REQUEST FOR A SPECIAL PROJECT 2013–2015

MEMBER STATE: France

Principal Investigator[1]: Jean-François Guérémy

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Other researchers:
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Project Title:

Sensitivity of decadal forecast to atmospheric resolution and physics

If this is a continuation of an existing project, please state the computer project account assigned previously.		
Starting year: (Each project will have a well defined duration, up to a maximum of 3 years, agreed at the beginning of the project.)	2013	
Would you accept support for 1 year only, if necessary?	YES ☒	NO ☐

Computer resources required for 2013-2015: (The maximum project duration is 3 years, therefore a continuation project cannot request resources for 2015.)	**2013**	**2014**	**2015**
High Performance Computing Facility (units)	14.5 10**6	14.5 10**6	15 10**6
Data storage capacity (total archive volume) (gigabytes)	40000	30000	30000

An electronic copy of this form ***must be sent*** *via e-mail to:* *special_projects@ecmwf.int*

Electronic copy of the form sent on (please specify date):
27/04/2012

Continue overleaf

[1] The Principal Investigator will act as contact person for this Special Project and, in particular, will be asked to register the project, provide an annual progress report of the project's activities, etc.

Principal Investigator: Jean-François Guérémy

Project Title: Sensitivity of decadal forecast to atmospheric resolution and physics

Extended abstract

It is expected that Special Projects requesting large amounts of computing resources (500,000 SBU or more) should provide a more detailed abstract/project description (3-5 pages) including a scientific plan, a justification of the computer resources requested and the technical characteristics of the code to be used. The Scientific Advisory Committee and the Technical Advisory Committee review the scientific and technical aspects of each Special Project application. The review process takes into account the resources available, the quality of the scientific and technical proposals, the use of ECMWF software and data infrastructure, and their relevance to ECMWF's objectives. - Descriptions of all accepted projects will be published on the ECMWF website.

Scientific proposal:
(plus gueremy_dec_forecasts.pdf, as attached file)

The climate group of CNRM-GAME (CNRM-GAME/GMGEC) has conducted many climate simulations using its own coupled global climate model (CGCM) over the last 15 years. These simulations cover scales ranging from seasonal forecasts up to climate change projections, including more recently decadal forecasts. For the purpose of CMIP5, a new version of the CGCM has been released, called CNRM-CM5 (Voldoire et al., 2012). CNRM-CM5 has been used to perform both the CMIP5 climate change projections together with the CMIP5 decadal forecasts. Moreover, this version will be used for the upcoming EUROSIP CNRM System 4.
Decadal forecast activity is more recent at CNRM. It started in the frame of the EU ENSEMBLES project in 2008. Last year, the CERFACS has carried out the CMIP5 decadal forecasts using the CNRM-CM5 model. At CNRM, I have been involved since the beginning of last year in a French research project (called EPIDOM) devoted to decadal forecast (Guérémy and Laanaia, 2012; see the attached file). My own activity at CNRM/GMGEC is shared between climate prediction research, notably with a participation to EU projects such as DEMETER (Guérémy et al, 2005) or MERSEA, and convective parameterization research (Guérémy, 2012).
The present proposal aims to take advantage of all these recent elements of context. The main goal will be the investigation of the sensitivity of decadal forecast to atmospheric resolution and physics. This particular topic has been partly addressed in the frame of EPIDOM. Indeed, using CNRM_CM5 (including a new parameterization of non-orographic gravity wave drag) with a coarser horizontal resolution (Tl63 instead of Tl127, the former being cheaper), ensembles of 10 member decadal forecasts have been performed considering 5 starting dates (1981 to 2001, every 5 years) in the frame of a twin experiment using a low top (LT, 62 vertical levels) in one hand and a high top (HT, 91 levels, identical in the troposphere but including the stratosphere) in the other hand. It is shown that the inclusion of the stratosphere provide significant differences between the anomalies of LT and HT in few places all around the globe (larger differences for the years 2-5 versus 6-9). At the same time, HT is providing light improvement in terms of scores particularly for years 6-9 and notably over mid-latitude and polar regions of both hemisphere.
Following this twin experiment, in the frame of the present proposal (for the first year), we would like to carry out another twin experiment including the stratosphere (91 levels), but using the CMIP5 horizontal resolution (Tl127). The first experiment would use the CMIP5 physics, while the second would use a more recent prognostic physics including a prognostic TKE turbulence scheme (Cuxart et al., 2000), a prognostic resolved microphysics (Lopez, 2002) and a CAPE relaxation convection scheme (Guérémy, 2011 and Piriou, 2012, personal communication for the prognostic convective microphysics following Lopez, 2002). The plan would be to consider 10 departure dates (the CMIP5 ones from 1960 to 2005, every 5 years) over 10 years with 8 members. With such an experimental design, it will be possible to compare the results to those obtained in the frame of

CMIP5 (Tl127l31) and EPIDOM (Tl63l91) beyond the only sensitivity test to the physics. Thus, both sensitivity of decadal forecasts to physics and resolution will be investigated.
During the second year, we propose to perform the same type of decadal forecast experiment (10 starting dates * 10 years * 8 members) only using the new physics but considering a larger horizontal geometry (Tl179 instead of Tl127). Such a larger geometry implies a factor 2 in terms of computing resources.
During the third year, we propose to perform another decadal forecast experiment (10 starting dates * 10 years * 8 members) only using the new physics but considering additional improvements, notably the inclusion of prognostic scheme for the aerosols.

<u>Technical characteristics:</u>

CNRM-CM5 includes ARPEGE-Climat as atmospheric component , NEMO v3 from IPSL (1°, 42 levels + GELATO ice model from CNRM) as oceanic component and OASIS v3 from CERFACS (coupler).
In order to perform a decadal experiment (10 starting dates * 10 years * 8 members) using the Tl127l91 geometry for ARPEGE-Climat, 7.25 10**6 units are needed. Therefore, 14.5 10**6 units are needed for the first year, together with data storage volume of 40 To.
The same experiment using the Tl179l91 geometry for ARPEGE-Climat requires the double in terms of computing resources. Therefore, 14.5 10**6 units are needed for the second and third year, together with data storage volume of 30 To.

References:

Cuxart, J., Bougeault, P. and Redelsperger, J. -L., 2000. A turbulence scheme allowing for mesoscale and large-eddy simulations. Q. J. R. Meteorol. Soc. 126, 1–30.

Guérémy, J.F., M. Déqué, A. Braun, J.P. Piedelievre, 2005: Actual and potential skill of seasonal predictions using the CNRM contribution to DEMETER: coupled versus uncoupled model. Tellus, 57A, 308-319.

Guérémy J.-F., 2011. A continuous buoyancy based convection scheme: one- and three-dimensional validation. Tellus A, 63, 687–706.

J.-F. Guérémy and N. Laanaia, 2012. Decadal forecasts with CNRM-CM5. Sensitivity to the nclusion of the stratosphere. EGU General Assembly 2012 (gueremy_dec_forecasts.pdf, as attached file).

Lopez, P. 2002. Implementation and validation of a new prognostic large scale cloud and precipitation scheme for climate and data-assimilation purposes. Q. J. R. Meteorol. Soc. 128, 229–257.

A. Voldoire, E. Sanchez-Gomez, D. Salas y Mélia, B. Decharme, C. Cassou, S. Sénési, S. Valcke, I. Beau, A. Alias and M. Chevallier, et al., 2012. The CNRM-CM5.1 global climate model: description and basic evaluation. Climate Dynamics.

Decadal forecasts with CNRM-CM5. Sensitivity to the inclusion of the stratosphere

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OUTLINE

Aim of the study: Sensitivity of the skill of decadal forecast to the inclusion of the stratosphere

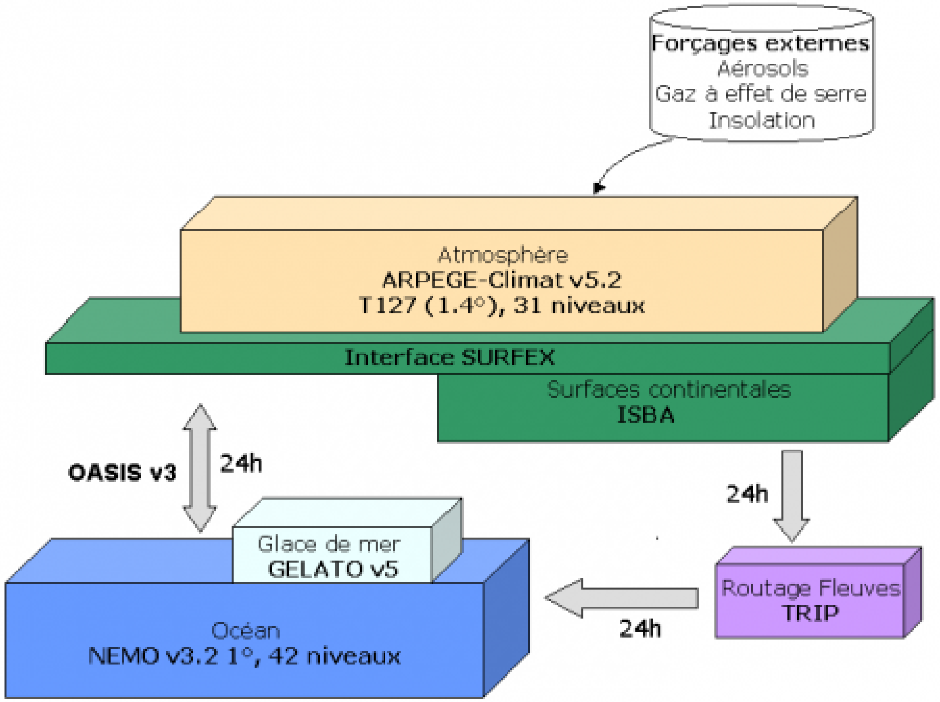
- Forecast datasets
- Biases, drifts and time series
- Anomaly time series and significance of the stratosphere inclusion
- Correlations and ROC
- Conclusion and prospects

Forecast dataset

Twin experiments performed with the coupled global model CNRM-CM5 (Voldoire et al., 2012), using a Tl63 ARPEGE-Climat geometry (310 km):

62 levels up to 5 hPa (Low Top, **LT**)

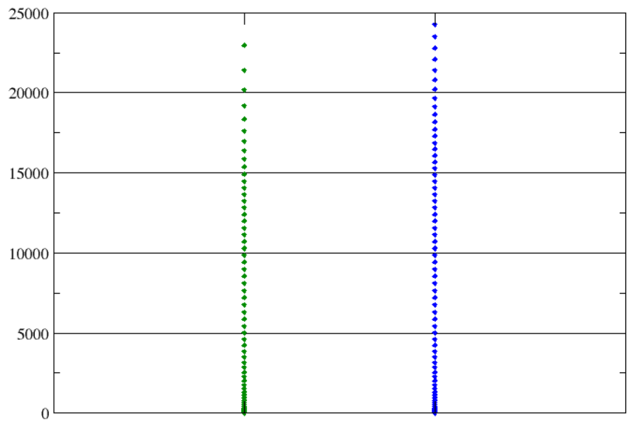
91 levels up to 0.01 hPa (High Top, **HT**)



Forecast dataset

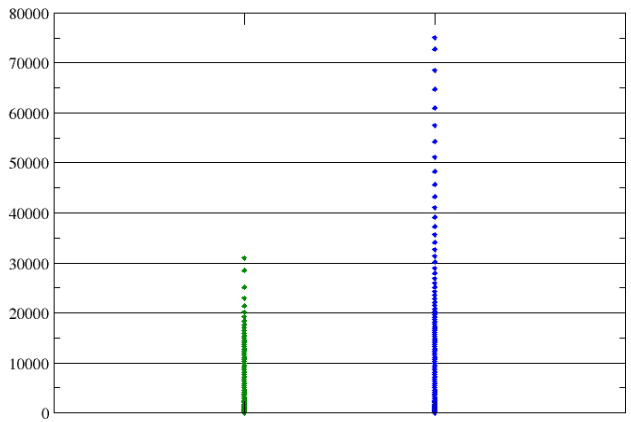
10 member ensembles for 5 starting dates (First of January 1981, 1986, 1991, 1996, 2001).

Initial conditions from a nudged coupled simulation; in the ocean toward ECWMF analysis of (T,S), and in the atmosphere toward ECWMF analysis of relative vorticity.



62 91

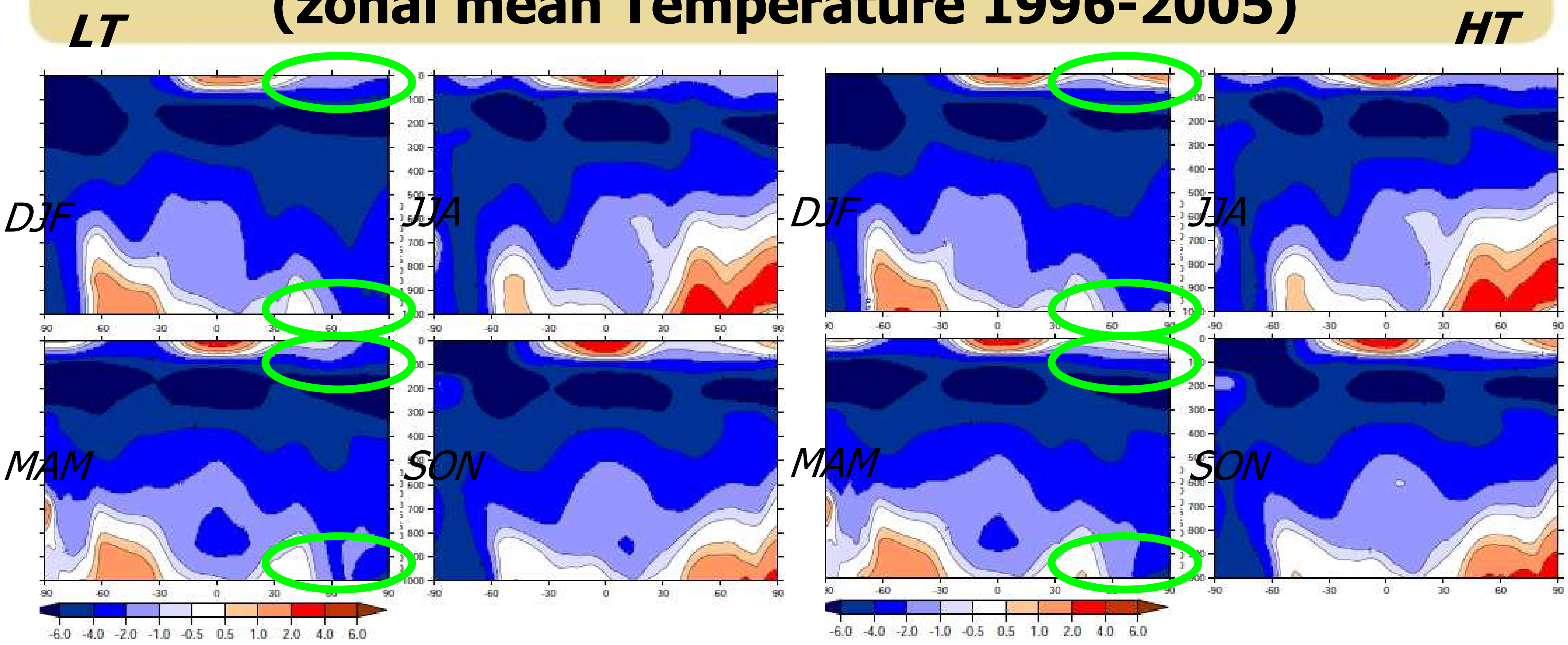
Troposphere



62 91

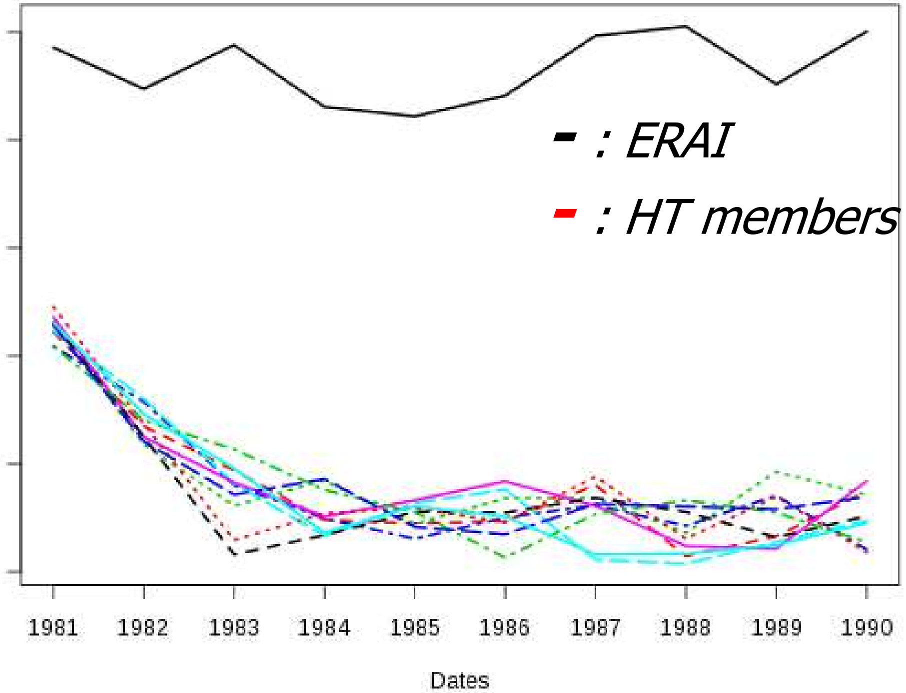
Troposphere + Stratosphere

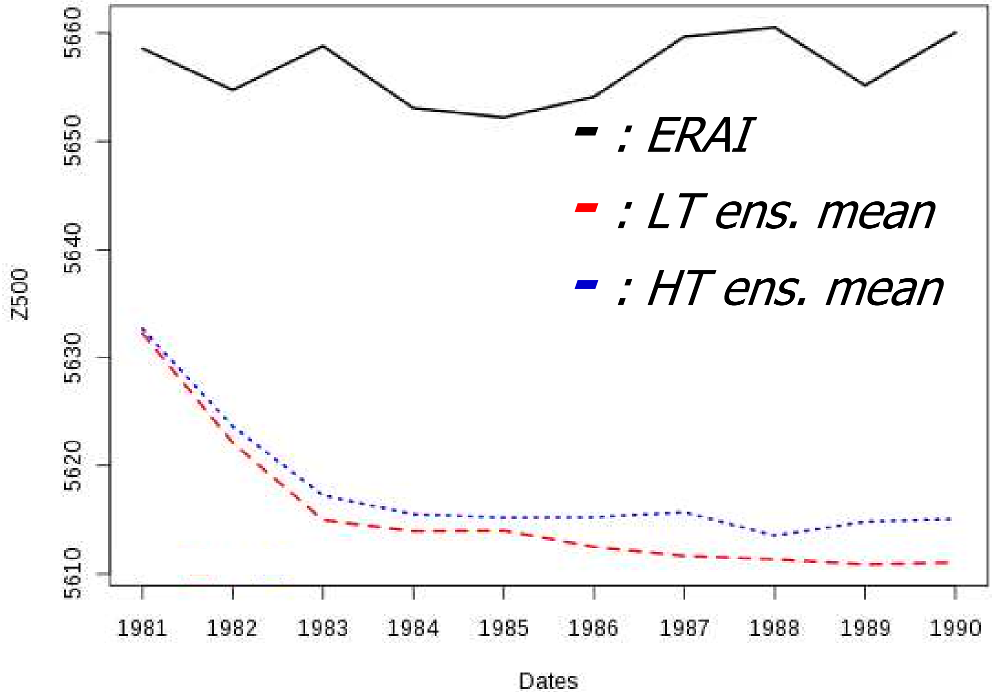
Biases
(zonal mean Temperature 1996-2005)



Larger colder biases for **LT** (versus **HT**) in DJF and MAM in the polar regions of the Northern Hemisphere at top and bottom; also in the tropics in the middle troposphere.

Drift
(Z500 for the first starting date)



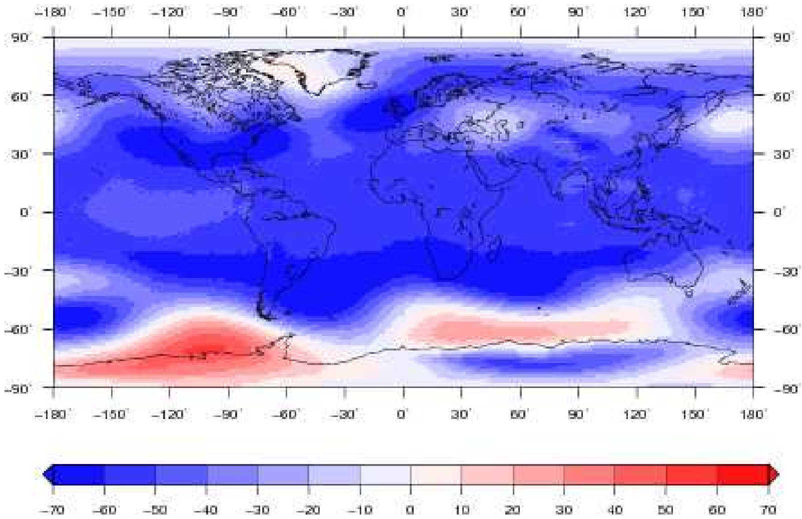


Typical negative drift over the first 5 years. This drift is removed from the raw forecasted data.

The LT bias is larger than the HT bias.

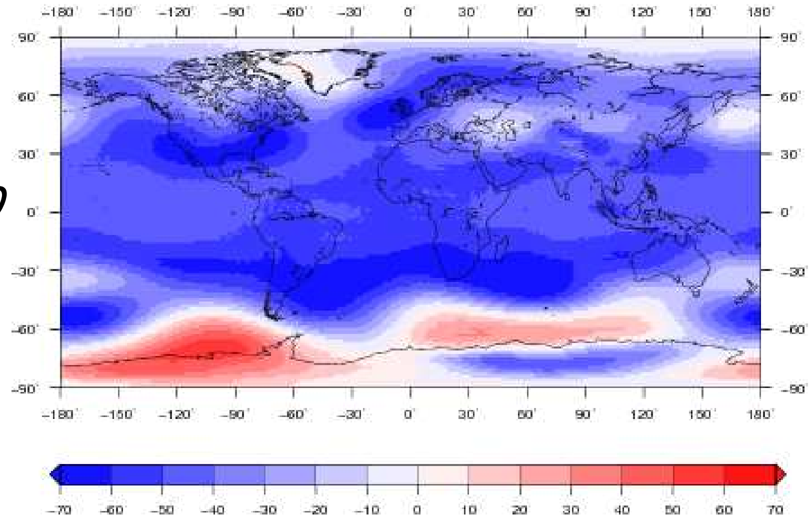
Biases
(Z500, mean over the 5 starting dates)

LT



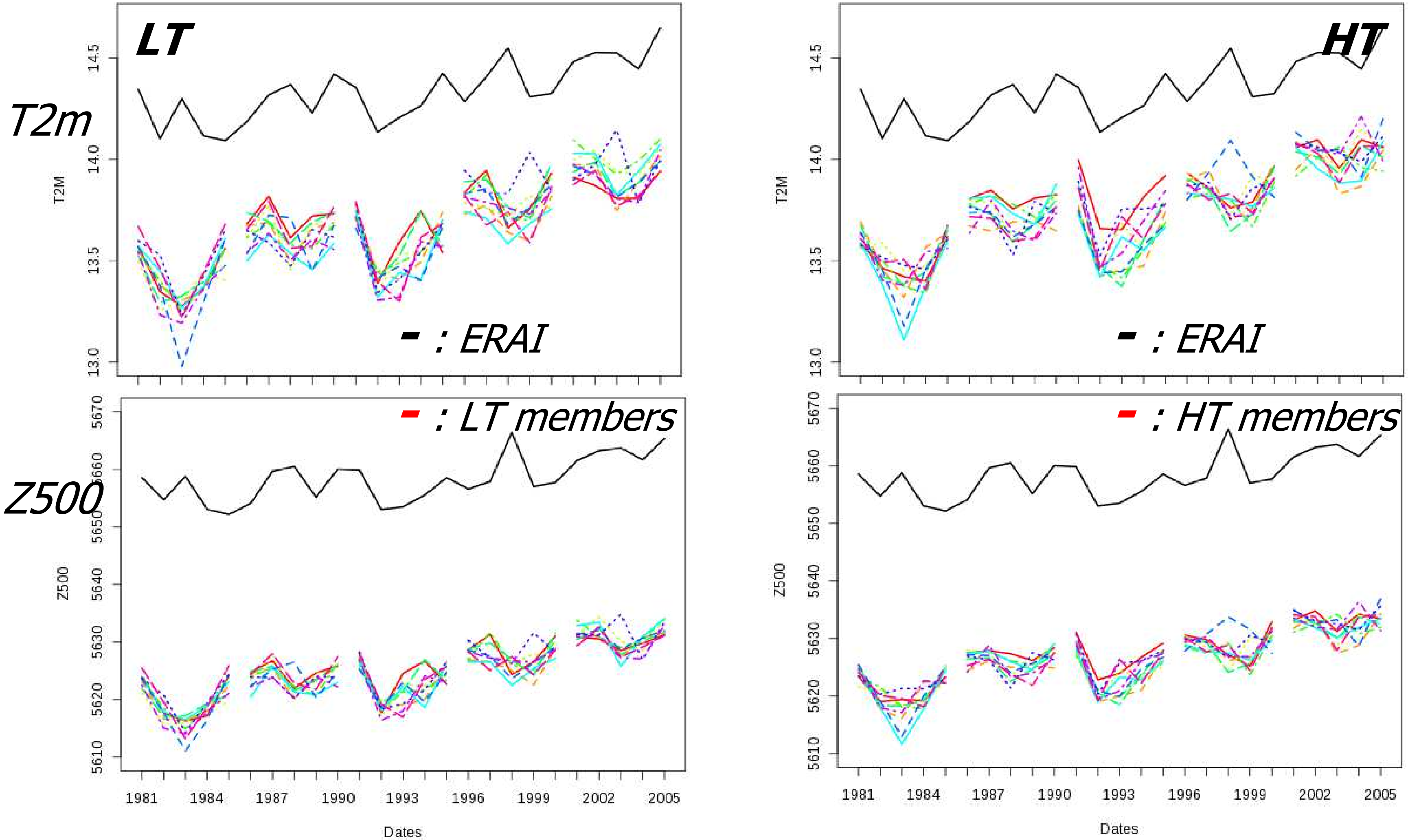
Years 6-9

HT



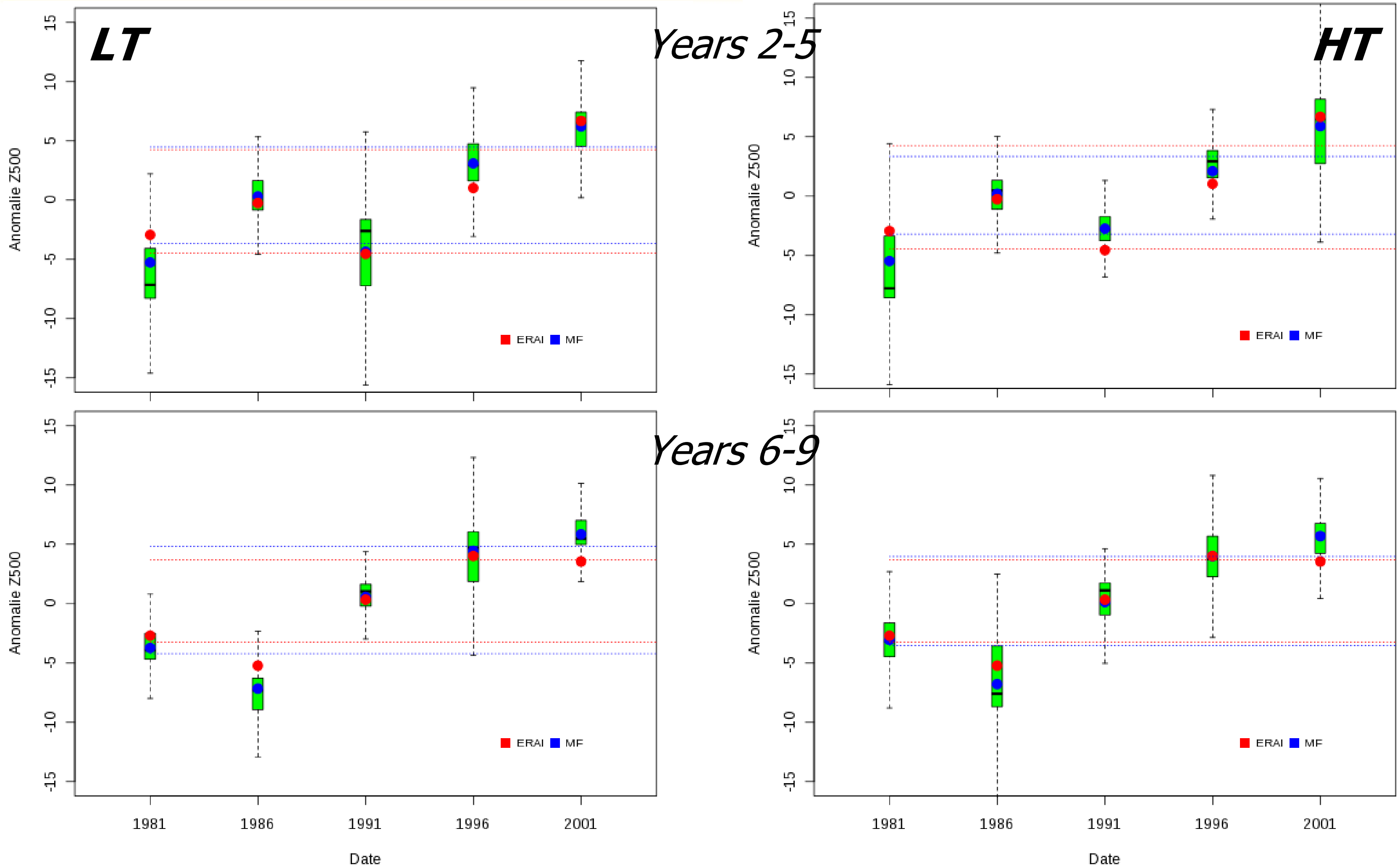
Larger colder (except Greenland) biases for **LT** (versus **HT**) in the polar regions of the Northern Hemisphere at top and bottom; also in the tropics.

Time series
(T2m and Z500 over the 5 starting dates)



The model is colder of about 0.6K, but follows the observed global warming of 0.2K/20 years.

Anomaly time series (Z500 over the 5 starting dates)



HT and LT are equivalent for years 2-5; but, HT is a little better than LT for years 6-9.

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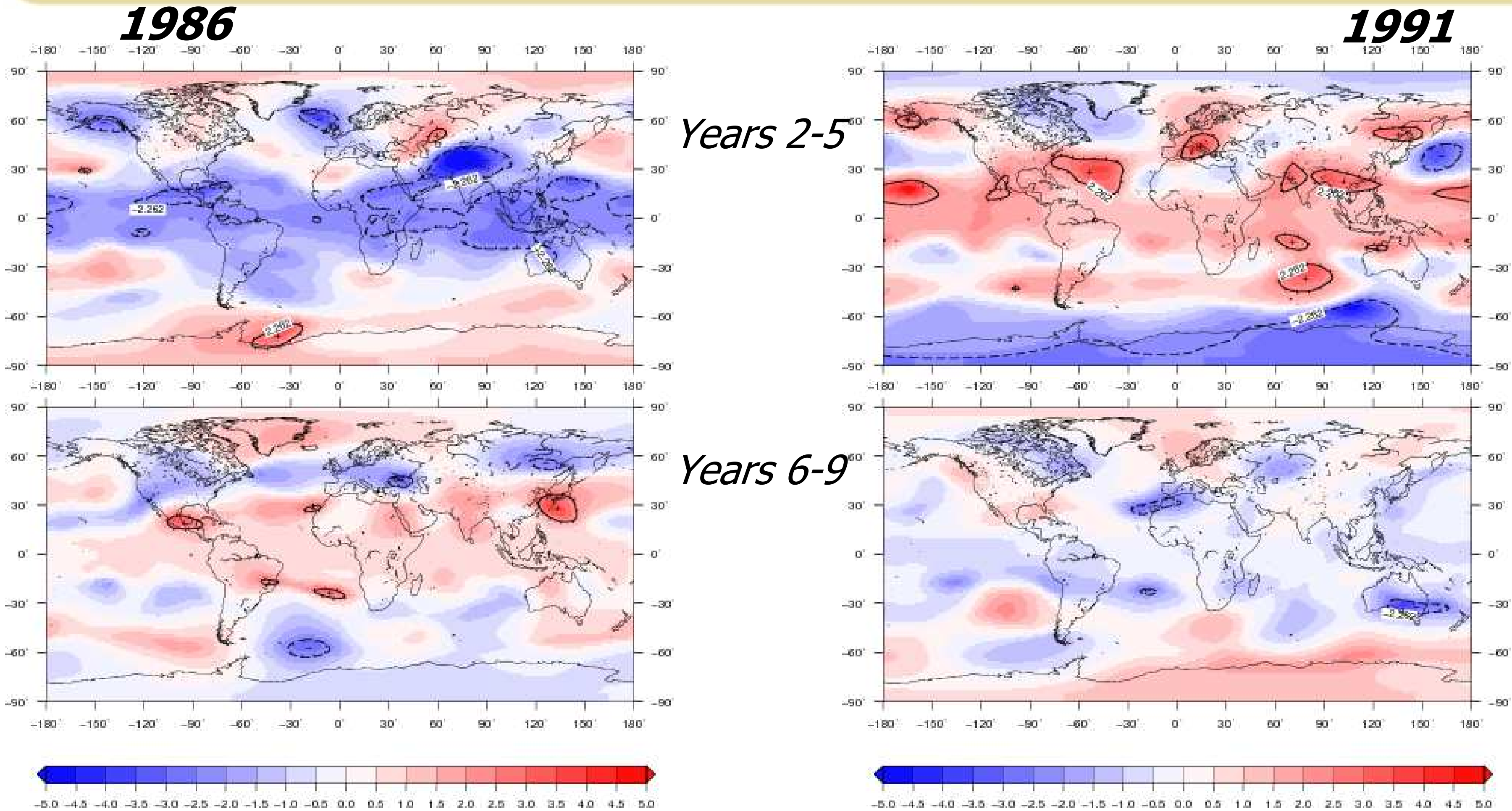
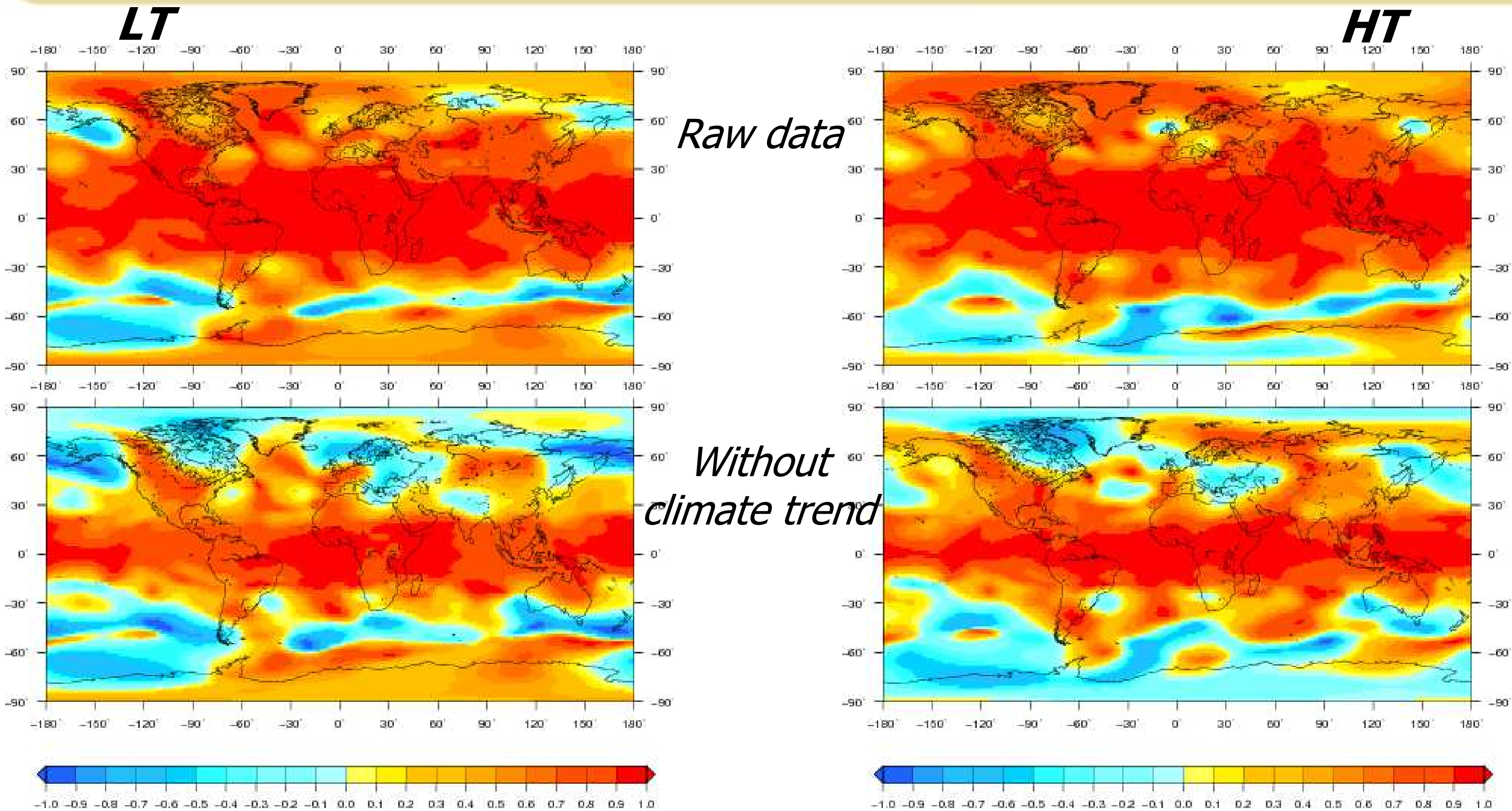
Significance of the stratosphere inclusion
(Student statistics for Z500 anomaly difference HT-LT)



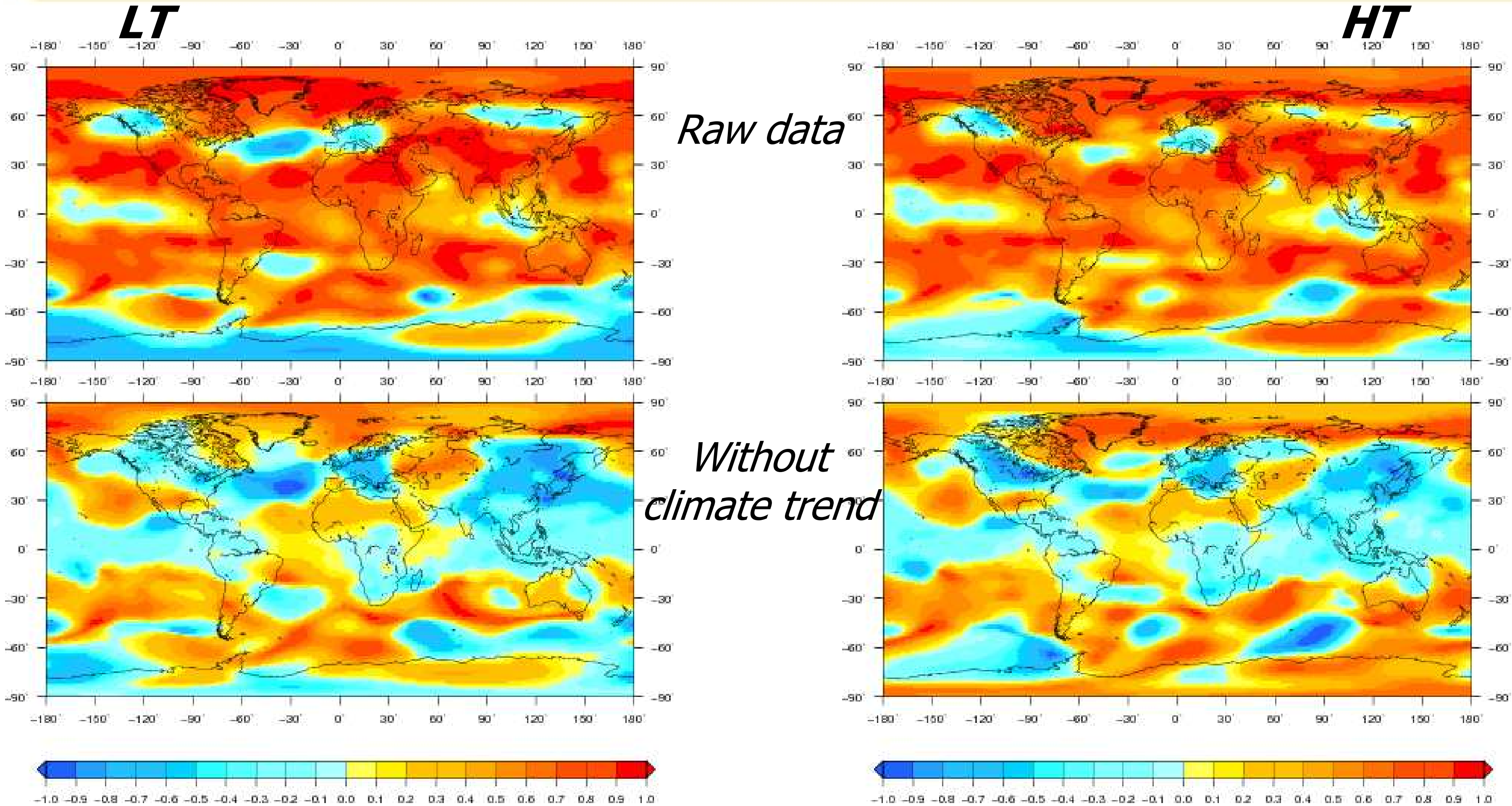
The differences between HT and LT are more significant for the years 2-5 than for the years 6-9 and they are located all around the world.

Temporal correlations (Z500 over the 5 starting dates, years 2-5)



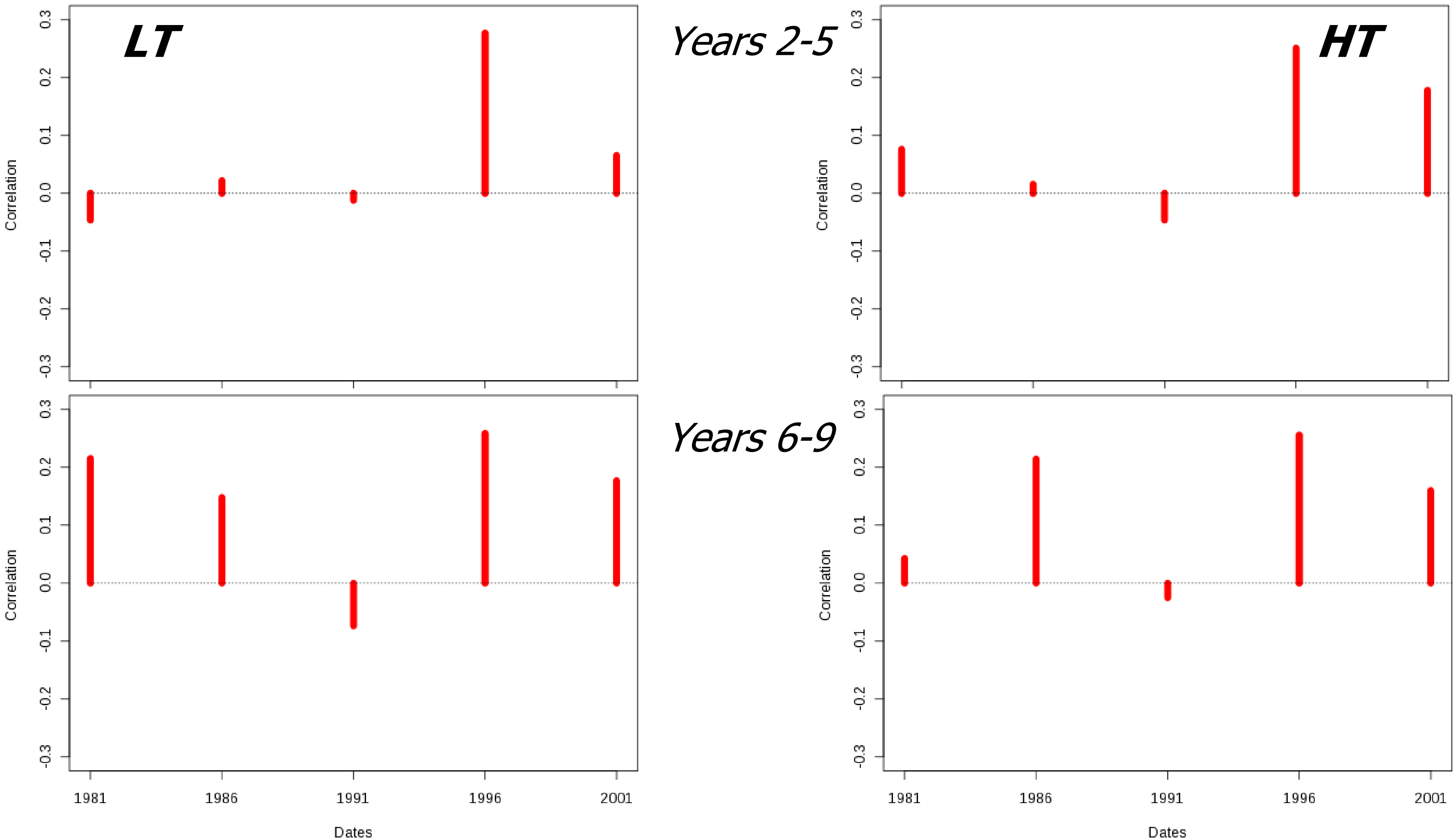
HT is a little better than LT over the tropics and the polar regions of the northern hemisphere. As expected, the skill is reduced without the climate trend, but it is still significant over the tropics and some regions of the northern hemisphere.

Temporal correlations
(Z500 over the 5 starting dates, years 6-9)



As expected, the skill is reduced for the years 6-9, but HT remains a little better than LT over the mid-latitude and polar regions of both hemisphere, with and without the climate trend.

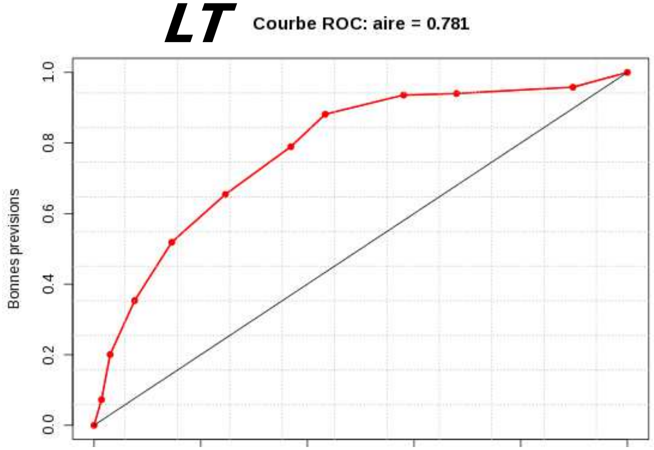
Spatial correlations
(Z500 over the globe, raw data)



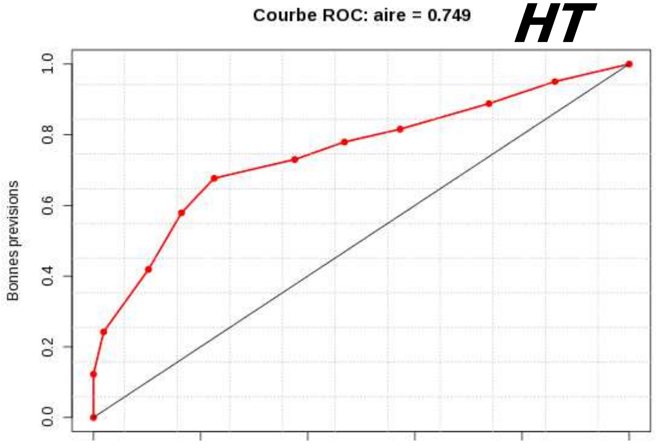
HT and LT are equivalent for the years 2-5 and 6-9; 1996 starting date provides the best score due to 1997 El Niño.

ROC
(Z500 over Europe, raw data, 50% of the distribution)

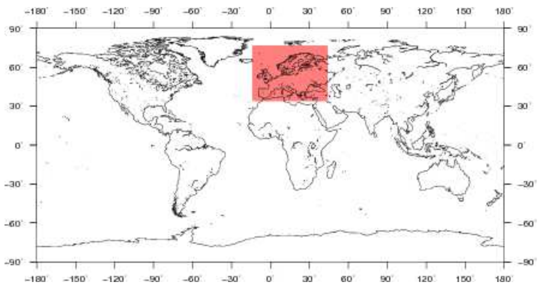
LT



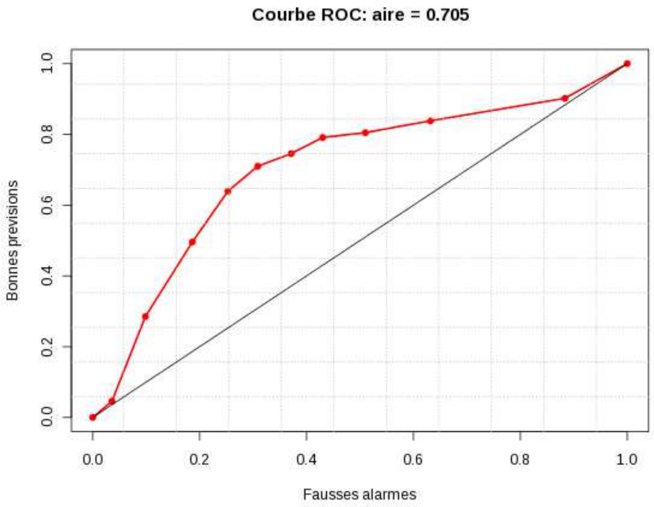
HT

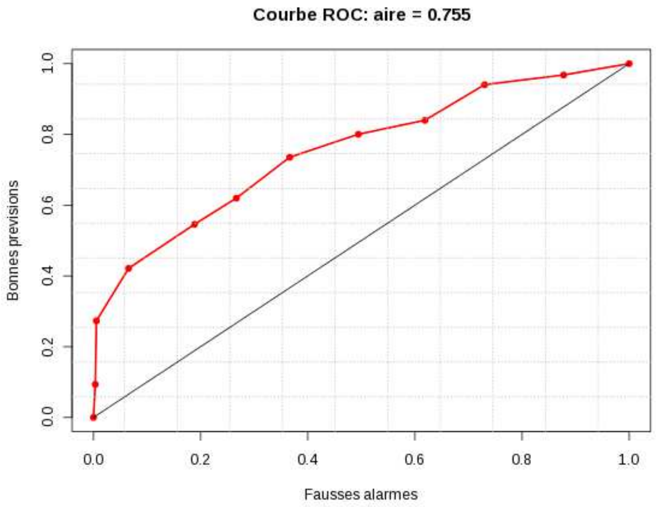


Years 2-5



Years 6-9





HT and LT are quasi equivalent for the years 2-5 and 6-9; but, HT is a little better than LT for years 6-9 .

Conclusion and prospects

Conclusion

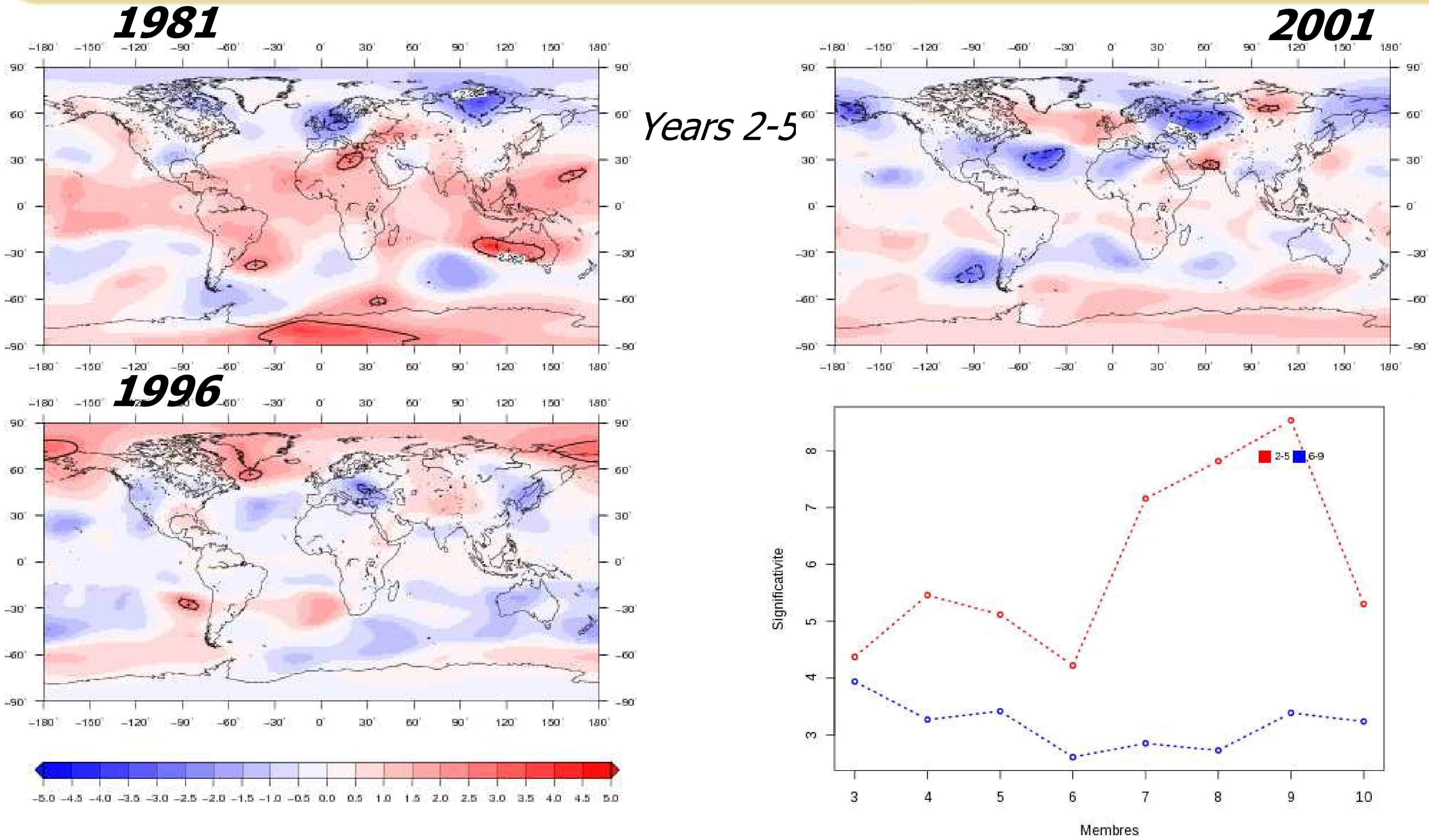
- HT significantly different from LT; differences larger for 2-5 years than for 6-9 years

- HT a little better than LT, notably for the years 6-9 over the mid-latitude and polar regions of both hemisphere

Prospects

- Sensitivity of decadal forecasts to atmospheric resolution and physics; Tl127l91 geometry with AR5 physics and a new prognostic physics (turbulence, convection, micro-physics)

Significance of the stratosphere inclusion (Student statistics for Z500 anomaly difference HT-LT)



The differences between HT and LT are more significant for the years 2-5 than for the years 6-9 and they are located all around the world.