Seasonal Forecasting and Numerical Weather Prediction – Are These Relevant to Climate Change Studies?

With thanks to Judith Berner, Paco Doblas-Reyes, Laura Ferranti, Mark Rodwell, Antje Weisheimer

EU-funded FP6 Integrated Project 2004-2009

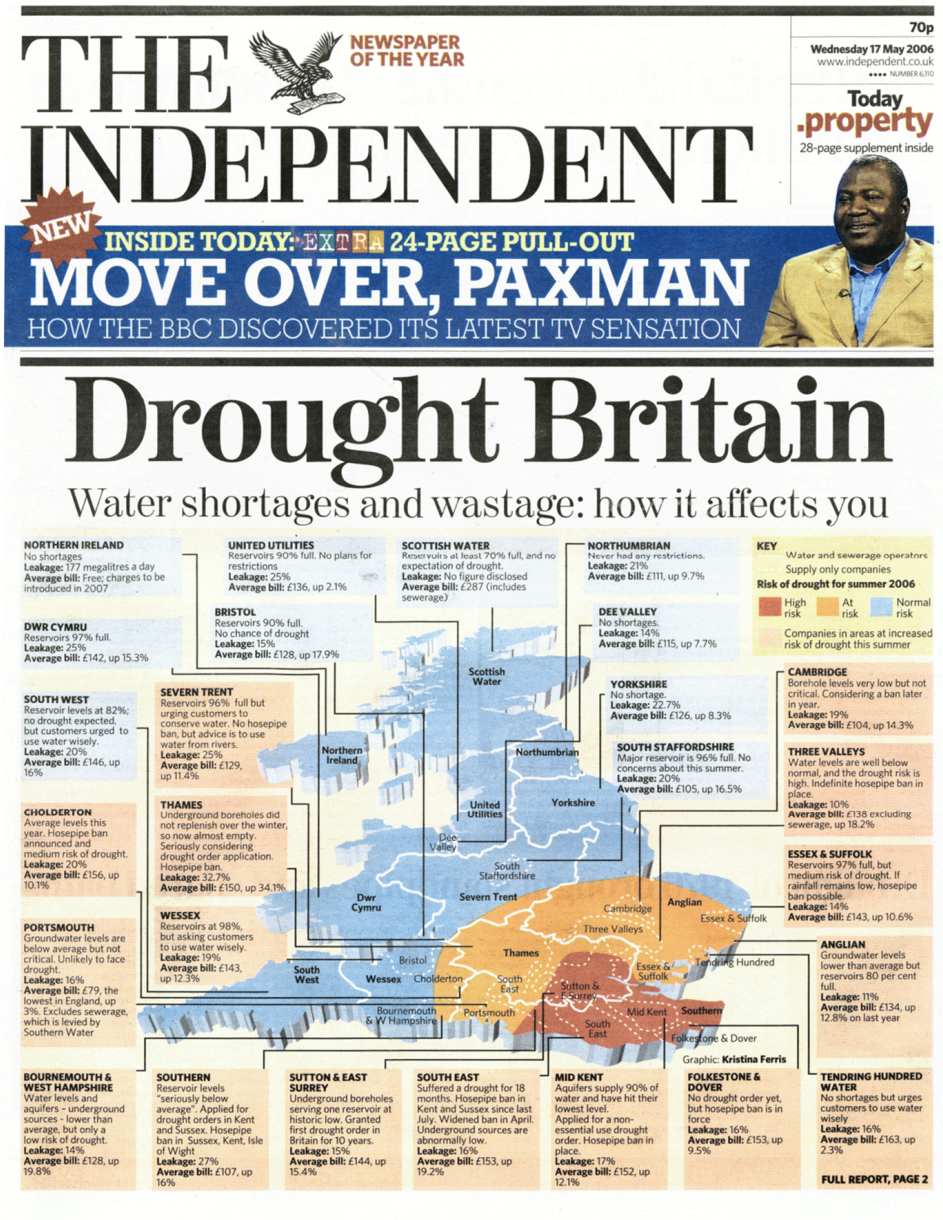
with ca 70 partners

ENSEMBLES

“ENSEMBLE-based Predictions of Climate Changes and their ImpactS”

Objective

Development of an ensemble prediction system based on the principal state-of-the-art, high resolution, global and regional Earth System models developed in Europe to produce for the first time, an objective probabilistic estimate of uncertainty in future climate at the seasonal to decadal and longer timescales.



THE INDEPENDENT

NEWSPAPER OF THE YEAR

70p

Wednesday 17 May 2006
www.independent.co.uk
NUMBER 6,110

Today
property
28-page supplement inside

NEW

INSIDE TODAY: EXTRA 24-PAGE PULL-OUT

MOVE OVER, PAXMAN

HOW THE BBC DISCOVERED ITS LATEST TV SENSATION

Drought Britain

Water shortages and wastage: how it affects you

NORTHERN IRELAND
No shortages
Leakage: 177 megalitres a day
Average bill: Free; charges to be introduced in 2007

DWR CYMRU
Reservoirs 97% full.
Leakage: 25%
Average bill: £142, up 15.3%

SOUTH WEST
Reservoir levels at 82%; no drought expected, but customers urged to use water wisely.
Leakage: 20%
Average bill: £146, up 16%

CHOLDERTON
Average levels this year. Hosepipe ban announced and medium risk of drought.
Leakage: 20%
Average bill: £156, up 10.1%

PORTSMOUTH
Groundwater levels are below average but not critical. Unlikely to face drought.
Leakage: 16%
Average bill: £79, the lowest in England, up 3%. Excludes sewerage, which is levied by Southern Water

UNITED UTILITIES
Reservoirs 90% full. No plans for restrictions
Leakage: 25%
Average bill: £136, up 2.1%

BRISTOL
Reservoirs 90% full. No chance of drought
Leakage: 15%
Average bill: £128, up 17.9%

SEVERN TRENT
Reservoirs 96% full but urging customers to conserve water. No hosepipe ban, but advice is to use water from rivers.
Leakage: 25%
Average bill: £129, up 11.4%

THAMES
Underground boreholes did not replenish over the winter, so now almost empty. Seriously considering drought order application. Hosepipe ban.
Leakage: 32.7%
Average bill: £150, up 34.1%

WESSEX
Reservoirs at 98%, but asking customers to use water wisely.
Leakage: 19%
Average bill: £143, up 12.3%

SCOTTISH WATER
Reservoirs at least 70% full, and no expectation of drought.
Leakage: No figure disclosed
Average bill: £287 (includes sewerage)

NORTHUMBRIAN
Never had any restrictions.
Leakage: 21%
Average bill: £111, up 9.7%

DEE VALLEY
No shortages.
Leakage: 14%
Average bill: £115, up 7.7%

YORKSHIRE
No shortage.
Leakage: 22.7%
Average bill: £126, up 8.3%

SOUTH STAFFORDSHIRE
Major reservoir is 96% full. No concerns about this summer.
Leakage: 20%
Average bill: £105, up 16.5%

SOUTH EAST
Suffered a drought for 18 months. Hosepipe ban in Kent and Sussex since last July. Widened ban in April. Underground sources are abnormally low.
Leakage: 16%
Average bill: £153, up 19.2%

MID KENT
Aquifers supply 90% of water and have hit their lowest level. Applied for a non-essential use drought order. Hosepipe ban in place.
Leakage: 17%
Average bill: £152, up 12.1%

FOLKESTONE & DOVER
No drought order yet, but hosepipe ban is in force
Leakage: 16%
Average bill: £153, up 9.5%

SOUTHERN
Reservoir levels "seriously below average". Applied for drought orders in Kent and Sussex. Hosepipe ban in Sussex, Kent, Isle of Wight
Leakage: 27%
Average bill: £107, up 16%

SUTTON & EAST SURREY
Underground boreholes serving one reservoir at historic low. Granted first drought order in Britain for 10 years.
Leakage: 15%
Average bill: £144, up 15.4%

BOURNEMOUTH & WEST HAMPSHIRE
Water levels and aquifers – underground sources – lower than average, but only a low risk of drought.
Leakage: 14%
Average bill: £128, up 19.8%

KEY
Water and sewerage operators
Supply only companies
Risk of drought for summer 2006
High risk | At risk | Normal risk
Companies in areas at increased risk of drought this summer

CAMBRIDGE
Borehole levels very low but not critical. Considering a ban later in year.
Leakage: 19%
Average bill: £104, up 14.3%

THREE VALLEYS
Water levels are well below normal, and the drought risk is high. Indefinite hosepipe ban in place.
Leakage: 10%
Average bill: £138 excluding sewerage, up 18.2%

ESSEX & SUFFOLK
Reservoirs 97% full, but medium risk of drought. If rainfall remains low, hosepipe ban possible.
Leakage: 14%
Average bill: £143, up 10.6%

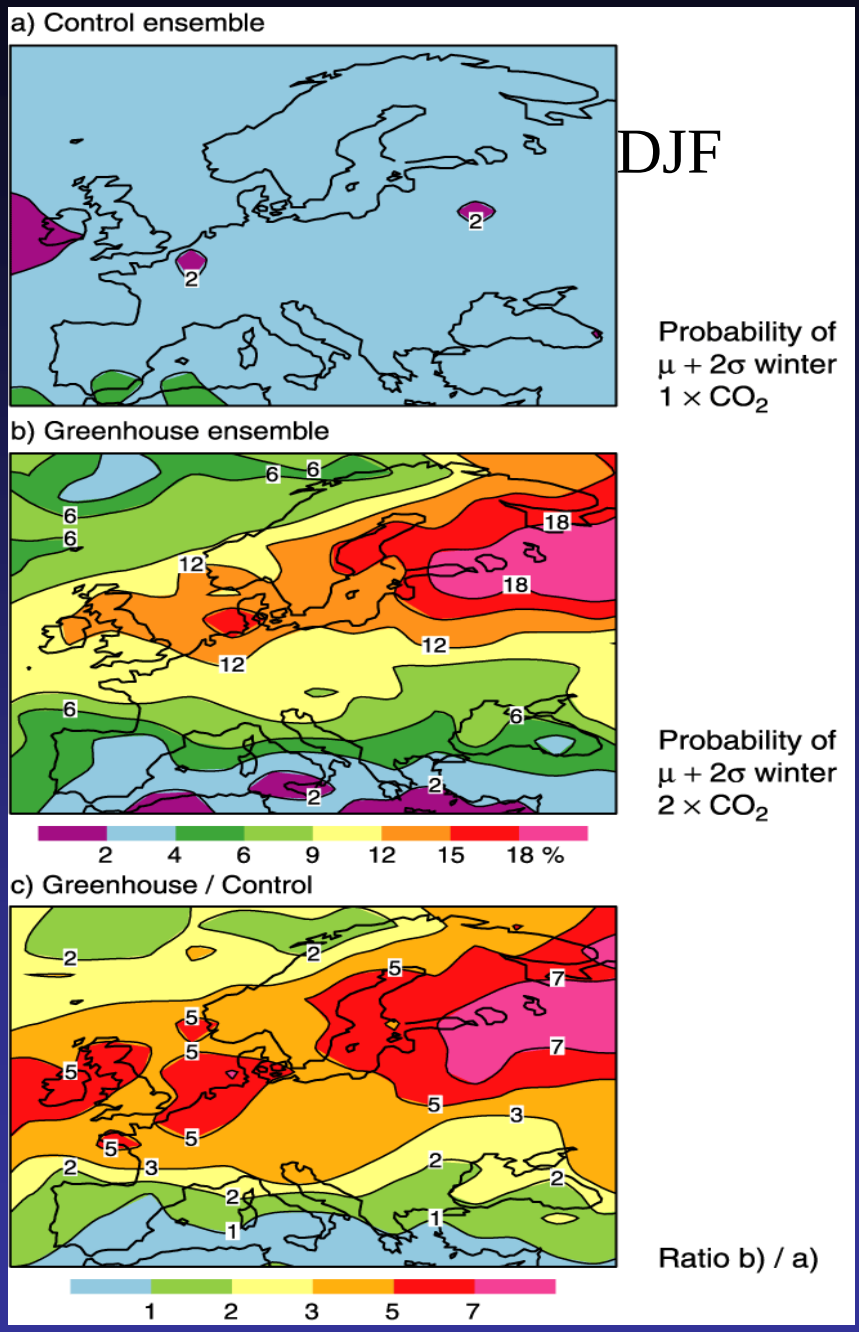
ANGLIAN
Groundwater levels lower than average but reservoirs 80 per cent full.
Leakage: 11%
Average bill: £134, up 12.8% on last year

TENDRING HUNDRED WATER
No shortages but urges customers to use water wisely
Leakage: 16%
Average bill: £163, up 2.3%

FULL REPORT, PAGE 2

Graphic: **Kristina Ferris**

Probability Analysis of Extreme Climate Change based on 19-member CMIP2 Multi-model Ensemble.



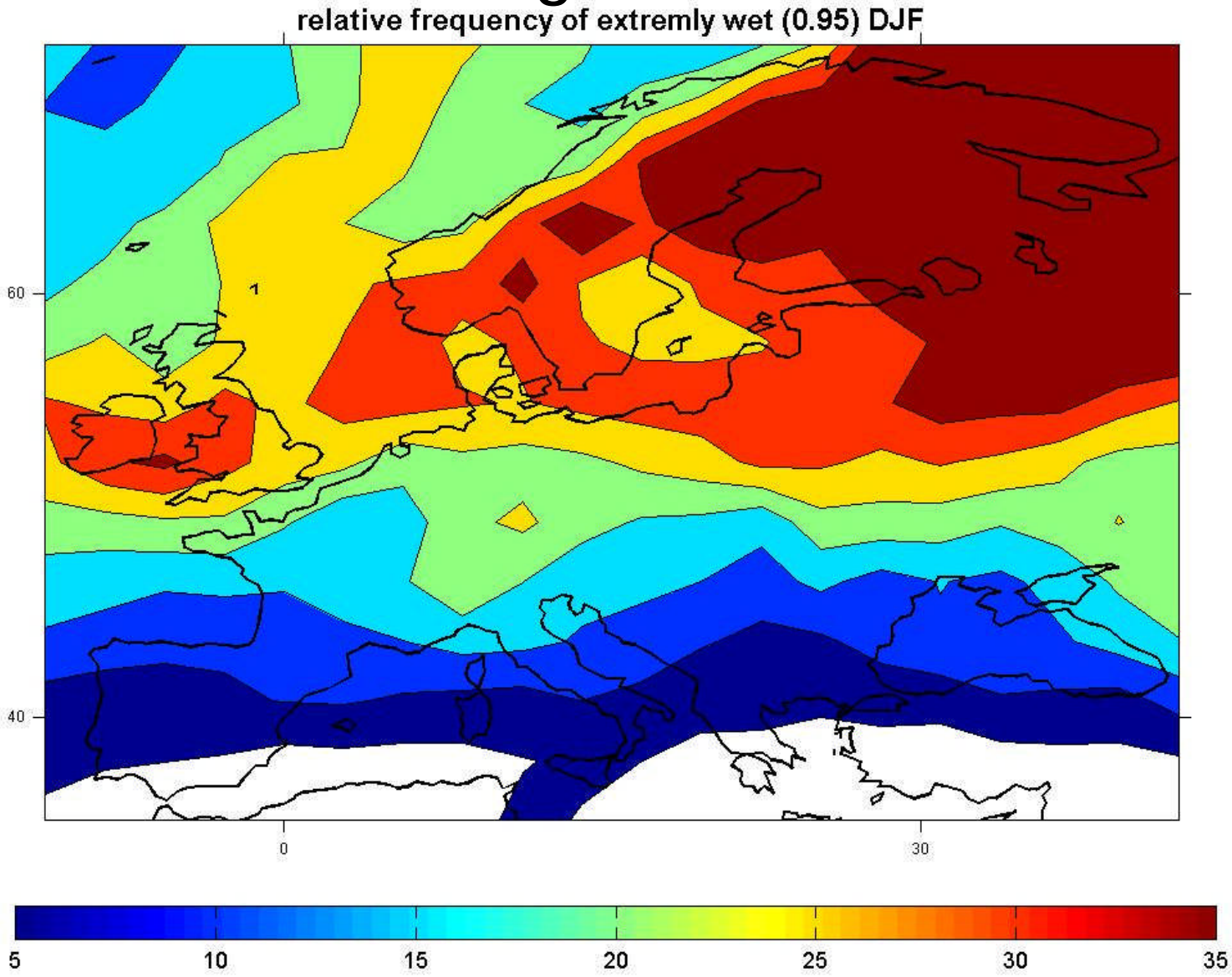
From: Palmer and Räisänen, Nature 2002


NO THROUGH ROAD
VICARAGE LANE

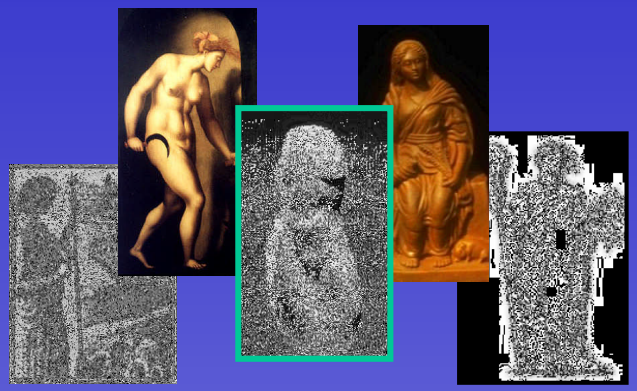

ROAD
CLOSED
Flood

Probability of 1-in-20 year **wet** winter based on AR4 integrations

Weisheimer and Palmer, 2006



Δημητηρ



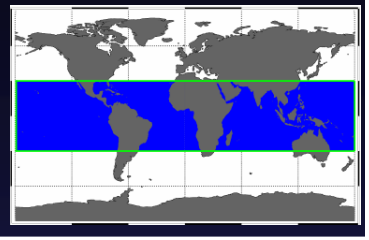
Development of a

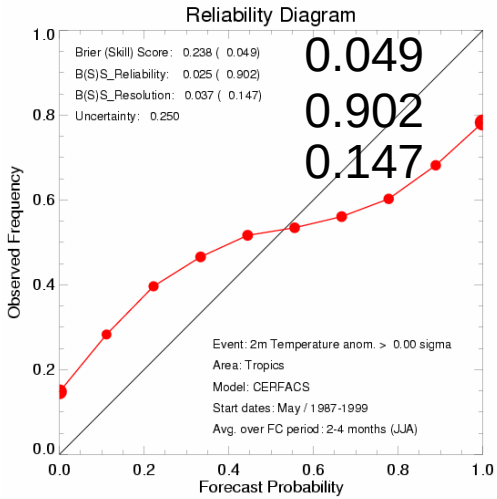
European Multi-Model Ensemble System

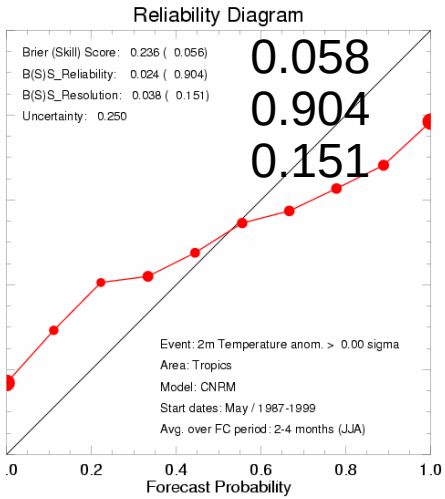
for

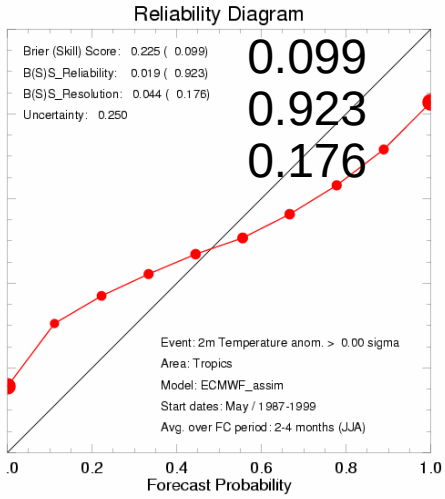
Seasonal to Interannual Prediction

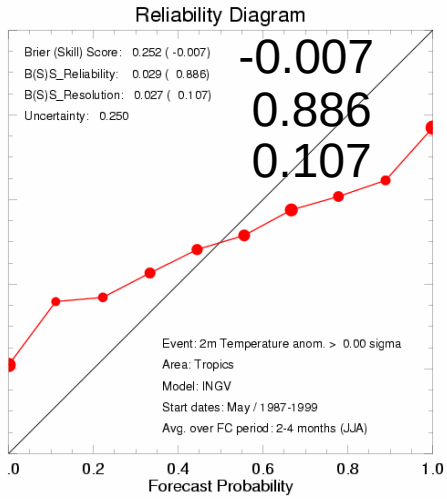
Reliability: 2m-Temp.>0

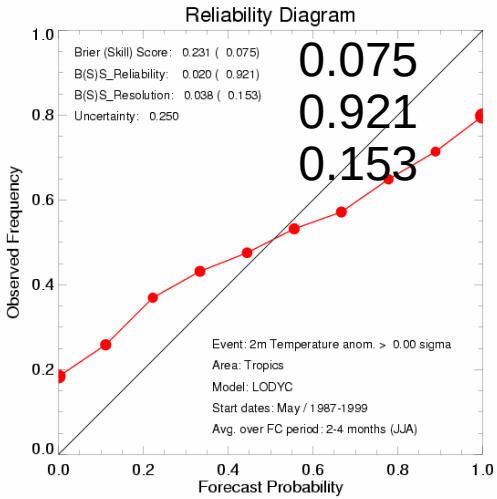


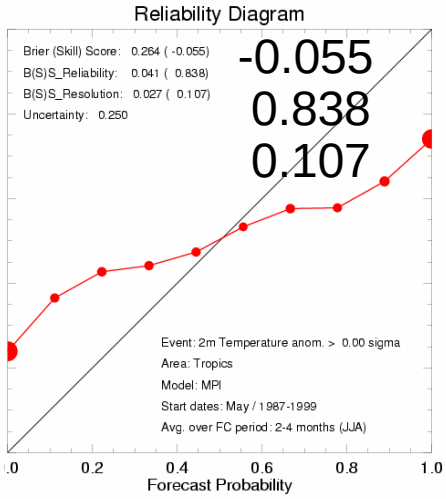


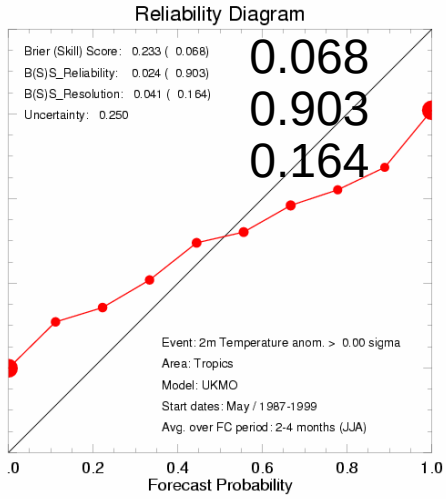


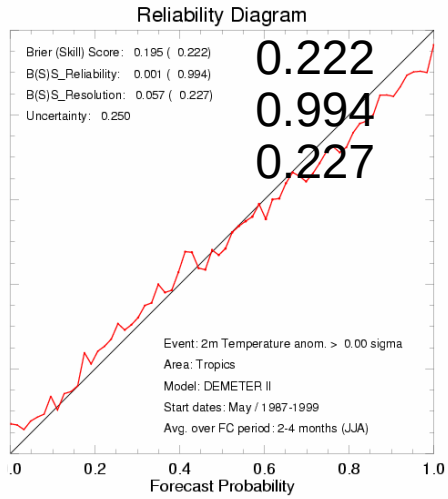




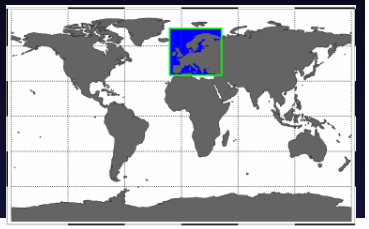


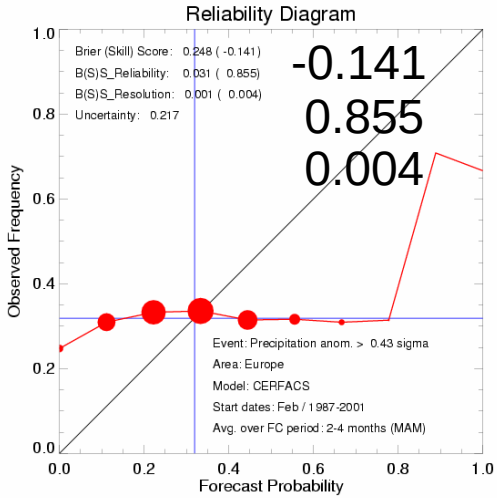


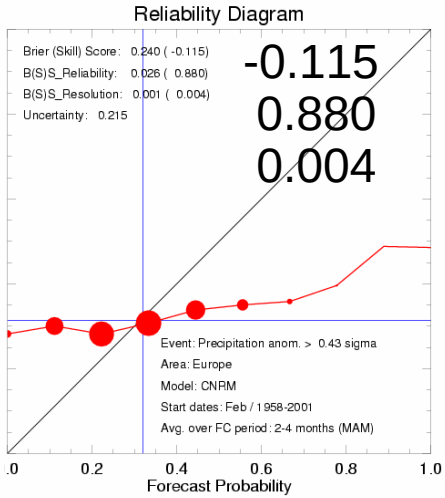


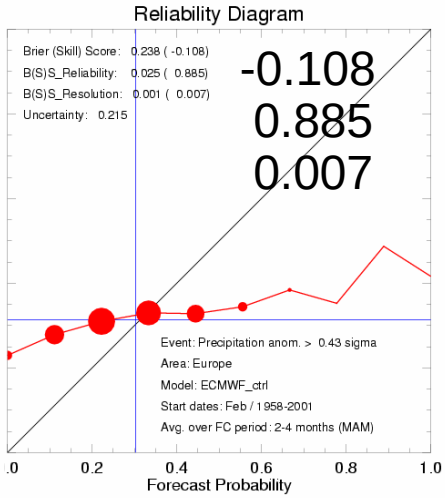


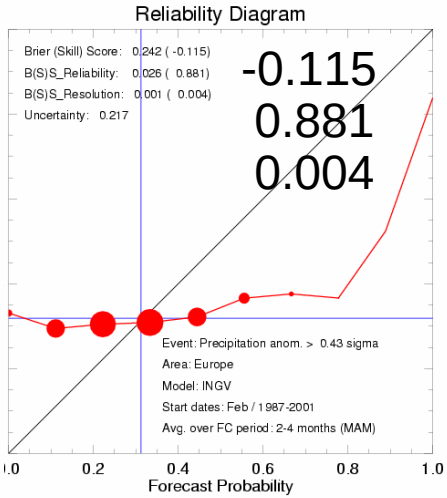
Reliability: Precip>0.43σ

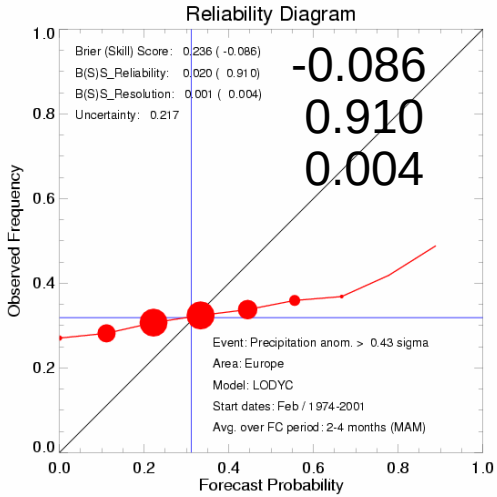


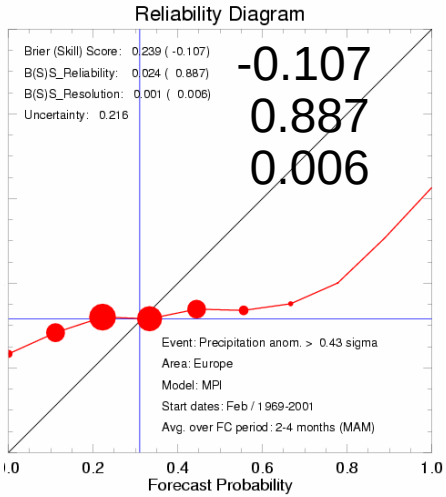


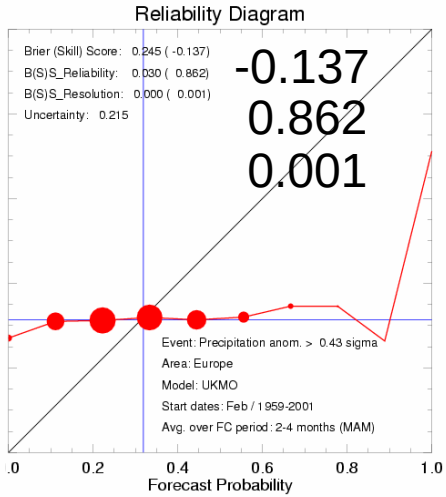


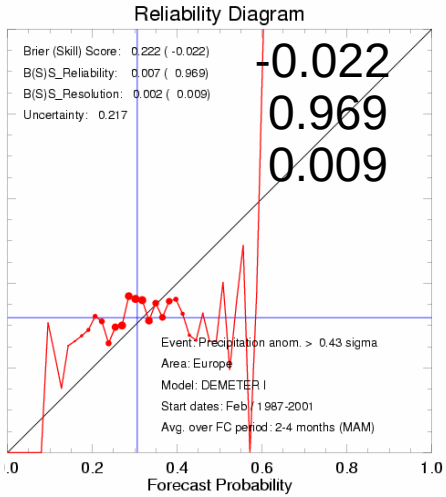












Records shatter as arctic weather grips Europe

Scores reported dead due to killer cold; utilities stretched to limit

Forum / Reuters

Snow-covered fishing and sailing boats were testament Tuesday to the chilly temperatures on the frozen Baltic Sea in Hel, northern Poland.

World News
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SLIDE SHOW

Launch

· **European cold snap**
Click to see the deep freeze that overtook Europe.

Associated Press
Updated: 10:03 p.m. ET Jan. 24, 2006

VIENNA, Austria - Vienna's subway tracks cracked, German authorities shut a key canal to ships after it iced up, and a zoo moved its penguins indoors Tuesday as a deadly deep freeze tightened its arctic grip on much of Europe.

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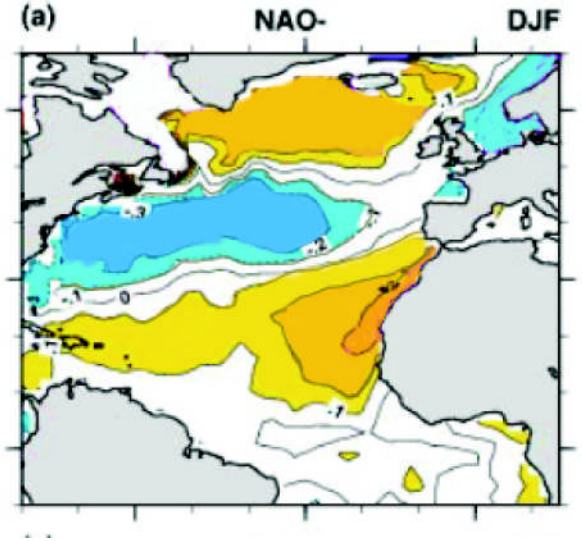
Background: The North Atlantic Oscillation

Sea surface temperature anomalies

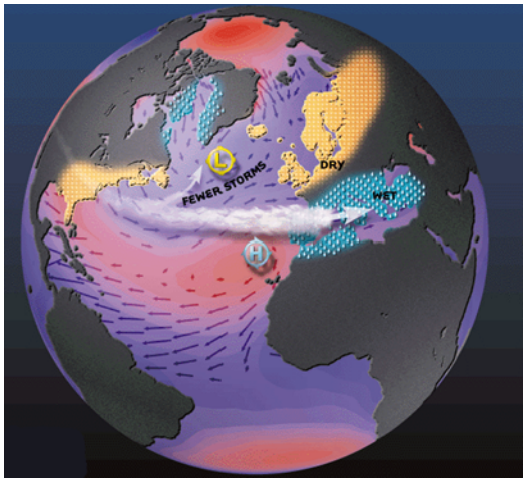


Negative NAO

WINTER

(Schematic)

North Atlantic Oscillation



- In mid-latitudes internal seasonal variability is much larger than forced signals. The scientific evidence suggests a weak forcing of the ocean on the atmosphere in winter (and the models underestimate the effect).
- Negative North Atlantic Oscillation (NAO) implies greater frequency of easterly flow.

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EUROSIP multi-model seasonal forecast

ECMWF/Met Office/Météo-France

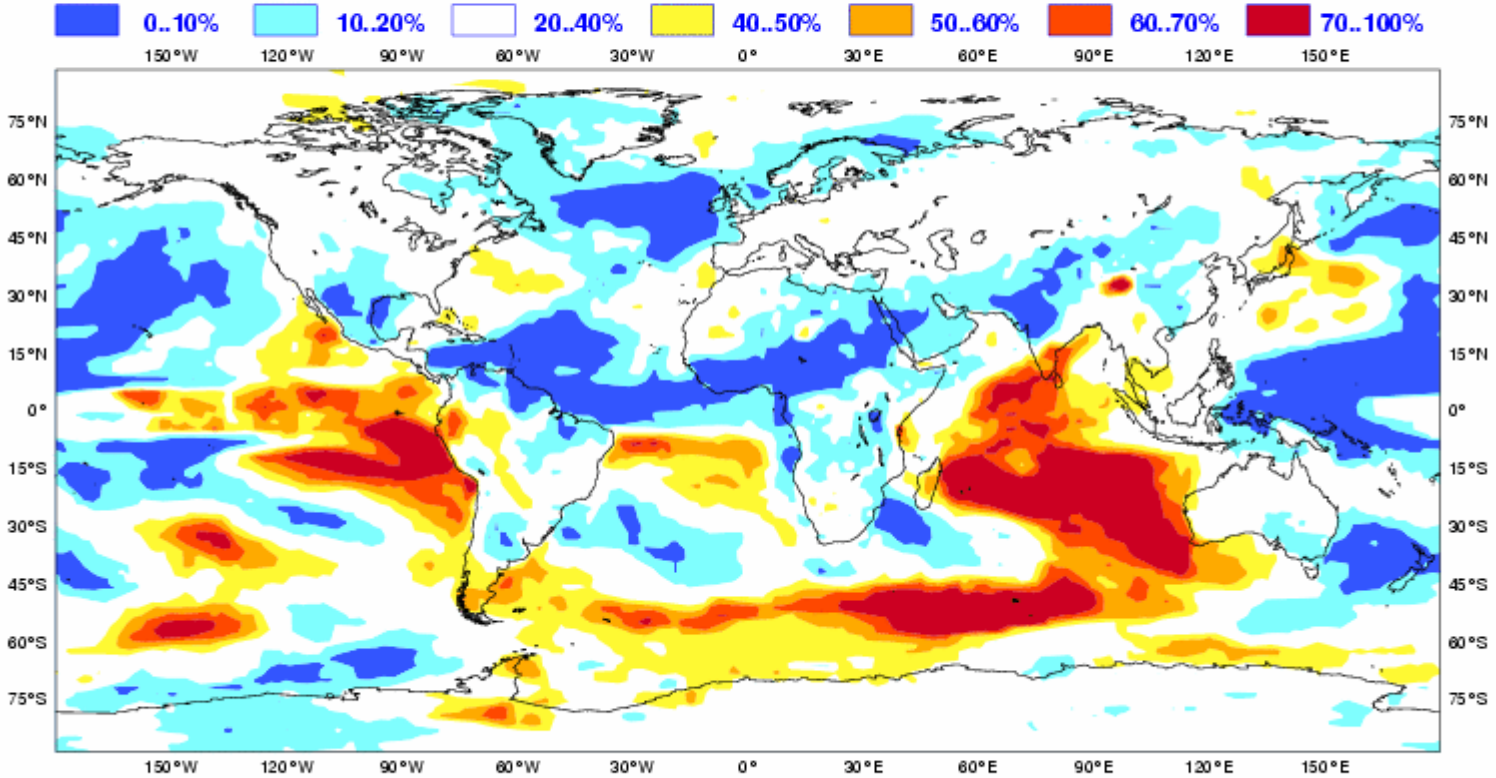
Prob(2m temperature < lower tercile)

DJF 2005/06

Forecast start reference is 01/11/05

No significance test applied

Unweighted mean



Produced from real-time forecast data

ECMWF

Blocking frequency in seasonal hindcasts

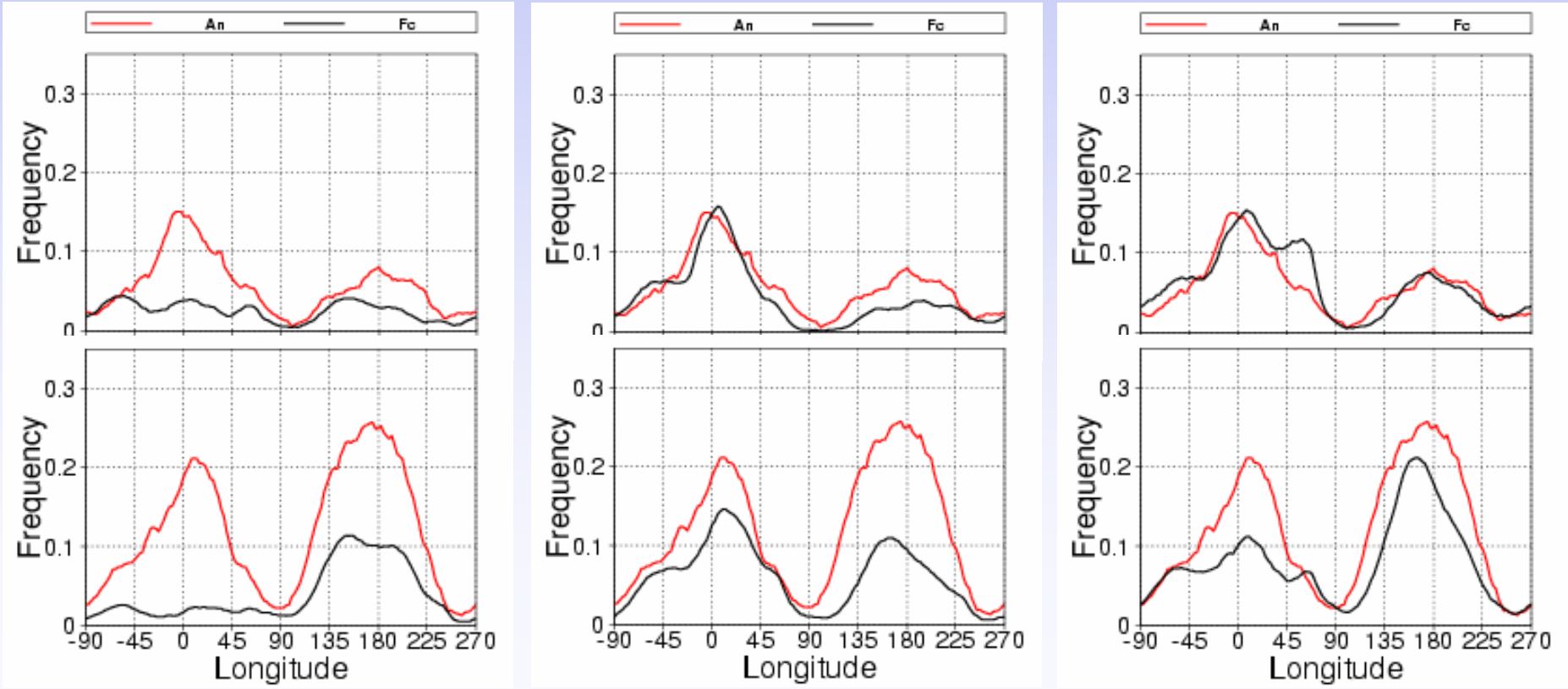
Northern Hemisphere blocking frequency for DEMETER hindcasts

November start, 1959-2001, 9-member ensembles

Top row: November (first month) Bottom row: January (third month)

ERA40 **Single models**

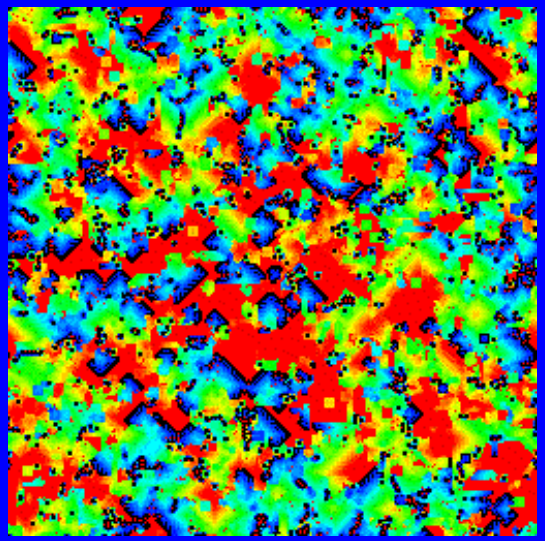
CNRM **ECMWF** **Met Office**



Representing Model Uncertainty

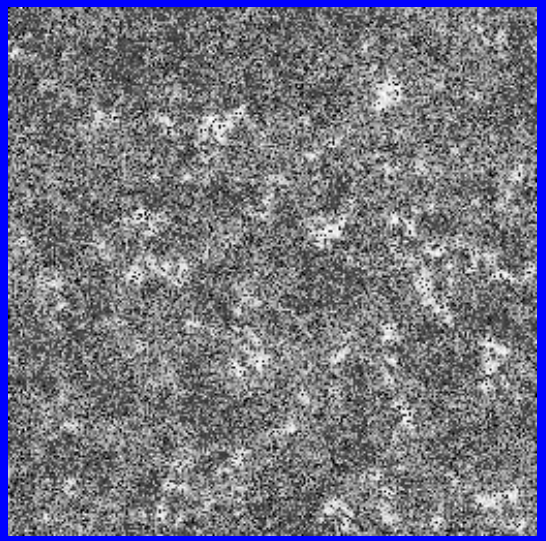
- Multi-models
- Perturbed Parameters
- Stochastic Physics

Cellular Automaton Stochastic Backscatter Scheme (CASBS)



smooth

scale



Cellular Automaton state

streamfunction forcing shape function Ψ

$$\frac{\partial \psi}{\partial t} = \alpha \cdot \Psi(x, y) \cdot \sqrt{D}$$

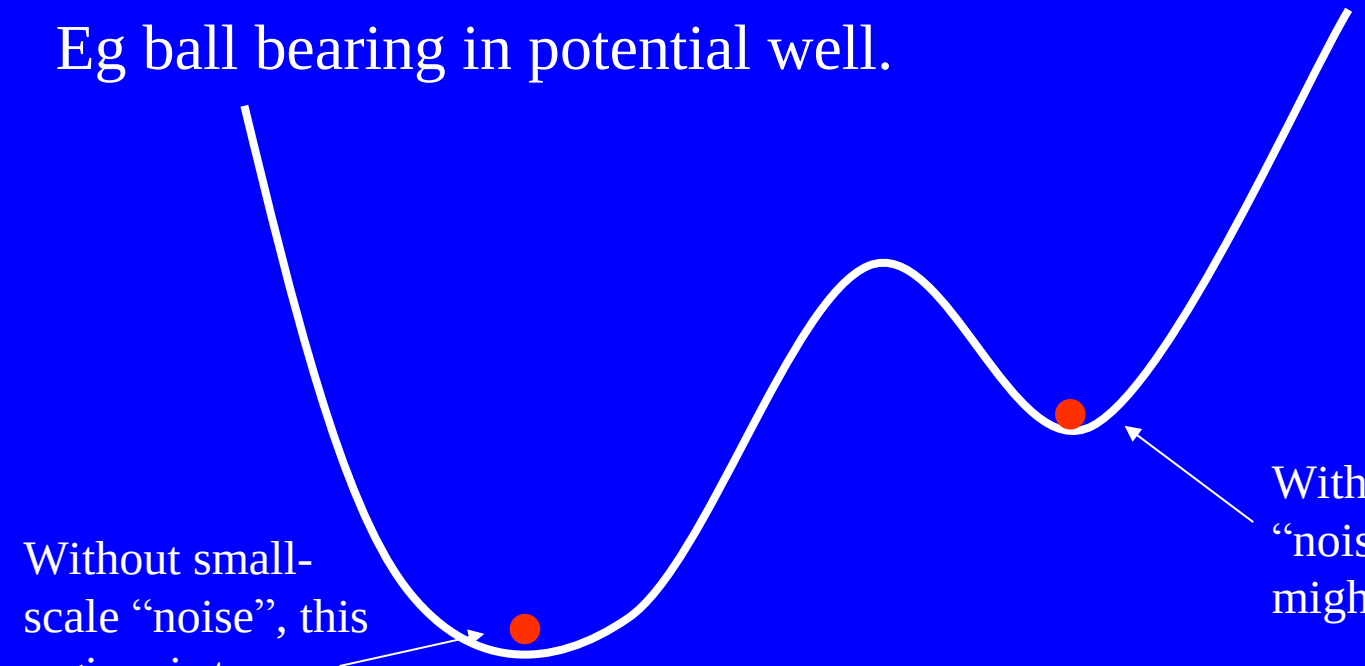
D = sub-grid energy dissipation due to numerical diffusion, mountain drag and convection

G.Shutts, 2005

α = dimensional parameter

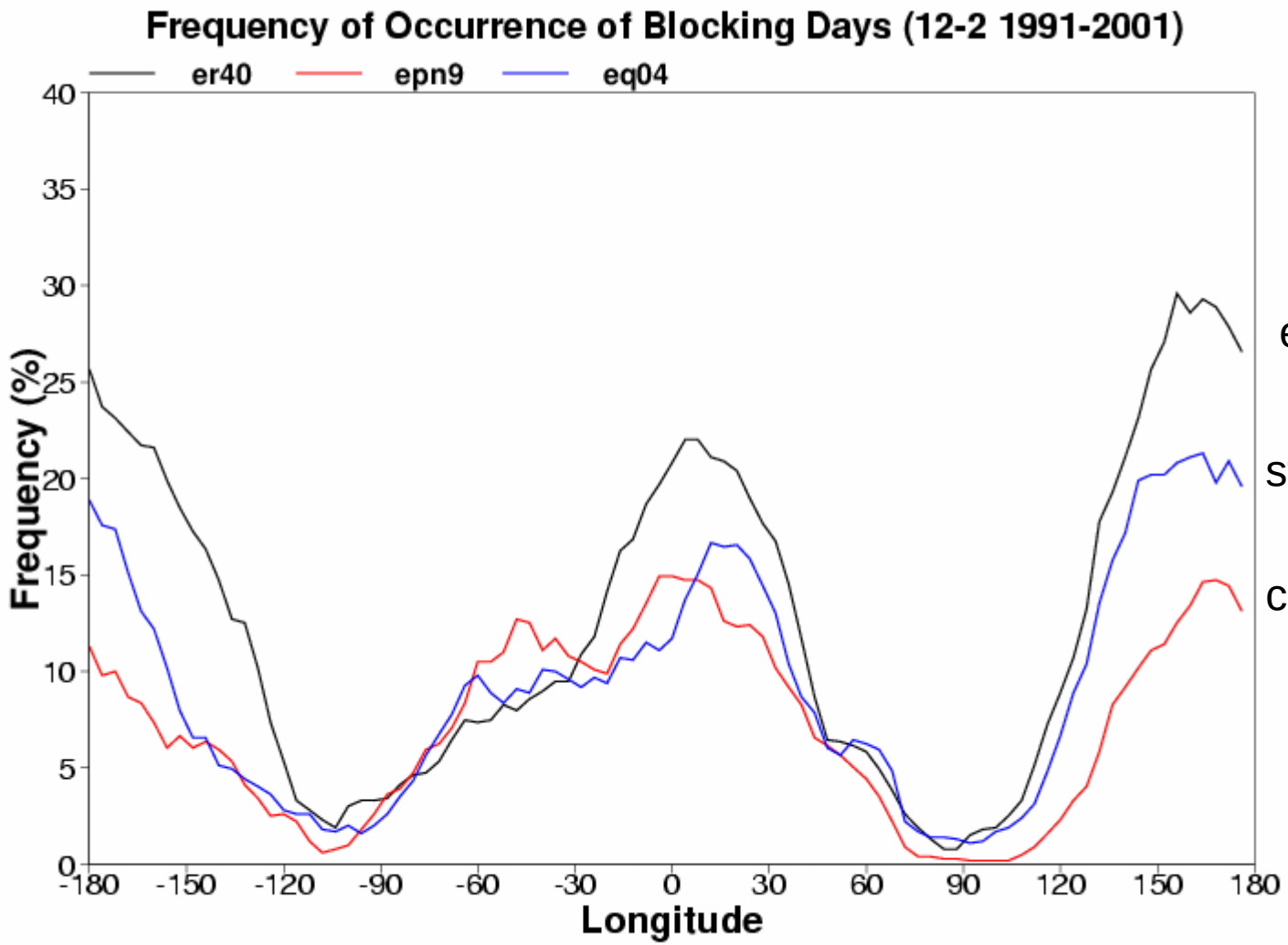
Possible impact of Stochastic Parametrisations on mean state

Eg ball bearing in potential well.



Without small-scale "noise", this regime is too dominant

Without small-scale "noise", this minimum might be inaccessible



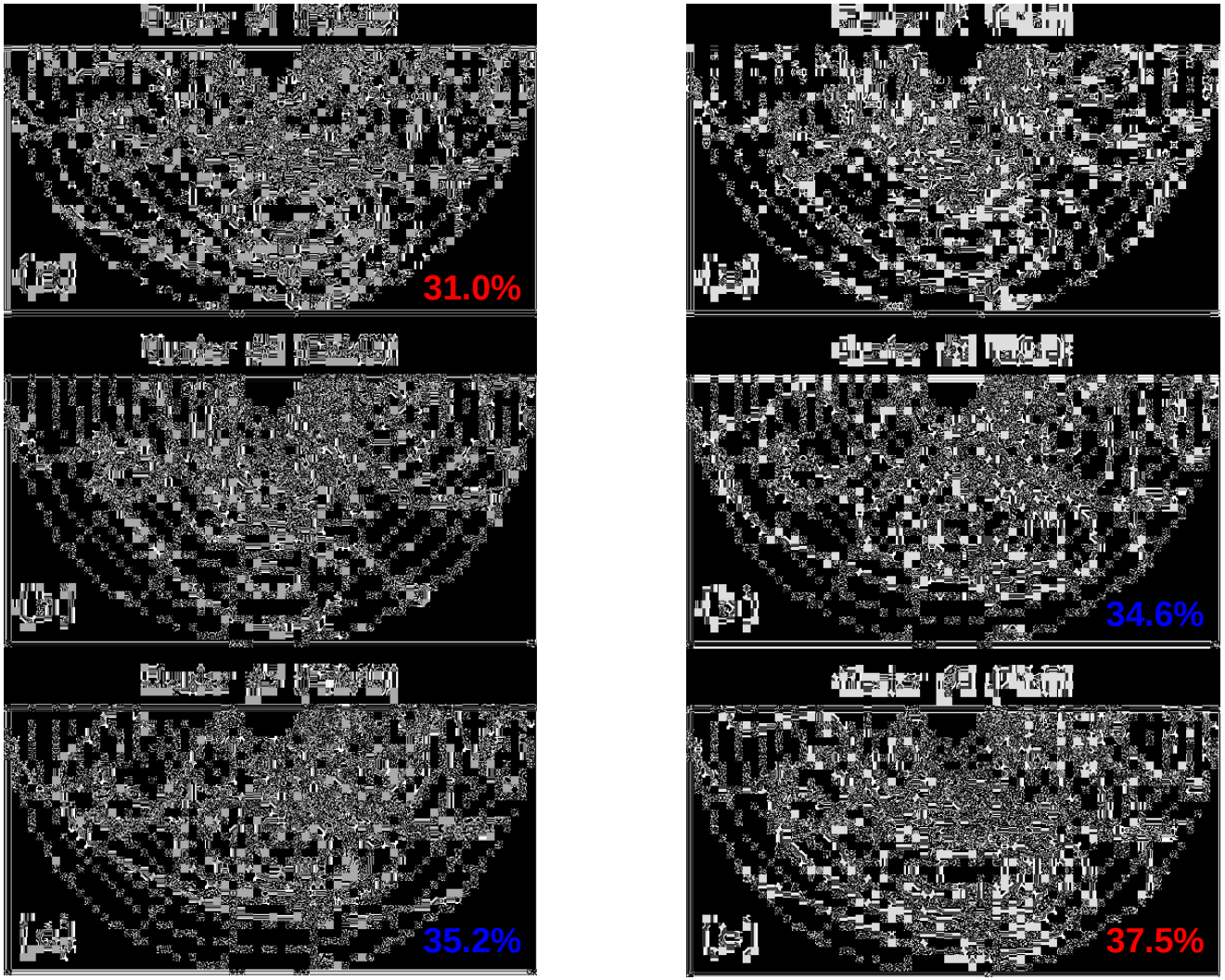
era-40

stoch phys

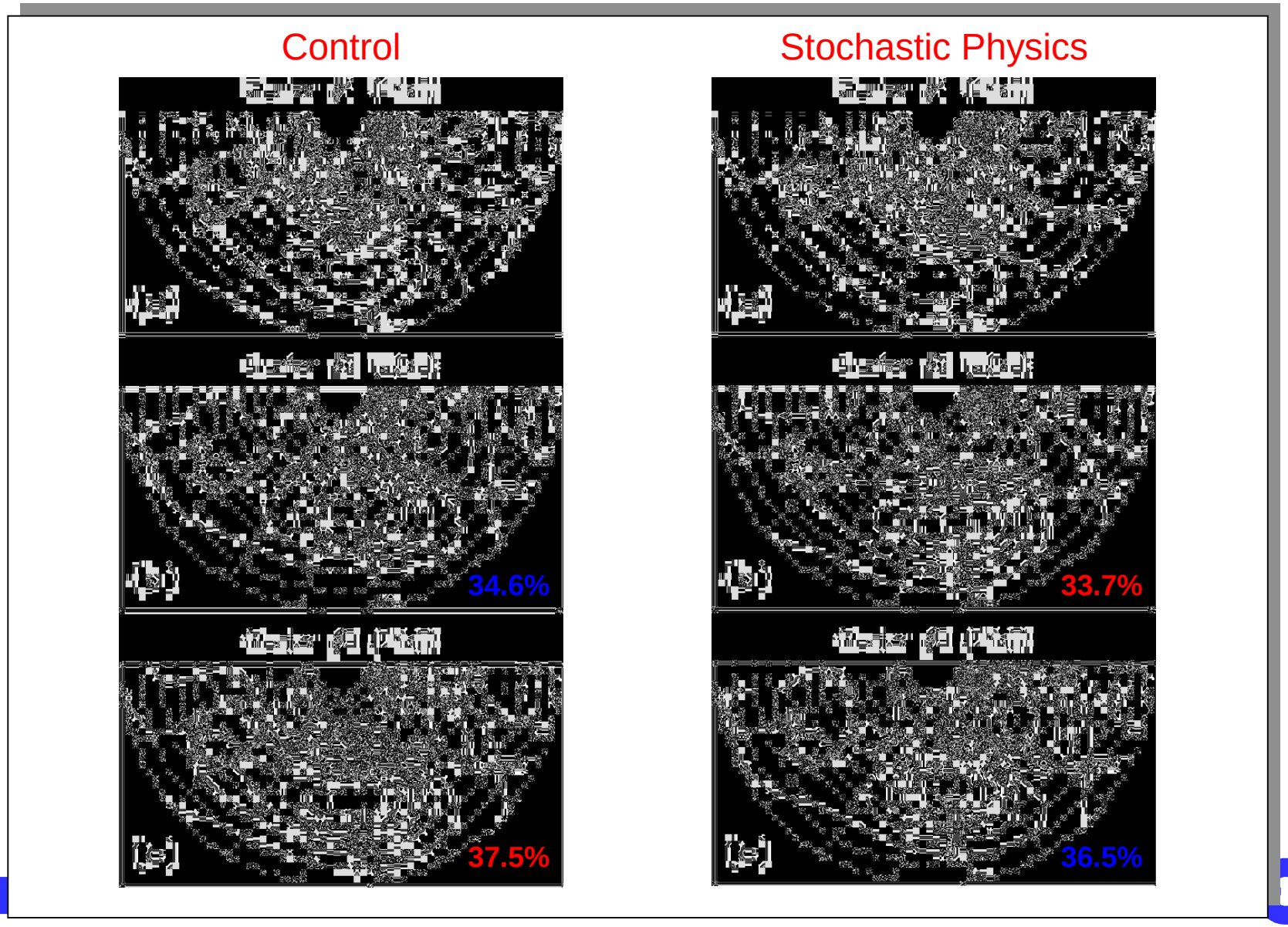
control

ECMWF

Weather Regimes: ERA-40 vs control (Jung et al, 2006)



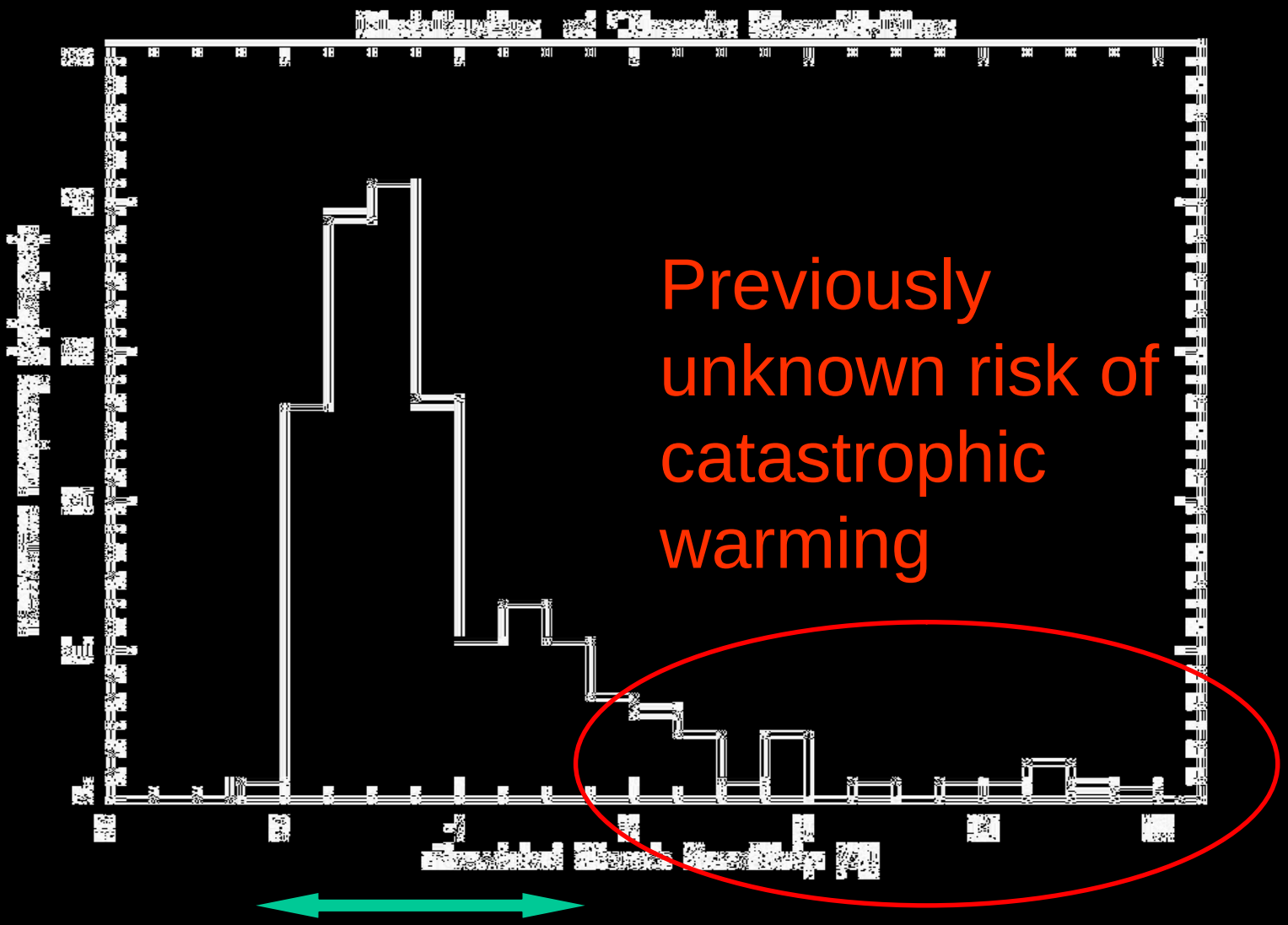
Weather Regimes: Impact of Stochastic Physics



Focus on 2005/2006 winter

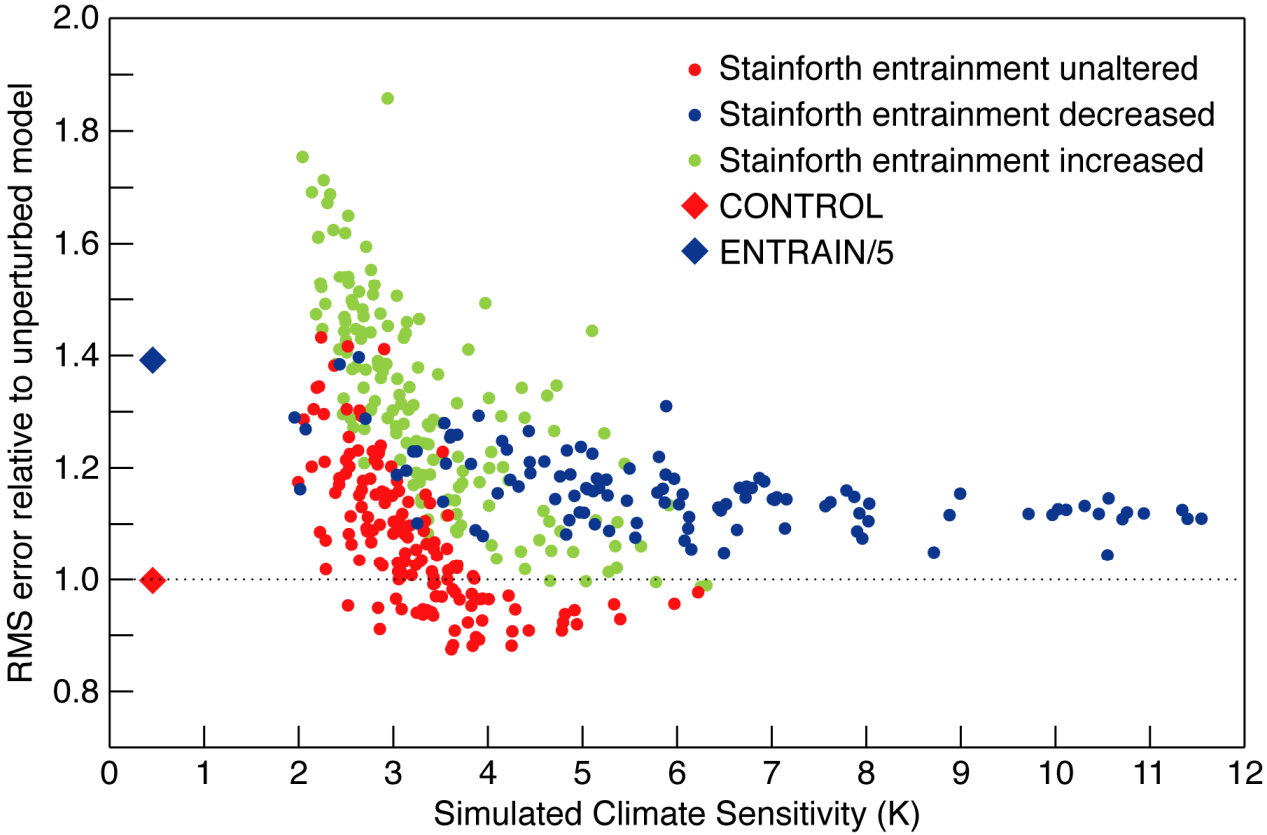
- Ensemble runs with multi-models, perturbed parameters and stochastic physics
- Coupled and uncoupled integrations
- Relaxation of tropics to analysis


27 January 2005
International weekly journal of science
nature
£10.00
www.nature.com/nature
Climate prediction
Computer power pays off



Probability of Global Warming

Climate: Error vs Sensitivity



All Stainforth models accepted

Highest sensitivity for low entrainment models

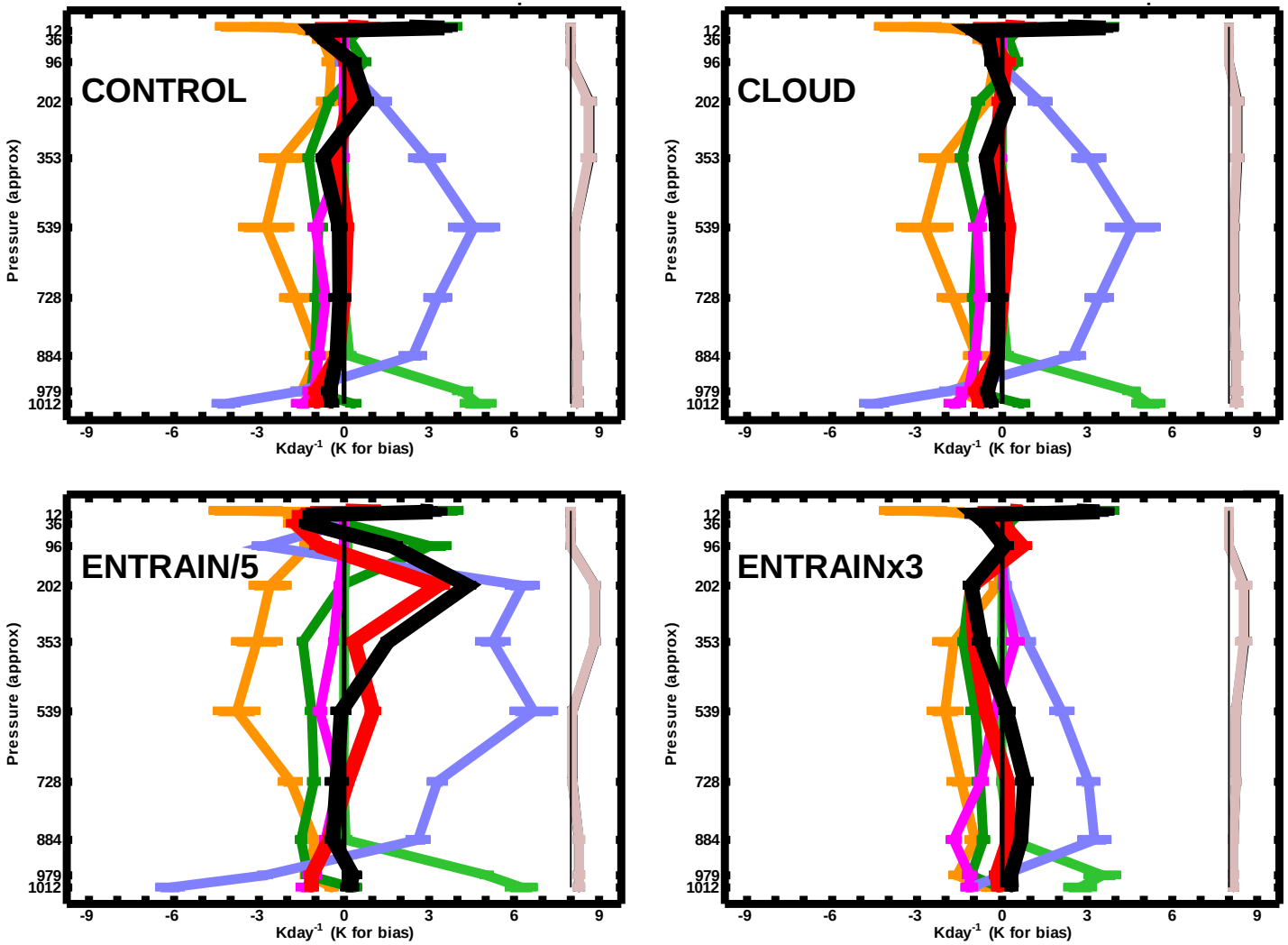
Initial Tendencies rejects ENTRAIN/5 but its climate is accepted

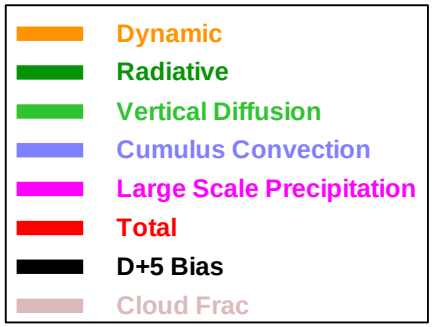
Circles: AGCM + Mixed-Layer model results from Stainforth et al. (2005) show combined RMSE of 8 year mean, annual mean T_{2m}, SLP, precipitation and ocean-atmosphere sensible+latent heat fluxes (equally weighted and normalised by the control).

Diamonds: AGCM results from Rodwell & Palmer (2006) show RMSE from 39 year mean, annual mean T_{850}, SLP and precipitation (equally weighted and normalised by the control).

January 2005 Initial T Tendencies

Rodwell and Palmer, 2006





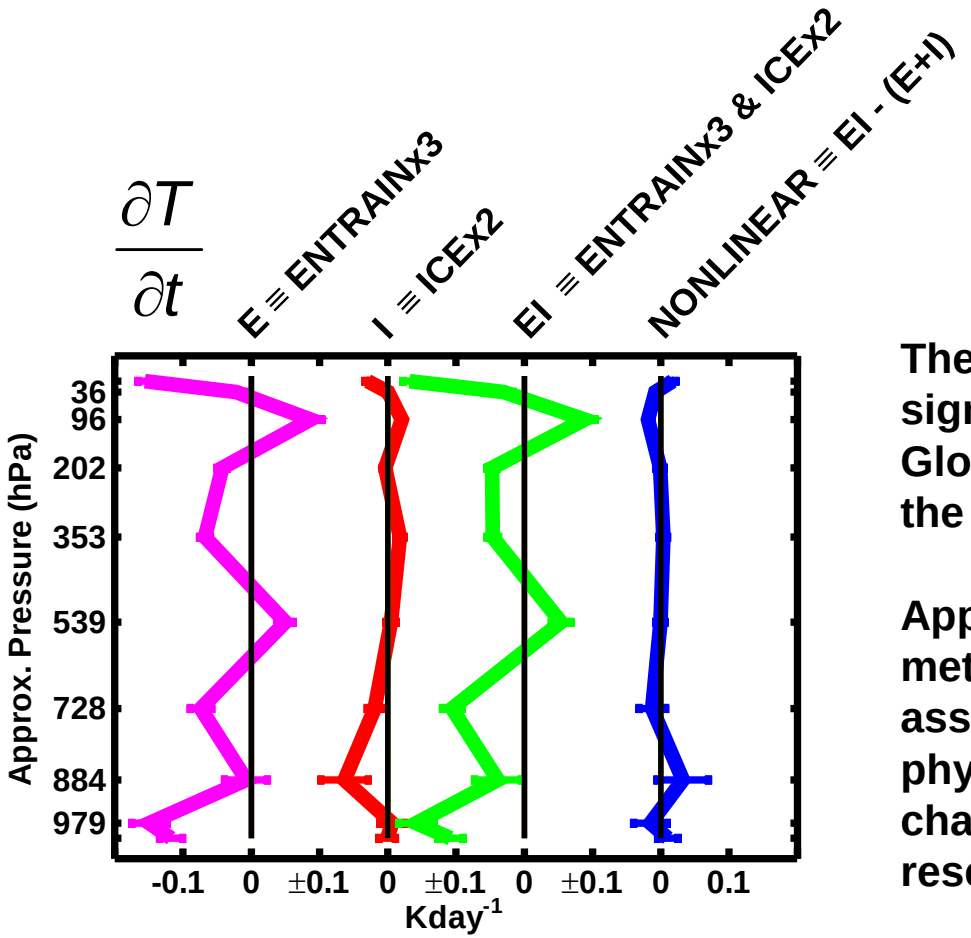
CLOUD better for T, worse for q

ENTRAIN/5 and ENTRAINx3 are completely out of balance: reject or down-weight?

By D+5, interactions between processes (non-linearity) leads to completely different balance

Amazon = [300°E-320°E, 20°S-0°N]. 70% confidence intervals shown. Model = 29R1,T159,L60,1800S.

Linearity of Initial Tendencies at 60ºS



The nonlinear component is not significantly different from zero. Globally it is generally as small as the smallest individual component

Approximate-linearity makes the method very powerful for assessing the impact on model physics of multiple model changes: e.g. in Climate Change research

E, I, EI are anomalies from CONTROL. 70% confidence intervals shown. Model = 29R1,T159,L60,1800S.

Conclusions

- Multi-model ensembles are not necessarily reliable. Models systematically under-simulate blocking.
- Stochastic parametrisations appear to increase the probability of occurrence of sub-dominant regimes
- Very short range budget tendencies can be used to constrain climatically-important fast-physics parameter perturbations
- Seasonal prediction and NWP are highly relevant to climate change studies – supports “seamless philosophy”.