SNOWGLACE

Impact of snow initialisation on subseasonal-to-seasonal forecasts

A 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 unrealistic (climatological, scrambled) 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 (OCT 2017)

Funding (so far) : Research Council of Norway (3 years, started OCT 2015), Korean Meteorological Administration (3 years, started in May 2016, probable new project 2018-2020), EU project SPECS (terminated)

1 full time postdoc at NILU (September 2016-September 2018)
Data Center : to be established in Korea (KOPRI), with support of 1 person

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

- ✓ Completed experiments :
- ✓ ECMWF (10 years) from SPECS projects
  --> discussion of new experiments with new S5.

- ✓ CNU-KOPRI done hindcasts, ready for snow initialised simulations
- ✓ NILU (NORCPM model) : 30 years, realistic or scrambled snow

- ✓ Analysis : deterministic and probabilistic forecast (skill score, reliability diagrams,…)

Joint meeting : Beijing (IAP) at end of OCT 2017

Two recent 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)

EARLY RESULTS FROM THE ECMWF SNOWGLACE EXPERIMENTS

Yvan J. Orsolini

NILU - Norwegian Institute for Air Research

and University of Bergen , Norway

D. Decremer, E. Dutra, T. Stockdale, A. Weisheimer, G. Balsamo
(ECMWF, England)

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 : snow verification with ERAINT-land

Land initialisation

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

S2 : clim based on ERAINT-land-u

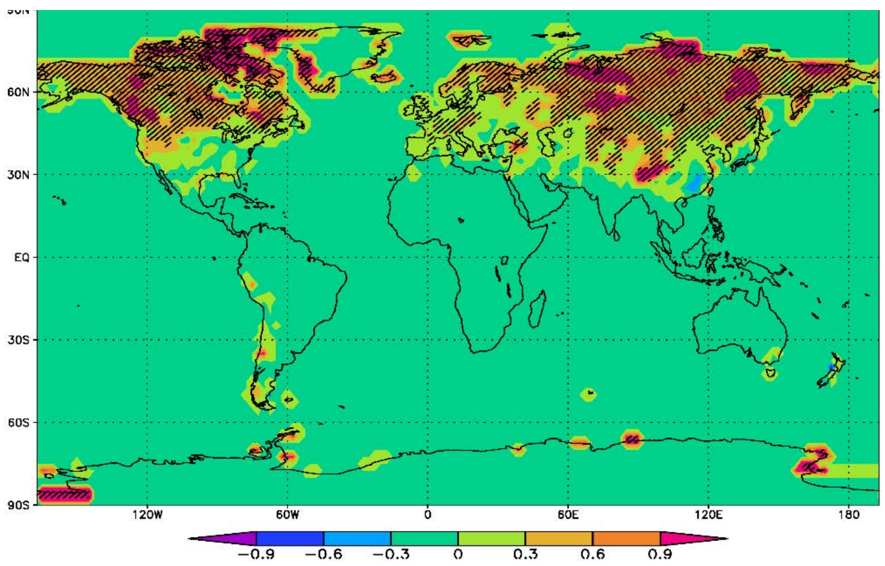
S4 (operational model) also realistic based on ERAINT-land-u

(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

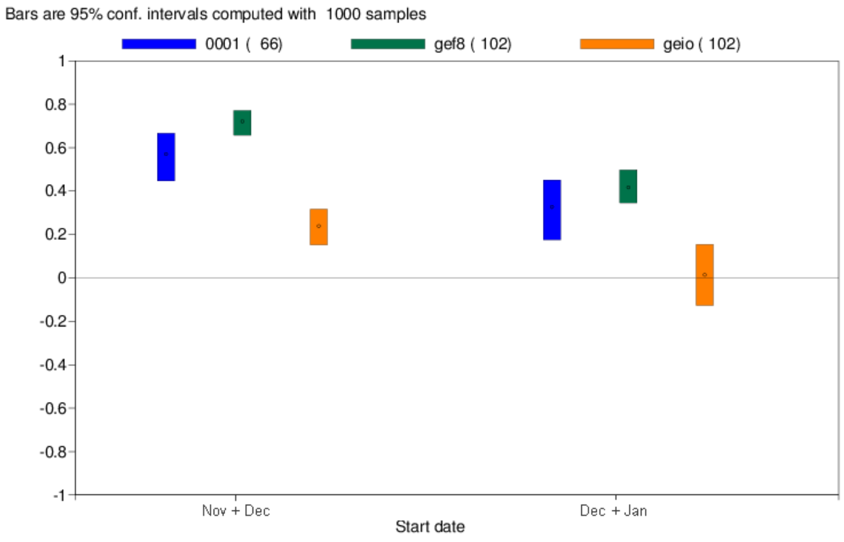
Aggregated autumn start dates (NOV 1, DEC 1)
Monthly means

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

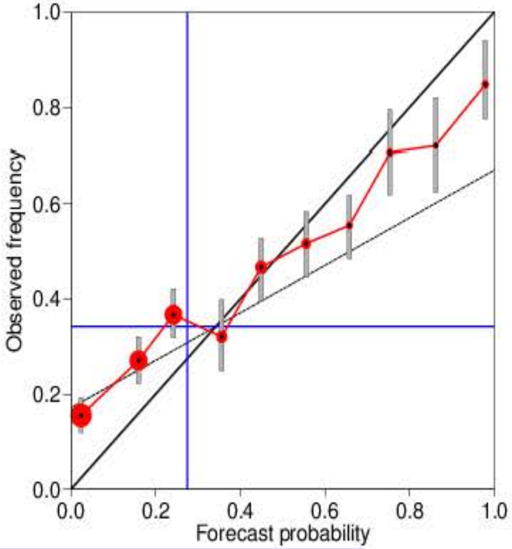
Figs : D. Decremer (ECMWF)

Reliability Diagrams for snow depth over Eurasia

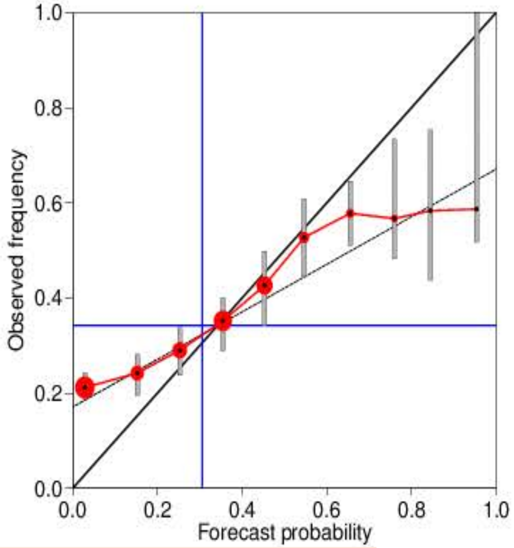
1st month

Lower Terc.

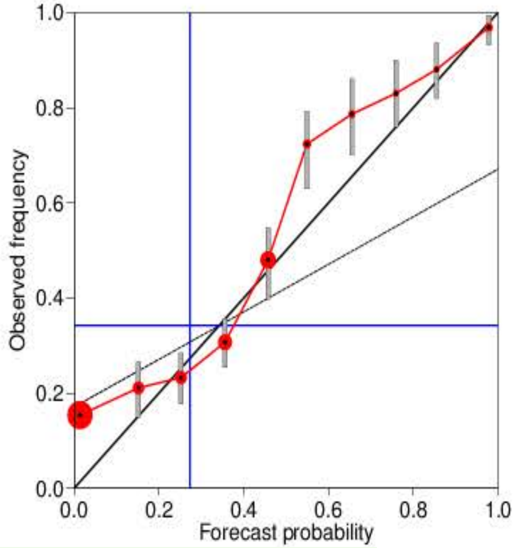
S4 : Operational
Brier skill score: 0.088



S2 : Clim
Brier skill score: 0.002

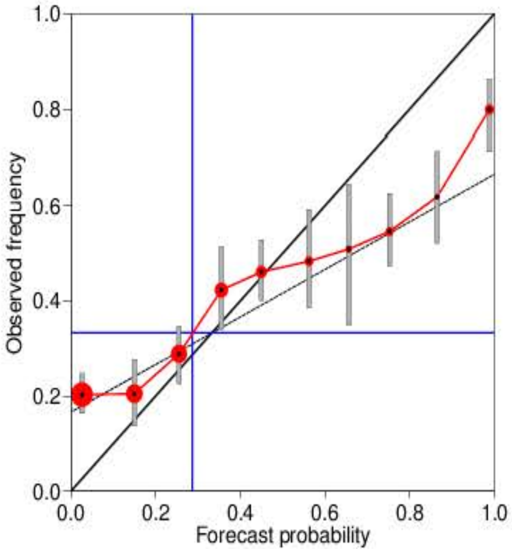


S1 : Realistic
Brier skill score: 0.216

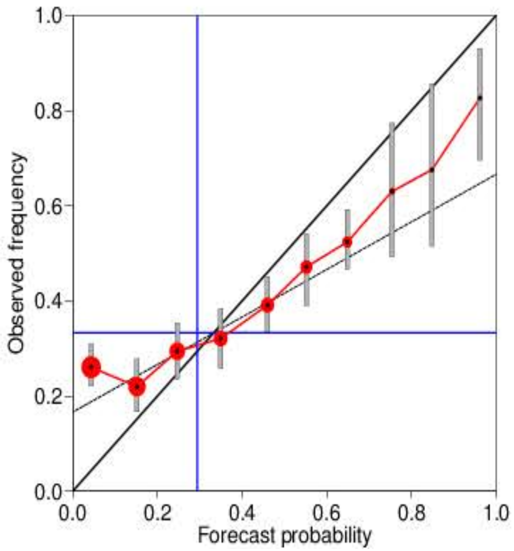


Upper Terc.

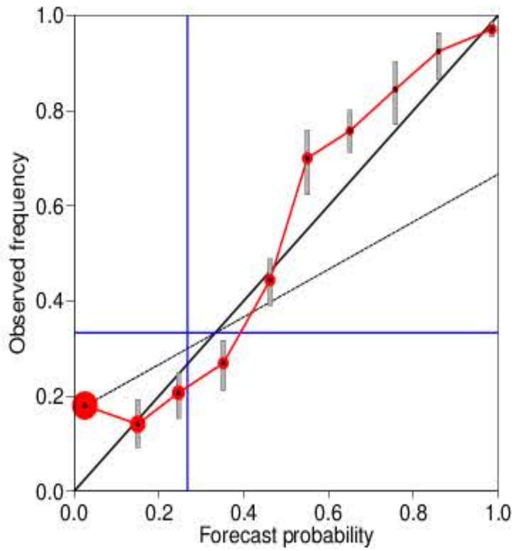
S4 : Operational
Brier skill score: 0.043



S2 : Clim
Brier skill score: -0.014



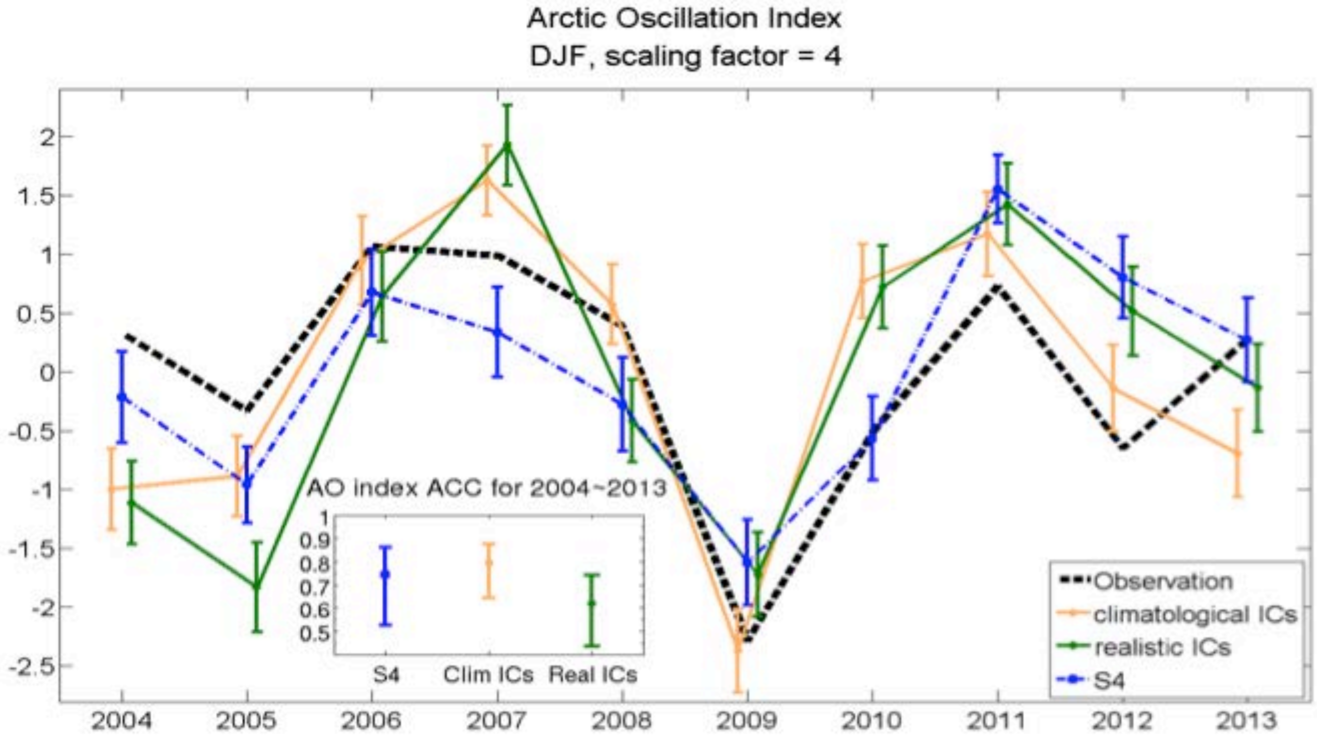
S1 : Realistic
Brier skill score: 0.247



Impact on circulation (rather than snow itself) :

- **Subseasonal scale : Strongest impact on snow prediction itself, little improvement on surface temperature except on parts of Eurasia**

- **Seasonal scale : Little impact on winter-mean (DJF) AO or NAO indices (confirmed by Meteo-France simulations)**



DJF AO

Figs : D. Decremer (ECMWF)
See also Stockdale GRL 2015

However, based on a case study of 2009/10 with older ECMWF simulations:

- ❑ **strong snow perturbations → impact on NAO on subseasonal scale !**
- ❑ **Needs to be verified over longer period.**

"SNOWGLACE" simulations with Norwegian Climate Prediction model (NorCPM)

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Initialisation

✓**Land**: **CLM**; the initial and boundary data is taken from an off-line run driven by NCEP reanalysis.

✓**Ocean & sea ice**: **NorCPM reanalyses**; SST anomaly and temperature and salinity profiles are monthly assimilated into the ocean component.

✓**Atmosphere**: nudging **WACCM** (for 2-week period) towards the ERA-Interim reanalysis.

Period

✓Ten of 3-month ensemble forecasts, started on every 1st November in the years 1980–2010.

Twin experiments

✓**Series 1**: realistic initialisation of snow variables based on CLM/NCEP.

✓**Series 2**: as in Series 1, but with "scrambled" snow initial conditions from an alternate year.

Verification datasets

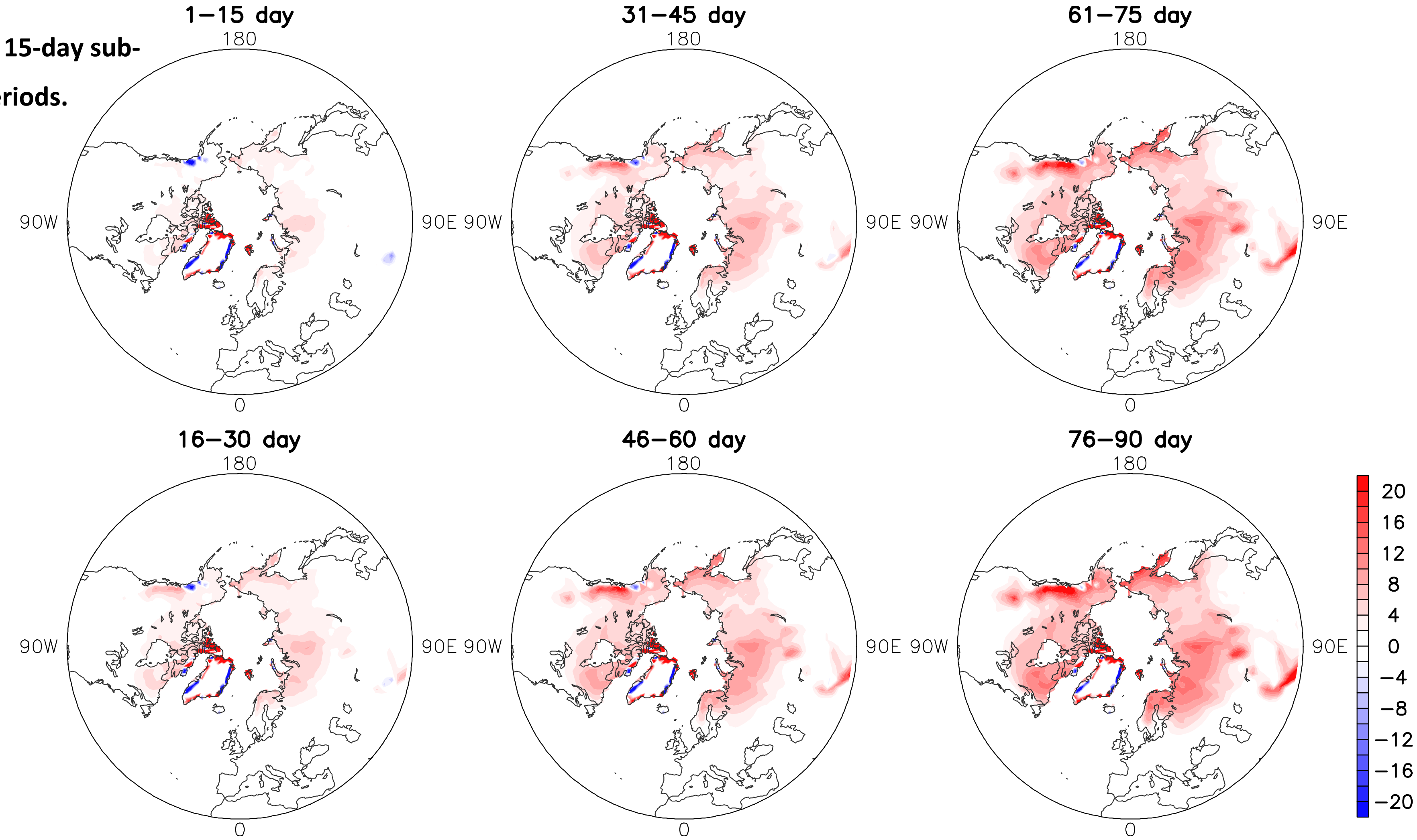
✓ ERA-Interim land (snow) [uncorrected version]

✓ ERA-Interim (temperature)

Snow depth (units: cm) biases (Series 1 minus ERAINT)

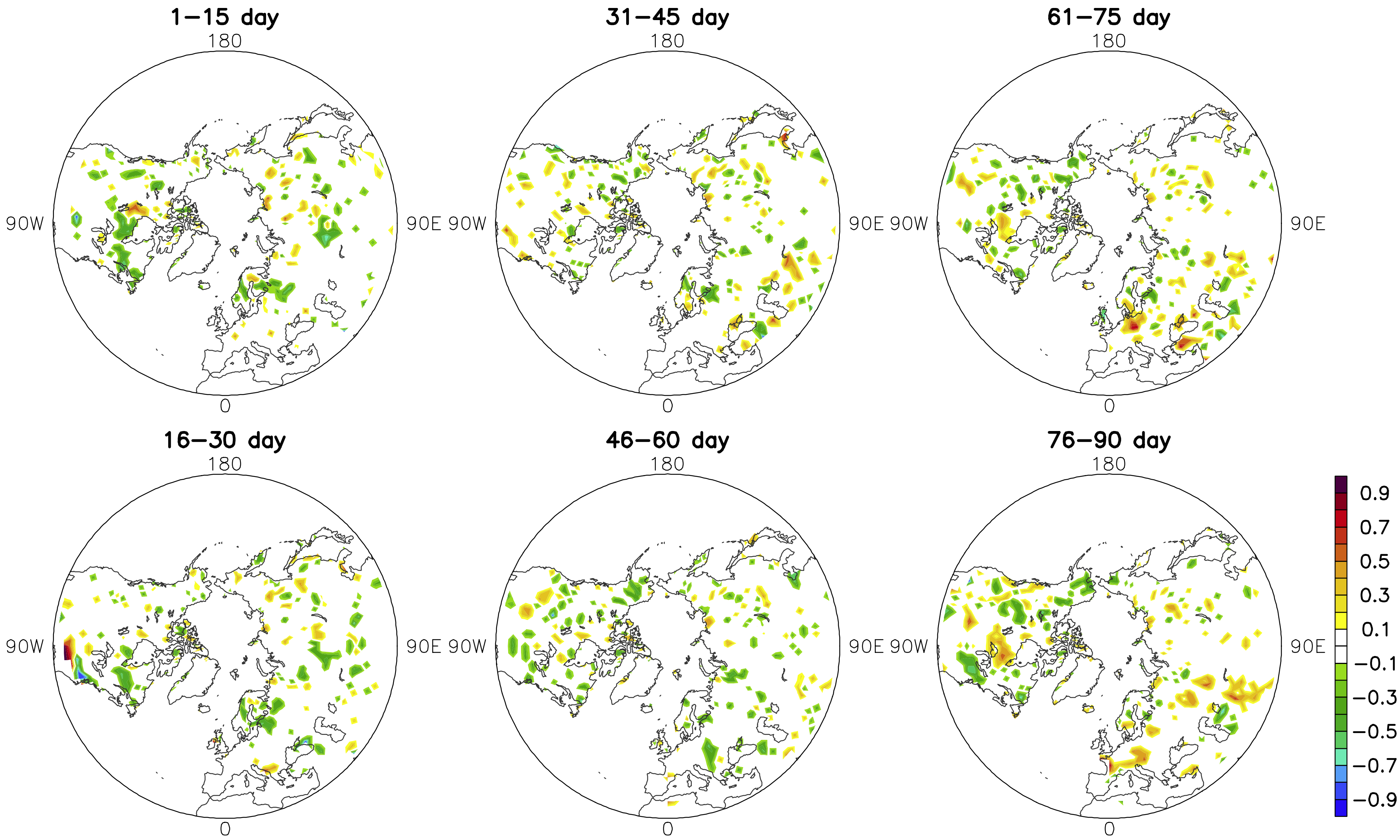
1982–2010

valid for 15-day sub-periods.



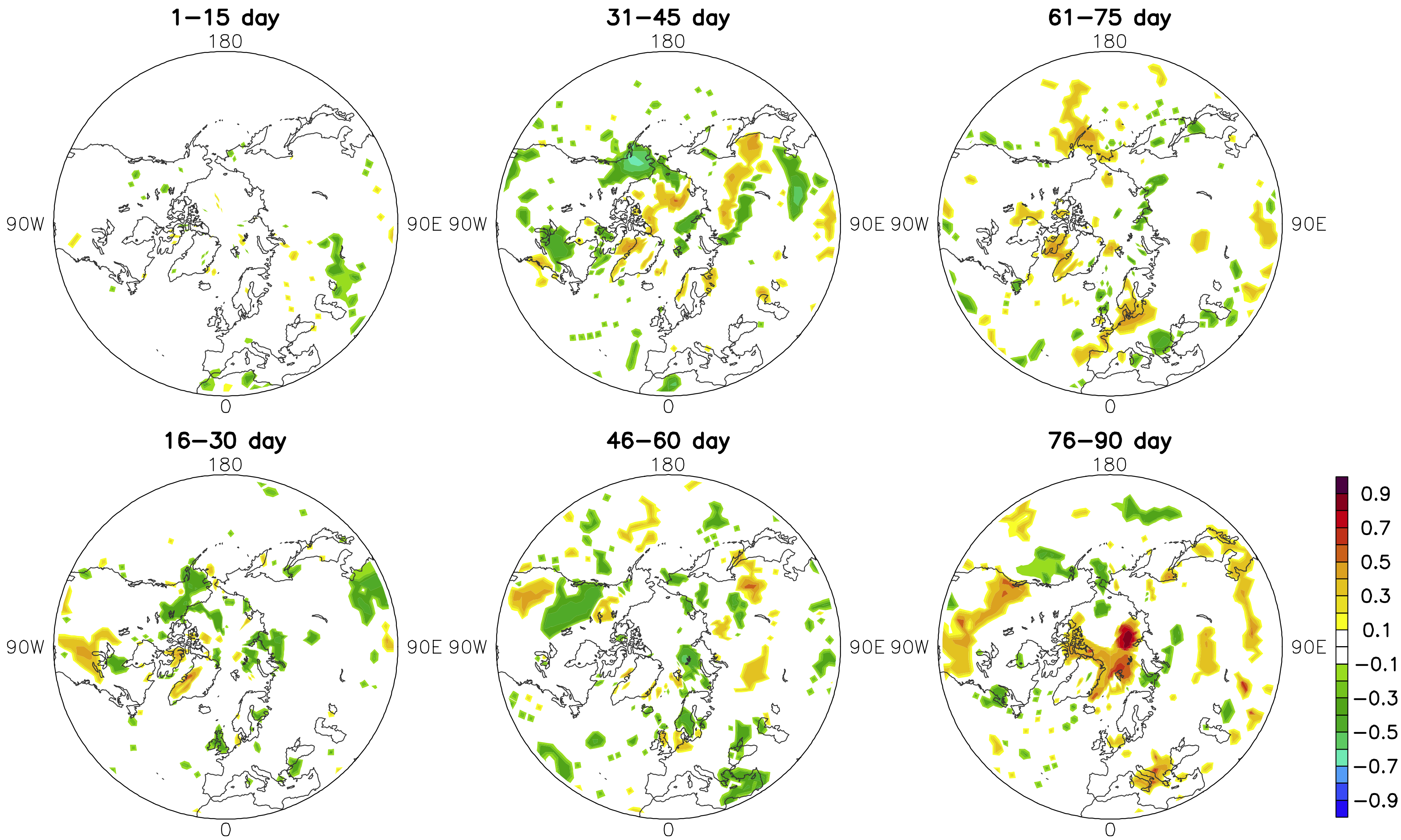
CLM develops a positive snow bias wrt ERAINT

Forecast skill (R) differences for snow depth (Series 1 minus Series2)



No clear signal (patchiness)

Forecast skill (R) differences for T2m (Series 1 minus Series2)



Intriguing high skill difference over Arctic at long leads (Month 3)

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

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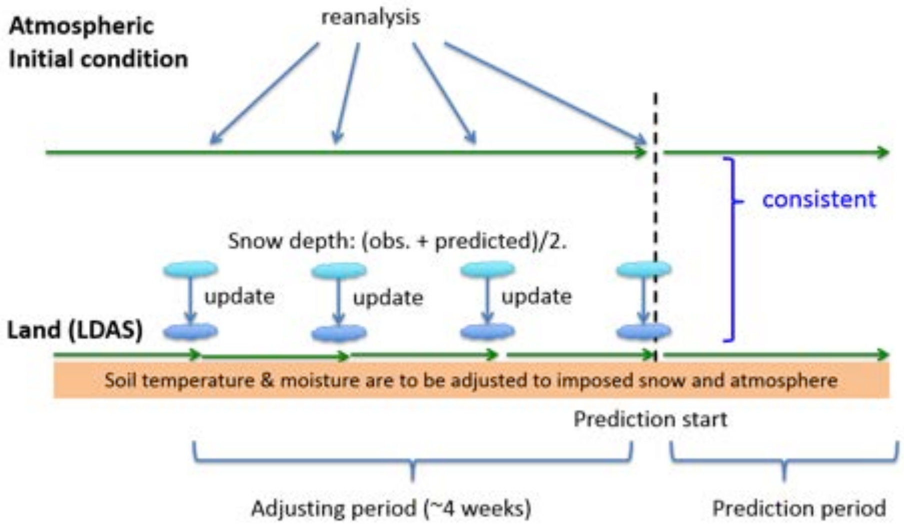
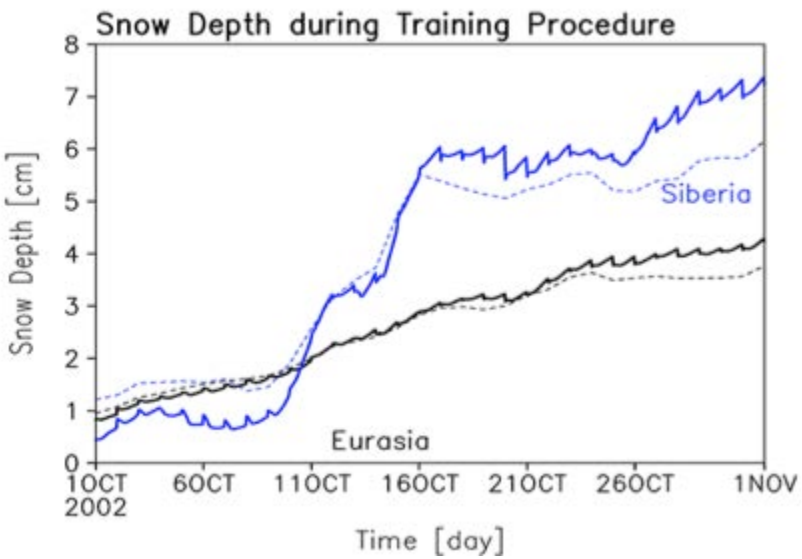
Chonnam National University

Baek-Min Kim
Korea Polar Research Institute

Snow depth nudging



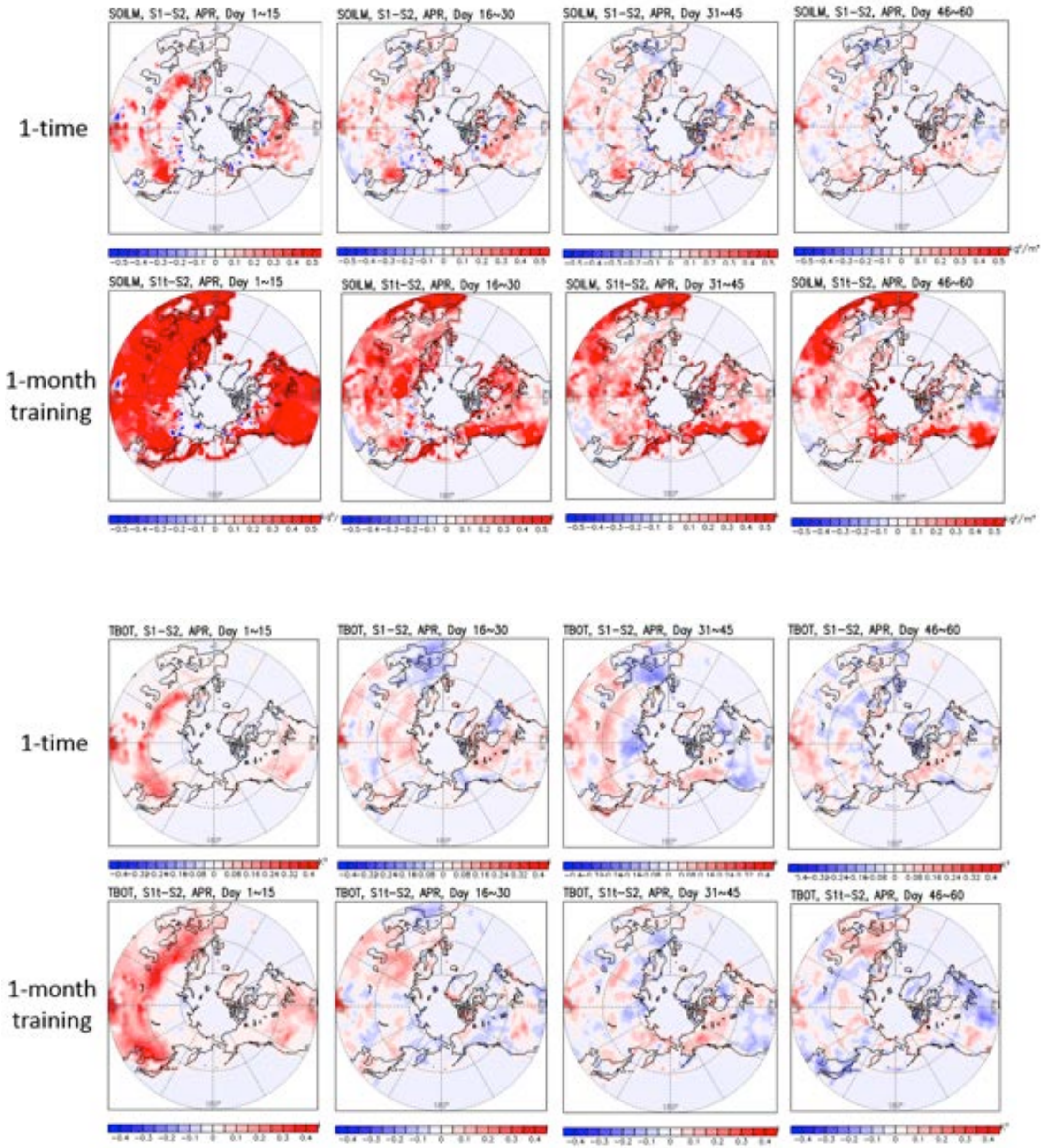


1. 1-month long, snow training period is applied to the seasonal prediction system (NCAR CAM4).

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

Suggested experiments/analysis to be done

- CCSM4 (Kopri-CNU) and GloSea5 (KMA-UNIST) forecasts with/without snow initialisation
- For ten years, two start dates: 1 Feb & 1 Mar
- Two options for snow initialisation
  - Snow depth from JRA-55 (CDF matching)
  - Nudging snow depth in offline LSM simulation

- Predictability gain w.r.t. observed snow, SAT, precipitation
- Changes in AO, drought predictability

UPDATE (October 2017)

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

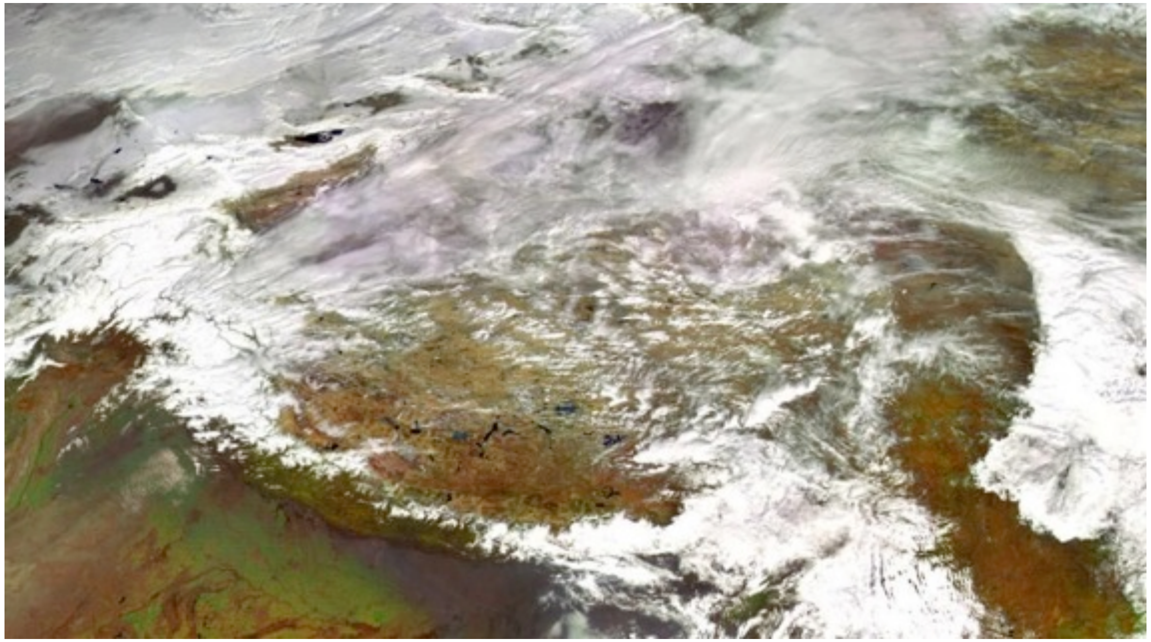
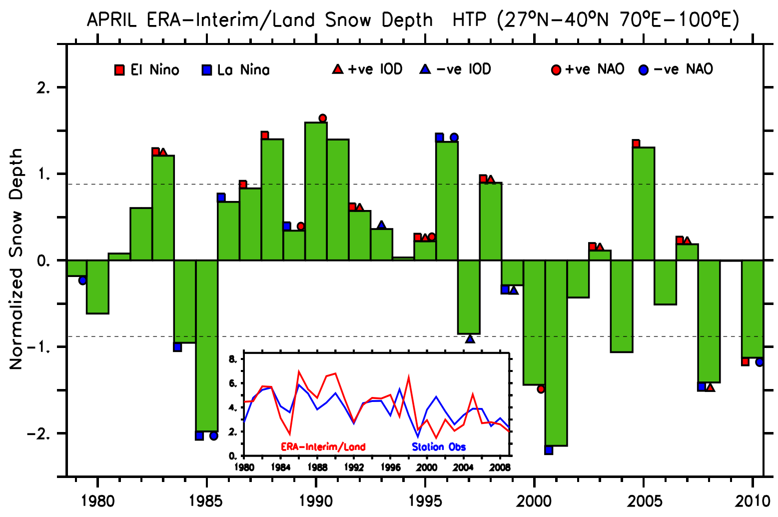


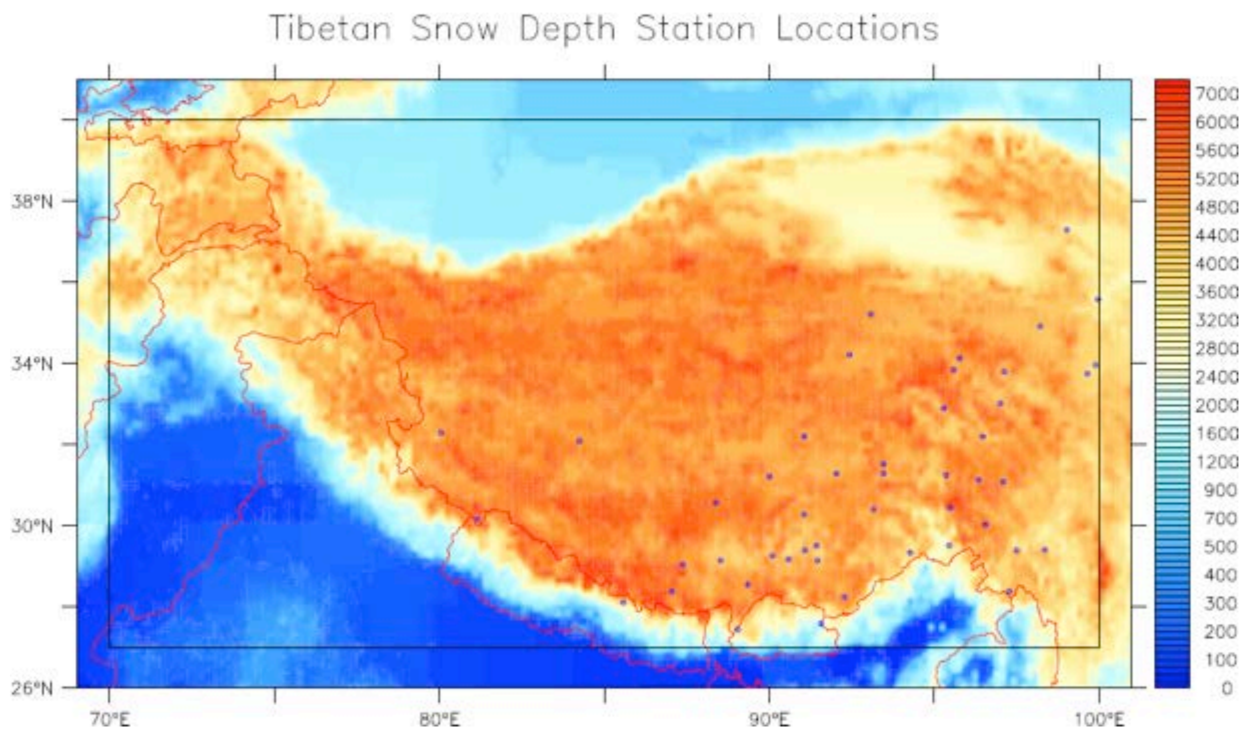
Image of the Tibetan-Plateau on 20 February 2017 from new Chinese Meteorological Satellite FY4 (source NSMC, CMA)

How realistic is the snow depth reanalysis (based on ERAINT-land) over HTP ?

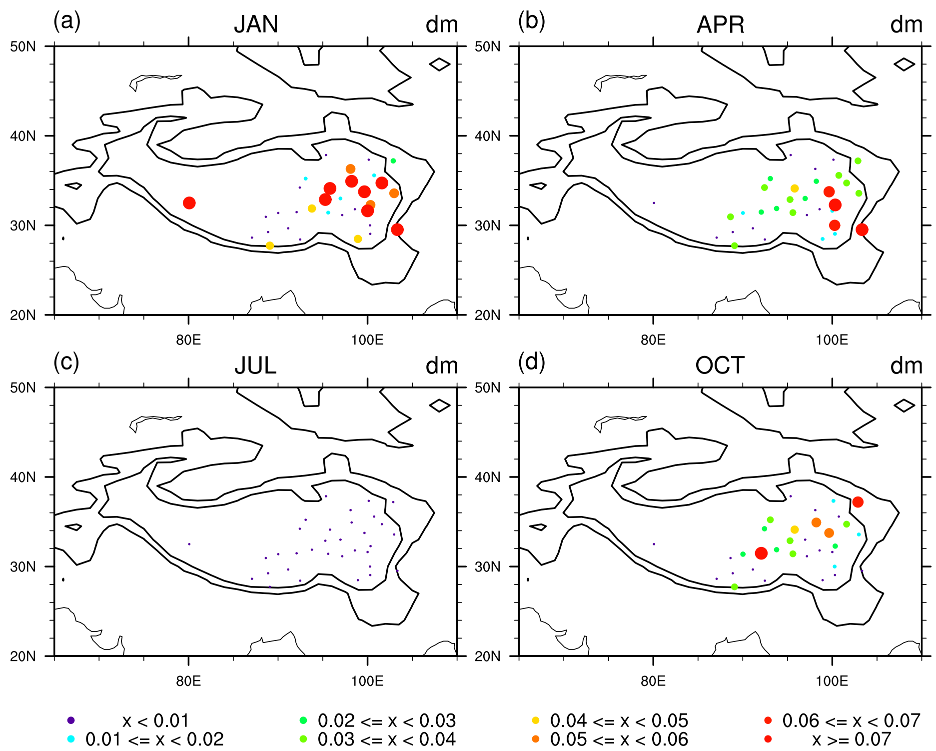
- corr= 0.57 with set of 47 stations, mostly at low elevation, with inhomogeneous distribution while there may be complex regional climate regimes
- How are the regional seasonal climatic regimes represented?
- Station data is April snow max :

→there a high snow model bias over HTP, common to many re-analyses with impact on forecasts
→over-estimating effect of snow on monsoon





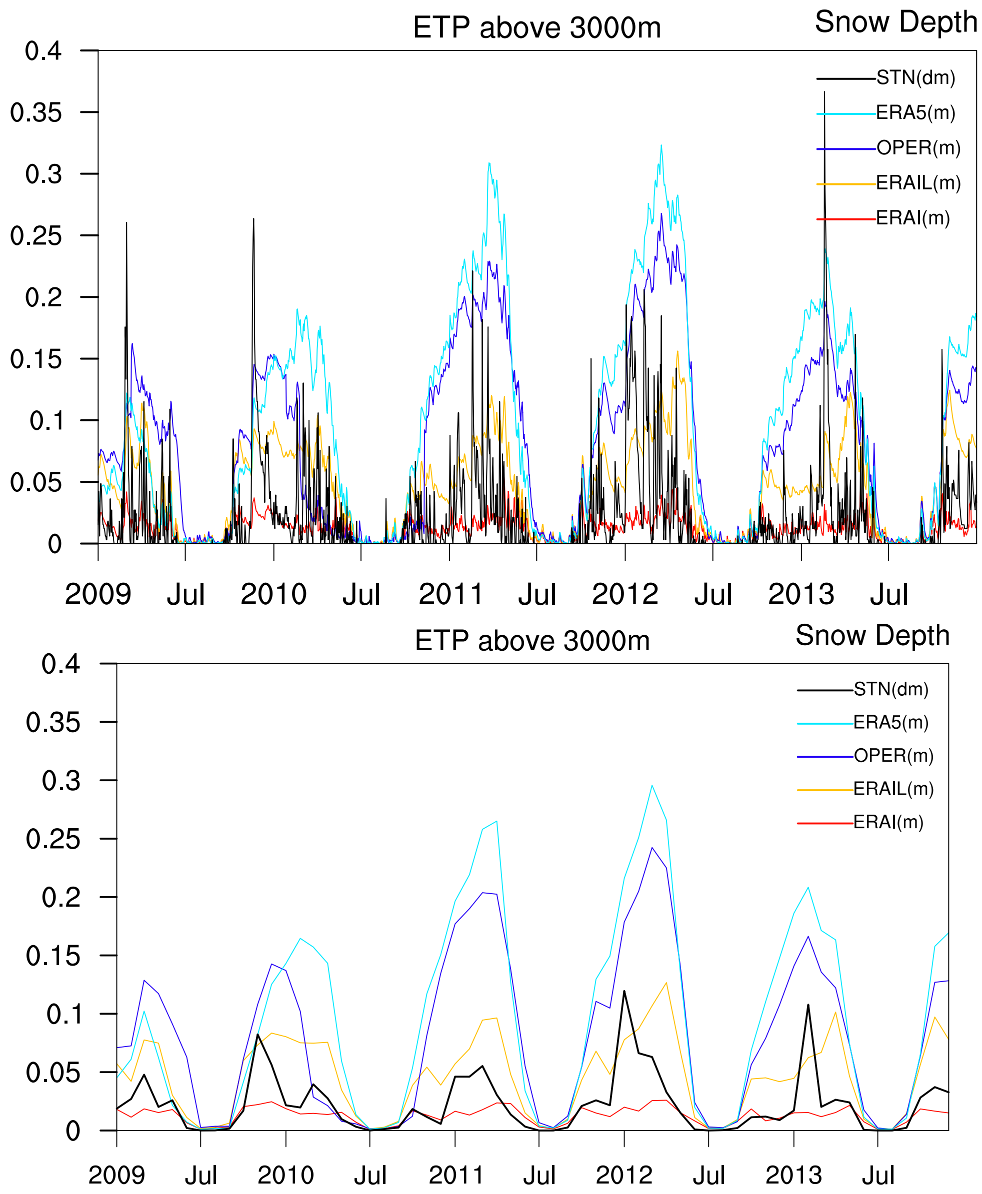
Seasonal evolution of climate-mean (2009-2013) in-situ observed snow depth (units: dm)



Compared with the ERA reanalysis, the in-situ observed snow depth over the HTP shows a similar seasonal evolution, but it is one scale smaller.

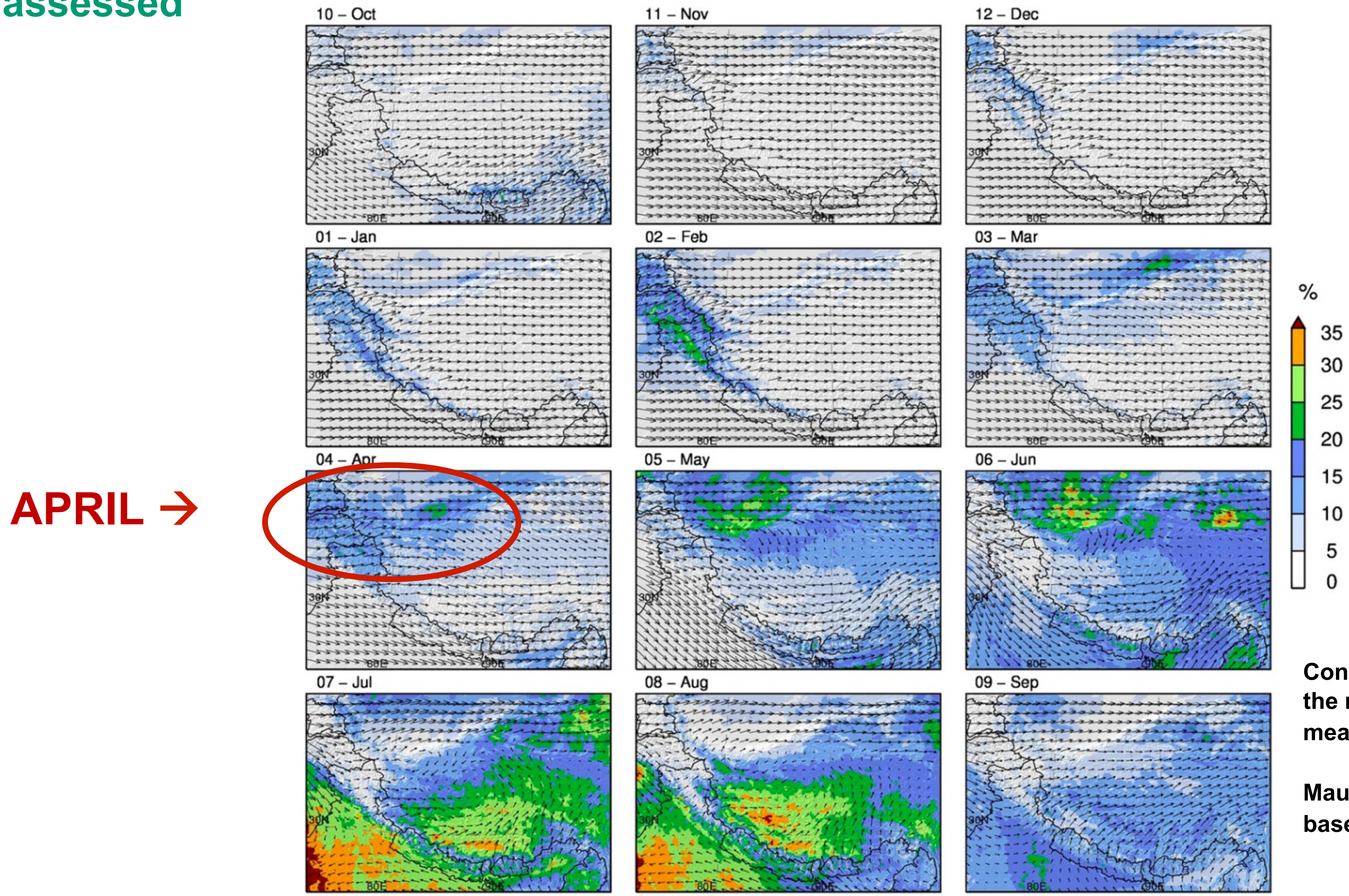
Courtesy of Boqi Liu (CAMS, Beijing)

Time series of snow depth averaged over the 33 GTS stations during 2009-2013



How realistic is the seasonality of precipitation in reanalysis over HTP

- mostly summer monsoonal precipitation in central TP, dry in winter
- most studies on precipitation focused on winter and summer, but spring has been little assessed

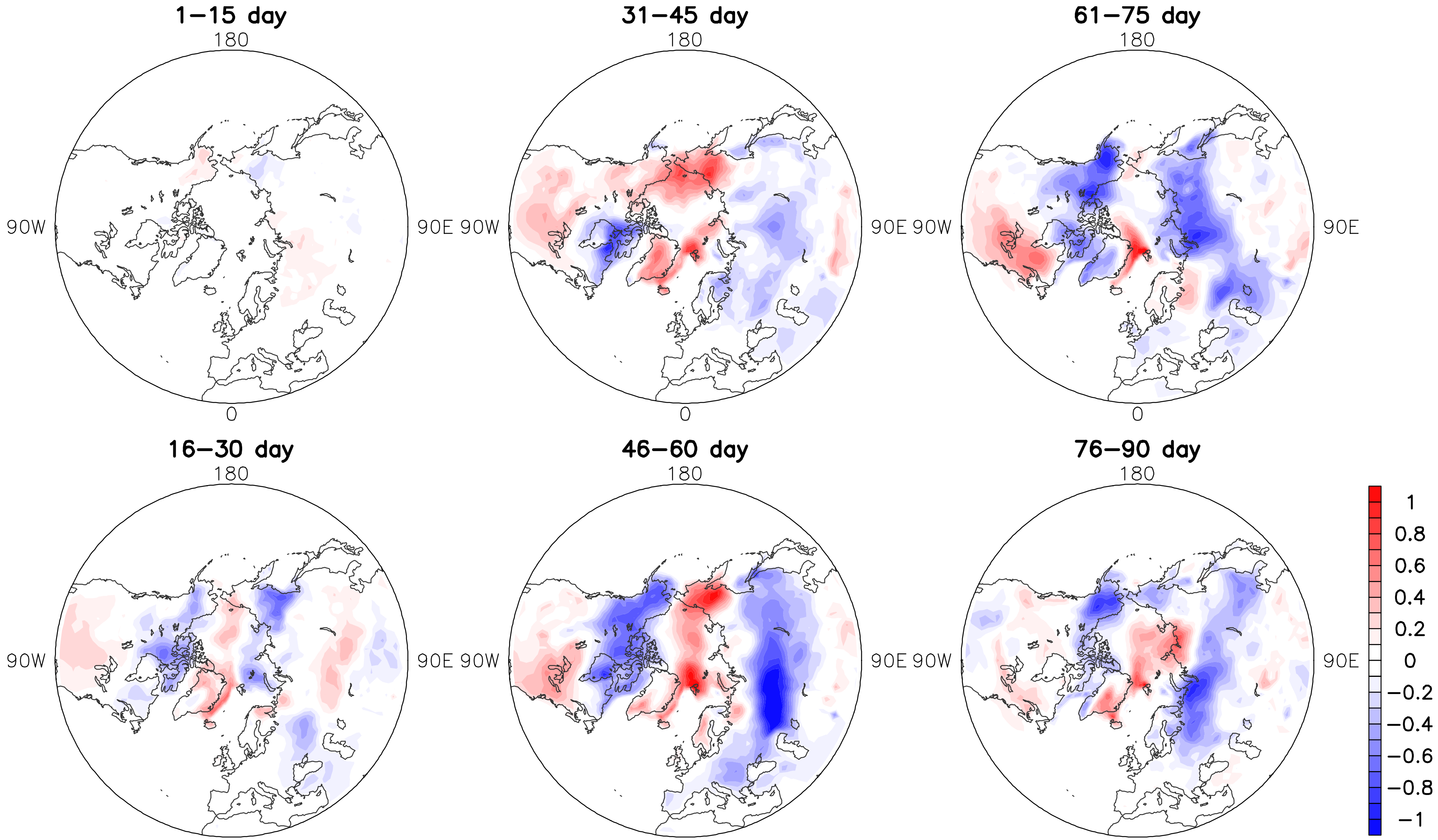


Contribution (%) of each month to the mean annual precipitation and mean monthly 500-hPa wind

Maussion et al., 2014
based on regional HR reanalysis

RESERVE SLIDES

T2m (units: ºC) differences (Series 1 minus Series2)



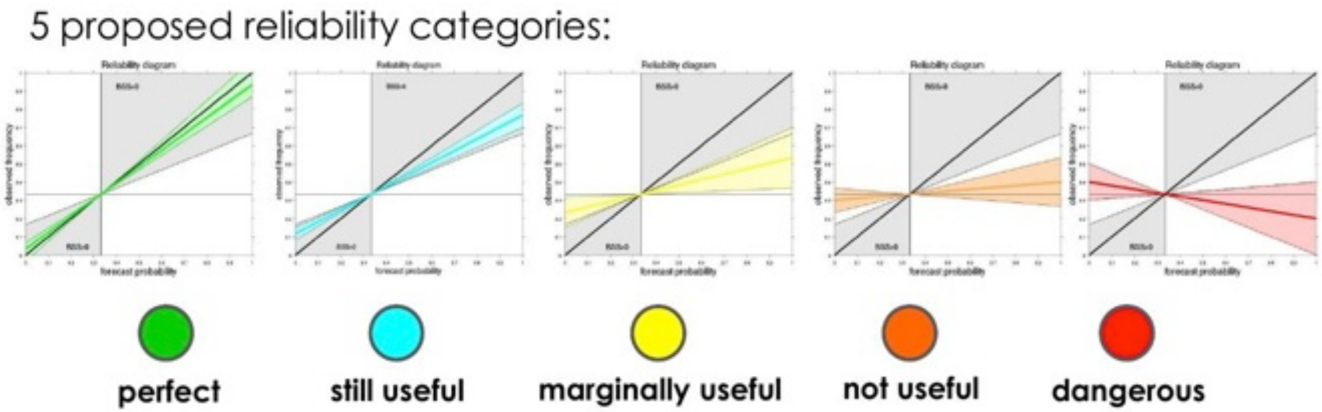
Warm Arctic cold northern continents (e.g. Siberia, N. America) at Month 2-3

Analogy with sea ice effect : sea ice retreat→ "WACS pattern" (although still debated)

Orsolini et al, Clim Dyn 2013

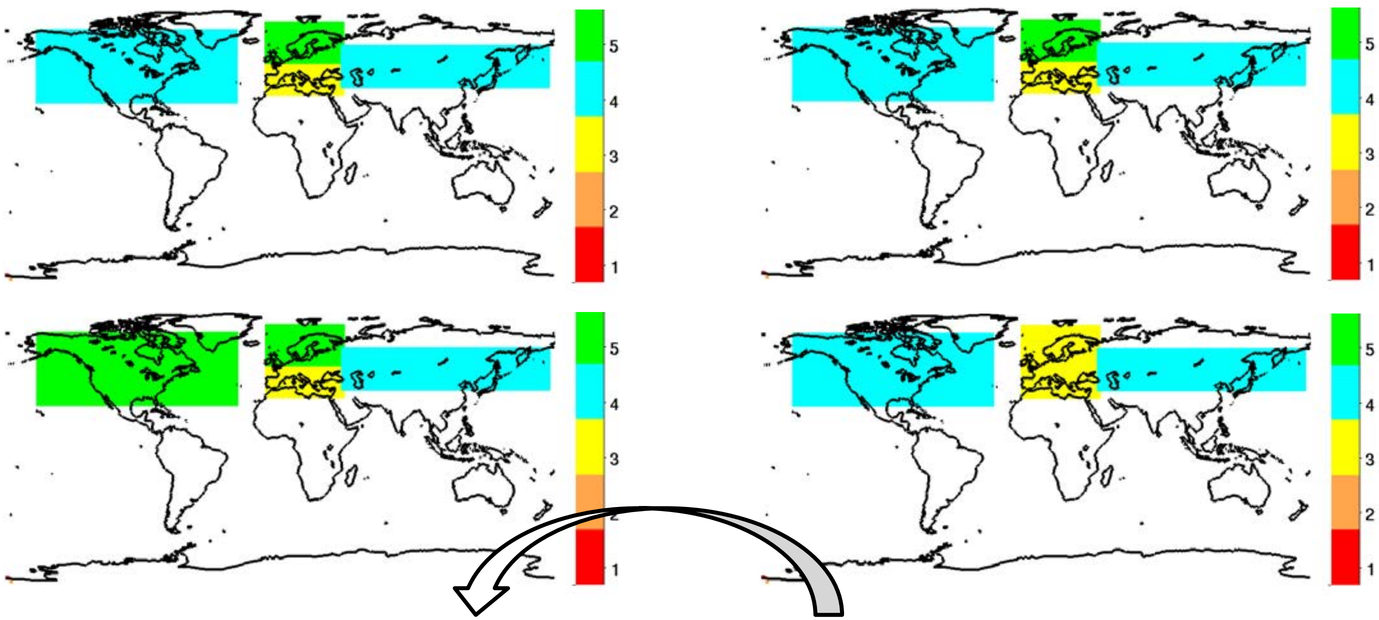
Reliability Diagrams for snow depth over Eurasia : categories of reliability

Weisheimer and Palmer (2014)



Lower Terc.

Upper Terc.



S1 : Realistic

S2 : Clim

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