Visual Analysis of time-dependent 2D Uncertainties in Decadal Climate Predictions

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Decadal Climate Predictions

- **Aim**: predict natural **internal variability** over the next few years
- **Forecast System**:
  - Earth System Model
  - Initialization with observations (Atmosphere, Ocean, Sea Ice, Land, ...)
- **Assess the uncertainty via ensemble simulations**

*Source:* IPCC AR5, Chapter 11, Box 11.1, Figure 2
Decadal Climate Predictions

- Verification of climate predictions?
- Not possible for forecasts
- Instead, use **hindcasts** to derive the skill of the system

Slide: Thanks to Iuliia Polkowa, Institute of Oceanography, University of Hamburg
Multivariate 2D Visualizations used in the Domain

Quantify success: RMS Skill Score (color) and Significance > 95% (black dots)

Figure shows temporal mean for year 2-5.
• Only limited information on the spatio-temporal structure of the skill!
• Only one threshold value visualized

Source: IPCC AR5, WG1, Chapter 11, Figure 11-04
The Data used

- 3 Quantities
  - 2m temperature anomalies over 2014-2023, ensemble mean (12 months running mean)
  - Predictive skill: Pearson’s correlation between prediction and reanalysis (based on hindcasts)
  - Ensemble standard deviation

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**Model system**
- MiKlip Baseline 1
- MPI-ESM Earth System Model (T63L47/1.5 deg L40)
- Initialization with ORAS4 ocean reanalyses (T & S anomalies), ERA40/ERA-Interim
- Yearly initialization for 1961-2010
- 10 ensemble members
- Described in Pohlmann et al., GRL 2013, DOI: 10.1002/2013GL058051
Temporal Patterns: 2m Temperature Anomaly

2m Temperature Anomaly

07/2015  (C) DKRZ / MPI-M
Temporal Patterns: Ensemble Standard Deviation
Temporal Patterns: Positive Skill / 2m Temperature

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Positive Forecast Skill

Positive F

0.5
1
NCL – NCAR Command Language

2m Temperature Anomaly

4/2018-3/2019
NCL – NCAR Command Language

- Vector Gfx
- Animation?
ParaView

Paraview: Uncertainty surface (ensemble spread)

Winter

2m Temperature Anomaly, Ensemble Standard Deviation and Forecast Skill

Years 2-5
DJF

Height: Standard Deviation
Isolines: Forecast Skill of 0.5, 0.55, 0.6, 0.65, ...

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Summer

2m Temperature Anomaly, Ensemble Standard Deviation and Forecast Skill

Years 2-5
JJA

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Conclusions

- Joint analysis of data and related uncertainty data
  - 2m temperature anomaly
  - predictive skill
  - internal variability (standard deviation)

- Solutions for 3 different visualization tools
  - **NCL**: 2 line based techniques for overlay
  - **ParaView**: interactive analysis based on linked views & brushing
  - **Avizo**: Animated 3D visualization of 2D data

- No swiss army knife found – each tool has strengths and weaknesses
Thank You!

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