Prediction of extreme climate events on seasonal time scales

Antje Weisheimer

ECMWF

UNIVERSITY OF OXFORD

Outline

Current state of knowledge

- Seasonal forecasts using state-of-the-art coupled GCMs are made routinely at several prediction centres around the world
- It is essential that these probabilistic forecasts are reliable
- How reliable are seasonal forecasts for extreme temperature/ precipitation/circulation seasons?

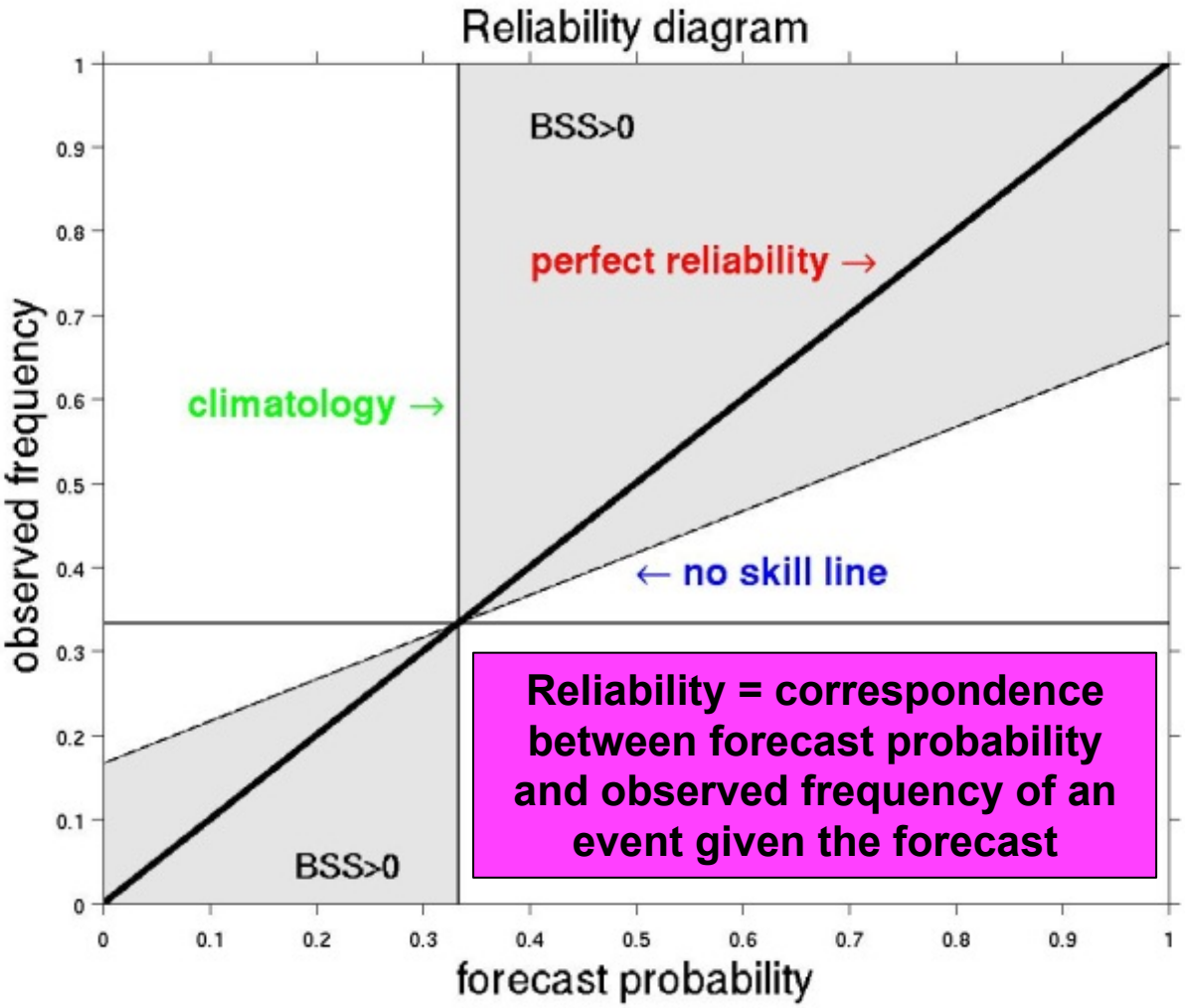
Key challenges

- Reliability for circulation extremes is still poor
- Role of tropical – extratropical links
- Fundamental physics (radiation, clouds, convection, hydrology) is important but difficult to parameterise in models
- Explicit representation of model uncertainty in the models

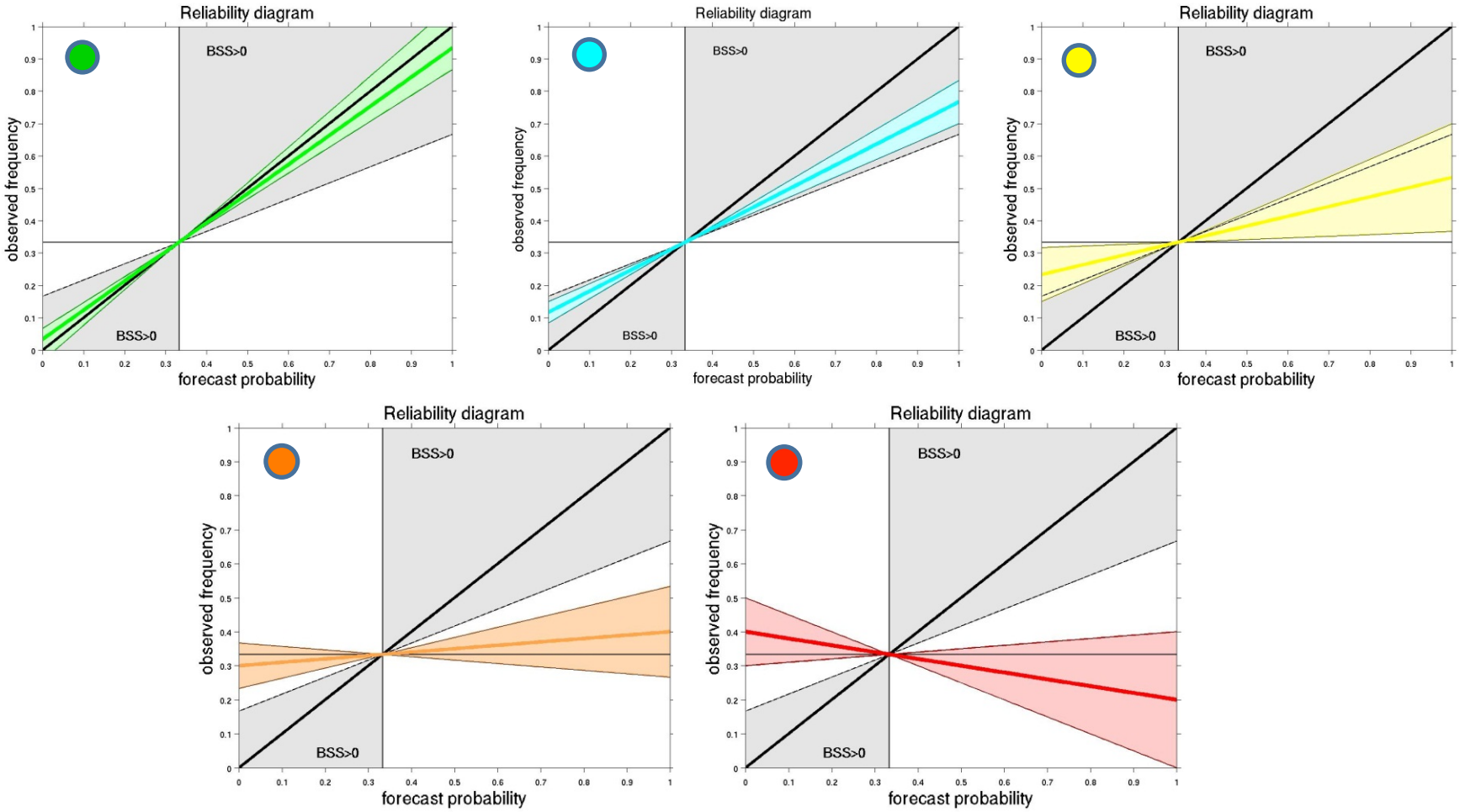
Cross community collaborations

- Seamless prediction across time scales from data assimilation, short-range weather prediction, extended-range forecasts (sub-seasonal, seasonal, decadal) to climate projections

Suppose an event *E* has a forecast probability of 70%. The forecasting system is said to be *reliable* if the observed frequency of *E* is, within its uncertainty, also 70%.



Reliability categories

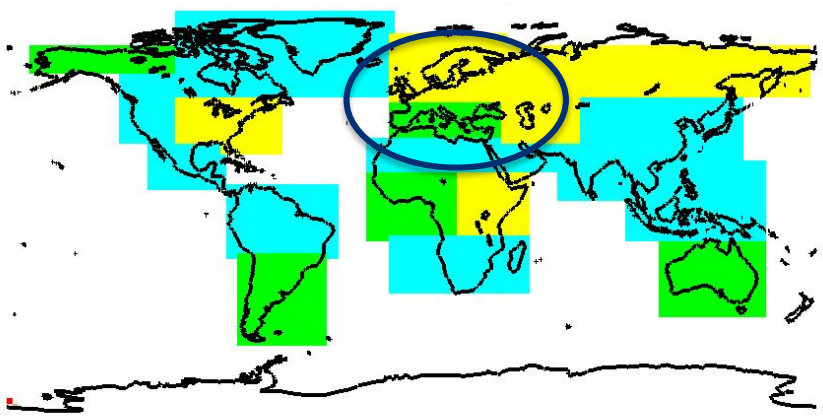


perfect **still useful** **marginally useful** **not useful** **dangerous**

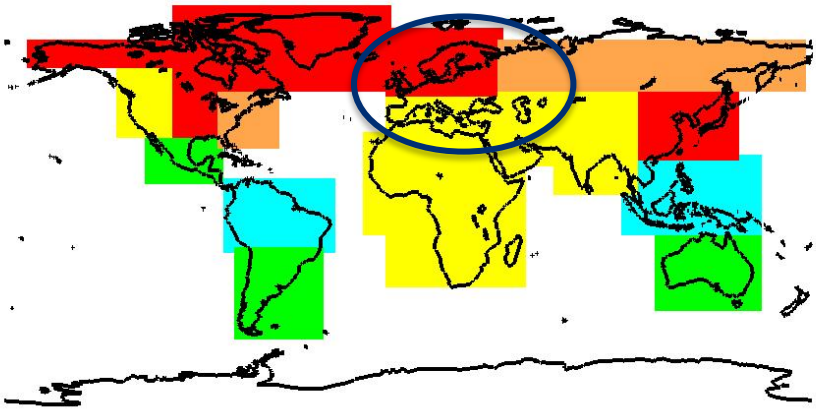
Weisheimer & Palmer, JRS Interface 2014

Forecast reliability during JJA for quintile extreme events

extremely warm JJA



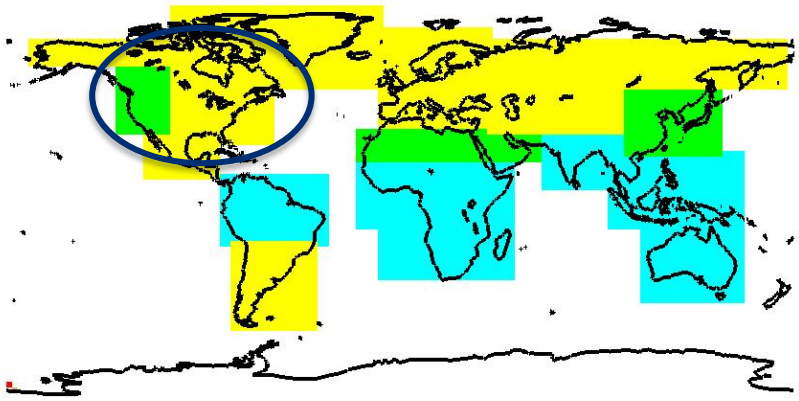
extremely dry JJA



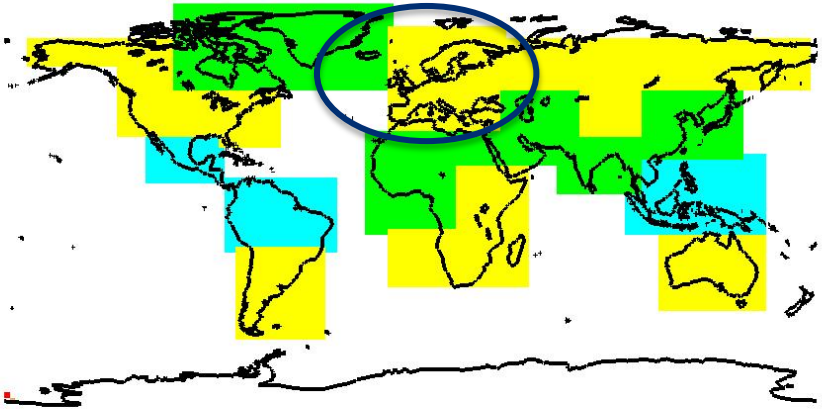
perfect | still useful | marginally useful | not useful | dangerous

Forecast reliability during DJF for quintile extreme events

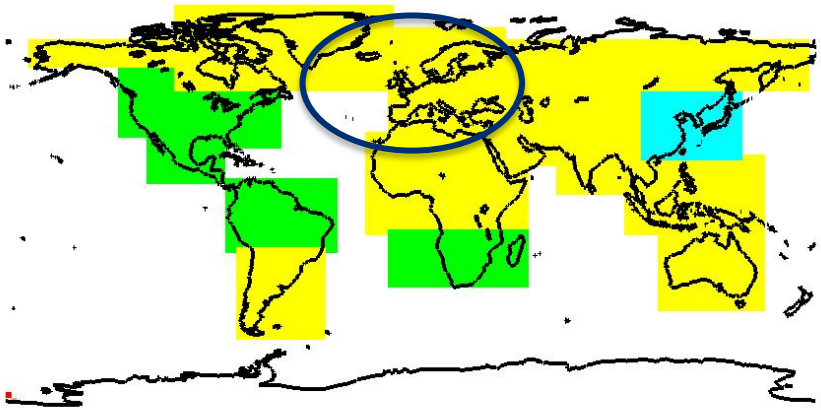
extremely cold DJF



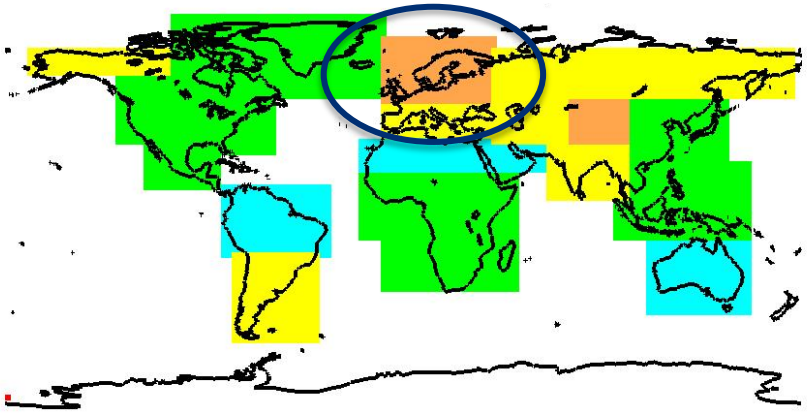
extremely warm DJF



extremely wet DJF



lower quintile Z500 DJF



perfect

still useful

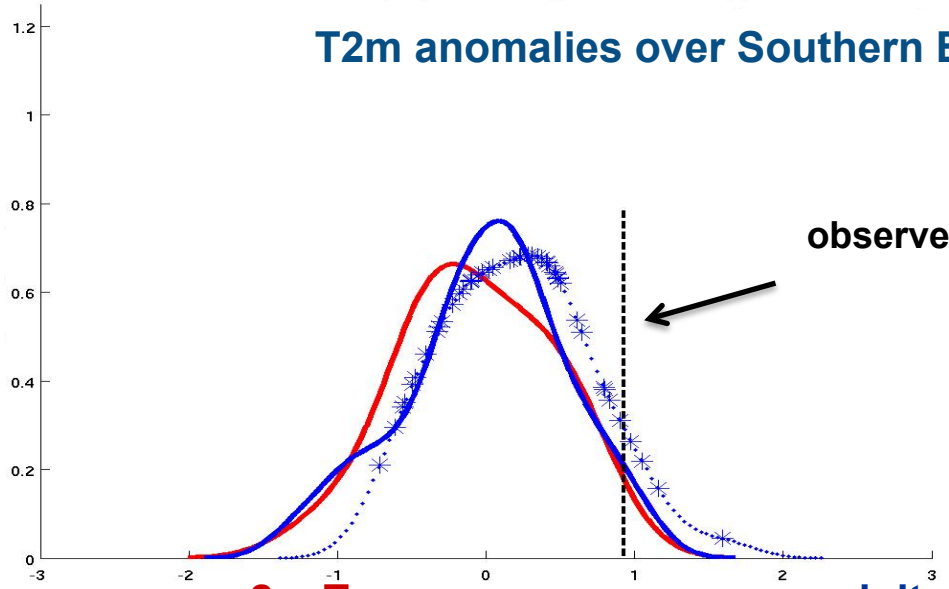
marginally useful

not useful

dangerous

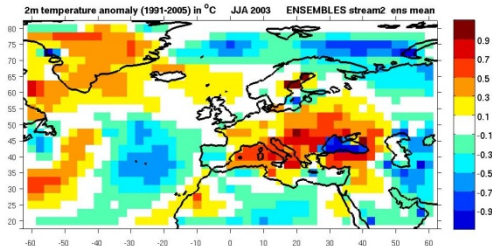
The European summer 2003: seasonal forecasts

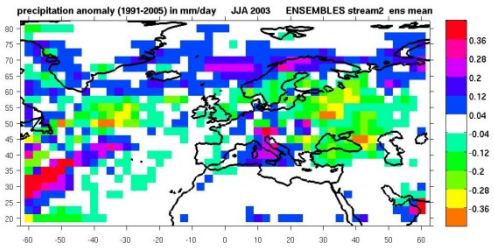
T2m anomalies over Southern Europe land points

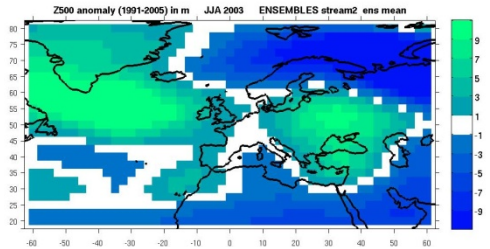


2m Temp | **precipitation** | **Z500**

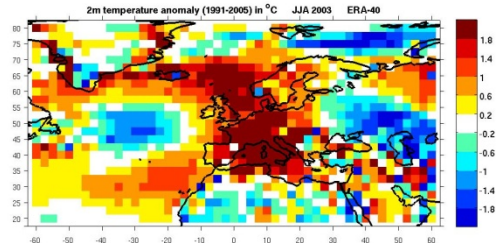
model

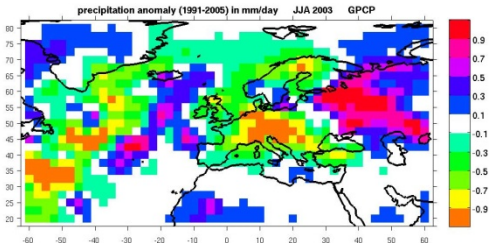


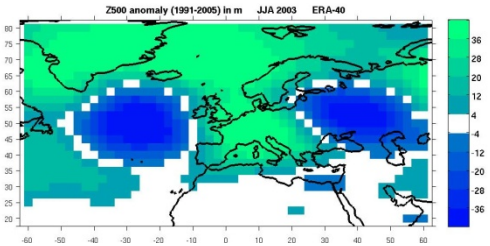




obs







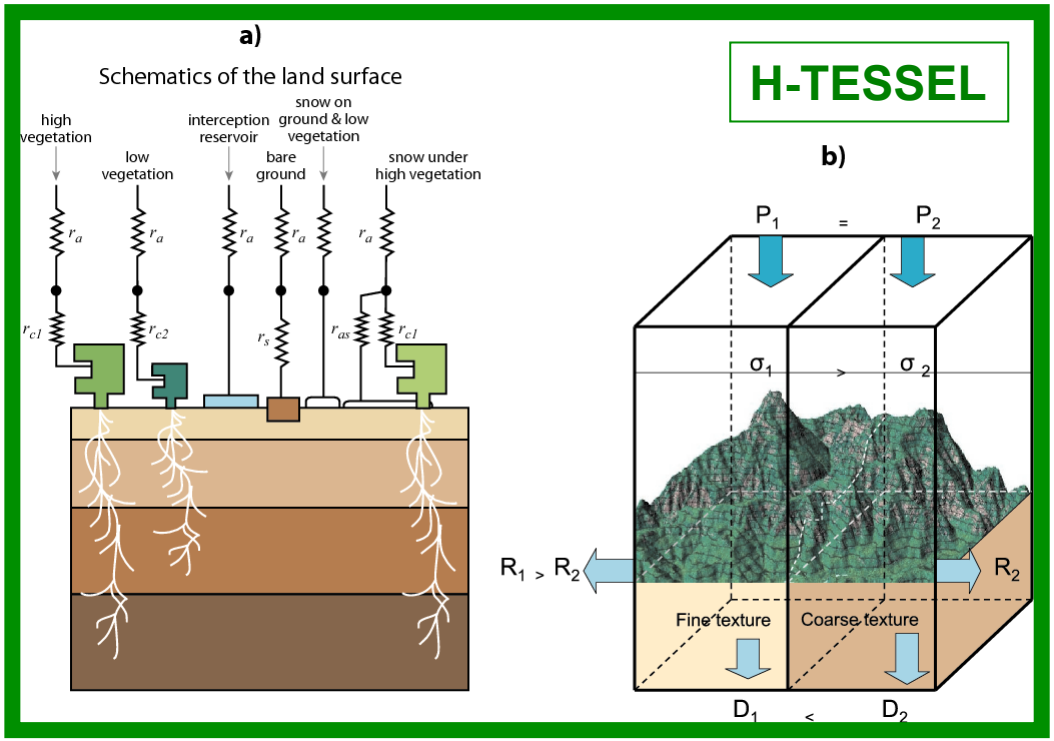
Weisheimer et al., 2011, GRL

The European summer 2003: improved model physics

land surface

new soil hydrology
H-TESSEL

- global soil texture
- new hydraulic properties
- variable infiltration
  (capacity and surface run-off)



Balsamo et al. 2009

McRad: new (RRTM) SW scheme, McICA cloud-radiation interaction, MODIS land surface albedo

radiation

convective entrainment → more active scheme

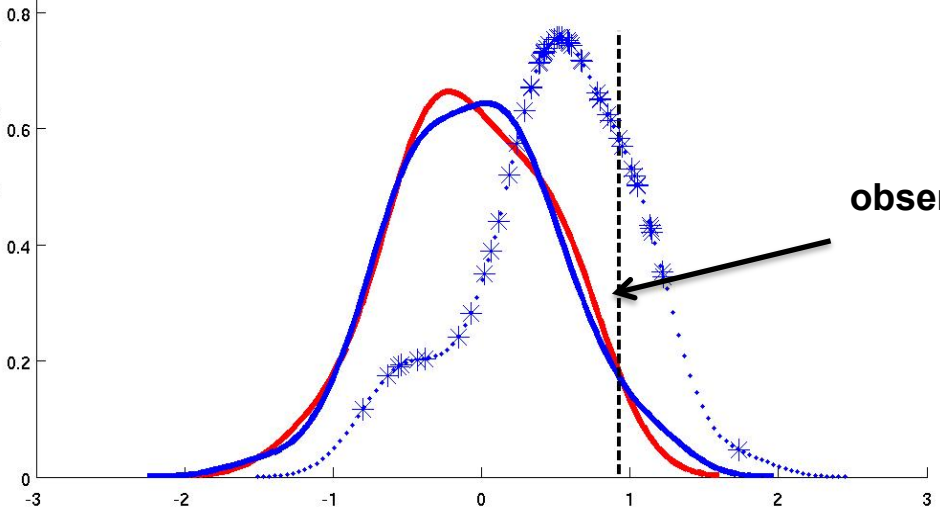
convection

vertical diffusion

reduced vertical mixing

The European summer 2003: improved forecasts

T2m anomalies over Southern Europe land points

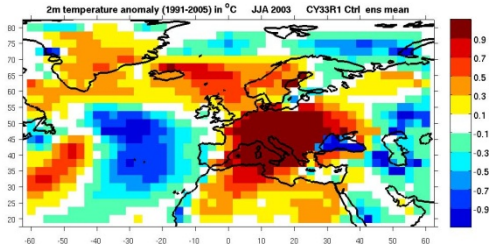
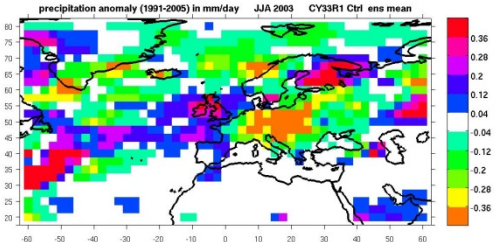
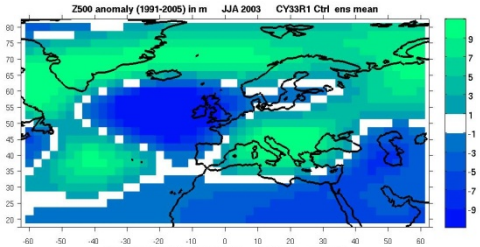
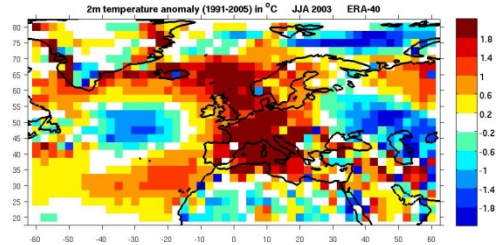
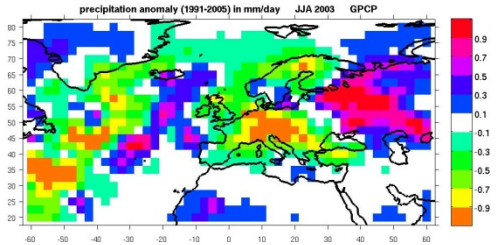
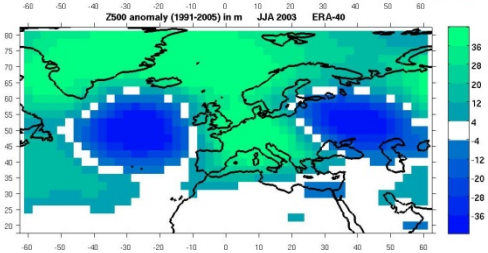


observed anomaly 2003

analysis climate

model climate

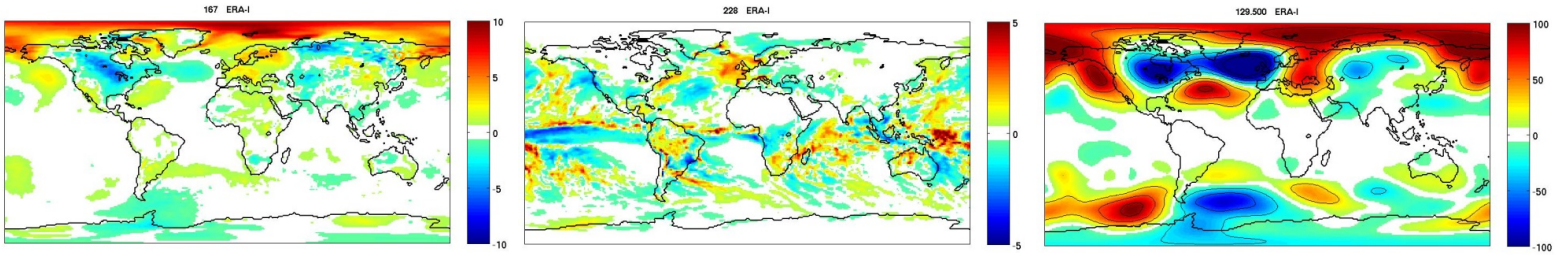
******* forecasts 2003

	2m Temp	precipitation	Z500
model			
obs			

Weisheimer et al., 2011, GRL

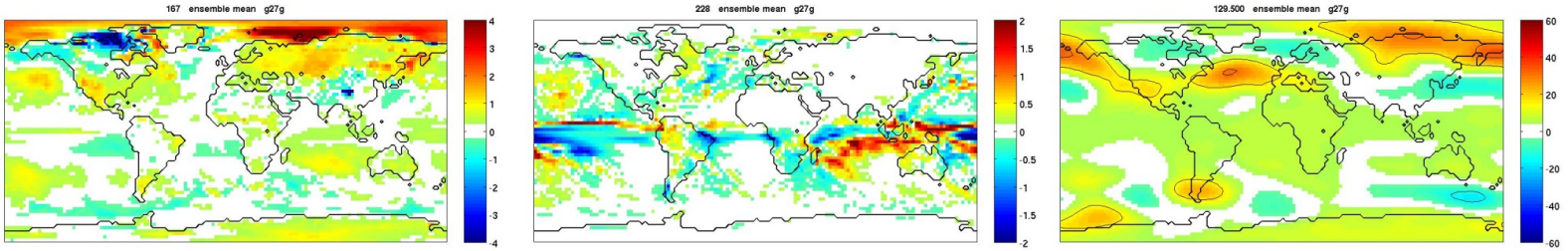
The extreme NH winter 2013/14

2m temp | **precipitation** | **Z500**

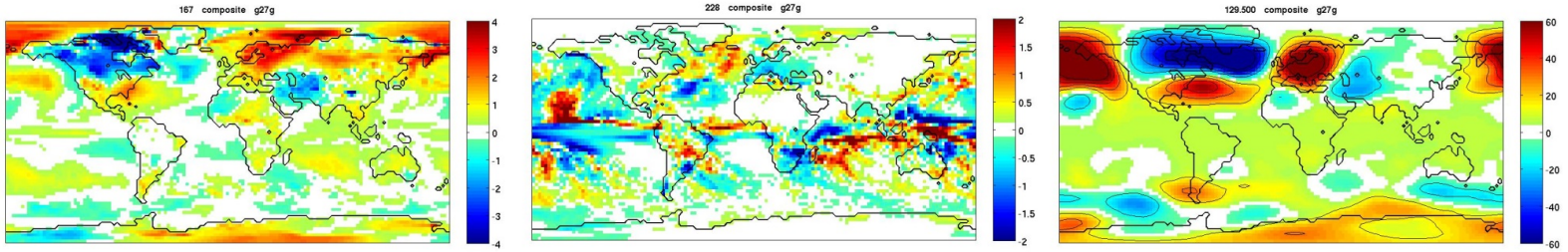


What were the drivers for these extreme mid-latitude conditions?

Seasonal forecasts from System 4 (ensemble mean anomaly):

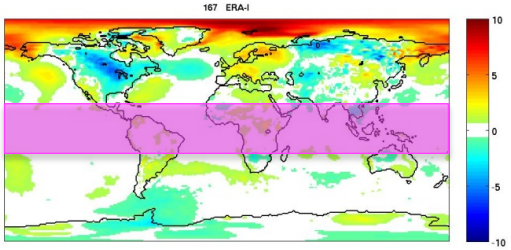


Composite of “good” members (15%):

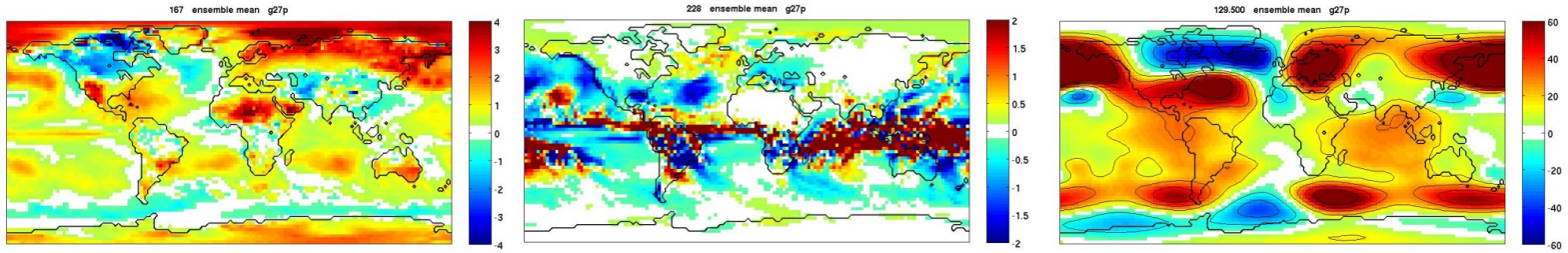


Tropical impact in the winter 2013/14

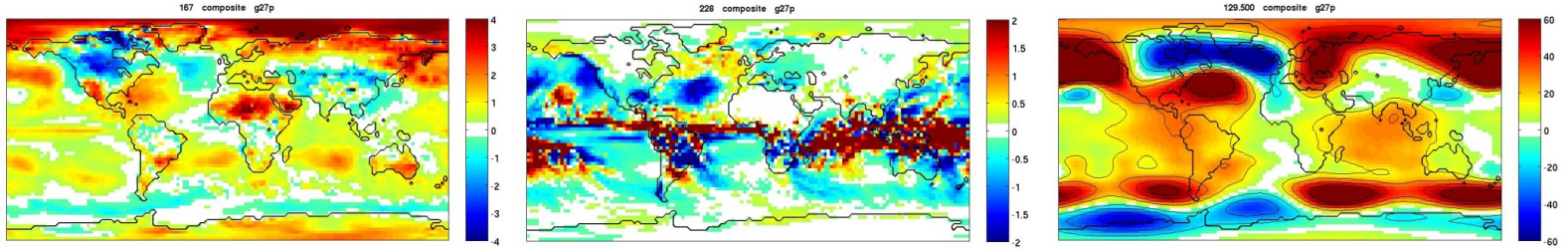
Relaxation/nudging of the tropical atmosphere towards ERA-Interim



ensemble mean anomaly



composite of “good” members (40%)



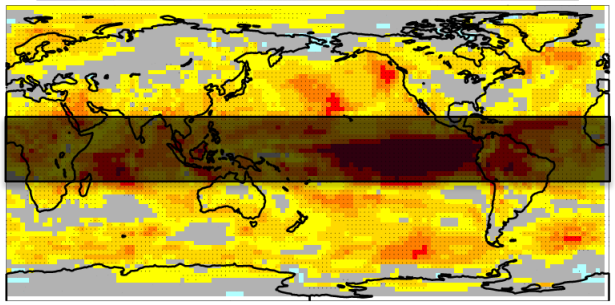
Tropics influence substantially the weather and climate of the extratropics

→ need for reducing model and forecast errors

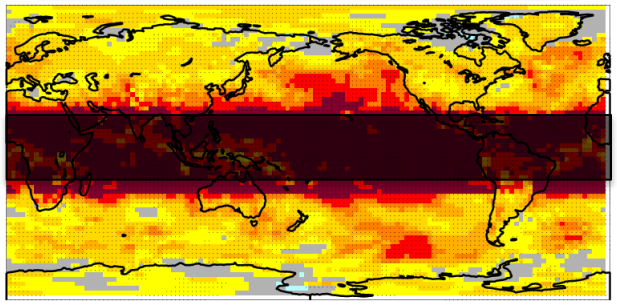
Tropical impacts on skill in the extratropics

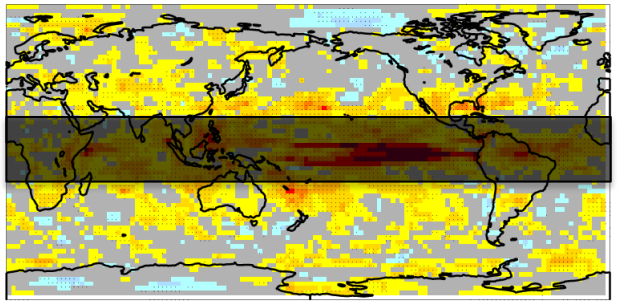
anomaly correlation in DJF

with tropical nudging

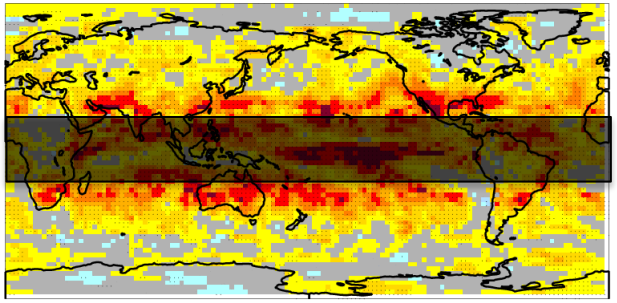


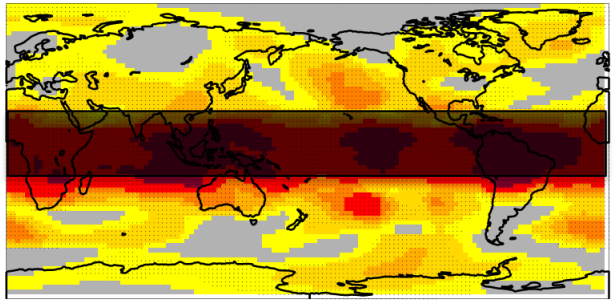
2m temperature



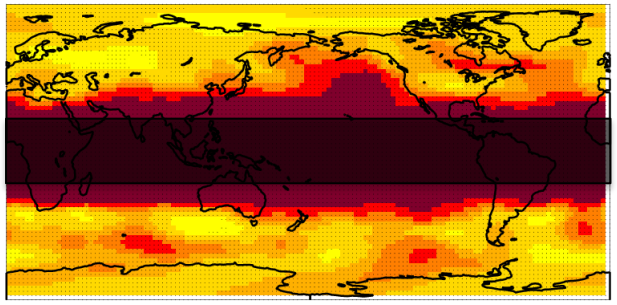


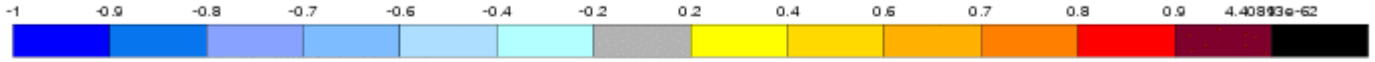
precipitation





Z500





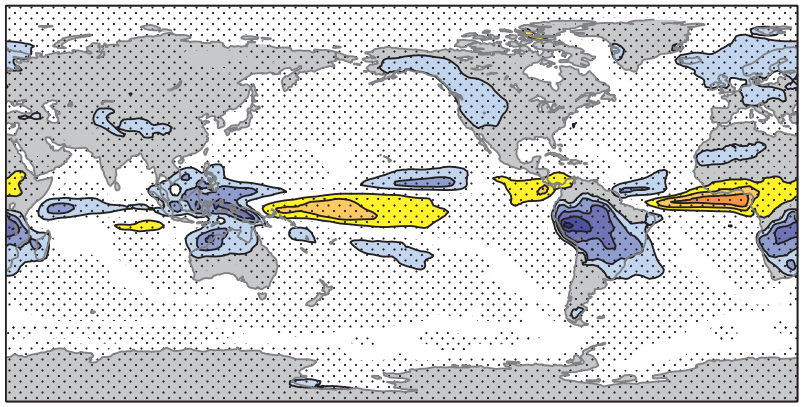
Broadly right vs precisely wrong?

Stochastic parametrisations:

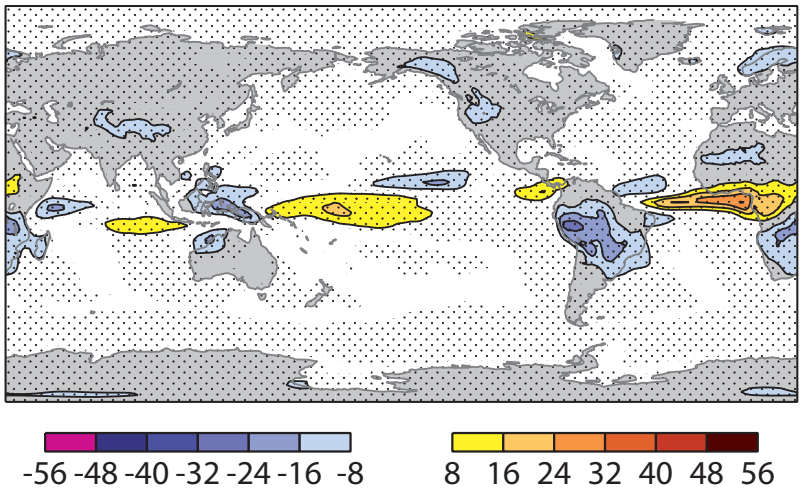
- Provide specific stochastic realisations of the sub-grid flow, not some assumed bulk average effect
- Describe the sub-grid tendency in terms of a probability distribution constrained by the resolved-scale flow
- Parametrisation development can be informed by coarse-graining budget analyses of very high resolution (e.g. cloud resolving) models

OLR bias in DJF

***stochphysOFF* – ERA-I**



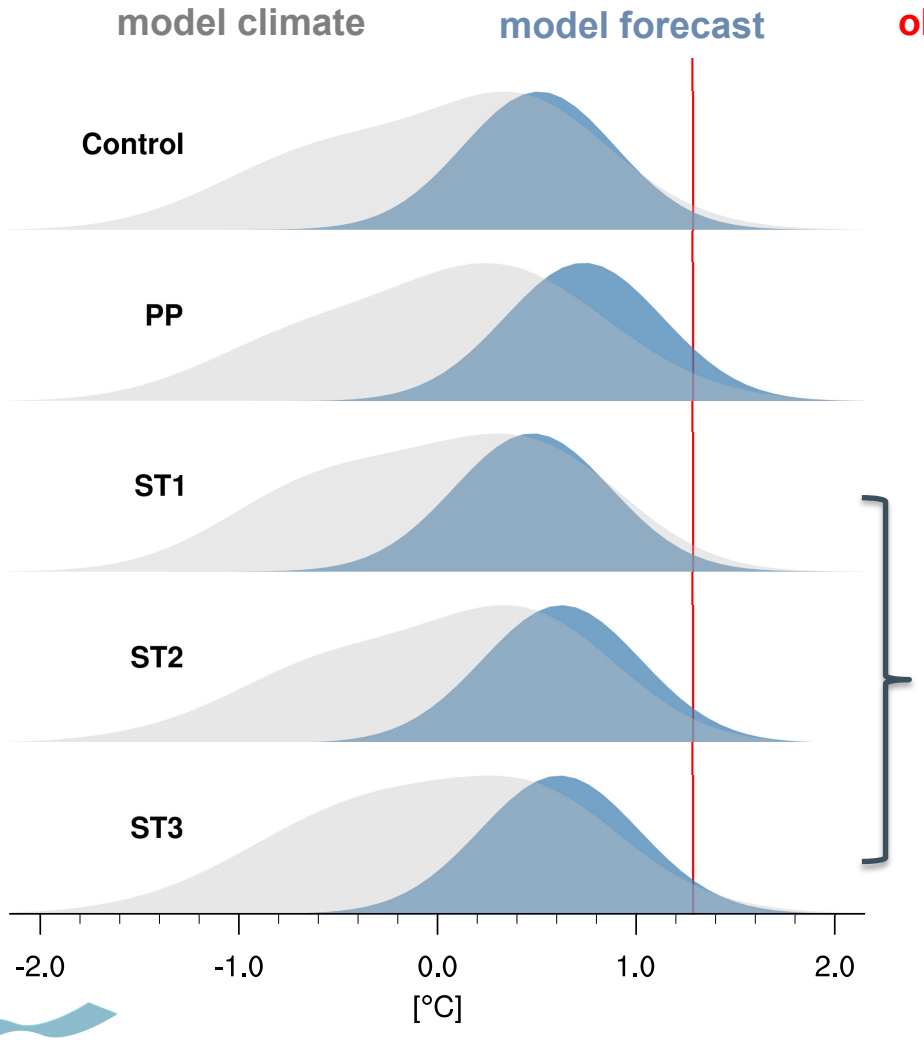
System4 – ERA-I



Weisheimer & al., PhilTransA 2014

European summer 2003: uncertainty representation

Seasonal forecasts of Southern European temperature in JJA 2003 for different schemes to represent uncertainty in the land surface model



Perturbed Parameters

Stochastic Tendency parametrisations

MacLeod et al., 2015, QJRMS

Summary

Current state of knowledge

- Seasonal forecasts using state-of-the-art coupled GCMs are made routinely at several prediction centres around the world
- It is essential that these probabilistic forecasts are reliable
- How reliable are seasonal forecasts for extreme temperature/ precipitation/circulation seasons?

Key challenges

- Reliability for circulation extremes is still poor
- Role of tropical – extratropical links
- Fundamental physics (radiation, clouds, convection, hydrology) is important but difficult to parameterise in models
- Explicit representation of model uncertainty in the models

Cross community collaborations

- Seamless prediction of weather and climate across time scales from data assimilation, short-range weather prediction, extended-range forecasts (sub-seasonal, seasonal, decadal) and climate simulations