Running HarmonEPS ensemble members in single precision

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Minimum requirements for single precision ensemble forecasts

- Confirm that single precision forecasts **run significantly faster** than double precision forecasts
- The difference between single and double precision forecasts must be **much smaller** than the difference between ensemble members
- Single precision forecasts must be numerically **stable**
My experiment

• “Single precision” only applies to forecasts – everything else is run in double precision
• 1 double precision, unperturbed (control) member
• 1 single precision, unperturbed member
• 3 single precision, perturbed members
• 3-hourly cycling, EDA, 18h forecasts, SLAF perturbations for LBC, cy43h2.1 + additional “HIRLAM_SP_HACKS”
• Two periods: 16-26 June 2020, 1-31 March 2021
Computational performance

• Single precision forecasts run ~30% faster than double precision forecasts on DMI’s Cray XT5

• Optimal NPROMA (single precision) ≈ 2 NPROMA (double precision);
we use $\text{NPROMA}_{DP} = -24; \text{NPROMA}_{SP} = -48$
Difference between single and double precision forecasts

- Difference measured using total energy norm
- Two possible configurations for single precision unperturbed member:
  1. Copy first-guess from DP to SP, so only the forecast differs
  2. Run independent data assimilation cycling for DP and SP forecasts
1. Forecast only difference

Difference between unperturbed and perturbed member

Difference between DP and SP unperturbed members
Precipitation forecast example

Double precision

Mbr000 accum precip [mm/3h] 2020061809+24h
Valid on Friday 19 Jun 09:00 UTC

Single precision

Mbr020 accum precip [mm/3h] 2020061809+24h
Valid on Friday 19 Jun 09:00 UTC
Precipitation forecast example

Double precision

Mbr000 accum precip [mm/3h] 2020061809+48h
Valid on Saturday 20 Jun 09:00 UTC

Single precision

Mbr020 accum precip [mm/3h] 2020061809+48h
Valid on Saturday 20 Jun 09:00 UTC
Single precision forecast stability

• 2 SP perturbed members crashed out of the last 1500+ SP members

• No crashes observed during summer runs – is SP more unstable in winter than in summer?
Forecast verification
Pmsl, RMSE

RMSE: 00:00 01 Mar 2021 - 18:00 31 Mar 2021
711 stations

SP unperturbed, independent cycling

SP pert., lag 3h
SP pert., unlagged

DP control

SP unperturbed, independent cycling

Verification for Pmsl
Forecast verification
Pmsl, bias

Bias: 00:00 01 Mar 2021 - 18:00 31 Mar 2021
711 stations

SP unperturbed, independent cycling
DP control

Verification for Pmsl
Forecast verification
T2m, Danish stations, RMSE

- and similarly for RMSE and bias for other surface parameters
**Forecast verification**

Temperature, vert. profile, RMSE

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<tr>
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- and similarly for RMSE and bias for other upper air parameters, except...
**Forecast verification**

**Dewpoint temperature, vert. profile, RMSE**

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RMSE: 00:00 10 Mar 2021 - 18:00 31 Mar 2021
40 stations

Verification for Td
Forecast verification
Dewpoint temperature, vert. profile, bias

Bias : 00:00 10 Mar 2021 - 18:00 31 Mar 2021
40 stations

Leadtime = 0h  Leadtime = 6h  Leadtime = 12h

Verification for Td
Summary

- Single precision forecasts are suitable for EPS as they
  - run ~30% faster than DP forecasts
  - differ much less from DP forecasts than from perturbed ensemble members (issue with dewpoint vertical profile needs to be resolved)
  - perform as well as DP forecasts
  - are stable enough to be used for perturbed ensemble members (but possible winter-time issue)