

The multi-ensemble approach : the NAEFS example.

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North American Ensemble Forecasting System

NAEFS :

- Canada-Mexico-USA agreement (official since Nov. 2004) about joint EPS research/development work

NAEFS expectations :

- Improve probabilistic forecast :
 - lower detection threshold by increasing ensemble size
 - uncertainty assessment via multi-model approach
 - skill for week 2
- Save development/production costs by sharing resources and competences

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EPS-components of NAEFS

NCEP EPS :

- 20 members
- model T126L28 (around 1°)
- Ensemble Transform (ET) method²

CMC EPS :

- 20 members
- gaussian grid 0.9° , L28
- Ensemble Kalman Filter (EnKF)
- multi-parametrization (convections scheme, surface scheme, gravity wave drag ...) and stochastic perturbations

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Verification system

Comparison tools³ :

- CRPS and its reliability/resolution decomposition⁴, Reduced Centered Random Variable (RCRV)
- 95%-confidence interval (CI) by bootstrap techniques

Verification dataset :

- 50 forecasts done at every 12h
from june 15 2007 to july 24 2007
- global radiosondes network : 374 upper-air stations
- forecast range : 360h

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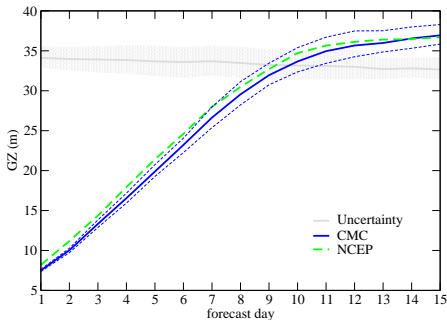
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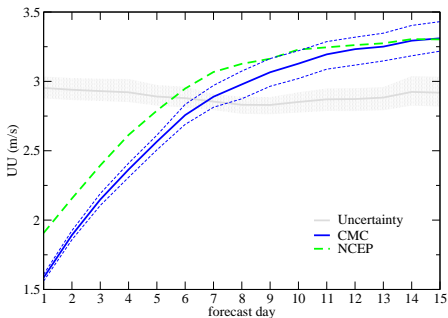
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NCEP vs. CMC : global skill (CRPS)

Geopotential height at 500mb (GZ500)



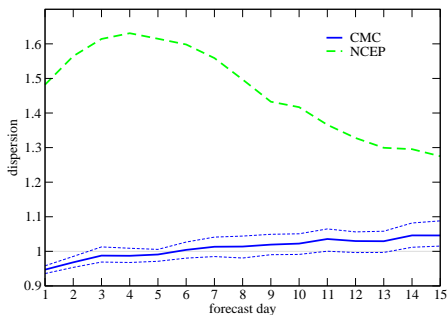
Horizontal wind at 850mb (UU850)



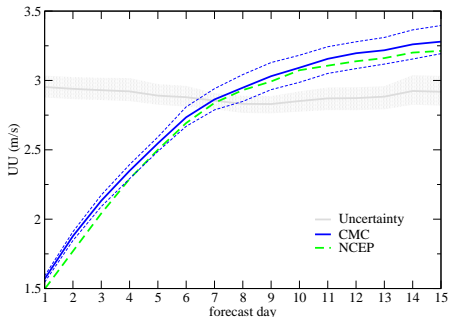
- NCEP/CMC have *significant* skill up to forecast days 8 (GZ) and 5/6 (UU)
- CMC performs *significantly* better up to days 7 (GZ) and 9 (UU)
→ difference $\approx 1/2$ (GZ) and 1 (UU) day

NCEP vs. CMC : reliability and resolution

reliability : dispersion of RCRV (UU850)

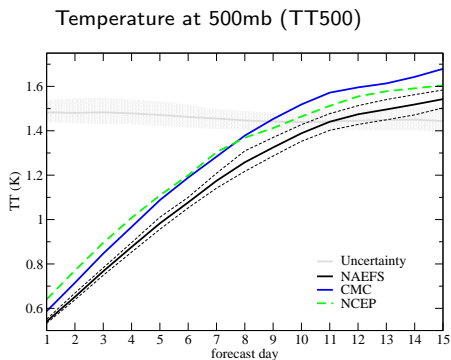
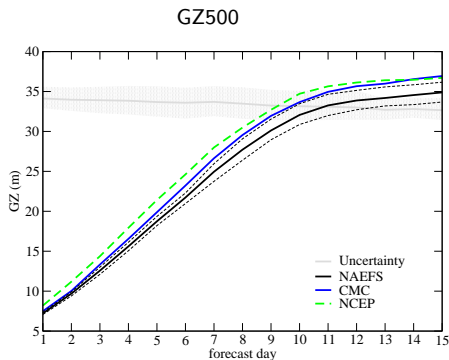


resolution component of CRPS (UU850)



- large underdispersion for NCEP → lack of reliability
- better reliability for CMC, but better *potential* skill for NCEP up to day 4

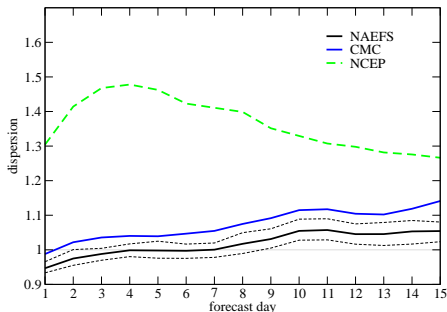
NAEFS vs. EPS-components : CRPS



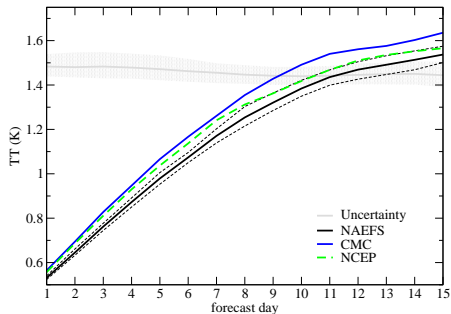
- *significant* global improvement for NAEFS : skill up to days 9 (GZ) and 10 (TT)
- gain from 1/2 to 1-1/2 forecast day compared to the best EPS-component

NAEFS vs. EPS-components : reliability and resolution

reliability : dispersion of RCRV (TT500)



resolution component of CRPS (TT500)



- reliability improvement
- *significant potential* skill up to day 10 for NAEFS
resolution improvement from 1/2 to 1 day compared to the best EPS-component

Ensemble size N

- Is the NAEFS improvement only due to increasing ensemble size $N : 20 \mapsto 40$?



$$CRPS_N = CRPS_\infty + \underbrace{\frac{1}{N} \int_{F_p} \int_{\Omega} F_p(\xi)(1 - F_p(\xi)) d\xi dg(F_p)}_{\mathcal{F}(\bar{\sigma})}$$

- NAEFS-redux = $\frac{1}{2}$ NCEP + $\frac{1}{2}$ CMC
20 members (10 + 10) randomly drawn at each realization of the EPS

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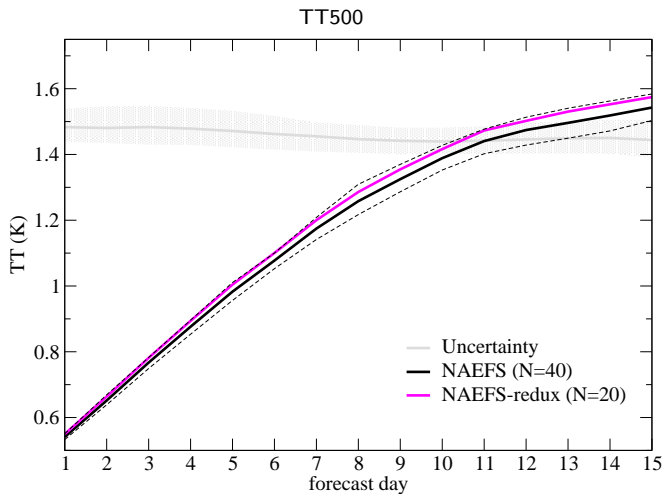
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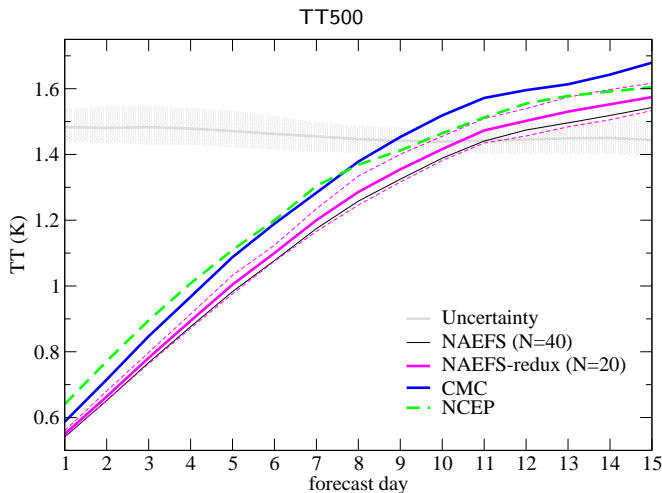
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Impact of N : CRPS



- no *significant* degradation on global score

NAEFS-redux vs. EPS-components : CRPS



- skill improvement is still *significant* with N-reduction

Summary

- NCEP vs. CMC :
 - best global skill for CMC
 - NCEP underdispersive \longrightarrow best reliability for CMC
 - best resolution for NCEP

- NAEFS = NCEP + CMC
 - *significant* improvement compared to the best EPS-component both in reliability and resolution
 - predictability gain from 1/2 to 1-1/2 forecast day
 - improvement not only due to increasing ensemble size N
 \longrightarrow **intrinsic gain by mixing models and perturbations methods**

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