Representing model uncertainty using multi-parametrisation methods

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METEO FRANCE
Toujours un temps d'avance

Outline

- Representation of model uncertainty in EPS
- The multi-parametrisation approach
- Multi-parametrisation approach in the Météo-France EPS
- Conclusion and Questions

Representation of model uncertainty in EPS

- A major contributor to forecast uncertainty
  - parameter and parametrisation uncertainty, subgrid-scale processes,...
  - *Houtekamer et al. 1996, Stensrud et al. 2000, Palmer et al. 2009*
- One problem, many approaches
  - Stochastic parametrisations (*Berner at al. 2011*)
  - Physics tendency perturbations (*Buizza at al. 1999*)
  - Perturbed parameters (*Stainforth at al. 2005*)
  - Multi-models (*Hagedorn et al. 2005*)
  - Multi-parametrisation (*Stensrud et al. 2000*)
- No unique method the scientific community has agreed upon

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- Representation of model uncertainty in EPS
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The multi-parametrisation approach

- Two main ideas
  - Major part of forecast error is linked with the assumptions used to develop the parametrisation schemes
  - Use of a variety of physical parametrisation schemes in the same forecast model to account for model uncertainties

The multi-parametrisation approach

- Major part of forecast error is linked with the assumptions used to develop the parametrisations schemes
  - The variety of the schemes should represent the uncertainty in the representation of the physical phenomena
  - The different schemes should produce different evolutions of the atmosphere having the same global skill

The multi-parametrisation approach

- Major part of forecast error is linked with the assumptions used to develop the parametrisations schemes
  - Using a mesoscale model, Wand and Seaman (1997) show that different convective schemes produce different evolutions of convective activity. Skill scores show no significant differences between the different schemes.

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In simulating the ’North American monsoon’
  - Bright and Mullen 2002
- In Global EPS
  - Houtekamer et al. 1996, Charron et al. 2010
- In Mesoscale LAM-EPS
  - Stensrud et al. 2000, Jones et al. 2007
  - Berner et al. 2011

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In simulating the ’North American monsoon’
  - Bright and Mullen 2002
    - Several experiments of Mesoscale EPS with MM5 with different cumulus and planetary boundary layer parametrisations
    - Some experiments include a simple stochastic forcing term
    - Ensembles with multi-parametrisation and perturbed analyses are the most skillfull

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In Global EPS
  - Houtekamer et al. 1996, Charron et al. 2010
    - Impact of multi-parametrisation approach on MSC global EPS
    - Increase by about 20% of the ensemble spread (Houtekamer et al. 1996)
    - Positive impact on reliability component of BSS for 24h rainfall
    - Impact on dynamical fields is more apparent on mid-tropospheric temperature

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In Mesoscale LAM-EPS
  - Stensrud et al. 2000
    - Two 19 mb SREF with MM5 model over central United States. Focus on two MCS cases
    - One ensemble with only perturbed IC, the other with only multi-parametrisation (PHS) (convective scheme, boundary layer scheme, moisture availability parameter)
    - When large-scale forcing is weak multi-physic ensemble is skillfull than IC ensemble
    - When large-scale forcing is strong IC ensemble is skillfull than PHS ensemble

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In Mesoscale LAM-EPS
  - Jones et al. 2007
    - 18-mb SREF with MM5 model over northeast United States
    - 7 members with only perturbed ICs, 12 members with only multi parametrisation (PHS) (cumulus param. and boundary layer scheme)
    - During warm season PHS ensemble is more skillfull than IC ensemble
    - Multi-parametrisation is more useful when large-scale forcing for upward motion is weak

The multi-parametrisation approach

- Effectiveness of the approach has been confirmed in several studies

- In Mesoscale LAM-EPS
  - Berner et al. 2011
    - two 10-mb SREF with AFWA JME system over United States
    - One ensemble uses multi-parametrisation approach, another uses SKEB
    - SKEB outperforms Multi-parametrisation approach for upper air variables
    - Multi-parametrisation approach outperforms SKEB near the surface
    - The best-performing ensemble system is obtained by combining the two approaches

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Multi-parametrisation approach at Météo-France

- PEARP : Prévision d'Ensemble ARPEGE
- Initialization procedure
  - EDA + 64 dry TE SVs (18h or 24h)
  - Perturbation amplitude controlled by analysis error variance 'of the day'
- Ensemble size
  - 34 perturbed members centered around control analysis + 1 control member

Multi-parametrisation approach at Météo-France

- PEARP : Prévision d'Ensemble ARPEGE
- Model characteristics
  - 35 4.5-Day forecasts run at T538c2.4 L65 resolution
  - Top of the model at 50 km
- Model error
  - Multi-parametrisation approach using a set of 10 'physical packages'

Multi-parametrisation approach at Météo-France

- Two different vertical diffusion schemes
  - the Louis scheme (Louis 1979)
  - a prognostic Turbulent Kinetic Energy scheme (TKE approach, Bouteloup et al. 2009).
- Two different schemes for shallow convection
  - the ’modified Richardson number’ formulation proposed by Geleyn (Geleyn 1987)
  - the convection mass flux approach (KFB) of Kain and Fritsch (Kain and Fritsch 1993)

Multi-parametrisation approach at Météo-France

- Two different schemes for deep convection
  - 'CAPE' formulation
  - a mass flux scheme with a moisture convergence developped by Bougeault (B85, Bougeault 1985)
- Two different schemes for computing oceanic fluxes
  - the classical Charnock formulation (Charnock 1955)
  - the ECUME (Exchange Coefficients from Multi-campaigns Estimates) scheme (Belamari 2005)

Multi-parametrisation approach at Météo-France

- Slightly modified version of some schemes are also used
  - In CAPE$_{mod}$ and B85$_{mod}$ the deep convection is allowed if cloud top is above 3000m
  - In TKE$_{mod}$, the parametrisation is used without horizontal advection
  - In ECUME$_{mod}$, ECUME is used with a modified tuning for the exchange coefficient for the humidity to reduce the evaporation over the sea

Multi-parametrisation approach at Météo-France

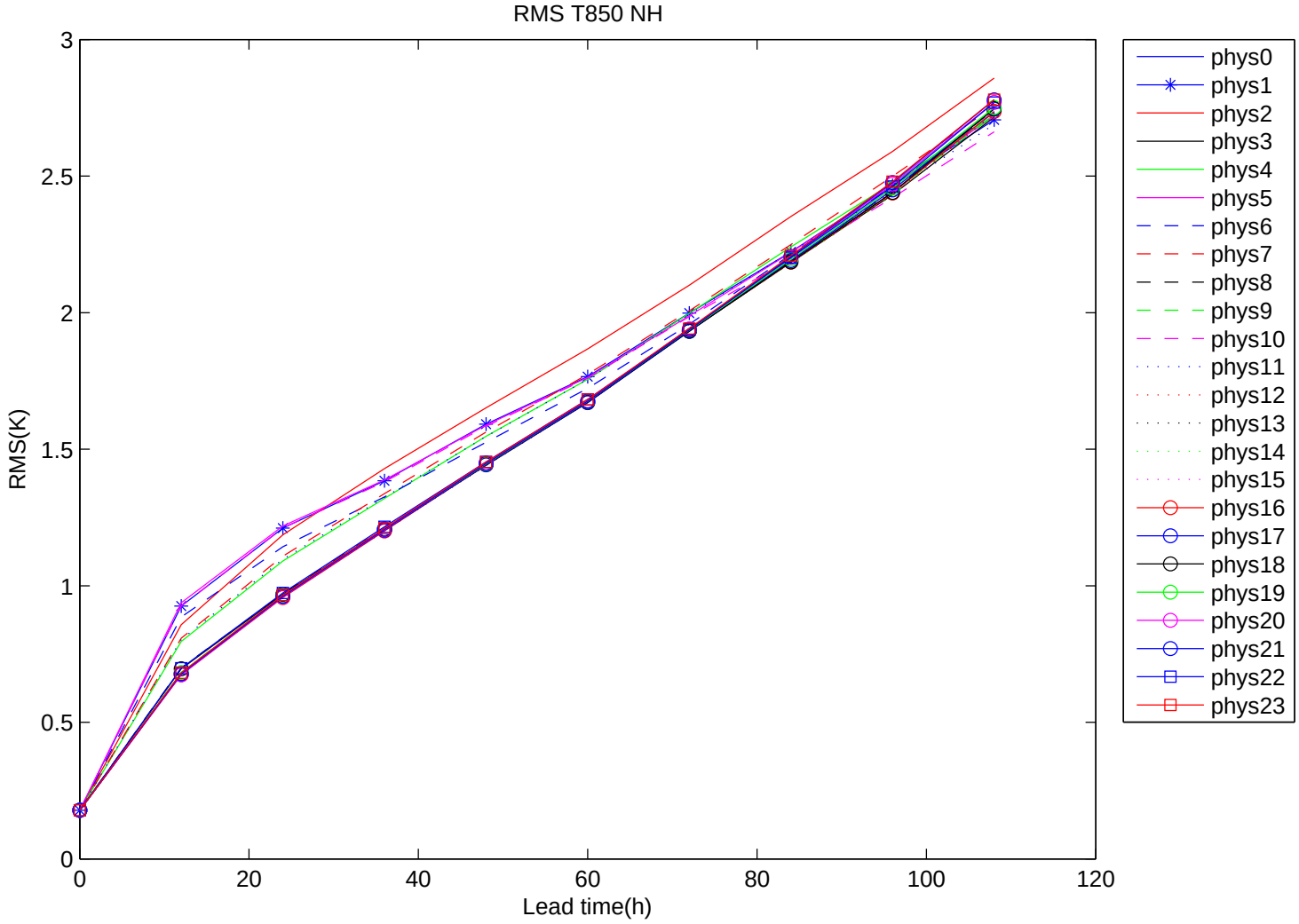
num.	diffusion	shallow conv.	deep conv.	oceanic fluxes
ref	TKE	KFB	B85	ECUME
001	L79	G87	B85	C55
002	L79	KFB	CAPE_{mod}	ECUME
003	TKE	KFB	B85	ECUME_{mod}
004	L79	KFB	B85_{mod}	C55
005	L79	G87	CAPE	C55
006	L79	G87	CAPE	ECUME
007	L79	KFB	CAPE_{mod}	C55
008	TKE_{mod}	KFB	B85	ECUME
009	TKE	KFB_{mod}	B85	ECUME_{mod}

Multi-parametrisation approach at Météo-France

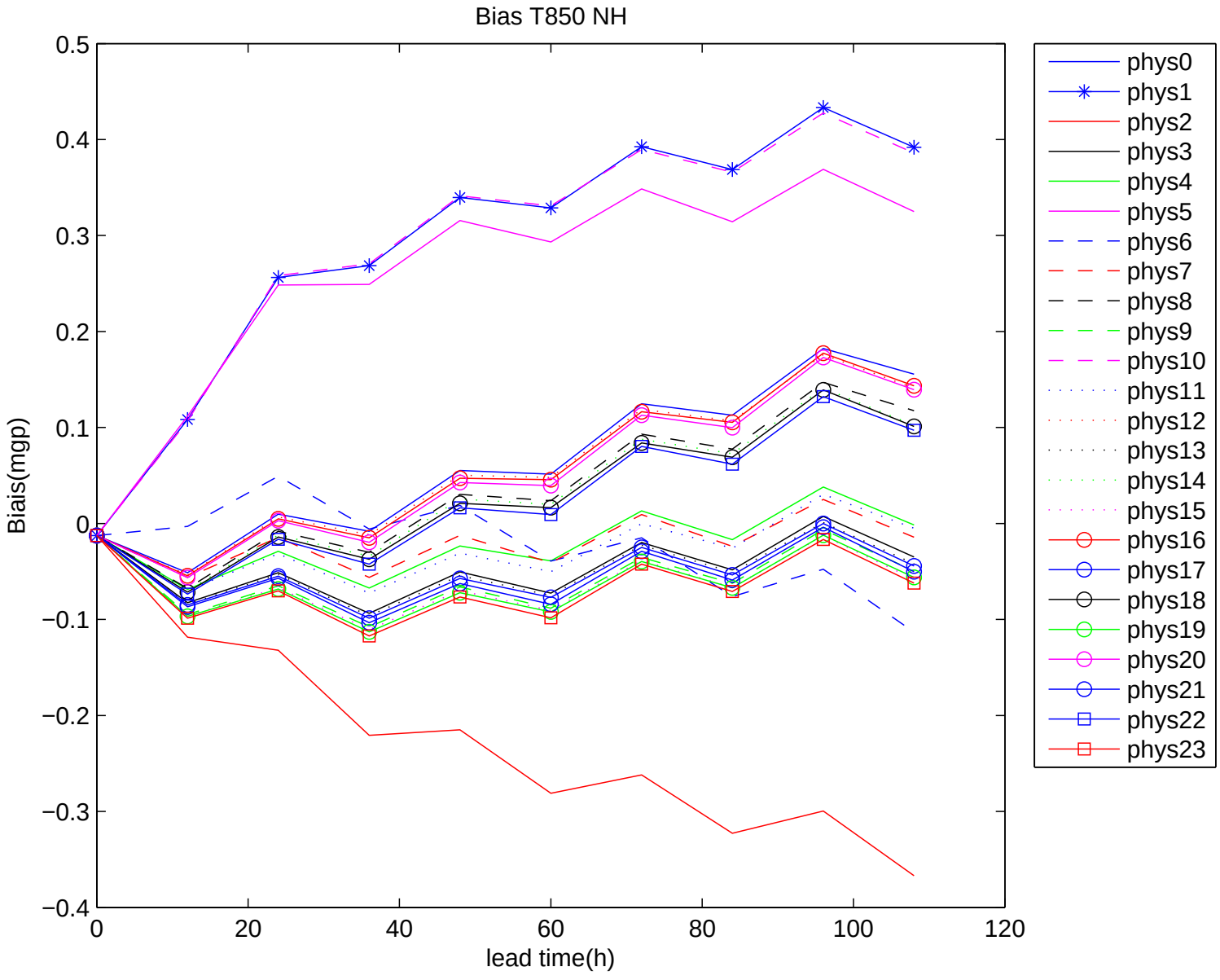
- Objective evaluation of the ’packages’
  - Scores computed over two 31-day periods (March 2008 and Dec. 2010)
  - Scores computed on Europe (Western Europe + Atl. Ocean) NH, SH and TROP.
  - Use of classical probabilistic scores
    - Rank Histogram (delta score)
    - Brier Skill Score

Multi-parametrisation approach at Météo-France

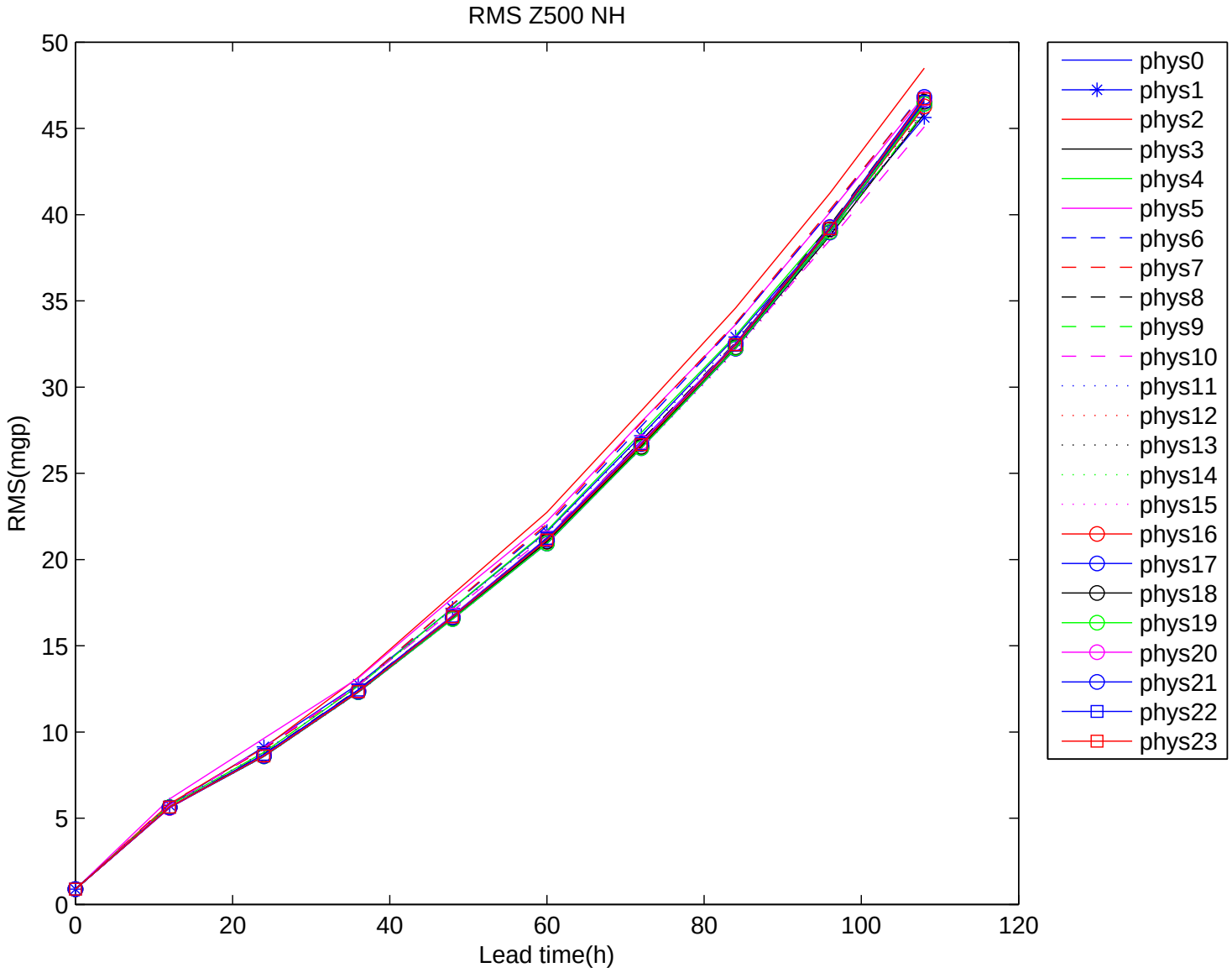
- Objective evaluation of the 'packages'



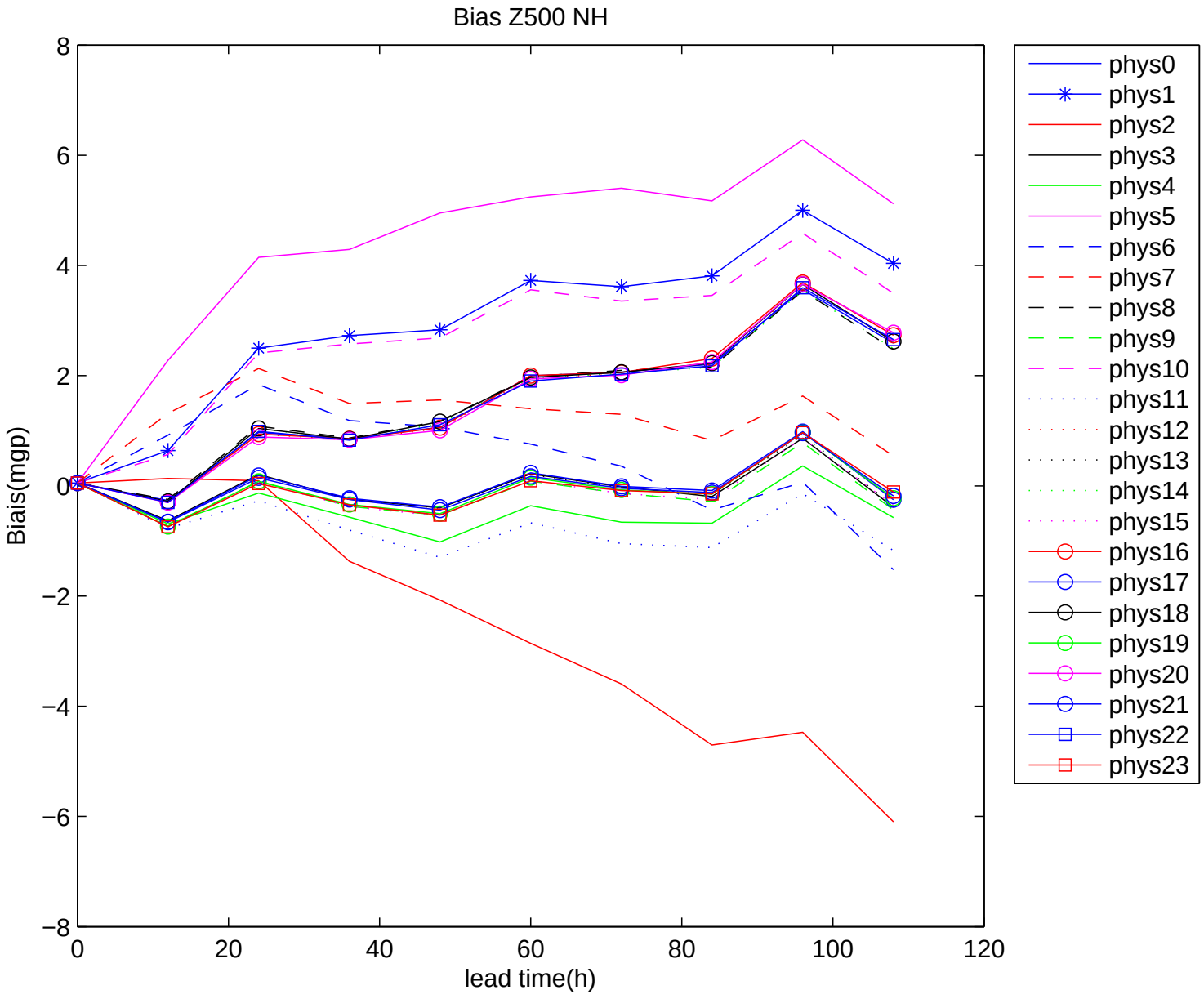
Multi-parametrisation approach at Météo-France



Multi-parametrisation approach at Météo-France

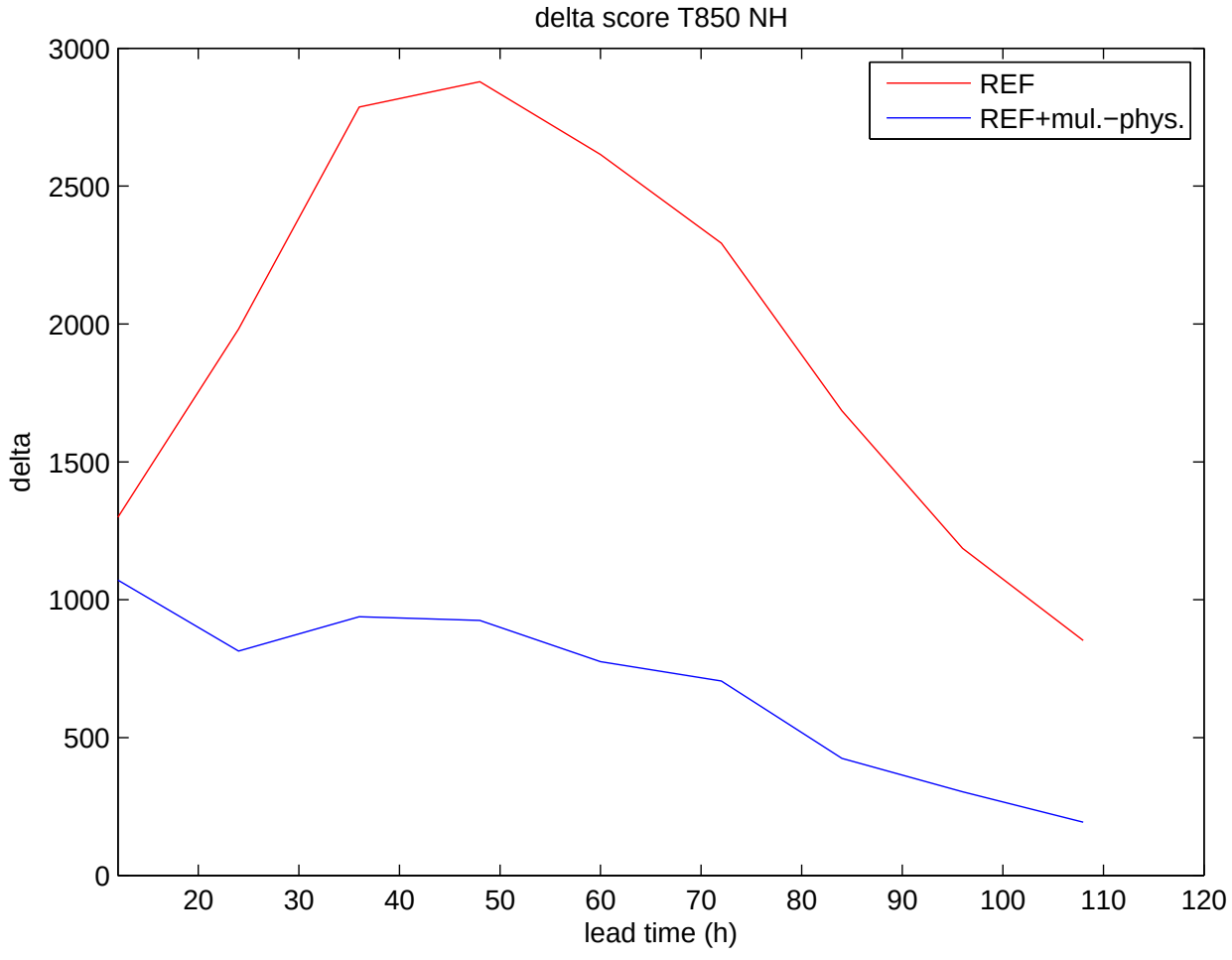


Multi-parametrisation approach at Météo-France



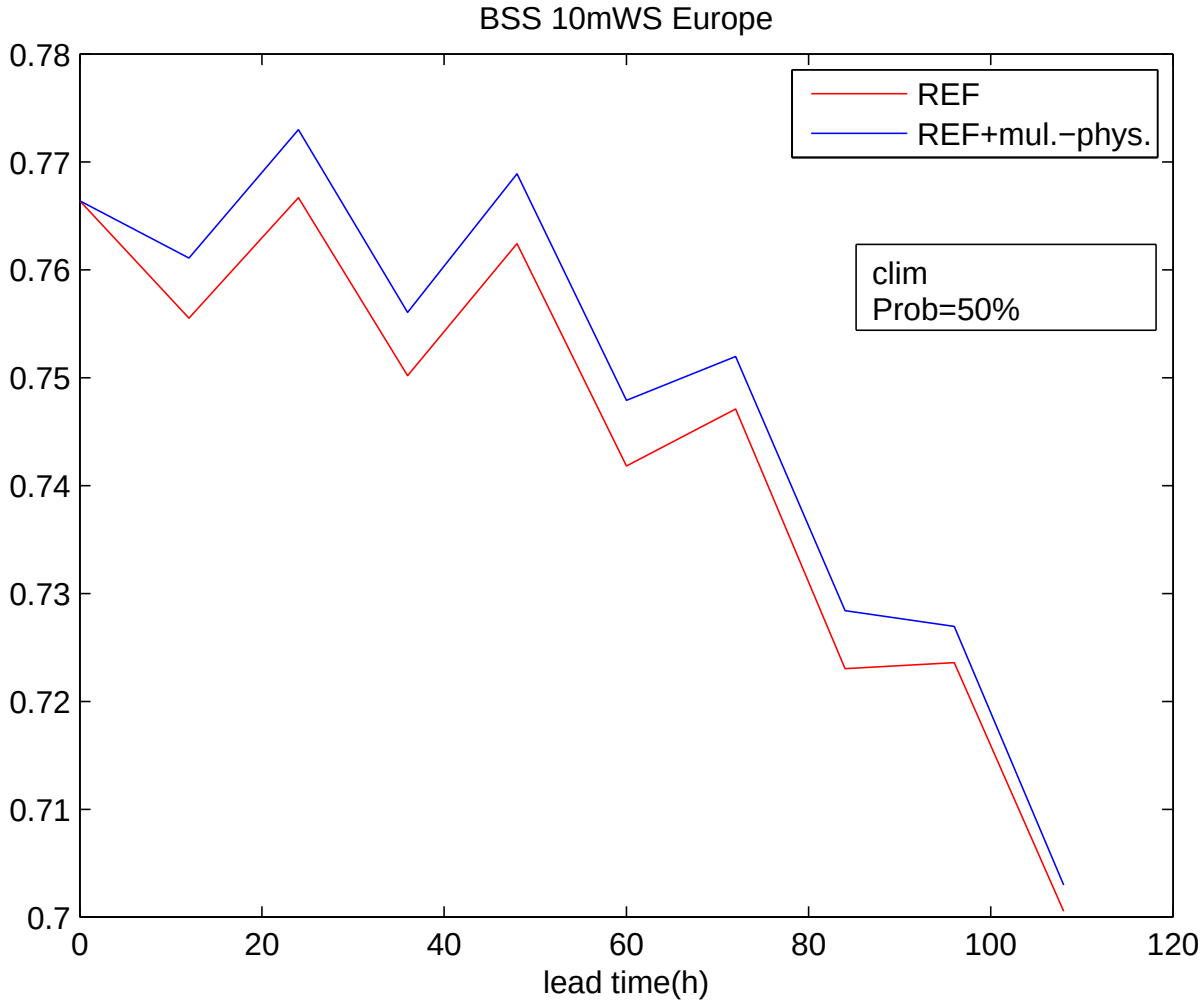
Multi-parametrisation approach at Météo-France

- Impact on EPS skill - Rank Hist.



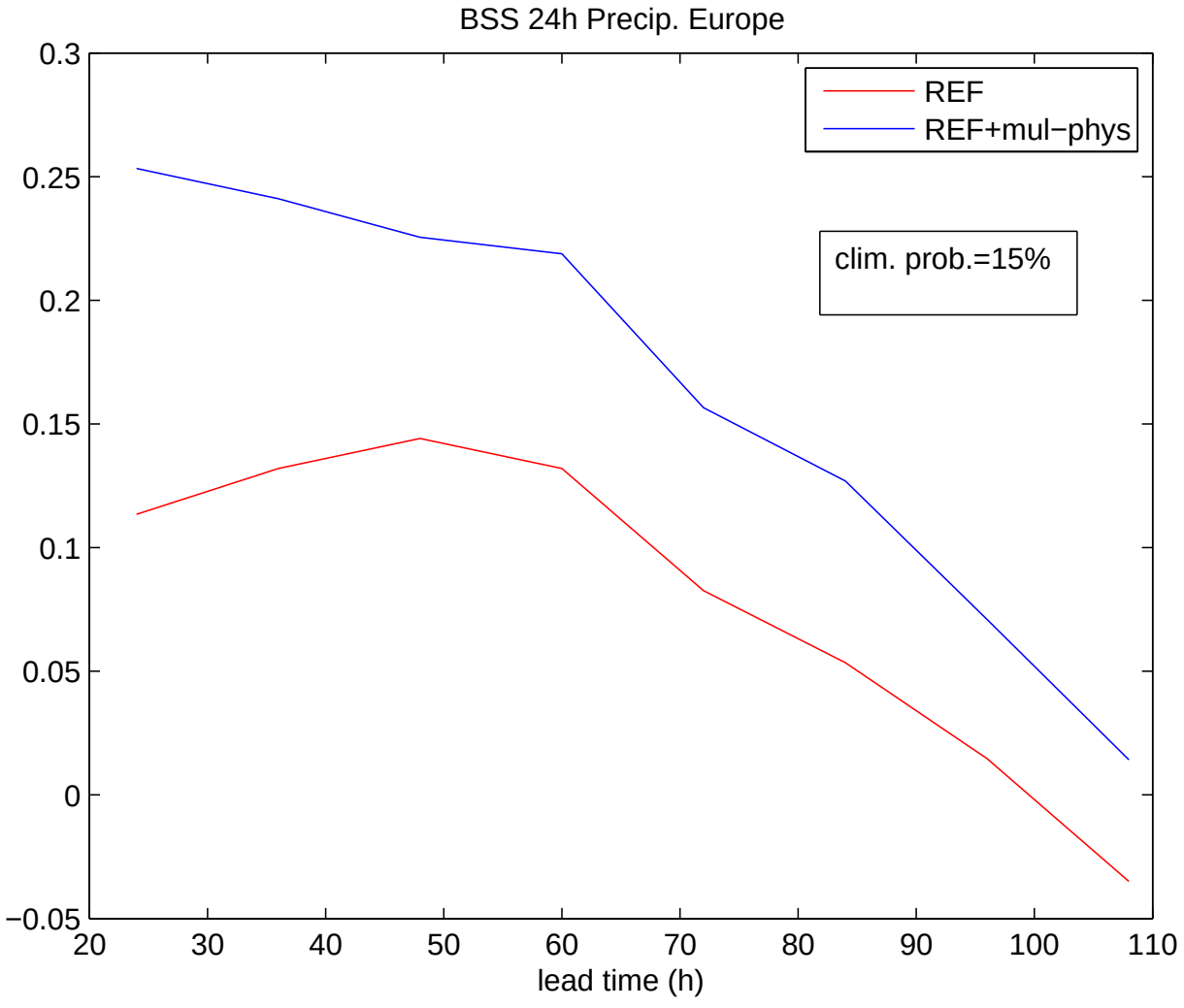
Multi-parametrisation approach at Météo-France

- Impact on EPS skill - BSS



Multi-parametrisation approach at Météo-France

- Impact on EPS skill - BSS



Multi-parametrisation approach at Météo-France

- Positive impact on EPS skill
  - More impact on reliability
  - More impact on Temperature and Precipitation

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Conclusion and Questions

- Multi-parametrisation approach is based on two main ideas
  - forecast error is due to the assumptions used to develop the parametrisations schemes
  - using multiple parametrisations schemes is a simple method to represent model uncertainties
- with two important conditions :
  - use of different parametrisations schemes should produce different forecasts
  - parametrisations schemes should have the same global skill

Conclusion and Questions

- Multi-parametrisation approach has a positive impact on EPS skill scores
  - For Global as for LAM EPS
  - More impact on temperature, precipitation and near surface variables

Conclusion and Questions

- Questions
  - Will the multi-parametrisation still be used in the future ?
    - Convergence of the parametrisation schemes
    - Difficulty to maintain different state-of-the-art schemes
  - Should we combine different approaches (SKEB + multi-parametrisation) ?
    - Different approaches to represent different sources of uncertainties
  - Is EPS calibration more difficult with multi-parametrisation ?
    - multiple parametrisations = multiple models
    - need to have multiple reforecast sets

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Any questions ?