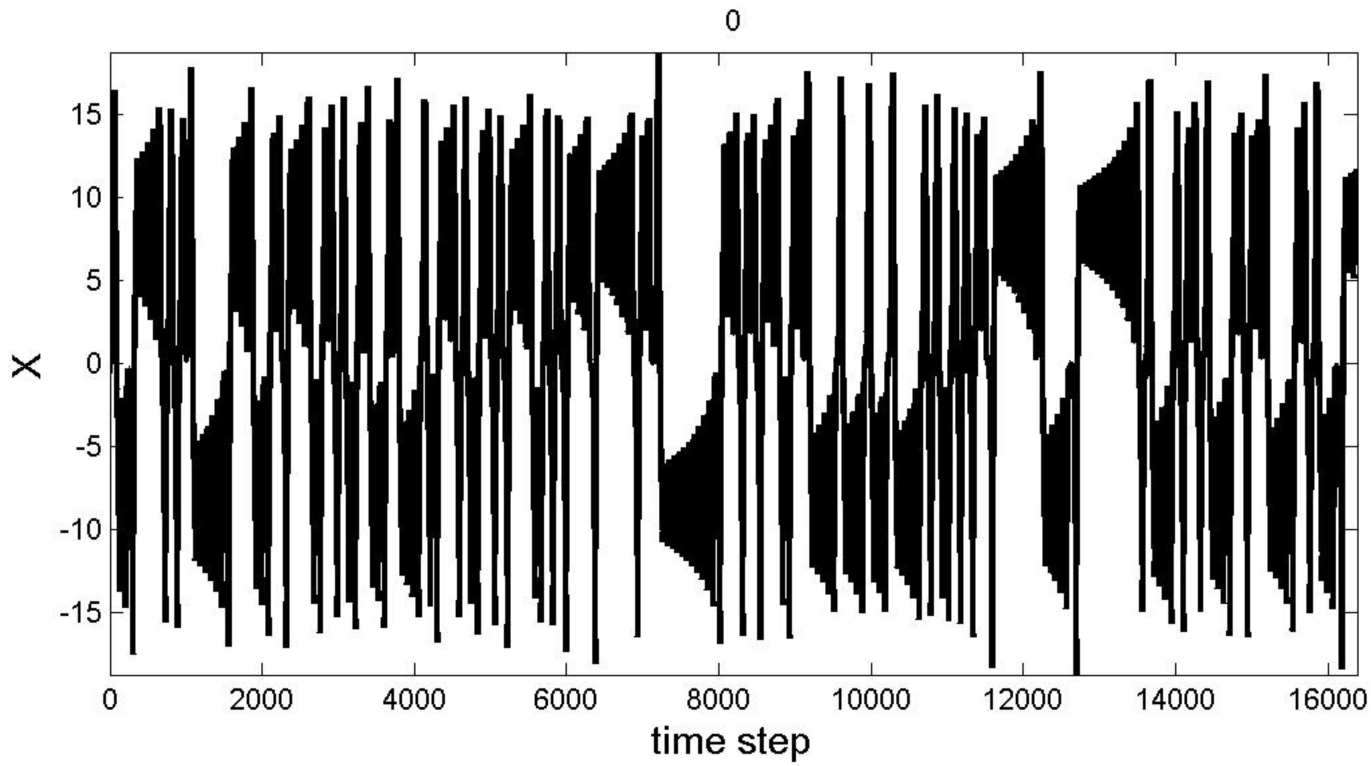
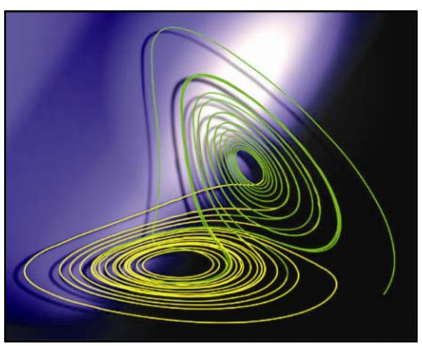
Impact of stochastic parametrisation (on systematic errors in the water cycle) in the tropics and extratropics

Tim Palmer

University of Oxford

With contributions from Andrew Dawson and Susanna Corti, Hannah Arnold, Hugh McNamara, Antje Weisheimer

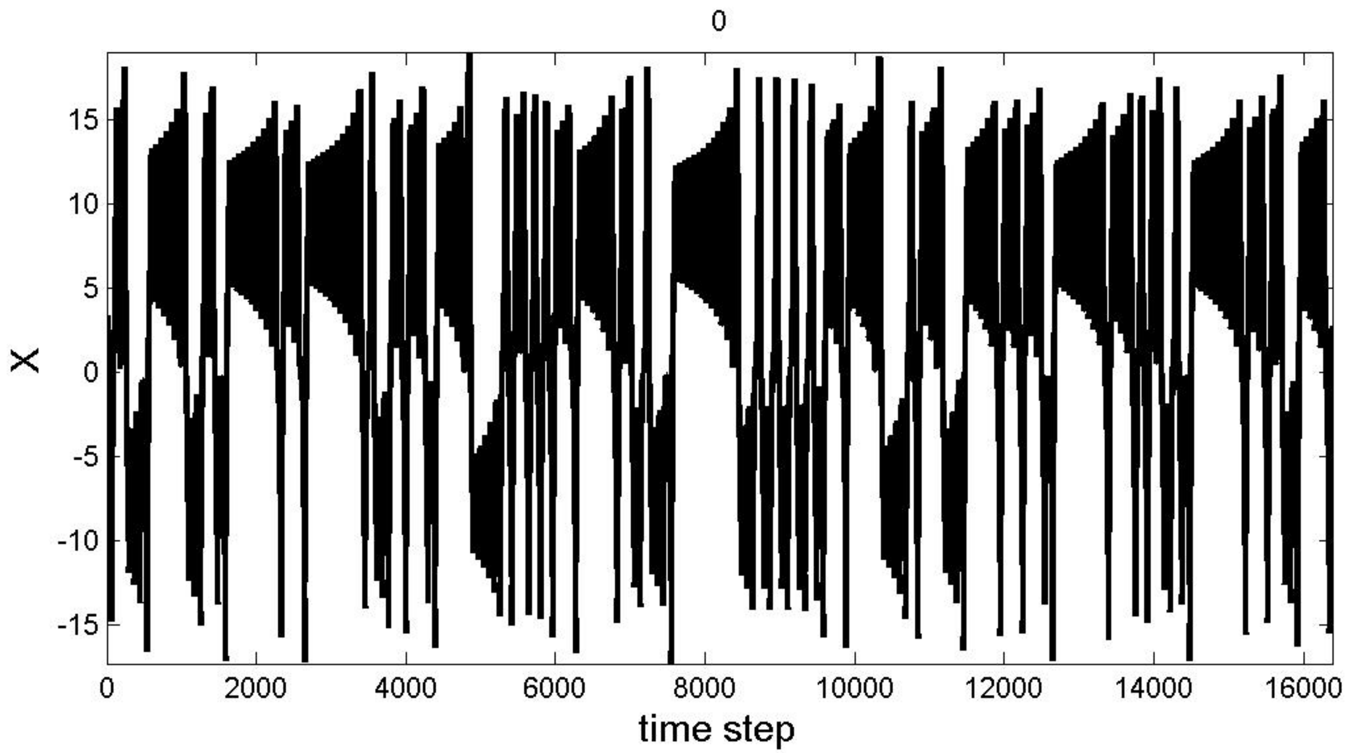




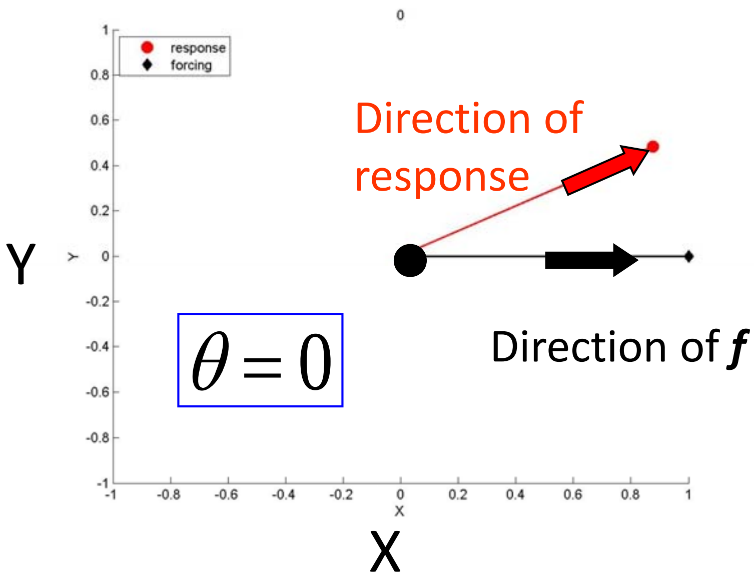
$$\dot{X} = -\sigma X + \sigma Y$$

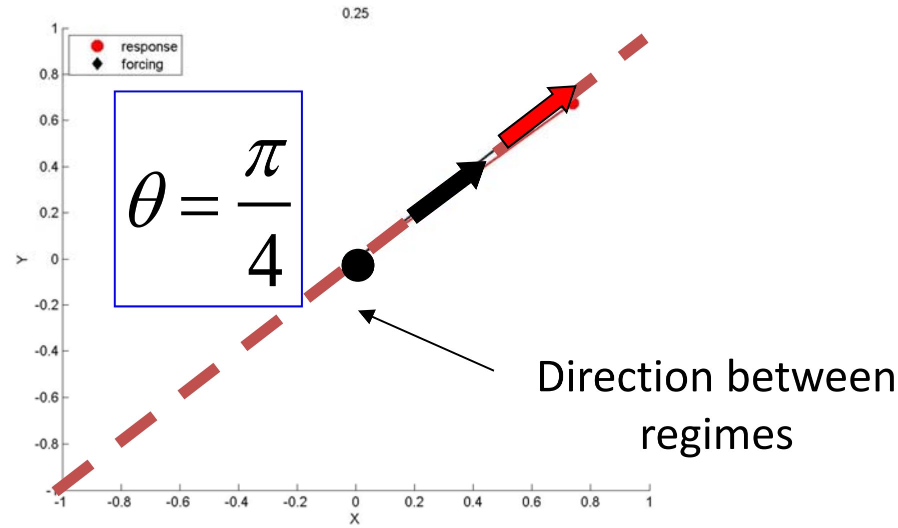
$$\dot{Y} = -XZ + rX - Y$$

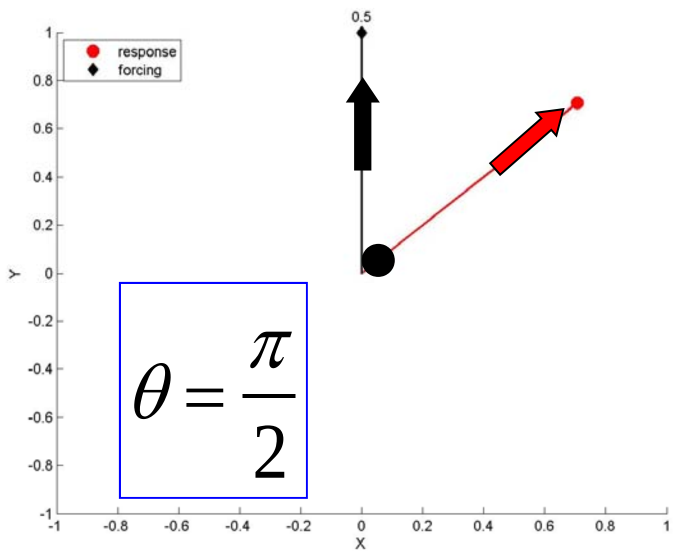
$$\dot{Z} = XY - bZ$$



$$\dot{X} = -\sigma X + \sigma Y + f$$
$$\dot{Y} = -XZ + rX - Y$$
$$\dot{Z} = XY - bZ$$







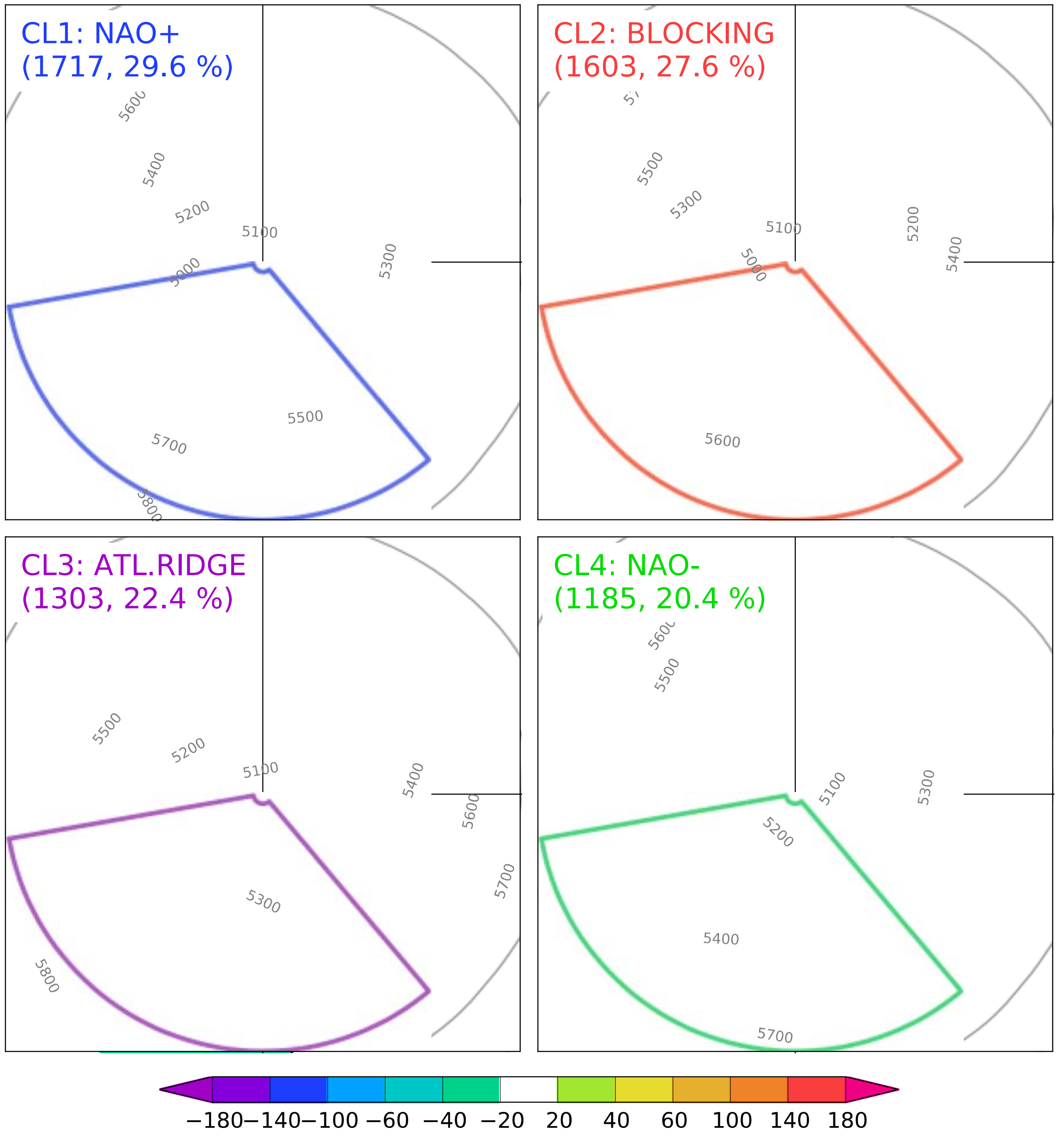
$$\dot{X} = -\sigma X + \sigma Y + f\cos\theta$$

$$\dot{Y} = -XZ + rX - Y + f\sin\theta$$

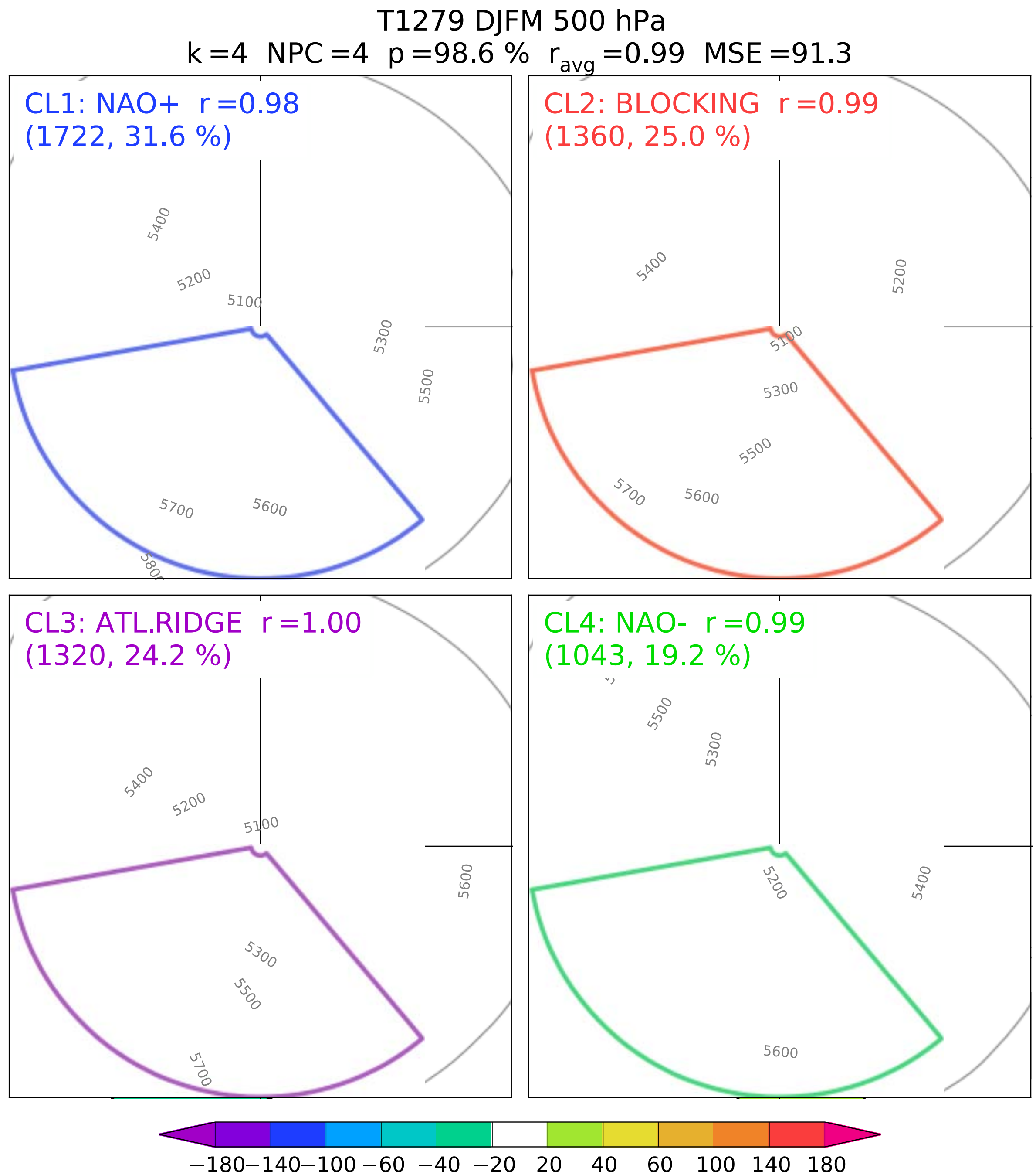
$$\dot{Z} = XY - bZ$$

Primary response to forcing: a change in frequency of occurrence of the two Lorenz regimes. (Palmer and Weisheimer, 2011 GAFD)

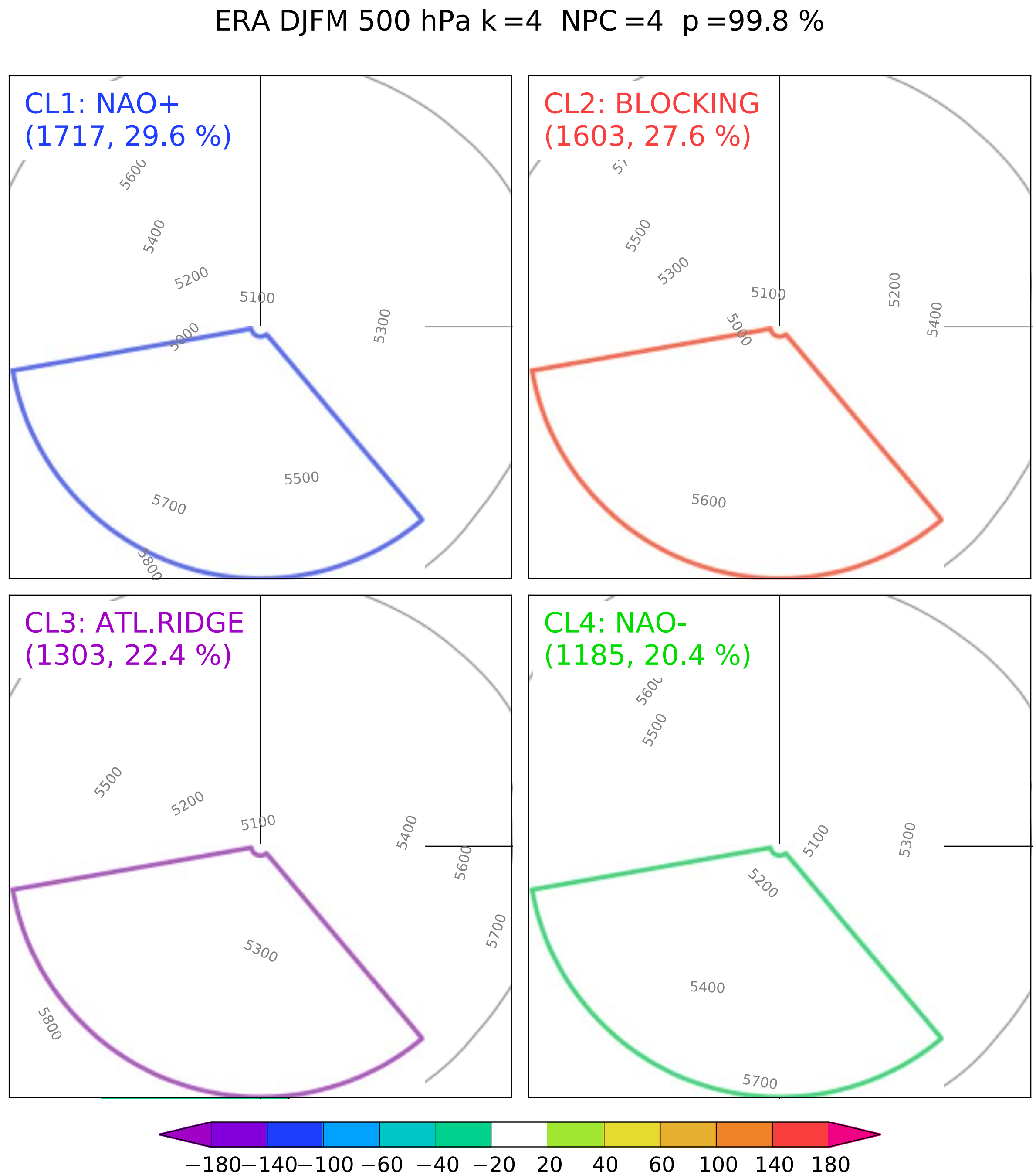
ERA DJFM 500 hPa k =4 NPC =4 p =99.8 %

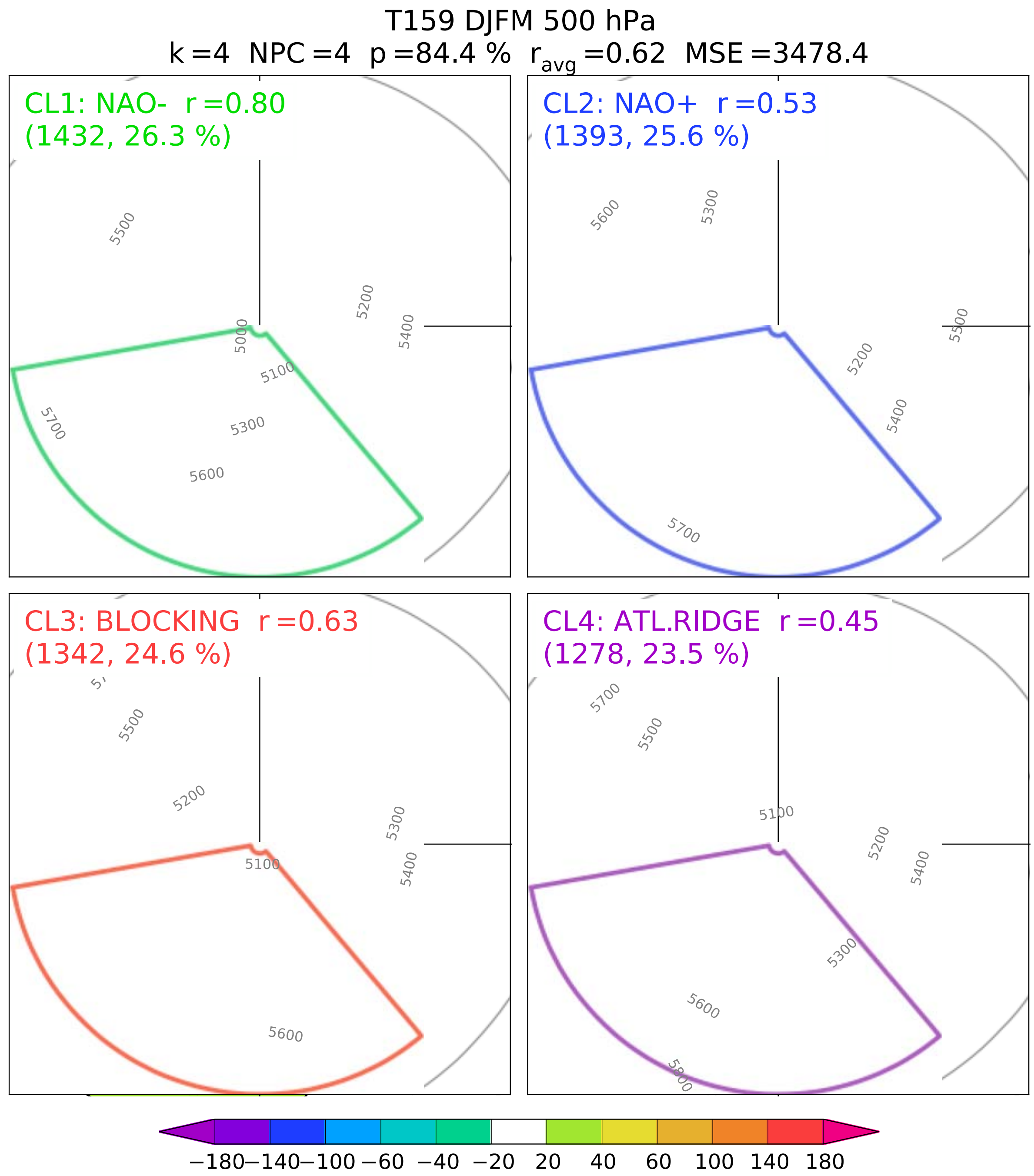


Dawson, Corti Palmer, GRL 2012



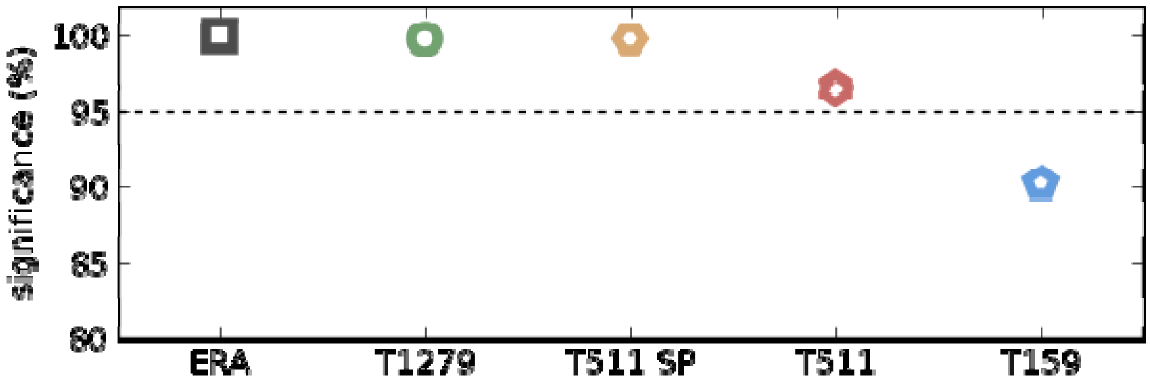
T1279 DJFM 500 hPa
k =4 NPC =4 p =98.6 % r avg =0.99 MSE =91.3
CL1: NAO+ r =0.98
(1722, 31.6 %)
CL2: BLOCKING r =0.99
(1360, 25.0 %)
CL3: ATL.RIDGE r =1.00
(1320, 24.2 %)
CL4: NAO- r =0.99
(1043, 19.2 %)
−180 −140 −100 −60 −40 −20 20 40 60 100 140 180


ERA DJFM 500 hPa k =4 NPC =4 p =99.8 %
CL1: NAO+
(1717, 29.6 %)
CL2: BLOCKING
(1603, 27.6 %)
CL3: ATL.RIDGE
(1303, 22.4 %)
CL4: NAO-
(1185, 20.4 %)
−180 −140 −100 −60 −40 −20 20 40 60 100 140 180

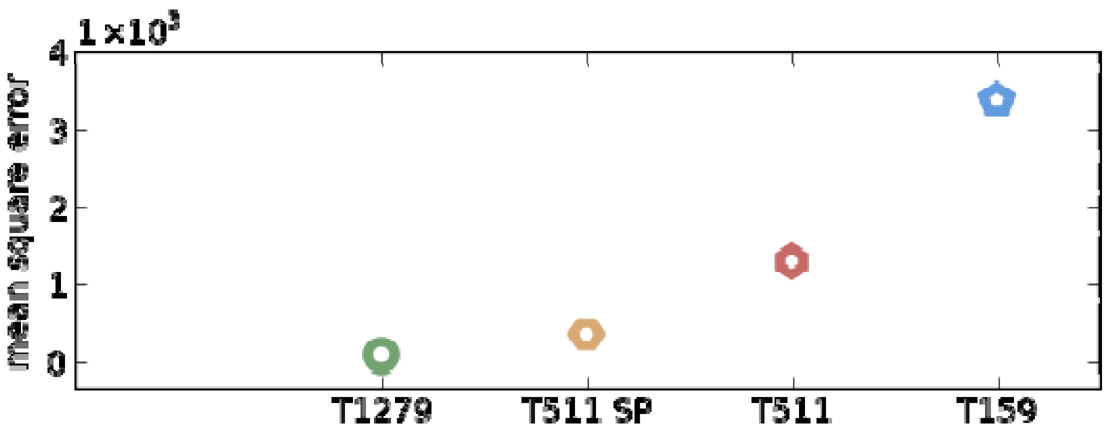


T159 DJFM 500 hPa
k =4 NPC =4 p =84.4 % r_{avg} =0.62 MSE =3478.4
CL1: NAO- r =0.80
(1432, 26.3 %)
CL2: NAO+ r =0.53
(1393, 25.6 %)
CL3: BLOCKING r =0.63
(1342, 24.6 %)
CL4: ATL.RIDGE r =0.45
(1278, 23.5 %)
−180 −140 −100 −60 −40 −20 20 40 60 100 140 180

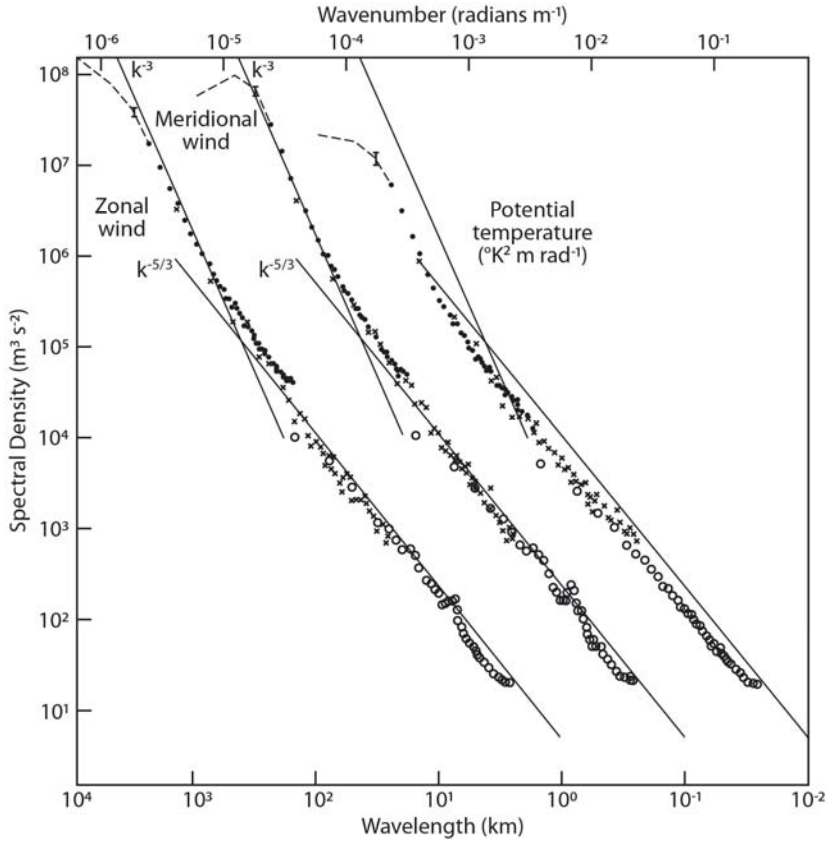
Athena: AMIP runs



Probability that clusters are not produced from a chance sampling of a gaussian



RMS error of simulated clusters against ERA



TECHNICAL MEMORANDUM

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Stochastic Parametrization and Model Uncertainty

Palmer, T.N., R. Buizza, F. Doblas-Reyes, T. Jung, M. Leutbecher, G.J. Shutts, M. Steinheimer, A. Weisheimer

Research Department

October 8, 2009

This paper has not been published and should be regarded as an Internal Report from ECMWF.
Permission to quote from it should be obtained from the ECMWF.

European Centre for Medium-Range Weather Forecasts
Europäisches Zentrum für mittelfristige Wettervorhersage
Centre européen pour les prévisions météorologiques à moyen terme

Experiments with the Lorenz '96 System

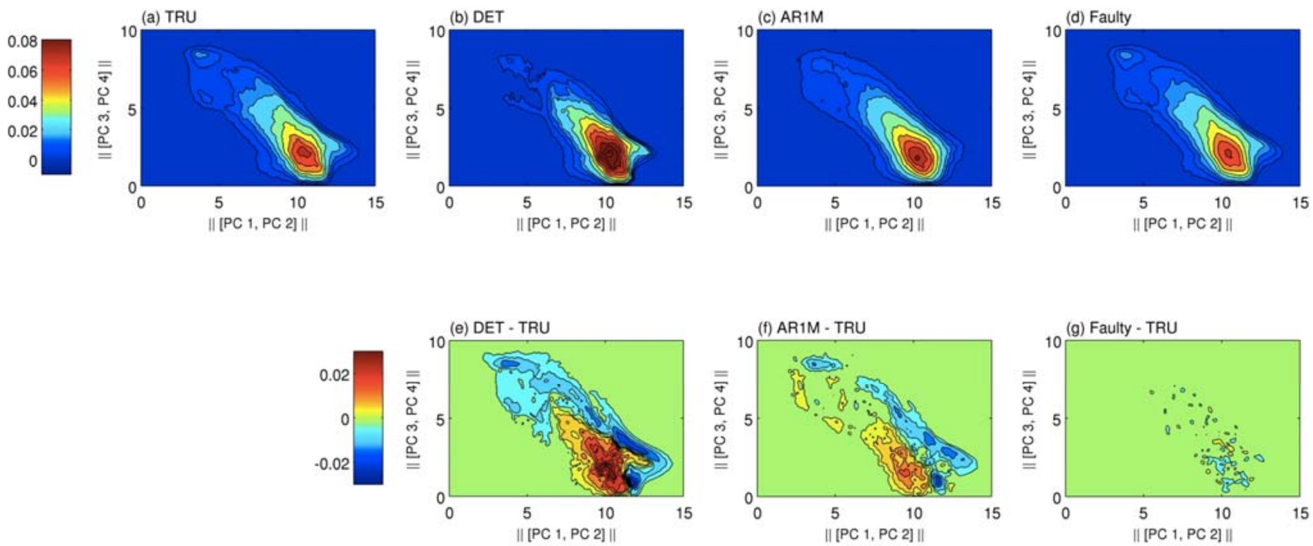
$$\frac{dX_k}{dt} = -X_{k-1}\left(X_{k-2} - X_{k+1}\right) - X_k + F - \frac{hc}{b}\sum_{j=J(k-1)+k}^{kJ} Y_j$$

$$\frac{dY_j}{dt} = -cbY_{j+1}\left(Y_{j+2} - Y_{j-1}\right) - cY_j + \frac{hc}{b}X_{\text{int}[(j-1)/J+1]}$$

Deterministic parametrisation of Y

Stochastic parametrisation of Y

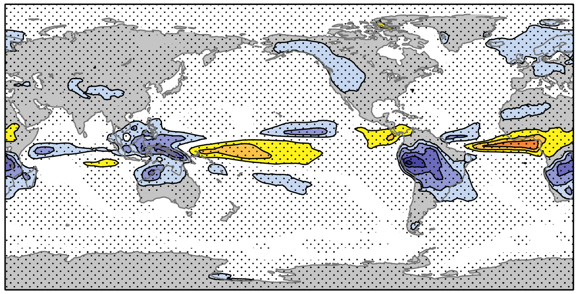
Low precision for Y



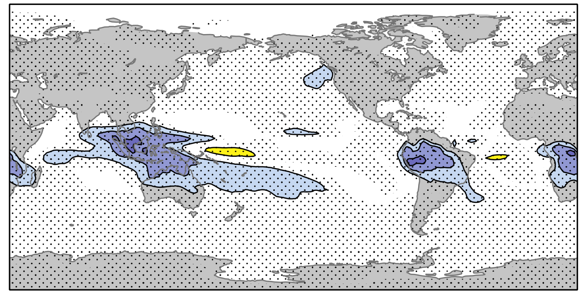
Impact of stochastic physics in ECMWF System 4 Seasonal Forecasts

OLR 1981-2010 DJF

b) *stochphysOFF* – reanalysis

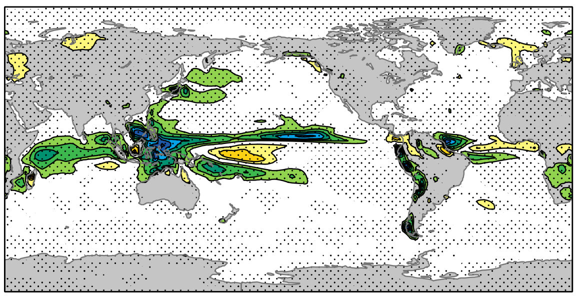


e) *stochphysOFF – SPPT_ON*

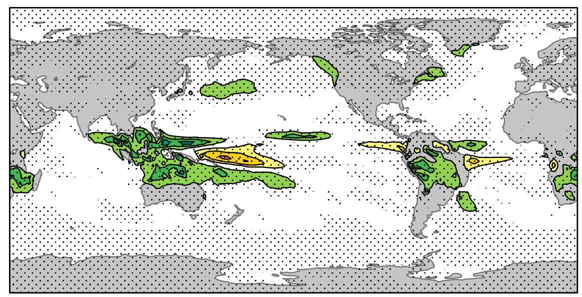


Precip 1981-2010 DJF

b) *stochphysOFF* – GPCP

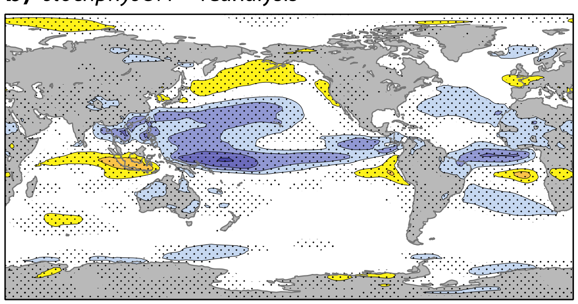


e) *stochphysOFF – SPPT_ON*

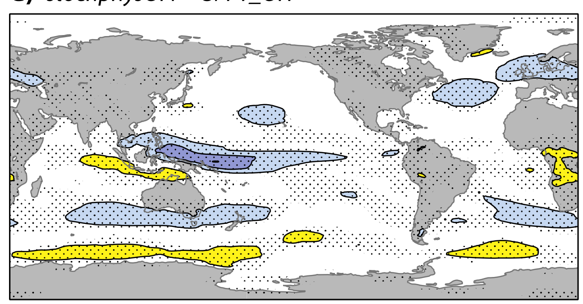


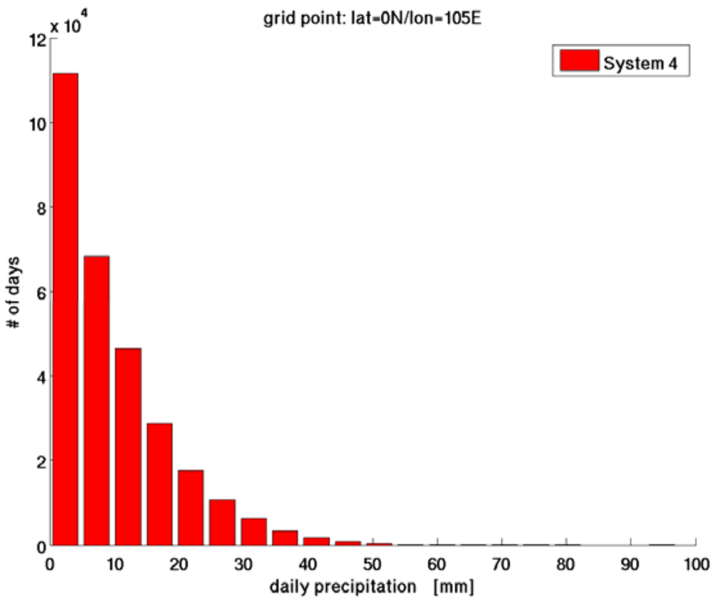
U 850mb Wind 1981-2010 DJF

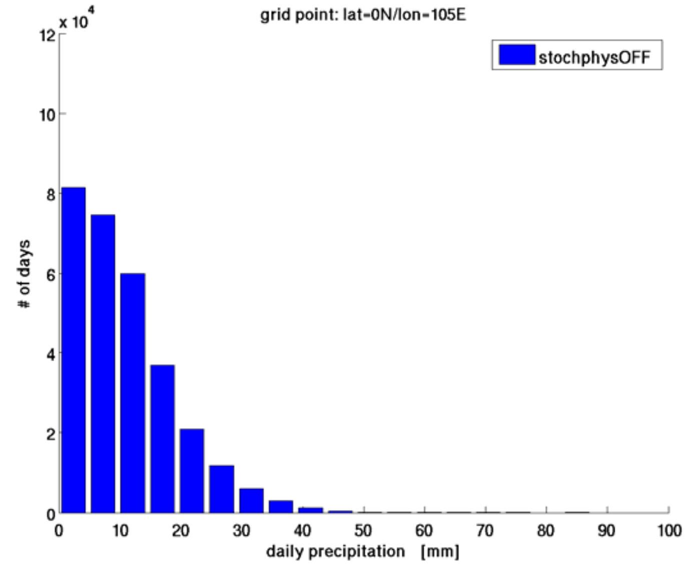
b) *stochphysOFF* – reanalysis



e) *stochphysOFF – SPPT_ON*







Dreary state of precipitation in global models

Graeme L. Stephens,[1] Tristan L'Ecuyer,[1] Richard Forbes,[2] Andrew Gettlemen,[3] Jean-Christophe Golaz,[4] Alejandro Bodas-Salcedo,[5] Kentaroh Suzuki,[1] Philip Gabriel,[1] and John Haynes[6]

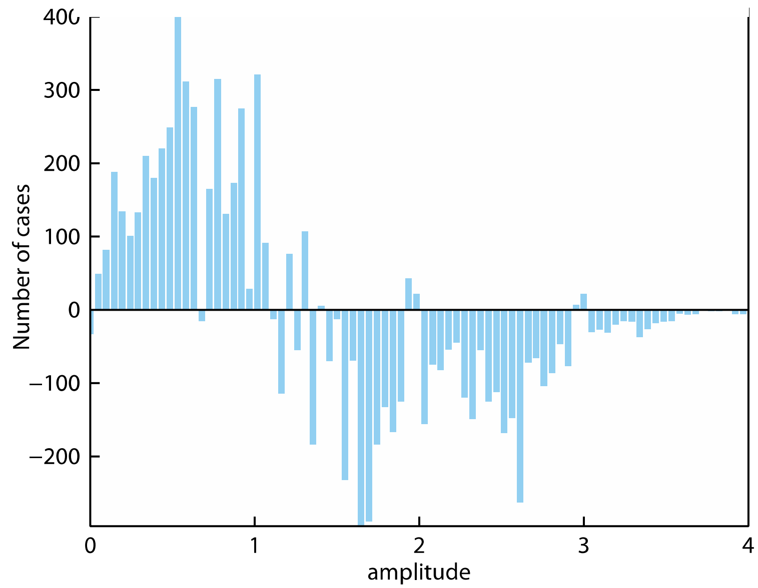
Received 25 May 2010; revised 7 September 2010; accepted 21 September 2010; published 21 December 2010.

[1] New, definitive measures of precipitation frequency provided by CloudSat are used to assess the realism of global model precipitation. The character of liquid precipitation (defined as a combination of accumulation, frequency, and intensity) over the global oceans is significantly different from the character of liquid precipitation produced by global weather and climate models. Five different models are used in this comparison representing state-of-the-art weather prediction models, state-of-the-art climate models, and the emerging high-resolution global cloud "resolving" models. The differences between observed and modeled precipitation are larger than can be explained by observational retrieval errors or by the inherent sampling differences between observations and models. We show that the time integrated accumulations of precipitation produced by models closely match observations when globally composited. However, these models produce precipitation approximately twice as often as that observed and make rainfall far too lightly. This finding reinforces similar findings from other studies based on surface accumulated rainfall measurements. The implications of this dreary state of model depiction of the real world are discussed.

Citation: Stephens, G. L., T. L'Ecuyer, R. Forbes, A. Gettlemen, J.-C. Golaz, A. Bodas-Salcedo, K. Suzuki, P. Gabriel, and J. Haynes (2010), Dreary state of precipitation in global models, *J. Geophys. Res.*, *115*, D24211, doi:10.1029/2010JD014532.

MJO

Stoch Off – Stoch On



Propagating versus Nonpropagating Madden–Julian Oscillation Events

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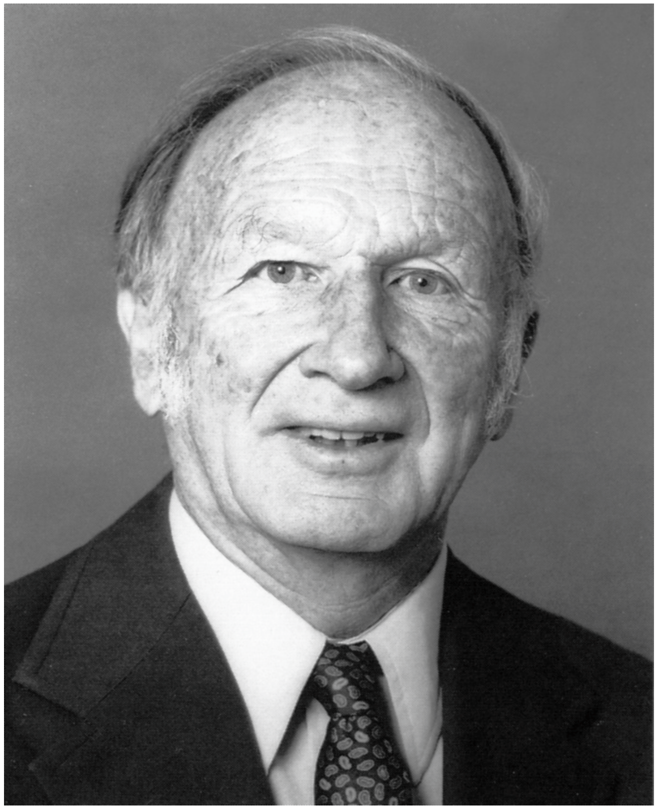
ABSTRACT

Basinwide convective anomalies over the Indian Ocean (IO) associated with the Madden–Julian oscillation (MJO) sometimes propagate eastward and reach the west Pacific (WP), but sometimes do not. Long-term observations and reanalysis products are used to investigate the difference between the propagating and nonpropagating MJO events. IO convection onset events associated with the MJO are grouped into three categories based on the strengths of the simultaneous dry anomalies over the eastern Maritime Continent and WP. The IO convection anomaly preferentially makes eastward propagation and reaches the WP when the dry anomaly is stronger.

Analysis of the column-integrated moist static energy (MSE) budget shows that horizontal advection moistens the atmosphere to the east of the positive MSE anomaly associated with the active convection over the IO and is of sufficient magnitude to explain the eastward propagation of the positive MSE anomaly. Interpretation is complicated, however, by lack of closure in the MSE budget. A residual term, of smaller but comparable magnitude to

Edward Norton Lorenz **(1917-2008)**



I believe that the ultimate climate models..will be stochastic, ie random numbers will appear somewhere in the time derivatives Lorenz (1975).