

Dynamical versus Statistical Projections of Ocean Wave Heights

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- Datasets and Methodologies
- Comparison - wave height climate and variability
- Comparison - the projected possible future changes
- Summary

Datasets and methodologies

Our previous studies → good relationships between SWH & atmospheric indices:

$$\hat{H}_{avg}(t) = \hat{a} + \hat{b}G_t + \hat{c}P_t \quad \text{– seasonal mean SWH}$$

$$\hat{H}_{20y}(t) \Leftarrow GEV(\hat{\mu}_t = \hat{\mu}_0 + \hat{\rho}_1 G_t + \hat{\rho}_2 P_t, \hat{\sigma}, \hat{\xi}) \quad \text{– seasonal extreme SWH}$$

Predictors $\left\{ \begin{array}{l} P_t: \text{Seasonal mean SLP anomalies} \\ G_t: \text{Seasonal anomalies of squared SLP gradient} \end{array} \right.$

ERA40 SLP for 1958-2001 (96x48 Gaussian grid) – “Observed” predictors

ERA40 waves (seasonal mean or max SWH) for 1958-2001 (1.5x1.5 lat/long grid)
– “Observed” predictands

Statistical projections of $H_{avg}(t)$ and $H_{20y}(t) \Leftarrow$ Projected predictors P_t and G_t

Projections of SLP (96x48 Gaussian grid)

CGCM2, IS92a scenario, 3 runs: each for 3x20-yr: 1975-94, 2040-59, 2080-99

Projections of surface winds → ODGP-2G

Dynamical projections of $H_{avg}(t)$, $H_{max}(t) \Leftarrow$ 6-hourly wave height fields

Datasets and methodologies (cont'd)

Statistical projections of $H_{avg}(t)$ and $\overset{\text{not } H_{max}(t)}{H_{20y}(t)} \leftarrow \text{Projected } P_t \text{ and } G_t$

Projected surface winds \rightarrow ODGP-2G \rightarrow Dynamical projections of $H_{avg}(t)$, $H_{max}(t)$

ERA40 & dynamically projected $H_{max}(t)$



$$\hat{H}_{20y}^{tr}(t) \Leftarrow GEV(\hat{\mu}_t = \hat{\mu}_0 + \hat{\beta}t + \hat{\lambda}t^2, \hat{\sigma}, \hat{\xi})$$

Compare long-term means

$$\hat{H}_{20y}^{tr}(t) = \hat{h}_0 + \hat{\beta}t + \hat{\lambda}t^2 \leftarrow \text{statistically projected } H_{20y}(t)$$

Will try this:

12-hly ERA40 SWH and SLP data

Statistical projections of 12-hly SWH: $\hat{H}_t = \hat{a} + \hat{b}G_t + \hat{c}P_t \leftarrow \text{Projected 12-hly } P_t \text{ \& } G_t$

Statistical projections of $H_{max}(t) \sim$ ERA40 & Dynamical projections of $H_{max}(t)$

Comparison of the wave height climate and variability

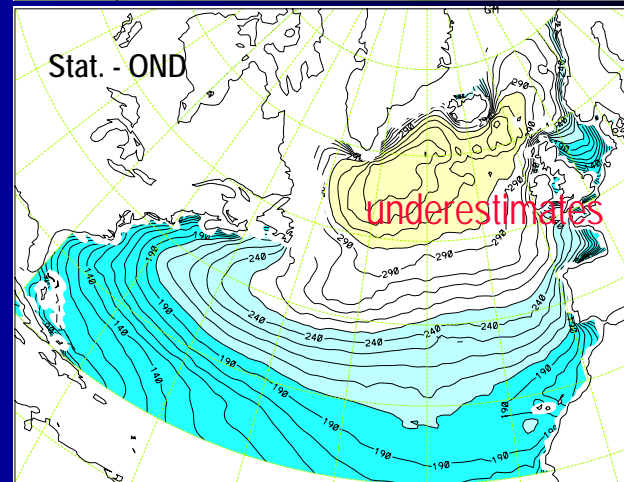
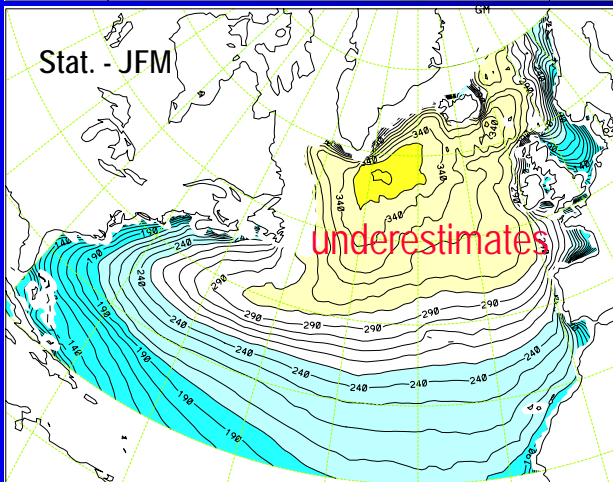
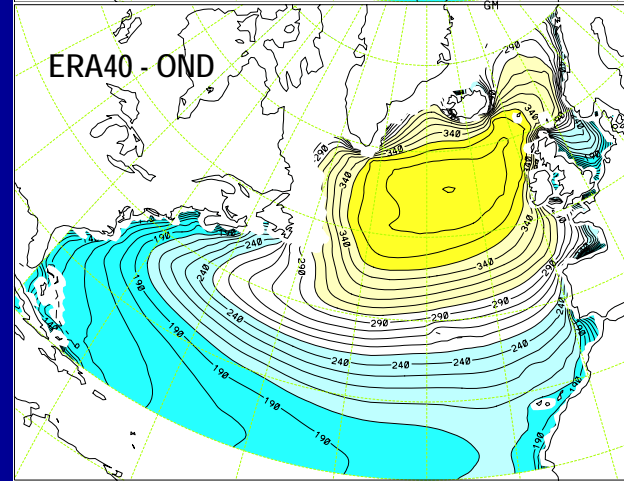
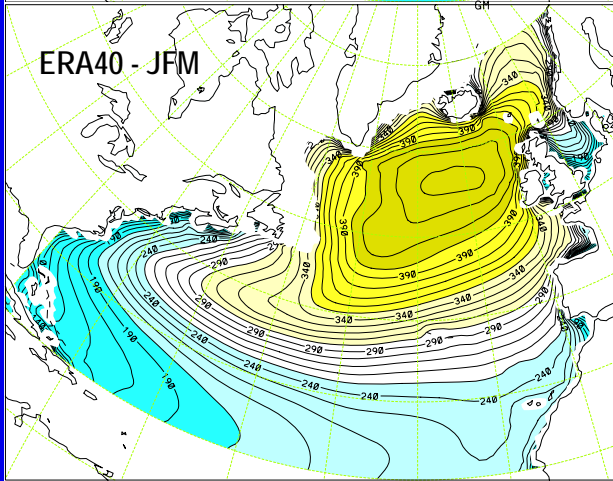
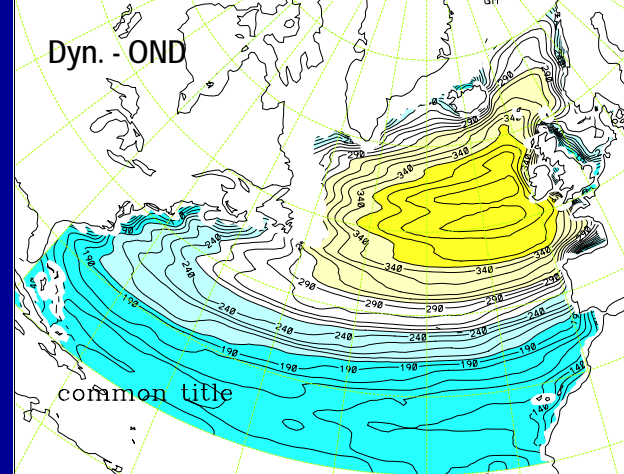
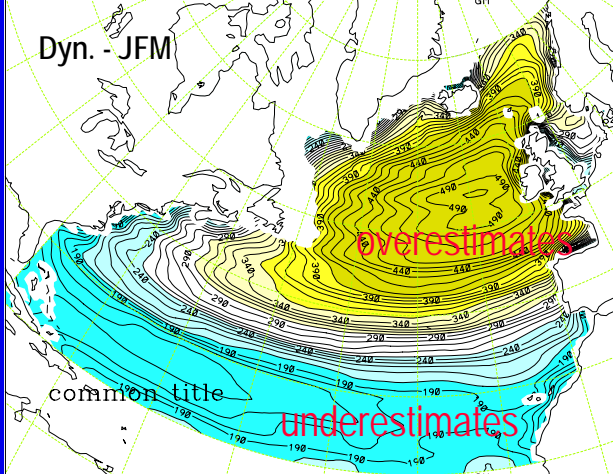
The 1975-94 climate of
seasonal mean SWH (cm)

Dynamical
projections:

better reproduce
the location of the
center of high waves

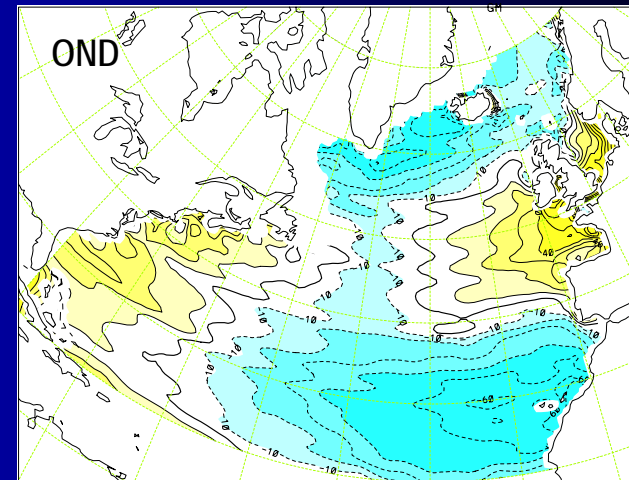
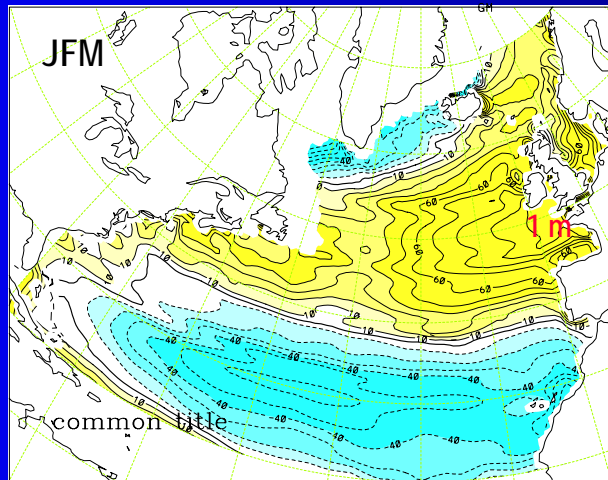
ERA40:

Statistical
projections:

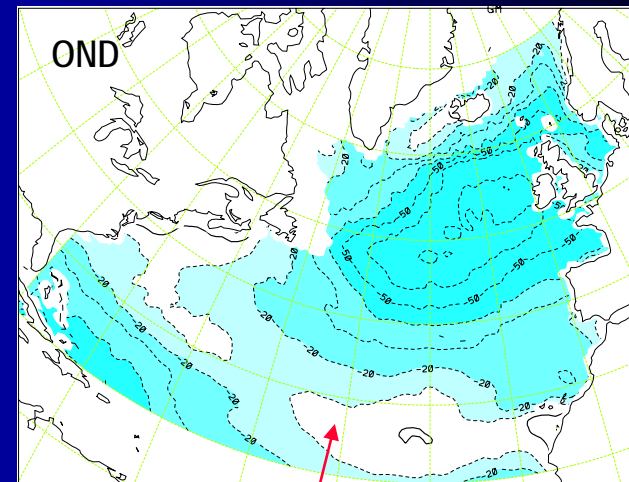
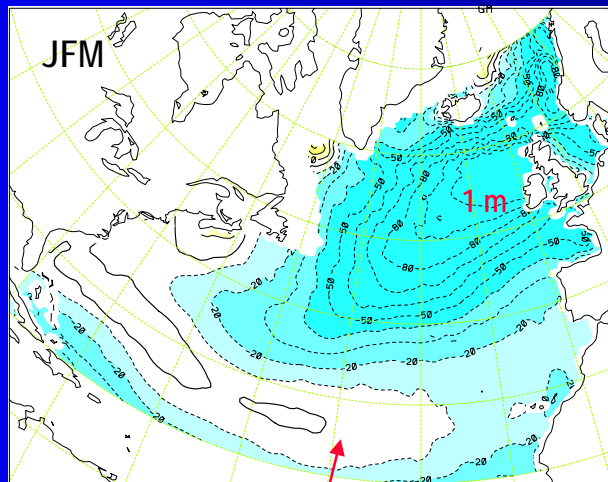


Differences in the 1975-94 climate of seasonal mean SWH (cm)

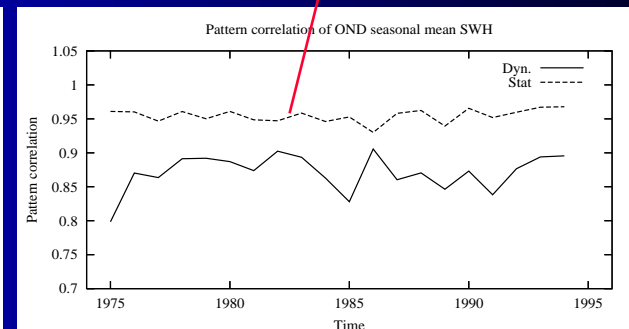
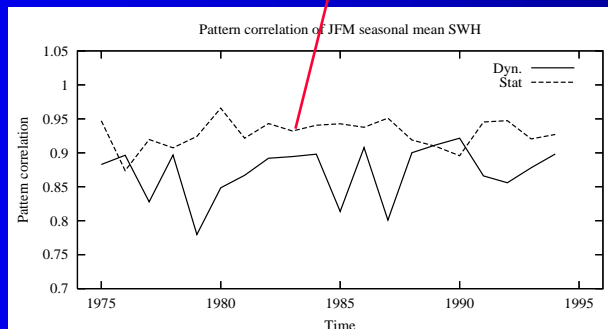
Dynamical projections
minus ERA40:



Statistical projections
minus ERA40:

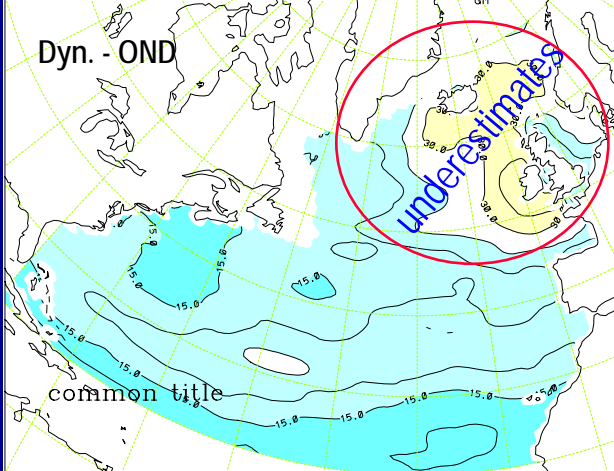
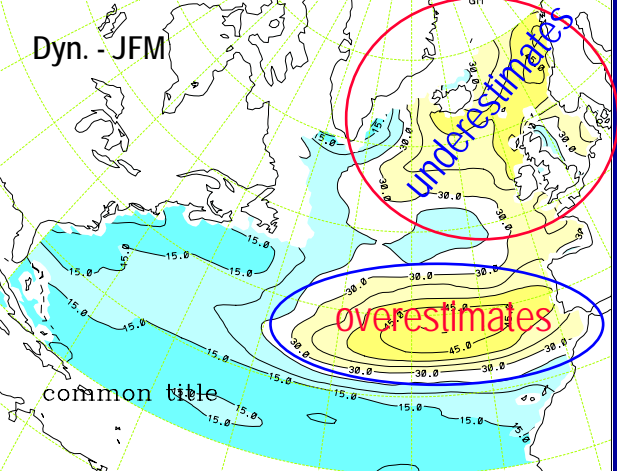


Pattern correlation
skill score:

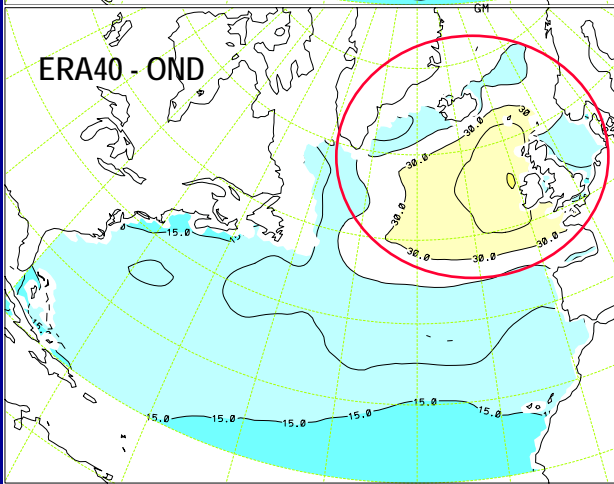
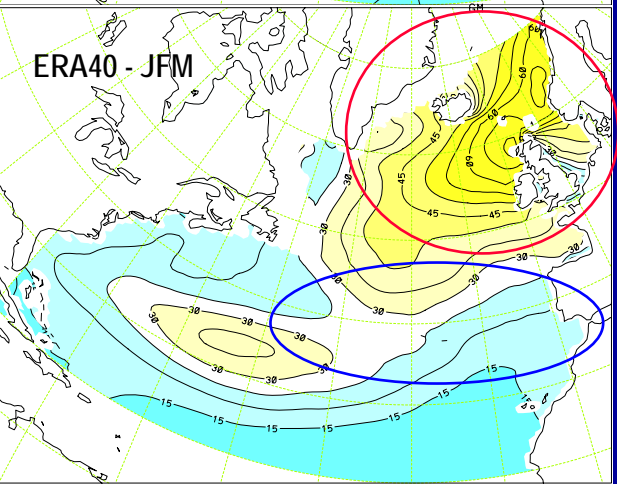


The 1975-94 std of
seasonal mean SWH (cm)

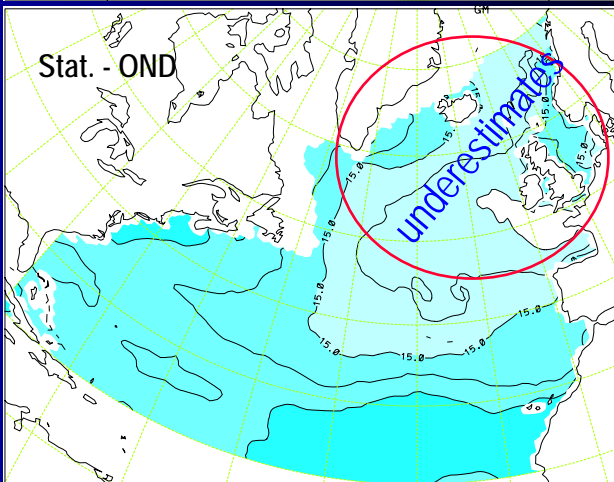
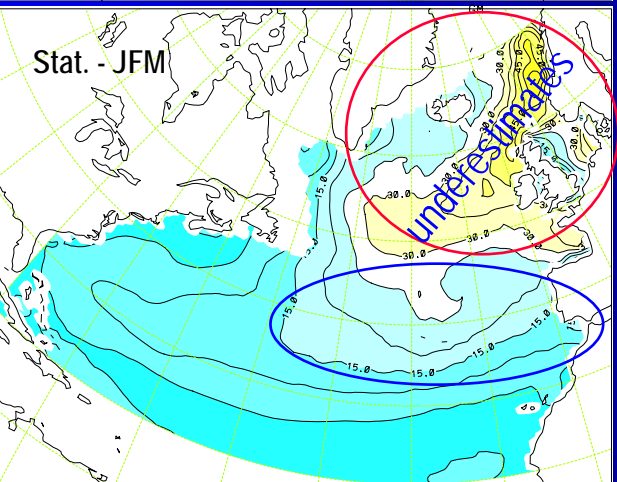
Dynamical
projections:



ERA40:

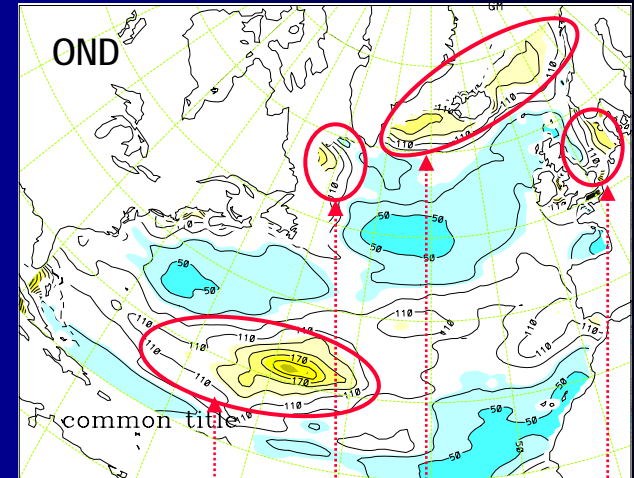
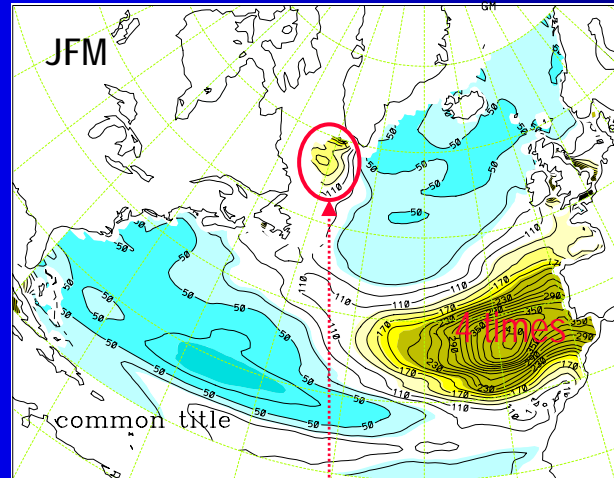


Statistical
projections:

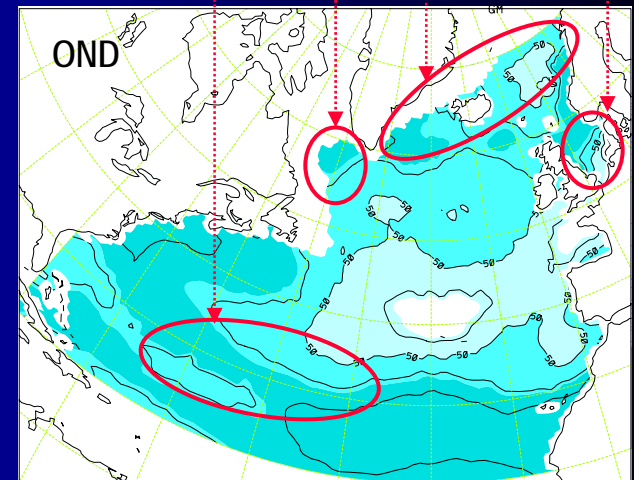
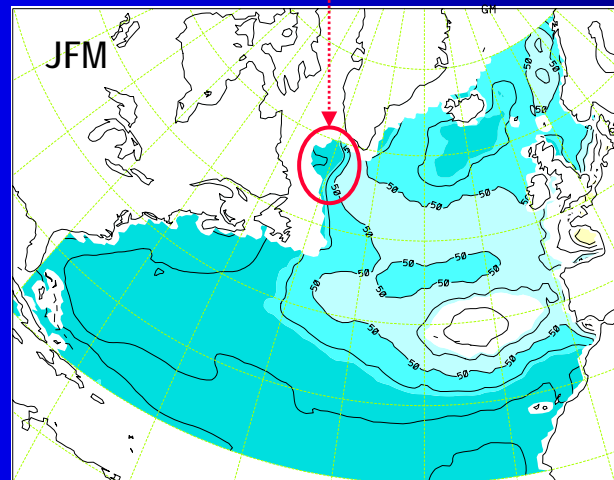


common title
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Ratios of the 1975-94 variance of seasonal mean SWH (cm)

Dynamical projections ~ ERA40:

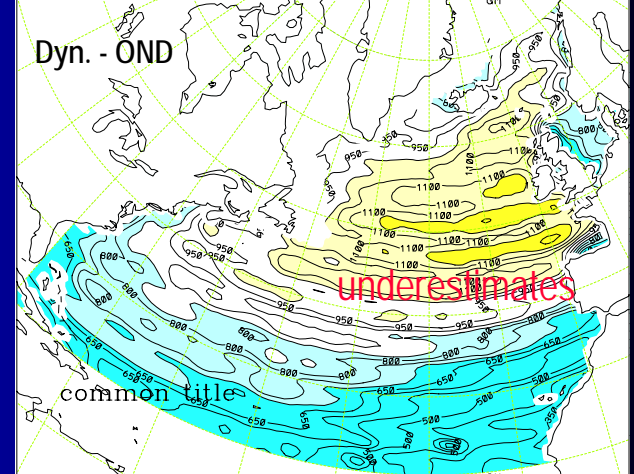
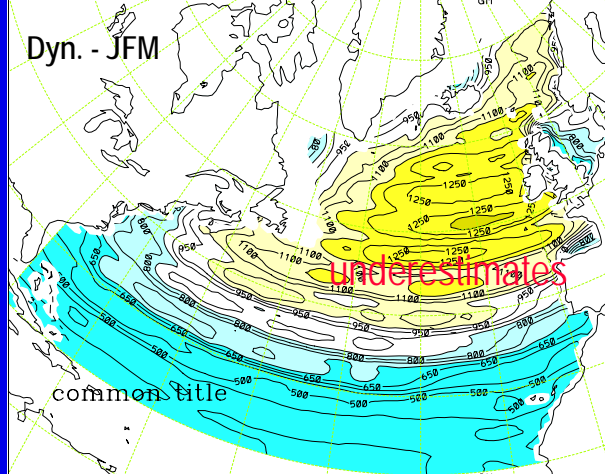


Statistical projections ~ ERA40:

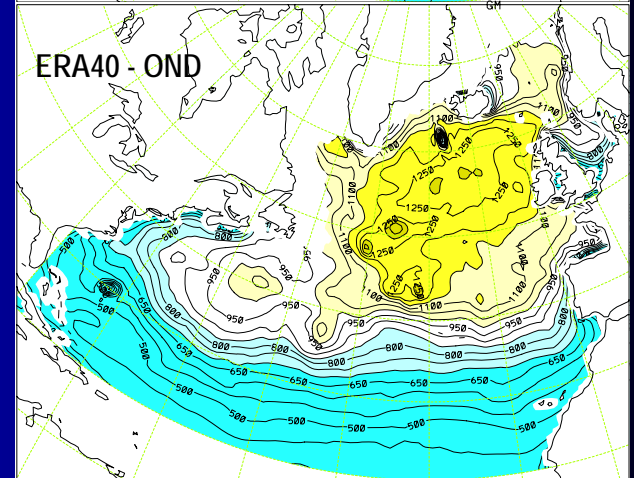
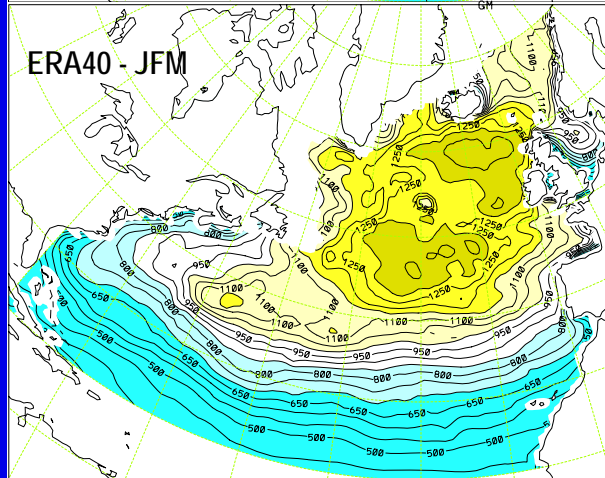


The 1975-94 climate
of seasonal H_{20y} (cm)

Dynamical
projections:

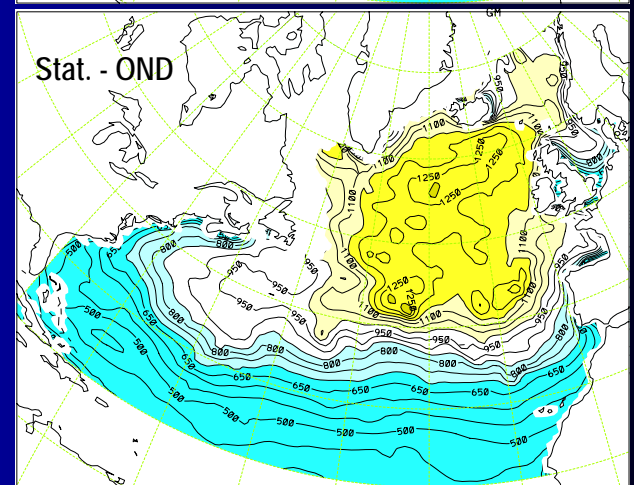
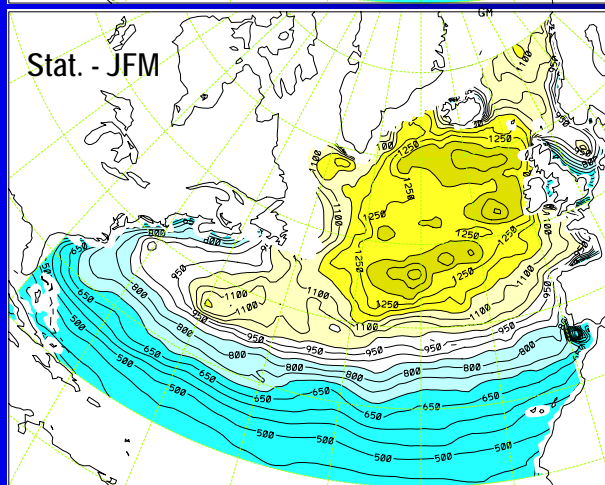


ERA40:



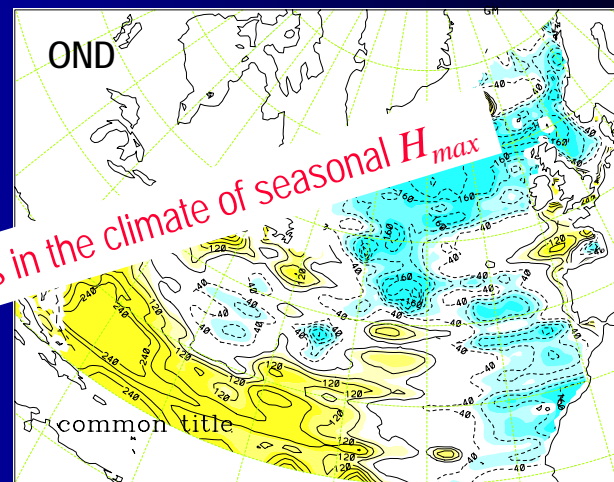
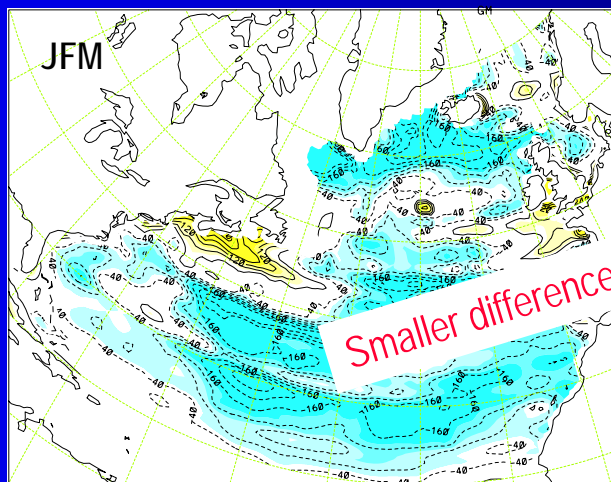
better reproduce the
observed patterns

↑
Statistical
projections:



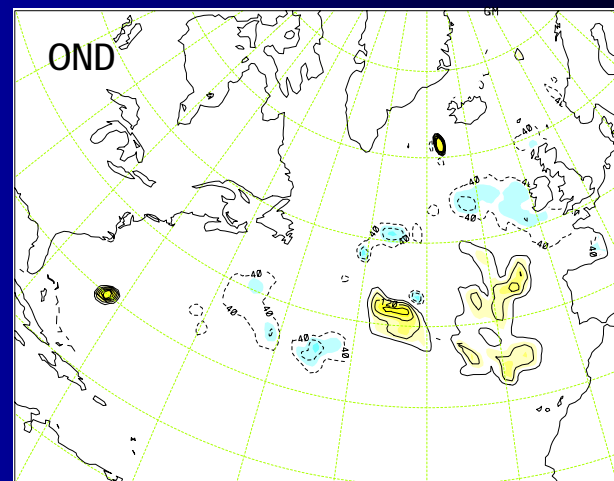
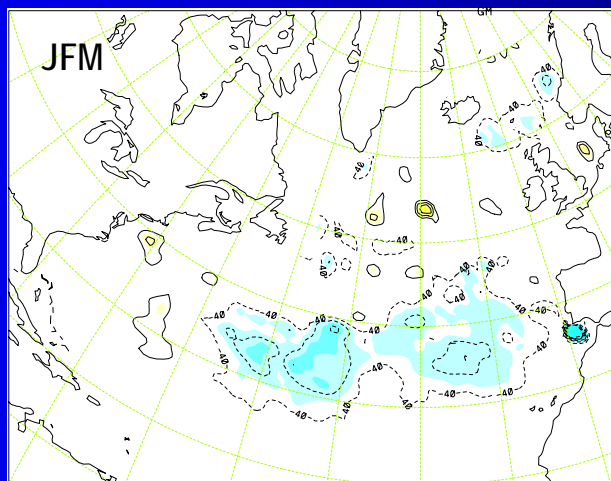
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Differences in the 1975-94 climate of seasonal H_{20y} (cm)
common title

Dynamical projections
minus ERA40



Smaller differences in the climate of seasonal H_{max}

Statistical projections
minus ERA40



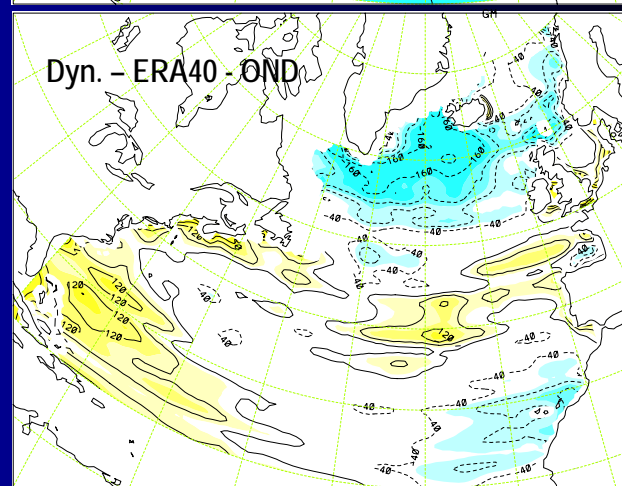
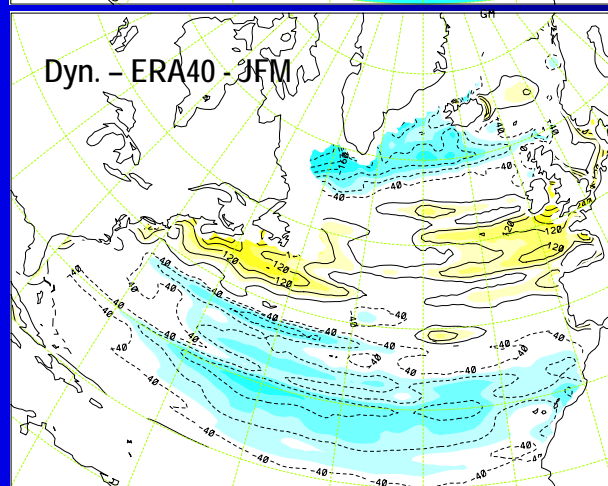
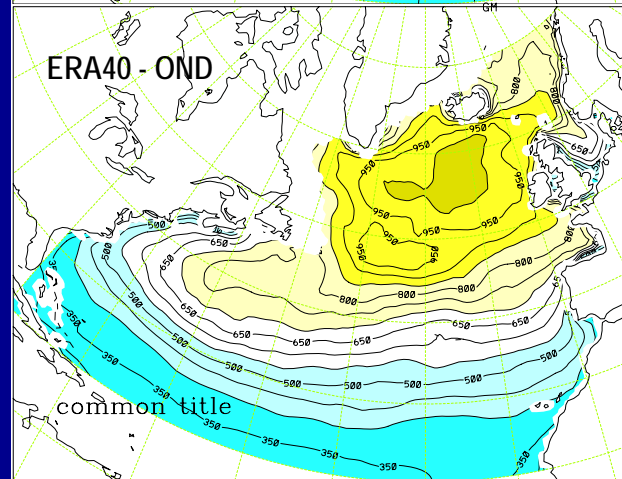
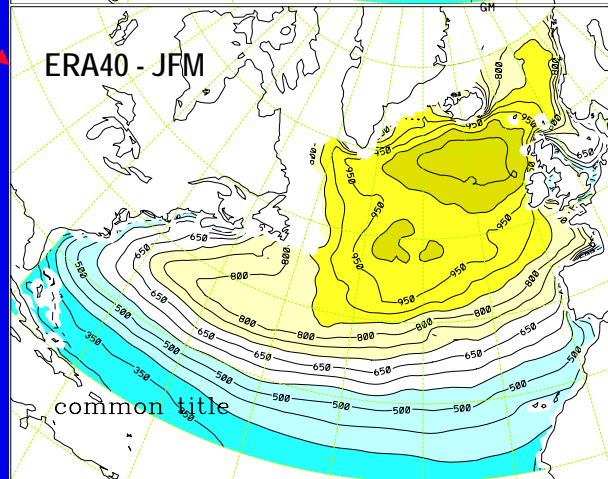
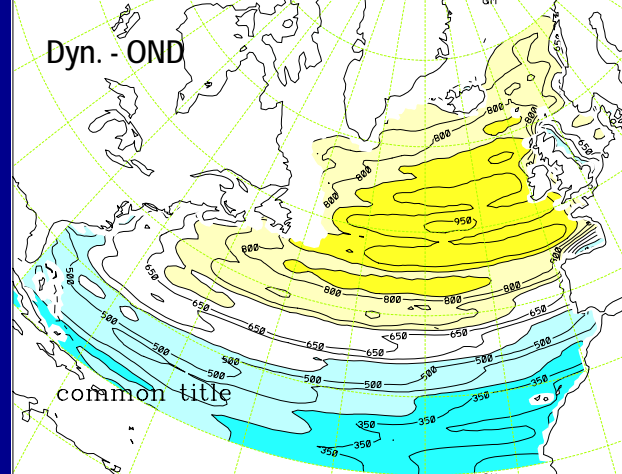
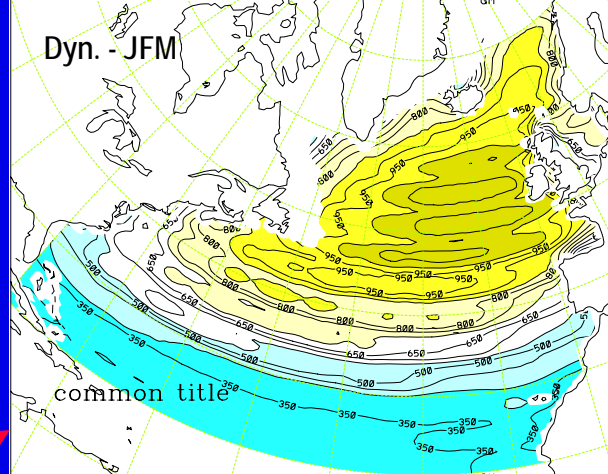
The 1975-94 climate
of seasonal H_{max} (cm)

Dynamical
projections:

Patterns similar to those
of the corresponding H_{20y}
→ little distortion

ERA40:

Dynamical projections
minus ERA40:



Comparison of the projected possible future changes

Projected changes in seasonal H_{avg} (cm) (2080-99's – 1975-94's)

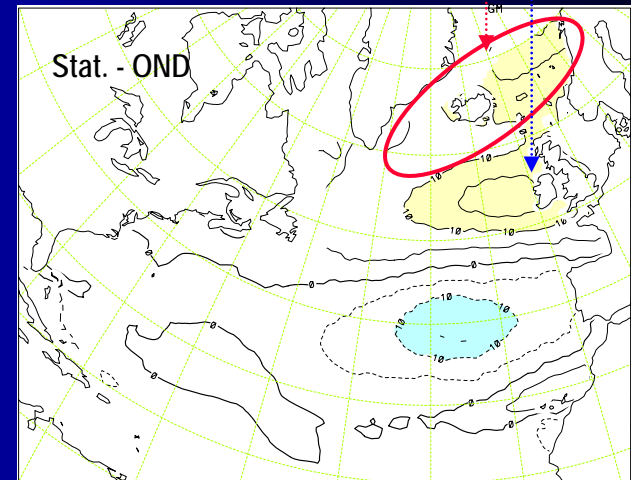
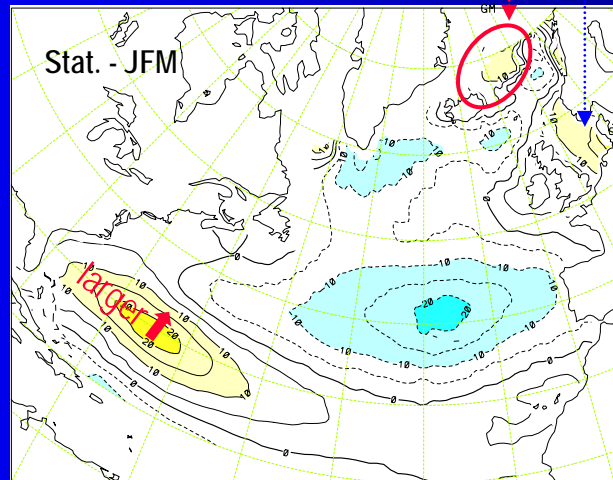
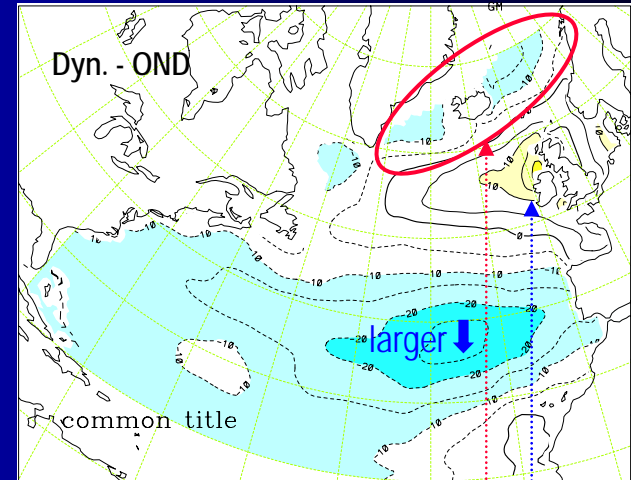
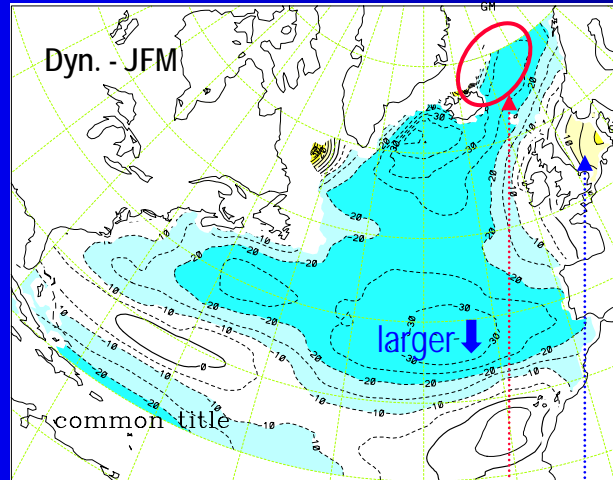
common title

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Dynamical
projections:

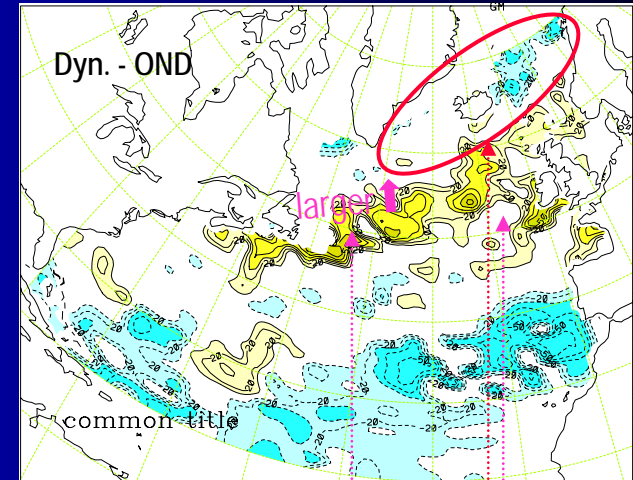
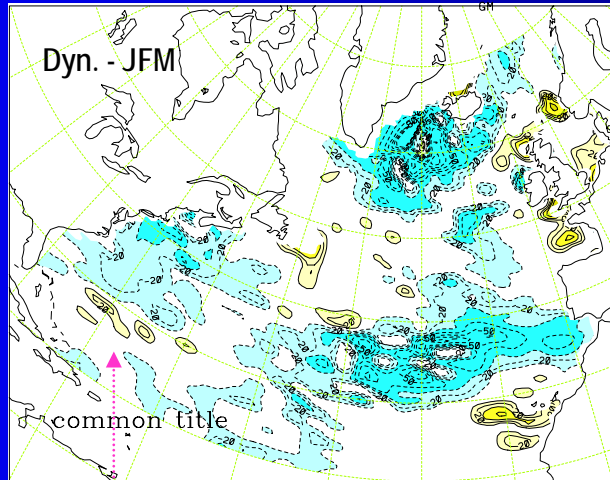
Patterns share
substantial similarity

Statistical
projections:

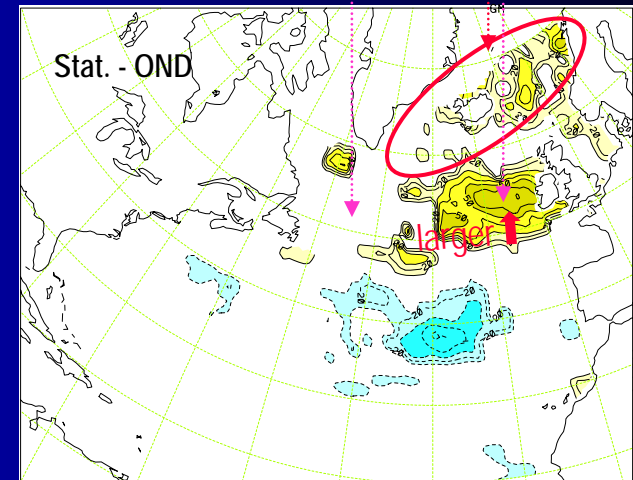
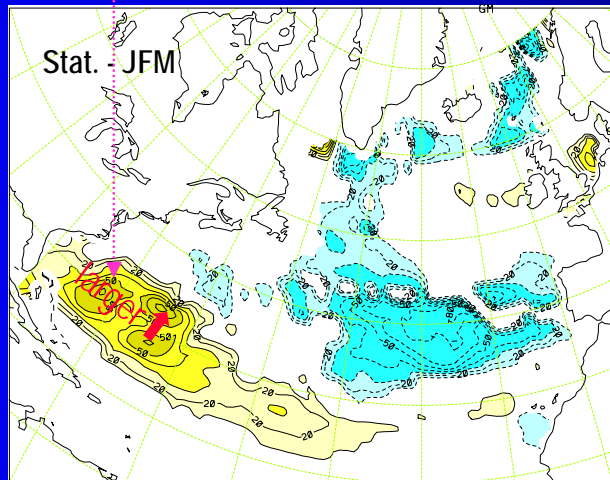


Projected changes in seasonal H_{20y} (cm) (2080-99's – 1975-94's)

Dynamical
projections:



Statistical
projections:



Summary

1. Projected mean SWH climate ~ ERA40:

- > Dynamical projections → better location of climatological center of high waves
- > mid-high latitude NA: dynamical ~ overestimate; statistical ~ underestimate
- > subtropical NA: dynamical ~ underestimate, statistical ~ very good
 - Statistical projections ~ higher pattern correlation skill

2. Projected variability (including trends) ~ ERA40:





- > Statistical projections ~ underestimate everywhere but central-eastern NA in both seasons
- > Dynamical projections ~ notably overestimate in central-eastern NA in winter
- > 60N-70N, North Sea, & Labrador Sea: dynamical ~ overestimate, in both seasons
statistical ~ underestimate,

Summary (cont'd)

3. Projected extreme SWH climate ~ ERA40:

- > dynamical ~ underestimate winter 20-yr return values everywhere
~ overestimate fall 20-yr return values in southwestern NA
and underestimate them elsewhere
- > statistical projections ~ very good in both seasons

4. Projected possible future changes:

- > dynamical & statistical projections show patterns of change of substantial similarity:
 in the mid-latitude NA,  in the North Sea in JFM & in the area west of Ireland in OND
dynamical ~ larger  in mid-latitude NA; statistical ~ larger  in southwestern NA in JFM
- > 60N-70N: dynamical & statistical projections show changes of the opposite signs, especially
in OND – uncertainty due to different “downscaling” methods or “predictors” used
– less confident

Dynamical ~ winds
Statistical ~ SLP

Acknowledgement

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- The End -

Thank you very much!