

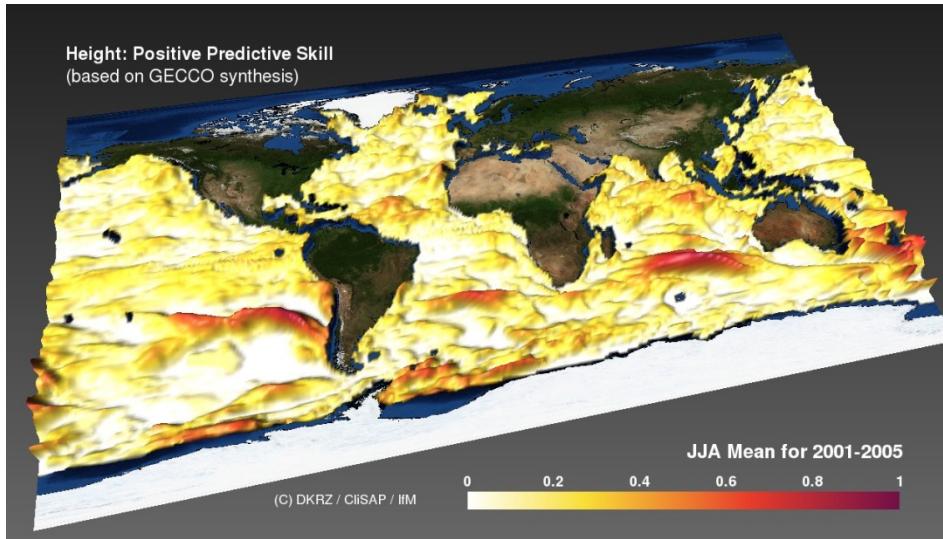
Forecast Skill Visualization in Climate Research

Michael Böttinger, Niklas Röber, Dela Spickermann

Deutsches Klimarechenzentrum (DKRZ)

Iuliia Polkova

Institute of Oceanography, University of Hamburg, CEN

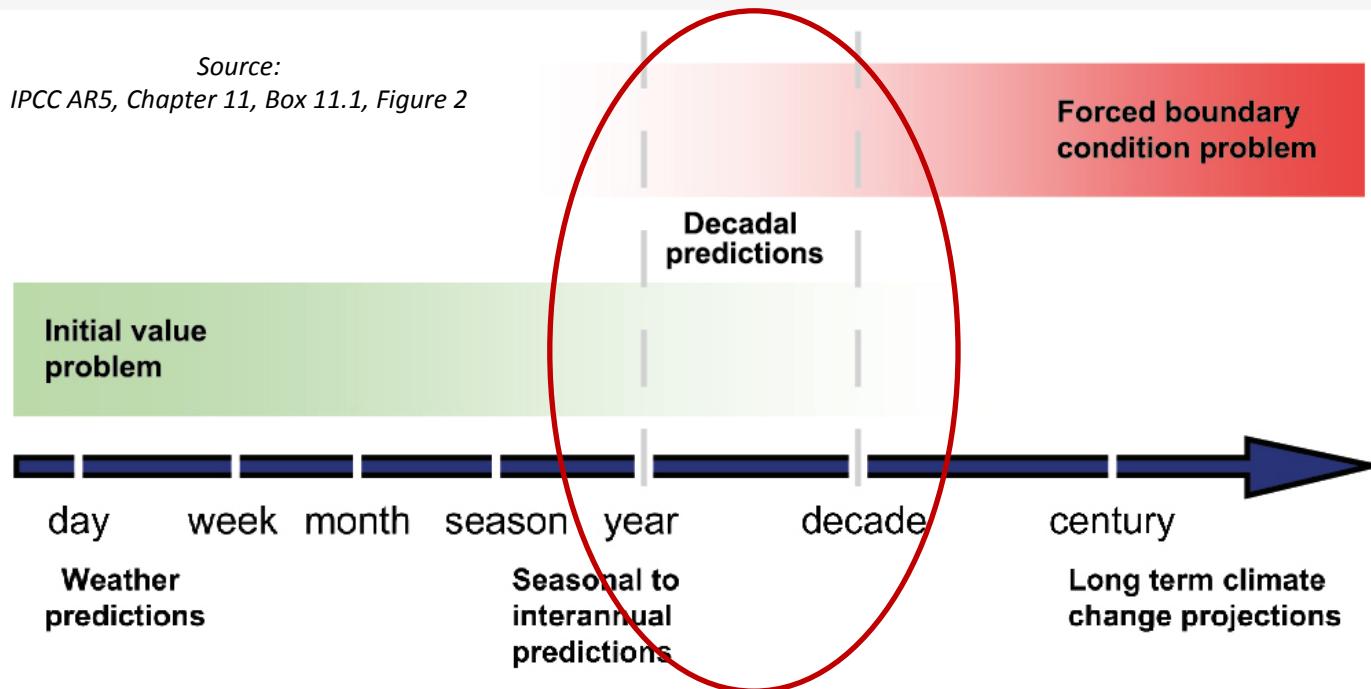


Uncertainty in Climate Simulations

“Uncertainty is the only certainty there is, and knowing how to live with insecurity is the only security.” (John Allen Paulos)

- Four categories of uncertainty:
 - Model uncertainty
 - Parameterization
 - Spatial/temporal resolution
 - Processes
 - Internal variability and initial conditions uncertainty
 - Forcing and boundary condition uncertainty (past)
 - Scenario uncertainty (future)

Decadal Climate Predictions

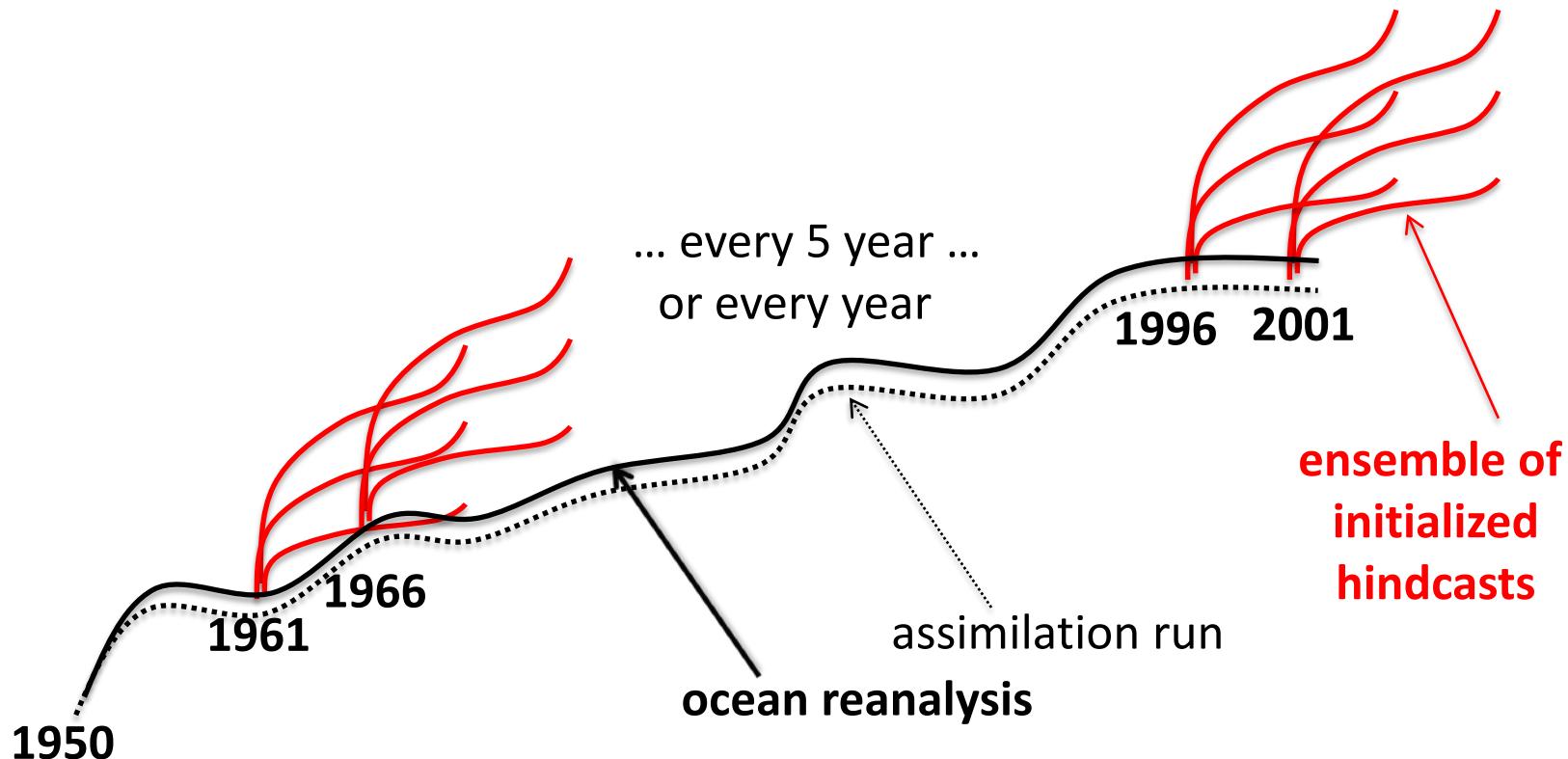


- Aim: predict natural **internal variability** over the next few years through knowledge of the observed climate state
- Initialization with observations (Atmosphere, Ocean, Sea Ice, Land, ...)
 - 3D ocean state (Reanalysis, Assimilation)
- Ensemble simulation techniques

Decadal Climate Predictions

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

Initialized retrospective predictions



Forecast Skill

- Quantify success of predictions
- Various definitions/methods used in literature
 - (Pearson's) Correlation (used here)
 - Root Mean Square Skill Score (RMSSS)
- Significance level
 - e.g. t-test, bootstrap
 - correlation values lower than significance level are statistically insignificant

The Data used

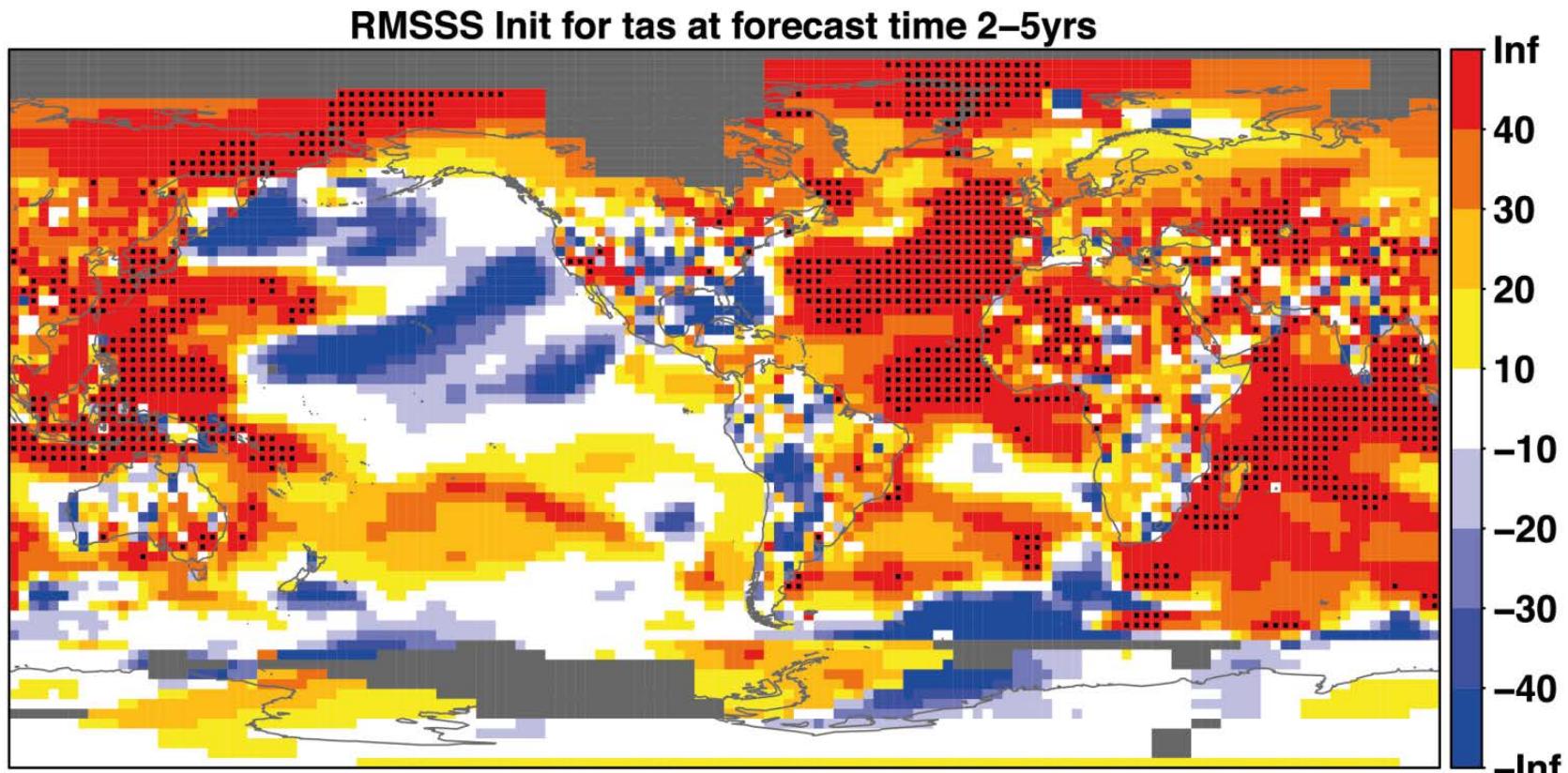
- Model system
 - UCLA/MITgcm coupled ocean-atmosphere model
 - Initialization with GECCO ocean synthesis (Koehl and Stammer, 2008)
 - Full state initialization with heat and freshwater flux correction
 - Initialization every 5 years over 1961-2001
- SST anomalies over 2001-2010, ensemble mean over 3 ensemble members
- Predictive skill
 - correlation between predictions and GECCO synthesis
 - Significance level (t-test)
- Described in Polkova et al., 2014, DOI 10.1007/s00382-013-1969-4

Visualization Software used in the domain

- 2D
- Script based
- Domain specific (Weather, Climate Oceanography)
- Examples:
 - NCL
 - GrADS
 - VCDAT
 - Ferret
 - GMT
 - ...

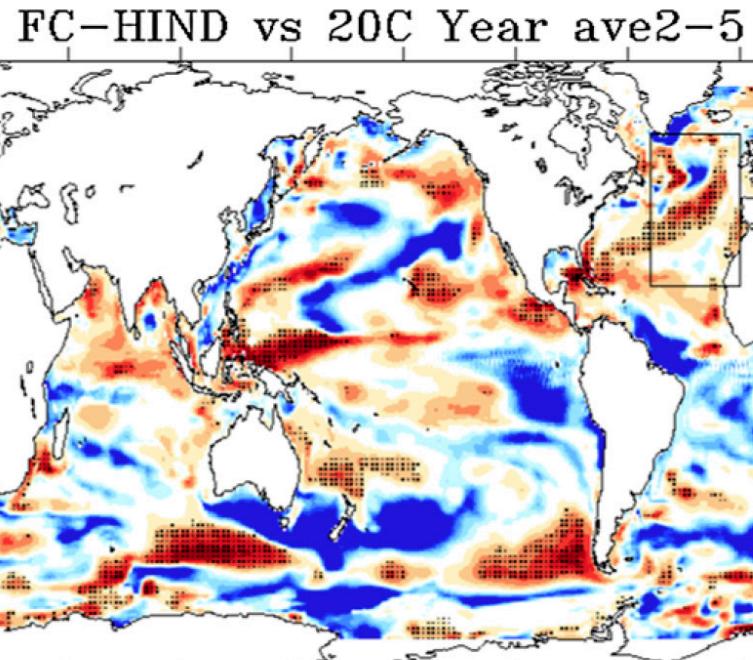
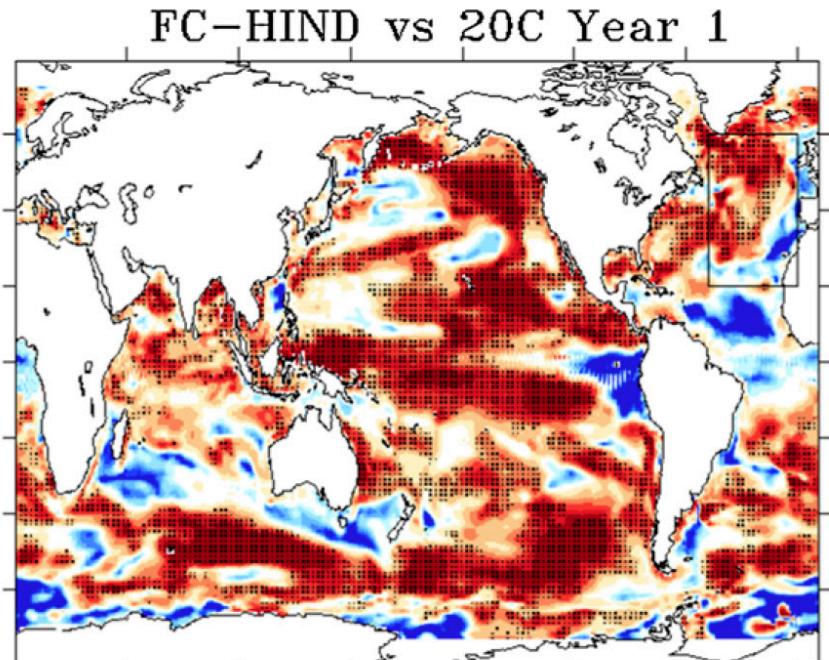
Multivariate 2D Visualizations used in the Domain

RMSSS (color) and Significance > 95 % (black dots)

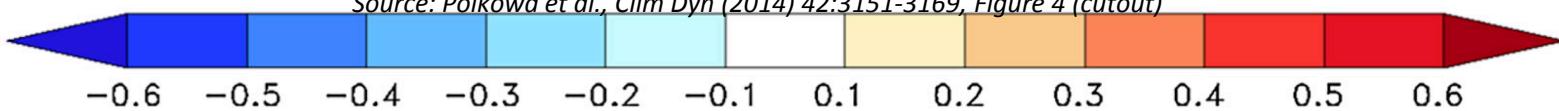


Source: IPCC AR5, WG1, Chapter 11, Figure 11-04

Multivariate 2D Visualizations used in the Domain



Source: Polkova et al., Clim Dyn (2014) 42:3151-3169, Figure 4 (cutout)

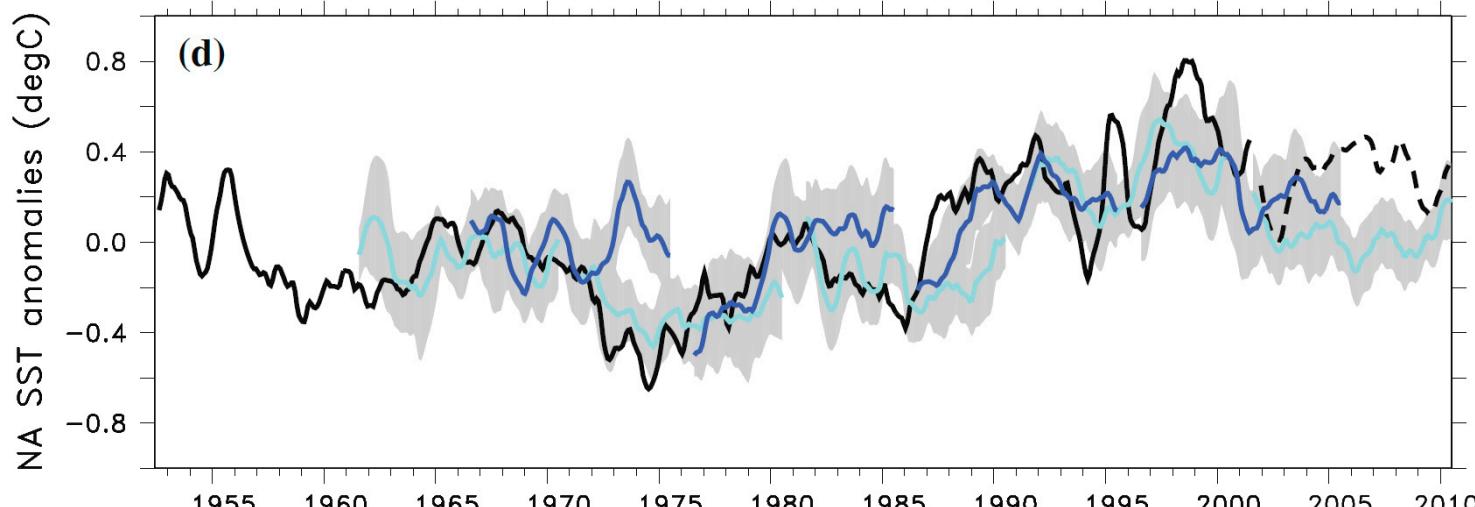


SST RMSS. Hatched regions: significant skill at 90% level

Figure shows temporal means for year 1 and year 2-5.

- Only limited information on the spatio-temporal structure of the skill!
- Only one threshold value visualized
- Not suited for animation

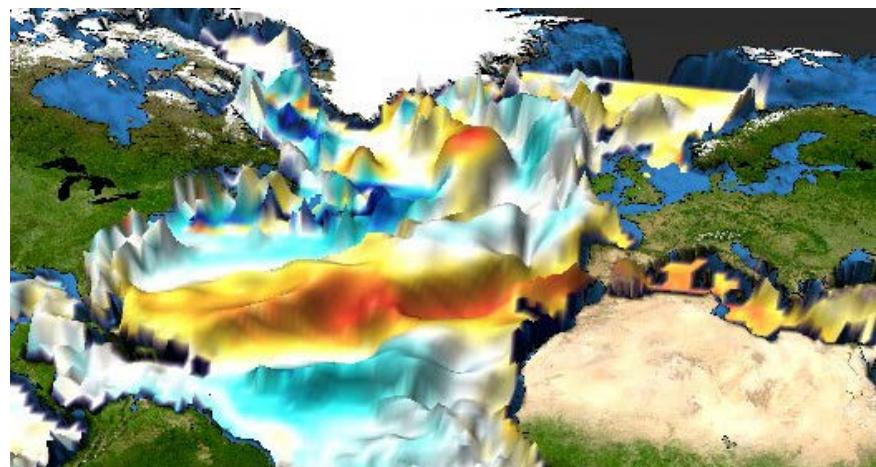
Temporal Analyses



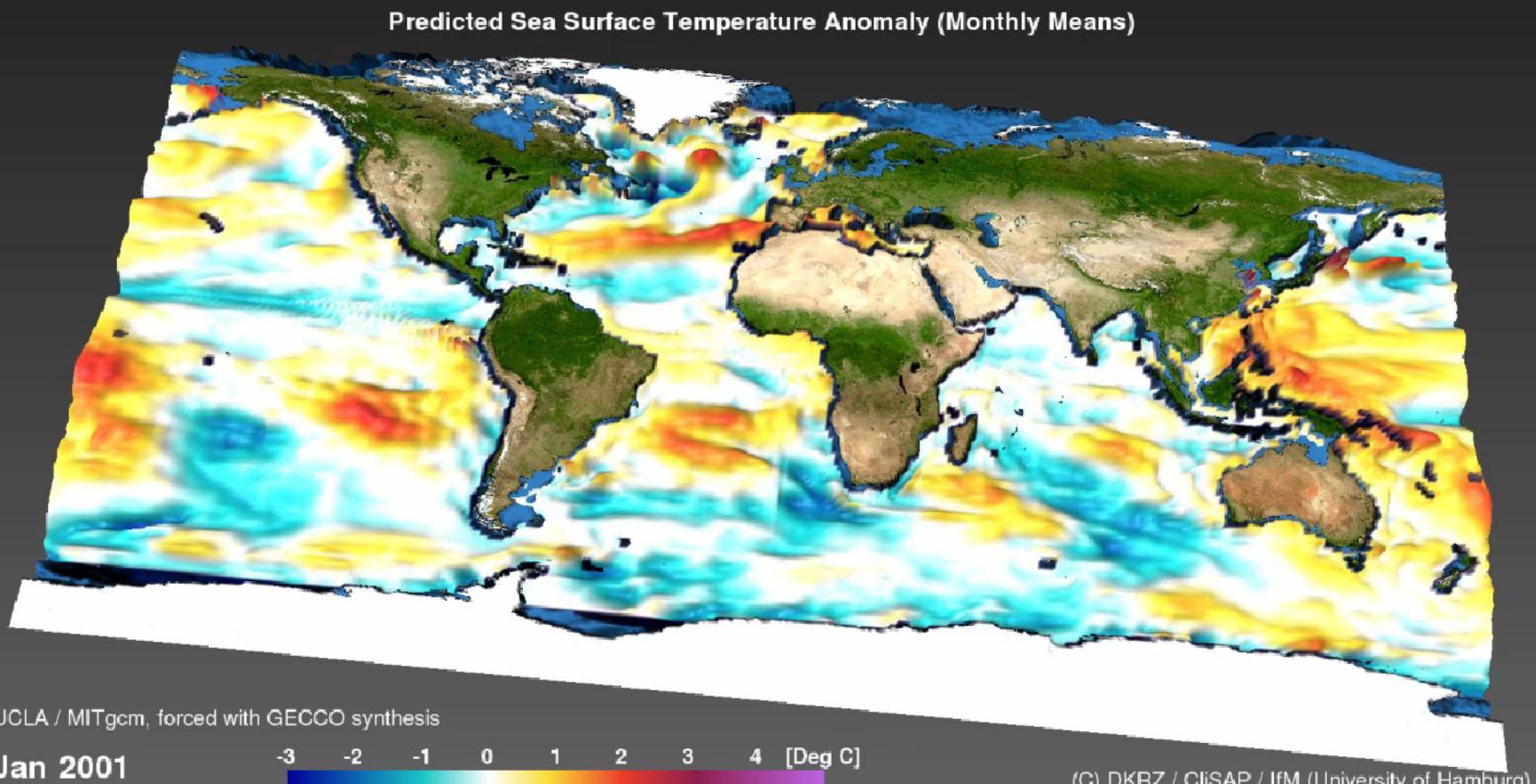
- Temporal development for a spatial mean (here: 50°W - 10°W , 20°N - 60°N)
- Limited information on spatiotemporal patterns
- Alternative: time animations of 2D fields

Our Approach: 3D + Animation

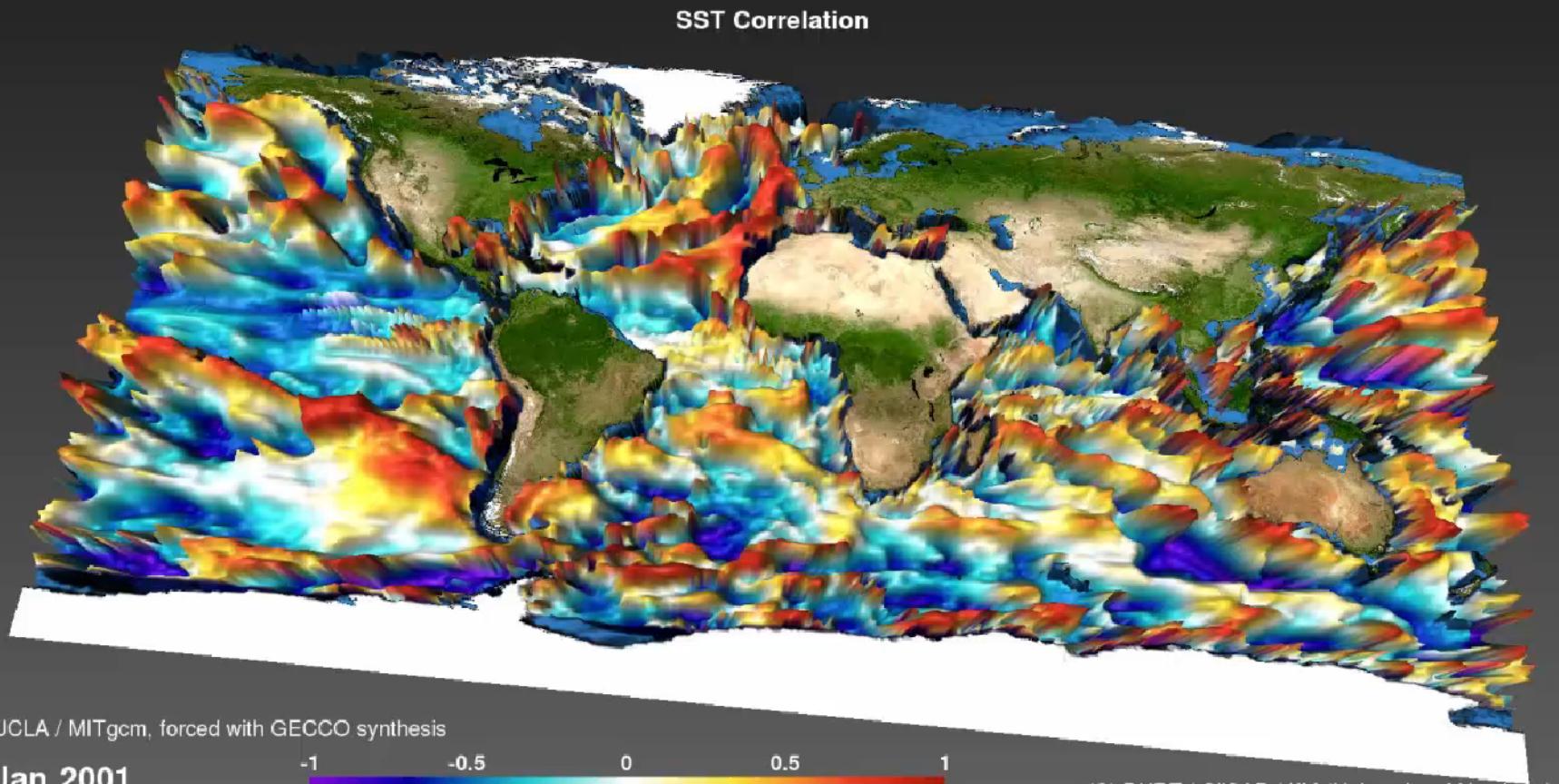
- Avizo Green (commercial 3D visualization system)
- Heightfield method
 - Color mapping & surface deformation according to physical and/or statistical values
 - Univariate or bivariate data visualization
 - Well suited for animation
- Geographical mapping
- Geographical context
- NetCDF CF



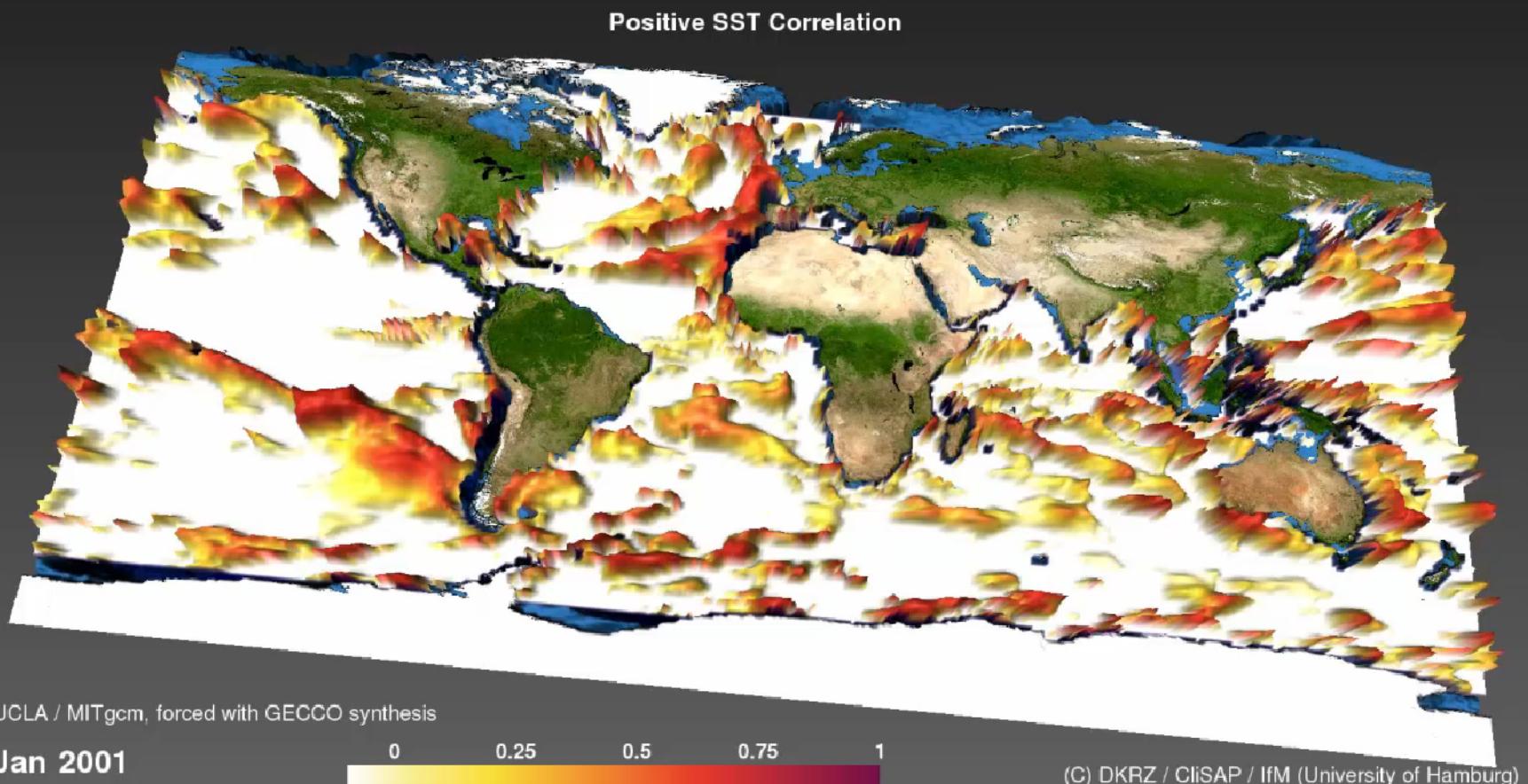
Temporal Patterns: SST Anomaly



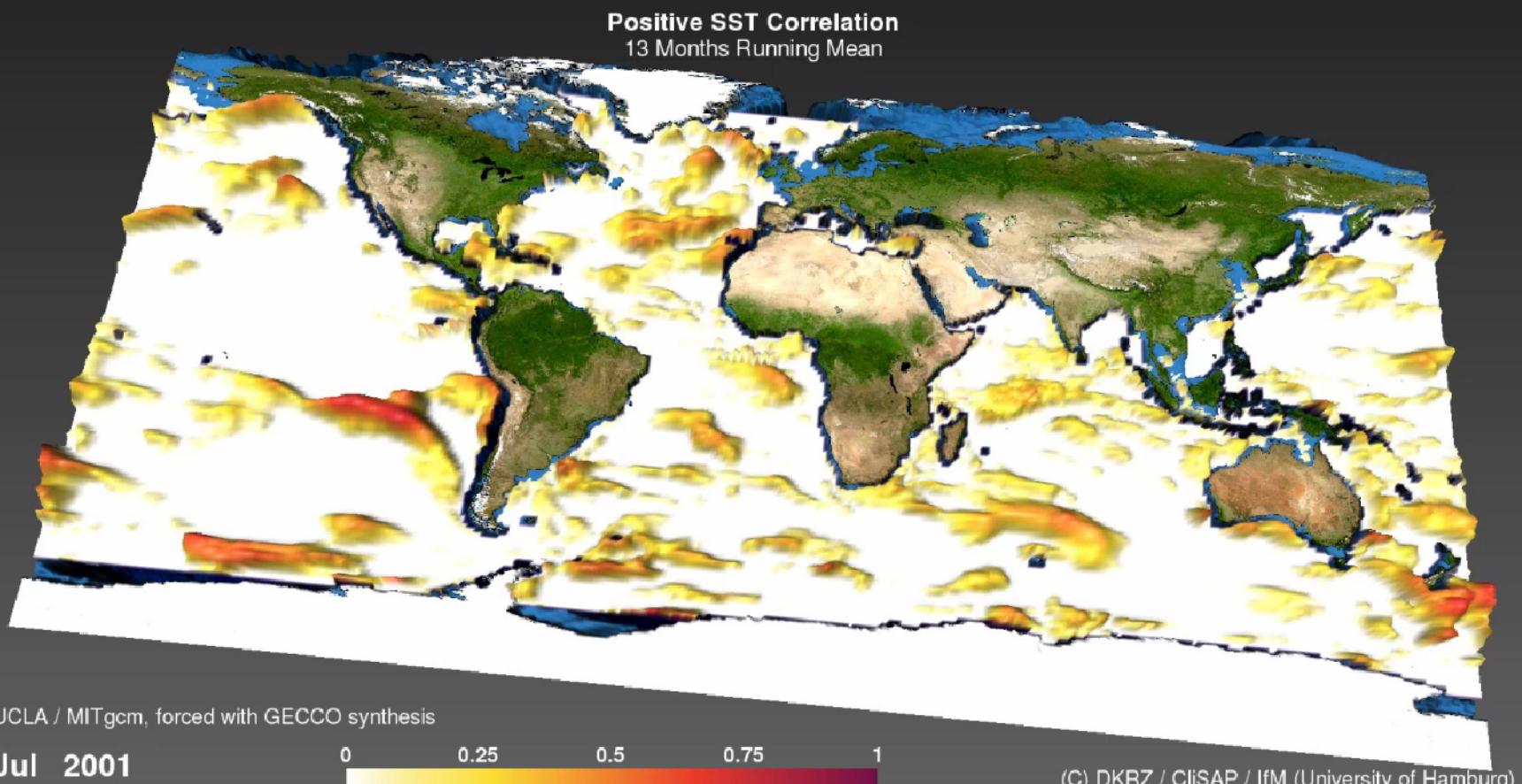
Temporal Patterns: SST Correlation (Skill)



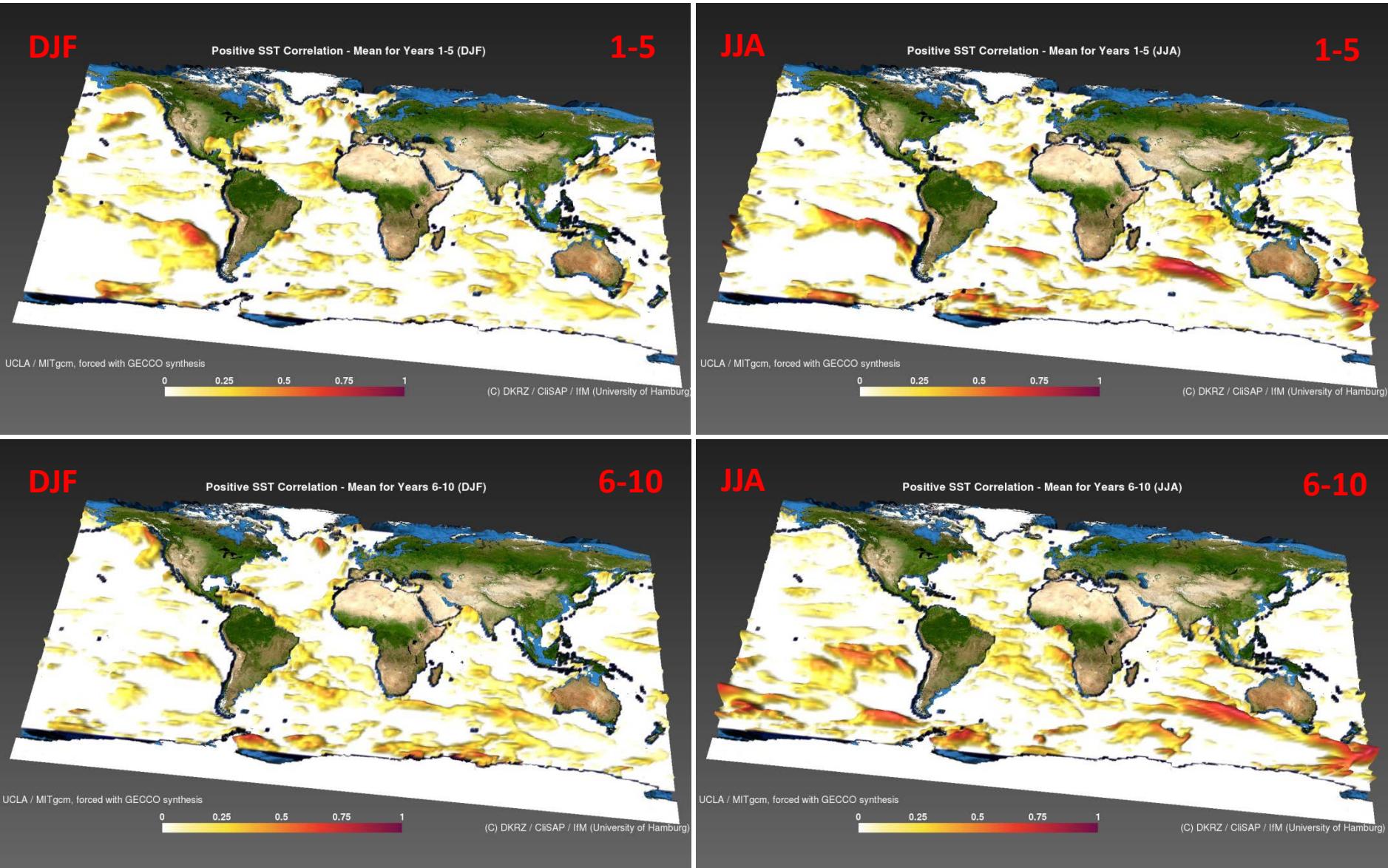
Positive SST Correlation (Skill)



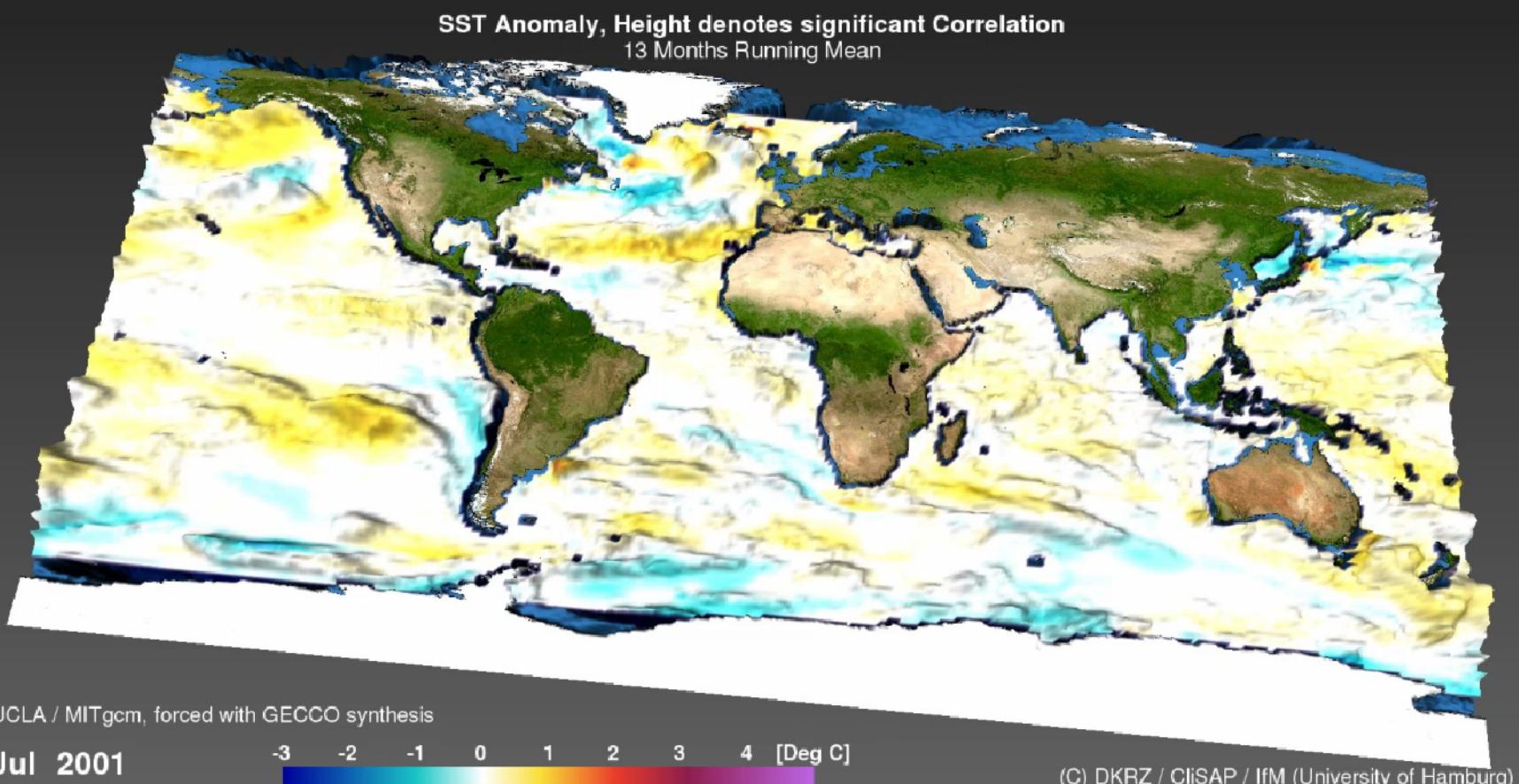
Low-pass filtered positive SST Correlation (Skill)



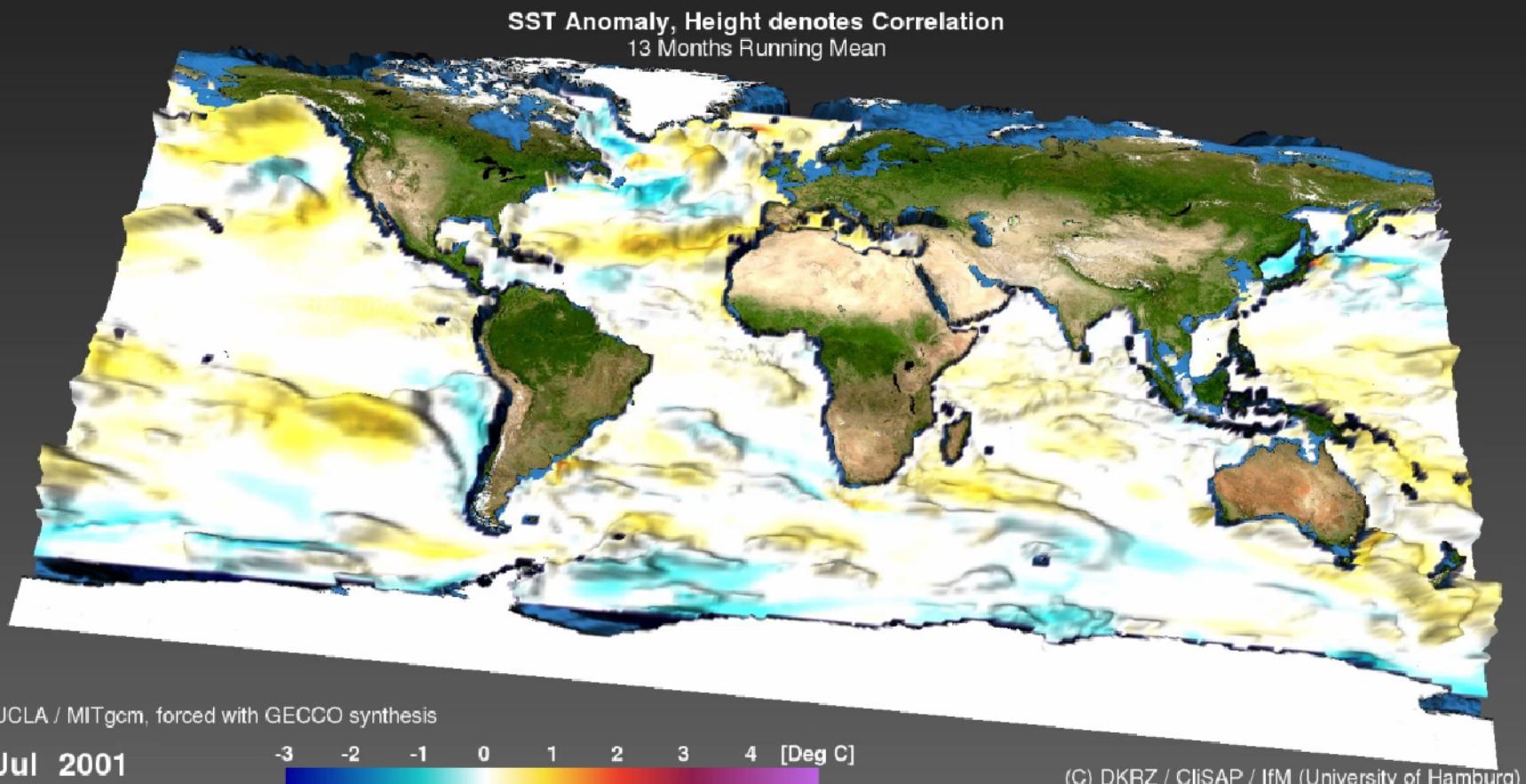
Seasonal Analyses



Low-pass filtered SST Anomaly and significant SST Correlation



Low-pass filtered SST Anomaly and positive SST Correlation



Conclusions

- 3D Visualization of 2D data
 - Qualitative Analysis of spatiotemporal predictive skill characteristics
 - Animated display of data and related (un)certainty information
 - For small ensembles: Positive correlation better suited than significance levels
- Future work
 - Combined visualization of forecast quantity, skill and standard deviation (-> EnvirVis 2015, co-located to EuroVis 2015, Cagliari, Sardinia)

Thank You!

<boettinger@dkrz.de>

Related Work

- Uncertainty Visualization
 - Potter et al. 2009: Ensemble Vis
 - Sanyal et al. 2010: Noodles: A Tool for Visualization of Numerical Weather Model Ensemble Uncertainty
 - Brodlie et al. 2012: Review of Uncertainty in Data Visualization
 - Bonneau et al. 2014: State of the Art of Uncertainty Visualization
 - Obermaier et al. 2014: Future Challenges for Ensemble Visualization: feature based methods vs. location based methods
- Decadal climate predictions
 - Smith et al. 2007: First paper preparing the ground for decadal climate predictions
 - Meehl et al. 2009,2013: Overview on the field, challenges
 - IPCC AR5 WG1, 2013: Chapter 11, Kirtman & Power 2013: Near-term climate change: State of the Art Review