INTERNATIONAL COUNCIL FOR SCIENCE

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

REPORT OF THE TWENTY-FIFTH SESSION OF THE WORKING GROUP ON NUMERICAL EXPERIMENTATION (WGNE)

(Offenbach, Germany, 2-6 November 2009)

SUPPORTING NUMERICAL EXPERIMENTATION RESEARCH ACTIVITIES OF THE

WMO/IOC/ICSU WORLD CLIMATE RESEARCH PROGRAMME

WMO WORLD WEATHER RESEARCH PROGRAMME

WMO GLOBAL ATMOSPHERE WATCH PROGRAMME

AND RESEARCH LINKS TO

OPERATIONAL WEATHER AND CLIMATE PRESCRIPTION

C A S / J S C-WCRP
WGNE NO. 25

WMO/TD-NO. 1524

2010

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WGNE-25 Session Report

The twenty fifth session of the joint World Climate Research Programme/Commission for Atmospheric Sciences (WCRP/CAS) Working Group on Numerical Experimentation (WGNE) and the Eleventh session of the GMPP took place from 2-6 November 2009 in Offenbach, Germany. This also included a joint session with the THORPEX ICSC-8. The meeting was hosted by the Deutscher Wetterdienst (DWD) at their new headquarters, and to whom the co-chairs of WGNE, Dr. Martin Miller and Prof. Christian Jakob and the participants express their sincere gratitude for the excellent hospitality the group experienced during the week.

This report provides a short summary highlighting the main discussions and resulting actions and decisions of the meeting. The report is structured by the main areas of discussion, which were issues related to parametrization, operational Numerical Weather Prediction (NWP), climate modelling, verification and the interaction with other WCRP and CAS activities, such as the Global Energy and Water Cycle Experiment (GEWEX) and the World Weather Research Programme (WWRP). The meeting also benefitted substantially from the joint session with THORPEX which resulted in a number of specific joint recommendations and actions for future work. A fuller annotated list of decisions and actions can be found in Appendix A.

a. Parametrization

Following an initiative at WGNE-23 by the then WGNE and GMPP chairs, and the successful establishment at WGNE-24 of an enhanced WGNE membership in the area of model parametrization and development, WGNE was tasked by both the WCRP and CAS to expand its portfolio to better meet the needs of WCRP and the programmes of CAS by providing expert advice, and acting as a catalyst for the development of numerical experimentation aimed at advancing physical parametrizations in the numerical models used by the climate and weather prediction communities.

The meeting received reports from all three GEWEX parametrization efforts, namely the GEWEX Cloud System Study (GCSS), the GEWEX Land-Atmosphere System Study (GLASS) and the GEWEX Atmospheric Boundary Layer Study (GABLS). WGNE congratulated the studies on their achievements in 2009 and encouraged all of them to continue along the plans they presented. In particular, WGNE encouraged GABLS to maintain its major efforts to improve the representation of the stable boundary layer in models and to withstand the temptation to move on to potentially easier problems. A particular suggestion to GABLS was to pursue closer links to the regional modelling community in CORDEX and WWRP with a particular focus on high-latitude issues. Such closer links would enable the group's work to more directly impact parametrization development.

WGNE encourages its members and the wider research community to participate in existing activities of the GEWEX groups and by suggesting new projects aimed at testing and improving parameterizations for climate and weather. In particular WGNE suggests building on the existing efforts in GCSS and expanding to include the increasing number of operational and research convection-permitting models in the GEWEX model evaluation and development activities. Furthermore the modelling groups involved in the WWRP Working Group on Mesoscale Weather Forecasting Research and the limited area modelling component of TIGGE (TIGGE-LAM) are also natural participants in the GCSS model evaluation efforts.

Initiatives from WGNE-24 were discussed and following up from last year, the co-chair reported on the progress made with the model development survey. This initiative has been greatly enhanced by joining with other WMO modelling groups and initial results from the survey are impressive in their range and extent. It was agreed to consider an urgent second call for responses to the survey to increase further its comprehensiveness. WWRP requested that it be kept well-informed and that it would participate in the analysis of the results. The survey's value would be augmented by the publication of a glossy summary suitable for funding agencies etc.

The organization of a conference/workshop, led by Dr Joao Teixeira (JPL), on the representation of physical processes in Earth System Models had progressed, if not quite as fast as the group had wished for, however WGNE agreed that the conference, rather than focussing on model components, will discuss parametrization issues in various applications and geographic regions. This would be an official WGNE workshop but with input from both the WCRP and WWRP communities and fixing the date was an urgent priority. WGNE also supported a proposal to write a white paper on parametrization issues. It was decided to tie the publication of the paper to the conference and to request the conference organizers to seek broad community input and support for the conclusions of the paper.

A possible workshop on stochastic representations of physical processes in models, which could span the ensemble and assimilation communities, will be investigated further.

SPARC has requested that one of its members participate in the model development expert group in WGNE. WGNE welcomed this and will formalize this soon.

b. Progress and challenges in NWP

Every WGNE meeting reviews the new developments, plans and progress made by the main NWP Centres. This is found useful, but it was agreed that consideration should be given to stream-lining the process such that the presentations take up a smaller fraction of the meeting.

As in recent years the drive to higher resolutions (both in the horizontal and now in the vertical also) for both global and regional systems continues, and several operational global models are running with grids of 20-40kms. Furthermore, several Centres are now generating short-range forecasts from non-hydrostatic models with 1-2km gridlengths. These are increasing the focus on boundary layer and land surface parametrizations and also cloud microphysics. There are substantial challenges emerging as to the choice of algorithms for data assimilation at convective scale resolutions. There is also increasing activity in the application of much higher resolution models for local (e.g. urban) forecasts.

The growing interest in coupling NWP models to the ocean was strengthened by a presentation from the OceanView community, and the opportunities for collaboration with this well-organized group (a ‘wet WGNE’!) will be pursued further.

A comprehensive set of Tables summarizing global NWP Centres forecast systems and plans can be found in Appendix D.

c. Climate modelling issues

A number of climate modelling issues were discussed at the meeting. Serious concerns were again voiced with the timelines set by the IPCC AR5 effort and reflected in the CMIP5 effort. These concerns mainly relate to the fact that due to the pressures of performing the CMIP5 experiments and the related need to add additional model components, many climate modelling groups will not have the resources to continue the much needed research to improve the atmospheric models.

A proposal to submit high resolution AMIP simulations under the CMIP5 protocol was well-supported with several NWP Centres indicating that they would try and do this.

WGNE continues to be highly supportive of the Transpose AMIP concept, and encourages centres to participate. Although the experiments are not formally part of CMIP5, it has been agreed the PCMDI will host the data. Keith Williams is chairing the project team and the WGNE co-chairs will act as contact points to the project.

With the inclusion of some aquaplanet experiments under CMIP, WGNE encouraged the APE leadership to publish the main findings in a high-level article. In particular the group felt that highlighting the large variation in the response of aquaplanet-GCMs to varying SST distributions is of great importance as it may highlight important issues for model improvement.

WGNE agreed with the plans of the ad-hoc climate metrics panel charged with defining an agreed initial set of metrics for climate models with a view to applying them in the CMIP5/AR5 process. It was noted that the timeline for the plans is now very tight.

For a number of years, WGNE has discussed the issues and potential pitfalls of Regional Climate Modelling. The formation of the new WCRP task force on regional climate modelling was reported and possible interactions of WGNE with this group were considered. WGNE recommended the extension of this task force for one more year by which time a decision needs to be made on future governance etc. WGNE believes it should, together with WGCM, maintain an oversight role in any future RCM international activity.

WGNE once again reiterated its overall support for reanalysis efforts and the activities of the WRCP's Observation and Assimilation Panel (WOAP). WGNE encourages these reanalysis efforts as they are important for advancing the goals of climate research, and also for research on issues associated with weather and seasonal variations - as evidenced by the large number and breadth of users of the major reanalysis products. WGNE expressed its grave concern about the lack of funding, noting that the funding agencies need to be made aware that the generation of reanalyses are costly in terms of human and computing resources and such efforts are all too often essentially unfunded mandates given to operational centres. A coordinated, cross WCRP action for reanalysis support through the WMO or IGFA should be considered.

d. Forecast verification and model evaluation

There are several WGNE-related projects involving **verification of forecasts** especially of less-standard quantities such as weather parameters and severe weather events. The meeting discussed a number of issues related to verification and reviewed the progress made in the multi-centre forecasts of tropical cyclone tracks and intensities, precipitation for various regions of the world, and verification and comparison of MJO forecasts. It also reviewed the encouraging improvements made in more traditional forecast performance in terms of objective scores such as the 500hPa height fields, MSLP and wind. WGNE members were encouraged to ensure that their model developers were kept up-to-date with all these results, especially the less conventional ones.

WGNE encouraged its members to contribute to the new satellite-based precipitation inter-comparison project, and mused that a summary paper on multi-centre precipitation verification might be timely.

The SURFA project was running routinely now with just two NWP Centres (ECMWF and DWD) contributing flux data currently. WGNE was concerned about the progress of this project, and agreed to pursue this directly with the main protagonists.

e. Joint WGNE/THORPEX activities and recommendations

The joint WGNE/THORPEX ICSC session made several recommendations for strengthening the collaboration between WGNE and WWRP-THORPEX. Closer interaction between WGNE and the THORPEX PDP working group was developed via a specific lecture which focussed on the progress and the need for good diagnostics of forecast errors in general and the importance of evaluating why forecasts occasionally go badly wrong, and several actions ensuring both longer-term liaison and shorter-term scientific progress were confirmed. Cross-attendance at meetings was agreed using designated members and a joint project between WGNE and the WWRP-Mesoscale WG on issues of model behaviour in the resolution 'grey zone' (2-10kms) was initiated.

It was agreed that THORPEX PDP WG and WGNE would organize an expert workshop on model error diagnosis during 2010.

WGNE discussed the plans for the joint WCRP-WWRP programme called the Year of Tropical Convection (YOTC) and encouraged YOTC to continue its very exciting activities. WGNE was very concerned at the apparent lack of progress in establishing a 'synoptic' diary or record of all the significant events that have occurred during the YOTC period, as this is seen to be absolutely essential in establishing the scientific synergy at the core of the YOTC concept. Without such a calendar/diary YOTC would not achieve its aims. WGNE offered to help in applying YOTC data and science to the improvement of parametrizations, and charged the co-chairs, who are members of the YOTC Science Team, to initiate further discussions with YOTC. It was agreed to carefully integrate the dates of a proposed YOTC workshop with those of the planned major WGNE Parametrization meeting.

The growing importance of extended-range forecasting, its prominence in the THORPEX aspirations, the increasing activities in the NWP Centres and the current lack of systematic verification exercises of such forecasts were all noted; and WGNE will ensure, with the aid of external expertise, that the topic will feature in WGNE-26.

Following directly on the initiative agreed at WGNE-24 which recognized that the prediction of atmospheric composition and hence pollution is becoming a more and more integrated part of NWP systems, a session of two expert talks and an ensuing discussion considered to what extent WGNE ought to become involved in these efforts and contribute via its areas of expertise. As a first step, it was agreed to expand the NWP tables (Appendix D) to include a summary of the operational centres current systems (global and regional) with respect to atmospheric composition.

f. Additional Issues

Model related activities (e.g., CMIP, YOTC, CEOP) can effectively exclude a sizeable fraction of the research community due to the size of the datasets involved. WGNE continued to urge all data systems groups to consider alternatives to the "download and process at home" paradigm currently in place.

The support of Canada in looking after the annual 'Blue Book' for many years was gratefully acknowledged, and it was agreed to review the situation at WGNE-26.

Following an invitation from the Japan Meteorological Agency (JMA), it was confirmed that WGNE-26 would be hosted by JMA in Tokyo the week of Oct 18-22nd 2010. Confirmation letters etc will be exchanged.

It was agreed that the sought after joint meeting of WGNE and WGCM would take place in 2011. The location is still to be confirmed, with Melbourne one possibility.

Appendix A

WGNE-25 Decisions and Actions

Climate Services

- WGNE was asked to form a position on the delivery of climate services-> Consider making this a topic for next year's session

Role of WGNE in the organization of the WCRP science conference:

- ***C Jakob*** is on the organizing committee and will communicate dates to WGNE and WWRP/THORPEX, once they have been set
- ***L Donner*** will assist in discussion on properly representing advances in Earth System Modelling by either having a symposium or making sure the other symposia have this represented
- ***P Gauthier*** will assist in ensuring coupled data assimilation is represented

Joint WGNE-WGCM meeting

- Agreed to have it in 2011
- Location proposed by WGCM is Melbourne
- ***Other offers are welcome and need to be sent to C Jakob by early February 2010***

AMIP contributions from NWP centres

- A number of centres agreed to contribute high-resolution simulations to AMIP part of the CMIP archive
- ***P Glecker and J Hack*** will consider the idea of having a coordinated resolution study as part of AMIP

Input into CORDEX plans

- WGNE recommends the extension of the Task Force for one more year and then a decision needs to be made on future governance
- WGNE feels that it should maintain an oversight role in any future RCM activity (jointly with WGCM).
- ***J Hack*** to write a paragraph for the meeting report and for communication to CORDEX
- ***P Siebesma*** will approach CORDEX to see if they can provide MOLTS output at selected locations for model evaluation

Blue book

- After initially stating that Canada can only support the blue book for one more year there is now a chance they will continue beyond that
- In any case, the future of the blue book ought to be discussed at the next session

SPARC connection

- SPARC requested to have a representative in the WGNE model development group
- WGNE supports this idea and will provide SPARC with the desired areas of expertise the person should cover **-> C *Jakob*** to write to SPARC
- After SPARC suggest someone, CAS and WCRP JSC approval will be sought for the extension similar to that recently accomplished for GCSS, GLASS and GABLS.

Model development survey

- WGNE welcomed the initiative
- WGNE recommended having a second call for input but NOT to change the survey in any way
- WWRP wishes to remain informed on the progress and to participate in the analysis of the results as they pertain to NWP
- ***WGNE members are urged to send their replies*** by the new deadline (likely end 2009)

- The team running the survey was urged to consider publication of a glossy two pager for funding agencies based on its results

YOTC workshop

- WGNE urged YOTC to consider broadening the scope of a proposed workshop on tropical processes
- WGNE encouraged YOTC to consider moving the workshop dates away from October 2010, as this is already a very busy period of meetings
- ***C Jakob*** to provide dates to Mitch Moncrieff of meetings already planned

Workshop on Physics of Earth System Models

- WGNE is strongly supporting this workshop – it should be a recognized WGNE workshop
- A date for the workshop needs to be set asap -> ***C Jakob*** to communicate with Joao Teixeira
- WGNE suggested there is a need to speed up the organization of the workshop involving both the WCRP and WWRP communities

WWRP-WGNE connections

- ***B Lapenta*** will serve as the direct WGNE liaison to the WWRP Mesoscale Forecasting group
- WGNE proposes a joint project between the WWRP Mesoscale group and WGNE on studying the issues of model resolutions in the "grey zone" where deep convection is not resolved and cannot easily be parametrized O(5 km).
- ***A Brown*** will serve as the direct WGNE liaison to the THORPEX PDP group
- ***T Jung*** will be the PDP liaison to WGNE
- THORPEX PDP and WGNE will organize a joint expert meeting on model error diagnosis methods in support of model development. ***T Jung*** will take the lead. Likely timeframe is summer 2010 in conjunction with the annual PDP meeting

Pan-GEWEX dates

- ***C Jakob*** to notify GEWEX on the potential clash of the Pan-GEWEX and WGNE meetings in 2010 and seek a solution

Potential MOLTS model output project

- ***GMPP*** is to take the lead in investigating the potential for a model evaluation project involving the MOLTS output from NWP, CFMIP and potentially CORDEX in support of model development

Model uncertainties

- A possible workshop on stochastic representations of physical processes was discussed. The main aim would be to bring together the community dealing with model uncertainty in EPS and DA with the stochastic parametrization community.
- ***T Hamill*** to investigate the possibilities for such a workshop

Seasonal prediction

- WGNE was asked to invite some experts on seasonal and decadal prediction to its next meeting with the aim to discuss potential collaboration and joint projects
- ***C Jakob, M Miller and A Brown*** to discuss this and issue invitations closer to the next meeting

GODAE OceanView

- The group supported strengthening the link to OceanView.
- First step is to canvass the NWP community on existing activities in coupled NWP. ***All members*** to report their activities at the next meeting.
- WGNE will aim to send a representative to the next OceanView meeting. ***C Jakob*** to find out dates and location.

- ***C Jakob*** to investigate the reporting structure in OceanView for lessons to be learned for WGNE – in particular check their annual report template for each centre

JPS support for WGNE meetings

- WGNE stressed that the local support of WGNE meetings by WCRP JPS staff needs to be brought back to previous levels (e.g., at least the taking of minutes during the meeting)
- WGNE also noted that the design and distribution of the meeting agenda, meeting decisions and actions and meeting reports need to be better supported by the JPS in the future. Much of this now rests entirely with the co-chairs.

Cloudy radiance intercomparison project

- ***F Rabier*** proposed an intercomparison of the use of cloudy radiances in DA and will take this forward together with ***P Gauthier***

Statement in support of reanalyses

- WGNE expressed its concern about the lack of funding of reanalysis efforts
- WGNE to approach other groups (WGCM and WOAP to start) to try and achieve a high-level WCRP or WMO push for support
- ***C Jakob*** to contact K Trenberth to discuss possible actions
- ***C Jakob*** to ensure that this is made a JSC item

Climate metrics

- WGNE endorses the plans of the metrics panel
- WGNE expresses concern about the model weighting approaches and the upcoming IPCC Expert meeting about this, which is held as a closed meeting without consultation of the model development community
- ***C Jakob and M Miller*** to consider writing to the IPCC WG1 and 2 co-chairs
- WGNE stresses the importance of sticking to the timelines the metrics panel proposes as they are now very tight

SURFA

- WGNE is still concerned about the uptake of the NWP data in this project
- ***Co-chairs*** will discuss next steps by email with ***D Majewski***

APE

- WGNE encourages the members to contribute to the Aquaplanet activities under CMIP
- WGNE encourages the APE leadership to consider publishing the main findings of the project in a high-level article (Science, Nature, …)
- APE should report back on this before the next meeting

Transpose AMIP

- WGNE endorses the plans for phase 2 and encourages participation and diagnostic sub-projects
- ***C Jakob and M Miller*** will serve as WGNE representatives on the steering group for now

Precipitation verification

- WGNE encourages ***members to contribute*** data to the satellite precipitation intercomparison
- WGNE proposed that the precipitation verification efforts should be summarized in a BAMS paper (or so)

Next WGNE meeting

- JMA kindly offered to host the next WGNE meeting
- WGNE accepted the offer and the meeting dates were set for 18-22 October 2010
- ***C Jakob*** to draft an email to JMA accepting the invitation, and to WMO including WWRP/THORPEX informing them of the plans

Appendix B

Meeting Agenda

WGNE-25/GMPP-11 agenda – Final Draft

Monday, 2 November

Agenda Item	Subject	Responsibility/Speaker
0900-1030		
	Welcome, Adoption of agenda, Local Arrangements	C Jakob, M Miller, D Majewski
	CAS matters	L Barrie
	WCRP matters incl. JSC and new strategy	G Asrar
	GEWEX matters incl. SSG	P van Oevelen
1030-1100	Coffee	
1100-1230		
	WGCM and CMIP progress report	P Gleckler
	Regional Climate Modelling Task Force Discussion	C Jones
1230-1400	Lunch	
1400-1430	25 Years of WGNE and beyond	D Williamson
1430-1530	Modelling Centre Reports 20 minutes + 10 minutes discussion each	Participants
1530-1600	Coffee	
1600-1800	Modelling Centre Reports 20 minutes + 10 minutes discussion each	Participants
1800	Ice Breaker at DWD canteen (jointly with THORPEX ICSC)	

Tuesday, 3 November

Agenda Item	Subject	Responsibility/ Speaker
0900-1030	*Joint with the THORPEX ICSC*	
	Introduction of session	D Burridge, M Miller
	General overview of THORPEX activities	D Burridge
	Report from the WWRP/JSC including presentation of the WWRP Strategic Plan	Introductory presentation G Brunet
	Report of the Joint Working Group for Verification	B Ebert
1030-1100	Coffee	
1100-1230	*Continuation of the Joint Session*	
	ECRTT outcomes	L Barrie/ D Parsons, G Asrar
	First outcomes of a WCRP survey on model development	C Jakob
	YOTC	D. Waliser
	Hydrology - HEPEX, HYMEX, MEDEX	D Parsons, V Ducrocq
1230-1400	Lunch	
1400-1530	*Continuation of the Joint Session*	
	Strengthening the THORPEX-PDP and WGNE connection	T Jung
	Discussion on input to CASXV (Five short papers available from http://www.wmo.int/pages/prog/arep/cas/FutureCASWorkProg.html	D Parsons, D Burridge?
	Discussion with some focus on WGNE-WWRP collaboration	Lead by C Jakob/ G Brunet
	End of the Joint Session	
1530-1600	Coffee	
1600-1730	*GMPP 1*	
	Introduction	C Jakob
	GLASS report and discussion	B van den Hurk

Wednesday, 4 November

Agenda Item	Subject	Responsibility/Speaker
0900-1030	*GMPP 2*	
	GCSS report and discussion	P Siebesma
	WCRP modeling survey revisited	C Jakob
1030-1100	Coffee	
1100-1230	*GMPP 3*	
	GABLS report and discussion	B Holtslag
	Conferences (Pan-WCRP, Physics)	G Asrar, P Siebesma
1230-1400	Lunch	
1400-1500	Modelling Centre Reports 20 minutes + 10 minutes discussion each	Participants
1500-1530	Developments at NOAA including Climate Service and GFDL	R Rosen
1530-1600	Coffee	
1600-1800	Modelling Centre Reports 20 minutes + 10 minutes discussion each	Participants
1900	Conference Dinner “Zum gemalten Haus” Schweizer Straße 67 Frankfurt Sachsenhausen http://www.zumgemaltenhaus.de/	

Thursday, 5 November

Agenda Item	Subject	Responsibility/Speaker
0900-1030		
	Recent developments in Numerical Methods	G Dietachmayer, M Tolstykh
	ICON: The next generation non-hydrostatic global model with local zooming option	B Stevens
	Recent developments in Ensemble Prediction	T Hamill, P Silva-Dias
1030-1100	Coffee	
1100-1230		
	Recent developments in Seasonal Prediction	C Jakob, X Shen
	Ocean Prediction – GODAE/OceanView	E Dombrowsky
	Discussion on collaboration with OceanView	Participants
1230-1400	Lunch	
1400-1530		
	Recent developments in high-resolution NWP	A Brown, B Lapenta
	The operational convection-permitting model COSMO-DE at DWD	M Baldauf
	The model system COSMO-ART	B Vogel
1530-1600	Coffee	
1600-1730		
	GEMS/MAAC	M Schultz
	Discussion on future directions in NWP and Chemistry	Participants
	Recent developments in Data assimilation	F Rabier, P Gauthier
	Recent developments in Reanalysis	C Muroi, M Miller

Friday, 6 November

Agenda Item	Subject	Responsibility/Speaker
0900-1030		
	Recent developments in Climate Modelling	J Hack
	Progress with Climate Model Metrics	P Gleckler
	Progress with SURFA	D Majewski
1030-1100	Coffee	
1100-1230		
	APE and Transpose AMIP	D Williamson
	Forecast Verification, incl. general, rainfall and typhoons	Participants
1230-1300	Closing Session	
	Decisions and Actions	C Jakob, M Miller

Appendix C

Meeting Participants

	Participants	Affiliation	Country
1	Ghassem Asrar	WMO	Switzerland
2	Michael Baldauf	Deutscher Wetterdienst	Germany
3	Len Barrie	WMO	Switzerland
4	Andy Brown	Met Office	United Kingdom
5	Gary Dietachmayer	Bureau of Meteorology	Australia
6	Eric Dombrowsky	GOOS	France
7	Beth Ebert	Bureau of Meteorology	Australia
8	Pierre Gauthier	University of Quebec	Canada
9	Peter Gleckler	PCMDI	USA
10	Jim Hack	Oak Ridge National Laboratory	USA
11	Tom Hamill	NOAA Earth System Research Lab.	USA
12	Hee-Dong Yoo	KMA	South Korea
13	Bert Holtslag	Wageningen University	Netherlands
14	Christian Jakob	Monash University	Australia
15	Colin Jones	University of Quebec	Canada
16	Bill Lapenta	NOAA/NCEP	USA
17	Detlev Majewski	Deutscher Wetterdienst	Germany
18	Martin Miller	European Centre for Medium-Range Weather Forecasts	United Kingdom
19	Chiashi Muroi	Japan Meteorological Agency	Japan
20	Florence Rabier	CNRM/GMAP	France
21	Rick Rosen	NOAA	USA
22	Xueshun Shen	China Meteorological Administration	China
23	Pier Siebesma	Royal Netherlands Meteorological Institute (KNMI)	Netherlands
24	Petro Silva Dias	Ministry of Science and Technology	Brazil
25	Björn Stevens	MPI-M	Germany
26	Mikhail Tolstykh	Russian Academy of Sciences	Russia
27	Bart van den Hurk	Royal Netherlands Meteorological Institute (KNMI)	Netherlands
28	Peter van Oevelen	GEWEX	USA
29	Bernhard Vogel	KIT	Germany
30	Dave Williamson	NCAR	USA

Appendix D

WGNE List of Operational Global Numerical Weather Prediction Systems (as of February 2010)

Forecast Centre (Country)	Computer (Sustained in TFlop/s)	High resolution Model (FC Range in days)	Ensemble Model (FC Range in days)	Type of Data Assimilation
ECMWF (Europe)	IBM p6 575, 2x272 (2x15)	T_L1279 L91 (10)	T_L639 L62; (10) T_L319 L62 (+5)	4D-Var (T_L255)
Met Office (UK)	IBM Power 6 106 nodes x2 (2*4.8)	~40 km L50 (6)	~90km L38; M24 (3)	4D-Var (~120km)
Météo France (France)	NEC SX9, 2x6 nodes (2x1.9)	T_L538(C2.4) L60 (4)	T_L358(C2.4) L55; M35 (4)	4D-Var (T_L224)
DWD (Germany)	NEC SX9; 2x14 nodes (2x4.5)	30 km L60 (7)	No global EPS	3D-Var
HMC (Russia)	SGI Altix4700; SGI ICE8200 (1.8; 1.3)	0.72°x0.9° L28 (10) T85 L31 (10)	No global EPS	3D-OI
NCEP (USA)	IBM p655 (Cluster 1600) (2x1.9)	T382 L64 (7.5) T190 L64 (16)	T126 L28; M45 (16)	3D-Var (T382)
Navy/FNMOC/NRL (USA)	SGI and IBM (800 proc) (3.2)	T239 L30 (7.5)	T119 L30; M16 (10.5)	3D-Var
CMC (Canada)	IBM p575, 2X40 nodes (1.0)	0.45°x0.3° L58 (10)	GEM (0.9°) L28; M20 (16)	Det: 4D-Var (1.5°) EPS: EnKF M96 (0.9°)
CPTEC/INPE (Brazil)	NEC SX6, 12 nodes (0.8) NEC/SUN 1100 Opteron Cluster (5.7)	T299 L64 (7); T126 L28 Coupled (30)	T126 L28; M15 (15)	3D-Var
JMA (Japan)	Hitachi SR11000-K1, 2*80 nodes (2x0.7)	T_L959 L60 (9)	T_L319 L60; M51 (9)	4D-Var (T159)
CMA (China)	IBM p655/p690 120 nodes (2.1)	T_L639 L60 (10)	T213 L31; M15 (10)	3D-Var
KMA (Korea)	Cray X1E-8/1024-L (2x0.7)	T426 L40 (10)	T213 L40; M32 (17/cycle) (10)	3D-Var
NCMRWF (India)	Cray X1E-64 processor (0.1) IBM P6 - 1280 processor (2.4)	T254 L64 (7)	T80 L18; M8 (7)	3D-Var (T254)
BoM (Australia)	NEC SX6, 23 nodes (0.4)	80km, L50 (10)	T_L119 L19; M33 (10)	4D-VAR (120km)

WGNE Overview of Plans at the NWP Centres with Global Forecasting Systems

Part I: Computer (Sustained Performance in TFlop/s based on main deterministic model)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	2x15	2x30	2x30	tbd	tbd	tbd
Met Office (UK)	2x4.8	2x4.8	2x16	2x16	tbd	tbd
Météo France (France)	2x1.9	2x3	2x3	tbd	tbd	tbd
DWD (Germany)	2x4.5	2x15	2x15	tbd	tbd	tbd
HMC (Russia)	1.8+1.3	1.8+1.3	1.8+1.3	1.8 + 1.3	tbd	tbd
NCEP (USA)	2x9.3	2x9.3	2x27	2x27	2x90	tbd
Navy/FNMOC/NRL (USA)	3	3	tbd	tbd	tbd	tbd
CMC (Canada)	3.2	3.2	tbd	tbd	tbd	tbd
CPTEC/INPE (Brazil)	15	15	tbd	tbd	tbd	tbd
JMA (Japan)	2x0.7	2x0.7	tbd	tbd	tbd	tbd
CMA (China)	2.1 5.0	2.1 5..0	tbd	tbd	tbd	tbd
KMA (Korea)	1.4 1.5	2x17	2x17	2x17	tbd	tbd
NCMRWF (India)	2.5	tbd	tbd	tbd	tbd	tbd
BoM (Australia)	1.5	3	3	tbd	tbd	tbd

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Part II: Global Modelling

a) Deterministic Model (Resolution and number of layers)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	T_L1279 L91	T_L1279 L140?	T_L1279 L140?	tbd	tbd	tbd
Met Office (UK)	25 km L70	25 km L70	20km L70	tbd	tbd	tbd
Météo France (France)	T_L798c2.4 L70 (10km on W Europe)	T_L798c2.4 L70 (10km on W Europe)	T_L798c2.4 L70 (10km on W Europe)	tbd	tbd	tbd
DWD (Germany)	30 km L60	20 km L60	20 km L70 (5 km for Europe)	20 km L70 (5 km for Europe)	tbd	tbd
HMC (Russia)	0.72°x0.9° L28 T169 L31	0.37°x0.45° L50 T339 L31	0.37°x0.45° L50 T339 L63	0.19°x0.22° L60 T679L63(10)	tbd	tbd
NCEP (USA)	T574 L64 (7.5) T254 L64 (16)	T878; L64 (7.5) T382; L64 (16)	T878; L64 (7.5) T382; L64 (16)	T878; L91 (7.5) T382; L91 (16)	T878; L91(7.5) T382; L91 (16)	TBD
Navy/FNMOC/NRL (USA)	T319 L42	T319 L42	T479 L60	T479 L60	T511 L64	T511 L64
CMC (Canada)	(0.45°x0.3°) L80	(0.45°x0.3°) L80	(0.35°x0.23°) L80	(0.35°x0.23°) L90	(0.3°x0.2°) L90	tbd
CPTEC/INPE (Brazil)	20 km L96	20 km L96	10 km L96	10 km L128	tbd	tbd
JMA (Japan)	T_L959 L60	T_L959 L60	tbd	tbd	tbd	tbd
CMA (China)	T_L639 L60 GRAPES 50 km L36	T_L639 L60 GRAPES 50 km L35	GRAPES 25 km L60	GRAPES 26 km L60	tbd	tbd
KMA (Korea)	40 km L50	25 km L70	25 km L70	20 km L90	tbd	tbd
NCMRWF (India)	T382 L64	25 km L70	25 km L70	tbd	tbd	tbd
BoM (Australia)	~40 km L70	25 km L70	25 km L90	tbd	tbd	tbd

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Part II: Global Modelling

b) Global Ensemble Prediction System (Resolution, number of layers, number of members, forecast range in days)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	T639 to D+10 T319 to D+15	T639 to D+10 T319 to D+15	T639 to D+10 T319 to D+15	tbd	tbd	tbd
Met Office (UK)	~60 km L70; M24; 3	~60 km L70; M24; 3	tbd	tbd	tbd	tbd
Météo France (France)	T358c2.4 L65; M35; 4	T538c2.4 L65; M35; 4 days	T538c2.4 L65; M35; 4 days	tbd	tbd	tbd
DWD (Germany)	~40 km L40; M20; 1	~40 km L40; M20; 1	~40 km L40; M20; 1	tbd	tbd	tbd
HMC (Russia)	T85L31 (13),T169L31 (1) 0.72°x0.9°L28;M15; 10	T169 L31, 0.72°x0.9°L28; M42; 10	T169 L31, 0.72°x0.9°L28; M42; 14	T169 L63, 0.72°x0.9°L50; M42; 14	tbd	tbd
NCEP (USA)	T190 L28; M88; 20/cycle; 16 days	T254 L42; M88; 16	T254L42; M88; 16	40 km L42; M88; 16	40km L42;M88; 16	40km; L42; M88; 16
Navy/FNMOC/NRL (USA)	T119L30; M20; 16	T119L30; M20; 16	T119L30; M20; 16	T239L42; M20; 16	T239L42; M20; 30	T239L42; M20; 30
CMC (Canada)	GEM (0.6°x0.6°) L48 M20 16	GEM (0.6°x0.6°) L58 M20 16	GEM (0.6°x0.6°) L58 M20 16	GEM (0.5°x0.5°) L58-80 M20 16	GEM (0.5°x0.5°) L58-80 M20 16	tbd
CPTEC/INPE (Brazil)	50 km, L42, M50; 15	50 km, L42, M50; 15	40 km, L64, M60; 15	40 km, L64, M60; 15	tbd	tbd
JMA (Japan)	T_L319 L60; M51; 9	T_L319 L60; M51; 9	tbd	tbd	tbd	tbd
CMA (China)	T213 L31; M30 (BGM, 10) GRAPES 100 km L31; M15;10	T213L31; M30 (BGM,10) GRAPES 100 km L31; M15;10	GRAPES 50 km M15, 10 L36, M15, 10	GRAPES 50km M15,10 L36,M15,10	tbd	tbd
KMA (Korea)	T213 L40; M34; 17/cycle; 10	40 km L50; M24; 10	40 km L70; M24; 15	40 km L70; M24; 15	tbd	tbd
NCMRWF (India)	tbd	tbd	tbd	tbd	tbd	tbd
BoM (Australia)	T119 L19; M33; (10)	MOGREPS, ~60 km L70; M24	MOGREPS, ~60 km L90; M24	tbd	tbd	tbd

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Part II: Global Modelling

c) Global Data Assimilation Scheme (Type, resolution, number of layers)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	4D-Var; T_L1279 with T255 final inner loop; L91	4D-Var; T_L1279 with T_L399 final inner loop; L140?	4D-Var; T_L1279 with T_L399 final inner loop; L140?	tbd	tbd	tbd
Met Office (UK)	4D-Var; 75 km; L70	4D-Var; 60 km; L70	tbd	tbd	tbd	tbd
Météo France (France)	4D-Var+ensemble; T_L224; L70	4D-Var+ensemble; T_L323; L70	4D-Var+ensemble; T_L323; L70	tbd	tbd	tbd
DWD (Germany)	3D-Var; 30 km; L60	3D-Var+ensemble; 20 km; L60	3D-Var+ensemble; 20 km; L70	tbd	tbd	tbd
HMC (Russia)	3D-Var 1°x1° L38	3D-Var 0.5°x0.5° L80	3D-Var + ENKF 0.5°x0.5° L80	3D-Var + ENKF 0.5°x0.5° L80	tbd	tbd
NCEP (USA)	Advanced-Var; T574; L64	Advanced-Var; T878; L64	Advanced-Var; T878; L64	Advanced-Var; T878; L91	Hybrid Ens-4D-Var T878; L91	tbd
Navy/FNMOC/NRL (USA)	4D-Var T319 L42	4D-Var T319 L42	4D-Var T479 L60	4D-Var T479 L60	4D-Var T511 L64	4D-Var T511 L64
CMC (Canada)	Det: 4D-Var (1.5°x1.5°), (0.45°x0.3°) L80 EPS: EnKF M96 (0.9°x0.9°)	Det: 4D-Var (0.9°x0.9°), (0.45°x0.3°) L80 EPS: EnKF M96 (0.6°x0.6°)	Det: 4D-Var (0.9°x0.9°), (0.35°x0.23°) L80 EPS: EnKF M96 (0.6°x0.6°)	Det: 4D-Var (0.6°x0.45°), (0.35°x0.23°) L90 EPS: EnKF M96 (0.6°x0.4°)	Det?: 4D-Var (0.6°x0.45°), (0.3°x0.2°) L90 EPS?: EnKF M96 (0.6°x0.4°)	tbd
CPTEC/INPE (Brazil)	LETKF; 40 km	LETKF; 40 km	LETKF; 20 km	LETKF; 21 km	tbd	tbd
JMA (Japan)	4D-Var; T159; L60	4D-Var; T_L319; L60	tbd	tbd	tbd	tbd
CMA (China)	SSI GRAPES_3D-Var 50 km; L36	SSI GRAPES_3D-VAR 50 km; L36	GRAPES_4D-VAR 100 km; L61	tbd	tbd	tbd

KMA (Korea)	4D-Var; 120km; L50	4D-Var; 75km; L70	4D-Var; 75km; L70	tbd	tbd	tbd
NCMRWF (India)	3D-Var; T382; L64	4D-VAR; 75 km L70	4D-VAR; 75 km L70	tbd	tbd	tbd
BoM (Australia)	4D-VAR; 75 km L70	4D-VAR; 75 km L70	4D-VAR; 60 km L90	tbd	tbd	tbd

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Part III: Regional Modelling

a) Regional deterministic model (number of gridpoints, resolution, number of layers)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	600*360; 12 km; L70 768*960; 1.5 km; L70	600*360; 12 km; L70 768*960; 1.5 km; L70	600*360; 12 km; L70 768*960; 1.5 km; L70	768*960; 1.5 km; L70	768*960; 1.5 km; L70	tbd
Météo France (France)	750x720; 2.5 km; L60	750x720; 2.5 km; L60	750x720; 2.5 km; L60	tbd	tbd	tbd
DWD (Germany)	665x657; 7 km; L40 421x461; 2.8 km; L50	665x657; 7 km; L40 421x461; 2.8 km; L50	zooming 5 km; L70 421x461; 2.8 km; L50	tbd	tbd	tbd
HMC (Russia)	670x430; 40 km; L30 700x620, 7km, L40 2 dom. 500x500,2.8km,L50	670x430; 40 km; L30 700x620, 7km, L40 2 dom. 500x500,2.8km,L50	1270x860; 25 km; L40 700x620, 7km, L60 2 dom. 500x500,2.8km,L80	1270x860; 25 km; L40 700x620, 7km, L60 2 dom. 500x500,2.8km,L80	tbd	tbd
NCEP (USA)	954x835; 12km; L60 778x1099; 4 km; L35 874x614; 5.15km; L35 191x309; 4 km; L35 214x174; 5.15km; L35	954x835; 12km; L70 1371x1100; 4 km; L70 595x625; 6 km; L70 373x561; 3 km; L70 241x241; 3 km; L70	954x835; 12km; L80 1371x1100; 4 km; L80 595x625; 6 km; L80 373x561; 3 km; L80 241x241; 3 km; L80	1145x1002; 10 km; L80 2193x1760; 2.5 km; L80 1071x1125; 3.33km; L80 559x841; 2 km; L80 361x361; 2 km; L80	1145x1002; 10 km; L91 2193x1760; 2.5 km; L91 1071x1125; 3.33km; L91 559x841; 2 km; L91 361x361; 2 km; L91	1273x1114; 9 km; L91 1182x1014; 2.25km; L91 1190x1250; 3 km; L91 621x935; 1.8 km; L91 401x401; 1.8 km; L91
Navy/FNMOC/NRL (USA)	45/15/5 km; L40	45/15/5; L40	27/9/3 km; L40	27/9/3 km; L50	9/3/1; L50	9/3/1 km; L60
CMC (Canada)	15 km; L80 4 LAMs at 2.5km; L58	15 km; L58 LAMs at 2.5km; L58	10 km; L58 LAMs at 2.5km; L58	10 km; L58 LAMs at 2.5km; L58	8km; L80 LAMs at 2.5km; L58	tbd
CPTEC/INPE (Brazil)	601x1201, 10 km; L50	601x1201, 10 km; L50	1001x2101, 5 km; L80	1001x2101, 5 km; L80	tbd	tbd
JMA (Japan)	721x577; 5 km; L50	721x577; 5 km; L50	tbd	tbd	tbd	tbd
CMA (China)	550x330, GRAPES-15km; L60	1650x990, GRAPES-5km; L60	1650x990, GRAPES-5km; L60	tbd	tbd	tbd
KMA (Korea)	574x514, 10 km, L40 540x432, 12 km, L38	574x514, 10 km, L40 540x432, 12 km, L70	540x432, 12 km, L70 1.5 km, L70	540x432, 12 km, L70 1.5 km, L70	tbd	tbd

NCMRWF (India	27km, L38 9km, L38	12 km L70	12 km L70	tbd	tbd	tbd
BoM (Australia)	320x220; 37.5km L70 680x544; 12km L70 6 LAMs 240x240; 5km L70	960x660; 12km L70 6 LAMs 600x600; 2km L70	960x660; 12km L90 6 LAMs 600x600; 2km L90	(960-1440)x(660-990); 8-12km L90 6 LAMs 600x600; 2km L90	tbd (960-1440)x(660-990); 8-12km L90 6 LAMs 600x600; 2km L90	tbd

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Part III: Regional Modelling

b) Regional Ensemble Prediction System (Resolution, number of members, forecast range in days)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	18 km; M24; 2	18 km; M24; 2	18 km; M24; 2 1.5 km; M6; 1	tbd	tbd	tbd
Météo France (France)	23 km; M35; 4	15 km; M35; 4	15 km; M35; 4	tbd	tbd	tbd
DWD (Germany)	2.8 km; M20; 1	2.8 km; M40; 1	2.8 km; M40; 1	tbd	tbd	tbd
HMC (Russia)	No regional EPS	tbd	tbd	tbd	tbd	tbd
NCEP (USA)	32 km; M21; 4cyc; 3.625day	32 km; M21; 4cyc; 3.625day	20 km; M25; 4cyc; 4day	20 km; M25; 4cyc; 4day	10km;M25;4cyc; 4day	3km nested; M6; 24cyc(hrly); 1day
				3 km; M6; 2	3 km; M6; 2	2.5km; M10; 2
Navy/FNMOC/NRL (USA)	No regional EPS	45/15 km; M20; 3	27/9 km; M20; 3	27/9 km; M20; 3	tbd	tbd
CMC (Canada)	33 km L28 M20 2	25 km L28 M20 2	25 km L60 M20 3	25 km L70 M20 3	15 km L80 M20 3	tbd
CPTEC/INPE (Brazil)	20 km; M21; 10	20 km; M21; 10	10 km, M21, 10	10 km, M21, 10	tbd	tbd
JMA (Japan)	T_L319 L60; M11; 4 times/day; 5	T_L319 L60; M11; 4 times/day; 5	tbd	tbd	tbd	tbd
CMA (China)	GRAPES 30 km; M15; 72hr	GRAPES 15 km; M30; 72 hr	GRAPES 15 km; M30; 72 hr	tbd	tbd	tbd
KMA (Korea)	No regional EPS	No regional EPS	12 km; M24; 3	12 km; M24; 3	tbd	tbd

NCMRWF (India	No regional EPS	No regional EPS	No regional EPS	tbd	tbd	tbd
BoM (Australia)	No operational regional EPS	MOGREPS; 24km L70; M24; 3	MOGREPS; 24km L90; M24; 3	tbd	tbd	tbd

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Part III: Regional Modelling

c) Regional Data Assimilation Scheme (Type and resolution)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	-	-	-	-	-	-
Met Office (UK)	4D-Var, 24 km 3D-Var + LH nudging, 1.5 km	4D-Var, 24 km 3D-Var + LH nudging, 1.5 km	4D-Var, 24 km 4D-Var, 4 km?	tbd	tbd	tbd
Météo France (France)	3D-Var, 2.5 km	3D-Var, 2.5 km	3D-Var, 2.5 km	tbd	tbd	tbd
DWD (Germany)	Nudging; 7 km Nudging, LH-N.; 2.8 km	Nudging; 7 km Nudging, LH-N.; 2.8 km	3D-Var + LETKF; 7 km LETKF; 2.8 km	3D-Var + LETKF; 7km LETKF; 2.8 km	tbd	tbd
HMC (Russia)	Nudging; 7km	3D-Var 15 km	3D-Var + EnKF 15 km	3D-Var + EnKF 12 km	3D-Var + EnKF 5 km	
NCEP (USA)	Advanced-Var; 12/4 km	Advanced-Var; 12/6/4/3 km	Advanced-Var; 12/6/4/3 km	Advanced-Var; 10/3.33/2.5/2 km	Hybrid: EnsK-4DVar; 10/3.33/2.5/2 km	Hybrid: EnsK-4DVar; 9/3/2.25/1.8 km
Navy/FNMOC/NRL (USA)	3D-Var 45/15/5 km	3D-Var 45/15/5 km	4D-Var 27/9/3 km	4D-Var 27/9/3 km	4D-Var 9/3/1 km	4D-Var 9/3/1 km
CMC (Canada)	Continental: 3D-Var 55 km L80	Continental: 4D-Var 55 km L80 Local: 3D-Var 10 km L58	Continental: 4D-Var 55 km L80 Local: 3D-Var 10 km L58	Continental: 4D-Var 55 km L80 Local: 3D-Var 10 km L58	Continental: 4D-Var 25 km L80 Local: 3D-Var 8 km L80	tbd
CPTEC/INPE (Brazil)	LETKF; 20 km	LETKF; 20 km	LETKF; 10 km	LETKF; 10 km	tbd tbd	tbd
JMA (Japan)	4D-Var,15 km	4D-Var, 15 km	tbd	tbd	tbd	tbd
CMA (China)	GRAPES-3D-VAR, 15 km	GRAPES-4D-VAR, 30 km	GRAPES-4D-VAR, 15 km	tbd	tbd	tbd
KMA (Korea)	3D-Var, 10 km	3D-Var, 10 km 4D-Var, 24 km	4D-Var, 24 km 3D-Var, 1.5 km	4D-Var, 24 km 3D-Var, 1.5 km	tbd	tbd

NCMRWF (India	3D-Var	tbd	tbd	tbd	tbd	tbd
BoM (Australia)	4D-VAR; 75 km; L70 4D-VAR; 36 km; L70	4D-VAR; 36 km; L70	4D-VAR; 36 km; L90 3D-VAR; 6 km; L90	4D-VAR; 36 km; L90 (3-4)D-VAR; 6 km; L90	4D-VAR; 36 km; L90 (3-4)D-VAR; 6 km; L90	tbd

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Part IV: Atmospheric composition

a) Global atmospheric composition modelling (Type [Aerosols? Chemically reactive gases?] and resolution)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF (Europe)	aerosol, O3, NO2, SO2, CO, HCHO, CO2, CH4, 4D-Var T255L60, NRT and reanalysis	aerosol, O3, NO2, SO2, CO, HCHO, CO2, CH4, 4D-Var T255L60, NRT and reanalysis	Pending contract negotiations with EC	Pending contract negotiations with EC	Pending contract negotiations with EC	-
Met Office (UK)	Aerosol climatologies in main global NWP	Prognostic dust	Prognostic sea-salt, biomass	tbd	tbd	tbd
Météo France (France)	Resolution: 2°. Gas phase Chemistry : 118 species, over 300 reactions (comprehensive strat+trop scheme). Aerosol : dusts, sea salts (mid-2010), black carbon (mid-2010), sulfate (mid-2010), anthropogenic PM2.5 and PM10-2.5 (mid-2010).	Resolution: 2°. Gas phase Chemistry : 118 species, over 300 reactions (comprehensive strat+trop scheme). Aerosol : dusts, sea salts, black carbon, sulfate, anthropogenic PM2.5 and PM10-2.5.	Implement a data assimilation step + Finalize comprehensive aerosol scheme (including SOA, ammonia,…)	tbd. CPU permitting, increase gradually to target resolutions : 1°	tbd. CPU permitting, increase gradually to target resolutions : 1°	tbd. CPU permitting, increase gradually to target resolutions : 1°
DWD (Germany)	Nil	tbd	tbd	tbd	tbd	tbd
HMC (Russia)	Nil	Nil	tbd	tbd	tbd	tbd
NCEP (USA)		Passive dust aerosols 75 km	Passive dust and smoke aerosols 75 km	Full aerosol sources (dust, smoke, anthropogenic & Sea-salt) w/ simple sulfate chemistry 50 km	Full aerosols w/ simple sulfate chemistry 50 km	Simple tropospheric gas-phase chem + full aerosols 25 km
Navy/FNMOC/NRL (USA)	Dust, Smoke, Sulfates, Sea Salt 100 km; L36	Dust, Smoke, Sulfates, Sea Salt 100 km; L36	Dust, Smoke, Sulfates, Sea Salt 50 km; L36	Dust, Smoke, Sulfates, Sea Salt 27 km; L60	Dust, Smoke, Sulfates, Sea Salt 25 km; L64	Dust, Smoke, Sulfates, Sea Salt 25 km; L64
CMC (Canada)	Nil	tbd	tbd	tbd	tbd	tbd
CPTEC/INPE (Brazil)	T126 L68 Chemistry gas-phase with Carbon bond chem. mechanism, aerosols including direct and indirect effect	T256 L68 volcanoes aerosols and SO2, soil dust, anthopogenic and seal salt and aqueous phase chemistry	tbd	tbd	tbd	tbd

JMA **(Japan)**	Stratospheric Ozones T42L68, Tropospheric Ozones T106L30 Aerosols T106L30	Stratospheric Ozones T42L68, Tropospheric Ozones T106L30 Aerosols T106L30	tbd	tbd	tbd	tbd
CMA **(China)**	tbd	tbd				
KMA **(Korea)**	Nil	tbd				
NCMRWF **(India**	Nil	tbd				
BoM **(Australia)**	Nil	tbd				

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Part IV: Atmospheric composition

b) Regional atmospheric composition modelling (Type [Aerosols? Chemically reactive gases?] and resolution)

Forecast Centre (Country)	2010	2011	2012	2013	2014	2015
ECMWF **(Europe)**	MACC European air quality analyses/forecasts from a 7-model ensemble at variable resolution (0.15° - 0.5°)	MACC European air quality analyses/forecasts from a 7-model ensemble at variable resolution (0.15° - 0.5°)	Pending contract negotiations with EC	Pending contract negotiations with EC	Pending contract negotiations with EC	Pending contract negotiations with EC
Met Office **(UK)**	Aerosols+chemistry 12km	Aerosols+chemistry 12km	Aerosols+chemistry 12km	tbd	tbd	tbd
Météo France (France)	Resolution : Europe EU27 0.5°, France 0.1°. Gas phase Chemistry : 118 species, over 300 reactions (comprehensive strat+trop scheme). Aerosol : dusts, sea salts (mid-2010), black carbon (mid-2010), sulfate (mid-2010), anthropogenic PM2.5 and PM10-2.5 (mid-2010)	increase Europe domain resolution to 0.2° and France domain resolution to 0.025° (for D1 forecast only)	Implement a data assimilation step + Finalize comprehensive aerosol scheme (including SOA, ammonia,…)	tbd. CPU permitting, increase gradually to target resolutions : Europe 0.1° and France 0.025° (beyond D1)	tbd. CPU permitting, increase gradually to target resolutions : Europe 0.1° and France 0.025° (beyond D1)	tbd. CPU permitting, increase gradually to target resolutions : Europe 0.1° and France 0.025° (beyond D1)
DWD **(Germany)**	Nil	Nil	tbd	tbd	tbd	tbd
HMC **(Russia)**	Nil	Nil	tbd	tbd	tbd	tbd
NCEP **(USA)**	Chemically reactive Gas-Phase only Passive wild-fire smoke 12 km	Chemically reactive Gas-phase only Passive wild-fire smoke and dust 4 km	Chemically reactive Gas-phase only Passive wild-fire smoke and dust 4 km	Chemically reactive Gas-phase only Passive wild-fire smoke and dust 2.5 km	Chemically reactive Gas-phase and full aerosols 2.5 km	Chemically reactive Gas-phase and full aerosols 2.25 km
Navy/FNMOC/NRL **(USA)**	Dust 45/15/5 km; L40	Dust 45/15/5 km; L40	Dust, Smoke, Sulfates, Sea Salt 27/9/3 km; L40	Dust, Smoke, Sulfates, Sea Salt 27/9/3 km; L50	Dust, Smoke, Sulfates, Sea Salt 9/3/1 km; L50	Dust, Smoke, Sulfates, Sea Salt 9/3/1 km; L50

CMC **(Canada)**	Continental air quality: GEM-MACH 15 km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry]	Continental air quality: GEM-MACH 15 km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry]	Continental air quality: GEM-MACH 10 km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry]	Continental air quality: GEM-MACH 10 km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry] GEM-MACH 2.5km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry] - 1 window	Continental air quality: GEM-MACH 8 km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry] GEM-MACH 2.5km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry] - 1 window	tbd GEM-MACH 2.5km [aerosols: 2 size bins,8 chemical species; NOx/VOC/O3 oxidant chemistry] - 1 window
CPTEC/INPE (Brazil)	30 km, 43 vertical levels (from 100m to 1000m) with the top at 22 km. Chemistry gas-phase with Carbon bond chem. mechanism, aerosols including direct and indirect effect	20 km, volcanoes aerosols and SO2, soil dust, anthopogenic and seal salt and aqueous phase chemistry	10 km	tbd	tbd	tbd
JMA **(Japan)**	No regional system	tbd	tbd	tbd	tbd	tbd
CMA **(China)**	tbd	tbd				
KMA **(Korea)**	Nil	tbd				
NCMRWF **(India**	Nil	tbd				
BoM **(Australia)**	Nil	tbd				