Detection of Human Influence on Trends of North Atlantic Ocean Wave Heights and Atmospheric Storminess

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Outline

Data sets
Methodology
Results
Concluding remarks

Data sets

- - P_t anomalies of seasonal mean SLP

 G_t – seasonal anomalies of squared SLP gradients (geostraphic wind energy)

"observed"

atmosphere

- P_t and $G_t \leftarrow$ SLP of ERA40 reanalysis for 1958-2001
- P_t and $G_t \leftarrow$ SLP of NCEP/NCAR reanalysis for 1958-2001 (anomalies relative to the 1961-1990 climate)
- Simulated P_t and $G_t \leftarrow 9$ ensembles of integrations of human-induced

climate change (45 in total)

Table 1.The nine coupled ocean-atmosphere models used
in this study and the number of integrations (runs)
conducted with each of these models.

Model	Number of runs
ECHO-G	5
GFDL CM2.0	3
GFDL CM2.1	3
GISS Model E H	5
GISS Model E R	9
MIROC 2 medres	3
MRI CGCM2 3 2a	5
NCAR CCSM 3	8
NCAR PCM 1	4
	Total: 45

Period of integration: 1900-1999 (used: 1900-1941 + 1958-1999: 2x42 yr.)

All with historical greenhouse gases and sulphate aerosols forcing

Obtained from the IPCC AR4 models output archive

Methodology

• Wave height not directly available \rightarrow Statistical simulations of SWH:

Parameters $\hat{a}, \hat{b}, \hat{c}, \hat{\sigma}, \hat{\xi} \in \text{ERA40 SWH}, P_t \text{ and } G_t (de-trended)$ Climate model simulations \rightarrow corresponding Seasonal means \hat{H}_{avg} $\hat{H}_t = \hat{a} + \hat{b}P_t + \hat{c}G_t$ SWH change $GEV(\hat{\mu}_t = \hat{a} + \hat{b}\hat{P}_t + \hat{c}\hat{G}_t, \hat{\sigma}, \hat{\xi})$ Seasonal 20-yr return values \hat{H}_{20y} Wave height not directly available from NNR \rightarrow NNR, ERA40 \rightarrow hindcasts <u>Linear trend patterns</u> of $P_t, G_t, H_{avg}, H_{20y}, \hat{H}_{avg}, \hat{H}_{20y} : T_o, T_m$ Multi-model mean "Observed"/hindcast (1958-1999)<u>Optimal detection approach</u> (TLS fit): $T_o = \beta(T_m - \varsigma) + \eta$ Simulated Observed If scaling factor $\beta > 0$ significantly, response to anthropogenic forcing is detected /nternal variability $\eta \sim \zeta$ consistent? using simulations for 1900-41



Trend patterns of seasonal mean SLP anomalies P_t



Trend patterns of seasonal mean SWH Have







Concluding remarks

In the cold seasons:

• The observed trend patterns of SWH and storminess:

1 in high-latitudes, J to the south





Concluding remarks

In the cold seasons:

• The observed trend patterns of SWH and storminess:

in high-latitudes, J to the south

- Anthropogenic forcing has had a detectable influence on the trends (all observed datasets used)
- The climate models significantly underestimate the magnitude of the response to anthropogenic forcing
- The climate models also underestimate the observed internal variability in fall (→ conservative detection conclusions)

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- The End -

Thank you very much!