Climate Prediction System of KMA: Current Status and Plans

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Introduction

GloSea5 (Global Seasonal Forecasting System version 5) of the U. K. Met Office was implemented to the KMA and started producing operational forecasts in 2014

Recently, KMA upgraded initialization process of GloSea5

- ocean data assimilation system
- soil moisture and temperature initialization

Assessment of probabilistic forecasts using 5 categories based on a reliability diagram is ongoing (Weisheimer and Palmer, 2014).

Quantitative measure of the reliability of the system can provides;

- useful information for decision-making
- background information for ensemble plans

Outline

- **Description of GloSea5 operated at KMA**
  - coupled models
  - initialization and ensemble prediction system
- **Assessment of seasonal forecasts probability**
  - reliability of regional temperature/ precipitation with 5 categories
  - reliability depending on ensemble size
- **Future plans**
  - enhance ensemble member, models resolution and initialization

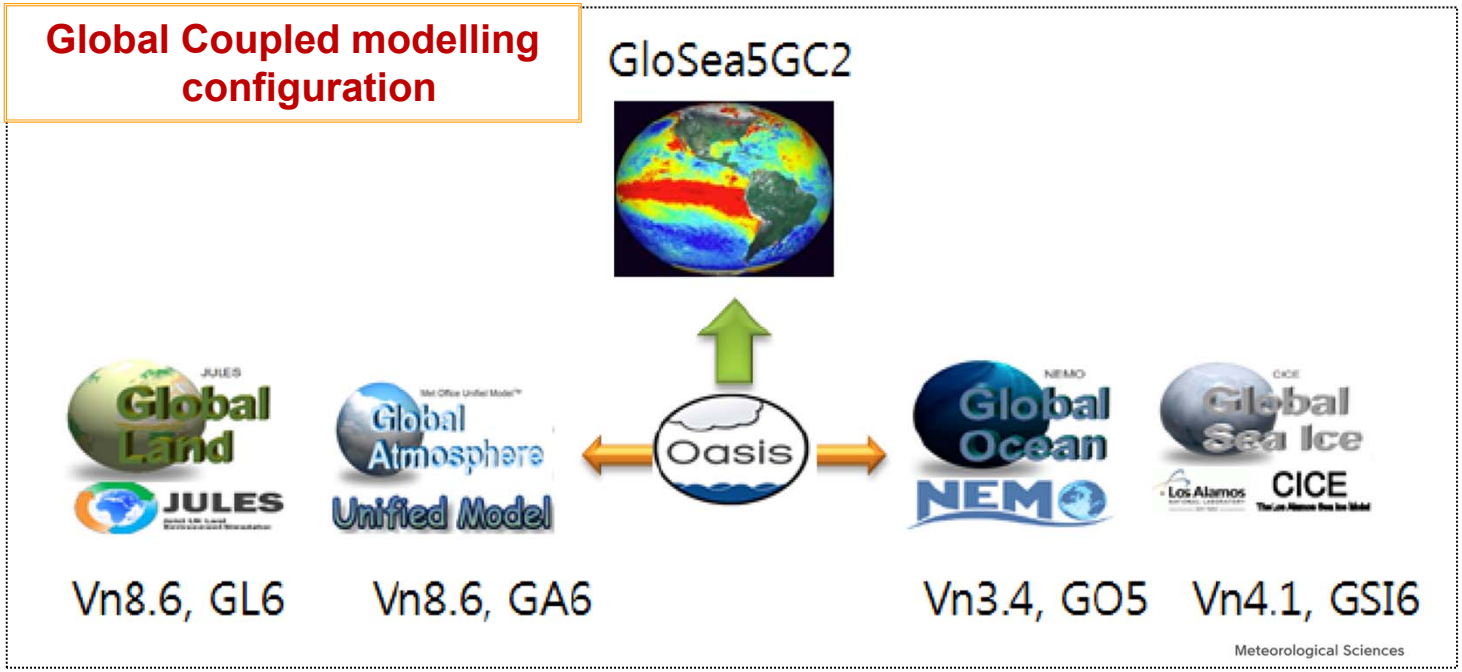
Description of GloSea5: model

The 5th version of the **UK Met Office ensemble prediction system** for monthly to seasonal forecasting based on the latest version of the HadGEM3.

It consists of following components:

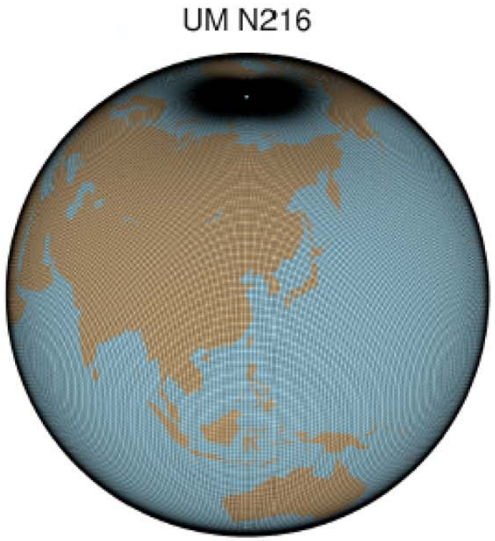
- Atmosphere**:** **UM** (Met Office Unified Model)
- Ocean: **NEMO** (Nucleus for European Modeling of the Ocean)
- Sea-ice: **CICE** (Los Alamos National Lab.)
- Land: **JULES** (Joint UK Land Environment Simulator)
- Coupler: **OASIS** (CERFACS)

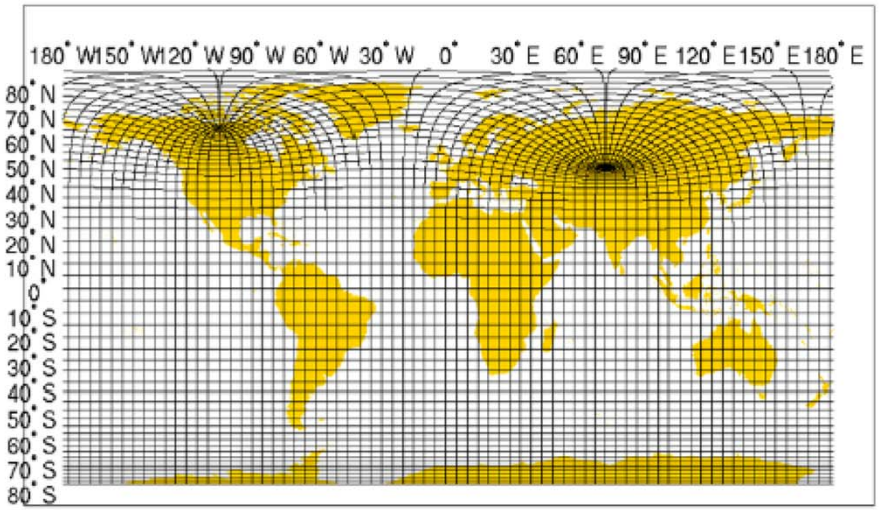
Global Coupled modelling configuration



Resolution

- Atmosphere: N216L85
  - 0.883 x 0.555 degrees (~60km) in the horizontal, and 85 levels up to 85 km (50 are below 18km) in height
- Ocean and Sea-ice: ORCA025L75
  - ORCA tripolar grid with 0.25 degrees in the horizontal, and 75 levels (1 meter near the surface) in the vertical

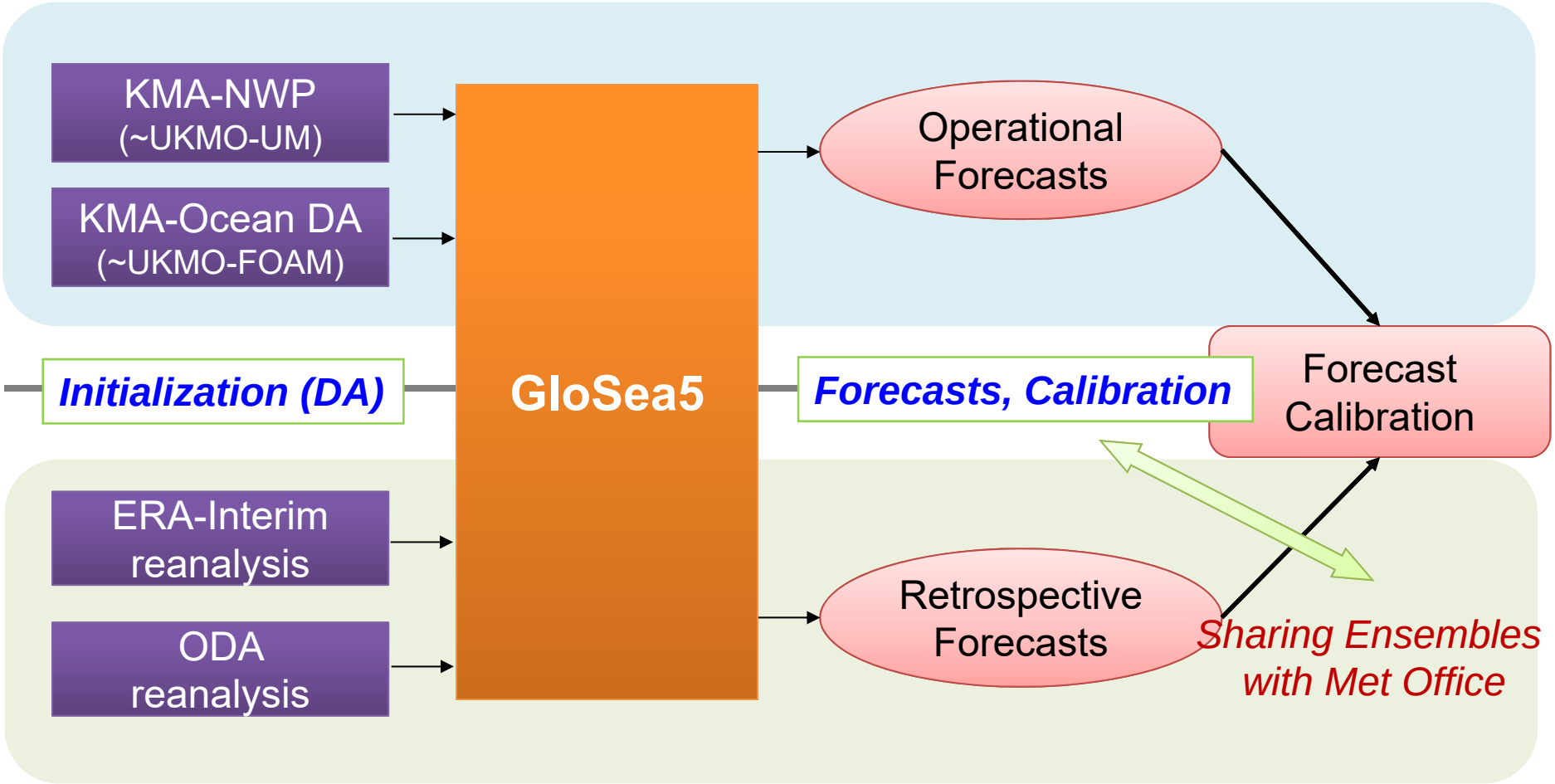




Forecast and Hindcast suites

Forecast

- Initialized daily (with atmosphere- and ocean-only DA system)
- 4 ensemble mem.



Hindcast
(1991-2010)

- fixed starts at 1, 9, 17, 25 of each month
- 3 ensemble mem.

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Consideration of uncertainties

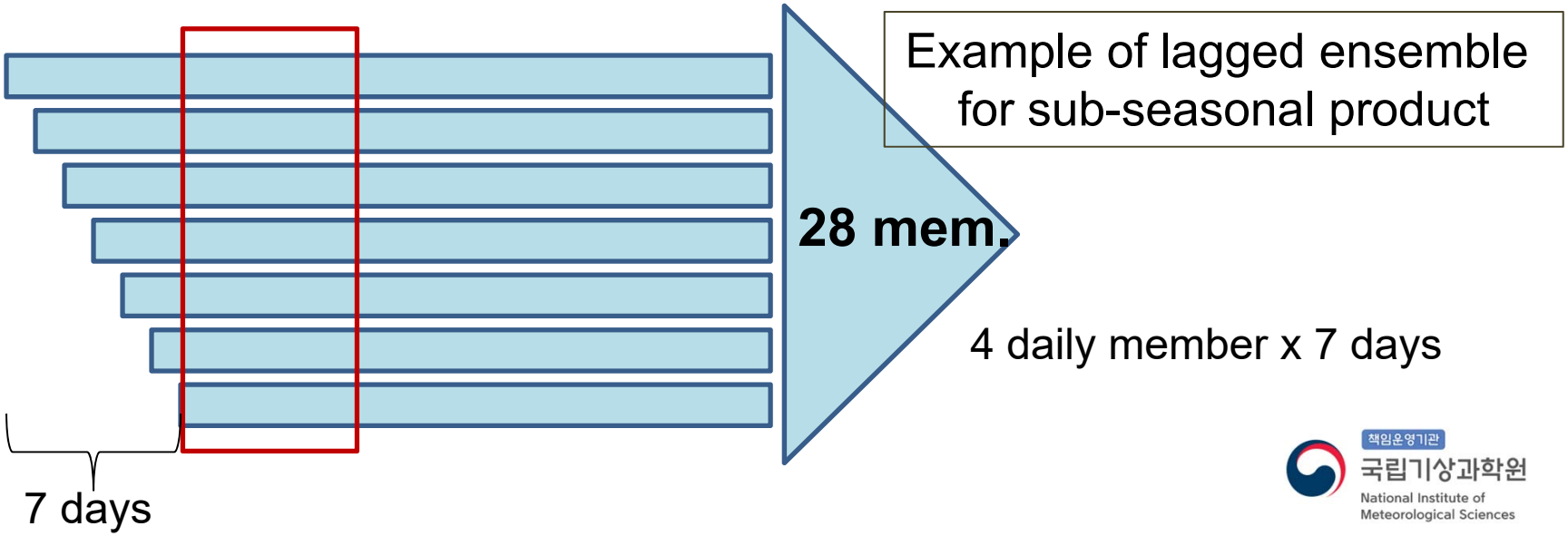
- **SKEB2** (2nd version of Kinetic Energy Backscatter; Tenant *et al*., 2011)

  → represents model uncertainty

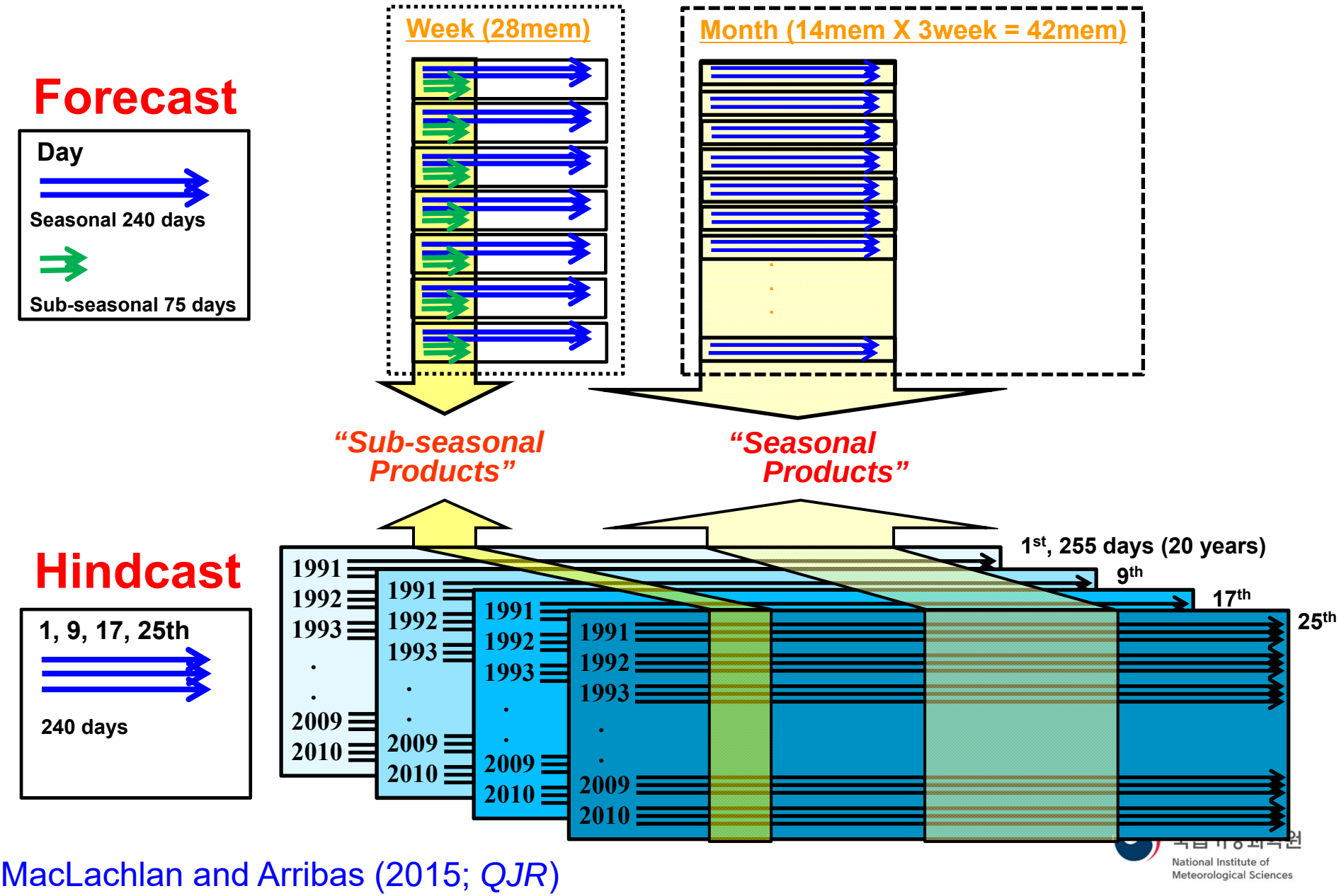
- **Time-lagged ensemble approach**

  → represents initialization uncertainty

  - Currently, no weighting approach is used



Schematic representation : the way ensembles are run



MacLachlan and Arribas (2015; *QJR*)

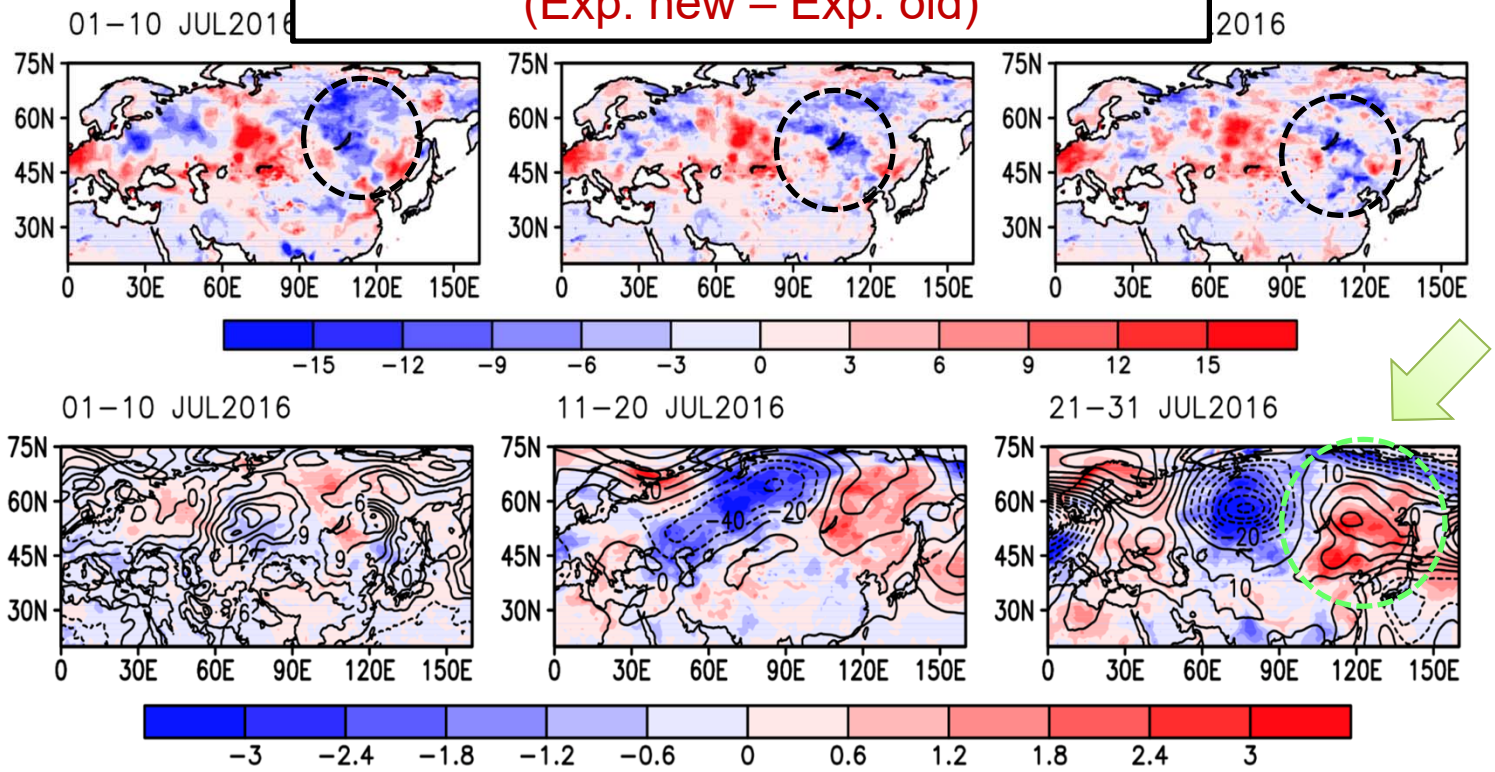
Updates in initialization process of GloSea5@KMA

- Global Ocean Data Assimilation System, based on NEMO/NEMOVAR, started operation to produce ocean and sea-ice restarts of GloSea5 in October 2018
- Established an analysis system that produces soil moisture and temperature based on Offline-JULES, forced by JRA-55 reanalysis data

Heat wave in Mongolia in summer 2016
(Exp. new – Exp. old)

Soil moisture difference between with and without land IC

Surface temperature difference (shading) and 500hPa GPH difference (contour)



How reliable are the GloSea5 seasonal forecasts?

- *quantify the reliability of probabilistic tercile events (e.g. warm, cold for temperature) by comparing forecast probability and corresponding observed frequency (i.e. reliability diagram)*

&

How can we improve the reliability?

- *enhance ensemble size?*
- *better Initialization?*
- *Model resolution & parameterization?*

Hindcast / verification data

	KMA	UKMO	ECMWF
System	GloSea5	GloSea5	System 4
Configure	UM8.6/ NEMO3.4	UM10.3/ NEMO3.4	IFS Cycle 36r4/ NEMO3.0
Resolution	N216L85/ ORCA025L75	N216L85/ ORCA025L75	TL255L91/ ORCA1L42
HCST period	1991-2010 (**20-yr**)	1991-2010 (**23-yr**)	1981-2010 (**30-yr**)
No. member	**3**	**3** (7)	**15** (51)
No. initiated date	**7**	**7**	**1**
Ens. Size	**420** (240)	**483** (644)	**450** (1530)

Red denotes adopted in this work

- **Verification data** : ECMWF re-analysis data for 2 m temperature and GPCP for precipitation

Reliability diagram & 5 categories

Reliability diagram

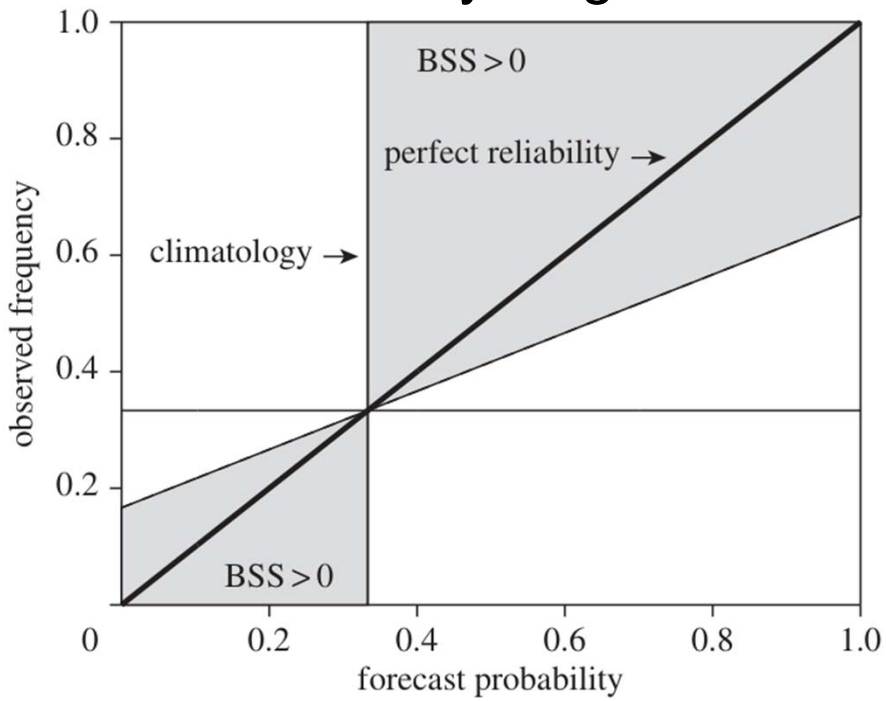
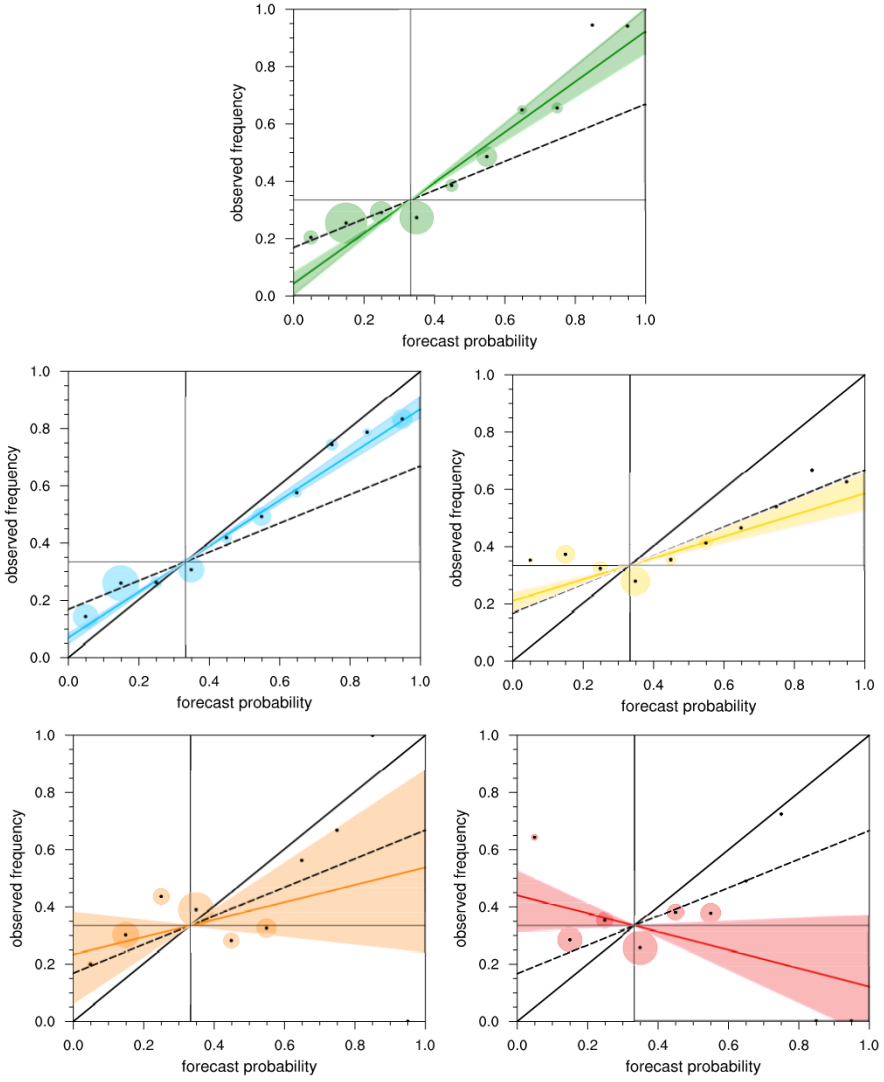


Figure 1. What is a reliability diagram? A reliability diagram shows the observed frequencies of an event as a function of its forecast probability. The thick diagonal line indicates perfect reliability. The thin horizontal and vertical lines show the climatological probabilities of the event in the forecasts and observations (here one-third for tercile events). The grey area defines a region in the diagram where data contribute positively to the Brier skill score.

(Weisheimer and Palmer, 2014)

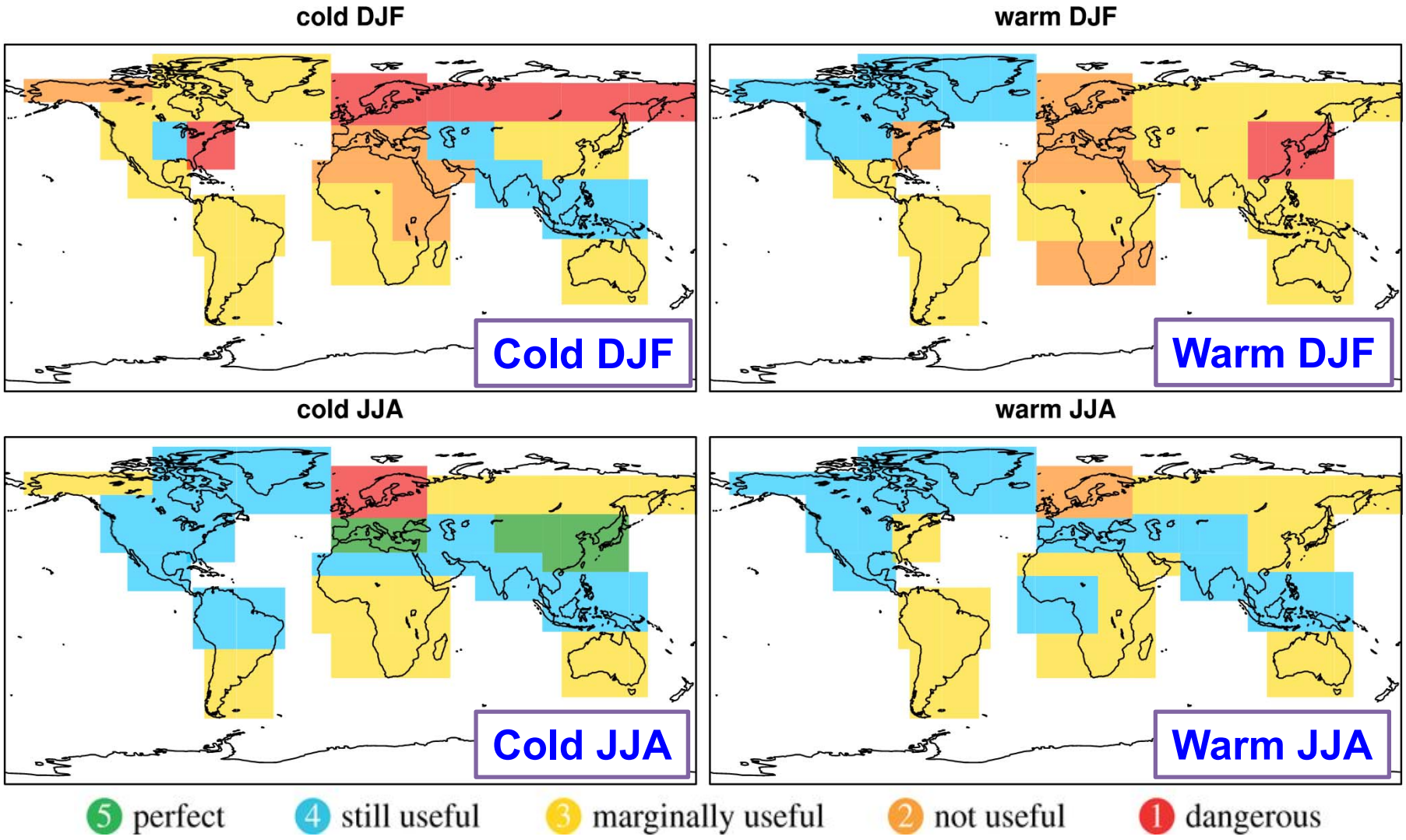


5 perfect 4 still useful 3 marginally useful 2 not useful 1 dangerous

Reliability map for 2 m temperature (GloSea5@KMA)

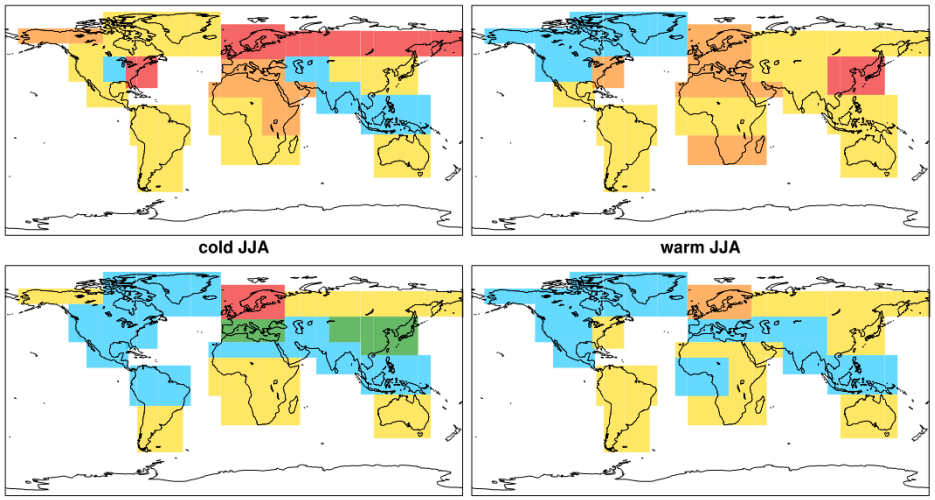
using ensembles initialized in May/November

- More categories 5 and 4 (‘good’) in boreal summer than in winter
- Northern Asia and Europe show categories 2 and 1 (‘poor’)

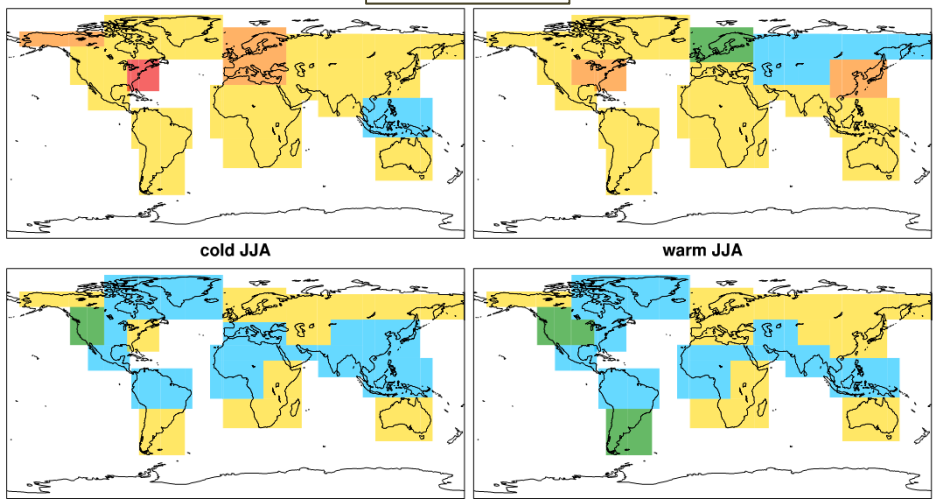


Comparison: reliability map for 2 m temperature

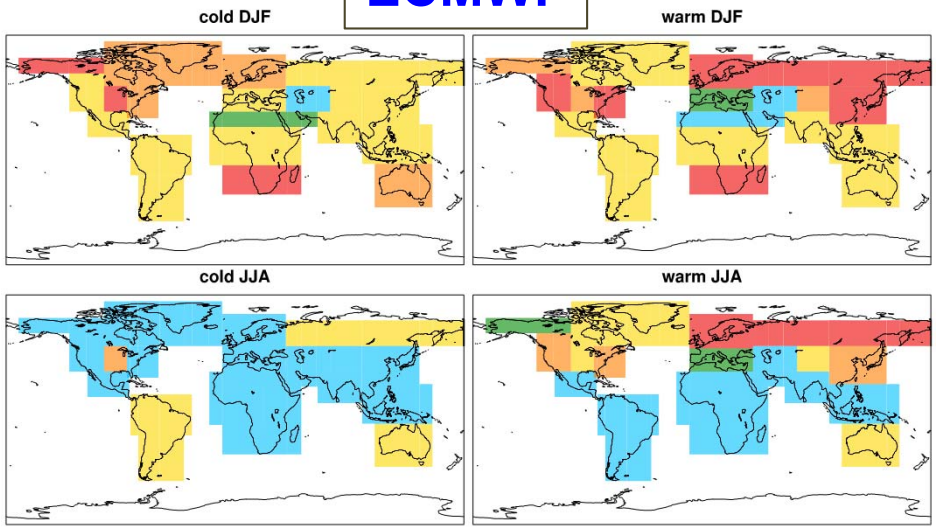
KMA



UKMO



ECMWF



- Reliability of KMA is comparable to UKMO & ECMWF (but limited ensembles)
- All systems imply more reliable forecasts in JJA than DJF
- Category 2, 1 are found in Europe and northern Asia in KMA & ECMWF

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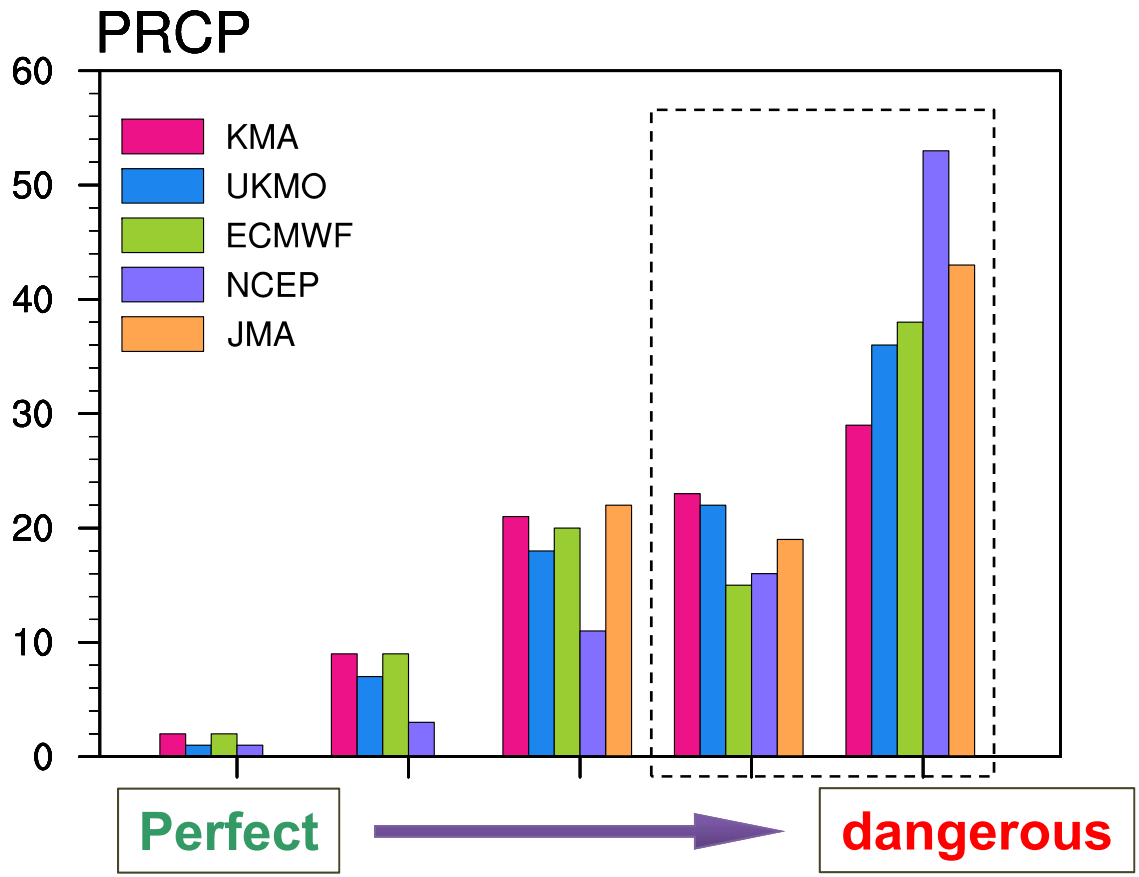
Reliability category for precipitation

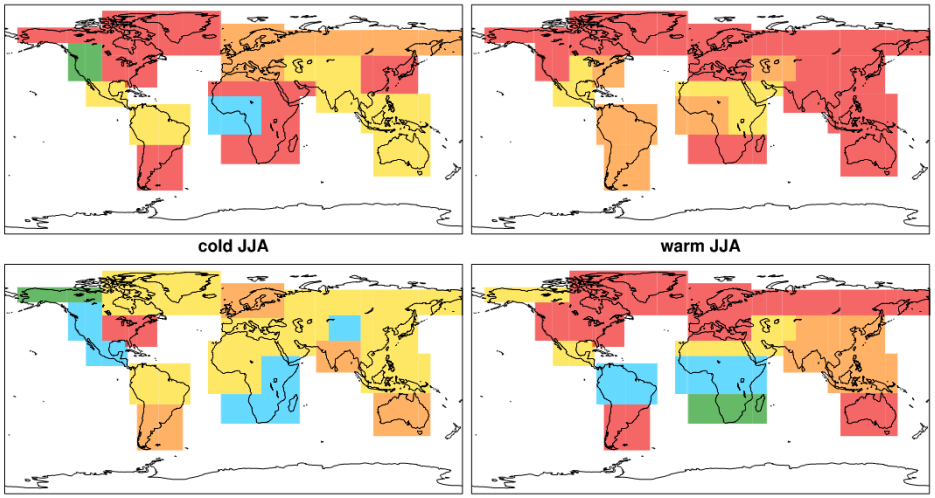
Number of regions that fall into each reliability category summed over all four events (wet/ dry in JJA/ DJF)



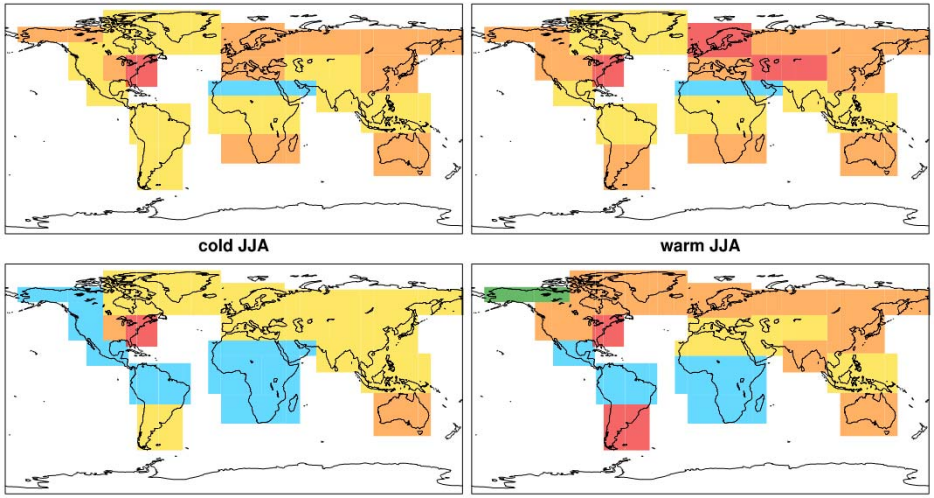
Reliability map for 2-m temperature of System 4

- effect of ensemble size and hindcast period

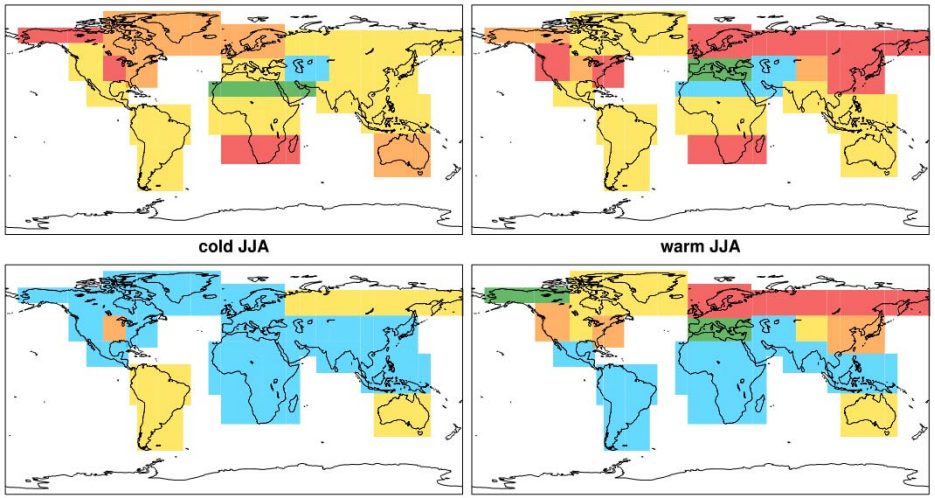
HCST 18-yr/ 15 mem. (270 ens.)



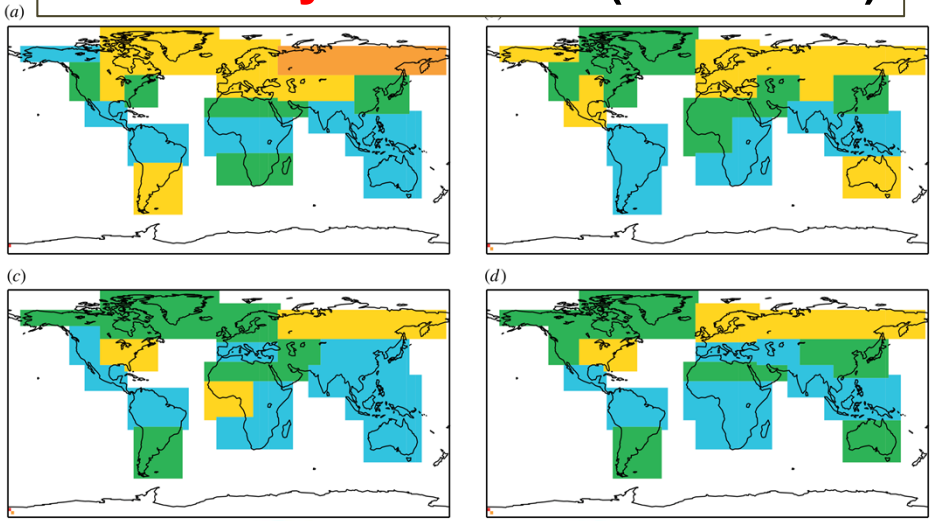
HCST 30-yr/ 9 mem. (270 ens.)



HCST 30-yr/ 15 mem. (450 ens.)



HCST 30-yr/ 51 mem. (1530 ens.)



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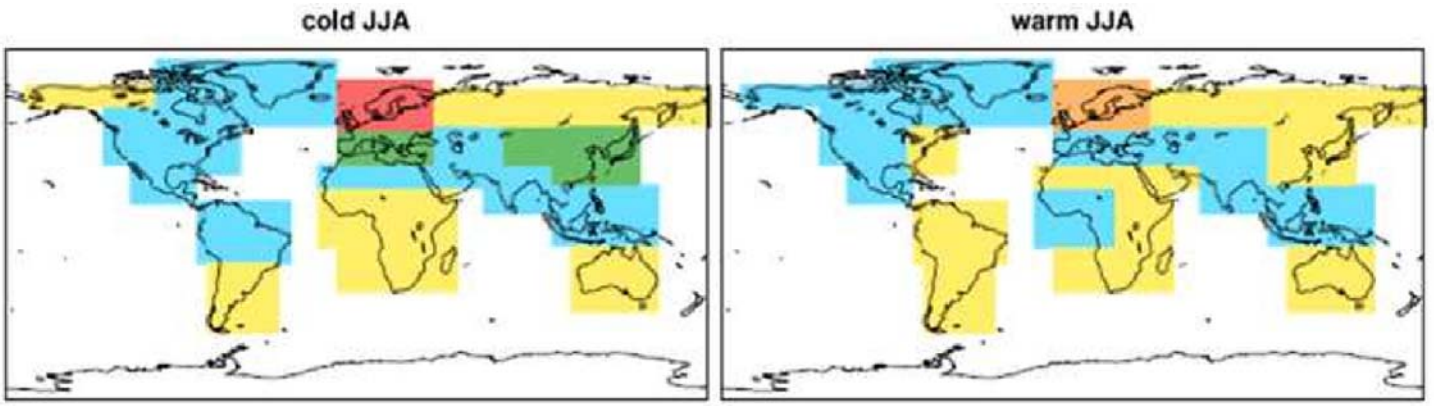
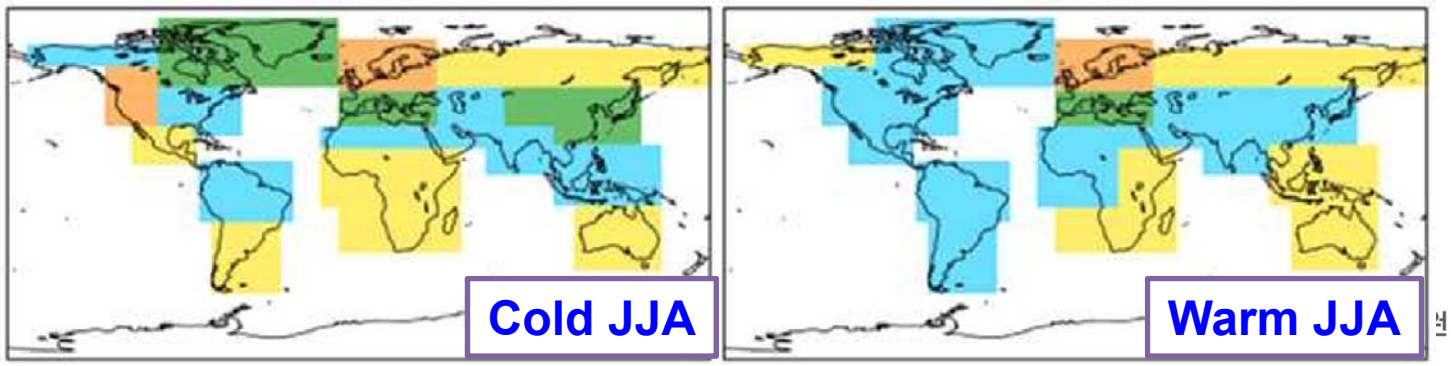
Reliability map for 2-m temperature in summer
- effect of land surface initialization

- New hindcasts initialized by upgraded land initial conditions was made in 2019
- Better representation of land initialization seems to improve reliability



After improving soil moisture and temperature initialization



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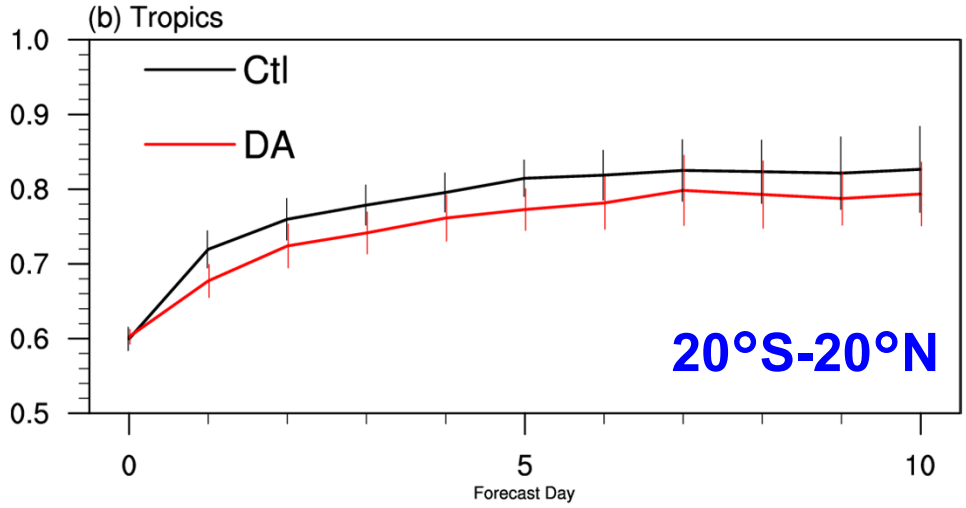
Future plans

- **Ensembles**
  - Enhance forecast (4 → 8) and hindcast (3 → 7) ensemble
  - Expand hindcast period from 20- to 25-year (i.e. 1991-2015)

- **Model/ initialization**
  - high-resolution version of GloSea5
    - ➢ Ocean: about 8 km; Atmosphere: about 25 km
  - reduce initialization shock, using 'coupled replay' (similar to NASA GEOS-5)

RMSE of temperature@1000hpa in tropics (red line: coupled replay)



Thanks for your kind attention