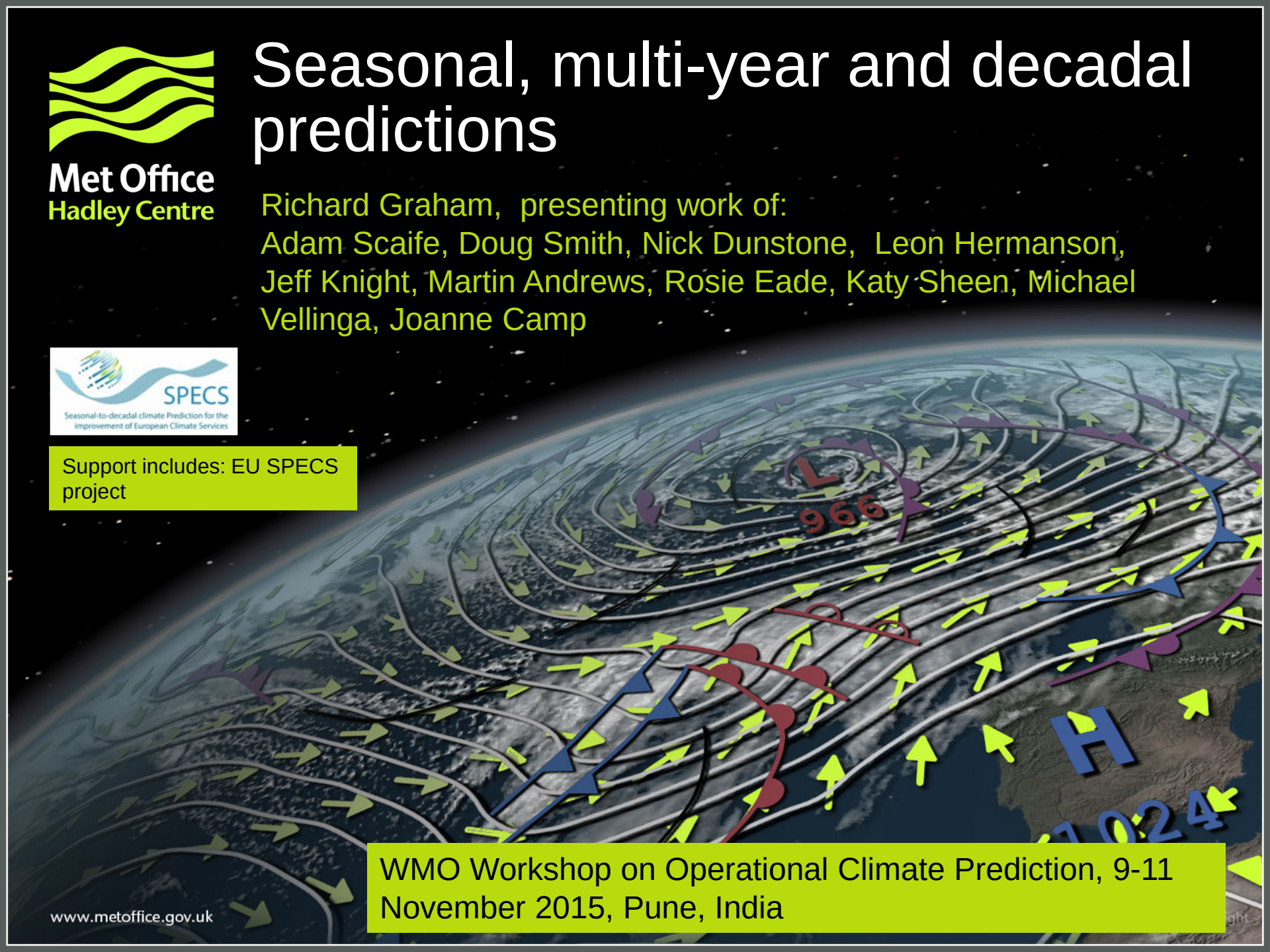
Seasonal, multi-year and decadal predictions

Met Office Hadley Centre

Richard Graham, presenting work of:
Adam Scaife, Doug Smith, Nick Dunstone, Leon Hermanson, Jeff Knight, Martin Andrews, Rosie Eade, Katy Sheen, Michael Vellinga, Joanne Camp

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

Support includes: EU SPECS project



WMO Workshop on Operational Climate Prediction, 9-11 November 2015, Pune, India

Seasonal timescale
~ 6 months ahead

GloSea5

Met Office Global Seasonal forecast system 5

Model: **HadGEM3 GC2**

Resolution: **Atmos, N216 L85 (~60km); Ocean: 0.25° L75**

Initialisation: **Daily, NWP state + NEMOVAR 0.25°**

Ensembles: S**tochastic physics + lagged initialisation**

Forecasts: **2 per day -> 42 members,**

Hindcasts: 3 per 4 times/month -> 12 members, 1996 – 2009

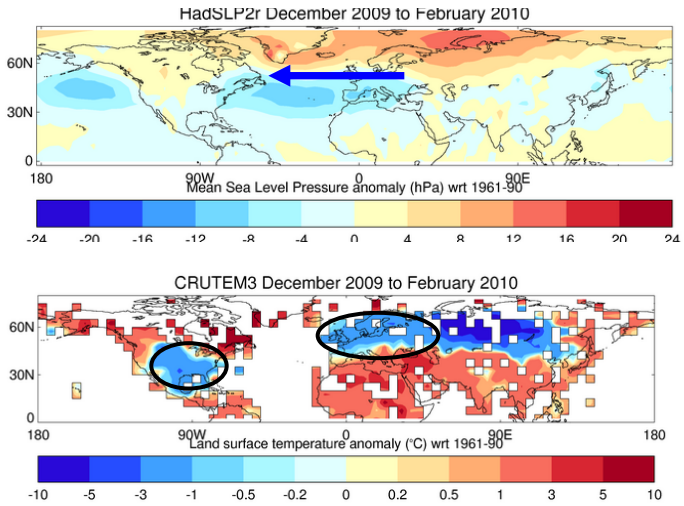
Products: http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/gpc-outlooks

MacLachlan et al. 2014, Scaife et al 2014

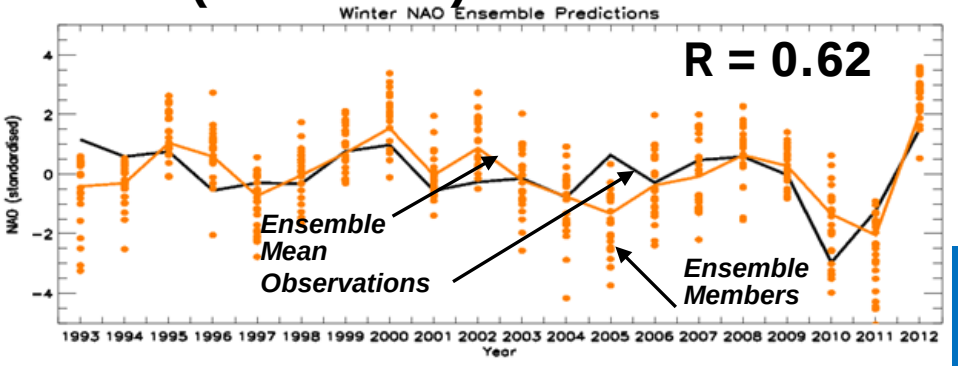
(New) skill for extratropics: winter NAO

Questionnaire: 11/21 respondents use NAO/AO

DJF 2009/10: PMSL anomaly



GloSea5 re-forecasts of DJF NAO (orange) (1993-2012) November starts

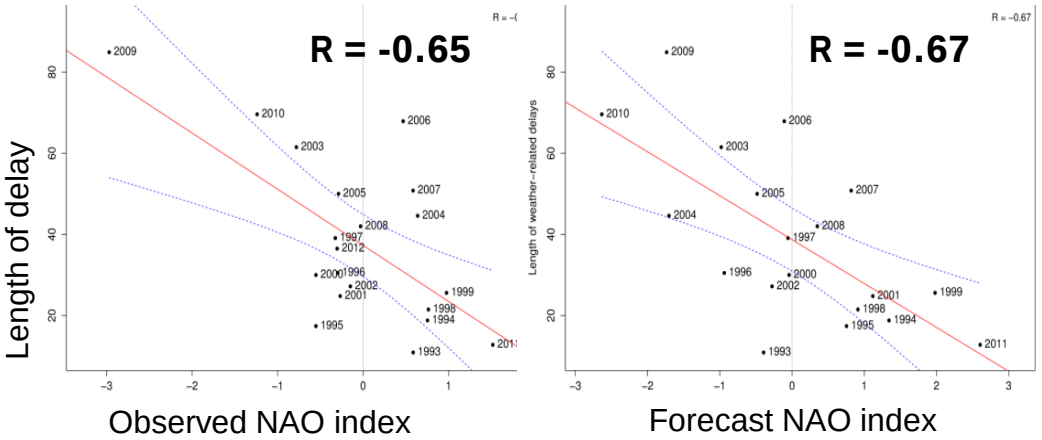


+NAO
N Europe
Mild, wet and stormy

-NAO
N Europe
Cold, snowy and still

Length of weather related delays: Heathrow (Nov-Mar)

Vs observed NAO **Vs GloSea5 forecast NAO**



Skill break-through (robust)

Other centres now finding similar skill (ECMWF, NCEP..)

Skill also for the AO and AAO

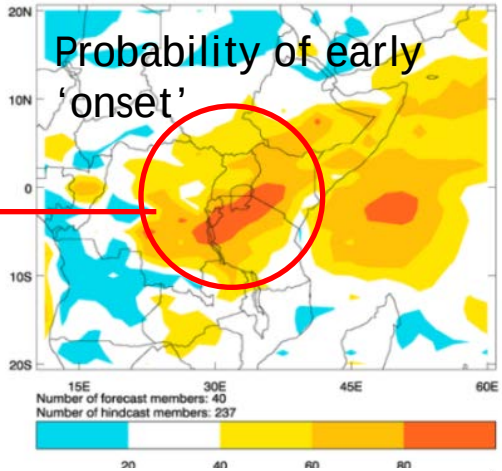
Scaife et al. 2014: Skillful long-range predictions of European and North American winters. GRL

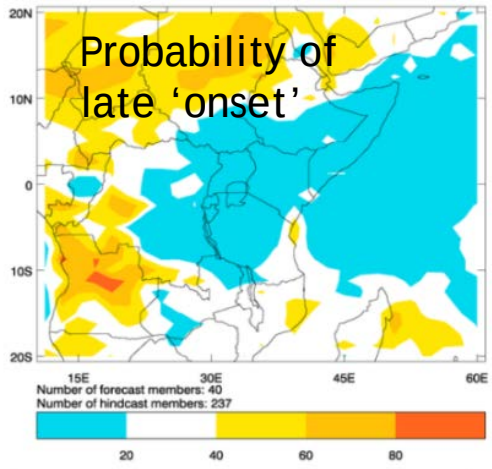
Skill for predicting rainy season onset timing – major requirement for many regions

Example: Greater Horn of Africa, short-rains season (Oct-Dec) 2011– predicted from August

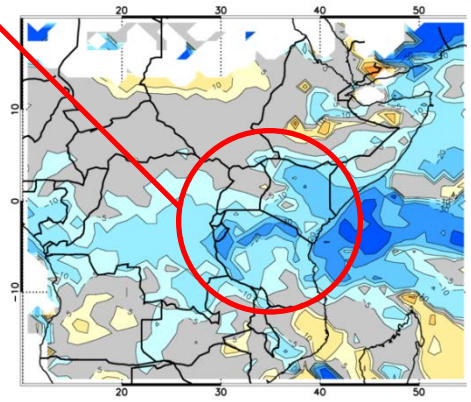
Early onset predicted most likely

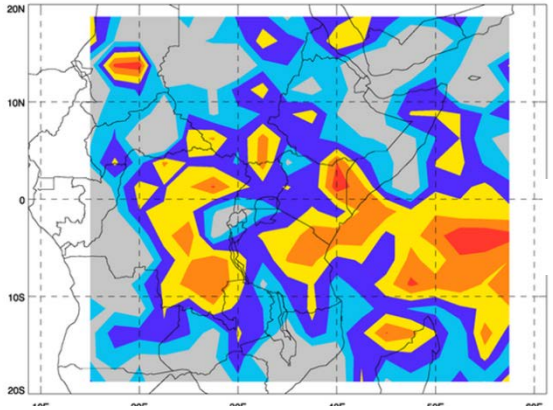
Early onset occurred





Based on local time by which 20% of long term average has accumulated





ROC scores 1996-2009

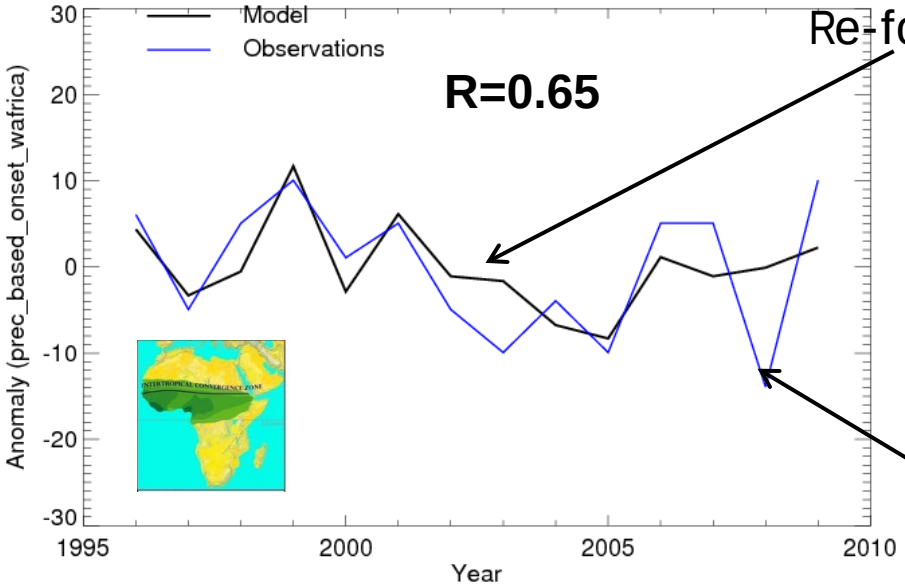
UKaid from the Department for International Development

Michael Vellinga/Lizzie Good

Predicting rainy season onset timing

Met Office GloSea4/5 system: May start spredictions1996-2009 (i.e. ~2 months lead)

Sahel onset

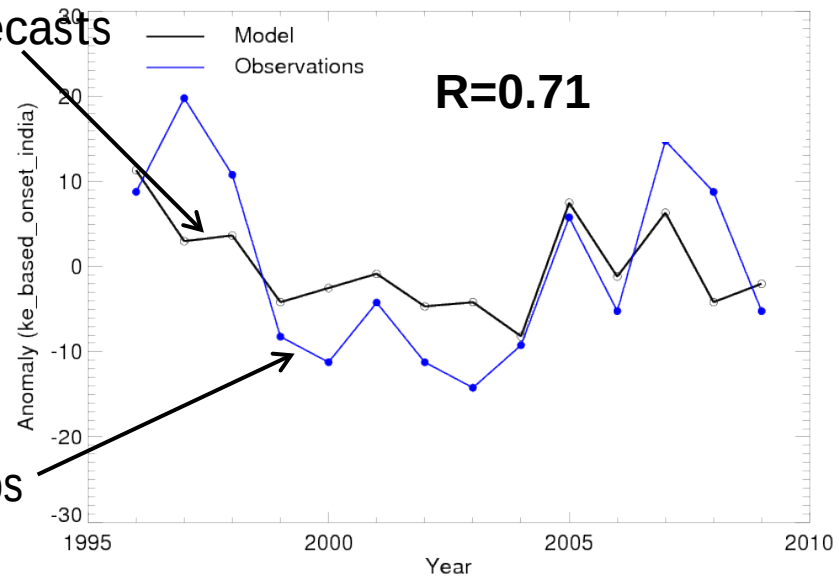


Based on first pentad when the main rainband moves and stays north of 10°N

EM Re-forecasts

obs

Indian monsoon onset



Based on 850hPa Kinetic Energy averaged over 5-15°N, 40-100°E > 40 m^2/s^2 for at least 5 days (Xavier et al 2007)

Vellinga et al. 2013: Seasonal forecasts for regional onset of the West African monsoon. Clim Dyn

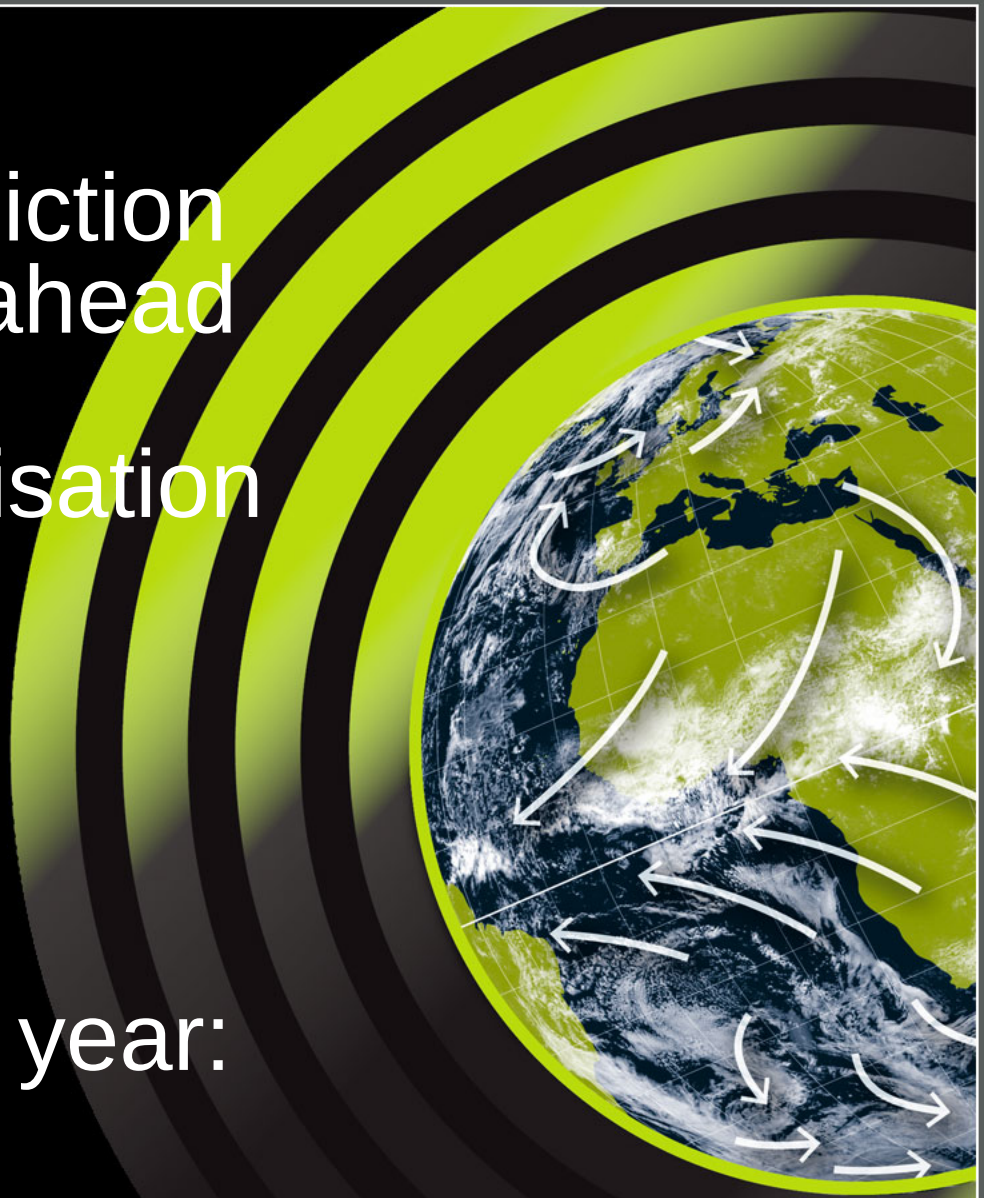
- Useful predictions of onset timing are feasible (skill similar to skill for totals)
- Forecasts tested in East, West and southern Africa, India
- Need coordinated initiative to advance (WCRP/GPCs)

Met Office multi-annual/decadal prediction system: 1-10 years ahead

- ocean/atmos initialisation
- CO_2
- aerosol
- solar cycle
- volcanoes

One prediction each year: from 1st November

First: ~ 1-year range

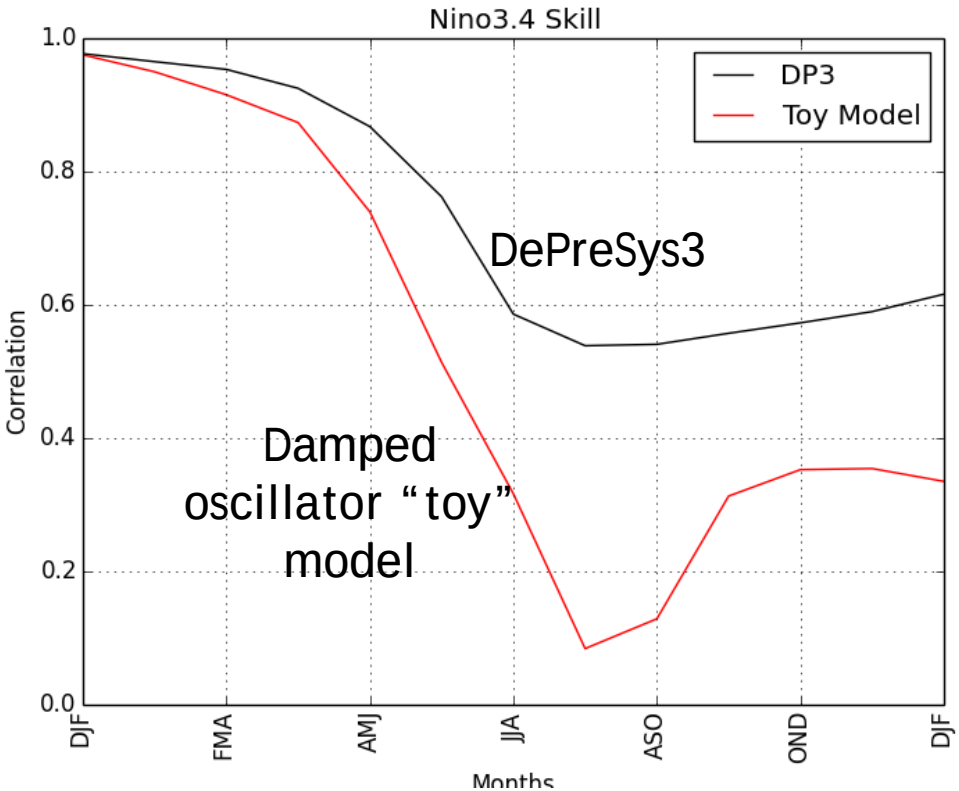


Nino3.4 prediction to1-year ahead (from November)

Questionnaire: all 21 respondents use ENSO

Correlation = 0.6 at 1 year lead

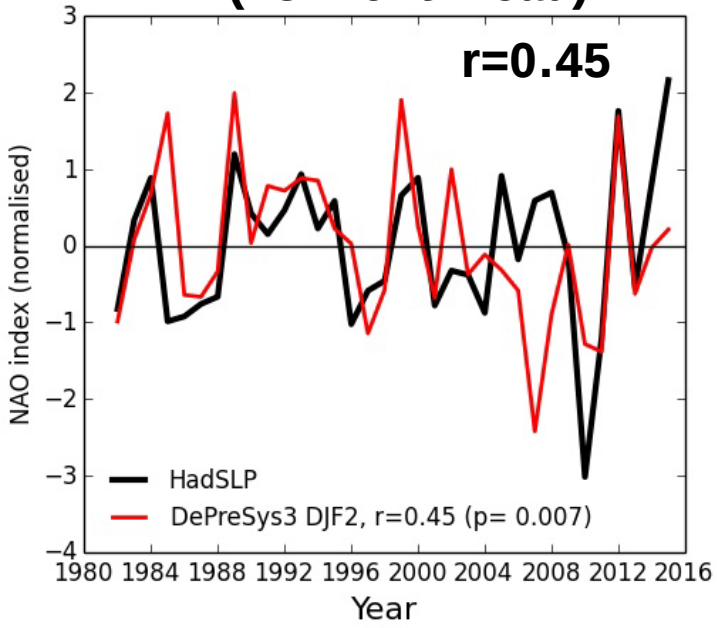
Increases lead time on potential flood/drought warning for many ENSO-affected regions of globe



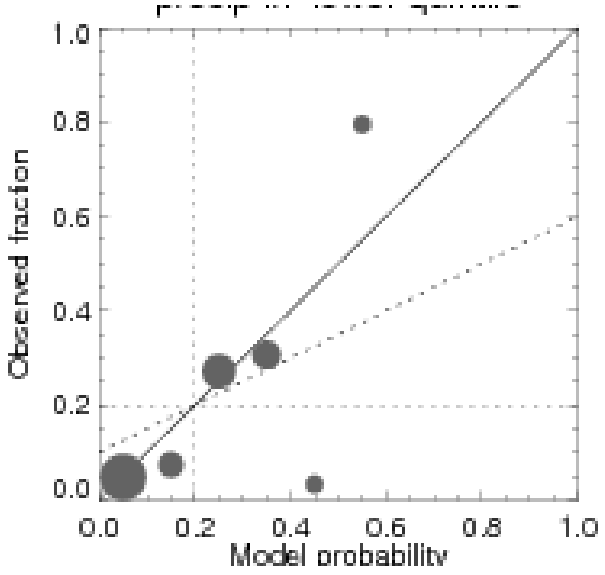
Michael Vellinga , Nick Dunstone

Predictions ~1 year ahead: NAO (DJF); Sahel (JAS), from November

Second winter NAO (13-month lead)



Sahel rainfal JAS (reliability lower quintile) 8-month lead

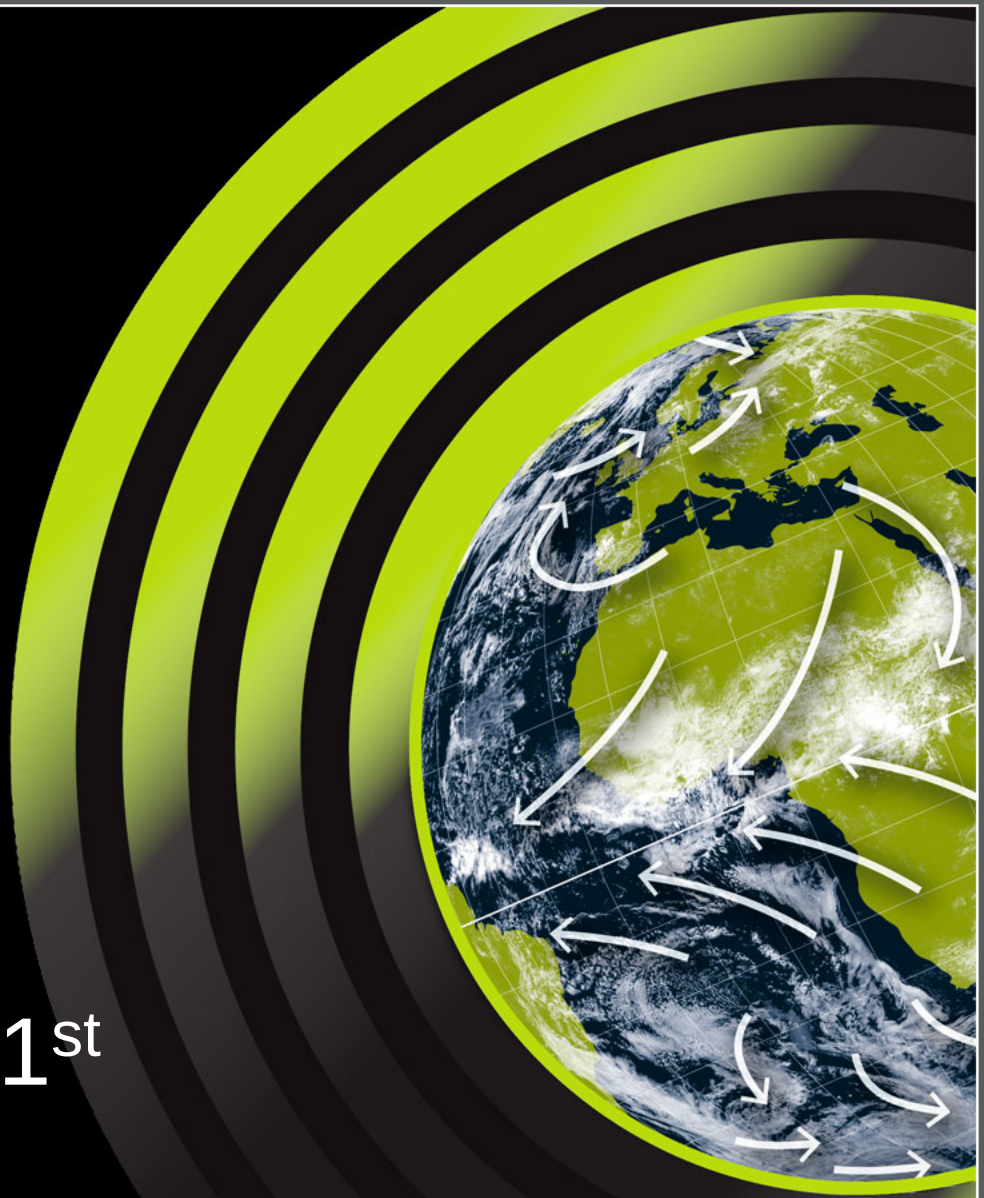


- **Skill for the second winter NAO (r=0.45, >99% significant)**
- **Potential for long-lead (8-month) warning of potential Sahel drought**

Nick Dunstone, Michael Vellinga

2-5 year timescale

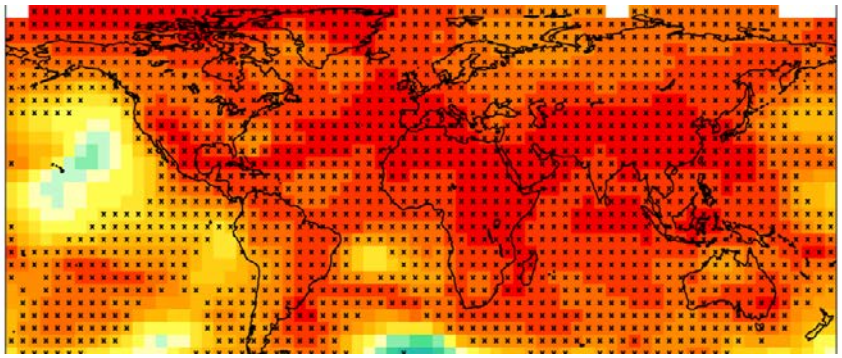
All predictions from 1st November

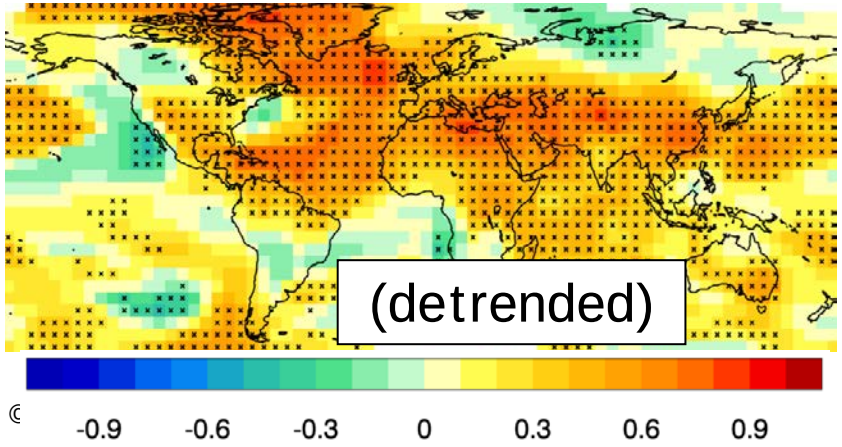


Multi-year forecast corr.skill: temperature

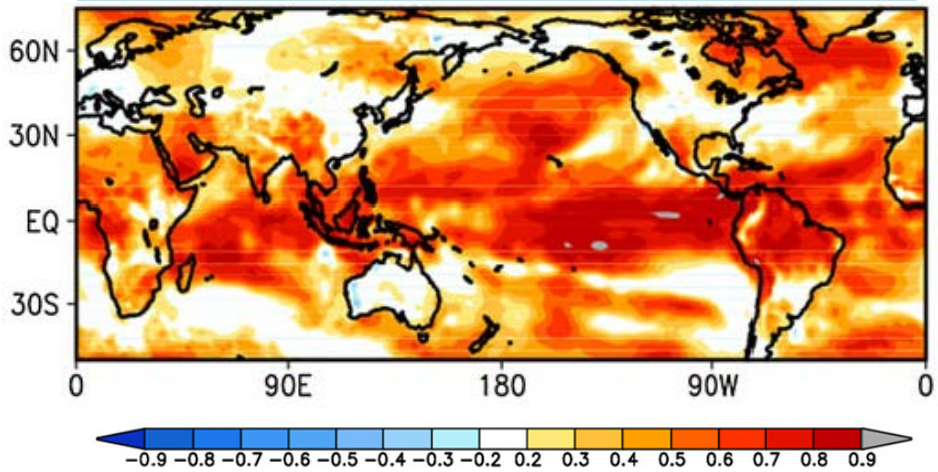
25 hindcasts 1960 - 2014

Multi-year: years 2-5





Seasonal: First DJF (from Nov)



Multi-year skill higher / more widespread than for seasonal!

Large contribution from trend – but still valuable (yearly updates – new systems)

Skill also for daily extremes frequency

Doug Smith, Rosie Eade

Role of Atlantic Multi-decadal Variability (AMV)

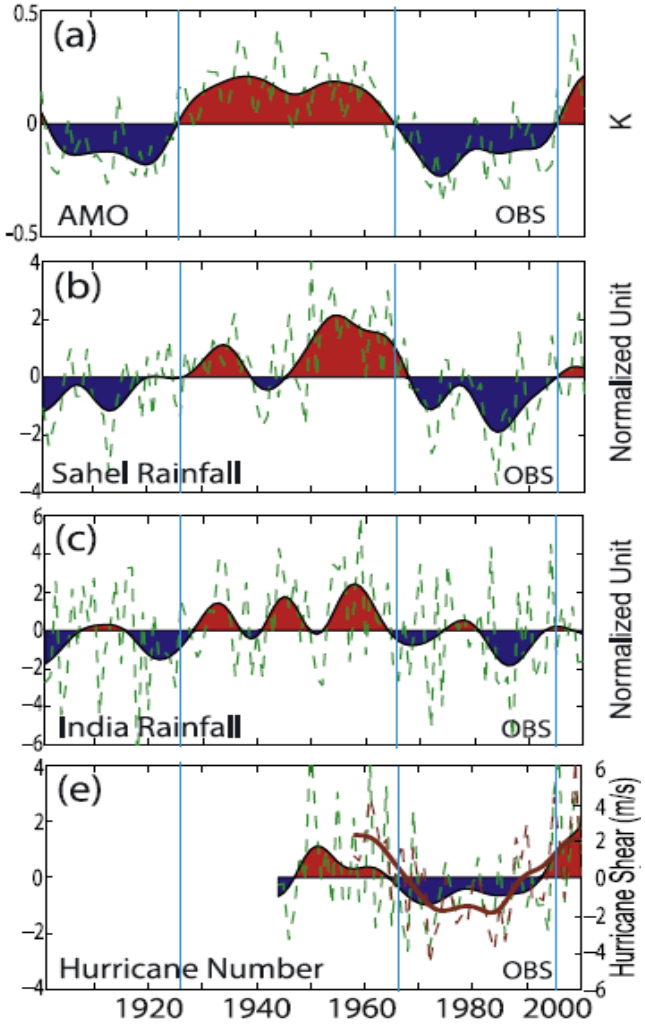
Met Office Hadley Centre

North Atlantic SST

Sahel rainfall

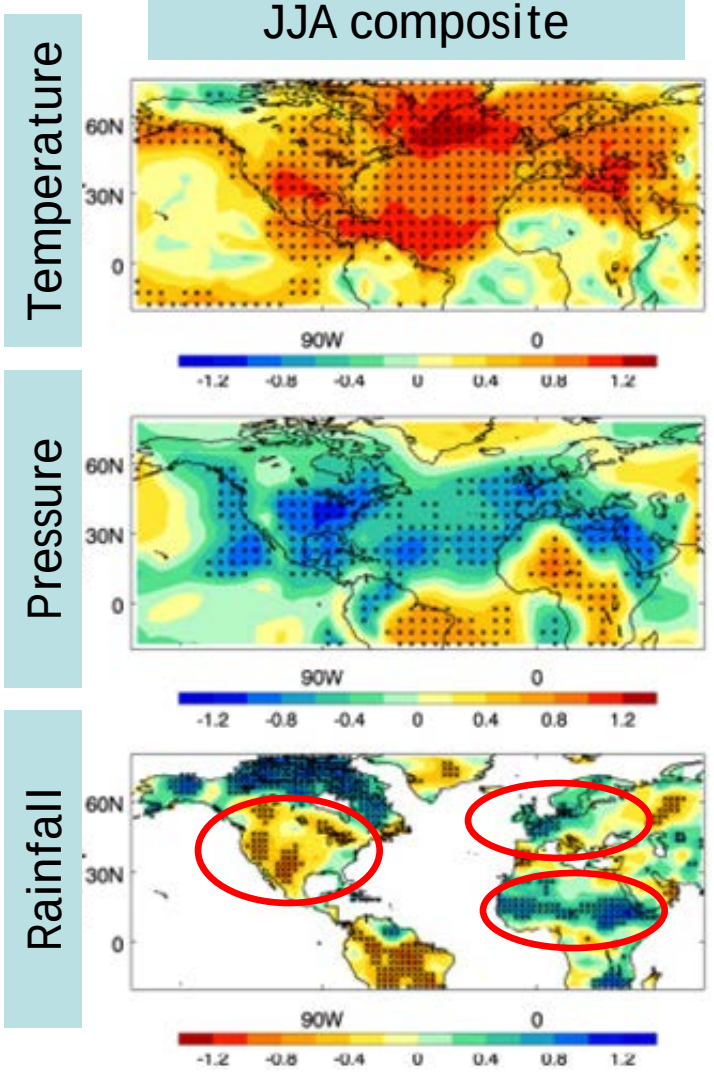
India rainfall

Hurricanes



(*Zhang and Delworth 2006; also Knight et al 2006*)

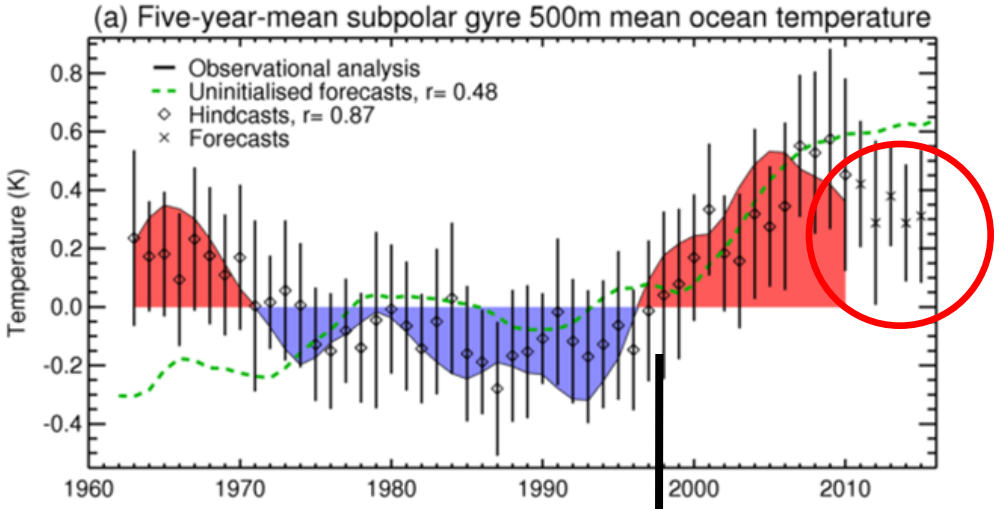
Warm – cold Atlantic: JJA composite



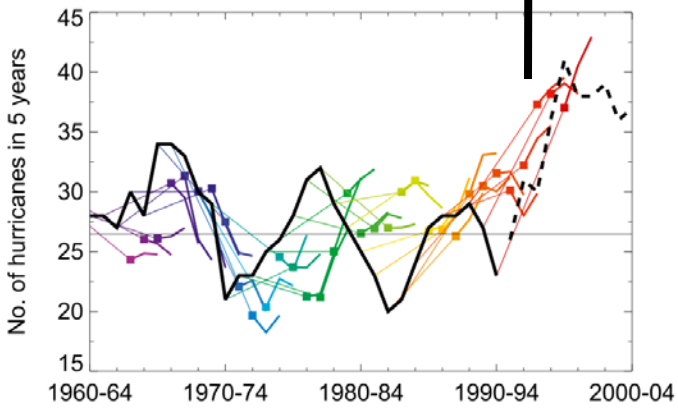
(*Hermanson et al 2014*)

Met Office decadal system predictions – opportunities for application

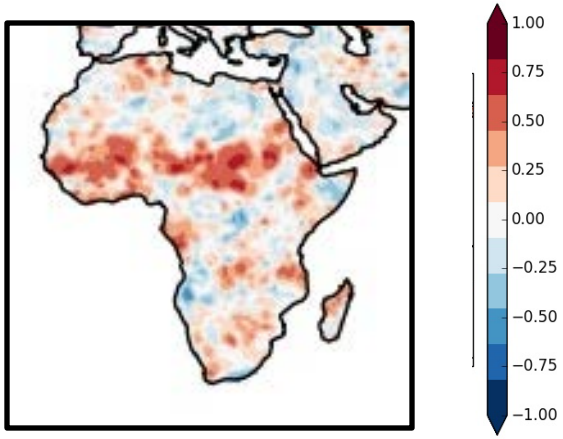
5-year
N. Atlantic
temp (SPG)
Corr = 0.87



Hermanson et al. 2014: Forecast cooling of the Atlantic subpolar gyre and associated impacts.



5-year hurricane numbers - 1995 transition to active regime could have been predicted



2-5 year JAS rainfall Sahel

Corr =~0.5

1960-2014

Also 1-year ahead skill

Doug Smith, Leon Hermanson, Rosy Eade, Katy Sheen

Operationalisation

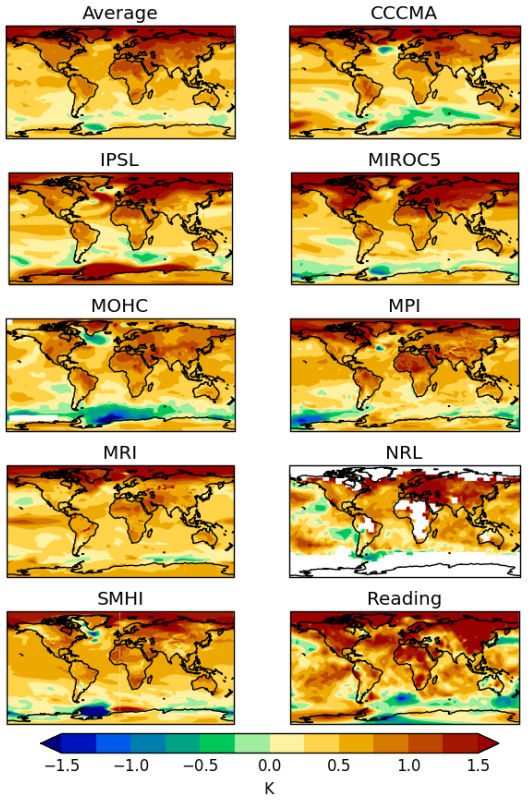
Supported by (proposed) WCRP grand challenge

- Predictability research
- Facilitate WMO infrastructure for real-time near-term predictions (working with ET-OPSLS)

Established informal international exchange of real-time decadal predictions

- Coordinated by Met Office since 2011
- 4 forecasts so far, 1 each year
- 9 dynamical systems + 2 empirical
- Multi-annual averages of temp and precipitation up to 5 years ahead, annual indices of AMV, PDV and ENSO
- Multi-model (helps avoid over reliance on single model)
- Roles and functions of a Lead Centre for Near-Term Climate Prediction – under review by WMO CBS/CCl Expert Team (WCRP grand challenge)
- Publication: Smith et al. 2012: Real-time multi-model decadal climate predictions. Clim Dyn
- Website: http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel

2014 predictions for 2015-2019 surface temperature (anomalies from 1971-2000 baseline)



Summary

Seasonal

- Useful skill in extra tropics as well as tropics (some models)
- Skill for tropical rainy seasonal onset
- Tropical storm landfall (not shown)

1-year

- Skill for ENSO – useful for many regions
- Winter NAO (NH) – skill for “second” winter
- Sahel rainfall – skill at 8 months lead

2-5 year

- For temperature skill better than seasonal!
- Opportunities for: Sahel rainfall, Atlantic hurricanes; European winter / summer; drought SW USA.

Multi-model collaboration, moving to formal CBS/CCl basis

Thank you

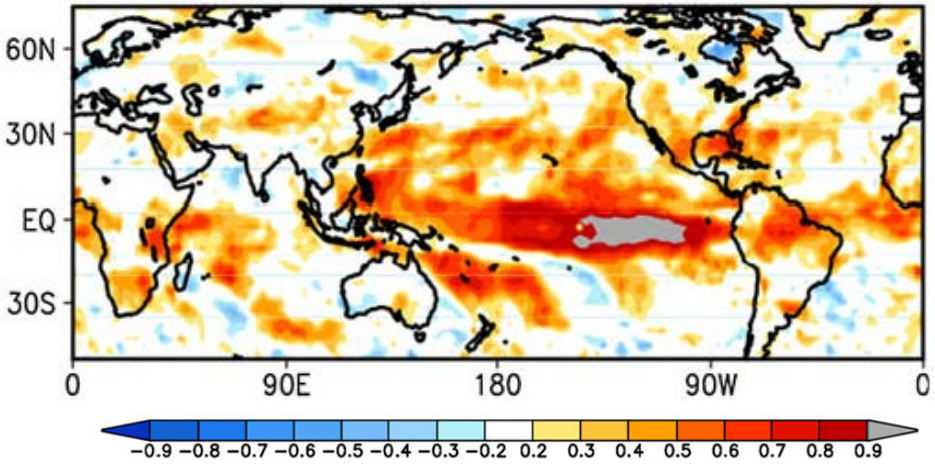
Any questions?

richard.graham@metoffice.gov.uk

Seasonal and multi-year forecast skill : precipitation

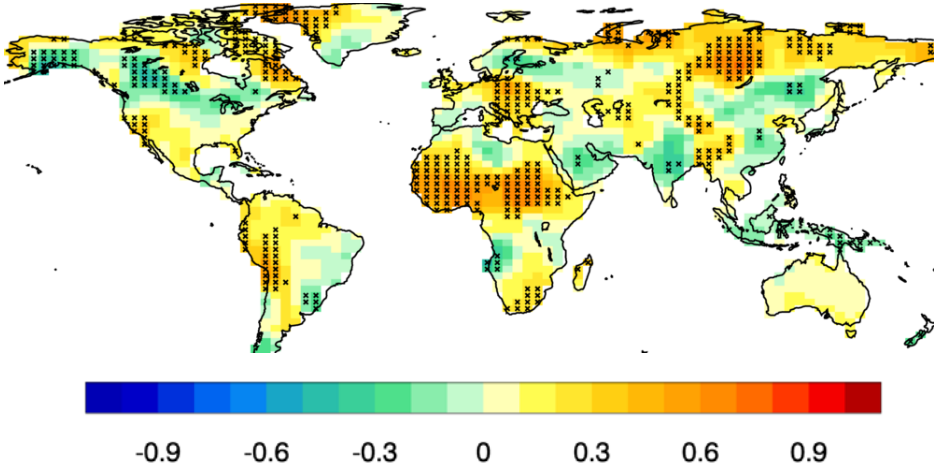
Seasonal:

First DJF (from Nov)

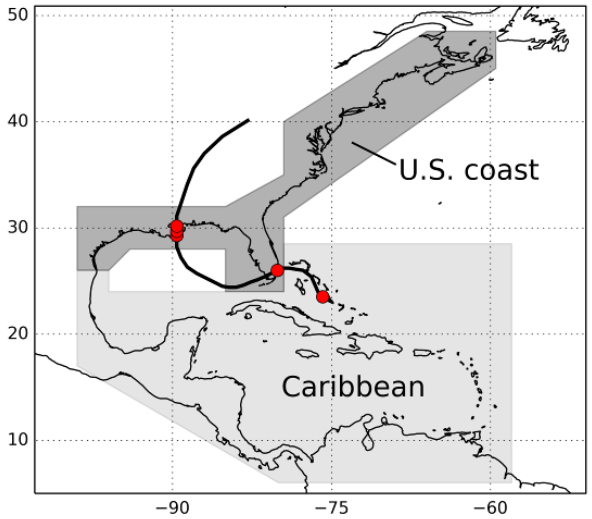


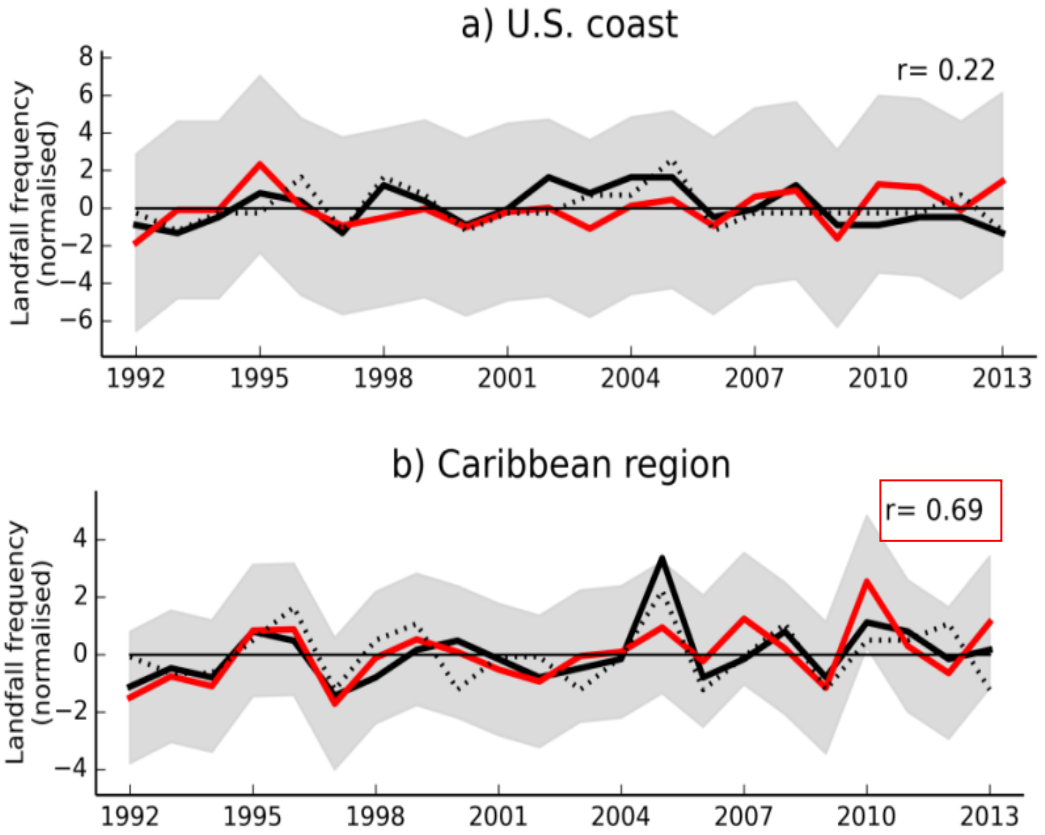
Multi-year:

Years 2-5 (detrended)



Tropical storm landfall prediction – Atlantic basin



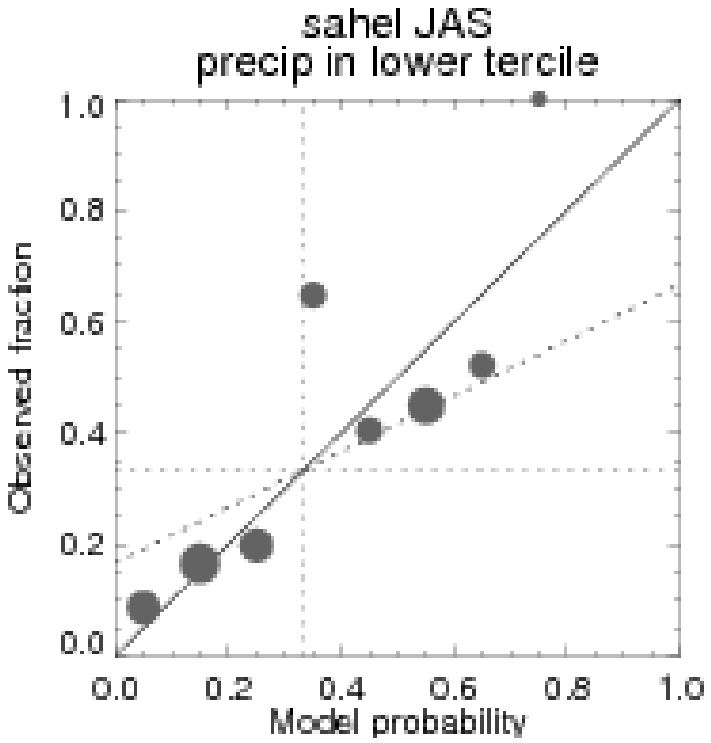


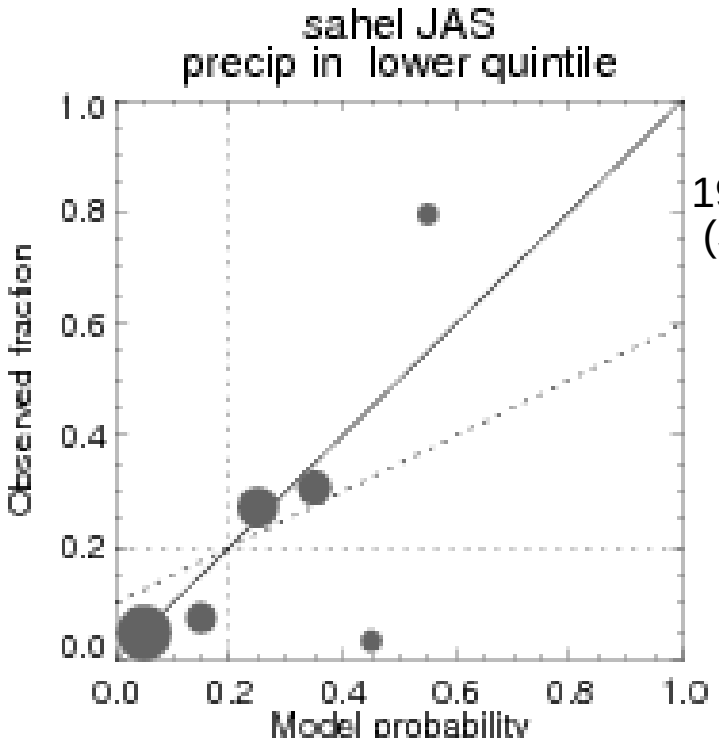
Dynamical predictions of seasonal frequency and ACE predicted for some years in all basins
GloSea5 now shows statistically significant skill for predictions of tropical storm landfall along the Caribbean coastline

Camp et al 2015

Sahel JAS rainfall (8-10 months lead) - reliability

Forecast issued Nov for Sahel (JAS) following year





1979-2011 GPCP (Satellite/gauge)

Reliability at 8-10 months lead comparable to seasonal (1-2 months lead)

Michael Vellinga | Lott et al. 2014 Reliability of African climate prediction and attribution across timescales

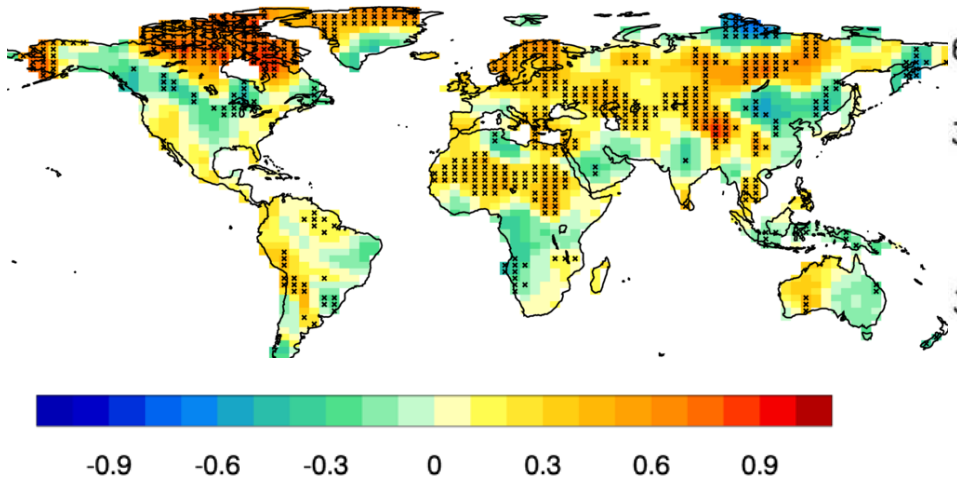
Multi-year forecast skill: precipitation

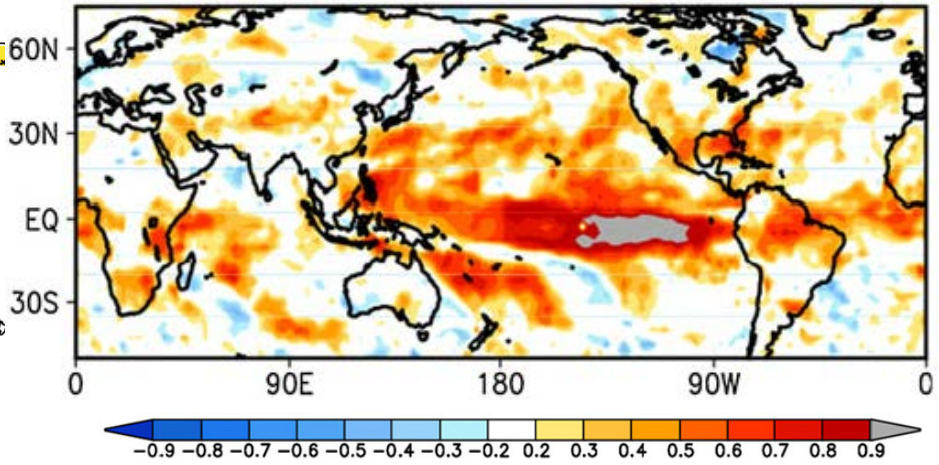
Multi-year:

Years 2-5

Seasonal:

First DJF (from Nov)





Multi-year skill higher also available in some regions for precipitation

Predicting winter (DJF) NAO from November, year 1 & 2

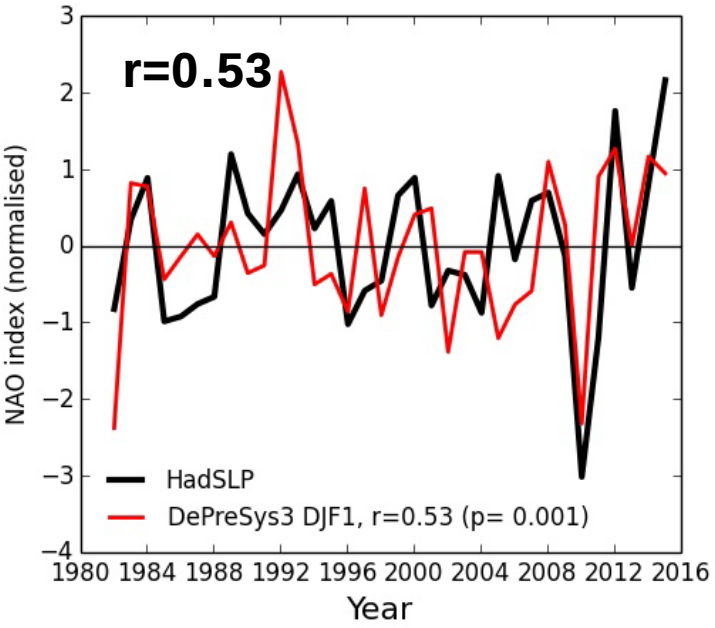
GloSea5 skill holds for:

Longer (35 year) time series

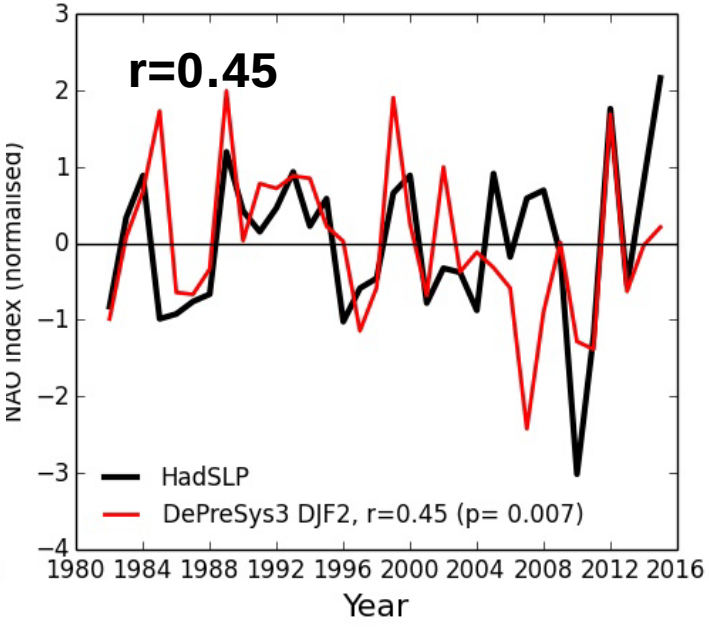
New physics

Corr = 0.52 / 0.57
For 1st / 2nd half period

First winter (DJF)



Second winter (13-month lead)



Decadal system; November starts; hindcast = 1980- 2014

Skill for the second winter NAO (r=0.45, >99% significant)
ENSO links to NAO and long-lead ENSO skill is a key driver

Nick Dunstone

Supported by proposed WCRP Grand Challenge (GC)

- WCRP Grand Challenge on Near-Term Climate Prediction
  - Co-leads: Adam Scaife and Yochanan Kushnir

Deliverables include (paraphrased):

- White paper announcing creation of a WCRP GC on Near-Term Climate Prediction, its motivation, aims and research activities.
- Standards for near-term predictions/outlooks in collaboration with WMO Expert Team and consider how to make seamless with long-term projections.
- Help guide formal WMO infrastructure for annual real-time near-term predictions (working with ET-OPSLS)