Norwegian Meteorological Institute
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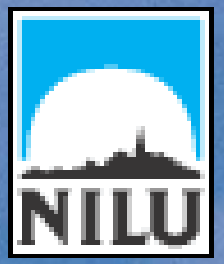
ECMWF



Norwegian Institute for Air Research

Bjerknes Centre for Climate Research

Impact of the autumn snow cover on high latitude climate variability

Orsolini, Y. (1,2), Senan R.(3), Balsamo G. (4), Doblas-Reyes P. (5), Weisheimer, A. (4), Vitart F. (4), Carrasco A. (3), Benestad R. (3)

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2 Bjerknes Centre for Climate Research, Bergen

3Norwegian Meteorological Institute, Oslo

4 ECMWF, Reading, UK

5 Catalan Institute of Climate Sciences, Barcelona, Spain

Eurasian snow cover impact on climate

- **Snow-covered land : key role in climate system due to snow unique radiative and thermodynamical properties:**
  high albedo, high thermal emissivity, insulating properties

- **Snowpack may impact not only local meteorological conditions but also global circulation patterns**

- **Eurasian autumn snow cover influences wave trains propagating downstream over the North Pacific and vertically into the stratosphere**
  (Cohen et al., 2007; Saito et al., 2001; Orsolini and Kvamstø, JGR 2011)

Here, we address the impact of the snowpack (snow cover and depth) on forecasts during autumn/early winter

Does snow initialisation have a quantitative impact on monthly to seasonal prediction skill ?

→Focus on high northern latitudes

In autumn/early winter at high latitudes → influence of snow mediated by long-wave cooling, soil insulation, and not short-wave albedo. ***(e.g. Dutra et al., 2010; 2011)***

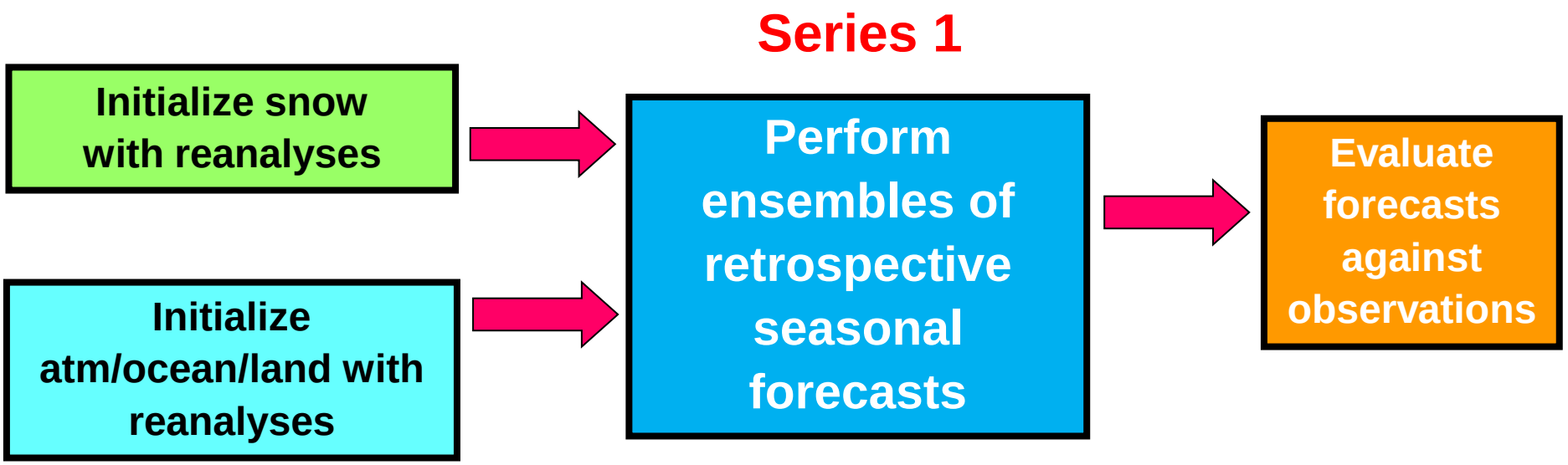
Seasonal forecast model from ECMWF

- High horizontal resolution (T255;l62) coupled ocean-atmosphere model (IFS HOPE V4)
- State-of-the-art ensemble prediction system: most recent version of atmospheric model
- land surface module is HTESSEL improved hydrology
- improved 1-layer snow scheme Dutra (2011)
- High horizontal resolution is same as ERAINT re-analyses

Experiment design:

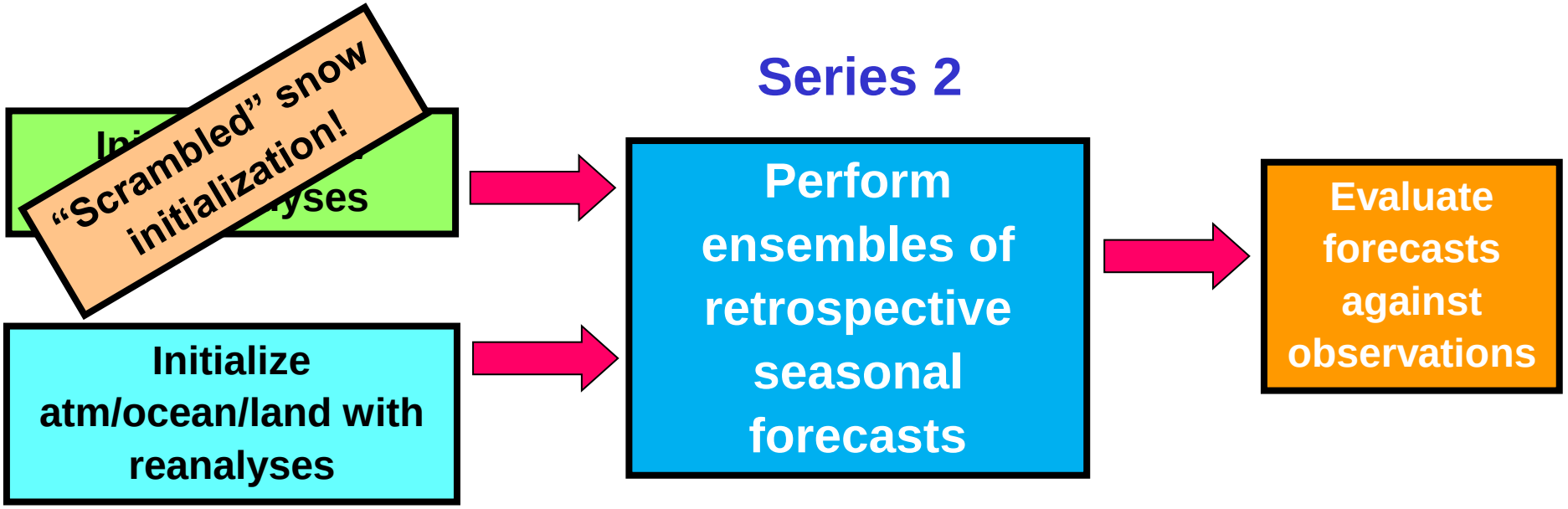
- GLACE-2 (focused at soil moisture in warm season) Koster et al. (2004; 2010)
- transpose the GLACE-2 approach to "snow"

A first ensemble of forecasts with accurate snow initialisation



→ Re-forecast recent years, focus on autumn-early winter

A second set of forecasts with ”scrambled” snow initialisation



“Scramble” snow variables in a consistent way: snow T, density, albedo, SWE

Series 1:

- 12-member ensemble
- atmospheric / oceanic / land initialisation
- forecast length : 2-month
- 4 Start dates:

OCT 15, NOV 1, NOV 15, DEC 1

- 6 Years 2004-2010

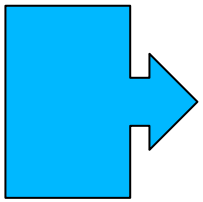
•realistic snow initialisation

(taken from re-analyses ERAINT)

Series 2:

identical , <u>but</u>

•"scrambled snow": other dates or years from the same set

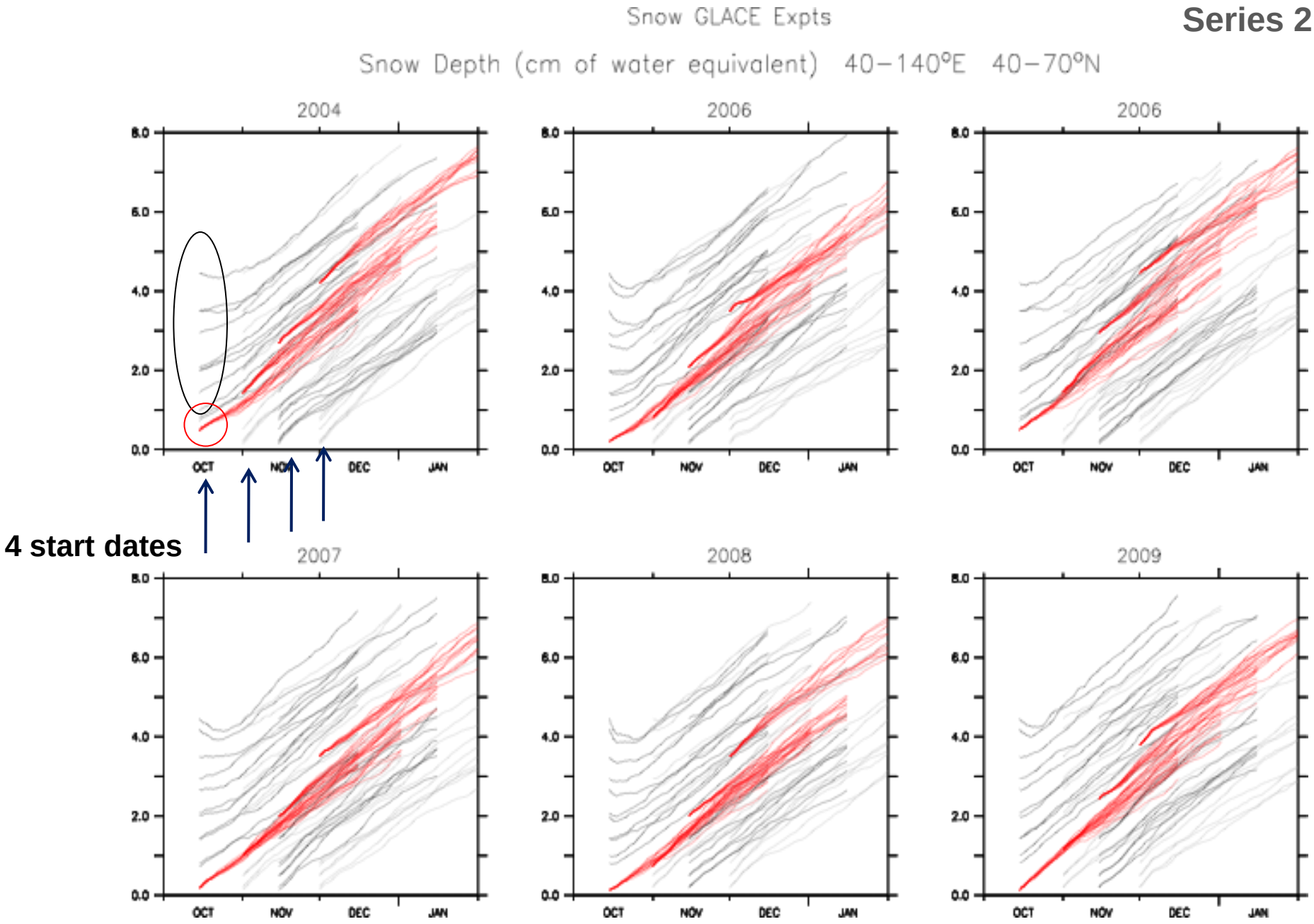


Anomaly field : Series 1 – Series 2
in 15-day averaged subperiods (day 1-15, day 16-30, …)

Evolution of the snow depth over Eurasia

Series 1

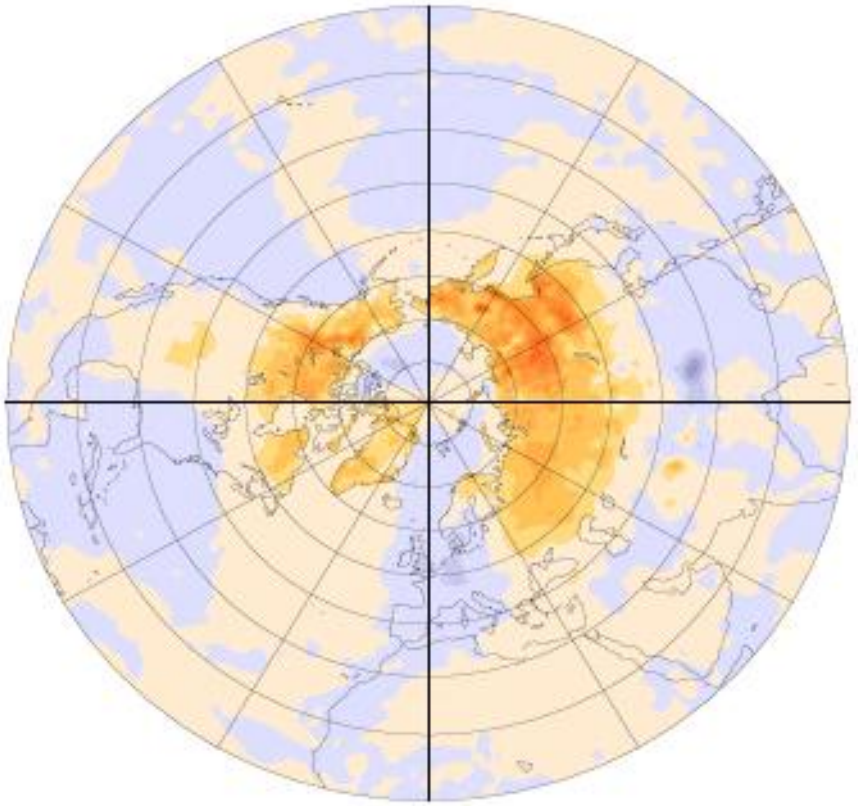
Series 2



Initial Surface Temp. differences (T2m): direct response

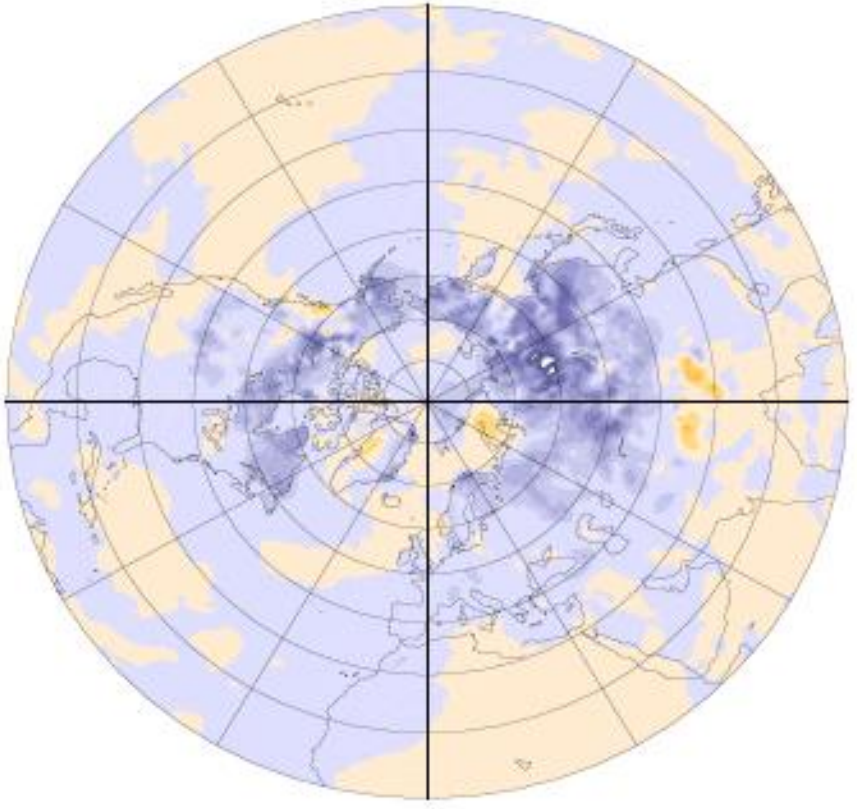
OCT 15 (first start date)

Low-High snow composite difference



DEC 1 (last start date)

High-Low snow composite difference

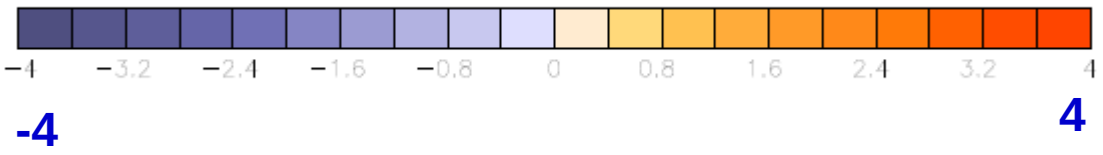


ensemble-mean

Series 1 – Series 2

Zero lead (1-15 days)

First sub-period



-4 **4**

Presence of snow pack → colder lower atmosphere (4K)

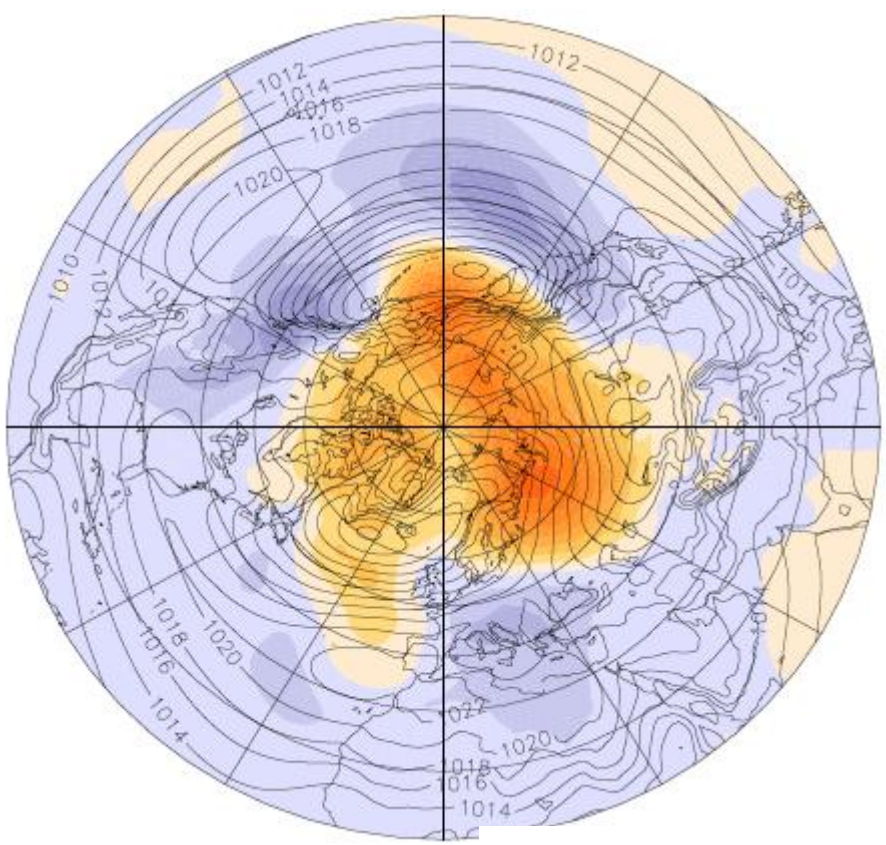
Sea level pressure differences: indirect response at 1-month lead

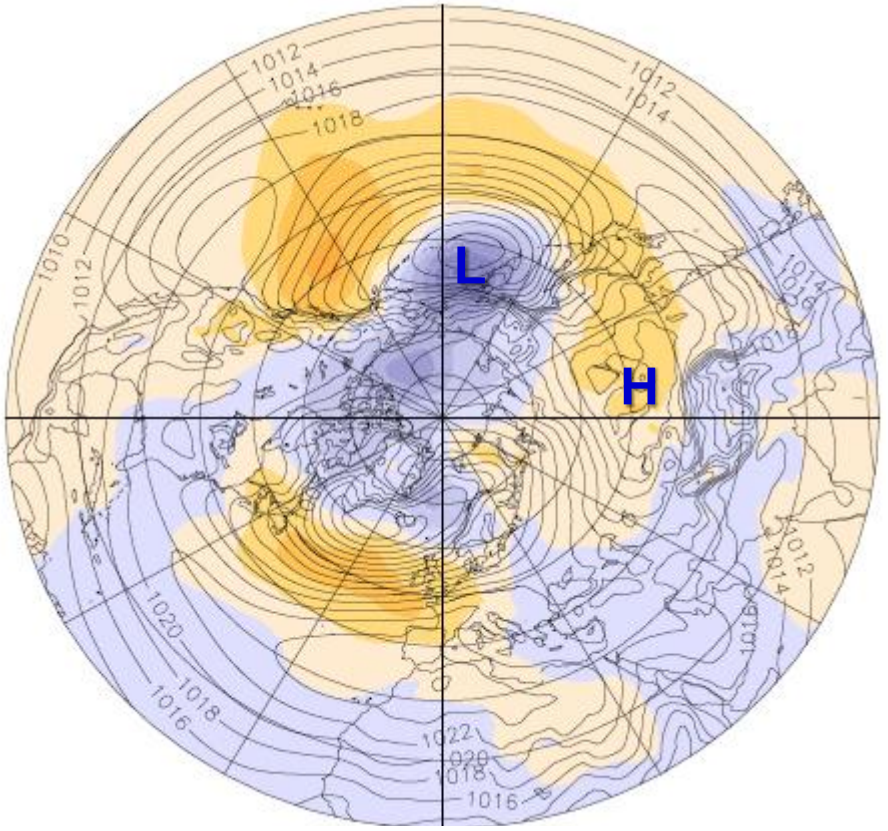
OCT 15 (first start date)

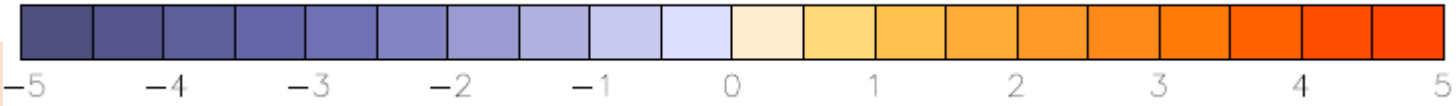
Low-High snow composite

DEC 1 (last start date)

High-Low snow composite (~mirror)







Series 1 – Series 2

1 month lead (30-60 days)

+ valid for one month

Indicative of circulation changes :

high snow → deeper Aleutian Low, stongerSiberian High, lower SLP over Arctic

Global forecast skill increment in surface temperature : evaluation against re-analyses

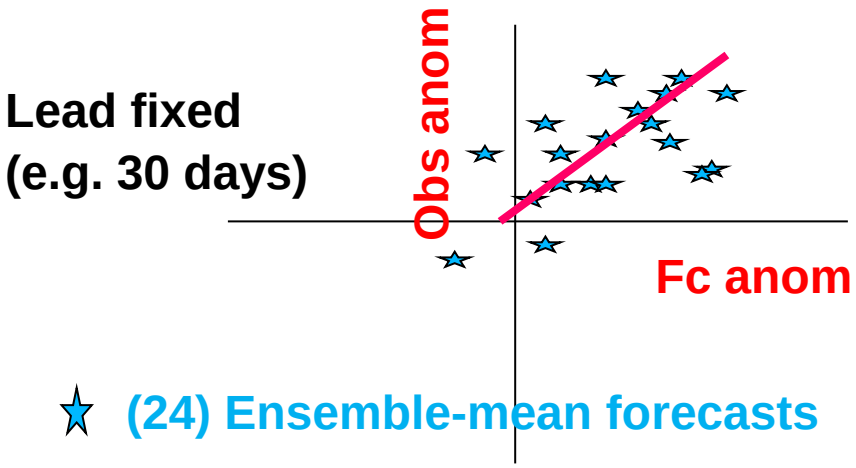
Forecast skill obtain in experiment using realistic snow initialization (SERIES 1)

—

Forecast skill obtained in identical experiment, except that snow is not initialized to realistic values (SERIES 2)

=

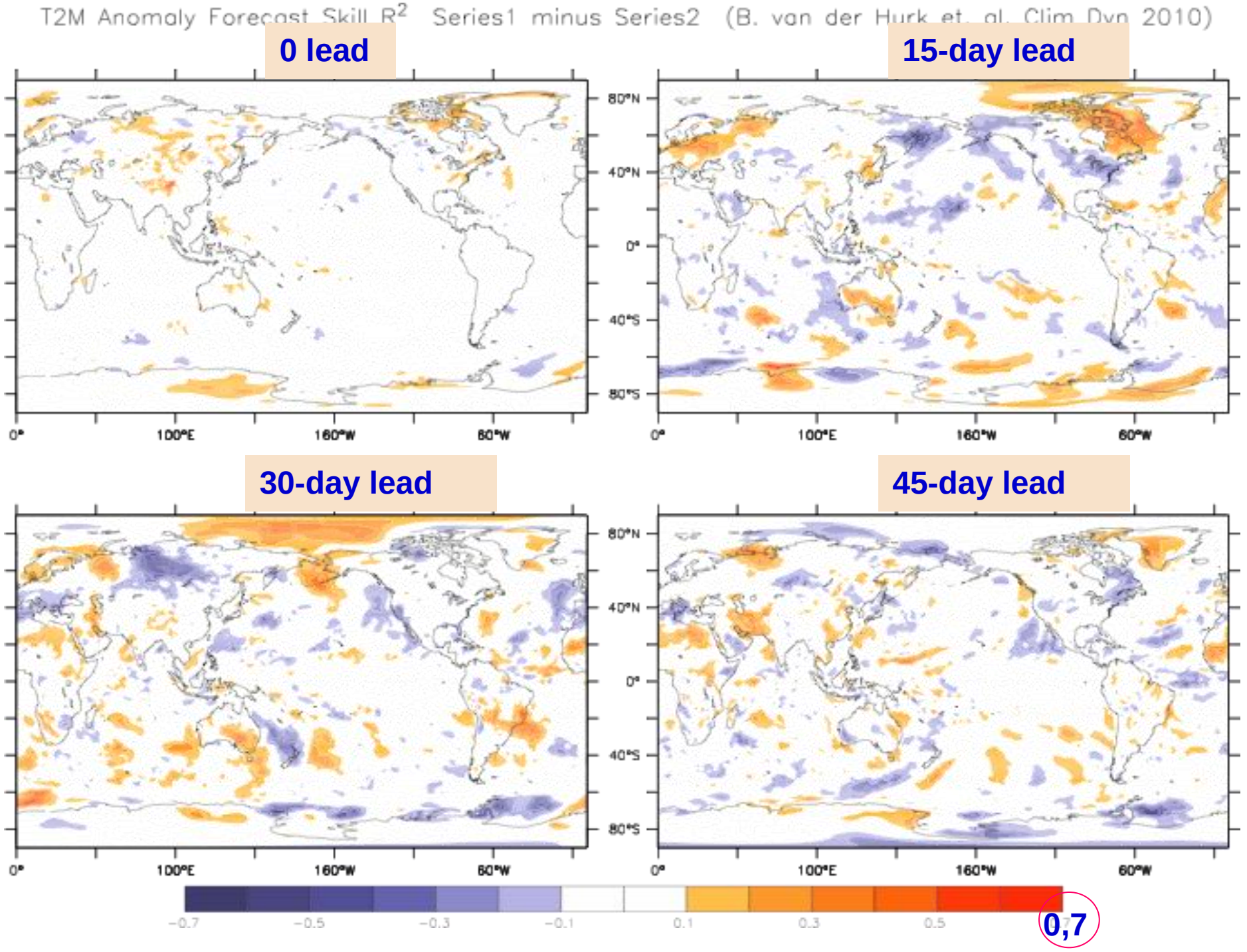
Forecast skill due to snow initialization



Skill measure : R^2 (correlation coefficient sqr)

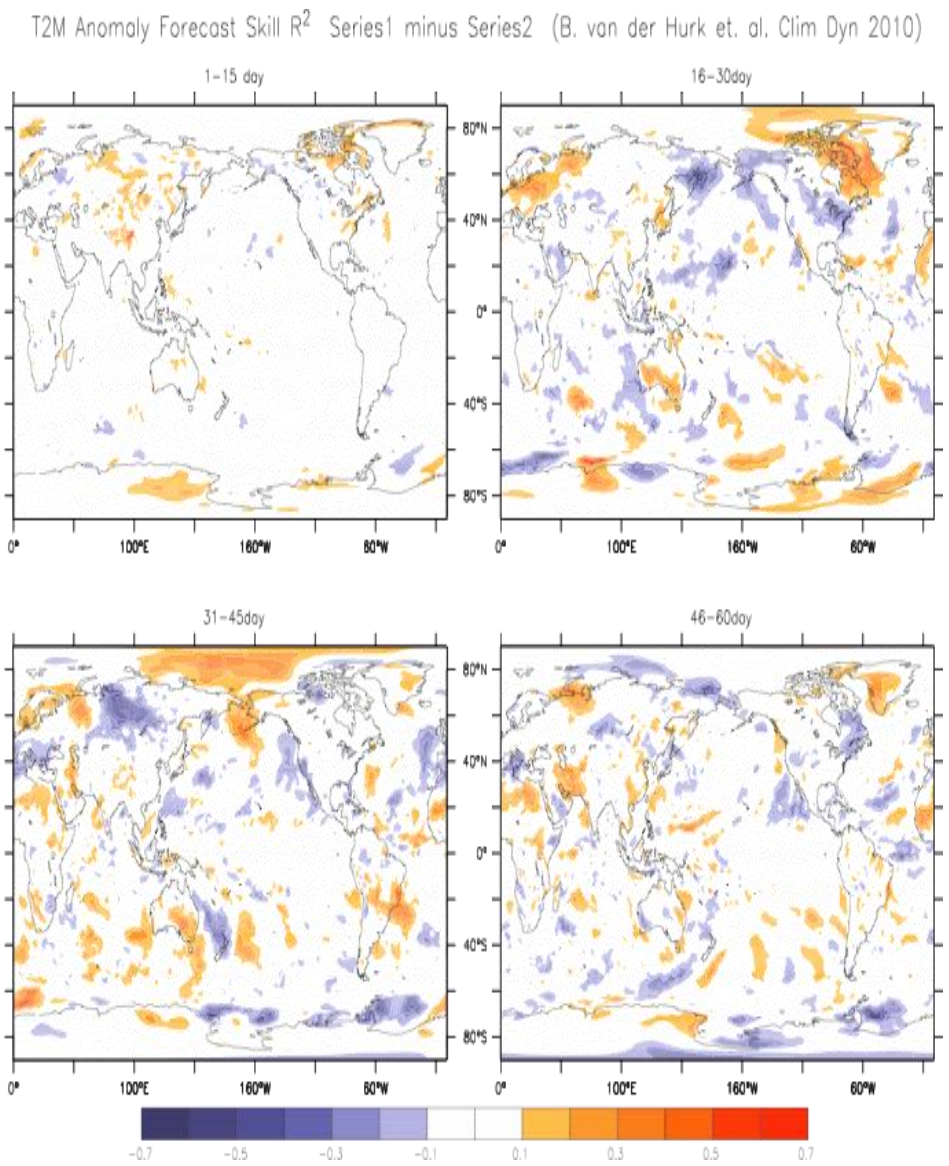
- **model anomaly is defined wrt lead and season**
- **skill multiplied by sign of ACC before differencing (not to reward negative skill)**

Forecast skill increment in T_{2m} vs. Lead time



Forecast skill increment vs. lead time

T2m



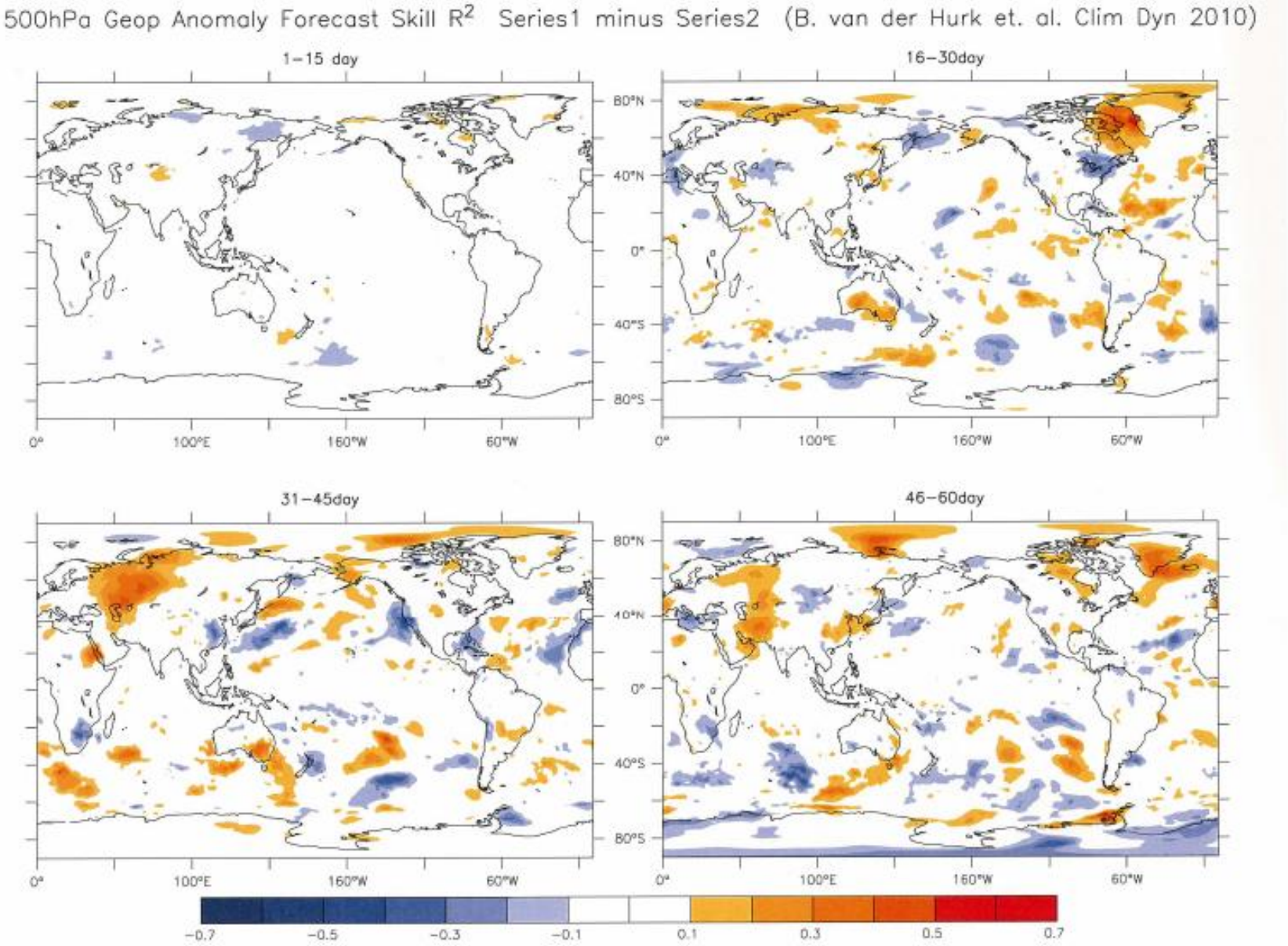
- **Initial (0 lead) weak positive increment over snow-covered land**
- **Very large (~0.7) over Arctic at 30-day lead**

Note: GLACE2 →soil moisture skill increment ~0.2-0.3] (Koster et al, 2006]

- **Teleconnection influence : 30-day lag consistent with remote forcing through planetary wave propagation (Fletcher et al., 2008; Cohen 2007)**

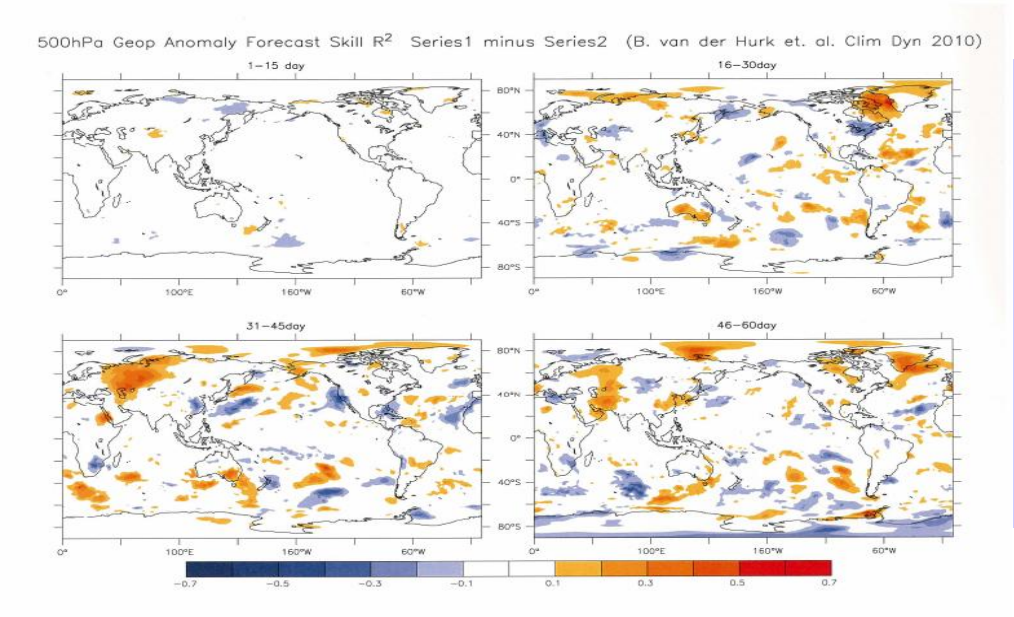
Note: in the latter, downward stratospheric influence after 2 months (cannot be seen in our 2-month forecasts)

Forecast skill increment in geop-500 vs. Lead time



Forecast skill increment vs. lead time

Geop 500



- Same large skill increment (~0.7) at latitudes poleward of 45N
- Not at initial time, but longer lead

Preliminary Conclusions

❑ **Snow pack initialisation has great potential to improve forecast skill in surface temperature over the Arctic, at monthly lead times.**
→Patchiness of skill increment remains to be explained

❑ **Heavy snow pack has cooling effect on lower atmosphere: consistent with role of snowpack in decoupling atmosphere from the soil layer below (Dutra et al., 2010; 2011)** ***(despite low insulation in autumn)***

❑ **Our high-resolution coupled forecasts partly confirm results from earlier studies:**

✓ **Eurasian autumn snow cover and Aleutian Low/Siberian High co-variability**
✓ **Eurasian autumn snow influences on Arctic heights**

(e.g. Cohen et al., 2007; Orsolini and Kvamstø, JGR 2009)

Orsolini, Y. J., and N. Kvamstø, The role of the Eurasian snow cover upon the wintertime circulation: decadal simulations forced with satellite observations, J. Geophys. Res.,114, D19108, doi:10.1029/2009JD012253, 2009.