FAX MESSAGE **FAX MESSAGE**

TO:	**TAC Representatives, Met. Contact Points and Computing Representatives**
FROM:	**Walter Zwieflhofer, Head, Operations Department**
DATE:	**15 March 2007**
SUBJECT:	**Changes in the ECMWF forecasting system**

Dear Colleagues

A new cycle of the ECMWF forecast and analysis system, cycle 32r1, is now ready for implementation. This version includes the following changes:

- Three-minimization version of 4D-Var assimilation scheme (T95/T159/T255) with improved moist linear physics (cloud and convection)
- Improved parametrization of the heterogeneous ozone chemistry
- New short-wave radiation scheme (RRTM-SW), plus McICA cloud-radiation interaction and MODIS albedo
- Retuned ice particle size
- revised subgrid-orography scheme
- explicit numerical treatment of convection in the moist tangent linear model used in the calculation of tropical singular vectors

The impact of the new cycle on the performance of the forecasting system has been tested in research mode for the months of July to November 2006, and in pre-operational runs over the period December 2006 to February 2007. The greatest impact is in the tropical troposphere which has significant improvements at all forecast ranges. There are also moderate but statistically significant improvements in the extra-tropical troposphere particularly in the first three days.

The EPS has been tested for December 2006. In the extra-tropics, ensemble spread is similar to the operational suite, while at 500 hPa the ensemble-mean error is reduced. In the tropics the spread at 850 hPa is increased, moving closer to the ensemble-mean error.

The new GRIB model identifiers will be: 129 (atmospheric model), 116 (global wave model) and 216 (limited area wave model).

The planned date for implementation of this model version is 27 March 2007. The first operational run using the new cycle will be the 06 UTC analysis and forecast in the Boundary Condition Project, followed by the 12 UTC main forecast. The monthly forecast system for the following Thursday, 29 March 2007, will also be run with this new IFS cycle.

Yours sincerely

Walter Zwieflhofer
Head, Operations Department

New short-wave radiation scheme RRTM-SW, plus McICA cloud-radiation interaction and MODIS albedo

The impact of the new cycle … has been tested … for the months of July to November 2006, … and December 2006 to February 2007 …

… significant improvements at all forecast ranges in the tropics … also moderate but statistically significant improvements in the extra-tropical troposphere particularly in the first three days.

Implementation on 27 March 2007

McICA: A state-of-the-art method for representing cloud-radiation interactions in GCMs

Jean-Jacques Morcrette

ECMWF

* McICA, the Monte-Carlo Independent Column Approximation
* The ECMWF McICA configuration: McRad
* Practical implementation
* Results in 13-month simulations at T_L159 L91
* Impact on forecasts at T_L511 L91 and analysis at T_L799 L91

Acknowledgments:

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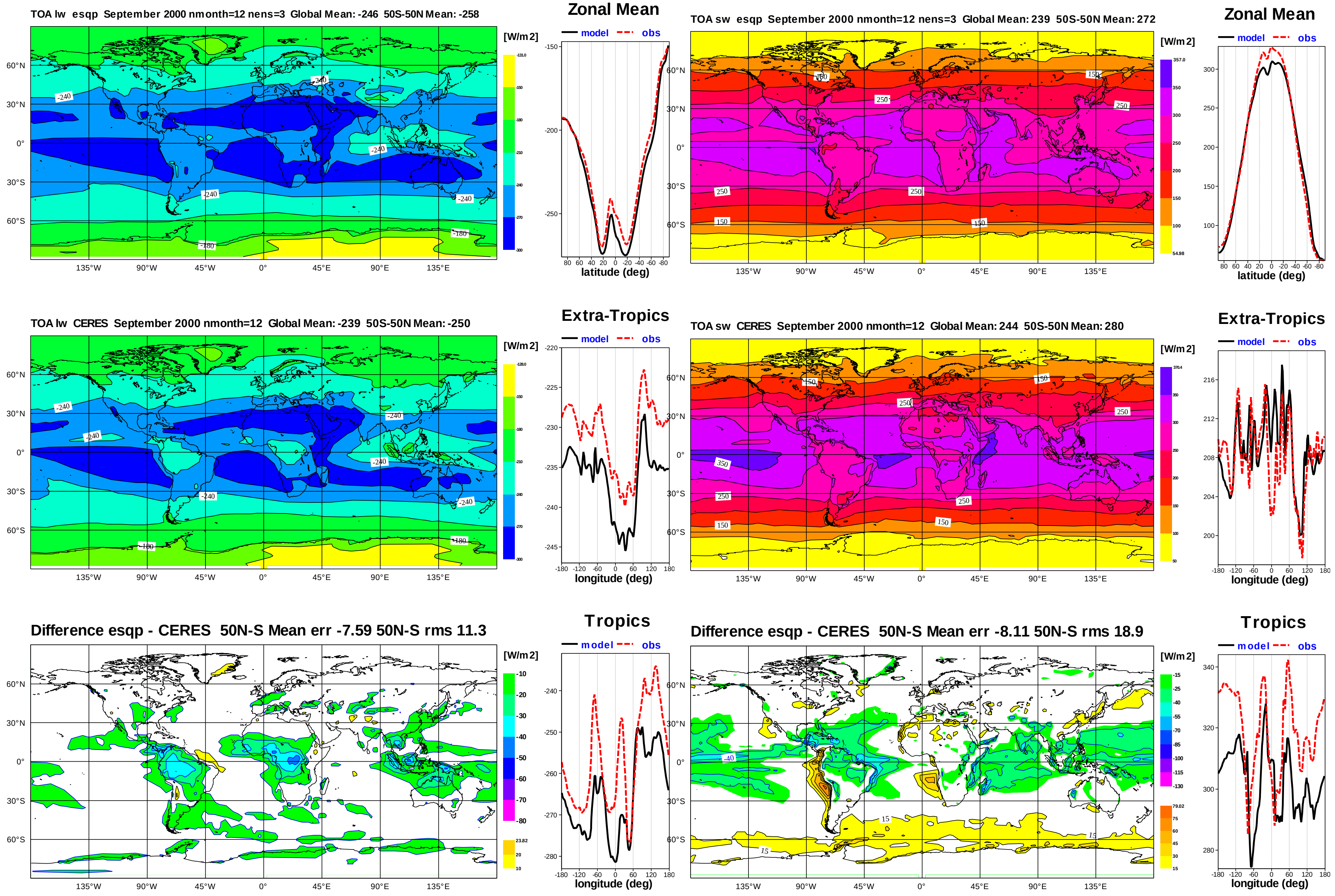
M.J. Iacono, E.J. Mlawer, S.A. Clough (AER, Inc)
D. Salmond, P. Bechtold, J. Hague, L. Isaksen, Th. Jung, A. Tompkins (ECMWF)

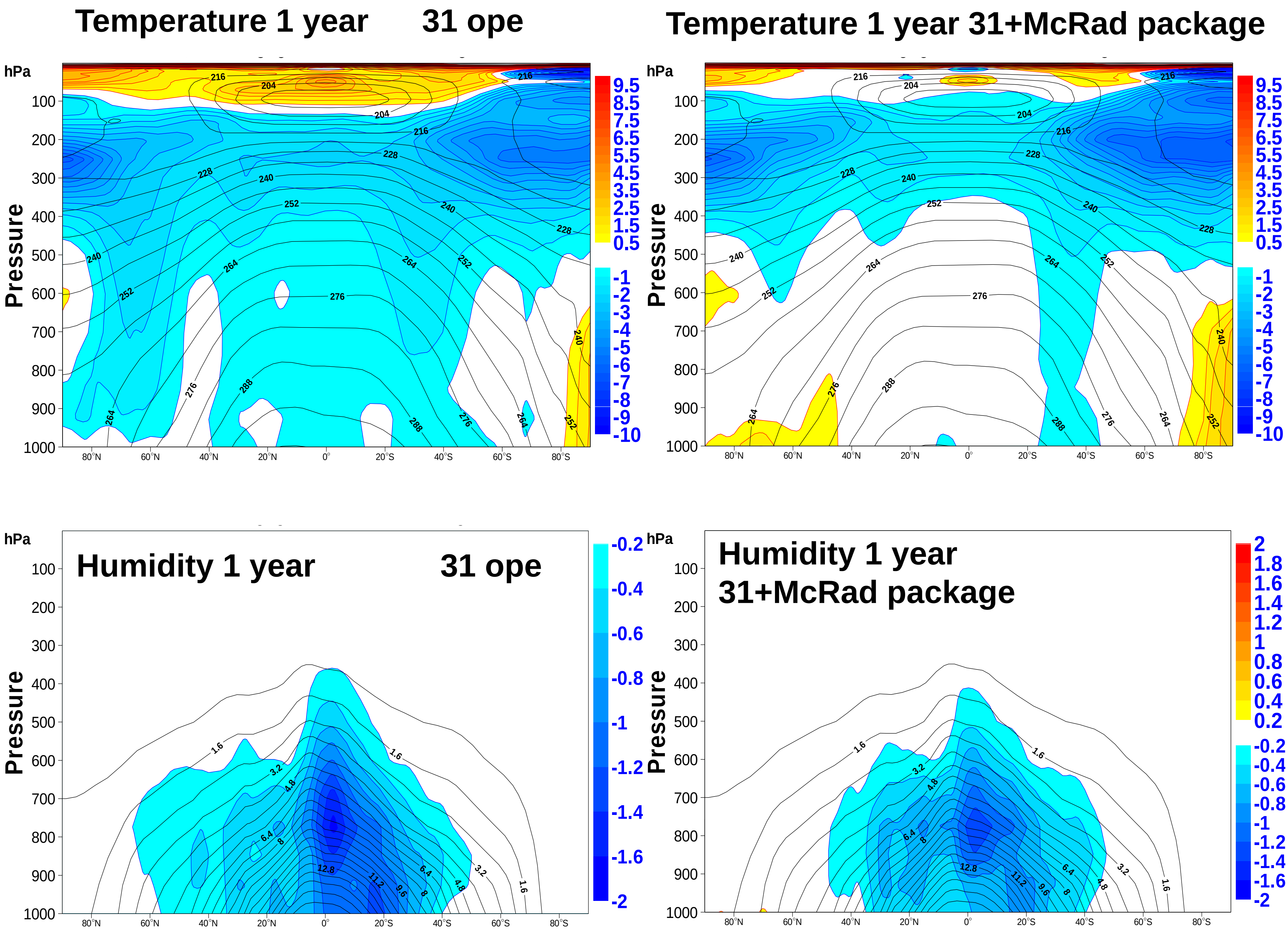
The problem in ECMWF model "climate" runs?



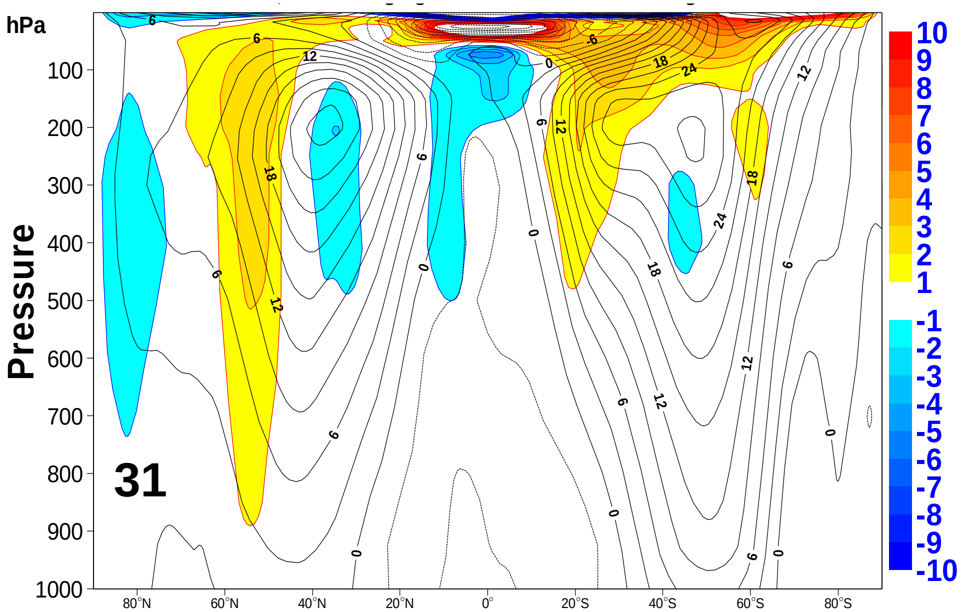
The ECMWF McRad configuration

= RRTM_LW + RRTM_SW + McICA + cloud optical properties

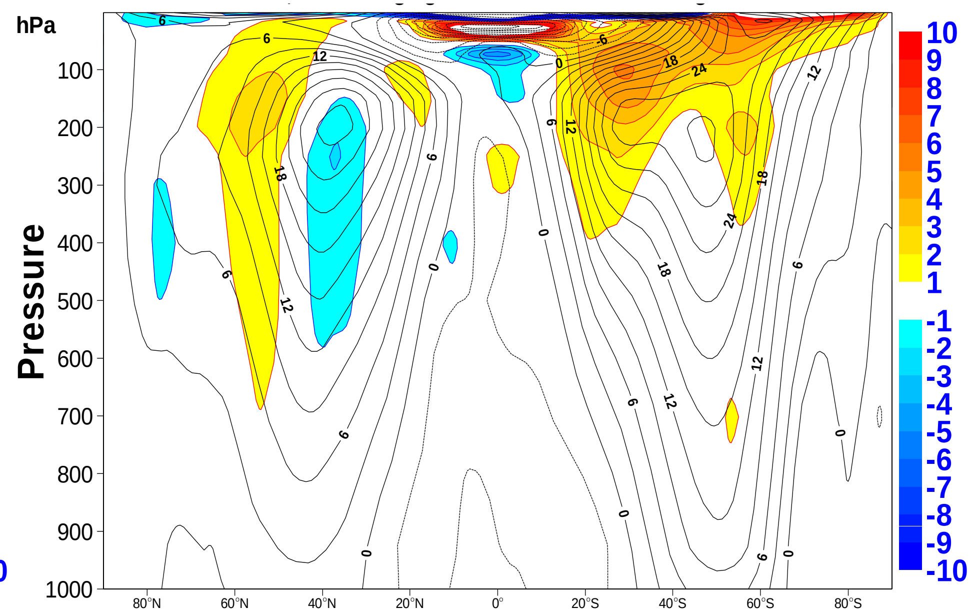
- **RRTM_SW from AER, Inc, with reduced number of g-points from the original 224 to 112**
  - **RRTM_SW is more expensive than SW6 (see later)**
- **McICA version for both RRTM_LW and RRTM_SW: no cloud fraction anymore: a layer is either clear-sky or overcast**
  - **McICA does not cost anything (as such)**
- **Random generator (Raisanen and Barker, 2004) gives 0 or 1 cloud for each layer and each of the 140 (112) g-points of the LW (SW) radiation scheme for either a maximum-random or a generalized overlap assumption, with loose constraint over the total cloudiness**
- **"New" cloud optical properties (see next table, main point: D_e=f(IWC,T))**
- **In the following, results are shown for the generalized overlap (a la Hogan and Illingworth, 2000) with a decorrelation length of 2km for cloud fraction, and 1km for cloud condensate (see later)**


Temperature 1 year 31 ope
Temperature 1 year 31+McRad package
Humidity 1 year 31 ope
Humidity 1 year
31+McRad package
hPa
Pressure
100
200
300
400
500
600
700
800
900
1000
80°N
60°N
40°N
20°N
0°
20°S
40°S
60°S
80°S
9.5
8.5
7.5
6.5
5.5
4.5
3.5
2.5
1.5
0.5
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2

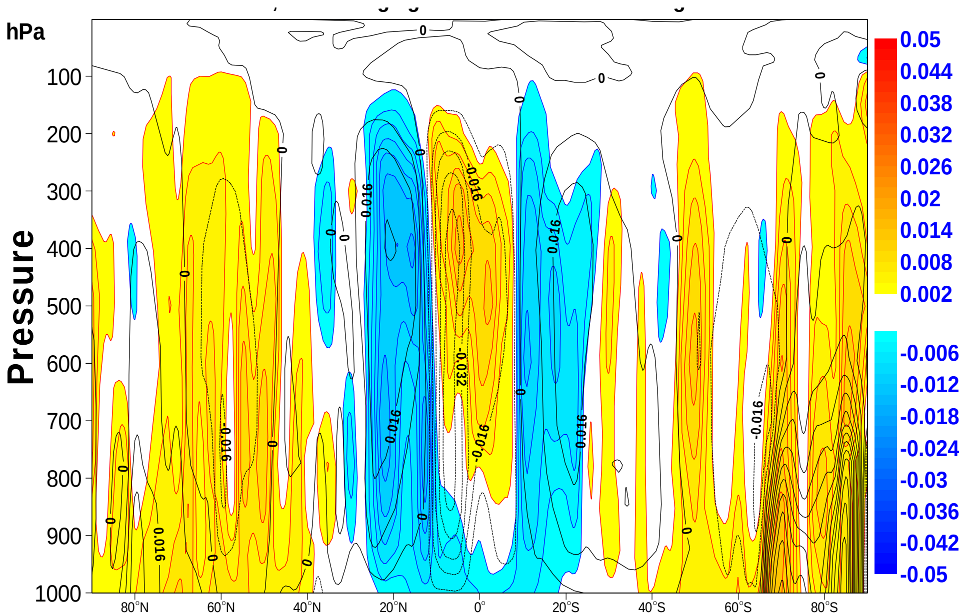
Zonal Wind 1 year 31 ope



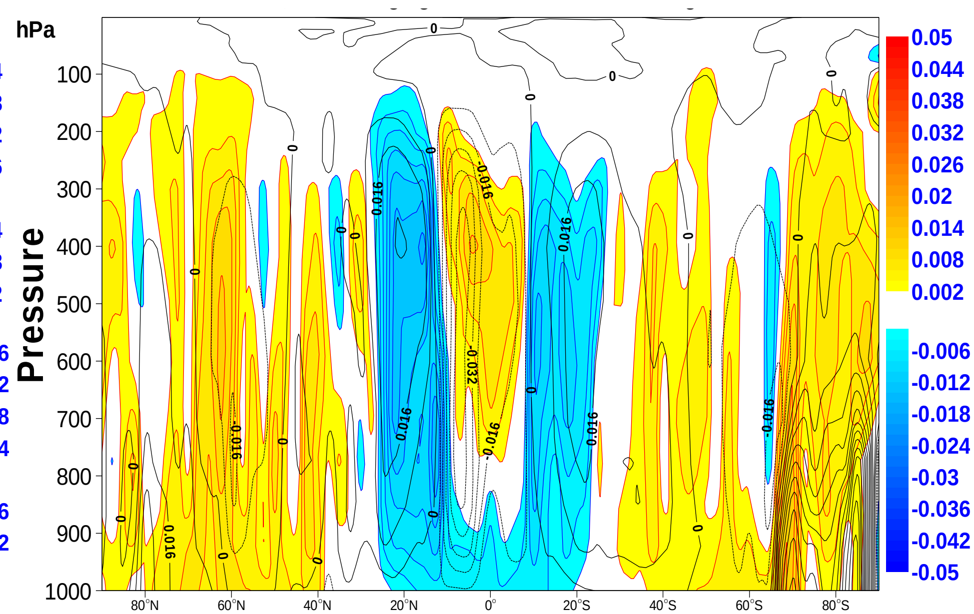
Zonal Wind 1 year 31+McRad package



Vert.Veloc. 1 year 31 ope



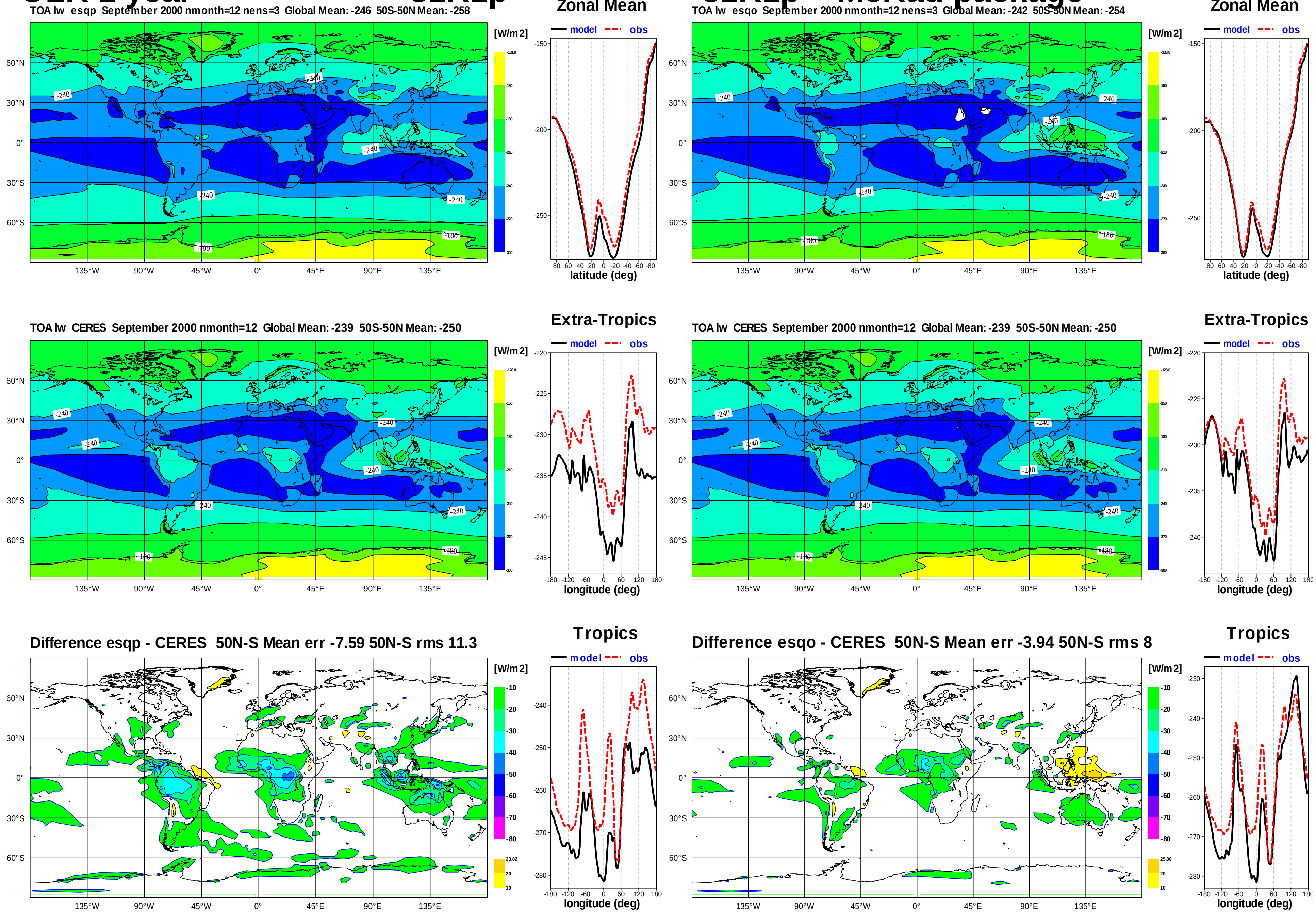
Vert.Veloc. 1 year 31+McRad package



OLR 1 year

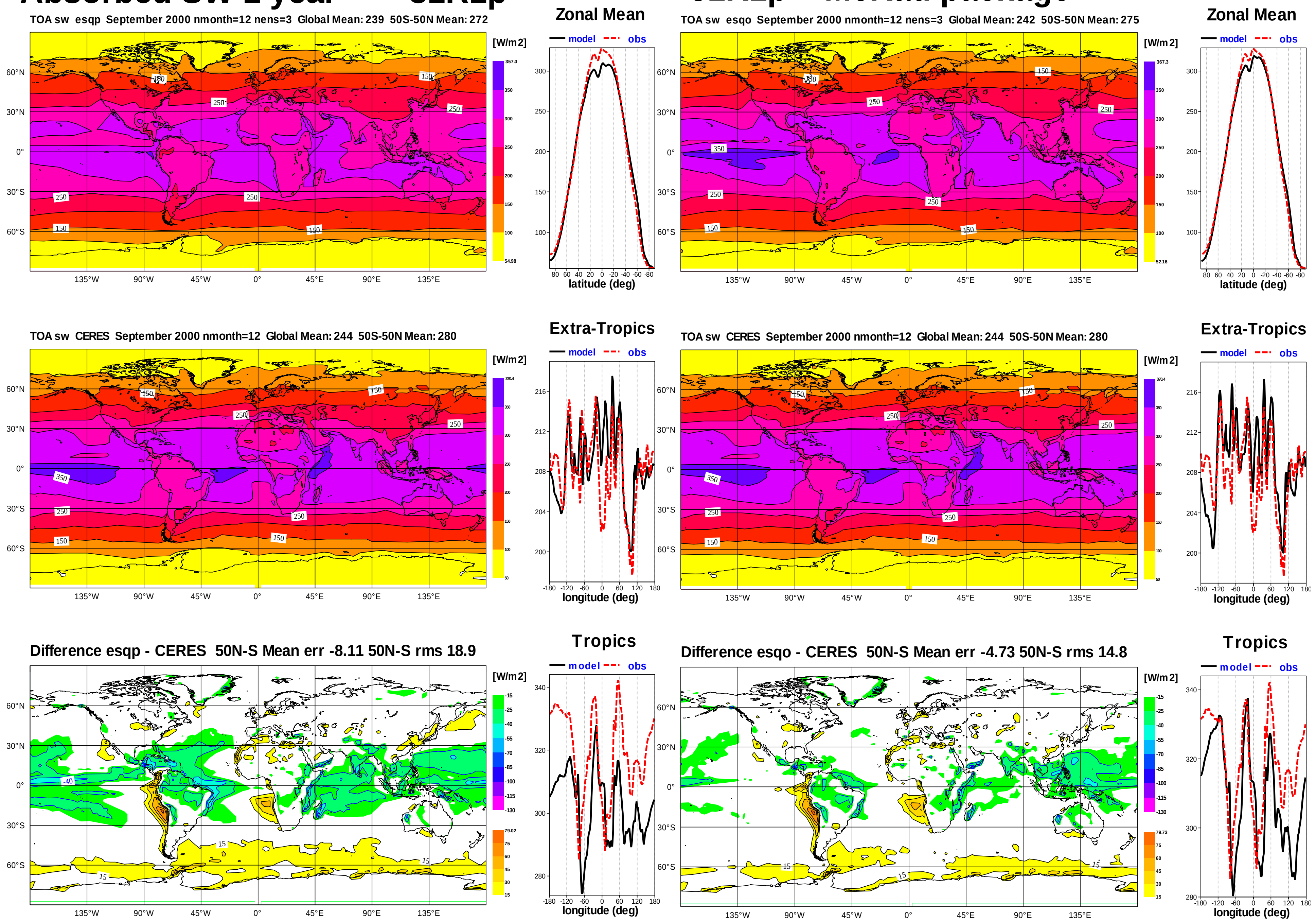
31R1p

31R1p + McRad package



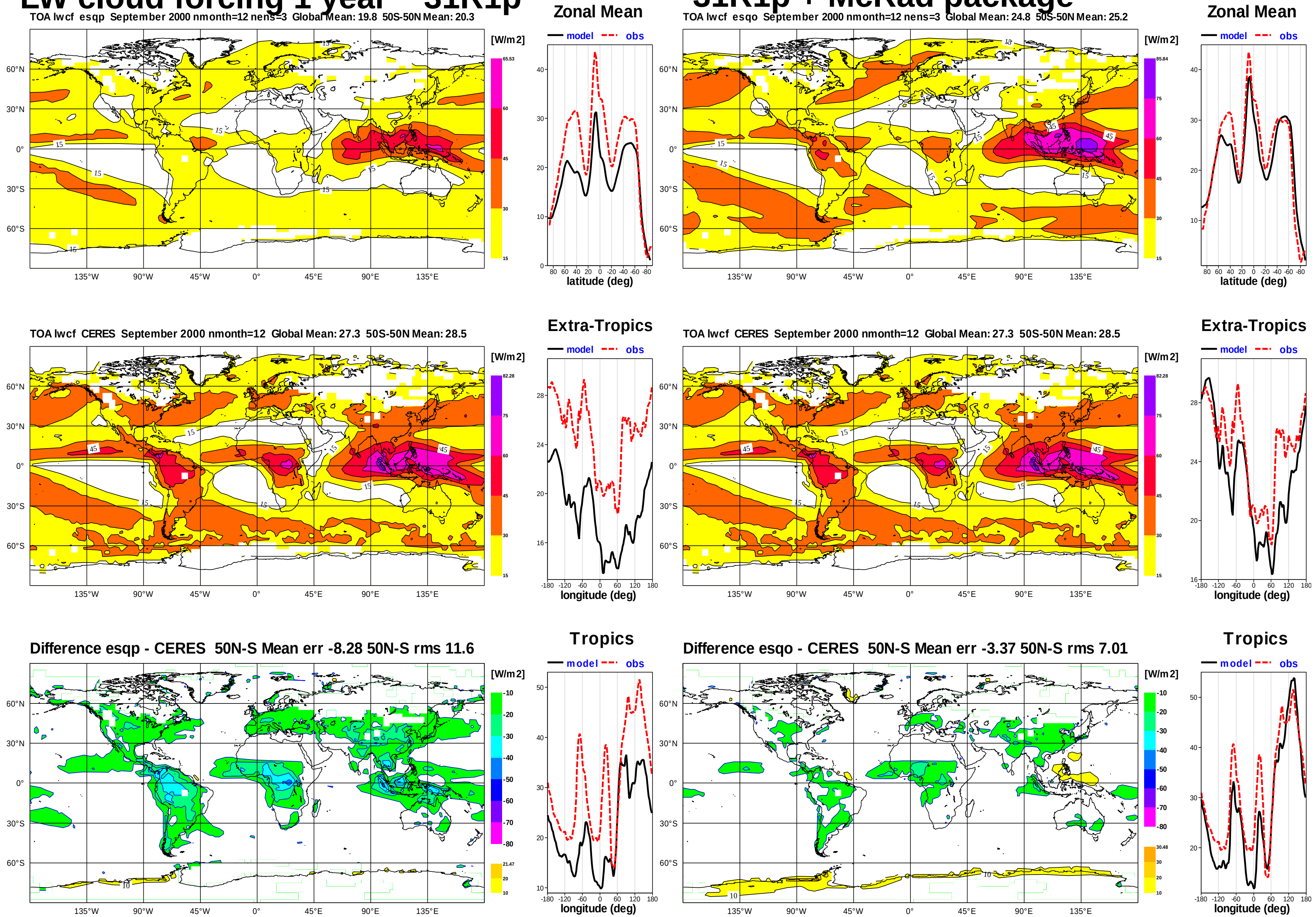
Absorbed SW 1 year 31R1p

31R1p + McRad package



LW cloud forcing 1 year 31R1p

31R1p + McRad package



SW cloud forcing 1 year 31R1p

31R1p + McRad package

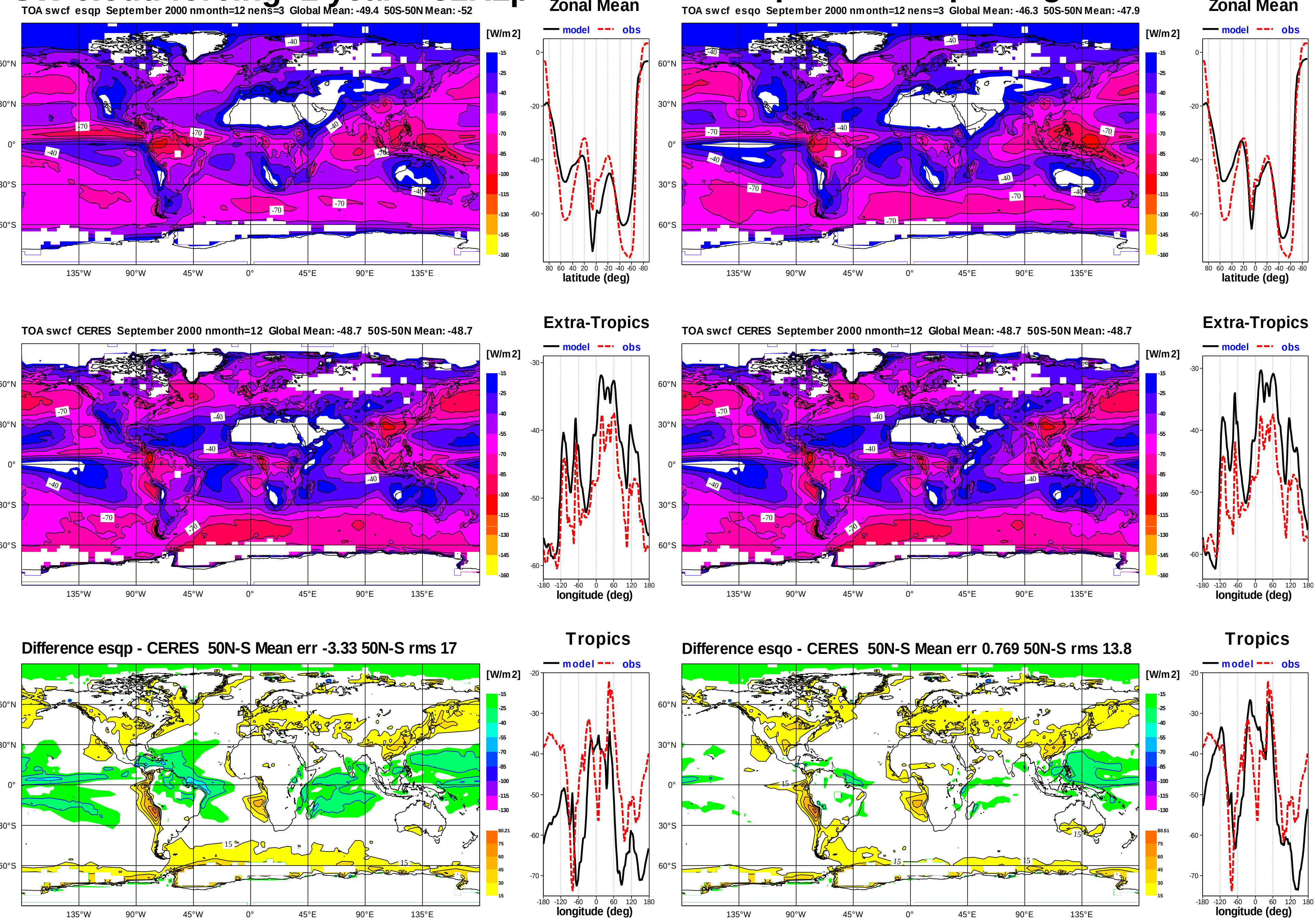


Table 2: Results from 13-month simulations at T_L159 L91. Radiative fluxes at TOA are compared to CERES measurements.

All quantities in W m^{-2}

	Annual		DJF		JJA	
OLR	-239.0		-236.0		-242.0	
cy31	-8.1	12.7	-6.1	15.0	-5.1	12.8
cy31+McICA	-3.2	7.9	-1.1	10.1	-0.6	10.5
cy31R1p	-7.6	11.2	-5.4	12.9	-5.0	11.9
cy31R1p+McICA	-3.9	8.0	-1.3	10.0	-1.5	11.2
Absorbed SW	244.0		251.0		238.0	
cy31	-10.0	17.5	-15.6	23.9	-9.2	19.7
cy31+McICA	-5.8	14.2	-11.4	20.5	-5.3	18.6
cy31R1p	-8.1	18.9	-13.9	25.0	-7.1	20.6
cy31R1p+McICA	-4.7	14.8	-10.8	20.8	-4.2	19.2
LW Cloud Forcing	27.3		26.8		26.1	
cy31	-9.6	13.6	-10.4	16.5	-8.3	14.1
cy31+McICA	-4.0	7.9	-4.8	10.3	-3.0	9.7
cy31R1p	-8.3	11.6	-9.1	14.2	-7.2	12.4
cy31R1p+McICA	-3.4	7.0	-4.1	9.4	-2.3	9.5
SW Cloud Forcing	-48.7		-52.8		-45.1	
cy31	-5.2	15.4	-4.1	18.6	-6.3	18.2
cy31+McICA	-0.2	12.9	0.5	17.0	-1.3	17.3
cy31R1p	-3.3	17.0	-2.4	20.1	-4.3	19.1
cy31R1p+McICA	0.8	13.8	1.1	17.3	-0.4	18.0

Table 3: Results from 13-month simulations at T_L159 L91. Total cloud cover (%) is compared to ISCCP D2 data, total column water vapour (kg m^{-2}) and liquid water (g m^{-2}) to SSM/I data, The total precipitation (mm day^{-1}) compared to GPCP or SSM/I data.

	Annual		DJF		JJA	
Total Column Water Vapour	29.0		27.7		29.3	
cy31	-2.10	3.65	-2.27	4.29	-1.73	3.69
cy31+McICA	-1.67	3.13	-1.80	3.63	-1.25	3.32
cy31R1p	-1.80	3.34	-2.00	4.00	-1.43	3.37
cy31R1p+McICA	-0.99	2.84	-1.29	3.33	-0.47	3.30
Total Cloud Cover	62.2		62.9		61.4	
cy31	-6.0	10.3	-5.7	12.3	-5.4	11.8
cy31+McICA	-5.3	9.5	-4.9	11.2	-4.7	11.4
cy31R1p	-4.0	11.0	-3.8	12.5	-3.7	13.0
cy31R1p+McICA	-2.2	10.9	-1.4	11.4	-2.2	13.4
Total Column Liquid Water	82.2		80.4		84.3	
cy31	1.7	22.1	3.1	33.4	-1.1	30.6
cy31+McICA	0.9	22.4	2.1	32.8	-1.2	30.8
cy31R1p	-8.1	22.4	-6.5	31.9	-11.1	31.6
cy31R1p+McICA	-6.0	21.0	-4.8	30.9	-8.7	29.8
Total Precipitation gpcp	2.61		2.58		2.63	
cy31	0.45	1.39	0.42	1.88	0.43	1.75
cy31+McICA	0.40	1.21	0.37	1.60	0.41	1.72
cy31R1p	0.32	1.27	0.30	1.68	0.31	1.80
cy31R1p+McICA	0.24	1.14	0.22	1.56	0.24	1.71
Total Precipitation ssmi	3.80		3.57		3.66	
cy31	0.67	2.45	0.57	3.56	0.44	3.90
cy31+McICA	0.50	2.23	0.38	3.32	0.35	3.81
cy31R1p	0.43	2.35	0.34	3.49	0.28	3.87
cy31R1p+McICA	0.22	2.17	0.13	3.33	0.10	3.70

Table 4: Results from 13-month simulations at T_L159 L91. The surface fluxes over the ocean are compared to the Da Silva climatology.

All quantities in W m^{-2}

OCEAN only	Annual	DJF	JJA
Net Solar Radiation	155.2	163.7	143.7
cy31	8.4	15.1	0.3
cy31+McICA	15.6	21.9	7.4
cy31R1p	11.5	18.8	3.0
cy31R1p+McICA	17.0	23.9	7.7
Net Longwave Radiation	-51.8	-52.5	-50.4
cy31	0.6	1.0	1.3
cy31+McICA	-0.1	0.3	0.6
cy31R1p	-4.3	-4.0	-3.4
cy31R1p+McICA	-4.0	-3.9	-3.1
Sensible Heat Flux	-11.0	-13.7	-9.0
cy31	-4.7	-3.0	-5.9
cy31+McICA	-3.5	-2.0	-4.9
cy31R1p	-3.0	-1.6	-4.2
cy31R1p+McICA	-1.4	0.0	-2.7
Latent Heat Flux	-96.5	-100.2	-94.2
cy31	-10.5	-7.7	-11.1
cy31+McICA	-7.2	-4.5	-7.9
cy31R1p	-6.3	-3.9	-6.6
cy31R1p+McICA	-1.7	0.4	-2.1
Surface Net Flux	-2.1	-0.9	-7.9
cy31	-8.1	3.6	-17.9
cy31+McICA	2.8	14.0	-6.8
cy31R1p	-4.0	7.3	-13.3
cy31R1p+McICA	7.8	18.7	-2.2

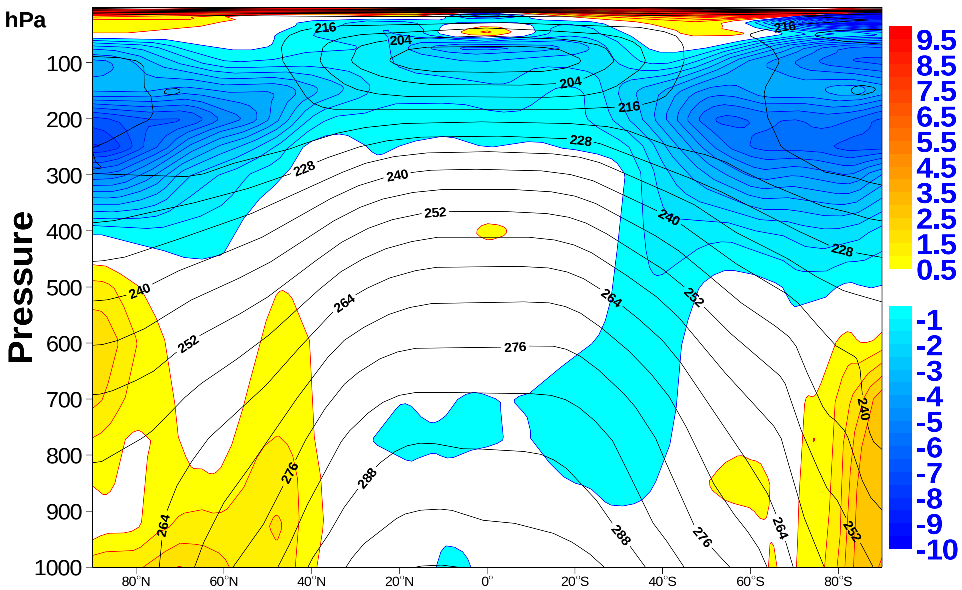
Impact of changes in decorrelation depths for CF and CW

- **Within the cloud generator, different use various decorrelation depths for cloud fraction and cloud water**
  - **Generalized overlap with**
    - **ddCF = 2 km, ccCW = 1 km**
    - **ddCF = 4 km, ccCW = 2 km**
    - **ddCF = 5 km, ccCW = 1 km**
  - **Maximum-random overlap**

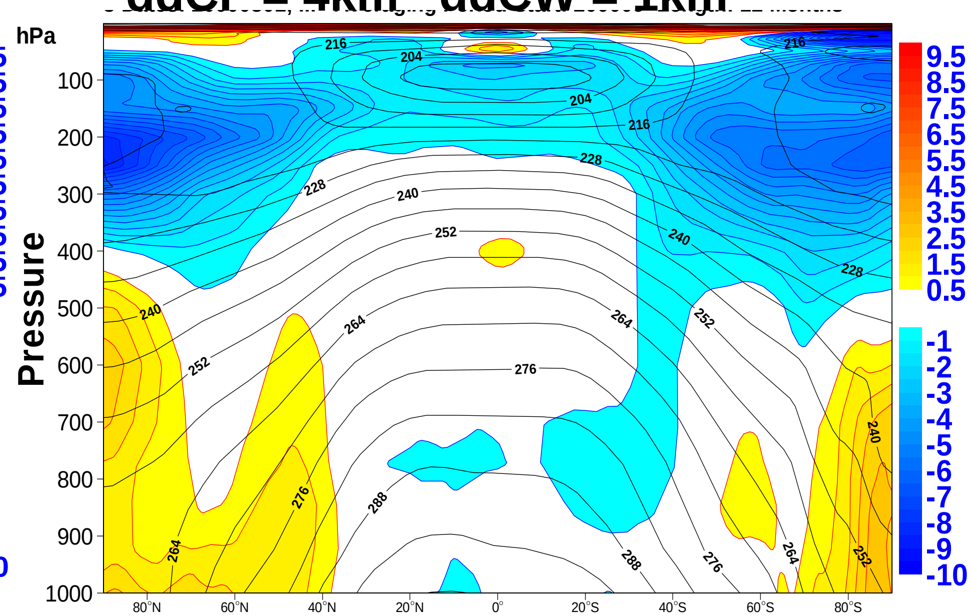
- **Comparisons over 13-month simulations at T_L159 L91**

- **The overall impact of these assumptions is small**

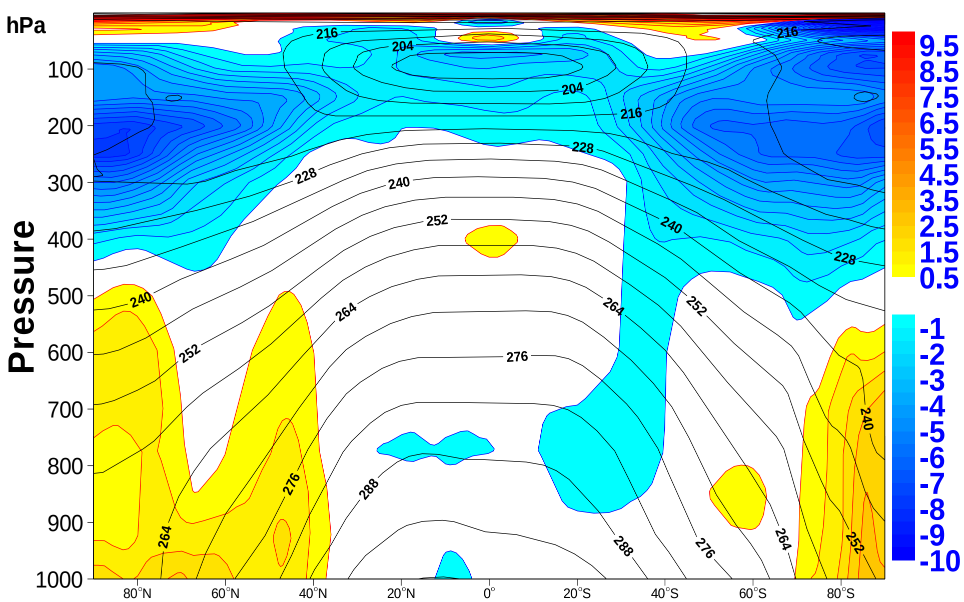
Generalized Overlap
ddCF = 2km   ddCW = 1km



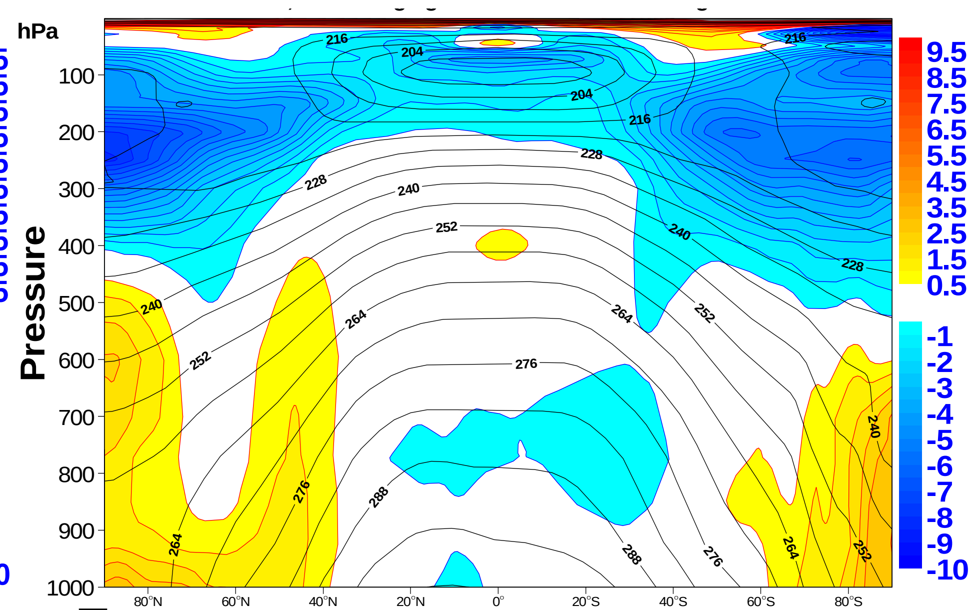
Generalized Overlap
ddCF = 4km   ddCW = 1km



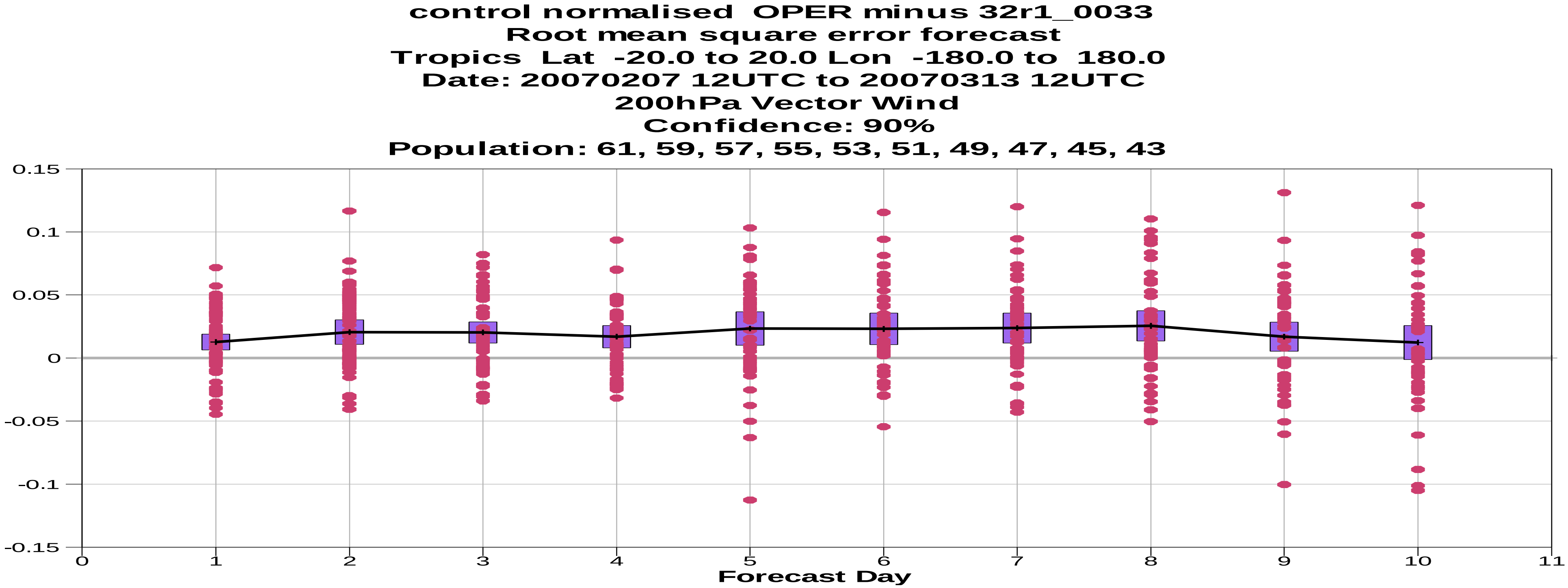
Generalized Overlap
ddCF = 5km   ddCW = 1km

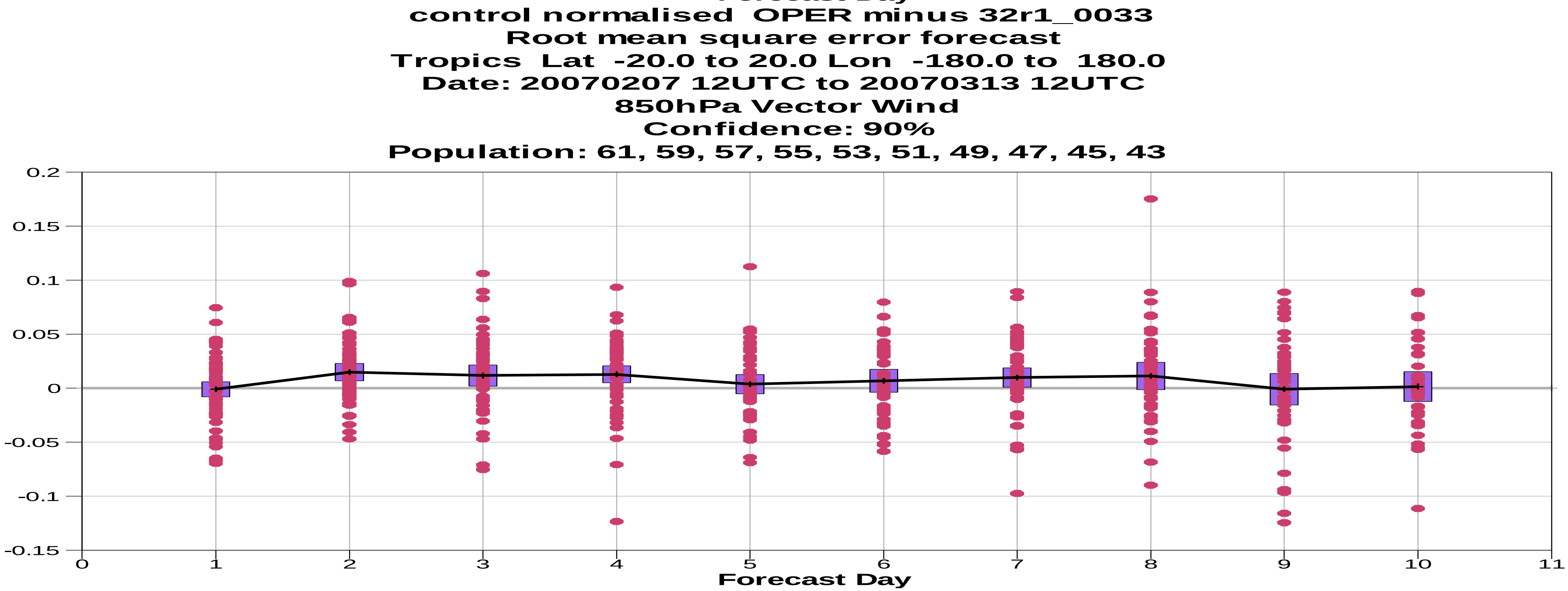


Maximum-Random



Temperature


control normalised OPER minus 32r1_0033
Root mean square error forecast
Tropics Lat -20.0 to 20.0 Lon -180.0 to 180.0
Date: 20070207 12UTC to 20070313 12UTC
200hPa Vector Wind
Confidence: 90%
Population: 61, 59, 57, 55, 53, 51, 49, 47, 45, 43
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0 1 2 3 4 5 6 7 8 9 10 11
Forecast Day


control normalised OPER minus 32r1_0033
Root mean square error forecast
Tropics Lat -20.0 to 20.0 Lon -180.0 to 180.0
Date: 20070207 12UTC to 20070313 12UTC
850hPa Vector Wind
Confidence: 90%
Population: 61, 59, 57, 55, 53, 51, 49, 47, 45, 43
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
0 1 2 3 4 5 6 7 8 9 10 11
Forecast Day

McICA: A state of the art method for representing cloud-radiation interactions in the ECMWF model

- **McICA allows a consistent approach on the definition of cloud overlap not only between LW and SW radiation, but also with other physical processes (precipitation/evaporation) (Jakob and Klein, 1999, 2000).**

- **RRTM_SW with 112 g-points is a "good scheme" to get the full benefit of McICA. It improves the temperature in the lower stratosphere.**

- **The operational radiation schemes uses Cahalan's homogeneity factors of 0.7 in both LW and SW to account for cloud inhomogeneities. McICA avoids the use of such factors. With McICA, clouds are made more transparent and the change in the distribution of the vertical cloud LW and SW radiative forcings appear to cure some systematic errors of the ECMWF IFS (shifting some of the convection back to tropical continents). This gives a marked improvement on the long term climate of the model. The exact mechanism requires further study.**

- **A similar improvement is seen in the short-term forecasts used as background for the analyses, and in the 10-day forecasts.**

McICA: A state of the art method for representing cloud-radiation interactions in the ECMWF model

- **Whereas McICA does not increase the computational burden, RRTM_SW does. Going for a slightly lower resolution for full radiation computations does not affect the quality of the forecasts.**

- **The model shows little dependence on the decorrelation depths used for cloud fraction and cloud water. But this formulation will allow further developments once knowledge of these quantities become available from CLOUDSAT measurements.**

- **The McICA approach appears particularly adapted to pdf-based cloud schemes**

McRad at ECMWF

- Now operational in
  - 10-day FC at T_L799 L91
  - Ensemble Prediction System: 50 x 10-day FCs at T_L399L62
  - Seasonal FC with mixed ocean layer: 9-month at T_L159 L62

- Thank you for your attention!