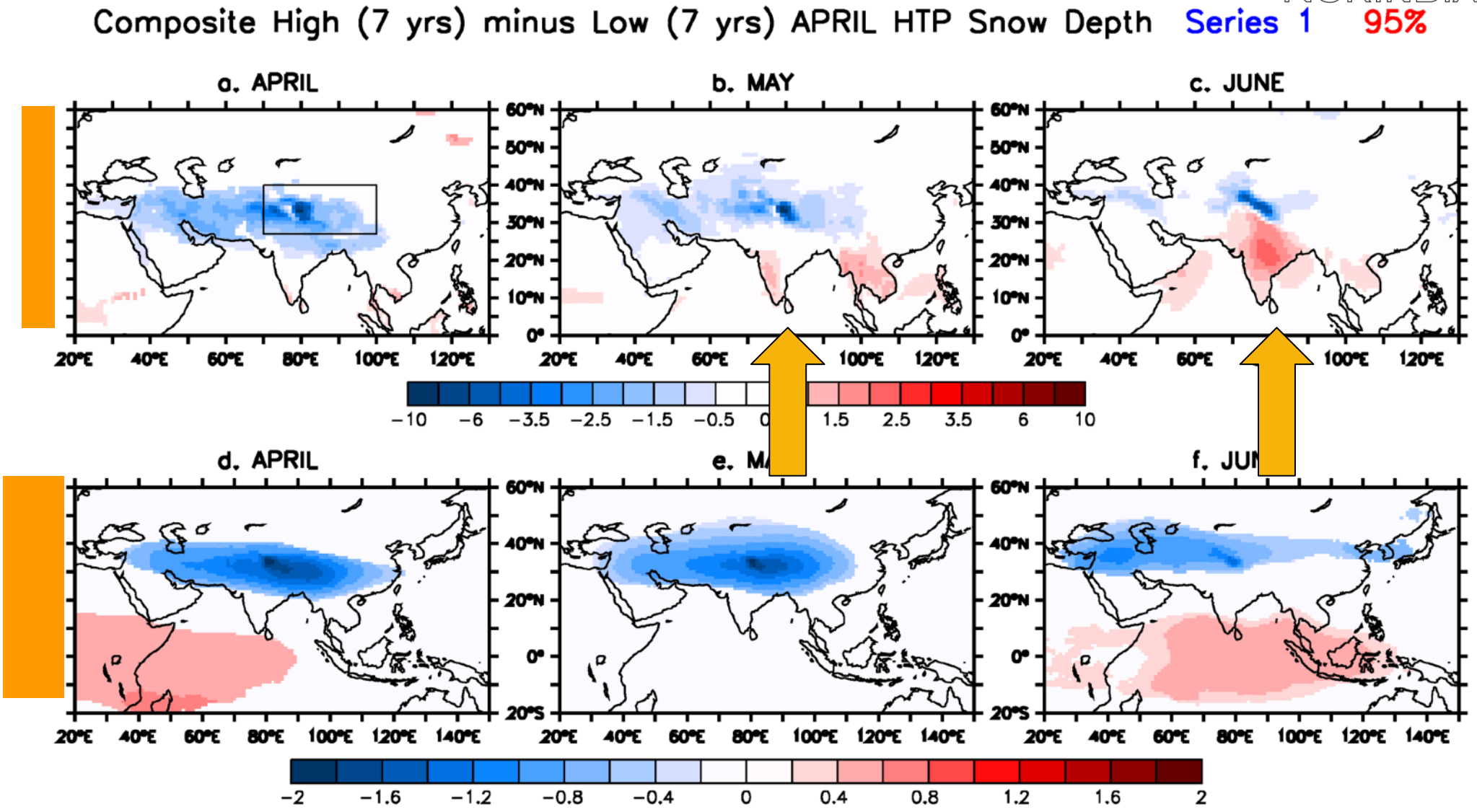


- **Reversal occurs earlier/later (← or →) or later in May in low/high April snow years over HTP region**
- **Average delay in onset is about 1 week**
- **<u>Note</u>: onset corresponds at a lead time : 2 months**

Based on (Xavier et. al, 2007)

- **TTG : difference of the vertically integrated (200-600hPa) temperature, between a northern region (5°N-35°N) and southern region (15°S-5°N) over 40°E -100°E**
- **Onset of the monsoon: TTG zero-crossing (in late May)**

Snow composite differences: temperature



- High APRIL HTP SNOW: warm anomaly in MAY-JUNE over India
- Consistent with delayed monsoon

UPDATE (November 2016)

More activity on this :

International Space Science Institute (Beijing) : team proposal accepted (May 2016-May 2018)

"Snow re-analyses over the Himalaya-Tibetan Plateau (HTP) region and the monsoons"

Team leaders: Yvan Orsolini (NILU, Norway) and Gianpaolo Balsamo (ECMWF, UK)

(J-H. Jeong is also member + two groups from China, CNRS-Grenoble, NERSC/Bergen)

AIM : assess the quality of snow re-analyses over the region, and impact on monsoon onset prediction

EARLY RESULTS FROM THE NEW ECMWF SNOWGLACE EXPERIMENTS

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NILU Norsk institutt for luftforskning

SPECS

Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

UNIVERSITAS BERGENSIS

Impact of snow initialisation on subseasonal-to-seasonal forecast

- twin forecast ensembles, only differing in snow initialisation (realistic vs clim) → attribute difference to snow initialisation ; we also compare with the operational model (S4)

- coupled ocean-atmosphere forecasts

- actual predictability experiments : verification with ERAINT-land

Land initialisation

S1 : «realistic» based on ERAINT-land-u

S2 : clim based on ERAINT-land-u

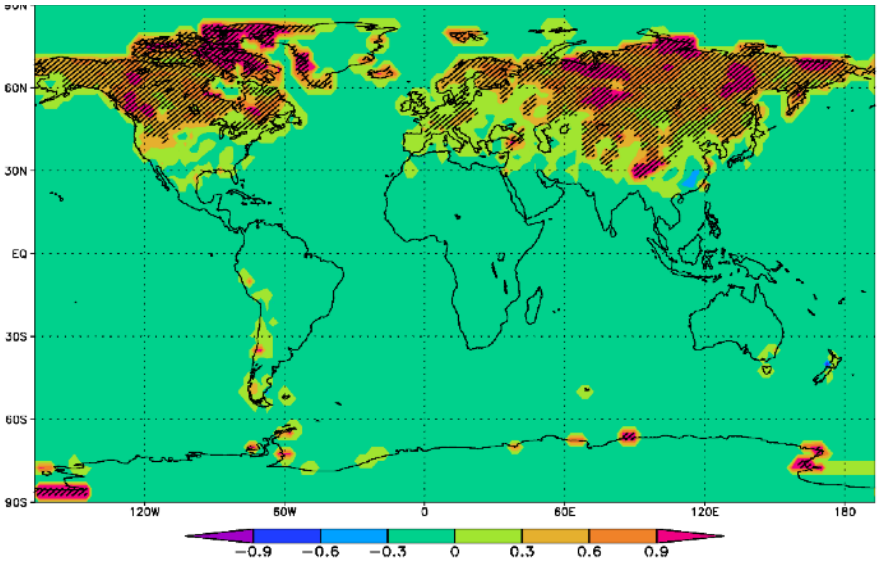
S4 (operational model) also realistic based on ERAINT-land-u

(only difference with S1 is the older model version)

Partner	ECMWF
Model	IFS-41r1
Start dates	NOV 1, DEC 1 (start dates in spring not used here)
Period	2004-2013
Length	3 or 4 months
Land Initialisation	ERAINT-land-u (uncorrected for precip)
perturbed run (S2)	Snow
Ensemble size	51

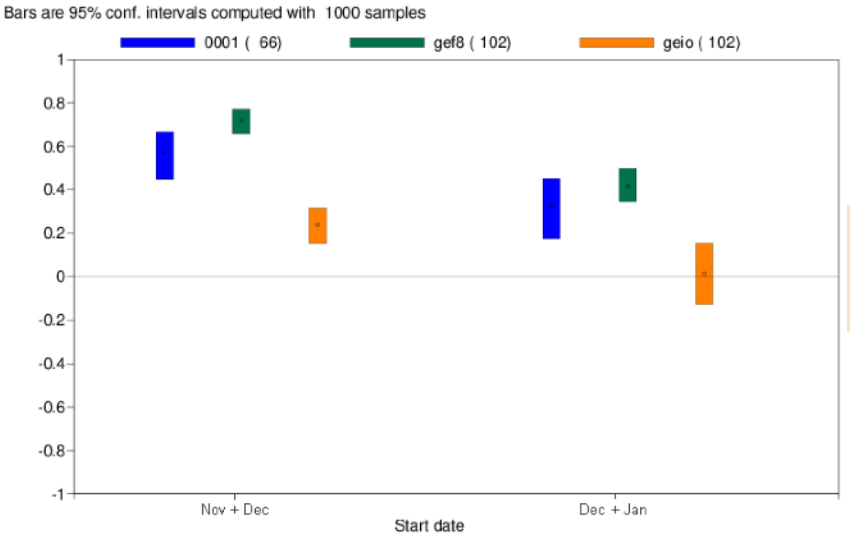
Aggregated autumn start dates (NOV 1, DEC 1)
Monthly means

ACC increment (S1 – S2)



1st month

ACC comparison (Eurasia land)



1st month **2nd month**

SNOW DEPTH

→ **Improved prediction of snow itself**

Operational S4
Realistic S1
Clim S2

Figs : D. Decremer (ECMWF)

Reliability Diagrams for snow depth over Eurasia

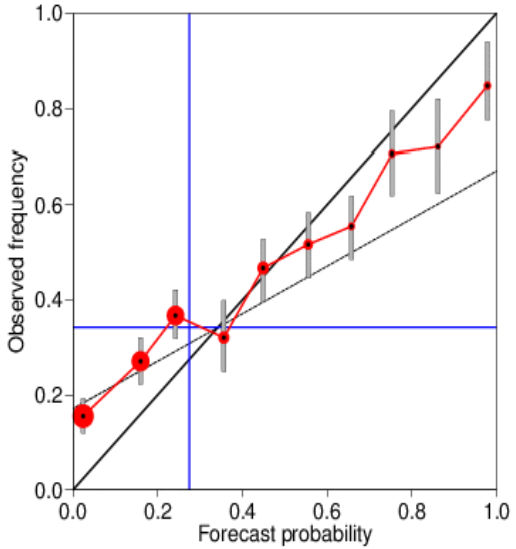
1st month

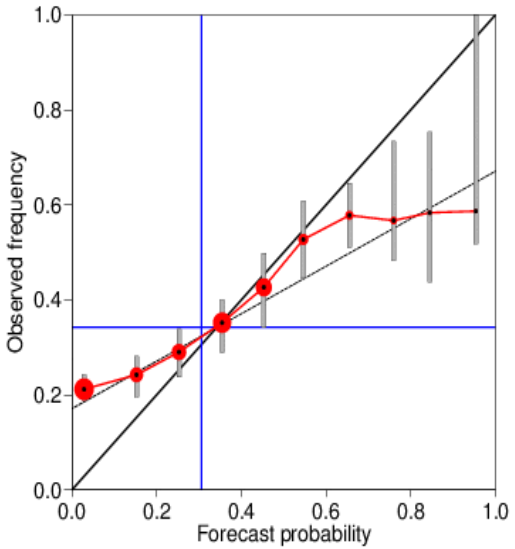
S4 : Operational
Brier skill score: 0.088

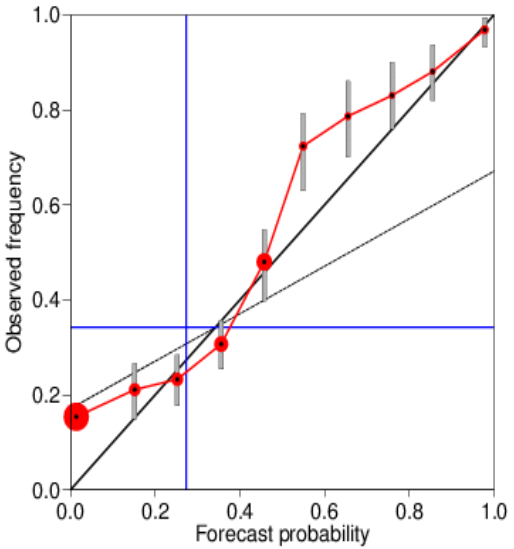
S2 : Clim
Brier skill score: 0.002

S1 : Realistic
Brier skill score: 0.216

Lower Terc.





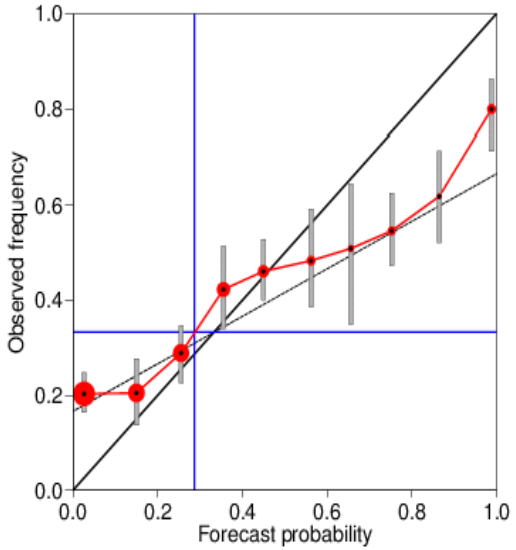


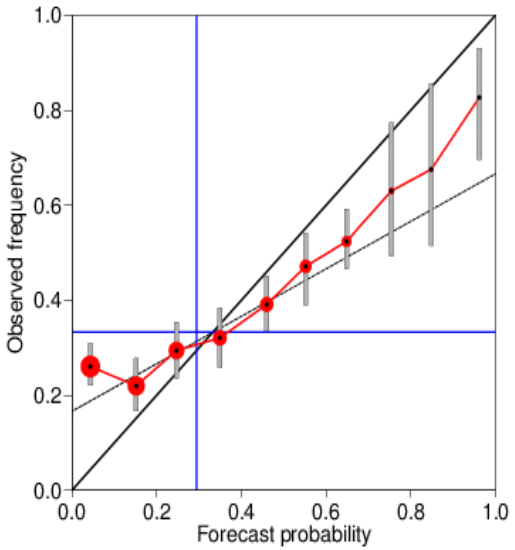
S4 : Operational
Brier skill score: 0.043

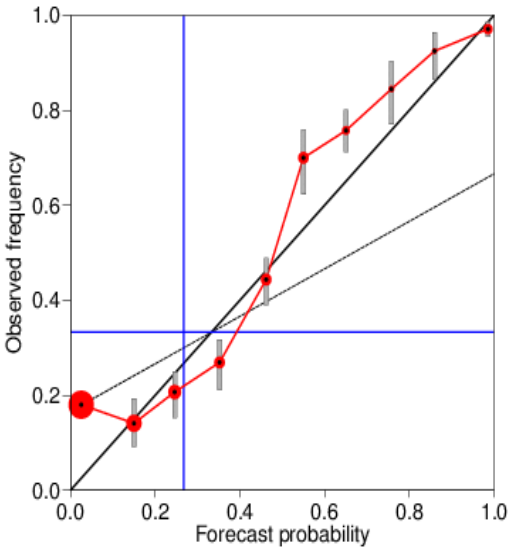
S2 : Clim
Brier skill score: -0.014

S1 : Realistic
Brier skill score: 0.247

Upper Terc.

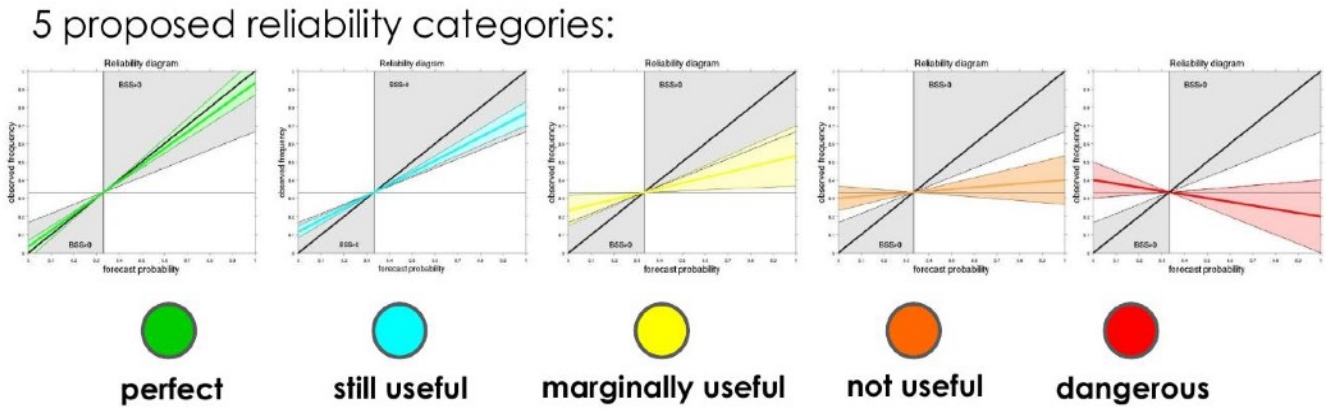


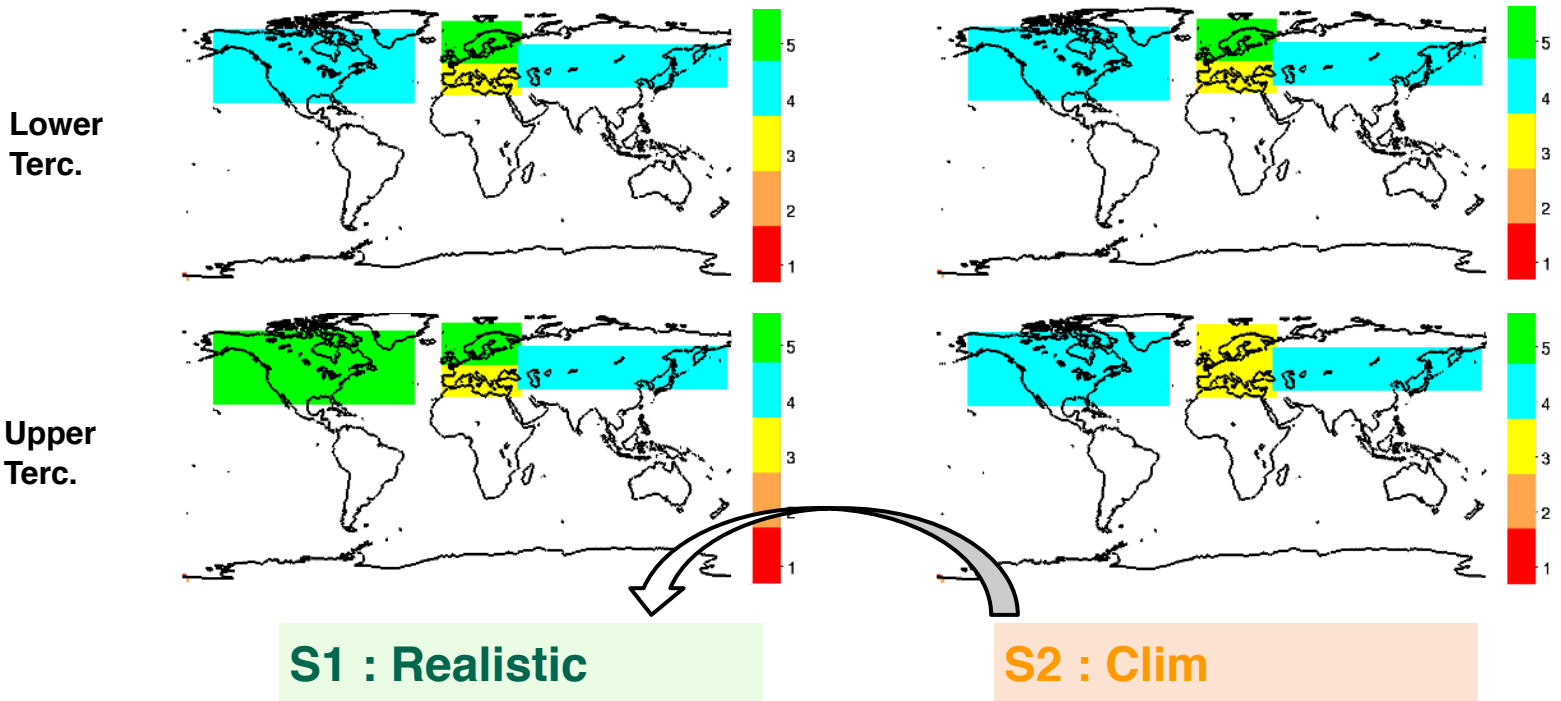




Reliability Diagrams for snow depth over Eurasia : categories of reliability

Weisheimer and Palmer (2014)





→ **Snow initialisation leads to more reliable snow forecast (upper Terc./high snow)**

Impact of snow initialization on spring soil-moisture and temperature prediction

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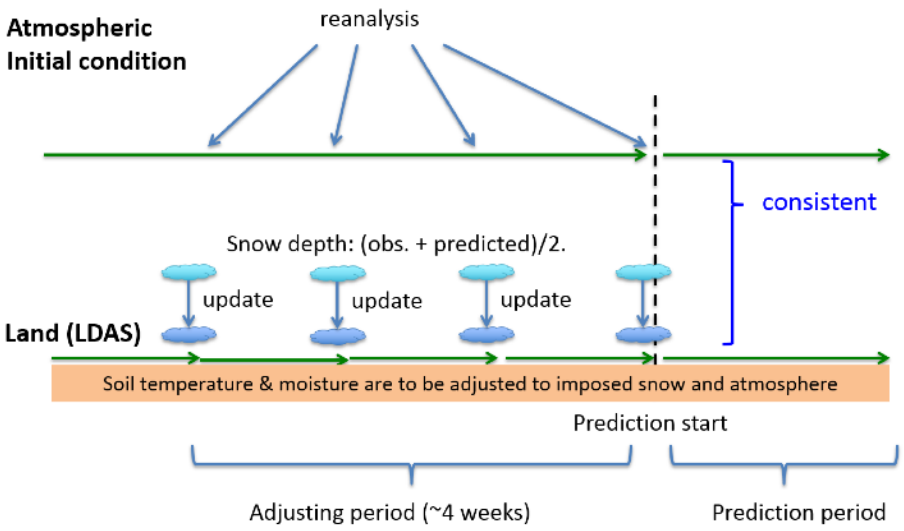
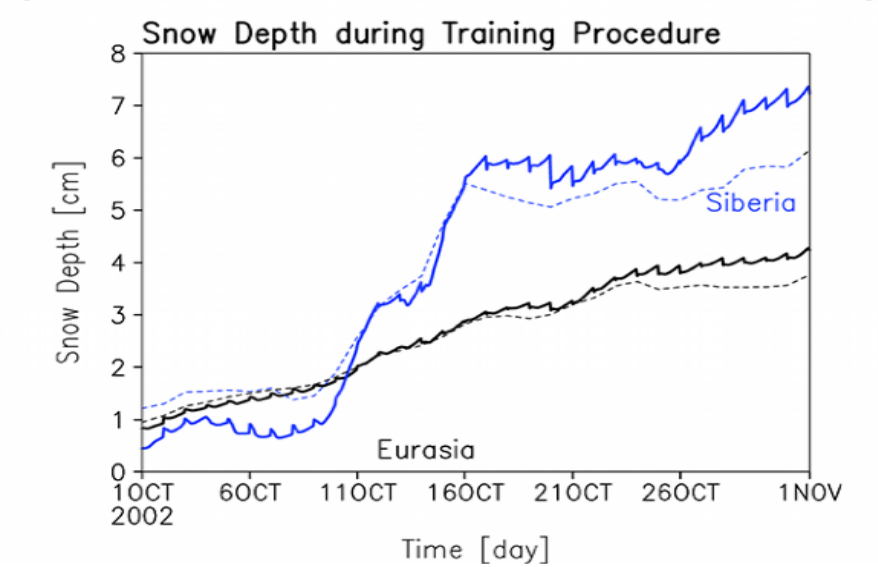
Korea Polar Research Institute

Snow depth nudging



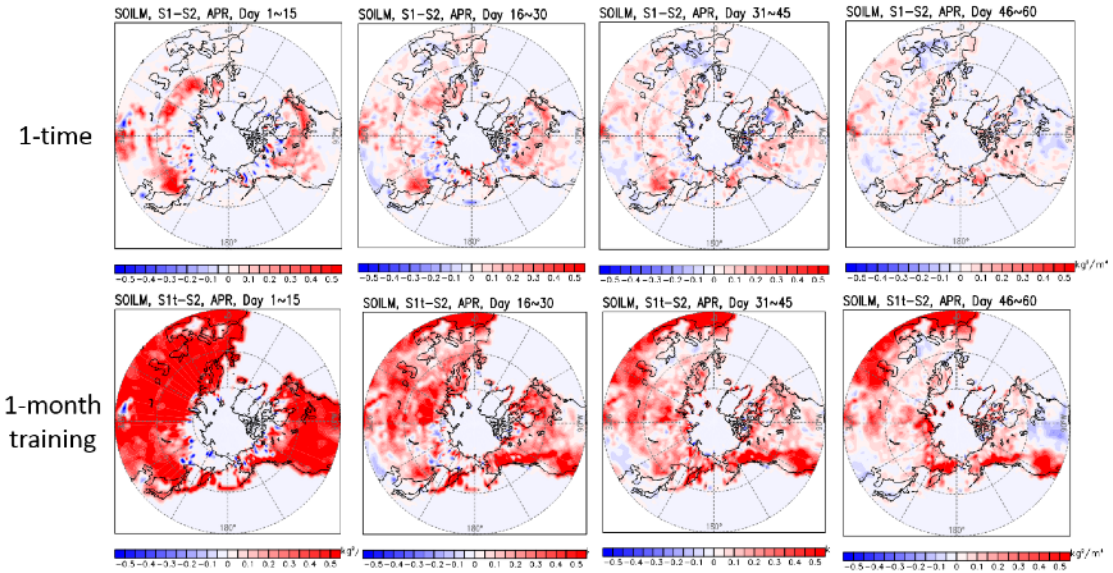


1. 1-month long, snow training period is applied to the seasonal prediction system (NCAR CAM4).

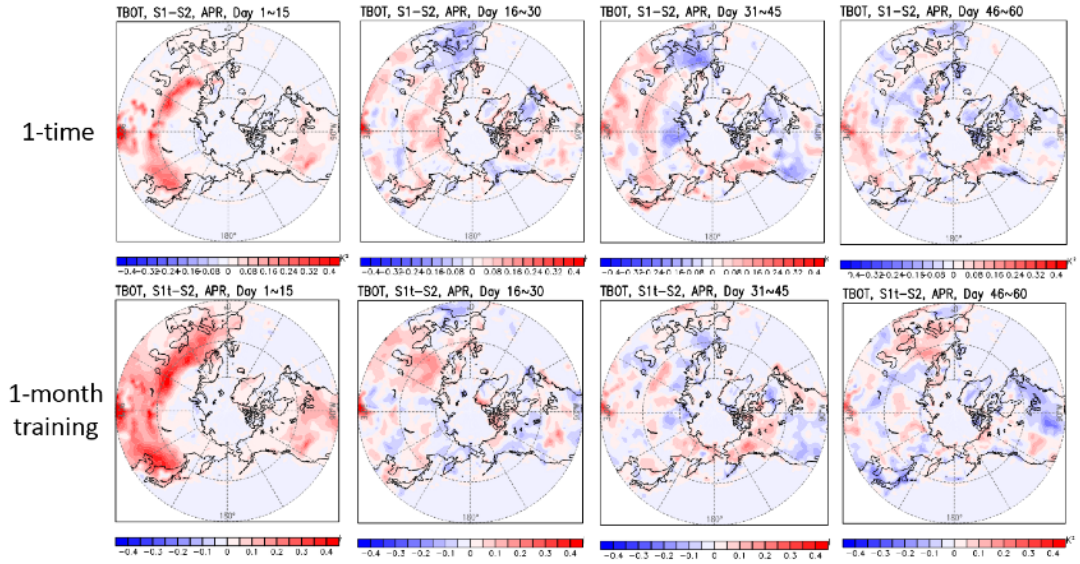
2. Observed snow depth is nudged everyday to initialize snow, and soil moisture & temperature more physically consistently.

3. Hindcast for 2006-2015, starting at 1st of April, 10 ensembles

Change in potential predictability (R^2) of soil moisture and temperature in spring (Initialization - No initialization)



Soil moisture potential predictability increase



Temperature potential predictability increase is modest