Summary of WGNE activities

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(WGNE co-chairs)

WCRP JSC-39
Nanjing, China, 16/04/18

WGNE - *Working Group on Numerical Experimentation*

fostering the **development of atmospheric circulation models** for use in weather prediction and climate studies on **all time scales**, and **diagnosing and resolving shortcomings**.

- WGNE has existed for **over 30 years**
- WGNE reports to both
  - ***WCRP Joint Scientific Committee (JSC)***
  - ***WMO Commission for Atmospheric Sciences (CAS)***

- WGNE has been a **pioneer of seamless work** (e.g. developing the AMIP and Transpose-AMIP methodologies)

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fostering the **development of atmospheric circulation models** for use in weather prediction and climate studies on **all time scales**, and **diagnosing and resolving shortcomings**.

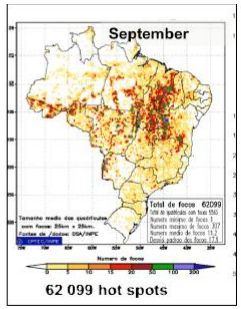
Objectives are achieved through

- Identification of **systematic errors** common to many models.
- Sharing **diagnostic tools and techniques** to get to the root of the error.
- Sharing knowledge around **sensitivity of errors to model formulation** (parametrizations, dynamical core, etc.).
- Work with other groups (e.g. GASS & GLASS) to **develop solutions**.

Cases of strong or persistent events of aerosol pollution studied by the WGNE Aerosols project

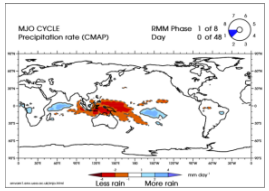
1) Dust over Egypt: 4/2012

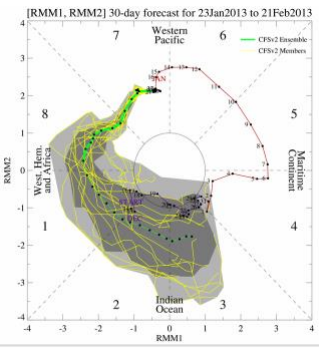
2) Pollution in China: 1/2013



3) Smoke in Brazil: 9/2012

MJO - Task Force: Real time MJO Index forecast activity using 20 forecast models





WMO IOC ICSU International Council for Science

WORLD METEOROLOGICAL ORGANIZATION

WCRP World Climate Research Programme

WGNE - *Working Group on Numerical Experimentation*

WGNE activities over recent years

- MJO-Task Force
- YoTC
- High-Res MIP
- Transpose-AMIP
- Grey Zone
- DCMIP
- WGNE Table of supercomputing development
- Drag Project
- Aerosols Project
- Parametrization development
- Routine model evaluation/verification
- WGNE-WGCM Climate Metrics and Diagnostics Panel
- JWGFVR
- Links to other groups
- WGNE Workshops on Systematic Errors

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Parametrization projects

- since 2009, WGNE has had an **increased focus on parametrization development** in models – sharing knowledge of sensitivities and different approaches
- close working relationship with **GEWEX GASS and GLASS** is important
- WGNE hopes to continue to **strengthen this in the future** with **more joint projects on parametrization development**, targeting **common systematic errors**

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Dynamical Core MIP

- **WGNE** acts as a **focal point within WCRP** for the **development of dynamical cores**, **DCMIP** being just **one recent activity** in this area.
- DCMIP provided an **intercomparison of different cores**, including
  - an assessment of different grids
  - discretization techniques
  - tracer-conservation
  - dynamics-physics coupling, etc.
- an associated **summer school** was held with DCMIP to
  - increase **expertise** in this area
  - assist the development of **early career scientists** in the field

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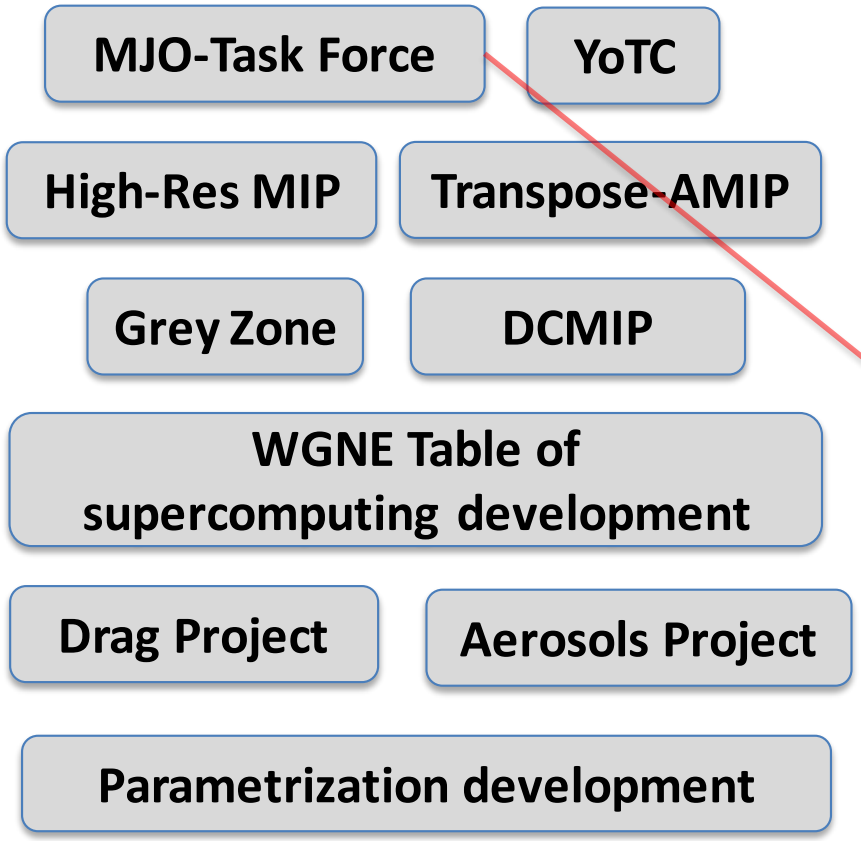
WGNE activities over recent years



WGNE MJO-Task Force

- goal is to **improve the representation and the predictive skill of the MJO** and related phenomena in weather and climate models
- 5 sub-projects:
  - i) Process-orientated **diagnostics**
  - ii) **Evaluation** of **real time** forecasts
  - iii) **Assessment** of intraseasonal variability in **CMIP models**
  - iv) **Joint MJO-TF – GASS diabatic processes experiment**
  - v) Investigation of MJO **air-sea interaction**
- in the coming years, focus will be around
  - **propagation of the MJO** across the Maritime Continent region
  - **teleconnections** with other parts of the tropics and mid-latitudes.

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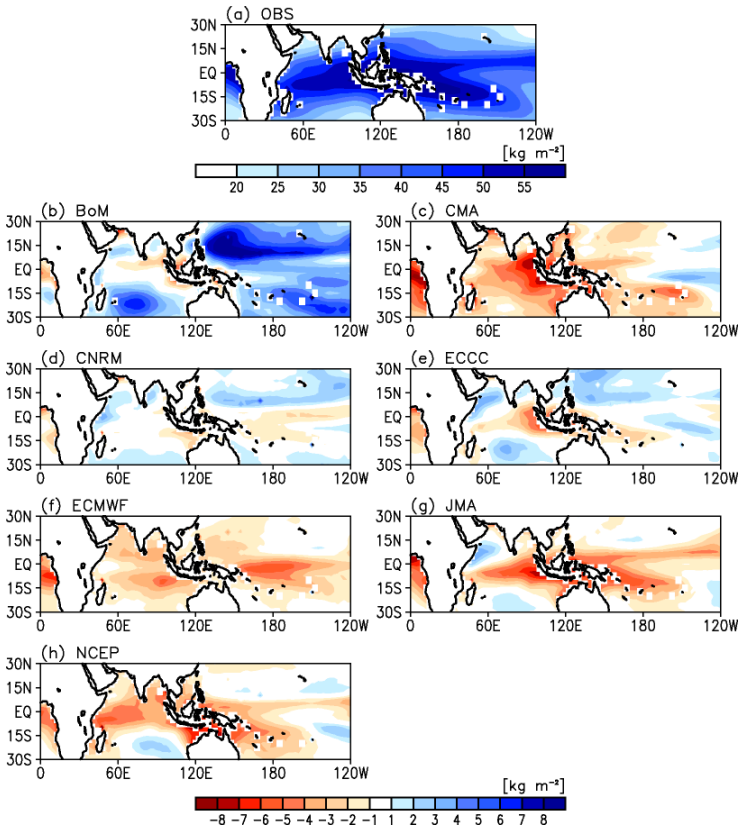
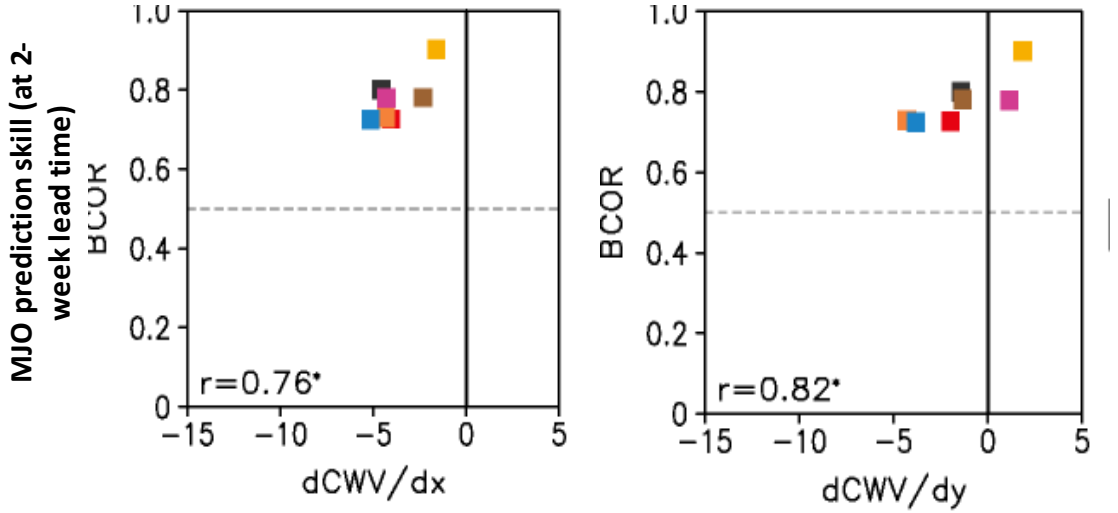
MJO-TF: Mean Moisture and MJO prediction skill





Bias in the zonal moisture gradient

Bias in the meridional moisture gradient

Wintertime (NDJFM) climatology of total column water, derived from satellite observations and model mean biases.

S2S database
Lim et al. (submitted)

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MJO-Task Force

YoTC

High-Res MIP

Transpose-AMIP

Grey Zone

DCMIP

WGNE Table of supercomputing development

Drag Project

Aerosols Project

Parametrization development

WGNE Drag Project

- to explore the parametrized component of **surface stress** and its **partitioning between schemes** (e.g. PBL, sub-grid orography).
- found to **vary significantly between models**; notable **impact on circulation & predictability**
- Following the **2016 ECMWF / WCRP / WWRP workshop on drag processes** (partly supported by SPARC / WGNE / GASS), 3 main **areas of research** were identified:
  - i) better **theoretical understanding**
  - ii) better understanding of **inter-model differences**
  - iii) use **high-res simulations + observations + new techniques** to understand model errors and **improve/constrain representation of drag** in models.

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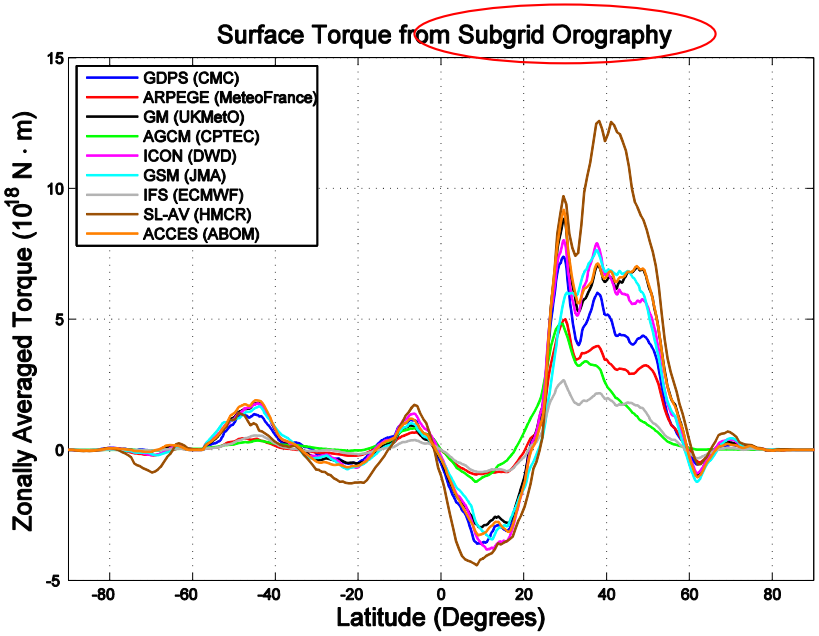
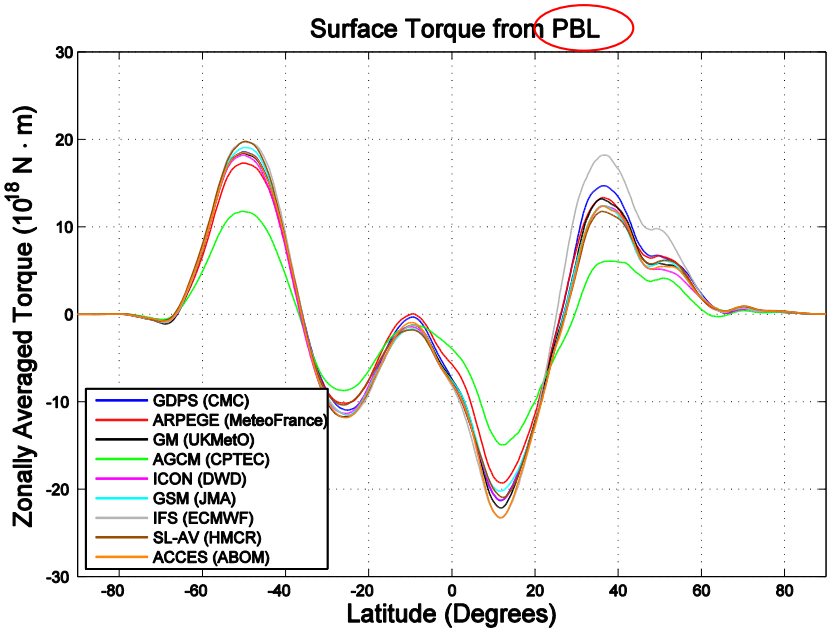
Drag project (Ayrton Zadra)





Whilst overall drag is comparable, partitioning of drag varies between models (this has been found to have notable impacts on circulation)

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WGNE Grey Zone project

- set up **with GASS.** Initial project focussed on a cold air outbreak case.
- investigate the possible **development of scale-aware schemes** to operate through these grey zones .
- **continued work** on this project is seen as a **priority.**
- Although initially considering deep convection, also need to consider grey zones for other processes.
- **GASS Grey Zone II project being initiated.**

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WGNE activities over recent years

WGNE-WSE

- **identification of systematic errors amongst weather and climate models**
- WGNE has organised 5 well attended workshops on Systematic Error1:
  - **1st Toronto, 1998**
  - **2nd Melbourne, 2000**
  - **3rd San Francisco, 2007**
  - **4th Exeter, 2013**
  - **5th Montreal, 2017**

  bringing weather and climate communities together to discuss common issues
- E.g. an outcome from the 2013 WGNE-WSE was the need to focus on surface fluxes, especially over the oceans and polar regions. Since then a number of field campaigns (e.g SOCRATES Southern Ocean and Year(s) of Polar Prediction campaigns) have made this a priority

Routine model evaluation/verification

WGNE-WGCM Climate Metrics and Diagnostics Panel

JWGFVR

Links to other groups

WGNE Workshops on Systematic Errors

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5th WGNE Workshop on Systematic Errors (WSE)

Zadra et al. (2017) Systematic Errors in Weather and Climate Models: Nature, Origins, and Way Forward. BAMS. https://doi.org/10.1175/BAMS-D-17-0287.1

Themes:

Atmosphere-land-ocean-cryosphere interactions: errors in the representation of surface fluxes and drag processes; stable boundary layer issues; impact of coupled modeling.

Clouds and precipitation: cloud-radiative feedback problem; tropical convection issues; representation of low clouds, especially at high latitudes; excess low accumulations of precipitation; underestimation of precipitation extremes; summer continental precipitation; precipitation over orography.

Resolution issues: dependence of systematic errors on model resolution; grey zones of physical parametrizations.

Teleconnections: errors in the simulation of interactions between high-latitudes, mid-latitudes and tropics.

Metrics and diagnostics: emphasis on novel techniques (e.g. process-based diagnostics; use of data assimilation or coupled modeling) to diagnose and measure systematic errors.

Model errors in ensembles: characterization of ensemble spread and identification of systematic errors in multi-model ensembles and ensemble prediction systems; evaluation of stochastic representations.

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Summary of key systematic errors from the 5th WGNE WSE:

- **Convective precipitation** (diurnal cycle, organisation of convective systems, precipitation intensity distribution, relationship with CWV, SST, Omega, MSE, etc.).
- **MJO** – propagation across the MC, response to mean errors & teleconnections elsewhere.
- **Sub-tropical boundary layer cloud** (too little, too bright) and their variation with large scale parameters (SST, EIS, Omega, etc.). Can have a coupled component/feedback (upwelling, evap., etc.).
- **Double ITCZ/ENSO** – possibly a complex combination of ENSO extension, cloud-ocean interaction, representation of TIWs.
- **Cloud microphysics** – especially mixed-phase, supercooled liquid cloud and warm rain.
- **Precipitation over orography** – distribution and intensity.
- ***Fog and low-based cloud*** – *no systematic errors identified but is hard to forecast.*
- **Tropical cyclones** sometimes too intense at high resolutions. Wind-pressure relationship errors.
- Biases, variability and predictability of large-scale dynamics very sensitive to **surface drag**. CMIP5 mean circulation errors consistent with too little drag.
- Representation of the **heterogeneity of the soil**.
- Current stochastic physics schemes, whilst beneficial, don't necessarily sufficiently capture all aspects of **model uncertainty.**
- **Surface turbulent and radiative flux** errors (incl. surface wind stress, evaporation, etc.).
- **Diurnal cycle of surface temperature**.
- Variability and trends in historical **external forcings**.
- Mid-latitude **synoptic regimes and blocking**.
- **Teleconnections through the stratosphere**.

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Recommendations from 5th WGNE WSE:

- Extend drag project to consider momentum more generally and consider representation of orography, etc.
- Consider setting up a group or extend drag group to look at surface flux errors.
- More research is required on how to represent model uncertainty.
- Encourage community to make use of S2S drifts database.
- Discuss with S2S/WGSIP regarding extension of aerosols project to seasonal timescale.
- Consider a cross weather-climate group looking at initial tendency analysis of common biases.
- Hold another WSE in 4-5 years time, possibly inviting submissions on solutions rather than just problems.

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WGNE 32 agreed that the drag project should evolve into momentum project and SPARC have expressed an interest in being involved. A GASS project is being set up to take this forward.

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- Hold another WSE in ~5 years time, possibly inviting submissions on solutions rather than just problems.

WGNE32: Francois Bouyssel (*Meteo-France*) and Carolyn Reynolds (*NRL*) are initiating a project on surface fluxes. Initial focus will be over oceans. Looking to develop jointly with GASS & GLASS (and in discussion with CLIVAR & DAOS).

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WGNE is meeting with PDEF in October and will discuss a joint project on model uncertainty (possibly starting with coarse graining).

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Agreed with S2S to take forward the aerosols project jointly, possibly focussed around ORACLES (S. Africa) or SAMBBA (S. Africa) field campaigns.

Other key outcomes from WGNE-32 linking across timescales

Verification/evaluation

CMDP and JWGFVR will work together to consider evaluation of climatology of NWP forecasts and forecast ability of climate models (in Transpose-AMIP). Proposed a joint 5 yearly joint evaluation of NWP & climate models.

Exascale challenge

Initiating discussions with OMDP to bring together cross-timescale community on exascale.

WGNE views on the WCRP Sponsors Review and Implementation Plan

- We welcome the recommendation in the sponsors review for a greater focus within WCRP on model development.
- Any/All model development group(s) must go across timescales (with equal responsibility to WWRP and WCRP). These must have links to the major model development centres (NWP & climate).
- It is too much for a single working group to do everything (all development of atmosphere, ocean, earth system specific processes (such as ice sheets/chemistry) across all timescales).
- Individual groups with specialist skills in development of the atmosphere, ocean, ESM processes, process modelling, research to "operations", should continue and work across timescales.
- An additional model development group sitting above these just adds bureaucracy.

WGNE views on the WCRP Sponsors Review and Implementation Plan

We suggest WGNE could evolve to act as a focal point for model development activities, so has some knowledge of coupling sub-models and the systems as a whole (DA, research to operations, etc.), but retains primary expertise in the atmosphere model development and works closely with other groups on ocean, ESM & process modelling, data assimilation, delivery to CMIP/CORDEX, etc.