Met Office
Hadley Centre

UK experience of CMIP5

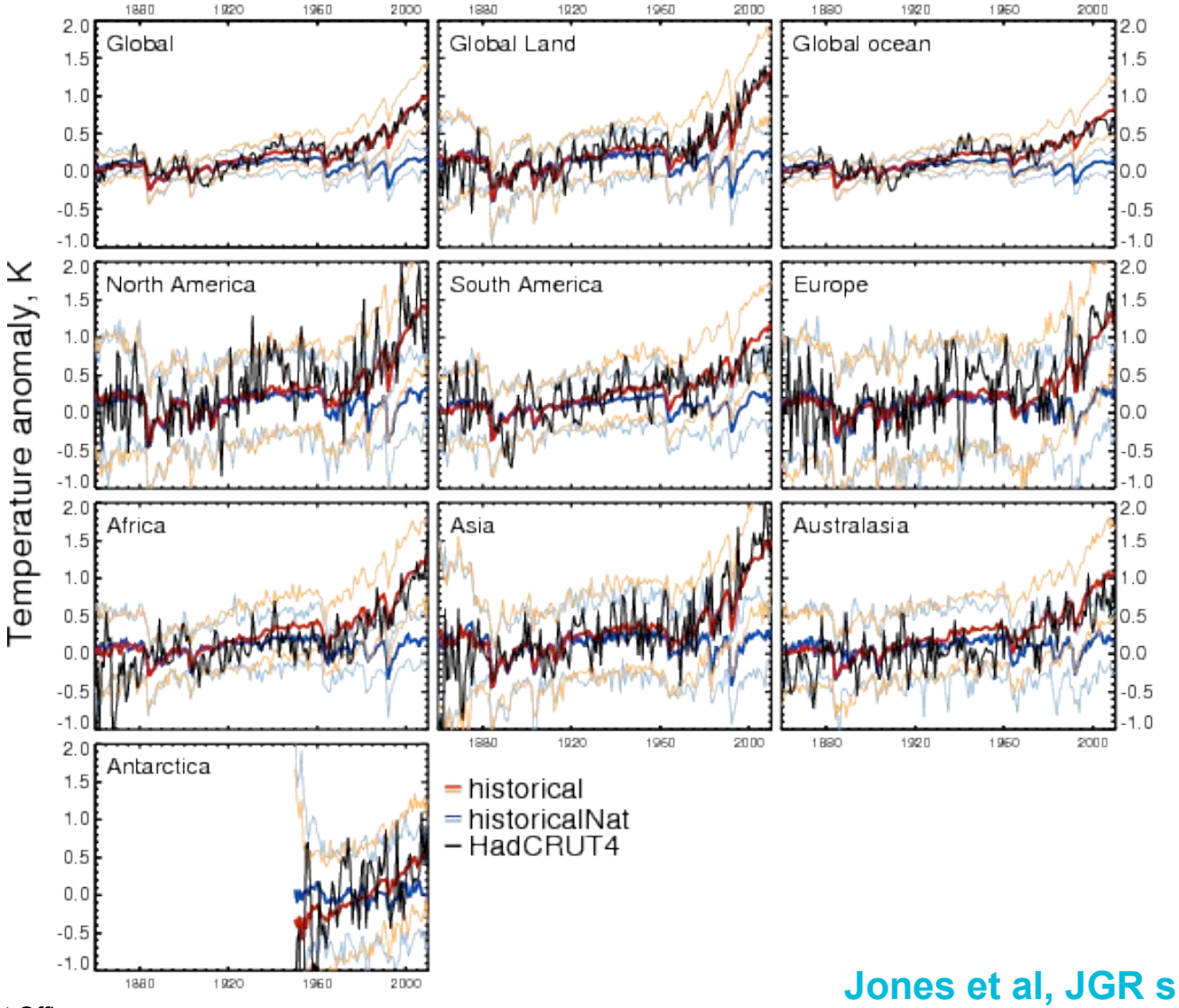
Catherine Senior

Presentation to WGCM16, Hamburg, September 25th, 2012

CMIP5 Strengths

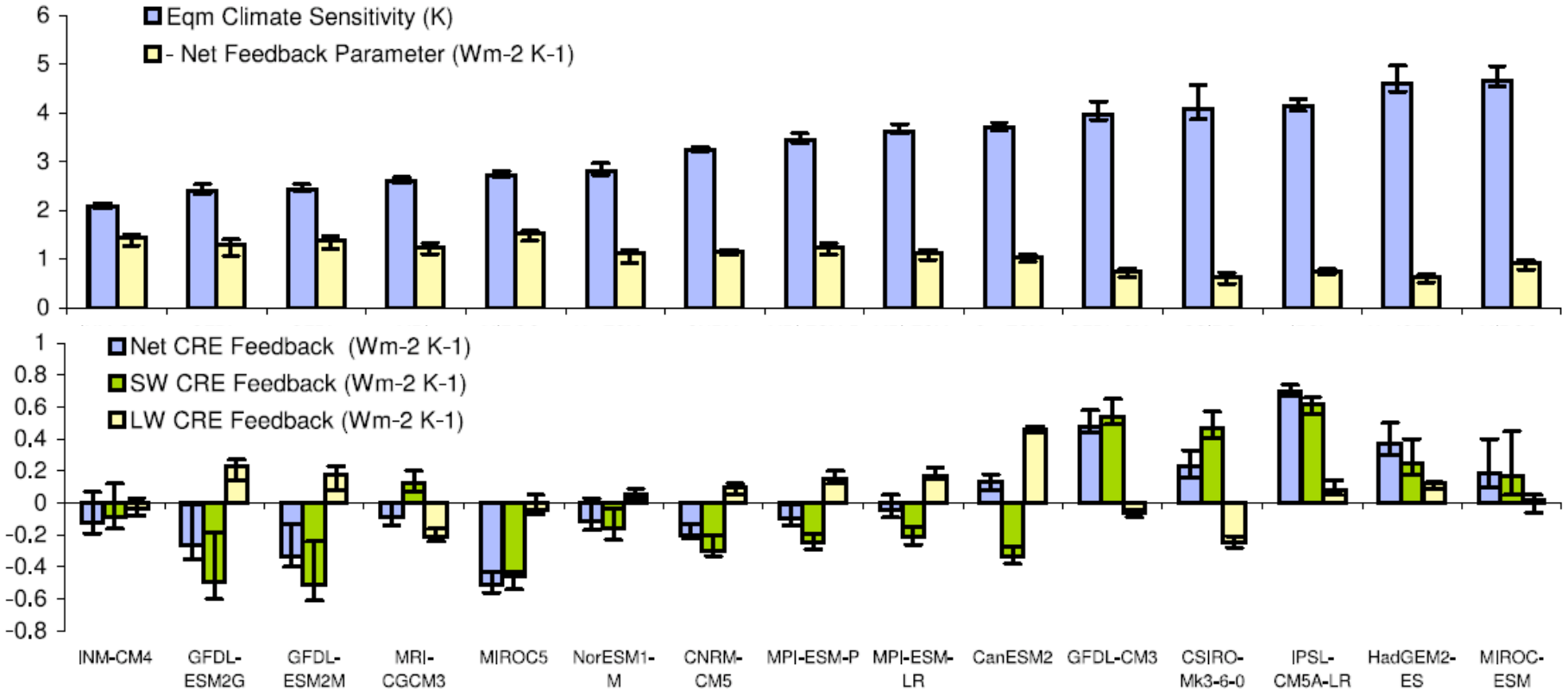
- CMIP5 provides an essential resource for the climate science community and for IPCC. Many papers have been submitted using CMIP5 data and these will figure prominently in AR5.
- First multi-model ensemble of ES models that will allow much improved analysis of carbon cycle and chemistry
- Through CMIP5, the Met Office Hadley Centre have managed to make huge amounts of our data available to the climate community.
- MOHC/UK academic community have managed to download data from wide range of other modelling centres
- In July 2012, MOHC submitted ~40 papers based on CMIP5 data

Regional temperature anomalies CMIP5



Jones et al, JGR submitted

Climate Sensitivity and cloud feedbacks CMIP5



Andrews et al, 2012, GRL

CMIP5 weaknesses

- Timetable for CMIP5 relative to AR5 has meant not enough time for enough analysis to feed into AR5
- An emerging view that CMIP5-AO models are behaving like CMIP3-AO models, suggesting little progress on physical modelling capability – perhaps not a long enough gap between MIPs?
- Too early to be specific about science weaknesses but protocol for near-term experiments too vague
- Data access has been more difficult than necessary
- High frequency temporal data still not available for many models
- Unsecure funding of resource needed to develop and maintain the archive/data provision

CMIP5 Technical issues

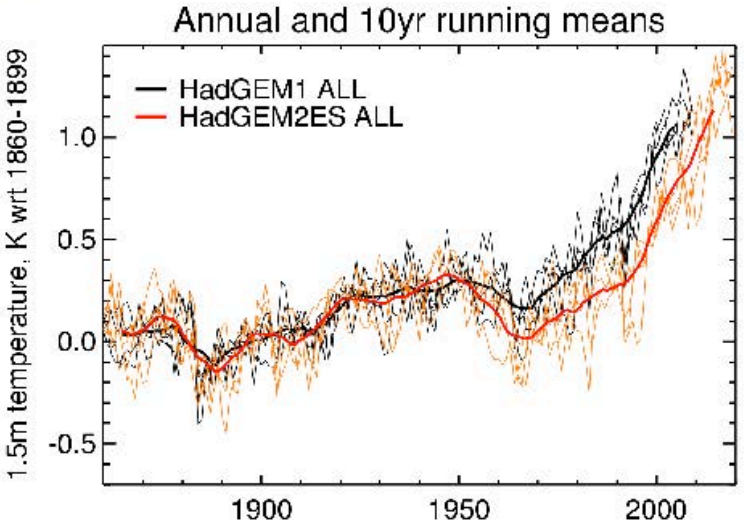
- Experiment specification – reasonable overview for sceintists but required more detail for effective configuration and management of runs
- CMOR and MIP tables – lack of stability of CMOR, updates to diagnostics list after runs had been started, not enough resource to support CMOR in light of such changing requirements
- Versioning – versioning policy not sufficiently defined and needs to be resolved before CMIP6
- Infrastructure for data access and retrieval – need for scriptable download methods from start; web interface slow unreliable and hard to use; poor reliability of data retrieval – we have invested ~6 months effort to invent our own solutions and are still not able to access data from some modelling centres.
- Metadata – Significantly improved since CMIP3 but still questionnaire was inefficient and hard to understand. Based on METAFOR format but this should not have prevented a more user friendly interface. Still difficult to inter-compare metadata across models

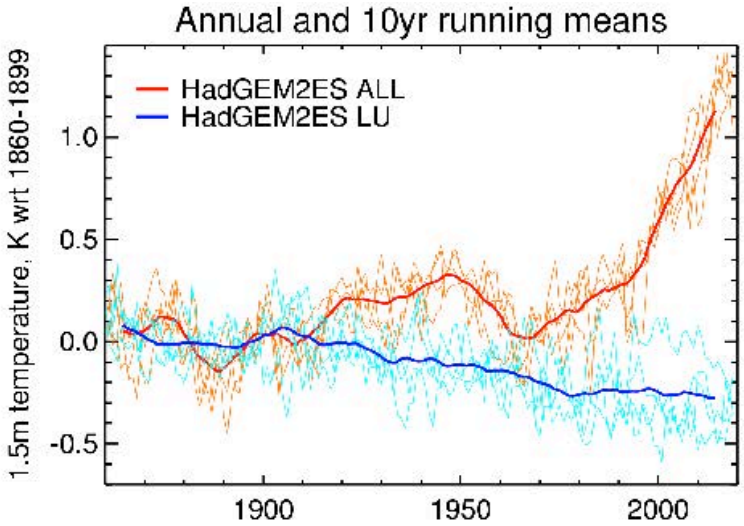
Jamie Kettleborough, Mark Elkington and others

CMIP5 Science Gaps

- Land Use is an emergent science question – role as forcing on physical climate and carbon cycle and need for a cleaner implementation next time
- ESM evaluation – an international approach to data requirements and development of metrics
- Ability to separate role of individual forcings (solar, volcanic, aerosol, methane, black carbon,…)
- Questions of reversibility for e.g. geo-engineering
- Real-time decadal prediction rather than hindcast evaluation

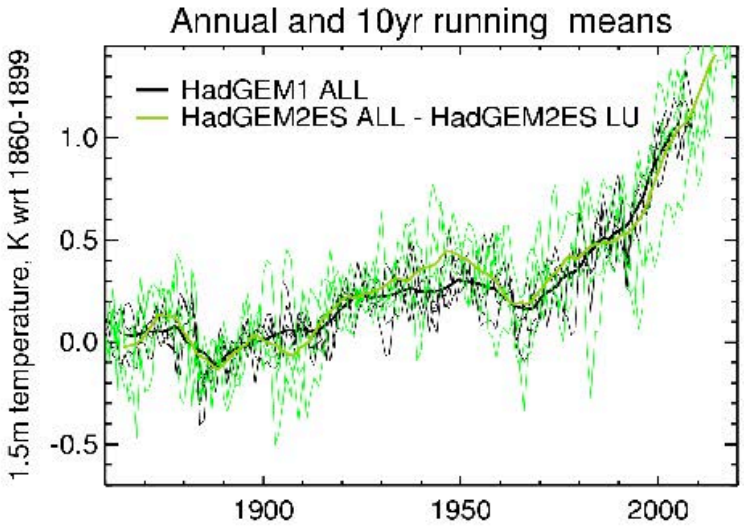
Importance of land use





In a modelling framework, we can at least explain why HadGEM2-ES warms less than HadGEM1 (which agreed well with obs)

Appears we have a significant negative forcing from land use, which is larger than previously seen because of interactive vegetation…



Courtesy of Gareth Jones

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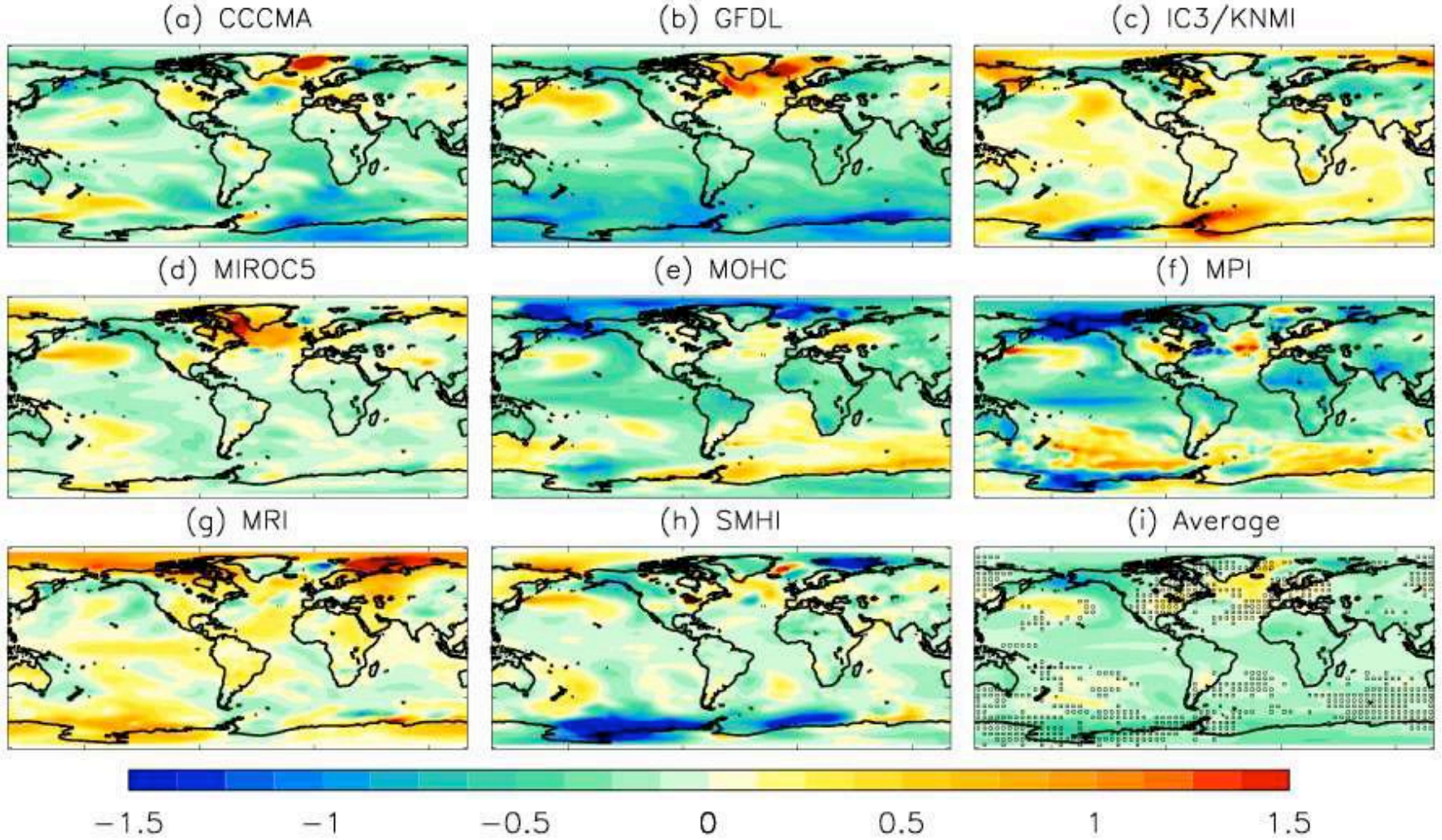
Decadal Forecast Exchange – Impact of initialisation – forecast for 2012-2016



Smith et al, 2012

Priorities for CMIP6

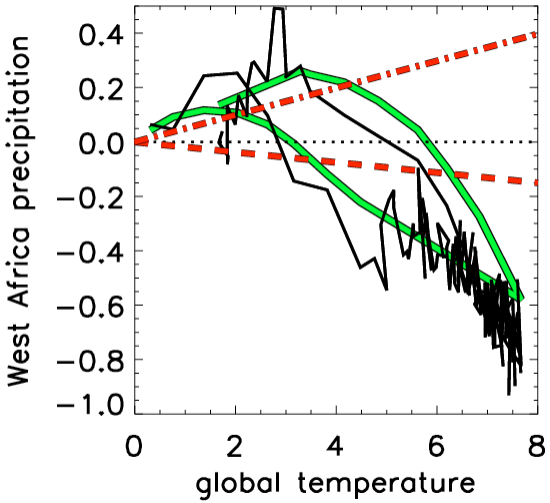
1. Second generation ESMs – 'from global to regional'
   - Nitrogen cycle
   - Ice-sheets
   - On-line impacts modelling (do away with bias correction)
2. High resolution physical models,
   - but in +6 years we will not be a step change away from where we are now. Maybe need to get to <10km? How long for this?
3. Experimental design
   - Limited extensions to CMIP5 protocol – value of idealised expts
   - Fuller implementation of the CMIP5 protocol across models
   - Protocol to be defined well in advance
4. Data access
   - Simpler system

Abrupt forcing experiments: 4xCO_2 and 2xCO_2?

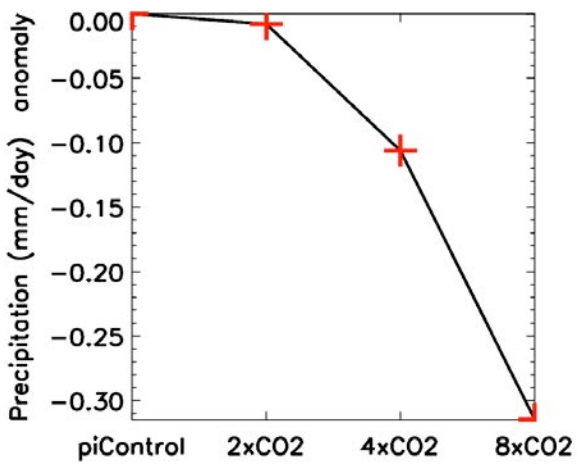
- **Abrupt forcing experiments;** allow a partitioning of mechanisms across timescales, offer high signal/noise; are traceable to transient experiments

- **… but what CO2 level?** there are non-linear responses (globally and regionally)…

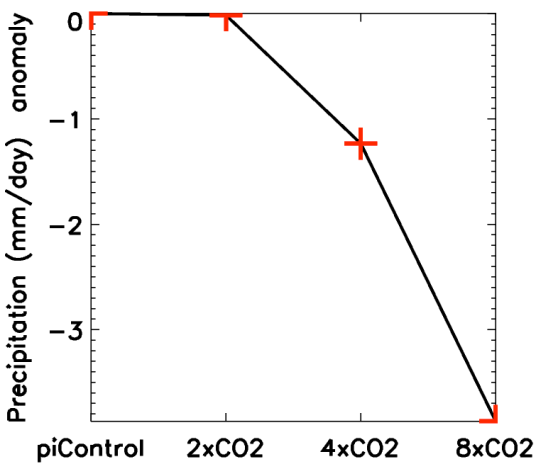
HadCM3



HadGEM2-ES
West Africa



HadGEM2-ES
West Amazon



Tropical patterns: interaction between robust thermodynamic and dynamic mechanisms, with land-surface role. *Distinct from linear mechanisms*.

Good et al in preparation

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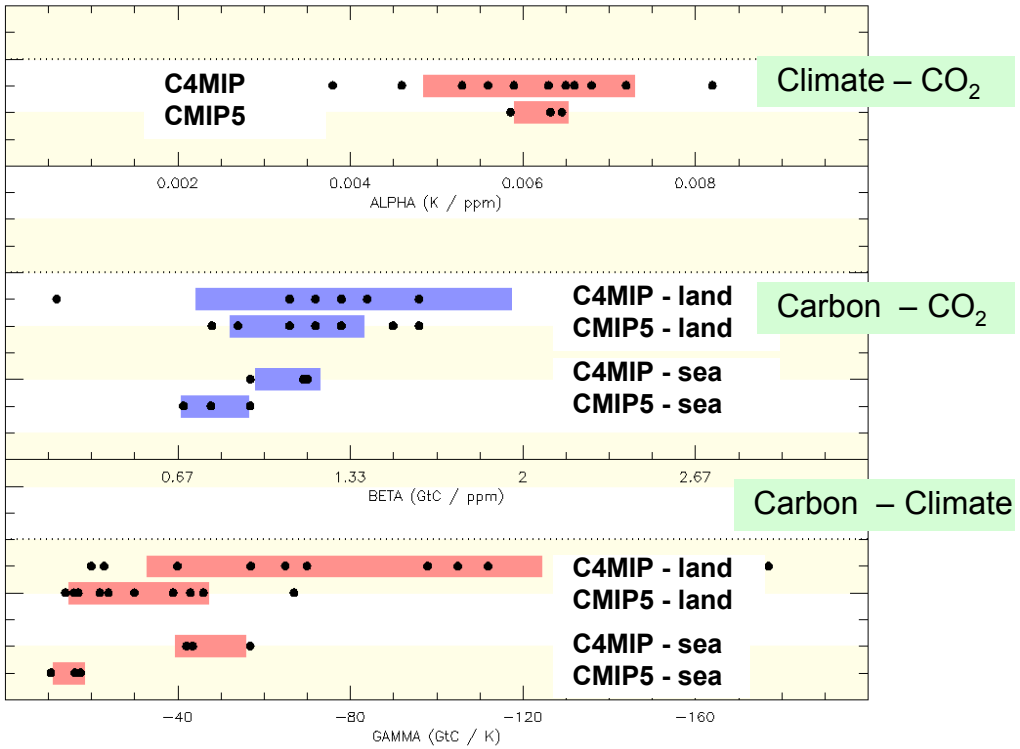
Summary

- More than 10,000 HadGEM2-ES simulated years completed. All runs complete
- Delivered 20TB of data and counting (42 times more data than for CMIP3
- A lot of analysis for AR5 ongoing – feeding directly in 1st order draft.
  - CMIP5 models reproduce the observed T* but with greater spread than CMIP3. Aerosol forcing differences?
  - HadGEM2-ES carbon-cycle feedback is weaker than HadCM3. No evidence for systematic difference CMIP5/CMIP3
  - Range of climate sensitivity unlikely to be less than CMIP3
  - 20th century MOC increase arising from salinity anomaly
- Decadal simulations complete with HadCM3 and progressing with HiGEM
  - No difference in skill in full-field or anomaly initialisation

Carbon Cycle Feedback: HadGEM2-ES vs HadCM3/ CMIP5 vs C4MIP

- HadGEM2-ES has a weaker climate-carbon feedback than HadCM3. No single reason, but
  - greater land differences than ocean
  - No Amazon dieback
  - Stronger high-lat carbon uptake
  - Sensitivity to parameters/tuning
  - Larger carbon cycle-CO_2 feedback
- No evidence that CMIP5 is systematically different from C4MIP but…
  - only 3 CMIP5 models
  - different scenario
  - can't say anything yet on model spread



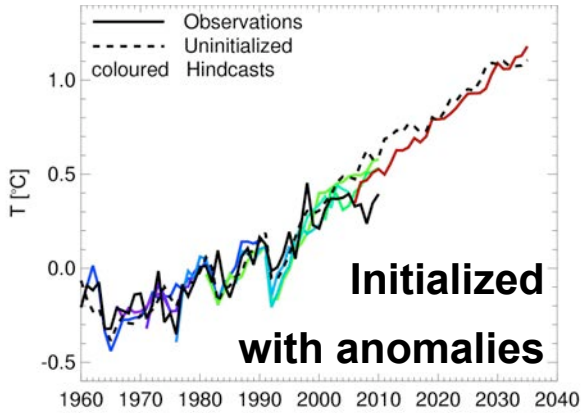
Chris Jones

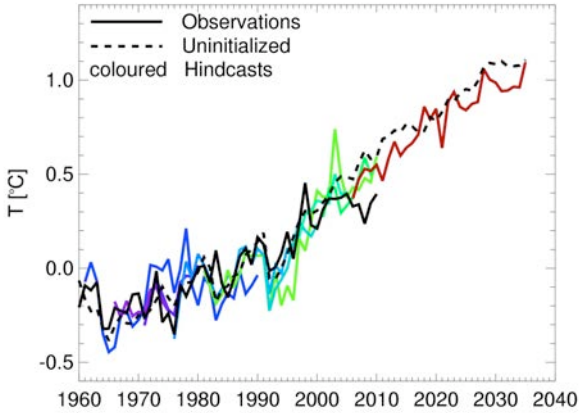
Prediction skill of global mean T: two methods of Initialisation

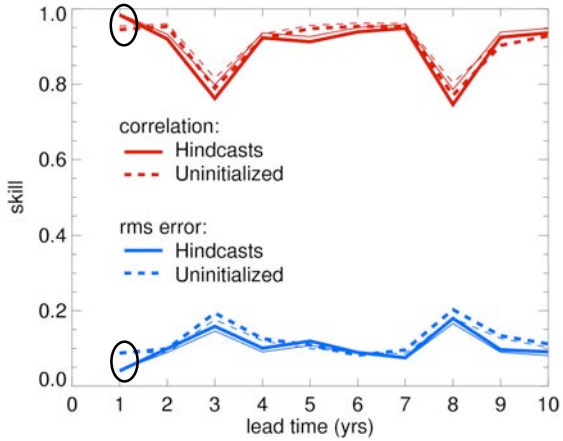
DePreSys CMIP5:

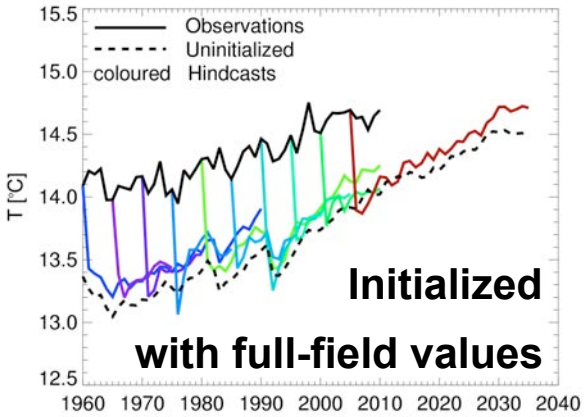
Bias corrected:

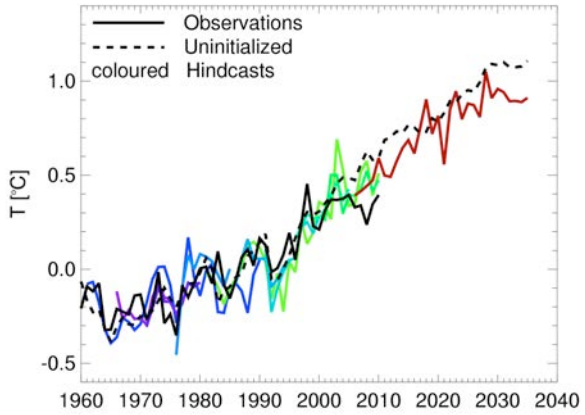
Skill:

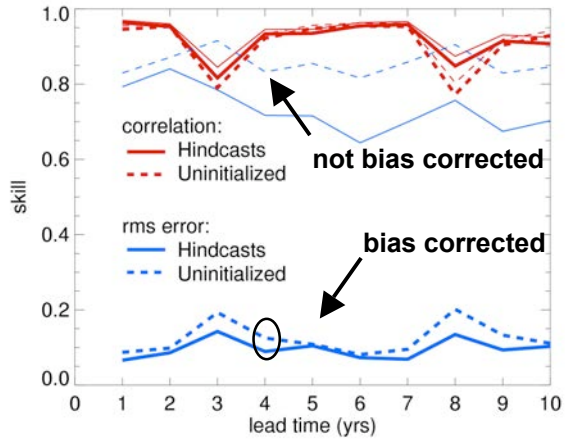












H. Pohlmann & D. Smith, paper in preparation

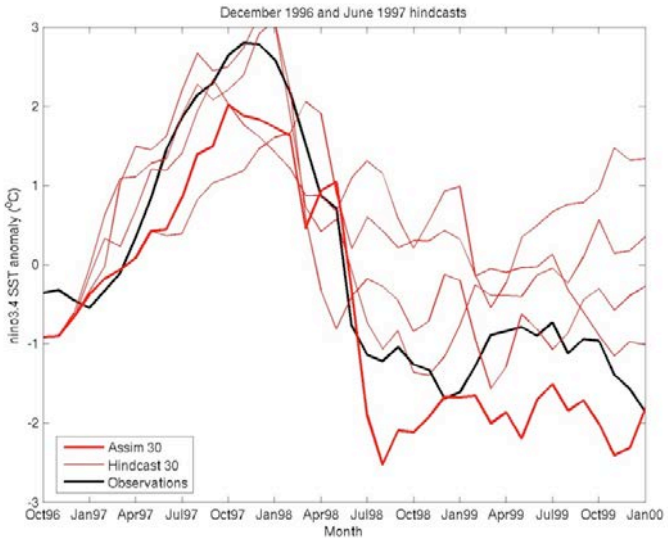
Decadal Prediction Experiments: HiGEM

Len Shaffrey NCAS-Climate

HiGEM is a higher resolution version of the Met Office coupled climate model, HadGEM1

Atmos: 1.25º x 0.86º (90km) Ocean: 1/3º x 1/3º

Century-length integrations of HiGEM have been performed (Shaffrey et al. 2009, *J. Climate*).

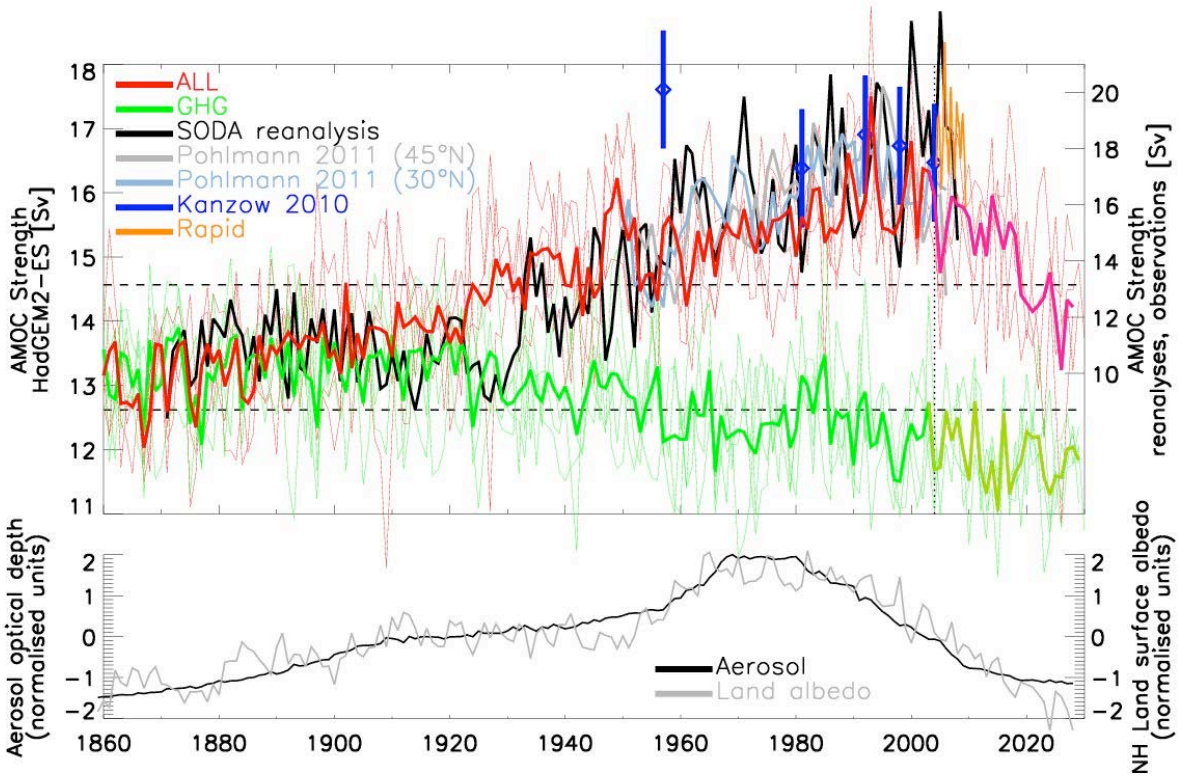


Dec 1996 and June 1997 HiGEM test hindcasts. Nino3.4 SST anomalies from obs (black), the assimilation run (thick red) and 4 HiGEM hindcasts (thin red)

- About 2/3 of the way through hindcast experiments. Hope to complete these by end of October
- Starting uploading of data to CMIP5 database next month, hope to complete by December
- Studying role of resolution on measures of forecast skill

Increasing MOC through the 20th Century – and rapid decline in the 21st?

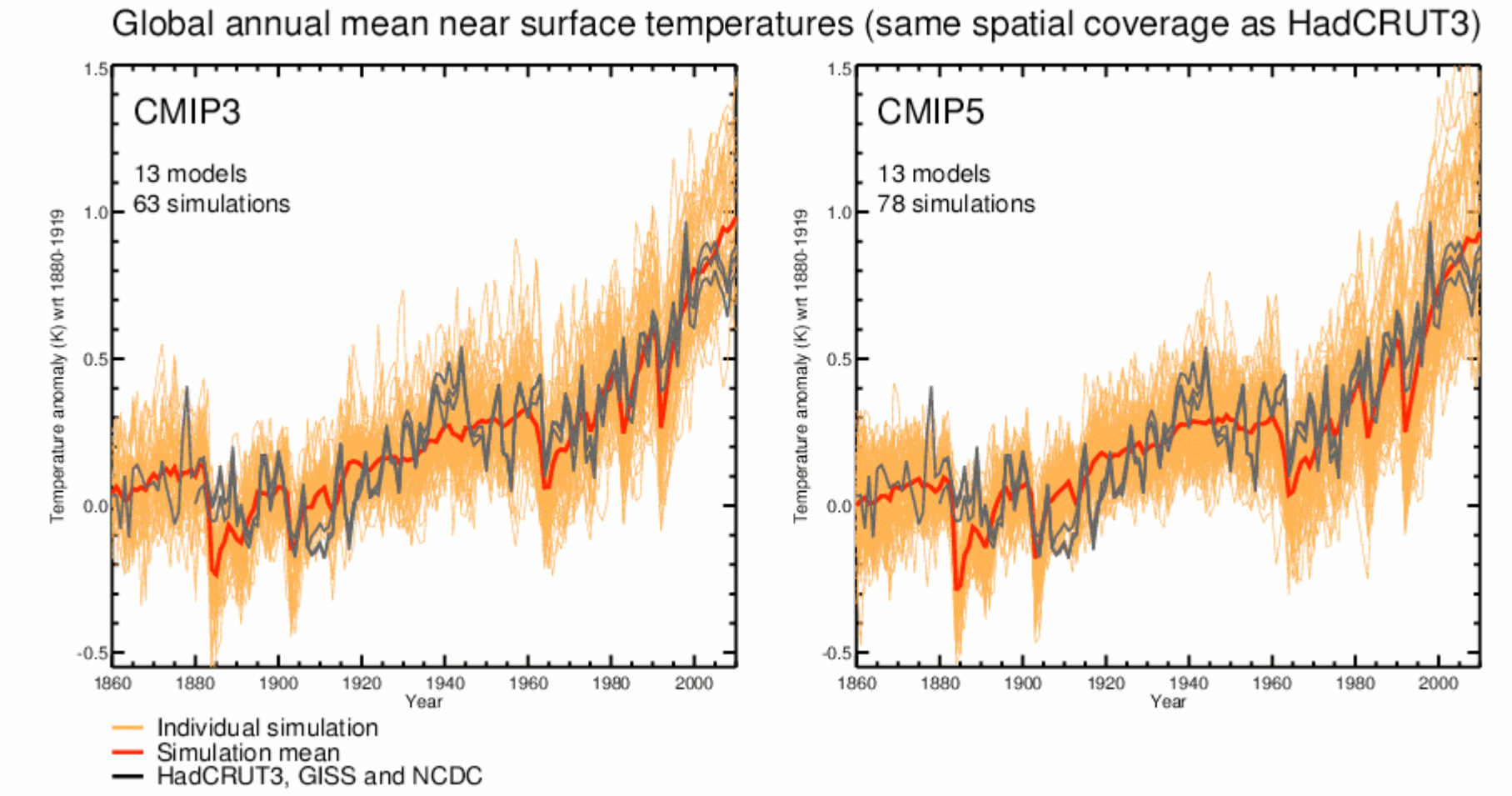
HadGEM2-ES 20th Century simulations



- Possible link to aerosol forcing driving changes in atmospheric circulation
- Anticyclonic anomaly in Beaufort Sea traps fresh water in Arctic
- Cyclonic anomaly in North Atlantic strengthens subpolar gyre, preconditioning convection
- Fresh water accumulates in Arctic during 20th Century and is released to North Atlantic in 21st Century

Menary et al. 2011 subm.

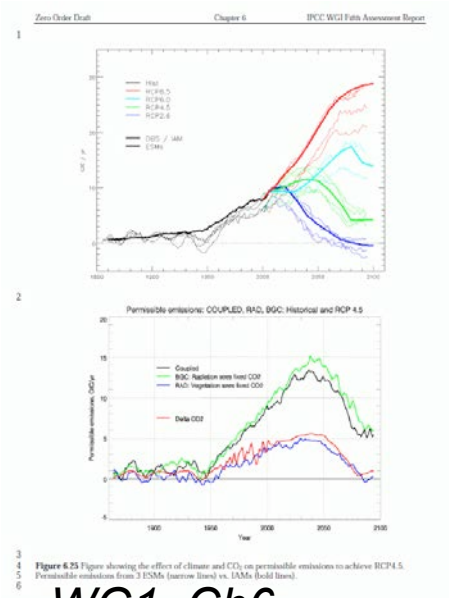
Temperature anomalies CMIP5 v CMIP3



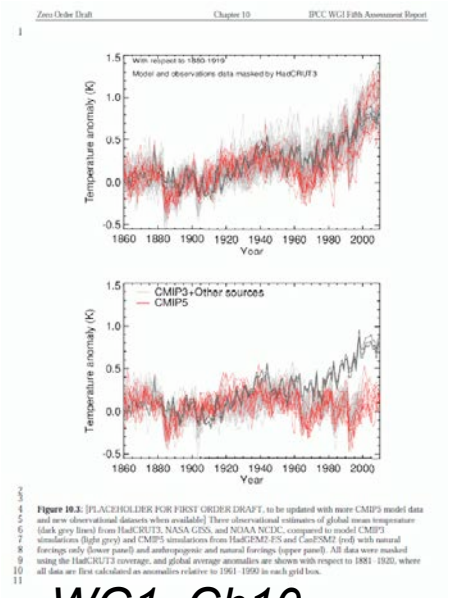
Gareth Jones

Examples of MO Science arising from CMIP5

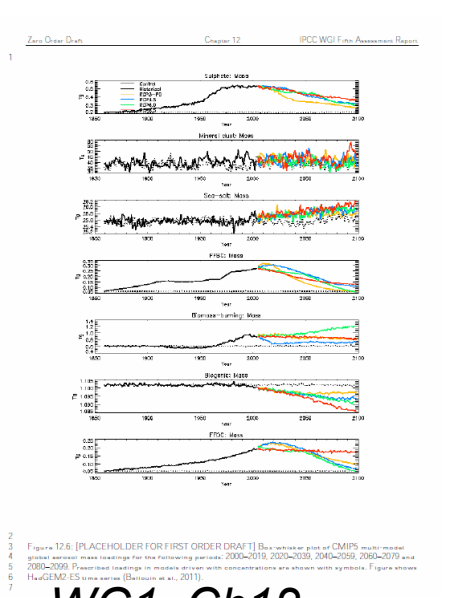
- Project to co-ordinate HadGEM2-ES / CMIP-5 Analysis and Model Publication
- Over 100 separate suggested analysis topics. 40+ papers submitted in July 2012



WG1, Ch6



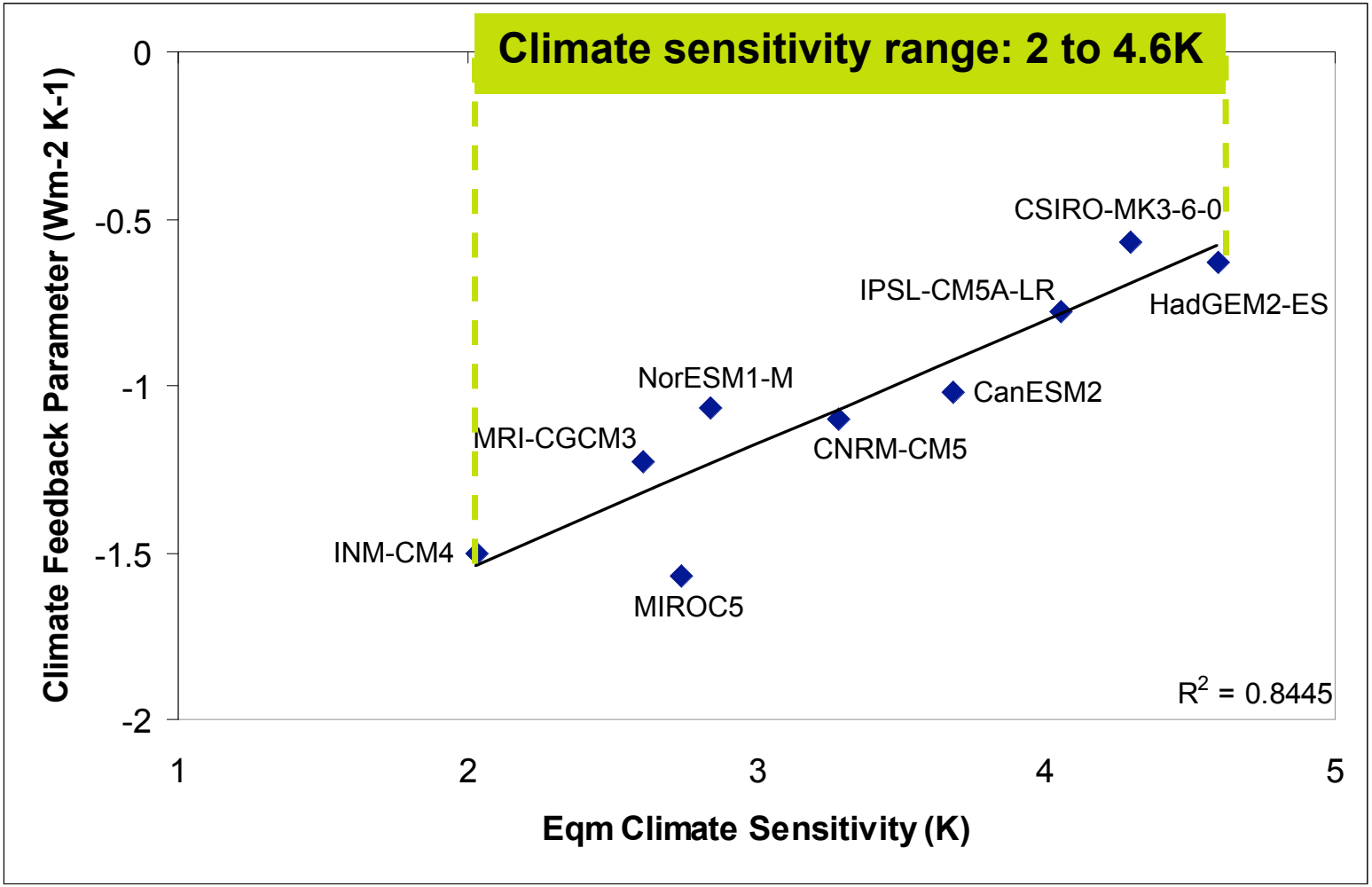
WG1, Ch10



WG1, Ch12

WG2, Ch4

Equilibrium Climate Sensitivity: CMIP5



Tim Andrews, Karl Taylor, Jonathan Gregory et al